MT6235 GSM/GPRS Baseband Processor Data Sheet

Revision 1.02

Apr 07, 2008

Revision History

Revision	Date	Comments
1.00	Sept 18, 2007	First Release
1.01	Dec 13, 2007	1. Update GPIO10 GPIO11 mode definition 2. Update ch8 audio front end and ch13 analog front end & analog blocks for PMU ball name change (VMC,VSW_A, VCAMERA) > (VBT, VCAM_A, VCAM_D)
1.02	Apr 07, 2008	1. Update RGU, MCU, RTC, SIM, EMI, GLCON, TG, System Overview, and Product Description

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Preface

Acronym for Register Type

R/W	Capable of both read and write access
RO	Read only
RC	Read only. After reading the register bank, each bit which is HIGH(1) will be cleared to LOW(0) automatically.
WO	Write only
W1S	Write only. When writing data bits to register bank, each bit which is HIGH(1) will cause the corresponding bit to be set to 1. Data bits which are LOW(0) has no effect on the corresponding bit.
W1C	Write only. When writing data bits to register bank, each bit which is HIGH(1) will cause the corresponding bit to be cleared to 0. Data bits which are LOW(0) has no effect on the corresponding bit.

1. System Overview

MT6235 is a highly-integrated and extremely powerful single-chip solution for GSM/GPRS/EDGE mobile phones. Based on the 32-bit ARM926EJ-S™ RISC processor, MT6235's superb processing power, along with high bandwidth architecture and dedicated hardware support, provides an unprecedented platform for high performance GPRS/EDGE Class 12 MODEM application. Overall, MT6235 presents a revolutionary platform for mobile devices.

Typical application diagram is shown in **Figure** 1.

Platform

MT6235 is capable of running the ARM926EJ-S™ RISC processor at up to 208 MHz, thus providing fast data processing capabilities. In addition to the high clock frequency, separate CODE and DATA caches are also included to further improve the overall system efficiency.

For large amounts of data transfer, high performance DMA (Direct Memory Access) with hardware flow control is implemented, which greatly enhances the data movement speed while reducing MCU processing load.

Targeted as a high performance platform for mobile applications, hardware flash content protection is also provided to prevent unauthorized porting of the software load to protect the manufacturer's development investment.

Memory

To provide the greatest capacity for expansion and maximum bandwidth for data intensive applications such as multimedia features, MT6235 supports up to 4 external state-of-the-art devices through its 8/16-bit host interface. High performance devices such as Mobile SDRAM and Cellular RAM are supported for maximum bandwidth. Traditional devices such as burst/page mode flash, page mode SRAM, and Pseudo SRAM are also supported. For greatest compatibility, the memory interface can also be used to connect to legacy devices such as Color/Parallel LCD, and multi-media companion chips are all supported through this interface. To minimize power consumption and ensure low noise, this interface is designed for flexible I/O voltage and allows lowering of the supply voltage down to 1.8V. The driving strength is configurable for signal integrity adjustment.

Multi-media

The MT6235 multi-media subsystem provides a connection to a CMOS image sensor and supports a resolution up to 2.0 Mpixels. With its high performance application platform, MT6235 allows efficient processing of image and video data.

In addition to image and video features, MT6235 utilizes high resolution DAC, digital audio, and audio synthesis technology to provide superior audio features for all future multi-media needs.

Connectivity and Storage

To take advantage of its incredible multimedia strengths, MT6235 incorporates myriads of advanced connectivity and storage options for data storage and communication. MT6235 supports UART, Fast IrDA, USB 2.0, SDIO, Bluetooth, Touch Screen Controller, WIFI Interface, and MMC/SD/MS/MS Pro storage systems. These interfaces provide MT6235 users with the highest degree of flexibility in implementing solutions suitable for the targeted application.

To achieve a complete user interface, MT6235 also brings together all the necessary peripheral blocks for a multi-media GSM/GPRS/EDGE phone. The peripheral blocks include the Keypad Scanner with the capability to detect multiple key presses, SIM Controller, Alerter, Real Time Clock, PWM, Serial LCD Controller, and General Purpose Programmable I/Os.

Furthermore, to provide much better configurability and bandwidth for multi-media products, an additional 18-bit parallel interface is incorporated. This interface enables connection to LCD panels as well as NAND flash devices for additional multi-media data storage.

Audio

Using a highly integrated mixed-signal Audio Front-End, the MT6235 architecture allows for easy audio interfacing with direct connection to the audio transducers. The audio interface integrates D/A and A/D Converters for Voice band, as well as high resolution Stereo D/A Converters for Audio band. In addition, MT6235 also provides Stereo Input and Analog MUX.

MT6235 supports AMR codec to adaptively optimize speech and audio quality. Moreover, HE-AAC codec is implemented to deliver CD-quality audio at low bit rates.

On the whole, MT6235's audio features provide a rich solution for multi-media applications.

Radio

MT6235 integrates a mixed-signal baseband front-end in order to provide a well-organized radio interface with flexibility for efficient customization. The front-end contains gain and offset calibration mechanisms, and filters with programmable coefficients for comprehensive compatibility control on RF modules. This approach allows the usage of a high resolution D/A Converter for controlling VCXO or crystal, reducing the need for an expensive TCVCXO. MT6235 achieves great MODEM performance by utilizing a 14-bit high resolution A/D Converter in the RF downlink path. Furthermore, to reduce the need for extra external current-driving component, the driving strength of some BPI outputs is designed to be configurable.

Debug Function

The JTAG interface enables in-circuit debugging of the software program with the ARM926EJ-S core. With this standardized debugging interface, MT6235 provides developers with a wide set of options in choosing ARM development kits from different third party vendors.

Power Management

The MT6235 offers various low-power features to help reduce system power consumption. These features include a Pause Mode of 32 KHz clocking in Standby State, Power Down Mode for individual peripherals, and Processor Sleep Mode. MT6235 is also fabricated in an advanced low leakage CMOS process, hence providing an overall ultra low leakage solution.

Package

The MT6235 device is offered in a 13mm×13mm, 362-ball, 0.5 mm pitch, TFBGA package.

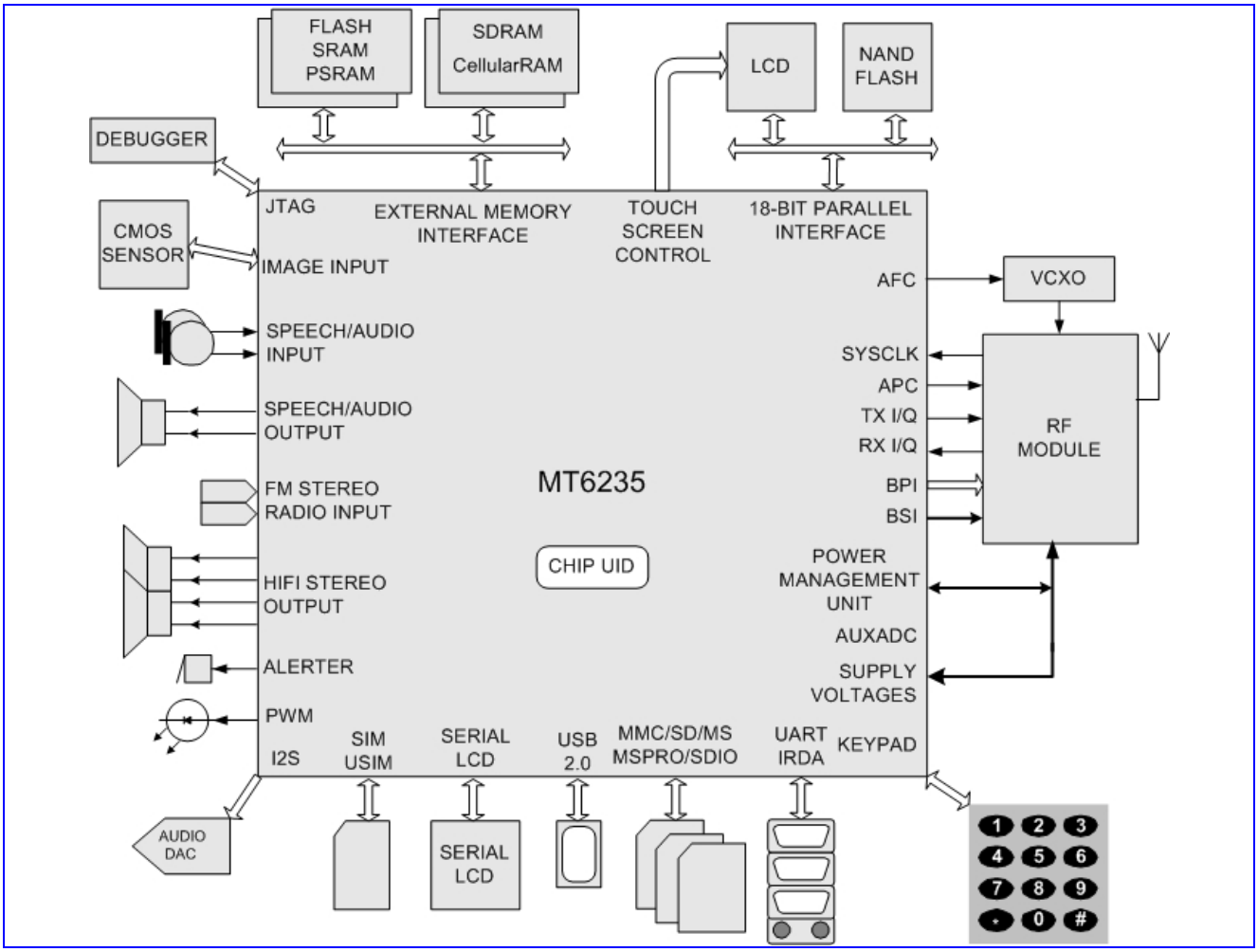


Figure 1 Typical application of MT6235

Platform Features

- **General**
  - Integrated voice-band, audio-band and base-band analog front ends
  - TFBGA 13mm×13mm, 362-ball, 0.5 mm pitch package
- **MCU Subsystem**
  - ARM926EJ-S 32-bit RISC processor
  - High performance multi-layer AMBA bus
  - Java hardware acceleration for fast Java-based games and applets
  - Operating frequency: 26/52/104/208 MHz
  - Dedicated DMA bus
  - 14 DMA channels
  - 512K bits on-chip SRAM
  - 384K bits Instruction-TCM
  - 640K bits Data-TCM
  - 128K bits Instruction-Cache
  - 128K bits Data-Cache
  - On-chip boot ROM for Factory Flash Programming
  - Watchdog timer for system crash recovery
  - 3 sets of General Purpose Timer
  - Circuit Switch Data coprocessor
  - Division coprocessor
  - PPP Framer coprocessor
- **External Memory Interface**
  - Supports up to 4 external memory devices
  - Supports 8-bit or 16-bit memory components with maximum size of up to 128M Bytes each
  - Supports Mobile SDRAM and Cellular RAM
  - Supports Flash and SRAM/PSRAM with page mode or burst mode
  - Industry standard Parallel LCD interface
  - Supports multi-media companion chips with 8/16 bits data width
  - Flexible I/O voltage of 1.8V ~ 2.8V for memory interface
  - Configurable driving strength for memory interface
- **User Interfaces**
  - 8-row × 8-column keypad controller with hardware scanner
  - Supports multiple key presses for gaming
  - SIM/USIM controller with hardware T=0/T=1 protocol control
  - Real Time Clock (RTC) operating with a separate power supply
  - General Purpose I/Os (GPIOs)
  - 4 sets of Pulse Width Modulation (PWM) output
  - Alerter output with Enhanced PWM or PDM
  - 8 external interrupt lines
- **Security**
  - Supports security key and 126 bit chip unique ID
- **Connectivity**
  - 3 UARTs with hardware flow control and speeds up to 921600 bps
  - IrDA modulator/demodulator with hardware framer. Supports SIR/MIR/FIR operating speeds.
  - USB 2.0 capability
  - Multi Media Card, Secure Digital Memory Card, Memory Stick, Memory Stick Pro host controller with flexible I/O voltage power

- Supports SDIO interface for SDIO peripherals as well as WIFI connectivity
- DAI/PCM and I2S interface for Audio application

■ **Power Management**

- Power Down Mode for analog and digital circuits
- Processor Sleep Mode
- Pause Mode of 32 KHz clocking in Standby State
- 4-channel Auxiliary 10-bit A/D Converter for charger and battery monitoring and photo sensing

■ **Test and Debug**

- Built-in digital and analog loop back modes for both Audio and Baseband Front-End
- DAI port complying with GSM Rec.11.10
- JTAG port for debugging embedded MCU

1.1 MODEM Features

- **Radio Interface and Baseband Front End**
  - GMSK modulator with analog I and Q channel outputs
  - 10-bit D/A Converter for uplink baseband I and Q signals
  - 14-bit high resolution A/D Converter for downlink baseband I and Q signals
  - Calibration mechanism of offset and gain mismatch for baseband A/D Converter and D/A Converter
  - 10-bit D/A Converter for Automatic Power Control
  - 13-bit high resolution D/A Converter for Automatic Frequency Control
  - Programmable Radio RX filter
  - 2 channels Baseband Serial Interface (BSI) with 3-wire control
  - Bi-directional BSI interface. RF chip register read access with 3-wire or 4-wire interface.
  - 10-Pin Baseband Parallel Interface (BPI) with programmable driving strength
  - Multi-band support
- **Voice and Modem CODEC**
  - Dial tone generation
  - Voice memo
  - Noise reduction
  - Echo suppression
  - Advanced sidetone Oscillation Reduction
  - Digital sidetone generator with programmable gain
  - Two programmable acoustic compensation filters
  - GSM/GPRS quad vocoders for adaptive multirate (AMR), enhanced full rate (EFR), full rate (FR) and half rate (HR)
  - GSM channel coding, equalization and A5/1, A5/2 and A5/3 ciphering
  - GPRS GEA1, GEA2 and GEA3 ciphering
  - Programmable GSM/GPRS/EDGE modem
  - Packet Switched Data with CS1/CS2/CS3/CS4 coding schemes
  - GSM Circuit Switch Data
  - GPRS/EDGE Class 12
- **Voice Interface and Voice Front End**
  - Two microphone inputs sharing one low noise amplifier with programmable gain and automatic gain control (AGC) mechanisms
  - Voice power amplifier with programmable gain
  - 2nd order Sigma-Delta A/D Converter for voice uplink path
  - D/A Converter for voice downlink path
  - Supports half-duplex hands-free operation
  - Compliant with GSM 03.50

1.2 Multi-Media Features

- **LCD/NAND Flash Interface**
  - Dedicated Parallel Interface supports 3 external devices with 8-/16-bit NAND flash interface, 8-/9-/16-/18-bit Parallel interface, and Serial interface for LCM
  - Built-in NAND Flash Controller with 1-bit ECC for mass storage
- **LCD Controller**
  - Supports simultaneous connection to up to 3 parallel LCD and 2 serial LCD modules
  - Supports LCM format: RGB332, RGB444, RGB565, RGB666, RGB888
  - Supports LCD module with maximum resolution up to 800x600 at 24bpp
  - Per pixel alpha channel
  - True color engine
  - Supports hardware display rotation
  - Capable of combining display memories with up to 6 blending layers
- **Image Signal Processor**
  - 8 bit YUV format image input
  - Capable of processing image of size up to 2.0 M pixels
  - IEEE Std 1180-1990 IDCT standards compliance
  - Supports progressive image processing to minimize storage space requirement
  - Supports reload-able DMA for VLD stream
- **Image Data Processing**
  - Supports Digital Zoom
  - Supports RGB888/565, YUV444 image processing
  - High throughput hardware scaler. Capable of tailoring an image to an arbitrary size.
  - Horizontal scaling in averaging method
  - Vertical scaling in bilinear method
  - YUV and RGB color space conversion
  - Boundary padding
- **2D Accelerator**
  - Supports 32-bpp ARGB8888, 24-bpp RGB888, 16-bpp RGB565, and 8-bpp index color modes
  - Supports SVG Tiny
  - Rectangle gradient fill
  - BitBlt: multi-BitBlt with 7 rotation, 16 binary ROP
  - Alpha blending with 7 rotation
  - Line drawing: normal line, dotted line, anti-aliasing
  - Circle drawing
  - Bezier curve drawing
  - Triangle flat fill
  - Font caching: normal font, italic font
  - Command queue with max depth of 2047
- **Audio CODEC**
  - Supports HE-AAC codec decode
  - Supports AAC codec decode
  - Wavetable synthesis with up to 64 tones
  - Advanced wavetable synthesizer capable of generating simulated stereo
  - Wavetable including GM full set of 128 instruments and 47 sets of percussions
  - PCM Playback and Record
  - Digital Audio Playback
- **Audio Interface and Audio Front End**
  - Supports I2S interface

- High resolution D/A Converters for Stereo Audio playback
- Stereo analog input for stereo audio source
- Analog multiplexer for stereo audio
- Stereo to mono conversion

1.3 General Description

Figure 2 depicts the block diagram of MT6235. Based on a dual-processor architecture, MT6235 integrates both an ARM926EJ-S core and a digital signal processor core. ARM926EJ-S is the main processor responsible for running high-level GSM/GPRS protocol software as well as multi-media applications. The digital signal processor manages the low-level MODEM as well as advanced audio functions. Except for a few mixed-signal circuitries, the other building blocks in MT6235 are connected to either the microcontroller or the digital signal processor.

MT6235consists of the following subsystems:

- Microcontroller Unit (MCU) Subsystem: includes an ARM926EJ-S RISC processor and its accompanying memory management and interrupt handling logics;
- Digital Signal Processor (DSP) Subsystem: includes a DSP and its accompanying memory, memory controller, and interrupt controller;
- MCU/DSP Interface: the junction at which the MCU and the DSP exchange hardware and software information;
- Microcontroller Peripherals: includes all user interface modules and RF control interface modules;
- Microcontroller Coprocessors: runs computing-intensive processes in place of the Microcontroller;
- DSP Peripherals: hardware accelerators for GSM/GPRS/EDGE channel codec;
- Multi-media Subsystem: integrates several advanced accelerators to support multi-media applications;
- Voice Front End: the data path for converting analog speech to and from digital speech;
- Audio Front End: the data path for converting stereo audio from an audio source;
- Baseband Front End: the data path for converting a digital signal to and from an analog signal from the RF modules;
- Timing Generator: generates the control signals related to the TDMA frame timing; and,
- Power, Reset and Clock Subsystem: manages the power, reset, and clock distribution inside MT6235.

Details of the individual subsystems and blocks are described in the following chapters.

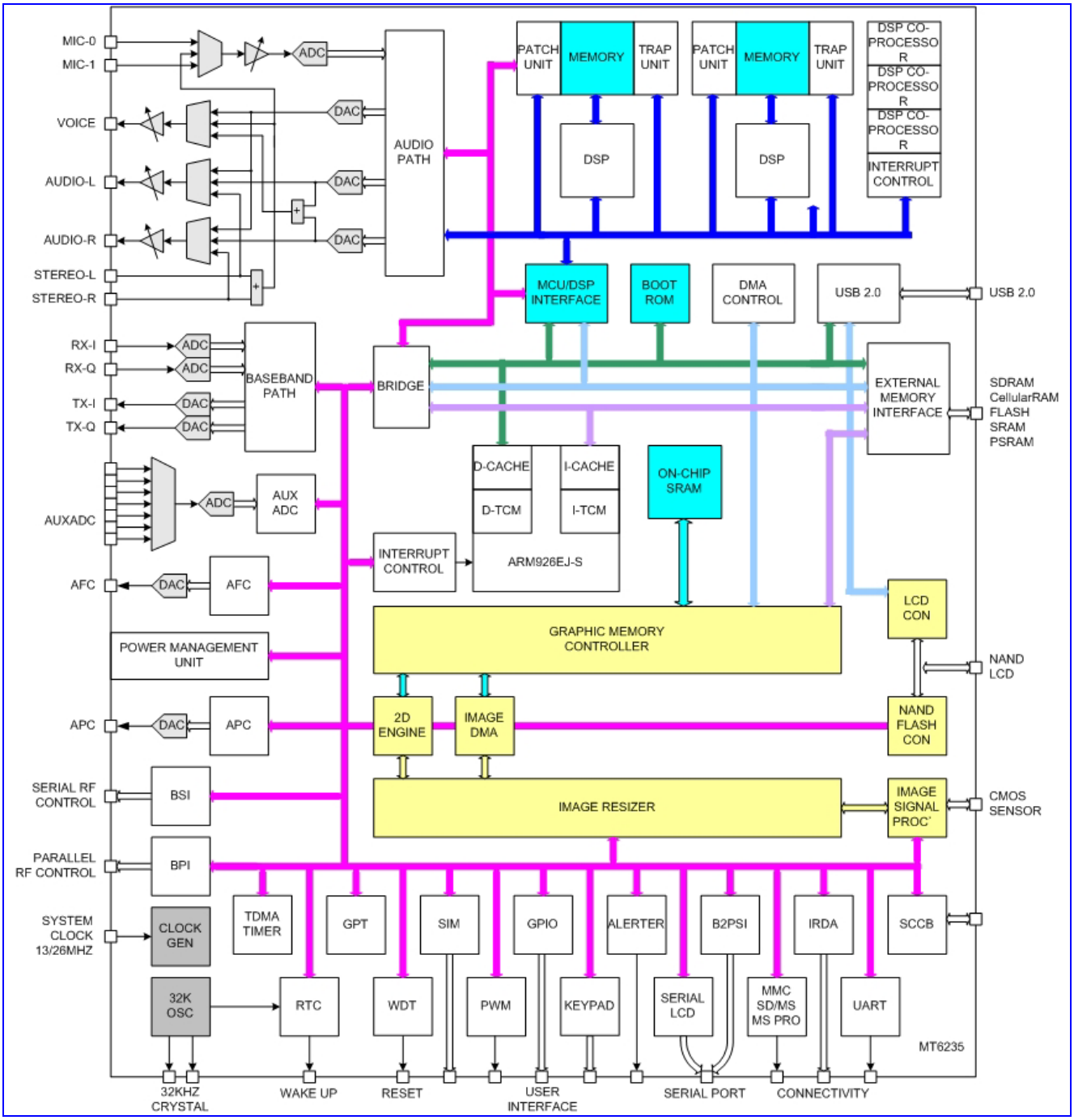


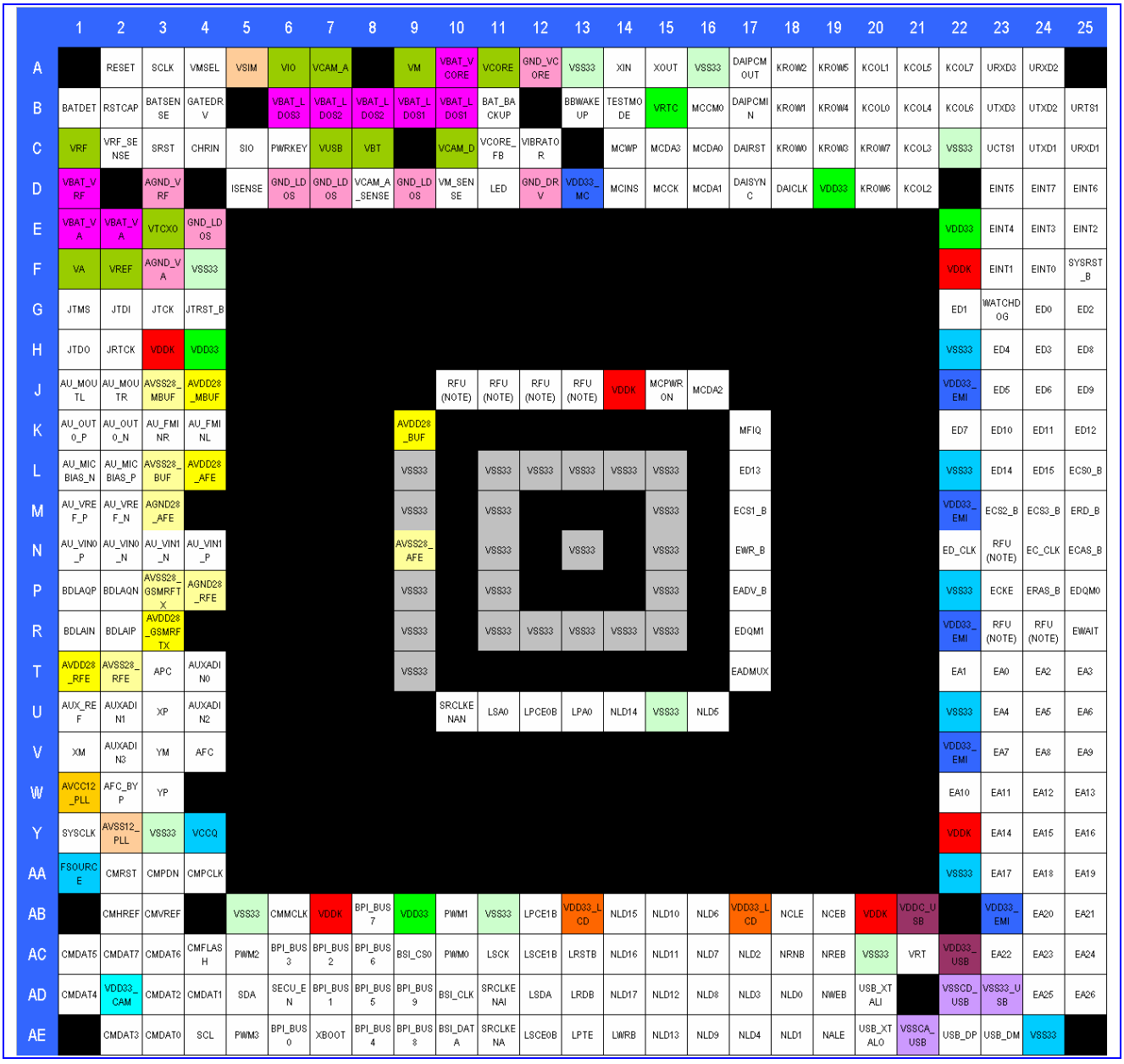
Figure 2 MT6235 block diagram.

2 Product Description

2.1 Pin Outs

One type of package for this product, TFBGA 13mm*13mm, 362-ball, 0.5 mm pitch package, is offered.

Pin-outs and the top view are illustrated in **Figure 3** for this package. Outline and dimension of package is illustrated in **Figure 4**, while the definition of package is shown in **Table 1**.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
A		RESET	SCLK	VMSEL	VSIM	VIO	VCAM_A		VM	VBAT_VCORE	VCORE	GND_VCORE	VSS33	XIN	XOUT	VSS33	DAIPCMOUT	KROW2	KROW5	KCOL1	KCOL5	KCOL7	URXD3	URXD2	
B	BATDET	RSTCAP	BATSENSE	GATEDRV		VBAT_LDO3	VBAT_LDO2	VBAT_LDO2	VBAT_LDO1	VBAT_LDO1	BAT_BACKUP		BBWAKEUP	TESTMODE	VRTC	MCCM0	DAIPCMIN	KROW1	KROW4	KCOL0	KCOL4	KCOL6	UTXD3	UTXD2	URTS1
C	VRF	VRF_SENSE	SRST	CHRIN	SIO	PWRKEY	VUSB	VBT		VCAM_D	VCORE_FB	VIBRATOR		MCWP	MCDA3	MCDA0	DAIRST	KROW0	KROW3	KROW7	KCOL3	VSS33	UCTS1	UTXD1	URXD1
D	VBAT_VRF		AGND_VRF		ISENSE	GND_LDOS	GND_LDOS	VCAM_A_SENSE	GND_LDOS	VM_SENSE	LED	GND_DRV	VDD33_MC	MCINS	MCCK	MCDA1	DAISYNC	DAICLK	VDD33	KROW6	KCOL2		EINT5	EINT7	EINT6
E	VBAT_VA	VBAT_VA	VTCXO	GND_LDOS																		VDD33	EINT4	EINT3	EINT2
F	VA	VREF	AGND_VA	VSS33																		VDDK	EINT1	EINT0	SYSRST_B
G	JTMS	JTDI	JTCK	JTRST_B																		ED1	WATCHDOG	ED0	ED2
H	JTDO	JRTCK	VDDK	VDD33																		VSS33	ED4	ED3	ED8
J	AU_MOUTL	AU_MOUTR	AVSS28_MBUF	AVDD28_MBUF						RFU (NOTE)	RFU (NOTE)	RFU (NOTE)	RFU (NOTE)	VDDK	MCPWRON	MCDA2						VDD33_EMI	ED5	ED6	ED9
K	AU_OUT0_P	AU_OUT0_N	AU_FMINR	AU_FMINL					AVDD28_BUF								MFIQ					ED7	ED10	ED11	ED12
L	AU_MICBIAS_N	AU_MICBIAS_P	AVSS28_BUF	AVDD28_AFE					VSS33		VSS33	VSS33	VSS33	VSS33	VSS33		ED13					VSS33	ED14	ED15	ECS0_B
M	AU_VREF_P	AU_VREF_N	AGND28_AFE						VSS33		VSS33				VSS33		ECS1_B					VDD33_EMI	ECS2_B	ECS3_B	ERD_B
N	AU_VIN0_P	AU_VIN0_N	AU_VIN1_N	AU_VIN1_P					AVSS28_AFE		VSS33		VSS33		VSS33		EWR_B					ED_CLK	RFU (NOTE)	EC_CLK	ECAS_B
P	BDLAQP	BDLAQN	AVSS28_GSMRFTX	AGND28_RFE					VSS33		VSS33				VSS33		EADV_B					VSS33	ECKE	ERAS_B	EDQM0
R	BDLAIN	BDLAIP	AVDD28_GSMRFTX						VSS33		VSS33	VSS33	VSS33	VSS33	VSS33		EDQM1					VDD33_EMI	RFU (NOTE)	RFU (NOTE)	EWAIT
T	AVDD28_RFE	AVSS28_RFE	APC	AUXADIN0					VSS33								EADMUX					EA1	EA0	EA2	EA3
U	AUX_REF	AUXADIN1	XP	AUXADIN2						SRCLKENAN	LSA0	LPCE0B	LPA0	NLD14	VSS33	NLD5						VSS33	EA4	EA5	EA6
V	XM	AUXADIN3	YM	AFC																		VDD33_EMI	EA7	EA8	EA9
W	AVCC12_PLL	AFC_BYP	YP																			EA10	EA11	EA12	EA13
Y	SYSCLK	AVSS12_PLL	VSS33	VCCQ																		VDDK	EA14	EA15	EA16
AA	FSOURCE	CMRST	CMPDN	CMPCLK																		VSS33	EA17	EA18	EA19
AB		CMHREF	CMVREF		VSS33	CMMCLK	VDDK	BPI_BUS7	VDD33	PWM1	VSS33	LPCE1B	VDD33_LCD	NLD15	NLD10	NLD6	VDD33_LCD	NCLE	NCEB	VDDK	VDDC_USB		VDD33_EMI	EA20	EA21
AC	CMDAT5	CMDAT7	CMDAT6	CMFLASH	PWM2	BPI_BUS3	BPI_BUS2	BPI_BUS6	BSI_CS0	PWM0	LSCK	LSCE1B	LRSTB	NLD16	NLD11	NLD7	NLD2	NRNB	NREB	VSS33	VRT	VDD33_USB	EA22	EA23	EA24
AD	CMDAT4	VDD33_CAM	CMDAT2	CMDAT1	SDA	SECU_EN	BPI_BUS1	BPI_BUS5	BPI_BUS9	BSI_CLK	SRCLKENAI	LSDA	LRDB	NLD17	NLD12	NLD8	NLD3	NLD0	NWEB	USB_XTALI		VSSCD_USB	VSS33_USB	EA25	EA26
AE		CMDAT3	CMDAT0	SCL	PWM3	BPI_BUS0	XBOOT	BPI_BUS4	BPI_BUS8	BSI_DATA	SRCLKENA	LSCE0B	LPTE	LWRB	NLD13	NLD9	NLD4	NLD1	NALE	USB_XTALO	VSSCA_USB	USB_DP	USB_DM	VSS33	

Figure 3 Top view of MT6235 TFBGA 13mm*13mm, 362-ball, 0.5 mm pitch package

Notes: RFU is reserved for future use and leave as NC in normal operation.

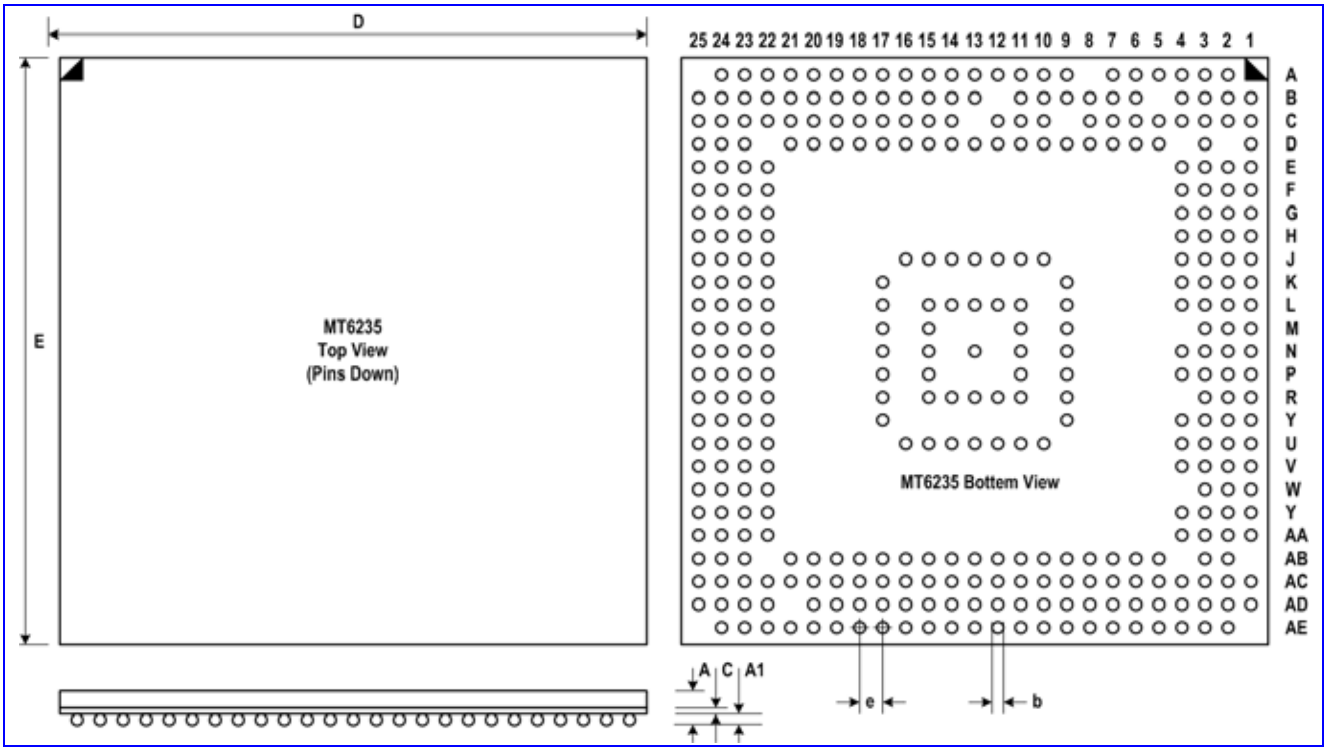
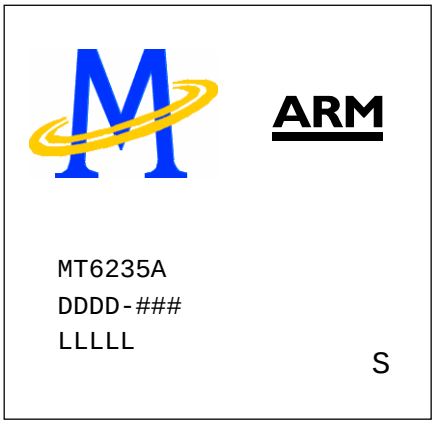


Figure 4 Outlines and dimension of TFBGA 13mm*13mm, 362-ball, 0.5 mm pitch package

Body Size		Ball Count	Ball Pitch	Ball Dia.	Package Thk.	Stand Off	Substrate Thk.
D	E	N	e	b	A (MAX)	A1(NOM)	C
13	13	362	0.5	0.3	1.2	0.21	0.36

Table 1 Definition of TFBGA 13mm*13mm, 362-ball, 0.5 mm pitch package (Unit: mm)

2.2 Top Marking Definition



MT6235A: Part No.
DDDD: Date Code
###: Subcontractor Code
LLLLL: U1 Die Lot No.
S: Special Code

2.3 DC Characteristics

2.3.1 Absolute Maximum Ratings

Prolonged exposure to absolute maximum ratings may reduce device reliability. Functional operation at these maximum ratings is not implied.

Item	Symbol	Min	Max	Unit
IO power supply	VDD33	-0.3	VDD33+0.3	V
I/O input voltage	VDD33	-0.3	VDD33+0.3	V
Operating temperature	Topr	-20	80	Celsius
Storage temperature	Tstg	-55	125	Celsius

2.4 Pin Description

Ball 13X13	Name	Dir	Description	Mode0	Mode1	Mode2	Mode3	PU/ PD	Reset
			JTAG Port						
G4	JTRST_B	I	JTAG test port reset input					PD	PD
G3	JTCK	I	JTAG test port clock input					PU	PU
G2	JTDI	I	JTAG test port data input					PU	PU
G1	JTMS	I	JTAG test port mode switch					PU	PU
H1	JTDO	IO	JTAG test port data output						
H2	JRTCK	IO	JTAG test port returned clock output						
			RF Parallel Control Unit						
AE6	BPI_BUS0	IO	RF hard-wire control bus 0						
AD7	BPI_BUS1	IO	RF hard-wire control bus 1						
AC7	BPI_BUS2	IO	RF hard-wire control bus 2						
AC6	BPI_BUS3	IO	RF hard-wire control bus 3	**GPIO19**	BPI_BUS3			PU/ PD	PD
AE8	BPI_BUS4	IO	RF hard-wire control bus 4						
AD8	BPI_BUS5	IO	RF hard-wire control bus 5						
AC8	BPI_BUS6	IO	RF hard-wire control bus 6	**GPIO20**	BPI_BUS6			PU/ PD	PD
AB8	BPI_BUS7	IO	RF hard-wire control bus 7	**GPIO21**	BPI_BUS7			PU/ PD	PD

AE9	BPI_BUS8	IO	RF hard-wire control bus 8	**GPIO22**	BPI_BUS8			PU/PD	PD
AD9	BPI_BUS9	IO	RF hard-wire control bus 9	**GPIO23**	BPI_BUS9	BSI_CS1		PU/PD	PD
			RF Serial Control Unit						
AC9	BSI_CS0	IO	RF 3-wire interface chip select 0						
AE10	BSI_DATA	IO	RF 3-wire interface data output						
AD10	BSI_CLK	IO	RF 3-wire interface clock output						
			PWM Interface						
AC10	PWM0	IO	Pulse width modulated signal 0	**GPIO39**	PWM0			PU/PD	PD
AB10	PWM1	IO	Pulse width modulated signal 1	**GPIO40**	PWM1	BSI_RFIN		PU/PD	PD
AC5	PWM2	IO	Pulse width modulated signal 2	**GPIO17**	PWM2		D2_TID5	PU/PD	PD
AE5	PWM3	IO	Pulse width modulated signal 3	**GPIO18**	PWM3		D2_TID6	PU/PD	PD
			Camera Control Interface						
AE4	SCL	IO		**GPIO15**	SCL		D2_TID3	PU/PD	PU
AD5	SDA	IO		**GPIO16**	SDA		D2_TID4	PU/PD	PU
			Serial LCD/PM IC Interface						
AC11	LSCK	IO	Serial display interface data output	**GPIO24**	LSCK	DSP_GPO2	IRQ0	PU/PD	PD
U11	LSA0	IO	Serial display interface address output	**GPIO25**	LSA0	DSP_GPO3	IRQ1	PU/PD	PD

AD12	LSDA	IO	Serial display interface clock output	**GPIO26**	LSDA	CLKM1	TDTIRQ	PU/ PD	PD
AE12	LSCE0B	IO	Serial display interface chip select 0 output	**GPIO27**	LSCE0B	CLKM2	TCTIRQ2	PU/ PD	PU
AC12	LSCE1B	IO	Serial display interface chip select 1 output	**GPIO28**	LSCE1B	LPCE2B	TCTIRQ1	PU/ PD	PU
			Parallel LCD/NAND-Flash Interface						
AB12	LPCE1B	IO	Parallel display interface chip select 1 output	**GPIO29**	LPCE1B	NCE1B	TEVTVAL	PU/ PD	PU
U12	LPCE0B	IO	Parallel display interface chip select 0 output						
AE13	LPTE	IO		**GPIO30**	LPTE			PU/ PD	PD
AC13	LRSTB	IO	Parallel display interface Reset Signal						
AD13	LRDB	IO	Parallel display interface Read Strobe						
U13	LPA0	IO	Parallel display interface address output						
AE14	LWRB	IO	Parallel display interface Write Strobe						
AD14	NLD17	IO	Parallel LCD/NAND-Flash Data 17	**GPIO31**	NLD17			PU/ PD	PD
AC14	NLD16	IO	Parallel LCD/NAND-Flash Data 16	**GPIO32**	NLD16			PU/ PD	PD
AB14	NLD15	IO	Parallel LCD/NAND-Flash Data 15					PD	
U14	NLD14	IO	Parallel LCD/NAND-Flash Data 14					PD	
AE15	NDL13	IO	Parallel LCD/NAND-Flash Data 13					PD	
AD15	NLD12	IO	Parallel LCD/NAND-Flash Data 12					PD	
AC15	NLD11	IO	Parallel LCD/NAND-Flash Data 11					PD	
AB15	NLD10	IO	Parallel LCD/NAND-Flash Data 10					PD	
AE16	NLD9	IO	Parallel LCD/NAND-Flash Data 9					PD	
AD16	NLD8	IO	Parallel LCD/NAND-Flash Data 8					PD	
AC16	NLD7	IO	Parallel LCD/NAND-Flash Data 7					PD	
AB16	NLD6	IO	Parallel LCD/NAND-Flash Data 6					PD	
U16	NLD5	IO	Parallel LCD/NAND-Flash Data 5					PD	
AE17	NLD4	IO	Parallel LCD/NAND-Flash Data 4					PD	
AD17	NLD3	IO	Parallel LCD/NAND-Flash Data 3					PD	
AC17	NLD2	IO	Parallel LCD/NAND-Flash Data 2					PD	
AE18	NLD1	IO	Parallel LCD/NAND-Flash Data 1					PD	
AD18	NLD0	IO	Parallel LCD/NAND-Flash Data 0					PD	
AC18	NRNB	IO	NAND-Flash Read/Busy Flag	GPIO33	**NRNB**			PU/ PD	PU
AB18	NCLE	IO	NAND-Flash Command Latch Signal	GPIO34	**NCLE**			PU/ PD	
AE19	NALE	IO	NAND-Flash Address Latch Signal	GPIO35	**NALE**			PU/ PD	
AD19	NWEB	IO	NAND-Flash Write Strobe	GPIO36	**NWEB**			PU/ PD	
AC19	NREB	IO	NAND-Flash Read Strobe	GPIO37	**NREB**			PU/ PD	

AB19	NCEB	IO	NAND-Flash Chip select output	GPIO38	**NCE0B**			PU/ PD	
			Miscellaneous						
F25	SYSRST_B	I	System reset input active low					PU	PU
G23	WATCHDOG	IO	Watchdog reset output						
U10	SRCLKENAN	IO	External TCXO enable output active low	GPIO42	**SRCLKENAN**			PU/ PD	
AE11	SRCLKENA	IO	External TCXO enable output active high	GPIO41	**SRCLKENA**			PU/ PD	
AD11	SRCLKENAI	IO	External TCXO enable input	**GPIO43**	SRCLKENAI			PU/ PD	PD
B14	TESTMODE	I	TESTMODE enable input					PD	PD
Y4	VCCQ	I							
AA1	FSOURCE	I							
AD6	SECU_EN	I							
AE7	XBOOT	I						PD	PD
			Keypad Interface						
A22	KCOL7	IO	Keypad column 7	**GPIO55**	KCOL7	IRDA_PDN		PU/ PD	PU
B22	KCOL6	IO	Keypad column 6	**GPIO56**	KCOL6			PU/ PD	PU
A21	KCOL5	IO	Keypad column 5					PU	PU
B21	KCOL4	IO	Keypad column 4					PU	PU
C21	KCOL3	IO	Keypad column 3					PU	PU
D21	KCOL2	IO	Keypad column 2					PU	PU
A20	KCOL1	IO	Keypad column 1					PU	PU
B20	KCOL0	IO	Keypad column 0					PU	PU
C20	KROW7	IO	Keypad row 7	**GPIO57**	KROW7	CLKM4		PU/ PD	PD
D20	KROW6	IO	Keypad row 6	**GPIO58**	KROW6			PU/ PD	PD
A19	KROW5	IO	Keypad row 5						
B19	KROW4	IO	Keypad row 4						
C19	KROW3	IO	Keypad row 3						
A18	KROW2	IO	Keypad row 2						
B18	KROW1	IO	Keypad row 1						
C18	KROW0	IO	Keypad row 0						
			External Interrupt Interface						
F24	EINT0	IO	External interrupt 0					PU	PU
F23	EINT1	IO	External interrupt 1					PU	PU
E25	EINT2	IO	External interrupt 2					PU	PU
E24	EINT3	IO	External interrupt 3	**GPIO44**	EINT3	DRF_DATA	IRQ2	PU/ PD	PU
E23	EINT4	IO	External interrupt 4	**GPIO45**	EINT4	DRF_EN	CLKM3	PU/ PD	PU
D23	EINT5	IO	External interrupt 5	**GPIO46**	EINT5	EDICK		PU/ PD	PU
D25	EINT6	IO	External interrupt 6	**GPIO47**	EINT6	EDIWS		PU/ PD	PU
D24	EINT7	IO	External interrupt 7	**GPIO48**	EINT7	EDIDAT		PU/ PD	PU

K17	MFIQ	IO	Interrupt to MCU	**GPIO66**	:nFIQ	CLKM7		PU/ PD	PU
			External Memory Interface						
G24	ED0	IO	External memory data bus 0						
G22	ED1	IO	External memory data bus 1						
G25	ED2	IO	External memory data bus 2						
H24	ED3	IO	External memory data bus 3						
H23	ED4	IO	External memory data bus 4						
J23	ED5	IO	External memory data bus 5						
J24	ED6	IO	External memory data bus 6						
K22	ED7	IO	External memory data bus 7						
H25	ED8	IO	External memory data bus 8						
J25	ED9	IO	External memory data bus 9						
K23	ED10	IO	External memory data bus 10						
K24	ED11	IO	External memory data bus 11						
K25	ED12	IO	External memory data bus 12						
L17	ED13	IO	External memory data bus 13						
L23	ED14	IO	External memory data bus 14						
L24	ED15	IO	External memory data bus 15						
M25	ERD_B	IO	External memory read strobe						
N17	EWR_B	IO	External memory write strobe						
L25	ECS0_B	IO	External memory chip select 0						
M17	ECS1_B	IO	External memory chip select 1						
M23	ECS2_B	IO	External memory chip select 2						
M24	ECS3_B	IO	External memory chip select 3						
R25	EWAIT	IO	Flash, PSRAM and CellularRAM data ready					PD	
N25	ECAS_B	IO	MobileRAM column address						
P24	ERAS_B	IO	MobileRAM row address						
P23	ECKE	IO	MobileRAM clock enable						
N22	ED_CLK	O	MobileRAM clock						
T17	EADMUX	IO		GPIO65	**EADMUX**	CLKM6		PU/ PD	
R17	EDQM1	IO							
P25	EDQM0	IO							
P17	EADV_B	O	Flash, PSRAM and CellularRAM address valid						
N24	EC_CLK	O	Flash, PSRAM and CellularRAM clock						
T23	EA0	IO	External memory address bus 0						
T22	EA1	IO	External memory address bus 1						
T24	EA2	IO	External memory address bus 2						
T25	EA3	IO	External memory address bus 3						
U23	EA4	IO	External memory address bus 4						
U24	EA5	IO	External memory address bus 5						
U25	EA6	IO	External memory address bus 6						
V23	EA7	IO	External memory address bus 7						
V24	EA8	IO	External memory address bus 8						
V25	EA9	IO	External memory address bus 9						
W22	EA10	IO	External memory address bus 10						

W23	EA11	IO	External memory address bus 11						
W24	EA12	IO	External memory address bus 12						
W25	EA13	IO	External memory address bus 13						
Y23	EA14	IO	External memory address bus 14						
Y24	EA15	IO	External memory address bus 15						
Y25	EA16	IO	External memory address bus 16						
AA23	EA17	IO	External memory address bus 17						
AA24	EA18	IO	External memory address bus 18						
AA25	EA19	IO	External memory address bus 19						
AB24	EA20	IO	External memory address bus 20						
AB25	EA21	IO	External memory address bus 21						
AC23	EA22	IO	External memory address bus 22						
AC24	EA23	IO	External memory address bus 23						
AC25	EA24	IO	External memory address bus 24						
AD24	EA25	IO	External memory address bus 25						
AD25	EA26	IO	External memory address bus 26	GPIO64	**EA26**	CLKM5		PU/ PD	
			USB Interface						
AD20	USB_XTALI	IO							
AE20	USB_XTALO	IO							
AE21	VSSCA_USB	IO							
AD22	VSSCD_USB	IO							
AC21	VRT	IO							
AD23	VSS33_USB	IO							
AE22	USB_DP	IO	USB D+ Input/Output						
AE23	USB_DM	IO	USB D- Input/Output						
			Memory Card Interface						
B16	MCCM0	IO	SD Command/MS Bus State Output	**GPIO67**	MC0CM0		TDMA_CK	PU/ PD	PU
C16	MCDA0	IO	SD Serial Data IO 0/MS Serial Data IO	**GPIO68**	MC0DA0		TDMA_D1	PU/ PD	PU
D16	MCDA1	IO	SD Serial Data IO 1	**GPIO69**	MC0DA1		TDMA_D0	PU/ PD	PU
J16	MCDA2	IO	SD Serial Data IO 2	**GPIO70**	MC0DA2		TDMA_FS	PU/ PD	PU
C15	MCDA3	IO	SD Serial Data IO 3	**GPIO71**	MC0DA3			PU/ PD	PU
D15	MCCK	IO	SD Serial Clock/MS Serial Clock Output	**GPIO72**	MC0CK			PU/ PD	PU
J15	MCPWRON	IO	SD Power On Control Output	**GPIO73**	MC0PWRON	CLKM8		PU/ PD	PU
C14	MCWP	IO	SD Write Protect Input	**GPIO74**	MC0WP	CLKM9		PU/ PD	PU
D14	MCINS	IO	SD Card Detect Input	**GPIO75**	MC0INS			PU/ PD	PU
			UART/IrDA Interface						
C25	URXD1	IO	UART 1 receive data					PU	
C24	UTXD1	IO	UART 1 transmit data						
C23	UCTS1	IO	UART 1 clear to send	GPIO49	**UCTS1**	UCTS2		PU/ PD	PU
B25	URTS1	IO	UART 1 request to send	GPIO50	**URTS1**	URTS2		PU/	

								PD	
A24	URXD2	IO	UART 2 receive data	**GPIO51**	URXD2	UCTS3		PU/ PD	PU
B24	UTXD2	IO	UART 2 transmit data	**GPIO52**	UTXD2	URTS3		PU/ PD	PU
A23	URXD3	IO	UART 3 receive data	**GPIO53**	URXD3	IRDA_RX D		PU/ PD	PU
B23	UTXD3	IO	UART 3 transmit data	**GPIO54**	UTXD3	IRDA_TX D		PU/ PD	PU
			Digital Audio Interface						
D18	DAICLK	IO	DAI clock output	**GPIO59**	DAICLK			PU/ PD	PD
A17	DAIPCMOUT	IO	DAI pcm data out	**GPIO60**	DAIPCMO UT			PU/ PD	PD
B17	DAIPCMIN	IO	DAI pcm data input	**GPIO61**	DAIPCMI N			PU/ PD	PD
C17	DAIRST	IO	DAI reset signal input	**GPIO62**	DAIRST			PU/ PD	PD
D17	DAISYNC	IO	DAI frame synchronization signal output	**GPIO63**	DAISYNC			PU/ PD	PD
			CMOS Sensor Interface						
AA2	CMRST	IO	CMOS sensor reset signal output	**GPIO0**	CMRST	CLKM0	DSP_GPO 0	PU/ PD	PD
AA3	CMPDN	IO	CMOS sensor power down control	**GPIO1**	CMPDN		DSP_GPO 1	PU/ PD	PD
AB3	CMVREF	IO	Sensor vertical reference signal input	**GPIO2**	CMVREF	TBTXEN	D1_TID0	PU/ PD	PD
AB2	CMHREF	IO	Sensor horizontal reference signal input	**GPIO3**	CMHREF	TBTXFS		PU/ PD	PD
AA4	CMPCLK	IO	CMOS sensor pixel clock input	**GPIO4**	CMPCLK	TBRXEN	D1_TID1	PU/ PD	PD
AB6	CMMCLK	IO	CMOS sensor master clock output	**GPIO5**	CMMCLK	TBRXFS		PU/ PD	PD
AC2	CMDAT7	IO	CMOS sensor data input 7	**GPIO6**	CMDAT7		D1ICK	PU/ PD	PD
AC3	CMDAT6	IO	CMOS sensor data input 6	**GPIO7**	CMDAT6		D1ID	PU/ PD	PD
AC1	CMDAT5	IO	CMOS sensor data input 5	**GPIO8**	CMDAT5		D1IMS	PU/ PD	PD
AD1	CMDAT4	IO	CMOS sensor data input 4	**GPIO9**	CMDAT4		D2ICK	PU/ PD	PD
AE2	CMDAT3	IO	CMOS sensor data input 3	**GPIO10**	CMDAT3		D2ID	PU/ PD	PD
AD3	CMDAT2	IO	CMOS sensor data input 2	**GPIO11**	CMDAT2		D2IMS	PU/ PD	PD
AD4	CMDAT1	IO	CMOS sensor data input 1	**GPIO12**	CMDAT1		D2_TID0	PU/ PD	PD
AE3	CMDAT0	IO	CMOS sensor data input 0	**GPIO13**	CMDAT0		D2_TID1	PU/ PD	PD
AC4	CMFLASH	IO		**GPIO14**	CMFLASH		D2_TID2	PU/ PD	PD
			Analog Interface						
J1	AU_MOUTL	O	Audio analog output left channel						

J2	AU_MOUTR	O	Audio analog output right channel						
K4	AU_FMINL	I	FM radio analog input left channel						
K3	AU_FMINR	I	FM radio analog input right channel						
K2	AU_OUT0_N	O	Earphone 0 amplifier output (-)						
K1	AU_OUT0_P	O	Earphone 0 amplifier output (+)						
L2	AU_MICBIAS_P	O	Microphone bias supply (+)						
L1	AU_MICBIAS_N	O	Microphone bias supply (-)						
M2	AU_VREF_N	O	Audio reference voltage (-)						
M1	AU_VREF_P	O	Audio reference voltage (+)						
N1	AU_VIN0_P	I	Microphone 0 amplifier input (+)						
N2	AU_VIN0_N	I	Microphone 0 amplifier input (-)						
N3	AU_VIN1_N	I	Microphone 1 amplifier input (-)						
N4	AU_VIN1_P	I	Microphone 1 amplifier input (+)						
P1	BDLAQP	I	Quadrature input (Q+) baseband codec downlink						
P2	BDLAQN	I	Quadrature input (Q-) baseband codec downlink						
R1	BDLAIN	I	In-phase input (I+) baseband codec downlink						
R2	BDLAIP	I	In-phase input (I-) baseband codec downlink						
T3	APC	I	Automatic power control DAC output						
T4	AUXADIN0	I	Auxiliary ADC input 0						
U2	AUXADIN1	I	Auxiliary ADC input 1						
U4	AUXADIN2	I	Auxiliary ADC input 2						
V2	AUXADIN3	I	Auxiliary ADC input 3						
U1	AUX_REF	I	Auxiliary ADC reference voltage input						
U3	XP	I							
V1	XM	I							
W3	YP	I							
V3	YM	I							
V4	AFC	O	Automatic frequency control DAC output						
W2	AFC_BYP	O	Automatic frequency control DAC bypass capacitance						
B1	BATDET	I							
C2	VRF_SENSE	I							
C1	VRF	I							
E3	VTCXO	I							
F2	VREF	I							
C12	VIBRATOR	O							
D11	LED	O							
A11	VCORE	I							
C11	VCORE_FB	I							
B11	BAT_BACKUP	I							
F1	VA								
A9	VM	I							
D10	VM_SENSE	I							

C10	VCAM_D	II							
D8	VCAM_A_SENSE	I							
A7	VCAM_A	I							
C8	VBT	I							
A6	VIO	I							
C7	VUSB	I							
A5	VSIM	I							
C5	SIO	IO							
C6	PWRKEY	I							
D5	ISENSE	I							
A4	VMSEL	I							
B4	GATEDRV	I							
C4	CHRIN	I							
A3	SCLK	I							
B3	BATSENSE	I							
C3	SRST	O							
A2	RESET	I							
B2	RSTCAP	IO							
			VCXO Interface						
Y1	SYSCLK	I	13MHz or 26MHz system clock input						
			RTC Interface						
A14	XIN	I	32.768 KHz crystal input						
A15	XOUT	O	32.768 KHz crystal output						
B13	BBWAKEUP	IO	Baseband power on/off control						
			Supply Voltages						
H3	VDDK		Supply voltage of internal logic						
AB7	VDDK		Supply voltage of internal logic						
AB20	VDDK		Supply voltage of internal logic						
Y22	VDDK		Supply voltage of internal logic						
F22	VDDK		Supply voltage of internal logic						
J14	VDDK		Supply voltage of internal logic						
AB23	VDD33_EMI		Supply voltage of memory interface driver						
V22	VDD33_EMI		Supply voltage of memory interface driver						
R22	VDD33_EMI		Supply voltage of memory interface driver						
M22	VDD33_EMI		Supply voltage of memory interface driver						
J22	VDD33_EMI		Supply voltage of memory interface driver						
AD2	VDD33_CAM								
AB13	VDD33_LCD								
AB17	VDD33_LCD								
AC22	VDD33_USB								
AB21	VDDC_USB								
D13	VDD33_MC								

H4	VDD33		Supply voltage of drivers except memory interface, USB and MS/MMC/SD						
AB9	VDD33		Supply voltage of drivers except memory interface, USB and MS/MMC/SD						
E22	VDD33		Supply voltage of drivers except memory interface, USB and MS/MMC/SD						
D19	VDD33		Supply voltage of drivers except memory interface, USB and MS/MMC/SD						
F4	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
Y3	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
AB5	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
AB11	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
U15	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
AC20	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
AE24	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
AA22	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
U22	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
P22	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
L22	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
H22	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
C22	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
A16	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
A13	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
L9	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
L11	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
L12	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
L13	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
L14	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
L15	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						

M9	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
M11	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
M15	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
N11	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
N13	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
N15	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
P9	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
P11	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
P15	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
R9	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
R11	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
R12	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
R13	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
R14	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
R15	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
T9	VSS33		Ground of drivers except memory interface, USB and MS/MMC/SD						
W1	AVCC12_PLL								
Y2	AVSS12_PLL								
B15	VRTC		Supply voltage for Real Time Clock						
			Analog Supplies						
J4	AVDD28_MBUF		Supply Voltage for Audio band section						
J3	AVSS28_MBUF		GND for Audio band section						
K9	AVDD28_BUF		Supply voltage for voice band transmit section						
L3	AVSS28_BUF		GND for voice band transmit section						
L4	AVDD28_AFE		Supply voltage for voice band receive section						
M3	AGND28_AFE		GND reference voltage for voice band section						
N9	AVSS28_AFE		GND for voice band receive section						
P4	AGND28_RFE		GND reference voltage for baseband section, APC, AFC and AUXADC						
P3	AVSS28_GSMRFTX		GND for baseband transmit section						

R3	AVDD28_GSMRFTX		Supply voltage for baseband transmit section						
T2	AVSS28_RFE		GND for baseband receive section, APC, AFC and AUXADC						
T1	AVDD28_RFE		Supply voltage for baseband receive section, APC, AFC and AUXADC						
D1	VBAT_VRF								
D3	AGND_VRF								
E4	GND_LDOS								
E2	VBAT_VA								
E1	VBAT_VA								
F3	AGND_VA								
D12	GND_DRV								
A12	GND_VCORE								
A10	VBAT_VCORE								
B10	VBAT_LDOS1								
B9	VBAT_LDOS1								
B8	VBAT_LDOS2								
D7	GND_LDOS								
B7	VBAT_LDOS2								
B6	VBAT_LDOS3								
D6	GND_LDOS								
D9	GND_LDOS								

Table 2 Pin Descriptions (**Bolded** types are functions at reset)

2.5 Power Description

BALL	NAME	IO SUPPLY	IO GND	CORE SUPPLY	CORE GND	REMARK
B1	BATDET					
C2	VRF_SENSE					
C1	VRF					
D1	VBAT_VRF					
D3	AGND_VRF					
E4	GND_LDOS					
E3	VTCXO					
E2	VBAT_VA					
F1	VA					
E1	VBAT_VA					
F2	VREF					
F3	AGND_VA					
G4	JTRST_B	VDD33	VSS33	VDDK	VSS33	
F4	VSS33					
G3	JTCK	VDD33	VSS33	VDDK	VSS33	
G2	JTDI	VDD33	VSS33	VDDK	VSS33	
G1	JTMS	VDD33	VSS33	VDDK	VSS33	
H1	JTDO	VDD33	VSS33	VDDK	VSS33	
H3	VDDK					
H2	JRTCK	VDD33	VSS33	VDDK	VSS33	
H4	VDD33					
J4	AVDD28_MBUF					
J2	AU_MOUTR					
J3	AVSS28_MBUF					
J1	AU_MOUTL					
K3	AU_FMINR					
K4	AU_FMINL					
K9	AVDD28_BUF					
K2	AU_OUT0_N					
K1	AU_OUT0_P					
L3	AVSS28_BUF					
L2	AU_MICBIAS_P					
L1	AU_MICBIAS_N					
L4	AVDD28_AFE					
M2	AU_VREF_N					
M1	AU_VREF_P					
M3	AGND28_AFE					
N1	AU_VIN0_P					
N2	AU_VIN0_N					
N3	AU_VIN1_N					
N4	AU_VIN1_P					
N9	AVSS28_AFE					
P3	AVSS28_GSMRFTX					
P4	AGND28_RFE					
R3	AVDD28_GSMRFTX					

P1	BDLAQP					
P2	BDLAQN					
R1	BDLAIN					
R2	BDLAIP					
T3	APC					
T1	AVDD28_RFE					
U1	AUX_REF					
T4	AUXADIN0					
U2	AUXADIN1					
T2	AVSS28_RFE					
U3	XP					
U4	AUXADIN2					
V1	XM					
V2	AUXADIN3					
V3	YM					
V4	AFC					
W3	YP					
W2	AFC_BYP					
W1	AVCC12_PLL					
Y1	SYSCLK	AVCC12_PLL	AVSS12_PLL	AVCC12_PLL	AVSS12_PLL	
Y2	AVSS12_PLL					
Y3	VSS33					
Y4	VCCQ					
AA1	FSOURCE					
AA2	CMRST	VDD33_CAM	VSS33	VDDK	VSS33	
AA3	CMPDN	VDD33_CAM	VSS33	VDDK	VSS33	
AB3	CMVREF	VDD33_CAM	VSS33	VDDK	VSS33	
AB2	CMHREF	VDD33_CAM	VSS33	VDDK	VSS33	
AA4	CMPCLK	VDD33_CAM	VSS33	VDDK	VSS33	
AB6	CMMCLK	VDD33_CAM	VSS33	VDDK	VSS33	
AC2	CMDAT7	VDD33_CAM	VSS33	VDDK	VSS33	
AC3	CMDAT6	VDD33_CAM	VSS33	VDDK	VSS33	
AC1	CMDAT5	VDD33_CAM	VSS33	VDDK	VSS33	
AD2	VDD33_CAM					
AD1	CMDAT4	VDD33_CAM	VSS33	VDDK	VSS33	
AE2	CMDAT3	VDD33_CAM	VSS33	VDDK	VSS33	
AD3	CMDAT2	VDD33_CAM	VSS33	VDDK	VSS33	
AD4	CMDAT1	VDD33_CAM	VSS33	VDDK	VSS33	
AE3	CMDAT0	VDD33_CAM	VSS33	VDDK	VSS33	
AC4	CMFLASH	VDD33_CAM	VSS33	VDDK	VSS33	
AB7	VDDK					
AE4	SCL	VDD33_CAM	VSS33	VDDK	VSS33	
AD5	SDA	VDD33_CAM	VSS33	VDDK	VSS33	
AC5	PWM2	VDD33_CAM	VSS33	VDDK	VSS33	
AE5	PWM3	VDD33_CAM	VSS33	VDDK	VSS33	
AB5	VSS33					
AD6	SECU_EN	VDD33	VSS33	VDDK	VSS33	
AE7	XBOOT	VDD33	VSS33	VDDK	VSS33	
AE6	BPI_BUS0	VDD33	VSS33	VDDK	VSS33	

AD7	BPI_BUS1	VDD33	VSS33	VDDK	VSS33	
AC7	BPI_BUS2	VDD33	VSS33	VDDK	VSS33	
AC6	BPI_BUS3	VDD33	VSS33	VDDK	VSS33	
AE8	BPI_BUS4	VDD33	VSS33	VDDK	VSS33	
AD8	BPI_BUS5	VDD33	VSS33	VDDK	VSS33	
AC8	BPI_BUS6	VDD33	VSS33	VDDK	VSS33	
AB8	BPI_BUS7	VDD33	VSS33	VDDK	VSS33	
AE9	BPI_BUS8	VDD33	VSS33	VDDK	VSS33	
AB9	VDD33					
AD9	BPI_BUS9	VDD33	VSS33	VDDK	VSS33	
AC9	BSI_CS0	VDD33	VSS33	VDDK	VSS33	
AE10	BSI_DATA	VDD33	VSS33	VDDK	VSS33	
AD10	BSI_CLK	VDD33	VSS33	VDDK	VSS33	
AC10	PWM0	VDD33	VSS33	VDDK	VSS33	
AB10	PWM1	VDD33	VSS33	VDDK	VSS33	
U10	SRCLKENAN	VDD33	VSS33	VDDK	VSS33	
AE11	SRCLKENA	VDD33	VSS33	VDDK	VSS33	
AD11	SRCLKENAI	VDD33	VSS33	VDDK	VSS33	
AB11	VSS33					
AC11	LSCK	VDD33_LCD	VSS33	VDDK	VSS33	
U11	LSA0	VDD33_LCD	VSS33	VDDK	VSS33	
AD12	LSDA	VDD33_LCD	VSS33	VDDK	VSS33	
AE12	LSCE0B	VDD33_LCD	VSS33	VDDK	VSS33	
AC12	LSCE1B	VDD33_LCD	VSS33	VDDK	VSS33	
AB12	LPCE1B	VDD33_LCD	VSS33	VDDK	VSS33	
U12	LPCE0B	VDD33_LCD	VSS33	VDDK	VSS33	
AE13	LPTE	VDD33_LCD	VSS33	VDDK	VSS33	
AC13	LRSTB	VDD33_LCD	VSS33	VDDK	VSS33	
AD13	LRDB	VDD33_LCD	VSS33	VDDK	VSS33	
AB13	VDD33_LCD					
U13	LPA0	VDD33_LCD	VSS33	VDDK	VSS33	
AE14	LWRB	VDD33_LCD	VSS33	VDDK	VSS33	
AD14	NLD17	VDD33_LCD	VSS33	VDDK	VSS33	
AC14	NLD16	VDD33_LCD	VSS33	VDDK	VSS33	
AB14	NLD15	VDD33_LCD	VSS33	VDDK	VSS33	
U14	NLD14	VDD33_LCD	VSS33	VDDK	VSS33	
AE15	NLD13	VDD33_LCD	VSS33	VDDK	VSS33	
AD15	NLD12	VDD33_LCD	VSS33	VDDK	VSS33	
AC15	NLD11	VDD33_LCD	VSS33	VDDK	VSS33	
U15	VSS33					
AB15	NLD10	VDD33_LCD	VSS33	VDDK	VSS33	
AE16	NLD9	VDD33_LCD	VSS33	VDDK	VSS33	
AD16	NLD8	VDD33_LCD	VSS33	VDDK	VSS33	
AC16	NLD7	VDD33_LCD	VSS33	VDDK	VSS33	
AB16	NLD6	VDD33_LCD	VSS33	VDDK	VSS33	
U16	NLD5	VDD33_LCD	VSS33	VDDK	VSS33	
AE17	NLD4	VDD33_LCD	VSS33	VDDK	VSS33	
AD17	NLD3	VDD33_LCD	VSS33	VDDK	VSS33	
AC17	NLD2	VDD33_LCD	VSS33	VDDK	VSS33	

AB17	VDD33_LCD					
AE18	NLD1	VDD33_LCD	VSS33	VDDK	VSS33	
AD18	NLD0	VDD33_LCD	VSS33	VDDK	VSS33	
AC18	NRNB	VDD33_LCD	VSS33	VDDK	VSS33	
AB18	NCLE	VDD33_LCD	VSS33	VDDK	VSS33	
AE19	NALE	VDD33_LCD	VSS33	VDDK	VSS33	
AD19	NWEB	VDD33_LCD	VSS33	VDDK	VSS33	
AC19	NREB	VDD33_LCD	VSS33	VDDK	VSS33	
AB19	NCEB	VDD33_LCD	VSS33	VDDK	VSS33	
AB20	VDDK					
AC20	VSS33					
AD20	USB_XTALI					
AE20	USB_XTALO					
AE21	VSSCA_USB					
AD22	VSSCD_USB					
AB21	VDDC_USB					
AC21	VRT					
AD23	VSS33_USB					
AC22	VDD33_USB					
AE22	USB_DP					
AE23	USB_DM					
AE24	VSS33					
AD25	EA26	VDD33_EMI	VSS33	VDDK	VSS33	
AD24	EA25	VDD33_EMI	VSS33	VDDK	VSS33	
AC25	EA24	VDD33_EMI	VSS33	VDDK	VSS33	
AC24	EA23	VDD33_EMI	VSS33	VDDK	VSS33	
AC23	EA22	VDD33_EMI	VSS33	VDDK	VSS33	
AB25	EA21	VDD33_EMI	VSS33	VDDK	VSS33	
AA22	VSS33					
AB24	EA20	VDD33_EMI	VSS33	VDDK	VSS33	
AA25	EA19	VDD33_EMI	VSS33	VDDK	VSS33	
AA24	EA18	VDD33_EMI	VSS33	VDDK	VSS33	
AB23	VDD33_EMI					
AA23	EA17	VDD33_EMI	VSS33	VDDK	VSS33	
Y25	EA16	VDD33_EMI	VSS33	VDDK	VSS33	
Y22	VDDK					
Y24	EA15	VDD33_EMI	VSS33	VDDK	VSS33	
Y23	EA14	VDD33_EMI	VSS33	VDDK	VSS33	
W25	EA13	VDD33_EMI	VSS33	VDDK	VSS33	
W24	EA12	VDD33_EMI	VSS33	VDDK	VSS33	
V22	VDD33_EMI					
W23	EA11	VDD33_EMI	VSS33	VDDK	VSS33	
W22	EA10	VDD33_EMI	VSS33	VDDK	VSS33	
V25	EA9	VDD33_EMI	VSS33	VDDK	VSS33	
V24	EA8	VDD33_EMI	VSS33	VDDK	VSS33	
V23	EA7	VDD33_EMI	VSS33	VDDK	VSS33	
U25	EA6	VDD33_EMI	VSS33	VDDK	VSS33	
U24	EA5	VDD33_EMI	VSS33	VDDK	VSS33	
U23	EA4	VDD33_EMI	VSS33	VDDK	VSS33	

T25	EA3	VDD33_EMI	VSS33	VDDK	VSS33	
U22	VSS33					
T24	EA2	VDD33_EMI	VSS33	VDDK	VSS33	
T22	EA1	VDD33_EMI	VSS33	VDDK	VSS33	
T23	EA0	VDD33_EMI	VSS33	VDDK	VSS33	
T17	EADMUX	VDD33_EMI	VSS33	VDDK	VSS33	
R25	EWAIT	VDD33_EMI	VSS33	VDDK	VSS33	
R17	EDQM1	VDD33_EMI	VSS33	VDDK	VSS33	
P25	EDQM0	VDD33_EMI	VSS33	VDDK	VSS33	
P24	ERAS_B	VDD33_EMI	VSS33	VDDK	VSS33	
N25	ECAS_B	VDD33_EMI	VSS33	VDDK	VSS33	
R22	VDD33_EMI					
P17	EADV_B	VDD33_EMI	VSS33	VDDK	VSS33	
N22	ED_CLK	VDD33_EMI	VSS33	VDDK	VSS33	
P22	VSS33					
N24	EC_CLK	VDD33_EMI	VSS33	VDDK	VSS33	
P23	ECKE	VDD33_EMI	VSS33	VDDK	VSS33	
N17	EWR_B	VDD33_EMI	VSS33	VDDK	VSS33	
M25	ERD_B	VDD33_EMI	VSS33	VDDK	VSS33	
M24	ECS3_B	VDD33_EMI	VSS33	VDDK	VSS33	
M23	ECS2_B	VDD33_EMI	VSS33	VDDK	VSS33	
M17	ECS1_B	VDD33_EMI	VSS33	VDDK	VSS33	
L25	ECS0_B	VDD33_EMI	VSS33	VDDK	VSS33	
L24	ED15	VDD33_EMI	VSS33	VDDK	VSS33	
M22	VDD33_EMI					
L23	ED14	VDD33_EMI	VSS33	VDDK	VSS33	
L17	ED13	VDD33_EMI	VSS33	VDDK	VSS33	
K25	ED12	VDD33_EMI	VSS33	VDDK	VSS33	
L22	VSS33					
K24	ED11	VDD33_EMI	VSS33	VDDK	VSS33	
K23	ED10	VDD33_EMI	VSS33	VDDK	VSS33	
J25	ED9	VDD33_EMI	VSS33	VDDK	VSS33	
H25	ED8	VDD33_EMI	VSS33	VDDK	VSS33	
K22	ED7	VDD33_EMI	VSS33	VDDK	VSS33	
J24	ED6	VDD33_EMI	VSS33	VDDK	VSS33	
J23	ED5	VDD33_EMI	VSS33	VDDK	VSS33	
H23	ED4	VDD33_EMI	VSS33	VDDK	VSS33	
H24	ED3	VDD33_EMI	VSS33	VDDK	VSS33	
J22	VDD33_EMI					
G25	ED2	VDD33_EMI	VSS33	VDDK	VSS33	
G22	ED1	VDD33_EMI	VSS33	VDDK	VSS33	
G24	ED0	VDD33_EMI	VSS33	VDDK	VSS33	
K17	MFIQ	VDD33_EMI	VSS33	VDDK	VSS33	
G23	WATCHDOG	VDD33_EMI	VSS33	VDDK	VSS33	
H22	VSS33					
F22	VDDK					
F25	SYSRST_B	VDD33	VSS33	VDDK	VSS33	
F24	EINT0	VDD33	VSS33	VDDK	VSS33	
F23	EINT1	VDD33	VSS33	VDDK	VSS33	

E25	EINT2	VDD33	VSS33	VDDK	VSS33	
E24	EINT3	VDD33	VSS33	VDDK	VSS33	
E23	EINT4	VDD33	VSS33	VDDK	VSS33	
D23	EINT5	VDD33	VSS33	VDDK	VSS33	
D25	EINT6	VDD33	VSS33	VDDK	VSS33	
D24	EINT7	VDD33	VSS33	VDDK	VSS33	
E22	VDD33					
C25	URXD1	VDD33	VSS33	VDDK	VSS33	
C24	UTXD1	VDD33	VSS33	VDDK	VSS33	
C23	UCTS1	VDD33	VSS33	VDDK	VSS33	
B25	URTS1	VDD33	VSS33	VDDK	VSS33	
A24	URXD2	VDD33	VSS33	VDDK	VSS33	
B24	UTXD2	VDD33	VSS33	VDDK	VSS33	
A23	URXD3	VDD33	VSS33	VDDK	VSS33	
B23	UTXD3	VDD33	VSS33	VDDK	VSS33	
C22	VSS33					
A22	KCOL7	VDD33	VSS33	VDDK	VSS33	
B22	KCOL6	VDD33	VSS33	VDDK	VSS33	
A21	KCOL5	VDD33	VSS33	VDDK	VSS33	
B21	KCOL4	VDD33	VSS33	VDDK	VSS33	
C21	KCOL3	VDD33	VSS33	VDDK	VSS33	
D21	KCOL2	VDD33	VSS33	VDDK	VSS33	
A20	KCOL1	VDD33	VSS33	VDDK	VSS33	
B20	KCOL0	VDD33	VSS33	VDDK	VSS33	
C20	KROW7	VDD33	VSS33	VDDK	VSS33	
D20	KROW6	VDD33	VSS33	VDDK	VSS33	
A19	KROW5	VDD33	VSS33	VDDK	VSS33	
D19	VDD33					
B19	KROW4	VDD33	VSS33	VDDK	VSS33	
C19	KROW3	VDD33	VSS33	VDDK	VSS33	
A18	KROW2	VDD33	VSS33	VDDK	VSS33	
B18	KROW1	VDD33	VSS33	VDDK	VSS33	
C18	KROW0	VDD33	VSS33	VDDK	VSS33	
D18	DAICLK	VDD33	VSS33	VDDK	VSS33	
A17	DAIPCMOUT	VDD33	VSS33	VDDK	VSS33	
B17	DAIPCMIN	VDD33	VSS33	VDDK	VSS33	
C17	DAIRST	VDD33	VSS33	VDDK	VSS33	
A16	VSS33					
D17	DAISYNC	VDD33	VSS33	VDDK	VSS33	
B16	MCCM0	VDD33_MC	VSS33	VDDK	VSS33	
C16	MCDA0	VDD33_MC	VSS33	VDDK	VSS33	
D16	MCDA1	VDD33_MC	VSS33	VDDK	VSS33	
J16	MCDA2	VDD33_MC	VSS33	VDDK	VSS33	
C15	MCDA3	VDD33_MC	VSS33	VDDK	VSS33	
D15	MCCK	VDD33_MC	VSS33	VDDK	VSS33	
J15	MCPWRON	VDD33_MC	VSS33	VDDK	VSS33	
C14	MCWP	VDD33_MC	VSS33	VDDK	VSS33	
J14	VDDK					
D14	MCINS	VDD33_MC	VSS33	VDDK	VSS33	

D13	VDD33_MC					
B15	VRTC					
A15	XOUT	VRTC	VSS33	VDDK	VSS33	
A14	XIN	VRTC	VSS33	VDDK	VSS33	
B13	BBWAKEUP	VRTC	VSS33	VDDK	VSS33	
B14	TESTMODE	VRTC	VSS33	VDDK	VSS33	
A13	VSS33					
C12	VIBRATOR					
D12	GND_DRV					
D11	LED					
A12	GND_VCORE					
A11	VCORE					
C11	VCORE_FB					
A10	VBAT_VCORE					
B11	BAT_BACKUP					
A9	VM					
D10	VM_SENSE					
B10	VBAT_LDOS1					
C10	VCAM_D					
B9	VBAT_LDOS1					
D9	GND_LDOS					
D8	VCAM_A_SENSE					
A7	VCAM_A					
C8	VBT					
B8	VBAT_LDOS2					
A6	VIO					
D7	GND_LDOS					
C7	VUSB					
B7	VBAT_LDOS2					
A5	VSIM					
C5	SIO					
C6	PWRKEY					
B6	VBAT_LDOS3					
D6	GND_LDOS					
D5	ISENSE					
A4	VMSEL					
B4	GATEDRV					
C4	CHRIN					
A3	SCLK					
B3	\BATSENSE					
C3	SRST					
A2	RESET					
B2	RSTCAP					
L9	VSS33					
L11	VSS33					
L12	VSS33					
L13	VSS33					
L14	VSS33					
L15	VSS33					

M9	VSS33					
M11	VSS33					
M15	VSS33					
N11	VSS33					
N13	VSS33					
N15	VSS33					
P9	VSS33					
P11	VSS33					
P15	VSS33					
R9	VSS33					
R11	VSS33					
R12	VSS33					
R13	VSS33					
R14	VSS33					
R15	VSS33					
T9	VSS33					

Table 3 Power Descriptions

3 Micro-Controller Unit Subsystem

Figure 5 illustrates the block diagram of the Micro-Controller Unit Subsystem in MT6235.The subsystem utilizes a main 32-bit ARM926EJ-S RISC processor, which plays the role of the main bus master controlling the whole subsystem. The ARM926EJ-S RISC is equipped with instruction cache, instruction TCM, data cache, and data TCM. The size of instruction cache and data cache are both 16KB. The size of instruction TCM is 48KB. The size of data TCM is 80KB. If the requested content is found in TCM or in cache, no bus transaction is required. If the code cache hit rate is high enough, bus traffic can be effectively reduced and processor core performance maximized.

The bus comprises of two-level system buses: Advanced High-Performance Bus (AHB) and Advanced Peripheral Bus (APB). All bus transactions originate from bus masters, while slaves can only respond to requests from bus masters. Before data transfer can be established, the bus master must ask for bus ownership, accomplished by request-grant handshaking protocol between masters and arbiters.

Two levels of bus hierarchy are designed to provide optimum usage for different performance requirements. Specifically, AHB Bus, the main system bus, is tailored toward high-speed requirements and provides 32-bit data path with multiplex scheme for bus interconnections. The APB Bus, on the other hand, is designed to reduce interface complexity for lower data transfer rate, and so it is isolated from high bandwidth AHB Bus by APB Bridge. APB Bus supports 16-bit addressing and both 16-bit and 32-bit data paths. APB Bus is also optimized for minimal power consumption by turning off the clock when there is no APB bus activity.

During operation, if the target slave is located on AHB Bus, the transaction is conducted directly on AHB Bus. However, if the target slave is a peripheral and is attached to the APB bus, then the transaction is conducted between AHB and APB bus through the use of APB Bridge.

The MT6235 MCU subsystem supports only memory addressing method. Therefore all components are mapped onto the MCU 32-bit address space. A Memory Management Unit is employed to allow for a central decode scheme. The MMU generates appropriate selection signals for each memory-addressed module on the AHB Bus.

In order to off-load the processor core, a DMA Controller is designated to act as a master and share the bus resources on AHB Bus to perform fast data movement between modules. This controller provides fourteen DMA channels.

The Interrupt Controller provides a software interface to manipulate interrupt events; it can handle up to 50 interrupt sources asserted at the same time. In general, the controller generates 2 levels of interrupt requests, FIQ and IRQ, to the processor.

A 64K Byte SRAM is provided as system memory for high-speed data access. For factory programming purposes, a Boot ROM module is also integrated. These two modules use the same Internal Memory Controller to connect to AHB Bus.

External Memory Interface supports both 8-bit and 16-bit devices. This interface supports both synchronous and asynchronous components, such as Flash, SRAM, SDRAM and parallel LCD. This interface supports page and burst mode type of Flash, Cellular RAM, as well as high performance MobileRAM. Since AHB Bus is 32-bit wide, all data transfers are converted into several 8-bit or 16-bit cycles depending on the data width of the target device.

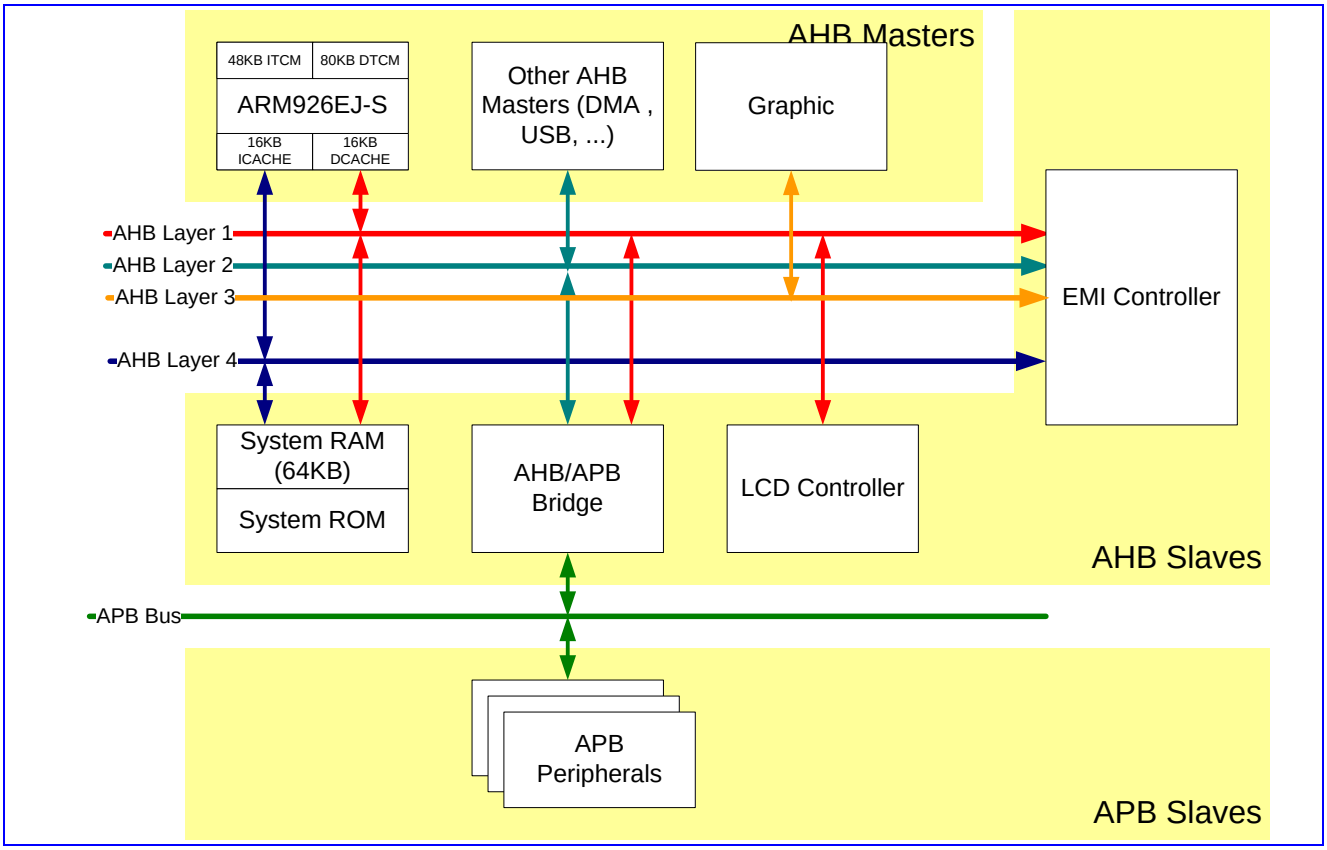


Figure 5 Block Diagram of the Micro-Controller Unit Subsystem in MT6235

3.1 Processor Core

3.1.1 General Description

The Micro-Controller Unit Subsystem in MT6235 uses the 32-bit ARM926EJ-S RISC processor that is based on the Von Neumann architecture with a single 32-bit data bus carrying both instructions and data. The memory interface of ARM926EJ-S is totally compliant with the AMBA based bus system, which allows direct connection to the AHB Bus.

3.2 Memory Management

3.2.1 General Description

The processor core of MT6235 supports only a memory addressing method for instruction fetch and data access. The core manages a 32-bit address space that has addressing capability of up to 4 GB. System RAM, System ROM, Registers, MCU Peripherals and external components are all mapped onto such 32-bit address space, as depicted in **Figure 6**.

BANK	Base Address	Description
BANK0	0000_0000h	EMI Band 0 / Boot Code
BANK1	1000_0000h	EMI Bank 1
BANK2	2000_0000h	EMI Bank 2
BANK3	3000_0000h	EMI Bank 3
BANK4	4000_0000h	System RAM
	4800_0000h	System ROM
BANK5	5000_0000h	TCM
BANK6	6000_0000h	USB
	6100_0000h	Virtual FIFO Slave
BANK7	7000_0000h	Reserved
BANK8	8000_0000h	APB Peripheral
BANK9	9000_0000h	LCD
BANK10	A000_0000h	CPU-DSP Share RAM1
	A100_0000h	CPU-DSP Share RAM2
	A200_0000h	DSP IDMA Port 1
	A300_0000h	DSP IDMA Port 2
BANK11	B000_0000h	Reserved
BANK12	C000_0000h	Reserved
BANK13	D000_0000h	Reserved
BANK14	E000_0000h	Reserved
BANK15	F000_0000h	Reserved

Figure 6 The Memory Layout of MT6235

The address space is organized into blocks of 256 MB each. The block number is uniquely selected by address line A31-A28 of the internal system bus.

3.2.1.1 External Access

To allow external access, the MT6235 can output 27bits (A26-A0) of address lines along with 4 selection signals that correspond to the associated memory blocks. That is, MT6235 can support up to 4 MCU addressable external components. The data width of internal system bus is fixed at 32-bit wide, while the data width of the external components is either 16–bit or 8-bit.

Since devices are usually available with varied operating grades, adaptive configurations for different applications are needed. MT6235 provides software programmable registers to configure their wait-states to adapt to different operating conditions.

3.2.1.2 Memory Re-mapping Mechanism

To permit more flexible system configuration, a memory re-mapping mechanism is provided. The mechanism allows software program to swap BANK0 (ECS0#) and BANK1 (ECS1#) dynamically. Whenever the bit value of RM0 in register EMI_REMAP is changed, these two banks are swapped accordingly. Furthermore, it allows system to boot from System ROM as detailed in 3.2.1.3 Boot Sequence.

3.2.1.3 Boot Sequence

Since the ARM926EJ-S core always starts to fetch instructions from the lowest memory address at 00000000h after system has been reset, the system is designed to have a dynamic mapping architecture capable of associating Boot Code, external Flash or external SRAM with the memory block 0000_0000h – 0fff_ffffh.

By default, the Boot Code is mapped onto 0000_0000h – 0fff_ffffh after a system reset. In this special boot mode, External Memory Controller does not access external memory; instead, the EMI Controller send predefined Boot Code back to the ARM926EJ-S core, which instructs the processor to execute the program in System ROM. This configuration can be changed by programming bit value of RM1 in register EMI_REMAP directly.

MT6235 system provides one boot up scheme:

- Start up system of running codes from Boot Code for factory programming or NAND flash boot.

3.2.1.3.1 Boot Code

The Boot Code is placed together with Memory Re-Mapping Mechanism in External Memory Controller, and comprises of just two words of instructions as shown below. A jump instruction leads the processor to run the code starting at address 48000000h where the System ROM is placed.

ADDRESS	BINARY CODE	ASSEMBLY
00000000h	E51FF004h	LDR PC, 0x4
00000004h	48000000h	(DATA)

3.2.1.3.2 Factory Programming

The configuration for factory programming is shown in **Figure 7**. Usually the Factory Programming Host connects with MT6235 via the UART interface. The download speed can be up to 921K bps while MCU is running at 26MHz.

After the system has reset, the Boot Code guides the processor to run the Factory Programming software placed in System ROM. Then, MT6235 starts and polls the UART1 port until valid information is detected. The first information received on the UART1 is used to configure the chip for factory programming. The Flash downloader program is then transferred into System RAM or external SRAM.

Further information is detailed in the MT6235 Software Programming Specification.

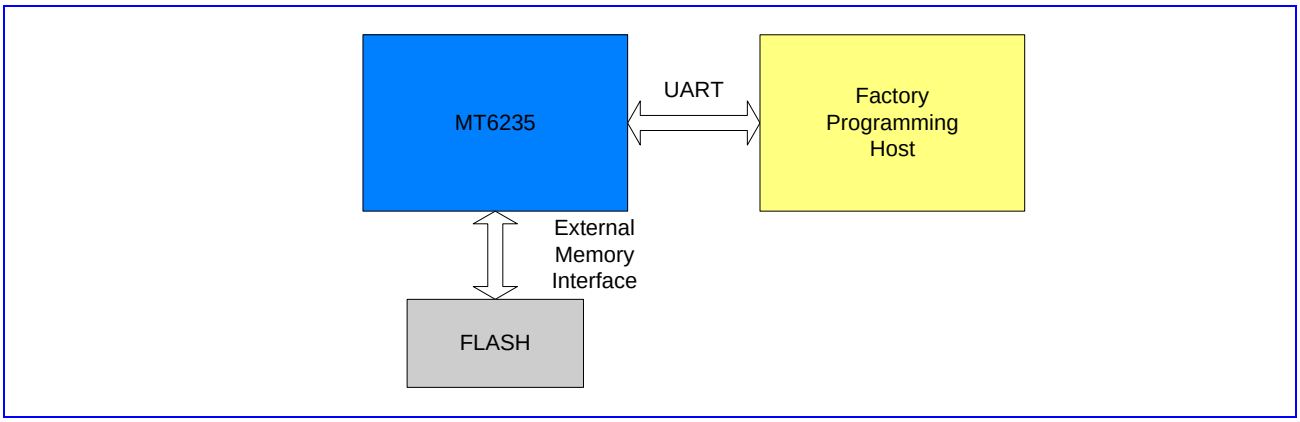


Figure 7 System configuration required for factory programming

3.2.1.3.3 NAND Flash Booting

If MT6235 cannot receive data from UART1 for a certain amount of time, the program in System ROM checks if any valid boot loader exists in NAND flash. If found, the boot loader code is copied from NAND flash to RAM (internal or external) and executed to start the real application software. If no valid boot loader can be found in NAND flash, MT6235 starts executing code in EMI bank0 memory. The whole boot sequence is shown in the following figure.

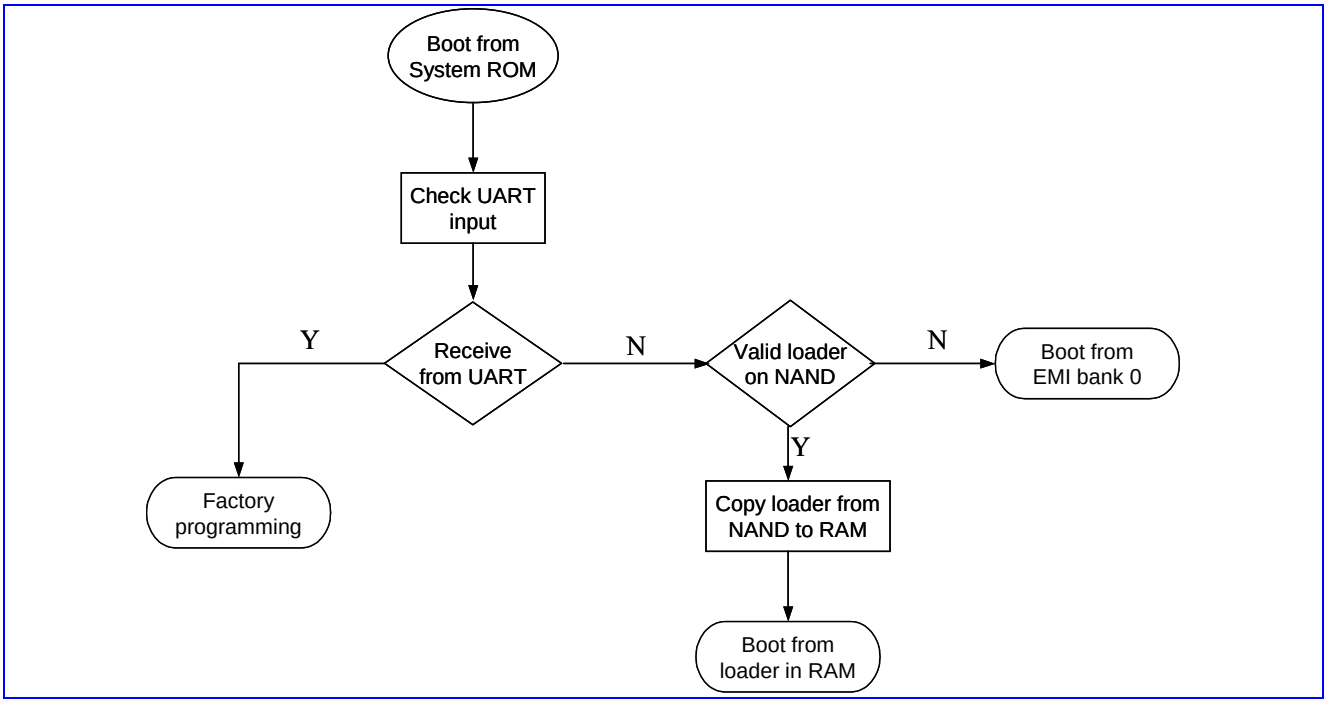


Figure 8 Boot sequence

3.2.1.4 Little Endian Mode

The MT6235 system always treats 32-bit words of memory in Little Endian format. In Little Endian mode, the lowest numbered byte in a word is stored in the least significant position, and the highest numbered byte in the most significant position. Byte 0 of the memory system is therefore connected to data lines 7 through 0.

3.3 Bus System

3.3.1 General Description

Two levels of bus hierarchy are employed in the Micro-Controller Unit Subsystem of MT6235. As depicted in **Figure 5**, AHB Bus and APB Bus serve as system backbone and peripheral buses, while an APB bridge connects these two buses. Both AHB and APB Buses operate at the same or half the clock rate of processor core.

The APB Bridge is the only bus master residing on the APB bus. All APB slaves are mapped onto memory block MB8 in the MCU 32-bit addressing space. A central address decoder is implemented inside the bridge to generate select signals for individual peripherals. In addition, since the base address of each APB slave is associated with select signals, the address bus on APB contains only the value of offset address.

The maximum address space that can be allocated to a single APB slave is 64 KB, i.e. 16-bit address lines. The width of the data bus is mainly constrained to 16 bits to minimize the design complexity and power consumption while some use 32-bit data buses to accommodate more bandwidth. In the case where an APB slave needs large amount of transfers, the device driver can also request DMA channels to conduct a burst of data transfer. The base address and data width of each peripheral are listed in **Table 4**.

Base Address	Description	Data Width	Software Base ID
8001_0000h	EFUSE Control	32	EFUSEC Base
8001_0000h	Configuration Registers (Clock, Power Down, Version and Reset)	16	CONFG Base
8002_0000h	General Purpose Inputs/Outputs	16	GPIO Base
8003_0000h	Reset Generation Unit	16	RGU Base
8100_0000h	External Memory Interface	32	EMI Base
8101_0000h	Interrupt Controller	32	CIRQ Base
8102_0000h	DMA Controller	32	DMA Base
8103_0000h	UART 1	16	UART1 Base
8104_0000h	UART 2	16	UART2 Base
8105_0000h	UART 3	16	UART3 Base
8106_0000h	General Purpose Timer	16	GPT Base
8107_0000h	Reserved	16	Reserved
8108_0000h	Keypad Scanner	16	KP Base
8109_0000h	Pulse-Width Modulation Outputs	32	PWM Base
810a_0000h	SIM Interface	16	SIM Base
810b_0000h	Reserved		
810c_0000h	Real Time Clock	16	RTC Base
810d_0000h	Secure Engine	32	SEJ Base
810e_0000h	Bus Monitor	32	BM Base
810f_0000h	IrDA	16	IRDA Base
8110_0000h	I2C	16	I2C Base
8111_0000h	MS/SD Controller	32	MSDC Base
8112_0000h	NAND Flash Interface	32	NFI Base
8113_0000h	Reserved		
8114_0000h	Second MS/SD Interface	16	MSDC2 Base
8200_0000h	TDMA Timer	32	TDMA Base
8201_0000h	Base-Band Serial Interface	32	BSI Base
8202_0000h	Base-Band Parallel Interface	16	BPI Base
8203_0000h	Automatic Frequency Control Unit	16	AFC Base
8204_0000h	Automatic Power Control Unit	32	APC Base
8205_0000h	Auxiliary ADC Unit	16	AUXADC Base
8206_0000h	Divider/Modulus Coprocessor	32	DIVIDER Base

8207_0000h	Frame Check Sequence	16	FCS Base
8208_0000h	GPRS Cipher Unit	32	GCU Base
8209_0000h	CSD Format Conversion Coprocessor	32	CSD_ACC Base
820a_0000h	MCU-DSP Shared Register 1	16	SHARE1 Base
820b_0000h	IRDBG1	16	IRDBG Base
820c_0000h	MCU-DSP Shared Register 2	16	SHARE2 Base
820d_0000h	IRDBG2	16	IRDBG2 Bas3
820e_0000h	DSP Patch Unit	16	PATCH Base
820f_0000h	Audio Front End	16	AFE Base
8210_0000h	Base-Band Front End	16	BFE Base
8211_0000h	Reserved		
8212_0000h	Reserved		
8300_0000h	PLL / Clock square configuration	16	PLL_CLKSQ Base
8301_0000h	Analog Chip Interface Controller	16	ACIF Base
8302_0000h	Reserved		
8400_0000h	Graphics Memory Controller	32	GMC Base
8401_0000h	2D Accelerator	32	G2D Base
8402_0000h	2D Command Queue	32	GCMQ Base
8403_0000h	Reserved		
8404_0000h	Reserved		
8405_0000h	Reserved		
8406_0000h	Reserved		
8407_0000h	Reserved		
8408_0000h	Reserved		
8409_0000h	Reserved		
840a_0000h	Reserved		
840b_0000h	Camera Interface	32	CAM Base
840c_0000h	Reserved		
840d_0000h	Reserved		
840e_0000h	Capture Resizer	32	CRZ Base
840f_0000h	Reserved		
8410_0000h	Reserved		
8411_0000h	Reserved		

Table 4 Register Base Addresses for MCU Peripherals

REGISTER ADDRESS	REGISTER NAME	SYNONYM
CONFG + 0000h	Hardware Version Register	HW_VER
CONFG + 0004h	Software Version Register	SW_VER
CONFG + 0008h	Hardware Code Register	HW_CODE

CONFG + 0404h	APB Bus Control Register	APB_CON
CONFG + 0500h	IRWIN Control Register	IRWIN_CON

Table 5 APB Bridge Register Map

3.3.2 Register Definitions

CONFG+0000h Hardware Version Register — HW_VERSION

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EXTP				MAJREV				MINREV							
Type	RO				RO				RO				RO			
Reset	8				A				0				0			

This register is used by software to determine the hardware version of the chip. The register contains a new value whenever each metal fix or major step is performed. All values are incremented by a step of 1.

MINREV Minor Revision of the chip

MAJREV Major Revision of the chip

EXTP This field shows the existence of Hardware Code Register that presents the Hardware ID while the value is other than zero.

CONFG+0004h Software Version Register — SW_VERSION

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EXTP				MAJREV				MINREV							
Type	RO				RO				RO				RO			
Reset	8				A				0				0			

This register is used by software to determine the software version used with this chip. All values are incremented by a step of 1.

MINREV Minor Revision of the Software

MAJREV Major Revision of the Software

EXTP This field shows the existence of Software Code Register that presents the Software ID when the value is other than zero.

CONFG+0008h Hardware Code Register — HW_CODE

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	CODE3				CODE2				CODE1				CODE0			
Type	RO				RO				RO				RO			
Reset	6				2				3				5			

This register presents the Hardware ID.

CODE This version of chip is coded as 6235h.

CONFG+0404h APB Bus Control Register — APB_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				APBW4	APBW3	APBW2	APBW1	APBW0				APBR4	APBR3	APBR2	APBR1	APBR0
Type				R/W	R/W	R/W	R/W	R/W				R/W	R/W	R/W	R/W	R/W
Reset				0	0	0	0	0				1	1	1	1	1

This register is used to control the timing of Read Cycle and Write Cycle on APB Bus. Note that APB Bridge 2 is different from other bridges: the access time is varied, and access is not complete until an acknowledge signal from APB slave is asserted.

APBR0-APBR6 Read Access Time on APB Bus

- **0** 1-Cycle Access
- **1** 2-Cycle Access

APBW0-APBW6 Write Access Time on APB Bus

- **0** 1-Cycle Access
- **1** 2-Cycle Access

3.4 Direct Memory Access

3.4.1 General Description

A generic DMA Controller is placed on Layer 2 AHB Bus to support fast data transfers and to off-load the processor. With this controller, specific devices on AHB or APB buses can benefit greatly from quick completion of data movement from or to memory modules such as Internal System RAM or External SRAM, excluding TCM. TCM is invisible for DMA engine.. Such Generic DMA Controller can also be used to connect any two devices other than memory module as long as they can be addressed in memory space.

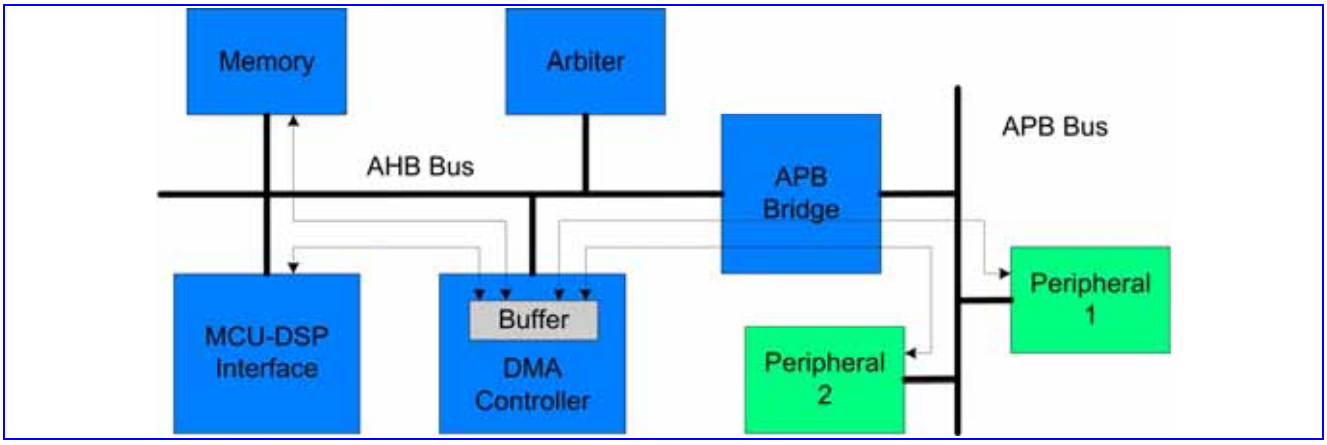


Figure 9 Variety Data Paths of DMA Transfers

Up to fourteen channels of simultaneous data transfers are supported. Each channel has a similar set of registers to be configured to different scheme as desired. If more than fourteen devices are requesting the DMA resources at the same time, software based arbitration should be employed. Once the service candidate is decided, the responsible device driver should configure the Generic DMA Controller properly in order to conduct DMA transfers. Both Interrupt and Polling based schemes in handling the completion event are supported. The block diagram of such generic DMA Controller is illustrated in **Figure 10**.

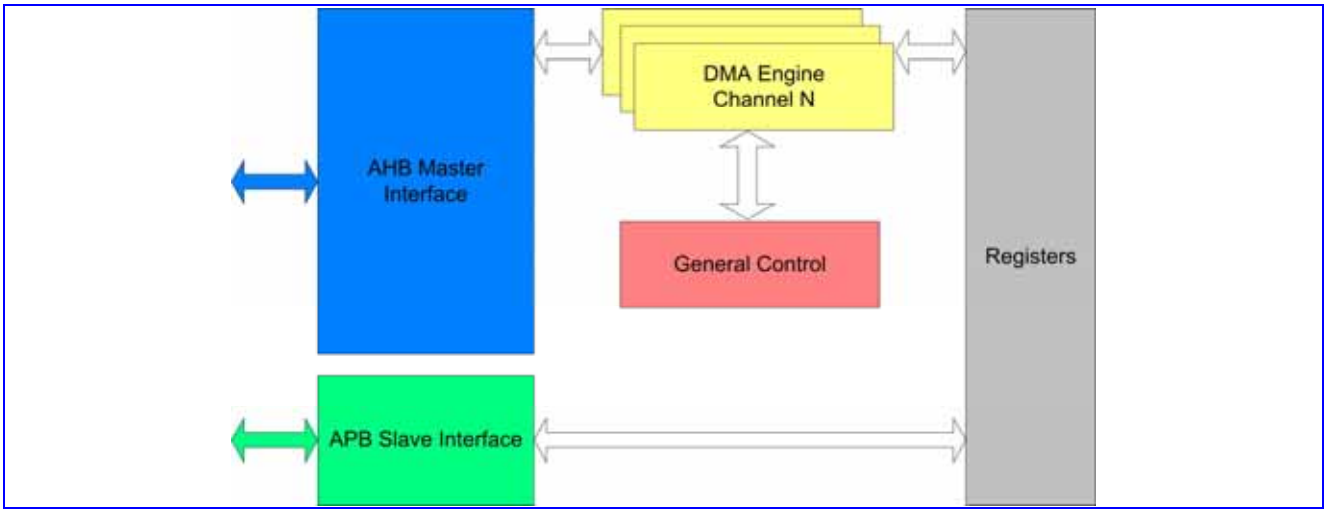


Figure 10 Block Diagram of Direct memory Access Module

3.4.1.1 Full-Size & Half-Size DMA Channels

There are three types of DMA channels in the DMA controller. The first one is called a full-size DMA channel, the second one is called a half-size DMA channel, and the last is Virtual FIFO DMA. Channels 1 through 3 are full-size DMA channels; channels 4 through 10 are half-size ones; and channels 11 through 14 are Virtual FIFO DMAs. The difference between the first two types of DMA channels is that both source and destination address are programmable in full-size DMA channels, but only the address of one side can be programmed in half-size DMA channel. In half-size channels, only either the source or destination address can be programmed, while the addresses of the other side is preset. Which preset address is used depends on the setting of MAS in DMA Channel Control Register. Refer to the Register Definition section for more detail.

3.4.1.2 Ring Buffer & Double Buffer Memory Data Movement

DMA channels 1 through 10 support ring-buffer and double-buffer memory data movement. This can be achieved by programming DMA_WPPT and DMA_WPTO, as well as setting WPEN in DMA_CON register to enable. **Figure 11** illustrates how this function works. Once the transfer counter reaches the value of WPPT, the next address jumps to the WPTO address after completing the WPPT data transfer. Note that only one side can be configured as ring-buffer or double-buffer memory, and this is controlled by WPSD in DMA_CON register.

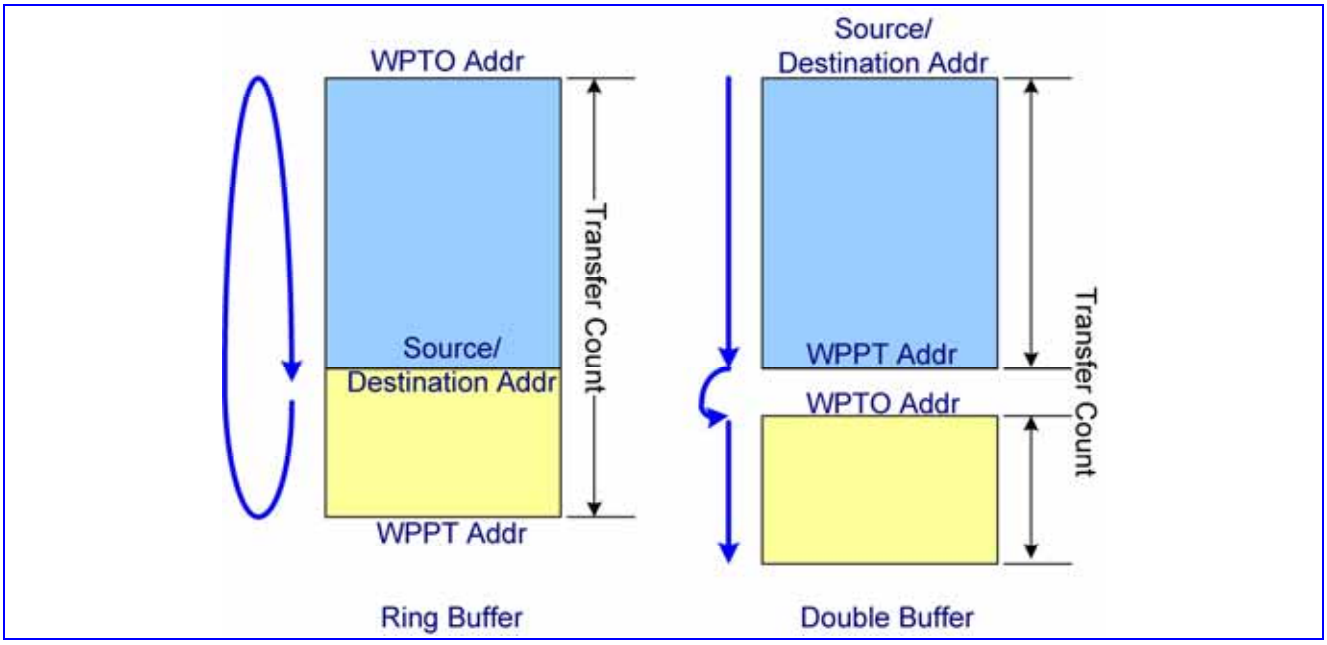


Figure 11 Ring Buffer and Double Buffer Memory Data Movement

3.4.1.3 Unaligned Word Access

The address of word access on AHB bus must be aligned to word boundary, or the 2 LSB is truncated to 00b. If programmers do not notice this, it may cause an incorrect data fetch. In the case where data is to be moved from unaligned addresses to aligned addresses, the word is usually first split into four bytes and then moved byte by byte. This results in four read and four write transfers on the bus.

To improve bus efficiency, unaligned-word access is provided in DMA4~10. While this function is enabled, DMAs move data from unaligned address to aligned address by executing four continuous byte-read access and one word-write access, reducing the number of transfers on the bus by three.

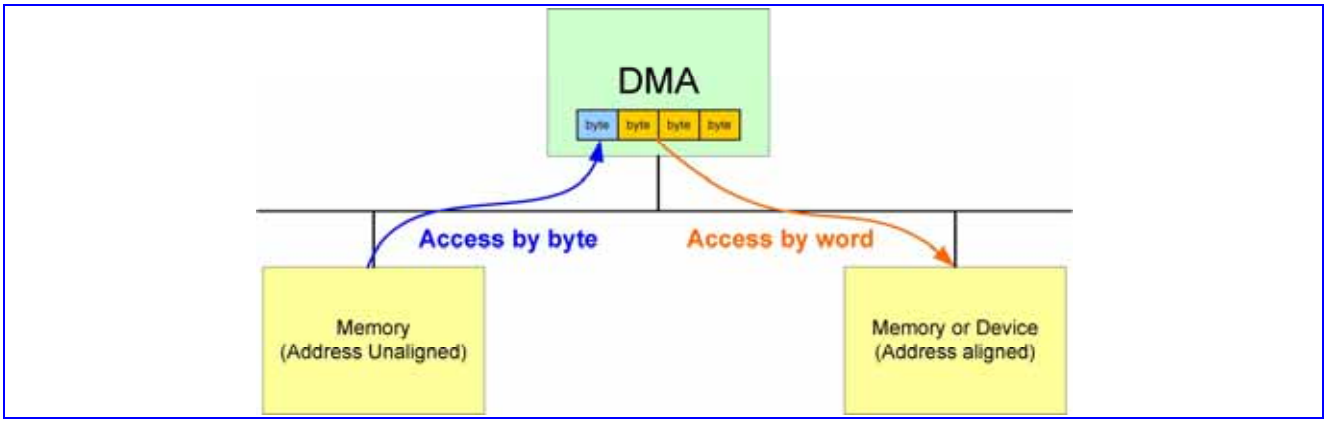


Figure 12 Unaligned Word Accesses

3.4.1.4 Virtual FIFO DMA

Virtual FIFO DMA is used to ease UART control. The difference between the Virtual FIFO DMAs and the ordinary DMAs is that Virtual FIFO DMA contains additional FIFO controller. The read and write pointers are kept in the Virtual FIFO DMA. During a read from the FIFO, the read pointer points to the address of the next data. During a write to the FIFO, the write pointer moves to the next address. If the FIFO is empty, a FIFO read is not allowed. Similarly, data is not written into the FIFO if the FIFO is full. Due to UART flow control requirements, an alert length is programmed. Once the FIFO Space is less than this value, an alert signal is issued to enable UART flow control. The type of flow control performed depends on the setting in UART.

Each Virtual FIFO DMA can be programmed as RX or TX FIFO. This depends on the setting of DIR in DMA_CON register. If DIR is "0"(READ), it means TX FIFO. On the other hand, if DIR is "1"(WRITE), the Virtual FIFO DMA is specified as a RX FIFO.

Virtual FIFO DMA provides an interrupt to MCU. This interrupt informs MCU that there is data in the FIFO, and the amount of data is over or under the value defined in DMA_COUNT register. With this, MCU does not need to poll DMA to know when data must be removed from or put into the FIFO.

Note that Virtual FIFO DMAs cannot be used as generic DMAs, i.e. DMA1~10.

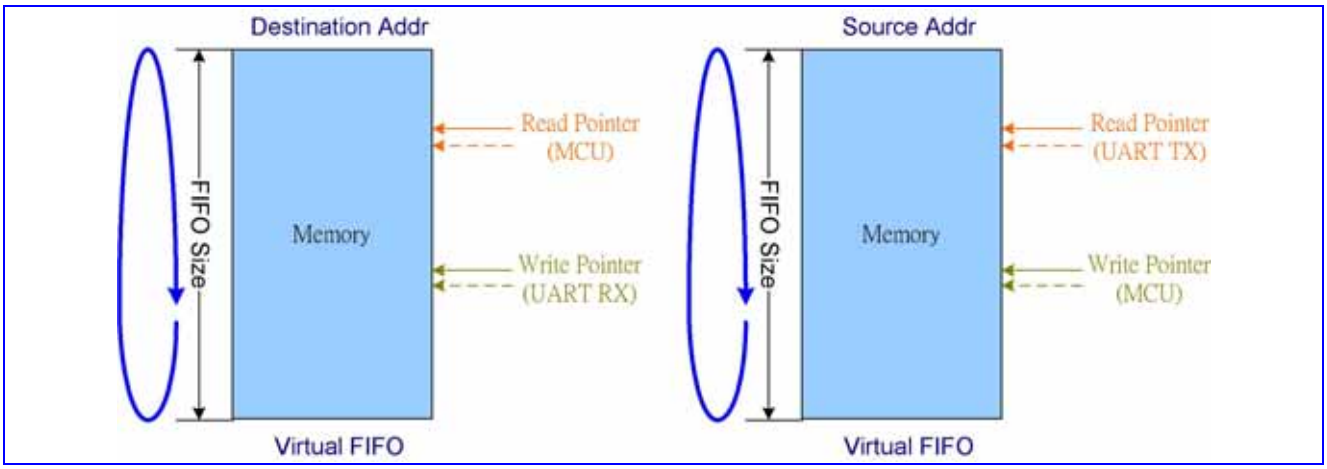


Figure 13 Virtual FIFO DMA

DMA number	Address of Virtual FIFO Access Port	Associated UART
DMA11	6100_0000h	UART1 RX / ALL UART TX
DMA12	6100_0100h	UART2 RX / ALL UART TX
DMA13	6100_0200h	UART3 RX / ALL UART TX
DMA14	6100_0300h	ALL UART TX

Table 6 Virtual FIFO Access Port

DMA number	Type	Ring Buffer	Double Buffer	Burst Mode	Unaligned Word Access
DMA1	Full Size	●	●	●	
DMA2	Full Size	●	●	●	

DMA3	Full Size	●	●	●	
DMA4	Half Size	●	●	●	●
DMA5	Half Size	●	●	●	●
DMA6	Half Size	●	●	●	●
DMA7	Half Size	●	●	●	●
DMA8	Half Size	●	●	●	●
DMA9	Half Size	●	●	●	●
DMA10	Half Size	●	●	●	●
DMA11	Virtual FIFO	●			
DMA12	Virtual FIFO	●			
DMA13	Virtual FIFO	●			
DMA14	Virtual FIFO	●			

Table 7 Function List of DMA channels

REGISTER ADDRESS	REGISTER NAME	SYNONYM
DMA + 0000h	DMA Global Status Register	DMA_GLBSTA
DMA + 0028h	DMA Global Bandwidth Limiter Register	DMA_GLBLIMITER
DMA + 0100h	DMA Channel 1 Source Address Register	DMA1_SRC
DMA + 0104h	DMA Channel 1 Destination Address Register	DMA1_DST
DMA + 0108h	DMA Channel 1 Wrap Point Address Register	DMA1_WPPT
DMA + 010Ch	DMA Channel 1 Wrap To Address Register	DMA1_WPTO
DMA + 0110h	DMA Channel 1 Transfer Count Register	DMA1_COUNT
DMA + 0114h	DMA Channel 1 Control Register	DMA1_CON
DMA + 0118h	DMA Channel 1 Start Register	DMA1_START
DMA + 011Ch	DMA Channel 1 Interrupt Status Register	DMA1_INTSTA
DMA + 0120h	DMA Channel 1 Interrupt Acknowledge Register	DMA1_ACKINT
DMA + 0124h	DMA Channel 1 Remaining Length of Current Transfer	DMA1_RLCT
DMA + 0128h	DMA Channel 1 Bandwidth Limiter Register	DMA1_LIMITER
DMA + 0200h	DMA Channel 2 Source Address Register	DMA2_SRC
DMA + 0204h	DMA Channel 2 Destination Address Register	DMA2_DST
DMA + 0208h	DMA Channel 2 Wrap Point Address Register	DMA2_WPPT
DMA + 020Ch	DMA Channel 2 Wrap To Address Register	DMA2_WPTO
DMA + 0210h	DMA Channel 2 Transfer Count Register	DMA2_COUNT
DMA + 0214h	DMA Channel 2 Control Register	DMA2_CON
DMA + 0218h	DMA Channel 2 Start Register	DMA2_START
DMA + 021Ch	DMA Channel 2 Interrupt Status Register	DMA2_INTSTA
DMA + 0220h	DMA Channel 2 Interrupt Acknowledge Register	DMA2_ACKINT
DMA + 0224h	DMA Channel 2 Remaining Length of Current Transfer	DMA2_RLCT
DMA + 0228h	DMA Channel 2 Bandwidth Limiter Register	DMA2_LIMITER

DMA + 0300h	DMA Channel 3 Source Address Register	DMA3_SRC
DMA + 0304h	DMA Channel 3 Destination Address Register	DMA3_DST
DMA + 0308h	DMA Channel 3 Wrap Point Address Register	DMA3_WPPT
DMA + 030Ch	DMA Channel 3 Wrap To Address Register	DMA3_WPTO
DMA + 0310h	DMA Channel 3 Transfer Count Register	DMA3_COUNT
DMA + 0314h	DMA Channel 3 Control Register	DMA3_CON
DMA + 0318h	DMA Channel 3 Start Register	DMA3_START
DMA + 031Ch	DMA Channel 3 Interrupt Status Register	DMA3_INTSTA
DMA + 0320h	DMA Channel 3 Interrupt Acknowledge Register	DMA3_ACKINT
DMA + 0324h	DMA Channel 3 Remaining Length of Current Transfer	DMA3_RLCT
DMA + 0328h	DMA Channel 3 Bandwidth Limiter Register	DMA3_LIMITER
DMA + 0408h	DMA Channel 4 Wrap Point Address Register	DMA4_WPPT
DMA + 040Ch	DMA Channel 4 Wrap To Address Register	DMA4_WPTO
DMA + 0410h	DMA Channel 4 Transfer Count Register	DMA4_COUNT
DMA + 0414h	DMA Channel 4 Control Register	DMA4_CON
DMA + 0418h	DMA Channel 4 Start Register	DMA4_START
DMA + 041Ch	DMA Channel 4 Interrupt Status Register	DMA4_INTSTA
DMA + 0420h	DMA Channel 4 Interrupt Acknowledge Register	DMA4_ACKINT
DMA + 0424h	DMA Channel 4 Remaining Length of Current Transfer	DMA4_RLCT
DMA + 0428h	DMA Channel 4 Bandwidth Limiter Register	DMA4_LIMITER
DMA + 042Ch	DMA Channel 4 Programmable Address Register	DMA4_PGMADDR
DMA + 0508h	DMA Channel 5 Wrap Point Address Register	DMA5_WPPT
DMA + 050Ch	DMA Channel 5 Wrap To Address Register	DMA5_WPTO
DMA + 0510h	DMA Channel 5 Transfer Count Register	DMA5_COUNT
DMA + 0514h	DMA Channel 5 Control Register	DMA5_CON
DMA + 0518h	DMA Channel 5 Start Register	DMA5_START
DMA + 051Ch	DMA Channel 5 Interrupt Status Register	DMA5_INTSTA
DMA + 0520h	DMA Channel 5 Interrupt Acknowledge Register	DMA5_ACKINT
DMA + 0524h	DMA Channel 5 Remaining Length of Current Transfer	DMA5_RLCT
DMA + 0528h	DMA Channel 5 Bandwidth Limiter Register	DMA5_LIMITER
DMA + 052Ch	DMA Channel 5 Programmable Address Register	DMA5_PGMADDR
DMA + 0608h	DMA Channel 6 Wrap Point Address Register	DMA6_WPPT
DMA + 060Ch	DMA Channel 6 Wrap To Address Register	DMA6_WPTO
DMA + 0610h	DMA Channel 6 Transfer Count Register	DMA6_COUNT
DMA + 0614h	DMA Channel 6 Control Register	DMA6_CON
DMA + 0618h	DMA Channel 6 Start Register	DMA6_START
DMA + 061Ch	DMA Channel 6 Interrupt Status Register	DMA6_INTSTA
DMA + 0620h	DMA Channel 6 Interrupt Acknowledge Register	DMA6_ACKINT
DMA + 0624h	DMA Channel 6 Remaining Length of Current Transfer	DMA6_RLCT

DMA + 0628h	DMA Channel 6 Bandwidth Limiter Register	DMA6_LIMITER
DMA + 062Ch	DMA Channel 6 Programmable Address Register	DMA6_PGMADDR
DMA + 0708h	DMA Channel 7 Wrap Point Address Register	DMA7_WPPT
DMA + 070Ch	DMA Channel 7 Wrap To Address Register	DMA7_WPTO
DMA + 0710h	DMA Channel 7 Transfer Count Register	DMA7_COUNT
DMA + 0714h	DMA Channel 7 Control Register	DMA7_CON
DMA + 0718h	DMA Channel 7 Start Register	DMA7_START
DMA + 071Ch	DMA Channel 7 Interrupt Status Register	DMA7_INTSTA
DMA + 0720h	DMA Channel 7 Interrupt Acknowledge Register	DMA7_ACKINT
DMA + 0724h	DMA Channel 7 Remaining Length of Current Transfer	DMA7_RLCT
DMA + 0728h	DMA Channel 7 Bandwidth Limiter Register	DMA7_LIMITER
DMA + 072Ch	DMA Channel 7 Programmable Address Register	DMA7_PGMADDR
DMA + 0808h	DMA Channel 8 Wrap Point Address Register	DMA8_WPPT
DMA + 080Ch	DMA Channel 8 Wrap To Address Register	DMA8_WPTO
DMA + 0810h	DMA Channel 8 Transfer Count Register	DMA8_COUNT
DMA + 0814h	DMA Channel 8 Control Register	DMA8_CON
DMA + 0818h	DMA Channel 8 Start Register	DMA8_START
DMA + 081Ch	DMA Channel 8 Interrupt Status Register	DMA8_INTSTA
DMA + 0820h	DMA Channel 8 Interrupt Acknowledge Register	DMA8_ACKINT
DMA + 0824h	DMA Channel 8 Remaining Length of Current Transfer	DMA8_RLCT
DMA + 0828h	DMA Channel 8 Bandwidth Limiter Register	DMA8_LIMITER
DMA + 082Ch	DMA Channel 8 Programmable Address Register	DMA8_PGMADDR
DMA + 0908h	DMA Channel 9 Wrap Point Address Register	DMA9_WPPT
DMA + 090Ch	DMA Channel 9 Wrap To Address Register	DMA9_WPTO
DMA + 0910h	DMA Channel 9 Transfer Count Register	DMA9_COUNT
DMA + 0914h	DMA Channel 9 Control Register	DMA9_CON
DMA + 0918h	DMA Channel 9 Start Register	DMA9_START
DMA + 091Ch	DMA Channel 9 Interrupt Status Register	DMA9_INTSTA
DMA + 0920h	DMA Channel 9 Interrupt Acknowledge Register	DMA9_ACKINT
DMA + 0924h	DMA Channel 9 Remaining Length of Current Transfer	DMA9_RLCT
DMA + 0928h	DMA Channel 9 Bandwidth Limiter Register	DMA9_LIMITER
DMA + 092Ch	DMA Channel 9 Programmable Address Register	DMA9_PGMADDR
DMA + 0A08h	DMA Channel 10 Wrap Point Address Register	DMA10_WPPT
DMA + 0A0Ch	DMA Channel 10 Wrap To Address Register	DMA10_WPTO
DMA + 0A10h	DMA Channel 10 Transfer Count Register	DMA10_COUNT
DMA + 0A14h	DMA Channel 10 Control Register	DMA10_CON
DMA + 0A18h	DMA Channel 10 Start Register	DMA10_START
DMA + 0A1Ch	DMA Channel 10 Interrupt Status Register	DMA10_INTSTA
DMA + 0A20h	DMA Channel 10 Interrupt Acknowledge Register	DMA10_ACKINT

DMA + 0A24h	DMA Channel 10 Remaining Length of Current Transfer	DMA10_RLCT
DMA + 0A28h	DMA Channel 10 Bandwidth Limiter Register	DMA10_LIMITER
DMA + 0A2Ch	DMA Channel 10 Programmable Address Register	DMA10_PGMADDR
DMA + 0B10h	DMA Channel 11 Transfer Count Register	DMA11_COUNT
DMA + 0B14h	DMA Channel 11 Control Register	DMA11_CON
DMA + 0B18h	DMA Channel 11 Start Register	DMA11_START
DMA + 0B1Ch	DMA Channel 11 Interrupt Status Register	DMA11_INTSTA
DMA + 0B20h	DMA Channel 11 Interrupt Acknowledge Register	DMA11_ACKINT
DMA + 0B28h	DMA Channel 11 Bandwidth Limiter Register	DMA11_LIMITER
DMA + 0B2Ch	DMA Channel 11 Programmable Address Register	DMA11_PGMADDR
DMA + 0B30h	DMA Channel 11 Write Pointer	DMA11_WRPTR
DMA + 0B34h	DMA Channel 11 Read Pointer	DMA11_RDPTR
DMA + 0B38h	DMA Channel 11 FIFO Count	DMA11_FFCNT
DMA + 0B3Ch	DMA Channel 11 FIFO Status	DMA11_FFSTA
DMA + 0B40h	DMA Channel 11 Alert Length	DMA11_ALTLEN
DMA + 0B44h	DMA Channel 11 FIFO Size	DMA11_FFSIZE
DMA + 0C10h	DMA Channel 12 Transfer Count Register	DMA12_COUNT
DMA + 0C14h	DMA Channel 12 Control Register	DMA12_CON
DMA + 0C18h	DMA Channel 12 Start Register	DMA12_START
DMA + 0C1Ch	DMA Channel 12 Interrupt Status Register	DMA12_INTSTA
DMA + 0C20h	DMA Channel 12 Interrupt Acknowledge Register	DMA12_ACKINT
DMA + 0C28h	DMA Channel 12 Bandwidth Limiter Register	DMA12_LIMITER
DMA + 0C2Ch	DMA Channel 12 Programmable Address Register	DMA12_PGMADDR
DMA + 0C30h	DMA Channel 12 Write Pointer	DMA12_WRPTR
DMA + 0C34h	DMA Channel 12 Read Pointer	DMA12_RDPTR
DMA + 0C38h	DMA Channel 12 FIFO Count	DMA12_FFCNT
DMA + 0C3Ch	DMA Channel 12 FIFO Status	DMA12_FFSTA
DMA + 0C40h	DMA Channel 12 Alert Length	DMA12_ALTLEN
DMA + 0C44h	DMA Channel 12 FIFO Size	DMA12_FFSIZE
DMA + 0D10h	DMA Channel 13 Transfer Count Register	DMA13_COUNT
DMA + 0D14h	DMA Channel 13 Control Register	DMA13_CON
DMA + 0D18h	DMA Channel 13 Start Register	DMA13_START
DMA + 0D1Ch	DMA Channel 13 Interrupt Status Register	DMA13_INTSTA
DMA + 0D20h	DMA Channel 13 Interrupt Acknowledge Register	DMA13_ACKINT
DMA + 0D28h	DMA Channel 13 Bandwidth Limiter Register	DMA13_LIMITER
DMA + 0D2Ch	DMA Channel 13 Programmable Address Register	DMA13_PGMADDR
DMA + 0D30h	DMA Channel 13 Write Pointer	DMA13_WRPTR
DMA + 0D34h	DMA Channel 13 Read Pointer	DMA13_RDPTR
DMA + 0D38h	DMA Channel 13 FIFO Count	DMA13_FFCNT

DMA + 0D3Ch	DMA Channel 13 FIFO Status	DMA13_FFSTA
DMA + 0D40h	DMA Channel 13 Alert Length	DMA13_ALTLEN
DMA + 0D44h	DMA Channel 13 FIFO Size	DMA13_FFSIZE
DMA + 0E10h	DMA Channel 14 Transfer Count Register	DMA14_COUNT
DMA + 0E14h	DMA Channel 14 Control Register	DMA14_CON
DMA + 0E18h	DMA Channel 14 Start Register	DMA14_START
DMA + 0E1Ch	DMA Channel 14 Interrupt Status Register	DMA14_INTSTA
DMA + 0E20h	DMA Channel 14 Interrupt Acknowledge Register	DMA14_ACKINT
DMA + 0E28h	DMA Channel 14 Bandwidth Limiter Register	DMA14_LIMITER
DMA + 0E2Ch	DMA Channel 14 Programmable Address Register	DMA14_PGMADDR
DMA + 0E30h	DMA Channel 14 Write Pointer	DMA14_WRPTR
DMA + 0E34h	DMA Channel 14 Read Pointer	DMA14_RDPTR
DMA + 0E38h	DMA Channel 14 FIFO Count	DMA14_FFCNT
DMA + 0E3Ch	DMA Channel 14 FIFO Status	DMA14_FFSTA
DMA + 0E40h	DMA Channel 14 Alert Length	DMA14_ALTLEN
DMA + 0E44h	DMA Channel 14 FIFO Size	DMA14_FFSIZE

Table 8 DMA Controller Register Map

3.4.2 Register Definitions

Register programming tips:

- Start registers shall be cleared, when associated channels are being programmed.
- PGMADDR, i.e. programmable address, only exists in half-size DMA channels. If DIR in Control Register is high, PGMADDR represents Destination Address. Conversely, If DIR in Control Register is low, PGMADDR represents Source Address.
- Functions of ring-buffer and double-buffer memory data movement can be activated on either source side or destination side by programming DMA_WPPT & and DMA_WPTO, as well as setting WPEN in DMA_CON register high. WPSD in DMA_CON register determines the activated side.

DMA+0000h DMA Global Status Register DMA_GLBSTA

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name					IT14	RUN14	IT13	RUN13	IT12	RUN12	IT11	RUN11	IT10	RUN10	IT9	RUN9
Type					RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
Reset					0	0	0	0	0	0	0	0	0	0	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IT8	RUN8	IT7	RUN7	IT6	RUN6	IT5	RUN5	IT4	RUN4	IT3	RUN3	IT2	RUN2	IT1	RUN1
Type	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

This register helps software program keep track of the global status of DMA channels.

RUN_N DMA channel n status

0 Channel n is stopped or has completed the transfer already.

1 Channel n is currently running.

IT_N Interrupt status for channel n

0 No interrupt is generated.

1 An interrupt is pending and waiting for service.

DMA+0028h DMA Global Bandwidth limiter Register — DMA_GLBLIMITER

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									GLBLIMITER							
Type									WO							
Reset									0							

Please refer to the expression in DMAn_LIMITER for detailed note. The value of DMA_GLBLIMITER is set to all DMA channels, from 1 to 14.

DMA+0n00h DMA Channel n Source Address Register — DMAn_SRC

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SRC[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SRC[15:0]															
Type	R/W															
Reset	0															

The above registers contain the base or current source address that the DMA channel is currently operating on. Writing to this register specifies the base address of transfer source for a DMA channel. Before programming these registers, the software program should make sure that STR in DMAn_START is set to 0; that is, the DMA channel is stopped and disabled completely. Otherwise, the DMA channel may run out of order. Reading this register returns the address value from which the DMA is reading.

Note that n is from 1 to 3 and SRC can't be TCM address. TCM is not accessible by DMA..

SRC **SRC**[31:0] specifies the base or current address of transfer source for a DMA channel, i.e. channel 1, 2 or 3.

WRITE Base address of transfer source

READ Address from which DMA is reading

DMA+0n04h DMA Channel n Destination Address Register — DMAn_DST

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DST[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DST[15:0]															
Type	R/W															
Reset	0															

The above registers contain the base or current destination address that the DMA channel is currently operating on.. Writing to this register specifies the base address of the transfer destination for a DMA channel. Before programming these registers, the software should make sure that STR in DMAn_START is set to '0'; that is, the DMA channel is stopped and disabled completely. Otherwise, the DMA channel may run out of order. Reading this register returns the address value to which the DMA is writing.

Note that n is from 1 to 3 and DST can't be TCM address. TCM is not accessible by DMA.

DST **DST**[31:0] specifies the base or current address of transfer destination for a DMA channel, i.e. channel 1, 2 or 3.
WRITE Base address of transfer destination.
READ Address to which DMA is writing.

DMA+0n08h DMA Channel n Wrap Point Count Register DMAn_WPPT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	WPPT[15:0]															
Type	R/W															
Reset	0															

The above registers are to specify the transfer count required to perform before the jump point. This can be used to support ring buffer or double buffer style memory accesses. To enable this function, two control bits, WPEN and WPSD, in DMA control register must be programmed. See the following register description for more details. If the transfercounter in the DMA engine matches this value, an address jump occurs, and the next address is the address specified in DMAn_WPTO. Before programming these registers, the software should make sure that STR in DMAn_START is set to '0', that is the DMA channel is stopped and disabled completely. Otherwise, the DMA channel may run out of order. To enable this function, WPEN in DMA_CON is set. Note that the total size of data specify in the wrap point count in a DMA channel is determined by LEN together with the SIZE in DMAn_CON, i.e. WPPT x SIZE.

Note that n is from 1 to 10.

WPPT **WPPT**[15:0] specifies the amount of the transfer count from start to jumping point for a DMA channel, i.e. channel 1 – 10.
WRITE Wrap point transfer count.
READ Value set by the programmer.

DMA+0n0Ch DMA Channel n Wrap To Address Register DMAn_WPTO

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	WPTO[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	WPTO[15:0]															
Type	R/W															
Reset	0															

The above registers specify the address of the jump destination of a given DMA transfer to support ring buffer or double buffer style memory accesses. To enable this function, set the two control bits, WPEN and WPSD, in the DMA control register . See the following register description for more details. Before programming these registers, the software

should make sure that STR in DMAn_START is set to '0', that is the DMA channel is stopped and disabled completely. Otherwise, the DMA channel may run out of order. To enable this function, WPEN in DMA_CON should be set.

Note that n is from 1 to 10.

WPTO **WPTO**[31:0] specifies the address of the jump point for a DMA channel, i.e. channel 1 – 10.
WRITE Address of the jump destination.
READ Value set by the programmer.

DMA+0n10h DMA Channel n Transfer Count Register DMAn_COUNT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LEN															
Type	R/W															
Reset	0															

This register specifies the amount of total transfer count that the DMA channel is required to perform. Upon completion, the DMA channel generates an interrupt request to the processor while ITEN in DMAn_CON is set as '1'. Note that the total size of data being transferred by a DMA channel is determined by LEN together with the SIZE in DMAn_CON, i.e. LEN x SIZE.

For virtual FIFO DMA, this register is used to configure the RX threshold and TX threshold. Interrupt is triggered while FIFO count >= RX threshold in RX path or FIFO count =< TX threshold in TX path. Note that ITEN bit in DMA_CON register shall be set, or no interrupt is issued.

Note that n is from 1 to 14.

LEN The amount of total transfer count

DMA+0n14h DMA Channel n Control Register DMAn_CON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name								MAS						DIR	WPEN	WPSD
Type								R/W						R/W	R/W	R/W
Reset								0						0	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ITEN					BURST					B2W	DRQ	DINC	SINC	SIZE	
Type	R/W					R/W					R/W	R/W	R/W	R/W	R/W	
Reset	0					0					0	0	0	0	0	

This register contains all the available control schemes for a DMA channel that is ready for software programmer to configure. Note that all these fields cannot be changed while DMA transfer is in progress or an unexpected situation may occur.

Note that n is from 1 to 14.

SIZE Data size within the confine of a bus cycle per transfer.
These bits confines the data transfer size between source and destination to the specified value for individual bus cycle. The size is in terms of byte and has maximum value of 4 bytes. It is mainly decided by the data width of a DMA master.
00 Byte transfer/1 byte

01 Half-word transfer/2 bytes
10 Word transfer/4 bytes
11 Reserved

SINC Incremental source address. Source addresses increase every transfer. If the setting of SIZE is Byte, Source addresses increase by 1 every single transfer. If Half-Word, increase by 2; and if Word, increase by 4.
0 Disable
1 Enable

DINC Incremental destination address. Destination addresses increase every transfer. If the setting of SIZE is Byte, Destination addresses increase by 1 every single transfer. If Half-Word, increase by 2; and Iif Word, increase by 4.
0 Disable
1 Enable

DREQ Throttle and handshake control for DMA transfer
0 No throttle control during DMA transfer or transfers occurred only between memories
1 Hardware handshake management
The DMA master is able to throttle down the transfer rate by way of request-grant handshake.

B2W Word to Byte or Byte to Word transfer for the applications of transferring non-word-aligned-address data to word-aligned-address data. Note that BURST is set to 4-beat burst while enabling this function, and the SIZE is set to Byte.
NO effect on channel 1 – 3 & 11 - 14.
0 Disable
1 Enable

BURST Transfer Type. Burst-type transfers have better bus efficiency. Mass data movement is recommended to use this kind of transfer. However, note that burst-type transfer does not stop until all of the beats in a burst are completed or transfer length is reached. FIFO threshold of peripherals must be configured carefully while being used to move data from/to the peripherals.
What transfer type can be used is restricted by the SIZE. If SIZE is 00b, i.e. byte transfer, all of the four transfer types can be used. If SIZE is 01b, i.e. half-word transfer, 16-beat incrementing burst cannot be used. If SIZE is 10b, i.e. word transfer, only single and 4-beat incrementing burst can be used.
NO effect on channel 11 - 14.
000 Single
001 Reserved
010 4-beat incrementing burst
011 Reserved
100 8-beat incrementing burst
101 Reserved
110 16-beat incrementing burst
111 Reserved

ITEN DMA transfer completion interrupt enable.
0 Disable
1 Enable

WPSD The side using address-wrapping function. Only one side of a DMA channel can activate address-wrapping function at a time.
NO effect on channel 11 - 14.

0 Address-wrapping on source .

1 Address-wrapping on destination.

WPEN Address-wrapping for ring buffer and double buffer. The next address of DMA jumps to WRAP TO address when the current address matches WRAP POINT count.

NO effect on channel 11 - 14.

0 Disable

1 Enable

DIR Directions of DMA transfer for half-size and Virtual FIFO DMA channels, i.e. channels 4~14. The direction is from the perspective of the DMA masters. WRITE means read from master and then write to the address specified in DMA_PGMADDR, and vice versa.

NO effect on channel 1 - 3.

0 Read

1 Write

MAS Master selection. Specifies which master occupies this DMA channel. Once assigned to certain master, the corresponding DREQ and DACK are connected. For half-size and Virtual FIFO DMA channels, i.e. channels 4 ~ 14, a predefined address is assigned as well.

00000 SIM
00001 MSDC
00010 IrDA TX
00011 IrDA RX
00100 Reserved
00101 Reserved
00110 Reserved
00111 Reserved
01000 UART1 TX
01001 UART1 RX
01010 UART2 TX
01011 UART2 RX
01100 UART3 TX
01101 UART3 RX
01110 DSP-DMA1
01111 NFI TX
10000 NFI RX
10001 DSP-DMA2
10010 I2C TX
10011 I2C RX
10100 Reserved
10101 Reserved
OTHERS Reserved

DMA+0n18h DMA Channel n Start Register DMAn_START

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	STR															
Type	R/W															
Reset	0															

This register controls the activity of a DMA channel. Note that prior to setting STR to "1", all the configurations should be done by giving proper value to the registers. Note also that once the STR is set to "1", the hardware does not clear it automatically no matter if the DMA channel accomplishes the DMA transfer or not. In other works, the value of **STR** stays "1" regardless of the completion of DMA transfer. Therefore, the software program should be sure to clear **STR** to "0" before restarting another DMA transfer. If this bit is cleared to "0" during DMA transfer is active, software should polling MDDMA_GLBSTA **RUN$_N$** after this bit is cleared to ensure current DMA transfer is terminated by DMA engine.

Note that n is from 1 to 14.

STR Start control for a DMA channel.

0 The DMA channel is stopped.

1 The DMA channel is started and running.

DMA+0n1Ch DMA Channel n Interrupt Status Register DMAn_INTSTA

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	INT															
Type	RO															
Reset	0															

This register shows the interrupt status of a DMA channel. It has the same value as DMA_GLBSTA.

Note that n is from 1 to 14.

INT Interrupt Status for DMA Channel

0 No interrupt request is generated.

1 One interrupt request is pending and waiting for service.

DMA+0n20h DMA Channel n Interrupt Acknowledge Register DMAn_ACKINT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ACK															
Type	WO															
Reset	0															

This register is used to acknowledge the current interrupt request associated with the completion event of a DMA channel by software program. Note that this is a write-only register, and any read to it returns a value of "0".

Note that n is from 1 to 14.

ACK Interrupt acknowledge for the DMA channel

0 No effect

1 Interrupt request is acknowledged and should be relinquished.

DMA+0n24h DMA Channel n Remaining Length of Current Transfer DMAn_RLCT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RLCT															
Type	RO															
Reset	0															

This register is to reflect the left count of the transfer. Note that this value is transfer count not the transfer data size.

Note that n is from 1 to 10.

DMA+0n28h DMA Bandwidth limiter Register DMAn_LIMITER

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									LIMITER							
Type									R/W							
Reset									0							

This register is to suppress the Bus utilization of the DMA channel. The value is from 0 to 255. 0 means no limitation, and 255 means totally banned. The value between 0 and 255 means certain DMA can have permission to use AHB every (4 X n) AHB clock cycles.

Note that it is not recommended to limit the Bus utilization of the DMA channels because this increases the latency of response to the masters, and the transfer rate decreases as well. Before using it, programmer must make sure that the bus masters have some protective mechanism to avoid entering the wrong states.

Note that n is from 1 to 14.

LIMITER from 0 to 255. 0 means no limitation, 255 means totally banned, and others mean Bus access permission every (4 X n) AHB clock.

DMA+0n2Ch DMA Channel n Programmable Address Register DMAn_PGMADDR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	PGMADDR[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	PGMADDR[15:0]															
Type	R/W															
Reset	0															

The above registers specify the address for a half-size DMA channel. This address represents a source address if DIR in DMA_CON is set to 0, and represents a destination address if DIR in DMA_CON is set to 1. Before being able to

program these register, the software should make sure that STR in DMAn_START is set to '0', that is the DMA channel is stopped and disabled completely. Otherwise, the DMA channel may run out of order.

Note that n is from 4 to 14 and PGMADDR can't be TCM address. TCM is not accessible by DMA.

PGMADDR **PGMADDR**[31:0] specifies the addresses for a half-size or a Virtual FIFO DMA channel, i.e. channel 4 – 14.

WRITE Base address of transfer source or destination according to DIR bit

READ Current address of the transfer.

DMA+0n30h DMA Channel n Virtual FIFO Write Pointer Register DMAn_WRPTR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	WRPTR[31:16]															
Type	RO															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	WRPTR[15:0]															
Type	RO															

Note that n is from 11 to 14.

WRPTR Virtual FIFO Write Pointer.

DMA+0n34h DMA Channel n Virtual FIFO Read Pointer Register DMAn_RDPTR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	RDPTR[31:16]															
Type	RO															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RDPTR[15:0]															
Type	RO															

Note that n is from 11 to 14.

RDPTR Virtual FIFO Read Pointer.

DMA+0n38h DMA Channel n Virtual FIFO Data Count Register DMAn_FFCNT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	FFCNT															
Type	RO															

Note that n is from 11 to 14.

FFCNT To display the number of data stored in FIFO. 0 means FIFO empty, and FIFO is full if FFCNT is equal to FFSIZE.

DMA+0n3Ch DMA Channel n Virtual FIFO Status Register DMAn_FFSTA

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name														ALT	EMPTY	FULL

Type														RO	RO	RO
Reset														0	1	0

Note that n is from 11 to 14.

FULL To indicate FIFO is full.

0 Not Full

1 Full

EMPTY To indicate FIFO is empty.

0 Not Empty

1 Empty

ALT To indicate FIFO Count is larger than ALTLEN. DMA issues an alert signal to UART to enable UART flow control.

0 Not reach alert region.

1 Reach alert region.

DMA+0n40h DMA Channel n Virtual FIFO Alert Length Register DMAn_ALTLEN

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											ALTLEN					
Type											R/W					
Reset											0					

Note that n is from 11 to 14.

ALTLEN Specifies the Alert Length of Virtual FIFO DMA. Once the remaining FIFO space is less than ALTLEN, an alert signal is issued to UART to enable flow control. Normally, ALTLEN shall be larger than 16 for UART application.

DMA+0n44h DMA Channel n Virtual FIFO Size Register DMAn_FFSIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	FFSIZE															
Type	R/W															
Reset	0															

Note that n is from 11 to 14.

FFSIZE Specifies the FIFO Size of Virtual FIFO DMA.

3.5 Interrupt Controller

3.5.1 General Description

Figure 14 outlines the major functionality of the MCU Interrupt Controller. The interrupt controller processes all interrupt sources coming from external lines and internal MCU peripherals. Since ARM9EJ-S core supports two levels of interrupt latency, this controller generates two request signals: FIQ for fast, low latency interrupt request and IRQ for more general interrupts with lower priority.

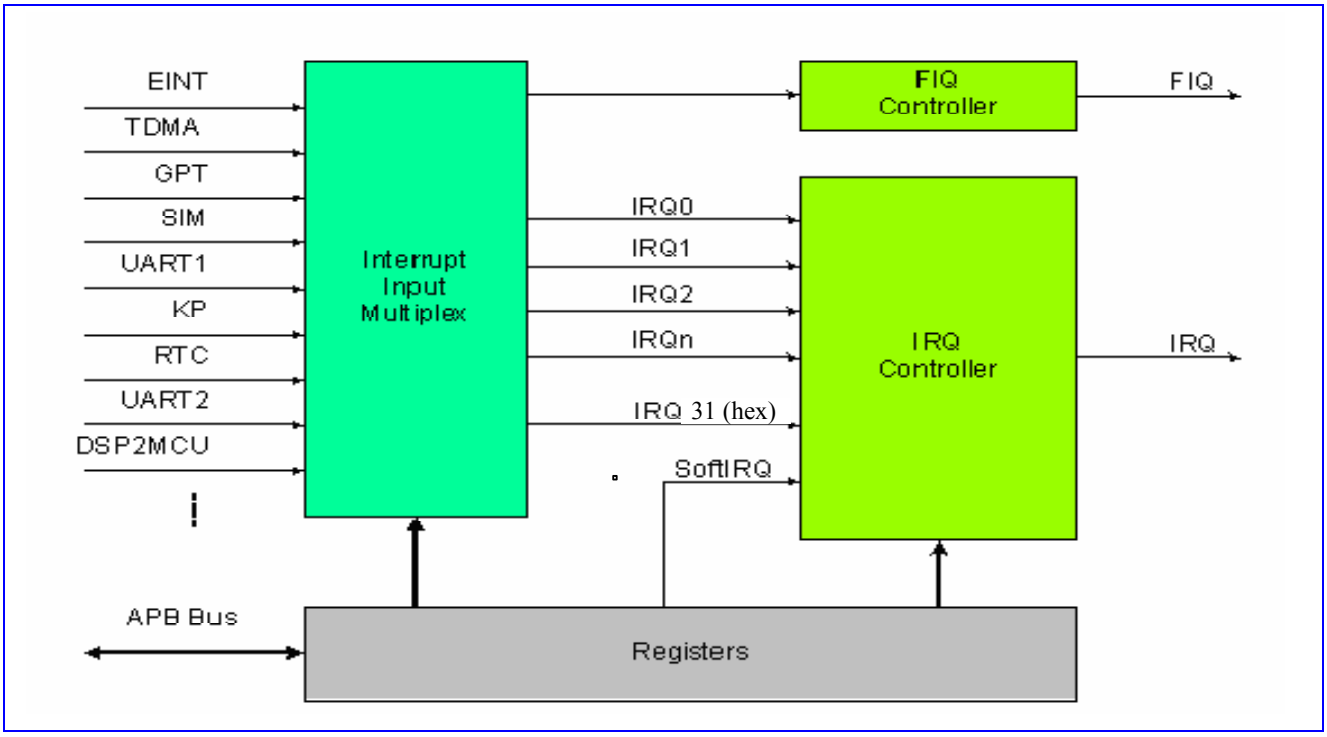


Figure 15 Block Diagram of the Interrupt Controller

One and only one of the interrupt sources can be assigned to FIQ Controller and have the highest priority in requesting timing critical service. All the others share the same IRQ signal by connecting them to IRQ Controller. The IRQ Controller manages up 50 interrupt lines of IRQ0 to IRQ31 with fixed priority in descending order.

The Interrupt Controller provides a simple software interface by mean of registers to manipulate the interrupt request shared system. IRQ Selection Registers and FIQ Selection Register determine the source priority and connecting relation among sources and interrupt lines. IRQ Source Status Register allows software program to identify the source of interrupt that generates the interrupt request. IRQ Mask Register provides software to mask out undesired sources some time. End of Interrupt Register permits software program to indicate to the controller that a certain interrupt service routine has been finished.

Binary coded version of IRQ Source Status Register is also made available for software program to helpfully identify the interrupt source. Note that while taking advantage of this, it should also take the binary coded version of End of Interrupt Register coincidently.

The essential Interrupt Table of ARM926EJ-S core is shown as Table **9**.

Address	Description
00000000h	System Reset
00000018h	IRQ
0000001Ch	FIQ

Table 10 Interrupt Table of ARM926EJ-S

3.5.1.1 Interrupt Source Masking

Interrupt controller provides the function of Interrupt Source Masking by the way of programming MASK register. Any of them can be masked individually.

However, because of the bus latency, the masking takes effect no earlier than 3 clock cycles later. In this time, the to-be-masked interrupts could come in and generate an IRQ pulse to MCU, and then disappear immediately. This IRQ forces MCU going to Interrupt Service Routine and polling Status Register (IRQ_STA(IRQ_STAH+IRQ_STAL) or IRQ_STA2), but the register shows there is no interrupt. This might cause MCU malfunction.

There are two ways for programmer to protect their software.

1. Return from ISR (Interrupt Service Routine) immediately while the Status register shows no interrupt.
2. Set I bit of MCU before doing Interrupt Masking, and then clear it after Interrupt Masking done.

Both avoid the problem, but the first item recommended to have in the ISR.

3.5.1.2 External Interrupt

This interrupt controller also integrates an External Interrupt Controller that can support up to 8 interrupt requests coming from external sources, the EINT0~7, and 4 WakeUp interrupt requests, i.e. EINT8-B, coming from peripherals. All external interrupts can inform system to resume the system clock.

The eight external interrupts can be used for different kind of applications, mainly for event detections: detection of hand free connection, detection of hood opening, detection of battery charger connection.

Since the external event may be unstable in a certain period, a de-bounce mechanism is introduced to ensure the functionality. The circuitry is mainly used to verify that the input signal remains stable for a programmable number of periods of the clock. When this condition is satisfied, for the appearance or the disappearance of the input, the output of the de-bounce logic changes to the desired state. Note that, because it uses the 32 KHz slow clock for performing the de-bounce process, the parameter of de-bounce period and de-bounce enable takes effect no sooner than one 32 KHz clock cycle (~31.25us) after the software program sets them. When the sources of External Interrupt Controller are used to resume the system clock in sleep mode, the de-bounce mechanism must be enabled. However, the polarities of EINTs are clocked with the system clock. Any changes to them take effect immediately.

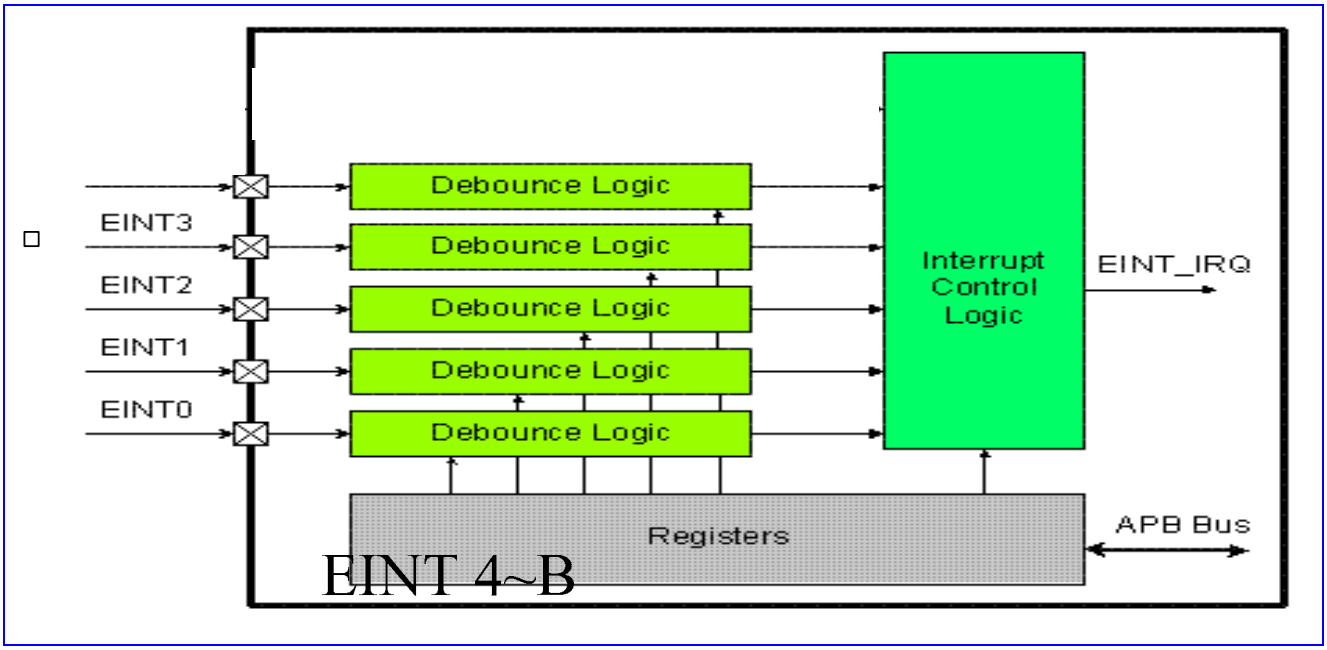


Figure 16 Block Diagram of External Interrupt Controller

3.5.1.3 External Interrupt Input Pins

EINT	Edge / Level HW Debounce	SOURCE PIN	SUPPLEMENT
EINT0	Edge / Level Yes	EINT0	1. GPIOs should be in the input mode and are effected by GPIO data input inversion registers. 2. GPIOxx_M is the GPIO mode control registers, please refer to GPIO segment.
EINT1	Edge / Level Yes	EINT1	
EINT2	Edge / Level Yes	EINT2	
EINT3	Edge / Level Yes	if(GPIO44_M==1) then EINT3=EINT3 else EINT3=1	
EINT4	Edge / Level Yes	if(GPIO45_M==1) then EINT4=EINT4 else EINT4=1	
EINT5	Edge / Level Yes	if(GPIO46_M==1) then EINT5=EINT5 else EINT5=1	
EINT6	Edge / Level Yes	if(GPIO47_M==1) then EINT6=EINT6 else EINT6=1	
EINT7	Edge / Level Yes	if(GPIO48_M==1) then EINT7=EINT7 else EINT7=1	
EINT8	Edge / Level Yes	PMIC Charge Detection (Low Active)	
EINT9	Edge / Level Yes	URXD1	

EINTA	Edge / Level Yes	URXD2	
EINTB	Edge / Level Yes	URXD3	

REGISTER ADDRESS	REGISTER NAME	SYNONYM
CIRQ + 0000h	IRQ Selection 0 Register	IRQ_SEL0
CIRQ + 0004h	IRQ Selection 1 Register	IRQ_SEL1
CIRQ + 0008h	IRQ Selection 2 Register	IRQ_SEL2
CIRQ + 000Ch	IRQ Selection 3 Register	IRQ_SEL3
CIRQ + 0010h	IRQ Selection 4 Register	IRQ_SEL4
CIRQ + 0014h	IRQ Selection 5 Register	IRQ_SEL5
CIRQ + 0018h	IRQ Selection 6 Register	IRQ_SEL6
CIRQ + 001ch	IRQ Selection 7 Register	IRQ_SEL7
CIRQ + 0020h	IRQ Selection 8 Register	IRQ_SEL8
CIRQ + 0034h	FIQ Selection Register	FIQ_SEL
CIRQ + 0038h	IRQ Mask Register (LSB)	IRQ_MASKL
CIRQ + 003ch	IRQ Mask Register (MSB)	IRQ_MASKH
CIRQ + 0040h	IRQ Mask Clear Register (LSB)	IRQ_MASK_CLRL
CIRQ + 0044h	IRQ Mask Clear Register (MSB)	IRQ_MASK_CLRH
CIRQ + 0048h	IRQ Mask Set Register (LSB)	IRQ_MASK_SETL
CIRQ + 004ch	IRQ Mask Set Register (MSB)	IRQ_MASK_SETH
CIRQ + 0050h	IRQ Status Register (LSB)	IRQ_STAL
CIRQ + 0054h	IRQ Status Register (MSB)	IRQ_STAH
CIRQ + 0058h	IRQ End of Interrupt Register (LSB)	IRQ_EOIL
CIRQ + 005ch	IRQ End of Interrupt Register (MSB)	IRQ_EOIH
CIRQ + 0060h	IRQ Sensitive Register (LSB)	IRQ_SENSL
CIRQ + 0064h	IRQ Sensitive Register (MSB)	IRQ_SENSH
CIRQ + 0068h	IRQ Software Interrupt Register (LSB)	IRQ_SOFTL
CIRQ + 006ch	IRQ Software Interrupt Register (MSB)	IRQ_SOFTH
CIRQ + 0070h	FIQ Control Register	FIQ_CON
CIRQ + 0074h	FIQ End of Interrupt Register	FIQ_EOI
CIRQ + 0078h	Binary Coded Value of IRQ_STATUS	IRQ_STA2
CIRQ + 007ch	Binary Coded Value of IRQ_EOI	IRQ_EOI2
CIRQ + 0080h	Binary Coded Value of IRQ_SOFT	IRQ_SOFT2
CIRQ + 0100h	EINT Status Register	EINT_STA
CIRQ + 0104h	EINT Mask Register	EINT_MASK
CIRQ + 0108h	EINT Mask Disable Register	EINT_MASK_DIS
CIRQ + 010Ch	EINT Mask Enable Register	EINT_MASK_EN

CIRQ + 0110h	EINT Interrupt Acknowledge Register	EINT_INTACK
CIRQ + 0114h	EINT Sensitive Register	EINT_SENS
CIRQ + 0120h	EINT0 De-bounce Control Register	EINT0_CON
CIRQ + 0130h	EINT1 De-bounce Control Register	EINT1_CON
CIRQ + 0140h	EINT2 De-bounce Control Register	EINT2_CON
CIRQ + 0150h	EINT3 De-bounce Control Register	EINT3_CON
CIRQ + 0160h	EINT4 De-bounce Control Register	EINT4_CON
CIRQ + 0170h	EINT5 De-bounce Control Register	EINT5_CON
CIRQ + 0180h	EINT6 De-bounce Control Register	EINT6_CON
CIRQ + 0190h	EINT7 De-bounce Control Register	EINT7_CON
CIRQ + 01a0h	EINT8 De-bounce Control Register	EINT8_CON
CIRQ + 01b0h	EINT9 De-bounce Control Register	EINT9_CON
CIRQ + 01c0h	EINTA De-bounce Control Register	EINT10_CON
CIRQ + 01d0h	EINTB De-bounce Control Register	EINT11_CON

Table 11 Interrupt Controller Register Map

3.5.2 Register Definitions

CIRQ+0000h IRQ Selection 0 Register IRQ_SEL0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name			IRQ4						IRQ3						IRQ2	
Type			R/W						R/W						R/W	
Reset			0x4						0x3							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQ2				IRQ1				IRQ0							
Type	R/W				R/W				R/W							
Reset	0x2				0x1				0x0							

CIRQ+0004h IRQ Selection 1 Register IRQ_SEL1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name			IRQ9						IRQ8						IRQ7	
Type			R/W						R/W						R/W	
Reset			0x9						0x8							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQ7				IRQ6				IRQ5							
Type	R/W				R/W				R/W							
Reset	0x7				0x6				0x5							

CIRQ+0008h IRQ Selection 2 Register IRQ_SEL2

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name			IRQE						IRQD						IRQC	
Type			R/W						R/W						R/W	
Reset			0xe						0xD							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQC				IRQB				IRQA							
Type	R/W				R/W				R/W							

Reset	0xc	0xb	0xa

CIRQ+000ch IRQ Selection 3 Register IRQ_SEL3

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name			IRQ13						IRQ12						IRQ11	
Type			R/W						R/W						R/W	
Reset			0x13						0x12							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQ11				IRQ10						IRQF					
Type	R/W				R/W						R/W					
Reset	0x11				0x10						0xf					

CIRQ+0010h IRQ Selection 4 Register IRQ_SEL4

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name			IRQ18						IRQ17						IRQ16	
Type			R/W						R/W						R/W	
Reset			0x18						0x17							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQ16				IRQ15						IRQ14					
Type	R/W				R/W						R/W					
Reset	0x16				0x15						0x14					

CIRQ+0014h IRQ Selection 5 Register IRQ_SEL5

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name			IRQ1D						IRQ1C						IRQ1B	
Type			R/W						R/W						R/W	
Reset			0x1d						0x1c							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQ1B				IRQ1A						IRQ19					
Type	R/W				R/W						R/W					
Reset	0x1b				0x1a						0x19					

CIRQ+0018h IRQ Selection 6 Register IRQ_SEL6

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name			IRQ22						IRQ21						IRQ20	
Type			R/W						R/W						R/W	
Reset			0x22						0x21							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQ20				IRQ1F						IRQ1E					
Type	R/W				R/W						R/W					
Reset	0x20				0x1f						0x1e					

CIRQ+001ch IRQ Selection 7 Register IRQ_SEL7

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name			IRQ27						IRQ26						IRQ25	
Type			R/W						R/W						R/W	
Reset			0x27						0x26							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQ25				IRQ24						IRQ23					
Type	R/W				R/W						R/W					
Reset	0x25				0x24						0x23					

CIRQ+0020h IRQ Selection 8 Register IRQ_SEL8

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name			IRQ2C						IRQ2B						IRQ2A	
Type			R/W						R/W						R/W	
Reset			0x2c						0x2b							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQ2A				IRQ29						IRQ28					
Type	R/W				R/W						R/W					
Reset	0x2a				0x29						0x28					

CIRQ+0024h IRQ Selection 9 Register IRQ_SEL9

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name			IRQ31						IRQ30						IRQ2F	
Type			R/W						R/W						R/W	
Reset			0x31						0x30							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQ2F				IRQ2E						IRQ2D					
Type	R/W				R/W						R/W					
Reset	0x2f				0x2e						0x2d					

CIRQ+0034h FIQ Selection Register FIQ_SEL

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											FIQ					
Type											R/W					
Reset											0					

The IRQ/FIQ Selection Registers provide system designers with a flexible routing scheme to make various mappings of priority among interrupt sources possible. The registers allow the interrupt sources to be mapped onto interrupt requests of either FIQ or IRQ. While only one interrupt source can be assigned to FIQ, the other ones share IRQs by mapping them onto IRQ0 to IRQ1F connected to IRQ controller. The priority sequence of IRQ0~IRQ31 is fixed, i.e. IRQ0 > IRQ1 > IRQ2 > … > IRQ30 > IRQ31. During the software configuration process, the Interrupt Source Code of desired interrupt source should be written into source field of the corresponding IRQ_SEL0-IRQ_SEL9/FIQ_SEL. Six-bit Interrupt Source Codes for all interrupt sources are fixed and defined.

Interrupt Source	STA2 (Hex)	STAH_STAL
GPI_FIQ	0	000_00000001
TDMA_CTIRQ1	1	000_00000002
TDMA_CTIRQ2	2	000_00000004
DSP2CPU	3	000_00000008
SIM	4	000_00000010
DMA	5	000_00000020

TDMA	6	000_00000040
UART1	7	000_00000080
KeyPad	8	000_00000100
UART2	9	000_00000200
GPTimer	a	000_00000400
EINT	b	000_00000800
USB MC	c	000_00001000
MSDC	d	000_00002000
RTC	e	000_00004000
IrDA	f	000_00008000
LCD	10	000_00010000
UART3	11	000_00020000
GPI0	12	000_00040000
WDT	13	000_00080000
Reserved	14	000_00100000
Reserved	15	000_00200000
NFI	16	000_00400000
Reserved	17	000_00800000
Reserved	18	000_01000000
Reserved	19	000_02000000
Reserved	1a	000_04000000
I2C	1b	000_08000000
G2D	1c	000_10000000
Reserved	1d	000_20000000
CAM	1e	000_40000000
Reserved	1f	000_80000000
Reserved	20	001_00000000
Reserved	21	002_00000000
Reserved	22	004_00000000
Reserved	23	008_00000000
Resizer_crz	24	010_00000000
Reserved	25	020_00000000
Reserved	26	040_00000000
Reserved	27	080_00000000
DSPINT	28	100_00000000
USB DMA	29	200_00000000
PWM	2A	400_00000000
GPI1	2B	800_00000000
GPI2	2C	1000_00000000
IRDebug1	2D	2000_00000000

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IRDebug2	2E	4000_00000000
Reserved	2F	8000_00000000
Reserved	30	10000_00000000
AUXADC	31	20000_00000000

Table 12 Interrupt Source Code for Interrupt Sources

FIQ, IRQ0-31 The 5-bit content of this field corresponds to an Interrupt Source Code shown above.

CIRQ+0038h IRQ Mask Register (LSB) IRQ_MASKL

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	IRQ1F	IRQ1E	IRQ1D	IRQ1C	IRQ1B	IRQ1A	IRQ19	IRQ18	IRQ17	IRQ16	IRQ15	IRQ14	IRQ13	IRQ12	IRQ11	IRQ10
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQF	IRQE	IRQD	IRQC	IRQB	IRQA	IRQ9	IRQ8	IRQ7	IRQ6	IRQ5	IRQ4	IRQ3	IRQ2	IRQ1	IRQ0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

CIRQ+003ch IRQ Mask Register (MSB) IRQ_MASKH

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name															IRQ31	IRQ30
Type															R/W	R/W
Reset															1	1
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQ2F	IRQ2E	IRQ2D	IRQ2C	IRQ2B	IRQ2A	IRQ29	IRQ28	IRQ27	IRQ26	IRQ25	IRQ24	IRQ23	IRQ22	IRQ21	IRQ20
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

This register contains a mask bit for each interrupt line in IRQ Controller. The register allows each interrupt source IRQ0 to IRQ1F to be disabled or masked separately under software control. After a system reset, all bit values are set to 1 to indicate that interrupt requests are prohibited.

IRQ0-31 Mask control for the associated interrupt source in the IRQ controller

0 Interrupt is enabled.

1 Interrupt is disabled.

CIRQ+0040h IRQ Mask Clear Register (LSB) IRQ_MASK_CLRL

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	IRQ1F	IRQ1E	IRQ1D	IRQ1C	IRQ1B	IRQ1A	IRQ19	IRQ18	IRQ17	IRQ16	IRQ15	IRQ14	IRQ13	IRQ12	IRQ11	IRQ10
Type	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQF	IRQE	IRQD	IRQC	IRQB	IRQA	IRQ9	IRQ8	IRQ7	IRQ6	IRQ5	IRQ4	IRQ3	IRQ2	IRQ1	IRQ0
Type	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C

CIRQ+0044h IRQ Mask Clear Register (MSB) IRQ_MASK_CLRH

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name															IRQ31	IRQ30
Type															W1C	W1C
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQ2F	IRQ2E	IRQ2D	IRQ2C	IRQ2B	IRQ2A	IRQ29	IRQ28	IRQ27	IRQ26	IRQ25	IRQ24	IRQ23	IRQ22	IRQ21	IRQ20
Type	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C

This register is used to clear bits in IRQ Mask Register. When writing to this register, the data bits that are HIGH cause the corresponding bits in IRQ Mask Register to be cleared. Data bits that are LOW have no effect on the corresponding bits in IRQ Mask Register.

IRQ0-31 Clear corresponding bits in IRQ Mask Register.

0 No effect.

1 Disable the corresponding MASK bit.

CIRQ+0048h IRQ Mask SET Register (LSB) IRQ_MASK_SETL

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	IRQ1F	IRQ1E	IRQ1D	IRQ1C	IRQ1B	IRQ1A	IRQ19	IRQ18	IRQ17	IRQ16	IRQ15	IRQ14	IRQ13	IRQ12	IRQ11	IRQ10
Type	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQF	IRQE	IRQD	IRQC	IRQB	IRQA	IRQ9	IRQ8	IRQ7	IRQ6	IRQ5	IRQ4	IRQ3	IRQ2	IRQ1	IRQ0
Type	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S

CIRQ+004ch IRQ Mask SET Register (MSB) IRQ_MASK_SETH

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name															IRQ31	IRQ30
Type															W1S	W1S
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQ2F	IRQ2E	IRQ2D	IRQ2C	IRQ2B	IRQ2A	IRQ29	IRQ28	IRQ27	IRQ26	IRQ25	IRQ24	IRQ23	IRQ22	IRQ21	IRQ20
Type	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S

This register is used to set bits in the IRQ Mask Register. When writing to this register, the data bits that are HIGH cause the corresponding bits in IRQ Mask Register to be set. Data bits that are LOW have no effect on the corresponding bits in IRQ Mask Register.

IRQ0-31 Set corresponding bits in IRQ Mask Register.

0 No effect.

1 Enable corresponding MASK bit.

CIRQ+0050h IRQ Source Status Register (LSB) IRQ_STAL

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	IRQ1F	IRQ1E	IRQ1D	IRQ1C	IRQ1B	IRQ1A	IRQ19	IRQ18	IRQ17	IRQ16	IRQ15	IRQ14	IRQ13	IRQ12	IRQ11	IRQ10
Type	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQF	IRQE	IRQD	IRQC	IRQB	IRQA	IRQ9	IRQ8	IRQ7	IRQ6	IRQ5	IRQ4	IRQ3	IRQ2	IRQ1	IRQ0

Type	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CIRQ+0054h IRQ Source Status Register (MSB) IRQ_STAH

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name															IRQ31	IRQ30
Type															RO	RO
Reset															0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQ2F	IRQ2E	IRQ2D	IRQ2C	IRQ2B	IRQ2A	IRQ29	IRQ28	IRQ27	IRQ26	IRQ25	IRQ24	IRQ23	IRQ22	IRQ21	IRQ20
Type	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

This Register allows software to poll which interrupt line has generated an IRQ interrupt request. A bit set to 1 indicates a corresponding active interrupt line. Only one flag is active at a time. The IRQ_STA is type of read-clear; write access has no effect on the content.

IRQ0-31 Interrupt indicator for the associated interrupt source.

0 The associated interrupt source is non-active.

1 The associated interrupt source is asserted.

CIRQ+0058h IRQ End of Interrupt Register (LSB) IRQ_EOIL

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	IRQ1F	IRQ1E	IRQ1D	IRQ1C	IRQ1B	IRQ1A	IRQ19	IRQ18	IRQ17	IRQ16	IRQ15	IRQ14	IRQ13	IRQ12	IRQ11	IRQ10
Type	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQF	IRQE	IRQD	IRQC	IRQB	IRQA	IRQ9	IRQ8	IRQ7	IRQ6	IRQ5	IRQ4	IRQ3	IRQ2	IRQ1	IRQ0
Type	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CIRQ+005ch IRQ End of Interrupt Register (MSB) IRQ_EOIH

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name															IRQ31	IRQ30
Type															WO	WO
Reset															0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQ2F	IRQ2E	IRQ2D	IRQ2C	IRQ2B	IRQ2A	IRQ29	IRQ28	IRQ27	IRQ26	IRQ25	IRQ24	IRQ23	IRQ22	IRQ21	IRQ20
Type	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

This register provides a mean for software to relinquish and to refresh the interrupt controller. Writing a 1 to a specific bit position results in an End of Interrupt command issued internally to the corresponding interrupt line.

IRQ0-31 End of Interrupt command for the associated interrupt line.

0 No service is currently in progress or pending.

1 Interrupt request is in-service.

CIRQ+0060h IRQ Sensitive Register (LSB) IRQ_SENSL

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	IRQ1F	IRQ1E	IRQ1D	IRQ1C	IRQ1B	IRQ1A	IRQ19	IRQ18	IRQ17	IRQ16	IRQ15	IRQ14	IRQ13	IRQ12	IRQ11	IRQ10
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQF	IRQE	IRQD	IRQC	IRQB	IRQA	IRQ9	IRQ8	IRQ7	IRQ6	IRQ5	IRQ4	IRQ3	IRQ2	IRQ1	IRQ0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CIRQ+0064h IRQ Sensitive Register (MSB) IRQ_SENSH

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name															IRQ31	IRQ30
Type															R/W	R/W
Reset															0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQ2F	IRQ2E	IRQ2D	IRQ2C	IRQ2B	IRQ2A	IRQ29	IRQ28	IRQ27	IRQ26	IRQ25	IRQ24	IRQ23	IRQ22	IRQ21	IRQ20
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

All interrupt lines of IRQ Controller, IRQ0~IRQ31 can be programmed as either edge or level sensitive. By default, all the interrupt lines are edge sensitive and should be active LOW. Once a interrupt line is programmed as edge sensitive, an interrupt request is triggered only at the falling edge of interrupt line, and the next interrupt is not accepted until the EOI command is given. However, level sensitive interrupts trigger is according to the signal level of the interrupt line. Once the interrupt line become from HIGH to LOW, an interrupt request is triggered, and another interrupt request is triggered if the signal level remain LOW after an EOI command. Note that in edge sensitive mode, even if the signal level remains LOW after EOI command, another interrupt request is not triggered. That is because edge sensitive interrupt is only triggered at the falling edge.

IRQ0-31 Sensitivity type of the associated Interrupt Source

- **0** Edge sensitivity with active LOW
- **1** Level sensitivity with active LOW

CIRQ+0068h IRQ Software Interrupt Register (LSB) IRQ_SOFTL

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	IRQ1F	IRQ1E	IRQ1D	IRQ1C	IRQ1B	IRQ1A	IRQ19	IRQ18	IRQ17	IRQ16	IRQ15	IRQ14	IRQ13	IRQ12	IRQ11	IRQ10
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQF	IRQE	IRQD	IRQC	IRQB	IRQA	IRQ9	IRQ8	IRQ7	IRQ6	IRQ5	IRQ4	IRQ3	IRQ2	IRQ1	IRQ0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CIRQ+006ch IRQ Software Interrupt Register (MSB) IRQ_SOFTH

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name															IRQ31	IRQ30
Type															R/W	R/W
Reset															0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQ2F	IRQ2E	IRQ2D	IRQ2C	IRQ2B	IRQ2A	IRQ29	IRQ28	IRQ27	IRQ26	IRQ25	IRQ24	IRQ23	IRQ22	IRQ21	IRQ20
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Setting “1” to the specific bit position generates a software interrupt for corresponding interrupt line before mask. This register is used for debug purpose.

IRQ0-IRQ31 Software Interrupt

CIRQ+0070h FIQ Control Register FIQ_CON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name															SENS	MASK
Type															R/W	R/W
Reset															0	1

This register provides a means for software program to control the FIQ controller.

MASK Mask control for the FIQ Interrupt Source

- **0** Interrupt is enabled.
- **1** Interrupt is disabled.

SENS Sensitivity type of the FIQ Interrupt Source

- **0** Edge sensitivity with active LOW
- **1** Level sensitivity with active LOW

CIRQ+0074h FIQ End of Interrupt Register FIQ_EOI

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																EOI
Type																WO
Reset																0

This register provides a means for software to relinquish and to refresh the FIQ controller. Writing a '1' to the specific bit position results in an End of Interrupt command issued internally to the corresponding interrupt line.

EOI End of Interrupt command

CIRQ+0078h Binary Coded Value of IRQ_STATUS IRQ_STA2

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name								NOIRQ			STS					
Type								RC			RC					
Reset								0			0					

This Register is a binary coded version of IRQ_STA. It is used by the software program to poll which interrupt line has generated the IRQ interrupt request in a much easier way. Any read to it has the same result as reading IRQ_STA. The IRQ_STA2 is also read-only and read-clear; write access has no effect on the content. Note that IRQ_STA2 should be coupled with IRQ_EOI2 while using it.

STS Binary coded value of IRQ_STA

NOIRQ Indicating if there is an IRQ or not. If there is no IRQ, this bit is HIGH, and the value of STS is 00_0000b.

CIRQ+007ch Binary Coded Value of IRQ_EOI IRQ_EOI2

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											EOI					
Type											WO					
Reset											0					

This register is a binary coded version of IRQ_EOI. It provides an easier way for software program to relinquish and to refresh the interrupt controller. Writing a specific code results in an End of Interrupt command issued internally to the corresponding interrupt line. Note that IRQ_EOI2 should be coupled with IRQ_STA2 while using it.

EOI Binary coded value of IRQ_EOI

CIRQ+0080h Binary Coded Value of IRQ_SOFT IRQ_SOFT2

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											SOFT					
Type											WO					
Reset											0					

This register is a binary coded version of IRQ_SOFT.

SOFT Binary Coded Value of IRQ_SOFT

CIRQ+0100h EINT Interrupt Status Register EINT_STA

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					EINTB	EINTA	EINT9	EINT8	EINT7	EINT6	EINT5	EINT4	EINT3	EINT2	EINT1	EINT0
Type					RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
Reset					0	0	0	0	0	0	0	0	0	0	0	0

This register keeps up with current status that which EINT Source generates the interrupt request. If EINT sources are set to edge sensitivity, EINT_IRQ is de-asserted while this register is read.

EINT0-EINTB Interrupt status

- **0** No interrupt request is generated.
- **1** Interrupt request is pending.

CIRQ+0104h EINT Interrupt Mask Register EINT_MASK

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					EINTB	EINTA	EINT9	EINT8	EINT7	EINT6	EINT5	EINT4	EINT3	EINT2	EINT1	EINT0
Type					R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset					1	1	1	1	1	1	1	1	1	1	1	1

This register controls whether or not EINT Source is allowed to generate an interrupt request. Setting a "1" to the specific bit position prohibits the external interrupt line from becoming active.

EINT0-EINTB Interrupt Mask

0 Interrupt request is enabled.

1 Interrupt request is disabled.

CIRQ+0108h EINT Interrupt Mask Clear Register — EINT_MASK_CLR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					EINTB	EINTA	EINT9	EINT8	EINT7	EINT6	EINT5	EINT4	EINT3	EINT2	EINT1	EINT0
Type					W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C

This register is used to clear individual mask bits. Only the bits set to 1 are in effect, and interrupt masks for which the mask bit is set are cleared (set to 0). Otherwise the interrupt mask bit retains its original value.

EINT0-EINTB Disable mask for the associated external interrupt source.

0 No effect.

1 Disable the corresponding MASK bit.

CIRQ+010Ch EINT Interrupt Mask Set Register — EINT_MASK_SET

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					EINTB	EINTA	EINT9	EINT8	EINT7	EINT6	EINT5	EINT4	EINT3	EINT2	EINT1	EINT0
Type					W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S

This register is used to set individual mask bits. Only the bits set to 1 are in effect, and interrupt masks for which the mask bit is set are set to 1. Otherwise the interrupt mask bit retains its original value.

EINT0-EINTB Disable mask for the associated external interrupt source.

0 No effect.

1 Enable corresponding MASK bit.

CIRQ+0110h EINT Interrupt Acknowledge Register — EINT_INTACK

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					EINTB	EINTA	EINT9	EINT8	EINT7	EINT6	EINT5	EINT4	EINT3	EINT2	EINT1	EINT0
Type					WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO

Reset					0	0	0	0	0	0	0	0	0	0	0	0

Writing "1" to the specific bit position acknowledge the interrupt request correspondingly to the external interrupt line source.

EINT0-EINTB Interrupt acknowledgement

- **0** No effect
- **1** Interrupt request is acknowledged.

CIRQ+0114h EINT Sensitive Register EINT_SENS

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					**EINTB**	**EINTA**	**EINT9**	**EINT8**	**EINT7**	**EINT6**	**EINT5**	**EINT4**	**EINT3**	**EINT2**	**EINT1**	**EINT0**
Type					R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset					1	1	1	1	1	1	1	1	1	1	1	1

Sensitivity type of external interrupt source.

EINT0-B Sensitivity type of the associated external interrupt source.

- **0** Edge sensitivity with active LOW.
- **1** Level sensitivity with active LOW.

CIRQ+01m0h EINTn De-bounce Control Register EINTn_CON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	**EN**				**POL**	**CNT**										
Type	R/W				R/W	R/W										
Reset	0				0	0										

These registers control the de-bounce logic for external interrupt sources in order to minimize the possibility of false activations. Note that n is from 0 to 11, and m is n + 2. When the external interrupt sources is used to resume the system clock from the sleep mode, the De-bounce control circuit must be enabled.

CNT De-bounce duration in terms of number of 32 KHz clock cycles.

POL Activation type of the EINT source

- **0** Negative polarity
- **1** Positive polarity

EN De-bounce control circuit

- **0** Disable
- **1** Enable

3.6 BUS Monitor (BM)

3.6.1 General Description

MT6235 contains 4-layer AHB BUS. Most of them contain AHB master and slave modules. BUS Monitor (BM) provides an interface to provide the BUS access usage to help analyze system performance. In BM, only EN is cleared to 0 after reset. Other registers do not effect by reset.

3.6.2 Register Definitions

BM+0000h BM control BM_CON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name															CLR	EN
Type															WO	R/W
Reset																0

EN Enable the BM. BM is off after reset. You have to turn on it by write EN =1.

0 BM is disabled.

1 BM is enabled.

CLR All statistics recorded in BM is going to clear if you write CLR=1. CLR is a one-shot control bit.

BM+0004h Layer-2 AHB master filter BM_LYR2_HMASTER

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									MASEN							
Type									R/W							

MASEN Master enable filter.

0 Disable the logging when the transaction is caused by the corresponding master.

1 Enable the logging when the transaction is caused by the corresponding master.

bit0 VFF Port
bit1 DMA
bit2 Wavetable
bit3 USB
bit4 IRDBG1
bit5 IRDBG2

bit6IRDA
bit7PWM

BM+0008h BM cycle count — BM_CYCLE_CNT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	CYCLE_CNT[31:16]															
Type	RO															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	CYCLE_CNT[15:0]															
Type	RO															

CYCLE_CNT CYCLE_CNT indicates how many cycles passed when EN=1.
CYCLE_CNT is only cleared by CLR and is not affected by RESET.

BM+0010h Layer-1 AHB active cycle count — BM_LYR1_ACCNT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	LYR1_ACCNT[31:16]															
Type	RO															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LYR1_ACCNT[15:0]															
Type	RO															

LYR1_ACCNT LYR1_ACCNT indicates how many cycles HTRANS is (non-IDLE and non-BUSY) and increments in every cycle when (EN=1) and (HTRANS=NON-SEQ or SEQ).
LYR1_ACCNT is only cleared by CLR and is not affected by RESET.

BM+0014h Layer-1 AHB transaction count — BM_LYR1_TCNT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	LYR1_TCNT[31:16]															
Type	RO															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LYR1_TCNT[15:0]															
Type	RO															

LYR1_TCNT LYR1_TCNT indicates transaction accumulation and increments in every cycle when (EN=1) and (HTRANS=NON-SEQ or SEQ) and (HREADY=1).
LYR1_ACNT is only cleared by CLR and is not affected by RESET.

BM+0018h Layer-1 AHB word count — BM_LYR1_WCNT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	LYR1_WCNT[31:16]															

Type	RO															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LYR1_WCNT[15:0]															
Type	RO															

LYR1_WCNT LYR1_WCNT indicates transaction of word counts been transferred and increases depends HSIZE in every cycle when (EN=1) and (HTRANS=NON-SEQ or SEQ) and (HREADY=1). A word means 4 bytes (32-bit) in this document. The total data counts transferred less then 1 word is truncated. (For example, the BUS transfers 33 bytes after EN=1. you will get 8 in WCNT. The last byte count is ignored.)

LYR1_WCNT is only cleared by CLR and is not affected by RESET.

HSIZE=00 8-bit data. WCNT increases 1.

HSIZE=01 16-bit data. WCNT increases 2.

HSIZE=10 32-bit data. WCNT increases 4.

OTHER Not supported.

BM+0020h Layer-1 AHB status FIFO 0~3 — BM_LYR1_FIFO 0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name		LYR1_HDY3				LYR1_HSEL3				LYR1_HDY2				LYR1_HSEL2		
Type		RO				RO				RO				RO		
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name		LYR1_HDY1				LYR1_HSEL1				LYR1_HDY0				LYR1_HSEL0		
Type		RO				RO				RO				RO		

BM+0024h Layer-1 AHB status FIFO 4~7 — BM_LYR1_FIFO 4

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name		LYR1_HDY7				LYR1_HSEL7				LYR1_HDY6				LYR1_HSEL6		
Type		RO				RO				RO				RO		
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name		LYR1_HDY5				LYR1_HSEL5				LYR1_HDY4				LYR1_HSEL4		
Type		RO				RO				RO				RO		

BM+0028h Layer-1 AHB status FIFO 8~11 — BM_LYR1_FIFO 8

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name		LYR1_HDY11				LYR1_HSEL11				LYR1_HDY10				LYR1_HSEL10		
Type		RO				RO				RO				RO		
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name		LYR1_HDY9				LYR1_HSEL9				LYR1_HDY8				LYR1_HSEL8		
Type		RO				RO				RO				RO		

BM+002ch Layer-1 AHB status FIFO 12~15 — BM_LYR1_FIFO C

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name		LYR1_HDY15				LYR1_HSEL15				LYR1_HDY14				LYR1_HSEL14		

Type		RO				RO				RO				RO			
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name		LYR1_HDY13				LYR1_HSEL13				LYR1_HDY12				LYR1_HSEL12		
Type		RO				RO				RO				RO		

BM keeps FIFOs internal recording HSEL and HREADY status on BUS for each layer. 0th is the latest one and 15th is the oldest. The FIFO only shifts when (EN=1) and (HTRANS=SEQ or NON-SEQ) and (HREADY=0) and (slaves' HREADYs differ from HDY0). If all above conditions meet, then (HRDY0=current HREADY on BUS) and (HRDY1=HRDY0) and (HRDY2=HRDY1) and … and (HRDY15=HRDY14). HSEL follows the same rules.

HSELx The xth HSEL status on BUS
- **bit0**EMI
- **bit1**System memory
- **bit2**LCD

HRDYx The xth HREADY status on BUS
- **bit0**EMI
- **bit1**System memory
- **bit2**LCD

BM+0030h Layer-2 AHB active cycle count — BM_LYR2_ACCNT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	LYR2_ACCNT[31:16]															
Type	RO															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LYR2_ACCNT[15:0]															
Type	RO															

LYR2_ACCNT LYR2_ACCNT indicates how many cycles HTRANS is (non-IDLE and non-BUSY) and increments in every cycle when (EN=1) and (HTRANS=NON-SEQ or SEQ).
LYR2_ACCNT is only cleared by CLR and is not affected by RESET.

BM+0034h Layer-2 AHB transaction count — BM_LYR2_TCNT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	LYR2_TCNT[31:16]															
Type	RO															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LYR2_TCNT[15:0]															
Type	RO															

LYR2_TCNT LYR2_TCNT indicates transaction accumulation and increments in every cycle when (EN=1) and (HTRANS=NON-SEQ or SEQ) and (HREADY=1).
LYR2_ACNT is only cleared by CLR and is not affected by RESET.

BM+0038h Layer-2 AHB word count — BM_LYR2_WCNT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	LYR2_WCNT[31:16]															
Type	RO															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LYR2_WCNT[15:0]															
Type	RO															

LYR2_WCNT LYR2_WCNT indicates transaction of word counts been transferred and increases depends HSIZE in every cycle when (EN=1) and (HTRANS=NON-SEQ or SEQ) and (HREADY=1). A word means 4 bytes (32-bit) in this document. The total data counts transferred less then 1 word is truncated. (For example, the BUS transfers 33 bytes after EN=1. you will get 8 in WCNT. The last byte count is ignored.)

LYR2_WCNT is only cleared by CLR and is not affected by RESET.

HSIZE=00 8-bit data. WCNT increases 1.

HSIZE=01 16-bit data. WCNT increases 2.

HSIZE=10 32-bit data. WCNT increases 4.

OTHER Not supported.

BM+0040h Layer-2 AHB status FIFO 0~1 — BM_LYR2_FIFO0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name				LYR2_HDY1								LYR2_HSEL1				
Type				RO								RO				
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				LYR2_HDY0								LYR2_HSEL0				
Type				RO								RO				

BM+0044h Layer-2 AHB status FIFO 2~3 — BM_LYR2_FIFO2

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name				LYR2_HDY3								LYR2_HSEL3				
Type				RO								RO				
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				LYR2_HDY2								LYR2_HSEL2				
Type				RO								RO				

BM+0048h Layer-2 AHB status FIFO 4~5 — BM_LYR2_FIFO4

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name				LYR2_HDY5								LYR2_HSEL5				
Type				RO								RO				
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				LYR2_HDY4								LYR2_HSEL4				
Type				RO								RO				

BM+004ch Layer-2 AHB status FIFO 6~7 BM_LYR2_FIFO 6

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name				LYR2_HDY7								LYR2_HSEL7				
Type				RO								RO				
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				LYR2_HDY6								LYR2_HSEL6				
Type				RO								RO				

BM+0050h Layer-2 AHB status FIFO 8~9 BM_LYR2_FIFO 8

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name				LYR2_HDY9								LYR2_HSEL9				
Type				RO								RO				
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				LYR2_HDY8								LYR2_HSEL8				
Type				RO								RO				

BM+0054h Layer-2 AHB status FIFO 10~11 BM_LYR2_FIFO A

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name				LYR2_HDY11								LYR2_HSEL11				
Type				RO								RO				
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				LYR2_HDY10								LYR2_HSEL10				
Type				RO								RO				

BM+0058h Layer-2 AHB status FIFO 12~13 BM_LYR2_FIFO C

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name				LYR2_HDY13								LYR2_HSEL13				
Type				RO								RO				
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				LYR2_HDY12								LYR2_HSEL12				
Type				RO								RO				

BM+005ch Layer-2 AHB status FIFO 14~15 BM_LYR2_FIFO E

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name				LYR2_HDY15								LYR2_HSEL15				
Type				RO								RO				
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				LYR2_HDY14								LYR2_HSEL14				
Type				RO								RO				

BM keeps FIFOs internal recording HSEL and HREADY status on BUS for each layer. 0^{th} is the latest one and 15^{th} is the oldest. The FIFO only shifts when (EN=1) and (HTRANS=SEQ or NON-SEQ) and (HREADY=0) and (slaves' HREADYs

differ from HDY0). If all above conditions meet, then (HRDY0=current HREADY on BUS) and (HRDY1=HRDY0) and (HRDY2=HRDY1) and … and (HRDY15=HRDY14). HSEL follows the same rules.

HSELx The x[th] HSEL status on BUS

bit0APB
bit1SHARE1
bit2SHARE2
bit3IDMA1
bit4IDMA2

HRDYx The x[th] HREADY status on BUS

bit0APB
bit1SHARE1
bit2SHARE2
bit3IDMA1
bit4IDMA2

BM+0060h Layer-2 AHB master FIFO 0~7

BM_LYR2_MFIFO0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name		LYR2_MSEL7				LYR2_MSEL6				LYR2_MSEL5				LYR2_MSEL4		
Type		RO				RO				RO				RO		
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name		LYR2_MSEL3				LYR2_MSEL2				LYR2_MSEL1				LYR2_MSEL0		
Type		RO				RO				RO				RO		

BM+0064h Layer-2 AHB master FIFO 8~15

BM_LYR2_MFIFO8

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name		LYR2_MSEL15				LYR2_MSEL14				LYR2_MSEL13				LYR2_MSEL12		
Type		RO				RO				RO				RO		
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name		LYR2_MSEL11				LYR2_MSEL10				LYR2_MSEL9				LYR2_MSEL8		
Type		RO				RO				RO				RO		

BM keeps a specific FIFO for layer-2 AHB to record HMASTER. 0[th] is the latest one and 15[th] is the oldest. The FIFO only shifts when (EN=1) and (HTRANS=SEQ or NON-SEQ) and (HREADY=1) and (the bus transaction is caused by master which is enabled in LYR2_HMASTER).
If all above conditions meet, then (MSEL0=current HMASTER_ENC) and (MSEL1=MSEL0) and (MSEL2=MSEL1) and … and (MSEL15=MSEL14).

MSELx The x[th] MSEL status on BUS.

000 Vitual FIFO
001 DMA
010 Wavetable
011 USB

100 IRDGB1
101 IRDBG2
110 IRDA
111 PWM

BM+0070h Layer-3 AHB active cycle count — BM_LYR3_ACCNT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	LYR3_ACCNT[31:16]															
Type	RO															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LYR3_ACCNT[15:0]															
Type	RO															

LYR3_ACCNT LYR3_ACCNT indicates how many cycles HTRANS is (non-IDLE and non-BUSY) and increments in every cycle when (EN=1) and (HTRANS=NON-SEQ or SEQ).
LYR3_ACCNT is only cleared by CLR and is not affected by RESET.

BM+0074h Layer-3 AHB transaction count — BM_LYR3_TCNT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	LYR3_TCNT[31:16]															
Type	RO															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LYR3_TCNT[15:0]															
Type	RO															

LYR3_TCNT LYR3_TCNT indicates transaction accumulation and increments in every cycle when (EN=1) and (HTRANS=NON-SEQ or SEQ) and (HREADY=1).
LYR3_ACNT is only cleared by CLR and is not affected by RESET.

BM+0078h Layer-3 AHB word count — BM_LYR3_WCNT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	LYR3_WCNT[31:16]															
Type	RO															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LYR3_WCNT[15:0]															
Type	RO															

LYR3_WCNT LYR3_WCNT indicates transaction of word counts been transferred and increases depends HSIZE in every cycle when (EN=1) and (HTRANS=NON-SEQ or SEQ) and (HREADY=1). A word means 4 bytes (32-bit) in this document. The total data counts transferred less then 1 word is truncated. (For example, the BUS transfers 33 bytes after EN=1. you will get 8 in WCNT. The last byte count is ignored.)
LYR3_WCNT is only cleared by CLR and is not affected by RESET.
HSIZE=00 8-bit data. WCNT increases 1.

HSIZE=01 16-bit data. WCNT increases 2.
HSIZE=10 32-bit data. WCNT increases 4.
OTHER Not supported.

BM+0090h Layer-4 AHB active cycle count — BM_LYR4_ACCNT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	LYR4_ACCNT[31:16]															
Type	RO															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LYR4_ACCNT[15:0]															
Type	RO															

LYR4_ACCNT LYR4_ACCNT indicates how many cycles HTRANS is (non-IDLE and non-BUSY) and increments in every cycle when (EN=1) and (HTRANS=NON-SEQ or SEQ).
LYR4_ACCNT is only cleared by CLR and is not affected by RESET.

BM+0094h Layer-4 AHB transaction count — BM_LYR4_TCNT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	LYR4_TCNT[31:16]															
Type	RO															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LYR4_TCNT[15:0]															
Type	RO															

LYR4_TCNT LYR4_TCNT indicates transaction accumulation and increments in every cycle when (EN=1) and (HTRANS=NON-SEQ or SEQ) and (HREADY=1).
LYR4_ACNT is only cleared by CLR and is not affected by RESET.

BM+0098h Layer-4 AHB word count — BM_LYR4_WCNT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	LYR4_WCNT[31:16]															
Type	RO															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LYR4_WCNT[15:0]															
Type	RO															

LYR4_WCNT LYR4_WCNT indicates transaction of word counts been transferred and increases depends HSIZE in every cycle when (EN=1) and (HTRANS=NON-SEQ or SEQ) and (HREADY=1). A word means 4 bytes (32-bit) in this document. The total data counts transferred less then 1 word is truncated. (For example, the BUS transfers 33 bytes after EN=1. you will get 8 in WCNT. The last byte count is ignored.)
LYR4_WCNT is only cleared by CLR and is not affected by RESET.
HSIZE=00 8-bit data. WCNT increases 1.
HSIZE=01 16-bit data. WCNT increases 2.

HSIZE=10 32-bit data. WCNT increases 4.
OTHER Not supported.

BM+00a0h Layer-4 AHB FIFO 0~3 BM_LYR4_FIFO 0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name			LYR4_HDY3				LYR4_HSEL3				LYR4_HDY2				LYR4_HSEL2	
Type			RO				RO				RO				RO	
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			LYR4_HDY1				LYR4_HSEL1				LYR4_HDY0				LYR4_HSEL0	
Type			RO				RO				RO				RO	

BM+00a4h Layer-4 AHB FIFO 4~7 BM_LYR4_FIFO 4

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name			LYR4_HDY7				LYR4_HSEL7				LYR4_HDY6				LYR4_HSEL6	
Type			RO				RO				RO				RO	
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			LYR4_HDY5				LYR4_HSEL5				LYR4_HDY4				LYR4_HSEL4	
Type			RO				RO				RO				RO	

BM+00a8h Layer-4 AHB FIFO 8~11 BM_LYR4_FIFO 8

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name			LYR4_HDY11				LYR4_HSEL11				LYR4_HDY10				LYR4_HSEL10	
Type			RO				RO				RO				RO	
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			LYR4_HDY9				LYR4_HSEL9				LYR4_HDY8				LYR4_HSEL8	
Type			RO				RO				RO				RO	

BM+00ach Layer-4 AHB FIFO 12~15 BM_LYR4_FIFO C

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name			LYR4_HDY15				LYR4_HSEL15				LYR4_HDY14				LYR4_HSEL14	
Type			RO				RO				RO				RO	
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			LYR4_HDY13				LYR4_HSEL13				LYR4_HDY12				LYR4_HSEL12	
Type			RO				RO				RO				RO	

BM keeps FIFOs internal recording HSEL and HREADY status on BUS for each layer. 0^{th} is the latest one and 15^{th} is the oldest. The FIFO only shifts when (EN=1) and (HTRANS=SEQ or NON-SEQ) and (HREADY=0) and (slaves' HREADYs

differ from HDY0). If all above conditions meet, then (HRDY0=current HREADY on BUS) and (HRDY1=HRDY0) and (HRDY2=HRDY1) and … and (HRDY15=HRDY14). HSEL follows the same rules.

HSELx The xth HSEL status on BUS

bit0EMI

bit1 System memory

HRDYx The xth HREADY status on BUS

bit0EMI

bit1 System memory

3.7 External Memory Interface (6235)

3.7.1 General Description

MT6235 incorporates a powerful and flexible memory controller, External Memory Interface, to connect with a variety of memory components. This controller provides one generic access scheme for FLASH Memory, SRAM, PSRAM and. Up to 4 memory banks can be supported simultaneously, BANK0-BANK3, with a maximum size of 128MB each. This controller also provides another access scheme for DRAM (SDR), and only one bank can be supported, with a maximum size of 128MB.

The software program can treat different components by simply specifying certain predefined parameters. All these parameters are based on cycle time of system clock.

The interface definition based on such scheme is listed in **Table 13**. Note that, this interface always operates data in Little Endian format for all types of accesses.

Signal Name	Type	Description
XADMUX	I	Define ADMUX or not in NOR flash / PSRAM
EWAIT	I	Wait Signal Input
ED[15:0]	I/O	Data Bus
EA[26:0]	I/O	Address Bus
ECS# [3:0]	O	BANK3~BANK0 Selection Signal
EWR#	O	Write Enable Strobe
ERD#	O	Read Enable Strobe
EDQM[1:0]#	O	Data mask
EADV#	O	Burst Mode FLASH Memory Address Latch Signal
ERAS#	O	Row address latch signal (SDR DRAM)
ECAS#	O	Column address latch signal (SDR DRAM)
ECKE#	O	CLOK enable signal (SDR DRAM)
EC_CLK	O	Burst Mode FLASH/PSRAM Memory Clock Signal
ED_CLK	O	DRAM clock signal

Table 13 External Memory Interface of MT6235

REGISTER ADDRESS	REGISTER NAME	SYNONYM
EMI + 0000h	PSRAM controller register for BANK0	EMI_CONA
EMI + 0008h	PSRAM controller register for BANK1	EMI_CONB
EMI + 0010h	PSRAM controller register for BANK2	EMI_CONC
EMI + 0018h	PSRAM controller register for BANK3	EMI_COND
EMI + 0040h	DRAM MR/EMR	EMI_CONI
EMI + 0048h	DRAM controller timing configuration I	EMI_CONJ

EMI + 0050h	DRAM controller timing configuration II	EMI_CONK
EMI + 0058h	DRAM controller read data path configuration	EMI_CONL
EMI + 0060h	DRAM controller read delay timing configuration	EMI_CONM
EMI + 0068h	DRAM controller function configuration	EMI_CONN
EMI + 0070h	EMI General Control Register A	EMI_GENA
EMI + 0078h	EMI General Control Register B	EMI_GENB
EMI + 0080h	EMI General Control Register C	EMI_GENC
EMI + 0088h	EMI General Control Register D	EMI_GEND

Table 14 External Memory Interface Register Map

3.7.2 Registers

+0000h ~ 0018h Register — EMI_CONA~D

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	PSIZE		WPLO	SRAM_16	AD_MUX	ADV_EN	AS_RD	AS_WR	AP_RD	AS_WAIT			CS_END		SY_SET	
Type	R/W		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W			R/W		R/W	
Reset	0		0	1	0	0	1	1	0	7			1		0	
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	WR_WAIT_1ST				RD_WAIT_1ST				AS_ADV		AS_SET		WAIT_EN	RESERVED	AS_HOLD	
Type	R/W				R/W				R/W		R/W		R/W		R/W	
Reset	F				F				3		3		0		3	

PSIZE : Page size for page read mode

PSIZE	00	01	10
Sram_16 = 1	8 byte	16 byte	32 byte
Sram_16 = 0	4 byte	8 byte	16 byte

WPOL :

1: Wait polarity change
0: Wait polarity not change

SRAM_16 :

1: Data bit [15:0]
0: Data bit [7:0]

ADMUX:

1: ADMUX type memory
0: Non ADMUX type memory

ADVEN:

1: ADV enable in asynchronous read / write
0: ADV disable in asynchronous read / write

AS_RD:

1: Turn on asynchronous read
0: Turn off asynchronous read

AS_WR:

1: Turn on asynchronous write
0: Turn off asynchronous write

AP_RD:

1: Turn on asynchronous page read (burst-page read)
0: Turn off asynchronous page read(burst-page read)

AS_WAIT:

Adjust wait time in every transaction of asynchronous mode (0: 1clk , 1: 2clk ……)

CS_END:

Adjust CS disable time in the end of every transaction (0: 1clk , 1: 2clk ……)

SY_SET:

Adjust init set up time in every transaction of synchronous mode (0: 1clk , 1: 2clk ……)

WR_WAIT_1st:

Adjust first write wait time in every transaction of page read mode (0: 1clk , 1: 2clk ……)

RD_WAIT_1st:

Adjust first read wait time in every transaction of page read mode (0: 1clk , 1: 2clk ……)
For synchronous mode, RD_WAIT_1st[1:0] is used to adjust read wait time in every transaction

AS_ADV:

Adjust ADV time in every transaction of asynchronous mode (0: 1clk , 1: 2clk ……)

AS_SET:

Adjust init set up time in every transaction of asynchronous mode (0: 1clk , 1: 2clk ……)

WAIT_EN:

1: Pass XWAIT signal from external memory to controller
0: Skip XWAIT signal and pass 1 to controller

AS_HOLD:

Adjust hold time in every transaction of asynchronous and synchronus mode (0: 1clk , 1: 2clk ……)

+0040h Register EMI_CONI

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name		MBA1	MBA0	MA12	MA11	MA10	MA9	MA8	MA7	MA6	MA5	MA4	MA3	MA2	MA1	MA0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name		EBA1	EBA0	EBA12	EBA11	EBA10	EBA9	EBA8	EBA7	EBA6	EBA5	EBA4	EBA3	EBA2	EBA1	EBA0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

MBA1~0 : DRAM bank address setting when load mode register to DRAM

MA12~0 : DRAM mode register value

EBA1~0 : DRAM bank address setting when load extended mode register to DRAM

EA12~0 : DRAM extended mode register value

+0048h Register EMI_CONJ

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	E_ES	PRAL_CYC			REF_CYC				EXIT_SREF_CYC						LDMR_CYC	
Type	R/W	R/W			R/W				R/W						R/W	
Reset	0	0			0				0						0	
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name		ACT_RC_CYC				ACT_RR_CYC					WR_WAIT_CYC				RD_WAIT_CYC	
Type		R/W				R/W					R/W				R/W	
Reset		0				0					0				0	

E_ES : Extend EXIT_SREF_CYC

PRAL_CYC : DRAM pre-charge cycle time (TRP)

REF_CYC : DRAM refresh cycle time (TRFC)

EXIT_SREF_CYC : DRAM exit self refresh to first valid command cycle time (TXSR)

LDMR_CYC : DRAM load mode/e-mode register cycle time (TMRD)

ACT_RC_CYC : DRAM active to read/write command delay cycle time (TRCD)

ACT_RR_CYC : DRAM active bank A to active bank b delay cycle time (TRRD)

WR_WAIT_CYC : DRAM write recovery cycle time (TWR)

RD_WAIT_CYC : DRAM read command to pre-charge delay cycle time (adjust final read command to pre-charge command delay cycle time

+0050h Register EMI_CONK

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name			REEP_CYC													
Type			R/W													
Reset			0													
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name		PW_EN	PW_CYC													
Type		R/W	R/W													
Reset		0	0													

REFP_CYC : Auto refresh period cycle time (TREF)

PW_EN : Power on wait-count enable

PW_CYC : Power on wait cycle time

+0058h Register EMI_CONL

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name		DW_PSEL												DPD_CYC		
Type		R/W												R/W		
Reset		0												0		
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name		RAS_MIN_CYC				PATH_SEL								RD_DEL_SEL		
Type		R/W				R/W								R/W		
Reset		0				0								0		

DW_PSEL : Define EMI output clock to DRAM phase select
DW_PSEL[5:0] : Adjust phase delay --- > 1 tape (0.3~0.5 ns)

DPD_CYC : Enter and exit DRAM power down state cycle time

RAS_MIN_CYC : Active to pre-charge minimum cycle time

PATH_SEL : Data input path select from external memory

RD_DEL_SEL : Read data delay cycle time to read command (SDR SDRAM), include CAS latency, IO pad delay, PCB delay

+0060h Register EMI_CONM

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																

Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name		RD_PDEL_SEL_BY1								RD_PDEL_SEL_BY0						
Type		R/W								R/W						
Reset		0								0						

RD_PDEL_SEL_BY1 : Read phase delay for DRAM input data bit [15:8]

RD_PDEL_SEL_BY0 : Read phase delay for DRAM input data bit [7:0]

+0068h Register EMI_CONN

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name				PRAL_EN	AREF1_EN	AREF2_EN	LDMR_EN	LDEMR_EN		ADDR_TYPE					DGB_EN	
Type				R/W	R/W	R/W	R/W	R/W		R/W					R/W	
Reset				0	0	0	0	0		0					0	
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									SREF_ST	PDN_ST	SREF_EN	PDN_EN			REF_CNT_EN	DRAM_EN
Type									R/W	R/W	R/W	R/W			R/W	R/W
Reset									0	0	0	0			0	0

PRAL_EN : Single pre-charge all enable (for DRAM initialize)

ARF1_EN : Single auto-refresh-1 enable (for DRAM initialize)

ARF2_EN : Single auto-refresh-2 enable (for DRAM initialize)

LDMR_EN : Single load mode register enable (for DRAM initialize)

LDEM_EN : Single load extended mode register enable (for DRAM initialize)

ADDR_TYPE : DRAM address type

ADDR_TYPE	Row address bits	Bank address bits	Column address bits
000	11	1	8
001	11	2	8
010	12	2	8
011	12	2	9
100	13	2	9
101	13	2	10
110	14	2	10

DBG_EN :

00 : Normal mode

Others : Internal debug mode, and do not set!

SREF_ST :

1 : DRAM in self refresh status
0 : DRAM exit self refresh status

PDN_ST :

1 : DRAM in power down status
0 : DRAM exit power down status

SREF_EN :

1 : DRAM enter self refresh
0 : DRAM exit self refresh

PDN_EN :

1 : DRAM enter power down, when dram controller is IDLE (the controller will exit power down status, and exercise auto refresh step to keep data correctable in DRAM, if the refresh time is end)
0 : DRAM will not enter power down .

REF_CNT_EN :

1 : Enable auto refresh
0 : Disable auto refresh

DRAM_EN :

1 : Enable DRAM controller
0 : Disable DRAM controller

+0070h Register EMI_GENA

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name		SW_PSEL							CRE_EN	CRE_VALUE	SYW_WTD	SYR_WTD	WRPS	LSS	EST	L2_EN
Type		R/W							R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset		0							0	0	0	0	0	0	0	1
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	HDD		SWAIT_NLAT_EN	SDATA_NLAT_EN	CRATE	SCLK_EN	DCLK_EN	SDAT_DLAT_EN	SDAT_NDAT_EN	AS_AP_RD_D	ACTIVE_WR_DIS	ACTIVE_RD_DIS	M1_TOP	M0_TOP	RM1	RM0
Type	R/W		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0

SW_PSEL : Define EMI output clock to PSRAM phase select
SW_PSEL[5:0] : Adjust phase delay --- > 1 tape (0.3~0.5 ns)

CRE_EN

1: Assign EA26 as GPIO function for PSRAM CRE
0: disable

CRE_VALUE

Assign CRE output value

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SYW_WTD :

1: Wait signal delay 1 more cycle at synchronous write mode of PSRAM
0: disable

SYR_WTD :

1: Wait signal delay 1 more cycle at synchronous read mode of PSRAM
0: disable

WRPS :

1: WRAP mode only PSRAM (The PSRAM cannot support continues access mode)
0: disable

LSS :

1: Low speed PSRAM (clock rate of EMI to PSRAM is 2:1)
0: disable

EST :

1: Extended PSRAM AS_WAIT timing 1 bit.
0: disable

L2_EN :

1: Resolve data consistence problem from L2.
0: disable

HDD :

1: Enable DRAM access at enough bus data rate without concern FIFO condition.
0: disable

SWAIT_NLAT_EN :

1: Latch XWAIT signal by negative edge of HCLK_CK enable (for low speed operation , especially in FPGA ENV)
0: disable

SDATA_NLAT_EN :

1: Latch XDATA(DEMUX) or XADDR(ADMUX) signal by negative edge of HCLK_CK enable
(for low speed operation , especially in FPGA ENV)
0: disable

CRATE:

1: If HDD is enable
0: disable

SCLKEN : : SRAM controller clock out enable

1: Enable
0: Disable

DCLKEN : DRAM controller clock out enable

1: Enable
0: Disable

SDAT_DLAT_EN: SRAM input data sampled by DLAT_CLK positive edge like DRAM

1: Enable
0: Disable

SDAT_NDLAT_EN: SRAM input data sampled by DLAT_CLK negative edge like DRAM
1: Enable
0: Disable

AS_AP_RD_D: SRAM input data delay 1T
1: Enable
0: Disable

ACTIVE_WR_DIS: Continuous active next access bank for DRAM write without pre-charge
1: Enable
0: Disable

ACTIVE_RD_DIS: Continuous active next access bank for DRAM read without pre-charge
1: Enable
0: Disable

M1_TOP : 1: Master-1 top priority on
0: Master-1 top priority off

M0_TOP : 1: Master-0 top priority on
0: Master-0 top priority off

RM1 : 1: External boot
0: Internal boot
When internal boot (RM1 = 0) is selected, ARM will fetch 2 fixed instructions from EMI and jump into the boot ROM area. During the boot ROM execution, RM1 must be set to 1 before burst transactions to EMI!

RM0 : 1: CS[0]/CS[1] change
0: CS[0]/CS[1] not change

+0078h Register EMI_GENB

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							DCKSR	DCKE2	DCKE4	DCKE8	DCKE16	SCKSR	SCKE2	SCKE4	SCKE8	SCKE16
Type							R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset							0	0	0	0	0	0	0	0	0	0

DCKSR : DCK Pad Slew Rate Control

DCKEx : DCK Pad Driving Control

SCKSR : SCK Pad Slew Rate Control

SCKEx : SCK Pad Driving Control

+0080h Register EMI_GENC

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name		EASR	EAE2	EAE4	EAE8	EAE16	EDSR	EDE2	EDE4	EDE8	EDE16	ECSSR	ECSE2	ECSE4	ECSE8	ECSE16
Type		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name		ERWSR	ERWE2	ERWE4	ERWE8	ERWE16	EADVSR	EADVE2	EADVE4	EADVE8	EADVE16	ERCSR	ERCE2	ERCE4	ERCE8	ERCE16
Type		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

EASR : Address Pad Slew Rate Control

EAEx : Address Pad Driving Control

EDSR : Data Pad Slew Rate Control

EDEx : Data Pad Driving Control

ECSSR : CS Pad Slew Rate Control

ECSEx : CS Pad Driving Control

ERWSR : RD/WR Pad Slew Rate Control

ERWEx: RD/WR Pad Driving Control

EADVSR : ADV Pad Slew Rate Control

EADVEx : ADV Pad Driving Control

ERCSR : RAS/CAS Pad Slew Rate Control

ERCEx : RAS/CAS Pad Driving Control

+0088h Register EMI_GEND

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	S_PSEL_BY1												DRAM_CS_EN			
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	S_PSEL_BY0												SRAM_CS_EN			
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1

S_PDEL_SEL_BY1 : Read phase delay for SRAM input data bit [15:8]

S_PDEL_SEL_BY0 : Read phase delay for SRAM input data bit [7:0]

DRAM_CS_EN : From bank_3 to bank_0 (only one bank can be turned on for DRAM controller)

1: Enable
0: Disable

SRAM_CS_EN : From bank_3 to bank_0 (all banks can be turned on, except the bank assigned to DRAM)

1: Enable
0: Disable

4 Microcontroller Peripherals

Microcontroller (MCU) Peripherals are devices that are under direct control of the Microcontroller. Most of the devices are attached to the Advanced Peripheral Bus (APB) of the MCU subsystem, and serve as APB slaves. Each MCU peripheral must be accessed as a memory-mapped I/O device; that is, the MCU or the DMA bus master reads from or writes to the specific peripheral by issuing memory-addressed transactions.

4.1 Security Engine with JTAG control

4.1.1 General Description

The Secure Engine module is responsible for security functions in the MT6235. SEJ realizes an efficient scheme to protect the program in non-volatile memory. Applying the flows in the IC with Chip-ID can: a) encrypted codes to protect the codes to be cracked (Confidentiality); b) guarantee the integrity; c) Copyright protection.

To protect the program in the novo memory, SEJ references 1: Chip UID; 2: custom seed; 3: Internal reproducible noise to enlarge the entropy space of ciphering. After proper configuration in BCON and BSEED, users can encrypt program plaintext into cipher-texts and store them onto NoVo memory. Due to the program are stored in ciphered mode, it's not easy to be disassembled. Further, the encryption process has referred to Chip UID, which may be different between two different chips, the cipher-text encrypted referred to Chip UIDA is very likely decrypted to wrong one referred to other IDs.

4.1.2 Register Definitions

Figure 17: SEJ Registers

Register Address	Register Function	Acronym
SEJ + 00c0h	SEJ Secure Booting control	**SEJ_BCON**
SEJ + 00c4h	SEJ Secure Booting source data	**SEJ_BSRC**
SEJ + 00c8h	SEJ Secure Booting seed data	**SEJ_BSEED**
SEJ + 00cch	SEJ Secure Booting encrypted data	**SEJ_BENC**
SEJ + 00d0h	SEJ Secure Booting decrypted data	**SEJ_BDEC**
SEJ + 00e0h	SEJ Soft OTP	**SEJ_SO0**
SEJ + 00e4h	SEJ Soft OTP	**SEJ_SO1**
SEJ + 00e8h	SEJ Soft OTP	**SEJ_SO2**
SEJ + 00ech	SEJ Soft OTP	**SEJ_SO3**
SEJ + 00f0h	SEJ Soft OTP	**SEJ_SO4**
SEJ + 00f4h	SEJ Soft OTP	**SEJ_SO5**
SEJ + 00f8h	SEJ Soft OTP	**SEJ_SO6**
SEJ + 00fch	SEJ Soft OTP	**SEJ_SO7**

SEJ+00c0h SEJ Secure Booting control SEJ_BCON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																

Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												SOTP_LOCK				DIS
Type												R/W				R/W
Reset												0				0

DIS Disable Secure Booting function. When DIS is asserted, the data read from SEJ_BENC and SEJ_BDEC is the same as SEJ_BSRC.

SOTP_LOCK SoftOTP lock bit. This bit can be modified from 0 to 1 and never return from 1 to 0. SEJ_SOx can be modified when OTP_LCOK=0.

SEJ+00c4h SEJ Secure Booting source data SEJ_BSRC

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	BSRC[31:16]															
Type	WO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BSRC[15:0]															
Type	WO															
Reset	0															

BSRC Source data for Secure Booting to be encrypted (obtained from SEJ_BENC) or decrypted (obtained from SEJ_BDEC).

SEJ+00c8h SEJ Secure Booting seed value SEJ_BSEED

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	BSEED[31:16]															
Type	WO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BSEED[15:0]															
Type	WO															
Reset	0															

BSEED Seed data needed to increase security of the Boot Secure function. Set the seed value before performing Boot Secure the first time.

SEJ+00cch SEJ Secure Booting encrypted data SEJ_BENC

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	BENC[31:16]															
Type	RO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BENC[15:0]															
Type	RO															
Reset	0															

BENC Encrypted data from SEJ_BSRC.

SEJ+00d0h SEJ Secure Booting decrypted data SEJ_BDEC

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	BDEC[31:16]															
Type	RO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BDEC[15:0]															
Type	RO															

Reset	0

BDEC Decrypted data from SEJ_BSRC.

SEJ+00e0h SEJ Soft OTP SEJ_SO0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SOFT_OTP[31:16]															
Type	R/W															
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SOFT_OTP[15:0]															
Type	R/W															
Reset																

SEJ+00e4h SEJ Soft OTP SEJ_SO1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SOFT_OTP[63:48]															
Type	R/W															
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SOFT_OTP[47:32]															
Type	R/W															
Reset																

SEJ+00e8h SEJ Soft OTP SEJ_SO2

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SOFT_OTP[95:80]															
Type	R/W															
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SOFT_OTP[79:64]															
Type	R/W															
Reset																

SEJ+00ech SEJ Soft OTP SEJ_SO3

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SOFT_OTP[127:112]															
Type	R/W															
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SOFT_OTP[111:96]															
Type	R/W															
Reset																

SEJ+00f0h SEJ Soft OTP SEJ_SO4

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SOFT_OTP[159:144]															
Type	R/W															
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SOFT_OTP[143:128]															
Type	R/W															
Reset																

SEJ+00f4h SEJ Soft OTP SEJ_SO5

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SOFT_OTP[191:176]															
Type	R/W															
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SOFT_OTP[175:160]															
Type	R/W															
Reset																

SEJ+00f8h SEJ Soft OTP SEJ_SO6

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SOFT_OTP[223:208]															
Type	R/W															
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SOFT_OTP[207:192]															
Type	R/W															
Reset																

SEJ+00fch SEJ Soft OTP SEJ_SO7

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SOFT_OTP[255:240]															
Type	R/W															
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SOFT_OTP[239:224]															
Type	R/W															
Reset																

SEJ_SO Software control values for Secure Booting usage (SEJ_BENC/SEJ_BDEC). SOFTOTP is one parameter of all for encryption/decryption function. This register can be modify when OTP_LOCK=0.

4.2 EFUSE Controller (efusec)

4.2.1 General Description

There are six 64-bit EFUSE macros in the chip. EFUSE macro is a one-time-programming non-volatile memory. We usually use it as storage of sensitive and important data. EFUSE controller delivers EFUSE status and re-initializes EFUSE macro. You can program the EFUSE via EFUSE controller with proper configuration and sequences.

4.2.2 Register Definitions

EFUSEC+0000h EFUSE control EFUSEC_CON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name					ESEL	WSEL				F52M		RD	BUSY	VLD
Type					R/W	R/W				R/W		WO	RO	RO
Reset					0	0				0		0	0	0

VLD Indicate if EFUSE data are valid or not. EFUSEC will initialize all EFUSE macros automatically. After finishing the initialization, this bit will change to 1 from 0. In other case, if you initialize EFUSE macros by write RD=1 manually, the VLD will go to low. After RD process done, VLD will go to high again.

BUSY EFUSE controller is busy. You can write EFUSEC control registers only when BUSY is low.

RD Initialize EFUSE macros manually. The BUSY is 1 and VLD is 0 while EFUSEC re-initialize all EFUSE macros. After finishing the initialization, BUSY changes to 0 and VLD changes to 1.

F52M System bus speed selection. Change this field depends on the reality.

0 System bus frequency is 26MHz

1 System bus frequency is 52MHz

WSEL EFUSE word selection. There are 2 32-bit words in each EFUSE macro. You should decide which word you will program

ESEL EFUSE macro selection. There are 6 EFUSE macros in the system. You should decide which macro you will program

ESEL	WSEL	EFUSE_Dx
001	0	EFUSE_D0
001	1	EFUSE_D1
010	0	EFUSE_D2
010	1	EFUSE_D3
011	0	EFUSE_D4
011	1	EFUSE_D5
100	0	EFUSE_D6
100	1	EFUSE_D7
101	0	EFUSE_D8
101	1	EFUSE_D9

EFUSEC+0004h EFUSE write data EFUSEC_WDAT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	WDAT[31:16]															
Type	R/W															
Reset	N/A															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	WDAT[15:0]															
Type	R/W															
Reset	N/A															

WDAT After setting the EFUSE_SEL and WSEL, you can write WDAT with values you want to program. Once you write EFUSEC_WDAT, EFUSEC starts blowing EFUSE operation. The BUSY flag rises. After the EFUSEC finished the blowing process, the BUSY flag lowers. You can follow the guidelines below:

1. Wait until BUSY is 0
2. Set VCCQ=3.7V from 2.8V; VFSOURCE=3.7V from Hi-Z or Ground
3. Set ESEL and WSEL.
4. Write EFUSEC_WDAT with your prefer value.
5. Wait until BUSY is 0

6. If you want to blow other EFUSE macro, jump step 1
7. Set VCCQ=2.8V; VFSOURCE=Hi-Z or Ground
8. Write RD = 1. Wait BUSY=0 and VALID=1. Check the EFUSE contents you blew.

Notice: each bit valued 1 in WDAT means a blowing operation. Blown bits can not be blown again. Such that the final EFUSE content should be the original EFUSE content OR WDAT.

EFUSEC+0010h EFUSE data out EFUSE_D0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	EFUSE_D0															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EFUSE_D0															
Type	R/W															
Reset	0															

EFUSEC+0014h EFUSE data out EFUSE_D1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	D01WP	EFUSE_D1														
Type	R/W	R/W														
Reset	0	0														
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EFUSE_D1															
Type	R/W															
Reset	0															

EFUSEC+0018h EFUSE data out EFUSE_D2

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	EFUSE_D2															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EFUSE_D2															
Type	R/W															
Reset	0															

EFUSEC+001ch EFUSE data out EFUSE_D3

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	D23WP	EFUSE_D3														
Type	R/W	R/W														
Reset	0	0														
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EFUSE_D3															

Type	R/W
Reset	0

EFUSEC+0020h EFUSE data out EFUSE_D4

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	EFUSE_D4															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EFUSE_D4															
Type	R/W															
Reset	0															

EFUSEC+0024h EFUSE data out EFUSE_D5

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	D45WP	EFUSE_D5														
Type	R/W	R/W														
Reset	0	0														
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EFUSE_D5															
Type	R/W															
Reset	0															

EFUSEC+0028h EFUSE data out EFUSE_D6

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	EFUSE_D6															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EFUSE_D6															
Type	R/W															
Reset	0															

EFUSEC+002ch EFUSE data out EFUSE_D7

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	D67WP	EFUSE_D7														
Type	R/W	R/W														
Reset	0	0														
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EFUSE_D7															
Type	R/W															
Reset	0															

EFUSEC+0030h **EFUSE data out** **EFUSE_D8**

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	EFUSE_D8															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EFUSE_D8															
Type	R/W															
Reset	0															

EFUSEC+0034h **EFUSE data out** **EFUSE_D9**

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	D89WP	EFUSE_D9														
Type	R/W	R/W														
Reset	0	0														
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EFUSE_D9															
Type	R/W															
Reset	0															

EFUSE_Dx EFUSE Dx output data

DxyWP Write protection bit for EFUSE_Dx and EFUSE_Dy

0 EFUSE_Dx and EFUSE_Dy can be blown.

1 EFUSE_Dx and EFUSE_Dy can not be blown.

4.3 Pulse-Width Modulation Outputs

4.3.1 General Description

Six generic pulse-width modulators are implemented to generate pulse sequences with programmable frequency and duration for LCD backlight, charging or other purpose. Before enabling PWM, the pulse sequences must be prepared either in the memory or registers. Then PWM, as shown in Fig. 1, will read the pulse sequences to generate random waveform to meet all kinds of applications.

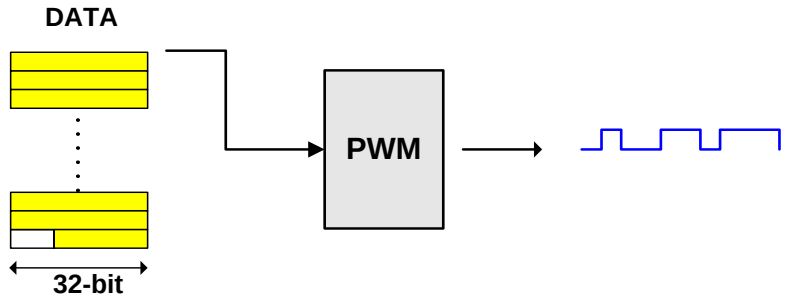

Fig. 1 The generation procedure of PWM.

There are two basic operational modes about PWM, which is set by PWM_MODE. In periodical mode, all pulse sequence with be repeatedly generated by the number of WAVE_NUM[15:0]. If WAVE_NUM is 0 which means infinite, the waveform generation could be stopped by PWM_EN. As for the pulse sequence data source in the periodical mode, if the data are less than or equal to 64 bits, they can be directly set in SEND_DATA0[31:0] and SEND_DATA1[31:0] and SRCSEL=0 to reduce memory bandwidth. STOP_BITPOS[5:0] is used to indicate the stop bit position in the total 64-bits data. For example, if STOP_BITPOS is 0, only SEND_DATA0[0] will be generated, and so on until SEND_DATA1[31]. If SRCSEL=1 which means memory mode, the pulse sequence data are put in memory with address set by BUF0_BASE_ADDR and the length is BUF0_SIZE. STOP_BITPOS[4:0] is to indicate the stop bit position in the last 32-bits data. The format of pulse sequences that stored in periodical mode is as shown in Fig. 2.

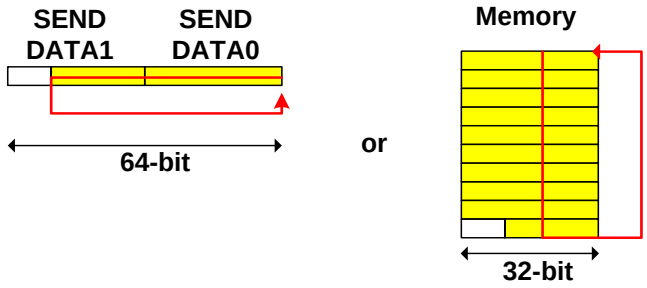

Fig. 2 The pulse sequence in periodical mode.

On the other hand, the pulse sequence is stored in dual memory buffers in random mode. The format of pulse sequences that stored in the memory is as shown in Fig. 3. Valid bit is used to indicate data are ready in the respective memory buffer. The PWM generation will clear this bit after all data in that buffer are fetched. The memory buffers are set by address BUF0_BASE_ADDR and BUF0_SIZE for memory buffer0 and BUF1_BASE_ADDR and BUF1_SIZE for memory buffer1. The program should prepare the pulse sequence and set the valid to 1 in time before all data in the other memory buffer are fetched or the HW will issue UNDERFLOW interrupt to inform pulse generation will be stopped because of no valid data.

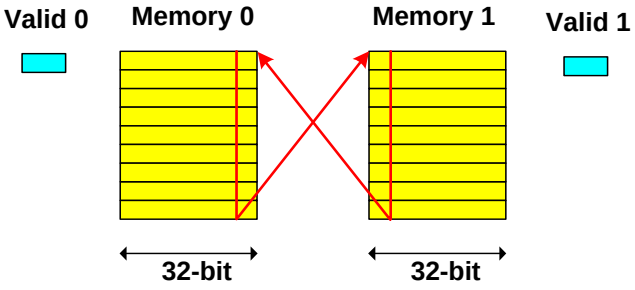

Fig. 3 The pulse sequence in random mode

PWM always reference bus block clock or 13MHz clock as base, and CLKDIV[2:0] and CLKSEL can decide the sample rate of each PWM. When system is in the sleep mode, block clock will be disabled and only OLD_PWM_MODE with CLKSEL=1 (32 KHz) is supported. Only PWM1, PWM2 and PWM3 support OLD_PWM_MODE. For each sample

output, the duration is decided by HDURATION[15:0] when output is high and LDURATION[15:0] when output is low. If the pulse sequence is repeated which is specified by WAVE_NUM[15:0], a special output could be set by GUARD_VALUE and GUARD_DURATION[15:0] between these pulse sequence. The PWM output will be the value specified by IDLE_VALUE when PWM is not enabled or the pulse sequence is finished.

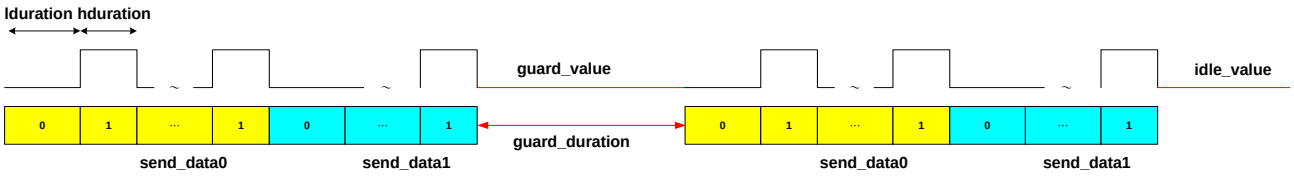

Fig. 4 The pulse sequence output pattern

In order to provide precise timing relation between different PWM outputs, we provide PWM_SEQ_MODE. In this mode, the starting position of waveform outputs of PWM3, PWM4, PWM5 and PWM6 will follow the previous one by the delay values PWM4_DEALY_DURATION[15:0], PWM5_DEALY_DURATION[15:0] and PWM6_DEALY_DURATION[15:0]. Also the clock scale of each delay can be specified by PWM4_DELAY_CLKSEL, PWM5_DELAY_CLKSEL and PWM6_DELAY_CLKSEL.

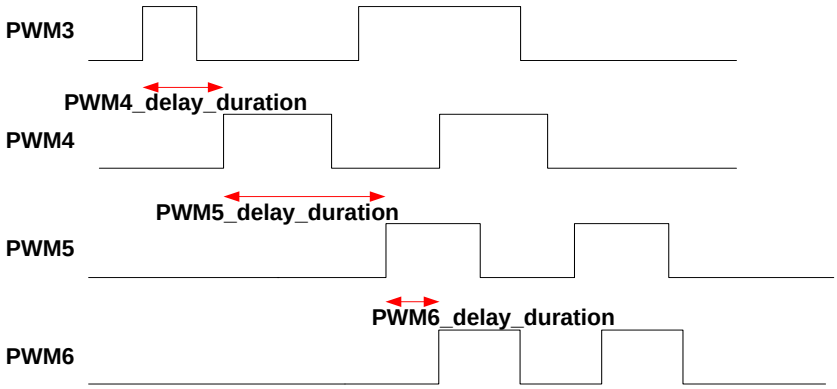

Fig. 5 The sequential output mode

Also PWM1, PWM2 and PWM3 support original PWM output mode. The output waveform is specified by DATA_WIDTH[12:0] and THRESH[12:0]. The output waveform is shown in Fig. 6.

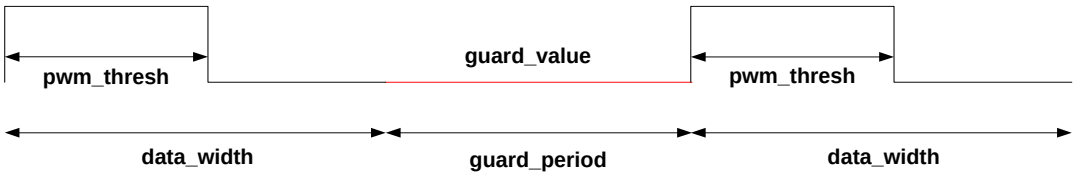

Fig. 6 The old PWM mode

For hardware and system consideration, CLKSRC might be slightly different in different situations. The following table is to summary all possible situations.

PWM_OLD_MODE	PWM_CLKSEL	PWM_FIX_CLK_MODE	CLKSRC
1	0	0	block clock
		1	13 MHz
	1	NA*	32 KHz
0	0	0	block clock
		1	13 MHz
	1	0	block clock / 1625
		1	13 MHz/1625 = 8 KHz

*: When both PWM_OLD_MODE and PWM_CLKSEL equal to 1, PWM_FIX_CLK_MODE should be 0 to avoid malfunction.

4.3.2 Register Table

Register Address	Register Function	Acronym
PWM + 0000h	PWM enable register	**PWM_ENABLE**
PWM + 0004h	PWM4 delay duration register	**PWM4_DELAY**
PWM + 0008h	PWM5 delay duration register	**PWM5_DELAY**
PWM + 000Ch	PWM6 delay duration register	**PWM6_DELAY**
PWM + 0010h	PWM1 control register	**PWM1_CON**
PWM + 0014h	PWM1 high duration register	**PWM1_HDURATION**
PWM + 0018h	PWM1 low duration register	**PWM1_LDURATION**
PWM + 001Ch	PWM1 guard duration register	**PWM1_GDURATION**
PWM + 0020h	PWM1 buffer0 base address register	**PWM1_BUF0_BASE_ADDR**
PWM + 0024h	PWM1 buffer0 size register	**PWM1_BUF0_SIZE**
PWM + 0028h	PWM1 buffer1 base address register	**PWM1_BUF1_BASE_ADDR**
PWM + 002Ch	PWM1 buffer1 size register	**PWM1_BUF1_SIZE**
PWM + 0030h	PWM1 send data0 register	**PWM1_SEND_DATA0**
PWM + 0034h	PWM1 send data1 register	**PWM1_SEND_DATA1**
PWM + 0038h	PWM1 wave number register	**PWM1_WAVE_NUM**
PWM + 003Ch	PWM1 data width	**PWM1_DATA_WIDTH**
PWM + 0040h	PWM1 threshold register	**PWM1_THRESH**
PWM + 0044h	PWM1 send waveform number register	**PWM1_SEND_WAVENUM**
PWM + 0048h	PWM1 valid register	**PWM1_VALID**
PWM + 0050h	PWM2 control register	**PWM2_CON**
PWM + 0054h	PWM2 high duration register	**PWM2_HDURATION**
PWM + 0058h	PWM2 low duration register	**PWM2_LDURATION**

PWM + 005Ch	PWM2 guard duration register	**PWM2_GDURATION**
PWM + 0060h	PWM2 buffer0 base address register	**PWM2_BUF0_BASE_ADDR**
PWM + 0064h	PWM2 buffer0 size register	**PWM2_BUF0_SIZE**
PWM + 0068h	PWM2 buffer1 base address register	**PWM2_BUF1_BASE_ADDR**
PWM + 006Ch	PWM2 buffer1 size register	**PWM2_BUF1_SIZE**
PWM + 0070h	PWM2 send data0 register	**PWM2_SEND_DATA0**
PWM + 0074h	PWM2 send data1 register	**PWM2_SEND_DATA1**
PWM + 0078h	PWM2 wave number register	**PWM2_WAVE_NUM**
PWM + 007Ch	PWM2 data width	**PWM2_DATA_WIDTH**
PWM + 0080h	PWM2 threshold register	**PWM2_THRESH**
PWM + 0084h	PWM2 send waveform number register	**PWM2_SEND_WAVENUM**
PWM + 0088h	PWM2 valid register	**PWM2_VALID**
PWM + 0090h	PWM3 control register	**PWM3_CON**
PWM + 0094h	PWM3 high duration register	**PWM3_HDURATION**
PWM + 0098h	PWM3 low duration register	**PWM3_LDURATION**
PWM + 009Ch	PWM3 guard duration register	**PWM3_GDURATION**
PWM + 00A0h	PWM3 buffer0 base address register	**PWM3_BUF0_BASE_ADDR**
PWM + 00A4h	PWM3 buffer0 size register	**PWM3_BUF0_SIZE**
PWM + 00A8h	PWM3 buffer1 base address register	**PWM3_BUF1_BASE_ADDR**
PWM + 00ACh	PWM3 buffer1 size register	**PWM3_BUF1_SIZE**
PWM + 00B0h	PWM3 send data0 register	**PWM3_SEND_DATA0**
PWM + 00B4h	PWM3 send data1 register	**PWM3_SEND_DATA1**
PWM + 00B8h	PWM3 wave number register	**PWM3_WAVE_NUM**
PWM + 00BCh	PWM3 data width	**PWM3_DATA_WIDTH**
PWM + 00C0h	PWM3 threshold register	**PWM3_THRESH**
PWM + 00C4h	PWM3 send waveform number register	**PWM3_SEND_WAVENUM**
PWM + 00C8h	PWM3 valid register	**PWM3_VALID**
PWM + 00D0h	PWM4 control register	**PWM4_CON**
PWM + 00D4h	PWM4 high duration register	**PWM4_HDURATION**
PWM + 00D8h	PWM4 low duration register	**PWM4_LDURATION**
PWM + 00DCh	PWM4 guard duration register	**PWM4_GDURATION**
PWM + 00E0h	PWM4 buffer0 base address register	**PWM4_BUF0_BASE_ADDR**
PWM + 00E4h	PWM4 buffer0 size register	**PWM4_BUF0_SIZE**
PWM + 00E8h	PWM4 buffer1 base address register	**PWM4_BUF1_BASE_ADDR**
PWM + 00ECh	PWM4 buffer1 size register	**PWM4_BUF1_SIZE**
PWM + 00F0h	PWM4 send data0 register	**PWM4_SEND_DATA0**
PWM + 00F4h	PWM4 send data1 register	**PWM4_SEND_DATA1**

PWM + 00F8h	PWM4 wave number register	**PWM4_WAVE_NUM**
PWM + 00FCh	PWM4 send waveform number register	**PWM4_SEND_WAVENUM**
PWM + 0100h	PWM4 valid register	**PWM4_VALID**
PWM + 0110h	PWM5 control register	**PWM5_CON**
PWM + 0114h	PWM5 high duration register	**PWM5_HDURATION**
PWM + 0118h	PWM5 low duration register	**PWM5_LDURATION**
PWM + 011Ch	PWM5 guard duration register	**PWM5_GDURATION**
PWM + 0120h	PWM5 buffer0 base address register	**PWM5_BUF0_BASE_ADDR**
PWM + 0124h	PWM5 buffer0 size register	**PWM5_BUF0_SIZE**
PWM + 0128h	PWM5 buffer1 base address register	**PWM5_BUF1_BASE_ADDR**
PWM + 012Ch	PWM5 buffer1 size register	**PWM5_BUF1_SIZE**
PWM + 0130h	PWM5 send data0 register	**PWM5_SEND_DATA0**
PWM + 0134h	PWM5 send data1 register	**PWM5_SEND_DATA1**
PWM + 0138h	PWM5 wave number register	**PWM5_WAVE_NUM**
PWM + 013Ch	PWM5 send waveform number register	**PWM5_SEND_WAVENUM**
PWM + 0140h	PWM5 valid register	**PWM5_VALID**
PWM + 0150h	PWM6 control register	**PWM6_CON**
PWM + 0154h	PWM6 high duration register	**PWM6_HDURATION**
PWM + 0158h	PWM6 low duration register	**PWM6_LDURATION**
PWM + 015Ch	PWM6 guard duration register	**PWM6_GDURATION**
PWM + 0160h	PWM6 buffer0 base address register	**PWM6_BUF0_BASE_ADDR**
PWM + 0164h	PWM6 buffer0 size register	**PWM6_BUF0_SIZE**
PWM + 0168h	PWM6 buffer1 base address register	**PWM6_BUF1_BASE_ADDR**
PWM + 016Ch	PWM6 buffer1 size register	**PWM6_BUF1_SIZE**
PWM + 0170h	PWM6 send data0 register	**PWM6_SEND_DATA0**
PWM + 0174h	PWM6 send data1 register	**PWM6_SEND_DATA1**
PWM + 0178h	PWM6 wave number register	**PWM6_WAVE_NUM**
PWM + 017Ch	PWM6 send waveform number register	**PWM6_SEND_WAVENUM**
PWM + 0180h	PWM6 valid register	**PWM6_VALID**
PWM + 0190h	PWM interrupt enable register	**PWM_INT_ENABLE**
PWM + 0194h	PWM interrupt status register	**PWM_INT_STATUS**
PWM + 0198h	PWM interrupt acknowledge register	**PWM_INT_ACK**

Table 15 PWM Registers

4.3.3 Register Definitions

PWM+0000h PWM Enable register PWM_ENABLE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									PWM_DELAY_FIX_CLK_MODE	PWM_SEQ_MODE	PWM6_EN	PWM5_EN	PWM4_EN	PWM3_EN	PWM2_EN	PWM1_EN
Type									R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset									0	0	0	0	0	0	0	0

PWM1_EN Set to 1 to enable PWM1

PWM2_EN Set to 1 to enable PWM2

PWM3_EN Set to 1 to enable PWM3

PWM4_EN Set to 1 to enable PWM4

PWM5_EN Set to 1 to enable PWM5

PWM6_EN Set to 1 to enable PWM6

PWM_SEQ_MODE Set to 1 to enable PWM3, PWM4, PWM5 and PWM6 sequential delay mode. In this mode, PWM3 starts first and then after PWM4_DELAY_TIME, PWM4 will start. After PWM4 starts, PWM5 will start after PWM5_DELAY_TIME and so on for PWM6.

Note: The output of PWM_SEQ_MODE is started after PWM3 is enabled. And PWM_SEQ_MODE should be set before PWM4, PWM5 and PWM6 are enabled or at the same time. Also this mode doesn't work when PWM3 is set at OLD_PWM_MODE and CLKSEL=1.

PWM_DELAY_FIX_CLK_MODE Set to 1 to force all delay between PWM3, PWM4, PWM5 and PWM6 in unit of 13MHz clock rather than block clock.

PWM+0004h PWM4 Delay Duration register PWM4_DELAY

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																DELAY_CLKSEL
Type																R/W
Reset																0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	PWM4_DELAY_DURATION[15:0]															
Type	R/W															
Reset	0															

PWM4_DELAY_DURATION The time difference between PWM3 and PWM4.

DELAY_CLKSEL The clock unit of PWM4_DELAY_DURATION.

0 CLK=CLKSRC

1 CLK=CLKSRC/1625

PWM+0008h PWM5 Delay Duration register PWM5_DELAY

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																DELAY_CLKSEL
Type																R/W
Reset																0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	PWM5_DELAY_DURATION[15:0]															
Type	R/W															
Reset	0															

PWM5_DELAY_DURATION The time difference between PWM4 and PWM5.

DELAY_CLKSEL The clock unit of PWM5_DELAY_DURATION.

0 CLK=CLKSRC

1 CLK=CLKSRC/1625

PWM+000Ch PWM6 Delay Duration register PWM6_DELAY

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																DELAY_CLKSEL
Type																R/W
Reset																0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	PWM6_DELAY_DURATION[15:0]															
Type	R/W															
Reset	0															

PWM6_DELAY_DURATION The time difference between PWM5 and PWM6.

DELAY_CLKSEL The clock unit of PWM6_DELAY_DURATION.

0 CLK=CLKSRC

1 CLK=CLKSRC/1625

PWM+0010h PWM1 Control register PWM1_CON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	OLD_PWM_MODE	STOP_BITPOS[5:0]						GUARD_VALUE	IDLE_VALUE	MODE	SRCSEL	FIX_CLK_MODE	CLKSEL	CLKDIV [2:0]		
Type	R/W	R/W						R/W	R/W	R/W	R/W	R/W	R/W	R/W		
Reset	0	3Fh						0	0	0	0	0	0	0		

CLKDIV Select PWM1 clock scale.

000 CLK Hz

001 CLK/2 Hz

010 CLK/4 Hz

011 CLK/8 Hz
100 CLK/16 Hz
101 CLK/32 Hz
110 CLK/64 Hz
111 CLK/128 Hz

CLKSEL Select PWM1 clock
0 CLK=CLKSRC
1 CLK=CLKSRC/1625

FIX_CLK_MODE Select PWM1 clock reference
0 CLKSRC= block clock
1 CLKSRC= 13 MHz

SRCSEL Select PWM1 data source
0 FIFO mode
1 Memory mode

MODE Select Random Generator mode
0 Periodical PWM mode.
1 Random PWM mode

Note: When using random generator mode, the data source comes from dual buffers in memory.

IDLE_VALUE PWM1 output value when idle state.

GUARD_VALUE PWM1 output value when guard time.

STOP_BITPOS The stop bit position for source data in periodical mode. In FIFO mode, it's used to indicate the stop bit position in total 64 bits. In Memory mode, it's for the stop bit position in the last 32 bits.

OLD_PWM_MODE Use old PWM mode
0 New PWM mode
1 Old PWM mode

Note: Using old PWM mode also means periodical mode. So SRCSEL and MODE is ignored in this situation. Only old PWM mode with 32 KHz clock source could work in the system sleep-mode.

PWM+0014h PWM1 High Duration register — PWM1_HDURATION

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	HDURATION[15:0]															
Type	R/W															
Reset	1															

HDURATION PWM1 pulse duration based on the current clock when PWM output is high. If duration =N, need to program N-1 in this register.

Note: The duration of PWM must not be 0.

PWM+0018h PWM1 Low Duration register — PWM1_LDURATION

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LDURATION[15:0]															
Type	R/W															
Reset	1															

LDURATION PWM1 pulse duration based on the current clock when PWM output is low. If duration =N, need to program N-1 in this register.

Note: The duration of PWM must not be 0.

PWM+001Ch PWM1 Guard Duration register — PWM1_GDRUATION

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GUARD_DURATION[15:0]															
Type	R/W															
Reset	0															

GUDAR_DURATION It's the guarding interval between individual waveforms and the output is decided by GUARD_VALUE. Also if it equals to N, it needs to program N-1 in this register.

Note: If this duration is 0, it means no guarding interval.

PWM+0020h PWM1 Buffer0 Base Address register — PWM1_BUF0_BASE_ ADDR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	BUF0_BS_ADDR[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF0_BS_ADDR[15:0]															
Type	R/W															
Reset	0															

BUF0_BS_ADDR The base address of memory buffer0 for PWM1's waveform data.

PWM+0024h PWM1 Buffer0 Size register — PWM1_BUF0_SIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																

Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF0_SIZE[15:0]															
Type	R/W															
Reset	0															

BUF0_SIZE The length of the waveform data in memory buffer0 that PWM1 should generate. If it equals to N, need to program N-1 in this register.

Note: The size is in unit of 32-bit data.

PWM+0028h PWM1 Buffer1 Base Address register — PWM1_BUF1_ _BASE_ ADDR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	BUF1_BS_ADDR[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF1_BS_ADDR[15:0]															
Type	R/W															
Reset	0															

BUF1_BS_ADDR The base address of memory buffer1 for PWM1's waveform data.

Note: The memory buffer1 is useless in periodical mode.

PWM+002Ch PWM1 Buffer1 Size register — PWM1_BUF1_SIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF1_SIZE[15:0]															
Type	R/W															
Reset	0															

BUF1_SIZE The length of the waveform data in memory buffer1 that PWM1 should generate. If it equals to N, need to program N-1 in this register.

PWM+0030h PWM1 Send Data0 register — PWM1_SEND_DATA0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SEND_DATA0 [31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SEND_DATA0[15:0]															
Type	R/W															
Reset	0															

SEND_DATA0 PWM1 local buffer0 of pulse sequence data to be generated.

Note: This value should be written only in periodically FIFO mode. In other mode, this buffer is for internal memory access.

PWM+0034h PWM1 Send Data1 register — PWM1_SEND_DATA1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SEND_DATA1[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SEND_DATA1[15:0]															
Type	R/W															
Reset	0															

SEND_DATA1 PWM1 local buffer0 of pulse sequence data to be generated.

Note: This value should be written only in periodically FIFO mode. In other mode, this buffer is for internal memory access.

PWM+0038h PWM1 Wave Number register — PWM1_WAVE_NUM

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	WAVE_NUM[15:0]															
Type	R/W															
Reset	0															

WAVE_NUM The number by which PWM1 will generate from the pulse data repeatedly.

Note: If WAVE_NUM=0, the waveform generation will not stop until it is disabled.

PWM+003Ch PWM1 Data Width register — PWM1_DATA_WIDTH

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				DATA_WIDTH[12:0]												
Type				R/W												
Reset				0												

DATA_WIDTH The PWM1 pulse data width in the old PWM mode.

PWM+0040h PWM1 Thresh register PWM1_THRESH

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				THRESH[12:0]												
Type				R/W												
Reset				0												

THRESH The PWM1 pulse data high/low switching threshold in the old PWM mode.

PWM+0044h PWM1 Send Wave Number register PWM1_SEND_WAVENUM

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SEND_WAVENUM[15:0]															
Type	RO															
Reset	0															

SEND_WAVENUM The number by which PWM1 has already generated from the specified data source in the periodical mode.

PWM+0048h PWM1 Valid register PWM1_VALID

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													BUF1_VALID_WEN	BUF1_VALID	BUF0_VALID_WEN	BUF0_VALID
Type													W	R/W	W	R/W
Reset													0	0	0	0

BUF0_VALID The valid status is used to indicate pulse data in memory buffer0 is ready.

BUF0_VALID_WEN This bit must be set to modify BUF0_VALID.

BUF1_VALID The valid status is used to indicate pulse data in memory buffer1 is ready.

BUF1_VALID_WEN This bit must be set to modify BUF1_VALID.

Note: The program should set these bits after data are prepared in memory. The HW will clear these bits after it has used all data in the specified memory.

PWM+0050h PWM2 Control register PWM2_CON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16

Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	OLD_PWM_MODE	STOP_BITPOS[5:0]						GUARD_VALUE	IDLE_VALUE	MODE	SRCSEL	FIX_CLK_MODE	CLKSEL	CLKDIV [2:0]		
Type	R/W	R/W						R/W	R/W	R/W	R/W	R/W	R/W	R/W		
Reset	0	3Fh						0	0	0	0	0	0	0		

CLKDIV Select PWM2 clock scale.

000 CLK Hz

001 CLK/2 Hz

010 CLK/4 Hz

011 CLK/8 Hz

100 CLK/16 Hz

101 CLK/32 Hz

110 CLK/64 Hz

111 CLK/128 Hz

CLKSEL Select PWM1 clock

0 CLK=CLKSRC

1 CLK=CLKSRC/1625

FIX_CLK_MODE Select PWM1 clock reference

0 CLKSRC= block clock

1 CLKSRC= 13 MHz

SRCSEL Select PWM2 data source

0 FIFO mode

1 Memory mode

MODE Select Random Generator mode

0 Periodical PWM mode.

1 Random PWM mode

Note: When using random generator mode, the data source comes from dual buffers in memory.

IDLE_VALUE PWM2 output value when idle state.

GUARD_VALUE PWM2 output value when guard time.

STOP_BITPOS The stop bit position for source data in periodical mode. In FIFO mode, it's used to indicate the stop bit position in total 64 bits. In Memory mode, it's for the stop bit position in the last 32 bits.

OLD_PWM_MODE Use old PWM mode

0 New PWM mode

1 Old PWM mode

Note: Using old PWM mode also means periodical mode. So SRCSEL and MODE is ignored in this situation. Only old PWM mode with 32 KHz clock source could work in the system sleep-mode.

PWM+0054h PWM2 High Duration register — PWM2_HDURATION

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	HDURATION[15:0]															
Type	R/W															
Reset	1															

HDURATION PWM2 pulse duration based on the current clock when PWM output is high. If duration =N, need to program N-1 in this register.

Note: The duration of PWM must not be 0.

PWM+0058h PWM2 Low Duration register — PWM2_LDURATION

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LDURATION[15:0]															
Type	R/W															
Reset	1															

LDURATION PWM2 pulse duration based on the current clock when PWM output is low. If duration =N, need to program N-1 in this register.

Note: The duration of PWM must not be 0.

PWM+005Ch PWM2 Guard Duration register — PWM2_GDRUATION

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GUARD_DURATION[15:0]															
Type	R/W															
Reset	0															

GUDAR_DURATION It's the guarding interval between individual waveforms and the output is decided by GUARD_VALUE. Also if it equals to N, it needs to program N-1 in this register.

Note: If this duration is 0, it means no guarding interval.

PWM+0060h PWM2 Buffer0 Base Address register — PWM2_BUF0_BASE_ ADDR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	BUF0_BS_ADDR[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF0_BS_ADDR[15:0]															
Type	R/W															
Reset	0															

BUF0_BS_ADDR The base address of memory buffer0 for PWM2's waveform data.

PWM+0064h PWM2 Buffer0 Size register — PWM2_BUF0_SIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF0_SIZE[15:0]															
Type	R/W															
Reset	0															

BUF0_SIZE The length of the waveform data in memory buffer0 that PWM2 should generate. If it equals to N, need to program N-1 in this register.

PWM+0068h PWM2 Buffer1 Base Address register — PWM2_BUF1_ _BASE_ ADDR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	BUF1_BS_ADDR[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF1_BS_ADDR[15:0]															
Type	R/W															
Reset	0															

BUF1_BS_ADDR The base address of memory buffer1 for PWM2's waveform data.

Note: The memory buffer1 is useless in periodical mode.

PWM+006Ch PWM2 Buffer1 Size register — PWM2_BUF1_SIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name	BUF1_SIZE[15:0]
Type	R/W
Reset	0

BUF1_SIZE The length of the waveform data in memory buffer1 that PWM2 should generate. If it equals to N, need to program N-1 in this register.

PWM+0070h PWM2 Send Data0 register — PWM2_SEND_DATA0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SEND_DATA0 [31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SEND_DATA0[15:0]															
Type	R/W															
Reset	0															

SEND_DATA0 PWM2 local buffer0 of pulse sequence data to be generated.

Note: This value should be written only in periodically FIFO mode. In other mode, this buffer is for internal memory access.

PWM+0074h PWM2 Send Data1 register — PWM2_SEND_DATA1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SEND_DATA1[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SEND_DATA1[15:0]															
Type	R/W															
Reset	0															

SEND_DATA1 PWM2 local buffer0 of pulse sequence data to be generated.

Note: This value should be written only in periodically FIFO mode. In other mode, this buffer is for internal memory access.

PWM+0078h PWM2 Wave Number register — PWM2_WAVE_NUM

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	WAVE_NUM[15:0]															
Type	R/W															
Reset	0															

WAVE_NUM The number by which PWM2 will generate from the pulse data repeatedly.

Note: If WAVE_NUM=0, the waveform generation will not stop until it is disabled.

PWM+007Ch PWM2 Data Width register — PWM2_DATA_WIDTH

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				DATA_WIDTH[12:0]												
Type				R/W												
Reset				0												

DATA_WIDTH The PWM2 pulse data width in the old PWM mode.

PWM+0080h PWM2 Thresh register — PWM2_THRESH

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				THRESH[12:0]												
Type				R/W												
Reset				0												

THRESH The PWM2 pulse data high/low switching threshold in the old PWM mode.

PWM+0084h PWM2 Send Wave Number register — PWM2_SEND_WAVENUM

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SEND_WAVENUM[15:0]															
Type	RO															
Reset	0															

SEND_WAVENUM The number by which PWM2 has already generated from the specified data source in the periodical mode.

PWM+0088h PWM2 Valid register — PWM2_VALID

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name													BUF1_VALID_WEN	BUF1_VALID	BUF0_VALID_WEN	BUF0_VALID
Type													W	R/W	W	R/W
Reset													0	0	0	0

BUF0_VALID The valid status is used to indicate pulse data in memory buffer0 is ready.

BUF0_VALID_WEN This bit must be set to modify BUF0_VALID.

BUF1_VALID The valid status is used to indicate pulse data in memory buffer1 is ready.

BUF1_VALID_WEN This bit must be set to modify BUF1_VALID.

Note: The program should set these bits after data are prepared in memory. The HW will clear these bits after it has used all data in the specified memory.

PWM+0090h PWM3 Control register PWM3_CON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	OLD_PWM_MODE	STOP_BITPOS[5:0]						GUARD_VALUE	IDLE_VALUE	MODE	SRCSEL	FIX_CLK_MODE	CLKSEL	CLKDIV [2:0]		
Type	R/W	R/W						R/W	R/W	R/W	R/W	R/W	R/W	R/W		
Reset	0	3Fh						0	0	0	0	0	0	0		

CLKDIV Select PWM3 clock scale.

000 CLK Hz

001 CLK/2 Hz

010 CLK/4 Hz

011 CLK/8 Hz

100 CLK/16 Hz

101 CLK/32 Hz

110 CLK/64 Hz

111 CLK/128 Hz

CLKSEL Select PWM1 clock

0 CLK=CLKSRC

1 CLK=CLKSRC/1625

FIX_CLK_MODE Select PWM1 clock reference

0 CLKSRC= block clock

1 CLKSRC= 13 MHz

SRCSEL Select PWM3 data source

0 FIFO mode

1 Memory mode

MODE Select Random Generator mode

0 Periodical PWM mode.

1 Random PWM mode

Note: When using random generator mode, the data source comes from dual buffers in memory.

IDLE_VALUE PWM3 output value when idle state.

GUARD_VALUE PWM3 output value when guard time.

STOP_BITPOS The stop bit position for source data in periodical mode. In FIFO mode, it's used to indicate the stop bit position in total 64 bits. In Memory mode, it's for the stop bit position in the last 32 bits.

OLD_PWM_MODE Use old PWM mode

0 New PWM mode

1 Old PWM mode

Note: Using old PWM mode also means periodical mode. So SRCSEL and MODE is ignored in this situation. Only old PWM mode with 32 KHz clock source could work in the system sleep-mode.

PWM+0094h PWM3 High Duration register — PWM3_HDURATION

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	HDURATION[15:0]															
Type	R/W															
Reset	1															

HDURATION PWM3 pulse duration based on the current clock when PWM output is high. If duration =N, need to program N-1 in this register.

Note: The duration of PWM must not be 0.

PWM+0098h PWM3 Low Duration register — PWM3_LDURATION

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LDURATION[15:0]															
Type	R/W															
Reset	1															

LDURATION PWM3 pulse duration based on the current clock when PWM output is low. If duration =N, need to program N-1 in this register.

Note: The duration of PWM must not be 0.

PWM+009Ch PWM3 Guard Duration register — PWM3_GDRUATION

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																

Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GUARD_DURATION[15:0]															
Type	R/W															
Reset	0															

GUDAR_DURATION It's the guarding interval between individual waveforms and the output is decided by GUARD_VALUE. Also if it equals to N, it needs to program N-1 in this register.

Note: If this duration is 0, it means no guarding interval.

PWM+00A0h PWM3 Buffer0 Base Address register — PWM3_BUF0_BASE_ ADDR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	BUF0_BS_ADDR[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF0_BS_ADDR[15:0]															
Type	R/W															
Reset	0															

BUF0_BS_ADDR The base address of memory buffer0 for PWM3's waveform data.

PWM+00A4h PWM3 Buffer0 Size register — PWM3_BUF0_SIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF0_SIZE[15:0]															
Type	R/W															
Reset	0															

BUF0_SIZE The length of the waveform data in memory buffer0 that PWM3 should generate. If it equals to N, need to program N-1 in this register.

PWM+00A8h PWM3 Buffer1 Base Address register — PWM3_BUF1_ _BASE_ ADDR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	BUF1_BS_ADDR[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF1_BS_ADDR[15:0]															
Type	R/W															
Reset	0															

BUF1_BS_ADDR The base address of memory buffer1 for PWM3's waveform data.

Note: The memory buffer1 is useless in periodical mode.

PWM+00ACh PWM3 Buffer1 Size register — PWM3_BUF1_SIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF1_SIZE[15:0]															
Type	R/W															
Reset	0															

BUF1_SIZE The length of the waveform data in memory buffer1 that PWM3 should generate. If it equals to N, need to program N-1 in this register.

PWM+00B0h PWM3 Send Data0 register — PWM3_SEND_DATA0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SEND_DATA0 [31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SEND_DATA0[15:0]															
Type	R/W															
Reset	0															

SEND_DATA0 PWM3 local buffer0 of pulse sequence data to be generated.

Note: This value should be written only in periodically FIFO mode. In other mode, this buffer is for internal memory access.

PWM+00B4h PWM3 Send Data1 register — PWM3_SEND_DATA1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SEND_DATA1[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SEND_DATA1[15:0]															
Type	R/W															
Reset	0															

SEND_DATA1 PWM3 local buffer0 of pulse sequence data to be generated.

Note: This value should be written only in periodically FIFO mode. In other mode, this buffer is for internal memory access.

PWM+00B8h PWM3 Wave Number register — PWM3_WAVE_NUM

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	WAVE_NUM[15:0]															
Type	R/W															
Reset	0															

WAVE_NUM The number by which PWM3 will generate from the pulse data repeatedly.
Note: If WAVE_NUM=0, the waveform generation will not stop until it is disabled.

PWM+00BCh PWM3 Data Width register — PWM3_DATA_WIDTH

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				DATA_WIDTH[12:0]												
Type				R/W												
Reset				0												

DATA_WIDTH The PWM3 pulse data width in the old PWM mode.

PWM+00C0h PWM3 Thresh register — PWM3_THRESH

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				THRESH[12:0]												
Type				R/W												
Reset				0												

THRESH The PWM3 pulse data high/low switching threshold in the old PWM mode.

PWM+00C4h PWM3 Send Wave Number register — PWM3_SEND_WAVENUM

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SEND_WAVENUM[15:0]															
Type	RO															

Reset	0

SEND_WAVENUM The number by which PWM3 has already generated from the specified data source in the periodical mode.

PWM+00C8h PWM3 Valid register PWM3_VALID

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													BUF1_VALID_WEN	BUF1_VALID	BUF0_VALID_WEN	BUF0_VALID
Type													W	R/W	W	R/W
Reset													0	0	0	0

BUF0_VALID The valid status is used to indicate pulse data in memory buffer0 is ready.

BUF0_VALID_WEN This bit must be set to modify BUF0_VALID.

BUF1_VALID The valid status is used to indicate pulse data in memory buffer1 is ready.

BUF1_VALID_WEN This bit must be set to modify BUF1_VALID.

Note: The program should set these bits after data are prepared in memory. The HW will clear these bits after it has used all data in the specified memory.

PWM+00D0h PWM4 Control register PWM4_CON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	OLD_PWM_MODE	STOP_BITPOS[5:0]						GUARD_VALUE	IDLE_VALUE	MODE	SRCSEL	FIX_CLK_MODE	CLKSEL	CLKDIV [2:0]		
Type	R/W	R/W						R/W	R/W	R/W	R/W	R/W	R/W	R/W		
Reset	0	3Fh						0	0	0	0	0	0	0		

CLKDIV Select PWM4 clock scale.

- **000** CLK Hz
- **001** CLK/2 Hz
- **010** CLK/4 Hz
- **011** CLK/8 Hz
- **100** CLK/16 Hz
- **101** CLK/32 Hz
- **110** CLK/64 Hz
- **111** CLK/128 Hz

CLKSEL Select PWM1 clock

- **0** CLK=CLKSRC
- **1** CLK=CLKSRC/1625

FIX_CLK_MODE Select PWM1 clock reference

0 CLKSRC= block clock

1 CLKSRC= 13 MHz

SRCSEL Select PWM4 data source

0 FIFO mode

1 Memory mode

MODE Select Random Generator mode

0 Periodical PWM mode.

1 Random PWM mode

Note: When using random generator mode, the data source comes from dual buffers in memory.

IDLE_VALUE PWM4 output value when idle state.

GUARD_VALUE PWM4 output value when guard time.

STOP_BITPOS The stop bit position for source data in periodical mode. In FIFO mode, it's used to indicate the stop bit position in total 64 bits. In Memory mode, it's for the stop bit position in the last 32 bits.

PWM+00D4h PWM4 High Duration register — PWM4_HDURATION

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	HDURATION[15:0]															
Type	R/W															
Reset	1															

HDURATION PWM4 pulse duration based on the current clock when PWM output is high. If duration =N, need to program N-1 in this register.

Note: The duration of PWM must not be 0.

PWM+00D8h PWM4 Low Duration register — PWM4_LDURATION

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LDURATION[15:0]															
Type	R/W															
Reset	1															

LDURATION PWM4 pulse duration based on the current clock when PWM output is low. If duration =N, need to program N-1 in this register.

Note: The duration of PWM must not be 0.

PWM+00DCh PWM4 Guard Duration register — PWM4_GDRUATION

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GUARD_DURATION[15:0]															
Type	R/W															
Reset	0															

GUDAR_DURATION It's the guarding interval between individual waveforms and the output is decided by GUARD_VALUE. Also if it equals to N, it needs to program N-1 in this register.

Note: If this duration is 0, it means no guarding interval.

PWM+00E0h PWM4 Buffer0 Base Address register — PWM4_BUF0_BASE_ ADDR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	BUF0_BS_ADDR[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF0_BS_ADDR[15:0]															
Type	R/W															
Reset	0															

BUF0_BS_ADDR The base address of memory buffer0 for PWM4's waveform data.

PWM+00E4h PWM4 Buffer0 Size register — PWM4_BUF0_SIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF0_SIZE[15:0]															
Type	R/W															
Reset	0															

BUF0_SIZE The length of the waveform data in memory buffer0 that PWM4 should generate. If it equals to N, need to program N-1 in this register.

PWM+00E8h PWM4 Buffer1 Base Address register — PWM4_BUF1_BASE_ ADDR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	BUF1_BS_ADDR[31:16]															
Type	R/W															

Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF1_BS_ADDR[15:0]															
Type	R/W															
Reset	0															

BUF1_BS_ADDR The base address of memory buffer1 for PWM4's waveform data.

Note: The memory buffer1 is useless in periodical mode.

PWM+00ECh PWM4 Buffer1 Size register

PWM4_BUF1_SIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF1_SIZE[15:0]															
Type	R/W															
Reset	0															

BUF1_SIZE The length of the waveform data in memory buffer1 that PWM4 should generate. If it equals to N, need to program N-1 in this register.

PWM+00F0h PWM4 Send Data0 register

PWM4_SEND_DATA0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SEND_DATA0 [31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SEND_DATA0[15:0]															
Type	R/W															
Reset	0															

SEND_DATA0 PWM4 local buffer0 of pulse sequence data to be generated.

Note: This value should be written only in periodically FIFO mode. In other mode, this buffer is for internal memory access.

PWM+00F4h PWM4 Send Data1 register

PWM4_SEND_DATA1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SEND_DATA1[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SEND_DATA1[15:0]															
Type	R/W															
Reset	0															

SEND_DATA1 PWM4 local buffer0 of pulse sequence data to be generated.

Note: This value should be written only in periodically FIFO mode. In other mode, this buffer is for internal memory access.

PWM+00F8h PWM4 Wave Number register — PWM4_WAVE_NUM

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	WAVE_NUM[15:0]															
Type	R/W															
Reset	0															

WAVE_NUM The number by which PWM4 will generate from the pulse data repeatedly.

Note: If WAVE_NUM=0, the waveform generation will not stop until it is disabled.

PWM+00FCh PWM4 Send Wave Number register — PWM4_SEND_WAVENUM

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SEND_WAVENUM[15:0]															
Type	RO															
Reset	0															

SEND_WAVENUM The number by which PWM4 has already generated from the specified data source in the periodical mode.

PWM+0100h PWM4 Valid register — PWM4_VALID

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													BUF1_VALID_WEN	BUF1_VALID	BUF0_VALID_WEN	BUF0_VALID
Type													W	R/W	W	R/W
Reset													0	0	0	0

BUF0_VALID The valid status is used to indicate pulse data in memory buffer0 is ready.

BUF0_VALID_WEN This bit must be set to modify BUF0_VALID.

BUF1_VALID The valid status is used to indicate pulse data in memory buffer1 is ready.

BUF1_VALID_WEN This bit must be set to modify BUF1_VALID.

Note: The program should set these bits after data are prepared in memory. The HW will clear these bits after it has used all data in the specified memory.

PWM+0110h PWM5 Control register PWM5_CON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	OLD_PWM_MODE	STOP_BITPOS[5:0]						GUARD_VALUE	IDLE_VALUE	MODE	SRCSEL	FIX_CLK_MODE	CLKSEL	CLKDIV [2:0]		
Type	R/W	R/W						R/W	R/W	R/W	R/W	R/W	R/W	R/W		
Reset	0	3Fh						0	0	0	0	0	0	0		

CLKDIV Select PWM5 clock scale.

000 CLK Hz

001 CLK/2 Hz

010 CLK/4 Hz

011 CLK/8 Hz

100 CLK/16 Hz

101 CLK/32 Hz

110 CLK/64 Hz

111 CLK/128 Hz

CLKSEL Select PWM1 clock

0 CLK=CLKSRC

1 CLK=CLKSRC/1625

FIX_CLK_MODE Select PWM1 clock reference

0 CLKSRC= block clock

1 CLKSRC= 13 MHz

SRCSEL Select PWM5 data source

0 FIFO mode

2 Memory mode

MODE Select Random Generator mode

2 Periodical PWM mode.

3 Random PWM mode

Note: When using random generator mode, the data source comes from dual buffers in memory.

IDLE_VALUE PWM5 output value when idle state.

GUARD_VALUE PWM5 output value when guard time.

STOP_BITPOS The stop bit position for source data in periodical mode. In FIFO mode, it's used to indicate the stop bit position in total 64 bits. In Memory mode, it's for the stop bit position in the last 32 bits.

PWM+0114h PWM5 High Duration register — PWM5_HDURATION

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	HDURATION[15:0]															
Type	R/W															
Reset	1															

HDURATION PWM5 pulse duration based on the current clock when PWM output is high. If duration =N, need to program N-1 in this register.

Note: The duration of PWM must not be 0.

PWM+0118h PWM5 Low Duration register — PWM5_LDURATION

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LDURATION[15:0]															
Type	R/W															
Reset	1															

LDURATION PWM5 pulse duration based on the current clock when PWM output is low. If duration =N, need to program N-1 in this register.

Note: The duration of PWM must not be 0.

PWM+011Ch PWM5 Guard Duration register — PWM5_GDRUATION

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GUARD_DURATION[15:0]															
Type	R/W															
Reset	0															

GUDAR_DURATION It's the guarding interval between individual waveforms and the output is decided by GUARD_VALUE. Also if it equals to N, it needs to program N-1 in this register.

Note: If this duration is 0, it means no guarding interval.

PWM+0120h PWM5 Buffer0 Base Address register — PWM5_BUF0_BASE_ ADDR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	BUF0_BS_ADDR[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF0_BS_ADDR[15:0]															
Type	R/W															
Reset	0															

BUF0_BS_ADDR The base address of memory buffer0 for PWM5's waveform data.

PWM+0124h PWM5 Buffer0 Size register — PWM5_BUF0_SIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF0_SIZE[15:0]															
Type	R/W															
Reset	0															

BUF0_SIZE The length of the waveform data in memory buffer0 that PWM5 should generate. If it equals to N, need to program N-1 in this register.

PWM+0128h PWM5 Buffer1 Base Address register — PWM5_BUF1_ _BASE_ ADDR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	BUF1_BS_ADDR[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF1_BS_ADDR[15:0]															
Type	R/W															
Reset	0															

BUF1_BS_ADDR The base address of memory buffer1 for PWM5's waveform data.

Note: The memory buffer1 is useless in periodical mode.

PWM+012Ch PWM5 Buffer1 Size register — PWM5_BUF1_SIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name	BUF1_SIZE[15:0]
Type	R/W
Reset	0

BUF1_SIZE The length of the waveform data in memory buffer1 that PWM5 should generate. If it equals to N, need to program N-1 in this register.

PWM+0130h PWM5 Send Data0 register — PWM5_SEND_DATA0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SEND_DATA0 [31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SEND_DATA0[15:0]															
Type	R/W															
Reset	0															

SEND_DATA0 PWM5 local buffer0 of pulse sequence data to be generated.

Note: This value should be written only in periodically FIFO mode. In other mode, this buffer is for internal memory access.

PWM+0134h PWM5 Send Data1 register — PWM5_SEND_DATA1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SEND_DATA1[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SEND_DATA1[15:0]															
Type	R/W															
Reset	0															

SEND_DATA1 PWM5 local buffer0 of pulse sequence data to be generated.

Note: This value should be written only in periodically FIFO mode. In other mode, this buffer is for internal memory access.

PWM+0138h PWM5 Wave Number register — PWM5_WAVE_NUM

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	WAVE_NUM[15:0]															
Type	R/W															
Reset	0															

WAVE_NUM The number by which PWM5 will generate from the pulse data repeatedly.

Note: If WAVE_NUM=0, the waveform generation will not stop until it is disabled.

PWM+013Ch PWM5 Send Wave Number register PWM5_SEND_WAVENUM

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SEND_WAVENUM[15:0]															
Type	RO															
Reset	0															

SEND_WAVENUM The number by which PWM5 has already generated from the specified data source in the periodical mode.

PWM+0140h PWM5 Valid register PWM5_VALID

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													BUF1_VALID_WEN	BUF1_VALID	BUF0_VALID_WEN	BUF0_VALID
Type													W	R/W	W	R/W
Reset													0	0	0	0

BUF0_VALID The valid status is used to indicate pulse data in memory buffer0 is ready.

BUF0_VALID_WEN This bit must be set to modify BUF0_VALID.

BUF1_VALID The valid status is used to indicate pulse data in memory buffer1 is ready.

BUF1_VALID_WEN This bit must be set to modify BUF1_VALID.

Note: The program should set these bits after data are prepared in memory. The HW will clear these bits after it has used all data in the specified memory.

PWM+0150h PWM6 Control register PWM6_CON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	OLD_PWM_MODE	STOP_BITPOS[5:0]						GUARD_VALUE	IDLE_VALUE	MODE	SRCSEL	FIX_CLK_MODE	CLKSEL	CLKDIV [2:0]		
Type	R/W	R/W						R/W	R/W	R/W	R/W	R/W	R/W	R/W		
Reset	0	3Fh						0	0	0	0	0	0	0		

CLKDIV Select PWM6 clock scale.

000 CLK Hz
001 CLK/2 Hz
010 CLK/4 Hz
011 CLK/8 Hz
100 CLK/16 Hz
101 CLK/32 Hz
110 CLK/64 Hz
111 CLK/128 Hz

CLKSEL Select PWM1 clock
0 CLK=CLKSRC
1 CLK=CLKSRC/1625

FIX_CLK_MODE Select PWM1 clock reference
0 CLKSRC= block clock
1 CLKSRC= 13 MHz

SRCSEL Select PWM6 data source
0 FIFO mode
3 Memory mode

MODE Select Random Generator mode
4 Periodical PWM mode.
5 Random PWM mode

Note: When using random generator mode, the data source comes from dual buffers in memory.

IDLE_VALUE PWM6 output value when idle state.

GUARD_VALUE PWM6 output value when guard time.

STOP_BITPOS The stop bit position for source data in periodical mode. In FIFO mode, it's used to indicate the stop bit position in total 64 bits. In Memory mode, it's for the stop bit position in the last 32 bits.

PWM+0154h PWM6 High Duration register — PWM6_HDURATION

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	HDURATION[15:0]															
Type	R/W															
Reset	1															

HDURATION PWM6 pulse duration based on the current clock when PWM output is high. If duration =N, need to program N-1 in this register.

Note: The duration of PWM must not be 0.

PWM+0158h PWM6 Low Duration register — PWM6_LDURATION

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LDURATION[15:0]															
Type	R/W															
Reset	1															

LDURATION PWM6 pulse duration based on the current clock when PWM output is low. If duration =N, need to program N-1 in this register.

Note: The duration of PWM must not be 0.

PWM+015Ch PWM6 Guard Duration register — PWM6_GDRUATION

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GUARD_DURATION[15:0]															
Type	R/W															
Reset	0															

GUDAR_DURATION It's the guarding interval between individual waveforms and the output is decided by GUARD_VALUE. Also if it equals to N, it needs to program N-1 in this register.

Note: If this duration is 0, it means no guarding interval.

PWM+0160h PWM6 Buffer0 Base Address register — PWM6_BUF0_BASE_ ADDR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	BUF0_BS_ADDR[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF0_BS_ADDR[15:0]															
Type	R/W															
Reset	0															

BUF0_BS_ADDR The base address of memory buffer0 for PWM6's waveform data.

PWM+0164h PWM6 Buffer0 Size register — PWM6_BUF0_SIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																

Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF0_SIZE[15:0]															
Type	R/W															
Reset	0															

BUF0_SIZE The length of the waveform data in memory buffer0 that PWM6 should generate. If it equals to N, need to program N-1 in this register.

PWM+0168h PWM6 Buffer1 Base Address register — PWM6_BUF1_ _BASE_ ADDR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	BUF1_BS_ADDR[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF1_BS_ADDR[15:0]															
Type	R/W															
Reset	0															

BUF1_BS_ADDR The base address of memory buffer1 for PWM6's waveform data.

Note: The memory buffer1 is useless in periodical mode.

PWM+016Ch PWM6 Buffer1 Size register — PWM6_BUF1_SIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF1_SIZE[15:0]															
Type	R/W															
Reset	0															

BUF1_SIZE The length of the waveform data in memory buffer1 that PWM6 should generate. If it equals to N, need to program N-1 in this register.

PWM+0170h PWM6 Send Data0 register — PWM6_SEND_DATA0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SEND_DATA0 [31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SEND_DATA0[15:0]															
Type	R/W															
Reset	0															

SEND_DATA0 PWM6 local buffer0 of pulse sequence data to be generated.

Note: This value should be written only in periodically FIFO mode. In other mode, this buffer is for internal memory access.

PWM+0174h PWM6 Send Data1 register — PWM6_SEND_DATA1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SEND_DATA1[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SEND_DATA1[15:0]															
Type	R/W															
Reset	0															

SEND_DATA1 PWM6 local buffer0 of pulse sequence data to be generated.

Note: This value should be written only in periodically FIFO mode. In other mode, this buffer is for internal memory access.

PWM+0178h PWM6 Wave Number register — PWM6_WAVE_NUM

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	WAVE_NUM[15:0]															
Type	R/W															
Reset	0															

WAVE_NUM The number by which PWM6 will generate from the pulse data repeatedly.

Note: If WAVE_NUM=0, the waveform generation will not stop until it is disabled.

PWM+017Ch PWM6 Send Wave Number register — PWM6_SEND_WAVENUM

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SEND_WAVENUM[15:0]															
Type	RO															
Reset	0															

SEND_WAVENUM The number by which PWM6 has already generated from the specified data source in the periodical mode.

PWM+0180h PWM6 Valid register PWM6_VALID

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													BUF1_VALID_WEN	BUF1_VALID	BUF0_VALID_WEN	BUF0_VALID
Type													W	R/W	W	R/W
Reset													0	0	0	0

BUF0_VALID The valid status is used to indicate pulse data in memory buffer0 is ready.

BUF0_VALID_WEN This bit must be set to modify BUF0_VALID.

BUF1_VALID The valid status is used to indicate pulse data in memory buffer1 is ready.

BUF1_VALID_WEN This bit must be set to modify BUF1_VALID.

Note: The program should set these bits after data are prepared in memory. The HW will clear these bits after it has used all data in the specified memory.

PWM+0190h PWM Interrupt Enable register PWM_INT_ENABLE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					PWM6_INT_UNDERFLOW_EN	PWM6_INT_FINISH_EN	PWM5_INT_UNDERFLOW_EN	PWM5_INT_FINISH_EN	PWM4_INT_UNDERFLOW_EN	PWM4_INT_FINISH_EN	PWM3_INT_UNDERFLOW_EN	PWM3_INT_FINISH_EN	PWM2_INT_UNDERFLOW_EN	PWM2_INT_FINISH_EN	PWM1_INT_UNDERFLOW_EN	PWM1_INT_FINISH_EN
Type					R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset					0	0	0	0	0	0	0	0	0	0	0	0

PWM1_INT_FINISH_EN Set to 1 to enable PWM1 finish interrupt

PWM1_INT_UNDERFLOW_EN Set to 1 to enable PWM1 underflow interrupt

PWM2_INT_FINISH_EN Set to 1 to enable PWM2 finish interrupt

PWM2_INT_UNDERFLOW_EN Set to 1 to enable PWM2 underflow interrupt

PWM3_INT_FINISH_EN Set to 1 to enable PWM3 finish interrupt

PWM3_INT_UNDERFLOW_EN Set to 1 to enable PWM3 underflow interrupt

PWM4_INT_FINISH_EN Set to 1 to enable PWM4 finish interrupt

PWM4_INT_UNDERFLOW_EN Set to 1 to enable PWM4 underflow interrupt

PWM5_INT_FINISH_EN Set to 1 to enable PWM5 finish interrupt

PWM5_INT_UNDERFLOW_EN Set to 1 to enable PWM5 underflow interrupt

PWM6_INT_FINISH_EN Set to 1 to enable PWM6 finish interrupt

PWM6_INT_UNDERFLOW_EN Set to 1 to enable PWM6 underflow interrupt

PWM+0194h PWM Interrupt Status register PWM_INT_STATUS

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					PWM6_INT_UNDERFLOW_ST	PWM6_INT_FINISH_ST	PWM5_INT_UNDERFLOW_ST	PWM5_INT_FINISH_ST	PWM4_INT_UNDERFLOW_ST	PWM4_INT_FINISH_ST	PWM3_INT_UNDERFLOW_ST	PWM3_INT_FINISH_ST	PWM2_INT_UNDERFLOW_ST	PWM2_INT_FINISH_ST	PWM1_INT_UNDERFLOW_ST	PWM1_INT_FINISH_ST
Type					R	R	R	R	R	R	R	R	R	R	R	R
Reset					0	0	0	0	0	0	0	0	0	0	0	0

PWM1_INT_FINISH_ST PWM1 finish status
PWM1_INT_UNDERFLOW_ST PWM1 underflow status
PWM2_INT_FINISH_ST PWM2 finish status
PWM2_INT_UNDERFLOW_ST PWM2 underflow status
PWM3_INT_FINISH_ST PWM3 finish status
PWM3_INT_UNDERFLOW_ST PWM3 underflow status
PWM4_INT_FINISH_ST PWM4 finish status
PWM4_INT_UNDERFLOW_ST PWM4 underflow status
PWM5_INT_FINISH_ST PWM5 finish status
PWM5_INT_UNDERFLOW_ST PWM5 underflow status
PWM6_INT_FINISH_ST PWM6 finish status
PWM6_INT_UNDERFLOW_ST PWM6 underflow status
Note: The interrupt status will be auto-cleared if interrupt enable or PWM enable is cleared.

PWM+0198h PWM Interrupt Acknowledge register PWM_INT_ACK

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					PWM6_INT_UNDERFLOW_ACK	PWM6_INT_FINISH_ACK	PWM5_INT_UNDERFLOW_ACK	PWM5_INT_FINISH_ACK	PWM4_INT_UNDERFLOW_ACK	PWM4_INT_FINISH_ACK	PWM3_INT_UNDERFLOW_ACK	PWM3_INT_FINISH_ACK	PWM2_INT_UNDERFLOW_ACK	PWM2_INT_FINISH_ACK	PWM1_INT_UNDERFLOW_ACK	PWM1_INT_FINISH_ACK
Type					W	W	W	W	W	W	W	W	W	W	W	W
Reset					0	0	0	0	0	0	0	0	0	0	0	0

PWM1_INT_FINISH_ACK Set to 1 to clear PWM1 finish interrupt
PWM1_INT_UNDERFLOW_ACK Set to 1 to clear PWM1 underflow interrupt
PWM2_INT_FINISH_ACK Set to 1 to clear PWM2 finish interrupt
PWM2_INT_UNDERFLOW_ACK Set to 1 to clear PWM2 underflow interrupt
PWM3_INT_FINISH_ACK Set to 1 to clear PWM3 finish interrupt

PWM3_INT_UNDERFLOW_ACK Set to 1 to clear PWM3 underflow interrupt
PWM4_INT_FINISH_ACK Set to 1 to clear PWM4 finish interrupt
PWM4_INT_UNDERFLOW_ACK Set to 1 to clear PWM4 underflow interrupt
PWM5_INT_FINISH_ACK Set to 1 to clear PWM5 finish interrupt
PWM5_INT_UNDERFLOW_ACK Set to 1 to clear PWM5 underflow interrupt
PWM6_INT_FINISH_ACK Set to 1 to clear PWM6 finish interrupt
PWM6_INT_UNDERFLOW_ACK Set to 1 to clear PWM6 underflow interrupt

4.4 SIM Interface

The MT6235 contains a dedicated smart card interface to allow the MCU to access. It can operate via 5 terminals, using SIMVCC, SIMSEL, SIMRST, SIMCLK and SIMDATA.

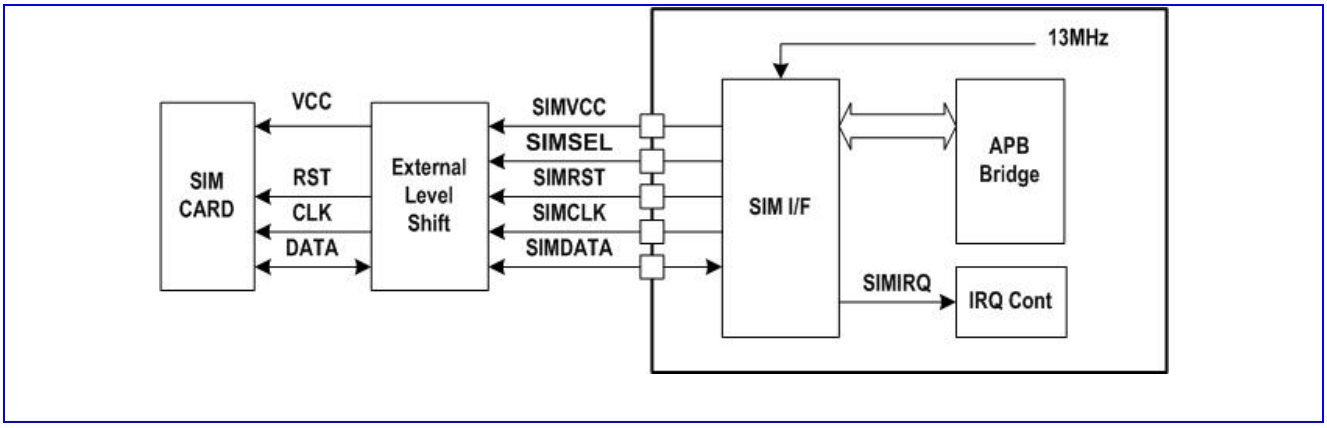

Figure 18 SIM Interface Block Diagram

The SIMVCC is used to control the external voltage supply to the SIM card and SIMSEL determines the regulated smart card supply voltage. SIMRST is used as the SIM card reset signal. Besides, SIMDATA and SIMCLK are used for data exchange purpose.

Basically, the SIM interface acts as a half duplex asynchronous communication port and its data format is composed of ten consecutive bits: a start bit in state Low, eight information bits, and a tenth bit used for parity checking. The data format can be divided into two modes as follows:

Direct Mode (ODD=SDIR=SINV=0)

SB D0 D1 D2 D3 D4 D5 D6 D7 PB

SB: Start Bit (in state Low)

Dx: Data Byte (LSB is first and logic level ONE is High)

PB: Even Parity Check Bit

Indirect Mode (ODD=SDIR=SINV=1)

SB N7 N6 N5 N4 N3 N2 N1 N0 PB

SB: Start Bit (in state Low)

Nx: Data Byte (MSB is first and logic level ONE is Low)

PB: Odd Parity Check Bit

If the receiver gets a wrong parity bit, it will respond by pulling the SIMDATA Low to inform the transmitter and the transmitter will retransmit the character.

When the receiver is a SIM Card, the error response starts 0.5 bits after the PB and it may last for 1~2 bit periods.

When the receiver is the SIM interface, the error response starts 0.5 bits after the PB and lasts for 1.5 bit period.

When the SIM interface is the transmitter, it will take totally 14 bits guard period whether the error response appears. If the receiver shows the error response, the SIM interface will retransmit the previous character again else it will transmit the next character.

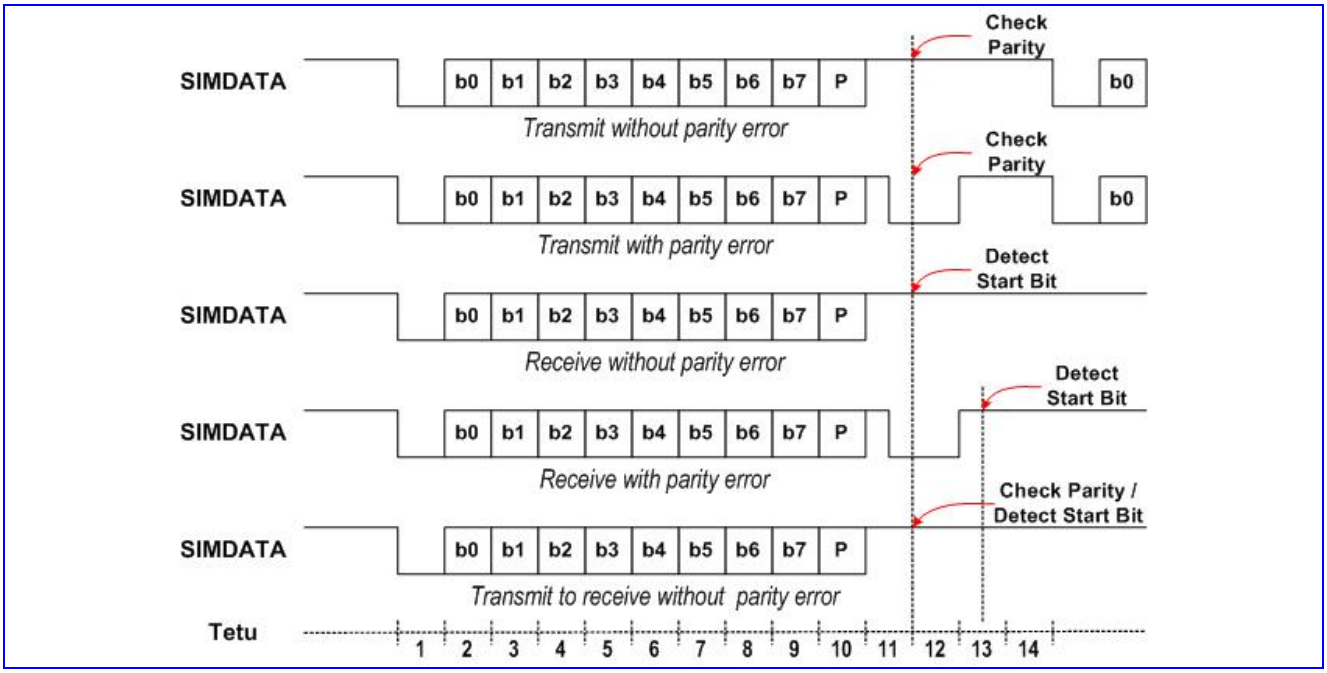

Figure 19 SIM Interface Timing Diagram

4.4.1 Register Definitions

SIM+0000h SIM module control register SIM_CONT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name														**WRST**	**CSTOP**	**SIMON**
Type														W	R/W	R/W
Reset														0	0	0

SIMON SIM card power-up/power-down control

- **0** Initiate the card deactivation sequence
- **1** Initiate the card activation sequence

CSTOP Enable clock stop mode. Together with CPOL in SIM_CNF register, it determines the polarity of the SIMCLK in this mode.

0 Enable the SIMCLK output.

1 Disable the SIMCLK output

WRST SIM card warm reset control

SIM+0004h SIM module configuration register SIM_CONF

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name						HFEN	T0EN	T1EN	TOUT	SIMSEL	ODD	SDIR	SINV	CPOL	TXACK	RXACK
Type						R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset						0	0	0	0	0	0	0	0	0	0	0

RXACK SIM card reception error handshake control

0 Disable character receipt handshaking

1 Enable character receipt handshaking

TXACK SIM card transmission error handshake control

0 Disable character transmission handshaking

1 Enable character transmission handshaking

CPOL SIMCLK polarity control in clock stop mode

0 Make SIMCLK stop in LOW level

1 Make SIMCLK stop in HIGH level

SINV Data Inverter.

0 Not invert the transmitted and received data

1 Invert the transmitted and received data

SDIR Data Transfer Direction

0 LSB is transmitted and received first

1 MSB is transmitted and received first

ODD Select odd or even parity

0 Even parity

1 Odd parity

SIMSEL SIM card supply voltage select

0 SIMSEL pin is set to LOW level

1 SIMSEL pin is set to HIGH level

TOUT SIM work waiting time counter control

0 Disable Time-Out counter

1 Enable Time-Out counter

T1EN T=1 protocol controller control

0 Disable T=1 protocol controller

1 Enable T=1 protocol controller

T0EN T=0 protocol controller control

0 Disable T=0 protocol controller

1 Enable T=0 protocol controller

HFEN Hardware flow control

0 Disable hardware flow control

1 Enable hardware flow control

SIM +0008h SIM Baud Rate Register SIM_BRR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name						ETU[8:0]									SIMCLK[1:0]	
Type						R/W									R/W	
Reset						372d									01	

SIMCLK Set SIMCLK frequency

00 13/2 MHz

01 13/4 MHz

10 13/8 MHz

11 13/32 MHz

ETU Determines the duration of elementary time unit in unit of SIMCLK

SIM +0010h SIM interrupt enable register SIM_IRQEN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name						EDCERR	T1END	RXERR	T0END	SIMOFF	ATRERR	TXERR	TOUT	OVRUN	RXTIDE	TXTIDE
Type						R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset						0	0	0	0	0	0	0	0	0	0	0

For all these bits

0 Interrupt is disabled

1 Interrupt is enabled

SIM +0014h SIM module status register SIM_STS

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name						EDCERR	T1END	RXERR	T0END	SIMOFF	ATRERR	TXERR	TOUT	OVRUN	RXTIDE	TXTIDE
Type						R/C	R/C	R/C	R/C	R/C	R/C	R/C	R/C	R/C	R	R
Reset						—	—	—	—	—	—	—	—	—	—	—

TXTIDE Transmit FIFO tide mark reached interrupt occurred

RXTIDE Receive FIFO tide mark reached interrupt occurred

OVRUN Transmit/Receive FIFO overrun interrupt occurred

TOUT Between character timeout interrupt occurred

TXERR Character transmission error interrupt occurred

ATRERR ATR start time-out interrupt occurred

SIMOFF Card deactivation complete interrupt occurred

T0END Data Transfer handled by T=0 Controller completed interrupt occurred

RXERR Character reception error interrupt occurred

T1END Data Transfer handled by T=1 Controller completed interrupt occurred

EDCERR T=1 Controller CRC error occurred

SIM +0020h SIM retry limit register SIM_RETRY

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name						TXRETRY								RXRETRY		
Type						R/W								R/W		
Reset						3h								3h		

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RXRETRY Specify the max. numbers of receive retries that are allowed when parity error has occurred.

TXRETRY Specify the max. numbers of transmit retries that are allowed when parity error has occurred.

SIM+0024h SIM FIFO tide mark register SIM_TIDE

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					TXTIDE[3:0]								RXTIDE[3:0]			
Type					R/W								R/W			
Reset					0h								0h			

RXTIDE Trigger point for RXTIDE interrupt

TXTIDE Trigger point for TXTIDE interrupt

SIM +0030h Data register used as Tx/Rx Data Register SIM_DATA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									DATA[7:0]							
Type									R/W							
Reset									—							

DATA Eight data digits. These correspond to the character being read or written

SIM +0034h SIM FIFO count register SIM_COUNT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												COUNT[4:0]				
Type												R/W				
Reset												0h				

COUNT The number of characters in the SIM FIFO when read, and flushes when written.

SIM +0040h SIM activation time register SIM_ATIME

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ATIME[15:0]															
Type	R/W															
Reset	AFC7h															

ATIME The register defines the duration, in SIM clock cycles, of the time taken for each of the three stages of the card activation process

SIM +0044h SIM deactivation time register SIM_DTIME

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					DTIME[11:0]											
Type					R/W											
Reset					3E7h											

DTIME The register defines the duration, in 13MHz clock cycles, of the time taken for each of the three stages of the card deactivation sequence

SIM+0048h Character to character waiting time register SIM_WTIME

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	WTIME[15:0]															
Type	R/W															
Reset	983h															

WTIME Maximum interval between the leading edge of two consecutive characters in 4 ETU unit

SIM+004Ch Block to block guard time register SIM_GTIME

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													GTIME			
Type													R/W			
Reset													10d			

GTIME Minimum interval between the leading edge of two consecutive characters sent in opposite directions in ETU unit

SIM +0050h Block to error signal time register SIM_ETIME

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											ETIME					
Type													R/W			
Reset													15d			

ETIME The register defines the interval, in 1/16 ETU unit, between the end of transmitted parity bit and time to check parity error signal sent from SIM card.

SIM +0060h SIM command header register: INS SIM_INS

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name								INSD	SIMINS[7:0]							
Type								R/W	R/W							
Reset								0h	0h							

SIMINS This field should be identical to the INS instruction code. When writing to this register, the T=0 controller will be activated and data transfer will be initiated.

INSD [Description for this register field]

0 T=0 controller receives data from the SIM card

1 T=0 controller sends data to the SIM card

SIM +0064h SIM command header register: P3 SIM_P3 (ICC_LEN)

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name								SIMP3[8:0]								
Type								R/W								
Reset								0h								

SIMP3 This field should be identical to the P3 instruction code. It should be written prior to the SIM_INS register. While the data transfer is going on, this field shows the no. of the remaining data to be sent or to be received

SIM +0068h SIM procedure byte register: SW1 SIM_SW1 (ICC_LEN)

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									SIMSW1[7:0]							
Type									R							
Reset									0h							

SIMSW1 This field holds the last received procedure byte for debug purpose. When the T0END interrupt occurred, it keeps the SW1 procedure byte.

SIM +006Ch SIM procedure byte register: SW2 SIM_SW2 (ICC_EDC)

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name									SIMSW2[7:0]
Type									R
Reset									0h

SIMSW2 This field holds the SW2 procedure byte

4.4.2 SIM Card Insertion and Removal

The detection of physical connection to the SIM card and card removal is done by the external interrupt controller or by GPIO.

4.4.3 Card Activation and Deactivation

The card activation and deactivation sequence both are controlled by H/W. The MCU initiates the activation sequence by writing a “1” to bit 0 of the SIM_CON register, and then the interface performs the following activation sequence:

- Assert SIMRST LOW
- Set SIMVCC at HIGH level and SIMDATA in reception mode
- Enable SIMCLK clock
- De-assert SIMRST HIGH (required if it belongs to active low reset SIM card)

The final step in a typical card session is contact deactivation in order that the card is not electrically damaged. The deactivation sequence is initiated by writing a “0” to bit 0 of the SIM_CONT register, and then the interface performs the following deactivation sequence:

- Assert SIMRST LOW
- Set SCIMCLK at LOW level
- Set SIMDATA at LOW level
- Set SIMVCC at LOW level

4.4.4 Answer to Reset Sequence

After card activation, a reset operation results in an answer from the card consisting of the initial character TS, followed by at most 32 characters. The initial character TS provides a bit synchronization sequence and defines the conventions to interpret data bytes in all subsequent characters.

On reception of the first character, TS, MCU should read this character, establish the respective required convention and reprogram the related registers. These processes should be completed prior to the completion of reception of the next character. And then, the remainder of the ATR sequence is received, read via the SIM_DATA in the selected convention and interpreted by the S/W.

The timing requirement and procedures for ATR sequence are handled by H/W and shall meet the requirement of ISO 7816-3 as shown in **Figure 20**.

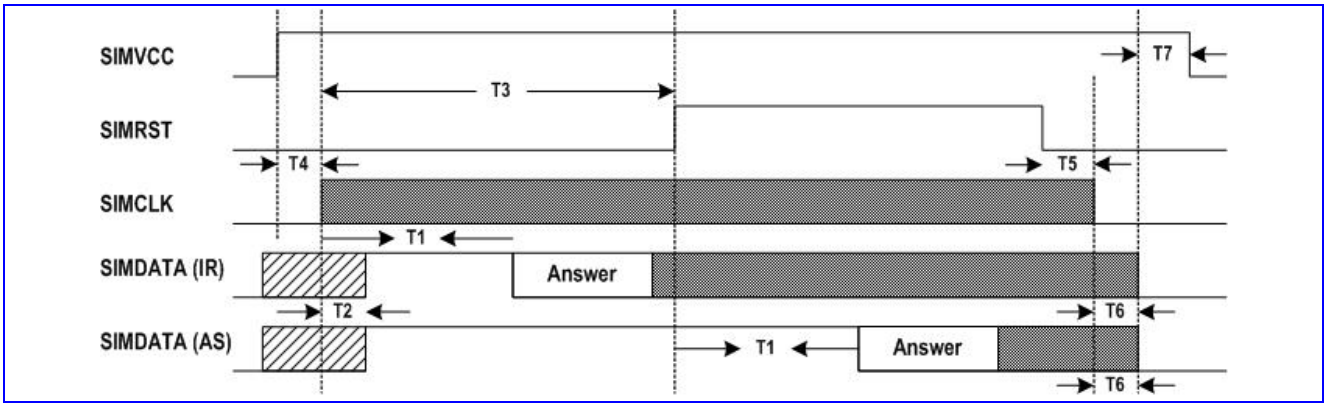


Figure 20 Answer to Reset Sequence

Time	Value	Comment
T1	> 400 SIMCLK	SIMCLK start to ATR appear
T2	< 200 SIMCLK	SIMCLK start to SIMDATA in reception mode
T3	> 40000 SIMCLK	SIMCLK start to SIMRST High
T4	—	SIMVCC High to SIMCLK start
T5	—	SIMRST Low to SIMCLK stop
T6	—	SIMCLK stop to SIMDATA Low
T7	—	SIMDATA Low to SIMVCC Low

Table 16 Answer to Reset Sequence Time-Out Condition

4.4.5 SIM Data Transfer

Two transfer modes are provided, either in software controlled byte by byte fashion or in a block fashion using T=0 controller and DMA controller. In both modes, the time-out counter could be enabled to monitor the elapsed time between two consecutive bytes.

1.1.1.1. Byte Transfer Mode

This mode is used during ATR and PPS procedure. In this mode, the SIM interface only ensures error free character transmission and reception.

Receiving Character

Upon detection of the start-bit sent by SIM card, the interface transforms into reception mode and the following bits are shifted into an internal register. If no parity error is detected or character-receive handshaking is disabled, the received-character is written into the SIM FIFO and the SIM_COUNT register is increased by one. Otherwise, the SIMDATA line is held low at 0.5 etu after detecting the parity error for 1.5 etus, and the character is re-received. If a character fails to be received correctly for the RXRETRY times, the receive-handshaking is aborted and the last-received character is written into the SIM FIFO, the SIM_COUNT is increased by one and the RXERR interrupt is generated

When the number of characters held in the receive FIFO exceeds the level defined in the SIM_TIDE register, a RXTIDE interrupt is generated. The number of characters held in the SIM FIFO can be

determined by reading the SIM_COUNT register and writing to this register will flush the SIM FIFO.

Sending Character

Characters that are to be sent to the card are first written into the SIM FIFO and then automatically transmitted to the card at timed intervals. If character-transmit handshaking is enabled, the SIMDATA line is sampled at 1 etu after the parity bit. If the card indicates that it did not receive the character correctly, the character is retransmitted a maximum of TXRETRY times before a TXERR interrupt is generated and the transmission is aborted. Otherwise, the succeeding byte in the SIM FIFO is transmitted.

If a character fails to be transmitted and a TXERR interrupt is generated, the interface needs to be reset by flushing the SIM FIFO before any subsequent transmit or receive operation.

When the number of characters held in the SIM FIFO falls below the level defined in the SIM_TIDE register, a TXTIDE interrupt is generated. The number of characters held in the SIM FIFO can be determined by reading the SIM_COUNT register and writing to this register will flush the SIM FIFO.

1.1.1.2. Block Transfer Mode

Basically, the SIM interface is designed to work in conjunction with the T=0 protocol controller and the DMA controller during non-ATR and non-PPS phase, though it is still possible for software to service the data transfer manually like in byte transfer mode if necessary and thus the T=0 protocol should be controlled by software.

The T=0 controller is accessed via four registers representing the instruction header bytes INS and P3, and the procedure bytes SW1 and SW2. These registers are:

SIM_INS, SIM_P3

SIM_SW1, SIM_SW2

During characters transfer, SIM_P3 holds the number of characters to be sent or to be received and SIM_SW1 holds the last received procedure byte including NULL, ACK, NACK and SW1 for debug purpose.

Data Receive Instruction

Data Receive Instructions receive data from the SIM card. It is instantiated as the following procedure.

1. Enable the T=0 protocol controller by setting the T0EN bit to 1 in SIM_CONF register
2. Program the SIM_TIDE register to 0x0000 (TXTIDE = 0, RXTIDE = 0)
3. Program the SIM_IRQEN to 0x019C (Enable RXERR, TXERR, T0END, TOUT and OVRUN interrupts)
4. Write CLA, INS, P1, P2 and P3 into SIM FIFO
5. Program the DMA controller :
   DMA*n*_MSBSRC and DMA*n*_LSBSRC : address of SIM_DATA register
   DMA*n*_MSBDST and DMA*n*_LSBDST : memory address reserved to store the received characters
   DMA*n*_COUNT : identical to P3 or 256 (if P3 == 0)
   DMA*n*_CON : 0x0078
6. Write P3 into SIM_P3 register and then INS into SIM_INS register (Data Transfer is initiated now)
7. Enable the Time-out counter by setting the TOUT bit to 1 in SIM_CONF register
8. Start the DMA controller by writing 0x8000 into the DMA*n*_START register to

Upon completion of the Data Receive Instruction, T0END interrupt will be generated and then the Time-out counter should be disabled by setting the TOUT bit back to 0 in SIM_CONF register.

If error occurs during data transfer (RXERR, TXERR, OVRUN or TOUT interrupt is generated), the SIM card should be deactivated first and then activated prior subsequent operations.

Data Send Instruction

Data Send Instructions send data to the SIM card. It is instantiated as the following procedure.

1. Enable the T=0 protocol controller by setting the T0EN bit to 1 in SIM_CONF register
2. Program the SIM_TIDE register to 0x0100 (TXTIDE = 1, RXTIDE = 0)
3. Program the SIM_IRQEN to 0x019C (Enable RXERR, TXERR, T0END, TOUT and OVRUN interrupts)
4. Write CLA, INS, P1, P2 and P3 into SIM FIFO
5. Program the DMA controller :
   DMA*n*_MSBSRC and DMA*n*_LSBSRC : memory address reserved to store the transmitted characters
   DMA*n*_MSBDST and DMA*n*_LSBDST : address of SIM_DATA register
   DMA*n*_COUNT : identical to P3
   DMA*n*_CON : 0x0074
6. Write P3 into SIM_P3 register and then (0x0100 | INS) into SIM_INS register (Data Transfer is initiated now)
7. Enable the Time-out counter by setting the TOUT bit to 1 in SIM_CONF register
8. Start the DMA controller by writing 0x8000 into the DMA*n*_START register

Upon completion of the Data Send Instruction, T0END interrupt will be generated and then the Time-out counter should be disabled by setting the TOUT bit back to 0 in SIM_CONF register.

If error occurs during data transfer (RXERR, TXERR, OVRUN or TOUT interrupt is generated), the SIM card should be deactivated first and then activated prior subsequent operations.

4.5 Keypad Scanner

4.5.1 General Description

The keypad can be divided into two parts: one is the keypad interface including 8 columns and 8 rows with one dedicated power-key, as shown in **Fig. 7** 錯誤! 找不到參照來源。錯誤! 找不到參照來源。; the other is the key detection block which provides key pressed, key released and de-bounce mechanisms. Each time the key is pressed or released, i.e. something different in the 8 x 8 matrix or power-key, the key detection block senses the change and recognizes if a key has been pressed or released. Whenever the key status changes and is stable, a KEYPAD IRQ is issued. The MCU can then read the key(s) pressed directly in KP_HI_KEY, KP_MID_KEY and KP_LOW_KEY registers. To ensure that the key pressed information is not missed, the status register in keypad is not read-cleared by APB read command. The status register can only be changed by the key-pressed detection FSM.

This keypad can detect one or two key-pressed simultaneously with any combination. **Fig. 8** shows one key pressed condition. **Fig. 9** (a) and **Fig. 9** (b) illustrate two keys pressed cases. Since the key press detection depends on the HIGH or LOW level of the external keypad interface, if keys are pressed at the same time and there exists a key that is on the same column and the same row with the other keys, the pressed key cannot be correctly decoded. For example, if there are three key presses: key1 = (x1, y1), key2 = (x2, y2), and key3 = (x1, y2), then both key3 and key4 = (x2, y1) are detected, and therefore they cannot be distinguished correctly. Hence, the keypad can detect only one or two keys pressed simultaneously at any combination. More than two keys pressed simultaneously in a specific pattern retrieve the wrong information.

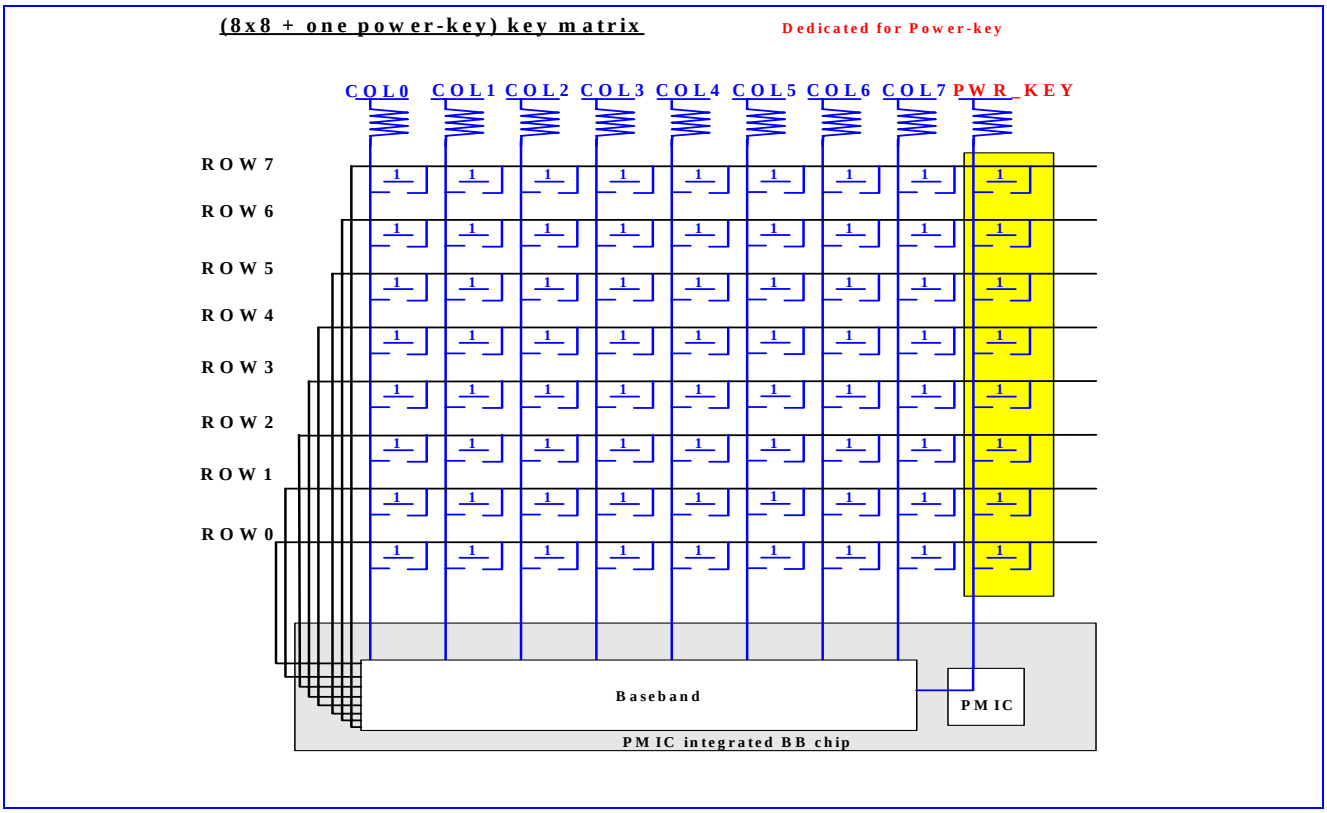


Fig. 7 8x8 matrix with one power-key

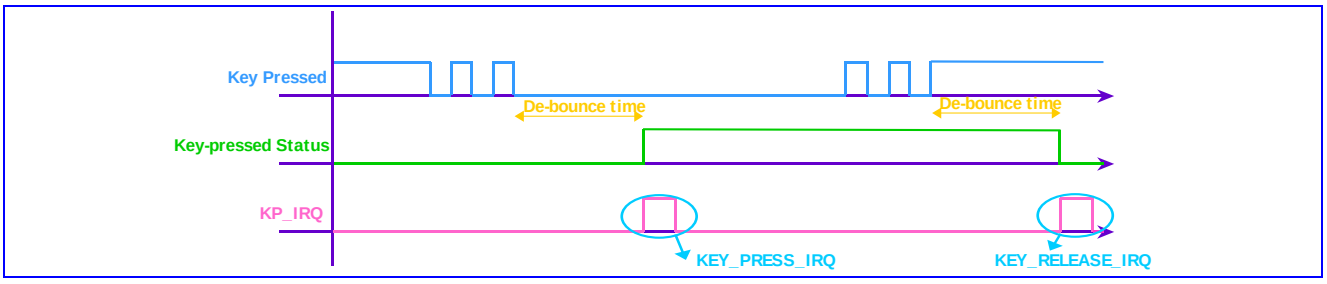


Fig. 8. One key pressed with de-bounce mechanism denoted

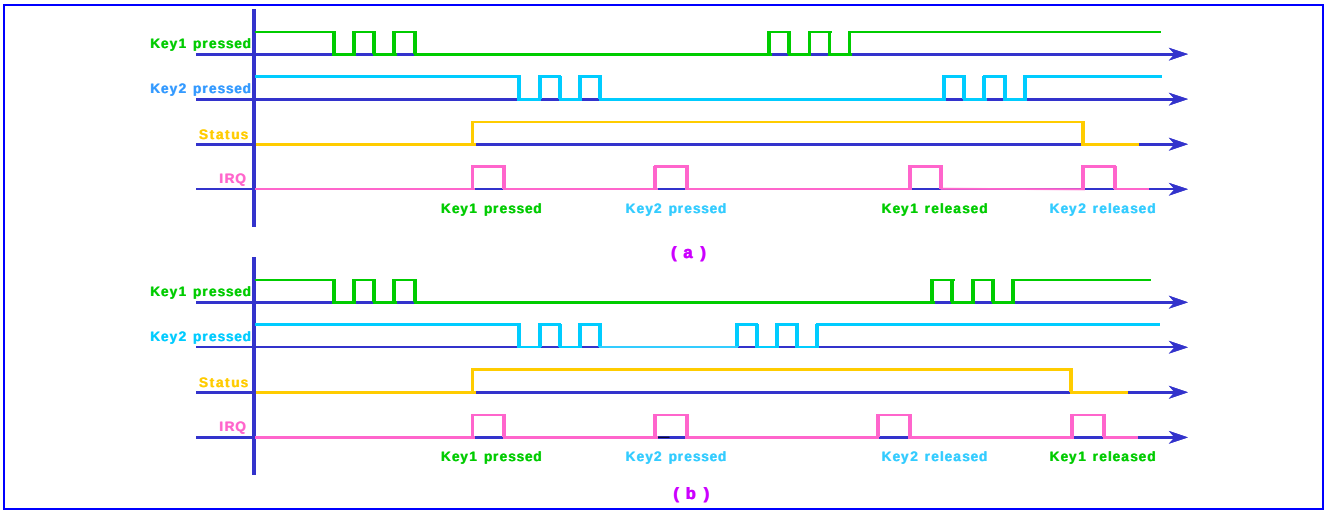


Fig. 9**. (a)** Two keys pressed, case 1 **(b)** Two keys pressed, case 2

4.5.2 Register Definitions

KP +0000h Keypad status KP_STA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																STA
Type																RO
Reset																0

STA This register indicates the keypad status. The register is not cleared by the read operation.

0 No key pressed

1 Key pressed

KP +0004h Keypad scanning output Register KP_MEM1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	KEYS [15:0]															
Type	RO															
Reset	16'hFFFF															

The register shows up the key-press status of key0~key15

KP +0008h Keypad scanning output Register KP_MEM2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	KEYS [15:0]															
Type	RO															
Reset	16'hFFFF															

The register shows up the key-press status of key16~key31

KP +000Ch Keypad scanning output Register KP_MEM3

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name	KEYS [15:0]
Type	RO
Reset	16'hFFFF

The register shows up the key-press status of key32~key47

KP +0010h Keypad scanning output Register KP_MEM4

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	KEYS [15:0]															
Type	RO															
Reset	16'hFFFF															

The register shows up the key-press status of key48~key63

KP +0014h Keypad scanning output Register KP_MEM5

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									KEYS [7:0]							
Type									RO							
Reset									8'hFF							

The register shows up the key-press status of key64~key71

These two registers list the status of 35 keys on the keypad but KEY[8], KEY[17], KEY[26], KEY[35], KEY[44] , KEY[53] , KEY[62] , KEY[71] is dedicated for power key. When the MCU receives the KEYPAD IRQ, both two registers must be read. If any key is pressed, the relative bit is set to 0.

KEYS Status list of the 72 keys.

KP +00018h De-bounce period setting KP_DEBOUNCE

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			DEBOUNCE [13:0]													
Type			R/W													
Reset			400h													

This register defines the waiting period before key press or release events are considered stale.

DEBOUNCE De-bounce time = KP_DEBOUNCE/32 ms.

4.6 General Purpose Inputs/Outputs

MT6235 offers 76 general-purpose I/O pins. By setting the control registers, MCU software can control the direction, the output value, and read the input values on these pins. These GPIOs are multiplexed with other functionalities to reduce the pin count. There are 10 clock-out ports embedded in 76 GPIO pins, and each clock-out can be programmed to output appropriate clock source.

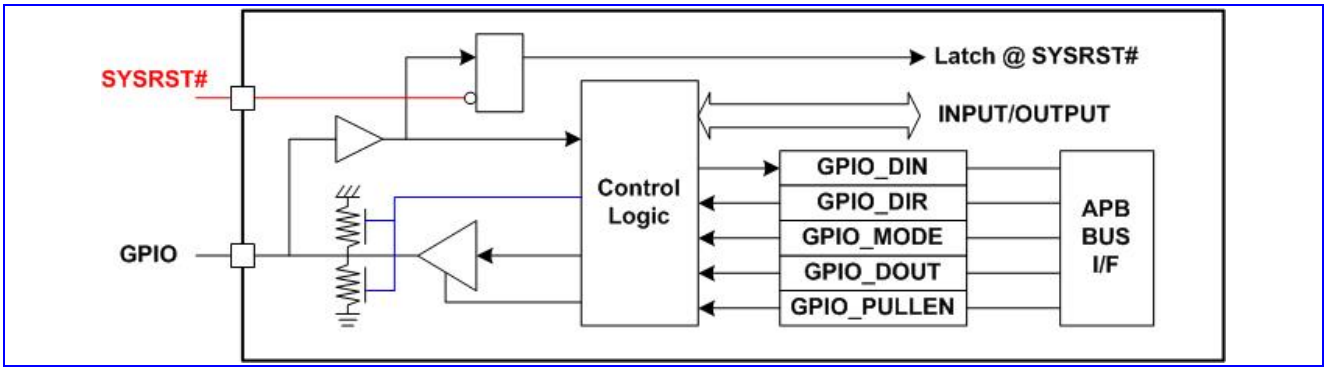


Figure 21 GPIO Block Diagram

GPIOs at RESET

Upon hardware reset (SYSRST#), GPIOs are all configured as inputs and the following alternative usages of GPIO pins are enabled:

These GPIOs are used to latch the inputs upon reset to memorize the desired configuration to make sure that the system restarts or boots in the right mode.

Multiplexing of Signals on GPIO

The GPIO pins can be multiplexed with other signals.

- CMRST, CMPDN, CMVREF, CMHREF, CMPCLK, CMMCLK, CMDAT7~0, CMFLASH: CMOS sensor interface
- SCL, SDL: I2C interface
- DAICLK, DAIPCMIN, DAIPCMOUT, DAIRST, DAISYNC: digital audio interface for FTA
- BPI_BUS3, BPI_BUS6, BPI_BUS7, BPI_BUS8, BPI_BUS9: radio hard-wire control
- BSI_CS1: additional chip select signal for radio 3-wire interface
- LSCK, LSA0, LSDA, LSCE0#, LSCE1#: serial display interface
- NRNB, NCLE, NALE, NWEB, NCE0# NCE1#: Nandflash interface
- NLD17, NLD16, LPCE1#, LPECE2#, LPTE: parallel display interface data and chip select signal
- PWM0, PWM1, PWM2, PWM3 : pulse width modulation signal
- URTS1, UCTS1: data and flow control signals for UART1
- URXD2, UTXD2, URTS2, UCTS2: data and flow control signals for UART2
- URXD3, UTXD3, URTS3, UCTS3: data signals for UART3
- IDRA_RXD, IRDA_TXD, IRDA_PDN: IrDA interface signals
- SRCLKENAI, SRCLKENA, SRCLKENAN: external power on signal of the external VCXO LDO
- EINT3, EINT4, EINT5, EINT6, EINT7: External interrupt signals
- KCOL7, KCOL6, KROW7, KROW6: Keypad signals

- EADMUX: External Memory AD-MUX select signal
- EA26: external memory interface address bit 26
- MC0CM0, MC0DA0~3, MC0CK, MC0PWRON, MC0WP, MC0INS : MMC Card 0 interface
- IRQ2, IRQ1, IRQ0 : external interrupt
- 32KHz, 6.5MHz, 13MHz, 26MHz clocks

4.6.1 Register Definitions

GPIO+0000h GPIO direction control register 1 GPIO_DIR1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO15	GPIO14	GPIO13	GPIO12	GPIO11	GPIO10	GPIO9	GPIO8	GPIO7	GPIO6	GPIO5	GPIO4	GPIO3	GPIO2	GPIO1	GPIO0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

GPIO +0040h GPIO direction control register 2 GPIO_DIR2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO31	GPIO30	GPIO29	GPIO28	GPIO27	GPIO26	GPIO25	GPIO24	GPIO23	GPIO22	GPIO21	PGIO20	GPIO19	GPIO18	GPIO17	GPIO16
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

GPIO+0080h GPIO direction control register 3 GPIO_DIR3

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO47	GPIO46	GPIO45	GPIO44	GPIO43	GPIO42	GPIO41	GPIO40	GPIO39	GPIO38	GPIO37	GPIO36	GPIO35	GPIO34	GPIO33	GPIO32
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

GPIO+00C0h GPIO direction control register 4 GPIO_DIR4

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO63	GPIO62	GPIO61	GPIO60	GPIO59	GPIO58	GPIO57	GPIO56	GPIO55	GPIO54	GPIO53	GPIO52	GPIO51	GPIO50	GPIO49	GPIO48
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

GPIO+0100h GPIO direction control register 5 GPIO_DIR5

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					GPIO75	GPIO74	GPIO73	GPIO72	GPIO71	GPIO70	GPIO69	GPIO68	GPIO67	GPIO66	GPIO65	GPIO64
Type					R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset					0	0	0	0	0	0	0	0	0	0	0	0

GPIO*n* GPIO direction control

0 GPIOs are configured as input

1 GPIOs are configured as output

GPIO +0200h GPIO pull-up/pull-down enable register 1 GPIO_PULLEN1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO15	GPIO14	GPIO13	GPIO12	GPIO11	GPIO10	GPIO9	GPIO8	GPIO7	GPIO6	GPIO5	GPIO4	GPIO3	GPIO2	GPIO1	GPIO0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

GPIO +0240h GPIO pull-up/pull-down enable register 2 GPIO_PULLEN2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO31	GPIO30	GPIO29	GPIO28	GPIO27	GPIO26	GPIO25	GPIO24	GPIO23	GPIO22	GPIO21	PGIO20	GPIO19	GPIO18	GPIO17	GPIO16
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

GPIO+0280h GPIO pull-up/pull-down enable register 3 GPIO_PULLEN3

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO47	GPIO46	GPIO45	GPIO44	GPIO43	GPIO42	GPIO41	GPIO40	GPIO39	GPIO38	GPIO37	GPIO36	GPIO35	GPIO34	GPIO33	GPIO32
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	1	1	1	1	1	0	0	1	1	0	0	0	0	0	1	1

GPIO+02C0h GPIO pull-up/pull-down enable register 4 GPIO_PULLEN4

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO63	GPIO62	GPIO61	GPIO60	GPIO59	GPIO58	GPIO57	GPIO56	GPIO55	GPIO54	GPIO53	GPIO52	GPIO51	GPIO50	GPIO49	GPIO48
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1

GPIO+0300h GPIO pull-up/pull-down enable register 5 GPIO_PULLEN5

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					GPIO75	GPIO74	GPIO73	GPIO72	GPIO71	GPIO70	GPIO69	GPIO68	GPIO67	GPIO66	GPIO65	GPIO64
Type					R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset					1	1	1	1	1	1	1	1	1	1	0	0

GPIO*n* GPIO pull up/down enable

- **0** GPIOs pull up/down is not enabled
- **1** GPIOs pull up/down is enabled

GPIO +0400h GPIO pull-up/pull-down select register 1 GPIO_PULLSEL1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO15	GPIO14	GPIO13	GPIO12	GPIO11	GPIO10	GPIO9	GPIO8	GPIO7	GPIO6	GPIO5	GPIO4	GPIO3	GPIO2	GPIO1	GPIO0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

GPIO +0440h GPIO pull-up/pull-down select register 2 GPIO_PULLSEL 2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO31	GPIO30	GPIO29	GPIO28	GPIO27	GPIO26	GPIO25	GPIO24	GPIO23	GPIO22	GPIO21	PGIO20	GPIO19	GPIO18	GPIO17	GPIO16
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1

GPIO+0480h GPIO pull-up/pull-down select register 3 GPIO_PULLSEL 3

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO47	GPIO46	GPIO45	GPIO44	GPIO43	GPIO42	GPIO41	GPIO40	GPIO39	GPIO38	GPIO37	GPIO36	GPIO35	GPIO34	GPIO33	GPIO32
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0

GPIO+04C0h GPIO pull-up/pull-down select register 4 GPIO_PULLSEL 4

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO63	GPIO62	GPIO61	GPIO60	GPIO59	GPIO58	GPIO57	GPIO56	GPIO55	GPIO54	GPIO53	GPIO52	GPIO51	GPIO50	GPIO49	GPIO48
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	1	0	0	0	0	0	1	1	1	1	1	1	0	1	1

GPIO+0500h GPIO pull-up/pull-down select register 5 GPIO_PULLSEL 5

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					GPIO75	GPIO74	GPIO73	GPIO72	GPIO71	GPIO70	GPIO69	GPIO68	GPIO67	GPIO66	GPIO65	GPIO64
Type					R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset					1	1	1	1	1	1	1	1	1	1	0	0

GPIO*n* GPIO pull up/down selection

- **0** GPIOs pull down is selected
- **1** GPIOs pull up is selected

GPIO +0600h GPIO data inversion control register 1 GPIO_DINV1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	INV15	INV14	INV13	INV12	INV11	INV10	INV9	INV8	INV7	INV6	INV5	INV4	INV3	INV2	INV1	INV0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

GPIO +0640h GPIO data inversion control register 2 GPIO_DINV2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	INV31	INV30	INV29	INV28	INV27	INV26	INV25	INV24	INV23	INV22	INV21	INV20	INV19	IVN18	INV17	INV16
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

GPIO +0680h GPIO data inversion control register 3 GPIO_DINV3

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	INV47	INV46	INV45	INV44	INV43	INV42	INV41	INV40	INV39	INV38	INV37	INV36	INV35	INV34	INV33	INV32
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

GPIO+06C0h GPIO data inversion control register 4 GPIO_DINV4

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	NV63	INV62	INV61	INV60	INV59	INV58	INV57	INV56	INV55	INV54	INV53	INV52	INV51	INV50	INV49	INV48
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

GPIO+0700h GPIO data inversion control register 5 GPIO_DINV5

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					INV75	INV74	INV73	INV72	INV71	INV70	INV69	INV68	INV67	INV66	INV65	INV64
Type					R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset					0	0	0	0	0	0	0	0	0	0	0	0

INVn GPIO inversion control

0 GPIOs data inversion disable

1 GPIOs data inversion enable

GPIO +0800h GPIO data output register 1 GPIO_DOUT1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO15	GPIO14	GPIO13	GPIO12	GPIO11	GPIO10	GPIO9	GPIO8	GPIO7	GPIO6	GPIO5	GPIO4	GPIO3	GPIO2	GPIO1	GPIO0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

GPIO +0840h GPIO data output register 2 GPIO_DOUT2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO31	GPIO30	GPIO29	GPIO28	GPIO27	GPIO26	GPIO25	GPIO24	GPIO23	GPIO22	GPIO21	PGIO20	GPIO19	GPIO18	GPIO17	GPIO16
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

GPIO +0880h GPIO data output register 3 GPIO_DOUT3

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO47	GPIO46	GPIO45	GPIO44	GPIO43	GPIO42	GPIO41	GPIO40	GPIO39	GPIO38	GPIO37	GPIO36	GPIO35	GPIO34	GPIO33	GPIO32
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

GPIO+08C0h GPIO data output register 4 GPIO_DOUT4

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name	GPIO63	GPIO62	GPIO61	GPIO60	GPIO59	GPIO58	GPIO57	GPIO56	GPIO55	GPIO54	GPIO53	GPIO52	GPIO51	GPIO50	GPIO49	GPIO48
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

GPIO+0900h GPIO data output register 5 GPIO_DOUT5

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					GPIO75	GPIO74	GPIO73	GPIO72	GPIO71	GPIO70	GPIO69	GPIO68	GPIO67	GPIO66	GPIO65	GPIO64
Type					R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset					0	0	0	0	0	0	0	0	0	0	0	0

GPIOn GPIO data output control

- **0** GPIOs data output 1
- **1** GPIOs data output 0

GPIO +0A00h GPIO data Input register 1 GPIO_DIN1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO15	GPIO14	GPIO13	GPIO12	GPIO11	GPIO10	GPIO9	GPIO8	GPIO7	GPIO6	GPIO5	GPIO4	GPIO3	GPIO2	GPIO1	GPIO0
Type	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
Reset	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

GPIO +0A40h GPIO data Input register 2 GPIO_DIN2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO31	GPIO30	GPIO29	GPIO28	GPIO27	GPIO26	GPIO25	GPIO24	GPIO23	GPIO22	GPIO21	PGIO20	GPIO19	GPIO18	GPIO17	GPIO16
Type	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
Reset	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

GPIO +0A80h GPIO data Input register 3 GPIO_DIN3

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO47	GPIO46	GPIO45	GPIO44	GPIO43	GPIO42	GPIO41	GPIO40	GPIO39	GPIO38	GPIO37	GPIO36	GPIO35	GPIO34	GPIO33	GPIO32
Type	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
Reset	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

GPIO+0AC0h GPIO data input register 4 GPIO_DIN4

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO63	GPIO62	GPIO61	GPIO60	GPIO59	GPIO58	GPIO57	GPIO56	GPIO55	GPIO54	GPIO53	GPIO52	GPIO51	GPIO50	GPIO49	GPIO48
Type	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
Reset	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

GPIO+0B00h GPIO data input register 5 GPIO_DIN5

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					GPIO75	GPIO74	GPIO73	GPIO72	GPIO71	GPIO70	GPIO69	GPIO68	GPIO67	GPIO66	GPIO65	GPIO64
Type					RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
Reset					X	X	X	X	X	X	X	X	X	X	X	X

GPIOn GPIOs data input

GPIO +1000h GPIO mode control register 1 GPIO_MODE1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO7_M		GPIO6_M		GPIO5_M		GPIO4_M		GPIO3_M		GPIO2_M		GPIO1_M		GPIO0_M	
Type	R/W		R/W		R/W		R/W		R/W		R/W		R/W		R/W	
Reset	00		00		00		00		00		00		00		00	

GPIO0_M GPIO mode selection
- **00** Configured as GPIO function
- **01** CMOS Sensor Reset control Signal (CMRST)
- **10** clk_out0
- **11** DSP_GPO0 (DSP_GPO0)

GPIO1_M GPIO mode selection
- **00** Configured as GPIO function
- **01** CMOS Sensor Power Down control Signal (CMPDN)
- **10** DSP_GPO1 (DSP_GPO1)
- **11** Reserved

GPIO2_M GPIO mode selection
- **00** Configured as GPIO function
- **01** CMOS Sensor Vertical Reference input (CMVREF)
- **10** TDMA Debug (TBTXEN)
- **11** Master DSP Task ID bit 0(D1_TID0)

GPIO3_M GPIO mode selection
- **00** Configured as GPIO function
- **01** CMOS Sensor Horizontal Reference input (CMHREF)
- **10** TDMA Debug (TBTXFS)
- **11** Reserved

GPIO4_M GPIO mode selection
- **00** Configured as GPIO function
- **01** CMOS Sensor Clock input signal (CMPCLK)
- **10** TDMA Debug (TBRXEN)
- **11** Master DSP Task ID bit 1(D1_TID1)

GPIO5_M GPIO mode selection
- **00** Configured as GPIO function
- **01** CMOS Sensor Clock output signal (CMMCLK)
- **10** TDMA Debug (TBRXFS)
- **11** Reserved

GPIO6_M GPIO mode selection
- **00** Configured as GPIO function
- **01** CMOS Sensor Data input signal bit7 (CMDAT7)
- **10** Reserved
- **11** Master DSP ICE Clock (D1ICK))

GPIO7_M GPIO mode selection
- **00** Configured as GPIO function

01 CMOS Sensor Data input signal bit6 (CMDAT6)
10 Reserved
11 Master DSP ICE Data (D1ID)

GPIO +1100h GPIO mode control register 2 GPIO_MODE2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO15_M		GPIO14_M		GPIO13_M		GPIO12_M		GPIO11_M		GPIO10_M		GPIO9_M		GPIO8_M	
Type	R/W		R/W		R/W		R/W		R/W		R/W		R/W		R/W	
Reset	00		00		00		00		00		00		00		00	

GPIO8_M GPIO mode selection
00 Configured as GPIO function
01 CMOS Sensor Data input signal bit5 (CMDAT5)
10 Reserved
11 Master DSP ICE Model Select (D1IMS)

GPIO9_M GPIO mode selection
00 Configured as GPIO function
01 CMOS Sensor Data input signal bit4 (CMDAT4)
10 Reserved
11 Slave DSP ICE Clock (D2ICK)

GPIO10_M GPIO mode selection
00 Configured as GPIO function
01 CMOS Sensor Data input signal bit3 (CMDAT3)
10 Reserved
11 Slave DSP ICE Data (D2ID)

GPIO11_M GPIO mode selection
00 Configured as GPIO function
01 CMOS Sensor Data input signal bit2 (CMDAT2)
10 Reserved
11 Slave DSP ICE Mode Select (D2IMS)

GPIO12_M GPIO mode selection
00 Configured as GPIO function
01 CMOS Sensor Data input signal bit1 (CMDAT1)
10 Reserved
11 Slave DSP Task ID Bit0 (D2_TID0)

GPIO13_M GPIO mode selection
00 Configured as GPIO function
01 CMOS Sensor Data input signal bit 0 (CMDAT0)
10 Resereved
11 Slave DSP Task ID Bit1 (D2_TID1)

GPIO14_M GPIO mode selection
00 Configured as GPIO function
01 CMOS Sensor Flash Control (CMFLASH)
10 Reserved
11 Slave DSP Task ID Bit2 (D2_TID2)

GPIO15_M GPIO mode selection

- **00** Configured as GPIO function
- **01** I2C Clock (SCL)
- **10** Reserved
- **11** Slave DSP Task ID Bit3 (D2_TID3)

GPIO +1200h GPIO mode control register 3 GPIO_MODE3

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO23_M		GPIO22_M		GPIO21_M		GPIO20_M		GPIO19_M		GPIO18_M		GPIO17_M		GPIO16_M	
Type	R/W		R/W		R/W		R/W		R/W		R/W		R/W		R/W	
Reset	00		00		00		00		00		00		00		00	

GPIO16_M GPIO mode selection

- **00** Configured as GPIO function
- **01** I2C Data (SDA)
- **10** Reserved
- **11** Slave DSP Task ID Bit4 (D2_TID4)

GPIO17_M GPIO mode selection

- **00** Configured as GPIO function
- **01** PWM2 (PWM2)
- **10** Reserved
- **11** Slave DSP Task ID Bit5 (D2_TID5)

GPIO18_M GPIO mode selection

- **00** Configured as GPIO function
- **01** PWM3 (PWM3)
- **10** Reserved
- **11** Slave DSP Task ID Bit6 (D2_TID6)

GPIO19_M GPIO mode selection

- **00** Configured as GPIO function
- **01** BPI_BUS3 (BPI_BUS3)
- **10** Reserved
- **11** Reserved

GPIO20_M GPIO mode selection

- **00** Configured as GPIO function
- **01** BPI_BUS6 (BPI_BUS6)
- **10** Reserved
- **11** Reserved

GPIO21_M GPIO mode selection

- **00** Configured as GPIO function
- **01** BPI_BUS7 (BPI_BUS7)
- **10** Reserved
- **11** Reserved

GPIO22_M GPIO mode selection

- **00** Configured as GPIO function
- **01** BPI_BUS8 (BPI_BUS8)

10 Reserved
11 Reserved

GPIO23_M GPIO mode selection
00 Configured as GPIO function
01 BPI_BUS9 (BPI_BUS9)
10 BSI_CS1 (BS1_CS1)
11 Reserved

GPIO +1300h GPIO mode control register 4 GPIO_MODE4

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO31_M		GPIO30_M		GPIO29_M		GPIO28_M		GPIO27_M		GPIO26_M		GPIO25_M		GPIO24_M	
Type	R/W		R/W		R/W		R/W		R/W		R/W		R/W		R/W	
Reset	00		00		00		00		00		00		00		00	

GPIO24_M GPIO mode selection
00 Configured as GPIO function
01 Serial LCD Clock Output (LSCK)
10 DSP_GPO2
11 Interrupt Input 0 (IRQ0)

GPIO25_M GPIO mode selection
00 Configured as GPIO function
01 Serial LCD Address (LSA0)
10 DSP_GPO3
11 Interrupt Input 1 (IRQ1)

GPIO26_M GPIO mode selection
00 Configured as GPIO function
01 Serial LCD Data (LSDA)
10 clk_out1
11 TDMA Timer Debug (TDTIRQ)

GPIO27_M GPIO mode selection
00 Configured as GPIO function
01 Serial LCD Chip Select 0 (LSCE0#)
10 clk_out2
11 TDMA Timer Debug (TCTIRQ2)

GPIO28_M GPIO mode selection
00 Configured as GPIO function
01 Serial LCD Chip Select 1 (LSCE1#)
10 Parallel LCD Chip Select 2 (LPCE2#)
11 TDMA Timer Debug (TCTIRQ1)

GPIO29_M GPIO mode selection
00 Configured as GPIO function
01 Parallel LCD Chip Select 1 (LPCE1#)
10 Nandflash Interface Chip Select 1 (NCE1#)
11 TDMA Timer Debug (TEVTVAL)

GPIO30_M GPIO mode selection
- **00** Configured as GPIO function
- **01** LCD LPTE (LPTE)
- **10** Reserved
- **11** Reserved

GPIO31_M GPIO mode selection
- **00** Configured as GPIO function
- **01** Parallel LCD Data Bit17 (NLD17)
- **10** Reserved
- **11** Reserved

GPIO +1400h GPIO mode control register 5 GPIO_MODE5

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO39_M		GPIO38_M		GPIO37_M		GPIO36_M		GPIO35_M		GPIO34_M		GPIO33_M		GPIO32_M	
Type	R/W		R/W		R/W		R/W		R/W		R/W		R/W		R/W	
Reset	00		01		01		01		01		01		01		00	

GPIO32_M GPIO mode selection
- **00** Configured as GPIO function
- **01** Nandflash/Parallel LCD Interface Bit16 (NLD16)
- **10** Reserved
- **11** Reserved

GPIO33_M GPIO mode selection
- **00** Configured as GPIO function
- **01** Nandflash Interface Ready/Busy Signal (NRNB)
- **10** Reserved
- **11** Reserved

GPIO34_M GPIO mode selection
- **00** Configured as GPIO function
- **01** Nandflash Interface Command Latch Signal (NCLE)
- **10** Reserved
- **11** Reserved

GPIO35_M GPIO mode selection
- **00** Configured as GPIO function
- **01** Nandflash Interface Address Latch Signal (NALE)
- **10** Reserved
- **11** Reserved

GPIO36_M GPIO mode selection
- **00** Configured as GPIO function
- **01** Nandflash Interface Write Enable Signal (NWEB)
- **10** Reserved
- **11** Reserved

GPIO37_M GPIO mode selection
- **00** Configured as GPIO function
- **01** Nandflash Interface Read Enable Signal (NREB)

10 Reserved
11 Reserved

GPIO38_M GPIO mode selection
00 Configured as GPIO function
01 Nandflash Interface Chip Select 0 (NCE0#)
10 Reserved
11 Reserved

GPIO39_M GPIO mode selection
00 Configured as GPIO function
01 PWM0 (PWM0)
10 Reserved
11 Reserved

GPIO +1500h GPIO mode control register 6 GPIO_MODE6

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO47_M		GPIO46_M		GPIO45_M		GPIO44_M		GPIO43_M		GPIO42_M		GPIO41_M		GPIO40_M	
Type	R/W		R/W		R/W		R/W		R/W		R/W		R/W		R/W	
Reset	00		00		00		00		00		01		01		00	

GPIO40_M GPIO mode selection
00 Configured as GPIO function
01 PWM1 (PWM1)
10 BSI_RFIN(BSI_RFIN)
11 Reserved

GPIO41_M GPIO mode selection
00 Configured as GPIO function
01 VCXO enable output signal high active (SRCLKENA)
10 Reserved
11 Reserved

GPIO42_M GPIO mode selection
00 Configured as GPIO function
01 VCXO enable output signal low active (SRCLKENAN)
10 Reserved
11 Reserved

GPIO43_M GPIO mode selection
00 Configured as GPIO function
01 VCXO enable input signal (SRCLKENAI)
10 Reserved
11 Reserved

GPIO44_M GPIO mode selection
00 Configured as GPIO function
01 External Interrupt 3 (EINT3)
10 Reserved
11 Interrupt Input 2 (IRQ2)

GPIO45_M GPIO mode selection
- **00** Configured as GPIO function
- **01** External Interrupt 4 (EINT4)
- **10** Reserved
- **11** clock_out3

GPIO46_M GPIO mode selection
- **00** Configured as GPIO function
- **01** External Interrupt 5 (EINT5)
- **10** EDICK (EDICK)
- **11** Reserved

GPIO47_M GPIO mode selection
- **00** Configured as GPIO function
- **01** External Interrupt 6 (EINT6)
- **10** EDIWS (EDIWS)
- **11** Reserved

GPIO +1600h GPIO mode control register 7 GPIO_MODE7

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO55		GPIO54		GPIO53		GPIO52		GPIO51		GPIO50		GPIO49		GPIO48	
Type	R/W		R/W		R/W		R/W		R/W		R/W		R/W		R/W	
Reset	00		00		00		00		00		01		01		00	

GPIO48_M GPIO mode selection
- **00** Configured as GPIO function
- **01** External Interrupt 7 (EINT7)
- **10** EDIDAT (EDIDAT)
- **11** Reserved

GPIO49_M GPIO mode selection
- **00** Configured as GPIO function
- **01** UART1 CTS Signal (UCTS1)
- **10** UART2 CTS Signal (UCTS2)
- **11** Reserved

GPIO50_M GPIO mode selection
- **00** Configured as GPIO function
- **01** UART1 RTC Signal (URTS1)
- **10** UART2 RTC Signal (URTS2)
- **11** Reserved

GPIO51_M GPIO mode selection
- **00** Configured as GPIO function
- **01** UART2 RXD Signal (URXD2)
- **10** UART3 CTS Signal (UCTS3)
- **11** Reserved

GPIO52_M GPIO mode selection
- **00** Configured as GPIO function
- **01** UART2 TXD Signal (UTXD2)

10 UART3 RTS Signal (URTS3)
11 Reserved

GPIO53_M GPIO mode selection
00 Configured as GPIO function
01 UART3 RXD Signal (URXD3)
10 IrDA RXD Signal (IRDA_RXD)
11 Reserved

GPIO54_M GPIO mode selection
00 Configured as GPIO function
01 UART3 TXD Signal (UTXD3)
10 IrDA TXD Signal (IRDA_TXD)
11 Reserved

GPIO55_M GPIO mode selection
00 Configured as GPIO function
01 Keyboard Column 7 (KCOL7)
10 IrDA Power Down Signal (IRDA_PDN)
11 Reserved

GPIO +1700h GPIO mode control register 8 GPIO_MODE8

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO63		GPIO62		GPIO61		GPIO60		GPIO59		GPIO58		GPIO57		GPIO56	
Type	R/W		R/W		R/W		R/W		R/W		R/W		R/W		R/W	
Reset	00		00		00		00		00		00		00		00	

GPIO56_M GPIO mode selection
00 Configured as GPIO function
01 Keyboard Column 6 (KCOL6)
10 Reserved
11 Reserved

GPIO57_M GPIO mode selection
00 Configured as GPIO function
01 Keyboard Row 7 (KROW7)
10 clock-out4
11 Reserved

GPIO58_M GPIO mode selection
00 Configured as GPIO function
01 Keyboard Row 6 (KROW6)
10 Reserved
11 Reserved

GPIO59_M GPIO mode selection
00 Configured as GPIO function
01 Digital Audio Interface PCM Clock Output (DAICLK)
10 Reserved
11 Reserved

GPIO60_M GPIO mode selection
- **00** Configured as GPIO function
- **01** Digital Audio Interface PCM Data Output (DAIPCMOUT)
- **10** Reserved
- **11** Reserved

GPIO61_M GPIO mode selection
- **00** Configured as GPIO function
- **01** Digital Audio Interface PCM Data Input (DAIPCMIN)
- **10** Reserved
- **11** Reserved

GPIO62_M GPIO mode selection
- **00** Configured as GPIO function
- **01** Digital Audio Interface Reset Signal (DAIRST)
- **10** Reserved
- **11** Reserved

GPIO63_M GPIO mode selection
- **00** Configured as GPIO function
- **01** Digital Audio Interface Sync Signal (DAISYNC)
- **10** Reserved
- **11** Reserved

GPIO +1800h GPIO mode control register 9 GPIO_MODE9

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO71		GPIO70		GPIO69		GPIO68		GPIO67		GPIO66		GPIO65		GPIO64	
Type	R/W		R/W		R/W		R/W		R/W		R/W		R/W		R/W	
Reset	00		00		00		00		00		00		01		01	

GPIO64_M GPIO mode selection
- **00** Configured as GPIO function
- **01** External memory address bit 26 (EA26)
- **10** clock_out5
- **11** Reserved

GPIO65_M GPIO mode selection
- **00** Configured as GPIO function
- **01** EADMUX Only used when being boot-up. After system reset, EADMUX is of no use.
- **10** clock_out6
- **11** Reserved

GPIO66_M GPIO mode selection
- **00** Configured as GPIO function
- **01** MFIQ (MFIQ)
- **10** clock_out7
- **11** Reserved

GPIO67_M GPIO mode selection
- **00** Configured as GPIO function

01 Memory Card 0 Command signal (MC0CM0)
10 Reserved
11 TDMA Timer Debug (TDMA_CK)

GPIO68_M GPIO mode selection
00 Configured as GPIO function
01 Memory Card 0 Data Bit 0 (MC0DA0)
10 Reserved
11 TDMA Timer Debug (TDMA_D1)

GPIO69_M GPIO mode selection
00 Configured as GPIO function
01 Memory Card 0 Data Bit 1 (MC0DA1)
10 Reserved
11 TDMA Timer Debug (TDMA_D0)

GPIO70_M GPIO mode selection
00 Configured as GPIO function
01 Memory Card 0 Data Bit 2 (MC0DA2)
10 Reserved
11 TDMA Timer Debug (TDMA_FS)

GPIO71_M GPIO mode selection
00 Configured as GPIO function
01 Memory Card 0 Data Bit 3 (MC0DA3)
10 Reserved
11 Reserved

GPIO +1900h GPIO mode control register A GPIO_MODEA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									GPIO75		GPIO74		GPIO73		GPIO72	
Type									R/W		R/W		R/W		R/W	
Reset									00		00		00		00	

GPIO72_M GPIO mode selection
00 Configured as GPIO function
01 Memory Card 0 Clock output (MC0CK)
10 Reserved
11 Reserved

GPIO73_M GPIO mode selection
00 Configured as GPIO function
01 Memory Card 0 Power On (MC0PWRON)
10 clock_out8
11 Reserved

GPIO74_M GPIO mode selection
00 Configured as GPIO function
01 Memory Card 0 Write Protection (MC0WP)
10 clock_out9

11 Reserved

GPIO75_M GPIO mode selection

00 Configured as GPIO function

01 Memory Card 0 Card insertion identification (MC0INS)

10 Reserved

11 Reserved

GPIO+3000h CLK_OUT1 setting CLK_OUT1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												CLKOUT				
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W				
Reset	0	0	0	0	0	0	0	0	0	0	0	0				

CLKOUT select the clock output source of clk_out0

0 f65m_ck, 6.5MHz

1 f104m_ck

2 f52m_ck

3 f26m_ck

4 f13m_ck

5 fmcu_ck

6 f32k_ck

7 gdsp1_ck

8 gdsp2_ck

9 mcu_hclk_ck,

A 104Mhz AHB clock

B mclk_ck

C slow_ck

D fdsp_ck

E fusb_ck

F f48m_ck

10 f52m_en

Other Reserved

GPIO+3100h CLK_OUT2 setting CLK_OUT2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												CLKOUT				
Type												R/W				
Reset												0				

CLKOUT select the clock output source of clk_out1

GPIO+3200h CLK_OUT3 setting CLK_OUT3

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												CLKOUT				

Type												R/W			
Reset												0			

CLKOUT select the clock output source of clk_out2

GPIO+3300h CLK_OUT4 setting CLK_OUT4

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												CLKOUT				
Type												R/W				
Reset												0				

CLKOUT select the clock output source of clk_out3

GPIO+3400h CLK_OUT5 setting CLK_OUT5

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												CLKOUT				
Type												R/W				
Reset												0				

CLKOUT select the clock output source of clk_out4

GPIO+3500h CLK_OUT6 setting CLK_OUT6

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												CLKOUT				
Type												R/W				
Reset												0				

CLKOUT select the clock output source of clk_out5

GPIO+3600h CLK_OUT7 setting CLK_OUT7

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												CLKOUT				
Type												R/W				
Reset												0				

CLKOUT select the clock output source of clk_out6

GPIO+3700h CLK_OUT8 setting CLK_OUT8

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												CLKOUT				
Type												R/W				
Reset												0				

CLKOUT select the clock output source of clk_out7

GPIO+3800h CLK_OUT9 setting CLK_OUT9

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name												CLKOUT
Type												R/W
Reset												0

CLKOUT select the clock output source of clk_out8

GPIO+3900h CLK_OUT10 setting CLK_OUT10

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												CLKOUT				
Type												R/W				
Reset												0				

CLKOUT select the clock output source of clk_out9

GPIO+xxx4h GPIO xxx register SET GPIO_XXX_SET

For all registers addresses listed above, writing to the +4h addresse offset will perform a bit-wise **OR** function between the 16bit written value and the 16bit register value already existing in the corresponding GPIO_xxx registers.
Eg.
If GPIO_DIR1 (GPIO+0000h) = 16'h0F0F,
writing GPIO_DIR1_SET (GPIO+0004h) = 16'F0F0 will result in GPIO_DIR1 = 16'hFFFF.

GPIO+xxx8h GPIO xxx register CLR GPIO_XXX_CLR

For all registers addresses listed above, writing to the +8h addresse offset will perform a bit-wise **AND-NOT** function between the 16bit written value and the 16bit register value already existing in the corresponding GPIO_xxx registers.
Eg.
If GPIO_DIR1 (GPIO+0000h) = 16'h0F0F,
writing GPIO_DIR1_CLR (GPIO+0008h) = 16'0F0F will result in GPIO_DIR1 = 16'h0000.

4.7 General Purpose Timer

4.7.1 General Description

Three general-purpose timers are provided. The timers are 16 bits long and run independently of each other, although they share the same clock source. Two timers can operate in one of two modes: one-shot mode and auto-repeat mode; the other is a free running timer. In one-shot mode, when the timer counts down and reaches zero, it is halted. In auto-repeat mode, when the timer reaches zero, it simply resets to countdown initial value and repeats the countdown to zero; this loop repeats until the disable signal is set to 1. Regardless of the timer's mode, if the countdown initial value (i.e. GPTIMER1_DAT for GPT1 or GPTIMER_DAT2 for GPT2) is written when the timer is running, the new initial value does not take effect until the next time the timer is restarted. In auto-repeat mode, the new countdown start value is used on the next countdown iteration. Therefore, before enabling the gptimer, the desired values for GPTIMER_DAT and the GPTIMER_PRESCALER registers must first be set.

4.7.2 Register Definitions

GPT +0000h GPT1 Control register GPTIMER1_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EN	MODE														
Type	R/W	R/W														
Reset	0	0														

MODE This register controls GPT1 to count repeatedly (in a loop) or just one-shot.

0 One-shot mode is selected.

1 Auto-repeat mode is selected.

EN This register controls GPT1 to start counting or to stop.

0 GPT1 is disabled.

1 GPT1 is enabled.

GPT +0004h GPT1 Time-Out Interval register GPTIMER1_DAT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	CNT [15:0]															
Type	R/W															
Reset	FFFFh															

CNT [15:0] Initial counting value. GPT1 counts down from GPTIMER1_DAT. When GPT1 counts down to zero, a GPT1 interrupt is generated.

GPT +0008h GPT2 Control register GPTIMER2_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EN	MODE														
Type	R/W	R/W														
Reset	0	0														

MODE This register controls GPT2 to count repeatedly (in a loop) or just one-shot.

0 One-shot mode is selected

1 Auto-repeat mode is selected

EN This register controls GPT2 to start counting or to stop.

0 GPT2 is disabled.

1 GPT2 is enabled.

GPT +000Ch GPT2 Time-Out Interval register GPTIMER2_DAT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	CNT [15:0]															
Type	R/W															
Reset	FFFFh															

CNT [15:0] Initial counting value. GPT2 counts down from GPTIMER2_DAT. When GPT2 counts down to zero, a GPT2 interrupt is generated.

GPT +0010h GPT Status register GPTIMER_STA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name															GPT2	GPT1
Type															RC	RC

Reset															0	0

This register illustrates the gptimer timeout status. Each flag is set when the corresponding timer countdown completes, and can be cleared when the CPU reads the status register.

GPT +0014h GPT1 Prescaler register — GPTIMER1_PRESCALER

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name														PRESCALER [2:0]		
Type														R/W		
Reset														100b		

PRESCALER This register controls the counting clock for gptimer1.

000 16384 Hz
001 8192 Hz
010 4096 Hz
011 2048 Hz
100 1024 Hz
101 512 Hz
110 256 Hz
111 128 Hz

GPT +0018h GPT2 Prescaler register — GPTIMER2_PRESCALER

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name														PRESCALER [2:0]		
Type														R/W		
Reset														100b		

PRESCALER This register controls the counting clock for gptimer2.

000 16384 Hz
001 8192 Hz
010 4096 Hz
011 2048 Hz
100 1024 Hz
101 512 Hz
110 256 Hz
111 128 Hz

GPT+001Ch GPT3 Control register — GPTIMER3_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																EN
Type																R/W
Reset																0

EN This register controls GPT3 to start counting or to stop.

0 GPT3 is disabled.
1 GPT3 is enabled.

GPT+0020h GPT3 Time-Out Interval register GPTIMER3_DAT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	CNT[15:0]															
Type	RO															
Reset	0															

CNT [15:0] If EN=1, GPT3 is a free running timer . Software reads this register for the countdown start value for GPT3.

GPT+0024h GPT3 Prescaler register GPTIMER3_PRESCALER

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name														PRESCALER [2:0]		
Type														R/W		
Reset														100b		

PRESCALER This register controls the counting clock for gptimer3.

000 16384 Hz
001 8192 Hz
010 4096 Hz
011 2048 Hz
100 1024 Hz
101 512 Hz
110 256 Hz
111 128 Hz

4.8 UART

4.8.1 General Description

The baseband chipset houses three UARTs. The UARTs provide full duplex serial communication channels between baseband chipset and external devices.

The UART has M16C450 and M16550A modes of operation, which are compatible with a range of standard software drivers. The extensions have been designed to be broadly software compatible with 16550A variants, but certain areas offer no consensus.

In common with the M16550A, the UART supports word lengths **from five to eight bits**, **an optional parity bit** and one or two stop bits, and is fully programmable by an 8-bit CPU interface. A 16-bit programmable baud rate generator and an 8-bit scratch register are included, together with separate transmit and receive FIFOs. Eight modem control lines and a diagnostic loop-back mode are provided. The UART also includes two DMA handshake lines, used to indicate when the FIFOs are ready to transfer data to the CPU. Interrupts can be generated from any of the 10 sources.

Note: The UART has been designed so that all internal operations are synchronized by the CLK signal. This synchronization results in minor timing differences between the UART and the industry standard 16550A device, which means that the core is not clock for clock identical to the original device.

After a hardware reset, the UART is in M16C450 mode. Its FIFOs can be enabled and the UART can then enter

M16550A mode. The UART adds further functionality beyond M16550A mode. Each of the extended functions can be selected individually under software control.

The UART provides more powerful enhancements than the industry-standard 16550:

- Hardware flow control. This feature is very useful when the ISR latency is hard to predict and control in the embedded applications. The MCU is relieved of having to fetch the received data within a fixed amount of time.
- Output of an IR-compatible electrical pulse with a width 3/16 of that of a regular bit period.

Note: In order to enable any of the enhancements, the Enhanced Mode bit, EFR[4], must be set. If EFR[4] is not set, IER[7:5], FCR[5:4], ISR[5:4] and MCR[7:6] cannot be written. The Enhanced Mode bit ensures that the UART is backward compatible with software that has been written for 16C450 and 16550A devices.

Figure 22 shows the block diagram of the UART device.

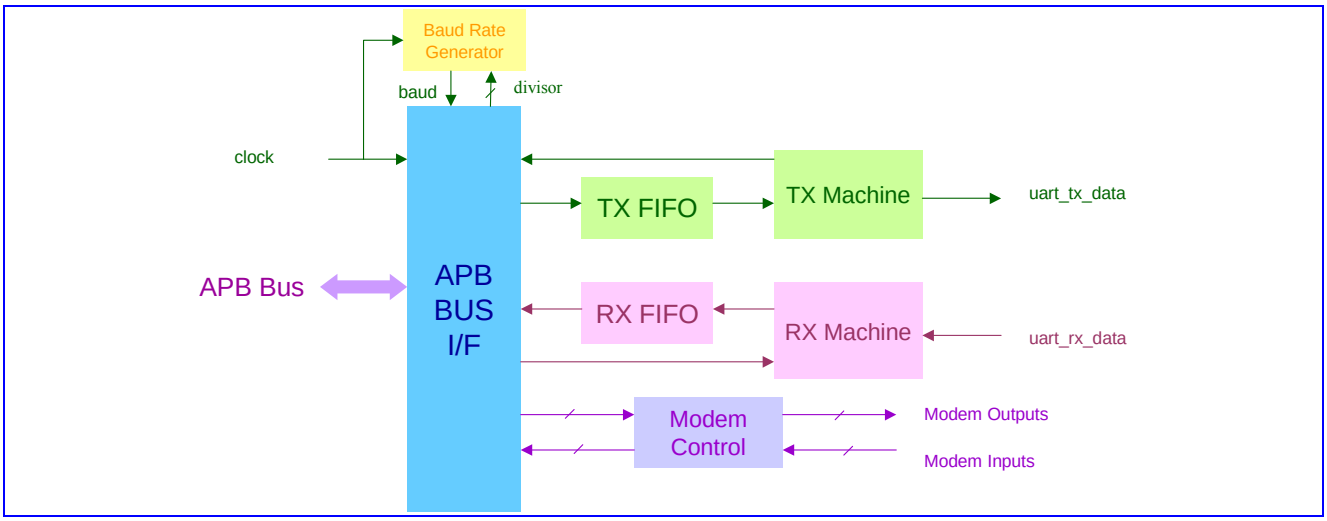


Figure 22 Block Diagram of UART

4.8.2 Register Definitions

n = 1, 2, 3; for uart1, uart2 and uart3 respectively.

UARTn+0000h RX Buffer Register — UARTn_RBR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									RBR[7:0]							
Type									RO							

RBR RX Buffer Register. Read-only register. The received data can be read by accessing this register. Modified when LCR[7] = 0.

UARTn+0000h TX Holding Register — UARTn_THR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									THR[7:0]							
Type									WO							

THR TX Holding Register. Write-only register. The data to be transmitted is written to this register, and then sent to the PC via serial communication.
Modified when LCR[7] = 0.

UARTn+0004h Interrupt Enable Register UARTn_IER

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									CTSI	RTSI	XOFFI	X	EDSSI	ELSI	ETBEI	ERBFI
Type									R/W							
Reset									0							

IER By storing a '1' to a specific bit position, the interrupt associated with that bit is enabled. Otherwise, the interrupt is disabled.
IER[3:0] are modified when LCR[7] = 0.
IER[7:4] are modified when LCR[7] = 0 & EFR[4] = 1.

CTSI Masks an interrupt that is generated when a rising edge is detected on the CTS modem control line.
Note*:* This interrupt is only enabled when hardware flow control is enabled.
0 Unmask an interrupt that is generated when a rising edge is detected on the CTS modem control line.
1 Mask an interrupt that is generated when a rising edge is detected on the CTS modem control line.

RTSI Masks an interrupt that is generated when a rising edge is detected on the RTS modem control line.
Note*:* This interrupt is only enabled when hardware flow control is enabled.
0 Unmask an interrupt that is generated when a rising edge is detected on the RTS modem control line.
1 Mask an interrupt that is generated when a rising edge is detected on the RTS modem control line.

XOFFI Masks an interrupt that is generated when an XOFF character is received.
Note*:* This interrupt is only enabled when software flow control is enabled.
0 Unmask an interrupt that is generated when an XOFF character is received.
1 Mask an interrupt that is generated when an XOFF character is received.

EDSSI When set ("1"), an interrupt is generated if DDCD, TERI, DDSR or DCTS (MSR[4:1]) becomes set.
0 No interrupt is generated if DDCD, TERI, DDSR or DCTS (MSR[4:1]) becomes set.
1 An interrupt is generated if DDCD, TERI, DDSR or DCTS (MSR[4:1]) becomes set.

ELSI When set ("1"), an interrupt is generated if BI, FE, PE or OE (LSR[4:1]) becomes set.
0 No interrupt is generated if BI, FE, PE or OE (LSR[4:1]) becomes set.
1 An interrupt is generated if BI, FE, PE or OE (LSR[4:1]) becomes set.

ETBEI When set ("1"), an interrupt is generated if the TX Holding Register is empty or the contents of the TX FIFO have been reduced to its Trigger Level.
0 No interrupt is generated if the TX Holding Register is empty or the contents of the TX FIFO have been reduced to its Trigger Level.
1 An interrupt is generated if the TX Holding Register is empty or the contents of the TX FIFO have been reduced to its Trigger Level

ERBFI When set ("1"), an interrupt is generated if the RX Buffer contains data.
0 No interrupt is generated if the RX Buffer contains data.
1 An interrupt is generated if the RX Buffer contains data.

UARTn+0008h Interrupt Identification Register UARTn_IIR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									FIFOE		ID4	ID3	ID2	ID1	ID0	NINT
Type									RO							

Reset									0	0	0	0	0	0	0	1

IIR Identify if there are pending interrupts; ID4 and ID3 are presented only when EFR[4] = 1.
The following table gives the IIR[5:0] codes associated with the possible interrupts:

IIR[5:0]	Priority Level	Interrupt	Source
000001	-	No interrupt pending	
000110	1	Line Status Interrupt	BI, FE, PE or OE set in LSR
000100	2	RX Data Received	RX Data received or RX Trigger Level reached.
001100	2	RX Data Timeout	Timeout on character in RX FIFO.
000010	3	TX Holding Register Empty	TX Holding Register empty or TX FIFO Trigger Level reached.
000000	4	Modem Status change	DDCD, TERI, DDSR or DCTS set in MSR
010000	5	Software Flow Control	XOFF Character received
100000	6	Hardware Flow Control	CTS or RTS Rising Edge

Table 17 The IIR[5:0] codes associated with the possible interrupts

Line Status Interrupt: A RX Line Status Interrupt (IIR[5:0`] == 000110b) is generated if ELSI (IER[2]) is set and any of BI, FE, PE or OE (LSR[4:1]) becomes set. The interrupt is cleared by reading the Line Status Register.

RX Data Received Interrupt: A RX Received interrupt (IER[5:0] == 000100b) is generated if EFRBI (IER[0]) is set and either RX Data is placed in the RX Buffer Register or the RX Trigger Level is reached. The interrupt is cleared by reading the RX Buffer Register or the RX FIFO (if enabled).

RX Data Timeout Interrupt:

When virtual FIFO mode is disabled, RX Data Timeout Interrupt is generated if all of the following apply:

1. FIFO contains at least one character;
2. The most recent character was received longer than four character periods ago (including all start, parity and stop bits);
3. The most recent CPU read of the FIFO was longer than four character periods ago.

The timeout timer is restarted on receipt of a new byte from the RX Shift Register, or on a CPU read from the RX FIFO.

The RX Data Timeout Interrupt is enabled by setting EFRBI (IER[0]) to 1, and is cleared by reading RX FIFO.

When virtual FIFO mode is enabled, RX Data Timeout Interrupt is generated if all of the following apply:

1. FIFO is empty;
2. The most recent character was received longer than four character periods ago (including all start, parity and stop bits);
3. The most recent CPU read of the FIFO was longer than four character periods ago.

The timeout timer is restarted on receipt of a new byte from the RX Shift Register.

RX Holding Register Empty Interrupt: A TX Holding Register Empty Interrupt (IIR[5:0] = 000010b) is generated if ETRBI (IER[1]) is set and either the TX Holding Register or, if FIFOs are enabled, the TX FIFO becomes empty. The interrupt is cleared by writing to the TX Holding Register or TX FIFO if FIFO enabled.

Modem Status Change Interrupt: A Modem Status Change Interrupt (IIR[5:0] = 000000b) is generated if EDSSI (IER[3]) is set and either DDCD, TERI, DDSR or DCTS (MSR[3:0]) becomes set. The interrupt is cleared by reading the Modem Status Register.

Software Flow Control Interrupt: A Software Flow Control Interrupt (IIR[5:0] = 010000b) is generated if Software Flow Control is enabled and XOFFI (IER[5]) becomes set, indicating that an XOFF character has been received. The interrupt is cleared by reading the Interrupt Identification Register.

Hardware Flow Control Interrupt: A Hardware Flow Control Interrupt (IER[5:0] = 100000b) is generated if Hardware Flow Control is enabled and either RTSI (IER[6]) or CTSI (IER[7]) becomes set indicating that a rising edge has been detected on either the RTS/CTS Modem Control line. The interrupt is cleared by reading the Interrupt Identification Register.

UARTn+0008h FIFO Control Register — UARTn_FCR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									RFTL1	RFTL0	TFTL1	TFTL0	DMA1	CLRT	CLRR	FIFOE
Type									WO							

FCR FCR is used to control the trigger levels of the FIFOs, or flush the FIFOs.
FCR[7:6] is modified when LCR != BFh
FCR[5:4] is modified when LCR != BFh & EFR[4] = 1
FCR[4:0] is modified when LCR != BFh

FCR[7:6] RX FIFO trigger threshold
- **0** 1
- **1** 6
- **2** 12
- **3** **RXTRIG**

FCR[5:4] TX FIFO trigger threshold
- **0** 1
- **1** 4
- **2** 8
- **3** 14 (FIFOSIZE - 2)

DMA1 This bit determines the DMA mode, which the TXRDY and RXRDY pins support. TXRDY and RXRDY act to support single-byte transfers between the UART and memory (DMA mode 0) or multiple byte transfers (DMA mode1). Note that this bit has no effect unless the FIFOE bit is set as well
- **0** The device operates in DMA Mode 0.
- **1** The device operates in DMA Mode 1.

TXRDY – mode0: Goes active (low) when the TX FIFO or the TX Holding Register is empty. Becomes inactive when a byte is written to the Transmit channel.
TXRDY – mode1: Goes active (low) when there are no characters in the TX FIFO. Becomes inactive when the TX FIFO is full.
RXRDY – mode0: Becomes active (low) when at least one character is in the RX FIFO or the RX Buffer Register is full. Becomes inactive when there are no more characters in the RX FIFO or RX Buffer register.
RXRDY – mode1: Becomes active (low) when the RX FIFO Trigger Level is reached or an RX FIFO Character Timeout occurs. Goes inactive when the RX FIFO is empty.

CLRT Clear Transmit FIFO. This bit is self-clearing.
- **0** Leave TX FIFO intact.

1 Clear all the bytes in the TX FIFO.

CLRR Clear Receive FIFO. This bit is self-clearing.

0 Leave RX FIFO intact.

1 Clear all the bytes in the RX FIFO.

FIFOE FIFO Enabled. This bit must be set to 1 for any of the other bits in the registers to have any effect.

0 Disable both the RX and TX FIFOs.

1 Enable both the RX and TX FIFOs.

UARTn+000Ch Line Control Register — UARTn_LCR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									DLAB	SB	SP	EPS	PEN	STB	WLS1	WLS0
Type									R/W							
Reset									0	0	0	0	0	0	0	0

LCR Line Control Register. Determines characteristics of serial communication signals. Modified when LCR[7] = 0.

DLAB Divisor Latch Access Bit.

0 The RX and TX Registers are read/written at Address 0 and the IER register is read/written at Address 4.

1 The Divisor Latch LS is read/written at Address 0 and the Divisor Latch MS is read/written at Address 4.

SB Set Break

0 No effect

1 SOUT signal is forced into the “0” state.

SP Stick Parity

0 No effect.

1 The Parity bit is forced into a defined state, depending on the states of EPS and PEN:
If EPS=1 & PEN=1, the Parity bit is set and checked = 0.
If EPS=0 & PEN=1, the Parity bit is set and checked = 1.

EPS Even Parity Select

0 When EPS=0, an odd number of ones is sent and checked.

1 When EPS=1, an even number of ones is sent and checked.

PEN Parity Enable

0 The Parity is neither transmitted nor checked.

1 The Parity is transmitted and checked.

STB Number of STOP bits

0 One STOP bit is always added.

1 Two STOP bits are added after each character is sent; unless the character length is 5 when 1 STOP bit is added.

WLS1, 0 Word Length Select.

0 5 bits

1 6 bits

2 7 bits

3 8 bits

UARTn+0010h Modem Control Register — UARTn_MCR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name									XOFF STATUS	~~IR ENABLE~~	X	LOOP	OUT2	OUT1	RTS	DTR
Type									R/W							
Reset									0	0	0	0	0	0	0	0

MCR Modem Control Register. Control interface signals of the UART.
MCR[4:0] are modified when LCR[7] = 0,
MCR[7:6] are modified when LCR[7] = 0 & EFR[4] = 1.

XOFF Status This is a read-only bit.

0 When an XON character is received.

1 When an XOFF character is received.**LOOP**Loop-back control bit.

0 No loop-back is enabled.

1 Loop-back mode is enabled.

OUT2 Controls the state of the output NOUT2, even in loop mode.

0 NOUT2=1.

1 NOUT2=0.

OUT1 Controls the state of the output NOUT1, even in loop mode.

0 NOUT1=1.

1 NOUT1=0.

RTS Controls the state of the output NRTS, even in loop mode.

0 NRTS=1.

1 NRTS=0.

DTR Control the state of the output NDTR, even in loop mode.

0 NDTR=1.

1 NDTR=0.

UARTn+0014h Line Status Register UARTn_LSR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									FIFOERR	TEMT	THRE	BI	FE	PE	OE	DR
Type									R/W							
Reset									0	1	1	0	0	0	0	0

LSR Line Status Register.
Modified when LCR[7] = 0.

FIFOERR RX FIFO Error Indicator.

0 No PE, FE, BI set in the RX FIFO.

1 Set to 1 when there is at least one PE, FE or BI in the RX FIFO.

TEMT TX Holding Register (or TX FIFO) and the TX Shift Register are empty.

0 Empty conditions below are not met.

1 If FIFOs are enabled, the bit is set whenever the TX FIFO and the TX Shift Register are empty. If FIFOs are disabled, the bit is set whenever TX Holding Register and TX Shift Register are empty.

THRE Indicates if there is room for TX Holding Register or TX FIFO is reduced to its Trigger Level.

0 **Reset whenever the contents of the TX FIFO are more than its Trigger Level (FIFOs are enabled), or whenever TX Holding Register is not empty(FIFOs are disabled).**

1 Set whenever the contents of the TX FIFO are reduced to its Trigger Level (FIFOs are enabled), or whenever TX Holding Register is empty and ready to accept new data (FIFOs are disabled).

BI Break Interrupt.

0 Reset by the CPU reading this register

1 If the FIFOs are disabled, this bit is set whenever the SIN is held in the 0 state for more than one transmission time (START bit + DATA bits + PARITY + STOP bits).

If the FIFOs are enabled, this error is associated with a corresponding character in the FIFO and is flagged when this byte is at the top of the FIFO. When a break occurs, only one zero character is loaded into the FIFO: the next character transfer is enabled when SIN goes into the marking state and receives the next valid start bit.

FE Framing Error.

0 Reset by the CPU reading this register

1 If the FIFOs are disabled, this bit is set if the received data did not have a valid STOP bit. If the FIFOs are enabled, the state of this bit is revealed when the byte it refers to is the next to be read.

PE Parity Error

0 Reset by the CPU reading this register

1 If the FIFOs are disabled, this bit is set if the received data did not have a valid parity bit. If the FIFOs are enabled, the state of this bit is revealed when the referred byte is the next to be read.

OE Overrun Error.

0 Reset by the CPU reading this register.

1 If the FIFOs are disabled, this bit is set if the RX Buffer was not read by the CPU before new data from the RX Shift Register overwrote the previous contents.

If the FIFOs are enabled, an overrun error occurs when the RX FIFO is full and the RX Shift Register becomes full. OE is set as soon as this happens. The character in the Shift Register is then overwritten, but not transferred to the FIFO.

DR Data Ready.

0 Cleared by the CPU reading the RX Buffer or by reading all the FIFO bytes.

1 Set by the RX Buffer becoming full or by a byte being transferred into the FIFO.

UARTn+0018h Modem Status Register — UARTn_MSR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									DCD	RI	DSR	CTS	DDCD	TERI	DDSR	DCTS
Type									R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset									Input	Input	Input	Input	0	0	0	0

Note: After a reset, D4-D7 are inputs. A modem status interrupt can be cleared by writing '0' or set by writing '1' to this register. D0-D3 can be written to.

Modified when LCR[7] = 0.

MSR Modem Status Register

DCD Data Carry Detect.

When Loop = "0", this value is the complement of the NDCD input signal.

When Loop = "1", this value is equal to the OUT2 bit in the Modem Control Register.

RI Ring Indicator.

When Loop = "0", this value is the complement of the NRI input signal.

When Loop = "1", this value is equal to the OUT1 bit in the Modem Control Register.

DSR Data Set Ready

When Loop = "0", this value is the complement of the NDSR input signal.

When Loop = "1", this value is equal to the DTR bit in the Modem Control Register.

CTS Clear To Send.

When Loop = "0", this value is the complement of the NCTS input signal.

When Loop = "1", this value is equal to the RTS bit in the Modem Control Register.

DDCD Delta Data Carry Detect.

0 The state of DCD has not changed since the Modem Status Register was last read

1 Set if the state of DCD has changed since the Modem Status Register was last read.

TERI Trailing Edge Ring Indicator

0 The NRI input does not change since this register was last read.

1 Set if the NRI input changes from "0" to "1" since this register was last read.

DDSR Delta Data Set Ready

0 Cleared if the state of DSR has not changed since this register was last read.

1 Set if the state of DSR has changed since this register was last read.

DCTS Delta Clear To Send

0 Cleared if the state of CTS has not changed since this register was last read.

1 Set if the state of CTS has changed since this register was last read.

UARTn+001Ch Scratch Register — UARTn_SCR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									SCR[7:0]							
Type									R/W							

A general purpose read/write register. After reset, its value is un-defined.

Modified when LCR[7] = 0.

UARTn+0000h Divisor Latch (LS) — UARTn_DLL

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									DLL[7:0]							
Type									R/W							
Reset									1							

UARTn+0004h Divisor Latch (MS) — UARTn_DLM

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									DLL[7:0]							
Type									R/W							
Reset									0							

Note: DLL & DLM can only be updated if DLAB is set ("1").. Note too that division by 1 generates a BAUD signal that is constantly high.

Modified when LCR[7] = 1.

The table below shows the divisor needed to generate a given baud rate from CLK inputs of 13, 26 MHz and 52 MHz. The effective clock enable generated is 16 x the required baud rate.

BAUD	13MHz	26MHz	52MHz
110	7386	14773	29545
300	2708	5417	10833
1200	677	1354	2708
2400	338	677	1354
4800	169	339	677
9600	85	169	339
19200	42	85	169
38400	21	42	85
57600	14	28	56
115200	6	14	28

Table 18 Divisor needed to generate a given baud rate

UARTn+0008h Enhanced Feature Register — UARTn_EFR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									AUTO CTS	AUTO RTS	D5	ENABLE -E	SW FLOW CONT[3:0]			
Type									R/W	R/W	R/W	R/W	R/W			
Reset									0	0	0	0	0			

*NOTE: Only when LCR=BF'h

Auto CTS Enables hardware transmission flow control
- **0** Disabled.
- **1** Enabled.

Auto RTS Enables hardware reception flow control
- **0** Disabled.
- **1** Enabled.

Enable-E Enable enhancement features.
- **0** Disabled.
- **1** Enabled.

CONT[3:0] Software flow control bits.
- **00xx** No TX Flow Control
- **10xx** Transmit XON1/XOFF1 as flow control bytes
- **01xx** Transmit XON2/XOFF2 as flow control bytes
- **11xx** Transmit XON1 & XON2 and XOFF1 & XOFF2 as flow control words
- **xx00** No RX Flow Control
- **xx10** Receive XON1/XOFF1 as flow control bytes
- **xx01** Receive XON2/XOFF2 as flow control bytes
- **xx11** Receive XON1 & XON2 and XOFF1 & XOFF2 as flow control words

UARTn+0010h XON1 — UARTn_XON1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name									XON1[7:0]
Type									R/W
Reset									0

UARTn+0014h XON2 UARTn_XON2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									XON2[7:0]							
Type									R/W							
Reset									0							

UARTn+0018h XOFF1 UARTn_XOFF1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									XOFF1[7:0]							
Type									R/W							
Reset									0							

UARTn+001Ch XOFF2 UARTn_XOFF2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									XOFF2[7:0]							
Type									R/W							
Reset									0							

*Note: XON1, XON2, XOFF1, XOFF2 are valid only when LCR=BFh.

UARTn+0020h AUTOBAUD_EN UARTn_AUTOBAUD_EN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																AUTO_EN
Type																R/W
Reset																0

AUTOBAUD_EN Auto-baud enable signal

0 Auto-baud function disable

1 Auto-baud function enable

UARTn+0024h HIGH SPEED UART UARTn_HIGHSPEED

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name															SPEED [1:0]	
Type															R/W	
Reset															0	

SPEED UART sample counter base

0 based on 16*baud_pulse, baud_rate = system clock frequency/16/{DLH, DLL}

1 based on 8*baud_pulse, baud_rate = system clock frequency/8/{DLH, DLL}

2 based on 4*baud_pulse, baud_rate = system clock frequency/4/{DLH, DLL}

3 based on sampe_count * baud_pulse, baud_rate = system clock frequency / sampe_count

The table below shows the divisor needed to generate a given baud rate from CLK inputs of 13M Hz based on different HIGHSPEED value.

BAUD	HIGHSPEED = 0	HIGHSPEED = 1	HIGHSPEED = 2
110	7386	14773	29545
300	2708	7386	14773
1200	677	2708	7386
2400	338	677	2708
4800	169	338	677
9600	85	169	338
19200	42	85	169
38400	21	42	85
57600	14	21	42
115200	7	14	21
230400	*	7	14
460800	*	*	7
921600	*	*	*

Table 19 Divisor needed to generate a given baud rate from 13MHz based on different HIGHSPEED value

The table below shows the divisor needed to generate a given baud rate from CLK inputs of 26 MHz based on different HIGHSPEED value.

BAUD	HIGHSPEED = 0	HIGHSPEED = 1	HIGHSPEED = 2
110	14773	29545	59091
300	5417	14773	29545
1200	1354	5417	14773
2400	677	1354	5417
4800	339	677	1354
9600	169	339	667
19200	85	169	339
38400	42	85	169
57600	28	42	85
115200	14	28	42
230400	7	14	28
460800	*	7	14
921600	*	*	7

Table 20 Divisor needed to generate a given baud rate from 26 MHz based on different HIGHSPEED value

The table below shows the divisor needed to generate a given baud rate from CLK inputs of 52MHz based on different HIGHSPEED value.

BAUD	HIGHSPEED = 0	HIGHSPEED = 1	HIGHSPEED = 2
110	29545	59091	118182
300	10833	29545	59091
1200	2708	10833	29545
2400	1354	2708	10833
4800	677	1354	2708
9600	339	677	1354
19200	169	339	677
38400	85	169	339
57600	56	85	169
115200	28	56	85
230400	14	28	56
460800	7	14	28
921600	*	7	14

Table 21 Divisor needed to generate a given baud rate from 52 MHz based on different HIGHSPEED value

UARTn+0028h SAMPLE_COUNT

UARTn_SAMPLE_COUNT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									SAMPLECOUNT [7:0]							
Type									R/W							
Reset									0							

When HIGHSPEED=3, the sample_count is the threshold value for UART sample counter (sample_num).

Count from 0 to sample_count.

For example, this register shall be set to 13 when you want to diveded by 14.

UARTn+002Ch SAMPLE_POINT

UARTn_SAMPLE_POINT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									SAMPLEPOINT [7:0]							
Type									R/W							
Reset									Ffh							

When HIGHSPEED=3, UART gets the input data when sample_count=sample_num.

e.g. system clock = 13MHz, 921600 = 13000000 / 14

sample_count = 14 and sample point = 7 (sample the central point to decrease the inaccuracy)

The SAMPLE_POINT is usually (SAMPLE_COUNT/2).

UARTn+0030h AUTOBAUD_REG

UARTn_AUTOBAUD_REG

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name									BAUD_STAT[3:0]	BAUDRATE[3:0]
Type									RO	RO
Reset									0	0

BAUD_RATE Autobaud baud rate

- **0** 115200
- **1** 57600
- **2** 38400
- **3** 19200
- **4** 9600
- **5** 4800
- **6** 2400
- **7** 1200
- **8** 300
- **9** 110

BAUDSTAT Autobaud format

- **0** Autobaud is detecting
- **1** AT_7N1
- **2** AT_7O1
- **3** AT_7E1
- **4** AT_8N1
- **5** AT_8O1
- **6** AT_8E1
- **7** at_7N1
- **8** at_7E1
- **9** at_7O1
- **10** at_8N1
- **11** at_8E1
- **12** at_8O1
- **13** Autobaud detection fails

UARTn+0034h Rate Fix Address — UARTn_RATEFIX_AD

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													RESTRICT	FREQ_SEL	AUTOBAUD_RATE_FIX	RXTE_FIX
Type													R/W	R/W	R/W	R/W
Reset													0	0	0	0

RATE_FIX When you set "rate_fix"(34H[0]), you can transmit and receive data only if 1) the f13m_en is enable and the freq_sel (34H[2]) is set to 1, or

2) the f26m_en is enable and the freq_sel (34H[2]) is set to 0.

AUTOBAUD_RATE_FIX When you set "autobaud_rate_fix"(34H[1]), you can tx/rx the autobaud packet only if

1) the f13m_en is enable and the freq_sel (34H[2]) is set to 1, or

2) the f26m_en is enable and the freq_sel (34H[2]) is set to 0.

FREQ_SEL

0 Select f26m_en for rate_fix and autobaud_rate_fix

1 Select f13m_en for rate_fix and autobaud_rate_fix

RESTRICT The "restrict" (34H[3]) is used to set a more condition for the autobaud fsm starting point

UARTn+0038h AUTOBAUDSAMPLE — UARTn_AUTOBAUDSAMPLE

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name										AUTOBAUDSAMPLE						
Type										R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset										dh						

Since the system clock may change, autobaud sample duration should change as system clock changes.
When system clock = 13MHz, autobaudsample = 6; when system clock = 26MHz, autobaudsample = 13.

UARTn+003Ch Guard time added register — UARTn_GUARD

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												GUARD_EN	GUARD_CNT[3:0]			
Type												R/W	R/W	R/W	R/W	R/W
Reset												0	0	0	0	0

GUARD_CNT Guard interval count value. Guard interval = (1/(system clock / **div_step** / div)) * GUARD_CNT.

GUARD_EN Guard interval add enable signal.

0 No guard interval added.

1 Add guard interval after stop bit.

UARTn+0040h Escape character register — UARTn_ESCAPE_DAT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									ESCAPE_DAT[7:0]							
Type									WO							
Reset									FFh							

ESCAPE_DAT Escape character added before software flow control data and escape character, i.e. if tx data is xon (31h), with esc_en =1, uart transmits data as esc + CEh (~xon).

UARTn+0044h Escape enable register — UARTn_ESCAPE_EN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																ESC_EN
Type																R/W
Reset																0

ESC_EN Add escape character in transmitter and remove escape character in receiver by UART.

0 Do not deal with the escape character.

1 Add escape character in transmitter and remove escape character in receiver.

UARTn+0048h Sleep enable register — UARTn_SLEEP_EN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name																SELLP_EN
Type																R/W
Reset																0

SLEEP_EN For sleep mode issue

0 Do not deal with sleep mode indicate signal

1 To activate hardware flow control or software control according to software initial setting when chip enters sleep mode. Releasing hardware flow when chip wakes up; but for software control, uart sends xon when awaken and when FIFO does not reach threshold level.

UARTn+004Ch Virtual FIFO enable register — UARTn_VFIFO_EN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																VFIFO_EN
Type																R/W
Reset																0

VFIFO_EN Virtual FIFO mechanism enable signal.

0 Disable VFIFO mode.

1 Enable VFIFO mode. When virtual mode is enabled, the flow control is based on the DMA threshold, and generates a timeout interrupt for DMA.

UARTn+0050h Rx Trigger Address — UARTn_RXTRI_AD

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													RXTRIG[3:0]			
Type													R/W			
Reset													0			

RXTRIG **When {rtm,rtl}=2'b11, The Rx FIFO threshold will be Rxtrig.**

4.9 IrDA Framer

4.9.1 General Description

IrDA framer is implemented to reduce the CPU loading for IrDA transmissions by performing all the physical level protocol framing in hardware. From a software perspective, the framer need only prepare and process the raw data for transmission and reception. Generic DMA is required to move the data between IrDA framer's internal FIFO and software-designated memory. The IrDA framer supports IrDA SIR, MIR, and FIR modes of operation. SIR mode includes operation from 9600bps ~ 115200bps, MIR includes operation at 567000bps or 1152000bps, and FIR mode includes operation at 4Mbps.

4.9.2 Register Definitions

IRDA+0000h TX BUF and RX BUF — BUF

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									BUF[7:0]							
Type									R/W							
Reset									0							

BUF IrDA Framer transmit or receive data.
A write to this register writes into the internal TX FIFO.
A read from this register reads from the internal RX FIFO.

IRDA+0004h TX BUF and RX BUF clear signal — BUF_CLEAR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																CLEAR
Type																R/W
Reset																0

CLEAR **SIR mode only**. When CLEAR=1, both the TX and RX FIFO are cleared. This is used primarily for debug purpose. Normal operation does not require this. This control signaled can only be issued under SIR mode.

IRDA+0008h Maximum Turn Around Time

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Name			MAX_T [13:0]												
Type			R/W												
Reset			3E80h												

MAX_T The maximum time that a station can hold the P/F bit. This parameter along with the baud rate parameter dictates the maximum number of bytes that a station can transmit before passing the line to another station by transmitting a frame with the P/F bit. This parameter is used by one station to indicate the maximum time the other station can send before it must turn the link around. For baud rates less than 115200 kbps, 500 ms is the only valid value. The default value is 500 ms.

IRDA+000Ch Minimum Turn Around Time — MIN_T

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	MIN_T [15:0]															
Type	R/W															
Reset	FDE8h															

MIN_T Minimum turn around time, the default value is 10 ms. The minimum turn around time parameter deals with the time needed for a receiver to recover following saturation by transmission from the same device. This parameter corresponds to the required time delay between the last byte of the last frame sent by a station and the point at which it is ready to receive the first byte of a frame from another station, i.e. the latency for a transmit to complete and be ready to receive.

IRDA+0010h Number of additional BOFs prefixed to the beginning of a frame — BOFS

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									TYPE	BOFS [6:0]						

Type									R/W	R/W
Reset									0	1011b

BOFs **For SIR mode**: the additional BOFs parameter indicates the number of additional flags needed at the beginning of every frame. The main purpose for the additional BOFs is to provide a delay at the beginning of each frame for devices with a long interrupt latency.

For MIR mode: This parameter indicates the number of double STA's to transmit in the beginning. This value should be set to 0 (for default 2 STA's) for MIR mode, unless more are required.

For FIR mode: This parameter has no effect.

TYPE **SIR mode only**. Additional BOFs type.

1 BOF = C0h

0 BOF = FFh

IRDA+0014h Baud rate divisor DIV

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DIV[15:0]															
Type	R/W															
Reset	55h															

DIV Transmit or receive rate divider. Rate = System clock frequency / DIV/ 16. The default value is 55h when in contention mode. **This divisor is also used to determine the RX FIFO timeout threshold.**

IRDA+0018h Transmit frame size TX_FRAME_SIZE

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					TX_FRAME_SIZE[11:0]											
Type					R/W											
Reset					40h											

TX_FRAME_SIZE Transmit frame size; the default value is 64 when in contention mode.

IRDA+001Ch Receiving frame1 size RX_FRAME1_SIZE

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					RX_FRAME1_SIZE[11:0]											
Type					RO											
Reset					0											

RX_FRAME1_SIZE Reports the number of byte received. Includes only the A+C+I fields.

IRDA+0020h Transmit abort indication ABORT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																ABORT
Type																R/W
Reset																0

ABORT **SIR mode only**. When set 1, the framer transmits an abort sequence and closes the frame without an FCS field or an ending flag.

Note: Tx abort can be achieved in MIR and FIR by simply disabling the tx_en signal.

IRDA+0024h IrDA framer transmit enable signal

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Name													TX_ONE	TXINVERT	MODE
Type													R/W	R/W	R/W
Reset													0	0	0

TX_EN Transmit enable.

MODE **SIR mode only**. Modulation type selection.

0 3/16 modulation

1 1.61us

TXINVERT Invert the transmit signal.

0 Transmit signal is not inverted.

1 Transmit signal is inverted.

TX_ONE: Controls the transmit enable signal is one or not.

0 tx_en is not de-asserted until software programs a so.

1 tx_en is de-asserted (i.e. transmit disabled) automatically after one frame has been sent.

IRDA+0028h IrDA framer receive enable signal RX_EN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name														RX_ONE	RXINVERT	RX_EN
Type														R/W	R/W	R/W
Reset														0	0	0

RX_EN Receive enable.

RXINVERT Invert the receive signal.

0 Receive signal is not inverted.

1 Receive signal is inverted.

RX_ONE Disable receive when get one frame.

0 rx_en is not de-asserted until software programs so.

1 rx_en is de-asserted (i.e. transmit disabled) automatically after one frame has been sent.

IRDA+002Ch FIFO trigger level indication TRIGGER

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													RX_TRIG[		TX_TRIG	
Type													R/W		R/W	
Reset													0		0	

TX_TRIG TX FIFO interrupt trigger threshold. When the amount of data in the TX FIFO is less than the specified amount, dma req is asserted. (When TX_TRIG = 03, dma req is always asserted as long as FIFO is not full.)

00 0 byte

01 1 byte

02 8 byte

03 16 byte

RX_TRIG RX FIFO interrupt trigger threshold. When the amount of data in RX FIFO is above the specified amount, dma req is asserted.

00 1 byte

01 2 byte

02 3 byte

IRDA+0030h IRQ enable signal IRQ_ENABLE

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				2NDRX_COMP	RXRESTART	THRESHTIMEOUT	FIFOTIMEOUT	TXABORT	RXABORT	MAXTIMEOUT	MINTIMEOUT	RXCOMPLETE	TXCOMPLETE	ERROR	RXTHRES	TXTHRES
Type					R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset					0	0	0	0	0	0	0	0	0	0	0	0

TXRES Transmit data reaches the threshold level. (For debug only. Should be set to 0.)

0 No interrupt is generated.

1 Interrupt is generated when transmit FIFO size reaches threshold.

RXRES Receive data reaches the threshold level. (For debug only. Should be set to 0.)

0 No interrupt is generated.

1 Interrupt is generated when receive FIFO size reaches threshold.

ERROR Error status interrupt enable.

0 No interrupt is generated.

1 Interrupt is generated when one of the error statuses occurs.

TXCOMPLETE Transmit one frame completely.

0 No interrupt is generated.

1 Interrupt is generated when transmitting one frame completely.

RXCOMPLETE Receive one frame completely.

0 No interrupt is generated.

1 Interrupt is generated when receiving one frame completely.

MINTIMEOUT Minimum time timeout.

0 No interrupt is generated.

1 Interrupt is generated when minimum timer is timed out.

MAXTIMEOUT Maximum time timeout.

0 No interrupt is generated.

1 Interrupt is generated when maximum timer is timed out.

RXABORT Receiving aborting frame.

0 No interrupt is generated.

1 Interrupt is generated when receiving aborting frame.

TXABORT **SIR mode only**. Transmitting aborting frame.

0 No interrupt is generated.

1 Interrupt is generated when transmitting aborting frame.

FIFOTIMEOUT FIFO timeout.

0 No interrupt is generated.

1 Interrupt is generated when FIFO timeout.

THRESHTIMEOUT Threshold time timeout.

0 No interrupt is generated.

1 Interrupt is generated when threshold timer is timed out.

RXRESTART **SIR mode only**. Receiving a new frame before one frame is received completely.

0 No interrupt is generated.

1 Interrupt is generated when receiving a new frame before one frame is received completely.

2NDRX_COMP Receiving second frame and get P/F bit.

0 No interrupt is generated.

1 Interrupt is generated when receiving second frame and get P/F bit completely.

IRDA+0034h Interrupt Status IRQ_STA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				2NDRX_COMP	RXRESTART	THRESHTIMEOUT	FIFOTIMEOUT	TXABORT	RXABORT	MAXTIMEOUT	MINTIMEOUT	RXCOMPLETE	TXCOMPLETE	ERROR	RXTRES	TXTRES
Type				RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC
Reset				0	0	0	0	0	0	0	0	0	0	0	0	0

TXFIFO Transmit FIFO reaches threshold. (For debug only. Not recommended for normal usage.)

RXFIFO Receive FIFO reaches threshold. (For debug only. Not recommended for normal usage.)

ERROR Generated when any of status in Error Status register occurs.

Once the source of an interrupt is determined to be caused by an error (bit 2), the error status register should be read. Once read, both the error status register and the interrupt source are read-cleared. If the error status register indicates either a frame 1 or frame 2 error, the corresponding frame status register should be read.

TXCOMPLETE Transmitting one frame completely.

RXCOMPLETE Receiving one frame completely.

MINTIMEOUT Minimum turn around time timeout.

MAXTIMEOUT Maximum turn around time timeout.

RXABORT Receiving aborting frame.

TXABORT Transmitting aborting frame.

FIFOTIMEOUT FIFO is timeout.

THRESHTIMEOUT Threshold time timeout.

RXRESTART Receiving a new frame before one frame is received completely.

2NDRX_COMP Receiving second frame and get P/F bit completely.

IRDA+0038h ERROR STATUS register ERR_STATUS

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name										TX FIFO UNDERRUN	FRAME 2 DATA ERR	FRAME 1 DATA ERR	RESERVED2	RESERVED	OVERRUN	RXSIZE
Type										R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset										0	0	0	0	0	0	0

RXSIZE Receive frame size error.

OVERRUN Frame overrun.

RESERVED Reserved for future use.

RESERVED2 Reserved for future use.

FRAME1 DATA ERR Indicates that an error condition occurred in RX frame1. Must check the RX frame1 status.

FRAME2 DATA ERR Indicates that an error condition occurred in RX frame2. Must check the RX frame2 status.

TX FIFO UNDERRUN **MIR and FIR mode only**.

TX FIFO underrun has occurred. Data transmission is aborted. Software must reset the tx_en signal.

IRDA+003Ch Transceiver power on/off control. Transceiver mode select. TRANSCEIVER_PDN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name														TXCVR CONFIG	TX MANUAL	TRANS_ PDN
Type														R/W	R/W	R/W
Reset														0	0	0

TRANSCEIVER_PDN Used for power on/off control for external IrDA transceiver.

TX_MANUAL When txcvr config is set to 1, this bit can be used to select the operation mode of the external IrDA transceiver (some transceivers require selection between high speed and low speed operating modes), by software programming the desired sequence to transmit through the irda_txd pin.

TXCVR CONFIG

0 Irda_txd comes from core logic.

1 Irda_txd depends on tx_manual value.

IRDA+0040h Maximum number of receiving frame size RX_FRAME_MAX

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					MAX_RX_FRAME_SIZE_											
Type					R/W											
Reset					0											

RX_FRAME_MAX Receive frame I field max size, when actual receiving frame size is larger than rx_frame_max, RXSIZE is asserted. The maximum allowed I field size is 2048.

IRDA+0044h Threshold Time THRESH_T

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DISCONNECT_TIME[15:0]															
Type	R/W															
Reset	bb8h															

THRESHOLD TIME Threshold time; used to control the time a station waits without receiving a valid frame before disconnecting the link. Associated with this is the time a station waits without receiving a valid frame before sending a status indication to the service user layer.

IRDA+0048h Counter enable signal COUNT_ENABLE

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name														THRESH_EN	MIN_EN	MAX_EN
Type														R/W	R/W	R/W
Reset														0	0	0

COUNT_ENABLE Counter enable signals.

IRDA+004Ch Indication of system clock rate CLOCK_RATE

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name															CLOCK_RATE	

Type															R/W
Reset															0

CLOCK_RATE **SIR mode only** Indication of the system clock rate.

0 26 MHz

1 52 MHz

2 13 MHz

IRDA+0050h System Clock Rate Fix RATE_FIX

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													MIR TIMING TUNE	CRC REPORT	SIR FRAMING SET	RATE_FIX
Type													R/W	R/W	R/W	R/W
Reset													0	0	0	0

RATE_FIX **SIR mode only** Fix the IrDA framer sample base clock rate as 13 MHz.

0 Clock rate based on clock_rate selection.

1 Clock rate fixed at 13 MHz.

SIR FRAMING SET **SIR mode only**. Framing error check condition.

0 Ignore the STOP bit of the last byte of a frame.

1 Check the STOP bit of the last byte of a frame.

CRC REPORT When set to 1, CRC error is reported via error status register and error interrupt.

MIR TIMING TUNE **MIR mode only**. For some transceivers, in MIR 0.576mbps mode, the RX output pulse does not conform to IRDA specification. Therefore, this option is used to detect the RX output from those transceivers correctly.

0 For transceivers that conform to spec.

1 For transceivers that do not conform to spec, and the RX output pulse is half of that specified.

IRDA+0054h RX Frame1 Status FRAME1_S

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Name										FIR STO ERR	FIR 4PPM ERR	MIR HDLC ERR	UNKNOW_ ERROR	PF_DETECT	CRC_FAI
Type										R/W	R/W	R/W	R/W	R/W	R/W
Reset										0	0	0	0	0	0

FRAME_ERROR **SIR mode only**. Framing error, i.e. STOP bit = 0.

0 No framing error

1 Framing error occurred

CRC_FAIL CRC check fail

2 CRC check successfully

3 CRC check fail

PF_DETECT P/F bit detect

0 Not a P/F bit frame

1 Detected P/F bit in this frame

UNKNOWN_ERROR **SIR mode only**. Receiving error data, i.e. escape character is followed by a character that is not an ESC, BOF, or EOF character.

0 Data received correctly.

1 Unknown error occurred.

MIR HDLC ERR **MIR mode only**. MIR HDLC encoding error

0 No error

1 Error

FIR 4PPM ERR **FIR mode only**. FIR 4ppm encoding error

0 No error

1 Error

FIR STO ERR **FIR mode only**. FIR STO sequence error

0 No error

1 Error

IRDA+0058h RX Frame2 Status — FRAME2_STATUS

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name										FIR STO ERR	FIR 4PPM ERR	MIR HDLC ERR	UNKNOW_ERROR	PF_DETECT	CRC_FAIL	FRAME_ERROR
Type										R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset										0	0	0	0	0	0	0

FRAME_ERROR **SIR mode only.** Framing error, i.e. STOP bit = 0

0 No framing error.

1 Framing error occurred.

CRC_FAIL CRC check fail.

0 CRC check successfully.

1 CRC check fail.

PF_DETECT P/F bit detect.

0 Not a P/F bit frame.

1 Detected P/F bit in this frame.

UNKNOWN_ERROR **SIR mode only**. Receiving error data, i.e. escape character is followed by a character that is not an ESC, BOF, or EOF character.

0 Data receiving correctly.

1 Unknown error occurred.

MIR HDLC ERR **MIR mode only**. MIR HDLC encoding error.

0 No error

1 Error

FIR 4PPM ERR **FIR mode only**.FIR 4ppm encoding error

0 No error

1 Error

FIR STO ERR **FIR mode only**.FIR STO sequence error

0 No error

1 Error

IRDA+005Ch Receiving frame2 size — RX_FRAME2_SIZE

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name					RX_FRAME2_SIZE[11:0]
Type					RO
Reset					0

RX_FRAME2_SIZE Reports the number of byte received. Includes only the A+C+I fields.

IRDA+0060h Irda Mode Select IRDA_

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Name														MIR SPEED	IRD
Type														R/W	R
Reset														0	

IRDA MODE Selects the IrDA operating mode. NOTE: this mode selection cannot be issued while transmitting or receiving.

- **00** IR mode
- **01** MIR mode
- **10** FIR mode

MIR SPEED Select the MIR speed.

- **0** 0.576 Mbps
- **1** 1.152 Mbps

IRDA+0064h Fifo Status FIFO_STAT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												RX FIFO HOLD	TX FIFO WR FULL	TX FIFO RD EMPTY	RX FIFO WR FULL	RX FIFO RD EMPTY
Type												RO	RO	RO	RO	RO
Reset												0	0	1	0	1

This register indicates the real time FIFO status, for monitoring purposes.

4.10 Real Time Clock

4.10.1 General Description

The Real Time Clock (RTC) module provides time and data information. The clock is based on a 32.768KHz oscillator with an independent power supply. When the mobile handset is powered off, a dedicated regulator supplies the RTC block. If the main battery is not present, a backup supply such as a small mercury cell battery or a large capacitor is used. In addition to providing timing data, an alarm interrupt is generated and can be used to power up the baseband core via the BBWAKEUP pin. Regulator interrupts corresponding to seconds, minutes, hours and days can be generated whenever the time counter value reaches a maximum value (e.g., 59 for seconds and minutes, 23 for hours, etc.). The year span is supported up to 2127. The maximum day-of-month values, which depend on the leap year condition, are stored in the RTC block.

4.10.2 Register Definitions

RTC+0000h Baseband power up RTC_BBPU

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	KEY_BBPU								DBING	CBUSY	RELOAD	CLRPKY	AUTO	BBPU	WRITE_EN	PWREN
Type	WO								RO	RO	WO	WO	R/W	R/W	R/W	R/W

KEY_BBPU A bus write is acceptable only when KEY_BBPU=0x43.

DBING This bit indicates RTC is still de-bouncing.

CBUSY The read/write channels between RTC / Core is busy. This bit indicates high after software program sequence to anyone of RTC data registers and enable the transfer by RTC_WRTGR=1. By the way, it is high after the reset from low to high because RTC reload process.

RELOAD Reload the values from RTC domain to Core domain. Generally speaking, RTC will reload synchronize the data from RTC to core when reset from 0 to 1. This bit can be treated as debug bit.

CLRPKY Clear powerkey1 and powerkey2 at the same time. In some cases, software may clear powerkey1 & powerkey2. The BBWAKEUP depends on the matching specific patterns of powerkey1 and powerkey2. If any one of powerkey1 or powerkey2 or BBPU is cleared, BBWAKEUP goes low immediately. Software can't program the other control bits without power. By program RTC_BBPU with CLRPKY=1 and BBPU=0 condition, RTC can clear powerkey1, powerkey2 and BBPU at the same moment.

AUTO Controls if BBWAKEUP is automatically in the low state when SYSRST# transitions from high to low.

0 BBWAKEUP is not automatically in the low state when SYSRST# transitions from high to low.

1 BBWAKEUP is automatically in the low state when SYSRST# transitions from high to low.

BBPU Controls the power of PMIC. If powerkey1=A357h and powerkey2=67D2h, PMIC takes on the value programmed by software; otherwise PMIC is low.

0 Power down

1 Power on

WRITE_EN When WRITE_EN is write 0 by the MCU, the RTC programing interface is disabled immediately (MCU can't program RTC). After the debounce counter is time-out, the interface enabled again (MCU can program RTC). The debounce counter time-out period is decided by RTC_PDN1. Note that the WRITE_EN value read out is meaningless. The hardware only care about the "write-0 action" to WRITE_EN control bit.

When WRITE_EN==0, avoid to "read out RTC_BBPU, AND/OR something and write back", like this -> *RTC_BBPU=*RTC_BBPU|RTC_BBPU_KEY|0x1. This would disable RTC write interface for a while and hard to debug.

PWREN

0 RTC alarm has no action on power switch.

1 When an RTC alarm occurs, BBPU is set to 1 and the system powers on by RTC alarm wakeup.

RTC+0004h RTC IRQ status RTC_IRQ_STA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name															TCSTA	ALSTA
Type															R/C	R/C

ALSTA This register indicates the IRQ status and whether or not the alarm condition has been met.

0 No IRQ occurred; the alarm condition has not been met.

1 IRQ occurred; the alarm condition has been met.

TCSTA This register indicates the IRQ status and whether or not the tick condition has been met.

0 No IRQ occurred; the tick condition has not been met.

1 IRQ occurred; the tick condition has been met.

RTC+0008h RTC IRQ enable RTC_IRQ_EN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name														ONESHOT	TC_EN	AL_EN
Type														R/W	R/W	R/W

The function is only active when RTC_POWERKEY1 & RTC_POWERKEY2 match the correct values.

ONESHOT Controls automatic reset of AL_EN and TC_EN.

AL_EN This register enables the control bit for IRQ generation if the alarm condition has been met.

0 Disable IRQ generations.

1 Enable the alarm time match interrupt. Clear the interrupt when ONESHOT is high upon generation of the corresponding IRQ.

TC_EN This register enables the control bit for IRQ generation if the tick condition has been met.

0 Disable IRQ generations.

1 Enable the tick time match interrupt. Clear the interrupt when ONESHOT is high upon generation of the corresponding IRQ.

RTC+000Ch Counter increment IRQ enable RTC_CII_EN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							1/8SECCII	1/4SECCII	1/2SECCII	YEACII	MTHCII	DOWCII	DOMCII	HOUCII	MINCII	SECCII
Type							R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

This register activates or de-activates the IRQ generation when the TC counter reaches its maximum value.

SECCII Set this bit to 1 to activate the IRQ at each second update.

MINCII Set the bit to 1 to activate the IRQ at each minute update.

HOUCII Set the bit to 1 to activate the IRQ at each hour update.

DOMCII Set the bit to 1 to activate the IRQ at each day-of-month update.

DOWCII Set the bit to 1 to activate the IRQ at each day-of-week update.

MTHCII Set the bit to 1 to activate the IRQ at each month update.

YEACII Set the bit to 1 to activate the IRQ at each year update.

1/2SECCII Set the bit to 1 to activate the IRQ at each one-half of a second update.

1/4SECCII Set the bit to 1 to activate the IRQ at each one-fourth of a second update.

1/8SECCII Set the bit to 1 to activate the IRQ at each one-eighth of a second update.

RTC+0010h RTC alarm mask RTC_AL_MASK

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name										YEA_MSK	MTH_MSK	DOW_MSK	DOM_MSK	HOU_MSK	MIN_MSK	SEC_MSK
Type										R/W	R/W	R/W	R/W	R/W	R/W	R/W

The alarm condition for alarm IRQ generation depends on whether or not the corresponding bit in this register is masked. Warning: If you set all bits 1 in RTC_AL_MASK (i.e. RTC_AL_MASK=0x7f) and PWREN=1 in RTC_BBPU, it means alarm comes EVERY SECOND, not disabled.

SEC_MSK

- **0** Condition (RTC_TC_SEC = RTC_AL_SEC) is checked to generate the alarm signal.
- **1** Condition (RTC_TC_SEC = RTC_AL_SEC) is masked, i.e. the value of RTC_TC_SEC does not affect the alarm IRQ generation.

MIN_MSK

- **0** Condition (RTC_TC_MIN = RTC_AL_MIN) is checked to generate the alarm signal.
- **1** Condition (RTC_TC_MIN = RTC_AL_MIN) is masked, i.e. the value of RTC_TC_MIN does not affect the alarm IRQ generation.

HOU_MSK

- **0** Condition (RTC_TC_HOU = RTC_AL_HOU) is checked to generate the alarm signal.
- **1** Condition (RTC_TC_HOU = RTC_AL_HOU) is masked, i.e. the value of RTC_TC_HOU does not affect the alarm IRQ generation.

DOM_MSK

- **0** Condition (RTC_TC_DOM = RTC_AL_DOM) is checked to generate the alarm signal.
- **1** Condition (RTC_TC_DOM = RTC_AL_DOM) is masked, i.e. the value of RTC_TC_DOM does not affect the alarm IRQ generation.

DOW_MSK

- **0** Condition (RTC_TC_DOW = RTC_AL_DOW) is checked to generate the alarm signal.
- **1** Condition (RTC_TC_DOW = RTC_AL_DOW) is masked, i.e. the value of RTC_TC_DOW does not affect the alarm IRQ generation.

MTH_MSK

- **0** Condition (RTC_TC_MTH = RTC_AL_MTH) is checked to generate the alarm signal.
- **1** Condition (RTC_TC_MTH = RTC_AL_MTH) is masked, i.e. the value of RTC_TC_MTH does not affect the alarm IRQ generation.

YEA_MSK

- **0** Condition (RTC_TC_YEA = RTC_AL_YEA) is checked to generate the alarm signal.
- **1** Condition (RTC_TC_YEA = RTC_AL_YEA) is masked, i.e. the value of RTC_TC_YEA does not affect the alarm IRQ generation.

RTC+0014h RTC seconds time counter register RTC_TC_SEC

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											TC_SECOND					
Type											R/W					

TC_SECOND The second initial value for the time counter. The range of its value is: 0-59.

RTC+0018h RTC minutes time counter register RTC_TC_MIN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											TC_MINUTE					
Type											R/W					

TC_MINUTE The minute initial value for the time counter. The range of its value is: 0-59.

RTC+001Ch RTC hours time counter register RTC_TC_HOU

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												TC_HOUR				
Type												R/W				

TC_HOUR The hour initial value for the time counter. The range of its value is: 0-23.

RTC+0x0020 RTC day-of-month time counter register RTC_TC_DOM

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												TC_DOM				
Type												R/W				

TC_DOM The day-of-month initial value for the time counter. The day-of-month maximum value depends on the leap year condition, i.e. 2 LSB of year time counter are zeros.

RTC+0x0024 RTC day-of-week time counter register RTC_TC_DOW

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name														TC_DOW		
Type														R/W		

TC_DOW The day-of-week initial value for the time counter. The range of its value is: 1-7.

RTC+0x0028 RTC month time counter register RTC_TC_MTH

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													TC_MONTH			
Type													R/W			

TC_MONTH The month initial value for the time counter. The range of its value is: 1-12.

RTC+0x002C RTC year time counter register RTC_TC_YEA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name										AL_SECOND						
Type										R/W						

TC_YEAR The year initial value for the time counter. The range of its value is: 0-127. (2000-2127)

RTC+0x0030 RTC second alarm setting register RTC_AL_SEC

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											AL_SECOND					
Type											R/W					

AL_SECOND The second value of the alarm counter setting. The range of its value is: 0-59.

RTC+0x0034 RTC minute alarm setting register RTC_AL_MIN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											AL_MINUTE					
Type											R/W					

AL_MINUTE The minute value of the alarm counter setting. The range of its value is: 0-59.

RTC+0x0038 RTC hour alarm setting register RTC_AL_HOU

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												AL_HOUR				
Type												R/W				

AL_HOUR The hour value of the alarm counter setting. The range of its value is: 0-23.

RTC+0x003C RTC day-of-month alarm setting register RTC_AL_DOM

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												AL_DOM				
Type												R/W				

AL_DOM The day-of-month value of the alarm counter setting. The day-of-month maximum value depends on the leap year condition, i.e. 2 LSB of year time counter are zeros.

RTC+0x0040 RTC day-of-week alarm setting register RTC_AL_DOW

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name														AL_DOW		
Type														R/W		

AL_DOW The day-of-week value of the alarm counter setting. The range of its value is: 1-7.

RTC+0x0044 RTC month alarm setting register RTC_AL_MTH

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													AL_MONTH			
Type													R/W			

AL_MONTH The month value of the alarm counter setting. The range of its value is: 1-12.

RTC+0x0048 RTC year alarm setting register RTC_AL_YEA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name										AL_YEAR						
Type										R/W						

AL_YEAR The year value of the alarm counter setting. The range of its value is: 0-127. (2000-2127)

RTC+0x004C XOSC bias current control register RTC_XOSCCALI

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												XOSCCALI				
Type												RO				

XOSCCALI This register controls the XOSC32 bias current.

RTC+0050h RTC_POWERKEY1 register RTC_POWERKEY1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RTC_POWERKEY1															
Type	R/W															

RTC+0054h RTC_POWERKEY2 register RTC_POWERKEY2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RTC_POWERKEY2															
Type	R/W															

These register sets are used to determine if the real time clock has been programmed by software; i.e. the time value in real time clock is correct. When the real time clock is first powered on, the register contents are all undefined, therefore the time values shown are incorrect. Software needs to know if the real time clock has been programmed. Hence, these two registers are defined to solve this power-on issue. After software programs the correct value, these two register sets do not need to be updated. In addition to programming the correct time value, when the contents of these register sets are wrong, the interrupt is not generated. Therefore, the real time clock does not generate the interrupts before the software programs the registers; unwanted interrupt due to wrong time value do not occur. The correct values of these two register sets are:

RTC_POWERKEY1 A357h
RTC_POWERKEY2 67D2h

RTC+0058h PDN1 RTC_PDN1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									RTC_PDN1[7:0]							
Type									R/W							

RTC_PDN1[3:1] is for reset de-bounce mechanism. When RTC_POWERKEY1 & RTC_POWERKEY2 do not match the correct values, RTC_PDN1[3:1] is set to 3 (011 in binary).

- **0** 2ms
- **1** 8ms
- **2** 32ms
- **3** 128ms
- **4** 256ms
- **5** 512ms
- **6** 1024ms
- **7** 2048ms

RTC_PDN1[7:4] & RTC_PDN1[0] is the spare register for software to keep power on and power off state information.

RTC+005Ch PDN2 RTC_PDN2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									RTC_PDN2[7:0]							
Type									R/W							

RTC_PDN2 The spare register for software to keep power on and power off state information.

RTC+0064h Spare register for specific purpose RTC_SPAR1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RTC_SPAR1															
Type	R/W															

RTC_SPAR$_X$ These registers are reserved for specific purpose.

RTC+006ch One-time calibration offset RTC_DIFF

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					RTC_DIFF											
Type					R/W											

The function is only active when RTC_POWERKEY1 & RTC_POWERKEY2 match the correct values.

RTC_DIFF These registers are used to adjust the internal counter of RTC. It effects once and returns to zero in done.

In some cases, you observe the RTC is faster or slower than the standard. To change RTC_TC_SEC is coarse and may cause alarm problem. RTC_DIFF provides a finer time unit. An internal 15-bit counter accumulates in each 32768-HZ clock. Entering a non-zero value into the RTC_DIFF causes the internal RTC counter increases or decreases RTC_DIFF when RTC_DIFF changes to zero again. RTC_DIFF represents as 2's completement form.

For example, if you fill in 0xfff into RTC_DIFF, the internal counter decreases 1 when RTC_DIFF returns to zero. In other words, you can only use RTC_DIFF continuously if RTC_DIFF is equal to zero now.

Note: RTC_DIFF ranges from 0x800 (-2048) to 0x7fd (2045). 0x7ff & 0x7fe are forbid to use.

RTC+0070h Repeat calibration offset RTC_CALI

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name										RTC_CALI						
Type										WO						

The function is only active when RTC_POWERKEY1 & RTC_POWERKEY2 match the correct values.

RTC_CALI These registers provide a repeat calibration scheme. RTC_CALI provides 7-bit calibration capability in 8-second duration; in other words, 5-bit calibration capability in each second. RTC_CALI represents in 2's complement form, such that you can adjust RTC increasing or decreasing.

Due to RTC_CALI is revealed in 8 seconds, the resolution is less than a 1/32768 clock.
Avg. resolution: 1/32768/8=3.81us
Avg. adjust range: -0.244~0.240ms/sec in 2's complement: -0x40~0x3f (-64~63)

RTC+0074h Enable the transfers from core to RTC in the queue RTC_WRTGR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																WRTGR
Type																WO

WRTGR This register enables the transfers from core to RTC. After you modify all the RTC registers you'd like to change, you must write RTC_WRTGR to 1 to trigger the transfer. The prior writing operations are queued at core power domain. The pending data will not be transferred to RTC domain until WRTGR=1.
After WRTGR=1, the pending data is transferred to RTC domain sequentially in order of register address, from low to high. For example: RTC_BBPU -> RTC_IRQ_EN -> RTC_CII_EN -> RTC_AL_MASK -> RTC_TC_SEC -> etc. The CBUSY in RTC_BBPU is equal to 1 in writing process. You can observe CBUSY to determine when the transmission completes.

4.11 Auxiliary ADC Unit

The auxiliary ADC unit is used to monitor the status of the battery and charger, to identify the plugged peripheral, and to perform temperature measurement. Seven input channels allow diverse applications in this unit.

Each channel can operate in one of two modes: immediate mode and timer-triggered mode. The mode of each channel can be individually selected through register AUXADC_CON0. For example, if the flag SYN0 in the register AUXADC_CON0 is set, the channel 0 is set in timer-triggered mode. Otherwise, the channel operates in immediate mode.

In immediate mode, the A/D converter samples the value once only when the flag in the AUXADC_CON1 register has been set. For example, if the flag IMM0 in AUXADC_CON1 is set, the A/D converter samples the data for channel 0. The IMM flags must be cleared and set again to initialize another sampling.

The value sampled for channel 0 is stored in register AUXADC_DAT0, the value for channel 1 is stored in register AUXADC_DAT1, etc.

If the AUTOSET flag in the register AUXADC_CON3 is set, the auto-sample function is enabled. The A/D converter samples the data for the channel in which the corresponding data register has been read. For example, in the case where the SYN1 flag is not set, the AUTOSET flag is set, when the data register AUXADC_DAT0 has been read, the A/D converter samples the next value for channel 1 immediately.

If multiple channels are selected at the same time, the task is performed sequentially on every selected channel. For example, if AUXADC_CON1 is set to 0x7f, that is, all 7 channels are selected, the state machine in the unit starts sampling from channel 6 to channel 0, and saves the values of each input channel in the respective registers. The same process also applies in timer-triggered mode.

In timer-triggered mode, the A/D converter samples the value for the channels in which the corresponding SYN flags are set when the TDMA timer counts to the value specified in the register TDMA_AUXEV1, which is placed in the TDMA timer. For example, if AUXADC_CON0 is set to 0x7f, all 7 channels are selected to be in timer-triggered mode. The state machine samples all 7 channels sequentially and save the values in registers from AUXADC_DAT0 to AUXADC_DAT6, as it does in immediate mode.

There is a dedicated timer-triggered scheme for channel 0. This scheme is enabled by setting the SYN7 flag in the register AUXADC_CON2. The timing offset for this event is stored in the register TDMA_AUXEV0 in the TDMA timer. The sampled data triggered by this specific event is stored in the register AUXADC_DAT7. It is used to separate the results of two individual software routines that perform actions on the auxiliary ADC unit.

The AUTOCLR*n* in the register AUXADC_CON3 is set when it is intended to sample only once after setting timer-triggered mode. If AUTOCLR1 flag has been set, after the data for the channels in timer-triggered mode has been stored, the SYN*n* flags in the register AUXADC_CON0 are cleared. If AUTOCLR0 flag has been set, after the data for the channel 0 has been stored in the register AUXADC_DAT7, the SYN7 flag in the register AUXADC_CON2 is cleared.

The usage of the immediate mode and timer-triggered mode are mutually exclusive in terms of individual channels.

The PUWAIT_EN bit in the registers AUXADC_CON3 is used to power up the analog port in advance. This ensures that the power has ramped up to the stable state before A/D converter starts the conversion. The analog part is automatically powered down after the conversion is completed.

In MT6235, there are only four external pins (channel 0~3) for voltage detection. The other channels (4~6) are for battery voltage, battery current, and charger, respectively.

4.11.1 Register Definitions

AUXADC+0000h Auxiliary ADC control register 0 AUXADC_CON0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name										**SYN6**	**SYN5**	**SYN4**	**SYN3**	**SYN2**	**SYN1**	**SYN0**
Type										R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset										0	0	0	0	0	0	0

SYN*n* These 7 bits define whether the corresponding channel is sampled or not in timer-triggered mode. It is associated with timing offset register TDMA_AUXEV1. It supports multiple flags. The flags can be automatically cleared after those channel have been sampled if AUTOCLR1 in the register AUXADC_CON3 is set. To monitor ISENSE and BATSNS, the register INT_NODE_MUX[2] must be set to 1 in advanced.

0 The channel is not selected.

1 The channel is selected.

AUXADC+0004h Auxiliary ADC control register 1 AUXADC_CON1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name										**IMM6**	**IMM5**	**IMM4**	**IMM3**	**IMM2**	**IMM1**	**IMM0**
Type										R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset										0	0	0	0	0	0	0

IMM*n* These 7 bits are set individually to sample the data for the corresponding channel. It supports multiple flags.

0 The channel is not selected.

1 The channel is selected.

AUXADC+0008h Auxiliary ADC control register 2 AUXADC_CON2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																SYN7
Type																R/W
Reset																0

SYN7 This bit is used only for channel 0 and is to be associated with timing offset register TDMA_AUXEV0 in the TDMA timer in timer-triggered mode. The flag can be automatically cleared after channel 0 has been sampled if AUTOCLR0 in the register AUXADC_CON3 is set.

0 The channel is not selected.

1 The channel is selected.

AUXADC+000Ch Auxiliary ADC control register 3 AUXADC_CON3

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	AUTOSET				PUWAIT_EN		AUTOCLR1	AUTOCLR0								STA
Type	R/W				R/W		R/W	R/W								RO
Reset	0				0		0	0								0

AUTOSET This field defines the auto-sample mode of the module. In auto-sample mode, each channel with its sample register being read can start sampling immediately without configuring the control register AUXADC_CON1 again.

PUWAIT_EN Thus field enables the power warm-up period to ensure power stability before the SAR process takes place. It is recommended to activate this field.

0 The mode is not enabled.

1 The mode is enabled.

AUTOCLR1 The field defines the auto-clear mode of the module for event 1. In auto-clear mode, each timer-triggered channel gets samples of the specified channels once the SYN*n* bit in the register AUXADC_CON0 has been set. The SYN*n* bits are automatically cleared and the channel is not enabled again by the timer event except when the SYN*n* flags are set again.

0 The automatic clear mode is not enabled.

1 The automatic clear mode is enabled.

AUTOCLR0 The field defines the auto-clear mode of the module for event 0. In auto-clear mode, the timer-triggered channel 0 gets the sample once the SYN7 bit in the register AUXADC_CON2 has been set. The SYN7 bit is automatically cleared and the channel is not enabled again by the timer event 0 except when the SYN7 flag is set again.

0 The automatic clear mode is not enabled.

1 The automatic clear mode is enabled.

STA The field defines the state of the module.

0 This module is idle.

1 This module is busy.

AUXADC+0010h Auxiliary ADC channel 0 register AUXADC_DAT0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							DAT									
Type							RO									
Reset							0									

The register stores the sampled data for the channel 0. There are 8 registers of the same type for the corresponding channel . The overall register definition is listed in **Table 22**.

Register Address	Register Function	Acronym
AUXADC+0010h	Auxiliary ADC channel 0 data register	AUXADC_DAT0
AUXADC+0014h	Auxiliary ADC channel 1 data register	AUXADC_DAT1
AUXADC+0018h	Auxiliary ADC channel 2 data register	AUXADC_DAT2
AUXADC+001Ch	Auxiliary ADC channel 3 data register	AUXADC_DAT3
AUXADC+0020h	Auxiliary ADC channel 4 data register	AUXADC_DAT4
AUXADC+0024h	Auxiliary ADC channel 5 data register	AUXADC_DAT5
AUXADC+0028h	Auxiliary ADC channel 6 data register	AUXADC_DAT6
AUXADC+002Ch	Auxiliary ADC channel 0 data register for TDMA event 0	AUXADC_DAT7

Table 22 Auxiliary ADC data register list

AUXADC+0030h Touch Screen Debounce Time AUX_TS_DEBT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			DEBOUNCE TIME													
Type			R/W													
Reset			0													

DEBOUNCE TIME While the analog touch screen irq signal is from high to low level, auxadc will issue an interrupt after the debounce time.

AUXADC+0034h Touch Screen Sample Command AUX_TS_CMD

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name										ADDRESS			MODE	SE/DF	PD	
Type										R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset										0	0	0	0	0	0	0

ADDRESS Define which x or y or z data will be sampled.

001 Y Position

011 Z1 Position

100 Z2 Position

101 X Position

Others Reserved

MODE Select the sample resolution

- **0** 10-bit resolution
- **1** 8-bit resolution

SE/DF Mode selection

- **0** Differential mode
- **1** Single-end mode

PD Power down control for analog IRQ signal and touch screen sample control signal

- **00** Turn on Y-_drive signal and PDN_sh_ref
- **01** Turn on PDN_IRQ and PDN_sh_ref
- **10** Reserved
- **11** Turn on PDN_IRQ

AUXADC +0038h **Touch Screen Control** **AUX_TS_CON**

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name															ST	SPL
Type															R	R/W
Reset															0	0

SPL Touch Screen Sample Trigger

- **0** No Action
- **1** While SW writes 1'b1, auxadc will trigger the touch screen process. After the sample process of touch screen finishes, this bit will be disserted.

ST Touch Screen Status

- **0** Touch Screen is idle.
- **1** Touch Screen is touched.

AUXADC +003Ch **Touch Screen Sample DATA** **AUX_TS_DAT0**

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							DAT									
Type							RO									
Reset							0									

This register stores the touch screen sample data.

4.12 I2C / SCCB Controller

4.12.1 General Description

I2C (Inter-IC) /SCCB (Serial Camera Control Bus) is a two-wire serial interface. The two signals are SCL and SDA. SCL is a clock signal that is driven by the master. SDA is a bi-directional data signal that can be driven by either the master or the slave. This generic controller supports the master role and conforms to the I2C specification.

4.12.1.1 Feature Support

I2C compliant master mode operation

Adjustable clock speed for LS/FS mode operation.

7bit/10 bit addressing support.

High Speed mode support.

Slave Clock Extension support.

START/STOP/REPEATED START condition

Manual/DMA Transfer Mode

Multi write per transfer (up to 8 data bytes for non dma mode and 255 data bytes for dma mode)

Multi read per transfer (up to 8 data bytes for non dma mode and 255 data bytes for dma mode)

Multi transfer per transaction (up to 256 write transfers or 256 read transfers with dma mode)

DMA mode with Fifo Flow Control and bus signal holding

Combined format transfer with length change capability.

Active drive / wired-and I/O configuration

4.12.1.2 Manual/DMA Transfer Mode

The controller offers 2 types of transfer mode, Manual and DMA.

When Manual mode is selected, in addition to the slave address register, the controller has a built-in 8byte deep FIFO which allows mcu to prepare up to 8 bytes of data for a write transfer, or read up to 8 bytes of data for a read transfer.

When DMA mode is enabled, the data to and from the FIFO is controlled via DMA transfer and can therefore support up to 255 bytes of consecutive read or write, with the data read from or write to another memory space. When DMA mode is enabled, flow control mechanism is also implemented to hold the bus clk when FIFO underflow or overflow condition is encountered.

4.12.1.3 Transfer format support

This controller has been designed to be as generic as possible in order to support a wide range of devices that may utilize different combinations of transfer formats. Here are the transfer format types that can be supported through different software configuration:

(Wording convention note:

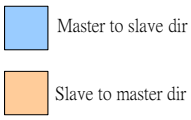
transfer = anything encapsulated within a Start and Stop or Repeated Start.

transfer length = the number of bytes within the transfer.

transaction = this is the top unit. Everything combined equals 1 transaction.

Transaction length = the number of transfers to be conducted.

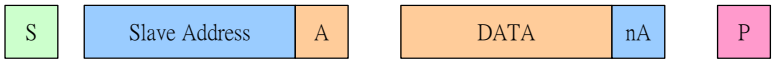
)



Single Byte Access

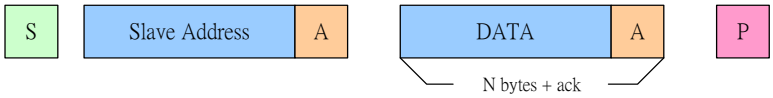
Single Byte Write

Single Byte Read

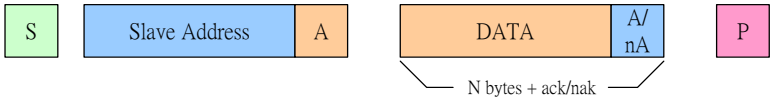


Multi Byte Access

Multi Byte Write

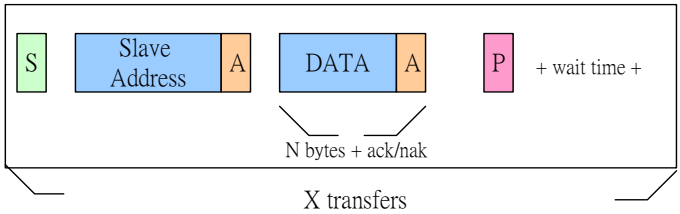


Multi Byte Read

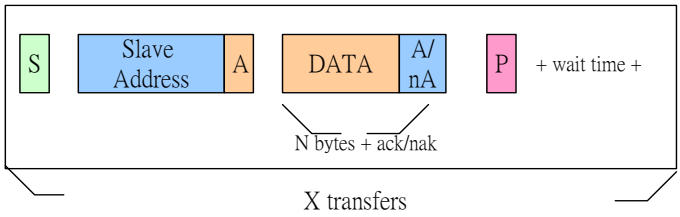


Multi Byte Transfer + Multi Transfer (same direction)

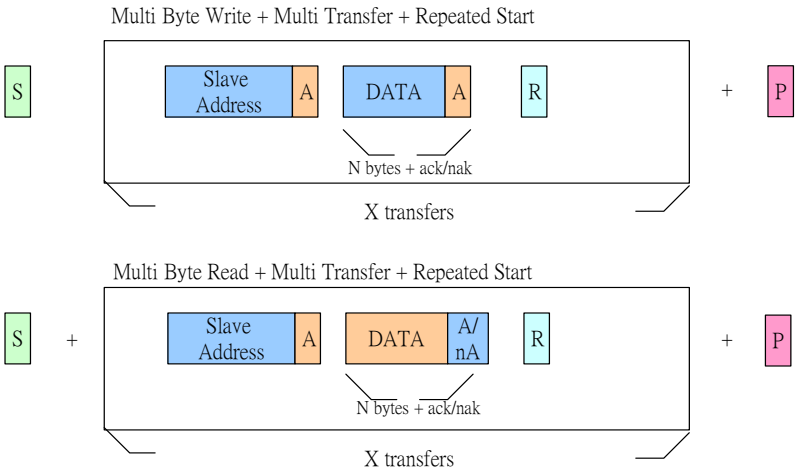
Multi Byte Write + Multi Transfer



Multi Byte Read + Multi Transfer

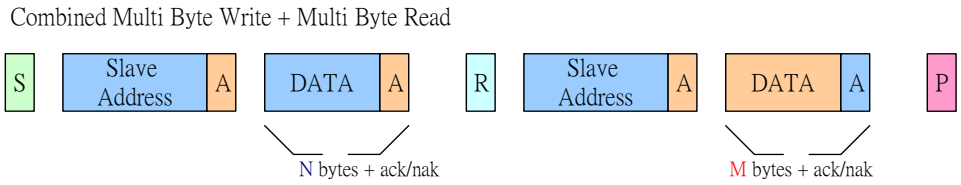


Multi Byte Transfer + Multi Transfer w RS (same direction)



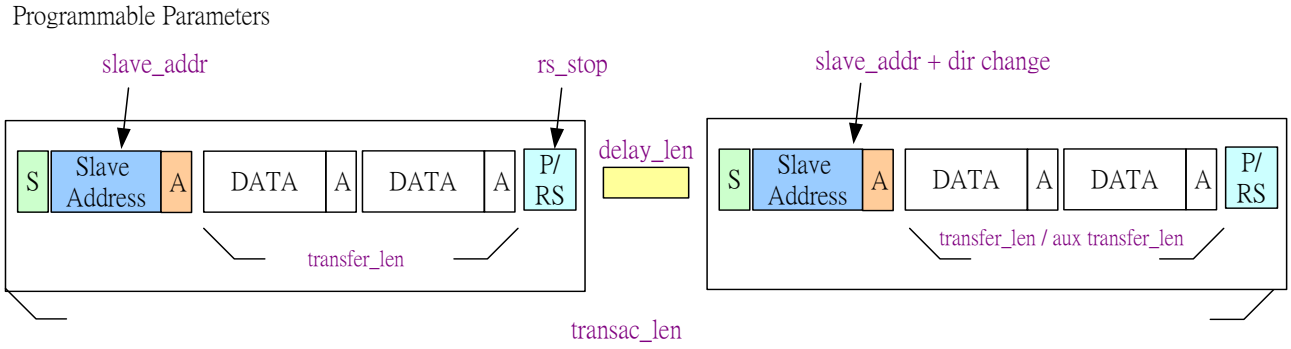
Combined Write/Read with Repeated Start (direction change)

(Note: Only supports Write and then Read sequence. Read and then Write is not supported)

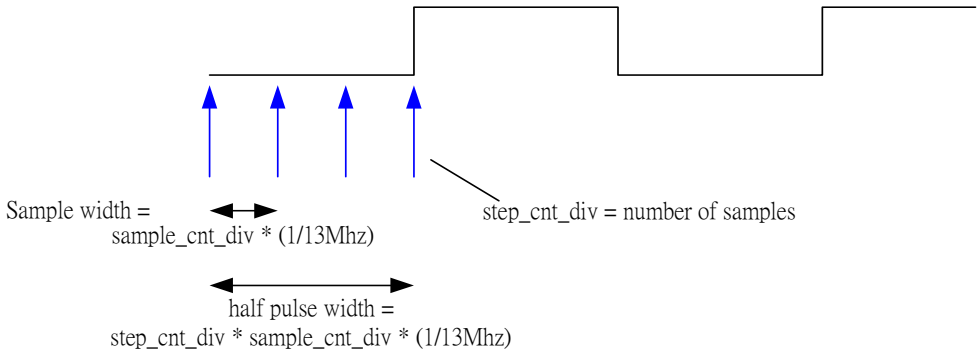


4.12.2 Programming Examples

Common Transfer Programmable Parameters



Output Waveform Timing Programmable Parameters



4.12.3 Register Definitions

I2CREG+0000h Data Port Register — DATA_PORT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									FIFO DATA							
Type									R/W							
Reset									0							

DATA_PORT[7:0] This is the FIFO access port. During master write sequences (slave_addr[0] = 0), this port can be written by APB, and during master read sequences (slave_addr[0] = 1), this port can be read by APB.

(NOTE) Slave_addr must be set correctly before accessing the fifo.

(DEBUG ONLY) If the fifo_apb_debug bit is set, then the FIFO can be read and write by the APB

I2CREG+0004h Slave Address Register — SLAVE_ADDR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									SLAVE_ADDR							
Type									R/W							
Reset									0							

SLAVE_ADDR [7:0] This specifies the slave address of the device to be accessed. Bit 0 is defined by the I2C protocol as a bit that indicates the direction of transfer. 1 = master read, 0 = master write.

I2CREG+0008h Interrupt Mask Register — INTR_MASK

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													DEBUG	HS_NACKER	ACKERR	TRANSAC_COMP
Type													R.W	R/W	R/W	R/W
Reset													1	1	1	1

This register provides masks for the corresponding interrupt sources as indicated in intr_stat register.

1 = allow interrupt

0 = disable interrupt

Note: while disabled, the corresponding interrupt will not be asserted, however the intr_stat will still be updated with the status. Ie. mask does not affect intr_stat register values.

I2CREG+000Ch Interrupt Status Register INTR_STAT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name														HS_NACKERR	ACKERR	TRANSAC_COMP
Type														W1C	W1C	W1C
Reset														0	0	0

When an interrupt is issued by i2c controller, this register will need to be read by mcu to determine the cause for the interrupt. After this status has been read and appropriate actions are taken, the corresponding interrupt source will need to be write 1 cleared.

HS_NACKERR This status is asserted if hs master code nack error detection is enabled. If enabled, hs master code nack err will cause transaction to end and stop will be issued.

ACKERR This status is asserted if ACK error detection is enabled. If enabled, ackerr will cause transaction to end and stop will be issued.

TRANSAC_COMP This status is asserted when a transaction has completed successfully.

I2CREG+0010h Control Register CONTROL

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name										TRANSFER_LEN_CHANGE	ACKERR_DET_EN	DIR_CHANGE	CLK_EXTEN	DMA_EN	RS_STOP	
Type										R/W	R/W	RW	RW	RW	RW	R/W
Reset										0	0	0	0	0	0	0

TRANSFER_LEN_CHANGE This options specifies whether or not to change the transfer length after the fist transfer completes. If enabled, the transfers after the first transfer will use the transfer_len_aux parameter.

ACKERR_DET_EN This option enables slave ack error detection. When enabled, if slave ack error is detected, the master shall terminate the transaction by issuing a STOP condition and then asserts ackerr interrupt. Mcu shall handle this case appropriately and then resets the fifo address before reissuing transaction again. If this option is disabled, the controller will ignore slave ack error and keep on scheduled transaction.

0 disable
1 enable

DIR_CHANGE This option is used for combined transfer format, where the direction of transfer is to be changed from write to read after the FIRST RS condition. Note: when set to 1, the transfers after the direction change will be based on the transfer_len_aux parameter.

0 disable
1 enable

CLK_EXT_EN I2C spec allows slaves to hold the SCL line low if it is not yet ready for further processing. Therefore, if this bit is set to 1, master controller will enter a high wait state until the slave releases the SCL line.

DMA_EN By default, this is disabled, and fifo data shall be manually prepared by mcu. This default setting should be used for transfer sizes of less than 8 data bytes and no multiple transfer is configured. When enabled, dma requests are turned on, and the fifo data should be prepared in memory.

RS_STOP In LS/FS mode, this bit affects multi-transfer transaction only. It controls whether or not REPEATED-START condition is used between transfers. The last ending transfer always ends with a STOP.

In HS mode, this bit must be set to 1.

0 use STOP

1 use REPEATED-START

I2CREG+0014h Transfer Length Register (Number of Bytesper Transfer) TRANSFER_LEN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				TRANSFER_LEN_AUX					TRANSFER_LEN							
Type				R/W												R/W
Reset				‘h1												‘h1

TRANSFER_LEN_AUX[4:0] This field is valid only when dir_change is set to 1. This indicates the number of DATA BYTES to be transferred in 1 transfer unit (excluding slave address byte) for the transfers following the direction change. I.e., if dir_change =1, then the first write transfer length depends on transfer_len, while the second read transfer length depend on transfer_len_aux. Dir change is always after the first transfer.

(NOTE) The value must be set greater than 1, otherwise no transfer will take place.

TRANSFER_LEN[7:0] This indicates the number of DATA BYTES to be transferred in 1 transfer unit (excluding slave address byte)

(NOTE) The value must be set greater than 1, otherwise no transfer will take place.

I2CREG+0018h Transaction Length Register (Number of Transfers per Transaction) TRANSAC_LEN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									TRANSAC_LEN							
Type																R/W
Reset																‘h1

TRANSAC_LEN[7:0] This indicates the number of TRANSFERS to be transferred in 1 transaction

(NOTE) The value must be set greater than 1, otherwise no transfer will take place.

I2CREG+001Ch Inter Delay Length Register DELAY_LEN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									DELAY_LEN							
Type									R/W							
Reset									‘h2							

DELAY_LEN[3:0] This sets the wait delay between consecutive transfers when RS_STOP bit is set to 0. (the unit is same as the half pulse width)

I2CREG+0020h Timing Control Register — TIMING

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DATA READ ADJ	DATA_READ_TIME				SAMPLE_CNT_DIV					STEP_CNT_DIV					
Type	R/W	R/W				R/W					R/W					
Reset	'h0	'h1				'h3					'h3					

LS/FS only. This register is used to control the output waveform timing. Each half pulse width (ie. each high or low pulse) is equal to = step_cnt_div * (sample_cnt_div * 1/13Mhz)

SAMPLE_CNT_DIV[2:0] Used for LS/FS only. This adjusts the width of each sample. (sample width = sample_cnt_div * 1/13Mhz)

STEP_CNT_DIV[5:0] This specifies the number of samples per half pulse width (ie. each high or low pulse)

DATA_READ_ADJ When set to 1, data latch in sampling time during master reads are adjusted according to DATA_READ_TIME value. Otherwise, by default, data is latched in at half of the high pulse width point. This value must be set to less or equal to half the high pulse width.

DATA_READ_TIME[2:0] This value is valid only when DATA_READ_ADJ is set to 1. This can be used to adjust so that data is latched in at earlier sampling points (assuming data is settled by then)

I2CREG+0024h Start Register — START

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																START
Type																R/W
Reset																0

START This register starts the transaction on the bus. It is auto deasserted at the end of the transaction.

I2CREG+0030h Fifo Status Register — FIFO_STAT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RD_ADDR				WR_ADDR				FIFO_OFFSET						WR_FULL	RD_EMPTY
Type	RO				RO				RO						RO	RO
Reset	0				0				0				0	0	0	0

RD_ADDR[3:0] The current rd address pointer. (only bit [2:0] has physical meaning)

WR_ADDR[3:0] The current wr address pointer. (only bit [2:0] has physical meaning)

FIFO_OFFSET[3:0] wr_addr[3:0] – rd_addr[3:0]

WR_FULL This indicates that the fifo is full.

RD_EMPTY This indicates that the fifo is empty.

I2CREG+0034h Fifo Thresh Register — FIFO_THRESH

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name						TX_TRIG_THRESH						RX_TRIG_THRESH
Type						RW						R/W
Reset						'h7						'h0

DEBUG ONLY. By default, these values do not need to be adjusted. Note! for RX, no timeout mechanism is implemented. Therefore, RX_trig_thresh must be left at 0, or there would be data left in the fifo that is not fetched by DMA controller.

TX_TRIG_THRESH[2:0] When tx fifo level is below this value, tx dma request is asserted.

RX_TRIG_THRESH[2:0] When rx fifo level is above this value, rx dma request is asserted.

I2CREG+0038h Fifo Address Clear Register — FIFO_ADDR_CLR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																FIFO_ADDR_CR
Type																WO
Reset																0

FIFO_ADDR_CLR When written with a 1'b1, a 1 pulse fifo_addr_clr is generated to clear the fifo address to back to 0.

I2CREG+0040h IO Config Register — IO_CONFIG

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name														IO SYNC EN	SDA_IO_CONFIG	SCL_IO_CONFIG
Type														R/W	R/W	R/W
Reset														0	0	0

This register is used to configure the I/O for the sda and scl lines to select between normal i/o mode, or open-drain mode to support wired-and bus.

IO_SYNC_EN DEBUG ONLY: When set to 1, scl and sda inputs will be first dual synced by bclk_ck. This should not be needed. Only reserved for debugging.

SDA_IO_CONFIG 0 normal tristate io mode

1 open-drain mode

SCL_IO_CONFIG 0 normal tristate io mode

1 open-drain mode

I2CREG+0044h RESERVED DEBUG Register — DEBUG

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																
Type														R/W	R/W	R/W
Reset														0	0	0

NOTE: This register is for DEBUG ONLY. The bits are R/W, do not change the values from the default value.

I2CREG+0048h High Speed Mode Register HS

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name		HS_SAMPLE_CNT DIV				HS_STEP_CNT_DIV				MASTER_CODE					HS_NACKERR_DET_EN	HS_EN
Type		R/W				R/W				R/W					R/W	R/W
Reset		0				1				0					1	0

This register contains options for supporting high speed operation features

Each HS half pulse width (ie. each high or low pulse) is equal to = step_cnt_div * (sample_cnt_div * 1/13Mhz)

HS_SAMPLE_CNT_DIV[2:0] When high speed mode is entered after the master code transfer has been completed, the sample width becomes dependent on this parameter.

HS_STEP_CNT_DIV[2:0] When high speed mode is entered after the master code transfer has been completed, the number of samples per half pulse width becomes dependent on this value.

MASTER_CODE[2:0] This is the 3 bit programmable value for the master code to be transmitted.

HS_NACKERR_DET_EN This enables NACKERR detection during the master code transmission. When enabled, if NACK is not received after master code has been transmitted, the transaction will terminated with a STOP condition.

HS_EN This enables the high speed transaction. (note: rs_stop must be set to 1 as well)

I2CREG+0050h Soft Reset Register SOFTRESET

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																SOFT_RESET
Type																WO
Reset																0

SOFT_RESET When written with a 1'b1, a 1 pulse soft reset is used as synchronous reset to reset the I2C internal hardware circuits.

I2CREG+0064h Debug Status Register DEBUGSTAT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name										BUS_BUSY	MASTER_WRITE	MASTER_READ	MASTER_STATE			
Type										RO	RO	RO	RO			
Reset										0	1	0	0			

BUS_BUSY DEBUG ONLY: valid when bus_detect_en is 1. bus_busy = 1 indicates a start transaction has been detected and no stop condition has been detected yet.

MASTER_WRITE DEBUG ONLY: 1 = current transfer is in the master write dir

MASTER_READ DEBUG ONLY: 1 = current transfer is in the master read dir

MASTER_STATE[3:0] DEBUG ONLY: reads back the current master_state.

I2CREG+0068h Debug Control Register DEBUGCTRL

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name															APB_DEBUG_RD	FIFO_APB_DEBUG
Type															WO	R/W
Reset															0	0

APB_DEBUG_RD This bit is only valid when fifo_apb_debug is set to 1. Writing to this register will generate a 1 pulsed fifo apb rd signal for reading the fifo data.

FIFO_APB_DEBUG This is used for trace32 debug purposes. When using trace32, and the memory map is shown, turning this bit on will block the normal apb read access. Apb read access to the fifo is then enabled by writing to apb_debug_rd.

0 disable
1 enable

5 Microcontroller Coprocessors

Microcontroller Coprocessors are designed to run computing-intensive processes in place of the Microcontroller (MCU). These coprocessors especially target timing critical GSM/GPRS Modem processes that require fast response and large data movement. Controls to the coprocessors are all through memory access via the APB.

5.1 Divider

To ease the processing load of MCU, a divider is employed here. The divider can operate signed and unsigned 32bit/32bit division, as well as modulus. The processing time of the divider is from 1 clock cycle to 33 clock cycles, which depends upon the magnitude of the value of the dividend. The detailed processing time is listed below in Table 18. From the table we can see that there are two kind of processing time (except for when the dividend is zero) in an item. Which kind depends on whether there is the need for restoration at the last step of the division operation.

After the divider is started by setting START to "1" in Divider Control Register, DIV_RDY will go low, and it will be asserted after the division process is finished. MCU could detect this status bit by polling it to know the correct access timing. In order to simplify polling, only the value of register DIV_RDY will appear while Divider Control Register is read. Hence, MCU does not need to mask other bits to extract the value of DIV_RDY.

In GSM/GPRS system, many divisions are executed with some constant divisors. Therefore, some often-used constants are stored in the divider to speed up the process. By controlling control bits IS_CNST and CNST_IDX in Divider Control register, one can start a division without giving a divisor. This could save the time for writing divisor in and the instruction fetch time, and thus make the process more efficient.

Signed Division		Unsigned Division	
Dividend	**Clock Cycles**	**Dividend**	**Clock Cycles**
0000_0000h	1	0000_0000h	1
0000_00ffh – (-0000_0100h), excluding 0x0000_0000	8 or 9	0000_0001h - 0000_00ffh	8 or 9
0000_ffffh – (-0001_0000h)	16 or 17	0000_0100h - 0000_ffffh	16 or 17
00ff_ffffh – (-0100_0000h)	24 or 25	0001_0000h - 00ff_ffffh	24 or 25
7fff_ffffh – (-8000_0000h)	32 or 33	0100_0000h - ffff_ffffh	32 or 33

Table 23 Processing time in different value of dividend.

5.1.1 Register Definitions

DIVIDER+0000h Divider Control Register DIV_CON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name														CNST_IDX		
Type														WO		
Reset														0		
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											IN_CNST	SIGN			DIV_RDY	START

Type											WO	WO			RO	WO
Reset											0	1			1	0

START To start division. It will return to 0 after division has started.

DIV_RDY Current status of divider. Note that when DIV_CON register is read, only the value of DIV_RDY will appear. That means program does not need to mask other part of the register to extract the information of DIV_RDY.

0 division is in progress.

1 division is finished.

SIGN To indicate signed or unsigned division.

0 Unsigned division.

1 Signed division.

IS_CNST To indicate if internal constant value should be used as a divisor. If IS_CNST is enabled, User does not need to write the value of the divisor, and divider will automatically use the internal constant value instead. What value divider will use depends on the value of CNST_IDX.

0 Normal division. Divisor is written in via APB

1 Using internal constant divisor instead.

CNST_IDX Index of constant divisor.

0 divisor = 13

1 divisor = 26

2 divisor = 51

3 divisor = 52

4 divisor = 102

5 divisor = 104

DIVIDER +0004h Divider Dividend register DIV_DIVIDEND

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DIVIDEND[31:16]															
Type	WO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DIVIDEND[15:0]															
Type	WO															
Reset	0															

Dividend.

DIVIDER +0008h Divider Divisor register DIV_DIVISOR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DIVISOR[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DIVISOR[15:0]															
Type	R/W															
Reset	0															

Divisor.

DIVIDER +000Ch **Divider Quotient register** **DIV_QUOTIENT**

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	QUOTIENT[31:16]															
Type	RO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	QUOTIENT[15:0]															
Type	RO															
Reset	0															

Quotient.

DIVIDER +0010h **Divider Remainder register** **DIV_REMAINDER**

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	REMAINDER[31:16]															
Type	RO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	REMAINDER[15:0]															
Type	RO															
Reset	0															

Remainder.

5.2 CSD Accelerator

5.2.1 General Description

This unit performs the data format conversion of RA0, RA1, and FAX in CSD service. CSD service consists of two major functions: data flow throttling and data format conversion. The data format conversion is a bit-wise operation and takes a number of instructions to complete a conversion. Therefore, it is not efficient to do by MCU itself. A coprocessor, CSD accelerator, is designed here to reduce the computing power needed to perform this function.

CSD accelerator only helps in converting data format; the data flow throttling function is still implemented by the MCU. CSD accelerator performs three types of data format conversion, RA0, RA1, and FAX.

For RA0 conversion, only uplink RA0 data format conversion is provided here. This is because there are too many judgments on the downlink path conversion, which will greatly increase area cost. Uplink RA0 conversion is to insert one start bit and one stop bit before and after a byte, respectively, during 16 bytes. **Figure 23** illustrates the detailed conversion table.

RA0 converter can only process RA0 data state by state. Before filling in new data, software must make sure the converted data of certain state is withdrawn, or the converted data will be replaced by the new data. For example, if 32-bit data is written, and the state pointer goes from state 0 to state 1, and word ready of state 0 is asserted; then, before writing the next 32-bit data, the word of state 0 should be withdrawn first, or the data will be lost.

RA0 records the number of written bytes, state pointer, and ready state word. The information can help software to perform flow control. See Register Definition for more detail.

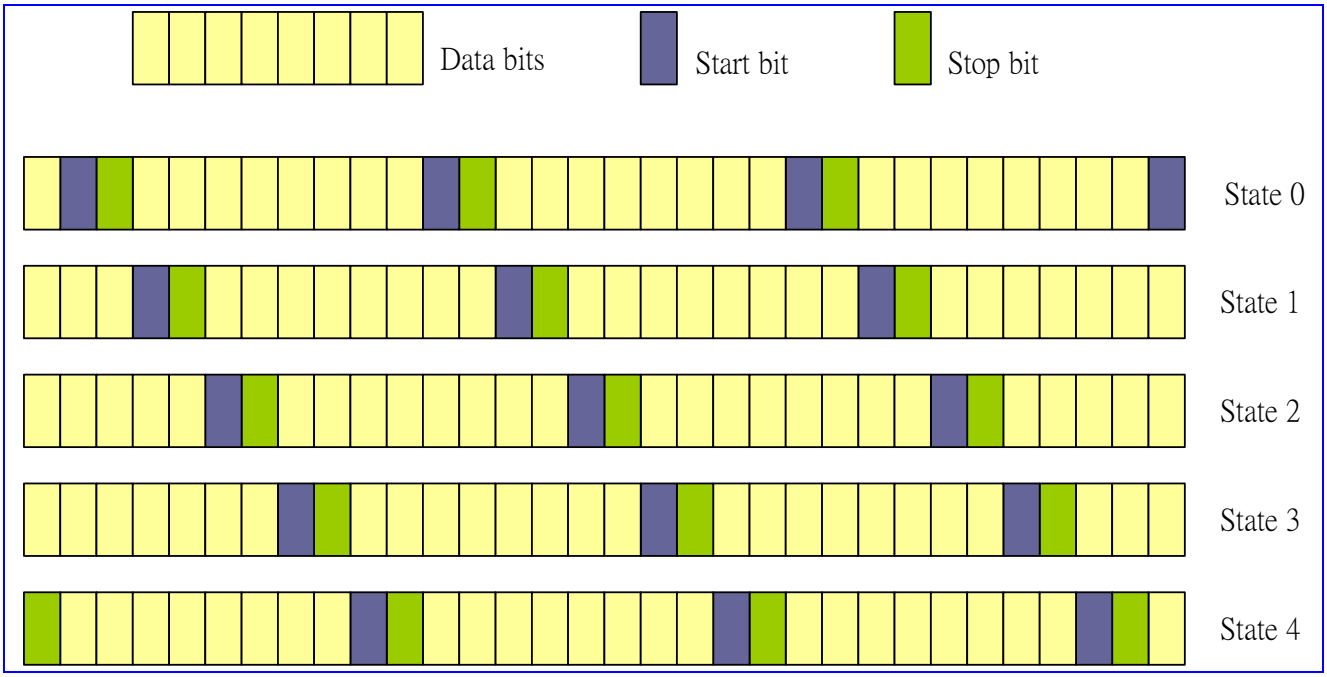


Figure 23 data format conversion of RA0

For RA1 conversion, both directions, downlink and uplink, are supported. The data formats vary in different data rate. The detailed conversion table is shown in **Figure 24** and **Figure 25**. The yellow part is the payload data, and the blue part is the status bit.

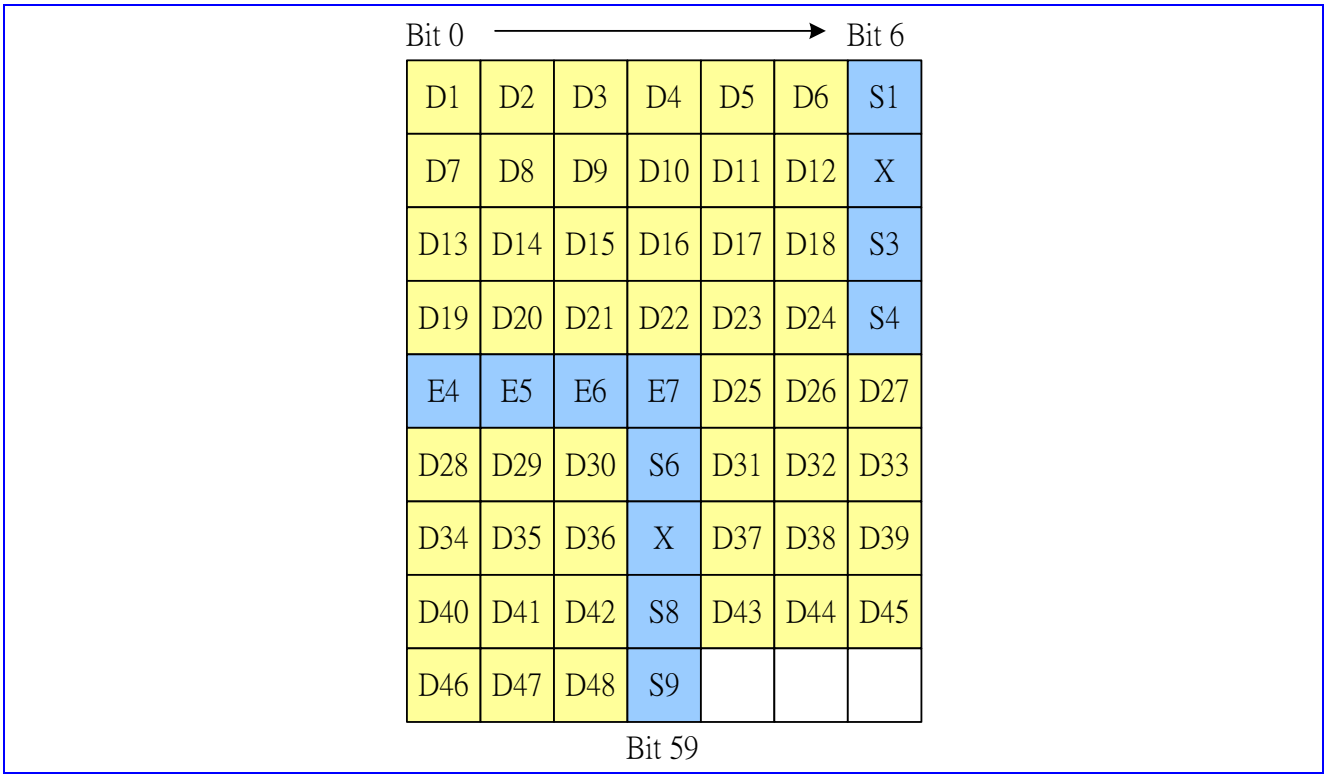


Figure 24 data format conversion for 6k/12k RA1

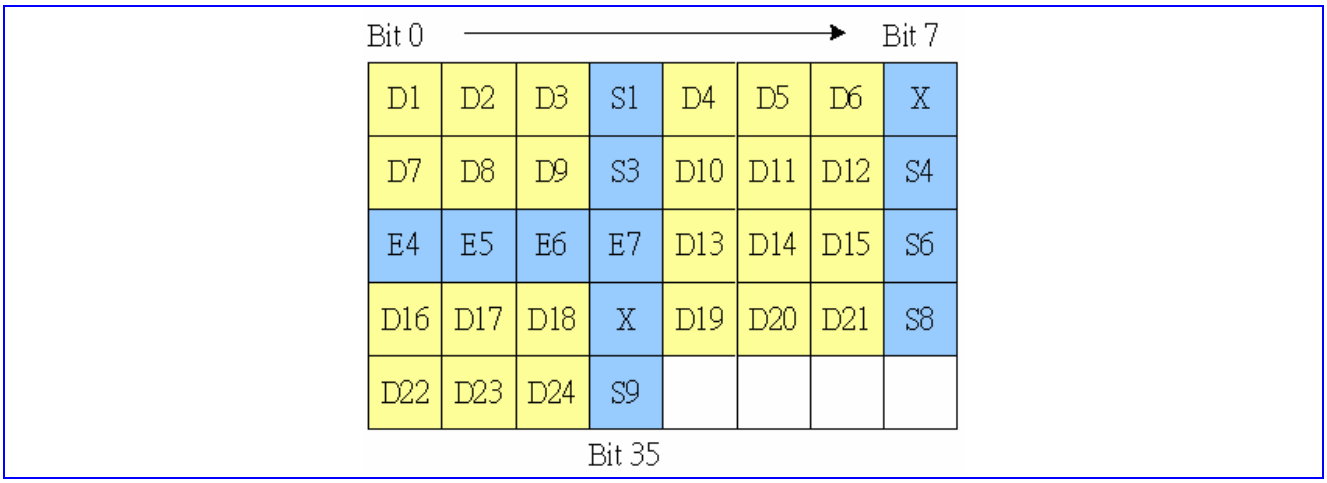


Figure 25 data format conversion for 3.6k RA1

For FAX, two types of bit-reversal functions are provided. One is bit-wise reversal, and the other is byte-wise reversal, which are illustrated in **Figure 26** and **Figure 27**, respectively.

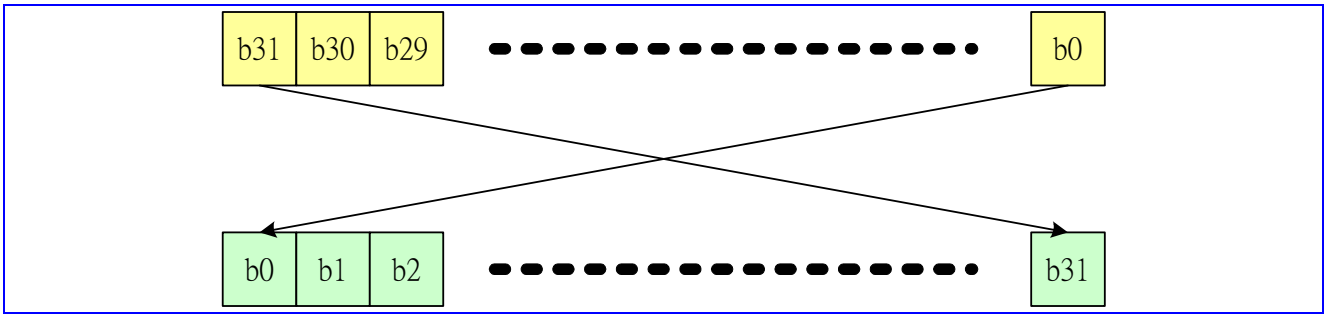


Figure 26 Type 1 bit reverse

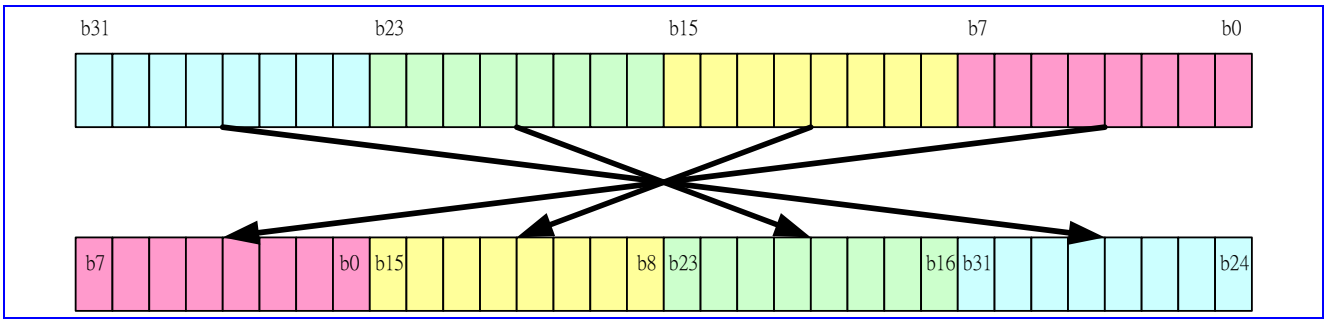


Figure 27 Type 2 bit reverse

Register Address	Register Function	Acronym
CSD + 0000h	CSD RA0 Control Register	**CSD_RA0_CON**
CSD + 0004h	CSD RA0 Status Register	**CSD_RA0_STA**
CSD + 0008h	CSD RA0 Input Data Register	**CSD_RA0_DI**
CSD + 000Ch	CSD RA0 Output Data Register	**CSD_RA0_DO**
CSD + 0100h	CSD RA1 6K/12K Uplink Input Data Register 0	**CSD_RA1_6K_12K_ULDI0**
CSD + 0104h	CSD RA1 6K/12K Uplink Input Data Register 1	**CSD_RA1_6K_12K_ULDI1**
CSD + 0108h	CSD RA1 6K/12K Uplink Status Data Register	**CSD_RA1_6K_12K_ULSTUS**
CSD + 010Ch	CSD RA1 6K/12K Uplink Output Data Register 0	**CSD_RA1_6K_12K_ULDO0**
CSD + 0110h	CSD RA1 6K/12K Uplink Output Data Register 1	**CSD_RA1_6K_12K_ULDO1**
CSD + 0200h	CSD RA1 6K/12K Downlink Input Data Register 0	**CSD_RA1_6K_12K_DLDI0**
CSD + 0204h	CSD RA1 6K/12K Downlink Input Data Register 1	**CSD_RA1_6K_12K_DLDI1**
CSD + 0208h	CSD RA1 6K/12K Downlink Output Data Register 0	**CSD_RA1_6K_12K_DLDO0**
CSD + 020Ch	CSD RA1 6K/12K Downlink Output Data Register 1	**CSD_RA1_6K_12K_DLDO1**
CSD + 0210h	CSD RA1 6K/12K Downlink Status Data Register	**CSD_RA1_6K_12K_DLSTUS**
CSD + 0300h	CSD RA13.6K Uplink Input Data Register 0	**CSD_RA1_3P6K_ULDI0**
CSD + 0304h	CSD RA13.6K Uplink Status Data Register	**CSD_RA1_3P6K_ULSTUS**
CSD + 0308h	CSD RA13.6K Uplink Output Data Register 0	**CSD_RA1_3P6K_ULDO0**
CSD + 030Ch	CSD RA13.6K Uplink Output Data Register 1	**CSD_RA1_3P6K_ULDO1**
CSD + 0400h	CSD RA1 3.6K Downlink Input Data Register 0	**CSD_RA1_3P6K_DLDI0**
CSD + 0404h	CSD RA1 3.6K Downlink Input Data Register 1	**CSD_RA1_3P6K_DLDI1**

CSD + 0408h	CSD RA1 3.6K Downlink Output Data Register 0	**CSD_RA1_3P6K_DLDO0**
CSD + 040Ch	CSD RA1 3.6K Downlink Status Data Register	**CSD_RA1_3P6K_DLSTUS**
CSD + 0500h	CSD FAX Bit Reverse Type 1 Input Data Register	**CSD_FAX_BR1_DI**
CSD + 0504h	CSD FAX Bit Reverse Type 1 Output Data Register	**CSD_FAX_BR1_DO**
CSD + 0510h	CSD FAX Bit Reverse Type 2 Input Data Register	**CSD_FAX_BR2_DI**
CSD + 0514h	CSD FAX Bit Reverse Type 2 Output Data Register	**CSD_FAX_BR2_DO**

Table 24 CSD Accelerater Registers

5.2.2 Register Definitions

CSD+0000h CSD RA0 Control Register CSD_RA0_CON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											RST	BTS0		VLD_BYTE		
Type											WO	WO		WO		
Reset											0	0		100		

VLD_BYTE Specify how many valid bytes in the current input data. It must be specified before filling data in.

BTS0 Back to state 0. Force RA0 converter go back to state 0. Incomplete word will be padded by STOP bit. For instance, back-to-state0 command is issued after 8 byte data are filled in. Then these bit after the 8th byte will be padded with stop bits, and RDYWD2 is asserted. After removing state word 2, the state pointer goes back to state 0. Note that new data filling should take place after removing state word 2, or the state pointer may be out of order.

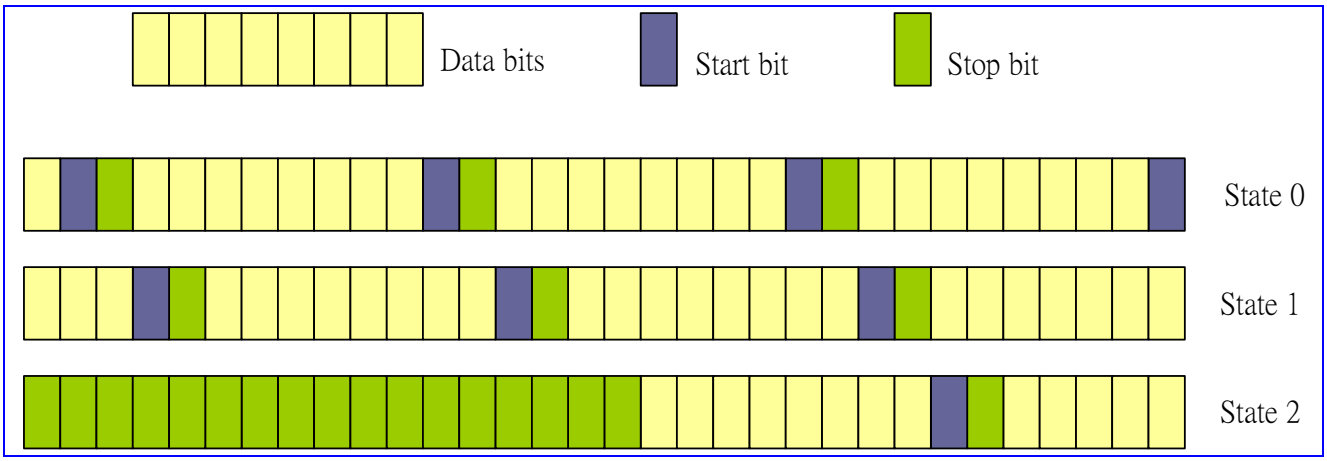


Figure 28 Example of Back to state 0

RST Reset RA0 converter. In case, erroneously operation makes data disordered. This bit can restore all state to original state.

CSD+0004h CSD RA0 Status Register CSD_RA0_STA

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					BYTECNT				CRTSTA			RDYWD				
Type					RO				RO			RC				
Reset					0				0			0				

RDYWD0~4 Ready word. To indicate which state word is ready for withdrawal. Data should be withdrawn before next data fills into CSD_RA0_DI, if there are any bits asserted.

0 Not ready

1 Ready

CRTSTA current state. State0 ~ state4. To indicate which state word software is filling in.

BYTECNT The total number of bytes software is filling in.

CSD+0008h CSD RA0 Input Data Register CSD_RA0_DI

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DIN															
Type	WO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DIN															
Type	WO															
Reset	0															

DIN The RA0 convert input data. Ready word indicator shall be check before filling in data. If any words are ready, withdraw them first; otherwise the ready data in RA0 converter will be replaced.

CSD+000Ch CSD RA0 Output Data Register CSD_RA0_DO

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DOUT															
Type	RO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DOUT															
Type	RO															
Reset	0															

DOUT RA0 converted data. The return data corresponds to the ready word indicator defined in CSD_RA0_STA register. The five bit of RDYWD map to state0 ~ state 4 accordingly. When CSD_RA0_DO is read, the asserted state word will be returned. If there are two state words asserted at the same time, the lower one will be returned.

CSD+0100h CSD RA1 6K/12K Uplink Input Data Register 0 CSD_RA1_6K_12K_ULDI0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DIN															
Type	WO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name	DIN
Type	WO
Reset	0

DIN The D1 to D32 of RA1 uplink data.

CSD+0104h CSD RA1 6K/12K Uplink Input Data Register 1

CSD_RA1_6K_12K_ULDI1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DIN															
Type	WO															
Reset	0															

DIN The D33 to D48 of RA1 uplink data.

CSD+0108h CSD RA1 6K/12K Uplink Status Data Register

CSD_RA1_6K_12K_ULSTUS

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name										E7	E6	E5	E4	X	SB	SA
Type										WO	WO	WO	WO	WO	WO	WO
Reset										0	0	0	0	0	0	0

SA Represents S1, S3, S6, and S8 of status bits.
SB Represents S4 and S9 of status bits.
X Represents X of status bits.
E4 Represents E4 of status bits.
E5 Represents E5 of status bits.
E6 Represents E6 of status bits.
E7 Represents E7 of status bits.

CSD+010Ch CSD RA1 6K/12K Uplink Output Data Register 0

CSD_RA1_6K_12K_ULDO0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DOUT															
Type	RO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DOU															
Type	RO															
Reset	0															

DOUT The bit 0 to bit 31 of RA1 6K/12K uplink frame.

CSD+0110h CSD RA1 6K/12K Uplink Output Data Register 1

CSD_RA1_6K_12K_ULDO1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name					DOUT											
Type					RO											
Reset					0											
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DOUT															
Type	RO															
Reset	0															

DOUT The bit32 to bit 59 of RA1 6K/12K uplink frame.

CSD+0200h CSD RA1 6K/12K Downlink Input Data Register 0

CSD_RA1_6K_12K_DLDI0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DIN															
Type	WO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DIN															
Type	WO															
Reset	0															

DIN The bit 0 to bit 31 of RA1 6K/12K downlink frame.

CSD+0204h CSD RA1 6K/12K Downlink Input Data Register 1

CSD_RA1_6K_12K_DLDI1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name					DIN											
Type					WO											
Reset					0											
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DIN															
Type	WO															
Reset	0															

DIN The bit32 to bit 59 of RA1 6K/12K downlink frame.

CSD+0208h CSD RA1 6K/12K Downlink Output Data Register 0

CSD_RA1_6K_12K_DLDO0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DOUT															
Type	RO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DOUT															
Type	RO															
Reset	0															

DOUT The D1 to D32 of RA1 downlink data.

CSD+020Ch CSD RA1 6K/12K Downlink Output Data Register 1

CSD_RA1_6K_12K_DLDO1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DOUT															
Type	RO															
Reset	0															

DOUT The D33 to D48 of RA1 downlink data.

CSD+0210h CSD RA1 6K/12K Downlink Status Data Register

CSD_RA1_6K_12K_DLSTUS

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name										E7	E6	E5	E4	X	SB	SA
Type										RO	RO	RO	RO	RO	RO	RO
Reset										0	0	0	0	0	0	0

SA The result of majority votes of S1, S3, S6 and S8. SA is “0” if equal vote.

SB The result of majority votes of S4 and S9. SB is “0” if equal vote.

X The result of majority votes of two X bits in downlink frame. X is “0” if equal vote.

E4 Represents E4 of status bits.

E5 Represents E5 of status bits.

E6 Represents E6 of status bits.

E7 Represents E7 of status bits.

CSD+0300h CSD RA1 3.6K Uplink Input Data Register 0

CSD_RA1_3P6K_ULDI0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name									DIN							
Type									WO							
Reset									0							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DIN															
Type	WO															
Reset	0															

DIN The D1 to D24 of RA1 3.6K uplink data.

CSD+0304h CSD RA1 3.6K Uplink Status Data Register

CSD_RA1_3P6K_ULSTUS

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																

Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name										E7	E6	E5	E4	X	SB	SA
Type										WO	WO	WO	WO	WO	WO	WO
Reset										0	0	0	0	0	0	0

SA Represents S1, S3, S6, and S8 of status bits.
SB Represents S4 and S9 of status bits.
X Represents X of status bits.
E4 Represents E4 of status bits.
E5 Represents E5 of status bits.
E6 Represents E6 of status bits.
E7 Represents E7 of status bits.

CSD+0308h CSD RA1 3.6K Uplink Output Data Register 0

CSD_RA1_3P6K_ULDO0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DOUT															
Type	RO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DOUT															
Type	RO															
Reset	0															

DOUT The bit 0 to bit 31 of RA1 3.6K uplink frame

CSD+030Ch CSD RA1 3.6K Uplink Output Data Register 1

CSD_RA1_3P6K_ULDO1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													DOUT			
Type													RO			
Reset													0			

DOUT The bit 32 to bit 35 of RA1 3.6K uplink frame

CSD+0400h CSD RA1 3.6K Downlink Input Data Register 0

CSD_RA1_3P6K_DLDI0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DIN															
Type	WO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DIN															
Type	WO															
Reset	0															

DIN The bit 0 to bit 31 of RA1 3.6K downlink frame

CSD+0404h CSD RA1 3.6K Downlink Input Data Register 1

CSD_RA1_3P6K_DLDI1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													DIN			
Type													WO			
Reset													0			

DIN The bit 32 to bit 35 of RA1 3.6K downlink frame

CSD+0408h CSD RA1 3.6K Downlink Output Data Register 0

CSD_RA1_3P6K_DLDO0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name									DOUT							
Type									RO							
Reset									0							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DOUT															
Type	RO															
Reset	0															

DIN The D1 to D24 of RA1 3.6K downlink data.

CSD+040Ch CSD RA1 3.6K Downlink Status Data Register

CSD_RA1_3P6K_DLSTUS

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name										E7	E6	E5	E4	X	SB	SA
Type										RO	RO	RO	RO	RO	RO	RO
Reset										0	0	0	0	0	0	0

SA The result of majority votes of S1, S3, S6 and S8. SA is “0” if equal vote.

SB The result of majority votes of S4 and S9. SB is “0” if equal vote.

X The result of majority votes of two X bits in downlink frame. X is “0” if equal vote.

E4 Represents E4 of status bits.

E5 Represents E5 of status bits.

E6 Represents E6 of status bits.

E7 Represents E7 of status bits.

CSD+0500h CSD FAX Bit Reverse Type 1 Input Data Register

CSD_FAX_BR1_DI

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DIN															
Type	WO															

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Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DIN															
Type	WO															
Reset	0															

DIN 32-bit input data for type 1 bit reverse of FAX data. The action of Type 1 bit reverse is to reverse this word by word.

CSD+0504h CSD FAX Bit Reverse Type 1 Output Data Register CSD_FAX_BR1_DO

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DOUT															
Type	RO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DOUT															
Type	RO															
Reset	0															

DOUT 32-bit result data for type 1 bit reverse of FAX data.

CSD+0510h CSD FAX Bit Reverse Type 2 Input Data Register CSD_FAX_BR2_DI

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DIN															
Type	WO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DIN															
Type	WO															
Reset	0															

DIN 32-bit input data for type 2 bit reverse of FAX data. The action of Type 1 bit reverse is to reverse this word by byte.

CSD+0514h CSD FAX Bit Reverse Type 2 Output Data Register CSD_FAX_BR2_DO

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DOUT															
Type	RO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DOUT															
Type	RO															
Reset	0															

DOUT 32-bit result data for type 2 bit reverse of FAX data.

5.3 FCS Codec

5.3.1 General Description

FCS (Frame Check Sequence) is used to detect errors in the following information bits:

- RLP-frame of CSD services in GSM. The frame length is fixed as 240 or 576 bits including the 24-bit FCS field.
- LLC-frame of GPRS service. The frame length is determined by the information field, and length of the FCS field is 24-bit.

Generation of the frame check sequence is very similar to the CRC coding in baseband signal processing. ETSI GSM specifications 04.22 and 04.64 both define the coding rule. The coding rules are:

1. The CRC shall be ones complement of the modulo-2 sum of:

- the remainder of $x^k \cdot (x^{23}+x^{22}+x^{21}+\ldots+x^2+x+1)$ modulo-2 divided by the generator polynomial, where k is the number of bits of the dividend. (i.e. fill the shift registers with all ones initially before feeding data)
- the remainder of the modulo-2 division by the generator polynomial of the product of x^{24} by the dividend, which are the information bits.

2. The CRC-24 generator polynomial is:

$G(x)=x^{24}+x^{23}+x^{21}+x^{20}+x^{19}+x^{17}+x^{16}+x^{15}+x^{13}+x^8+x^7+x^5+x^4+x^2+1$

3. The 24-bit CRC are appended to the data bits in the MSB-first manner.

4. Decoding is identical to encoding except that data fed into the syndrome circuit is 24-bit longer than the information bits at encoding. The dividend is also multiplied by x^{24}. If no error occurs, the remainder should satisfy

$R(x)=x^{22}+x^{21}+x^{19}+x^{18}+x^{16}+x^{15}+x^{11}+x^8+x^5+x^4$ (0x6d8930)

And the parity output word will be 0x9276cf.

In contrast to conventional CRC, this special coding scheme makes the encoder fully identical to the decoder and simplifies the hardware design.

5.3.2 Register Definitions

FCS+0000h FCS input data register FCS_DATA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

THE DX data bits input. First write of this register is the starting point of the encode or decode process. X=0…15. The input format is $D15 \cdot x^n + D14 \cdot x^{n-1} + D13 \cdot x^{n-2} + \ldots + Dk \cdot x^k + \ldots$, thus D15 is the first bit being pushed into the shift register. If the last data word is less than 16 bits, the rest bits are neglected.

FCS+0004h Input data length indication register FCS_DLEN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LEN															
Type	WO															

THE MCU specifies the total data length in bits to be encoded or decoded.

LEN The data length. A number of multiple-of-8 is required (Number_of_Bytes x 8)

FCS+0x0008h FCS parity output register 1, MSB part FCS_PAR1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	**P15**	**P14**	**P13**	**P12**	**P11**	**P10**	**P9**	**P8**	**P7**	**P6**	**P5**	**P4**	**P3**	**P2**	**P1**	**P0**
Type	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FCS+000Ch FCS parity output register 2, LSB part FCS_PAR2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									**P23**	**P22**	**P21**	**P20**	**P19**	**P18**	**P17**	**P16**
Type									RC	RC	RC	RC	RC	RC	RC	RC
Reset									0	0	0	0	0	0	0	0

PARITY bits output. For FCS_PAR2, bit 8 to bit15 will be filled by zeros when reading.

PX X=0…23. The output format is $P23 \cdot D^{23} + P22 \cdot D^{22} + P21 \cdot D^{21} + \ldots + Pk \cdot D^{k} + \ldots + P1 \cdot D^{1} + P0$, thus P23 is the earliest bit being popped out from the shift register and first appended to the information bits. In other words, {FCS_PAR2[7:0], FCS_PAR1[15:8], FCS_PAR1[7:0] } is the order of appending parity to data.

FCS+0010h FCS codec status register FCS_STAT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name														**BUSY**	**FER**	**RDY**
Type														RC	RC	RC
Reset														0	1	0

BUSY Since the codec works in serial manner and the data word is input in parallel manner, BUSY = 1 indicates that current data word is being processed and write to FCS_DATA is invalid. BUSY = 0 allows write of FCS_DATA during encode or decode process.

FER Frame error indication, only for decode mode. FER = 0 means no error occurs and FER = 1 means the parity check has failed. Write of FCS_RST.RST or first write of FCS_DATA will reset this bit to 0.

RDY When RDY = 1, the encode or decode process has been finished. For encode, the parity data in FCS_PAR1 and FCS_PAR2 are correctly available. For decode, FCS_STAT.FER indication is valid. Write of FCS_RST.RST or first write of FCS_DATA will reset this bit to 0.

FCS+0014h FCS codec reset register FCS_RST

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													**EN_DE**	**PAR**	**BIT**	**RST**
Type													WO	WO	WO	WO

RST RST = 0 resets the CRC coprocessor. Before setup of FCS codec, the MCU needs to set RST = 0 to flush the shift register content before encode or decode.

BIT BIT = 0 means not to invert the bit order in a byte of data words when the codec is running. BIT = 1 means the bit order in a byte written in FCS_DATA should be reversed.

PAR PAR = 0 means not to invert the bit order in a byte of parity words when the codec is running, include reading of FCS_PAR1 and FCS_PAR2. PAR = 1 means bit order of parity words should be reversed, in decoding or encoding.

EN_DE EN_DE = 0 means encode; EN_DE = 1 means decode

5.4 GPRS Cipher Unit

5.4.1 General Description

The unit implements the GPRS encryption/decryption scheme that accelerates the computation of encryption and decryption GPRS pattern. The block accelerates the computation of the key stream. However the bit-wise encryption/decryption of the data is still done by the MCU.

Both GEA and GEA2 are supported.

Register Address	Register Function	Acronym
GCU+0000h	GPRS Encryption Algorithm Control Register	GCU_CON
GCU+0004h	GPRS Encryption Algorithm Status Register	GCU_SAT
GCU+0008h	GPRS Secret Key Kc 0 Register	GCU_SKEY0
GCU+000Ch	GPRS Secret Key Kc 1 Register	GCU_SKEY1
GCU+0010h	GPRS Message Key Register	GCU_MKEY
GCU+0014h	GPRS Ciphered Data Register	GCU_CDATA

Table 25 GCU Registers

5.4.2 Register Definitions

GCU+0000h GPRS Encryption Algorithm Control Register GCU_CON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											RBO	KS		SINIT	DIR	GEA2
Type											R/W	R/W		WO	R/W	R/W
Reset											0	10		0	0	0

This register controls the key generation function of the GPRS Encryption Algorithm.

GEA2 Choose the encryption/decryption scheme. 1 = GEA2, while 0 = GEA.

DIR The DIRECTION input of the GPRS Encryption Algorithm.

SINIT Start initialization. The MCU writes 1 to start initialization. The bit is always read at 0.

KS Control the read access. 00 = byte access, 01 = half word (16 bits) access, 10 = word access, 11 reserved. Default value is 10.

RBO Reversal Byte Order bit. If the bit was set to 1, the byte order of GCU_SKEY0, GCU_SKEY1, GCU_MKEY in write operation and GCU_SKEY0, GCU_SKEY1, GCU_MKEY, GCU_CDATA in read operation would be the reverse of baseband processor, and if the bit was 0, the behavior would be the same as baseband processor. Byte-order of GCU_CON and GCU_SAT is not affected. The default value is 0 which is different from that in MT6217.

GCU+0004h GPRS Encryption Algorithm Status Register GCU_SAT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	STAT													KEY_COM	INIT	
Type	RO													RO	RO	
Reset	110													0	0	

This register shows the status of the GPRS Encryption unit.

INIT Initialization flag. 1 = the GCU is currently performing the initialization phase.

KEY_COM Key-stream computation. 1 = the GCU is computing new key stream, while 0 = a new key is available or the GCU is in initialization phase.

STAT The state of GCU core. For debug purpose.

GCU+0008h GPRS Secret Key Kc 0 Register GCU_SKEY0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	KC[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	KC[15:0]															
Type	R/W															
Reset	0															

GCU+000Ch GPRS Secret Key Kc 1 Register GCU_SKEY1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	KC[63:48]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	KC[47:32]															
Type	R/W															
Reset	0															

This set of registers shall be programmed with the GPRS Encryption Algorithm secret key.

GCU+0010h GPRS Message Key Register GCU_MKEY

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	MKEY[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	MKEY[15:0]															
Type	R/W															
Reset	0															

This register shall be programmed with the “message key” for the GPRS Encryption Algorithm.

GCU+0014h GPRS Ciphered DATA Register GCU_CDATA

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	CDATA[31:16]															
Type	RO															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	CDATA[15:0]															
Type	RO															

The register contains the key stream. GCU will continue to generate next word of key while current word of key is removed.

6 MCU/DSP Interface

MCU/DSP Interface resides between the Microcontroller Unit Subsystem and the Digital Signal Processor Subsystem. It serves as the command and data exchange medium by which the MCU and the DSP communicate with each other.

As shown in **Figure 29**, MCU/DSP Interface is composed of three parts, namely:

- MCU/DSP Shared Registers, which are used for hardware controls and status signaling;
- MCU/DSP Shared RAM, where software of both sides exchange commands and data;
- AHB-to-DDMA Bridge, which translates AHB cycles to the DSP's Internal DMA cycles and allows an AHB master to access the memory of the DSP.

On the MCU Subsystem side, MCU/DSP Shared Registers are connected to APB, while MCU/DSP Shared RAM and AHB-to-DDMA Bridge are connected to AHB. Therefore, MCU/DSP Shared Registers are allocated an APB address space, whereas MCU/DSP Shared RAM and AHB-to-DDMA Bridge are mapped to AHB pages. On the DSP Subsystem side, MCU/DSP Shared RAM and most MCU/DSP Shared Registers are attached to the DSP I/O bus through DSP I/O Hub.

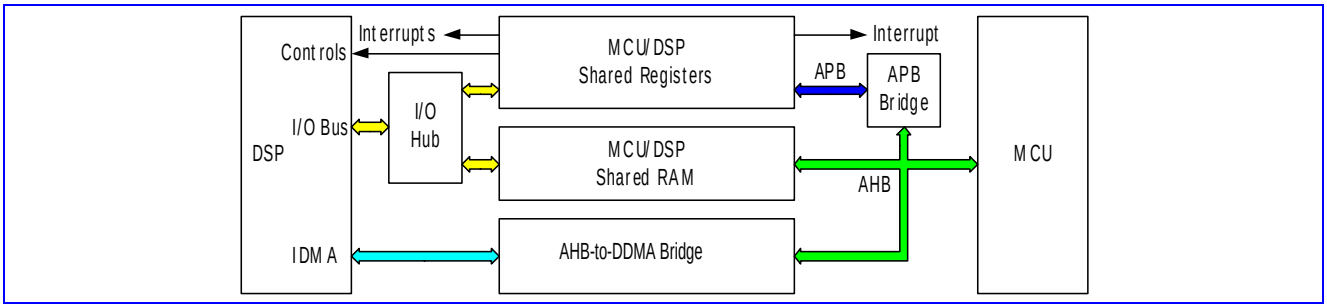


Figure 29 MCU/DSP Interface block diagram.

Referring to **Figure 1**, the 640 16-bit words of MCU/DSP Shared RAM are allocated to the beginning of the AHB page at 50000000h for master DSP and at 58000000h for slave DSP. This memory can be accessed in 16-bit half-words or 8-bit bytes by an AHB master, but *not* in 32-bit words.

The AHB pages beginning from 60000000h and from 68000000h are devoted to AHB-to-DDMA Bridges of the master and slave DSP, which link DSP memories to AHB like AHB slaves. Specifically, the master DSP Code Memory, Program Memory and Data Memory are mapped to the 1M-byte areas starting at 60000000h, 60100000h and 60200000h, respectively (or 68000000h, 68100000h, and 68200000h for slave DSP). Each 1M-byte area is evenly partitioned to sixteen 64K-byte blocks corresponding to the 16 pages of one type of DSP memory. Because CM is 24-bit wide, its word is zero extended to 32 bits over AHB and thus must be accessed in 32-bit words. PM and DM are both 16-bit wide, thus shall be accessed in half-words (16-bit). Moreover, the PM data are protected when written through IDMA of slave DSP. Correspondingly, L1 should prepare the PM data by specific encryption method in advance, and the hardware should take responsibility of decryption before writing them into PM RAM through IDMA. The following block diagram depicts the relation.

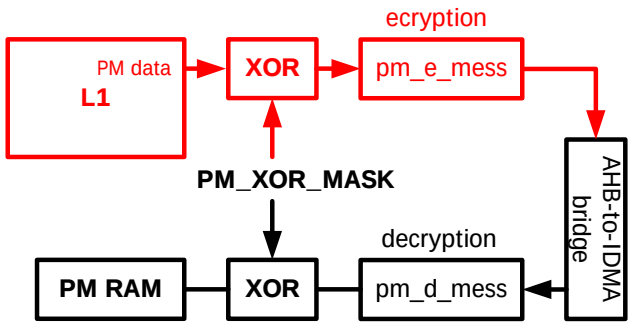


Figure 30 PM data encryption/decryption

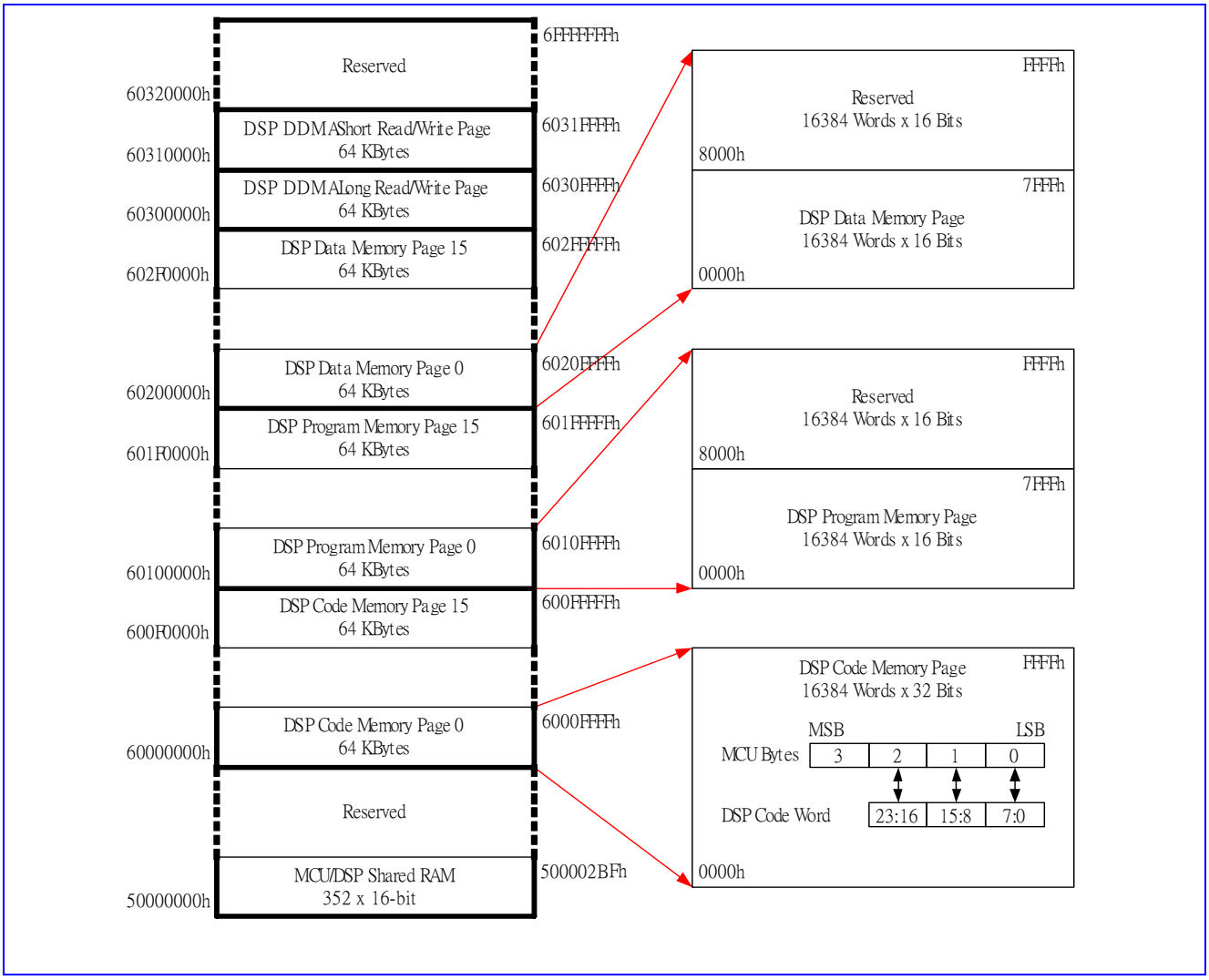


Figure 3 Mapping of MCU/Master DSP Interface on the MCU memory space. For the MCU/Slave DSP Interface, the difference is 08000000h base address offset at MCU side only.

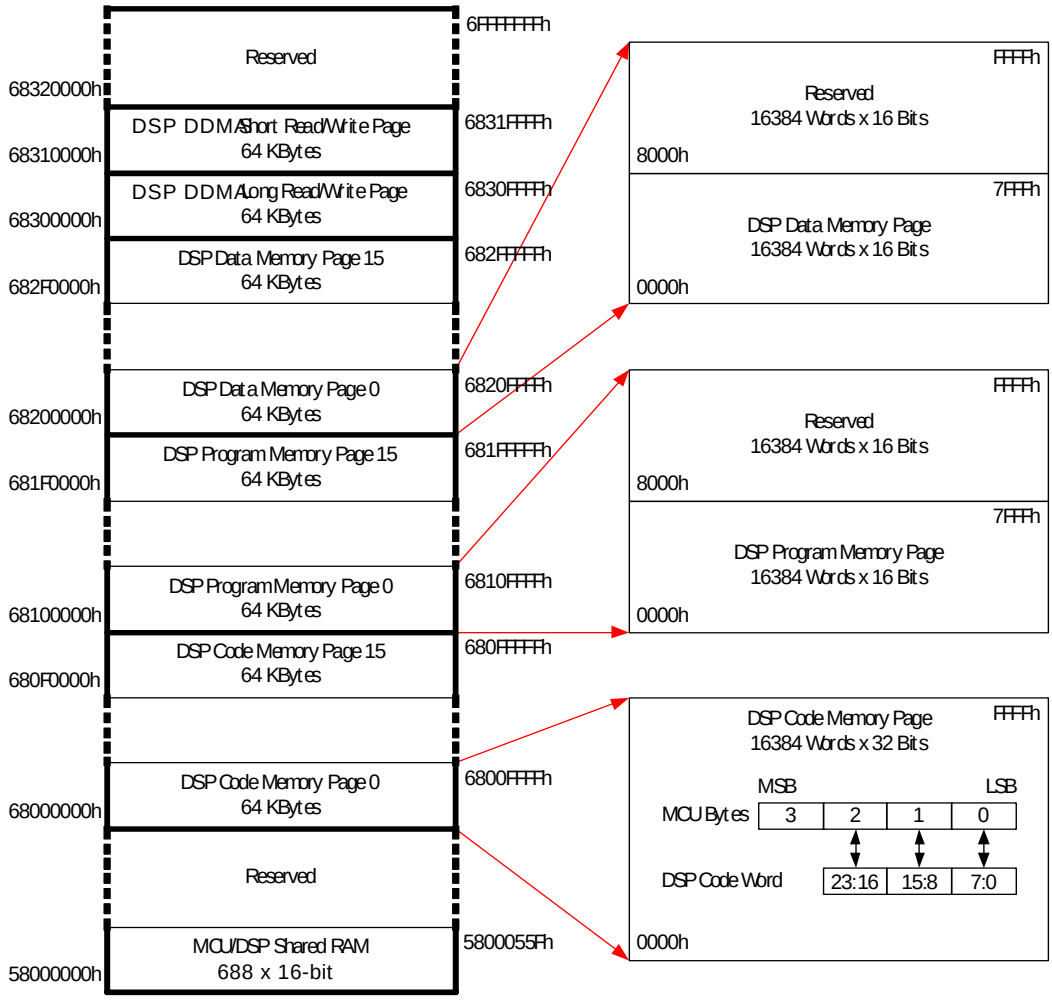


Figure 31 Mapping of MCU/Slave DSP Interface on the MCU memory space. For the MCU/Master DSP Interface, the difference is 08000000h base address offset at MCU side only

6.1 MCU/DSP Shared Registers

6.1.1 General Description

MCU/DSP Shared Registers are a set of registers that are accessible by both the MCU and the DSP for

- the control of the DSP hardware, such as reset and power-down;
- the identification of the ongoing DSP tasks,

- the recognition of the DSP to MCU Interrupt, which informs the MCU of certain events happening in the DSP side;
- the generation of the MCU to DSP Interrupt, by which the MCU sends commands and messages to the DSP;
- TDMA frame counts, which are referenced by the software for TDMA timing and are employed by GSM Cipher Coprocessor in generating ciphering keys.

Functionalities of MCU/DSP Shared Registers are hardwired, which is different from MCU/DSP Shared RAM whose usage is software-defined.

6.1.2 Register Definitions

Table 26 and **Table2** list MCU/DSP Shared Registers and their address mapping to the MCU address space and DSP I/O space. The MCU register addresses are the offsets from the base address 80300000h for master DSP (DSP1) and 80320000h for slave DSP (DSP2) on APB bus.

MCU Register Address	DSP Register Address	Register Function	Acronym
0000h	N/A	DSP1 Control Register	SHARE_DSP1CTL
0004h	601h	MCU-to-DSP1 Interrupt 1 Register	SHARE_M2D1I1
0008h	602h	MCU-to-DSP1 Interrupt 2 Register	SHARE_M2D1I2
000Ch	N/A	DSP1-to-MCU Interrupt Control Register	SHARE_D12MCTL
0010h	N/A	DSP1-to-MCU Interrupt Status Register	SHARE_D12MSTA
0014h	605h	DSP1 Task Identification Register	SHARE_D12MTID
0018h	606h	TDMA Counter Enable Register	SHARE_1TDMAEN
001Ch	607h	TDMA T1 Counter	SHARE_1TDMAT1
0020h	608h	TDMA T2 Counter	SHARE_1TDMAT2
0024h	608h	TDMA T3 Counter	SHARE_1TDMAT3
0028h	60Ah	DSP1 Debugging Control	SHARE_DSP1DBG
0030h	N/A	DSP1 Task 1 Time Out	SHARE_DSP1T1TO
0034h	N/A	DSP1 Task 2 Time Out	SHARE_DSP1T2TO
N/A	60Bh	DSP power-down source	SHREG_1PWDNSRC
0048h	60Ch	DSP self power-down control	SHARE_1PWDNCON
N/A	60Dh	DSP PC	SHREG_D1PC
N/A	60Eh	DSP CNTR	SHREG_D1CNTR
004Ch	N/A	DSP slow-idle mode switch	SHARE_DSP1CKR

Table 26 MCU/DSP1 Shared Registers

MCU Register Address	DSP Register Address	Register Function	Acronym
0000h	N/A	DSP2 Control Register	SHARE_DSP2CTL

0004h	601h	MCU-to-DSP2 Interrupt 1 Register	SHARE_M2D2I1
0008h	602h	MCU-to-DSP2 Interrupt 2 Register	SHARE_M2D2I2
000Ch	N/A	DSP2-to-MCU Interrupt Control Register	SHARE_D22MCTL
0010h	N/A	DSP2-to-MCU Interrupt Status Register	SHARE_D22MSTA
0014h	605h	DSP2 Task Identification Register	SHARE_D22MTID
0018h	606h	TDMA Counter Enable Register	SHARE_2TDMAEN
001Ch	607h	TDMA T1 Counter	SHARE_2TDMAT1
0020h	608h	TDMA T2 Counter	SHARE_2TDMAT2
0024h	608h	TDMA T3 Counter	SHARE_2TDMAT3
0028h	60Ah	DSP2 Debugging Control	SHARE_DSP2DBG
002Ch	N/A	DSP2 Task 0 Time Out	SHARE_DSP2T0TO
0030h	N/A	DSP2 Task 1 Time Out	SHARE_DSP2T1TO
0034h	N/A	DSP2 Task 2 Time Out	SHARE_DSP2T2TO
0038h	N/A	DSP2 Task 3 Time Out	SHARE_DSP2T3TO
003Ch	N/A	DSP2 Task 4 Time Out	SHARE_DSP2T4TO
N/A	60Bh	DSP power-down source	SHREG_2PWDNSRC
0048h	60Ch	DSP self power-down control	SHARE_2PWDNCON
N/A	60Dh	DSP PC	SHREG_D1PC
N/A	60Eh	DSP CNTR	SHREG_D1CNTR
004Ch	N/A	DSP slow-idle mode switch	SHARE_DSP2CKR

Table 2 MCU/DSP2 Shared Registers

+0000hMCU N/ADSP DSP1 CONTROL REGISTER

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													PWDACK	PWDN	BOOT	RSTN
Type													R	R/W	R/W	R/W
Reset													0	1	1	0

This register directly controls the DSP signals: RSTn, BMODE, and PWDn. After the hardware reset, the RSTN bit and BOOT bit are reset to 0 and 1, respectively, thus keeping the DSP in reset state with BMODE = 1. The MCU shall then write 1 to RSTN to end the reset and to start booting of the DSP. Only bit 0 is accessible by DSP, by which DSP can learn how it is reset, whether by MCU (RSTN = 1) or due to DSP-code crazy execution. Therefore after normal DSP booting sequence from MCU, DSP code should read back the RSTN bit before entering any task.

PWDACK DSP power-down mode acknowledgement. This bit is read true when the DSP enter the IDLE state.

PWDN DSP power-down control. This bit is connected to the PWDN pin of the DSP. A 1-to-0 transition of this bit causes the DSP to enter power-down mode, while a 0-to-1 transition of this bit wakes the DSP.

BOOT DSP boot mode. This bit is connected to the BMODE pin of the DSP. If BMODE is 1 when RSTn transit from 0 to 1, the DSP will enter the boot mode waiting for the completion of its program download.

RSTN DSP reset. This bit controls the RSTn input of the DSP.

0 Reset DSP.

+0000hMCU N/ADSP DSP2 CONTROL REGISTER

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													PWDACK	PWDN	BOOT	RSTN
Type													R	R/W	R/W	R/W
Reset													0	1	1	1

This register resides at slave DSP side with the same function with SHARE_DSP1CTL. However, since slave DSP should be reset from DSP1, therefore RSTN of SHARE_DSP2CTL has to be initialized to be bit 0. Only bit 0 is accessible by DSP, by which DSP can learn how it is reset, whether by MCU (RSTN = 1) or due to DSP-code crazy execution. Therefore after normal DSP booting sequence from MCU, DSP code should read back the RSTN bit before entering any task.

+0004hMCU 601hDSP MCU-TO-DSP1 INTERRUPT 1 REGISTER

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	INTERRUPT LABEL															
Type	R/W															

This register is written by the MCU to generate an interrupt request to the DSP. The generated interrupt shall have a higher priority in the DSP side so that it can be serviced regardless of the status of DSP tasks. Contents of the register have no hardware significance but shall be referenced by the MCU and DSP as the reason for the interrupt.

+0008hMCU 602hDSP MCU-TO-DSP1 INTERRUPT 2 REGISTER

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	INTERRUPT LABEL															
Type	R/W															

This register is written by the MCU to generate an interrupt request to the DSP. The generated interrupt should have a lower priority in the DSP side; therefore it may or may not be serviced immediately, depending on the status of DSP tasks. Contents of the register have no hardware significance but shall be referenced by the MCU and DSP as the reason for the interrupt.

+000ChMCU N/ADSP DSP1-TO-MCU INTERRUPT CONTROL REGISTER

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name									TASK 7	TASK 6	TASK 5	TASK 4	TASK 3	TASK 2	TASK 1	TASK 0
Type									R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset									0	0	0	0	0	0	0	0

This register is programmed by the MCU to enable or disable the task interrupts asserted by the DSP. The interrupt for Task X is asserted when TASKX is set and the MCU/DSP Shared RAM word at address X is written by the DSP.

TASKX Task Interrupt X Enable.

- **0** Disable the interrupt for Task X.
- **1** Enable the interrupt for Task X.

+0010hMCU N/ADSP DSP1-TO-MCU INTERRUPT STATUS REGISTER

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									TASK 7	TASK 6	TASK 5	TASK 4	TASK 3	TASK 2	TASK 1	TASK 0
Type									RC	RC	RC	RC	RC	RC	RC	RC
Reset									0	0	0	0	0	0	0	0

Bits of this register are set by the DSP to assert an interrupt to the MCU. When the DSP writes to the word address X in MCU/DSP Shared RAM, the corresponding TASKX bit is set in this register. An MCU interrupt will be generated if TASKX is not masked in SHARE_D1MCTL. To acknowledge the interrupt, the MCU shall read this register for the interrupt status. After the read the interrupt flags will be cleared so that new Task Interrupts can be generated.

TASKX Task X Interrupt flag.

- **0** Task X Interrupt has not been asserted.
- **1** Task X Interrupt has been asserted.

+0014hMCU 605hDSP DSP1 TASK IDENTIFICATION REGISTER

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name										TASK IDENTIFICATION CODE						
Type										R						

This register is used by the DSP software posting its task status to the MCU. Contents of the register are observable as debug signals.

+0018hMCU 606hDSP TDMA COUNTER ENABLE REGISTER

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name														T3EN	T2EN	T1EN
Type														R/W	R/W	R/W

This register is programmed by the MCU software to enable or disable the TDMA frame counter (T1, T2, T3) Shared Registers. Contents of T1, T2 and T3 are referenced by the GSM Cipher Coprocessor for key generations.

T3EN T3 counter enable.
- **0** Disable SHARE_TDMAT3 counting so that it will not be updated by DTIRQ.
- **1** Enable SHARE_TDMAT3 counting so that it will be updated by DTIRQ.

T2EN T2 counter enable. 0 = disable, 1 = enable.
- **0** Disable SHARE_TDMAT2 counting so that it will not be updated by DTIRQ.
- **1** Enable SHARE_TDMAT2 counting so that it will be updated by DTIRQ.

T1EN T1 counter enable. 0 = disable, 1 = enable.
- **0** Disable SHARE_TDMAT1 counting so that it will not be updated by DTIRQ.
- **1** Enable SHARE_TDMAT1 counting so that it will be updated by DTIRQ.

+001ChMCU 607hDSP T1 COUNTER

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name						T1										
Type						R/W										

This register is the T1 part of the reduced TDMA frame number (RFN), i.e.,

T1 = TDMA frame number div (26 × 51).

At the asserting edge of the TDMA Frame Interrupt for DSP (DTIRQ), if the MCU has written to this register in advance, T1 will be initialized to the written value. Otherwise T1 will be incremented by 1 if T2 = 25, T3 = 50 and T1EN = T2EN = T3EN = 1.

+0020hMCU 608hDSP T2 COUNTER

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												T2				
Type												R/W				

This register is the T2 part of the reduced TDMA frame number, i.e., T2 = TDMA frame number modulo 26.

At the asserting edge of DTIRQ, if the MCU has written to this register in advance, T2 will be initialized to the written value. Otherwise T2 will be incremented by 1 modulo 26 if T2EN = 1.

+0024hMCU 609hDSP T3 COUNTER

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											T3					
Type											R/W					

This register is the T3 count for calculating T3′ of the reduced TDMA frame number. Specifically,

T3 = TDMA frame number modulo 51.

At the asserting edge of DTIRQ, if the MCU has written to this register in advance, T3 will be initialized to the written value. Otherwise T3 will be incremented by 1 modulo 51 if T3EN = 1.

+0048hMCU 60ChDSP DSP SELF POWER-DOWN CONTROL

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SELF_PWDNEN		DSP_CNTR_WORD													
Type	R/W		R/W													

SEL_PWDNEN self power-down enable, programmed by MCU to enable the DSP self power-down mechanism through CNTR internal register.

0 disable

1 enable

DSP_CNTR_WORD programmed by MCU to indicate the upper bound of CNTR value

+004ChMCU N/ADSP SHARE_DSP1CKR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									HOST_DEEP_CKR							
Type									R/W							
Reset									0							

DEEP_CKR To further saving host DSP power dissipation, the traditional CKR (DSP clock divider ratio for slow IDLE mode) is split to two selections. One is for deep-sleep control, as configured by this register; the other is for shallow sleep, which is programmed through SHRAM as before. Whenever RX frames assert, the CKR switch from HOST_DEEP_CKR to another accordingly.

+004ChMCU N/ADSP SHARE_DSP2CKR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									SLAVE_DEEP_CKR							
Type									R/W							
Reset									0							

DEEP_CKR To further saving slave DSP power dissipation, the traditional CKR (DSP clock divider ratio for slow IDLE mode) is split to two selections. One is for deep-sleep control, as configured by this register; the other is for shallow sleep, which is programmed through SHRAM as before. Whenever TX frames assert, the CKR switch from SLAVE_DEEP_CKR to another accordingly.

N/AMCU 60BhDSP **DSP POWER-DOWN SOURCE**

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name															DSP_PWDN	HW_PWDN
Type															RO	RO
Reset															0	0

This register is used to indicate the power-down source comes either from HW or DSP self. The signal is active high. And the HW_PWDN includes the effect of MCU power-down (write through SHARE_DSPCTL), trap indicator (see the spec. of patch unit), timeout indication (debug unit in sherif), and stack error.

N/AMCU 60DhDSP **SHREG_DXPC**

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DSP_PC															
Type	R/W															
Reset	0															

N/AMCU 60EhDSP **SHREG_DXCNTR**

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DSP_CNTR															
Type	R/W															
Reset	0															

6.2 MCU/DSP Shared RAM

6.2.1 General Description

This is a 640 words × 16 bits dual-port static RAM that is accessible by both the MCU and the DSP. It serves as the command and data exchange medium between the two processors. Except for some MCU/DSP Shared RAM words that trigger interrupts, the software can allocate the memory for whatever purposes, such as

- Speech algorithm control parameters,
- Software task control parameters,
- Downlink channel processing results,
- Downlink channel data buffers, and
- Uplink channel data buffers.

The first eight MCU/DSP Shared RAM words are used for DSP event reports. When the DSP writes to one of these words, a respective bit will be set in the SHARE_D2MSTA register and the DSP-to-MCU Interrupt will be asserted. Then the MCU may read the MCU/DSP Shared RAM word to see the reason for the interrupt.

MCU/DSP Shared RAM can be accessed by the MCU in halfwords (16 bits) or bytes, but not in words (32 bits). Simultaneous accesses from the MCU and the DSP are allowed, but simultaneous writes from both sides to the same word should be avoided by the software as the word content would be undefined.

6.2.2 MCU/DSP Shared RAM Utilizations

Table3 and **Table4** are the utilization of MCU/DSP Shared RAM, whose base address in the MCU side is 50000000h for DSP1 and 58000000h for DSP2.

MCU Address	DSP I/O Address	Acronym	Description
0000h	0000h	DP_D12M_TASK0	First DSP task interrupt.
0002h	0001h	DP_D12M_TASK1	Second DSP task interrupt.
0004h	0002h	DP_D12M_TASK2	Third DSP task interrupt.
0006h	0003h	DP_D12M_TASK3	Fourth DSP task interrupt.
0008h	0004h	DP_D12M_TASK4	Fifth DSP task interrupt.
000Ah	0005h	DP_D12M_TASK5	Sixth DSP task interrupt.
000Ch	0006h	DP_D12M_TASK6	Seventh DSP task interrupt.
000Eh	0007h	DP_D12M_TASK7	Eighth DSP task interrupt.
0010h | 02BFh	0008h | 014Fh	N/A	Software defined.

Table 3 MCU/DSP1 Shared RAM utilizations.

MCU Address	DSP I/O Address	Acronym	Description
0000h	0000h	DP_D22M_TASK0	First DSP task interrupt.
0002h	0001h	DP_D22M_TASK1	Second DSP task interrupt.
0004h	0002h	DP_D22M_TASK2	Third DSP task interrupt.
0006h	0003h	DP_D22M_TASK3	Fourth DSP task interrupt.
0008h	0004h	DP_D22M_TASK4	Fifth DSP task interrupt.
000Ah	0005h	DP_D22M_TASK5	Sixth DSP task interrupt.
000Ch	0006h	DP_D22M_TASK6	Seventh DSP task interrupt.
000Eh	0007h	DP_D22M_TASK7	Eighth DSP task interrupt.
0010h | 055Fh	0008h | 02B0h	N/A	Software defined.

Table 4 MCU/DSP2 Shared RAM utilizations.

6.3 AHB-to-DDMA Bridge

6.3.1 General Description

AHB-to-DDMA Bridge links the AHB to the DSP DDMA port, which allows an external host to read from or write to the DSP memory directly, so the AHB masters, i.e., the MCU and the AHB DMA Controller, can access the DSP program and data memory without interrupting the DSP. This capability is useful in

- DSP Program downloading or uploading,
- DSP Data exchange, and
- DSP booting.

Referring to **Figure 3**, AHB-to-DDMA Bridge works in the AHB memory space beginning from 60000000h to 67FFFFFFh for DSP1 and from 68000000h to 6FFFFFFFh for DSP2. As for the memory mapping on AHB bus, MCU/DSP1and MCU/DSP2 interfaces differ in nothing more than the base address, therefore the following description is illustrated by DSP1 case only.

The DSP Program Code Memory space comprising of sixteen 16384 × 24-bit pages is mapped to the AHB region from 60000000h to 600FFFFFh. The region further consists of sixteen 65536-byte blocks corresponding to the sixteen DSP Program Code overlay pages, whose data words are transferred to or from AHB as 32-bit words.

The second 1M-byte AHB region from 60100000h to 601FFFFFh is mapped to the sixteen 16384 × 16-bit DSP Program Data Memory pages. Again the region is partitioned to sixteen 65536-byte blocks. In each block the lower 32768 bytes are mapped to one DSP Program Data overlay page and the upper 32768 bytes are reserved. Data in this region shall be accessed as halfwords over AHB.

The third 1M-byte AHB region from 60200000h to 602FFFFFh is mapped to the sixteen 16384 × 16-bit DSP Data Memory pages. The region is also partitioned to sixteen 65536-byte blocks, whose lower halves correspond to the sixteen DSP Data Memory overlay pages. Data in this region shall be accessed as halfwords over AHB.

Access to the above three regions are converted to the DSP DDMA cycles carrying data and address information, thus are called *addressed* DDMA cycles. The inclusion of address information enables random access at the expense of lower transfer rate. For sequential read or write to the DSP memory, a more efficient way would be to provide address information for the very first data transfer, and then rely on the auto-incrementing DDMA address register in the DSP core to provide addresses of the rest of the data transfers. This way, the transfer rate can be improved as address information is not converted every time.

Contrary to the addressed DDMA cycles produced by AHB accessing 6000000h to 602FFFFFh, the DDMA Short Read/Write port (0x60310000 ~ 0x6031FFFF) may be used. This port relies on the DDMA address maintained within the DSP core, thus generates no address latching cycles when they are accessed. Whenever a DDMA read/write is completed, the DSP increments the internal DDMA address by one, so the next word can be accessed readily. Therefore, to access a DSP memory block, only the first word needs to be accessed with an explicitly addressed DDMA cycle. All the other words can be read or written through the Long or Short DDMA port.

An AHB-to-DDMA access will sometimes introduce wait states on AHB by toggling idma_hready. For write operations, if throttle control is carefully executed (i.e., two DDMA transfers are expanded by enough cycles that the first transaction has enough time to complete), idma_hready will never be toggled. For read operations, things are different in address mode access and short mode access. For address mode, idma_hready always toggles until the read transaction is completed. In

short mode, since the actual read data is fetched at the previous transaction, idma_hready will not be toggled unless the consecutive request comes too soon.

The Short DDMA ports shall be accessed in words if the DSP Program Code memory is targeted; or in half-words if the DSP Program Data or DSP Data memory is targeted.

During DSP booting, the DSP program execution is held off until the DDMA writes to the Program Code Memory address zero. Therefore, MCU software should load all necessary DSP memory locations with proper code/data before writing to the DSP Program Code Memory address 0, which is mapped to MCU address 0x60000000. As for the PM encryption/decryption, the PM_XOR_MASK is 0xBF96, and the following table can describe the encryption

Before encryption	After encryption
pm_data[0]	pm_e_data[13]
pm_data[1]	pm_e_data[4]
pm_data[2]	pm_e_data[15]
pm_data[3]	pm_e_data[1]
pm_data[4]	pm_e_data[12]
pm_data[5]	pm_e_data[3]
pm_data[6]	pm_e_data[8]
pm_data[7]	pm_e_data[0]
pm_data[8]	pm_e_data[9]
pm_data[9]	pm_e_data[11]
pm_data[10]	pm_e_data[5]
pm_data[11]	pm_e_data[10]
pm_data[12]	pm_e_data[6]
pm_data[13]	pm_e_data[7]
pm_data[14]	pm_e_data[2]
pm_data[15]	pm_e_data[14]

Table 5 PM encription

6.3.2 Register Definitions

60310000h DDMA Short Read/Write Port DDMA_SHORT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DDMA_SHORT															
Type	R/W															

This is the read/write port for AHB-to-DDMA data access using short DDMA cycles. When this port is read, an DDMA read cycle is sent to the DSP, which returns the content of DDMA data buffer to AHB via AHB-to-DDMA Bridge, then reads a specific location in its memory and puts the read data into the DDMA data buffer. When this port is written, a DDMA write cycle is sent to the DSP, which writes the AHB data to a specific location in its memory. Meanwhile, another AHB transaction can be proceeding.

For CM transfers, bits 0 to 23 contain the data word. For PM or DM transfers, only bits 0 to 15 are used. The unused bits have *undefined* values if read.

7 Multi-Media Subsystem

MT6235 is specially designed to support multi-media terminals. It integrates several hardware based accelerators, like advanced LCD display controller and hardware Image Resizer. Besides, MT6235 also incorporates NAND Flash, USB 2.0 Device and SD/MMC/MS/MS Pro Controllers for massive data transfers and storages. This chapter describes those functional blocks in detail.

7.1 LCD Interface

7.1.1 General Description

MT6235 contains a versatile LCD controller which is optimized for multimedia applications. This controller supports many types of LCD modules and contains a rich feature set to enhance the functionality. These features are:

- Up to 320 x 240 resolution
- The internal frame buffer supports 8bpp indexed color, RGB 565, RGB 888 and ARGB 8888 format.
- Supports 8-bpp (RGB332), 12-bpp (RGB444), 16-bpp (RGB565), 18-bit (RGB666) and 24-bit (RGB888) LCD modules.
- 6 Layers Overlay with individual color depth, window size, vertical and horizontal offset, source key, alpha value and display rotation control(90°,180°, 270°, mirror and mirror then 90°, 180° and 270°)
- One Color Look-Up Table
- Three Gamma Correction Tables

For parallel LCD modules, the LCD controller can reuse external memory interface or use dedicated 8/9/16/18-bit parallel interface to access them and 8080 type interface is supported. It can transfer the display data from the internal SRAM or external SRAM/Flash Memory to the off-chip LCD modules.

For serial LCD modules, this interface performs parallel to serial conversion and both 8- and 9- bit serial interface is supported. The 8-bit serial interface uses four pins – LSCE#, LSDA, LSCK and LSA0 – to enter commands and data. Meanwhile, the 9-bit serial interface uses three pins – LSCE#, LSDA and LSCK – for the same purpose. Data read is not available with the serial interface and data entered must be 8 bits.

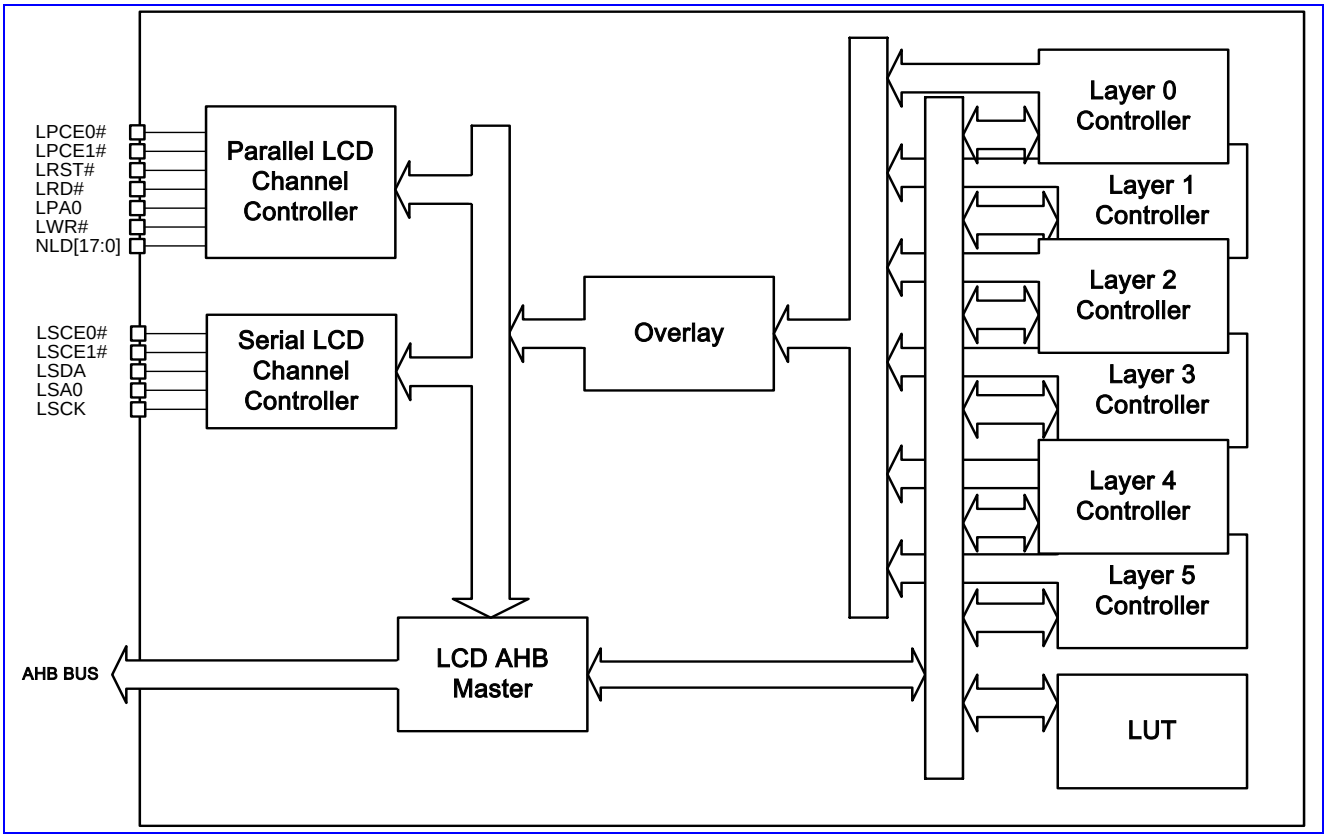


Figure 32 LCD Interface Block Diagram

Figure 33 shows the timing diagram of this serial interface. When the block is idle, LSCK is forced LOW and LSCE# is forced HIGH. Once the data register contains data and the interface is enabled, LSCE# is pulled LOW and remain LOW for the duration of the transmission.

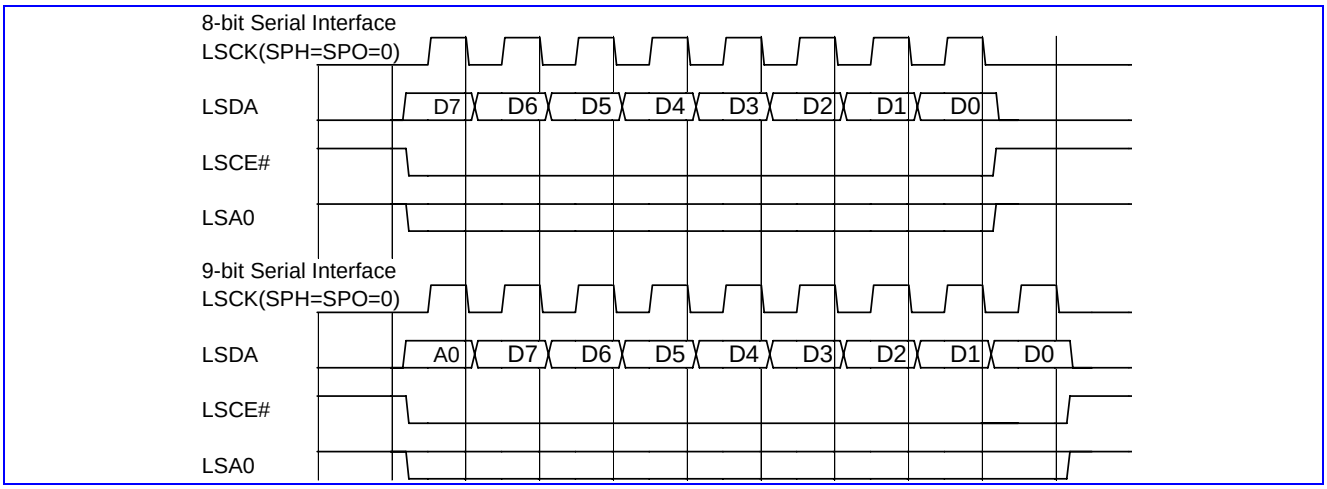


Figure 33 LCD Interface Transfer Timing Diagram

LCD = 0x9000_0000

Address	Register Function	Width	Acronym
LCD + 0000h	LCD Interface Status Register	16	**LCD_STA**
LCD + 0004h	LCD Interface Interrupt Enable Register	16	**LCD_INTEN**
LCD + 0008h	LCD Interface Interrupt Status Register	16	**LCD_INTSTA**
LCD + 000ch	LCD Interface Frame Transfer Register	16	**LCD_START**
LCD + 0010h	LCD Parallel/Serial LCM Reset Register	16	**LCD_RSTB**
LCD + 0014h	LCD Serial Interface Configuration Register	16	**LCD_SCNF**
LCD + 0018h	LCD Parallel Interface 0 Configuration Register	32	**LCD_PCNF0**
LCD + 001ch	LCD Parallel Interface 1 Configuration Register	32	**LCD_PCNF1**
LCD + 0020h	LCD Parallel Interface 2 Configuration Register	32	**LCD_PCNF2**
LCD + 0024h	LCD Tearing Control Register	32	**LCD_TECON**
LCD + 0040h	LCD Main Window Size Register	32	**LCD_MWINSIZE**
LCD + 0044h	LCD ROI Window Write to Memory Offset Register	32	**LCD_WROI_W2MOFS**
LCD + 0048h	LCD ROI Window Write to Memory Control Register	24	**LCD_WROI_W2MCON**
LCD + 004ch	LCD ROI Window Write to Memory Address Register	32	**LCD_WROI_W2MADD**
LCD + 0050h	LCD ROI Window Control Register	32	**LCD_WROICON**
LCD + 0054h	LCD ROI Window Offset Register	32	**LCD_WROIOFS**
LCD + 0058h	LCD ROI Window Command Start Address Register	16	**LCD_WROICADD**
LCD + 005ch	LCD ROI Window Data Start Address Register	16	**LCD_WROIDADD**
LCD + 0060h	LCD ROI Window Size Register	32	**LCD_WROISIZE**
LCD + 0064h	LCD ROI Window Hardware Refresh Register	32	**LCD_WROI_HWREF**
LCD + 0068h	LCD ROI Window Background Color Register	32	**LCD_WROI_BGCLR**
LCD + 0070h	LCD Layer 0 Window Control Register	32	**LCD_L0WINCON**
LCD + 0074h	LCD Layer 0 Source Color Key Register	32	**LCD_L0WINSKEY**
LCD + 0078h	LCD Layer 0 Window Display Offset Register	32	**LCD_L0WINOFS**
LCD + 007ch	LCD Layer 0 Window Display Start Address Register	32	**LCD_L0WINADD**
LCD + 0080h	LCD Layer 0 Window Size	32	**LCD_L0WINSIZE**
LCD + 0090h	LCD Layer 1 Window Control Register	32	**LCD_L1WINCON**
LCD + 0094h	LCD Layer 1 Source Color Key Register	32	**LCD_L1WINSKEY**
LCD + 0098h	LCD Layer 1 Window Display Offset Register	32	**LCD_L1WINOFS**
LCD + 009ch	LCD Layer 1 Window Display Start Address Register	32	**LCD_L1WINADD**
LCD + 00a0h	LCD Layer 1 Window Size	32	**LCD_L1WINSIZE**
LCD + 00b0h	LCD Layer 2 Window Control Register	32	**LCD_L2WINCON**
LCD + 00b4h	LCD Layer 2 Source Color Key Register	32	**LCD_L2WINSKEY**
LCD + 00b8h	LCD Layer 2 Window Display Offset Register	32	**LCD_L2WINOFS**
LCD + 00bch	LCD Layer 2 Window Display Start Address Register	32	**LCD_L2WINADD**
LCD + 00c0h	LCD Layer 2 Window Size	32	**LCD_L2WINSIZE**
LCD + 00d0h	LCD Layer 3 Window Control Register	32	**LCD_L3WINCON**
LCD + 00d4h	LCD Layer 3 Source Color Key Register	32	**LCD_L3WINSKEY**

LCD + 00d8h	LCD Layer 3 Window Display Offset Register	32	**LCD_L3WINOFS**
LCD + 00dch	LCD Layer 3 Window Display Start Address Register	32	**LCD_L3WINADD**
LCD + 00e0h	LCD Layer 3 Window Size	32	**LCD_L3WINSIZE**
LCD + 00f0h	LCD Layer 4 Window Control Register	32	**LCD_L4WINCON**
LCD + 00f4h	LCD Layer 4 Source Color Key Register	32	**LCD_L4WINSKEY**
LCD + 00f8h	LCD Layer 4 Window Display Offset Register	32	**LCD_L4WINOFS**
LCD + 00fch	LCD Layer 4 Window Display Start Address Register	32	**LCD_L4WINADD**
LCD + 0100h	LCD Layer 4 Window Size	32	**LCD_L4WINSIZE**
LCD + 0110h	LCD Layer 5 Window Control Register	32	**LCD_L5WINCON**
LCD + 0114h	LCD Layer 5 Source Color Key Register	32	**LCD_L5WINSKEY**
LCD + 0118h	LCD Layer 5 Window Display Offset Register	32	**LCD_L5WINOFS**
LCD + 011ch	LCD Layer 5 Window Display Start Address Register	32	**LCD_L5WINADD**
LCD + 0120h	LCD Layer 5 Window Size	32	**LCD_L5WINSIZE**
LCD + 4000h	LCD Parallel Interface 0 Data	32	**LCD_PDAT0**
LCD + 4100h	LCD Parallel Interface 0 Command	32	**LCD_PCMD0**
LCD + 5000h	LCD Parallel Interface 1 Data	32	**LCD_PDAT1**
LCD + 5100h	LCD Parallel Interface 1 Command	32	**LCD_PCMD1**
LCD + 6000h	LCD Parallel Interface 2 Data	32	**LCD_PDAT2**
LCD + 6100h	LCD Parallel Interface 2 Command	32	**LCD_PCMD2**
LCD + 8000h	LCD Serial Interface 1 Data	16	**LCD_SDAT1**
LCD + 8100h	LCD Serial Interface 1 Command	16	**LCD_SCMD1**
LCD + 9000h	LCD Serial Interface 0 Data	16	**LCD_SDAT0**
LCD + 9100h	LCD Serial Interface 0 Command	16	**LCD_SCMD0**
LCD + c000h ~ c3fch	LCD Gamma Correction LUT Register	32	**LCD_GAMMA**
LCD + c400h ~ c7fch	LCD Color Palette LUT Register	32	**LCD_PAL**
LCD + c800h ~ c87c	LCD Interface Command/Parameter0 Register	32	**LCD_COMD0**
LCD + c880h ~ c8fch	LCD Interface Command/Parameter1 Register	32	**LCD_COMD1**

Table 27 Memory map of LCD Interface

7.1.2 Register Definitions

LCD +0000h LCD Interface Status Register LCD_STA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													TE_PEND	CMD_CPEND	DATA_PEND	RUN
Type													R/W	R	R	R
Reset													0	0	0	0

RUN LCD Interface Running Status
DATA_PEND Data Pending Indicator in Hardware Trigger Mode
CMD_PEND Command Pending Indicator in Hardware Triggered Refresh Mode
TE_PEND Frame update pending for tearing input

LCD +0004h LCD Interface Interrupt Enable Register LCD_INTEN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													TE_CPL	CMD_CPL	DATA_CPL	CPL
Type													R/W	R/W	R/W	R/W
Reset													0	0	0	0

CPL LCD Frame Transfer Complete Interrupt Control
DATA_CPL Data Transfer Complete in Hardware Triggered Refresh Mode Interrupt Control
CMD_CPL Command Transfer Complete in Hardware Trigger Refresh Mode Interrupt Control
TE_CPL Issue an interrupt when TE pending complete

LCD +0008h LCD Interface Interrupt Status Register LCD_INTSTA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													TE_CPL	CMD_CPL	DATA_CPL	CPL
Type													R	R	R	R
Reset													0	0	0	0

CPL LCD Frame Transfer Complete Interrupt
DATA_CPL Data Transfer Complete in Hardware Triggered Refresh Mode Interrupt
CMD_CPL Command Transfer Complete in Hardware Triggered Refresh Mode Interrupt
TE_ CPL Frame update pending for tearing input

LCD +000Ch LCD Interface Frame Transfer Register LCD_START

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	START															
Type	R/W															
Reset	0															

START Start Control of LCD Frame Transfer

LCD +0010h LCD Parallel/Serial Interface Reset Register LCD_RSTB

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																RSTB
Type																R/W
Reset																1

RSTB Parallel/Serial LCD Module Reset Control

LCD +0014h LCD Serial Interface Configuration Register LCD _SCNF

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	26M	13M	GAMMA_ID				CSP1	CSP0				8/9	DIV		SPH	SPO
Type	R/W	R/W	R/W				R/W	R/W				R/W	R/W		R/W	R/W
Type	0	0	0				0	0				0	0		0	0

SPO Clock Polarity Control
SPH Clock Phase Control
DIV Serial Clock Divide Select Bits
8/9 8-bit or 9-bit Interface Selection
CSP0 Serial Interface Chip Select 0 Polarity Control
CSP1 Serial Interface Chip Select 1 Polarity Control
GAMMA_ID Gamma correction LUT ID
- **00** table 0
- **01** table 1
- **10** table 2
- **11** no table selected

13M Enable 13MHz clock gating.
26M Enable 26MHz clock gating.

LCD +0018h LCD Parallel Interface Configuration Register 0 LCD_PCNF0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	C2WS		C2WH		C2RS				GAMMA_ID_R		GAMMA_ID_G		GAMMA_ID_B		DW	
Type	R/W		R/W		R/W				R/W		R/W		R/W		R/W	
	0		0		0				0		0		0		0	
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	52M	26M		WST								RLT				
Type	R/W	R/W		R/W								R/W				
Reset	0	0		0								0				

RLT Read Latency Time
Actual Read Latency cycles = RLT+2 cycles
WST Write Wait State Time
26M Enable 26MHz clock gating.
52M Enable 52MHz clock gating.
DW Data width of the parallel interface
- **00** 8-bit.
- **01** 9-bit
- **10** 16-bit
- **11** 18-bit

GAMMA_ID_R Gamma Correction LUT ID for Red Component
- **00** table 0
- **01** table 1
- **10** table 2
- **11** no table selected

GAMMA_ID_G Gamma correction LUT ID for Green Component
- **00** table 0
- **01** table 1
- **10** table 2
- **11** no table selected

GAMMA_ID_B Gamma correction LUT ID for Blue Component

00 table 0
01 table 1
10 table 2
11 no table selected

C2RS Chip Select (LPCE#) to Read Strobe (LRD#) Setup Time
C2WH Chip Select (LPCE#) to Write Strobe (LWR#) Hold Time
C2WS Chip Select (LPCE#) to Write Strobe (LWR#) Setup Time

LCD +001Ch LCD Parallel Interface Configuration Register 1 LCD_PCNF1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	C2WS		C2WH		C2RS						GAMMA_ID				DW	
Type	R/W		R/W		R/W						R/W				R/W	
	0		0		0						11				0	
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	52M	26M		WST								RLT				
Type	R/W	R/W		R/W								R/W				
Reset	0	0		0								0				

RLT Read Latency Time
Actual Read Latency cycles = RLT+2 cycles
WST Write Wait State Time
26M Enable 26MHz clock gating.
52M Enable 52MHz clock gating.
DW Data width of the parallel interface
00 8-bit.
01 9-bit
10 16-bit
11 18-bit
GAMMA_ID Gamma correction LUT ID
00 table 0
01 table 1
10 table 2
11 no table selected
C2RS Chip Select (LPCE#) to Read Strobe (LRD#) Setup Time
C2WH Chip Select (LPCE#) to Write Strobe (LWR#) Hold Time
C2WS Chip Select (LPCE#) to Write Strobe (LWR#) Setup Time

LCD +0020h LCD Parallel Interface Configuration Register 2 LCD_PCNF2

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	C2WS		C2WH		C2RS						GAMMA_ID				DW	
Type	R/W		R/W		R/W						R/W				R/W	
	0		0		0						0				0	
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	52M	26M		WST								RLT				
Type	R/W	R/W		R/W								R/W				
Reset	0	0		0								0				

RLT Read Latency Time
Actual Read Latency cycles = RLT+2 cycles

WST Write Wait State Time

26M Enable 26MHz clock gating.

52M Enable 52MHz clock gating.

DW Data width of the parallel interface.

- **00** 8-bit.
- **01** 9-bit
- **10** 16-bit
- **11** 18-bit

GAMMA_ID Gamma correction LUT ID

- **00** table 0
- **01** table 1
- **10** table 2
- **11** no table selected

C2RS Chip Select (LPCE#) to Read Strobe (LRD#) Setup Time

C2WH Chip Select (LPCE#) to Write Strobe (LWR#) Hold Time

C2WS Chip Select (LPCE#) to Write Strobe (LWR#) Setup Time

LCD Controller Synchronization Modes

When TE_EN is enabled, LCD controller will synchronize its updating to LCM refresh timing. And it supports two synchronizing modes depending on TE_MODE.

TE Signal Polarity

TE_EDGE_SEL can be used to select TE polarity for TE signal detection.

TE_EDGE_SEL value	TE signal detection
0	**Detect a TE signal at its rising edge. This setting is for active high TE signal.**
1	**Detect a TE signal at its falling edge. This setting if for active low TE signal.**

Table 2 TE Signal Polarity

Vertical Synchronization Mode

MT6235 LCD supports vertical synchronization mode to avoid tearing effect.

In this mode, LCD controller starts to update LCM after each rising edge of the TE input (or falling edge, if TE_EDGE_SEL is set to 1) (see Figure 3).

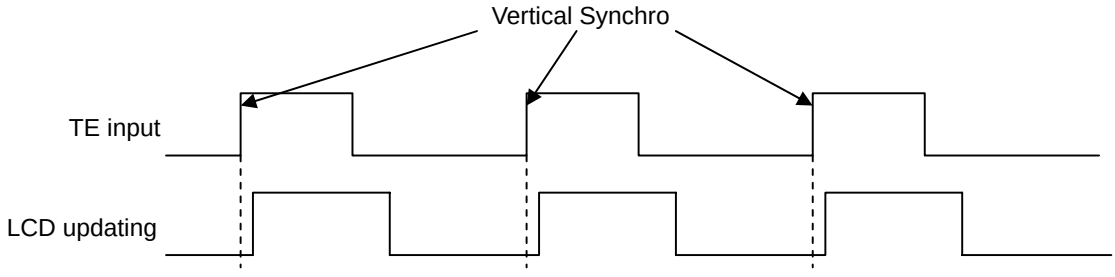


Figure 34 Vertical Synchronization Mode

LCD +0024h LCD Tearing Control Register LCD_TECON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16

Name															TE_EDGE_SEL	TE_EN
Type															R/W	R/W
Reset															0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

TE_EN Enable tearing control. LCD controller will synchronize to LCM refresh timing.

TE_EDGE_SEL Select sync edge.

0 Rising edge

1 Falling edge

LCD +4000h LCD Parallel 0 Interface Data LCD_PDAT0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DATA[31:16]															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DATA[15:0]															
Type	R/W															

DATA Writing to LCD+4000 will drive LPA0 low when sending this data out in parallel BANK0, while writing to LCD+4100 will drive LPA0 high.

LCD +5000h LCD Parallel 1 Interface Data LCD_PDAT1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DATA[31:16]															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DATA[15:0]															
Type	R/W															

DATA Writing to LCD+5000 will drive LPA1 low when sending this data out in parallel BANK1, while writing to LCD+5100 will drive LPA1 high

LCD +6000h LCD Parallel 2 Interface Data LCD_PDAT2

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DATA[31:16]															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DATA[15:0]															
Type	R/W															

DATA Writing to LCD+6000 will drive LPA2 low when sending this data out in parallel BANK2, while writing to LCD+6100 will drive LPA2 high

LCD +8000/8100h LCD Serial Interface 1 Data LCD_SDAT1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									DATA							

Type									W							

DATA Writing to LCD+8000 will drive LSA0 low while sending this data out in serial BANK1, while writing to LCD+8100 will drive LSA0 high

LCD +9000/9100h LCD Serial Interface 0 Data LCD_SDAT0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									DATA							
Type									W							

DATA Writing to LCD+9000 will drive LSA0 low while sending this data out in serial BANK0, while writing to LCD+9100 will drive LSA0 high

LCD +0040h Main Window Size Register LCD_MWINSIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name							ROW									
Type							R/W									
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							COLUMN									
Type							R/W									

COLUMN 10-bit Virtual Image Window Column Size
ROW 10-bit Virtual Image Window Row Size

LCD +0044h Region of Interest Window Write to Memory Offset Register LCD_WROI_W2MOFS

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name							Y-OFFSET									
Type							R/W									
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							X-OFFSET									
Type							R/W									

This control register is used to specify the offset of the ROI window from the LCD_WROI_W2MADDR when writing the ROI window's content to memory.
X-OFFSET the x offset of ROI window in the destination memory.
Y-OFFSET the y offset of ROI window in the destination memory.

LCD +0048h Region of Interest Window Write to Memory Control Register LCD_WROI_W2MCON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	OUTPUT_ALPHA										DC_OUT_EN	ADDINC_DISABLE	DISCON	W2M_FORMAT		W2LCM
Type	R/W										R/W	R/W	R/W	R/W		R/W
Reset	0xff										0	0	0	0		0

This control register is effective only when the W2M bit is set in LCD_WROICON register.

W2LCM Write to LCM simultaneously.

W2M_FORMAT Write to memory format.

00 RGB565

01 RGB888

10 ARGB8888

DISCON Block Write Enable Control. By setting both DISCON and W2M to 1, the LCD controller will write out the ROI pixel data as a part of MAIN window, using the width of MAIN window to calculate the write-out address. If this bit is not set, the ROI window will be written to memory in continuous addresses.

ADDINC_DISABLE Disable address increase when writing to memory.

DC_OUT_EN Enable direct couple to rotator 3.

OUTPUT_ALPHA Output Alpha value.

LCD +004Ch Region of Interest Window Write to Memory Address Register LCD_WROI_W2M ADD

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	W2M_ADDR															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	W2M_ADDR															
Type	R/W															

W2M_ADDR Write to memory address. For better memory write efficiency, it is recommended to 64 bytes alignment, but it is not restricted to 64 bytes alignment.

LCD +0050h Region of Interest Window Control Register LCD_WROICON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	EN0	EN1	EN2	EN3	EN4	EN5	PERIOD									
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W									
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ENC	W2M	COM_SEL	COMMAND					FORMAT							
Type	R/W	R/W	R/W	R/W					R/W							

FORMAT LCD Module Data Format

Bit 0 : in BGR sequence, otherwise in RGB sequence.

Bit 1 : LSB first, otherwise MSB first.

Bit 2 : padding bits on MSBs, otherwise on LSBs.

Bit 5-3 : 000 for RGB332, 001 for RGB444, 010 for RGB565, 011 for RGB666, 100 for RGB888.

Bit 7-6 : 00 for 8-bit interface, 01 for 16-bit interface, 10 for 9-bit interface, 11 for 18-bit interface.

Note: When the interface is configured as 9 bit or 18 bit, the field of bit5-2 is ignored.

00000000	8bit	1cycle/1pixel	RGB3.3.2	RRRGGGBB
00000001		1cycle/1pixel	RGB3.3.2	BBGGGRRR
00001000		3cycle/2pixel	RGB4.4.4	RRRRGGGG BBBBRRRR GGGGBBBB

00001011		3cycle/2pixel	RGB4.4.4	GGGGRRRR RRRRBBBB BBBBGGGG
00010000		2cycle/1pixel	RGB5.6.5	RRRRRGGG GGGBBBBB
00010011		2cycle/1pixel	RGB5.6.5	GGGRRRRR BBBBBGGG
00011000		3cycle/1pixel	RGB6.6.6	RRRRRRXX GGGGGGXX BBBBBBXX
00011100		3cycle/1pixel	RGB6.6.6	XXRRRRRR XXGGGGGG XXBBBBBB
00100000		3cycle/1pixel	RGB8.8.8	RRRRRRRR GGGGGGGG BBBBBBBB
10xxxx00	9bit	2cycle/1pixel	RGB6.6.6	RRRRRRGGG GGGBBBBBB
10xxxx11		2cycle/1pixel	RGB6.6.6	GGGRRRRRR BBBBBBGGG
01000000	16bit	1cycle/2pixel	RGB3.3.2	RRRGGGBBRRRGGGBB
01000010		1cycle/2pixel	RGB3.3.2	RRRGGGBBRRRGGGBB
01000001		1cycle/2pixel	RGB3.3.2	BBGGGRRRBBGGGRRR
01000011		1cycle/2pixel	RGB3.3.2	BBGGGRRRBBGGGRRR
01001100		1cycle/1pixel	RGB4.4.4	XXXXRRRRGGGGBBBB
01001101		1cycle/1pixel	RGB4.4.4	XXXXBBBBGGGGRRRR
01001000		1cycle/1pixel	RGB4.4.4	RRRRGGGGBBBBXXXX
01001001		1cycle/1pixel	RGB4.4.4	BBBBGGGGRRRRXXXX
01010000		1cycle/1pixel	RGB5.6.5	RRRRRGGGGGGBBBBB
01010001		1cycle/1pixel	RGB5.6.5	BBBBBGGGGGGRRRRR
01011100		3cycle/2pixel	RGB6.6.6	XXXXRRRRRRGGGGGG XXXXBBBBBBRRRRRR XXXXGGGGGGBBBBBB
01011111		3cycle/2pixel	RGB6.6.6	XXXXGGGGGGRRRRRR XXXXRRRRRRBBBBBB XXXXBBBBBBGGGGGG
01011000		3cycle/2pixel	RGB6.6.6	RRRRRRGGGGGGXXXX BBBBBBRRRRRRXXXX GGGGGGBBBBBBXXXX
01011011		3cycle/2pixel	RGB6.6.6	GGGGGGRRRRRRXXXX RRRRRRBBBBBBXXXX BBBBBBGGGGGGXXXX
01100000		3cycle/2pixel	RGB8.8.8	RRRRRRRRGGGGGGGG

				BBBBBBBBRRRRRRRR GGGGGGGGBBBBBBBB
01100011		3cycle/2pixel	RGB8.8.8	GGGGGGGGRRRRRRRR RRRRRRRRBBBBBBBB BBBBBBBBRRRRRRRR
11xxxx00	18bit	1cycle/1pixel	RGB6.6.6	RRRRRRGGGGGGBBBBBB
11xxxx01		1cycle/1pixel	RGB6.6.6	BBBBBBGGGGGGRRRRRR
11100000		3cycle/2pixel	RGB8.8.8	RRRRRRRRGGGGGGGG BBBBBBBBRRRRRRRR GGGGGGGGBBBBBBBB
11100011		3cycle/2pixel	RGB8.8.8	GGGGGGGGRRRRRRRR RRRRRRRRBBBBBBBB BBBBBBBBRRRRRRRR

COM_SEL Command Queue ID Selection

COMMAND Number of Commands to be sent to LCD module. Maximum is 31.

W2M Enable Write to Memory

ENC Command Transfer Enable Control

PERIOD Waiting period between two consecutive transfers, effective for both data and command.

ENn Layer Window Enable Control

LCD +0054h Region of Interest Window Offset Register LCD_WROIOFS

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name							Y-OFFSET									
Type							R/W									
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							X-OFFSET									
Type							R/W									

X-OFFSET ROI Window Column Offset

Y-OFFSET ROI Window Row Offset

LCD +0058h Region of Interest Window Command Start Address Register LCD_WROICADD

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ADDR															
Type	R/W															

ADDR ROI Window Command Address. Only writing to LCD modules is allowed.

LCD +005Ch Region of Interest Window Data Start Address Register LCD_WROIDADD

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ADDR															
Type	R/W															

ADDR ROI Window Data Address Only writing to LCD modules is allowed.

LCD +0060h Region of Interest Window Size Register LCD_WROISIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name							ROW									
Type							R/W									
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							COLUMN									
Type							R/W									

COLUMN ROI Window Column Size

ROW ROI Window Row Size

LCD +0064h Region of Interest Window Hardware Refresh Register LCD_WROI_HWREF

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	EN0	EN1	EN2	EN3	EN4	EN5									HWREF_SEL	
Type	R/W	R/W	R/W	R/W	R/W	R/W									R/W	
Reset	0	0	0	0	0	0									0	
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									HWEN							HWREF
Type									R/W							R/W
Reset									0							0

EN*n* Enable layer n source address from Image_DMA.

HWEN Enable hardware triggered LCD fresh.

HWREF_SEL Select hardware triggered source.

- **00** triggered by IRT1.
- **01** triggered by IBW1.
- **10** triggered by IRT2 (without base address).
- **11** triggered by IBW2 (without base address).

HWREF Starting the hardware triggered LCD frame transfer.

LCD +0068h Region of Interest Window Direct Couple Register LCD_WROI_DC

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	EN0	EN1	EN2	EN3	EN4	EN5										
Type	R/W	R/W	R/W	R/W	R/W	R/W										
Reset	0	0	0	0	0	0										
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DC_SEL0		DC_SEL1		DC_SEL2		DC_SEL3		DC_SEL4		DC_SEL5					
Type	R/W		R/W		R/W		R/W		R/W		R/W					
Reset	0		0		0		0		0		0					

EN*n* Enable layer n source data from Image_DMA.

DC_SELn Select source layer n data.

- **00** Reserved.
- **01** IBW1
- **10** IRT2
- **11** IBW2

Note : When direct couple is enabled on mulitple layers, the source data of each layer should be different.

LCD +006Ch Region of Interest Background Color Register — LCD_WROI_BGCLR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name									RED[7:0]							
Type									R/W							
Reset									1111_1111							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GREEN[7:0]								BLUE[7:0]							
Type	R/W								R/W							
Reset	1111_1111								1111_1111							

RED Red component of ROI window's background color
GREEN Green component of ROI window's background color
BLUE Blue component of ROI window's background color

LCD +0070h Layer 0 Window Control Register — LCD_L0WINCON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name												READ_CACHE_DIS				SWP
Type												R/W				R/W
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SRC	KEYEN	ROTATE			CLRDPT		OPAEN	OPA							
Type	R/W	R/W	R/W			R/W		R/W	R/W							

OPA Opacity value, used as constant alpha value.
OPAEN Opacity enabled
CLRDPT Color format
- **00** 8bpp indexed color.
- **01** RGB 565
- **10** ARGB 8888
- **11** RGB 888

ROTATE Rotation Configuration
- **000** 0 degree rotation
- **001** 90 degree rotation anti-counterclockwise
- **010** 180 degree rotation anti-counterclockwise
- **011** 270 degree rotation anti-counterclockwise
- **100** Horizontal flip
- **101** Horizontal flip then 90 degree rotation anti-counterclockwise
- **110** Horizontal flip then 180 degree rotation anti-counterclockwise
- **111** Horizontal flip then 270 degree rotation anti-counterclockwise

KEYEN Source Key Enable Control
SRC Disable auto-increment of the source pixel address
SWP Swap high byte and low byte of pixel data
READ_CACHE_DIS Disable read cache, issue single access

LCD +0074h Layer 0 Source Color Key Register — LCD_L0WINSKEY

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SRCKEY[31:16]															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SRCKEY[15:0]															
Type	R/W															

SRCKEY Transparent color key of the source image.

LCD +0078h Layer 0 Window Display Offset Register — LCD_L0WINOFS

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name							Y-OFFSET									
Type							R/W									
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							X-OFFSET									
Type							R/W									

Y-OFFSET Layer 0 Window Row Offset

X-OFFSET Layer 0 Window Column Offset

LCD+007Ch Layer 0 Window Display Start Address Register — LCD_L0WINADD

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	ADDR															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ADDR															
Type	R/W															

ADDR Layer 0 Window Data Address. Note that the layer start address must be word-aligned.

LCD +0080h Layer 0 Window Size — LCD_L0WINSIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name							ROW									
Type							R/W									
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							COLUMN									
Type							R/W									

ROW Layer 0 Window Row Size

COLUMN Layer 0 Window Column Size

LCD +0090h Layer 1 Window Control Register — LCD_L1WINCON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																SWP
Type																R/W
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name	SRC	KEYEN	ROTATE	CLRDPT	OPAEN	OPA
Type	R/W	R/W	R/W	R/W	R/W	R/W

OPA Opacity value, used as constant alpha value.
OPAEN Opacity enabled
CLRDPT Color format
- **00** 8bpp indexed color.
- **01** RGB 565
- **10** ARGB 8888
- **11** RGB 888

ROTATE Rotation Configuration
- **000** 0 degree rotation
- **001** 90 degree rotation anti-counterclockwise
- **010** 180 degree rotation anti-counterclockwise
- **011** 270 degree rotation anti-counterclockwise
- **100** Horizontal flip
- **101** Horizontal flip then 90 degree rotation anti-counterclockwise
- **110** Horizontal flip then 180 degree rotation anti-counterclockwise
- **111** Horizontal flip then 270 degree rotation anti-counterclockwise

KEYEN Source Key Enable Control
SRC Disable auto-increment of the source pixel address
SWP Swap high byte and low byte of pixel data
READ_CACHE_DIS Disable read cache, issue single access

LCD +0094h Layer 1 Source Color Key Register — LCD_L1WINSKEY

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SRCKEY[31:16]															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SRCKEY[15:0]															
Type	R/W															

SRCKEY Transparent color key of the source image.

LCD +0098h Layer 1 Window Display Offset Register — LCD_L1WINOFS

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name							Y-OFFSET									
Type							R/W									
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							X-OFFSET									
Type							R/W									

Y-OFFSET Layer 1 Window Row Offset
X-OFFSET Layer 1 Window Column Offset

LCD+009Ch Layer 1 Window Display Start Address Register — LCD_L1WINADD

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16

Name	ADDR															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ADDR															
Type	R/W															

ADDR Layer 1 Window Data Address. Note that the layer start address must be word-aligned.

LCD +00A0h Layer 1 Window Size

LCD_L1WINSIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name							ROW									
Type							R/W									
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							COLUMN									
Type							R/W									

ROW Layer 1 Window Row Size

COLUMN Layer 1 Window Column Size

LCD +00B0h Layer 2 Window Control Register

LCD_L2WINCON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																SWP
Type																R/W
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SRC	KEYEN	ROTATE			CLRDPT		OPAEN	OPA							
Type	R/W	R/W	R/W			R/W		R/W	R/W							

OPA Opacity value, used as constant alpha value.

OPAEN Opacity enabled

CLRDPT Color format

- **00** 8bpp indexed color.
- **01** RGB 565
- **10** ARGB 8888
- **11** RGB 888

ROTATE Rotation Configuration

- **000** 0 degree rotation
- **001** 90 degree rotation anti-counterclockwise
- **010** 180 degree rotation anti-counterclockwise
- **011** 270 degree rotation anti-counterclockwise
- **100** Horizontal flip
- **101** Horizontal flip then 90 degree rotation anti-counterclockwise
- **110** Horizontal flip then 180 degree rotation anti-counterclockwise
- **111** Horizontal flip then 270 degree rotation anti-counterclockwise

KEYEN Source Key Enable Control

SRC Disable auto-increment of the source pixel address

SWP Swap high byte and low byte of pixel data

READ_CACHE_DIS Disable read cache, issue single access

LCD +00B4h Layer 2 Source Color Key Register — LCD_L2WINSKEY

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SRCKEY[31:16]															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SRCKEY[15:0]															
Type	R/W															

SRCKEY Transparent color key of the source image.

LCD +00B8h Layer 2 Window Display Offset Register — LCD_L2WINOFS

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name							Y-OFFSET									
Type							R/W									
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							X-OFFSET									
Type							R/W									

Y-OFFSET Layer 2 Window Row Offset
X-OFFSET Layer 2 Window Column Offset

LCD+00BCh Layer 2 Window Display Start Address Register — LCD_L2WINADD

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	ADDR															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ADDR															
Type	R/W															

ADDR Layer 1 Window Data Address Note that the layer start address must be word-aligned.

LCD +00C0h Layer 2 Window Size — LCD_L2WINSIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name							ROW									
Type							R/W									
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							COLUMN									
Type							R/W									

ROW Layer 2 Window Row Size
COLUMN Layer 2 Window Column Size

LCD +00D0h Layer 3 Window Control Register — LCD_L3WINCON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																SWP
Type																R/W
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name	SRC	KEYEN	ROTATE	CLRDPT	OPAEN	OPA
Type	R/W	R/W	R/W	R/W	R/W	R/W

OPA Opacity value, used as constant alpha value.
OPAEN Opacity enabled
CLRDPT Color format
- **00** 8bpp indexed color.
- **01** RGB 565
- **10** ARGB 8888
- **11** RGB 888

ROTATE Rotation Configuration
- **000** 0 degree rotation
- **001** 90 degree rotation anti-counterclockwise
- **010** 180 degree rotation anti-counterclockwise
- **011** 270 degree rotation anti-counterclockwise
- **100** Horizontal flip
- **101** Horizontal flip then 90 degree rotation anti-counterclockwise
- **110** Horizontal flip then 180 degree rotation anti-counterclockwise
- **111** Horizontal flip then 270 degree rotation anti-counterclockwise

KEYEN Source Key Enable Control
SRC Disable auto-increment of the source pixel address
SWP Swap high byte and low byte of pixel data
READ_CACHE_DIS Disable read cache, issue single access

LCD +00D4h Layer 3 Source Color Key Register — LCD_L3WINSKEY

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SRCKEY[31:16]															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SRCKEY[15:0]															
Type	R/W															

SRCKEY Transparent color key of the source image.

LCD +00D8h Layer 3 Window Display Offset Register — LCD_L3WINOFS

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name							Y-OFFSET									
Type							R/W									
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							X-OFFSET									
Type							R/W									

Y-OFFSET Layer 3 Window Row Offset
X-OFFSET Layer 3 Window Column Offset

LCD+00DCh Layer 3 Window Display Start Address Register — LCD_L3WINADD

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16

Name	ADDR															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ADDR															
Type	R/W															

ADDR Layer 3 Window Data Address Note that the layer start address must be word-aligned.

LCD +00E0h Layer 3 Window Size

LCD_L3WINSIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name							ROW									
Type							R/W									
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							COLUMN									
Type							R/W									

ROW Layer 3 Window Row Size

COLUMN Layer 3 Window Column Size

LCD +00F0h Layer 4 Window Control Register

LCD_L4WINCON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																SWP
Type																R/W
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SRC	KEYEN	ROTATE			CLRDPT		OPAEN	OPA							
Type	R/W	R/W	R/W			R/W		R/W	R/W							

OPA Opacity value, used as constant alpha value.

OPAEN Opacity enabled

CLRDPT Color format

- **00** 8bpp indexed color.
- **01** RGB 565
- **10** ARGB 8888
- **11** RGB 888

ROTATE Rotation Configuration

- **000** 0 degree rotation
- **001** 90 degree rotation anti-counterclockwise
- **010** 180 degree rotation anti-counterclockwise
- **011** 270 degree rotation anti-counterclockwise
- **100** Horizontal flip
- **101** Horizontal flip then 90 degree rotation anti-counterclockwise
- **110** Horizontal flip then 180 degree rotation anti-counterclockwise
- **111** Horizontal flip then 270 degree rotation anti-counterclockwise

KEYEN Source Key Enable Control

SRC Disable auto-increment of the source pixel address

SWP Swap high byte and low byte of pixel data

READ_CACHE_DIS Disable read cache, issue single access

LCD +00F4h Layer 4 Source Color Key Register — LCD_L4WINSKEY

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SRCKEY[31:16]															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SRCKEY[15:0]															
Type	R/W															

SRCKEY Transparent color key of the source image.

LCD +00F8h Layer 4 Window Display Offset Register — LCD_L4WINOFS

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name							Y-OFFSET									
Type							R/W									
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							X-OFFSET									
Type							R/W									

Y-OFFSET Layer 4 Window Row Offset
X-OFFSET Layer 4 Window Column Offset

LCD+00FCh Layer 4 Window Display Start Address Register — LCD_L4WINADD

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	ADDR															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ADDR															
Type	R/W															

ADDR Layer 4 Window Data Address Note that the layer start address must be word-aligned.

LCD +0100h Layer 4 Window Size — LCD_L4WINSIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name							ROW									
Type							R/W									
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							COLUMN									
Type							R/W									

ROW Layer 4 Window Row Size
COLUMN Layer 4 Window Column Size

LCD +0110h Layer 5 Window Control Register — LCD_L5WINCON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																SWP
Type																R/W
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name	SRC	KEYEN	ROTATE	CLRDPT	OPAEN	OPA
Type	R/W	R/W	R/W	R/W	R/W	R/W

OPA Opacity value, used as constant alpha value.
OPAEN Opacity enabled
CLRDPT Color format
- **00** 8bpp indexed color.
- **01** RGB 565
- **10** ARGB 8888
- **11** RGB 888

ROTATE Rotation Configuration
- **000** 0 degree rotation
- **001** 90 degree rotation anti-counterclockwise
- **010** 180 degree rotation anti-counterclockwise
- **011** 270 degree rotation anti-counterclockwise
- **100** Horizontal flip
- **101** Horizontal flip then 90 degree rotation anti-counterclockwise
- **110** Horizontal flip then 180 degree rotation anti-counterclockwise
- **111** Horizontal flip then 270 degree rotation anti-counterclockwise

KEYEN Source Key Enable Control
SRC Disable auto-increment of the source pixel address
SWP Swap high byte and low byte of pixel data
READ_CACHE_DIS Disable read cache, issue single access

LCD +0114h Layer 5 Source Color Key Register — LCD_L5WINSKEY

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SRCKEY[31:16]															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SRCKEY[15:0]															
Type	R/W															

SRCKEY Transparent color key of the source image.

LCD +0118h Layer 5 Window Display Offset Register — LCD_L5WINOFS

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name							Y-OFFSET									
Type							R/W									
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							X-OFFSET									
Type							R/W									

Y-OFFSET Layer 5 Window Row Offset
X-OFFSET Layer 5 Window Column Offset

LCD+011Ch Layer 5 Window Display Start Address Register — LCD_L5WINADD

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16

Name	ADDR															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ADDR															
Type	R/W															

ADDR Layer 5 Window Data Address Note that the layer start address must be word-aligned.

LCD +0120h Layer 5 Window Size LCD_L5WINSIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name							ROW									
Type							R/W									
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							COLUMN									
Type							R/W									

ROW Layer 5 Window Row Size
COLUMN Layer 5 Window Column Size

LCD +C000h~C3FCh LCD Interface Gamma Correction LUT Registers LCD_GAMMA

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name									GAMMA_LUT2							
Type									R/W							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GAMM_LUT1								GAMMA_LUT0							
Type	R/W								R/W							

GAMMA_LUT0 These Bits Set Gamma LUT 0.
GAMMA_LUT1 These Bits Set Gamma LUT 1.
GAMMA_LUT2 These Bits Set Gamma LUT 2.

LCD +C400h~C7FCh LCD Interface Color Palette LUT Registers LCD_PAL

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name									LUT							
Type									R/W							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LUT															
Type	R/W															

LUT These Bits Set Color Palette in RGB888 format.

LCD +C800h~C8FC LCD Interface Command/Parameter Registers LCD_COMD

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name									C0						COMM[17:16]	
Type									R/W						R/W	
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	COMM[15:0]															
Type	R/W															

COMM Command Data and Parameter Data for LCD Module
C0 Write to ROI Command Address if C0 = 1, otherwise write to ROI Data Address

7.2 Capture Resize

7.2.1 General Description

This block provides the image resizing function for image and video capturing scenarios. It receives image data from the ISP module, performs the image resizing function and outputs to the IMG_DMA module. **Figure 35** shows the block diagram. The capture resize is composed of horizontal and vertical resizing blocks. It can scale up or down the input image by any ratio. However, the maximum sizes of input and output images are limited to 4095x4095.

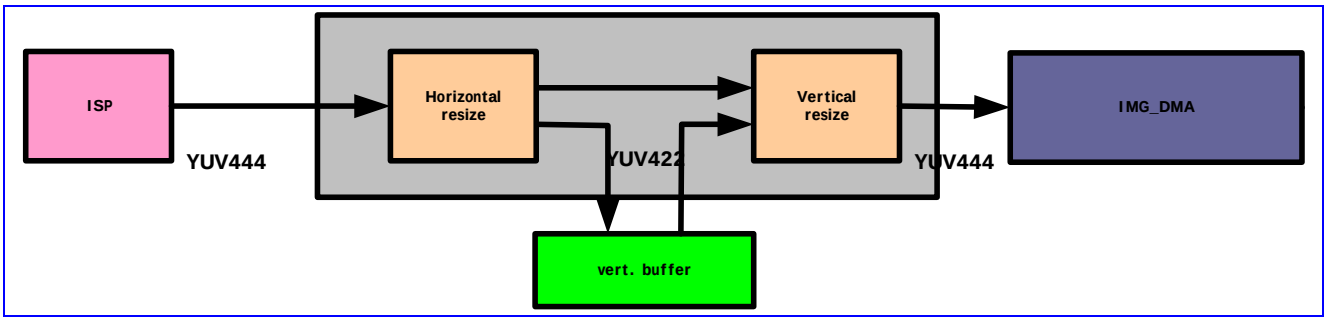


Figure 35 Block diagram of the capture resize

The resizing function is cubic interpolation. The input and output format are both YUV444. But the internal working memory format is YUV422 to mitigate memory and bandwidth requirements.

7.2.2 Register Definitions

REGISTER ADDRESS	REGISTER NAME	SYNONYM
CRZ+ 0000h	Capture Resize Configuration Register	CRZ_CFG
CRZ + 0004h	Capture Resize Control Register	CRZ_CON
CRZ + 0008h	Capture Resize Status Register	CRZ_STA
CRZ + 000Ch	Capture Resize Interrupt Register	CRZ_INT
CRZ + 0010h	Capture Resize Source Image Size Register 1	CRZ_SRCSZ1
CRZ + 0014h	Capture Resize Target Image Size Register 1	CRZ_TARSZ1
CRZ + 0018h	Capture Resize Horizontal Ratio Register 1	CRZ_HRATIO1
CRZ + 001Ch	Capture Resize Vertical Ratio Register 1	CRZ_VRATIO1
CRZ +003Ch	Capture Resize Coefficient Table	CRZ_GMCBASE
CRZ + 0040h	Capture Resize Coefficient Table	CRZ_FRCFG
CRZ+0044h	Capture Resize YUV Y-Component Target Memory Base Address Register	CRZ_TMBASE_Y
CRZ+0048h	Capture Resize YUV U-Component Target Memory Base Address Register	CRZ_TMBASE_U
CRZ+004Ch	Capture Resize YUV V-Component Target Memory Base Address	CRZ_TMBASE_V

	Register	
CRZ+0084h	Capture Resize Target Memory Base Address Register 1	CRZ_TMBASE1
CRZ+0088h	Capture Resize Target Memory Base Address Register 2	CRZ_TMBASE1

7.2.2.1 Capture Resize Configuration Register

CRZ+0000h Capture Resize Configuration Register CRZ_CFG

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name							LBMAX									
Type							R/W									
Reset							0									
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	NORGBDB	NORFDB	VSRSTEN	ECV	INTEN[1]	INTEN[0]	LBSEL	PCON			OUTFMT					
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W			R/W					
Reset	0	0	0	0	0	0	1	0			0					

The register is for global configuration of Capture Resize.

OUTFMT The register field specifies which format reszier outputs

0 RGB565

1 YUV420

3 YUV422

Others Reserved

Note: If YUV420 or YUV422 is selected, output width will be padded to 16's multiples.

PCON The register bit specifies if pixel-based resizing continues whenever an image finishes processing. Once continuous run for pixel-based resizing is enabled and pixel-based resizing is running, the only way to stop is to reset Capture Resize. If to stop immediately is desired, reset Capture Resize directly. If the last image is desired, set the register bit to '0' first. Then wait until image resizer is not busy again. Finally reset image resizer.

0 Single run

1 Continuous run

LBSEL Line buffer selection.

0 CRZ cant work!

1 Dedicated memory.

INTEN[0] Frame Done Interrupt Enable. When interrupt is enabled, an interrupt is generated whenever CRZ finishes.

0 Interrupt for is disabled.

1 Interrupt for is enabled.

INTEN[1] Frame Start Interrupt Enable. When interrupt is enabled, an interrupt is generated whenever CRZ begin working.

0 Interrupt for is disabled.

1 Interrupt for is enabled.

ECV The register field determines whether using 'ec' algorithm for vertical downscaling

0 cubic

1 ec. It helps when bandwidth is very critical.

VSRSTEN The register field determines whether force reset when vsync arise but previous frame not done yet.

0 Not force reset

1 Force reset when vsync

NORFDB The register field determines not double buffer some registers.

0 Double buffering registers

1 No double buffering registers

NORGBDB The register field determines whether base address of RGB565 output switching or not.

0 Auto switching between CRZ_TMBASE1 and CRZ_TMBASE2

1 No auto switching. Always CRZ_TMBASE1.

LBMAX **Number of lines used in upsampling scenario :**

```
WMIN = ((WS > WT) ? WT : WS);   // use for Width down, and Height up
WMIN_EVEN = WMIN + WMIN%2;
(int)(1600 / WMIN_EVEN) * 6;
```

7.2.2.2 Capture Resize Control Register

CRZ+0004h Capture Resize Control Register CRZ_CON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																PELRST
Type																R/W
Reset																0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
Name																PELENA
Type																R/W
Reset																0

The register is for global control of Capture Resize. **Note that software reset does NOT reset all register settings. Remember to trigger Capture Resize first before triggering image sources to Capture Resize.**

PELENA Writing '1' to the register bit causes CRZ proceed to work.

PELRST Writing '1' to the register causes CRZ to stop immediately and keep in reset state. In order to go to normal state, write '0' to the register bit.

7.2.2.3 Capture Resize Status Register

CRZ+0008h Capture Resize Status Register CRZ_STA

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name															BUSYI	BUSYO
Type															RO	RO
Reset																

The register indicates global status of Capture Resize.

BUSYI Input interface busy.

BUSYO Output interface busy.

7.2.2.4 Capture Resize Interrupt Register

CRZ+000Ch Capture Resize Interrupt Register CRZ_INT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name															FSTINT	PELINT
Type															RC	RC
Reset															0	0

The register shows up the interrupt status of resizer.

PELINT Interrupt for CRZ. No matter the register bit CRZ_CFG.INTEN[0] is enabled or not, the register bit is active whenever CRZ completes. It could be as software interrupt by polling the register bit. Clear it by reading the register.

FSTINT Interrupt for CRZ. No matter the register bit CRZ_CFG.INTEN[1] is enabled or not, the register bit is active whenever CRZ start working. It could be as software interrupt by polling the register bit. Clear it by reading the register.

7.2.2.5 Capture Resize Source Image Size Register 1

CRZ+0010h Capture Resize Source Image Size Register 1 CRZ_SRCSZ1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	HS															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	WS															
Type	R/W															

The register specifies the size of source image after coarse shrink process. **The allowable maximum size is 4095x4095 with limitation written in application notes.**

WS The register field specifies the width of source image after coarse shrink process.

1 The width of source image after coarse shrink process is 1.

2 The width of source image is 2.

…

HS The register field specifies the height of source image after coarse shrink process.

1 The height of source image after coarse shrink process is 1.

2 The height of source image after coarse shrink process is 2.

…

7.2.2.6 Capture Resize Target Image Size Register 1

CRZ+0014h Capture Resize Target Image Size Register 1 CRZ_TARSZ1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	HT															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	WT															
Type	R/W															

The register specifies the size of target image. **The allowable maximum size is 4095x4095 with limitation written in application notes.**

WT The register field specifies the width of target image.

1 The width of target image is 1.

2 The width of target image is 2.

…

HT The register field specifies the height of target image.

1 The height of target image is 1.

2 The height of target image is 2.

…

7.2.2.7 Capture Resize Horizontal Ratio Register 1

CRZ+0018h Capture Resize Horizontal Ratio Register CRZ_HRATIO1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	RATIO [31:16]															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RATIO [15:0]															
Type	R/W															

The register specifies horizontal resizing ratio. It is obtained by

CRZ_SRCSZ.HS > CRZ_TARSZ.HT

? ((CRZ_TARSZ.HT - 1)* 2^{20} + (CRZ_SRCSZ.HS -1)/2) / (CRZ_SRCSZ.HS -1)

: ((CRZ_SRCSZ.HS - 1)* 2^{20} + (CRZ_TARSZ.HT-1)/2) / (CRZ_TARSZ.HT-1).

7.2.2.8 Capture Resize Vertical Ratio Register 1

CRZ+001Ch Capture Resize Vertical Ratio Register 1 CRZ_VRATIO1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	RATIO [31:16]															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RATIO [15:0]															
Type	R/W															

The register specifies vertical resizing ratio. It is obtained by

CRZ_SRCSZ.VS > CRZ_TARSZ.VT

? ((CRZ_TARSZ.VT - 1)* 2^{20} + (CRZ_SRCSZ.VS -1)/2) / (CRZ_SRCSZ.VS -1)

: ((CRZ_SRCSZ.VS - 1)* 2^{20} + (CRZ_TARSZ.VT-1)/2) / (CRZ_TARSZ.VT-1).

7.2.2.9 Capture Resize GMC BASE Register

CRZ+003Ch Capture Resize Coefficient Table CRZ_GMCBASE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	GMCBASE[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GMCBASE[15:2]															
Type	R/W															
Reset	0															

The register specifies the base address of GMC buffer address. It should be word-aligned. And it is meaningful to use internal ram. When CRZ_FRCFG..GMCPIXLE = 0, this register is meaningless.

7.2.2.10 Capture Resize Coefficient Table Register

CRZ+0040h Capture Resize Coefficient Table CRZ_FRCFG

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	GMCPIXEL															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				USEL								DSEL				
Type				R/W								R/W				
Reset				0	1	1	0	1				0	1	1	0	1

The register specifies the coefficient table for resizing. Valid number is form 0 to 19. While ‘1’ is the most blur and ‘19’ is the sharpest. ‘0’ is a special case, may or may not sharp than ‘1’.

USEL choose ‘USEL’ > 12 may get undesirable result, ‘8’ is recommended.

DSEL ‘15’ is recommended.

GMCPIXEL Use how many bytes of internal memory as additional resizer buffer. Only even numbers are allowed.

- **0** Disable this feature.
- **2** 2 pixels; 4 bytes.
- **4** 4 pixels; 8 bytes.
- **6** 6 pixels; 12 bytes.

…

CRZ+0044h Capture Resize YUV Y-Component Target Memory Base Address Register CRZ_TMBASE_Y

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	TMBASE_Y[31:16]															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	TMBASE_Y[15:2]															
Type	R/W															

The register specifies the base address of YUV output for Y-component. It should be word-aligned. It's only useful in YUV mode.

CRZ+0048h Capture Resize YUV U-Component Target Memory Base Address Register CRZ_TMBASE_U

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	TMBASE_U[31:16]															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	TMBASE_U[15:2]															
Type	R/W															

The register specifies the base address of YUV output for U-component. It should be word-aligned. It's only useful in mode.

CRZ+004Ch Capture Resize YUV V-Component Target Memory Base Address Register CRZ_TMBASE_V

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	TMBASE_V[31:16]															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	TMBASE_V[15:2]															
Type	R/W															

The register specifies the base address of YUV output for V-component. It should be word-aligned. It's only useful in YUV mode.

CRZ+0084h Capture Resize Target Memory Base Address Register CRZ_TMBASE1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	TMBASE1 [31:16]															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	TMBASE1 [15:1]															
Type	R/W															

The register specifies the base address of target memory for RGB565 mode. Target memory is memory space for destination of YUV2RGB. It' must be half-word (2 bytes) aligned. RESZ_TMBASE1 and RESZ_TMBASE2 are auto-switched by hardware, so both two registers should be filled. If dual buffer is not required, please fill these two registers with the same value.

CRZ+0088h **Capture Resize Target Memory Base Address Register** **CRZ_TMBASE2**

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	TMBASE2 [31:16]															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	TMBASE2 [15:1]															
Type	R/W															

The register specifies the base address of target memory for RGB565 mode. Target memory is memory space for destination of YUV2RGB. It' must be half-word (2 bytes) aligned. RESZ_TMBASE1 and RESZ_TMBASE2 are auto-switched by hardware, so both two registers should be filled. If dual buffer is not required, please fill these two registers with the same value.

7.2.3 Application Notes

- SRCSZ and TARSZ limitation for upscaling

```
CRZ_SRCSZ.WS >= 3;
CRZ_SRCSZ.HS >= 3;
(CRZ_TARSZ.WT-1) / (CRZ_SRCSZ.WS-1) <= 64;
```

- SRCSZ and TARSZ limitation for downcaling

```
2 <= CRZ_TARSZ.WT <= 1600;
2 <= CRZ_TARSZ.HT <= 1600;
(CRZ_TARSZ.WT-1) / (CRZ_SRCSZ.WS-1) >= 1/2048;
```

- Configuration procedure for pixel-based image sources

```
CRZ_SRCSZ = source image size;
CRZ_TARSZ = target image size;
CRZ_CFG.LBSEL = 1; // must be 1, crz cant work when set to 0
CRZ_CFG.OUTFMT = 3 or 1 or 0;
WMIN = (WS > WT) ? WT : WS; // use for Width down and Height up
WMIN_EVEN  = WMIN + WMIN%2;
CRZ_CFG.LBMAX = (int)(1600/ WMIN_EVEN) * 6;
CRZ_HRATIO = horizontal ratio;
CRZ_VRATIO = vertical ratio;
CRZ_TMBASE*
CRZ_CON = 0x1;
```

7.3 NAND FLASH interface

7.3.1 General description

MT6235 provides NAND flash interface.

The NAND FLASH interface support features as follows:

- ECC (Hamming code) acceleration capable of one-bit error correction or two bits error detection.
- Programmable ECC block size. Support 1, 2 or 4 ECC block within a page.
- Word/byte access through APB bus.
- Direct Memory Access for massive data transfer.
- Latch sensitive interrupt to indicate ready state for read, program, erase operation and error report.
- Programmable wait states, command/address setup and hold time, read enable hold time, and write enable recovery time.
- Support page size: 512(528) bytes and 2048(2112) bytes.
- Support 2 chip select for NAND flash parts.
- Support 8/16 bits I/O interface.

The NFI core can automatically generate ECC parity bits when programming or reading the device. If the user approves the way it stores the parity bits in the spare area for each page, the AUTOECC mode can be used. Otherwise, the user can prepare the data (may contains operating system information or ECC parity bits) for the spare area with another arrangement. In the former case, the core can check the parity bits when reading from the device. The ECC module features the hamming code, which is capable of correcting one bit error or detecting two bits error within one ECC block.

7.3.2 Registers Memory Map

Software responsibility and controllable functions

Register Address	Acronym	Register Function
NFI +0000h	NFI_ACCCON	NAND Flash Access Control
NFI +0004h	NFI_PAGEFMT	NFI Page Format Control
NFI +0008h	NFI_OPCON	Operation Control
NFI +0010h	NFI_CMD	Command
NFI +0020h	NFI_ADDRNOB	Address Length
NFI +0024h	NFI_ADDRL	Least Significant Address
NFI +0028h	NFI_ADDRM	Most Significant Address
NFI +0030h	NFI_DATAW	Write Data Buffer
NFI +0034h	NFI_DATAWB	Write Data Buffer for Byte Access

NFI +0038h	NFI_DATAR	Read Data Buffer
NFI +003Ch	NFI_DATARB	Read Data Buffer for Byte Access
NFI +0040h	NFI_PSTA	NFI Status
NFI +0044h	NFI_FIFOSTA	NFI FIFO Status
NFI +0050h	NFI_FIFODATA0	NFI FIFO Data 0
NFI +0054h	NFI_FIFODATA1	NFI FIFO Data 1
NFI +0058h	NFI_FIFODATA2	NFI FIFO Data 2
NFI +005Ch	NFI_FIFODATA3	NFI FIFO Data 3
NFI +0060h	NFI_CON	NFI Control
NFI +0064h	NFI_INTR	NFI Interrupt Status
NFI +0068h	NFI_INTR_EN	NFI Interrupt Enable
NFI +0070h	NFI_PAGECNTR	NAND Flash Page Counter
NFI +0074h	NFI_ADDRCNTR	NAND Flash Page Address Counter
Main Area ECC		
NFI +0080h	NFI_SYM0_ADDR	ECC Block 0 Parity Error Detect Syndrome Address
NFI +0084h	NFI_SYM1_ADDR	ECC Block 1 Parity Error Detect Syndrome Address
NFI +0088h	NFI_SYM2_ADDR	ECC Block 2 Parity Error Detect Syndrome Address
NFI +008Ch	NFI_SYM3_ADDR	ECC Block 3 Parity Error Detect Syndrome Address
NFI +0090h	NFI_SYM4_ADDR	ECC Block 4 Parity Error Detect Syndrome Address
NFI +0094h	NFI_SYM5_ADDR	ECC Block 5 Parity Error Detect Syndrome Address
NFI +0098h	NFI_SYM6_ADDR	ECC Block 6 Parity Error Detect Syndrome Address
NFI +009Ch	NFI_SYM7_ADDR	Spare ECC Block 7 Parity Error Detect Syndrome Address
NFI +00A0h	NFI_SYMS0_ADDR	Spare ECC Block 0 Parity Error Detect Syndrome Address
NFI +00A4h	NFI_SYMS1_ADDR	Spare ECC Block 1 Parity Error Detect Syndrome Address
NFI +00A8h	NFI_SYMS2_ADDR	Spare ECC Block 2 Parity Error Detect Syndrome Address
NFI +00ACh	NFI_SYMS3_ADDR	Spare ECC Block 3 Parity Error Detect Syndrome Address
NFI +00B0h	NFI_SYM0_DATA	ECC Block 0 Parity Error Detect Syndrome Word
NFI +00B4h	NFI_SYM1_DATA	ECC Block 1 Parity Error Detect Syndrome Word
NFI +00B8h	NFI_SYM2_DATA	ECC Block 2 Parity Error Detect Syndrome Word
NFI +00BCh	NFI_SYM3_DATA	ECC Block 3 Parity Error Detect Syndrome Word
NFI +00C0h	NFI_SYM4_DATA	ECC Block 4 Parity Error Detect Syndrome Word
NFI +00C4h	NFI_SYM5_DATA	ECC Block 5 Parity Error Detect Syndrome Word

NFI +00C8h	NFI_SYM6_DATA	ECC Block 6 Parity Error Detect Syndrome Word
NFI +00CCh	NFI_SYM7_DATA	ECC Block 7 Parity Error Detect Syndrome Word
NFI +00D0h	NFI_SYMS0_DATA	Spare ECC Block 0 Parity Error Detect Syndrome Word
NFI +00D4h	NFI_SYMS1_DATA	Spare ECC Block 1 Parity Error Detect Syndrome Word
NFI +00D8h	NFI_SYMS2_DATA	Spare ECC Block 2 Parity Error Detect Syndrome Word
NFI +00DCh	NFI_SYMS3_DATA	Spare ECC Block 3 Parity Error Detect Syndrome Word
NFI +00E0h	NFI_PAR_0P	NFI ECC Parity Word 0
NFI +00E4h	NFI_PAR_0C	NFI ECC Parity Word 0
NFI +00E8h	NFI_PAR_1P	NFI ECC Parity Word 1
NFI +00ECh	NFI_PAR_1C	NFI ECC Parity Word 1
NFI +00F0h	NFI_PAR_2P	NFI ECC Parity Word 2
NFI +00F4h	NFI_PAR_2C	NFI ECC Parity Word 2
NFI +00F8h	NFI_PAR_3P	NFI ECC Parity Word 3
NFI +00FCh	NFI_PAR_3C	NFI ECC Parity Word 3
NFI +0100h	NFI_PAR_4P	NFI ECC Parity Word 4
NFI +0104h	NFI_PAR_4C	NFI ECC Parity Word 4
NFI +0108h	NFI_PAR_5P	NFI ECC Parity Word 5
NFI +010Ch	NFI_PAR_5C	NFI ECC Parity Word 5
NFI +0110h	NFI_PAR_6P	NFI ECC Parity Word 6
NFI +0114h	NFI_PAR_6C	NFI ECC Parity Word 6
NFI +0118h	NFI_PAR_7P	NFI ECC Parity Word 7
NFI +011Ch	NFI_PAR_7C	NFI ECC Parity Word 7
NFI +0120h	NFI_PARS_0P	NFI Spare ECC Parity Word 0
NFI +0124h	NFI_PARS_0C	NFI Spare ECC Parity Word 0
NFI +0128h	NFI_PARS_1P	NFI Spare ECC Parity Word 1
NFI +012Ch	NFI_PARS_1C	NFI Spare ECC Parity Word 1
NFI +0130h	NFI_PARS_2P	NFI Spare ECC Parity Word 2
NFI +0134h	NFI_PARS_2C	NFI Spare ECC Parity Word 2
NFI +0138h	NFI_PARS_3P	NFI Spare ECC Parity Word 3
NFI +013Ch	NFI_PARS_3C	NFI Spare ECC Parity Word 3
NFI +0140h	NFI_ECCDET	NFI ECC Error Detect Indication
NFI +0144h	NFI_PARECC	NFI ECC Parity Error Indication
NFI +0148h	NFI_SCON	NFI Spare ECC Control
I/O Pin Control		
NFI +0200h	NFI_CSEL	NAND Flash Device Select

NFI +0204h	NFI_IOCON	NFI IO Control

Table 5 Registers Memory Map Table

7.3.3 Register definition

NFI+0000h NAND flash access control register NFI_ACCCON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	LCD2NAND										C2R					
Type	R/W										R/W					
Reset	0										0					
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	W2R				WH				WST				RLT			
Type	R/W				R/W				R/W				R/W			
Reset	0				0				0				0			

This is the timing access control register for the NAND FLASH interface. In order to accommodate operations for different system clock frequency ranges from 13MHz to 52MHz, wait states and setup/hold time margin can be configured in this register.

C2R The field represents the minimum required time from NCEB low to NREB low.

W2R The field represents the minimum required time from NWEB high to NREB low. It's in unit of 2T. So the actual time ranges from 2T to 8T in step of 2T.

WH Write-enable hold-time.

The field specifies the hold time of NALE, NCLE, NCEB signals relative to the rising edge of NWEB. This field is associated with **WST** to expand the write cycle time, and is associated with **RLT** to expand the read cycle time.

RLT Read Latency Time

The field specifies how many wait states to be inserted to meet the requirement of the read access time for the device.

00 No wait state.

01 1T wait state.

10 2T wait state.

11 3T wait state.

WST Write Wait State

The field specifies the wait states to be inserted to meet the requirement of the pulse width of the NWEB signal.

00 No wait state.

01 1T wait state.

10 2T wait state.

11 3T wait state.

LCD2NAND Arbitration Wait State

The field specifies the wait states to be inserted for the APB arbitrator when bus user changes.

NFI +0004h NFI page format control register NFI_PAGEFMT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name								B16EN		ECCBLKSIZE	ADRMODE	PSIZE
Type								R/W		R/W	R/W	R/W
Reset								0		0	0	0

This register manages the page format of the device. It includes the bus width selection, the page size, the associated address format, and the ECC block size.

B16EN 16 bits I/O bus interface enable.

ECCBLKSIZE ECC block size.

This field represents the size of one ECC block. The hardware-fuelled ECC generation provides 2 or 4 blocks within a single page.

0 ECC block size: 128 bytes. Used for devices with page size equal to 512 bytes.

1 ECC block size: 256 bytes. Used for devices with page size equal to 512 bytes.

2 ECC block size: 512 bytes. Used for devices with page size equal to 512 (1 ECC block) or 2048 bytes (4 ECC blocks).

3 ECC block size: 1024 bytes. Used for devices with page size equal to 2048 bytes.

4~ Reserved.

ADRMODE Address mode. This field specifies the input address format.

0 Normal input address mode, in which the half page identifier is not specified in the address assignment but in the command set. As in **Table 28**, A7 to A0 identifies the byte address within half a page, A12 to A9 specifies the page address within a block, and other bits specify the block address. The mode is used mostly for the device with 512 bytes page size.

1 Large size input address mode, in which all address information is specified in the address assignment rather than in the command set. As in **Table 29**, A11 to A0 identifies the byte address within a page. The mode is used for the device with 2048 bytes page size and 8bits I/O interface.

2 Large size input address mode. As in **Table 29**, A10 to A0 identifies the column address within a page. The mode is used for the device with 2048 byte page size and 16bits I/O interface.

	NLD7	NLD6	NLD5	NLD4	NLD3	NLD2	NLD1	NLD0
First cycle	A7	A6	A5	A4	A3	A2	A1	A0
Second cycle	A16	A15	A14	A13	A12	A11	A10	A9

Table 28 Page address assignment of the first type (ADRMODE = 0)

	NLD7	NLD6	NLD5	NLD4	NLD3	NLD2	NLD1	NLD0
First cycle	A7	A6	A5	A4	A3	A2	A1	A0
Second cycle	0	0	0	0	A11	A10	A9	A8

Table 29 Page address assignment of the second type (ADRMODE = 1 or 2)

PSIZE Page Size.

The field specifies the size of one page for the device. Two most widely used page size are supported.

0 The page size is 512 bytes or 528 bytes (including 512 bytes data area and 16 bytes spare area).

1 The page size is 2048 bytes or 2112 bytes (including 2048 bytes data area and 64 bytes spare area).

2~ Reserved.

NFI +0008h Operation control register NFI_OPCON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			NOB		FIFO_RST	FIFO_FLUSH		SRD							BWR	BRD
Type			W/R		WO	WO		WO							R/W	R/W
Reset			0		0	0		0							0	0

This register controls the burst mode and the single of the data access. In burst mode, the core supposes there are one or more than one page of data to be accessed. On the contrary, in single mode, the core supposes there are only less than 4 bytes of data to be accessed. This is recommended to reset the state machine, data FIFO and flush the data FIFO before starting a new command sequence.

BRD *Burst read mode.* Setting this field to be logic-1 enables the data read operation. The NFI core will issue read cycles to retrieve data from the device when the data FIFO is not full or the device is not in the busy state. The NFI core supports consecutive page reading. A page address counter is built in. If the reading reaches to the end of the page, the device will enter the busy state to prepare data of the next page, and the NFI core will automatically pause reading and remain inactive until the device returns to the ready state. The page address counter will restart to count from 0 after the device returns to the ready state and start retrieving data again.

BWR *Burst write mode.* Setting to be logic-1 enables the data burst write operation for DMA operation. Actually the NFI core will issue write cycles once if the data FIFO is not empty even without setting this flag. But if DMA is to be utilized, the bit should be enabled. If DMA is not to be utilized, the bit didn't have to be enabled.

SRD Setting to be logic-1 initializes the one-shot data read operation. It's mainly used for read ID and read status command, which requires no more than 4 read cycles to retrieve data from the device.

NOB The field represents the number of bytes to be retrieved from the device in single mode, and the number of bytes per AHB transaction in both single and burst mode.

- **0** Read 4 bytes from the device.
- **1** Read 1 byte from the device.
- **2** Read 2 bytes from the device.
- **3** Read 3 bytes from the device.

FIFO_RST Reset the state machine and data FIFO.

FIFO_FLUSH Flush the data FIFO.

NFI +0010h Command register NFI_CMD

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									CMD							
Type									R/W							
Reset									45							

This is the command input register. The user should write this register to issue a command. Please refer to device datasheet for the command set. The core can issue some associated commands automatically. Please check out register **NFI_CON** for those commands.

CMD Command word.

NFI +0020h Address length register NFI_ADDRNOB

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													ADDR_NOB			

Type													R/W
Reset													0

This register represents the number of bytes corresponding to current command. The valid number of bytes ranges from 1 to 8. The address format depends on what device to be used and what commands to be applied. The NFI core is made transparent to those different situations except that the user has to define the number of bytes.
The user should write the target address to the address register **NFI_ADDRL** before programming this register.

ADDR_NOB Number of bytes for the address

NFI +0024h Least significant address register NFI_ADDRL

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	ADDR3								ADDR2							
Type	R/W								R/W							
Reset	0								0							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ADDR1								ADDR0							
Type	R/W								R/W							
Reset	0								0							

This defines the least significant 4 bytes of the address field to be applied to the device. Since the device bus width is 1 byte, the NFI core arranges the order of address data to be least significant byte first. The user should put the first address byte in the field **ADDR0**, the second byte in the field **ADDR1**, and so on.

ADDRn The n-th address byte.

NFI +0028h Most significant address register NFI_ADDRM

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	ADDR7								ADDR6							
Type	R/W								R/W							
Reset	0								0							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ADDR5								ADDR4							
Type	R/W								R/W							
Reset	0								0							

This register defines the most significant byte of the address field to be applied to the device. The NFI core supports address size up to 8 bytes. Programming this register implicitly indicates that the number of address field is larger than 4.

ADDRn The n-th address byte.

NFI +0030h Write data buffer NFI_DATAW

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DW3								DW2							
Type	R/W								R/W							
Reset	0								0							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DW1								DW0							
Type	R/W								R/W							
Reset	0								0							

This is the write port of the data FIFO. It supports word access. The least significant byte **DW0** is to be programmed to the device first, then **DW1**, and so on.
If the data to be programmed is not word aligned, byte write access will be needed. Instead, the user should use another

register **NFI_DATAWB** for byte programming. Writing a word to **NFI_DATAW** is equivalent to writing four bytes **DW0**, **DW1**, **DW2**, **DW3** in order to **NFI_DATAWB**. Be reminded that the word alignment is from the perspective of the user. The device bus is byte-wide. According to the flash's nature, the page address will wrap around once it reaches the end of the page.

DW3 Write data byte 3.
DW2 Write data byte 2.
DW1 Write data byte 1.
DW0 Write data byte 0.

NFI +0034h Write data buffer for byte access NFI_DATAWB

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									DW0							
Type									R/W							
Reset									0							

This is the write port for the data FIFO for byte access.

DW0 Write data byte.

NFI +0038h Read data buffer NFI_DATAR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DR3								DR2							
Type	RO								RO							
Reset	0								0							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DR1								DR0							
Type	RO								RO							
Reset	0								0							

This is the read port of the data FIFO. It supports word access. The least significant byte **DR0** is the first byte read from the device, then **DR1**, and so on.

DR3 Read data byte 3.
DR2 Read data byte 2.
DR1 Read data byte 1.
DR0 Read data byte 0.

NFI +003Ch Read data buffer for byte access NFI_DATARB

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									DR0							
Type									RO							
Reset									0							

This is the read port of the data FIFO for byte access.

DR0 Read data byte 0.

NFI +0040h NFI status NFI_PSTA

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name				NAND_FSM									NFI_FSM			
Type				RO									RO			
Reset				0									0			

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							NAND_BUSY	BUSY					DATAW	DATAR	ADDR	CMD
Type							RO	RO					RO	RO	RO	RO
Reset							0	0*					0	0	0	0

This register represents the NFI core control status including command mode, address mode, data program and read mode. The user should poll this register for the end of those operations.

*The value of **BUSY/NAND_BUSY** bit depends on the GPIO configuration. If GPIO is configured for NAND flash application, the reset value should be 0, which represents that NAND flash is in idle status. When the NAND flash is busy, the value will be 1.

BUSY Synchronized busy signal from the NAND flash. It's read-only. This signal is sampled from NFI

NAND_BUSY Asynchronized busy signal from the output pin of the NAND flash. It's read-only.

DATAW The NFI core is in data write mode.

DATAR The NFI core is in data read mode.

ADDR The NFI core is in address mode.

CMD The NFI core is in command mode.

NFI_FSM The field represents the state of NFI internal FSM.

- **0000** idle.
- **0001** reset. Reset command to ready
- **0010** read busy.
- **0011** read data.
- **0100** program busy
- **0101** program data. Input data command to program command
- **1000** erase busy. Erase command to ready
- **1001** erase data. Erase command 1 to erase command 2

NAND_FSM The field represents the state of NAND interface FSM.

- **00000** IDLE. idle.
- **00101** CMD_WRST. command write set up
- **00110** CMD_WR. Command write enable.
- **00111** CMD_WRHD. Command write hold.
- **00100** CMD_WRRDY
- **01001** ADDR_WRST. Address write set up
- **01010** ADDR_WR. Address write enable
- **01011** ADDR_WRHD. Address write hold
- **01000** ADDR_WRRDY.
- **01100** CA2DEXT. Command address write extension.
- **10001** DATA_RDST. Data read set up.
- **10010** DATA_RD. Data read enable.
- **10011** DATA_RDHD. Data read hold.
- **11000** DATA_WRRDY.
- **11001** DATA_WRST. Data write set up.
- **11010** DATA_WR. Data write enable.
- **11011** DATA_WRHD. Data write hold.

NFI +0044h FIFO Status NFI_FIFOSTA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	WR_FULL	WR_EMPTY		WR_REMAIN					RD_FULL	RD_EMPTY		RD_REMAIN				
Type	RO	RO		RO					RO	RO		RO				
Reset	0	1		0					0	1		0				

The register represents the status of the data FIFO.

WR_FULL Data FIFO full in burst write mode.

WR_EMPTY Data FIFO empty in burst write mode.

RD_FULL Data FIFO full in burst read mode.

RD_EMPTY Data FIFO empty in burst read mode.

RD_REMAIN Data FIFO remaining byte number in burst read mode.

WR_REMAIN Data FIFO remaining byte number in burst write mode.

NFI +0050h FIFO Content Data 0 NFI_FIFODATA0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	FIFO_DATA0															
Type	RO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	FIFO_DATA0															
Type	RO															
Reset	0															

This register represents the content data 0 of fifo.

NFI +0054h FIFO Content Data 1 NFI_FIFODATA1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	FIFO_DATA1															
Type	RO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	FIFO_DATA1															
Type	RO															
Reset	0															

This register represents the content data 1 of fifo.

NFI +0058h FIFO Content Data 2 NFI_FIFODATA2

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	FIFO_DATA2															
Type	RO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	FIFO_DATA2															
Type	RO															
Reset	0															

This register represents the content data 2 of fifo.

NFI +005Ch FIFO Content Data 3 NFI_FIFODATA3

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	FIFO_DATA3															
Type	RO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	FIFO_DATA3															
Type	RO															
Reset	0															

This register represents the content data 3 of fifo.

NFI +0060h NFI control NFI_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BYTE_RW						MAIN_ECC_EN	SPARE_ECC_EN		DMA_PAUSE_EN	SPARE_EN	MULTI_PAGE_RD_EN	AUTOECC_ENC_EN	AUTOECC_DEC_EN	DMA_WR_EN	DMA_RD_EN
Type	R/W						R/W	R/W		R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0						0	0		0	0	0	0	0	0	0

The register controls the DMA and ECC functions. For all field, Setting to be logic-1 represents enabled, while 0 represents disabled.

BYTE_RW **Enable byte access**. The valid bytes read from NFI_DATAR and NFI_DATAW is only DR0 and DW0 if BYTE_RW is enabled.

SPARE_EN If enabled, the NFI core allows the user to program or read the spare area directly. Otherwise, the spare area can be programmed or read by the core.

MULTI_PAGE_RD_EN Multiple page burst read enable. If enabled, the burst read operation could continue through multiple pages within a block. It's also possible and more efficient to associate with DMA scheme to read a sector of data contained within the same block.

AUTOECC_ENC_EN Automatic ECC encoding enable. If enabled, the ECC parity is written automatically to the spare area. If disable ECC encoding engine, it write the default parity in the spare area.

AUTOECC_DEC_EN Automatic ECC decoding enabled, the error checking and correcting are performed automatically on the data read from the memory and vice versa. If enabled, when the page address reaches the end of the data read of one page

DMA_WR_EN This field is used to control the activity of DMA write transfer.

DMA_RD_EN This field is used to control the activity of DMA read transfer.

DMA_PAUSE_EN DMA pause

MAIN_ECC_EN This field is used to enable generation of ECC parities for main area.

SPARE_ECC_EN This field is used to enable generation of ECC parities for spare area. If **SPARE_EN** is not set, however, the mode can't be enabled since the core can't access the spare area.

NFI +0064h Interrupt status register NFI_INTR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name				BUSY_RETURN	ERRS_COR3	ERRS_COR2	ERRS_COR1	ERRS_COR0	ERR_COR7	ERR_COR6	ERR_COR5	ERR_COR4	ERR_COR3	ERR_COR2	ERR_COR1	ERR_COR0
Type				RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC

Reset				0	0	0	0	0	0	0	0	0	0	0	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ERASE_COMPLETE	RESET_COMPLETE	WR_COMPLETE	RD_COMPLETE	ERRS_DET3	ERRS_DET2	ERRS_DET1	ERRS_DET0	ERR_DET7	ERR_DET6	ERR_DET5	ERR_DET4	ERR_DET3	ERR_DET2	ERR_DET1	ERR_DET0
Type	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

The register indicates the status of all the interrupt sources. Read this register will clear all interrupts.

BUSY_RETURN Indicates that the device state returns from busy by inspecting the R/B# pin.
ERR_CORn Indicates that the single bit error in ECC block n needs to be corrected.
ERR_DETn Indicates an uncorrectable error in ECC block n.
ERRS_CORn Indicates that the single bit error in spare ECC block n needs to be corrected.
ERRS_DETn Indicates an uncorrectable error in spare ECC block n.
ERASE_COMPLETE Indicates that the erase operation is completed.
RESET_COMPLETE Indicates that the reset operation is completed.
WR_COMPLETE Indicates that the write operation is completed.
RD_COMPLETE Indicates that the single page read operation is completed.

NFI +0068h Interrupt enable register NFI_INTR_EN

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name				BUSY_RETURN_EN	ERRS_COR3_EN	ERRS_COR2_EN	ERRS_COR1_EN	ERRS_COR0_EN	ERR_COR7_EN	ERR_COR6_EN	ERR_COR5_EN	ERR_COR4_EN	ERR_COR3_EN	ERR_COR2_EN	ERR_COR1_EN	ERR_COR0_EN
Type				R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset				0	0	0	0	0	0	0	0	0	0	0	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ERASE_COMPLETE_EN	RESET_COMPLETE_EN	WR_COMPLETE_EN	RD_COMPLETE_EN	ERRS_DET3_EN	ERRS_DET2_EN	ERRS_DET1_EN	ERRS_DET0_EN	ERR_DET7_EN	ERR_DET6_EN	ERR_DET5_EN	ERR_DET4_EN	ERR_DET3_EN	ERR_DET2_EN	ERR_DET1_EN	ERR_DET0_EN
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

This register controls the activity for the interrupt sources.

ERR_CORn_EN The error correction interrupt enable for the n ECC block.
ERR_DETn_EN The error detection interrupt enable for the n ECC block.
ERRS_DETn_EN The error detection interrupt enable for the n spare ECC block.
ERRS_DETn_EN The error detection interrupt enable for the n spare ECC block.
BUSY_RETURN_EN The busy return interrupt enable.
ERASE_COMPLETE_EN The erase completion interrupt enable.
RESET_COMPLETE_EN The reset completion interrupt enable.
WR_COMPLETE_EN The single page write completion interrupt enable.
RD_COMPLETE_EN The single page read completion interrupt enable.

NFI+0070h NAND flash page counter NFI_PAGECNTR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name									CNTR
Type									RO
Reset									0

The register represents the number of pages that the NFI has read since the issuing of the read command. For some devices, the data can be read consecutively through different pages without the need to issue another read command. The user can monitor this register to know current page count, particularly when read DMA is enabled.

CNTR The page counter.

NFI+0074h NAND flash page address counter NFI_ADDRCNTR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					CNTR											
Type					RO											
Reset					0											

The register represents the current read/write address with respect to initial address input. It counts in unit of byte. In page read and page program operation, the address should be the same as that in the state machine in the target device.

NFI supports the address counter up to 4096 bytes.

CNTR The address count.

NFI +0080h ECC block 0 parity error detect syndrome address NFI_ SYM0_ADDR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							SYM									
Type							RO									
Reset							0									

This register identifies the address within ECC block 0 that a single bit error has been detected.

SYM The byte address of the error-correctable bit.

Register Address	Register Function	Acronym
NFI +0080h	NFI ECC Syndrome address 0	NFI_SYM0_ADDR
NFI +0084h	NFI ECC Syndrome address 1	NFI_SYM1_ADDR
NFI +0088h	NFI ECC Syndrome address 2	NFI_SYM2_ADDR
NFI +008Ch	NFI ECC Syndrome address 3	NFI_SYM3_ADDR
NFI +0090h	NFI ECC Syndrome address 4	NFI_SYM4_ADDR
NFI +0094h	NFI ECC Syndrome address 5	NFI_SYM5_ADDR
NFI +0098h	NFI ECC Syndrome address 6	NFI_SYM6_ADDR
NFI +009Ch	NFI ECC Syndrome address 7	NFI_SYM7_ADDR
NFI +00A0h	NFI Spare ECC Syndrome address 0	NFI_SYMS0_ADDR
NFI +00A4h	NFI Spare ECC Syndrome address 1	NFI_SYMS1_ADDR
NFI +00A8h	NFI Spare ECC Syndrome address 2	NFI_SYMS2_ADDR
NFI +00ACh	NFI Spare ECC Syndrome address 3	NFI_SYMS3_ADDR

Table 30 NFI Syndrome address register table

NFI +00B0h ECC block 0 parity error detect syndrome word NFI_SYM0_DATA

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	ED3								ED2							
Type	RO								RO							
Reset	0								0							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ED1								ED0							
Type	RO								RO							
Reset	0								0							

This register represents the syndrome word for the corrected ECC block 0. To correct the error, the user should first read **NFI_ SYM0_ADDR** for the address of the correctable word, and then read **NFI_SYM0_DAT**, directly XOR the syndrome word with the data word to obtain the correct word.

Register Address	Register Function	Acronym
NFI +00B0h	NFI ECC Syndrome data 0	NFI_SYM0_DATA
NFI +00B4h	NFI ECC Syndrome data 1	NFI_SYM1_DATA
NFI +00B8h	NFI ECC Syndrome data 2	NFI_SYM2_DATA
NFI +00BCh	NFI ECC Syndrome data 3	NFI_SYM3_DATA
NFI +00C0h	NFI ECC Syndrome data 4	NFI_SYM4_DATA
NFI +00C4h	NFI ECC Syndrome data 5	NFI_SYM5_DATA
NFI +00C8h	NFI ECC Syndrome data 6	NFI_SYM6_DATA
NFI +00CCh	NFI ECC Syndrome data 7	NFI_SYM7_DATA
NFI +00D0h	NFI Spare ECC Syndrome data 0	NFI_SYMS0_DATA
NFI +00D4h	NFI Spare ECC Syndrome data 1	NFI_SYMS1_DATA
NFI +00D8h	NFI Spare ECC Syndrome data 2	NFI_SYMS2_DATA
NFI +00DCh	NFI Spare ECC Syndrome data 3	NFI_SYMS3_DATA

Table 4 NFI Syndrome data register table

NFI +00E0h NFI ECC parity word 0 NFI_PAR_0P

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				PAR												
Type				RO												
Reset				0												

This register represents the ECC parity for the ECC block 0. It's calculated by the NFI core and can be read by the user. It's generated when writing or reading a page.

Register Address	Register Function	Acronym
NFI +00E0h	NFI ECC parity word 0	NFI_PAR_0P
NFI +00E4h	NFI ECC parity word 0	NFI_PAR_0C
NFI +00E8h	NFI ECC parity word 1	NFI_PAR_1P
NFI +00ECh	NFI ECC parity word 1	NFI_PAR_1C
NFI +00F0h	NFI ECC parity word 2	NFI_PAR_2P

NFI +00F4h	NFI ECC parity word 2	NFI_PAR_2C
NFI +00F8h	NFI ECC parity word 3	NFI_PAR_3P
NFI +00FCh	NFI ECC parity word 3	NFI_PAR_3C
NFI +0100h	NFI ECC parity word 4	NFI_PAR_4P
NFI +0104h	NFI ECC parity word 4	NFI_PAR_4C
NFI +0108h	NFI ECC parity word 5	NFI_PAR_5P
NFI +010Ch	NFI ECC parity word 5	NFI_PAR_5C
NFI +0110h	NFI ECC parity word 6	NFI_PAR_6P
NFI +0114h	NFI ECC parity word 6	NFI_PAR_6C
NFI +0118h	NFI ECC parity word 7	NFI_PAR_7P
NFI +011Ch	NFI ECC parity word 7	NFI_PAR_7C
NFI +0120h	NFI ECC parity word 0	NFI_PARS_0P
NFI +0124h	NFI ECC parity word 0	NFI_PARS_0C
NFI +0128h	NFI ECC parity word 1	NFI_PARS_1P
NFI +012Ch	NFI ECC parity word 1	NFI_PARS_1C
NFI +0130h	NFI ECC parity word 2	NFI_PARS_2P
NFI +0134h	NFI ECC parity word 2	NFI_PARS_2C
NFI +0138h	NFI ECC parity word 3	NFI_PARS_3P
NFI +013Ch	NFI ECC parity word 3	NFI_PARS_3C

Table 5 NFI parity bits register table

NFI +0140h NFI ECC error detect indication register NFI_ERRDET

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name					CES_BLK3	CES_BLK2	CES_BLK1	CES_BLK0	CE_BLK7	CE_BLK6	CE_BLK5	CE_BLK4	CE_BLK3	CE_BLK2	CE_BLK1	CE_BLK0
Type					RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
Reset					0	0	0	0	0	0	0	0	0	0	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					ESBLK3	ESBLK2	ESBLK1	ESBLK0	EBLK7	EBLK6	EBLK5	EBLK4	EBLK3	EBLK2	EBLK1	EBLK0
Type					RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
Reset					0	0	0	0	0	0	0	0	0	0	0	0

This register identifies the block in which an uncorrectable error has been detected.

EBLKn The uncorrectable errors in the block n.

CE_BLKn The correctable error of the block n.

ESBLKn The uncorrectable errors in the spare block n.

CES_BLKn The correctable error of the spare block n.

NFI +0144h NFI ECC parity error indication register NFI_PARERR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name					PES_BLK3	PES_BLK2	PES_BLK1	PES_BLK0	PE_BLK7	PE_BLK6	PE_BLK5	PE_BLK4	PE_BLK3	PE_BLK2	PE_BLK1	PE_BLK0
Type					RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO

Reset					0	0	0	0	0	0	0	0	0	0	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					NO_ESBLK3	NO_ESBLK2	NO_ESBLK1	NO_ESBLK0	NO_EBLK7	NO_EBLK6	NO_EBLK5	NO_EBLK4	NO_EBLK3	NO_EBLK2	NO_EBLK1	NO_EBLK0
Type					RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
Reset					0	0	0	0	0	0	0	0	0	0	0	0

This register identifies the block in which an uncorrectable error has been detected.

NO_EBLKn No errors in the block n.
PE_BLKn The correctable error in parities of the block n.
NO_ESBLKn No errors in the spare block n.
PES_BLKn The correctable error in parities of the spare block n.

NFI+0148h NFI Spare ECC Control register NFI_SCON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name						SPARE_ECC_STR							SPARE_ECC_NUM			
Type						R/W							R/W			
Reset						0							0			

The register is used to control ECC for spare data.

SPARE_ECC_NUM byte number in spare for ECC. (0-8)
SPARE_ECC_STR start byte number in spare for ECC. (0-7)

NFI+0200h NFI device select register NFI_CSEL

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																CSEL
Type																R/W
Reset																0

The register is used to select the target device. It decides which CEB pin to be functional. This is useful while using the high-density device.

CSEL Chip select. The value defaults to 0.
0 Device 1 is selected.
1 Device 2 is selected.

NFI+0204h NFI IO Control register NFI_IOCON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																NLD_PD
Type																R/W
Reset																0

Data bus pull down when no use.

NLD_PD data bus pull down when no use.
0 disable.
1 enable.

7.3.4 Device timing control

This section illustrates the timing diagram.

The ideal timing for write access is listed as listed in **Table 31**.

Parameter	Description	Timing specification	Timing at 13MHz (WST, WH) = (0,0)	Timing at 26MHz (WST, WH) = (0,0)	Timing at 52MHz (WST, WH) = (1,0)
T_{WC1}	*Write cycle time*	3T + WST + WH	230.8ns	105.4ns	76.9ns
T_{WC2}	*Write cycle time*	2T + WST + WH	153.9ns	76.9ns	57.7ns
T_{DS}	*Write data setup time*	1T + WST	76.9ns	38.5ns	38.5ns
T_{DH}	*Write data hold time*	1T + WH	76.9ns	38.5ns	19.2ns
T_{WP}	*Write enable time*	1T + WST	76.9ns	38.5ns	38.5ns
T_{WH}	*Write high time*	1T + WH	76.9ns	38.5ns	19.2ns
T_{CLS}	*Command latch enable setup time*	1T	76.9ns	38.5ns	19.2ns
T_{CLH}	*Command latch enable hold time*	1T + WH	76.9ns	38.5ns	19.2ns
T_{ALS}	*Address latch enable setup time*	1T	76.9ns	38.5ns	19.2ns
T_{ALH}	*Address latch enable hold time*	1T + WH	76.9ns	38.5ns	19.23ns
F_{WC}	*Write data rate*	1 / T_{WC2}	6.5Mbytes/s	13Mbytes/s	17.3Mbytes/s

Table 31 Write access timing

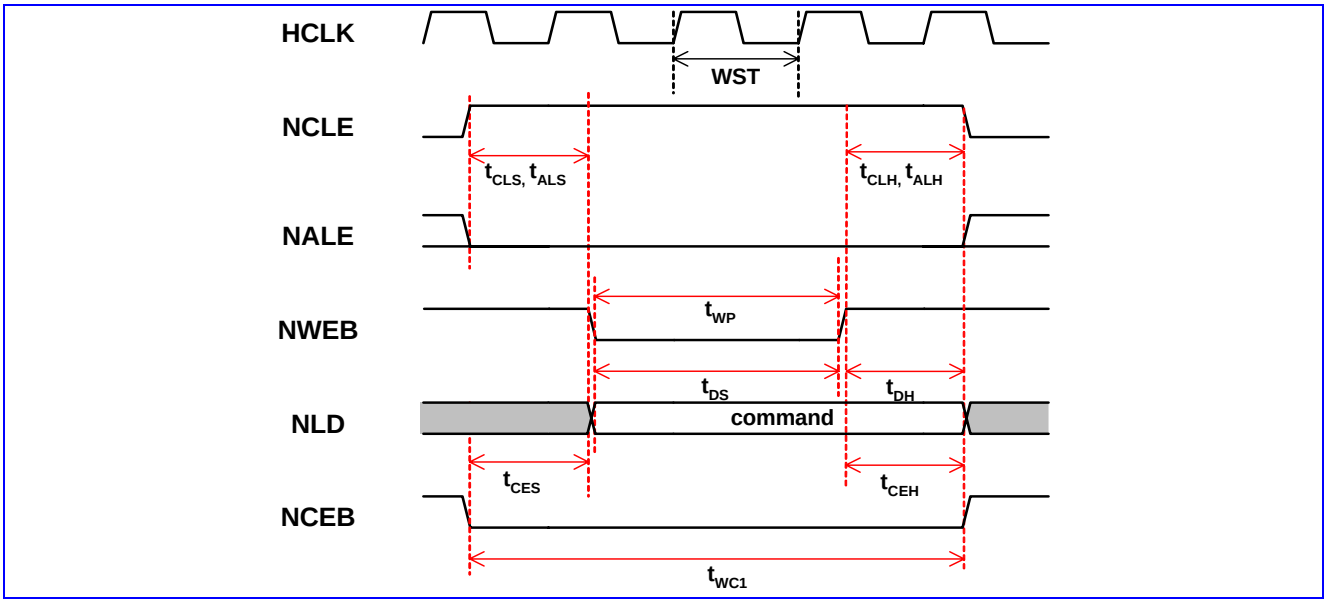


Figure 36 Command input cycle (1 wait state).

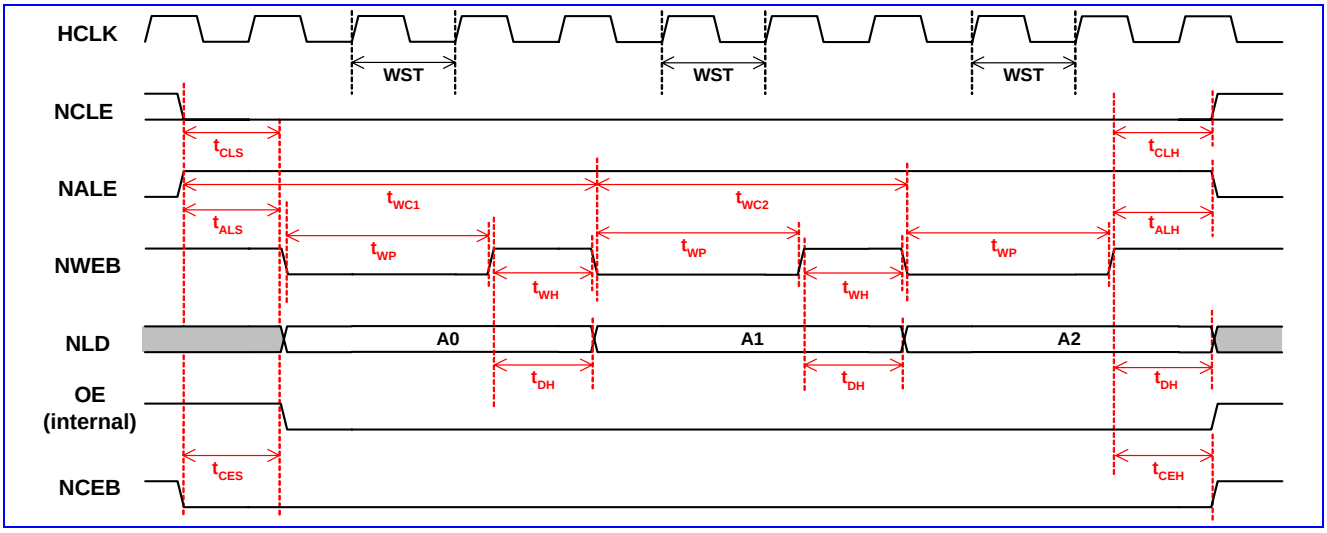


Figure 37 Address input cycle (1 wait state)

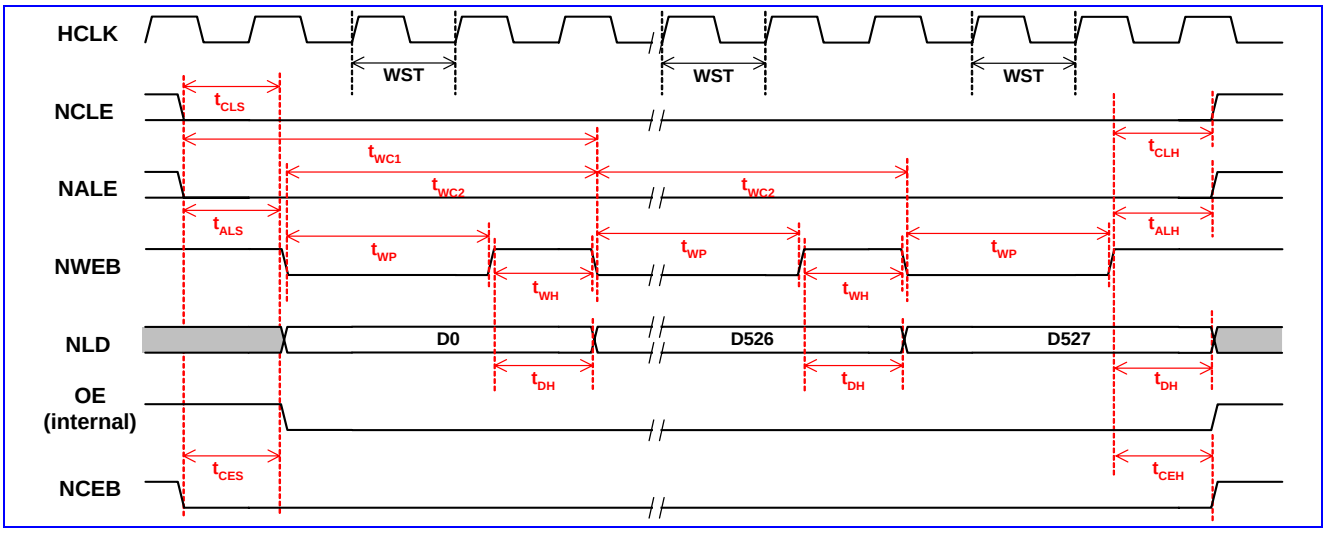


Figure 38 Consecutive data write cycles (1 wait state, 0 hold time extension)

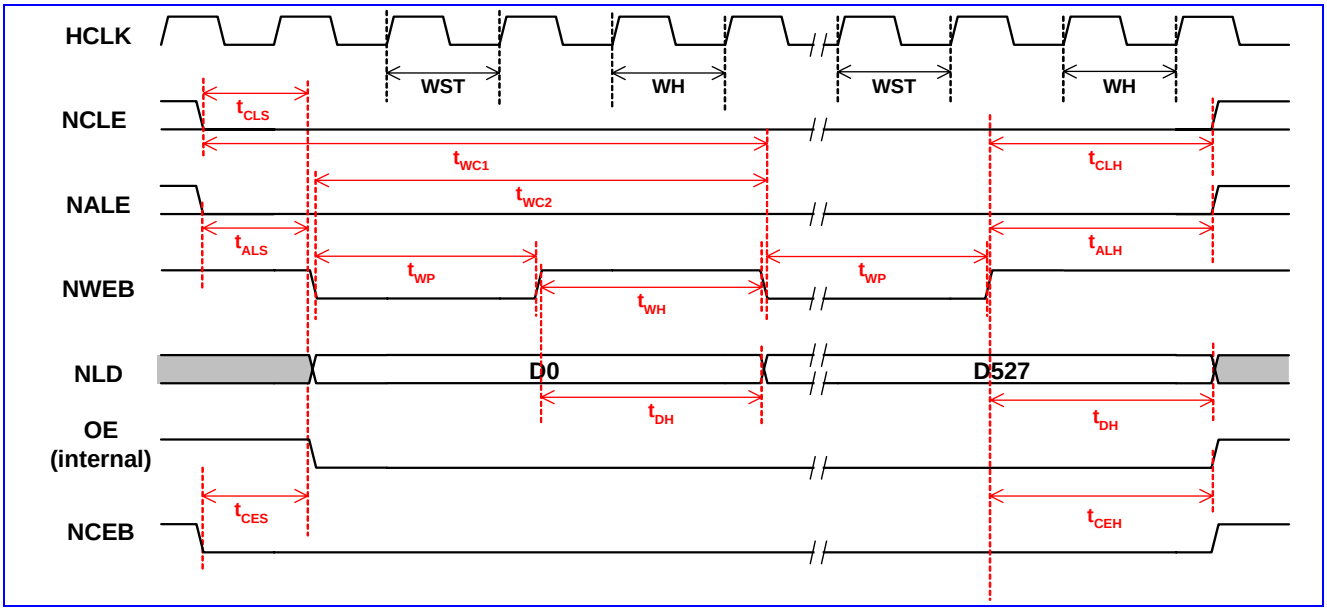


Figure 39 Consecutive data write cycles (1 wait state, 1 hold time extension)

The ideal timing for read access is as listed in Table 18.

Parameter	Description	Timing specification	Timing at 13MHz (RLT, WH) = (0,0)	Timing at 26MHz (RLT, WH) = (1,0)	Timing at 52MHz (RLT, WH) = (2,0)
T_{RC1}	*Read cycle time*	3T + RLT + WH	230.8ns	153.8ns	96.2ns
T_{RC2}	*Read cycle time*	2T + RLT + WH	153.9ns	115.4ns	76.9ns
T_{DS}	*Read data setup time*	1T + RLT	76.9ns	76.9ns	57.7ns
T_{DH}	*Read data hold time*	1T + WH	76.9ns	38.5ns	19.2ns
T_{RP}	*Read enable time*	1T + RLT	76.9ns	76.9ns	57.7ns
T_{RH}	*Read high time*	1T + WH	76.9ns	38.5ns	19.2ns
T_{CLS}	*Command latch enable setup time*	1T	76.9ns	38.5ns	19.2ns
T_{CLH}	*Command latch enable hold time*	1T + WH	76.9ns	38.5ns	19.2ns
T_{ALS}	*Address latch enable setup time*	1T	76.9ns	38.5ns	19.2ns
T_{ALH}	*Address latch enable hold time*	1T + WH	76.9ns	38.5ns	19.2ns
F_{RC}	*Write data rate*	1 / T_{RC2}	6.5Mbytes/s	8.7Mbytes/s	13Mbytes/s

Table 32 Read access timing

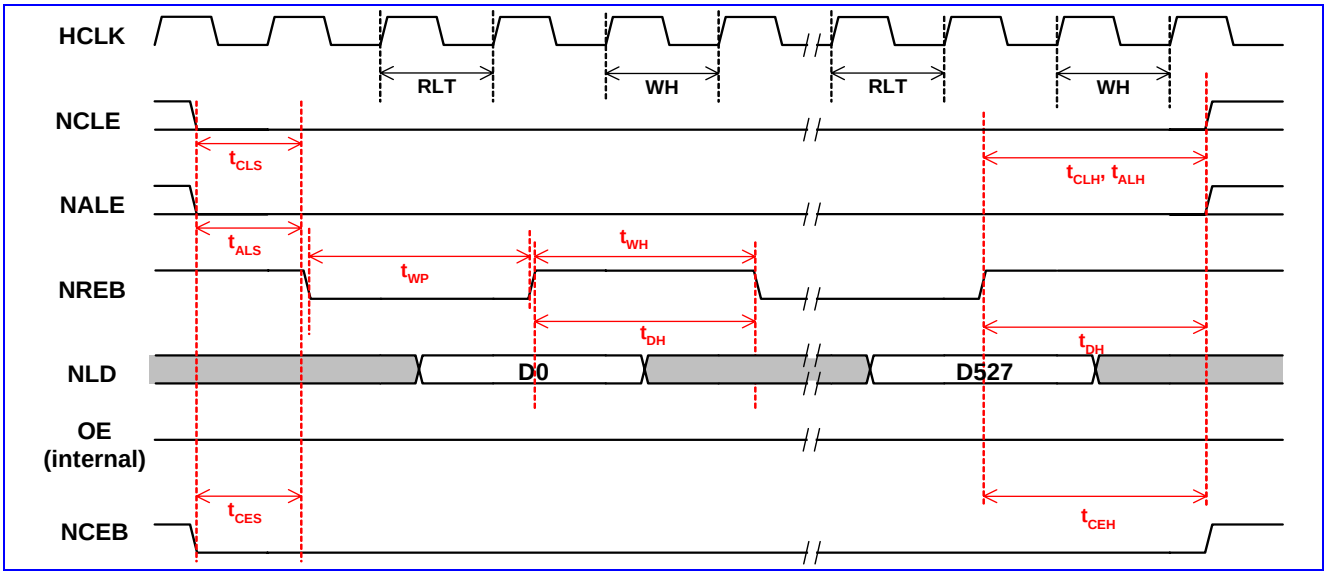


Figure 40 Serial read cycle (1 wait state, 1 hold time extension)

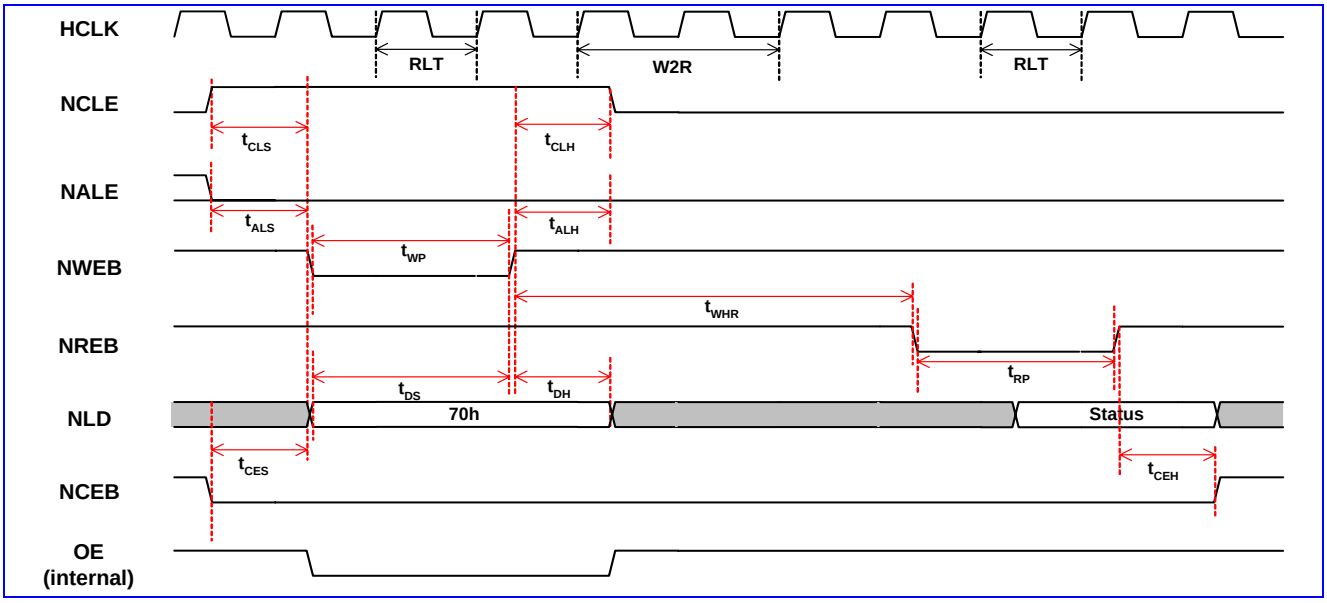


Figure 41 Status read cycle (1 wait state)

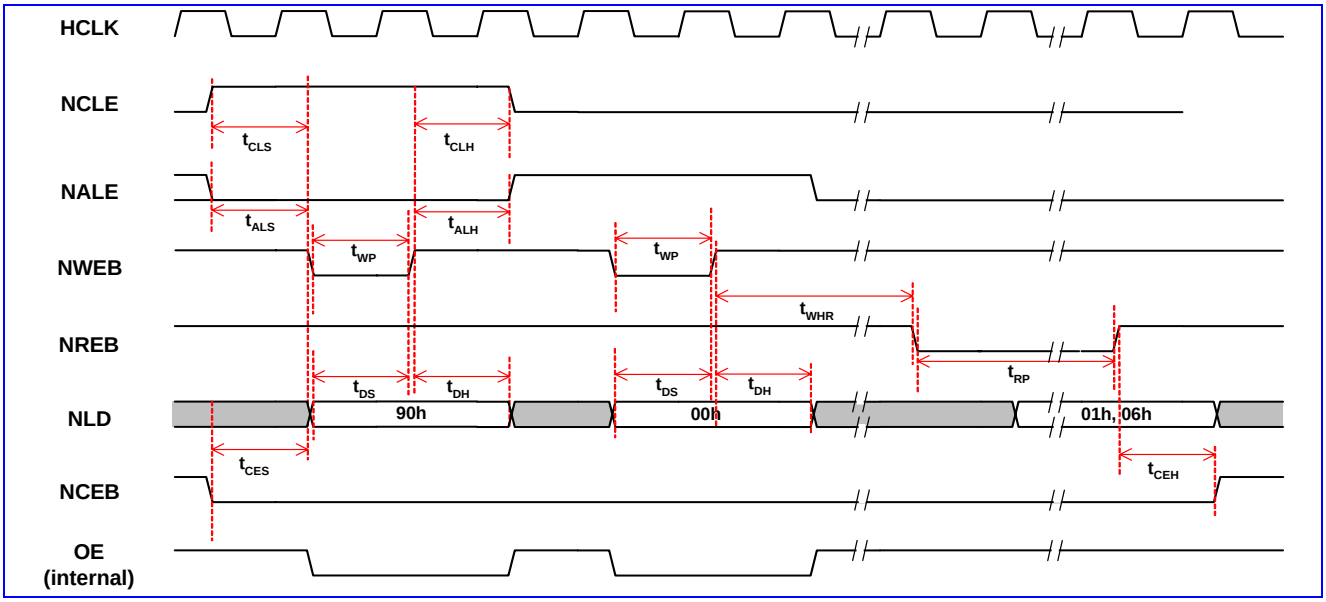


Figure 42 ID and manufacturer read (0 wait state)

7.4 USB 2.0 High-Speed Dual-Role Controller

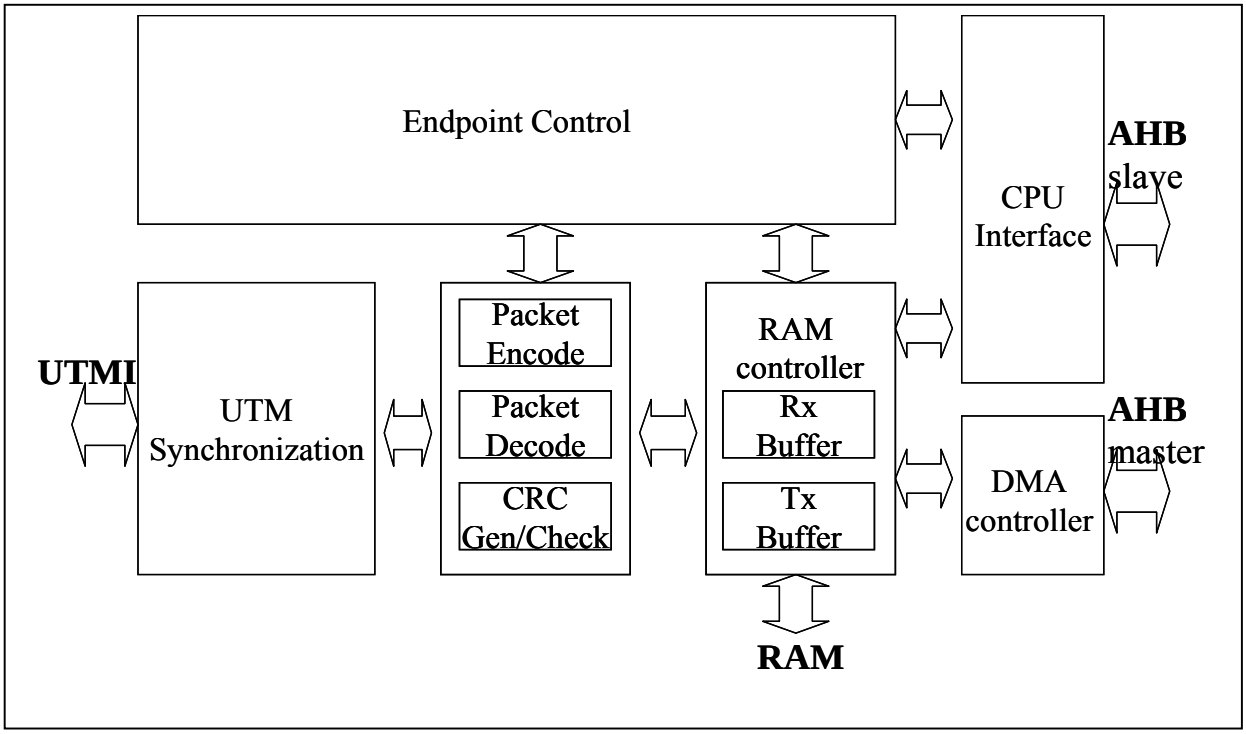
7.4.1 General Description

The USB2.0 Controller can support 4 Tx and 3 Rx endpoints(excluding Endpoint 0). These endpoints can be individually configured in software to handle either Bulk transfers, Interrupt transfers or Isochronous transfers. There are 4 DMA channels and the embedded RAM size is 4Kbytes. The embedded RAM can be dynamically configured to each endpoint.

Here is provided features.

- Operates as the peripheral in point-to-point communications with another USB function
- Complies with the USB 2.0 standard for high-speed (480Mbps) functions
- Supports point-to-point communications with one high- or full-speed device
- Supports Suspend and Resume signaling
- Supports High-Bandwidth Isochronous & Interrupt transfers
- UTMI+ Level 2 Transceiver Interface
- Synchronous RAM interface for FIFOs
- Support for DMA access to FIFOs
- Software connect/disconnect option
- Supports multi-layer operations on the AHB bus
- Performs all transaction scheduling in hardware

The USB2.0 Controller Block Diagram is as illustrated.



7.4.2 Register Definitions

USB COMMON REGISTER

USB+0000h Function Address Register FADDR

Bit									7	6	5	4	3	2	1	0
Name										FUNCTION ADDRESS						
Type									R	R/W						
Reset									0	0						

Function Address FAddr is an 8-bit register that should be written with the 7-bit address of the peripheral part of the transaction. When the USB2.0 controller is being used in Peripheral mode (DevCtl.bit2=0), this register should be written with the address received through a SET_ADDRESS command, which will then be used for decoding the function address in subsequent token packets. When the USB2.0 controller is being used in Host mode (DevCtl.bit2=1), this register should be set to the value sent in a SET_ADDRESS command during device enumeration as the address for the peripheral device.

Peripheral Mode

USB+0001h Power Management Register POWER

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name									ISO UPDATE	SOFT CONN	HS ENAB	HS MODE	RESET	RESUME	SUSPEND MODE	ENABLE SUSPENDM
Type									R/W	R/W	R/W	R	R	R/W	R	R/W
Reset									0	0	1	0	0	0	0	0

Host Mode

USB+0001h Power Management Register POWER

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											HS ENAB	HS MODE	RESET	RESUME	SUSPEND MODE	ENABLE SUSPENDM
Type											R/W	R	R/W	R/W	set	R/W
Reset											1	0	0	0	0	0

EnableSuspendM Set by the CPU to enable the SUSPENDM output

SuspendMode In Host mode, this bit is set by the CPU to enter Suspend mode. In Peripheral mode, this bit is set on entry into Suspend mode. It is cleared when the CPU reads the interrupt register, or sets the Resume bit above.

Resume Set by the CPU to generate Resume signaling when the function is in Suspend mode. The CPU should clear this bit after 10 ms (a maximum of 15 ms) to end Resume signaling. In Host mode, this bit is also automatically set when Resume signaling from the target is detected while the USB2.0 controller is suspended.

Reset This bit is set when Reset signaling is present on the bus. Note: This bit is Read/Write from the CPU in Host Mode but Read-Only in Peripheral Mode.

HSMode When set, this read-only bit indicates High-speed mode successfully negotiated during USB reset. In Peripheral Mode, becomes valid when USB reset completes (as indicated by USB reset interrupt). In Host Mode, becomes valid when Reset bit is cleared. Remains valid for the duration of the session.

Note: Allowance is made for Tiny-J signaling in determining the transfer speed to select.

HSEnab When set by the CPU, the USB2.0 controller will negotiate for High-speed mode when the device is reset by the hub. If not set, the device will only operate in Full-speed mode.

SoftConn If Soft Connect/Disconnect feature is enabled, then the USB D+/D- lines is enabled when this bit is set by the CPU and tri-stated when this bit is cleared by the CPU. Note: Only valid in Peripheral Mode.

ISOupdate When set by the CPU, the USB2.0 controller will wait for an SOF token from the time TxPktRdy is set before sending the packet. If an IN token is received before an SOF token, then a zero length data packet will be sent.

Note: Only valid in Peripheral Mode. Also, this bit only affects endpoints performing Isochronous transfers.

USB+0002h Tx Interrupt Status Register INTRTX

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											EP5 TX	EP4 TX	EP3 TX	EP2 TX	EP1 TX	EP0

Type											R	R	R	R	R	R
Reset											0	0	0	0	0	0

EP0 Endpoint0 interrupt event

EP1_TX Tx Endpoint 1 interrupt event

EP2_TX Tx Endpoint 2 interrupt event

EP3_TX Tx Endpoint 3 interrupt event

EP4_TX Tx Endpoint 4 interrupt event

EP5_TX Tx Endpoint 5 interrupt event

USB+0004h Rx Interrupt Status Register INTRRX

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													EP3 RX	EP2 RX	EP1 RX	
Type													R/W	R/W	R/W	
Reset													0	0	0	

INTRRX[15:0] Rx Interrupt Status register is “write 0 clear”

EP1_RX Rx Endpoint 1 interrupt event

EP2_RX Rx Endpoint 2 interrupt event

EP3_RX Rx Endpoint 3 interrupt event

USB+0006h Tx Interrupt Enable Register INTRTXE

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											EP5 TXE	EP4 TXE	EP3 TXE	EP2 TXE	EP1 TXE	EP0 E
Type											R/W	R/W	R/W	R/W	R/W	R/W
Reset											1	1	1	1	1	1

EP0_E 0: Endpoint0 interrupt event disable 1: Endpoint0 interrupt event enable

EP1_TXE 0:Tx Endpoint 1 interrupt event disable 1:Tx Endpoint 1 interrupt event enable

EP2_TXE 0:Tx Endpoint 2 interrupt event disable 1:Tx Endpoint 2 interrupt event enable

EP3_TXE 0:Tx Endpoint 3 interrupt event disable 1:Tx Endpoint 3 interrupt event enable

EP4_TXE 0:Tx Endpoint 4 interrupt event disable 1:Tx Endpoint 4 interrupt event enable

EP5_TXE 0:Tx Endpoint 5 interrupt event disable 1:Tx Endpoint 5 interrupt event enable

USB+0008h Rx Interrupt Enable Register INTRRXE

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													EP3 RXE	EP2 RXE	EP1 RXE	
Type													R/W	R/W	R/W	
Reset													1	1	1	

EP1_RXE 0:Rx Endpoint 1 interrupt event disable 1:Rx Endpoint 1 interrupt event enable

EP2_RXE 0:rx Endpoint 2 interrupt event disable 1:Rx Endpoint 2 interrupt event enable

EP3_RXE 0:Rx Endpoint 3 interrupt event disable 1:Rx Endpoint 3 interrupt event enable

USB+000Ah Common USB interrupts Register INTRUSB

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									VBUSERROR	SESSREQ	DISCON	CONN	SOF	RESET/BABBLE	RESUME	SUSPEND
Type									R	R	R	R	R	R	R	R
Reset									0	0	0	0	0	0	0	0

Suspend Set when Suspend signaling is detected on the bus. *Only valid in Peripheral mode.*

Resume Set when Resume signaling is detected on the bus while the USB2.0 controller is in Suspend mode.

Reset Set in Peripheral mode when Reset signaling is detected on the bus.

Babble Set in Host mode when babble is detected. *Note:* Only active after first SOF has been sent.

SOF Set when a new frame starts.

Conn Set when a device connection is detected. Only valid in Host mode. Valid at all transaction speeds.

Discon Set in Host mode when a device disconnect is detected. Set in Peripheral mode when a session ends. *Valid at all transaction speeds.*

SessReq Set when Session Request signaling has been detected. *Only valid when USB2.0 controller is 'A' device.*

VBusError Set when VBus drops below the VBus Valid threshold during a session. *Only valid when USB2.0 controller is 'A' device.*

USB+000Bh Common USB interrupts Enable Register INTRUSBE

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									VBUSERROR_E	SESSREQ_E	DISCON_E	CONN_E	SOF_E	RESET/BABBLE_E	RESUME_E	SUSPEND_E
Type									R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset									0	0	0	0	0	1	1	0

SuspendE Suspend interrupt enable.

ResumeE Resume interrupt enable

Reset/BabbleE Reset/Babble interrupt enable

SOFE SOF interrupt enable

ConnE Conn interrupt enable

DisconE Discon interrupt enable

SessReqE SessReq interrupt enable

VBusErrorE VBusError interrupt enable

USB+000Ch Frame Number Register FRAME

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	0					FRAME NUMBER										
Type	R					R										
Reset	0					0										

FRAME Frame is a 11-bit read-only register that holds the last received frame number.

USB+000Eh Endpoint Selecting Index Register INDEX

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													SELECTED ENDPOINT			
Type													R/W			
Reset													0			

INDEX Each Tx endpoint and each Rx endpoint have their own set of control/status registers located between 29900h – 299FFh. In addition one set of Tx control/status and one set of Rx control/status registers appear at 29810h – 2981Fh. Index is a 4-bit register that determines which endpoint control/status registers are accessed. Before accessing an endpoint's control/status registers at 29810h – 2981Fh, the endpoint number should be written to the Index register to ensure that the correct control/status registers appear in the memory map.

USB+000Fh Test Mode Enable Register TESTMODE

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									FORCE_HOST	FIFO_ACCESS	FORCE_FS	FORCE_HS	TEST_PACKET	TEST_K	TEST J	TEST_SE0_NAK
Type									R/W	SET	R/W	R/W	R/W	R/W	R/W	R/W
Reset									0	0	0	0	0	0	0	0

Test_SE0_NAK *(High-speed mode)* The CPU sets this bit to enter the Test_SE0_NAK test mode. In this mode, the USB2.0 controller remains in High-speed mode but responds to any valid IN token with a NAK.

Test_J *(High-speed mode)* The CPU sets this bit to enter the Test_J test mode. In this mode, the USB2.0 controller transmits a continuous J on the bus.

Test_K *(High-speed mode)* The CPU sets this bit to enter the Test_K test mode. In this mode, the USB2.0 controller transmits a continuous K on the bus.

Test_Packet *(High-speed mode)* The CPU sets this bit to enter the Test_Packet test mode. In this mode, the USB2.0 controller repetitively transmits on the bus a 53-byte test packet, the form of which is defined in the *Universal Serial Bus Specification* Revision 2.0, Section 7.1.20. *Note:* The test packet has a fixed format and must be loaded into the Endpoint 0 FIFO before the test mode is entered.

Force_HS The CPU sets this bit either in conjunction with bit 7 above or to force the USB2.0 controller into High-speed mode when it receives a USB reset.

Force_FS The CPU sets this bit either in conjunction with bit 7 above or to force the USB2.0 controller into Fullspeed mode when it receives a USB reset.

FIFO_Access The CPU sets this bit to transfer the packet in the Endpoint 0 Tx FIFO to the Endpoint 0 Rx FIFO. It is cleared automatically.

Force_Host The CPU sets this bit to instruct the core to enter Host mode when the Session bit is set, regardless of whether it is connected to any peripheral. The state of the CID input, HostDisconnect and LineState signals are ignored. The core will then remain in Host mode until the Session bit is cleared, even if a device is disconnected, and if the Force_Host bit remains set, will re-enter Host mode the next time the Session bit is set.While in this

mode, the status of the HOSTDISCON signal from the PHY may be read from bit 7 of the ACTLR0.DevCtl register.

The operating speed is determined from the Force_HS and Force_FS bits as follows:

Force_HS	Force_FS	Operating Speed
0	0	Low Speed
0	1	Full Speed
1	0	High Speed
1	1	*Undefined*

USB INDEXED REGISTER

EP0 INDEXED REGISTER

Peripheral Mode

USB+0100h EP0 Control Status Register CSR0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name								**FLUSHFIFO**	**SERVICESETUPEND**	**SERVICEDRXPKTRDY**	**SENDSTALL**	**SETUPEND**	**DATAEND**	**SENDSTALL**	**TXPKTRDY**	**RXPKTRDY**
Type								SET	SET	SET	SET	R	SET	R/CLEAR	R/SET	R
Reset								0	0	0	0	0	0	0	0	0

RxPktRdy This bit is set when a data packet has been received. An interrupt is generated when this bit is set. The CPU clears this bit by setting the ServicedRxPktRdy bit.

TxPktRdy The CPU sets this bit after loading a data packet into the FIFO. It is cleared automatically when a data packet has been transmitted. An interrupt is also generated at this point (if enabled).

SentStall This bit is set when a STALL handshake is transmitted. The CPU should clear this bit.

DataEnd The CPU sets this bit:

1. When setting TxPktRdy for the last data packet.
2. When clearing RxPktRdy after unloading the last data packet.
3. When setting TxPktRdy for a zero length data packet.

It is cleared automatically.

SetupEnd This bit will be set when a control transaction ends before the DataEnd bit has been set. An interrupt will be generated and the FIFO flushed at this time. The bit is cleared by the CPU writing a 1 to the ServicedSetupEnd bit.

SendStall The CPU writes a 1 to this bit to terminate the current transaction. The STALL handshake will be transmitted and then this bit will be cleared automatically. *Note: The FIFO should be flushed before SendStall is set.*

ServiceRxPktRdy The CPU writes a 1 to this bit to clear the RxPktRdy bit. It is cleared automatically.

ServiceSetupEnd The CPU writes a 1 to this bit to clear the SetupEnd bit. It is cleared automatically.

FlushFIFO The CPU writes a 1 to this bit to flush the next packet to be transmitted/read from the Endpoint 0 FIFO. It is cleared automatically. The FIFO pointer is reset and the TxPktRdy/RxPktRdy bit (below) is cleared. *Note:* FlushFIFO should only be used when TxPktRdy/RxPktRdy is set. At other times, it may cause data to be corrupted.

Host Mode

USB+0100h EP0 Control Status Register CSR0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					DISPING			FLUSHFIFO	NAKTIMEOUT	STATUSPKT	REQPKT	ERROR	SETUPPKT	RXSTALL	TXPKTRDY	RXPKTRDY
Type					R/W			SET	R/CLEAR	R/W	R/W	R/CLEAR	R/CLEAR	R/CLEAR	R/SET	R/CLEAR
Reset					0			0	0	0	0	0	0	0	0	0

RxPktRdy This bit is set when a data packet has been received. An interrupt is generated (if enabled) when this bit is set. The CPU should clear this bit when the packet has been read from the FIFO.

TxPktRdy The CPU sets this bit after loading a data packet into the FIFO. It is cleared automatically when a data packet has been transmitted. An interrupt is also generated at this point (if enabled).

RxStall This bit is set when a STALL handshake is received. The CPU should clear this bit.

SetupPkt The CPU sets this bit, at the same time as the TxPktRdy bit is set, to send a SETUP token instead of an OUT token for the transaction. Note: Setting this bit also clears the DataToggle.

Error This bit will be set when three attempts have been made to perform a transaction with no response from the peripheral. The CPU should clear this bit. An interrupt is generated when this bit is set.

ReqPkt The CPU sets this bit to request an IN transaction. It is cleared when RxPktRdy is set.

StatusPkt The CPU sets this bit at the same time as the TxPktRdy or ReqPkt bit is set, to perform a status stage transaction. Setting this bit ensures that the data toggle is set to 1 so that a DATA1 packet is used for the Status Stage transaction.

NAKTimeout This bit will be set when Endpoint 0 is halted following the receipt of NAK responses for longer than the time set by the NAKLimit0 register. The CPU should clear this bit to allow the endpoint to continue.

FlushFIFO The CPU writes a 1 to this bit to flush the next packet to be transmitted/read from the Endpoint 0 FIFO. The FIFO pointer is reset and the TxPktRdy/RxPktRdy bit (below) is cleared. Note: FlushFIFO should only be used when TxPktRdy/RxPktRdy is set. At other times, it may cause data to be corrupted.

DisPing The CPU writes a 1 to this bit to instruct the core not to issue PING tokens in data and status phases of a high-speed Control transfer (for use with devices that do not respond to PING)

USB+0108h EP0 Received bytes Register COUNT0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name										EP0 RX COUNT						
Type										R						
Reset										0						

EP0 RX Count0 Count0 is a 7-bit read-only register that indicates the number of received data bytes in the Endpoint 0 FIFO. The value returned changes as the contents of the FIFO change and is only valid while RxPktRdy (IDXEPR0.CSR0.bit0) is set.

Host Mode

USB+010Bh NAK Limit Register NAKLIMT0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												NAK LIMIT0				
Type												R/W				
Reset												0				

NAKLimit0 NAKLimit0 is a 5-bit register that sets the number of frames/microframes (High-Speed transfers) after which Endpoint 0 should timeout on receiving a stream of NAK responses. (Equivalent settings for other endpoints can be made through their TxInterval and RxInterval registers.). The number of frames/microframes selected is $2^{(m-1)}$ (where *m* is the value set in the register, valid values 2 – 16). If the host receives NAK responses from the target for more frames than the number represented by the Limit set in this register, the endpoint will be halted. *Note:* A value of 0 or 1 disables the NAK timeout function.

USB+010Fh Core Configuration Register CONFIGDATA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									MP RXE	MP TXE	BIGE NDIA N	HBRX E	HBTX E	DYNFI FOSIZ ING	SOFT CONE	UTMI DATA WIDT H
Type									R	R	R	R	R	R	R	R
Reset																

UTMIDataWidth Indicates selected UTMI+ data width. 0 8 bits; 1 16 bits.

SoftConE When set to '1' indicates Soft Connect/Disconnect option selected.

DynFIFOSizeing When set to '1' indicates Dynamic FIFO Sizing option selected.

HBTxE When set to '1' indicates High-bandwidth Tx ISO Endpoint Support selected.

HBRxE When set to '1' indicates High-bandwidth Rx ISO Endpoint Support selected

BigEndian When set to '1' indicates Big Endian ordering is selected.

MPTxE When set to '1', automatic splitting of bulk packets is selected.

MPRxE When set to '1', automatic amalgamation of bulk packets is selected.

EP1 INDEXED REGISTER

USB+0110h TXMAP Register TXMAP

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	M-1					MAXIMUM PAYLOAD TRANSACTION										
Type	R/W					R/W										
Reset	0					0										

TxMaxP Maxmum payload size for indexed TX endpoint
***m*-1** Packet multiplier *m*

TxMaxP Register

The TxMaxP register defines the maximum amount of data that can be transferred through the selected Tx endpoint in a single operation. There is a TxMaxP register for each Tx endpoint (except Endpoint 0).

Bits 10:0 define (in bytes) the maximum payload transmitted in a single transaction. The value set can be up to 1024 bytes but is subject to the constraints placed by the USB Specification on packet sizes for Bulk, Interrupt and Isochronous transfers in Fullspeed and High-speed operations. Where the option of High-bandwidth Isochronous/Interrupt endpoints or of packet splitting on Bulk endpoints has been taken when the core is configured, the register includes either 2 or 5 further bits that define a multiplier *m* which is equal to one more than the value recorded.

In the case of Bulk endpoints with the packet splitting option enabled, the multiplier *m* can be up to 32 and defines the maximum number of 'USB' packets (i.e. packets for transmission over the USB) of the specified payload into which a single data packet placed in the FIFO should be split, prior to transfer. (If the packet splitting option is not enabled, bit15–13 is not implemented and bit12–11(if included) is ignored.) Note: The data packet is required to be an exact multiple of the payload specified by bits 10:0, which is itself required to be either 8, 16, 32, 64 or (in the case of High Speed transfers) 512 bytes.

For Isochronous/Interrupt endpoints operating in High-Speed mode and with the High-bandwidth option enabled, *m* may only be either 2 or 3 (corresponding to bit 11 set or bit 12 set, respectively) and it specifies the maximum number of such transactions that can take place in a single microframe. If either bit 11 or bit 12 is non-zero, the USB2.0 controller will automatically split any data packet written to the FIFO into up to 2 or 3 'USB' packets, each containing the specified payload (or less). The maximum payload for each transaction is 1024 bytes, so this allows up to 3072 bytes to be transmitted in each microframe. (For Isochronous/Interrupt transfers in Full-speed mod, bits 11 and 12 are ignored.)

The value written to bits 10:0 (multiplied by *m* in the case of high-bandwidth Isochronous/Interrupt transfers) must match the value given in the *wMaxPacketSize* field of the Standard Endpoint Descriptor for the associated endpoint (see *USB Specification* Revision 2.0, Chapter 9). A mismatch could cause unexpected results.

The total amount of data represented by the value written to this register (specified payload × *m*) must not exceed the FIFO size for the Tx endpoint, and should not exceed half the FIFO size if double-buffering is required.

If this register is changed after packets have been sent from the endpoint, the Tx endpoint FIFO should be completely flushed (using the FlushFIFO bit in TxCSR) after writing the new value to this register.

Peripheral Mode

USB+0112h Tx CSR Register TXCSR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	AUTOSET	ISO	MODE	DMAREQEN	FRCDATATOG	DMAREQMODE	AUTOSETEN_SPKT		INCOMPTX	CLRDATATOG	SENTSTALL	SENDSTALL	FLUSHFIFO	UNDERRUN	FIFONOTEMPTY	TXPKTRDY
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W		R/W	R/W	R/W	R/W	R/W	R/W	R	R/W
Reset	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0

TxPktRdy The CPU sets this bit after loading a data packet into the FIFO. It is cleared automatically when a data packet has been transmitted. An interrupt is also generated at this point (if enabled). TxPktRdy is also

automatically cleared (but no interrupt is generated) prior to loading a second packet into a double-buffered FIFO.

FIFONotEmpty The USB sets this bit when there is at least 1 packet in the TxFIFO.

UnderRun The USB sets this bit if an IN token is received when the TxPktRdy bit not set. The CPU should clear this bit (write 0 clear).

FlushFIFO The CPU writes a 1 to this bit to flush the latest packet from the endpoint TxFIFO. The FIFO pointer is reset, the TxPktRdy bit is cleared and an interrupt is generated. May be set simultaneously with TxPktRdy to abort the packet that is currently being loaded into the FIFO. Note: FlushFIFO should only be used when TxPktRdy is set. At other times, it may cause data to be corrupted. Also note that, if the FIFO is double-buffered, FlushFIFO may need to be set twice to completely clear the FIFO.

SendStall The CPU writes a 1 to this bit to issue a STALL handshake to an IN token. The CPU clears this bit to terminate the stall condition. *Note: This bit has no effect where the endpoint is being used for Isochronous transfer.*

SentStall This bit is set when a STALL handshake is transmitted. The FIFO is flushed and the TxPktRdy bit is cleared. The CPU should clear this bit.

ClrDataTog The CPU writes a 1 to this bit to reset the endpoint data toggle to 0.

IncompTx When the endpoint is being used for high-bandwidth Isochronous/Interrupt transfers, this bit is set to indicate where a large packet has been split into 2 or 3 packets for transmission but insufficient IN tokens have been received to send all the parts. *Note: In anything other than a high-bandwidth transfer, this bit will always return 0.*

AutoSetEn_SPKT If the CPU sets this bit, TxPktRdy will be automatically set when the short packet is loaded into the TxFIFO completely. But, this function only works in Tx endpoint 1 and 2. Besides, Tx endpoint 1 has to use DMA channel 1 to move data and Tx endpoint 2 has to use DMA channel 2 to move data.

DMAReqMode The CPU sets this bit to select DMA Request Mode 1 and clears it to select DMA Request Mode 0. *Note: This bit must not be cleared either before or in the same cycle as the DMAReqEn bit is cleared.*

FrcDataTog The CPU sets this bit to force the endpoint data toggle to switch and the data packet to be cleared from the FIFO, regardless of whether an ACK was received. This can be used by Interrupt Tx endpoints that are used to communicate rate feedback for Isochronous endpoints.

DMAReqEn The CPU sets this bit to enable the DMA request for the Tx endpoint.

Mode The CPU sets this bit to enable the endpoint direction as Tx, and clears the bit to enable it as Rx. *Note: This bit only has any effect where the same endpoint FIFO is used for both Tx and Rx transactions.*

ISO The CPU sets this bit to enable the Tx endpoint for Isochronous transfers, and clears it to enable the Tx endpoint for Bulk or Interrupt transfers. N*ote: This bit only has any effect in Peripheral mode. In Host mode, it always returns zero.*

AutoSet If the CPU sets this bit, TxPktRdy will be automatically set when data of the maximum packet size (value in TxMaxP) is loaded into the TxFIFO. If a packet of less than the maximum packet size is loaded, then TxPktRdy will have to be set manually if AutoSetEn_SPKT is not enabled.

Host Mode

USB+0112h Tx CSR Register TXCSR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	AUTOSET		MODE	DMAREQEN	FRCDATATOG	DMAREQMODE			NAKTIMEOUT/INCOMPTX	CLRDATATOG	RXSTALL		FLUSHFIFO	ERROR	FIFONOTEMPTY	TXPKTRDY
Type	R/W	R/W	R/W	R/W	R/W	R/W			R/CLEAR	SET	R/CLEAR		SET	R/CLEAR	R/CLEAR	R/SET
Reset	0	0	0	0	0	0			0	0	0		0	0	0	0

TxPktRdy The CPU sets this bit after loading a data packet into the FIFO. It is cleared automatically when a data packet has been transmitted. An interrupt is also generated at this point (if enabled). TxPktRdy is also automatically cleared prior to loading a second packet into a double-buffered FIFO.

FIFONotEmpty The USB sets this bit when there is at least 1 packet in the Tx FIFO.

Error The USB sets this bit when 3 attempts have been made to send a packet and no handshake packet has been received. When the bit is set, an interrupt is generated, TxPktRdy is cleared and the FIFO is completely flushed. The CPU should clear this bit. *Valid only when the endpoint is operating in Bulk or Interrupt mode.*

FlushFIFO The CPU writes a 1 to this bit to flush the latest packet from the endpoint Tx FIFO. The FIFO pointer is reset, the TxPktRdy bit (below) is cleared and an interrupt is generated. May be set simultaneously with TxPktRdy to abort the packet that is currently being loaded into the FIFO. *Note:* FlushFIFO should only be used when TxPktRdy is set. At other times, it may cause data to be corrupted. Also note that, if the FIFO is double-buffered, FlushFIFO may need to be set twice to completely clear the FIFO.

RxStall This bit is set when a STALL handshake is received. When this bit is set, any DMA request that is in progress is stopped, the FIFO is completely flushed and the TxPktRdy bit is cleared (see below). The CPU should clear this bit.

ClrDataTog The CPU writes a 1 to this bit to reset the endpoint data toggle to 0.

NAKTimeout *Bulk endpoints only:* This bit will be set when the Tx endpoint is halted following the receipt of NAK responses for longer than the time set as the NAK Limit by the TxInterval register. The CPU should clear this bit to allow the endpoint to continue.

IncompTx *High-bandwidth Interrupt endpoints only:* This bit will be set if no response is received from the device to which the packet is being sent.

DMAReqMode The CPU sets this bit to select DMA Request Mode 1 and clears it to select DMA Request Mode 0. Note: This bit must not be cleared either before or in the same cycle as the above DMAReqEnab bit is cleared.

FrcDataTog The CPU sets this bit to force the endpoint data toggle to switch and the data packet to be cleared from the FIFO, regardless of whether an ACK was received. This can be used by Interrupt Tx endpoints that are used to communicate rate feedback for Isochronous endpoints.

DMAReqEnab The CPU sets this bit to enable the DMA request for the Tx endpoint.

Mode The CPU sets this bit to enable the endpoint direction as Tx, and clears it to enable the endpoint direction as Rx. *Note: This bit only has any effect where the same endpoint FIFO is used for both Tx and Rx transactions.*

AutoSet If the CPU sets this bit, TxPktRdy will be automatically set when a packet of the maximum packet size (TxMaxP) is loaded into the Tx FIFO. If a packet of less than the maximum packet size is loaded, then TxPktRdy will have to be set manually. *Note: Should not be set for either high-bandwidth Isochronous endpoints or high-bandwidth Interrupt endpoints.*

USB+0114h RXMAP Register RXMAP

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	M-1					MAXIMUM PAYLOA TRANSACTION										
Type	R/W					R/W										
Reset	0					0										

RxMaxP Maxmum payload size for indexed RX endpoint

***m*-1** Packet multiplier *m*

RxMaxP Register The RxMaxP register defines the maximum amount of data that can be transferred through the selected Rx endpoint in a single operation. There is a RxMaxP register for each Rx endpoint (except Endpoint 0).

Bits 10:0 define (in bytes) the maximum payload transmitted in a single transaction. The value set can be up to 1024 bytes but is subject to the constraints placed by the USB Specification on packet sizes for Bulk, Interrupt and Isochronous transfers in Full-speed and High-speed operations.

Where the option of High-bandwidth Isochronous/Interrupt endpoints or of combining Bulk packets has been taken when the core is configured, the register includes either 2 or 5 further bits that define a multiplier *m* which is equal to one more than the value recorded.

For Bulk endpoints with the packet combining option enabled, the multiplier *m* can be up to 32 and defines the number of USB packets of the specified payload which are to be combined into a single data packet within the FIFO. (If the packet splitting option is not enabled, bit15–bit13 is not implemented and bit12–bit11 (if included) is ignored.)

For Isochronous/Interrupt endpoints operating in High-Speed mode and with the High-bandwidth option enabled, *m* may only be either 2 or 3 (corresponding to bit 11 set or bit 12 set, respectively) and it specifies the maximum number of such transactions that can take place in a single microframe. If either bit 11 or bit 12 is non-zero, the USB2.0 controller will automatically combine the separate USB packets received in any microframe into a single packet within the Rx FIFO. The maximum payload for each transaction is 1024 bytes, so this allows up to 3072 bytes to be received in each microframe. (For Isochronous/Interrupt transfers in Full-speed mode or if High-bandwidth is not enabled, bits 11 and 12 are ignored.) The value written to bits 10:0 (multiplied by *m* in the case of high-bandwidth Isochronous/Interrupt transfers) must match the value given in the *wMaxPacketSize* field of the Standard Endpoint Descriptor for the associated endpoint (see *USB Specification* Revision 2.0, Chapter 9). A mismatch could cause unexpected results.

The total amount of data represented by the value written to this register (specified payload × *m*) must not exceed the FIFO size for the OUT endpoint, and should not exceed half the FIFO size if double-buffering is required.

Peripheral Mode

USB+0116h Rx CSR Register RXCSR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	AUTOCLEAR	ISO	DMAREQEN	DISNYET/PIDERR	DMAREQMODE	AUTOCLREN_SPKT	INCOMPRXINTREN	INCOMPRX	CLRDATATOG	SENTSTALL	SENDSTALL	FLUSHFIFO	DATAERR	OVERRUN	FIFOFULL	RXPKTRDY
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

RxPktRdy This bit is set when a data packet has been received (to RxFIFO). The CPU should clear this bit when the packet has been unloaded from the RxFIFO. An interrupt is generated when the bit is set.

FIFOFull This bit is set when no more packets can be loaded into the RxFIFO.

OverRun This bit is set if an OUT packet cannot be loaded into the RxFIFO. The CPU should clear this bit (write 0 clear). *Note: This bit is only valid when the endpoint is operating in ISO mode. In Bulk Mode, it always returns zero.* The new incoming packet won't be written to RxFIFO. An interrupt is generated when the bit is set and OverRunIntrEn is set.

DataError This bit is set when RxPktRdy is set if the data packet has a CRC or bit-stuff error. The CPU should write 0 to clear this bit. *Note: This bit is only valid when the endpoint is operating in ISO mode. In Bulk Mode, it always returns zero.* An interrupt is generated when the bit is set and DataErrIntrEn is set.

FlushFIFO The CPU writes a 1 to this bit to flush the next packet to be read from the endpoint RxFIFO. The RxFIFO pointer is reset and the RxPktRdy bit is cleared. Note: FlushFIFO should only be used when RxPktRdy is set. At other times, it may cause data to be corrupted. Also note that, if the RxFIFO is double buffered, FlushFIFO may need to be set twice to completely clear the RxFIFO.

SendStall The CPU writes a 1 to this bit to issue a STALL handshake. The CPU clears this bit to terminate the stall condition. *Note: This bit has no effect where the endpoint is being used for ISO transfers*.

SentStall This bit is set when a STALL handshake is transmitted. The CPU should clear this bit. An interrupt is generated when the bit is set.

ClrDataTog The CPU writes a 1 to this bit to reset the endpoint data toggle to 0.

IncompRx This bit is set in a high-bandwidth Isochronous/Interrupt transfer if the packet in the RxFIFO is incomplete because parts of the data were not received. It is cleared when RxPktRdy is cleared or write 0 to clear. *Note: In anything other than a high-bandwidth transfer, this bit will always return 0.* An interrupt is generated when the bit is set and IncompRxIntrEn is set.

IncompRxIntrEn IncompRx and PidErr interrupt enable.

AutoClrEn_SPKT The CPU write a 1 to this bit to enable short packets' RxPktRdy to be automatically cleared. Whe this bit is turned on, AutoClear must also be turned on. If ISO and AutoClrEn_SPKT are both set, when

short packets are unloaded, RxPktRdy will be cleared automatically. But, these short packets must have no IncompRx, PidErr, DataErr or OverRun status.

DMAReqMode The CPU sets this bit to select DMA Request Mode 1 and clears it to select DMA Request Mode 0.

DMA Request Mode 1: Rx endpoint interrupt is generated only when DMA Request Mode 1 and received a short packet. RxDMAReq is generated when receiving a Max-Packet-size packet.

DMA Request Mode 0: No Rx endpoint interrupt. RxDMAReq is generated when RxPktRdy is set.

DisNyet(bulk/interrupt transactions) The CPU sets this bit to disable the sending of NYET handshakes. When set, all successfully received Rx packets are ACK'd including at the point at which the RxFIFO becomes full. *Note: This bit only has any effect in High-speed mode, in which mode it should be set for all interrupt endpoint.*

PidErr(ISO transactions) This bit is set when there is a PID error in the received packet. It is cleared when RxPktRdy is cleared or write 0 to clear. An interrupt is generated when the bit is set and IncompRxIntrEn is set.

DMAReqEn The CPU sets this bit to enable the DMA request for the Rx endpoint.

ISO The CPU sets this bit to enable the Rx endpoint for Isochronous transfers, and clears it to enable the Rx endpoint for Bulk/Interrupt transfers.

AutoClear If the CPU sets this bit then the RxPktRdy bit will be automatically cleared when a packet of RxMaxP bytes has been unloaded from the RxFIFO. When packets of less than the maximum packet size are unloaded, RxPktRdy will have to be cleared manually if AutoClrEn_SPKT is not enabled.

Host Mode

USB+0116h Rx CSR Register RXCSR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	AUTOCLEAR	AUTOREQ	DMAREQENAB	PIDERROR	DMAREQMODE			INCOMPRX	CLRDATATOG	RXSTALL	REQPKT	FLUSHFIFO	DATAERR/NAKTIMREOUT	ERROR	FIFOFULL	RXPKTRDY
Type	R/W	R/W	R/W	R	R/W			R/CLEAR	R/W	R/CLEAR	R/W	SET	R/CLEAR	R/CLEAR	R	R/CLEAR
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

RxPktRdy This bit is set when a data packet has been received. The CPU should clear this bit when the packet has been unloaded from the Rx FIFO. An interrupt is generated when the bit is set.

FIFOFull This bit is set when no more packets can be loaded into the Rx FIFO.

Error The USB sets this bit when 3 attempts have been made to receive a packet and no data packet has been received. The CPU should clear this bit. An interrupt is generated when the bit is set. *Note: This bit is only valid when the Rx endpoint is operating in Bulk or Interrupt mode. In ISO mode, it always returns zero.*

NAKTimeout In Bulk mode, this bit will be set when the Rx endpoint is halted following the receipt of NAK responses for longer than the time set as the NAK Limit by the RxInterval register.

DataError When operating in ISO mode, this bit is set when RxPktRdy is set if the data packet has a CRC or bit-stuff error and cleared when RxPktRdy is cleared.

FlushFIFO The CPU writes a 1 to this bit to flush the next packet to be read from the endpoint Rx FIFO. The FIFO pointer is reset and the RxPktRdy bit (below) is cleared. *Note:* FlushFIFO should only be used when RxPktRdy is set. At other times, it may cause data to be corrupted. Also note that, if the FIFO is double-buffered, FlushFIFO may need to be set twice to completely clear the FIFO.

ReqPkt The CPU writes a 1 to this bit to request an IN transaction. It is cleared when RxPktRdy is set.

RxStall When a STALL handshake is received, this bit is set and an interrupt is generated. The CPU should clear this bit.

ClrDataTog The CPU writes a 1 to this bit to reset the endpoint data toggle to 0.

IncompRx This bit will be set in a high-bandwidth Isochronous/Interrupt transfer if the packet received is incomplete. It will be cleared when RxPktRdy is cleared. *Note: If USB protocols are followed correctly, this bit should never be set. The bit becoming set indicates a failure of the associated Peripheral device to behave correctly. (In anything other than a high-bandwidth transfer, this bit will always return 0.)*

DMAReqMode The CPU sets this bit to select DMA Request Mode 1 and clears it to select DMA Request Mode 0. *Note: This bit should not be cleared in the same cycle as RxPktRdy is cleared*

PIDError *ISO Transactions Only:* The core sets this bit to indicate a PID error in the received packet. Bulk/Interrupt Transactions: The setting of this bit is ignored.

DMAReqEnab The CPU sets this bit to enable the DMA request for the Rx endpoint.

AutoReq If the CPU sets this bit, the ReqPkt bit will be automatically set when the RxPktRdy bit is cleared. *Note:* This bit is automatically cleared when a short packet is received.

AutoClr f the CPU sets this bit then the RxPktRdy bit will be automatically cleared when a packet of RxMaxP bytes has been unloaded from the Rx FIFO. When packets of less than the maximum packet size are unloaded, RxPktRdy will have to be cleared manually. *Note: Should not be set for highbandwidth Isochronous endpoints.*

USB+0118h Rx Count Register RXCOUNT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			RXCOUNT													
Type			R													
Reset			0													

RxCount It is a 14-bit read-only register that holds the number of received data bytes in the packet in the RxFIFO. Note: The value returned changes as the FIFO is unloaded and is only valid while RxPktRdy(RxCSR.D0) is set.

Host Mode

USB+011Ah TxType Register TXTYPE

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											TX_PROTOCOL		TX_TARGET EP NUMBER			
Type											R/W		R/W			
Reset											0		0			

Target EndpointNumber (Host Mode Only) The CPU should set this value to the endpoint number contained in the Tx endpoint descriptor returned to the USB2.0 Controller during device enumeration.

Protocol (Host Mode Only) The CPU should set this to select the required protocol for the Tx endpoint:

00 : Illegal

01 : Isochronous

10 : Bulk

11 : Interrupt

USB+011Bh TxInterval Register TXINTERVAL

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									TX POLLING INTERVAL/NAK LIMIT M							
Type									R/W							
Reset									0							

TxInterval Register TxInterval is an 8-bit register that, for Interrupt and Isochronous transfers, defines the polling interval for the currently-selected Tx endpoint. For Bulk endpoints, this register sets the number of frames/microframes after which the endpoint should timeout on receiving a stream of NAK responses. There is a TxInterval register for each configured Tx endpoint (except Endpoint 0).

Tx Polling Interval / NAK Limit (*m*), (Host Mode Only)

In each case the value that is set defines a number of frames/microframes (High Speed transfers), as follows:

Transfer Type	Speed	Valid values (*m*)	Interpretation
Interrupt	Low Speed or Full Speed	1 – 255	Polling interval is *m* frames.
	High Speed	1 – 16	Polling interval is $2^{(m-1)}$ microframes
Isochronous	Full Speed or High Speed	1 – 16	Polling interval is $2^{(m-1)}$ frames/microframes
Bulk	Full Speed or High Speed	2 – 16	NAK Limit is $2^{(m-1)}$ frames/microframes. *Note:* A value of 0 or 1 disables the NAK timeout function.

USB+011Ch RxType Register RXTYPE

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											RX_PROTOCOL		RX_TARGET EP NUMBER			

Type											R/W	R/W
Reset											0	0

Target EndpointNumber (Host Mode Only) The CPU should set this value to the endpoint number contained in the Tx endpoint descriptor returned to the USB2.0 Controller during device enumeration.

Protocol (Host Mode Only) The CPU should set this to select the required protocol for the Tx endpoint:

00 : Illegal

01 : Isochronous

10 : Bulk

11 : Interrupt

USB+011Dh RxInterval Register RXINTERVAL

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									RX POLLING INTERVAL/NAK LIMIT M							
Type									R/W							
Reset									0							

RxInterval Register RxInterval is an 8-bit register that, for Interrupt and Isochronous transfers, defines the polling interval for the currently-selected Rx endpoint. For Bulk endpoints, this register sets the number of frames/microframes after which the endpoint should timeout on receiving a stream of NAK responses. There is a RxInterval register for each configured Rx endpoint (except Endpoint 0).

Rx Polling Interval / NAK Limit (*m*), (Host Mode Only)

In each case the value that is set defines a number of frames/microframes (High Speed transfers), as follows:

Transfer Type	Speed	Valid values (*m*)	Interpretation
Interrupt	Low Speed or Full Speed	1 – 255	Polling interval is *m* frames.
	High Speed	1 – 16	Polling interval is $2^{(m-1)}$ microframes
Isochronous	Full Speed or High Speed	1 – 16	Polling interval is $2^{(m-1)}$ frames/microframes
Bulk	Full Speed or High Speed	2 – 16	NAK Limit is $2^{(m-1)}$ frames/microframes. *Note:* A value of 0 or 1 disables the NAK timeout function.

Peripheral Mode

USB+011Fh Configured FIFO Size Register FIFOSIZE

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name									RXFIFOSIZE	TXFIFOSIZE
Type									R	R
Reset										

TxFIFOSize Indicate the TxFIFO size of 2^n bytes, (ex: value 10 means 2^{10} = 1024 bytes.)

RxFIFOSize Indicate the RxFIFO size of 2^n bytes, (ex: value 10 means 2^{10} = 1024 bytes.)

USB+0120h ~ USB+012Fh stands for Endpoint 2 Registers and their behaviors are the same as Endpoint 1.

USB+0130h ~ USB+013Fh stands for Endpoint 3 Registers and their behaviors are the same as Endpoint 1.

USB+0140h ~ USB+014Fh stands for Endpoint 4 Registers and their behaviors are the same as Endpoint 1.

USB+0150h ~ USB+015Fh stands for Endpoint 5 Registers and their behaviors are the same as Endpoint 1.

USB ENDPOINT FIFOS REGISTER

USB+0020h~ USB+005F USB Endpoint FIFO Register FIFOX

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	FIFO_DATA[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	FIFODATA[15:0]															
Type	R/W															
Reset	0															

FIFOData 32-bits FIFO data access window

The Endpoint FIFO Registers provides 5 addresses for CPU access to the FIFOs for each endpoint. Writing to these addresses loads data into the TxFIFO for the corresponding endpoint. Reading from these addresses unloads data from the RxFIFO for the corresponding endpoint.

ote: (i) Transfers to and from FIFOs may be 8-bit, 16-bit or 32-bit as required, and any combination of access is allowed provided the data accessed is contiguous. However, all the transfers associated with one packet must be of the same width so that the data is consistently byte-, word- or double-word-aligned. The last transfer may however contain fewer bytes than the previous transfers in order to complete an odd-byte or odd-word transfer.

(ii) Depending on the size of the FIFO and the expected maximum packet size, the FIFOs support either single-packet or double-packet buffering. However, burst writing of multiple packets is not supported as flags need to be set after each packet is written.

(iii) Following a STALL response or a Tx Strike Out error on Endpoint 0 – 4, the associated FIFO is completely flushed

USB ADDITIONAL CONTROL AND CONFIGURATION REGISTER

USB+0060h OTG device control Register DEVCTL

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name									B-DEVICE	FS DEV	LS DEV	VBUS	HOST MODE	HOST REQ	SESSION
Type									R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset									0	0	0	0	0	0	0

Session *When operating as an 'A' device,* this bit is set or cleared by the CPU to start or end a session. *When operating as a 'B' device,* this bit is set/cleared by the USB2.0 controller when a session starts/ends. It is also set by the CPU to initiate the Session Request Protocol. When the USB2.0 controller is in Suspend mode, the bit may be cleared by the CPU to perform a software disconnect. *Note:* Clearing this bit when the core is not suspended will result in undefined behavior.

HostReq When set, the USB2.0 controller will initiate the Host Negotiation when Suspend mode is entered. It is cleared when Host Negotiation is completed. *('B' device only)*

HostMode This Read-only bit is set when the USB2.0 controller is acting as a Host.

VBus

These Read-only bits encode the current VBus level as follows:

Bit4	Bit3	Meaning
0	0	Below SessionEnd
0	1	Above SessionEnd, below AValid
1	0	Above AValid, below VBusValid
1	1	Above VBusValid

LSDev This Read-only bit is set when a low-speed device has been detected being connected to the port. *Only valid in Host mode*.

FSDev This Read-only bit is set when a full-speed or high-speed device has been detected being connected to the port. (High-speed devices are distinguished from full-speed by checking for high-speed chirps when the device is reset.) *Only valid in Host mode*.

B-Device This Read-only bit indicates whether the USB2.0 controller is operating as the 'A' device or the 'B' device. 0 ⇒ 'A' device; 1 ⇒ 'B' device. *Only valid while a session is in progress. Note:* If the core is in Force_Host mode (i.e. a session has been started with Testmode Register, *2980Ch.bit24* = 1), this bit will indicate the state of the HOSTDISCON input signal from the PHY.

USB+0061h Power Up Counter Register PWRUPCNT

Bit									7	6	5	4	3	2	1	0
Name													PWRUPCNT			
Type													R/W			
Reset													4'hf			

PWRUPCNT[3:0] Power Up Counter Limit. Power Up Counter is used to count the K state duration during suspend and when it is timeout, the resume interrupt will be issued. The register should be configured according to AHB clock speed.

USB+0062h Tx FIFO Size Register TXFIFOSZ

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												TX DPB	TXSZ			
Type												R/W	R/W			
Reset												0	0			

TXDPB Defines whether double-packet buffering supported for TxFIFO. When '1', double-packet buffering is supported. When '0', only single-packet buffering is supported.

TXSZ Maximum packet size to be allowed for (*before* any splitting within the FIFO of Bulk/High-Bandwidth packets prior to transmission). If TxDPB = 0, the FIFO will also be this size; if TxDPB = 1, the FIFO will be twice this size

TxSZ[3:0]				Packet Size (Bytes)
0	0	0	0	8
0	0	0	1	16
0	0	1	0	32
0	0	1	1	64
0	1	0	0	128
0	1	0	1	256
0	1	1	0	512
0	1	1	1	1024
1	0	0	0	2048 (Single-packet buffering only)
1	0	0	1	4096 (Single-packet buffering only)
1	1	1	1	3072 (Single-packet buffering only)

USB+0063h Rx FIFO Size Register RXFIFOSZ

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												RX DPB	RXSZ			
Type												R/W	R/W			
Reset												0	0			

RXDPB Defines whether double-packet buffering supported for TxFIFO. When '1', double-packet buffering is supported. When '0', only single-packet buffering is supported.

RXSZ Maximum packet size to be allowed for (*before* any splitting within the FIFO of Bulk/High-Bandwidth packets prior to transmission). If TxDPB = 0, the FIFO will also be this size; if TxDPB = 1, the FIFO will be twice this size

TxSZ[3:0]				Packet Size (Bytes)
0	0	0	0	8
0	0	0	1	16
0	0	1	0	32
0	0	1	1	64
0	1	0	0	128
0	1	0	1	256
0	1	1	0	512
0	1	1	1	1024
1	0	0	0	2048 (Single-packet buffering only)
1	0	0	1	4096 (Single-packet buffering only)
1	1	1	1	3072 (Single-packet buffering only)

USB+0064h Tx FIFO Address Register TXFIFOADD

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				TXFIFOADD												
Type				R/W												
Reset				0												

TxFIFOadd TxFIFOadd is a 13-bit register which controls the start address of the selected Rx endpoint FIFO.

TxFIFOadd[12:0]				Start Address
0	0	0	0	0000
0	0	0	1	0008
0	0	0	2	0010
0	0	0	3	0018
		...		...
1	F	F	F	FFF8

USB+0066h Rx FIFO Address Register RXFIFOADD

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DATAERRINTREN	OVERRUNINTREN		RXFIFOADD												
Type	R/W	R/W		R/W												
Reset	0	0		0												

RxFIFOadd RxFIFOadd is a 13-bit register which controls the start address of the selected Rx endpoint FIFO.

RxFIFOadd[12:0]				Start Address
0	0	0	0	0000
0	0	0	1	0008
0	0	0	2	0010
0	0	0	3	0018
		...		...
1	F	F	F	FFF8

OVERRUNINTREN OverRun interrupt enable. The OverRun status bit is in RxCSR[2] and it should be write 0 to clear.

DATAERRINTREN DataErr interrupt enable. The DataErr status bit is in RxCSR[3] and it should be write 0 to clear.

USB+006Ch Register HWVERS

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RC	XX					YY									
Type	R	R					R									
Reset	0	0					0									

RC Set to '1' if RTL used from a Release Candidate rather than from a full release of the core.

XX Major Version Number (Range 0 – 31).

YYY Minor Version Number (Range 0 – 999).

HWVers register is a 16-bit read-only register that returns information about the version of the RTL from which the core hardware was generated, in particular the RTL version number (v*xx.yyy*).

USB+0070h Software Reset Register SWRST

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			OPSTATE									REDUCEDLY	UNDO_SRPFIX	FRC_VBUSVALID	SWRST	DISUSBRESET
Type			RO									R/W	R/W	R/W	R/W	R/W
Reset			0									0	0	0	0	0

DisUSBReset The CPU sets this bit to Disable USBReset function. And, then the CPU can reset the hardware by SwRst. USBReset will be asserted when doing High Speed Detection Handshake. (This bit will only be reset when hardware reset.)

SWRst The CPU sets this bit to reset the endpoint and RAM interface hardware.

FRC_VbusValid The CPU sets this bit to force VBusVal = 1, VBusSess = 1 and VBusLo = 0.

Undo_SRPFix The CPU sets this bit to recover to the original circuit of USB2.0 IP about SRP.

ReduceDly The CPU can set this bit to reduce inter-pkt delay.

OpState This register indicates the USB controller state information.

USB+0078h Info. about number of Tx and Rx Register EPINFO

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									RXENDPOINTS				TXENDPOINTS			
Type									R				R			
Reset									0				0			

TxEndPoints The number of Tx endpoints implemented in the design.

RxEndPoints The number of Rx endpoints implemented in the design.

This 8-bit read-only register allows read-back of the number of Tx and Rx endpoints included in the design.

USB+0079h Info. about the width of RAM and the number of DMA channel Register RAMINFO

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									DMACHANS				RAMBITS			
Type									R				R			
Reset									0				0			

RamBits The width of the RAM address bus – 1.

DMA Channels The number of DMA channels implemented in the design.

This 8-bit read-only register provides information about the width of the RAM and the number of DMA channels.

USB+007Ah Info. about delay to be applied Register LINKINFO

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									WTCON				WTID			
Type									R/W				R/W			
Reset									8'h5C							

Wait ID Filter

Sets the delay to be applied from IDPULLUP being asserted to IDDIG being considered valid in units of 4.369ms. (The default setting corresponds to 52.43ms.)

Wait Connect Filter

Sets the wait to be applied to allow for the user's connect/disconnect filter in units of 533.3ns. (The default setting corresponds to 2.667µs.)

This 8-bit register allows some delays to be specified.

USB+007Bh VBus Pulsing Charge Register VPLEN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									VPLEN							
Type									R/W							
Reset									8'h3C							

VPLen Sets the duration of the VBus pulsing charge in units of 136.5 us. (The default setting corresponds to 8.19ms)

This 8-bit register sets the duration of the VBus pulsing charge.

USB+007Ch Time buffer available on HS transactions Register HS_EOF1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									HS_EOF1							
Type									R/W							
Reset									8'h80							

High-Speed End-Of-Frame 1 Sets for High-speed transactions the time before EOF to stop beginning new transactions, in units of 133.3ns. (The default setting corresponds to 17.07µs.)

USB+007Dh Time buffer available on FS transactions Register FS_EOF1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									FS_EOF1							
Type									R/W							
Reset									8'h77							

Full-Speed End-Of-Frame 1 Sets for Full-speed transactions the time before EOF to stop beginning new transactions, in units of 533.3ns. (The default setting corresponds to 63.46µs.)

USB+007Eh Time buffer available on LS transactions Register LS_EOF1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									LS_EOF1							
Type									R/W							
Reset									8'h72							

Low-Speed End-Of-Frame 1 Sets for Low-speed transactions the time before EOF to stop beginning new transactions, in units of 1.067µs. (The default setting corresponds to 121.6µs.).

USB+007Fh RESET Information Register RSTINFO

Bit									7	6	5	4	3	2	1	0
Name									WTFSSE0				WTCHRP			
Type									R/W				R/W			
Reset									0				0			

WTChrp Sets the delay to be applied from detecting Reset to sending chirp K (for Device only). The duration = 272.8 x WTChrp + 0.1 usec. (This register will only be reset when hardware reset.)

WTFSSE0 The field signifies the SE0 signal duration before issue the reset signal(for Device only). The duration = 272.8 x WTFSSE0 + 2.5 usec. (This register will only be reset when hardware reset.)

USB RQPKTCOUNT REGISTER

USB+0300h EP1 RxPktCount Register EP1RXPKTCOUNT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EP1RXPKTCOUNT															
Type	R/W															
Reset	0															

EP1RqPktCount (Host Mode Only) Sets the number of packets of Rx Endpoint 1 size MaxP that are to be transferred in a block transfer. *Only used in Host mode when AutoReq is set. Has no effect in Peripheral mode or when AutoReq is not set.*

USB+0302h EP2 RxPktCount Register EP2RXPKTCOUNT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EP1RXPKTCOUNT															
Type	R/W															
Reset	0															

EP2RqPktCount (Host Mode Only) Sets the number of packets of Rx Endpoint 1 size MaxP that are to be transferred in a block transfer. *Only used in Host mode when AutoReq is set. Has no effect in Peripheral mode or when AutoReq is not set.*

USB+0304h EP3 RxPktCount Register EP3RXPKTCOUNT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EP1RXPKTCOUNT															
Type	R/W															
Reset	0															

EP3RqPktCount (Host Mode Only) Sets the number of packets of Rx Endpoint 1 size MaxP that are to be transferred in a block transfer. *Only used in Host mode when AutoReq is set. Has no effect in Peripheral mode or when AutoReq is not set.*

RqPktCount (Host Mode Only) For each Rx Endpoint 1 – 3, the USB2.0 controller provides a 16-bit RqPktCount register. This read/write register is used in Host mode to specify the number of packets that are to be transferred in a block transfer of one or more Bulk packets of length MaxP to Rx Endpoint *n*. The core uses the value recorded in this register to determine the number of requests to issue where the AutoReq option (included in the RxCSR register) has been set.

Note: Multiple packets combined into a single bulk packet within the FIFO count as one packet.

USB DMA CONTROL REGISTER

USB+0200h DMA Interrupt Status Register DMA_INTR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name									PPB_FINISH4	PPA_FINISH4	PPB_FINISH3	PPA_FINISH3	PPB_FINISH2	PPA_FINISH2	PPB_FINISH1	PPA_FINISH1
Type									R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset									0	0	0	0	0	0	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													DMA_INTR			
Type													R/W			
Reset													0			

DMA_INTR Indicates pending DMA interrupts, one bit per DMA channel implemented. Bit 0 is used for DMA channel 1, Bit 1 is used for DMA channel 2 etc. Write 0 clear.

PPA_Finish1 Indicates dma channel 1 PingPongA finish status. Write 0 clear.

PPB_Finish1 Indicates dma channel 1 PingPongB finish status. Write 0 clear.

PPA_Finish2 Indicates dma channel 2 PingPongA finish status. Write 0 clear.

PPB_Finish2 Indicates dma channel 2 PingPongB finish status. Write 0 clear.

PPA_Finish3 Indicates dma channel 3 PingPongA finish status. Write 0 clear.

PPB_Finish3 Indicates dma channel 3 PingPongB finish status. Write 0 clear.

PPA_Finish4 Indicates dma channel 4 PingPongA finish status. Write 0 clear.

PPB_Finish4 Indicates dma channel 4 PingPongB finish status. Write 0 clear.

USB+0204h DMA Channel 1 Control Register DMA_CNTL1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			ENDMAMODE2	PP_RST	PP_EN	BURST_MODE		BUS_ERR	ENDPNT				INT_EN	DMA_MODE	DMA_DIR	DMA_EN
Type			R/W	R/W	R/W	R/W		R/W	R/W				R/W	R/W	R/W	R/W
Reset			0	0	0	0		0	0				0	0	0	0

DMA_EN Enable DMA. The bit will be cleared when the DMA transfer is completed.

DMA_DIR Direction. 0 : DMA Write(Rx endpoint), 1 : DMA Read(Tx endpoint).

DMA_MODE DMA Mode.

INT_EN Interrupt Enable.

EndPnt[3 :0] Endpoint number.

BUS_ERR Bus Error.

BURST_MODE Burst Mode.

00 : Burst Mode 0 : Bursts of unspecified length.

01: Burst Mode 1 : INCR4 or unspecified length.

10: Burst Mode 2 : INCR8, INCR4 or unspecified length.

11: Burst Mode 3 : INCR16, INCR8, INCR4 or unspecified length.

PP_EN PingPong Buffer Enable.

PP_RST The CPU writes 1 to this bit to reset PingPong Buffer Sequence. The bit stands for current PingPong Buffer Sequence when read.

EnDMAMode2 Enable DMA mode 2 function. DMA mode 2: The short packets will be moved even the short packets are not the last transfer of this DMA Count.

DMA_CNTL2, **DMA_CNTL3**, **DMA_CNTL4**, **DMA_CNTL5** and **DMA_CNTL6** have the same modification.

USB+0208h DMA Channel 1 ADDRESS Register DMA_ADDR1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DMA_ADDR1[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DMA_ADDR1[15:0]															
Type	R/W															
Reset	0															

DMA_ADDR1 32bits DMA start address, updated (increase) by USB2.0 controller automatically while multiple packet DMA (DMA Mode = 1) is used

DMA_ADDR2, **DMA_ADDR3**, **DMA_ADDR4**, **DMA_ADDR5** and **DMA_ADDR6** have the same modification.

USB+020Ch DMA Channel 1 BYTE COUNT Register DMA_COUNT1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DMA_COUNT1[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DMA_COUNT1[15:0]															
Type	R/W															
Reset	0															

DMA_COUNT1 32bits DMA transfer count with byte unit, updated (decrease) by USB2.0 controller automatically while each packet is transferred.

DMA_ COUNT 2, **DMA_ COUNT3**, **DMA_ COUNT4**, **DMA_ COUNT5** and **DMA_ COUNT6** have the same modification.

USB+0210h DMA Channel 1 Limiter Register DMA_LIMITER1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DMA_LIMITER															
Type	R/W															
Reset	0								0	0	0	0	0	0	0	0

DMA_LIMITER This register is to suppress the Bus utilization of the DMA channel. The value is from 0 to 255. 0 means no limitation, and 255 means totally banned. The value between 0 and 255 means certain DMA can have permission to use AHB every (4 X n) AHB clock cycles.

Note that it is not recommended to limit the Bus utilization of the DMA channels because this increases the latency of response to the masters, and the transfer rate decreases as well. Before using it, programmer must make sure that the bus masters have some protective mechanism to avoid entering the wrong states.

USB+0214h ~ USB+0220h stands for DMA Channel 2 Registers and their behaviors are the same as DMA channel 1.

USB+0224h ~ USB+0230h stands for DMA Channel 3 Registers and their behaviors are the same as DMA channel 1.

USB+0234h ~ USB+0240h stands for DMA Channel 4 Registers and their behaviors are the same as DMA channel 1.

USB+0244h ~ USB+0250h stands for DMA Channel 5 Registers and their behaviors are the same as DMA channel 1.

USB+0254h ~ USB+0260h stands for DMA Channel 6 Registers and their behaviors are the same as DMA channel 1.

USB+0284h DMA Channel 1 PingPong Control Register DMA_PP_CNTL1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																DMA_EN
Type																R/W
Reset																0

DMA_EN Enable DMA(PingPong Buffer DMA). The bit will be cleared when the DMA transfer is completed.

USB+0288h DMA Channel 1 PingPong Address Register — DMA_PP_ADDR1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DMA_PP_ADDR1[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DMA_PP_ADDR1[15:0]															
Type	R/W															
Reset	0															

DMA_PP_ADDR1[31:0] DMA(PingPong Buffer DMA) Channel 1 AHB Memory Address.

USB+028Ch DMA Channel 1 PingPong Count Register — DMA_PP_CNT1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DMA_PP_CNT1[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DMA_PP_CNT1[15:0]															
Type	R/W															
Reset	0															

DMA_PP_CNT1[31:0] DMA(PingPong Buffer DMA) Channel 1 Byte Count.

USB+0294h ~ USB+029Ch stands for DMA Channel 2 PingPong Registers and their behaviors are the same as DMA channel 1.

USB+02A4h ~ USB+02ACh stands for DMA Channel 3 PingPong Registers and their behaviors are the same as DMA channel 1.

USB+02B4h ~ USB+02BCh stands for DMA Channel 4 PingPong Registers and their behaviors are the same as DMA channel 1.

USB+02C4h ~ USB+02CCh stands for DMA Channel 5 PingPong Registers and their behaviors are the same as DMA channel 1.

USB+02D4h ~ USB+02DCh stands for DMA Channel 6 PingPong Registers and their behaviors are the same as DMA channel 1.

USB+0400h DMA Channel 1 Real Count Register — DMA_REALCNT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DMA_REALCNT[31:16]															
Type	R															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DMA_REACNT[15:0]															
Type	R															
Reset	0															

DMA_REALCNT[31:0] Indicate current transferred bytes of DMA channel 1.

USB+0404h DMA Channel 1 PingPong Real Count Register — DMA_PP_REALCNT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DMA_PP_REALCNT[31:16]															
Type	R															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DMA_PP_REALCNT[15:0]															

Type	R
Reset	0

DMA_PP_REALCNT[31:0] Indicate current transferred bytes of DMA channel 1 PingPong.

USB+0408h DMA Channel 1 Timer Register DMA_TIMER

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name								TIMEOUT_STATUS	ENTIMER	REG_TIMEOUT						
Type								R/W	R/W	R/W						
Reset								0	0	0						

EnTimer Enable timer. When the timer is enabled and there is no this DMA transaction during the reg_timeout duration, then DMA interrupt will be issued. The timer will be reset whenever EnTimer = 0 or (DMA_EN = 0 and DAM_EN_PP = 0).

REG_TIMEOUT To config timeout duration. Timeout duration = 1280 * reg_timeout + 2.5 us.

Timeout_Status Indicates the DMA channel has timeout situation. Write 0 clear.

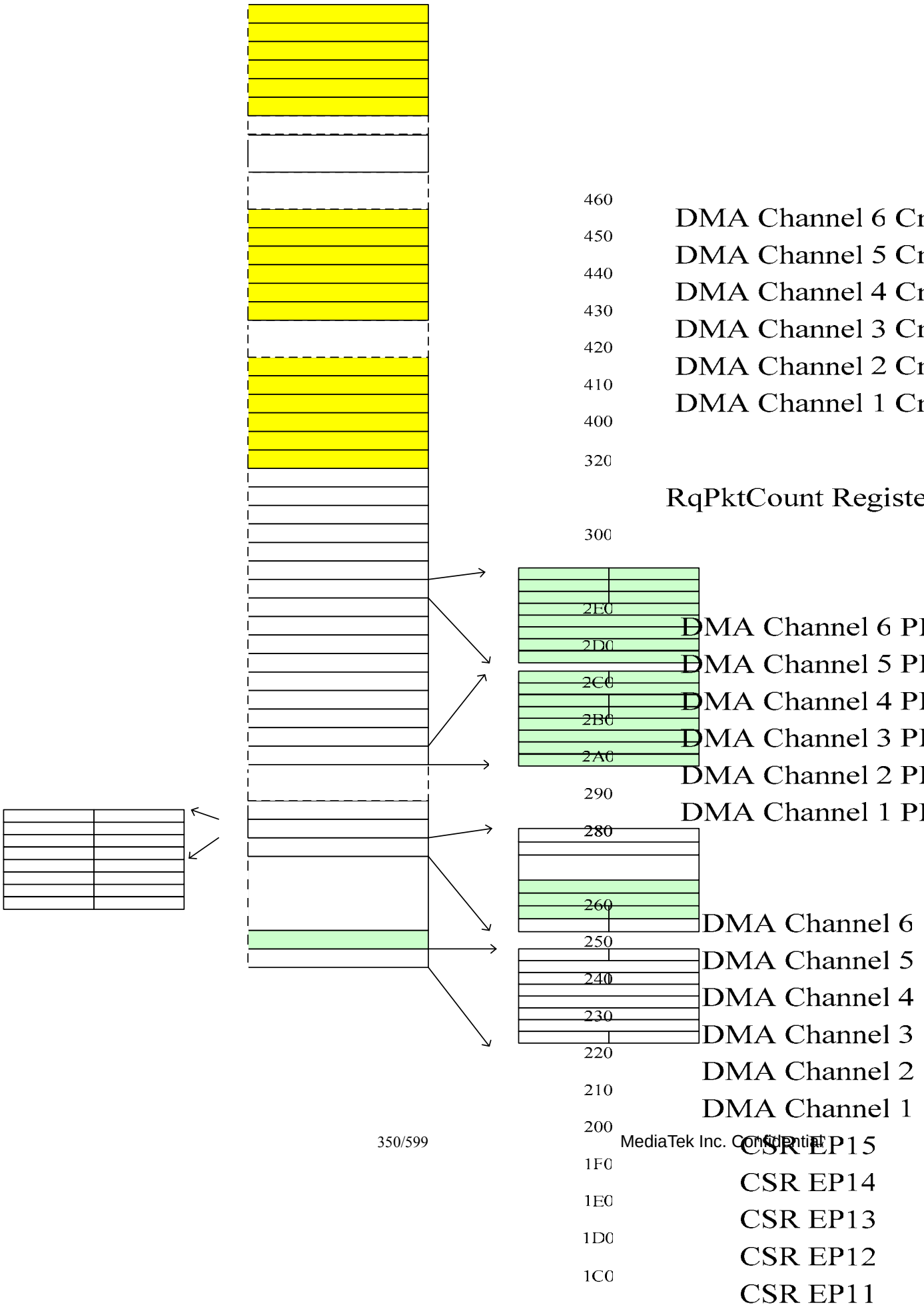
USB+0410h ~ USB+0418h stands for DMA Channel 2 Registers and their behaviors are the same as DMA channel 1.

USB+0420h ~ USB+0428h stands for DMA Channel 3 Registers and their behaviors are the same as DMA channel 1.

USB+0430h ~ USB+0438h stands for DMA Channel 4 Registers and their behaviors are the same as DMA channel 1.

USB+0440h ~ USB+0448h stands for DMA Channel 5 Registers and their behaviors are the same as DMA channel 1.

USB+0450h ~ USB+0458h stands for DMA Channel 6 Registers and their behaviors are the same as DMA channel 1.



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USB PHY CONTROL REGISTER

USB+0600h PHY Control Register 1 PHYCR1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	HS_TX_I_EN_MODE	HS_TX_SP_SEL	HS_SQ_INIT_EN_DG[1:0]		HS_SQ_EN_DG	HS_SQ_EN_MODE	HS_SQS	HS_RCV_EN_MODE	HS_RCVB[3:0]				PLL_VCOG[1:0]		PLL_VCOB[1:0]	
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	1	0	0	1	1	1	0	0	0	1	0	0	0	0	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	PLL_CCP[3:0]						PLL_CLF	EN_LS_CMPSAT	PLL_EN		NEG_TRI_EN_B	USB20_TX_TST	BIDI_MODE	CDR_TST[1:0]		GATE_EN_B
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0

GATED_EN_B High level clock gating enable 0: enable 1: disable

CDR_TST CDR function option ，CDR_TST[1]: phase accumulation option，0: accumulation disable，1: accumulation enable CDR_TST[0]: reference phase number option，0: 4 phases，1: 6 phases

BIDI_MODE UTMI data bus bi-directional mode 0: disable，1: enable

USB20_TX_TST TX macro test option, debug usage，0: disable，1: enable

NEG_TRI_EN_B UTMI output signal aligned to negative edge for hold time issue，0: negative edge triggered output，1: positive edge triggered output

PLL_EN USB2.0 PHY PLL enable，0: disable，1: enable

EN_LS_CMPSAT LS Tx mode DM RPU compensation enable when in client mode，0: disable，1: enable

PLL_CLF PLL loop filter control，0: disable，1: enable

PLL_CPP PLL CP bias current selection，charge pump current = 3.125uA * n，0001 : 3.125uA * 1，0010 : 3.125uA * 2…1111 : 3.125uA * 15

PLL_VCOB PLL VCO bias current selection，00: 0uA，01: 25uA * 1.5，10: 25uA * 2.5，11: 25uA * 3.5

PLL_VCOG PLL VCO gain selection ，x0 : enhance Kvco gain，x1: normal Kvco gain

HS_RCVB HS RCV bias selection, HS RCV 1st stage bias current，xxx0: 600u，xxx1: 675u

HS_RCV_EN_MODE HS RCV enable mode selection，0: HS RCV enable by HS RCV，1: HS RCV always enabled while USB operating in HS mode

HS_SQS HS SQ hystress mode Reserved

HS_SQ_EN_MODE HS SQ enable mode selection，0: SQ enable by HS RCV，1: SQ always enabled while USB operating

HS_SQ_EN_DG HS SQ de-glitch time after HS RCV enabled，0:SQ output de-glitch 4T 480M CLK，1:SQ output de-glitch 5T 480M CLK

HS_SQ_INIT_EN_DG HS SQ first time initializing de-glitch:gated by

00: 1T ref CLK

01: 1.5T ref CLK

10: 2T ref CLK

11: 2.5T ref CLK

HS_TX_SP_SEL HS TX LOAD sampling point selection，0: sampling the HS TX data at rising edge，1: sampling the HS TX data at falling edge

HS_TX_I_EN_MODE HS TX I enable mode selection，0: HS TX current always enabled while HS TERM enabled，1: HS_TX current enabled when HS TX module enabled

USB+0604h PHY Control Register 2 PHYCR2

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	FORCE_DRV_VBUS	FORCE_DM_PULLDOWN	FORCE_DP_PULLDOWN	HS_TERMC[4:0]						FORCE_DATA_IN	FORCE_TXVALID	HS_TERM_SEL	HS_DISCN[1:0]		HS_DISCP[1:0]	
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name		HS_SQTL[2:0]				HS_SQTH[2:0]			HS_SQD[3:0]				HS_SQB[3:0]			
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	1	1	0	1	0	0	0	0	1	0	0	1	0	0

HS_SQB HS SQ bias selection，HS_SQB[0]: HS SQ 1st stage bias current，xxx0: 600uA，xxx1: 675uA

HS_SQD HS SQ de-glitch control

xx00: 16u (min current, max de-glitch)

xx01: 32u

xx10: 61u

xx11: 122u (max current, min de-glitch)

HS_SQTH HS SQ threshold high selection

000: 165mV

001: 155mV

010: 145mV

011: 135mV

100: 125mV

101: 115mV

110: 105mV

111: 95mV

HS_SQTL HS SQ threshold low selection，Reserved

HS_DISCP HS_DISCP[0] : see HS_DISCN[1:0] ，HS_DISCP[1]: disconnect 1st stage bias current，

0: 420uA 1: 490uA

HS_DISCN HS DISC reference level HS_DISCP[0],HS_DISCN[1:0]

000: 615mV

001: 605mV

010: 595mV

011: 585mV

100: 575mV

101: 565mV

110: 555mV

111: 545mV

HS_TERM_SEL HS TERM module selection (see HS_TERMC)，0: analog termination，1: digital termination

FORCE_TAVALID FORCE PHY TXVALID SIGNAL ENABLE WHEN PHY_TESTMODE = 1，1: enable 0: disable

FORCE_TAVALIDH FORCE PHY TXVALIDH SIGNAL ENABLE WHEN PHY_TESTMODE = 1，1: enable 0: disable

HS_TERMC HS TERM impedence control code (see HS_TERM_SEL)，In analog termination mode

HS_TERM_SEL: 0

internal reference voltage:

x0000: 480mV

x0001: 470mV

x0010: 460mV

x0011: 450mV

x0100: 440mV

x0101: 430mV

x0110: 420mV

x0111: 410mV

x1000: 400mV

x1001: 390mV

x1010: 380mV

x1011: 370mV

the final output swing is about (the termnation voltage + 400mv)/2.

In digital termination mode HS_TERM_SEL: 1

00000: for max swing

...

11111: for min swing

FORCE_DP_PULLDOWN FORCE PHY DP_PULLDOWN SIGNAL ENABLE WHEN PHY_TESTMODE = 1，1: enable 0: disable

FORCE_DM_PULLDOWN FORCE PHY DM_PULLDOWN SIGNAL ENABLE WHEN PHY_TESTMODE = 1，1: enable 0: disable

FORCE_DRV_VBUS FORCE PHY DRV_VBUS SIGNAL ENABLE WHEN PHY_TESTMODE = 1，1: enable 0: disable

USB+0608h PHY Control Register 3 PHYCR3

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name		AIO1_SEL[2:0]			GHX_SEL[3:0]				CLKMODE	XTAL_BIAS[2:0]			TEST_CTRL[3:0]			
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			PLL_DR[5:0]						FEN_HS_TX_I	FEN_FS_LS_RCV	FEN_FS_LS_TX	IREF_MODE_SEL	FEN_HS_RCV	IADJ[2:0]		
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0

IADJ HS TX bias current selection

000: 840mV/(Rext + 300)

001: 830mV/(Rext + 300)

010: 820mV/(Rext + 300)

011: 810mV/(Rext + 300)

100: 800mV/(Rext + 300)

101: 790mV/(Rext + 300)

110: 780mV/(Rext + 300)

111: 770mV/(Rext + 300)

Rext = 5.1k (typ.)

FEN_HS_RCV Forced HS RCV and Squelch enable for test purpose，0: disable，1: enable

IREF_MODE_SEL HS SQ reference current mode selection ，0: HS SQ current always enabled while USB operating ，1: HS SQ current enabled while HS RX module enabled

FEN_FS_LS_TX Forced FS/LS output enable for test purpose，0: disable，1: enable

FEN_FS_LS_RCV Forced FS/LS RCV enable for test purpose，0: disable，1: enable

FEN_HS_TX_I Forced HS TX current source enable for test purpose，0: disable，1: enable

PLL_DR PLL div ratio 480/reference CLK=PLL_DR ex: 30MHz xtal case, PLL_DR = 480/30 = 16 = 0x10

TEST_CTRL Test mode control TEST_CTRL[3]:0: normal UTMI operation

1: 240MHz clock ouput, with while TEST_CTRL[0]=1 and FEN_HS_TX_I=11

TEST_CTRL[2:1]:

0x: termination resistor connected to PAD_VRT

10: termination resistor connected to PAD_VRT1

11: termination resistor connected to inaccurate internal 5.1k

TEST_CTRL[0]:

0: normal UTMI operation

1: TX controlled by FEN_HS_TX_I/FEN_FS_LS_TX

XTAL_BIAS XTAL bias selection Reserved

CLKMODE External/Internal input CLK source selection

x00: internal clk source USB_INTA1_CK

x01: internal clk source USB_INTA2_CK

x10: internal clk source USB_INTD_CK

GHX_SEL GHX Digital output selection

xx00: none

xx01: HS DISC output for USB 2.0 RX DC test (see DOUT1_SEL)

xx10: HS SQ output for USB 2.0 RX DC test (see DOUT1_SEL)

xx11: HS RX output for USB 2.0 RX DC test (see DOUT1_SEL)

AIO1_SEL Analog IO1 selection for test (IO via XTALI pin)

0xxx: diable AIO1

100: external bgr input

101: monitor internal bgr voltage

110: monitor internal pll loop filter voltage

111: monitor internal hs termination control voltage

AIO ouput only valid for XTALI_GPIO_EN=1 & XTALI_GPIO_OE=0

USB+060Ch PHY Control Register 4 PHYCR4

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name							XTALO_GPIO_O	XTALI_GPIO_I	XTALO_GPIO_OE	XTALO_GPIO_E8	XTALO_GPIO_EN	XTALIO_GPIO_I	XTALI_GPIO_OE	XTALI_GPIO_E8	XTALI_GPIO_EN	XTALI_GPIO_I
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BGR_DIV[1:0]			BGR_SELPH	BGR_CHIP_EN	BGR_ISRC_EN	BGR_CLK_EN	BGR_BGR_EN		DOUT2_SEL[2:0]				DOUT1_SEL[2:0]		
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	1	0	0	1	0	0	0	0	1	0	0	0	1	0	0

DOUT1_SEL Digital output 1 selection for test (output via VRT pin)

000: normal function

001: bgr ph1

010: bgr ph1s_

011: bgr pheq_

100: USB 2.0 RX DC test (see GHX_SEL)

101: USB 1.1 RXM

110: USB 1.1 RXP

111: USB 1.1 RXD

DOUT1 ouput only valid for XTALI_GPIO_EN=1 & XTALI_GPIO_OE=1

DOUT2_SEL Digital output 2 selection for test (output via VRT pin)

000: normal function

x01: bgr ph2

x10: bgr ph2s_

x11: bgr pho_

DOUT2 ouput only valid for XTALO_GPIO_EN=1 & XTALO_GPIO_OE=1

BGR_BGR_EN Force BGR enable 0: disable 1: enableBGRCLKEN

BGR_CLK_EN Force BGR chop clock enable 0: disable 1: enable

BGR_ISRC_EN Force BGR current source generator enable 0: disable 1: enable

BGR_CHP_EN BGR chop enable 0: disable 1: enable

BGR_DIV BGR chop clk rate

00: 836k

11: 836k/2

10: 836k/4

11: 836k/8

XTALI_GPIO_I XTALI pin GPIO output data Reserved

XTALI_GPIO_EN XTALI output pin GPIO enable Reserved

XTALI_GPIO_E8 XTALI output pin GPIO output capability control Reserved

XTALI_GPIO_OE XTALI output pin GPIO direction selection Reserved

XTALO_GPIO_I XTALO pin GPIO output data Reserved

XTALO_GPIO_EN XTALO output pin GPIO enable Reserved

XTALO_GPIO_E8 XTALO output pin GPIO output capability control Reserved

XTALO_GPIO_OE XTALO output pin GPIO direction selection reserved

XTALI_GPIO_I XTALI pin GPIO output data Reserved

XTALO_GPIO_I XTALO pin GPIO output data Reserved

USB+0610h PHY Control Register 5 PHYCR5

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DM_PULL_DOWN	DP_PULL_DOWN	XCVR_SELECT[1:0]		SUSPENDM	TERM_SELECT	OP_MODEL[1:0]		FORCE_IDPULLUP	UTMI_MUXSEL	USB_MODE[1:0]		FORCE_XCVR_SELECT	FORCE_SUSPENDM	FORCE_TERM_SELECT	FORCE_OPMODE
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name	PROBE_SEL[7:0]								VBUS CMP_ EN	CLK_DIV_CNT[2:0]			CDR_FILT[3:0]			
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0

CDR_FILT CDR low pass filter selection, debug usage

CLK_DIVC_CNT The divide ratio of div_ck

PROBE_SEL Debug signal selection

FORCE_OPMODE FORCE PHY OPMODE SIGNAL ENABLE WHEN PHY_TESTMODE = 1，1: enable 0: disable

FORCE_TERM_SELECT FORCE PHY TERM_SELECT SIGNAL ENABLE WHEN PHY_TESTMODE = 1，1: enable 0: disable

FORCE_SUSPENDM FORCE PHY SUSPENDM SIGNAL ENABLE WHEN PHY_TESTMODE = 1，1: enable 0: disable

FORCE_XCVR_SELECT FORCE PHY XCVR_SELECT SIGNAL ENABLE WHEN PHY_TESTMODE = 1，1: enable 0: disable

USB_MODE Test mode selection (for testing)

00: normal operation

01: loop-back mode1 enable, the pseudo random number will be generated inside USB2.0 PHY macro and transmit onto USB bus. The data will be received by receiver and then be compared. The compared result is muxed on line_state[1] and should be always be 1.

10: loop-back mode2 enable, the packet is longer.

UTMI_MUXSEL FORCE PHY UTMI SIGNAL ENABLE WHEN PHY_TESTMODE = 1，1: enable 0: disable

FORCE_IDPULLUP FORCE PHY IDPULLUP SIGNAL ENABLE WHEN PHY_TESTMODE = 1，1: enable 0: disable

OPMODE It controls the USB2.0 controller to PHY output signal: OPMODE[1:0] when PHY_TESTMODE = 1

TERMSEL It controls the USB2.0 controller to PHY output signal: TERMSEL when PHY_TESTMODE = 1

SUSPENDM It controls the USB2.0 controller to PHY output signal: SUSPENDM when PHY_TESTMODE = 1

XCVRSEL It controls the USB2.0 controller to PHY output signal: XCVRSEL[1:0] when PHY_TESTMODE = 1

DPPULLDOWN It controls the USB2.0 controller to PHY output signal: DPPULLDOWN when PHY_TESTMODE = 1

DMPULLDOWN It controls the USB2.0 controller to PHY output signal: DMPULLDOWN when PHY_TESTMODE = 1

USB+0614h PHY UTMI Interface Register 1 PHYIR1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	LINESTATE[1:0]		HOST DISC ON	TXRE ADY	RXER ROR	RXAC TIVE	RXVA LIDH	RXVA LID	XDATA_OUT[15:8]							

Type	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	XDATA_OUT[7:0]								XDATA_IN[7:4]				TX_VALIDH	TX_VALID	DRVVBUS	IDPULLUP
Type	R	R	R	R	R	R	R	R	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

IDPULLUP It controls the USB2.0 controller to PHY output signal: IDPULLUP when PHY_TESTMODE = 1

DRVVBUS It controls the USB2.0 controller to PHY output signal: DRVVBUS when PHY_TESTMODE = 1

TX_VALID It controls the USB2.0 controller to PHY output signal: TX_VALID when PHY_TESTMODE = 1

TX_VALIDH It controls the USB2.0 controller to PHY output signal: TX_VALIDH when PHY_TESTMODE = 1

XDATA_IN It controls the USB2.0 controller to PHY input signal: XDATA_IN[15:0] when PHY_TESTMODE = 1

XDATA_OUT It controls the USB2.0 controller to PHY input signal: XDATA_OUT[15:0] when PHY_TESTMODE = 1

RXVALID It controls the USB2.0 controller to PHY input signal: RXVALID when PHY_TESTMODE = 1

RXVALIDH It controls the USB2.0 controller to PHY input signal: RXVALIDH when PHY_TESTMODE = 1

RXACTIVE It controls the USB2.0 controller to PHY input signal: RXACTIVE when PHY_TESTMODE = 1

RXERROR It controls the USB2.0 controller to PHY input signal: RXERROR when PHY_TESTMODE = 1

TXREADY It controls the USB2.0 controller to PHY input signal: TXREADY when PHY_TESTMODE = 1

HOSTDISCON It controls the USB2.0 controller to PHY input signal: HOSTDISCON when PHY_TESTMODE = 1

LINE_STATE It controls the USB2.0 controller to PHY input signal: LINE_STATE when PHY_TESTMODE = 1

USB+0618h PHY UTMI Interface Register 2 PHYIR2

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													IDDIG	VBUSVALID	SESSEND	AVALID
Type													R	R	R	R
Reset													0	0	0	0

AVALID It controls the USB2.0 controller to PHY input signal: AVALID when PHY_TESTMODE = 1

SESSEND It controls the USB2.0 controller to PHY input signal: SESSEND when PHY_TESTMODE = 1

VBUSVALID It controls the USB2.0 controller to PHY input signal: VBUSVALID when PHY_TESTMODE = 1

IDDIG It controls the USB2.0 controller to PHY input signal: IDDIG when PHY_TESTMODE = 1

7.5 Memory Stick and SD Memory Card Controller

7.5.1 Introduction

The controller fully supports the Memory Stick bus protocol as defined in Format Specification version 2.0 of Memory Stick Standard (Memory Stick PRO) and the SD Memory Card bus protocol as defined in SD Memory Card Specification

Part 1 Physical Layer Specification version 1.0 as well as the MultiMediaCard (MMC) bus protocol as defined in MMC system specification version 2.2. Since SD Memory Card bus protocol is backward compatible to MMC bus protocol, the controller is capable of working well as the host on MMC bus under control of proper firmware. Furthermore, the controller also support SDIO card specification version 1.0 partially. However, the controller can only be configured as either the host of Memory Stick or the host of SD/MMC Memory Card at one time. Hereafter, the controller is also abbreviated as MS/SD controller. The following are the main features of the controller.

- Interface with MCU by APB bus
- 16/32-bit access on APB bus
- 16/32-bit access for control registers
- 32-bit access for FIFO
- Shared pins for Memory Stick and SD/MMC Memory Card
- Built-in 32 bytes FIFO buffers for transmit and receive, FIFO is shared for transmit and receive
- Built-in CRC circuit
- CRC generation can be disabled
- DMA supported
- Interrupt capabilities
- Automatic command execution capability when an interrupt from Memory Stick
- Data rate up to 26 Mbps in serial mode, 26x4 Mbps in parallel model, the module is targeted at 26 MHz operating clock
- Serial clock rate on MS/SD/MMC bus is programmable
- Card detection capabilities
- Controllability of power for memory card
- Not support SPI mode for MS/SD/MMC Memory Card
- Not support multiple SD Memory Cards

7.5.2 Overview

7.5.2.1 Pin Assignment

Since the controller can only be configured as either the host of Memory Stick or the host of SD/MMC Memory Card at one time, pins for Memory Stick and SD/MMC Memory Card are shared in order to save pin counts. The following lists pins required for Memory Stick and SD/MMC Memory Card. **Table 33** shows how they are shared. In **Table 33**, all I/O pads have embedded both pull up and pull down resistor because they are shared by both the Memory Stick and SD/MMC Memory Card. Pins 2,4,5,8 are only useful for SD/MMC Memory Card. Pull down resistor for these pins can be used for power saving. All embedded pull-up and pull-down resistors can be disabled by programming the corresponding control registers if optimal pull-up or pull-down resistors are required on the system board. The pin VDDPD is used for power saving. Power for Memory Stick or SD/MMC Memory Card can be shut down by programming the corresponding control

register. The pin WP (Write Protection) is only valid when the controller is configured for SD/MMC Memory Card. It is used to detect the status of Write Protection Switch on SD/MMC Memory Card.

No.	Name	Type	MMC	SD	MS	MSPRO	Description
1	SD_CLK	O	CLK	CLK	SCLK	SCLK	Clock
2	SD_DAT3	I/O/PP		CD/DAT3		DAT3	Data Line [Bit 3]
3	SD_DAT0	I/O/PP	DAT0	DAT0	SDIO	DAT0	Data Line [Bit 0]
4	SD_DAT1	I/O/PP		DAT1		DAT1	Data Line [Bit 1]
5	SD_DAT2	I/O/PP		DAT2		DAT2	Data Line [Bit 2]
6	SD_CMD	I/O/PP	CMD	CMD	BS	BS	Command Or Bus State
7	SD_PWRON	O					VDD ON/OFF
8	SD_WP	I					Write Protection Switch in SD
9	SD_INS	I	VSS2	VSS2	INS	INS	Card Detection

Table 33 Sharing of pins for Memory Stick and SD/MMC Memory Card Controller

7.5.2.2 Card Detection

For Memory Stick, the host or connector should provide a pull up resistor on the signal INS. Therefore, the signal INS will be logic high if no Memory Stick is on line. The scenario of card detection for Memory Stick is shown in **Figure 43**. Before Memory Stick is inserted or powered on, on host side SW1 shall be closed and SW2 shall be opened for card detection. It is the default setting when the controller is powered on. Upon insertion of Memory Stick, the signal INS will have a transition from high to low. Hereafter, if Memory Stick is removed then the signal INS will return to logic high. If card insertion is intended to not be supported, SW1 shall be opened and SW2 closed always.

For SD/MMC Memory Card, detection of card insertion/removal by hardware is also supported. Because a pull down resistor with about 470 KΩ resistance which is impractical to embed in an I/O pad is needed on the signal CD/DAT3, and it has to be capable of being connected or disconnected dynamically onto the signal CD during initialization period, an additional I/O pad is needed to switch on/off the pull down resistor on the system board. The scenario of card detection for SD/MMC Memory Card is shown in **Figure 44**. Before SD/MMC Memory Card is inserted or powered on, SW1 and SW2 shall be opened for card detection on the host side. Meanwhile, pull down resistor R_{CD} on system board shall attach onto the signal CD/DAT3 by the output signal RCDEN. In addition, SW3 on the card is default to be closed. Upon insertion of SD/MMC Memory Card, the signal CD/DAT3 will have a transition from low to high. If SD/MMC Memory Card is removed then the signal CD/DAT3 will return to logic low. After the card identification process, pull down resistor R_{CD} on system board shall disconnect with the signal CD/DAT3 and SW3 on the card shall be opened for normal operation.

Since the scheme above needs a mechanical switch such as a relay on system board, it is not ideal enough. Thus, a dedicated pin “INS” is used to perform card insertion and removal for SD/MMC. The pin “INS” will connect to the pin “VSS2” of a SD/MMC connector. Then the scheme of card detection is the same as that for MS. It is shown in **Figure 43**.

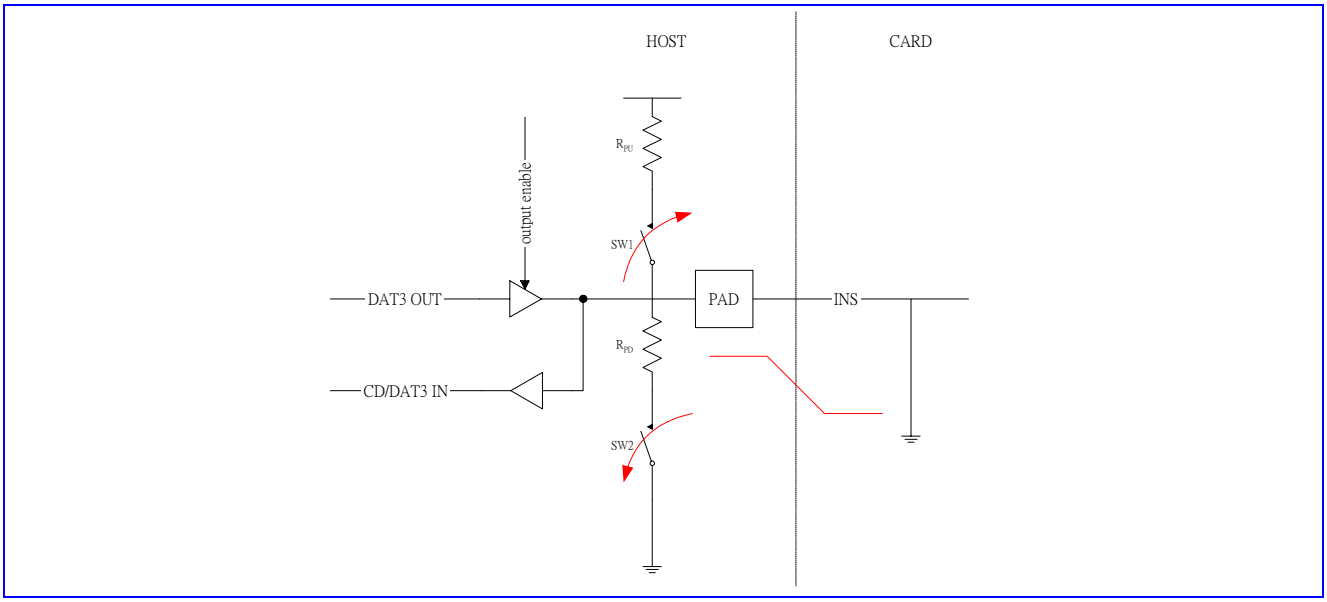


Figure 43 Card detection for Memory Stick

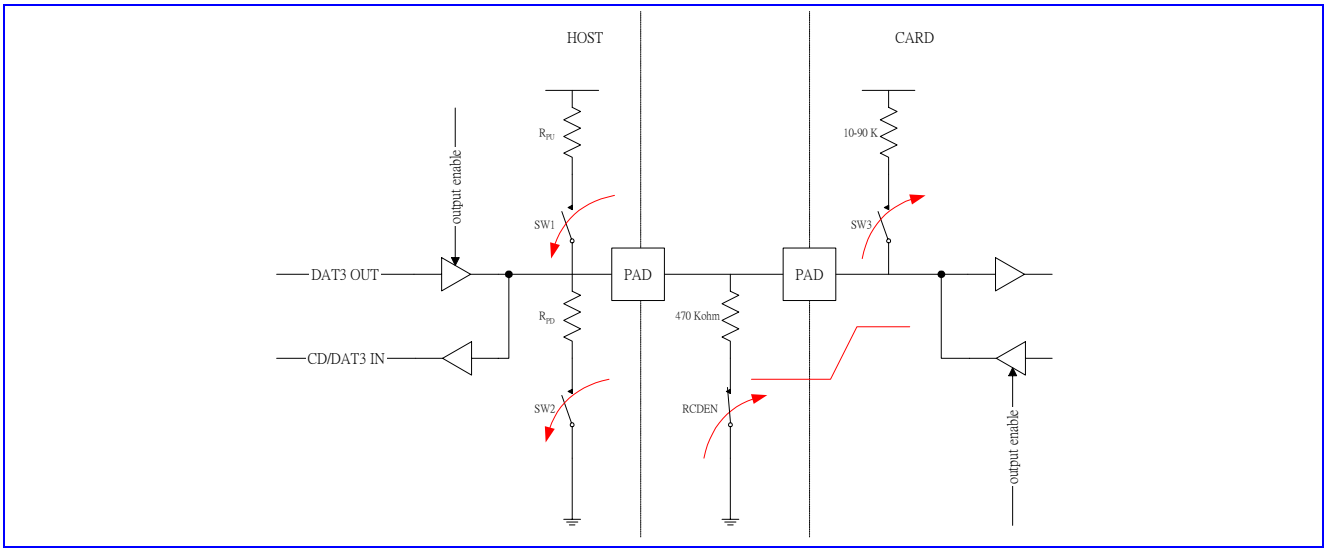


Figure 44 Card detection for SD/MMC Memory Card

7.5.3 Register Definitions

REGISTER ADDRESS	REGISTER NAME	SYNONYM
MSDC + 0000h	MS/SD Memory Card Controller Configuration Register	MSDC_CFG
MSDC + 0004h	MS/SD Memory Card Controller Status Register	MSDC_STA
MSDC + 0008h	MS/SD Memory Card Controller Interrupt Register	MSDC_INT
MSDC + 000Ch	MS/SD Memory Card Controller Data Register	MSDC_DAT
MSDC + 00010h	MS/SD Memory Card Pin Status Register	MSDC_PS
MSDC + 00014h	MS/SD Memory Card Controller IO Control Register	MSDC_IOCON
MSDC + 0020h	SD Memory Card Controller Configuration Register	SDC_CFG
MSDC + 0024h	SD Memory Card Controller Command Register	SDC_CMD
MSDC + 0028h	SD Memory Card Controller Argument Register	SDC_ARG
MSDC + 002Ch	SD Memory Card Controller Status Register	SDC_STA
MSDC + 0030h	SD Memory Card Controller Response Register 0	SDC_RESP0
MSDC + 0034h	SD Memory Card Controller Response Register 1	SDC_RESP1
MSDC + 0038h	SD Memory Card Controller Response Register 2	SDC_RESP2
MSDC + 003Ch	SD Memory Card Controller Response Register 3	SDC_RESP3
MSDC + 0040h	SD Memory Card Controller Command Status Register	SDC_CMDSTA
MSDC + 0044h	SD Memory Card Controller Data Status Register	SDC_DATSTA
MSDC + 0048h	SD Memory Card Status Register	SDC_CSTA
MSDC + 004Ch	SD Memory Card IRQ Mask Register 0	SDC_IRQMASK0
MSDC + 0050h	SD Memory Card IRQ Mask Register 1	SDC_IRQMASK1
MSDC + 0054h	SDIO Configuration Register	SDIO_CFG
MSDC + 0058h	SDIO Status Register	SDIO_STA
MSDC + 0060h	Memory Stick Controller Configuration Register	MSC_CFG
MSDC + 0064h	Memory Stick Controller Command Register	MSC_CMD
MSDC + 0068h	Memory Stick Controller Auto Command Register	MSC_ACMD
MSDC + 006Ch	Memory Stick Controller Status Register	MSC_STA

Table 34 MS/SD Controller Register Map

7.5.3.1 Global Register Definitions

MSDC+0000h MS/SD Memory Card Controller Configuration Register MSDC_CFG

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	FIFOTHD				PRCFG2		PRCFG1		PRCFG0		VDDPD	RCDEN	DIRQEN	PINEN	DMAEN	INTEN
Type	R/W				R/W		R/W		R/W		R/W	R/W	R/W	R/W	R/W	R/W
Reset	0001				01		01		10		0	0	0	0	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SCLKF								SCLKON	RED	STDBY	CLKSRC	RST	NOCRC		MSDC
Type	R/W								R/W	R/W	R/W	R/W	W	R/W		R/W

Reset	00000000	0	0	1	0	0	0		0

The register is for general configuration of the MS/SD controller. Note that MSDC_CFG[31:16] can be accessed by 16-bit APB bus access.

MSDC The register bit is used to configure the controller as the host of Memory Stick or as the host of SD/MMC Memory card. The default value is to configure the controller as the host of Memory Stick.

0 Configure the controller as the host of Memory Stick

1 Configure the controller as the host of SD/MMC Memory card

NOCRC CRC Disable. A '1' indicates that data transfer without CRC is desired. For write data block, data will be transmitted without CRC. For read data block, CRC will not be checked. It is for testing purpose.

0 Data transfer with CRC is desired.

1 Data transfer without CRC is desired.

RST Software Reset. Writing a '1' to the register bit will cause internal synchronous reset of MS/SD controller, but does not reset register settings.

0 Otherwise

1 Reset MS/SD controller

CLKSRC The register bit specifies which clock is used as source clock of memory card. If MUC clock is used, the fastest clock rate for memory card is 52/2=26MHz. If USB clock is used, the fastest clock rate for memory card is 48/2=24MHz.

0 Use MCU clock as source clock of memory card.

1 Use USB clock as source clock of memory card.

STDBY Standby Mode. If the module is powered down, operating clock to the module will be stopped. At the same time, clock to card detection circuitry will also be stopped. If detection of memory card insertion and removal is desired, write '1' to the register bit. If interrupt for detection of memory card insertion and removal is enabled, interrupt will take place whenever memory is inserted or removed.

0 Standby mode is disabled.

1 Standby mode is enabled.

RED Rise Edge Data. The register bit is used to determine that serial data input is latched at the falling edge or the rising edge of serial clock. The default setting is at the rising edge. If serial data has worse timing, set the register bit to '1'. **When memory card has worse timing on return read data, set the register bit to '1'.**

0 Serial data input is latched at the rising edge of serial clock.

1 Serial data input is latched at the falling edge of serial clock.

SCLKON Serial Clock Always On. It is for debugging purpose.

0 Not to have serial clock always on.

1 To have serial clock always on.

SCLKF The register field controls clock frequency of serial clock on MS/SD bus. Denote clock frequency of MS/SD bus serial clock as f_{slave} and clock frequency of the MS/SD controller as f_{host} which is 104 or 52 MHz. Then the value of the register field is as follows. **Note that the allowable maximum frequency of f_{slave} is 26MHz**.

00000000b $f_{slave} = (1/2) * f_{host}$

00000001b $f_{slave} = (1/(4*1)) * f_{host}$

00000010b $f_{slave} = (1/(4*2)) * f_{host}$

00000011b $f_{slave} = (1/(4*3)) * f_{host}$

…

00010000b $f_{slave} = (1/(4*16)) * f_{host}$

…

11111111b $f_{slave} = (1/(4*255)) * f_{host}$

INTEN Interrupt Enable. Note that if interrupt capability is disabled then application software must poll the status of the register MSDC_STA to check for any interrupt request.

0 Interrupt induced by various conditions is disabled, no matter the controller is configured as the host of either SD/MMC Memory Card or Memory Stick.

1 Interrupt induced by various conditions is enabled, no matter the controller is configured as the host of either SD/MMC Memory Card or Memory Stick.

DMAEN DMA Enable. Note that if DMA capability is disabled then application software must poll the status of the register MSDC_STA for checking any data transfer request. If DMA is desired, the register bit must be set before command register is written.

0 DMA request induced by various conditions is disabled, no matter the controller is configured as the host of either SD/MMC Memory Card or Memory Stick.

1 DMA request induced by various conditions is enabled, no matter the controller is configured as the host of either SD/MMC Memory Card or Memory Stick.

PINEN Pin Interrupt Enable. The register bit is used to control if the pin for card detection is used as an interrupt source.

0 The pin for card detection is not used as an interrupt source.

1 The pin for card detection is used as an interrupt source.

DIRQEN Data Request Interrupt Enable. The register bit is used to control if data request is used as an interrupt source.

0 Data request is not used as an interrupt source.

1 Data request is used as an interrupt source.

RCDEN The register bit controls the output pin RCDEN that is used for card identification process when the controller is for SD/MMC Memory Card. Its output will control the pull down resistor on the system board to connect or disconnect with the signal CD/DAT3.

0 The output pin RCDEN will output logic low.

1 The output pin RCDEN will output logic high.

VDDPD The register bit controls the output pin VDDPD that is used for power saving. The output pin VDDPD will control power for memory card.

0 The output pin VDDPD will output logic low. The power for memory card will be turned off.

1 The output pin VDDPD will output logic high. The power for memory card will be turned on.

PRCFG0 Pull Up/Down Register Configuration for the pin WP. The default value is 10.

00 Pull up resistor and pull down resistor in the I/O pad of the pin WP are all disabled.

01 Pull down resistor in the I/O pad of the pin WP is enabled.

10 Pull up resistor in the I/O pad of the pin WP is enabled.

11 Use keeper of IO pad.

PRCFG1 Pull Up/Down Register Configuration for the pin CMD/BS. The default value is 0b01.

00 Pull up resistor and pull down resistor in the I/O pad of the pin CMD/BS are all disabled.

01 Pull down resistor in the I/O pad of the pin CMD/BS is enabled.

10 Pull up resistor in the I/O pad of the pin CMD/BS is enabled.

11 Use keeper of IO pad.

PRCFG2 Pull Up/Down Register Configuration for the pins DAT0, DAT1, DAT2, DAT3. The default value is 0b01.

00 Pull up resistor and pull down resistor in the I/O pads o the pins DAT0, DAT1, DAT2, DAT3. are all disabled.

01 Pull down resistor in the I/O pads of the pins DAT0, DAT1, DAT2, DAT3 and WP. is enabled.

10 Pull up resistor in the I/O pads of the pins DAT0, DAT1, DAT2, DAT3. is enabled.

11 Use keeper of IO pad.

FIFOTHD FIFO Threshold. The register field determines when to issue a DMA request. For write transactions, DMA requests will be asserted if the number of free entries in FIFO are larger than or equal to the value in the register field. For read transactions, DMA requests will be asserted if the number of valid entries in FIFO are larger than or equal to the value in the register field. The register field must be set according to the setting of data transfer count in DMA burst mode. If single mode for DMA transfer is used, the register field shall be set to 0b0001.

0000 Invalid.

0001 Threshold value is 1.

0010 Threshold value is 2.

…

1000 Threshold value is 8.

others Invalid

MSDC+0004h MS/SD Memory Card Controller Status Register MSDC_STA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUSY	FIFOCLR							FIFOCNT				INT	DRQ	BE	BF
Type	R	W							RO				RO	RO	RO	RO
Reset	0	-							0000				0	0	0	0

The register contains the status of FIFO, interrupts and data requests.

BF The register bit indicates if FIFO in MS/SD controller is full.

0 FIFO in MS/SD controller is not full.

1 FIFO in MS/SD controller is full.

BE The register bit indicates if FIFO in MS/SD controller is empty.

0 FIFO in MS/SD controller is not empty.

1 FIFO in MS/SD controller is empty.

DRQ The register bit indicates if any data transfer is required. While any data transfer is required, the register bit still will be active even if the register bit DIRQEN in the register MSDC_CFG is disabled. Data transfer can be achieved by DMA channel alleviating MCU loading, or by polling the register bit to check if any data transfer is requested. While the register bit DIRQEN in the register MSDC_CFG is disabled, the second method is used.

0 No DMA request exists.

1 DMA request exists.

INT The register bit indicates if any interrupt exists. While any interrupt exists, the register bit still will be active even if the register bit INTEN in the register MSDC_CFG is disabled. MS/SD controller can interrupt MCU by issuing interrupt request to Interrupt Controller, or software/application polls the register endlessly to check if any interrupt request exists in MS/SD controller. While the register bit INTEN in the register MSDC_CFG is disabled, the second method is used. For read commands, it is possible that timeout error takes place. Software can read the status register to check if timeout error takes place without OS time tick support or data request is asserted. Note that the register bit will be cleared when reading the register MSDC_INT.

0 No interrupt request exists.

1 Interrupt request exists.

FIFOCNT FIFO Count. The register field shows how many valid entries are in FIFO.

0000 There is 0 valid entry in FIFO.

0001 There is 1 valid entry in FIFO.

0010 There are 2 valid entries in FIFO.

…

1000 There are 8 valid entries in FIFO.

others Invalid

FIFOCLR Clear FIFO. Writing '1' to the register bit will cause the content of FIFO clear and reset the status of FIFO controller.

0 No effect on FIFO.

1 Clear the content of FIFO clear and reset the status of FIFO controller.

BUSY Status of the controller. If the controller is in busy state, the register bit will be '1'. Otherwise '0'.

0 The controller is in busy state.

1 The controller is in idle state.

MSDC+0008h MS/SD Memory Card Controller Interrupt Register MSDC_INT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									SDIOIRQ	SDR1BIRQ	MSIFIRQ	SDMCIRQ	SDDATIRQ	SDCMDIRQ	PINIRQ	DIRQ
Type									RC	RC	RC	RC	RC	RC	RC	RC
Reset									0	0	0	0	0	0	0	0

The register contains the status of interrupts. Note that the register still show status of interrupt even though interrupt is disabled, that is, the register bit INTEN of the register MSDC_CFG is set to '0. It implies that software interrupt can be implemented by polling the register bit INT of the register MSDC_STA and this register. **However, if hardware interrupt is desired, remember to clear the register before setting the register bit INTEN of the register MSDC_CFG to '1'. Or undesired hardware interrupt arisen from previous interrupt status may take place.**

DIRQ Data Request Interrupt. The register bit indicates if any interrupt for data request exists. Whenever data request exists and data request as an interrupt source is enabled, i.e., the register bit DIRQEN in the register MSDC_CFG is set to '1', the register bit will be active. It will be reset when reading it. For software, data requests can be recognized by polling the register bit DRQ or by data request interrupt. Data request interrupts will be generated every FIFOTHD data transfers.

0 No Data Request Interrupt.

1 Data Request Interrupt occurs.

PINIRQ Pin Change Interrupt. The register bit indicates if any interrupt for memory card insertion/removal exists. Whenever memory card is inserted or removed and card detection interrupt is enabled, i.e., the register bit PINEN in the register MSDC_CFG is set to '1', the register bit will be set to '1'. It will be reset when the register is read.

0 Otherwise.

1 Card is inserted or removed.

SDCMDIRQ SD Bus CMD Interrupt. The register bit indicates if any interrupt for SD CMD line exists. Whenever interrupt for SD CMD line exists, i.e., any bit in the register SDC_CMDSTA is active, the register bit will be set to '1' if interrupt is enabled. It will be reset when the register is read.

0 No SD CMD line interrupt.

1 SD CMD line interrupt exists.

SDDATIRQ SD Bus DAT Interrupt. The register bit indicates if any interrupt for SD DAT line exists. Whenever interrupt for SD DAT line exists, i.e., any bit in the register SDC_ DATSTA is active, the register bit will be set to '1' if interrupt is enabled. It will be reset when the register is read.

0 No SD DAT line interrupt.

1 SD DAT line interrupt exists.

SDMCIRQ SD Memory Card Interrupt. The register bit indicates if any interrupt for SD Memory Card exists. Whenever interrupt for SD Memory Card exists, i.e., any bit in the register SDC_CSTA is active, the register bit will be set to '1' if interrupt is enabled. It will be reset when the register is read.

0 No SD Memory Card interrupt.

1 SD Memory Card interrupt exists.

MSIFIRQ MS Bus Interface Interrupt. The register bit indicates if any interrupt for MS Bus Interface exists. Whenever interrupt for MS Bus Interface exists, i.e., any bit in the register MSC_STA is active, the register bit will be set to '1' if interrupt is enabled. It will be reset when the register MSDC_STA or MSC_STA is read.

0 No MS Bus Interface interrupt.

1 MS Bus Interface interrupt exists.

SDR1BIRQ SD/MMC R1b Response Interrupt. The register bit will be active when a SD/MMC command with R1b response finishes and the DAT0 line has transition from busy to idle state. **Single block write commands with R1b response will cause the interrupt when the command completes no matter successfully or with CRC error. However, multi-block write commands with R1b response do not cause the interrupt because multi-block write commands are always stopped by STOP_TRANS commands. STOP_TRANS commands (with R1b response) behind multi-block write commands will cause the interrupt. Single block read command with R1b response will cause the interrupt when the command completes but multi-block read commands do not. Note that STOP_TRANS commands (with R1b response) behind multi-block read commands will cause the interrupt.**

0 No interrupt for SD/MMC R1b response.

1 Interrupt for SD/MMC R1b response exists.

MSDC+000Ch MS/SD Memory Card Controller Data Register MSDC_DAT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DATA[31:16]															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DATA[15:0]															
Type	R/W															

The register is used to read/write data from/to FIFO inside MS/SD controller. Data access is in unit of 32 bits.

MSDC+0010h MS/SD Memory Card Pin Status Register MSDC_PS

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name								CMD	DAT							
Type								RO	RO							
Reset								-	-							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	CDDEBOUNCE											PINCHG	PIN0	POEN0	PIEN0	CDEN
Type	RW											RC	RO	R/W	R/W	R/W
Reset	0000											0	1	0	0	0

The register is used for card detection. When the memory card controller is powered on, and the system is powered on, the power for the memory card is still off unless power has been supplied by the PMIC. Meanwhile, pad for card detection defaults to pull down when the system is powered on. The scheme of card detection for MS is the same as that for SD/MMC.

For detecting card insertion, first pull up INS pin, and then enable card detection and input pin at the same time. After 32 cycles of controller clock, status of pin changes will emerge. For detecting card removal, just keep enabling card detection and input pin.

CDEN Card Detection Enable. The register bit is used to enable or disable card detection.

- **0** Card detection is disabled.
- **1** Card detection is enabled.

PIEN0 The register bit is used to control input pin for card detection.

- **0** Input pin for card detection is disabled.
- **1** Input pin for card detection is enabled.

POEN0 The register bit is used to control output of input pin for card detection.

- **0** Output of input pin for card detection is disabled.
- **1** Output of input pin for card detection is enabled.

PIN0 The register shows the value of input pin for card detection.

- **0** The value of input pin for card detection is logic low.
- **1** The value of input pin for card detection is logic high.

PINCHG Pin Change. The register bit indicates the status of card insertion/removal. If memory card is inserted or removed, the register bit will be set to '1' no matter pin change interrupt is enabled or not. It will be cleared when the register is read.

- **0** Otherwise.
- **1** Card is inserted or removed.

CDDEBOUNCE The register field specifies the time interval for card detection de-bounce. Its default value is 0. It means that de-bounce interval is 32 cycle time of 32KHz. The interval will extend one cycle time of 32KHz by increasing the counter by 1.

DAT Memory Card Data Lines.

CMD Memory Card Command Lines.

MSDC+0014h MS/SD Memory Card Controller IO Control Register MSDC_IOCON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DLT															
Type	R/W															
Reset	00000010															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	CMDRE						PRCFG3		SRCFG1	SRCFG0	ODCCFG1			ODCCFG0		
Type	R/W						R/W		R/W	R/W	R/W			R/W		
Reset	0						10		1	1	000			011		

The register specifies **Output Driving Capability** and **Slew Rate** of IO pads for MSDC. The reset value is suggestion setting. If output driving capability of the pins DAT0, DAT1, DAT2 and DAT3 is too large, it's possible to arise ground bounce and thus result in glitch on SCLK.

ODCCFG0 Output driving capability the pins CMD/BS and SCLK

- **000** 4mA
- **010** 8mA
- **100** 12mA
- **110** 16mA

ODCCFG1 Output driving capability the pins DAT0, DAT1, DAT2 and DAT3

000 4mA
010 8mA
100 12mA
110 16mA

SRCFG0 Output driving capability the pins CMD/BS and SCLK
0 Fast Slew Rate
1 Slow Slew Rate

SRCFG1 Output driving capability the pins DAT0, DAT1, DAT2 and DAT3
0 Fast Slew Rate
1 Slow Slew Rate

PRCFG3 Pull Up/Down Register Configuration for the pin INS. The default value is 10.
00 Pull up resistor and pull down resistor in the I/O pad of the pin INS are all disabled.
01 Pull down resistor in the I/O pad of the pin INS is enabled.
10 Pull up resistor in the I/O pad of the pin INS is enabled.
11 Use keeper of IO pad.

CMDRE The register bit is used to determine whether the host should latch response token (which is sent from card on CMD line) at rising edge or falling edge of serial clock.
0 Host latches response at rising edge of serial clock
1 Host latches response at falling edge of serial clock

DLT Data Latch Timing. The register is used for SW to select the latch timing on data line.
Figure 3 illustrates the data line latch timing. sclk_out is the serial clock output to card. div_clk is the internal clock used for generating divided clock. The number "1 2 1 2" means the current sclk_out is divided from div_clk by a ratio of 2. data_in is the output data from card, and latched_data(r)/(f) is the rising/falling edge latched data inside the host (configured by RED in MSDC_CFG). In this example, SCLKF(in MSDC_CFG) is set to 8'b0 which means the division ratio is 2, and DLT is set to 1. Note that the value of DLT CANNOT be set as 0 and its value should not exceed the division ratio (in the example, the division ratio is 2). Also note that, the latching time will be one div_clk later than the indicated DLT value and the falling edge is always half div_clk ahead from rising edge. The default value of DLT is set to 8'b2.

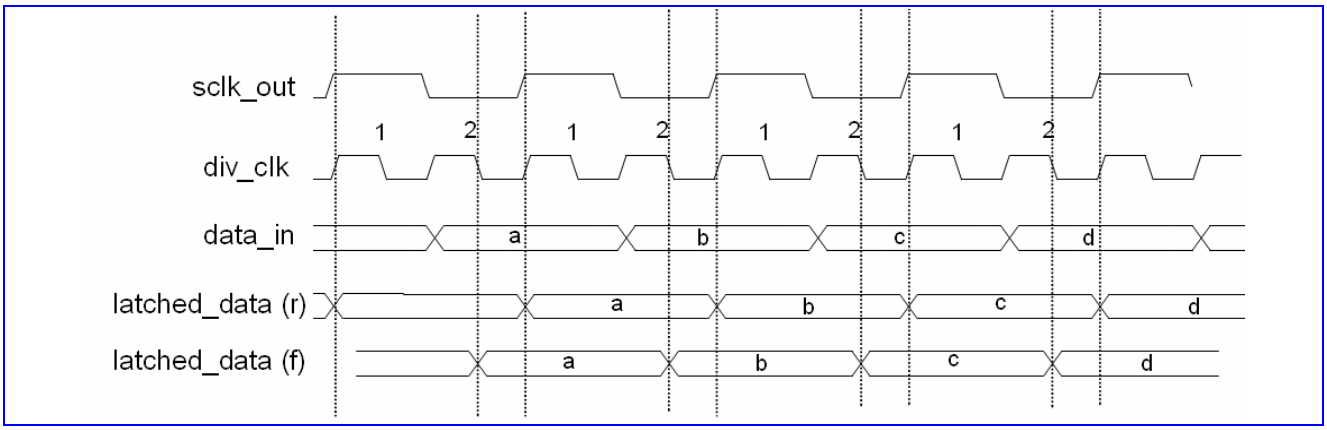


Figure 3 Illustration of data line latch timing

7.5.3.2 SD Memory Card Controller Register Definitions

MSDC+0020h SD Memory Card Controller Configuration Register SDC_CFG

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DTOC								WDOD				SDIO	MDLW8	MDLEN	SIEN
Type	R/W								R/W				R/W	R/W	R/W	R/W
Reset	00000000								0000				0	0	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BSYDLY				BLKLEN											
Type	R/W				R/W											
Reset	1000				00000000000											

The register is used for configuring the MS/SD Memory Card Controller when it is configured as the host of SD Memory Card. If the controller is configured as the host of Memory Stick, the contents of the register have no impact on the operation of the controller. Note that SDC_CFG[31:16] can be accessed by 16-bit APB bus access.

BLKLEN It refers to Block Length. The register field is used to define the length of one block in unit of byte in a data transaction. The maximal value of block length is 2048 bytes.

000000000000 Reserved.
000000000001 Block length is 1 byte.
000000000010 Block length is 2 bytes.
…
011111111111 Block length is 2047 bytes.
100000000000 Block length is 2048 bytes.

BSYDLY The register field is only valid for the commands with R1b response. If the command has a response of R1b type, MS/SD controller must monitor the data line 0 for card busy status from the bit time that is two serial clock cycles after the command end bit to check if operations in SD/MMC Memory Card have finished. The register field is used to expand the time between the command end bit and end of detection period to detect card busy status. If time is up and there is no card busy status on data line 0, then the controller will abandon the detection.

0000 No extend.
0001 Extend one more serial clock cycle.
0010 Extend two more serial clock cycles.
…
1111 Extend fifteen more serial clock cycle.

SIEN Serial Interface Enable. It should be enabled as soon as possible before any command.

0 Serial interface for SD/MMC is disabled.
1 Serial interface for SD/MMC is enabled.

MDLW8 Eight Data Line Enable. The register works when MDLEN is enabled. The register can be enabled only when MultiMediaCard 4.0 is applied and detected by software application.

0 4-bit Data line is enabled.
1 8-bit Data line is enabled.

SDIO SDIO Enable.

0 SDIO mode is disabled
1 SDIO mode is enabled

MDLEN Multiple Data Line Enable. The register can be enabled only when SD Memory Card is applied and detected by software application. It is the responsibility of the application to program the bit correctly when an

MultiMediaCard is applied. If an MultiMediaCard is applied and 4-bit data line is enabled, then 4 bits will be output every serial clock. Therefore, data integrity will fail.

0 4-bit Data line is disabled.

1 4-bit Data line is enabled.

WDOD Write Data Output Delay. The period from finish of the response for the initial host write command or the last write data block in a multiple block write operation to the start bit of the next write data block requires at least two serial clock cycles. The register field is used to extend the period (Write Data Output Delay) in unit of one serial clock.

0000 No extend.

0001 Extend one more serial clock cycle.

0010 Extend two more serial clock cycles.

…

1111 Extend fifteen more serial clock cycle.

DTOC Data Timeout Counter. The period from finish of the initial host read command or the last read data block in a multiple block read operation to the start bit of the next read data block requires at least two serial clock cycles. The counter is used to extend the period (Read Data Access Time) in unit of 65,536 serial clock. See the register field description of the register bit RDINT for reference.

00000000 Extend 65,536 more serial clock cycle.

00000001 Extend 65,536x2 more serial clock cycle.

00000010 Extend 65,536x3 more serial clock cycle.

…

11111111 Extend 65,536x 256 more serial clock cycle.

MSDC+0024h SD Memory Card Controller Command Register SDC_CMD

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																CMDFAIL
Type																R/W
Reset																0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	INTC	STOP	RW	DTYPE		IDRT	RSPTYP			BREAK	CMD					
Type	R/W	R/W	R/W	R/W		R/W	R/W			R/W	R/W					
Reset	0	0	0	00		0	000			0	000000					

The register defines a SD Memory Card command and its attribute. Before MS/SD controller issues a transaction onto SD bus, application shall specify other relative setting such as argument for command. After application writes the register, MS/SD controller will issue the corresponding transaction onto SD serial bus. If the command is GO_IDLE_STATE, the controller will have serial clock on SD/MMC bus run 128 cycles before issuing the command.

CMD SD Memory Card command. It is totally 6 bits.

BREAK Abort a pending MMC GO_IRQ_MODE command. It is only valid for a pending GO_IRQ_MODE command waiting for MMC interrupt response.

0 Other fields are valid.

1 Break a pending MMC GO_IRQ_MODE command in the controller. Other fields are invalid.

RSPTYP The register field defines response type for the command. For commands with R1 and R1b response, the register SDC_CSTA (not SDC_STA) will update after response token is received. This register SDC_CSTA

contains the status of the SD/MMC and it will be used as response interrupt sources. Note that if CMD7 is used with all 0's RCA then RSPTYP must be "000". And the command "GO_TO_IDLE" also have RSPTYP='000'.

000 There is no response for the command. For instance, broadcast command without response and GO_INACTIVE_STATE command.

001 The command has R1 response. R1 response token is 48-bit.

010 The command has R2 response. R2 response token is 136-bit.

011 The command has R3 response. Even though R3 is 48-bit response, but it does not contain CRC checksum.

100 The command has R4 response. R4 response token is 48-bit. (Only for MMC)

101 The command has R5 response. R5 response token is 48-bit. (Only for MMC)

110 The command has R6 response. R6 response token is 48-bit.

111 The command has R1b response. If the command has a response of R1b type, MS/SD controller must monitor the data line 0 for card busy status from the bit time that is two or four serial clock cycles after the command end bit to check if operations in SD/MMC Memory Card have finished. There are two cases for detection of card busy status. The first case is that the host stops the data transmission during an active write data transfer. The card will assert busy signal after the stop transmission command end bit followed by four serial clock cycles. The second case is that the card is in idle state or under a scenario of receiving a stop transmission command between data blocks when multiple block write command is in progress. The register bit is valid only when the command has a response token.

Note that the response type R4 and R5 mentioned above is for MMC only.

For SDIO, RSPTYP definition is different and shall be set to :

001 **(i) CMD5 of SDIO is to be issued. (Where the response is defined as R4 in SDIO spec)**
(ii) CMD52 or CMD53 for READ is to be issued. (Where the response is defined as R5 in SDIO spec)

111 **CMD52 for I/O abort or CMD53 for WRITE is to be issued (Where the response is defined as R5 in SDIO spec)**

IDRT Identification Response Time. The register bit indicates if the command has a response with N_{ID} (that is, 5 serial clock cycles as defined in SD Memory Card Specification Part 1 Physical Layer Specification version 1.0) response time. The register bit is valid only when the command has a response token. Thus the register bit must be set to '1' for CMD2 (ALL_SEND_CID) and ACMD41 (SD_APP_OP_CMD).

0 Otherwise.

1 The command has a response with N_{ID} response time.

DTYPE The register field defines data token type for the command.

00 No data token for the command

01 Single block transaction

10 Multiple block transaction. That is, the command is a multiple block read or write command.

11 Stream operation. It only shall be used when an MultiMediaCard is applied.

RW The register bit defines the command is a read command or write command. The register bit is valid only when the command will cause a transaction with data token.

0 The command is a read command.

1 The command is a write command.

STOP The register bit indicates if the command is a stop transmission command. **It should be set to 1 when CMD12 (SD/MMC) or CMD52 with I/O abort (SDIO) is to be issued.**

0 The command is not a stop transmission command.

1 The command is a stop transmission command.

INTC The register bit indicates if the command is GO_IRQ_STATE. If the command is GO_IRQ_STATE, the period between command token and response token will not be limited.

0 The command is not GO_IRQ_STATE.

1 The command is GO_IRQ_STATE.

CMDFAIL The register bit is used for controlling SDIO interrupt period when CRC error or Command/Data timeout condition occurs. It is useful only when SDIO 4-bit mode is activated.

0 SDIO Interrupt period will re-start after a stop command (CMD12) or I/O abort command (CMD52) is issued.

1 SDIO Interrupt period will re-start whenever DAT line is not busy.

MSDC+0028h SD Memory Card Controller Argument Register SDC_ARG

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	ARG [31:16]															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ARG [15:0]															
Type	R/W															

The register contains the argument of the SD/MMC Memory Card command.

MSDC+002Ch SD Memory Card Controller Status Register SDC_STA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	WP											R1BSY	RSV	DATBUSY	CMDBUSY	SDCBUSY
Type	R											RO	RO	RO	RO	RO
Reset	-											0	0	0	0	0

The register contains various status of MS/SD controller as the controller is configured as the host of SD Memory Card.

SDCBUSY The register field indicates if MS/SD controller is busy, that is, any transmission is going on CMD or DAT line on SD bus.

0 MS/SD controller is idle.

1 MS/SD controller is busy.

CMDBUSY The register field indicates if any transmission is going on CMD line on SD bus.

0 No transmission is going on CMD line on SD bus.

1 There exists transmission going on CMD line on SD bus.

DATBUSY The register field indicates if any transmission is going on DAT line on SD bus. **For those commands without data but still involving DAT line, the register bit is useless. For example, if an Erase command is issued, then checking if the register bit is '0' before issuing next command with data would not guarantee that the controller is idle. In this situation, use the register bit SDCBUSY.**

0 No transmission is going on DAT line on SD bus.

1 There exists transmission going on DAT line on SD bus.

R1BSY The register field shows the status of DAT line 0 for commands with R1b response.

0 SD/MMC Memory card is not busy.

1 SD/MMC Memory card is busy.

WP It is used to detect the status of Write Protection Switch on SD Memory Card. The register bit shows the status of Write Protection Switch on SD Memory Card. There is no default reset value. The pin WP (Write Protection) is also only useful while the controller is configured for SD Memory Card.

1 Write Protection Switch ON. It means that memory card is desired to be write-protected.

0 Write Protection Switch OFF. It means that memory card is writable.

MSDC+0030h SD Memory Card Controller Response Register 0 SDC_RESP0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	RESP [31:16]															
Type	RO															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RESP [15:0]															
Type	RO															

The register contains parts of the last SD/MMC Memory Card bus response. See description for the register field SDC_RESP3.

MSDC+0034h SD Memory Card Controller Response Register 1 SDC_RESP1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	RESP [63:48]															
Type	RO															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RESP [47:32]															
Type	RO															

The register contains parts of the last SD/MMC Memory Card bus response. See description for the register field SDC_RESP3.

MSDC+0038h SD Memory Card Controller Response Register 2 SDC_RESP2

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	RESP [95:80]															
Type	RO															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RESP [79:64]															
Type	RO															

The register contains parts of the last SD/MMC Memory Card bus response. See description for the register field SDC_RESP3.

MSDC+003Ch SD Memory Card Controller Response Register 3 SDC_RESP3

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	RESP [127:112]															
Type	RO															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RESP [111:96]															
Type	RO															

The register contains parts of the last SD/MMC Memory Card bus response. The register fields SDC_RESP0, SDC_RESP1, SDC_RESP2 and SDC_RESP3 compose the last SD/MMC Memory card bus response. For response of type R2, that is, response of the command ALL_SEND_CID, SEND_CSD and SEND_CID, only bit 127 to 0 of response token is stored in

the register field SDC_RESP0, SDC_RESP1, SDC_RESP2 and SDC_RESP3. For response of other types, only bit 39 to 8 of response token is stored in the register field SDC_RESP0.

MSDC+0040h SD Memory Card Controller Command Status Register SDC_CMDSTA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													MMCIRQ	RSPCRCERR	CMDTO	CMDRDY
Type													RC	RC	RC	RC
Reset													0	0	0	0

The register contains the status of MS/SD controller during command execution and that of MS/SD bus protocol after command execution when MS/SD controller is configured as the host of SD/MMC Memory Card. The register will also be used as interrupt sources. The register will be cleared when reading the register. Meanwhile, if interrupt is enabled and thus interrupt caused by the register is generated, reading the register will deassert the interrupt.

CMDRDY For command without response, the register bit will be '1' once the command completes on SD/MMC bus. For command with response, the register bit will be '1' whenever the command is issued onto SD/MMC bus and its corresponding response is received **without CRC error**.

0 Otherwise.

1 Command with/without response finish successfully without CRC error.

CMDTO Timeout on CMD detected. A '1' indicates that MS/SD controller detected a timeout condition while waiting for a response on the CMD line.

0 Otherwise.

1 MS/SD controller detected a timeout condition while waiting for a response on the CMD line.

RSPCRCERR CRC error on CMD detected. A '1' indicates that MS/SD controller detected a CRC error **after reading a response from the CMD line.**

0 Otherwise.

1 MS/SD controller detected a CRC error after reading a response from the CMD line.

MMCIRQ MMC requests an interrupt. A '1' indicates that a MMC supporting command class 9 issued an interrupt request.

0 Otherwise.

1 A '1' indicates that a MMC supporting command class 9 issued an interrupt request.

MSDC+0044h SD Memory Card Controller Data Status Register SDC_DATSTA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name														DATCRCERR	DATTO	BLKDONE
Type														RC	RC	RC
Reset														0	0	0

The register contains the status of MS/SD controller during data transfer on DAT line(s) when MS/SD controller is configured as the host of SD/MMC Memory Card. The register also will be used as interrupt sources. The register will be cleared when reading the register. Meanwhile, if interrupt is enabled and thus interrupt caused by the register is generated, reading the register will deassert the interrupt.

BLKDONE The register bit indicates the status of data block transfer.

0 Otherwise.

1 A data block was successfully transferred.

DATTO Timeout on DAT detected. A '1' indicates that MS/SD controller detected a timeout condition while waiting for data token on the DAT line.

0 Otherwise.

1 MS/SD controller detected a timeout condition while waiting for data token on the DAT line.

DATCRCERR CRC error on DAT detected. A '1' indicates that MS/SD controller detected a CRC error after reading a block of data from the DAT line or SD/MMC signaled a CRC error after writing a block of data to the DAT line.

0 Otherwise.

1 MS/SD controller detected a CRC error after reading a block of data from the DAT line or SD/MMC signaled a CRC error after writing a block of data to the DAT line.

MSDC+0048h SD Memory Card Status Register SDC_CSTA

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	CSTA [31:16]															
Type	RC															
Reset	0000000000000000															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	CSTA [15:0]															
Type	RC															
Reset	0000000000000000															

After commands with R1 and R1b response this register contains the status of the SD/MMC card and it will be used as response interrupt sources. In all register fields, logic high indicates error and logic low indicates no error. The register will be cleared when reading the register. Meanwhile, if interrupt is enabled and thus interrupt caused by the register is generated, reading the register will deassert the interrupt.

CSTA31 **OUT_OF_RANGE**. The command's argument was out of the allowed range for this card.

CSTA30 **ADDRESS_ERROR**. A misaligned address that did not match the block length was used in the command.

CSTA29 **BLOCK_LEN_ERROR**. The transferred block length is not allowed for this card, or the number of transferred bytes does not match the block length.

CSTA28 **ERASE_SEQ_ERROR**. An error in the sequence of erase commands occurred.

CSTA27 **ERASE_PARAM**. An invalid selection of write-blocks for erase occurred.

CSTA26 **WP_VIOLATION**. Attempt to program a write-protected block.

CSTA25 Reserved. Return zero.

CSTA24 **LOCK_UNLOCK_FAILED**. Set when a sequence or password error has been detected in lock/unlock card command or if there was an attempt to access a locked card.

CSTA23 **COM_CRC_ERROR**. The CRC check of the previous command failed.

CSTA22 **ILLEGAL_COMMAND**. Command not legal for the card state.

CSTA21 **CARD_ECC_FAILED**. Card internal ECC was applied but failed to correct the data.

CSTA20 **CC_ERROR**. Internal card controller error.

CSTA19 **ERROR**. A general or an unknown error occurred during the operation.

CSTA18 **UNDERRUN**. The card could not sustain data transfer in stream read mode.

CSTA17 **OVERRUN**. The card could not sustain data programming in stream write mode.

CSTA16 **CID/CSD_OVERWRITE**. It can be either one of the following errors: 1. The CID register has been already written and cannot be overwritten 2. The read only section of the CSD does not match the card. 3. An attempt to reverse the copy (set as original) or permanent WP (unprotected) bits was made.

CSTA[15:4] Reserved. Return zero.

CSTA3 **AKE_SEQ_ERROR**. Error in the sequence of authentication process

CSTA[2:0] Reserved. Return zero.

MSDC+004Ch SD Memory Card IRQ Mask Register 0 SDC_IRQMASK0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	IRQMASK [31:16]															
Type	R/W															
Reset	0000000000000000															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQMASK [15:0]															
Type	R/W															
Reset	0000000000000000															

The register contains parts of SD Memory Card Interrupt Mask Register. See the register description of the register SDC_IRQMASK1 for reference. The register will mask interrupt sources from the register SDC_CMDSTA and SDC_DATSTA. IRQMASK[15:0] is for SDC_CMDSTA and IRQMASK[31:16] for SDC_DATSTA. A '1' in some bit of the register will mask the corresponding interrupt source with the same bit position. For example, if IRQMASK[0] is '1' then interrupt source from the register field CMDRDY of the register SDC_ CMDSTA will be masked. A '0' in some bit will not cause interrupt mask on the corresponding interrupt source from the register SDC_CMDSTA and SDC_DATSTA.

MSDC+0050h SD Memory Card IRQ Mask Register 1 SDC_IRQMASK1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	IRQMASK [63:48]															
Type	R/W															
Reset	0000000000000000															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRQMASK [47:32]															
Type	R/W															
Reset	0000000000000000															

The register contains parts of SD Memory Card Interrupt Mask Register. The registers SDC_IRQMASK1 and SDC_IRQMASK0 compose the SD Memory Card Interrupt Mask Register. The register will mask interrupt sources from the register SDC_CSTA. A '1' in some bit of the register will mask the corresponding interrupt source with the same bit position. For example, if IRQMASK[63] is '1' then interrupt source from the register field OUT_OF_RANGE of the register SDC_ CSTA will be masked. A '0' in some bit will not cause interrupt mask on the corresponding interrupt source from the register SDC_ CSTA.

MSDC+0054h SDIO Configuration Register SDIO_CFG

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name														DSBSEL	INTSEL	INTEN
Type														R/W	R/W	R/W
Reset														0	0	0

The register is used to configure functionality for SDIO.

INTEN Interrupt enable for SDIO.

0 Disable

1 Enable

INTSEL Interrupt Signal Selection

0 Use data line 1 as interrupt signal

1 Use data line 5 as interrupt signal

DSBSEL Data Block Start Bit Selection.

0 Use data line 0 as start bit of data block and other data lines are ignored.

1 Start bit of a data block is received only when data line 0-3 all become low.

MSDC+0058h SDIO Status Register SDIO_STA

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																IRQ
Type																RO
Reset																0

7.5.3.3 Memory Stick Controller Register Definitions

MSDC+0060h Memory Stick Controller Configuration Register MSC_CFG

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	PMODE	PRED											BUSYCNT			SIEN
Type	R/W	R/W											R/W			R/W
Reset	0	0											101			0

The register is used for Memory Stick Controller Configuration when MS/SD controller is configured as the host of Memory Stick.

SIEN Serial Interface Enable. It should be enabled as soon as possible before any command.

0 Serial interface for Memory Stick is disabled.

1 Serial interface for Memory Stick is enabled.

BUSYCNT RDY timeout setting in unit of serial clock cycle. The register field is set to the maximum BUSY timeout time (set value x 4 +2) to wait until the RDY signal is output from the card. RDY timeout error detection is not performed when BUSYCNT is set to 0. The initial value is 0x5. That is, BUSY signal exceeding 5x4+2=22 serial clock cycles causes a RDY timeout error.

000 Not detect RDY timeout

001 BUSY signal exceeding 1x4+2=6 serial clock cycles causes a RDY timeout error.

010 BUSY signal exceeding 2x4+2=10 serial clock cycles causes a RDY timeout error.

…

111 BUSY signal exceeding 7x4+2=30 serial clock cycles causes a RDY timeout error.

PRED Parallel Mode Rising Edge Data. The register field is only valid in parallel mode, that is, MSPRO mode. In parallel mode, data must be driven and latched at the falling edge of serial clock on MS bus. In order to mitigate

hold time issue, the register can be set to '1' such that write data is driven by MSDC at the rising edge of serial clock on MS bus.

0 Write data is driven by MSDC at the falling edge of serial clock on MS bus.

1 Write data is driven by MSDC at the rising edge of serial clock on MS bus.

PMODE Memory Stick PRO Mode.

0 Use Memory Stick serial mode.

1 Use Memory Stick parallel mode.

MSDC+0064h Memory Stick Controller Command Register MSC_CMD

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	PID						DATASIZE									
Type	R/W						R/W									
Reset	0000						0000000000									

The register is used for issuing a transaction onto MS bus. Transaction on MS bus is started by writing to the register MSC_CMD. The direction of data transfer, that is, read or write transaction, is extracted from the register field PID. 16-bit CRC will be transferred for a write transaction even if the register field DATASIZE is programmed as zero under the condition where the register field NOCRC in the register MSDC_CFG is '0'. If the register field NOCRC in the register MSDC_CFG is '1' and the register field DATASIZE is programmed as zero, then writing to the register MSC_CMD will not induce transaction on MS bus. The same applies for when the register field RDY in the register MSC_STA is '0'.

DATASIZE Data size in unit of byte for the current transaction.

0000000000 Data size is 0 byte.

0000000001 Data size is one byte.

0000000010 Data size is two bytes.

…

0111111111 Data size is 511 bytes.

1000000000 Data size is 512 bytes.

PID Protocol ID. It is used to derive Transfer Protocol Code (TPC). The TPC can be derived by cascading PID and its reverse version. For example, if PID is 0x1, then TPC is 0x1e, that is, 0b0001 cascades 0b1110. In addition, the direction of the bus transaction can be determined from the register bit 15, that is, PID[3].

MSDC+0068h Memory Stick Controller Auto Command Register MSC_ACMD

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	APID					ADATASIZE										ACEN
Type	R/W					R/W										R/W
Reset	0111					0000000001										0

The register is used for issuing a transaction onto MS bus automatically after the MS command defined in MSC_CMD completed on MS bus. Auto Command is a function used to automatically execute a command like GET_INT or READ_REG for checking status after SET_CMD ends. If auto command is enabled, the command set in the register will be executed once the INT signal on MS bus is detected. After auto command is issued onto MS bus, the register bit ACEN will become disabled automatically. Note that if auto command is enabled then the register bit RDY in the register MSC_STA caused by the command defined in MSC_CMD will be suppressed until auto command completes. Note that the register field ADATASIZE cannot be set to zero, or the result will be unpredictable.

ACEN Auto Command Enable.

0 Auto Command is disabled.

1 Auto Command is enabled.

ADATASIZE Data size in unit of byte for Auto Command. Initial value is 0x01.

0000000000 Data size is 0 byte.

0000000001 Data size is one byte.

0000000010 Data size is two bytes.

…

0111111111 Data size is 511 bytes.

1000000000 Data size is 512 bytes.

APID Auto Command Protocol ID. It is used to derive Transfer Protocol Code (TPC). Initial value is GSET_INT(0x7).

MSDC+006Ch Memory Stick Controller Status Register MSC_STA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	CMDNK	BREQ	ERR	CED								HSRDY	CRCER	TOER	SIF	RDY
Type	R	R	R	R								RO	RO	RO	RO	RO
Reset	0	0	0	0								0	0	0	0	1

The register contains various status of Memory Stick Controller, that is, MS/SD controller is configured as Memory Stick Controller. These statuses can be used as interrupt sources. Reading the register will NOT clear it. The register will be cleared whenever a new command is written to the register MSC_CMD.

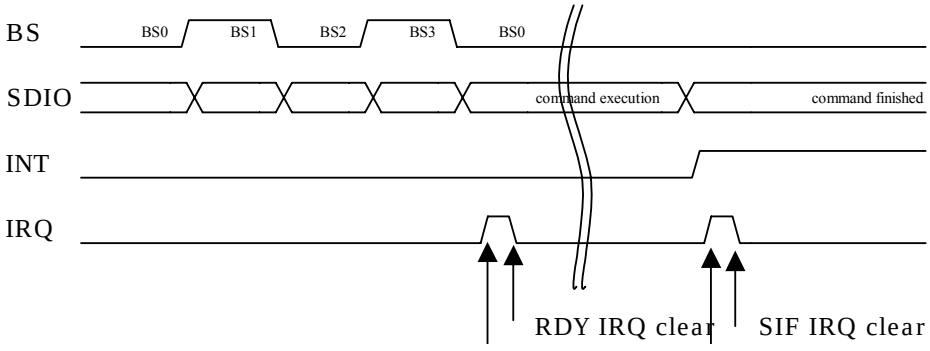
RDY The register bit indicates the status of transaction on MS bus. The register bit will be cleared when writing to the command register MSC_CMD.

0 Otherwise.

1 A transaction on MS bus is ended.

SIF The register bit indicates the status of serial interface. If an interrupt is active on MS bus, the register bit will be active. Note the difference between the signal RDY and SIF. When parallel mode is enabled, the signal SIF will be active whenever any of the signal CED, ERR, BREQ and CMDNK is active. **In order to separate interrupts caused by the signals RDY and SIF, the register bit SIF will not become active until the register MSDC_INT is read once. That is, the sequence for detecting the register bit SIF by polling is as follows:**

1. Detect the register bit RDY of the register MSC_STA
2. Read the register MSDC_INT
3. Detect the register bit SIF of the register MSC_STA



0 Otherwise.

1 An interrupt is active on MS bus

TOER The register bit indicates if a BUSY signal timeout error takes place. When timeout error occurs, the signal BS will become logic low '0'. The register bit will be cleared when writing to the command register MSC_CMD.

0 No timeout error.

1 A BUSY signal timeout error takes place. The register bit RDY will also be active.

CRCER The register bit indicates if a CRC error occurs while receiving read data. The register bit will be cleared when writing to the command register MSC_CMD.

0 Otherwise.

1 A CRC error occurs while receiving read data. The register bit RDY will also be active.

HSRDY The register bit indicates the status of handshaking on MS bus. The register bit will be cleared when writing to the command register MSC_CMD.

0 Otherwise.

1 A Memory Stick card responds to a TPC by RDY.

CED The register bit is only valid when parallel mode is enabled. In fact, it's value is from DAT[0] when serial interface interrupt takes place. See Format Specification version 2.0 of Memory Stick Standard (Memory Stick PRO) for more details.

0 Command does not terminate.

1 Command terminates normally or abnormally.

ERR The register bit is only valid when parallel mode is enabled. In fact, it's value is from DAT[1] when serial interface interrupt takes place. See Format Specification version 2.0 of Memory Stick Standard (Memory Stick PRO) for more details.

0 Otherwise.

1 Indicate memory access error during memory access command.

BREQ The register bit is only valid when parallel mode is enabled. In fact, it's value is from DAT[2] when serial interface interrupt takes place. See Format Specification version 2.0 of Memory Stick Standard (Memory Stick PRO) for more details.

0 Otherwise.

1 Indicate request for data.

CMDNK The register bit is only valid when parallel mode is enabled. In fact, it's value is from DAT[3] when serial interface interrupt takes place. See Format Specification version 2.0 of Memory Stick Standard (Memory Stick PRO) for more details.

0 Otherwise

1 Indicate non-recognized command.

7.5.4 Application Notes

7.5.4.1 Initialization Procedures After Power On

```
Disable power down control for MSDC module
```

Remember to power on MSDC module before starting any operation to it.

7.5.4.2 Card Detection Procedures

The pseudo code is as follows:

```
MSDC_CFG.PRCFG0 = 2’b10
MSDC_PS = 2’b11
MSDC_CFG.VDDPD = 1
if(MSDC_PS.PINCHG) { // card is inserted
     . . .
}
```

The pseudo code segment perform the following tasks:

1. First pull up CD/DAT3 (INS) pin.
2. Enable card detection and input pin at the same time.
3. Turn on power for memory card.
4. Detect insertion of memory card.

7.5.4.3 Notes on Commands

For MS, check if MSC_STA.RDY is ‘1’ before issuing any command.

For SD/MMC, if the command desired to be issued involves data line, for example, commands with data transfer or R1b response, check if SDC_STA.SDCBUSY is ‘0’ before issuing. If the command desired to be issued does not involve data line, only check if SDC_STA.CMDBUSY is ‘0’ before issuing.

7.5.4.4 Notes on Data Transfer

- For SD/MMC, if multiple-block-write command is issued then only issue STOP_TRANS command inter-blocks instead of intra-blocks.
- Once SW decides to issue STOP_TRANS commands, no more data transfer from or to the controller.

7.5.4.5 Notes on Frequency Change

Before changing the frequency of serial clock on MS/SD/MMC bus, it is necessary to disable serial interface of the controller. That is, set the register bit SIEN of the register SDC_CFG to ‘0’ for SD/MMC controller, and set the register bit SIEN of the register MSC_CFG to ‘0’ for Memory Stick controller. Serial interface of the controller needs to be enabled again before starting any operation to the memory card.

7.5.4.6 Notes on Response Timeout

If a read command doest not receive response, that is, it terminates with a timeout, then register SDC_DATSTA needs to be cleared by reading it. The register bit “DATTO” should be active. However, it may take a while before the register bit becomes active. The alternative is to send the STOP_TRANS command. However, this method will receive response with illegal-command information. Also, remember to check if the register bit SDC_STA.CMDBUSY is active before issuing the STOP_TRANS command. The procedure is as follows:

1. Read command => response time out
2. Issue STOP_TRANS command => Get Response
3. Read register SDC_DATSTA to clear it

7.5.4.7 Source or Destination Address is not word-aligned

It is possible that the source address is not word-aligned when data move from memory to MSDC. Similarly, destination address may be not word-aligned when data move from MSDC to memory. This can be solved by setting DMA byte-to-word functionality.

1. DMAn_CON.SIZE=0
2. DMAn_CON.BTW=1
3. DMAn_CON.BURST=2 (or 4)
4. DMAn_COUNT=byte number instead of word number
5. fifo threshold setting must be 1 (or 2), depending on DMAn_CON.BURST

Note n=4 ~ 11

7.5.4.8 Miscellaneous notes

- Siemens MMC card: When a write command is issued and followed by a STOP_TRANS command, Siemens MMC card will de-assert busy status even though flash programming has not yet finished. Software must use “Get Status” command to make sure that flash programming finishes.

7.6 2D acceleration

7.6.1 2D Engine

7.6.1.1 General Description

To enhance MMI display and gaming experiences, a 2D acceleration engine is implemented. It supports ARGB8888, RGB888, ARGB4444, RGB565 and 8-bpp color modes. Main features are listed as follows:

- Rectangle fill with color gradient.
- Bitblt: multi-Bitblt without transform, 7 rotate, mirror (transparent) Bitblt
- Alpha blending
- Binary ROP
- Line drawing: normal line, dotted line, anti-alias line
- Font caching: normal font, italic font
- Circle drawing or circle fill
- Quadratic Bezier curve drawing
- Triangle drawing
- Polygon fill with single color or image pattern

- Thick line drawing
- Specific output color replacement

MCU can program 2D engine registers via APB. However, MCU has to make sure that the 2D engine is not BUSY before any write to 2D engine registers occurs. An interrupt scheme is also provided for more flexibility.

A command parser is implemented for further offloading of MCU. The command queue can be randomly assigned in the system memory, with a maximum depth of 2047 commands. If the command queue is enabled, MCU has to check if the command queue has free space before writing to the command queue. Command queue parser will consume command queue entries upon 2D engine requests. **Figure 45** shows the command queue and 2D engine block diagram. Please refer to the graphic command queue functional specification for more details.

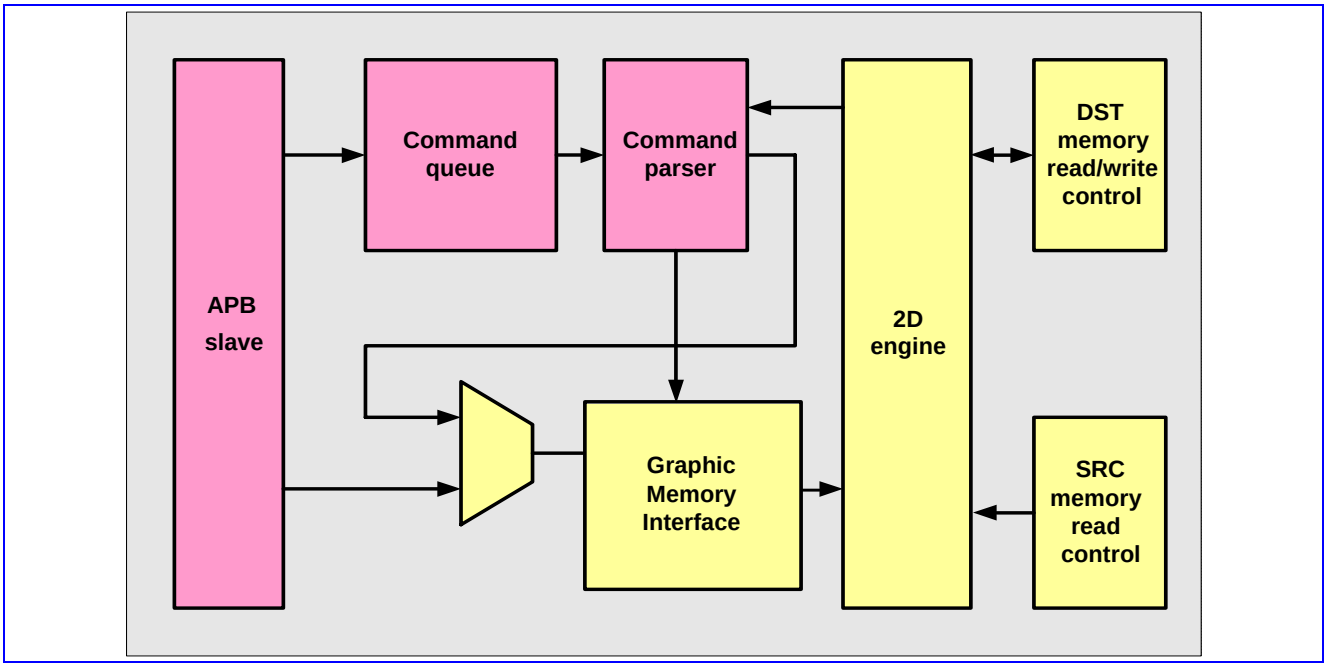


Figure 45 The command queue and 2D engine block diagram.

7.6.1.2 Features Introduction

7.6.1.2.1 2D Coordinate

The coordinates in the 2D engine are represented as 12-bit signed integers. The negative part is clipped during rendering. The maximum resolution can achieve 2047x2047 pixels. The programmed base address is mapped to the origin of the picture, which is illustrated in **Figure 46**.

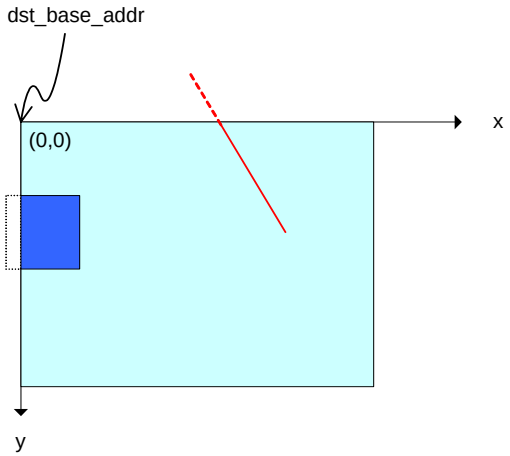


Figure 46 The coordinate of the 2D engine.

7.6.1.2.2 Color format

The 2D engine support the color format of 8bpp, RGB565, RGB888, ARGB4444, and ARGB 8888. The color formats of source and destination can be specified separately. Note that when using the 8bpp format, the source and destination color formats have to be the same, since table-lookup of color palette is not provided in 2D engine. Graphic modes of Bitblt, Bitblt with alpha blending, and Bitblt with binary ROP require color format setting for both source and destination. For other graphic modes, only destination color format needs to be specified. The possible settings are listed as **Table 35Table 36**.

Bitblt (Copy, ROP)	
Source color format	**Destination color format**
8bpp	8bpp
RGB565	RGB565
	RGB888
RGB888	RGB565
	RGB888
ARGB4444	ARGB4444
	ARGB8888
ARGB8888	ARGB4444
	ARGB8888

Table 35 source and destination color format setting for Bitblt.

Bitblt with Alpha Blending	
Source color format	**Destination color format**
8bpp	8bpp
RGB565	RGB565
	RGB888
RGB888	RGB565

	RGB888
ARGB4444	RGB565
	RGB888
ARGB8888	RGB565
	RGB888

Table 36 source and destination color format setting for alpha blending.

When source image is used, the source key function could be enabled or disabled. When enabled, the source color key is in the same format of source color. Be aware that the source key is still effective for alpha blending mode.

7.6.1.2.3 Clipping Window

The setting for clipping window is effective for all the 2D graphics. A pair of minimum and maximum boundary is applied on destination side. The portion outside the clipping window will not be drawn to the destination, but the pixels on the boundary will be kept. The clipping operation is illustrated in **Figure 47**.

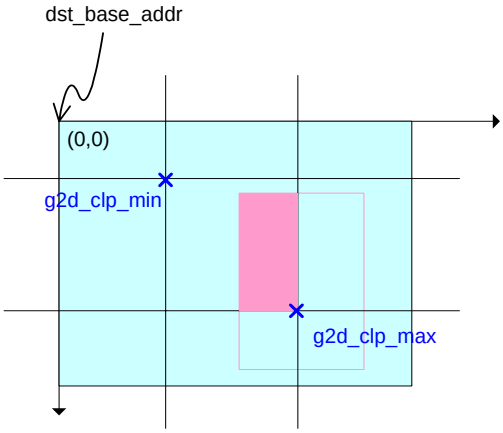


Figure 47 The clipping operation of the 2D engine.

7.6.1.2.4 Bitblt operation

The Bitblt function copies the pixels from source picture to destination. To be more flexible, 4 copy directions and 7 kinds of rotations are provided when doing Bitblt operation. **Figure 48** illustrates the Bitblt operation and required settings.

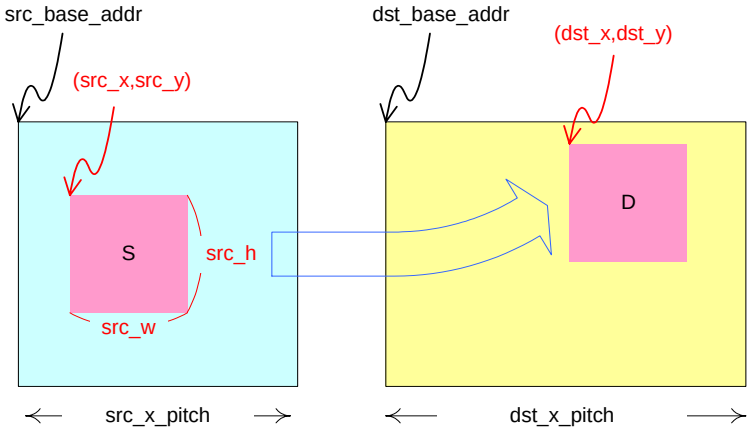


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Figure 48 The clipping operation of the 2D engine.

Note that the size of source and destination blocks can be different. If the source block is larger than destination block, the size of destination block is used instead of the source size. When source block size is smaller than destination block size, the pattern of source block is repeated horizontally and vertically in the destination block, which is illustrated as **Figure 49** below.

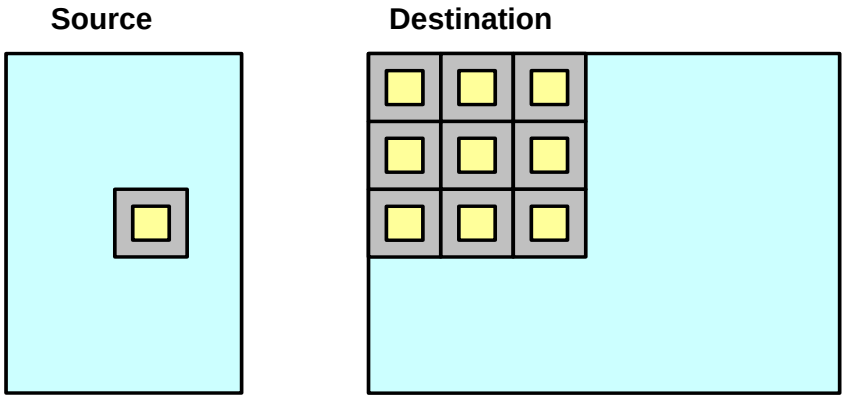


Figure 49 The Bitblt operation when destination size > source size.

7.6.1.2.4.1 Copy direction

When the source block and destination blocks are on the same picture, they may be overlapped by each other. To prevent error from occurring, 4 directions for Bitblt can be programmed. However, the copy direction shall not be enabled when doing rotation, or it will produce unwanted results. The 4 kinds of copy direction are shown in **Figure 50**.

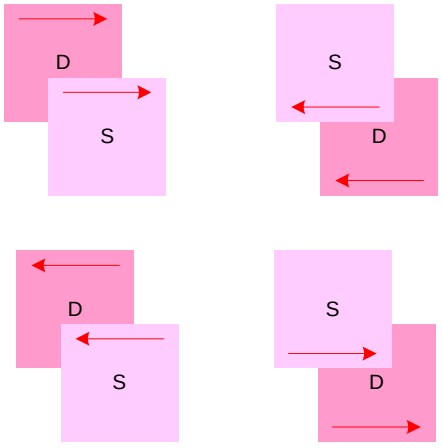


Figure 50 The 4 directions of Bitblt operation.

7.6.1.2.4.2 Rotation

To facilitate Bitblt operation, 7 kinds of rotation can be set at the same time. The rotation operation is illustrated as **Figure 51**. Here the rotation is done on the destination side, while the read sequence of pixels in source block is fixed.

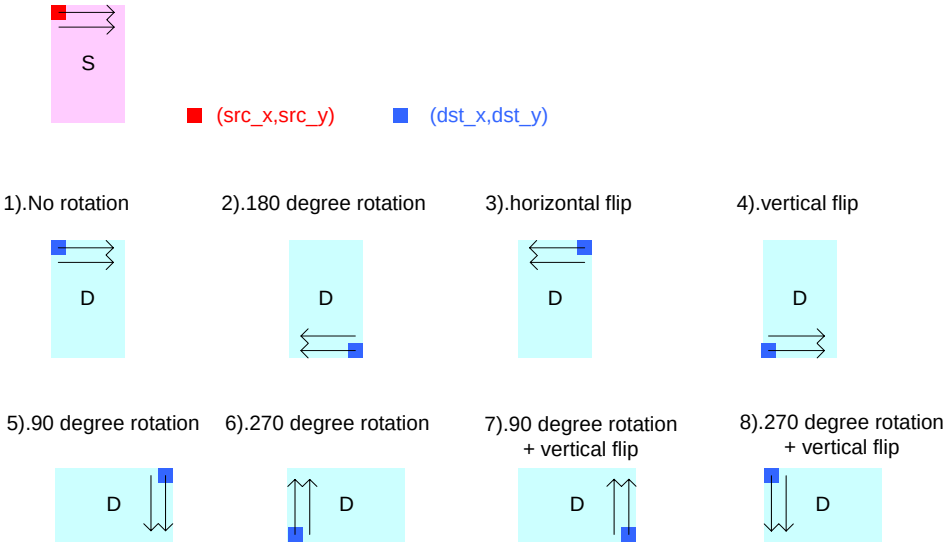


Figure 51 The rotations of Bitblt operation.

7.6.1.2.5 Bitblt with Alpha Blending

Similar to simple Bitblt operation, alpha blending function is provided as well. The pixels in source block are blended onto destination block. Blending is performed according the formula listed below:

$$C = (\text{alpha} * Cs + (255 - \text{alpha}) * Cd)/255,$$

where Cs is the source color, Cd is the destination color, and alpha is an unsigned integer range from 0 to 255.

The alpha value programmed into the 2D control registers is called constant alpha. When no alpha channel exists, the constant alpha is used to calculate blended color. If the alpha channel exists (in ARGB color mode), the per-pixel alpha is used for blending operation instead of constant alpha.

In addition, the setting of copy directions and rotations are also effective for alpha blending mode. Also, the size and color format of source block can be different from destination.

7.6.1.2.6 Bitblt with Binary ROP

The ROP (Raster Operation) is another block-wise functional mode. Here the 2D engine provides a set of binary ROPs. The ROP code has 16 different combinations, which is listed in the definition of 2D control registers --- G2D_SMODE_CON. Please see sec.7.6.1.3 for detail descriptions.

Similar with other block-wise functions, the copy directions and rotations are also applicable in ROP mode. The size and color format of source and destination do not need to be the same.

7.6.1.2.7 Rectangle Fill with Color Gradient

Rectangle fill mode provides the configurations for color gradient for both x-direction and y-direction. Each of the color gradient of component A, R, G, B is represented by 9.16 signed fixed point number. In order to prevent color crossing the boundary of 0 and 255, it is clipped to 0 and 255 when performing gradient fill. When the color gradient is disabled, the rectangle is filled by one color. An example of gradient fill is shown in **Figure 52**.

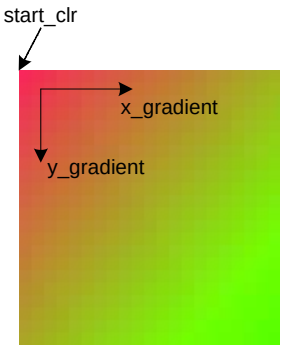


Figure 52 Rectangle gradient fill.

7.6.1.2.8 Line Draw

The line drawing function is implemented with the mid-point algorithm. Given the two endpoints of a line, the points on the line are calculated recursively. The line anti-aliasing is also supported but it requires extra register configurations. In addition, dotted line is also provided for use. Simultaneously turning on anti-aliasing and dotted-line is not recommended since the line may result in a strange look.

7.6.1.2.9 Circle Draw

The circle drawing is quite similar with line drawing, using the mid-point algorithm as well. A center point and a radius have to be programmed into 2D control registers. There are 4 enable bits for each quadrant of a circle, each determines whether the arcs shall be rendered or not. The setting of circle drawing is illustrated in **Figure 53**.

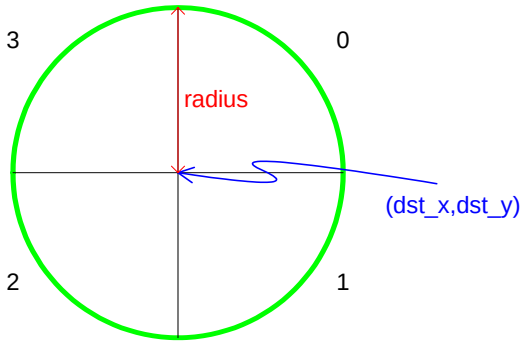


Figure 53 Circle drawing.

7.6.1.2.10 Bezier curve

The quadratic Bezier curve is implemented, too. The quadratic Bezier curve is defined by three control points, as illustrated in **Figure 54**. The Bezier curve drawing is implemented with subdivision method. The amount of subdivisions is programmed by software. The curve gets more detailed with the increase of subdivision factor, but it requires more memory and computing time. To be more precise, doing n times of subdivision needs a buffer of $2^{(n+1)} * 4$ bytes.

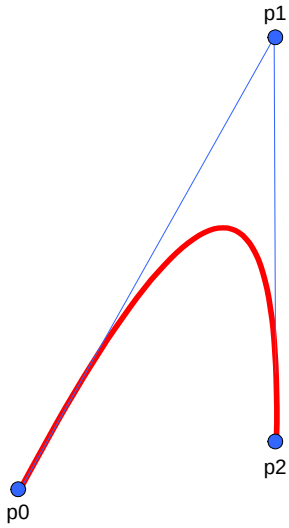


Figure 54 Bezier curve.

7.6.1.2.11 Triangle Flat Fill

The 2D engine supports the function of triangle flat fill with the help of software. First, the software divides the triangle into upper plane and lower plane and passes them to hardware individually. Given the starting vertex's coordinate and the slopes of left and right edges, the 2D hardware fills the horizontal segments between the two edges until the horizontal end is reached. The slope of each edge is in 12.16 bit signed fix-point representation. The programming of triangle drawing is illustrated in **Figure 55**.

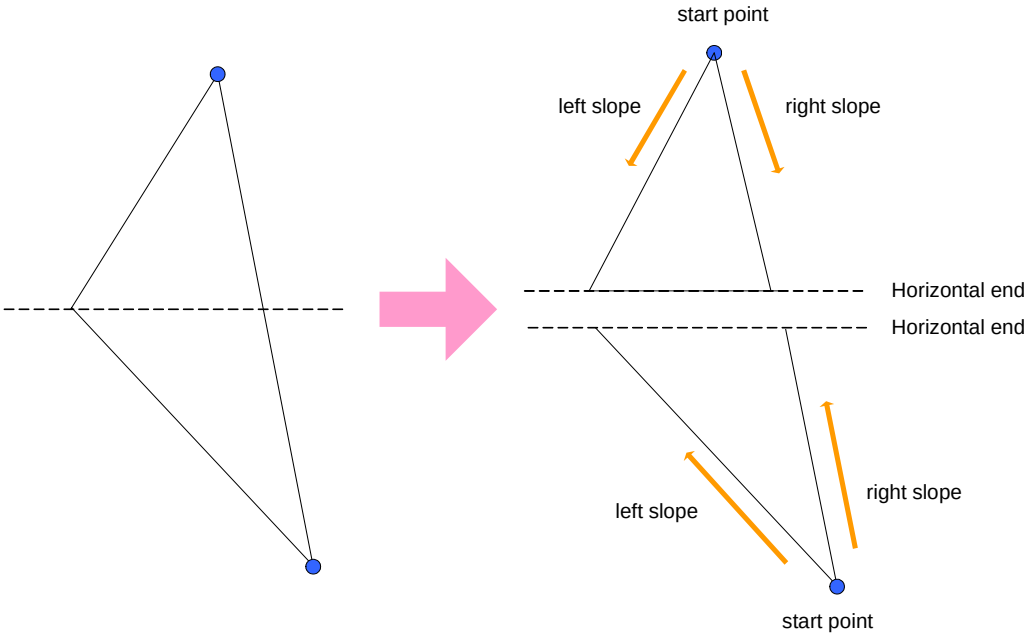


Figure 55 Triangle drawing.

7.6.1.2.12 Font Drawing

The 2D engine helps to render fonts stored in one-bit-per-pixel format. It expends the zero bits to background color and expands one bits to foreground color. The background color can be set as transparent. The font drawing can be programmed as tilt, when given each line's tilt value.

The start bit of font drawing can be non-byte aligned to save memory usage for font caching. In addition, the rotations can be performed at the same time when drawing fonts.

7.6.1.2.13 Polygon Fill

In MT6511, 2D engine supports the function of polygon fill with its edges specified in memory. The maximum number of edge is 2047, which will occupy 32KB memory space (16 bytes per edge) during polygon fill processing. Software need to indicate the starting address of input edge list by setting G2D_BUF_STA_ADDR_0 and allocate another memory space for the polygon fill processing by setting G2D_BUF_STA_ADDR_1. It's noted that filling a polygon with a list of cross edges will cause an un-expected result. Dividing this kind of polygon into several ones without cross edges is recommended. Polygon fill with image is also supported. The maximum image pattern size is 64x64 which is needed to be put in memory starting from BUF_STA_ADDR_2.

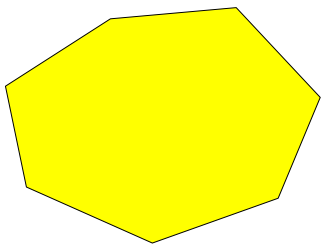


Figure 56 Polygon fill.

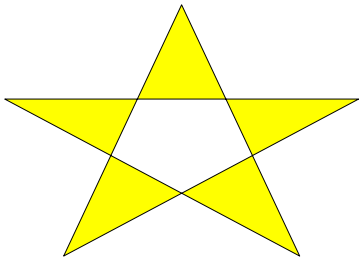


Figure 57 Cross edges. Divide into 1 - 5 triangles is recommended.

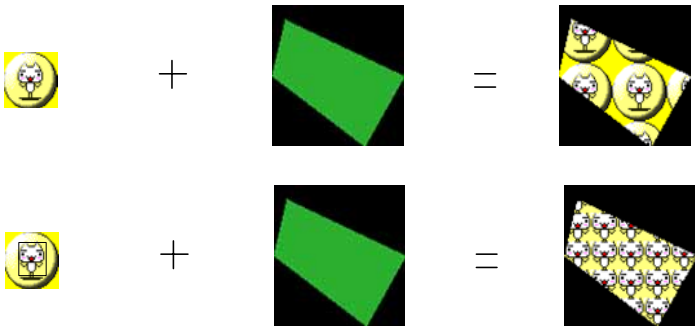


Figure 14 Polygon fill with image pattern.

7.6.1.2.14 Thick Line Drawing

2D engine line drawing with thickness, i.e. thick line drawing. The two end caps of the thick line could be selected as round type or flat (no end cap). Line pattern is also supported in thick line drawing mode. No end cap would be added in patterned thick line.

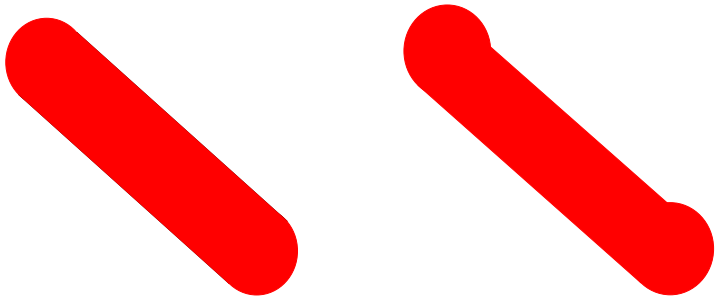


Figure 16 Thick Line Drawing, odd thickness and even thickness.

7.6.1.3 Register Definitions

Table 37 The 2D engine register mapping. summarizes the 2D engine register mapping on APB and through command queue. The base address of 2D engine is 80670000h.

APB Address	CMQ mapped Address	Register Function	Acronym
G2D+0100h	100h	2D engine fire mode control register	**FMODE_CON**
	102h	Reserved	
G2D+0104h	104h	2D Engine sub-mode control lower register	**SMODE_CON_L**
	106h	2D Engine sub-mode control higher register	**SMODE_CON_H**
G2D+0108h	108h	2D engine common control register	**COM_CON**
	10Ah	Reserved	
G2D+0110h	110h	2D engine status register	**STA**
	112h	Reserved	
G2D+0200h	200h	Source base address lower hword register	**SRC_BASE_L**
	202h	Source base address higher hword register	**SRC_BASE_H**
G2D+0204h	204h	Source pitch register	**SRC_PITCH**
	206h	Reserved	
G2D+0208h	208h	Source y coordinate register	**SRC_Y**
	20Ah	Source x coordinate register	**SRC_X**
G2D+020Ch	20Ch	Source height register	**SRC_H**
	20Eh	Source width register	**SRC_W**
G2D+0210h	210h	Source color key lower hword register	**SRC_KEY_L**
	212h	Source color key lower hword register	**SRC_KEY_H**

G2D+0300h	300h	Destination base address lower hword register	**DST_BASE_L**
	302h	Destination base address higher hword register	**DST_BASE_H**
G2D+0304h	304h	Destination Pitch Register	**DST_PITCH**
	306h	Reserved	
G2D+0308h	308h	Destination y coordinate register 0	**DST_Y0**
	30Ah	Destination x coordinate register 0	**DST_X0**
G2D+030Ch	30Ch	Destination y coordinate register 1	**DST_Y1**
	30Eh	Destination x coordinate register 1	**DST_X1**
G2D+0310h	310h	Destination y coordinate register 2	**DST_Y2**
	312h	Destination x coordinate register 2	**DST_X2**
G2D+0318h	318h	Destination height register	**DST_H**
	31Ah	Destination width register	**DST_W**
G2D+320	320h	Pattern width and height register	**PAT_WH**
	322h	Pattern x and y offset register	**PAT_XY**
G2D+324	324h	Pattern pitch Register	**PAT_PITCH**
G2D+400h	400h	Foreground color lower hword register	**FGCLR_L**
	402h	Foreground color lower hword register	**FGCLR_H**
G2D+404h	404h	Background color lower hword register	**BGCLR_L**
	406h	Background color lower hword register	**BGCLR_H**
G2D+408h	408h	Clipping minimum y coordinate register	**CLP_MIN_Y**
	40Ah	Clipping minimum x coordinate register	**CLP_MIN_X**
G2D+40Ch	40Ch	Clipping maximum y coordinate register	**CLP_MAX_Y**
	40Eh	Clipping maximum x coordinate register	**CLP_MAX_X**
G2D+410h	410h	Rectangle color gradient of alpha componet x lower hword register	**ALPGR_X_L**
	412h	Rectangle color gradient of alpha componet x higher hword register	**ALPGR_X_H**
G2D+414h	414h	Rectangle color gradient of red component y lower hword register	**REDGR_X_L**
	416h	Rectangle color gradient of red component y higher hword register	**REDGR_X_H**
G2D+418h	418h	Rectangle color gradient of green component x lower hword register	**GREENGR_X_L**
	41Ah	Rectangle color gradient of green component x higher hword register	**GREENGR_X_H**
G2D+41Ch	41Ch	Rectangle color gradient of blue component x lower hword register	**BLUEGR_X_L**
	41Eh	Rectangle color gradient of blue component x higher hword register	**BLUE_X_H**
G2D+420h	420h	Rectangle color gradient of alpha component y lower hword register	**ALPGR_Y_L**
	422h	Rectangle color gradient of alpha component y	**ALPGR_Y_H**

		higher hword register	
G2D+424h	424h	Rectangle color gradient of red component y lower hword register	REDGR_Y_L
	426h	Rectangle color gradient of red component y higher hword register	REDGR_Y_H
G2D+428h	428h	Rectangle color gradient of green component y lower hword register	GREENGR_Y_L
	42Ah	Rectangle color gradient of green component y higher hword register	GREENGR_Y_H
G2D+42Ch	42Ch	Rectangle color gradient of blue component y lower hword register	BLUEGR_Y_L
	42Eh	Rectangle color gradient of blue component y higher hword register	BLUEGR_Y_H
G2D+430h	430h	Buffer 0 start address lower hword register	BUF_STA_ADDR_0_L
	432h	Buffer 0 start address higher hword register	BUF_STA_ADDR_0_H
G2D+434h	434h	Buffer 1 start address lower hword register	BUF_STA_ADDR_1_L
	436h	Buffer 1 start address higher hword register	BUF_STA_ADDR_1_H
G2D+438h	438h	Buffer 2 start address lower hword register	BUF_STA_ADDR_2_L
	43Ah	Buffer 2 start address higher hword register	BUF_STA_ADDR_2_H
G2D+0700h ~ G2D+071Fh	700h ~ 71Fh		TILT_0300 ~ TILT_1F1C

Table 37 The 2D engine register mapping.

There are several function modes in 2D graphics engine. Some registers are shared between different them. **Table 38** summarizes the settings under different function modes.

APB Address	CMQ Address	Rectangle fill	Bitblt Operations	Line/Circle drawing	Bezier curve drawing	Triangle drawing	Font caching
G2D+0200h	200h		SRC_BASE			SLOPE_L	SRC_BASE
G2D+0204h	204h		SRC_PITCH				
G2D+0208h	208h		SRC_XY				
G2D+020Ch	20Ch		SRC_SIZE				
G2D+0210h	210h		SRC_KEY				SRC_KEY
G2D+0214h	214h	AVO_CLR	AVO_CLR	AVO_CLR	AVO_CLR	AVO_CLR	AVO_CLR
G2D+0218h	218h	REP_CLR	REP_CLR	REP_CLR	REP_CLR	REP_CLR	REP_CLR
G2D+0300h	300h	DST_BASE	DST_BASE	DST_BASE	DST_BASE	DST_BASE	DST_BASE
G2D+0304h	304h	DST_PITCH	DST_PITCH	DST_PITCH	DST_PITCH	DST_PITCH	DST_PITCH
G2D+0308h	308h	DST_XY	DST_XY	DST_XY0	DST_XY0	DST_XY_START	DST_XY

G2D+030Ch	30Ch			**DST_XY1/ RADIUS**	**DST_XY1**	**DST_Y_END**	
G2D+0310h	310h				**DST_XY2**		
G2D+0318h	318h	**DST_SIZE**	**DST_SIZE**				**DST_SIZE**
G2D+0320h	320h						
G2D+0324h	324h						
G2D+0400h	400h	**START_CLR**		**FGCLR**	**FGCLR**	**FGCLR**	**FGCLR**
G2D+0404h	404h		**DST_KEY**	**XY_SQRT**			**BGCLR**
G2D+0408h	408h	**CLP_MIN**	**CLP_MIN**	**CLP_MIN**	**CLP_MIN**	**CLP_MIN**	**CLP_MIN**
G2D+040Ch	40Ch	**CLP_MAX**	**CLP_MAX**	**CLP_MAX**	**CLP_MAX**	**CLP_MAX**	**CLP_MAX**
G2D+0410h	410h	**ALPGD_X**					
G2D+0414h	414h	**RED_GD_X**			**SUBDIV_TIME**		
G2D+0418h	418h	**GREEN_GD_X**					
G2D+041Ch	41Ch	**BLUE_GD_X**					
G2D+0420h	420h	**ALPGD_Y**					
G2D+0424h	424h	**RED_GD_Y**					
G2D+0428h	428h	**GREEN_GD_Y**					
G2D+042Ch	42Ch	**BLUE_GD_Y**					
G2D+430h	430h				**BUF_STA_ADD**	**SLOPE_R**	
G2D+434h	434h						
G2D+438h	438h						
G2D+0700h ~ G2D+071Fh	700h ~ 71Fh	**TILT_0300 ~ TILT_1F1C**	**TILT_0300 ~ TILT_1F1C**				**TILT_0300 ~ TILT_1F1C**

APB Address	**CMQ Address**	**Horizontal Line Gradient**	**Horizontal Line Copy with Mask**	**Polygon Fill with Image Pattern**	**Thick Line Drawing**		
G2D+0200h	200h		**SRC_BASE**				
G2D+0204h	204h						
G2D+0208h	208h						
G2D+020Ch	20Ch		**SRC_SIZE**				
G2D+0210h	210h						
G2D+0214h	214h	**AVO_CLR**	**AVO_CLR**	**AVO_CLR**	**AVO_CLR**		
G2D+0218h	218h	**REP_CLR**	**REP_CLR**	**REP_CLR**	**REP_CLR**		
G2D+0300h	300h	**DST_BASE**	**DST_BASE**	**DST_BASE**	**DST_BASE**		
G2D+0304h	304h			**DST_PITCH**	**DST_PITCH**		
G2D+0308h	308h				**DST_XY0**		
G2D+030Ch	30Ch				**DST_XY1**		
G2D+0310h	310h						

G2D+0318h	318h	**DST_SIZE**	**DST_SIZE**				
G2D+320h	320h			**PAT_XYWH**			
G2D+324h	324h			**PAT_PITCH**			
G2D+0400h	400h	**START_CLR**		**FG_CLR**	**FG_CLR**		
G2D+0404h	404h						
G2D+0408h	408h			**CLP_MIN**	**CLP_MIN**		
G2D+040Ch	40Ch			**CLP_MAX**	**CLP_MAX**		
G2D+0410h	410h	**ALPGD_X**					
G2D+0414h	414h	**RED_GD_X**					
G2D+0418h	418h	**GREEN_GD_X**			**TLINE_CON**		
G2D+041Ch	41Ch	**BLUE_GD_X**					
G2D+0420h	420h						
G2D+0424h	424h						
G2D+0428h	428h						
G2D+042Ch	42Ch						
G2D+430h	430h		**MASK_BASE**	**EDGE_ADDR**	**EDGE_ADDR**		
G2D+434h	434h			**SORT_ADDR**	**SORT_ADDR**		
G2D+438h	438h			**PAT_ADDR**			
G2D+0700h ~ G2D+071Fh	700h ~ 71Fh						

Table 38 2D engine common registers

Below shows common control registers.

G2D+0100h Graphic 2D Engine Fire Mode Control Register — G2D_FMODE_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					SRC_CLR_MODE				DST_CLR_MODE				G2D_ENG_MODE			
Type					R/W				R/W				R/W			
Reset					000				000				0000			

Write this register will fire the 2D engine according to the CLR_MODE and ENG_MODE field.

SRC_CLR_MODE source color mode

- **000** 8-bpp, LUT disabled
- **001** 16-bpp, RGB 565 format
- **010** 32-bpp, ARGB 8888 format
- **011** 24-bpp, RGB 888 format
- **101** 16-bpp, ARGB 4444 format
- **others** reserved

DST_CLR_MODE destination color mode

- **000** 8-bpp, LUT disabled
- **001** 16-bpp, RGB 565 format

010 32-bpp, ARGB 8888 format
011 24-bpp, RGB 888 format
101 16-bpp, ARGB 4444 format
others reserved

G2D_ENG_MODE 2D engine function mode
0000 Line draw.
0001 Circle draw.
0010 Bezier curve draw.
0011 Triangle fill.
0110 Polygon fill.
0111 Thick line mode.
1000 Rectangle fill.
1001 Bitblt.
1010 Bitblt with alpha blending.
1011 Bitblt with ROP.
1100 Font drawing.
1101 Horizontal line fill with color gradient. In this mode, the source key and the clipping functions are disabled automatically.
1110 Horizontal line copy with mask. In this mode, the source key and the clipping functions are disabled automatically.
others not allowed

G2D+0104h Graphic 2D Engine Sub-mode Control Register — G2D_SMODE_CON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	FITA	FNBG	FMSB_FIRST		CLR_REP_EN	CF_EN			ALPHA				ROP_CODE			
Type	R/W	R/W	R/W		R/W	R/W			R/W				R/W			
Reset	0	0	0		0	0			0000				0000			
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					LDOT		LIMG	LAA_EN	DST_KEY_EN	CLRGD_EN	BDIR		BITA	BROT		
Type					R/W		R/W	R/W	R/W	R/W	R/W		R/W	R/W		
Reset					0		0	0	0	0	11		0	111		

Write this register to set the 2D engine configuration.

FITA font italic enabled.
FNBG font drawing with no background color
FMSB_FIRST font drawing from most significant bit
CLR_REP_EN Output color replacement enable.
CF_EN Circle fill enabled.
ALPHA Bit 7-4 of constant alpha value. ROP_CODE is Bit3-0 of constant alpha value.
ROP_CODE Binary ROP code. Bits 2-0 are also used to specify the start bit position for Font drawing and enabled arcs for circle drawing.

Bitblt ROP Code	Boolean Function	Start Bit Position for Font Drawing	Enabled Arcs
0000	0 (Black)	Bit 0	None
0001	~(S + D)	Bit 1	Ⅰ
0010	~S . D	Bit 2	Ⅱ
0011	~S	Bit 3	Ⅰ, Ⅱ
0100	S . ~D	Bit 4	Ⅲ
0101	~D	Bit 5	Ⅰ, Ⅲ
0110	S ^ D	Bit 6	Ⅱ, Ⅲ
0111	~(S . D)	Bit 7	Ⅰ,Ⅱ, Ⅲ
1000	S . D	Bit 0	Ⅳ
1001	~(S ^ D)	Bit 1	Ⅰ, Ⅳ
1010	D	Bit 2	Ⅱ, Ⅲ
1011	~S + D	Bit 3	Ⅰ, Ⅱ, Ⅳ
1100	S	Bit 4	Ⅲ, Ⅳ
1101	S + ~D	Bit 5	Ⅰ, Ⅲ, Ⅳ
1110	S + D	Bit 6	Ⅱ, Ⅲ, Ⅳ
1111	1 (White)	Bit 7	Ⅰ, Ⅱ, Ⅲ, Ⅳ

S = Source, D = Destination.

Ⅰ = first quadrant, II = second quadrant, III = third quadrant, IV = fourth quadrant.

LIMG Polygon fill with image pattern.

LDOT line dotted

LAA_EN line anti-aliasing enabled

DST_KEY_EN Destination key enabled for Bitblt functions

CLRGR_EN Color gradient enabled for rectangle fill

BDIR Bitblt direction:

00 from lower right corner

01 from lower left corner

10 from upper right corner

11 from upper left corner

This field only takes effect when the Bitblt rotation is set as none (111). When doing rotation the Bitblt direction of source image is always from upper left corner.

BITA Bitblt italic enabled, using the tilt value defined in G2D_TILT_00 ~ G2D_TILT_1F registers. The tilt function should not be enabled in Alpha Blending and ROP mode.

BROT Bitblt rotation:

000 mirror then rotate 90

001 rotate 90

010 rotate 270

011 mirror then rotate 270

100 rotate 180

101 mirror
110 mirror then rotate 180
111 none

G2D+0108h Graphic 2D Engine Common Control Register G2D_COM_CON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name														CLP_EN	SRCKEY_EN	RST
Type														R/W	R/W	R/W
Reset														0	0	0

Write this register to set the 2D engine configuration.

RST 2D engine reset, only the state machine is reset, the content of control registers will not be reset.
SRCKEY_EN Source key enabled.
CLP_EN Clipping enabled.

G2D+010Ch Graphic 2D Engine Interrupt Control Register G2D_IRQ_CON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																EN
Type																R/W
Reset																0

Write this register to set the 2D engine IRQ configuration.

EN interrupt enable. The interrupt is negative edge sensitive.

G2D+0110h Graphic 2D Engine Common Status Register G2D_COM_STA

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																BUSY
Type																RO
Reset																0

Read this register to get the 2D engine status. 2D engine may function abnormally if any 2D engine register is modified when BUSY.

BUSY 2D engine is busy

G2D+0200h Graphic 2D Source Base Address Register G2D_SRC_BASE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SRC_BASE[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SRC_BASE[15:0]															
Type	R/W															
Reset	0															

SRC_BASE The base address of source image. Also, this field is used for the slope of the left triangle edges represented in 12.16 format.

G2D+0204h Graphic 2D Engine Source Pitch Register G2D_SRC_PITCH

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					SRC_PITCH											
Type					R/W											
Reset					0											

SRC_PITCH The width of source image in the unit of pixels.

G2D+0208h Graphic 2D Engine Source X and Y Register G2D_SRC_XY

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name					SRC_X											
Type					R/W											
Reset					0											
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					SRC_Y											
Type					R/W											
Reset					0											

SRC_Y The starting y co-ordinate of source image. It must be positive although represented as 12-bit signed integer.
SRC_X The starting x co-ordinate of source image. It must be positive although represented as 12-bit signed integer.

G2D+020Ch Graphic 2D Engine Source Size Register G2D_SRC_SIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name					SRC_W											
Type					R/W											
Reset					0											
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					SRC_H											
Type					R/W											
Reset					0											

SRC_H The source height for Bitblt, alpha blending and ROP. It must be positive although represented as 12-bit signed integer.
SRC_W The source width for Bitblt, alpha blending and ROP. It must be positive although represented as 12-bit signed integer.

G2D+0210h Graphic 2D Engine Source Color Key Register G2D_SRC_KEY

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	SRC_KEY[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SRC_KEY[15:0]															
Type	R/W															
Reset	0															

SRC_KEY The source color key. The color will be transparent if color keying is enabled.

G2D+0214h Graphic 2D Engine Destination Avoidance Color G2D_DST_AVO_CLR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DST_AVO_CLR[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DST_AVO_CLR[15:0]															
Type	R/W															
Reset	0															

DST_AVO_CLR The output color with DST_AVO_CLR would be replaced with DST_REP_CLR when CLR_REP_EN is enabled.

G2D+0218h Graphic 2D Engine Destination Replacement Color G2D_DST_REP_CLR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DST_REP_CLR[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DST_REP_CLR[15:0]															
Type	R/W															
Reset	0															

DST_REP_CLR The output color with DST_AVO_CLR would be replaced with DST_REP_CLR when CLR_REP_EN is enabled.

G2D+0300h Graphic 2D Destination Base Address Register G2D_DST_BASE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DST_BASE[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DST_BASE[15:0]															

Type	R/W
Reset	0

DST_BASE The base address of destination image.

G2D+0304h Graphic 2D Engine Destination Pitch Register G2D_DST_PITCH

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					SRC_PITCH											
Type					R/W											
Reset					0											

DST_PITCH The width of destination image in the unit of pixels.

G2D+0308h Graphic 2D Engine Destination X and Y Register 0 G2D_DST_XY0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name					DST_X0											
Type					R/W											
Reset					0											
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					DST_Y0											
Type					R/W											
Reset					0											

(DST_X0 , DST_Y0) is used as the starting co-ordinate in Bitblt, alpha blending, ROP, and font drawing mode. In line mode or triangle fill mode, it is used as one end point. For Bezier curve drawing, it is one of the control points. While in circle drawing mode, it is the center of the circle. Also this filed is used as the starting point of triangle draw.

DST_X0 Represented by 12-bit signed integer. Negative co-ordinate is allowed.
DST_Y0 Represented by 12-bit signed integer. Negative co-ordinate is allowed.

G2D+030Ch Graphic 2D Engine Destination X and Y Register 1 G2D_DST_XY1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name					DST_X1											
Type					R/W											
Reset					0											
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					DST_Y1											
Type					R/W											
Reset					0											

(DST_X1 , DST_Y1) is used as one end point in Line drawing and triangle fill mode. For Bezier curve drawing, it is one of the control points. While in circle drawing mode, DST_X1 must be positive since it is the radius of the circle. Also, Bit 15-0 is used as the vertical end of triangle draw.

DST_X1 Represented by 12-bit signed integer. Negative co-ordinate is allowed.
DST_Y1 Represented by 12-bit signed integer. Negative co-ordinate is allowed.

G2D+0310h Graphic 2D Engine Destination X and Y Register 2 G2D_DST_XY2

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name					DST_X2											
Type					R/W											

Reset					0											
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					DST_Y2											
Type					R/W											
Reset					0											

(DST_X2 , DST_Y2) is used as one end point in triangle fill mode. For Bezier curve drawing, it is one of the control points.

DST_X2 Represented by 12-bit signed integer. Negative co-ordinate is allowed.
DST_Y2 Represented by 12-bit signed integer. Negative co-ordinate is allowed.

G2D+0318h Graphic 2D Engine Destination Size Register G2D_DST_SIZE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name					DST_W											
Type					R/W											
Reset					0											
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					DST_H											
Type					R/W											
Reset					0											

SRC_H The source height for Bitblt, alpha blending and ROP. It must be positive although represented as 12-bit signed integer.
SRC_W The source width for Bitblt, alpha blending and ROP. It must be positive although represented as 12-bit signed integer.

G2D+0320h Graphic 2D Engine Pattern X Y W H Register G2D_PAT_XYWH

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name			PAT_X								PAT_Y					
Type			R/W								R/W					
Reset			0								0					
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			PAT_W								PAT_H					
Type			R/W								R/W					
Reset			0								0					

PAT_X The starting x co-ordinate of pattern image for Polygon-Fill.
PAT_Y The starting y co-ordinate of pattern image for Polygon-Fill.
PAT_W The pattern width for Polygon-Fill.
PAT_H The pattern height for Polygon-Fill.

G2D+0324h Graphic 2D EnginePattern Pitch Register G2D_PAT_PITCH

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											PAT_PITCH					

Type											R/W
Reset											0

PAT_PITCH The width of pattern in the unit of pixels. The maximum width of pattern is 32.

G2D+0400h Graphic 2D Engine Foreground Color Register G2D_ FGCLR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	FGCLR[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	FGCLR[15:0]															
Type	R/W															
Reset	0															

FGCLR The foreground color used for line/circle drawing and font drawing. It is also the start color of rectangle fill. The format of foreground color depends on the source color mode set in G2D_FMODE_CON register.

G2D+0404h Graphic 2D Engine Background Color Register G2D_BGCLR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	BGCLR[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BGCLR[15:0]															
Type	R/W															
Reset	0															

BGCLR The background color of the source. The format of background color depends on the source color mode set in G2D_FMODE_CON register. Bit 15-0 also used as the **XY_SQRT** for anti-aliased line drawing. The XY_SQRT calculation is listed as bellow.

$$XY_SQRT = 2 * \sqrt{(DST_X1 - DST_X0)^2 + (DST_Y1 - DST_Y0)^2}$$

G2D+0408h Graphic 2D Engine Clipping Minimum Register G2D_CLIP_MIN

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name						CLIP_MIN_X										
Type						R/W										
Reset						0										
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name						CLIP_MIN_Y										
Type						R/W										
Reset						0										

CLIP_MIN_X The minimum value of x co-ordinate in clipping window, signed 12-bit integer.

CLIP_MIN_Y The minimum value of y co-ordinate in clipping window, signed 12-bit integer..

G2D+040ch Graphic 2D Engine Clipping Maximum Register G2D_CLIP_MAX

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name						CLIP_MAX_X										
Type						R/W										

Reset						11111111111										
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name						CLIP_MAX_Y										
Type						R/W										
Reset						11111111111										

CLIP_MAX_X The maximum value of x co-ordinate in clipping window, signed 12-bit integer...

CLIP_MAX_Y The maximum value of y co-ordinate in clipping window, signed 12-bit integer..

G2D+0410h Graphic 2D X Alpha Gradient Register G2D_ALPGR_X

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name								ALPHA_GR_X[24:16]								
Type								R/W								
Reset								0								
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ALPHA_GR_X[15:0]															
Type	R/W															
Reset	0															

The color gradient of alpha in x direction for rectangle gradient fill.

ALPHA_GR_X The color gradient of alpha channel, represented in signed 9.16 format.

G2D+0414h Graphic 2D X Red Gradient Register G2D_REDGR_X

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name								RED_GR_X[24:16]								
Type								R/W								
Reset								0								
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RED_GR_X[15:0]															
Type	R/W															
Reset	0															

The color gradient of red in x direction for rectangle gradient fill. Bit 3-0 also used as the times of subdivision for Bezier curve drawing.

RED_GR_X The color gradient of red component, represented in signed 9.16 format.

G2D+0418h Graphic 2D X Green Gradient Register G2D_GREENGR_X

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name								GREEN_GR_X[24:16]								
Type								R/W								
Reset								0								
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GREEN_GR_X[15:0]															
Type	R/W															
Reset	0															

GREEN_GR_X The color gradient of blue component, represented in signed 9.16 format.

GREEN_GR_X[15] Enable thick line pattern.

GREEN_GR_X[14] Thick line starting point cap drawing enable.

GREEN_GR_X[13] Thick line end point cap drawing enable.

GREEN_GR_X[12] Thickness error auto compensation enable.

GREEN_GR_X[11] Adjusted polygon fill algorithm for thick line drawing.

GREEN_GR_X[10:0] Thickness of the thick line.

G2D+041Ch Graphic 2D X Blue Gradient Register G2D_BLUEGR_X

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name								BLUE_GR_X[24:16]								
Type								R/W								
Reset								0								
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BLUE_GR_X[15:0]															
Type	R/W															
Reset	0															

BLUE_GR_X The color gradient of blue component, represented in signed 9.16 format.

G2D+0420h Graphic 2D Y Alpha Gradient Register G2D_ALPGR_Y

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name								ALPHA_GR_Y[24:16]								
Type								R/W								
Reset								0								
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ALPHA_GR_Y[15:0]															
Type	R/W															
Reset	0															

The color gradient of alpha in x direction for rectangle gradient fill.

ALPHA_GR_Y The color gradient of alpha channel, represented in signed 9.16 format.

G2D+0424h Graphic 2D Y Red Gradient Register G2D_REDGR_Y

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name								RED_GR_Y[24:16]								
Type								R/W								
Reset								0								
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RED_GR_Y[15:0]															
Type	R/W															
Reset	0															

The color gradient of red in x direction for rectangle gradient fill.

RED_GR_Y The color gradient of red component, represented in signed 9.16 format.

G2D+0428h Graphic 2D Y Green Gradient Register G2D_GREENGR_Y

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name								GREEN_GR_Y24:16]								
Type								R/W								
Reset								0								
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name	GREEN_GR_Y15:0]
Type	R/W
Reset	0

GREEN_GR_Y The color gradient of blue component, represented in signed 9.16 format.

G2D+042Ch Graphic 2D Y Blue Gradient Register G2D_BLUEGR_Y

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name								BLUE_GR_Y[24:16]								
Type								R/W								
Reset								0								
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BLUE_GR_Y[15:0]															
Type	R/W															
Reset	0															

BLUE_GR_Y The color gradient of blue component, represented in signed 9.16 format.

G2D+0430h Graphic 2D Engine Buffer Start Address 0 G2D_BUF_STA_ADDR_0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	BUF_STA_ADDR_0[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF_STA_ADDR_0[15:0]															
Type	R/W															
Reset	0															

BUF_STA_ADDR_0 The buffer 0 start address. Buffer 0 is used for storing temporal CP data for Bezier Curve function, raw edge data for Polygon-Fill function, and temporary edge (4 edges) storage for thick line drawing. Also, this field is used for the slope of the right triangle edges represented in signed 12.16 format and mask address of horizontal line copy with mask function.

G2D+0434h Graphic 2D Engine Buffer Start Address 1 G2D_BUF_STA_ADDR_1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	BUF_STA_ADDR_1[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF_STA_ADDR_1[15:0]															
Type	R/W															
Reset	0															

BUF_STA_ADDR_1 The buffer 1 start address. Buffer 1 is used for storing edge processing temporal data for Polygon-Fill function.

G2D+0438h Graphic 2D Engine Buffer Start Address 2 G2D_BUF_STA_ADDR_2

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16

Name	BUF_STA_ADDR_2[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BUF_STA_ADDR_2[15:0]															
Type	R/W															
Reset	0															

BUF_STA_ADDR_2 The buffer 2 start address. Buffer 2 is used for storing image data for polygon fill with image pattern.

7.6.2 Command Queue

7.6.2.1 General Description

To enhance MMI display and gaming experiences, a command queue controllrt is implemented for further offloading of MCU. If the command queue is enabled, software program has to check the command queue free space before writing to the command queue data register. Command queue parser will consume command queue entries upon 2D engine requests. **Figure 45** shows the command queue and 2D engine block diagram.

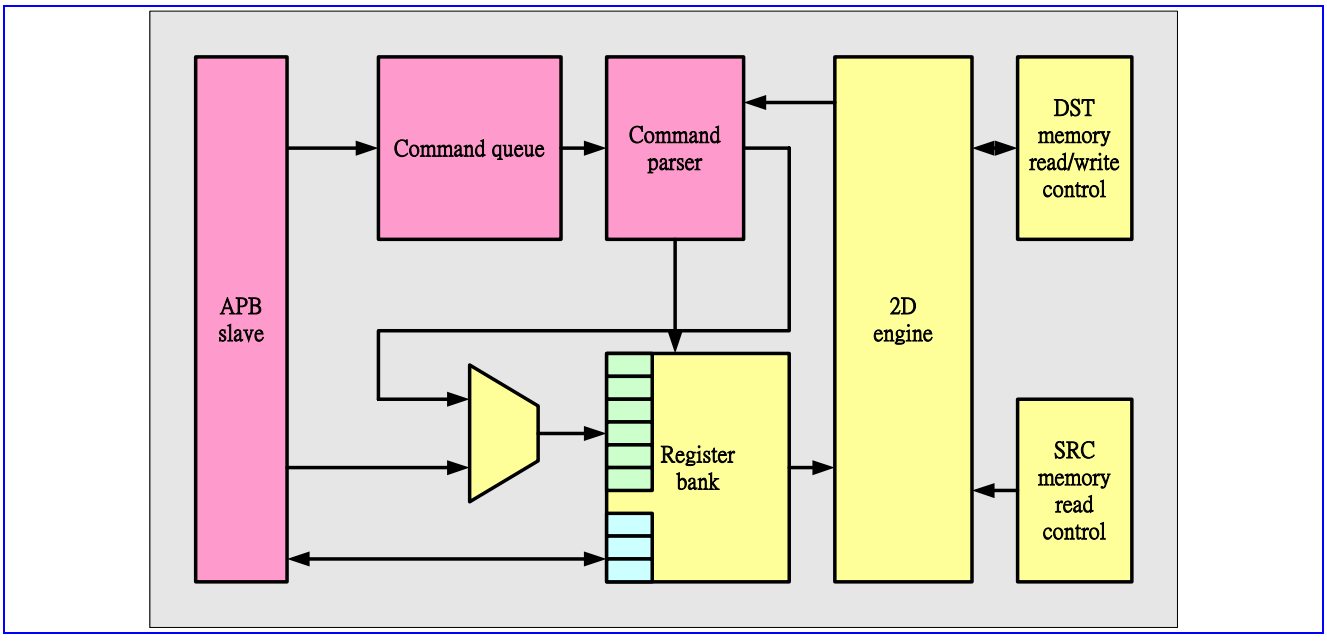


Figure 58 The command queue and 2D engine block diagram.

7.6.2.2 Register Definitions

MCU APB bus registers are listed as followings. The base address of the command queue controller is 80660000h.

GCMQ+0000h Graphic Command Queue Control Register GCMQ_CON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																

Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name															WEN	EN
Type															R/W	R/W
Reset															0	0

EN command queue enable. When EN is low, the command queue controller will be reset.

WEN command queue in write mode. When WEN is low, the command queue will consume the commands in the queue if command queue is not empty.

GCMQ+0004h Graphic Command Queue Status Register GCMQ_STA

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	WR_RDY					FREE										
Type	RO					RO										
Reset	0					100000000										

FREE number of free command queue entries

WR_RDY ready to receive command, command-write is not allowed when this status bit is 0. Software has to check this bit before writing command to gcmq.

GCMQ+0008h Graphic Command Queue Data Register GCMQ_DAT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name					ADDR											
Type					WO											
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DATA															
Type	WO															

ADDR [11:0] write address for mapped 2D engine registers

DATA [15:0] write data for mapped 2D engine registers

GCMQ+000Ch Graphic Command Queue Base Address Register GCMQ_BASE_ADD

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	BASE_ADD[31:16]															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BASE_ADD[15:0]															
Type	R/W															

BASE_ADD the starting address of the command queue in the memory.

Note : This field only can be modified while the command queue is not enabled. Otherwise the behavior of the command queue will be unpredictable.

GCMQ+0010h Graphic Command Queue Buffer Length Register GCMQ_LENGTH

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16

Name																
Type																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name						LENGTH										
Type						R/W										

LENGTH[9:0] the occupied space of the command queue in the memory is LENGTH *4Bytes.

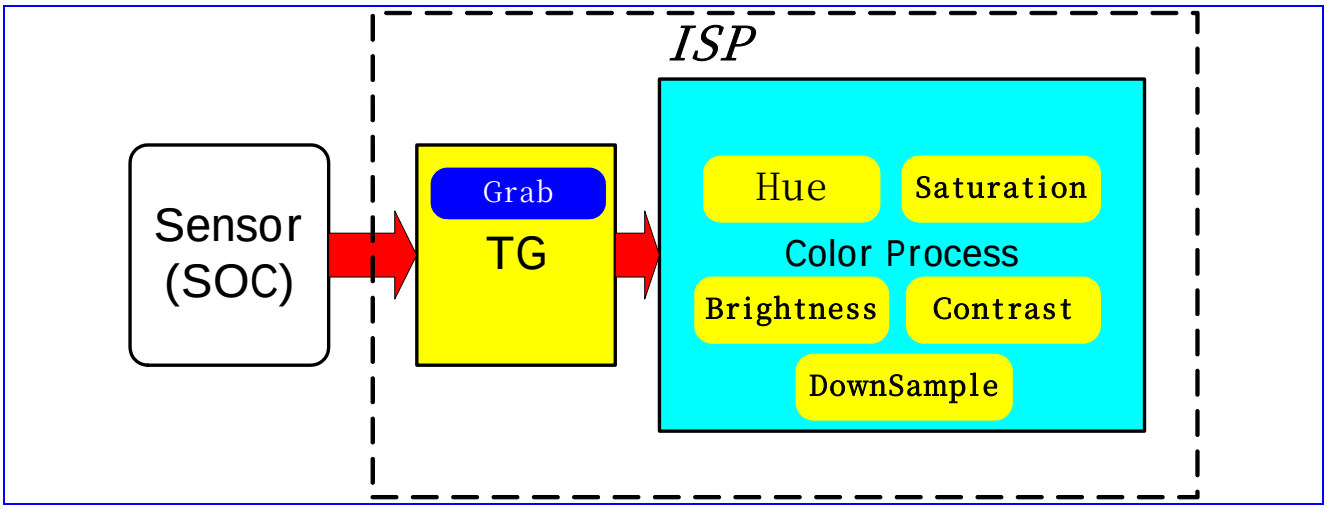
Note : This field only can be modified while the command queue is not enabled. Otherwise the behavior of the command queue will be unpredictable.

GCMQ+0014h Graphic Command Queue Current Register — GCMQ_DMA_ADDR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	GCMQ_DMA_ADDR															
Type	RO															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GCMQ_DMA_ADDR															
Type	RO															

GCMQ_DMA_ADDR the current read or write DMA address of GCMQ.

7.7 Camera Interface



MT6235 ISP support VGA/XGA Sensor YUV422/RGB565 interface. Included Functions are Brightness、Contrast、Saturation、Hue Tuning and Input Image Grab Window. Down Sample Function can be used before image output from ISP.

7.7.1 Register Table

REGISTER ADDRESS	REGISTER NAME	SYNONYM
CAM + 0000h	TG Phase Counter Register	CAM_PHSCNT
CAM + 0004h	Sensor Size Configuration Register	CAM_CAMWIN
CAM + 0008h	TG Grab Range Start/End Pixel Configuration Register	CAM_GRABCOL
CAM + 000Ch	TG Grab Range Start/End Line Configuration Register	CAM_GRABROW

CAM + 0010h	Sensor Mode Configuration Register	CAM_CSMODE
CAM + 0018h	View Finder Mode Control Register	CAM_VFCON
CAM + 001Ch	Camera Module Interrupt Enable Register	CAM_INTEN
CAM + 0020h	Camera Module Interrupt Status Register	CAM_INTSTA
CAM + 0024h	Camera Module Path Config Register	CAM_PATH
CAM + 0028h	Camera Module Input Address Register	CAM_INADDR
CAM + 002Ch	Camera Module Output Address Register	CAM_OUTADDR
CAM + 0030h	Preprocessing Control Register 1	CAM_CTRL1
CAM + 00B8h	Y Channel Configuration Register	CAM_YCHAN
CAM + 00BCh	UV Channel Configuration Register	CAM_UVCHAN
CAM + 00C0h	Space Convert YUV Register 1	CAM_SCONV1
CAM + 00C4h	Space Convert YUV Register 2	CAM_SCONV2
CAM + 0128h	Vertical Subsample Control Register	CAM_VSUB
CAM + 012Ch	Horizontal Subsample Control Register	CAM_HSUB
CAM + 0174h	Result Window Vertical Size Register	RWINV_SEL
CAM + 0178h	Result Window Horizontal Size Register	RWINH_SEL
CAM + 0180h	Camera Interface Debug Mode Control Register	CAM_DEBUG
CAM + 0184h	Camera Module Debug Information Write Out Destination Address	CAM_DSTADDR
CAM + 0188h	Camera Module Debug Information Last Transfer Destination Address	CAM_LSTADDR
CAM + 018Ch	Camera Module Frame Buffer Transfer Out Count Register	CAM_XFERCNT
CAM + 0190h	Sensor Test Module Configuration Register 1	CAM_MDLCFG1
CAM + 0194h	Sensor Test Module Configuration Register 2	CAM_MDLCFG2
CAM + 01D8h	Cam Reset Register	CAM_RESET
CAM + 01DCh	TG Status Register	TG_STATUS
CAM + 0248h	GMC Debug Register	CAM_GMCDEBUG
CAM + 0274h	Cam Version Register	CAM_VERSION

Table 39 Camera Interface Register Map

7.7.1.1 TG Register Definitions

CAM+0000h TG Phase Counter Register CAM_PHSCNT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	PCEN		CLKEN	CLKPOL	CLKCNT				CLKRS				CLKFL			
Type	R/W		R/W	R/W	R/W				R/W				R/W			
Reset	0		0	0	1				0				1			
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	HVALID_EN	PXCLK_EN	PXCLK_INV	PXCLK_IN	CLKFL_POL			TGCLK_SEL	PIXCNT				DLATCH			
Type	R/W	R/W	R/W	R/W	R/W			R/W	R/W				R/W			
Reset	0	0	0	0	0			0	1				1			

PCEN TG phase counter enable control

CLKEN Enable sensor master clock (mclk) output to sensor

CLKPOL Sensor master clock polarity control

CLKCNT Sensor master clock frequency divider control.
Sensor master clock will be 52Mhz/CLKCNT, where CLKCNT >=1.

CLKRS Sensor master clock rising edge control

CLKFL Sensor master clock falling edge control

HVALID_EN Sensor hvalid or href enable

PXCLK_EN Sensor clock input monitor.

PXCLK_INV Pixel clock inverse

PXCLK_IN Pixel clock sync enable. If sensor master based clock is 48 Mhz, PXCLK_IN must be enabled.

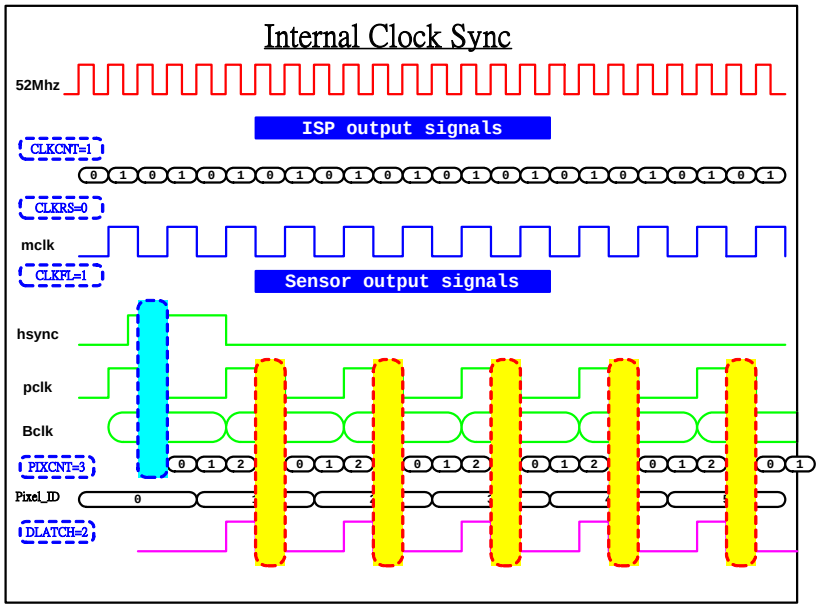
CLKFL_POL Sensor clock falling edge polarity

TGCLK_SEL Sensor master based clock selection (0: 52 Mhz, 1: 48 Mhz)

PIXCNT Sensor data latch frequency control

DLATCH Sensor data latch position control

Example waveform(CLKCNT=1,CLKRS=0,CLKFL=1,PIXCNT=3,DLATCH=2**)**



CAM+0004h Sensor Size Configuration Register CAM_CAMWIN

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name					PIXELS											
Type					R/W											
Reset					ffffh											
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					LINES											
Type					R/W											
Reset					ffffh											

PIXEL Total input pixel number

LINE Total input line number

CAM+0008h TG Grab Range Start/End Pixel Configuration Register CAM_GRABCOL

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name					START											
Type					R/W											
Reset					0											
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					END											
Type					R/W											
Reset					0											

START Grab start pixel number

END Grab end pixel number

CAM+000Ch TG Grab Range Start/End Line Configuration Register CAM_GRABROW

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name					START											
Type					R/W											
Reset					0											
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					END											
Type					R/W											
Reset					0											

START Grab start line number

END Grab end line number

CAM+0010h Sensor Mode Configuration Register CAM_CSMODE

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									VSPOL	HSPOL	PWRON	RST	AUTO			EN
Type									R/W	R/W	R/W	R/W	R/W			R/W
Reset									0	0	0	0	0			0

VSPOL Sensor Vsync input polarity

HSPOL Sensor Hsync input polarity

AUTO Auto lock sensor input horizontal pixel numbers enable

EN Sensor process counter enable

CAM+0018h View Finder Mode Control Register CAM_VFCON

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	AV_SYNC_SEL				AV_SYNC_LINENO[11:0]											
Type	R/W				R/W											
Reset	0				0											
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name						SP_DELAY	SP_MODE	TAKE_PIC				FR_CON
Type						R/W	R/W	R/W				R/W
Reset						0	0	0				0

AV_SYNC_SEL Av_sync start point selection
- **0** Start from AV_SYNC_LINENO
- **1** Start from vsync

AV_SYNC_LINENO Av_sync start point line counts

SP_DELAY Still Picture Mode delay

SP_MODE Still Picture Mode

TAKE_PIC Take Picture Request

FR_CON Frame Sampling Rate Control
- **000** Every frame is sampled
- **001** One frame is sampled every 2 frames
- **010** One frame is sampled every 3 frames
- **011** One frame is sampled every 4 frames
- **100** One frame is sampled every 5 frames
- **101** One frame is sampled every 6 frames
- **110** One frame is sampled every 7 frames
- **111** One frame is sampled every 8 frames

CAM+001Ch Camera Module Interrupt Enable Register CAM_INTEN

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	VSYNC_INT_SEL															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name								AV_SYNC_INT	VSYNC_INT			ISPDONE	IDLE	GMCOVRUN	REZOVRUN	EXPDO
Type								R/W	R/W			R/W	R/W	R/W	R/W	R/W
Reset								0	0			0	0	0	0	0

VSYNC_SEL Vsync interrupt selection
- **0** From Vsync Falling Edge
- **1** From Vsync Rising Edge

AV_SYNC_INT AV sync interrupt

VSYNC_INT Vsync interrupt

ISPDONE ISP done interrupt enable control

IDLE Returning idle state interrupt enable control

GMCOVRUN GMC port over run interrupt enable control

REZOVRUN Resizer over run interrupt enable control

EXPDO Exposure done interrupt enable control

CAM+0020h Camera Module Interrupt Status Register CAM_INTSTA

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16

Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name								AV_SYNC_INT	VSYNC_INT			ISPDONE	IDLE	GMCOVRUN	REZOVRUN	EXPDO
Type								R/W	R			R	R	R	R	R
Reset								0	0			0	0	0	0	0

CAM+0024h Camera Module Path Config Register CAM_PATH

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	CNTON	CNTMODE		WRITE_LEVEL				BAYER10_OUT	REZ_DISCONN	REZ_LPF_OFF	OUTPATH_TYPE					OUTPATH_EN
Type	R/W	R/W		R/W				R/W	RW	RW	R/W					R/W
Reset	0	0		3				0	0	0	0					0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			SWAP_Y	SWAP_CBCR	INDATA_FORMAT	INTYPE_SEL			INPATH_RATE						INPATH_THROTEN	INPATH_SEL
Type		R/W	R/W	R/W	R/W	R/W			R/W						R/W	R/W
Reset		0	0	0	0	1			0						0	0

CNTON Enable Debug Mode Data Transfer Counter

CNTMODE Data Transfer Count Selection

- **00** sRGB count
- **01** YCbCr count

REZ_DISCONN Resizer disconnect enable

REZ_LPF_OFF Resizer low-Pass disable

WRITE_LEVEL Write FIFO threshold level

BAYER10_OUT 10-bit Bayer Format output.

Outpath type should be set to 00.

OUTPATH_TYPE Outpath Type Select

- **00** Bayer Format
- **01** ISP output
- **02** RGB888 Format
- **03** RGB565 Format

OUTPATH_EN Enable Output to Memory

SWAP_Y YCbCr in Swap Y

SWAP_CBCR YCbCr in Swap Cb Cr

INDATA_FORMAT Sensor Input Data connection

INTYPE_SEL Input type selection

- **000** Bayer Format
- **001** YUV422 Format

  Default Input Format : **UYVY**
- **101** YCbCr422 Format
- **010** RGB Format

To enable YUV422/YCbCr422 input fast mode, refer to CAM + 011C bit 20

INPATH_RATE Input type rate control

INPATH_THROTEN Input path throttle enable

INPATH_SEL Input path selection

0 Sensor input

1 From memory

CAM+0028h Camera Module Input Address Register CAM_INADDR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	CAM_INADDR[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	CAM_INADDR[15:0]															
Type	R/W															
Reset	0															

CAM_INADDR Input memory address

CAM+002Ch Camera Module Output Address Register CAM_OUTADDR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	CAM_OUTADDR[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	CAM_OUTADDR[15:0]															
Type	R/W															
Reset	0															

CAM_OUTADDR Output memory address

7.7.1.2 Color Process Register Definition

CAM+00B8h Y Channel Configuration Register CAM_YCHAN

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name										CONTRAST_GAIN						
Type										R/W						
Reset										40h						
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SIGN_BRIGHT_OFFSET	BRIGHT_OFFSET							VSUP_EN		UV_LP_EN	CSUP_EDGE_GAIN				
Type	R/W	R/W							R/W		R/W	R/W				
Reset	1	0							0		0	10h				

CONTRAST_GAIN Y channel contrast gain value

SIGN_BRIGHT_OFFSET Sign bit of Y channel brightness offset value

BRIGHT_OFFSET Y channel brightness offset value

VSUP_EN Vertical Edge color suppression enable

UV_LP_EN UV channel low pass enable

CSUP_EDGE_GAIN Chroma suppression edge gain value(1.3)

CAM+00BCh UV Channel Configuration Register CAM_UVCHAN

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	U11								V22							
Type	R/W								R/W							
Reset	20h								20h							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SIGN_U_OFFSET	U_OFFSET							SIGN_V_OFFSET	V_OFFSET						
Type	R/W	R/W							R/W	R/W						
Reset	0	0							0	0						

U11 Hue U channel operating value
V11 Hue V channel operating value
SIGN_U_OFFSET Sign bit of Hue U channel offset value
U_OFFSET Hue U channel offset value
SIGN_V_OFFSET Sign bit of Hue V channel offset value
V_OFFSET Hue V channel offset value

CAM+00C0h Space Convert YUV Register 1 CAM_SCONV1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name									Y_GAIN							
Type									R/W							
Reset									FFh							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	U_GAIN								V_GAIN							
Type	R/W								R/W							
Reset	91h								B8h							

Y_GAIN Space Convert Y channel gain value
U_GAIN Space Convert U channel gain value
V_GAIN Space Convert V channel gain value

CAM+00C4h Space Convert YUV Register 2 CAM_SCONV2

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name									Y_OFFSET							
Type									R/W							
Reset									01h							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	U_OFFSET								V_OFFSET							
Type	R/W								R/W							
Reset	80h								80h							

Y_OFFSET Space Convert Y channel offset value
U_OFFSET Space Convert U channel offset value
V_OFFSET Space Convert V channel offset value

CAM+0128h Vertical Subsample Control Register CAM_VSUB

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16

Name				V_SUB_EN	V_SUB_IN										
Type				R/W	R/W										
Reset				0	0										
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					V_SUB_OUT											
Type					R/W											
Reset					0											

V_SUB_EN Vertical sub-sample enable
V_SUB_IN Source vertical size
V_SUB_OUT Sub-sample vertical size

CAM+012ch Horizontal Subsample Control Register CAM_HSUB

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name				H_SUB_EN	H_SUB_IN											
Type				R/W	R/W											
Reset				0	0											
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					H_SUB_OUT											
Type					R/W											
Reset					0											

H_SUB_EN Horizontal sub-sample enable
H_SUB_IN Source horizontal size
H_SUB_OUT Sub-sample horizontal size

CAM+0174h Result Window Vertical Size Register RWINV_SEL

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name				RWIN_EN	RWINV_START											
Type				R/W	R/W											
Reset				0h	0h											
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					RWINV_END											
Type					R/W											
Reset					0h											

RWIN_EN Result window enable
RWINV_START Result window vertical start line
RWINV_END Result window vertical end line

CAM+0178h Result Window Horizontal Size Register RWINH_SEL

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name					RWINH_START											
Type					R/W											
Reset					0h											
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					RWINH_END											
Type					R/W											
Reset					0h											

RWINH_START Result window horizontal start pixel

RWINH_END Result window horizontal end pixel

CAM+0180h Camera Interface Debug Mode Control Register CAM_DEBUG

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																
Type																
Reset																

CAM+0184h Camera Module Debug Information Write Out Destination Address CAM_DSTADDR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DST_ADD[31:16]															
Type	R/W															
Reset	4000h															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DST_ADD[15:0]															
Type	R/W															
Reset	0000h															

DST_ADD Debug Information Write Output Destination Address

CAM+0188h Camera Module Debug Information Last Transfer Destination Address CAM_LASTADDR

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	LAST_ADD[31:16]															
Type	R/W															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LAST_ADD[15:0]															
Type	R/W															
Reset	0															

LAST_ADD Debug Information Last Transfer Destination Address

CAM+018Ch Camera Module Frame Buffer Transfer Out Count Register CAM_XFERCNT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	XFER_COUNT [31:16]															
Type	RO															
Reset	0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	XFER_COUNT[15:0]															
Type	RO															
Reset	0															

XFER_COUNT Pixel Transfer Count per Frame

CAM+0190h Sensor Test Model Configuration Register 1 CAM_MDLCFG1

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	VSYNC								IDLE_PIXEL_PER_LINE							
Type	R/W								R/W							
Reset	0								0							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			LINECHG_EN	GRAY_LEVEL			ON	RST	STILL	PATTERN	PIXEL_SEL		CLK_DIV			
Type			R/W	R/W			R/W	R/W	R/W	R/W	R/W		R/W			
Reset			0	0			0	0	0	0	0		0			

VSYNC VSYNC high duration in line unit(IDLE_PIXEL_PER_LINE + PIXEL)

IDLE_PIXEL_PER_LINE HSYNC low duration in pixel unit

LINECHG_EN Pattern 0 2 lines change mode enable

GRAY_LEVEL Sensor Model Gray Level Enable. When gray level is enable, increased gray level pattern will be generated.

ON Enable Sensor Model.

RST Reset Sensor Model

STILL Still picture Mode

PATTERN Sensor Model Test Pattern Selection

PIXEL_SEL Sensor Model output pixel selection.

- **00** All pixels
- **01** 01 pixel
- **10** 10 pixel
- **11** 00 and 11 pixels

CLK_DIV Pixel_Clock/System_Clock Ratio

CAM +0194h Sensor Test Model Configuration Register 2 CAM_MDLCFG2

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name						LINE										
Type						R/W										
Reset						0										
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name						PIXEL										
Type						R/W										
Reset						0										

LINE Sensor Model Line Number

PIXEL Sensor Model Pixel Number (HSYNC high duration in pixel unit)

CAM +01D8h CAM RESET Register CAM_RESET

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name												TG_STATUS				
Type												R				
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ISP_FRAME_COUNT[7:0]															ISP_RESET

Type	RW								RW
Reset	0								0

ISP_FRAME_COUNT ISP frame counter

ISP_RESET ISP reset

CAM +01DCh TG STATUS Register TG_STATUS

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name				SYN_VFON	LINE_COUNT[11:0]											
Type				R	R											
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					PIXEL_COUNT[11:0]											
Type					R											
Reset																

SYN_VFON TG view finder status

LINE_COUNT TG line counter

PIXEL_COUNT TG pixel counter

CAM +0248h CAM GMC DEBUG Register CAM_DEBUG

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name																
Type																
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																
Type																
Reset																

CAM +0274h CAM VERSION Register CAM_VERSION

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	YEAR[16:0]															
Type	R															
Reset																
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	MONTH[15:0]								DATE[15:0]							
Type	R								R							
Reset																

YEAR Year ASCII

MONTH Month ASCII

DATE Date ASCII

8 Audio Front-End

8.1 General Description

The audio front-end essentially consists of voice and audio data paths. **Figure 59** shows the block diagram of the audio front-end. All voice band data paths comply with the GSM 03.50 specification. Mono hands-free audio or external FM radio playback paths are also provided. The audio stereo path facilitates CD-quality playback, external FM radio, and voice playback through a headset.

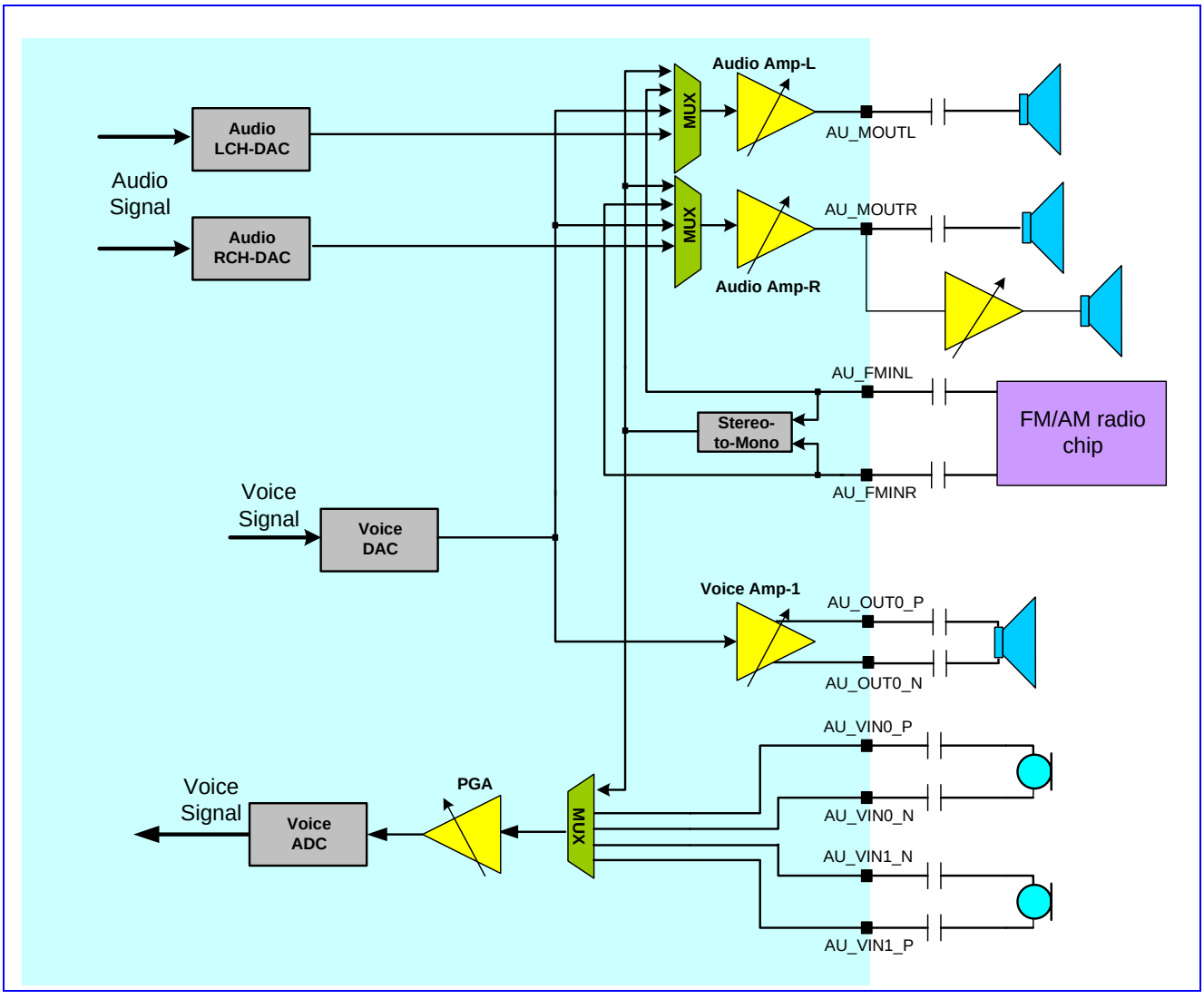


Figure 59 Block diagram of audio front-end

Figure 60 shows the digital circuits block diagram of the audio front-end. The APB register block is an APB peripheral that stores settings from the MCU. The DSP audio port (DAP) block interfaces with the DSP for control and data communications. The digital filter block performs filter operations for voice band and audio band signal processing. The Digital Audio Interface (DAI) block communicates with the System Simulator for FTA or external Bluetooth modules.

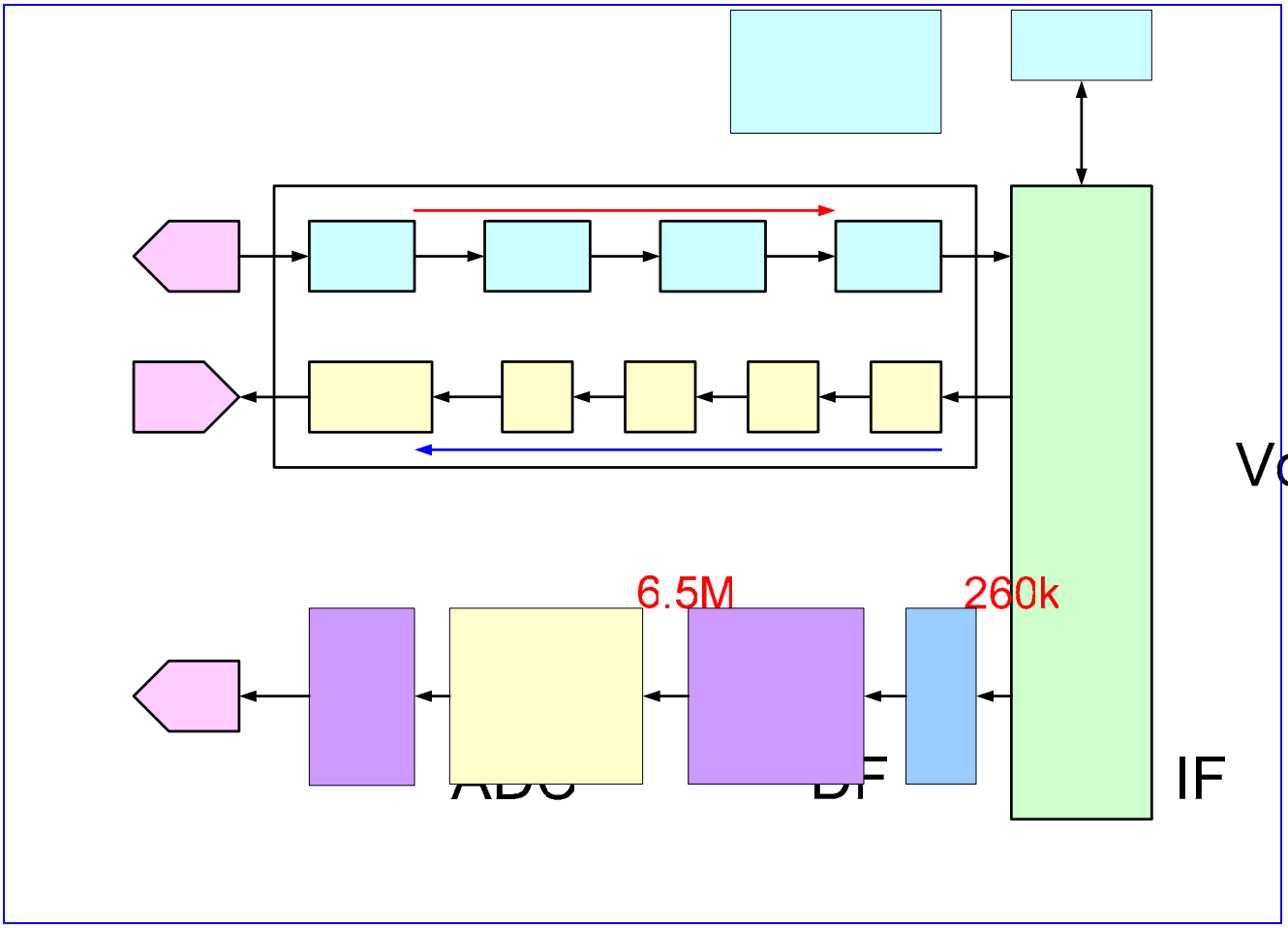


Figure 60 Block diagram of digital circuits of the audio front-end

To communicate with the external Bluetooth module, the master-mode PCM interface and master-mode I2S/EIAJ interface are supported. The clock of PCM interface is 256 kHz while the frame sync is 8 kHz. Both long sync and short sync interfaces are supported. The PCM interface can transmit 16-bit stereo or 32-bit mono 8 kHz sampling rate voice signal. **Figure 61** shows the timing diagram of the PCM interface. Note that the serial data changes when the clock is rising and is latched when the clock is falling.

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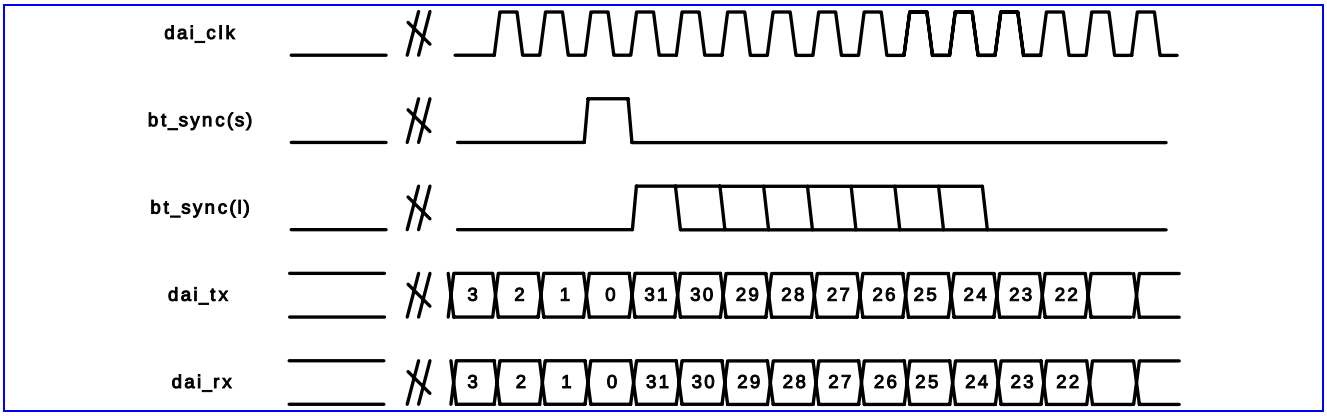


Figure 61 Timing diagram of Bluetooth application

I2S/EIAJ interface is designed to transmit high quality audio data. **Figure 62** and **Figure 63** EDI Format 2: I^2S (FMT = 1). illustrate the timing diagram of the two types of interfaces. I2S/EIAJ can support 32 kHz, 44.1 kHz, and 48 kHz sampling rate audio signals. The clock frequency of I2S/EIAJ can be 32×(sampling frequency), or 64×(sampling frequency). For example, to transmit a 44.1 kHz CD-quality music, the clock frequency should be 32 × 44.1 kHz = 1.4112 MHz or 64 × 44.1 kHz = 2.8224 MHz.

I2S/EIAJ interface is not only used for Bluetooth module, but also for external DAC components. Audio data can easily be sent to the external DAC through the I2S/EIAJ interface.

In this document, the I2S/EIAJ interface is referred to as EDI (External DAC Interface).

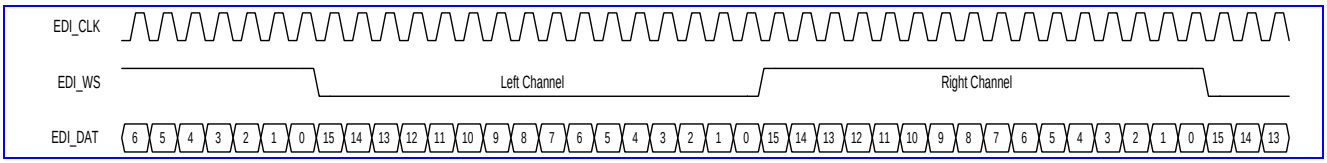


Figure 62 EDI Format 1: EIAJ (FMT = 0).

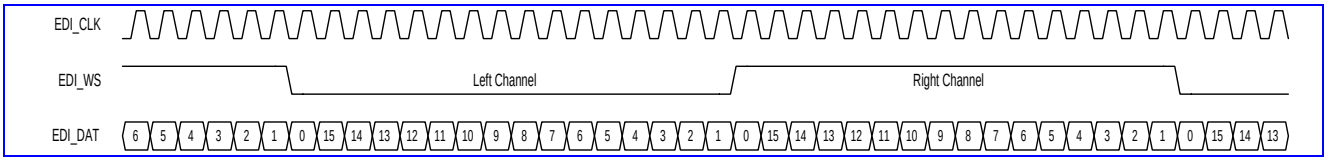


Figure 63 EDI Format 2: I^2S (FMT = 1).

8.1.1 DAI, PCM and EDI Pin Sharing

DAI, PCM, and EDI interfaces share the same pins. The pin mapping is listed in **Table 40**.

PIN NAME	DAI	PCM	EDI
DAI_CLK (OUTPUT)	DAI_CLK	PCM_CLK	EDI_CLK
DAI_TX (OUTPUT)	DAI_TX	PCM_OUT	EDI_DAT
DAI_RX (INPUT)	DAI_RX	PCM_IN	

BT_SYNC (OUTPUT)	-	PCM_SYNC	EDI_WS

Table 40 Pin mapping of DAI, PCM, and EDI interfaces.

Beside the shared pins, the EDI interface can also use other dedicated pins. With the dedicated pins, PCM and EDI interfaces can operate at the same time.

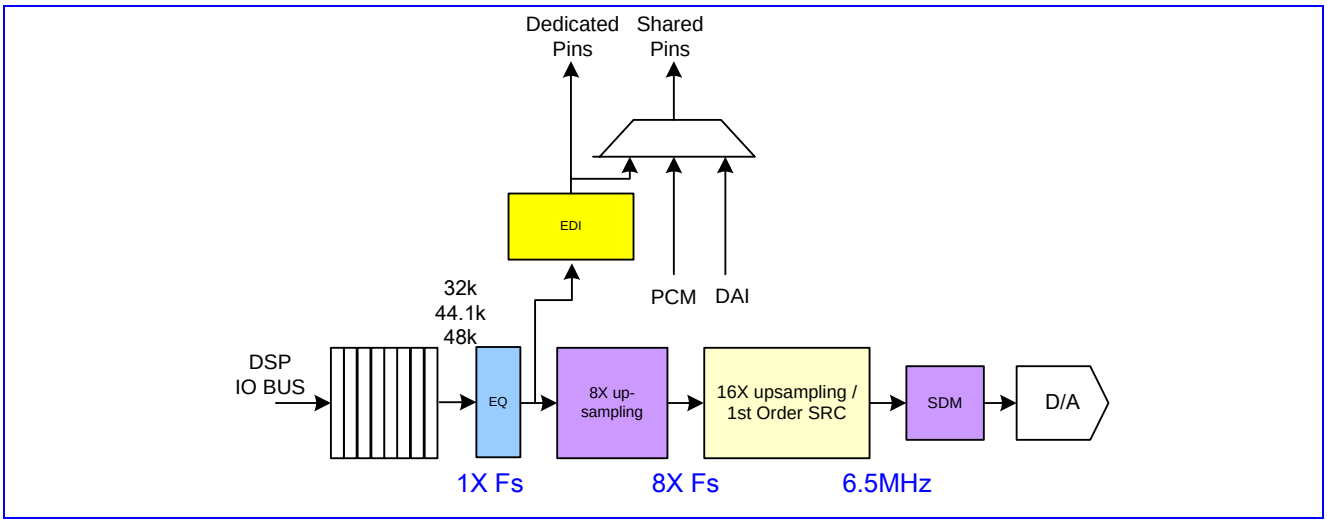


Figure 64 DAI, PCM, EDI interfaces

8.2 Register Definitions

MCU APB bus registers in audio front-end are listed as follows.

0x820F0000 AFE Voice MCU Control Register — AFE_VMCU_CON0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																VAFEON
Type																R/W
Reset																0

MCU sets this register to start AFE voice operation. A synchronous reset signal is issued, then periodical interrupts of 8-KHz frequency are issued. Clearing this register stops the interrupt generation.

VAFEON Turn on voice front-end operations.

0 off

1 on

0x820F000C AFE Voice Analog-Circuit Control Register 1 — AFE_VMCU_CON1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name							VMODE4K	VAFECLR_EN	VRSDON	VDL_IIRMODE	VUL_IIRMODE	VDLDITH_VAL	VDLDITH_ON
Type							R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset							0	0	0	00	00	00	0

Set this register for consistency of analog circuit setting. Suggested value is 80h.

VMODE4K DSP data mode selection

0 8k mode

1 4k mode

VAFECLR_EN Enable signal to reset voice downlink buffer or not while VAFE is powered down.

0 NO reset voice downlink buffer while VAFE is powered down

1 Reset voice downlink buffer while VAFE is powered down

VRSDON Turn on the voice-band redundant signed digit function.

0 1-bit 2-level mode

1 2-bit 3-level mode

VDL_IIRMODE Voice downlink IIR coefficients set selection

00 4k : 90Hz, 8k: 180Hz.

01 4k : 160Hz, 8k: 320Hz.

10 4k : 200Hz, 8k: 400Hz

11 4k : 320Hz, 8k: 640Hz

VUL_IIRMODE Voice uplink IIR coefficients set selection

00 4k : 90Hz, 8k: 180Hz.

01 4k : 160Hz, 8k: 320Hz.

10 4k : 200Hz, 8k: 400Hz

11 4k : 320Hz, 8k: 640Hz

VDITHVAL Voice downlink dither scaling setting

00 1

01 2

10 4

11 8

VDITHON Turn on the voice downlink dither function.

0 Turn off

1 Turn on

0x820F0014 AFE Voice DAI Bluetooth Control Register AFE_VDB_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									VDAIBT_CLR_EN	EDION	VDAION	VBTON	VBTSYNC	VBTSLEN		
Type									R/W	RW	R/W	R/W	R/W	R/W		
Reset									0	0	0	0	0	000		

Set this register for DAI test mode and Bluetooth application.

DAIBT_CLR_EN Enable signal to reset DAIBT buffer or not while VAFE is powered down.

0 NO reset DAIBT buffer while VAFE is powered down

1 Reset DAIBT buffer while VAFE is powered down

EDION EDI signals are selected as the output of DAI, PCM, EDI shared interface.

0 EDI is not selected. A dedicated EDI interface can be enabled by programming the GPIO selection. Please refer to GPIO section for details.

1 EDI is selected. VDAION and VBTON are not set.

VDAION Turn on the DAI function.

0 off

1 on

VBTON Turn on the Bluetooth PCM function.

0 off

1 on

VBTSYNC Bluetooth PCM frame sync type

0: short

1: long

VBTSLEN Bluetooth PCM long frame sync length = VBTSLEN+1

0x820F0018 AFE Voice Look-Back mode Control Register AFE_VLB_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											VDSPBYPASS	VDSPCSMODE	VBYPASSIIR	VDAPINMODE	VINTINMODE	VDECINMODE
Type											R/W	R/W	R/W	R/W	R/W	R/W
Reset											0	0	0	0	0	0

Set this register for AFE voice digital circuit configuration control. Several loop back modes are implemented for test purposes. Default values correspond to the normal function mode.

VDSPBYPASS Loopback data won't be gated by VDSPRDY.

0 Normal Mode

1 Bypass DSP loopback mode

VDSPCSMODE DSP COSIM only, to align DATA.

0 Normal mode

1 DSP COSIM mode

VBYPASSIIR Bypass IIR filter

0 Normal mode

1 Bypass

VDAPINMODE DSP audio port input mode control

0 Normal mode

1 Loop back mode

VINTINMODE interpolator input mode control

0 Normal mode

1 Loop back mode

VDECINMODE decimator input mode control

0 Normal mode

1 Loop back mode

0x820F0020 AFE Audio MCU Control Register 0 AFE_AMCU_CON0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																AAFEON
Type																R/W
Reset																0

MCU sets this register to start AFE audio operation. A synchronous reset signal is issued, and then periodical interrupts of 1/6 sampling frequency are issued. Clearing this register stops the interrupt generation.

AAFEON Turn on audio front-end operations.

0 off

1 on

0x820F0024 AFE Audio Control Register 1 AFE_AMCU_CON1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ASDMCK_PHASE	MONO		SEL_IDWA	BYPASS		SDM_MODE		GAIN		ARAMPSP		AMUTER	AMUTEL	AFS	
Type	R/W	R/W		R/W	RW		R/W		R/W		R/W		R/W	R/W	R/W	
Reset	0	0		1	00		0		0		00		0	0	00	

MCU sets this register to inform hardware of the sampling frequency of audio being played back.

ASDMCK_PHASE Phase of Audio SDM Clock. Please set to 0.

SEL_IDWA IDWA function selection.

0 Disable IDWA

1 Enable IDWA

MONO Mono mode select. AFE HW will do (left + right) / 2 operation to the audio sample pair. Thus both right/left channels DAC will have the same inputs.

0 Disable mono mode.

1 Enable mono mode.

BYPASS To bypass part of the audio hardware path. Bit 1 please always set to 1 to bypass Interpolation.

00 No bypass. The input data rate is 1/4 sampling frequency. For example, if the sampling frequency is 32 KHz, then the input data rate is 8 KHz.

01 Bypass the first stage of interpolation. The input data rate is 1/2 the sampling frequency.

10 Bypass two stages of interpolation. The input data rate is the same as the sampling frequency.

11 Bypass two stages of interpolation and EQ filter. The input data rate is the same as the sampling frequency.

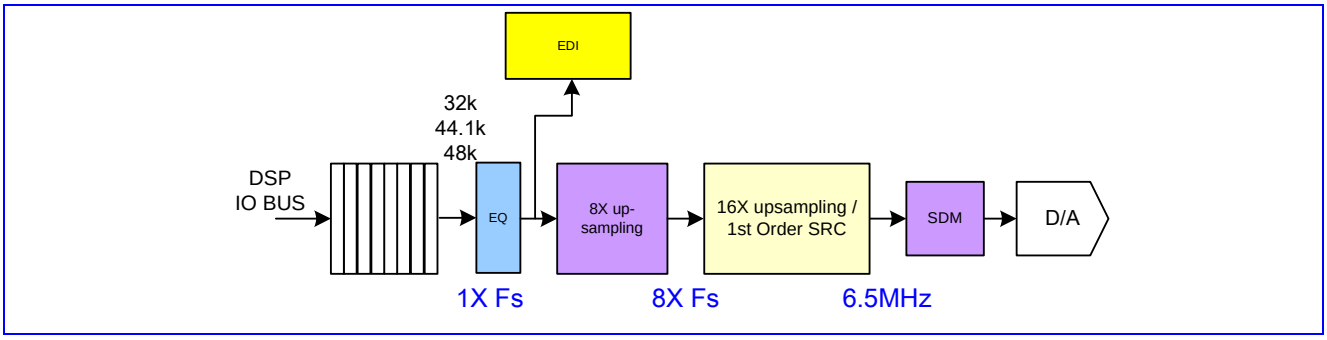


Figure 65 Block diagram of the audio path.

SDM_MODE SDM mode control

0 zero extension.

1 sign extension.

GAIN Gain Setting at Audio SDM input, Please set to 1.

0 1X

1 1/2X

ARAMPSP ramp up/down speed selection

00 8, 4096/AFS

01 16, 2048/AFS

10 24, 1024/AFS

11 32, 512/AFS

AMUTER Mute the audio R-channel, with a soft ramp up/down.

0 no mute

1 mute

AMUTEL Mute the audio L-channel, with a soft ramp up/down.

0 no mute

1 mute

AFS Sampling frequency setting.

00 32-KHz

01 44.1-KHz

10 48-KHz

11 reserved

0x820F0028 AFE EDI Control Register AFE_EDI_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name								DIR	SRC	WCYCLE					FMT	EN
Type								R/W	R/W	R/W					R/W	R/W
Reset								0	0	01111					0	0

This register is used to control the EDI

EN Enable EDI. When EDI is disabled, EDI_DAT and EDI_WS hold low.

0 disable EDI

1 enable EDI

FMT EDI format

0 EIAJ

1 I2S

WCYCLE Clock cycle count in a word. Cycle count = WCYCLE + 1, and WCYCLE can be 15 or 31 only. Any other values result in an unpredictable error.

15 Cycle count is 16.

31 Cycle count is 32.

SRC I2S clock and WS signal source.

0 Internal mode. The clock and word select signals are fed to external device from AFE.

1 External mode. The clock and word select signals are fed externally from the connected device. There is a buffer control mechanism to deal with the clock mismatch between internal and external clocks.

DIR Serial data bit direction

0 Output mode. Audio data is fed out to the external device.

1 Input mode or recording mode. By this recording mechanism, DSP can do some post processing or voice memos.

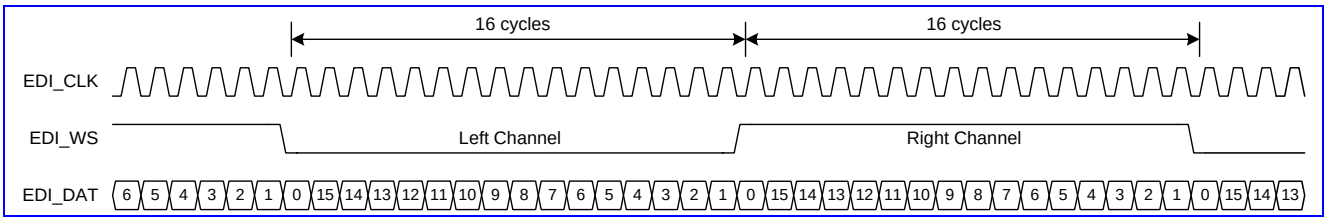


Figure 66 Cycle count is 16 for I2S format.

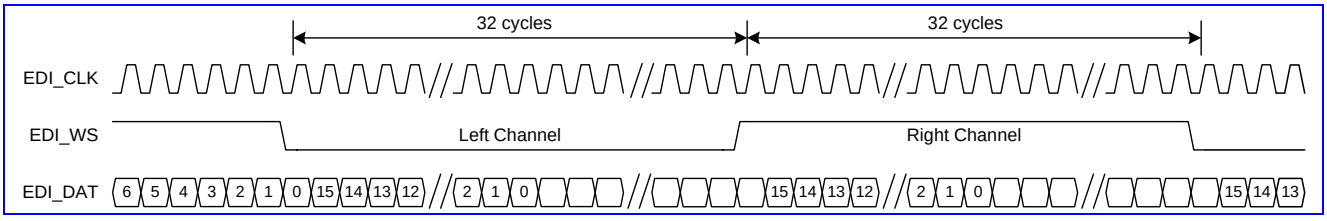


Figure 67 Cycle count is 32 for I2S format.

0x820F0030 Audio/Voice DAC SineWave Generator AFE_DAC_TEST

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	VON	AON	MUTE			AMP_DIV			FREQ_DIV							
Type	R/W	R/W	R/W			R/W			R/W							
Reset	0	0	0			111			0000_0001							

This register is only for analog design verification on audio/voice DACs.

VON Makes voice DAC output the test sine wave.

0 Voice DAC inputs are normal voice samples

1 Voice DAC inputs are sine waves

AON Makes audio DAC output the test sine wave.

0 Audio DAC inputs are normal audio samples

1 Audio DAC inputs are sine waves

MUTE Mute switch.

0 Turn on the sine wave output in this test mode.

1 Mute the sine wave output.

AMP_DIV Amplitude setting.

111 full scale

110 1/2 full scale

101 1/4 full scale

100 1/8 full scale

FREQ_DIV Frequency setting, 1 hot.

0000_0001 1X frequency

0000_0010 2X frequency

0000_0100 3X frequency

0000_1000 4X frequency

0001_0000 8X frequency

0010_0000 16X frequency

0100_0000 32X frequency

1000_0000 64X frequency

0x820F0034 Audio/Voice Interactive Mode Setting AFE_VAM_SET

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	A2V													PER_VAL		
Type	R/W													R/W		
Reset	0													101		

A2V Redirect audio interrupt to voice interrupt. In other words, replace voice interrupt by audio interrupt.

0 [voice interrupt / audio interrupt] → [voice / audio]

1 [audio interrupt / no interrupt] → [voice / audio]

PER_VAL Counter reset value for audio interrupt generation period setting. For example, by default, the setting = 5 causes interrupt per 6 L/R samples. Changing this value can change the rate of audio interrupt.

0x820F0040~ 0x820F00F0 AFE Audio Equalizer Filter Coefficient Register AFE_EQCOEF

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	A															
Type	WO															

Audio front-end provides a 45-tap equalizer filter. The filter is shown below.

DO = (A44 X DI44 + A43 X DI43 … + A1 X DI1 + A0 X DI0)/32768.

DIn is the input data, and An is the coefficient of the filter, which is a 16-bit 2's complement signed integer. DI0 is the last input data.

The coefficient cannot be programmed when the audio path is enabled, or unpredictable noise may be generated. If coefficient programming is necessary while the audio path is enabled, the audio path must be muted during programming. After programming is complete, the audio path is not to be resumed (unmated) for 100 sampling periods.

A Coefficient of the filter.

Address	Coefficient	Address	Coefficient	Address	Coefficient
0x820f0040	A0	0x820f007C	A15	0x820f00B8	A30
0x820f0044	A1	0x820f0080	A16	0x820f00BC	A31
0x820f0048	A2	0x820f0084	A17	0x820f00C0	A32
0x820f004C	A3	0x820f0088	A18	0x820f00C4	A33
0x820f0050	A4	0x820f008C	A19	0x820f00C8	A34
0x820f0054	A5	0x820f0090	A20	0x820f00CC	A35
0x820f0058	A6	0x820f0094	A21	0x820f00D0	A36
0x820f005C	A7	0x820f0098	A22	0x820f00D4	A37
0x820f0060	A8	0x820f009C	A23	0x820f00D8	A38
0x820f0064	A9	0x820f00A0	A24	0x820f00DC	A39
0x820f0068	A10	0x820f00A4	A25	0x820f00E0	A40
0x820f006C	A11	0x820f00A8	A26	0x820f00E4	A41
0x820f0070	A12	0x820f00Ac	A27	0x820f00E8	A42
0x820f0074	A13	0x820f00B0	A28	0x820f00EC	A43
0x820f0078	A14	0x820f00B4	A29	0x820f00F0	A44

Table 41

0x820F0100 AFE AGC Control Register 0 AFE_VAGC_CON0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	MINPGAGAIN						PGAGAIN						FRFLG	RATKFLG	SATKFLG	AGCON
Type	R/W						R/W						R/W	R/W	R/W	R/W
Reset	001010						101000						0	1	1	1

This register sets the control signals for AGC.

AGCON Switch of the AGC
- **0** Off
- **1** On

SATKFLG Sample Attack Flag
- **0** off
- **1** on

RATKFLG RMS Attack Flag
- **0** off
- **1** on

FRFLG Free Release Flag
- **0** off
- **1** on

PGAGAIN PGA gain settings (from -43dB to 20 dB), it is also the maximum PGA gain settings while AGC is on.

000000 -43dB
000001 -42dB
|
111110 19dB
111111 20dB

MINPGAGAIN minima PGA gain settings (from -43 to 20 dB). PGA gain is always larger than MINPGAGAIN.

000000 -43dB
000001 -42dB
|
111110 19dB
111111 20dB

0x820F0104 AFE AGC Control Register 1 AFE_VAGC_CON1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name		VSDM_GAIN	VAGC_SEL	VAGC_CTRL	ECNTRRLZS				ECNTRRLZF				ECNTRATK			
Type		R/W	R/W	R/W	R/W				R/W				R/W			
Reset		0	1	0	1100				1100				1000			

This register sets the control signals for AGC and VSDM.

VSDM_GAIN Input gain before Voice SDM
0 1/2 X
1 1X

VAGC_SEL Selection of AGC output.
0 bypass AGC.
1 AGC compensation on.

VAGC_CTRL Selection the AGC gain control master.
0 Control by AFE.
1 Control by DSP.

ECNTRATK Attack counter, control attack speed.(unit: N samples@52kHz). Attach will be triggered if N samples amplitude exceed attack threshold (ENTHDATK)
0 always attack, please don't set to this values.
1~15 N=1~15

ECNTRRLZF Fast release counter, control fast release speed.(unit: N samples@52kHz). Release will be triggered if N samples amplitude lower than slow release threshold (ENTHDRLS)
0 1
1 3
2 7
3 15

4 31
5 63
6 127
7 255
8 511
9 1023
10 2043
11 4095
12 8191
13 16383
14 32767
15 65535

ECNTRRLZS Slow release counter, control slow release speed.(unit: N samples@52kHz). Release will be triggered if N samples amplitude lower than hysteresis threshold (ENTHDHYS)

0 1
1 3
2 7
3 15
4 31
5 63
6 127
7 255
8 511
9 1023
10 2043
11 4095
12 8191
13 16383
14 32767
15 65535

0x820F0108 AFE AGC Control Register 2 AFE_VAGC_CON2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ERMSFBATTF				ERMSFBATTR				ERMSFBF				ERMSFBR			
Type	R/W				R/W				R/W				R/W			
Reset	1010				0100				1011				0101			

This register sets the control signals for AGC.

ERMSFBR RMS rising factor**.** The larger the number; the slower the signal energy estimation.

0 1x RMS power estimation.
1 2x RMS power estimation.
2 4x RMS power estimation.

3 8x RMS power estimation.

|

14 16384x RMS power estimation.

15 32768x RMS power estimation.

ERMSFBF RMS falling factor. The larger the number; the slower the signal energy estimation.

0 1x RMS power estimation.

1 2x RMS power estimation.

2 4x RMS power estimation.

3 8x RMS power estimation.

|

14 16384x RMS power estimation.

15 32768x RMS power estimation.

ERMSFBATTR RMS for Attack rising factor. The larger the number; the slower the signal energy estimation.

0 1x RMS power estimation.

1 2x RMS power estimation.

2 4x RMS power estimation.

3 8x RMS power estimation.

|

14 16384x RMS power estimation.

15 32768x RMS power estimation.

ERMSFBATTF RMS for Attack falling factor. The larger the number; the slower the signal energy estimation.

0 1x RMS power estimation.

1 2x RMS power estimation.

2 4x RMS power estimation.

3 8x RMS power estimation.

|

14 16384x RMS power estimation.

15 32768x RMS power estimation.

0x820F010C AFE AGC Control Register 3 AFE_VAGC_CON3

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EGAINCOMP_CSS			EGAINCOMP_CSM			EGAINCOMP_CSF			EGAINCOMP_FC_THD			EGAINCOMP_LOWER		EGAINCOMP_UPPER	
Type	R/W			R/W			R/W			R/W			R/W		R/W	
Reset	001			011			011			101			01		01	

This register sets the control signals for AGC.

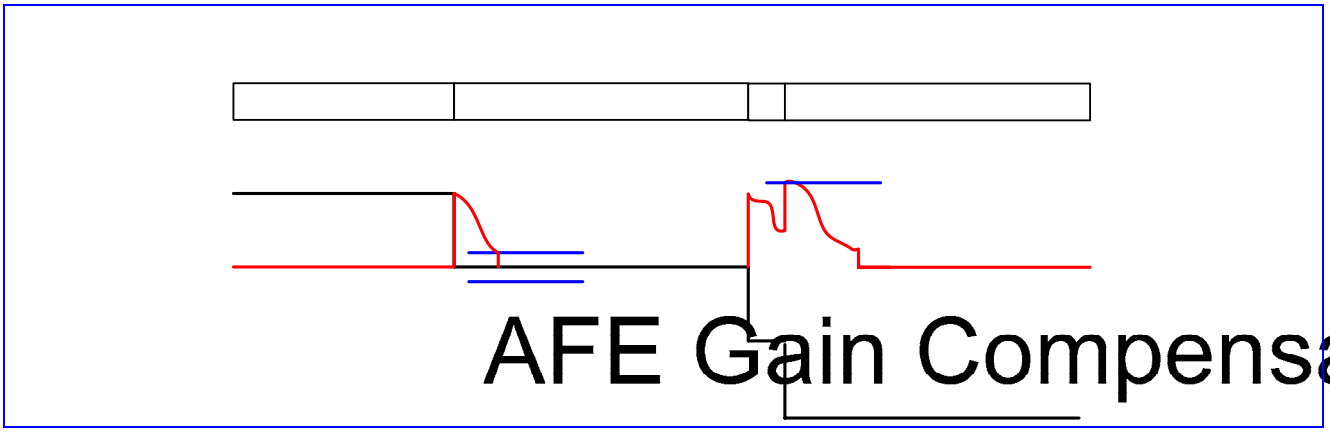


Figure 68 Gain Compensation procedures.

EGAINCOMP_UPPER Gain compensation upper threshold, 32768 = 0dB (**Figure 68** Gain Compensation procedures.)

00 33095
01 33423
10 33751
11 34078

EGAINCOMP_LOWER Gain compensation lower threshold, 32768 = 0dB (**Figure 68** Gain Compensation procedures.)

00 32440
01 32112
10 31784
11 31457

EGAINCOMP_FC_THD Gain compensation convergence threshold (**Figure 68** Gain Compensation procedures.).

000 34406
001 36044
010 37683
011 39321
100 40960
101 42598
110 44236
111 45875

EGAINCOMP_FC_CSF Gain compensation fast converge speed. (While compensation gain is 0.3dB far from 32768, the convergence speed is fast)

000 31948 (8X)
001 31129 (7X)
010 30310 (6X)
011 29491 (5X)

100 28672 (4X)
101 27852 (3X)
110 27033 (2X)
111 26214 (1X)

EGAINCOMP_FC_CSM Gain compensation converge speed middle. (While compensation gain is 0.15dB ~ 0.3dB from 32768, the convergence speed is middle)

000 32686 (8X)
001 32604 (7X)
010 32552 (6X)
011 32440 (5X)
100 32358 (4X)
101 32276 (3X)
110 32194 (2X)
111 32112 (1X)

EGAINCOMP_FC_CSS Gain compensation converge speed slow. (While compensation gain is inside 0.15dB from 32768, the convergence speed is slow)

000 32751 (8X)
001 32735 (7X)
010 32718 (6X)
011 32702 (5X)
100 32686 (4X)
101 32669 (3X)
110 32653 (2X)
111 32636 (1X)

0x820F0110 AFE AGC Control Register 4 AFE_VAGC_CON4

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ENTHDATKRMS						ENTHDATK						ESRELWINWIDTH1			
Type	R/W						R/W						R/W			
Reset	000100						000001						1000			

This register sets the control signals for AGC.

ESRELWINWIDTH1 speech release window width for strong VAD

0 10 @ 52kHz samples
1 20 @ 52kHz samples
2 40 @ 52kHz samples
3 80 @ 52kHz samples
4 160 @ 52kHz samples
5 325 @ 52kHz samples
6 650 @ 52kHz samples
7 1300 @ 52kHz samples

8 2600 @ 52kHz samples
9 5200 @ 52kHz samples
10 10000 @ 52kHz samples
11 15000 @ 52kHz samples
12 20000 @ 52kHz samples
13 25000 @ 52kHz samples
14 30000 @ 52kHz samples
15 32767 @ 52kHz samples

ENTHDATK Attack threshold
[0~63] is map to [-63~0]dB FS

ENTHDATKRMS RMS attack threshold
[0~63] is map to [-63~0]dB FS

0x820F0114 AFE AGC Control Register 5 AFE_VAGC_CON5

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ENTHDRLS						ENTHDHYS						ESRELWINWIDTH2			
Type	R/W						R/W						R/W			
Reset	001101						000111						1000			

This register sets the control signals for AGC.

ESRELWINWIDTH2 speech release window width for weak VAD

0 10 @ 52kHz samples
1 20 @ 52kHz samples
2 40 @ 52kHz samples
3 80 @ 52kHz samples
4 160 @ 52kHz samples
5 325 @ 52kHz samples
6 650 @ 52kHz samples
7 1300 @ 52kHz samples
8 2600 @ 52kHz samples
9 5200 @ 52kHz samples
10 10000 @ 52kHz samples
11 15000 @ 52kHz samples
12 20000 @ 52kHz samples
13 25000 @ 52kHz samples
14 30000 @ 52kHz samples
15 32767 @ 52kHz samples

ENTHDHYS Hysteresis threshold
[0~63] is map to [-63~0]dB FS

ENTHDRLS Slow release threshold

[0~63] is map to [-63~0]dB FS

0x820F0118 AFE AGC Control Register 6 AFE_VAGC_CON6

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EPATTLIMITER				PATTRELD				NATKFLG	PATTRELFLG	ENTHDNOZ					
Type	R/W				R/W				R/W	R/W	R/W					
Reset	0100				0000				1	1	111101					

This register sets the control signals for AGC.

ENTHDNOZ Idle threshold

[0~63] is map to [-63~0]dB FS

PATTRELFLG post attack/release flag

0 off

1 on

NATKFLG noise adaptive attenuation enable attack flag

0 off

1 on

PATTRELD Post attack/release latency

0~15 is map to 0~15 sample @260kHz sampling rate

EPATTLIMITER Post attack limiter

[0,15] is map to [0,-7.5dBFs], the spacing is 0.5dB

8.3 DSP Register Definitions

0x640 AFE Voice Uplink Data Register 0 AFE_VUL_DAT0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	VUL_DAT0															
Type	RO															
Reset	0															

Voice band uplink transmission data register 0. The content of this register is updated by uplink digital filter outputs. This register is read by DSP in an 8K ISR.

0x641 AFE Voice Uplink Data Register 1 AFE_VUL_DAT1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	VUL_DAT1															
Type	RO															
Reset	0															

Voice band uplink transmission data register 1. The content of this register is updated by uplink digital filter outputs. This register is read by DSP in an 8K ISR if VBYPASSIIR of AFE_LB_CON is set.

0x642 AFE Voice Downlink Data Register 0 AFE_VDL_DAT0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	VDL_DAT0															
Type	WO															
Reset	0															

Voice band downlink receiving data register 0. This register is written by DSP in an 8K ISR. The content of this register is used as downlink digital filter inputs.

0x643 AFE Voice Downlink Data Register 1 AFE_VDL_DAT1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	VDL_DAT1															
Type	WO															
Reset	0															

Voice band downlink receiving data register 1. This register is written by DSP in an 8K ISR if VBYPASSIIR of AFE_VLB_CON is set. The content of this register is used as downlink digital filter inputs.

0x644 AFE Voice DAI Bluetooth Transmission Data Register 0 AFE_VDBTX_DAT0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	VDBTX_DAT0															
Type	WO															
Reset	0															

DAI Bluetooth transmission data register 0. This register is written by DSP in an 8K ISR if the Bluetooth function is turned on. The content of this register is shifted out to the Bluetooth interface.

0x645 AFE Voice DAI Bluetooth Transmission Data Register 1 AFE_VDBTX_DAT1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	VDBTX_DAT 1															
Type	WO															
Reset	0															

DAI Bluetooth transmission data register 1. This register is written by DSP in an 8K ISR if the corresponding DAI test is set or the Bluetooth function is turned on. The content of this register is shifted out to the SS or Bluetooth interface.

0x646 AFE Voice DAI Bluetooth Receiving Data Register 0 AFE_VDBRX_DAT0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	VDBRX_DAT 0															
Type	RO															
Reset	0															

DAI Bluetooth receiving data register 0. This register is read by DSP in an 8K ISR if the Bluetooth function is turned on. The content of this register is shifted in from the Bluetooth interface.

0x647 AFE Voice DAI Bluetooth Receiving Data Register 1 AFE_VDBRX_DAT1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	VDBRX_DAT 1															
Type	RO															
Reset	0															

DAI Bluetooth receiving data register 1. This register is read by DSP in an 8K ISR if the corresponding DAI test is set or the Bluetooth function is turned on. The content of this register is shifted in from the SS or Bluetooth module.

0x648 AFE Voice DAI Bluetooth Control Register AFE_VDSP_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																VDSP_RDY
Type																R/W
Reset																0

DSP sets this register to inform hardware that it is ready for data transmission. In DAI test modes, DSP starts a test by setting vdsp_rdy when speech samples are required or are ready. In normal mode, the DSP asserts this bit to ungate the downlink path data. Otherwise, the downlink data remains zero.

VDSP_RDY Ready indication to start the voice band data path.

- **0** DSP data is not ready.
- **1** DSP data is ready.

0x649 AFE I2S Input Mode Buffer AFE_EDI_RDATA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RDATA															
Type	RO															
Reset	0															

This is the register for reading I2S input data. For each audio interrupt, DSP should read 6 pairs (total 12 reads) of the input data. If DSP is reading too fast or too slow, there is a 2-word margin for repeating or dropping the samples that DSP read rate can not match-up with audio front end.

DATA Read data port. Left channel first, and then right channel.

0x64A AFE AGC DSP Control AEF_VAGC_VAD

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name								NADPATT_DBGAIN						NGATEOPEN	VAD2	VAD
Type								R/W						R/W	R/W	R/W
Reset								000000						0	0	0

This register is for DSP to read/write the parameter of AGC.

VAD Strong VAD flag

0 off

1 on

VAD2 Weak VAD flag

0 off

1 on

NGATEOPEN noise gate flag

0 noise gate close

1 noise gate open

NADPATT_DBGAIN noise adaptive attenuation DB gain

[0,63] 0~63dB

0x64B AFE AGC DSP Control AEF_VAGC_CNTR

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	CNTR_REL_FF															TONE FLG
Type	R/W															R/W
Reset	000000000000000															0

This register is for DSP to read/write the parameter of AGC.

TONEFLG Tone flag

0 off

1 on

CNTR_REL_FF Proceed very fast release if N samples value smaller than the fast release threshold

0~32767 N=0~32767 @ 52kHz sampling rate.

0x64C AFE AGC DSP Control1 AEF_VAGC_CNTR1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	NCNTRRLZ								NCNTRATK							
Type	RO								RO							
Reset	0000_0000								0000_0000							

This register is for DSP to read the parameter of AGC.

NCNTRRLZ Release counter (in unit of 52kHz/256 sampling rate).

NCNTRATK Attack counter (in unit of 52kHz/16 sampling rate).

0x64D AFE AGC DSP Control AEF_VAGC_STETE

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									SSTATE		FGAINDB					
Type									RO		RO					
Reset									00		000000					

This register is for DSP to read the parameter of AGC.

FGAINDB Current PGA gain (from 0 to 63 dB).
SSTATE Current AGC state.

0x64E AFE AGC DSP Control AEF_VAGC_RMS

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SIGRMSATT								SIGRMS							
Type	RO								RO							
Reset	00000000								00000000							

This register is for DSP to read the parameter of AGC.

SIGRMS RMS of signal
SIGRMSATT RMS of signal for attack usage

0x64F AFE Audio Control Register AFE_ADSP_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name															ARST_FIFO	ADSP_RDY
Type															R/W	R/W
Reset															0	0

DSP sets this register to inform hardware that it is ready for data transmission. DSP asserts this bit to ungate the audio path data. Otherwise, the audio path data remains zero.

ADSP_RDY Ready to ungate audio data path.

ARST_FIFO Reset the FIFO read/write pointers and the interrupt counter.

0x650 AFE Audio Right-Channel Data Register 0 AFE_ARCH_DAT0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ARCH_DAT0															
Type	W															
Reset	0															

Audio right channel data register 0. The content of this register is used as the right channel digital filter inputs.

The frequency of audio interrupts varies with the audio sampling rate and bypass setting, and can be 1/6 the audio sampling rate, or 1/12 the sampling rate, or 1/24 the sampling rate. The frequency depends on the setting of BYPASS.

- BYPASS = 00b: 1/24 the sampling rate.
- BYPASS = 01b: 1/12 the sampling rate.
- BYPASS = 10b: 1/6 the sampling rate.
- BYPASS = 11b: 1/6 the sampling rate.

For DSP, 6 audio samples are written when an interrupt is received.

0x651 AFE AGC DSP GAIN AFE_VAGC_GAIN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											VAGC_GAIN					
Type											R/W					
Reset											000000					

AGC Gain setting by AGC. It is only validate while VAGC_CTRL is set to 1.

0x658 AFE Audio Left-Channel Data Register 0 AFE_ALCH_DAT 0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ALCH_DAT0															
Type	W															
Reset	0															

Audio left channel data register 0. The content of this register is used as the left channel digital filter inputs.

8.4 Programming Guide

Several cases – including speech call, voice memo record, voice memo playback, melody playback and DAI tests – requires that partial or the whole audio front-end be turned on.

The following are the recommended voice band path programming procedures to turn on audio front-end:

1. MCU programs the AFE_VMCU_CON1, AFE_DAI_CON, AFE_VAGC_CON1, AFE_VAGC_CON2, AFE_VAGC_CON3, AFE_VAGC_CON4, AFE_VAGC_CON5, AFE_VAGC_CON6, AFE_VLB_CON, AFE_VAG_CON, AFE_VAC_CON0, AFE_VAC_CON1 and AFE_VAPDN_CON registers for specific operation modes. Refer also to the analog chip interface specification.
2. MCU clears the VAFE bit of the PDN_CON2 register to ungate the clock for the voice band path. Refer to the software power down control specification.
3. MCU sets AFE_VMCU_CON0 to start operation of the voice band path.

The following are the recommended voice band path programming procedures to turn off audio front-end:

1. MCU programs AFE_VAPDN_CON to power down the voice band path analog blocks.
2. MCU clears AFE_VMCU_CON0 to stop operation of the voice band path.
3. MCU sets VAFE bit of PDN_CON2 register to gate the clock for the voice band path.

The following are the recommended audio band path programming procedures to turn on audio front-end:

1. MCU programs the AFE_AMCU_CON1, AFE_AAG_CON, AFE_AAC_CON, and AFE_AAPDN_CON registers for specific configurations. Refer also to the analog chip interface specification.

2. MCU clears the AAFE bit of the PDN_CON2 register to ungate the clock for the audio band path. Refer to the software power down control specification.
3. MCU sets AFE_AMCU_CON0 to start operation of the audio band path.

The following are the recommended audio band path programming procedures to turn off audio front-end:

1. MCU programs the AFE_AAPDN_CON to power down the audio band path analog blocks. Refer also to the analog block specification for further details.
2. MCU clears AFE_AMCU_CON0 to stop operation of the audio band path.
3. MCU sets the AAFE bit of the PDN_CON2 register to gate the clock for the audio band path.

9 Radio Interface Control

This chapter details the MT6235 interface control with the radio part of a GSM terminal. Providing a comprehensive control scheme, the MT6235 radio interface consists of Baseband Serial Interface (BSI), Baseband Parallel Interface (BPI), Automatic Power Control (APC) and Automatic Frequency Control (AFC), together with APC-DAC and AFC-DAC.

9.1 Baseband Serial Interface

The Baseband Serial Interface controls external radio components. A 3-wire serial bus transfers data to RF circuitry for PLL frequency change, reception gain setting, and other radio control purposes. In this unit, BSI data registers are double-buffered in the same way as the TDMA event registers. The user writes data into the write buffer and the data is transferred from the write buffer to the active buffer when a TDMA_EVTVAL signal (from the TDMA timer) is pulsed.

Each data register BSI_D*n*_DAT is associated with one data control register BSI_D*n*_CON, where *n* denotes the index. Each data control register identifies which events (signaled by TDMA_BSISTR*n*, generated by the TDMA timer) trigger the download process of the word in register BSI_D*n*_DAT. The word and its length (in bits) is downloaded via the serial bus. A special event is triggered when the IMOD flag is set to 1: it provides immediate download process without software programming the TDMA timer.

If more than one data word is to be downloaded on the same BSI event, the word with the lowest address among them is downloaded first, followed by the next lowest and so on.

The total download time depends on the word length, the number of words to download, and the clock rates. The programmer must space the successive event to provide enough time. If the download process of the previous event is not complete before a new event arrives, the latter is suppressed.

The unit has four output pins: BSI_CLK is the output clock, BSI_DATA is the serial data port, and BSI_CS0 and BSI_CS1 are the select pins for 2 external components. BSI_CS1 is multiplexed with another function. Please refer to GPIO table for more detail.

In order to support bi-directional read and write operations of the RF chip, software can directly write values to BSI_CLK, BSI_DATA and BSI_CS by programming the BSI_DOUT register. Data from the RF chip can be read by software via the register BSI_DIN. If the RF chip interface is a 3-wire interface, then BSI_DATA is bi-directional. Before software can program the 3-wire behavior, the BSI_IO_CON register must be set. An additional signal path from GPIO accommodates RF chips with a 4-wire interface.

The block diagram of the BSI unit is as depicted in **Figure 69.**

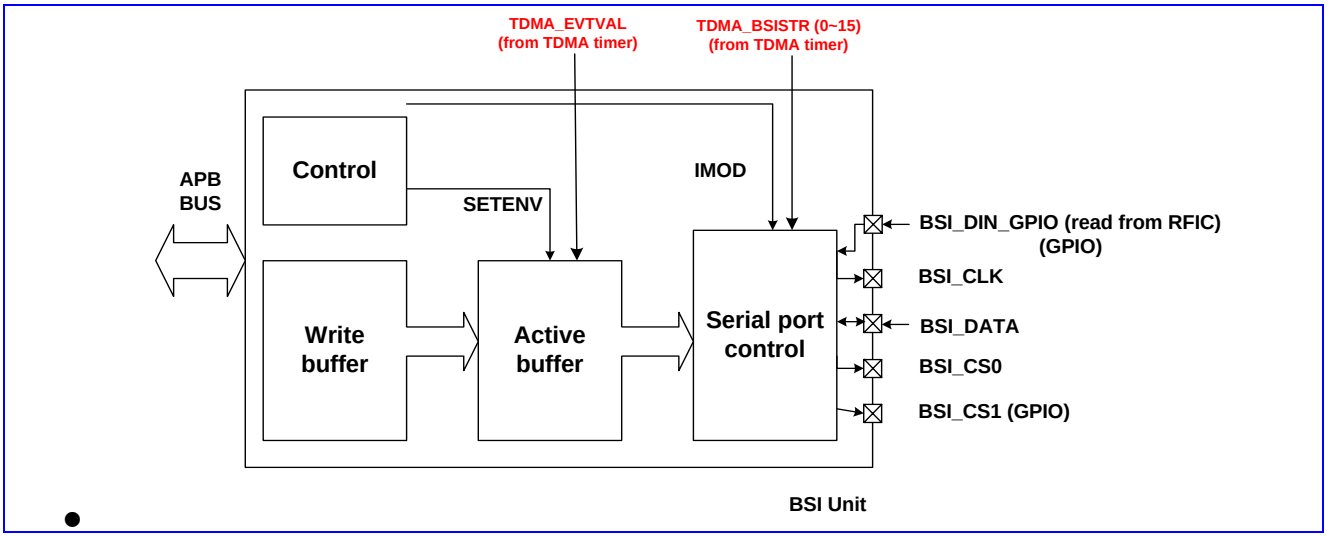


Figure 69 Block diagram of BSI unit.

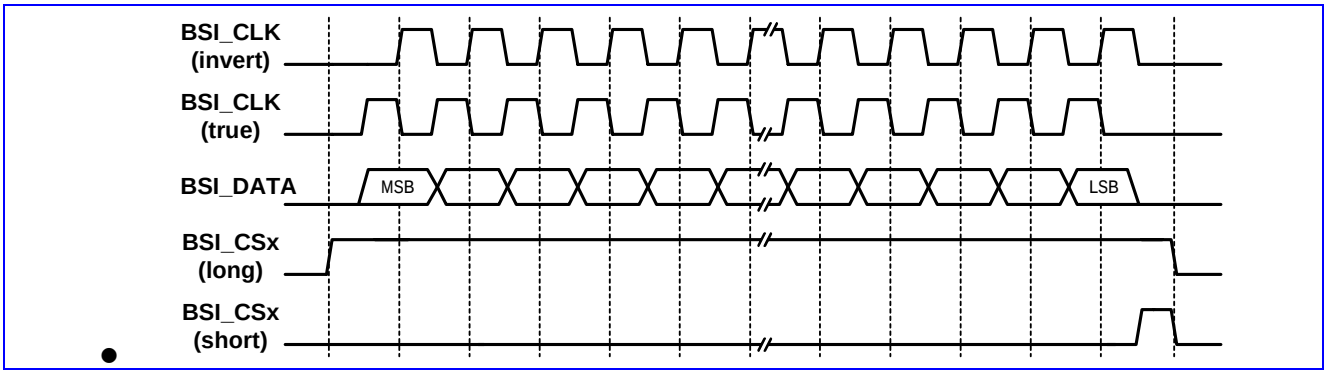


Figure 70 Timing characteristic of BSI interface.

9.1.1 Register Definitions

BSI+0000h BSI control register **BSI_CON**

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name								SETENV	EN1_POL	EN1_LEN	EN0_POL	EN0_LEN	IMOD	CLK_SPD		CLK_POL
Type								R/W	R/W	R/W	R/W	R/W	WO	R/W		R/W
Reset								0	0	0	0	0	N/A	0		0

This register is the control register for the BSI unit. The register controls the signal type of the 3-wire interface.

CLK_POL Controls the polarity of BSI_CLK. Refer to **Figure 70.**

0 True clock polarity

1 Inverted clock polarity

CLK_SPD Defines the clock rate of BSI_CLK. The 3-wire interface provides 4 choices of data bit rate. The default is 52/2 MHz.

00 52/2 MHz

01 52/4 MHz

10 52/6 MHz

11 52/8 MHz

IMOD Enables immediate mode. If the user writes 1 to the flag, the download is triggered immediately without waiting for the timer events. The words for which the register event ID equals 1Fh are downloaded following this signal. This flag is write-only. The immediate write is exercised only once: the programmer must write the flag again to invoke another immediate download. Setting the flag does not disable the other events from the timer; the programmer can disable all events by setting BSI_ENA to all zeros.

ENX_LEN Controls the type of signals BSI_CS0 and BSI_CS1. Refer to **Figure 69.**

0 Long enable pulse

1 Short enable pulse

ENX_POL Controls the polarity of signals BSI_CS0 and BSI_CS1.

0 True enable pulse polarity

1 Inverted enable pulse polarity

SETENV Enables the write operation of the active buffer.

0 The user writes to the write buffer. The data is then latched in the active buffer after TDMA_EVTVAL is pulsed.

1 The user writes data directly to the active buffer.

BSI+0004h Control part of data register 0 BSI_D0_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ISB	LEN										EVT_ID				
Type	R/W	R/W										R/W				

This register is the control part of the data register 0. The register determines the required length of the download data word, the event to trigger the download process of the word, and the targeted device.

Table 43 lists the 44 data registers of this type. The max length of the first 40 data registers is 32 bits, and that of the last 4 data registers is 78 bits. Multiple data control registers may contain the same event ID. The data words of all registers with the same event ID are downloaded when the event occurs.

EVT_ID Stores the event ID for which the data word awaits to be downloaded.

00000~10011 Synchronous download of the word with the selected EVT_ID event. The relationship between this field and the event is listed as **Table 42.**

Event ID (in binary) – EVT_ID	Event name
00000	TDMA_BSISTR0
00001	TDMA_BSISTR1
00010	TDMA_BSISTR2
00011	TDMA_BSISTR3
00100	TDMA_BSISTR4
00101	TDMA_BSISTR5
00110	TDMA_BSISTR6
00111	TDMA_BSISTR7
01000	TDMA_BSISTR8
01001	TDMA_BSISTR9

01010	TDMA_BSISTR10
01011	TDMA_BSISTR11
01100	TDMA_BSISTR12
01101	TDMA_BSISTR13
01110	TDMA_BSISTR14
01111	TDMA_BSISTR15
10000	TDMA_BSISTR16
10001	TDMA_BSISTR17
10010	TDMA_BSISTR18
10011	TDMA_BSISTR19

Table 42 The relationship between the value of EVT_ID field in the BSI control registers and the TDMA_BSISTR events.

10100~11110 Reserved

11111 Immediate download

LEN The field stores the length of the data word. The actual length is defined as LEN + 1 in units of bits. For data registers 0~39, the value ranges from 0 to 31, corresponding to 1 to 32 bits in length. For data registers 40~43, the value ranges from 0 to 77, corresponding to 1 to 78 bits in length.

ISB The flag selects the target device.

0 Device 0 is selected.

1 Device 1 is selected.

BSI +0008h Data part of data register 0 BSI_D0_DAT

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	DAT [31:16]															
Type	R/W															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DAT [15:0]															
Type	R/W															

This register is the data part of the data register 0. The legal length of the data is up to 32 bits. The actual number of bits to be transmitted is specified in LEN field in the BSI_D0_CON register.

DAT The field signifies the data part of the data register.

Table 43 lists the address mapping and function of the 44 pairs of data registers.

Register Address	Register Function	Acronym
BSI +0004h	Control part of data register 0	BSI_D0_CON
BSI +0008h	Data part of data register 0	BSI_D0_DAT
BSI +000Ch	Control part of data register 1	BSI_D1_CON
BSI +0010h	Data part of data register 1	BSI_D1_ DAT
BSI +0014h	Control part of data register 2	BSI_D2_CON
BSI +0018h	Data part of data register 2	BSI_D2_ DAT
BSI +001Ch	Control part of data register 3	BSI_D3_CON
BSI +0020h	Data part of data register 3	BSI_D3_ DAT

BSI +0024h	Control part of data register 4	BSI_D4_CON
BSI +0028h	Data part of data register 4	BSI_D4_ DAT
BSI +002Ch	Control part of data register 5	BSI_D5_CON
BSI +0030h	Data part of data register 5	BSI_D5_ DAT
BSI +0034h	Control part of data register 6	BSI_D6_CON
BSI +0038h	Data part of data register 6	BSI_D6_ DAT
BSI +003Ch	Control part of data register 7	BSI_D7_CON
BSI +0040h	Data part of data register 7	BSI_D7_ DAT
BSI +0044h	Control part of data register 8	BSI_D8_CON
BSI +0048h	Data part of data register 8	BSI_D8_ DAT
BSI +004Ch	Control part of data register 9	BSI_D9_CON
BSI +0050h	Data part of data register 9	BSI_D9_ DAT
BSI +0054h	Control part of data register 10	BSI_D10_CON
BSI +0058h	Data part of data register 10	BSI_D10_ DATA
BSI +005Ch	Control part of data register 11	BSI_D11_CON
BSI +0060h	Data part of data register 11	BSI_D11_ DAT
BSI +0064h	Control part of data register 12	BSI_D12_CON
BSI +0068h	Data part of data register 12	BSI_D12_ DAT
BSI +006Ch	Control part of data register 13	BSI_D13_CON
BSI +0070h	Data part of data register 13	BSI_D13_ DAT
BSI +0074h	Control part of data register 14	BSI_D14_CON
BSI +0078h	Data part of data register 14	BSI_D14_ DAT
BSI +007Ch	Control part of data register 15	BSI_D15_CON
BSI +0080h	Data part of data register 15	BSI_D15_ DAT
BSI +0084h	Control part of data register 16	BSI_D16_CON
BSI +0088h	Data part of data register 16	BSI_D16_ DAT
BSI +008Ch	Control part of data register 17	BSI_D17_CON
BSI +0090h	Data part of data register 17	BSI_D17_ DAT
BSI +0094h	Control part of data register 18	BSI_D18_CON
BSI +0098h	Data part of data register 18	BSI_D18_ DAT
BSI +009Ch	Control part of data register 19	BSI_D19_CON
BSI +00A0h	Data part of data register 19	BSI_D19_ DAT
BSI +00A4h	Control part of data register 20	BSI_D20_CON
BSI +00A8h	Data part of data register 20	BSI_D20_ DAT
BSI +00ACh	Control part of data register 21	BSI_D21_CON
BSI +00B0h	Data part of data register 21	BSI_D21_ DAT
BSI +00B4h	Control part of data register 22	BSI_D22_CON
BSI +00B8h	Data part of data register 22	BSI_D22_ DAT
BSI +00BCh	Control part of data register 23	BSI_D23_CON

BSI +00C0h	Data part of data register 23	BSI_D23_ DAT
BSI +00C4h	Control part of data register 24	BSI_D24_CON
BSI +00C8h	Data part of data register 24	BSI_D24_ DAT
BSI +00CCh	Control part of data register 25	BSI_D25_CON
BSI +00D0h	Data part of data register 25	BSI_D25_ DAT
BSI +00D4h	Control part of data register 26	BSI_D26_CON
BSI +00D8h	Data part of data register 26	BSI_D26_ DAT
BSI +00DCh	Control part of data register 27	BSI_D27_CON
BSI +00E0h	Data part of data register 27	BSI_D27_ DAT
BSI +00E4h	Control part of data register 28	BSI_D28_CON
BSI +00E8h	Data part of data register 28	BSI_D28_ DAT
BSI +00ECh	Control part of data register 29	BSI_D29_CON
BSI +00F0h	Data part of data register 29	BSI_D29_ DAT
BSI +00F4h	Control part of data register 30	BSI_D30_CON
BSI +00F8h	Data part of data register 30	BSI_D30_ DAT
BSI +00FCh	Control part of data register 31	BSI_D31_CON
BSI +0100h	Data part of data register 31	BSI_D31_ DAT
BSI +0104h	Control part of data register 32	BSI_D32_CON
BSI +0108h	Data part of data register 32	BSI_D32_ DAT
BSI +010Ch	Control part of data register 33	BSI_D33_CON
BSI +0110h	Data part of data register 33	BSI_D33_ DAT
BSI +0114h	Control part of data register 34	BSI_D34_CON
BSI +0118h	Data part of data register 34	BSI_D34_ DAT
BSI +011Ch	Control part of data register 35	BSI_D35_CON
BSI +0120h	Data part of data register 35	BSI_D35_ DAT
BSI +0124h	Control part of data register 36	BSI_D36_CON
BSI +0128h	Data part of data register 36	BSI_D36_ DAT
BSI +012Ch	Control part of data register 37	BSI_D37_CON
BSI +0130h	Data part of data register 37	BSI_D37_ DAT
BSI +0134h	Control part of data register 38	BSI_D38_CON
BSI +0138h	Data part of data register 38	BSI_D38_ DAT
BSI +013Ch	Control part of data register 39	BSI_D39_CON
BSI +0140h	Data part of data register 39	BSI_D39_ DAT
BSI +0144h	Control part of data register 40	BSI_D40_CON
BSI +0148h	Data part of data register 40 (MSB 14 bits)	BSI_D40_ DAT2
BSI +014Ch	Data part of data register 40	BSI_D40_ DAT1
BSI +0150h	Data part of data register 40 (LSB 32 bits)	BSI_D40_ DAT0
BSI +0154h	Control part of data register 41	BSI_D41_CON
BSI +0158h	Data part of data register 41 (MSB 14 bits)	BSI_D41_ DAT2

BSI +015Ch	Data part of data register 41	BSI_D41_ DAT1
BSI +0160h	Data part of data register 41 (LSB 32 bits)	BSI_D41_ DAT0
BSI +0164h	Control part of data register 42	BSI_D42_CON
BSI +0168h	Data part of data register 42 (MSB 14 bits)	BSI_D42_ DAT2
BSI +016Ch	Data part of data register 42	BSI_D42_ DAT1
BSI +0170h	Data part of data register 42 (LSB 32 bits)	BSI_D42_ DAT0
BSI +0174h	Control part of data register 43	BSI_D43_CON
BSI +0178h	Data part of data register 43 (MSB 14 bits)	BSI_D43_ DAT2
BSI +017Ch	Data part of data register 43	BSI_D43_ DAT1
BSI +0180h	Data part of data register 43 (LSB 32 bits)	BSI_D43_ DAT0

Table 43 BSI data registers

BSI +0190h BSI event enable register BSI_ENA_0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BSI15	BSI14	BSI13	BSI12	BSI11	BSI10	BSI9	BSI8	BSI7	BSI6	BSI5	BSI4	BSI3	BSI2	BSI1	BSI0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

This register enables an event by setting the corresponding bit. After a hardware reset, all bits are initialized to 1. These bits are also set to 1 after TDMA_EVTVAL pulse.

BSIx Enables downloading of the words corresponding to the events signaled by TMDA_BSI.

0 The event is not enabled.

1 The event is enabled.

BSI +0194h BSI event enable register – MSB 4 bits BSI_ENA_1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													BSI19	BSI18	BSI17	BSI16
Type													R/W	R/W	R/W	R/W
Reset													1	1	1	1

The register could enable the event by setting the corresponding bit. After hardware reset, all bits are initialized as 1. Besides, those bits are set as 1 after TDMA_EVTVAL is pulsed.

BSIx The flag enables the downloading of the words that corresponds to the events signaled by TMDA_BSI.

0 The event is not enabled.

The event is enabled.

BSI +0198h BSI IO mode control register BSI_IO_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													SEL_CS1	4_WIRE	DAT_DIR	MODE
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

MODE Defines the source of BSI signal.

0 BSI signal is generated by the hardware.

1 BSI signal is generated by the software. In this mode, the BSI clock depends on the value of the field DOUT.CLK. BSI_CS depends on the value of the field DOUT.CS and BSI_DATA depends on the value of the field DOUT.DATA.

DAT_DIR Defines the direction of BSI_DATA.

0 BSI _DATA is configured as input. The 3-wire interface is used and BSI_DATA is bi-directional.

1 BSI_DATA is configured as output.

4_WIRE Defines the BSI_DIN source.

0 The 3-wire interface is used and BSI_DATA is bi-directional. BSI_DIN comes from the same pin as BSI_DATA.

1 The 4-wire interface is used. Another pin (GPIO) is used as BSI_DIN.

SEL_CS1 Defines which of the BSI_CSx (BSI_CS0 or BSI_CS1) is written by the software.

0 BSI_CS0 is selected.

1 BSI_CS1 is selected.

BSI +019Ch Software-programmed data out BSI_DOUT

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name														DATA	CS	CLK
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	W	W	W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CLK Signifies the BSI_CLK signal.

CS Signifies the BSI_CS signal.

DATA Signifies the BSI_DATA signal.

BSI +01A0h Input data from RF chip BSI_DIN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																DIN
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DIN Registers the input value of BSI_DATA from the RF chip.

BSI +01A4h BSI data pair number BSI_PAIR_NUM

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											PAIR_NUM					
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R					
Reset	0	0	0	0	0	0	0	0	0	0	28					

PAIR_NUM The software can program how many pairs of data register to be used. The default value is 28 pairs. This value must be smaller or equal to 44. The first 40 pairs are 32-bit long, and the last four pairs are 78-bit long.

9.2 Baseband Parallel Interface

9.2.1 General Description

The Baseband Parallel Interface features 10 control pins, which are used for timing-critical external circuits. These pins typically control front-end components which must be turned on or off at specific times during GSM operation, such as transmit-enable, band switching, TR-switch, etc.

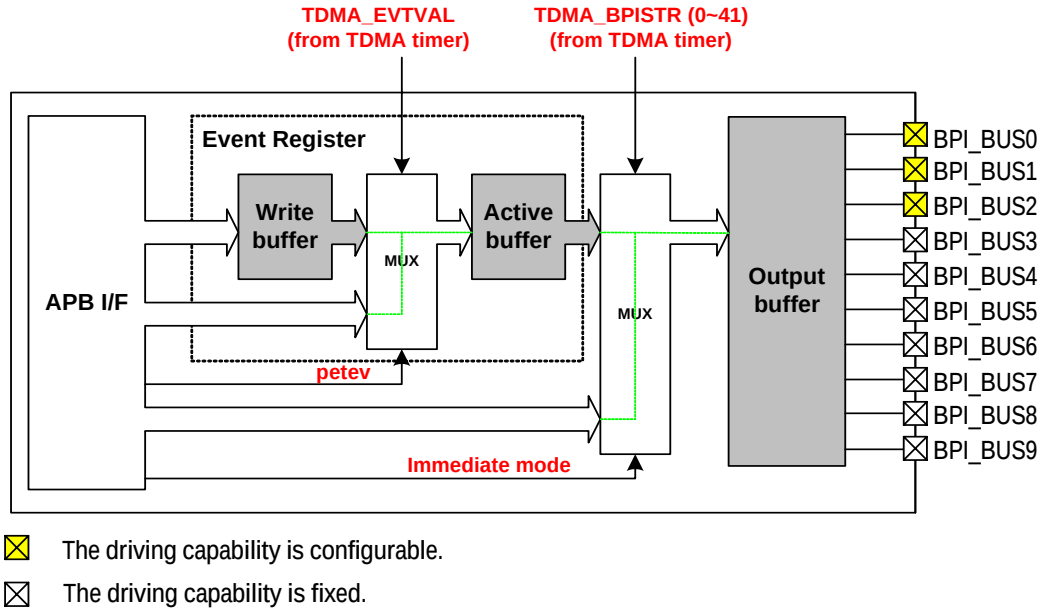


Figure 71 Block diagram of BPI interface

The user can program 42 sets of 10-bit registers to set the output value of BPI_BUS0~BPI_BUS9. The data is stored in the write buffers. The write buffers are then forwarded to the active buffers when the TDMA_EVTVAL signal is pulsed, usually once per frame. Each of the 42 write buffers corresponds to an active buffer, as well as to a TDMA event.

Each TDMA_BPISTR event triggers the transfer of data in the corresponding active buffer to the output buffer, thus changing the value of the BPI bus. The user can disable the events by programming the enable registers in the TDMA timer. If the TDMA_BPISTR event is disabled, the corresponding signal TDMA_BPISTR is not pulsed, and the value on the BPI bus remains unchanged.

For applications in which BPI signals serve as the switch, current-driving components are typically added to enhance driving capability. Three configurable output pins provide current up to 8 mA, and help reduce the number of external components. The output pins BPI_BUS6, BPI_BUS7, BPI_BUS8, and BPI_BUS9 are multiplexed with GPIO. Please refer to the GPIO table for more detailed information.

9.2.2 Register Definitions

BPI+0000h BPI control register BPI_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name													PINM2	PINM1	PINM0	PETEV
Type													WO	WO	WO	R/W
Reset													0	0	0	0

This register is the control register of the BPI unit. The register controls the direct access mode of the active buffer and the current driving capability for the output pins.

The driving capabilities of BPI_BUS0, BPI_BUS1 and BPI_BUS2 can be 2 mA or 8 mA, determined by the value of PINM0, PINM1 and PINM2 respectively. These output pins provide a higher driving capability and save on external current-driving components. In addition to the configurable pins, pins BPI_BUS3 to BPI_BUS9 provide a driving capability of 2 mA (fixed).

PETEV Enables direct access to the active buffer.

- **0** The user writes data to the write buffer. The data is latched in the active buffer after the TDMA_EVTVAL signal is pulsed.
- **1** The user directly writes data to the active buffer without waiting for the TDMA_EVTVAL signal.

PINM0 Controls the driving capability of BPI_BUS0.

- **0** The output driving capability is 2mA.
- **1** The output driving capability is 8mA.

PINM1 Controls the driving capability of BPI_BUS1.

- **0** The output driving capability is 2mA.
- **1** The output driving capability is 8mA.

PINM2 Controls the driving capability of BPI_BUS2.

- **0** The output driving capability is 2mA.
- **1** The output driving capability is 8mA.

BPI +0004h BPI data register 0 BPI_BUF0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							PO9	PO8	PO7	PO6	PO5	PO4	PO3	PO2	PO1	PO0
Type							R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

This register defines the BPI signals that are associated with the event TDMA_BPI0.

Table 44 lists 42 registers of the same structure, each of which is associated with one specific event signal from the TDMA timer. The data registers are all double-buffered. When PETEV is set to 0, the data register links to the write buffer. When PETEV is set to 1, the data register links to the active buffer.

One register, BPI_BUFI, is dedicated for use in immediate mode. Writing a value to that register effects an immediate change in the corresponding BPI signal and bus.

POx This flag defines the corresponding signals for BPIx after the TDMA event 0 takes place.

The overall data register definition is listed in **Table 44.**

Register Address	Register Function	Acronym
BPI +0004h	BPI pin data for event TDMA_BPI 0	BPI_BUF0
BPI +0008h	BPI pin data for event TDMA_BPI 1	BPI_BUF1
BPI +000Ch	BPI pin data for event TDMA_BPI 2	BPI_BUF2
BPI +0010h	BPI pin data for event TDMA_BPI 3	BPI_BUF3

BPI +0014h	BPI pin data for event TDMA_BPI 4	BPI_BUF4
BPI +0018h	BPI pin data for event TDMA_BPI 5	BPI_BUF5
BPI +001Ch	BPI pin data for event TDMA_BPI 6	BPI_BUF6
BPI +0020h	BPI pin data for event TDMA_BPI 7	BPI_BUF7
BPI +0024h	BPI pin data for event TDMA_BPI 8	BPI_BUF8
BPI +0028h	BPI pin data for event TDMA_BPI 9	BPI_BUF9
BPI +002Ch	BPI pin data for event TDMA_BPI 10	BPI_BUF10
BPI +0030h	BPI pin data for event TDMA_BPI 11	BPI_BUF11
BPI +0034h	BPI pin data for event TDMA_BPI 12	BPI_BUF12
BPI +0038h	BPI pin data for event TDMA_BPI 13	BPI_BUF13
BPI +003Ch	BPI pin data for event TDMA_BPI 14	BPI_BUF14
BPI +0040h	BPI pin data for event TDMA_BPI 15	BPI_BUF15
BPI +0044h	BPI pin data for event TDMA_BPI 16	BPI_BUF16
BPI +0048h	BPI pin data for event TDMA_BPI 17	BPI_BUF17
BPI +004Ch	BPI pin data for event TDMA_BPI 18	BPI_BUF18
BPI +0050h	BPI pin data for event TDMA_BPI 19	BPI_BUF19
BPI +0054h	BPI pin data for event TDMA_BPI 20	BPI_BUF20
BPI +0058h	BPI pin data for event TDMA_BPI 21	BPI_BUF21
BPI +005Ch	BPI pin data for event TDMA_BPI 22	BPI_BUF22
BPI +0060h	BPI pin data for event TDMA_BPI 23	BPI_BUF23
BPI +0064h	BPI pin data for event TDMA_BPI 24	BPI_BUF24
BPI +0068h	BPI pin data for event TDMA_BPI 25	BPI_BUF25
BPI +006Ch	BPI pin data for event TDMA_BPI 26	BPI_BUF26
BPI +0070h	BPI pin data for event TDMA_BPI 27	BPI_BUF27
BPI +0074h	BPI pin data for event TDMA_BPI 28	BPI_BUF28
BPI +0078h	BPI pin data for event TDMA_BPI 29	BPI_BUF29
BPI +007Ch	BPI pin data for event TDMA_BPI 30	BPI_BUF30
BPI +0080h	BPI pin data for event TDMA_BPI 31	BPI_BUF31
BPI +0084h	BPI pin data for event TDMA_BPI 32	BPI_BUF32
BPI +0088h	BPI pin data for event TDMA_BPI 33	BPI_BUF33
BPI +008Ch	BPI pin data for event TDMA_BPI 34	BPI_BUF34
BPI +0090h	BPI pin data for event TDMA_BPI 35	BPI_BUF35
BPI +0094h	BPI pin data for event TDMA_BPI 36	BPI_BUF36
BPI +0098h	BPI pin data for event TDMA_BPI 37	BPI_BUF37
BPI +009Ch	BPI pin data for event TDMA_BPI 38	BPI_BUF38
BPI +00A0h	BPI pin data for event TDMA_BPI 39	BPI_BUF39
BPI +00A4h	BPI pin data for event TDMA_BPI 40	BPI_BUF40
BPI +00A8h	BPI pin data for event TDMA_BPI 41	BPI_BUF41
BPI +00ACh	BPI pin data for immediate mode	BPI_BUFI

Table 44 BPI Data Registers.

BPI +00B0h BPI event enable register 0 BPI_ENA0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BEN15	BEN14	BEN13	BEN12	BEN11	BEN10	BEN9	BEN8	BEN7	BEN6	BEN5	BEN4	BEN3	BEN2	BEN1	BEN0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

This register enables the events that are signaled by the TDMA timer: by clearing a register bit, the corresponding event signal is ignored. After a hardware reset, all the enable bits default to 1 (enabled). Upon receiving a TDMA_EVTVAL pulse, all register bits are also set to 1 (enabled).

BENn This flag indicates whether event n signals are heeded or ignored.

0 Event n is disabled (ignored).

1 Event n is enabled.

BPI+00B4h BPI event enable register 1 BPI_ENA1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BEN31	BEN30	BEN29	BEN28	BEN27	BEN26	BEN25	BEN24	BEN23	BEN22	BEN21	BEN20	BEN19	BEN18	BEN17	BEN16
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

This register enables the events that are signaled by the TDMA timing generator: by clearing a register bit, the corresponding event signal is ignored. After a hardware reset, all the enable bits default to 1 (enabled). Upon receiving the TDMA_EVTVAL pulse, all register bits are also set to 1 (enabled).

BENn This flag indicates whether event n signals are heeded or ignored.

0 Event n is disabled (ignored).

1 **Event n is enabled.**

BPI+00B8h BPI event enable register 2 BPI_ENA2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							BEN41	BEN40	BEN39	BEN38	BEN37	BEN36	BEN35	BEN34	BEN33	BEN32
Type							R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset							0	0	0	0	0	0	0	0	0	0

The register is used to enable the events that are signaled by the TDMA timing generator. After hardware reset, all the enable bits defaults to be 1 (enabled). Upon receiving the TDMA_EVTVAL pulse, those bits are also set to 1 (enabled).

BENn The flag controls the function of event n.

0 The event n is disabled.

1 The event n is enabled.

9.3 Automatic Power Control (APC) Unit

9.3.1 General Description

The Automatic Power Control (APC) unit controls the Power Amplifier (PA) module. Through APC unit, the proper transmit power level of the handset can be set to ensure that burst power ramping requirements are met. In one TDMA

frame, up to 7 TDMA events can be enabled to support multi-slot transmission. In practice, 5 banks of ramp profiles are used in one frame to make up 4 consecutive transmission slots.

The shape and magnitude of the ramp profiles are configurable to fit ramp-up (ramp up from zero), intermediate ramp (ramp between transmission windows), and ramp-down (ramp down to zero) profiles. Each bank of the ramp profile consists of 16 8-bit unsigned values, which are adjustable for different conditions.

The entries from one bank of the ramp profile are partitioned into two parts, with 8 values in each half. In normal operation, the entries in the left half are multiplied by a 10-bit left scaling factor, and the entries in the right half are multiplied by a 10-bit right scaling factor. The values are then truncated to form 16 10-bit intermediate values. Finally the intermediate ramp profile are linearly interpolated into 32 10-bit values and sequentially used to update the D/A converter. The block diagram of the APC unit is shown in **Figure 72 .**

The APB bus interface is 32 bits wide. Four write accesses are required to program each bank of ramp profile. The detailed register allocations are listed in **Table 45.**

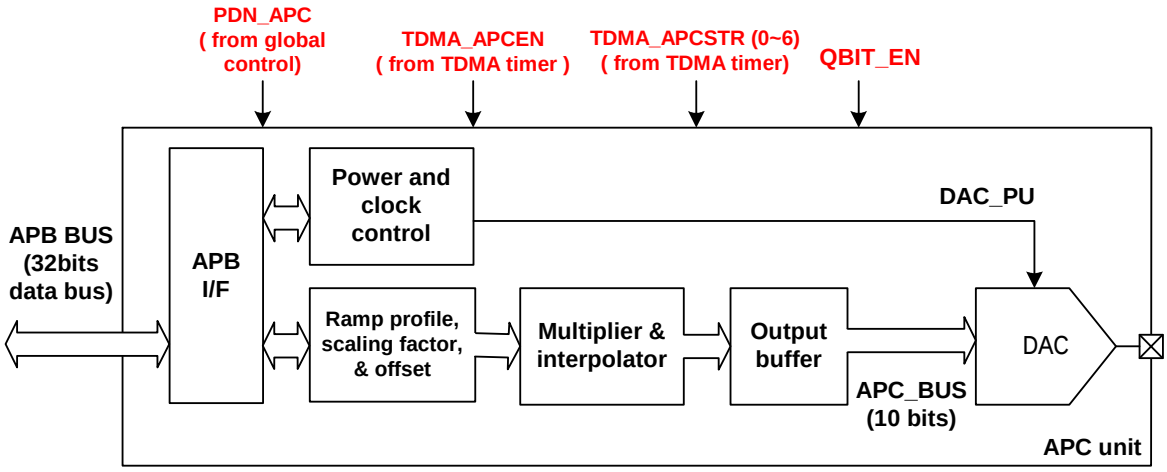


Figure 72 Block diagram of APC unit.

9.3.2 Register Definitions

APC+0000h APC 1st ramp profile #0 APC_PFA0

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Name	ENT3								ENT2							
Type	R/W								R/W							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ENT1								ENT0							
Type	R/W								R/W							

The register stores the first four entries of the first power ramp profile. The first entry resides in the least significant byte [7:0], the second entry in the second byte [15:8], the third entry in the third byte [23:16], and the fourth in the most significant byte [31:24]. Since this register provides no hardware reset, the programmer must configure it before any APC event takes place.

ENT3 The field signifies the 4th entry of the 1st ramp profile.

ENT2 The field signifies the 3rd entry of the 1st ramp profile.

ENT1 The field signifies the 2nd entry of the 1st ramp profile.

ENT0 The field signifies the 1st entry of the 1st ramp profile.

The overall ramp profile register definition is listed in **Table 45.**

Register Address	Register Function	Acronym
APC +0000h	APC 1st ramp profile #0	APC_PFA0
APC +0004h	APC 1st ramp profile #1	APC_PFA1
APC +0008h	APC 1st ramp profile #2	APC_PFA2
APC +000Ch	APC 1st ramp profile #3	APC_PFA3
APC +0020h	APC 2nd ramp profile #0	APC_PFB0
APC +0024h	APC 2nd ramp profile #1	APC_PFB1
APC +0028h	APC 2nd ramp profile #2	APC_PFB2
APC +002Ch	APC 2nd ramp profile #3	APC_PFB3
APC +0040h	APC 3rd ramp profile #0	APC_PFC0
APC +0044h	APC 3rd ramp profile #1	APC_PFC1
APC +0048h	APC 3rd ramp profile #2	APC_PFC2
APC +004Ch	APC 3rd ramp profile #3	APC_PFC3
APC +0060h	APC 4th ramp profile #0	APC_PFD0
APC +0064h	APC 4th ramp profile #1	APC_PFD1
APC +0068h	APC 4th ramp profile #2	APC_PFD2
APC +006Ch	APC 4th ramp profile #3	APC_PFD3
APC +0080h	APC 5th ramp profile #0	APC_PFE0
APC +0084h	APC 5th ramp profile #1	APC_PFE1
APC +0088h	APC 5th ramp profile #2	APC_PFE2
APC +008Ch	APC 5th ramp profile #3	APC_PFE3
APC +00A0h	APC 6th ramp profile #0	APC_PFF0
APC +00A4h	APC 6th ramp profile #1	APC_PFF1
APC +00A8h	APC 6th ramp profile #2	APC_PFF2
APC +00ACh	APC 6th ramp profile #3	APC_PFF3
APC +00C0h	APC 7th ramp profile #0	APC_PFG0
APC +00C4h	APC 7th ramp profile #1	APC_PFG1
APC +00C8h	APC 7th ramp profile #2	APC_PFG2
APC +00CCh	APC 7th ramp profile #3	APC_PFG3

Table 45 APC ramp profile registers

APC +0010h APC 1st ramp profile left scaling factor APC_SCAL0L

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							SF									
Type							R/W									
Reset							1_0000_0000									

The register stores the left scaling factor of the 1st ramp profile. This factor multiplies the first 8 entries of the 1st ramp profile to provide the scaled profile, which is then interpolated to control the D/A converter.

After a hardware reset, the initial value of the register is 256. In this case, no scaling is done (each entry of the ramp profile is multiplied by 1), because the 8 least significant bits are truncated after multiplication.

The overall scaling factor register definition is listed in **Table 46 .**

SF Scaling factor. After a hardware reset, the value is 256.

APC +0014h APC 1st ramp profile right scaling factor APC_SCAL0R

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							SF									
Type							R/W									
Reset							1_0000_0000									

The register stores the right scaling factor of the 1st ramp profile. This factor multiplies the last 8 entries of the 1st ramp profile to provide the scaled profile, which is then interpolated to control the D/A converter.

After a hardware reset, the initial value of the register is 256. In this case, no scaling is done (each entry of the ramp profile is multiplied by 1), because the 8 least significant bits are truncated after multiplication.

The overall scaling factor register definition is listed in **Table 46 .**

SF Scaling factor. After a hardware reset, the value is 256.

APC+0018h APC 1st ramp profile offset value APC_OFFSET0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							OFFSET									
Type							R/W									
Reset							0									

There are 7 offset values for the corresponding ramp profile.

The 1st offset value also serves as the pedestal value. The value is used to power up the APC D/A converter before the RF signals start to transmit. The D/A converter is then biased on the value, to provide the initial control voltage for the external control loop. The exact value depends on the characteristics of the external components. The timing to output the pedestal value is configurable through the TDMA_BULCON2 register of the timing generator; its valid range is 0~127 quarter-bits of time after the baseband D/A converter is powered up.

OFFSET Offset value for the corresponding ramp profile. After a hardware reset, the default value is 0.
The overall offset register definition is listed in **Table 46.**

Register Address	Register Function	Acronym
APC +0010h	APC 1st ramp profile left scaling factor	APC_SCAL0L
APC +0014h	APC 1st ramp profile right scaling factor	APC_SCAL0R
APC +0018h	APC 1st ramp profile offset value	APC_OFFSET0
APC +0030h	APC 2nd ramp profile left scaling factor	APC_SCAL1L
APC +0034h	APC 2nd ramp profile right scaling factor	APC_SCAL1R
APC +0038h	APC 2nd ramp profile offset value	APC_OFFSET1
APC +0050h	APC 3rd ramp profile left scaling factor	APC_SCAL2L
APC +0054h	APC 3rd ramp profile right scaling factor	APC_SCAL2R
APC +0058h	APC 3rd ramp profile offset value	APC_OFFSET2

APC +0070h	APC 4th ramp profile left scaling factor	APC_SCAL3L
APC +0074h	APC 4th ramp profile right scaling factor	APC_SCAL3R
APC +0078h	APC 4th ramp profile offset value	APC_OFFSET3
APC +0090h	APC 5th ramp profile left scaling factor	APC_SCAL4L
APC +0094h	APC 5th ramp profile right scaling factor	APC_SCAL4R
APC +0098h	APC 5th ramp profile offset value	APC_OFFSET4
APC +00B0h	APC 6th ramp profile left scaling factor	APC_SCAL5L
APC +00B4h	APC 6th ramp profile right scaling factor	APC_SCAL5R
APC +00B8h	APC 6th ramp profile offset value	APC_OFFSET5
APC +00D0h	APC 7th ramp profile left scaling factor	APC_SCAL6L
APC +00D4h	APC 7th ramp profile right scaling factor	APC_SCAL6R
APC +00D8h	APC 7th ramp profile offset value	APC_OFFSET6

Table 46 APC scaling factor and offset value registers

APC+00E0h APC control register APC_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name															GSM	FPU
Type															R/W	R/W
Reset															1	0

GSM Defines the operation mode of the APC module. In GSM mode, each frame has only one slot, thus only one scaling factor and one offset value must be configured. If the GSM bit is set, the programmer needs only to configure APC_SCAL0L and APC_OFFSET0. If the bit is not set, the APC module is operating in GPRS mode.

0 The APC module is operating in GPRS mode.

1 The APC module is operating in GSM mode. Default value.

FPU Forces the APC D/A converter to power up. Test only.

0 The APC D/A converter is not forced to power up. The converter is only powered on when the transmission window is opened. Default value.

1 The APC D/A converter is forced to power up.

9.3.3 Ramp Profile Programming

The first value of the first normalized ramp profile must be written in the least significant byte of the APC_PFA0 register. The second value must be written in the second least significant byte of the APC_PFA0, and so on.

Each ramp profile can be programmed to form an arbitrary shape.

The start of ramping is triggered by one of the TDMA_APCSTR signals. The timing relationship between TDMA_APCSTR and TDMA slots is depicted in **Figure 73** for 4 consecutive time slots case. The power ramping profile must comply with the timing mask defined in GSM SPEC 05.05. The timing offset values for 7 ramp profiles are stored in the TDMA timer register from TDMA_APC0 to TDMA_APC6.

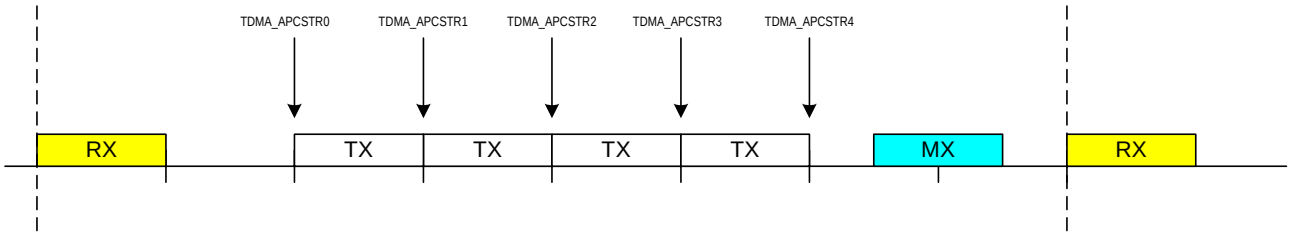


Figure 73 Timing diagram of TDMA_APCSTR.

Because the APC unit provides more than 5 ramp profiles, up to 4 consecutive transmission slots can accommodated. The 2 additional ramp profiles are useful particularly when the timing between the last 2 transmission time slots and CTIRQ is uncertain; software can begin writing the ramp profiles for the succeeding frame during the current frame, alleviating the risk of not writing the succeeding frame's profile data in time.

In GPRS mode, to fit the intermediate ramp profile between different power levels, a simple scaling scheme is used to synthesize the ramp profile. The equation is as follows:

$$DA_0 = OFF + S_0 \cdot \frac{DN_{15,pre} + DN_0}{2}$$

$$DA_{2k} = OFF + S_l \cdot \frac{DN_{k-1} + DN_k}{2}, k = 1,...,15$$

$$DA_{2k+1} = OFF + S_l \cdot DN_k, k = 0,1,...,15$$

$$l = \begin{cases} 0, & \text{if } 8 > k \geq 0 \\ 1, & \text{if } 15 \geq k \geq 8 \end{cases}$$

where **DA** = the data to present to the D/A converter,
DN = the normalized data which is stored in the register **APC_PF*n***,
$\mathbf{S_0}$ = the left scaling factor stored in register **APC_SCAL*nL***,
$\mathbf{S_1}$ = the right scaling factor stored in register **APC_SCAL*nR***, and
OFF = the offset value stored in the register **APC_OFFSET*n***.

The subscript ***n*** denotes the index of the ramp profile.

The ramp calculation before interpolation is as depicted in **Figure 74**.

During each ramp process, each word of the normalized profile is first multiplied by 10-bit scaling factors and added to an offset value to form a bank of 18-bit words. The first 8 words (in the left half part as in **Figure 74**) are multiplied by the left scaling factor $\mathbf{S_0}$ and the last 8 words (in the right half part as in **Figure 74**) are multiplied by the right scaling factor $\mathbf{S_1}$. The lowest 8 bits of each word are then truncated to get a 10-bit result. The scaling factor is 0x100, which represents no scaling on reset. A value smaller than 0x100 scales the ramp profile down, and a value larger than 100 scales the ramp profile up.

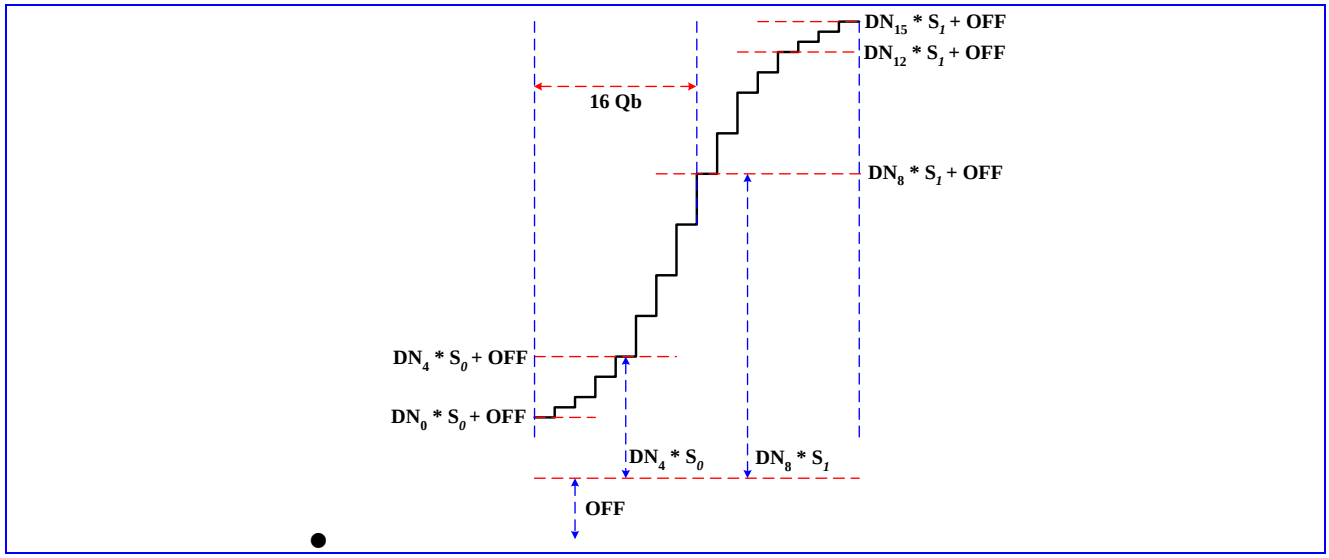


Figure 74 The timing diagram of the APC ramp.

The 16 10-bit words are linearly interpolated into 32 10-bit words. A 10-bit D/A converter is then used to convert these 32 ramp values at a rate of 1.0833 MHz, that is, at quarter-bit rate. The timing diagram is shown in **Figure 75** and the final value is retained on the output until the next event occurs.

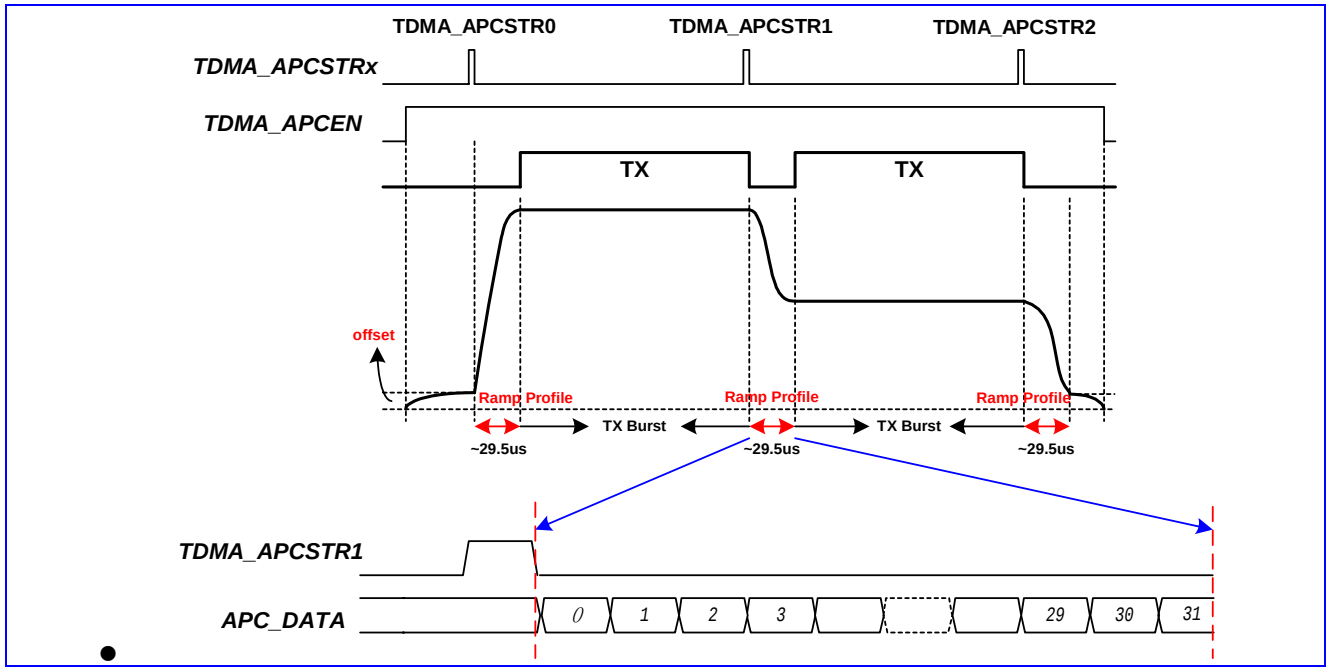


Figure 75 Timing diagram of the APC ramping.

The APC unit is only powered up when the APC window is open. The APC window is controlled by configuring the TDMA registers TDMA_BULCON1 and TDMA_BULCON2. Please refer to the TDMA timer unit for more detailed information.

The first offset value stored in the register APC_OFFSET0 also serves as the pedestal value, which is used to provide the initial power level for the PA.

Since the profile is not double-buffered, the timing to write the ramping profile is critical. The programmer must be restricted from writing to the data buffer during the ramping process, otherwise the ramp profile may be incorrect and lead to a malfunction.

9.4 Automatic Frequency Control (AFC) Unit

9.4.1 General description

The Automatic Frequency Control (AFC) unit provides the direct control of the oscillator for frequency offset and Doppler shift compensation. The block diagram is of the AFC unit depicted in **Figure 76.** The module utilizes a 13-bit D/A converter to achieve high-resolution control. Two modes of operation provide flexibility when controlling the oscillator; they are described as follows.

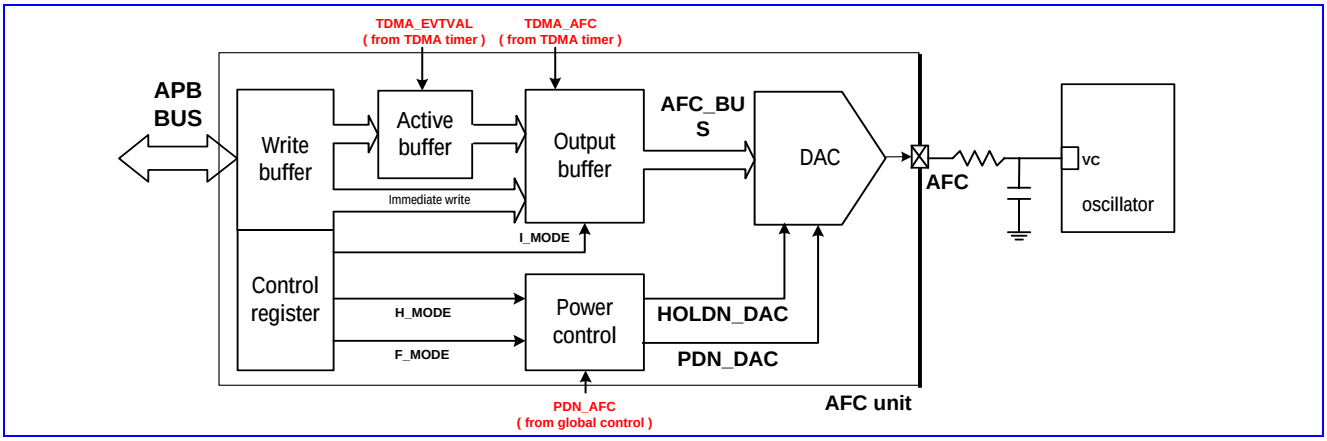


Figure 76 The block diagram of the AFC controller

In timer-triggered mode, the TDMA timer controls the AFC enabling events. Each TDMA frame can pulse at most four events. Double buffer architecture is supported. AFC values can be written to the write buffers. When the signal TDMA_EVTVAL is received, the values in the write buffers are latched into the active buffers. However, AFC values can also be written to the active buffers directly. Each event is associated with an active buffer sharing the same index. When a TDMA event is triggered by TDMA_AFC, the value in the corresponding active buffer takes effect. **Figure 77** shows a timing diagram of AFC events with respect to TX/RX/MX windows. In this mode, the D/A converter can stay powered on or be powered on for a programmable duration (256 quarter-bits, by default). The latter option is for power saving.

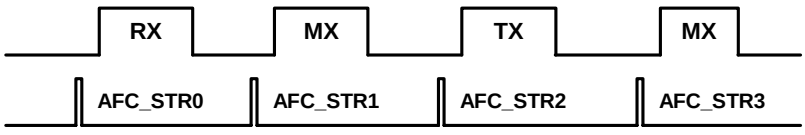


Figure 77 Timing Diagram for the AFC Controller

In immediate mode, the MCU can directly control the AFC value without event-triggering. The value written by the MCU takes effect immediately. In this mode, the D/A converter must be powered on continuously. When transitioning from immediate mode into timer-triggered mode (by setting flag I_MODE in the register AFC_CON to be 0), the D/A converter is kept powered on for a programmable duration (256 quarter-bits by default) if a TDMA_AFC is not been pulsed. The duration is prolonged upon receiving events.

9.4.2 Register Definitions

AFC+0000h AFC control register AFC_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												H_MODE	RDACT	F_MODE	FETENV	I_MODE
Type												R/w	R/W	R/W	R/W	R/W
Reset												0	0	0	0	0

Four control modes are defined and can be controlled through the AFC control register. F_MODE enables the force power up mode. FETENV enables the direct write operation to the active buffer. I_MODE enables the immediate mode. RDACT enables the direct read operation from the active buffer. HOLD_ON enables the AFC DAC hold mode.

RDACT The flag enables the direct read operation from the active buffer. Note the control flag is only applicable to the four data buffer including AFC_DAT0, AFC_DAT1, AFC_DAT2, and AFC_DAT3.

- **0** APB read from the write buffer.
- **1** APB read from the active buffer.

FETENV The flag enables the direct write operation to the active buffer. Note the control flag is only applicable to the for data buffer including AFC_DAT0, AFC_DAT1, AFC_DAT2, and AFC_DAT3.

- **0** APB write to the write buffer.
- **1** APB write to the active buffer.

F_MODE The flag enables the force power up mode.

- **0** The force power up mode is not enabled.
- **1** The force power up mode is enabled.

I_MODE The flag enables the immediate mode. To enable the immediate mode also enable the force power up mode.

- **0** The immediate mode is not enabled.
- **1** The immediate mode is enabled.

H_MODE The flag enables the hold mode of AFC DAC. If this mode is enabled, the DAC will keep the previous voltage level instead of power down.

- **0** The hold mode is not enabled.
- **1** The hold mode is enabled.

While SRCLKENAI = 1'b1, AFC DAC will be turned on at the normal mode. SRCLKENAI is a gpio_mux pin. Make sure that the gpio mode is configured at the correct mode before BB enters the sleep mode.

AFC +0004h AFC data register 0 AFC_DAT0

Bit	15	14	13	12	11	10	9	8	7	6	15	4	3	2	1	0
Name				AFCD												
Type				R/W												

The register stores the AFC value for the event 0 triggered by the TDMA timer in timer-triggered mode. When the RDACT or FETENV bit (of the AFC_CON register) is set, the data transfer operates on the active buffer. When neither flag is set, the data transfer operates on the write buffer.

AFCD The AFC sample for the D/A converter.

Four registers (AFC_DAT0, AFC_DAT1, AFC_DAT2, AFC_DAT3) of the same type correspond to the event triggered by the TDMA timer. The four registers are summarized in **Table 1**.

Register Address	Register Function	Acronym
AFC +0004h	AFC control value 0	AFC_DAT0
AFC +0008h	AFC control value 1	AFC_DAT1
AFC +000Ch	AFC control value 2	AFC_DAT2
AFC +0010h	AFC control value 3	AFC_DAT3

Table 1 AFC Data Registers

Immediate mode can only use AFC_DAT0. In this mode, only the control value in the AFC_DAT0 write buffer is used to control the D/A converter. Unlike timer-triggered mode, the control value in AFC_DAT0 write buffer can bypass the active buffer stage and be directly coupled to the output buffer in immediate mode. To use immediate mode, program the AFC_DAT0 in advance and then enable immediate mode by setting the I_MODE flag in the AFC_CON register.

The registers AFC_DATA0, AFC_DAT1, AFC_DAT2, and AFC_DAT3 have no initial values, thus the register must be programmed before any AFC event takes place. The AFC value for the D/A converter, i.e., the output buffer value, is initially 0 after power up before any event occurs.

AFC +0014h AFC power up period AFC_PUPER

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				PU_PER												
Type				R/W												
Reset				ff												

This register stores the AFC power up period, which is 13 bits wide. The value ranges from 0 to 8191. If the I_MODE or F_MODE flag is set, this register has no effect since the D/A converter is powered up continuously. If neither flag is set, the register controls the power up duration of the D/A converter. During that period, the signal PDN_DAC in **Figure 76** is set to 1(power up).

PU_PER Stores the AFC power up period. After hardware power up, the field is initialized to 255.

10 Baseband Front End

Baseband Front End is a modem interface between TX/RX mixed-signal modules and digital signal processor (DSP). We can divide this block into two parts (see **Figure 78**). The first is the uplink (transmitting) path, which converts bit-stream from DSP into digital in-phase (I) and quadrature (Q) signals for TX mixed-signal module. The second part is the downlink (receiving) path, which receives digital in-phase (I) and quadrature (Q) signals from RX mixed-signal module, performs FIR filtering and then sends results to DSP. **Figure 78** illustrates interconnection around Baseband Front End. In the figure the shadowed blocks compose Baseband Front End.

To enhance the capability of data processing of mobile phone and base station, the Enhanced Data for GSM Evolution (EDGE), which used 8PSK Modulation rather than GMSK Modulation in GSM system may provide the triple data transmission rate of 384 kbps for system to supply the solution of voice, data, Internet linkage, and other kinds of mutual linkage, while 3bits per symbols in 8PSK Modulation and 1 bit per symbol in GMSK Modulation.

The uplink path is mainly composed of GMSK Modulator or 8PSK Modulator and uplink parts of Baseband Serial Ports, and the downlink path is mainly composed of RX digital FIR filter and downlink parts of Baseband Serial Ports. Baseband Serial Ports is a serial interface used to communicate with DSP. In addition, there is a set of control registers in Baseband Front End that is intended for control of TX/RX mixed-signal modules, inclusive of several compensation circuit :calibration of I/Q DC offset, I/Q Quadrature Phase Compensation and I/Q Gain Mismatch of uplink analog-to-digital (D/A) converters as well as I/Q Gain Mismatch for downlink digital-to-analog (A/D) converters in TX/RX mixed-signal modules. The timing of bit streaming through Baseband Front End is completely under control of TDMA timer. Usually only either of uplink and downlink paths is active at one moment. However, both of the uplink and downlink paths will be active simultaneously when Baseband Front End is in loopback mode.

When either of TX windows in TDMA timer is opened, the uplink path in Baseband Front End will be activated. Accordingly components on the uplink path such as GMSK Modulator or 8PSK Modulator will be powered on, and then TX mixed-signal module is also powered on. The subblock Baseband Serial Ports will sink TX data bits from DSP and then forward them to GMSK Modulator or 8PSK Modulator. The outputs from GMSK Modulator or 8PSK Modulator are sent to TX mixed-signal module in format of I/Q signals. Finally D/A conversions are performed in TX mixed-signal module and the output analog signal is output to RF module. Additionally, 8PSK Modulation intrinsically extends the bursts window and reports in 8MVD (8PSK Modulation Valid) in BFE_STA status register.

Similarly, while either of RX windows in TDMA timer is opened, the downlink path in Baseband Front End will be activated. Accordingly components on the downlink path such as RX mixed-signal module and RX digital FIR filter are then powered on. First A/D conversions are performed in RX mixed-signal module, and then the results in format of I/Q signals are sourced to Low Pass Filtering with different bandwidth (Narrow one about Fc = 90 khz, Wide one about FC = 110khz), Interference Detection Circuit to determine which Filter to be used by judging receiving power on current burst, Additionally, “I/Q Compensation Circuit” is an option in data path for modifying Receiving I/Q pair gain mismatch.. Finally the results will be sourced to DSP through Baseband Serial Ports.

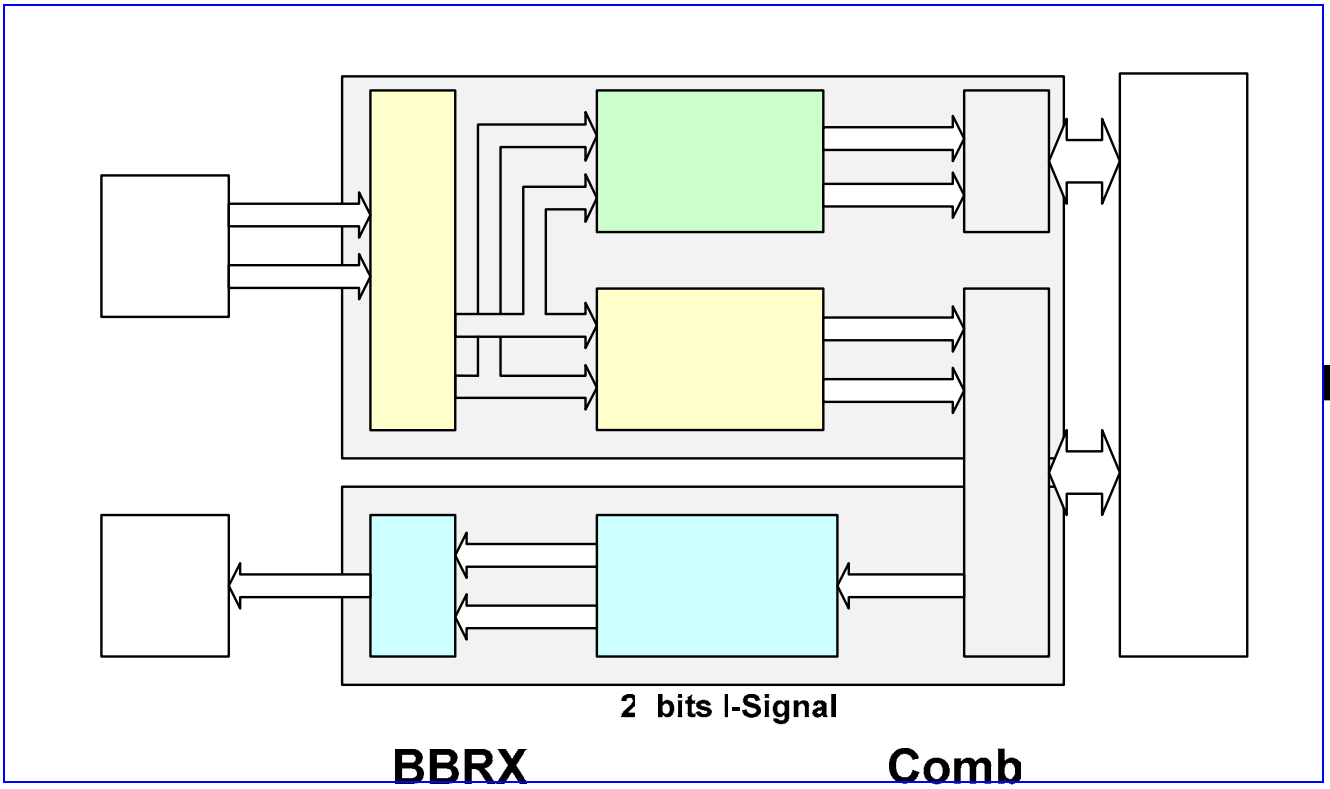


Figure 78 Block Diagram Of Baseband Front End

10.1 Baseband Serial Ports

10.1.1 General Description

Baseband Front End communicates with DSP through the sub block of Baseband Serial Ports. Baseband Serial Ports interfaces with DSP in serial manner. This implies that DSP must be configured carefully in order to have Baseband Serial Ports cooperate with DSP core correctly.

If downlink path is programmed in bypass-filter mode (**NOT** bypass-filter loopback mode), behavior of Baseband Serial Ports will be completely be different from that in normal function mode. The special mode is for testing purpose. Please see the subsequent section of Downlink Path for more details.

TX and RX windows are under control of TDMA timer. Please refer to functional specification of TDMA timer for the details on how to open/close a TX/RX window. Opening/Closing of TX/RX windows have two major effects on Baseband Front End : power on/off of corresponding components and data souring/sinking. It is worth noticing that Baseband Serial Ports is only intended for sinking TX data from DSP or sourcing data to DSP. It does not involve power on/off of TX/RX mixed-signal modules.

As far as downlink path is concerned, if a RX window is opened by TDMA timer Baseband Front End will have RX mixed-signal module proceed to make A/D conversion, two parallel RX digital filter proceed to performfiltering and Baseband Serial Ports be activated to source data from RX digital filter to Master DSP while Power Measurement through Baseband Serial Ports to Slave DSP no matter the data is meaningful or not However, the interval between the moment that

RX mixed-signal module is powered on and the moment that data proceed to be dumped by Baseband Serial Ports can be well controlled in TDMA timer. Let us denote RX enable window as the interval that RX mixed-signal module is powered on and denote RX dump window as the interval that data is dumped by Baseband Serial Ports. If the first samples from RX digital filter desire to be discarded, the corresponding RX enable window must cover the corresponding RX dump window. Note that RX dump windows always win over RX enable windows. It means that a RX dump window will always raise a RX enable window. RX enable windows can be raised by TDMA timer or by programming RX power-down bit in global control registers to be '0'. This is useful in debugging environment.

Similarly, a TX dump window refers to the interval that Baseband Serial Ports sinks data from DSP on uplink path and a TX enable window refers to the interval that TX mixed-signal module is powered on. A TX window controlled by TDMA timer involves a TX dump window and a TX enable window simultaneously. The interval between the moment that TX mixed-signal module is powered on and the moment that data proceed to be forwarded from DSP to GMSK or 8PSK modulator by Baseband Serial Ports can be well controlled in TDMA timer. TX dump windows always win over TX enable windows. It means that a TX dump window will always raise a TX enable window. TX enable windows can be raised by TDMA timer or by programming TX power-down bit in global control registers to be '0'. It is useful in debugging environment.

Accordingly, Baseband Serial Ports are only under the control of TX/RX dump window. Note that if TX/RX dump window is not integer multiplies of bit-time it will be extended to be integer multiplies of bit-time. For example, if TX/RX dump window has interval of 156.25 bit-times then it will be extended to 157 bit-times in Baseband Serial Ports.

For uplink path, if uplink path is enabled, then the bit BULEN (Baseband Up-Link Enable) will be '1'. Otherwise the bit BULEN will be 0.

The MDSEL(Modulation Mode Select[3:0]) in TX_CONF control register needs to be latched in MDSEL shadow register according to the rising edge of TDMA Event Validate signal from TDMA controller, which used to indicate the modulation scheme selection between 8PSK or GMSK modulator for four transmit Burst.

Generally there will at most 4 sequential Bursts, 1st Burst, 2nd Burst, 3rd Bursts, and 4th Bursts, which are not necessary to be all turn on in a burst sequence. The BTXEN1, BTXEN2, BTXEN3, BTXEN4 will be asserted prior to each Bursts, and their rising edge will update the Mode selection control bit to select appropriate Modulation type for current input data symbols in each bursts. Additionally, this Mode selection status for each bursts will be stored in BFE_STA status register, including MDSTS1(MoDulation mode StatuS1) , MDSTS2(MoDulation mode StatuS2), MDSTS3(MoDulation mode StatuS3), MDSTS4(MoDulation mode StatuS4), respectively.(Figure 79 Uplink Modulation Mode Selection Status Timing Diagram)

During these 4 bursts valid period, the bit BULFS (Baseband Uplink Frame Sync) in BFE_STA status register will be '1'. Otherwise will be '0'. Meanwhile, uplink path will forward TX bit from DSP to GMSK modulator or 8PSK Modulation

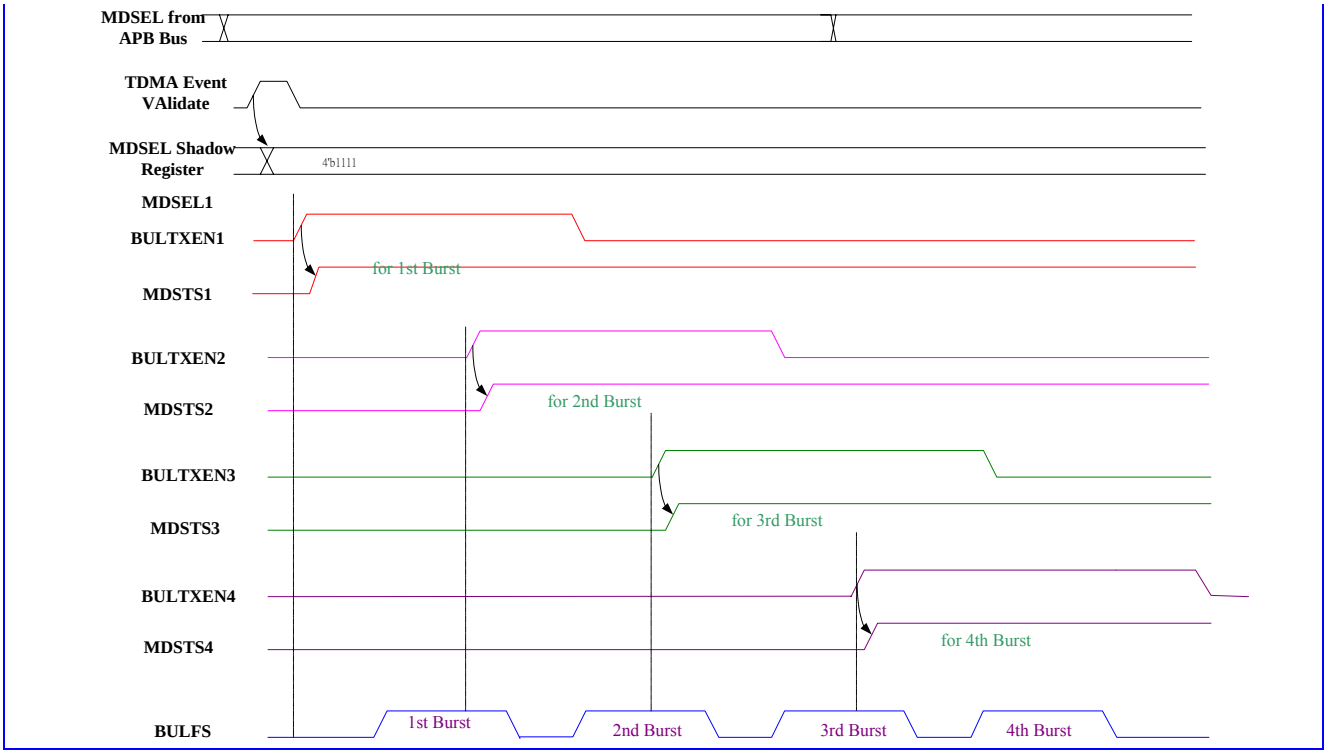


Figure 79 Uplink Modulation Mode Selection Status Timing Diagram

For downlink path, if BDLEN(Baseband DownLink Enable) is enabled, RX mixed-signal module will also be powered on. Similarly, once uplink path is enabled, TX mixed-signal module will also be powered on. Furthermore, enabling BDLFS(Baseband Down-Link FrameSync)Baseband Serial Ports for downlink path refers to dumping results from RX digital FIR filter to DSP.

10.1.2 Register Definitions

BFE+0000h Base-band Common Control Register BFE_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																BCIEN
Type																R/W
Reset																0

This register is for common control of Baseband Front End. It consists of ciphering encryption control.

BCIEN The bit is for ciphering encryption control. If the bit is set to '1', XOR will be performed on some TX bits (payload of Normal Burst) and ciphering pattern bit from DSP, and then the result is forwarded to GMSK Modulator only. Meanwhile, Baseband Front End will generate signals to drive DSP ciphering process and produce corresponding ciphering pattern bits if the bit is set to '1'. If the bit is set to '0', the TX bit from DSP will be forwarded to GMSK modulator directly. Baseband Front End will not activate DSP ciphering process.

0 Disable ciphering encryption.

1 Enable ciphering encryption.

BFE +0004h Base-band Common Status Register BFE_STA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			MDSTS4	MDSTS3	MDSTS2	MDSTS1	BULEN4	BULEN3	BULEN2	BULEN1	BULFS4	BULFS3	BULFS2	BULFS1	BDLFS	BDLEN
Type			RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
Reset			0	0	0	0	0	0	0	0	0	0	0	0	0	0

This register indicates status of Baseband Front End This register indicates status of Baseband Front End. Under control of TDMA timer, Baseband Front End can be driven in several statuses. If downlink path is enabled, then the bit BDLEN will be '1'. Otherwise the bit BDLEN will be '0'. If downlink parts of Baseband Serial Ports is enabled, the bit BDLFS will be '1'. Otherwise the bit BDLFS will be '0'. If uplink path is enabled, then the bit BULEN will be '1'. Otherwise the bit BULEN will be 0. If uplink parts of Baseband Serial Ports is enabled, the bit BULFS will be '1'. Otherwise the bit BULFS will be '0'. Once downlink path is enabled, RX mixed-signal module will also be powered on. Similarly, once uplink path is enabled, TX mixed-signal module will also be powered on. Furthermore, enabling Baseband Serial Ports for downlink path refers to dumping results from RX digital FIR filter to DSP. Similarly, enabling Baseband Serial Ports for uplink path refers to forwarding TX bit from DSP to GMSK modulator. BDLEN stands for "**B**aseband **D**own**L**ink **En**able". BULEN stands for "**B**aseband **U**p**L**ink **En**able". BDLFS stands for "**B**aseband **D**own**L**ink **F**rame**S**ync". BULFS stands for "**B**aseband **U**pLink **F**rame**S**ync".

BDLEN Indicate if downlink path is enabled.
- **0** Disabled
- **1** Enabled

BDLFS Indicate if Baseband Serial Ports for downlink path is enabled.
- **0** Disabled
- **1** Enabled

BULFS1 Indicate if Baseband Serial Ports for uplink path is enabled in 1st burst
- **0** Disabled
- **1** Enabled

BULFS2 Indicate if Baseband Serial Ports for uplink path is enabled in 2nd burst
- **0** Disabled
- **1** Enabled

BULFS3 Indicate if Baseband Serial Ports for uplink path is enabled in 3rd burst
- **0** Disabled
- **1** Enabled

BULFS4 Indicate if Baseband Serial Ports for uplink path is enabled in 4th burst
- **0** Disabled
- **1** Enabled

BULEN1 Indicate if uplink path is enabled in 1st burst.
- **0** Disabled
- **1** Enabled

BULEN2 Indicate if uplink path is enabled in 2nd burst.
- **0** Disabled
- **1** Enabled

BULEN3 Indicate if uplink path is enabled in 3rd burst.
- **0** Disabled

1 Enabled

BULEN4 Indicate if uplink path is enabled in 4th burst.

0 Disabled

1 Enabled

MDSTS1 Indicate the current Modulation Mode Selection in 1st burst

0 GMSK Modulation

1 8PSK Modulation

MDSTS2 Indicate the current Modulation Mode Selection in 2nd burst

0 GMSK Modulation

1 8PSK Modulation

MDSTS3 Indicate the current Modulation Mode Selection in 3rd burst

0 GMSK Modulation

1 8PSK Modulation

MDSTS4 Indicate the current Modulation Mode Selection in 4th burst

0 GMSK Modulation

1 8PSK Modulation

10.2 Downlink Path (RX Path)

10.2.1 General Description

On the downlink path, the sub-block between RX mixed-signal module and Baseband Serial Ports is RX Path. It mainly consists of two parallel digital FIR filter with programmable tap number, two sets of multiplexing paths for loopback modes, interface for RX mixed-signal module, Interference Detection Circuit, I/Q Gain Mismatch compensation circuit, and interface for Baseband Serial Ports. The block diagram is shown in **Figure 80** Block Diagram of RX Path.

While RX enable windows are open, RX Path will issue control signals to have RX mixed-signal module proceed to make A/D conversion. As each conversion is finished, one set of I/Q signals will be latched. There exists a digital FIR filter for these I/Q signals. The result of filtering will be dumped to Baseband Serial Ports whenever RX dump windows are opened.

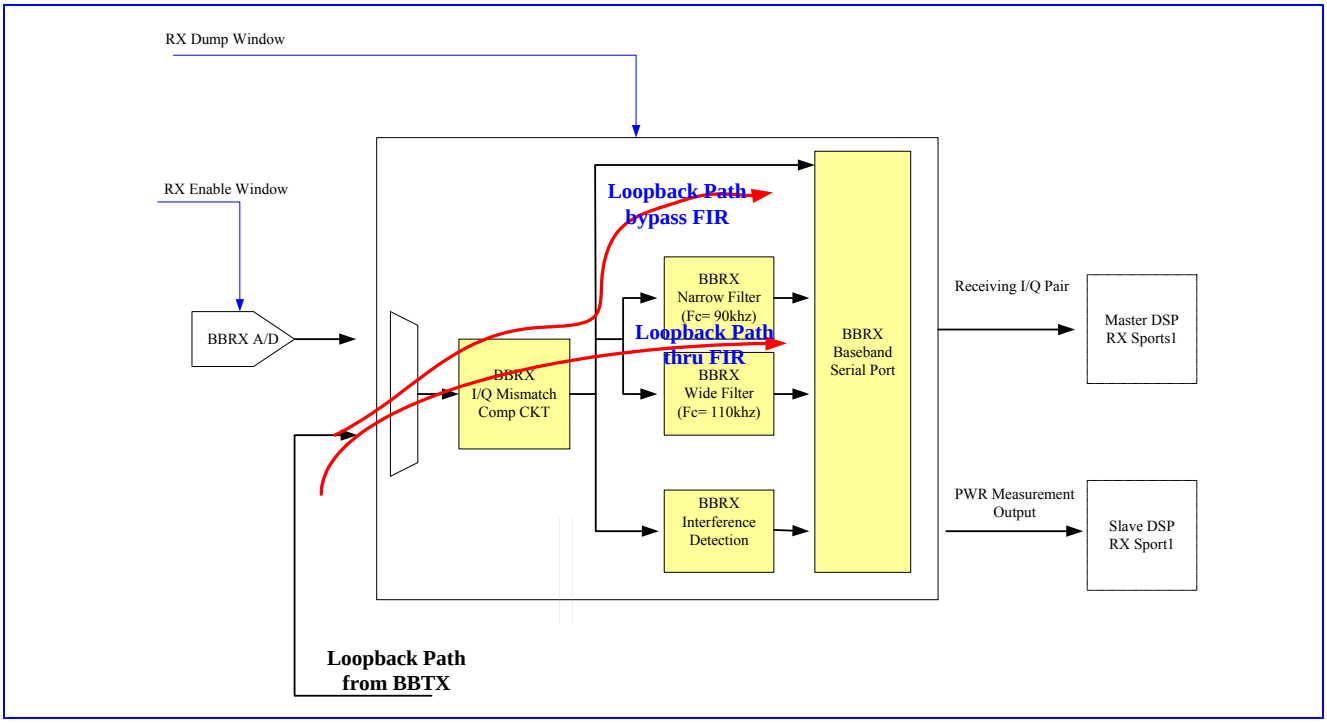


Figure 80 Block Diagram of RX Path

10.2.2 Comb Filter

The comb filter which takes the 2-bit A/D converter as input, and output the 18-bit I/Q data words to the baseband receiving path. The system is designed as 48X over-sampling with symbol period 541.7 kHz, thus the data inputs are 26MHz 2-bit signal. The input 2-bit signals are formed in (sign, magnitude) manner; that is, total 3 values are permitted as input: (-1, 0, +1).

The data path is mainly a decimation filter which contains the integration stages and the decimation stages. For a 3rd order design with 48X over-sampling, gain of the data path is $48^3 = 110592$, which locates between 2^{16} and 2^{17}. Thus the internal word-length must be set to 18-bit to avoid overflow in the integration process.

10.2.3 Compensation Circuit - I/Q Gain Mismatch

In order to compensate I/Q Gain Mismatch , configure IGAINSEL(I Gain Selection) in RX_CON control register, the I over Q ratio can be compensate for 0.3 dB/step, totally 11 steps resulted in dynamic range up to +/-1.5dB.

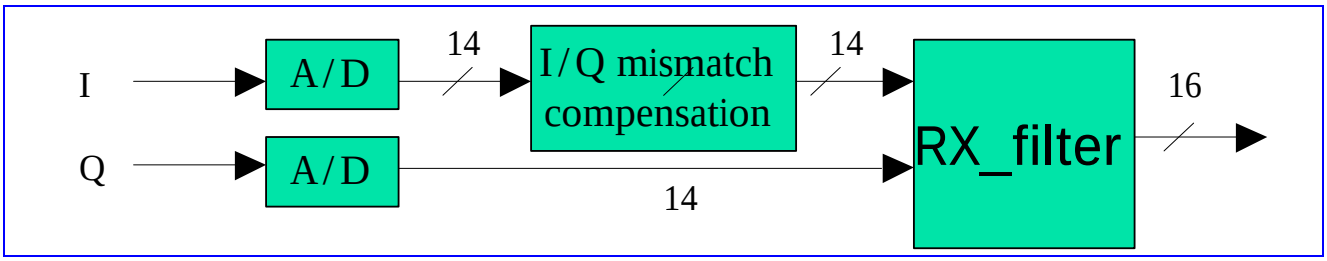


Figure 81 I/Q Mismatch Compensation Block Diagram

The I/Q swap functionality can be setting “1” for SWAP(I/Q Swapping) in RX_CFG control register, which is used to swap I/Q channel signals from RX mixed-signal module before they are latched into RX digital FIR filter. It is intended to provide flexibility for I/Q connection with RF modules

10.2.4 Phase De-rotation Circuit

Phase De-rotation Mode will usually turn on during FCB Detection for down conversion the wide spread receiving power to 67.7khz single tone.

Two separate control for implement this mode on data path through NarrowFIR filter or WideFIR filter by setting ‘1’ to PHROEN_N(Phase Rotate Enable for NarrowFIR) or PHROEN_W(Phase Rotate Enable for WideFIR) in RX_CON control register, respectively.

10.2.5 Adaptive Bandwidth & Programmable Digital FIR Filter

For the two parallel digital FIR Filter, the total tap number is programmable by FIRTPNO(FIR Tap number) in RX_CFG control register, which will configure the filter with different tap buffer depth.

10.2.5.1 Programmable tap & programmable Coefficient for FIR

In order to satisfy the signal requirements in both of idle and traffic modes, two sets of coefficients must be provided for the RX digital FIR filter. Therefore, the RX digital FIR filter is implemented as a FIR filter with programmable coefficients which can be accessed on the APB bus. The coefficient number can be programmable, range from from 1~31. Each coefficient is ten-bit wide and coded in 2’s complement.

Take 21 Tap Coefficient for example, based on assumption that the FIR filter has symmetric coefficients, only 11 coefficients are implemented as programmable registers to save gate count. Denoting these digital filter coefficients as RX_RAM0_CS0 ~ RX_RAM0_CS11(RX_RAM0 Coefficient Set 0~11), and these tap registers for I/Q channel signals as I/QTAPR [0:20], then the RX digital FIR filtering can be represented as the following equation:

$$I_{out}(m) = \sum_{i=0}^{20} BDLDFCR[i] * ITAPR[i]\Big|_{\text{at time n+4m}} = BDLDFCR[11] * ITAPR[11] + \sum_{i=0}^{11} BDLDFCR[i] * (ITAPR[i] + ITAPR[20-i])\Big|$$

$$Q_{out}(m) = \sum_{i=0}^{20} BDLDFCR[i] * QTAPR[i]\Big|_{\text{at time n+4m}} = BDLDFCR[11] * QTAPR[11] + \sum_{i=0}^{11} BDLDFCR[i] * (QTAPR[i] + QTAPR[20-i])\Big|$$

$$BDLDFCR[i] = BDLDFCR[20-i], i = 0,1,...,11$$

where ITAPR [0] and QTAPR [0] are the latest samples for I- and Q-channel respectively and assume $I_{out}(0), Q_{out}(0)$ are obtained based on the content of tap registers at time moment *n*. From the equation above it follows that the digital RX FIR filter will produce one output every four data conversions out of A/D converters. That is, filtering and decimation are performed simultaneously to achieve low power design.

However, different "Coefficient Set ID"(CS ID) will be dump to Slave DSP RX buffer to represent the current selecting of coefficient Set from either 2 ROM table or 2 set of programmable RAM table according to different burst mode, while ROM table are fixed coefficient and RAM table can be programmed through 2set of 16 control register (RX_RAM0_CS0~ RX_RAM_CS15, (RX_RAM1_CS0~RX_RAM1_CS15). Generally, CSID = 0 represent ROM table selection, while CSID 2~ CSID 15 represent RAM table selection. Please be noted that the total coefficient number in a RAM table should be greater than half of the FIRTPNO(total FIR Tap number) and smaller than half of maximum tap number(15) since the FIR function in symmetric behavior.

Additionally, the data sequence of two parallel FIR filter output will dump to Master DSP RX buffer in following order : "I channel output from Narrow FIR"=> " I channel output from Wide FIR""=>"Q channel output from Narrow FIR=>" Q channel output from Wide FIR.

10.2.5.1.1 Coefficient Set Selection

The Coefficient Set used for digital FIR can be changed during different burst mode switching. For example, during Normal Burst while no FB_STROBE (Frequency Burst Strobe, comes from TDMA controller) assertion, defined as "State B", "Coefficient Set ID" (CS ID) selection for both Narrow/Wide filter can be configured by ST_B_WCOF_SEL(State B Wide FIR Coefficient Selection) and "ST_B_NCOF_SEL" (State B Narrow FIR Coefficient Selection) on RX_FIR_CSID_CON control register, respectively. Usually during State B, Layer 1 software will select RAM table confidence from either RAM0 or RAM1 table in condition I for Narrow FIR and Wide FIR, respectively. The CS ID for both Narrow / Wide FIR filter be stored at Slave DSP RX buffer once TDMA trigger RX interrupt to DSP..ST_A_NCOF_SEL" (State A Narrow FIR Coefficient Selection) on RX_FIR_CSID_CON control register.

During FCB detection, MCU will notice TDMA controller by assertion FB_STROBE, defined as "StateA". "Coefficient Set ID" (CS ID) selection for both Narrow/Wide filter can be configured by ST_A_WCOF_SEL(State A Wide FIR Coefficient Selection) and "ST_A_NCOF_SEL" (State A Narrow FIR Coefficient Selection) on RX_FIR_CSID_CON control register, respectively. Usually during State B, Layer 1 software will select CS ID 2 and CSID 3 from either ROM0 or ROM1 table or RAM0 or RAM1 table in Condition II for Narrow FIR and Wide FIR, respectively.

10.2.5.2 Interference Detection Circuit for Adaptive Bandwidth Scheme

Used to compare the power of Co-channel Interference and Adjacent-channel Interference for determine if WideFIR filter is needed rather than default NarrowFIR filter. Two parallel path of power measurement for evaluating Co-channel effect or Adjacent Channel Effect by analyzing power after High Pass Filter(HPF) or Band Pass Filter(BPF), respectively. If Co-channel effect is worse than Adjacent Channel effect, WideFIR filter is needed.

The power measurement is accumulate I/Q Root Mean Square (RMS) power over the whole RX burst window, while exact accumulation period within the burst can be adjusted the starting point offset and duration length.. The “starting point Offset” and be configured by “RXID_PWR_OFF[7:0]” (RX Interference Detection Power Starting Point Offset) and duration period by “ RXID_PWR_PER[7:0]”(RX Interference Detection Power Duration Period) in RX_PM_CON control register, while default value for starting offset is 11 and duration period is 141. The two accumulated power measurement output for Co-channel and Adjacent-channel will be dump to Slave DSP RX buffer alternatively at the end of the duration period within a burst. However, if the duration period is longer than the RX Dump Window, the accumulated measurement output will be dump out at falling edge of RX_DUMP_Window rather than the end of configured duration priod.

Additionally, the power measurement data sequence at Slave DSP RX buffer will be “Coefficient Set ID for NarrowFIR filter”=> “Coefficient Set ID for WideFIR filter”=>“Power output of HPF(Co-channel)=>”Power output of BPF(Adjacent-channel), while the coefficient Set ID (CSID) is for DSP debug purpose.

The power result can be further scale down by control the PWR_SHFT_NO(power right Shift Number) in RX_CON control register. E.g. set to “1” will divied the power output by two.

10.2.6 Debug Mode

10.2.6.1 Normal Mode bypass Filter

By setting “1” for BYPFLTR(Bypass Filter) in RX_CFG control register, the ADC outputs out of RX mixed-signal module will be directed into Baseband Serial Ports directly without through FIR. Limited by bandwidth of the serial interface between Baseband Serial Ports and DSP, only ADC outputs which are from either I-channel or Q-channel ADC can be dumped into DSP. Both I- and Q-channel ADC outputs cannot be dumped simultaneously. Which channel will be dumped is controlled by the register bit SWAP of the control register RX_CFG when downlink path is programmed in “Bypass RX digital FIR filter” mode. See register definition below for more details. The mode is for measurement of performance of A/D converters in RX mixed-signal module.

10.2.6.2 TX-RX Digital Loopback Mode (Debug Mode)

In addition to normal function, there are two loopback modes in RX Path. One is bypass-filter loopback mode, and the other is through-filter loopback mode. They are intended for verification of DSP firmware and hardware. The bypass-filter loopback mode refers to that RX digital FIR filter is not on the loopback path. However, the through-filter loopback mode refers to that RX digital FIR filter is on the loopback path, while “ thru-Filter Loopback Mode” can be configured by setting “2’b10” for BLPEN(Baseband Loopback Enable) or “bypass-Filter Loopback Mode” by setting “ 2’b01” for BLPEN in RX_CON control register.

10.2.7 Register Definitions

10.2.7.1 APB Register

BFE +0010h RX Configuration Register RX_CFG

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							FIRTPNO								BYPFLTR	SWAP
Type							R/W								R/W	R/W
Reset							000000								0	0

This register is for configuration of downlink path, inclusive of configuration of RX mixed-signal module and RX path in Baseband Front End.

SWAP This register bit is for control of whether I/Q channel signals need to swap before they are inputted to Baseband Front End. It provides flexibility flexible of connection of I/Q channel signals between RF module and baseband module. The register bit has another purpose when the register bit "BYPFLTR" is set to 1. Please see description for the register bit "BYPFLTR".

0 I- and Q-channel signals are not swapped

1 I- and Q-channel signals are swapped

BYPFLTR Bypass RX FIR filter control. The register bit is used to configure Baseband Front End in the state called "Bypass RX FIR filter state" or not. Once the bit is set to '1', RX FIR filter will be bypassed. That is, ADC outputs of RX mixed-signal module that are has 14-bit resolution and at sampling rate of 571 kHz can be dumped into DSP by Baseband Serial Ports and RX FIR filtering will not be performed on them.

0 Not bypass RX FIR filter

1 Bypass RX FIR filter

FIRTPNO RX FIR filter tap no. select. This control register will control the two parallel digital filter with different tap buffer depth since the FIR function in symmetric behavior. The maximum tap number is 31, minimum is 1., ODD number only.

BFE+0014h RX Control Register RX_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					PWR_SHFT_NO				IGAINSEL				PH_ROEN_N	PH_ROEN_W	BLPEN	
Type					R/W				R/W				R/W	R/W	R/W	
Reset					0000				0000				0	0	00	

This register is for control of downlink path, inclusive of control of RX mixed-signal module and RX path in Baseband Front End module.

BLPEN The register field is for loopback configuration selection in Baseband Front End.

00 Configure Baseband Front End in normal function mode

01 Configure Baseband Front End in bypass-filter loopback mode

10 Configure Baseband Front End in through-filter loopback mode

11 Reserved

PH_ROEN_W Enable for I/Q pair Phase De-rotation in Wide FIR Data Path,

0 Disable Phase De-rotation for I/Q pair

1 Enable Phase De-rotation for I/Q pair

PH_ROEN_N Enable for I/Q pair Phase De-rotation in Narrow FIR Data Path,

0 Disable Phase De-rotation for I/Q pair.

1 Enable Phase De-rotation for I/Q pair

IGAINSEL RX I data Gain Compensation Select. 0.3dB/step, totally 11 steps and dynamic range up to +/-1.5dB for

0000 compensate 0dB for I/Q

0001 compensate 0.3dB for I/Q

0010 compensate 0.6dB for I/Q

0011 compensate 0.9dB for I/Q

0100 compensate 1.2dB for I/Q
0101 compensate 1.5dB for I/Q
1001 compensate –0.3dB for I/Q
1010 compensate -0.6dB for I/Q
1011 compensate –0.9dB for I/Q
1100 compensate –1.2dB for I/Q
1101 compensate –1.5dB for I/Q
Default no compensation for I/Q

PWR_SHFT_NO Power measuring Result Right Shift Number. The Power level measurement result can be right shift from 0 to 16 bits.

BFE+0018h RX Interference Detection Power Measurement Control Register RX_PM_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RXID_PWR_PER								RXID_PWR_OFF							
Type	R/W								R/W							
Reset	8D								b							

RXID_PWR_OFF RX Interference Detection Power Measurement Starting Offset. Setting this register will delay the starting time of Interference Detection Power Measurement in symbol time unit. Maximum value is 156, while default value is 11 (0xB).

RXID_PWR_PER RX Interference Detection Power Measurement Accumulation Period. By setting this control register will determine the length of accumulation duration for power Measurement. Minimum value is 0, Maximum value is 156, while default value is 141(0x8D). Please notice that RXID_PWR_OFF + RXID_PWR_PER should less than 154 due to hardware implementation limitation.

BFE+001Ch RX FIR Coefficient Set ID Control Register RX_FIR_CSID_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ST_A_NCOF_SEL								ST_B_NCOF_SEL				ST_B_WCOF_SEL			
Type	R/W								R/W				R/W			
Reset	0000								0010				0011			

These three set of Coefficient Set ID will be dump to slave DSP RX Buffer for indicating the current selection of FIR coefficient from either RAM or ROM table, while CSID= 0 represents ROM table selection, and CSID2~CSID15 represent RAM table selection.

ST_B_WCOF_SEL State B Coefficient Set Selection for Wide FIR.
ST_B_NCOF_SEL State B Coefficient Set Selection for Narrow FIR.
ST_A_NCOF_SEL State A Coefficient Set Selection for Narrow FIR.

BFE +0070h RX RAM0Coefficient Set 0Register RX_RAM0_CS0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							RX_RAM0_CS0									
Type							R/W									
Reset							000000000									

This register is 1st of the 16 coefficient in RAM0 table, Coefficient Set ID 2 or 4. The content is coded in 2's complement. That is, its maximum is 255 and its minimum is –256, while the total coefficient number in this Coefficient Set has to be greater than half of TAPNO(programmable Tap no.) and smaller than half of maximum tap no(15).

Register Address	Register Function	Acronym
BFE +0070h	RX RAM0Coefficient Set 0 Register	RX_RAM0_CS0
BFE +0074h	RX RAM0Coefficient Set 1 Register	RX_RAM0_CS1
BFE +0078h	RX RAM0Coefficient Set 2 Register	RX_RAM0_CS2
BFE +007Ch	RX RAM0Coefficient Set 3 Register	RX_RAM0_CS3
BFE +0080h	RX RAM0Coefficient Set 4 Register	RX_RAM0_CS4
BFE +0084h	RX RAM0Coefficient Set 5 Register	RX_RAM0_CS5
BFE +0088h	RX RAM0Coefficient Set 6 Register	RX_RAM0_CS6
BFE +008Ch	RX RAM0Coefficient Set 7 Register	RX_RAM0_CS7
BFE +0090h	RX RAM0Coefficient Set 8 Register	RX_RAM0_CS8
BFE +0094h	RX RAM0Coefficient Set 9 Register	RX_RAM0_CS9
BFE +0098h	RX RAM0Coefficient Set 10 Register	RX_RAM0_CS10
BFE +009Ch	RX RAM0Coefficient Set 11Register	RX_RAM0_CS11
BFE +00a0h	RX RAM0Coefficient Set 12Register	RX_RAM0_CS12
BFE +00a4h	RX RAM0Coefficient Set 13Register	RX_RAM0_CS13
BFE +00a8h	RX RAM0Coefficient Set 14 Register	RX_RAM0_CS14
BFE +00aCh	RX RAM0Coefficient Set 15 Register	RX_RAM0_CS15

BFE +0020h RX RAM1 Coefficient Set 0 Register RX_RAM1_CS0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							RX_RAM1_CS0									
Type							R/W									
Reset							000000000									

This register is 1st of the 16 coefficient in RAM1 table, Coefficient Set ID 2 or 4. The content is coded in 2's complement. That is, its maximum is 255 and its minimum is –256, while the total coefficient number in this Coefficient Set has to be greater than half of TAPNO(programmable Tap no.) and smaller than half of maximum tap no(15).

Register Address	Register Function	Acronym
BFE +0020h	RX RAM1 Coefficient Set 0 Register	RX_RAM1_CS0
BFE +0024h	RX RAM1 Coefficient Set 1Register	RX_RAM1_CS1
BFE +0028h	RX RAM1 Coefficient Set 2 Register	RX_RAM1_CS2
BFE +002Ch	RX RAM1 Coefficient Set 3 Register	RX_RAM1_CS3
BFE +0030h	RX RAM1 Coefficient Set 4 Register	RX_RAM1_CS4
BFE +0034h	RX RAM1 Coefficient Set 5 Register	RX_RAM1_CS5
BFE +0038h	RX RAM1 Coefficient Set 6 Register	RX_RAM1_CS6
BFE +003Ch	RX RAM1 Coefficient Set 7 Register	RX_RAM1_CS7
BFE +0040h	RX RAM1 Coefficient Set 8 Register	RX_RAM1_CS8
BFE +0044h	RX RAM1 Coefficient Set 9 Register	RX_RAM1_CS9
BFE +0048h	RX RAM1 Coefficient Set 10 Register	RX_RAM1_CS10

BFE +004Ch	RX RAM1 Coefficient Set 11 Register	RX_RAM1_CS11
BFE +0050h	RX RAM1 Coefficient Set 12 Register	RX_RAM1_CS12
BFE +0054h	RX RAM1 Coefficient Set 13 Register	RX_RAM1_CS13
BFE +0058h	RX RAM1 Coefficient Set 14 Register	RX_RAM1_CS14
BFE +005Ch	RX RAM1 Coefficient Set 15 Register	RX_RAM1_CS15

BFE+00B0h RX Interference Detection HPF Power Register RX_HPWR_STS

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RX_PWR_HPF															
Type	R/O															
Reset	0000000000000000															

This register is for read the power measurement result of the HPF interference detection filter.

RX_PWR_HPF Value of the power measurement result for the outband interference detection.

BFE+00B4h RX Interference Detection BPF Power Register RX_BPWR_STS

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RX_PWR_BPF															
Type	R/O															
Reset	0000000000000000															

This register is for read the power measurement result of the BPF interference detection filter.

RX_PWR_BPF Value of the power measurement result for the inband interference detection

10.3 Uplink Path (TX Path)

10.3.1 General Description

The purpose of the uplink path inside Baseband Front End is to sink TX symbols, from DSP, then perform GMSK modulation or 8PSK Modulation on them, then perform offset cancellation on I/Q digital signals, and finally control TX mixed-signal module to make D/A conversion on I/Q signals out of GMSK Modulator or 8PSK Modulator with offset cancellation. Accordingly, the uplink path is composed of uplink parts of Baseband Serial Ports, GSM Encryptor, GMSK Modulator, 8PSK Modulator and several compensation circuit including I/Q DC offset, I/Q Quadrature Phase Compensation, and I/Q Gain Mismatch. The block diagram of uplink path is shownas followed.

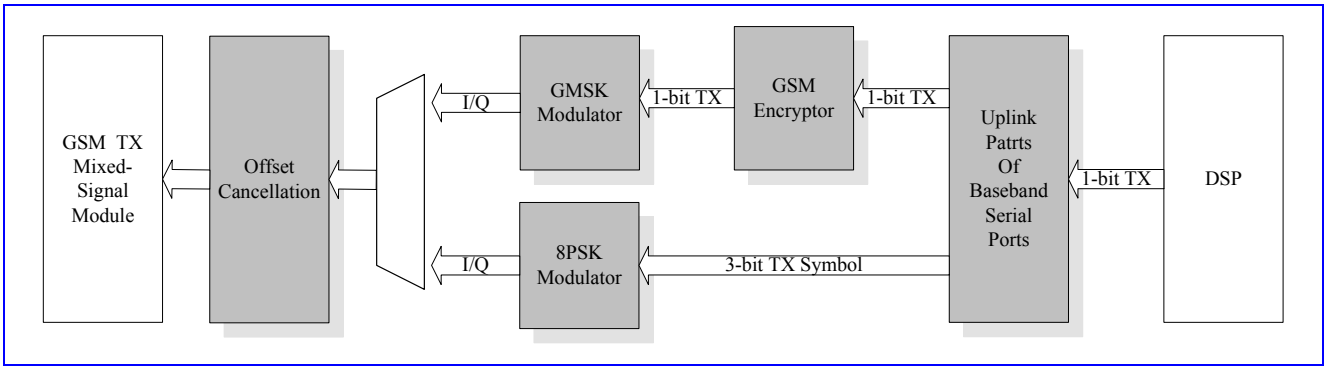


Figure 82 Block Diagram Of Uplink Path

On uplink path, the content of a burst, including tail bits, data bits, and training sequence bits is sent from DSP. DSP outputs will be t Translated by either GMSK Modulator or 8PSK Modulator. The Modulation Mode Selection is controlled by MDSEL1 (Modulation Mode Select1) MDSEL2, MDSEL3, MDSEL4 in TX_CFG control register, and these translated bits after modulation will become I/Q digital signals with certain latency.

TDMA timer having a quarter-bit timing accuracy gives the timing windows for uplink operation. Uplink operation is controlled by TX enable window and TX dump window of TDMA timer. Usually, TX enable window is opened earlier than TX dump window. When TX enable window of TDMA timer is opened, uplink path in Baseband Front End will power-on GSK TX mixed-signal module and thus drive valid outputs to RF module. However, uplink parts of Baseband Serial Ports still do not sink data from DSP through the serial interface between Baseband Serial Ports and DSP until TX dump window of TDMA timer is opened.

10.3.2 Compensation Circuit

10.3.2.1 Quadrature Phase

For 8PSK Modulation, in order to improve the EVM performance, use PHSEL[2:0](Phase Select) in TX_CFG control register to compensate the quadrature phase. 6 steps, 1degree/step, up to +/3 degree dynamic range.

10.3.2.2 DC offset Cancellation

Offset cancellation will be performed on these I/Q digital signals to compensate offset error of D/A converters (DAC) in TX mixed-signal module. Finally the generated I/Q digital signals will be input to TX mixed-signal module that contains two DAC for I/Q signal respectively.

10.3.3 Auxiliary Calibration Circuit - 540khz Sine Tone Generator

By setting ‘1’ to SGEN(Sine Tone Generation) in TX_CFG control register, the BBTX output will become 540khz single sine tone, which is used for Factory Calibration scheme for Mixed Signal Low Pass Filter Cut-off Frequency Accuracy.

10.3.4 GSM Encryptor

When uplink parts of Baseband Serial Ports pass a TX symbol to GSM Encryptor, GSM Encryptor will perform encryption on the TX symbol if set ‘1’ to BCIEN(Baseband Ciphering Encryption) in **BFE_CON** register. Otherwise, the TX symbol will be directed to GMSK modulator directly.

10.3.5 Modulation

10.3.5.1 GMSK Modulation

GMSK Modulator is used to convert bit stream of GSM bursts into in-phase and quadrature-phase outputs by means of GMSK modulation scheme. It consists of a ROM table, timing control logic and some state registers for GMSK modulation scheme. GMSK Modulator is activated when TX dump window is opened. There is latency between assertion of TX dump window and the first valid output of GMSK Modulator. The reason is because the bit rate of TX symbols is 270.833 KHz and the output rate of GMSK Modulator is 4.333 MHz, and therefore timing synchronization is necessary between the two rates.

Additionally, in order to prevent phase discontinuity in between the multiple-burst Mode, the GMSK modulator will output continuous 67.7khs sine tone outside the burst once RX DAC Enable window is still asserted. Once RX DAC Enable window is disserted, GMSK modulator will park at DC level.

10.3.5.2 8PSK Modulation

8PSK Modulator is used to convert bit stream of EDGE bursts into basically 8 phase I/Q pair output by means of 8PSK modulation scheme. It consists of ROM table, timing control logic and some state registers for 8PSK modulation scheme. The conversion is based on 5 sequential symbol and performed moving average from the ROM table lookup. 8PSK Modulator is activated when TX dump window is opened. There is one clock delay between assertion of TX dump window and the first valid output of 8PSK Modulator. The reason is because the bit rate of TX symbols is 270.833 KHz and the output rate of 8PSK Modulator is 4.333 MHz, and therefore timing synchronization is necessary between the two rates.

10.3.5.2.1 8PSK Ramp Profile

During 8PSKModulation, there will be 3 Ramp Profile to select to choose the BBTX I/Q output during the guard period, where the DAC_ON is asserted while TX_WINDOW is de-asserted. This control register is an option to adjust the transmitter performance on “Modulation Transient Spectrum” requirement of ETSI SPEC if different companion Power Amplifier solution is chosen

By setting RPSEL (Ramp Profile Select) in TX_CFG control register to ‘0’will configured 8PSK Modulator to Ramp Profile I and I/Q output will be about 50 kHz Sine-tone before the first rising edge of BULFS, after the last falling edge of BULFS, and in between the bursts. For Ramp Profile II, BBTX I/Q output will be quiescent low DC (null-DC) level during the guard period.

For Ramp Profile III, initial guard period will be 50 kHz sine-tone, while the reset guard period will be null-DC level.

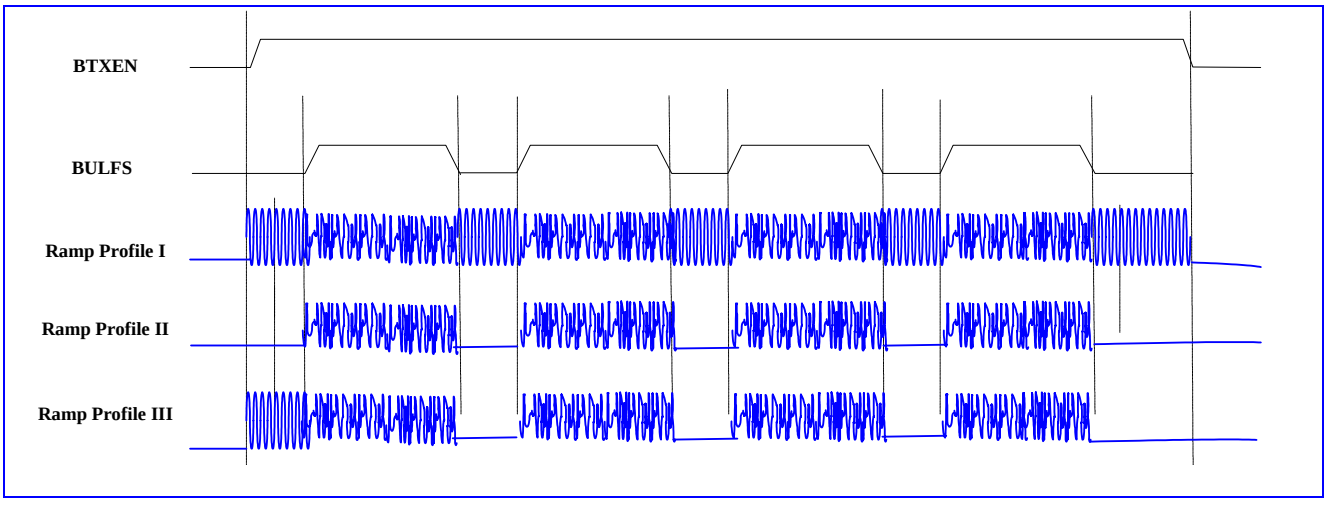


Figure 83 Ramp Profile I/II/III in 8PSK Modulation for Multi-Bursts configuration..

10.3.5.3 I/Q Swap

By setting ‘1’ to IQSWP in TX_CFG control register, phase on I/Q plane will rotate in inverse direction. This option is to meet the different requirement form RF chip regarding I/Q plane. This control signal is for GMSK Modulation only.

10.3.5.4 Modulation Output Latency Adjustment

For Multiple bursts, there maybe are consecutive bursts with different modulation mode. (E.g. switch GMSK to 8PSK or vice versa). However, there are about 8 to 10 QB output latencies for either GMSK/8PSKmodulation output. In order to match the transition timing of power ramp control in the power amplifier outside the baseband chip, we have to precisely control the SW_QBCNT (modulation Switching Quarter Bit CouNT) in TX_CFG control register. , which will program the mode switching timing in QB count unit during the inter-slot period. Normally the inter-slot period is about 33 QB Count, and the default value to switch the modulation mode is 24 QB count (8 QB count after the middle point)

Additionally, by programming GMSK_DTAP_SYM(GMSK Delay Tap) in TX_CFG and GMSK_DTAP_QB in TX_CON control register, the output latency for GMSK modulation output can be adjust to compensate the offset between GMSK/8PSK modulator. The GMSK_DTAP_SYM adjust the output latency in symbol time(3.69us), while GMSK_DTA_QB adjust in Quarter Bit(QB) Time (0.92us).Default value is delay 1 symbol (3.69us) of GMSK modulator output.

10.3.5.5 Modulation Mode Switching

By setting '1' to INTEN(Interpolation Enable) in TX_CFG control register, if two consecutive bursts belongs to 8PSK Modulation and GMSK Modulation, or vice versa, 32 steps interpolation between two Modulator outputs for 4quater bit long in guard period..

10.3.5.6 Debug Mode

10.3.5.6.1 Modulation Bypass Mode

For DSP debug purpose, set both '1' for MDBYP(Modulator Bypass) in TX_CFG control register and BYPFLR(Bypass RX Filter) in RX_CFG control register for directly loopback DSP 16-bits data (10bits valid data plus sign or zero extension) through DAC only.

10.3.5.6.2 Force GMSK/8PSK Modulator turn on

By setting '1' to APNDEN(Append Enable) bit in TX CFG control register, both GMSK and 8PSK modulator will park on constant DC level during the non-burst period, while the I/Q pair output phase maybe discontinuous since both modulator will be reset at the beginning of the burst. However, the reset of the modulator will be helpful for the debugging purpose.

10.3.6 Register Definitions

BFE +0060h TX Configuration Register TX_CFG

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name		GMSK_DTAP_SYM		SW_QBCNT					ALL_10_EN		SGEN	MDBYP	INTEN	RPSEL		APNDEN
Type		R/W		RW					RW		R/W	R/W	R/W	R/W	R/W	R/W
Reset		00		18					00		0	0	0	00		0

This register is for configuration of uplink path, inclusive of configuration of TX mixed-signal module and TX path in Baseband Front End.

APNDEN Appending Bits Enable.(For DSP digital loopback debug mode) The register bit is used to control the ending scheme of GPRS Mode GMSK modulation only.

0 Suitable for GPRS /EDGE mode. If a TX enable window contains several TX dump window, then GMSK modulator will still output in the intervals between two TX dump window and all 1's will be fed into GMSK modulator. In the other word, mainly used PA to perform the power ramp up/down, while Modulator output low amplitude sinewave. **Note that when the bit is set to '0', the interval between the moment at which TX enable window is activated and the moment at which TX dump window is activated must be multiples of one bit time.**

1 Suitable for GSM only. After a TX dump window, GMSK modulator will only output for some bit time.

RPSEL Ramp Profile Select for 8PSK Modulation. The register bit is used to select either Ramp Profile I / Ramp Profile II for EDGE Mode 8PSK Modulation only.

0 Ramp Profile I. Generate 50Khz sine tone during the guard period among BBTX bursts by repeated input pattern [7 7 7 7]

1 Ramp Profile II. Generate null DC I/Q output during guard period among BBTX bursts

2 Reserved

3 Ramp Profile III , Generate 50 kHz sine tone after DAC_ON asserted and before TX_WIDNOW asserted if 1st burst is 8PSK modulation, while the reset guard period always output null DC I/Q output. If the 1st burst is GMSK modulation, the I/Q output will be always null DC as Ramp Profile II.

INTEN Interpolation Enable. During Multi-bursts Mode, if two consecutive bursts belongs to 8PSK Modulation and GMSK Modulation~~, and vise versa~~ or vice versa, set this bit to select either takes 32 steps interpolation between two Modulator outputs in guard period..

0 Regular Transition Mode.

1 Interpolation Transition Mode.

MDBYP Modulator Bypass (For DSP Debug Mode) Select. The register bit is used to select the bypass mode for I/Q pair outputs bypassed both the GMSK/8PSK modulator

0 Regular Modulation Mode

1 Bypass Modulator Mode (DSP Debug Mode).

SGEN SineTone Generator Enable.(For Factory Calibration Purpose). The register bit is used to select the TX modulator output switch to 540 kHz Sine Tone.

0 BBTX output from regulator modulator output.

1 BBTX output switch to 540 kHz sine Tone

ALL_10GEN For Debug mode of BBTX. Generate all 1's or zero's input during BBTX valid burst. For GMSK modulation, set 2'b1 or 2'b10 will generate 67.7 kHz sine tone, while 8PSK modulator will generate 50khz sine tone. Default value 2'b00 is normal mode.

0 Normal Mode, regular modulator input from Slave DSP TX Buffer.

1 Debug Mode, All zero's input pattern generated; GMSK modulator will generate 67.7 kHz sine tone. 8PSK modulator will generate 50 kHz sine tone.

2 Debug Mode All 1's input pattern generated; GMSK modulator will generate 67.7 kHz sine tone. 8PSK modulator will generate 50 kHz sine tone.

SW_QBCNT Control the mode switching timing in the inter-slot period in Quarter Bit Count for modulation mode switching in multiple bursts. Normally the inter-slot period is about 33 QB Count, and the default value to switch the modulation mode is 24 QB count (8 QB count after the middle point). Program range from "5~31", while default value is 24.

GMSK_DTAP_SYM Control the GMSK modulator output latency in symbol time (3.69us/symbol) in order to match the output latency offset between 8PSK /GMSK modulator

0 Delay 1 TAP for GMSK modulator output

1 No delay for GMSK modulator output

2 Delay 2 TAP for GMSK modulator output

BFE +0064h TX Control Register TX_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			GMSK_DTAP_QB		PHSEL						MDSEL4	MDSEL3	MDSEL2	MDSEL1		IQSWP
Type			R/W		R/W						R/W	R/W	R/W	R/W		R/W
Reset			00		0000						0	0	0	0		0

This register is for control of uplink path, inclusive of control of TX mixed-signal module and TX path in Baseband Front End.

IQSWP The register bit is for control of I/Q swapping. When the bit is set to '1', phase on I/Q plane will rotate in inverse direction. Moreover, this register is double buffered by EVENT_VALIDATE.

0 I and Q are not swapped.

1 I and Q are swapped.

MDSEL1 Modulation Mode Select for 1st Burst. The register bit is used to select either GMSK or 8PSK Modulation for GSM/GPRS mode or EDGE mode.

0 GMSK Modulation for GSM/GPRS mode.

1 8PSK Modulation for EDGE mode.

MDSEL2 Modulation Mode Select for 2nd Burst. The register bit is used to select either GMSK or 8PSK Modulation for GSM/GPRS mode or EDGE mode.

0 GMSK Modulation for GSM/GPRS mode.

1 8PSK Modulation for EDGE mode.

MDSEL3 Modulation Mode Select for 3rd Burst. The register bit is used to select either GMSK or 8PSK Modulation for GSM/GPRS mode or EDGE mode.

0 GMSK Modulation for GSM/GPRS mode.

1 8PSK Modulation for EDGE mode.

MDSEL4 Modulation Mode Select for 4th Burst. The register bit is used to select either GMSK or 8PSK Modulation for GSM/GPRS mode or EDGE mode.

0 GMSK Modulation for GSM/GPRS mode.

1 8PSK Modulation for EDGE mode.

PHSEL Quadrature phase compensation select

0000: 0 degree compensation.

0001: 1 degree compensation.

0010: 2 degree compensation.

0011: 3 degree compensation.

0100: 4 degree compensation.

0101: 5 degree compensation.

1010: -5 degree compensation.

1011: -4 degree compensation.

1100: -3 degree compensation.

1101: -2 degree compensation.

1110: -1 degree compensation.

1111: 0 degree compensation.

GMSK_DTAP_QB Control the GMSK modulator output latency in Quarter Bit(QB) Time (0.92us/QB) in order to match the output latency offset between 8PSK /GMSK modulator

- **0** No Delay GMSK modulator output
- **1** Delay 1QB for GMSK modulator output
- **2** Delay 2 QB for GMSK modulator output
- **3** Delay 3QB for GMSK modulator output

BFE +0068h TX I/Q Channel Offset Compensation Register TX_OFF

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	OFF_TYP		OFFQ[5:0]								OFFI[5:0]					
Type	R/W		R/W								R/W					
Reset	0		000000								000000					

The register is for offset cancellation of I-channel DAC in TX mixed-signal module. It is for compensation of offset error caused by I/Q-channel DAC in TX mixed-signal module. It is coded in 2's complement, that is, with maximum 31 and minimum –32.

OFFI Value of offset cancellation for I-channel DAC in TX mixed-signal module

OFFQ Value of offset cancellation for Q-channel DAC in TX mixed-signal module

OFF_TYP Type of the OFFI and OFFQ register. While OFF_TYP = 1, the offset values are double buffered and can be chaneged burst by burst after EVENT_VALIDATE comes. Otherwise, the offset values would change immidately after the coming of APB commands, which can't be adjusted burst by burst.

- **0** No double buffer
- **1** Double buffered

11 Timing Generator

Timing is the most critical issue in GSM/GPRS applications. The TDMA timer provides a simple interface for the MCU to program all the timing-related events for receive event control, transmit event control and the timing adjustment. Detailed descriptions are mentioned in Section 11.1.

11.1 TDMA timer

The TDMA timer unit is composed of three major blocks: Quarter bit counter, Signal generator and Event registers.

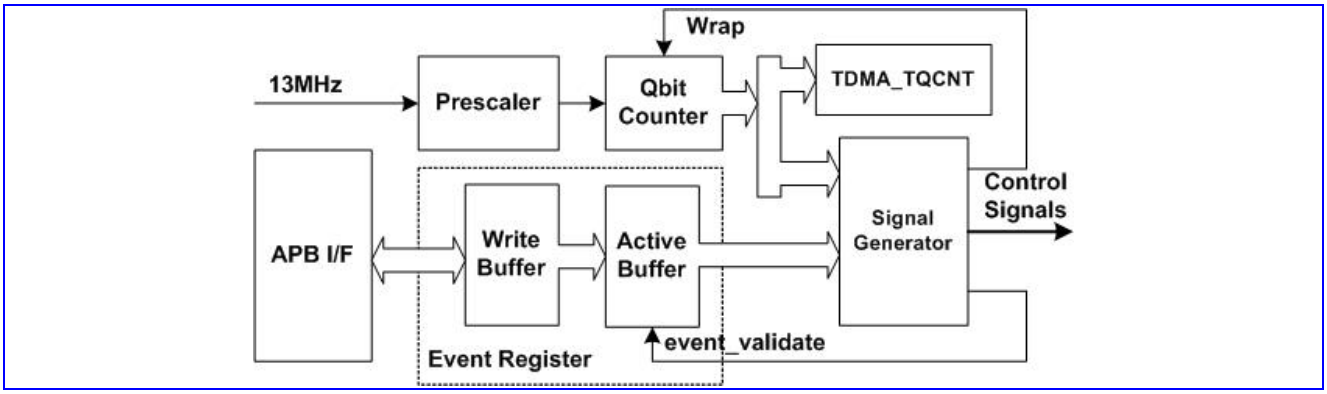
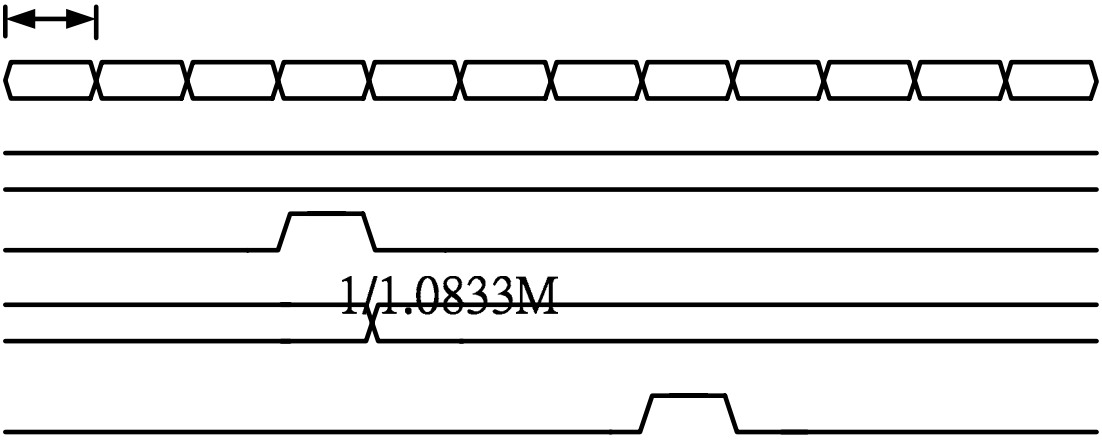


Figure 84 The block diagram of TDMA timer

By default, the quarter-bit counter continuously counts from 0 to the wrap position. In order to apply to cell synchronization and neighboring cell monitoring, the wrap position can be changed by the MCU to shorten or lengthen a TDMA frame. The wrap position is held in the TDMA_WRAP register and the current value of the TDMA quarter bit counter may be read by the MCU via the TDMA_TQCNT register.

The signal generator handles the overall comparing and event-generating processes. When a match has occurred between the quarter bit counter and the event register, a predefined control signal is generated. These control signals may be used for on-chip and off-chip purposes. Signals that change state more than once per frame make use of more than one event register.



The event registers are programmed to contain the quarter bit position of the event that is to occur. The event registers are double buffered. The MCU writes into the write buffers of the registers, and the event TDMA_EVTVAL trigger HW to transfer the data from the write buffers to the active buffers. Caution: values in the active buffers are updated at the end of qbit count (TDMA_EVTVAL). The TDMA_EVTVAL signal itself may be programmed at any quarter bit position. These event registers could be classified into four groups:

On-chip Control Events

TDMA_EVTVAL

This event allows the data values written by the MCU to pass through to the active buffers.

TDMA_WRAP

TDMA quarter bit counter wrap position. This sets the position at which the TDMA quarter bit counter resets back to zero. The default value is 4999, changing this value will advance or retard the timing events in the frame following the next TDMA_EVTVAL signal. Caution: The wrap value of the first frame after the sleep mode will refer to TQWRAP_SM value if SW enables turbo sleep mode.

TDMA_DTIRQ

DSP TDMA interrupt requests. DTIRQ triggers the DSP to read the command from the MCU/DSP Shard RAM to schedule the activities that will be executed in the current frame.

TDMA_CTIRQ1/CTIRQ2

MCU TDMA interrupt requests. CTIRQx triggers the ARM to schedule the activities that will be executed in the next frame.

TDMA_AUXADC [1:0]

This signal triggers the monitoring ADC to measure the voltage, current, temperature, device id etc..

TDMA_AFC [3:0]

This signal powers up the automatic frequency control DAC for a programmed duration after this event.

Note: For both MCU and DSP TDMA interrupt requests, these signals are all active Low during one quarter bit duration and they should be used as edge sensitive events by the respective interrupt controllers.

On-chip Receive Events

TDMA_BDLON [5:0]

These registers are a set of six which contain the quarter bit event that initiates the receive window assertion sequence which powers up and enables the receive ADC, and then enables loading of the receive data into the receive buffer.

TDMA_BDLOFF [5:0]

These registers are a set of six which contain the quarter bit event that initiates the receive window de-assertion sequence which disables loading of the receive data into the receive buffer, and then powers down the receive ADC.

TDMA_RXWIN[5:0]

DSP TDMA interrupt requests. TDMA_RXWIN is usually used to initiate the related RX processing including two modes. In single-shot mode, TDMA_RXWIN is generated when the BRXFS signal is de-asserted. In repetitive mode, TDMA_RXWIN will be generated both regularly with a specific interval after BRXFS signal is asserted and when the BRXFS signal is de-asserted.

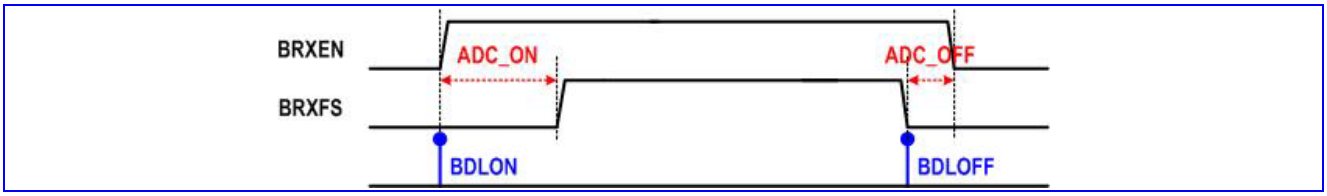


Figure 85 The timing diagram of BRXEN and BRXFS

Note: TDMA_BDLON/OFF event registers, together with TDMA_BDLCON register, generate the corresponding BRXEN and BRXFS window used to power up/down baseband downlink path and control the duration of data transmission to the DSP, respectively.

On-chip Transmit Events

TDMA_APC [6:0]

These registers initiate the loading of the transmit burst shaping values from the transmit burst shaping RAM into the transmit power control DAC.

TDMA_BULON [3:0]

This register contains the quarter bit event that initiates the transmit window assertion sequence which powers up the modulator DAC and then enables reading of bits from the transmit buffer into the GMSK modulator.

TDMA_BULOFF [3:0]

This register contains the quarter bit event that initiates the transmit window de-assertion sequence which disables the reading of bits from the transmit buffer into the GMSK modulator, and then power down the modulator DAC.

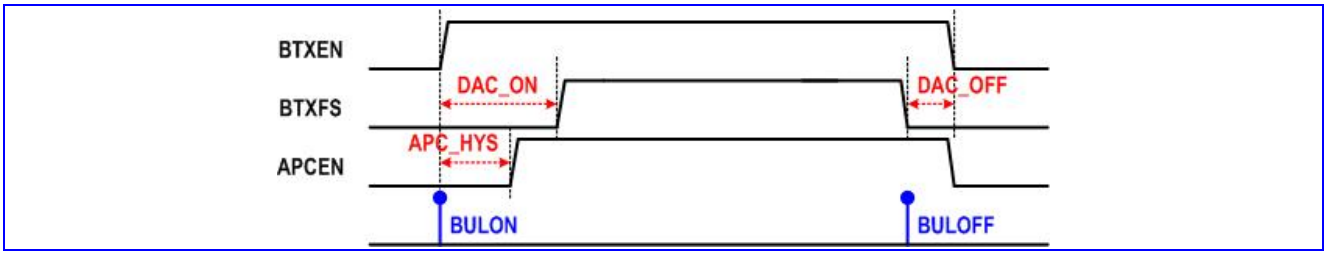


Figure 86 The timing diagram of BTXEN and BTXFS

Note: TDMA_BULON/OFF event registers, together with TDMA_BULCON1, TDMA_BULCON2 register, generate the corresponding BTXEN, BTXFS and APCEN window used to power up/down the baseband uplink path, control the duration of data transmission from the DSP and power up/down the APC DAC, respectively.

Off-chip Control Events

TDMA_BSI [19:0]

The quarter bit positions of these 20 BSI events are used to initiate the transfer of serial words to the transceiver and synthesizer for gain control and frequency adjustment.

TDMA_BPI [41:0]

The quarter bit positions of these 30 BPI events are used to generate changes of state on the output pins to control the external radio components.

11.1.1 Register Definitions

0x82000150 Event Enable Register 0 — TDMA_EVTENA 0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	AFC3	AFC2	AFC1	AFC0	BDL5	BDL4	BDL3	BDL2	BDL1	BDL0				CTIRQ2	CTIRQ1	DTIRQ
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W				R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0				0	0	0

DTIRQ Enable TDMA_DTIRQ

CTIRQ*n* Enable TDMA_CTIRQ*n*

AFC*n* Enable TDMA_AFC*n*

BDL*n* Enable TDMA_BDLON*n* and TDMA_BDLOFF*n*

For all these bits,

0 function is disabled

1 function is enabled

0x82000154h Event Enable Register 1 — TDMA_EVTENA 1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPRS				BUL3	BUL2	BUL1	BUL0		APC6	APC5	APC4	APC3	APC2	APC1	APC0
Type	R/W				R/W	R/W	R/W	R/W		R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0				0	0	0	0		0	0	0	0	0	0	0

GPRS Indicate which mode is on-going.

0 TDMA_APC0 & TDMA_APC1 events are controlled by APC0 & APC1 in the register TDMA_EVTENA1 & TDMA_DTXCON. (GSM mode)

1 TDMA_APC0 & TDMA_APC1 events are controlled by APC0 & APC1 in the register TDMA_EVTENA1 only. (GPRS mode)

APC*n* Enable TDMA_APC*n*

BUL*n* Enable TDMA_BULON*n* and TDMA_BULOFF*n*

For all these bits,

0 function is disabled

1 function is enabled

0x82000158 Event Enable Register 2 — TDMA_EVTENA 2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	BSI15	BSI14	BSI13	BSI12	BSI11	BSI10	BSI9	BSI8	BSI7	BSI6	BSI5	BSI4	BSI3	BSI2	BSI1	BSI0

Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

0x8200015C Event Enable Register 3

TDMA_EVTENA 3

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													**BSI19**	**BSI18**	**BSI17**	**BSI16**
Type													R/W	R/W	R/W	R/W
Reset													0	0	0	0

BSI*n* BSI event enable control

0 Disable TDMA_BSI*n*

1 Enable TDMA_BSI*n*

0x82000160 Event Enable Register 4

TDMA_EVTENA 4

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	**BPI15**	**BPI14**	**BPI13**	**BPI12**	**BPI11**	**BPI10**	**BPI9**	**BPI8**	**BPI7**	**BPI6**	**BPI5**	**BPI4**	**BPI3**	**BPI2**	**BPI1**	**BPI0**
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

0x82000164 Event Enable Register 5

TDMA_EVTENA 5

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	**BPI31**	**BPI30**	**BPI29**	**BPI28**	**BPI27**	**BPI26**	**BPI25**	**BPI24**	**BPI23**	**BPI22**	**BPI21**	**BPI20**	**BPI19**	**BPI18**	**BPI17**	**BPI16**
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

BPI*n* BPI event enable control

0 Disable TDMA_BPI*n*

1 Enable TDMA_BPI*n*

0x82000168 Event Enable Register 6

TDMA_EVTENA 6

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							**BPI41**	**BPI40**	**BPI39**	**BPI38**	**BPI37**	**BPI36**	**BPI35**	**BPI34**	**BPI33**	**BPI32**
Type							R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset							0	0	0	0	0	0	0	0	0	0

BPI*n* BPI event enable control

0 Disable TDMA_BPI*n*

1 Enable TDMA_BPI*n*

0x8200016C Event Enable Register 7 — TDMA_EVTENA7

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name															AUX1	AUX0
Type															R/W	R/W
Reset															0	0

AUX Auxiliary ADC event enable control

0 Disable Auxiliary ADC event

1 Enable Auxiliary ADC event

0x82000170 Qbit Timer Offset Control Register — TDMA_WRAPOFS

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name															TOI[1:0]	
Type															R/W	
Reset															0	

TOI This register defines the value used to advance the Qbit timer in unit of 1/4 quarter bit; the timing advance will be take place as soon as the TDMA_EVTVAL is occurred, and it will be cleared automatically.

0x82000174 Qbit Timer Biasing Control Register — TDMA_REGBIAS

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			TQ_BIAS[13:0]													
Type			R/W													
Reset			0													

TQ_BIAS This register defines the Qbit offset value which will be added to the registers being programmed. It only takes effects on AFC, BDLON/OFF, BULON/OFF, APC, AUXADC, BSI and BPI event registers.

0x82000180 DTX Control Register — TDMA_DTXCON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													DTX3	DTX2	DTX1	DTX0
Type													R/W	R/W	R/W	R/W

DTX DTX flag is used to disable the associated transmit signals

0 BULON0~3, BULOFF0~3, APC_EV0 & APC_EV1 are controlled by TDMA_EVTENA1 register

1 BULON0~3, BULOFF0~3, APC_EV0 & APC_EV1 are disabled

0x82000184 Receive Interrupt Control Register — TDMA_RXCON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	MOD5	MOD4	MOD3	MOD2	MOD1	MOD0	RXINTCNT[9:0]									
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W									

RXINTCNT TDMA_RXWIN interrupt generation interval in quarter bit unit

MOD*n* Mode of Receive Interrupts

0 Single shot mode for the corresponding receive window

1 Repetitive mode for the corresponding receive window

0x82000188 Baseband Downlink Control Register TDMA_BDLCON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ADC_ON										ADC_OFF					
Type	R/W										R/W					

ADC_ON BRXEN to BRXFS setup up time in quarter bit unit.

ADC_OFF BRXEN to BRXFS hold up time in quarter bit unit.

0x8200018C Baseband Uplink Control Register 1 TDMA_BULCON 1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DAC_ON								DAC_OFF							
Type	R/W								R/W							

DAC_ON BTXEN to BTXFS setup up time in quarter bit unit.

DAC_OFF BTXEN to BTXFS hold up time in quarter bit unit.

0x82000190 Baseband Uplink Control Register 2 TDMA_BULCON 2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									APC_HYS							
Type									R/W							

APC_HYS APCEN to BTXEN hysteresis time in quarter bit unit.

0x82000194 Frequency Burst Indication Register TDMA_FB_FLAG

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											FBDL5	FBDL4	FBDL3	FBDL2	FBDL1	FBDL0
Type											R/W	R/W	R/W	R/W	R/W	R/W

FBDLn Indication of frequency burst for RX window n

The register is double-buffered. The value at the write buffers will be auto-cleared at the next event-validate (TDMA_EVTVAL) and its value will be at the same time loaded to the active buffer. The exact FB indication comes from the active buffer and the corresponding mode in register TDMA_RXCON (Bit15~Bit10). It will be asserted after TDMA_EVTVAL signals if the corresponding FBDLx & TDMA_RXCON[x+10] are set to 1. The FB indication de-assertion only depends TDMA_FB_CLRI and the falling edge of the corresponding RX window.

0x82000198 Direct Frequency Burst Closing TDMA_FB_CLRI

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																
Type																

As long as the register is written, active buffer for FB indication will be reset then therefore the frequency burst indication will be forced to 0.

Address	Type	Width	Reset Value	Name	Description
0x80000000	R	[13:0]	—	TDMA_TQCNT	Read quarter bit counter
0x82000004	R/W	[13:0]	0x1387	TDMA_WRAP	Latched Qbit counter reset position
0x82000008	R/W	[13:0]	0x1387	TDMA_WRAPIMD	Direct Qbit counter reset position
0x8200000C	R/W	[13:0]	0x0000	TDMA_EVTVAL	Event latch position
0x82000010	R/W	[13:0]	—	TDMA_DTIRQ	DSP software control
0x82000014	R/W	[13:0]	—	TDMA_CTIRQ1	MCU software control 1
0x82000018	R/W	[13:0]	—	TDMA_CTIRQ2	MCU software control 2
0x82000020	R/W	[13:0]	—	TDMA_AFC0	The 1st AFC control
0x82000024	R/W	[13:0]	—	TDMA_AFC1	The 2nd AFC control
0x82000028	R/W	[13:0]	—	TDMA_AFC2	The 3rd AFC control
0x8200002C	R/W	[13:0]	—	TDMA_AFC3	The 4th AFC control
0x82000030	R/W	[13:0]	—	TDMA_BDLON0	Data serialization of the 1st RX block
0x82000034	R/W	[13:0]	—	TDMA_BDLOFF0	
0x82000038	R/W	[13:0]	—	TDMA_BDLON1	Data serialization of the 2nd RX block
0x8200003C	R/W	[13:0]	—	TDMA_BDLOFF1	
0x82000040	R/W	[13:0]	—	TDMA_BDLON2	Data serialization of the 3rd RX block
0x82000044	R/W	[13:0]	—	TDMA_BDLOFF2	
0x82000048	R/W	[13:0]	—	TDMA_BDLON3	Data serialization of the 4th RX block
0x8200004C	R/W	[13:0]	—	TDMA_BDLOFF3	
0x82000050	R/W	[13:0]	—	TDMA_BDLON4	Data serialization of the 5th RX block
0x82000054	R/W	[13:0]	—	TDMA_BDLOFF4	
0x82000058	R/W	[13:0]	—	TDMA_BDLON5	Data serialization of the 6th RX block
0x8200005C	R/W	[13:0]	—	TDMA_BDLOFF5	
0x82000060	R/W	[13:0]	—	TDMA_BULON0	Data serialization of the 1st TX slot
0x82000064	R/W	[13:0]	—	TDMA_BULOFF0	
0x82000068	R/W	[13:0]	—	TDMA_BULON1	Data serialization of the 2nd TX slot
0x8200006C	R/W	[13:0]	—	TDMA_BULOFF1	
0x82000070	R/W	[13:0]	—	TDMA_BULON2	Data serialization of the 3rd TX slot
0x82000074	R/W	[13:0]	—	TDMA_BULOFF2	
0x82000078	R/W	[13:0]	—	TDMA_BULON3	Data serialization of the 4th TX slot
0x8200007C	R/W	[13:0]	—	TDMA_BULOFF3	

0x82000090	R/W	[13:0]	—	TDMA_APC0	The 1st APC control
0x82000094	R/W	[13:0]	—	TDMA_APC1	The 2nd APC control
0x82000098	R/W	[13:0]	—	TDMA_APC2	The 3rd APC control
0x8200009C	R/W	[13:0]	—	TDMA_APC3	The 4th APC control
0x820000A0	R/W	[13:0]	—	TDMA_APC4	The 5th APC control
0x820000A4	R/W	[13:0]	—	TDMA_APC5	The 6th APC control
0x820000A8	R/W	[13:0]	—	TDMA_APC6	The 7th APC control
0x820000B0	R/W	[13:0]	—	TDMA_BSI0	BSI event 0
0x820000B4	R/W	[13:0]	—	TDMA_BSI1	BSI event 1
0x820000B8	R/W	[13:0]	—	TDMA_BSI2	BSI event 2
0x820000BC	R/W	[13:0]	—	TDMA_BSI3	BSI event 3
0x820000C0	R/W	[13:0]	—	TDMA_BSI4	BSI event 4
0x820000C4	R/W	[13:0]	—	TDMA_BSI5	BSI event 5
0x820000C8	R/W	[13:0]	—	TDMA_BSI6	BSI event 6
0x820000CC	R/W	[13:0]	—	TDMA_BSI7	BSI event 7
0x820000D0	R/W	[13:0]	—	TDMA_BSI8	BSI event 8
0x820000D4	R/W	[13:0]	—	TDMA_BSI9	BSI event 9
0x820000D8	R/W	[13:0]	—	TDMA_BSI10	BSI event 10
0x820000DC	R/W	[13:0]	—	TDMA_BSI11	BSI event 11
0x820000E0	R/W	[13:0]	—	TDMA_BSI12	BSI event 12
0x820000E4	R/W	[13:0]	—	TDMA_BSI13	BSI event 13
0x820000E8	R/W	[13:0]	—	TDMA_BSI14	BSI event 14
0x820000EC	R/W	[13:0]	—	TDMA_BSI15	BSI event 15
0x820000F0	R/W	[13:0]	—	TDMA_BSI16	BSI event 16
0x820000F4	R/W	[13:0]	—	TDMA_BSI17	BSI event 17
0x820000F8	R/W	[13:0]	—	TDMA_BSI18	BSI event 18
0x820000FC	R/W	[13:0]	—	TDMA_BSI19	BSI event 19
0x82000100	R/W	[13:0]	—	TDMA_BPI0	BPI event 0
0x82000104	R/W	[13:0]	—	TDMA_BPI1	BPI event 1
0x82000108	R/W	[13:0]	—	TDMA_BPI2	BPI event 2
0x8200010C	R/W	[13:0]	—	TDMA_BPI3	BPI event 3
0x82000110	R/W	[13:0]	—	TDMA_BPI4	BPI event 4
0x82000114	R/W	[13:0]	—	TDMA_BPI5	BPI event 5
0x82000118	R/W	[13:0]	—	TDMA_BPI6	BPI event 6
0x8200011C	R/W	[13:0]	—	TDMA_BPI7	BPI event 7
0x82000120	R/W	[13:0]	—	TDMA_BPI8	BPI event 8
0x82000124	R/W	[13:0]	—	TDMA_BPI9	BPI event 9
0x82000128	R/W	[13:0]	—	TDMA_BPI10	BPI event 10
0x8200012C	R/W	[13:0]	—	TDMA_BPI11	BPI event 11

0x82000130	R/W	[13:0]	—	TDMA_BPI12	BPI event 12
0x82000134	R/W	[13:0]	—	TDMA_BPI13	BPI event 13
0x82000138	R/W	[13:0]	—	TDMA_BPI14	BPI event 14
0x8200013C	R/W	[13:0]	—	TDMA_BPI15	BPI event 15
0x82000140	R/W	[13:0]	—	TDMA_BPI16	BPI event 16
0x82000144	R/W	[13:0]	—	TDMA_BPI17	BPI event 17
0x82000148	R/W	[13:0]	—	TDMA_BPI18	BPI event 18
0x8200014C	R/W	[13:0]	—	TDMA_BPI19	BPI event 19
0x820001A0	R/W	[13:0]	—	TDMA_BPI20	BPI event 20
0x820001A4	R/W	[13:0]	—	TDMA_BPI21	BPI event 21
0x820001A8	R/W	[13:0]	—	TDMA_BPI22	BPI event 22
0x820001AC	R/W	[13:0]	—	TDMA_BPI23	BPI event 23
0x820001B0	R/W	[13:0]	—	TDMA_BPI24	BPI event 24
0x820001B4	R/W	[13:0]	—	TDMA_BPI25	BPI event 25
0x820001B8	R/W	[13:0]	—	TDMA_BPI26	BPI event 26
0x820001BC	R/W	[13:0]	—	TDMA_BPI27	BPI event 27
0x820001C0	R/W	[13:0]	—	TDMA_BPI28	BPI event 28
0x820001C4	R/W	[13:0]	—	TDMA_BPI29	BPI event 29
0x820001C8	R/W	[13:0]	—	TDMA_BPI30	BPI event 30
0x820001CC	R/W	[13:0]	—	TDMA_BPI31	BPI event 31
0x820001D0	R/W	[13:0]	—	TDMA_BPI32	BPI event 32
0x820001D4	R/W	[13:0]	—	TDMA_BPI33	BPI event 33
0x820001D8	R/W	[13:0]	—	TDMA_BPI34	BPI event 34
0x820001DC	R/W	[13:0]	—	TDMA_BPI35	BPI event 35
0x820001E0	R/W	[13:0]	—	TDMA_BPI36	BPI event 36
0x820001E4	R/W	[13:0]	—	TDMA_BPI37	BPI event 37
0x820001E8	R/W	[13:0]	—	TDMA_BPI38	BPI event 38
0x820001EC	R/W	[13:0]	—	TDMA_BPI39	BPI event 39
0x820001F0	R/W	[13:0]	—	TDMA_BPI40	BPI event 40
0x820001F4	R/W	[13:0]	—	TDMA_BPI41	BPI event 41
0x82000400	R/W	[13:0]	—	TDMA_AUXEV0	Auxiliary ADC event 0
0x82000404	R/W	[13:0]	—	TDMA_AUXEV1	Auxiliary ADC event 1
0x82000150	R/W	[15:0]	0x0000	TDMA_EVTENA0	Event Enable Control 0
0x82000154	R/W	[15:0]	0x0000	TDMA_EVTENA1	Event Enable Control 1
0x82000158	R/W	[15:0]	0x0000	TDMA_EVTENA2	Event Enable Control 2
0x8200015C	R/W	[3:0]	0x0000	TDMA_EVTENA3	Event Enable Control 3
0x82000160	R/W	[15:0]	0x0000	TDMA_EVTENA4	Event Enable Control 4
0x82000164	R/W	[13:0]	0x0000	TDMA_EVTENA5	Event Enable Control 5
0x82000168	R/W	[1:0]	0x0000	TDMA_EVTENA6	Event Enable Control 6

0x8200016C	R/W	[11:0]	0x0000	TDMA_EVTENA7	Event Enable Control 7
0x82000170	R/W	[1:0]	0x0000	TDMA_WRAPOFS	TQ Counter Offset Control Register
0x82000174	R/W	[13:0]	0x0000	TDMA_REGBIAS	Biasing Control Register
0x82000180	R/W	[3:0]	—	TDMA_DTXCON	DTX Control Register
0x82000184	R/W	[15:0]	—	TDMA_RXCON	Receive Interrupt Control Register
0x82000188	R/W	[15:0]	—	TDMA_BDLCON	Downlink Control Register
0x8200018C	R/W	[15:0]	—	TDMA_BULCON1	Uplink Control Register 1
0x82000190	R/W	[7:0]	—	TDMA_BULCON2	Uplink Control Register 2
0x82000194	R/W	[5:0]	—	TDMA_FB_FLAG	FB indicator
0x82000198	W		—	TDMA_FB_CLRI	Direct clear of FB indicator

Table 47 TDMA Timer Register Map

11.1.2 Application Note

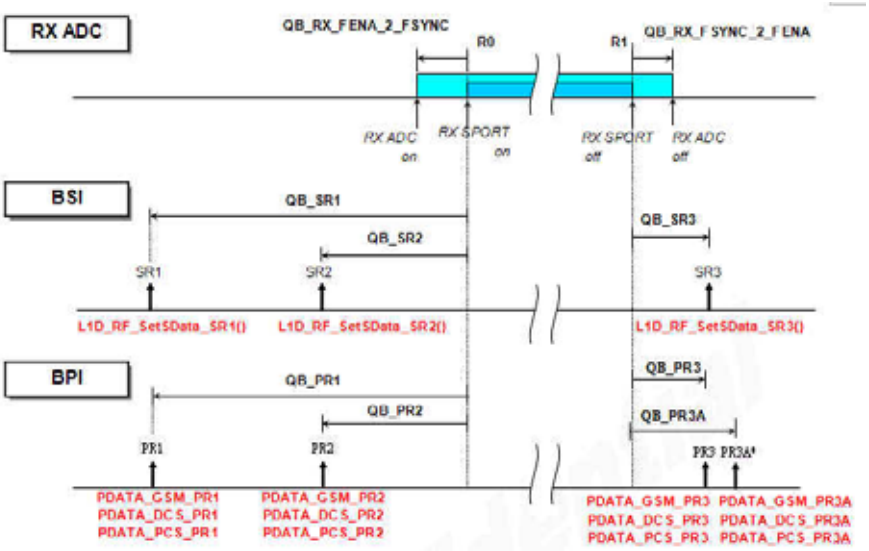


Figure 87 RX Timing Set Example

The TDMA timing and data setting are described in 2 parts. One part is that before turning on RX SPORT to receiving I/Q data. And the other part is after turning off RX SPORT to finish receiving I/Q data. To describe these two parts easily, the timing of turning on RX SPORT is taken as one base named **R0**. And the timing of turning off RX SPORT is taken as one base named **R1**.

RX ADC part:

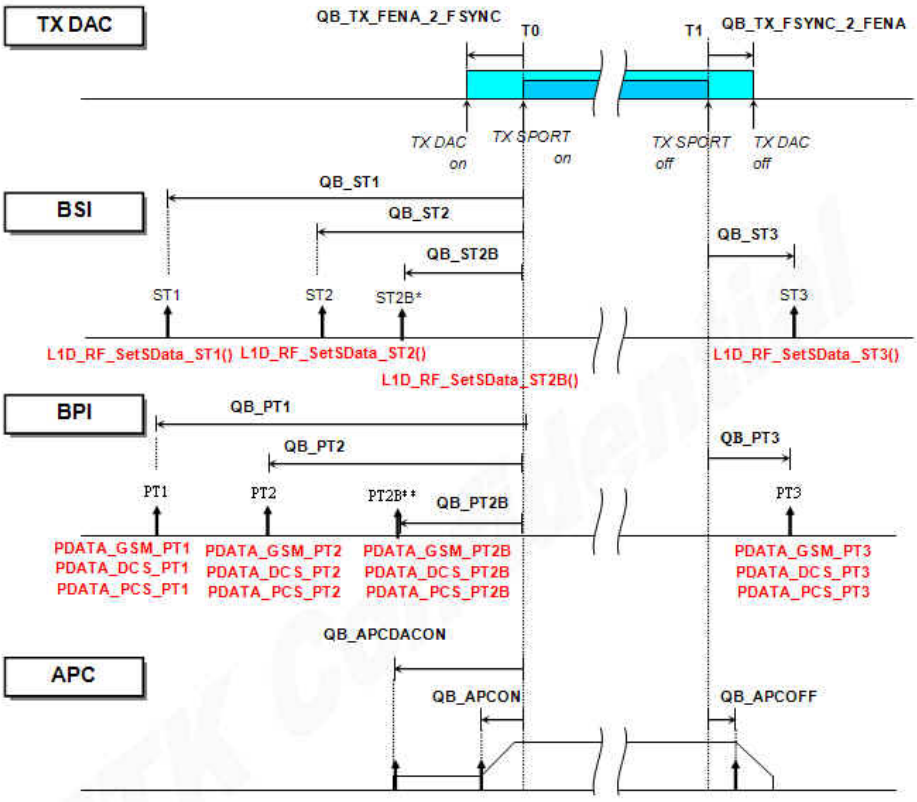
To setup the timing of RX ADC and SPORT, 2 timings need to be defined in **l1d_custom_rf.h**. The time from RX ADC enabling to RX SPORT turning on (**R0**) is defined as **QB_RX_FENA_2_FSYNC**.The time from RX SPORT turning on (**R1**) to RX ADC disabling is defined as **QB_RX_FSYNC_2_FENA**. The value of this two aliases should be positive or zero. These two values is defined in the register **TDMA_BDLCON**.

BSI part:

BSI data and events need to be set in serial to a 3-wire base RF module. Each RX window is allocated 3 BSI events. Usually 1'st BSI event is used to warm up the synthesizer and set its N-counter to lock the operation frequency. The 2'nd BSI is used to set the receiving amplifier gain of transceiver. The 3'rd BSI is used to command transceiver entering idle mode. BSI events are defined in the registers **TDMA_BSI0~19**.

BPI part:

The connection of HW signals of BPI data bus and RF module is flexible and depends on customer's design. The setting timing and data setting of BPI bus are used to specify at what time and which BPI states are changed. The BPI data may be varied by the operation band, so the dedicate BPI data of each band should be defined. The states transient of BPI signals are decided by the time of event, therefore the active time and the BPI states for each band shall be defined. BPI events are defined in the registers **TDMA_BPI0~41**.



TX ADC part:

To setup the timing of TX DAC and SPORT, 2 timings need to be defined in **l1d_custom.h**. The time from TX DAC enabling to TX SPORT turning on (**T0**) is defined as **QB_TX_FENA_2_FSYNC**.The time from TX SPORT turning on (**T1**) to TX DAC disabling is defined as **QB_TX_FSYNC_2_FENA**. The value of this two aliases should be positive or zero. These two values is defined in the register **TDMA_BULCON1**.

BSI part:

BSI data and events need to be set in order to sent serial data to 3-wire devices on RF module. Each TX window is allocated 3 BSI events. Usually 1'st BSI event is used to warm up the set synthesizer and set its N-counter to lock the

operation frequency. The 2'nd BSI is used to set the transmit command and indicate the operation band. The 3'rd BSI is used to command transceiver entering idle mode. BSI events are defined in the registers **TDMA_BSI0~19**.

BPI parts:

The setting of BPI bus includes timing and data setting to specify at what time what BPI states are changed. The BPI data may be varied by operation band, so the BPI data of each band should be defined. The 1'st BPI event is usually used to activate the RF components on RF module in transmit mode. The 2'nd BPI event is usually used to select band and switch R/TX. The 3'rd BPI event is usually used to force the RF module into idle mode. BPI events are defined in the registers **TDMA_BPI0~41**.

APC parts:

In addition to TX DAC, TX SPORT, BSI, BPI unit needs to be set, the control of PA is important for TX window. The PA is control by the APC unit of MT62xx. Before the data transmission, APC ramps up the PA to the indicated power level. Data is transmitted at that level. After finishing transmission, APC ramps down the PA. Before PA ramping up, A DC offset of PA is performed to let PA ramp up smoothly. APC events are defined in the registers **TDMA_APC0~6**.

11.2 Slow Clocking Unit

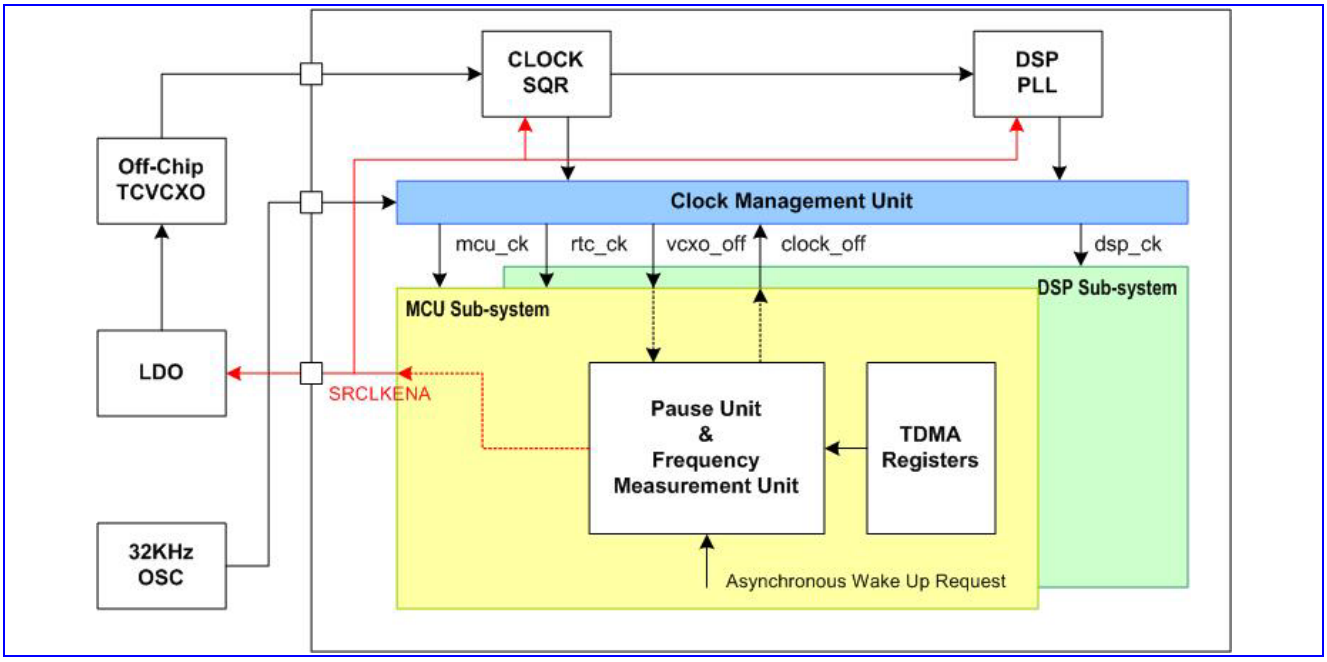


Figure 88 The block diagram of the slow clocking unit

The slow clocking unit is provided to maintain the synchronization to the base-station timing using a 32KHz crystal oscillator while the 13MHz reference clock is switched off. As shown in Figure 88, this unit is composed of frequency measurement unit, pause unit, and clock management unit.

Because of the inaccuracy of the 32KHz oscillator, a frequency measurement unit is provided to calibrate the 32KHz crystal taking the accurate 13MHz source as the reference. The calibration procedure always takes place prior to the pause period.

The pause unit is used to initiate and terminate the pause mode procedure and it also works as a coarse time-base during the pause period.

The clock management unit is used to control the system clock while switching between the normal mode and the pause mode. SRCLKENA is used to turn on/off the clock squarer, DSP PLL and off-chip TCVCXO. CLOCK_OFF signal is used for gating the main MCU and DSP clock, and VCXO_OFF is used as the acknowledgement signal of the CLOCK_OFF request.

11.2.1 Register Definitions

0x82000218 Slow clocking unit control register SM_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name															PAUSE_START	FM_START
Type															W	W
Reset															0	0

FM_START Initiate the frequency measurement procedure
PAUSE_START Initiate the pause mode procedure at the next timer wrap position

0x8200021C Slow clocking unit status register SM_STA

Bit	15	14	13	12	11	10	9	8
Name								PAUSE_ABORT
Type								R
Bit	7	6	5	4	3	2	1	0
Name	SETTLE_CPL	PAUSE_CPL	PAUSE_INT	PAUSE_RQST			FM_CPL	FM_RQST
Type	R	R	R	R			R	R

FM_RQST Frequency measurement procedure is requested
FM_CPL Frequency measurement procedure is completed
PAUSE_RQST Pause mode procedure is requested
PAUSE_INT Asynchronous wake up from pause mode
PAUSE_CPL Pause period is completed
SETTLE_CPL Settling period is completed
PAUSE_ABORT Pause mode is aborted because of the reception of interrupt prior to entering pause mode

0x8200022C Slow clocking unit configuration register SM_CNF

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									TP		MSDC	RTC	EINT	KP	SM	FM
Type									R/W		R/W	R/W	R/W	R/W	R/W	R/W
Reset									0		0	0	0	0	1	1

FM Enable interrupt generation upon completion of frequency measurement procedure
SM Enable interrupt generation upon completion of pause mode procedure
KP Enable asynchronous wake-up from pause mode by key press
EINT Enable asynchronous wake-up from pause mode by external interrupt
RTC Enable asynchronous wake-up from pause mode by real time clock interrupt
MSDC Enable asynchronous wake-up from pause mode by memory card insertion interrupt

TP Enable asynchronous wake-up from pause mode by touch panel press

0x82000238 WAKE_PLL_SETTING (TIME & ENABLE)

WAKE_PLL_SETTING

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EN		TIME													
Type	R/W		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	1		0	0	0	0	0	0	0	0	1	0	0	0	0	0

TIME The time sleep control generates a reset signal for PLL in the clk setting time.

EN Enable the generation of the reset signal

- **0** Disable
- **1** Enable

Address	Type	Width	Reset Value	Name	Description
0x82000200	R/W	[2:0]	—	SM_PAUSE_M	MSB of pause duration
0x82000204	R/W	[15:0]	—	SM_PAUSE_L	16 LSB of pause duration
0x82000208	R/W	[13:0]	—	SM_CLK_SETTLE	Off-chip VCXO settling duration
0x8200020C	R	[2:0]	—	SM_FINAL_PAUSE_M	MSB of final pause count
0x82000210	R	[15:0]	—	SM_FINAL_PAUSE_L	16 LSB of final pause count
0x82000214	R	[13:0]	—	SM_QBIT_START	TQ_ COUNT value at the start of the pause
0x82000218	W	[1:0]	0x0000	SM_CON	SM control register
0x8200021C	R	[7:3,1:0]	0x0000	SM_STA	SM status register
0x82000220	R/W	[15:0]	—	SM_FM_DURATION	32KHz measurement duration
0x82000224	R	[9:0]	—	SM_FM_RESULT_M	10 MSB of frequency measurement result
0x82000228	R	[15:0]	—	SM_FM_RESULT_L	16 LSB of frequency measurement result
0x8200022C	R/W	[4:0]	0x0000	SM_CNF	SM configuration register
0x82000230	R	[23:0]	0x000000	RTCCOUNT	RTC count

0x82000238	R/W	[15:0]	0x8020	WAKE_PLL_SETTING	PLL RST time in the clk settling time.

12 Power, Clocks and Reset

12.1 Clocks

There are two major time bases in the MT6235. For the faster one is the 13 MHz clock originating from an off-chip temperature-compensated voltage controlled oscillator (TCVCXO) that can be either 13MHz or 26MHz. This signal is the input from the SYSCLK pad then is converted to the square-wave signal. The other time base is the 32768 Hz clock generated by an on-chip oscillator connected to an external crystal. **Figure 89** shows the clock sources as well as their utilizations inside the chip.

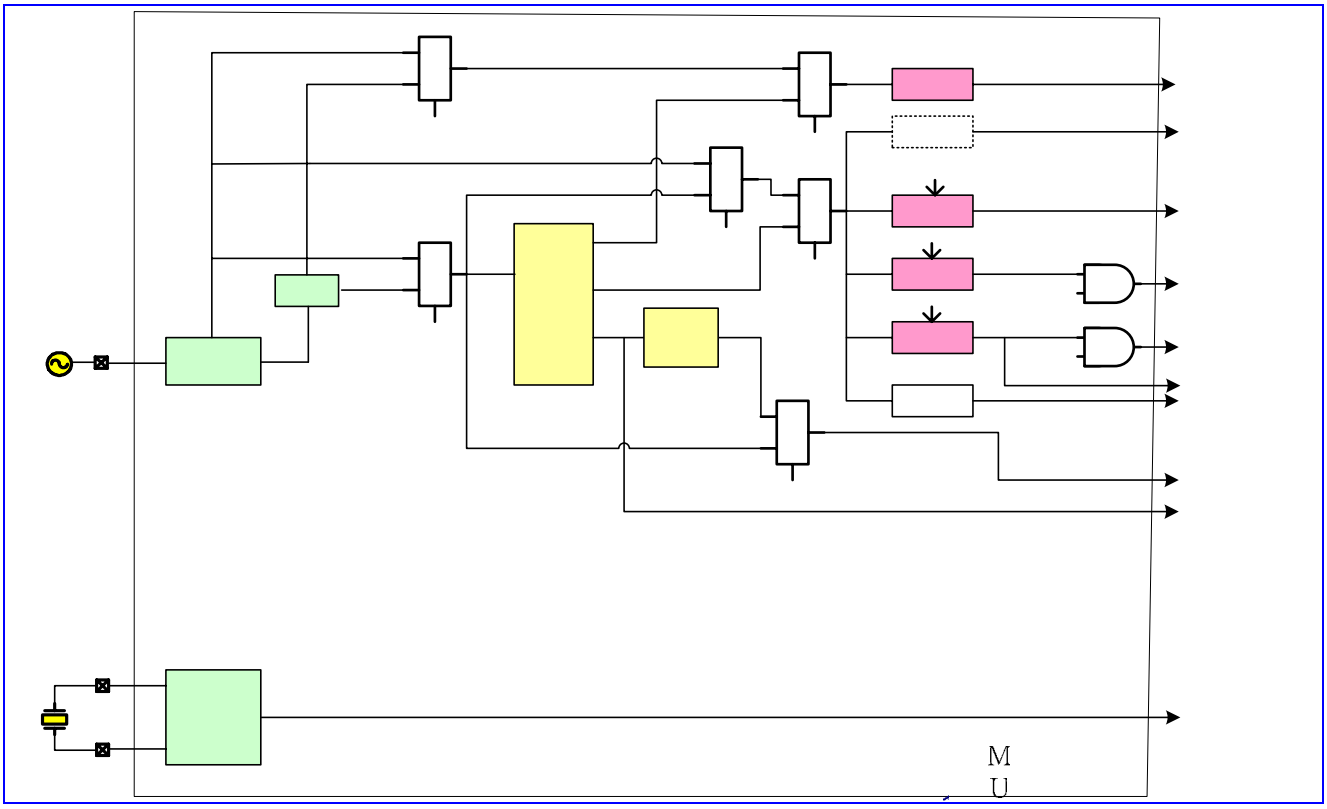


Figure 89 Clock distributions inside the MT6235

12.1.1 32.768 KHz Time Base

CLKSQ_DIV2_DSP

The 32768 Hz clock is always running. It's mainly used as the time base of the Real Time Clock (RTC) module, which maintains time and date with counters. Therefore, both the 32768Hz oscillator and the RTC module is powered by separate voltage supplies that shall not be powered down when the other supplies do.

In low power mode, the 13 MHz time base is turned off, so the 32768 Hz clock shall be employed to update the critical TDMA timer and Watchdog Timer. This time base is also used to clocks the keypad scanner logic.

104Mhz

12.1.2 13 MHz Time Base

M
U
X

13Mhz

208Mhz

One 1/2-dividers for PLL existing to allow using 26 or 13 MHz TCVCXO.

1/2

PLL

SYSCLK

CLKSQ_DIV2_MCU

48Mhz

U

CLKSQ

MediaTek Inc. Confidential

CLKSQ_PLD

One phase-locked loops (PLL) to generate 624Mhz clock output, then a frequency divider futher divide 6, 3, 13 to generate 104Mhz, 208Mhz, 48Mhz for three primary clocks, DSP_CLOCK, MCU_CLOCK and USB_CLOCK, respectively. These three primary clocks then feed to DSP Clock Domain and MCU Clock Domain and USB, respectively. The PLL require no off-chip components for operations and can be turn off in order to save power. After power-on, the PLLs are off by default and the source clock signal is selected through multiplexers. The software shall take cares of the PLL lock time while changing the clock selections. The PLL and usages are listed below.

PLL supplies three clock source

DSP system clock, *DSP_CLOCK*. The outputted 104MHz clock is connected to DSP DCM (dynamic clock manager) for dynamically adjusting clock rate by digital clock divider.

MCU system clock, *MCU_CLOCK*, which paces the operations of the MCU cores, MCU memory system, and MCU peripherals as well. The outputted 208MHz clock is connected to ARM DCM and AHB DCM for dynamically adjusting clock rate by digital clock divider. The usage of DCM is described in MCUCLK_CON registers of CONFIG.

USB system clock, *USB_CLOCK*. The 48MHz is sent to USB module for its operation.

Note that PLL need some time to become stable after being powered up. The software shall take cares of the PLL lock time before switching them to the proper frequency. Usually, a software loop longer than the PLL lock time is employed to deal with the problem.

For power management, the MCU software program may stop MCU Clock by setting the Sleep Control Register. Any interrupt requests to MCU can pause the sleep mode, and thus MCU return to the running mode.

AHB also can be stop by setting the Sleep Control Register. However the behavior of AHB in sleep mode is a little different from that of MCU. After entering Sleep Mode, it can be temporarily waken up by any “hreq” (bus request), and then goes back to sleep automatically after all “hreqs” de-assert. Any transactions can take place as usual in sleep mode, and it can save power while there is no transaction on it. However the penalty is losing a little system efficiency for switching on and off bus clock, but the impact is small.

12.1.3 Dynamic Clock Switch of MCU Clock

Dynamic Clock Manager is implemented to allow MCU and DSP switching clock dynamically without any jitter, and enabling signal drift, and system can operate stably during any clock rate switch.

Please note that PLL must be enabled and the frequency shall be set as 624MHz, therefore the required MCU/DSP/USB clocks can be generated from 624MHz. Before switching to 52MHz clock rate, the clock from the CLKSQ will feed through the dynamic clock manager (DCM) directly. That means if CLKSQ divider is enabled (MPLL_DIV2=1) and PLL clock is bypassed (MPLL_SEL=00), the internal clock rate is the half of SYSCLK. Contrarily, the internal clock rate is identical to SYSCLK.

However, the settings of some hardware modules is required to be changed before or after clock rate change. Software has the responsibility to change them at proper timing. The following table is list of hardware modules needed to be changed their setting during clock rate change.

EMI clock is always fixed at 104Mhz when MCU clock is dynamically changed.

Module Name	Programming Sequence
NAND	1. Low clock speed -> high clock speed

	Changing wait state before clock change. New wait state will not take effect until current EMI access is complete. Software should insert a period of time before switching clock. 2. High clock speed -> low clock speed Changing wait state after clock change.
LCD	Change wait state while LCD in IDLE state.

Table 48 Programming sequence during clock switch

12.1.4 Standard PLL Power-on Sequence

```
// 0x8300001C, Power on DSP_DIV2, MPLL, DPLL, MCU_DIV2, and CLKSQ
*(volatile kal_uint16 *)PDN_CON = 0x0000;

// 0x83000108, Switch to 13MHz input for PLL reference clock
*(volatile kal_uint16 *)CLK_CON = 0x0003;

// After power-on PLL.....

*PLL = 0x0080; // 0x83000000, reset PLL

*PLL = 0x0000; // 0x83000000, reset release, and wait for  PLL output stable

 for (i=0;i<200;i++);

*PLL = 0x0070; // 0x83000000, select PLL output
```

12.1.5 Register Definitions

PLL_CLKSQ+0000h MPLL(DPLL, UPLL) Frequency Register1 **PLL**

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				CALI					RST	UPLL SEL	DPLL SEL	MPLLSEL			PLLVCOSEL	
Type				R/W					R/W	R/W	R/W	R/W			R/W	
Reset				0					0	0	0	0			00	

PLLVCOSEL Selects VCO in PLL frequency for PLL debug purpose. Default value is 0x0.

MPLLSEL Select MCU Clock source. Using this mux to gate out unstable clock output from PLL after system boot up

00 PLL bypassed, using CLK from CLKSQ, default value after chip power up.

01 PLL bypassed, using CLK from SYSCLK

10 Using PLL Clock for MCU

11 Reserved

DPLLSEL Select DSP Clock source. Using this mux to gate out unstable clock output from PLL after system boot up

0 PLL bypassed, using CLK from CLKSQ

1 Using PLL Clock for DSP

UPLLSEL Select USB Clock source. Using this mux to gate out unstable clock output from PLL after system boot up

0 PLL bypassed, using CLK from CLKSQ

1 Using PLL Clock for USB

RST Reset Control of PLL

0 Normal Operation

1 Reset the PLL

CALI Calibration Control for PLL

PLL_CLKSQ +0004h MPLL(DPLL, UPLL) Frequency Register2 PLL2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	PLL_DIVCTRL												PLL_TEST			
Type	R/W												R/W			
Reset	1110												0			

PLL_TEST Entering test mode

PLL_DIVCTRL Just for test purpose. Fine tune the 624MHz main frequency of VCO in PLL

(PLL_DIVCTRL + 2) x 3 x13 = 624

PLL_CLKSQ+0018h Clock Control Register CLK_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	CLKSQ_TEST								SRCCLK					CLKSQ_PLD	CLKSQ_DIV2_MCU	CLKSQ_DIV2_DSP
Type	R/W								R/W					R/W	R/W	R/W
Reset	0								1					0	0	0

CLKSQ_DIV2_DSP Control the clock divider for DSP clock domain

0 Divider bypassed

1 Divider not bypassed

CLKSQ_DIV2_MCU Control the x2 clock divider for MCU clock domain

0 Divider bypassed

1 Divider not bypassed

CLKSQ_PLD Pull Down Control

0 Disable

1 Enables

CLKSQ_TEST CLKSQ test mode

SRCCLK Indicate the frequency of SYSCLK

0 13MHz

1 26MHz

PLL_CLKSQ+001Ch **Power-down control** **PDN_CON**

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DSP_DIV2		PLL	MCU_DIV2	CLKSQ											
Type	R/W		R/W	R/W	R/W											
Reset	1		1	1	0											

CLKSQ Control CLKSQ power-down

MCU_DIV2 Control CLKSQ divide-by-2 power-down for MCU clock

DSP_DIV2 Control CLKSQ divide-by-2 power-down for DSP clock

PLL Control MPLL(including DPLL and UPLL) power-down

12.2 Reset Generation Unit (RGU)

Figure 90 shows the reset scheme used in MT6235. MT6235 provides three kinds of resets: hardware reset, watchdog reset, and software reset.

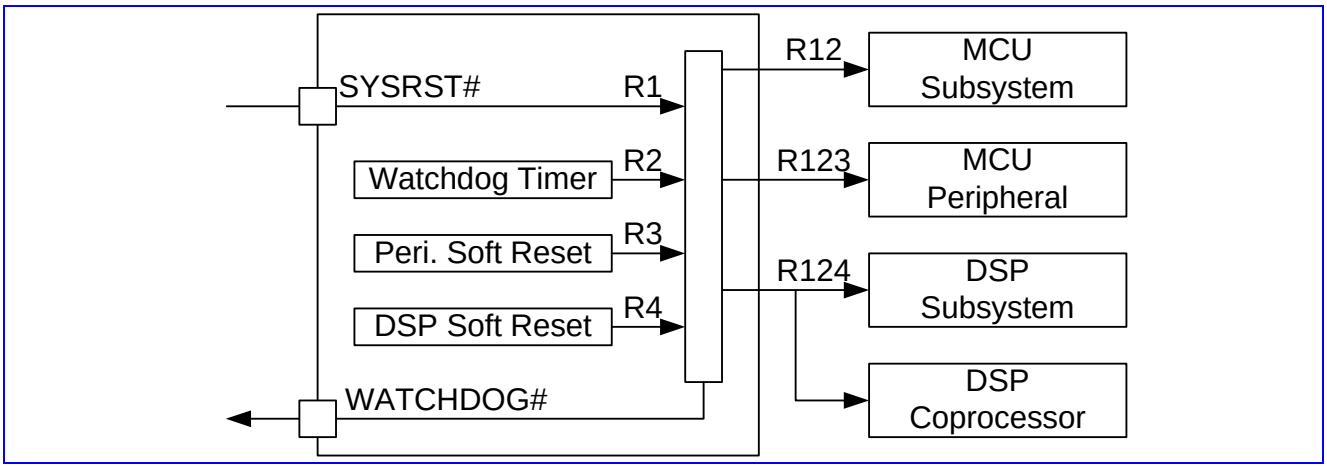


Figure 90 Reset Scheme Used in MT6235

12.2.1 General Description

12.2.1.1 Hardware Reset

This reset is input through the SYSRST# pin, which is driven low during power-on. The hardware reset has a global effect on the chip: all digital and analog circuits are initialized, except the Real Time Clock module. The initial states of the MT6235 sub-blocks are as follows:.

- All analog circuits are turned off.
- All PLLs are turned off and bypassed. The 13 MHz system clock is the default time base.

12.2.1.2 Watchdog Reset

A watchdog reset is generated when the Watchdog Timer expires: the MCU software failed to re-program the timer counter in time. This situation is typically induced by abnormal software execution, which can be aborted by a hardwired watchdog reset. Hardware blocks that are affected by the watchdog reset are:

- MCU subsystem,
- DSP subsystem, and
- External components (trigged by software).

12.2.1.3 Software Resets

Software resets are local reset signals that initialize specific hardware components. For example, if hardware failures are detected, the MCU or DSP software may write to software reset trigger registers to reset those specific hardware modules to their initial states.

The following modules have software resets.

- DSP Core
- DSP Coprocessors

12.2.2 Register Definitions

RGU +0000h Watchdog Timer Control Register WDT_MODE

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	KEY[7:0]											AUTO-RESTART	IRQ	EXTEN	EXTPOL	ENABLE
Type	WO											R/W	R/W	R/W	R/W	R/W
Reset												0	0	0	0	1

ENABLE Enables the Watchdog Timer.
- **0** Disables the Watchdog Timer.
- **1** Enables the Watchdog Timer.

EXTPOL Defines the polarity of the external watchdog pin.
- **0** Active low.
- **1** Active high.

EXTEN Specifies whether or not to generate an external watchdog reset signal.

0 The watchdog does not generate an external watchdog reset signal.

1 If the watchdog counter reaches zero, an external watchdog signal is generated.

IRQ Issues an interrupt instead of a Watchdog Timer reset. For debug purposes, RGU issues an interrupt to the MCU instead of resetting the system.

0 Disable.

1 Enable.

AUTO-RESTART Restarts the Watchdog Timer counter with the value of WDT_LENGTH while task ID is written into Software Debug Unit.

0 Disable. The counter restarts by writing KEY into the WDT_RESTART register.

1 Enable. The counter restarts by writing KEY into the WDT_RESTART register or by writing task ID into the software debug unit.

KEY Write access is allowed if KEY=0x22.

RGU +0004h Watchdog Time-Out Interval Register WDT_LENGTH

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	TIMEOUT[10:0]											KEY[4:0]				
Type	R/W											WO				
Reset	111_1111_1111b															

KEY Write access is allowed if KEY=08h.

TIMEOUT The counter is restarted with {TIMEOUT [10:0], 1_1111_1111b}. Thus the Watchdog Timer time-out period is a multiple of 512*T_{32k}=15.6ms.

RGU +0008h Watchdog Timer Restart Register WDT_RESTART

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	KEY[15:0]															
Type	WO															
Reset																

KEY Restart the counter if KEY=1971h.

RGU +000Ch Watchdog Timer Status Register WDT_STA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	WDT	SW_WDT														
Type	RO	RO														
Reset	0	0														

WDT Indicates the cause of the watchdog reset.

0 Reset not due to Watchdog Timer.

1 Reset because the Watchdog Timer time-out period expired.

SW_WDT Indicates if the watchdog was triggered by software.

0 Reset not due to software-triggered Watchdog Timer.

1 Reset due to software-triggered Watchdog Timer.

NOTE: A system reset does not affect this register. This bit is cleared when the WTU_MODE register ENABLE bit is written.

RGU +0010h CPU Peripheral Software Reset Register — SW_PERIPH_RSTN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name		DMARST							KEY							
Type		R/W							WO							
Reset		0														

KEY Write access is allowed if KEY=37h.

DMARST Reset the DMA peripheral.

0 No reset.

1 Invoke a reset.

RGU +0014h DSP Software Reset Register — SW_DSP_RSTN

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RST															
Type	R/W															
Reset	0															

RST Controls the DSP System Reset Control.

0 No reset.

1 Invoke a reset.

RGU +0018h Watchdog Timer Reset Signal Duration Register — WDT_RSTINTREVAL

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name					LENGTH[11:0]											
Type					R/W											
Reset					FFFh											

LENGTH This register indicates the reset duration when Watchdog Timer times out. However, if the WDT_MODE register IRQ bit is set to 1, an interrupt is issued instead of a reset.

RGU+001Ch Watchdog Timer Software Reset Register — WDT_SWRST

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	KEY[15:0]															
Type	WO															
Reset																

Software-triggered Watchdog Timer reset. If the register content matches the KEY, a watchdog reset is issued. However, if the WDT_MODE register IRQ bit is set to 1, an interrupt is issued instead of a reset.

KEY 1209h

12.3 Global Configuration Registers

12.3.1 Register Definitions

CONFG+0000h Hardware Version Register — HW_VERSION

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EXTP				MAJREV				MINREV				HFIX			
Type	RO				RO				RO				RO			
Reset	8				A				0				0			

This register is useful for software program to determine the hardware version of the chip. It will have a new value whenever each metal fix or major step is performed. All these values are incremented by a step of 1.

HFIX Iteration to fix a hardware bug, in case of some layer mask fixed

MINREV Minor Revision of the chip, in case of all layer masks changed

MAJREV Major Revision of the chip

EXTP This field shows the existence of Hardware Code Register that presents the Hardware ID while the value is other than zero.

CONFG+0004h Firmware Version Register — FW_VERSION

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EXTP				MAJREV				MINREV				FFIX			
Type	RO				RO				RO				RO			
Reset	8				A				0				0			

This register is useful for software program to determine the Firmware ROM version that is included in this chip. All these values are incremented by a step of 1.

FFIX Iteration to fix a firmware bug

MINREV Minor Revision of the firmware

MAJREV Major Revision of the firmware

EXTP This field shows the existence of Hardware Code Register that presents the Hardware ID when the value is other than zero.

CONFG+0008h Hardware Code Register — HW_CODE

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	CODE3				CODE2				CODE1				CODE0			
Type	RO				RO				RO				RO			
Reset	6				2				3				5			

This register presents the Hardware ID.

CONFG+114h Sleep Control Register — SLEEP_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name													DSP2	DSP1	AHB	MCU

Type													WO	WO	WO	RO
Reset													0	0	0	0

MCU Interrupt status. This bit represents if any irq or fiq occurs.

0 There is irq or firq

1 There is no irq and firq

To make MCU clock off, this bit should in 1 state and an instruction should be executed .

MCR p15,0,<Rd>,c7,c0,4

AHB Stops the AHB Bus Clock to force the entire bus to enter sleep mode. AHB clock resumes as long as there is an interrupt request or system is reset.

0 AHB Bus Clock is running

1 AHB Bus Clock is stopped

DSP1 Stops the DSP1 Clock.

0 DSP1 Bus Clock is running

1 DSP1 Bus Clock is stopped

DSP2 Stops the DSP2Clock.

0 DSP2 Bus Clock is running

1 DSP2 Bus Clock is stopped

CODE This version of chip is coded as 6235h.

CONFG+0118h MCU Clock Control Register MCUCLK_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	EMICLK				ARMCLK				AHBX4CLK				AHBX8CLK			
Type	R				R/W				R/W				R/W			
Reset	0111				0111				0011				0111			

The register specifies MCU Subsystem and ARM clock frequency.

ARMCLK is used for ARM926 MCU processor. AHBX8CLK is used for 104Mhz AHB bus system and AHBX4CLK is used for 52Mhz AHB bus system. EMICLK must be 0111 for normal operation and other settings are only used for debug purpose. The clock rate must be ARM CLOCK > AHBX8CLK > AHBX4CLK. The max operation frequency for ARMCLK is 208Mhz (1111), for AHBX8CLK is 104Mhz (0111), for AHBX4CLK is 52Mhz.

MCUCLK_CON control register is only active when internal PLL is enabled. Be sure to turn MCUCLK_CON to its default setting before turn clock source from PLL to clock squarer.

ARMCLK Select the Output Clock Rate for ARM926

0000 13Mhz

0001 13MHz x 2

0010 reserved

0011 13MHz x 4

0100 reserved

0101 reserved

0110 reserved

0111 13MHz x 8

1111 13MHz x 16
OTHERS reserved

AHBX8CLK Select the Clock Rate for 104Mhz Bus clock
0000 13Mhz
0001 13MHz x 2
0010 reserved
0011 13MHz x 4
0100 reserved
0101 reserved
0110 reserved
0111 13MHz x 8
1111 reserved
OTHERS reserved

AHBX4CLK Select the Clock Rate for 52Mhz Bus clock
0000 13Mhz
0001 13MHz x 2
0010 reserved
0011 13MHz x 4
0100 reserved
0101 reserved
0110 reserved
0111 reserved
1111 reserved
OTHERS reserved

CONFG+011Ch DSP Clock Control Register DSPCLK_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									SPDS				SPDM			
Type									R/W				R/W			
Reset									0000				0000			

SPDM, SPDS Select the Output Clock Rate for Master/Slave DSPCLK
0000 power down
0001 13MHz x 2
0010 13MHz x 3
0011 13MHz x 4
0100 13MHz x 5
0101 13MHz x 6
0110 13MHz x 7
0111 13MHz x 8

CONFG+0200h Internal Debug Select Register IDN_SEL

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name	TV_EXTCK	DSP_EXTCK		IRWIN	ROM_WAIT				AHB_SLEEP	RESERVED	TDMA	CLKSQ			MPLL	
Type	R/W	R/W		R/W	R/W				R/W	R/W	R/W	R/W			R/W	
Reset	0	0		0	0				0	0	0	0			0	

TV_EXTCK Use EINT3 as clock source of TV logic instead of internal PLL

DSP_EXTCK Use EINT2 as clock source of DSP logic instead of internal PLL

IRWIN IRDMA has highest priority at DMA AMBA bus

ROM_WAIT Controls the wait cycle of SYSROM when bus is run at 104Mhz

AHB_SLEEP When this bit is 0, then AHB Clock only can stop when the MCU is in idle power down mode

TDMA TDMA Internal Debug Signal

MPLL MCU PLL Internal Debug Signal

CONFG+300h Power Down Control 0 Register PDN_CON0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			IRDBG2	IRDBG1		SIM2		PWM	PWM3	IR		SEJ	WAVETABLE	GCU	USB	DMA
Type			R	R		R		R	R	R		R	R	R	R	R
Reset			1	1		1		1	1	1		1	1	1	1	1

DMA Controls the DMA Controller Power Down

USB Controls the USB Controller Power Down

GCU Controls the GCU Controller Power Down

WAVETALBE Controls the DSP WaveTable DMA Power Down

SEJ Controls the Secure Engine Power Down

IR **Controls the IR (IR DMA) Power Down**

PWM3 Controls the the 3rd PWM Generator Power Down

PWM Controls the Main PWM Generator Power Down. Only set this bit when all PWM are in power down.

SIM2 Controls the second SIM Controller Power Down

IRDBG1 Controls the IRDBG1 Power Down

IRDBG2 Controls the IRDBG2 Power Down

CONFG +304h Power Down Control 1 Register PDN_CON1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRDA	UART3		NFI	PWM2	TP	MSDC	UART2	LCD		PWM1	SIM	UART1	GPIO	KP	GPT
Type	R	R		R	R	R	R	R	R		R	R	R	R	R	R
Reset	1	1		1	1	1	1	1	1		1	1	0	1	1	1

GPT Controls the General Purpose Timer Power Down

KP Controls the Keypad Scanner Power Down

GPIO Controls the GPIO Power Down
UART1 Controls the UART1 Controller Power Down
SIM Controls the SIM Controller Power Down
PWM1 Controls the 1st PWM Generator Power Down
LCD Controls the Serial LCD Controller Power Down
UART2 Controls the UART2 Controller Power Down
MSDC Controls the MS/SD Controller Power Down
TP Controls the Touch Panel Power Down
PWM2 Controls the 2nd PWM Generator Power Down
NFI Controls the NAND FLASH Interface Power Down
UART3 Controls the UART3 Controller Power Down
IRDA Controls the IrDA Framer Power Down

CONFG +308h Power Down Control 2 Register PDN_CON2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GMSK	BBRX	I2C	AAFE	DIV	GCC	BFE	VAFE	AUXAD	FCS	APC	AFC	BPI	BSI	RTC	TDMA
Type	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

TDMA Controls the TDMA Power Down
RTC Controls the RTC Power Down
BSI Controls the BSI Power Down. This control will not be updated until both tdma_evtval and qbit_en are asserted.
BPI Controls the BPI Power Down. This control will not be updated until both tdma_evtval and qbit_en are asserted.
AFC Controls the AFC Power Down. This control will not be updated until both tdma_evtval and qbit_en are asserted.
APC Controls the APC Power Down. This control will not be updated until both tdma_evtval and qbit_en are asserted.
FCS Controls the FCS Power Down
AUXAD Controls the AUX ADC Power Down
VAFE Controls the Audio Front End of VBI Power Down
BFE Controls the Base-Band Front End Power Down
GCU Controls the GCU Power Down
DIV Controls the Divider Power Down
AAFE Controls the Audio Front End of MP3 Power Down
I2C Controls the I2C Power Down
BBRX Controls the BB RX Power Down
GMSK Controls the GMSK Power Down

CONFG +30Ch Power Down Control 3 Register PDN_CON3

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				ISP				G2D	GCMQ					CRZ		
Type				R				R	R					R		
Reset				1				1	1					1		

CRZ Controls CRZ Power Down
GCMQ Controls the Graphic Command Queue Power Down
G2D Controls the 2D Accelerator Power Down
ISP Controls the Image Signal Processor Power Down

CONFG+0310h Power Down Set 0 Register — PDN_SET0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			IRDBG2	IRDBG1		SIM2		PWM	PWM3	IR		SEJ	WAVETABLE	GCU	USB	DMA
Type	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S

CONFG+0314h Power Down Set 1 Register — PDN_SET1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRDA	UART3		NFI	PWM2	TP	MSDC	UART2	LCD	ALTER	PWM1	SIM	UART1	GPIO	KP	GPT
Type	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S

CONFG+0318h Power Down Set 2 Register — PDN_SET2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GMSK	BBRX	I2C	AAFE	DIV	GCC	BFE	VAFE	AUXAD	FCS	APC	AFC	BPI	BSI	RTC	TDMA
Type	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S

CONFG+031Ch Power Down Set 3 Register — PDN_SET3

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				ISP				G2D	GCMQ					CRZ		
Type	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S	W1S		W1S

These registers are used to individually set power down control bit. Only the bits set to 1 are in effect. Setting the bits to 1 also sets the corresponding power down control bits will to 1. Otherwise, the bits keep their original value. However, the control bits APC, AFC, BPI and BSI in PDN_SET2 register will NOT be updated until both *tdma_evtval* and *qbit_en* are asserted.

EACH BIT Set the Associated Power Down Control Bit to 1.

0 no effect

1 Set corresponding bit to 1

CONFG+0320h Power Down Clear 0 Register — PDN_CLR0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			IRDBG2	IRDBG1		SIM2		PWM	PWM3	IR		SEJ	WAVETABLE	GCU	USB	DMA
Type	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C

CONFG+0324h Power Down Clear 1 Register — PDN_CLR1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	IRDA	UART3		NFI	PWM2	TP	MSDC	UART2	LCD	ALTER	PWM1	SIM	UART1	GPIO	KP	GPT
Type	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C

CONFG+0328h Power Down Clear 2 Register — PDN_CLR2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name	GMSK	BBRX	I2C	AAFE	DIV	GCC	BFE	VAFE	AUXAD	FCS	APC	AFC	BPI	BSI	RTC	TDMA
Type	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C

CONFG+032Ch Power Down Clear 3 Register PDN_CLR3

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				ISP				G2D	GCMQ					CRZ		
Type	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C		W1C

These registers are used to individually clear power down control bit. Only the bits set to 1 are in effect. Setting the bits to 1 also sets the corresponding power down control bits to 0. Otherwise, the bits keep their original value. However, the control bits APC, AFC, BPI and BSI in PDN_SET2 register will NOT be updated until both *tdma_evtval* and *qbit_en* are asserted.

EACH BIT Clear the Associated Power Down Control Bit.

0 no effect

1 Set corresponding bit to 0

CONFG +330h Power Down Control 4 Register PDN_CON4

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											APC	AFC	BPI	BSI		
Type											WO	WO	WO	WO		
Reset											1	1	1	1		

BSI Controls the BSI Power Down. This control will be updated immediately.

BPI Controls the BPI Power Down. This control will be updated immediately.

AFC Controls the AFC Power Down. This control will be updated immediately.

APC Controls the APC Power Down. This control will be updated immediately.

CONFG+334 Power Down Set 4 Register PDN_SET4

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											APC	AFC	BPI	BSI		
Type											W1S	W1S	W1S	W1S		
Reset											1	1	1	1		

EACH BIT Set the Associated Power Down Control Bit to 1. This control will be updated immediately

0 no effect

1 Set corresponding bit to 1

CONFG+338 Power Down Clear 4 Register PDN_CLR4

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											APC	AFC	BPI	BSI		
Type											W1C	W1C	W1C	W1C		
Reset											1	1	1	1		

EACH BIT Clear the Associated Power Down Control Bit to 1. This control will be updated immediately

0 no effect

1 Set corresponding bit to 0

CONFG+0404h APB Bus Control Register APB_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				APBW4	APBW3	APBW2	APBW1	APBW0				APBR4	APBR3	APBR2	APBR1	APBR0
Type				R/W	R/W	R/W	R/W	R/W				R/W	R/W	R/W	R/W	R/W
Reset				0	0	0	0	0				1	1	1	1	1

This register is used to control the timing of Read Cycle and Write Cycle on APB Bus. **Note that APB Bridge 2 is different from other bridges. The access time is varied, and access is not completed until acknowledge signal from APB slave is asserted and must be configured as 2-Cycle Read/Write Access.**

APBR0-APBR4 Read Access Time on APB Bus

- **0** 1-Cycle Access
- **1** 2-Cycle Access

APBW0-APBW4 Write Access Time on APB Bus

- **0** 1-Cycle Access
- **1** 2-Cycle Access

CONFG+0408h Slow Down Control Register SLOWDN_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name																DIS
Type																R/W
Reset																0

DIS Slow Down Disable Control

- **0** Others
- **1** Disable all slow down functionality.

CONFG+040Ch IRDMA CON IRDMA_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	WAVETABLE_SD								IRDMA_SD							
Type																
Reset																

IRDMA_SD IRDMA Slow Down Limit Count

WAVETABLE_SD Wavetable Slow Down Limit Count

CONFG+0700h Analog Chip Interface Control Register 0 ACIF_CON0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	NLI_OD			NAND_OD					LCD_OD				CMPCLK_SMT	CMMCLK_OD		
Type	R/W			R/W					R/W				RW	R/W		
Reset	000			000					000				0	000		

The register specifies IO driving capability of external interface.

CONFG+0704h Analog Chip Interface Control Register 1 ACIF_CON1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	UR2_OD				UR1_OD				SDA_OD				SCL_OD			
Type	R/W				R/W				R/W				R/W			
Reset	000				000				000				000			

The register specifies IO driving capability of external interface.

UR2_OD UART2 output driving control
UR1_OD UART1 output driving control
SDA1_OD PAD SDA output driving control
SCL_OD PAD SCL output driving control

CONFG+0708h Analog Chip Interface Control Register 2 ACIF_CON2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	CMVREF_PD_B	CMHREF_PD_B	CMPCLK_PD_B	CMDAT_PU_B	EWAIT_PD_B	MFIQ_PU_B	PWM2_OD	PWM3_OD				ED_CLK_BDIS	EADMUX_OD			
Type	R/W	R/W	R/W	R/W	R/W	R/W						R/W	R/W			
Reset	0	0	0	0	0	0						0	0000			

CMVREF_PD_B Pull down enable of CMVREF (0: enable, 1: disable)
CMHREF_PD_B Pull down enable of CMHREF(0: enable, 1: disable)
CMPCLK_PD_B Pull down enable of CMPCLK(0: enable, 1: disable)
CMDAT_PU_B Pull down enable of CMDAT[9:0] (0: enable, 1: disable)
EADMUX_OD Pad EADMUX output driving control
ED_CLK_B DIS ED_CLK_B output enable control (0: enable output 1:disable output)

The following 28 registers specify the setting of the sense amplifier delay for MediaTek in-house made ROM and RAM macros.

CONFG+0900h MCU ROM Setting Control Register 0 ROM_DELSEL0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	MDSP_MCN0								MCUROM							
Type	R/W								R/W							
Reset	00001100								00001100							

CONFG+0904h ROM Setting Control Register 1 ROM_DELSEL1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	MDSP_MPN0								MDSP_MCN1							
Type	R/W								R/W							
Reset	00000011								00001100							

CONFG+0908h ROM Setting Control Register 2

ROM_DELSEL 2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SDSP_SDC20								SDSP_SC21							
Type	R/W								R/W							
Reset	00001100								00001100							

CONFG+090Ch ROM Setting Control Register 3

ROM_DELSEL 3

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SDSP_SC10								SDSP_SC11							
Type	R/W								R/W							
Reset	00001100								00001100							

CONFG+0910h ROM Setting Control Register 4

ROM_DELSEL 4

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SDSP_SC00								SDSP_SC01							
Type	R/W								R/W							
Reset	00001100								00001100							

CONFG+0914h ROM Setting Control Register 5

ROM_DELSEL 5

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SDSP_SC51								SDSP_SC60							
Type	R/W								R/W							
Reset	00001100								00001100							

CONFG+0918h ROM Setting Control Register 6

ROM_DELSEL 6

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SDSP_SC31								SDSP_SC50							
Type	R/W								R/W							
Reset	00001100								00001100							

CONFG+091Ch ROM Setting Control Register 7

ROM_DELSEL 7

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SDSP_SP10								SDSP_SC30							
Type	R/W								R/W							
Reset	00001100								00001100							

CONFG+0920h ROM Setting Control Register 8

ROM_DELSEL8

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SDSP_SP31								SDSP_SP00							
Type	R/W								R/W							
Reset	00000011								00000011							

CONFG+0924h ROM Setting Control Register 9

ROM_DELSEL9

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SDSP_SP50								SDSP_SP40							
Type	R/W								R/W							
Reset	00001100								00001100							

CONFG+0A00h MCU RAM Setting Control Register 0

RAM_DELSEL0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	MDSP_MPN1				MDSP_MCN2				MDSP_MD00				L2CACHE			
Type	R/W				R/W				R/W				R/W			
Reset	0001				0001				0001				0101			

CONFG+0A04h RAM Setting Control Register 1

RAM_DELSEL1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SDSP_SP30				SDSP_SC40				MDSP_MD02				MDSP_MD01			
Type	R/W				R/W				R/W				R/W			
Reset	0101				0011				0101				0001			

CONFG+0A08h RAM Setting Control Register 2

RAM_DELSEL2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SDSP_SD10				SDSP_SD20				SDSP_SD11				SDSP_SPN1			
Type	R/W				R/W				R/W				R/W			
Reset	0001				0101				0001				0001			

CONFG+0A0Ch RAM Setting Control Register 3

RAM_DELSEL3

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	SDSP_SD12				SDSP_SD30				SDSP_SD01				SDSP_SDN3			
Type	R/W				R/W				R/W				R/W			
Reset	0001				0101				0001				0001			

CONFG+0A10h RAM Setting Control Register 4

RAM_DELSEL4

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name	BSI_RAM	SHARE_RAM2	SHARE_RAM1	VTB_MEM
Type	R/W	R/W	R/W	R/W
Reset	0001	0001	0001	0001

CONFG+0A14h RAM Setting Control Register 5

RAM_DELSEL5

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ISP_AWB		ISP_SHAD		RESZ_LB_RAM				IMG_RAM		PRF_RAM		EQ_RAM		AFE_RAM	
Type	R/W		R/W		R/W				R/W		R/W		R/W		R/W	
Reset	01		01		0001				01		01		01		01	

CONFG+0A18h RAM Setting Control Register 6

RAM_DELSEL6

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	LCD_RAM				TVC_RAM				ISP_COLOR							
Type	R/W				R/W				R/W							
Reset	0001				0001				00010101							

CONFG+0A1Ch RAM Setting Control Register 7

RAM_DELSEL7

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ISP_DM0[7:4]				ISP_DM[3:0]				USB RAM				GMC_RAM			
Type	R/W				R/W				R/W				R/W			
Reset	0001				0001				0001				0001			

CONFG+0A20h RAM Setting Control Register 8

RAM_DELSEL8

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ISP_DM0[23:20]				ISP_DM0[19:16]				ISP_DM0[15:12]				ISP_DM0[11:8]			
Type	R/W				R/W				R/W				R/W			
Reset	0001				0001				0001				0001			

CONFG+0A24h RAM Setting Control Register 9

RAM_DELSEL9

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ISP_DM1[15:0]															
Type	R/W				R/W				R/W				R/W			
Reset	0001				0001				0001				0001			

CONFG+0A28h RAM Setting Control Register10

RAM_DELSEL10

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ISP_NR11[15:0]															
Type	R/W				R/W				R/W				R/W			
Reset	0001				0001				0001				0001			

CONFG+0A2Ch RAM Setting Control Register 11

RAM_DELSEL11

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ARM_M32[3:0]				ARM_M31[3:2]		ISP_AWBSB		ISP_AWBSG		ISP_AWBSR		ISP_AEHI		ISP_3A	
Type	R/W				R/W		R/W		R/W		R/W		R/W		R/W	
Reset	0001				00		01		01		01		01		01	

CONFG+0A30 RAM Setting Control Register12

RAM_DELSEL12

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ARM_M6		ARM_M5				ARM_M4		ARM_M3		ARM_M2		ARM_M1		ARM_M0	
Type	R/W		R/W				R/W		R/W		R/W		R/W		R/W	
Reset	01		0001				01		01		01		01		01	

CONFG+0A34 RAM Setting Control Register13

RAM_DELSEL13

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ARM_M10		ARM_M9				ARM_M8				ARM_M7				ARM_M6	
Type	R/W		R/W				R/W				R/W				R/W	
Reset	01		0001				0001				0001				00	

CONFG+0A38 RAM Setting Control Register14

RAM_DELSEL14

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ARM_M15		ARM_M14		ARM_M13		ARM_M12				ARM_M11				ARM_M10	
Type	R/W		R/W		R/W		R/W				R/W				R/W	
Reset	01		01		01		0001				0001				00	

CONFG+0A3C RAM Setting Control Register15

RAM_DELSEL15

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ARM_M23		ARM_M22		ARM_M21		ARM_M20		ARM_M19		ARM_M18		ARM_M17		ARM_M16	
Type	R/W		R/W		R/W		R/W		R/W		R/W		R/W		R/W	
Reset	01		01		01		01		01		01		01		01	

CONFG+0A40 RAM Setting Control Register16

RAM_DELSEL16

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ARM_M27		ARM_M26				ARM_M25				ARM_M24				ARM_M23	
Type	R/W		R/W				R/W				R/W				R/W	
Reset	01		0001				0001				0001				00	

CONFG+0A44 RAM Setting Control Register17

RAM_DELSEL17

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	ARM_M31[1:0]		ARM_M30				ARM_M29				ARM_M28				ARM_M27	
Type	R/W		R/W				R/W				R/W				R/W	

Reset	01	0001	0001	0001	00

13 Analog Front-end & Analog Blocks

13.1 General Description

To communicate with analog blocks, a common control interface for all analog blocks is implemented. In addition, there are some dedicated interfaces for data transfer. The common control interface translates APB bus write and read cycle for specific addresses related to analog front-end control. During writing or reading of any of these control registers, there is a latency associated with transferring of data to or from the analog front-end. Dedicated data interface of each analog block is implemented in the corresponding digital block. The Analog Blocks includes the following analog function for complete GSM/GPRS base-band signal processing:

1. *Base-band RX*: For I/Q channels base-band A/D conversion
2. *Base-band TX*: For I/Q channels base-band D/A conversion and smoothing filtering, DC level shifting
3. *RF Control*: Two DACs for automatic power control (APC) and automatic frequency control (AFC) are included. Their outputs are provided to external RF power amplifier and VCXO), respectively.
4. *Auxiliary ADC*: Providing an ADC for battery and other auxiliary analog function monitoring
5. *Audio mixed-signal blocks:* It provides complete analog voice signal processing including microphone amplification, A/D conversion, D/A conversion, earphone driver, and etc. Besides, dedicated stereo D/A conversion and amplification for audio signals are included).
6. *Clock Generation*: A clock squarer for shaping system clock, and three PLLs that provide clock signals to DSP, MCU, and USB units are included
7. *XOSC32*: It is a 32-KHz crystal oscillator circuit for RTC application Analog Block Descriptions

13.1.1 BBRX

13.1.1.1 Block Descriptions

The receiver (RX) performs base-band I/Q channels downlink analog-to-digital conversion:

1. *Analog input multiplexer:* For each channel, a 4-input multiplexer that supports offset and gain calibration is included.
2. *A/D converter:* Two 14-bit sigma-delta ADCs perform I/Q digitization for further digital signal processing.

13.1.1.2 Functional Specifications

The functional specifications of the base-band downlink receiver are listed in the following table.

Symbol	Parameter	Min	Typical	Max	Unit

N	Resolution		14		Bit
FC	Clock Rate		26		MHz
FS	Output Sampling Rate		13/12		MSPS
	Input Swing When GAIN='0' When GAIN='1'		 0.8*AVDD 0.4*AVDD		 Vpk Vpk
OE	Offset Error		+/- 10		mV
FSE	Full Swing Error		+/- 30		mV
	I/Q Gain Mismatch			0.5	dB
SINAD	Signal to Noise and Distortion Ratio - 45kHz sine wave in [0:90] kHz bandwidth - 145kHz sine wave in [10:190] kHz bandwidth	 65 65			 dB dB
ICN	Idle channel noise - [0:90] kHz bandwidth - [10:190] kHz bandwidth			 -74 -70	 dB dB
DR	Dynamic Range - [0:90] kHz bandwidth - [10:190] kHz bandwidth	 74 70			 dB dB
RIN	Input Resistance	75			kΩ
DVDD	Digital Power Supply	1.1	1.2	1.3	V
AVDD	Analog Power Supply	2.5	2.8	3.1	V
T	Operating Temperature	-20		80	℃
	Current Consumption Power-up Power-Down		 5 5		 mA μA

Table 49 Base-band Downlink Specifications

13.1.2 BBTX

13.1.2.1 Block Descriptions

The transmitter (TX) performs base-band I/Q channels up-link digital-to-analog conversion. Each channel includes:

1. *10-Bits D/A Converter:* It converts digital GMSK modulated signals to analog domain. The input to the DAC is sampled at 4.33-MHz rate with 10-bits resolution.
2. *Smoothing Filter:* The low-pass filter performs smoothing function for DAC output signals with a 350-kHz 2^{nd}-order Butterworth frequency response.

13.1.2.2 Function Specifications

The functional specifications of the base-band uplink transmitter are listed in the following table.

Symbol	Parameter	Min	Typical	Max	Unit
N	Resolution		10		Bit
FS	Sampling Rate		4.33		MSPS
SINAD	Signal to Noise and Distortion Ratio	57	60		dB
	Output Swing	0.18*AVDD		0.89*AVDD	V
VOCM	Output CM Voltage	0.34*AVDD	0.5*AVDD	0.62*AVDD	V
	Output Capacitance			20	PF
	Output Resistance	10			KΩ
DNL	Differential Nonlinearity		+/- 0.5		LSB
INL	Integral Nonlinearity		+/- 1.0		LSB
OE	Offset Error		+/- 15		mV
FSE	Full Swing Error		+/- 30		mV
FCUT	Filter –3dB Cutoff Frequency	300	350	400	KHz
ATT	Filter Attenuation at 100-KHz 270-KHz 4.33-MHz	 0.01 1.81 69.4	 0.0 0.85 65.7	 0.0 0.39 61.9	 dB dB dB
	I/Q Gain Mismatch		+/- 0.5		dB
	I/Q Gain Mismatch Correction Range	-0.96		+0.84	dB
DVDD	Digital Power Supply	1.1	1.2	1.3	V
AVDD	Analog Power Supply	2.5	2.8	3.1	V
T	Operating Temperature	-20		80	℃
	Current Consumption Power-up Power-Down		 5 5		 mA μA

Table 50 Base-band Uplink Transmitter Specifications

13.1.3 AFC-DAC

13.1.3.1 Block Descriptions

As shown in the following figure, together with a 2nd-oder digital sigma-delta modulator, AFC-DAC is designed to produce a single-ended output signal at AFC pin. AFC pin should be connected to an external 1st-order R-C low pass filter to meet the 13-bits resolution (DNL) requirement[1].

[1] DNL performance depends on external output RC filter bandwidth: the narrower the bandwidth, the better the DNL. Thus, there exists a tradeoff between output setting speed and DNL performance

The AFC_BYP pin is the mid-tap of a resistor divider inside the chip to offer the AFC output common-mode level. Nominal value of this common-mode voltage is half the analog power supply, and typical value of output impedance of AFC_BYP pin is about 21kΩ. To suppress the noise on common mode level, it is suggested to add an external capacitance between AFC_BYP pin and ground. The value of the bypass capacitor should be chosen as large as possible but still meet the settling time requirement set by overall AFC algorithm[2].

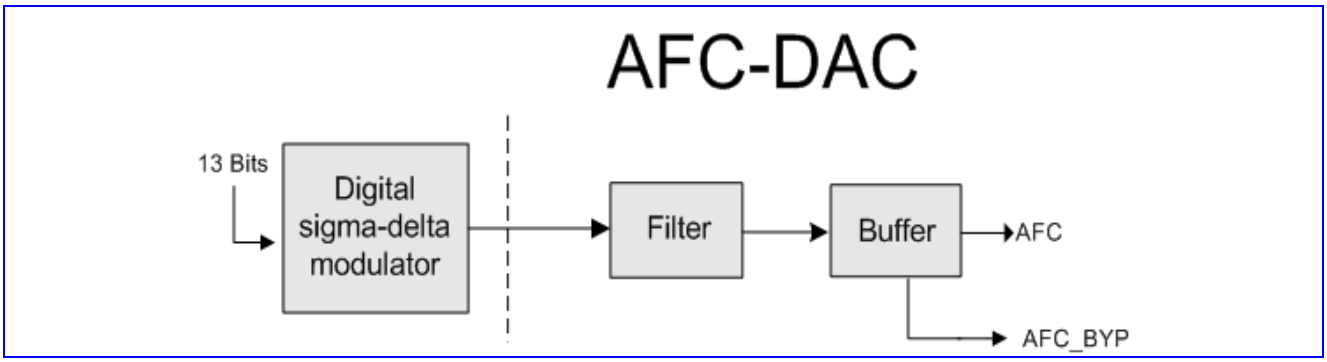


Figure 91 Block diagram of AFC-DAC

13.1.3.2 Functional Specifications

The following table gives the electrical specification of AFC-DAC.

Symbol	Parameter	Min	Typical	Max	Unit
N	Resolution		13		Bit
FS	Sampling Rate		1083.3		KHz
DVDD	Digital Power Supply	1.08	1.2	1.32	V
AVDD	Analog Power Supply	2.6	2.8	3.1	V
T	Operating Temperature	-20		80	℃
	Current Consumption Power-up Power-Down		 0.3	 1	 mA μA
	Output Swing @GAINSEL=0 Output Swing @GAINSEL=1		0.75*AVDD AVDD		V
	Output Resistor (in AFC output RC network)	1			KΩ
DNL	Differential Nonlinearity		+1/-1		LSB
INL	Integral Nonlinearity		+4.0/-4.0		LSB

Table 51 Functional specification of AFC-DAC

[2] AFC_BYP output impedance and bypass capacitance determine the common-mode settling RC time constant. Insufficient common-mode settling will affect the INL performance. A typical value of 1nF is suggested.

13.1.4 APC-DAC

13.1.4.1 Block Descriptions

The APC-DAC is a 10-bits DAC with output buffer aimed for automatic power control. Here blow are its analog pin assignment and functional specification tables.

13.1.4.2 Function Specifications

Symbol	Parameter	Min	Typical	Max	Unit
N	Resolution		10		Bit
FS	Sampling Rate			1.0833	MSPS
SINAD	Signal to Noise and Distortion Ratio (10-KHz Sine with 1.0V Swing & 100-KHz BW)		50		dB
	99% Settling Time (Full Swing on Maximal Capacitance)			5	µS
	Output Swing			AVDD-0.2	V
	Output Capacitance			200	pF
	Output Resistance	10			KΩ
DNL	Differential Nonlinearity		+/- 0.5		LSB
INL	Integral Nonlinearity		+/- 1.0		LSB
OE	Offset Error		+/- 10		mV
FSE	Full Swing Error		+/- 10		mV
DVDD	Digital Power Supply	1.1	1.2	1.3	V
AVDD	Analog Power Supply	2.5	2.8	3.1	V
T	Operating Temperature	-20		80	℃
	Current Consumption Power-up Power-Down		 400 1		 µA µA

Table 52 APC-DAC Specifications

13.1.5 Auxiliary ADC

13.1.5.1 Block Descriptions

The auxiliary ADC includes the following functional blocks:

1. *Analog Multiplexer:* The analog multiplexer selects signal from one of the seven auxiliary input pins. Real word message to be monitored, like temperature, should be transferred to the voltage domain.
2. *10 bits A/D Converter:* The ADC converts the multiplexed input signal to 10-bit digital data.

13.1.5.2 Function Specifications

The functional specifications of the auxiliary ADC are listed in the following table.

Symbol	Parameter	Min	Typical	Max	Unit

N	Resolution		10		Bit
FC	Clock Rate	0.1	1.0833	5	MHz
FS	Sampling Rate @ N-Bit			5/(N+1)	MSPS
	Input Swing	1.0		AVDD	V
VREFP	Positive Reference Voltage (Defined by AUX_REF pin)	1.0		AVDD	V
CIN	Input Capacitance Unselected Channel Selected Channel			 50 1.2	 fF pF
RIN	Input Resistance Unselected Channel Selected Channel	 10 1.8			 MΩ MΩ
RS	Resistor String Between AUX_REF pin & ground Power Up Power Down	 35 10	50	65	 KΩ MΩ
	Clock Latency		11		1/FC
DNL	Differential Nonlinearity		+0.5/-0.5		LSB
INL	Integral Nonlinearity		+1.0/-1.0		LSB
OE	Offset Error		+/- 10		mV
FSE	Full Swing Error		+/- 10		mV
SINAD	Signal to Noise and Distortion Ratio (10-KHz Full Swing Input & 13-MHz Clock Rate)		50		dB
DVDD	Digital Power Supply	1.1	1.2	1.3	V
AVDD	Analog Power Supply	2.5	2.8	3.1	V
T	Operating Temperature	-20		80	℃
	Current Consumption Power-up Power-Down		 150 1		 μA μA

Table 53 The Functional specification of Auxiliary ADC

13.1.6 Audio mixed-signal blocks

13.1.6.1 Block Descriptions

Audio mixed-signal blocks (AMB) integrate complete voice uplink/downlink and audio playback functions. As shown in the following figure, it includes mainly three parts. The first consists of stereo audio DACs and speaker amplifiers for audio playback. The second is the voice downlink path, including voice-band DACs and amplifiers, which produces voice signal to earphone or other auxiliary output device. Amplifiers in these two blocks are equipped with multiplexers to accept signals from internal audio/voice or external radio sources. The last is the voice uplink path, which

is the interface between microphone (or other auxiliary input device) input and MT6235 DSP. A set of bias voltage is provided for external electret microphone..

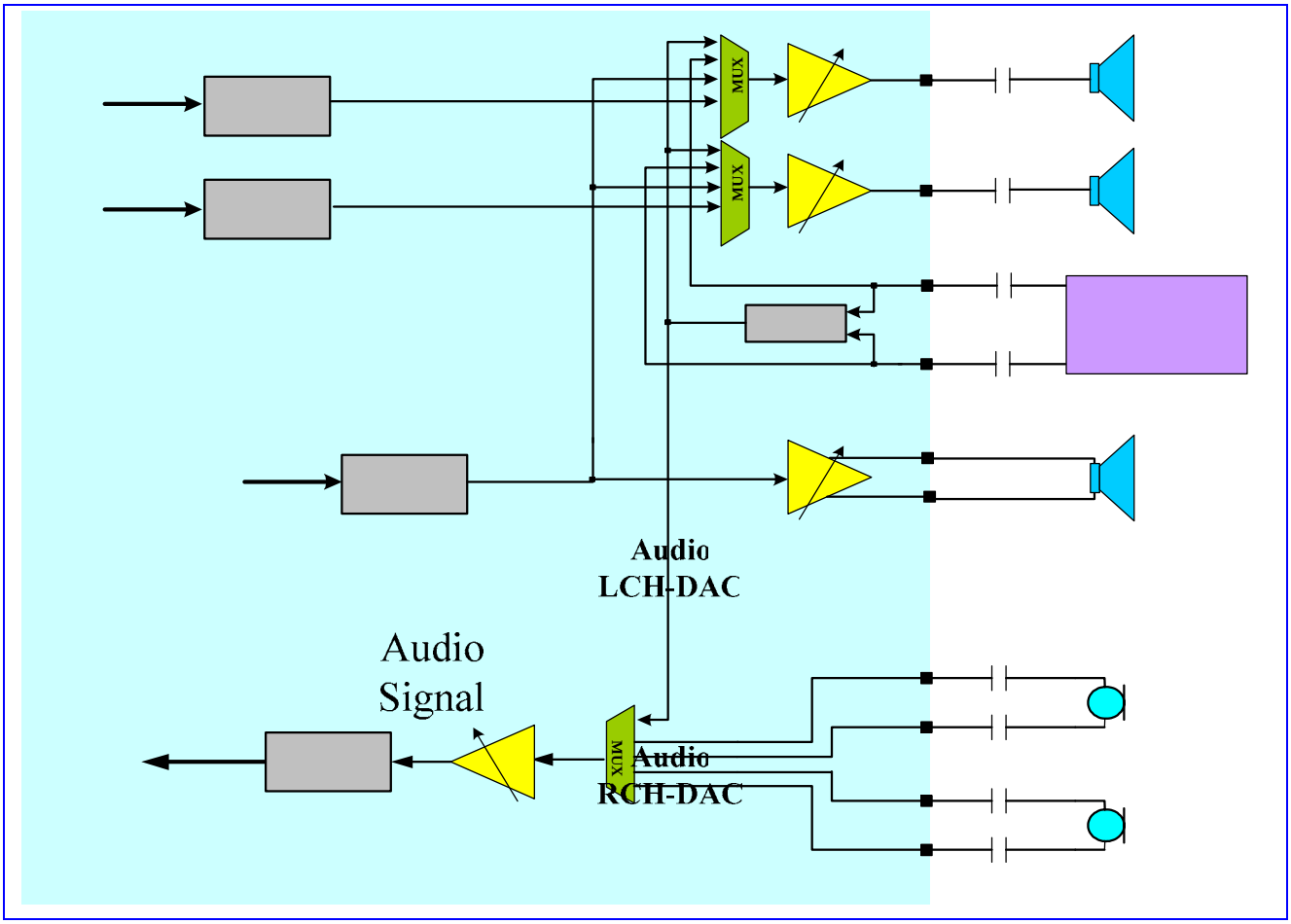


Figure 92 Block diagram of audio mixed-signal blocks.

13.1.6.2 Functional Specifications

The following table gives functional specifications of voice-band uplink/downlink blocks.

Symbol	Parameter	Min	Typical	Max	Unit
FS	Sampling Rate		6500		KHz
CREF	Decoupling Cap Between AU_VREF_P And AU_VREF_N		47		NF
DVDD	Digital Power Supply		1.2	1.32	V
AVDD	Analog Power Supply	2.5	2.8	3.1	V
T	Operating Temperature	-20		80	℃
IDC	Current Consumption		5		mA
VMIC	Microphone Biasing Voltage		1.9		V
IMIC	Current Draw From Microphone Bias			2	mA

Voice
Signal
Voice DAC
Voice
PGA

	Pins				
Uplink Path[3]					
SINAD	Signal to Noise and Distortion Ratio Input Level: -40 dbm0 Input Level: 0 dbm0	29	 69		 dB dB
RIN	Input Impedance (Differential)	13	20	27	KΩ
ICN	Idle Channel Noise			-67	dBm0
XT	Crosstalk Level			-66	dBm0
Downlink Path[4]					
SINAD	Signal to Noise and Distortion Ratio Input Level: -40 dBm0 Input Level: 0 dBm0	29	 69		 dB dB
RLOAD	Output Resistor Load (Differential)	28			Ω
CLOAD	Output Capacitor Load			200	pF
ICN	Idle Channel Noise of Transmit Path			-67	dBm0
XT	Crosstalk Level on Transmit Path			-66	dBm0

Table 54 Functional specifications of analog voice blocks

Functional specifications of the audio blocks are described in the following.

Symbol	Parameter	Min	Typical	Max	Unit
FCK	Clock Frequency		6.5		MHz
Fs	Sampling Rate	32	44.1	48	KHz
AVDD	Power Supply	2.6	2.8	3.1	V
T	Operating Temperature	-20		80	℃
IDC	Current Consumption		5		mA
PSNR	Peak Signal to Noise Ratio		80		dB
DR	Dynamic Range		80		dB
VOUT	Output Swing for 0dBFS Input Level		0.85		Vrms
THD	Total Harmonic Distortion 45mW at 16 Ω Load			-40	 dB dB

[3] For uplink-path, not all gain setting of VUPG meets the specification listed on table, especially for the several highest gains. The maximum gain that meets the specification is to be determined.

[4] For downlink-path, not all gain setting of VDPG meets the specification listed on table, especially for the several lowest gains. The minimum gain that meets the specification is to be determined.

	22mW at 32 Ω Load			-60	
RLOAD	Output Resistor Load (Single-Ended)	16			Ω
CLOAD	Output Capacitor Load			200	pF
XT	L-R Channel Cross Talk			TBD	dB

Table 55 Functional specifications of the analog audio blocks

13.1.7 Clock Squarer

13.1.7.1 Block Descriptions

For most VCXO, the output clock waveform is sinusoidal with too small amplitude (about several hundred mV) to make MT6235 digital circuits function well. Clock squarer is designed to convert such a small signal to a rail-to-rail clock signal with excellent duty-cycle. It provides also a pull-down function when the circuit is powered-down.

13.1.7.2 Function Specifications

The functional specification of clock squarer is shown in Table 56.

Symbol	Parameter	Min	Typical	Max	Unit
Fin	Input Clock Frequency		13		MHz
Fout	Output Clock Frequency		13		MHz
Vin	Input Signal Amplitude		500	AVDD	mVpp
DcycIN	Input Signal Duty Cycle		50		%
DcycOUT	Output Signal Duty Cycle	DcycIN-5		DcycIN+5	%
TR	Rise Time on Pin CLKSQOUT			5	ns/pF
TF	Fall Time on Pin CLKSQOUT			5	ns/pF
DVDD	Digital Power Supply	1.08	1.2	1.32	V
AVDD	Analog Power Supply	2.6	2.8	3.0	V
T	Operating Temperature	-20		80	℃
	Current Consumption		TBD		MA

Table 56 The Functional Specification of Clock Squarer

13.1.7.3 Application Notes

Here below in the figure is an equivalent circuit of the clock squarer. Please be noted that the clock squarer is designed to accept a sinusoidal input signal. If the input signal is not sinusoidal, its harmonic distortion should be low enough to not produce a wrong clock output. As an reference, for a 13MHz sinusoidal signal input with amplitude of 0.2V the harmonic distortion should be smaller than 0.02V.

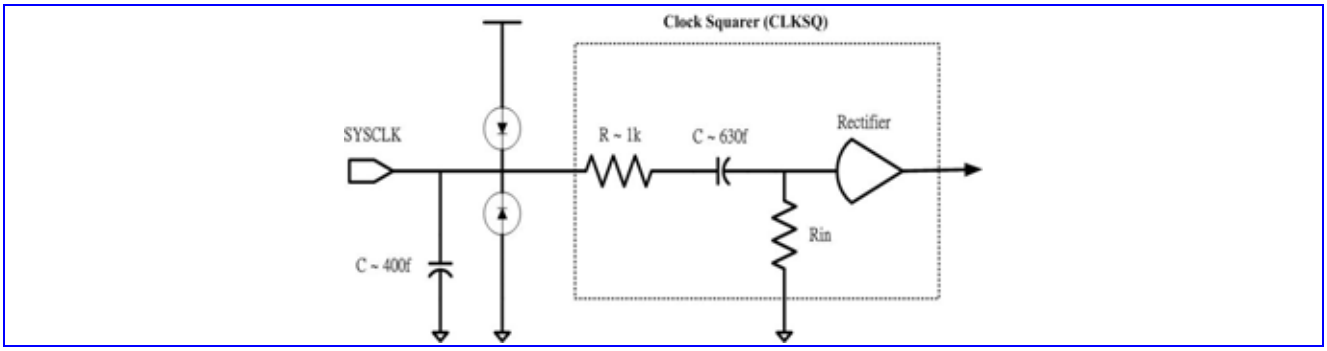


Figure 93 Equivalent circuit of Clock Squarer.

13.1.8 Phase Locked Loop

13.1.8.1 Block Descriptions

MT6235 includes three PLLs: DSP PLL, MCU PLL, and USB PLL. DSP PLL and MCU PLL are identical and programmable to provide 104MHz and 208 MHz output clock while accepts 13MHz signal. USB PLL is designed to also accept 13MHz input clock signal and provides 48MHz output clock.

13.1.8.2 Function Specifications

The functional specification of DSP/MCU PLL is shown in the following table.

Symbol	Parameter	Min	Typical	Max	Unit
Fin	Input Clock Frequency		13		MHz
Fout	Output Clock Frequency		208		MHz
	Lock-in Time		TBD		Ms
	Output Clock Duty Cycle	40	50	60	%
	Output Clock Jitter		650		ps
DVDD	Digital Power Supply	1.08	1.2	1.32	V
AVDD	Analog Power Supply	2.6	2.8	3.0	V
T	Operating Temperature	-20		80	℃
	Current Consumption		TBD		μA

Table 57 The Functional Specification of DSP/MCU PLL

The functional specification of USB PLL is shown below.

Symbol	Parameter	Min	Typical	Max	Unit
Fin	Input Clock Frequency		13		MHz
Fout	Output Clock Frequency		48		MHz
	Lock-in Time		TBD		μs

	Output Clock Duty Cycle	40	50	60	%
	Output Clock Jitter		650		ps
DVDD	Digital Power Supply	1.08	1.2	1.32	V
AVDD	Analog Power Supply	2.5	2.8	3.1	V
T	Operating Temperature	-20		80	℃
	Current Consumption		TBD		μA

Table 58 The Functional Specification of USB PLL

13.1.9 32-KHz Crystal Oscillator

13.1.9.1 Block Descriptions

The low-power 32-KHz crystal oscillator XOSC32 is designed to work with an external piezoelectric 32.768kHz crystal and a load composed of two functional capacitors, as shown in the following figure.

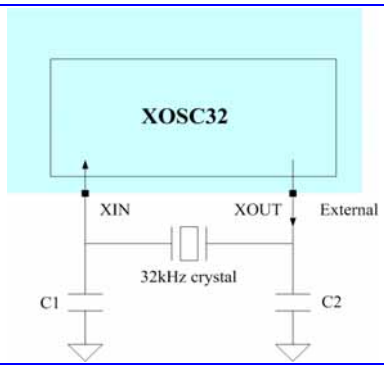


Figure 94 Block diagram of XOSC32

13.1.9.2 Functional specifications

The functional specification of XOSC32 is shown in the following table.

Symbol	Parameter	Min	Typical	Max	Unit
AVDDRTC	Analog power supply	1.08	1.2	1.32	V
Tosc	Start-up time			5	sec
Dcyc	Duty cycle		50		%
TR	Rise time on XOSCOUT		TBD		ns/pF
TF	Fall time on XOSCOUT		TBD		ns/pF
	Current consumption			5	μA
	Leakage current		1		μA
T	Operating temperature	-20		80	℃

Table 59 Functional Specification of XOSC32

Here below are a few recommendations for the crystal parameters for use with XOSC32.

Symbol	Parameter	Min	Typical	Max	Unit
F	Frequency range		32768		Hz
GL	Drive level			5	uW
Δf/f	Frequency tolerance		+/- 20		Ppm
ESR	Series resistance			50	KΩ
C0	Static capacitance			1.6	pF
CL[5]	Load capacitance	6		12.5	pF

Table 60 Recommended Parameters of the 32kHz crystal

13.2 MCU Register Definitions

13.2.1 BBRX

MCU APB bus registers for BBRX ADC are listed as followings.

0x83010300 BBRX ADC Analog-Circuit Control Register BBRX_AC_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				DITHEN	QSEL		ISEL		RSV	GAIN		CALBIAS				
Type				R/W	R/W		R/W		R/W	R/W		R/W				
Reset				0	00		00		0	00		00000				

Set this register for analog circuit configuration controls.

CALBIAS The register field is for control of biasing current in BBRX mixed-signal module. It is coded in 2's complement. That is, its maximum is 15 and minimum is –16. Biasing current in BBRX mixed-signal module has impact on the performance of A/D conversion. The larger the value of the register field, the larger the biasing current in BBRX mixed-signal module, and the larger the SNR.

GAIN The register bit is for configuration of gain control of analog inputs in GSM RX mixed-signal module.

00 Input range is 0.8x AVDD for analog inputs in GSM RX mixed-signal module.

01 Input range is 0.4x AVDD for analog inputs in GSM RX mixed-signal module.

10 Input range is 0.57x AVDD for analog inputs in GSM RX mixed-signal module.

11 Input range is 0.33x AVDD for analog inputs in GSM RX mixed-signal module.

ISEL Loopback configuration selection for I-channel in BBRX mixed-signal module

00 Normal mode

01 Loopback TX analog I

10 Loopback TX analog Q

11 Select the grounded input

QSEL Loopback configuration selection for Q-channel in BBRX mixed-signal module

00 Normal mode

01 Loopback TX analog Q

[5] CL is the parallel combination of C1 and C2 in the block diagram.

10 Loopback TX analog I

11 Select the grounded input

DITHDIS Dither feature Disable control register, which can effectively reduce the THD (total harmonic distortion) of the BBRX ADC.

0 turn on the dither (default value)

1 Disable the dither

13.2.2 BBTX

MCU APB bus registers for BBTX DAC are listed as followings.

0x83010400 BBTX DAC Analog-Circuit Control Register 0 BBTX_AC_CON0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	CALRCDONE	STARTCALRC	GAIN			CALRCSEL			TRIMI				TRIMQ			
Type	R	R/W	R/W			R/W			R/W				R/W			
Reset	0	0	000			000			0000				0000			

Set this register for analog circuit configuration controls. The procedure to perform calibration processing for smoothing filter in BBTX mixed-signal module is as follows:

1. Write 1 to the register bit STARTCALRC. Start calibration process.
2. Read the register bit CALRCDONE. If read as 1, then calibration process finished. Otherwise repeat the step.
3. Write 0 to the register bit STARTCALRC. Stop calibration process.
4. The result of calibration process can be read from the register field CALRCOUT of the register BBTX_AC_CON1. Software can set the value to the register field CALRCSEL for 3-dB cutoff frequency selection of smoothing filter in DAC of BBTX.

Remember to set the register field CALRCCONT of the register BBTX_AC_CON1 to 0xb before the calibration process. It only needs to be set once.

TRIMQ The register field is used to control gain trimming of Q-channel DAC in BBTX mixed-signal module. It is coded in 2's complement, that is, with maximum 7 and minimum –8.

TRIMI The register field is used to control gain trimming of I-channel DAC in BBTX mixed-signal module. It is coded in 2's complement, that is, with maximum 7 and minimum –8.

CALRCSEL The register field is for selection of cutoff frequency of smoothing filter in BBTX mixed-signal module. It is coded in 2's complement. That is, its maximum is 3 and minimum is –4.

GAIN The register field is used to control gain of DAC in BBTX mixed-signal module. It has impact on both of I- and Q-channel DAC in BBTX mixed-signal module. It is coded in 2's complement, that is, with maximum 3 and minimum –4.

STARTCALRC Whenever 1 is writing to the bit, calibration process for smoothing filter in BBTX mixed-signal module will be triggered. Once the calibration process is completed, the register bit CARLDONE will be read as 1.

CALRCDONE The register bit indicates if calibration process for smoothing filter in BBTX mixed-signal module has finished. When calibration processing finishes, the register bit will be 1. When the register bit STARTCALRC is set to 0, the register bit becomes 0 again.

0x83010404 BBTX DAC Analog-Circuit Control Register 1 — BBTX_AC_CON1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	CALRCOUT			FLOAT	CALRCCNT					CALBIAS				CMV		
Type	R/O			R/W	R/W					R./W				R/W		
Reset	-			0	00000					0000				000		

Set this register for analog circuit configuration controls.

CMV The register field is used to control common voltage in BBTX mixed-signal module. It is coded in 2's complement, that is, with maximum 3 and minimum –4.

CALBIAS The register field is for control of biasing current in BBTX mixed-signal module. It is coded in 2's complement. That is, its maximum is 7 and minimum is –8. Biasing current in BBTX mixed-signal module has impact on performance of D/A conversion. Larger the value of the register field, the larger the biasing current in BBTX mixed-signal module.

CALRCCNT Parameter for calibration process of smoothing filter in BBTX mixed-signal module. Default value is '22'. Note that it is **NOT** coded in 2's complement. Therefore the range of its value is from 0 to 31. Remember to set it to 0x16 before BBTX calibration process if clock sent to BBTX is 26Mhz. Otherwise set to 0xb if clock is 13Mhz. It only needs to be set once. In MT6235, only 26MHz clock is available

FLOAT The register field is used to have the outputs of DAC in BBTX mixed-signal module float or not.

CALRCOUT After calibration processing for smoothing filter in BBTX mixed-signal module, a set of 3-bit value is obtained. It is coded in 2's complement.

0x83010408 BBTX DAC Analog-Circuit Control Register 2 — BBTX_AC_CON2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name				DCCOARSEQ		DCCOARSEI			DAC_PTR			DWAEN	COARSE		CALRCAUTOL	CALRCOPEN
Type				R/W		R/W			R/W			R/W	R/W		R/W	R/W
Reset				00		00			000			0	0		0	0

Set this register for analog circuit configuration controls.

CALRCOPEN The register field is used to control normal Mode(close loop) or debug mode (open loop) for BBTX comparator in mixed signal

0 normal Mode (close loop)

1 debug Mode (open Loop)

CALRCAUTO The register field is used to control the result of calibration process of smoothing filter can automatically load to control the smoothing filter or not.

0 Not auto load, need manual load (default)

1 Auto load

COARSE The register field is used to control the central nominal value of BBTX DAC output

00 central nominal @ 1V

01 central nominal @ 1V –0.2V

10 reserved

11 central nominal @ 1V +0.2V

DWAEN The register field is used to turn on the DWA scheme of the BBTX DAC,

0 DWA scheme off (default)

1 DWA scheme on

DACPTR The register field is used to configured the staring pointer of 1 hot pulling of LSB[7:0] signal to BBTX DAC, range from 0~7. There is two different configuration. For DWAEN = 0, pointer always starts from the configuration value (e.g. if DACPTR = 3'b1, 1 hot will start pulling from LSB[1]). However, for DWAEN=1, the initial starting pointer will follow the configuration, while the pointer will move to most significant 1 hot pointer + 1 from the last LSB[7:0] input. (e.g. if DACPTR = 3'b1,and LSB[7:0] maybe 8'b00001110, then the next starting poiter will starts from LSB[4].). Defulat value is 0h.

DCCOARSEI The register field is used to control the central nominal value of BBTX DAC for I channel offset

00 central nominal @ +0mV

01 central nominal @ +30mV

11 central nominal @ - 30mV

10 reserved

DCCOARSEQ The register field is used to control the central nominal value of BBTX DAC for Q channel offset

00 central nominal @ +0mV

01 central nominal @ +30mV

11 central nominal @ - 30mV

10 reserved

13.2.3 AFC DAC

MCU APB bus registers for AFC DAC are listed as follows.

0x83010500 AFC DAC Analog-Circuit Control Register AFC_AC_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name								GAIN SEL			11BS	CALI				
Type								R/W			R/W	R/W				
Reset								0			0	0				

Set this register for analog circuit configuration controls. Please refer to analog functional specification for more details.

GAINSEL gain selection of output swing

0 3/4VDD

1 Full VDD

11BS Test purpose. Degrade the resolution of AFC from 13 bits to 11 bits

CALI biasing current control

13.2.4 APC DAC

MCU APB bus registers for APC DAC are listed as followings.

CALI biasing current control

13.2.4 APC DAC

MCU APB bus registers for APC DAC are listed as followings.

APC DAC Analog-Circuit Control Register **APC_AC_CON**

0x83010600

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											BYP	CALI				
Type											R/W	R/W				
Reset											0	0				

Set this register for analog circuit configuration controls. Please refer to analog functional specification for more details.

BYP bypass output buffer

CALI biasing current control

13.2.5 Auxiliary ADC

MCU APB bus registers for AUX ADC are listed as followings.

0x83010700 **Auxiliary ADC Analog-Circuit Control Register** **AUX_AC_CON**

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name										ENB		CALI				
Type										R/W		R/W				
Reset										0		0				

Set this register for analog circuit configuration controls. Please refer to analog functional specification for more details.

CALI Biasing current control

ENB Comparator switch enable signal.

13.2.6 Voice Front-end

MCU APB bus registers for speech are listed as followings.

0x83010100 AFE Voice Analog Gain Control Register AFE_VAG_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			VUPG						VDPG0							VAGC_GAIN_STEP
Type			R/W						R/W							R/W
Reset			000000						0000							0

Set this register for analog PGA gains. VUPG is set for microphone input volume control. And VDPG0 and VDPG1 are set for two output volume controls

VAGC_GAIN_STEP Gain step for old AGC.

0 1 dB

1 2 dB

VUPG voice-band up-link PGA gain control bits. For VCFG[3] = 1, it is only valid for INPUT 1.

VCFG[3] = 0 Gain value = VUPG - 20

VCFG[3] = 1 Gain value fixed at 0dB

VCFG [3] ='0'		VCFG [3] ='1'	
VUPG [5:0]	Gain	VUPG [5:0]	Gain
111111	43 dB	XXXXXX	0dB
111110	42 dB		
111101	41 dB		
111100	40 dB		
111011	39 dB		
111010	38 dB		
111001	37 dB		
111000	36 dB		
110111	35 dB		
110110	34 dB		
110101	33 dB		
110100	32 dB		
110011	31dB		
110010	30 dB		

110001	29 dB		
110000	28 dB		
101111	27 dB		
101110	26 dB		
101101	25 dB		
101100	24 dB		
1101011	23 dB		
101010	22 dB		
101001	21 dB		
101000	20 dB		
100111	19 dB		
100110	18 dB		
100101	17 dB		
100100	16 dB		
100011	15 dB		
100010	14 dB		
100001	13 dB		
100000	12 dB		
011111	11 dB		
011110	10 dB		
011101	9 dB		
011100	8 dB		
011011	7 dB		
011010	6 dB		
011001	5 dB		
011000	4 dB		
010111	3 dB		
010110	2 dB		
010101	1 dB		
010100	0 dB		
010011	-1dB		
010010	-2 dB		
010001	-3 dB		
010000	-4 dB		
001111	-5 dB		
001110	-6 dB		
001101	-7 dB		
001100	-8 dB		
0101011	-9 dB		

001010	-10 dB		
001001	-11 dB		
001000	-12 dB		
000111	-13 dB		
000110	-14 dB		
000101	-15 dB		
000100	-16 dB		
000011	-17 dB		
000010	-18 dB		
000001	-19 dB		
000000	-20 dB		

VDPG0 voice-band down-link PGA0 gain control bits

VDPG0 [3:0]	Gain
1111	8dB
1110	6dB
1101	4dB
1100	2dB
1011	0dB
1010	-2dB
1001	-4dB
1000	-6dB
0111	-8dB
0110	-10dB
0101	-12dB
0100	-14dB
0011	-16dB
0010	-18dB
0001	-20dB
0000	-22dB

0x83010104 AFE Voice Analog-Circuit Control Register 0 AFE_VAC_CON0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	VDC_COUPLE	VMIC_SHORT	VMIC_VREF		VCFG						VDSEND0	VCALI				
Type	R/W	R/W	R/W		R/W						R/W	R/W				
Reset	0	0	00		00000						0	00000				

Set this register for analog circuit configuration controls.

VDC_COUPLE Selectively choose DC couple microphone sense.

0 Disable DC couple sense of microphone

1 Enable DC couple sense of microphone

VMIC_SHORT Selectively short AU_MICBIASP / AU_MICBIASN.

0 float MIC_BIASN and short it to MIC_BIASP when handsfree mode mic is plugged in

1 short MIC_BIASN to ground when handsfree mode mic is plugged in. In this mode, differential mic has current leakage and cause power loss.

VMIC_VREF Tuning MICBIASP DC voltage.

00 1.9V

01 2.0V

10 2.1V

11 2.2V

VCFG[4] microphone biasing control

0 differential biasing

1 single-ended biasing

VCFG[3] gain mode control. This control register is only valid to input 1. Others can be amplification mode only.

0 amplification

1 attenuation

VCFG[2] coupling control

0 AC

1 DC

VCFG[1:0] input select control

00 input 0

01 input 1

10 FM

11 reserved

VDSEND0 single-ended configuration control for out0

VCALI biasing current control, in 2's complement format

0x83010108 AFE Voice Analog-Circuit Control Register 1 AFE_VAC_CON1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	VUPOP_EN	VBIAS_EN		VOC_EN	VBG_CTRL			VIBOOT	VFLOAT	VRSDON	VGBOOT	VADC_DVREF_CAL	VADC_DENB	VDIFF_BIAS	VADCINMODE	VDACINMODE
Type	R/W	R/W		R/W	R/W			R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0		0	000			1	0	0	0	0	0	0	0	0

Set this register for analog circuit configuration controls. There are several loop back modes and test modes implemented for test purposes. Suggested value is 0280h.

VUPOP_EN de-pop noise enable

0: disable

1: enable

VBIAS_EN voice downlink buffer bias current control

1: normal bias current

0: increase bias current

VOC_EN voice downlink buffer over current protection

0: disable

1: enable

VBG_CTRL voice-band bandgap control

IBOOT voice downlink DAC bias current control

0: increase bias current

1: normal bias current

VFLOAT voice-band output driver float

0: normal operating mode

1: float mode

VRSDON voice-band redundant signed digit function on

0: 1-bit 2-level mode

1: 2-bit 3-level mode

VGBOOT VBI DAC Gain boost

0 2X

1 1X

VADC_DVREF_CAL ADC Dither Reference Voltage Calibration

VADC_DENB ADC Dither Enable

VDIFF_BIAS Differential Bandgap Reference Activated Register

0: Single-ended reference

1: Differential reference

VADCINMODE Voice-band ADC output mode.

0: normal operating mode

1: the ADC input from the DAC output

VDACINMODE Voice-band DAC input mode.

0: normal operating mode

1: the DAC input from the ADC output

0x8301010C AFE Voice Analog Power Down Control Register AFE_VAPDN_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name											VPDN_BIAS	VPDN_LNA	VPDN_ADC	VPDN_DAC		VPDN_OUT0
Type											R/W	R/W	R/W	R/W		R/W
Reset											0	0	0	0		0

Set this register to power up analog blocks. 0: power down, 1: power up.

VPDN_BIAS bias block

VPDN_LNA low noise amplifier block

VPDN_ADC ADC block

VPDN_DAC DAC block

VPDN_OUT0 OUT0 buffer block

0x83010110 AFE Voice AGC Control Register

AFE_VAGC_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	AGC_MODE	AAGCEN	AGCTEST	RELNOIDURSEL		RELNOILEVSEL		FRELCKSEL		SRELCKSEL		ATTTHDCAL		ATTCKSEL	HYSTEREN	DAGCEN
Type	R/W	R/W	R/W	R/W		R/W		R/W		R/W		R/W		R/W	R/W	R/W
Reset	0	0	0	00		00		00		00		00		0	0	0

Set this register for analog circuit configuration controls. There are several loop back modes and test modes implemented for test purposes. Suggested value is 4dcfh.

DAGCEN Digital AGC function enable. The loop-back path of AGC comprises analog comparators and digital gain control circuitry. This control register is used to enable the digital gain control circuitry. For normal function, DAGCEN and AAGCEN shall be set to "1" to enable voice AGC function.

HYSTEREN AGC hysteresis function enable

ATTCKSEL attack clock selection

0: 16 KHz
1: 32 KHz

ATTTHDCAL attack threshold calibration

SRELCKSEL release slow clock selection

00: 1000/512 Hz
01: 1000/256 Hz
10: 1000/128 Hz
11: 1000/64 Hz

FRELCKSEL release fast clock selection

00: 1000/64 Hz
01: 1000/32 Hz
10: 1000/16 Hz
11: 1000/8 Hz

RELNOILEVSEL release noise level selection

00: -8 dB
01: -14 dB
10: -20 dB
11: -26 dB

RELNOIDURSEL release noise duration selection

00: 64 ms
01: 32 ms
10: 16 ms
11: 8 ms, 32768/4096

AAGCEN Analog AGC function enable. This control bit is used to enable the comparators of AGC loop-back path.

AGC_MODE AGC algorithm selection.

0 New digital algorithm.
1 Original analog algorithm.

13.2.7 Audio Front-end

MCU APB bus registers for audio are listed as followings.

0x83010200 AFE Audio Analog Gain Control Register AFE_AAG_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name							AMUTER	AMUTEL	APGR				APGL			
Type							R/W	R/W	R/W				R/W			
Reset							0	0	0000				0000			

Set this register for analog PGA gains.

AMUTER audio PGA L-channel mute control
AMUTEL audio PGA R-channel mute control
APGR audio PGA R-channel gain control
APGL audio PGA L-channel gain control

APGR [3:0] / APGL [3:0]	Gain
1111	23dB
1110	20dB
1101	17dB
1100	14dB
1011	13dB
1010	8dB
1001	5dB
1000	2dB
0111	-1dB
0110	-4dB
0101	-7dB
0100	-10dB
0011	-13dB
0010	-16dB
0001	-19dB
0000	-22dB

0x83010204 AFE Audio Analog-Circuit Control Register AFE_AAC_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			APRO_SC	ADEPOP		ABUFSELR			ABUFSELL			ACALI				
Type			R/W	R/W		R/W			R/W			R/W				
Reset			0	0		000			000			00000				

Set this register for analog circuit configuration controls.

APRO_SC Short circuit protection.

0 disable
1 enable

ADEPOP De-POP noise.
0 disable
1 enable

ABUFSELR audio buffer R-channel input selection
00X: audio DAC R-channel output
010: voice DAC output
100: external FM R/L-channel radio output, stereo to mono
101: external FM R-channel radio output
OTHERS: reserved.

ABUFSELL audio buffer L-channel input selection
00X: audio DAC L-channel output
010: voice DAC output
100: external FM R/L-channel radio output, stereo to mono
101: external FM L-channel radio output
OTHERS: reserved.

ACALI audio bias current control, in 2's complement format

0x83010208 AFE Audio Analog Power Down Control Register — AFE_AAPDN_CON

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												APDN_BIAS	APDN_DACR	APDN_DACL	APDN_OUTR	APDN_OUTL
Type												R/W	R/W	R/W	R/W	R/W
Reset												0	0	0	0	0

Set this register to power up analog blocks. 0: power down, 1: power up. Suggested value is 00ffh.

APDN_BIAS BIAS block
APDN_DACR R-channel DAC block
APDN_DACL L-channel DAC block
APDN_OUTR R-channel OUT buffer block
APDN_OUTL L-channel OUT buffer block

0x8301020C Enhanced Audio Analog Front End Control & Parameters — AFE_AAC_NEW

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name									BUF_BIAS			MUX			VCM_MODE	
Type									R/W			R/W			R/W	
Reset									0						0	

MT6235 ehnahced audio DAC application circuitry selection and control parameters.

BUF_BIAS Select buffer quasi-current.
00 Nominal bias current
01 Larger bias current

10 Smallest bias current

11 Smaller bias current

MUX Mux audio DAC output to DM R/L pins.

00 FM input

01 FM input

10 Left channel DAC

11 Right channel O/P

VCM_MODE Change common mode generation circuitry.

0 New VCM circuitry

1 Old VCM circuitry

13.2.8 Register setting path

0x8301000C Switch the register configuring path CCI_WR_PATH

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name												AD_INF_PATH	PMIC_WR_PATH	MODEM_WR_PATH	VBI_WR_PATH	ABI_WR_PATH
Type												R/W	R/W	R/W	R/W	R/W
Reset												0	0	0	0	0

WR_PATH

0 Switch the register setting to MCU side

1 Switch the register setting to manually control by TRACE32 through JTAG

The bit is to facilitate ACD members for verifying purpose; the hardware supports write path switching, without being disturbed by existing MCU load. However, when with manually control, all register address are offset by 0x1000. For example, MCU configures AFE_AAC_NEW through the address 0x8301020c, while the manually control path take effect when configuring 0x8301120c. Notice that before finishing manual control, the register must be reset to be 0. The modem part includes BBRX, BBTX, APC, AFC, and AUXADC.

AD_INF_PATH The register bit decides the input/output path of the mixed-mode module. For ABI and VBI, it can be configured to feed the pattern from AFE or from CHIP I/O (shared with A_FUNC_MODE). For BBTX, APC, and AFC, the input selection interface is divided at either MIX_DIG or CHIP I/O (also shared with A_FUNC_MODE). As for the BBRX, the output pattern can be bypass to CHIPIO with this register bit being true. The bit is for convenient debug-use in normal mode, such that the data pattern can be observed or be feed-in by external device, while control register setting still comes from the chip internally(By use of JTAG). It should be notice that this special debug mode should be accompanied by proper setting of GPIO, which decides the PAD OE when in normal function.

0 data pattern comes from chip internally, and the output data cannot be bypassed to chip I/O

1 analog debug mode in normal function

13.2.9 Power Management Control

Power management unit, so called PMU, is integrated into analog part. To facilitate software control and interface design, PMU control share the CCI interface along with other analog parts, such as BBTX, BBRX, and ABI, etc.

13.2.9.1 Block Description

Low Dropout Regulators (LDOs), Buck converterand Reference

The PMU Integrates 12 LDOs that are optimized for their given functions by balancing quiescent current, dropout voltage, line/load regulation, ripple rejection, and output noise.

RF LDO (Vrf)

The RF LDO is a linear regulator that could source 250mA (max) with 2.8V output voltage. It supplies the RF circuitry of the handset. The LDO is optimized for high performance and adequate quiescent current.

Digital Core Buck Converter (Vcore)

The digital core regulator is a DC-DC step-down converter (Buck converter) that could source 350mA (max) with 1.2V to 0.9V programmable output voltage based on software register setting. It supplies the baseband circuitry of the SoC. The buck converter is optimized for high efficiency and low quiescent current.

Digital IO LDO (Vio)

The digital IO LDO is a linear regulator that could source 100mA (max) with 2.8V output voltage. It supplies the baseband circuitry of the SoC. The LDO is optimized for very low quiescent current and turns on automatically together with Vm/Va LDOs.

Analog LDO (Va)

The analog LDO is a linear regulator that could source 125mA (max) with 2.8V output voltage. It supplies the analog sections of the SoC. The LDO is optimized for low frequency ripple rejection in order to reject the ripple coming from the burst at 217Hz of RF power amplifier.

TCXO LDO (Vtcxo)

The TCXO LDO is a linear regulator that could source 40mA (max) with 2.8V output voltage. It supplies the temperature compensated crystal oscillator, which needs ultra low noise supply with very good ripple rejection.

Two-Step RTC LDO (Vrtc)

The two-step RTC LDO is a set of regulators that could source 600µA (max) with 1.2V output voltage. The first-step LDO charges up a capacitor-type backup coin cell to 2.6V; the second-step LDO utilizes the backup coin to regulate the 1.2V Vrtc which supplies the real-time clock module even at the absence of the battery. The first-step LDO features the reverse current protection and the second-step LDO is optimized for ultra low quiescent current while sustaining the RTC function as long as possible.

Memory LDO (Vm)

The memory LDO is a linear regulator that could source 300mA (max) with 1.8V or 2.8V output voltage selection based on the supply specification of memory chips. It supplies the memory circuitry in the handset. The LDO is optimized for very low quiescent current with wide output loading range.

SIM LDO (Vsim)

The SIM LDO is a linear regulator that could source 80mA (max) with 1.8V or 3.0V output voltage selection based on the supply specs of subscriber identity modules (SIM) card. It supplies the SIM card and SIM level shifter circuitry in the handset. The Vsim LDO is controlled independently by the register named VSIM_EN.

SIM2 LDO (Vsim2)

The SIM2 LDO is a linear regulator that could source 20mA (max) with 1.8V or 3.0V output voltage selection based on the supply specs of the 2nd subscriber identity modules (SIM) card. It supplies the 2nd SIM card and SIM level shifter circuitry in the handset. The Vsim2 LDO is controlled independently by the register named VSIM2_EN.

USB LDO (Vusb)

The USB LDO is a linear regulator that could source 75mA (max) with 3.3V output dedicated for USB circuitry. It is controlled independently by the register named VUSB_EN.

Memory Card / Bluetooth LDO (Vbt)

The VBT LDO is a linear regulator that could source 100mA (max) with 2.8V or 3.0V output for memory card or Bluetooth module. It is controlled independently by the register named VBT_EN.

Analog Camera LDO (Vcam_a)

The VCAM_A LDO is a linear regulator that could source 250mA (max) with 1.5V, 1.8V, 2.5V or 2.8V output which is selected by the register named VCAM_A_SEL[1:0]. It supplies the analog power of the camera module. VCAM_A is controlled independently by the register named VCAM_A_EN.

Digital Camera LDO (Vcam_d)

The VCAM_D LDO is a linear regulator that could source 75mA (max) with 1.3V, 1.5V, 1.8V or 2.8V output which is selected by the register named VCAM_D_SEL[1:0]. It supplies the digital power of the camera module. VCAM_D is controlled independently by the register named VCAM_D_EN.

Reference Voltage Output (Vref)

The reference voltage output is a low noise, high PSRR and high precision reference with a guaranteed accuracy of 1.5% over temperature. It is used as the voltage reference in PMU internally. For the sake of accuracy, special care should be taken for the Vref output. Avoid loading the reference voltage and bypass Vref to GND with 100 nF minimum.

SIM Card Interface

There are two SIM card interface modules to support two SIM cards simultaneously. The SIM card interface circuitry of PMU meets all ETSI and IMT-2000 SIM interface requirements. It provides level shifting needs for low voltage GSM controller to communicate with either 1.8V or 3V SIM cards. All SIM cards contain a clock input, a reset input, and a bi-directional data input/output. The clock and reset inputs to SIM cards are level shifted from the supply of digital IO (Vio) of baseband chipset to the SIM supply (Vsim). The bi-directional data bus is internal pull high to Vsim via 10kohm resistor.

The 2nd SIM card interface can be used for supporting another SIM card or mobile TV. The interface pins such as SIO2/SRST2/SCLK2 can be configured as GPIO when there is no need to use the 2nd SIM card interface.

All pins that connect to the SIM card (Vsim, SRST, SCLK, SIO) withstand over ??(5kV) of human body mode ESD. In order to ensure proper ESD protection, careful board layout is required.

Vibrator and Keypad LED Switches

Two built-in open-drain output switches drive the vibrator motor and Keypad LED in the handset. Each switch is controlled by baseband with enable registers. The switch of keypad LED can sink 150mA. The switch of vibrator can sink 250mA. And both the open-drain output switches are high impedance when disabled.

Power-on Sequence and Protection Logic

The PMU handles the powering ON and OFF of the handset. There are three ways to power-on the handset system :

- Push PWRKEY (Pull the PWRKEY pin to the low level)
- RTC module generate PWRBB to wakeup the system
- Valid charger plug-in (CHRIN voltage is within the valid range)

Pulling PWRKEY low is the typical way to turn on the handset. The Vcore buck converter will be turned-on first, and then Va/Vio/Vm LDOs turn-on at the same time. After that, the supplies for the baseband are ready and it will send the PWRBB signal back to PMU for acknowledgement. To successfully power-on the handset, PWRKEY should be kept low until PMU receives the PWRBB from BB. Besides, the system reset ends at the moment when the Vcore/Va/Vio/Vm are fully turned-on to ensure the correct timing and function.

If the RTC module is scheduled to wakeup the handset at some time, the PWRBB signal will directly control the PMU. In this case, PWRBB becomes high at the specific moment and let PMU power-on just like the on-sequence described above. This is the case named RTC alarm.

Charger plugging-in will also turn on the handset if the charger is a valid charger. However, if the battery voltage is too low to power-on the handset (UVLO state), the system won't be turned-on by any of the three ways. In this case, charger will charge the battery first and the handset will be powered-on automatically as long as the battery voltage is high enough.

Table 1 shows states of the handset and the regulators

Table 1. States of Mobile Handset and regulator

Phone State	CHRON	UVLO	PWRKEY && (~PWRBB)	Vrtc (1st step)	Vcore, Vio, Vm, Va	Vtcxo, Vrf
No Battery or Vbat < 2.5V	X	H	X	Off	Off	Off
2.5V < Vbat < 3.2V	L	H	X	On	Off	Off
Pre-Charging	H	H	X	On	Off	Off
Charger-on (Vbat>3.2V)	H	L	X	On	On	On
Switched off	L	L	H	On	Off	Off
Stand-by	L	L	L	On	On	Off
Active	L	L	L	On	On	On

Under-voltage Lockout (UVLO)

The UVLO state in the PMU prevents startup if the initial voltage of the main battery is below the 3.2V threshold. It ensures that the handset is powered-on with the battery in good condition. The UVLO function is performed by a hysteretic comparator which can ensure the smooth power-on sequence. In addition, when the battery voltage is getting lower and lower, it will enter UVLO state and the PMU will be turned-off by itself, except for Vrtc LDO, to prevent further discharging.

Once the PMU enters UVLO state, it draws low quiescent current. The 1st-step RTC LDO is still working until the DDLO disables it.

Deep Discharge Lockout (DDLO)

PMU will enter to the deep discharge lockout (DDLO) state when the battery voltage drops below 2.5V. In this state, the 1st step Vrtc LDO will be shutdown. Besides, it draws very low quiescent current to prevent further discharging or even damage to the cells.

Reset

The PMU contains a reset control circuit which takes effect at both power-up and power-down. The SYSRST pin is held at low in the beginning of power-up and returns to high after the pre-determined delay time. The delay is set by an external capacitor on RSTCAP:

$$t_{Delay} = 2\frac{ms}{nF} \times C_{RSTCAP} \qquad (1)$$

At power-off, RESET will return to low immediately without any delay.

Over-temperature Protection

If the die temperature of PMU exceeds 150°C, the PMU will automatically disable all the LDOs except the Vrtc. Once the over-temperature state is resolved, a new power on sequence is required to enable the LDOs.

Battery Charger

The battery charger is optimized for the Li-ion batteries. The typical charging procedure can be divided into three phases: pre-charging, constant current mode charging, and constant voltage mode charging. Figure 2 shows the flow chart of the charging procedure. Most of the charger circuits are integrated in the PMU except for one PMOS, one diode and one accurate resistor for current sensing. Those components should be applied externally.

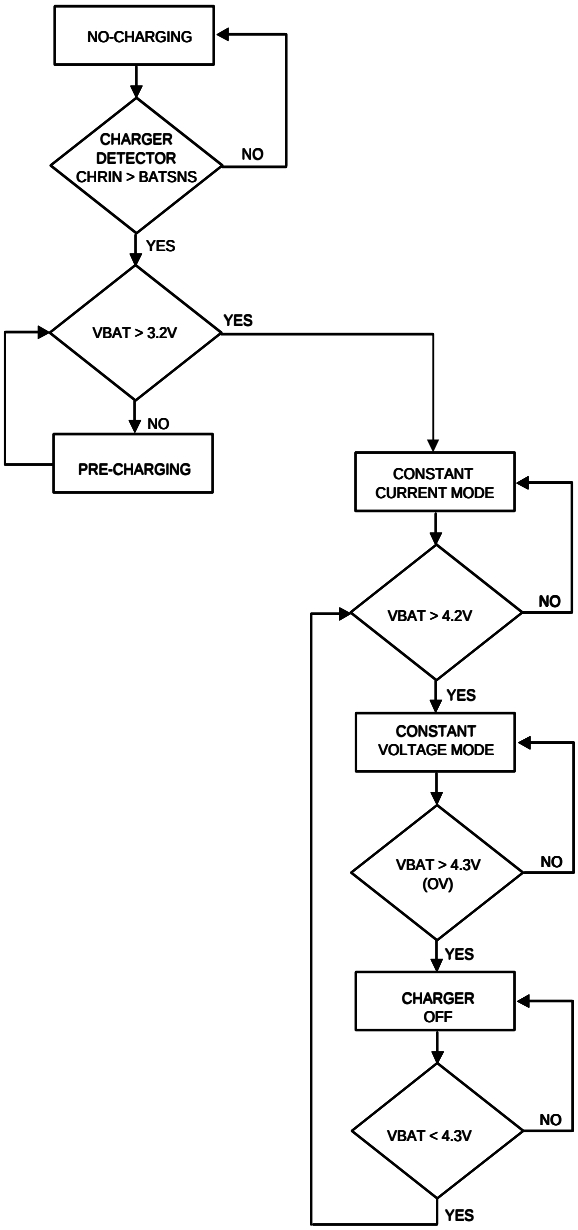


Figure 2. Battery Charger Flow Chart

Charge Detection

The PMU charger block has a detection circuit that senses the charger plug-in/out and provides the correct information to the baseband. If the CHRIN voltage is over 7V, the detection circuit reports invalid charger and CHRDET signal goes low to stop charging.

Pre-Charging mode

When the battery voltage is below the UVLO threshold, the charging status is in the pre-charging mode. There are two steps in this mode. While the battery voltage is deeply discharged below 2V, a 10mA trickle current generated internally charges the battery. When the battery voltage exceeds 2V, the closed-loop pre-charge mode is enabled, which allows 10mV (typically) voltage drop across the external current sense resistor. The pre-charge current can be calculated:

$$I_{PRE_CHARGING} = \frac{V_{SENSE}}{R_{SENSE}} = \frac{10mV}{R_{SENSE}} \quad (2)$$

Constant Current Charging Mode

Once the battery voltage has exceeded the UVLO threshold, the charger will switch to the constant current charging mode. It allows up to 800mA constant charging current which is controlled by the registers. The relation between the voltage drop across the external current sense resistor and the charging current is as follows,

$$I_{CONSTANT} = \frac{V_{SENSE}}{R_{SENSE}} \quad (3)$$

Before the battery voltage reaches 4.2V, the charger will be in the constant current charging mode.

Constant Voltage Charging Mode

If the battery voltage has reached 4.2V, a constant voltage is applied to the battery and keeps it at 4.2V. As the charger is kept in the constant voltage charging mode, the charging current will be lower and lower until the charge completion. The charge termination is determined by the baseband, which will set the register CHR_EN to stop the charger.

Once the battery voltage exceeds 4.3V, a hardware over voltage protection (OV) should be activated and turn off the charger immediately.

External Components Selection

Input Capacitor Selection

For each of input pins (VBAT) of PMU, a local bypass capacitor is recommended. Use a 10µF, low ESR capacitor. MLCC capacitors provide the best combination of low ESR and small size. Using a 10µF Tantalum capacitor with a small (1µF or 2.2µF) ceramic in parallel is an alternative low cost solution.

For charger input pin (CHRIN), a bypass 1µF ceramic capacitor is recommended.

LDO/Buck converter Capacitor/inductor Selection

The analog and RF LDOs require a 4.7µF capacitor, the digital core buck converter requires a 2.2uF capacitor??, and the other LDOs require a 1µF capacitor. Large value capacitor may be used for desired noise or PSRR requirement. But the acceptable settling time should be taken into consideration. The MLCC X5R type capacitors must be used with VRF, VTCXO, VCAM_A and VA LDOs for good system performance. For other LDOs, MLCC X5R type capacitors are also recommended to use.

RESET Capacitor Selection

RESET is held low at power-up until a delay time when LDOs are on. The delay is set by an external capacitor on RESCAP pin. It can be determined by the Eq.(1).

For example, a 100nF capacitor can produce 200ms delay.

Setting the Charge Current

PMU is capable of charging battery. The charging current is controlled with an external sense resistor, Rsense. It is calculated as the Eq.(3). If the charge current is pre-defined, Rsense can be determined.

Accurate sense resistors are available from the following vendors: Vishay Dale, IRC, Panasonic.

Charger FET Selection

The PMOS FET selection used in charger should consider the minimum drain-source breakdown voltage (BVDS), the minimum turn-on threshold voltage (VGS), and heat-dissipating ability.

These specifications can be calculated as below:

$V_{GS} = V_{CHRIN} - V_{GATEDRV}$

$V_{DS} = V_{CHRIN} - V_{DIODE} - V_{SENSE} - VBAT$

$$R_{DS(ON)} = \frac{V_{DS}}{I_{CHR}}$$

$P_{DISS} = (V_{CHRIN}-V_{DIODE}-V_{SENSE}-VBAT) \times I_{CHR}$

Appropriate PMOS FETs are available from the following vendors: Siliconix, IR, Fairchild.

Charger Diode Selection

The diode is used to prevent the battery from discharging through the PMOS's body diode into the charger's internal circuits. Choose a diode with sufficient current rating to handle the battery charging current and voltage rating greater than Vbat.

Layout Guideline

Use the general guidelines listed below to design the printed circuit boards:

1. Split battery connection to the VBAT, VBATRF and AVBAT pins for PMU. Place the input capacitor as close to the power pins as possible.
2. Va and Vtcxo capacitors should be returned to AGND. Vrf capacitor should be returned to AGND_RF.
3. Split the ground connection. Use separate traces or planes for the analog, digital, and power grounds (i.e. AGND, AGND_RF, DGND, PGND pins of PMU, respectively) and tie them together at a single point, preferably close to battery return.
4. Place a separate trace from the BATSNS pin to the battery input to prevent voltage drop error when sensing the battery voltage.
5. Kelvin-connect the charge current sense resistor by placing separate traces to the BATSNS and ISENSE pins. Make sure that the traces are terminated as close to the resistor's body as possible.
6. Careful use of copper area, weight, and multi-layer construction will help to improve thermal performance.

13.2.9.2 Functional Specification

13.2.9.2.1 Electrical Characteristics

VBAT = 3 V ~ 5 V, minimum loads applied on all outputs, unless other noted. Typical values are at T_A = 25 °C.

Parameter	Conditions	Min.	Typical	Max.	Unit
Switch-Off Mode: Supply Current					
VBAT < 2.5 V	RTC LDO OFF		TBD		µA
2.5 V < VBAT < 3.3 V	VBAT=3.3V		TBD		µA
3.3 V < VBAT	VBAT=4.2V		TBD		µA
Operation: Supply Current					
All outputs on	VBAT=4.2V		TBD		µA
VSIM, VSIM2, VTXCO, VRF, VUSB, VCAM_A, VCAM_D, VBT off; all others on	VBAT=4.2V		TBD		µA
Under Voltage (UV)					
Under voltage falling threshold 1	UV_SEL[1:0] = 00	2.85	2.9	2.95	V
Under voltage falling threshold 2	UV_SEL[1:0] = 01	2.7	2.75	2.8	V
Under voltage falling threshold 3	UV_SEL[1:0] = 10	2.55	2.6	2.65	V
Under voltage falling threshold 4	UV_SEL[1:0] = 11	2.35	2.5	2.65	V
Under voltage rising threshold	UV_SEL[1:0] = xx	3.1	3.2	3.3	V
Reset Generator					
Output High		V_{IO}-0.5			V
Output Low				0.2	V
Output Current			TBD		mA
On Delay Time per Unit Capacitance		1.5	2.5	4	ms/nF
Power Key Input					
High Voltage		0.7*VBAT			V
Low Voltage				0.3*VBAT	V
Control Input Voltage					
Other Control Input High		2.0			V
Other Control Input Low				0.5	
Thermal Shutdown					
Threshold			150		degree
Hysteresis			40		degree
LDO Enable Response Time			250		µs

13.2.9.2.2 Regulator Output

Parameter	Conditions	Min.	Typical	Max.	Unit
Digital Core Voltage					
Output voltage (V_D)	Register VOSEL=0	1.7	1.8	1.9	V
		~~1.4~~	~~1.5~~	~~1.6~~	V
	Register VO_SEL=1	1.1	1.2	1.3	V
Output current (Id_max)			350		mA

Line regulation				TBD	mV
Load regulation				TBD	mV
Digital IO Voltage					
Output voltage (V_IO)		2.7	2.8	2.9	V
Output current (Iio_max)			100		mA
Line regulation				TBD	mV
Load regulation				TBD	mV
RF Voltage					
Output voltage (V_A)		2.7	2.8	2.9	V
Output current (Ia_max)			250		mA
Line regulation				TBD	mV
Load regulation				TBD	mV
Output noise voltage	f = 1k Hz to 100 kHz		40		uVrms
Ripple rejection	at 1kHz		65		dB
Analog Voltage					
Output voltage (V_A)		2.7	2.8	2.9	V
Output current (Ia_max)			125		mA
Line regulation				TBD	mV
Load regulation				TBD	mV
Output noise voltage	f = 10 Hz to 100 kHz		50		uVrms
Ripple rejection	10 Hz < freq. < 3 kHz		65		dB
	3 kHz < freq. < 1 MHz		40		dB
VTCXO Voltage					
Output voltage (V_TCXO)		2.7	2.8	2.9	V
Output current (Itcxo_max)			40		mA
Line regulation				TBD	mV
Load regulation				TBD	mV
Output noise voltage	f = 10 Hz to 100 kHz		50		µVrms
Ripple rejection	10 Hz < freq. < 3 kHz		65		dB
	3 kHz < freq. < 1 MHz		40		dB
RTC Voltage					
1st stage output voltage		2.5	2.6	TBD	V
2nd stage output voltage (V_RTC)	RTC_SEL=H	TBD	1.2	TBD	V
Output current limit (Irtc_max)	1st stage RTC		0.6		mA
Off reverse input current			1		µA
External Memory Voltage					
Output voltage (V_M)	VMSEL=L	1.7	1.8	1.9	V
	VMSEL=H	2.7	2.8	2.9	V
Output current (Im_max)			300		mA
Line regulation				TBD	mV
Load regulation				TBD	mV
SIM Voltage					
Output voltage (V_SIM)	Register VSIM_SEL=L	1.71	1.8	1.89	V

	Register VSIM_SEL=H	2.82	3.0	3.18	V
Output current (Isim_max)			80		mA
Line regulation				TBD	mV
Load regulation				TBD	mV
SIM2 Voltage					
Output voltage (V_SIM2)	Register VSIM2_SEL=L	1.71	1.8	1.89	V
	Register VSIM2_SEL=H	2.82	3.0	3.18	V
Output current (Isim2_max)			20		mA
Line regulation				TBD	mV
Load regulation				TBD	mV
Memory card/Blue-Tooth Voltage					
Output voltage (V_BT)	Register VBT_SEL=L	2.7	2.8	2.9	V
	Register VBT_SEL=H	2.8	3.0	3.2	V
Output current (Ibt_max)			100		mA
Line regulation				TBD	mV
Load regulation				TBD	mV
USB Voltage					
Output voltage (V_USB)		2.97	3.3	3.63	V
Output current (Iusb_max)			75		mA
Line regulation				TBD	mV
Load regulation				TBD	mV
Digital Camera Voltage					
Output voltage (V_CAM_D)	Register VCAM_D_SEL=00	1.4	1.5	1.6	V
	Register VCAM_D_SEL=01	1.7	1.8	1.9	V
	Register VCAM_D_SEL=10	2.4	2.5	2.6	V
	Register VCAM_D_SEL=11	2.7	2.8	2.9	V
Output current (Icamera_max)			75		mA
Line regulation				TBD	mV
Load regulation				TBD	mV
Analog Camera Voltage					
Output voltage (V_CAM_A)	Register VCAM_A_SEL=00	1.2	1.3	1.4	V
	Register VCAM_A_SEL=01	1.4	1.5	1.6	V
	Register VCAM_A_SEL=10	1.7	1.8	1.9	V
	Register VCAM_A_SEL=11	2.7	2.8	2.9	V
Output current (Icamera_max)			250		mA
Line regulation				TBD	mV
Load regulation				TBD	mV

LED /Vibrator Driver					
Sink Current of Key-Pad LED Driver	Von<0.5V		150		mA
Sink Current of Vibrator Driver	Von<0.5V		250		mA

13.2.9.2.3 SIM interface

Parameter	Conditions	Min.	Typical	Max.	Unit
Interface to 3 V SIM Card					
Volrst	I = 20 µA			0.4	V
Vohrst	I = -200 µA	0.9*VSIM			V
Volclk	I = 20 µA			0.4	V
Vohclk	I = -200 µA	0.9*VSIM			V
Vihsio , Vohsio	I = ±20 µA	VSIM-0.4			V
Iil	Vil = 0 V			-1	mA
Vol	Iol = 1 mA			0.15*VSIM	V
Interface to 1.8 V SIM Card					
Volrst	I = 20 µA			0.2*VSIM	V
Vohrst	I = -200 µA	0.9*VSIM			V
Volclk	I = 20 µA			0.2*VSIM	V
Vohclk	I = -200 µA	0.9*VSIM			V
Vil				0.15*VSIM	V
Vihsio , Vohsio	I = ±20 µA	VSIM-0.4			V
Iil	Vil = 0 V			-1	mA
Vol	Iol = 1 mA			0.15*VSIM	V
SIM Card Interface Timing					
SIO pull-up resistance to VSIM		8	10	12	kΩ
SRST, SIO rise/fall times	VSIM = 3, 1.8 V, load with 30 pF			1	µs
SCLK rise/fall times	VSIM = 3 V, CLK load with 30 pF			18	ns
	VSIM = 1.8 V, CLK load with 30 pF			50	ns
SCLK frequency	CLK load with 30 pF	5			MHz
SCLK duty cycle	SIMCLK Duty = 50%, fsimclk = 5 MHz	47		53	%

SCLK propagation delay			30	50	ns

13.2.9.2.4 Charger Circuit

Parameter	Conditions	Min.	Typical	Max.	Unit
AC charger input voltage		4.2		8	V
AC charger detect on threshold (Vchg_on)	VBAT<3.2V	4.2		7	V
	VBAT>=3.2V	VBAT +120mV		7	V
Maximum charging current (AC charging)	VBAT>=3.2V		0.16 / R_{sense}		A
Pre-charging current	VBAT<2.3V		10		mA
	VBAT>=2.3V	TBD	100	TBD	mA
Pre-charging off threshold			3.2		V
Pre-charging off hysteresis			0.3		V
CC mode to CV mode threshold		4.15	4.2	4.25	V
BAT_ON (Vih)		2.4		2.6	V
GATEDRV rising time (T_r)	BAT_ON, or OV	1		5	µs
Over voltage protection threshold (OV)			4.3		V

13.2.9.2.5 Regulators and Drivers

Item	LDO	Voltage	Current	Description
1	VCORE	1.8V/1.2V / 0.9V	350 mA	Digital core
2	VIO	2.8V	100 mA	Digital IO
3	VRF	2.8V	250 mA	RF chip
4	VA	2.8V	125 mA	Analog baseband
5	VRTC	1.2V	0.6 mA	Real-time clock
6	VM	1.8V / 2.8V	300 mA	External memory, selectable
7	VSIM	1.8V / 3.0V	80 mA	SIM card, selectable
8	VTCXO	2.8V	40 mA	13/26 MHz reference clock
9	VSIM2	1.8V / 3.0V	20 mA	SIM2 card, selectable
10	VUSB	3.3V	75 mA	USB

11	VBT	2.8V / 3.0V	100 mA	Memory card or Bluetooth
12	VCAM_A	1.5V / 1.8V / 2.5V / 2.8V	250 mA	Analog camera power
13	VCAM_D	1.3V / 1.5V / 1.8V / 2.8V	75 mA	Digital camera power

Driver	Type	Current	Description
LED	Open-drain NMOS switch	150 mA	Drives the keypad LEDs
VIBRATOR	Open-drain NMOS switch	250 mA	Drives the vibrator

The output current ratings for the above drivers already include a 50% margin on their nominal current consumption, e.g. if a regulator output is listed as 150 mA, the peak consumption current is 100 mA. In the active state, the phone consumes peak output current at each driver, which must be considered for the thermal design.

13.2.9.2.6 Register Setting

0x83010800 Control LDO of V_{RF} and test setting PMIC_CON0

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	TPSEL					VRF_ON_SEL	VRF_CAL				ICALRF_EN		VRF_PLNMOS_DIS	VRF_EN_FORCE	VRF_EN	VRF_STATUS
Type	R/W					R/W	R/W				R/W		R/W	R/W	R/W	RO
Reset	0					0	0				0		0	0	0	0

VRF_STATUS RF LDO ON/OFF Status excluding Force-Enable

VRF_EN RF LDO Enable Control Signal

0 Disable

1 Enable

VRF_EN_FORCE RF LDO Force-Enable Control Signal

0 Disable

1 Enable

VRF_PLNMOS_DIS RF LDO Pull-low NMOS disable Signal

0 Enable pull-low

1 Disable pull-low

ICALRF_EN RF LDO Bias Current Calibration Code

0 x1

1 x0.5

2 x2

3 x3

VRF_CAL RF LDO Output Voltage Calibration Code in monotonic transfer function

0000 maximum value

1111 minimum value

VRF_ON_SEL RF LDO Enable Control Signal

0 enable with VTCXO_EN(equivalent to “PMIC_CON4[2] | SRCLKENA”)

1 enable with VRF_EN

TPSEL Internal Node-set Selection for Mux-out on LED PAD. Reserved for the testing purpose.

0x83010804 Control LDO of V_{CORE} , V_{RTC}, and status of V_{IO} and V_M PMIC_CON1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	~~VM_STATUS~~	VIO_STATUS	VRTC_EN_FORCE	VRTC_STATUS					ACC_OUT_INIT				PWMB	FAST_SLOW	ADC_IN_EDGE	VCORE_EN_FORCE
Type	~~RO~~	RO	R/W	RO					R/W				R/W	R/W	R/W	R/W
Reset	~~0~~	0	0	0					1100				1	1	0	0

VCORE_EN_FORCE VCORE LDO Force-Enable Control Signal for MCU write. When being read, this register returns the value of VCORE_STATUS, which is quite different from other LDO's force enable bit

0 Disable

1 Enable

ADC_IN_EDGE use positive/ negative edge as ADC_COUNTER input

0 negative

1 positive

FAST_SLOW PWM switching frequency

0 26MHz divided by 32

1 26MHz divided by 16

PWMB select PWM bit resolution

0 3 bits

1 4 bits

ACC_OUT_INIT PID compensator integrator initial value setup

VRTC_STATUS VRTC LDO ON/OFF Status excluding Force-Enable

VRTC_EN_FORCE VRTC LDO Force-Enable Control Signal

0 Disable

1 Enable

VIO_STATUS VIO LDO ON/OFF Status excluding Force-Enable

~~**VM_STATUS** VM LDO ON/OFF Status exeluding Force-Enable~~

0x83010808 Control LDO of V_{IO} and V_M PMIC_CON2

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	VM_CAL				ANTIUDSH_M_DN	ICALM_EN		VM_EN_FORCE	VIO_CAL				ANTIUDSH_IO_DN	ICALIO_EN		VIO_EN_FORCE
Type	R/W				R/W	R/W		R/W	R/W				R/W	R/W		R/W
Reset	0				0	0		0	0				0	0		0

VIO_EN_FORCE VIO LDO Force-Enable Control Signal

0 Disable

1 Enable

ICALIO_EN VIO LDO Bias Current Calibration Code

0 x1
1 x0.5
2 x2
3 x3

ANTIUDSH_IO_DN VIO LDO Anti-Undershoot Disable Control Signal
0 Enable function
1 Disable function

VIO_CAL VIO LDO Output Voltage Calibration Code
0000 maximum
1111 minimum

VM_EN_FORCE VM LDO Force-Enable Control Signal
0 Disable
1 Enable

ICALM_EN VM LDO Bias Current Calibration Code
0 x1
1 x0.5
2 x2
3 x3

ANTIUDSH_M_DN VM LDO Anti-Undershoot Disable Control Signal
0 Enable function
1 Disable function

VM_CAL VM LDO Output Voltage Calibration Code in monotonic transfer function
0000 maximum
1111 minimum

0x8301080C Control and Status of LDO of V_{SIM}, Calibration of V_{RTC} PMIC_CON3

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	VRTC_STEP2_CAL			VRTC_STEP1_CAL			VSIM_CAL				VSIM_PLNMOS_DIS	ANTIUDSH_SIM_DN	ICALSIM_EN		VSIM_EN_FORCE	VSIM_STATUS
Type	R/W			R/W			R/W				R/W	R/W	R/W		R/W	RO
Reset	0			0			0				0	0	0		0	0

VSIM_STATUS VSIM LDO ON/OFF Status excluding Force-Enable
VSIM_EN_FORCE VSIM LDO Force-Enable Control Signal
0 Disable
1 Enable

ICALSIM_EN VSIM LDO Bias Current Calibration Code
0 x1
1 x0.5
2 x2
3 x3

ANTIUDSH_SIM_DN VSIM LDO Anti-Undershoot Disable Control Signal
0 Enable function

1 Disable function

VSIM_PLNMOS_DIS VSIM LDO Pull-low NMOS disable Signal

0 Enable pull low

1 Disable pull low

VSIM_CAL VSIM LDO Output Voltage Calibration Code in monotonic transfer function

0000 maximum value

1111 minimum value

VRTC_STEP1_CAL VRTC LDO1 Output Voltage Calibration Code in 2's complements monotonic transfer function for the 1st step. Configuration of the register must be followed by toggling VRTC_CAL_LATCH_EN (VRTC_STEP1_CAL -> VRTC_CAL_LATCH_EN "TRUE" -> VRTC_CAL_LATCH_EN "FALSE")

000 nominal value

111 minimum value

011 maximum value

VRTC_STEP2_CAL VRTC LDO2 Output Voltage Calibration Code in 2's complement monotonic transfer function for the 2nd step. Configuration of the register must be followed by toggling VRTC_CAL_LATCH_EN(VRTC_STEP2_CAL -> VRTC_CAL_LATCH_EN "TRUE" -> VRTC_CAL_LATCH_EN "FALSE")

000 nominal value

111 minimum value

111 maximum value

0x83010810 Control and Status of LDO of V_{TCXO} and V_A PMIC_CON4

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	VRTC_CAL_LATCH_EN	VA_CAL				VA_EN_SEL	VA_EN_FORCE	VA_STATUS	VTCXO_CAL				VTCXO_PLNMOS_DIS	RG_VTCXO_EN	VTCXO_EN_FORCE	VTCXO_STATUS
Type	R/W	R/W				R/W	R/W	RO	R/W				R/W	R/W	R/W	RO
Reset	0	0				0	0	0	0				0	0	0	0

VCTXP_STATUS VTCXO LDO ON/OFF Status excluding Force-Enable

VCTXO_EN_FORCE VTCXO LDO Force-Enable Control Signal

0 Disable

1 Enable

RG_VCTXO_EN VTCXO LDO Enable Control Signal

0 Disable

1 Enable. Will force VCTXO LDO enabled discarding sleep mode control (SRCLKENA)

VCTXO_PLNMOS_DIS VTCXO LDO Pull-low NMOS disable Signal

0 Enable pull low

1 Disable pull low

VCTXO_CAL VTCXO LDO Output Voltage Calibration Code in monotonic transfer function

0000 maximum value

1111 minimum value

VA_STATUS VA LDO ON/OFF Status excluding Force-Enable

VA_EN_FORCE VA LDO Force-Enable Control Signal

0 Disable

1 Enable

VA_EN_SEL VA LDO Enable Control Selection

VA_CAL VA LDO Output Voltage Calibration Code

0000 maximum value

1111 minimum value

VRTC_CAL_LATCH_EN Latch enable for the VRTC calibration bits. To stabilize the VRTC right after VCORE power-on, analog PMIC unit needs to latch the VRTC_STEP1_CAL and VRTC_STEP2_CAL in advance (before VCORE power off).

0 Disable

1 Enable

0x83010814 Driver Control and Charger Status PMIC_CON5

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	CHRG_DIS	CV	AC_DET	BAT_ON	CHR_DET	OVP	VSIM_SEL	VSIM_EN	INT_NODE_MUX			BLED_EN	GLED_EN	RLED_EN	KPLED_EN	VIBR_EN
Type	RO	RO	RO	RO	RO	RO	R/W	R/W	R/W			R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0	0			0	0	0	0	0

VIBR_EN Vibrator Driver Enable Control Signal

0 Disable.

1 Enable. Controlled by hardware PWM2 output signal

KPLED_EN KPLED Driver Enable Control Signal

0 Disable.

1 Enable. Controlled by hardware PWM1 output signal

RLED_EN Reserved

GLED_EN Reserved

BLED_EN Reserved

VSIM_EN Only valid for analog test mode. For normal operation, this LDO enable is actually connected to "simvcc" port of SIM hardware.

0 Disable

1 Enable

VSIM_SEL Only valid for analog test mode. For normal operation, this LDO voltage select is actually connected to "simsel" port of SIM hardware. VSIM LDO voltage selection

0 1.8V

1 1.3V

OVP Charger OV occurred

0 AC<7V

1 AC>7V

CHR_DET Charger detected

0 No charger

1 With charger. The signal is connected to EINT8(active low), acting as an internal interrupt, and can wakeup baseband chip even in sleep mode

BAT_ON Battery is connected

0 Battery is connected

1 Battery is removed

AC_DET AC power detected. Reserved

CV CV mode Indication

0 Not in CV mode

1 In CV mode

CHRG_DIS Not in Charging. Reserved. This register is used by PMU to indicate the test mode when being true. Under the test mode, the system reset, power key, and SIM card data input would come from external PMIC, rather than from PMU.

INT_NODE_MUX MUX the PMU internal nodes, to be monitored by AUXADC. The function is reserved for the testing purpose.

000 GND (Reserved)

001 GND (Reserved)

010 GND (Reserved)

011 VREG12D_DCV (DC-DC internal LDO voltage)

100 internal charger BGR voltage

101 Ratioed Battery voltage

110 Ratioed ISENSE voltage

111 Ratioed CHRIN voltage

0x83010818 Charger and GPIO Control PMIC_CON6

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	GPIO_DRV	MTV_EN		CV_TUNE			CV_RT		CHRON_FORCE	CLASS_D			CHOFST			CHR_EN
Type	R/W	R/W		R/W			R/W		R/W	R/W			R/W			R/W
Reset	0	0		0			0		0	0			0			0

CHR_EN Enable Charging (CC and CV mode)

0 Disable

1 Enable

CHOFST Charging Current Offset (for CC mode current calibration)

000 No offset

001 plus 1 step

010 plus 2 step

011 No offset

100 No offset

101 No offset

110 minus 2 step

111 minus 1 step

CLASS_D CC mode charge current level

- **000** 50mA
- **001** 87.5mA
- **010** 150mA
- **011** 225mA
- **100** 300mA
- **101** 450mA
- **110** 650mA
- **111** 800mA

CHRON_FORCE Charger Force-Enable Control Signal

- **0** Disable (normal)
- **1** Enable (force charge on)

CV_RT Coarse tune the CV voltage according to VREF

CV_TUNE Fine tune the CV voltage according to VREF

- **000** VBG = 1.2V
- **001** VBG = 1.205V
- **010** VBG = 1.210V
- **011** VBG = 1.215V
- **100** VBG = 1.18V
- **101** VBG = 1.185V
- **110** VBG = 1.190V
- **111** VBG = 1.195V

MTV_EN Define Mobile TV application, the register is only for test purpose. If GPIO in normal function is intended, please refer to “General-purpose IO” chapter

- **0** Non-Mobile-TV application, SCLK2/SRST2/SIO2 are used as GPIO pins
- **1** Mobile-TV application, SCLK2/SRST2/SIO2 are used as SIM2 interface

GPIO_DRV SCLK2/SRST2/SIO2 GPIO Driving Strength Control

- **0** 8mA
- **1** 4mA

0x8301081C Start Up PMIC_CON7

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	PWRKEY_DEB		OV_TH_FREEZE	OV_HYS_ENB	BIAS_GEN_FORCE	IBIASSEL		CKSEL	OSCEN	IBGSEL		RBGSEL			UV_SEL	
Type	RO		R/W	R/W	R/W	R/W		R/W	R/W	R/W		R/W			R/W	
Reset	0		0	0	0	0		0	0	0		0			0	

UV_SEL UVLO High to Low Threshold Selection

- **00** 2.9V

01 2.75V
10 2.6V
11 Follow DDLO

RBGSEL Bandgap T.C. fine tuning
000 initial setting
001 plus 1 step
010 plus 2 step
011 plus 3 step
100 minus 4 step
101 minus 3 step
110 minus 2 step
111 minus 1 step

IBGSEL Current setting for bandgap and oscillator
00 initial setting
01 plus 1 step
10 minus 2 step
11 minus 1 step

OSCEN Enable the oscillator in bandgap block
0 Disable
1 Enable

CKSEL Setting the clock rate of CKMON
0 ~10kHz
1 ~5kHz

VBSSEL Internal reference current tuning (global bias of PMU)
00 VBG/1200K
01 VBG/1320K
10 VBG/960K
11 VBG/1080K

BIAS_GEN_EN_FORCE Force the IBIAS/VBIAS Generator ON in the Testmode
0 Normal
1 Force on

OV_TH_HIGH Set the OV threshold when RG_OV_THFREEZE=1
0 Lower
1 Higher

OV_TH_FREEZE OV threshold freeze at 4.3V
0 OV threshold auto tuning
1 Fixed OV threshold

PWRKEY_DEB De-bounced PWRKEY signal

0x83010820 DC-DC controller for VCORE PMIC_CON8

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name	SDM_FB_EN	VOSEL	DUTY_INIT	GAIN_D	GAIN	GAIN_P	SDM_ORDER
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	1	1	1000	010	100	010	1

SDM_ORDER select SDM order

0 1st order

1 2nd order

GAIN_P PID proportional gain select

MSB:

00 0.25

01 0.5

01 1

11 2

LSB: x 1.5

GAIN PID integration gain select

MSB:

00 0.015625

01 0.03125

01 0.0625

11 0.125

LSB: x 1.5

GAIN_D PID derivative gain select

MSB:

00 2

01 4

01 8

11 16

LSB: x 1.5

DUTY_INIT DCV test mode monitor select

VOSEL vcore voltage select

0 1.8V

1 1.2V

SDM_FB_EN SDM feedback path enable

0 Disable

1 Enable

0x83010824 DC-DC controller for VCORE PMIC_CON9

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	DCV_TEST_EN	MODESEL1A	MODECMP	MODEEN[0]	MODESET	ADJCKSEL			ISEL		DCV_CK_SEL	DIRECT_CTRL_EN	VFBADJ			
Type	R/W	R/W	R/W	R/W	R/W	R/W			R/W		R/W	R/W	R/W			
Reset	0	1	0	1	1	100			10		1	0	1000			

VFBADJ output voltage soft adjustment(4 bits resolution) "0000" ~ "1111" 16 step, 50mV/step when not in sleep mode(SRLKENA high)

0000 minimum: 0.8V

1111 maximum: 1.6V

DIRECT_CTRL_EN voltage feedback direct feed through

0 DVFS

1 direct feed through

DCV_CK_SEL DCV digital PWM clock source select

0 internal free run ring oscillator

1 CLK_TCXO

ISEL reference gen bias current select

00 0.25X

01 1.5X

10 1X

11 2X

ADJCKSEL internal free run ring oscilltor frequency adjustment, 000~111

MODESET Manual mode setting

0 PFM mode

1 PWM mode

MODEEN Enable auto mode change, bit 1 is located at PMIC_CONB[11]

0 Manual change

1 Auto mode change

MODECMP select comparator entering PWM mode

0 low offset comparator

1 auto-zero comparator

MODESEL1A Select average current mode

0 NCD mode

1 average current mode

DCV_TEST_ENDCV test mode enable

0 normal mode

1 test mode

0x83010828 DC-DC controller for VCORE PMIC_CONA

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RSEL		IASEL		DCVTRIM			NCDOF		PFMSEL						
Type	R/W		R/W		R/W			R/W		R/W						
Reset	01		01		011			10		0000110						

PFMSEL[3:0] PFM max load current select (constant bias)

3 160mA

2 80mA

1 40mA
0 20mA

PFMSEL[6:4] PFM max load current select (proportional to Vin)
6 50ohm
5 100phm
4 200ohm

NCDOF NCD comparator offset
00 -3mV
01 5mV
10 12mV
11 17mV

DCVTRIM reference voltage trimming . Each step = 10mV (for Vout=1.2V)

IASEL select vavgl
00 50mV
01 100mV
10 150mV
11 200mV

RSEL curdet bias current select
00 32k
01 28k
10 24k
11 18k

0x8301082C Control and Status of LDO of V_{USB} PMIC_CONB

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	VFBADJ_SLP				MODEN[1]	VUSB_CAL				VUSB_PLNMOS_DIS	ANTIUDSH_USB_DN	ICALUSB_EN		VUSB_EN	VSUB_EN_FORCE	VUSB_STATUS
Type	R/W				R/W	R/W				R/W	R/W	R/W		R/W	R/W	RO
Reset	0000				0	0				0	0	0		0	0	0

VUSB_STATUS VUSB LDO ON/OFF Status excluding Force-Enable

VUSB_EN_FORCE VUSB LDO Force-Enable Control Signal
0 Disable
1 Enable

VUSB_EN VUSB LDO Enable Control Signal
0 Disable
1 Enable

ICALUSB_EN VUSB LDO Bias Current Calibration Code
0 x1
1 x0.5
2 x2
3 x3

ANTIUDSH_USB_DN VUSB LDO Anti-Undershoot Disable Control Signal

0 Enable function
1 Disable function

VUSB_PLNMOS_DIS VUSB LDO Pull-low NMOS disable Signal
0 Enable pull low
1 Disable pull low

VUSB_CAL VUSB LDO Output Voltage Calibration Code in monotonic transfer function
0000 maximum value
1111 minimum value

VFBADJ_SLP output voltage soft adjustment(4 bits resolution) "0000" ~ "1111" 16 step, 50mV/step when in sleep mode(SRLKENA low)
0000 minimum: 0.8V
1111 maximum: 1.6V

0x83010830 Control and Status of LDO of V_{SIM2} PMIC_CONC

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	VSIM2_SEL	VSIM2_EN		VSIM_PWR_SAVING	VTCXO_ON_SEL	CLK_SOURCE_SEL	VSIM2_CAL				VSIM2_PLNMOS_DIS	ANTIUDSH_SIM2_DN	ICALSIM2_EN		VSIM2_EN_FORCE	VSIM2_STATUS
Type	R/W	R/W		R/W	R/W	R/W	R/W				R/W	R/W	R/W		R/W	RO
Reset	0	0		0	0	0	0				0	0	0		0	0

CLK_SOURCE_SEL Select 26MHz clock source for VCORE PWM control
0 2.8V 26MHz directly from CLKSQ
1 1.2V 26MHz clock from TCXO26M_CK

VTCXO_ON_SEL VTCXO LDO enable control signal
0 Enable with VTCXO_EN (equivalent to "PMIC_CON4[2] | SRCLKENA")
1 Enable with RG_VTCXO_EN(PMIC_CON4[2])

VSIM2_STATUS VSIM LDO ON/OFF Status excluding Force-Enable

VSIM2_EN_FORCE VSIM LDO Force-Enable Control Signal
0 Disable
1 Enable

ICALSIM2_EN VSIM LDO Bias Current Calibration Code
0 x1
1 x0.5
2 x2
3 x3

ANTIUDSH_SIM2_DN VSIM LDO Anti-Undershoot Disable Control Signal
0 Enable function
1 Disable function

VSIM2_PLNMOS_DIS VSIM LDO Pull-low NMOS disable Signal
0 Disable pull low
1 Enable pull low

VSIM2_CAL VSIM LDO Output Voltage Calibration Code in monotonic transfer function

0000 maximum value

1111 minimum value

VSIM2_EN Only valid for analog test mode. For normal operation, this LDO enable is actually connected to "simvcc" port of SIM hardware.

0 Disable

1 Enable

VSIM2_SEL Only valid for analog test mode. For normal operation, this LDO voltage select is actually connected to "simsel" port of SIM hardware. VSIM LDO voltage selection

0 1.8V

1 1.3V

VSIM_PWR_SAVING Used for power saving. Since design topology of SIM LS, SIM data out path tends to conduct leakage current when VSIM LDO is not enable if default SIM data output is kept low. If the power saving is enabled, SIM data output will keep high before VSIM LDO is turned on.

0 Disable

1 Enable

0x83010834 Control and Status of LDO of V_{BT} PMIC_COND

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	VBT_SEL	VBT_EN					VBT_CAL				VBT_PLNMOS_DIS	ANTIUDSH_BT_DN	ICALBT_EN		VBT_EN_FORCE	VBT_STATUS
Type	R/W	R/W					R/W				R/W	R/W	R/W		R/W	RO
Reset	0	0					0				0	0	0		0	0

VBT_STATUS VBT LDO ON/OFF Status excluding Force-Enable

VBT_EN_FORCE VBT LDO Force-Enable Control Signal

0 Disable

1 Enable

ICALBT_EN VBT LDO Bias Current Calibration Code

0 x1

1 x0.5

2 x2

3 x3

ANTIUDSH_BT_DN VBT LDO Anti-Undershoot Disable Control Signal

0 Enable function

1 Disable function

VBT_PLNMOS_DIS VBT LDO Pull-low NMOS disable Signal

0 Enable pull low

1 Disable pull low

VBT_CAL VBT LDO Output Voltage Calibration Code in monotonic transfer function

0000 maximum value

1111 minimum value

VBT_EN VBT LDO Enable Control Signal

0 Disable

1 Enable

VBT_SEL VBT LDO Voltage Selection

0 2.8V

1 1.3V

0x83010838 Control and Status of LDO of V_{cam_d} PMIC_CONE

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	VCAM_D_SEL		VCAM_D_EN	DCV_SLEW_CTRL			VCAM_D_CAL				VCAM_D_PLNMOS_DIS	ANTIUDSH_CAM_D_DN	ICALCAM_D_EN		VCAM_D_ERA_EN_FORCE	VCAM_D_ERA_STATUS
Type	R/W		R/W	R/W			R/W				R/W	R/W	R/W		R/W	RO
Reset	0		0	0			0				0	0	0		0	0

VCAM_D_STATUS VCAM_D LDO ON/OFF Status excluding Force-Enable

VCAM_D_EN_FORCE VCAM_D LDO Force-Enable Control Signal

0 Disable

1 Enable

ICALCAM_D_EN VCAM_D LDO Bias Current Calibration Code

0 x1

1 x0.5

2 x2

3 x3

ANTIUDSH_CAM_D_DN VCAM_D LDO Anti-Undershoot Disable Control Signal

0 Enable function

1 Disable function

VCAM_D_PLNMOS_DIS VCAM_D LDO Pull-low NMOS disable Signal

0 Enable pull low

1 Disable pull low

VCAM_D_CAL VCAM_D LDO Output Voltage Calibration Code in monotonic transfer function

0000 maximum value

1111 minimum value

VCAM_D_EN VCAM_D LDO Enable Control Signal

0 Disable

1 Enable

VCAM_D_SEL VCAM_D LDO Voltage Selection

0 2.8V

1 1.3V

DCV_SLEW_CTRL DCV power slew-rate control

0x8301083C Control and Status of LDO of V_{cam_a}, V_{tcxo}, and V_a PMIC_CONF

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	OC_FOLD_EN	VCAM_A_EN	ICALTCXO_EN		ICALA_EN		VCAM_A_CAL				VCAM_A_SEL		ICALCAM_A_EN		VCAM_A_EN_FORCE	VCAM_A_STATUS
Type	R/W	R/W	R/W		R/W		R/W				R/W		R/W		R/W	RO
Reset	0	0	0		0		0				0		0		0	0

VCAM_A_STATUS VCAM_A LDO ON/OFF Status excluding Force-Enable

VCAM_A_EN_FORCE VCAM_A LDO Force-Enable Control Signal

- **0** Disable
- **1** Enable

ICALCAM_A_EN VCAM_A LDO Bias Current Calibration Code

- **0** x1
- **1** x0.5
- **2** x2
- **3** x3

VCAM_A_CAL VCAM_A LDO Output Voltage Calibration Code in monotonic transfer function

- **0000** maximum value
- **1111** minimum value

VCAM_A_EN VCAM_A LDO Enable Control Signal

- **0** Disable
- **1** Enable

VCAN_A_SEL VCAM_A LDO Voltage Selection

- **0** 2.8V
- **1** 1.3V

ICALTCXO_EN VTCXO LDO Bias Current Calibration Code

- **0** x1
- **1** x0.5
- **2** x2
- **3** x3

ICALA_EN VA LDO Bias Current Calibration Code

- **0** x1
- **1** x0.5
- **2** x2
- **3** x3

OC_FOLD_EN Reserved

0x83010840 Start Up & AUXADC Related Control Register 2 PMIC_CONG

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Name			VBAT_OUT_EN	ISENSE_OUT_EN	TPSEL_LED			LDO_SOFT_ST	THR_SEL	VREF_BG
Type	R/W	R/W	R/W	R/W	R/W			R/W	R/W	R/W
Reset	0	0	0	0	0			0	0	0

VREF_BG Reference voltage fine tuning according to VBG

- **000** initial setting
- **001** plus 1 step
- **010** plus 2 step
- **011** plus 3 step
- **100** minus 4 step
- **101** minus 3 step
- **110** minus 2 step
- **111** minus 1 step

THR_SEL Thermal shut-down threshold fine tuning

- **00** Initial setting
- **01** +10˚C
- **10** -20˚C
- **11** -10˚C

LDO_SOFT_ST Disable the LDO soft-start function

- **0** VM/VIO/VA/VTCXO has soft-start function when turning-on
- **1** VM/VIO/VA/VTCXO has no soft-start function when turning-on

TPSEL_LED Internal Node-set Selection for Mux-out on SCLK/SRST/SCLK2/SRST2. It's reserved for testing purpose.

ISENSE_OUT_EN Pass ISENSE voltage to one of the AUXADC channel

- **0** Disable
- **1** Enable

VBAT_OUT_EN Pass Battery voltage to one of the AUXADC channel

- **0** Disable
- **1** Enable

13.3 Programming Guide

13.3.1 BBRX Register Setup

The register used to control analog base-band receiver is BBRX_AC_CON.

13.3.1.1 Programmable Biasing Current

To maximize the yield in modern digital process, the receiver features providing 5-bit 32-level programmable current to bias internal analog blocks. The 5-bits registers CALBIAS [4:0] is coded with 2's complement format.

13.3.1.2 Offset / Gain Calibration

The base-band downlink receiver (RX), together with the base-band uplink transmitter (TX) introduced in the next section, provides necessary analog hardware for DSP algorithm to correct the mismatch and offset error. The connection for measurement of both RX/TX mismatch and gain error is shown in **Figure** 95, and the corresponding calibration procedure is described below.

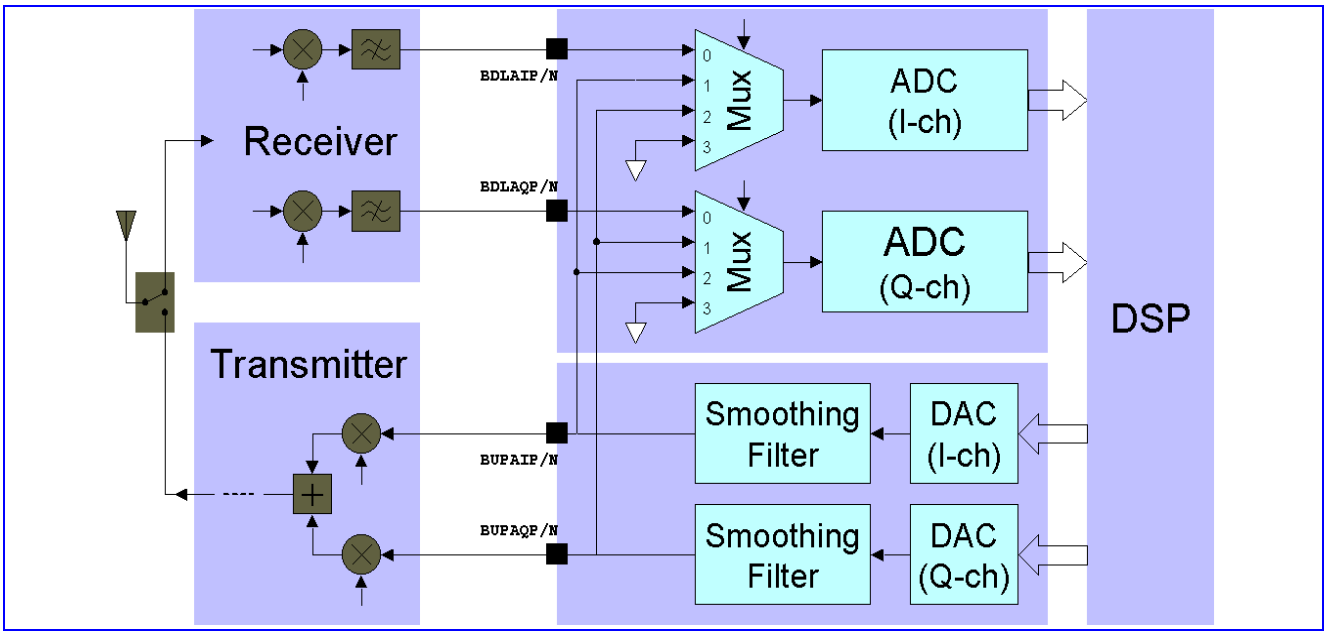


Figure 95 Base-band A/D and D/A Offset and Gain Calibration

13.3.1.3 Downlink RX Offset Error Calibration

The RX offset measurement is achieved by selecting grounded input to A/D converter (set ISEL [1:0] ='11' and QSEL [1:0] ='11' to select channel 3 of the analog input multiplexer, as shown in **Figure** 96. The output of the ADC is sent to DSP for further offset cancellation. The offset cancellation accuracy depends on the number of samples being converted. That is, more accurate measurement can be obtained by collecting more samples followed by averaging algorithm.

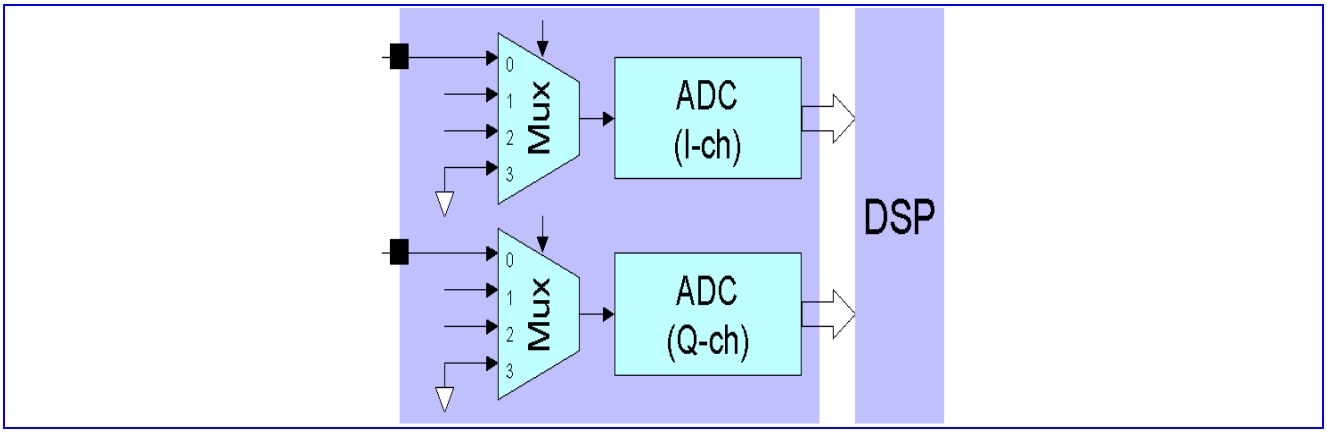


Figure 96 Downlink ADC Offset Error Measurement

13.3.1.4 Downlink RX and Uplink TX Gain Error Calibration

To measure the gain mismatch error, both I/Q uplink TXs should be programmed to produce full-scale pure sinusoidal waves output. Such signals are then fed to downlink RX for A/D conversion, in the following two steps.

A. The uplink I-channel output are connected to the downlink I-channel input, and the uplink Q-channel output are connected to the downlink Q-channel input. This can be achieved by setting ISEL [1:0] ='01' and QSEL [1:0] ='01' (shown in **Figure** 97 (A))..

B. The uplink I-channel output are then connected to the downlink Q-channel input, and the uplink Q-channel output are connected to the downlink I-channel input. This can be achieved by setting ISEL [1:0] ='10' and QSEL [1:0] ='10' (shown in **Figure** 97 (B)).

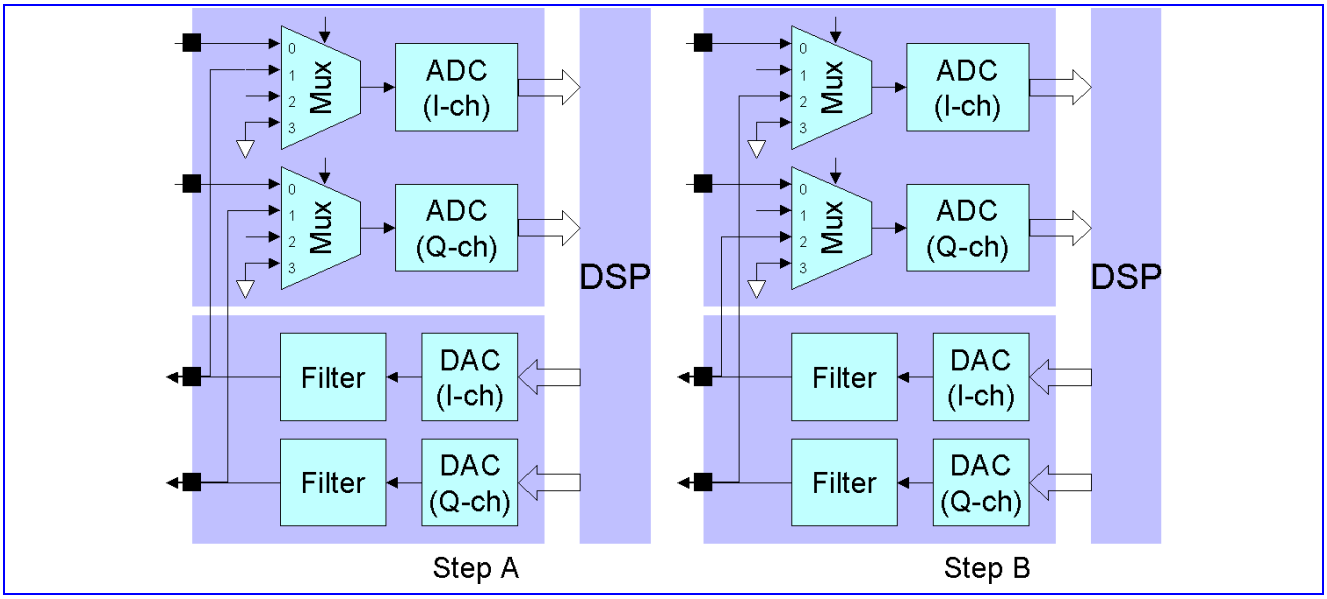


Figure 97 Downlink RX and Up-link TX Gain Mismatch Measurement (A) I/Q TX connect to I/Q RX (B) I/Q TX connect to Q/I RX

Once above successive procedures are completed, RX/TX gain mismatch could be easily obtained because the amplitude mismatch on RX digitized result in step A and B is the sum and difference of RX and TX gain mismatch, respectively.

The gain error of the downlink RX can be corrected in the DSP section and the uplink TX gain error can be corrected by the gain trimming facility that TX block provide.

13.3.1.5 Uplink TX Offset Error Calibration

Once the offset of the downlink RX is known and corrected, the offset of the uplink TX alone could be easily estimated. The offset error of TX should be corrected in the digital domain by means of the programmable feature of the digital GMSK modulator.

Finally, it is important that above three calibration procedures should be exercised in order, that is, correct the RX offset first, then RX/TX gain mismatch, and finally TX offset. This is owing to that analog gain calibration in TX will affect its offset, while the digital offset correction has no effect on gain.

13.3.2 BBTX Register Setup

The register used to control analog base-band transmitter is BBTX_AC_CON0 and BBTX_AC_CON1.

13.3.2.1 Output Gain Control

The output swing of the uplink transmitter is controlled by register GAIN [2:0] coded in 2's complement with about 2dB step. When TRIMI [3:0] / TRIMQ [3:0] = 0 the swing is listed in **Table** 61, defined to be the difference between positive and negative output signal.

GAIN [2:0]	Output Swing	For AVDD=2.8 (V)
+3 (011)	AVDD*0.453 (+2.0 dB)	1.27
+2 (010)	AVDD*0.418 (+1.3 dB)	1.17
+1 (001)	AVDD*0.386 (+0.6 dB)	1.08
+0 (000)	AVDD*0.360 (+0.00 dB)	1
-1 (111)	AVDD*0.336 (-0.6dB)	0.94
-2 (110)	AVDD*0.310 (-1.3 dB)	0.87
-3 (101)	AVDD*0.286 (-2.0 dB)	0.80
-4 (100)	AVDD*0.267 (-2.6 dB)	0.74

Table 61 Output Swing Control Table

13.3.2.2 Output Gain Trimming

I/Q channels can also be trimmed separately to compensate gain mismatch in the base-band transmitter or the whole transmission path including RF module. The gain trimming is adjusted in 16 steps spread from -0.96dB to +0.84dB (**Table** 62), compared to the full-scale range set by GAIN [2:0].

TRIMI [3:0] / TRIMQ [3:0]	Gain Step (dB)
+7 (0111)	0.84
+6 (0110)	0.72
+5 (0101)	0.60
+4 (0100)	0.48
+3 (0011)	0.36
+2 (0010)	0.24
+1 (0001)	0.12
+0 (0000)	0.00
-1 (1111)	-0.12
-2 (1110)	-0.24
-3 (1101)	-0.36
-4 (1100)	-0.48
-5 (1011)	-0.60
-6 (1010)	-0.72
-7 (1001)	-0.84
-8 (1000)	-0.96

Table 62 Gain Trimming Control Table

13.3.2.3 Output Common-Mode Voltage

The output common-mode voltage is controlled by CMV [2:0] with about 0.08*AVDD step, as listed in the following table.

CMV [2:0]	Common-Mode Voltage
+3 (011)	AVDD*0.62
+2 (010)	AVDD*0.58
+1 (001)	AVDD*0.54
+0 (000)	AVDD*0.50
-1 (111)	AVDD*0.46
-2 (110)	AVDD*0.42
-3 (101)	AVDD*0.38
-4 (100)	AVDD*0.34

Table 63 Output Common-Mode Voltage Control Table

13.3.2.4 Programmable Biasing Current

The transmitter features providing 5-bit 32-level programmable current to bias internal analog blocks. The 5-bits registers CALBIAS [4:0] is coded with 2's complement format.

13.3.2.5 Smoothing Filter Characteristic

The 2nd –order Butterworth smoothing filter is used to suppress the image at DAC output: it provides more than 40dB attenuation at the 4.44MHz sampling frequency. To tackle with the digital process component variation, programmable cutoff frequency control bits CALRCSEL [2:0] are included. User can directly change the filter cut-off frequency by different CALRCSEL value (coded with 2's complement format and with a default value 0). In addition, an internal calibration process is provided, by setting START CALRC to high and CALRCCNT to an appropriate value (default is 11). After the calibration process, the filter cut-off frequency is calibrated to 350kHz +/- 50 kHz and a new CALRCOUT value is stored in the register. During the calibration process, the output of the cell is high-impedance.

13.3.3 AFC-DAC Register Setup

The register used to control the APC DAC is AFC_AC_CON, which providing 5-bit 32-level programmable current to bias internal analog blocks. The 5-bits registers CALI [4:0] is coded with 2's complement format.

13.3.4 APC-DAC Register Setup

The register used to control the APC DAC is AFC_AC_CON, which providing 5-bit 32-level programmable current to bias internal analog blocks. The 5-bits registers CALI [4:0] is coded with 2's complement format.

13.3.5 Auxiliary A/D Conversion Register Setup

The register used to control the Aux-ADC is AUX_AC_CON. For this register, which providing 5-bit 32-level programmable current to bias internal analog blocks. The 5-bits registers CALI [4:0] is coded with 2's complement format.

13.3.6 Voice-band Blocks Register Setup

The registers used to control AMB are AFE_VAG_CON, AFE_VAC_CON0, AFE_VAC_CON1, and AFE_VAPDN_CON. For these registers, please refer to chapter "Analog Chip Interface"

13.3.6.1 Reference Circuit

The voice-band blocks include internal bias circuits, a differential bandgap voltage reference circuit

and a differential microphone bias circuit. Internal bias current could be calibrated by varying VCALI[4:0] (coded with 2's complement format).

The differential bandgap circuit generates a low temperature dependent voltage for internal use. For proper operation, there should be an external 47nF capacitor connected between differential output pins AU_VREFP and AU_VREFN. The bandgap voltage (~1.24V[6], typical) also defines the dBm0 reference level through out the audio mixed-signal blocks**.** The following table illustrates typical 0dBm0 voltage when uplink/downlink programmable gains are unity. For other gain setting, 0dBm0 reference level should be scaled accordingly.

Symbol	Parameter	Min	Typical	Max	Unit
$V_{0dBm0,UP}$	0dBm0 Voltage for Uplink Path, Applied Differentially Between Positive and Negative Microphone Input Pins		0.2V		V-rms
$V_{0dBm0,Dn}$	0dBm0 voltage for Downlink Path, Appeared Differentially Between Positive and Negative Power Amplifier Output Pins		0.6V		V-rms

Table 64 0dBm0 reference level for unity uplink/downlink gain

The microphone bias circuit generates a differential output voltage between AU_MICBIAS_P and AU_MICBIAS_N for external electret type microphone. Typical output voltage is 1.9 V. In singled-ended mode, by set VCFG[3] =1, AU_MICBIAS_N is pull down while output voltage is present on AU_MICBIAS_P, respect to ground. The max current supplied by microphone bias circuit is 2mA.

13.3.6.2 Uplink Path

Uplink path of voice-band blocks includes an uplink programmable gain amplifier and a sigma-delta modulator.

13.3.6.2.1 Uplink Programmable Gain Amplifier

Input to the PGA is a multiplexer controlled by VCFG [3:0], as described in the following table. In normal operation, both input AC and DC coupling are feasible for attenuation the input signal (gain <= 0dB). However, only AC coupling is suggested if amplification of input signal is desired (gain>=0dB).

Control Signal	Function	Descriptions
VCFG [0]	Input Selector	0: Input 0 (From AU_VIN0_P / AU_VIN0_N) Is Selected 1: Input 1 (From AU_VIN1_P / AU_VIN1_N) Is Selected

[6] The bandgap voltage could be calibrated by adjusting control signal VBG_CTRL[1:0]. Its default value is [00]. VBG_CTRL not only adjust the bandgap voltage but also vary its temperature dependence. Optimal value of VBG_CTRL is to be determined.

VCFG [1]	Coupling Mode	0: AC Coupling 1: DC Coupling
VCFG [2]	Gain Mode	0: Amplification Mode (gain >= 0 dB) 1: Attenuation Mode (gain <= 0dB)
VCFG [3]	Microphone Biasing	0: Differential Biasing (Take Bias Voltage Between AU_MICBIAS_P and AU_MICBIAS_N) 1: Signal-Ended Biasing (Take Bias Voltage From AU_MICBIAS_P Respected to Ground. AU_MICBIAS_N Is Connected to Ground)

Table 65 Uplink PGA input configuration setting

The PGA itself provides programmable gain (through VUPG [3:0]) with step of 3dB, as listed in the following table.

VCFG [2] ='0'		VCFG [2] ='1'	
VUPG [3:0]	Gain	VUPG [3:0]	Gain
1111	NA	X111	-21dB
1110	42dB	X110	-18dB
1101	39dB	X101	-15dB
1100	36dB	X100	-12dB
1011	33dB	X011	-9dB
1010	30dB	X010	-6dB
1001	27dB	X001	-3dB
1000	24dB	X000	0dB
0111	21dB		
0110	18dB		
0101	15dB		
0100	12dB		
0011	9dB		
0010	6dB		
0001	3dB		
0000	0dB		

Table 66 Uplink PGA gain setting (VUPG [3:0])

The following table illustrates typically the 0dBm0 voltage applied at the microphone inputs, differentially, for several gain settings.

VCFG [2] ='0'		VCFG [2] ='1'	
VUPG [3:0]	0dBm0 (V-rms)	VUPG [3:0]	0dBm0 (V-rms)
1100	3.17mV	X110	1.59V
1000	12.6mV	X100	0.8V
0100	50.2mV	X010	0.4V

0000	0.2V	X000	0.2V

Table 67 0dBm0 voltage at microphone input pins

13.3.6.2.2 Sigma-Delta Modulator

Analog-to-digital conversion in uplink path is made with a second-order sigma-delta modulator (SDM) whose sampling rate is 4096kHz. Output signals are coded in either one-bit or RSD format, optionally controlled by VRSDON register.

For test purpose, one can set VADCINMODE to HI to form a look-back path from downlink DAC output to SDM input. The default value of VADCINMODE is zero.

13.3.6.3 Downlink Path

Downlink path of voice-band blocks includes a digital to analog converter (DAC) and two programmable output power amplifiers.

13.3.6.3.1 Digital to Analog Converter

The DAC converts input bit-stream to analog signal by sampling rate of 4096kHz. . Besides, it performs a 2^{nd}-order 40kHz butterworth filtering. The DAC receives input signals from MT6235 DSP by set VDACINMODE = 0. It can also take inputs from SDM output by setting VDACINMODE = 1.

13.3.6.3.2 Downlink Programmable Power Amplifier

Voice-band analog blocks include two identical output power amplifiers with programmable gain. Amplifier 0 and amplifier 1 can be configured to either differential or single-ended mode by adjusting VDSEND [0] and VDSEND [1], respectively. In single-ended mode, when VDSEND[0] =1, output signal is present at AU_VOUT0_P pin respect to ground. Same as VDSEND[1] for AU_VOUT1_P pin.

For the amplifier itself, programmable gain setting is described in the following table.

VDPG0 [3:0] / VDPG1 [3:0]	Gain
1111	8dB
1110	6dB
1101	4dB
1100	2dB
1011	0dB
1010	-2dB
1001	-4dB
1000	-6dB
0111	-8dB

0110	-10dB
0101	-12dB
0100	-14dB
0011	-16dB
0010	-18dB
0001	-20dB
0000	-22dB

Table 68 Downlink power amplifier gain setting

Control signal VFLOAT, when set to 'HI', is used to make output nodes totally floating in power down mode. If VFLOAT is set to 'LOW" in power down mode, there will be a resistor of 50k ohm (typical) between AU_VOUT0_P and AU_VOUT0_N, as well as between AU_VOUT0_P and AU_VOUT0_N.

The amplifiers deliver signal power to drive external earphone. The minimum resistive load is 28 ohm and the upper limit of the output current is 50mA. On the basis that 3.14dBm0 digital input signal into downlink path produces DAC output differential voltage of 0.87V-rms (typical), the following table illustrates the power amplifier output signal level (in V-rms) and signal power for an external 32 ohm resistive load.

VDPG	Output Signal Level (V-rms)	Output Signal Power (mW / dBm)
0010	0.11	0.37/-4.3
0110	0.27	2.28/3.6
1010	0.69	14.8/11.7
1110	1.74	94.6/19.8

Table 69 Output signal level/power for 3.14dBm0 input. External resistive load = 32 ohm

The following table illustrates the output signal level and power for different resistive load when VDPG =1110.

RLOAD	Output Signal Level (V-rms)	Output Signal Power (mW / dBm)
30	1.74	101/20
100	1.74	30.3/14.8
600	1.74	5/7

Table 70 Output signal level/power for 3.14dBm0 input, VDPG =1110

13.3.6.4 Power Down Control

Each block inside audio mixed-signal blocks features dedicated power-down control, as illustrated in the following table.

Control Signal	Descriptions
VPDN_BIAS	Power Down Reference Circuits (Active Low)
VPDN_LNA	Power Down Uplink PGA (Active Low)
VPDN_ADC	Power Down Uplink SDM (Active Low)
VPDN_DAC	Power Down DAC (Active Low)
VPDN_OUT0	Power Down Downlink Power Amp 0 (Active Low)
VPDN_OUT1	Power Down Downlink Power Amp 1 (Active Low)

Table 71 Voice-band blocks power down control

13.3.7 Audio-band Blocks Register Setup

The registers used to control audio blocks are AFE_AAG_CON, AFE_AAC_CON, and AFE_AAPDN_CON. For these registers, please refer to chapter “Analog Chip Interface”

13.3.7.1 Output Gain Control

Audio blocks include stereo audio DACs and programmable output power amplifiers. The DACs convert input bit-stream to analog signal by sampling rate of Fs*128 where Fs could be 32kHz, 44.1kHz, or 48kHz. Besides, it performs a 2^{nd}-order butterworth filtering. The two identical output power amplifiers with programmable gain are designed to driving external AC-coupled single-end speaker. The minimum resistor load is 16 ohm and the maximum driving current is 50mA. The programmable gain setting, controlled by APGR[] and APGL[], is the same as that of the voice-band amplifiers.

Unlike voice signals, 0dBFS defines the full-scale audio signals amplitude. Based on bandgap reference voltage again, the following table illustrates the power amplifier output signal level (in V-rms) and signal power for an external 16 ohm resistive load.

APGR[]/ APGL[]	Output Signal Level (V-rms)	Output Signal Power (mW / dBm)
0010	0.055	0.19/-7.2
0110	0.135	1.14/0.6
1010	0.345	7.44/8.7
1110	0.87	47.3/16.7

Table 72 Output signal level/power for 0dBFS input. External resistive load = 16 ohm

13.3.7.2 Mute Function and Power Down Control

By setting AMUTER (AMUTEL) to high, right (Left) channel output will be muted.

Each block inside audio mixed-signal blocks features dedicated power-down control, as illustrated in the following table.

Control Signal	Descriptions
APDN_BIAS	Power Down Reference Circuits (Active Low)
APDN_DACL	Power Down L-Channel DAC (Active Low)
APDN_DACR	Power Down R-Channel DAC (Active Low)
APDN_OUTL	Power Down L-Channel Audio Amplifier (Active Low)
APDN_OUTR	Power Down R-Channel Audio Amplifier (Active Low)

Table 73 Audio-band blocks power down control

13.3.8 Multiplexers for Audio and Voice Amplifiers

The audio/voice amplifiers feature accepting signals from various signal sources including AU_FMINR/AU_FMINL pins, that aimed to receive stereo AM/FM signal from external radio chip:

1) Voice-band amplifier 0 accepts signals from voice DAC output only.
2) Voice-band amplifier 1 accepts signal from either voice DAC, audio DAC, or AM/FM radio input pins (controlled by register VBUF1SEL[]). For the last two cases, left and right channel signals will be summed together to form a mono signal first.
3) Audio left/right channel amplifiers receive signals from either voice DAC, audio DAC, or AM/FM radio input pins (controlled by registers ABUFSELL[] and ABUFSELR[]), too. Left and right channel amplifiers will produce identical output waveforms when receiving mono signals from voice DAC.

13.3.9 Preferred Microphone and Earphone Connections

In this section, preferred microphone and earphone connections are discussed.

Differential connection of microphone is shown below. This is the preferred method to obtain the possible best performance. C1 and Rin form an AC coupling and high-pass network. C1*Rin should be chosen such that the in-band signal will not be attenuated too much. For differential minimum resistance of 13k ohm, minimum value of C1 is 170nF for less than 1dB attenuation at 300Hz. R2 is determined by microphone sensitivity. C2 and R2 form another low-pass filter to filtering noise coming from microphone bias pins. Pole frequency less than 50Hz is recommended.

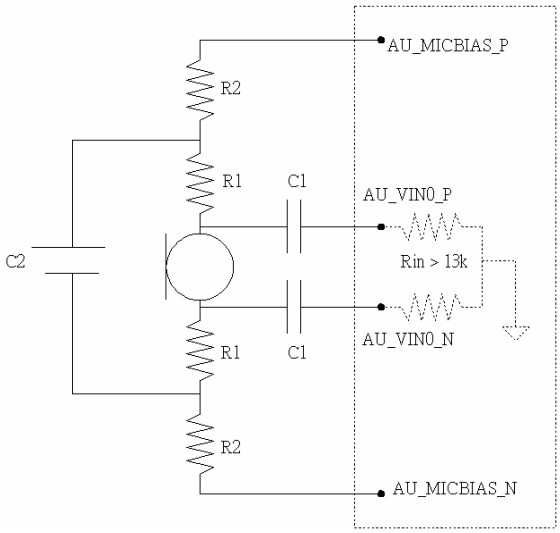


Figure 6 Differential Microphone Connection

For reference, single-ended connection method of microphone is shown below. R1 and R3 are chosen based on microphone sensitivity requirement. C1 and Rin form an AC coupling and high-pass network. R2 and C2 constitute a low-pass network for filtering out noise from microphone bias pins.

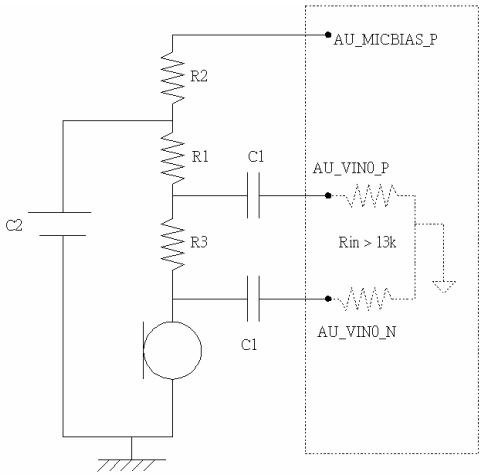


Figure 7 Single-ended Microphone Connection

For earphone, both differential and single-ended connections can be used. Advantage of differential connection includes lower cost and better click-noise immunity. For single-ended connection, an additional AC-coupling capacitor is necessary to not provide DC voltage to earphone. The high-pass cut-off frequency formed by AC-coupling capacitor and earphone equivalent load should be low enough (e.g. < 300 Hz).

13.3.10 Clock Squarer Register Setup

The register used to control clock squarer is CLK_CON. For this register, please refer to chapter "Clocks"

CLKSQ_PLD is used to bypass the clock squarer.

13.3.11 Phase-Locked Loop Register Setup

For registers control the PLL, please refer to chapter "Clocks" and "Software Power Down Control"

13.3.11.1 Frequency Setup

The DSP/MCU PLL itself could be programmable to output either 52MHz or 78MHz clocks. Accompanied with additional digital dividers, 13/26/39/52/65/78 MHz clock outputs are supported.

13.3.11.2 Programmable Biasing Current

The PLLs feature providing 5-bit 32-level programmable current to bias internal analog blocks. The 5-bits registers CALI [4:0] is coded with 2's complement format.

13.3.12 32-khz Crystal Oscillator Register Setup

For registers that control the oscillator, please refer to chapter "Real Time Clock" and "Software Power Down Control".

14 Digital Pin Electrical Characteristics

- **Based on I/O power supply (VDD33) = 3.3 V**
- **Vil (max) = 0.8 V**
- **Vih (min) = 2.0 V**

Ball 13x13	Name	Dir	Driving Iol & Ioh Typ (mA)	Vol at Iol Max (V)	Voh at Ioh Min (V)	PU/PD Resistor			Pull	Cin (pF)
						Min	Typ	Max		
			JTAG Port							
G4	JTRST_B	I				40K	75K	190K	PD	2
G3	JTCK	I				40K	75K	190K	PU	2
G2	JTDI	I				40K	75K	190K	PU	2
G1	JTMS	I				40K	75K	190K	PU	2
H1	JTDO	IO	2/4	0.4	2.4					
H2	JRTCK	IO	2/4	0.4	2.4					
			RF Parallel Control Unit							
AE6	BPI_BUS0	IO	2/4/6/8	0.4	2.4					
AD7	BPI_BUS1	IO	2/4/6/8	0.4	2.4					
AC7	BPI_BUS2	IO	2/4/6/8	0.4	2.4					
AC6	BPI_BUS3	IO	2	0.4	2.4	40K	75K	190K	PU/PD	2
AE8	BPI_BUS4	IO	2	0.4	2.4					
AD8	BPI_BUS5	IO	2	0.4	2.4					
AC8	BPI_BUS6	IO	2	0.4	2.4	40K	75K	190K	PU/PD	2
AB8	BPI_BUS7	IO	2	0.4	2.4	40K	75K	190K	PU/PD	2
AE9	BPI_BUS8	IO	2	0.4	2.4	40K	75K	190K	PU/PD	2
AD9	BPI_BUS9	IO	2	0.4	2.4	40K	75K	190K	PU/PD	2
			RF Serial Control Unit							
AC9	BSI_CS0	IO	2	0.4	2.4					
AE10	BSI_DATA	IO	2/4/6/8	0.4	2.4					
AD10	BSI_CLK	IO	2	0.4	2.4					
			PWM Interface							
AC10	PWM0	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2
AB10	PWM1	IO	2	0.4	2.4	40K	75K	190K	PU/PD	2
AC5	PWM2	IO	4/8			40K	75K	190K	PU/PD	2
AE5	PWM3	IO	4/8	0.4	2.4	40K	75K	190K	PU/PD	2
			Camera Control Interface							
AE4	SCL	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
AD5	SDA	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
			Serial LCD/PM IC Interface							

AC11	LSCK	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2
U11	LSA0	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2
AD12	LSDA	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2
AE12	LSCE0B	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2
AC12	LSCE1B	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2
			Parallel LCD/NAND-Flash Interface							
AB12	LPCE1B	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2
U12	LPCE0B	IO	2/4/6/8	0.4	2.4					
AE13	LPTE	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2
AC13	LRSTB	IO	2/4/6/8	0.4	2.4					
AD13	LRDB	IO	2/4/6/8	0.4	2.4					
U13	LPA0	IO	2/4/6/8	0.4	2.4					
AE14	LWRB	IO	2/4/6/8	0.4	2.4					
AD14	NLD17	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2
AC14	NLD16	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2
AB14	NLD15	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PD	2
U14	NLD14	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PD	2
AE15	NDL13	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PD	2
AD15	NLD12	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PD	2
AC15	NLD11	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PD	2
AB15	NLD10	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PD	2
AE16	NLD9	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PD	2
AD16	NLD8	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PD	2
AC16	NLD7	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PD	2
AB16	NLD6	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PD	2
U16	NLD5	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PD	2
AE17	NLD4	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PD	2
AD17	NLD3	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PD	2
AC17	NLD2	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PD	2
AE18	NLD1	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PD	2
AD18	NLD0	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PD	2
AC18	NRNB	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2
AB18	NCLE	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2
AE19	NALE	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2

AD19	NWEB	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2
AC19	NREB	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2
AB19	NCEB	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2
			USB Interface							
AD20	USB_XTALI	IO								
AE20	USB_XTALO	IO								
AE21	VSSCA_USB	IO								
AD22	VSSCD_USB	IO								
AC21	VRT	IO								
AD23	VSS33_USB	IO								
AE22	USB_DP	IO								
AE23	USB_DM	IO								
			Miscellaneous							
F25	SYSRST_B	I				40K	75K	190K	PU	2
G23	WATCHDOG	IO	2	0.4	2.4					
U10	SRCLKENAN	IO	2	0.4	2.4	40K	75K	190K	PU/PD	2
AE11	SRCLKENA	IO	2	0.4	2.4	40K	75K	190K	PU/PD	2
AD11	SRCLKENAI	IO	2	0.4	2.4	40K	75K	190K	PU/PD	2
B14	TESTMODE	I				40K	75K	190K	PD	2
Y4	VCCQ	I								
AA1	FSOURCE	I								
AD6	SECU_EN	I								
AE7	XBOOT	I				40K	75K	190K	PD	2
			Keypad Interface							
A22	KCOL7	IO	2/4	0.4	2.4	40K	75K	190K	PU/PD	2
B22	KCOL6	IO	2/4	0.4	2.4	40K	75K	190K	PU/PD	2
A21	KCOL5	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU	2
B21	KCOL4	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU	2
C21	KCOL3	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU	2
D21	KCOL2	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU	2
A20	KCOL1	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU	2
B20	KCOL0	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU	2
C20	KROW7	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2
D20	KROW6	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2

A19	KROW5	IO	2/4/6/8	0.4	2.4					
B19	KROW4	IO	2/4/6/8	0.4	2.4					
C19	KROW3	IO	2/4/6/8	0.4	2.4					
A18	KROW2	IO	2	0.4	2.4					
B18	KROW1	IO	2	0.4	2.4					
C18	KROW0	IO	2	0.4	2.4					
External Interrupt Interface										
F24	EINT0	IO	2	0.4	2.4	40K	75K	190K	PU	2
F23	EINT1	IO	2	0.4	2.4	40K	75K	190K	PU	2
E25	EINT2	IO	2	0.4	2.4	40K	75K	190K	PU	2
E24	EINT3	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2
E23	EINT4	IO	2	0.4	2.4	40K	75K	190K	PU/PD	2
D23	EINT5	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2
D25	EINT6	IO	2	0.4	2.4	40K	75K	190K	PU/PD	2
D24	EINT7	IO	2	0.4	2.4	40K	75K	190K	PU/PD	2
K17	MFIQ	IO	2	0.4	2.4	40K	75K	190K	PU/PD	2
External Memory Interface										
G24	ED0	IO	2~16	0.4	2.4					
G22	ED1	IO	2~16	0.4	2.4					
G25	ED2	IO	2~16	0.4	2.4					
H24	ED3	IO	2~16	0.4	2.4					
H23	ED4	IO	2~16	0.4	2.4					
J23	ED5	IO	2~16	0.4	2.4					
J24	ED6	IO	2~16	0.4	2.4					
K22	ED7	IO	2~16	0.4	2.4					
H25	ED8	IO	2~16	0.4	2.4					
J25	ED9	IO	2~16	0.4	2.4					
K23	ED10	IO	2~16	0.4	2.4					
K24	ED11	IO	2~16	0.4	2.4					
K25	ED12	IO	2~16	0.4	2.4					
L17	ED13	IO	2~16	0.4	2.4					
L23	ED14	IO	2~16	0.4	2.4					
L24	ED15	IO	2~16	0.4	2.4					
M25	ERD_B	IO	2~16	0.4	2.4					
N17	EWR_B	IO	2~16	0.4	2.4					
L25	ECS0_B	IO	2~16	0.4	2.4					
M17	ECS1_B	IO	2~16	0.4	2.4					
M23	ECS2_B	IO	2~16	0.4	2.4					
M24	ECS3_B	IO	2~16	0.4	2.4					

R25	EWAIT	IO	2~16	0.4	2.4	40K	75K	190K	PD	2
N25	ECAS_B	IO	2~16	0.4	2.4					
P24	ERAS_B	IO	2~16	0.4	2.4					
P23	ECKE	IO	2~16	0.4	2.4					
N22	ED_CLK	O	2~16	0.4	2.4					
T17	EADMUX	IO	2~16	0.4	2.4	40K	75K	190K	PU/PD	2
R17	EDQM1	IO	2~16	0.4	2.4					
P25	EDQM0	IO	2~16	0.4	2.4					
P17	EADV_B	O	2~16	0.4	2.4					
N24	EC_CLK	O	2~16	0.4	2.4					
T23	EA0	IO	2~16	0.4	2.4					
T22	EA1	IO	2~16	0.4	2.4					
T24	EA2	IO	2~16	0.4	2.4					
T25	EA3	IO	2~16	0.4	2.4					
U23	EA4	IO	2~16	0.4	2.4					
U24	EA5	IO	2~16	0.4	2.4					
U25	EA6	IO	2~16	0.4	2.4					
V23	EA7	IO	2~16	0.4	2.4					
V24	EA8	IO	2~16	0.4	2.4					
V25	EA9	IO	2~16	0.4	2.4					
W22	EA10	IO	2~16	0.4	2.4					
W23	EA11	IO	2~16	0.4	2.4					
W24	EA12	IO	2~16	0.4	2.4					
W25	EA13	IO	2~16	0.4	2.4					
Y23	EA14	IO	2~16	0.4	2.4					
Y24	EA15	IO	2~16	0.4	2.4					
Y25	EA16	IO	2~16	0.4	2.4					
AA23	EA17	IO	2~16	0.4	2.4					

AA24	EA18	IO	2~16	0.4	2.4					
AA25	EA19	IO	2~16	0.4	2.4					
AB24	EA20	IO	2~16	0.4	2.4					
AB25	EA21	IO	2~16	0.4	2.4					
AC23	EA22	IO	2~16	0.4	2.4					
AC24	EA23	IO	2~16	0.4	2.4					
AC25	EA24	IO	2~16	0.4	2.4					
AD24	EA25	IO	2~16	0.4	2.4					
AD25	EA26	IO	2~16	0.4	2.4	40K	75K	190K	PU/PD	2
			Memory Card Interface							
B16	MCCM0	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
C16	MCDA0	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
D16	MCDA1	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
J16	MCDA2	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
C15	MCDA3	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
D15	MCCK	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
J15	MCPWRON	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
C14	MCWP	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
D14	MCINS	IO	4	0.4	2.4	40K	75K	190K	PU/PD	2
			UART/IrDA Interface							
C25	URXD1	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU	2
C24	UTXD1	IO	4/8/12/16	0.4	2.4					
C23	UCTS1	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
B25	URTS1	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
A24	URXD2	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
B24	UTXD2	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
A23	URXD3	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
B23	UTXD3	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
			Digital Audio Interface							
D18	DAICLK	IO	2/4	0.4	2.4	40K	75K	190K	PU/PD	2
A17	DAIPCMOUT	IO	2/4	0.4	2.4	40K	75K	190K	PU/PD	2

B17	DAIPCMIN	IO	2/4	0.4	2.4	40K	75K	190K	PU/PD	2
C17	DAIRST	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2
D17	DAISYNC	IO	2/4/6/8	0.4	2.4	40K	75K	190K	PU/PD	2
CMOS Sensor Interface										
AA2	CMRST	IO	4	0.4	2.4	40K	75K	190K	PU/PD	2
AA3	CMPDN	IO	4	0.4	2.4	40K	75K	190K	PU/PD	2
AB3	CMVREF	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
AB2	CMHREF	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
AA4	CMPCLK	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
AB6	CMMCLK	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
AC2	CMDAT7	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
AC3	CMDAT6	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
AC1	CMDAT5	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
AD1	CMDAT4	IO	4/8/12/16	0.4	2.4	40K	75K	190K	PU/PD	2
AE2	CMDAT3	IO	4	0.4	2.4	40K	75K	190K	PU/PD	2
AD3	CMDAT2	IO	4	0.4	2.4	40K	75K	190K	PU/PD	2
AD4	CMDAT1	IO	4	0.4	2.4	40K	75K	190K	PU/PD	2
AE3	CMDAT0	IO	4	0.4	2.4	40K	75K	190K	PU/PD	2
AC4	CMFLASH	IO	4	0.4	2.4	40K	75K	190K	PU/PD	2