EM785830AD

8-BIT MICRO-CONTROLLER

Version 1.5

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Version History

Specification Revision History	
Version	Content
eFH5830AD	
1.0	Initial version
1.1	Add 17.91MHz main CLK
1.2	ADD eFHP5830D, eFHP5830AD, and eFHP5830BD package
1.3	ADD the description about ADC's offset voltage
1.4	Modify stack level from 16 to 12 Modify program ROM size from 4K to 16K Rename "eFH5830D" to eFH5830AD Remove IDLE mode Remove 17.9MHz main CLK
1.5	Rename from eFH5830AD to EM785830AD

Relative to EM785830AD's ROM-less, OTP and mask:

ROM-less	OTP	Mask
ICE5830	EM78P5830D	EM785830AD
	EM78P5830AD	

Difference between EM785830AD/EM78P5830D/EM78P5830AD

Some differences are betweenEM785830AD, EM78P5830D and EM78P5830AD, these differences are list at next table:

	EM78P5830D	EM78P5830AD	EM785830AD
ADIS (code option bit9)	Un-effect	Un-effect	Must = 1
VERSEL (code option bit10)	Un-effect	Must = 0	Must = 0
PHO (code option bit11)	Un-effect	Must = 0	Must = 0
MS (IOCC page1 bit0)	Must = 1	Un-effect	Un-effect
Stack number	16	16	12

User Application Note

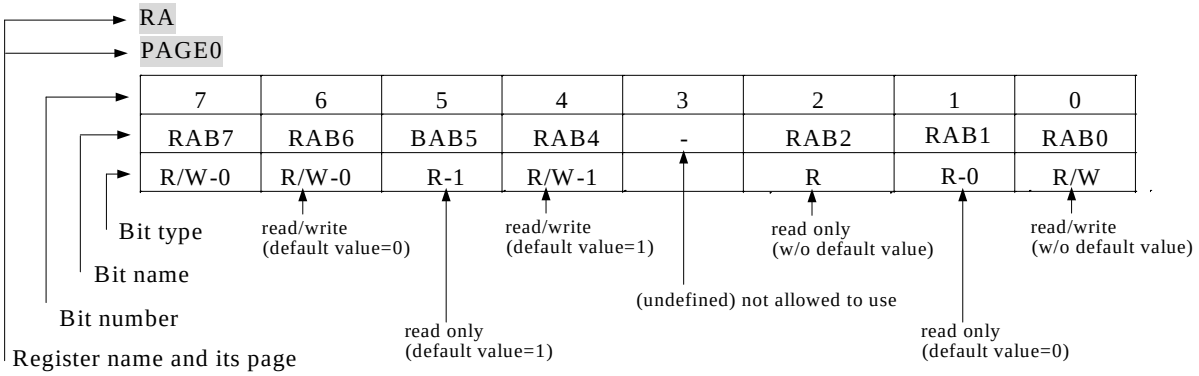
(Before using this chip, take a look at the following description note, it includes important messages.)

1. There are some undefined bits in the registers. The values in these bits are unpredicted. These bits are not allowed to use. We use the symbol "-" in the spec to recognize them. ***A fixed value must be write in some specific unused bits by software or some unpredicted wrong will occur***

These bits are as below:

Register			Default value	Initial Setting value (by user software)	Effect
Register	PAGE	Bit			
R7	1	1	0	0	RAM access will error
RA	2	7	X	1	Un-expect error
RD	0	5~6	X	0	Power consumption increase
RE	0	1~3	0	0	Un-expect error
IOC6	1	7	0	0	LCD display error
IOC8	0	1~7	1	0	Power consumption increase
IOC8	1	1~7	0	0	Power consumption increase
IOCA	1	3,6	X	0	Power consumption increase
IOCB	0	0~7	1	0	Power consumption increase
IOCC	0	4~7	1	0	Power consumption increase
IOCC	1	0	X	***1***	***AD function will error***
IOCC	1	3~7	X	***0***	Un-expect error
IOCE	0	0~3	0	0	Un-expect error
IOCF	0	6~7	0	0	Un-expect error

2. You will see some names for the register bits definitions. Some name will be appear very frequently in the whole spec. The following describes the meaning for the register's definitions such as bit type, bit name, bit number and so on.



3. *Always set IOCC PAGE1 bit 0 = 1 otherwise partial ADC function cannot be used.*
4. *Please do not switch MCU operation mode from normal mode to sleep mode directly. Before into sleep mode, please switch MCU to green mode.*
5. *While switching main clock (regardless of high freq to low freq or on the other hand), adding 6 instructions delay (NOP) is required.*
6. *Offset voltage will effect ADC's result, please refer to figure 20 to detail.*

I. General Description

The EM785830AD is an 8-bit RISC type microprocessor with low power, high speed CMOS technology. There are 16Kx13 bits Memory within it. This integrated single chip has an on_chip watchdog timer (WDT), program ROM, data RAM, LCD driver, programmable real time clock/counter, internal interrupt, power down mode, built-in three-wire SPI, dual PWM(Pulse Width Modulation), 6-channel 10-bit A/D converter and tri-state I/O.

II. Feature

CPU

- Operating voltage : 2.2V~5.5V at main CLK less then 3.58MHz.

Main CLK(Hz)	Under 3.58M	7.16M	10.74M	14.3M
Operating Voltage(min)	2.2	2.5	3	3.6

- 16k x 13 on chip Program Memory.
- 0.5k x 8 on chip data RAM
- Up to 31 bi-directional tri-state I/O ports
- 12 level stack for subroutine nesting
- 8-bit real time clock/counter (TCC)
- two 8-bit counters : COUNTER1 and COUNTER2
- On-chip watchdog timer (WDT)
- 99.9% single instruction cycle commands
- Three operating modes (Main clock can be programmed from 447.829k to 14.3MHz generated by internal PLL)

Mode	CPU status	Main clock	32.768kHz clock status
Sleep mode	Turn off	Turn off	Turn off
Green mode	Turn on	Turn off	Turn on
Normal mode	Turn on	Turn on	Turn on

- Input port interrupt function
- 12 interrupt source, 4 external, 8 internal
- Dual clocks operation (Internal PLL main clock , External 32.768KHz)

SPI

- Serial Peripheral Interface (SPI) : a kind of serial I/O interface
- Interrupt flag available for the read buffer full or transmitter buffer empty.
- Programmable baud rates of communication
- Three-wire synchronous communication. (shared with IO)

PWM

- Dual PWM (Pulse Width Modulation) with 10-bit resolution
- Programmable period (or baud rate)
- Programmable duty cycle

ADC

- Operating : 2.5V 5.5V
- 6-channel 10-bit successive approximation A/D converter
- Internal (VDD) or external reference

POR

- Power-on voltage detector reset

LCD

- Common driver pins : 4
- Segment driver pins : 13
- 1/3 bias
- 1/4 duty, 1/2 duty
- 16 Level LCD contrast control by software

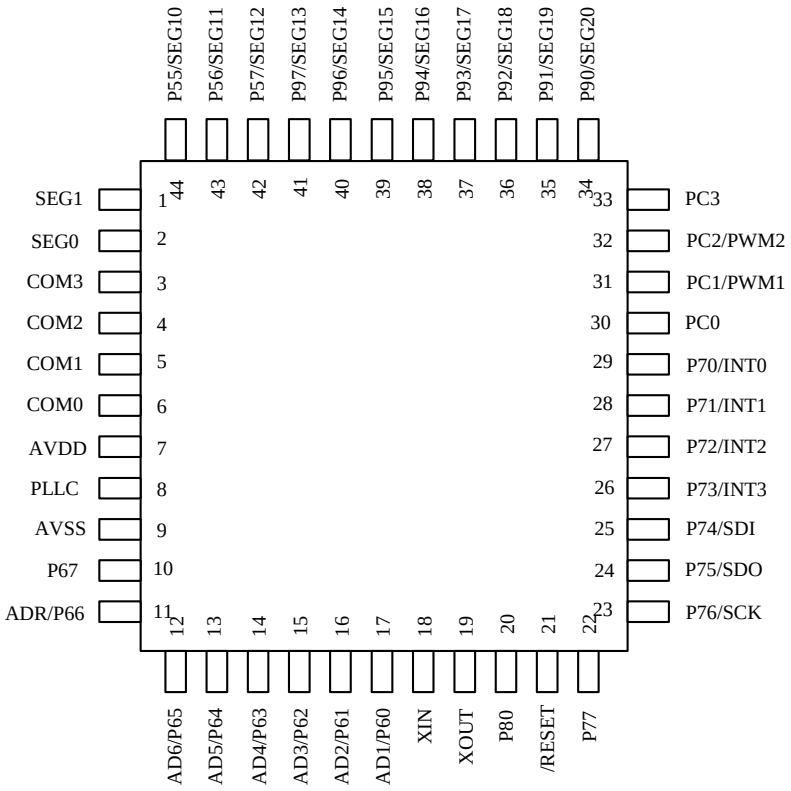
PACKAGE

- EM785830ADQ, EM78P5830DQ, EM78P5830ADQ → 44 pin QFP

III. Application

Communication or general product.

IV. Pin Configuration



EM78P5830DQ,
EM78P5830ADQ
EM785830ADQ

Fig.1: 44-pin QFP assignment

V. Functional Block Diagram

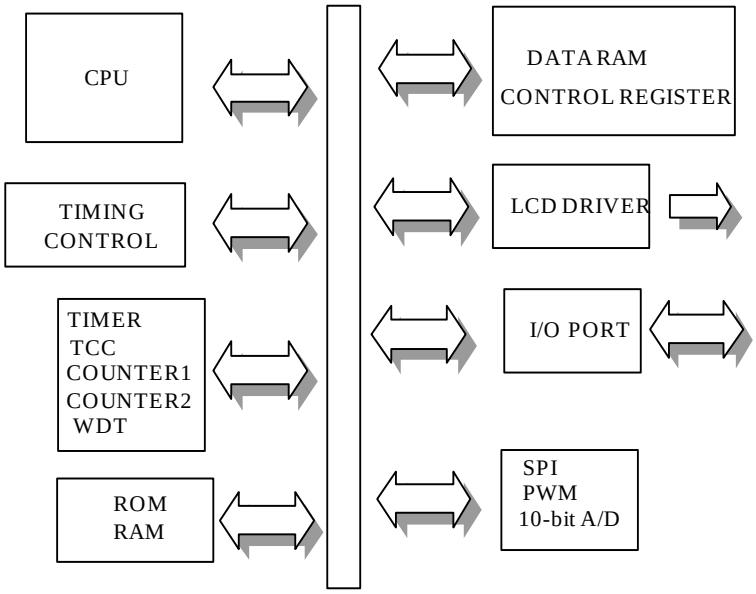


Fig.2a Block diagram

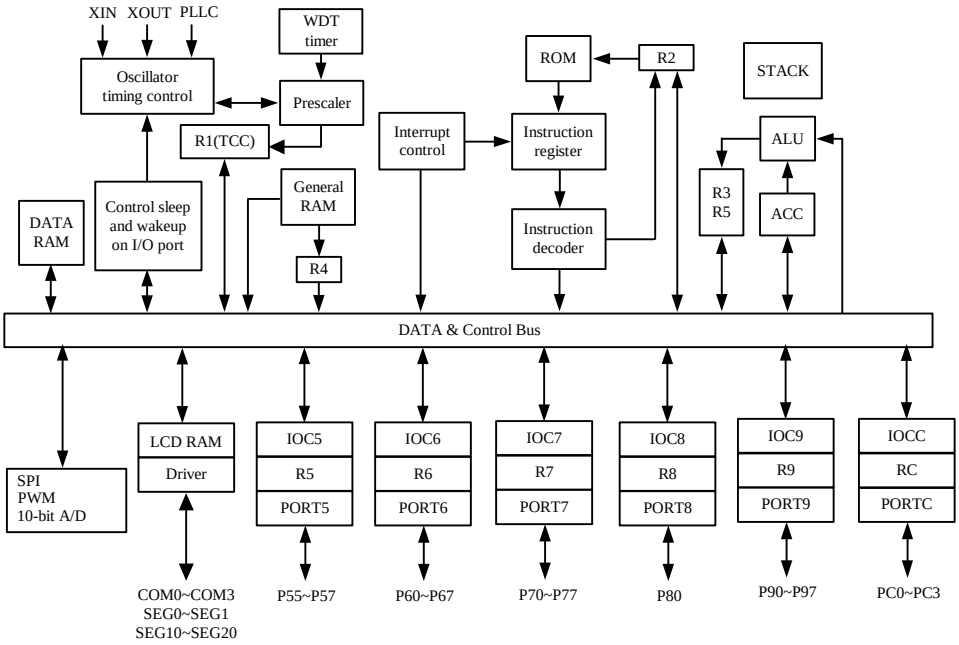


Fig.2b Block diagram

VI. Pin Descriptions

PIN	I/O	DESCRIPTION
POWER		
AVDD	POWER	Power
AVSS	POWER	Ground
CLOCK		
XIN	I	Input pin for 32.768 kHz oscillator
XOUT	O	Output pin for 32.768 kHz oscillator
PLLC	I	Phase loop lock capacitor, connect a capacitor 0.047u to 0.1u to the ground.
LCD		
COM0 ~ COM3	O	Common driver pins of LCD drivers
SEG0 ~ SEG1 SEG10 ~ SEG12 SEG13 ~ SEG20	O O (I/O : PORT5) O (I/O : PORT9)	Segment driver pins of LCD drivers SEG10 to SEG20 are shared with IO PORT.
6 channel 10-bit A/D		
AD1	I (P60)	ADC input channel 1. Shared with PORT60
AD2	I (P61)	ADC input channel 2. Shared with PORT61
AD3	I (P62)	ADC input channel 3. Shared with PORT62
AD4	I (P63)	ADC input channel 4. Shared with PORT63
AD5	I (P64)	ADC input channel 1. Shared with PORT64
AD6	I (P65)	ADC input channel 2. Shared with PORT65
ADR	I (P66)	ADC external reference input. Shared with PORT66
SPI		
SCK	IO (PORT76)	Master: output pin, Slave: input pin. This pin shared with PORT76.
SDO	O (PORT75)	Output pin for serial data transferring. This pin shared with PORT75.
SDI	I (PORT74)	Input pin for receiving data. This pin shared with PORT74.
PWM		
PWM1	O (PC1)	Pulse width modulation output channel 1. This pin is shared with PC1
PWM2	O (PC2)	Pulse width modulation output channel 2. The pin is shared with PC2
IO		
P55~P57	I/O	PORT5 can be INPUT or OUTPUT port each bit. PORT5(7:5) are shared with LCD Segment signal.
P60 ~P67	I/O	PORT6 can be INPUT or OUTPUT port each bit.
P70 ~ P77	I/O	PORT7 can be INPUT or OUTPUT port each bit. PORT7(4~6) are shared with SPI interface pins Internal Pull high function. PORT7(0~3) has interrupt function.
P80	I/O	P80 can be INPUT or OUTPUT port each bit. Internal pull high. PORT80 have wake-up functions(set by RE PAGE0)
P90 ~ P97	I/O	PORT9 can be INPUT or OUTPUT port each bit. PORT90~93 are shared with ADC input. PORT9 are shared with LCD Segment signal.
PC0 ~ PC3	I/O	PORTC can be INPUT or OUTPUT port each bit. PORTC(1~2) are shared with PWM output pins
INT0	(PORT70)	Interrupt sources. Once PORT70 has a falling edge or rising edge signal

		(controlled by CONT register), it will generate a interruption.
INT1	(PORT71)	Interrupt sources which has the same interrupt flag. Any pin from PORT71 has a falling edge signal, it will generate a interruption.
INT2	(PORT72)	Interrupt sources which has the same interrupt flag. Any pin from PORT72 has a falling edge signal, it will generate a interruption.
INT3	(PORT73)	Interrupt sources which has the same interrupt flag. Any pin from PORT73 has a falling edge signal, it will generate a interruption.
/RESET	I	Low reset

VII. Functional Descriptions

VII.1 Operational Registers

Register configuration

	R PAGE registers			
Addr	R PAGE0	R PAGE1	R PAGE2	R PAGE3
00	Indirect addressing			
01	TCC			
02	PC			
03	Page, Status			
04	RAM bank, RSR			
05	Port5 I/O data, Program ROM page	LCD RAM address	SPI control	PWM control
06	Port6 I/O data	LCD RAM data buffer	SPI data buffer	Duty of PWM1
07	Port7 I/O data	Data RAM bank		PWM1 control Duty of PWM1
08	Port8 I/O data	Data RAM address		Period of PWM1
09	Port9 I/O data	Data RAM data buffer		Duty of PWM2
0A	PLL, Main clock, WDTE			PWM2 control Duty of PWM2
0B		ADC output data buffer		Period of PWM2
0C	PortC I/O data	Counter1 data		
0D	LCD control	Counter2 data		
0E	Wake-up control, Interrupt flag			
0F	Interrupt flag			
10 : 1F	16 bytes Common registers			
20 : 3F	Bank0~Bank3 Common registers (32x8 for each bank)			

	IOC PAGE registers	
Addr	IOC PAGE0	IOC PAGE1
00		
01		
02		
03		
04		
05	Port5 I/O control, LCD bias control	
06	Port6 I/O control	Port6 switches
07	Port7 I/O control	Port7 pull high
08	Port8 I/O control	Port8 pull high
09	Port9 I/O control	Port9 switches
0A		

0B		ADC control
0C	PortC I/O control	Port5,8,B,C switch
0D		Clock source(CN1,CN2) Prescaler(CN1,CN2)
0E	Interrupt mask	
0F	Interrupt mask	
10		
:		
1F		
20		
:		
3F		

VII.2 Operational Register Detail Description

R0 (Indirect Addressing Register)

R0 is not a physically implemented register. It is used as indirect addressing pointer. Any instruction using R0 as register actually accesses data pointed by the RAM Select Register (R4).

Example:

```
Mov    A, @0x20        ;store a address at R4 for indirect addressing
Mov    0x04, A
Mov    A, @0xAA        ;write data 0xAA to R20 at bank0 through R0
Mov    0x00, A
```

R1 (TCC)

TCC data buffer. Increased by 16.384KHz or by the instruction cycle clock (controlled by CONT register). Written and read by the program as any other register.

R2 (Program Counter)

The structure is depicted in Fig.3.

Generates 16k × 13 on-chip PROGRAM OTP-ROM addresses to the relative programming instruction codes.

"JMP" instruction allows the direct loading of the low 10 program counter bits.

"CALL" instruction loads the low 10 bits of the PC, PC+1, and then push into the stack.

"RET" ("RETL k", "RETI") instruction loads the program counter with the contents at the top of stack.

"MOV R2, A" allows the loading of an address from the A register to the PC, and the ninth and tenth bits are cleared to "0".

"ADD R2,A" allows a relative address be added to the current PC, and contents of the ninth and tenth bits are cleared to "0".

"TBL" allows a relative address added to the current PC, and contents of the ninth and tenth bits don't change.

The most significant bit (A10~A11) will be loaded with the contents of bit PS0~PS1 in the status register (R5 PAGE0) upon the execution of a "JMP", "CALL", "ADD R2, A", or "MOV R2, A" instruction.

If an interrupt is triggered, PROGRAM ROM will jump to address 0x08 at page0. The CPU will store ACC, R3 status and R5 PAGE automatically, and they will be restored after instruction RETI.

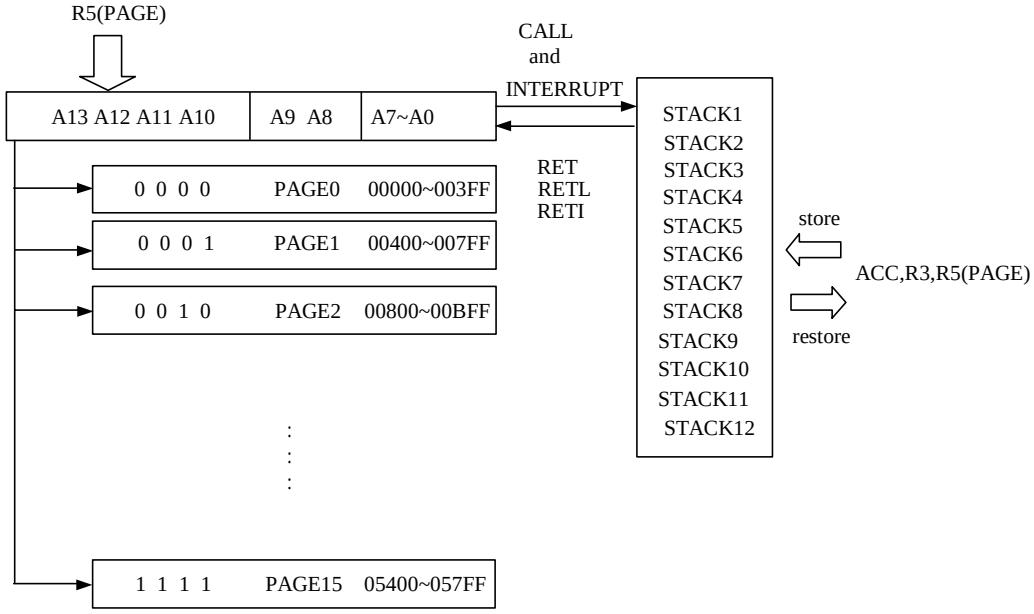


Fig.3 Program counter organization

R3 (Status, Page selection)

(Status flag, Page selection bits)

7	6	5	4	3	2	1	0
RPAGE1	RPAGE0	IOCPAGE	T	P	Z	DC	C
R/W-0	R/W-0	R/W-0	R	R	R/W	R/W	R/W

Bit 0(C) : Carry flag

Bit 1(DC) : Auxiliary carry flag

Bit 2(Z) : Zero flag

Bit 3(P) : Power down bit

Set to 1 during power on or by a "WDTC" command and reset to 0 by a "SLEP" command.

Bit 4(T) : Time-out bit

Set to 1 by the "SLEP" and "WDTC" command, or during power up and reset to 0 by WDT timeout.

EVENT	T	P	REMARK
WDT wake up from sleep mode	0	0	
WDT time out (not sleep mode)	0	1	
/RESET wake up from sleep	1	0	
Power up	1	1	
Low pulse on /RESET	x	X	x : don't care

Bit 5(IOCPAGE) : change IOC5 ~ IOCE to another page

0/1 ➔ IOC page0 / IOC page1

Please refer to VII.1 Operational registers for detail IOC PAGE register configuration.

Bit 6 ~ Bit 7 (RPAGE0 ~ RPAGE1) : change R5 ~ RE to another page

(RPAGE1,RPAGE0)	R page # selected
(0,0)	R page 0
(0,1)	R page 1
(1,0)	R page 2
(1,1)	R page 3

Please refer to VII.1 Operational registers for detail R PAGE register configuration.

R4 (RAM selection for common registers R20 ~ R3F))

(RAM selection register)

7	6	5	4	3	2	1	0
RB1	RB0	RSR5	RSR4	RSR3	RSR2	RSR1	RSR0
R/W-0	R/W-0	R/W	R/W	R/W	R/W	R/W	R/W

Bit 0 ~ Bit 5 (RSR0 ~ RSR5) : Indirect addressing for common registers R20 ~ R3F

RSR bits are used to select up to 32 registers (R20 to R3F) in the indirect addressing mode.

Bit 6 ~ Bit 7 (RB0 ~ RB1) : Bank selection bits for common registers R20 ~ R3F

These selection bits are used to determine which bank is activated among the 4 banks for 32 register (R20 to R3F)..

Please refer to VII.1 Operational registers for details.

R5 (PORT5 I/O data, Program page selection, LCD address, SPI control, PWM control)

PAGE0 (PORT5 I/O data register, Program page register)

7	6	5	4	3	2	1	0
P57	P56	P55	0	PS3	PS2	PS1	PS0
R/W	R/W	R/W	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

Bit 0 ~ Bit 3 (PS0 ~ PS3) : Program page selection bits

PS3	PS2	PS1	PS0	Program memory page (Address)
0	0	0	0	Page 0
0	0	0	1	Page 1
0	0	1	0	Page 2
0	0	1	1	Page 3
:	:	:	:	:
:	:	:	:	:
1	1	1	0	Page 14
1	1	1	1	Page 15

User can use PAGE instruction to change page to maintain program page by user.

Bit 4 : (undefined) not allowed to use. These 2 bits must clear to 0 or some unpredicted wrong will occur.

Bit 5 ~ Bit 7 (P55 ~ P57) : 8-bit PORT5(5~7) I/O data register

User can use IOC register to define input or output each bit.

PAGE1 (LCD address)

7	6	5	4	3	2	1	0
		-	-	LCDA3	LCDA2	LCDA1	LCDA0
				R/W-0	R/W-0	R/W-0	R/W-0

Bit 0 ~ Bit 3 (LCDA0 ~ LCDA3) : LCD address for LCD RAM read or write

The address of the LCD RAM correspond to the COMMON and SEGMENT signals as the table.

COM3 ~ COM0	LCD address (LCDA3 ~ LCDA0)
SEG1, SEG0	00H
SEG9 , SEG2	Un-exist
SEG11, SEG10	05H
SEG13, SEG12	06H
SEG15, SEG14	07H
SEG17, SEG16	08H
SEG19, SEG18	09H
SEG20	0AH

Bit4~Bit7 : *(undefined) not allowed to use*

PAGE2 (SPI control)

7	6	5	4	3	2	1	0
RBF	SPIE	SRO	SE	SCES	SBR2	SBR1	SBR0
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

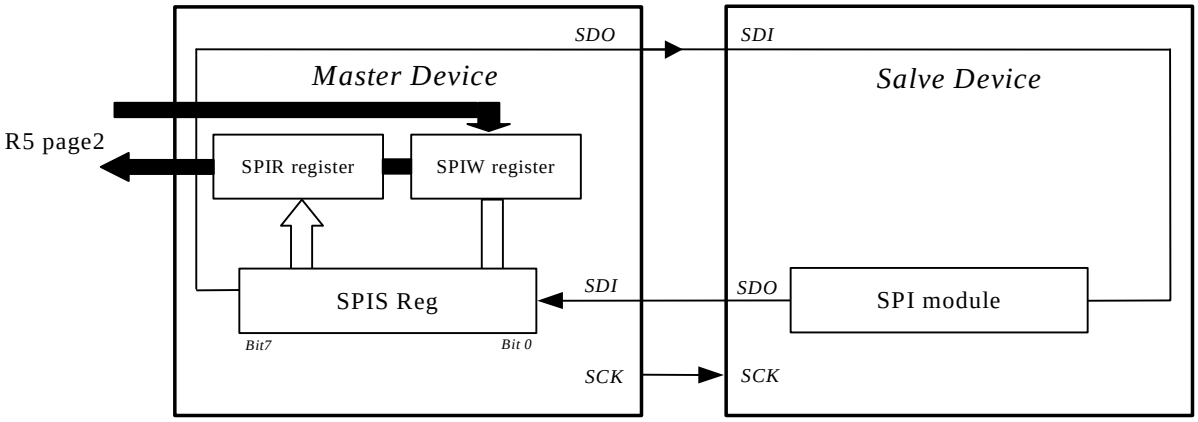


Fig.4 Single SPI Master / Salve Communication

Fig. 4 shows how SPI to communicate with other device by SPI module. If SPI is a master controller, it sends clock through the SCK pin. An 8-bit data is transmitted and received at the same time. If SPI, however, is defined as a slave, its SCK pin could be programmed as an input pin. Data will continue to be shifted on a basis of both the clock rate and the selected edge.

Bit 0 ~ Bit 2 (SBR0 ~ SBR2) : SPI baud rate selection bits

SBR2	SBR1	SBR0	Mode	Baud rate
0	0	0	Master	Fsco
0	0	1	Master	Fsco/2
0	1	0	Master	Fsco/4
0	1	1	Master	Fsco/8
1	0	0	Master	Fsco/16
1	0	1	Master	Fsco/32
1	1	0	Slave	
1	1	1	Master	16.384k

<Note> Fsco = CPU instruction clock

For example :

If PLL is enabled and main clock is selected to 3.5826MHz, the instruction clock is 3.5826MHz/2
➔ Fsco=3.5862MHz/2

If PLL is enabled and main clock is selected to 3.5826MHz, the instruction clock is 0.895MHz/2
➔ Fsco=0.895MHz/2

If PLL is disabled, the instruction clock is 32.768kHz/2 ➔ Fsco=32.768kHz/2.

Bit 3 (SCES) : SPI clock edge selection bit

1➔Data shifts out on falling edge, and shifts in on rising edge. Data is hold during the high level.

0➔Data shifts out on rising edge, and shifts in on falling edge. Data is hold during the low level.

Bit 4 (SE) : SPI shift enable bit

1 ➔ Start to shift, and keep on 1 while the current byte is still being transmitted.

0 ➔ Reset as soon as the shifting is complete, and the next byte is ready to shift.

<Note> This bit has to be reset in software.

Bit 5 (SRO) : SPI read overflow bit

1 ➔ A new data is received while the previous data is still being hold in the SPIB register. In this situation, the data in SPIS register will be destroyed. To avoid setting this bit, users had better to read SPIB register even

if the transmission is implemented only.

0 ➔ No overflow, <Note> This can only occur in slave mode.

Bit 6 (SPIE) : SPI enable bit

1 ➔ Enable SPI mode

0 ➔ Disable SPI mode

Bit 7 (RBF) : SPI read buffer full flag

1 ➔ Receive is finished, SPIB is full.

0 ➔ Receive is not finish yet, SPIB is empty.

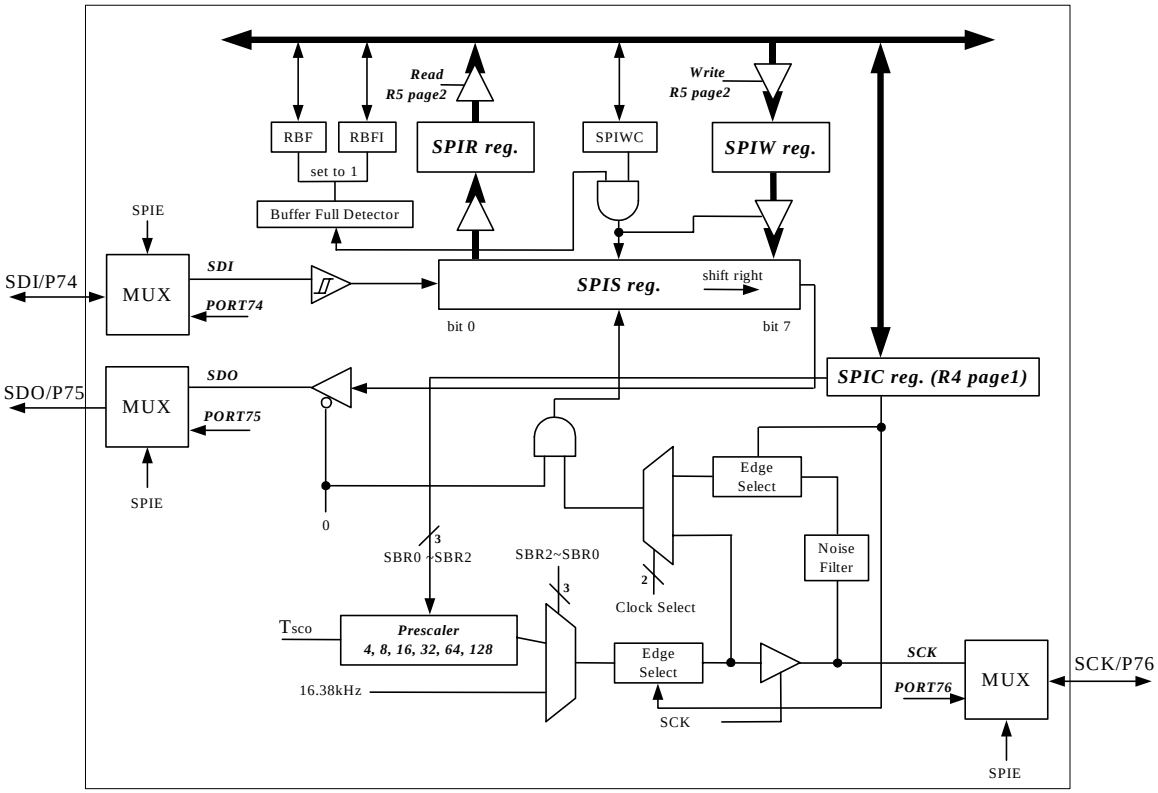


Fig.5 SPI structure

SPIC reg. : SPI control register

SDO/P75 : Serial data out

SDI/P74 : Serial data in

SCK/P76 : Serial clock

RBF : Set by buffer full detector, and reset in software.

RBFI : Interrupt flag. Set by buffer full detector, and reset in software.

Buffer Full Detector : Sets to 1, while an 8-bit shifting is complete.

SE : Loads the data in SPIW register, and begin to shift

SPIE : SPI control register

SPIS reg. : Shifting byte out and in.

The MSB will be shifted first. Both the SPIS register and the SPIW register are loaded at the same time. Once data being written to, SPIS starts transmission / reception. The received data will be moved to the SPIR register, as the shifting of the 8-bit data is complete. The RBF (Read Buffer Full) flag and the RBFI(Read Buffer Full Interrupt) flag are set.

SPIR reg. : Read buffer.

The buffer will be updated as the 8-bit shifting is complete. The data must be read before the next reception is finished. The RBF flag is cleared as the SPIR register read.

SPIW reg. : Write buffer.

The buffer will deny any write until the 8-bit shifting is complete. The SE bit will be kept in 1 if the communication is still under going. This flag must be cleared as the shifting is finished. Users can determine if

the next write attempt is available.
SBR2 ~ SBR0: Programming the clock frequency/rates and sources.
Clock select : Selecting either the internal instruction clock or the external 16.338KHz clock as the shifting clock.
Edge Select : Selecting the appropriate clock edges by programming the SCES bit

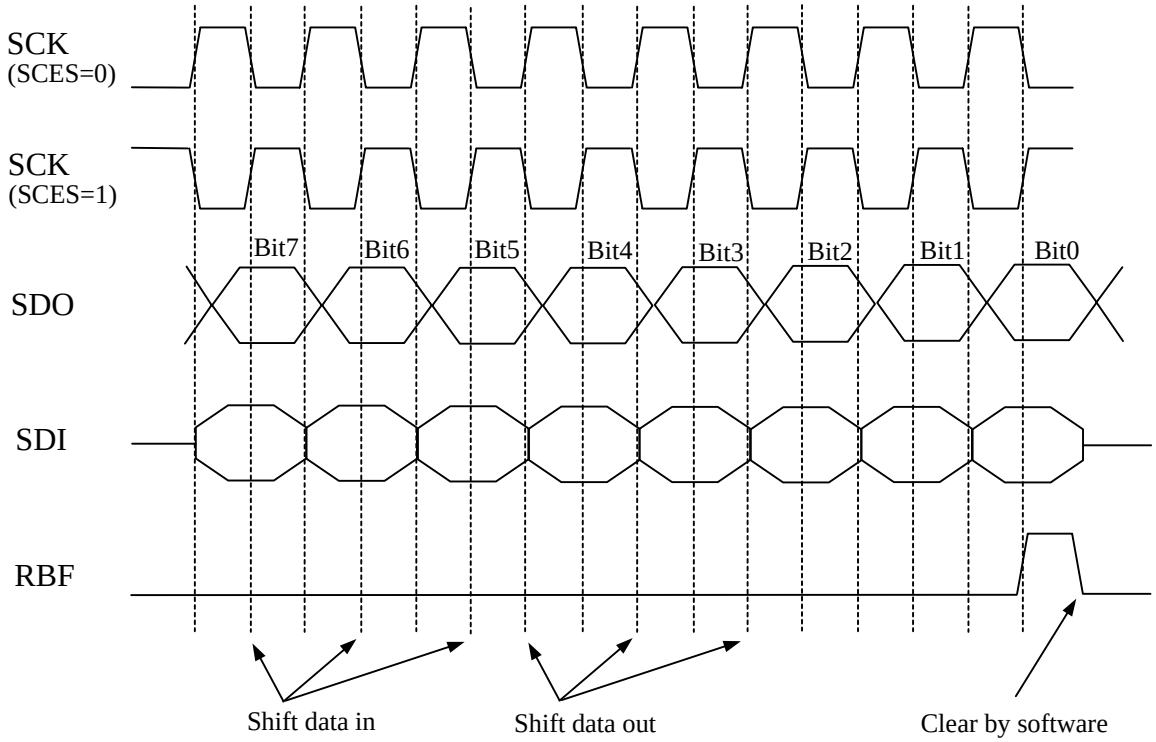


Fig.6 SPI timing

PAGE3 (PWMCON)

7	6	5	4	3	2	1	0
PWM2E	PWM1E	T2EN	T1EN	T2P1	T2P0	T1P1	T1P0
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

Bit 0 ~ Bit 1 (T1P0 ~ T1P1): TMR1 clock prescale option bits.

T1P1	T1P0	Prescale
0	0	1:2(Default)
0	1	1:8
1	0	1:32
1	1	1:64

Bit 2 ~ Bit 3 (T2P0 ~ T2P1): TMR2 clock prescale option bits.

T2P1	T2P0	Prescale
0	0	1:2(Default)
0	1	1:8
1	0	1:32
1	1	1:64

Bit 4 (T1EN): TMR1 enable bit
0 ➔ TMR1 is off (default value).
1 ➔ TMR1 is on.

Bit 5 (T2EN): TMR2 enable bit
0 ➔ TMR2 is off (default value).
1 ➔ TMR2 is on.
Bit 6 (PWM1E): PWM1 enable bit
0 ➔ PWM1 is off (default value), and its related pin carries out the PC1 function;
1 ➔ PWM1 is on, and its related pin will be set to output automatically.
Bit 7 (PWM2E): PWM2 enable bit
0 ➔ PWM2 is off (default value), and its related pin carries out the PC2 function.
1 ➔ PWM2 is on, and its related pin will be set to output automatically.

R6 (PORT6 I/O data, LCD data, SPI data buffer, PWM1 duty)

PAGE0 (PORT6 I/O data register)

7	6	5	4	3	2	1	0
P67	P66	P65	P64	P63	P62	P61	P60
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Bit 0 ~ Bit 8 (P60 ~ P67) : 8-bit PORT6(0~7) I/O data register

User can use IOC register to define input or output each bit.

PAGE1 (LCD data)

7	6	5	4	3	2	1	0
LCDD7	LCDD6	LCDD5	LCDD4	LCDD3	LCDD2	LCDD1	LCDD0
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Bit 0 ~ Bit 7 (LCDD0 ~ LCDD7) : LCD data buffer for LCD RAM read or write

LCD data vs. COM-SEG		LCD address (LCDA3 ~ LCDA0)
LCDD7 ~ LCDD4	LCDD3 ~ LCDD0	
COM3 ~ COM0	COM3 ~ COM0	
SEG1	SEG0	00H
SEG11	SEG10	05H
SEG13	SEG12	06H
SEG15	SEG14	07H
SEG17	SEG16	08H
SEG19	SEG18	09H
X	SEG20	0AH

PAGE2 (SPI data buffer)

7	6	5	4	3	2	1	0
SPIB7	SPIB6	SPIB5	SPIB4	SPIB3	SPIB2	SPIB1	SPIB0
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Bit 0 ~ Bit 7 (SPIB0 ~ SPIB7) : SPI data buffer

If you write data to this register, the data will write to SPIW register. If you read this data, it will read the data from SPIR register. Please refer to figure7

PAGE3 (DT1L: the Least Significant Byte (Bit 7 ~ Bit 0) of Duty Cycle of PWM1)

7	6	5	4	3	2	1	0
PWM1[7]	PWM1[6]	PWM1[5]	PWM1[4]	PWM1[3]	PWM1[2]	PWM1[1]	PWM1[0]
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

A specified value keeps the output of PWM1 to stay at high until the value matches with TMR1.

R7 (PORT7 I/O data, Data RAM bank, PWM1 duty, ADC output and resolution)

PAGE0 (PORT7 I/O data register)

7	6	5	4	3	2	1	0
P77	P76	P75	P74	P73	P72	P71	P70
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Bit 0 ~ Bit 7 (P70 ~ P77) : 8-bit PORT7(0~7) I/O data register

User can use IOC register to define input or output each bit.

PAGE1 (ADC output data(8~9), AD resolution control, Data RAM bank selection bits)

7	6	5	4	3	2	1	0
	-	AD9	AD8	-	ADRES	0	RAM_B0
		R	R		R/W-0	R/W-0	R/W-0

Bit 0 (RAM_B0) : Data RAM bank selection bits

Each bank has address 0 ~ address 255 which is total 256 (0.25k) bytes RAM size.

Data RAM bank selection : (Total RAM = 0.5K)

RAM_B0	RAM bank
0	Bank0
1	Bank1

Bit 1 : Unused. This bit must be 0.

Bit 2(ADRES) : Resolution selection for ADC

0 ➔ ADC is 8-bit resolution

When 8-bit resolution is selected, the most significant(MSB) 8-bit data output of the internal 10-bit ADC will be mapping to RB PAGE1 so R7 PAGE1 bit 4 ~5 will be of no use.

1 ➔ ADC is 10-bit resolution

When 10-bit resolution is selected, 10-bit data output of the internal 10-bit ADC will be exactly mapping to RB PAGE1 and R7 PAGE1 bit 4 ~5.

Bit 3 : (undefined) not allowed to use

Bit 4 ~ Bit 5(AD8 ~ AD9) : The most significant 2 bit of 10-bit ADC conversion output data

Combine there two bits and RB PAGE1 as complete 10-bit ADC conversion output data.

Bit 6~Bit7 : (undefined) not allowed to use

PAGE2 : (undefined) not allowed to use

PAGE3 (DT1H: the Most Significant Byte (Bit 1 ~ Bit 0) of Duty Cycle of PWM1)

7	6	5	4	3	2	1	0
-	-	-	-	-	-	PWM1[9]	PWM1[8]
						R/W-0	R/W-0

Bit 0 ~ Bit 1 (PWM1[8] ~ PWM1[9]): The Most Significant Byte of PWM1 Duty Cycle

A specified value keeps the PWM1 output to stay at high until the value matches with TMR1.

Bit 2 ~ Bit 7 : (undefined) not allowed to use.

R8 (PORT8 I/O data, Data RAM address, PWM1 period)

PAGE0 (PORT8 I/O data register)

7	6	5	4	3	2	1	0
							P80
							R/W

Bit 0 (P80) : PORT80 I/O data register

User can use IOC register to define this pin input or output each bit.

Bit1~Bit7 : (undefined) not allowed to use

PAGE1 (Data RAM address register)

7	6	5	4	3	2	1	0
RAM_A7	RAM_A6	RAM_A5	RAM_A4	RAM_A3	RAM_A2	RAM_A1	RAM_A0
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

Bit 0 ~ Bit 7 (RAM_A0 ~ RAM_A7) : data RAM address

The data RAM bank's selection is from R7 PAGE1 bit0 (RAM_B0).

PAGE2 : (undefined) not allowed to use

PAGE3 (PRD1: Period of PWM1)

7	6	5	4	3	2	1	0
PRD1[7]	PRD1[6]	PRD1[5]	PRD1[4]	PRD1[3]	PRD1[2]	PRD1[1]	PRD1[0]
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

The content of this register is a period (time base) of PWM1. The frequency of PWM1 is the reverse of the period.

R9 (PORT9 I/O data, Data RAM data buffer, PWM2 duty)

PAGE0 (PORT9 I/O data register)

7	6	5	4	3	2	1	0
P97	P96	P95	P94	P93	P92	P91	P90
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Bit 0 ~ Bit 7 (P90 ~ P97) : 8-bit PORT9(0~7) I/O data register

User can use IOC register to define input or output each bit.

PAGE1 (Data RAM data register)

7	6	5	4	3	2	1	0
RAM_D7	RAM_D6	RAM_D5	RAM_D4	RAM_D3	RAM_D2	RAM_D1	RAM_D0
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Bit 0 ~ Bit 7 (RAM_D0 ~ RAM_D7) : Data RAM's data

The address for data RAM is accessed from R8 PAGE1. The data RAM bank is selected by R7 PAGE1 Bit 0 (RAM_B0).

PAGE2 (undefined) not allowed to use

PAGE3 (DT2L: the Least Significant Byte (Bit 7 ~ Bit 0) of Duty Cycle of PWM2)

7	6	5	4	3	2	1	0
PWM2[7]	PWM2[6]	PWM2[5]	PWM2[4]	PWM2[3]	PWM2[2]	PWM2[1]	PWM2[0]
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

A specified value keeps the output of PWM2 to stay at high until the value matches with TMR2.

RA (PLL, Main clock selection, Comparator flag, Watchdog timer, PWM2 duty, LCD option)

PAGE0 (PLL enable bit, Main clock selection bits, Comparator control bits, Watchdog timer enable bit)

7	6	5	4	3	2	1	0
0	PLLEN	CLK2	CLK1	CLK0	-	-	WDTEN
R/W-0	R/W-0	R/W-0	R/W-1	R/W-1			R/W-0

Bit 0(WDTEN) : Watch dog control bit

0/1 ➔ disable/enable

User can use WDTC instruction to clear watch dog counter. The counter 's clock source is 32768/2 Hz. If the prescaler assigns to TCC. Watch dog will time out by (1/32768)*2 * 256 = 15.616mS. If the prescaler assigns to WDT, the time of time out will be more times depending on the ratio of prescaler.

Bit 1 ~ Bit 2 : (undefined) not allowed to use

Bit 3 ~ Bit 5 (CLK0 ~ CLK2) : MAIN clock selection bits

User can choose different frequency of main clock by CLK1 and CLK2. All the clock selection is list below.

PLLEN	CLK2	CLK1	CLK0	Sub clock	MAIN clock	CPU clock
1	0	0	0	32.768kHz	447.829kHz	447.829kHz (Normal mode)
1	0	0	1	32.768kHz	895.658kHz	895.658kHz (Normal mode)
1	0	1	0	32.768kHz	1.791MHz	1.791MHz (Normal mode)
1	0	1	1	32.768kHz	3.582MHz	3.582MHz (Normal mode)
1	1	0	0	32.768kHz	7.165MHz	7.165MHz (Normal mode)
1	1	0	1	32.768kHz	10.747MHz	10.747MHz (Normal mode)
1	1	1	0	32.768kHz	14.331MHz	14.331MHz (Normal mode)
1	1	1	1	***Can't allowed to used***		
0	don't care	don't care	don't care	32.768kHz	don't care	32.768kHz (Green mode)

Bit 6(PLLEN) : PLL's power control bit which is CPU mode control register

0/1 ➔ disable PLL/enable PLL

If enable PLL, CPU will operate at normal mode (high frequency). Otherwise, it will run at green mode (low frequency, 32768 Hz).

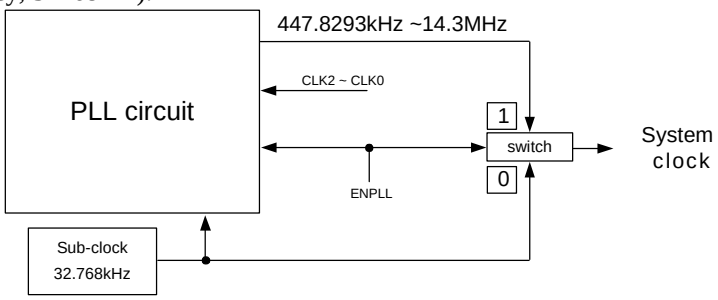


Fig.7 The relation between 32.768kHz and PLL

Bit 7: Unused register. Always keep this bit to 0 or some un-expect error will happen!

The status after wake-up and the wake-up sources list as the table below.

Wakeup signal	SLEEP mode
	RA(7,6)=(0,0) + SLEP
TCC time out IOCF bit0=1	No function
COUNTER1 time out IOCF bit1=1	No function
COUNTER2 time out IOCF bit2=2	No function
WDT time out	Reset and jump to address 0
PORT7(0~3)	Reset and Jump to

IOCF bit3 or bit4 or bit5 or bit7=1	address 0

<Note> PORT70 's wakeup function is controlled by IOCF bit 3. It's falling edge or rising edge trigger (controlled by CONT register bit7).
PORT7(1~3) 's wakeup functions are controlled by IOCF bit (4,5,7). They are falling edge trigger.
PORT80's wakeup function is controlled by RE PAGE0 bit 0 . This is falling edge trigger.

PAGE1 (undefined, not allowed to use)

PAGE2 (Undefined, not allowed to use)

7	6	5	4	3	2	1	0
1	X	X	X	X	X	X	X
RW-0	-	-	-	-	-	-	-

Bit0~Bit6 : (undefined) not allowed to use.

Bit 7 :Unused. Please set this bit to 1.

PAGE3 (DT2H: the Most Significant Byte (Bit 1 ~ Bit 0) of Duty Cycle of PWM2)

7	6	5	4	3	2	1	0
X	X	X	X	X	X	PWM2[9]	PWM2[8]
-	-	-	-	-	-	R/W-0	R/W-0

Bit 0 ~ Bit 1 (PWM2[8] ~ PWM2[9]): The Most Significant Byte of PWM1 Duty Cycle
A specified value keeps the PWM1 output to stay at high until the value matches with TMR1.
Bit 2 ~ Bit 7 : (undefined) not allowed to use

RB (ADC output data buffer, PWM2 period)

PAGE0 (Undefined, not allowed to use)

PAGE1 (ADC output data register)

7	6	5	4	3	2	1	0
AD7	AD6	AD5	AD4	AD3	AD2	AD1	AD0
R	R	R	R	R	R	R	R

Bit 0 ~ Bit 7 (AD0 ~ AD7) : These 8 bit is full ADC data buffer when 8-bit resolution is selected(R7 page1 bit 2 ADREF = 0), or the least significant 8-bit data when 10 bit resolution(ADREF = 1) selected..

PAGE2(Undefined, not allowed to use)

PAGE3 (PRD2: Period of PWM2)

7	6	5	4	3	2	1	0
PRD2[7]	PRD2[6]	PRD2[5]	PRD2[4]	PRD2[3]	PRD2[2]	PRD2[1]	PRD2[0]
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

The content of this register is a period (time base) of PWM2. The frequency of PWM2 is the reverse of the period.

RC (PORTC I/O data, Counter1 data, PWM1 duty latch)

PAGE0 (PORT9 I/O data register)

7	6	5	4	3	2	1	0
				PC3	PC2	PC1	PC0
				R/W	R/W	R/W	R/W

Bit 0 ~ Bit 3 (PC0 ~ PC3) : 4-bit PORTC(0~3) I/O data register
User can use IOC register to define input or output each bit.
Bit4 ~ Bit7 : ***Undefined. Not allowed to used .***

PAGE1 (Counter1 data register)

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
CN17	CN16	CN15	CN14	CN13	CN12	CN11	CN10
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

Bit 0 ~ Bit 7 (CN10 ~ CN17) : Counter1's buffer that user can read and write.
Counter1 is a 8-bit up-counter with 8-bit prescaler that user can use RC PAGE1 to preset and read the counter.(write ➔ preset) After a interruption , it will reload the preset value.
Example for writing :
MOV 0x0C, A ; write the data at accumulator to counter1 (preset)
Example for reading :
MOV A, 0x0C ; read the data at counter1 to accumulator

PAGE2 (***Undefined, not allowed to use***)
PAGE3 (***Undefined, not allowed to use***)

RD (LCD control, Counter2 data, PWM1,2 duty latch)

PAGE0 (LCD driver control bits)

7	6	5	4	3	2	1	0
-	***0***	***0***	***1***	-	LCD_C1	LCD_C0	LCD_M
	R/W-0	R/W-0	R/W-0		R/W-0	R/W-0	R/W-0

Bit 0 (LCD_M) : LCD operation method including duty and frame frequency
Bit 1 ~ Bit 2 (LCD_C0 ~ LCD_C1) : LCD display control

LCD_C1	LCD_C0	LCD_M	LCD Display Control	Duty	Bias
0	0	0	change duty	1/4	1/3
		1	Disable(turn off LCD)	1/2	1/3
0	1	:	Blanking	:	:
1	1	:	LCD display enable	:	:

Ps. To change the display duty must set the "LCD_C1 ,LCD_C0" to "00".
The controller can drive LCD directly. The LCD block is made up of common driver, segment driver, display LCD RAM, common output pins, segment output pins and LCD operating power supply. The basic structure contains a timing control. This timing control uses the basic frequency 32.768KHz to generate the proper timing for different duty and display access.
RD PAGE0 Bit 0 ~ Bit 2 are LCD control bits for LCD driver. These LCD control bits determine the duty, the number of common and the frame frequency. The LCD display (disable, enable, blanking) is controlled by Bit 1 and Bit 2. The driving duty is decided by Bit 0. The display data is stored in LCD RAM which address and data access controlled by registers R5 PAGE1 and R6 PAGE1.
User can regulate the contrast of LCD display by IOC5 PAGE0 Bit 0 ~ Bit 3 (BIAS0 ~ BIAS3). Up to 16 levels contrast is convenient for better display.
Bit 3 , Bit 7 : *(undefined) not allowed to use*
Bit4 ~ Bit6 : These 3 bits are unused in mask/OTP EM785830, but they are used for ICE5830. About the definition of these 3 bits, please refer to appendixII. In ICE5830, please clear bit5 and bit6 to 0 and set bit4 to 1.

PAGE1 (Counter2 data register)

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
CN27	CN26	CN25	CN24	CN23	CN22	CN21	CN20
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

Bit 0 ~ Bit 7 (CN20 ~ CN27) : Counter2's buffer that user can read and write.

Counter2 is a 8-bit up-counter with 8-bit prescaler that user can use RD PAGE1 to preset and read the counter.(write ➔ preset) After a interruption, it will reload the preset value.

Example for writing :

```
MOV   0x0D, A   ; write the data at accumulator to counter2 (preset)
```

Example for reading :

```
MOV   A, 0x0D   ; read the data at counter2 to accumulator
```

PAGE2 (***Undefined, not allowed to use***)

PAGE3 (***Undefined, not allowed to use***)

RE (Interrupt flag, Wake-up control, PWM2 duty latch)

PAGE0 (Interrupt flag, Wake-up control bits)

7	6	5	4	3	2	1	0
PWM2	RBF	ADI	PWM1	0	0	0	/WUP80
R/W	R/W-0	R/W-0	R/W-0				R/W-0

Bit 0 (/WUP80) : PORT80 wake-up control, 0/1 ➔ disable/enable P80 pin wake-up function

Bit 1~Bit 3 : Undefined. These 3 bits must clear to 0 or unpredicted wrong will occur.

Bit 4 (PWM1) : PWM1 (Pulse Width Modulation channel 1) interrupt flag

Set when a selected period is reached, reset by software.

Bit 5 (ADI) : ADC interrupt flag after a sampling

Bit 6 (RBF) : SPI data transfer complete interrupt

If SPI's RBF signal has a rising edge signal (RBF set to "1" when transfer data completely), CPU will set this bit.

Bit 7 (PWM2) : PWM2 (Pulse Width Modulation channel 2) interrupt flag

Set when a selected period is reached, reset by software.

PAGE1~PAGE3(***Undefined, not allowed to use***)

RF (Interrupt status)

(Interrupt status register)

7	6	5	4	3	2	1	0
INT3	-	INT2	INT1	INT0	CNT2	CNT1	TCIF
R/W-0		R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

"1" means interrupt request, "0" means non-interrupt

Bit 0(TCIF) : TCC timer overflow interrupt flag

Set when TCC timer overflows.

Bit 1(CNT1) : counter1 timer overflow interrupt flag

Set when counter1 timer overflows.

Bit 2(CNT2) : counter2 timer overflow interrupt flag

Set when counter2 timer overflows.

Bit 3(INT0) : external INT0 pin interrupt flag

If PORT70 has a falling edge/rising edge (controlled by CONT register) trigger signal, CPU will set this bit.

Bit 4(INT1) : external INT1 pin interrupt flag

If PORT71 has a falling edge trigger signal, CPU will set this bit.

Bit 5(INT2) : external INT2 pin interrupt flag

If PORT72 has a falling edge trigger signal, CPU will set this bit.

Bit 6 : *(undefined) not allowed to use*

Bit 7(INT3) : external INT3 pin interrupt flag

If PORT73 has a falling edge trigger signal, CPU will set this bit.

<Note> IOCF is the interrupt mask register. User can read and clear.

Trigger edge as the table

Signal	Trigger
TCC	Time out
COUNTER1	Time out
COUNTER2	Time out
INT0	Falling Rising edge
INT1	Falling edge
INT2	Falling edge
INT3	Falling edge

R10~R3F (General Purpose Register)

R10~R3F (Banks 0 ~ 3) : all are general purpose registers.

VII.3 Special Purpose Registers

A (Accumulator)

Internal data transfer, or instruction operand holding

It's not an addressable register.

CONT (Control Register)

7	6	5	4	3	2	1	0
P70EG	INT	TS	RETBK	PAB	PSR2	PSR1	PSR0

Bit 0 ~ Bit 2 (PSR0 ~ PSR2) : TCC/WDT prescaler bits

PSR2	PSR1	PSR0	TCC rate	WDT rate
0	0	0	1:2	1:1
0	0	1	1:4	1:2
0	1	0	1:8	1:4
0	1	1	1:16	1:8
1	0	0	1:32	1:16
1	0	1	1:64	1:32
1	1	0	1:128	1:64
1	1	1	1:256	1:128

Bit 3(PAB) : Prescaler assignment bit

0/1 ➔ TCC/WDT

Bit 4(RETBK) : Return value backup control for interrupt routine

0 ➔ disable/enable

When this bit is set to 1, the CPU will store ACC,R3 status and R5 PAGE automatically after an interrupt is triggered. And it will be restored after instruction RETI. When this bit is set to 0, the user need to store ACC, R3 and R5 PAGE in user program.

Bit 5(TS) : TCC signal source

0 ➔ internal instruction cycle clock

1 ➔ 16.384kHz

Bit 6 (INT) : INT enable flag

0 ➔ interrupt masked by DISI or hardware interrupt

1 ➔ interrupt enabled by ENI/RETI instructions

Bit 7(P70EG) : interrupt edge type of P70

0 ➔ P70 's interruption source is a rising edge signal.

1 ➔ P70 's interruption source is a falling edge signal.

CONT register is readable (CONTR) and writable (CONTW).

TCC and WDT :

There is an 8-bit counter available as prescaler for the TCC or WDT. The prescaler is available for the TCC only or WDT only at the same time.

An 8 bit counter is available for TCC or WDT determined by the status of the bit 3 (PAB) of the CONT register.

See the prescaler ratio in CONT register.

Fig.8 depicts the circuit diagram of TCC/WDT.

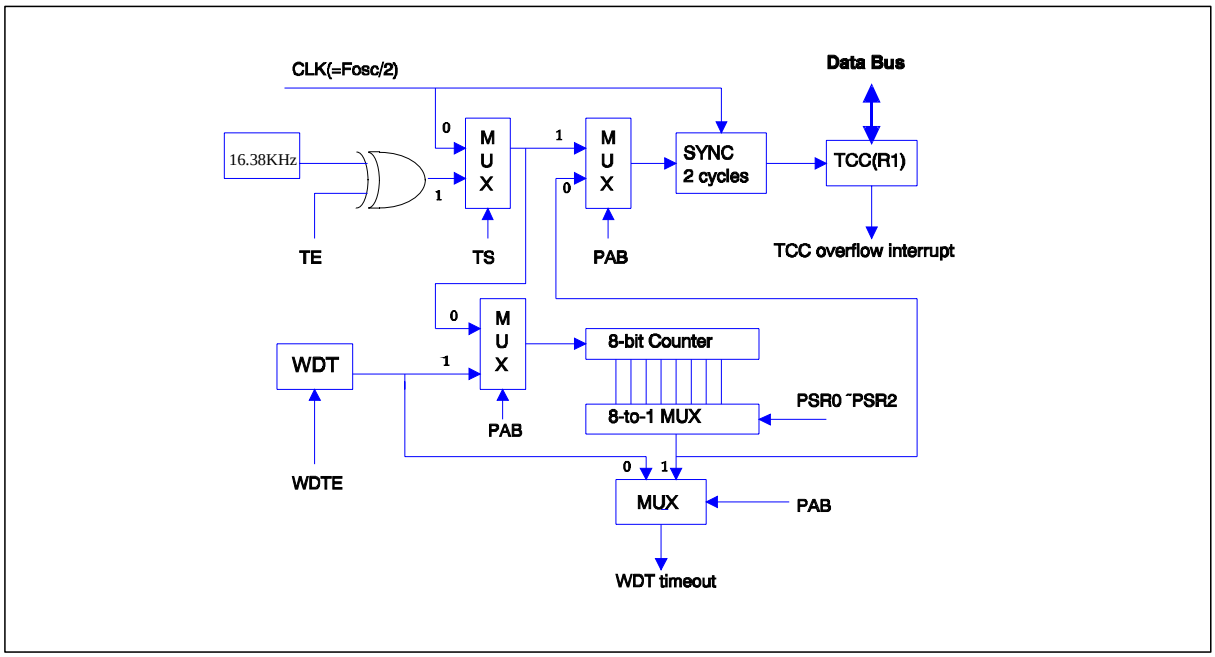


Fig.8 Block diagram of TCC WDT

IOC5 (PORT5 I/O control, LCD bias control)

PAGE0 (LCD bias control bits)

7	6	5	4	3	2	1	0
IOC57	IOC56	IOC55	-	BIAS3	BIAS2	BIAS1	BIAS0
R/W-1	R/W-1	R/W-1		R/W-0	R/W-0	R/W-0	R/W-0

Bit 0 ~ Bit 3 (BIAS0 ~ BIAS3) : LCD operation voltage selection. V1 = VDD * (1 - n/60)

BIAS3	BIAS2	BIAS1	BIAS0	Vop (=VDD-VLCD)	Example (VDD = 3V)
0	0	0	0	VDD * (1-0/60)	3V
0	0	0	1	VDD * (1-1/60)	2.95V
0	0	1	0	VDD * (1-2/60)	2.90V
0	0	1	1	VDD * (1-3/60)	2.85V
0	1	0	0	VDD * (1-4/60)	2.80V
:	:	:	:	:	:
1	1	0	1	VDD * (1-13/60)	2.35V
1	1	1	0	VDD * (1-14/60)	2.30V
1	1	1	1	VDD * (1-15/60)	2.25V

Bit 4 : (undefined) not allowed to use

Bit 5 ~ Bit 7 (IOC55 ~ IOC57) : PORT5(5~7) I/O direction control register

0 ➔ put the relative I/O pin as output

1 ➔ put the relative I/O pin into high impedance

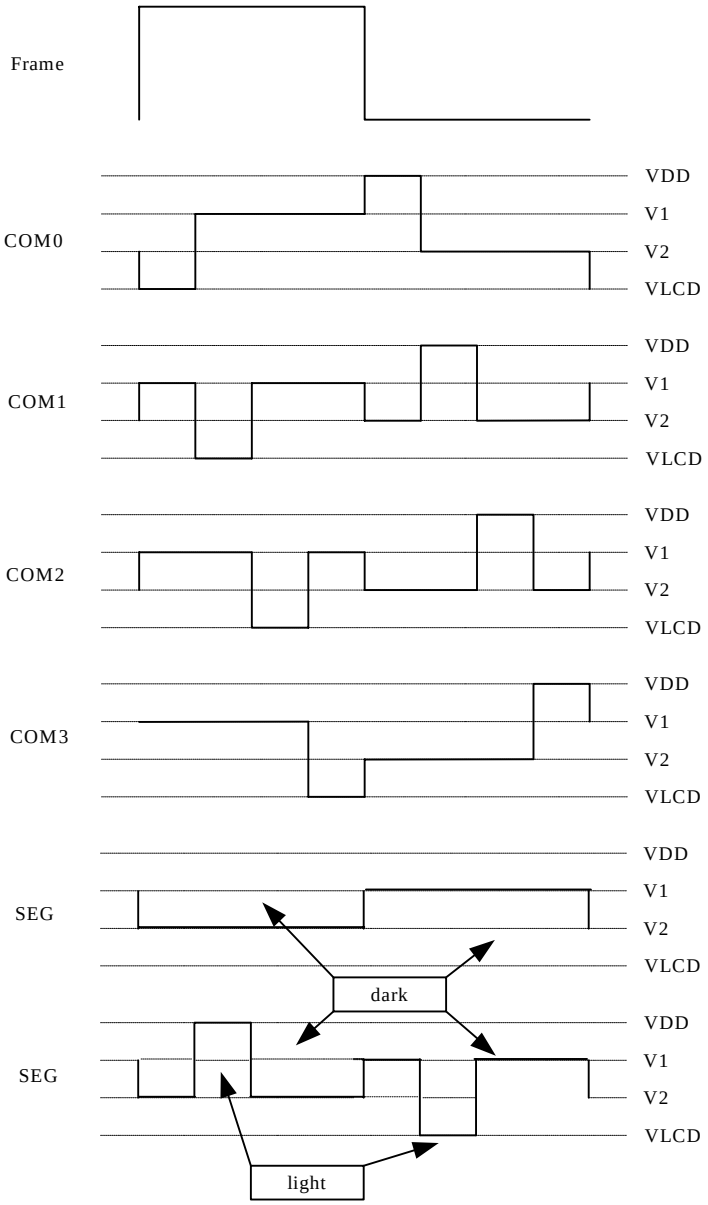


Fig.10 LCD waveform for 1/3 bias, 1/4 duty

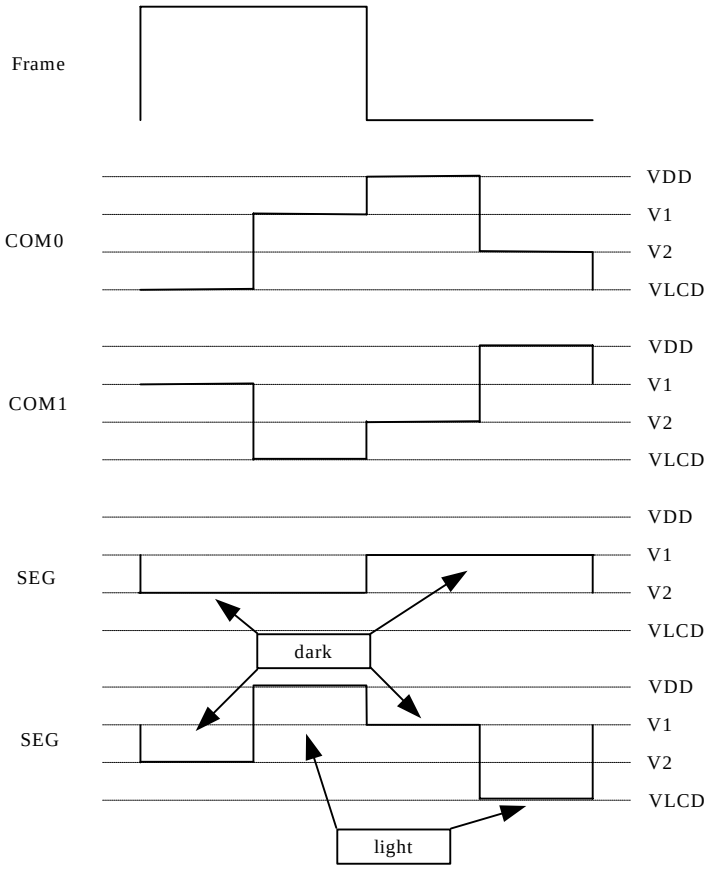


Fig.11 LCD waveform for 1/3 bias, 1/2 duty

IOC6 (PORT6 I/O control, P6* pins switch control)

PAGE0 (PORT6 I/O control register)

7	6	5	4	3	2	1	0
IOC67	IOC66	IOC65	IOC64	IOC63	IOC62	IOC61	IOC60
R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1

Bit 0 ~ Bit 7 (IOC60 ~ IOC67) : PORT6(0~7) I/O direction control register

0 ➔ put the relative I/O pin as output

1 ➔ put the relative I/O pin into high impedance

PAGE1 (P6* pins switch control register)

7	6	5	4	3	2	1	0
-	P66S	P65S	P64S	P63S	P62S	P61S	P60S
	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

"Before using bit 0 ~ Bit 6, please set IOCE PAGE1 bit0(MS) = 1 to enable these port switches function"

Bit 0(P60S) : Select normal I/O PORT60 pin or channel 1 input AD1 pin of ADC

0 ➔ P60 (I/O PORT60) pin is selected

1 ➔ AD1 (Channel 1 input of ADC) pin is selected

Bit 1(P61S) : Select normal I/O PORT61 pin or channel 2 input AD2 pin of ADC

0 ➔ P61 (I/O PORT61) pin is selected

1 ➔ AD2 (Channel 2 input of ADC) pin is selected

Bit 2(P62S) : Select normal I/O PORT62 pin or channel 3 input AD3 pin of ADC

0 ➔ P62 (I/O PORT62) pin is selected
1 ➔ AD3 (Channel 3 input of ADC) pin is selected
Bit 3(P63S) : Select normal I/O PORT63 pin or channel 4 input AD4 pin of ADC
0 ➔ P63 (I/O PORT63) pin is selected
1 ➔ AD4 (Channel 4 input of ADC) pin is selected
Bit 4(P64S) : Select normal I/O PORT64 pin or channel 5 input AD5 pin of ADC
0 ➔ P64 (I/O PORT64) pin is selected
1 ➔ AD5 (Channel 5 input of ADC) pin is selected
Bit 4(P65S) : Select normal I/O PORT65 pin or channel 6 input AD6 pin of ADC
0 ➔ P65 (I/O PORT65) pin is selected
1 ➔ AD6 (Channel 6 input of ADC) pin is selected
Bit 6(P66S) : Select normal I/O PORT66 pin or external reference voltage input of ADC
0 ➔ P66 (I/O PORT66) pin is selected and ADC reference voltage come from internal VDD
1 ➔ VREF (External reference voltage input of ADC) pin is selected
This bit can switch AD converter reference voltage coming from internal or external voltage.
If this bit set to internal, then the reference voltage will be VDD and PORT66 is a normal I/O PORT. If it set to external reference voltage, then the voltage will connected to VREF pin.
Bit 7 : (undefined) not allowed to use

IOC7 (PORT7 I/O control, PORT7 pull high control)

PAGE0 (PORT7 I/O control register)

7	6	5	4	3	2	1	0
IOC77	IOC76	IOC75	IOC74	IOC73	IOC72	IOC71	IOC70
R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1

Bit 0 ~ Bit 7 (IOC70 ~ IOC77) : PORT7(0~7) I/O direction control register
0 ➔ put the relative I/O pin as output
1 ➔ put the relative I/O pin into high impedance

PAGE1 (PORT7 pull high control register)

7	6	5	4	3	2	1	0
PH77	PH76	PH75	PH74	PH73	PH72	PH71	PH70
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

Bit 0 ~ Bit 7 (PH70 ~ PH77) : PORT7 bit0~bit7 pull high control register
0 ➔ disable pull high function.
1 ➔ enable pull high function

IOC8 (PORT8 I/O control, PORT8 pull high control)

PAGE0 (PORT8 I/O control register)

7	6	5	4	3	2	1	0
0	***0***	***0***	***0***	***0***	***0***	***0***	IOC80
R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1

Bit 0 (IOC80) : PORT80 I/O direction control register
0 ➔ put the relative I/O pin as output
1 ➔ put the relative I/O pin into high impedance
Bit 1~Bit 7 : Undefined, not allow to use.
***** This 7 bits must clear to 0 or MCU power consumption will increase.***
The default value in these 7 bits are "1". Please clear them to "0" when init MCU.

PAGE1 (PORT8 pull high control register)

7	6	5	4	3	2	1	0
							PH80
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

Bit 0 (PH80) : PORT8 bit0 pull high control register
0 ➔ disable pull high function.
1 ➔ enable pull high function

Bit 1~Bit 7 : Undefined, not allow to use.

***** This 7 bits must clear to 0 or MCU power consumption will increase.***

IOC9 (PORT9 I/O control, PORT9 switches)

PAGE0 (PORT9 I/O control register)

7	6	5	4	3	2	1	0
IOC97	IOC96	IOC95	IOC94	IOC93	IOC92	IOC91	IOC90
R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1

Bit 0 ~ Bit 7 (IOC90 ~ IOC97) : PORT9(0~7) I/O direction control register
0 ➔ put the relative I/O pin as output
1 ➔ put the relative I/O pin into high impedance

PAGE1 (PORT9 switches)

7	6	5	4	3	2	1	0
P97S	P96S	P95S	P94S	P93S	P92S	P91S	P90S
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

Bit 0(P90S) : Switch I/O PORT90 or LCD segment signal
0 ➔ (P90 pin is selected) : normal PORT90
1 ➔ (SEG20 pin) : SEGMENT output
Bit 1(P91S) : Switch I/O PORT91 or LCD segment signal
0 ➔ (P91 pin is selected) : normal PORT91
1 ➔ (SEG19 pin) : SEGMENT output
Bit 2(P92S) : Switch I/O PORT92 or LCD segment signal
0 ➔ (P92 pin is selected) : normal PORT92
1 ➔ (SEG18 pin) : SEGMENT output
Bit 3(P93S) : Switch I/O PORT93 or LCD segment signal
0 ➔ (P93 pin is selected) : normal PORT93
1 ➔ (SEG17 pin) : SEGMENT output
Bit 4(P94S) : Switch I/O PORT94 or LCD segment signal
0 ➔ (P94 pin is selected) : normal PORT94
1 ➔ (SEG16 pin) : SEGMENT output
Bit 5(P95S) : Switch I/O PORT95 or LCD segment signal
0 ➔ (P95 pin is selected) : normal PORT95
1 ➔ (SEG15 pin) : SEGMENT output
Bit 6(P96S) : Switch I/O PORT96 or LCD segment signal
0 ➔ (P96 pin is selected) : normal PORT96
1 ➔ (SEG14 pin) : SEGMENT output
Bit 7(P97S) : Switch I/O PORT97 or LCD segment signal
0 ➔ (P97 pin is selected) : normal PORT97
1 ➔ (SEG13 pin) : SEGMENT output

IOCA (Reserved)

PAGE0(undefined) not allowed to use

PAGE1(undefined) not allowed to use

7	6	5	4	3	2	1	0
-	***0***	-	-	***0***	-		
	R/W			R/W			

Bit0~Bit1 : Undefined.

Bit3 , Bit6 (Unused) : These 2 bits must clear to 0 or MCU power consumption will increase.

IOCB (ADC control)

PAGE0 (Unused)

7	6	5	4	3	2	1	0
0	***0***	***0***	***0***	***0***	***0***	***0***	***0***
R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1

***** This page must clear to 0 or MCU power consumption will increase.***

The default value in these 8 bits are "1". Please clear them to "0" when init MCU.

PAGE1 (ADC control bits)

7	6	5	4	3	2	1	0
IN2	IN1	IN0	ADCLK1	ADCLK0	ADPWR	-	ADST
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0		R/W-0

Bit 0(ADST) : AD converter start to sample

By setting to "1", the AD will start to sample data. This bit will be cleared by hardware automatically after a sampling.

Bit 1 : *(undefined) not allowed to use*

Bit 2(ADPWR) : AD converter power control, 1/0 ➔ enable/disable

Bit 3 ~ Bit 4 (ADCLK0 ~ ADCLK1) : AD circuit 's sampling clock source.

For PLL clock = 895.658kHz ~ 14.3MHz (CLK2~CLK0 = 001 ~ 111)

ADCLK1	ADCLK0	Sampling rate	Operation voltage
0	0	74.6K	>=3.5V
0	1	37.4K	>=3.0V
1	0	18.7K	>=2.5V
1	1	9.3K	>=2.5V

For PLL clock = 447.829kHz (CLK2~CLK0 = 000)

ADCLK1	ADCLK0	Sampling rate	Operation voltage
0	0	37.4K	>=3.0V
0	1	18.7K	>=3.0V
1	0	9.3K	>=2.5V
1	1	4.7K	>=2.5V

This is a CMOS multi-channel 10-bit successive approximation A/D converter.

Features

74.6kHz maximum conversion speed at 5V.
Adjusted full scale input
External reference voltage input or internal(VDD) reference voltage
8 analog inputs multiplexed into one A/D converter
Power down mode for power saving
A/D conversion complete interrupt
Interrupt register, A/D control and status register, and A/D data register

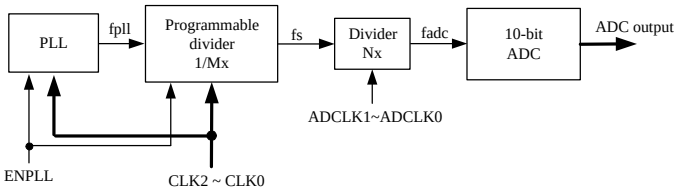


Fig.12 ADC sampling clock control logic

fpll	Mx	fs	fadcon = fadc / 12			
			Nx = 1	Nx = 2	Nx = 4	Nx = 8
14.331MHz	16	895.658kHz	74.638kHz	37.391kHz	18.659khz	9.329kHz
10.747MHz	12	895.658kHz	74.638kHz	37.391kHz	18.659khz	9.329kHz
7.165MHz	8	895.658kHz	74.638kHz	37.391kHz	18.659khz	9.329kHz
3.582MHz	4	895.658kHz	74.638kHz	37.391kHz	18.659khz	9.329kHz
1.791MHz	2	895.658kHz	74.638kHz	37.391kHz	18.659khz	9.329kHz
895.658kHz	1	895.658kHz	74.638kHz	37.391kHz	18.659khz	9.329kHz
447.829kHz	1	447.829kHz	37.391kHz	18.659khz	9.329kHz	4.665kHz

Bit 5 ~ Bit 7(IN0~ IN2) : Input channel selection of AD converter

These two bits can choose one of three AD input.

IN2	IN1	IN0	Input	Pin
0	0	0	AD1	P60
0	0	1	AD2	P61
0	1	0	AD3	P62
0	1	1	AD4	P63
1	0	0	AD5	P64
1	0	1	AD6	P65

IOCC (PORTC I/O control, ADC control)

PAGE0 (PORTC I/O control register)

7	6	5	4	3	2	1	0
0	***0***	***0***	***0***	IOCC3	IOCC2	IOCC1	IOCC0
R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1

Bit 0 ~ Bit 3 (IOCC0 ~ IOCC3) : PORTC(0~3) I/O direction control register

0 ➔ put the relative I/O pin as output

1 ➔ put the relative I/O pin into high impedance

Bit 4~Bit 7 : Undefined, not allow to use.

***** These 4 bits must clear to 0 or MCU power consumption will increase.***

The default value in these 4 bits are "1". Please clear them to "0" when init MCU.

PAGE1 (PORT switch)

7	6	5	4	3	2	1	0
0	0	0	0	0	P5SH	-	MS
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0		R/W-0

Bit 0(MS) : P6* switch mode selection

0 ➔ (default unknown)

1 ➔ ADC input mode selection

(Always set this bit to "1" otherwise partial ADC function cannot be used)

Bit 1: *(undefined) not allowed to use*

Bit 2(P5SH) : Switch I/O PORT5 high nibble(5~7) or LCD segment signal

0 ➔ (P55 ~ P57 pins are selected) : normal PORT5 high nibble(5~7)

1 ➔ (SEG10 ~ SEG12 pins are selected) : SEGMENT output

Bit 3 ~ Bit 7: *(undefined) not allowed to use. Please keep these bits to 0.*

IOCD (Clock source, Prescaler of CN1 and CN2)

PAGE0: *(undefined) not allowed to use*

PAGE1 (Clock source and prescaler for COUNTER1 and COUNTER2)

7	6	5	4	3	2	1	0
CNT2S	C2_PSC2	C2_PSC1	C2_PSC0	CNT1S	C1_PSC2	C1_PSC1	C1_PSC0
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

Bit 0 ~ Bit 2 (C1_PSC0 ~ C1_PSC2) : COUNTER1 prescaler ratio

C1_PSC2	C1_PSC1	C1_PSC0	COUNTER1
0	0	0	1:2
0	0	1	1:4
0	1	0	1:8
0	1	1	1:16
1	0	0	1:32
1	0	1	1:64
1	1	0	1:128
1	1	1	1:256

Bit 3(CNT1S) : COUNTER1 clock source

0/1 ➔ 16.384kHz/system clock

Bit 4 ~ Bit 6 (C2_PSC0 ~ C2_PSC2) : COUNTER2 prescaler ratio

C2_PSC2	C2_PSC1	C2_PSC0	COUNTER2
0	0	0	1:2
0	0	1	1:4
0	1	0	1:8
0	1	1	1:16
1	0	0	1:32
1	0	1	1:64
1	1	0	1:128
1	1	1	1:256

Bit 7(CNT2S) : COUNTER2 clock source

0/1 ➔ 16.384kHz/system clock

IOCE (Interrupt mask)

PAGE0 (Interrupt mask)

7	6	5	4	3	2	1	0
PWM2	RBF	ADI	PWM1	-	-	-	-
R/W-0	R/W-0	R/W-0	R/W-0				

Bit 0 ~ Bit 3 : unused

Bit 4(PWM1) : PWM1 one period reach interrupt mask.

Bit 5 (ADI) : ADC conversion complete interrupt mask

0/1 ➔ disable/enable interrupt

There are four registers for A/D converter. Use one bit of interrupt control register (IOCE PAGE0 Bit5) for A/D conversion complete interrupt. The status and control register of A/D (IOCB PAGE1 and RE PAGE0 Bit5) responses the A/D conversion status or takes control on A/D. The A/D data register (RB PAGE1) stores A/D conversion result.

ADI bit in IOCE PAGE0 register is end of A/D conversion complete interrupt enable/disable. It

enables/disables ADI flag in RE register when A/D conversion is complete. ADI flag indicates the end of an A/D conversion. The A/D converter sets the interrupt flag, ADI in RE PAGE0 register when a conversion is complete. The interrupt can be disabled by setting ADI bit in IOCE PAGE0 Bit5 to '0'.

The A/D converter has 6 analog input channels AD1~AD8 multiplexed into one sample and hold to A/D module. Reference voltage can be driven from VREF pin or internal power. The A/D converter itself is of an 8-bit successive approximation type and produces an 8-bit result in the RB PAGE1 data register. A conversion is initiated by setting a control bit ADST in IOCB PAGE1 Bit0. Prior to conversion, the appropriate channel must be selected by setting IN0~IN1 bits in RE register and allowed for enough time to sample data. Every conversion data of A/D need 12-clock cycle time. The minimum conversion time required is 13 us (73K sample rate). ADST Bit in IOCB PAGE1 Bit0 must be set to begin a conversion.

It will be automatically reset in hardware when conversion is complete. At the end of conversion, the START bit is cleared and the A/D interrupt is activated if ADI in IOCE PAGE0 Bit5 = 1. ADI will be set when conversion is complete. It can be reset in software.

If ADI = 0 in IOCE PAGE0 Bit5, when A/D start conversion by setting ADST(IOCB PAGE1 Bit0) = 1 then A/D will continue conversion without stop and hardware won't reset ADST bit. In this condition, ADI is deactived. After ADI in IOCE PAGE0 bit5 is set, ADI in RE PAGE0 bit5 will activate again.

To minimum operating current , all biasing circuits in the A/D module that consume DC current are power down when ADPWR bit in IOCB PAGE1 Bit2 register is a '0'. When ADPWR bit is a '1', A/D converter module is operating.

User has to set PORT60~PORT65 as AD converter input pin or bi-direction IO PORT

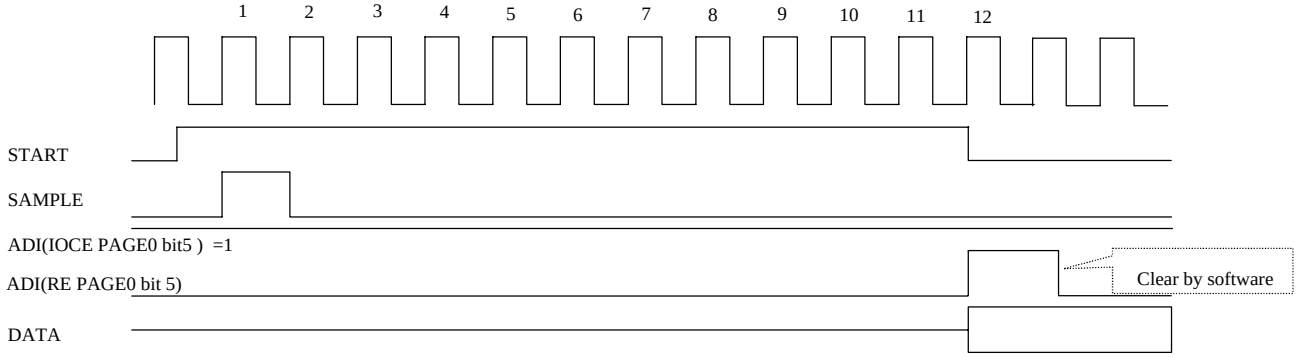


Fig.14 A/D converter timing

Bit 6 (RBF) : SPI's RBF interrupt mask
0/1 ➔ disable/enable interrupt
Bit 7 (PWM2) : PWM2 interrupt enable bit
0/1 ➔ disable/enable interrupt

IOCF (Interrupt mask)

(Interrupt mask register)

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
INT3	-	INT2	INT1	INT0	CNT2	CNT1	TCIF
R/W-0		R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

Bit 0 ~ 5,7 : interrupt enable bit
0 ➔ disable interrupt
1 ➔ enable interrupt
Bit 6 *: (remain these values to "0"othwise it will generate unpredicted interrupts)*

The status after interrupt and the interrupt sources list as the table below.

Interrupt signal	GREEN mode	NORMAL mode
	RA(7,6)=(x,0) no SLEP	RA(7,6)=(x,1) no SLEP
TCC time out IOCF bit0=1 And "ENI"	Interrupt (jump to address 8 at page0)	Interrupt (jump to address 8 at page0)
COUNTER1 time out IOCF bit1=1 And "ENI"	Interrupt (jump to address 8 at page0)	Interrupt (jump to address 8 at page0)
COUNTER2 time out IOCF bit2=2 And "ENI"	Interrupt (jump to address 8 at page0)	Interrupt (jump to address 8 at page0)
PORT7(0~3) IOCF bit3 or bit4 or bit5 or bit7=1 And "ENI"	Interrupt (jump to address 8 at page0)	Interrupt (jump to address 8 at page0)
RBF IOCE bit6 = 1 And “ENI	Interrupt <ps> (jump to address 8 at page0)	Interrupt (jump to address 8 at page0)
ADI IOCE bit5 = 1 And “ENI	No function	Interrupt (jump to address 8 at page0)
PWM1 IOCE bit4 = 1 And “ENI	Interrupt <ps> (jump to address 8 at page0)	Interrupt (jump to address 8 at page0)
PWM2 IOCE bit7 = 1 And “ENI	Interrupt <ps> (jump to address 8 at page0)	Interrupt (jump to address 8 at page0)

<Note> PORT70 's interrupt function is controlled by IOCF bit 3. It's falling edge or rising edge trigger (controlled by CONT register bit7).
PORT7(1~3) 's wakeup functions are controlled by IOCF bit (4,5,7). They are falling edge trigger.
ADI interrupt source function is controlled by RE PAGE0 bit 5. It is rising edge trigger after ADC sample complete.

<ps> It only happens when master and 16.386kHz mode is selected.

VII.4 I/O Port

The I/O registers are bi-directional tri-state I/O ports. The I/O ports can be defined as "input" or "output" pins by the I/O control registers under program control. The I/O data registers and I/O control registers are both readable and writable. The I/O interface circuit is shown in Fig.15.

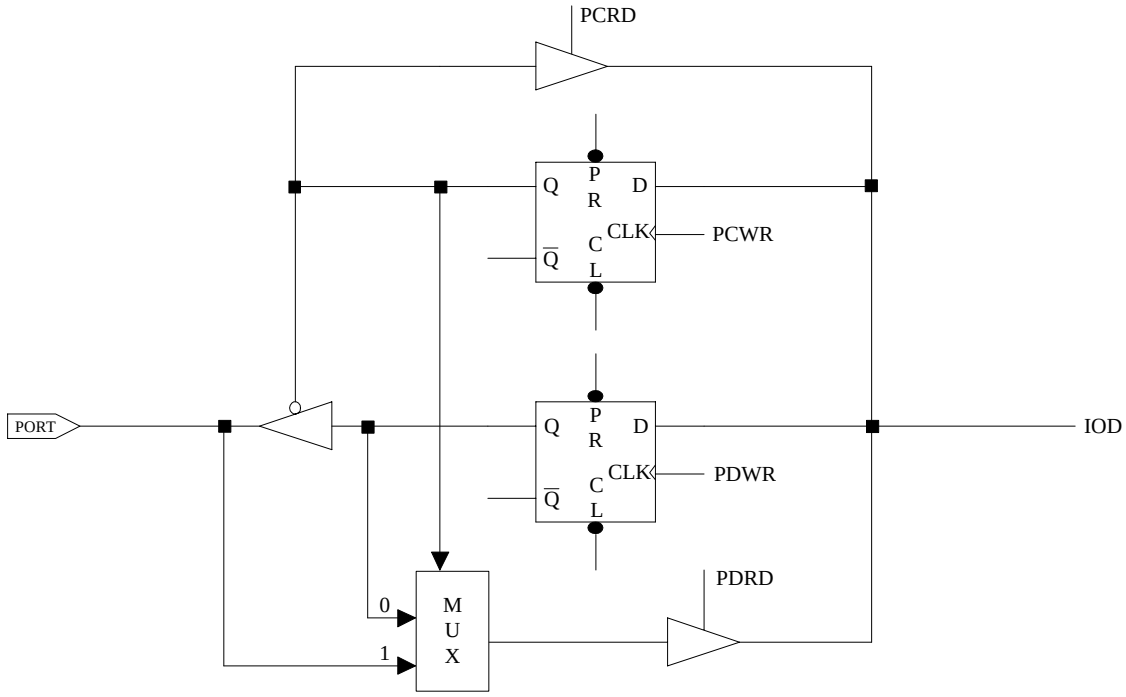


Fig.15 The circuit of I/O port and I/O control register

VII.5 RESET

The RESET can be caused by

(1) WDT timeout. (if enabled and in GREEN or NORMAL mode)

(2) /RESET pin pull low

Once the RESET occurs, the following functions are performed.

- The oscillator is running, or will be started.
- The Program Counter (R2) is set to all "0".
- When power on, the upper 3 bits of R3 and the upper 2 bits of R4 are cleared.
- The Watchdog timer and prescaler counter are cleared.
- The Watchdog timer is disabled.
- The CONT register is set to all "1"
- The other register (bit 7 ~ bit 0) default values are as follows.

Operation registers :

Address	R register PAGE0	R register PAGE1	R register PAGE2	R register PAGE3	IOC register PAGE0	IOC register PAGE1
0x4	00xxxxxx					
0x5	xxxx0000	xxxx0000	00000000	00000000	111x0000	
0x6	xxxxxxxx	xxxxxxxx	xxxxxxxx	00000000	11111111	00000000
0x7	xxxxxxxx	xxxx0000		xxxxxx00	11111111	00000000
0x8	xxxxxxxx	00000000		00000000	11111111	00000000
0x9	xxxxxxxx	xxxxxxxx		00000000	11111111	00000000
0xA	00011xx0	11111111	0x000000	xxxxxx00	xxxxxxxx	x0xx0xx
0xB	xxxxxxxx	xxxxxxxx	xxxxxxxx	00000000	11111111	000000x0
0xC	xxxxxxxx	00000000	xxxxxxxx		11111111	00000000
0xD	xxxxx000	00000000	xxxxxxxx		xxxxxxxx	00000000
0xE	00000000		xxxxxxxx		0000xxxx	xxxxxxxx
0xF	00000000				00000000	

VII.6 Wake-up

The controller provided sleep mode for power saving :

(1) SLEEP mode, RA(7) = 0 + "SLEP" instruction

The controller will turn off all the CPU and crystal. Other circuit with power control like key tone control or PLL control (which has enable register), user has to turn it off by software.

Wake-up from SLEEP mode

(1) WDT time out

(2) External interrupt

(3) /RESET pull low

All these cases will reset controller , and run the program at address zero. The status just like the power on reset..

VII.7 Interrupt

RF is the interrupt status register which records the interrupt request in flag bit. IOCF is the interrupt mask register. Global interrupt is enabled by ENI instruction and is disabled by DISI instruction. When one of the interrupts (when enabled) generated, will cause the next instruction to be fetched from address 008H. Once in the interrupt service routine, the source of the interrupt can be determined by polling the flag bits in the RF register.

The interrupt flag bit must be cleared in software before leaving the interrupt service routine and enabling interrupts to avoid recursive interrupts.

VII.8 Instruction Set

Instruction set has the following features:

(1) Every bit of any register can be set, cleared, or tested directly.

(2) The I/O register can be regarded as general register. That is, the same instruction can operates on I/O register.

The symbol "R" represents a register designator which specifies which one of the 64 registers (including operational registers and general purpose registers) is to be utilized by the instruction. Bits 6 and 7 in R4 determine the selected register bank. "b" represents a bit field designator which selects the number of the bit, located in the register "R", affected by the operation. "k" represents an 8 or 10-bit constant or literal value.

INSTRUCTION BINARY	HEX	MNEMONIC	OPERATION	STATUS AFFECTED	Instruction cycle
0 0000 0000 0000	0000	NOP	No Operation	None	1
0 0000 0000 0001	0001	DAA	Decimal Adjust A	C	1
0 0000 0000 0010	0002	CONTW	A → CONT	None	1
0 0000 0000 0011	0003	SLEP	0 → WDT, Stop oscillator	T,P	1
0 0000 0000 0100	0004	WDTC	0 → WDT	T,P	1
0 0000 0000 rrrr	000r	IOW R	A → IOCR	None	1
0 0000 0001 0000	0010	ENI	Enable Interrupt	None	1
0 0000 0001 0001	0011	DISI	Disable Interrupt	None	1
0 0000 0001 0010	0012	RET	[Top of Stack] → PC	None	2
0 0000 0001 0011	0013	RETI	[Top of Stack] → PC Enable Interrupt	None	2
0 0000 0001 0100	0014	CONTR	CONT → A	None	1
0 0000 0001 rrrr	001r	IOR R	IOCR → A	None	1
0 0000 0010 0000	0020	TBL	R2+A → R2 bits 9,10 do not clear	Z,C,DC	2
0 0000 01rr rrrr	00rr	MOV R,A	A → R	None	1
0 0000 1000 0000	0080	CLRA	0 → A	Z	1
0 0000 11rr rrrr	00rr	CLR R	0 → R	Z	1
0 0001 00rr rrrr	01rr	SUB A,R	R-A → A	Z,C,DC	1
0 0001 01rr rrrr	01rr	SUB R,A	R-A → R	Z,C,DC	1
0 0001 10rr rrrr	01rr	DECA R	R-1 → A	Z	1
0 0001 11rr rrrr	01rr	DEC R	R-1 → R	Z	1
0 0010 00rr rrrr	02rr	OR A,R	A ∨R → A	Z	1
0 0010 01rr rrrr	02rr	OR R,A	A ∨R → R	Z	1
0 0010 10rr rrrr	02rr	AND A,R	A & R → A	Z	1
0 0010 11rr rrrr	02rr	AND R,A	A & R → R	Z	1
0 0011 00rr rrrr	03rr	XOR A,R	A ⊕ R → A	Z	1
0 0011 01rr rrrr	03rr	XOR R,A	A ⊕ R → R	Z	1
0 0011 10rr rrrr	03rr	ADD A,R	A + R → A	Z,C,DC	1
0 0011 11rr rrrr	03rr	ADD R,A	A + R → R	Z,C,DC	1
0 0100 00rr rrrr	04rr	MOV A,R	R → A	Z	1
0 0100 01rr rrrr	04rr	MOV R,R	R → R	Z	1
0 0100 10rr rrrr	04rr	COMA R	/R → A	Z	1

0	0100	11rr	rrrr	04rr	COM R	/R → R	Z	1
0	0101	00rr	rrrr	05rr	INCA R	R+1 → A	Z	1
0	0101	01rr	rrrr	05rr	INC R	R+1 → R	Z	1
0	0101	10rr	rrrr	05rr	DJZA R	R-1 → A, skip if zero	None	2 if skip
0	0101	11rr	rrrr	05rr	DJZ R	R-1 → R, skip if zero	None	2 if skip
0	0110	00rr	rrrr	06rr	RRCA R	R(n) → A(n-1) R(0) → C, C → A(7)	C	1
0	0110	01rr	rrrr	06rr	RRC R	R(n) → R(n-1) R(0) → C, C → R(7)	C	1
0	0110	10rr	rrrr	06rr	RLCA R	R(n) → A(n+1) R(7) → C, C → A(0)	C	1
0	0110	11rr	rrrr	06rr	RLC R	R(n) → R(n+1) R(7) → C, C → R(0)	C	1
0	0111	00rr	rrrr	07rr	SWAPA R	R(0-3) → A(4-7) R(4-7) → A(0-3)	None	1
0	0111	01rr	rrrr	07rr	SWAP R	R(0-3) ↔ R(4-7)	None	1
0	0111	10rr	rrrr	07rr	JZA R	R+1 → A, skip if zero	None	2 if skip
0	0111	11rr	rrrr	07rr	JZ R	R+1 → R, skip if zero	None	2 if skip
0	100b	bbrr	rrrr	0xxx	BC R,b	0 → R(b)	None	1
0	101b	bbrr	rrrr	0xxx	BS R,b	1 → R(b)	None	1
0	110b	bbrr	rrrr	0xxx	JBC R,b	if R(b)=0, skip	None	2 if skip
0	111b	bbrr	rrrr	0xxx	JBS R,b	if R(b)=1, skip	None	2 if skip
1	00kk	kkkk	kkkk	1kkk	CALL k	PC+1 → [SP] (Page, k) → PC	None	2
1	01kk	kkkk	kkkk	1kkk	JMP k	(Page, k) → PC	None	2
1	1000	kkkk	kkkk	18kk	MOV A,k	k → A	None	1
1	1001	kkkk	kkkk	19kk	OR A,k	A ∨ k → A	Z	1
1	1010	kkkk	kkkk	1Akk	AND A,k	A & k → A	Z	1
1	1011	kkkk	kkkk	1Bkk	XOR A,k	A ⊕ k → A	Z	1
1	1100	kkkk	kkkk	1Ckk	RETL k	k → A, [Top of Stack] → PC	None	2
1	1101	kkkk	kkkk	1Dkk	SUB A,k	k-A → A	Z,C,DC	1
1	1110	0000	0001	1E01	INT	PC+1 → [SP] 001H → PC	None	1
1	1110	100k	kkkk	1E8k	PAGE k	K->R5(4:0)	None	1
1	1111	kkkk	kkkk	1Fkk	ADD A,k	k+A → A	Z,C,DC	1

1 Instruction cycle = 2 main CLK

VII.9 Code Option

CODE Option Register

13	12	11	10	9	8	7	6	5	4	3	2	1	0
		PHO	***VERSEL***	***ADIS***						MER			

Bit 3(MER) : Memory error recover function

0 ➔ disable memory error recover function

1 ➔ enable memory error recovery function

If user enable memory error recovery function, MCU will improve effect from environment noise.

Bit 9(ADIS) : Please set this bit to 1.

Bit 10 (VERSEL): Please clear this bit to 0.

Bit 11 (PHO): Please clear this bit to 0.

VII.10 Dual sets of PWM (Pulse Width Modulation)

(1) Overview

In PWM mode, both PWM1 and PWM2 pins produce up to a 10-bit resolution PWM output (see. Fig.16 for the functional block diagram). A PWM output has a period and a duty cycle, and it keeps the output in high. The baud rate of the PWM is the inverse of the period. Fig.17 depicts the relationships between a period and a duty cycle.

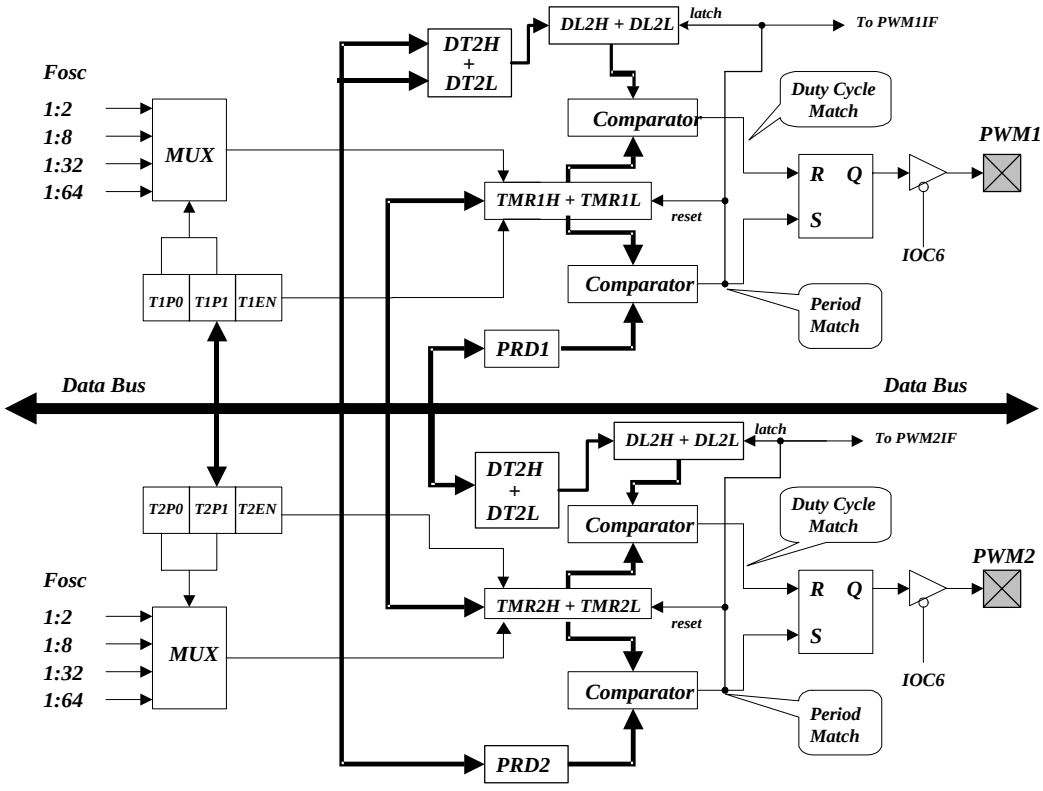


Fig.16 The Functional Block Diagram of the Dual PWMs

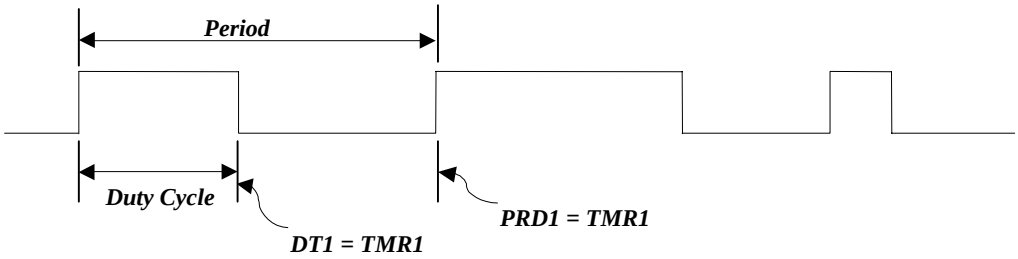


Fig.17 The Output Timing of the PWM

(2) Increment Timer Counter (TMRX: TMR1H/TWR1L or TMR2H/TWR2L)

TMRX are ten-bit clock counters with programmable prescalers. They are designed for the PWM module as baud rate clock generators. TMRX can be read, written, and cleared at any reset conditions. If employed, they can be turned down for power saving by setting T1EN bit [PWMCON<4>] or T2EN bit [PWMCON<5>] to 0.

(3) PWM Period (PRDX : PRD1 or PRD2)

The PWM period is defined by writing to the PRDX register. When TMRX is equal to PRDX, the following events occur on the next increment cycle:
• TMRX is cleared.
• The PWMX pin is set to 1.
• The PWM duty cycle is latched from DT1/DT2 to DTL1/DTL2.
< Note > The PWM output will not be set, if the duty cycle is 0;
• The PWMXIF pin is set to 1.
The following formula describes how to calculate the PWM period:

PERIOD = (PRDX + 1) * 4 * (1/Fosc) * (TMRX prescale value)

Where Fosc is system clock

(4) PWM Duty Cycle (DTX: DT1H/ DT1L and DT2H/ DT2L; DTL: DL1H/DL1L and DL2H/DL2L)

The PWM duty cycle is defined by writing to the DTX register, and is latched from DTX to DLX while TMRX is cleared. When DLX is equal to TMRX, the PWMX pin is cleared. DTX can be loaded at any time. However, it cannot be latched into DTL until the current value of DLX is equal to TMRX.
The following formula describes how to calculate the PWM duty cycle:

Duty Cycle = (DTX) * (1/Fosc) * (TMRX prescale value)

(5) Comparator X

To change the output status while the match occurs, the TMRXIF flag will be set at the same time.

(6) PWM Programming Procedures/Steps

Load PRDX with the PWM period.
(1) Load DTX with the PWM Duty Cycle.
(2) Enable interrupt function by writing IOCF PAFE0, if required.
(3) Set PWMX pin to be output by writing a desired value to IOCC PAGE0.
(4) Load a desired value to R5 PAGE3 with TMRX prescaler value and enable both PWMX and TMRX.

(7) Timer

Timer1 (TMR1) and Timer2 (TMR2) (TMRX) are 10-bit clock counters with programmable prescalers, respectively. They are designed for the PWM module as baud rate clock generators. TMRX can be read, written, and cleared at any reset conditions.
The figure in the next page shows TMRX block diagram. Each signal and block are described as follows:

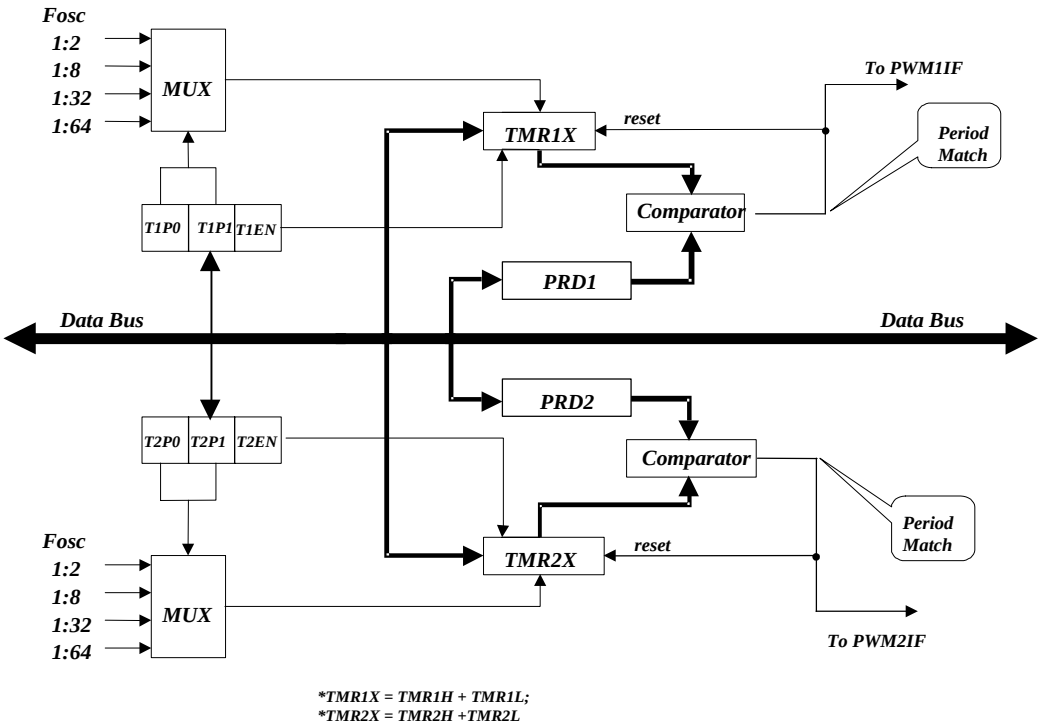


Fig.18 TMRX Block Diagram

- Fosc: Input clock.
- Prescaler (T1P0 and T1P1/T2P1 and T2P0): Options of 1:2, 1:8, 1:32, and 1:64 are defined by TMRX. It is cleared when any type of reset occurs.
- TMR1X and TMR2X (TMR1H/TWR1L and TMR2H/TMR2L):Timer X register; TMRX is increased until it matches with PRDX, and then is reset to 0. TMRX cannot be read.
- PRDX (PRD1 and PRD2): PWM period register.
- ComparatorX (Comparator 1 and Comparator 2): To reset TMRX while a match occurs and the TMRXIF flag is set at the same time.

When defining TMRX, refer to the related registers of its operation as shown in prescale register. It must be noted that the PWMX bits must be disabled if their related TMRXs are employed. That is, bit 7 and bit 6 of the PWMCON register must be set to '0'.

Related Control Registers(R5 PAGE3) of TMR1 and TMR2

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
PWM2E	PWM1E	T2EN	T1EN	T2P1	T2P0	T1P1	T1P0

Timer programming procedures/steps

(1) Load PRDX with the TIMER period.
(2) Enable interrupt function by writing IOCF PAGE0, if required
(3) Load a desired value to PWMCON with the TMRX prescaler value and enable both TMRX and disable PWMX.

VIII. Absolute Operation Maximum Ratings

RATING	SYMBOL	VALUE	UNIT
DC SUPPLY VOLTAGE	VDD	-0.3 To 6	V
INPUT VOLTAGE	Vin	-0.5 to VDD +0.5	V
OPERATING TEMPERATURE RANGE	Ta	0 to 70	℃

IX. DC Electrical Characteristic

(Ta = 25°C, AVDD=VDD=5V±5%, VSS=0V)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Input leakage current for input pins	IIL1	VIN = VDD, VSS			±1	μA
Input leakage current for bi-directional pins	IIL2	VIN = VDD, VSS			±1	μA
Input high voltage	VIH		2.5			V
Input low voltage	VIL				0.8	V
Input high threshold voltage	VIHT	/RESET, TCC	2.0			V
Input low threshold voltage	VILT	/RESET, TCC			0.8	V
Clock input high voltage	VIHX	OSCI	3.5			V
Clock input low voltage	VILX	OSCI			1.5	V
Output high voltage for PORT5,B,C	VOH1	IOH = -6mA	2.4			V
Output high voltage for PORT6,7,8	VOH2	IOH = -10mA	2.4			V
Output high voltage for PORT9	VOH3	IOH = -20mA	2.4			V
Output low voltage for PORT5,B,C	VOL1	IOH = 6mA			0.4	V
Output low voltage for PORT6,7,8	VOL2	IOH = 10mA			0.4	V
Output low voltage for PORT9	VOL3	IOH = 20mA			0.4	V
LCD drive reference voltage	VLCD	VDD=5V, Contrast adjust		4 ~ 5		V
Pull-high current	IPH	Pull-high active input pin at VSS		-10	-15	μA
Power down current (SLEEP mode)	ISB1	All input and I/O pin at VDD, output pin floating, WDT disabled		4	8	μA
Low clock current (GREEN mode)	ISB2	CLK=32.768KHz, All analog circuits disabled, All input and I/O pin at VDD, output pin floating, WDT disabled, LCD enabled		35	50	μA
Operating supply current (Normal mode)	ICC1	/RESET=High, CLK=3.582MHz, All analog circuits disabled, output pin floating		1	2	mA

XI. AC Electrical Characteristic

CPU instruction timing (Ta = 25°C, AVDD=VDD=5V, VSS=0V)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Input CLK duty cycle	Dclk		45	50	55	%
Instruction cycle time	Tins	32.768kHz 3.582MHz		60 550		us ns
Device delay hold time	Tdrh			16		ms
TCC input period	Ttcc	Note 1	(Tins+20)/N			ns
Watchdog timer period	Twdt	Ta = 25°C		16		ms

Note 1: N= selected prescaler ratio.

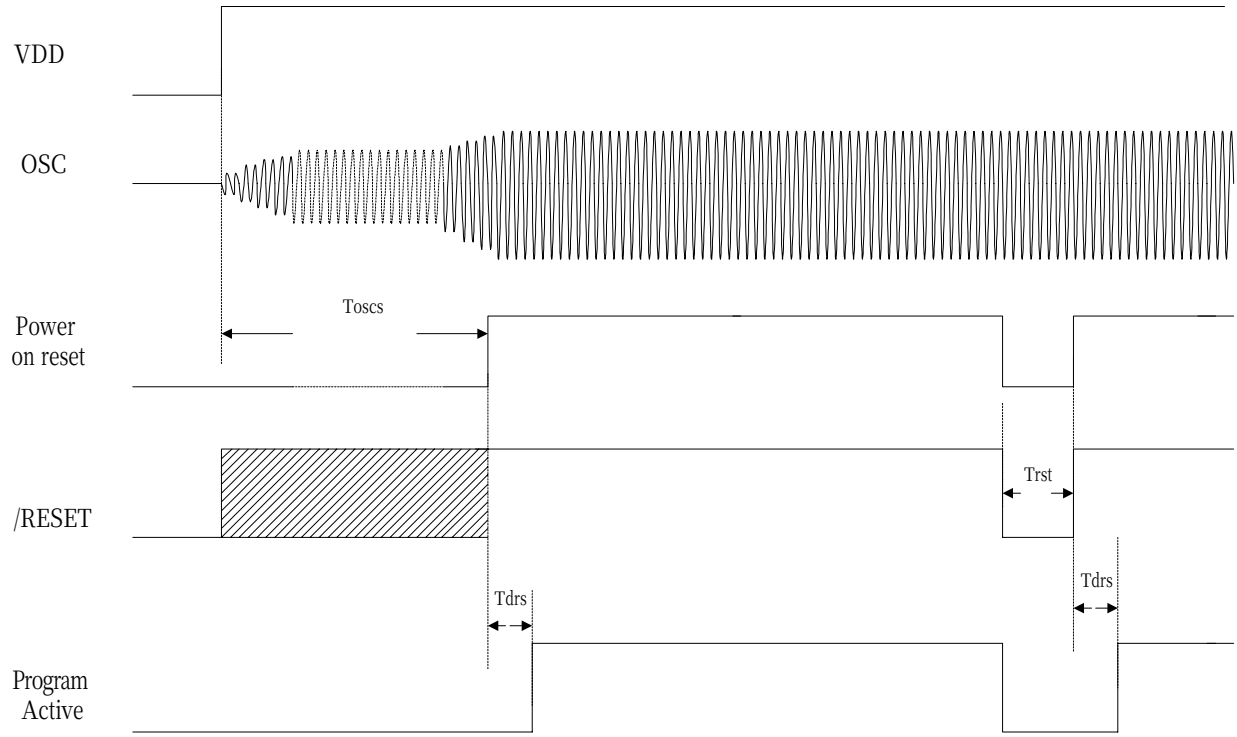
ADC characteristic (VDD = 5V, Ta = +25°C, for internal reference voltage)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Upper bound offset voltage	Vofh			44	52.8	mV
Lower bound offset voltage	Vofl			32	38.4	mV

*These parameters are characterized but not tested.
* About ADC characteristic, please refer to next page.

Timing characteristic (AVDD=VDD=5V,Ta=+25°C)

Description		Symbol	Min	Typ	Max	Unit
Oscillator timing characteristic						
OSC start up	32.768kHz	Toscs	400		1500	ms
	3.579MHz PLL			5	10	us
SPI timing characteristic (CPU clock 3.58MHz and Fsco = 3.58Mhz /2)						
/SS set-up time		Tcss	560			ns
/SS hold time		Tcsh	250			
SCLK high time		Thi	250			ns
SCLK low time		Tlo	250			ns
SCLK rising time		Tr		15	30	ns
SCLK falling time		Tf		15	30	ns
SDI set-up time to the reading edge of SCLK		Tisu	25			ns
SDI hold time to the reading edge of SCLK		Tihd	25			ns
SDO disable time		Tdis			560	ns
Timing characteristic of reset						
The minimum width of reset low pulse		Trst	3			uS
The delay between reset and program start		Tdrs		18		mS



The relative between OSC stable time and power on reset

EM785830AD operation voltage(X axis → min VDD ; Y axis → main CLK):

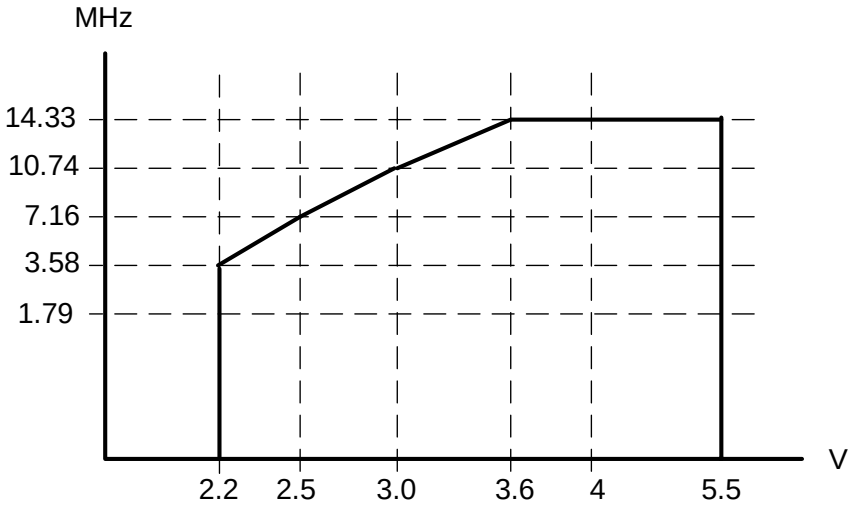


Fig.19 The relative between operating voltage and main CLK

EM785830AD's 10 bit ADC characteristic

EM785830AD build in 10 bit resolution, multi channel ADC function. In ideal, if ADC's reference voltage is 5V, the ADC's LSB will be 5V/1024. But in practical, for some physics or circuit's character, some un-ideal will effect the converter result. As the next figure, offset voltage will reduce AD's converter range. If AD's input voltage less than VOFL, ADC will output 0; in opposition, if input voltage is larger than (VDD-VOFH), ADC will output 1023. That is to say the physics AD converter range will replace by (VDD-VOFH+LSB-VOFL+LSB). If we defined that VRB = VOFL – LSB and VRT = VDD-VOFH+LSB, the physics LSB is:

LSB = (VRT - VRB) / 1024

= ***(VDD – (VOFH+VOFL)) / 1022***

For real operating, please think about the effect of AD's offset voltage. If converter the range of (VRT - VRB), the AD converter's opposite result will be précised.

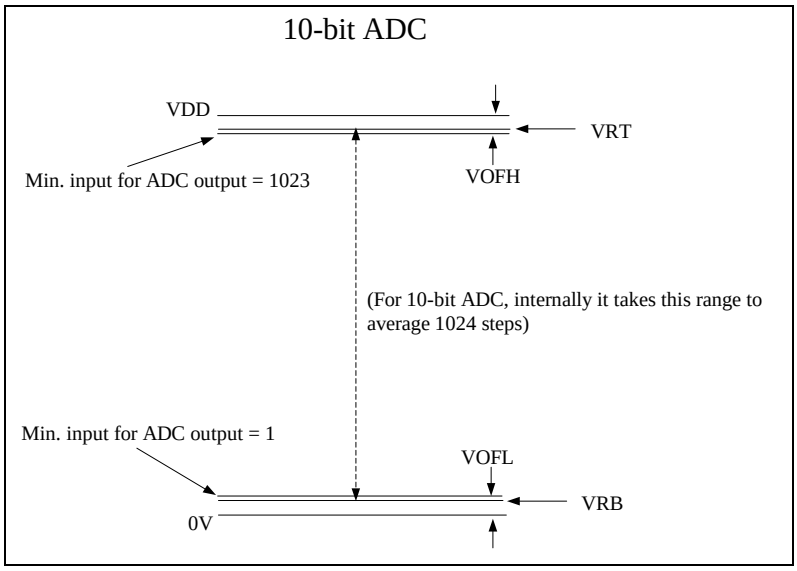
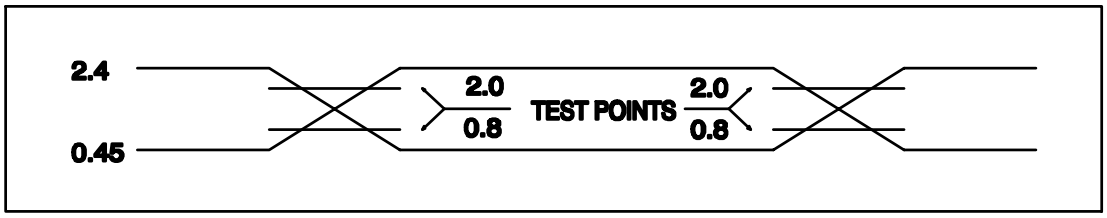


Fig.20 The relative between ADC and offset voltage

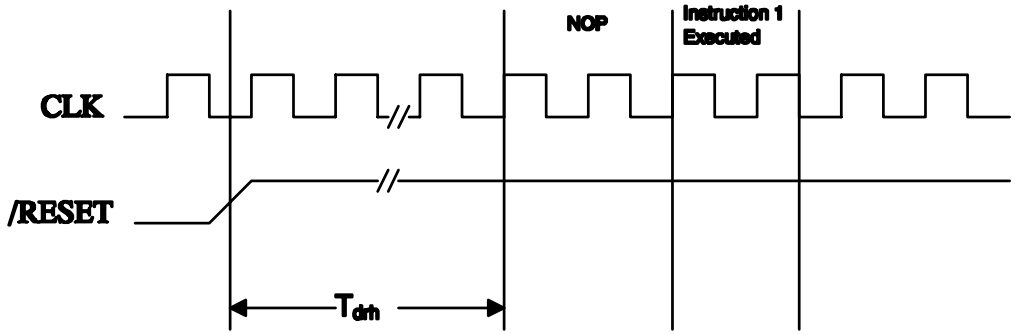
XII. Timing Diagrams

AC Test Input/Output Waveform



AC Testing: Input are driven at 2.4V for logic "1", and 0.45V for logic "0". Timing measurements are made at 2.0V for logic "1", and 0.8V for logic "0".

RESET Timing



TCC Input Timing

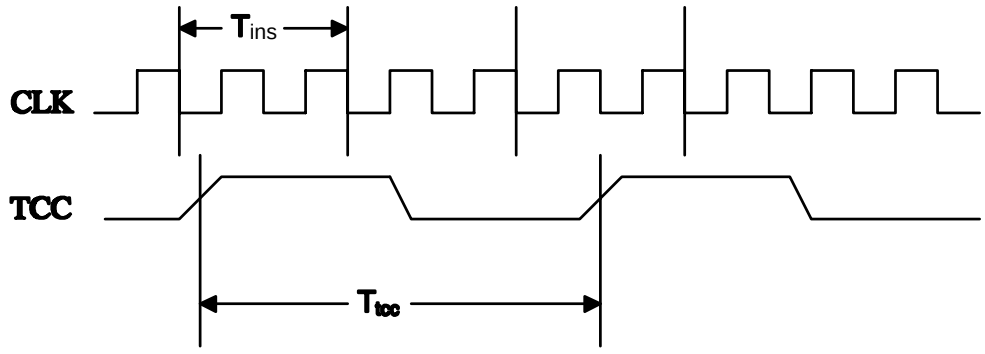


Fig.19 AC timing

Appendix I: Describe of EM78P5830D/AD (only list the difference between mask and OTP)

The EM78P5830D is an 8-bit RISC type microprocessor with low power, high speed CMOS technology. There are 16Kx13 bits Electrical One Time Programmable Read Only Memory (OTP-ROM) within it. It provides security bits and some One time programmable Option bits to protect the OTP memory code from any external access as well as to meet user's options.

This integrated single chip has an on_chip watchdog timer (WDT), program OTP-ROM, data RAM, programmable real time clock/counter, internal interrupt, power down mode, built-in three-wire SPI, dual PWM(Pulse Width Modulation), 8-channel 10-bit A/D converter and tri-state I/O.

Feature

CPU

- Operating voltage : 2.2V~5.5V at main CLK less then 3.58MHz.

Main CLK(Hz)	Under 3.58M	7.16M	10.74M	14.4M
Operating Voltage(min)	2.2	2.5	3	3.6

- ***16k x 13*** on chip Program Memory.
- ***0.5k x 8*** on chip data RAM
- Up to 31 bi-directional tri-state I/O ports
- ***16*** level stack for subroutine nesting
- 8-bit real time clock/counter (TCC)
- two 8-bit counters : COUNTER1 and COUNTER2
- On-chip watchdog timer (WDT)
- 99.9% single instruction cycle commands
- Four modes (Main clock can be programmed from 447.829k to 14.3MHz generated by internal PLL)

Mode	CPU status	Main clock	32.768kHz clock status
Sleep mode	Turn off	Turn off	Turn off
Green mode	Turn on	Turn off	Turn on
Normal mode	Turn on	Turn on	Turn on

- Input port interrupt function
- 12 interrupt source, 4 external, 8 internal
- Dual clocks operation (Internal PLL main clock , External 32.768KHz)

SPI

- Serial Peripheral Interface (SPI) : a kind of serial I/O interface
- Interrupt flag available for the read buffer full,
- Programmable baud rates of communication
- Three-wire synchronous communication. (shared with IO)

PWM

- Dual PWM (Pulse Width Modulation) with 10-bit resolution
- Programmable period (or baud rate)
- Programmable duty cycle

ADC

- Operating : 2.5V 5.5V
- 6-channel 10-bit successive approximation A/D converter
- Internal (VDD) or external reference

POR

- 2.0V Power-on voltage detector reset

LCD

- Common driver pins : 4
- Segment driver pins : 13
- 1/3 bias
- 1/4 duty, 1/2 duty

· 16 Level LCD contrast control by software

One time programmable ROM burner pin

OTP PIN NAME	MASK ROM PIN NAME	P.S.
VDD	AVDD	
VPP	/RESET	
DINCK	P65	
ACLK	P64	
PGMB	P63	
OEB	P62	
DATA	P73	
GND	AVSS	

EM78P5830D CODE Option Register

13	12	11	10	9	8	7	6	5	4	3	2	1	0
		PHO	***VERSEL***	***ADIS***						MER			/POT0

Bit 0 (/POT0): program ROM protect option.

If set 1 to the bit, program memory can be access; else if clear this bit , program memory can not be access.

Bit 3(MER) : Memory error recover function

0 ➔ disable memory error recover function

1 ➔ enable memory error recovery function

If user enable memory error recovery function, MCU will improve effect from environment noise**.**

Bit 9(ADIS) : This bit must set to 1.

Bit 10 (VERSEL): Please clear this bit to 0.

Bit 11 (PHO): Please clear this bit to 0.

DC Electrical Characteristic

(Ta = 25°C, AVDD=VDD=5V±5%, VSS=0V)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Output high voltage for PORT6, 8	VOH2	IOH = -10mA	2.4			V
Output high voltage for PORT7, 9	VOH3	IOH = -20mA	2.4			V
Output low voltage for PORT6, 8	VOL2	IOH = 10mA			0.4	V
Output low voltage for PORT7, 9	VOL3	IOH = 20mA			0.4	V

Appendix II: Notice about EM785830AD developing tool. (ICE5830)

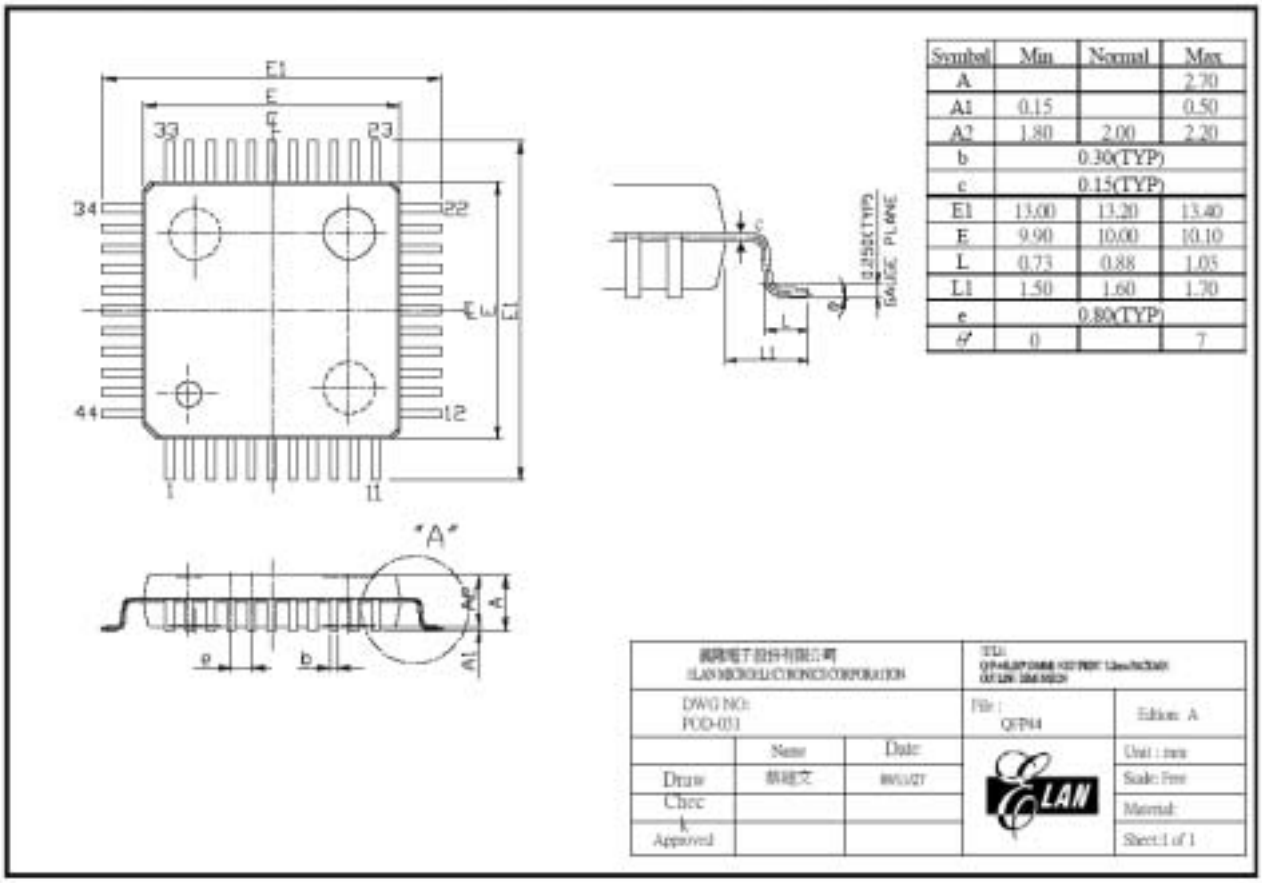
During developing program on ICE5830, please fix these 3 bit (RD page1 bit4 ~ bit6) on initial and do not change them among program.

RD page0

7	6	5	4	3	2	1	0
-	***VERSEL***	***PHO***	***ADIS***	-	LCD_C1	LCD_C0	LCD_M
	R/W-0	***R/W-0***	***R/W-0***		R/W-0	R/W-0	R/W-0

Please clear VERSEL and PHO to 0 and set ADIS to 1 on initial.

Appendix III: Package spec of EM785830AD, EM78P5830D/AD



Symbol	Min	Normal	Max
A			2.70
A1	0.15		0.50
A2	1.80	2.00	2.20
b		0.30(TYP)	
c		0.15(TYP)	
E1	13.00	13.20	13.40
E	9.90	10.00	10.10
L	0.73	0.88	1.03
L1	1.50	1.60	1.70
e		0.80(TYP)	
θ	0		7

DWG NO: POD-031		File : QFP44	Edition: A
	Name	Date:	Unit : mm
Draw			Scale: Free
Chec			Material:
Approved			Sheet:1 of 1