

Index

- 1. Overview 3
 - 1.1 Features 3
 - 1.2 System configuration 4
 - 1.2.1 Low-cost configuration: No external line driver (direct drive)) 4
 - 1.2.2 High-drive configuration: External line driver 4
- 2. Pin function 5
 - 2.1 Pin assignment 5
 - 2.2 Pin description 6
 - 2.2.1 System Clocks & Reset 6
 - 2.2.2 BOOT I/F 6
 - 2.2.3 PORT I/F 7
 - 2.2.4 TX_PGA I/F 7
 - 2.2.5 RX_PGA I/F 7
 - 2.2.6 ADC I/F 8
 - 2.2.7 Power/Other 8
 - 2.2.8 Debug I/F 8
- 3. Function overview 9
 - 3.1 Block diagram 9
 - 3.2 ARM domain 10
 - 3.2.1 ARM M0+ 10
 - 3.2.2 Memory 10
 - 3.3 DSP domain 10
 - 3.3.1 DSP 10
 - 3.3.2 Memory 10
 - 3.4 AFE (Analog Front End) domain 10
 - 3.4.1 DAC 10
 - 3.4.2 TX_PGA 10
 - 3.4.3 RX_PGA 10
 - 3.4.4 ADC 10
 - 3.5 Regulator 11
 - 3.5.1 DC-DC 11
- 4. Electrical characteristics 12
 - 4.1 Absolute maximum ratings 12
 - 4.2 Recommended operating condition 13
 - 4.3 Power Up/Down and Reset Sequence 14
 - 4.3.1 Power Up/Down Sequence 14
 - 4.3.2 Reset Sequence 14
 - 4.3.3 System Clocks & Timings 15
 - 4.4 DC Characteristics 16
 - 4.5 AC Characteristics 17
 - 4.5.1 UART I/F 17

4.5.2	SPIs I/F	17
4.5.3	Serial-ROM I/F	18
4.5.4	Debug I/F	18
4.5.5	Current Consumption.....	19
4.6	Analog block characteristics	20
4.6.1	DC characteristics.....	20
4.6.2	Performance characteristics	20
4.7	Zero-crossing Detection.....	22
5.	Package.....	23
6.	Part Number	24
7.	Appendix.....	25

1. Overview

R9A06G061 is a modem LSI for narrow-band power line communications (Narrow Band PLC). The R9A06G061 is a product that optimizes performance and functionality (small package, low power, low cost) and provides demodulation signal processing (physical layer) for software-based PLCs based on a high-performance DSP with an MCU (link layer) (ARM® Cortex™-M0+) to provide a flexible and inexpensive PLC solution.

1.1 Features

- High-performance DSP
 - Handle PHY layer of power line communication etc.
 - Maximum operating frequency: 276MHz
 - IRAM: 128KB, DRAM: 128KB
 - Dedicated instructions for Viterbi and Reed Solomon processing, AES128 encryption/decryption processing, and others
- MCU (ARM® Cortex™-M0+)
 - Handle protocol conversion processing for the external MCU interface etc.
 - Maximum operating frequency: 92MHz
 - RAM: 32KB
 - CRC Operation H/W Core
- Analog front-end (AFE) circuit
 - DAC
 - ◇ Delta Sigma DA converter
 - ◇ ENOB:11bit
 - Variable Output Amplifiers
 - ◇ 114dBuVrms output (high output mode, 50-ohm drive for differential terminals)
 - ◇ Gain variable, in 3dB steps
 - Variable Receiving Amplifiers
 - ◇ Dynamic range: -18dB to +60dB, 2dB steps
 - ◇ AGC with DSP control
 - ADC
 - ◇ Delta Sigma ADC
 - ◇ ENOB:10bit
- A variety of External IOs
 - ◇ UART(1ch), SPIs(1ch), Serial Flash IF(Single/Dual)
 - ◇ PORT(10ch) (* however, exclusive use with above peripherals)
- Built-in regulator: 3.3V input, 1.15V DC-DC converter
- Supply voltage:3.3V
- PKG:40-pin QFN 6mm x 6mm, 0.5mm pitch□
- Operating temperature
 - R9A06G061GNP#AA0 : -40 to +85 degrees
 - R9A06G061GNP#AAA : -40 to +105 degrees

2. Pin function

2.1 Pin assignment

Fig.2.1 shows the pin assignment of R9A06G061.

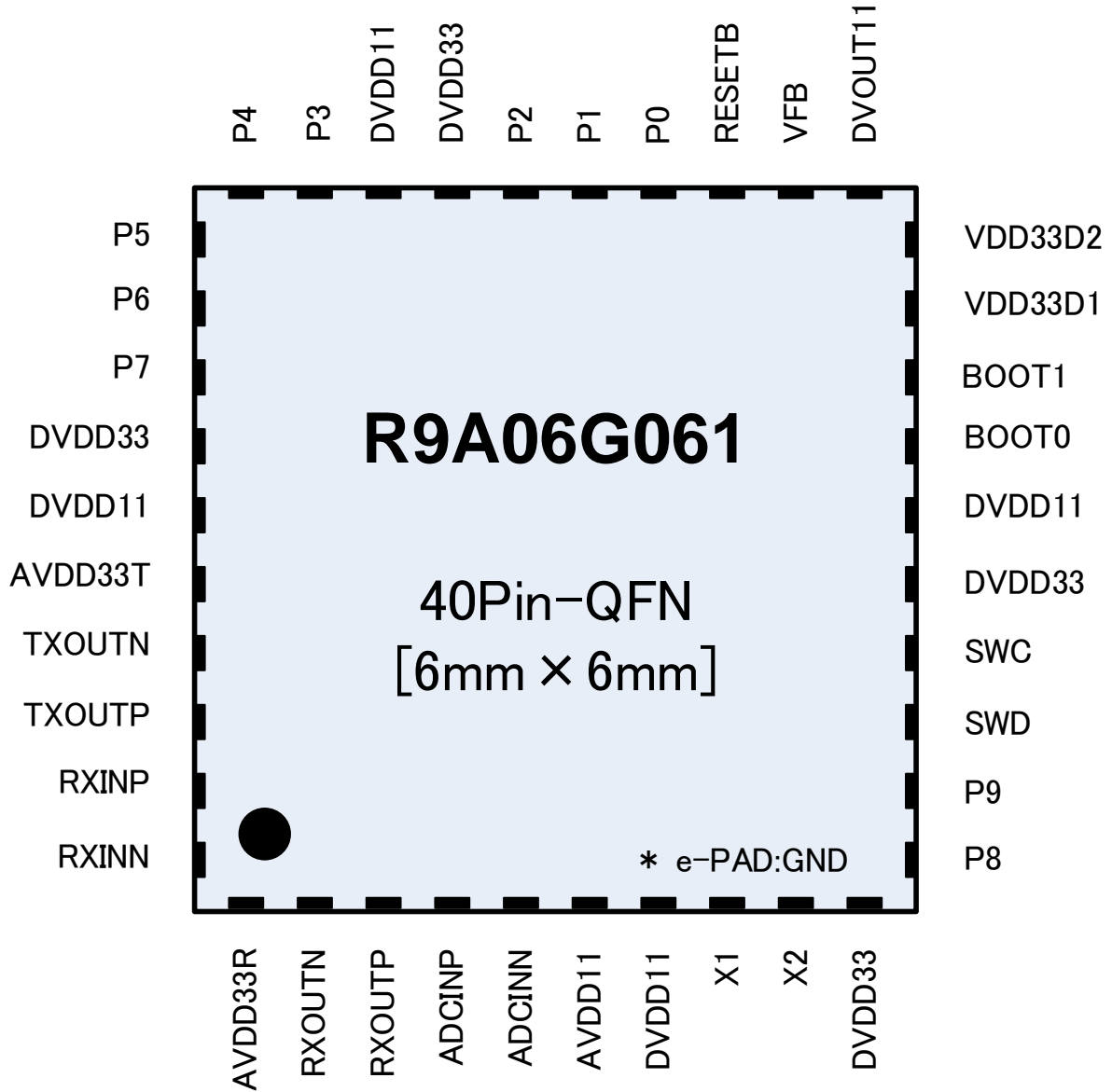


Figure 2. 1 configuration

2.2 Pin description

2.2.1 System Clocks & Reset

Pin name	I/O	BUFTYPE	Pin No	Functions
X1	I	-	8	External X'tal oscillator input f:16MHz
X2	O	-	9	External X'tal oscillator Output
RESETB	I	Schmitt/PU	23	System Reset (with Pull-Up resistor)

PU: With a 50K Ω internal pullup resistor

2.2.2 BOOT I/F

Pin name	I/O	BUFTYPE	Pin No	Functions
BOOT0	I	PU	17	Boot mode selection (with an internal Pullup resistor)
				UART [BOOT1 =High, BOOT0=High] SPI [BOOT1 =Low, BOOT0=High] SROM [BOOT1 =High, BOOT0=Low]
				<u>UART_S-IF</u> RXD :P2 TXD :P1
BOOT1	I	PU	18	<u>SPI-IF</u> SO :P1 SSB :P4 SCK :P3 SI :P2 REQ :P5
				<u>SROM-IF</u> SIO1/MISO :P9 SSB :P7 SCK :P8 SIO0/MOSI :P6

PU: With a 130K Ω internal pullup resistor

2.2.3 PORT I/F

Pin name	I/O	BUFTYPE	Pin No	Functions
P0	I/O	B-4/8mA Schmitt/PU/PD	24	I/O Port [0]
P1	I/O	B-4/8mA Schmitt/PU/PD	25	I/O Port [1] *Note1
P2	I/O	B-4/8mA Schmitt/PU/PD	26	I/O Port [2] *Note1
P3	I/O	B-4/8mA Schmitt/PU/PD	29	I/O Port [3]
P4	I/O	B-4/8mA Schmitt/PU/PD	30	I/O Port [4]
P5	I/O	B-4/8mA Schmitt/PU/PD	31	I/O Port [5]
P6	I/O	B-4/8mA Schmitt/PU/PD	32	I/O Port [6]
P7	I/O	B-4/8mA Schmitt/PU/PD	33	I/O Port [7]
P8	I/O	B-4/8mA Schmitt/PU/PD	11	I/O Port [8]
P9	I/O	B-4/8mA Schmitt/PU/PD	12	I/O Port [9]

PD: With a 160KΩ internal pulldown resistor / PU: With a 130KΩ internal pullup resistor.
The default buffer type for P1-P9 is 8mA / PU ((with 130KΩ internal pullup resistor).
The function of each PORT pins can be selected from UART, CSI, IIC, Serial-ROM-IF (Single/Dual/Quad), PWM.

*Note1: Please set P1 and P2 to Hi-Z(Open) or High when the system reset is released (RESETB: Low → High).

2.2.4 TX_PGA I/F

Pin name	I/O	BUFTYPE	Pin No	Functions
TXOUTP	O	Analog	38	TX_PGA signal output (+)
TXOUTN	O	Analog	37	TX_PGA signal output (-)

2.2.5 RX_PGA I/F

Pin name	I/O	BUFTYPE	Pin No	Functions
RXINP	I	Analog	39	RX_PGA signal input (+)
RXINN	I	Analog	40	RX_PGA signal input (-)
RXOUTP	O	Analog	3	RX_PGA signal output (+)
RXOUTN	O	Analog	2	RX_PGA signal output (-)

2.2.6 ADC I/F

Pin name	I/O	BUFTYPE	Pin No	Functions
ADCINP	I	Analog	4	ADC signal input (+)
ADCINN	I	Analog	5	ADC signal input (-)

2.2.7 Power/Other

Pin name	I/O	BUFTYPE	Pin No	Functions
DVDD33	I	-	10 15 27 34	IO buffer power supply 3.3V
DVDD11	I	-	7 16 28 35	Internal core power supply 1.15V (Supplied from DCDC output DVOUT11 with external LC smoothing filter)
VDD33D1	I	-	19	DCDC 3.3V power supply (control unit)
VDD33D2	I	-	20	DCDC 3.3V power supply (output stage)
DVOUT11	O	-	21	DCDC output (3.3V PWM) 1.15V generation with external LC smoothing filter
VFB	I	-	22	DCDC 1.15V Feedback (for PWM control)
AVDD33T	I	-	36	Analog power supply 3.3V (for transmission circuit)
AVDD33R	I	-	1	Analog power supply 3.3V (for receiving and common circuit)
AVDD11	I	-	6	Analog power supply 1.15V (Supplied from DCDC output DVOUT11 with external LC smoothing filter)
GND	I	-	-	Common Ground (Backside PAD)

2.2.8 Debug I/F

Pin name	I/O	BUFTYPE	Pin No	Functions
SWC	I	Schmitt/PU	14	SWDCLK
SWD	I/O	Schmitt/PU	13	SWDIO

PU: With a 130K Ω internal pullup resistor

3. Function overview

3.1 Block diagram

Figure 3. 1 shows an internal functional block diagram of R9A06G061. R9A06G061 is made up of ARM domain, DSP domain and AFE domain. It also has a built-in PORT and regulator.

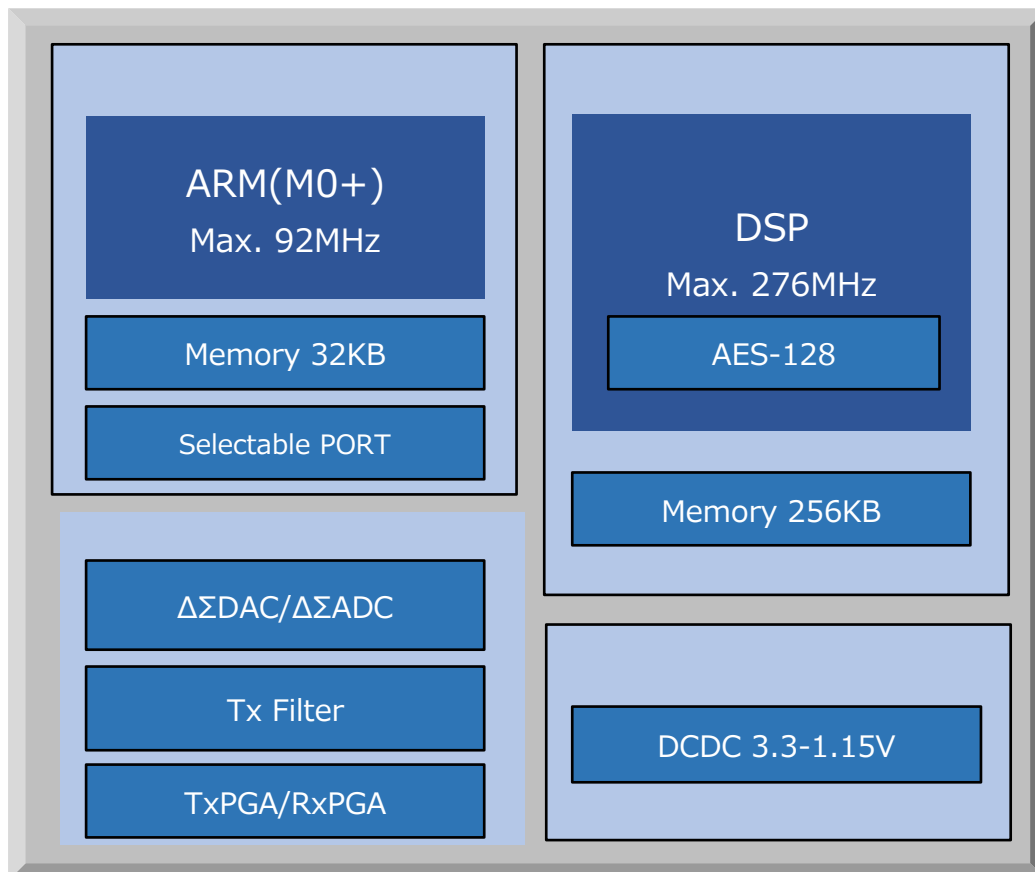


Figure 3. 1 R9A06G061 Block Diagram

3.2 ARM domain

3.2.1 ARM M0+

R9A06G061 integrates ARM® Cortex™-M0+. Maximum operational clock frequency is 92MHz.

3.2.2 Memory

ARM domain includes 32Kbytes of RAM. This is used for protocol processing and data translation between ARM and DSP domains.

3.3 DSP domain

3.3.1 DSP

DSP domain has a high-performance DSP. The DSP supports a variety of hardware-based instructions for Viterbi, Reed Solomon and other functions. The DSP can effectively realize various power line communication PHY layer with the hardware-based instructions. The maximum clock frequency of the DSP is 276MHz.

3.3.2 Memory

DSP domain includes 128KBytes of instruction RAM and 128KBytes of data RAM.

3.4 AFE (Analog Front End) domain

3.4.1 DAC

Delta sigma DA converter. Achieves ENOB :11bit accuracy at a sampling frequency of 138MHz.

3.4.2 TX_ PGA

Programable Transmit Amplifier that can adjust output signal gain. The gain is programmable in 3dB steps from -3dB to +18dB

3.4.3 RX_ PGA

Programable Receive Amplifier that can adjust received signal gain. The gain is programmable in 2dB steps from -18dB to +60dB. DSP computes the received signal level optimization. DSP controls the gain of RX PGA based on the computation. Then, AGC (Auto Gain Control) that controls the amplitude of the received signal automatically can be realized.

3.4.4 ADC

Delta Sigma AD converter. Maximum sampling frequency 276MHz. Achieves ENOB :10bit accuracy (SINAD :62 dB) in PLC signal bands below 600KHz.

3.5 Regulator

3.5.1 DC-DC

3.3V to 1.15V power supply voltage is generated by the switching regulator. It can supply 1.15V power supplies for digital and analog circuits in R9A06G061.

4. Electrical characteristics

4.1 Absolute maximum ratings

Parameter	Symbol	Conditions	Rating	Unit
Power supply voltage	VDD, AVDD	1.15V	-0.3~+1.6	V
		3.3V	-0.3~+4.2	V
I/O voltage	V_i/V_o	$V_i/V_o < VDD + 0.5V$	-0.3~+4.2	V
Output current (3.3V buffer)	I_o	4mA/8mA	8.7/16	mA
Junction temperature (R9A06G061GNP#AA0)	T_j	-	-40~105	°C
Junction temperature (R9A06G061GNP#AAA)	T_j	-	-40~125	°C

Cautions)

Product quality may be impaired if the absolute maximum rating is exceeded even momentarily for any parameter. That is, the absolute maximum ratings are rated values at which the product is on the verge of suffering physical damage, therefore, the product must be used under conditions that ensure that the absolute maximum ratings are not exceeded.

Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements.

4.2 Recommended operating condition

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Power supply voltage (Digital)	VDD	1.15V ^{*Note1}	1.04	1.15	1.26	V
		3.3V	3.0	3.3	3.6	V
Power supply voltage (Analog)	AVDD	1.15V ^{*Note1}	1.04	1.15	1.26	V
		3.3V	3.0	3.3	3.6	V
Negative trigger input voltage	V _N	3.3V operation	0.8		1.8	V
Positive trigger input voltage	V _P	3.3V operation	1.1		2.4	V
Hysteresis Voltage	V _H	3.3V operation	0.15		1.1	V
Low level input voltage	V _{IL}	3.3V operation	-0.3		0.8	V
High level input voltage	V _{IH}	3.3V operation	2.4		VDD33+0.3	V
An input rise/ fall time (data)	t _{rid}	-	0		200	ns
	t _{fid}	-	0		200	ns
An input rise/ fall time (clock)	t _{ric}	-	0		4	ns
	t _{fic}	-	0		4	ns
An input rise/ fall time (Schmidt)	t _{ris}	-	0		1	ms
	t _{fis}	-	0		1	ms
Operating ambient temperature (R9A06G061GNP#AA0)	T _a		-40		+85	°C
Operating ambient temperature (R9A06G061GNP#AAA)	T _a		-40		+105	°C

*Note1: When using the integrated DCDC output DVOUT11 with an appropriate LC smoothing filter and snubber circuit, there is no need for an external 1.15V power supply. Please refer to the reference schematic for the LC smoothing filter and snubber circuit.

4.3 Power Up/Down and Reset Sequence

4.3.1 Power Up/Down Sequence

Figure 4. 1 shows the power up/down sequence. It is recommended that the time which elapses from the start of power-supply rise (Analog power (AVDD33) and I/O power (IO_VDD) until both power supplies are stabilized should be within 100ms, regardless of the order of power supply.

Power supply voltage is recommended to rise from 0.1 VDD to 0.95 VDD within 100ms.

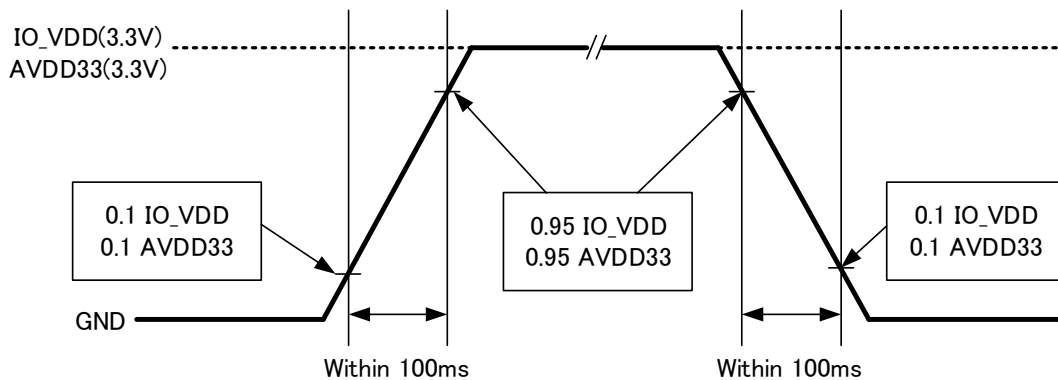


Figure 4. 1 diagram of the power ON/OFF sequence

4.3.2 Reset Sequence

Figure 4. 2 shows R9A06G061 reset sequence. Do not de-assert RESETB before keeping the low level for at least 1ms from the moment IO power supply reaches 95% of 3.3V (0.95 IO_VDD).

After power-up, please keep RESETB low level at least for 200us when resetting.

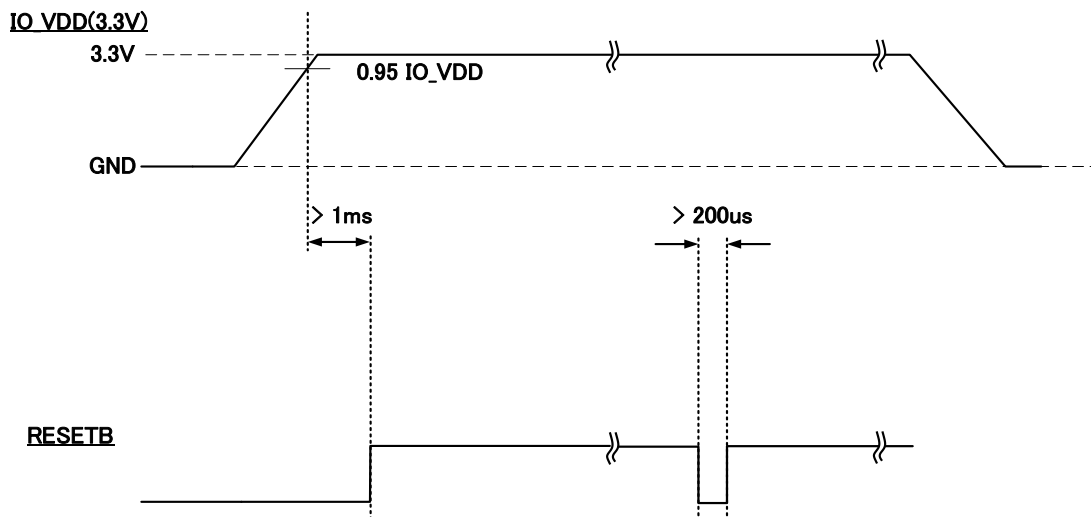


Figure 4. 2 Timing diagram of reset sequence and power-up constraints

4.3.3 System Clocks & Timings

Symbol	Parameter	MIN	TYP	MAX	Units
$F_{XTALcyc}$	X1/X2 X'tal clock frequency		$16 \pm 25ppm$		MHz

Clock timing

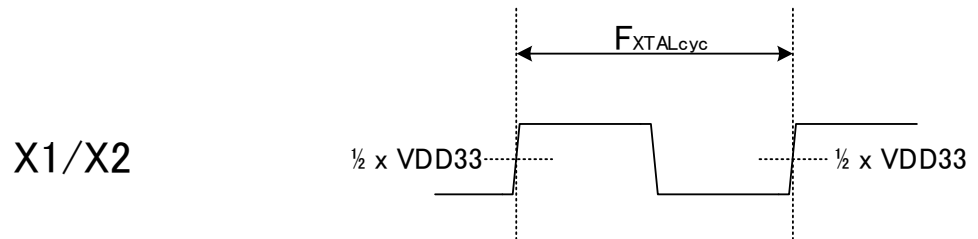


Figure 4. 3 System clock timing

4.4 DC Characteristics

DC Characteristics (VDD=3.3+/-0.3V, T_a = -40~+85 °C)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Input leakage current	I _{IL}	Normal input V _{in} =GND	-	-	-10	μA
	I _{IH}	Normal input V _{in} =IOVDD	-	-	10	μA
	I _{PU1} (Other than RESETB)	Pull-up resistor V _{in} =GND	-6.7	-	-200	μA
	I _{PD1} (Other than RESETB)	Pull-down resistor V _{in} =IOVDD	6.7	-	200	μA
	I _{PU2} (RESETB only)	Pull-up resistor V _{in} =GND	-30	-	-144	μA
Output leakage current	I _{oZL}	V _o =GND	-	-	-10	μA
	I _{oZH}	V _o =IOVDD	-	-	10	μA
Low level output current	I _{oL}	V _{oL} =0.4V 4mA/8mA	4/8	-	-	mA
High level output current	I _{oH}	V _{oH} =IOVDD-0.4V 4mA/8mA	-4/-8	-	-	mA
Pull up resistor 1 (other than RESETB)	R _{PU1}	V _{in} =GND	18	130	450	KΩ
Pull down resistor	R _{PD1}	V _{in} =IOVDD	18	160	450	KΩ
Pull-up resistor 2 (RESETB Pull up resistor only)	R _{PU2}	V _{in} =GND	25	50	100	KΩ
Low level output voltage	V _{oL}	I _{oL} =0mA	-	-	0.1	V
High level output voltage	V _{oH}	I _{oH} =0mA	IOVDD-0.1	-	-	V

4.5 AC Characteristics

4.5.1 UART I/F

Figure 4. 4shows a timing diagram of UART interface.

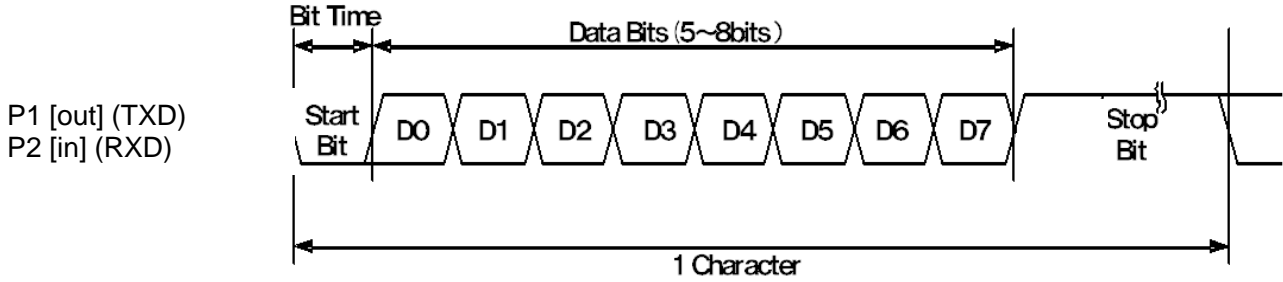


Figure 4. 4of UART interface

4.5.2 SPIs I/F

Figure 4. 5shows a timing diagram of SPIs interface.

Symbol	Parameter	MIN	TYP	MAX	Units
FCLK	Communication clock frequency			25 ($T_{SCK} = 40.0ns$)	MHz
T_{SCKH}, T_{SCKL}	Communication clock high-low width	$T_{SCK} \times 0.45$		$T_{SCK} \times 0.55$	ns
T_{DD}	Output signal (SI,SO,SS) Data delay (P1)	0		9	ns
	Output signal (SI,SO,SS) Data delay (P6)	0		14	ns
T_{DS}	Input signal (SI,SO) Data set-up time (P2)	4.6			ns
	Input signal (SI,SO) Data set-up time (P7))	5.6			ns
T_{DH}	Input signal (SI,SO) Data hold time	0			ns
T_{CS}	SS Signal Inactive Time	$T_{SCK} \times 1.0$			ns
T_{CSS}	SS Signal Setup Time	$T_{SCK} \times 1.5$			ns
T_{CSH}	SS Signal Hold Time	$T_{SCK} \times 1.5$			ns

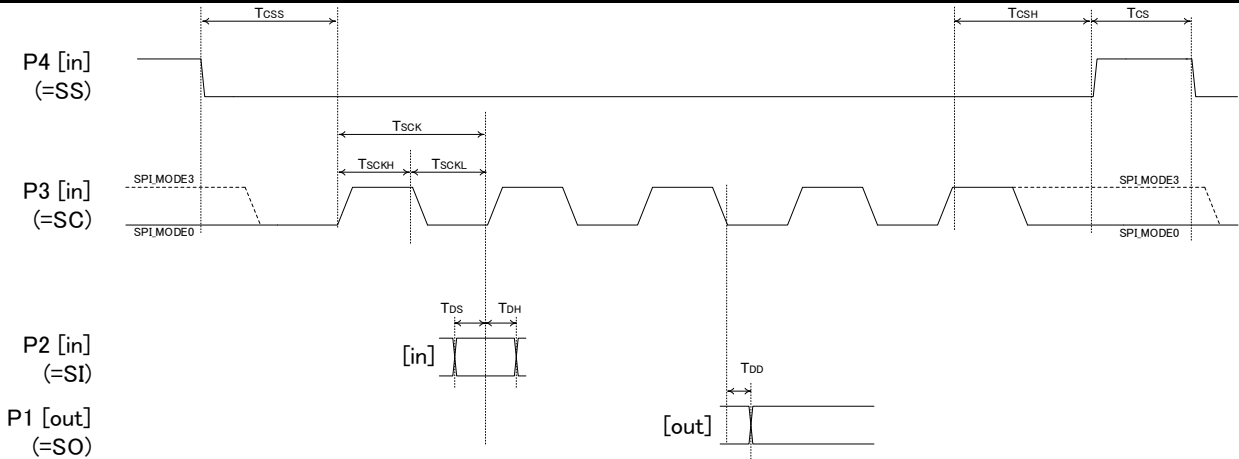


Figure 4. 5of SPIs interface

4.5.3 Serial-ROM I/F

Figure 4. 6 shows a timing diagram of the SerialROM interface.

Symbol	Parameter	MIN	TYP	MAX	Units
FCLK	Communication clock frequency	2.875 ($T_{SCK} = 347.8\text{ns}$)		46 ($T_{SCK} = 21.7\text{ns}$)	MHz
T_{SCKH} , T_{SCKL}	Communication clock high-low width	$T_{SCK} \times 0.45$		$T_{SCK} \times 0.55$	ns
TDD	Output signal (SI,SO,SS) Data delay	0		5	ns
TDS	Input signal (SI,SO) Data setup time (P1,P2)	6			ns
	Input signal (SI,SO) Data setup time (P6,P9)	7			ns
TDH	Input signal (SI,SO) Data hold time	0			ns

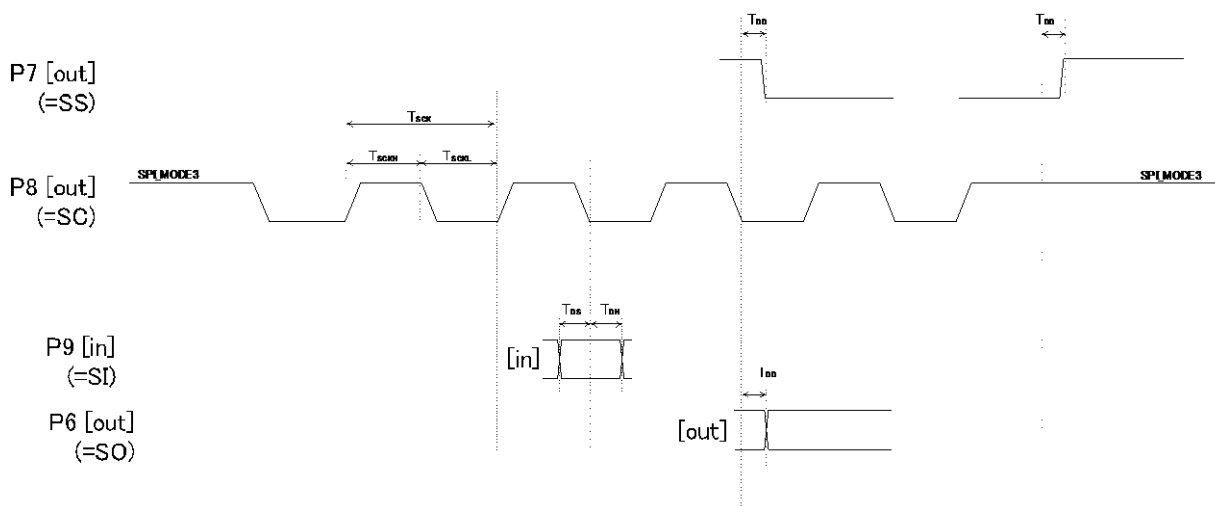


Figure 4. 6 Timing diagram of the SerialROM interface

4.5.4 Debug I/F

Figure 4. 7 shows a timing diagram of SCHED interface.

Symbol	Parameter	MIN	TYP	MAX	Units
FCLK	Communication clock frequency			50 ($T_{SCK} = 20.0\text{ns}$)	MHz
T_{SCKH} , T_{SCKL}	Communication clock high-low width	$T_{SCK} \times 0.45$		$T_{SCK} \times 0.55$	ns
TDD	Output Signal(SWD)) Data Delay	4.0		14.0	ns
TDS	Input Signal(SWD)) Data Setup Time	3.6			ns
TDH	Input Signal(SWD)) Data Hold Time	0			ns

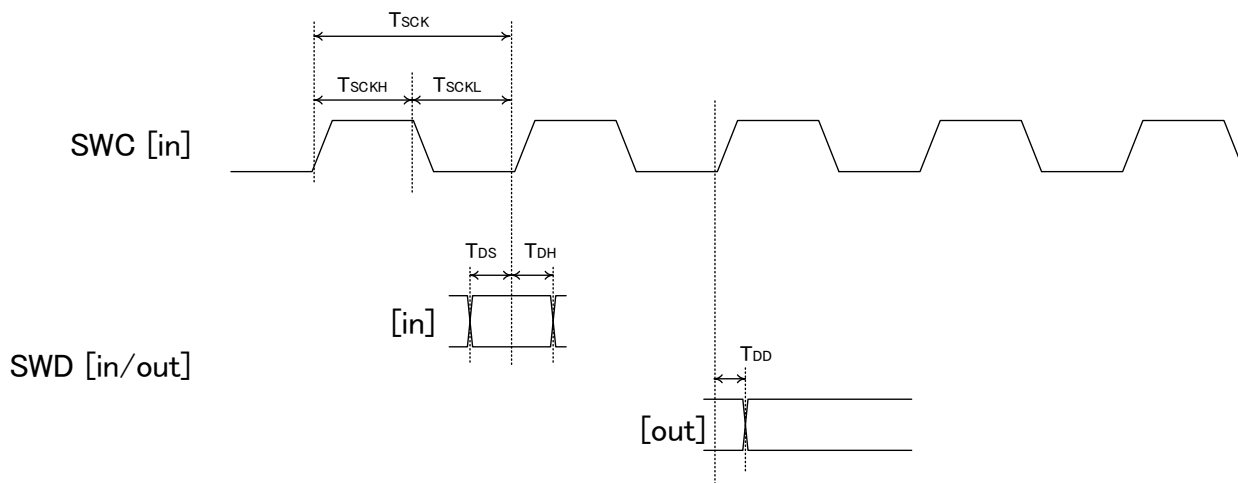


Figure 4.7 PWD interface

4.5.5 Current Consumption

VDD	MIN.	TYP.	MAX.	Unit
VDD33		38		mA

Conditions: VDD33 = $3.3 \pm 0.3V$, VDD11 is generated by internal DC-DC converter
 With Renesas evaluation board, DSP:276MHz, receive mode with G3-FCC

4.6 Analog block characteristics

4.6.1 DC characteristics

Pin No.	Parameter	Conditions	Symbol	MIN	TYP	MAX	Unit
2	Power Supply Voltage		AVDD33T	3.0	3.3	3.6	V
12	Power Supply Voltage		AVDD33R	3.0	3.3	3.6	V

4.6.2 Performance characteristics

4.6.2.1 Receiving blocks

(a) RX_PGA interface

Parameter	Conditions	Symbol	MIN	TYP	MAX	Unit
Input voltage range	Differential	V_i	60u		3.0	Vp-p
Input frequency		F_{sig}	30		500	kHz
Dynamic range (voltage gain range)		DR		78		dB
Gain control step		D_{STEP}		2		dB
Input 1dB Compression	$G_V = -14dB, f_{sig} = 30kHz, \text{Differential}$	$P_{in\ 1dB}$	2.8	3.3		Vp-p
Maximum voltage gain	$f_{sig} = 500kHz$	G_{V_max}		60		dB
Minimum voltage gain	$f_{sig} = 500kHz$	G_{V_min}		-18		dB
Input impedance		Z_i		1		k Ω
Output load impedance		R_L		20		k Ω

(b) ADC Interfaces

Parameter	Conditions	Symbol	MIN	TYP	MAX	Unit
Input voltage range	Differential	V_{sig}			800	mVp-p
Input Frequency		F_{SIG}			500	kHz
Sampling frequency		F_{CLK}	-	138	-	MHz
ENOB		ENOB	-	10	-	bit
SINAD		SINAD	-	62	-	dB
Input Impedance		Z_i		20		k Ω

4.6.2.2 Transmit block

(a) TX_PGA interface

Direct-drive (high-power) mode

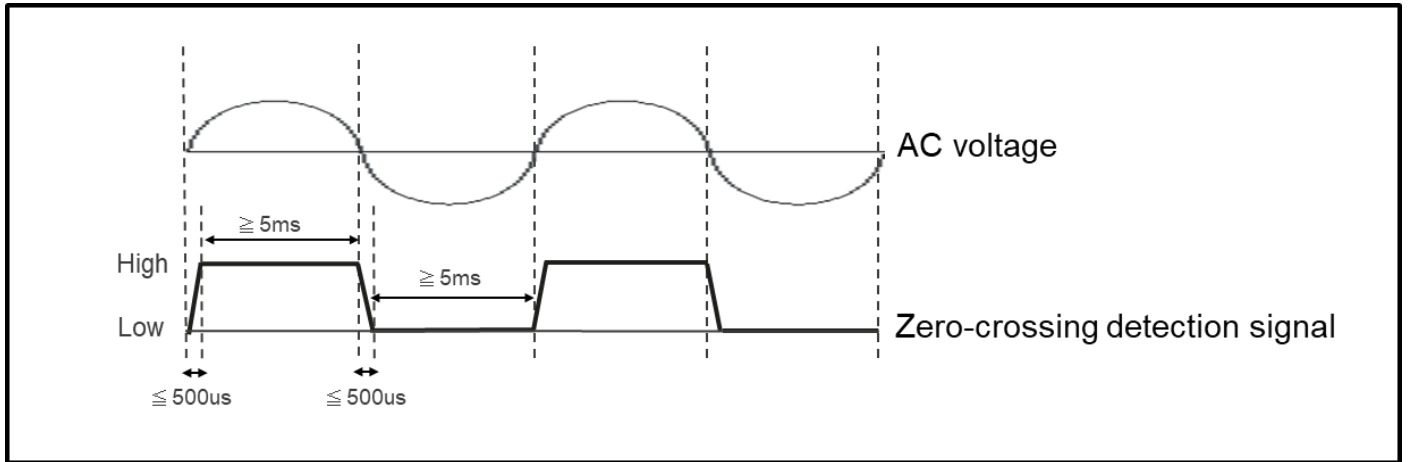
Parameter	Conditions	Symbol	MIN	TYP	MAX	Unit
Output frequency band		f_{sig}	30		500	kHz
Dynamic range (voltage gain range)		DR		21		dB
Gain control step		DSTEP		3		
Maximum voltage gain	$f_{sig}= 500\text{kHz}$, differential output	G_{v_max}		18		dB
Minimum voltage gain	$f_{sig}= 500\text{kHz}$, differential output	G_{v_min}		-3		dB
Output -1dB compression	$f_{sig}= 500\text{kHz}$, differential output $Z_L=50\Omega$ (Each terminal), $G_V = +3\text{dB}$	P_1	3			Vp-p
Harmonic Distortion	$f_{sig}= 100\text{kHz}$, 1.4Vp-p differential output, $Z_L= 50\Omega$ (each pin), $G_V =$ $+9\text{dB}$,	HD	-	-70	-60	dBc
Output load impedance		Z_L		50		Ω

External send driver (low output) mode

Parameter	Conditions	Symbol	MIN	TYP	MAX	Unit
Output frequency band		f_{sig}	30		500	kHz
Dynamic range (voltage gain range)		DR		21		dB
Gain control step		DSTEP		3		
Maximum voltage gain	$f_{sig}= 500\text{kHz}$, differential output	G_{v_max}		18		dB
Minimum voltage gain	$f_{sig}= 500\text{kHz}$, differential output	G_{v_min}		-3		dB
Output-1dB compression	$f_{sig}= 500\text{kHz}$, differential output $Z_L=,390\text{ohms}$ (Each terminal), $G_V = +3\text{dB}$,	P_1	2			Vp-p
Harmonic Distortion	$f_{sig}=100\text{kHz}$, 0.9Vp-p differential output, $Z_L= 390\Omega$ (each pin), $G_V= +3\text{dB}$	HD	-	-70	-60	dBc
Output load impedance		Z_L		390		Ω

4.7 Zero-crossing Detection

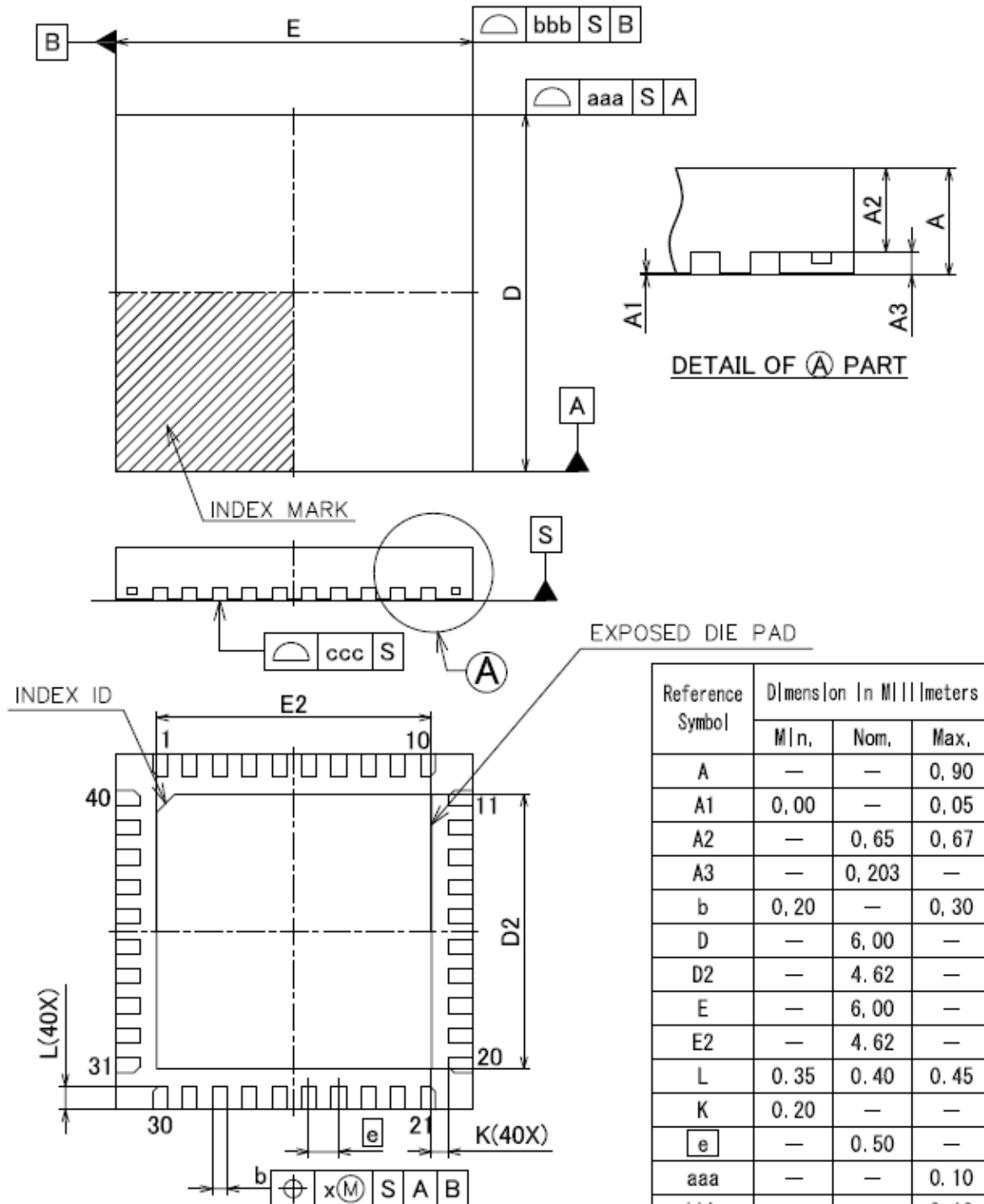
The phase detection function is available by inputting the following Zero-crossing detection signal to P3 (in case of UART or SROM boot mode) or P6 (in case of SPI boot mode).



The rise time and fall times of the Zero-crossing detection signal including chattering time should be within 500 μs . After the rise of the signal, maintain a high level for 5ms or more. After the fall of the signal, maintain a low level for 5ms or more.

5. Package

JEITA Package Code	RENESAS Code	MASS [Typ.]
P-HVQFN40-6 × 6-0.50	PVQN0040KK-A	0.10g



Reference Symbol	Dimension in Millimeters		
	Min.	Nom.	Max.
A	—	—	0.90
A1	0.00	—	0.05
A2	—	0.65	0.67
A3	—	0.203	—
b	0.20	—	0.30
D	—	6.00	—
D2	—	4.62	—
E	—	6.00	—
E2	—	4.62	—
L	0.35	0.40	0.45
K	0.20	—	—
e	—	0.50	—
aaa	—	—	0.10
bbb	—	—	0.10
ccc	—	—	0.05
x	—	—	0.10

6. Part Number

R9A06G061GNP#AA0

Ta: -40 ~ 85°C

R9A06G061GNP#AAA

Ta: -40 ~ 105°C

7. Appendix

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.

"Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.

"High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.

6. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
10. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
11. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

(Note2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.4.0-1 November 2017)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,

Koto-ku, Tokyo 135-0061, Japan

www.renesas.com

Contact Information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit:

www.renesas.com/contact/

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.