

Ultra low power 48 MHz Arm® Cortex®-M23 core, up to 128-KB code flash memory, 16-KB SRAM, Capacitive Sensing Unit (CTS2U), 12-bit A/D Converter, Security and Safety features.

## Features

- **Arm Cortex-M23 Core**
  - Armv8-M architecture
  - Maximum operating frequency: 48 MHz
  - Arm Memory Protection Unit (Arm MPU) with 8 regions
  - Debug and Trace: DWT, FPB, CoreSight™ MTB-M23
  - CoreSight Debug Port: SW-DP
- **Memory**
  - Up to 128-KB code flash memory
  - 4-KB data flash memory (100,000 program/erase (P/E) cycles)
  - 16-KB SRAM
  - Memory protection units
  - 128-bit unique ID
- **Connectivity**
  - Serial Communications Interface (SCI) × 4
    - Asynchronous interfaces
    - 8-bit clock synchronous interface
    - Simple IIC
    - Simple SPI
    - Smart card interface
  - Serial Peripheral Interface (SPI) × 1
  - I<sup>2</sup>C bus interface (IIC) × 1
- **Analog**
  - 12-bit A/D Converter (ADC12)
  - Low-Power Analog Comparator (ACMPLP) × 2
  - Temperature Sensor (TSN)
- **Timers**
  - General PWM Timer 32-bit (GPT32) × 1
  - General PWM Timer 16-bit (GPT16) × 6
  - Low Power Asynchronous General Purpose Timer (AGT) × 2
  - Watchdog Timer (WDT)
- **Safety**
  - SRAM parity error check
  - Flash area protection
  - ADC self-diagnosis function
  - Clock Frequency Accuracy Measurement Circuit (CAC)
  - Cyclic Redundancy Check (CRC) calculator
  - Data Operation Circuit (DOC)
  - Port Output Enable for GPT (POEG)
  - Independent Watchdog Timer (IWDT)
  - GPIO readback level detection
  - Register write protection
  - Main oscillator stop detection
  - Illegal memory access detection
- **Security and Encryption**
  - AES128/256
  - True Random Number Generator (TRNG)
- **System and Power Management**
  - Low power modes
  - Realtime Clock (RTC)
  - Event Link Controller (ELC)
  - Data Transfer Controller (DTC)
  - Key Interrupt Function (KINT)
  - Power-on reset
  - Low Voltage Detection (LVD) with voltage settings
- **Human Machine Interface (HMI)**
  - Capacitive Sensing Unit (CTS2U)
- **Multiple Clock Sources**
  - Main clock oscillator (MOSC) (1 to 20 MHz)
  - Sub-clock oscillator (SOSC) (32.768 kHz)
  - High-speed on-chip oscillator (HOCO) (24/32/48/64 MHz)
  - Middle-speed on-chip oscillator (MOCO) (8 MHz)
  - Low-speed on-chip oscillator (LOCO) (32.768 kHz)
  - Clock trim function for HOCO/MOCO/LOCO
  - IWDT-dedicated on-chip oscillator (15 kHz)
- Clock out support
- **Up to 56 pins for general I/O ports**
  - 5-V tolerance, open drain, input pull-up, switchable driving ability
- **Operating Voltage**
  - VCC: 1.6 to 5.5 V
- **Operating Temperature and Packages**
  - Ta = -40°C to +85°C
    - 64-pin LQFP (14 mm × 14 mm, 0.8 mm pitch)
    - 64-pin LQFP (10 mm × 10 mm, 0.5 mm pitch)
    - 64-pin BGA (4 mm × 4 mm, 0.4 mm pitch)
    - 48-pin LQFP (7 mm × 7 mm, 0.5 mm pitch)
    - 48-pin HWQFN (7 mm × 7 mm, 0.5 mm pitch)
    - 36-pin LGA (4 mm × 4 mm, 0.5 mm pitch)
    - 32-pin LQFP (7 mm × 7 mm, 0.8 mm pitch)
    - 32-pin HWQFN (5 mm × 5 mm, 0.5 mm pitch)
    - 25-pin WLCSP (2.14 mm × 2.27 mm, 0.4 mm pitch)
  - Ta = -40°C to +105°C
    - 64-pin LQFP (14 mm × 14 mm, 0.8 mm pitch)
    - 64-pin LQFP (10 mm × 10 mm, 0.5 mm pitch)
    - 64-pin BGA (4 mm × 4 mm, 0.4 mm pitch)
    - 48-pin LQFP (7 mm × 7 mm, 0.5 mm pitch)
    - 48-pin HWQFN (7 mm × 7 mm, 0.5 mm pitch)
    - 36-pin LGA (4 mm × 4 mm, 0.5 mm pitch)
    - 32-pin LQFP (7 mm × 7 mm, 0.8 mm pitch)
    - 32-pin HWQFN (5 mm × 5 mm, 0.5 mm pitch)
    - 25-pin WLCSP (2.14 mm × 2.27 mm, 0.4 mm pitch)

## 1. Overview

The MCU integrates multiple series of software- and pin-compatible Arm<sup>®</sup>-based 32-bit cores that share a common set of Renesas peripherals to facilitate design scalability.

The MCU in this series incorporates an energy-efficient Arm Cortex<sup>®</sup>-M23 32-bit core, that is particularly well suited for cost-sensitive and low-power applications, with the following features:

- Up to 128-KB code flash memory
- 16-KB SRAM
- 12-bit A/D Converter (ADC12)
- Security features

### 1.1 Function Outline

**Table 1.1 Arm core**

Feature	Functional description
Arm Cortex-M23 core	<ul style="list-style-type: none"> <li>• Maximum operating frequency: up to 48 MHz</li> <li>• Arm Cortex-M23 core:               <ul style="list-style-type: none"> <li>– Revision: r1p0-00rel0</li> <li>– Armv8-M architecture profile</li> <li>– Single-cycle integer multiplier</li> <li>– 19-cycle integer divider</li> </ul> </li> <li>• Arm Memory Protection Unit (Arm MPU):               <ul style="list-style-type: none"> <li>– Armv8 Protected Memory System Architecture</li> <li>– 8 protect regions</li> </ul> </li> <li>• SysTick timer:               <ul style="list-style-type: none"> <li>– Driven by SYSTICCLK (LOCO) or ICLK</li> </ul> </li> </ul>

**Table 1.2 Memory**

Feature	Functional description
Code flash memory	Maximum 128-KB of code flash memory.
Data flash memory	4-KB of data flash memory.
Option-setting memory	The option-setting memory determines the state of the MCU after a reset.
SRAM	On-chip high-speed SRAM with parity bit.

**Table 1.3 System (1 of 2)**

Feature	Functional description
Operating modes	Two operating modes: <ul style="list-style-type: none"> <li>• Single-chip mode</li> <li>• SCI boot mode</li> </ul>
Resets	The MCU provides 12 resets (RES pin reset, power-on reset, independent watchdog timer reset, watchdog timer reset, voltage monitor 0/1/2 resets, SRAM parity error reset, bus master/slave MPU error resets, CPU stack pointer error reset, software reset).
Low Voltage Detection (LVD)	The Low Voltage Detection (LVD) module monitors the voltage level input to the VCC pin. The detection level can be selected by register settings. The LVD module consists of three separate voltage level detectors (LVD0, LVD1, LVD). LVD0, LVD1, and LVD measure the voltage level input to the VCC pin. LVD registers allow your application to configure detection of VCC changes at various voltage thresholds.
Clocks	<ul style="list-style-type: none"> <li>• Main clock oscillator (MOSC)</li> <li>• Sub-clock oscillator (SOSC)</li> <li>• High-speed on-chip oscillator (HOCO)</li> <li>• Middle-speed on-chip oscillator (MOCO)</li> <li>• Low-speed on-chip oscillator (LOCO)</li> <li>• IWDT-dedicated on-chip oscillator</li> <li>• Clock out support</li> </ul>

**Table 1.3 System (2 of 2)**

Feature	Functional description
Clock Frequency Accuracy Measurement Circuit (CAC)	The Clock Frequency Accuracy Measurement Circuit (CAC) counts pulses of the clock to be measured (measurement target clock) within the time generated by the clock selected as the measurement reference (measurement reference clock), and determines the accuracy depending on whether the number of pulses is within the allowable range. When measurement is complete or the number of pulses within the time generated by the measurement reference clock is not within the allowable range, an interrupt request is generated.
Interrupt Controller Unit (ICU)	The Interrupt Controller Unit (ICU) controls which event signals are linked to the Nested Vector Interrupt Controller (NVIC), and the Data Transfer Controller (DTC) modules. The ICU also controls non-maskable interrupts.
Key Interrupt Function (KINT)	The key interrupt function (KINT) generates the key interrupt by detecting rising or falling edge on the key interrupt input pins.
Low power modes	Power consumption can be reduced in multiple ways, including setting clock dividers, stopping modules, selecting power control mode in normal operation, and transitioning to low power modes.
Register write protection	The register write protection function protects important registers from being overwritten due to software errors. The registers to be protected are set with the Protect Register (PRCR).
Memory Protection Unit (MPU)	The MCU has four Memory Protection Units (MPUs) and a CPU stack pointer monitor function are provided.
Watchdog Timer (WDT)	The Watchdog Timer (WDT) is a 14-bit down counter that can be used to reset the MCU when the counter underflows because the system has run out of control and is unable to refresh the WDT. In addition, the WDT can be used to generate a non-maskable interrupt or an underflow interrupt or watchdog timer reset.
Independent Watchdog Timer (IWDT)	The Independent Watchdog Timer (IWDT) consists of a 14-bit down counter that must be serviced periodically to prevent counter underflow. The IWDT provides functionality to reset the MCU or to generate a non-maskable interrupt or an underflow interrupt. Because the timer operates with an independent, dedicated clock source, it is particularly useful in returning the MCU to a known state as a fail-safe mechanism when the system runs out of control. The IWDT can be triggered automatically by a reset, underflow, refresh error, or a refresh of the count value in the registers.

**Table 1.4 Event link**

Feature	Functional description
Event Link Controller (ELC)	The Event Link Controller (ELC) uses the event requests generated by various peripheral modules as source signals to connect them to different modules, allowing direct link between the modules without CPU intervention.

**Table 1.5 Direct memory access**

Feature	Functional description
Data Transfer Controller (DTC)	A Data Transfer Controller (DTC) module is provided for transferring data when activated by an interrupt request.

**Table 1.6 Timers (1 of 2)**

Feature	Functional description
General PWM Timer (GPT)	The General PWM Timer (GPT) is a 32-bit timer with GPT32 × channel and a 16-bit timer with GPT16 × channels. PWM waveforms can be generated by controlling the up-counter, down-counter, or the up- and down-counter. In addition, PWM waveforms can be generated for controlling brushless DC motors. The GPT can also be used as a general-purpose timer.
Port Output Enable for GPT (POEG)	The Port Output Enable (POEG) function can place the General PWM Timer (GPT) output pins in the output disable state
Low power Asynchronous General Purpose Timer (AGT)	The Low Power Asynchronous General Purpose Timer (AGT) is a 16-bit timer that can be used for pulse output, external pulse width or period measurement, and counting external events. This timer consists of a reload register and a down counter. The reload register and the down counter are allocated to the same address, and can be accessed with the AGT register.

**Table 1.6 Timers (2 of 2)**

Feature	Functional description
Realtime Clock (RTC)	For calendar count mode, the RTC has a 100-year calendar from 2000 to 2099 and automatically adjusts dates for leap years. For binary count mode, the RTC counts seconds and retains the information as a serial value. Binary count mode can be used for calendars other than the Gregorian (Western) calendar.

**Table 1.7 Communication interfaces**

Feature	Functional description
Serial Communications Interface (SCI)	The Serial Communications Interface (SCI) × channels have asynchronous and synchronous serial interfaces: <ul style="list-style-type: none"> <li>Asynchronous interfaces (UART and Asynchronous Communications Interface Adapter (ACIA))</li> <li>8-bit clock synchronous interface</li> <li>Simple IIC (master-only)</li> <li>Simple SPI</li> <li>Smart card interface</li> </ul> The smart card interface complies with the ISO/IEC 7816-3 standard for electronic signals and transmission protocol. SCIn (n = ) has FIFO buffers to enable continuous and full-duplex communication, and the data transfer speed can be configured independently using an on-chip baud rate generator.
I <sup>2</sup> C bus interface (IIC)	The I <sup>2</sup> C bus interface (IIC) has channel. The IIC module conforms with and provides a subset of the NXP I <sup>2</sup> C (Inter-Integrated Circuit) bus interface functions.
Serial Peripheral Interface (SPI)	The Serial Peripheral Interface (SPI) has 1 channel. The SPI provides high-speed full-duplex synchronous serial communications with multiple processors and peripheral devices.

**Table 1.8 Analog**

Feature	Functional description
12-bit A/D Converter (ADC12)	A 12-bit successive approximation A/D converter is provided. Up to 13 analog input channels are selectable. Temperature sensor output and internal reference voltage are selectable for conversion.
Temperature Sensor (TSN)	The on-chip Temperature Sensor (TSN) determines and monitors the die temperature for reliable operation of the device. The sensor outputs a voltage directly proportional to the die temperature, and the relationship between the die temperature and the output voltage is fairly linear. The output voltage is provided to the for conversion and can be further used by the end application.
Low-Power Analog Comparator (ACMPLP)	The Low-Power Analog Comparator (ACMPLP) compares a reference input voltage with an analog input voltage. Comparator channels ACMPLP0 and ACMPLP1 are independent of each other. The comparison result of the reference input voltage and analog input voltage can be read by software. The comparison result can also be output externally. The reference input voltage can be selected from either an input to the CMPREFi (i = 0, 1) pin or from the internal reference voltage (Vref) generated internally in the MCU. The ACMPLP response speed can be set before starting an operation. Setting high-speed mode decreases the response delay time, but increases current consumption. Setting low-speed mode increases the response delay time, but decreases current consumption.

**Table 1.9 Human machine interfaces**

Feature	Functional description
Capacitive Sensing Unit (CTS2)	The Capacitive Sensing Unit (CTS2) measures the electrostatic capacitance of the sensor. Changes in the electrostatic capacitance are determined by software that enables the to detect whether a finger is in contact with the sensor. The electrode surface of the sensor is usually enclosed with a dielectric film so that a finger does not come into direct contact with the electrode.

**Table 1.10 Data processing**

Feature	Functional description
Cyclic Redundancy Check (CRC) calculator	The Cyclic Redundancy Check (CRC) generates CRC codes to detect errors in the data. The bit order of CRC calculation results can be switched for LSB-first or MSB-first communication. Additionally, various CRC-generation polynomials are available. The snoop function allows to monitor the access to specific addresses. This function is useful in applications that require CRC code to be generated automatically in certain events, such as monitoring writes to the serial transmit buffer and reads from the serial receive buffer.
Data Operation Circuit (DOC)	The Data Operation Circuit (DOC) compares, adds, and subtracts 16-bit data. When a selected condition applies, 16-bit data is compared and an interrupt can be generated.

**Table 1.11 I/O ports**

Feature	Functional description
I/O ports	<ul style="list-style-type: none"> <li>• I/O ports for the 64-pin LQFP/BGA <ul style="list-style-type: none"> <li>– I/O pins: 53</li> <li>– Input pins: 3</li> <li>– Pull-up resistors: 53</li> <li>– N-ch open-drain outputs: 40</li> <li>– 5-V tolerance: 3</li> </ul> </li> <li>• I/O ports for the 48-pin LQFP/HWQFN <ul style="list-style-type: none"> <li>– I/O pins: 37</li> <li>– Input pins: 3</li> <li>– Pull-up resistors: 37</li> <li>– N-ch open-drain outputs: 26</li> <li>– 5-V tolerance: 3</li> </ul> </li> <li>• I/O ports for the 36-pin LGA <ul style="list-style-type: none"> <li>– I/O pins: 27</li> <li>– Input pins: 3</li> <li>– Pull-up resistors: 27</li> <li>– N-ch open-drain outputs: 17</li> <li>– 5-V tolerance: 1</li> </ul> </li> <li>• I/O ports for the 32-pin LQFP/HWQFN <ul style="list-style-type: none"> <li>– I/O pins: 23</li> <li>– Input pins: 3</li> <li>– Pull-up resistors: 23</li> <li>– N-ch open-drain outputs: 15</li> <li>– 5-V tolerance: 1</li> </ul> </li> <li>• I/O ports for the 25-pin WLCSP <ul style="list-style-type: none"> <li>– I/O pins: 20</li> <li>– Input pins: 1</li> <li>– Pull-up resistors: 20</li> <li>– N-ch open-drain outputs: 14</li> <li>– 5-V tolerance: 3</li> </ul> </li> </ul>

## 1.2 Block Diagram

Figure 1.1 shows a block diagram of the MCU superset. Some individual devices within the group have a subset of the features.

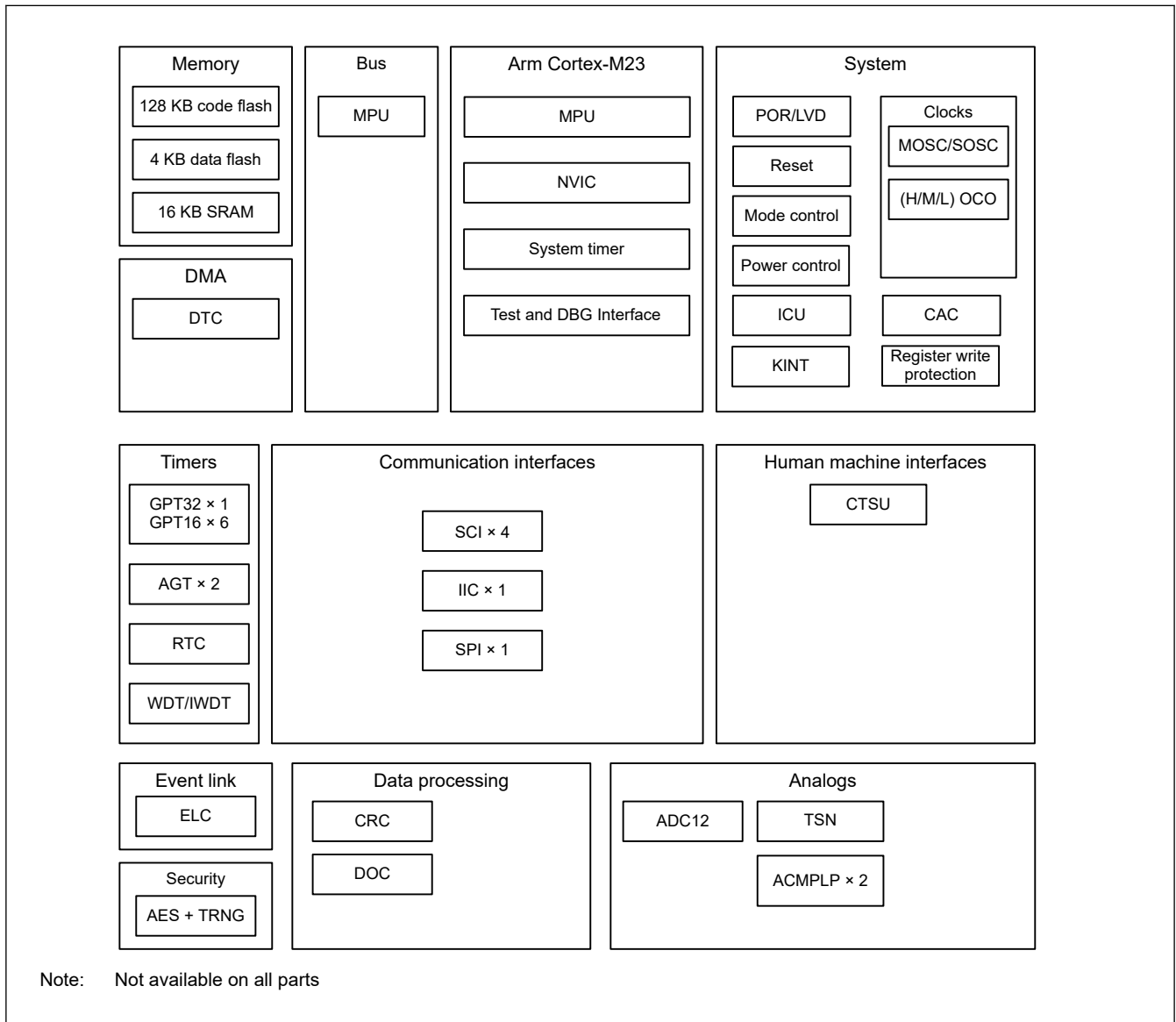


Figure 1.1 Block diagram

## 1.3 Part Numbering

Figure 1.2 shows the product part number information, including memory capacity and package type. Table 1.12 shows a list of products.

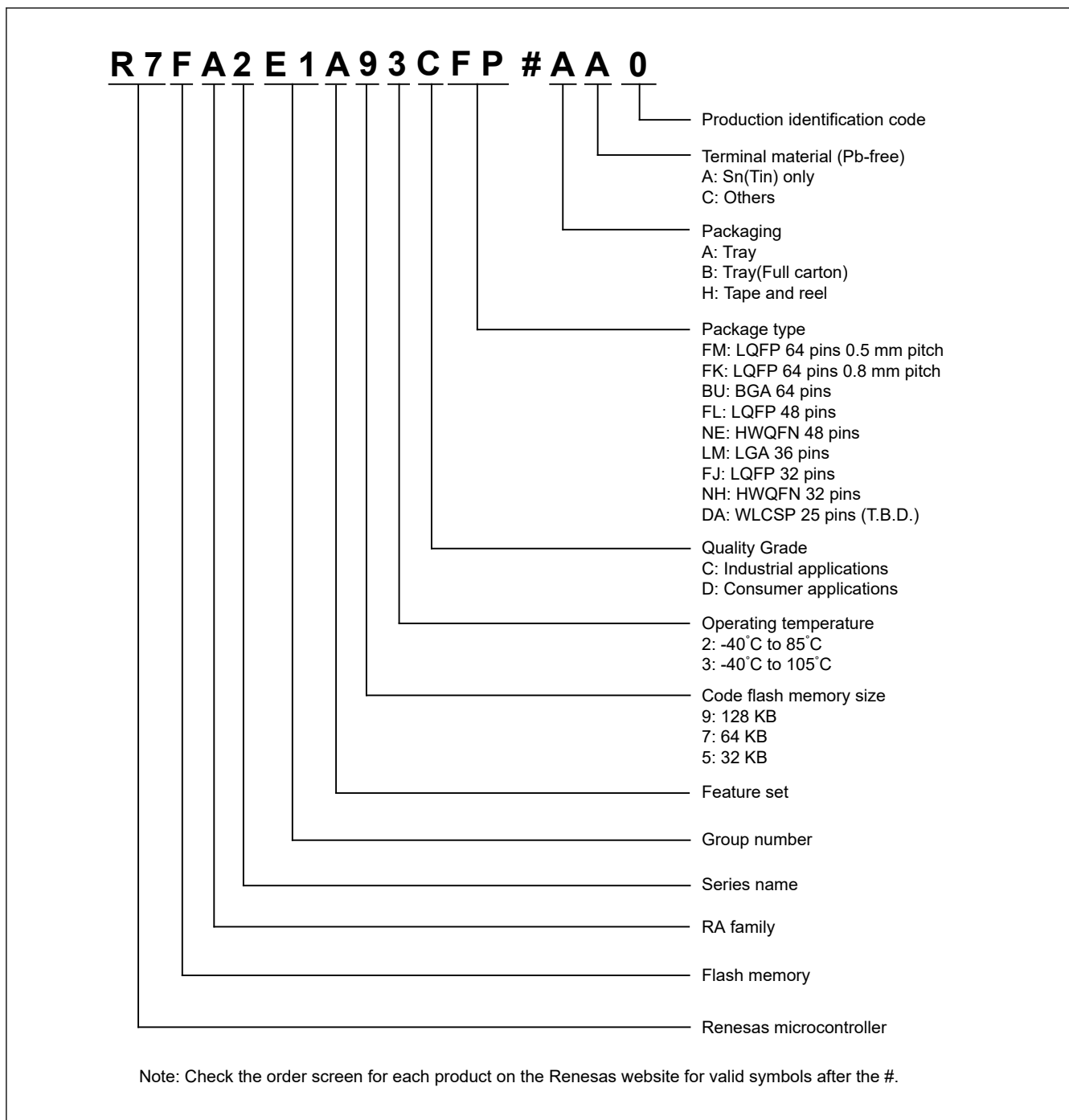


Figure 1.2 Part numbering scheme

Table 1.12 Product list (1 of 2)

Product part number	Package code	Code flash	Data flash	SRAM	Operating temperature
R7FA2E1A93CFM	PLQP0064KB-C PLQP0064KL-A	128	4	16	-40 to +105°C
R7FA2E1A93CFK	PLQP0064GA-A				
R7FA2E1A93CFL	PLQP0048KB-B PLQP0048KL-A				
R7FA2E1A93CFJ	PLQP0032GB-A PLQP0032GE-A				
R7FA2E1A93CNH	PWQN0032KE-A				
R7FA2E1A93CBU	PVBG0064LB-A				
R7FA2E1A93CLM	PWLG0036KB-A				
R7FA2E1A93CDA	T.B.D.				
R7FA2E1A93CNE	PWQN0048KC-A				
R7FA2E1A92DFM	PLQP0064KB-C PLQP0064KL-A				
R7FA2E1A92DFK	PLQP0064GA-A				
R7FA2E1A92DFL	PLQP0048KB-B PLQP0048KL-A				
R7FA2E1A92DFJ	PLQP0032GB-A PLQP0032GE-A				
R7FA2E1A92DNH	PWQN0032KE-A				
R7FA2E1A92DBU	PVBG0064LB-A				
R7FA2E1A92DLM	PWLG0036KB-A				
R7FA2E1A92DDA	T.B.D.				
R7FA2E1A92DNE	PWQN0048KC-A				



Table 1.12 Product list (2 of 2)

Product part number	Package code	Code flash	Data flash	SRAM	Operating temperature				
R7FA2E1A73CFM	PLQP0064KB-C PLQP0064KL-A	64	4	16	-40 to +105°C				
R7FA2E1A73CFK	PLQP0064GA-A								
R7FA2E1A73CFL	PLQP0048KB-B PLQP0048KL-A								
R7FA2E1A73CFJ	PLQP0032GB-A PLQP0032GE-A								
R7FA2E1A73CNH	PWQN0032KE-A								
R7FA2E1A73CBU	PVBG0064LB-A								
R7FA2E1A73CLM	PWLG0036KB-A								
R7FA2E1A73CDA	T.B.D.								
R7FA2E1A73CNE	PWQN0048KC-A								
R7FA2E1A72DFM	PLQP0064KB-C PLQP0064KL-A					32	4	16	-40 to +85°C
R7FA2E1A72DFK	PLQP0064GA-A								
R7FA2E1A72DFL	PLQP0048KB-B PLQP0048KL-A								
R7FA2E1A72DFJ	PLQP0032GB-A PLQP0032GE-A								
R7FA2E1A72DNH	PWQN0032KE-A								
R7FA2E1A72DBU	PVBG0064LB-A								
R7FA2E1A72DLM	PWLG0036KB-A								
R7FA2E1A72DDA	T.B.D.								
R7FA2E1A72DNE	PWQN0048KC-A								
R7FA2E1A53CFL	PLQP0048KB-B PLQP0048KL-A				32				
R7FA2E1A53CFJ	PLQP0032GB-A PLQP0032GE-A								
R7FA2E1A53CNH	PWQN0032KE-A								
R7FA2E1A53CLM	PWLG0036KB-A								
R7FA2E1A53CDA	T.B.D.								
R7FA2E1A53CNE	PWQN0048KC-A								
R7FA2E1A52DFL	PLQP0048KB-B PLQP0048KL-A	32	4	16		-40 to +85°C			
R7FA2E1A52DFJ	PLQP0032GB-A PLQP0032GE-A								
R7FA2E1A52DNH	PWQN0032KE-A								
R7FA2E1A52DLM	PWLG0036KB-A								
R7FA2E1A52DDA	T.B.D.								
R7FA2E1A52DNE	PWQN0048KC-A								

## 1.4 Function Comparison

Table 1.13 Function Comparison (1 of 2)

Parts number		R7FA2E1A9xxFM R7FA2E1A9xxFK R7FA2E1A9xxBU	R7FA2E1A7xxFM R7FA2E1A7xxFK R7FA2E1A7xxBU	R7FA2E1A9xxFL R7FA2E1A9xxNE	R7FA2E1A7xxFL R7FA2E1A7xxNE	R7FA2E1A5xxFL R7FA2E1A5xxNE	R7FA2E1A9xxLM	R7FA2E1A7xxLM	R7FA2E1A5xxLM	R7FA2E1A9xxFJ R7FA2E1A9xxNH	R7FA2E1A7xxFJ R7FA2E1A7xxNH	R7FA2E1A5xxFJ R7FA2E1A5xxNH	R7FA2E1A9xxDA	R7FA2E1A7xxDA	R7FA2E1A5xxDA
Pin count		64		48			36			32			25		
Package		LQFP/BGA		LQFP/HWQFN			LGA			LQFP/HWQFN			WLCSP		
Code flash memory		128 KB	64 KB	128 KB	64 KB	32 KB	128 KB	64 KB	32 KB	128 KB	64 KB	32 KB	128 KB	64 KB	32 KB
Data flash memory		4 KB		4 KB			4 KB			4 KB			4 KB		
SRAM(Parity)		16 KB		16 KB			16 KB			16 KB			16 KB		
System	CPU clock	48 MHz		48 MHz			48 MHz			48 MHz			48 MHz		
	Sub clock oscillator	Yes		Yes			Yes			Yes			No		
	ICU	Yes		Yes			Yes			Yes			Yes		
	KINT	8		5			4			4			4		
Event control	ELC	Yes		Yes			Yes			Yes			Yes		
DMA	DTC	Yes		Yes			Yes			Yes			Yes		
Timers	GPT32	1 (PWM outputs: 2)		1 (PWM outputs: 2)			1 (PWM outputs: 2)			1 (PWM outputs: 2)			1 (PWM outputs: 2)		
	GPT16	6 (PWM outputs: 12)		6 (PWM outputs: 12)			6 (PWM outputs: 8)			6 (PWM outputs: 7)			6 (PWM outputs: 9)		
	AGT	2		2			2			2			2		
	RTC	Yes		Yes			Yes			Yes			Yes (Clock source: LOCO only)		
	WDT/IWDT	Yes		Yes			Yes			Yes			Yes		
Communication	SCI	4		4			3			3			3		
	IIC	1		1			1			1			1		
	SPI	1		1			1			1			1		
Analog	ADC12	13		13			12			10			8		
	ACMPLP	2		2			2			2			2		
	TSN	Yes		Yes			Yes			Yes			Yes		
HMI	CTSUS	30 (CFC:18)		20 (CFC:15)			14 (CFC:12)			11 (CFC:11)			10 (CFC : 9)		
Data processing	CRC	Yes		Yes			Yes			Yes			Yes		
	DOC	Yes		Yes			Yes			Yes			Yes		
Security	AES & TRNG		AES & TRNG			AES & TRNG			AES & TRNG			AES & TRNG			

**Table 1.13 Function Comparison (2 of 2)**

Parts number		R7FA2E1A9xxFM R7FA2E1A9xxFK R7FA2E1A9xxBU	R7FA2E1A7xxFM R7FA2E1A7xxFK R7FA2E1A7xxBU	R7FA2E1A9xxFL R7FA2E1A9xxNE	R7FA2E1A7xxFL R7FA2E1A7xxNE	R7FA2E1A5xxFL R7FA2E1A5xxNE	R7FA2E1A9xxLM	R7FA2E1A7xxLM	R7FA2E1A5xxLM	R7FA2E1A9xxFJ R7FA2E1A9xxNH	R7FA2E1A7xxFJ R7FA2E1A7xxNH	R7FA2E1A5xxFJ R7FA2E1A5xxNH	R7FA2E1A9xxDA	R7FA2E1A7xxDA	R7FA2E1A5xxDA	
I/O ports	I/O pins	53			37			27			23			20		
	Input pins	3			3			3			3			1		
	Pull-up resistors	53			37			27			23			20		
	N-ch open-drain outputs	40			26			17			15			14		
	5-V tolerance	3			3			1			1			3		

## 1.5 Pin Functions

Table 1.14 Pin functions (1 of 3)

Function	Signal	I/O	Description
Power supply	VCC	Input	Power supply pin. Connect it to the system power supply. Connect this pin to VSS by a 0.1- $\mu$ F capacitor. Place the capacitor close to the pin.
	VCL	I/O	Connect this pin to the VSS pin by the smoothing capacitor used to stabilize the internal power supply. Place the capacitor close to the pin.
	VSS	Input	Ground pin. Connect it to the system power supply (0 V).
Clock	XTAL	Output	Pins for a crystal resonator. An external clock signal can be input through the EXTAL pin.
	EXTAL	Input	
	XCIN	Input	Input/output pins for the sub-clock oscillator. Connect a crystal resonator between XCOU and XCIN.
	XCOU	Output	
	CLKOUT	Output	Clock output pin
Operating mode control	MD	Input	Pin for setting the operating mode. The signal level on this pin must not be changed during operation mode transition on release from the reset state.
System control	RES	Input	Reset signal input pin. The MCU enters the reset state when this signal goes low.
CAC	CACREF	Input	Measurement reference clock input pin
On-chip debug	SWDIO	I/O	Serial wire debug data input/output pin
	SWCLK	Input	Serial wire clock pin
Interrupt	NMI	Input	Non-maskable interrupt request pin
	IRQ0 to IRQ7	Input	Maskable interrupt request pins
GPT	GTETRG, GTETRGB	Input	External trigger input pins
	GTIOChA (n = 0, 4 to 9), GTIOChB (n = 0, 4 to 9)	I/O	Input capture, output compare, or PWM output pins
	GTIU	Input	Hall sensor input pin U
	GTIV	Input	Hall sensor input pin V
	GTIW	Input	Hall sensor input pin W
	GTOUUP	Output	3-phase PWM output for BLDC motor control (positive U phase)
	GTOULO	Output	3-phase PWM output for BLDC motor control (negative U phase)
	GTOVUP	Output	3-phase PWM output for BLDC motor control (positive V phase)
	GTOVLO	Output	3-phase PWM output for BLDC motor control (negative V phase)
	GTOUWP	Output	3-phase PWM output for BLDC motor control (positive W phase)
	GTOWLO	Output	3-phase PWM output for BLDC motor control (negative W phase)
AGT	AGTEE0, AGTEE1	Input	External event input enable signals
	AGTIO0, AGTIO1	I/O	External event input and pulse output pins
	AGTO0, AGTO1	Output	Pulse output pins
	AGTOA0, AGTOA1	Output	Output compare match A output pins
	AGTOB0, AGTOB1	Output	Output compare match B output pins
RTC	RTCOU	Output	Output pin for 1-Hz or 64-Hz clock

Table 1.14 Pin functions (2 of 3)

Function	Signal	I/O	Description
SCI	SCKn (n = 0 to 2, 9)	I/O	Input/output pins for the clock (clock synchronous mode)
	RXDn (n = 0 to 2, 9)	Input	Input pins for received data (asynchronous mode/clock synchronous mode)
	TXDn (n = 0 to 2, 9)	Output	Output pins for transmitted data (asynchronous mode/clock synchronous mode)
	CTS <sub>n</sub> _RTS <sub>n</sub> (n = 0 to 2, 9)	I/O	Input/output pins for controlling the start of transmission and reception (asynchronous mode/clock synchronous mode), active-low.
	SCLn (n = 0 to 2, 9)	I/O	Input/output pins for the IIC clock (simple IIC mode)
	SDAn (n = 0 to 2, 9)	I/O	Input/output pins for the IIC data (simple IIC mode)
	SCKn (n = 0 to 2, 9)	I/O	Input/output pins for the clock (simple SPI mode)
	MISO <sub>n</sub> (n = 0 to 2, 9)	I/O	Input/output pins for slave transmission of data (simple SPI mode)
	MOSI <sub>n</sub> (n = 0 to 2, 9)	I/O	Input/output pins for master transmission of data (simple SPI mode)
	SS <sub>n</sub> (n = 0 to 2, 9)	Input	Chip-select input pins (simple SPI mode), active-low
IIC	SCLn (n = 0)	I/O	Input/output pins for the clock
	SDAn (n = 0)	I/O	Input/output pins for data
SPI	RSPCKA	I/O	Clock input/output pin
	SSLA0	I/O	Input or output pin for slave selection
	SSLA1 to SSLA3	Output	Output pins for slave selection
	MOSIA	I/O	Input or output pins for data output from the master
	MISOA	I/O	Input or output pins for data output from the slave
Analog power supply	AVCC0	Input	Analog power supply pin for the ADC12
	AVSS0	Input	Analog ground pin for the ADC12
	VREFH0	Input	Analog reference voltage supply pin for the ADC12. Connect this pin to AVCC0 when not using the ADC12.
	VREFL0	Input	Analog reference ground pin for the ADC12. Connect this pin to AVSS0 when not using the ADC12.
ADC12	AN000 to AN010, AN017 to AN022	Input	Input pins for the analog signals to be processed by the A/D converter.
	ADTRG0	Input	Input pin for the external trigger signals that start the A/D conversion, active-low.
ACMPLP	VCOUT	Output	Comparator output pin
	CMPREF0, CMPREF1	Input	Reference voltage input pins
	CMPIN0, CMPIN1	Input	Analog voltage input pins
CTSU	TS00, TS02-CFC, TS04 to TS07, TS08-CFC to TS16-CFC, TS17, TS18, TS21 to TS25, TS26-CFC to TS28-CFC, TS30-CFC to TS34-CFC	Input	Capacitive touch detection pins (touch pins)
	TSCAP	—	Secondary power supply pin for the touch driver
KINT	KR00 to KR07	Input	Key interrupt input pins

**Table 1.14 Pin functions (3 of 3)**

Function	Signal	I/O	Description
I/O ports	P000 to P004, P010 to P015	I/O	General-purpose input/output pins
	P100 to P113	I/O	General-purpose input/output pins
	P200	Input	General-purpose input pin
	P201, P204 to P208, P212, P213	I/O	General-purpose input/output pins
	P214, P215	Input	General-purpose input pins
	P300 to P304	I/O	General-purpose input/output pins
	P400 to P403, P407 to P411	I/O	General-purpose input/output pins
	P500 to P502	I/O	General-purpose input/output pins
	P913 to P915	I/O	General-purpose input/output pins

### 1.6 Pin Assignments

Figure 1.3 to Figure 1.8 show the pin assignments from the top view.

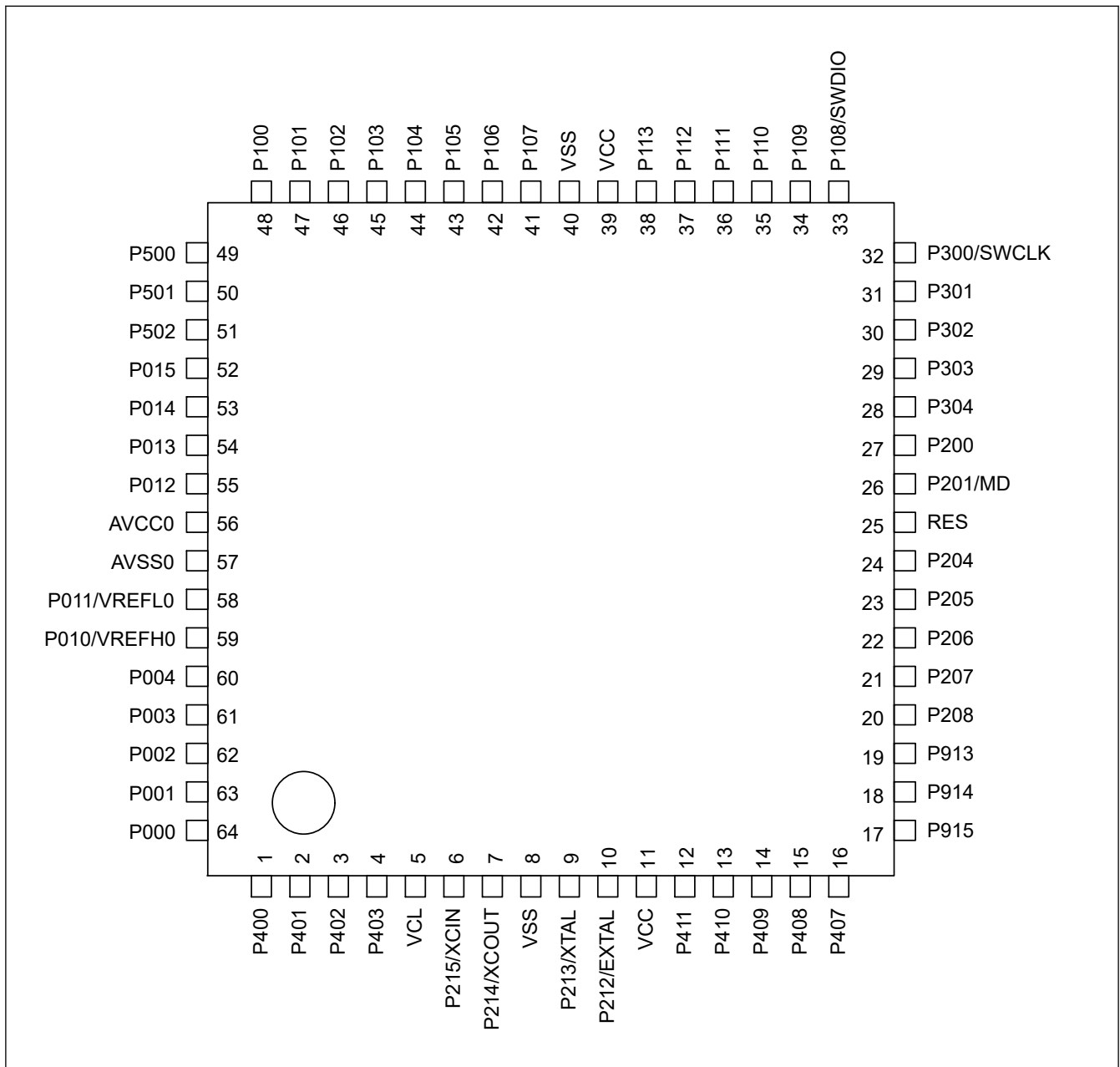


Figure 1.3 Pin assignment for LQFP 64-pin (top view)

	A	B	C	D	E	F	G	H	
8	P100	P101	P102	VSS	VCC	P112	P108/ SWDIO	P300/ SWCLK	8
7	P015	P500	P103	P104	P113	P111	P110	P301	7
6	P014	P013	P501	P105	P106	P107	P109	P302	6
5	AVCC0	P012	P502	P207	P206	P205	P304	P303	5
4	AVSS0	P011/ VREFL0	P004	P914	P913	P208	P201/MD	P200	4
3	P010/ VREFH0	P003	P000	P915	P213/ XTAL	P411	RES	P204	3
2	P002	P001	P402	P403	P212/ EXTAL	P410	P409	P408	2
1	P400	P401	VCL	P215/ XCIN	P214/ XCOUT	VSS	VCC	P407	1
	A	B	C	D	E	F	G	H	

Figure 1.4 Pin assignment for BGA 64-pin (top view, pad side down)



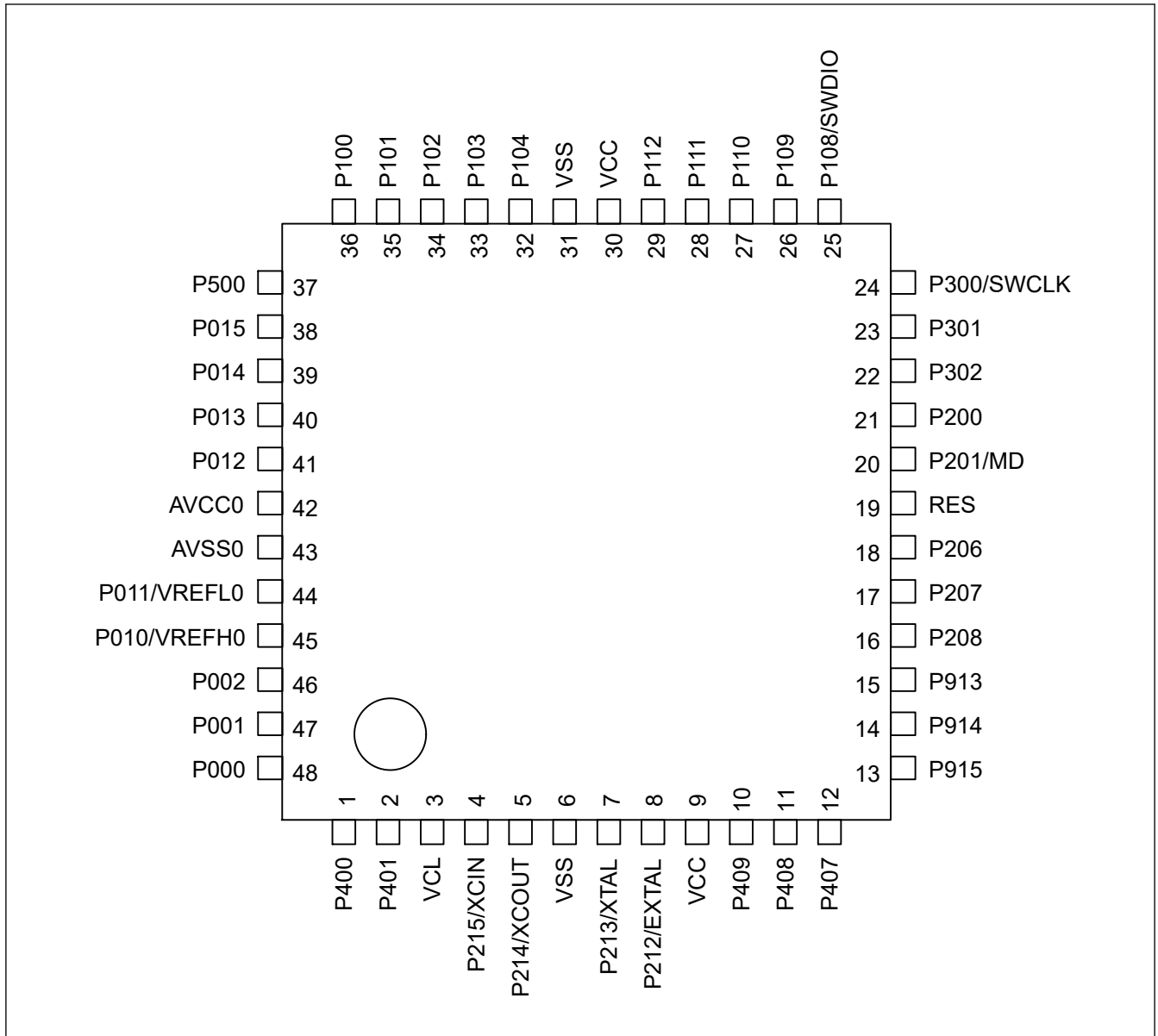


Figure 1.5 Pin assignment for LQFP/QFN 48-pin (top view)

Note: Exposed die pad of QFN is recommended to connect to VSS.

	A	B	C	D	E	F	
6	P015	P100	P112	P111	P108/ SWDIO	P300/ SWCLK	6
5	P014	P013	P101	P110	P200	P207	5
4	AVCC0	P012	P102	P109	P201/MD	P208	4
3	AVSS0	P011/ VREFL0	P103	P213/ XTAL	RES	P913	3
2	P010/ VREFH0	P000	P001	P212/ EXTAL	P407	P914	2
1	VCL	P215/ XCIN	P214/ XCOUT	VSS	VCC	P915	1
	A	B	C	D	E	F	

Figure 1.6 Pin assignment for LGA 36-pin (top view, pad side down)

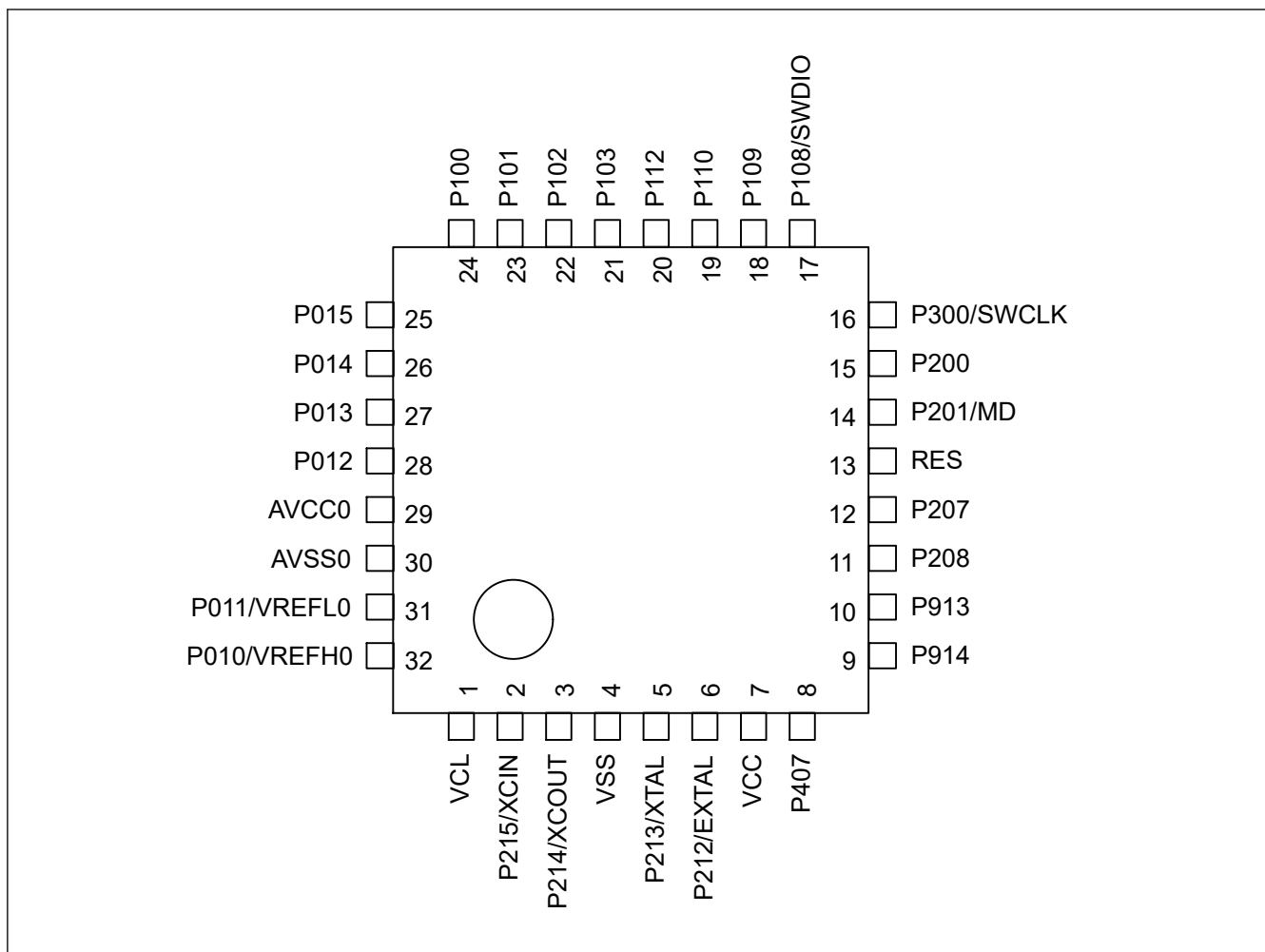


Figure 1.7 Pin assignment for LQFP/QFN 32-pin (top view)

Note: Exposed die pad of QFN is recommended to connect to VSS.

	A	B	C	D	E	
5	P110	P112	P102	P103	P101	5
4	P300/ SWCLK	P109	P100	P014	P015	4
3	RES	P108/ SWDIO	P200	VCC	VSS	3
2	P204	P201/MD	VCL	P011/ VREFLO	P010/ VREFHO	2
1	P407	P212/ EXTAL	P213/ XTAL	P401	P400	1
	A	B	C	D	E	

Figure 1.8 Pin assignment for WLCSP 25-pin (top view, pad side down)

1.7 Pin Lists

Table 1.15 Pin list (1 of 3)

Pin number						Power, System, Clock, Debug, CAC	I/O ports	Timers				Communication interfaces			Analog		HMI			
LQFP 64-pin	BGA 64-pin	LQFP/QFN 48-pin	LGA 38-pin	LQFP/QFN 32-pin	WL CSP 25-pin			AGT	GPT_OPS, POEG	GPT	RTC	SCI	IIC	SPI	ADC	ACMPLP	CTS	Interrupt		
1	A1	1	—	—	E1	CACREF_C	P400	AGTIO1_C	—	GTIOC9A_A	—	SCK0_B/ SCK1_B	SCL0_A	—	—	—	—	IRQ0_A		
2	B1	2	—	—	D1	—	P401	—	GTETRG_A_B	GTIOC9B_A	—	CTS0_RTS0_B/ SS0_B/ TXD1_B/ MOSI1_B/ SDA1_B	SDA0_A	—	—	—	—	IRQ5		
3	C2	—	—	—	—	—	P402	AGTIO0_E/ AGTIO1_D	—	—	—	RxD1_B/ MISO1_B/ SCL1_B	—	—	—	—	TS18	IRQ4		
4	D2	—	—	—	—	—	P403	AGTIO0_F/ AGTIO1_E	—	—	—	CTS1_RTS1_B/ SS1_B	—	—	—	—	—	TS17		
5	C1	3	A1	1	C2	VCL	—	—	—	—	—	—	—	—	—	—	—	—		
6	D1	4	B1	2	—	XCIN	P215	—	—	—	—	—	—	—	—	—	—	—		
7	E1	5	C1	3	—	XCOU	P214	—	—	—	—	—	—	—	—	—	—	—		
8	F1	6	D1	4	E3	VSS	—	—	—	—	—	—	—	—	—	—	—	—		
9	E3	7	D3	5	C1	XTAL	P213	—	GTETRG_A_D	GTIOC0A_D	—	TXD1_A/ MOSI1_A/ SDA1_A	—	—	—	—	—	IRQ2_B		
10	E2	8	D2	6	B1	EXTAL	P212	AGTEE1	GTETRGB_D	GTIOC0B_D	—	RxD1_A/ MISO1_A/ SCL1_A	—	—	—	—	—	IRQ3_B		
11	G1	9	E1	7	D3	VCC	—	—	—	—	—	—	—	—	—	—	—	—		
12	F3	—	—	—	—	—	P411	AGTOA1	GTOVUP_B	—	—	TXD0_B/ MOSI0_B/ SDA0_B	—	MOSIA_B	—	—	—	TS7	IRQ4_B	
13	F2	—	—	—	—	—	P410	AGTOB1	GTOVLO_B	—	—	RxD0_B/ MISO0_B/ SCL0_B	—	MISOA_B	—	—	—	TS6	IRQ5_B	
14	G2	10	—	—	—	—	P409	—	GTOWUP_B	—	—	—	—	—	—	—	—	TS5	IRQ6_B	
15	H2	11	—	—	—	—	P408	—	GTOWLO_B	—	—	CTS1_RTS1_D/ SS1_D	SCL0_C	—	—	—	—	TS4	IRQ7_B	
16	H1	12	E2	8	A1	—	P407	AGTIO0_C	—	—	RTCCOUT	CTS0_RTS0_D/ SS0_D	SDA0_B	—	ADTRG0_B	—	—	—		
17	D3	13	F1	—	—	—	P915	—	—	—	—	—	—	—	—	—	—	—		
18	D4	14	F2	9	—	—	P914	AGTOA1_A	GTETRGB_F	—	—	—	—	—	—	—	—	—		
19	E4	15	F3	10	—	—	P913	AGTIO1_F	GTETRG_A_F	—	—	—	—	—	—	—	—	—		
20	F4	16	F4	11	—	—	P208	AGTOB0_A	—	—	—	—	—	—	—	—	—	—		
21	D5	17	F5	12	—	—	P207	—	—	—	—	—	—	—	—	—	—	—		
22	E5	18	—	—	—	—	P206	—	GTIU_A	—	—	RxD0_D/ MISO0_D/ SCL0_D	—	—	—	—	—	—	IRQ0	
23	F5	—	—	—	—	CLKOUT_A	P205	AGTO1	GTIV_A	—	—	TXD0_D/ MOSI0_D/ SDA0_D/ CTS9_RTS9_A/ SS9_A	—	—	—	—	—	—	IRQ1	
24	H3	—	—	—	A2	CACREF_A	P204	AGTIO1_A	GTIW_A	—	—	SCK0_D/ SCK9_A	SCL0_B	—	—	—	—	TS0	—	
25	G3	19	E3	13	A3	RES	—	—	—	—	—	—	—	—	—	—	—	—		
26	G4	20	E4	14	B2	MD	P201	—	—	—	—	—	—	—	—	—	—	—		
27	H4	21	E5	15	C3	—	P200	—	—	—	—	—	—	—	—	—	—	—	NMI	
28	G5	—	—	—	—	—	P304	—	—	—	—	—	—	—	—	—	—	—		
29	H5	—	—	—	—	—	P303	—	—	—	—	—	—	—	—	—	—	—	TS2-CFC	
30	H6	22	—	—	—	—	P302	—	GTOUUP_A	GTIOC7A_A	—	TXD2_A/ MOSI2_A/ SDA2_A	—	—	—	—	—	—	TS8-CFC	IRQ5_A

Table 1.15 Pin list (2 of 3)

Pin number						Power, System, Clock, Debug, CAC	I/O ports	Timers				Communication interfaces			Analog		HMI	
LoFP 64-pin	BGA 64-pin	LoFP/QFN 48-pin	LGA 36-pin	LoFP/QFN 32-pin	WLSP 25-pin			AGT	GPT_OPS, POEG	GPT	RTC	SCI	IIC	SPI	ADC	ACMPLP	CTSU	Interrupt
31	H7	23	—	—	—		P301	AGTIO0_D	GTOULO_A	GTIOC7B_A	—	RxD2_A/ MISO2_A/ SCL2_A/ CTS9_RTS 9_D/SS9_D	—	—	—	—	TS9-CFC	IRQ6_A
32	H8	24	F6	16	A4	SWCLK	P300	—	GTOUUP_C	GTIOC0A_A	—	—	—	—	—	—	—	—
33	G8	25	E6	17	B3	SWDIO	P108	—	GTOULO_C	GTIOC0B_A	—	CTS9_RTS 9_B/SS9_B	—	—	—	—	—	—
34	G6	26	D4	18	B4	CLKOUT_B	P109	—	GTOVUP_A	GTIOC4A_A	—	SCK1_E/ TXD9_B/ MOSI9_B/ SDA9_B	—	—	—	—	TS10-CFC	—
35	G7	27	D5	19	A5		P110	—	GTOVLO_A	GTIOC4B_A	—	CTS2_RTS 2_B/ SS2_B/ RxD9_B/ MISO9_B/ SCL9_B	—	—	—	VCOU	TS11-CFC	IRQ3_A
36	F7	28	D6	—	—		P111	AGTOA0	—	GTIOC6A_A	—	SCK2_B/ SCK9_B	—	—	—	—	TS12-CFC	IRQ4_A
37	F8	29	C6	20	B5		P112	AGTOB0	—	GTIOC6B_A	—	SCK1_D/ TXD2_B/ MOSI2_B/ SDA2_B	—	—	—	—	TSCAP	—
38	E7	—	—	—	—		P113	—	—	—	—	—	—	—	—	—	TS27-CFC	—
39	E8	30	—	—	—	VCC		—	—	—	—	—	—	—	—	—	—	—
40	D8	31	—	—	—	VSS		—	—	—	—	—	—	—	—	—	—	—
41	F6	—	—	—	—		P107	—	—	—	—	—	—	—	—	—	—	KR07
42	E6	—	—	—	—		P106	—	—	—	—	—	SSLA3_A	—	—	—	—	KR06
43	D6	—	—	—	—		P105	—	GTETRG_A_C	GTIOC4A_B	—	—	—	SSLA2_A	—	—	TS34-CFC	KR05/ IRQ0_B
44	D7	32	—	—	—		P104	—	GTETRGB_B	GTIOC4B_B	—	RxD0_C/ MISO0_C/ SCL0_C	—	SSLA1_A	—	—	TS13-CFC	KR04/ IRQ1_B
45	C7	33	C3	21	D5		P103	—	GTOWUP_A	GTIOC5A_A	—	CTS0_RTS 0_A/SS0_A	—	SSLA0_A	AN019 <sup>1</sup>	CMPREF1	TS14-CFC	KR03
46	C8	34	C4	22	C5		P102	AGTO0	GTOWLO_A	GTIOC5B_A	—	SCK0_A/ TXD2_D/ MOSI2_D/ SDA2_D	—	RSPCKA_A	ADTRG0_A /AN020 <sup>1</sup>	CMPIN1	TS15-CFC	KR02
47	B8	35	C5	23	E5		P101	AGTEE0	GTETRGB_A	GTIOC8A_A	—	TXD0_A/ MOSI0_A/ SDA0_A/ CTS1_RTS 1_A/SS1_A	SDA0_C	MOSIA_A	AN021 <sup>1</sup>	CMPREF0	TS16-CFC	KR01/ IRQ1_A
48	A8	36	B6	24	C4		P100	AGTIO0_A	GTETRG_A_A	GTIOC8B_A	—	RxD0_A/ MISO0_A/ SCL0_A/ SCK1_A	SCL0_D	MISOA_A	AN022 <sup>1</sup>	CMPIN0	TS26-CFC	KR00/ IRQ2_A
49	B7	37	—	—	—		P500	—	GTIU_B	GTIOC5A_B	—	—	—	—	—	—	—	—
50	C6	—	—	—	—		P501	—	GTIV_B	GTIOC5B_B	—	TXD1_C/ MOSI1_C/ SDA1_C	—	—	AN017	—	—	—
51	C5	—	—	—	—		P502	—	GTIW_B	—	—	RxD1_C/ MISO1_C/ SCL1_C	—	—	AN018	—	—	—
52	A7	38	A6	25	E4		P015	—	—	—	—	—	—	—	AN010	—	TS28-CFC	IRQ7_A
53	A6	39	A5	26	D4		P014	—	—	—	—	—	—	—	AN009	—	—	—
54	B6	40	B5	27	—		P013	—	—	—	—	—	—	—	AN008	—	TS33-CFC	—
55	B5	41	B4	28	—		P012	—	—	—	—	—	—	—	AN007	—	TS32-CFC	—
56	A5	42	A4	29	—	AVCC0		—	—	—	—	—	—	—	—	—	—	—
57	A4	43	A3	30	—	AVSS0		—	—	—	—	—	—	—	—	—	—	—
58	B4	44	B3	31	D2	VREFL0	P011	—	—	—	—	—	—	—	AN006	—	TS31-CFC	—
59	A3	45	A2	32	E2	VREFH0	P010	—	—	—	—	—	—	—	AN005	—	TS30-CFC	—
60	C4	—	—	—	—		P004	—	—	—	—	—	—	—	AN004	—	TS25	IRQ3
61	B3	—	—	—	—		P003	—	—	—	—	—	—	—	AN003	—	TS24	—

**Table 1.15 Pin list (3 of 3)**

Pin number						Power, System, Clock, Debug, CAC	I/O ports	Timers				Communication interfaces			Analog		HMI	
LOFP 64-pin	BGA 64-pin	LOFP/QFN 48-pin	LGA 36-pin	LOFP/QFN 32-pin	WLSP 25-pin			AGT	GPT, OPS, POEG	GPT	RTC	SCI	IIC	SPI	ADC	ACMPLP	CTS	Interrupt
62	A2	46	—	—	—		P002	—	—	—	—	—	—	AN002	—	TS23	IRQ2	
63	B2	47	C2	—	—		P001	—	—	—	—	—	—	AN001	—	TS22	IRQ7	
64	C3	48	B2	—	—		P000	—	—	—	—	—	—	AN000	—	TS21	IRQ6	

Note: Several pin names have the added suffix of \_A, \_B, \_C, \_D, \_E and \_F. The suffix can be ignored when assigning functionality.

Note 1. Unsupport in 64-pin product

## 2. Electrical Characteristics

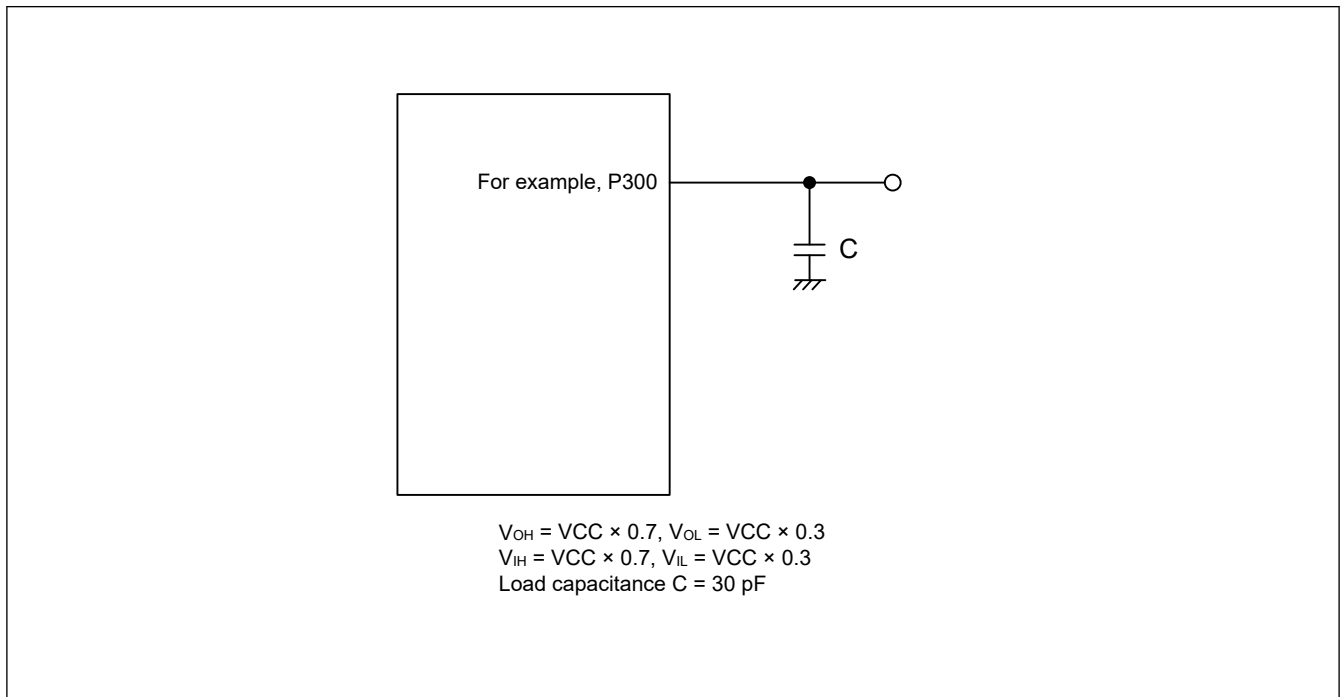
Unless otherwise specified, the electrical characteristics of the MCU are defined under the following conditions:

$$VCC^{*1} = AVCC0 = 1.6 \text{ to } 5.5 \text{ V, } VREFH0 = 1.6 \text{ V to } AVCC0$$

$$VSS = AVSS0 = VREFL0 = 0 \text{ V, } T_a = T_{opr}$$

Note 1. The typical condition is set to  $VCC = 3.3 \text{ V}$ .

Figure 2.1 shows the timing conditions.



**Figure 2.1** Input or output timing measurement conditions

The measurement conditions of the timing specifications for each peripheral are recommended for the best peripheral operation. However, make sure to adjust driving abilities for each pin to meet the conditions of your system.

Each function pin used for the same function must select the same drive ability. If the I/O drive ability of each function pin is mixed, the AC characteristics of each function are not guaranteed.

### 2.1 Absolute Maximum Ratings

**Table 2.1** Absolute maximum ratings (1 of 2)

Parameter	Symbol	Value	Unit	
Power supply voltage	VCC	-0.5 to +6.5	V	
Input voltage	5V-tolerant ports*1	$V_{in}$	-0.3 to +6.5	V
	P000 to P004, P010 to P015	$V_{in}$	-0.3 to AVCC0 + 0.3	V
	Others	$V_{in}$	-0.3 to VCC + 0.3	V
Reference power supply voltage	VREFH0	-0.3 to +6.5	V	
Analog power supply voltage	AVCC0	-0.5 to +6.5	V	
Analog input voltage	When AN000 to AN010 are used	$V_{AN}$	-0.3 to AVCC0 + 0.3	V
	When AN017 to AN022 are used		-0.3 to VCC + 0.3	V
Operating temperature*2 *3 *4	$T_{opr}$	-40 to +85 -40 to +105	°C	



**Table 2.1 Absolute maximum ratings (2 of 2)**

Parameter	Symbol	Value	Unit
Storage temperature	T <sub>stg</sub>	-55 to +125	°C

Note 1. Ports P400, P401, and P407 are 5V-tolerant.

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

Note 2. See [section 2.2.1. Tj/Ta Definition](#).

Note 3. Contact Renesas Electronics sales office for information on derating operation under Ta = +85°C to +105°C. Derating is the systematic reduction of load for improved reliability.

Note 4. The upper limit of the operating temperature is 85°C or 105°C, depending on the product.

**Caution: Permanent damage to the MCU may result if absolute maximum ratings are exceeded.**

To preclude any malfunctions due to noise interference, insert capacitors with high frequency characteristics between the VCC and VSS pins, between the AVCC0 and AVSS0 pins, and between the VREFH0 and VREFL0 pins when VREFH0 is selected as the high potential reference voltage for the ADC12. Place capacitors of the following value as close as possible to every power supply pin and use the shortest and heaviest possible traces:

- VCC and VSS: about 0.1 µF
- AVCC0 and AVSS0: about 0.1 µF
- VREFH0 and VREFL0: about 0.1 µF

Also, connect capacitors as stabilization capacitance.

Connect the VCL pin to a VSS pin by a 4.7 µF capacitor. Each capacitor must be placed close to the pin.

**Table 2.2 Recommended operating conditions**

Parameter	Symbol	Min	Typ	Max	Unit	
Power supply voltages	VCC <sup>*1 *2</sup>	1.6	—	5.5	V	
	VSS	—	0	—	V	
Analog power supply voltages	AVCC0 <sup>*1 *2</sup>	1.6	—	5.5	V	
	AVSS0	—	0	—	V	
	VREFH0	When used as ADC12 Reference	1.6	—	AVCC0	V
	VREFL0		—	0	—	V

Note 1. Use AVCC0 and VCC under the following conditions:  
AVCC0 = VCC

Note 2. When powering on the VCC and AVCC0 pins, power them on at the same time or the VCC pin first and then the AVCC0 pins. When powering off the VCC and AVCC0 pins, power them off at the same time or the AVCC0 pin first and then the VCC pins.

## 2.2 DC Characteristics

### 2.2.1 Tj/Ta Definition

**Table 2.3 DC characteristics**

Conditions: Products with operating temperature (Ta) -40 to +105°C

Parameter	Symbol	Typ	Max	Unit	Test conditions
Permissible junction temperature	Tj	—	125	°C	High-speed mode Middle-speed mode Low-speed mode Subosc-speed mode
			105 <sup>*1</sup>		

Note: Make sure that  $T_j = T_a + \theta_{ja} \times \text{total power consumption (W)}$ , where total power consumption =  $(V_{CC} - V_{OH}) \times \Sigma I_{OH} + V_{OL} \times \Sigma I_{OL} + I_{CCmax} \times V_{CC}$ .

Note 1. The upper limit of operating temperature is 85°C or 105°C, depending on the product. If the part number shows the operation temperature at 85°C, then the maximum value of Tj is 105°C, otherwise it is 125°C.

2.2.2 I/O  $V_{IH}$ ,  $V_{IL}$ **Table 2.4** I/O  $V_{IH}$ ,  $V_{IL}$ Conditions:  $V_{CC} = AV_{CC0} = 1.6$  to  $5.5$  V

Parameter		Symbol	Min	Typ	Max	Unit	Test Conditions
Schmitt trigger input voltage	IIC (except for SMBus)* <sup>1</sup>	$V_{IH}$	$V_{CC} \times 0.7$	—	5.8	V	—
		$V_{IL}$	—	—	$V_{CC} \times 0.3$		
		$\Delta V_T$	$V_{CC} \times 0.10$	—	—		
			$V_{CC} \times 0.05$	—	—		
	RES, NMI Other peripheral input pins excluding IIC	$V_{IH}$	$V_{CC} \times 0.8$	—	—		—
		$V_{IL}$	—	—	$V_{CC} \times 0.2$		
		$\Delta V_T$	$V_{CC} \times 0.10$	—	—		
			$V_{CC} \times 0.05$	—	—		
Input voltage (except for Schmitt trigger input pin)	IIC (SMBus)* <sup>2</sup>	$V_{IH}$	2.2	—	—	—	$V_{CC} = 3.6$ to $5.5$ V
		$V_{IH}$	2.0	—	—		$V_{CC} = 2.7$ to $3.6$ V
		$V_{IL}$	—	—	0.8		$V_{CC} = 3.6$ to $5.5$ V
		$V_{IL}$	—	—	0.5		$V_{CC} = 2.7$ to $3.6$ V
	5V-tolerant ports* <sup>3</sup>	$V_{IH}$	$V_{CC} \times 0.8$	—	5.8		—
		$V_{IL}$	—	—	$V_{CC} \times 0.2$		
	P000 to P004, P010 to P015	$V_{IH}$	$AV_{CC0} \times 0.8$	—	—		—
		$V_{IL}$	—	—	$AV_{CC0} \times 0.2$		
	EXTAL Input ports pins except for P000 to P004, P010 to P015	$V_{IH}$	$V_{CC} \times 0.8$	—	—		—
		$V_{IL}$	—	—	$V_{CC} \times 0.2$		

Note 1. SCL0\_A, SDA0\_A, SDA0\_B (total 3 pins)

Note 2. SCL0\_A, SCL0\_B, SCL0\_C, SDA0\_A, SDA0\_B, SCL0\_D, SDA0\_C (total 7 pins)

Note 3. P400, P401, P407 (total 3 pins)

2.2.3 I/O  $I_{OH}$ ,  $I_{OL}$ **Table 2.5** I/O  $I_{OH}$ ,  $I_{OL}$  (1 of 6)Conditions:  $V_{CC} = AV_{CC0} = 1.6$  to  $5.5$  V

Parameter		Symbol	Min	Typ	Max	Unit	Test conditions
Permissible output current (max value per pin)	Ports P000 to P004, P010 to P015, P212, P213, P400, P401, P407	$I_{OH}$	—	—	-4.0	mA	
		$I_{OL}$	—	—	8.0	mA	
	Other output pins* <sup>1</sup>	$I_{OH}$	—	—	-4.0	mA	
		$I_{OL}$	—	—	20.0	mA	

**Table 2.5 I/O I<sub>OH</sub>, I<sub>OL</sub> (2 of 6)**

Conditions: VCC = AVCC0 = 1.6 to 5.5 V

Parameter		Symbol	Min	Typ	Max	Unit	Test conditions	
Permissible output current (max value total pins)* <sup>2</sup>	64 pin products	Total of ports P000 to P004, P010 to P015	$\Sigma I_{OH} (max)$	—	—	-30	mA	AVCC0 = 2.7 to 5.5 V
				—	—	-8		AVCC0 = 1.8 to 2.7 V
				—	—	-4		AVCC0 = 1.6 to 1.8 V
			$\Sigma I_{OL} (max)$	—	—	50		AVCC0 = 2.7 to 5.5 V
				—	—	4		AVCC0 = 1.8 to 2.7 V
				—	—	2		AVCC0 = 1.6 to 1.8 V
		Total of ports P212, P213	$\Sigma I_{OH} (max)$	—	—	-8	mA	VCC = 2.7 to 5.5 V
				—	—	-2		VCC = 1.8 to 2.7 V
				—	—	-1		VCC = 1.6 to 1.8 V
			$\Sigma I_{OL} (max)$	—	—	16.0		VCC = 2.7 to 5.5 V
				—	—	1.2		VCC = 1.8 to 2.7 V
				—	—	0.6		VCC = 1.6 to 1.8 V
		Total of ports P204 to P208, P400 to P403, P407 to P411, P913 to P915	$\Sigma I_{OH} (max)$	—	—	-30	mA	VCC = 2.7 to 5.5 V
				—	—	-8		VCC = 1.8 to 2.7 V
				—	—	-4		VCC = 1.6 to 1.8 V
			$\Sigma I_{OL} (max)$	—	—	50		VCC = 2.7 to 5.5 V
				—	—	4		VCC = 1.8 to 2.7 V
				—	—	2		VCC = 1.6 to 1.8 V
		Total of ports P100 to P113, P201, P300 to P304, P500 to P502	$\Sigma I_{OH} (max)$	—	—	-30	mA	VCC = 2.7 to 5.5 V
				—	—	-8		VCC = 1.8 to 2.7 V
				—	—	-4		VCC = 1.6 to 1.8 V
			$\Sigma I_{OL} (max)$	—	—	50		VCC = 2.7 to 5.5 V
				—	—	4		VCC = 1.8 to 2.7 V
				—	—	2		VCC = 1.6 to 1.8 V
Total of all output pin	$\Sigma I_{OH} (max)$	—	—	-60	mA			
	$\Sigma I_{OL} (max)$	—	—	100				

**Table 2.5 I/O I<sub>OH</sub>, I<sub>OL</sub> (3 of 6)**

Conditions: VCC = AVCC0 = 1.6 to 5.5 V

Parameter		Symbol	Min	Typ	Max	Unit	Test conditions			
Permissible output current (max value total pins)* <sup>2</sup>	48 pin products	Total of ports P000 to P002, P010 to P015	$\Sigma I_{OH} (max)$	—	—	-30	mA	AVCC0 = 2.7 to 5.5 V		
				—	—	-8		AVCC0 = 1.8 to 2.7 V		
				—	—	-4		AVCC0 = 1.6 to 1.8 V		
			$\Sigma I_{OL} (max)$	—	—	50		AVCC0 = 2.7 to 5.5 V		
				—	—	4		AVCC0 = 1.8 to 2.7 V		
				—	—	2		AVCC0 = 1.6 to 1.8 V		
			Total of ports P212, P213	$\Sigma I_{OH} (max)$	—	—		-8	mA	VCC = 2.7 to 5.5 V
					—	—		-2		VCC = 1.8 to 2.7 V
					—	—		-1		VCC = 1.6 to 1.8 V
		$\Sigma I_{OL} (max)$		—	—	16.0	VCC = 2.7 to 5.5 V			
				—	—	1.2	VCC = 1.8 to 2.7 V			
				—	—	0.6	VCC = 1.6 to 1.8 V			
		Total of ports P206 to P208, P400, P401, P407 to P409, P913 to P915		$\Sigma I_{OH} (max)$	—	—	-30	mA		VCC = 2.7 to 5.5 V
					—	—	-8			VCC = 1.8 to 2.7 V
					—	—	-4			VCC = 1.6 to 1.8 V
			$\Sigma I_{OL} (max)$	—	—	50	VCC = 2.7 to 5.5 V			
				—	—	4	VCC = 1.8 to 2.7 V			
				—	—	2	VCC = 1.6 to 1.8 V			
			Total of ports P100 to P104, P108 to P112, P201, P300 to P302, P500	$\Sigma I_{OH} (max)$	—	—	-30		mA	VCC = 2.7 to 5.5 V
					—	—	-8			VCC = 1.8 to 2.7 V
					—	—	-4			VCC = 1.6 to 1.8 V
		$\Sigma I_{OL} (max)$		—	—	50	VCC = 2.7 to 5.5 V			
				—	—	4	VCC = 1.8 to 2.7 V			
				—	—	2	VCC = 1.6 to 1.8 V			
Total of all output pin	$\Sigma I_{OH} (max)$	—		—	-60	mA	—			
	$\Sigma I_{OL} (max)$	—		—	100		—			

**Table 2.5 I/O I<sub>OH</sub>, I<sub>OL</sub> (4 of 6)**

Conditions: VCC = AVCC0 = 1.6 to 5.5 V

Parameter		Symbol	Min	Typ	Max	Unit	Test conditions		
Permissible output current (max value total pins) <sup>*2</sup>	36 pin products	Total of ports P000, P001, P010 to P015	$\Sigma I_{OH} (max)$	—	—	-30	mA	AVCC0 = 2.7 to 5.5 V	
				—	—	-8		AVCC0 = 1.8 to 2.7 V	
				—	—	-4		AVCC0 = 1.6 to 1.8 V	
			$\Sigma I_{OL} (max)$	—	—	50		AVCC0 = 2.7 to 5.5 V	
				—	—	4		AVCC0 = 1.8 to 2.7 V	
				—	—	2		AVCC0 = 1.6 to 1.8 V	
		Total of ports P212, P213	$\Sigma I_{OH} (max)$	—	—	-8	mA	VCC = 2.7 to 5.5 V	
				—	—	-2		VCC = 1.8 to 2.7 V	
				—	—	-1		VCC = 1.6 to 1.8 V	
			$\Sigma I_{OL} (max)$	—	—	16.0		VCC = 2.7 to 5.5 V	
				—	—	1.2		VCC = 1.8 to 2.7 V	
				—	—	0.6		VCC = 1.6 to 1.8 V	
	Total of other output ports	$\Sigma I_{OH} (max)$	—	—	-30	mA	VCC = 4.0 to 5.5 V		
			—	—	-20		VCC = 2.7 to 4.0 V		
			—	—	-12		VCC = 1.8 to 2.7 V		
			—	—	-6		VCC = 1.6 to 1.8 V		
			$\Sigma I_{OL} (max)$	—	—		50	VCC = 4.0 to 5.5 V	
				—	—		20	VCC = 2.7 to 4.0 V	
		—		—	8	VCC = 1.8 to 2.7 V			
		—		—	4	VCC = 1.6 to 1.8 V			
		Total of all output pin		$\Sigma I_{OH} (max)$	—	—	-60	mA	—
				$\Sigma I_{OL} (max)$	—	—	100		—

**Table 2.5 I/O I<sub>OH</sub>, I<sub>OL</sub> (5 of 6)**

Conditions: VCC = AVCC0 = 1.6 to 5.5 V

Parameter		Symbol	Min	Typ	Max	Unit	Test conditions		
Permissible output current (max value total pins) <sup>*2</sup>	32 pin products	Total of ports P010 to P015	$\Sigma I_{OH} (max)$	—	—	-24	mA	AVCC0 = 2.7 to 5.5 V	
				—	—	-6		AVCC0 = 1.8 to 2.7 V	
				—	—	-3		AVCC0 = 1.6 to 1.8 V	
			$\Sigma I_{OL} (max)$	—	—	48		AVCC0 = 2.7 to 5.5 V	
				—	—	3.6		AVCC0 = 1.8 to 2.7 V	
				—	—	1.8		AVCC0 = 1.6 to 1.8 V	
		Total of ports P212, P213	$\Sigma I_{OH} (max)$	—	—	-8	mA	VCC = 2.7 to 5.5 V	
				—	—	-2		VCC = 1.8 to 2.7 V	
				—	—	-1		VCC = 1.6 to 1.8 V	
			$\Sigma I_{OL} (max)$	—	—	16.0		VCC = 2.7 to 5.5 V	
				—	—	1.2		VCC = 1.8 to 2.7 V	
				—	—	0.6		VCC = 1.6 to 1.8 V	
	Total of other output ports	$\Sigma I_{OH} (max)$	—	—	-30	mA	VCC = 4.0 to 5.5 V		
			—	—	-20		VCC = 2.7 to 4.0 V		
			—	—	-12		VCC = 1.8 to 2.7 V		
			—	—	-6		VCC = 1.6 to 1.8 V		
			$\Sigma I_{OL} (max)$	—	—		50	VCC = 4.0 to 5.5 V	
				—	—		20	VCC = 2.7 to 4.0 V	
		—		—	8	VCC = 1.8 to 2.7 V			
		—		—	4	VCC = 1.6 to 1.8 V			
		Total of all output pin		$\Sigma I_{OH} (max)$	—	—	-54	mA	—
				$\Sigma I_{OL} (max)$	—	—	98		—

**Table 2.5 I/O I<sub>OH</sub>, I<sub>OL</sub> (6 of 6)**

Conditions: VCC = AVCC0 = 1.6 to 5.5 V

Parameter		Symbol	Min	Typ	Max	Unit	Test conditions		
Permissible output current (max value total pins)* <sup>2</sup>	25 pin products	Total of ports P010, P011, P014, P015	ΣI <sub>OH</sub> (max)	—	—	-16	mA	AVCC0 = 2.7 to 5.5 V	
				—	—	-4		AVCC0 = 1.8 to 2.7 V	
				—	—	-2		AVCC0 = 1.6 to 1.8 V	
			ΣI <sub>OL</sub> (max)	—	—	32		AVCC0 = 2.7 to 5.5 V	
				—	—	2.4		AVCC0 = 1.8 to 2.7 V	
				—	—	1.2		AVCC0 = 1.6 to 1.8 V	
		Total of ports P212, P213	ΣI <sub>OH</sub> (max)	—	—	-8	mA	VCC = 2.7 to 5.5 V	
				—	—	-2		VCC = 1.8 to 2.7 V	
				—	—	-1		VCC = 1.6 to 1.8 V	
				ΣI <sub>OL</sub> (max)	—	—	16.0		VCC = 2.7 to 5.5 V
					—	—	1.2		VCC = 1.8 to 2.7 V
					—	—	0.6		VCC = 1.6 to 1.8 V
	Total of other output ports	ΣI <sub>OH</sub> (max)	—	—	-30	mA	VCC = 4.0 to 5.5 V		
			—	—	-20		VCC = 2.7 to 4.0 V		
			—	—	-12		VCC = 1.8 to 2.7 V		
			—	—	-6		VCC = 1.6 to 1.8 V		
			ΣI <sub>OL</sub> (max)	—	—	50		VCC = 4.0 to 5.5 V	
				—	—	20		VCC = 2.7 to 4.0 V	
				—	—	8		VCC = 1.8 to 2.7 V	
				—	—	4		VCC = 1.6 to 1.8 V	
Total of all output pin	ΣI <sub>OH</sub> (max)	—	—	-46	mA	—			
	ΣI <sub>OL</sub> (max)	—	—	82		—			

Note 1. Except for Ports P200, P214, and P215, which are input ports.

Note 2. Specification under conditions where the duty factor ≤ 70%.

The output current value that has changed to the duty factor > 70% the duty ratio can be calculated with the following expression (when changing the duty factor from 70% to n%).

$$\text{Total output current of pins} = (I_{OH} \times 0.7) / (n \times 0.01)$$

<Example> Where n = 80% and I<sub>OH</sub> = -30.0 mA

$$\text{Total output current of pins} = (-30.0 \times 0.7) / (80 \times 0.01) \cong -26.2 \text{ mA}$$

However, the current that is allowed to flow into one pin does not vary depending on the duty factor.

**Caution:** To protect the reliability of the MCU, the output current values should not exceed the values in [Table 2.5](#).

### 2.2.4 I/O V<sub>OH</sub>, V<sub>OL</sub>, and Other Characteristics

**Table 2.6 I/O V<sub>OH</sub>, V<sub>OL</sub> (1)**

Conditions: VCC = AVCC0 = 4.0 to 5.5 V

Parameter		Symbol	Min	Typ	Max	Unit	Test conditions
Output voltage	Ports P000 to P004, P010 to P015	V <sub>OH</sub>	AVCC0 - 0.8	—	—	V	I <sub>OH</sub> = -4.0 mA
	Output pins except for P000 to P004 and P010 to P015* <sup>1</sup>	V <sub>OH</sub>	VCC - 0.8	—	—		I <sub>OH</sub> = -4.0 mA
	Ports P000 to P004, P010 to P015	V <sub>OL</sub>	—	—	0.8		I <sub>OL</sub> = 8.0 mA
	Ports P212, P213, P400, P401, P407	V <sub>OL</sub>	—	—	0.8		I <sub>OL</sub> = 8.0 mA
	Output pins except for P000 to P004, P010 to P015, P212, P213, P400, P401, and P407* <sup>1</sup>	V <sub>OL</sub>	—	—	1.2		I <sub>OL</sub> = 20.0 mA

Note 1. Except for Ports P200, P214, and P215, which are input ports.

**Table 2.7 I/O  $V_{OH}$ ,  $V_{OL}$  (2)**Conditions:  $V_{CC} = AV_{CC0} = 2.7$  to  $4.0$  V

Parameter		Symbol	Min	Typ	Max	Unit	Test conditions
Output voltage	Ports P000 to P004, P010 to P015	$V_{OH}$	$AV_{CC0} - 0.8$	—	—	V	$I_{OH} = -4.0$ mA
	Output pins except for P000 to P004 and P010 to P015 <sup>*1</sup>	$V_{OH}$	$V_{CC} - 0.8$	—	—		$I_{OH} = -4.0$ mA
	Ports P000 to P004, P010 to P015	$V_{OL}$	—	—	0.8		$I_{OL} = 8.0$ mA
	Output pins except for P000 to P004 and P010 to P015 <sup>*1</sup>	$V_{OL}$	—	—	0.8		$I_{OL} = 8.0$ mA

Note 1. Except for Ports P200, P214, and P215, which are input ports.

**Table 2.8 I/O  $V_{OH}$ ,  $V_{OL}$  (3)**Conditions:  $V_{CC} = AV_{CC0} = 1.6$  to  $2.7$  V

Parameter		Symbol	Min	Typ	Max	Unit	Test conditions
Output voltage	Ports P000 to P004, P010 to P015	$V_{OH}$	$AV_{CC0} - 0.5$	—	—	V	$I_{OH} = -1.0$ mA $AV_{CC0} = 1.8$ to $2.7$ V
			$AV_{CC0} - 0.5$	—	—		$I_{OH} = -0.5$ mA $AV_{CC0} = 1.6$ to $1.8$ V
	Output pins except for P000 to P004 and P010 to P015 <sup>*1</sup>	$V_{OH}$	$V_{CC} - 0.5$	—	—		$I_{OH} = -1.0$ mA $V_{CC} = 1.8$ to $2.7$ V
			$V_{CC} - 0.5$	—	—		$I_{OH} = -0.5$ mA $V_{CC} = 1.6$ to $1.8$ V
	Ports P000 to P004, P010 to P015	$V_{OL}$	—	—	0.4		$I_{OL} = 0.6$ mA $AV_{CC0} = 1.8$ to $2.7$ V
			—	—	0.4		$I_{OL} = 0.3$ mA $AV_{CC0} = 1.6$ to $1.8$ V
	Output pins except for P000 to P004 and P010 to P015 <sup>*1</sup>	$V_{OL}$	—	—	0.4		$I_{OL} = 0.6$ mA $V_{CC} = 1.8$ to $2.7$ V
			—	—	0.4		$I_{OL} = 0.3$ mA $V_{CC} = 1.6$ to $1.8$ V

Note 1. Except for Ports P200, P214, and P215, which are input ports.

**Table 2.9 I/O other characteristics**Conditions:  $V_{CC} = AV_{CC0} = 1.6$  to  $5.5$  V

Parameter		Symbol	Min	Typ	Max	Unit	Test conditions
Input leakage current	RES, ports P200, P214, P215	$ I_{in} $	—	—	1.0	$\mu$ A	$V_{in} = 0$ V $V_{in} = V_{CC}$
Three-state leakage current (off state)	5V-tolerant ports <sup>*1</sup>	$ I_{TSI} $	—	—	1.0	$\mu$ A	$V_{in} = 0$ V $V_{in} = 5.8$ V
	Other ports (except for P200, P214, P215, and 5V-tolerant ports)		—	—	1.0		$V_{in} = 0$ V $V_{in} = V_{CC}$
Input pull-up resistor	All ports (except for P200, P214, P215)	$R_U$	10	20	100	k $\Omega$	$V_{in} = 0$ V
Input capacitance	P200	$C_{in}$	—	—	30	pF	$V_{in} = 0$ V $f = 1$ MHz $T_a = 25^\circ$ C
	Other input pins		—	—	15		

Note 1. P400, P401, and P407 (total 3 pins)



## 2.2.5 Operating and Standby Current

**Table 2.10** Operating and standby current (1) (1 of 2)

Conditions: VCC = AVCC0 = 1.6 to 5.5 V

Parameter				Symbol	Typ <sup>*10</sup>	Max	Unit	Test Conditions
Supply current <sup>*1</sup>	High-speed mode <sup>*2</sup>	Normal mode	All peripheral clocks disabled, CoreMark code executing from flash <sup>*5</sup>	ICLK = 48 MHz	4.80	—	mA	*7 *11
				ICLK = 32 MHz	3.45	—		*7
				ICLK = 16 MHz	2.05	—		
				ICLK = 8 MHz	1.40	—		
					—	13.0		*9 *11
		Sleep mode	All peripheral clocks disabled <sup>*5</sup>	ICLK = 48 MHz	1.05	—		*7
				ICLK = 32 MHz	0.85	—		*7
				ICLK = 16 MHz	0.70	—		
	ICLK = 8 MHz			0.60	—			
	All peripheral clocks enabled <sup>*5</sup>		ICLK = 48 MHz	4.15	—	*9		
			ICLK = 32 MHz	3.95	—	*8		
				ICLK = 16 MHz	2.25	—		
				ICLK = 8 MHz	1.35	—		
	Increase during BGO operation <sup>*6</sup>				2.1	—		—

**Table 2.10 Operating and standby current (1) (2 of 2)**

Conditions: VCC = AVCC0 = 1.6 to 5.5 V

Parameter					Symbol	Typ <sup>*10</sup>	Max	Unit	Test Conditions			
Supply current <sup>*1</sup>	Middle-speed mode <sup>*2</sup>	Normal mode	All peripheral clocks disabled, CoreMark code executing from flash <sup>*5</sup>	ICLK = 24 MHz	I <sub>CC</sub>	2.60	—	mA	*7			
				ICLK = 4 MHz		0.90	—					
			All peripheral clocks enabled, code executing from flash <sup>*5</sup>	ICLK = 24 MHz		—	8.1		*8			
		Sleep mode	All peripheral clocks disabled <sup>*5</sup>	ICLK = 24 MHz		0.70	—		*7			
				ICLK = 4 MHz		0.55	—					
			All peripheral clocks enabled <sup>*5</sup>	ICLK = 24 MHz		3.05	—		*8			
		ICLK = 4 MHz	0.90	—								
	Increase during BGO operation <sup>*6</sup>					1.90	—		—			
	Low-speed mode <sup>*3</sup>	Normal mode	All peripheral clocks disabled, CoreMark code executing from flash <sup>*5</sup>	ICLK = 2 MHz	I <sub>CC</sub>	0.30	—	mA	*7			
				ICLK = 2 MHz		—	2.2			*8		
		Sleep mode	All peripheral clocks disabled <sup>*5</sup>	ICLK = 2 MHz		0.13	—		*7			
				All peripheral clocks enabled <sup>*5</sup>		ICLK = 2 MHz	0.31			—	*8	
		Subosc-speed mode <sup>*4</sup>	Normal mode	All peripheral clocks enabled, code executing from flash <sup>*5</sup>		ICLK = 32.768 kHz	I <sub>CC</sub>		—	530	μA	*8
						ICLK = 32.768 kHz			1.90	—		*8
	Sleep mode		All peripheral clocks enabled <sup>*5</sup>	ICLK = 32.768 kHz	4.90	—		*8				

Note 1. Supply current is the total current flowing into VCC. Supply current values apply when internal pull-up MOSs are in the off state and these values do not include output charge/discharge current from any of the pins.

Note 2. The clock source is HOCO.

Note 3. The clock source is MOCO.

Note 4. The clock source is the sub-clock oscillator.

Note 5. This does not include BGO operation.

Note 6. This is the increase for programming or erasure of the flash memory for data storage during program execution.

Note 7. PCLKB and PCLKD are set to divided by 64.

Note 8. PCLKB and PCLKD are the same frequency as that of ICLK.

Note 9. PCLKB are set to be divided by 2 and PCLKD is the same frequency as that of ICLK.

Note 10. VCC = 3.3 V.

Note 11. The prefetch buffer is operating.

**Table 2.11 Operating and standby current (2)**

Conditions: VCC = AVCC0 = 1.6 to 5.5 V

Parameter				Symbol	Typ <sup>*3</sup>	Max	Unit	Test conditions	
Supply current <sup>*1</sup>	Software Standby mode <sup>*2</sup>	Peripheral modules stop	All SRAMs (0x2000_4000 to 0x2000_7FFF) are on	T <sub>a</sub> = 25°C	I <sub>CC</sub>	0.25	1.3	μA	—
				T <sub>a</sub> = 55°C		0.55	3.7		
				T <sub>a</sub> = 85°C		1.95	12		
				T <sub>a</sub> = 105°C		3.90	42		
		Only 8KB SRAM (0x2000_4000 to 0x2000_5FFF) is on	T <sub>a</sub> = 25°C	0.25		1.3			
			T <sub>a</sub> = 55°C	0.55		3.7			
			T <sub>a</sub> = 85°C	1.70		12			
			T <sub>a</sub> = 105°C	3.55		42			
			Increment for RTC operation with low-speed on-chip oscillator <sup>*4</sup>		0.30	—	—	—	
			Increment for RTC operation in normal operation mode with sub-clock oscillator <sup>*4</sup>		0.20	—	—	SOMCR.SODRV[1:0] are 11b (Low power mode 3) RCR4.ROPSEL is 0 (RTC operation in normal operation mode)	
					0.95	—	—	SOMCR.SODRV[1:0] are 00b (normal mode) RCR4.ROPSEL is 0 (RTC operation in normal operation mode)	
			Increment for RTC operation in low-consumption clock mode with sub-clock oscillator <sup>*4</sup>		0.11	—	—	SOMCR.SODRV[1:0] are 11b (Low power mode 3) RCR4.ROPSEL is 1 (RTC operation in low-consumption clock mode)	
				0.90	—	—	SOMCR.SODRV[1:0] are 00b (normal mode) RCR4.ROPSEL is 1 (RTC operation in low-consumption clock mode)		

Note 1. Supply current is the total current flowing into VCC. Supply current values apply when internal pull-up MOSs are in the off state and these values do not include output charge/discharge current from any of the pins.

Note 2. The IWDT and LVD are not operating.

Note 3. VCC = 3.3 V.

Note 4. Includes the low-speed on-chip oscillator or sub-oscillation circuit current.

**Table 2.12 Operating and standby current (3) (1 of 2)**

Conditions: VCC = AVCC0 = 1.6 to 5.5 V

Parameter		Symbol	Min	Typ	Max	Unit	Test conditions
Analog power supply current	During 12-bit A/D conversion (at high-speed A/D conversion mode)	I <sub>AVCC0</sub>	—	—	1.44	mA	—
	During 12-bit A/D conversion (at low-power A/D conversion mode)		—	—	0.78	mA	—
	Waiting for 12-bit A/D conversion (all units) <sup>*1</sup>		—	—	1.0	μA	—
Reference power supply current	During 12-bit A/D conversion	I <sub>REFH0</sub>	—	—	120	μA	—
	Waiting for 12-bit A/D conversion		—	—	60	nA	—
Temperature Sensor (TSN) operating current		I <sub>TNS</sub>	—	95	—	μA	—

**Table 2.12 Operating and standby current (3) (2 of 2)**

Conditions: VCC = AVCC0 = 1.6 to 5.5 V

Parameter		Symbol	Min	Typ	Max	Unit	Test conditions
Low-power Analog Comparator (ACMPLP) operating current	Window comparator (high-speed mode)	I <sub>CMPLP</sub>	—	12	—	μA	—
	Comparator (high-speed mode)		—	6.4	—	μA	—
	Comparator (low-speed mode)		—	1.8	—	μA	—

Note 1. When the MCU is in Software Standby mode or the MSTPCRD.MSTPD16 (ADC120 module-stop bit) is in the module-stop state.

### 2.2.6 VCC Rise and Fall Gradient and Ripple Frequency

**Table 2.13 Rise and fall gradient characteristics**

Conditions: VCC = AVCC0 = 0 to 5.5 V

Parameter		Symbol	Min	Typ	Max	Unit	Test conditions
Power-on VCC rising gradient	Voltage monitor 0 reset disabled at startup	SrVCC	0.02	—	2	ms/V	—
	Voltage monitor 0 reset enabled at startup*1 *2				—		
	SCI boot mode*2				2		

Note 1. When OFS1.LVDAS = 0.

Note 2. At boot mode, the reset from voltage monitor 0 is disabled regardless of the value of OFS1.LVDAS bit.

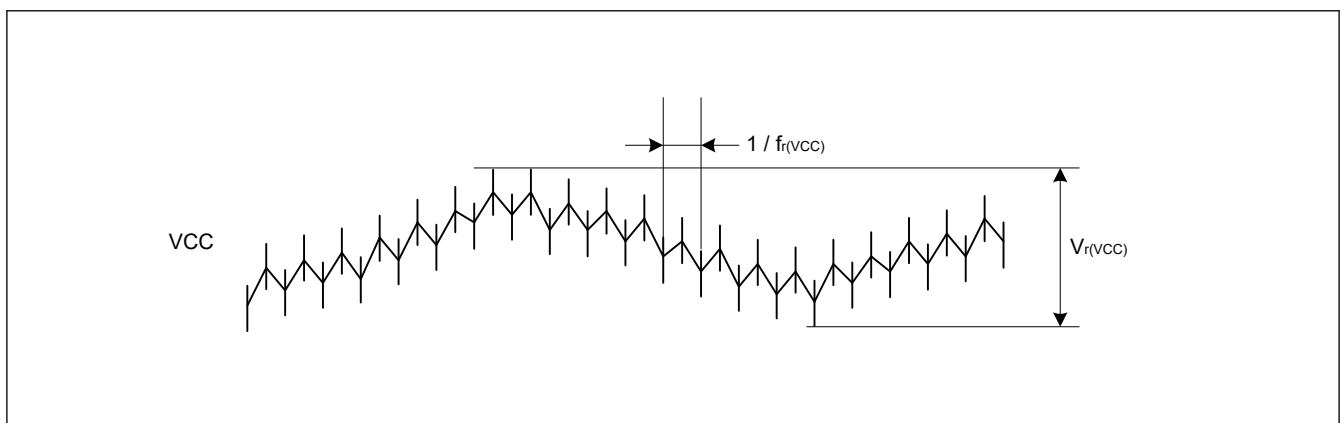
**Table 2.14 Rising and falling gradient and ripple frequency characteristics**

Conditions: VCC = AVCC0 = 1.6 to 5.5 V

The ripple voltage must meet the allowable ripple frequency  $f_{r(VCC)}$  within the range between the VCC upper limit (5.5 V) and lower limit (1.6 V).

When the VCC change exceeds VCC ± 10%, the allowable voltage change rising and falling gradient dt/dVCC must be met.

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions
Allowable ripple frequency	$f_{r(VCC)}$	—	—	10	kHz	Figure 2.2 $V_{r(VCC)} \leq VCC \times 0.2$
		—	—	1	MHz	Figure 2.2 $V_{r(VCC)} \leq VCC \times 0.08$
		—	—	10	MHz	Figure 2.2 $V_{r(VCC)} \leq VCC \times 0.06$
Allowable voltage change rising and falling gradient	dt/dVCC	1.0	—	—	ms/V	When VCC change exceeds VCC ± 10%



**Figure 2.2 Ripple waveform**

### 2.3 AC Characteristics

### 2.3.1 Frequency

**Table 2.15 Operation frequency in high-speed operating mode**

Conditions: VCC = AVCC0 = 1.8 to 5.5 V

Parameter			Symbol	Min	Typ	Max <sup>*4</sup>	Unit
Operation frequency	System clock (ICLK) <sup>*1*2</sup>	1.8 to 5.5 V	f	0.032768	—	48	MHz
	Peripheral module clock (PCLKB)	1.8 to 5.5 V		—	—	32	
	Peripheral module clock (PCLKD) <sup>*3</sup>	1.8 to 5.5 V		—	—	64	

Note 1. The lower-limit frequency of ICLK is 1 MHz while programming or erasing the flash memory. When using ICLK for programming or erasing the flash memory at below 4 MHz, the frequency can be set to 1 MHz, 2 MHz, or 3 MHz. A non-integer frequency such as 1.5 MHz cannot be set.

Note 2. The frequency accuracy of ICLK must be  $\pm 1.0\%$  during programming or erasing the flash memory. Confirm the frequency accuracy of the clock source.

Note 3. The lower-limit frequency of PCLKD is 1 MHz when the ADC12 is in use.

Note 4. The maximum value of operation frequency does not include internal oscillator errors. For details on the range for guaranteed operation, see [Table 2.19](#).

**Table 2.16 Operation frequency in middle-speed mode**

Conditions: VCC = AVCC0 = 1.6 to 5.5 V

Parameter			Symbol	Min	Typ	Max <sup>*4</sup>	Unit
Operation frequency	System clock (ICLK) <sup>*1*2</sup>	1.8 to 5.5 V	f	0.032768	—	24	MHz
		1.6 to 1.8 V		0.032768	—	4	
	Peripheral module clock (PCLKB)	1.8 to 5.5 V		—	—	24	
		1.6 to 1.8 V		—	—	4	
	Peripheral module clock (PCLKD) <sup>*3</sup>	1.8 to 5.5 V		—	—	24	
		1.6 to 1.8 V		—	—	4	

Note 1. The lower-limit frequency of ICLK is 1 MHz while programming or erasing the flash memory. When using ICLK for programming or erasing the flash memory at below 4 MHz, the frequency can be set to 1 MHz, 2 MHz, or 3 MHz. A non-integer frequency such as 1.5 MHz cannot be set.

Note 2. The frequency accuracy of ICLK must be  $\pm 1.0\%$  while programming or erasing the flash memory. Confirm the frequency accuracy of the clock source.

Note 3. The lower-limit frequency of PCLKD is 1 MHz when the ADC12 is in use.

Note 4. The maximum value of operation frequency does not include internal oscillator errors. For details on the range for guaranteed operation, see [Table 2.19](#).

**Table 2.17 Operation frequency in low-speed mode**

Conditions: VCC = AVCC0 = 1.6 to 5.5 V

Parameter			Symbol	Min	Typ	Max <sup>*4</sup>	Unit
Operation frequency	System clock (ICLK) <sup>*1*2</sup>	1.6 to 5.5 V	f	0.032768	—	2	MHz
	Peripheral module clock (PCLKB)	1.6 to 5.5 V		—	—	2	
	Peripheral module clock (PCLKD) <sup>*3</sup>	1.6 to 5.5 V		—	—	2	

Note 1. The lower-limit frequency of ICLK is 1 MHz while programming or erasing the flash memory.

Note 2. The frequency accuracy of ICLK must be  $\pm 1.0\%$  while programming or erasing the flash memory. Confirm the frequency accuracy of the clock source.

Note 3. The lower-limit frequency of PCLKD is 1 MHz when the ADC12 is in use.

Note 4. The maximum value of operation frequency does not include internal oscillator errors. For details on the range for guaranteed operation, see [Table 2.19](#).

**Table 2.18 Operation frequency in Subosc-speed mode**

Conditions: VCC = AVCC0 = 1.6 to 5.5 V

Parameter			Symbol	Min	Typ	Max	Unit
Operation frequency	System clock (ICLK) <sup>*1</sup>	1.6 to 5.5 V	f	27.8528	32.768	37.6832	kHz
	Peripheral module clock (PCLKB)	1.6 to 5.5 V		—	—	37.6832	
	Peripheral module clock (PCLKD) <sup>*2</sup>	1.6 to 5.5 V		—	—	37.6832	

Note 1. Programming and erasing the flash memory is not possible.

Note 2. The ADC12 cannot be used.

## 2.3.2 Clock Timing

**Table 2.19** Clock timing

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions
EXTAL external clock input cycle time	$t_{XCYC}$	50	—	—	ns	Figure 2.3
EXTAL external clock input high pulse width	$t_{XH}$	20	—	—	ns	
EXTAL external clock input low pulse width	$t_{XL}$	20	—	—	ns	
EXTAL external clock rising time	$t_{Xr}$	—	—	5	ns	
EXTAL external clock falling time	$t_{Xf}$	—	—	5	ns	
EXTAL external clock input wait time*1	$t_{EXWT}$	0.3	—	—	$\mu$ s	—
EXTAL external clock input frequency	$f_{EXTAL}$	—	—	20	MHz	$1.8 \leq VCC \leq 5.5$
		—	—	4		$1.6 \leq VCC < 1.8$
Main clock oscillator oscillation frequency	$f_{MAIN}$	1	—	20	MHz	$1.8 \leq VCC \leq 5.5$
		1	—	4		$1.6 \leq VCC < 1.8$
LOCO clock oscillation frequency	$f_{LOCO}$	27.8528	32.768	37.6832	kHz	—
LOCO clock oscillation stabilization time	$t_{LOCO}$	—	—	100	$\mu$ s	Figure 2.4
IWDT-dedicated clock oscillation frequency	$f_{ILOCO}$	12.75	15	17.25	kHz	—
MOCO clock oscillation frequency	$f_{MOCO}$	6.8	8	9.2	MHz	—
MOCO clock oscillation stabilization time	$t_{MOCO}$	—	—	1	$\mu$ s	—
HOCO clock oscillation frequency*5	$f_{HOCO24}$	23.76	24	24.24	MHz	$T_a = -40$ to $105^\circ\text{C}$ $1.6 \leq VCC \leq 5.5$
	$f_{HOCO32}$	31.68	32	32.32		$T_a = -40$ to $105^\circ\text{C}$ $1.6 \leq VCC \leq 5.5$
	$f_{HOCO48}$	47.52	48	48.48		$T_a = -40$ to $105^\circ\text{C}$ $1.6 \leq VCC \leq 5.5$
	$f_{HOCO64}$	63.36	64	64.64		$T_a = -40$ to $105^\circ\text{C}$ $1.6 \leq VCC \leq 5.5$
HOCO clock oscillation stabilization time*3 *4	$t_{HOCO24}$	—	6.7	7.7	$\mu$ s	Figure 2.5
	$t_{HOCO32}$	—				
	$t_{HOCO48}$	—				
	$t_{HOCO64}$	—				
Sub-clock oscillator oscillation frequency	$f_{SUB}$	—	32.768	—	kHz	—
Sub-clock oscillation stabilization time*2	$t_{SUBOSC}$	—	0.5	—	s	Figure 2.6

Note 1. Time until the clock can be used after the Main Clock Oscillator stop bit (MOSCCR.MOSTP) is set to 0 (operating) when the external clock is stable.

Note 2. After changing the setting of the SOSCCR.SOSTP bit to start sub-clock oscillator operation, only start using the sub-clock oscillator after the sub-clock oscillation stabilization wait time elapsed. Use the oscillator wait time value recommended by the oscillator manufacturer.

Note 3. This is a characteristic when the HOCOCCR.HCSTP bit is set to 0 (oscillation) in the MOCO stop state. When the HOCOCCR.HCSTP bit is set to 0 (oscillation) during MOCO oscillation, this specification is shortened by 1  $\mu$ s.

Note 4. Check OSCSF.HOCOSF to confirm whether stabilization time has elapsed.

Note 5. Accuracy at production test.

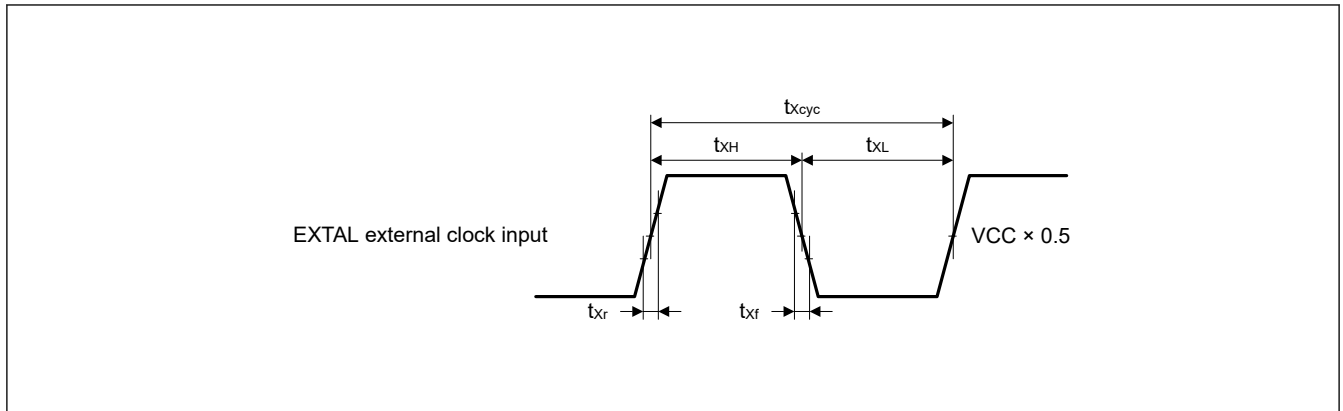


Figure 2.3 EXTAL external clock input timing

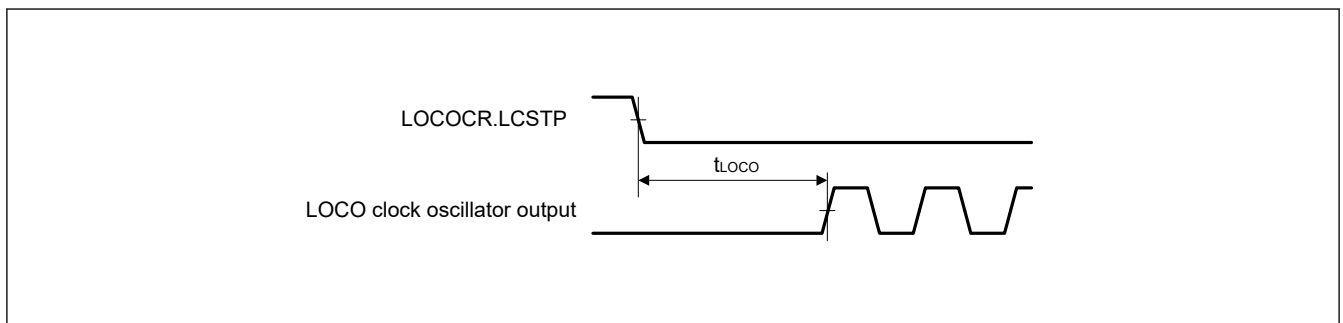


Figure 2.4 LOCO clock oscillation start timing

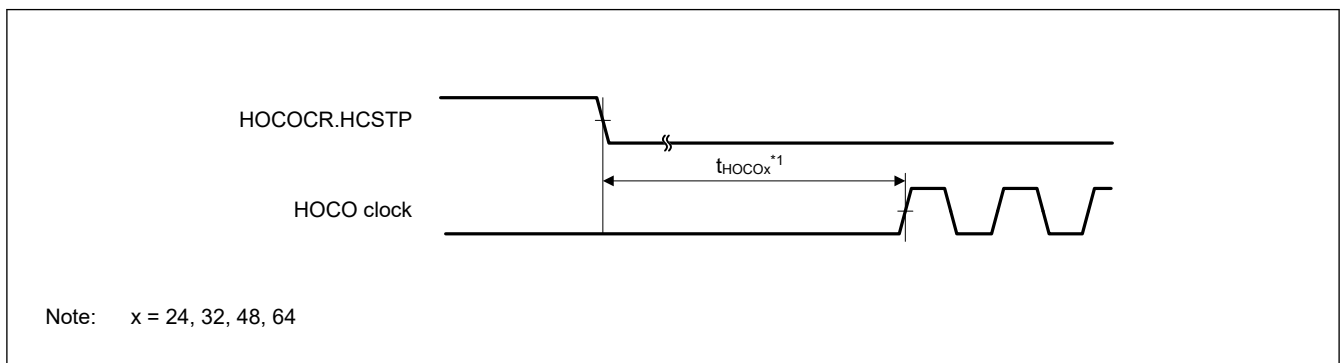


Figure 2.5 HOCO clock oscillation start timing (started by setting the HOCOCR.HCSTP bit)

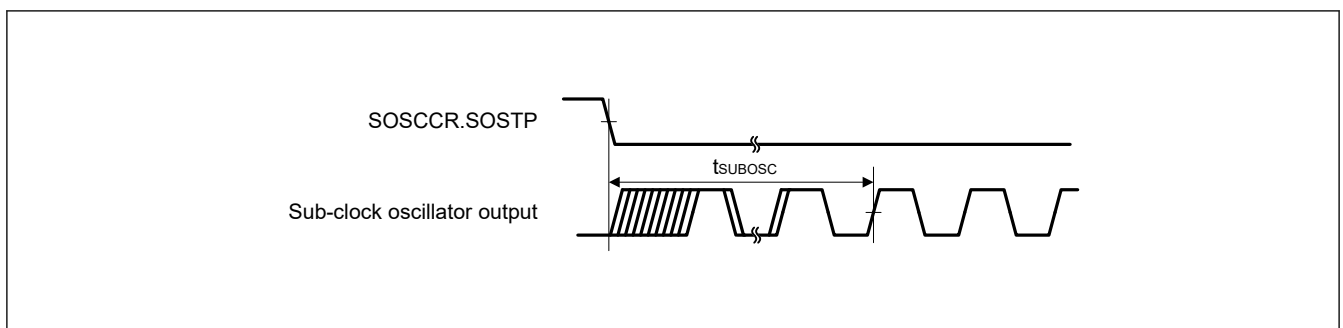


Figure 2.6 Sub-clock oscillation start timing

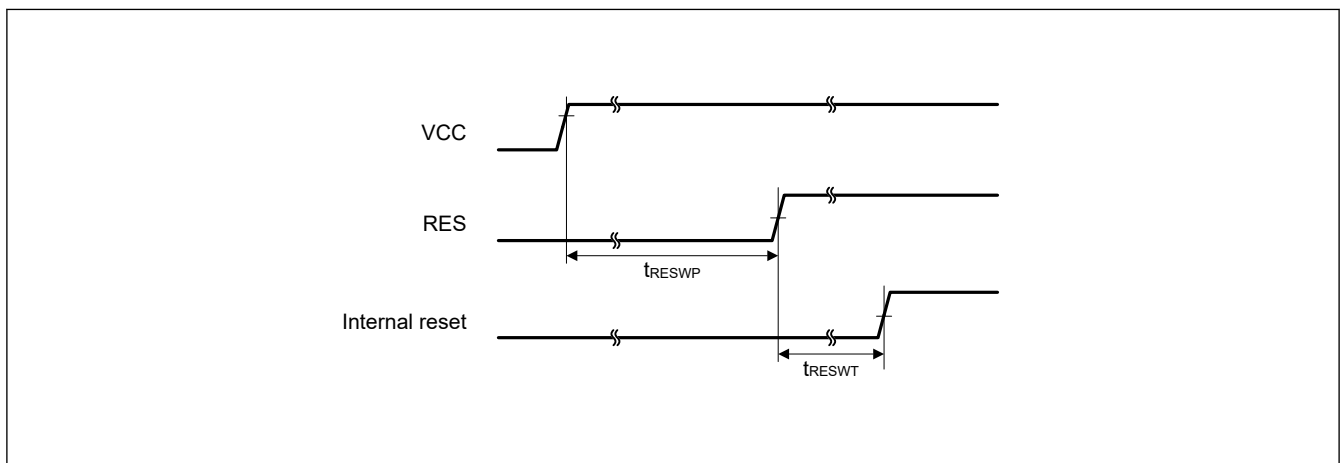
### 2.3.3 Reset Timing

**Table 2.20** Reset timing

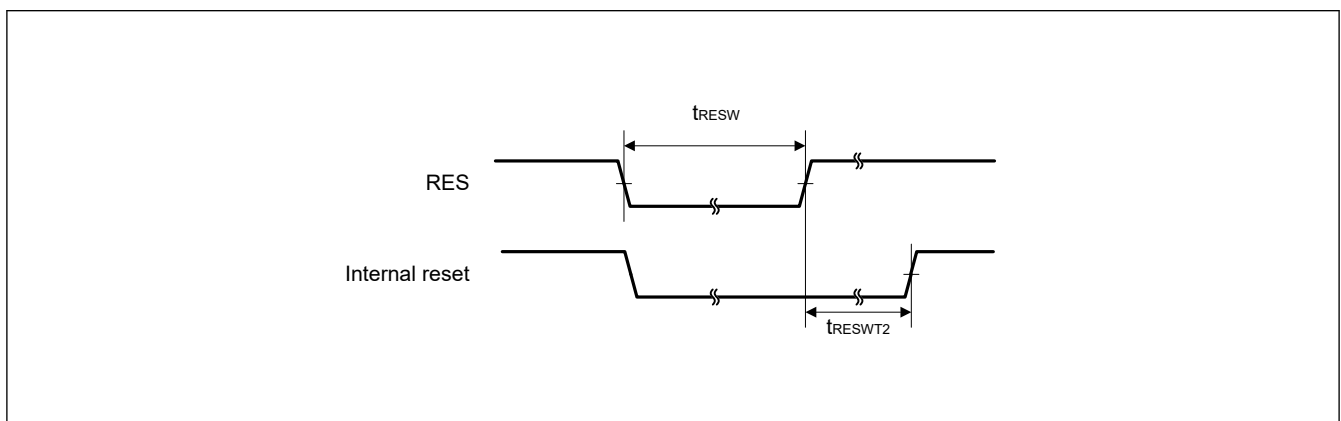
Parameter		Symbol	Min	Typ	Max	Unit	Test conditions
RES pulse width	At power-on	$t_{RESWP}$	10	—	—	ms	Figure 2.7
	Not at power-on	$t_{RESW}$	30	—	—	$\mu$ s	Figure 2.8
Wait time after RES cancellation (at power-on)	LVD0 enabled*1	$t_{RESWT}$	—	0.9	—	ms	Figure 2.7
	LVD0 disabled*2		—	0.2	—		
Wait time after RES cancellation (during powered-on state)	LVD0 enabled*1	$t_{RESWT2}$	—	0.9	—	ms	Figure 2.8
	LVD0 disabled*2		—	0.2	—		
Wait time after internal reset cancellation (Watchdog timer reset, SRAM parity error reset, bus master MPU error reset, bus slave MPU error reset, stack pointer error reset, software reset)	LVD0 enabled*1	$t_{RESWT3}$	—	0.9	—	ms	Figure 2.9
	LVD0 disabled*2		—	0.15	—		

Note 1. When OFS1.LVDAS = 0.

Note 2. When OFS1.LVDAS = 1.



**Figure 2.7** Reset input timing at power-on



**Figure 2.8** Reset input timing (1)



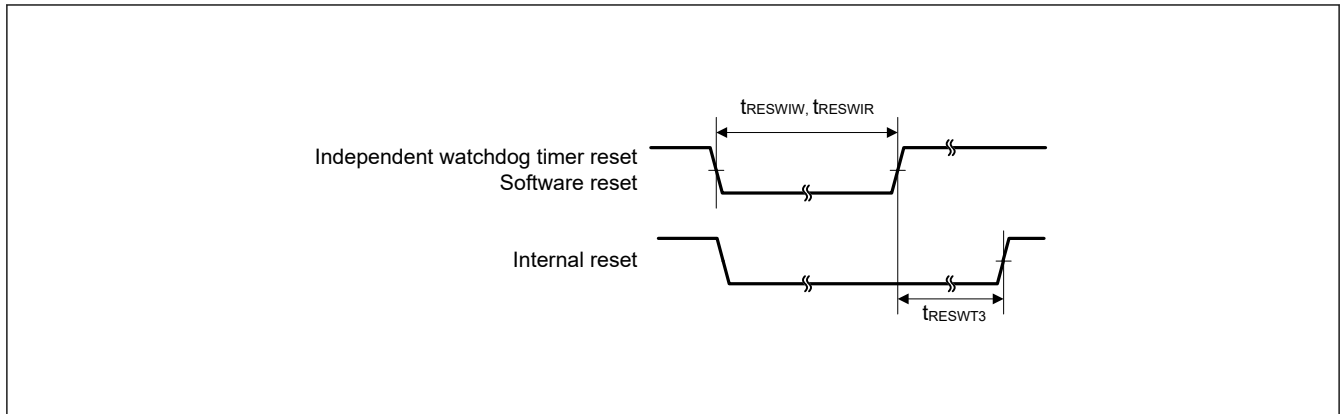


Figure 2.9 Reset input timing (2)

### 2.3.4 Wakeup Time

Table 2.21 Timing of recovery from low power modes (1)

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions	
Recovery time from Software Standby mode <sup>*1</sup>	High-speed mode						
	Crystal resonator connected to main clock oscillator	System clock source is main clock oscillator (20 MHz) <sup>*2</sup>	t <sub>SBYMC</sub>	—	2	3	ms
	External clock input to main clock oscillator	System clock source is main clock oscillator (20 MHz) <sup>*3</sup>	t <sub>SBYEX</sub>	—	2.4	3.1	μs
	System clock source is HOCO (HOCO clock is 32 MHz) <sup>*4</sup>	t <sub>SBYHO</sub>	—	7.4	9.1	μs	Figure 2.10
	System clock source is HOCO (HOCO clock is 48 MHz) <sup>*5</sup>	t <sub>SBYHO</sub>	—	7.3	8.9	μs	
	System clock source is HOCO (HOCO clock is 64 MHz) <sup>*4</sup>	t <sub>SBYHO</sub>	—	7.4	9.1	μs	
System clock source is MOCO (8 MHz)	t <sub>SBYMO</sub>	—	4	5	μs		

Note 1. The division ratio of ICLK and PCLKx is the minimum division ratio within the allowable frequency range. The recovery time is determined by the system clock source.

Note 2. The Main Clock Oscillator Wait Control Register (MOSCWTCR) is set to 0x05.

Note 3. The Main Clock Oscillator Wait Control Register (MOSCWTCR) is set to 0x00.

Note 4. The system clock is 32 MHz.

Note 5. The system clock is 48 MHz.

**Table 2.22 Timing of recovery from low power modes (2)**

Parameter				Symbol	Min	Typ	Max	Unit	Test conditions
Recovery time from Software Standby mode*1	Middle-speed mode	Crystal resonator connected to main clock oscillator	System clock source is main clock oscillator (20 MHz)*2	t <sub>SBYMC</sub>	—	2	3	ms	Figure 2.10
		External clock input to main clock oscillator	System clock source is main clock oscillator (20 MHz)*3 VCC = 1.8 V to 5.5 V	t <sub>SBYEX</sub>	—	2.4	3.1	μs	
			System clock source is main clock oscillator (20 MHz)*3 VCC = 1.6 V to 1.8 V						
		System clock source is HOCO*4	VCC = 1.8 V to 5.5 V	t <sub>SBYHO</sub>	—	7.7	9.4	μs	
			VCC = 1.6 V to 1.8 V						
		System clock source is MOCO (8 MHz)	VCC = 1.8 V to 5.5 V	t <sub>SBYMO</sub>	—	4	5	μs	
VCC = 1.6 V to 1.8 V									

Note 1. The division ratio of ICLK and PCLKx is the minimum division ratio within the allowable frequency range. The recovery time is determined by the system clock source.

Note 2. The Main Clock Oscillator Wait Control Register (MOSCWTCR) is set to 0x05.

Note 3. The Main Clock Oscillator Wait Control Register (MOSCWTCR) is set to 0x00.

Note 4. The system clock is 24 MHz.

**Table 2.23 Timing of recovery from low power modes (3)**

Parameter				Symbol	Min	Typ	Max	Unit	Test conditions
Recovery time from Software Standby mode*1	Low-speed mode	Crystal resonator connected to main clock oscillator	System clock source is main clock oscillator (2 MHz)*2	t <sub>SBYMC</sub>	—	2	3	ms	Figure 2.10
		External clock input to main clock oscillator	System clock source is main clock oscillator (2 MHz)*3	t <sub>SBYEX</sub>	—	14.5	16	μs	
			System clock source is MOCO (2 MHz)						

Note 1. The division ratio of ICLK and PCLKx is the minimum division ratio within the allowable frequency range. The recovery time is determined by the system clock source.

Note 2. The Main Clock Oscillator Wait Control Register (MOSCWTCR) is set to 0x05.

Note 3. The Main Clock Oscillator Wait Control Register (MOSCWTCR) is set to 0x00.

**Table 2.24 Timing of recovery from low power modes (4)**

Parameter			Symbol	Min	Typ	Max	Unit	Test conditions
Recovery time from Software Standby mode*1	Subosc-speed mode	System clock source is sub-clock oscillator (32.768 kHz)	t <sub>SBYSC</sub>	—	0.85	1	ms	Figure 2.10
		System clock source is LOCO (32.768 kHz)	t <sub>SBYLO</sub>	—	0.85	1.2	ms	

Note 1. The sub-clock oscillator or LOCO itself continues oscillating in Software Standby mode during Subosc-speed mode.

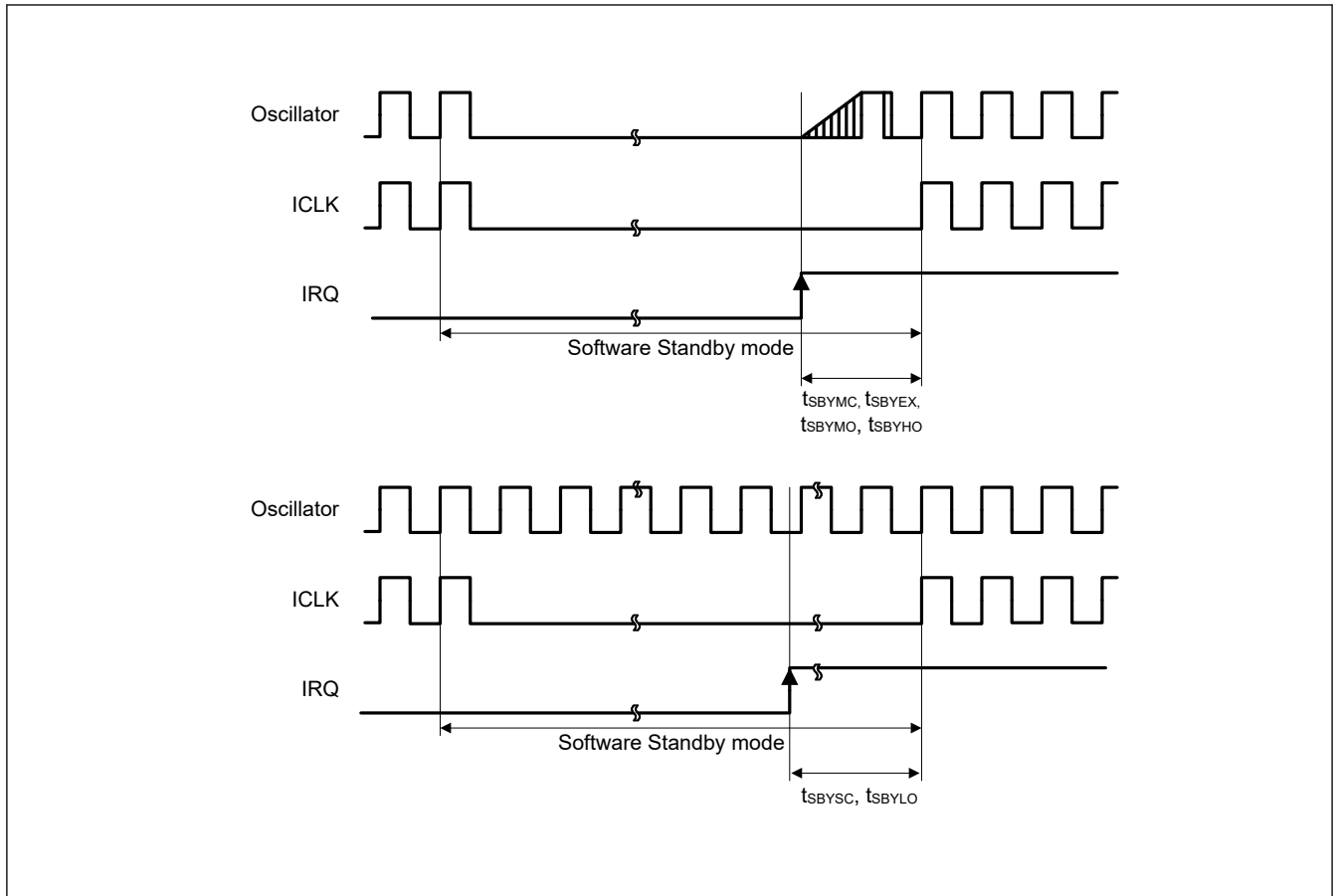


Figure 2.10 Software Standby mode cancellation timing

Table 2.25 Timing of recovery from low power modes (5)

Parameter		Symbol	Min	Typ	Max	Unit	Test conditions
Recovery time from Software Standby mode to Snooze mode	High-speed mode System clock source is HOCO	$t_{SNZ}$	—	6.6	8.1	$\mu\text{s}$	Figure 2.11
	Middle-speed mode System clock source is HOCO (24 MHz) VCC = 1.8 V to 5.5 V	$t_{SNZ}$	—	6.7	8.2	$\mu\text{s}$	
	Middle-speed mode System clock source is HOCO (24 MHz) VCC = 1.6 V to 1.8 V	$t_{SNZ}$	—	10.8	12.9	$\mu\text{s}$	
	Low-speed mode System clock source is MOCO (2 MHz)	$t_{SNZ}$	—	6.7	8.0	$\mu\text{s}$	

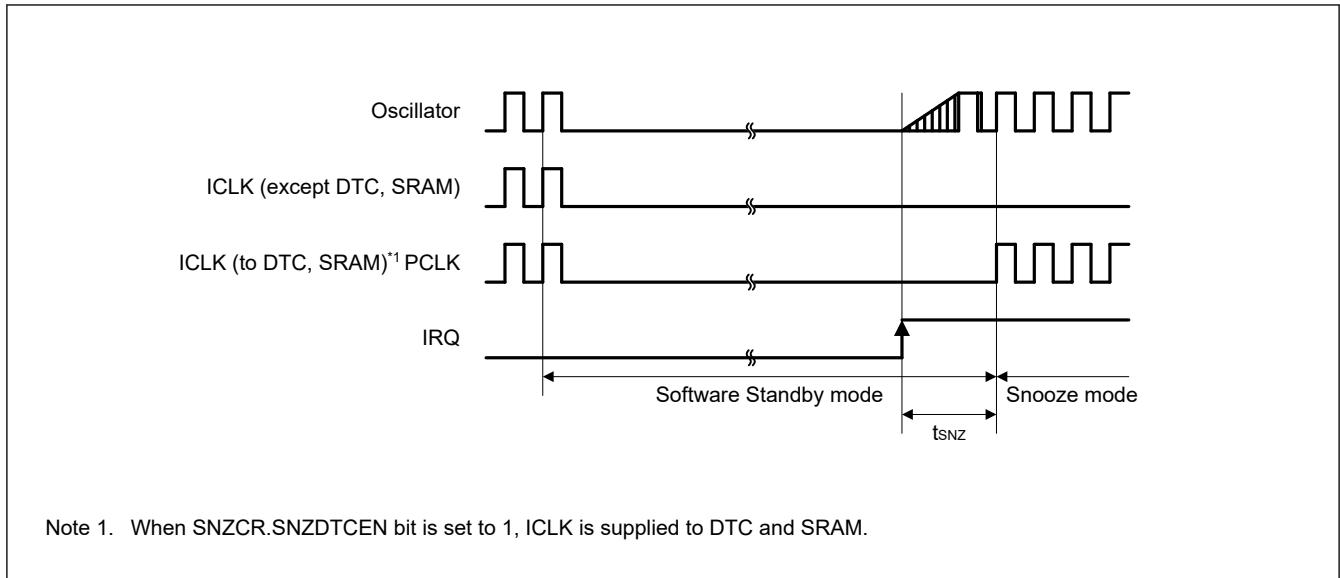


Figure 2.11 Recovery timing from Software Standby mode to Snooze mode

### 2.3.5 NMI and IRQ Noise Filter

Table 2.26 NMI and IRQ noise filter

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions	
NMI pulse width	$t_{NMIW}$	200	—	—	ns	NMI digital filter disabled	$t_{Pcyc} \times 2 \leq 200$ ns
		$t_{Pcyc} \times 2^{+1}$	—	—			$t_{Pcyc} \times 2 > 200$ ns
		200	—	—		NMI digital filter enabled	$t_{NMICK} \times 3 \leq 200$ ns
		$t_{NMICK} \times 3.5^{+2}$	—	—			$t_{NMICK} \times 3 > 200$ ns
IRQ pulse width	$t_{IRQW}$	200	—	—	ns	IRQ digital filter disabled	$t_{Pcyc} \times 2 \leq 200$ ns
		$t_{Pcyc} \times 2^{+1}$	—	—			$t_{Pcyc} \times 2 > 200$ ns
		200	—	—		IRQ digital filter enabled	$t_{IRQCK} \times 3 \leq 200$ ns
		$t_{IRQCK} \times 3.5^{+3}$	—	—			$t_{IRQCK} \times 3 > 200$ ns

Note: 200 ns minimum in Software Standby mode.

Note: If the clock source is being switched it is needed to add 4 clock cycle of switched source.

Note 1.  $t_{Pcyc}$  indicates the PCLKB cycle.

Note 2.  $t_{NMICK}$  indicates the cycle of the NMI digital filter sampling clock.

Note 3.  $t_{IRQCK}$  indicates the cycle of the IRQi digital filter sampling clock (i = 0 to 7).

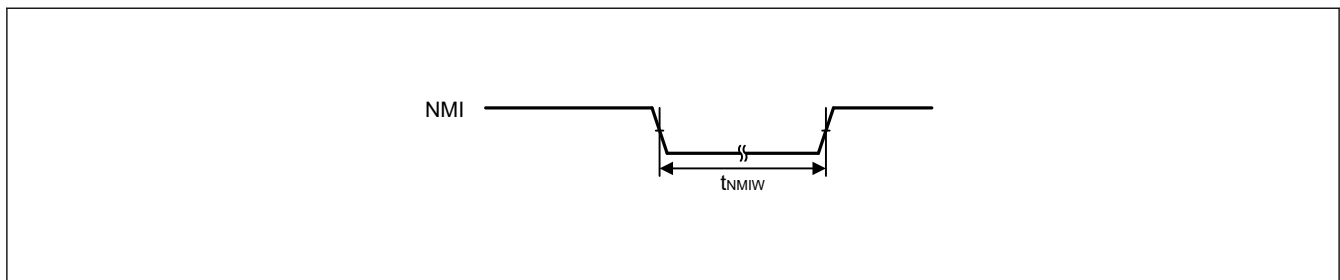


Figure 2.12 NMI interrupt input timing

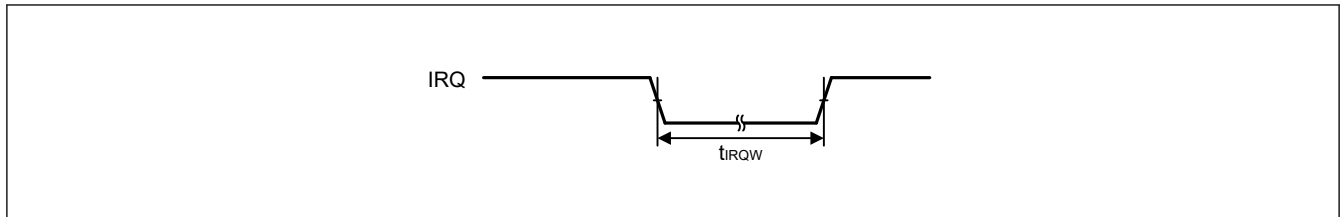


Figure 2.13 IRQ interrupt input timing

### 2.3.6 I/O Ports, POEG, GPT, AGT, KINT, and ADC12 Trigger Timing

Table 2.27 I/O Ports, POEG, GPT, AGT, KINT, and ADC12 trigger timing

Parameter		Symbol	Min	Max	Unit	Test conditions	
I/O Ports	Input data pulse width	$2.7\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	$t_{PRW}$	2	—	$t_{Pcyc}$	Figure 2.14
		$2.4\text{ V} \leq \text{VCC} < 2.7\text{ V}$		3			
		$1.6\text{ V} \leq \text{VCC} < 2.4\text{ V}$		4			
POEG	POEG input trigger pulse width	$t_{POEW}$	3	—	$t_{Pcyc}$	Figure 2.15	
GPT	Input capture pulse width	Single edge	$t_{GTICW}$	1.5	—	$t_{PDcyc}$	Figure 2.16
		Dual edge		2.5	—		
AGT	AGTIO, AGTEE input cycle	$1.8\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	$t_{ACYC}^{*1}$	250	—	ns	Figure 2.17
		$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$		2000	—	ns	
	AGTIO, AGTEE input high-level width, low-level width	$1.8\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	$t_{ACKWH}$	100	—	ns	Figure 2.17
		$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$	$t_{ACKWL}$	800	—	ns	
	AGTIO, AGTO, AGTOA, AGTOB output cycle	$2.7\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	$t_{ACYC2}$	62.5	—	ns	
		$2.4\text{ V} \leq \text{VCC} < 2.7\text{ V}$		125	—	ns	
$1.8\text{ V} \leq \text{VCC} < 2.4\text{ V}$		250		—	ns		
$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$		500		—	ns		
ADC12	12-bit A/D converter trigger input pulse width	$t_{TRGW}$	1.5	—	$t_{Pcyc}$	Figure 2.18	
KINT	KRn (n = 00 to 07) pulse width	$t_{KR}$	250	—	ns	Figure 2.19	

Note 1. Constraints on AGTIO input:  $t_{Pcyc} \times 2$  ( $t_{Pcyc}$ : PCLKB cycle)  $< t_{ACYC}$ .

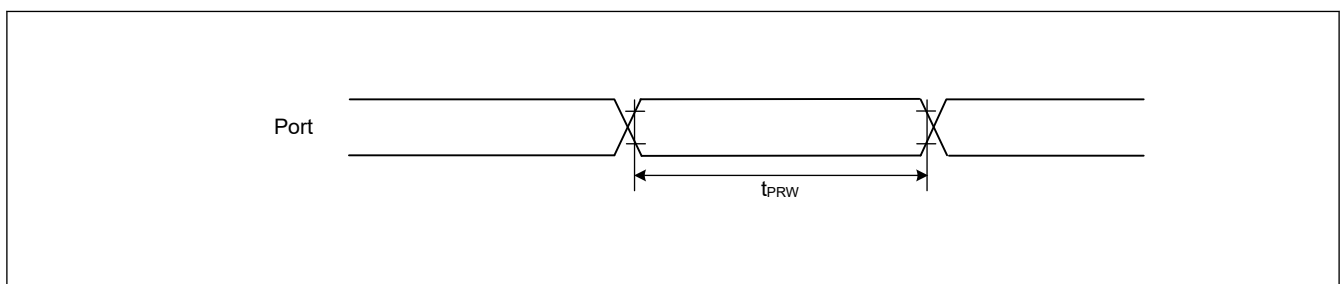


Figure 2.14 I/O ports input timing



Figure 2.15 POEG input trigger timing



Figure 2.16 GPT input capture timing



Figure 2.17 AGT I/O timing



Figure 2.18 ADC12 trigger input timing

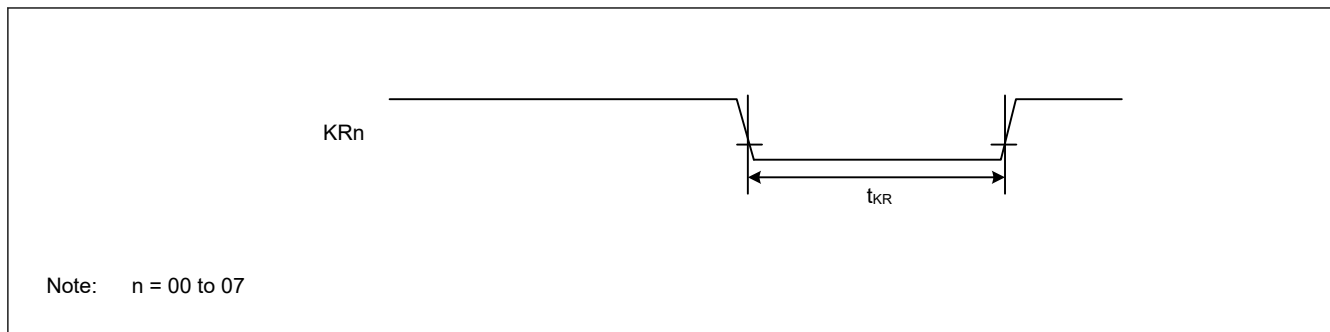


Figure 2.19 Key interrupt input timing

### 2.3.7 CAC Timing

Table 2.28 CAC timing

Conditions: VCC = AVCC0 = 1.6 to 5.5 V

Parameter		Symbol	Min	Typ	Max	Unit	Test conditions
CAC	CACREF input pulse width	t <sub>CACREF</sub>	t <sub>Pcyc</sub> <sup>*1</sup> ≤ t <sub>CAC</sub> <sup>*2</sup>	—	—	ns	—
			t <sub>Pcyc</sub> <sup>*1</sup> > t <sub>CAC</sub> <sup>*2</sup>	4.5 × t <sub>CAC</sub> + 3 × t <sub>Pcyc</sub>	—	—	

Note 1. t<sub>Pcyc</sub>: PCLKB cycle.

Note 2. t<sub>CAC</sub>: CAC count clock source cycle.

## 2.3.8 SCI Timing

Table 2.29 SCI timing (1)

Conditions: VCC = AVCC0 = 1.6 to 5.5 V

Parameter				Symbol	Min	Max	Unit	Test conditions	
SCI	Input clock cycle	Asynchronous	$2.7\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	$t_{\text{Scyc}}$	125	—	ns	Figure 2.20	
			$2.4\text{ V} \leq \text{VCC} < 2.7\text{ V}$		250	—			
			$1.8\text{ V} \leq \text{VCC} < 2.4\text{ V}$		500	—			
			$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$		1000	—			
		Clock synchronous	$2.7\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$		187.5	—			
			$2.4\text{ V} \leq \text{VCC} < 2.7\text{ V}$		375	—			
			$1.8\text{ V} \leq \text{VCC} < 2.4\text{ V}$		750	—			
			$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$		1500	—			
	Input clock pulse width				$t_{\text{SCKW}}$	0.4	0.6		$t_{\text{Scyc}}$
	Input clock rise time				$t_{\text{SCKr}}$	—	20		ns
	Input clock fall time				$t_{\text{SCKf}}$	—	20		ns
	Output clock cycle	Asynchronous	$2.7\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	$t_{\text{Scyc}}$	187.5	—	ns		
			$2.4\text{ V} \leq \text{VCC} < 2.7\text{ V}$		375	—			
			$1.8\text{ V} \leq \text{VCC} < 2.4\text{ V}$		750	—			
			$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$		1500	—			
		Clock synchronous	$2.7\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$		125	—			
$2.4\text{ V} \leq \text{VCC} < 2.7\text{ V}$			250		—				
$1.8\text{ V} \leq \text{VCC} < 2.4\text{ V}$			500		—				
$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$			1000		—				
Output clock pulse width				$t_{\text{SCKW}}$	0.4	0.6	$t_{\text{Scyc}}$		
Output clock rise time			$1.8\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	$t_{\text{SCKr}}$	—	20	ns		
			$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$		—	30			
Output clock fall time			$1.8\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	$t_{\text{SCKf}}$	—	20	ns		
			$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$		—	30			
Transmit data delay time (master)	Clock synchronous			$t_{\text{TXD}}$	—	40	ns		
					$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$	—		45	
Transmit data delay time (slave)	Clock synchronous			$t_{\text{TXD}}$	—	55	ns		
					$2.4\text{ V} \leq \text{VCC} < 2.7\text{ V}$	—		60	
					$1.8\text{ V} \leq \text{VCC} < 2.4\text{ V}$	—		100	
					$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$	—		125	
Receive data setup time (master)	Clock synchronous			$t_{\text{RXS}}$	45	—	ns		
					$2.4\text{ V} \leq \text{VCC} < 2.7\text{ V}$	55		—	
					$1.8\text{ V} \leq \text{VCC} < 2.4\text{ V}$	90		—	
					$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$	110		—	
Receive data setup time (slave)	Clock synchronous			$t_{\text{RXS}}$	40	—	ns		
					$1.6\text{ V} \leq \text{VCC} < 2.7\text{ V}$	45		—	
Receive data hold time (master)	Clock synchronous				$t_{\text{RXH}}$	5	—	ns	
Receive data hold time (slave)	Clock synchronous				$t_{\text{RXH}}$	40	—	ns	



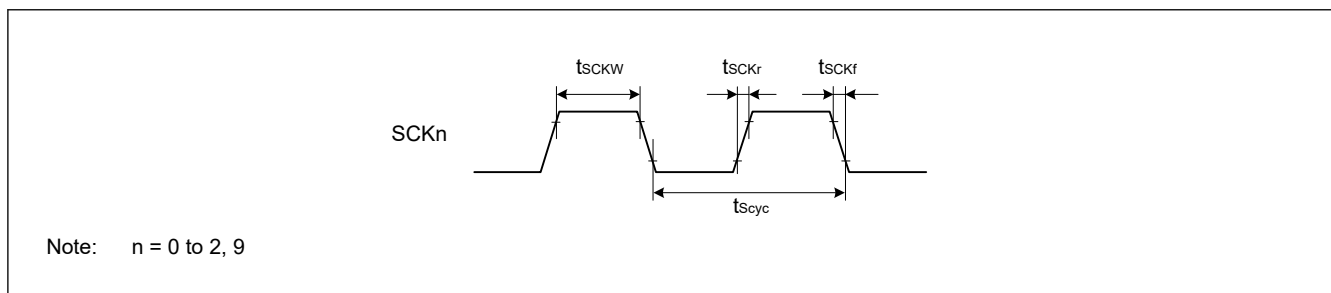


Figure 2.20 SCK clock input timing

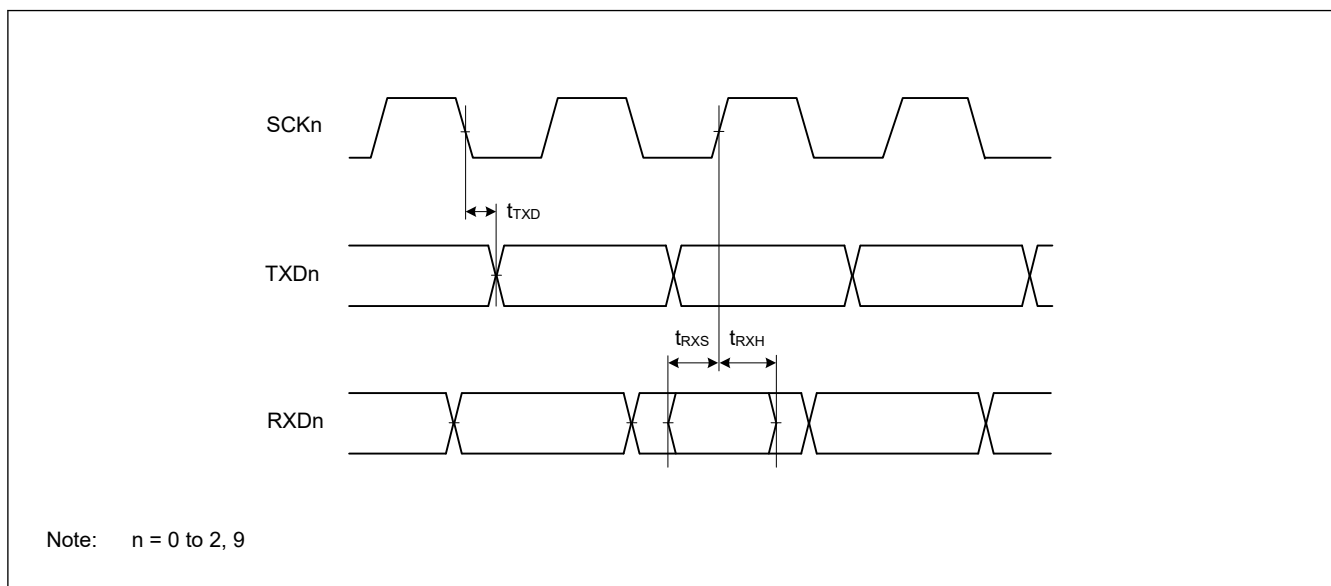


Figure 2.21 SCI input/output timing in clock synchronous mode

**Table 2.30 SCI timing (2) (1 of 2)**

Conditions: VCC = AVCC0 = 1.6 to 5.5 V

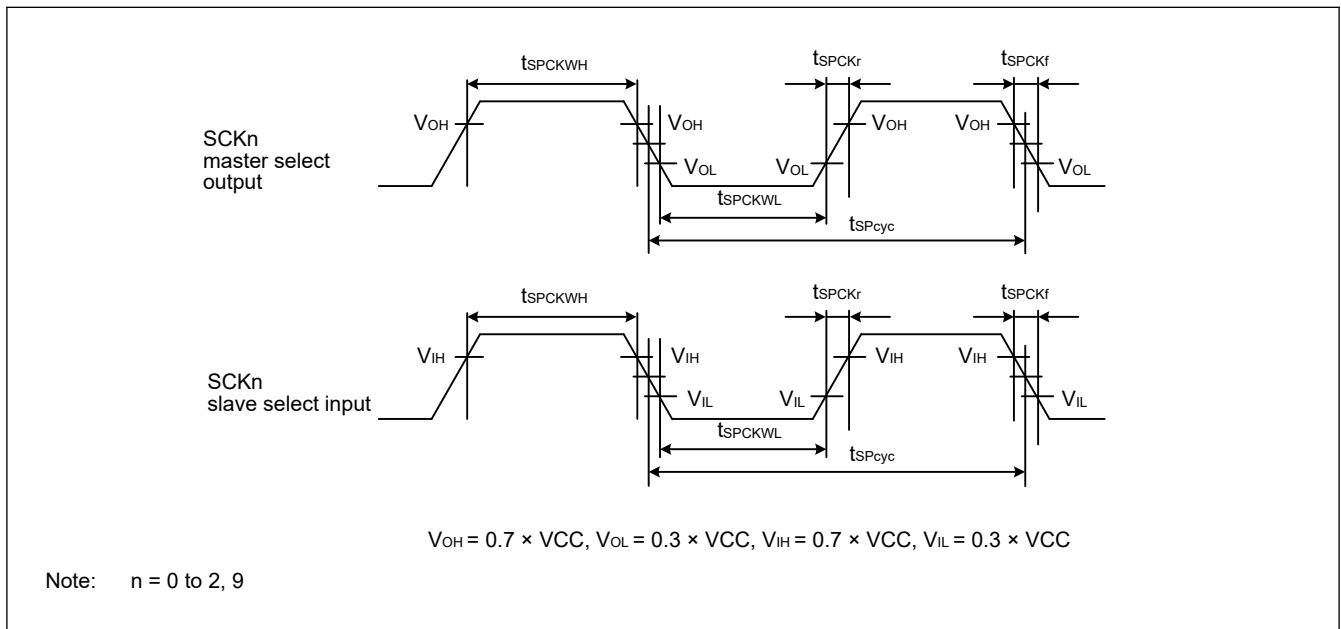
Parameter			Symbol	Min	Max	Unit*1	Test conditions	
Simple SPI	SCK clock cycle output (master)	$2.7\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	$t_{\text{SPcyc}}$	125	—	ns	Figure 2.22	
		$2.4\text{ V} \leq \text{VCC} < 2.7\text{ V}$		250	—			
		$1.8\text{ V} \leq \text{VCC} < 2.4\text{ V}$		500	—			
		$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$		1000	—			
	SCK clock cycle input (slave)	$2.7\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$		187.5	—			
		$2.4\text{ V} \leq \text{VCC} < 2.7\text{ V}$		375	—			
		$1.8\text{ V} \leq \text{VCC} < 2.4\text{ V}$		750	—			
		$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$		1500	—			
	SCK clock high pulse width			$t_{\text{SPCKWH}}$	0.4	0.6		$t_{\text{SPcyc}}$
	SCK clock low pulse width			$t_{\text{SPCKWL}}$	0.4	0.6		$t_{\text{SPcyc}}$
	SCK clock rise and fall time		$1.8\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	$t_{\text{SPCKr}}$ $t_{\text{SPCKf}}$	—	20		ns
			$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$		—	30		
Data input setup time	Master	$2.7\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	$t_{\text{SU}}$	45	—	ns	Figure 2.23 to Figure 2.26	
		$2.4\text{ V} \leq \text{VCC} < 2.7\text{ V}$		55	—			
		$1.8\text{ V} \leq \text{VCC} < 2.4\text{ V}$		80	—			
		$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$		110	—			
	Slave	$2.7\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$		40	—			
		$1.6\text{ V} \leq \text{VCC} < 2.7\text{ V}$		45	—			
Data input hold time	Master		$t_{\text{H}}$	33.3	—	ns		
	Slave			40	—			
SS input setup time			$t_{\text{LEAD}}$	1	—	$t_{\text{SPcyc}}$		
SS input hold time			$t_{\text{LAG}}$	1	—	$t_{\text{SPcyc}}$		
Data output delay time	Master	$1.8\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	$t_{\text{OD}}$	—	40	ns		
		$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$		—	50			
	Slave	$2.4\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$		—	65			
		$1.8\text{ V} \leq \text{VCC} < 2.4\text{ V}$		—	100			
		$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$		—	125			
				—	125			
Data output hold time	Master	$2.7\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	$t_{\text{OH}}$	-10	—	ns		
		$2.4\text{ V} \leq \text{VCC} < 2.7\text{ V}$		-20	—			
		$1.8\text{ V} \leq \text{VCC} < 2.4\text{ V}$		-30	—			
		$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$		-40	—			
	Slave				-10		—	
	Data rise and fall time	Master		$1.8\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	$t_{\text{Dr}}, t_{\text{Df}}$		—	20
$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$			—	30				
Slave		$1.8\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	—	20				
		$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$	—	30				

**Table 2.30 SCI timing (2) (2 of 2)**

Conditions: VCC = AVCC0 = 1.6 to 5.5 V

Parameter		Symbol	Min	Max	Unit*1	Test conditions		
Simple SPI	Slave access time	2.4 V ≤ VCC ≤ 5.5 V	—	6	t <sub>Pcyc</sub>	Figure 2.26		
		1.8 V ≤ VCC < 2.4 V	24 MHz ≤ PCLKB ≤ 32 MHz	—			7	
			PCLKB < 24 MHz	—			6	
		1.6 V ≤ VCC < 1.8 V	—	6				
	Slave output release time	2.4 V ≤ VCC ≤ 5.5 V	t <sub>REL</sub>	—	6		t <sub>Pcyc</sub>	
		1.8 V ≤ VCC < 2.4 V		24 MHz ≤ PCLKB ≤ 32 MHz	—			7
				PCLKB < 24 MHz	—			6
		1.6 V ≤ VCC < 1.8 V		—	6			

Note 1. t<sub>Pcyc</sub>: PCLKB cycle.



**Figure 2.22 SCI simple SPI mode clock timing**

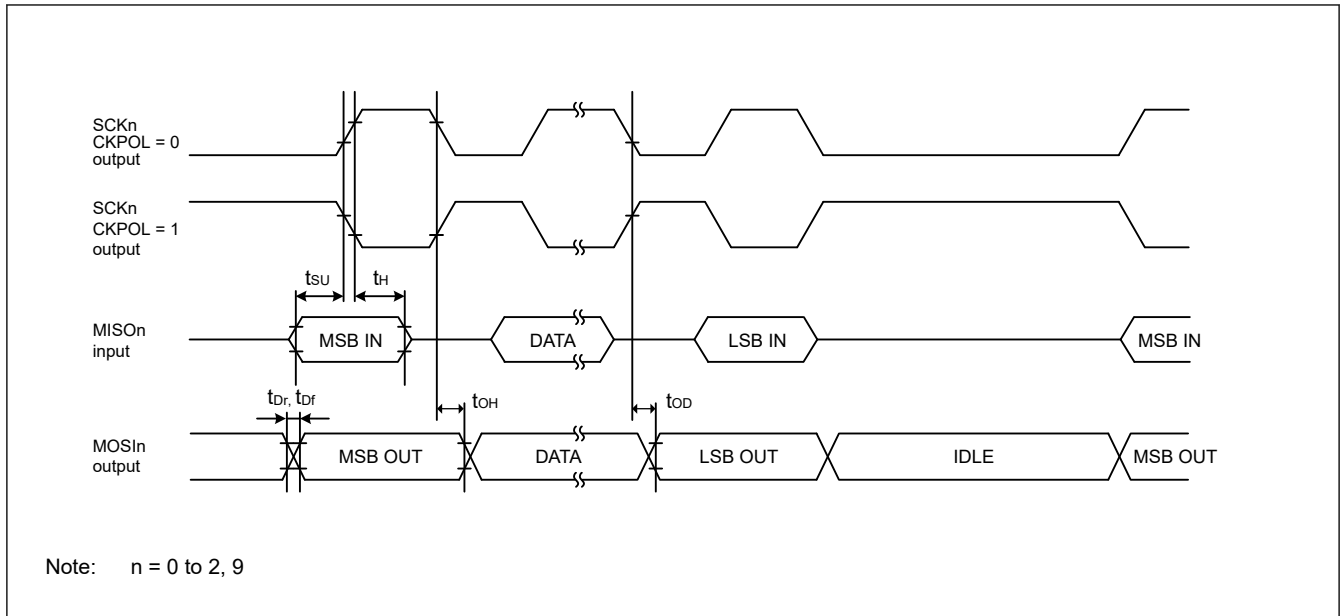


Figure 2.23 SCI simple SPI mode timing (master, CKPH = 1)

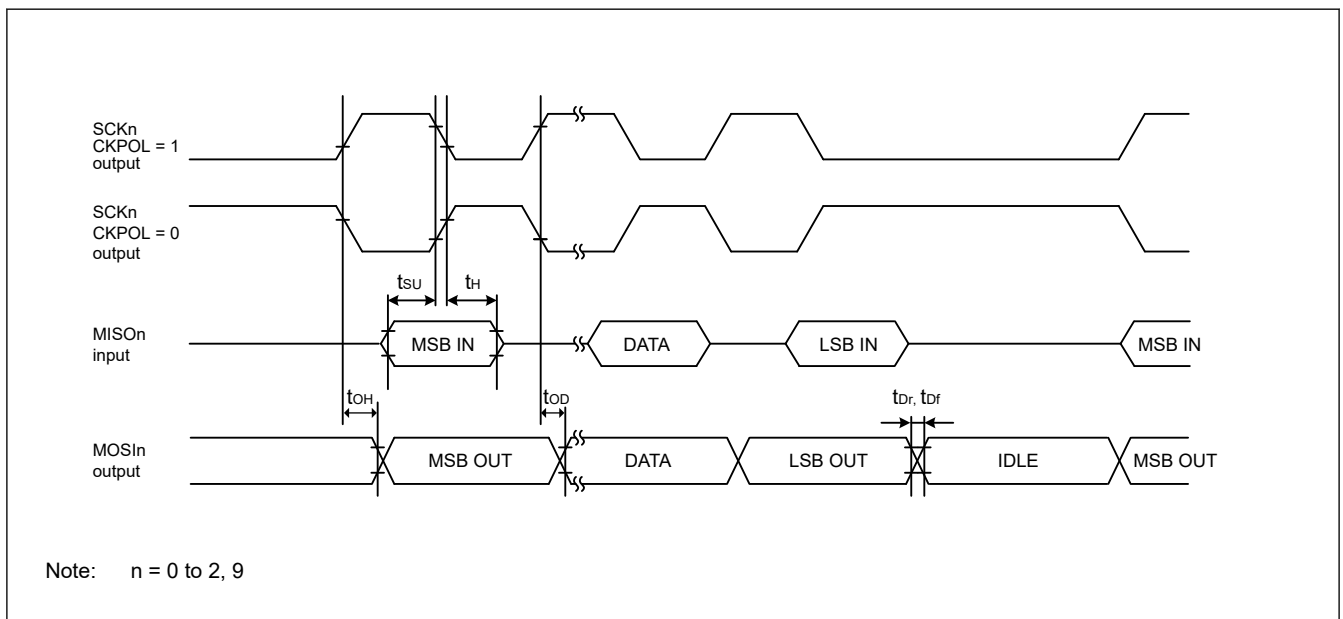


Figure 2.24 SCI simple SPI mode timing (master, CKPH = 0)

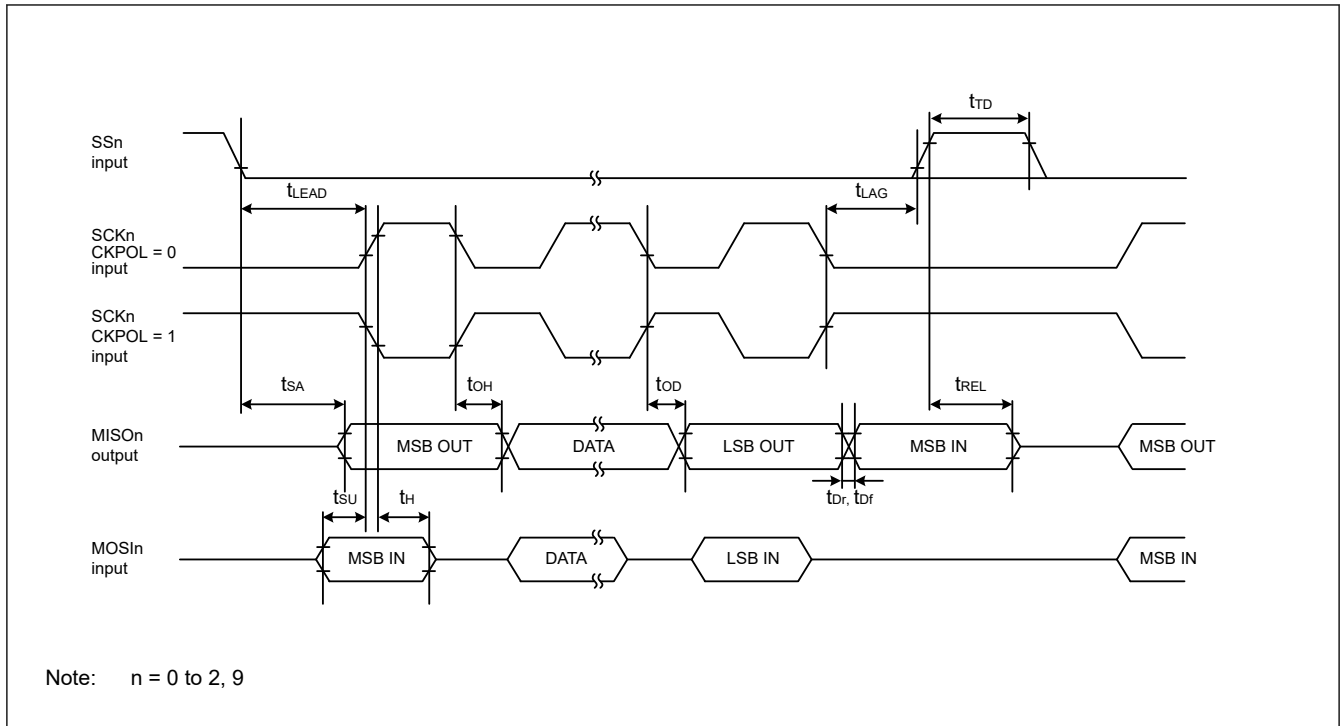


Figure 2.25 SCI simple SPI mode timing (slave, CKPH = 1)

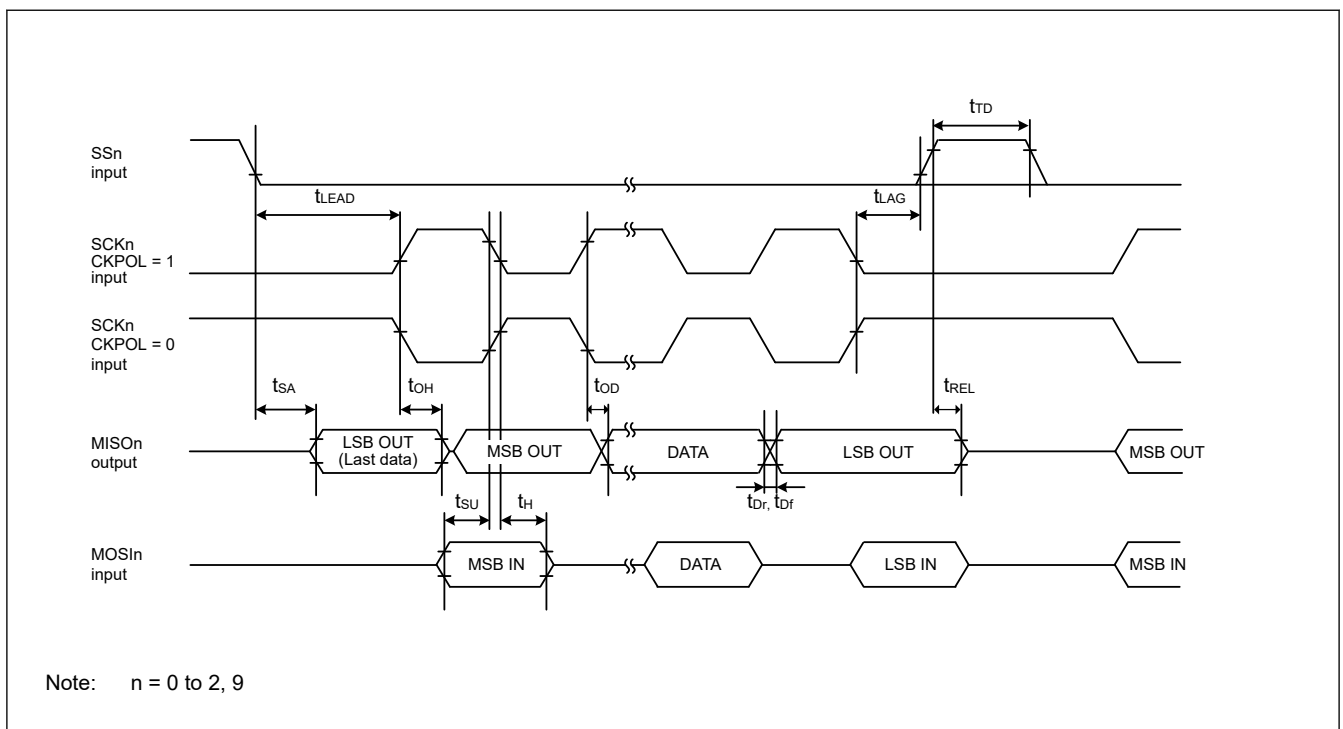


Figure 2.26 SCI simple SPI mode timing (slave, CKPH = 0)

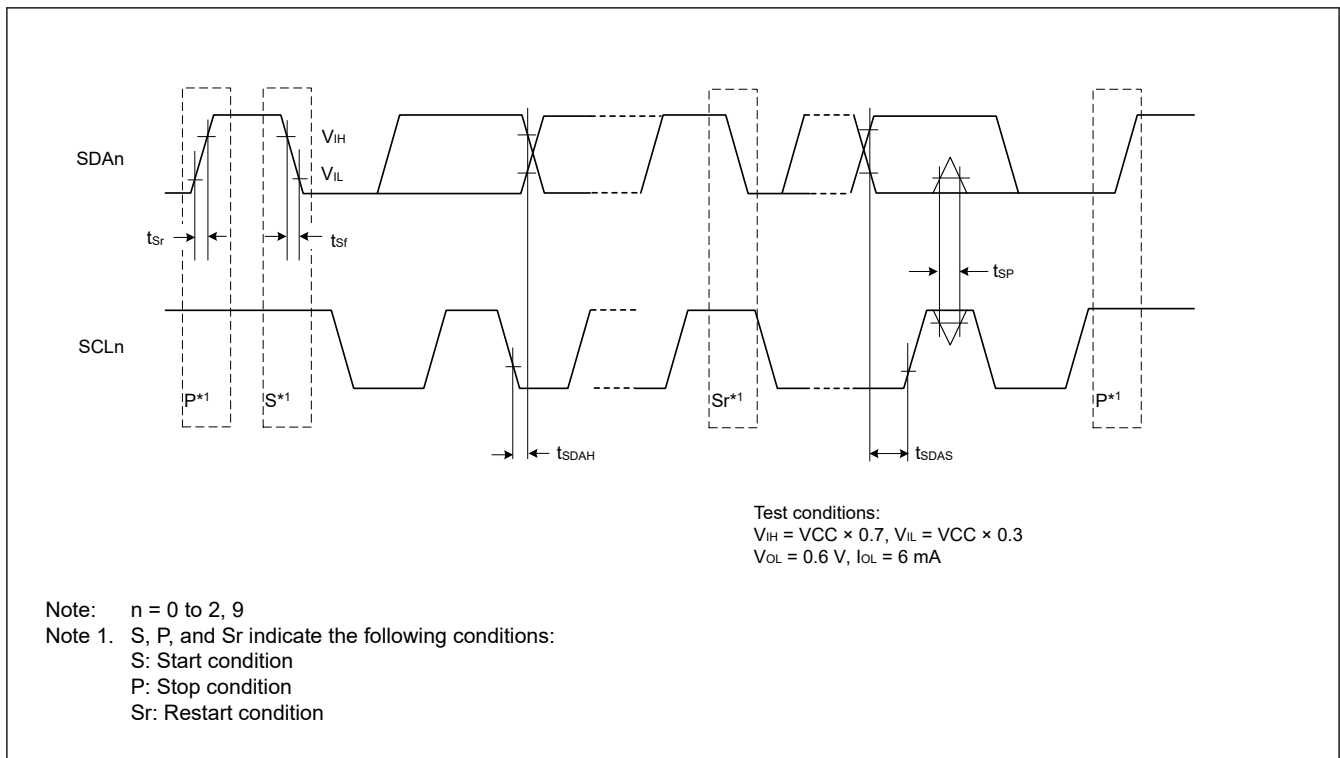
**Table 2.31 SCI timing (3)**

Conditions: VCC = AVCC0 = 2.7 to 5.5 V

Parameter	Symbol	Min	Max	Unit	Test conditions	
Simple IIC (Standard mode)	SDA input rise time	$t_{Sr}$	—	1000	ns	Figure 2.27
	SDA input fall time	$t_{Sf}$	—	300	ns	
	SDA input spike pulse removal time	$t_{SP}$	0	$4 \times t_{IICcyc}^{*1}$	ns	
	Data input setup time	$t_{SDAS}$	250	—	ns	
	Data input hold time	$t_{SDAH}$	0	—	ns	
	SCL, SDA capacitive load	$C_b^{*2}$	—	400	pF	
Simple IIC (Fast mode)	SDA input rise time	$t_{Sr}$	—	300	ns	Figure 2.27
	SDA input fall time	$t_{Sf}$	—	300	ns	
	SDA input spike pulse removal time	$t_{SP}$	0	$4 \times t_{IICcyc}^{*1}$	ns	
	Data input setup time	$t_{SDAS}$	100	—	ns	
	Data input hold time	$t_{SDAH}$	0	—	ns	
	SCL, SDA capacitive load	$C_b^{*2}$	—	400	pF	

Note 1.  $t_{IICcyc}$ : Clock cycle selected by the SMR.CKS[1:0] bits.

Note 2.  $C_b$  indicates the total capacity of the bus line.



**Figure 2.27 SCI simple IIC mode timing**

## 2.3.9 SPI Timing

Table 2.32 SPI timing (1 of 3)

Parameter			Symbol	Min	Max	Unit <sup>*1</sup>	Test conditions	
SPI	RSPCK clock cycle	Master	$2.7\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	$t_{\text{SPcyc}}$	62.5	—	ns	Figure 2.28 C = 30 pF
			$2.4\text{ V} \leq \text{VCC} < 2.7\text{ V}$	125	—			
			$1.8\text{ V} \leq \text{VCC} < 2.4\text{ V}$	250	—			
			$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$	500	—			
		Slave	$2.7\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	187.5	—			
			$2.4\text{ V} \leq \text{VCC} < 2.7\text{ V}$	375	—			
			$1.8\text{ V} \leq \text{VCC} < 2.4\text{ V}$	750	—			
			$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$	1500	—			
	RSPCK clock high pulse width	Master	$t_{\text{SPCKWH}}$	$(t_{\text{SPcyc}} - t_{\text{SPCKr}} - t_{\text{SPCKf}}) / 2 - 3$	—	ns		
		Slave	$3 \times t_{\text{Pcyc}}$	—				
	RSPCK clock low pulse width	Master	$t_{\text{SPCKWL}}$	$(t_{\text{SPcyc}} - t_{\text{SPCKr}} - t_{\text{SPCKf}}) / 2 - 3$	—	ns		
		Slave	$3 \times t_{\text{Pcyc}}$	—				
RSPCK clock rise and fall time	Output	$2.7\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	$t_{\text{SPCKr}}$	—	10	ns		
		$2.4\text{ V} \leq \text{VCC} < 2.7\text{ V}$	$t_{\text{SPCKf}}$	—	15			
		$1.8\text{ V} \leq \text{VCC} \leq 2.4\text{ V}$	—	20				
		$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$	—	30				
	Input	—	—	0.1	$\mu\text{s/V}$			

Table 2.32 SPI timing (2 of 3)

Parameter				Symbol	Min	Max	Unit*1	Test conditions		
SPI	Data input setup time	Master	2.7 V ≤ VCC ≤ 5.5 V		t <sub>SU</sub>	10	—	ns	Figure 2.29 to Figure 2.34 C = 30 pF	
			2.4 V ≤ VCC < 2.7 V	16 MHz < PCLKB ≤ 32 MHz		30	—			
				PCLKB ≤ 16 MHz		10	—			
				1.8 V ≤ VCC < 2.4 V		55	—			
			1.8 V ≤ VCC < 2.4 V	16 MHz < PCLKB ≤ 32 MHz		30	—			
				8 MHz < PCLKB ≤ 16 MHz		10	—			
		PCLKB ≤ 8 MHz		10		—				
		1.6 V ≤ VCC < 1.8 V		10		—				
		Slave	2.4 V ≤ VCC ≤ 5.5 V			10	—			
	1.8 V ≤ VCC < 2.4 V		15	—						
	1.6 V ≤ VCC < 1.8 V		20	—						
	Data input hold time	Master (RSPCK is PCLKB/2)		t <sub>HF</sub>	0	—	ns			
Master (RSPCK is not PCLKB/2)		t <sub>H</sub>	t <sub>Pcyc</sub>	—						
Slave		t <sub>H</sub>	20	—						
SPI	SSL setup time	Master	1.8 V ≤ VCC ≤ 5.5 V		t <sub>LEAD</sub>	-30 + N × t <sub>SPcyc</sub> <sup>*2</sup>	—	ns		
			1.6 V ≤ VCC < 1.8 V			-50 + N × t <sub>SPcyc</sub> <sup>*2</sup>	—			
		Slave		6 × t <sub>Pcyc</sub>		—	ns			
	SSL hold time	Master		t <sub>LAG</sub>	-30 + N × t <sub>SPcyc</sub> <sup>*3</sup>	—	ns			
		Slave		6 × t <sub>Pcyc</sub>	—	ns				
	Data output delay time	Master	2.7 V ≤ VCC ≤ 5.5 V		t <sub>OD</sub>	—	14	ns		
2.4 V ≤ VCC < 2.7 V			—	20						
1.8 V ≤ VCC < 2.4 V			—	25						
1.6 V ≤ VCC < 1.8 V			—	30						
2.7 V ≤ VCC ≤ 5.5 V			—	50						
2.4 V ≤ VCC < 2.7 V			—	60						
1.8 V ≤ VCC < 2.4 V			—	85						
1.6 V ≤ VCC < 1.8 V			—	110						
Data output hold time	Master		t <sub>OH</sub>	0	—	ns				
	Slave		0	—						
Successive transmission delay time	Master		t <sub>TD</sub>	t <sub>SPcyc</sub> + 2 × t <sub>Pcyc</sub>	8 × t <sub>SPcyc</sub> + 2 × t <sub>Pcyc</sub>	ns				
	Slave		6 × t <sub>Pcyc</sub>	—						



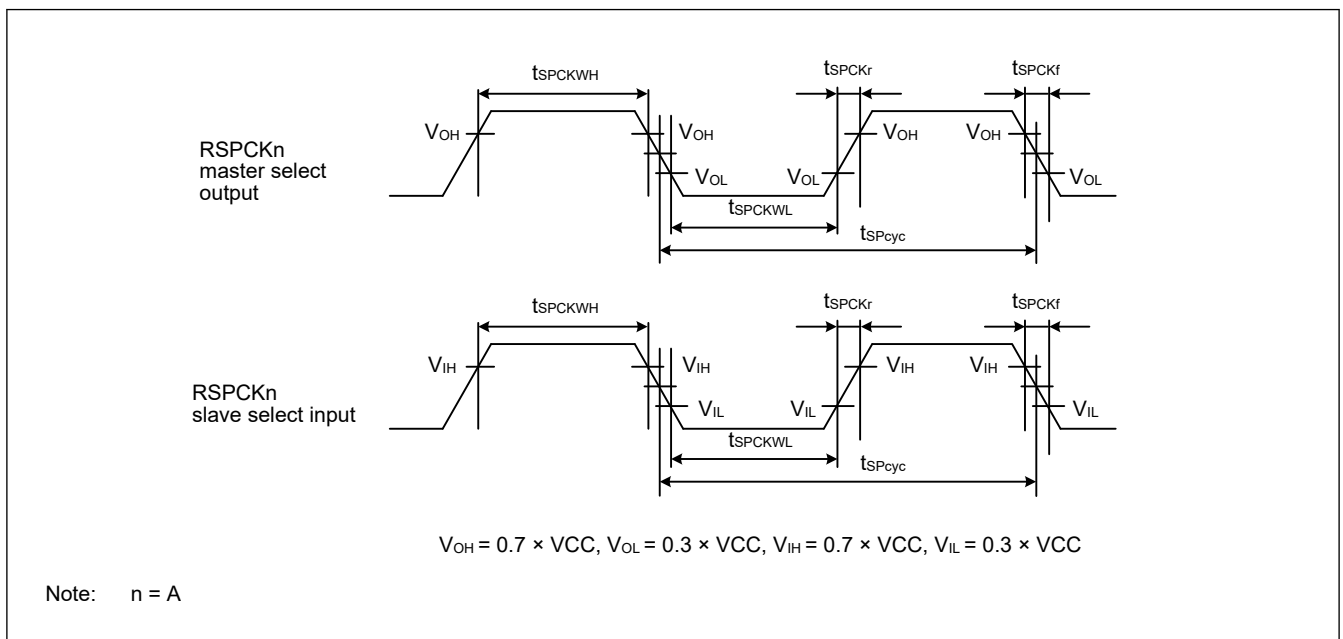
**Table 2.32 SPI timing (3 of 3)**

Parameter		Symbol	Min	Max	Unit*1	Test conditions			
SPI	MOSI and MISO rise and fall time	Output	$2.7\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	$t_{Dr}, t_{Df}$	—	10	ns Figure 2.29 to Figure 2.34 C = 30 pF		
			$2.4\text{ V} \leq \text{VCC} < 2.7\text{ V}$	—	15				
			$1.8\text{ V} \leq \text{VCC} < 2.4\text{ V}$	—	20				
			$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$	—	30				
		Input		—	1	$\mu\text{s}$			
		SSL rise and fall time	Output	$2.7\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	$t_{SSLr}, t_{SSLf}$	—		10	ns
				$2.4\text{ V} \leq \text{VCC} < 2.7\text{ V}$	—	15			
				$1.8\text{ V} \leq \text{VCC} < 2.4\text{ V}$	—	20			
	$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$			—	30				
	Input		—	1	$\mu\text{s}$				
	Slave access time		$2.4\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	$t_{SA}$	—	$2 \times t_{Pcyc} + 100$	ns Figure 2.33 and Figure 2.34 C = 30 pF		
			$1.8\text{ V} \leq \text{VCC} < 2.4\text{ V}$		—	$2 \times t_{Pcyc} + 140$			
$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$			—		$2 \times t_{Pcyc} + 180$				
Slave output release time		$2.4\text{ V} \leq \text{VCC} \leq 5.5\text{ V}$	$t_{REL}$	—	$2 \times t_{Pcyc} + 100$	ns			
		$1.8\text{ V} \leq \text{VCC} < 2.4\text{ V}$		—	$2 \times t_{Pcyc} + 140$				
		$1.6\text{ V} \leq \text{VCC} < 1.8\text{ V}$		—	$2 \times t_{Pcyc} + 180$				

Note 1.  $t_{Pcyc}$ : PCLKB cycle.

Note 2. N is set as an integer from 1 to 8 by the SPCKD register.

Note 3. N is set as an integer from 1 to 8 by the SSLND register.



**Figure 2.28 SPI clock timing**



Figure 2.29 SPI timing (master, CPHA = 0) (bit rate: PCLKB division ratio is set to any value other than 1/2)

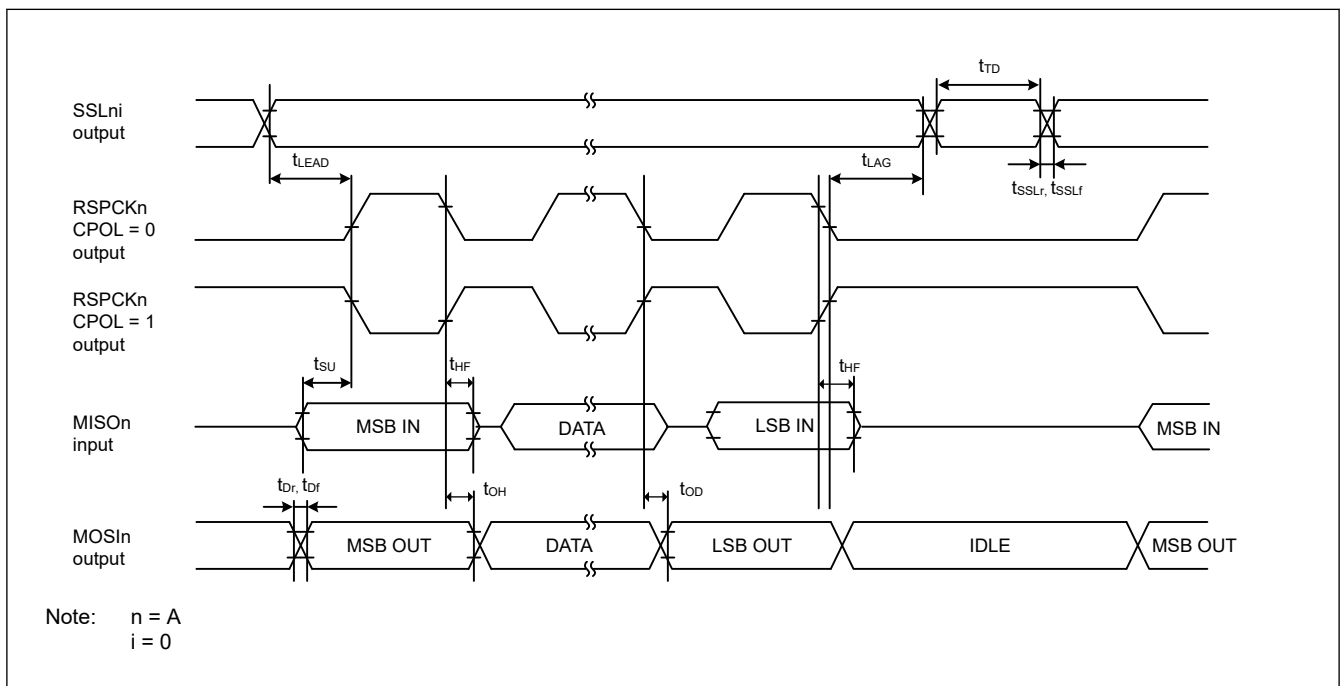


Figure 2.30 SPI timing (master, CPHA = 0) (bit rate: PCLKB division ratio is set to 1/2)



Figure 2.31 SPI timing (master, CPHA = 1) (bit rate: PCLKB division ratio is set to any value other than 1/2)



Figure 2.32 SPI timing (master, CPHA = 1) (bit rate: PCLKB division ratio is set to 1/2)

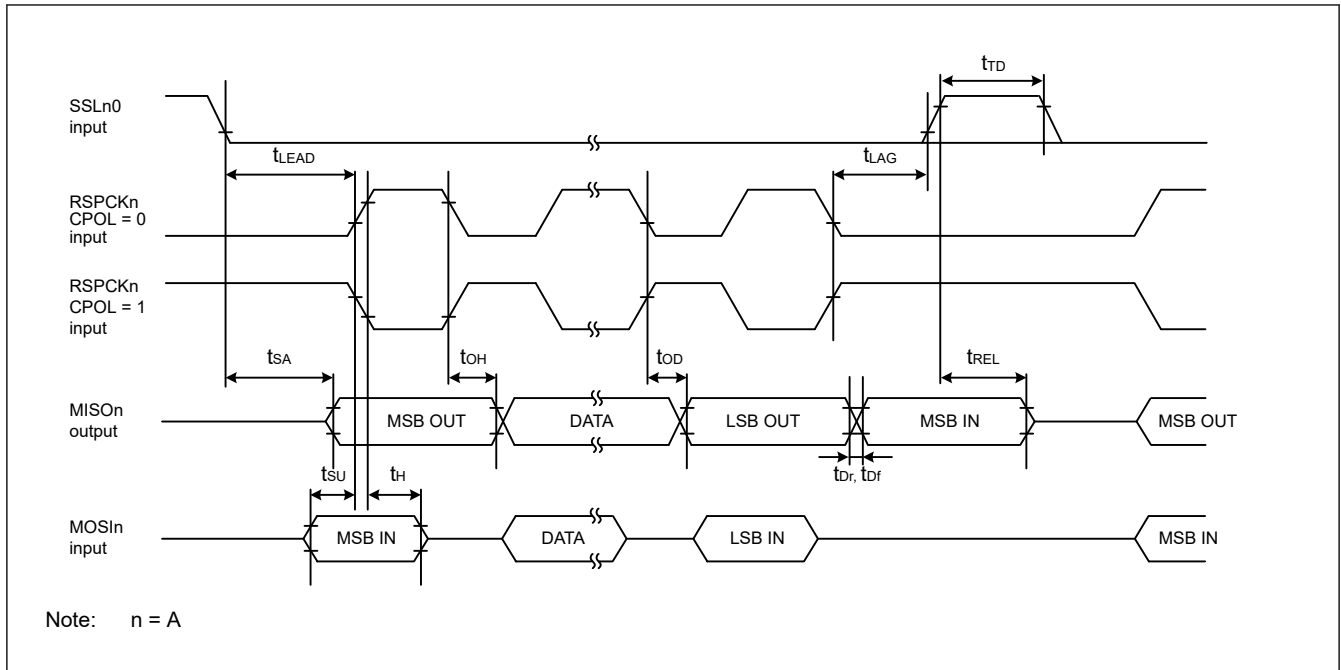


Figure 2.33 SPI timing (slave, CPHA = 0)

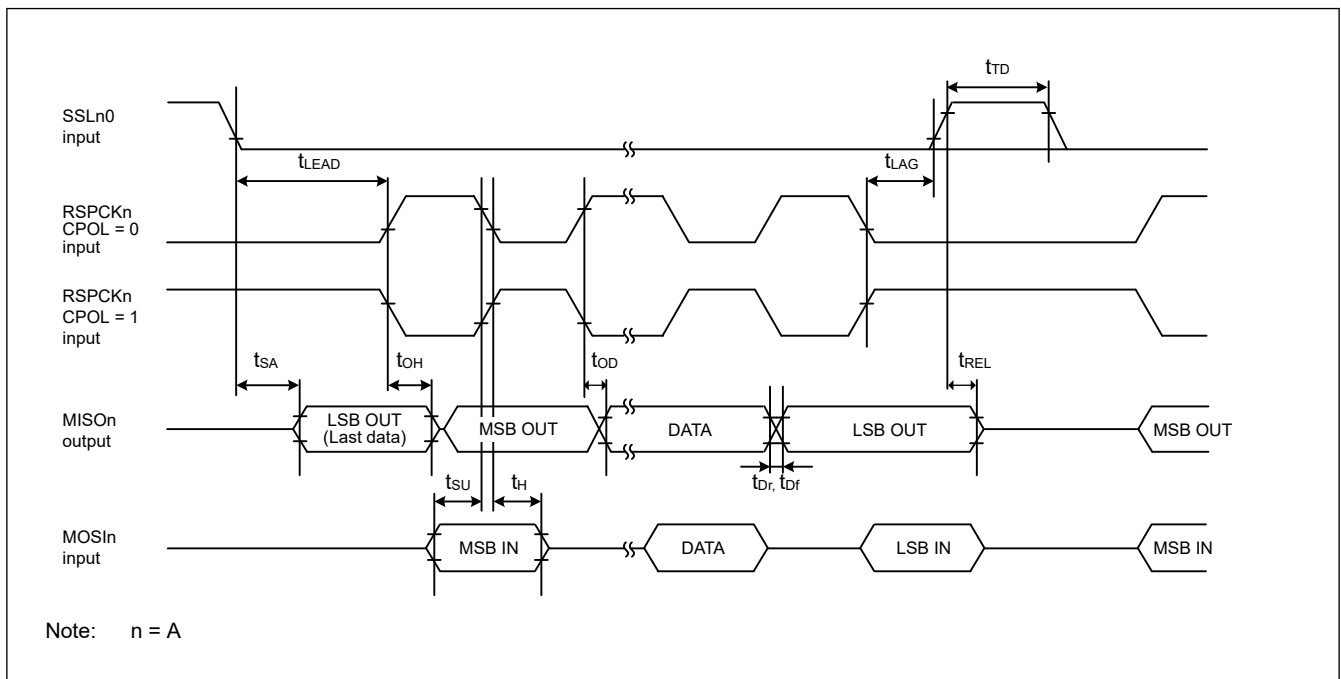


Figure 2.34 SPI timing (slave, CPHA = 1)

## 2.3.10 IIC Timing

Table 2.33 IIC timing

Conditions: VCC = AVCC0 = 2.7 to 5.5 V

Parameter	Symbol	Min*1	Max	Unit	Test conditions	
IIC (standard mode, SMBus)	SCL input cycle time	$t_{SCL}$	$6 (12) \times t_{IICcyc} + 1300$	—	ns	Figure 2.35
	SCL input high pulse width	$t_{SCLH}$	$3 (6) \times t_{IICcyc} + 300$	—	ns	
	SCL input low pulse width	$t_{SCLL}$	$3 (6) \times t_{IICcyc} + 300$	—	ns	
	SCL, SDA input rise time	$t_{Sr}$	—	1000	ns	
	SCL, SDA input fall time	$t_{Sf}$	—	300	ns	
	SCL, SDA input spike pulse removal time	$t_{SP}$	0	$1 (4) \times t_{IICcyc}$	ns	
	SDA input bus free time (when wakeup function is disabled)	$t_{BUF}$	$3 (6) \times t_{IICcyc} + 300$	—	ns	
	SDA input bus free time (when wakeup function is enabled)	$t_{BUF}$	$3 (6) \times t_{IICcyc} + 4 \times t_{Pcyc} + 300$	—	ns	
	START condition input hold time (when wakeup function is disabled)	$t_{STAH}$	$t_{IICcyc} + 300$	—	ns	
	START condition input hold time (when wakeup function is enabled)	$t_{STAH}$	$1 (5) \times t_{IICcyc} + t_{Pcyc} + 300$	—	ns	
	Repeated START condition input setup time	$t_{STAS}$	1000	—	ns	
	STOP condition input setup time	$t_{STOS}$	1000	—	ns	
	Data input setup time	$t_{SDAS}$	$t_{IICcyc} + 50$	—	ns	
	Data input hold time	$t_{SDAH}$	0	—	ns	
	SCL, SDA capacitive load	$C_b$	—	400	pF	
IIC (Fast mode)	SCL input cycle time	$t_{SCL}$	$6 (12) \times t_{IICcyc} + 600$	—	ns	Figure 2.35
	SCL input high pulse width	$t_{SCLH}$	$3 (6) \times t_{IICcyc} + 300$	—	ns	
	SCL input low pulse width	$t_{SCLL}$	$3 (6) \times t_{IICcyc} + 300$	—	ns	
	SCL, SDA input rise time	$t_{Sr}$	—	300	ns	
	SCL, SDA input fall time	$t_{Sf}$	—	300	ns	
	SCL, SDA input spike pulse removal time	$t_{SP}$	0	$1 (4) \times t_{IICcyc}$	ns	
	SDA input bus free time (When wakeup function is disabled)	$t_{BUF}$	$3 (6) \times t_{IICcyc} + 300$	—	ns	
	SDA input bus free time (When wakeup function is enabled)	$t_{BUF}$	$3 (6) \times t_{IICcyc} + 4 \times t_{Pcyc} + 300$	—	ns	
	START condition input hold time (When wakeup function is disabled)	$t_{STAH}$	$t_{IICcyc} + 300$	—	ns	
	START condition input hold time (When wakeup function is enabled)	$t_{STAH}$	$1 (5) \times t_{IICcyc} + t_{Pcyc} + 300$	—	ns	
	Repeated START condition input setup time	$t_{STAS}$	300	—	ns	
	STOP condition input setup time	$t_{STOS}$	300	—	ns	
	Data input setup time	$t_{SDAS}$	$t_{IICcyc} + 50$	—	ns	
	Data input hold time	$t_{SDAH}$	0	—	ns	
	SCL, SDA capacitive load	$C_b$	—	400	pF	

Note:  $t_{IICcyc}$ : IIC internal reference clock (IIC $\phi$ ) cycle,  $t_{Pcyc}$ : PCLKB cycle

Note 1. Values in parentheses apply when ICMR3.NF[1:0] is set to 11b while the digital filter is enabled with ICFER.NFE set to 1.

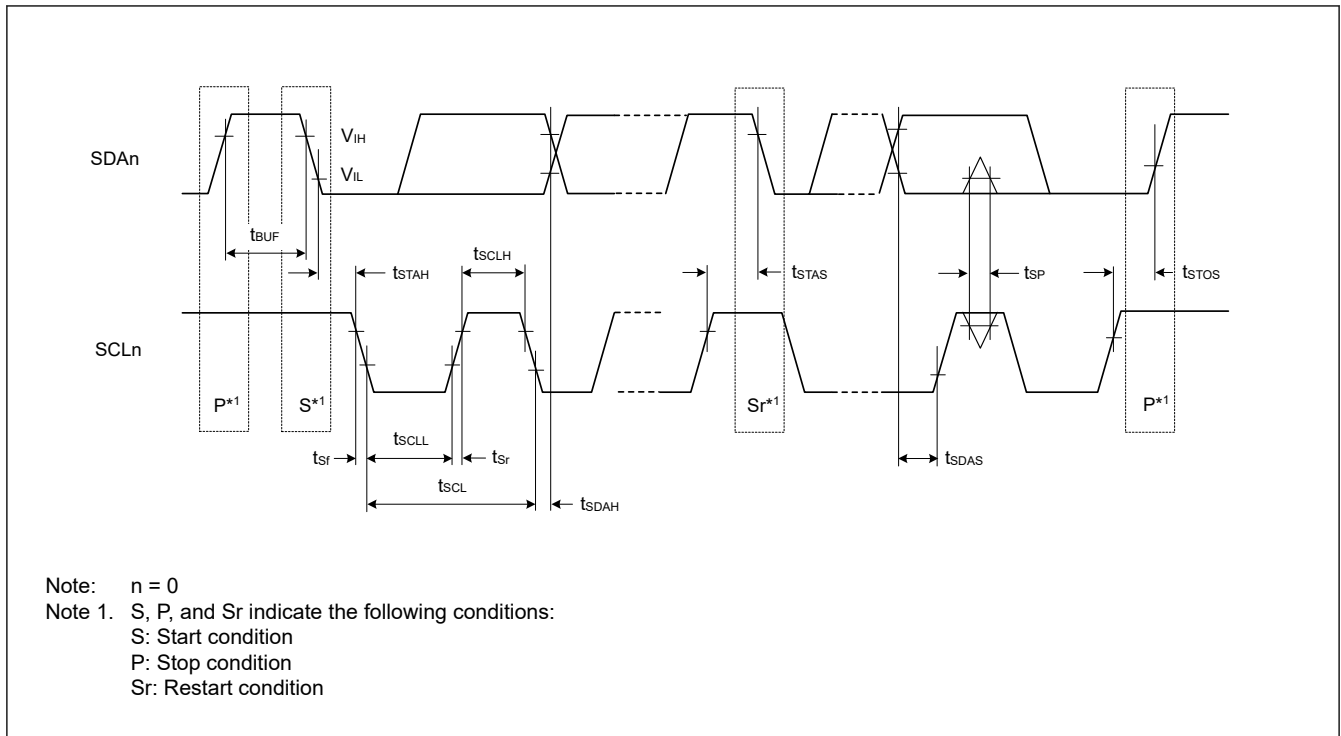


Figure 2.35 I<sup>2</sup>C bus interface input/output timing

### 2.3.11 CLKOUT Timing

Table 2.34 CLKOUT timing

Parameter		Symbol	Min	Max	Unit	Test conditions	
CLKOUT	CLKOUT pin output cycle* <sup>1</sup>	$t_{Cyc}$	$2.7\text{ V} \leq V_{CC} \leq 5.5\text{ V}$	62.5	—	ns	Figure 2.36
			$1.8\text{ V} \leq V_{CC} < 2.7\text{ V}$	125	—		
			$1.6\text{ V} \leq V_{CC} < 1.8\text{ V}$	250	—		
CLKOUT pin high pulse width* <sup>2</sup>		$t_{CH}$	$2.7\text{ V} \leq V_{CC} \leq 5.5\text{ V}$	15	—	ns	
			$1.8\text{ V} \leq V_{CC} < 2.7\text{ V}$	30	—		
			$1.6\text{ V} \leq V_{CC} < 1.8\text{ V}$	150	—		
CLKOUT pin low pulse width* <sup>2</sup>		$t_{CL}$	$2.7\text{ V} \leq V_{CC} \leq 5.5\text{ V}$	15	—	ns	
			$1.8\text{ V} \leq V_{CC} < 2.7\text{ V}$	30	—		
			$1.6\text{ V} \leq V_{CC} < 1.8\text{ V}$	150	—		
CLKOUT pin output rise time		$t_{Cr}$	$2.7\text{ V} \leq V_{CC} \leq 5.5\text{ V}$	—	12	ns	
			$1.8\text{ V} \leq V_{CC} < 2.7\text{ V}$	—	25		
			$1.6\text{ V} \leq V_{CC} < 1.8\text{ V}$	—	50		
CLKOUT pin output fall time		$t_{Cf}$	$2.7\text{ V} \leq V_{CC} \leq 5.5\text{ V}$	—	12	ns	
			$1.8\text{ V} \leq V_{CC} < 2.7\text{ V}$	—	25		
			$1.6\text{ V} \leq V_{CC} < 1.8\text{ V}$	—	50		

Note 1. When the EXTAL external clock input or an oscillator is used with division by 1 (the CKOCR.CKOSSEL[2:0] bits are 011b and the CKOCR.CKODIV[2:0] bits are 000b) to output from CLKOUT, specifications in Table 2.34 should be satisfied with 45% to 55% of input duty cycle.

Note 2. When MOCO is selected as the clock output source (the CKOCR.CKOSSEL[2:0] bits are 001b), set the clock output division ratio to be divided by 2 (the CKOCR.CKODIV[2:0] bits are 001b).

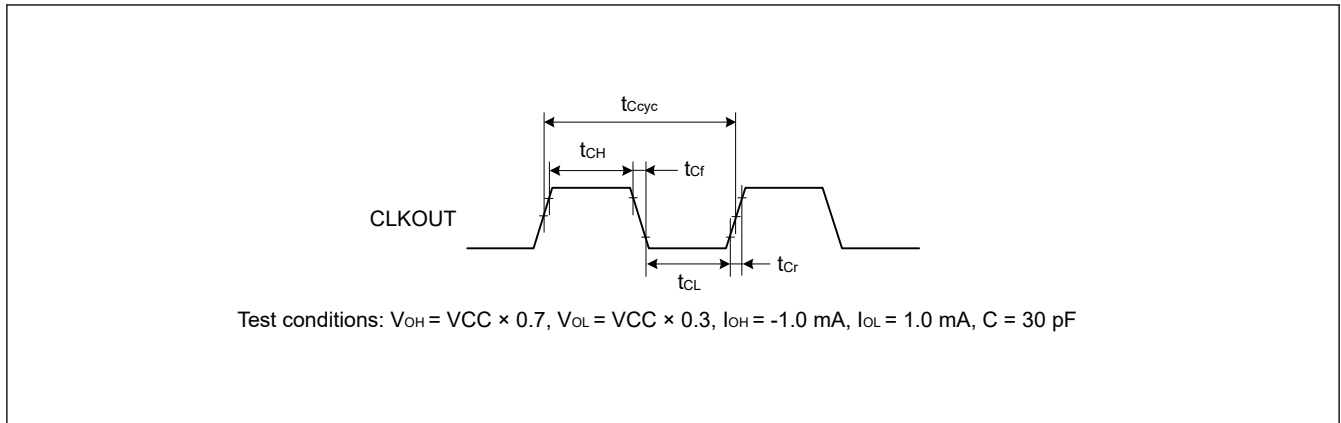


Figure 2.36 CLKOUT output timing

### 2.4 ADC12 Characteristics

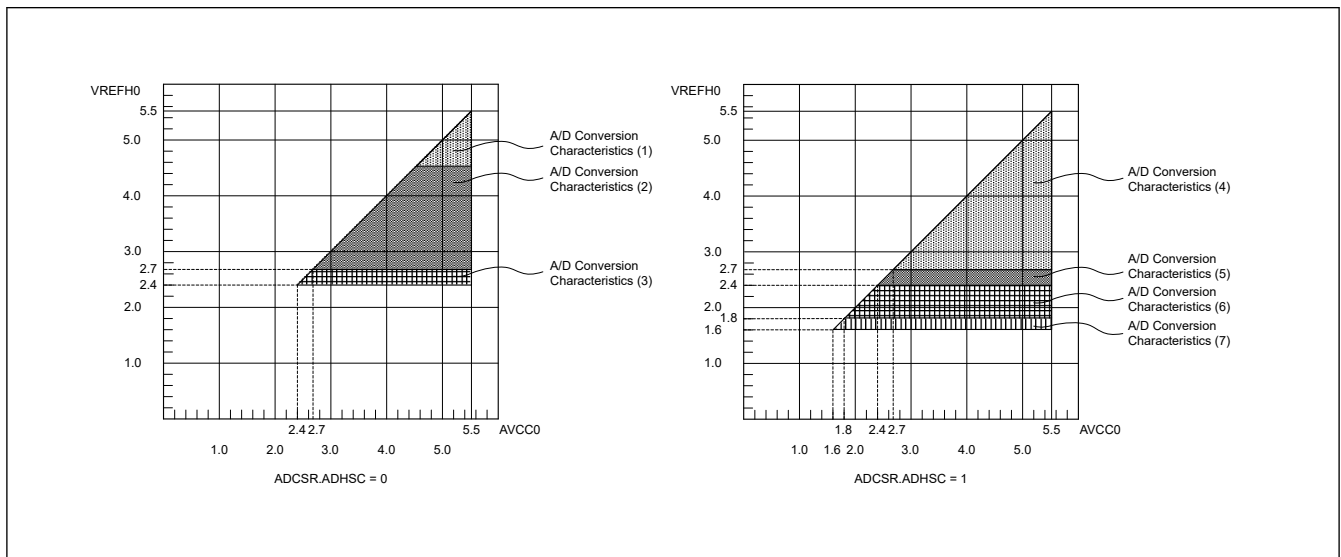


Figure 2.37 AVCC0 to VREFH0 voltage range

Table 2.35 A/D conversion characteristics (1) in high-speed A/D conversion mode (1 of 2)

Conditions:  $V_{CC} = AV_{CC0} = V_{REFH0} = 4.5 \text{ to } 5.5 \text{ V}^{*5}$ ,  $V_{SS} = AV_{SS0} = V_{REFL0} = 0 \text{ V}$   
 Reference voltage range applied to the  $V_{REFH0}$  and  $V_{REFL0}$ .

Parameter	Min	Typ	Max	Unit	Test conditions
PCLKD (ADCLK) frequency	1	—	64	MHz	ADACSR.ADSAC = 0
			48	MHz	ADACSR.ADSAC = 1
Analog input capacitance*2	Cs	—	$9^{*3}$	pF	High-precision channel
			$10^{*3}$	pF	Normal-precision channel
Analog input resistance	Rs	—	$1.3^{*3}$	k $\Omega$	High-precision channel
			$5.0^{*3}$	k $\Omega$	Normal-precision channel
Analog input voltage range	Ain	0	VREFH0	V	—
Resolution	—	—	12	Bit	—

**Table 2.35 A/D conversion characteristics (1) in high-speed A/D conversion mode (2 of 2)**

Conditions: VCC = AVCC0 = VREFH0 = 4.5 to 5.5 V<sup>\*5</sup>, VSS = AVSS0 = VREFL0 = 0 V  
Reference voltage range applied to the VREFH0 and VREFL0.

Parameter		Min	Typ	Max	Unit	Test conditions
Conversion time <sup>*1</sup> (Operation at PCLKD = 64 MHz)	Permissible signal source impedance Max. = 0.3 kΩ	0.70 (0.211) <sup>*4</sup>	—	—	μs	High-precision channel ADCSR.ADHSC = 0 ADSSTRn.SST[7:0] = 0x0D ADACSR.ADSAC = 0
		1.34 (0.852) <sup>*4</sup>	—	—	μs	Normal-precision channel ADCSR.ADHSC = 0 ADSSTRn.SST[7:0] = 0x36 ADACSR.ADSAC = 0
Conversion time <sup>*1</sup> (Operation at PCLKD = 48 MHz)	Permissible signal source impedance Max. = 0.3 kΩ	0.67 (0.219) <sup>*4</sup>	—	—	μs	High-precision channel ADCSR.ADHSC = 0 ADSSTRn.SST[7:0] = 0x0A ADACSR.ADSAC = 1
		1.29 (0.844) <sup>*4</sup>	—	—	μs	Normal-precision channel ADCSR.ADHSC = 0 ADSSTRn.SST[7:0] = 0x28 ADACSR.ADSAC = 1
Offset error		—	±1.0	±4.5	LSB	High-precision channel
				±6.0	LSB	Other than specified
Full-scale error		—	±1.0	±4.5	LSB	High-precision channel
				±6.0	LSB	Other than specified
Quantization error		—	±0.5	—	LSB	—
Absolute accuracy		—	±2.5	±5.0	LSB	High-precision channel
				±8.0	LSB	Other than specified
DNL differential nonlinearity error		—	±1.0	—	LSB	—
INL integral nonlinearity error		—	±1.5	±3.0	LSB	—

Note: The characteristics apply when no pin functions other than 12-bit A/D converter input are used. Absolute accuracy does not include quantization errors. Offset error, full-scale error, DNL differential nonlinearity error, and INL integral nonlinearity error do not include quantization errors.

Note 1. The conversion time is the sum of the sampling time and the comparison time. The number of sampling states is indicated for the test conditions.

Note 2. Except for I/O input capacitance (C<sub>in</sub>), see [section 2.2.4. I/O VOH, VOL, and Other Characteristics](#).

Note 3. Reference data.

Note 4. ( ) lists sampling time.

Note 5. When VREFH0 < AVCC0, the MAX. values are as follows.

Absolute accuracy/Offset error/Full-scale error:

For voltage difference between AVCC0 and VREFH0, it should be added ±0.75 LSB/V to the Max spec.

INL integral non-linearity error:

For voltage difference between AVCC0 and VREFH0, it should be added ±0.2 LSB/V to the Max spec.

**Table 2.36 A/D conversion characteristics (2) in high-speed A/D conversion mode (1 of 2)**

Conditions: VCC = AVCC0 = VREFH0 = 2.7 to 5.5 V<sup>\*5</sup>, VSS = AVSS0 = VREFL0 = 0 V  
Reference voltage range applied to the VREFH0 and VREFL0.

Parameter		Min	Typ	Max	Unit	Test conditions
PCLKD (ADCLK) frequency		1	—	48	MHz	—
Analog input capacitance <sup>*2</sup>	Cs	—	—	9 <sup>*3</sup>	pF	High-precision channel
		—	—	10 <sup>*3</sup>	pF	Normal-precision channel
Analog input resistance	Rs	—	—	1.9 <sup>*3</sup>	kΩ	High-precision channel
		—	—	6.0 <sup>*3</sup>	kΩ	Normal-precision channel
Analog input voltage range	A <sub>in</sub>	0	—	VREFH0	V	—
Resolution		—	—	12	Bit	—



**Table 2.36 A/D conversion characteristics (2) in high-speed A/D conversion mode (2 of 2)**

Conditions: VCC = AVCC0 = VREFH0 = 2.7 to 5.5 V<sup>\*5</sup>, VSS = AVSS0 = VREFL0 = 0 V  
Reference voltage range applied to the VREFH0 and VREFL0.

Parameter		Min	Typ	Max	Unit	Test conditions
Conversion time <sup>*1</sup> (Operation at PCLKD = 48 MHz)	Permissible signal source impedance Max. = 0.3 kΩ	0.67 (0.219) <sup>*4</sup>	—	—	μs	High-precision channel ADCSR.ADHSC = 0 ADSSTRn.SST[7:0] = 0x0A ADACSR.ADSAC = 1
		1.29 (0.844) <sup>*4</sup>	—	—	μs	Normal-precision channel ADCSR.ADHSC = 0 ADSSTRn.SST[7:0] = 0x28 ADACSR.ADSAC = 1
Offset error		—	±1.0	±5.5	LSB	High-precision channel
				±7.0	LSB	Other than specified
Full-scale error		—	±1.0	±5.5	LSB	High-precision channel
				±7.0	LSB	Other than specified
Quantization error		—	±0.5	—	LSB	—
Absolute accuracy		—	±2.5	±6.0	LSB	High-precision channel
				±9.0	LSB	Other than specified
DNL differential nonlinearity error		—	±1.0	—	LSB	—
INL integral nonlinearity error		—	±1.5	±3.0	LSB	—

Note: The characteristics apply when no pin functions other than 12-bit A/D converter input are used. Absolute accuracy does not include quantization errors. Offset error, full-scale error, DNL differential nonlinearity error, and INL integral nonlinearity error do not include quantization errors.

Note 1. The conversion time is the sum of the sampling time and the comparison time. The number of sampling states is indicated for the test conditions.

Note 2. Except for I/O input capacitance (C<sub>in</sub>), see [section 2.2.4. I/O VOH, VOL, and Other Characteristics](#).

Note 3. Reference data.

Note 4. ( ) lists sampling time.

Note 5. When VREFH0 < AVCC0, the MAX. values are as follows.

Absolute accuracy/Offset error/Full-scale error:

For voltage difference between AVCC0 and VREFH0, it should be added ±0.75 LSB/V to the Max spec.

INL integral non-linearity error:

For voltage difference between AVCC0 and VREFH0, it should be added ±0.2 LSB/V to the Max spec.

**Table 2.37 A/D conversion characteristics (3) in high-speed A/D conversion mode (1 of 2)**

Conditions: VCC = AVCC0 = VREFH0 = 2.4 to 5.5 V<sup>\*5</sup>, VSS = AVSS0 = VREFL0 = 0 V  
Reference voltage range applied to the VREFH0 and VREFL0.

Parameter		Min	Typ	Max	Unit	Test conditions
PCLKD (ADCLK) frequency		1	—	32	MHz	—
Analog input capacitance <sup>*2</sup>	Cs	—	—	9 <sup>*3</sup>	pF	High-precision channel
		—	—	10 <sup>*3</sup>	pF	Normal-precision channel
Analog input resistance	Rs	—	—	2.2 <sup>*3</sup>	kΩ	High-precision channel
		—	—	7.0 <sup>*3</sup>	kΩ	Normal-precision channel
Analog input voltage range	A <sub>in</sub>	0	—	VREFH0	V	—
Resolution		—	—	12	Bit	—
Conversion time <sup>*1</sup> (Operation at PCLKD = 32 MHz)	Permissible signal source impedance Max. = 1.3 kΩ	1.00 (0.328) <sup>*4</sup>	—	—	μs	High-precision channel ADCSR.ADHSC = 0 ADSSTRn.SST[7:0] = 0x0A ADACSR.ADSAC = 1
		1.94 (1.266) <sup>*4</sup>	—	—	μs	Normal-precision channel ADCSR.ADHSC = 0 ADSSTRn.SST[7:0] = 0x28 ADACSR.ADSAC = 1

**Table 2.37 A/D conversion characteristics (3) in high-speed A/D conversion mode (2 of 2)**

Conditions: VCC = AVCC0 = VREFH0 = 2.4 to 5.5 V<sup>\*5</sup>, VSS = AVSS0 = VREFL0 = 0 V  
Reference voltage range applied to the VREFH0 and VREFL0.

Parameter	Min		Max	Unit	Test conditions
Offset error	—	±1.0	±5.5	LSB	High-precision channel
			±7.0	LSB	Other than specified
Full-scale error	—	±1.0	±5.5	LSB	High-precision channel
			±7.0	LSB	Other than specified
Quantization error	—	±0.5	—	LSB	—
Absolute accuracy	—	±2.50	±6.0	LSB	High-precision channel
			±9.0	LSB	Other than specified
DNL differential nonlinearity error	—	±1.0	—	LSB	—
INL integral nonlinearity error	—	±1.5	±3.0	LSB	—

Note: The characteristics apply when no pin functions other than 12-bit A/D converter input are used. Absolute accuracy does not include quantization errors. Offset error, full-scale error, DNL differential nonlinearity error, and INL integral nonlinearity error do not include quantization errors.

Note 1. The conversion time is the sum of the sampling time and the comparison time. The number of sampling states is indicated for the test conditions.

Note 2. Except for I/O input capacitance (Cin), see [section 2.2.4. I/O VOH, VOL, and Other Characteristics](#).

Note 3. Reference data.

Note 4. ( ) lists sampling time.

Note 5. When VREFH0 < AVCC0, the MAX. values are as follows.

Absolute accuracy/Offset error/Full-scale error:

For voltage difference between AVCC0 and VREFH0, it should be added ±0.75 LSB/V to the Max spec.

INL integral non-linearity error:

For voltage difference between AVCC0 and VREFH0, it should be added ±0.2 LSB/V to the Max spec.

**Table 2.38 A/D conversion characteristics (4) in low-power A/D conversion mode (1 of 2)**

Conditions: VCC = AVCC0 = VREFH0 = 2.7 to 5.5 V<sup>\*5</sup>, VSS = AVSS0 = VREFL0 = 0 V  
Reference voltage range applied to the VREFH0 and VREFL0.

Parameter	Min	Typ	Max	Unit	Test conditions	
PCLKD (ADCLK) frequency	1	—	24	MHz	—	
Analog input capacitance <sup>*2</sup>	Cs	—	9 <sup>*3</sup>	pF	High-precision channel	
			10 <sup>*3</sup>	pF	Normal-precision channel	
Analog input resistance	Rs	—	1.9 <sup>*3</sup>	kΩ	High-precision channel	
			6 <sup>*3</sup>	kΩ	Normal-precision channel	
Analog input voltage range	Ain	0	VREFH0	V	—	
Resolution	—	—	12	Bit	—	
Conversion time <sup>*1</sup> (Operation at PCLKD = 24 MHz)	Permissible signal source impedance Max. = 1.1 kΩ	1.58 (0.438) <sup>*4</sup>	—	—	μs	High-precision channel ADCSR.ADHSC = 1 ADSSTRn.SST[7:0] = 0x0A ADACSR.ADSAC = 1
		2.0 (0.854) <sup>*4</sup>	—	—	μs	Normal-precision channel ADCSR.ADHSC = 1 ADSSTRn.SST[7:0] = 0x14 ADACSR.ADSAC = 1
Offset error	—	±1.25	±6.0	LSB	High-precision channel	
			±7.5	LSB	Other than specified	
Full-scale error	—	±1.25	±6.0	LSB	High-precision channel	
			±7.5	LSB	Other than specified	
Quantization error	—	±0.5	—	LSB	—	

**Table 2.38 A/D conversion characteristics (4) in low-power A/D conversion mode (2 of 2)**

Conditions: VCC = AVCC0 = VREFH0 = 2.7 to 5.5 V<sup>\*5</sup>, VSS = AVSS0 = VREFL0 = 0 V  
Reference voltage range applied to the VREFH0 and VREFL0.

Parameter	Min	Typ	Max	Unit	Test conditions
Absolute accuracy	—	±3.25	±7.0	LSB	High-precision channel
			±10.0	LSB	Other than specified
DNL differential nonlinearity error	—	±1.5	—	LSB	—
INL integral nonlinearity error	—	±1.75	±4.0	LSB	—

Note: The characteristics apply when no pin functions other than 12-bit A/D converter input are used. Absolute accuracy does not include quantization errors. Offset error, full-scale error, DNL differential nonlinearity error, and INL integral nonlinearity error do not include quantization errors.

Note 1. The conversion time is the sum of the sampling time and the comparison time. The number of sampling states is indicated for the test conditions.

Note 2. Except for I/O input capacitance (C<sub>in</sub>), see [section 2.2.4. I/O VOH, VOL, and Other Characteristics](#).

Note 3. Reference data.

Note 4. ( ) lists sampling time.

Note 5. When VREFH0 < AVCC0, the MAX. values are as follows.

Absolute accuracy/Offset error/Full-scale error:

For voltage difference between AVCC0 and VREFH0, it should be added ±0.75 LSB/V to the Max spec.

INL integral non-linearity error:

For voltage difference between AVCC0 and VREFH0, it should be added ±0.2 LSB/V to the Max spec.

**Table 2.39 A/D conversion characteristics (5) in low-power A/D conversion mode**

Conditions: VCC = AVCC0 = VREFH0 = 2.4 to 5.5 V<sup>\*5</sup>, VSS = AVSS0 = VREFL0 = 0 V  
Reference voltage range applied to the VREFH0 and VREFL0.

Parameter	Min	Typ	Max	Unit	Test conditions	
PCLKD (ADCLK) frequency	1	—	16	MHz	—	
Analog input capacitance*2	Cs	—	9 <sup>*3</sup>	pF	High-precision channel	
			10 <sup>*3</sup>	pF	Normal-precision channel	
Analog input resistance	Rs	—	2.2 <sup>*3</sup>	kΩ	High-precision channel	
			7 <sup>*3</sup>	kΩ	Normal-precision channel	
Analog input voltage range	Ain	0	VREFH0	V	—	
Resolution	—	—	12	Bit	—	
Conversion time*1 (Operation at PCLKD = 16 MHz)	Permissible signal source impedance Max. = 2.2 kΩ	2.38 (0.656) <sup>*4</sup>	—	—	μs	High-precision channel ADCSR.ADHSC = 1 ADSSTRn.SST[7:0] = 0x0A ADACSR.ADSAC = 1
		3.0 (1.281) <sup>*4</sup>	—	—	μs	Normal-precision channel ADCSR.ADHSC = 1 ADSSTRn.SST[7:0] = 0x14 ADACSR.ADSAC = 1
Offset error	—	±1.25	±6.0	LSB	High-precision channel	
			±7.5	LSB	Other than specified	
Full-scale error	—	±1.25	±6.0	LSB	High-precision channel	
			±7.5	LSB	Other than specified	
Quantization error	—	±0.5	—	LSB	—	
Absolute accuracy	—	±3.25	±7.0	LSB	High-precision channel	
			±10.0	LSB	Other than specified	
DNL differential nonlinearity error	—	±1.5	—	LSB	—	
INL integral nonlinearity error	—	±1.75	±4.0	LSB	—	

Note: The characteristics apply when no pin functions other than 12-bit A/D converter input are used. Absolute accuracy does not include quantization errors. Offset error, full-scale error, DNL differential nonlinearity error, and INL integral nonlinearity error do not include quantization errors.

- Note 1. The conversion time is the sum of the sampling time and the comparison time. The number of sampling states is indicated for the test conditions.
- Note 2. Except for I/O input capacitance (C<sub>in</sub>), see [section 2.2.4. I/O VOH, VOL, and Other Characteristics](#).
- Note 3. Reference data.
- Note 4. ( ) lists sampling time.
- Note 5. When VREFH0 < AVCC0, the MAX. values are as follows.  
 Absolute accuracy/Offset error/Full-scale error:  
 For voltage difference between AVCC0 and VREFH0, it should be added ±0.75 LSB/V to the Max spec.  
 INL integral non-linearity error:  
 For voltage difference between AVCC0 and VREFH0, it should be added ±0.2 LSB/V to the Max spec.

**Table 2.40 A/D conversion characteristics (6) in low-power A/D conversion mode**

Conditions: VCC = AVCC0 = VREFH0 = 1.8 to 5.5 V<sup>5</sup>, VSS = AVSS0 = VREFL0 = 0 V  
 Reference voltage range applied to the VREFH0 and VREFL0.

Parameter		Min	Typ	Max	Unit	Test conditions
PCLKD (ADCLK) frequency		1	—	8	MHz	—
Analog input capacitance <sup>*2</sup>	Cs	—	—	9 <sup>*3</sup>	pF	High-precision channel
		—	—	10 <sup>*3</sup>	pF	Normal-precision channel
Analog input resistance	Rs	—	—	6 <sup>*3</sup>	kΩ	High-precision channel
		—	—	14 <sup>*3</sup>	kΩ	Normal-precision channel
Analog input voltage range	Ain	0	—	VREFH0	V	—
Resolution		—	—	12	Bit	—
Conversion time <sup>*1</sup> (Operation at PCLKD = 8 MHz)	Permissible signal source impedance Max. = 5 kΩ	4.75 (1.313) <sup>*4</sup>	—	—	μs	High-precision channel ADCSR.ADHSC = 1 ADSSTRn.SST[7:0] = 0x0A ADACSR.ADSAC = 1
		6.0 (2.563) <sup>*4</sup>	—	—	μs	Normal-precision channel ADCSR.ADHSC = 1 ADSSTRn.SST[7:0] = 0x14 ADACSR.ADSAC = 1
Offset error		—	±1.25	±7.5	LSB	High-precision channel
				±10.0	LSB	Other than specified
Full-scale error		—	±1.5	±7.5	LSB	High-precision channel
				±10.0	LSB	Other than specified
Quantization error		—	±0.5	—	LSB	—
Absolute accuracy		—	±3.75	±9.5	LSB	High-precision channel
				±13.5	LSB	Other than specified
DNL differential nonlinearity error		—	±2.0	—	LSB	—
INL integral nonlinearity error		—	±2.25	±4.5	LSB	—

Note: The characteristics apply when no pin functions other than 12-bit A/D converter input are used. Absolute accuracy does not include quantization errors. Offset error, full-scale error, DNL differential nonlinearity error, and INL integral nonlinearity error do not include quantization errors.

- Note 1. The conversion time is the sum of the sampling time and the comparison time. The number of sampling states is indicated for the test conditions.
- Note 2. Except for I/O input capacitance (C<sub>in</sub>), see [section 2.2.4. I/O VOH, VOL, and Other Characteristics](#).
- Note 3. Reference data.
- Note 4. ( ) lists sampling time.
- Note 5. When VREFH0 < AVCC0, the MAX. values are as follows.  
 Absolute accuracy/Offset error/Full-scale error:  
 For voltage difference between AVCC0 and VREFH0, it should be added ±0.75 LSB/V to the Max spec.  
 INL integral non-linearity error:  
 For voltage difference between AVCC0 and VREFH0, it should be added ±0.2 LSB/V to the Max spec.

**Table 2.41 A/D conversion characteristics (7) in low-power A/D conversion mode**

Conditions: VCC = AVCC0 = VREFH0 = 1.6 to 5.5 V<sup>\*5</sup>, VSS = AVSS0 = VREFL0 = 0 V  
Reference voltage range applied to the VREFH0 and VREFL0.

Parameter		Min	Typ	Max	Unit	Test conditions
PCLKD (ADCLK) frequency		1	—	4	MHz	—
Analog input capacitance <sup>*2</sup>	Cs	—	—	9 <sup>*3</sup>	pF	High-precision channel
		—	—	10 <sup>*3</sup>	pF	Normal-precision channel
Analog input resistance	Rs	—	—	12 <sup>*3</sup>	kΩ	High-precision channel
		—	—	28 <sup>*3</sup>	kΩ	Normal-precision channel
Analog input voltage range	Ain	0	—	VREFH0	V	—
Resolution		—	—	12	Bit	—
Conversion time <sup>*1</sup> (Operation at PCLKD = 4 MHz)	Permissible signal source impedance Max. = 9.9 kΩ	9.5 (2.625) <sup>*4</sup>	—	—	μs	High-precision channel ADCSR.ADHSC = 1 ADSSTRn.SST[7:0] = 0x0A ADACSR.ADSAC = 1
		12.0 (5.125) <sup>*4</sup>	—	—	μs	Normal-precision channel ADCSR.ADHSC = 1 ADSSTRn.SST[7:0] = 0x14 ADACSR.ADSAC = 1
Offset error		—	±1.25	±7.5	LSB	High-precision channel
				±10.0	LSB	Other than specified
Full-scale error		—	±1.5	±7.5	LSB	High-precision channel
				±10.0	LSB	Other than specified
Quantization error		—	±0.5	—	LSB	—
Absolute accuracy		—	±3.75	±9.5	LSB	High-precision channel
				±13.5	LSB	Other than specified
DNL differential nonlinearity error		—	±2.0	—	LSB	—
INL integral nonlinearity error		—	±2.25	±4.5	LSB	—

Note: The characteristics apply when no pin functions other than 12-bit A/D converter input are used. Absolute accuracy does not include quantization errors. Offset error, full-scale error, DNL differential nonlinearity error, and INL integral nonlinearity error do not include quantization errors.

Note 1. The conversion time is the sum of the sampling time and the comparison time. The number of sampling states is indicated for the test conditions.

Note 2. Except for I/O input capacitance (Cin), see [section 2.2.4. I/O VOH, VOL, and Other Characteristics](#).

Note 3. Reference data.

Note 4. ( ) lists sampling time.

Note 5. When VREFH0 < AVCC0, the MAX. values are as follows.

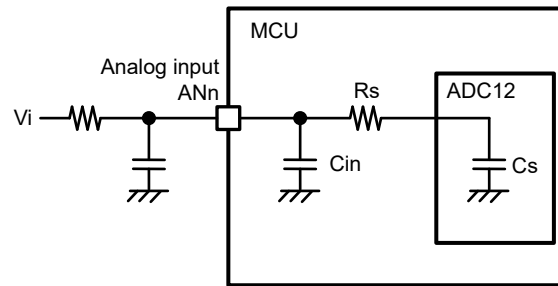
Absolute accuracy/Offset error/Full-scale error:

For voltage difference between AVCC0 and VREFH0, it should be added ±0.75 LSB/V to the Max spec.

INL integral non-linearity error:

For voltage difference between AVCC0 and VREFH0, it should be added ±0.2 LSB/V to the Max spec.

Figure 2.38 shows the equivalent circuit for analog input.



Note: Terminal leakage current is not shown in this figure.

Figure 2.38 Equivalent circuit for analog input

Table 2.42 12-bit A/D converter channel classification

Classification	Channel	Conditions	Remarks
High-precision channel	AN000 to AN010	AVCC0 = 1.6 to 5.5 V	Pins AN000 to AN010 cannot be used as general I/O, TS transmission, when the A/D converter is in use.
Normal-precision channel	AN017 to AN022		
Internal reference voltage input channel	Internal reference voltage	AVCC0 = 1.8 to 5.5 V	—
Temperature sensor input channel	Temperature sensor output	AVCC0 = 1.8 to 5.5 V	—
Input channel from CTSU	CTSU TSCAP voltage	AVCC0 = 1.6 to 5.5 V	—

Table 2.43 A/D internal reference voltage characteristics

Conditions: VCC = AVCC0 = VREFH0 = 1.8 to 5.5 V<sup>\*1</sup>

Parameter	Min	Typ	Max	Unit	Test conditions
Internal reference voltage input channel <sup>*2</sup>	1.42	1.48	1.54	V	—
PCLKD (ADCLK) frequency <sup>*3</sup>	1	—	2	MHz	—
Sampling time <sup>*4</sup>	5.0	—	—	μs	—

Note 1. The internal reference voltage cannot be selected for input channels when AVCC0 < 1.8 V.

Note 2. The 12-bit A/D internal reference voltage indicates the voltage when the internal reference voltage is input to the 12-bit A/D converter.

Note 3. When the internal reference voltage is selected as the high-potential reference voltage.

Note 4. When the internal reference voltage is converted.

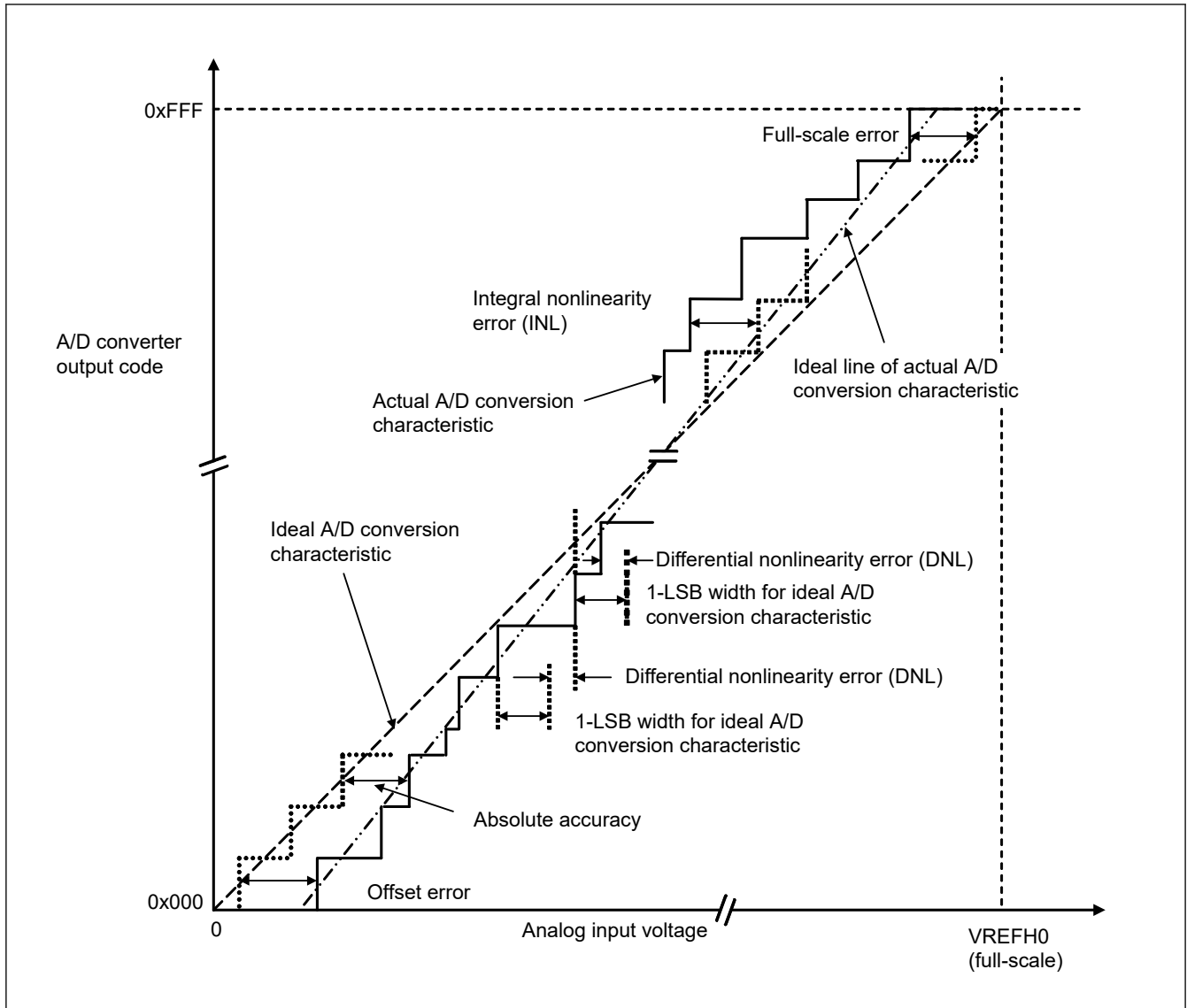


Figure 2.39 Illustration of 12-bit A/D converter characteristic terms

### Absolute accuracy

Absolute accuracy is the difference between output code based on the theoretical A/D conversion characteristics, and the actual A/D conversion result. When measuring absolute accuracy, the voltage at the midpoint of the width of the analog input voltage (1-LSB width), which can meet the expectation of outputting an equal code based on the theoretical A/D conversion characteristics, is used as the analog input voltage. For example, if 12-bit resolution is used and the reference voltage  $V_{REFH0} = 3.072$  V, then 1-LSB width becomes 0.75 mV, and 0 mV, 0.75 mV, and 1.5 mV are used as the analog input voltages. If analog input voltage is 6 mV, an absolute accuracy of  $\pm 5$  LSB means that the actual A/D conversion result is in the range of 0x003 to 0x00D, though an output code of 0x008 can be expected from the theoretical A/D conversion characteristics.

### Integral nonlinearity error (INL)

Integral nonlinearity error is the maximum deviation between the ideal line when the measured offset and full-scale errors are zeroed, and the actual output code.

### Differential nonlinearity error (DNL)

Differential nonlinearity error is the difference between 1-LSB width based on the ideal A/D conversion characteristics and the width of the actual output code.

### Offset error

Offset error is the difference between the transition point of the ideal first output code and the actual first output code.

**Full-scale error**

Full-scale error is the difference between the transition point of the ideal last output code and the actual last output code.

**2.5 TSN Characteristics**

**Table 2.44 TSN characteristics**

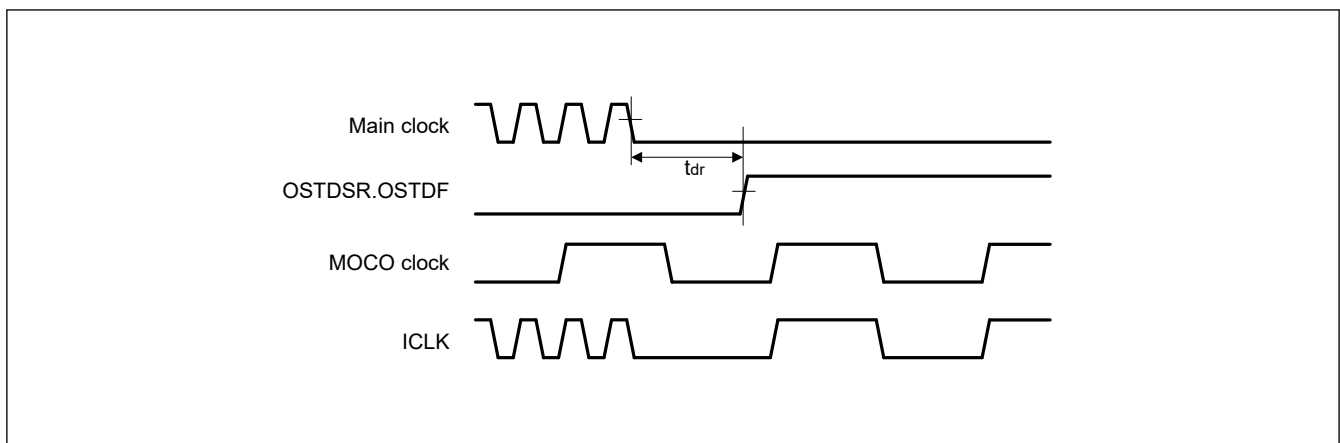
Conditions: VCC = AVCC0 = 1.8 to 5.5 V

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions
Relative accuracy	—	—	± 1.5	—	°C	2.4 V or above
		—	± 2.0	—	°C	Below 2.4 V
Temperature slope	—	—	-3.3	—	mV/°C	—
Output voltage (at 25°C)	—	—	1.05	—	V	VCC = 3.3 V
Temperature sensor start time	t <sub>START</sub>	—	—	5	µs	—
Sampling time	—	5	—	—	µs	

**2.6 OSC Stop Detect Characteristics**

**Table 2.45 Oscillation stop detection circuit characteristics**

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions
Detection time	t <sub>dr</sub>	—	—	1	ms	Figure 2.40



**Figure 2.40 Oscillation stop detection timing**



## 2.7 POR and LVD Characteristics

Table 2.46 Power-on reset circuit and voltage detection circuit characteristics (1) (1 of 2)

Parameter			Symbol	Min	Typ	Max	Unit	Test Conditions
Voltage detection level <sup>*1</sup>	Power-on reset (POR)	When power supply rise	V <sub>POR</sub>	1.47	1.51	1.55	V	<a href="#">Figure 2.41</a>
		When power supply fall	V <sub>PDR</sub>	1.46	1.50	1.54		<a href="#">Figure 2.42</a>
	Voltage detection circuit (LVD0) <sup>*2</sup>	When power supply rise	V <sub>det0_0</sub>	3.74	3.91	4.06	V	<a href="#">Figure 2.43</a> At falling edge VCC
			When power supply fall		3.68	3.85		
		When power supply rise	V <sub>det0_1</sub>	2.73	2.9	3.01		
			When power supply fall		2.68	2.85		
		When power supply rise	V <sub>det0_2</sub>	2.44	2.59	2.70		
			When power supply fall		2.38	2.53		
		When power supply rise	V <sub>det0_3</sub>	1.83	1.95	2.07		
			When power supply fall		1.78	1.90		
		When power supply rise	V <sub>det0_4</sub>	1.66	1.75	1.88		
			When power supply fall		1.60	1.69		
Voltage detection level <sup>*1</sup>	Voltage detection circuit (LVD1) <sup>*3</sup>	When power supply rise	V <sub>det1_0</sub>	4.23	4.39	4.55	V	<a href="#">Figure 2.44</a> At falling edge VCC
			When power supply fall		4.13	4.29		
		When power supply rise	V <sub>det1_1</sub>	4.07	4.25	4.39		
			When power supply fall		3.98	4.16		
		When power supply rise	V <sub>det1_2</sub>	3.97	4.14	4.29		
			When power supply fall		3.86	4.03		
		When power supply rise	V <sub>det1_3</sub>	3.74	3.92	4.06		
			When power supply fall		3.68	3.86		
		When power supply rise	V <sub>det1_4</sub>	3.05	3.17	3.29		
			When power supply fall		2.98	3.10		
		When power supply rise	V <sub>det1_5</sub>	2.95	3.06	3.17		
			When power supply fall		2.89	3.00		
		When power supply rise	V <sub>det1_6</sub>	2.86	2.97	3.08		
			When power supply fall		2.79	2.90		
		When power supply rise	V <sub>det1_7</sub>	2.74	2.85	2.96		
			When power supply fall		2.68	2.79		

**Table 2.46 Power-on reset circuit and voltage detection circuit characteristics (1) (2 of 2)**

Parameter		Symbol	Min	Typ	Max	Unit	Test Conditions	
Voltage detection level*1	Voltage detection circuit (LVD1)*3	When power supply rise	V <sub>det1_8</sub>	2.63	2.75	2.85	V	Figure 2.44 At falling edge VCC
		When power supply fall		2.58	2.68	2.78		
		When power supply rise	V <sub>det1_9</sub>	2.54	2.64	2.75		
		When power supply fall		2.48	2.58	2.68		
		When power supply rise	V <sub>det1_A</sub>	2.43	2.53	2.63		
		When power supply fall		2.38	2.48	2.58		
		When power supply rise	V <sub>det1_B</sub>	2.16	2.26	2.36		
		When power supply fall		2.10	2.20	2.30		
		When power supply rise	V <sub>det1_C</sub>	1.88	2	2.09		
		When power supply fall		1.84	1.96	2.05		
		When power supply rise	V <sub>det1_D</sub>	1.78	1.9	1.99		
		When power supply fall		1.74	1.86	1.95		
		When power supply rise	V <sub>det1_E</sub>	1.67	1.79	1.88		
		When power supply fall		1.63	1.75	1.84		
		When power supply rise	V <sub>det1_F</sub>	1.65	1.7	1.78		
		When power supply fall		1.60	1.65	1.73		
Voltage detection level*1	Voltage detection circuit (LVD2)*4	When power supply rise	V <sub>det2_0</sub>	4.20	4.40	4.57	V	Figure 2.45 At falling edge VCC
		When power supply fall		4.11	4.31	4.48		
		When power supply rise	V <sub>det2_1</sub>	4.05	4.25	4.42		
		When power supply fall		3.97	4.17	4.34		
		When power supply rise	V <sub>det2_2</sub>	3.91	4.11	4.28		
		When power supply fall		3.83	4.03	4.20		
		When power supply rise	V <sub>det2_3</sub>	3.71	3.91	4.08		
		When power supply fall		3.64	3.84	4.01		

Note 1. These characteristics apply when noise is not superimposed on the power supply. When a setting causes this voltage detection level to overlap with that of the voltage detection circuit, it cannot be specified whether LVD1 or LVD2 is used for voltage detection.

Note 2. # in the symbol V<sub>det0\_#</sub> denotes the value of the OFS1.VDSEL0[2:0] bits.

Note 3. # in the symbol V<sub>det1\_#</sub> denotes the value of the LVDLVLRLVD1LVL[4:0] bits.

Note 4. # in the symbol V<sub>det2\_#</sub> denotes the value of the LVDLVLRLVD2LVL[2:0] bits.

**Table 2.47 Power-on reset circuit and voltage detection circuit characteristics (2) (1 of 2)**

Parameter		Symbol	Min	Typ	Max	Unit	Test Conditions
Wait time after power-on reset cancellation	LVD0: enable	t <sub>POR</sub>	—	4.3	—	ms	—
	LVD0: disable	t <sub>POR</sub>	—	3.7	—	ms	—
Wait time after voltage monitor 0, 1, 2 reset cancellation	LVD0: enable*1	t <sub>LVD0,1,2</sub>	—	1.4	—	ms	—
	LVD0: disable*2	t <sub>LVD1,2</sub>	—	0.7	—	ms	—
Power-on reset response delay time*3		t <sub>det</sub>	—	—	500	μs	Figure 2.41, Figure 2.42
LVD0 response delay time*3		t <sub>det</sub>	—	—	500	μs	Figure 2.43
LVD1 response delay time*3		t <sub>det</sub>	—	—	350	μs	Figure 2.44
LVD2 response delay time*3		t <sub>det</sub>	—	—	600	μs	Figure 2.45
Minimum VCC down time		t <sub>VOFF</sub>	500	—	—	μs	Figure 2.41, VCC = 1.0 V or above
Power-on reset enable time		t <sub>W (POR)</sub>	1	—	—	ms	Figure 2.42, VCC = below 1.0 V

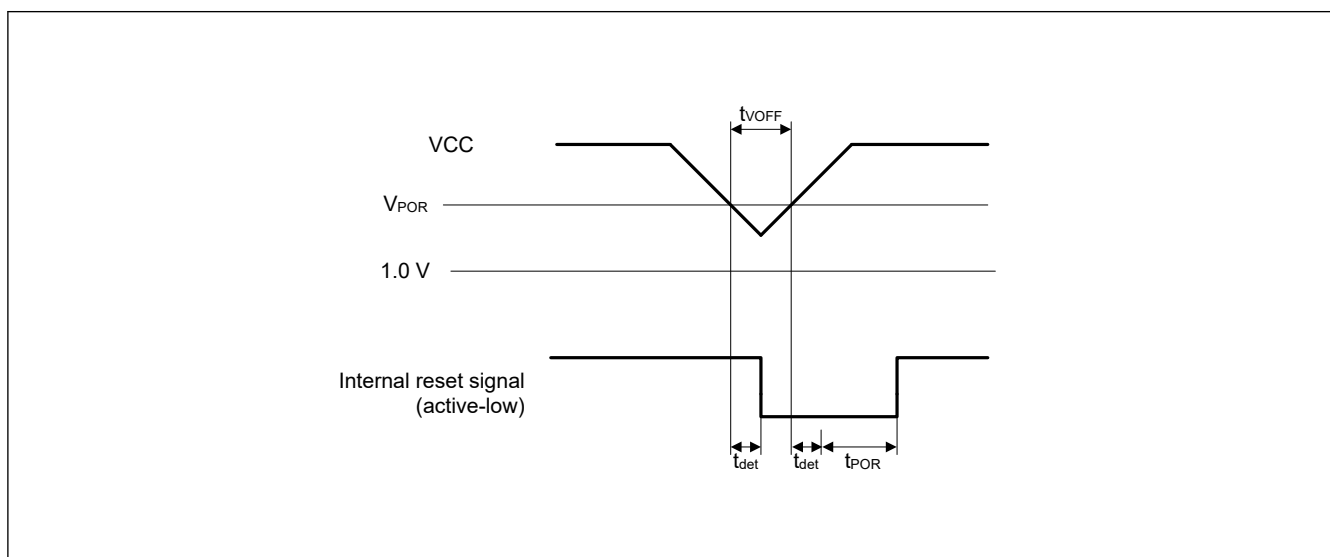
**Table 2.47 Power-on reset circuit and voltage detection circuit characteristics (2) (2 of 2)**

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions
LVD1 operation stabilization time (after LVD1 is enabled)	$T_d (E-A)$	—	—	300	$\mu s$	Figure 2.44
LVD2 operation stabilization time (after LVD2 is enabled)	$T_d (E-A)$	—	—	1200	$\mu s$	Figure 2.45
Hysteresis width (POR)	$V_{PORH}$	—	10	—	mV	—
Hysteresis width (LVD0, LVD1 and LVD2)	$V_{LVH}$	—	60	—	mV	LVD0 selected
		—	110	—		$V_{det1\_0}$ to $V_{det1\_2}$ selected
		—	70	—		$V_{det1\_3}$ to $V_{det1\_9}$ selected
		—	60	—		$V_{det1\_A}$ to $V_{det1\_B}$ selected
		—	50	—		$V_{det1\_C}$ to $V_{det1\_F}$ selected
		—	90	—		LVD2 selected

Note 1. When OFS1.LVDAS = 0.

Note 2. When OFS1.LVDAS = 1.

Note 3. The minimum VCC down time indicates the time when VCC is below the minimum value of voltage detection levels  $V_{POR}$ ,  $V_{det0}$ ,  $V_{det1}$ , and  $V_{det2}$  for the POR/LVD.



**Figure 2.41 Voltage detection reset timing**

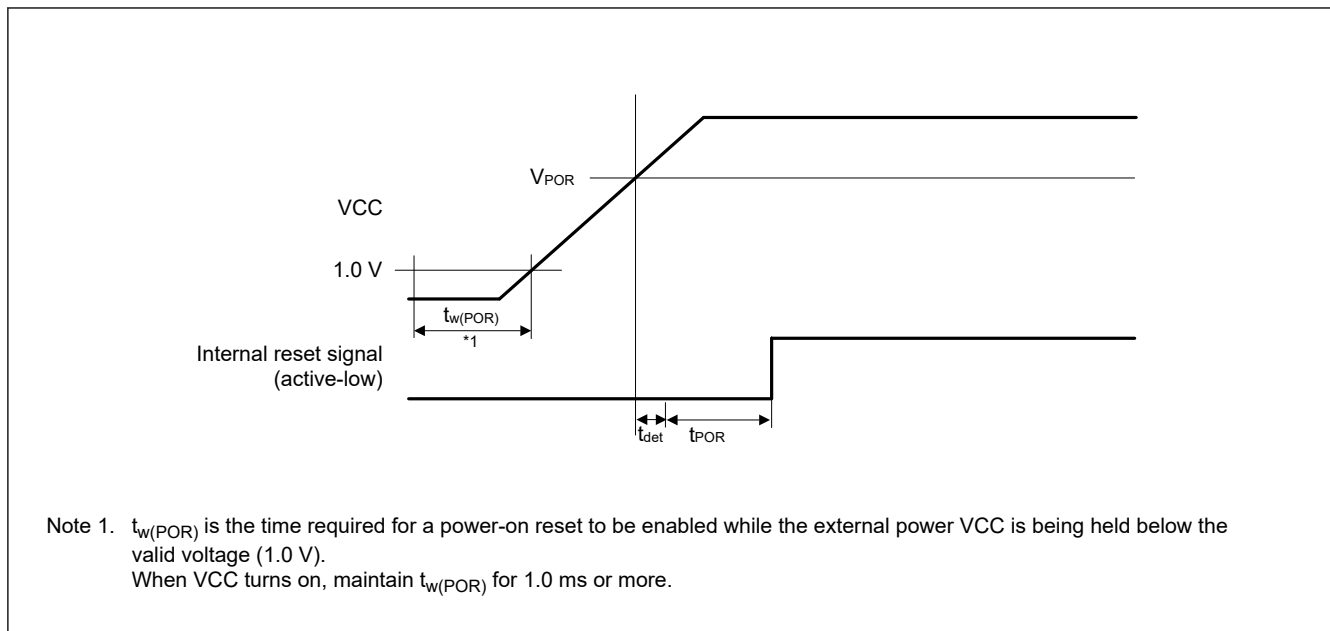


Figure 2.42 Power-on reset timing

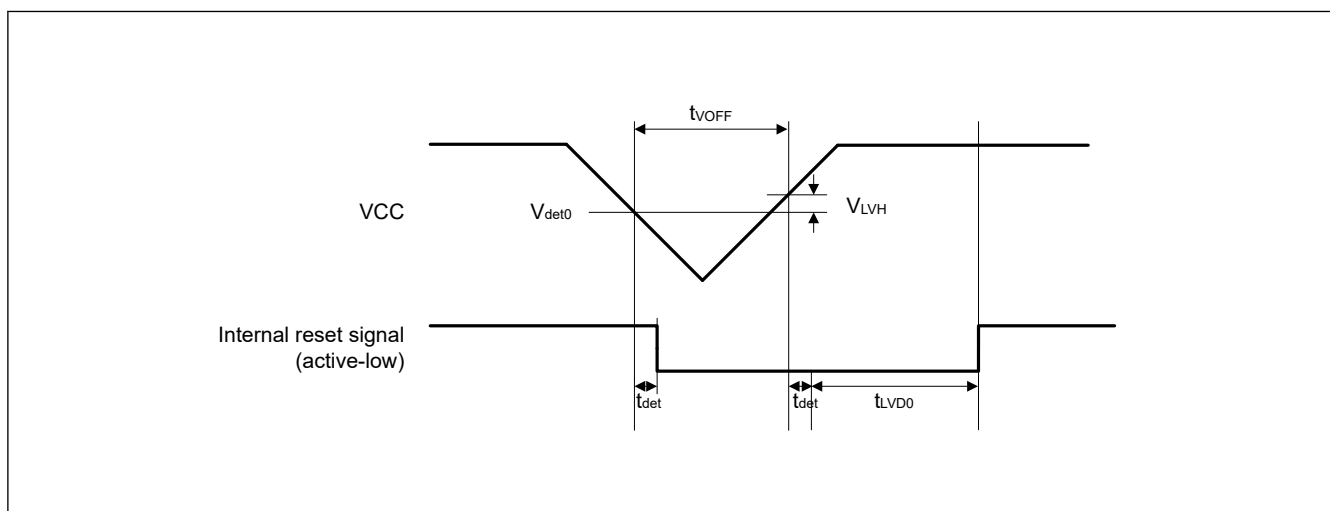


Figure 2.43 Voltage detection circuit timing ( $V_{det0}$ )

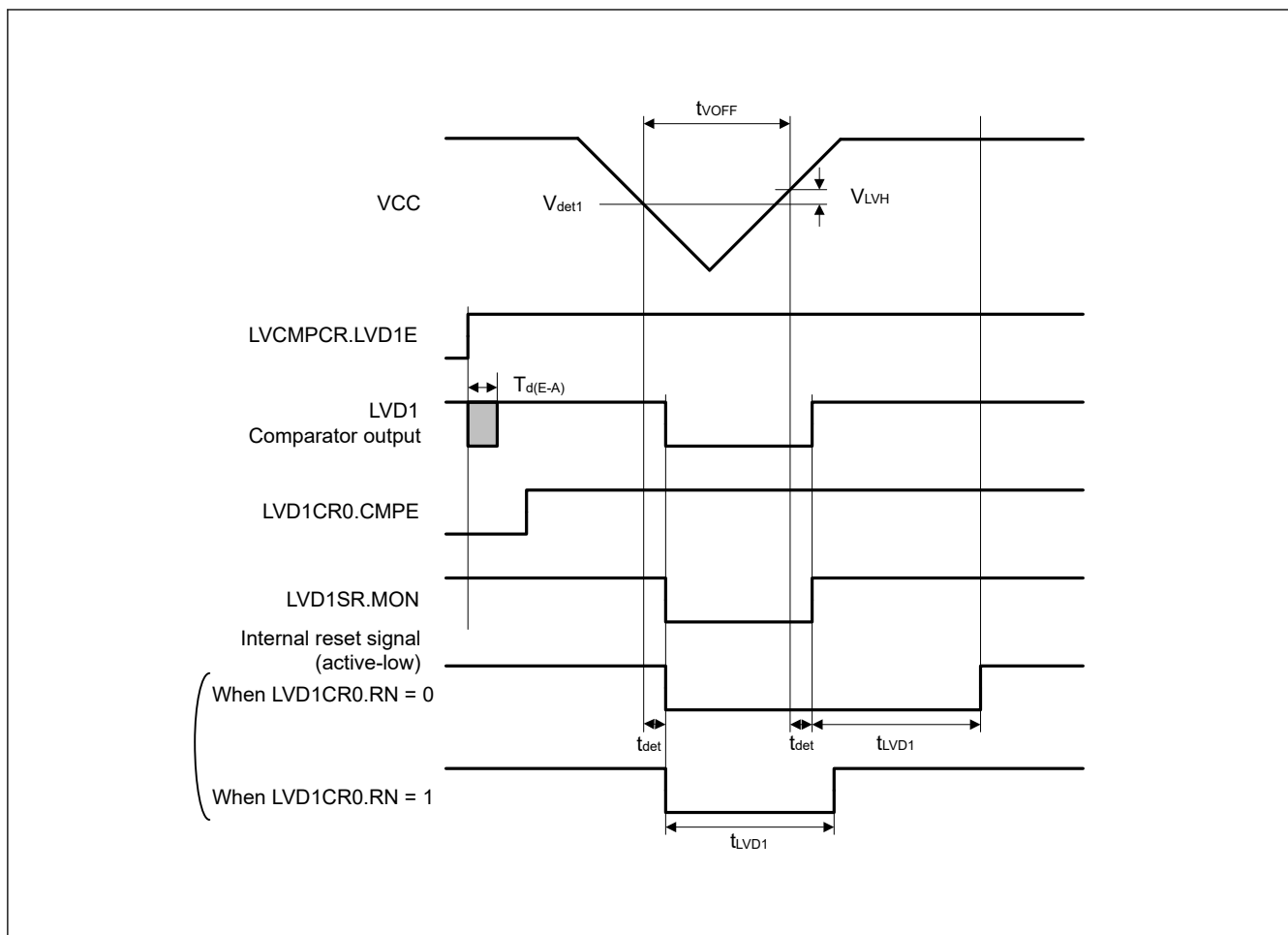


Figure 2.44 Voltage detection circuit timing ( $V_{det1}$ )

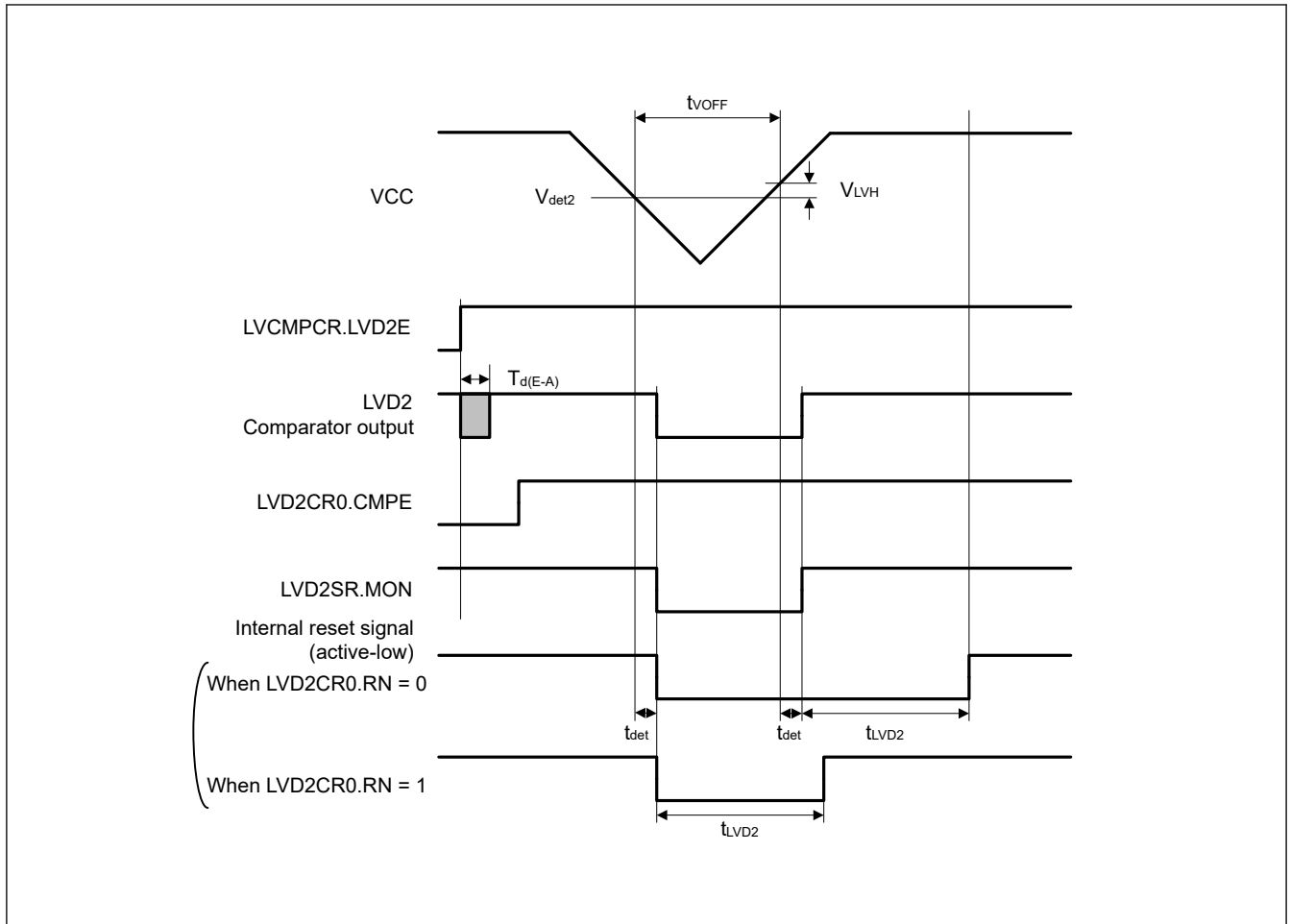


Figure 2.45 Voltage detection circuit timing ( $V_{det2}$ )

## 2.8 CTSU Characteristics

Table 2.48 CTSU characteristics

Conditions:  $V_{CC} = AVCC0 = 1.8$  to  $5.5$  V

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions
External capacitance connected to TSCAP pin	$C_{tscap}$	9	10	11	nF	—

## 2.9 Comparator Characteristics

Table 2.49 ACMLP characteristics (1 of 2)

Conditions:  $V_{CC} = AVCC0 = 1.6$  to  $5.5$  V,  $V_{SS} = AVSS0 = 0$  V

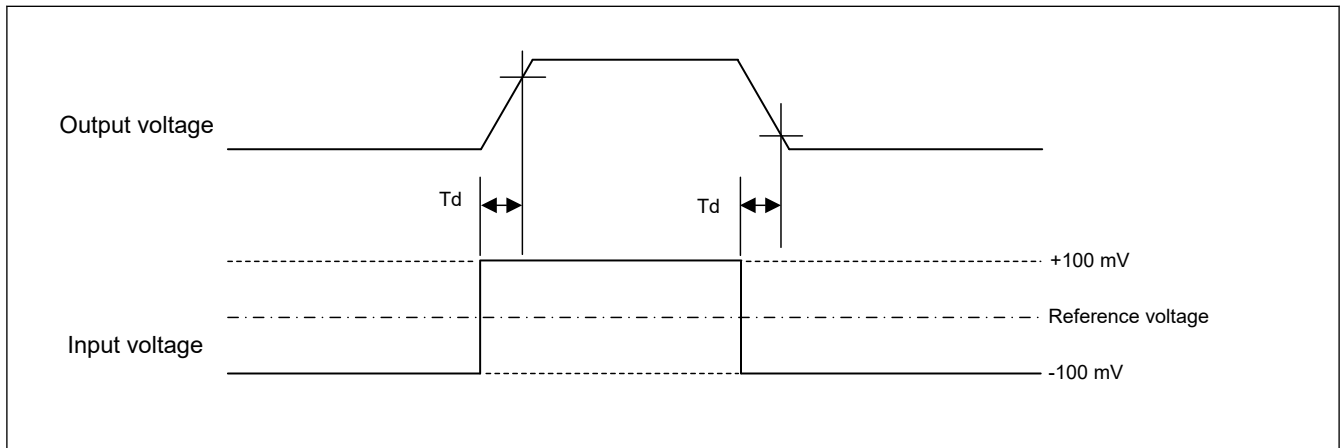
Parameter	Symbol	Min	Typ	Max	Unit	Test conditions	
Reference voltage range	$V_{REF}$	0	—	$V_{CC}-1.4$	V	—	
Input voltage range	$V_I$	0	—	$V_{CC}$	V	—	
Internal reference voltage*1	—	1.34	1.44	1.54	V	—	
Output delay time	High-speed mode	$T_d$	—	—	1.2	$\mu s$	$V_{CC} = 3.0$ V
	Low-speed mode		—	—	9	$\mu s$	
	Window mode		—	—	2	$\mu s$	
Offset voltage	High-speed mode	—	—	50	mV	—	
	Low-speed mode	—	—	40	mV	—	
	Window mode	—	—	60	mV	—	

**Table 2.49 ACMPLP characteristics (2 of 2)**

Conditions: VCC = AVCC0 = 1.6 to 5.5 V, VSS = AVSS0 = 0 V

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions	
Internal reference voltage for window mode	V <sub>RFH</sub>	—	0.76 × VCC	—	V	—	
	V <sub>RFL</sub>	—	0.24 × VCC	—	V	—	
Operation stabilization wait time	High-speed mode	T <sub>cmp</sub>	100	—	—	μs	—
			200	—	—		

Note 1. The internal reference voltage can be selected as ACMPLP reference voltage only when 2.94 V ≤ VCC ≤ 5.50 V.



**Figure 2.46 Output delay time**

## 2.10 Flash Memory Characteristics

### 2.10.1 Code Flash Memory Characteristics

**Table 2.50 Code flash characteristics (1)**

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Reprogramming/erasure cycle*1	N <sub>PEC</sub>	1000	—	—	Times	—
Data hold time	After 1000 times N <sub>PEC</sub>	t <sub>DRP</sub>	20*2*3	—	Year	T <sub>a</sub> = +85°C T <sub>a</sub> = +105°C

Note 1. The reprogram/erase cycle is the number of erasures for each block. When the reprogram/erase cycle is n times (n = 1,000), erasing can be performed n times for each block. For instance, when 4-byte programming is performed 512 times for different addresses in 2-KB blocks, and then the entire block is erased, the reprogram/erase cycle is counted as one. However, programming the same address for several times as one erasure is not enabled (overwriting is prohibited).

Note 2. Characteristic when using the flash memory programmer and the self-programming library provided by Renesas Electronics.

Note 3. This result is target spec, may be changed after reliability testing.

**Table 2.51 Code flash characteristics (2) (1 of 2)**

High-speed operating mode

Conditions: VCC = AVCC0 = 1.8 to 5.5 V

Parameter	Symbol	ICLK = 1 MHz			ICLK = 48 MHz			Unit	
		Min	Typ	Max	Min	Typ	Max		
Programming time	4-byte	t <sub>P4</sub>	—	86	732	—	34	321	μs
Erasure time	2-KB	t <sub>E2K</sub>	—	12.5	355	—	5.6	215	ms
Blank check time	4-byte	t <sub>BC4</sub>	—	—	46.5	—	—	8.3	μs
	2-KB	t <sub>BC2K</sub>	—	—	3681	—	—	240	μs
Erase suspended time	t <sub>SED</sub>	—	—	22.3	—	—	10.5	μs	

**Table 2.51 Code flash characteristics (2) (2 of 2)**

High-speed operating mode

Conditions: VCC = AVCC0 = 1.8 to 5.5 V

Parameter	Symbol	ICLK = 1 MHz			ICLK = 48 MHz			Unit
		Min	Typ	Max	Min	Typ	Max	
Access window information program Start-up area selection and security setting time	t <sub>AWSSAS</sub>	—	21.2	570	—	11.4	423	ms
OCD/serial programmer ID setting time*1	t <sub>OSIS</sub>	—	84.7	2280	—	45.3	1690	ms
Flash memory mode transition wait time 1	t <sub>DIS</sub>	2	—	—	2	—	—	μs
Flash memory mode transition wait time 2	t <sub>MS</sub>	15	—	—	15	—	—	μs

Note: Does not include the time until each operation of the flash memory is started after instructions are executed by software.

Note: The lower-limit frequency of ICLK is 1 MHz during programming or erasing the flash memory. When using ICLK at below 4 MHz, the frequency can be set to 1 MHz, 2 MHz, or 3 MHz. A non-integer frequency such as 1.5 MHz cannot be set.

Note: The frequency accuracy of ICLK must be ± 1.0% during programming or erasing the flash memory. Confirm the frequency accuracy of the clock source.

Note 1. Total time of four commands.

**Table 2.52 Code flash characteristics (3)**

Middle-speed operating mode

Conditions: VCC = AVCC0 = 1.8 to 5.5 V

Parameter	Symbol	ICLK = 1 MHz			ICLK = 24 MHz*2			Unit	
		Min	Typ	Max	Min	Typ	Max		
Programming time	4-byte	t <sub>P4</sub>	—	86	732	—	39	356	μs
Erase time	2-KB	t <sub>E2K</sub>	—	12.5	355	—	6.2	227	ms
Blank check time	4-byte	t <sub>BC4</sub>	—	—	46.5	—	—	11.3	μs
	2-KB	t <sub>BC2K</sub>	—	—	3681	—	—	534	μs
Erase suspended time	t <sub>SED</sub>	—	—	22.3	—	—	11.7	μs	
Access window information program Start-up area selection and security setting time	t <sub>AWSSAS</sub>	—	21.2	570	—	12.2	435	ms	
OCD/serial programmer ID setting time*1	t <sub>OSIS</sub>	—	84.7	2280	—	48.7	1740	ms	
Flash memory mode transition wait time 1	t <sub>DIS</sub>	2	—	—	2	—	—	μs	
Flash memory mode transition wait time 2	t <sub>MS</sub>	15	—	—	15	—	—	μs	

Note: Does not include the time until each operation of the flash memory is started after instructions are executed by software.

Note: The lower-limit frequency of ICLK is 1 MHz during programming or erasing the flash memory. When using ICLK at below 4 MHz, the frequency can be set to 1 MHz, 2 MHz, or 3 MHz. A non-integer frequency such as 1.5 MHz cannot be set.

Note: The frequency accuracy of ICLK must be ± 1.0% during programming or erasing the flash memory. Confirm the frequency accuracy of the clock source.

Note 1. Total time of four commands.

Note 2. When 1.8 V ≤ VCC = AVCC0 ≤ 5.5 V

**Table 2.53 Code flash characteristics (4) (1 of 2)**

Low-speed operating mode

Conditions: VCC = AVCC0 = 1.6 to 5.5 V

Parameter	Symbol	ICLK = 1 MHz			ICLK = 2 MHz			Unit	
		Min	Typ	Max	Min	Typ	Max		
Programming time	4-byte	t <sub>P4</sub>	—	86	732	—	57	502	μs
Erase time	2-KB	t <sub>E2K</sub>	—	12.5	355	—	8.8	280	ms



**Table 2.53 Code flash characteristics (4) (2 of 2)**

Low-speed operating mode

Conditions: VCC = AVCC0 = 1.6 to 5.5 V

Parameter	Symbol	ICLK = 1 MHz			ICLK = 2 MHz			Unit	
		Min	Typ	Max	Min	Typ	Max		
Blank check time	4-byte	t <sub>BC4</sub>	—	—	46.5	—	—	23.3	μs
	2-KB	t <sub>BC2K</sub>	—	—	3681	—	—	1841	μs
Erase suspended time	t <sub>SED</sub>	—	—	22.3	—	—	16.2	μs	
Access window information program Start-up area selection and security setting time	t <sub>AWSSAS</sub>	—	21.2	570	—	15.9	491	ms	
OCD/serial programmer ID setting time*1	t <sub>OSIS</sub>	—	84.7	2280	—	63.5	1964	ms	
Flash memory mode transition wait time 1	t <sub>DIS</sub>	2	—	—	2	—	—	μs	
Flash memory mode transition wait time 2	t <sub>MS</sub>	15	—	—	15	—	—	μs	

Note: Does not include the time until each operation of the flash memory is started after instructions are executed by software.

Note: The lower-limit frequency of ICLK is 1 MHz during programming or erasing the flash memory. When using ICLK at below 4 MHz, the frequency can be set to 1 MHz or 2 MHz. A non-integer frequency such as 1.5 MHz cannot be set.

Note: The frequency accuracy of ICLK must be ± 1.0% during programming or erasing the flash memory. Confirm the frequency accuracy of the clock source.

Note 1. Total time of four commands.

## 2.10.2 Data Flash Memory Characteristics

**Table 2.54 Data flash characteristics (1)**

Parameter	Symbol	Min	Typ	Max	Unit	Conditions	
Reprogramming/erasure cycle*1	N <sub>DPEC</sub>	100000	1000000	—	Times	—	
Data hold time	After 10000 times of N <sub>DPEC</sub>	t <sub>DDRP</sub>	20*2 *3	—	—	Year	Ta = +85°C Ta = +105°C
	After 100000 times of N <sub>DPEC</sub>		5*2 *3	—	—	Year	
	After 1000000 times of N <sub>DPEC</sub>		—	1*2 *3	—	—	Year

Note 1. The reprogram/erase cycle is the number of erasure for each block. When the reprogram/erase cycle is n times (n = 100,000), erasing can be performed n times for each block. For instance, when 1-byte programming is performed 1,024 times for different addresses in 1-KB blocks, and then the entire block is erased, the reprogram/erase cycle is counted as one. However, programming the same address for several times as one erasure is not enabled. (overwriting is prohibited.)

Note 2. Characteristics when using the flash memory programmer and the self-programming library provided by Renesas Electronics.

Note 3. These results are target spec, may changed after reliability testing.

**Table 2.55 Data flash characteristics (2)**

High-speed operating mode

Conditions: VCC = AVCC0 = 1.8 to 5.5 V

Parameter	Symbol	ICLK = 1 MHz			ICLK = 48 MHz			Unit	
		Min	Typ	Max	Min	Typ	Max		
Programming time	1-byte	t <sub>DP1</sub>	—	45	404	—	34	321	μs
Erase time	1-KB	t <sub>DE1K</sub>	—	8.8	280	—	6.1	224	ms
Blank check time	1-byte	t <sub>DBC1</sub>	—	—	15.2	—	—	8.3	μs
	1-KB	t <sub>DBC1K</sub>	—	—	1832	—	—	466	μs
Suspended time during erasing	t <sub>DSED</sub>	—	—	13.2	—	—	10.5	μs	
Data flash STOP recovery time	t <sub>DSTOP</sub>	250	—	—	250	—	—	ns	

Note: Does not include the time until each operation of the flash memory is started after instructions are executed by software.

Note: The lower-limit frequency of ICLK is 1 MHz during programming or erasing the flash memory. When using ICLK at below 4 MHz, the frequency can be set to 1 MHz, 2 MHz, or 3 MHz. A non-integer frequency such as 1.5 MHz cannot be set.

Note: The frequency accuracy of ICLK must be  $\pm 1.0\%$  during programming or erasing the flash memory. Confirm the frequency accuracy of the clock source.

**Table 2.56 Data flash characteristics (3)**

Middle-speed operating mode

Conditions: VCC = AVCC0 = 1.8 to 5.5 V

Parameter		Symbol	ICLK = 1 MHz			ICLK = 24 MHz*1			Unit
			Min	Typ	Max	Min	Typ	Max	
Programming time	1-byte	t <sub>DP1</sub>	—	45	404	—	39	356	μs
Erasure time	1-KB	t <sub>DE1K</sub>	—	8.8	280	—	7.3	248	ms
Blank check time	1-byte	t <sub>DBC1</sub>	—	—	15.2	—	—	11.3	μs
	1-KB	t <sub>DBC1K</sub>	—	—	1.84	—	—	1.06	ms
Suspended time during erasing		t <sub>DSED</sub>	—	—	13.2	—	—	11.7	μs
Data flash STOP recovery time		t <sub>DSTOP</sub>	250	—	—	250	—	—	ns

Note: Does not include the time until each operation of the flash memory is started after instructions are executed by software.

Note: The lower-limit frequency of ICLK is 1 MHz during programming or erasing the flash memory. When using ICLK at below 4 MHz, the frequency can be set to 1 MHz, 2 MHz, or 3 MHz. A non-integer frequency such as 1.5 MHz cannot be set.

Note: The frequency accuracy of ICLK must be  $\pm 1.0\%$  during programming or erasing the flash memory. Confirm the frequency accuracy of the clock source.

Note 1. When  $1.8\text{ V} \leq \text{VCC} = \text{AVCC0} \leq 5.5\text{ V}$

**Table 2.57 Data flash characteristics (4)**

Low-speed operating mode

Conditions: VCC = AVCC0 = 1.6 to 5.5 V

Parameter		Symbol	ICLK = 1 MHz			ICLK = 2 MHz			Unit
			Min	Typ	Max	Min	Typ	Max	
Programming time	1-byte	t <sub>DP1</sub>	—	86	732	—	57	502	μs
Erasure time	1-KB	t <sub>DE1K</sub>	—	19.7	504	—	12.4	354	ms
Blank check time	1-byte	t <sub>DBC1</sub>	—	—	46.5	—	—	23.3	μs
	1-KB	t <sub>DBC1K</sub>	—	—	7.3	—	—	3.66	ms
Suspended time during erasing		t <sub>DSED</sub>	—	—	22.3	—	—	16.2	μs
Data flash STOP recovery time		t <sub>DSTOP</sub>	250	—	—	250	—	—	ns

Note: Does not include the time until each operation of the flash memory is started after instructions are executed by software.

Note: The lower-limit frequency of ICLK is 1 MHz during programming or erasing the flash memory. When using ICLK at below 2 MHz, the frequency can be set to 1 MHz or 2 MHz. A non-integer frequency such as 1.5 MHz cannot be set.

Note: The frequency accuracy of ICLK must be  $\pm 1.0\%$  during programming or erasing the flash memory. Confirm the frequency accuracy of the clock source.

## 2.11 Serial Wire Debug (SWD)

**Table 2.58 SWD characteristics (1)**

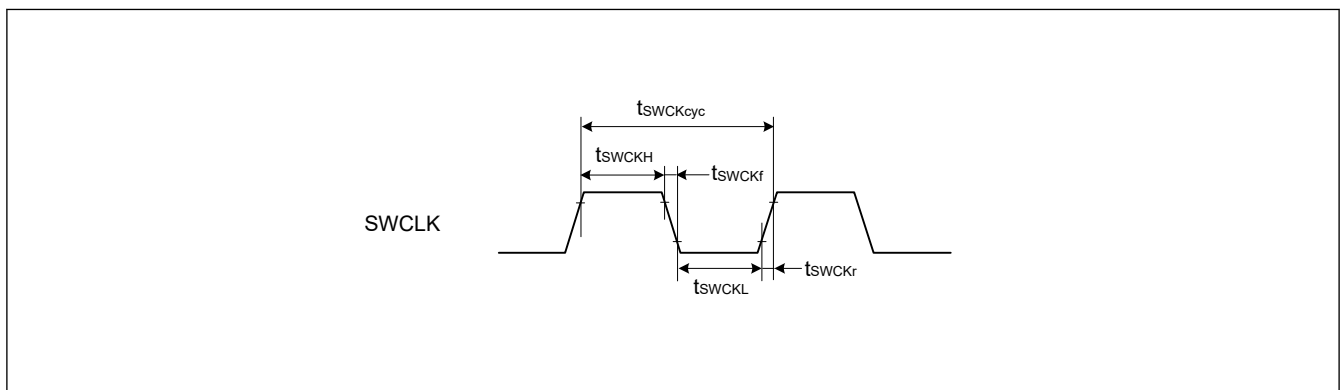
Conditions: VCC = AVCC0 = 2.4 to 5.5 V

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions
SWCLK clock cycle time	t <sub>SWCKcyc</sub>	80	—	—	ns	Figure 2.47
SWCLK clock high pulse width	t <sub>SWCKH</sub>	35	—	—	ns	
SWCLK clock low pulse width	t <sub>SWCKL</sub>	35	—	—	ns	
SWCLK clock rise time	t <sub>SWCKr</sub>	—	—	5	ns	
SWCLK clock fall time	t <sub>SWCKf</sub>	—	—	5	ns	
SWDIO setup time	t <sub>SWDS</sub>	16	—	—	ns	Figure 2.48
SWDIO hold time	t <sub>SWDH</sub>	16	—	—	ns	
SWDIO data delay time	t <sub>SWDD</sub>	2	—	70	ns	

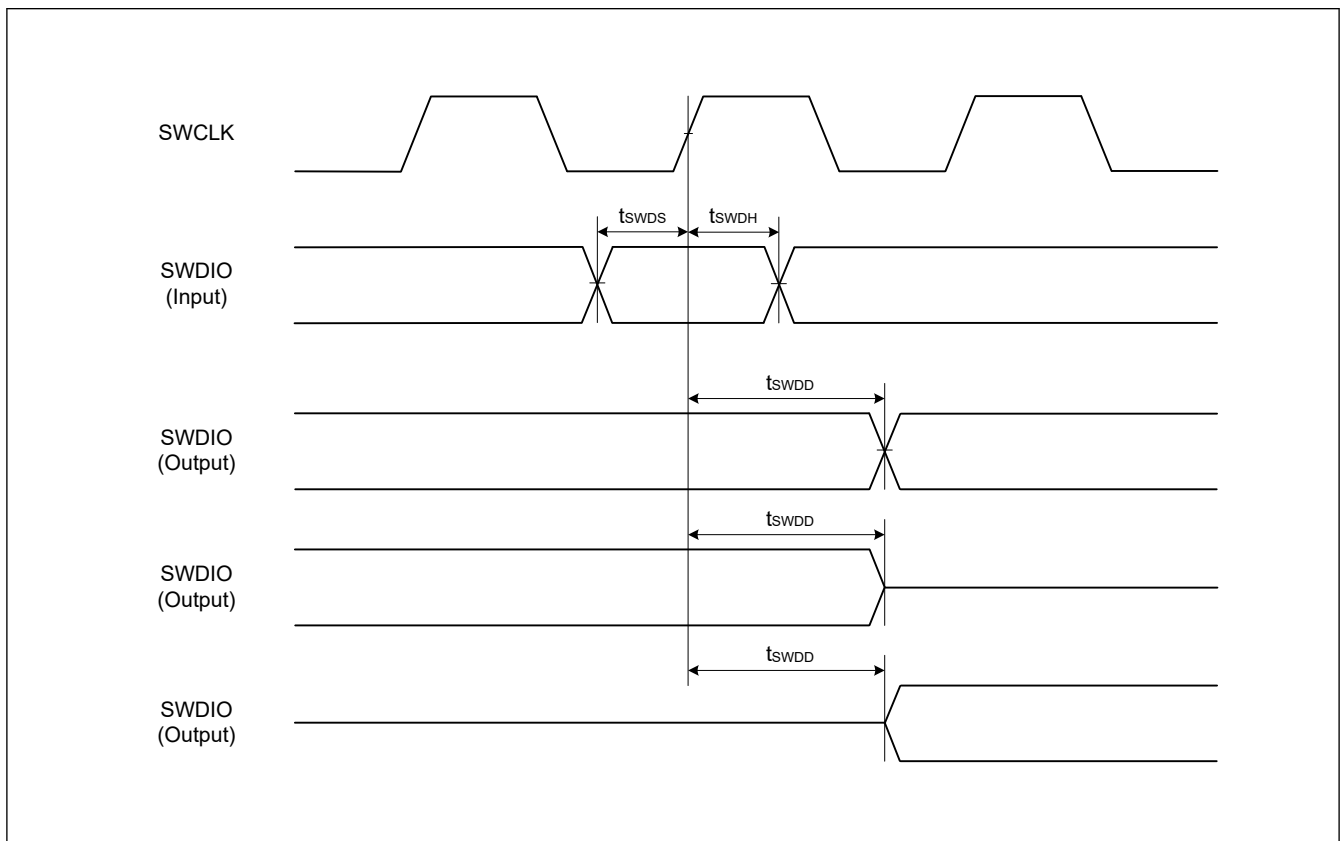
**Table 2.59 SWD characteristics (2)**

Conditions: VCC = AVCC0 = 1.6 to 2.4 V

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions
SWCLK clock cycle time	$t_{SWCLKcyc}$	250	—	—	ns	Figure 2.47
SWCLK clock high pulse width	$t_{SWCKH}$	120	—	—	ns	
SWCLK clock low pulse width	$t_{SWCKL}$	120	—	—	ns	
SWCLK clock rise time	$t_{SWCKr}$	—	—	5	ns	
SWCLK clock fall time	$t_{SWCKf}$	—	—	5	ns	
SWDIO setup time	$t_{SWDS}$	50	—	—	ns	Figure 2.48
SWDIO hold time	$t_{SWDH}$	50	—	—	ns	
SWDIO data delay time	$t_{SWDD}$	2	—	170	ns	



**Figure 2.47 SWD SWCLK timing**



**Figure 2.48 SWD input/output timing**

## Appendix 1. Port States in each Processing Mode

**Table 1.1 Port states in each processing mode (1 of 3)**

Port name	Reset	Software Standby Mode
P000/AN000/TS21/IRQ6	Hi-Z	Keep-O <sup>*1</sup>
P001/AN001/TS22/IRQ7	Hi-Z	Keep-O <sup>*1</sup>
P002/AN002/TS23/IRQ2	Hi-Z	Keep-O <sup>*1</sup>
P003/AN003/TS24	Hi-Z	Keep-O
P004/AN004/TS25/IRQ3	Hi-Z	Keep-O <sup>*1</sup>
P010/AN005/TS30-CFC	Hi-Z	Keep-O
P011/AN006/TS31-CFC	Hi-Z	Keep-O
P012/AN007/TS32-CFC	Hi-Z	Keep-O
P013/AN008/TS33-CFC	Hi-Z	Keep-O
P014/AN009	Hi-Z	Keep-O
P015/AN010/TS28-CFC/IRQ7_A	Hi-Z	Keep-O <sup>*1</sup>
P100/CMPIN0/TS26-CFC/AGTIO0_A/ GTETRG_A/GTIOC8B_A/RXD0_A/ SCL0_D/SCK1_A/MISOA_A/KRM00/ IRQ2_A	Hi-Z	[AGTIO0_A output selected] AGTIO0_A output <sup>*2</sup> [Other than the above] Keep-O <sup>*1</sup>
P101/CMPREF0/TS16-CFC/AGTEE0/ GTETRGB_A/GTIOC8A_A/TXD0_A/ MOSI0_A/SDA0_C/CTS1_RTS1_A/KRM01/ IRQ1_A	Hi-Z	Keep-O <sup>*1</sup>
P102/CMPIN1/ADTRG0_A/TS15-CFC/ AGTO0/GTOWLO_A/GTIOC5B_A/SCK0_A/ TXD2_D/MOSI2_D/SDA2_D/RSPCKA_A/ KRM02	Hi-Z	[AGTO0 selected] AGTO0 output <sup>*2</sup> [Other than the above] Keep-O <sup>*1</sup>
P103/CMPREF1/TS14-CFC/GTOWUP_A/ GTIOC5A_A/CTS0_RTS0_A/SSLA0_A/ KRM03	Hi-Z	Keep-O <sup>*1</sup>
P104/TS13-CFC/GTETRGB_B/GTIOC4B_C/ RXD0_C/MISO0_C/SSLA1_A/KRM04/ IRQ1_B	Hi-Z	Keep-O <sup>*1</sup>
P105/TS34-CFC/GTETRG_C/ GTIOC4A_C/SSLA2_A/KRM05/IRQ0_B	Hi-Z	Keep-O <sup>*1</sup>
P106/SSLA3_A/KRM06	Hi-Z	Keep-O <sup>*1</sup>
P107/KRM07	Hi-Z	Keep-O <sup>*1</sup>
P108/SWDIO/GTOULO_C/GTIOC0B_A/ CTS9_RTS9_B	Pull-up	Keep-O
P109/TS10-CFC/GTOVUP_A/GTIOC4A_A/ SCK1_E/TXD9_B/MOSI9_B/SDA9_B/ CLKOUT_B	Hi-Z	[CLKOUT selected] CLKOUT output [Other than the above] Keep-O
P110/TS11-CFC/GTOVLO_A/GTIOC4B_A/ CTS2_RTS2_B/RXD9_B/SCL9_B/ MISOB_B/IRQ3_A/VCOUT	Hi-Z	[ACMPLP selected] VCOUT output [Other than the above] Keep-O <sup>*1</sup>
P111/TS12-CFC/AGTOA0/GTIOC6A_A/ SCK2_B/SCK9_B/IRQ4_A	Hi-Z	[AGTOA0 selected] AGTOA0 output <sup>*2</sup> [Other than the above] Keep-O <sup>*1</sup>

Table 1.1 Port states in each processing mode (2 of 3)

Port name	Reset	Software Standby Mode
P112/TSCAP/AGTOB0/GTIOC6B_A/ TXD2_B/MOSI2_B/SDA2_B/SCK1_D	Hi-Z	[AGTOB0 selected] AGTOB0 output* <sup>2</sup> [Other than the above] Keep-O
P113/TS27-CFC	Hi-Z	Keep-O
P200/NMI	Hi-Z	Hi-Z
P201/MD	Pull-up	Keep-O
P204/CACREF_A/TS0/AGTIO1_A/GTIW_A/ GTIOC4B_B/SCK0_D/SCK9_A/SCL0_B	Hi-Z	[AGTIO1_A output selected] AGTIO1_A output* <sup>2</sup> [Other than the above] Keep-O* <sup>1</sup>
P205/AGTO1/GTIV_A/TXD0_D/MOSI0_D/ SDA0_D/CTS9_RTS9_A/IRQ1/CLKOUT_A	Hi-Z	[AGTO1 selected] AGTO1 output* <sup>2</sup> [CLKOUT selected] CLKOUT output [Other than the above] Keep-O* <sup>1</sup>
P206/GTIU_A/RXD0_D/MISO0_D/SCL0_D/ IRQ0	Hi-Z	Keep-O* <sup>1</sup>
P207	Hi-Z	Keep-O
P208/AGTOB0_A	Hi-Z	[AGTOB0_A selected] AGTOB0_A output* <sup>2</sup> [Other than the above] Keep-O
P212/EXTAL /AGTEE1/GTETRGB_D/ GTIOC0B_D/RXD1_A/MISO1_A/SCL1_A/ IRQ3_B	Hi-Z	Keep-O* <sup>1</sup>
P213/XTAL /GTETRGA_D/GTIOC0A_D/ TXD1_A/MOSI1_A/SDA1_A/IRQ2_B	Hi-Z	Keep-O* <sup>1</sup>
P214/XCOUT, P215/XCIN	Hi-Z	[Sub-clock Oscillator selected] Sub-clock Oscillator is operating [Other than the above] Hi-Z
P300/SWCLK/GTOUUP_C/GTIOC0A_A	Pull-up	Keep-O
P301/TS9-CFC/AGTIO0_D/GTOULO_A/ GTIOC7B_A/RXD2_A/MISO2_A/SCL2_A/ CTS9_RTS9_D/IRQ6_A	Hi-Z	[AGTIO0_D output selected] AGTIO0_D output* <sup>2</sup> [Other than the above] Keep-O* <sup>1</sup>
P302/TS8-CFC/GTOUUP_A/GTIOC7A_A/ TXD2_A/MOSI2_A/SDA2_A/IRQ5_A	Hi-Z	Keep-O* <sup>1</sup>
P303/TS2-CFC	Hi-Z	Keep-O
P304	Hi-Z	Keep-O
P400/CACREF_C/AGTIO1_C/GTIOC9A_A/ SCK0_B/SCK1_B/SCL0_A/IRQ0_A	Hi-Z	[AGTIO1_C output selected] AGTIO1_C output* <sup>2</sup> [Other than the above] Keep-O* <sup>1</sup>
P401/GTETRGA_B/GTIOC9B_A/ CTS0_RTS0_B/TXD1_B/MOSI1_B/SDA1_B/ SDA0_A/IRQ5	Hi-Z	Keep-O* <sup>1</sup>
P402/TS18/AGTIO0_E/AGTIO1_D/RXD1_B/ MISO1_B/SCL1_B/IRQ4	Hi-Z	[AGTIO0_E, AGTIO1_D output selected] AGTIO0_E, AGTIO1_D output* <sup>2</sup> [Other than the above] Keep-O* <sup>1</sup>

**Table 1.1 Port states in each processing mode (3 of 3)**

Port name	Reset	Software Standby Mode
P403/TS17/AGTIO0_F/AGTIO1_E/ CTS1_RTS1_B	Hi-Z	[AGTIO0_F, AGTIO1_E output selected] AGTIO0_F, AGTIO1_E output* <sup>2</sup> [Other than the above] Keep-O* <sup>1</sup>
P407/ADTRG0_B/AGTIO0_C/RTCOU T/CTS0_RTS0_D/SDA0_B	Hi-Z	[AGTIO0_C output selected] AGTIO0_C output* <sup>2</sup> [RTCOU selected] RTCOU output [Other than the above] Keep-O* <sup>1</sup>
P408/TS4/GTOWLO_B/CTS1_RTS1_D/ SCL0_C/IRQ7_B	Hi-Z	Keep-O* <sup>1</sup>
P409/TS5/GTOWUP_B/IRQ6_B	Hi-Z	Keep-O* <sup>1</sup>
P410/TS6/AGTOB1/GTOVLO_B/RXD0_B/ MISO0_B/SCL0_B/MISOA_B/IRQ5_B	Hi-Z	[AGTOB1 selected] AGTOB1 output* <sup>2</sup> [Other than the above] Keep-O* <sup>1</sup>
P411/TS7/AGTOA1/GTOVUP_B/TXD0_B/ MOSI0_B/SDA0_B/MOSIA_B/IRQ4_B	Hi-Z	[AGTOA1 selected] AGTOA1 output* <sup>2</sup> [Other than the above] Keep-O* <sup>1</sup>
P500/GTIU_B/GTIOC5A_B	Hi-Z	Keep-O
P501/AN017/GTIV_B/GTIOC5B_B/TXD1_C/ MOSI1_C/SDA1_C	Hi-Z	Keep-O
P502/AN018/GTIW_B/RXD1_C/MISO1_C/ SCL1_C	Hi-Z	Keep-O
P913/AGTIO1_F/GTETRGA_F	Hi-Z	Keep-O
P914/AGTOA1_A/GTETRGA_F	Hi-Z	Keep-O
P915	Hi-Z	Keep-O

Note: Hi-Z: High-impedance

Keep-O: Output pins retain their previous values. Input pins become high-impedance.

Note 1. Input is enabled if the pin is specified as the software standby canceling source while it is used as an external interrupt pin.

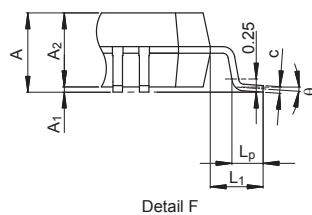
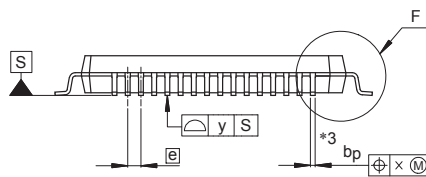
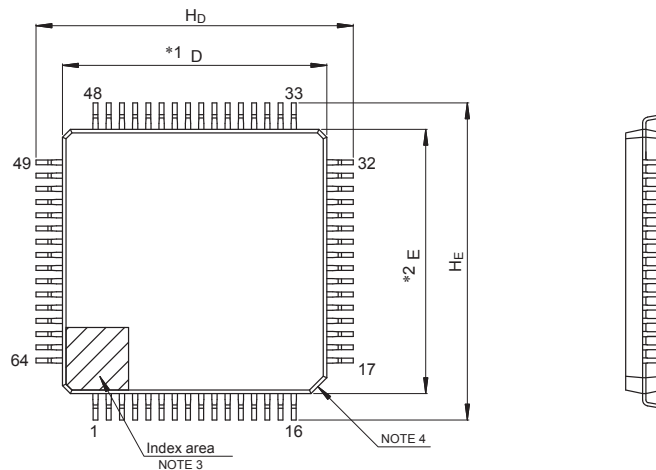
Note 2. AGTIO output is enabled while LOCO or SOSC is selected as a count source.

## Appendix 2. Package Dimensions

Information on the latest version of the package dimensions or mountings is displayed in “Packages” on the Renesas Electronics Corporation website.

JEITA Package Code	RENESAS Code	Previous Code	MASS (Typ) [g]
P-LFQFP64-10x10-0.50	PLQP0064KB-C	—	0.3

Unit: mm



NOTE)

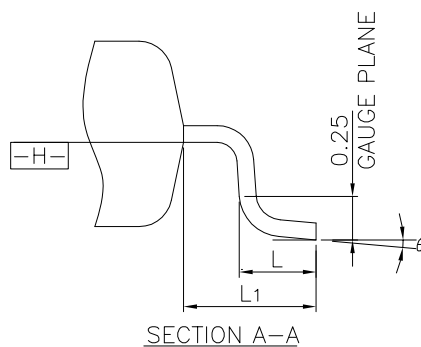
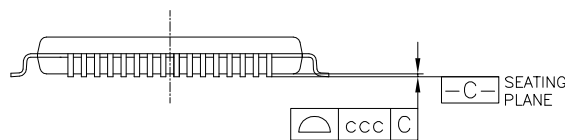
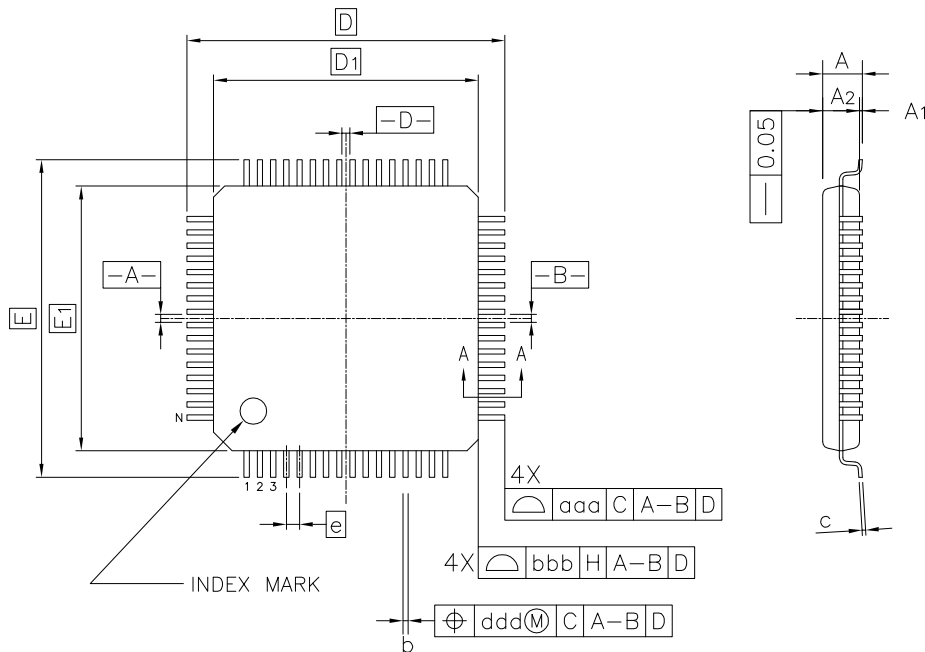
1. DIMENSIONS \*\*1" AND \*\*2" DO NOT INCLUDE MOLD FLASH.
2. DIMENSION \*\*3" DOES NOT INCLUDE TRIM OFFSET.
3. PIN 1 VISUAL INDEX FEATURE MAY VARY, BUT MUST BE LOCATED WITHIN THE HATCHED AREA.
4. CHAMFERS AT CORNERS ARE OPTIONAL, SIZE MAY VARY.

Reference Symbol	Dimensions in millimeters		
	Min	Nom	Max
D	9.9	10.0	10.1
E	9.9	10.0	10.1
A <sub>2</sub>	—	1.4	—
H <sub>D</sub>	11.8	12.0	12.2
H <sub>E</sub>	11.8	12.0	12.2
A	—	—	1.7
A <sub>1</sub>	0.05	—	0.15
b <sub>p</sub>	0.15	0.20	0.27
c	0.09	—	0.20
θ	0°	3.5°	8°
Ⓢ	—	0.5	—
x	—	—	0.08
y	—	—	0.08
L <sub>p</sub>	0.45	0.6	0.75
L <sub>1</sub>	—	1.0	—

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Figure 2.1 LQFP 64-pin 0.5mm pitch (1)

JEITA Package code	RENESAS code	MASS(TYP.)[g]
P-LFQFP064-10x10-0.50	PLQP0064KL-A	0.36

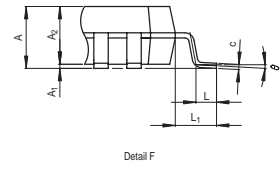
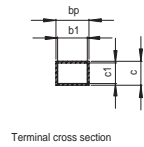
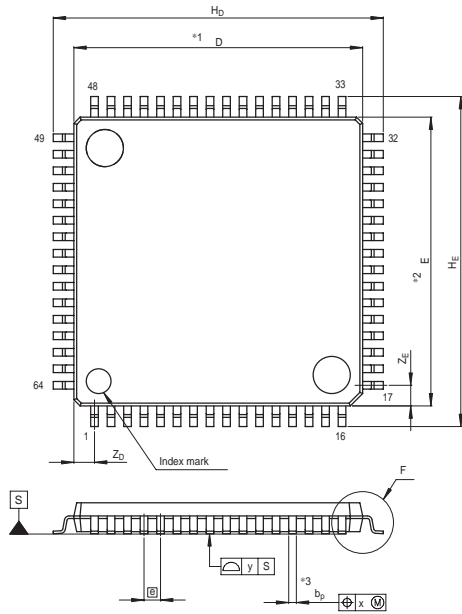


Reference Symbol	Dimension in Millimeters		
	Min.	Nom.	Max.
A	—	—	1.60
A <sub>1</sub>	0.05	—	0.15
A <sub>2</sub>	1.35	1.40	1.45
D	—	12.00	—
D <sub>1</sub>	—	10.00	—
E	—	12.00	—
E <sub>1</sub>	—	10.00	—
N	—	64	—
e	—	0.50	—
b	0.17	0.22	0.27
c	0.09	—	0.20
θ	0°	3.5°	7°
L	0.45	0.60	0.75
L <sub>1</sub>	—	1.00	—
aaa	—	—	0.20
bbb	—	—	0.20
ccc	—	—	0.08
ddd	—	—	0.08

Figure 2.2 LQFP 64-pin 0.5mm pitch (2)



JEITA Package Code	RENESAS Code	Previous Code	MASS[Typ.]
P-LQFP64-14x14-0.80	PLQP0064GA-A	64P6U-A/—	0.7g



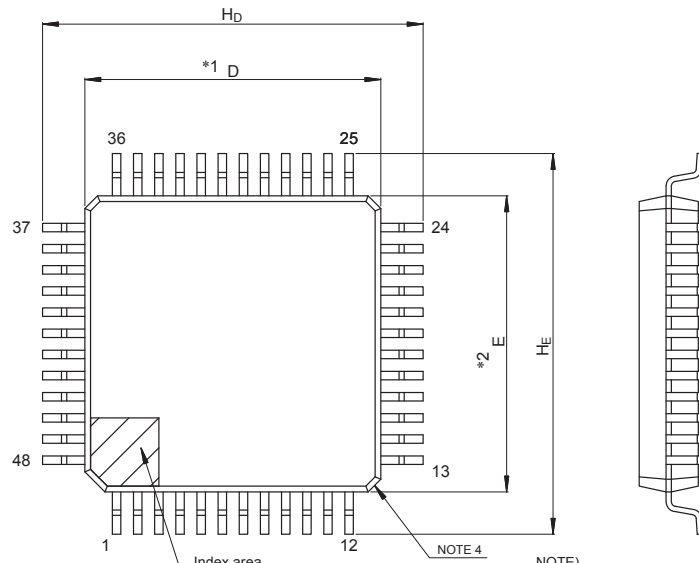
NOTE)  
 1. DIMENSIONS \*\*1\* AND \*\*2\* DO NOT INCLUDE MOLD FLASH.  
 2. DIMENSION \*\*3\* DOES NOT INCLUDE TRIM OFFSET.

Reference Symbol	Dimension in Millimeters		
	Min	Nom	Max
D	13.9	14.0	14.1
E	13.9	14.0	14.1
A <sub>2</sub>	—	1.4	—
H <sub>D</sub>	15.8	16.0	16.2
H <sub>E</sub>	15.8	16.0	16.2
A	—	—	1.7
A <sub>1</sub>	0	0.1	0.2
b <sub>p</sub>	0.32	0.37	0.42
b <sub>1</sub>	—	0.35	—
c	0.09	0.145	0.20
c <sub>1</sub>	—	0.125	—
φ	0°	—	8°
⊖	—	0.8	—
x	—	—	0.20
y	—	—	0.10
Z <sub>D</sub>	—	1.0	—
Z <sub>E</sub>	—	1.0	—
L	0.3	0.5	0.7
L <sub>1</sub>	—	1.0	—

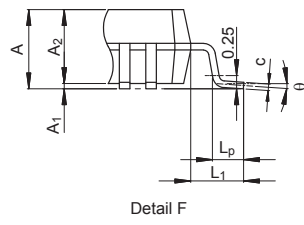
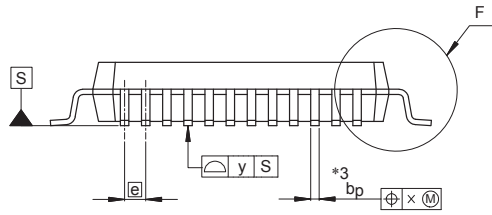
Figure 2.3 LQFP 64-pin

<b>JEITA Package Code</b>	<b>RENESAS Code</b>	<b>Previous Code</b>	<b>MASS (Typ) [g]</b>
P-LFQFP48-7x7-0.50	PLQP0048KB-B	—	0.2

Unit: mm



- NOTE)
1. DIMENSIONS “\*1” AND “\*2” DO NOT INCLUDE MOLD FLASH.
  2. DIMENSION “\*3” DOES NOT INCLUDE TRIM OFFSET.
  3. PIN 1 VISUAL INDEX FEATURE MAY VARY, BUT MUST BE LOCATED WITHIN THE HATCHED AREA.
  4. CHAMFERS AT CORNERS ARE OPTIONAL, SIZE MAY VARY.

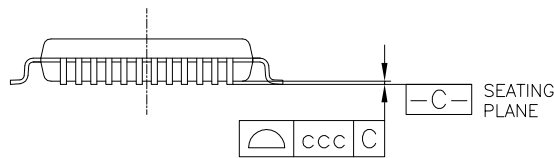
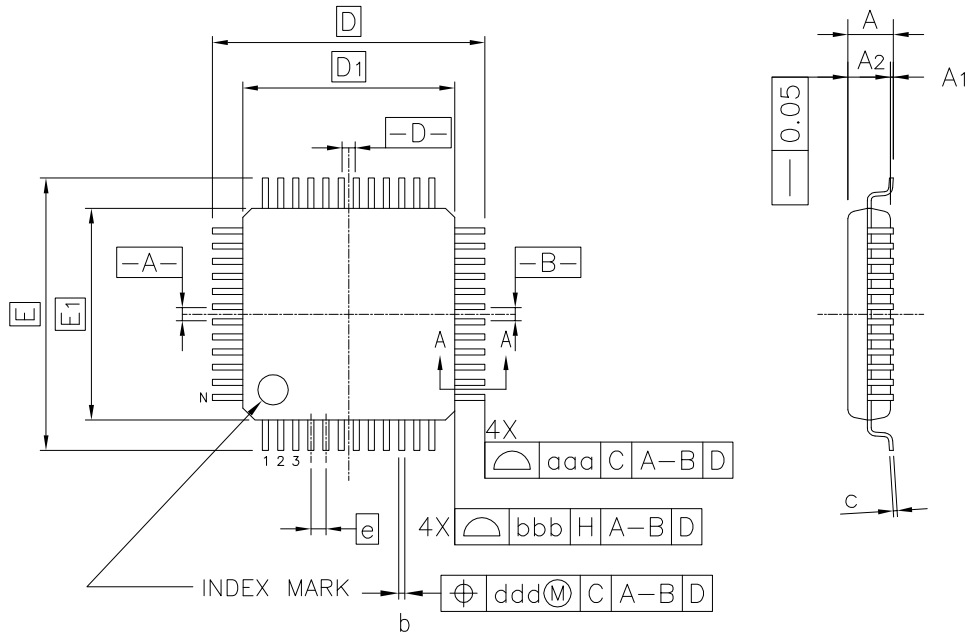


Reference Symbol	Dimensions in millimeters		
	Min	Nom	Max
D	6.9	7.0	7.1
E	6.9	7.0	7.1
A <sub>2</sub>	—	1.4	—
H <sub>D</sub>	8.8	9.0	9.2
H <sub>E</sub>	8.8	9.0	9.2
A	—	—	1.7
A <sub>1</sub>	0.05	—	0.15
b <sub>p</sub>	0.17	0.20	0.27
c	0.09	—	0.20
θ	0°	3.5°	8°
[e]	—	0.5	—
x	—	—	0.08
y	—	—	0.08
L <sub>p</sub>	0.45	0.6	0.75
L <sub>1</sub>	—	1.0	—

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Figure 2.4 LQFP 48-pin (1)

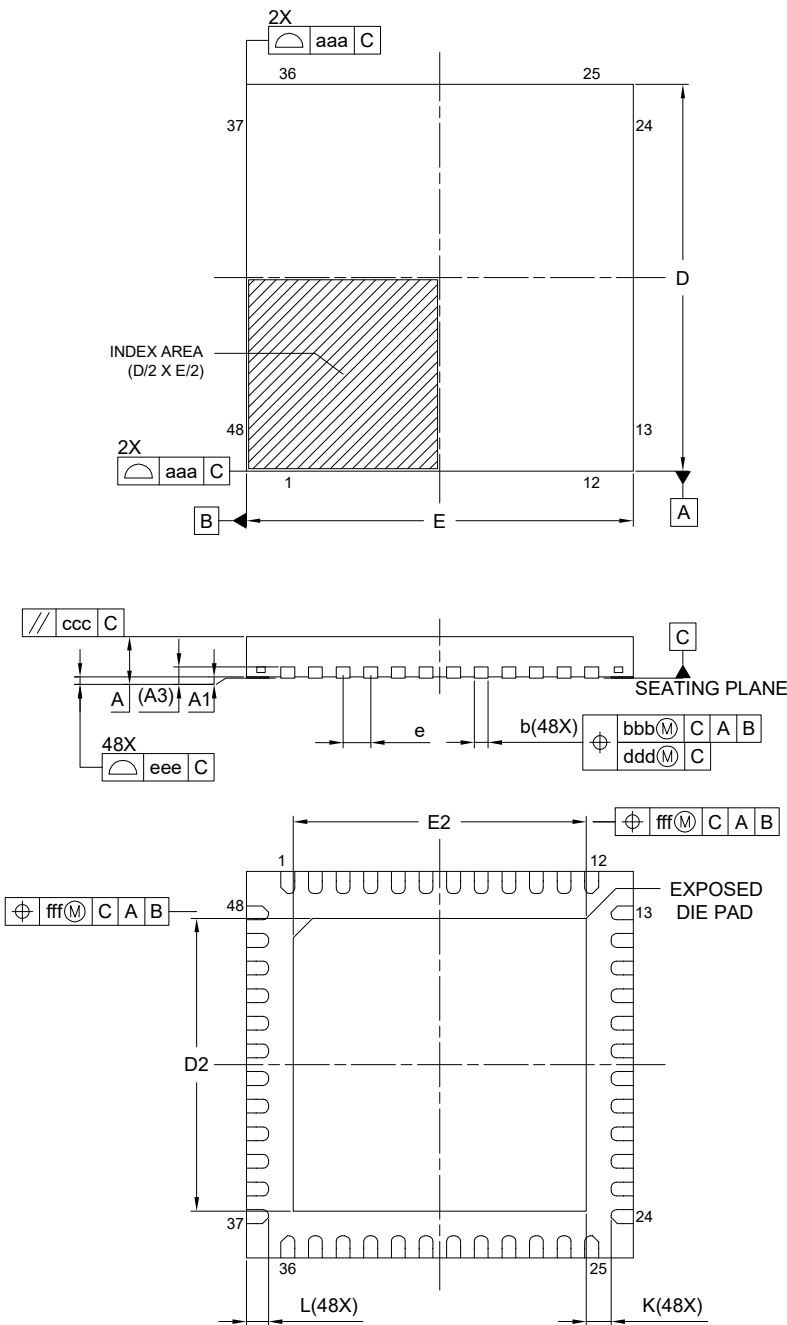
JEITA Package code	RENESAS code	MASS(TYP.)[g]
P-LFQFP48-7x7-0.50	PLQP0048KL-A	0.18



Reference Symbol	Dimension in Millimeters		
	Min.	Nom.	Max.
A	—	—	1.60
A <sub>1</sub>	0.05	—	0.15
A <sub>2</sub>	1.35	1.40	1.45
D	—	9.00	—
D <sub>1</sub>	—	7.00	—
E	—	9.00	—
E <sub>1</sub>	—	7.00	—
N	—	48	—
e	—	0.50	—
b	0.17	0.22	0.27
c	0.09	—	0.20
θ	0°	3.5°	7°
L	0.45	0.60	0.75
L <sub>1</sub>	—	1.00	—
aaa	—	—	0.20
bbb	—	—	0.20
ccc	—	—	0.08
ddd	—	—	0.08

Figure 2.5 LQFP 48-pin (2)

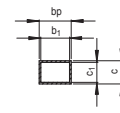
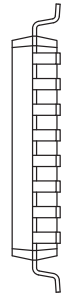
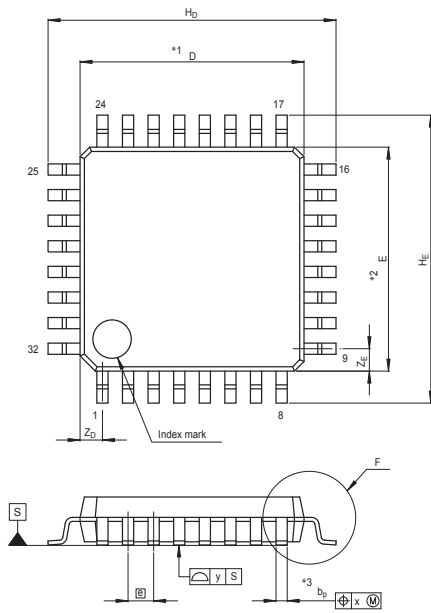
JEITA Package code	RENESAS code	MASS(TYP.)[g]
P-HWQFN048-7x7-0.50	PWQN0048KC-A	0.13 g



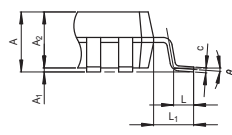
Reference Symbol	Dimension in Millimeters		
	Min.	Nom.	Max.
A	—	—	0.80
A <sub>1</sub>	0.00	0.02	0.05
A <sub>3</sub>	0.203 REF.		
b	0.20	0.25	0.30
D	7.00 BSC		
E	7.00 BSC		
e	0.50 BSC		
L	0.30	0.40	0.50
K	0.20	—	—
D <sub>2</sub>	5.25	5.30	5.35
E <sub>2</sub>	5.25	5.30	5.35
aaa	0.15		
bbb	0.10		
ccc	0.10		
ddd	0.05		
eee	0.08		
fff	0.10		

Figure 2.6 HWQFN 48-pin

JEITA Package Code	RENESAS Code	Previous Code	MASS[Typ.]
P-LQFP32-7x7-0.80	PLQP0032GB-A	32P6U-A	0.2g



Terminal cross section



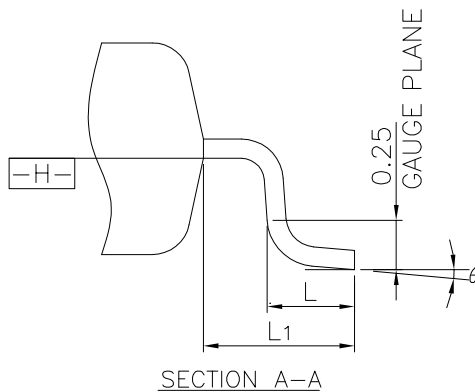
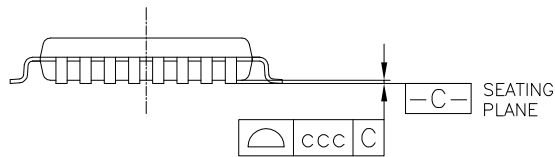
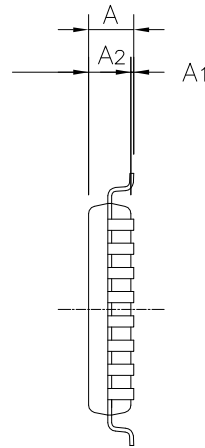
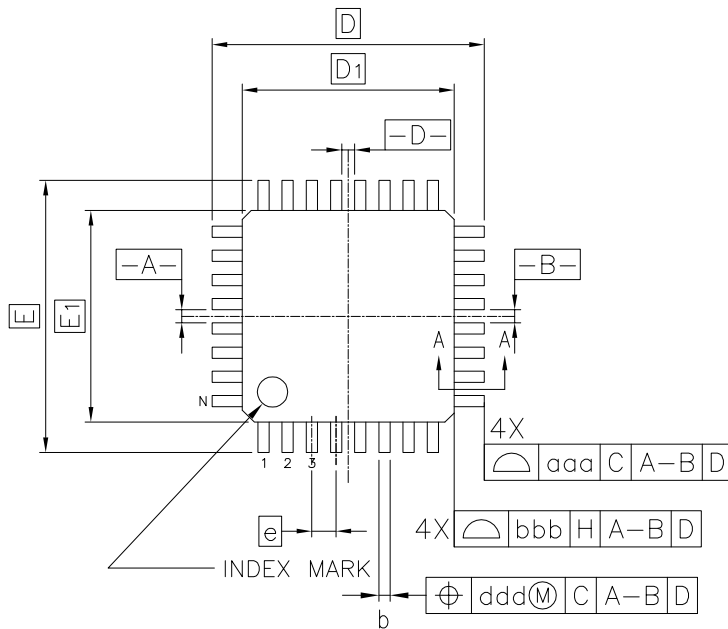
Detail F

NOTE)  
 1. DIMENSIONS \*1\* AND \*2\* DO NOT INCLUDE MOLD FLASH.  
 2. DIMENSION \*3\* DOES NOT INCLUDE TRIM OFFSET.

Reference Symbol	Dimension in Millimeters		
	Min	Nom	Max
D	6.9	7.0	7.1
E	6.9	7.0	7.1
A2	—	1.4	—
H <sub>D</sub>	8.8	9.0	9.2
H <sub>E</sub>	8.8	9.0	9.2
A	—	—	1.7
A <sub>1</sub>	0	0.1	0.2
b <sub>p</sub>	0.32	0.37	0.42
b <sub>1</sub>	—	0.35	—
c	0.09	0.145	0.20
c <sub>1</sub>	—	0.125	—
θ	0°	—	8°
⌀	—	0.8	—
x	—	—	0.20
y	—	—	0.10
Z <sub>D</sub>	—	0.7	—
Z <sub>E</sub>	—	0.7	—
L	0.3	0.5	0.7
L <sub>1</sub>	—	1.0	—

Figure 2.7 LQFP 32-pin (1)

JEITA Package code	RENESAS code	MASS(TYP.)[g]
P-LQFP32-7x7-0.80	PLQP0032GE-A	0.18



Reference Symbol	Dimension in Millimeters		
	Min.	Nom.	Max.
A	—	—	1.60
A <sub>1</sub>	0.05	—	0.15
A <sub>2</sub>	1.35	1.40	1.45
D	—	9.00	—
D <sub>1</sub>	—	7.00	—
E	—	9.00	—
E <sub>1</sub>	—	7.00	—
N	—	32	—
e	—	0.80	—
b	0.30	0.37	0.45
c	0.09	—	0.20
θ	0°	3.5°	7°
L	0.45	0.60	0.75
L <sub>1</sub>	—	1.00	—
aaa	—	—	0.20
bbb	—	—	0.20
ccc	—	—	0.10
ddd	—	—	0.20

Figure 2.8 LQFP 32-pin (2)

JEITA Package code	RENESAS code	MASS(TYP.)[g]
P-HWQFN032-5x5-0.50	PWQN0032KE-A	0.06

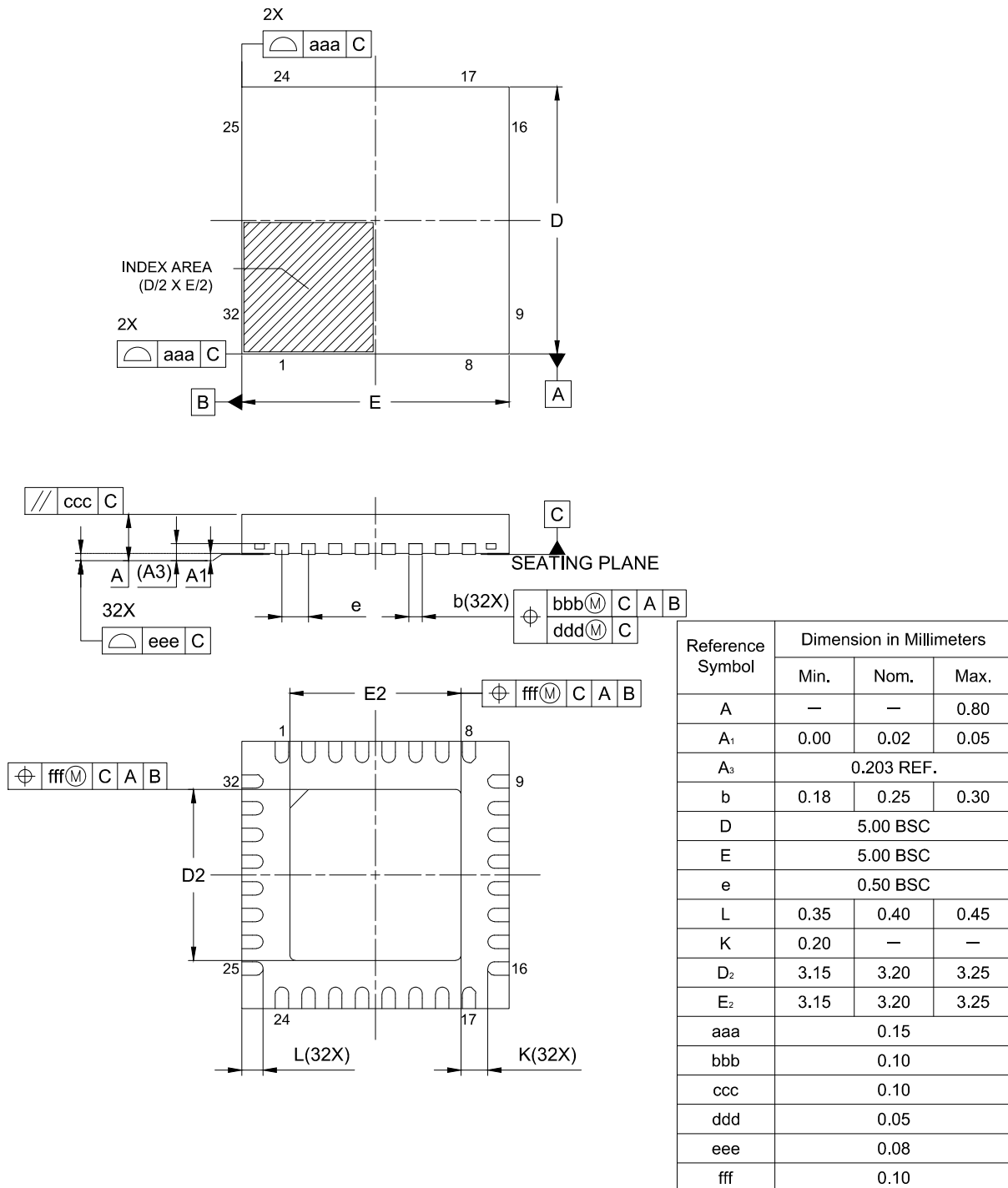
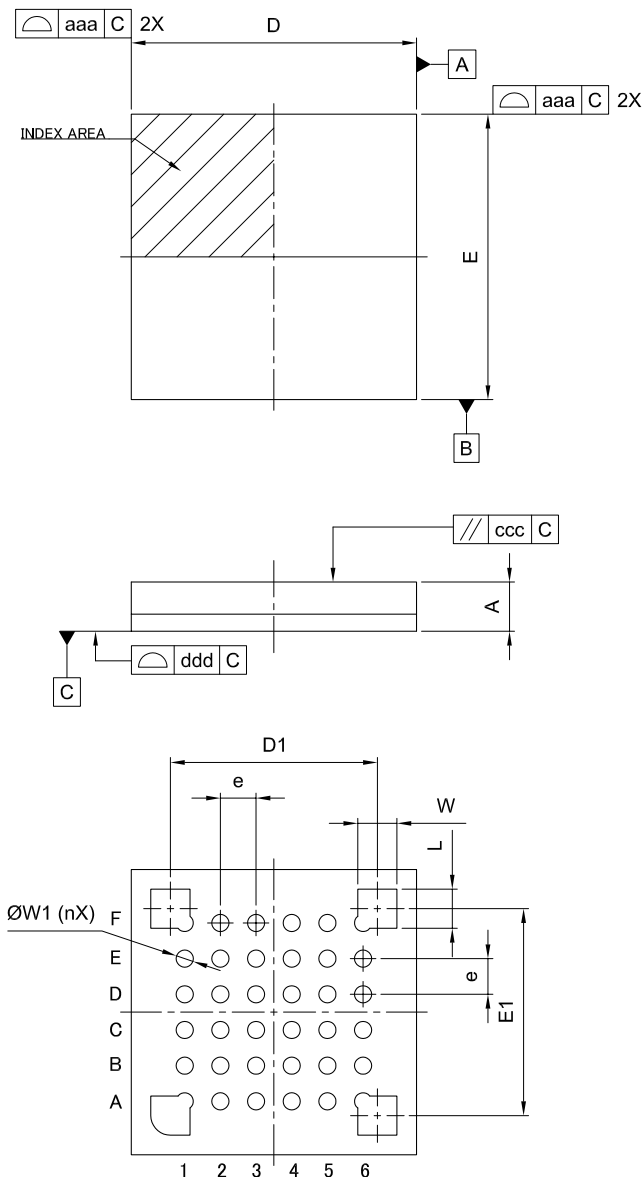


Figure 2.9 HWQFN 32-pin

JEITA Package Code	RENESAS Code	MASS (Typ.) [g]
P-WFLGA36-4 × 4-0.50	PWL0036KB-A	0.02

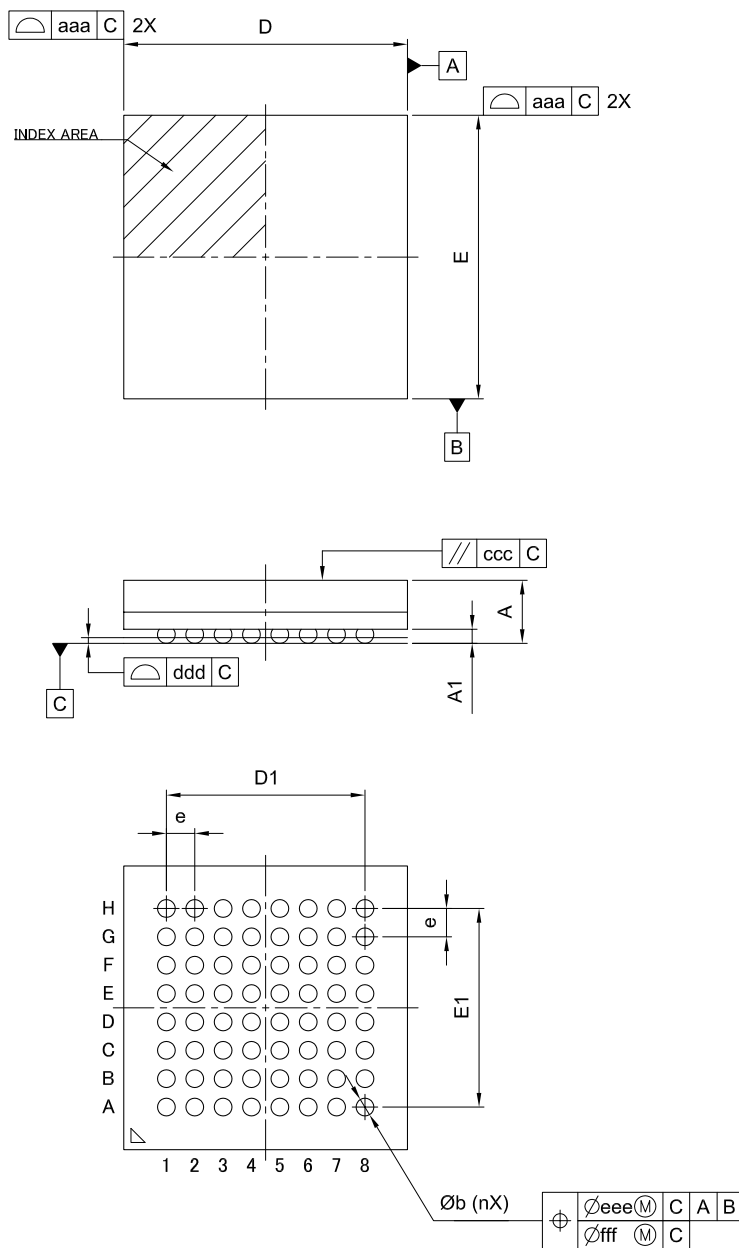


Reference Symbol	Dimension in Millimeters		
	Min.	Nom.	Max.
D	—	4.00	—
E	—	4.00	—
D1	2.90 BSC		
E1	2.90 BSC		
A	—	—	0.76
W1	0.19	0.24	0.29
W	—	0.55	—
L	—	0.55	—
e	0.50 BSC		
aaa	0.10		
ccc	0.20		
ddd	0.08		
n	—	36	—

Figure 2.10 WFLGA 36-pin



JEITA Package Code	RENESAS Code	MASS (Typ.) [g]
P-VFBGA64-4 × 4-0.40	PVBG0064LB-A	0.03



Reference Symbol	Dimension in Millimeters		
	Min.	Nom.	Max.
D	—	4.00	—
E	—	4.00	—
D1	2.80 BSC		
E1	2.80 BSC		
A	—	—	0.99
A <sub>1</sub>	0.15	0.20	0.25
b	0.20	0.25	0.30
e	0.40 BSC		
aaa	0.10		
ccc	0.10		
ddd	0.10		
eee	0.15		
fff	0.05		
n	—	64	—

Figure 2.11 VFBGA 64-pin

## Appendix 3. I/O Registers

This appendix describes I/O register addresses, access cycles, and reset values by function.

### 3.1 Peripheral Base Addresses

This section provides the base addresses for peripherals described in this manual.

Table 3.1 shows the name, description, and the base address of each peripheral.

**Table 3.1 Peripheral base address (1 of 2)**

Name	Description	Base address
MPU	Memory Protection Unit	0x4000_0000
SRAM	SRAM Control	0x4000_2000
BUS	BUS Control	0x4000_3000
DTC	Data Transfer Controller	0x4000_5400
ICU	Interrupt Controller	0x4000_6000
CPU_DBG	Debug Function	0x4001_B000
SYSC	System Control	0x4001_E000
PORT0	Port 0 Control Registers	0x4004_0000
PORT1	Port 1 Control Registers	0x4004_0020
PORT2	Port 2 Control Registers	0x4004_0040
PORT3	Port 3 Control Registers	0x4004_0060
PORT4	Port 4 Control Registers	0x4004_0080
PORT5	Port 5 Control Registers	0x4004_00A0
PORT9	Port 9 Control Registers	0x4004_0120
PFS	Pmn Pin Function Control Register	0x4004_0800
ELC	Event Link Controller	0x4004_1000
POEG	Port Output Enable Module for GPT	0x4004_2000
RTC	Realtime Clock	0x4004_4000
WDT	Watchdog Timer	0x4004_4200
IWDT	Independent Watchdog Timer	0x4004_4400
CAC	Clock Frequency Accuracy Measurement Circuit	0x4004_4600
MSTP	Module Stop Control B, C, D	0x4004_7000
IIC0	Inter-Integrated Circuit 0	0x4005_3000
IIC0WU	Inter-Integrated Circuit 0 Wakeup Unit	0x4005_3014
DOC	Data Operation Circuit	0x4005_4100
ADC12	12-bit A/D Converter	0x4005_C000
SCI0	Serial Communication Interface 0	0x4007_0000
SCI1	Serial Communication Interface 1	0x4007_0020
SCI2	Serial Communication Interface 2	0x4007_0040
SCI9	Serial Communication Interface 9	0x4007_0120
SPI0	Serial Peripheral Interface 0	0x4007_2000
CRC	CRC Calculator	0x4007_4000
GPT320	General PWM Timer 0 (32-bit)	0x4007_8000
GPT164	General PWM Timer 4 (16-bit)	0x4007_8400
GPT165	General PWM Timer 5 (16-bit)	0x4007_8500

**Table 3.1 Peripheral base address (2 of 2)**

Name	Description	Base address
GPT166	General PWM Timer 6 (16-bit)	0x4007_8600
GPT167	General PWM Timer 7 (16-bit)	0x4007_8700
GPT168	General PWM Timer 8 (16-bit)	0x4007_8800
GPT169	General PWM Timer 9 (16-bit)	0x4007_8900
GPT_OPS	Output Phase Switching Controller	0x4007_8FF0
KINT	Key Interrupt Function	0x4008_0000
CTSU	Capacitive Sensing Unit 2	0x4008_2000
AGT0	Low Power Asynchronous General Purpose Timer 0	0x4008_4000
AGT1	Low Power Asynchronous General Purpose Timer 1	0x4008_4100
ACMPLP	Low-Power Analog Comparator	0x4008_5E00
FLCN	Flash I/O Registers	0x407E_C000

Note: Name = Peripheral name  
Description = Peripheral functionality  
Base address = Lowest reserved address or address used by the peripheral

### 3.2 Access Cycles

This section provides access cycle information for the I/O registers described in this manual.

The following information applies to [Table 3.2](#):

- Registers are grouped by associated module.
- The number of access cycles indicates the number of cycles based on the specified reference clock.
- In the internal I/O area, reserved addresses that are not allocated to registers must not be accessed, otherwise operations cannot be guaranteed.
- The number of I/O access cycles depends on bus cycles of the internal peripheral bus, divided clock synchronization cycles, and wait cycles of each module. Divided clock synchronization cycles differ depending on the frequency ratio between ICLK and PCLK.
- When the frequency of ICLK is equal to that of PCLK, the number of divided clock synchronization cycles is always constant.
- When the frequency of ICLK is greater than that of PCLK, at least 1 PCLK cycle is added to the number of divided clock synchronization cycles.

Note: This applies to the number of cycles when access from the CPU does not conflict with the instruction fetching to the external memory or bus access from other bus master such as DTC.

[Table 3.2](#) shows the register access cycles for non-GPT modules.

**Table 3.2 Access cycles for non-GPT modules (1 of 2)**

Peripherals	Address		Number of access cycles				Cycle unit	Related function
			ICLK = PCLK		ICLK > PCLK*1			
			From	To	Read	Write		
MPU, SRAM, BUS, DTC, ICU, CPU_DBG	0x4000_2000	0x4001_BFFF	3				ICLK	Memory Protection Unit, SRAM, Buses, Data Transfer Controller, Interrupt Controller, CPU, Flash Memory
SYSC	0x4001_E000	0x4001_E6FF	4				ICLK	Low Power Modes, Resets, Low Voltage Detection, Clock Generation Circuit, Register Write Protection

**Table 3.2 Access cycles for non-GPT modules (2 of 2)**

Peripherals	Address		Number of access cycles				Cycle unit	Related function
			ICLK = PCLK		ICLK > PCLK*1			
	From	To	Read	Write	Read	Write		
PORTn, PFS, ELC, POEG, RTC, WDT, IWDT, CAC, MSTP	0x4004_0000	0x4004_7FFF	3		2 to 3		PCLKB	I/O Ports, Event Link Controller, Port Output Enable for GPT, Realtime Clock, Watchdog Timer, Independent Watchdog Timer, Clock Frequency Accuracy Measurement Circuit, Module Stop Control
IICn (n = 0), IIC0WU, DOC, ADC12	0x4005_0000	0x4005_EFFF	3		2 to 3		PCLKB	I <sup>2</sup> C Bus Interface, Data Operation Circuit, 12-bit A/D Converter
SCIn (n = 0 to 2, 9 <sup>2</sup> )	0x4007_0000	0x4007_0EFF	5		2 to 3		PCLKB	Serial Communications Interface
SPIIn (n = 0) <sup>3</sup>	0x4007_2000	0x4007_2FFF	5		2 to 3		PCLKB	Serial Peripheral Interface
CRC	0x4007_4000	0x4007_4FFF	3		2 to 3		PCLKB	CRC Calculator
GPT32n (n = 0), GPT16n (n = 4 to 9), GPT_OPS	0x4007_8000	0x4007_BFFF	See <a href="#">Table 3.3</a> .				PCLKB	General PWM Timer
KINT, CTSU	0x4008_0000	0x4008_2FFF	3		2 to 3		PCLKB	Key interrupt Function, Capacitive Sensing Unit 2
AGTn	0x4008_4000	0x4008_4FFF	3		2 to 3		PCLKB	Low Power Asynchronous General Purpose Timer
ACMPLP	0x4008_5000	0x4008_6FFF	3		2 to 3		PCLKB	Low-Power Analog Comparator
FLCN	0x407E_C000	0x407E_FFFF	7		7		ICLK	Data Flash, Temperature Sensor, Capacitive Sensing Unit 2, Flash Control

Note 1. If the number of PCLK cycles is non-integer (for example 1.5), the minimum value is without the decimal point, and the maximum value is rounded up to the decimal point. For example, 1.5 to 2.5 is 1 to 3.

Note 2. Regarding n = 0, when accessing a 16-bit register (FTDRHL, FRDRHL, FCR, FDR, LSR, and CDR), access is 2 cycles more than the value shown in [Table 3.2](#). When accessing an 8-bit register (FTDRH, FTDRL, FRDRH, and FRDRL), the access cycles are as shown in [Table 3.2](#).

Note 3. When accessing the 32-bit register (SPDR), access is 2 cycles more than the value in [Table 3.2](#). When accessing an 8-bit or 16-bit register (SPDR\_HA), the access cycles are as shown in [Table 3.2](#).

[Table 3.3](#) shows register access cycles for GPT modules.

**Table 3.3 Access cycles for GPT modules**

Frequency ratio between ICLK and PCLK	Number of access cycles		Cycle unit
	Read	Write	
ICLK > PCLKD = PCLKB	5 to 6	3 to 4	PCLKB
ICLK > PCLKD > PCLKB	3 to 4	2 to 3	PCLKB
PCLKD = ICLK = PCLKB	6	4	PCLKB
PCLKD = ICLK > PCLKB	2 to 3	1 to 2	PCLKB
PCLKD > ICLK = PCLKB	4	3	PCLKB
PCLKD > ICLK > PCLKB	2 to 3	1 to 2	PCLKB

### 3.3 Register Descriptions

This section provides information associated with registers described in this manual.

[Table 3.4](#) shows a list of registers including address offsets, address sizes, access rights, and reset values.

**Table 3.4 Register description (1 of 13)**

Peripheral name	Dim	Dim inc.	Dim index	Register name	Description	Address offset	Size	R/W	Reset value	Reset mask
MPU	-	-	-	MMPUCTLA	Bus Master MPU Control Register	0x000	16	R/W	0x0000	0xFFFF
MPU	-	-	-	MMPUPTA	Group A Protection of Register	0x102	16	R/W	0x0000	0xFFFF
MPU	4	0x010	0-3	MMPUACA%s	Group A Region %s access control register	0x200	16	R/W	0x0000	0xFFFF
MPU	4	0x010	0-3	MMPUSA%s	Group A Region %s Start Address Register	0x204	32	R/W	0x00000000	0x00000003
MPU	4	0x010	0-3	MMPUEA%s	Group A Region %s End Address Register	0x208	32	R/W	0x00000003	0x00000003
MPU	-	-	-	SMPUCTL	Slave MPU Control Register	0xC00	16	R/W	0x0000	0xFFFF
MPU	-	-	-	SMPUMBIU	Access Control Register for Memory Bus 1	0xC10	16	R/W	0x0000	0xFFFF
MPU	-	-	-	SMPUFBIU	Access Control Register for Internal Peripheral Bus 9	0xC14	16	R/W	0x0000	0xFFFF
MPU	-	-	-	SMPUSRAM0	Access Control Register for Memory Bus 4	0xC18	16	R/W	0x0000	0xFFFF
MPU	-	-	-	SMPUP0BIU	Access Control Register for Internal Peripheral Bus 1	0xC20	16	R/W	0x0000	0xFFFF
MPU	-	-	-	SMPUP2BIU	Access Control Register for Internal Peripheral Bus 3	0xC24	16	R/W	0x0000	0xFFFF
MPU	-	-	-	SMPUP6BIU	Access Control Register for Internal Peripheral Bus 7	0xC28	16	R/W	0x0000	0xFFFF
MPU	-	-	-	MSPMPUOAD	Stack Pointer Monitor Operation After Detection Register	0xD00	16	R/W	0x0000	0xFFFF
MPU	-	-	-	MSPMPUCTL	Stack Pointer Monitor Access Control Register	0xD04	16	R/W	0x0000	0xFEFF
MPU	-	-	-	MSPMPUPT	Stack Pointer Monitor Protection Register	0xD06	16	R/W	0x0000	0xFFFF
MPU	-	-	-	MSPMPUSA	Main Stack Pointer (MSP) Monitor Start Address Register	0xD08	32	R/W	0x00000000	0x00000000
MPU	-	-	-	MSPMPUEA	Main Stack Pointer (MSP) Monitor End Address Register	0xD0C	32	R/W	0x00000000	0x00000000
MPU	-	-	-	PSPMPUOAD	Stack Pointer Monitor Operation After Detection Register	0xD10	16	R/W	0x0000	0xFFFF
MPU	-	-	-	PSPMPUCTL	Stack Pointer Monitor Access Control Register	0xD14	16	R/W	0x0000	0xFEFF
MPU	-	-	-	PSPMPUPT	Stack Pointer Monitor Protection Register	0xD16	16	R/W	0x0000	0xFFFF
MPU	-	-	-	PSPMPUSA	Process Stack Pointer (PSP) Monitor Start Address Register	0xD18	32	R/W	0x00000000	0x00000000
MPU	-	-	-	PSPMPUEA	Process Stack Pointer (PSP) Monitor End Address Register	0xD1C	32	R/W	0x00000000	0x00000000
SRAM	-	-	-	PARIOAD	SRAM Parity Error Operation After Detection Register	0x00	8	R/W	0x00	0xFF
SRAM	-	-	-	SRAMPSCR	SRAM Protection Register	0x04	8	R/W	0x00	0xFF
BUS	-	-	-	BUSMCNTSYS	Master Bus Control Register SYS	0x1008	16	R/W	0x0000	0xFFFF
BUS	-	-	-	BUSMCNDMA	Master Bus Control Register DMA	0x100C	16	R/W	0x0000	0xFFFF
BUS	-	-	-	BUS3ERRADD	Bus Error Address Register 3	0x1820	32	R	0x00000000	0x00000000
BUS	-	-	-	BUS3ERRSTAT	BUS Error Status Register 3	0x1824	8	R	0x00	0xFE
BUS	-	-	-	BUS4ERRADD	Bus Error Address Register 4	0x1830	32	R	0x00000000	0x00000000
BUS	-	-	-	BUS4ERRSTAT	BUS Error Status Register 4	0x1834	8	R	0x00	0xFE
DTC	-	-	-	DTCCR	DTC Control Register	0x00	8	R/W	0x08	0xFF
DTC	-	-	-	DTCVBR	DTC Vector Base Register	0x04	32	R/W	0x00000000	0xFFFFFFFF
DTC	-	-	-	DTCST	DTC Module Start Register	0x0C	8	R/W	0x00	0xFF
DTC	-	-	-	DTCSTS	DTC Status Register	0x0E	16	R	0x0000	0xFFFF
ICU	8	0x1	0-7	IRQCR%s	IRQ Control Register	0x000	8	R/W	0x00	0xFF
ICU	-	-	-	NMICR	NMI Pin Interrupt Control Register	0x100	8	R/W	0x00	0xFF
ICU	-	-	-	NMIER	Non-Maskable Interrupt Enable Register	0x120	16	R/W	0x0000	0xFFFF









Table 3.4 Register description (5 of 13)

Peripheral name	Dim	Dim inc.	Dim index	Register name	Description	Address offset	Size	R/W	Reset value	Reset mask
ELC	2	0x04	14-15	ELSR%s	Event Link Setting Register %s	0x48	16	R/W	0x0000	0xFFFF
ELC	-	-	-	ELSR18	Event Link Setting Register 18	0x58	16	R/W	0x0000	0xFFFF
POEG	-	-	-	POEGGA	POEG Group A Setting Register	0x000	32	R/W	0x00000000	0xFFFFFFFF
POEG	-	-	-	POEGGB	POEG Group B Setting Register	0x100	32	R/W	0x00000000	0xFFFFFFFF
RTC	-	-	-	R64CNT	64-Hz Counter	0x00	8	R	0x00	0x00
RTC	4	0x02	0-3	BCNT%s	Binary Counter %s	0x02	8	R/W	0x00	0x00
RTC	-	-	-	RSECCNT	Second Counter (in Calendar Count Mode)	0x02	8	R/W	0x00	0x00
RTC	-	-	-	RMINCNT	Minute Counter (in Calendar Count Mode)	0x04	8	R/W	0x00	0x00
RTC	-	-	-	RHRCNT	Hour Counter (in Calendar Count Mode)	0x06	8	R/W	0x00	0x00
RTC	-	-	-	RWKCNT	Day-of-Week Counter (in Calendar Count Mode)	0x08	8	R/W	0x00	0x00
RTC	-	-	-	RDAYCNT	Day Counter	0x0A	8	R/W	0x00	0xC0
RTC	-	-	-	RMONCNT	Month Counter	0x0C	8	R/W	0x00	0xE0
RTC	-	-	-	RYRCNT	Year Counter	0x0E	16	R/W	0x0000	0xFF00
RTC	4	0x02	0-3	BCNT%sAR	Binary Counter %s Alarm Register	0x10	8	R/W	0x00	0x00
RTC	-	-	-	RSECAR	Second Alarm Register (in Calendar Count Mode)	0x10	8	R/W	0x00	0x00
RTC	-	-	-	RMINAR	Minute Alarm Register (in Calendar Count Mode)	0x12	8	R/W	0x00	0x00
RTC	-	-	-	RHRAR	Hour Alarm Register (in Calendar Count Mode)	0x14	8	R/W	0x00	0x00
RTC	-	-	-	RWKAR	Day-of-Week Alarm Register (in Calendar Count Mode)	0x16	8	R/W	0x00	0x00
RTC	2	0x02	0-1	BCNT%sAER	Binary Counter %s Alarm Enable Register	0x18	8	R/W	0x00	0x00
RTC	-	-	-	RDAYAR	Date Alarm Register (in Calendar Count Mode)	0x18	8	R/W	0x00	0x00
RTC	-	-	-	RMONAR	Month Alarm Register (in Calendar Count Mode)	0x1A	8	R/W	0x00	0x00
RTC	-	-	-	BCNT2AER	Binary Counter 2 Alarm Enable Register	0x1C	16	R/W	0x0000	0xFF00
RTC	-	-	-	RYRAR	Year Alarm Register (in Calendar Count Mode)	0x1C	16	R/W	0x0000	0xFF00
RTC	-	-	-	BCNT3AER	Binary Counter 3 Alarm Enable Register	0x1E	8	R/W	0x00	0x00
RTC	-	-	-	RYRAREN	Year Alarm Enable Register (in Calendar Count Mode)	0x1E	8	R/W	0x00	0x00
RTC	-	-	-	RCR1	RTC Control Register 1	0x22	8	R/W	0x00	0x0A
RTC	-	-	-	RCR2	RTC Control Register 2 (in Calendar Count Mode)	0x24	8	R/W	0x00	0x0E
RTC	-	-	-	RCR2	RTC Control Register 2 (in Binary Count Mode)	0x24	8	R/W	0x00	0x0E
RTC	-	-	-	RCR4	RTC Control Register 4	0x28	8	R/W	0x00	0x7E
RTC	-	-	-	RFRH	Frequency Register H	0x2A	16	R/W	0x0000	0xFFFE
RTC	-	-	-	RFRL	Frequency Register L	0x2C	16	R/W	0x0000	0x0000
RTC	-	-	-	RADJ	Time Error Adjustment Register	0x2E	8	R/W	0x00	0x00
WDT	-	-	-	WDTRR	WDT Refresh Register	0x00	8	R/W	0xFF	0xFF
WDT	-	-	-	WDTCR	WDT Control Register	0x02	16	R/W	0x0000	0xFFFF
WDT	-	-	-	WDTSR	WDT Status Register	0x04	16	R/W	0x0000	0xFFFF
WDT	-	-	-	WDTRCR	WDT Reset Control Register	0x06	8	R/W	0x80	0xFF
WDT	-	-	-	WDTCSNPR	WDT Count Stop Control Register	0x08	8	R/W	0x80	0xFF
IWDT	-	-	-	IWDTTRR	IWDT Refresh Register	0x00	8	R/W	0xFF	0xFF
IWDT	-	-	-	IWDTSR	IWDT Status Register	0x04	16	R/W	0x0000	0xFFFF

Table 3.4 Register description (6 of 13)

Peripheral name	Dim	Dim inc.	Dim index	Register name	Description	Address offset	Size	R/W	Reset value	Reset mask
CAC	-	-	-	CACR0	CAC Control Register 0	0x00	8	R/W	0x00	0xFF
CAC	-	-	-	CACR1	CAC Control Register 1	0x01	8	R/W	0x00	0xFF
CAC	-	-	-	CACR2	CAC Control Register 2	0x02	8	R/W	0x00	0xFF
CAC	-	-	-	CAICR	CAC Interrupt Control Register	0x03	8	R/W	0x00	0xFF
CAC	-	-	-	CASTR	CAC Status Register	0x04	8	R	0x00	0xFF
CAC	-	-	-	CAULVR	CAC Upper-Limit Value Setting Register	0x06	16	R/W	0x0000	0xFFFF
CAC	-	-	-	CALLVR	CAC Lower-Limit Value Setting Register	0x08	16	R/W	0x0000	0xFFFF
CAC	-	-	-	CACNTBR	CAC Counter Buffer Register	0x0A	16	R	0x0000	0xFFFF
MSTP	-	-	-	MSTPCRB	Module Stop Control Register B	0x000	32	R/W	0xFFFFFFFF	0xFFFFFFFF
MSTP	-	-	-	MSTPCRC	Module Stop Control Register C	0x004	32	R/W	0xFFFFFFFF	0xFFFFFFFF
MSTP	-	-	-	MSTPCRD	Module Stop Control Register D	0x008	32	R/W	0xFFFFFFFF	0xFFFFFFFF
IIC0	-	-	-	ICCR1	I2C Bus Control Register 1	0x00	8	R/W	0x1F	0xFF
IIC0	-	-	-	ICCR2	I2C Bus Control Register 2	0x01	8	R/W	0x00	0xFF
IIC0	-	-	-	ICMR1	I2C Bus Mode Register 1	0x02	8	R/W	0x08	0xFF
IIC0	-	-	-	ICMR2	I2C Bus Mode Register 2	0x03	8	R/W	0x06	0xFF
IIC0	-	-	-	ICMR3	I2C Bus Mode Register 3	0x04	8	R/W	0x00	0xFF
IIC0	-	-	-	ICFER	I2C Bus Function Enable Register	0x05	8	R/W	0x72	0xFF
IIC0	-	-	-	ICSER	I2C Bus Status Enable Register	0x06	8	R/W	0x09	0xFF
IIC0	-	-	-	ICIER	I2C Bus Interrupt Enable Register	0x07	8	R/W	0x00	0xFF
IIC0	-	-	-	ICSR1	I2C Bus Status Register 1	0x08	8	R/W	0x00	0xFF
IIC0	-	-	-	ICSR2	I2C Bus Status Register 2	0x09	8	R/W	0x00	0xFF
IIC0	3	0x02	0-2	SARL%s	Slave Address Register Ly	0x0A	8	R/W	0x00	0xFF
IIC0	3	0x02	0-2	SARU%s	Slave Address Register Uy	0x0B	8	R/W	0x00	0xFF
IIC0	-	-	-	ICBRL	I2C Bus Bit Rate Low-Level Register	0x10	8	R/W	0xFF	0xFF
IIC0	-	-	-	ICBRH	I2C Bus Bit Rate High-Level Register	0x11	8	R/W	0xFF	0xFF
IIC0	-	-	-	ICDRT	I2C Bus Transmit Data Register	0x12	8	R/W	0xFF	0xFF
IIC0	-	-	-	ICDRR	I2C Bus Receive Data Register	0x13	8	R	0x00	0xFF
IIC0WU	-	-	-	ICWUR	I2C Bus Wakeup Unit Register	0x02	8	R/W	0x10	0xFF
IIC0WU	-	-	-	ICWUR2	I2C Bus Wakeup Unit Register 2	0x03	8	R/W	0xFD	0xFF
DOC	-	-	-	DOCR	DOC Control Register	0x00	8	R/W	0x00	0xFF
DOC	-	-	-	DODIR	DOC Data Input Register	0x02	16	R/W	0x0000	0xFFFF
DOC	-	-	-	DODSR	DOC Data Setting Register	0x04	16	R/W	0x0000	0xFFFF
ADC12	-	-	-	ADCSR	A/D Control Register	0x000	16	R/W	0x0000	0xFFFF
ADC12	-	-	-	ADANSA0	A/D Channel Select Register A0	0x004	16	R/W	0x0000	0xFFFF
ADC12	-	-	-	ADANSA1	A/D Channel Select Register A1	0x006	16	R/W	0x0000	0xFFFF
ADC12	-	-	-	ADADS0	A/D-Converted Value Addition/Average Channel Select Register 0	0x008	16	R/W	0x0000	0xFFFF
ADC12	-	-	-	ADADS1	A/D-Converted Value Addition/Average Channel Select Register 1	0x00A	16	R/W	0x0000	0xFFFF
ADC12	-	-	-	ADADC	A/D-Converted Value Addition/Average Count Select Register	0x00C	8	R/W	0x00	0xFF
ADC12	-	-	-	ADCER	A/D Control Extended Register	0x00E	16	R/W	0x0000	0xFFFF
ADC12	-	-	-	ADSTRGR	A/D Conversion Start Trigger Select Register	0x010	16	R/W	0x0000	0xFFFF
ADC12	-	-	-	ADEXICR	A/D Conversion Extended Input Control Registers	0x012	16	R/W	0x0000	0xFFFF
ADC12	-	-	-	ADANSB0	A/D Channel Select Register B0	0x014	16	R/W	0x0000	0xFFFF
ADC12	-	-	-	ADANSB1	A/D Channel Select Register B1	0x016	16	R/W	0x0000	0xFFFF

Table 3.4 Register description (7 of 13)

Peripheral name	Dim	Dim inc.	Dim index	Register name	Description	Address offset	Size	R/W	Reset value	Reset mask
ADC12	-	-	-	ADDBLDR	A/D Data Duplexing Register	0x018	16	R	0x0000	0xFFFF
ADC12	-	-	-	ADTSDR	A/D Temperature Sensor Data Register	0x01A	16	R	0x0000	0xFFFF
ADC12	-	-	-	ADOCDR	A/D Internal Reference Voltage Data Register	0x01C	16	R	0x0000	0xFFFF
ADC12	-	-	-	ADRD	A/D Self-Diagnosis Data Register	0x01E	16	R	0x0000	0xFFFF
ADC12	11	0x2	0-10	ADDR%s	A/D Data Registers %s	0x020	16	R	0x0000	0xFFFF
ADC12	-	-	-	ADCTDR	A/D CTSU TSCAP Voltage Data Register	0x040	16	R	0x0000	0xFFFF
ADC12	6	0x2	17-22	ADDR%s	A/D Data Registers %s	0x042	16	R	0x0000	0xFFFF
ADC12	-	-	-	ADDISCR	A/D Disconnection Detection Control Register	0x07A	8	R/W	0x00	0xFF
ADC12	-	-	-	ADACSR	A/D Conversion Operation Mode Select Register	0x07E	8	R/W	0x00	0xFF
ADC12	-	-	-	ADGSPCR	A/D Group Scan Priority Control Register	0x080	16	R/W	0x0000	0xFFFF
ADC12	-	-	-	ADDBLDRA	A/D Data Duplexing Register A	0x084	16	R	0x0000	0xFFFF
ADC12	-	-	-	ADDBLDRB	A/D Data Duplexing Register B	0x086	16	R	0x0000	0xFFFF
ADC12	-	-	-	ADHVREFCNT	A/D High-Potential/Low-Potential Reference Voltage Control Register	0x08A	8	R/W	0x00	0xFF
ADC12	-	-	-	ADWINMON	A/D Compare Function Window A/B Status Monitor Register	0x08C	8	R	0x00	0xFF
ADC12	-	-	-	ADCMPCR	A/D Compare Function Control Register	0x090	16	R/W	0x0000	0xFFFF
ADC12	-	-	-	ADCMPANSER	A/D Compare Function Window A Extended Input Select Register	0x092	8	R/W	0x00	0xFF
ADC12	-	-	-	ADCMPLER	A/D Compare Function Window A Extended Input Comparison Condition Setting Register	0x093	8	R/W	0x00	0xFF
ADC12	-	-	-	ADCMPANSR0	A/D Compare Function Window A Channel Select Register 0	0x094	16	R/W	0x0000	0xFFFF
ADC12	-	-	-	ADCMPANSR1	A/D Compare Function Window A Channel Select Register 1	0x096	16	R/W	0x0000	0xFFFF
ADC12	-	-	-	ADCMPLR0	A/D Compare Function Window A Comparison Condition Setting Register 0	0x098	16	R/W	0x0000	0xFFFF
ADC12	-	-	-	ADCMPLR1	A/D Compare Function Window A Comparison Condition Setting Register 1	0x09A	16	R/W	0x0000	0xFFFF
ADC12	2	0x2	0-1	ADCMPDR%s	A/D Compare Function Window A Lower-Side/Upper-Side Level Setting Register	0x09C	16	R/W	0x0000	0xFFFF
ADC12	-	-	-	ADCMPSR0	A/D Compare Function Window A Channel Status Register 0	0x0A0	16	R/W	0x0000	0xFFFF
ADC12	-	-	-	ADCMPSR1	A/D Compare Function Window A Channel Status Register1	0x0A2	16	R/W	0x0000	0xFFFF
ADC12	-	-	-	ADCMPSER	A/D Compare Function Window A Extended Input Channel Status Register	0x0A4	8	R/W	0x00	0xFF
ADC12	-	-	-	ADCMPBNSR	A/D Compare Function Window B Channel Select Register	0x0A6	8	R/W	0x00	0xFF
ADC12	-	-	-	ADWINLLB	A/D Compare Function Window B Lower-Side/Upper-Side Level Setting Register	0x0A8	16	R/W	0x0000	0xFFFF
ADC12	-	-	-	ADWINULB	A/D Compare Function Window B Lower-Side/Upper-Side Level Setting Register	0x0AA	16	R/W	0x0000	0xFFFF
ADC12	-	-	-	ADCMPBSR	A/D Compare Function Window B Status Register	0x0AC	8	R/W	0x00	0xFF
ADC12	-	-	-	ADSSTRL	A/D Sampling State Register	0x0DD	8	R/W	0x0D	0xFF
ADC12	-	-	-	ADSSTRT	A/D Sampling State Register	0x0DE	8	R/W	0x0D	0xFF
ADC12	-	-	-	ADSSTRO	A/D Sampling State Register	0x0DF	8	R/W	0x0D	0xFF
ADC12	11	0x1	0-10	ADSSTR%s	A/D Sampling State Register	0x0E0	8	R/W	0x0D	0xFF

Table 3.4 Register description (8 of 13)

Peripheral name	Dim	Dim inc.	Dim index	Register name	Description	Address offset	Size	R/W	Reset value	Reset mask
SCI0	-	-	-	SMR	Serial Mode Register for Non-Smart Card Interface Mode (SCMR.SMIF = 0)	0x00	8	R/W	0x00	0xFF
SCI0	-	-	-	SMR_SMC1	Serial Mode Register for Smart Card Interface Mode (SCMR.SMIF = 1)	0x00	8	R/W	0x00	0xFF
SCI0	-	-	-	BRR	Bit Rate Register	0x01	8	R/W	0xFF	0xFF
SCI0	-	-	-	SCR	Serial Control Register for Non-Smart Card Interface Mode (SCMR.SMIF = 0)	0x02	8	R/W	0x00	0xFF
SCI0	-	-	-	SCR_SMC1	Serial Control Register for Smart Card Interface Mode (SCMR.SMIF = 1)	0x02	8	R/W	0x00	0xFF
SCI0	-	-	-	TDR	Transmit Data Register	0x03	8	R/W	0xFF	0xFF
SCI0	-	-	-	SSR	Serial Status Register for Non-Smart Card Interface and Non-FIFO Mode (SCMR.SMIF = 0 and FCR.FM = 0)	0x04	8	R/W	0x84	0xFF
SCI0	-	-	-	SSR_FIFO	Serial Status Register for Non-Smart Card Interface and FIFO Mode (SCMR.SMIF = 0 and FCR.FM = 1)	0x04	8	R/W	0x80	0xFD
SCI0	-	-	-	SSR_SMC1	Serial Status Register for Smart Card Interface Mode (SCMR.SMIF = 1)	0x04	8	R/W	0x84	0xFF
SCI0	-	-	-	RDR	Receive Data Register	0x05	8	R/W	0x00	0xFF
SCI0	-	-	-	SCMR	Smart Card Mode Register	0x06	8	R/W	0xF2	0xFF
SCI0	-	-	-	SEMR	Serial Extended Mode Register	0x07	8	R/W	0x00	0xFF
SCI0	-	-	-	SNFR	Noise Filter Setting Register	0x08	8	R/W	0x00	0xFF
SCI0	-	-	-	SIMR1	IIC Mode Register 1	0x09	8	R/W	0x00	0xFF
SCI0	-	-	-	SIMR2	IIC Mode Register 2	0x0A	8	R/W	0x00	0xFF
SCI0	-	-	-	SIMR3	IIC Mode Register 3	0x0B	8	R/W	0x00	0xFF
SCI0	-	-	-	SISR	IIC Status Register	0x0C	8	R	0x00	0xCB
SCI0	-	-	-	SPMR	SPI Mode Register	0x0D	8	R/W	0x00	0xFF
SCI0	-	-	-	TDRHL	Transmit Data Register	0x0E	16	R/W	0xFFFF	0xFFFF
SCI0	-	-	-	FRDRHL	Receive FIFO Data Register	0x10	16	R	0x0000	0xFFFF
SCI0	-	-	-	FTDRHL	Transmit FIFO Data Register	0x0E	16	W	0xFFFF	0xFFFF
SCI0	-	-	-	RDRHL	Receive Data Register	0x10	16	R	0x0000	0xFFFF
SCI0	-	-	-	FRDRH	Receive FIFO Data Register	0x10	8	R	0x00	0xFF
SCI0	-	-	-	FTDRH	Transmit FIFO Data Register	0x0E	8	W	0xFF	0xFF
SCI0	-	-	-	FRDRL	Receive FIFO Data Register	0x11	8	R	0x00	0xFF
SCI0	-	-	-	FTDRL	Transmit FIFO Data Register	0x0F	8	W	0xFF	0xFF
SCI0	-	-	-	MDDR	Modulation Duty Register	0x12	8	R/W	0xFF	0xFF
SCI0	-	-	-	DCCR	Data Compare Match Control Register	0x13	8	R/W	0x40	0xFF
SCI0	-	-	-	FCR	FIFO Control Register	0x14	16	R/W	0xF800	0xFFFF
SCI0	-	-	-	FDR	FIFO Data Count Register	0x16	16	R	0x0000	0xFFFF
SCI0	-	-	-	LSR	Line Status Register	0x18	16	R	0x0000	0xFFFF
SCI0	-	-	-	CDR	Compare Match Data Register	0x1A	16	R/W	0x0000	0xFFFF
SCI0	-	-	-	SPTR	Serial Port Register	0x1C	8	R/W	0x03	0xFF
SCI1-2,9	-	-	-	SMR	Serial Mode Register for Non-Smart Card Interface Mode (SCMR.SMIF = 0)	0x00	8	R/W	0x00	0xFF
SCI1-2,9	-	-	-	SMR_SMC1	Serial Mode Register for Smart Card Interface Mode (SCMR.SMIF = 1)	0x00	8	R/W	0x00	0xFF
SCI1-2,9	-	-	-	BRR	Bit Rate Register	0x01	8	R/W	0xFF	0xFF
SCI1-2,9	-	-	-	SCR	Serial Control Register for Non-Smart Card Interface Mode (SCMR.SMIF = 0)	0x02	8	R/W	0x00	0xFF
SCI1-2,9	-	-	-	SCR_SMC1	Serial Control Register for Smart Card Interface Mode (SCMR.SMIF = 1)	0x02	8	R/W	0x00	0xFF

Table 3.4 Register description (9 of 13)

Peripheral name	Dim	Dim inc.	Dim index	Register name	Description	Address offset	Size	R/W	Reset value	Reset mask
SCI1-2,9	-	-	-	TDR	Transmit Data Register	0x03	8	R/W	0xFF	0xFF
SCI1-2,9	-	-	-	SSR	Serial Status Register for Non-Smart Card Interface and Non-FIFO Mode (SCMR.SMIF = 0 and FCR.FM = 0)	0x04	8	R/W	0x84	0xFF
SCI1-2,9	-	-	-	SSR_SMCI	Serial Status Register for Smart Card Interface Mode (SCMR.SMIF = 1)	0x04	8	R/W	0x84	0xFF
SCI1-2,9	-	-	-	RDR	Receive Data Register	0x05	8	R/W	0x00	0xFF
SCI1-2,9	-	-	-	SCMR	Smart Card Mode Register	0x06	8	R/W	0xF2	0xFF
SCI1-2,9	-	-	-	SEMR	Serial Extended Mode Register	0x07	8	R/W	0x00	0xFF
SCI1-2,9	-	-	-	SNFR	Noise Filter Setting Register	0x08	8	R/W	0x00	0xFF
SCI1-2,9	-	-	-	SIMR1	IIC Mode Register 1	0x09	8	R/W	0x00	0xFF
SCI1-2,9	-	-	-	SIMR2	IIC Mode Register 2	0x0A	8	R/W	0x00	0xFF
SCI1-2,9	-	-	-	SIMR3	IIC Mode Register 3	0x0B	8	R/W	0x00	0xFF
SCI1-2,9	-	-	-	SISR	IIC Status Register	0x0C	8	R	0x00	0xCB
SCI1-2,9	-	-	-	SPMR	SPI Mode Register	0x0D	8	R/W	0x00	0xFF
SCI1-2,9	-	-	-	TDRHL	Transmit Data Register	0x0E	16	R/W	0xFFFF	0xFFFF
SCI1-2,9	-	-	-	RDRHL	Receive Data Register	0x10	16	R	0x0000	0xFFFF
SCI1-2,9	-	-	-	MDDR	Modulation Duty Register	0x12	8	R/W	0xFF	0xFF
SCI1-2,9	-	-	-	DCCR	Data Compare Match Control Register	0x13	8	R/W	0x40	0xFF
SCI1-2,9	-	-	-	CDR	Compare Match Data Register	0x1A	16	R/W	0x0000	0xFFFF
SCI1-2,9	-	-	-	SPTR	Serial Port Register	0x1C	8	R/W	0x03	0xFF
SPI0	-	-	-	SPCR	SPI Control Register	0x00	8	R/W	0x00	0xFF
SPI0	-	-	-	SSLP	SPI Slave Select Polarity Register	0x01	8	R/W	0x00	0xFF
SPI0	-	-	-	SPPCR	SPI Pin Control Register	0x02	8	R/W	0x00	0xFF
SPI0	-	-	-	SPSR	SPI Status Register	0x03	8	R/W	0x20	0xFF
SPI0	-	-	-	SPDR	SPI Data Register	0x04	32	R/W	0x00000000	0xFFFFFFFF
SPI0	-	-	-	SPDR_HA	SPI Data Register	0x04	16	R/W	0x0000	0xFFFF
SPI0	-	-	-	SPBR	SPI Bit Rate Register	0x0A	8	R/W	0xFF	0xFF
SPI0	-	-	-	SPDCR	SPI Data Control Register	0x0B	8	R/W	0x00	0xFF
SPI0	-	-	-	SPCKD	SPI Clock Delay Register	0x0C	8	R/W	0x00	0xFF
SPI0	-	-	-	SSLND	SPI Slave Select Negation Delay Register	0x0D	8	R/W	0x00	0xFF
SPI0	-	-	-	SPND	SPI Next-Access Delay Register	0x0E	8	R/W	0x00	0xFF
SPI0	-	-	-	SPCR2	SPI Control Register 2	0x0F	8	R/W	0x00	0xFF
SPI0	-	-	-	SPCMD0	SPI Command Register 0	0x10	16	R/W	0x070D	0xFFFF
CRC	-	-	-	CRCCR0	CRC Control Register 0	0x00	8	R/W	0x00	0xFF
CRC	-	-	-	CRCCR1	CRC Control Register 1	0x01	8	R/W	0x00	0xFF
CRC	-	-	-	CRCDIR	CRC Data Input Register	0x04	32	R/W	0x00000000	0xFFFFFFFF
CRC	-	-	-	CRCDIR_BY	CRC Data Input Register	0x04	8	R/W	0x00	0xFF
CRC	-	-	-	CRCDOR	CRC Data Output Register	0x08	32	R/W	0x00000000	0xFFFFFFFF
CRC	-	-	-	CRCDOR_HA	CRC Data Output Register	0x08	16	R/W	0x0000	0xFFFF
CRC	-	-	-	CRCDOR_BY	CRC Data Output Register	0x08	8	R/W	0x00	0xFF
CRC	-	-	-	CRCSAR	Snoop Address Register	0x0C	16	R/W	0x0000	0xFFFF
GPT320	-	-	-	GTWP	General PWM Timer Write-Protection Register	0x00	32	R/W	0x00000000	0xFFFFFFFF
GPT320	-	-	-	GTSTR	General PWM Timer Software Start Register	0x04	32	R/W	0x00000000	0xFFFFFFFF
GPT320	-	-	-	GTSTP	General PWM Timer Software Stop Register	0x08	32	R/W	0xFFFFFFFF	0xFFFFFFFF

Table 3.4 Register description (10 of 13)

Peripheral name	Dim	Dim inc.	Dim index	Register name	Description	Address offset	Size	R/W	Reset value	Reset mask
GPT320	-	-	-	GTCLR	General PWM Timer Software Clear Register	0x0C	32	W	0x00000000	0xFFFFFFFF
GPT320	-	-	-	GTSSR	General PWM Timer Start Source Select Register	0x10	32	R/W	0x00000000	0xFFFFFFFF
GPT320	-	-	-	GTCSR	General PWM Timer Stop Source Select Register	0x14	32	R/W	0x00000000	0xFFFFFFFF
GPT320	-	-	-	GTCSR	General PWM Timer Clear Source Select Register	0x18	32	R/W	0x00000000	0xFFFFFFFF
GPT320	-	-	-	GTUPSR	General PWM Timer Up Count Source Select Register	0x1C	32	R/W	0x00000000	0xFFFFFFFF
GPT320	-	-	-	GTDNSR	General PWM Timer Down Count Source Select Register	0x20	32	R/W	0x00000000	0xFFFFFFFF
GPT320	-	-	-	GTICASR	General PWM Timer Input Capture Source Select Register A	0x24	32	R/W	0x00000000	0xFFFFFFFF
GPT320	-	-	-	GTICBSR	General PWM Timer Input Capture Source Select Register B	0x28	32	R/W	0x00000000	0xFFFFFFFF
GPT320	-	-	-	GTCR	General PWM Timer Control Register	0x2C	32	R/W	0x00000000	0xFFFFFFFF
GPT320	-	-	-	GTUDDTYC	General PWM Timer Count Direction and Duty Setting Register	0x30	32	R/W	0x00000001	0xFFFFFFFF
GPT320	-	-	-	GTIOR	General PWM Timer I/O Control Register	0x34	32	R/W	0x00000000	0xFFFFFFFF
GPT320	-	-	-	GTINTAD	General PWM Timer Interrupt Output Setting Register	0x38	32	R/W	0x00000000	0xFFFFFFFF
GPT320	-	-	-	GTST	General PWM Timer Status Register	0x3C	32	R/W	0x00008000	0xFFFFFFFF
GPT320	-	-	-	GTBER	General PWM Timer Buffer Enable Register	0x40	32	R/W	0x00000000	0xFFFFFFFF
GPT320	-	-	-	GTCNT	General PWM Timer Counter	0x48	32	R/W	0x00000000	0xFFFFFFFF
GPT320	-	-	-	GTCCRA	General PWM Timer Compare Capture Register A	0x4C	32	R/W	0xFFFFFFFF	0xFFFFFFFF
GPT320	-	-	-	GTCCRB	General PWM Timer Compare Capture Register B	0x50	32	R/W	0xFFFFFFFF	0xFFFFFFFF
GPT320	-	-	-	GTCCRC	General PWM Timer Compare Capture Register C	0x54	32	R/W	0xFFFFFFFF	0xFFFFFFFF
GPT320	-	-	-	GTCCRE	General PWM Timer Compare Capture Register E	0x58	32	R/W	0xFFFFFFFF	0xFFFFFFFF
GPT320	-	-	-	GTCCRD	General PWM Timer Compare Capture Register D	0x5C	32	R/W	0xFFFFFFFF	0xFFFFFFFF
GPT320	-	-	-	GTCCRF	General PWM Timer Compare Capture Register F	0x60	32	R/W	0xFFFFFFFF	0xFFFFFFFF
GPT320	-	-	-	GTPR	General PWM Timer Cycle Setting Register	0x64	32	R/W	0xFFFFFFFF	0xFFFFFFFF
GPT320	-	-	-	GTPBR	General PWM Timer Cycle Setting Buffer Register	0x68	32	R/W	0xFFFFFFFF	0xFFFFFFFF
GPT320	-	-	-	GTDTCR	General PWM Timer Dead Time Control Register	0x88	32	R/W	0x00000000	0xFFFFFFFF
GPT320	-	-	-	GTDVU	General PWM Timer Dead Time Value Register U	0x8C	32	R/W	0xFFFFFFFF	0xFFFFFFFF
GPT164-9	-	-	-	GTWP	General PWM Timer Write-Protection Register	0x00	32	R/W	0x00000000	0xFFFFFFFF
GPT164-9	-	-	-	GTSTR	General PWM Timer Software Start Register	0x04	32	R/W	0x00000000	0xFFFFFFFF
GPT164-9	-	-	-	GTSTP	General PWM Timer Software Stop Register	0x08	32	R/W	0xFFFFFFFF	0xFFFFFFFF
GPT164-9	-	-	-	GTCLR	General PWM Timer Software Clear Register	0x0C	32	W	0x00000000	0xFFFFFFFF
GPT164-9	-	-	-	GTSSR	General PWM Timer Start Source Select Register	0x10	32	R/W	0x00000000	0xFFFFFFFF

Table 3.4 Register description (11 of 13)

Peripheral name	Dim	Dim inc.	Dim index	Register name	Description	Address offset	Size	R/W	Reset value	Reset mask
GPT164-9	-	-	-	GTPSR	General PWM Timer Stop Source Select Register	0x14	32	R/W	0x00000000	0xFFFFFFFF
GPT164-9	-	-	-	GTCSR	General PWM Timer Clear Source Select Register	0x18	32	R/W	0x00000000	0xFFFFFFFF
GPT164-9	-	-	-	GTUPSR	General PWM Timer Up Count Source Select Register	0x1C	32	R/W	0x00000000	0xFFFFFFFF
GPT164-9	-	-	-	GTDNSR	General PWM Timer Down Count Source Select Register	0x20	32	R/W	0x00000000	0xFFFFFFFF
GPT164-9	-	-	-	GTICASR	General PWM Timer Input Capture Source Select Register A	0x24	32	R/W	0x00000000	0xFFFFFFFF
GPT164-9	-	-	-	GTICBSR	General PWM Timer Input Capture Source Select Register B	0x28	32	R/W	0x00000000	0xFFFFFFFF
GPT164-9	-	-	-	GTCR	General PWM Timer Control Register	0x2C	32	R/W	0x00000000	0xFFFFFFFF
GPT164-9	-	-	-	GTUDDTYC	General PWM Timer Count Direction and Duty Setting Register	0x30	32	R/W	0x00000001	0xFFFFFFFF
GPT164-9	-	-	-	GTIOR	General PWM Timer I/O Control Register	0x34	32	R/W	0x00000000	0xFFFFFFFF
GPT164-9	-	-	-	GTINTAD	General PWM Timer Interrupt Output Setting Register	0x38	32	R/W	0x00000000	0xFFFFFFFF
GPT164-9	-	-	-	GTST	General PWM Timer Status Register	0x3C	32	R/W	0x00008000	0xFFFFFFFF
GPT164-9	-	-	-	GTBER	General PWM Timer Buffer Enable Register	0x40	32	R/W	0x00000000	0xFFFFFFFF
GPT164-9	-	-	-	GTCNT	General PWM Timer Counter	0x48	32	R/W	0x00000000	0xFFFFFFFF
GPT164-9	-	-	-	GTCCRA	General PWM Timer Compare Capture Register A	0x4C	32	R/W	0xFFFFFFFF	0xFFFFFFFF
GPT164-9	-	-	-	GTCCRB	General PWM Timer Compare Capture Register B	0x50	32	R/W	0xFFFFFFFF	0xFFFFFFFF
GPT164-9	-	-	-	GTCCRC	General PWM Timer Compare Capture Register C	0x54	32	R/W	0xFFFFFFFF	0xFFFFFFFF
GPT164-9	-	-	-	GTCCRE	General PWM Timer Compare Capture Register E	0x58	32	R/W	0xFFFFFFFF	0xFFFFFFFF
GPT164-9	-	-	-	GTCCRD	General PWM Timer Compare Capture Register D	0x5C	32	R/W	0xFFFFFFFF	0xFFFFFFFF
GPT164-9	-	-	-	GTCCRF	General PWM Timer Compare Capture Register F	0x60	32	R/W	0xFFFFFFFF	0xFFFFFFFF
GPT164-9	-	-	-	GTPR	General PWM Timer Cycle Setting Register	0x64	32	R/W	0xFFFFFFFF	0xFFFFFFFF
GPT164-9	-	-	-	GTPBR	General PWM Timer Cycle Setting Buffer Register	0x68	32	R/W	0xFFFFFFFF	0xFFFFFFFF
GPT164-9	-	-	-	GTDTCR	General PWM Timer Dead Time Control Register	0x88	32	R/W	0x00000000	0xFFFFFFFF
GPT164-9	-	-	-	GTDVU	General PWM Timer Dead Time Value Register U	0x8C	32	R/W	0xFFFFFFFF	0xFFFFFFFF
GPT_OPS	-	-	-	OPSCR	Output Phase Switching Control Register	0x00	32	R/W	0x00000000	0xFFFFFFFF
KINT	-	-	-	KRCTL	Key Return Control Register	0x00	8	R/W	0x00	0xFF
KINT	-	-	-	KRF	Key Return Flag Register	0x04	8	R/W	0x00	0xFF
KINT	-	-	-	KRM	Key Return Mode Register	0x08	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUCRA	CTSU Control Register A	0x00	32	R/W	0x00000000	0xFFFFFFFF
CTSU	-	-	-	CTSUCRAL	CTSU Control Register A	0x00	16	R/W	0x0000	0xFFFF
CTSU	-	-	-	CTSUCR0	CTSU Control Register A	0x00	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUCR1	CTSU Control Register A	0x01	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUCR2	CTSU Control Register A	0x02	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUCR3	CTSU Control Register A	0x03	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUCRB	CTSU Control Register B	0x04	32	R/W	0x00000000	0xFFFFFFFF
CTSU	-	-	-	CTSUCRBL	CTSU Control Register B	0x04	16	R/W	0x0000	0xFFFF

Table 3.4 Register description (12 of 13)

Peripheral name	Dim	Dim inc.	Dim index	Register name	Description	Address offset	Size	R/W	Reset value	Reset mask
CTSU	-	-	-	CTSUSDPRS	CTSU Control Register B	0x04	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUSST	CTSU Control Register B	0x05	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUCRBH	CTSU Control Register B	0x06	16	R/W	0x0000	0xFFFF
CTSU	-	-	-	CTSUDCLKC	CTSU Control Register B	0x07	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUMCH	CTSU Measurement Channel Register	0x08	32	R/W	0x00003F3F	0xFFFFFFFF
CTSU	-	-	-	CTSUMCHL	CTSU Measurement Channel Register	0x08	16	R/W	0x0000	0xFFFF
CTSU	-	-	-	CTSUMCH0	CTSU Measurement Channel Register	0x08	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUMCH1	CTSU Measurement Channel Register	0x09	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUMCHH	CTSU Measurement Channel Register	0x0A	16	R/W	0x3F3F	0xFFFF
CTSU	-	-	-	CTSUMFAF	CTSU Measurement Channel Register	0x0A	8	R/W	0x3F	0xFF
CTSU	-	-	-	CTSUCHACA	CTSU Channel Enable Control Register A	0x0C	32	R/W	0x00000000	0xFFFFFFFF
CTSU	-	-	-	CTSUCHACAL	CTSU Channel Enable Control Register A	0x0C	16	R/W	0x0000	0xFFFF
CTSU	-	-	-	CTSUCHAC0	CTSU Channel Enable Control Register A	0x0C	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUCHAC1	CTSU Channel Enable Control Register A	0x0D	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUCHACAH	CTSU Channel Enable Control Register A	0x0E	16	R/W	0x0000	0xFFFF
CTSU	-	-	-	CTSUCHAC2	CTSU Channel Enable Control Register A	0x0E	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUCHAC3	CTSU Channel Enable Control Register A	0x0F	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUCHACB	CTSU Channel Enable Control Register B	0x10	32	R/W	0x00000000	0xFFFFFFFF
CTSU	-	-	-	CTSUCHACBL	CTSU Channel Enable Control Register B	0x10	16	R/W	0x0000	0xFFFF
CTSU	-	-	-	CTSUCHAC4	CTSU Channel Enable Control Register B	0x10	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUCHTRCA	CTSU Channel Transmit/Receive Control Register A	0x14	32	R/W	0x00000000	0xFFFFFFFF
CTSU	-	-	-	CTSUCHTRCAL	CTSU Channel Transmit/Receive Control Register A	0x14	16	R/W	0x0000	0xFFFF
CTSU	-	-	-	CTSUCHTRC0	CTSU Channel Transmit/Receive Control Register A	0x14	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUCHTRC1	CTSU Channel Transmit/Receive Control Register A	0x15	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUCHTRCAH	CTSU Channel Transmit/Receive Control Register A	0x16	16	R/W	0x0000	0xFFFF
CTSU	-	-	-	CTSUCHTRC2	CTSU Channel Transmit/Receive Control Register A	0x16	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUCHTRC3	CTSU Channel Transmit/Receive Control Register A	0x17	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUCHTRCB	CTSU Channel Transmit/Receive Control Register B	0x18	32	R/W	0x00000000	0xFFFFFFFF
CTSU	-	-	-	CTSUCHTRCBL	CTSU Channel Transmit/Receive Control Register B	0x18	16	R/W	0x0000	0xFFFF
CTSU	-	-	-	CTSUCHTRC4	CTSU Channel Transmit/Receive Control Register B	0x18	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUSR	CTSU Status Register	0x1C	32	R/W	0x00000000	0xFFFFFFFF
CTSU	-	-	-	CTSUSRL	CTSU Status Register	0x1C	16	R/W	0x0000	0xFFFF
CTSU	-	-	-	CTSUSR0	CTSU Status Register	0x1C	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUST	CTSU Status Register	0x1D	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUSRH	CTSU Status Register	0x1E	16	R/W	0x0000	0xFFFF
CTSU	-	-	-	CTSUSR2	CTSU Status Register	0x1E	8	R/W	0x00	0xFF
CTSU	-	-	-	CTSUSO	CTSU Sensor Offset Register	0x20	32	R/W	0x00000000	0xFFFFFFFF
CTSU	-	-	-	CTSUSO0	CTSU Sensor Offset Register	0x20	16	R/W	0x0000	0xFFFF
CTSU	-	-	-	CTSUSO1	CTSU Sensor Offset Register	0x22	16	R/W	0x0000	0xFFFF
CTSU	-	-	-	CTSUSCNT	CTSU Sensor Counter Register	0x24	32	R	0x00000000	0xFFFFFFFF



**Table 3.4 Register description (13 of 13)**

Peripheral name	Dim	Dim inc.	Dim index	Register name	Description	Address offset	Size	R/W	Reset value	Reset mask
CTSU	-	-	-	CTSUSC	CTSU Sensor Counter Register	0x24	16	R	0x0000	0xFFFF
CTSU	-	-	-	CTSUCALIB	CTSU Calibration Register	0x28	32	R/W	0x00000000	0xFFFFFFFF
CTSU	-	-	-	CTSUDBGR0	CTSU Calibration Register	0x28	16	R/W	0x0000	0xFFFF
CTSU	-	-	-	CTSUDBGR1	CTSU Calibration Register	0x2A	16	R/W	0x0000	0xFFFF
CTSU	-	-	-	CTSUSUCLKA	CTSU Sensor Unit Clock Control Register A	0x2C	32	R/W	0x00000000	0xFFFFFFFF
CTSU	-	-	-	CTSUSUCLK0	CTSU Sensor Unit Clock Control Register A	0x2C	16	R/W	0x0000	0xFFFF
CTSU	-	-	-	CTSUSUCLK1	CTSU Sensor Unit Clock Control Register A	0x2E	16	R/W	0x0000	0xFFFF
CTSU	-	-	-	CTSUSUCLKB	CTSU Sensor Unit Clock Control Register B	0x30	32	R/W	0x00000000	0xFFFFFFFF
CTSU	-	-	-	CTSUSUCLK2	CTSU Sensor Unit Clock Control Register B	0x30	16	R/W	0x0000	0xFFFF
CTSU	-	-	-	CTSUSUCLK3	CTSU Sensor Unit Clock Control Register B	0x32	16	R/W	0x0000	0xFFFF
CTSU	-	-	-	CTSUCFCNT	CTSU CFC Counter Register	0x34	32	R	0x00000000	0xFFFFFFFF
CTSU	-	-	-	CTSUCFCNTL	CTSU CFC Counter Register	0x34	16	R	0x0000	0xFFFF
AGT0-1	-	-	-	AGT	AGT Counter Register	0x00	16	R/W	0xFFFF	0xFFFF
AGT0-1	-	-	-	AGTCMB	AGT Compare Match B Register	0x04	16	R/W	0xFFFF	0xFFFF
AGT0-1	-	-	-	AGTCMA	AGT Compare Match A Register	0x02	16	R/W	0xFFFF	0xFFFF
AGT0-1	-	-	-	AGTCR	AGT Control Register	0x08	8	R/W	0x00	0xFF
AGT0-1	-	-	-	AGTMR1	AGT Mode Register 1	0x09	8	R/W	0x00	0xFF
AGT0-1	-	-	-	AGTMR2	AGT Mode Register 2	0x0A	8	R/W	0x00	0xFF
AGT0-1	-	-	-	AGTIOC	AGT I/O Control Register	0x0C	8	R/W	0x00	0xFF
AGT0-1	-	-	-	AGTISR	AGT Event Pin Select Register	0x0D	8	R/W	0x00	0xFF
AGT0-1	-	-	-	AGTCMSR	AGT Compare Match Function Select Register	0x0E	8	R/W	0x00	0xFF
AGT0-1	-	-	-	AGTIOSEL	AGT Pin Select Register	0x00F	8	R/W	0x00	0xFF
ACMLP	-	-	-	COMPMDR	ACMLP Mode Setting Register	0x00	8	R/W	0x00	0xFF
ACMLP	-	-	-	COMPFIR	ACMLP Filter Control Register	0x01	8	R/W	0x00	0xFF
ACMLP	-	-	-	COMPOCR	ACMLP Output Control Register	0x02	8	R/W	0x00	0xFF
FLCN	-	-	-	DFLCTL	Data Flash Enable Register	0x0090	8	R/W	0x00	0xFF
FLCN	-	-	-	TSCDR	Temperature Sensor Calibration Data Register	0x0228	16	R	Unique value for each chip	0x0000
FLCN	-	-	-	CTSUTRIMA	CTSU Trimming Register A	0x03A4	32	R/W	Unique value for each chip	0x00000000
FLCN	-	-	-	FLDWAITR	Memory Wait Cycle Control Register for Data Flash	0x3FC4	8	R/W	0x00	0xFF
FLCN	-	-	-	PFBER	Prefetch Buffer Enable Register	0x3FC8	8	R/W	0x00	0xFF

Note: Peripheral name = Name of peripheral  
Dim = Number of elements in an array of registers  
Dim inc. = Address increment between two simultaneous registers of a register array in the address map  
Dim index = Sub string that replaces the %s placeholder within the register name  
Register name = Name of register  
Description = Register description  
Address offset = Address of the register relative to the base address defined by the peripheral of the register  
Size = Bit width of the register  
Reset value = Default reset value of a register  
Reset mask = Identifies which register bits have a defined reset value

# Revision History

## Revision 1.00 — October 02, 2020

First edition, issued

## Revision 1.10 — December 28, 2020

### 1. Overview:

- Updated the functional description of Resets in Table 1.3 System.
- Removed Code flash memory 96 KB from section 1.3 Part Numbering and 1.4 Function Comparison.
- Changed from TSCAP\_C to TSCAP in Table 1.15 Pin list (also in Table 1.1 in Appendix 1).

### APP2. Appendix 2 Package Dimensions:

- Added Figure 2.4 HWQFN 48-pin.
- Added Figure 2.6 HWQFN 32-pin.

## Revision 1.20 — February 4, 2022

### 1. Overview:

- Added Table 1.12 I/O ports.
- Updated Figure 1.2 Part numbering scheme.
- Updated Table 1.13 Product list.
- Updated Table 1.14 Function Comparison.
- Added Note to Figure 1.5 Pin assignment for LQFP/QFN 48-pin (top view).
- Added Note to Figure 1.7 Pin assignment for LQFP/QFN 32-pin (top view).
- Removed Note 1 from Table 1.15 Pin list.

### 2. Electrical Characteristics:

- Updated Table 2.4 I/O  $V_{IH}$ ,  $V_{IL}$ .
- Updated Table 2.11 Operating and standby current (2).
- Updated Note 2 in Table 2.46 Power-on reset circuit and voltage detection circuit characteristics (1).

### APP2. Appendix 2 Package Dimensions:

- Added Figure 2.7 WFLGA 36-pin.
- Added Figure 2.8 VFBGA 64-pin.
- Added Figure 2.9 WLCSP 25-pin.

## Revision 1.21 — February 9, 2022

### Revision History:

The changes for "Overview" in Revision 1.20 — February 4, 2022 in the Revision History section were incorrectly written.

- In the first bullet, "Table 1.12" should be modified to "Table 1.11" for the I/O ports table.
- In the third bullet, "Table 1.13" should be modified to "Table. 1.12" for the Product list table.
- In the fourth bullet, "Table 1.14" should be modified to "Table. 1.13" for the Function Comparison table.

## Revision 1.30 — November 30, 2022

### 0. Features:

- Updated Features.

### 1. Overview:

- Updated 1.3 Part Numbering.
- Updated Table 1.13 Function Comparison.
- Updated Table 1.15 Pin list.

### 2. Electrical Characteristics:

- Updated Table 2.4 I/O  $V_{IH}$ ,  $V_{IL}$ .
- Updated Table 2.5 I/O  $I_{OH}$ ,  $I_{OL}$ .
- Updated Table 2.32 SPI timing.
- Updated 2.10.1 Code Flash Memory Characteristics and 2.10.2 Data Flash Memory Characteristics.

### Appendix 2. Package Dimensions:

- Updated the figure title of Figure 2.1 LQFP 64-pin 0.5mm pitch (1).
- Added Figure 2.2 LQFP 64-pin 0.5mm pitch (2).
- Updated the figure title of Figure 2.4 LQFP 48-pin (1).
- Added Figure 2.5 LQFP 48-pin (2).
- Updated the figure title of Figure 2.7 LQFP 32-pin (1).
- Added Figure 2.8 LQFP 32-pin (2).
- Removed Figure 2.9 WLCSP 25-pin.

**Revision 1.30 — November 30, 2022****Appendix 3. I/O Registers:**

- Updated Table 3.4 Register description.

# General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

## 1. Precaution against Electrostatic Discharge (ESD)

A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity.

Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.

## 2. Processing at power-on

The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.

## 3. Input of signal during power-off state

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. Follow the guideline for input signal during power-off state as described in your product documentation.

## 4. Handling of unused pins

Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.

## 5. Clock signals

After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.

## 6. Voltage application waveform at input pin

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between  $V_{IL}$  (Max.) and  $V_{IH}$  (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between  $V_{IL}$  (Max.) and  $V_{IH}$  (Min.).

## 7. Prohibition of access to reserved addresses

Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.

## 8. Differences between products

Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.