

RL78/G22

R01DS0424EJ0110

RENESAS MCU

Rev.1.10

Jun 12, 2024

True low-power platform, 37.5- $\mu$ A/MHz operating current, 200-nA stop current, 32-/64-KB code flash memory and 4-KB RAM, up to 29 capacitive touch sensors, from 16 to 48 pins, 1.6 to 5.5 V

## 1. Outline

### 1.1 Features

Ultra-low power consumption technology

- VDD = single power supply voltage of 1.6 to 5.5 V
- HALT mode
- STOP mode
  - High-speed wakeup from the STOP mode is possible.
- SNOOZE mode

RL78 CPU core

- CISC architecture with 3-stage pipeline
- The minimum instruction execution time can be changed from high to ultra-low speed.
  - High speed: 0.03125  $\mu$ s at 32-MHz operation with the high-speed on-chip oscillator clock
  - Ultra-low speed: 30.5  $\mu$ s at 32.768-kHz operation with the subsystem clock
- Multiply/divide/multiply & accumulate instructions are supported.
- Address space: 1 MB
- General-purpose registers: (8-bit register  $\times$  8)  $\times$  4 banks
- On-chip RAM: 4 KB

Code flash memory

- Code flash memory: 32 or 64 KB
- Block size: 2 KB
- Security function: Prohibition of block erase and rewriting
- On-chip debugging
- Self-programming with boot swapping and flash shield window

Data flash memory

- Data flash memory: 2 KB
- Background operation (BGO): Instructions can be executed from the program memory while rewriting the data flash memory.
- Number of rewrites: 1,000,000 times (typ.)

High-speed on-chip oscillator

- Selectable from among 32 MHz, 24 MHz, 16 MHz, 12 MHz, 8 MHz, 6 MHz, 4 MHz, 3 MHz, 2 MHz, and 1 MHz
- High accuracy:  $\pm 1.0\%$  (VDD = 1.8 to 5.5 V, TA = -20 to +85°C)

Middle-speed on-chip oscillator

- Selectable from among 4 MHz, 2 MHz, and 1 MHz with adjustability

Low-speed on-chip oscillator

- 32.768 kHz (typ.) with adjustability

Operating ambient temperature

- TA = -40 to +85°C (2D: Consumer applications)
- TA = -40 to +105°C (3C: Industrial applications)

Power management and reset function

- On-chip power-on-reset (POR) circuit
- On-chip voltage detectors (LVD0 and LVD1)

Data transfer controller (DTC)

- Transfer modes: Normal transfer mode, repeat transfer mode, block transfer mode
- Activation sources: Activated by interrupt sources.
- Chain transfer function

SNOOZE mode sequencer (SMS)

- Calculations and comparison of values by the commands for use in processing by the sequencer can realize intermittent operations where the RL78/G22 does not have to return to normal operation.
- Sequentially handling a total of 32 processes with the use of desired commands from among 21 different ones
- The SNOOZE mode sequencer offers operation with low power consumption without using the CPU, flash memory, and RAM.

## Event link controller (ELC)

- Event signals can be set up between specified peripheral functions.

## Serial interface

- Simplified SPI (CSI<sup>Note</sup>): 1 to 5 channels
- UART/UART (LIN-bus supported)/UARTA: 1 to 4 channels
- I<sup>2</sup>C/Simplified I<sup>2</sup>C: 2 to 6 channels

## Timers

- 16-bit timer: 8 channels
- 32-bit interval timer: 1 channel in 32-bit counter mode  
2 channels in 16-bit counter mode  
4 channels in 8-bit counter mode
- Realtime clock: 1 channel (counting of one second to 99 years, alarm interrupt, and clock correction)
- Watchdog timer: 1 channel (operates with the dedicated low-speed on-chip oscillator clock)

## A/D converter

- 8-/10-bit resolution A/D converter
- Analog input: 3 to 10 channels
- Internal reference voltage (1.48 V) and temperature sensor

## Capacitive sensing unit

- Operating voltage: V<sub>DD</sub> = 1.8 to 5.5 V
- Self-capacitance method: A single pin configures a single key, supporting up to 29 keys
- Mutual capacitance method: Matrix configuration with 8 × 8 pins, supporting up to 64 keys

## Input/output port pins

- Number of port pins: 12 to 44  
N-ch open drain I/O pins [withstand voltage of 6 V]: 0 to 4  
N-ch open drain I/O pins [withstand voltage of V<sub>DD</sub>]: 4 to 13
- Can be set to N-ch open drain or TTL input buffer, and use of an on-chip pull-up resistor can be specified.
- Connectable to a device with different voltage (1.8, 2.5, or 3 V)

## Others

- Binary-coded decimal (BCD) correction circuit
- Key interrupt input
- Clock output/buzzer output controller

**Note** Although the CSI function is generally called SPI, it is also called CSI in this product, so it is referred to as such in this manual.

**Remark** The functions mounted depend on the product. See **1.6 Outline of Functions**.

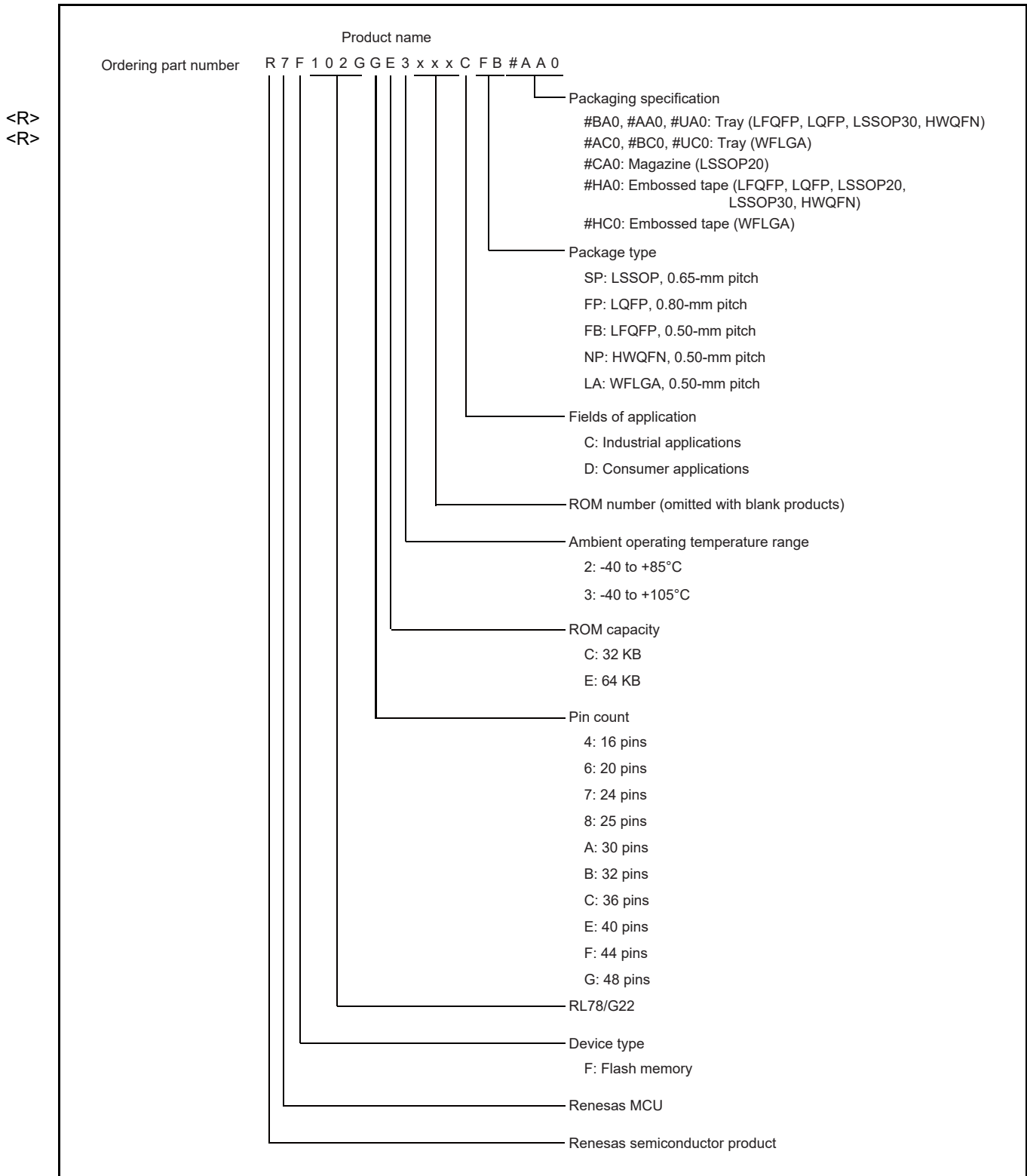
## O ROM, RAM capacities

Flash ROM	Data flash memory	RAM	RL78/G22				
			16 pins	20 pins	24 pins	25 pins	30 pins
64 KB	2 KB	4 KB	R7F102G4E	R7F102G6E	R7F102G7E	R7F102G8E	R7F102GAE
32 KB	2 KB	4 KB	R7F102G4C	R7F102G6C	R7F102G7C	R7F102G8C	R7F102GAC

Flash ROM	Data flash memory	RAM	RL78/G22				
			32 pins	36 pins	40 pins	44 pins	48 pins
64 KB	2 KB	4 KB	R7F102GBE	R7F102GCE	R7F102GEE	R7F102GFE	R7F102GGE
32 KB	2 KB	4 KB	R7F102GBC	R7F102GCC	R7F102GEC	R7F102GFC	R7F102GGC

## 1.2 List of Part Numbers

Figure 1 - 1 Part Number, Memory Size, and Package of RL78/G22



&lt;R&gt; Table 1 - 1 List of Ordering Part Numbers

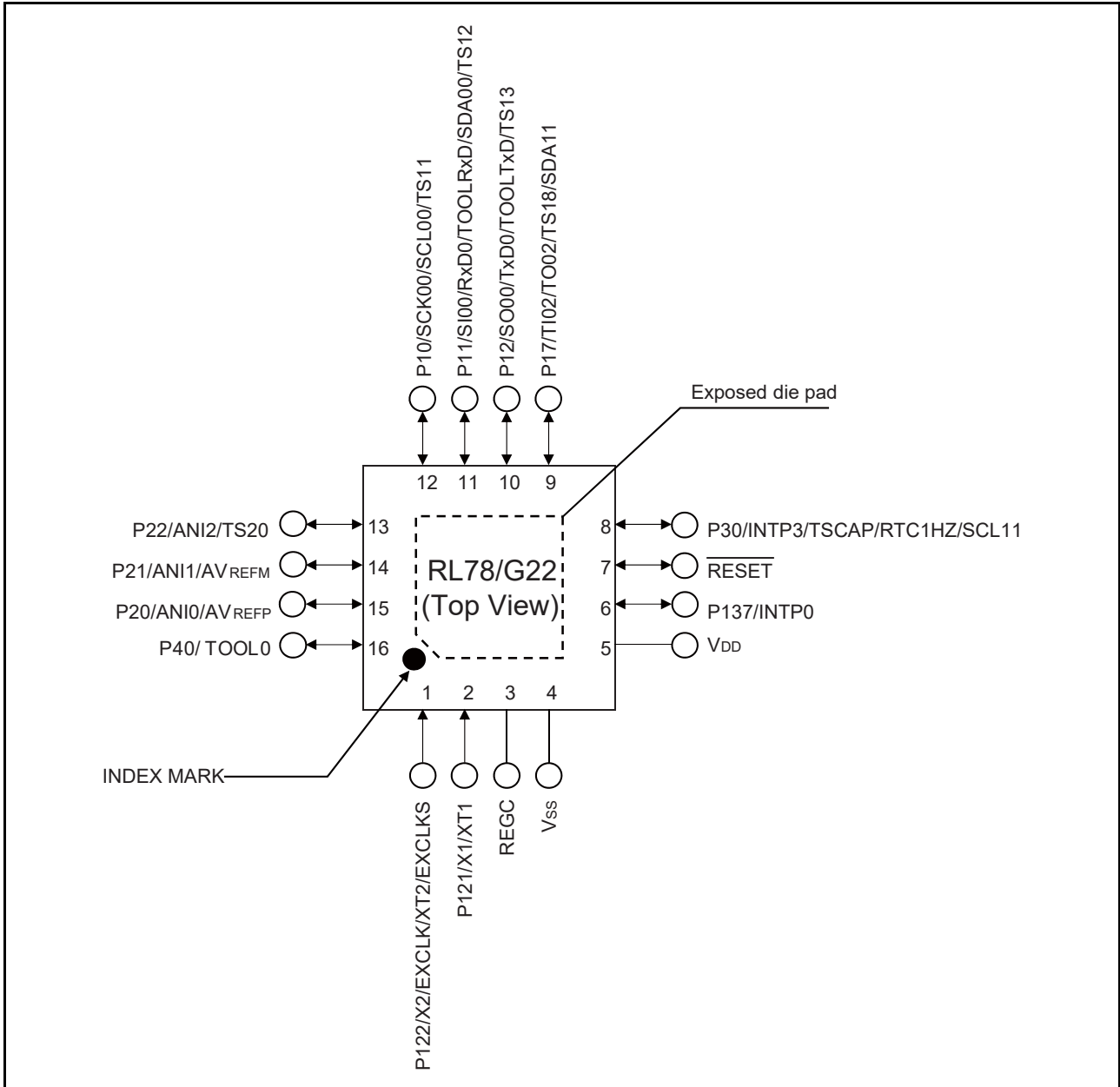
Pin Count	Package	Fields of Application Note	Ordering Part Number		Renesas Code
			Product Name	Packaging Specification	
16	16-pin plastic HWQFN (3 × 3 mm, 0.50-mm pitch)	C	R7F102G4C3CNP, R7F102G4E3CNP	#AA0, #BA0, #UA0, #HA0	PWQN0016KD-A
		D	R7F102G4C2DNP, R7F102G4E2DNP		
20	20-pin plastic LSSOP (4.4 × 6.5 mm, 0.65-mm pitch)	C	R7F102G6C3CSP, R7F102G6E3CSP	#CA0, #HA0	PLSP0020JB-A
		D	R7F102G6C2DSP, R7F102G6E2DSP		
24	24-pin plastic HWQFN (4 × 4 mm, 0.5 mm pitch)	C	R7F102G7C3CNP, R7F102G7E3CNP	#AA0, #BA0, #UA0, #HA0	PWQN0024KG-A
		D	R7F102G7C2DNP, R7F102G7E2DNP		
25	25-pin plastic WFLGA (3 × 3 mm, 0.5 mm pitch)	C	R7F102G8C3CLA, R7F102G8E3CLA	#AC0, #BC0, #UC0, #HC0	PWL0025KB-A
		D	R7F102G8C2DLA, R7F102G8E2DLA		
30	30-pin plastic LSSOP (7.62 mm (300), 0.65-mm pitch)	C	R7F102GAC3CSP, R7F102GAE3CSP	#AA0, #BA0, #UA0, #HA0	PLSP0030JB-B
		D	R7F102GAC2DSP, R7F102GAE2DSP		
32	32-pin plastic HWQFN (5 × 5 mm, 0.50-mm pitch)	C	R7F102GBC3CNP, R7F102GBE3CNP	#AA0, #BA0, #UA0, #HA0	PWQN0032KE-A
		D	R7F102GBC2DNP, R7F102GBE2DNP		
	32-pin plastic LQFP (7 × 7 mm, 0.80-mm pitch)	C	R7F102GBC3CFP, R7F102GBE3CFP	#AA0, #BA0, #UA0, #HA0	PLQP0032GB-A PLQP0032GE-A
		D	R7F102GBC2DFP, R7F102GBE2DFP		
36	36-pin plastic WFLGA (4 × 4 mm, 0.50-mm pitch)	C	R7F102GCC3CLA, R7F102GCE3CLA	#BC0, #AC0, #UC0, #HC0	PWL0036KB-A
		D	R7F102GCC2DLA, R7F102GCE2DLA		
40	40-pin plastic HWQFN (6 × 6 mm, 0.50-mm pitch)	C	R7F102GEC3CNP, R7F102GEE3CNP	#AA0, #BA0, #UA0, #HA0	PWQN0040KD-A
		D	R7F102GEC2DNP, R7F102GEE2DNP		
44	44-pin plastic LQFP (10 × 10 mm, 0.80-mm pitch)	C	R7F102GFC3CFP, R7F102GFE3CFP	#AA0, #BA0, #UA0, #HA0	PLQP0044GC-A PLQP0044GE-A
		D	R7F102GFC2DFP, R7F102GFE2DFP		
48	48-pin plastic LFQFP (7 × 7 mm, 0.50-mm pitch)	C	R7F102GGC3CFB, R7F102GGE3CFB	#AA0, #BA0, #UA0, #HA0	PLQP0048KB-B PLQP0048KL-A
		D	R7F102GGC2DFB, R7F102GGE2DFB		
	48-pin plastic HWQFN (7 × 7 mm, 0.50-mm pitch)	C	R7F102GGC3CNP, R7F102GGE3CNP	#AA0, #BA0, #UA0, #HA0	PWQN0048KC-A
		D	R7F102GGC2DNP, R7F102GGE2DNP		

**Note** For the fields of application, see **Figure 1 - 1 Part Number, Memory Size, and Package of RL78/G22**.

### 1.3 Pin Configuration (Top View)

#### 1.3.1 16-pin products

- 16-pin plastic HWQFN (3 × 3 mm, 0.5-mm pitch)



**Caution** Connect the REGC pin to Vss via a capacitor (0.47 to 1 μF).

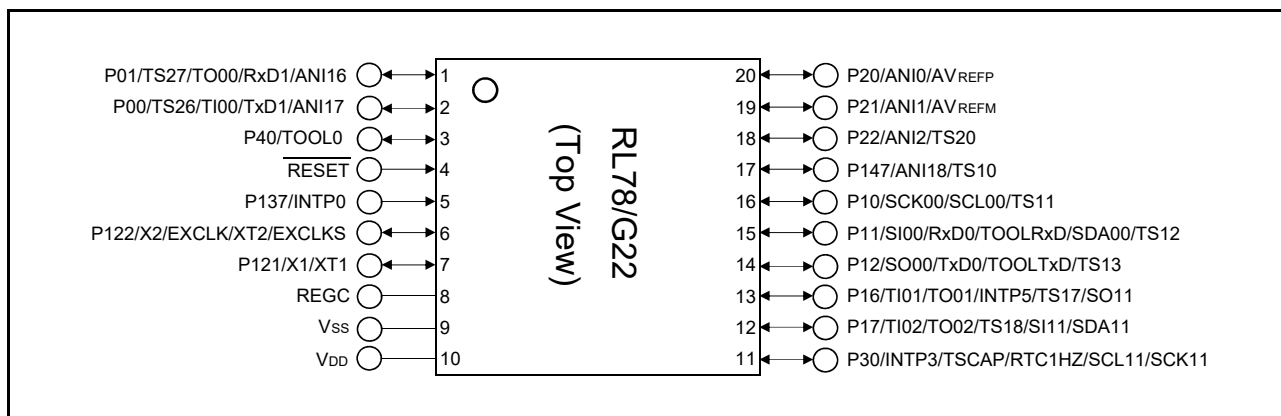
**Remark** For pin identification, see 1.4 Pin Identification.

Table 1 - 2 Multiplexed Pin Functions of the 16-pin Products

Pin Number	I/O	Power supply, system clock, and debugging	Analog Circuit	HMI			Timers		Communications Interfaces		
			A/D converter (ADC)	Interrupt (INTP)	Key interrupt (KR)	Capacitive sensing unit (CTSUS2La)	Timer array unit (TAU)	Realtime Clock (RTC)	Serial array unit (SAU)	Serial interface IICA (IICA)	Serial interface UARTA (UARTA)
16HWQFN	Digital port										
1	P122	X2/XT2/EXCLK/ EXCLKS	—	—	—	—	—	—	—	—	—
2	P121	X1/XT1	—	—	—	—	—	—	—	—	—
3	—	REGC	—	—	—	—	—	—	—	—	—
4	—	Vss	—	—	—	—	—	—	—	—	—
5	—	Vdd	—	—	—	—	—	—	—	—	—
6	P137	—	—	INTP0	—	—	—	—	—	—	—
7	—	RESET	—	—	—	—	—	—	—	—	—
8	P30	—	—	INTP3	—	TSCAP	—	RTC1HZ	SCL11	—	—
9	P17	—	—	—	—	TS18	TI02/TO02	—	SDA11	—	—
10	P12	TOOLTxD	—	—	—	TS13	—	—	SO00/ TxD0	—	—
11	P11	TOOLRxD	—	—	—	TS12	—	—	SI00/RxD0/ SDA00	—	—
12	P10	—	—	—	—	TS11	—	—	SCK00/ SCL00	—	—
13	P22	—	ANI2	—	—	TS20	—	—	—	—	—
14	P21	—	ANI1/ AVREFM	—	—	—	—	—	—	—	—
15	P20	—	ANI0/ AVREFP	—	—	—	—	—	—	—	—
16	P40	TOOL0	—	—	—	—	—	—	—	—	—

### 1.3.2 20-pin products

- 20-pin plastic LSSOP (4.4 × 6.5 mm, 0.65-mm pitch)



**Caution** Connect the REGC pin to Vss via a capacitor (0.47 to 1 μF).

**Remark** For pin identification, see 1.4 Pin Identification.

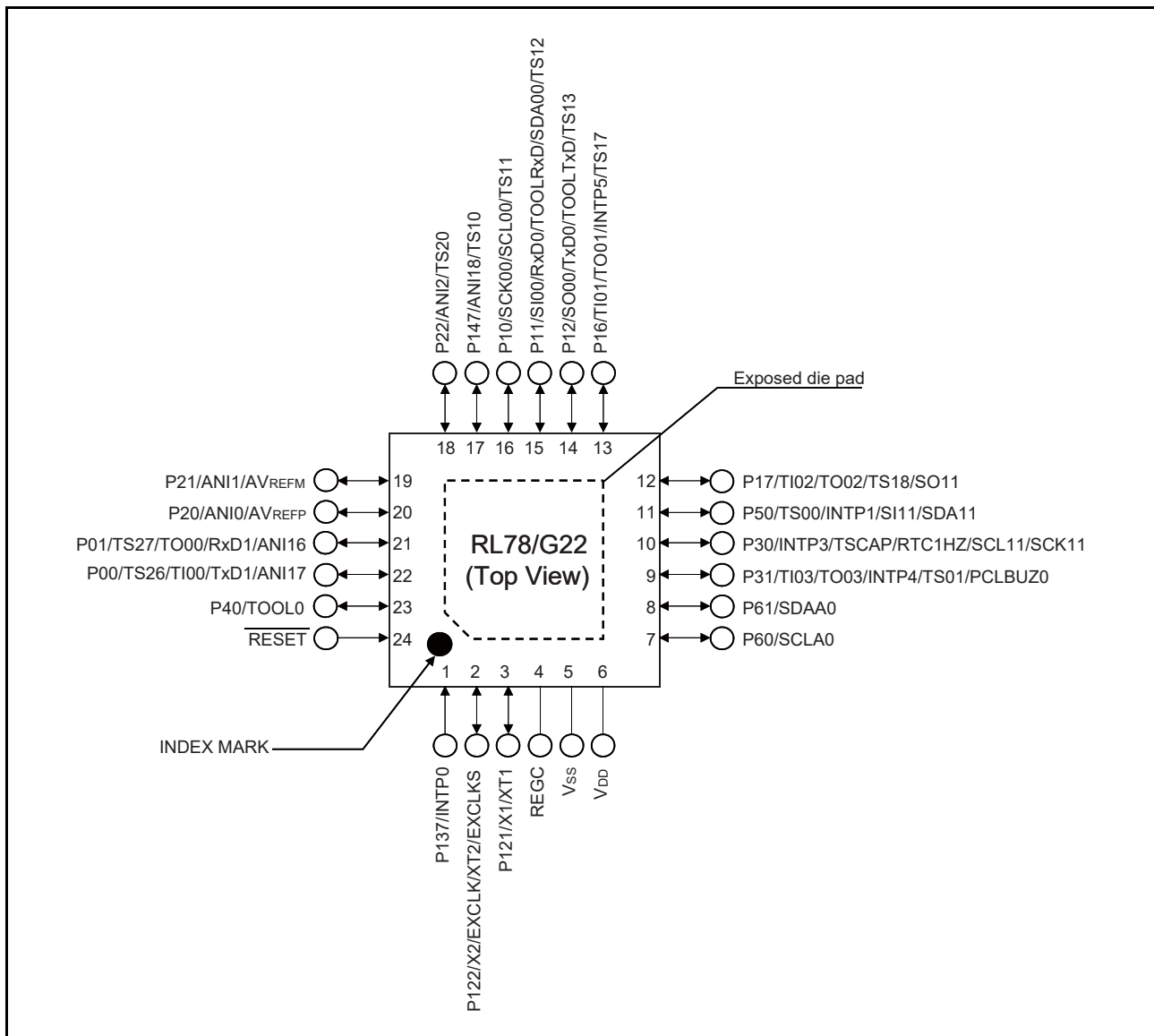


Table 1 - 3 Multiplexed Pin Functions of the 20-pin Products

Pin Number	I/O	Power supply, system clock, and debugging	Analog Circuit	HMI			Timers		Communications Interfaces		
				A/D converter (ADC)	Interrupt (INTP)	Key interrupt (KR)	Capacitive sensing unit (CTS2La)	Timer array unit (TAU)	Realtime Clock (RTC)	Serial array unit (SAU)	Serial interface IICA (IICA)
1	P01	—	ANI16	—	—	TS27	TO00	—	RxD1	—	—
2	P00	—	ANI17	—	—	TS26	TI00	—	TxD1	—	—
3	P40	TOOL0	—	—	—	—	—	—	—	—	—
4	—	RESET	—	—	—	—	—	—	—	—	—
5	P137	—	—	INTP0	—	—	—	—	—	—	—
6	P122	X2/XT2/EXCLK/ EXCLKS	—	—	—	—	—	—	—	—	—
7	P121	X1/XT1	—	—	—	—	—	—	—	—	—
8	—	REGC	—	—	—	—	—	—	—	—	—
9	—	VSS	—	—	—	—	—	—	—	—	—
10	—	VDD	—	—	—	—	—	—	—	—	—
11	P30	—	—	INTP3	—	TSCAP	—	RTC1HZ	SCK11/ SCL11	—	—
12	P17	—	—	—	—	TS18	TI02/TO02	—	SI11/ SDA11	—	—
13	P16	—	—	INTP5	—	TS17	TI01/TO01	—	SO11	—	—
14	P12	TOOLTxD	—	—	—	TS13	—	—	SO00/ TxD0	—	—
15	P11	TOOLRxD	—	—	—	TS12	—	—	SI00/RxD0/ SDA00	—	—
16	P10	—	—	—	—	TS11	—	—	SCK00/ SCL00	—	—
17	P147	—	ANI18	—	—	TS10	—	—	—	—	—
18	P22	—	ANI2	—	—	TS20	—	—	—	—	—
19	P21	—	ANI1/ AVREFM	—	—	—	—	—	—	—	—
20	P20	—	ANI0/ AVREFP	—	—	—	—	—	—	—	—

### 1.3.3 24-pin products

- 24-pin plastic HWQFN (4 × 4 mm, 0.5-mm pitch)



**Caution** Connect the REGC pin to V<sub>SS</sub> via a capacitor (0.47 to 1 μF).

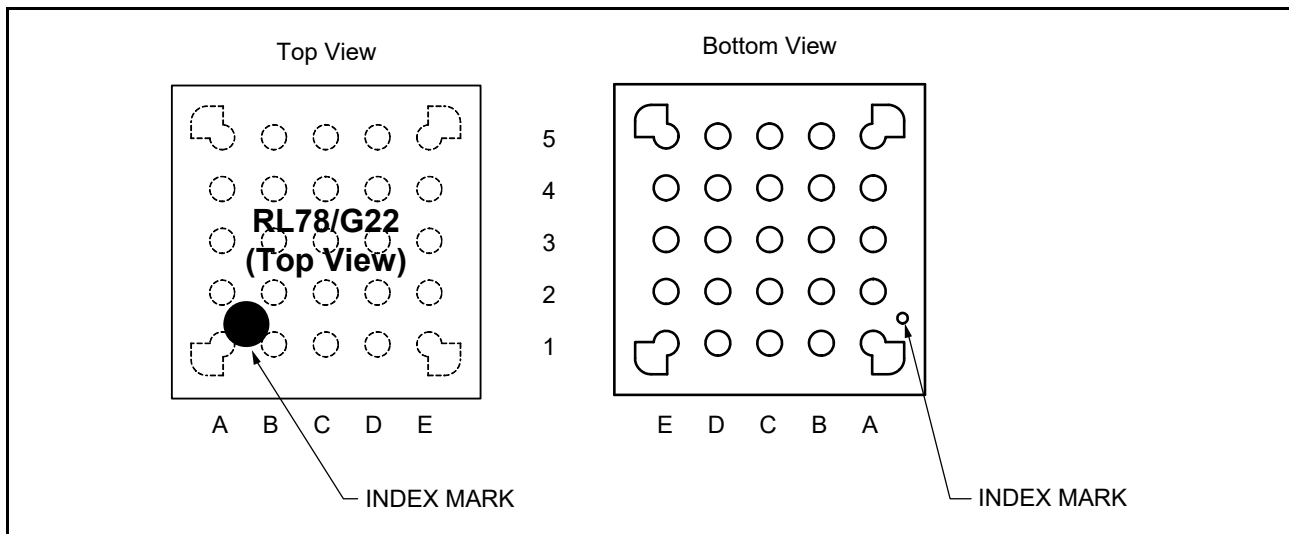
**Remark** For pin identification, see 1.4 Pin Identification.

Table 1 - 4 Multiplexed Pin Functions of the 24-pin Products

Pin Number	I/O	Power supply, system clock, and debugging	Analog Circuit	HMI			Timers		Communications Interfaces		
			A/D converter (ADC)	Interrupt (INTP)	Key interrupt (KR)	Capacitive sensing unit (CTS02La)	Timer array unit (TAU)	Realtime Clock (RTC)	Serial array unit (SAU)	Serial interface IICA (IICA)	Serial interface UAR2TA (UAR2TA)
1	P137	—	—	INTP0	—	—	—	—	—	—	—
2	P122	X2/XT2/EXCLK/EXCLKS	—	—	—	—	—	—	—	—	—
3	P121	X1/XT1	—	—	—	—	—	—	—	—	—
4	—	REGC	—	—	—	—	—	—	—	—	—
5	—	VSS	—	—	—	—	—	—	—	—	—
6	—	VDD	—	—	—	—	—	—	—	—	—
7	P60	—	—	—	—	—	—	—	—	SCLA0	—
8	P61	—	—	—	—	—	—	—	—	SDAA0	—
9	P31	PCLBUZ0	—	INTP4	—	TS01	TI03/TO03	—	—	—	—
10	P30	—	—	INTP3	—	TSCAP	—	RTC1HZ	SCK11/SCL11	—	—
11	P50	—	—	INTP1	—	TS00	—	—	SI11/SDA11	—	—
12	P17	—	—	—	—	TS18	TI02/TO02	—	SO11	—	—
13	P16	—	—	INTP5	—	TS17	TI01/TO01	—	—	—	—
14	P12	TOOLTxD	—	—	—	TS13	—	—	SO00/TxD0	—	—
15	P11	TOOLRxD	—	—	—	TS12	—	—	SI00/RxD0/SDA00	—	—
16	P10	—	—	—	—	TS11	—	—	SCK00/SCL00	—	—
17	P147	—	ANI18	—	—	TS10	—	—	—	—	—
18	P22	—	ANI2	—	—	TS20	—	—	—	—	—
19	P21	—	ANI1/AVREFM	—	—	—	—	—	—	—	—
20	P20	—	ANI0/AVREFP	—	—	—	—	—	—	—	—
21	P01	—	ANI16	—	—	TS27	TO00	—	RxD1	—	—
22	P00	—	ANI17	—	—	TS26	TI00	—	TxD1	—	—
23	P40	TOOL0	—	—	—	—	—	—	—	—	—
24	—	RESET	—	—	—	—	—	—	—	—	—

### 1.3.4 25-pin products

- 25-pin plastic WFLGA (3 × 3 mm, 0.5-mm pitch)



	A	B	C	D	E	
5	P40/TOOL0	RESET	P01/TS27/TO00/RxD1/ANI16	P22/ANI2/TS20	P147/ANI18/TS10	5
4	P122/X2/EXCLK/XT2/EXCLKS	P137/INTP0	P00/TS26/TI00/TxD1/ANI17	P21/ANI1/AVREFM	P10/SCK00/SCL00/TS11	4
3	P121/X1/XT1	VDD	P20/ANI0/AVREFP	P12/SO00/TxD0/TOOLTxD/TS13	P11/SI00/RxD0/TOOLRxD/SDA00/TS12	3
2	REGC	VSS	P30/INTP3/TSCAP/RTC1HZ/SCL11/SCK11	P17/TI02/TO02/TS18/SO11	P50/TS00/INTP1/SI11/SDA11	2
1	P60/SCLA0	P61/SDAA0	P31/TI03/TO03/INTP4/TS01/PCLBUZ0	P16/TI01/TO01/INTP5/TS17	P130/TS19	1
	A	B	C	D	E	

**Caution** Connect the REGC pin to VSS via a capacitor (0.47 to 1 μF).

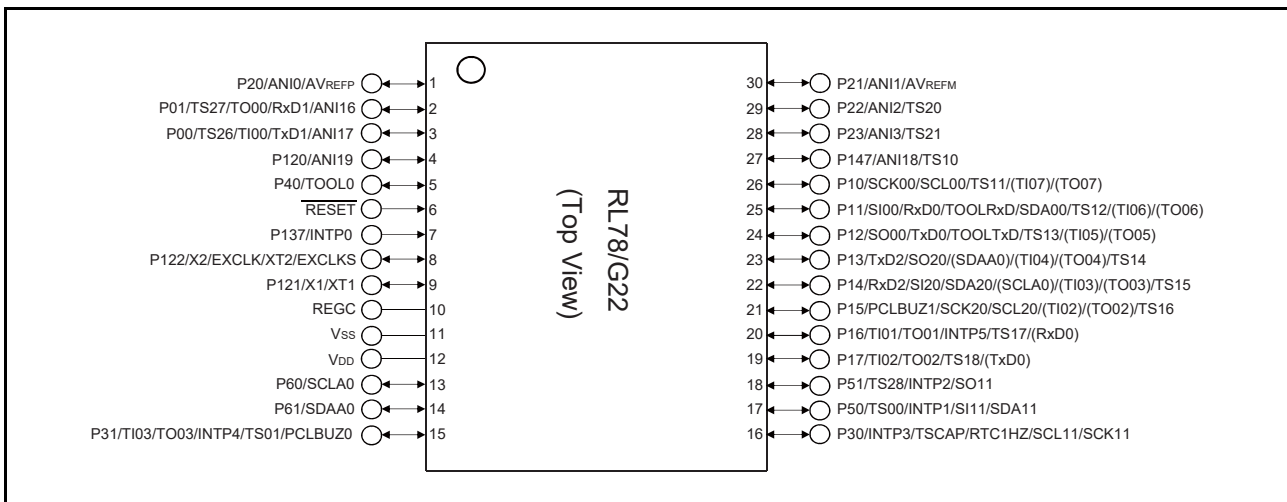
**Remark** For pin identification, see 1.4 Pin Identification.

Table 1 - 5 Multiplexed Pin Functions of the 25-pin Products

Pin Number	I/O	Power supply, system clock, and debugging	Analog Circuit	HMI			Timers		Communications Interfaces		
			A/D converter (ADC)	Interrupt (INTP)	Key interrupt (KR)	Capacitive sensing unit (CTSUS2La)	Timer array unit (TAU)	Realtime Clock (RTC)	Serial array unit (SAU)	Serial interface IICA (IICA)	Serial interface UARTA (UARTA)
A1	P60	—	—	—	—	—	—	—	—	SCLA0	—
A2	—	REGC	—	—	—	—	—	—	—	—	—
A3	P121	X1/XT1	—	—	—	—	—	—	—	—	—
A4	P122	X2/XT2/EXCLK/ EXCLKS	—	—	—	—	—	—	—	—	—
A5	P40	TOOL0	—	—	—	—	—	—	—	—	—
B1	P61	—	—	—	—	—	—	—	—	SDAA0	—
B2	—	VSS	—	—	—	—	—	—	—	—	—
B3	—	VDD	—	—	—	—	—	—	—	—	—
B4	P137	—	—	INTP0	—	—	—	—	—	—	—
B5	—	RESET	—	—	—	—	—	—	—	—	—
C1	P31	PCLBUZ0	—	INTP4	—	TS01	TI03/TO03	—	—	—	—
C2	P30	—	—	INTP3	—	TSCAP	—	RTC1HZ	SCK11/ SCL11	—	—
C3	P20	—	ANI0/ AVREFP	—	—	—	—	—	—	—	—
C4	P00	—	ANI17	—	—	TS26	TI00	—	TxD1	—	—
C5	P01	—	ANI16	—	—	TS27	TO00	—	RxD1	—	—
D1	P16	—	—	INTP5	—	TS17	TI01/TO01	—	—	—	—
D2	P17	—	—	—	—	TS18	TI02/TO02	—	SO11	—	—
D3	P12	TOOLTxD	—	—	—	TS13	—	—	SO00/ TxD0	—	—
D4	P21	—	ANI1/ AVREFM	—	—	—	—	—	—	—	—
D5	P22	—	ANI2	—	—	TS20	—	—	—	—	—
E1	P130	—	—	—	—	TS19	—	—	—	—	—
E2	P50	—	—	INTP1	—	TS00	—	—	SI11/ SDA11	—	—
E3	P11	TOOLRxD	—	—	—	TS12	—	—	SI00/RxD0/ SDA00	—	—
E4	P10	—	—	—	—	TS11	—	—	SCK00/ SCL00	—	—
E5	P147	—	ANI18	—	—	TS10	—	—	—	—	—

### 1.3.5 30-pin products

- 30-pin plastic LSSOP (7.62 mm (300), 0.65-mm pitch)



**Caution** Connect the REGC pin to V<sub>SS</sub> via a capacitor (0.47 to 1 μF).

**Remark 1.** For pin identification, see 1.4 Pin Identification.

**Remark 2.** Functions in parentheses in the above figure can be assigned via settings in the peripheral I/O redirection register (PIOR).

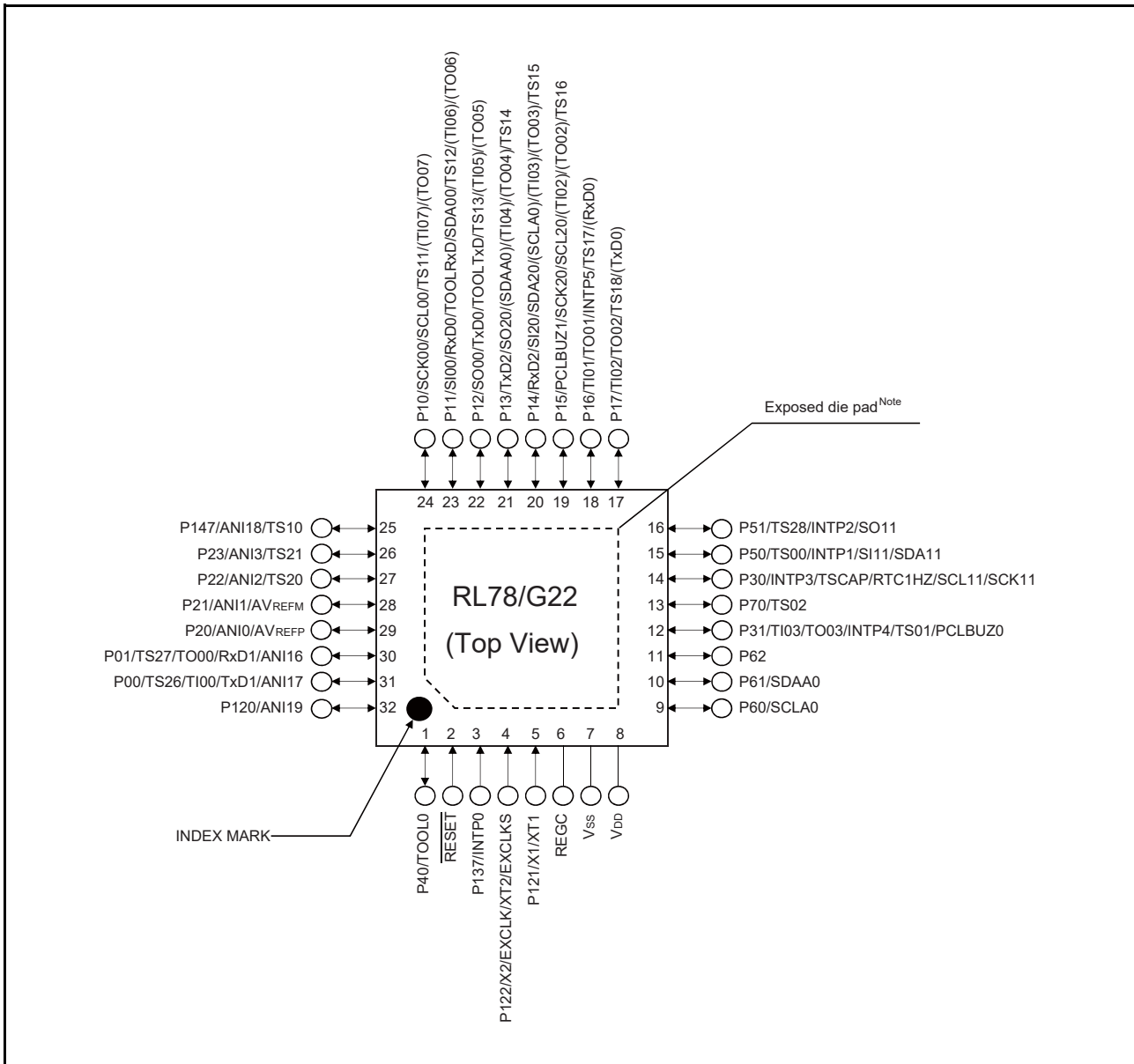
Refer to **Figure 4 - 9 Format of Peripheral I/O Redirection Register (PIOR)** in the RL78/G22 User's Manual.

Table 1 - 6 Multiplexed Pin Functions of the 30-pin Products

Pin Number	I/O	Power supply, system clock, and debugging	Analog Circuit	HMI			Timers		Communications Interfaces		
				A/D converter (ADC)	Interrupt (INTP)	Key interrupt (KR)	Capacitive sensing unit (CTSUS2La)	Timer array unit (TAU)	Realtime Clock (RTC)	Serial array unit (SAU)	Serial interface IICA (IICA)
1	P20	—	ANI0/ AVREFP	—	—	—	—	—	—	—	—
2	P01	—	ANI16	—	—	TS27	TO00	—	RxD1	—	—
3	P00	—	ANI17	—	—	TS26	TI00	—	TxD1	—	—
4	P120	—	ANI19	—	—	—	—	—	—	—	—
5	P40	TOOL0	—	—	—	—	—	—	—	—	—
6	—	RESET	—	—	—	—	—	—	—	—	—
7	P137	—	—	INTP0	—	—	—	—	—	—	—
8	P122	X2/XT2/EXCLK/ EXCLKS	—	—	—	—	—	—	—	—	—
9	P121	X1/XT1	—	—	—	—	—	—	—	—	—
10	—	REGC	—	—	—	—	—	—	—	—	—
11	—	Vss	—	—	—	—	—	—	—	—	—
12	—	Vdd	—	—	—	—	—	—	—	—	—
13	P60	—	—	—	—	—	—	—	—	SCLA0	—
14	P61	—	—	—	—	—	—	—	—	SDAA0	—
15	P31	PCLBUZ0	—	INTP4	—	TS01	TI03/TO03	—	—	—	—
16	P30	—	—	INTP3	—	TSCAP	—	RTC1HZ	SCK11/ SCL11	—	—
17	P50	—	—	INTP1	—	TS00	—	—	SI11/ SDA11	—	—
18	P51	—	—	INTP2	—	TS28	—	—	SO11	—	—
19	P17	—	—	—	—	TS18	TI02/TO02	—	(TxD0)	—	—
20	P16	—	—	INTP5	—	TS17	TI01/TO01	—	(RxD0)	—	—
21	P15	PCLBUZ1	—	—	—	TS16	(TI02)/ (TO02)	—	SCK20/ SCL20	—	—
22	P14	—	—	—	—	TS15	(TI03)/ (TO03)	—	SI20/RxD2/ SDA20	(SCLA0)	—
23	P13	—	—	—	—	TS14	(TI04)/ (TO04)	—	SO20/ TxD2	(SDAA0)	—
24	P12	TOOLTxD	—	—	—	TS13	(TI05)/ (TO05)	—	SO00/ TxD0	—	—
25	P11	TOOLRxD	—	—	—	TS12	(TI06)/ (TO06)	—	SI00/RxD0/ SDA00	—	—
26	P10	—	—	—	—	TS11	(TI07)/ (TO07)	—	SCK00/ SCL00	—	—
27	P147	—	ANI18	—	—	TS10	—	—	—	—	—
28	P23	—	ANI3	—	—	TS21	—	—	—	—	—
29	P22	—	ANI2	—	—	TS20	—	—	—	—	—
30	P21	—	ANI1/ AVREFM	—	—	—	—	—	—	—	—

### 1.3.6 32-pin products

- 32-pin plastic HWQFN (5 × 5 mm, 0.50-mm pitch)
- 32-pin plastic LQFP (7 × 7 mm, 0.80-mm pitch)



**Note** The 32-pin plastic LQFP (7 × 7 mm, 0.80-mm pitch) products do not have an exposed die pad.

**Caution** Connect the REGC pin to Vss via a capacitor (0.47 to 1 μF).

**Remark 1.** For pin identification, see 1.4 Pin Identification.

**Remark 2.** Functions in parentheses in the above figure can be assigned via settings in the peripheral I/O redirection register (PIOR). Refer to **Figure 4 - 9 Format of Peripheral I/O Redirection Register (PIOR)** in the RL78/G22 User's Manual.

**Remark 3.** It is recommended to connect an exposed die pad to Vss.

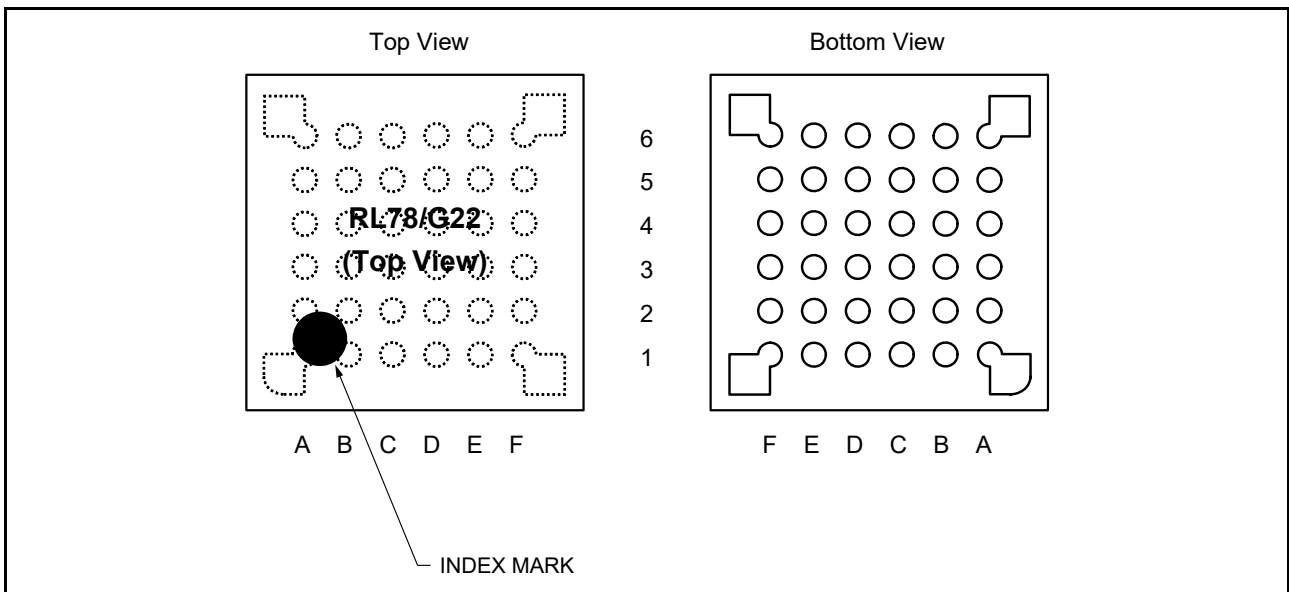


Table 1 - 7 Multiplexed Pin Functions of the 32-pin Products

Pin Number	I/O	Power supply, system clock, and debugging	Analog Circuit	HMI			Timers		Communications Interfaces		
			A/D converter (ADC)	Interrupt (INTP)	Key interrupt (KR)	Capacitive sensing unit (CTSUS2La)	Timer array unit (TAU)	Realtime Clock (RTC)	Serial array unit (SAU)	Serial interface IICA (IICA)	Serial interface UARTEA (UARTEA)
1	P40	TOOL0	—	—	—	—	—	—	—	—	—
2	—	RESET	—	—	—	—	—	—	—	—	—
3	P137	—	—	INTP0	—	—	—	—	—	—	—
4	P122	X2/XT2/EXCLK/ EXCLKS	—	—	—	—	—	—	—	—	—
5	P121	X1/XT1	—	—	—	—	—	—	—	—	—
6	—	REGC	—	—	—	—	—	—	—	—	—
7	—	VSS	—	—	—	—	—	—	—	—	—
8	—	VDD	—	—	—	—	—	—	—	—	—
9	P60	—	—	—	—	—	—	—	—	SCLA0	—
10	P61	—	—	—	—	—	—	—	—	SDAA0	—
11	P62	—	—	—	—	—	—	—	—	—	—
12	P31	PCLBUZ0	—	INTP4	—	TS01	TI03/TO03	—	—	—	—
13	P70	—	—	—	—	TS02	—	—	—	—	—
14	P30	—	—	INTP3	—	TSCAP	—	RTC1HZ	SCK11/ SCL11	—	—
15	P50	—	—	INTP1	—	TS00	—	—	SI11/ SDA11	—	—
16	P51	—	—	INTP2	—	TS28	—	—	SO11	—	—
17	P17	—	—	—	—	TS18	TI02/TO02	—	(TxD0)	—	—
18	P16	—	—	INTP5	—	TS17	TI01/TO01	—	(RxD0)	—	—
19	P15	PCLBUZ1	—	—	—	TS16	(TI02)/ (TO02)	—	SCK20/ SCL20	—	—
20	P14	—	—	—	—	TS15	(TI03)/ (TO03)	—	SI20/RxD2/ SDA20	(SCLA0)	—
21	P13	—	—	—	—	TS14	(TI04)/ (TO04)	—	SO20/ TxD2	(SDAA0)	—
22	P12	TOOLTxD	—	—	—	TS13	(TI05)/ (TO05)	—	SO00/ TxD0	—	—
23	P11	TOOLRxD	—	—	—	TS12	(TI06)/ (TO06)	—	SI00/RxD0/ SDA00	—	—
24	P10	—	—	—	—	TS11	(TI07)/ (TO07)	—	SCK00/ SCL00	—	—
25	P147	—	ANI18	—	—	TS10	—	—	—	—	—
26	P23	—	ANI3	—	—	TS21	—	—	—	—	—
27	P22	—	ANI2	—	—	TS20	—	—	—	—	—
28	P21	—	ANI1/ AVREFM	—	—	—	—	—	—	—	—
29	P20	—	ANI0/ AVREFP	—	—	—	—	—	—	—	—
30	P01	—	ANI16	—	—	TS27	TO00	—	RxD1	—	—
31	P00	—	ANI17	—	—	TS26	TI00	—	TxD1	—	—
32	P120	—	ANI19	—	—	—	—	—	—	—	—

1.3.7 36-pin products

- 36-pin plastic WFLGA (4 × 4 mm, 0.50-mm pitch)



	A	B	C	D	E	F
6	P60/SCLA0	VDD	P121/X1/XT1	P122/X2/EXCLK/ XT2/EXCLKS	P137/INTP0	P40/TOOL0
5	P62	P61/SDAA0	VSS	REGC	RESET	P120/ANI19
4	P72/TS04/SO21/ TxDA0	P71/TS03/SI21/ SDA21/RxDA0	P14/RxD2/SI20/ SDA20/(SCLA0)/ (TI03)/(TO03)/TS15	P31/TI03/TO03/ INTP4/TS01/ PCLBUZ0	P00/TS26/TI00/ TxD1	P01/TS27/TO00/ RxD1
3	P50/TS00/INTP1/ SI11/SDA11	P70/TS02/SCK21/ SCL21	P15/PCLBUZ1/ SCK20/SCL20/ (TI02)/(TO02)/TS16	P22/ANI2/TS20	P20/ANI0/AVREFP	P21/ANI1/AVREFM
2	P30/INTP3/TSCAP/ RTC1HZ/SCL11/ SCK11	P16/TI01/TO01/ INTP5/TS17/(RxD0)	P12/SO00/TxD0/ TOOLTxD/TS13/ (TI05)/(TO05)	P11/SI00/RxD0/ TOOLRxD/SDA00/ TS12/(TI06)/(TO06)	P24/ANI4/TS22	P23/ANI3/TS21
1	P51/TS28/INTP2/ SO11	P17/TI02/TO02/ TS18/(TxD0)	P13/TxD2/SO20/ (SDAA0)/(TI04)/ (TO04)/TS14	P10/SCK00/SCL00/ TS11/(TI07)/(TO07)	P147/ANI18/TS10	P25/ANI5/TS23

**Caution** Connect the REGC pin to VSS via a capacitor (0.47 to 1 μF).

**Remark 1.** For pin identification, see 1.4 Pin Identification.

**Remark 2.** Functions in parentheses in the above figure can be assigned via settings in the peripheral I/O redirection register (PIOR). Refer to **Figure 4 - 9 Format of Peripheral I/O Redirection Register (PIOR)** in the RL78/G22 User's Manual.

Table 1 - 8 Multiplexed Pin Functions of the 36-pin Products (1/2)

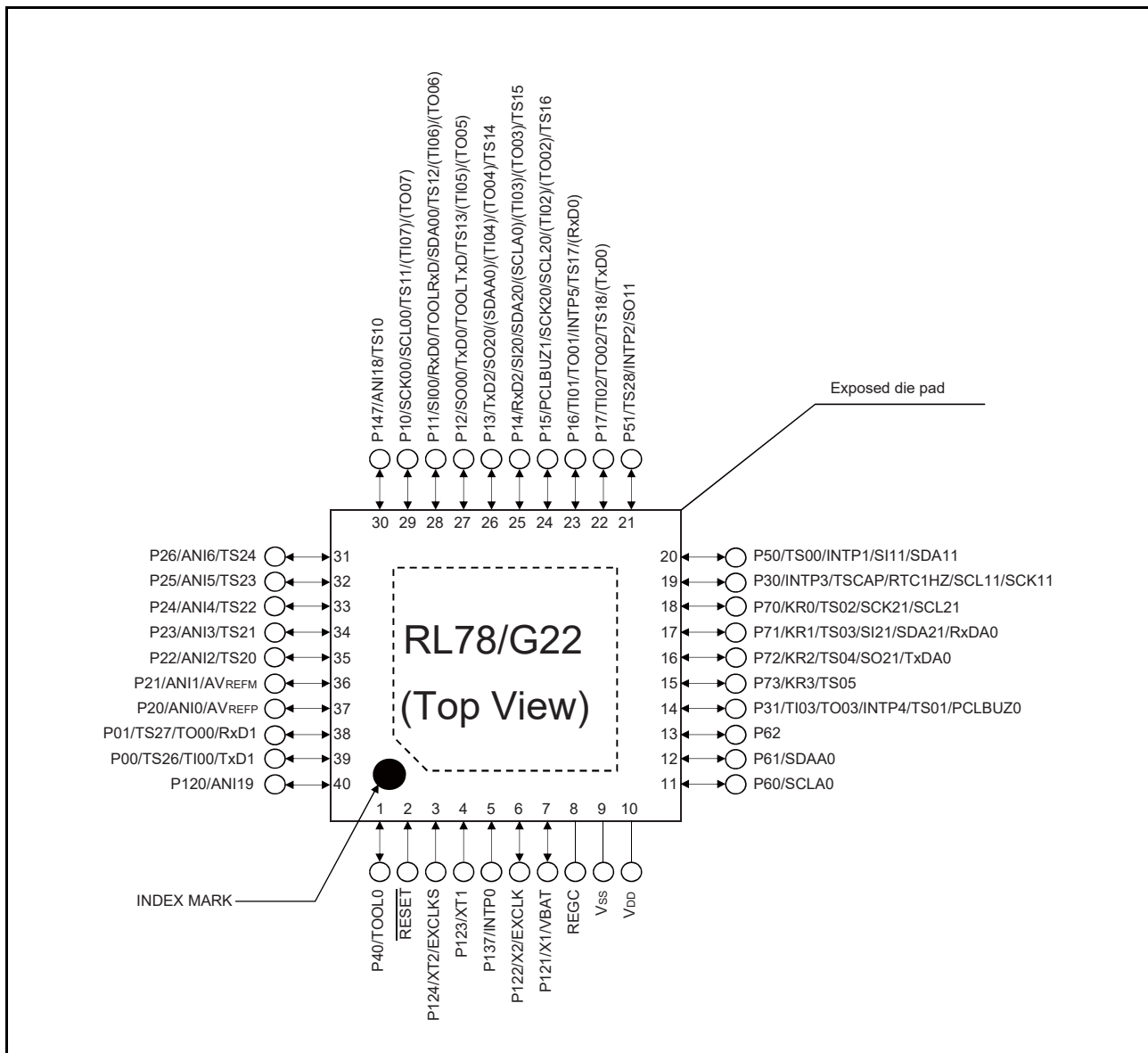
Pin Number	I/O	Power supply, system clock, and debugging	Analog Circuit	HMI			Timers		Communications Interfaces		
				A/D converter (ADC)	Interrupt (INTP)	Key interrupt (KR)	Capacitive sensing unit (CTSUS2La)	Timer array unit (TAU)	Realtime Clock (RTC)	Serial array unit (SAU)	Serial interface IICA (IICA)
A1	P51	—	—	INTP2	—	TS28	—	—	SO11	—	—
A2	P30	—	—	INTP3	—	TSCAP	—	RTC1HZ	SCK11/ SCL11	—	—
A3	P50	—	—	INTP1	—	TS00	—	—	SI11/ SDA11	—	—
A4	P72	—	—	—	—	TS04	—	—	SO21	—	TxDA0
A5	P62	—	—	—	—	—	—	—	—	—	—
A6	P60	—	—	—	—	—	—	—	—	SCLA0	—
B1	P17	—	—	—	—	TS18	TI02/TO02	—	(TxD0)	—	—
B2	P16	—	—	INTP5	—	TS17	TI01/TO01	—	(RxD0)	—	—
B3	P70	—	—	—	—	TS02	—	—	SCK21/ SCL21	—	—
B4	P71	—	—	—	—	TS03	—	—	SI21/ SDA21	—	RxDA0
B5	P61	—	—	—	—	—	—	—	—	SDAA0	—
B6	—	V <sub>DD</sub>	—	—	—	—	—	—	—	—	—
C1	P13	—	—	—	—	TS14	(TI04)/ (TO04)	—	SO20/ TxD2	(SDAA0)	—
C2	P12	TOOLTxD	—	—	—	TS13	(TI05)/ (TO05)	—	SO00/ TxD0	—	—
C3	P15	PCLBUZ1	—	—	—	TS16	(TI02)/ (TO02)	—	SCK20/ SCL20	—	—
C4	P14	—	—	—	—	TS15	(TI03)/ (TO03)	—	SI20/RxD2/ SDA20	(SCLA0)	—
C5	—	V <sub>SS</sub>	—	—	—	—	—	—	—	—	—
C6	P121	X1/XT1	—	—	—	—	—	—	—	—	—
D1	P10	—	—	—	—	TS11	(TI07)/ (TO07)	—	SCK00/ SCL00	—	—
D2	P11	TOOLRxD	—	—	—	TS12	(TI06)/ (TO06)	—	SI00/RxD0/ SDA00	—	—
D3	P22	—	ANI2	—	—	TS20	—	—	—	—	—
D4	P31	PCLBUZ0	—	INTP4	—	TS01	TI03/TO03	—	—	—	—
D5	—	REGC	—	—	—	—	—	—	—	—	—
D6	P122	X2/XT2/EXCLK/ EXCLKS	—	—	—	—	—	—	—	—	—
E1	P147	—	ANI18	—	—	TS10	—	—	—	—	—
E2	P24	—	ANI4	—	—	TS22	—	—	—	—	—
E3	P20	—	ANI0/ AVREFF	—	—	—	—	—	—	—	—
E4	P00	—	—	—	—	TS26	TI00	—	TxD1	—	—
E5	—	RESET	—	—	—	—	—	—	—	—	—
E6	P137	—	—	INTP0	—	—	—	—	—	—	—
F1	P25	—	ANI5	—	—	TS23	—	—	—	—	—
F2	P23	—	ANI3	—	—	TS21	—	—	—	—	—

Table 1 - 8 Multiplexed Pin Functions of the 36-pin Products (2/2)

Pin Number	I/O	Power supply, system clock, and debugging	Analog Circuit	HMI			Timers		Communications Interfaces		
				A/D converter (ADC)	Interrupt (INTP)	Key interrupt (KR)	Capacitive sensing unit (CTS02La)	Timer array unit (TAU)	Realtime Clock (RTC)	Serial array unit (SAU)	Serial interface IICA (IICA)
F3	P21	—	ANI1/ AVREFM	—	—	—	—	—	—	—	—
F4	P01	—	—	—	—	TS27	TO00	—	RxD1	—	—
F5	P120	—	ANI19	—	—	—	—	—	—	—	—
F6	P40	TOOL0	—	—	—	—	—	—	—	—	—

### 1.3.8 40-pin products

- 40-pin plastic HWQFN (6 × 6 mm, 0.50-mm pitch)



**Caution** Connect the REGC pin to Vss via a capacitor (0.47 to 1 μF).

**Remark 1.** For pin identification, see 1.4 Pin Identification.

**Remark 2.** Functions in parentheses in the above figure can be assigned via settings in the peripheral I/O redirection register (PIOR).

Refer to **Figure 4 - 9 Format of Peripheral I/O Redirection Register (PIOR)** in the RL78/G22 User's Manual.

**Remark 3.** It is recommended to connect an exposed die pad to Vss.

Table 1 - 9 Multiplexed Pin Functions of the 40-pin Products (1/2)

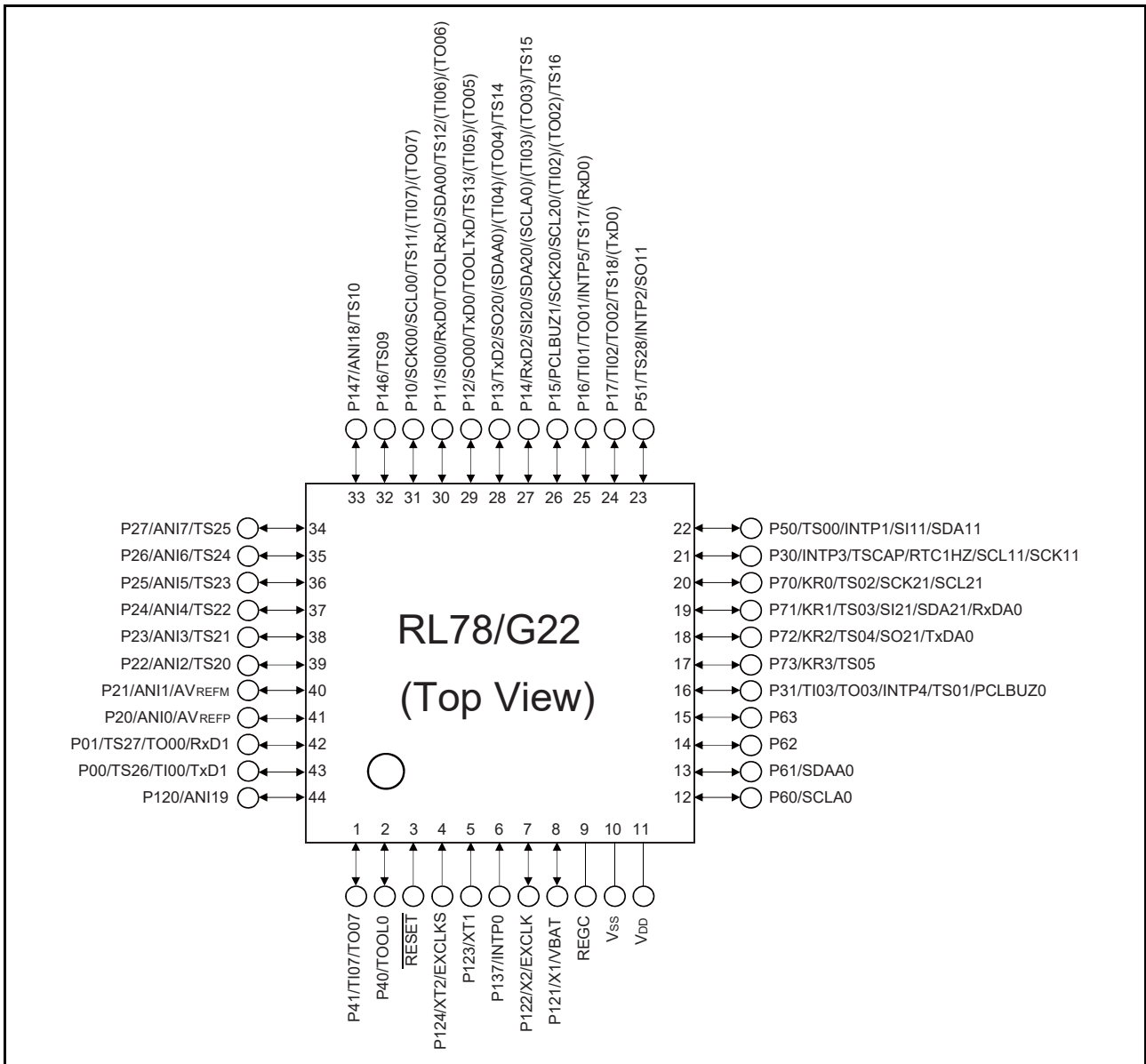
Pin Number	I/O	Power supply, system clock, and debugging	Analog Circuit	HMI			Timers		Communications Interfaces		
				A/D converter (ADC)	Interrupt (INTP)	Key interrupt (KR)	Capacitive sensing unit (CTSUS2La)	Timer array unit (TAU)	Realtime Clock (RTC)	Serial array unit (SAU)	Serial interface IICA (IICA)
1	P40	TOOL0	—	—	—	—	—	—	—	—	—
2	—	RESET	—	—	—	—	—	—	—	—	—
3	P124	XT2/EXCLKS	—	—	—	—	—	—	—	—	—
4	P123	XT1	—	—	—	—	—	—	—	—	—
5	P137	—	—	INTP0	—	—	—	—	—	—	—
6	P122	X2/EXCLK	—	—	—	—	—	—	—	—	—
7	P121	X1/VBAT	—	—	—	—	—	—	—	—	—
8	—	REGC	—	—	—	—	—	—	—	—	—
9	—	Vss	—	—	—	—	—	—	—	—	—
10	—	Vdd	—	—	—	—	—	—	—	—	—
11	P60	—	—	—	—	—	—	—	—	SCLA0	—
12	P61	—	—	—	—	—	—	—	—	SDAA0	—
13	P62	—	—	—	—	—	—	—	—	—	—
14	P31	PCLBUZ0	—	INTP4	—	TS01	TI03/TO03	—	—	—	—
15	P73	—	—	—	KR3	TS05	—	—	—	—	—
16	P72	—	—	—	KR2	TS04	—	—	SO21	—	TxDA1
17	P71	—	—	—	KR1	TS03	—	—	SI21/ SDA21	—	RxDA0
18	P70	—	—	—	KR0	TS02	—	—	SCK21/ SCL21	—	—
19	P30	—	—	INTP3	—	TSCAP	—	RTC1HZ	SCK11/ SCL11	—	—
20	P50	—	—	INTP1	—	TS00	—	—	SI11/ SDA11	—	—
21	P51	—	—	INTP2	—	TS28	—	—	SO11	—	—
22	P17	—	—	—	—	TS18	TI02/TO02	—	(TxD0)	—	—
23	P16	—	—	INTP5	—	TS17	TI01/TO01	—	(RxD0)	—	—
24	P15	PCLBUZ1	—	—	—	TS16	(TI02)/ (TO02)	—	SCK20/ SCL20	—	—
25	P14	—	—	—	—	TS15	(TI03)/ (TO03)	—	SI20/RxD2/ SDA20	(SCLA0)	—
26	P13	—	—	—	—	TS14	(TI04)/ (TO04)	—	SO20/ TxD2	(SDAA0)	—
27	P12	TOOLTxD	—	—	—	TS13	(TI05)/ (TO05)	—	SO00/ TxD0	—	—
28	P11	TOOLRxD	—	—	—	TS12	(TI06)/ (TO06)	—	SI00/RxD0/ SDA00	—	—
29	P10	—	—	—	—	TS11	(TI07)/ (TO07)	—	SCK00/ SCL00	—	—
30	P147	—	ANI18	—	—	TS10	—	—	—	—	—
31	P26	—	ANI6	—	—	TS24	—	—	—	—	—
32	P25	—	ANI5	—	—	TS23	—	—	—	—	—
33	P24	—	ANI4	—	—	TS22	—	—	—	—	—

Table 1 - 9 Multiplexed Pin Functions of the 40-pin Products (2/2)

Pin Number	I/O	Power supply, system clock, and debugging	Analog Circuit	HMI			Timers		Communications Interfaces		
				A/D converter (ADC)	Interrupt (INTP)	Key interrupt (KR)	Capacitive sensing unit (CTS/J2La)	Timer array unit (TAU)	Realtime Clock (RTC)	Serial array unit (SAU)	Serial interface IICA (IICA)
34	P23	—	ANI3	—	—	TS21	—	—	—	—	—
35	P22	—	ANI2	—	—	TS20	—	—	—	—	—
36	P21	—	ANI1/ AVREFM	—	—	—	—	—	—	—	—
37	P20	—	ANI0/ AVREFP	—	—	—	—	—	—	—	—
38	P01	—	—	—	—	TS27	TO00	—	RxD1	—	—
39	P00	—	—	—	—	TS26	TI00	—	TxD1	—	—
40	P120	—	ANI19	—	—	—	—	—	—	—	—

### 1.3.9 44-pin products

- 44-pin plastic LQFP (10 × 10 mm, 0.80-mm pitch)



**Caution** Connect the REGC pin to V<sub>SS</sub> via a capacitor (0.47 to 1 μF).

**Remark 1.** For pin identification, see 1.4 Pin Identification.

**Remark 2.** Functions in parentheses in the above figure can be assigned via settings in the peripheral I/O redirection register (PIOR). Refer to **Figure 4 - 9 Format of Peripheral I/O Redirection Register (PIOR)** in the RL78/G22 User's Manual.



Table 1 - 10 Multiplexed Pin Functions of the 44-pin Products (1/2)

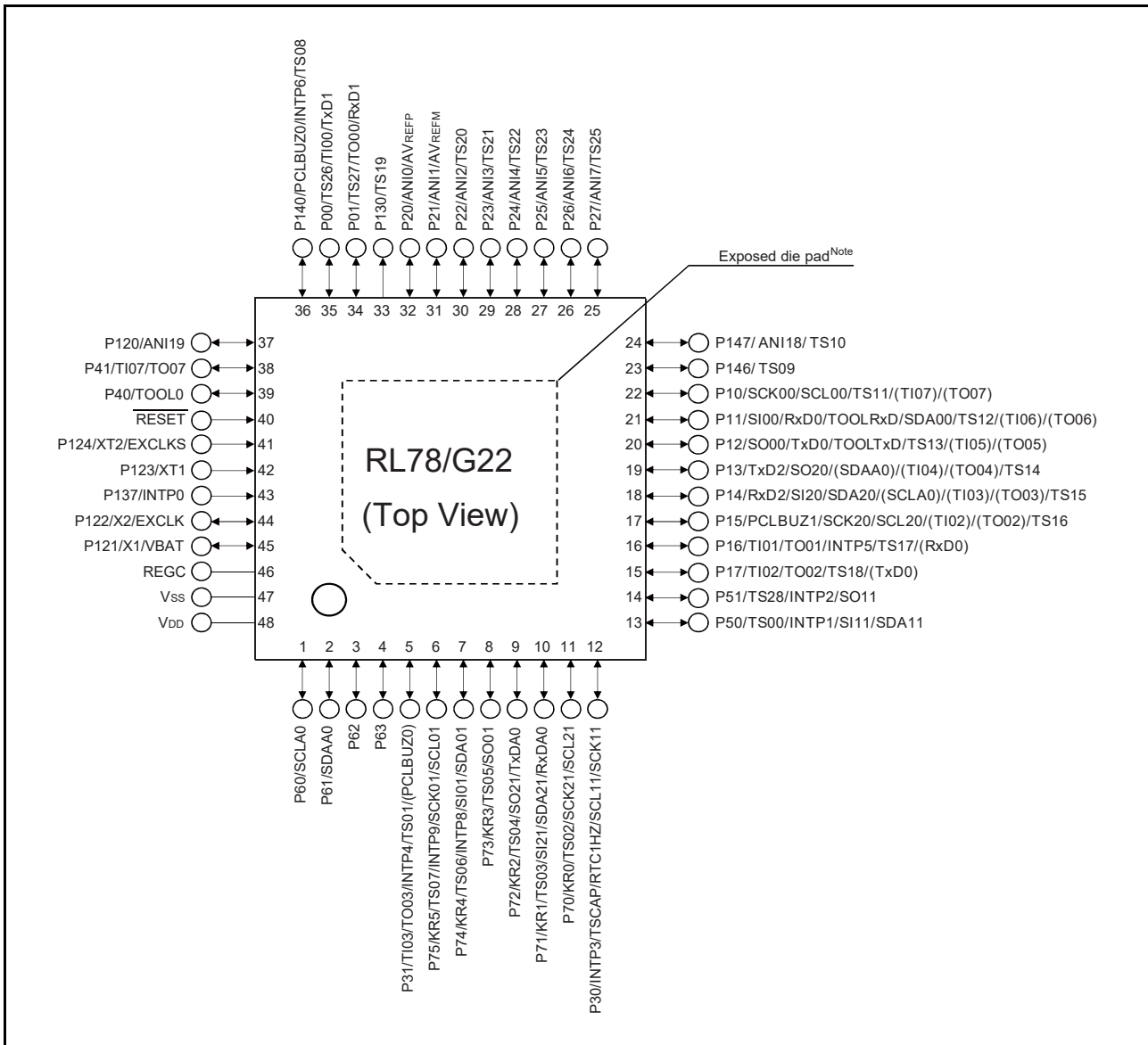
Pin Number	I/O	Power supply, system clock, and debugging	Analog Circuit	HMI			Timers		Communications Interfaces			
				A/D converter (ADC)	Interrupt (INTP)	Key interrupt (KR)	Capacitive sensing unit (CTS02La)	Timer array unit (TAU)	Realtime Clock (RTC)	Serial array unit (SAU)	Serial interface IICA (IICA)	Serial interface UARTA (UARTA)
1	P41	—	—	—	—	—	—	TI07/TO07	—	—	—	—
2	P40	TOOL0	—	—	—	—	—	—	—	—	—	—
3	—	RESET	—	—	—	—	—	—	—	—	—	—
4	P124	XT2/EXCLKS	—	—	—	—	—	—	—	—	—	—
5	P123	XT1	—	—	—	—	—	—	—	—	—	—
6	P137	—	—	INTP0	—	—	—	—	—	—	—	—
7	P122	X2/EXCLK	—	—	—	—	—	—	—	—	—	—
8	P121	X1/VBAT	—	—	—	—	—	—	—	—	—	—
9	—	REGC	—	—	—	—	—	—	—	—	—	—
10	—	Vss	—	—	—	—	—	—	—	—	—	—
11	—	Vdd	—	—	—	—	—	—	—	—	—	—
12	P60	—	—	—	—	—	—	—	—	—	SCLA0	—
13	P61	—	—	—	—	—	—	—	—	—	SDAA0	—
14	P62	—	—	—	—	—	—	—	—	—	—	—
15	P63	—	—	—	—	—	—	—	—	—	—	—
16	P31	PCLBUZ0	—	INTP4	—	TS01	—	TI03/TO03	—	—	—	—
17	P73	—	—	—	KR3	TS05	—	—	—	—	—	—
18	P72	—	—	—	KR2	TS04	—	—	SO21	—	TxDA1	—
19	P71	—	—	—	KR1	TS03	—	—	SI21/ SDA21	—	RxDA0	—
20	P70	—	—	—	KR0	TS02	—	—	SCK21/ SCL21	—	—	—
21	P30	—	—	INTP3	—	TSCAP	—	RTC1HZ	SCK11/ SCL11	—	—	—
22	P50	—	—	INTP1	—	TS00	—	—	SI11/ SDA11	—	—	—
23	P51	—	—	INTP2	—	TS28	—	—	SO11	—	—	—
24	P17	—	—	—	—	TS18	—	TI02/TO02	—	(TxD0)	—	—
25	P16	—	—	INTP5	—	TS17	—	TI01/TO01	—	(RxD0)	—	—
26	P15	PCLBUZ1	—	—	—	TS16	—	(TI02)/ (TO02)	—	SCK20/ SCL20	—	—
27	P14	—	—	—	—	TS15	—	(TI03)/ (TO03)	—	SI20/RxD2/ SDA20	(SCLA0)	—
28	P13	—	—	—	—	TS14	—	(TI04)/ (TO04)	—	SO20/ TxD2	(SDAA0)	—
29	P12	TOOLTxD	—	—	—	TS13	—	(TI05)/ (TO05)	—	SO00/ TxD0	—	—
30	P11	TOOLRxD	—	—	—	TS12	—	(TI06)/ (TO06)	—	SI00/RxD0/ SDA00	—	—
31	P10	—	—	—	—	TS11	—	(TI07)/ (TO07)	—	SCK00/ SCL00	—	—
32	P146	—	—	—	—	TS09	—	—	—	—	—	—
33	P147	—	ANI18	—	—	TS10	—	—	—	—	—	—

Table 1 - 10 Multiplexed Pin Functions of the 44-pin Products (2/2)

Pin Number	I/O	Power supply, system clock, and debugging	Analog Circuit	HMI			Timers		Communications Interfaces		
				A/D converter (ADC)	Interrupt (INTP)	Key interrupt (KR)	Capacitive sensing unit (CTS/J2La)	Timer array unit (TAU)	Realtime Clock (RTC)	Serial array unit (SAU)	Serial interface IICA (IICA)
34	P27	—	ANI7	—	—	TS25	—	—	—	—	—
35	P26	—	ANI6	—	—	TS24	—	—	—	—	—
36	P25	—	ANI5	—	—	TS23	—	—	—	—	—
37	P24	—	ANI4	—	—	TS22	—	—	—	—	—
38	P23	—	ANI3	—	—	TS21	—	—	—	—	—
39	P22	—	ANI2	—	—	TS20	—	—	—	—	—
40	P21	—	ANI1/ AVREFM	—	—	—	—	—	—	—	—
41	P20	—	ANI0/ AVREFP	—	—	—	—	—	—	—	—
42	P01	—	—	—	—	TS27	TO00	—	RxD1	—	—
43	P00	—	—	—	—	TS26	TI00	—	TxD1	—	—
44	P120	—	ANI19	—	—	—	—	—	—	—	—

### 1.3.10 48-pin products

- 48-pin plastic LFQFP (7 × 7 mm, 0.50-mm pitch)
- 48-pin plastic HWQFN (7 × 7 mm, 0.50-mm pitch)



**Note** The 48-pin plastic LFQFP (7 × 7 mm, 0.50-mm pitch) products do not have an exposed die pad.

**Caution** Connect the REGC pin to Vss via a capacitor (0.47 to 1 μF).

**Remark 1.** For pin identification, see 1.4 Pin Identification.

**Remark 2.** Functions in parentheses in the above figure can be assigned via settings in the peripheral I/O redirection register (PIOR).

Refer to **Figure 4 - 9 Format of Peripheral I/O Redirection Register (PIOR)** in the RL78/G22 User's Manual.

**Remark 3.** It is recommended to connect an exposed die pad to Vss.

Table 1 - 11 Multiplexed Pin Functions of the 48-pin Products (1/2)

Pin Number	I/O	Power supply, system clock, and debugging	Analog Circuit	HMI			Timers		Communications Interfaces		
				A/D converter (ADC)	Interrupt (INTP)	Key interrupt (KR)	Capacitive sensing unit (CTSUS2La)	Timer array unit (TAU)	Realtime Clock (RTC)	Serial array unit (SAU)	Serial interface IICA (IICA)
1	P60	—	—	—	—	—	—	—	—	SCLA0	—
2	P61	—	—	—	—	—	—	—	—	SDAA0	—
3	P62	—	—	—	—	—	—	—	—	—	—
4	P63	—	—	—	—	—	—	—	—	—	—
5	P31	(PCLBUZ0)	—	INTP4	—	TS01	TI03/TO03	—	—	—	—
6	P75	—	—	INTP9	KR5	TS07	—	—	SCK01/ SCL01	—	—
7	P74	—	—	INTP8	KR4	TS06	—	—	SI01/ SDA01	—	—
8	P73	—	—	—	KR3	TS05	—	—	SO01	—	—
9	P72	—	—	—	KR2	TS04	—	—	SO21	—	TxDA0
10	P71	—	—	—	KR1	TS03	—	—	SI21/ SDA21	—	RxDA0
11	P70	—	—	—	KR0	TS02	—	—	SCK21/ SCL21	—	—
12	P30	—	—	INTP3	—	TSCAP	—	RTC1HZ	SCK11/ SCL11	—	—
13	P50	—	—	INTP1	—	TS00	—	—	SI11/ SDA11	—	—
14	P51	—	—	INTP2	—	TS28	—	—	SO11	—	—
15	P17	—	—	—	—	TS18	TI02/TO02	—	(TxD0)	—	—
16	P16	—	—	INTP5	—	TS17	TI01/TO01	—	(RxD0)	—	—
17	P15	PCLBUZ1	—	—	—	TS16	(TI02)/ (TO02)	—	SCK20/ SCL20	—	—
18	P14	—	—	—	—	TS15	(TI03)/ (TO03)	—	SI20/RxD2/ SDA20	(SCLA0)	—
19	P13	—	—	—	—	TS14	(TI04)/ (TO04)	—	SO20/ TxD2	(SDAA0)	—
20	P12	TOOLTxD	—	—	—	TS13	(TI05)/ (TO05)	—	SO00/ TxD0	—	—
21	P11	TOOLRxD	—	—	—	TS12	(TI06)/ (TO06)	—	SI00/RxD0/ SDA00	—	—
22	P10	—	—	—	—	TS11	(TI07)/ (TO07)	—	SCK00/ SCL00	—	—
23	P146	—	—	—	—	TS09	—	—	—	—	—
24	P147	—	ANI18	—	—	TS10	—	—	—	—	—
25	P27	—	ANI7	—	—	TS25	—	—	—	—	—
26	P26	—	ANI6	—	—	TS24	—	—	—	—	—
27	P25	—	ANI5	—	—	TS23	—	—	—	—	—
28	P24	—	ANI4	—	—	TS22	—	—	—	—	—
29	P23	—	ANI3	—	—	TS21	—	—	—	—	—
30	P22	—	ANI2	—	—	TS20	—	—	—	—	—
31	P21	—	ANI1/ AVREFM	—	—	—	—	—	—	—	—

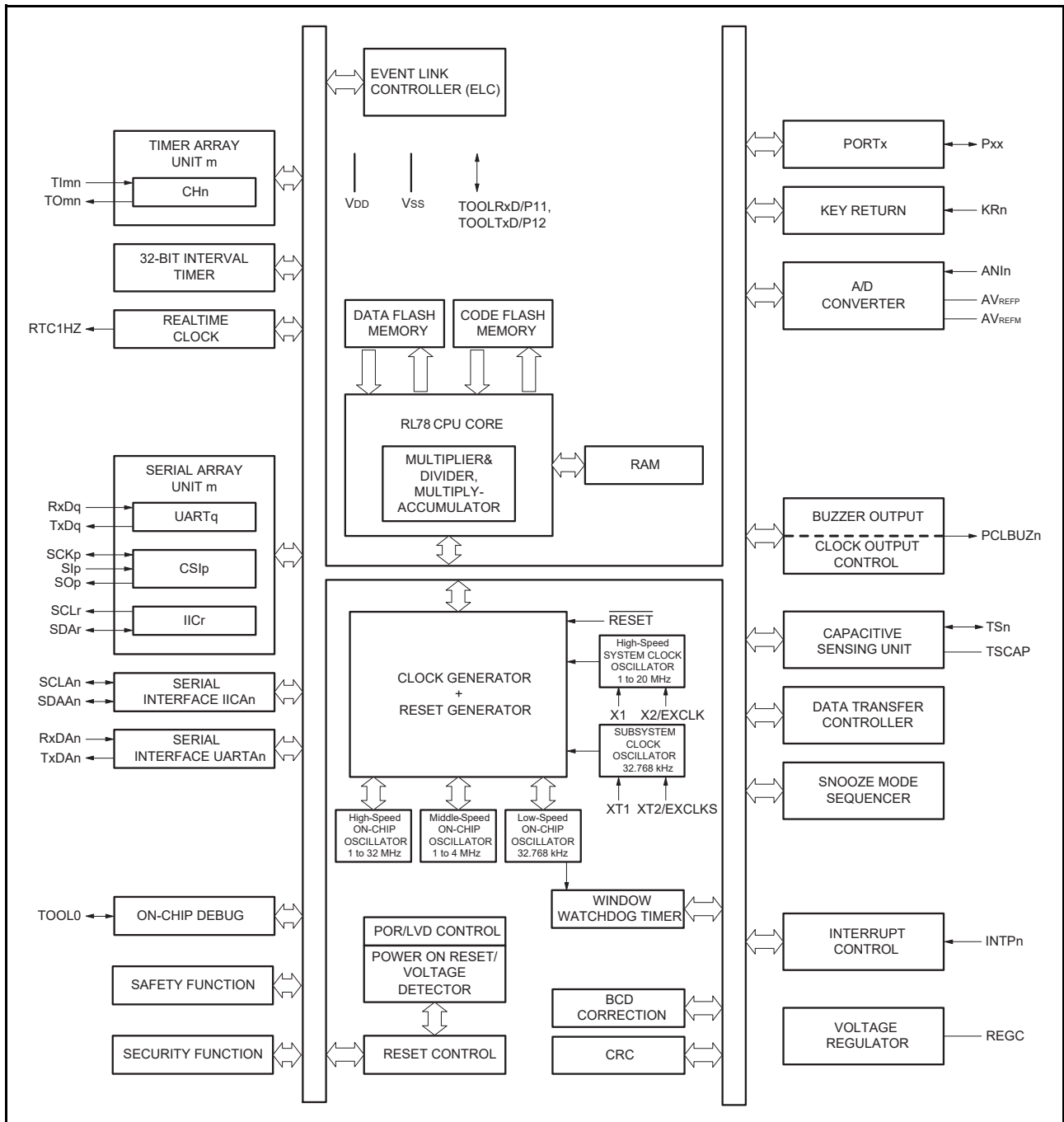
Table 1 - 11 Multiplexed Pin Functions of the 48-pin Products (2/2)

Pin Number	I/O	Power supply, system clock, and debugging	Analog Circuit	HMI			Timers		Communications Interfaces		
				A/D converter (ADC)	Interrupt (INTP)	Key interrupt (KR)	Capacitive sensing unit (CTS[U]2La)	Timer array unit (TAU)	Realtime Clock (RTC)	Serial array unit (SAU)	Serial interface IICA (IICA)
32	P20	—	ANI0/ AVREFP	—	—	—	—	—	—	—	—
33	P130	—	—	—	—	TS19	—	—	—	—	—
34	P01	—	—	—	—	TS27	TO00	—	RxD1	—	—
35	P00	—	—	—	—	TS26	TI00	—	TxD1	—	—
36	P140	PCLBUZ0	—	INTP6	—	TS08	—	—	—	—	—
37	P120	—	ANI19	—	—	—	—	—	—	—	—
38	P41	—	—	—	—	—	TI07/TO07	—	—	—	—
39	P40	TOOL0	—	—	—	—	—	—	—	—	—
40	—	RESET	—	—	—	—	—	—	—	—	—
41	P124	XT2/EXCLKS	—	—	—	—	—	—	—	—	—
42	P123	XT1	—	—	—	—	—	—	—	—	—
43	P137	—	—	INTP0	—	—	—	—	—	—	—
44	P122	X2/EXCLK	—	—	—	—	—	—	—	—	—
45	P121	X1/VBAT	—	—	—	—	—	—	—	—	—
46	—	REGC	—	—	—	—	—	—	—	—	—
47	—	VSS	—	—	—	—	—	—	—	—	—
48	—	VDD	—	—	—	—	—	—	—	—	—

## 1.4 Pin Identification

ANI0 to ANI7,		RxD0 to RxD2,	
ANI16 to ANI19	: Analog input	RxDA0	: Receive data
AVREFM	: Analog reference voltage minus	SCLA0,	
AVREFP	: Analog reference voltage plus	SCK00, SCK01,	
EXCLK	: External clock input (main system clock)	SCK11, SCK20, SCK21	: Serial clock input/output
EXCLKS	: External clock input (subsystem clock)	SCL00, SCL01, SCL11, SCL20, SCL21	: Serial clock output
INTP0 to INTP6, INTP8,		SDAA0, SDA00,	
INTP9	: Interrupt request from peripheral	SDA01, SDA11,	
KR0 to KR5	: Key return	SDA20, SDA21	: Serial data input/output
P00, P01	: Port 0	SI00, SI01, SI11,	
P10 to P17	: Port 1	SI20, SI21	: Serial data input
P20 to P27	: Port 2	SO00, SO01	
P30, P31	: Port 3	SO11, SO20, SO21	: Serial data output
P40, P41	: Port 4	TSCAP	: Touch sensor capacitance
P50, P51	: Port 5	TI00 to TI07	: Timer input
P60 to P63	: Port 6	TO00 to TO07	: Timer output
P70 to P75	: Port 7	TOOL0	: Data input/output for tool
P120 to P124	: Port 12	TOOLRxD, TOOLTxD	: Data input/output for external device
P130, P137	: Port 13	TS00 to TS28	: Capacitive touch sensor
P140, P146, P147	: Port 14	TxD0 to TxD2	: Transmit data
PCLBUZ0, PCLBUZ1	: Programmable clock output/buzzer output	TxDA0	
REGC	: Regulator capacitance	VBAT	: Battery backup power supply
$\overline{\text{RESET}}$	: Reset	VDD	: Power supply
RTC1HZ	: Realtime clock correction clock (1 Hz) output	VSS	: Ground
		X1, X2	: Crystal oscillator (main system clock)
		XT1, XT2	: Crystal oscillator (subsystem clock)

1.5 Block Diagram



**Caution 1.** The serial interface IICA is only incorporated in the 24- to 48-pin products.

**Caution 2.** The serial interface UARTA is only incorporated in the 36- to 48-pin products.

**Caution 3.** The key return function is only incorporated in the 40- to 48-pin products.

**Remark** m: Unit number, n: Channel number, p: Simplified SPI (CSI) number, q: UART number, r: Simplified I<sup>2</sup>C number, xx: Port number

## 1.6 Outline of Functions

**Caution** This outline describes the functions at the time when peripheral I/O redirection register (PIOR) is set to 00H.

(1/4)

Item	16-pin	20-pin	24-pin	25-pin	30-pin	32-pin	36-pin	40-pin	44-pin	48-pin	
	R7F102G4x	R7F102G6x	R7F102G7x	R7F102G8x	R7F102GAx	R7F102GBx	R7F102GCx	R7F102GEx	R7F102GFx	R7F102GGx	
Code flash memory	32 or 64 KB										
Data flash memory	2 KB										
RAM	4 KB										
Address space	1 Mbyte										
CPU/ peripheral hardware clock frequency (fCLK)	Main system clock	HS (high-speed main) mode: 1 to 32 MHz (V <sub>DD</sub> = 1.8 to 5.5 V) HS (high-speed main) mode: 1 to 4 MHz <sup>Note 1</sup> (V <sub>DD</sub> = 1.6 to 5.5 V) LS (low-speed main) mode: 1 to 24 MHz (V <sub>DD</sub> = 1.8 to 5.5 V) LS (low-speed main) mode: 1 to 4 MHz <sup>Note 1</sup> (V <sub>DD</sub> = 1.6 to 5.5 V) LP (low-power main) mode: 1 to 2 MHz <sup>Note 1</sup> (V <sub>DD</sub> = 1.6 to 5.5 V)									
	Subsystem clock	SUB mode: 32.768 kHz (V <sub>DD</sub> = 1.6 to 5.5 V)									
Main system clock	High- speed system clock (fMX)	1 to 20 MHz									
	High- speed on- chip oscillator clock (fIH)	1 MHz, 2 MHz, 3 MHz, 4 MHz, 6 MHz, 8 MHz, 12 MHz, 16 MHz, 24 MHz, 32 MHz									
	Middle- speed on- chip oscillator clock (fIM)	1 MHz, 2 MHz, 4 MHz									
Subsystem clock	Subsystem clock X (fsx)	32.768 kHz (V <sub>DD</sub> = 2.4 to 5.5 V)						32.768 kHz (V <sub>DD</sub> = 1.6 to 5.5 V)			
	Low-speed on-chip oscillator clock (fIL)	32.768 kHz (typ.)									
General-purpose registers	8 bits × 32 registers (8 bits × 8 registers × 4 banks)										
Minimum instruction execution time	0.03125 μs (at the 32-MHz operation with the high-speed on-chip oscillator clock (fIH))										
Instruction set	<ul style="list-style-type: none"> <li>• Data transfer (8/16 bits)</li> <li>• Adder and subtractor/logical operation (8/16 bits)</li> <li>• Multiplication (8 bits × 8 bits, 16 bits × 16 bits), division (16 bits ÷ 16 bits, 32 bits ÷ 32 bits)</li> <li>• Multiplication and accumulation (16 bits × 16 bits + 32 bits)</li> <li>• Rotate, barrel shift, and bit manipulation (set, reset, test, and Boolean operation), etc.</li> </ul>										



(2/4)

Item		16-pin	20-pin	24-pin	25-pin	30-pin	32-pin	36-pin	40-pin	44-pin	48-pin	
		R7F102G4x	R7F102G6x	R7F102G7x	R7F102G8x	R7F102GAx	R7F102GBx	R7F102GCx	R7F102GEx	R7F102GFx	R7F102GGx	
I/O port	Total number of pins	12	16	20	21	26	28	32	36	40	44	
	CMOS I/O	11 (N-ch open drain I/O [withstand voltage of VDD]: 4)	15 (N-ch open drain I/O [withstand voltage of VDD]: 5)	17 (N-ch open drain I/O [withstand voltage of VDD]: 6)		23 (N-ch open drain I/O [withstand voltage of VDD]: 10)	24 (N-ch open drain I/O [withstand voltage of VDD]: 10)	28 (N-ch open drain I/O [withstand voltage of VDD]: 12)	30 (N-ch open drain I/O [withstand voltage of VDD]: 12)	33 (N-ch open drain I/O [withstand voltage of VDD]: 12)	36 (N-ch open drain I/O [withstand voltage of VDD]: 13)	
	CMOS input	1							3			
	CMOS output	—				1	—		1			
	N-ch open drain I/O [withstand voltage of 6 V]	—			2			3			4	
Timers	16-bit timer	8 channels										
	Watchdog timer	1 channel										
	Realtime clock (RTC)	1 channel										
	32-bit interval timer (TML32)	1 channel in 32-bit counter mode, 2 channels in 16-bit counter mode, 4 channels in 8-bit counter mode										
	Timer output	1 channel (PWM output: 1)	3 channels (PWM outputs: 2 <sup>Note 2</sup> )	4 channels (PWM outputs: 3 <sup>Note 2</sup> )		4 channels (PWM outputs: 3 <sup>Note 2</sup> ), 8 channels (PWM outputs: 7 <sup>Note 2</sup> ) <sup>Note 3</sup>						
	RTC output	1 channel										
Clock output/buzzer output	2											
	<ul style="list-style-type: none"> <li>3.91 kHz, 7.81 kHz, 15.63 kHz, 2 MHz, 4 MHz, 8 MHz, 16 MHz (at the 32-MHz operation with the main system clock (f<sub>MAIN</sub>))</li> <li>256 Hz, 512 Hz, 1.024 kHz, 2.048 kHz, 4.096 kHz, 8.192 kHz, 16.384 kHz, 32.768 kHz (at the 32.768-kHz operation with the low-speed peripheral clock (f<sub>SP</sub>))</li> </ul>											
8-/10-bit resolution A/D converter	3 channels	6 channels			8 channels			9 channels	10 channels			

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Item	16-pin	20-pin	24-pin	25-pin	30-pin	32-pin	36-pin	40-pin	44-pin	48-pin	
	R7F102G4x	R7F102G6x	R7F102G7x	R7F102G8x	R7F102GAx	R7F102GBx	R7F102GCx	R7F102GEx	R7F102GFx	R7F102GGx	
Serial interfaces	[16-pin products]										
	<ul style="list-style-type: none"> <li>• Simplified SPI (CSI): 1 channel, simplified I<sup>2</sup>C: 1 channel, UART: 1 channel</li> <li>• Simplified I<sup>2</sup>C: 1 channel</li> </ul>										
	[20-, 24-, and 25-pin products]										
	<ul style="list-style-type: none"> <li>• Simplified SPI (CSI): 1 channel, simplified I<sup>2</sup>C: 1 channel, UART: 1 channel</li> <li>• Simplified SPI (CSI): 1 channel, simplified I<sup>2</sup>C: 1 channel, UART: 1 channel</li> </ul>										
	[30- and 32-pin products]										
<ul style="list-style-type: none"> <li>• Simplified SPI (CSI): 1 channel, simplified I<sup>2</sup>C: 1 channel, UART: 1 channel</li> <li>• Simplified SPI (CSI): 1 channel, simplified I<sup>2</sup>C: 1 channel, UART: 1 channel</li> <li>• Simplified SPI (CSI): 1 channel, simplified I<sup>2</sup>C: 1 channel, UART (UART supporting LIN-bus): 1 channel</li> </ul>											
[36-, 40-, and 44-pin products]											
<ul style="list-style-type: none"> <li>• Simplified SPI (CSI): 1 channel, simplified I<sup>2</sup>C: 1 channel, UART: 1 channel</li> <li>• Simplified SPI (CSI): 1 channel, simplified I<sup>2</sup>C: 1 channel, UART: 1 channel</li> <li>• Simplified SPI (CSI): 2 channels, simplified I<sup>2</sup>C: 2 channels, UART (UART supporting LIN-bus): 1 channel</li> </ul>											
[48-pin products]											
<ul style="list-style-type: none"> <li>• Simplified SPI (CSI): 2 channels, simplified I<sup>2</sup>C: 2 channels, UART: 1 channel</li> <li>• Simplified SPI (CSI): 1 channel, simplified I<sup>2</sup>C: 1 channel, UART: 1 channel</li> <li>• Simplified SPI (CSI): 2 channels, simplified I<sup>2</sup>C: 2 channels, UART (UART supporting LIN-bus): 1 channel</li> </ul>											
UARTA	—						1 channel				
I <sup>2</sup> C bus	—			1 channel							
Data transfer controller (DTC)	21 sources	23 sources	25 sources		28 sources		30 sources	31 sources		32 sources	
Event link controller (ELC)	1										
SNOOZE mode sequencer (SMS)	1										
Capacitive sensing unit	5	9	11	12	16	17	21	23	25	29	
Vectored interrupt sources	Internal	23	25	26		29		32			
	External	2	3	5		6			7	10	
Key interrupt	—							4		6	
Reset	<ul style="list-style-type: none"> <li>• Reset by <math>\overline{\text{RESET}}</math> pin</li> <li>• Internal reset by watchdog timer</li> <li>• Internal reset by power-on-reset</li> <li>• Internal reset by voltage detectors (LVD0 and LVD1)</li> <li>• Internal reset by illegal instruction execution<sup>Note 4</sup></li> <li>• Internal reset by RAM parity error</li> <li>• Internal reset by illegal-memory access</li> </ul>										
Power-on-reset circuit	Detection voltage • 1.50 V (typ.)										
Voltage detector	LVD0	Detection voltage • Rising edge: 1.67 to 4.00 V (6 stages) • Falling edge: 1.63 to 3.92 V (6 stages)									
	LVD1	Detection voltage • Rising edge: 1.67 to 4.16 V (18 stages) • Falling edge: 1.63 to 4.08 V (18 stages)									
On-chip debugging	Available										
Power supply voltage	V <sub>DD</sub> = 1.6 to 5.5 V										

(4/4)

Item	16-pin	20-pin	24-pin	25-pin	30-pin	32-pin	36-pin	40-pin	44-pin	48-pin
	R7F102G4x	R7F102G6x	R7F102G7x	R7F102G8x	R7F102GAx	R7F102GBx	R7F102GCx	R7F102GEx	R7F102GFx	R7F102GGx
Operating ambient temperature	TA = -40 to +85°C (2D: Consumer applications), TA = -40 to +105°C (3C: Industrial applications)									

- Note 1.** Ensure that the operating voltage is at least 1.8 V during overwriting of the flash memory.
- Note 2.** The number of PWM outputs varies depending on the setting of channels in use (the number of masters and slaves). For details, see **7.9.3 Operation for the multiple PWM output function** in the RL78/G22 User's Manual.
- Note 3.** This applies when the setting of the PIOR0 bit is 1.
- Note 4.** In normal operation, executing the instruction code FFH triggers an internal reset, but this is not the case during emulation by the on-chip debugging emulator.

## 2. Electrical Characteristics

This section describes the electrical characteristics of the following products.

- 2D: Consumer applications, TA = -40 to +85°C  
R7F102Gxx2Dxx
- 3C: Industrial applications, TA = -40 to +105°C  
R7F102Gxx3Cxx

**Caution 1.** RL78 microcontrollers have on-chip debugging functionality for use in the development and evaluation of user systems. Do not use on-chip debugging with products designated as part of mass production, because using this function may cause the guaranteed number of times the flash memory is rewritten to be exceeded, and product reliability therefore cannot be guaranteed. Renesas Electronics is not liable for problems occurring when on-chip debugging is used with products designated as part of mass production.

**Caution 2.** For the consumer application products, the ambient operating temperature of TA = -40 to +85°C applies. Note that the characteristics of the A/D converter for each of the ranges of ambient operating temperature are described in the following sections.

2.6.1 Characteristics of the A/D converter for TA = -40 to +85°C

2.6.2 Characteristics of the A/D converter for TA = -40 to +105°C

**Caution 3.** The present pins differ depending on the products. For details, see section 2.1 Functions of Port Pins through section 2.2.1 Functions for each product in the RL78/G22 User's Manual.

## 2.1 Absolute Maximum Ratings

(1/2)

Item	Symbols	Conditions		Ratings	Unit
Supply voltage	VDD			-0.5 to +6.5	V
REGC pin input voltage	VIREGC	REGC		-0.3 to +2.1 and -0.3 to VDD + 0.3 <sup>Note 1</sup>	V
Input voltage	Vi1	P00, P01, P10 to P17, P30, P31, P40, P41, P50, P51, P70 to P75, P120, P140, P146, P147		-0.3 to VDD + 0.3 <sup>Note 2</sup>	V
	Vi2	P60 to P63 (N-ch open-drain)		-0.3 to +6.5	V
	Vi3	P20 to P27, P121 to P124, P137, EXCLK, EXCLKS, RESET		-0.3 to VDD + 0.3 <sup>Note 2</sup>	V
Output voltage	VO1	P00, P01, P10 to P17, P30, P31, P40, P41, P50, P51, P60 to P63, P70 to P75, P130, P140, P146, P147		-0.3 to VDD + 0.3 <sup>Note 2</sup>	V
	VO2	P20 to P27, P121, P122		-0.3 to VDD + 0.3 <sup>Note 2</sup>	V
Analog input voltage	VAI1	ANI16 to ANI19		-0.3 to VDD + 0.3 and -0.3 to AVREFP + 0.3 <b>Notes 2, 3</b>	V
	VAI2	ANI0 to ANI7		-0.3 to VDD + 0.3 and -0.3 to AVREFP + 0.3 <b>Notes 2, 3</b>	V
High-level output current	IOH1	Per pin	P00, P01, P10 to P17, P30, P31, P40, P41, P50, P51, P70 to P75, P120, P130, P140, P146, P147	-40	mA
		Total of all pins -170 mA	P00, P01, P40, P41, P120, P130, P140	-70	mA
			P10 to P17, P30, P31, P50, P51, P70 to P75, P146, P147	-100	mA
	IOH2	Per pin	P20 to P27, P121, P122	-5	mA
		Total of all pins		-20	mA
	Low-level output current	IOL1	Per pin	P00, P01, P10 to P17, P30, P31, P40, P41, P50, P51, P60 to P63, P70 to P75, P120, P130, P140, P146, P147	40
Total of all pins 170 mA			P00, P01, P40, P41, P120, P130, P140	70	mA
			P10 to P17, P30, P31, P50, P51, P60 to P63, P70 to P75, P146, P147	100	mA
IOL2		Per pin	P20 to P27, P121, P122	10	mA
		Total of all pins		20	mA

**Note 1.** Connect the REGC pin to Vss via a capacitor (0.47 to 1  $\mu$ F). The listed value is the absolute maximum rating of the REGC pin. Only use the capacitor connection. Do not apply a specific voltage to this pin.

**Note 2.** This voltage must be no higher than 6.5 V.

**Note 3.** The voltage on a pin in use for A/D conversion must not exceed AVREFP + 0.3.

(Caution and Remarks are listed on the next page.)

(2/2)

Item	Symbols	Conditions		Ratings	Unit
Ambient operating temperature	TA	In normal operation mode	3C: Industrial applications	-40 to +105	°C
			2D: Consumer applications	-40 to +85	
		In flash memory programming mode	3C: Industrial applications	-40 to +105	
			2D: Consumer applications	-40 to +85	
Storage temperature	T <sub>stg</sub>			-65 to +150	°C

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

**Remark 1.** The characteristics of functions multiplexed on a given pin are the same as those for the port pin unless otherwise specified.

**Remark 2.** AVREFP refers to the positive reference voltage of the A/D converter.

**Remark 3.** The reference voltage is V<sub>SS</sub>.

## 2.2 Characteristics of the Oscillators

### 2.2.1 Characteristics of the X1 oscillator

(TA = -40 to +105°C, 1.6 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

Item	Resonator	Conditions	Min.	Typ.	Max.	Unit
X1 clock oscillation allowable input cycle time <b>Note</b>	Ceramic resonator/ crystal resonator		0.05		1	μs

**Note** The listed time and frequency indicate permissible ranges of the oscillator. For actual applications, request evaluation by the manufacturer of the oscillator circuit mounted on a board so you can use appropriate values. See **2.4 AC Characteristics** for instruction execution time.

**Caution** Since the CPU is started by the high-speed on-chip oscillator clock after release from the reset state, the user should use the oscillation stabilization time counter status register (OSTC) to check the X1 clock oscillation stabilization time. Specify the values for the oscillation stabilization time in the OSTC register and the oscillation stabilization time select register (OSTS) after having sufficiently evaluated the oscillation stabilization time with the resonator to be used.

### 2.2.2 Characteristics of the XT1 oscillator

(TA = -40 to +105°C, 2.4 V ≤ VDD ≤ 5.5 V (16- to 36-pin products), 1.6 V ≤ VDD ≤ 5.5 V (40- to 48-pin products), VSS = 0 V)

Item	Resonator	Conditions	Min.	Typ.	Max.	Unit
XT1 clock oscillation frequency (f <sub>XT</sub> ) <b>Note</b>	Crystal resonator			32.768		kHz

**Note** The listed time and frequency indicate permissible ranges of the oscillator. For actual applications, request evaluation by the manufacturer of the oscillator circuit mounted on a board so you can use appropriate values. See **2.4 AC Characteristics** for instruction execution time.

### 2.2.3 Characteristics of the On-chip Oscillators

(TA = -40 to +105°C, 1.6 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

Item	Symbol	Conditions			Min.	Typ.	Max.	Unit
High-speed on-chip oscillator clock frequency	f <sub>H</sub>				1		32	MHz
High-speed on-chip oscillator clock frequency accuracy <sup>Note 1</sup>		HIPREC = 1	+85 to +105°C	1.8 V ≤ VDD ≤ 5.5 V	-2.0		+2.0	%
				1.6 V ≤ VDD ≤ 5.5 V	-6.0		+6.0	%
			-20 to +85°C	1.8 V ≤ VDD ≤ 5.5 V	-1.0		+1.0	%
				1.6 V ≤ VDD ≤ 5.5 V	-5.0		+5.0	%
			-40 to -20°C	1.8 V ≤ VDD ≤ 5.5 V	-1.5		+1.5	%
				1.6 V ≤ VDD ≤ 5.5 V	-5.5		+5.5	%
		HIPREC = 0 <sup>Note 4</sup>			-15		0	%
High-speed on-chip oscillator clock correction resolution						0.05		%
Middle-speed on-chip oscillator clock frequency <sup>Note 2</sup>	f <sub>M</sub>				1		4	MHz
Middle-speed on-chip oscillator clock frequency accuracy <sup>Note 1</sup>					-12		+12	%
Middle-speed on-chip oscillator clock correction resolution						0.15		%
Middle-speed on-chip oscillator frequency temperature coefficient							±0.17 <sup>Note 3</sup>	%/°C
Low-speed on-chip oscillator clock frequency <sup>Note 2</sup>	f <sub>L</sub>					32.768		kHz
Low-speed on-chip oscillator clock frequency accuracy <sup>Note 1</sup>					-15		+15	%
Low-speed on-chip oscillator clock correction resolution						0.3		%
Low-speed on-chip oscillator frequency temperature coefficient							±0.21 <sup>Note 3</sup>	%/°C

**Note 1.** The accuracy values were obtained in testing of this product.

**Note 2.** The listed values only indicate the characteristics of the oscillators. See **2.4 AC Characteristics** for instruction execution time.

**Note 3.** Guaranteed by characterization results.

**Note 4.** The listed condition applies when the setting of the FRQSEL3 bit is 1.



## 2.3 DC Characteristics

### 2.3.1 Characteristics of Pins

(TA = -40 to +105°C, 1.6 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

(1/5)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit	
Allowable high-level output current <b>Note 1</b>	IOH1	Per pin for P00, P01, P10 to P17, P30, P31, P40, P41, P50, P51, P70 to P75, P120, P130, P140, P146, P147	1.6 V ≤ VDD ≤ 5.5 V			-10.0 <b>Note 2</b>	mA
		Total of P00, P01, P40, P41, P120, P130, P140 (when duty ≤ 70% <b>Note 3</b> )	4.0 V ≤ VDD ≤ 5.5 V			-55.0 <b>Note 4</b>	mA
			2.7 V ≤ VDD < 4.0 V			-10.0	mA
			1.8 V ≤ VDD < 2.7 V			-5.0	mA
			1.6 V ≤ VDD < 1.8 V			-2.5	mA
		Total of P10 to P17, P30, P31, P50, P51, P70 to P75, P146, P147 (when duty ≤ 70% <b>Note 3</b> )	4.0 V ≤ VDD ≤ 5.5 V			-80.0 <b>Note 5</b>	mA
			2.7 V ≤ VDD < 4.0 V			-19.0	mA
			1.8 V ≤ VDD < 2.7 V			-10.0	mA
			1.6 V ≤ VDD < 1.8 V			-5.0	mA
		Total of all pins (when duty ≤ 70% <b>Note 3</b> )	1.6 V ≤ VDD ≤ 5.5 V			-135.0 <b>Note 6</b>	mA
	IOH2	Per pin for P20 to P27, P121, P122	4.0 V ≤ VDD ≤ 5.5 V			-3.0 <b>Note 2</b>	mA
			2.7 V ≤ VDD < 4.0 V			-1.0 <b>Note 2</b>	mA
			1.8 V ≤ VDD < 2.7 V			-1.0 <b>Note 2</b>	mA
			1.6 V ≤ VDD < 1.8 V			-0.5 <b>Note 2</b>	mA
		Total of all pins (when duty ≤ 70% <b>Note 3</b> )	4.0 V ≤ VDD ≤ 5.5 V			-20.0	mA
			2.7 V ≤ VDD < 4.0 V			-10.0	mA
			1.8 V ≤ VDD < 2.7 V			-5.0	mA
			1.6 V ≤ VDD < 1.8 V			-5.0	mA

**Note 1.** Device operation is guaranteed at the listed currents even if current is flowing from the VDD pin to an output pin.

**Note 2.** The combination of these and other pins must also not exceed the value for maximum total current.

**Note 3.** The listed currents apply when the duty cycle is no greater than 70%.

Use the following formula to calculate the output current when the duty cycle is greater than 70%, where n is the duty cycle.

• Total output current from the listed pins = (IOH × 0.7)/(n × 0.01)

Example when n = 80% and IOH = -10.0 mA

Total output current from the listed pins = (-10.0 × 0.7)/(80 × 0.01) ≈ -8.7 mA

Note that the duty cycle has no effect on the current that is allowed to flow into a single pin. A current higher than the absolute maximum rating must not flow into a single pin.

**Note 4.** The maximum value is -30 mA in the products for industrial applications (R7F102Gxx3xxxC) with an ambient operating temperature range of +85 to +105°C.

**Note 5.** The maximum value is -50 mA in the products for industrial applications (R7F102Gxx3xxxC) with an ambient operating temperature range of +85 to +105°C.

**Note 6.** The maximum values are respectively -100 mA and -60 mA in the products for industrial applications (R7F102Gxx3xxxC) with an ambient operating temperature range of -40 to +85°C and of +85 to +105°C.

**Caution** The following pins are not capable of the output of high-level signals in the N-ch open-drain mode.  
**P00, P10 to P15, P17, P50, P71, P72, P74, and P120**

**Remark** The characteristics of functions multiplexed on a given pin are the same as those for the port pin unless otherwise specified.

(TA = -40 to +105°C, 1.6 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

(2/5)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit	
Allowable low-level output current <sup>Note 1</sup>	IoL1	Per pin for P00, P01, P10 to P17, P30, P31, P40, P41, P50, P51, P70 to P75, P120, P130, P140, P146, P147			20.0 <sup>Note 2</sup>	mA	
		Per pin for P60 to P63			15.0 <sup>Note 2</sup>	mA	
		Total of P00, P01, P40, P41, P120, P130, P140 (when duty ≤ 70% <sup>Note 3</sup> )	4.0 V ≤ VDD ≤ 5.5 V			70.0 <sup>Note 4</sup>	mA
			2.7 V ≤ VDD < 4.0 V			15.0	mA
			1.8 V ≤ VDD < 2.7 V			9.0	mA
			1.6 V ≤ VDD < 1.8 V			4.5	mA
		Total of P10 to P17, P30, P31, P50, P51, P60 to P63, P70 to P75, P146, P147 (when duty ≤ 70% <sup>Note 3</sup> )	4.0 V ≤ VDD ≤ 5.5 V			80.0 <sup>Note 4</sup>	mA
			2.7 V ≤ VDD < 4.0 V			35.0	mA
			1.8 V ≤ VDD < 2.7 V			20.0	mA
			1.6 V ≤ VDD < 1.8 V			10.0	mA
	Total of all pins (when duty ≤ 70% <sup>Note 3</sup> )				150.0 <sup>Note 5</sup>	mA	
	IoL2	Per pin for P20 to P27, P121, P122	4.0 V ≤ VDD ≤ 5.5 V			8.5 <sup>Note 2</sup>	mA
			2.7 V ≤ VDD < 4.0 V			1.5 <sup>Note 2</sup>	mA
			1.8 V ≤ VDD < 2.7 V			0.6 <sup>Note 2</sup>	mA
			1.6 V ≤ VDD < 1.8 V			0.4 <sup>Note 2</sup>	mA
		Total of all pins (when duty ≤ 70% <sup>Note 3</sup> )	4.0 V ≤ VDD ≤ 5.5 V			20	mA
			2.7 V ≤ VDD < 4.0 V			20	mA
			1.8 V ≤ VDD < 2.7 V			15	mA
1.6 V ≤ VDD < 1.8 V					10	mA	

**Note 1.** Device operation is guaranteed at the listed currents even if current is flowing from an output pin to the VSS pin.

**Note 2.** The combination of these and other pins must also not exceed the value for maximum total current.

**Note 3.** The listed currents apply when the duty cycle is no greater than 70%.

Use the following formula to calculate the output current when the duty cycle is greater than 70%, where n is the duty cycle.

• Total output current from the listed pins = (IoL × 0.7)/(n × 0.01)

Example when n = 80% and IoL = 10.0 mA

Total output current from the listed pins = (10.0 × 0.7)/(80 × 0.01) ≈ 8.7 mA

Note that the duty cycle has no effect on the current that is allowed to flow into a single pin. A current higher than the absolute maximum rating must not flow into a single pin.

**Note 4.** The maximum value is 40 mA in the products for industrial applications (R7F102Gxx3xxx) with an ambient operating temperature range of +85 to +105°C.

**Note 5.** The maximum value is 80 mA in the products for industrial applications (R7F102Gxx3xxx) with an ambient operating temperature range of +85 to +105°C.

**Remark** The characteristics of functions multiplexed on a given pin are the same as those for the port pin unless otherwise specified.

(TA = -40 to +105°C, 1.6 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

(3/5)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit	
Input voltage, high	VIH1	P00, P01, P10 to P17, P30, P31, P40, P41, P50, P51, P70 to P75, P120, P140, P146, P147	Normal input buffer	0.8 VDD		VDD	V
	VIH2	P01, P10, P11, P13 to P17, P41, P71	TTL input buffer 4.0 V ≤ VDD ≤ 5.5 V	2.2		VDD	V
			TTL input buffer 3.3 V ≤ VDD < 4.0 V	2.0		VDD	V
			TTL input buffer 1.6 V ≤ VDD < 3.3 V	1.5		VDD	V
	VIH3	P20 to P27		0.7 VDD		VDD	V
	VIH4	P60 to P63		0.7 VDD		6.0	V
	VIH5	P121 to P124, P137, EXCLK, EXCLKS, $\overline{\text{RESET}}$		0.8 VDD		VDD	V
Input voltage, low	UIL1	P00, P01, P10 to P17, P30, P31, P40, P41, P50, P51, P70 to P75, P120, P140, P146, P147	Normal input buffer	0		0.2 VDD	V
	UIL2	P01, P10, P11, P13 to P17, P41, P71	TTL input buffer 4.0 V ≤ VDD ≤ 5.5 V	0		0.8	V
			TTL input buffer 3.3 V ≤ VDD < 4.0 V	0		0.5	V
			TTL input buffer 1.6 V ≤ VDD < 3.3 V	0		0.32	V
	UIL3	P20 to P27		0		0.3 VDD	V
	UIL4	P60 to P63		0		0.3 VDD	V
	UIL5	P121 to P124, P137, EXCLK, EXCLKS, $\overline{\text{RESET}}$		0		0.2 VDD	V

**Caution** The maximum value of VIH of pins P00, P10 to P15, P17, P50, P71, P72, P74, and P120 is VDD, even in the N-ch open-drain mode.

**Remark** The characteristics of functions multiplexed on a given pin are the same as those for the port pin unless otherwise specified.

(TA = -40 to +105°C, 1.6 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

(4/5)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit	
Output voltage, high	VOH1	P00, P01, P10 to P17, P30, P31, P40, P41, P50, P51, P70 to P75, P120, P130, P140, P146, P147	4.0 V ≤ VDD ≤ 5.5 V, IOH1 = -10.0 mA	VDD - 1.5			V
			4.0 V ≤ VDD ≤ 5.5 V, IOH1 = -3.0 mA	VDD - 0.7			V
			2.7 V ≤ VDD ≤ 5.5 V, IOH1 = -2.0 mA	VDD - 0.6			V
			1.8 V ≤ VDD ≤ 5.5 V, IOH1 = -1.5 mA	VDD - 0.5			V
			1.6 V ≤ VDD < 5.5 V, IOH1 = -1.0 mA	VDD - 0.5			V
	VOH2	P20 to P27, P121, P122	4.0 V ≤ VDD ≤ 5.5 V, IOH2 = -3.0 mA	VDD - 0.7			V
			2.7 V ≤ VDD < 4.0 V, IOH2 = -1.0 mA	VDD - 0.5			V
			1.8 V ≤ VDD < 2.7 V, IOH2 = -1.0 mA	VDD - 0.5			V
			1.6 V ≤ VDD < 1.8 V, IOH2 = -0.5 mA	VDD - 0.5			V
	Output voltage, low	VOL1	P00, P01, P10 to P17, P30, P31, P40, P41, P50, P51, P70 to P75, P120, P130, P140, P146, P147	4.0 V ≤ VDD ≤ 5.5 V, IOL1 = 20.0 mA			1.3
4.0 V ≤ VDD ≤ 5.5 V, IOL1 = 8.5 mA						0.7	V
2.7 V ≤ VDD ≤ 5.5 V, IOL1 = 3.0 mA						0.6	V
2.7 V ≤ VDD ≤ 5.5 V, IOL1 = 1.5 mA						0.4	V
1.8 V ≤ VDD ≤ 5.5 V, IOL1 = 0.6 mA						0.4	V
1.6 V ≤ VDD ≤ 5.5 V, IOL1 = 0.3 mA						0.4	V
VOL2		P20 to P27, P121, P122	4.0 V ≤ VDD ≤ 5.5 V, IOL2 = 8.5 mA			0.7	V
			2.7 V ≤ VDD < 4.0 V, IOL2 = 1.5 mA			0.5	V
			1.8 V ≤ VDD < 2.7 V, IOL2 = 0.6 mA			0.4	V
			1.6 V ≤ VDD < 1.8 V, IOL2 = 0.4 mA			0.4	V
VOL3		P60 to P63	4.0 V ≤ VDD ≤ 5.5 V, IOL3 = 15.0 mA			2.0	V
			4.0 V ≤ VDD ≤ 5.5 V, IOL3 = 5.0 mA			0.4	V
			2.7 V ≤ VDD ≤ 5.5 V, IOL3 = 3.0 mA			0.4	V
			1.8 V ≤ VDD ≤ 5.5 V, IOL3 = 2.0 mA			0.4	V
			1.6 V ≤ VDD ≤ 5.5 V, IOL3 = 1.0 mA			0.4	V

**Caution** P00, P10 to P15, P17, P50, P71, P72, P74, and P120 do not output high-level signals in the N-ch open-drain mode.

**Remark** The characteristics of functions multiplexed on a given pin are the same as those for the port pin unless otherwise specified.

(TA = -40 to +105°C, 1.6 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

(5/5)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Input leakage current, high	LIH1	P00, P01, P10 to P17, P30, P31, P40, P41, P50, P51, P60 to P63, P70 to P75, P120, P130, P140, P146, P147			0.5	μA
	LIH2	P20 to P27, P137, $\overline{\text{RESET}}$			0.5	μA
	LIH3	P121 to P124 (X1, X2, XT1, XT2, EXCLK, EXCLKS)			0.5	μA
Input leakage current, low	LIL1	P00, P01, P10 to P17, P30, P31, P40, P41, P50, P51, P60 to P63, P70 to P75, P120, P130, P140, P146, P147			-0.5	μA
	LIL2	P20 to P27, P137, $\overline{\text{RESET}}$			-0.5	μA
	LIL3	P121 to P124 (X1, X2, XT1, XT2, EXCLK, EXCLKS)			-0.5	μA
On-chip pull-up resistance	RU	P00, P01, P10 to P17, P30, P31, P40, P41, P50, P51, P70 to P75, P120 to P122, P140, P146, P147	10	20	100	kΩ

**Remark** The characteristics of functions multiplexed on a given pin are the same as those for the port pin unless otherwise specified.

## 2.3.2 Characteristics of the supply current

(TA = -40 to +105°C, 1.6 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

(1/4)

Item	Symbol	Conditions				Min.	Typ.	Max.	Unit	
Supply current Note 1	IDD1	Operating mode	HS (high-speed main) mode	f <sub>IH</sub> = 32 MHz <sup>Note 2</sup>	Basic operation	VDD = 5.0 V		1.2		mA
						VDD = 1.8 V		1.2		
				Normal operation	VDD = 5.0 V		2.7	4.6	mA	
					VDD = 1.8 V		2.7	4.6		
			LS (low-speed main) mode	f <sub>IH</sub> = 24 MHz <sup>Note 2</sup>	Normal operation	VDD = 5.0 V		2.0	3.5	mA
						VDD = 1.8 V		2.0	3.5	
				f <sub>IH</sub> = 16 MHz <sup>Note 2</sup>	Normal operation	VDD = 5.0 V		1.5	2.5	mA
				VDD = 1.8 V		1.5	2.5			
			f <sub>IM</sub> = 4 MHz <sup>Note 3</sup>	Normal operation	VDD = 5.0 V		0.4	0.7	mA	
					VDD = 1.6 V		0.4	0.7		
		LP (low-power main) mode	f <sub>IM</sub> = 2 MHz <sup>Note 3</sup>	Normal operation	VDD = 5.0 V		179	300	μA	
					VDD = 1.6 V		179	300		
			f <sub>IM</sub> = 1 MHz <sup>Note 3</sup>	Normal operation	VDD = 5.0 V		100	163	μA	
					VDD = 1.6 V		100	163		
		HS (high-speed main) mode	f <sub>MX</sub> = 20 MHz <sup>Note 4</sup> , Square wave input	Normal operation	VDD = 5.0 V		1.7	2.9	mA	
					VDD = 1.8 V		1.6	2.8		
		LS (low-speed main) mode	f <sub>MX</sub> = 20 MHz <sup>Note 4</sup> , Square wave input	Normal operation	VDD = 5.0 V		1.5	2.7	mA	
					VDD = 1.8 V		1.5	2.7		
			f <sub>MX</sub> = 20 MHz <sup>Note 4</sup> , Resonator connection	Normal operation	VDD = 5.0 V		1.7	3.0	mA	
					VDD = 1.8 V		1.7	3.0		
f <sub>MX</sub> = 10 MHz <sup>Note 4</sup> , Square wave input	Normal operation		VDD = 5.0 V		0.8	1.5	mA			
			VDD = 1.8 V		0.8	1.4				
f <sub>MX</sub> = 10 MHz <sup>Note 4</sup> , Resonator connection	Normal operation		VDD = 5.0 V		0.9	1.6	mA			
			VDD = 1.8 V		0.9	1.6				
f <sub>MX</sub> = 8 MHz <sup>Note 4</sup> , Square wave input	Normal operation	VDD = 5.0 V		0.7	1.2	mA				
		VDD = 1.8 V		0.7	1.2					
f <sub>MX</sub> = 8 MHz <sup>Note 4</sup> , Resonator connection	Normal operation	VDD = 5.0 V		0.8	1.3	mA				
		VDD = 1.8 V		0.8	1.3					

**Note 1.** The listed currents are the total currents flowing into VDD, including the input leakage currents flowing when the level of the input pin is fixed to VDD or VSS. The following points apply in the HS (high-speed main), LS (low-speed main), and LP (low-power main) modes.

- The currents in the "Typ." column do not include the operating currents of the peripheral modules.
- The currents in the "Max." column include the operating currents of the peripheral modules, except for those flowing into the A/D converter, LVD circuit, I/O port, and on-chip pull-up/pull-down resistors, and those flowing while the data flash memory is being rewritten.

**Note 2.** The listed currents apply when the high-speed system clock, middle-speed on-chip oscillator, low-speed on-chip oscillator, and subsystem clock are stopped.

**Note 3.** The listed currents apply when the high-speed on-chip oscillator, high-speed system clock, low-speed on-chip oscillator, and subsystem clock are stopped.

**Note 4.** The listed currents apply when the high-speed on-chip oscillator, middle-speed on-chip oscillator, low-speed on-chip oscillator, and subsystem clock are stopped.

(Remarks are listed on the next page.)

**Remark 1.** f<sub>H</sub>: High-speed on-chip oscillator clock frequency

**Remark 2.** f<sub>M</sub>: Middle-speed on-chip oscillator clock frequency

**Remark 3.** f<sub>MX</sub>: High-speed system clock frequency (X1 clock oscillation frequency or external main system clock frequency)

**Remark 4.** The typical value for the ambient operating temperature (T<sub>A</sub>) is +25°C unless otherwise specified.

(TA = -40 to +105°C, 1.6 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

(2/4)

Item	Symbol	Conditions					Min.	Typ.	Max.	Unit
Supply current Note 1	IDD1	Operating mode	Subsystem clock operation mode	fsUB = 32.768 kHzNote 2, Low-speed on-chip oscillator operation	Normal operation	TA = -40°C		2.9	4.7	μA
						TA = +25°C		3.1	4.9	
						TA = +50°C		3.3	6.3	
						TA = +70°C		3.6	9.6	
						TA = +85°C		4.1	15.2	
						TA = +105°C		5.4	32.2	
				fsUB = 32.768 kHzNote 3, Square wave input	Normal operation	TA = -40°C		2.9	4.9	μA
						TA = +25°C		3.0	5.0	
						TA = +50°C		3.2	6.4	
						TA = +70°C		3.5	9.7	
						TA = +85°C		4.0	15.3	
				fsUB = 32.768 kHzNote 3, Resonator connection	Normal operation	TA = -40°C		2.9	4.9	μA
						TA = +25°C		3.1	5.3	
						TA = +50°C		3.3	6.7	
						TA = +70°C		3.6	10.2	
TA = +85°C		4.1	15.8							
				TA = +105°C		5.5	33.3			

**Note 1.** The listed currents are the total currents flowing into VDD, including the input leakage currents flowing when the level of the input pin is fixed to VDD or VSS. In the subsystem clock operation mode, the currents in both the “Typ.” and “Max.” columns do not include the operating currents of the peripheral modules.

**Note 2.** The listed currents apply when the high-speed on-chip oscillator, middle-speed on-chip oscillator, high-speed system clock, and subsystem clock are stopped. They do not include the current flowing into the RTC, 32-bit interval timer, and watchdog timer.

**Note 3.** The listed currents apply when the high-speed on-chip oscillator, high-speed system clock, middle-speed on-chip oscillator, and low-speed on-chip oscillator are stopped, and the low power consumption oscillation 3 is specified (AMPHS1, AMPHS0 = 1, 1). They do not include the currents flowing into the RTC, 32-bit interval timer, and watchdog timer.

**Remark 1.** fil: Low-speed on-chip oscillator clock frequency

**Remark 2.** fsUB: Subsystem clock frequency (XT1 clock oscillation frequency)



(TA = -40 to +105°C, 1.6 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

(3/4)

Item	Symbol	Conditions				Min.	Typ.	Max.	Unit
Supply current <b>Note 1</b>	IDD2 <b>Note 2</b>	HALT mode	HS (high-speed main) mode	f <sub>I</sub> H = 32 MHz <b>Note 3</b>	VDD = 5.0 V		0.49	1.87	mA
					VDD = 1.8 V		0.49	1.87	
			LS (low-speed main) mode	f <sub>I</sub> H = 24 MHz <b>Note 3</b>	VDD = 5.0 V		0.41	1.46	mA
					VDD = 1.8 V		0.40	1.45	
				f <sub>I</sub> H = 16 MHz <b>Note 3</b>	VDD = 5.0 V		0.42	1.15	mA
					VDD = 1.8 V		0.41	1.14	
				f <sub>I</sub> M = 4 MHz <b>Note 4</b>	VDD = 5.0 V		0.08	0.26	mA
					VDD = 1.6 V		0.07	0.25	
			LP (low-power main) mode	f <sub>I</sub> M = 2 MHz <b>Note 4</b>	VDD = 5.0 V		29	115	μA
					VDD = 1.6 V		29	115	
				f <sub>I</sub> M = 1 MHz <b>Note 4</b>	VDD = 5.0 V		25	71	μA
					VDD = 1.6 V		25	71	
			HS (high-speed main) mode	f <sub>M</sub> X = 20 MHz <b>Note 5</b> , Square wave input	VDD = 5.0 V		0.19	1.03	mA
					VDD = 1.8 V		0.16	0.99	
			LS (low-speed main) mode	f <sub>M</sub> X = 20 MHz <b>Note 5</b> , Square wave input	VDD = 5.0 V		0.19	1.03	mA
					VDD = 1.8 V		0.16	0.99	
				f <sub>M</sub> X = 20 MHz <b>Note 5</b> , Resonator connection	VDD = 5.0 V		0.38	1.26	mA
					VDD = 1.8 V		0.37	1.25	
				f <sub>M</sub> X = 10 MHz <b>Note 5</b> , Square wave input	VDD = 5.0 V		0.12	0.54	mA
					VDD = 1.8 V		0.10	0.52	
				f <sub>M</sub> X = 10 MHz <b>Note 5</b> , Resonator connection	VDD = 5.0 V		0.22	0.67	mA
					VDD = 1.8 V		0.22	0.66	
			f <sub>M</sub> X = 8 MHz <b>Note 5</b> , Square wave input	VDD = 5.0 V		0.10	0.45	mA	
				VDD = 1.8 V		0.09	0.43		
f <sub>M</sub> X = 8 MHz <b>Note 5</b> , Resonator connection	VDD = 5.0 V		0.20	0.57	mA				
	VDD = 1.8 V		0.20	0.56					

**Note 1.** The listed currents are the total currents flowing into VDD, including the input leakage currents flowing when the level of the input pin is fixed to VDD or VSS. The following points apply in the HS (high-speed main), LS (low-speed main), and LP (low-power main) modes.

- The currents in the “Typ.” column do not include the operating currents of the peripheral modules.
- The currents in the “Max.” column include the operating currents of the peripheral modules, except for those flowing into the A/D converter, LVD circuit, I/O port, and on-chip pull-up/pull-down resistors, and those flowing while the data flash memory is being rewritten.

**Note 2.** The listed currents apply when the HALT instruction has been fetched from the flash memory for execution.

**Note 3.** The listed currents apply when the high-speed system clock, middle-speed on-chip oscillator, low-speed on-chip oscillator, and subsystem clock are stopped.

**Note 4.** The listed currents apply when the high-speed on-chip oscillator, high-speed system clock, low-speed on-chip oscillator, and subsystem clock are stopped.

**Note 5.** The listed currents apply when the high-speed on-chip oscillator, middle-speed on-chip oscillator, low-speed on-chip oscillator, and subsystem clock are stopped.

(Remarks are listed on the next page.)

**Remark 1.** f<sub>H</sub>: High-speed on-chip oscillator clock frequency

**Remark 2.** f<sub>M</sub>: Middle-speed on-chip oscillator clock frequency

**Remark 3.** f<sub>MX</sub>: High-speed system clock frequency (X1 clock oscillation frequency or external main system clock frequency)

**Remark 4.** The typical value for the ambient operating temperature (T<sub>A</sub>) is +25°C unless otherwise specified.

(TA = -40 to +105°C, 1.6 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

(4/4)

Item	Symbol	Conditions			Min.	Typ.	Max.	Unit	
Supply current Note 1	IDD2 Note 2	HALT mode	Subsystem clock operation mode	fsUB = 32.768 kHz Note 3, Low-speed on-chip oscillator operation	TA = -40°C		0.48	1.84	μA
					TA = +25°C		0.57	1.89	
					TA = +50°C		0.67	3.19	
					TA = +70°C		0.91	6.33	
					TA = +85°C		1.69	12.66	
					TA = +105°C		3.04	29.93	
				fsUB = 32.768 kHz, Square wave input Note 4	TA = -40°C		0.20	1.72	μA
					TA = +25°C		0.29	1.75	
					TA = +50°C		0.49	3.75	
					TA = +70°C		0.90	8.16	
					TA = +85°C		1.41	14.55	
					TA = +105°C		2.79	32.65	
				fsUB = 32.768 kHz, Resonator connection Note 5	TA = -40°C		0.21	1.79	μA
					TA = +25°C		0.33	2.03	
					TA = +50°C		0.44	3.40	
					TA = +70°C		0.97	8.65	
					TA = +85°C		1.48	15.04	
					TA = +105°C		2.92	33.56	
IDD3	STOP mode	TA = -40°C		0.15	1.10	μA			
		TA = +25°C		0.20	1.10				
		TA = +50°C		0.40	2.40				
		TA = +70°C		0.80	5.50				
		TA = +85°C		1.30	11.00				
		TA = +105°C		2.70	28.00				

**Note 1.** The listed currents are the total currents flowing into VDD, including the input leakage currents flowing when the level of the input pin is fixed to VDD or VSS. In the subsystem clock operation mode or the STOP mode, the currents in both the “Typ.” and “Max.” columns do not include the operating currents of the peripheral modules.

**Note 2.** The listed currents apply when the HALT instruction has been fetched from the flash memory for execution.

**Note 3.** The listed currents apply when the high-speed on-chip oscillator, middle-speed on-chip oscillator, high-speed system clock, and subsystem clock are stopped. They do not include the current flowing into the RTC, 32-bit interval timer, and watchdog timer.

**Note 4.** The listed currents apply when the high-speed on-chip oscillator, middle-speed on-chip oscillator, high-speed system clock, and low-speed on-chip oscillator are stopped. They do not include the current flowing into the RTC, 32-bit interval timer, and watchdog timer.

**Note 5.** The listed currents apply when the high-speed on-chip oscillator, middle-speed on-chip oscillator, high-speed system clock, and low-speed on-chip oscillator are stopped, and the setting of RTCLPC is 1, and the low power consumption oscillation 3 is specified (AMPHS1, AMPHS0 = 1, 1). They do not include the current flowing into the RTC, 32-bit interval timer, and watchdog timer.

**Remark 1.** fL: Low-speed on-chip oscillator clock frequency

**Remark 2.** fsUB: Subsystem clock frequency (XT1 clock oscillation frequency)

## Peripheral Functions

(TA = -40 to +105°C, 1.6 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

Item	Symbol	Conditions		Min.	Typ.	Max.	Unit	
High-speed on-chip oscillator operating current	IFIH <b>Note 1</b>				380		μA	
Middle-speed on-chip oscillator operating current	IFIM <b>Note 1</b>				20		μA	
Low-speed on-chip oscillator operating current	IFIL <b>Note 1</b>				0.3		μA	
RTC operating current	IRTC <b>Notes 1, 2, 3</b>	fRTCCLK = 32.768 kHz			0.005		μA	
		fRTCCLK = 128 Hz			0.002		μA	
32-bit interval timer operating current	IIT <b>Notes 1, 2, 4</b>				0.04		μA	
Watchdog timer operating current	IWDT <b>Notes 1, 2, 5</b>	fIL = 32.768 kHz (typ.)			0.32		μA	
A/D converter operating current	IADC <b>Notes 1, 6</b>	When conversion at maximum speed	Normal mode, AVREFF = VDD = 5.0 V		1.3	1.7	mA	
			Low voltage mode, AVREFF = VDD = 3.0 V		0.5	0.7	mA	
A/D converter internal reference voltage current	IADREF <b>Note 1</b>				100		μA	
Temperature sensor operating current	ITMPS <b>Note 1</b>				110		μA	
LVD operating current	ILVD0 <b>Notes 1, 7</b>				0.02		μA	
	ILVD1 <b>Notes 1, 7</b>				0.02		μA	
Self-programming operating current	IFSP <b>Notes 1, 8</b>				2.5	12.2	mA	
Data flash rewrite operating current	IBGO <b>Notes 1, 9</b>				2.5	12.2	mA	
SNOOZE mode sequencer operating current	ISMS <b>Notes 1, 10</b>	fIH = 32 MHz			0.93		mA	
		fIL = 32.768 kHz			0.97		μA	
SNOOZE operating current	ISNOZ <b>Note 1</b>	fIH=32 MHz	ADC to be in use	The ADC is shifting from the STOP mode to the SNOOZE mode. <b>Note 11</b>		0.5	0.7	mA
				The ADC is operating in the low-voltage mode. AVREFF = VDD = 3.0 V		0.9	1.4	
				Simplified SPI (CSI)/UART to be in use		0.6	0.79	mA
				SMS <b>Note 13</b>		1.4		mA
Low-speed peripheral clock supply current	ISXP <b>Notes 1, 12</b>	RTCLPC = 0			0.22		μA	
Operating current of the true random number generator	ITRNG <b>Note 1</b>				1.1		mA	

(Notes and Remarks are listed on the next page.)

- Note 1.** This current flows into VDD.
- Note 2.** The listed currents apply when the high-speed on-chip oscillator, middle-speed on-chip oscillator, and high-speed system clock are stopped.
- Note 3.** This current flows into the realtime clock (RTC). It does not include the operating current of the low-speed on-chip oscillator or the XT1 oscillator. The supply current of the RL78 microcontrollers is the sum of either IDD1 or IDD2, and IRTC, when the realtime clock is operating or in the HALT mode. When the low-speed on-chip oscillator is selected, IFIL should be included in the supply current. IDD2 in the subsystem clock operation mode includes the operating current of the realtime clock.
- Note 4.** This current only flows to the 32-bit interval timer. It does not include the operating current of the low-speed on-chip oscillator or the XT1 oscillator. The supply current of the RL78 microcontrollers is the sum of either IDD1 or IDD2, and IIT, when the 32-bit interval timer is operating or in the HALT mode. When the low-speed on-chip oscillator is selected, IFIL should be included in the supply current.
- Note 5.** This current only flows to the watchdog timer. It includes the operating current of the low-speed on-chip oscillator. The supply current of the RL78 microcontrollers is the sum of IDD1, IDD2 or IDD3 and IWDT when the watchdog timer is operating.
- Note 6.** This current only flows to the A/D converter. The supply current of the RL78 microcontrollers is the sum of IDD1 or IDD2 and IADC when the A/D converter is operating or in the HALT mode.
- Note 7.** This current only flows to the LVD circuit. The supply current of the RL78 microcontrollers is the sum of IDD1, IDD2 or IDD3 and ILVD when the LVD circuit is in operation.
- Note 8.** This current only flows during self-programming.
- Note 9.** This current only flows while the data flash memory is being rewritten.
- Note 10.** This current only flows into the SNOOZE mode sequencer. Note that the operating current of the low-speed on-chip oscillator and the XT1 oscillator are not included. The supply current of the RL78 microcontrollers is the sum of either IDD1 or IDD2, and ISMS, when the SNOOZE mode sequencer is operating or in the HALT mode.
- Note 11.** For shift time to the SNOOZE mode, see **20.3.3 SNOOZE mode** in the RL78/G22 User's Manual.
- Note 12.** This current is added to the supply current in the HALT mode when the setting of RTCLPC is 0 in the STOP mode, or when the setting of RTCLPC is 0 with the subsystem clock X (fsx) selected as the CPU clock, while the subsystem clock X (fsx) is oscillating.
- Note 13.** The listed values apply when the SNOOZE mode sequencer is in normal operation equivalent to IDD1. They do not include the current flowing into the peripheral functions other than the SNOOZE mode sequencer.

**Remark 1.** f<sub>IL</sub>: Low-speed on-chip oscillator clock frequency

**Remark 2.** f<sub>SX</sub>: Subsystem clock X frequency

**Remark 3.** f<sub>CLK</sub>: CPU/peripheral hardware clock frequency

**Remark 4.** The typical value for the ambient operating temperature (T<sub>A</sub>) is +25°C unless otherwise specified.

## 2.4 AC Characteristics

(TA = -40 to +105°C, 1.6 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

Item	Symbol	Conditions		Min.	Typ.	Max.	Unit	
Instruction cycle (minimum instruction execution time)	TCY	Main system clock (fMAIN) operation	HS (high-speed main) mode	1.8 V ≤ VDD ≤ 5.5 V	0.03125	1	μs	
				1.6 V ≤ VDD ≤ 1.8 V	0.25	1	μs	
			LS (low-speed main) mode	1.8 V ≤ VDD ≤ 5.5 V	0.04167	1	μs	
				1.6 V ≤ VDD ≤ 1.8 V	0.25	1	μs	
		LP (low-power main) mode	1.6 V ≤ VDD ≤ 5.5 V	0.5	1	μs		
		Subsystem clock (fSUB) operation		1.6 V ≤ VDD ≤ 5.5 V	26.041	30.5	31.3	μs
		In the self-programming mode	HS (high-speed main) mode	1.8 V ≤ VDD ≤ 5.5 V	0.03125	1	μs	
				LS (low-speed main) mode	1.8 V ≤ VDD ≤ 5.5 V	0.04167	1	μs
External system clock frequency	fEX	1.8 V ≤ VDD ≤ 5.5 V		1.0		20.0	MHz	
		1.6 V ≤ VDD < 1.8 V		1.0		4.0	MHz	
	fEXS			32		38.4	kHz	
External system clock input high-level width, low-level width	tEXH, tEXL	1.8 V ≤ VDD ≤ 5.5 V		24			ns	
		1.6 V ≤ VDD < 1.8 V		120			ns	
	tEXHS, tEXLS			13.7			μs	
Ti00 to Ti07 input high-level width, low-level width	tTIH, tTIL			1/fMCK + 10			ns <sup>Note</sup>	
TO00 to TO07 output frequency	fTO	HS (high-speed main) mode LS (low-speed main) mode	4.0 V ≤ VDD ≤ 5.5 V			16	MHz	
			2.7 V ≤ VDD < 4.0 V			8	MHz	
			1.8 V ≤ VDD < 2.7 V			4	MHz	
			1.6 V ≤ VDD < 1.8 V			2	MHz	
		LP (low-power main) mode	1.6 V ≤ VDD ≤ 5.5 V			2	MHz	
PCLBUZ0, PCLBUZ1 output frequency	fPCL	HS (high-speed main) mode LS (low-speed main) mode	4.0 V ≤ VDD ≤ 5.5 V			16	MHz	
			2.7 V ≤ VDD < 4.0 V			8	MHz	
			1.8 V ≤ VDD < 2.7 V			4	MHz	
			1.6 V ≤ VDD < 1.8 V			2	MHz	
		LP (low-power main) mode	1.6 V ≤ VDD < 1.8 V			2	MHz	
Interrupt input high-level width, low-level width	tINTH, tINTL	INTP0 to INTP6, INTP8, INTP9		1.6 V ≤ VDD ≤ 5.5 V	1		μs	
Key interrupt input low- level width	tKRH, tKRL	KR0 to KR5		1.8 V ≤ VDD ≤ 5.5 V	250		ns	
				1.6 V ≤ VDD < 1.8 V	1		μs	
RESET low-level width	tRSL				10		μs	

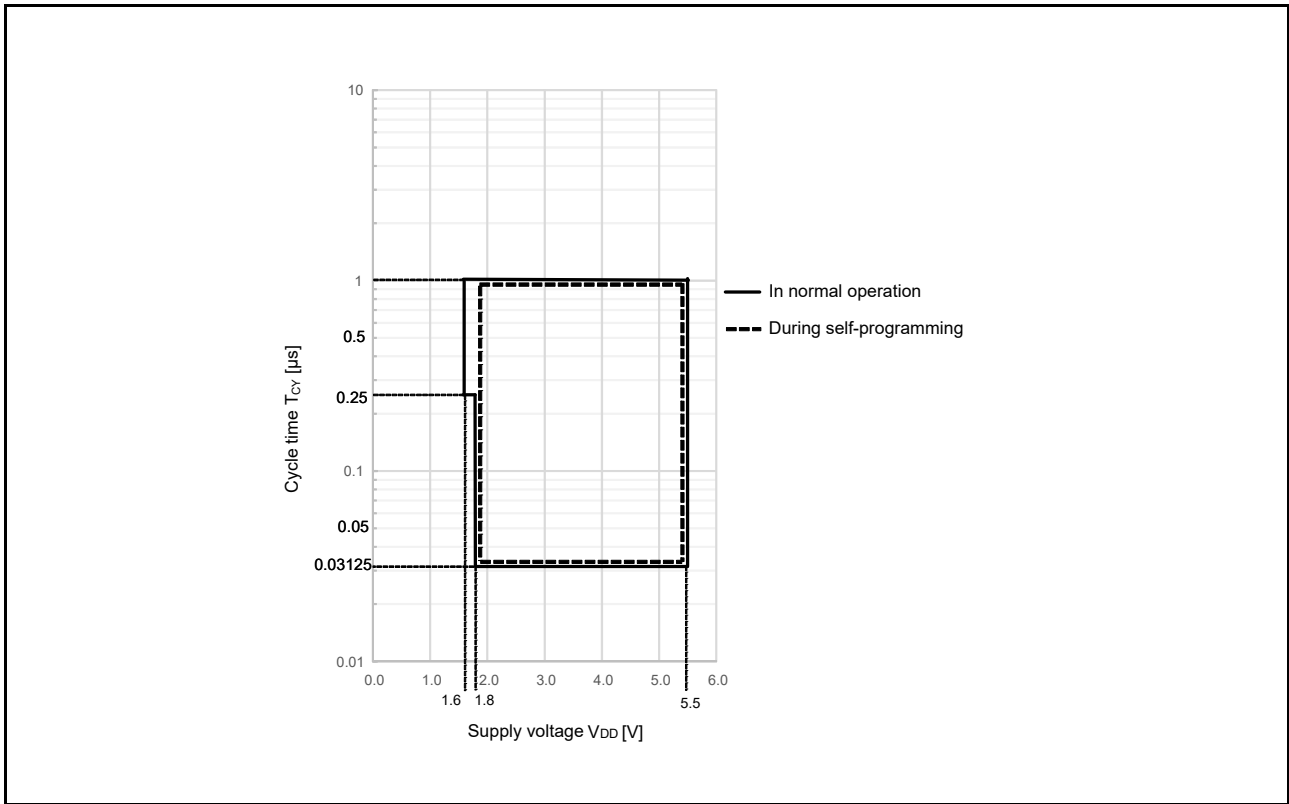
**Remark** fMCK: Timer array unit operating clock frequency

To set this operating clock, use the CKSmn0 and CKSmn1 bits of the timer mode register mn (TMRmn).

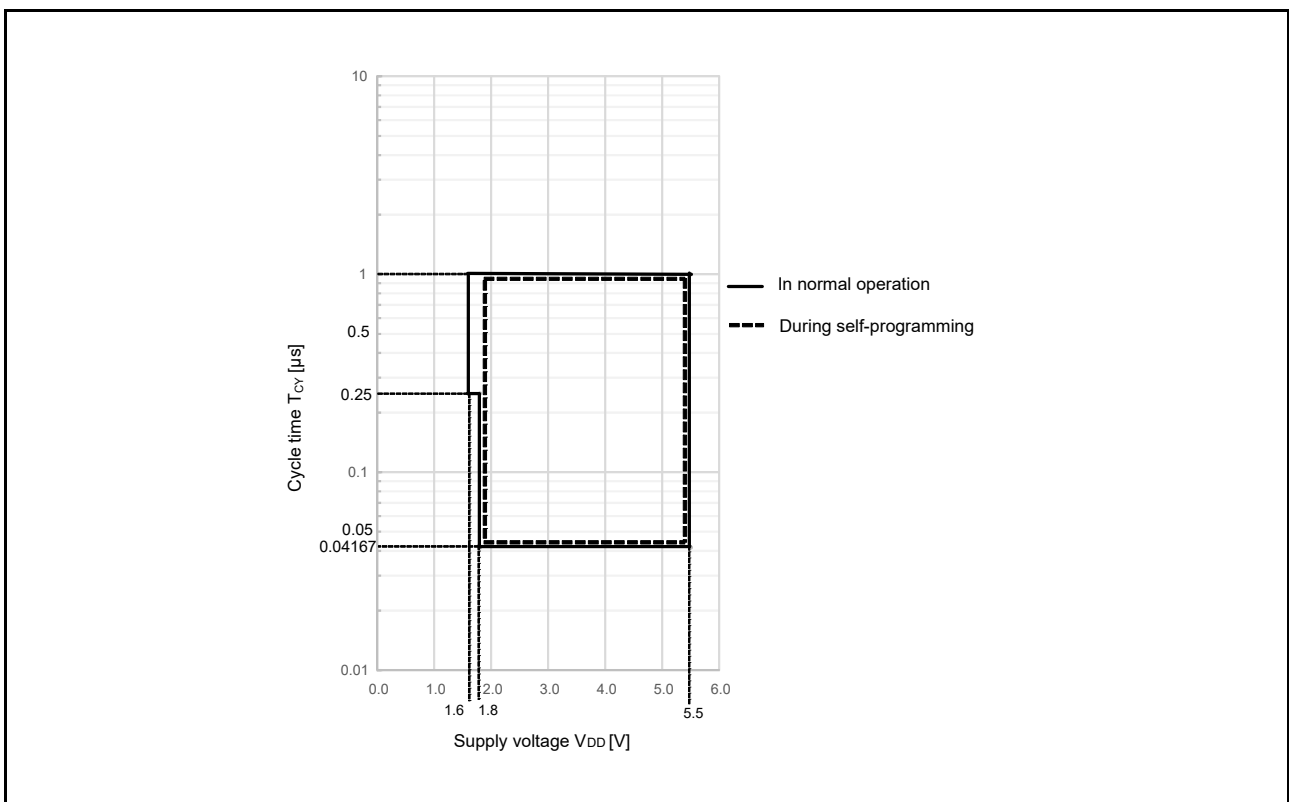
m: Unit number (m = 0), n: Channel number (n = 0 to 3)

- Minimum Instruction Execution Time during Main System Clock Operation

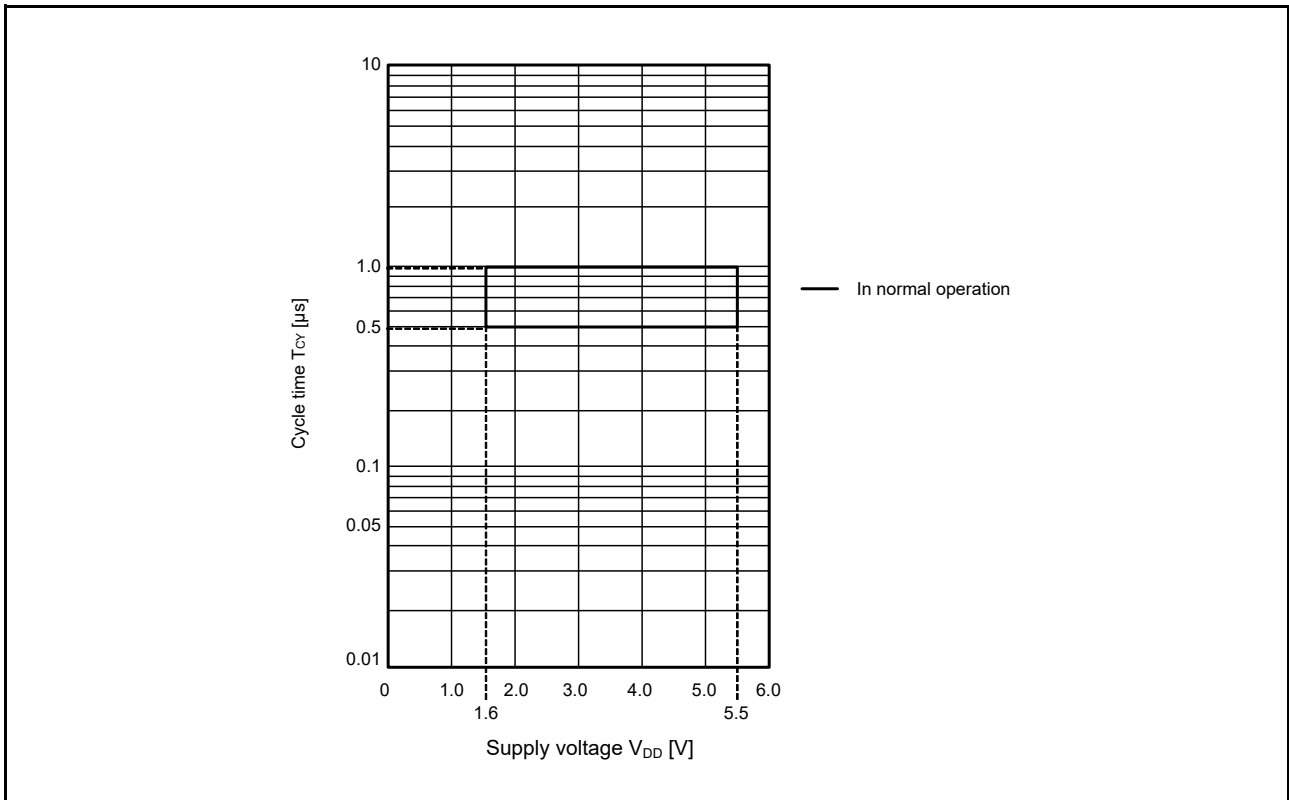
(a)  $T_{CY}$  vs  $V_{DD}$  in HS (high-speed main) mode



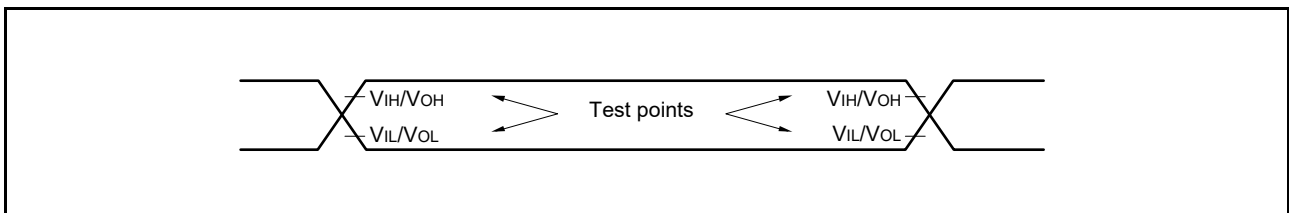
(b)  $T_{CY}$  vs  $V_{DD}$  in LS (low-speed main) mode



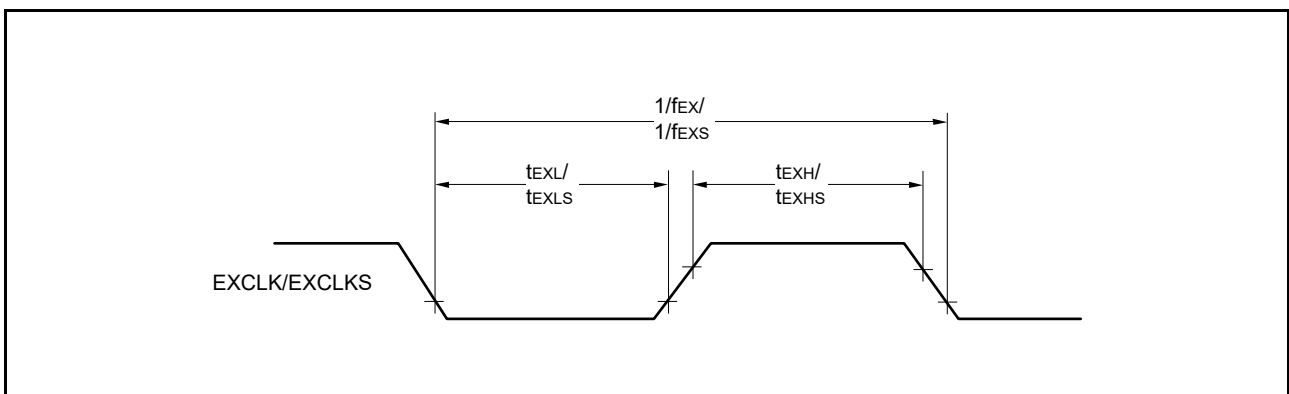
(c)  $T_{CY}$  vs  $V_{DD}$  in LP (low-power main) mode



(d) AC Timing Test Points

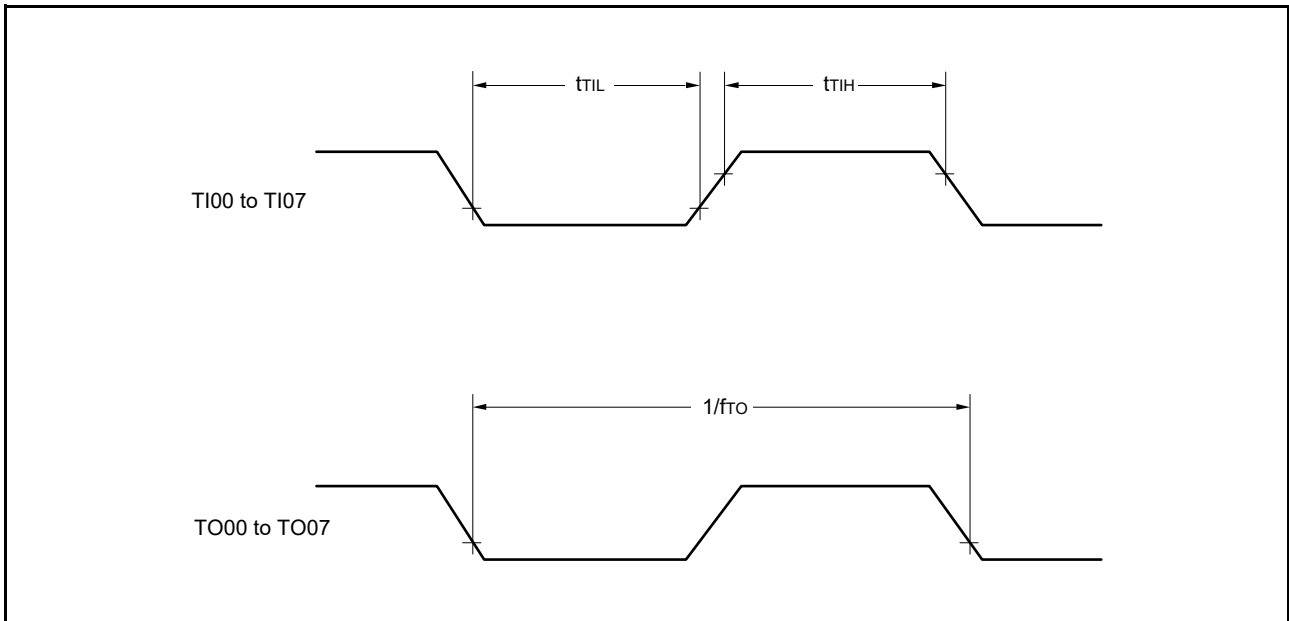


(e) External System Clock Timing

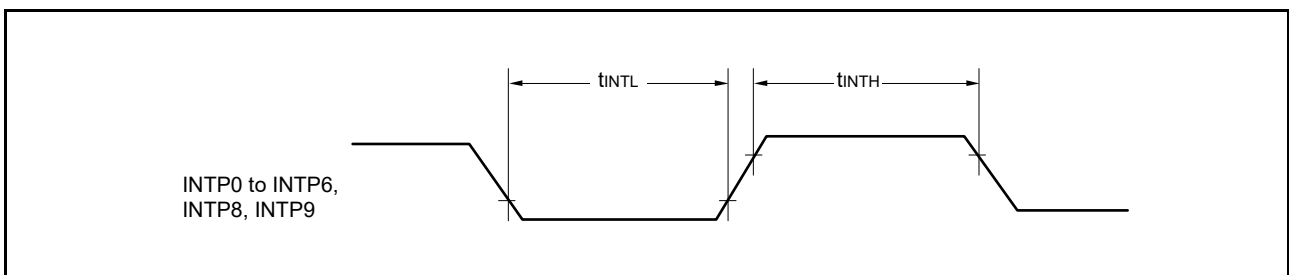




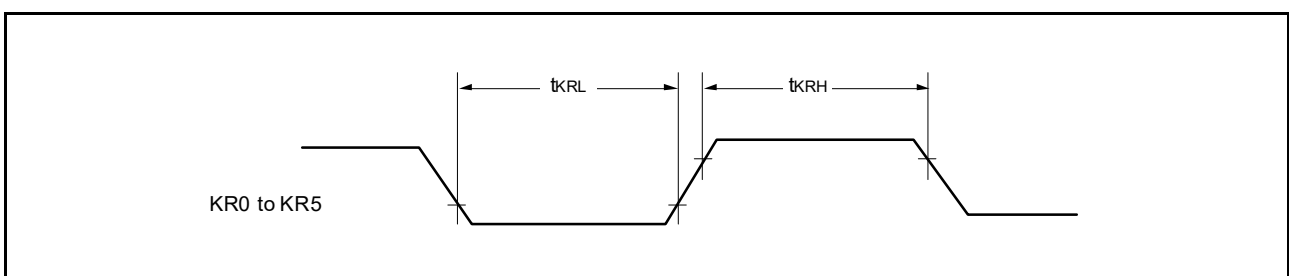
(f) TI/TO Timing



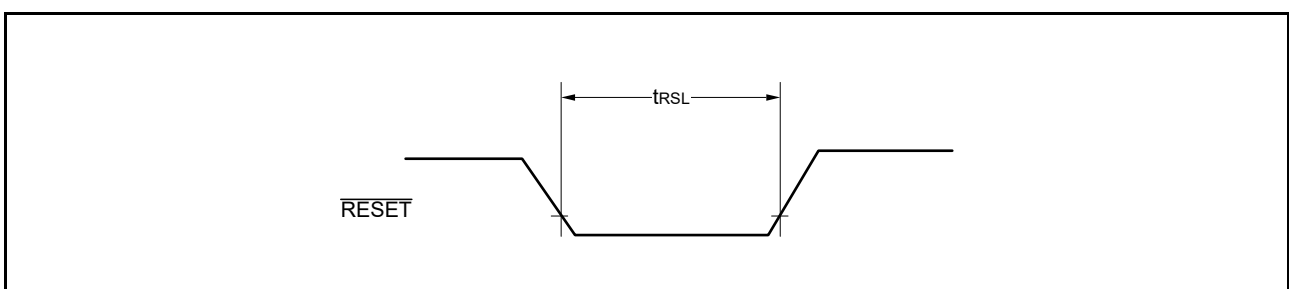
(g) Interrupt Request Input Timing



(h) Key Interrupt Input Timing

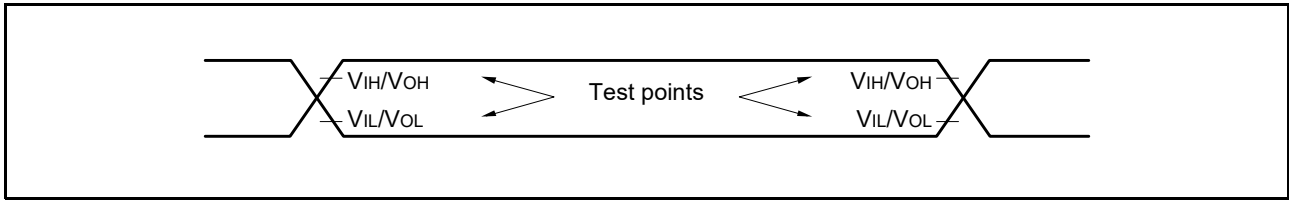


(i)  $\overline{\text{RESET}}$  Input Timing



## 2.5 Characteristics of the Peripheral Functions

### AC Timing Test Points



### 2.5.1 Serial array unit

(1) In UART communications with devices operating at same voltage levels

( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $1.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )

Item	Symbol	Conditions	HS (High-Speed Main) Mode		LS (Low-Speed Main) Mode		LP (Low-Power Main) Mode		Unit
			Min.	Max.	Min.	Max.	Min.	Max.	
Transfer rate Note 1		$1.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		fMCK/6		fMCK/6		fMCK/6	bps
		Theoretical value of the maximum transfer rate $f_{MCK} = f_{CLK}$ Note 2		5.3		4		0.33	Mbps

**Note 1.** The transfer rate in the SNOOZE mode is within the range from 4800 to 9600 bps.

**Note 2.** The maximum operating frequencies of the CPU/peripheral hardware clock (fCLK) are as follows.

HS (high-speed main) mode: 32 MHz ( $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ )

4 MHz ( $1.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ )

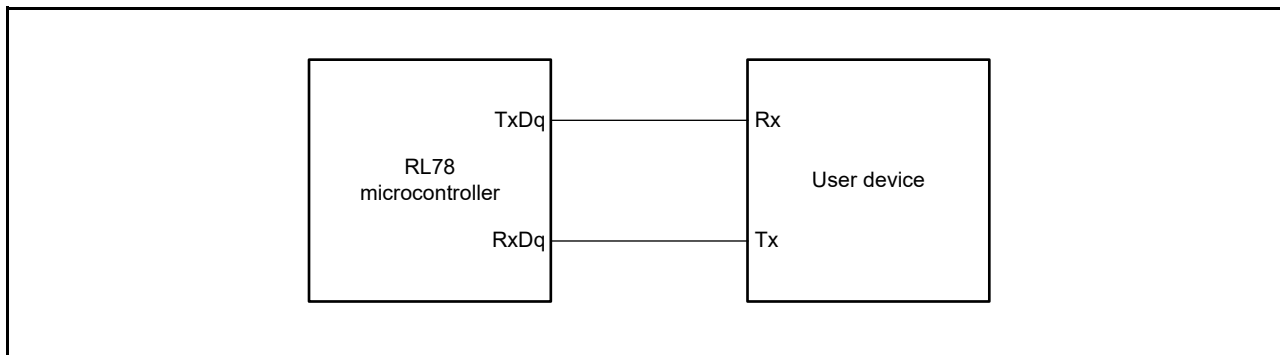
LS (low-speed main) mode: 24 MHz ( $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ )

4 MHz ( $1.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ )

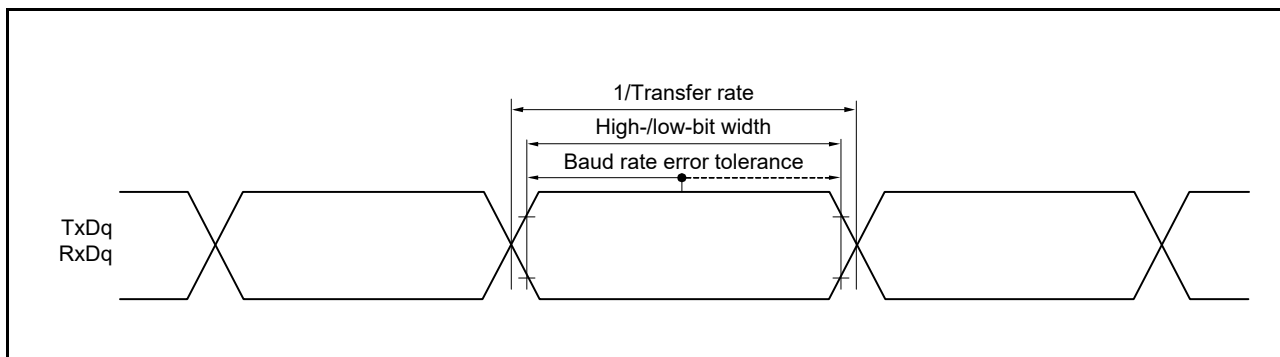
LP (low-power main) mode: 2 MHz ( $1.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ )

**Caution** Select the normal input buffer for the RxDq pin and the normal output mode for the TxDq pin by using port input mode register g (PIMg) and port output mode register g (POMg).

(a) Connection in the UART communications with devices operating at same voltage levels



(b) Bit width in the UART communications when interfacing devices operate at the same voltage level (reference)



**Remark 1.** q: UART number (q = 0 to 2), g: PIM and POM number (g = 0, 1)

**Remark 2.** f<sub>MCK</sub>: Serial array unit operation clock frequency

To set this operating clock, set the CKSMn bit in the serial mode register mn (SMRmn).

m: Unit number, n: Channel number (mn = 00, 01, 03, 10, 11)

(2) In simplified SPI (CSI) communications in the master mode with devices operating at same voltage levels with the internal SCKp clock (the ratings below are only applicable to CSI00)

(TA = -40 to +85°C, 2.7 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

Item	Symbol	Conditions		HS (High-Speed Main) Mode		LS (Low-Speed Main) Mode		LP (Low-Power Main) Mode		Unit
				Min.	Max.	Min.	Max.	Min.	Max.	
SCKp cycle time	tkCY1	tkCY1 ≥ 2/fCLK	4.0 V ≤ VDD ≤ 5.5 V	62.5		83.3		1000		ns
			2.7 V ≤ VDD ≤ 5.5 V	83.3		125		1000		ns
SCKp high-/low-level width	tkH1, tkL1	4.0 V ≤ VDD ≤ 5.5 V		tkCY1/2 - 7		tkCY1/2 - 10		tkCY1/2 - 50		ns
		2.7 V ≤ VDD ≤ 5.5 V		tkCY1/2 - 10		tkCY1/2 - 15		tkCY1/2 - 50		ns
Slp setup time (to SCKp↑) <sup>Note 1</sup>	tsIK1	4.0 V ≤ VDD ≤ 5.5 V		23		33		110		ns
		2.7 V ≤ VDD ≤ 5.5 V		33		50		110		ns
Slp hold time (from SCKp↑) <sup>Note 1</sup>	tkSI1	2.7 V ≤ VDD ≤ 5.5 V		10		10		10		ns
Delay time from SCKp↓ to SOp output <sup>Note 2</sup>	tkSO1	C = 20 pF <sup>Note 3</sup>			10		10		10	ns

**Note 1.** The setting applies when DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1. The setting for the Slp setup time becomes “to SCKp↓” and that for the Slp hold time becomes “from SCKp↓” when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.

**Note 2.** This setting applies when DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1. The setting for the delay time to SOp output becomes “from SCKp↑” when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.

**Note 3.** C is the load capacitance of the SCKp and SOp output lines.

**Caution** Select the normal input buffer for the Slp pin and the normal output mode for the SOp pin and SCKp pin by using the port input mode register g (PIMg) and the port output mode register g (POMg).

**Remark 1.** The listed times are only valid when the peripheral I/O redirect function of CSI00 is not in use.

**Remark 2.** p: CSI number (p = 00), m: Unit number (m = 0), n: Channel number (n = 0), g: PIM and POM numbers (g = 1)

**Remark 3.** fMCK: Serial array unit operation clock frequency

To set this operating clock, use the CKSmn bit in the serial mode register mn (SMRmn).

m: Unit number, n: Channel number (mn = 00)

- (3) In simplified SPI (CSI) communications in the master mode with devices operating at same voltage levels with the internal SCKp clock

(TA = -40 to +105°C, 1.6 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

Item	Symbol	Conditions	HS (High-Speed Main) Mode		LS (Low-Speed Main) Mode		LP (Low-Power Main) Mode		Unit	
			Min.	Max.	Min.	Max.	Min.	Max.		
SCKp cycle time	tkCY1	tkCY1 ≥ 4/fCLK	2.7 V ≤ VDD ≤ 5.5 V	125		166		2000		ns
			2.4 V ≤ VDD ≤ 5.5 V	250		250		2000		ns
			1.8 V ≤ VDD ≤ 5.5 V	500		500		2000		ns
			1.6 V ≤ VDD ≤ 5.5 V	1000		1000		2000		ns
SCKp high-/low-level width	tkH1, tkL1	4.0 V ≤ VDD ≤ 5.5 V	tkCY1/2 - 12		tkCY1/2 - 21		tkCY1/2 - 50		ns	
		2.7 V ≤ VDD ≤ 5.5 V	tkCY1/2 - 18		tkCY1/2 - 25		tkCY1/2 - 50		ns	
		2.4 V ≤ VDD ≤ 5.5 V	tkCY1/2 - 38		tkCY1/2 - 38		tkCY1/2 - 50		ns	
		1.8 V ≤ VDD ≤ 5.5 V	tkCY1/2 - 50		tkCY1/2 - 50		tkCY1/2 - 50		ns	
		1.6 V ≤ VDD ≤ 5.5 V	tkCY1/2 - 100		tkCY1/2 - 100		tkCY1/2 - 100		ns	
Slp setup time (to SCKp↑)Note 1	tSIK1	4.0 V ≤ VDD ≤ 5.5 V	44		54		110		ns	
		2.7 V ≤ VDD ≤ 5.5 V	44		54		110		ns	
		2.4 V ≤ VDD ≤ 5.5 V	75		75		110		ns	
		1.8 V ≤ VDD ≤ 5.5 V	110		110		110		ns	
		1.6 V ≤ VDD ≤ 5.5 V	220		220		220		ns	
Slp hold time (from SCKp↑) Note 1	tkSI1	1.6 V ≤ VDD ≤ 5.5 V	19		19		19		ns	
Delay time from SCKp↓ to SOP outputNote 2	tkSO1	1.6 V ≤ VDD ≤ 5.5 V C = 30 pFNote 3		25		25		25	ns	

**Note 1.** This setting applies when DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1. The setting for the Slp setup time becomes “to SCKp↓” and that for the Slp hold time becomes “from SCKp↓” when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.

**Note 2.** This setting applies when DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1. The setting for the delay time to SOP output becomes “from SCKp↑” when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.

**Note 3.** C is the load capacitance of the SCKp and SOP output lines.

**Caution** Select the normal input buffer for the Slp pin and the normal output mode for the SOP pin and SCKp pin by using the port input mode register g (PIMg) and the port output mode register g (POMg).

**Remark 1.** p: CSI number (p = 00, 01, 11, 20, 21), m: Unit number (m = 0, 1), n: Channel number (n = 0, 1, 3), g: PIM and POM numbers (g = 0, 1, 5, 7)

**Remark 2.** fMCK: Serial array unit operation clock frequency

To set this operating clock, use the CKSmn bit in the serial mode register mn (SMRmn).

m: Unit number, n: Channel number (mn = 00, 01, 11)

(4) In simplified SPI (CSI) communications in the slave mode with devices operating at same voltage levels with the SCKp external clock

(TA = -40 to +105°C, 1.6 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

(1/2)

Item	Symbol	Conditions		HS (High-Speed Main) Mode		LS (Low-Speed Main) Mode		LP (Low-Power Main) Mode		Unit	
				Min.	Max.	Min.	Max.	Min.	Max.		
SCKp cycle time Note 4	tkCY2	4.0 V ≤ VDD ≤ 5.5 V	20 MHz < fMCK	8/fMCK		8/fMCK		—		ns	
			fMCK ≤ 20 MHz	6/fMCK		6/fMCK		6/fMCK		ns	
		2.7 V ≤ VDD ≤ 5.5 V	16 MHz < fMCK	8/fMCK		8/fMCK		—		ns	
			fMCK ≤ 16 MHz	6/fMCK		6/fMCK		6/fMCK		ns	
		2.4 V ≤ VDD ≤ 5.5 V			6/fMCK and 500		6/fMCK and 500		6/fMCK and 500		ns
		1.8 V ≤ VDD ≤ 5.5 V			6/fMCK and 750		6/fMCK and 750		6/fMCK and 750		ns
1.6 V ≤ VDD ≤ 5.5 V			6/fMCK and 1500		6/fMCK and 1500		6/fMCK and 1500		ns		
SCKp high-/ low-level width	tkH2, tkL2	4.0 V ≤ VDD ≤ 5.5 V		tkCY2/2 - 7		tkCY2/2 - 7		tkCY2/2 - 7		ns	
		2.7 V ≤ VDD ≤ 5.5 V		tkCY2/2 - 8		tkCY2/2 - 8		tkCY2/2 - 8		ns	
		1.8 V ≤ VDD ≤ 5.5 V		tkCY2/2 - 18		tkCY2/2 - 18		tkCY2/2 - 18		ns	
		1.6 V ≤ VDD ≤ 5.5 V		tkCY2/2 - 66		tkCY2/2 - 66		tkCY2/2 - 66		ns	

(Notes, Caution, and Remarks are listed on the next page.)

- (4) In simplified SPI (CSI) communications in the slave mode with devices operating at same voltage levels with the SCKp external clock

(TA = -40 to +105°C, 1.6 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

(2/2)

Item	Symbol	Conditions	HS (High-Speed Main) Mode		LS (Low-Speed Main) Mode		LP (Low-Power Main) Mode		Unit	
			Min.	Max.	Min.	Max.	Min.	Max.		
Slp setup time (to SCKp↑) <b>Note 1</b>	tsIK2	2.7 V ≤ VDD ≤ 5.5 V	1/fMCK + 20		1/fMCK + 30		1/fMCK + 30		ns	
		1.8 V ≤ VDD ≤ 5.5 V	1/fMCK + 30		1/fMCK + 30		1/fMCK + 30		ns	
		1.6 V ≤ VDD ≤ 5.5 V	1/fMCK + 40		1/fMCK + 40		1/fMCK + 40		ns	
Slp hold time (from SCKp↑) <b>Note 1</b>	tkSI2	1.8 V ≤ VDD ≤ 5.5 V	1/fMCK + 31		1/fMCK + 31		1/fMCK + 31		ns	
		1.6 V ≤ VDD ≤ 5.5 V	1/fMCK + 250		1/fMCK + 250		1/fMCK + 250		ns	
Delay time from SCKp↓ to SOp output <b>Note 2</b>	tkSO2	C = 30 pF <b>Note 3</b>	2.7 V ≤ VDD ≤ 5.5 V		2/fMCK + 44		2/fMCK + 110		2/fMCK + 110	ns
			2.4 V ≤ VDD ≤ 5.5 V		2/fMCK + 75		2/fMCK + 110		2/fMCK + 110	ns
			1.8 V ≤ VDD ≤ 5.5 V		2/fMCK + 110		2/fMCK + 110		2/fMCK + 110	ns
			1.6 V ≤ VDD ≤ 5.5 V		2/fMCK + 220		2/fMCK + 220		2/fMCK + 220	ns

**Note 1.** This setting applies when DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1. The setting for the Slp setup time becomes “to SCKp↓” and that for the Slp hold time becomes “from SCKp↓” when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.

**Note 2.** This setting applies when DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1. The setting for the delay time to SOp output becomes “from SCKp↑” when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.

**Note 3.** C is the load capacitance of the SOp output line.

**Note 4.** Transfer rate in the SNOOZE mode is 1 Mbps at the maximum.

**Caution** Select the normal input buffer for the Slp pin and SCKp pin and the normal output mode for the SOp pin by using the port input mode register g (PIMg) and the port output mode register g (POMg).

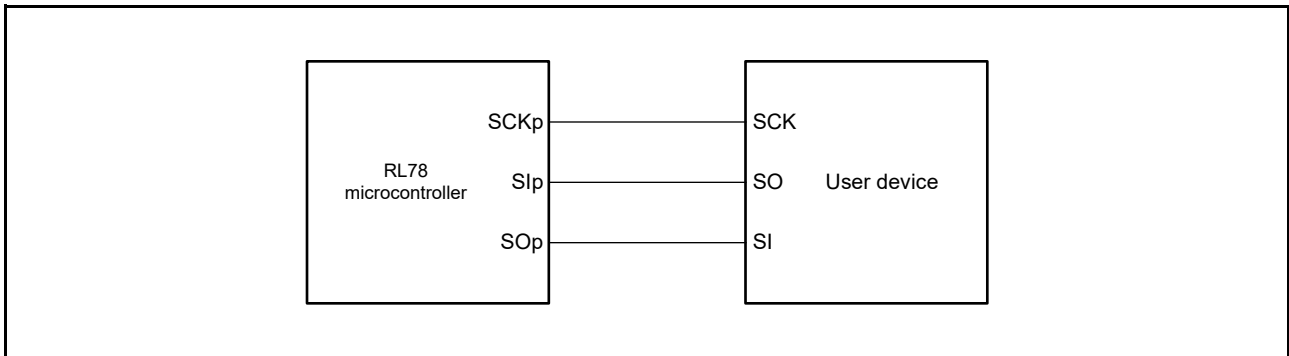
**Remark 1.** p: CSI number (p = 00, 01, 11, 20, 21), m: Unit number (m = 0, 1), n: Channel number (n = 0, 1, 3), g: PIM and POM numbers (g = 0, 1, 5, 7)

**Remark 2.** fMCK: Serial array unit operation clock frequency

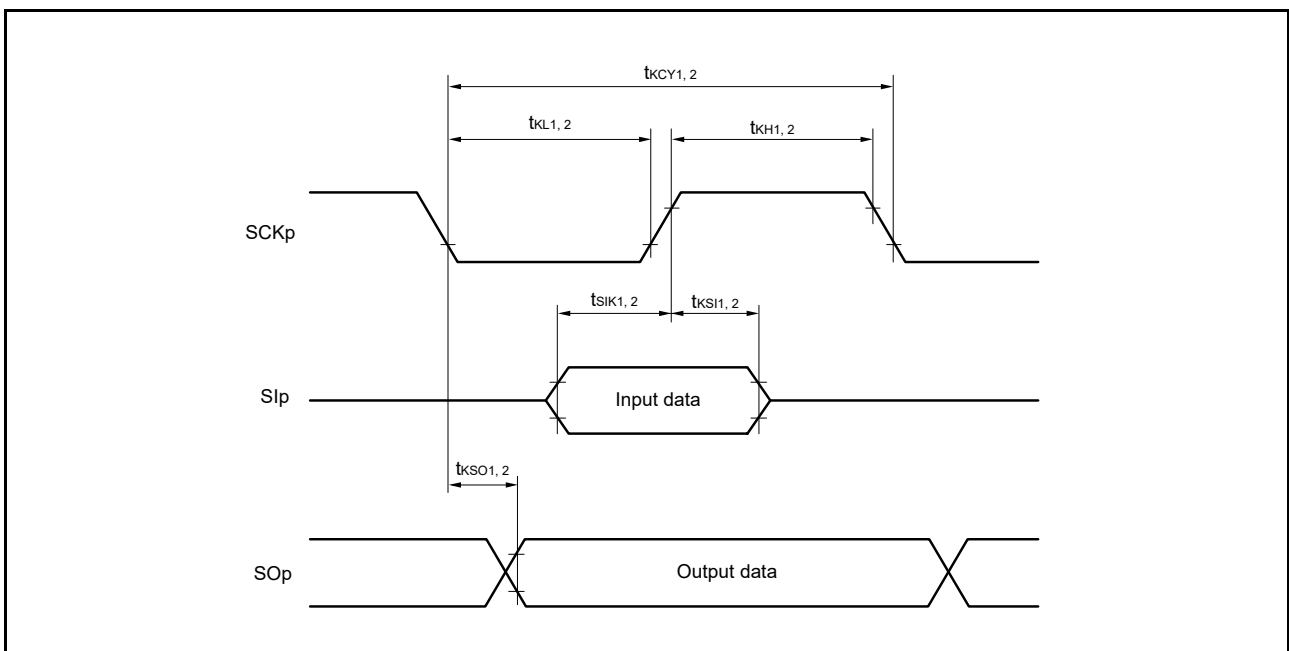
To set this operating clock, use the CKS<sub>mn</sub> bit in the serial mode register mn (SMR<sub>mn</sub>).

m: Unit number, n: Channel number (mn = 00, 01, 03, 10, 11)

(a) Connection in the simplified SPI (CSI) communications with devices operating at same voltage levels

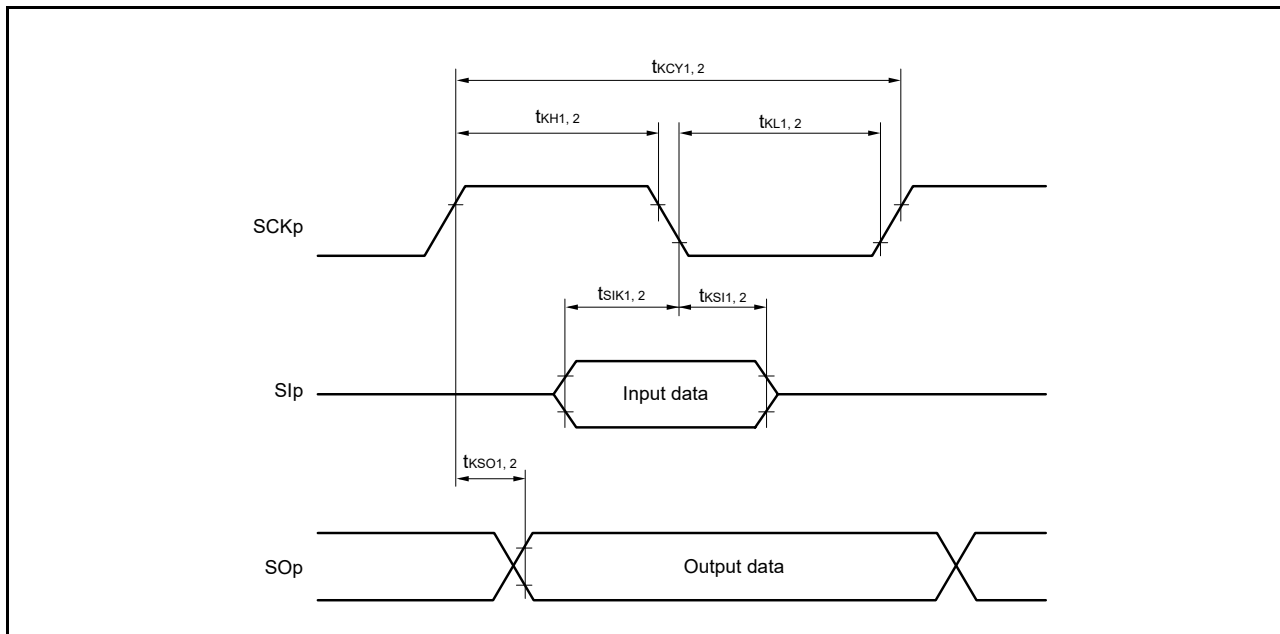


(b) Timing of serial transfer in the simplified SPI (CSI) communications with devices operating at same voltage levels when DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1





(c) Timing of serial transfer in the simplified SPI (CSI) communications with devices operating at same voltage levels when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0



**Remark 1.** p: CSI number (p = 00, 01, 11, 20, 21)

**Remark 2.** m: Unit number, n: Channel number (mn = 00, 01, 03, 10, 11)

(5) In simplified I<sup>2</sup>C communications with devices operating at same voltage levels

(TA = -40 to +105°C, 1.6 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

(1/2)

Item	Symbol	Conditions	HS (High-Speed Main) Mode		LS (Low-Speed Main) Mode		LP (Low-Power Main) Mode		Unit
			Min.	Max.	Min.	Max.	Min.	Max.	
SCLr clock frequency	fSCL	2.7 V ≤ VDD ≤ 5.5 V, Cb = 50 pF, Rb = 2.7 kΩ		1000 Note 1		1000 Note 1		400Note 1	kHz
		1.8 V ≤ VDD ≤ 5.5 V, Cb = 100 pF, Rb = 3 kΩ		400Note 1		400Note 1		400Note 1	kHz
		1.8 V ≤ VDD < 2.7 V, Cb = 100 pF, Rb = 5 kΩ		300Note 1		300Note 1		300Note 1	kHz
		1.6 V ≤ VDD < 1.8 V, Cb = 100 pF, Rb = 5 kΩ		250Note 1		250Note 1		250Note 1	kHz
Hold time when SCLr is low	tLOW	2.7 V ≤ VDD ≤ 5.5 V, Cb = 50 pF, Rb = 2.7 kΩ	475		475		1150		ns
		1.8 V ≤ VDD ≤ 5.5 V, Cb = 100 pF, Rb = 3 kΩ	1150		1150		1150		ns
		1.8 V ≤ VDD < 2.7 V, Cb = 100 pF, Rb = 5 kΩ	1550		1550		1550		ns
		1.6 V ≤ VDD < 1.8 V, Cb = 100 pF, Rb = 5 kΩ	1850		1850		1850		ns
Hold time when SCLr is high	tHIGH	2.7 V ≤ VDD ≤ 5.5 V, Cb = 50 pF, Rb = 2.7 kΩ	475		475		1150		ns
		1.8 V ≤ VDD ≤ 5.5 V, Cb = 100 pF, Rb = 3 kΩ	1150		1150		1150		ns
		1.8 V ≤ VDD < 2.7 V, Cb = 100 pF, Rb = 5 kΩ	1550		1550		1550		ns
		1.6 V ≤ VDD < 1.8 V, Cb = 100 pF, Rb = 5 kΩ	1850		1850		1850		ns

(Notes and Caution are listed on the next page, and Remarks are listed on the page after the next page.)

(5) In simplified I<sup>2</sup>C communications with devices operating at same voltage levels

(T<sub>A</sub> = -40 to +105°C, 1.6 V ≤ V<sub>DD</sub> ≤ 5.5 V, V<sub>SS</sub> = 0 V)

(2/2)

Item	Symbol	Conditions	HS (High-Speed Main) Mode		LS (Low-Speed Main) Mode		LP (Low-Power Main) Mode		Unit
			Min.	Max.	Min.	Max.	Min.	Max.	
Data setup time (reception)	t <sub>SU:DAT</sub>	2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V, C <sub>b</sub> = 50 pF, R <sub>b</sub> = 2.7 kΩ	1/f <sub>MCK</sub> + 85 <b>Note 2</b>		1/f <sub>MCK</sub> + 85 <b>Note 2</b>		1/f <sub>MCK</sub> + 145 <b>Note 2</b>		ns
		1.8 V ≤ V <sub>DD</sub> ≤ 5.5 V, C <sub>b</sub> = 100 pF, R <sub>b</sub> = 3 kΩ	1/f <sub>MCK</sub> + 145 <b>Note 2</b>		1/f <sub>MCK</sub> + 145 <b>Note 2</b>		1/f <sub>MCK</sub> + 145 <b>Note 2</b>		ns
		1.8 V ≤ V <sub>DD</sub> < 2.7 V, C <sub>b</sub> = 100 pF, R <sub>b</sub> = 5 kΩ	1/f <sub>MCK</sub> + 230 <b>Note 2</b>		1/f <sub>MCK</sub> + 230 <b>Note 2</b>		1/f <sub>MCK</sub> + 230 <b>Note 2</b>		ns
		1.6 V ≤ V <sub>DD</sub> < 1.8 V, C <sub>b</sub> = 100 pF, R <sub>b</sub> = 5 kΩ	1/f <sub>MCK</sub> + 290 <b>Note 2</b>		1/f <sub>MCK</sub> + 290 <b>Note 2</b>		1/f <sub>MCK</sub> + 290 <b>Note 2</b>		ns
Data hold time (transmission)	t <sub>HD:DAT</sub>	2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V, C <sub>b</sub> = 50 pF, R <sub>b</sub> = 2.7 kΩ	0	305	0	305	0	305	ns
		1.8 V ≤ V <sub>DD</sub> ≤ 5.5 V, C <sub>b</sub> = 100 pF, R <sub>b</sub> = 3 kΩ	0	355	0	355	0	355	ns
		1.8 V ≤ V <sub>DD</sub> < 2.7 V, C <sub>b</sub> = 100 pF, R <sub>b</sub> = 5 kΩ	0	405	0	405	0	405	ns
		1.6 V ≤ V <sub>DD</sub> < 1.8 V, C <sub>b</sub> = 100 pF, R <sub>b</sub> = 5 kΩ	0	405	0	405	0	405	ns

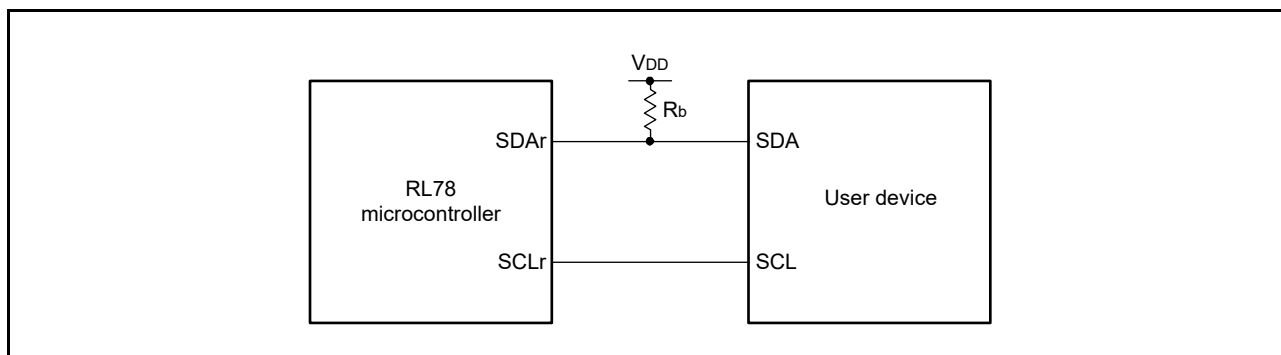
**Note 1.** The listed times must be no greater than f<sub>MCK</sub>/4.

**Note 2.** Set f<sub>MCK</sub> so that it will not exceed the hold time when SCLr is low or high.

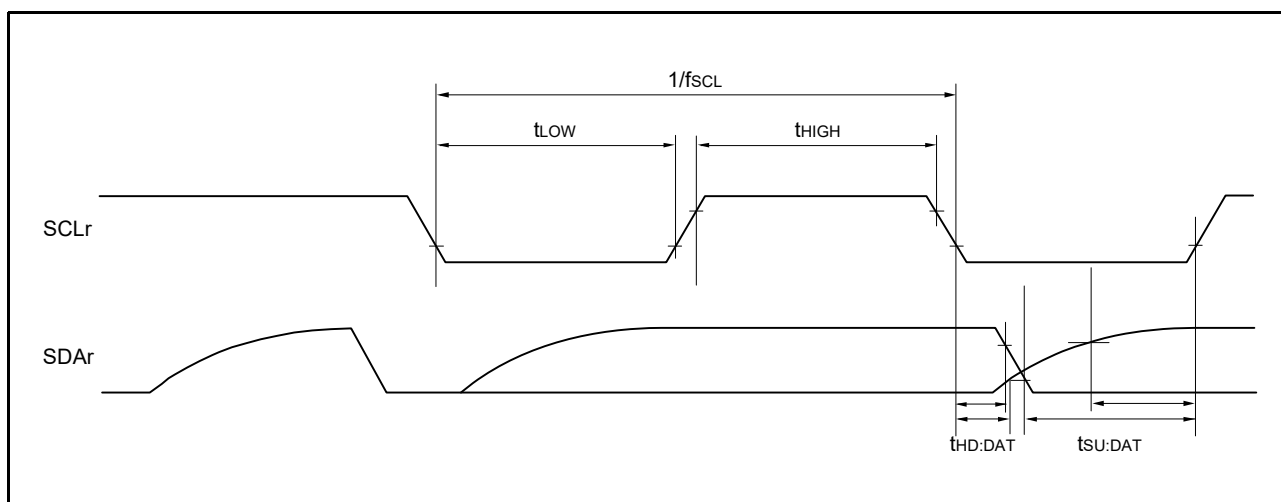
**Caution** Select the normal input buffer and the N-ch open drain output [withstand voltage of V<sub>DD</sub>] mode for the SDAr pin and the normal output mode for the SCLr pin by using port input mode register g (PIMg) and port output mode register h (POMh).

(Remarks are listed on the next page.)

(a) Connection in the simplified I<sup>2</sup>C communications with devices operating at same voltage levels



(b) Timing of serial transfer in the simplified I<sup>2</sup>C communications with devices operating at same voltage levels



**Remark 1.** R<sub>b</sub>[Ω]: Communication line (SDAr) pull-up resistance, C<sub>b</sub>[F]: Communication line (SDAr, SCLr) load capacitance

**Remark 2.** r: IIC number (r = 00, 01, 10, 11, 20, 21), g: PIM number (g = 0, 1, 3, 7), h: POM number (g = 1, 5, 7)

**Remark 3.** f<sub>MCK</sub>: Serial array unit operation clock frequency

To set this operating clock, use the CKSmn bit in the serial mode register mn (SMRmn).

m: Unit number, n: Channel number (mn = 00, 01, 03, 10, 11)



(6) In UART communications with devices operating at different voltage levels (1.8 V, 2.5 V, 3 V)

(TA = -40 to +105°C, 1.8 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

(2/2)

Item	Symbol	Conditions	HS (High-Speed Main) Mode		LS (Low-Speed Main) Mode		LP (Low-Power Main) Mode		Unit
			Min.	Max.	Min.	Max.	Min.	Max.	
Transfer rate	Transmission	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V		Note 1		Note 1		Note 1	bps
		Theoretical value of the maximum transfer rate Cb = 50 pF, Rb = 1.4 kΩ, Vb = 2.7 V		2.8Note 2		2.8Note 2		2.8Note 2	Mbps
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V		Note 3		Note 3		Note 3	bps
		Theoretical value of the maximum transfer rate Cb = 50 pF, Rb = 2.7 kΩ, Vb = 2.3 V		1.2Note 4		1.2Note 4		1.2Note 4	Mbps
		1.8 V ≤ VDD < 3.3 V, 1.6 V ≤ Vb ≤ 2.0 V		Notes 5, 6		Notes 5, 6		Notes 5, 6	bps
		Theoretical value of the maximum transfer rate Cb = 50 pF, Rb = 5.5 kΩ, Vb = 1.6 V		0.43 Note 7		0.43 Note 7		0.43 Note 7	Mbps

**Note 1.** The smaller maximum transfer rate derived by using fmCK/6 or the following expression is the valid maximum transfer rate. Expression for calculating the transfer rate when 4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V

$$\text{Maximum transfer rate} = \frac{1}{\{-C_b \times R_b \times \ln(1 - \frac{2.2}{V_b})\} \times 3} \text{ [bps]}$$

$$\text{Baud rate error (theoretical value)} = \frac{\frac{1}{\text{Transfer rate} \times 2} - \{-C_b \times R_b \times \ln(1 - \frac{2.2}{V_b})\}}{(\frac{1}{\text{Transfer rate}}) \times \text{Number of transferred bits}} \times 100 \text{ [%]}$$

This value is the theoretical value of the relative difference between the transmission and reception sides.

**Note 2.** This rate is calculated as an example when the conditions described in the “Conditions” column are met. See **Note 1** above to calculate the maximum transfer rate under conditions of the customer.

(Notes 3 to 7 and Caution are listed on the next page.)

**Note 3.** The smaller maximum transfer rate derived by using  $f_{MCK}/6$  or the following expression is the valid maximum transfer rate. Expression for calculating the transfer rate when  $2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ ,  $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$

$$\text{Maximum transfer rate} = \frac{1}{\{-C_b \times R_b \times \ln(1 - \frac{2.0}{V_b})\} \times 3} \text{ [bps]}$$

$$\text{Baud rate error (theoretical value)} = \frac{\frac{1}{\text{Transfer rate} \times 2} - \{-C_b \times R_b \times \ln(1 - \frac{2.0}{V_b})\}}{(\frac{1}{\text{Transfer rate}}) \times \text{Number of transferred bits}} \times 100 \text{ [%]}$$

This value is the theoretical value of the relative difference between the transmission and reception sides.

**Note 4.** This rate is calculated as an example when the conditions described in the “Conditions” column are met. See **Note 3** above to calculate the maximum transfer rate under conditions of the customer.

**Note 5.** Use this rate with  $V_{DD} \geq V_b$ .

**Note 6.** The smaller maximum transfer rate derived by using  $f_{MCK}/6$  or the following expression is the valid maximum transfer rate. Expression for calculating the transfer rate when  $1.8\text{ V} \leq V_{DD} < 3.3\text{ V}$ ,  $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$

$$\text{Maximum transfer rate} = \frac{1}{\{-C_b \times R_b \times \ln(1 - \frac{1.5}{V_b})\} \times 3} \text{ [bps]}$$

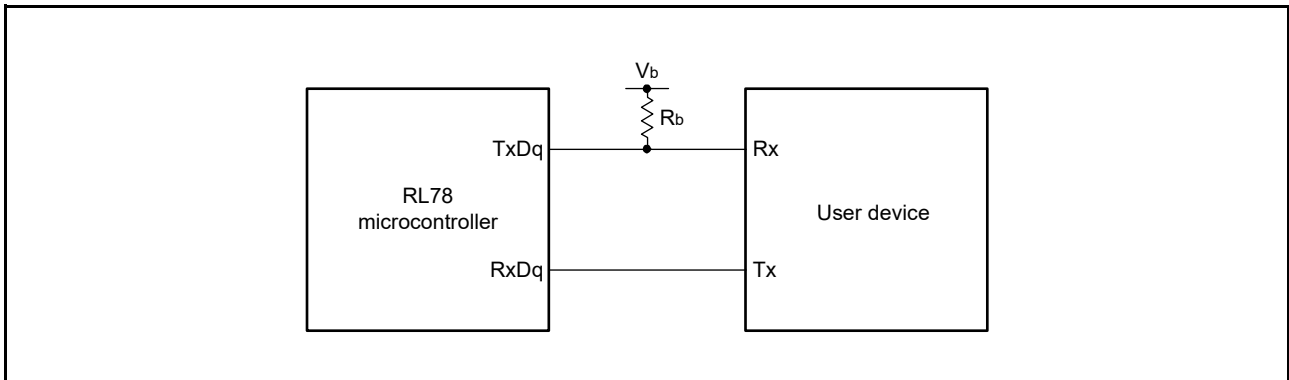
$$\text{Baud rate error (theoretical value)} = \frac{\frac{1}{\text{Transfer rate} \times 2} - \{-C_b \times R_b \times \ln(1 - \frac{1.5}{V_b})\}}{(\frac{1}{\text{Transfer rate}}) \times \text{Number of transferred bits}} \times 100 \text{ [%]}$$

This value is the theoretical value of the relative difference between the transmission and reception sides.

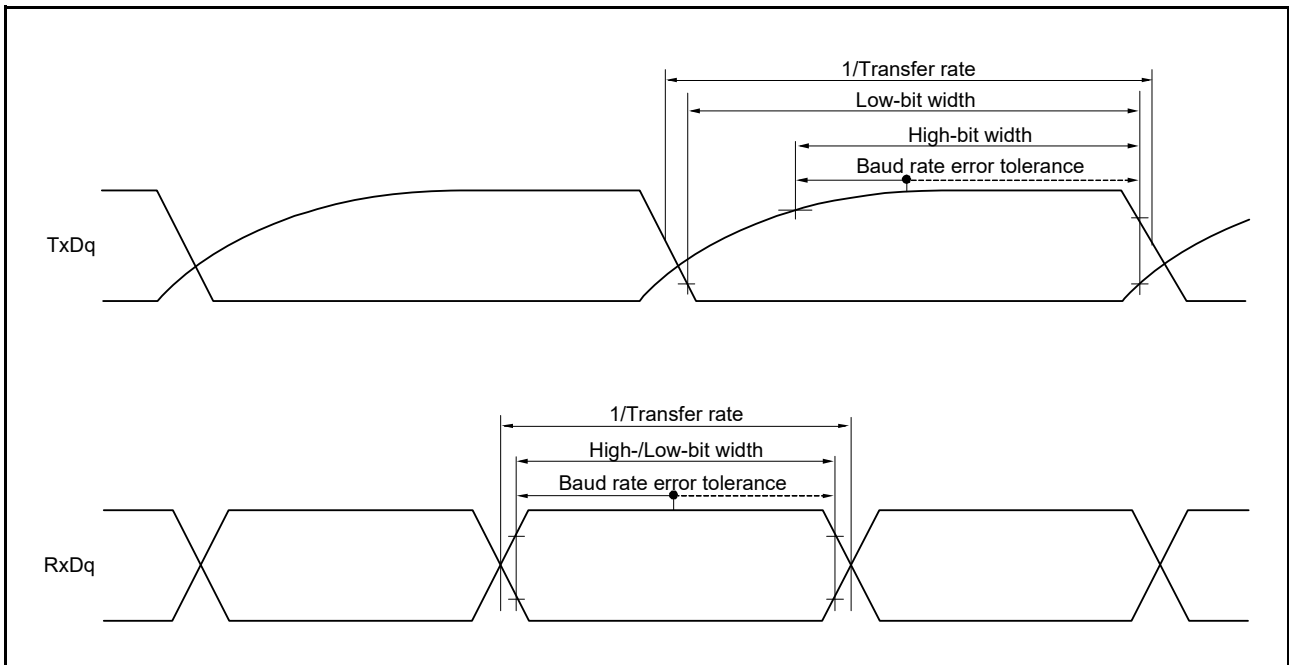
**Note 7.** This rate is calculated as an example when the conditions described in the “Conditions” column are met. See **Note 6** above to calculate the maximum transfer rate under conditions of the customer.

**Caution** Select the TTL input buffer for the RxDq pin and the N-ch open drain output [withstand voltage of  $V_{DD}$ ] mode for the TxDq pin by using port input mode register g (PIMg) and port output mode register g (POMg). For  $V_{IH}$  and  $V_{IL}$ , see the DC characteristics with TTL input buffer selected.

(a) In UART communications with devices operating at different voltage levels



(b) Bit width in the UART communications with devices operating at different voltage levels (reference)



**Remark 1.**  $R_b[\Omega]$ : Communication line (TxDq) pull-up resistance,  $C_b[F]$ : Communication line (TxDq) load capacitance,  $V_b[V]$ : Communication line voltage

**Remark 2.** q: UART number (q = 0 to 2), g: PIM and POM number (g = 0, 1)

**Remark 3.** fMCK: Serial array unit operation clock frequency

To set this operating clock, use the CKSmn bit in the serial mode register mn (SMRmn).

m: Unit number, n: Channel number (mn = 00, 01)

**Remark 4.** Communications by using UART2 with devices operating at different voltage levels are not possible when the setting of bit 1 (PIOR1) of the peripheral I/O redirection register (PIOR) is 1.



- (7) In simplified SPI (CSI) communications in the master mode with devices operating at different voltage levels (2.5 V or 3 V) with the internal SCKp clock (the ratings below are only applicable to CSI00)

(TA = -40 to +105°C, 2.7 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

(1/2)

Item	Symbol	Conditions	HS (High-Speed Main) Mode		LS (Low-Speed Main) Mode		LP (Low-Power Main) Mode		Unit
			Min.	Max.	Min.	Max.	Min.	Max.	
SCKp cycle time	tkCY1	tkCY1 ≥ 2/fCLK 4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V, Cb = 20 pF, Rb = 1.4 kΩ	200		200		2300		ns
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V, Cb = 20 pF, Rb = 2.7 kΩ	300		300		2300		ns
SCKp high-level width	tkH1	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V, Cb = 20 pF, Rb = 1.4 kΩ	tkCY1/2 - 50		tkCY1/2 - 50		tkCY1/2 - 50		ns
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V, Cb = 20 pF, Rb = 2.7 kΩ	tkCY1/2 - 120		tkCY1/2 - 120		tkCY1/2 - 120		ns
SCKp low-level width	tkL1	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V, Cb = 20 pF, Rb = 1.4 kΩ	tkCY1/2 - 7		tkCY1/2 - 7		tkCY1/2 - 50		ns
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V, Cb = 20 pF, Rb = 2.7 kΩ	tkCY1/2 - 10		tkCY1/2 - 10		tkCY1/2 - 50		ns
Slp setup time (to SCKp↑)Note 1	tsIK1	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V, Cb = 20 pF, Rb = 1.4 kΩ	58		58		479		ns
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V, Cb = 20 pF, Rb = 2.7 kΩ	121		121		479		ns
Slp hold time (from SCKp↑)Note 1	tkSI1	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V, Cb = 20 pF, Rb = 1.4 kΩ	10		10		10		ns
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V, Cb = 20 pF, Rb = 2.7 kΩ	10		10		10		ns
Delay time from SCKp↓ to SOp outputNote 1	tkSO1	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V, Cb = 20 pF, Rb = 1.4 kΩ		60		60		60	ns
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V, Cb = 20 pF, Rb = 2.7 kΩ		130		130		130	ns

(Notes, Caution, and Remarks are listed on the next page.)

- (7) In simplified SPI (CSI) communications in the master mode with devices operating at different voltage levels (2.5 V or 3 V) with the internal SCKp clock (the ratings below are only applicable to CSI00)

(TA = -40 to +105°C, 2.7 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

(2/2)

Item	Symbol	Conditions	HS (High-Speed Main) Mode		LS (Low-Speed Main) Mode		LP (Low-Power Main) Mode		Unit
			Min.	Max.	Min.	Max.	Min.	Max.	
Slp setup time (to SCKp↓) <sup>Note 2</sup>	tsIK1	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V, Cb = 20 pF, Rb = 1.4 kΩ	23		23		110		ns
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V, Cb = 20 pF, Rb = 2.7 kΩ	33		33		110		ns
Slp hold time (from SCKp↓) <sup>Note 2</sup>	tkSI1	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V, Cb = 20 pF, Rb = 1.4 kΩ	10		10		10		ns
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V, Cb = 20 pF, Rb = 2.7 kΩ	10		10		10		ns
Delay time from SCKp↑ to SOp output <sup>Note 2</sup>	tkSO1	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V, Cb = 20 pF, Rb = 1.4 kΩ		10		10		10	ns
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V, Cb = 20 pF, Rb = 2.7 kΩ		10		10		10	ns

**Note 1.** This setting applies when DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1.

**Note 2.** This setting applies when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.

**Caution** Select the TTL input buffer for the Slp pin and the N-ch open drain output [withstand voltage of VDD] mode for the SOp pin and SCKp pin by using port input mode register g (PIMg) and port output mode register g (POMg). For VIH and VIL, see the DC characteristics with TTL input buffer selected.

**Remark 1.** Rb[Ω]: Communication line (SCKp, SOp) pull-up resistance, Cb[F]: Communication line (SCKp, SOp) load capacitance, Vb[V]: Communication line voltage

**Remark 2.** p: CSI number (p = 00), m: Unit number (m = 0), n: Channel number (n = 0), g: PIM and POM numbers (g = 1)

**Remark 3.** fMCK: Serial array unit operation clock frequency

To set this operating clock, use the CKSmn bit in the serial mode register mn (SMRmn).

m: Unit number, n: Channel number (mn= 00)

**Remark 4.** The listed times are only valid when the peripheral I/O redirect function of CSI00 is not in use.

- (8) In simplified SPI (CSI) communications in the master mode with devices operating at different voltage levels (1.8 V, 2.5 V, or 3 V) with the internal SCKp clock

(TA = -40 to +105°C, 1.8 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

(1/3)

Item	Symbol	Conditions	HS (High-Speed Main) Mode		LS (Low-Speed Main) Mode		LP (Low-Power Main) Mode		Unit	
			Min.	Max.	Min.	Max.	Min.	Max.		
SCKp cycle time	tkCY1	tkCY1 ≥ 4/fCLK	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V, Cb = 30 pF, Rb = 1.4 kΩ	300		300		2300		ns
			2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V, Cb = 30 pF, Rb = 2.7 kΩ	500		500		2300		ns
			1.8 V ≤ VDD < 3.3 V, 1.6 V ≤ Vb ≤ 2.0 V <sup>Note</sup> , Cb = 30 pF, Rb = 5.5 kΩ	1150		1150		2300		ns
SCKp high-level width	tkH1	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V, Cb = 30 pF, Rb = 1.4 kΩ	tkCY1/2 - 75		tkCY1/2 - 75		tkCY1/2 - 75		ns	
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V, Cb = 30 pF, Rb = 2.7 kΩ	tkCY1/2 - 170		tkCY1/2 - 170		tkCY1/2 - 170		ns	
		1.8 V ≤ VDD < 3.3 V, 1.6 V ≤ Vb ≤ 2.0 V <sup>Note</sup> , Cb = 30 pF, Rb = 5.5 kΩ	tkCY1/2 - 458		tkCY1/2 - 458		tkCY1/2 - 458		ns	
SCKp low-level width	tkL1	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V, Cb = 30 pF, Rb = 1.4 kΩ	tkCY1/2 - 12		tkCY1/2 - 12		tkCY1/2 - 50		ns	
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V, Cb = 30 pF, Rb = 2.7 kΩ	tkCY1/2 - 18		tkCY1/2 - 18		tkCY1/2 - 50		ns	
		1.8 V ≤ VDD < 3.3 V, 1.6 V ≤ Vb ≤ 2.0 V <sup>Note</sup> , Cb = 30 pF, Rb = 5.5 kΩ	tkCY1/2 - 50		tkCY1/2 - 50		tkCY1/2 - 50		ns	

**Note** Use this setting with VDD ≥ Vb.

**Caution** Select the TTL input buffer for the SIp pin and the N-ch open drain output [withstand voltage of VDD] mode for the SOp pin and SCKp pin by using port input mode register g (PIMg) and port output mode register g (POMg). For VIH and VIL, see the DC characteristics with TTL input buffer selected.

(Remarks are listed two pages after the next page.)

- (8) In simplified SPI (CSI) communications in the master mode with devices operating at different voltage levels (1.8 V, 2.5 V, or 3 V) with the internal SCKp clock

(TA = -40 to +105°C, 1.8 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

(2/3)

Item	Symbol	Conditions	HS (High-Speed Main) Mode		LS (Low-Speed Main) Mode		LP (Low-Power Main) Mode		Unit
			Min.	Max.	Min.	Max.	Min.	Max.	
Slp setup time (to SCKp↑) <sup>Note 1</sup>	tsIK1	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V, Cb = 30 pF, Rb = 1.4 kΩ	81		81		479		ns
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V, Cb = 30 pF, Rb = 2.7 kΩ	177		177		479		ns
		1.8 V ≤ VDD < 3.3 V, 1.6 V ≤ Vb ≤ 2.0 V <sup>Note 2</sup> , Cb = 30 pF, Rb = 5.5 kΩ	479		479		479		ns
Slp hold time (from SCKp↑) <sup>Note 1</sup>	tKSI1	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V, Cb = 30 pF, Rb = 1.4 kΩ	19		19		19		ns
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V, Cb = 30 pF, Rb = 2.7 kΩ	19		19		19		ns
		1.8 V ≤ VDD < 3.3 V, 1.6 V ≤ Vb ≤ 2.0 V <sup>Note 2</sup> , Cb = 30 pF, Rb = 5.5 kΩ	19		19		19		ns
Delay time from SCKp↓ to SOp output <sup>Note 1</sup>	tKSO1	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V, Cb = 30 pF, Rb = 1.4 kΩ		100		100		100	ns
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V, Cb = 30 pF, Rb = 2.7 kΩ		195		195		195	ns
		1.8 V ≤ VDD < 3.3 V, 1.6 V ≤ Vb ≤ 2.0 V <sup>Note 2</sup> , Cb = 30 pF, Rb = 5.5 kΩ		483		483		483	ns

**Note 1.** This setting applies when DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1.

**Note 2.** Use this setting with VDD ≥ Vb.

**Caution** Select the TTL input buffer for the Slp pin and the N-ch open drain output [withstand voltage of VDD] mode for the SOp pin and SCKp pin by using port input mode register g (PIMg) and port output mode register g (POMg). For VIH and VIL, see the DC characteristics with TTL input buffer selected.

(Remarks are listed on the page after the next page.)

- (8) In simplified SPI (CSI) communications in the master mode with devices operating at different voltage levels (1.8 V, 2.5 V, or 3 V) with the internal SCKp clock

(TA = -40 to +105°C, 1.8 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

(3/3)

Item	Symbol	Conditions	HS (High-Speed Main) Mode		LS (Low-Speed Main) Mode		LP (Low-Power Main) Mode		Unit
			Min.	Max.	Min.	Max.	Min.	Max.	
Slp setup time (to SCKp↓) <sup>Note 1</sup>	tsIK1	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V, Cb = 30 pF, Rb = 1.4 kΩ	44		44		110		ns
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V, Cb = 30 pF, Rb = 2.7 kΩ	44		44		110		ns
		1.8 V ≤ VDD < 3.3 V, 1.6 V ≤ Vb ≤ 2.0 V <sup>Note 2</sup> , Cb = 30 pF, Rb = 5.5 kΩ	110		110		110		ns
Slp hold time (from SCKp↓) <sup>Note 1</sup>	tkSI1	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V, Cb = 30 pF, Rb = 1.4 kΩ	19		19		19		ns
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V, Cb = 30 pF, Rb = 2.7 kΩ	19		19		19		ns
		1.8 V ≤ VDD < 3.3 V, 1.6 V ≤ Vb ≤ 2.0 V <sup>Note 2</sup> , Cb = 30 pF, Rb = 5.5 kΩ	19		19		19		ns
Delay time from SCKp↑ to SOp output <sup>Note 1</sup>	tkSO1	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V, Cb = 30 pF, Rb = 1.4 kΩ		25		25		25	ns
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V, Cb = 30 pF, Rb = 2.7 kΩ		25		25		25	ns
		1.8 V ≤ VDD < 3.3 V, 1.6 V ≤ Vb ≤ 2.0 V <sup>Note 2</sup> , Cb = 30 pF, Rb = 5.5 kΩ		25		25		25	ns

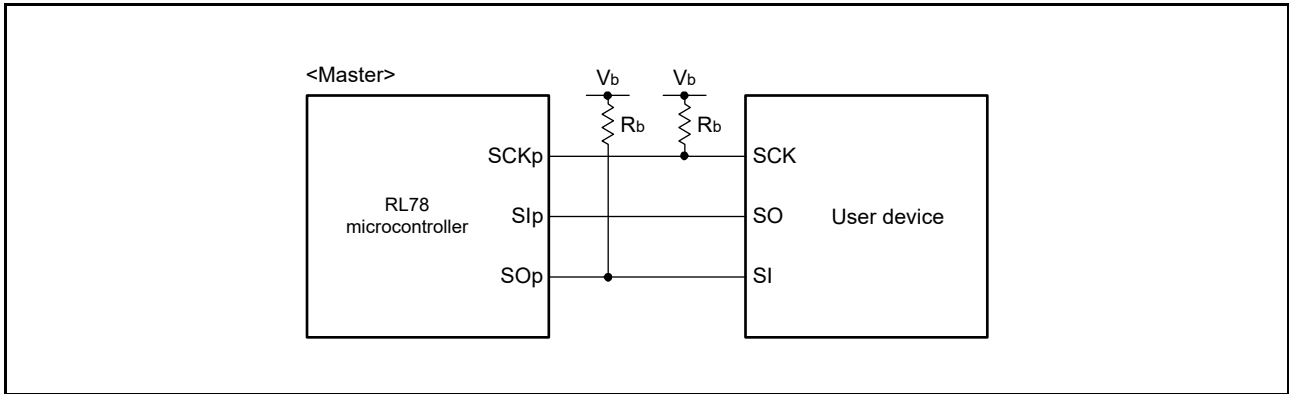
**Note 1.** This setting applies when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.

**Note 2.** Use this setting with VDD ≥ Vb.

**Caution** Select the TTL input buffer for the Slp pin and the N-ch open drain output [withstand voltage of VDD] mode for the SOp pin and SCKp pin by using port input mode register g (PIMg) and port output mode register g (POMg). For VIH and VIL, see the DC characteristics with TTL input buffer selected.

(Remarks are listed on the next page.)

(a) Connection in the simplified SPI (CSI) communications with devices operating at different voltage levels



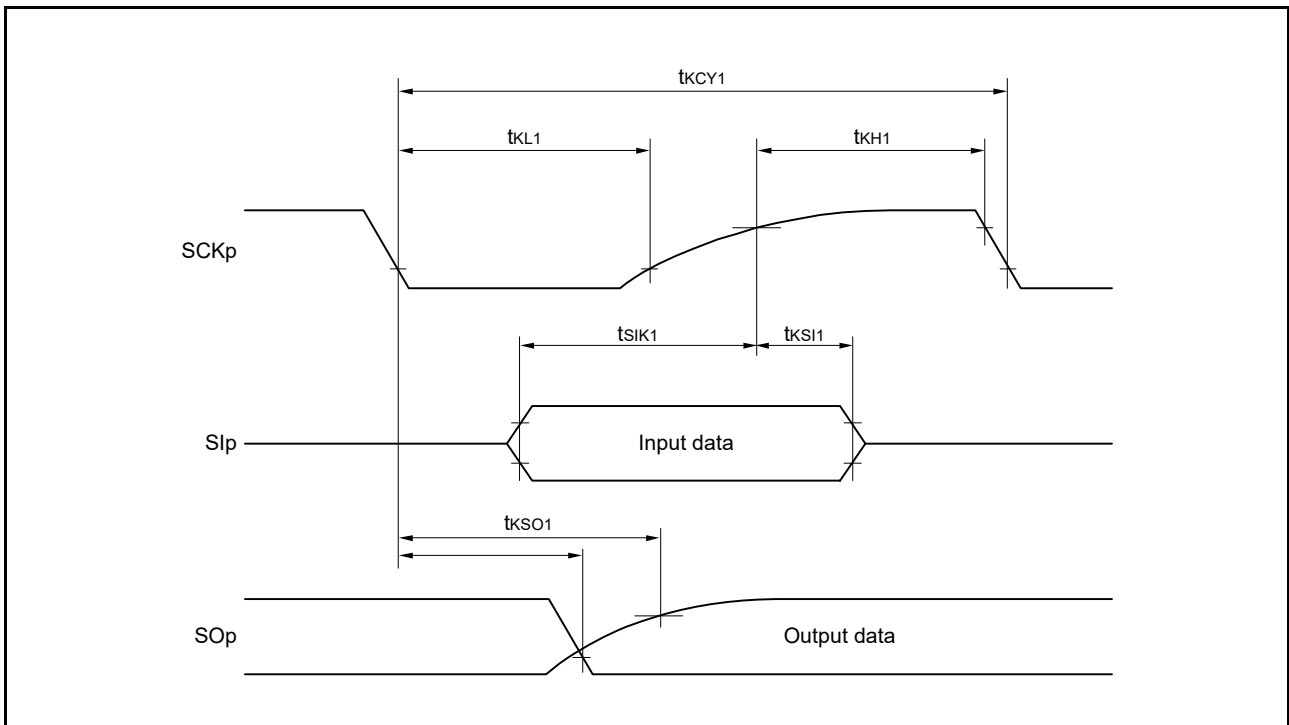
**Remark 1.**  $R_b[\Omega]$ : Communication line (SCKp, SOp) pull-up resistance,  $C_b[F]$ : Communication line (SCKp, SOp) load capacitance,  $V_b[V]$ : Communication line voltage

**Remark 2.** p: CSI number (p = 00, 01, 20), m: Unit number, n: Channel number (mn = 00, 01, 03, 10, 11), g: PIM and POM number (g = 1, 3, 7)

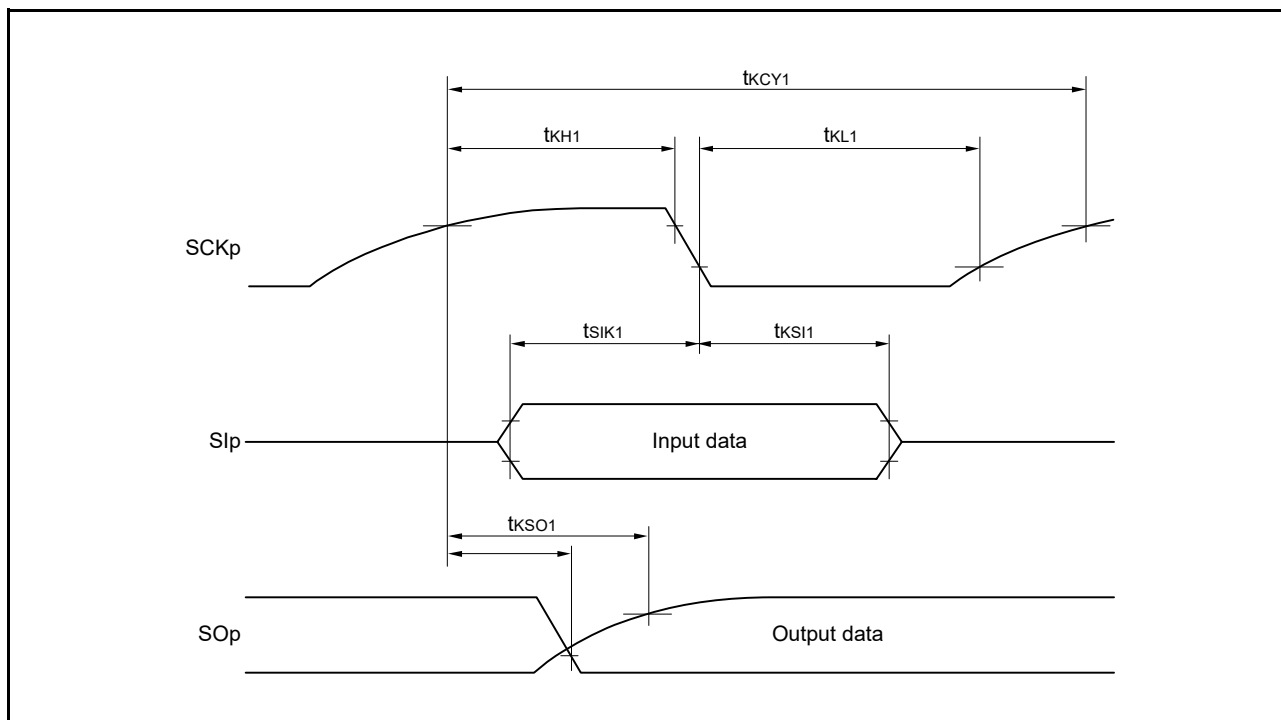
**Remark 3.**  $f_{MCK}$ : Serial array unit operation clock frequency  
 To set this operating clock, use the CKSmn bit in the serial mode register mn (SMRmn).  
 m: Unit number, n: Channel number (mn = 00)

**Remark 4.** Communications by using CSI01 of 48-pin products, and CSI11 and CSI21 with devices operating at different voltage levels are not possible. Use other CSI channels to handle such communications.

(b) Timing of serial transfer in the simplified SPI (CSI) communications in the master mode with devices operating at different voltage levels when  $DAP_{mn} = 0$  and  $CKP_{mn} = 0$ , or  $DAP_{mn} = 1$  and  $CKP_{mn} = 1$



(c) Timing of serial transfer in the simplified SPI (CSI) communications in the master mode with devices operating at different voltage levels when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0



**Remark 1.** p: CSI number (p = 00, 01, 20), m: Unit number, n: Channel number (mn = 00, 01, 03, 10, 11), g: PIM and POM number (g = 1, 3, 7)

**Remark 2.** Communications by using CSI01 of 48-pin products, and CSI11 and CSI21 with devices operating at different voltage levels are not possible. Use other CSI channels to handle such communications.

(9) In simplified SPI (CSI) communications in the slave mode with devices operating at different voltage levels (1.8 V, 2.5 V, or 3 V) with the external SCKp clock

(TA = -40 to +105°C, 1.8 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

(1/2)

Item	Symbol	Conditions		HS (High-Speed Main) Mode		LS (Low-Speed Main) Mode		LP (Low-Power Main) Mode		Unit	
				Min.	Max.	Min.	Max.	Min.	Max.		
SCKp cycle time <b>Note 1</b>	tkCY2	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V	24 MHz < fMCK	14/fMCK		—		—		ns	
			20 MHz < fMCK ≤ 24 MHz	12/fMCK		12/fMCK		—		ns	
			8 MHz < fMCK ≤ 20 MHz	10/fMCK		10/fMCK		—		ns	
			4 MHz < fMCK ≤ 8 MHz	8/fMCK		8/fMCK		—		ns	
			fMCK ≤ 4 MHz	6/fMCK		6/fMCK		10/fMCK		ns	
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V,	24 MHz < fMCK	20/fMCK		—		—		ns	
			20 MHz < fMCK ≤ 24 MHz	16/fMCK		16/fMCK		—		ns	
			16 MHz < fMCK ≤ 20 MHz	14/fMCK		14/fMCK		—		ns	
			8 MHz < fMCK ≤ 16 MHz	12/fMCK		12/fMCK		—		ns	
			4 MHz < fMCK ≤ 8 MHz	8/fMCK		8/fMCK		—		ns	
		1.8 V ≤ VDD < 3.3 V, 1.6 V ≤ Vb ≤ 2.0 V <b>Note 2</b>	24 MHz < fMCK	48/fMCK		—		—		ns	
			20 MHz < fMCK ≤ 24 MHz	36/fMCK		36/fMCK		—		ns	
			16 MHz < fMCK ≤ 20 MHz	32/fMCK		32/fMCK		—		ns	
			8 MHz < fMCK ≤ 16 MHz	26/fMCK		26/fMCK		—		ns	
			4 MHz < fMCK ≤ 8 MHz	16/fMCK		16/fMCK		—		ns	
				fMCK ≤ 4 MHz	10/fMCK		10/fMCK		10/fMCK		ns

(Notes and Caution are listed on the next page, and Remarks are listed on the page after the next page.)



- (9) In simplified SPI (CSI) communications in the slave mode with devices operating at different voltage levels (1.8 V, 2.5 V, or 3 V) with the external SCKp clock

(TA = -40 to +105°C, 1.8 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

(2/2)

Item	Symbol	Conditions	HS (High-Speed Main) Mode		LS (Low-Speed Main) Mode		LP (Low-Power Main) Mode		Unit
			Min.	Max.	Min.	Max.	Min.	Max.	
SCKp high-/low-level width	tkH2, tkL2	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V	tkCY2/2 - 12		tkCY2/2 - 12		tkCY2/2 - 50		ns
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V	tkCY2/2 - 18		tkCY2/2 - 18		tkCY2/2 - 50		ns
		1.8 V ≤ VDD < 3.3 V, 1.6 V ≤ Vb ≤ 2.0 V <sup>Note 2</sup>	tkCY2/2 - 50		tkCY2/2 - 50		tkCY2/2 - 50		ns
Slp setup time (to SCKp↑) <sup>Note 3</sup>	tsIK2	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V	1/fMCK + 20		1/fMCK + 20		1/fMCK + 30		ns
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V	1/fMCK + 20		1/fMCK + 20		1/fMCK + 30		ns
		1.8 V ≤ VDD < 3.3 V, 1.6 V ≤ Vb ≤ 2.0 V <sup>Note 2</sup>	1/fMCK + 30		1/fMCK + 30		1/fMCK + 30		ns
Slp hold time (from SCKp↑) <sup>Note 3</sup>	tkSI2		1/fMCK + 31		1/fMCK + 31		1/fMCK + 31		ns
Delay time from SCKp↓ to SOp output <sup>Note 4</sup>	tkSO2	4.0 V ≤ VDD ≤ 5.5 V, 2.7 V ≤ Vb ≤ 4.0 V, Cb = 30 pF, Rb = 1.4 kΩ		2/fMCK + 120		2/fMCK + 120		2/fMCK + 573	ns
		2.7 V ≤ VDD < 4.0 V, 2.3 V ≤ Vb ≤ 2.7 V, Cb = 30 pF, Rb = 2.7 kΩ		2/fMCK + 214		2/fMCK + 214		2/fMCK + 573	ns
		1.8 V ≤ VDD < 3.3 V, 1.6 V ≤ Vb ≤ 2.0 V <sup>Note 2</sup> , Cb = 30 pF, Rb = 5.5 kΩ		2/fMCK + 573		2/fMCK + 573		2/fMCK + 573	ns

**Note 1.** Transfer rate in the SNOOZE mode: 1 Mbps (max.)

**Note 2.** Use this setting with VDD ≥ Vb.

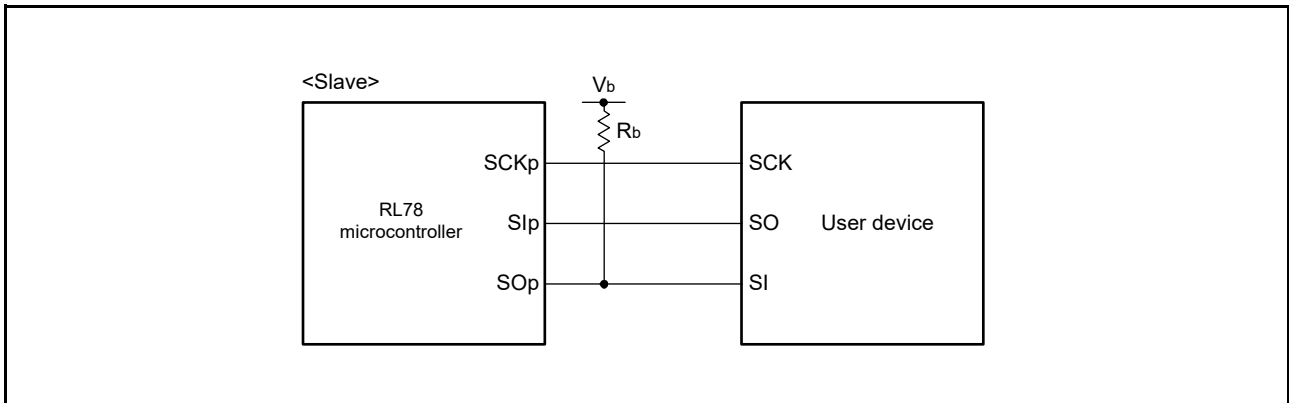
**Note 3.** This setting applies when DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1. The Slp setup time becomes “to SCKp↓” and Slp hold time becomes “from SCKp↓” when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.

**Note 4.** This setting applies when DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1. The delay time to SOp output becomes “from SCKp↑” when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.

**Caution** Select the TTL input buffer for the Slp pin and the N-ch open drain output [withstand voltage of VDD] mode for the SOp pin and SCKp pin by using port input mode register g (PIMg) and port output mode register g (POMg). For VIH and VIL, see the DC characteristics with TTL input buffer selected.

(Remarks are listed on the next page.)

(a) Connection in the simplified SPI (CSI) communications with devices operating at different voltage levels



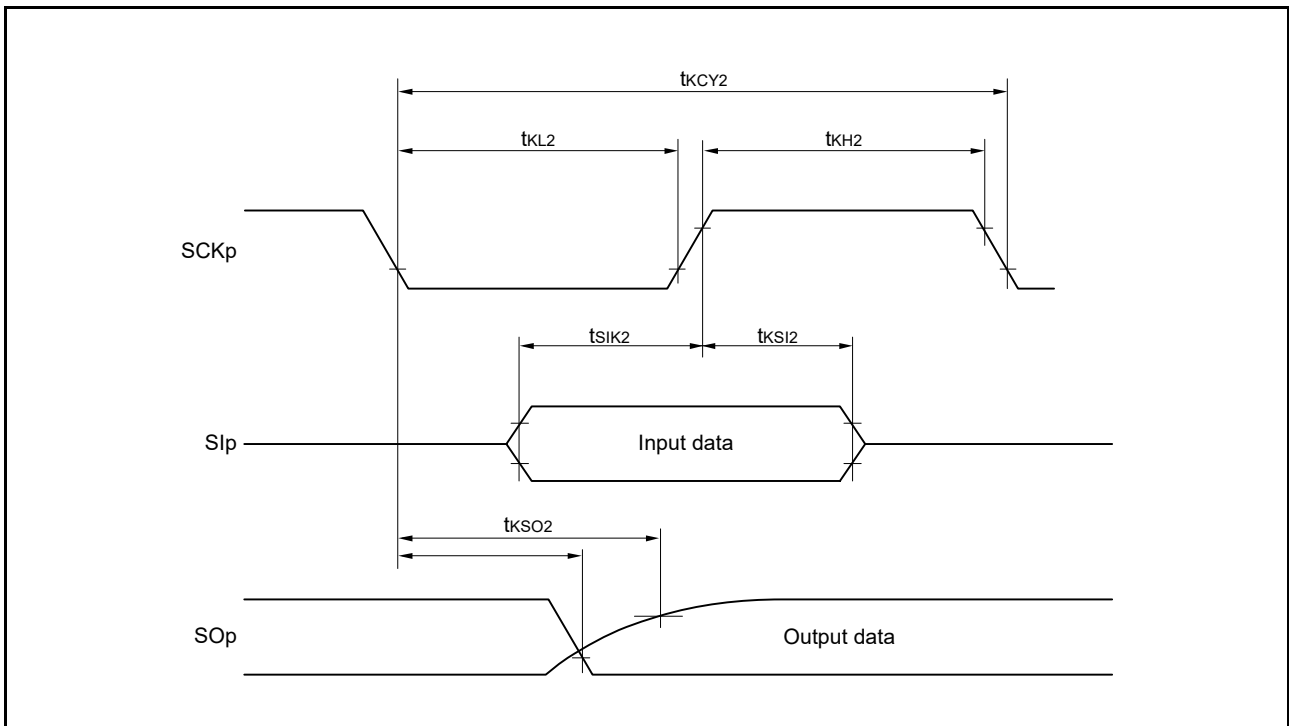
**Remark 1.**  $R_b[\Omega]$ : Communication line (SO<sub>p</sub>) pull-up resistance,  $C_b[F]$ : Communication line (SO<sub>p</sub>) load capacitance,  $V_b[V]$ : Communication line voltage

**Remark 2.** p: CSI number (p = 00, 01, 20), m: Unit number, n: Channel number (mn = 00, 01, 03, 10, 11), g: PIM and POM number (g = 1, 3, 7)

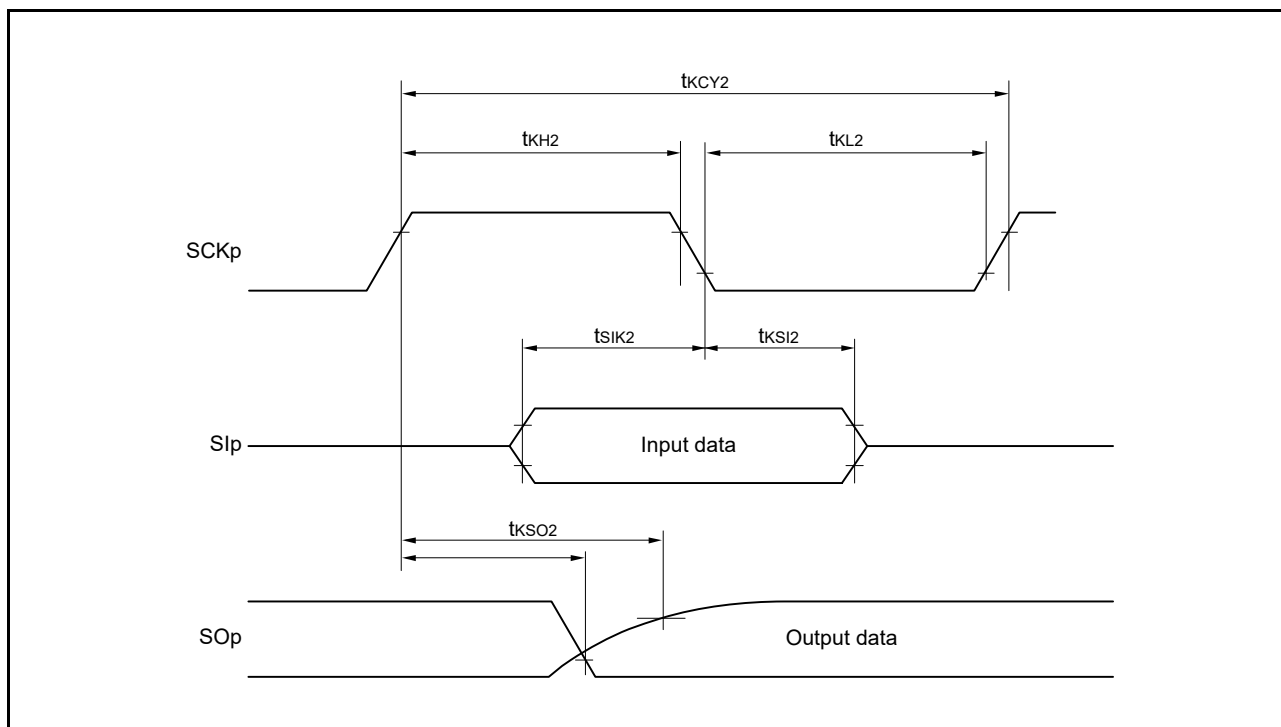
**Remark 3.** f<sub>MCK</sub>: Serial array unit operation clock frequency  
 To set this operating clock, use the CKSmn bit in the serial mode register mn (SMRmn).  
 m: Unit number, n: Channel number (mn = 00, 01, 03, 10, 11)

**Remark 4.** Communications by using CSI01 of 48-pin products, and CSI11 and CSI21 with devices operating at different voltage levels are not possible. Use other CSI channels to handle such communications.

(b) Timing of serial transfer in the simplified SPI (CSI) communications in the slave mode with devices operating at different voltage levels when DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1



(c) Timing of serial transfer in the simplified SPI (CSI) communications in the slave mode with devices operating at different voltage levels when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0



**Remark 1.** p: CSI number (p = 00, 01, 20), m: Unit number, n: Channel number (mn = 00, 01, 03, 10, 11), g: PIM and POM number (g = 1, 3, 7)

**Remark 2.** Communications by using CSI01 of 48-pin products, and CSI11 and CSI21 with devices operating at different voltage levels are not possible. Use other CSI channels to handle such communications.

(10) Simplified I<sup>2</sup>C communications with devices operating at different voltage levels (1.8 V, 2.5 V, or 3 V)(T<sub>A</sub> = -40 to +105°C, 1.8 V ≤ V<sub>DD</sub> ≤ 5.5 V, V<sub>SS</sub> = 0 V)

(1/2)

Item	Symbol	Conditions	HS (High-Speed Main) Mode		LS (Low-Speed Main) Mode		LP (Low-Power Main) Mode		Unit
			Min.	Max.	Min.	Max.	Min.	Max.	
SCLr clock frequency	f <sub>SCL</sub>	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V, 2.7 V ≤ V <sub>b</sub> ≤ 4.0 V, C <sub>b</sub> = 50 pF, R <sub>b</sub> = 2.7 kΩ		1000 Note 1		1000 Note 1		300 Note 1	kHz
		2.7 V ≤ V <sub>DD</sub> < 4.0 V, 2.3 V ≤ V <sub>b</sub> ≤ 2.7 V, C <sub>b</sub> = 50 pF, R <sub>b</sub> = 2.7 kΩ		1000 Note 1		1000 Note 1		300 Note 1	kHz
		4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V, 2.7 V ≤ V <sub>b</sub> ≤ 4.0 V, C <sub>b</sub> = 100 pF, R <sub>b</sub> = 2.8 kΩ		400 Note 1		400 Note 1		300 Note 1	kHz
		2.7 V ≤ V <sub>DD</sub> < 4.0 V, 2.3 V ≤ V <sub>b</sub> ≤ 2.7 V, C <sub>b</sub> = 100 pF, R <sub>b</sub> = 2.7 kΩ		400 Note 1		400 Note 1		300 Note 1	kHz
		1.8 V ≤ V <sub>DD</sub> < 3.3 V, 1.6 V ≤ V <sub>b</sub> ≤ 2.0 V <sup>Note 2</sup> , C <sub>b</sub> = 100 pF, R <sub>b</sub> = 5.5 kΩ		300 Note 1		300 Note 1		300 Note 1	kHz
Hold time when SCLr is low	t <sub>LOW</sub>	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V, 2.7 V ≤ V <sub>b</sub> ≤ 4.0 V, C <sub>b</sub> = 50 pF, R <sub>b</sub> = 2.7 kΩ	475		475		1550		ns
		2.7 V ≤ V <sub>DD</sub> < 4.0 V, 2.3 V ≤ V <sub>b</sub> ≤ 2.7 V, C <sub>b</sub> = 50 pF, R <sub>b</sub> = 2.7 kΩ	475		475		1550		ns
		4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V, 2.7 V ≤ V <sub>b</sub> ≤ 4.0 V, C <sub>b</sub> = 100 pF, R <sub>b</sub> = 2.8 kΩ	1150		1550		1550		ns
		2.7 V ≤ V <sub>DD</sub> < 4.0 V, 2.3 V ≤ V <sub>b</sub> ≤ 2.7 V, C <sub>b</sub> = 100 pF, R <sub>b</sub> = 2.7 kΩ	1150		1550		1550		ns
		1.8 V ≤ V <sub>DD</sub> < 3.3 V, 1.6 V ≤ V <sub>b</sub> ≤ 2.0 V <sup>Note 2</sup> , C <sub>b</sub> = 100 pF, R <sub>b</sub> = 5.5 kΩ	1550		1550		1550		ns
Hold time when SCLr is high	t <sub>HIGH</sub>	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V, 2.7 V ≤ V <sub>b</sub> ≤ 4.0 V, C <sub>b</sub> = 50 pF, R <sub>b</sub> = 2.7 kΩ	245		245		610		ns
		2.7 V ≤ V <sub>DD</sub> < 4.0 V, 2.3 V ≤ V <sub>b</sub> ≤ 2.7 V, C <sub>b</sub> = 50 pF, R <sub>b</sub> = 2.7 kΩ	200		200		610		ns
		4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V, 2.7 V ≤ V <sub>b</sub> ≤ 4.0 V, C <sub>b</sub> = 100 pF, R <sub>b</sub> = 2.8 kΩ	675		675		610		ns
		2.7 V ≤ V <sub>DD</sub> < 4.0 V, 2.3 V ≤ V <sub>b</sub> ≤ 2.7 V, C <sub>b</sub> = 100 pF, R <sub>b</sub> = 2.7 kΩ	600		600		610		ns
		1.8 V ≤ V <sub>DD</sub> < 3.3 V, 1.6 V ≤ V <sub>b</sub> ≤ 2.0 V <sup>Note 2</sup> , C <sub>b</sub> = 100 pF, R <sub>b</sub> = 5.5 kΩ	610		610		610		ns

(10) Simplified I<sup>2</sup>C communications with devices operating at different voltage levels (1.8 V, 2.5 V, and 3 V)(T<sub>A</sub> = -40 to +105°C, 1.8 V ≤ V<sub>DD</sub> ≤ 5.5 V, V<sub>SS</sub> = 0 V)

(2/2)

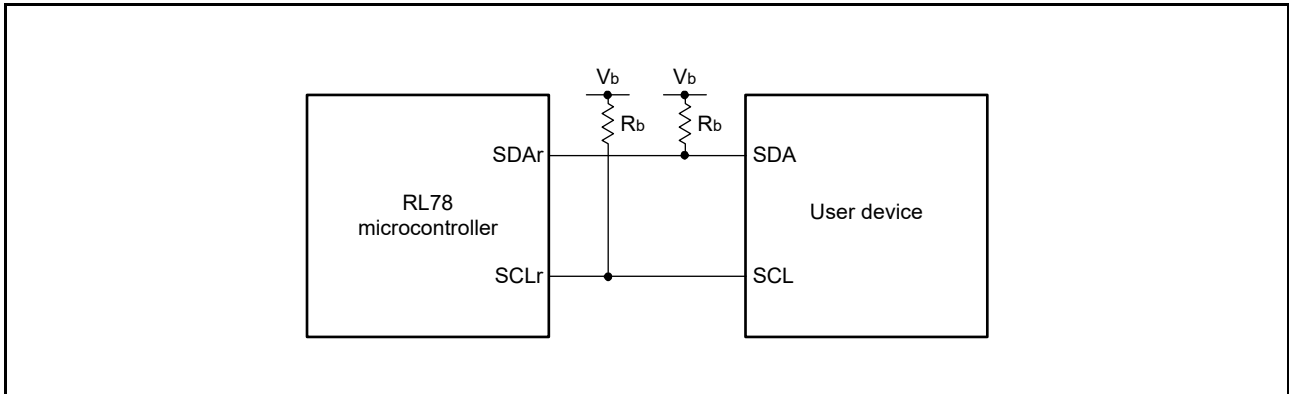
Item	Symbol	Conditions	HS (High-Speed Main) Mode		LS (Low-Speed Main) Mode		LP (Low-Power Main) Mode		Unit
			Min.	Max.	Min.	Max.	Min.	Max.	
Data setup time (reception)	t <sub>SU:DAT</sub>	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V, 2.7 V ≤ V <sub>b</sub> ≤ 4.0 V, C <sub>b</sub> = 50 pF, R <sub>b</sub> = 2.7 kΩ	1/f <sub>MCK</sub> + 135 <b>Note 3</b>		1/f <sub>MCK</sub> + 135 <b>Note 3</b>		1/f <sub>MCK</sub> + 190 <b>Note 3</b>		ns
		2.7 V ≤ V <sub>DD</sub> < 4.0 V, 2.3 V ≤ V <sub>b</sub> ≤ 2.7 V, C <sub>b</sub> = 50 pF, R <sub>b</sub> = 2.7 kΩ	1/f <sub>MCK</sub> + 135 <b>Note 3</b>		1/f <sub>MCK</sub> + 135 <b>Note 3</b>		1/f <sub>MCK</sub> + 190 <b>Note 3</b>		ns
		4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V, 2.7 V ≤ V <sub>b</sub> ≤ 4.0 V, C <sub>b</sub> = 100 pF, R <sub>b</sub> = 2.8 kΩ	1/f <sub>MCK</sub> + 190 <b>Note 3</b>		1/f <sub>MCK</sub> + 190 <b>Note 3</b>		1/f <sub>MCK</sub> + 190 <b>Note 3</b>		ns
		2.7 V ≤ V <sub>DD</sub> < 4.0 V, 2.3 V ≤ V <sub>b</sub> ≤ 2.7 V, C <sub>b</sub> = 100 pF, R <sub>b</sub> = 2.7 kΩ	1/f <sub>MCK</sub> + 190 <b>Note 3</b>		1/f <sub>MCK</sub> + 190 <b>Note 3</b>		1/f <sub>MCK</sub> + 190 <b>Note 3</b>		ns
		1.8 V ≤ V <sub>DD</sub> < 3.3 V, 1.6 V ≤ V <sub>b</sub> ≤ 2.0 V <b>Note 2</b> , C <sub>b</sub> = 100 pF, R <sub>b</sub> = 5.5 kΩ	1/f <sub>MCK</sub> + 190 <b>Note 3</b>		1/f <sub>MCK</sub> + 190 <b>Note 3</b>		1/f <sub>MCK</sub> + 190 <b>Note 3</b>		ns
Data hold time (transmission)	t <sub>HD:DAT</sub>	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V, 2.7 V ≤ V <sub>b</sub> ≤ 4.0 V, C <sub>b</sub> = 50 pF, R <sub>b</sub> = 2.7 kΩ	0	305	0	305	0	305	ns
		2.7 V ≤ V <sub>DD</sub> < 4.0 V, 2.3 V ≤ V <sub>b</sub> ≤ 2.7 V, C <sub>b</sub> = 50 pF, R <sub>b</sub> = 2.7 kΩ	0	305	0	305	0	305	ns
		4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V, 2.7 V ≤ V <sub>b</sub> ≤ 4.0 V, C <sub>b</sub> = 100 pF, R <sub>b</sub> = 2.8 kΩ	0	355	0	355	0	355	ns
		2.7 V ≤ V <sub>DD</sub> < 4.0 V, 2.3 V ≤ V <sub>b</sub> ≤ 2.7 V, C <sub>b</sub> = 100 pF, R <sub>b</sub> = 2.7 kΩ	0	355	0	355	0	355	ns
		1.8 V ≤ V <sub>DD</sub> < 3.3 V, 1.6 V ≤ V <sub>b</sub> ≤ 2.0 V <b>Note 2</b> , C <sub>b</sub> = 100 pF, R <sub>b</sub> = 5.5 kΩ	0	405	0	405	0	405	ns

**Note 1.** The listed times must be no greater than f<sub>MCK</sub>/4.**Note 2.** Use this setting with V<sub>DD</sub> ≥ V<sub>b</sub>.**Note 3.** Set f<sub>MCK</sub> so that it will not exceed the hold time when SCLr is low or high.

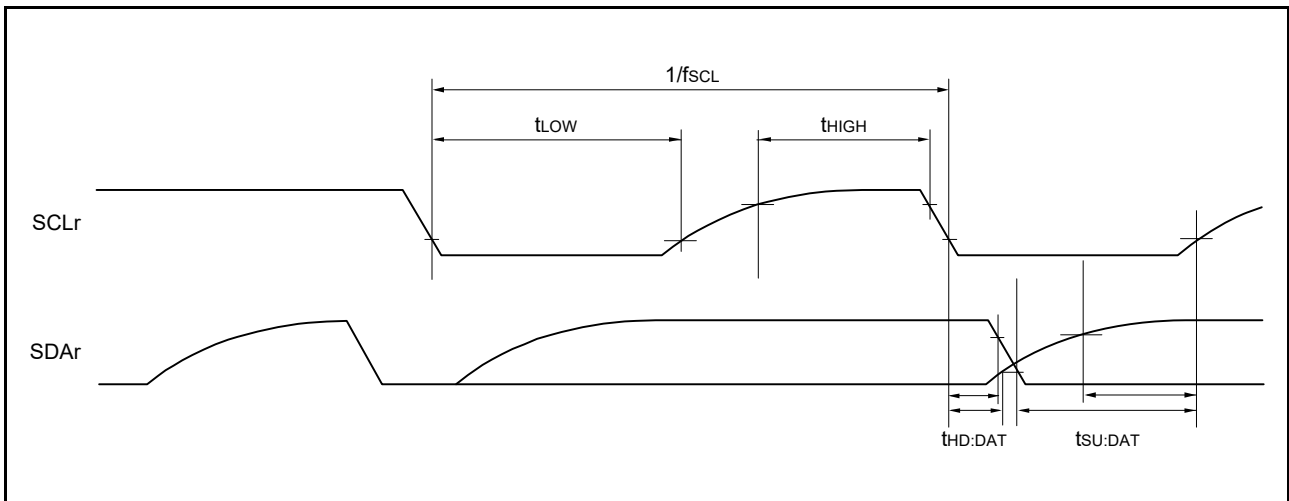
**Caution** Select the TTL input buffer and the N-ch open drain output [withstand voltage of V<sub>DD</sub>] mode for the SDAr pin and the N-ch open drain output [withstand voltage of V<sub>DD</sub>] mode for the SCLr pin by using port input mode register g (PIMg) and port output mode register g (POMg). For V<sub>IH</sub> and V<sub>IL</sub>, see the DC characteristics with TTL input buffer selected.

(Remarks are listed on the next page.)

(a) Connection in the I<sup>2</sup>C communications with devices operating at different voltage levels



(b) Timing of serial transfer in the simplified I<sup>2</sup>C communications with devices operating at different voltage levels



**Remark 1.**  $R_b[\Omega]$ : Communication line (SDAr, SCLr) pull-up resistance,  $C_b[F]$ : Communication line (SDAr, SCLr) load capacitance,  $V_b[V]$ : Communication line voltage

**Remark 2.** r: IIC number (r = 00, 01, 11, 20, 21), g: PIM and POM number (g = 0, 1, 3, 7), POM number (h = 1, 5, 7)

**Remark 3.**  $f_{MCK}$ : Serial array unit operation clock frequency

To set this operating clock, use the CKSmn bit in the serial mode register mn (SMRmn).

m: Unit number, n: Channel number (mn = 00, 01, 03, 10, 11)

## 2.5.2 Serial interface UARTA

(TA = -40 to +105°C, 1.6 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Transfer rate			200	0	153600	bps

**Caution** Select the normal input buffer for the RxDAn pin and the normal output mode for the TxDAn pin by using port input mode register g (PIMg) and port output mode register g (POMg).

**Remark** n: Unit number (n = 0), g: PIM or POM number (g = 7)

### 2.5.3 Serial interface IICA

#### (1) I<sup>2</sup>C standard mode

(T<sub>A</sub> = -40 to +105°C, 1.6 V ≤ V<sub>DD</sub> ≤ 5.5 V, V<sub>SS</sub> = 0 V)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
SCLA0 clock frequency	fSCL	Standard mode: fCLK ≥ 1 MHz	0		100	kHz
Setup time of restart condition	tSU:STA		4.7			μs
Hold time <sup>Note 1</sup>	tHD:STA		4.0			μs
Hold time when SCLA0 is low	tLOW		4.7			μs
Hold time when SCLA0 is high	tHIGH		4.0			μs
Data setup time (reception)	tSU:DAT		250			ns
Data hold time (transmission) <sup>Note 2</sup>	tHD:DAT		0		3.45	μs
Setup time of stop condition	tSU:STO		4.0			μs
Bus-free time	tBUF		4.7			μs

**Note 1.** The first clock pulse is generated after this period when the start or restart condition is detected.

**Note 2.** The maximum value of tHD:DAT applies to normal transfer. The clock stretching will be inserted on reception of an acknowledgment (ACK) signal.

**Caution** The listed frequency and times apply even when bit 2 (PIOR2) in the peripheral I/O redirection register (PIOR) is 1. In such cases, the pin characteristics (IOH1, IOL1, VOH1, VOL1) must satisfy the values in the redirect destination.

**Remark** The maximum value of communication line capacitance (Cb) and communication line pull-up resistor (Rb) are as follows.  
Cb = 400 pF, Rb = 2.7 kΩ



(2) I<sup>2</sup>C fast mode

(TA = -40 to +105°C, 1.6 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
SCLA0 clock frequency	fSCL	Fast mode: fCLK ≥ 3.5 MHz 1.8 V ≤ VDD ≤ 5.5 V	0		400	kHz
Setup time of restart condition	tSU:STA	1.8 V ≤ VDD ≤ 5.5 V	0.6			μs
Hold time <sup>Note 1</sup>	tHD:STA	1.8 V ≤ VDD ≤ 5.5 V	0.6			μs
Hold time when SCLA0 is low	tLOW	1.8 V ≤ VDD ≤ 5.5 V	1.3			μs
Hold time when SCLA0 is high	tHIGH	1.8 V ≤ VDD ≤ 5.5 V	0.6			μs
Data setup time (reception)	tSU:DAT	1.8 V ≤ VDD ≤ 5.5 V	100			ns
Data hold time (transmission) <sup>Note 2</sup>	tHD:DAT	1.8 V ≤ VDD ≤ 5.5 V	0		0.9	μs
Setup time of stop condition	tSU:STO	1.8 V ≤ VDD ≤ 5.5 V	0.6			μs
Bus-free time	tBUF	1.8 V ≤ VDD ≤ 5.5 V	1.3			μs

**Note 1.** The first clock pulse is generated after this period when the start or restart condition is detected.

**Note 2.** The maximum value of tHD:DAT applies to normal transfer. The clock stretching will be inserted on reception of an acknowledgment (ACK) signal.

**Caution** The values in the above table apply even when bit 2 (PIOR2) in the peripheral I/O redirection register (PIOR) is 1. In such cases, the pin characteristics (IOH1, IOL1, VOH1, VOL1) must satisfy the values in the redirect destination.

**Remark** The maximum value of communication line capacitance (Cb) and communication line pull-up resistor (Rb) are as follows.  
Cb = 320 pF, Rb = 1.1 kΩ

(3) I<sup>2</sup>C fast mode plus

(T<sub>A</sub> = -40 to +105°C, 1.6 V ≤ V<sub>DD</sub> ≤ 5.5 V, V<sub>SS</sub> = 0 V)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
SCLA0 clock frequency	f <sub>SCL</sub>	Fast mode plus: f <sub>CLK</sub> ≥ 10 MHz 2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V	0		1000	kHz
Setup time of restart condition	t <sub>SU:STA</sub>	2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V	0.26			μs
Hold time <sup>Note 1</sup>	t <sub>HD:STA</sub>	2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V	0.26			μs
Hold time when SCLA0 is low	t <sub>LOW</sub>	2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V	0.5			μs
Hold time when SCLA0 is high	t <sub>HIGH</sub>	2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V	0.26			μs
Data setup time (reception)	t <sub>SU:DAT</sub>	2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V	50			ns
Data hold time (transmission) <sup>Note 2</sup>	t <sub>HD:DAT</sub>	2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V	0		0.45	μs
Setup time of stop condition	t <sub>SU:STO</sub>	2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V	0.26			μs
Bus-free time	t <sub>BUF</sub>	2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V	0.5			μs

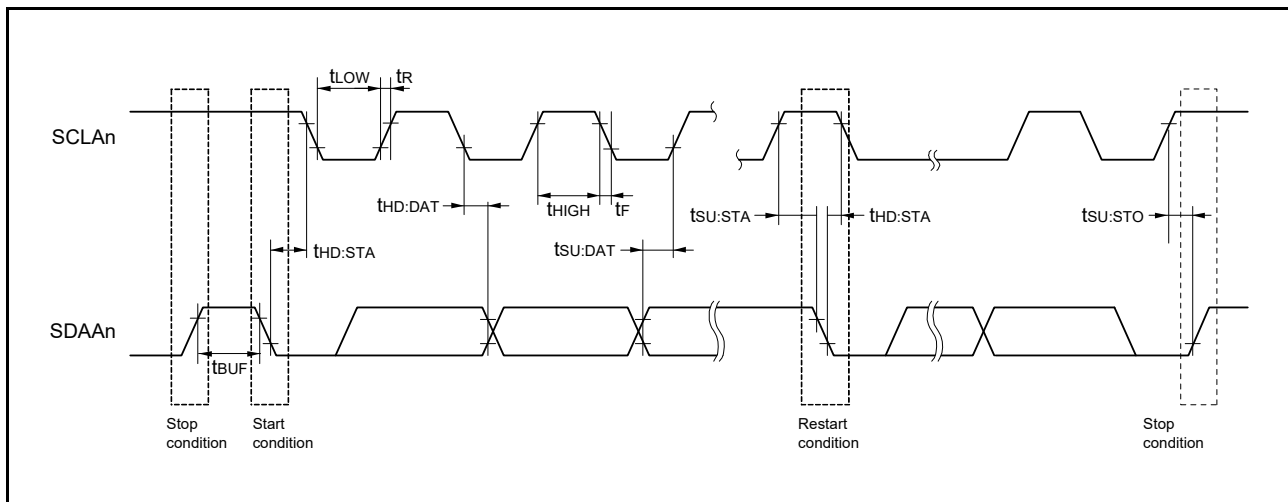
**Note 1.** The first clock pulse is generated after this period when the start or restart condition is detected.

**Note 2.** The maximum value of t<sub>HD:DAT</sub> applies to normal transfer. The clock stretching will be inserted on reception of an acknowledgment (ACK) signal.

**Caution** The values in the above table apply even when bit 2 (PIOR2) in the peripheral I/O redirection register (PIOR) is 1. In such cases, the pin characteristics (IOH1, IOL1, VOH1, VOL1) must satisfy the values in the redirect destination.

**Remark** The maximum value of communication line capacitance (C<sub>b</sub>) and communication line pull-up resistor (R<sub>b</sub>) are as follows.  
C<sub>b</sub> = 120 pF, R<sub>b</sub> = 1.1 kΩ

I<sup>2</sup>C serial transfer timing



**Remark** n = 0

## 2.6 Characteristics of the Analog Circuits

### 2.6.1 Characteristics of the A/D converter for TA = -40 to +85°C

Reference for the characteristics of the A/D converter

Reference Voltage Input Channel	Reference Voltage (+) = AVREFP Reference Voltage (-) = AVREFM	Reference Voltage (+) = VDD Reference Voltage (-) = VSS	Reference Voltage (+) = VBGR Reference Voltage (-) = AVREFM
ANI0 to ANI7	See 2.6.1 (1)	See 2.6.1 (3)	See 2.6.1 (4)
ANI16 to ANI19	See 2.6.1 (2)		
Internal reference voltage, temperature sensor output voltage, and TSCAP voltage of the CTSU	See 2.6.1 (1)		—

- (1) Reference voltage (+) = AVREFP/ANI0 (ADREFP1 = 0, ADREFP0 = 1), reference voltage (-) = AVREFM/ANI1 (ADREFM = 1), conversion target: ANI2 to ANI7, internal reference voltage, temperature sensor output voltage, and TSCAP voltage of the CTSU

(TA = -40 to +85°C, 1.6 V ≤ AVREFP ≤ VDD ≤ 5.5 V, VSS = 0 V, reference voltage (+) = AVREFP,

reference voltage (-) = AVREFM = 0 V) (1/2)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit	
Resolution	RES		8		10	Bit	
Overall error <sup>Note 1</sup>	AINL	10-bit resolution AVREFP = VDD <sup>Note 3</sup>	1.8 V ≤ AVREFP ≤ 5.5 V		1.2	±3.5	LSB
			1.6 V ≤ AVREFP ≤ 5.5 V <sup>Note 4</sup>		1.2	±7.0	LSB
Conversion time	tCONV	10-bit resolution conversion target: ANI2 to ANI7	3.6 V ≤ VDD ≤ 5.5 V	2.125		39	μs
			2.7 V ≤ VDD ≤ 5.5 V	3.1875		39	μs
			1.8 V ≤ VDD ≤ 5.5 V	17		39	μs
			1.6 V ≤ VDD ≤ 5.5 V	57		95	μs
		10-bit resolution conversion target: Internal reference temperature sensor output voltage, and TSCAP voltage of the CTSU	3.6 V ≤ VDD ≤ 5.5 V	2.375		39	μs
			2.7 V ≤ VDD ≤ 5.5 V	3.5625		39	μs
Zero-scale error <sup>Notes 1, 2</sup>	Ezs	10-bit resolution AVREFP = VDD <sup>Note 3</sup>	1.8 V ≤ AVREFP ≤ 5.5 V			±0.25	%FSR
			1.6 V ≤ AVREFP ≤ 5.5 V <sup>Note 4</sup>			±0.50	%FSR
Full-scale error <sup>Notes 1, 2</sup>	EFS	10-bit resolution AVREFP = VDD <sup>Note 3</sup>	1.8 V ≤ AVREFP ≤ 5.5 V			±0.25	%FSR
			1.6 V ≤ AVREFP ≤ 5.5 V <sup>Note 4</sup>			±0.50	%FSR
Integral linearity error <sup>Note 1</sup>	ILE	10-bit resolution AVREFP = VDD <sup>Note 3</sup>	1.8 V ≤ AVREFP ≤ 5.5 V			±2.5	LSB
			1.6 V ≤ AVREFP ≤ 5.5 V <sup>Note 4</sup>			±5.0	LSB
Differential linearity error <sup>Note 1</sup>	DLE	10-bit resolution AVREFP = VDD <sup>Note 3</sup>	1.8 V ≤ AVREFP ≤ 5.5 V			±1.5	LSB
			1.6 V ≤ AVREFP ≤ 5.5 V <sup>Note 4</sup>			±2.0	LSB

( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.6\text{ V} \leq AV_{REFP} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ , reference voltage (+) =  $AV_{REFP}$ ,  
reference voltage (-) =  $AV_{REFM} = 0\text{ V}$ ) (2/2)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Analog input voltage	VAIN	ANI2 to ANI7	0		$AV_{REFP}$	V
		Internal reference voltage ( $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ )	VBGR <sup>Note 5</sup>			V
		Temperature sensor output voltage ( $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ )	VTMPS25 <sup>Note 5</sup>			V
		TSCAP voltage of the CTSU ( $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ )	VTSCAP			V

**Note 1.** This value does not include the quantization error ( $\pm 1/2$  LSB).

**Note 2.** This value is indicated as a ratio (%FSR) to the full-scale value.

**Note 3.** When reference voltage (+) =  $V_{DD}$  and reference voltage (-) =  $V_{SS}$ , the maximum values are as follows.

Overall error: Add  $\pm 10$  LSB to the maximum value when  $V_{DD} = AV_{REFP}$ .

Zero-scale/full-scale error: Add  $\pm 0.05\%$ FSR to the maximum value when  $V_{DD} = AV_{REFP}$ .

Integral linearity error and differential linearity error: Add  $\pm 0.5$  LSB to the maximum value when  $V_{DD} = AV_{REFP}$ .

**Note 4.** The listed value applies when the settings of the maximum and minimum conversion time values are respectively  $57\ \mu\text{s}$  and  $95\ \mu\text{s}$ .

**Note 5.** See **2.6.3 Characteristics of the temperature sensor and internal reference voltage.**

(2) Reference voltage (+) =  $AV_{REFP}/ANI0$  ( $ADREFP1 = 0$ ,  $ADREFP0 = 1$ ), reference voltage (-) =  $AV_{REFM}/ANI1$  ( $ADREFM = 1$ ), conversion target: ANI16 to ANI19

( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.6\text{ V} \leq AV_{REFP} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  
reference voltage (+) =  $AV_{REFP}$ , reference voltage (-) =  $AV_{REFM} = 0\text{ V}$ )

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit	
Resolution	RES		8		10	Bit	
Overall error <sup>Note 1</sup>	AINL	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>	$1.8\text{ V} \leq AV_{REFP} \leq 5.5\text{ V}$		1.2	$\pm 5.0$	LSB
			$1.6\text{ V} \leq AV_{REFP} \leq 5.5\text{ V}$ <sup>Note 4</sup>		1.2	$\pm 5.0$	
Conversion time	tCONV	10-bit resolution conversion target: ANI16 to ANI19	$3.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	2.125		39	$\mu\text{s}$
			$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	3.1875		39	$\mu\text{s}$
			$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	17		39	$\mu\text{s}$
			$1.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	57		95	
Zero-scale error <sup>Notes 1, 2</sup>	Ezs	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>	$1.8\text{ V} \leq AV_{REFP} \leq 5.5\text{ V}$			$\pm 0.35$	%FSR
			$1.6\text{ V} \leq AV_{REFP} \leq 5.5\text{ V}$ <sup>Note 4</sup>			$\pm 0.60$	
Full-scale error <sup>Notes 1, 2</sup>	Efs	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>	$1.8\text{ V} \leq AV_{REFP} \leq 5.5\text{ V}$			$\pm 0.35$	%FSR
			$1.6\text{ V} \leq AV_{REFP} \leq 5.5\text{ V}$ <sup>Note 4</sup>			$\pm 0.60$	
Integral linearity error <sup>Note 1</sup>	ILE	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>	$1.8\text{ V} \leq AV_{REFP} \leq 5.5\text{ V}$			$\pm 3.5$	LSB
			$1.6\text{ V} \leq AV_{REFP} \leq 5.5\text{ V}$ <sup>Note 4</sup>			$\pm 6.0$	
Differential linearity error <sup>Note 1</sup>	DLE	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>	$1.8\text{ V} \leq AV_{REFP} \leq 5.5\text{ V}$			$\pm 2.0$	LSB
			$1.6\text{ V} \leq AV_{REFP} \leq 5.5\text{ V}$ <sup>Note 4</sup>			$\pm 2.5$	
Analog input voltage	VAIN	ANI16 to ANI19	0		$AV_{REFP}$	V	

**Note 1.** This value does not include the quantization error ( $\pm 1/2$  LSB).

**Note 2.** This value is indicated as a ratio (%FSR) to the full-scale value.

**Note 3.** When  $AV_{REFP} < V_{DD}$ , the maximum values are as follows.

- Overall error: Add  $\pm 4.0$  LSB to the maximum value when  $V_{DD} = AV_{REFP}$ .
- Zero-scale/full-scale error: Add  $\pm 0.20\%$  FSR to the maximum value when  $V_{DD} = AV_{REFP}$ .
- Integral linearity error/differential linearity error: Add  $\pm 2.0$  LSB to the maximum value when  $V_{DD} = AV_{REFP}$ .

**Note 4.** The listed value applies when the settings of the maximum and minimum conversion time values are respectively  $57\ \mu\text{s}$  and  $95\ \mu\text{s}$ .

- (3) Reference voltage (+) =  $V_{DD}$  (ADREFP1 = 0, ADREFP0 = 0), reference voltage (-) =  $V_{SS}$  (ADREFM = 0), conversion target: ANI0 to ANI7, and ANI16 to ANI19, internal reference voltage<sup>Note 5</sup>, temperature sensor output voltage<sup>Note 5</sup>, TSCAP voltage of the CTSU

( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ , reference voltage (+) =  $V_{DD}$ , reference voltage (-) =  $V_{SS}$ )

Item	Symbol	Conditions		Min.	Typ.	Max.	Unit
Resolution	RES			8		10	Bit
Overall error <sup>Note 1</sup>	AINL	10-bit resolution	$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		1.2	$\pm 7.0$	LSB
			$1.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ <sup>Note 3</sup>		1.2	$\pm 10.5$	LSB
Conversion time	tCONV	10-bit resolution conversion target: ANI0 to ANI7, ANI16 to ANI19	$3.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	2.125		39	$\mu\text{s}$
			$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	3.1875		39	$\mu\text{s}$
			$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	17		39	$\mu\text{s}$
			$1.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	57		95	$\mu\text{s}$
		10-bit resolution conversion target: Internal reference voltage, temperature sensor output voltage, and TSCAP voltage of the CTSU	$3.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	2.375		39	$\mu\text{s}$
			$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	3.5625		39	$\mu\text{s}$
			$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	17		39	$\mu\text{s}$
Zero-scale error <sup>Notes 1, 2</sup>	Ezs	10-bit resolution	$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$			$\pm 0.60$	%FSR
			$1.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ <sup>Note 3</sup>			$\pm 0.85$	%FSR
Full-scale error <sup>Notes 1, 2</sup>	EFS	10-bit resolution	$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$			$\pm 0.60$	%FSR
			$1.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ <sup>Note 3</sup>			$\pm 0.85$	%FSR
Integral linearity error <sup>Note 1</sup>	ILE	10-bit resolution	$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$			$\pm 4.0$	LSB
			$1.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ <sup>Note 3</sup>			$\pm 6.0$	LSB
Differential linearity error <sup>Note 1</sup>	DLE	10-bit resolution	$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$			$\pm 2.0$	LSB
			$1.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ <sup>Note 3</sup>			$\pm 2.5$	LSB
Analog input voltage	VAIN	ANI0 to ANI7, ANI16 to ANI19		0		$V_{DD}$	V
		Internal reference voltage ( $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ )		$V_{BGR}$ <sup>Note 4</sup>			V
		Temperature sensor output voltage ( $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ )		$V_{TMPS25}$ <sup>Note 4</sup>			V
		TSCAP voltage of the CTSU ( $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ )		$V_{TSCAP}$			V

**Note 1.** This value does not include the quantization error ( $\pm 1/2$  LSB).

**Note 2.** This value is indicated as a ratio (%FSR) to the full-scale value.

**Note 3.** The listed value applies when the settings of the maximum and minimum conversion time values are respectively 57  $\mu\text{s}$  and 95  $\mu\text{s}$ .

**Note 4.** See 2.6.3 Characteristics of the temperature sensor and internal reference voltage.

**Note 5.** If the internal reference voltage or temperature sensor output voltage is to be A/D converted,  $V_{DD}$  must be at least 1.8 V.

- (4) Reference voltage (+) =  $V_{DD}$  (ADREFP1 = 1, ADREFP0 = 0), reference voltage (-) =  $AV_{REFM}/ANI1$  (ADREFM = 1), conversion target: ANI0, ANI2 to ANI7, ANI16 to ANI19

( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ , reference voltage (+) =  $V_{BGR}$ <sup>Note 3</sup>, reference voltage (-) =  $AV_{REFM}$ <sup>Note 4</sup> = 0 V)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Resolution	RES		8			Bit
Conversion time	tCONV		17		39	$\mu\text{s}$
Zero-scale error <sup>Notes 1, 2</sup>	EZS				$\pm 0.60$	%FSR
Integral linearity error <sup>Note 1</sup>	ILE				$\pm 2.0$	LSB
Differential linearity error <sup>Note 1</sup>	DLE				$\pm 1.0$	LSB
Analog input voltage	VAIN		0		$V_{BGR}$ <sup>Note 3</sup>	V

**Note 1.** This value does not include the quantization error ( $\pm 1/2$  LSB).

**Note 2.** This value is indicated as a ratio (%FSR) to the full-scale value.

**Note 3.** See **2.6.3 Characteristics of the temperature sensor and internal reference voltage.**

**Note 4.** When reference voltage (-) =  $V_{SS}$ , the maximum values are as follows.

- Zero-scale error: Add  $\pm 0.35\%$ FSR to the maximum value when reference voltage (-) =  $AV_{REFM}$ .
- Integral linearity error: Add  $\pm 0.5$  LSB to the maximum value when reference voltage (-) =  $AV_{REFM}$ .
- Differential linearity error: Add  $\pm 0.2$  LSB to the maximum value when reference voltage (-) =  $AV_{REFM}$ .

## 2.6.2 Characteristics of the A/D converter for $T_A = -40$ to $+105^\circ\text{C}$

Reference for the characteristics of the A/D converter

Reference Voltage Input Channel	Reference Voltage (+) = AVREFF Reference Voltage (-) = AVREFM	Reference Voltage (+) = VDD Reference Voltage (-) = VSS	Reference Voltage (+) = VBGR Reference Voltage (-) = AVREFM
ANI0 to ANI7	See 2.6.2 (1)	See 2.6.2 (3)	See 2.6.2 (4)
ANI16 to ANI19	See 2.6.2 (2)		
Internal reference voltage, temperature sensor output voltage, and TSCAP voltage of the CTSU	See 2.6.2 (1)		—

- (1) Reference voltage (+) = AVREFF/ANI0 (ADREFF1 = 0, ADREFF0 = 1), reference voltage (-) = AVREFM/ANI1 (ADREFM = 1), conversion target: ANI2 to ANI7, internal reference voltage, temperature sensor output voltage, and TSCAP voltage of the CTSU

( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $2.4\text{ V} \leq \text{AVREFF} \leq \text{VDD} \leq 5.5\text{ V}$ ,  $\text{VSS} = 0\text{ V}$ , reference voltage (+) = AVREFF, reference voltage (-) = AVREFM = 0 V)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Resolution	RES		8		10	Bit
Overall error <sup>Note 1</sup>	AINL	10-bit resolution AVREFF = VDD <sup>Note 3</sup> $2.4\text{ V} \leq \text{AVREFF} \leq 5.5\text{ V}$		1.2	$\pm 3.5$	LSB
Conversion time	tCONV	10-bit resolution conversion target: ANI2 to ANI7	$3.6\text{ V} \leq \text{VDD} \leq 5.5\text{ V}$	2.125	39	$\mu\text{s}$
			$2.7\text{ V} \leq \text{VDD} \leq 5.5\text{ V}$	3.1875	39	$\mu\text{s}$
			$2.4\text{ V} \leq \text{VDD} \leq 5.5\text{ V}$	17	39	$\mu\text{s}$
		10-bit resolution conversion target: Internal reference voltage, temperature sensor output voltage, and TSCAP voltage of the CTSU	$3.6\text{ V} \leq \text{VDD} \leq 5.5\text{ V}$	2.375	39	$\mu\text{s}$
			$2.7\text{ V} \leq \text{VDD} \leq 5.5\text{ V}$	3.5625	39	$\mu\text{s}$
			$2.4\text{ V} \leq \text{VDD} \leq 5.5\text{ V}$	17	39	$\mu\text{s}$
Zero-scale error <sup>Notes 1, 2</sup>	EZS	10-bit resolution AVREFF = VDD <sup>Note 3</sup> $2.4\text{ V} \leq \text{AVREFF} \leq 5.5\text{ V}$			$\pm 0.25$	%FSR
Full-scale error <sup>Notes 1, 2</sup>	EFS	10-bit resolution AVREFF = VDD <sup>Note 3</sup> $2.4\text{ V} \leq \text{AVREFF} \leq 5.5\text{ V}$			$\pm 0.25$	%FSR
Integral linearity error <sup>Note 1</sup>	ILE	10-bit resolution AVREFF = VDD <sup>Note 3</sup> $2.4\text{ V} \leq \text{AVREFF} \leq 5.5\text{ V}$			$\pm 2.5$	LSB
Differential linearity error <sup>Note 1</sup>	DLE	10-bit resolution AVREFF = VDD <sup>Note 3</sup> $2.4\text{ V} \leq \text{AVREFF} \leq 5.5\text{ V}$			$\pm 1.5$	LSB
Analog input voltage	VAIN	ANI2 to ANI7	0		AVREFF	V
		Internal reference voltage	VBGR <sup>Note 4</sup>		V	
		Temperature sensor output voltage	VTMP25 <sup>Note 4</sup>		V	
		TSCAP voltage of the CTSU	VTSCAP		V	

**Note 1.** This value does not include the quantization error ( $\pm 1/2$  LSB).

**Note 2.** This value is indicated as a ratio (%FSR) to the full-scale value.

**Note 3.** When reference voltage (+) = VDD and reference voltage (-) = VSS, the maximum values are as follows.

Overall error: Add  $\pm 10$  LSB to the maximum value when  $\text{VDD} = \text{AVREFF}$ .

Zero-scale/full-scale error: Add  $\pm 0.05\%$ FSR to the maximum value when  $\text{VDD} = \text{AVREFF}$ .

Integral linearity error and differential linearity error: Add  $\pm 0.5$  LSB to the maximum value when  $\text{VDD} = \text{AVREFF}$ .

**Note 4.** See 2.6.3 Characteristics of the temperature sensor and internal reference voltage.



(2) Reference voltage (+) =  $AV_{REFP}/ANI0$  ( $ADREFP1 = 0, ADREFP0 = 1$ ), reference voltage (-) =  $AV_{REFM}/ANI1$  ( $ADREFM = 1$ ), conversion target: ANI16 to ANI19

( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $2.4\text{ V} \leq AV_{REFP} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  
reference voltage (+) =  $AV_{REFP}$ , reference voltage (-) =  $AV_{REFM} = 0\text{ V}$ )

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit	
Resolution	RES		8		10	Bit	
Overall error <sup>Note 1</sup>	AINL	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>	$2.4\text{ V} \leq AV_{REFP} \leq 5.5\text{ V}$		1.2	$\pm 5.0$	LSB
Conversion time	tCONV	10-bit resolution conversion target: ANI16 to ANI19	$3.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	2.125		39	$\mu\text{s}$
			$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	3.1875		39	$\mu\text{s}$
			$2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	17		39	$\mu\text{s}$
Zero-scale error <sup>Notes 1, 2</sup>	EZS	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>	$2.4\text{ V} \leq AV_{REFP} \leq 5.5\text{ V}$			$\pm 0.35$	%FSR
Full-scale error <sup>Notes 1, 2</sup>	EFS	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>	$2.4\text{ V} \leq AV_{REFP} \leq 5.5\text{ V}$			$\pm 0.35$	%FSR
Integral linearity error <sup>Note 1</sup>	ILE	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>	$2.4\text{ V} \leq AV_{REFP} \leq 5.5\text{ V}$			$\pm 3.5$	LSB
Differential linearity error <sup>Note 1</sup>	DLE	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>	$2.4\text{ V} \leq AV_{REFP} \leq 5.5\text{ V}$			$\pm 2.0$	LSB
Analog input voltage	VAIN	ANI16 to ANI19	0		$AV_{REFP}$	V	

**Note 1.** This value does not include the quantization error ( $\pm 1/2$  LSB).

**Note 2.** This value is indicated as a ratio (%FSR) to the full-scale value.

**Note 3.** When  $AV_{REFP} < V_{DD}$ , the maximum values are as follows.

- Overall error: Add  $\pm 4.0$  LSB to the maximum value when  $V_{DD} = AV_{REFP}$ .
- Zero-scale/full-scale error: Add  $\pm 0.20\%$  FSR to the maximum value when  $V_{DD} = AV_{REFP}$ .
- Integral linearity error/differential linearity error: Add  $\pm 2.0$  LSB to the maximum value when  $V_{DD} = AV_{REFP}$ .

- (3) Reference voltage (+) =  $V_{DD}$  (ADREFP1 = 0, ADREFP0 = 0), reference voltage (-) =  $V_{SS}$  (ADREFM = 0), conversion target: ANI0 to ANI7, and ANI16 to ANI19, internal reference voltage, temperature sensor output voltage, and TSCAP voltage of the CTSU

( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ , reference voltage (+) =  $V_{DD}$ , reference voltage (-) =  $V_{SS}$ )

Item	Symbol	Conditions		Min.	Typ.	Max.	Unit
Resolution	RES			8		10	Bit
Overall error <sup>Note 1</sup>	AINL	10-bit resolution	$2.4\text{ V} \leq AV_{REFP} \leq 5.5\text{ V}$		1.2	$\pm 7.0$	LSB
Conversion time	tCONV	10-bit resolution conversion target: ANI0 to ANI7, ANI16 to ANI19	$3.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	2.125		39	$\mu\text{s}$
			$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	3.1875		39	$\mu\text{s}$
			$2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	17		39	$\mu\text{s}$
		10-bit resolution conversion target: Internal reference voltage, temperature sensor output voltage, and and TSCAP voltage of the CTSU	$3.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	2.375		39	$\mu\text{s}$
			$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	3.5625		39	$\mu\text{s}$
			$2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	17		39	$\mu\text{s}$
Zero-scale error <sup>Notes 1, 2</sup>	Ezs	10-bit resolution	$2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$			$\pm 0.60$	%FSR
Full-scale error <sup>Notes 1, 2</sup>	EFS	10-bit resolution	$2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$			$\pm 0.60$	%FSR
Integral linearity error <sup>Note 1</sup>	ILE	10-bit resolution	$2.4\text{ V} \leq AV_{REFP} \leq 5.5\text{ V}$			$\pm 4.0$	LSB
Differential linearity error <sup>Note 1</sup>	DLE	10-bit resolution	$2.4\text{ V} \leq AV_{REFP} \leq 5.5\text{ V}$			$\pm 2.0$	LSB
Analog input voltage	VAIN	ANI0 to ANI7, ANI16 to ANI19		0		$V_{DD}$	V
		Internal reference voltage		$V_{BGR}$ <sup>Note 3</sup>			V
		Temperature sensor output voltage		$V_{TMPS25}$ <sup>Note 3</sup>			V
		TSCAP voltage of the CTSU		$V_{TSCAP}$			V

**Note 1.** This value does not include the quantization error ( $\pm 1/2$  LSB).

**Note 2.** This value is indicated as a ratio (%FSR) to the full-scale value.

**Note 3.** See **2.6.3 Characteristics of the temperature sensor and internal reference voltage.**

- (4) Reference voltage (+) =  $V_{DD}$  (ADREFP1 = 1, ADREFP0 = 0), reference voltage (-) =  $AV_{REFM}/ANI1$  (ADREFM = 1), conversion target: ANI0, ANI2 to ANI7, ANI16 to ANI19

( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ , reference voltage (+) =  $V_{BGR}$ <sup>Note 3</sup>, reference voltage (-) =  $AV_{REFM}$ <sup>Note 4</sup> = 0 V)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Resolution	RES		8			Bit
Conversion time	tCONV		17		39	$\mu\text{s}$
Zero-scale error <sup>Notes 1, 2</sup>	Ezs				$\pm 0.60$	%FSR
Integral linearity error <sup>Note 1</sup>	ILE				$\pm 2.0$	LSB
Differential linearity error <sup>Note 1</sup>	DLE				$\pm 1.0$	LSB
Analog input voltage	VAIN		0		$V_{BGR}$ <sup>Note 3</sup>	V

**Note 1.** This value does not include the quantization error ( $\pm 1/2$  LSB).

**Note 2.** This value is indicated as a ratio (%FSR) to the full-scale value.

**Note 3.** See **2.6.3 Characteristics of the temperature sensor and internal reference voltage.**

**Note 4.** When reference voltage (-) =  $V_{SS}$ , the maximum values are as follows.

- Zero-scale error: Add  $\pm 0.35\%$ FSR to the maximum value when reference voltage (-) =  $AV_{REFM}$ .
- Integral linearity error: Add  $\pm 0.5$  LSB to the maximum value when reference voltage (-) =  $AV_{REFM}$ .
- Differential linearity error: Add  $\pm 0.2$  LSB to the maximum value when reference voltage (-) =  $AV_{REFM}$ .

### 2.6.3 Characteristics of the temperature sensor and internal reference voltage

( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )

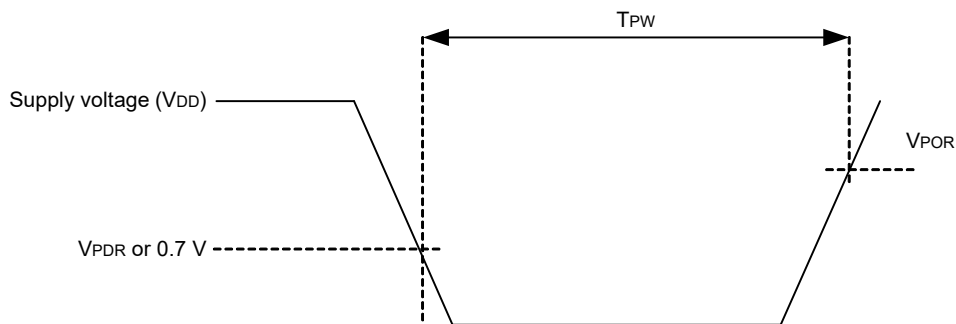
Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Temperature sensor output voltage	VTMPS25	Setting ADS register = 80H, $T_A = +25^\circ\text{C}$		1.05		V
Internal reference voltage	VBGR	Setting ADS register = 81H	1.42	1.48	1.54	V
Temperature coefficient	FVTMPS	Temperature dependency of the temperature sensor voltage		-3.3		mV/ $^\circ\text{C}$
Operation stabilization wait time	tAMP		5			$\mu\text{s}$

### 2.6.4 Characteristics of the POR circuit

( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $V_{SS} = 0\text{ V}$ )

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Detection voltage	VPOR, VPDR		1.43	1.50	1.57	V
Minimum pulse width <sup>Note</sup>	TPW		300			$\mu\text{s}$

**Note** This width is the minimum time required for a POR reset when  $V_{DD}$  falls below  $VPDR$ . This width is also the minimum time required for a POR reset from when  $V_{DD}$  falls below  $0.7\text{ V}$  to when  $V_{DD}$  exceeds  $VPOR$  in the STOP mode or while the main system clock is stopped through setting bit 0 (HIOSTOP) and bit 7 (MSTOP) in the clock operation status control register (CSC).



## 2.6.5 Characteristics of the LVD circuit

### (1) LVD0 Detection Voltage in the Reset Mode and Interrupt Mode

(TA = -40 to +105°C, VPDR ≤ VDD ≤ 5.5 V, VSS = 0 V)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit	
Detection voltage	VLVD00	The power supply voltage is rising.	3.84	3.96	4.08	V	
		The power supply voltage is falling.	3.76	3.88	4.00	V	
	VLVD01	The power supply voltage is rising.	2.88	2.97	3.06	V	
		The power supply voltage is falling.	2.82	2.91	3.00	V	
	VLVD02	The power supply voltage is rising.	2.59	2.67	2.75	V	
		The power supply voltage is falling.	2.54	2.62	2.70	V	
	VLVD03	The power supply voltage is rising.	2.31	2.38	2.45	V	
		The power supply voltage is falling.	2.26	2.33	2.40	V	
	VLVD04	The power supply voltage is rising.	1.84	1.90	1.95	V	
		The power supply voltage is falling.	1.80	1.86	1.91	V	
	VLVD05	The power supply voltage is rising.	1.64	1.69	1.74	V	
		The power supply voltage is falling.	1.60	1.65	1.70	V	
	Minimum pulse width	tLW		500			μs
	Detection delay time					500	μs

## (2) LVD1 Detection Voltage of Reset Mode and Interrupt Mode

(TA = -40 to +105°C, VPDR ≤ VDD ≤ 5.5 V, VSS = 0 V)

Item		Symbol	Conditions	Min.	Typ.	Max.	Unit
Detection voltage	Supply voltage level	VLVD10	The power supply voltage is rising.	4.08	4.16	4.24	V
			The power supply voltage is falling.	4.00	4.08	4.16	V
		VLVD11	The power supply voltage is rising.	3.88	3.96	4.04	V
			The power supply voltage is falling.	3.80	3.88	3.96	V
		VLVD12	The power supply voltage is rising.	3.68	3.75	3.82	V
			The power supply voltage is falling.	3.60	3.67	3.74	V
		VLVD13	The power supply voltage is rising.	3.48	3.55	3.62	V
			The power supply voltage is falling.	3.40	3.47	3.54	V
		VLVD14	The power supply voltage is rising.	3.28	3.35	3.42	V
			The power supply voltage is falling.	3.20	3.27	3.34	V
		VLVD15	The power supply voltage is rising.	3.07	3.13	3.19	V
			The power supply voltage is falling.	3.00	3.06	3.12	V
		VLVD16	The power supply voltage is rising.	2.91	2.97	3.03	V
			The power supply voltage is falling.	2.85	2.91	2.97	V
		VLVD17	The power supply voltage is rising.	2.76	2.82	2.87	V
			The power supply voltage is falling.	2.70	2.76	2.81	V
		VLVD18	The power supply voltage is rising.	2.61	2.66	2.71	V
			The power supply voltage is falling.	2.55	2.60	2.65	V
		VLVD19	The power supply voltage is rising.	2.45	2.50	2.55	V
			The power supply voltage is falling.	2.40	2.45	2.50	V
		VLVD110	The power supply voltage is rising.	2.35	2.40	2.45	V
			The power supply voltage is falling.	2.30	2.35	2.40	V
		VLVD111	The power supply voltage is rising.	2.25	2.30	2.34	V
			The power supply voltage is falling.	2.20	2.25	2.29	V
		VLVD112	The power supply voltage is rising.	2.15	2.20	2.24	V
			The power supply voltage is falling.	2.10	2.15	2.19	V
		VLVD113	The power supply voltage is rising.	2.05	2.09	2.13	V
			The power supply voltage is falling.	2.00	2.04	2.08	V
		VLVD114	The power supply voltage is rising.	1.94	1.98	2.02	V
			The power supply voltage is falling.	1.90	1.94	1.98	V
		VLVD115 Note	The power supply voltage is rising.	1.84	1.88	1.91	V
			The power supply voltage is falling.	1.80	1.84	1.87	V
		VLVD116 Note	The power supply voltage is rising.	1.74	1.78	1.81	V
			The power supply voltage is falling.	1.70	1.74	1.77	V
VLVD117 Note	The power supply voltage is rising.	1.64	1.67	1.70	V		
	The power supply voltage is falling.	1.60	1.63	1.66	V		
Minimum pulse width		tLW		500			μs
Detection delay time						500	μs

**Note** This setting can only be used when LVD0 is disabled.

### 2.6.6 Characteristics of the rising slope of the power supply voltage

(TA = -40 to +105°C, VSS = 0 V)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Power supply voltage rising slope	SVDD				54	V/ms

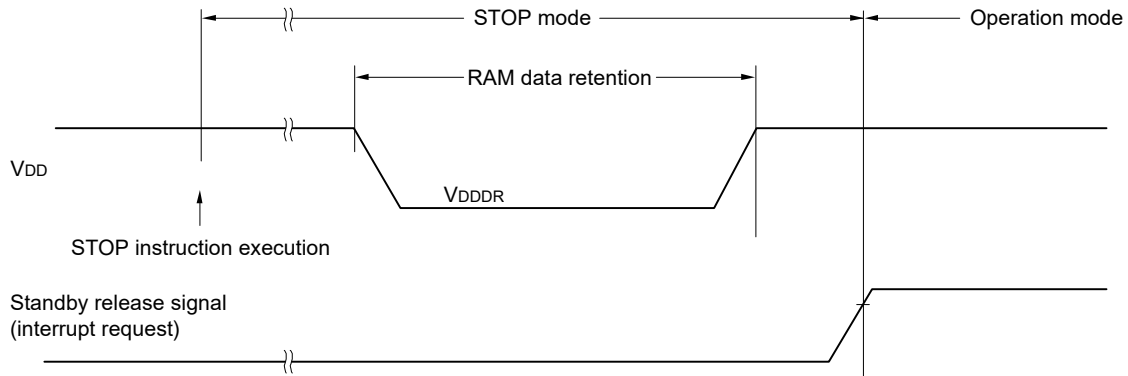
**Caution** Make sure to keep the internal reset state by the LVD0 circuit or an external reset until VDD reaches the operating voltage range shown in AC characteristics.

### 2.7 Characteristics of Retention of RAM Data

(TA = -40 to +105°C, VSS = 0V)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Data retention supply voltage	VDDDR		1.43 <sup>Note</sup>		5.5	V

**Note** This voltage depends on the POR detection voltage. When the voltage drops, the data in RAM are retained until a POR is applied, but are not retained following a POR.



### 2.8 Characteristics of Flash Memory Programming

(TA = -40 to +105°C, 1.8 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
CPU/peripheral hardware clock frequency	fCLK		1		32	MHz
Number of code flash rewrites <sup>Notes 1, 2, 3</sup>	Cerwr	Retained for 20 years TA = +85°C	1,000			Times
Number of data flash rewrites <sup>Notes 1, 2, 3</sup>		Retained for 1 year TA = +25°C		1,000,000		
		Retained for 5 years TA = +85°C	100,000			
		Retained for 20 years TA = +85°C	10,000			

**Note 1.** 1 erase + 1 write after the erase is regarded as 1 rewrite.  
The retaining years are until next rewrite after the rewrite.

**Note 2.** The listed numbers of times apply when using flash memory programmer and Renesas Electronics self-programming library.

**Note 3.** These are the characteristics of the flash memory and the results obtained from reliability testing by Renesas Electronics Corporation.



## (1) Code flash memory

(TA = -40 to +105°C, 1.8 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

Item		Symbol	fCLK = 1 MHz			fCLK = 2 MHz, 3 MHz			4 MHz ≤ fCLK < 8 MHz			8 MHz ≤ fCLK < 32 MHz			fCLK = 32 MHz			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
Programming time	4 bytes	tp4	—	74.7	656.5	—	51.0	464.6	—	41.7	384.8	—	37.1	346.2	—	34.2	321.9	μs
Erasure time	2 Kbytes	te2K	—	10.4	312.2	—	7.7	258.5	—	6.4	231.8	—	5.8	218.4	—	5.6	214.4	ms
Blank checking time	4 bytes	tbc4	—	—	38.4	—	—	19.2	—	—	13.1	—	—	10.2	—	—	8.3	μs
	2 Kbytes	tbc2K	—	—	2618.9	—	—	1309.5	—	—	658.3	—	—	332.8	—	—	234.1	μs
Time taken to forcibly stop the erasure		tSED	—	—	18.0	—	—	14.0	—	—	12.0	—	—	11.0	—	—	10.3	μs
Security setting time		tAWSSAS	—	18.2	526.2	—	14.4	469.2	—	12.5	441.1	—	11.6	427.1	—	11.3	422.6	ms
Time until programming starts following cancellation of the STOP instruction		—	20	—	—	20	—	—	20	—	—	20	—	—	20	—	—	μs

**Caution** The listed values do not include the time until the operations of the flash memory start following execution of an instruction by software.

## (2) Data flash memory

(TA = -40 to +105°C, 1.8 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

Item		Symbol	fCLK = 1 MHz			fCLK = 2 MHz, 3 MHz			4 MHz ≤ fCLK < 8 MHz			8 MHz ≤ fCLK < 32 MHz			fCLK = 32 MHz			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
Programming time	1 byte	tp4	—	74.7	656.5	—	51.0	464.6	—	41.7	384.8	—	37.1	346.2	—	34.2	321.9	μs
Erasure time	256 bytes	te2K	—	7.8	259.2	—	6.4	232.0	—	5.8	218.5	—	5.5	211.8	—	5.4	209.7	ms
Blank checking time	1 byte	tbc4	—	—	38.4	—	—	19.2	—	—	13.1	—	—	10.2	—	—	8.3	μs
	256 bytes	tbc2K	—	—	1326.1	—	—	663.1	—	—	335.1	—	—	171.2	—	—	121.0	μs
Time taken to forcibly stop the erasure		tSED	—	—	18.0	—	—	14.0	—	—	12.0	—	—	11.0	—	—	10.3	μs
Time until programming starts following cancellation of the STOP instruction		—	20	—	—	20	—	—	20	—	—	20	—	—	20	—	—	μs
Time until reading starts following setting DFLEN to 1		—	0.25	—	—	0.25	—	—	0.25	—	—	0.25	—	—	0.25	—	—	μs

**Caution** The listed values do not include the time until the operations of the flash memory start following execution of an instruction by software.

### 2.9 Dedicated Flash Memory Programmer Communication (UART)

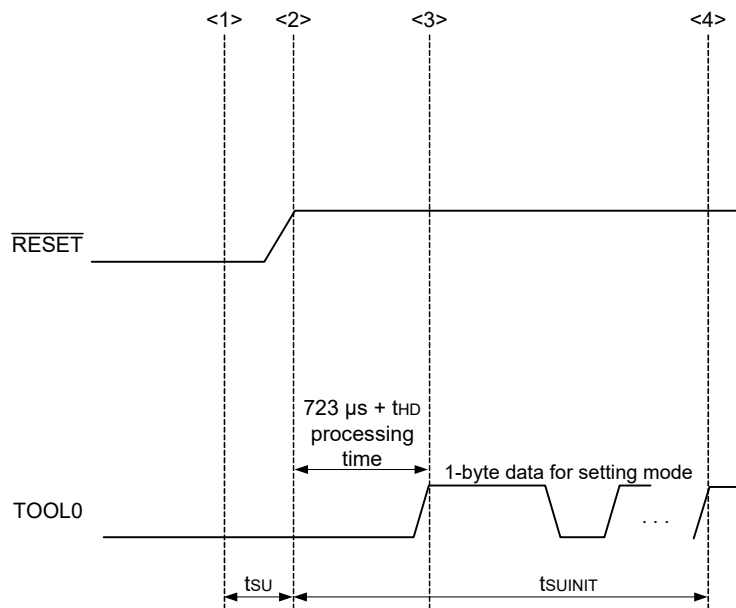
(TA = -40 to +105°C, 1.8 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Transfer rate		During serial programming	115,200		1,000,000	bps

### 2.10 Timing of Entry to Flash Memory Programming Modes

(TA = -40 to +105°C, 1.8 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Time to complete the communication for the initial setting after the external reset is released	tsuINIT	POR and LVD reset must be released before the external reset is released.			100	ms
Time to release the external reset after the TOOL0 pin is set to the low level	tsu	POR and LVD reset must be released before the external reset is released.	10			μs
Time to hold the TOOL0 pin at the low level after the external reset is released (the processing time of the firmware to control the flash memory is not included)	tHD	POR and LVD reset must be released before the external reset is released.	1			ms



- <1> The low level is input to the TOOL0 pin.
- <2> The external reset is released. Note that the POR and LVD reset must be released before the external reset is released.
- <3> The TOOL0 pin is set to the high level.
- <4> Setting of the flash memory programming mode by UART reception and complete the baud rate setting.

**Remark** tsuINIT: The time during which the communications for the initial setting must be completed within 100 ms after the external reset is released.

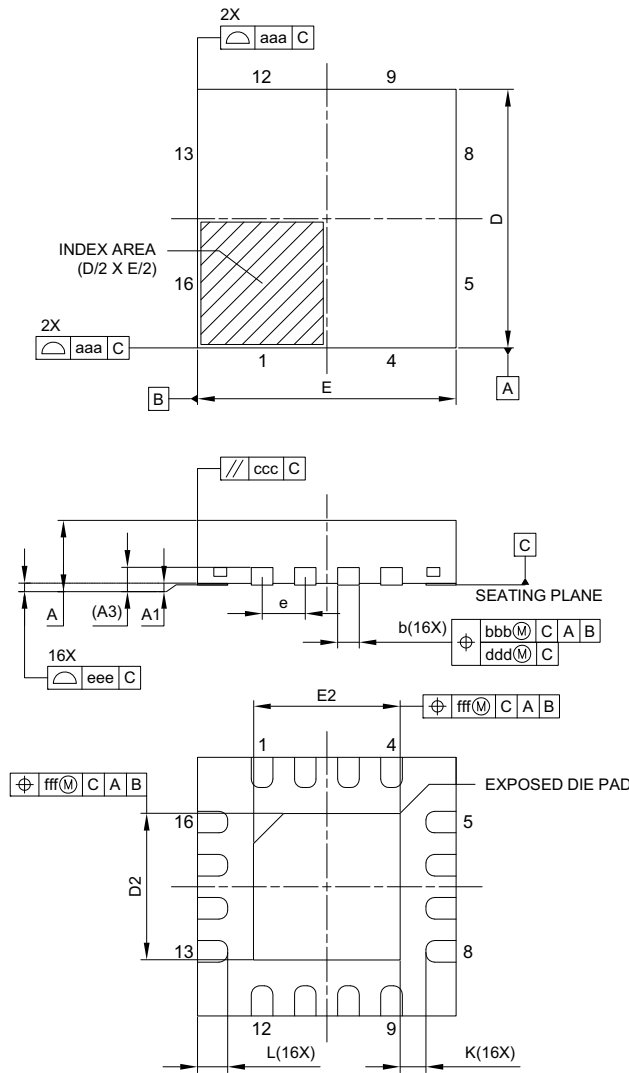
tsu: Time to release the external reset after the TOOL0 pin is set to the low level

tHD: Time to hold the TOOL0 pin at the low level after the external reset is released. It does not include the processing time of the firmware to control the flash memory.

### 3. Package Drawings

#### 3.1 16-pin Products

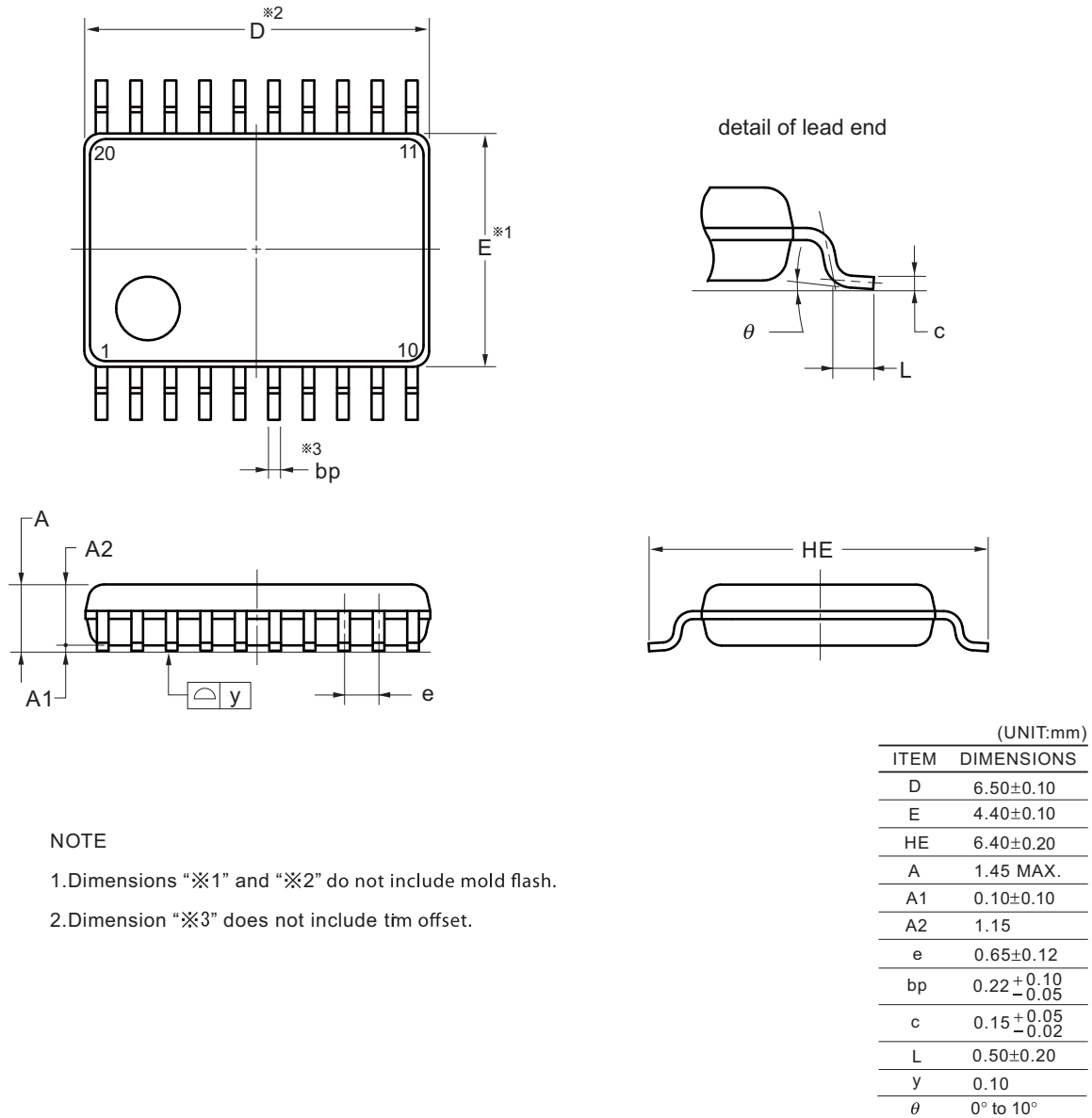
JEITA Package code	RENESAS code	MASS(TYP.)[g]
P-HWQFN016-3x3-0.50	PWQN0016KD-A	0.02



Reference Symbol	Dimension in Millimeters		
	Min.	Nom.	Max.
A	—	—	0.80
A1	0.00	0.02	0.05
A3	0.203 REF.		
b	0.20	0.25	0.30
D	3.00 BSC		
E	3.00 BSC		
e	0.50 BSC		
L	0.30	0.35	0.40
K	0.20	—	—
D2	1.65	1.70	1.75
E2	1.65	1.70	1.75
aaa	0.15		
bbb	0.10		
ccc	0.10		
ddd	0.05		
eee	0.08		
fff	0.10		

3.2 20-pin Products

JEITA Package Code	RENESAS Code	Previous Code	MASS (TYP.) [g]
P-LSSOP20-4.4x6.5-0.65	PLSP0020JB-A	P20MA-65-NAA-1	0.1



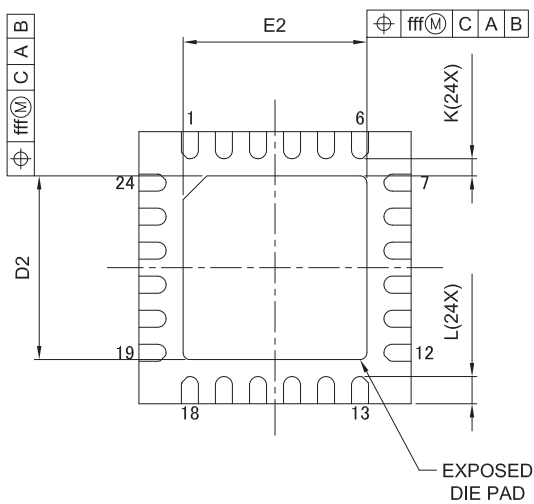
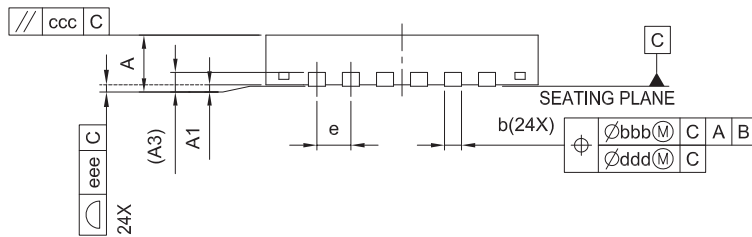
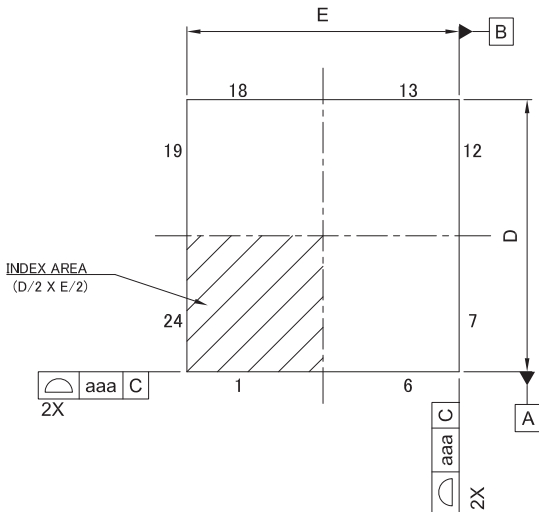
NOTE

1. Dimensions "※1" and "※2" do not include mold flash.
2. Dimension "※3" does not include trim offset.

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### 3.3 24-pin Products

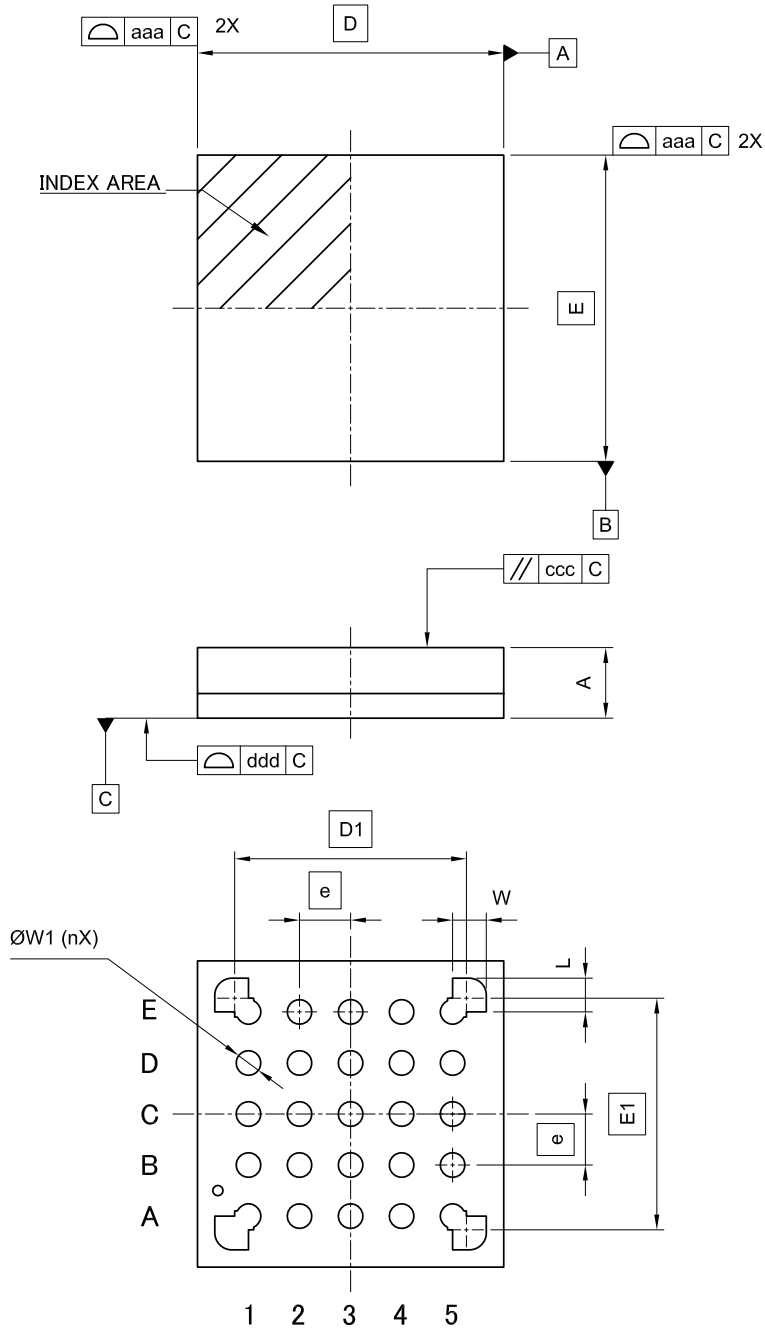
JEITA Package Code	RENESAS Code	MASS (TYP.) [g]
P-HWQFN24-4x4-0.50	PWQN0024KG-A	0.04



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	0.18	0.25	0.30
D	4.00 BSC		
E	4.00 BSC		
e	0.50 BSC		
L	0.35	0.40	0.45
K	0.20	—	—
D <sub>2</sub>	2.65	2.70	2.75
E <sub>2</sub>	2.65	2.70	2.75
aaa	0.15		
bbb	0.10		
ccc	0.10		
ddd	0.05		
eee	0.08		
fff	0.10		

3.4 25-pin Products

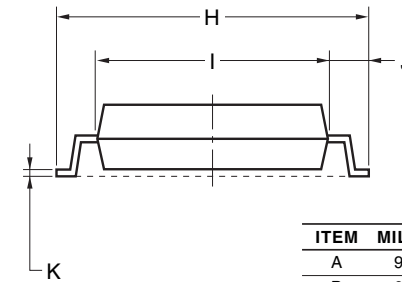
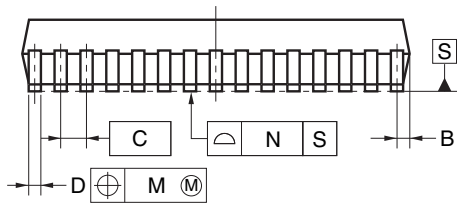
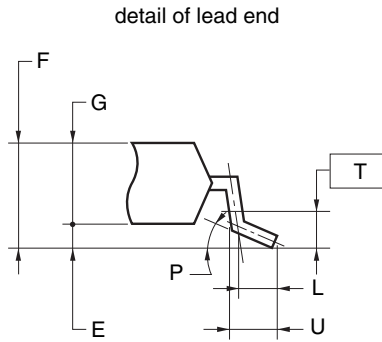
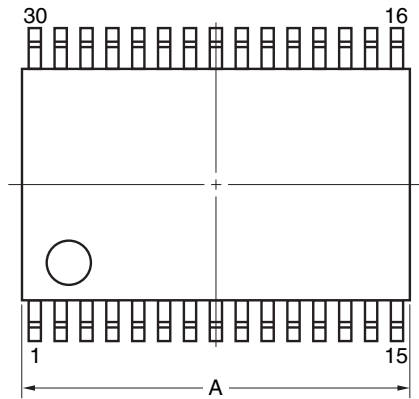
JEITA Package code	RENESAS code	MASS(TYP.)[g]
P-WLGA25-3x3-0.50	PWLG0025KB-A	0.01



Reference Symbol	Dimension in Millimeters		
	Min.	Nom.	Max.
$D$	—	3.00	—
$E$	—	3.00	—
$D1$	2.27		
$E1$	2.27		
A	—	—	0.76
W1	0.19	0.24	0.29
W	—	0.330	—
L	—	0.330	—
$e$	0.50		
aaa	—	—	0.10
ccc	—	—	0.20
ddd	—	—	0.08
n	—	25	—

3.5 30-pin Products

JEITA Package Code	RENESAS Code	Previous Code	MASS (TYP.) [g]
P-LSSOP30-0300-0.65	PLSP0030JB-B	S30MC-65-5A4-3	0.18



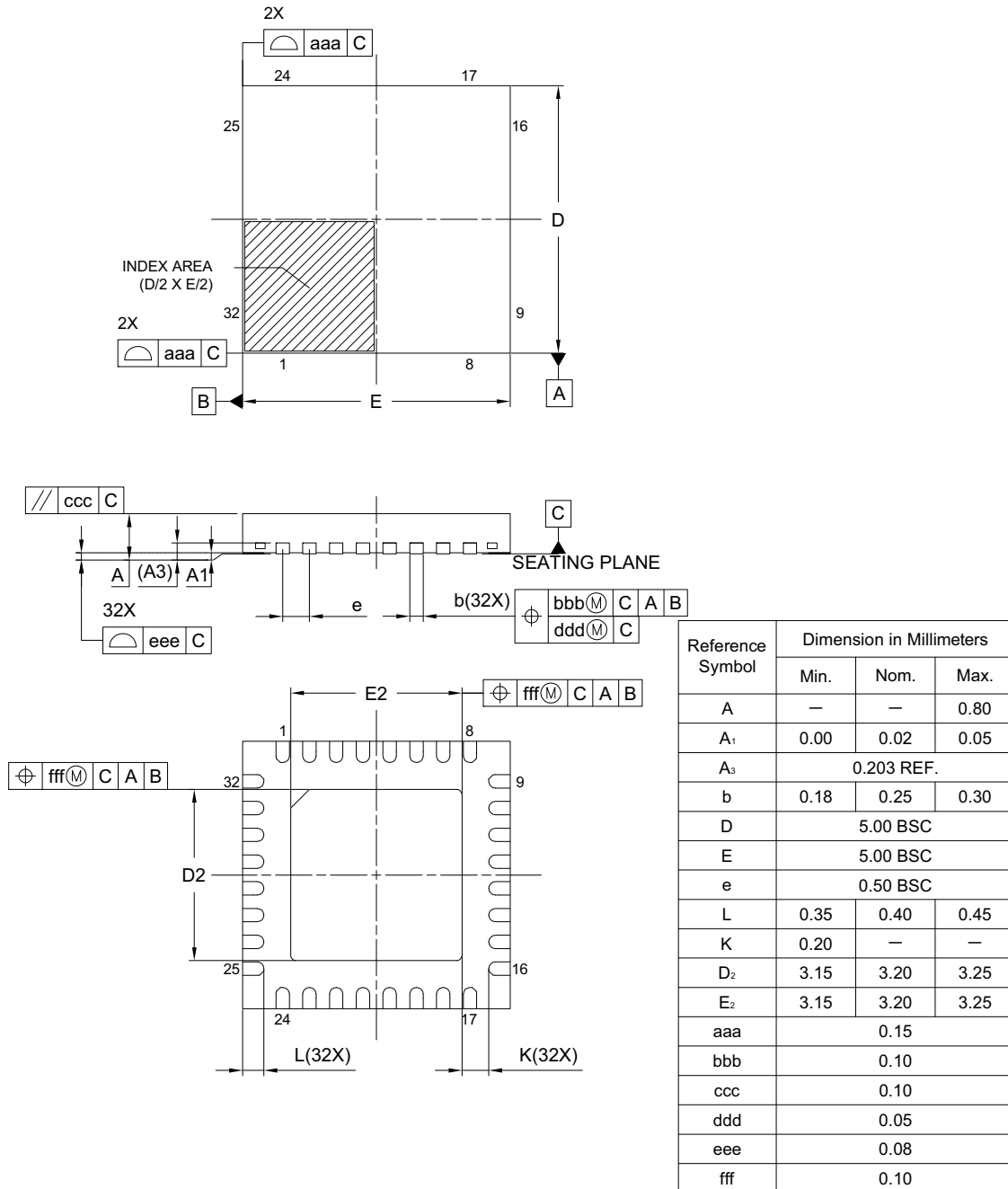
**NOTE**  
Each lead centerline is located within 0.13 mm of its true position (T.P.) at maximum material condition.

ITEM	MILLIMETERS
A	9.85±0.15
B	0.45 MAX.
C	0.65 (T.P.)
D	0.24 <sup>+0.08</sup> <sub>-0.07</sub>
E	0.1±0.05
F	1.3±0.1
G	1.2
H	8.1±0.2
I	6.1±0.2
J	1.0±0.2
K	0.17±0.03
L	0.5
M	0.13
N	0.10
P	3° <sup>+5°</sup> <sub>-3°</sub>
T	0.25
U	0.6±0.15

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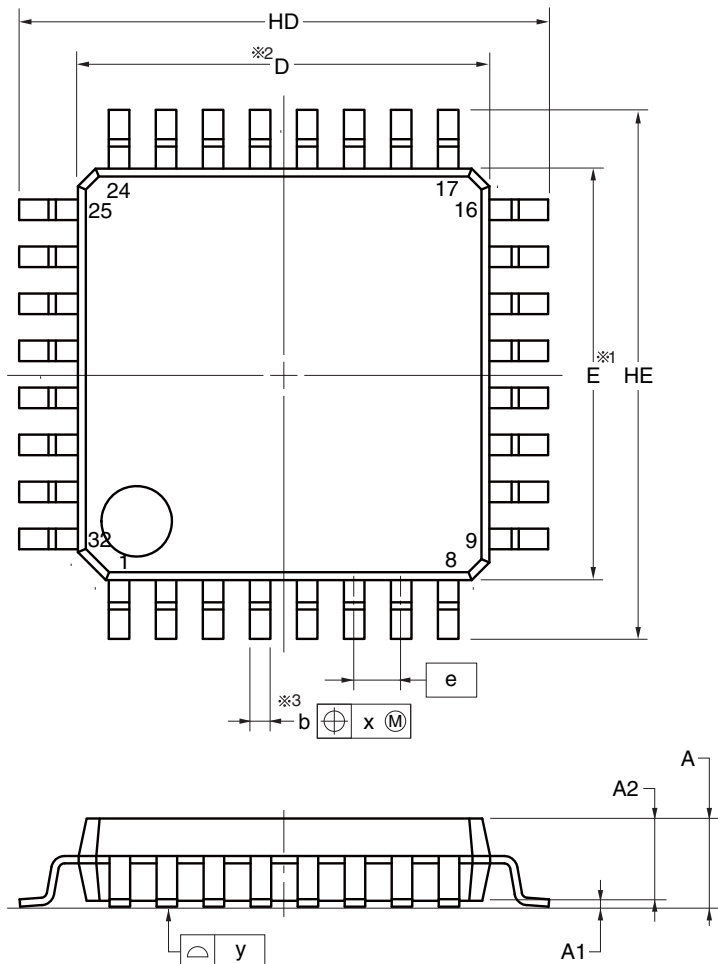
3.6 32-pin Products

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

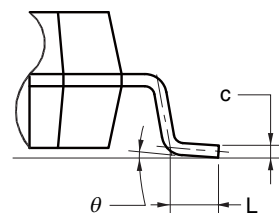




JEITA Package Code	RENESAS Code	Previous Code	MASS (TYP.) [g]
P-LQFP32-7x7-0.80	PLQP0032GB-A	P32GA-80-GBT-1	0.2



detail of lead end



(UNIT: mm)

ITEM	DIMENSIONS
D	7.00±0.10
E	7.00±0.10
HD	9.00±0.20
HE	9.00±0.20
A	1.70 MAX.
A1	0.10±0.10
A2	1.40
b	0.37±0.05
c	0.145±0.055
L	0.50±0.20
$\theta$	0° to 8°
e	0.80
x	0.20
y	0.10

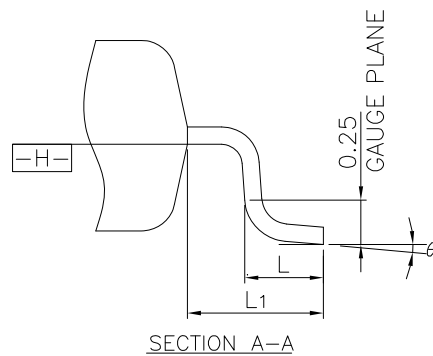
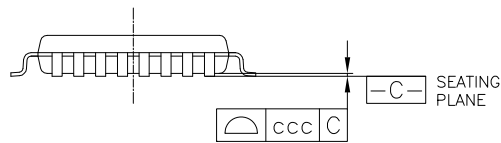
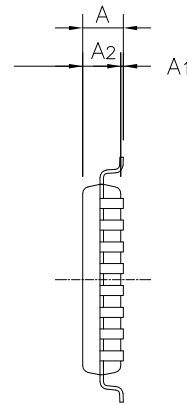
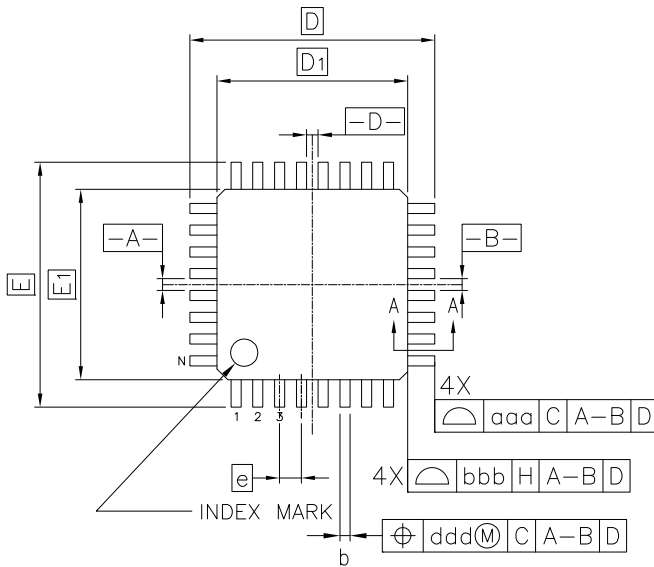
**NOTE**

1. Dimensions " $\times 1$ " and " $\times 2$ " do not include mold flash.
2. Dimension " $\times 3$ " does not include trim offset.

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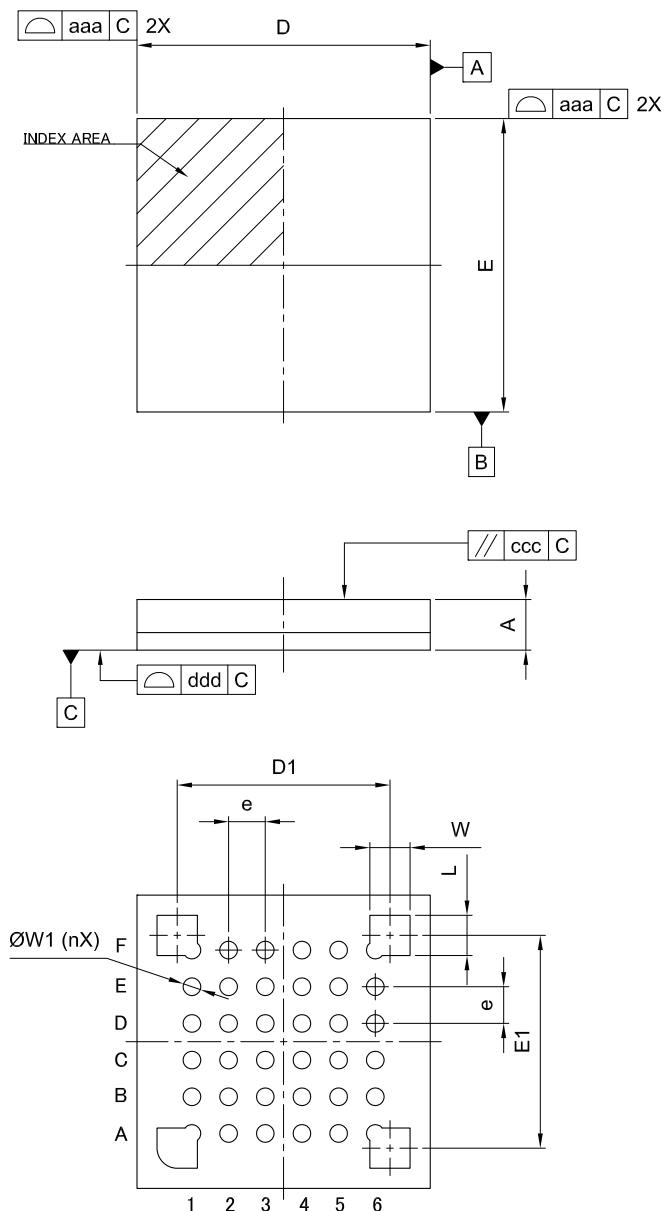
JEITA Package code	RENESAS code	MASS(TYP.)[g]
P-LQFP32-7x7-0.80	PLQP0032GE-A	0.18



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

3.7 36-pin Products

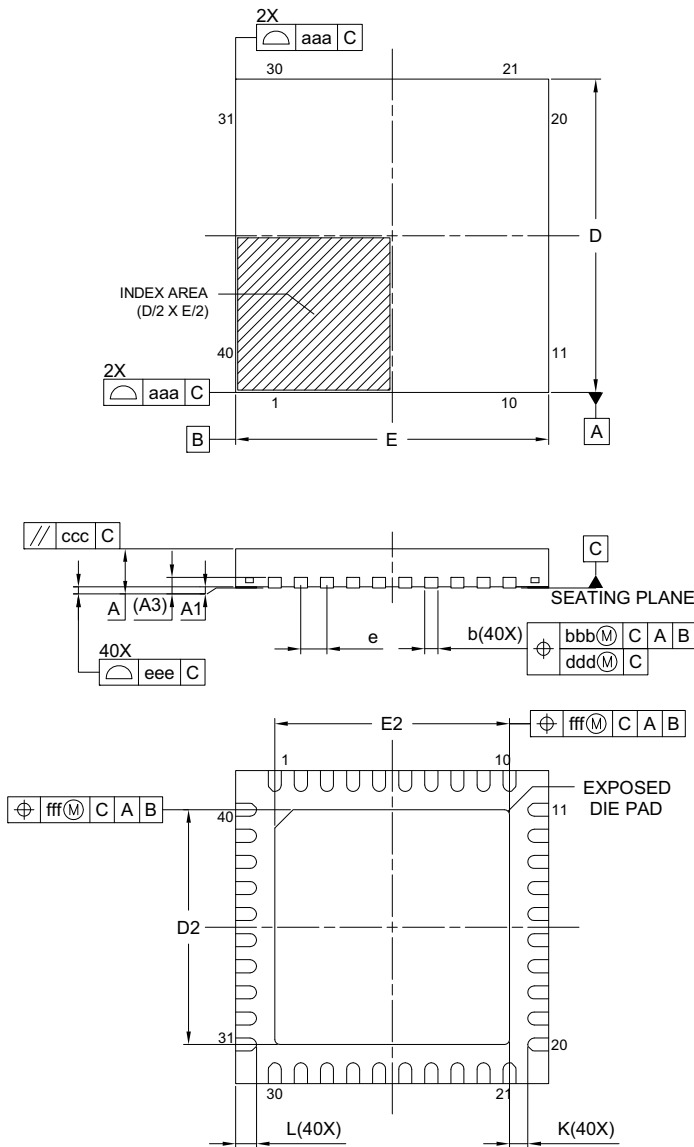
JEITA Package Code	RENESAS Code	MASS (Typ.) [g]
P-WFLGA36-4 × 4-0.50	PWLG0036KB-A	0.02



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	—

3.8 40-pin Products

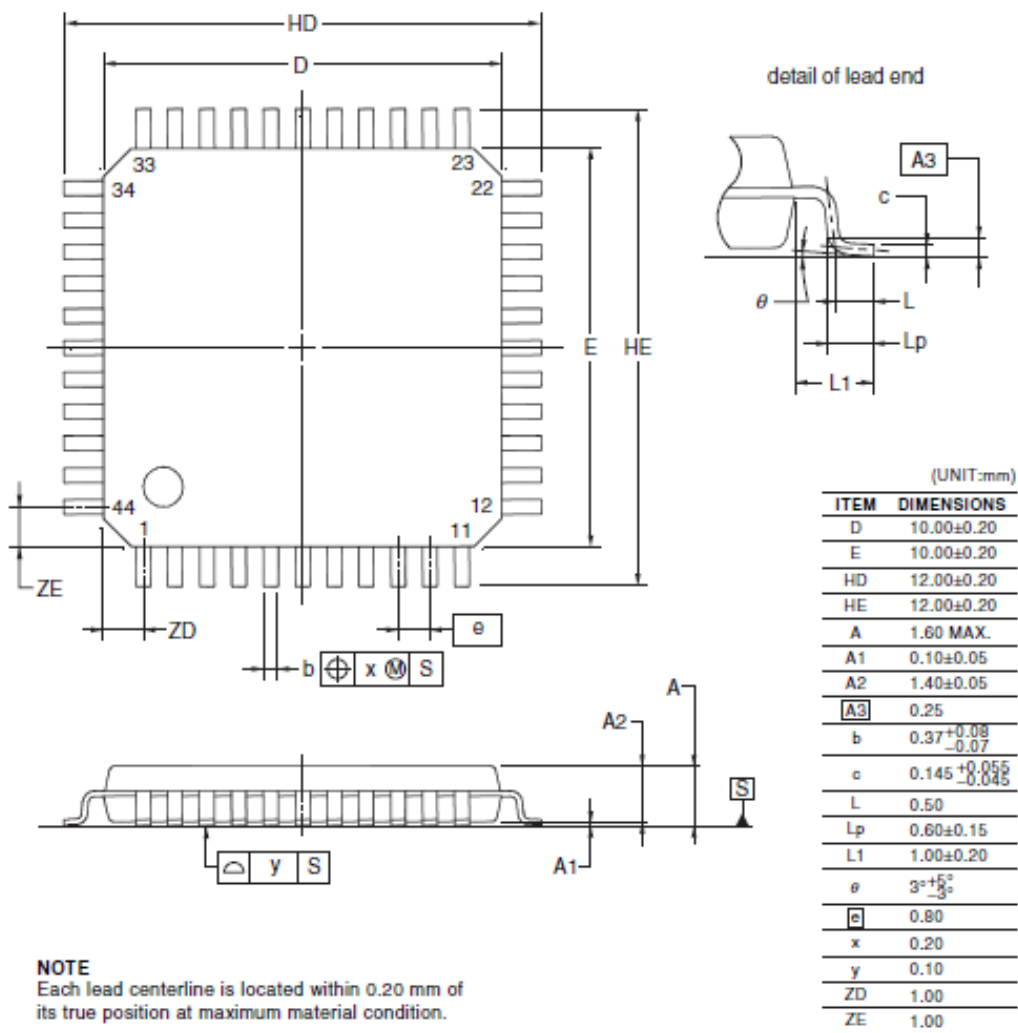
JEITA Package code	RENESAS code	MASS (TYP.) [g]
P-HWQFN040-6x6-0.50	PWQN0040KD-A	0.08



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	0.18	0.25	0.30
D	6.00 BSC		
E	6.00 BSC		
e	0.50 BSC		
L	0.30	0.40	0.50
K	0.20	—	—
D <sub>2</sub>	4.45	4.50	4.55
E <sub>2</sub>	4.45	4.50	4.55
aaa	0.15		
bbb	0.10		
ccc	0.10		
ddd	0.05		
eee	0.08		
fff	0.10		

3.9 44-pin Products

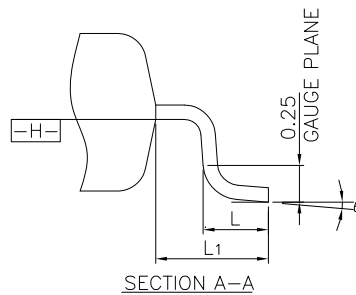
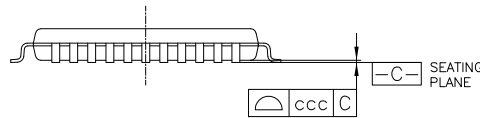
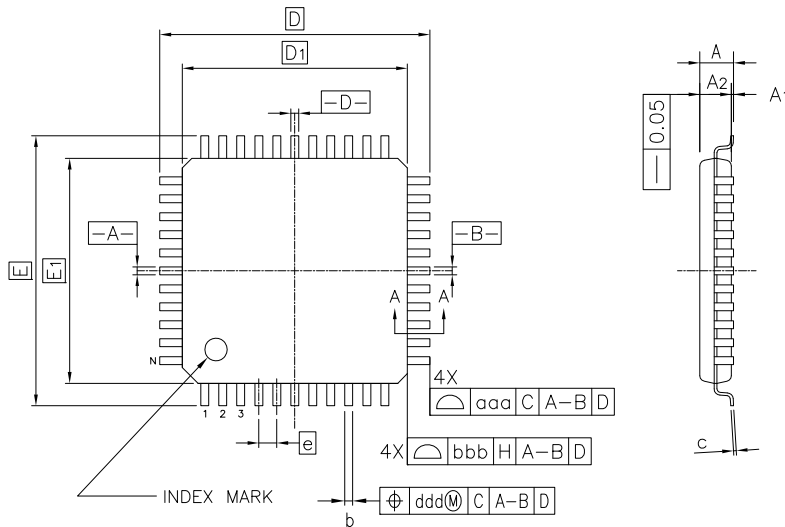
JEITA Package Code	RENESAS Code	Previous Code	MASS (TYP.) [g]
P-LQFP44-10x10-0.80	PLQP0044GC-A	P44GB-80-UES-2	0.36



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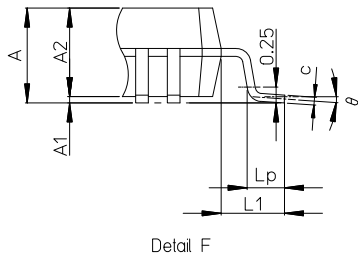
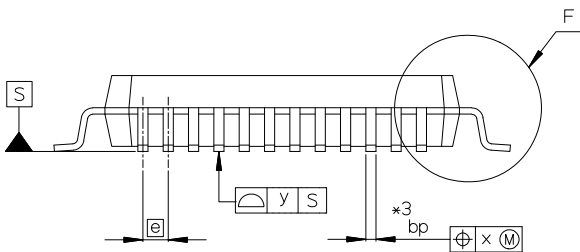
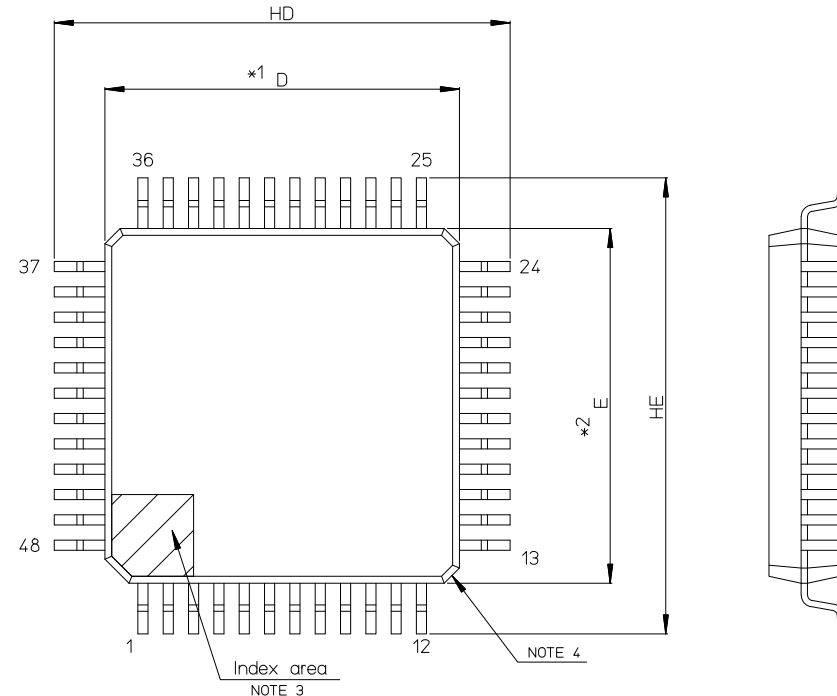
JEITA Package code	RENESAS code	MASS(TYP.)[g]
P-LQFP044-10x10-0.80	PLQP0044GE-A	0.34



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	—	44	—
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

3.10 48-pin Products

JEITA Package Code	RENESAS Code	Previous Code	MASS[Typ.]
P-LFQFP48-7x7-0.50	PLQFP0048KB-B	—	0.2g

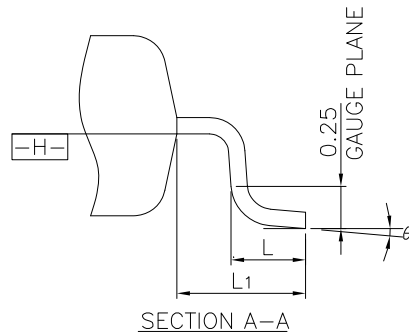
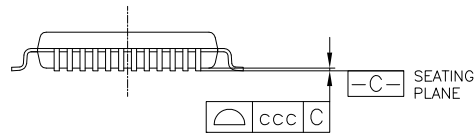
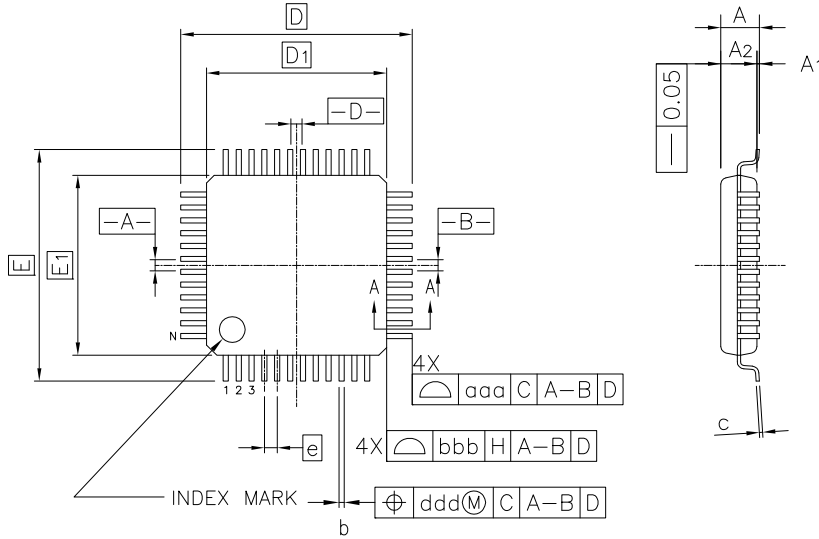


- NOTE)
1. DIMENSIONS \*1\* AND \*2\* DO NOT INCLUDE MOLD FLASH.
  2. DIMENSION \*3\* DOES NOT INCLUDE TRIM OFFSET.
  3. PIN 1 VISUAL INDEX FEATURE MAY VARY, BUT MUST BE LOCATED WITHIN THE HATCHED AREA.
  4. CHAMFERS AT CORNERS ARE OPTIONAL, SIZE MAY VARY.

Reference Symbol	Dimension in Millimeters		
	Min	Nom	Max
D	6.9	7.0	7.1
E	6.9	7.0	7.1
A2	—	1.4	—
HD	8.8	9.0	9.2
HE	8.8	9.0	9.2
A	—	—	1.7
A1	0.05	—	0.15
bp	0.17	0.20	0.27
c	0.09	—	0.20
$\theta$	0°	3.5°	8°
e	—	0.5	—
x	—	—	0.08
y	—	—	0.08
Lp	0.45	0.6	0.75
L1	—	1.0	—

<R>

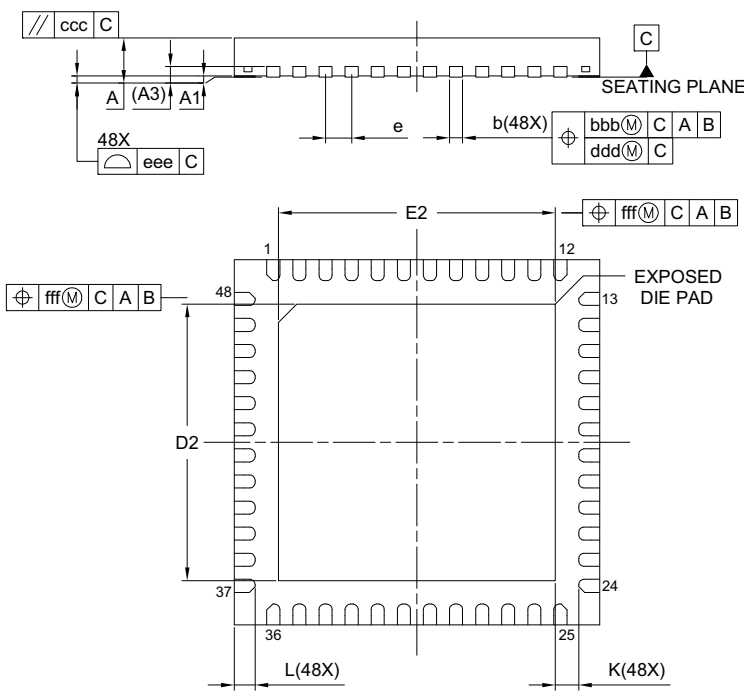
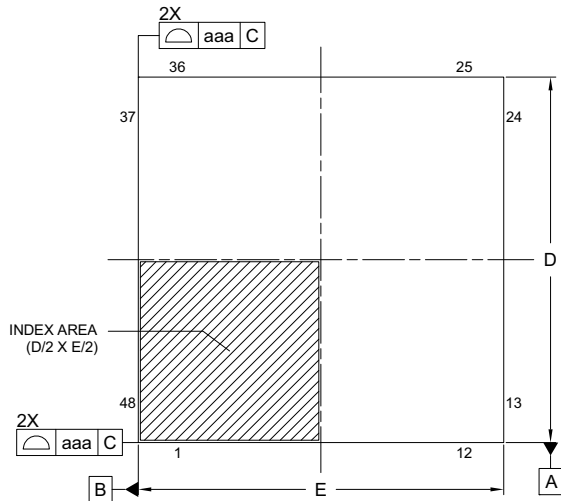
JEITA Package code	RENESAS code	MASS(TYP.)[g]
P-LFQFP48-7x7-0.50	PLQP0048KL-A	0.18



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



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		

Revision History	RL78/G22 Datasheet
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Rev.	Date	Description	
		Page	Summary
1.00	Dec 28, 2022	—	First edition issued
1.10	Jun 12, 2024	p.4	Figure 1 - 1 Part Number, Memory Size, and Package of RL78/G22 was modified.
		p.5	Table 1 - 1 List of Ordering Part Numbers was modified.
		p.54	2.4 AC Characteristics was modified.
		p.114	3.6 32-pin Products: The figure was added.
		p.118	3.9 44-pin Products: The figure was added.
		p.120	3.10 48-pin Products: The figure was added.

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## 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.

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