

## RL78/G12

RENESAS MCU

R01DS0193EJ0210

Rev.2.10

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True Low Power Platform (as low as 63  $\mu$ A/MHz), 1.8V to 5.5V operation,  
2 to 16 Kbyte Flash, 31 DMIPS at 24MHz, for General Purpose Applications

## 1. OUTLINE

### 1.1 Features

#### Ultra-low power consumption technology

- $V_{DD}$  = single power supply voltage of 1.8 to 5.5 V which can operate at a low voltage
- HALT mode
- STOP mode
- SNOOZE mode

#### RL78 CPU core

- CISC architecture with 3-stage pipeline
- Minimum instruction execution time: Can be changed from high speed (0.04167  $\mu$ s: @ 24 MHz operation with high-speed on-chip oscillator) to ultra-low speed (1  $\mu$ s: @ 1 MHz operation)
- Address space: 1 MB
- General-purpose registers: (8-bit register x 8) x 4 banks
- On-chip RAM: 256 B to 2 KB

#### Code flash memory

- Code flash memory: 2 to 16 KB
- Block size: 1 KB
- Prohibition of block erase and rewriting (security function)
- On-chip debug function
- Self-programming (with flash shield window function)

#### Data flash memory <sup>Note</sup>

- Data flash memory: 2 KB
- Back ground operation (BGO): Instructions are executed from the program memory while rewriting the data flash memory.
- Number of rewrites: 1,000,000 times (TYP.)
- Voltage of rewrites:  $V_{DD}$  = 1.8 to 5.5 V

#### High-speed on-chip oscillator

- Select from 24 MHz, 16 MHz, 12 MHz, 8 MHz, 6 MHz, 4 MHz, 3 MHz, 2 MHz, and 1 MHz
- High accuracy:  $\pm 1.0$  % ( $V_{DD}$  = 1.8 to 5.5 V,  $T_A$  = -20 to +85  $^{\circ}$ C)

#### Operating ambient temperature

- $T_A$  = -40 to +85  $^{\circ}$ C (A: Consumer applications, D: Industrial applications)
- $T_A$  = -40 to +105  $^{\circ}$ C (G: Industrial applications) <sup>Note</sup>

#### Power management and reset function

- On-chip power-on-reset (POR) circuit
- On-chip voltage detector (LVD) (Select interrupt and reset from 12 levels)

#### DMA (Direct Memory Access) controller <sup>Note</sup>

- 2 channels
- Number of clocks during transfer between 8/16-bit SFR and internal RAM: 2 clocks

#### Multiplier and divider/multiply-accumulator

- 16 bits x 16 bits = 32 bits (Unsigned or signed)
- 32 bits x 32 bits = 32 bits (Unsigned)
- 16 bits x 16 bits + 32 bits = 32 bits (Unsigned or signed)

#### Serial interface

- CSI : 1 to 3 channels
- UART : 1 to 3 channels
- Simplified I<sup>2</sup>C communication : 0 to 3 channels
- I<sup>2</sup>C communication : 1 channel

#### Timer

- 16-bit timer : 4 to 8 channels
- 12-bit interval timer : 1 channel
- Watchdog timer : 1 channel (operable with the dedicated low-speed on-chip oscillator)

#### A/D converter

- 8/10-bit resolution A/D converter ( $V_{DD}$  = 1.8 to 5.5 V)
- 8 to 11 channels, internal reference voltage (1.45 V), and temperature sensor <sup>Note</sup>

#### I/O port

- I/O port: 18 to 26  
(N-ch open drain I/O [withstand voltage of 6 V]: 2, N-ch open drain I/O [ $V_{DD}$  withstand voltage]: 4 to 9)
- Can be set to N-ch open drain, TTL input buffer, and on-chip pull-up resistor
- Different potential interface: Can connect to a 1.8/2.5/3 V device
- On-chip key interrupt function
- On-chip clock output/buzzer output controller

#### Others

- On-chip BCD (binary-coded decimal) correction circuit

<sup>Note</sup> Can be selected only in HS (high-speed main) mode.

<sup>Remark</sup> The functions mounted depend on the product.  
See 1.7 Outline of Functions.

**\* There is difference in specifications between every product.  
Please refer to specification for details.**

## ○ ROM, RAM capacities

Code flash	Data flash	RAM	20 pins	24 pins	30 pins
16 KB	2 KB	2 KB	—	—	R5F102AA
	—		—	—	R5F103AA
	2 KB	1.5 KB	R5F1026A <sup>Note 1</sup>	R5F1027A <sup>Note 1</sup>	—
	—		R5F1036A <sup>Note 1</sup>	R5F1037A <sup>Note 1</sup>	—
12 KB	2KB	1 KB	R5F10269 <sup>Note 1</sup>	R5F10279 <sup>Note 1</sup>	R5F102A9
	—		R5F10369 <sup>Note 1</sup>	R5F10379 <sup>Note 1</sup>	R5F103A9
8 KB	2 KB	768 B	R5F10268 <sup>Note 1</sup>	R5F10278 <sup>Note 1</sup>	R5F102A8
	—		R5F10368 <sup>Note 1</sup>	R5F10378 <sup>Note 1</sup>	R5F103A8
4 KB	2KB	512 B	R5F10267	R5F10277	R5F102A7
	—		R5F10367	R5F10377	R5F103A7
2 KB	2 KB	256 B	R5F10266 <sup>Note 2</sup>	—	—
	—		R5F10366 <sup>Note 2</sup>	—	—

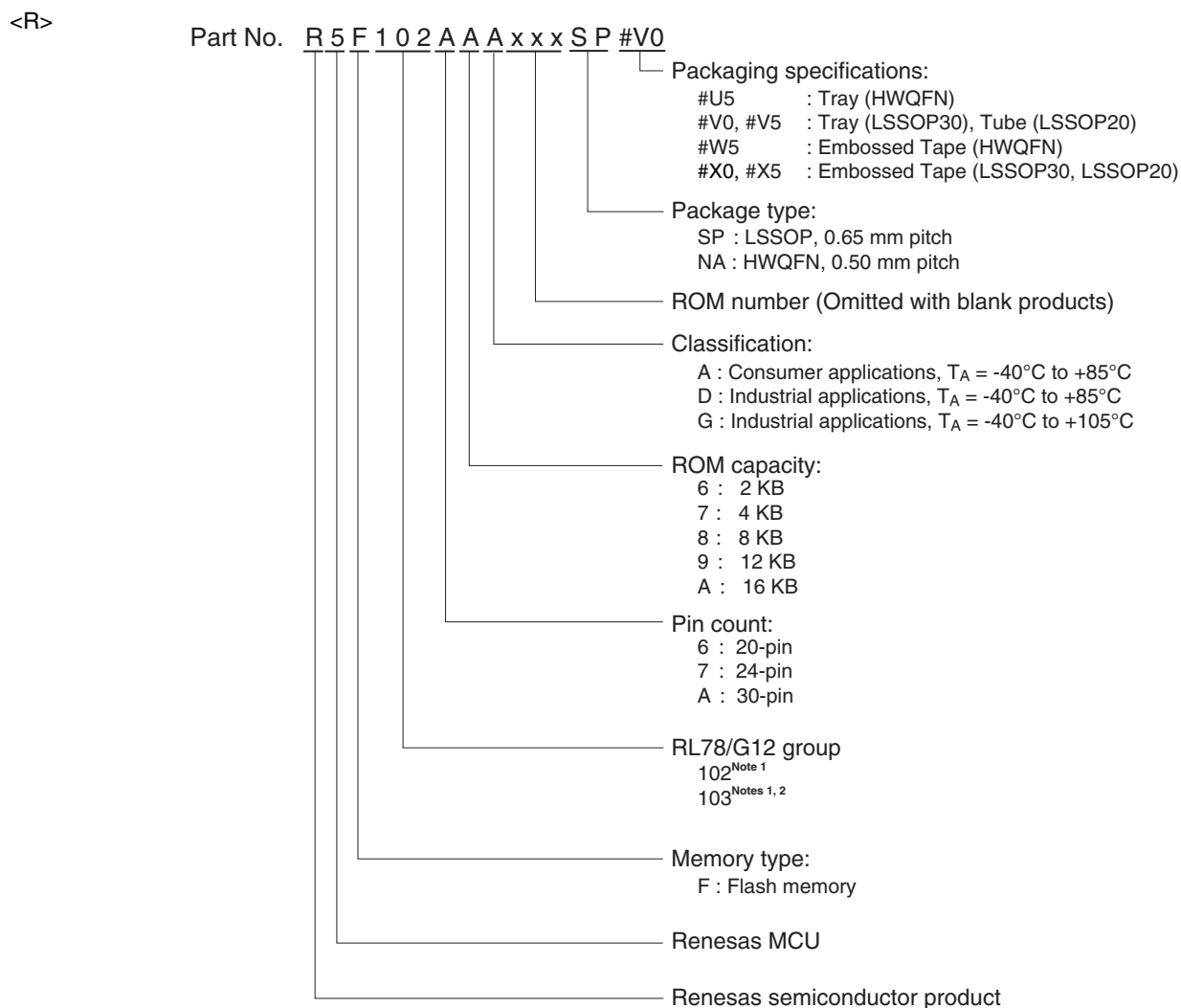
**Notes** 1. This is 640 bytes when the self-programming function or data flash function is used. (For details, see **CHAPTER 3 CPU ARCHITECTURE**.)

2. The self-programming function cannot be used for R5F10266 and R5F10366.

**Caution** When the flash memory is rewritten via a user program, the code flash area and RAM area are used because each library is used. When using the library, refer to RL78 Family Flash Self Programming Library Type01 User's Manual and RL78 Family Data Flash Library Type04 User's Manual.

## 1.2 List of Part Numbers

Figure 1-1. Part Number, Memory Size, and Package of RL78/G12



- Notes**
- For details about the differences between the R5F102 products and the R5F103 products of RL78/G12, see **1.1 Differences between the R5F102 Products and the R5F103 Products**.
  - Products only for "A: Consumer applications ( $T_A = -40$  to  $+85^{\circ}\text{C}$ )" and "D: Industrial applications ( $T_A = -40$  to  $+85^{\circ}\text{C}$ )"

Table 1-1. List of Ordering Part Numbers

	Pin count	Package	Data flash	Fields of Application	Part Number
<R>	20 pins	20-pin plastic LSSOP (4.4 × 6.5 mm, 0.65 mm pitch)	Mounted	A	R5F1026AASP#V5, R5F10269ASP#V5, R5F10268ASP#V5, R5F10267ASP#V5, R5F10266ASP#V5 R5F1026AASP#X5, R5F10269ASP#X5, R5F10268ASP#X5, R5F10267ASP#X5, R5F10266ASP#X5
				D	R5F1026ADSP#V5, R5F10269DSP#V5, R5F10268DSP#V5, R5F10267DSP#V5, R5F10266DSP#V5 R5F1026ADSP#X5, R5F10269DSP#X5, R5F10268DSP#X5, R5F10267DSP#X5, R5F10266DSP#X5
				G	R5F1026AGSP#V5, R5F10269GSP#V5, R5F10268GSP#V5, R5F10267GSP#V5, R5F10266GSP#V5 R5F1026AGSP#X5, R5F10269GSP#X5, R5F10268GSP#X5, R5F10267GSP#X5, R5F10266GSP#X5
			Not mounted	A	R5F1036AASP#V5, R5F10369ASP#V5, R5F10368ASP#V5, R5F10367ASP#V5, R5F10366ASP#V5 R5F1036AASP#X5, R5F10369ASP#X5, R5F10368ASP#X5, R5F10367ASP#X5, R5F10366ASP#X5
				D	R5F1036ADSP#V5, R5F10369DSP#V5, R5F10368DSP#V5, R5F10367DSP#V5, R5F10366DSP#V5 R5F1036ADSP#X5, R5F10369DSP#X5, R5F10368DSP#X5, R5F10367DSP#X5, R5F10366DSP#X5
				G	R5F1036AGSP#V5, R5F10369GSP#V5, R5F10368GSP#V5, R5F10367GSP#V5, R5F10366GSP#V5 R5F1036AGSP#X5, R5F10369GSP#X5, R5F10368GSP#X5, R5F10367GSP#X5, R5F10366GSP#X5
<R>	24 pins	24-pin plastic HWQFN (4 × 4 mm, 0.5 mm pitch)	Mounted	A	R5F1027AANA#U5, R5F10279ANA#U5, R5F10278ANA#U5, R5F10277ANA#U5 R5F1027AANA#W5, R5F10279ANA#W5, R5F10278ANA#W5, R5F10277ANA#W5
				D	R5F1027ADNA#U5, R5F10279DNA#U5, R5F10278DNA#U5, R5F10277DNA#U5 R5F1027ADNA#W5, R5F10279DNA#W5, R5F10278DNA#W5, R5F10277DNA#W5
				G	R5F1027AGNA#U5, R5F10279GNA#U5, R5F10278GNA#U5, R5F10277GNA#U5 R5F1027AGNA#W5, R5F10279GNA#W5, R5F10278GNA#W5, R5F10277GNA#W5
			Not mounted	A	R5F1037AANA#V5, R5F10379ANA#V5, R5F10378ANA#V5, R5F10377ANA#V5 R5F1037AANA#X5, R5F10379ANA#X5, R5F10378ANA#X5, R5F10377ANA#X5
				D	R5F1037ADNA#V5, R5F10379DNA#V5, R5F10378DNA#V5, R5F10377DNA#V5 R5F1037ADNA#X5, R5F10379DNA#X5, R5F10378DNA#X5, R5F10377DNA#X5
				G	R5F1037AGNA#V5, R5F10379GNA#V5, R5F10378GNA#V5, R5F10377GNA#V5 R5F1037AGNA#X5, R5F10379GNA#X5, R5F10378GNA#X5, R5F10377GNA#X5
<R>	30 pins	30-pin plastic LSSOP (7.62 mm (300), 0.65 mm pitch)	Mounted	A	R5F102AAASP#V0, R5F102A9ASP#V0, R5F102A8ASP#V0, R5F102A7ASP#V0 R5F102AAASP#X0, R5F102A9ASP#X0, R5F102A8ASP#X0, R5F102A7ASP#X0
				D	R5F102AADSP#V0, R5F102A9DSP#V0, R5F102A8DSP#V0, R5F102A7DSP#V0 R5F102AADSP#X0, R5F102A9DSP#X0, R5F102A8DSP#X0, R5F102A7DSP#X0
				G	R5F102AAGSP#V0, R5F102A9GSP#V0, R5F102A8GSP#V0, R5F102A7GSP#V0 R5F102AAGSP#X0, R5F102A9GSP#X0, R5F102A8GSP#X0, R5F102A7GSP#X0
			Not mounted	A	R5F103AAASP#V0, R5F103A9ASP#V0, R5F103A8ASP#V0, R5F103A7ASP#V0 R5F103AAASP#X0, R5F103A9ASP#X0, R5F103A8ASP#X0, R5F103A7ASP#X0
				D	R5F103AADSP#V0, R5F103A9DSP#V0, R5F103A8DSP#V0, R5F103A7DSP#V0 R5F103AADSP#X0, R5F103A9DSP#X0, R5F103A8DSP#X0, R5F103A7DSP#X0
				G	R5F103AAGSP#V0, R5F103A9GSP#V0, R5F103A8GSP#V0, R5F103A7GSP#V0 R5F103AAGSP#X0, R5F103A9GSP#X0, R5F103A8GSP#X0, R5F103A7GSP#X0

**Note** For fields of application, see **Figure 1-1 Part Number, Memory Size, and Package of RL78/G12**.

**Caution** The ordering part numbers represent the numbers at the time of publication. For the latest ordering part numbers, refer to the target product page of the Renesas Electronics website.

### 1.3 Differences between the R5F102 Products and the R5F103 Products

The following are differences between the R5F102 products and the R5F103 products.

- Whether the data flash memory is mounted or not
- High-speed on-chip oscillator oscillation frequency accuracy
- Number of channels in serial interface
- Whether the DMA function is mounted or not
- Whether a part of the safety functions are mounted or not

#### 1.3.1 Data Flash

The data flash memory of 2 KB is mounted on the R5F102 products, but not on the R5F103 products.

Product	Data Flash
<b>R5F102 products</b> R5F1026A, R5F1027A, R5F102AA, R5F10269, R5F10279, R5F102A9, R5F10268, R5F10278, R5F102A8, R5F10267, R5F10277, R5F102A7, R5F10266 <small>Note</small>	2KB
<b>R5F103 products</b> R5F1036A, R5F1037A, R5F103AA, R5F10369, R5F10379, R5F103A9, R5F10368, R5F10378 R5F103A8, R5F10367, R5F10377, R5F103A7, R5F10366	Not mounted

**Note** The RAM in the R5F10266 has capacity as small as 256 bytes. Depending on the customer's program specification, the stack area to execute the data flash library may not be kept and data may not be written to or erased from the data flash memory.

**Caution** When the flash memory is rewritten via a user program, the code flash area and RAM area are used because each library is used. When using the library, refer to RL78 Family Flash Self Programming Library Type01 User's Manual and RL78 Family Data Flash Library Type04 User's Manual.

### 1.3.2 On-chip oscillator characteristics

(1) High-speed on-chip oscillator oscillation frequency of the R5F102 products

Oscillator	Condition	MIN	MAX	Unit
High-speed on-chip oscillator oscillation frequency accuracy	$T_A = -20$ to $+85$ °C	-1.0	+1.0	%
	$T_A = -40$ to $-20$ °C	-1.5	+1.5	
	$T_A = +85$ to $+105$ °C	-2.0	+2.0	

(2) High-speed on-chip oscillator oscillation frequency of the R5F103 products

Oscillator	Condition	MIN	MAX	Unit
High-speed on-chip oscillator oscillation frequency accuracy	$T_A = -40$ to $+85$ °C	-5.0	+5.0	%

### 1.3.3 Peripheral Functions

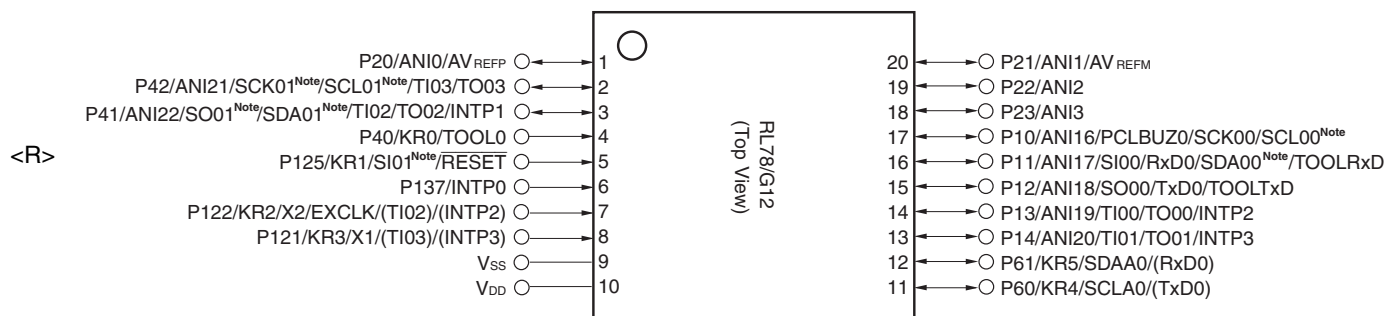
The following are differences in peripheral functions between the R5F102 products and the R5F103 products.

RL78/G12		R5F102 product		R5F103 product	
		20, 24 pin product	30 pin product	20, 24 pin product	30 pin product
Serial interface	UART	1 channel	3 channels	1 channel	
	CSI	2 channels	3 channels	1 channel	
	Simplified I <sup>2</sup> C	2 channels	3 channels	None	
DMA function		2 channels		None	
Safety function	CRC operation	Yes		None	
	RAM guard	Yes		None	
	SFR guard	Yes		None	

## 1.4 Pin Configuration (Top View)

### 1.4.1 20-pin products

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



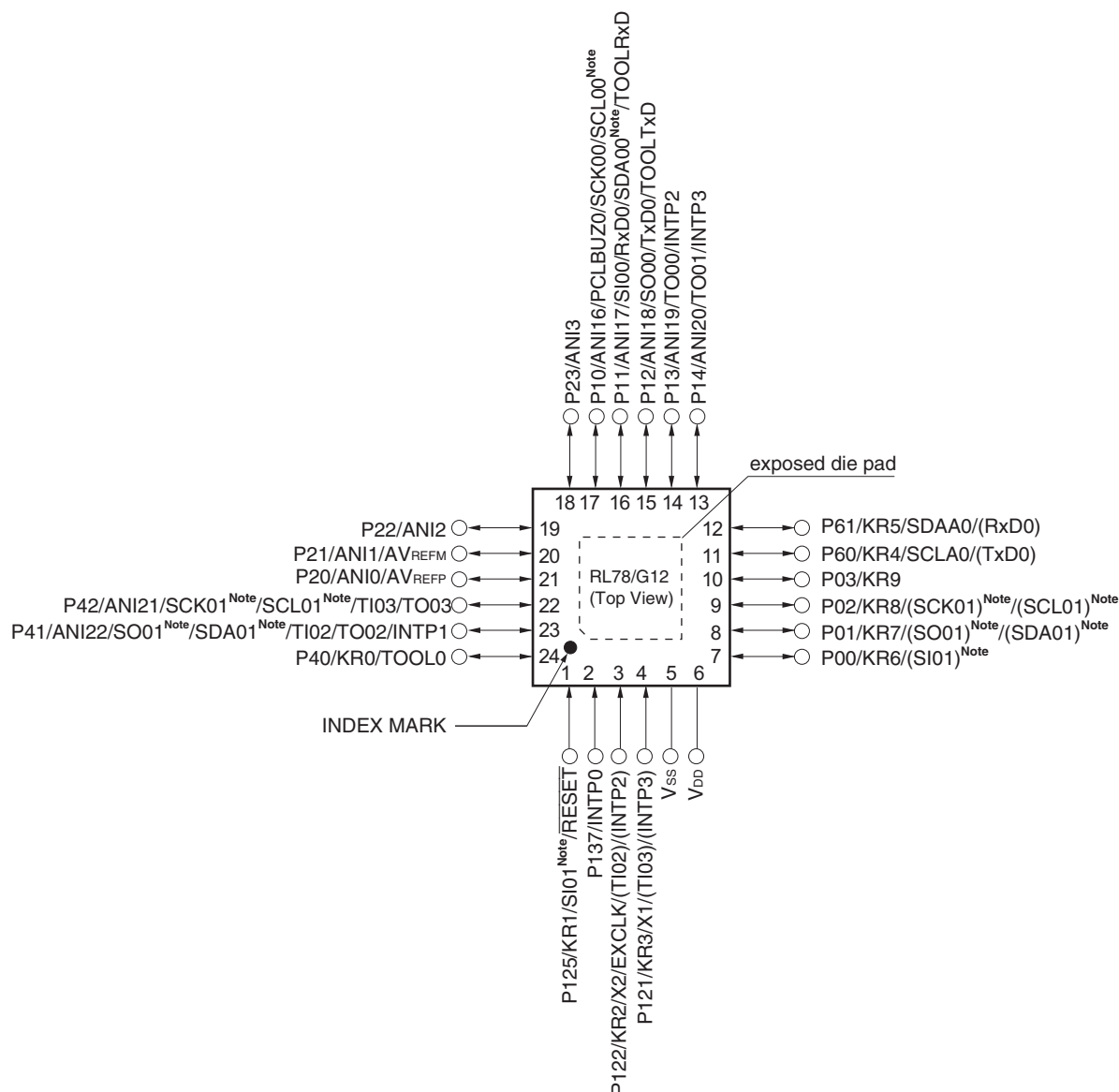
**Note** Provided only in the R5F102 products.

**Remarks 1.** For pin identification, see 1.5 Pin Identification.

**2.** Functions in parentheses in the above figure can be assigned via settings in the peripheral I/O redirection register (PIOR). See **Figure 4-8 Format of Peripheral I/O Redirection Register (PIOR)**.

## 1.4.2 24-pin products

- <R> • 24-pin plastic HWQFN (4 × 4 mm, 0.5 mm pitch)



**Note** Provided only in the R5F102 products.

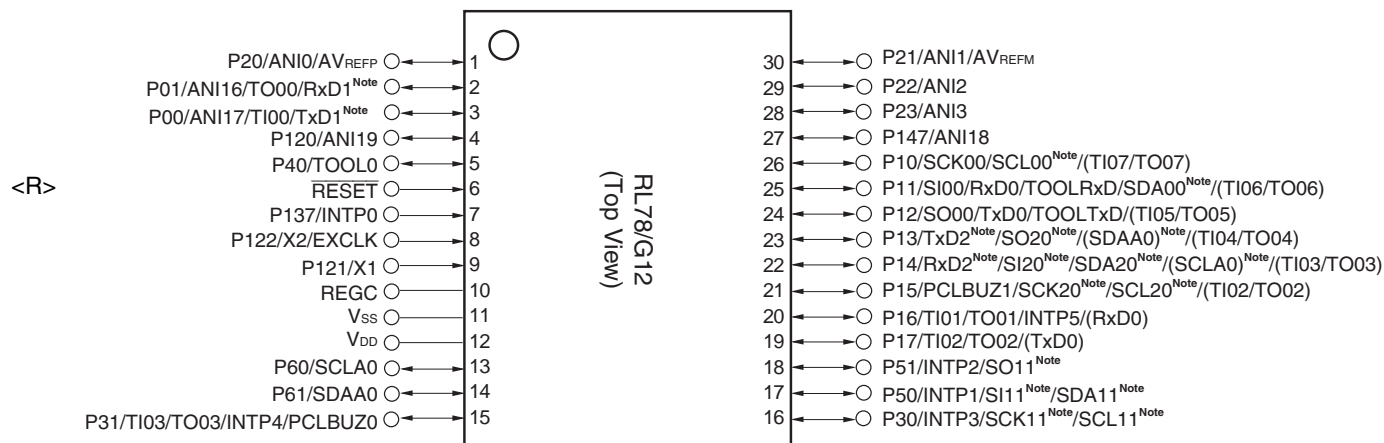
**Remarks 1.** For pin identification, see **1.5 Pin Identification**.

- Functions in parentheses in the above figure can be assigned via settings in the peripheral I/O redirection register (PIOR). See **Figure 4-8 Format of Peripheral I/O Redirection Register (PIOR)**.
- It is recommended to connect an exposed die pad to Vss.



## 1.4.3 30-pin products

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



**Note** Provided only in the R5F102 products.

**Caution** Connect the REGC pin to V<sub>SS</sub> via capacitor (0.47 to 1  $\mu$ F).

**Remarks 1.** For pin identification, see 1.5 Pin Identification.

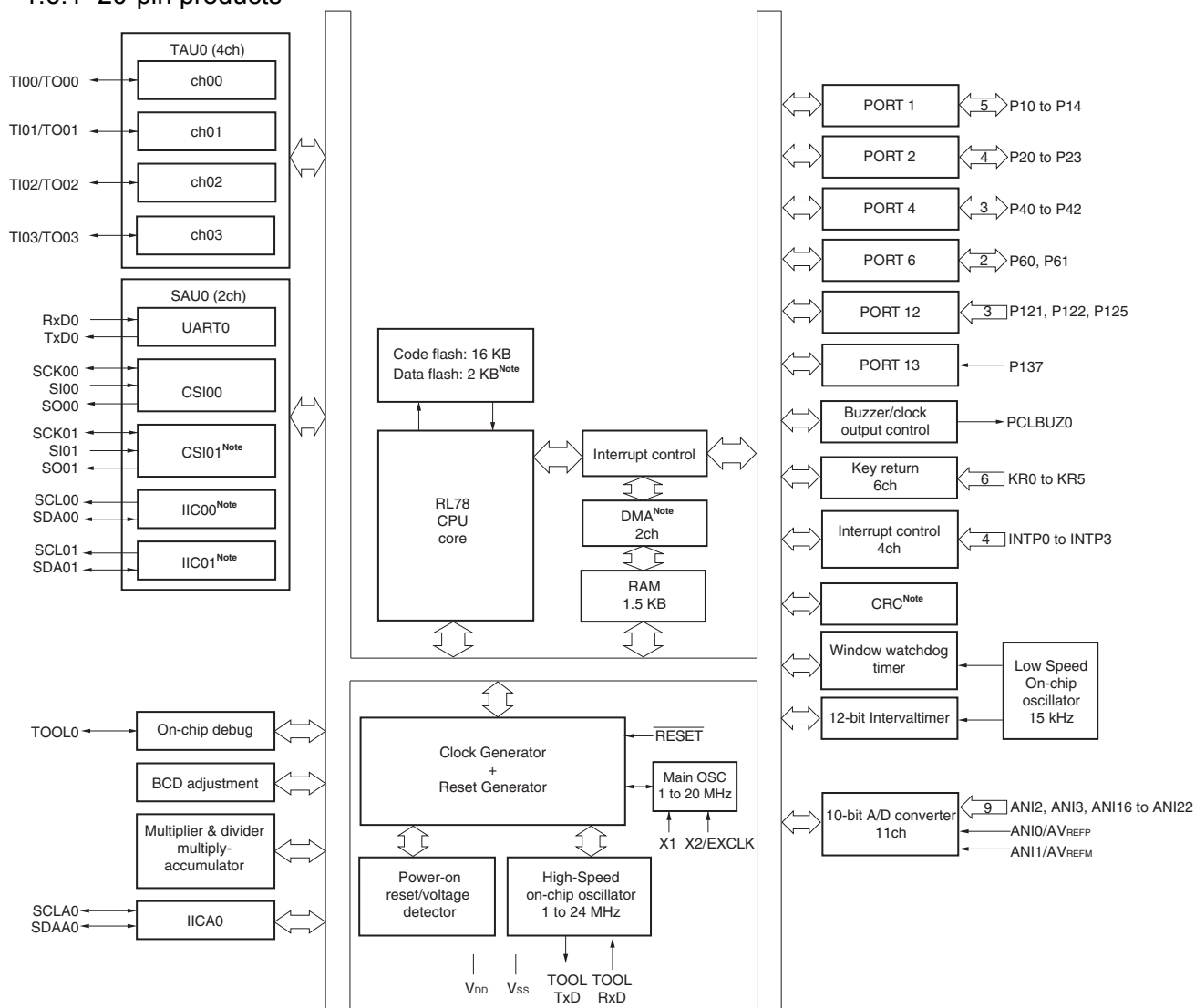
**2.** Functions in parentheses in the above figure can be assigned via settings in the peripheral I/O redirection register (PIOR). See **Figure 4-8 Format of Peripheral I/O Redirection Register (PIOR)**.

## 1.5 Pin Identification

ANI0 to ANI3, ANI16 to ANI22:	Analog input	REGC:	Regulator Capacitance
AVREFM:	Analog Reference Voltage Minus	$\overline{\text{RESET}}$ :	Reset
AVREFP:	Analog reference voltage plus	RxD0 to RxD2:	Receive Data
EXCLK:	External Clock Input (Main System Clock)	SCK00, SCK01, SCK11, SCK20:	Serial Clock Input/Output
INTP0 to INTP5	Interrupt Request From Peripheral	SCL00, SCL01, SCL11, SCL20, SCLA0:	Serial Clock Input/Output
KR0 to KR9:	Key Return	SDA00, SDA01, SDA11, SDA20, SDAA0:	Serial Data Input/Output
P00 to P03:	Port 0	SI00, SI01, SI11, SI20:	Serial Data Input
P10 to P17:	Port 1	SO00, SO01, SO11, SO20:	Serial Data Output
P20 to P23:	Port 2	TI00 to TI07:	Timer Input
P30 to P31:	Port 3	TO00 to TO07:	Timer Output
P40 to P42:	Port 4	TOOL0:	Data Input/Output for Tool
P50, P51:	Port 5	TOOLRxD, TOOLTxD:	Data Input/Output for External Device
P60, P61:	Port 6	TxD0 to TxD2:	Transmit Data
P120 to P122, P125:	Port 12	VDD:	Power supply
P137:	Port 13	VSS:	Ground
P147:	Port 14	X1, X2:	Crystal Oscillator (Main System Clock)
PCLBUZ0, PCLBUZ1:	Programmable Clock Output/ Buzzer Output		

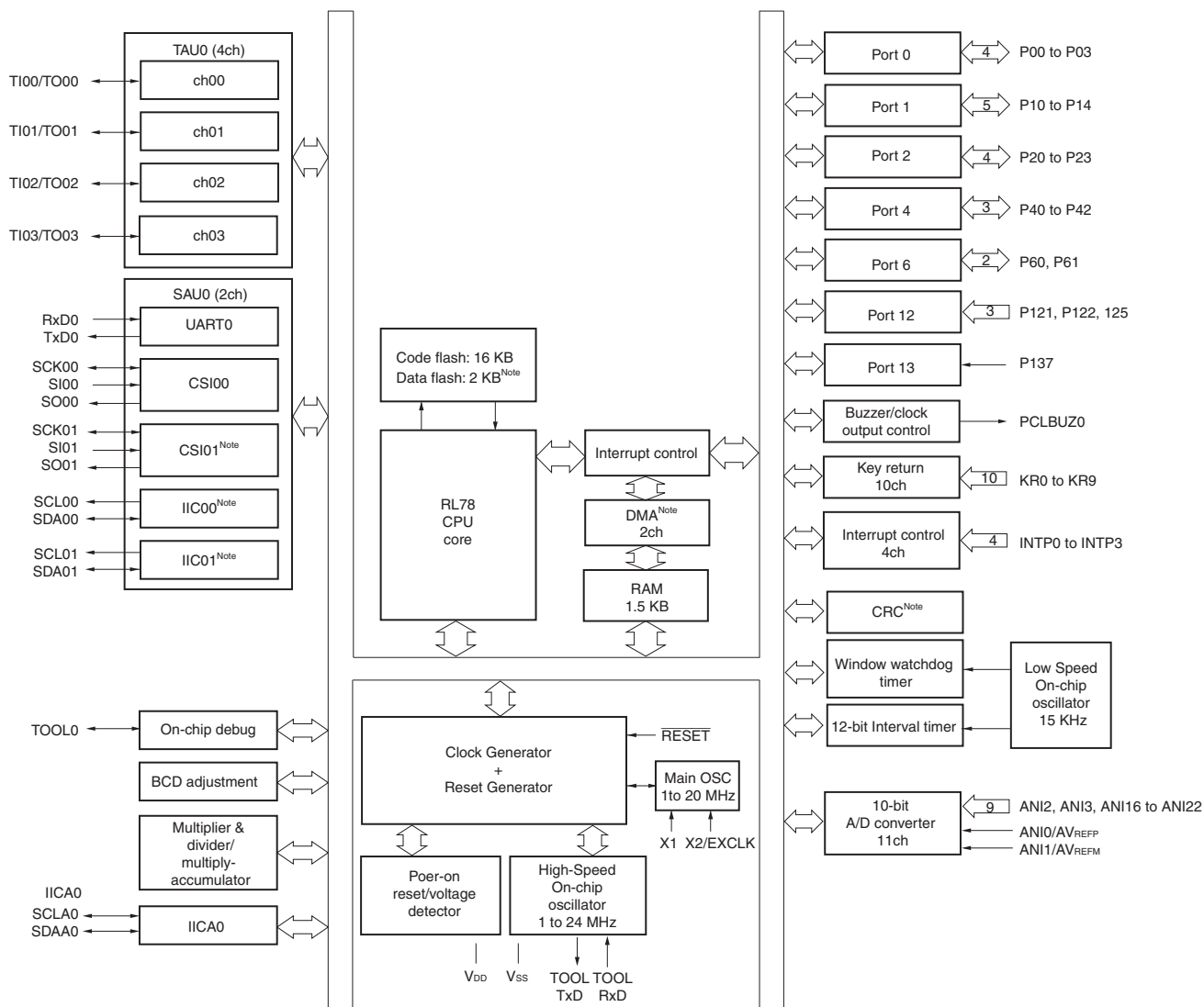
## 1.6 Block Diagram

### 1.6.1 20-pin products



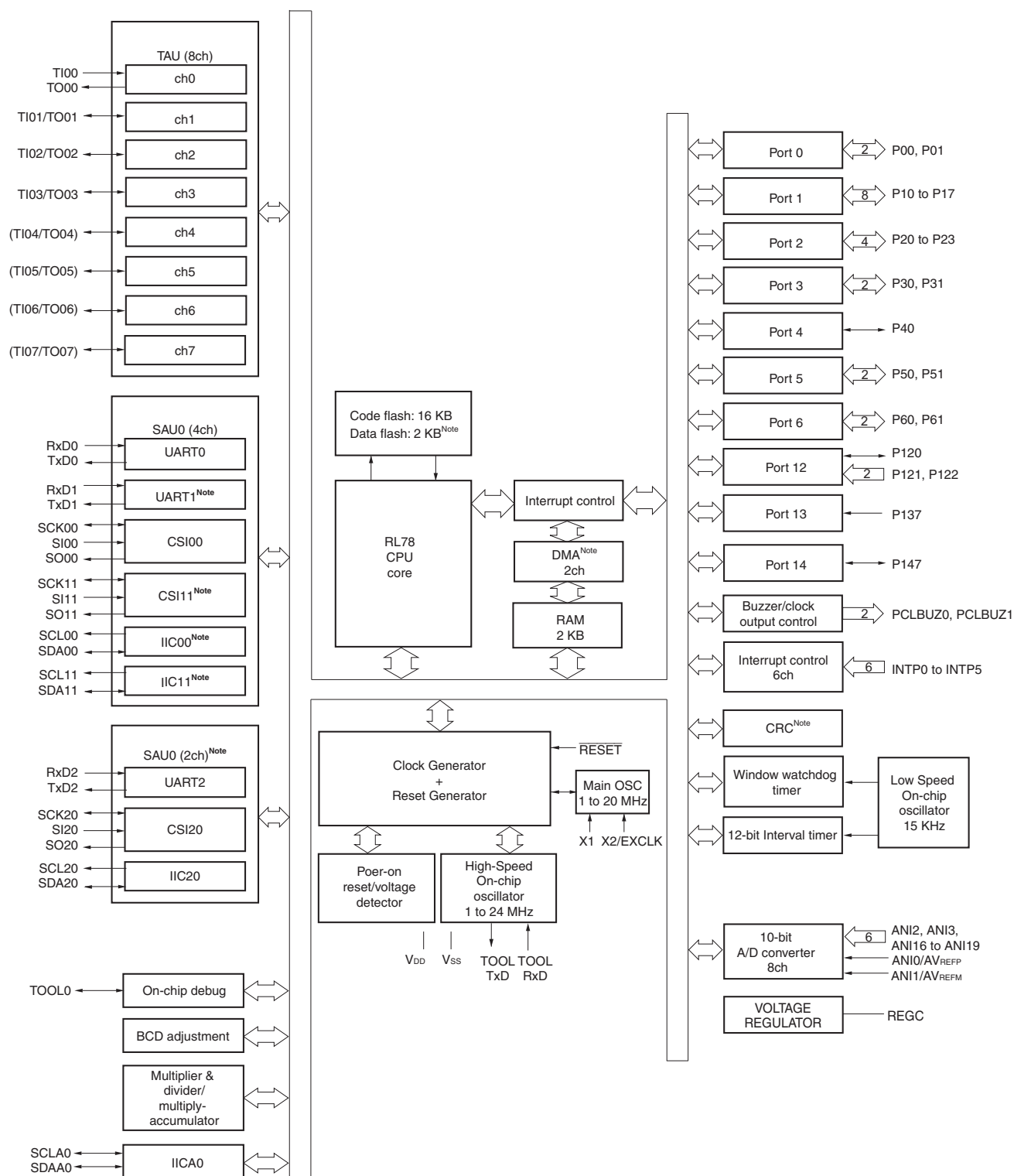
**Note** Provided only in the R5F102 products.

## 1.6.2 24-pin products



**Note** Provided only in the R5F102 products.

## 1.6.3 30-pin products



**Note** Provided only in the R5F102 products.

**Remark** Functions in parentheses in the above figure can be assigned via settings in the peripheral I/O redirection register (PIOR). See **Figure 4-8 Format of Peripheral I/O Redirection Register (PIOR)**.

## 1.7 Outline of Functions

This outline describes the function at the time when Peripheral I/O redirection register (PIOR) is set to 00H.

(1/2)

<R>

Item		20-pin		24-pin		30-pin	
		R5F1026x	R5F1036x	R5F1027x	R5F1037x	R5F102Ax	R5F103Ax
Code flash memory		2 to 16 KB <sup>Note 1</sup>		4 to 16 KB			
Data flash memory		2 KB	–	2 KB	–	2 KB	–
RAM		256 B to 1.5 KB		512 B to 1.5 KB		512 B to 2KB	
Address space		1 MB					
Main system clock	High-speed system clock	X1 (crystal/ceramic) oscillation, external main system clock input (EXCLK) HS (High-speed main) mode : 1 to 20 MHz (V <sub>DD</sub> = 2.7 to 5.5 V), HS (High-speed main) mode : 1 to 16 MHz (V <sub>DD</sub> = 2.4 to 5.5 V), LS (Low-speed main) mode : 1 to 8 MHz (V <sub>DD</sub> = 1.8 to 5.5 V)					
	High-speed on-chip oscillator clock	HS (High-speed main) mode : 1 to 24 MHz (V <sub>DD</sub> = 2.7 to 5.5 V), HS (High-speed main) mode : 1 to 16 MHz (V <sub>DD</sub> = 2.4 to 5.5 V), LS (Low-speed main) mode : 1 to 8 MHz (V <sub>DD</sub> = 1.8 to 5.5 V)					
Low-speed on-chip oscillator clock		15 kHz (TYP)					
General-purpose register		(8-bit register × 8) × 4 banks					
Minimum instruction execution time		0.04167 μs (High-speed on-chip oscillator clock: f <sub>IH</sub> = 24 MHz operation)					
		0.05 μs (High-speed system clock: f <sub>MX</sub> = 20 MHz operation)					
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)</li><li>• Rotate, barrel shift, and bit manipulation (set, reset, test, and Boolean operation), etc.</li></ul>					
I/O port	Total	18		22		26	
	CMOS I/O	12 (N-ch O.D. I/O [V <sub>DD</sub> withstand voltage]: 4)		16 (N-ch O.D. I/O [V <sub>DD</sub> withstand voltage]: 5)		21 (N-ch O.D. I/O [V <sub>DD</sub> withstand voltage]: 9)	
	CMOS input	4		4		3	
	N-ch open-drain I/O (6 V tolerance)	2					
Timer	16-bit timer	4 channels				8 channels	
	Watchdog timer	1 channel					
	12-bit Interval timer	1 channel					
	Timer output	4 channels (PWM outputs: 3 <sup>Note 3</sup> )				8 channels (PWM outputs: 7 <sup>Note 3</sup> <sup>Note 2</sup> )	

**Notes** 1. The self-programming function cannot be used in the R5F10266 and R5F10366.

2. The maximum number of channels when PIOR0 is set to 1.

3. The number of PWM outputs varies depending on the setting of channels in use (the number of masters and slaves). (See **6.9.3 Operation as multiple PWM output function.**)

**Caution** When the flash memory is rewritten via a user program, the code flash area and RAM area are used because each library is used. When using the library, refer to RL78 Family Flash Self Programming Library Type01 User's Manual and RL78 Family Data Flash Library Type04 User's Manual.

(2/2)

Item		20-pin		24-pin		30-pin	
		R5F1026x	R5F1036x	R5F1027x	R5F1037x	R5F102Ax	R5F103Ax
Clock output/buzzer output		1				2	
		2.44 kHz to 10 MHz: (Peripheral hardware clock: f <sub>MAIN</sub> = 20 MHz operation)					
8/10-bit resolution A/D converter		11 channels				8 channels	
Serial interface		[R5F1026x (20-pin), R5F1027x (24-pin)]					
		• CSI: 2 channels/Simplified I <sup>2</sup> C: 2 channels/UART: 1 channel					
		[R5F102Ax (30-pin)]					
		• CSI: 1 channel/Simplified I <sup>2</sup> C: 1 channel/UART: 1 channel					
		• CSI: 1 channel/Simplified I <sup>2</sup> C: 1 channel/UART: 1 channel					
		• CSI: 1 channel/Simplified I <sup>2</sup> C: 1 channel/UART: 1 channel					
		[R5F1036x (20-pin), R5F1037x (24-pin)]					
		• CSI: 1 channel/Simplified I <sup>2</sup> C: 0 channel/UART: 1 channel					
		[R5F103Ax (30-pin)]					
		• CSI: 1 channel/Simplified I <sup>2</sup> C: 0 channel/UART: 1 channel					
		I <sup>2</sup> C bus		1 channel			
		Multiplier and divider/multiply-accumulator		• 16 bits × 16 bits = 32 bits (unsigned or signed)			
		• 32 bits × 32 bits = 32 bits (unsigned)					
		• 16 bits × 16 bits + 32 bits = 32 bits (unsigned or signed)					
DMA controller		2 channels	—	2 channels	—	2 channels	—
Vectored interrupt sources	Internal	18	16	18	16	26	19
	External	5				6	
Key interrupt		6		10		—	
Reset		• Reset by $\overline{\text{RESET}}$ pin					
		• Internal reset by watchdog timer					
		• Internal reset by power-on-reset					
		• Internal reset by voltage detector					
		• Internal reset by illegal instruction execution <sup>Note</sup>					
		• Internal reset by RAM parity error					
		• Internal reset by illegal-memory access					
Power-on-reset circuit		• Power-on-reset: 1.51 V (TYP)					
		• Power-down-reset: 1.50 V (TYP)					
Voltage detector		• Rising edge : 1.88 to 4.06 V (12 stages)					
		• Falling edge : 1.84 to 3.98 V (12 stages)					
On-chip debug function		Provided					
Power supply voltage		V <sub>DD</sub> = 1.8 to 5.5 V					
Operating ambient temperature		T <sub>A</sub> = −40 to +85°C (A: Consumer applications, D: Industrial applications), T <sub>A</sub> = −40 to +105°C (G: Industrial applications)					

**Note** The illegal instruction is generated when instruction code FFH is executed.

Reset by the illegal instruction execution not issued by emulation with the in-circuit emulator or on-chip debug emulator.

## <R> 2. ELECTRICAL SPECIFICATIONS ( $T_A = -40$ to $+85^\circ\text{C}$ )

<R> This chapter describes the following electrical specifications.

Target products A: Consumer applications  $T_A = -40$  to  $+85^\circ\text{C}$

<R> R5F102xxAxx, R5F103xxAxx

D: Industrial applications  $T_A = -40$  to  $+85^\circ\text{C}$

<R> R5F102xxDxx, R5F103xxDxx

G: Industrial applications when  $T_A = -40$  to  $+105^\circ\text{C}$  products is used in the range of  $T_A = -40$  to  $+85^\circ\text{C}$

<R> R5F102xxGxx

**Cautions** 1. The RL78 microcontrollers have an on-chip debug function, which is provided for development and evaluation. Do not use the on-chip debug function in products designated for mass production, because the guaranteed number of rewritable times of the flash memory may be exceeded when this function is used, and product reliability therefore cannot be guaranteed. Renesas Electronics is not liable for problems occurring when the on-chip debug function is used.

2. The pins mounted depend on the product. Refer to 2.1 Port Functions to 2.2.1 Functions for each product.



## 2.1 Absolute Maximum Ratings

Absolute Maximum Ratings (T<sub>A</sub> = 25°C)

Parameter	Symbols	Conditions		Ratings	Unit
Supply Voltage	V <sub>DD</sub>			–0.5 to +6.5	V
REGC terminal input voltage <sup>Note 1</sup>	V <sub>I REGC</sub>	REGC		–0.3 to +2.8 and –0.3 to V <sub>DD</sub> + 0.3 <sup>Note 2</sup>	V
Input Voltage	V <sub>I1</sub>	Other than P60, P61		–0.3 to V <sub>DD</sub> + 0.3 <sup>Note 3</sup>	V
	V <sub>I2</sub>	P60, P61 (N-ch open drain)		–0.3 to 6.5	V
Output Voltage	V <sub>O</sub>			–0.3 to V <sub>DD</sub> + 0.3 <sup>Note 3</sup>	V
Analog input voltage	V <sub>AI</sub>	20-, 24-pin products: ANI0 to ANI3, ANI16 to ANI22 30-pin products: ANI0 to ANI3, ANI16 to ANI19		–0.3 to V <sub>DD</sub> + 0.3 and –0.3 to AVREF(+) + 0.3 <sup>Notes 3, 4</sup>	V
Output current, high	I <sub>OH1</sub>	Per pin	Other than P20 to P23	–40	mA
		Total of all pins	All the terminals other than P20 to P23	–170	mA
			20-, 24-pin products: P40 to P42 30-pin products: P00, P01, P40, P120	–70	mA
			20-, 24-pin products: P00 to P03 <sup>Note 5</sup> , P10 to P14 30-pin products: P10 to P17, P30, P31, P50, P51, P147	–100	mA
	I <sub>OH2</sub>	Per pin	P20 to P23	–0.5	mA
		Total of all pins		–2	mA
Output current, low	I <sub>OL1</sub>	Per pin	Other than P20 to P23	40	mA
		Total of all pins	All the terminals other than P20 to P23	170	mA
			20-, 24-pin products: P40 to P42 30-pin products: P00, P01, P40, P120	70	mA
			20-, 24-pin products: P00 to P03 <sup>Note 5</sup> , P10 to P14, P60, P61 30-pin products: P10 to P17, P30, P31, P50, P51, P60, P61, P147	100	mA
	I <sub>OL2</sub>	Per pin	P20 to P23	1	mA
		Total of all pins		5	mA
Operating ambient temperature	T <sub>A</sub>			–40 to +85	°C
Storage temperature	T <sub>stg</sub>			–65 to +150	°C

**Notes** 1. 30-pin product only.

2. Connect the REGC pin to V<sub>SS</sub> via a capacitor (0.47 to 1 μF). This value determines the absolute maximum rating of the REGC pin. Do not use it with voltage applied.
3. Must be 6.5 V or lower.
4. Do not exceed AVREF(+) + 0.3 V in case of A/D conversion target pin.
5. 24-pin products only.

**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.

- Remarks** 1. Unless specified otherwise, the characteristics of alternate-function pins are the same as those of the port pins.
2. AVREF(+) : + side reference voltage of the A/D converter.
  3. V<sub>SS</sub> : Reference voltage

## 2.2 Oscillator Characteristics

### 2.2.1 X1 oscillator characteristics

( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )

Parameter	Resonator	Conditions	MIN.	TYP.	MAX.	Unit
X1 clock oscillation frequency ( $f_x$ ) <sup>Note</sup>	Ceramic resonator / crystal oscillator	$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	1.0		20.0	MHz
		$1.8\text{ V} \leq V_{DD} < 2.7\text{ V}$	1.0		8.0	

**Note** Indicates only permissible oscillator frequency ranges. Refer to AC Characteristics for instruction execution time. Request evaluation by the manufacturer of the oscillator circuit mounted on a board to check the oscillator characteristics.

**Caution** Since the CPU is started by the high-speed on-chip oscillator clock after a reset release, check the X1 clock oscillation stabilization time using the oscillation stabilization time counter status register (OSTC) by the user. Determine the oscillation stabilization time of the OSTC register and the oscillation stabilization time select register (OSTS) after sufficiently evaluating the oscillation stabilization time with the resonator to be used.

**Remark** When using the X1 oscillator, refer to **5.4 System Clock Oscillator**.

### 2.2.2 On-chip oscillator characteristics

( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )

Oscillators	Parameters	Conditions		MIN.	TYP.	MAX.	Unit
High-speed on-chip oscillator clock frequency <sup>Notes 1, 2</sup>	$f_{IH}$			1		24	MHz
High-speed on-chip oscillator clock frequency accuracy		R5F102 products	$T_A = -20$ to $+85^\circ\text{C}$	-1.0		+1.0	%
			$T_A = -40$ to $-20^\circ\text{C}$	-1.5		+1.5	%
		R5F103 products		-5.0		+5.0	%
Low-speed on-chip oscillator clock frequency	$f_{IL}$				15		kHz
Low-speed on-chip oscillator clock frequency accuracy				-15		+15	%

**Notes 1.** High-speed on-chip oscillator frequency is selected by bits 0 to 3 of option byte (000C2H) and bits 0 to 2 of HOCODIV register.

**2.** This only indicates the oscillator characteristics. Refer to AC Characteristics for instruction execution time.

## 2.3 DC Characteristics

## 2.3.1 Pin characteristics

(T<sub>A</sub> = –40 to +85°C, 1.8 V ≤ V<sub>DD</sub> ≤ 5.5 V, V<sub>SS</sub> = 0 V)

(1/4)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Output current, high <sup>Note 1</sup>	I <sub>OH1</sub>	20-, 24-pin products: Per pin for P00 to P03 <sup>Note 4</sup> , P10 to P14, P40 to P42  30-pin products: Per pin for P00, P01, P10 to P17, P30, P31, P40, P50, P51, P120, P147			–10.0 <sup>Note 2</sup>	mA
		20-, 24-pin products: Total of P40 to P42	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V		–30.0	mA
			2.7 V ≤ V <sub>DD</sub> < 4.0 V		–6.0	mA
		30-pin products: Total of P00, P01, P40, P120 (When duty ≤ 70% <sup>Note 3</sup> )	1.8 V ≤ V <sub>DD</sub> < 2.7 V		–4.5	mA
		20-, 24-pin products: Total of P00 to P03 <sup>Note 4</sup> , P10 to P14	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V		–80.0	mA
			2.7 V ≤ V <sub>DD</sub> < 4.0 V		–18.0	mA
		30-pin products: Total of P10 to P17, P30, P31, P50, P51, P147 (When duty ≤ 70% <sup>Note 3</sup> )	1.8 V ≤ V <sub>DD</sub> < 2.7 V		–10.0	mA
		Total of all pins (When duty ≤ 70% <sup>Note 3</sup> )			–100	mA
	I <sub>OH2</sub>	Per pin for P20 to P23			–0.1	mA
		Total of all pins			–0.4	mA

**Notes** 1. value of current at which the device operation is guaranteed even if the current flows from the V<sub>DD</sub> pin to an output pin.

2. However, do not exceed the total current value.

3. The output current value under conditions where the duty factor ≤ 70%.

If duty factor > 70%: The output current value can be calculated with the following expression (where n represents the duty factor as a percentage).

- Total output current of pins = (I<sub>OH</sub> × 0.7)/(n × 0.01)

<Example> Where n = 80% and I<sub>OH</sub> = –10.0 mA

$$\text{Total output current of pins} = (-10.0 \times 0.7) / (80 \times 0.01) \cong -8.7 \text{ mA}$$

However, the current that is allowed to flow into one pin does not vary depending on the duty factor. A current higher than the absolute maximum rating must not flow into one pin.

4. 24-pin products only.

**Caution** P10 to P12 and P41 for 20-pin products, P01, P10 to P12, and P41 for 24-pin products, and P00, P10 to P15, P17, and P50 for 30-pin products do not output high level in N-ch open-drain mode.

**Remark** Unless specified otherwise, the characteristics of alternate-function pins are the same as those of the port pins.

**( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )****(2/4)**

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Output current, low <sup>Note 1</sup>	I <sub>OL1</sub>	20-, 24-pin products: Per pin for P00 to P03 <sup>Note 4</sup> , P10 to P14, P40 to P42  30-pin products: Per pin for P00, P01, P10 to P17, P30, P31, P40, P50, P51, P120, P147			20.0 <sup>Note 2</sup>	mA
		Per pin for P60, P61			15.0 <sup>Note 2</sup>	mA
		20-, 24-pin products: Total of P40 to P42  30-pin products: Total of P00, P01, P40, P120 (When duty $\leq 70\%$ <sup>Note 3</sup> )	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		60.0	mA
			$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$		9.0	mA
			$1.8\text{ V} \leq V_{DD} < 2.7\text{ V}$		1.8	mA
		20-, 24-pin products: Total of P00 to P03 <sup>Note 4</sup> , P10 to P14, P60, P61  30-pin products: Total of P10 to P17, P30, P31, P50, P51, P60, P61, P147 (When duty $\leq 70\%$ <sup>Note 3</sup> )	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		80.0	mA
			$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$		27.0	mA
			$1.8\text{ V} \leq V_{DD} < 2.7\text{ V}$		5.4	mA
		Total of all pins (When duty $\leq 70\%$ <sup>Note 3</sup> )			140	mA
	I <sub>OL2</sub>	Per pin for P20 to P23			0.4	mA
		Total of all pins			1.6	mA

**Notes** 1. Value of current at which the device operation is guaranteed even if the current flows from an output pin to the  $V_{SS}$  pin.

2. However, do not exceed the total current value.

3. The output current value under conditions where the duty factor  $\leq 70\%$ .

If duty factor  $> 70\%$ : The output current value can be calculated with the following expression (where  $n$  represents the duty factor as a percentage).

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

<Example> Where  $n = 80\%$  and  $I_{OL} = 10.0\text{ mA}$

$$\text{Total output current of pins} = (10.0 \times 0.7)/(80 \times 0.01) \cong 8.7\text{ mA}$$

However, the current that is allowed to flow into one pin does not vary depending on the duty factor. A current higher than the absolute maximum rating must not flow into one pin.

4. 24-pin products only.

**Remark** Unless specified otherwise, the characteristics of alternate-function pins are the same as those of the port pins.

**( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )****(3/4)**

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Input voltage, high	$V_{IH1}$	Normal input buffer 20-, 24-pin products: P00 to P03 <sup>Note 2</sup> , P10 to P14, P40 to P42 30-pin products: P00, P01, P10 to P17, P30, P31, P40, P50, P51, P120, P147	$0.8V_{DD}$		$V_{DD}$	V
	$V_{IH2}$	TTL input buffer 20-, 24-pin products: P10, P11 30-pin products: P01, P10, P11, P13 to P17	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	2.2	$V_{DD}$	V
			$3.3\text{ V} \leq V_{DD} < 4.0\text{ V}$	2.0	$V_{DD}$	V
			$1.8\text{ V} \leq V_{DD} < 3.3\text{ V}$	1.5	$V_{DD}$	V
	$V_{IH3}$	P20 to P23	$0.7V_{DD}$		$V_{DD}$	V
	$V_{IH4}$	P60, P61	$0.7V_{DD}$		6.0	V
Input voltage, low	$V_{IH5}$	P121, P122, P125 <sup>Note 1</sup> , P137, EXCLK, RESET	$0.8V_{DD}$		$V_{DD}$	V
	$V_{IL1}$	Normal input buffer 20-, 24-pin products: P00 to P03 <sup>Note 2</sup> , P10 to P14, P40 to P42 30-pin products: P00, P01, P10 to P17, P30, P31, P40, P50, P51, P120, P147	0		$0.2V_{DD}$	V
	$V_{IL2}$	TTL input buffer 20-, 24-pin products: P10, P11 30-pin products: P01, P10, P11, P13 to P17	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	0	0.8	V
			$3.3\text{ V} \leq V_{DD} < 4.0\text{ V}$	0	0.5	V
			$1.8\text{ V} \leq V_{DD} < 3.3\text{ V}$	0	0.32	V
Output voltage, high	$V_{IL3}$	P20 to P23	0		$0.3V_{DD}$	V
	$V_{IL4}$	P60, P61	0		$0.3V_{DD}$	V
	$V_{IL5}$	P121, P122, P125 <sup>Note 1</sup> , P137, EXCLK, RESET	0		$0.2V_{DD}$	V
	$V_{OH1}$	20-, 24-pin products: P00 to P03 <sup>Note 2</sup> , P10 to P14, P40 to P42 30-pin products: P00, P01, P10 to P17, P30, P31, P40, P50, P51, P120, P147	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $I_{OH1} = -10.0\text{ mA}$	$V_{DD}-1.5$		V
			$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $I_{OH1} = -3.0\text{ mA}$	$V_{DD}-0.7$		V
			$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $I_{OH1} = -2.0\text{ mA}$	$V_{DD}-0.6$		V
			$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $I_{OH1} = -1.5\text{ mA}$	$V_{DD}-0.5$		V
Output voltage, low	$V_{OH2}$	P20 to P23	$I_{OH2} = -100\text{ }\mu\text{A}$	$V_{DD}-0.5$		V

**Notes** 1. 20, 24-pin products only.

2. 24-pin products only.

**Caution** The maximum value of  $V_{IH}$  of pins P10 to P12 and P41 for 20-pin products, P01, P10 to P12, and P41 for 24-pin products, and P00, P10 to P15, P17, and P50 for 30-pin products is  $V_{DD}$  even in N-ch open-drain mode. High level is not output in the N-ch open-drain mode.

**Remark** Unless specified otherwise, the characteristics of alternate-function pins are the same as those of the port pins.

**( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )****(4/4)**

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Output voltage, low	$V_{OL1}$	20-, 24-pin products: P00 to P03 <sup>Note</sup> , P10 to P14, P40 to P42  30-pin products: P00, P01, P10 to P17, P30, P31, P40, P50, P51, P120, P147	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $I_{OL1} = 20.0\text{ mA}$			1.3	V
			$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $I_{OL1} = 8.5\text{ mA}$			0.7	V
			$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $I_{OL1} = 3.0\text{ mA}$			0.6	V
			$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $I_{OL1} = 1.5\text{ mA}$			0.4	V
			$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $I_{OL1} = 0.6\text{ mA}$			0.4	V
	$V_{OL2}$	P20 to P23	$I_{OL2} = 400\text{ }\mu\text{A}$			0.4	V
	$V_{OL3}$	P60, P61	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $I_{OL1} = 15.0\text{ mA}$			2.0	V
			$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $I_{OL1} = 5.0\text{ mA}$			0.4	V
			$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $I_{OL1} = 3.0\text{ mA}$			0.4	V
			$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $I_{OL1} = 2.0\text{ mA}$			0.4	V
Input leakage current, high	$I_{LIH1}$	Other than P121, P122	$V_I = V_{DD}$			1	$\mu\text{A}$
	$I_{LIH2}$	P121, P122 (X1, X2/EXCLK)	$V_I = V_{DD}$ Input port or external clock input			1	$\mu\text{A}$
			When resonator connected			10	$\mu\text{A}$
Input leakage current, low	$I_{LIL1}$	Other than P121, P122	$V_I = V_{SS}$			-1	$\mu\text{A}$
	$I_{LIL2}$	P121, P122 (X1, X2/EXCLK)	$V_I = V_{SS}$ Input port or external clock input			-1	$\mu\text{A}$
			When resonator connected			-10	$\mu\text{A}$
On-chip pull-up resistance	$R_U$	20-, 24-pin products: P00 to P03 <sup>Note</sup> , P10 to P14, P40 to P42, P125, RESET  30-pin products: P00, P01, P10 to P17, P30, P31, P40, P50, P51, P120, P147	$V_I = V_{SS}$ , input port	10	20	100	$\text{k}\Omega$

**Note** 24-pin products only.**Remark** Unless specified otherwise, the characteristics of alternate-function pins are the same as those of the port pins.

## 2.3.2 Supply current characteristics

## (1) 20-, 24-pin products

 $(T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V})$ 

(1/2)

Parameter	Symbol	Conditions					MIN.	TYP.	MAX.	Unit
Supply current <sup>Note 1</sup>	I <sub>DD1</sub>	Operating mode	HS(High-speed main) mode <sup>Note 4</sup>	f <sub>IH</sub> = 24 MHz <sup>Note 3</sup>	Basic operation	V <sub>DD</sub> = 5.0 V		1.5		mA
						V <sub>DD</sub> = 3.0 V		1.5		
					Normal operation	V <sub>DD</sub> = 5.0 V		3.3	5.0	mA
				V <sub>DD</sub> = 3.0 V			3.3	5.0		
				f <sub>IH</sub> = 16 MHz <sup>Note 3</sup>	V <sub>DD</sub> = 5.0 V		2.5	3.7	mA	
					V <sub>DD</sub> = 3.0 V		2.5	3.7		
			LS(Low-speed main) mode <sup>Note 4</sup>	f <sub>IH</sub> = 8 MHz <sup>Note 3</sup>	V <sub>DD</sub> = 3.0 V		1.2	1.8	mA	
					V <sub>DD</sub> = 2.0 V		1.2	1.8		
			HS(High-speed main) mode <sup>Note 4</sup>	f <sub>MX</sub> = 20 MHz <sup>Note 2</sup> , V <sub>DD</sub> = 5.0 V	Square wave input		2.8	4.4	mA	
					Resonator connection		3.0	4.6		
					f <sub>MX</sub> = 20 MHz <sup>Note 2</sup> , V <sub>DD</sub> = 3.0 V	Square wave input		2.8	4.4	mA
				Resonator connection			3.0	4.6		
				f <sub>MX</sub> = 10 MHz <sup>Note 2</sup> , V <sub>DD</sub> = 5.0 V		Square wave input		1.8	2.6	mA
					Resonator connection		1.8	2.6		
			HS(High-speed main) mode <sup>Note 4</sup>	f <sub>MX</sub> = 10 MHz <sup>Note 2</sup> , V <sub>DD</sub> = 3.0 V	Square wave input		1.8	2.6	mA	
					Resonator connection		1.8	2.6		
					LS(Low-speed main) mode <sup>Note 4</sup>	f <sub>MX</sub> = 8 MHz <sup>Note 2</sup> , V <sub>DD</sub> = 3.0 V	Square wave input		1.1	1.7
				Resonator connection				1.1	1.7	
f <sub>MX</sub> = 8 MHz <sup>Note 2</sup> , V <sub>DD</sub> = 2.0 V	Square wave input			1.1		1.7	mA			
	Resonator connection			1.1	1.7					

**Notes** 1. Total current flowing into  $V_{DD}$ , including the input leakage current flowing when the level of the input pin is fixed to  $V_{DD}$  or  $V_{SS}$ . The values below the MAX. column include the peripheral operation current. However, not including the current flowing into the A/D converter, LVD circuit, I/O port, and on-chip pull-up/pull-down resistors and the current flowing during data flash rewrite.

2. When high-speed on-chip oscillator clock is stopped.

3. When high-speed system clock is stopped

4. Relationship between operation voltage width, operation frequency of CPU and operation mode is as follows.

HS(High speed main) mode:  $V_{DD} = 2.7\text{ V}$  to  $5.5\text{ V}$  @  $1\text{ MHz}$  to  $24\text{ MHz}$

$V_{DD} = 2.4\text{ V}$  to  $5.5\text{ V}$  @  $1\text{ MHz}$  to  $16\text{ MHz}$

LS(Low speed main) mode:  $V_{DD} = 1.8\text{ V}$  to  $5.5\text{ V}$  @  $1\text{ MHz}$  to  $8\text{ MHz}$

**Remarks** 1.  $f_{MX}$ : High-speed system clock frequency (X1 clock oscillation frequency or external main system clock frequency)

2.  $f_{IH}$ : high-speed on-chip oscillator clock frequency

3. Temperature condition of the TYP. value is  $T_A = 25^\circ\text{C}$ .

## (1) 20-, 24-pin products

 $(T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )

(2/2)

Parameter	Symbol	Conditions				MIN.	TYP.	MAX.	Unit	
Supply current <sup>Note 1</sup>	I <sub>DD2</sub> <sup>Note 2</sup>	HALT mode	HS (High-speed main) mode <sup>Note 6</sup>	f <sub>IH</sub> = 24 MHz <sup>Note 4</sup>	V <sub>DD</sub> = 5.0 V		440	1210	μA	
					V <sub>DD</sub> = 3.0 V		440	1210		
				f <sub>IH</sub> = 16 MHz <sup>Note 4</sup>	V <sub>DD</sub> = 5.0 V		400	950	μA	
					V <sub>DD</sub> = 3.0 V		400	950		
			LS (Low-speed main) mode <sup>Note 6</sup>	f <sub>IH</sub> = 8 MHz <sup>Note 4</sup>	V <sub>DD</sub> = 3.0 V		270	542	μA	
					V <sub>DD</sub> = 2.0 V		270	542		
			HS (High-speed main) mode <sup>Note 6</sup>	f <sub>MX</sub> = 20 MHz <sup>Note 3</sup> , V <sub>DD</sub> = 5.0 V	Square wave input		280	1000	μA	
					Resonator connection		450	1170		
				f <sub>MX</sub> = 20 MHz <sup>Note 3</sup> , V <sub>DD</sub> = 3.0 V	Square wave input		280	1000	μA	
					Resonator connection		450	1170		
				f <sub>MX</sub> = 10 MHz <sup>Note 3</sup> , V <sub>DD</sub> = 5.0 V	Square wave input		190	590	μA	
					Resonator connection		260	660		
				f <sub>MX</sub> = 10 MHz <sup>Note 3</sup> , V <sub>DD</sub> = 3.0 V	Square wave input		190	590	μA	
					Resonator connection		260	660		
			LS (Low-speed main) mode <sup>Note 6</sup>	f <sub>MX</sub> = 8 MHz <sup>Note 3</sup> , V <sub>DD</sub> = 3.0 V	Square wave input		110	360	μA	
					Resonator connection		150	416		
				f <sub>MX</sub> = 8 MHz <sup>Note 3</sup> , V <sub>DD</sub> = 2.0 V	Square wave input		110	360	μA	
					Resonator connection		150	416		
	I <sub>DD3</sub> <sup>Note 5</sup>	STOP mode	T <sub>A</sub> = −40°C					0.19	0.50	μA
			T <sub>A</sub> = +25°C					0.24	0.50	
			T <sub>A</sub> = +50°C					0.32	0.80	
			T <sub>A</sub> = +70°C					0.48	1.20	
			T <sub>A</sub> = +85°C					0.74	2.20	

- Notes**
1. Total current flowing into  $V_{DD}$ , including the input leakage current flowing when the level of the input pin is fixed to  $V_{DD}$  or  $V_{SS}$ . The values below the MAX. column include the peripheral operation current. However, not including the current flowing into the A/D converter, LVD circuit, I/O port, and on-chip pull-up/pull-down resistors and the current flowing during data flash rewrite.
  2. During HALT instruction execution by flash memory.
  3. When high-speed on-chip oscillator clock is stopped.
  4. When high-speed system clock is stopped.
  5. Not including the current flowing into the 12-bit interval timer and watchdog timer.
  6. Relationship between operation voltage width, operation frequency of CPU and operation mode is as follows.  
 HS(High speed main) mode:  $V_{DD} = 2.7\text{ V}$  to  $5.5\text{ V}$  @  $1\text{ MHz}$  to  $24\text{ MHz}$   
 $V_{DD} = 2.4\text{ V}$  to  $5.5\text{ V}$  @  $1\text{ MHz}$  to  $16\text{ MHz}$   
 LS(Low speed main) mode:  $V_{DD} = 1.8\text{ V}$  to  $5.5\text{ V}$  @  $1\text{ MHz}$  to  $8\text{ MHz}$

- Remarks**
1.  $f_{MX}$ : High-speed system clock frequency (X1 clock oscillation frequency or external main system clock frequency)
  2.  $f_{IH}$ : high-speed on-chip oscillator clock frequency
  3. Except temperature condition of the TYP. value is  $T_A = 25^\circ\text{C}$ , other than STOP mode



## (2) 30-pin products

 $(T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V})$ 

(1/2)

Parameter	Symbol	Conditions					MIN.	TYP.	MAX.	Unit
Supply current <small>Note 1</small>	$I_{DD1}$	Operating mode	HS (High-speed main) mode <small>Note 4</small>	$f_{IH} = 24\text{ MHz}$ <small>Note 3</small>	Basic operation	$V_{DD} = 5.0\text{ V}$		1.5		mA
						$V_{DD} = 3.0\text{ V}$		1.5		
				$f_{IH} = 16\text{ MHz}$ <small>Note 3</small>	Normal operation	$V_{DD} = 5.0\text{ V}$		3.7	5.5	mA
						$V_{DD} = 3.0\text{ V}$		3.7	5.5	
			LS (Low-speed main) mode <small>Note 4</small>	$f_{IH} = 8\text{ MHz}$ <small>Note 3</small>		$V_{DD} = 5.0\text{ V}$		2.7	4.0	mA
						$V_{DD} = 3.0\text{ V}$		2.7	4.0	
			HS (High-speed main) mode <small>Note 4</small>	$f_{MX} = 20\text{ MHz}$ <small>Note 2</small> , $V_{DD} = 5.0\text{ V}$		$V_{DD} = 3.0\text{ V}$		1.2	1.8	mA
						$V_{DD} = 2.0\text{ V}$		1.2	1.8	
						Square wave input		3.0	4.6	mA
						Resonator connection		3.2	4.8	
				$f_{MX} = 20\text{ MHz}$ <small>Note 2</small> , $V_{DD} = 3.0\text{ V}$		Square wave input		3.0	4.6	mA
						Resonator connection		3.2	4.8	
				$f_{MX} = 10\text{ MHz}$ <small>Note 2</small> , $V_{DD} = 5.0\text{ V}$		Square wave input		1.9	2.7	mA
						Resonator connection		1.9	2.7	
			LS (Low-speed main) mode <small>Note 4</small>	$f_{MX} = 10\text{ MHz}$ <small>Note 2</small> , $V_{DD} = 3.0\text{ V}$		Square wave input		1.9	2.7	mA
						Resonator connection		1.9	2.7	
				$f_{MX} = 8\text{ MHz}$ <small>Note 2</small> , $V_{DD} = 3.0\text{ V}$		Square wave input		1.1	1.7	mA
						Resonator connection		1.1	1.7	
				$f_{MX} = 8\text{ MHz}$ <small>Note 2</small> , $V_{DD} = 2.0\text{ V}$		Square wave input		1.1	1.7	mA
						Resonator connection		1.1	1.7	

**Notes** 1. Total current flowing into  $V_{DD}$ , including the input leakage current flowing when the level of the input pin is fixed to  $V_{DD}$  or  $V_{SS}$ . The values below the MAX. column include the peripheral operation current. However, not including the current flowing into the A/D converter, LVD circuit, I/O port, and on-chip pull-up/pull-down resistors and the current flowing during data flash rewrite.

2. When high-speed on-chip oscillator clock is stopped.

3. When high-speed system clock is stopped

4. Relationship between operation voltage width, operation frequency of CPU and operation mode is as follows.

HS(High speed main) mode:  $V_{DD} = 2.7\text{ V}$  to  $5.5\text{ V}$  @  $1\text{ MHz}$  to  $24\text{ MHz}$

$V_{DD} = 2.4\text{ V}$  to  $5.5\text{ V}$  @  $1\text{ MHz}$  to  $16\text{ MHz}$

LS(Low speed main) mode:  $V_{DD} = 1.8\text{ V}$  to  $5.5\text{ V}$  @  $1\text{ MHz}$  to  $8\text{ MHz}$

**Remarks** 1.  $f_{MX}$ : High-speed system clock frequency (X1 clock oscillation frequency or external main system clock frequency)

2.  $f_{IH}$ : high-speed on-chip oscillator clock frequency

3. Temperature condition of the TYP. value is  $T_A = 25^\circ\text{C}$ .

## (2) 30-pin products

 $(T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )

(2/2)

Parameter	Symbol	Conditions				MIN.	TYP.	MAX.	Unit	
Supply current <sup>Note 1</sup>	I <sub>DD2</sub> <sup>Note 2</sup>	HALT mode	HS (High-speed main) mode <sup>Note 6</sup>	f <sub>IH</sub> = 24 MHz <sup>Note 4</sup>	V <sub>DD</sub> = 5.0 V		440	1280	μA	
					V <sub>DD</sub> = 3.0 V		440	1280		
				f <sub>IH</sub> = 16 MHz <sup>Note 4</sup>	V <sub>DD</sub> = 5.0 V		400	1000	μA	
					V <sub>DD</sub> = 3.0 V		400	1000		
			LS (Low-speed main) mode <sup>Note 6</sup>	f <sub>IH</sub> = 8 MHz <sup>Note 4</sup>	V <sub>DD</sub> = 3.0 V		260	530	μA	
					V <sub>DD</sub> = 2.0 V		260	530		
			HS (High-speed main) mode <sup>Note 6</sup>	f <sub>MX</sub> = 20 MHz <sup>Note 3</sup> , V <sub>DD</sub> = 5.0 V	Square wave input		280	1000	μA	
					Resonator connection		450	1170		
				f <sub>MX</sub> = 20 MHz <sup>Note 3</sup> , V <sub>DD</sub> = 3.0 V	Square wave input		280	1000	μA	
					Resonator connection		450	1170		
				f <sub>MX</sub> = 10 MHz <sup>Note 3</sup> , V <sub>DD</sub> = 5.0 V	Square wave input		190	600	μA	
					Resonator connection		260	670		
				f <sub>MX</sub> = 10 MHz <sup>Note 3</sup> , V <sub>DD</sub> = 3.0 V	Square wave input		190	600	μA	
					Resonator connection		260	670		
	LS (Low-speed main) mode <sup>Note 6</sup>	f <sub>MX</sub> = 8 MHz <sup>Note 3</sup> , V <sub>DD</sub> = 3.0 V	Square wave input		95	330	μA			
			Resonator connection		145	380				
		f <sub>MX</sub> = 8 MHz <sup>Note 3</sup> , V <sub>DD</sub> = 2.0 V	Square wave input		95	330	μA			
			Resonator connection		145	380				
	I <sub>DD3</sub> <sup>Note 5</sup>	STOP mode	T <sub>A</sub> = −40°C					0.18	0.50	μA
			T <sub>A</sub> = +25°C					0.23	0.50	
			T <sub>A</sub> = +50°C					0.30	1.10	
			T <sub>A</sub> = +70°C					0.46	1.90	
			T <sub>A</sub> = +85°C					0.75	3.30	

**Notes** 1. Total current flowing into  $V_{DD}$ , including the input leakage current flowing when the level of the input pin is fixed to  $V_{DD}$  or  $V_{SS}$ . The values below the MAX. column include the peripheral operation current. However, not including the current flowing into the A/D converter, LVD circuit, I/O port, and on-chip pull-up/pull-down resistors and the current flowing during data flash rewrite.

2. During HALT instruction execution by flash memory.

3. When high-speed on-chip oscillator clock is stopped.

4. When high-speed system clock is stopped.

5. Not including the current flowing into the 12-bit interval timer and watchdog timer.

6. Relationship between operation voltage width, operation frequency of CPU and operation mode is as follows.

HS (High speed main) mode:  $V_{DD} = 2.7\text{ V}$  to  $5.5\text{ V}$  @  $1\text{ MHz}$  to  $24\text{ MHz}$

$V_{DD} = 2.4\text{ V}$  to  $5.5\text{ V}$  @  $1\text{ MHz}$  to  $16\text{ MHz}$

LS (Low speed main) mode:  $V_{DD} = 1.8\text{ V}$  to  $5.5\text{ V}$  @  $1\text{ MHz}$  to  $8\text{ MHz}$

**Remarks** 1.  $f_{MX}$ : High-speed system clock frequency (X1 clock oscillation frequency or external main system clock frequency)

2.  $f_{IH}$ : high-speed on-chip oscillator clock frequency

3. Except STOP mode, temperature condition of the TYP. value is  $T_A = 25^\circ\text{C}$ .

**(3) Peripheral functions (Common to all products)****(T<sub>A</sub> = -40 to +85°C, 1.8 V ≤ V<sub>DD</sub> ≤ 5.5 V, V<sub>SS</sub> = 0 V)**

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Low-speed onchip oscillator operating current	I <sub>FIL</sub> <sup>Note 1</sup>				0.20		μA
12-bit interval timer operating current	I <sub>TMKA</sub> <sup>Notes 1, 2, 3</sup>				0.02		μA
Watchdog timer operating current	I <sub>WDT</sub> <sup>Notes 1, 2, 4</sup>	f <sub>IL</sub> = 15 kHz			0.22		μA
A/D converter operating current	I <sub>ADC</sub> <sup>Notes 1, 5</sup>	When conversion at maximum speed	Normal mode, AV <sub>REFP</sub> = V <sub>DD</sub> = 5.0 V		1.30	1.70	mA
			Low voltage mode, AV <sub>REFP</sub> = V <sub>DD</sub> = 3.0 V		0.50	0.70	mA
A/D converter reference voltage operating current	I <sub>ADREF</sub> <sup>Note 1</sup>				75.0		μA
Temperature sensor operating current	I <sub>TMPS</sub> <sup>Note 1</sup>				75.0		μA
LVD operating current	I <sub>LVD</sub> <sup>Notes 1, 6</sup>				0.08		μA
Self-programming operating current	I <sub>FSP</sub> <sup>Notes 1, 8</sup>				2.00	12.20	mA
BGO operating current	I <sub>BGO</sub> <sup>Notes 1, 7</sup>				2.00	12.20	mA
SNOOZE operating current	I <sub>SNOZ</sub> <sup>Note 1</sup>	ADC operation	The mode is performed <sup>Note 9</sup>		0.50	0.60	mA
			The A/D conversion operations are performed, Low voltage mode, AV <sub>REFP</sub> = V <sub>DD</sub> = 3.0 V		1.20	1.44	mA
		CSI/UART operation			0.70	0.84	mA

**Notes** 1. Current flowing to the V<sub>DD</sub>.

2. When high speed on-chip oscillator and high-speed system clock are stopped.

3. Current flowing only to the 12-bit interval timer (excluding the operating current of the low-speed on-chip oscillator). The current value of the RL78 microcontrollers is the sum of I<sub>DD1</sub>, I<sub>DD2</sub> or I<sub>DD3</sub>, and I<sub>FIL</sub> and I<sub>TMKA</sub> when the 12-bit interval timer operates.4. Current flowing only to the watchdog timer (including the operating current of the low-speed on-chip oscillator). The current value of the RL78 microcontrollers is the sum of I<sub>DD1</sub>, I<sub>DD2</sub> or I<sub>DD3</sub> and I<sub>WDT</sub> when the watchdog timer operates.5. Current flowing only to the A/D converter. The current value of the RL78 microcontrollers is the sum of I<sub>DD1</sub> or I<sub>DD2</sub> and I<sub>ADC</sub> when the A/D converter operates in an operation mode or the HALT mode.6. Current flowing only to the LVD circuit. The current value of the RL78 microcontrollers is the sum of I<sub>DD1</sub>, I<sub>DD2</sub> or I<sub>DD3</sub> and I<sub>LVD</sub> when the LVD circuit operates.

7. Current flowing only during data flash rewrite.

8. Current flowing only during self programming.

9. For shift time to the SNOOZE mode, see **17.3.3 SNOOZE mode**.**Remarks** 1. f<sub>IL</sub>: Low-speed on-chip oscillator clock frequency2. Temperature condition of the TYP. value is T<sub>A</sub> = 25°C

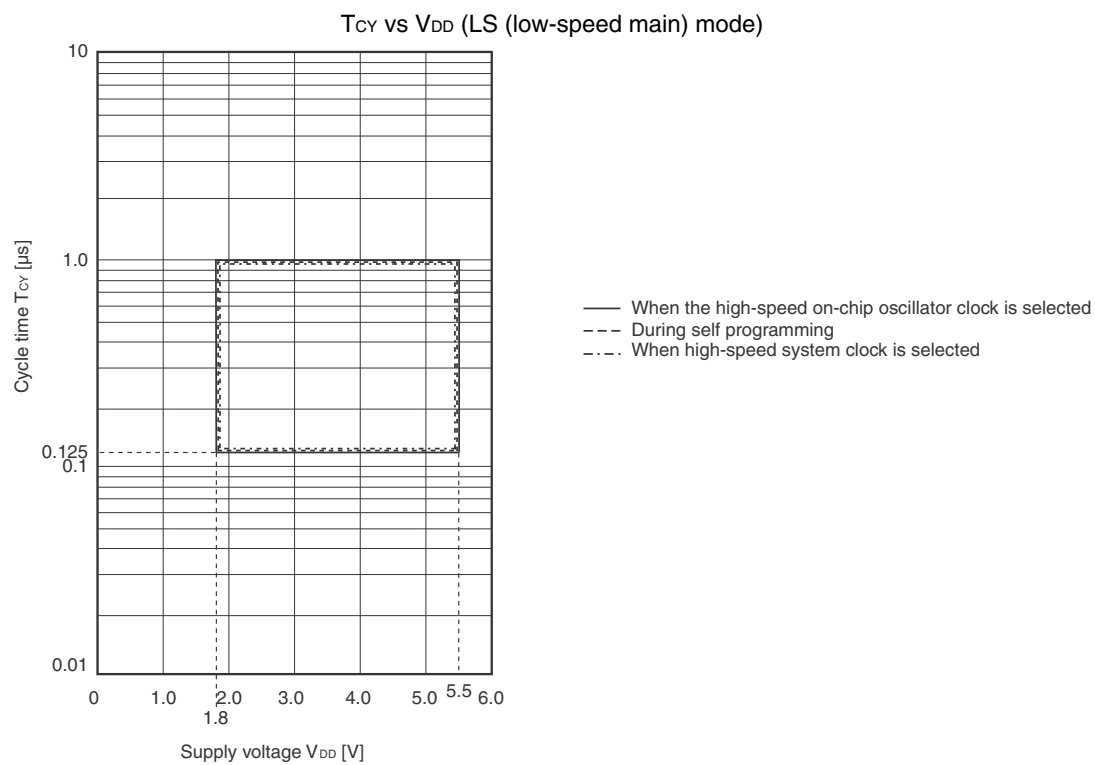
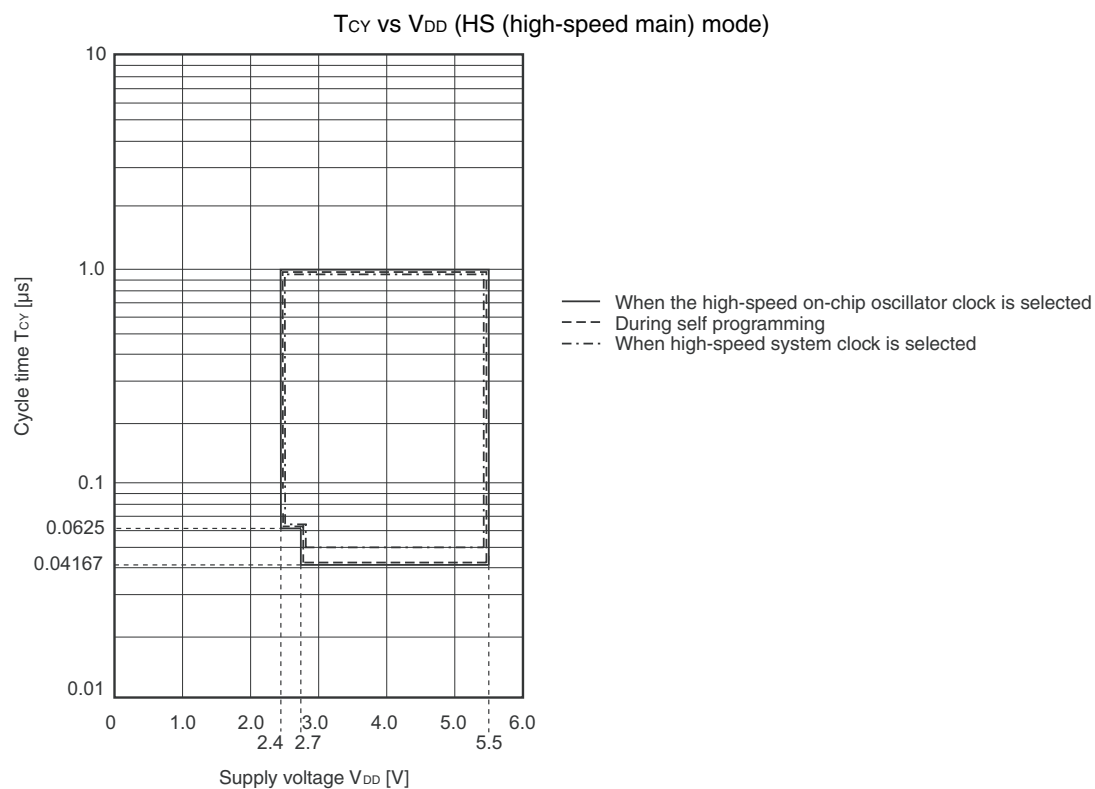
## 2.4 AC Characteristics

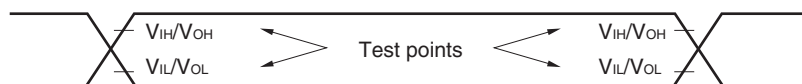
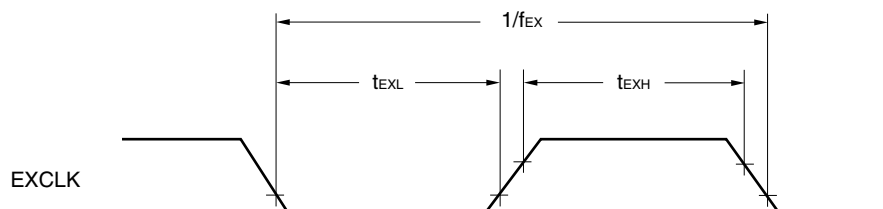
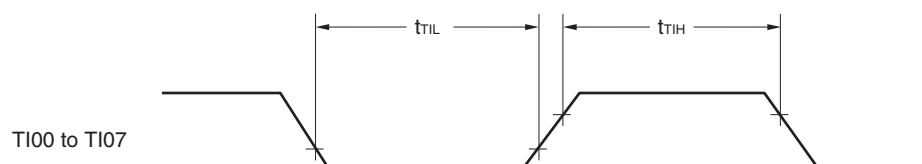
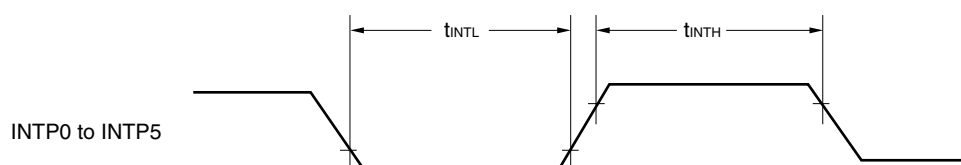
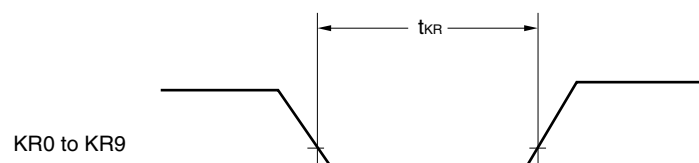
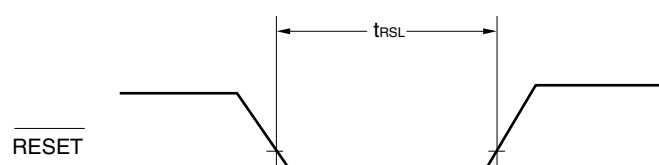
(TA = -40 to +85°C, 1.8 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

Items	Symbol	Conditions			MIN.	TYP.	MAX.	Unit
Instruction cycle (minimum instruction execution time)	TCY	Main system clock (fMAIN) operation	HS (High-speed main) mode	2.7 V ≤ VDD ≤ 5.5 V	0.04167		1	μs
				2.4 V ≤ VDD < 2.7 V	0.0625		1	μs
			LS (Low-speed main) mode	1.8 V ≤ VDD ≤ 5.5 V	0.125		1	μs
		During self programming	HS (High-speed main) mode	2.7 V ≤ VDD ≤ 5.5 V	0.04167		1	μs
				2.4 V ≤ VDD < 2.7 V	0.0625		1	μs
			LS (Low-speed main) mode	1.8 V ≤ VDD ≤ 5.5 V	0.125		1	μs
External main system clock frequency	fEX	2.7 V ≤ VDD ≤ 5.5 V			1.0		20.0	MHz
		2.4 V ≤ VDD < 2.7 V			1.0		16.0	MHz
		1.8 V ≤ VDD < 2.4 V			1.0		8.0	MHz
External main system clock input high-level width, low-level width	tEXH, tEXL	2.7 V ≤ VDD ≤ 5.5 V			24			ns
		2.4 V ≤ VDD < 2.7 V			30			ns
		1.8 V ≤ VDD < 2.4 V			60			ns
TI00 to TI07 input high-level width, low-level width	tTIH, tTIL				1/fMCK + 10			ns
TO00 to TO07 output frequency	fTO	4.0 V ≤ VDD ≤ 5.5 V					12	MHz
		2.7 V ≤ VDD < 4.0 V					8	MHz
		1.8 V ≤ VDD < 2.7 V					4	MHz
PCLBUZ0, or PCLBUZ1 output frequency	fPCL	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
INTP0 to INTP5 input high-level width, low-level width	tINTH, tINTL				1			μs
KR0 to KR9 input available width	tKR				250			ns
RESET low-level width	tRSL				10			μs

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

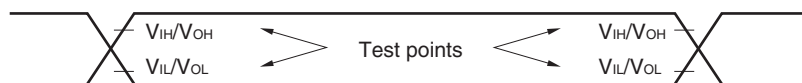
(Operation clock to be set by the timer clock select register 0 (TPS0) and the CKS0n bit of timer mode register 0n (TMR0n). n: Channel number (n = 0 to 7))

**Minimum Instruction Execution Time during Main System Clock Operation**

**AC Timing Test Point****External Main System Clock Timing****TI/TO Timing****Interrupt Request Input Timing****Key Interrupt Input Timing****RESET Input Timing**

## 2.5 Peripheral Functions Characteristics

### AC Timing Test Point



### 2.5.1 Serial array unit

#### (1) During communication at same potential (UART mode)

( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )

Parameter	Symbol	Conditions	HS (high-speed main) Mode		LS (low-speed main) Mode		Unit
			MIN.	MAX.	MIN.	MAX.	
Transfer rate				$f_{MCK}/6$		$f_{MCK}/6$	bps
Note 1		Theoretical value of the maximum transfer rate $f_{CLK} = f_{MCK}$ <sup>Note2</sup>		4.0		1.3	Mbps

**Notes** 1. Transfer rate in the SNOOZE mode is 4800 bps only.

2. The maximum operating frequencies of the CPU/peripheral hardware clock ( $f_{CLK}$ ) are:

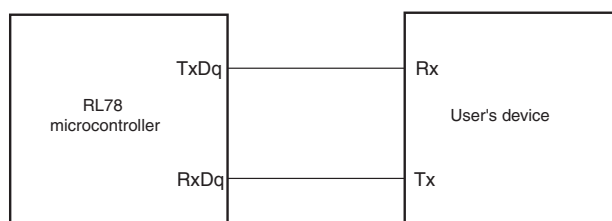
HS (high-speed main) mode: 24 MHz ( $2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ )

16 MHz ( $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ )

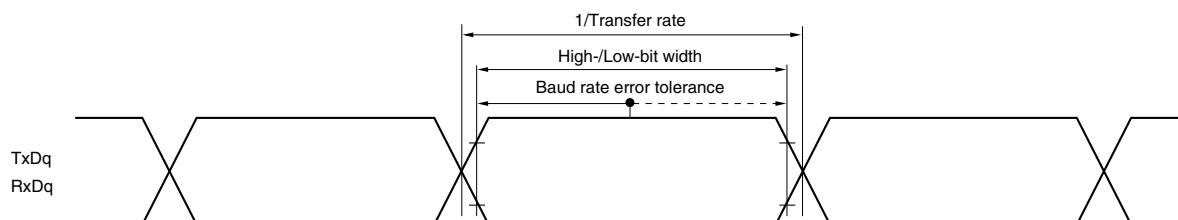
LS (low-speed main) mode: 8 MHz ( $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ )

**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).

#### UART mode connection diagram (during communication at same potential)



#### UART mode bit width (during communication at same potential) (reference)



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

2.  $f_{MCK}$ : Serial array unit operation clock frequency

(Operation clock to be set by the serial clock select register m (SPSm) and the CKSmn bit of serial mode register mn (SMRmn).

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

**(2) During communication at same potential (CSI mode) (master mode, SCK00... internal clock output, corresponding CSI00 only)**

**(T<sub>A</sub> = -40 to +85°C, 2.7 V ≤ V<sub>DD</sub> ≤ 5.5 V, V<sub>SS</sub> = 0 V)**

Parameter	Symbol	Conditions	HS (high-speed main) Mode		LS (low-speed main) Mode		Unit
			MIN.	MAX.	MIN.	MAX.	
SCK00 cycle time	t <sub>KCY1</sub>	t <sub>KCY1</sub> ≥ 2/f <sub>CLK</sub>	83.3		250		ns
SCK00 high-/low-level width	t <sub>KH1</sub> , t <sub>KL1</sub>	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V	t <sub>KCY1</sub> /2-7		t <sub>KCY1</sub> /2-50		ns
		2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V	t <sub>KCY1</sub> /2-10		t <sub>KCY1</sub> /2-50		ns
SI00 setup time (to SCK00↑) <sup>Note 1</sup>	t <sub>SIK1</sub>	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V	23		110		ns
		2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V	33		110		ns
SI00 hold time (from SCK00↑) <sup>Note 2</sup>	t <sub>KSI1</sub>		10		10		ns
Delay time from SCK00↓ to SO00 output <sup>Note 3</sup>	t <sub>KSO1</sub>	C = 20 pF <sup>Note 4</sup>		10		10	ns

- Notes**
1. When DAP00 = 0 and CKP00 = 0, or DAP00 = 1 and CKP00 = 1. The SI00 setup time becomes “to SCK00↓” when DAP00 = 0 and CKP00 = 1, or DAP00 = 1 and CKP00 = 0.
  2. When DAP00 = 0 and CKP00 = 0, or DAP00 = 1 and CKP00 = 1. The SI00 hold time becomes “from SCK00↓” when DAP00 = 0 and CKP00 = 1, or DAP00 = 1 and CKP00 = 0.
  3. When DAP00 = 0 and CKP00 = 0, or DAP00 = 1 and CKP00 = 1. The delay time to SO00 output becomes “from SCK00↑” when DAP00 = 0 and CKP00 = 1, or DAP00 = 1 and CKP00 = 0.
  4. C is the load capacitance of the SCK00 and SO00 output lines.

**Caution** Select the normal input buffer for the SI00 pin and the normal output mode for the SO00 and SCK00 pins by using port input mode register 1 (PIM1) and port output mode register 1 (POM1).

- Remarks**
1. This specification is valid only when CSI00's peripheral I/O redirect function is not used.
  2. f<sub>MCK</sub>: Serial array unit operation clock frequency  
(Operation clock to be set by the serial clock select register 0 (SPS0) and the CKS00 bit of serial mode register 00 (SMR00).)



**(3) During communication at same potential (CSI mode) (master mode, SCKp... internal clock output)****(T<sub>A</sub> = -40 to +85°C, 1.8 V ≤ V<sub>DD</sub> ≤ 5.5 V, V<sub>SS</sub> = 0 V)**

Parameter	Symbol	Conditions		HS (high-speed main) Mode		LS (low-speed main) Mode		Unit
				MIN.	MAX.	MIN.	MAX.	
SCKp cycle time	t <sub>KCY1</sub>	t <sub>KCY1</sub> ≥ 4/f <sub>CLK</sub>	2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V	167		500		ns
			2.4 V ≤ V <sub>DD</sub> ≤ 5.5 V	250		500		ns
			1.8 V ≤ V <sub>DD</sub> ≤ 5.5 V	–		500		ns
SCKp high-/low-level width	t <sub>KH1</sub> , t <sub>KL1</sub>	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V		t <sub>KCY1</sub> /2–12		t <sub>KCY1</sub> /2–50		ns
		2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V		t <sub>KCY1</sub> /2–18		t <sub>KCY1</sub> /2–50		ns
		2.4 V ≤ V <sub>DD</sub> ≤ 5.5 V		t <sub>KCY1</sub> /2–38		t <sub>KCY1</sub> /2–50		ns
		1.8 V ≤ V <sub>DD</sub> ≤ 5.5 V		–		t <sub>KCY1</sub> /2–50		ns
Slp setup time (to SCKp↑) <small>Note 1</small>	t <sub>SIK1</sub>	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V		44		110		ns
		2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V		44		110		ns
		2.4 V ≤ V <sub>DD</sub> ≤ 5.5 V		75		110		ns
		1.8 V ≤ V <sub>DD</sub> ≤ 5.5 V		–		110		ns
Slp hold time (from SCKp↑) <small>Note 2</small>	t <sub>SH1</sub>			19		19		ns
Delay time from SCKp↓ to SOp output <small>Note 3</small>	t <sub>KSO1</sub>	C = 30 pF <small>Note 4</small>			25		25	ns

- Notes**
1. When DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1. The Slp setup time becomes “to SCKp↓” when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.
  2. When DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1. The Slp hold time becomes “from SCKp↓” when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.
  3. 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.
  4. 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 and SCKp pins by using port input mode register 1 (PIM1) and port output mode registers 0, 1, 4 (POM0, POM1, POM4).

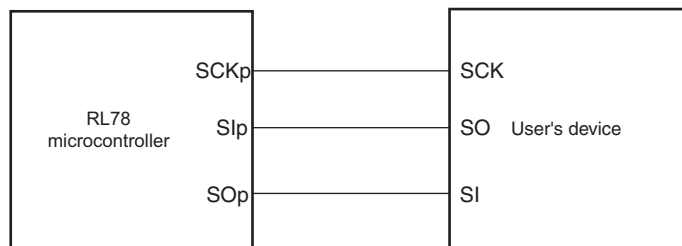
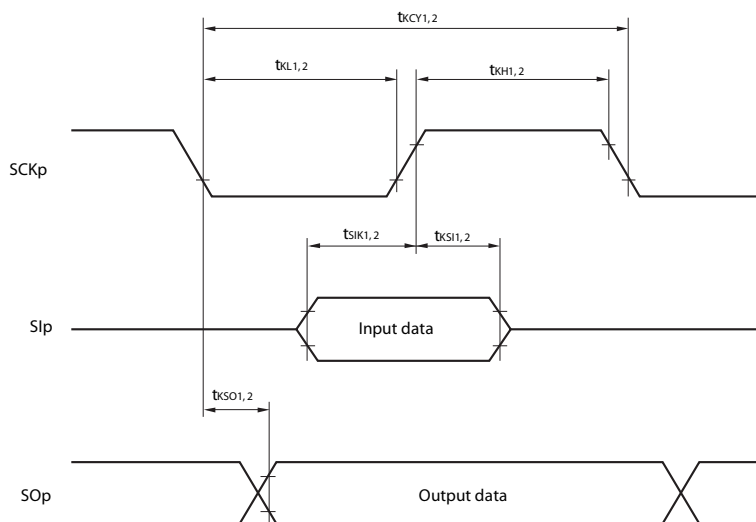
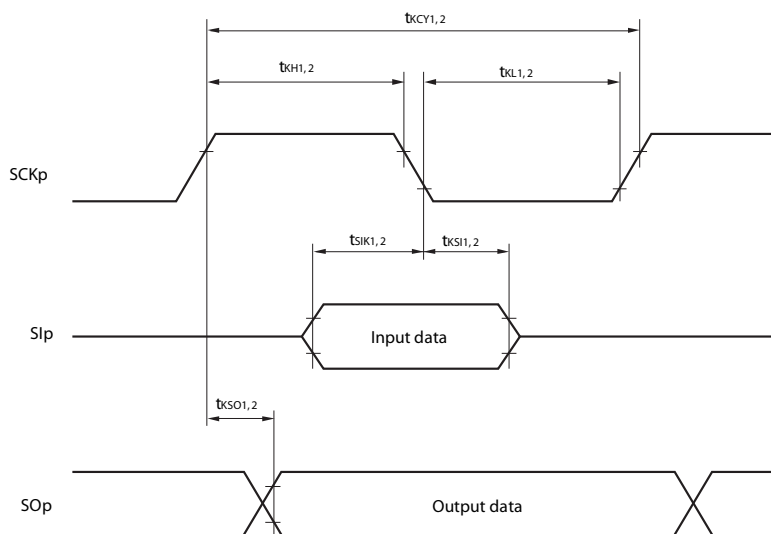
- Remarks**
1. p: CSI number (p = 00, 01, 11, 20), m: Unit number (m = 0, 1), n: Channel number (n = 0, 1, 3: “1, 3” is only for the R5F102 products)
  2. f<sub>MCK</sub>: Serial array unit operation clock frequency  
(Operation clock to be set by the serial clock select register m (SPSm) and the CKSmn bit of serial mode register mn (SMRmn). m: Unit number (m = 0, 1), n: Channel number (n = 0, 1, 3: “1, 3” is only for the R5F102 products.))

**(4) During communication at same potential (CSI mode) (slave mode, SCKp... external clock input)****( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )**

Parameter	Symbol	Conditions		HS (high-speed main) Mode		LS (low-speed main) Mode		Unit
				MIN.	MAX.	MIN.	MAX.	
SCKp cycle time <sup>Note 4</sup>	$t_{KCY2}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	$20\text{ MHz} < f_{MCK}$	$8/f_{MCK}$		—		ns
			$f_{MCK} \leq 20\text{ MHz}$	$6/f_{MCK}$		$6/f_{MCK}$		ns
		$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	$16\text{ MHz} < f_{MCK}$	$8/f_{MCK}$		—		ns
			$f_{MCK} \leq 16\text{ MHz}$	$6/f_{MCK}$		$6/f_{MCK}$		ns
		$2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		$6/f_{MCK}$ and 500		$6/f_{MCK}$ and 500		ns
		$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		—		$6/f_{MCK}$ and 750		ns
SCKp high-/low-level width	$t_{KH2}$ , $t_{KL2}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		$t_{KCY2}/2-7$		$t_{KCY2}/2-7$		ns
		$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		$t_{KCY2}/2-8$		$t_{KCY2}/2-8$		ns
		$2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		$t_{KCY2}/2-18$		$t_{KCY2}/2-18$		ns
		$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		—		$t_{KCY2}/2-18$		ns
Slp setup time (to SCKp $\uparrow$ ) <sup>Note 1</sup>	$t_{SIK2}$	$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		$1/f_{MCK} + 20$		$1/f_{MCK} + 30$		ns
		$2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		$1/f_{MCK} + 30$		$1/f_{MCK} + 30$		ns
		$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		—		$1/f_{MCK} + 30$		ns
Slp hold time (from SCKp $\uparrow$ ) <sup>Note 2</sup>	$t_{KSI2}$			$1/f_{MCK} + 31$		$1/f_{MCK} + 31$		ns
Delay time from SCKp $\downarrow$ to SOp output <sup>Note 3</sup>	$t_{KSO2}$	$C = 30\text{ pF}$ <sup>Note 4</sup>	$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		$2/f_{MCK} + 44$		$2/f_{MCK} + 110$	ns
			$2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		$2/f_{MCK} + 75$		$2/f_{MCK} + 110$	ns
			$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		—		$2/f_{MCK} + 110$	ns

- Notes**
1. When  $DAPmn = 0$  and  $CKPmn = 0$ , or  $DAPmn = 1$  and  $CKPmn = 1$ . The Slp setup time becomes “to SCKp $\downarrow$ ” when  $DAPmn = 0$  and  $CKPmn = 1$ , or  $DAPmn = 1$  and  $CKPmn = 0$ .
  2. When  $DAPmn = 0$  and  $CKPmn = 0$ , or  $DAPmn = 1$  and  $CKPmn = 1$ . The Slp hold time becomes “from SCKp $\downarrow$ ” when  $DAPmn = 0$  and  $CKPmn = 1$ , or  $DAPmn = 1$  and  $CKPmn = 0$ .
  3. When  $DAPmn = 0$  and  $CKPmn = 0$ , or  $DAPmn = 1$  and  $CKPmn = 1$ . The delay time to SOp output becomes “from SCKp $\uparrow$ ” when  $DAPmn = 0$  and  $CKPmn = 1$ , or  $DAPmn = 1$  and  $CKPmn = 0$ .
  4. C is the load capacitance of the SOp output lines.
  5. Transfer rate in the SNOOZE mode: MAX. 1 Mbps

**Caution** Select the normal input buffer for the Slp and SCKp pins and the normal output mode for the SOp pin by using port input mode register 1 (PIM1) and port output mode registers 0, 1, 4 (POM0, POM1, POM4).

**CSI mode connection diagram (during communication at same potential)****CSI mode serial transfer timing (during communication at same potential)  
(When DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1.)****CSI mode serial transfer timing (during communication at same potential)  
(When DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.)**

(Remarks are listed on the next page.)

- Remarks 1.** p: CSI number (p = 00, 01, 11, 20), m: Unit number (m = 0, 1), n: Channel number (n = 0, 1, 3: "1, 3" is only for the R5F102 products.)
- 2.**  $f_{MCK}$ : Serial array unit operation clock frequency  
(Operation clock to be set by the serial clock select register m (SPSm) and the CKSmn bit of serial mode register mn (SMRmn). m: Unit number (m = 0, 1), n: Channel number (n = 0, 1, 3: "1, 3" is only for the R5F102 products.))

**(5) During communication at same potential (simplified I<sup>2</sup>C mode)**

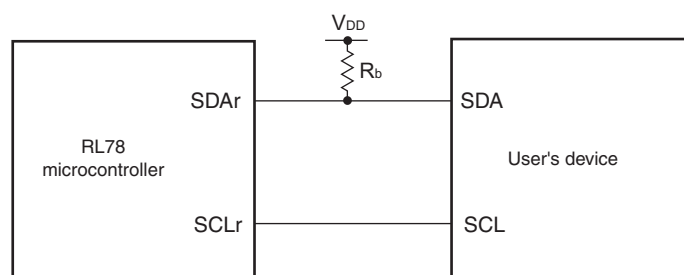
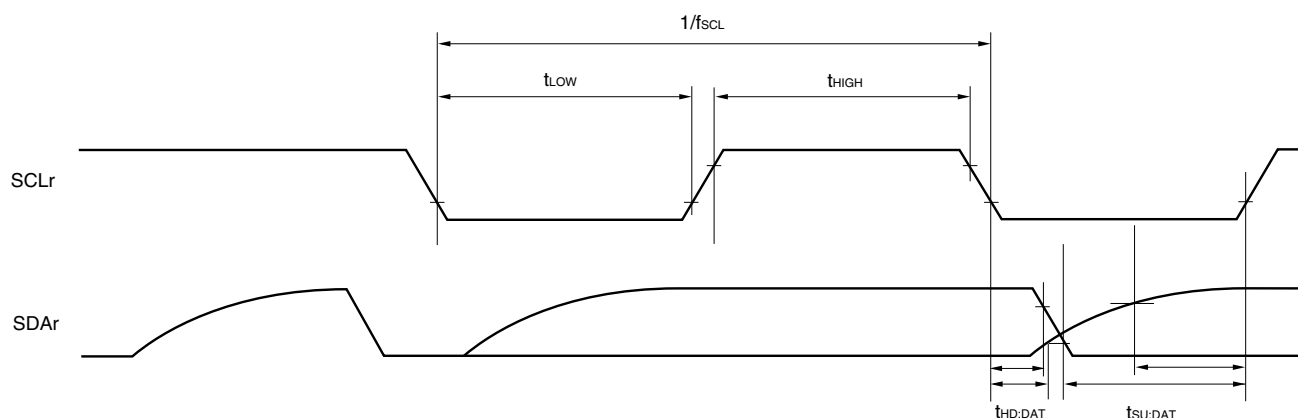
**( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )**

Parameter	Symbol	Conditions	HS (high-speed main) Mode LS (low-speed main) Mode		Unit
			MIN.	MAX.	
SCLr clock frequency	$f_{SCL}$	$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 3\text{ k}\Omega$		400 <sup>Note 1</sup>	kHz
		$1.8\text{ V} \leq V_{DD} < 2.7\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 5\text{ k}\Omega$		300 <sup>Note 1</sup>	kHz
Hold time when SCLr = "L"	$t_{LOW}$	$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 3\text{ k}\Omega$	1150		ns
		$1.8\text{ V} \leq V_{DD} < 2.7\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 5\text{ k}\Omega$	1550		ns
Hold time when SCLr = "H"	$t_{HIGH}$	$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 3\text{ k}\Omega$	1150		ns
		$1.8\text{ V} \leq V_{DD} < 2.7\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 5\text{ k}\Omega$	1550		ns
Data setup time (reception)	$t_{SU:DAT}$	$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 3\text{ k}\Omega$	$1/f_{MCK} + 145$ <sup>Note 2</sup>		ns
		$1.8\text{ V} \leq V_{DD} < 2.7\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 5\text{ k}\Omega$	$1/f_{MCK} + 230$ <sup>Note 2</sup>		ns
Data hold time (transmission)	$t_{HD:DAT}$	$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 3\text{ k}\Omega$	0	355	ns
		$1.8\text{ V} \leq V_{DD} < 2.7\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 5\text{ k}\Omega$	0	405	ns

- Notes 1.** The value must also be equal to or less than  $f_{MCK}/4$ .
- 2.** Set  $t_{SU:DAT}$  so that it will not exceed the hold time when SCLr = "L" or SCLr = "H".

**Caution** Select the N-ch open drain output ( $V_{DD}$  tolerance) mode for SDAr by using port output mode register h (POMh).

(Remarks are listed on the next page.)

**Simplified I<sup>2</sup>C mode connection diagram (during communication at same potential)****Simplified I<sup>2</sup>C mode serial transfer timing (during communication at same potential)**

- Remarks**
1.  $R_b$  [ $\Omega$ ]: Communication line (SDAr) pull-up resistance  
 $C_b$  [F]: Communication line (SCLr, SDAr) load capacitance
  2.  $r$ : IIC number ( $r = 00, 01, 11, 20$ ),  $h$ : = POM number ( $h = 0, 1, 4, 5$ )
  3.  $f_{MCK}$ : Serial array unit operation clock frequency  
 (Operation clock to be set by the serial clock select register  $m$  (SPSm) and the CKSmn bit of serial mode register  $mn$  (SMRmn).  $m$ : Unit number ( $m = 0, 1$ ),  $n$ : Channel number ( $0, 1, 3$ ))
  4. Simplified I<sup>2</sup>C mode is supported only by the R5F102 products.

**(6) Communication at different potential (1.8 V, 2.5 V, 3 V) (UART mode)****(T<sub>A</sub> = -40 to +85°C, 1.8 V ≤ V<sub>DD</sub> ≤ 5.5 V, V<sub>SS</sub> = 0 V)**

Parameter	Symbol	Conditions	HS (high-speed main) Mode		LS (low-speed main) Mode		Unit
			MIN.	MAX.	MIN.	MAX.	
Transfer rate <small>Note4</small>		Reception	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V, 2.7 V ≤ V <sub>b</sub> ≤ 4.0 V			f <sub>MCK</sub> /6 <small>Note1</small>	bps
			Theoretical value of the maximum transfer rate f <sub>MCK</sub> = f <sub>CLK</sub> <small>Note3</small>			4.0	Mbps
			2.7 V ≤ V <sub>DD</sub> < 4.0 V, 2.3 V ≤ V <sub>b</sub> ≤ 2.7 V			f <sub>MCK</sub> /6 <small>Note1</small>	bps
			Theoretical value of the maximum transfer rate f <sub>MCK</sub> = f <sub>CLK</sub> <small>Note3</small>			4.0	Mbps
			1.8 V ≤ V <sub>DD</sub> < 3.3 V, 1.6 V ≤ V <sub>b</sub> ≤ 2.0 V			f <sub>MCK</sub> /6 <small>Notes1, 2</small>	bps
			Theoretical value of the maximum transfer rate f <sub>MCK</sub> = f <sub>CLK</sub> <small>Note3</small>			4.0	Mbps
		Transmission	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V, 2.7 V ≤ V <sub>b</sub> ≤ 4.0 V			<b>Note4</b>	bps
			Theoretical value of the maximum transfer rate C <sub>b</sub> = 50 pF, R <sub>b</sub> = 1.4 kΩ, V <sub>b</sub> = 2.7 V			2.8 <small>Note5</small>	Mbps
			2.7 V ≤ V <sub>DD</sub> < 4.0 V, 2.3 V ≤ V <sub>b</sub> ≤ 2.7 V			<b>Note6</b>	bps
			Theoretical value of the maximum transfer rate C <sub>b</sub> = 50 pF, R <sub>b</sub> = 2.7 kΩ, V <sub>b</sub> = 2.3 V			1.2 <small>Note7</small>	Mbps
			1.8 V ≤ V <sub>DD</sub> < 3.3 V, 1.6 V ≤ V <sub>b</sub> ≤ 2.0 V			<b>Notes 2, 8</b>	bps
			Theoretical value of the maximum transfer rate C <sub>b</sub> = 50 pF, R <sub>b</sub> = 5.5 kΩ, V <sub>b</sub> = 1.6 V			0.43 <small>Note9</small>	Mbps

**Notes** 1. Transfer rate in the SNOOZE mode is 4800 bps only.2. Use it with V<sub>DD</sub> ≥ V<sub>b</sub>.3. The maximum operating frequencies of the CPU/peripheral hardware clock (f<sub>CLK</sub>) are:HS (high-speed main) mode: 24 MHz (2.7 V ≤ V<sub>DD</sub> ≤ 5.5 V)16 MHz (2.4 V ≤ V<sub>DD</sub> ≤ 5.5 V)LS (low-speed main) mode: 8 MHz (1.8 V ≤ V<sub>DD</sub> ≤ 5.5 V)4. The smaller maximum transfer rate derived by using f<sub>MCK</sub>/6 or the following expression is the valid maximum transfer rate.Expression for calculating the transfer rate when 4.0 V ≤ V<sub>DD</sub> ≤ 5.5 V and 2.7 V ≤ V<sub>b</sub> ≤ 4.0 V

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

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

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

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

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  $2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$  and  $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$

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

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

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

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

8. 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  $1.8\text{ V} \leq V_{DD} < 3.3\text{ V}$ ,  $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$

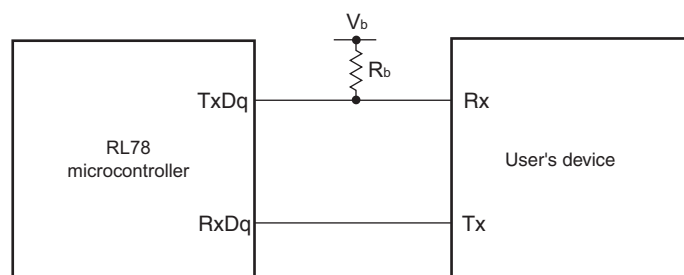
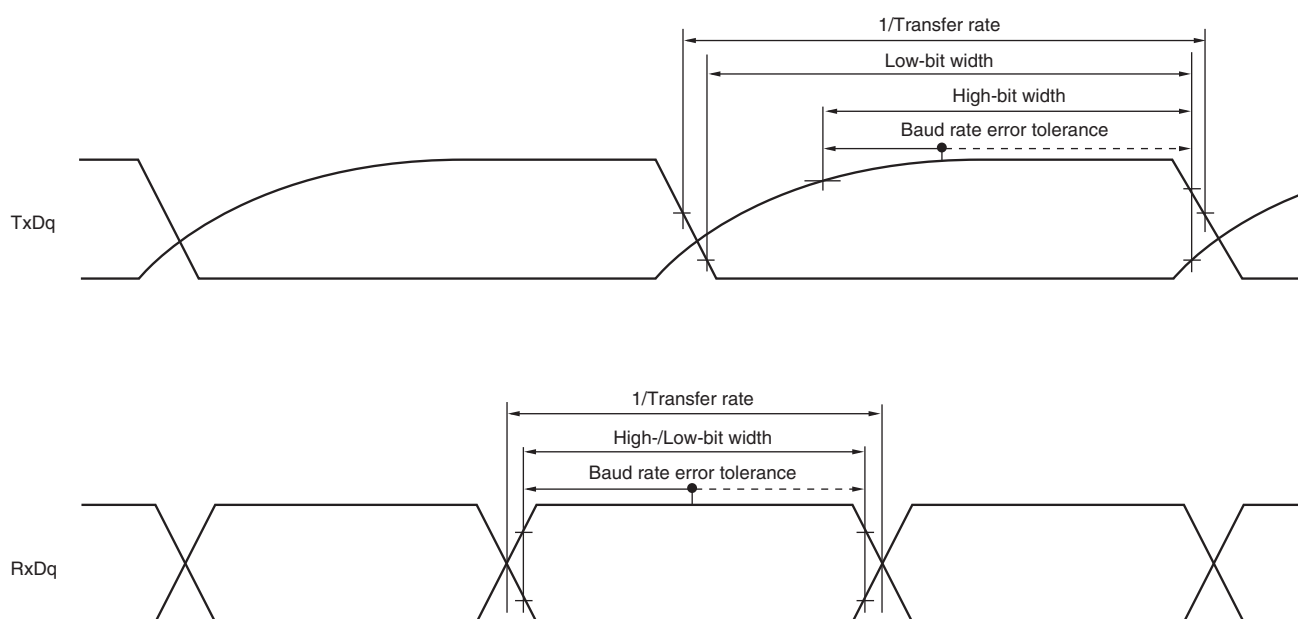
$$\text{Maximum transfer rate} = \frac{1}{\{-C_b \times R_b \times \ln(1 - \frac{1.5}{V_b})\} \times 3} \quad [\text{bps}]$$

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

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

9. This value as an example is calculated when the conditions described in the “Conditions” column are met. Refer to **Note 8** 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 ( $V_{DD}$  tolerance) 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.**

**UART mode connection diagram (during communication at different potential)****UART mode bit width (during communication at different potential) (reference)**

- Remarks**
1.  $R_b[\Omega]$ : Communication line (TxDq) pull-up resistance,  $C_b[\text{F}]$ : Communication line (TxDq) load capacitance,  $V_b[\text{V}]$ : Communication line voltage
  2. q: UART number (q = 0 to 2), g: PIM and POM number (g = 0, 1)
  3.  $f_{\text{MCK}}$ : Serial array unit operation clock frequency  
(Operation clock to be set by the serial clock select register m (SPSm) and the CKSmn bit of serial mode register mn (SMRmn).  
m: Unit number, n: Channel number (mn = 00 to 03, 10, 11))
  4. UART0 of the 20- and 24-pin products supports communication at different potential only when the peripheral I/O redirection function is not used.



## (7) Communication at different potential (2.5 V, 3 V) (CSI mode) (master mode, SCK00... internal clock output, corresponding CSI00 only)

 $(T_A = -40$  to  $+85^\circ\text{C}$ ,  $2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )

Parameter	Symbol	Conditions		HS (high-speed main) Mode		LS (low-speed main) Mode		Unit
				MIN.	MAX.	MIN.	MAX.	
SCK00 cycle time	$t_{KCY1}$	$t_{KCY1} \geq 2/f_{CLK}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 20\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$	200		1150		ns
			$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 20\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$	300		1150		ns
SCK00 high-level width	$t_{KH1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 20\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$		$t_{KCY1}/2 - 50$		$t_{KCY1}/2 - 50$		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 20\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$		$t_{KCY1}/2 - 120$		$t_{KCY1}/2 - 120$		ns
SCK00 low-level width	$t_{KL1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 20\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$		$t_{KCY1}/2 - 7$		$t_{KCY1}/2 - 50$		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 20\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$		$t_{KCY1}/2 - 10$		$t_{KCY1}/2 - 50$		ns
SI00 setup time (to SCK00 $\uparrow$ ) <sup>Note 1</sup>	$t_{SIK1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 20\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$		58		479		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 20\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$		121		479		ns
SI00 hold time (from SCK00 $\uparrow$ ) <sup>Note 1</sup>	$t_{KSI1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 20\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$		10		10		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 20\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$		10		10		ns
Delay time from SCK00 $\downarrow$ to SO00 output <sup>Note 1</sup>	$t_{KSO1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 20\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$			60		60	ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 20\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$			130		130	ns
SI00 setup time (to SCK00 $\downarrow$ ) <sup>Note 2</sup>	$t_{SIK1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 20\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$		23		110		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 20\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$		33		110		ns
SI00 hold time (from SCK00 $\downarrow$ ) <sup>Note 2</sup>	$t_{KSI1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 20\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$		10		10		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 20\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$		10		10		ns
Delay time from SCK00 $\uparrow$ to SO00 output <sup>Note 2</sup>	$t_{KSO1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 20\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$			10		10	ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 20\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$			10		10	ns

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

- Notes**
1. When DAP00 = 0 and CKP00 = 0, or DAP00 = 1 and CKP00 = 1
  2. When DAP00 = 0 and CKP00 = 1, or DAP00 = 1 and CKP00 = 0.

**Caution** Select the TTL input buffer for the SI00 pin and the N-ch open drain output ( $V_{DD}$  tolerance) mode for the SO00 pin and SCK00 pin by using port input mode register 1 (PIM1) and port output mode register 1 (POM1).  
**For  $V_{IH}$  and  $V_{IL}$ , see the DC characteristics with TTL input buffer selected.**

- Remarks**
1.  $R_b$  [ $\Omega$ ]: Communication line (SCK00, SO00) pull-up resistance,  $C_b$  [F]: Communication line (SCK00, SO00) load capacitance,  $V_b$  [V]: Communication line voltage
  2.  $f_{MCK}$ : Serial array unit operation clock frequency  
(Operation clock to be set by the serial clock select register 0 (SPS0) and the CKS00 bit of serial mode register 00 (SMR00).)

**(8) Communication at different potential (1.8 V, 2.5 V, 3 V) (CSI mode) (master mode, SCKp... internal clock output) (1/3)****( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )**

Parameter	Symbol	Conditions		HS (high-speed main) Mode		LS (low-speed main) Mode		Unit
				MIN.	MAX.	MIN.	MAX.	
SCKp cycle time	$t_{KCY1}$	$t_{KCY1} \geq 4/f_{CLK}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$	300		1150		ns
			$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$	500		1150		ns
			$1.8\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}^{\text{Note}}$ , $C_b = 30\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$	1150		1150		ns
SCKp high-level width	$t_{KH1}$		$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$	$t_{KCY1}/2 - 75$		$t_{KCY1}/2 - 75$		ns
			$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$	$t_{KCY1}/2 - 170$		$t_{KCY1}/2 - 170$		ns
			$1.8\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}^{\text{Note}}$ , $C_b = 30\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$	$t_{KCY1}/2 - 458$		$t_{KCY1}/2 - 458$		ns
SCKp low-level width	$t_{KL1}$		$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$	$t_{KCY1}/2 - 12$		$t_{KCY1}/2 - 50$		ns
			$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$	$t_{KCY1}/2 - 18$		$t_{KCY1}/2 - 50$		ns
			$1.8\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}^{\text{Note}}$ , $C_b = 30\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$	$t_{KCY1}/2 - 50$		$t_{KCY1}/2 - 50$		ns

**Note** Use it with  $V_{DD} \geq V_b$ .

**Cautions 1.** Select the TTL input buffer for the SIp pin and the N-ch open drain output ( $V_{DD}$  tolerance) mode for the SOp pin and SCKp pin by using port input mode register 1 (PIM1) and port output mode register 1 (POM1). For  $V_{IH}$  and  $V_{IL}$ , see the DC characteristics with TTL input buffer selected.

**2.** CSI01 and CSI11 cannot communicate at different potential.

**Remarks 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

**2.** p: CSI number (p = 00, 20)

**(8) Communication at different potential (1.8 V, 2.5 V, 3 V) (CSI mode) (master mode, SCKp... internal clock output) (2/3)****( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )**

Parameter	Symbol	Conditions	HS (high-speed main) Mode		LS (low-speed main) Mode		Unit
			MIN.	MAX.	MIN.	MAX.	
Slp setup time (to SCKp $\uparrow$ ) <sup>Note 1</sup>	$t_{SIK1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$	81		479		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$	177		479		ns
		$1.8\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ <sup>Note 2</sup> , $C_b = 30\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$	479		479		ns
Slp hold time (from SCKp $\uparrow$ ) <sup>Note 1</sup>	$t_{KSI1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$	19		19		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$	19		19		ns
		$1.8\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ <sup>Note 2</sup> , $C_b = 30\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$	19		19		ns
Delay time from SCKp $\downarrow$ to SOp output <sup>Note 1</sup>	$t_{KSO1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$		100		100	ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$		195		195	ns
		$1.8\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ <sup>Note 2</sup> , $C_b = 30\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$		483		483	ns

**Notes** 1. When DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1.2. Use it with  $V_{DD} \geq V_b$ .

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

**(8) Communication at different potential (1.8 V, 2.5 V, 3 V) (CSI mode) (master mode, SCKp... internal clock output) (3/3)****( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )**

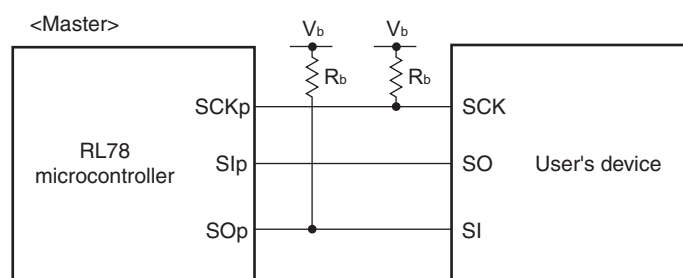
Parameter	Symbol	Conditions	HS (high-speed main) Mode		LS (low-speed main) Mode		Unit
			MIN.	MAX.	MIN.	MAX.	
Slp setup time (to SCKp↓) <sup>Note 1</sup>	$t_{SIK1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$	44		110		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$	44		110		ns
		$1.8\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ <sup>Note 2</sup> , $C_b = 30\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$	110		110		ns
Slp hold time (from SCKp↓) <sup>Note 1</sup>	$t_{KSI1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$	19		19		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$	19		19		ns
		$1.8\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ <sup>Note 2</sup> , $C_b = 30\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$	19		19		ns
Delay time from SCKp↑ to SOp output <sup>Note 1</sup>	$t_{KSO1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$		25		25	ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$		25		25	ns
		$1.8\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ <sup>Note 2</sup> , $C_b = 30\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$		25		25	ns

**Notes** 1. When DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.2. Use it with  $V_{DD} \geq V_b$ .**Cautions** 1. Select the TTL input buffer for the Slp pin and the N-ch open drain output ( $V_{DD}$  tolerance) mode for the SOp pin and SCKp pin by using port input mode register 1 (PIM1) and port output mode register 1 (POM1). For  $V_{IH}$  and  $V_{IL}$ , see the DC characteristics with TTL input buffer selected.

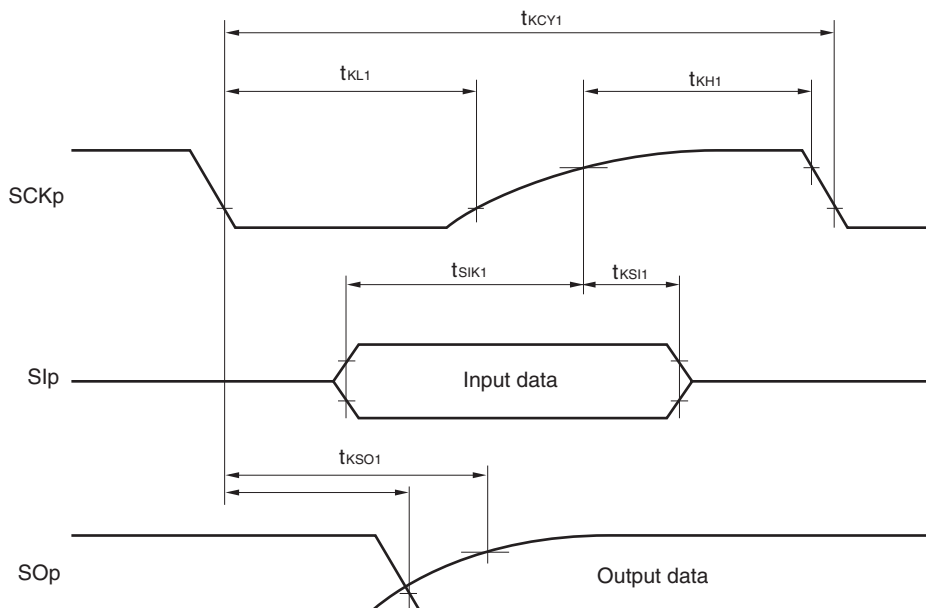
2. CSI01 and CSI11 cannot communicate at different potential.

**Remarks** 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

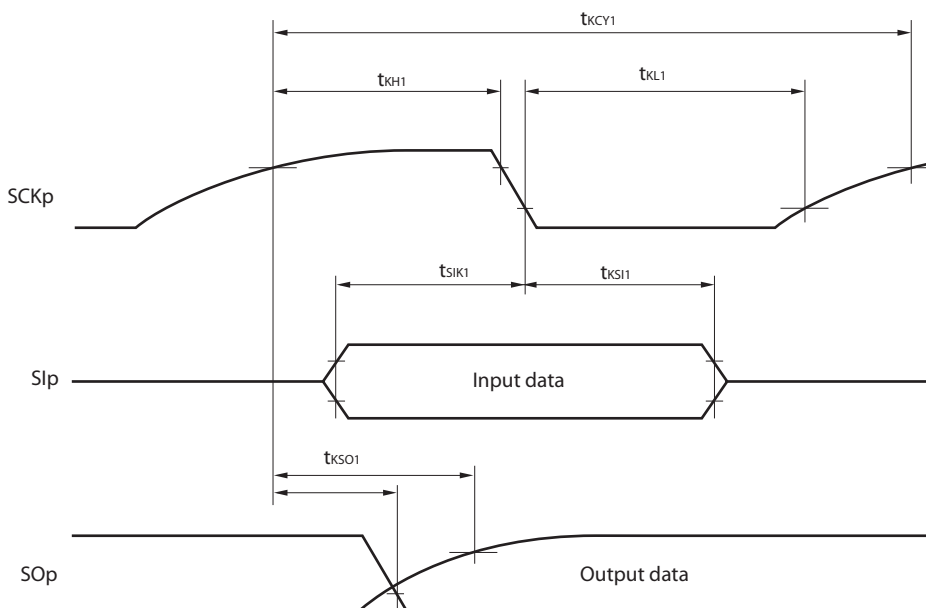
2. p: CSI number (p = 00, 20), m: Unit number (m = 0, 1), n: Channel number (n = 0)

**CSI mode connection diagram (during communication at different potential)**

**CSI mode serial transfer timing (master mode) (during communication at different potential)**  
**(When DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1)**



**CSI mode serial transfer timing (master mode) (during communication at different potential)**  
**(When DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.)**



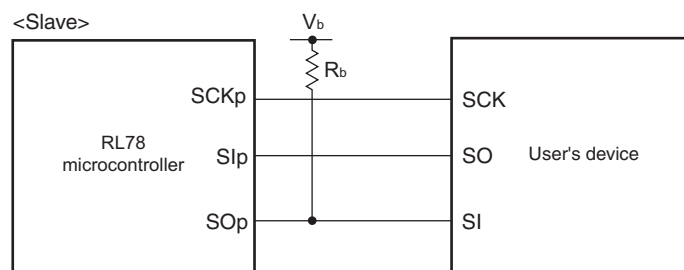
**(9) Communication at different potential (1.8 V, 2.5 V, 3 V) (CSI mode) (slave mode, SCKp... external clock input)**  
**(T<sub>A</sub> = -40 to +85°C, 1.8 V ≤ V<sub>DD</sub> ≤ 5.5 V, V<sub>SS</sub> = 0 V)**

Parameter	Symbol	Conditions		HS (high-speed main) Mode		LS (low-speed main) Mode		Unit
				MIN.	MAX.	MIN.	MAX.	
SCKp cycle time <sup>Note 1</sup>	t <sub>KCY2</sub>	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V, 2.7 V ≤ V <sub>b</sub> ≤ 4.0 V	20 MHz < f <sub>MCK</sub> ≤ 24 MHz	12/f <sub>MCK</sub>		—		ns
			8 MHz < f <sub>MCK</sub> ≤ 20 MHz	10/f <sub>MCK</sub>		—		ns
			4 MHz < f <sub>MCK</sub> ≤ 8 MHz	8/f <sub>MCK</sub>		16/f <sub>MCK</sub>		ns
			f <sub>MCK</sub> ≤ 4 MHz	6/f <sub>MCK</sub>		10/f <sub>MCK</sub>		ns
		2.7 V ≤ V <sub>DD</sub> < 4.0 V, 2.3 V ≤ V <sub>b</sub> ≤ 2.7 V	20 MHz < f <sub>MCK</sub> ≤ 24 MHz	16/f <sub>MCK</sub>		—		ns
			16 MHz < f <sub>MCK</sub> ≤ 20 MHz	14/f <sub>MCK</sub>		—		ns
			8 MHz < f <sub>MCK</sub> ≤ 16 MHz	12/f <sub>MCK</sub>		—		ns
			4 MHz < f <sub>MCK</sub> ≤ 8 MHz	8/f <sub>MCK</sub>		16/f <sub>MCK</sub>		ns
			f <sub>MCK</sub> ≤ 4 MHz	6/f <sub>MCK</sub>		10/f <sub>MCK</sub>		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>	20 MHz < f <sub>MCK</sub> ≤ 24 MHz	36/f <sub>MCK</sub>		—		ns
			16 MHz < f <sub>MCK</sub> ≤ 20 MHz	32/f <sub>MCK</sub>		—		ns
			8 MHz < f <sub>MCK</sub> ≤ 16 MHz	26/f <sub>MCK</sub>		—		ns
			4 MHz < f <sub>MCK</sub> ≤ 8 MHz	16/f <sub>MCK</sub>		16/f <sub>MCK</sub>		ns
			f <sub>MCK</sub> ≤ 4 MHz	10/f <sub>MCK</sub>		10/f <sub>MCK</sub>		ns
SCKp high-/low-level width	t <sub>KH2</sub> , t <sub>KL2</sub>	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V, 2.7 V ≤ V <sub>b</sub> ≤ 4.0 V		t <sub>KCY2</sub> /2 - 12		t <sub>KCY2</sub> /2 - 50		ns
		2.7 V ≤ V <sub>DD</sub> < 4.0 V, 2.3 V ≤ V <sub>b</sub> ≤ 2.7 V		t <sub>KCY2</sub> /2 - 18		t <sub>KCY2</sub> /2 - 50		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>		t <sub>KCY2</sub> /2 - 50		t <sub>KCY2</sub> /2 - 50		ns
Slp setup time (to SCKp↑) <sup>Note 3</sup>	t <sub>SIK2</sub>	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V, 2.7 V ≤ V <sub>DD</sub> ≤ 4.0 V		1/f <sub>MCK</sub> + 20		1/f <sub>MCK</sub> + 30		ns
		2.7 V ≤ V <sub>DD</sub> < 4.0 V, 2.3 V ≤ V <sub>b</sub> ≤ 2.7 V		1/f <sub>MCK</sub> + 20		1/f <sub>MCK</sub> + 30		ns
		1.8 V ≤ V <sub>DD</sub> < 3.3 V, 1.6 V ≤ V <sub>DD</sub> ≤ 2.0 V <sup>Note 2</sup>		1/f <sub>MCK</sub> + 30		1/f <sub>MCK</sub> + 30		ns
Slp hold time (from SCKp↑) <sup>Note 4</sup>	t <sub>KSI2</sub>			1/f <sub>MCK</sub> + 31		1/f <sub>MCK</sub> + 31		ns
Delay time from SCKp↓ to SOP output <sup>Note 5</sup>	t <sub>KSO2</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> = 30 pF, R <sub>b</sub> = 1.4 kΩ			2/f <sub>MCK</sub> + 120		2/f <sub>MCK</sub> + 573	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> = 30 pF, R <sub>b</sub> = 2.7 kΩ			2/f <sub>MCK</sub> + 214		2/f <sub>MCK</sub> + 573	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> = 30 pF, R <sub>b</sub> = 5.5 kΩ			2/f <sub>MCK</sub> + 573		2/f <sub>MCK</sub> + 573	ns

- Notes**
1. Transfer rate in the SNOOZE mode: MAX. 1 Mbps
  2. Use it with V<sub>DD</sub> ≥ V<sub>b</sub>.
  3. When DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1. The Slp setup time becomes “to SCKp↓” when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.
  4. When DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1. The Slp hold time becomes “from SCKp↓” when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.
  5. 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.

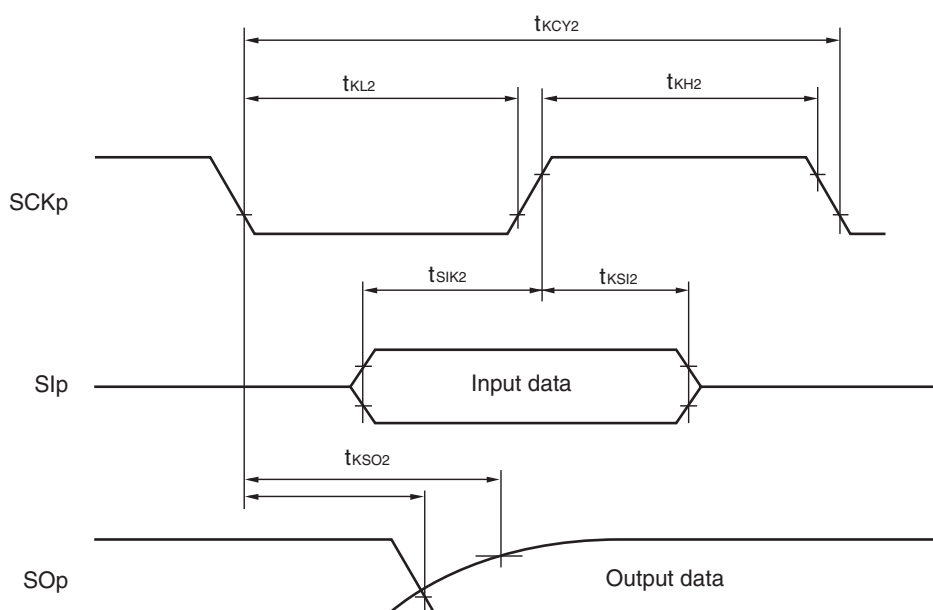
**Cautions**

1. Select the TTL input buffer for the Slp and SCKp pins and the N-ch open drain output (V<sub>DD</sub> tolerance) mode for the SOP pin by using port input mode register 1 (PIM1) and port output mode register 1 (POM1).  
**For V<sub>IH</sub> and V<sub>IL</sub>, see the DC characteristics with TTL input buffer selected.**
2. CSI01 and CSI11 cannot communicate at different potential.

**CSI mode connection diagram (during communication at different potential)**

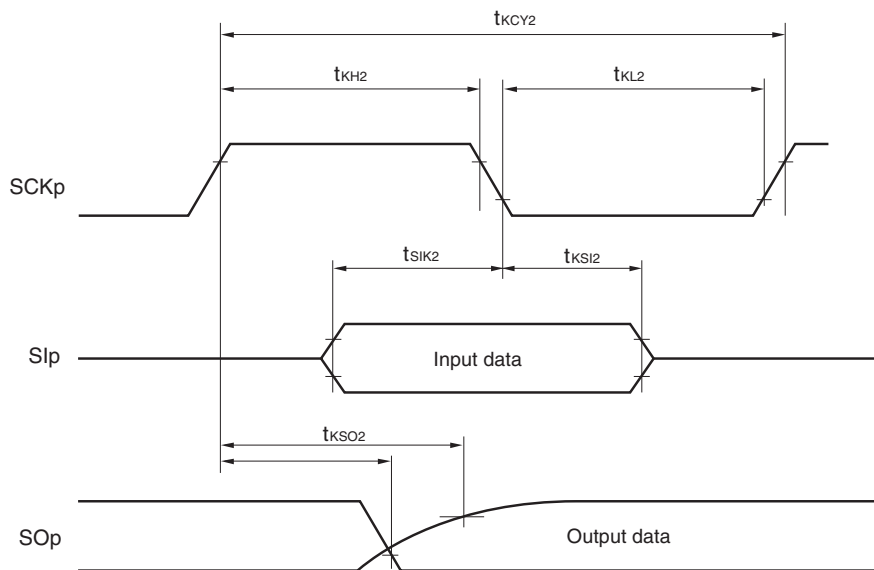
- Remarks**
1.  $R_b$  [ $\Omega$ ]: Communication line (SOp) pull-up resistance,  $C_b$  [F]: Communication line (SOp) load capacitance,  $V_b$  [V]: Communication line voltage
  2. p: CSI number ( $p = 00, 20$ ), m: Unit number ( $m = 0, 1$ ), n: Channel number ( $n = 0$ )
  3.  $f_{MCK}$ : Serial array unit operation clock frequency  
(Operation clock to be set by the serial clock select register m (SPSm) and the CKSmn bit of serial mode register mn (SMRmn). m: Unit number, n: Channel number ( $mn = 00, 10$ ))

**CSI mode serial transfer timing (slave mode) (during communication at different potential)**  
**(When DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1.)**





**CSI mode serial transfer timing (slave mode) (during communication at different potential)**  
**(When DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.)**



**Remark** p: CSI number (p = 00, 20), m: Unit number (m = 0, 1), n: Channel number (n = 0)

**(10) Communication at different potential (1.8 V, 2.5 V, 3 V) (simplified I<sup>2</sup>C mode)****( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )**

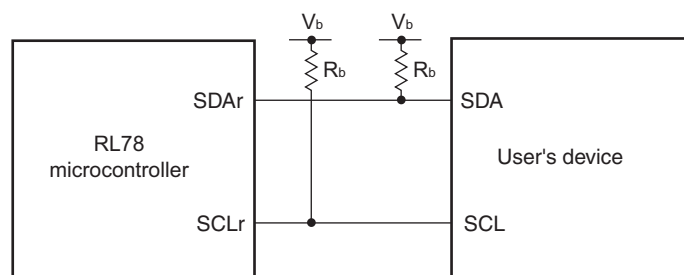
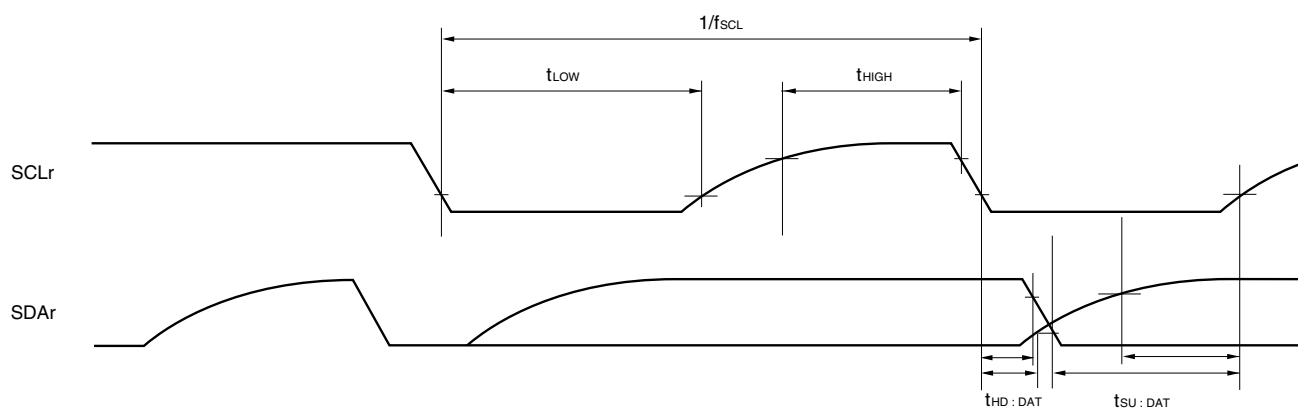
Parameter	Symbol	Conditions	HS (high-speed main) Mode		LS (low-speed main) Mode		Unit
			MIN.	MAX.	MIN.	MAX.	
SCLr clock frequency	$f_{SCL}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 2.8\text{ k}\Omega$		400 <sup>Note1</sup>		300 <sup>Note1</sup>	kHz
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$		400 <sup>Note1</sup>		300 <sup>Note1</sup>	kHz
		$1.8\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ , <sup>Note2</sup> $C_b = 100\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$		300 <sup>Note1</sup>		300 <sup>Note1</sup>	kHz
Hold time when SCLr = "L"	$t_{LOW}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 2.8\text{ k}\Omega$	1150		1550		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$	1150		1550		ns
		$1.8\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ , <sup>Note2</sup> $C_b = 100\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$	1550		1550		ns
Hold time when SCLr = "H"	$t_{HIGH}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 2.8\text{ k}\Omega$	675		610		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$	600		610		ns
		$1.8\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ , <sup>Note2</sup> $C_b = 100\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$	610		610		ns
Data setup time (reception)	$t_{SU:DAT}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 2.8\text{ k}\Omega$	$1/f_{MCK}$ + 190 <sup>Note3</sup>		$1/f_{MCK}$ + 190 <sup>Note3</sup>		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$	$1/f_{MCK}$ + 190 <sup>Note3</sup>		$1/f_{MCK}$ + 190 <sup>Note3</sup>		ns
		$1.8\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ , <sup>Note2</sup> $C_b = 100\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$	$1/f_{MCK}$ + 190 <sup>Note3</sup>		$1/f_{MCK}$ + 190 <sup>Note3</sup>		ns
Data hold time (transmission)	$t_{HD:DAT}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 2.8\text{ k}\Omega$	0	355	0	355	ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$	0	355	0	355	ns
		$1.8\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ , <sup>Note2</sup> $C_b = 100\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$	0	405	0	405	ns

**Notes** 1. The value must also be equal to or less than  $f_{MCK}/4$ .2. Use it with  $V_{DD} \geq V_b$ .3. Set  $t_{SU:DAT}$  so that it will not exceed the hold time when SCLr = "L" or SCLr = "H".

**Cautions** 1. Select the TTL input buffer and the N-ch open drain output ( $V_{DD}$  tolerance) mode for the SDAr pin and the N-ch open drain output ( $V_{DD}$  tolerance) mode for the SCLr pin by using port input mode register 1 (PIM1) and port output mode register 1 (POM1). For  $V_{IH}$  and  $V_{IL}$ , see the DC characteristics with TTL input buffer selected.

2. IIC01 and IIC11 cannot communicate at different potential.

(Remarks are listed on the next page.)

**Simplified I<sup>2</sup>C mode connection diagram (during communication at different potential)****Simplified I<sup>2</sup>C mode serial transfer timing (during communication at different potential)**

- Remarks**
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
  2. r: IIC Number (r = 00, 20)
  3.  $f_{MCK}$ : Serial array unit operation clock frequency  
(Operation clock to be set by the serial clock select register m (SPSm) and the CKSmn bit of serial mode register mn (SMRmn).  
m: Unit number (m = 0,1), n: Channel number (n = 0))
  4. Simplified I<sup>2</sup>C mode is supported only by the R5F102 products.

## 2.5.2 Serial interface IICA

(T<sub>A</sub> = -40 to +85°C, 1.8 V ≤ V<sub>DD</sub> ≤ 5.5 V, V<sub>SS</sub> = 0 V)

Parameter	Symbol	Conditions	HS (high-speed main) mode LS (low-speed main) mode				Unit
			Standard Mode		Fast Mode		
			MIN.	MAX.	MIN.	MAX.	
SCLA0 clock frequency	f <sub>SCL</sub>	Fast mode: f <sub>CLK</sub> ≥ 3.5 MHz			0	400	kHz
		Normal mode: f <sub>CLK</sub> ≥ 1 MHz	0	100			kHz
Setup time of restart condition	t <sub>SU:STA</sub>		4.7		0.6		μs
Hold time <sup>Note 1</sup>	t <sub>HD:STA</sub>		4.0		0.6		μs
Hold time when SCLA0 = “L”	t <sub>LOW</sub>		4.7		1.3		μs
Hold time when SCLA0 = “H”	t <sub>HIGH</sub>		4.0		0.6		μs
Data setup time (reception)	t <sub>SU:DAT</sub>		250		100		ns
Data hold time (transmission) <sup>Note 2</sup>	t <sub>HD:DAT</sub>		0	3.45	0	0.9	μs
Setup time of stop condition	t <sub>SU:STO</sub>		4.0		0.6		μs
Bus-free time	t <sub>BUF</sub>		4.7		1.3		μs

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

2. The maximum value (MAX.) of t<sub>HD:DAT</sub> is during normal transfer and a wait state is inserted in the ACK (acknowledge) timing.

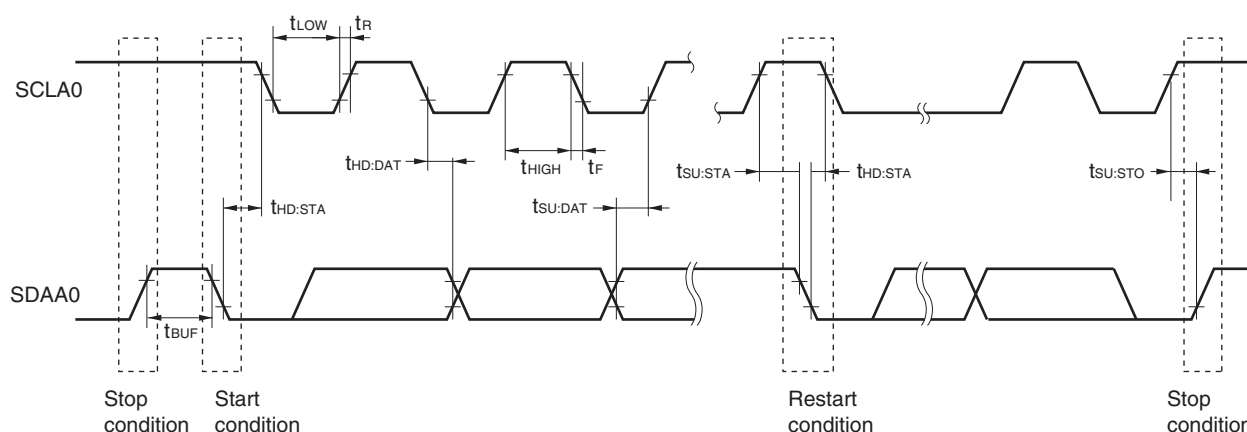
**Caution** Only in the 30-pin products, the values in the above table are applied even when bit 2 (PIOR2) in the peripheral I/O redirection register (PIOR) is 1. At this time, the pin characteristics (I<sub>OH1</sub>, I<sub>OL1</sub>, V<sub>OH1</sub>, V<sub>OL1</sub>) must satisfy the values in the redirect destination.

**Remark** The maximum value of C<sub>b</sub> (communication line capacitance) and the value of R<sub>b</sub> (communication line pull-up resistor) at that time in each mode are as follows.

Normal mode: C<sub>b</sub> = 400 pF, R<sub>b</sub> = 2.7 kΩ

Fast mode: C<sub>b</sub> = 320 pF, R<sub>b</sub> = 1.1 kΩ

IICA serial transfer timing



## 2.6 Analog Characteristics

### 2.6.1 A/D converter characteristics

#### Classification of A/D converter characteristics

Input channel	Reference Voltage		
	Reference voltage (+) = $AV_{REFP}$ Reference voltage (-) = $AV_{REFM}$	Reference voltage (+) = $V_{DD}$ Reference voltage (-) = $V_{SS}$	Reference voltage (+) = $V_{BGR}$ Reference voltage (-) = $AV_{REFM}$
ANI0 to ANI3	Refer to 28.6.1 (1).	Refer to 28.6.1 (3).	Refer to 28.6.1 (4).
ANI16 to ANI22	Refer to 28.6.1 (2).		
Internal reference voltage Temperature sensor output voltage	Refer to 28.6.1 (1).		—

(1) When reference voltage (+) =  $AV_{REFP}/ANI0$  ( $ADREFP1 = 0$ ,  $ADREFP0 = 1$ ), reference voltage (-) =  $AV_{REFM}/ANI1$  ( $ADREFM = 1$ ), target pin: ANI2, ANI3, internal reference voltage, and temperature sensor output voltage

( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq AV_{REFP} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ , Reference voltage (+) =  $AV_{REFP}$ , Reference voltage (-) =  $AV_{REFM} = 0\text{ V}$ )

Parameter	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>			1.2	$\pm 3.5$	LSB
					1.2	$\pm 7.0$ <sup>Note 4</sup>	LSB
Conversion time	$t_{CONV}$	10-bit resolution Target pin: ANI2, ANI3	$3.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	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	$\mu\text{s}$
				57		95	$\mu\text{s}$
		10-bit resolution Target pin: Internal reference voltage, and temperature sensor output voltage (HS (high-speed main) mode)	$3.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	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 $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>				$\pm 0.25$	%FSR
						$\pm 0.50$ <sup>Note 4</sup>	%FSR
Full-scale error <sup>Notes 1, 2</sup>	EFS	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>				$\pm 0.25$	%FSR
						$\pm 0.50$ <sup>Note 4</sup>	%FSR
Integral linearity error <sup>Note 1</sup>	ILE	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>				$\pm 2.5$	LSB
						$\pm 5.0$ <sup>Note 4</sup>	LSB
Differential linearity error <sup>Note 1</sup>	DLE	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>				$\pm 1.5$	LSB
						$\pm 2.0$ <sup>Note 4</sup>	LSB
Analog input voltage	$V_{AIN}$	ANI2, ANI3		0		$AV_{REFP}$	V
		Internal reference voltage ( $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , HS (high-speed main) mode)		$V_{BGR}$ <sup>Note 5</sup>			V
		Temperature sensor output voltage ( $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , HS (high-speed main) mode)		$V_{TMPS25}$ <sup>Note 5</sup>			V

(Notes are listed on the next page.)

- Notes**
1. Excludes quantization error ( $\pm 1/2$  LSB).
  2. This value is indicated as a ratio (%FSR) to the full-scale value.
  3. When  $AV_{REFP} < V_{DD}$ , the MAX. values are as follows.  
 Overall error: Add  $\pm 1.0$  LSB to the MAX. value when  $AV_{REFP} = V_{DD}$ .  
 Zero-scale error/Full-scale error: Add  $\pm 0.05\%$ FSR to the MAX. value when  $AV_{REFP} = V_{DD}$ .  
 Integral linearity error/ Differential linearity error: Add  $\pm 0.5$  LSB to the MAX. value when  $AV_{REFP} = V_{DD}$ .
  4. Values when the conversion time is set to  $57\ \mu\text{s}$  (min.) and  $95\ \mu\text{s}$  (max.).
  5. Refer to **28.6.2 Temperature sensor/internal reference voltage characteristics**.

(2) When reference voltage (+) =  $AV_{REFP}/ANI0$  ( $ADREFP1 = 0$ ,  $ADREFP0 = 1$ ), reference voltage (–) =  $AV_{REFM}/ANI1$  ( $ADREFM = 1$ ), target pin: ANI16 to ANI22

( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\ \text{V} \leq AV_{REFP} \leq V_{DD} \leq 5.5\ \text{V}$ ,  $V_{SS} = 0\ \text{V}$ , Reference voltage (+) =  $AV_{REFP}$ , Reference voltage (–) =  $AV_{REFM} = 0\ \text{V}$ )

Parameter	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>			1.2	$\pm 5.0$	LSB
					1.2	$\pm 8.5$ <sup>Note 4</sup>	LSB
Conversion time	t <sub>CONV</sub>	10-bit resolution Target ANI pin: ANI16 to ANI22	$3.6\ \text{V} \leq V_{DD} \leq 5.5\ \text{V}$	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	$\mu\text{s}$
				57		95	$\mu\text{s}$
Zero-scale error <sup>Notes 1, 2</sup>	E <sub>ZS</sub>	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>				$\pm 0.35$	%FSR
						$\pm 0.60$ <sup>Note 4</sup>	%FSR
Full-scale error <sup>Notes 1, 2</sup>	E <sub>FS</sub>	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>				$\pm 0.35$	%FSR
						$\pm 0.60$ <sup>Note 4</sup>	%FSR
Integral linearity error <sup>Note 1</sup>	ILE	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>				$\pm 3.5$	LSB
						$\pm 6.0$ <sup>Note 4</sup>	LSB
Differential linearity error <sup>Note 1</sup>	DLE	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>				$\pm 2.0$	LSB
						$\pm 2.5$ <sup>Note 4</sup>	LSB
Analog input voltage	V <sub>AIN</sub>	ANI16 to ANI22		0		$AV_{REFP}$ and $V_{DD}$	V

- Notes**
1. Excludes quantization error ( $\pm 1/2$  LSB).
  2. This value is indicated as a ratio (%FSR) to the full-scale value.
  3. When  $AV_{REFP} \leq V_{DD}$ , the MAX. values are as follows.  
 Overall error: Add  $\pm 4.0$  LSB to the MAX. value when  $AV_{REFP} = V_{DD}$ .  
 Zero-scale error/Full-scale error: Add  $\pm 0.20\%$ FSR to the MAX. value when  $AV_{REFP} = V_{DD}$ .  
 Integral linearity error/ Differential linearity error: Add  $\pm 2.0$  LSB to the MAX. value when  $AV_{REFP} = V_{DD}$ .
  4. When the conversion time is set to  $57\ \mu\text{s}$  (min.) and  $95\ \mu\text{s}$  (max.).

(3) When reference voltage (+) =  $V_{DD}$  (ADREFP1 = 0, ADREFP0 = 0), reference voltage (–) =  $V_{SS}$  (ADREFM = 0), target pin: ANI0 to ANI3, ANI16 to ANI22, internal reference voltage, and temperature sensor output voltage

( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ , Reference voltage (+) =  $V_{DD}$ , Reference voltage (–) =  $V_{SS}$ )

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Resolution	RES			8		10	bit
Overall error <sup>Note 1</sup>	AINL	10-bit resolution			1.2	$\pm 7.0$	LSB
					1.2	$\pm 10.5$ <sup>Note 3</sup>	LSB
Conversion time	$t_{CONV}$	10-bit resolution Target pin: ANI0 to ANI3, ANI16 to ANI22	$3.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	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	$\mu\text{s}$
				57		95	$\mu\text{s}$
Conversion time	$t_{CONV}$	10-bit resolution Target pin: internal reference voltage, and temperature sensor output voltage (HS (high-speed main) mode)	$3.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	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>	EZX	10-bit resolution				$\pm 0.60$	%FSR
						$\pm 0.85$ <sup>Note 3</sup>	%FSR
Full-scale error <sup>Notes 1, 2</sup>	EFS	10-bit resolution				$\pm 0.60$	%FSR
						$\pm 0.85$ <sup>Note 3</sup>	%FSR
Integral linearity error <sup>Note 1</sup>	ILE	10-bit resolution				$\pm 4.0$	LSB
						$\pm 6.5$ <sup>Note 3</sup>	LSB
Differential linearity error <sup>Note 1</sup>	DLE	10-bit resolution				$\pm 2.0$	LSB
						$\pm 2.5$ <sup>Note 3</sup>	LSB
Analog input voltage	$V_{AIN}$	ANI0 to ANI3, ANI16 to ANI22		0		$V_{DD}$	V
		Internal reference voltage ( $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , HS (high-speed main) mode)		$V_{BGR}$ <sup>Note 4</sup>			V
		Temperature sensor output voltage ( $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , HS (high-speed main) mode)		$V_{TSPS25}$ <sup>Note 4</sup>			V

**Notes** 1. Excludes quantization error ( $\pm 1/2$  LSB).

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

3. When the conversion time is set to 57  $\mu\text{s}$  (min.) and 95  $\mu\text{s}$  (max.).

4. Refer to **28.6.2 Temperature sensor/internal reference voltage characteristics**.

(4) When reference voltage (+) = Internal reference voltage (ADREFP1 = 1, ADREFP0 = 0), reference voltage (-) = AV<sub>REFM</sub> (ADREFM = 1), target pin: ANI0, ANI2, ANI3, and ANI16 to ANI22

(T<sub>A</sub> = -40 to +85°C, 2.4 V ≤ V<sub>DD</sub> ≤ 5.5 V, V<sub>SS</sub> = 0 V, Reference voltage (+) = V<sub>BGR</sub><sup>Note 3</sup>, Reference voltage (-) = AV<sub>REFM</sub>  
<sup>Note 4</sup> = 0 V, HS (high-speed main) mode)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Resolution	RES		8			bit
Conversion time	t <sub>CONV</sub>	8-bit resolution	17		39	μs
Zero-scale error <sup>Notes 1, 2</sup>	EZS	8-bit resolution			±0.60	%FSR
Integral linearity error <sup>Note 1</sup>	ILE	8-bit resolution			±2.0	LSB
Differential linearity error <sup>Note 1</sup>	DLE	8-bit resolution			±1.0	LSB
Analog input voltage	V <sub>AIN</sub>		0		V <sub>BGR</sub> <sup>Note 3</sup>	V

**Notes** 1. Excludes quantization error (±1/2 LSB).

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

3. Refer to **28.6.2 Temperature sensor/internal reference voltage characteristics**.

4. When reference voltage (-) = V<sub>SS</sub>, the MAX. values are as follows.

Zero-scale error: Add ±0.35%FSR to the MAX. value when reference voltage (-) = AV<sub>REFM</sub>.

Integral linearity error: Add ±0.5 LSB to the MAX. value when reference voltage (-) = AV<sub>REFM</sub>.

Differential linearity error: Add ±0.2 LSB to the MAX. value when reference voltage (-) = AV<sub>REFM</sub>.



## 2.6.2 Temperature sensor/internal reference voltage characteristics

**( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ , HS (high-speed main) mode)**

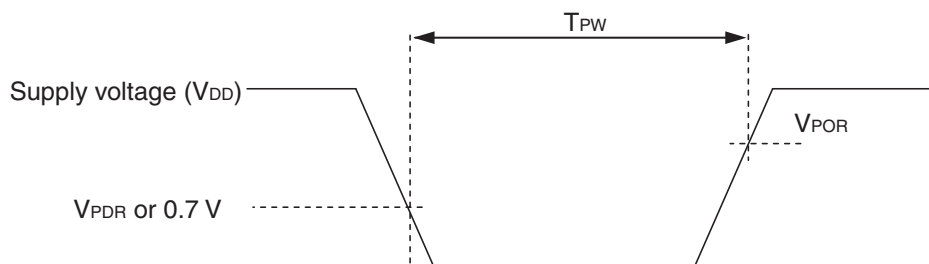
Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Temperature sensor output voltage	$V_{TMPS25}$	Setting ADS register = 80H, $T_A = +25^\circ\text{C}$		1.05		V
Internal reference voltage	$V_{BGR}$	Setting ADS register = 81H	1.38	1.45	1.50	V
Temperature coefficient	$F_{VTMPS}$	Temperature sensor output voltage that depends on the temperature		-3.6		mV/ $^\circ\text{C}$
Operation stabilization wait time	$t_{AMP}$		5			$\mu\text{s}$

## 2.6.3 POR circuit characteristics

**( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $V_{SS} = 0\text{ V}$ )**

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Detection voltage	$V_{POR}$	Power supply rise time	1.47	1.51	1.55	V
	$V_{PDR}$	Power supply fall time	1.46	1.50	1.54	V
Minimum pulse width <sup>Note</sup>	$T_{PW}$		300			$\mu\text{s}$

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



## 2.6.4 LVD circuit characteristics

## LVD Detection Voltage of Reset Mode and Interrupt Mode

(T<sub>A</sub> = -40 to +85°C, V<sub>PDR</sub> ≤ V<sub>DD</sub> ≤ 5.5 V, V<sub>SS</sub> = 0 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Detection supply voltage	V <sub>LVD0</sub>	Power supply rise time	3.98	4.06	4.14	V
		Power supply fall time	3.90	3.98	4.06	V
	V <sub>LVD1</sub>	Power supply rise time	3.68	3.75	3.82	V
		Power supply fall time	3.60	3.67	3.74	V
	V <sub>LVD2</sub>	Power supply rise time	3.07	3.13	3.19	V
		Power supply fall time	3.00	3.06	3.12	V
	V <sub>LVD3</sub>	Power supply rise time	2.96	3.02	3.08	V
		Power supply fall time	2.90	2.96	3.02	V
	V <sub>LVD4</sub>	Power supply rise time	2.86	2.92	2.97	V
		Power supply fall time	2.80	2.86	2.91	V
	V <sub>LVD5</sub>	Power supply rise time	2.76	2.81	2.87	V
		Power supply fall time	2.70	2.75	2.81	V
	V <sub>LVD6</sub>	Power supply rise time	2.66	2.71	2.76	V
		Power supply fall time	2.60	2.65	2.70	V
	V <sub>LVD7</sub>	Power supply rise time	2.56	2.61	2.66	V
		Power supply fall time	2.50	2.55	2.60	V
	V <sub>LVD8</sub>	Power supply rise time	2.45	2.50	2.55	V
		Power supply fall time	2.40	2.45	2.50	V
	V <sub>LVD9</sub>	Power supply rise time	2.05	2.09	2.13	V
		Power supply fall time	2.00	2.04	2.08	V
	V <sub>LVD10</sub>	Power supply rise time	1.94	1.98	2.02	V
		Power supply fall time	1.90	1.94	1.98	V
	V <sub>LVD11</sub>	Power supply rise time	1.84	1.88	1.91	V
		Power supply fall time	1.80	1.84	1.87	V
Minimum pulse width	t <sub>LW</sub>		300			μs
Detection delay time					300	μs

**LVD detection voltage of interrupt & reset mode****( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $V_{PDR} \leq V_{DD} \leq 5.5$  V,  $V_{SS} = 0$  V)**

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Interrupt and reset mode	V <sub>LVD0</sub>	V <sub>POC2</sub> , V <sub>POC1</sub> , V <sub>POC0</sub> = 0, 0, 1, falling reset voltage		1.80	1.84	1.87	V
	V <sub>LVD1</sub>	LVIS1, LVIS0 = 1, 0	Rising reset release voltage	1.94	1.98	2.02	V
			Falling interrupt voltage	1.90	1.94	1.98	V
	V <sub>LVD2</sub>	LVIS1, LVIS0 = 0, 1	Rising reset release voltage	2.05	2.09	2.13	V
			Falling interrupt voltage	2.00	2.04	2.08	V
	V <sub>LVD3</sub>	LVIS1, LVIS0 = 0, 0	Rising reset release voltage	3.07	3.13	3.19	V
			Falling interrupt voltage	3.00	3.06	3.12	V
	V <sub>LVD0</sub>	V <sub>POC2</sub> , V <sub>POC1</sub> , V <sub>POC0</sub> = 0, 1, 0, falling reset voltage		2.40	2.45	2.50	V
	V <sub>LVD1</sub>	LVIS1, LVIS0 = 1, 0	Rising reset release voltage	2.56	2.61	2.66	V
			Falling interrupt voltage	2.50	2.55	2.60	V
	V <sub>LVD2</sub>	LVIS1, LVIS0 = 0, 1	Rising reset release voltage	2.66	2.71	2.76	V
			Falling interrupt voltage	2.60	2.65	2.70	V
	V <sub>LVD3</sub>	LVIS1, LVIS0 = 0, 0	Rising reset release voltage	3.68	3.75	3.82	V
			Falling interrupt voltage	3.60	3.67	3.74	V
	V <sub>LVD0</sub>	V <sub>POC2</sub> , V <sub>POC1</sub> , V <sub>POC0</sub> = 0, 1, 1, falling reset voltage		2.70	2.75	2.81	V
	V <sub>LVD1</sub>	LVIS1, LVIS0 = 1, 0	Rising reset release voltage	2.86	2.92	2.97	V
			Falling interrupt voltage	2.80	2.86	2.91	V
	V <sub>LVD2</sub>	LVIS1, LVIS0 = 0, 1	Rising reset release voltage	2.96	3.02	3.08	V
			Falling interrupt voltage	2.90	2.96	3.02	V
	V <sub>LVD3</sub>	LVIS1, LVIS0 = 0, 0	Rising reset release voltage	3.98	4.06	4.14	V
			Falling interrupt voltage	3.90	3.98	4.06	V

**2.6.5 Power supply voltage rising slope characteristics****( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $V_{SS} = 0$  V)**

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Power supply voltage rising slope	S <sub>VDD</sub>				54	V/ms

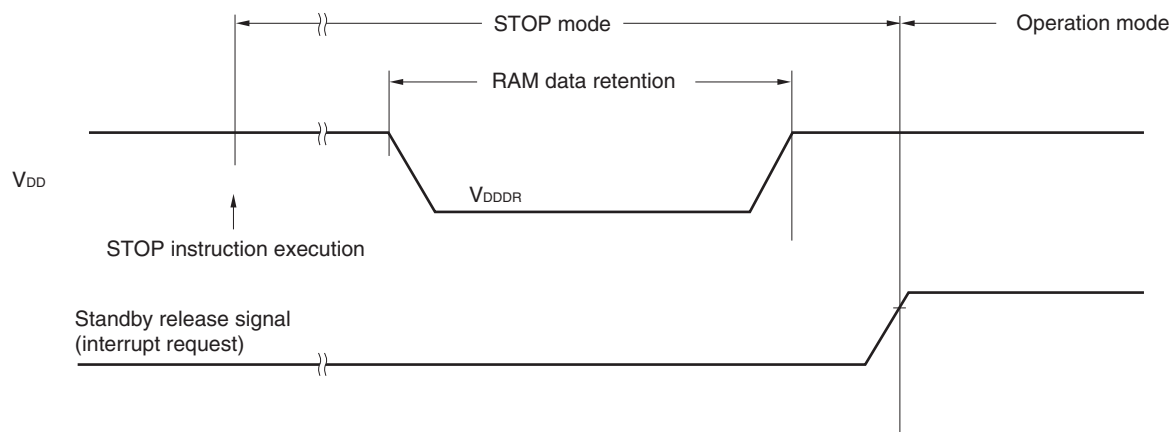
**Caution** Make sure to keep the internal reset state by the LVD circuit or an external reset until  $V_{DD}$  reaches the operating voltage range shown in 28.4 AC Characteristics.

## &lt;R&gt; 2.7 Data Memory STOP Mode Low Supply Voltage Data Retention Characteristics

**( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $V_{SS} = 0\text{ V}$ )**

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Data retention supply voltage	$V_{DDDR}$		1.46 <sup>Note</sup>		5.5	V

<R> **Note** This depends on the POR detection voltage. For a falling voltage, data in RAM are retained until the voltage reaches the level that triggers a POR reset but not once it reaches the level at which a POR reset is generated.



## 2.8 Flash Memory Programming Characteristics

**( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )**

<R>

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
System clock frequency	f <sub>CLK</sub>		1		24	MHz
Code flash memory rewritable times <small>Notes 1, 2, 3</small>	C <sub>erwr</sub>	Retained for 20 years T <sub>A</sub> = 85°C	1,000			Times
Data flash memory rewritable times <small>Notes 1, 2, 3</small>		Retained for 1 year T <sub>A</sub> = 25°C		1,000,000		
		Retained for 5 years T <sub>A</sub> = 85°C	100,000			
		Retained for 20 years T <sub>A</sub> = 85°C	10,000			

- Notes**
- 1 erase + 1 write after the erase is regarded as 1 rewrite. The retaining years are until next rewrite after the rewrite.
  2. When using flash memory programmer and Renesas Electronics self programming library
  3. These are the characteristics of the flash memory and the results obtained from reliability testing by Renesas Electronics Corporation.

## 2.9 Dedicated Flash Memory Programmer Communication (UART)

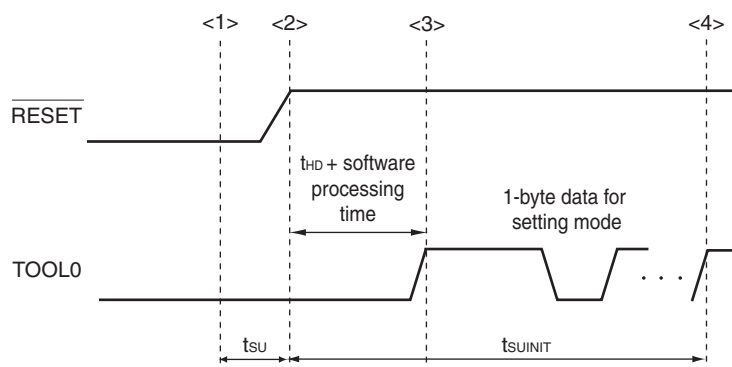
**( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )**

Parameter	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

**( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )**

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Time to complete the communication for the initial setting after the external reset is released	$t_{\text{SUNIT}}$	POR and LVD reset are released before external reset release			100	ms
Time to release the external reset after the TOOL0 pin is set to the low level	$t_{\text{SU}}$	POR and LVD reset are released before external reset release	10			$\mu\text{s}$
Time to hold the TOOL0 pin at the low level after the external reset is released (excluding the processing time of the firmware to control the flash memory)	$t_{\text{HD}}$	POR and LVD reset are released before external reset release	1			ms



- <1> The low level is input to the TOOL0 pin.
- <2> The external reset is released (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**  $t_{\text{SUNIT}}$ : Communication for the initial setting must be completed within 100 ms after the external reset is released during this period.

$t_{\text{SU}}$ : Time to release the external reset after the TOOL0 pin is set to the low level

$t_{\text{HD}}$ : Time to hold the TOOL0 pin at the low level after the external reset is released (excluding the processing time of the firmware to control the flash memory)

### <R> 3. ELECTRICAL SPECIFICATIONS (G: INDUSTRIAL APPLICATIONS $T_A = -40$ to $+105^\circ\text{C}$ )

<R> This chapter describes the following electrical specifications.

Target products G: Industrial applications  $T_A = -40$  to  $+105^\circ\text{C}$

<R> R5F102xxGxx

- Cautions**
1. The RL78 microcontrollers have an on-chip debug function, which is provided for development and evaluation. Do not use the on-chip debug function in products designated for mass production, because the guaranteed number of rewritable times of the flash memory may be exceeded when this function is used, and product reliability therefore cannot be guaranteed. Renesas Electronics is not liable for problems occurring when the on-chip debug function is used.
  2. The pins mounted depend on the product. Refer to 2.1 Port Functions to 2.2.1 Functions for each product.
  3. Please contact Renesas Electronics sales office for derating of operation under  $T_A = +85^\circ\text{C}$  to  $+105^\circ\text{C}$ . Derating is the systematic reduction of load for the sake of improved reliability.

**Remark** When the RL78 microcontroller is used in the range of  $T_A = -40$  to  $+85^\circ\text{C}$ , see CHAPTER 28  
**ELECTRICAL SPECIFICATIONS (A:  $T_A = -40$  to  $+85^\circ\text{C}$ ).**

<R>

There are following differences between the products "G: Industrial applications ( $T_A = -40$  to  $+105^\circ\text{C}$ )" and the products "A: Consumer applications, and D: Industrial applications".

Parameter	Application	
	A: Consumer applications, D: Industrial applications	G: Industrial applications
Operating ambient temperature	$T_A = -40$ to $+85^\circ\text{C}$	$T_A = -40$ to $+105^\circ\text{C}$
Operating mode Operating voltage range	HS (high-speed main) mode: $2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ @ 1 MHz to 24 MHz $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ @ 1 MHz to 16 MHz LS (low-speed main) mode: $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ @ 1 MHz to 8 MHz	HS (high-speed main) mode only: $2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ @ 1 MHz to 24 MHz $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ @ 1 MHz to 16 MHz
High-speed on-chip oscillator clock accuracy	R5F102 products, $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ : $\pm 1.0\%$ @ $T_A = -20$ to $+85^\circ\text{C}$ $\pm 1.5\%$ @ $T_A = -40$ to $-20^\circ\text{C}$ R5F103 products, $1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ : $\pm 5.0\%$ @ $T_A = -40$ to $+85^\circ\text{C}$	R5F102 products, $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ : $\pm 2.0\%$ @ $T_A = +85$ to $+105^\circ\text{C}$ $\pm 1.0\%$ @ $T_A = -20$ to $+85^\circ\text{C}$ $\pm 1.5\%$ @ $T_A = -40$ to $-20^\circ\text{C}$
Serial array unit	UART CSI: $f_{CLK}/2$ (supporting 12 Mbps), $f_{CLK}/4$ Simplified I <sup>2</sup> C communication	UART CSI: $f_{CLK}/4$ Simplified I <sup>2</sup> C communication
Voltage detector	Rise detection voltage: 1.88 V to 4.06 V (12 levels) Fall detection voltage: 1.84 V to 3.98 V (12 levels)	Rise detection voltage: 2.61 V to 4.06 V (8 levels) Fall detection voltage: 2.55 V to 3.98 V (8 levels)

**Remark** The electrical characteristics of the products G: Industrial applications ( $T_A = -40$  to  $+105^\circ\text{C}$ ) are different from those of the products "A: Consumer applications, and D: Industrial applications". For details, refer to 29.1 to 29.10.

## 3.1 Absolute Maximum Ratings

Absolute Maximum Ratings ( $T_A = 25^{\circ}\text{C}$ )

Parameter	Symbols	Conditions		Ratings	Unit
Supply Voltage	$V_{DD}$			$-0.5$ to $+6.5$	V
REGC terminal input voltage <sup>Note 1</sup>	$V_{IREGC}$	REGC		$-0.3$ to $+2.8$ and $-0.3$ to $V_{DD} + 0.3$ <sup>Note 2</sup>	V
Input Voltage	$V_{I1}$	Other than P60, P61		$-0.3$ to $V_{DD} + 0.3$ <sup>Note 3</sup>	V
	$V_{I2}$	P60, P61 (N-ch open drain)		$-0.3$ to $6.5$	V
Output Voltage	$V_O$			$-0.3$ to $V_{DD} + 0.3$ <sup>Note 3</sup>	V
Analog input voltage	$V_{AI}$	20, 24-pin products: ANI0 to ANI3, ANI16 to ANI22 30-pin products: ANI0 to ANI3, ANI16 to ANI19		$-0.3$ to $V_{DD} + 0.3$ and $-0.3$ to $AVREF(+)+0.3$ <sup>Notes 3, 4</sup>	V
Output current, high	$I_{OH1}$	Per pin	Other than P20 to P23	$-40$	mA
		Total of all pins	All the terminals other than P20 to P23	$-170$	mA
			20-, 24-pin products: P40 to P42 30-pin products: P00, P01, P40, P120	$-70$	mA
			20-, 24-pin products: P00 to P03 <sup>Note 5</sup> , P10 to P14 30-pin products: P10 to P17, P30, P31, P50, P51, P147	$-100$	mA
	$I_{OH2}$	Per pin	P20 to P23	$-0.5$	mA
		Total of all pins		$-2$	mA
Output current, low	$I_{OL1}$	Per pin	Other than P20 to P23	$40$	mA
		Total of all pins	All the terminals other than P20 to P23	$170$	mA
			20-, 24-pin products: P40 to P42 30-pin products: P00, P01, P40, P120	$70$	mA
			20-, 24-pin products: P00 to P03 <sup>Note 5</sup> , P10 to P14, P60, P61 30-pin products: P10 to P17, P30, P31, P50, P51, P60, P61, P147	$100$	mA
	$I_{OL2}$	Per pin	P20 to P23	$1$	mA
		Total of all pins		$5$	mA
Operating ambient temperature	$T_A$			$-40$ to $+105$	$^{\circ}\text{C}$
Storage temperature	$T_{stg}$			$-65$ to $+150$	$^{\circ}\text{C}$

**Notes** 1. 30-pin product only.

2. Connect the REGC pin to  $V_{SS}$  via a capacitor (0.47 to 1  $\mu\text{F}$ ). This value determines the absolute maximum rating of the REGC pin. Do not use it with voltage applied.

3. Must be 6.5 V or lower.

4. Do not exceed  $AVREF(+) + 0.3$  V in case of A/D conversion target pin.

5. 24-pin products only.

**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.

**Remarks** 1. Unless specified otherwise, the characteristics of alternate-function pins are the same as those of the port pins.

2.  $AVREF(+)$  : + side reference voltage of the A/D converter.

3.  $V_{SS}$  : Reference voltage

### 3.2 Oscillator Characteristics

#### 3.2.1 X1 oscillator characteristics

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

Parameter	Resonator	Conditions	MIN.	TYP.	MAX.	Unit
X1 clock oscillation frequency ( $f_x$ ) <sup>Note</sup>	Ceramic resonator / crystal oscillator	$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	1.0		20.0	MHz
		$2.4\text{ V} \leq V_{DD} < 2.7\text{ V}$	1.0		8.0	

**Note** Indicates only permissible oscillator frequency ranges. Refer to AC Characteristics for instruction execution time. Request evaluation by the manufacturer of the oscillator circuit mounted on a board to check the oscillator characteristics.

**Caution** Since the CPU is started by the high-speed on-chip oscillator clock after a reset release, check the X1 clock oscillation stabilization time using the oscillation stabilization time counter status register (OSTC) by the user. Determine the oscillation stabilization time of the OSTC register and the oscillation stabilization time select register (OSTS) after sufficiently evaluating the oscillation stabilization time with the resonator to be used.

**Remark** When using the X1 oscillator, refer to **5.4 System Clock Oscillator**.

#### 3.2.2 On-chip oscillator characteristics

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

Oscillators	Parameters	Conditions		MIN.	TYP.	MAX.	Unit
High-speed on-chip oscillator clock frequency <sup>Notes 1, 2</sup>	$f_{IH}$			1		24	MHz
High-speed on-chip oscillator clock frequency accuracy		R5F102 products	$T_A = -20$ to $+85^\circ\text{C}$	-1.0		+1.0	%
			$T_A = -40$ to $-20^\circ\text{C}$	-1.5		+1.5	%
			$T_A = +85$ to $+105^\circ\text{C}$	-2.0		+2.0	%
Low-speed on-chip oscillator clock frequency	$f_{IL}$				15		kHz
Low-speed on-chip oscillator clock frequency accuracy				-15		+15	%

**Notes** 1. High-speed on-chip oscillator frequency is selected by bits 0 to 3 of option byte (000C2H) and bits 0 to 2 of HOCODIV register.

2. This only indicates the oscillator characteristics. Refer to AC Characteristics for instruction execution time.



## 3.3 DC Characteristics

## 3.3.1 Pin characteristics

(T<sub>A</sub> = -40 to +105°C, 2.4 V ≤ V<sub>DD</sub> ≤ 5.5 V, V<sub>SS</sub> = 0 V)

(1/4)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Output current, high <sup>Note 1</sup>	I <sub>OH1</sub>	20-, 24-pin products: Per pin for P00 to P03 <sup>Note 4</sup> , P10 to P14, P40 to P42  30-pin products: Per pin for P00, P01, P10 to P17, P30, P31, P40, P50, P51, P120, P147			-3.0 <sup>Note 2</sup>	mA
		20-, 24-pin products: Total of P40 to P42	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V		-9.0	mA
			2.7 V ≤ V <sub>DD</sub> < 4.0 V		-6.0	mA
		30-pin products: Total of P00, P01, P40, P120 (When duty ≤ 70% <sup>Note 3</sup> )	2.4 V ≤ V <sub>DD</sub> < 2.7 V		-4.5	mA
		20-, 24-pin products: Total of P00 to P03 <sup>Note 4</sup> , P10 to P14	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V		-27.0	mA
			2.7 V ≤ V <sub>DD</sub> < 4.0 V		-18.0	mA
		30-pin products: Total of P10 to P17, P30, P31, P50, P51, P147 (When duty ≤ 70% <sup>Note 3</sup> )	2.4 V ≤ V <sub>DD</sub> < 2.7 V		-10.0	mA
		Total of all pins (When duty ≤ 70% <sup>Note 3</sup> )			-36.0	mA
	I <sub>OH2</sub>	Per pin for P20 to P23			-0.1	mA
		Total of all pins			-0.4	mA

**Notes** 1. value of current at which the device operation is guaranteed even if the current flows from the V<sub>DD</sub> pin to an output pin.

2. However, do not exceed the total current value.

3. The output current value under conditions where the duty factor ≤ 70%.

If duty factor > 70%: The output current value can be calculated with the following expression (where n represents the duty factor as a percentage).

- Total output current of pins = (I<sub>OH</sub> × 0.7)/(n × 0.01)

<Example> Where n = 80% and I<sub>OH</sub> = -10.0 mA

$$\text{Total output current of pins} = (-10.0 \times 0.7)/(80 \times 0.01) \cong -8.7 \text{ mA}$$

However, the current that is allowed to flow into one pin does not vary depending on the duty factor. A current higher than the absolute maximum rating must not flow into one pin.

4. 24-pin products only.

**Caution** P10 to P12 and P41 for 20-pin products, P01, P10 to P12, and P41 for 24-pin products, and P00, P10 to P15, P17, and P50 for 30-pin products do not output high level in N-ch open-drain mode.

**Remark** Unless specified otherwise, the characteristics of alternate-function pins are the same as those of the port pins.

(T<sub>A</sub> = -40 to +105°C, 2.4 V ≤ V<sub>DD</sub> ≤ 5.5 V, V<sub>SS</sub> = 0 V)

(2/4)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Output current, low <sup>Note 1</sup>	I <sub>OL1</sub>	20-, 24-pin products: Per pin for P00 to P03 <sup>Note 4</sup> , P10 to P14, P40 to P42			8.5 <sup>Note 2</sup>	mA
		30-pin products: Per pin for P00, P01, P10 to P17, P30, P31, P40, P50, P51, P120, P147				
		Per pin for P60, P61			15.0 <sup>Note 2</sup>	mA
		20-, 24-pin products: Total of P40 to P42	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V		25.5	mA
			2.7 V ≤ V <sub>DD</sub> < 4.0 V		9.0	mA
		30-pin products: Total of P00, P01, P40, P120 (When duty ≤ 70% <sup>Note 3</sup> )	2.4 V ≤ V <sub>DD</sub> < 2.7 V		1.8	mA
		20-, 24-pin products: Total of P00 to P03 <sup>Note 4</sup> , P10 to P14, P60, P61	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V		40.0	mA
			2.7 V ≤ V <sub>DD</sub> < 4.0 V		27.0	mA
		30-pin products: Total of P10 to P17, P30, P31, P50, P51, P60, P61, P147 (When duty ≤ 70% <sup>Note 3</sup> )	2.4 V ≤ V <sub>DD</sub> < 2.7 V		5.4	mA
		Total of all pins (When duty ≤ 70% <sup>Note 3</sup> )			65.5	mA
	I <sub>OL2</sub>	Per pin for P20 to P23			0.4	mA
		Total of all pins			1.6	mA

**Notes** 1. Value of current at which the device operation is guaranteed even if the current flows from an output pin to the V<sub>SS</sub> pin.

2. However, do not exceed the total current value.

3. The output current value under conditions where the duty factor ≤ 70%.

If duty factor > 70%: The output current value can be calculated with the following expression (where n represents the duty factor as a percentage).

- Total output current of pins = (I<sub>OL</sub> × 0.7)/(n × 0.01)

<Example> Where n = 80% and I<sub>OL</sub> = 10.0 mA

$$\text{Total output current of pins} = (10.0 \times 0.7)/(80 \times 0.01) \cong 8.7 \text{ mA}$$

However, the current that is allowed to flow into one pin does not vary depending on the duty factor. A current higher than the absolute maximum rating must not flow into one pin.

4. 24-pin products only.

**Remark** Unless specified otherwise, the characteristics of alternate-function pins are the same as those of the port pins.

**( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )****(3/4)**

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Input voltage, high	$V_{IH1}$	Normal input buffer 20-, 24-pin products: P00 to P03 <sup>Note 2</sup> , P10 to P14, P40 to P42 30-pin products: P00, P01, P10 to P17, P30, P31, P40, P50, P51, P120, P147	$0.8V_{DD}$		$V_{DD}$	V
	$V_{IH2}$	TTL input buffer 20-, 24-pin products: P10, P11 30-pin products: P01, P10, P11, P13 to P17	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	2.2	$V_{DD}$	V
			$3.3\text{ V} \leq V_{DD} < 4.0\text{ V}$	2.0	$V_{DD}$	V
			$2.4\text{ V} \leq V_{DD} < 3.3\text{ V}$	1.5	$V_{DD}$	V
	$V_{IH3}$	Normal input buffer P20 to P23	$0.7V_{DD}$		$V_{DD}$	V
	$V_{IH4}$	P60, P61	$0.7V_{DD}$		6.0	V
	$V_{IH5}$	P121, P122, P125 <sup>Note 1</sup> , P137, EXCLK, RESET	$0.8V_{DD}$		$V_{DD}$	V
Input voltage, low	$V_{IL1}$	Normal input buffer 20-, 24-pin products: P00 to P03 <sup>Note 2</sup> , P10 to P14, P40 to P42 30-pin products: P00, P01, P10 to P17, P30, P31, P40, P50, P51, P120, P147	0		$0.2V_{DD}$	V
	$V_{IL2}$	TTL input buffer 20-, 24-pin products: P10, P11 30-pin products: P01, P10, P11, P13 to P17	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	0	0.8	V
			$3.3\text{ V} \leq V_{DD} < 4.0\text{ V}$	0	0.5	V
			$2.4\text{ V} \leq V_{DD} < 3.3\text{ V}$	0	0.32	V
	$V_{IL3}$	P20 to P23	0		$0.3V_{DD}$	V
	$V_{IL4}$	P60, P61	0		$0.3V_{DD}$	V
	$V_{IL5}$	P121, P122, P125 <sup>Note 1</sup> , P137, EXCLK, RESET	0		$0.2V_{DD}$	V
Output voltage, high	$V_{OH1}$	20-, 24-pin products: P00 to P03 <sup>Note 2</sup> , P10 to P14, P40 to P42 30-pin products: P00, P01, P10 to P17, P30, P31, P40, P50, P51, P120, P147	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $I_{OH1} = -3.0\text{ mA}$	$V_{DD}-0.7$		V
			$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $I_{OH1} = -2.0\text{ mA}$	$V_{DD}-0.6$		V
			$2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $I_{OH1} = -1.5\text{ mA}$	$V_{DD}-0.5$		V
	$V_{OH2}$	P20 to P23	$I_{OH2} = -100\text{ }\mu\text{A}$	$V_{DD}-0.5$		V

**Notes** 1. 20, 24-pin products only.

2. 24-pin products only.

**Caution** The maximum value of  $V_{IH}$  of pins P10 to P12 and P41 for 20-pin products, P01, P10 to P12, and P41 for 24-pin products, and P00, P10 to P15, P17, and P50 for 30-pin products is  $V_{DD}$  even in N-ch open-drain mode. High level is not output in the N-ch open-drain mode.

**Remark** Unless specified otherwise, the characteristics of alternate-function pins are the same as those of the port pins.

**( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )****(4/4)**

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Output voltage, low	V <sub>OL1</sub>	20-, 24-pin products: P00 to P03 <sup>Note</sup> , P10 to P14, P40 to P42 30-pin products: P00, P01, P10 to P17, P30, P31, P40, P50, P51, P120, P147	4.0 V $\leq V_{DD} \leq 5.5\text{ V}$ , I <sub>OL1</sub> = 8.5 mA			0.7	V
			2.7 V $\leq V_{DD} \leq 5.5\text{ V}$ , I <sub>OL1</sub> = 3.0 mA			0.6	V
			2.7 V $\leq V_{DD} \leq 5.5\text{ V}$ , I <sub>OL1</sub> = 1.5 mA			0.4	V
			2.4 V $\leq V_{DD} \leq 5.5\text{ V}$ , I <sub>OL1</sub> = 0.6 mA			0.4	V
	V <sub>OL2</sub>	P20 to P23	I <sub>OL2</sub> = 400 $\mu\text{A}$			0.4	V
	V <sub>OL3</sub>	P60, P61	4.0 V $\leq V_{DD} \leq 5.5\text{ V}$ , I <sub>OL1</sub> = 15.0 mA			2.0	V
			4.0 V $\leq V_{DD} \leq 5.5\text{ V}$ , I <sub>OL1</sub> = 5.0 mA			0.4	V
			2.7 V $\leq V_{DD} \leq 5.5\text{ V}$ , I <sub>OL1</sub> = 3.0 mA			0.4	V
			2.4 V $\leq V_{DD} \leq 5.5\text{ V}$ , I <sub>OL1</sub> = 2.0 mA			0.4	V
Input leakage current, high	I <sub>LIH1</sub>	Other than P121, P122	V <sub>I</sub> = V <sub>DD</sub>			1	$\mu\text{A}$
	I <sub>LIH2</sub>	P121, P122 (X1, X2/EXCLK)	V <sub>I</sub> = V <sub>DD</sub> Input port or external clock input			1	$\mu\text{A}$
			When resonator connected			10	$\mu\text{A}$
Input leakage current, low	I <sub>LIL1</sub>	Other than P121, P122	V <sub>I</sub> = V <sub>SS</sub>			-1	$\mu\text{A}$
	I <sub>LIL2</sub>	P121, P122 (X1, X2/EXCLK)	V <sub>I</sub> = V <sub>SS</sub> Input port or external clock input			-1	$\mu\text{A}$
			When resonator connected			-10	$\mu\text{A}$
On-chip pull-up resistance	R <sub>U</sub>	20-, 24-pin products: P00 to P03 <sup>Note</sup> , P10 to P14, P40 to P42, P125, RESET 30-pin products: P00, P01, P10 to P17, P30, P31, P40, P50, P51, P120, P147	V <sub>I</sub> = V <sub>SS</sub> , input port	10	20	100	k $\Omega$

**Note** 24-pin products only.**Remark** Unless specified otherwise, the characteristics of alternate-function pins are the same as those of the port pins.

## 3.3.2 Supply current characteristics

## (1) 20-, 24-pin products

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

(1/2)

Parameter	Symbol	Conditions					MIN.	TYP.	MAX.	Unit
Supply current <sup>Note 1</sup>	I <sub>DD1</sub>	Operating mode	HS (High-speed main) mode <sup>Note 4</sup>	$f_{IH} = 24\text{ MHz}$ <sup>Note 3</sup>	Basic operation	$V_{DD} = 5.0\text{ V}$		1.5		mA
						$V_{DD} = 3.0\text{ V}$		1.5		
					Normal operation	$V_{DD} = 5.0\text{ V}$		3.3	5.3	mA
						$V_{DD} = 3.0\text{ V}$		3.3	5.3	
				$f_{IH} = 16\text{ MHz}$ <sup>Note 3</sup>		$V_{DD} = 5.0\text{ V}$		2.5	3.9	mA
						$V_{DD} = 3.0\text{ V}$		2.5	3.9	
				$f_{MX} = 20\text{ MHz}$ <sup>Note 2</sup> , $V_{DD} = 5.0\text{ V}$		Square wave input		2.8	4.7	mA
						Resonator connection		3.0	4.8	
				$f_{MX} = 20\text{ MHz}$ <sup>Note 2</sup> , $V_{DD} = 3.0\text{ V}$		Square wave input		2.8	4.7	mA
						Resonator connection		3.0	4.8	
				$f_{MX} = 10\text{ MHz}$ <sup>Note 2</sup> , $V_{DD} = 5.0\text{ V}$		Square wave input		1.8	2.8	mA
						Resonator connection		1.8	2.8	
				$f_{MX} = 10\text{ MHz}$ <sup>Note 2</sup> , $V_{DD} = 3.0\text{ V}$		Square wave input		1.8	2.8	mA
						Resonator connection		1.8	2.8	

**Notes** 1. Total current flowing into  $V_{DD}$ , including the input leakage current flowing when the level of the input pin is fixed to  $V_{DD}$  or  $V_{SS}$ . The values below the MAX. column include the peripheral operation current. However, not including the current flowing into the A/D converter, LVD circuit, I/O port, and on-chip pull-up/pull-down resistors and the current flowing during data flash rewrite.

2. When high-speed on-chip oscillator clock is stopped.

3. When high-speed system clock is stopped

4. Relationship between operation voltage width, operation frequency of CPU and operation mode is as follows.

HS(High speed main) mode:  $V_{DD} = 2.7\text{ V}$  to  $5.5\text{ V}$  @  $1\text{ MHz}$  to  $24\text{ MHz}$

$V_{DD} = 2.4\text{ V}$  to  $5.5\text{ V}$  @  $1\text{ MHz}$  to  $16\text{ MHz}$

**Remarks** 1.  $f_{MX}$ : High-speed system clock frequency (X1 clock oscillation frequency or external main system clock frequency)

2.  $f_{IH}$ : high-speed on-chip oscillator clock frequency

3. Temperature condition of the TYP. value is  $T_A = 25^\circ\text{C}$ .

## (1) 20-, 24-pin products

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

(2/2)

Parameter	Symbol	Conditions				MIN.	TYP.	MAX.	Unit	
Supply current <sup>Note 1</sup>	I <sub>DD2</sub> <sup>Note 2</sup>	HALT mode	HS (High-speed main) mode <sup>Note 6</sup>	f <sub>IH</sub> = 24 MHz <sup>Note 4</sup>	V <sub>DD</sub> = 5.0 V		440	2230	μA	
					V <sub>DD</sub> = 3.0 V		440	2230		
				f <sub>IH</sub> = 16 MHz <sup>Note 4</sup>	V <sub>DD</sub> = 5.0 V		400	1650	μA	
					V <sub>DD</sub> = 3.0 V		400	1650		
				f <sub>MX</sub> = 20 MHz <sup>Note 3</sup> , V <sub>DD</sub> = 5.0 V	Square wave input		280	1900	μA	
					Resonator connection		450	2000		
				f <sub>MX</sub> = 20 MHz <sup>Note 3</sup> , V <sub>DD</sub> = 3.0 V	Square wave input		280	1900	μA	
					Resonator connection		450	2000		
				f <sub>MX</sub> = 10 MHz <sup>Note 3</sup> , V <sub>DD</sub> = 5.0 V	Square wave input		190	1010	μA	
					Resonator connection		260	1090		
				f <sub>MX</sub> = 10 MHz <sup>Note 3</sup> , V <sub>DD</sub> = 3.0 V	Square wave input		190	1010	μA	
					Resonator connection		260	1090		
	I <sub>DD3</sub> <sup>Note 5</sup>	STOP mode	T <sub>A</sub> = −40°C					0.19	0.50	μA
			T <sub>A</sub> = +25°C					0.24	0.50	
T <sub>A</sub> = +50°C					0.32	0.80				
T <sub>A</sub> = +70°C					0.48	1.20				
T <sub>A</sub> = +85°C					0.74	2.20				
T <sub>A</sub> = +105°C					1.50	10.20				

- Notes**
1. Total current flowing into  $V_{DD}$ , including the input leakage current flowing when the level of the input pin is fixed to  $V_{DD}$  or  $V_{SS}$ . The values below the MAX. column include the peripheral operation current. However, not including the current flowing into the A/D converter, LVD circuit, I/O port, and on-chip pull-up/pull-down resistors and the current flowing during data flash rewrite.
  2. During HALT instruction execution by flash memory.
  3. When high-speed on-chip oscillator clock is stopped.
  4. When high-speed system clock is stopped.
  5. Not including the current flowing into the 12-bit interval timer and watchdog timer.
  6. Relationship between operation voltage width, operation frequency of CPU and operation mode is as follows.

HS (High speed main) mode:  $V_{DD} = 2.7\text{ V}$  to  $5.5\text{ V}$  @  $1\text{ MHz}$  to  $24\text{ MHz}$

$V_{DD} = 2.4\text{ V}$  to  $5.5\text{ V}$  @  $1\text{ MHz}$  to  $16\text{ MHz}$

- Remarks**
1.  $f_{MX}$ : High-speed system clock frequency (X1 clock oscillation frequency or external main system clock frequency)
  2.  $f_{IH}$ : high-speed on-chip oscillator clock frequency
  3. Except temperature condition of the TYP. value is  $T_A = 25^\circ\text{C}$ , other than STOP mode

## (2) 30-pin products

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

(1/2)

Parameter	Symbol	Conditions					MIN.	TYP.	MAX.	Unit
Supply current <sup>Note 1</sup>	$I_{DD1}$	Operating mode	HS (High-speed main) mode <sup>Note 4</sup>	$f_{IH} = 24\text{ MHz}$ <sup>Note 3</sup>	Basic operation	$V_{DD} = 5.0\text{ V}$		1.5		mA
						$V_{DD} = 3.0\text{ V}$		1.5		
					Normal operation	$V_{DD} = 5.0\text{ V}$		3.7	5.8	mA
						$V_{DD} = 3.0\text{ V}$		3.7	5.8	
				$f_{IH} = 16\text{ MHz}$ <sup>Note 3</sup>		$V_{DD} = 5.0\text{ V}$		2.7	4.2	mA
						$V_{DD} = 3.0\text{ V}$		2.7	4.2	
				$f_{MX} = 20\text{ MHz}$ <sup>Note 2</sup> , $V_{DD} = 5.0\text{ V}$		Square wave input		3.0	4.9	mA
						Resonator connection		3.2	5.0	
				$f_{MX} = 20\text{ MHz}$ <sup>Note 2</sup> , $V_{DD} = 3.0\text{ V}$		Square wave input		3.0	4.9	mA
						Resonator connection		3.2	5.0	
				$f_{MX} = 10\text{ MHz}$ <sup>Note 2</sup> , $V_{DD} = 5.0\text{ V}$		Square wave input		1.9	2.9	mA
						Resonator connection		1.9	2.9	
				$f_{MX} = 10\text{ MHz}$ <sup>Note 2</sup> , $V_{DD} = 3.0\text{ V}$		Square wave input		1.9	2.9	mA
						Resonator connection		1.9	2.9	

**Notes** 1. Total current flowing into  $V_{DD}$ , including the input leakage current flowing when the level of the input pin is fixed to  $V_{DD}$  or  $V_{SS}$ . The values below the MAX. column include the peripheral operation current. However, not including the current flowing into the A/D converter, LVD circuit, I/O port, and on-chip pull-up/pull-down resistors and the current flowing during data flash rewrite.

2. When high-speed on-chip oscillator clock is stopped.

3. When high-speed system clock is stopped

4. Relationship between operation voltage width, operation frequency of CPU and operation mode is as follows.

HS(High speed main) mode:  $V_{DD} = 2.7\text{ V}$  to  $5.5\text{ V}$  @  $1\text{ MHz}$  to  $24\text{ MHz}$

$V_{DD} = 2.4\text{ V}$  to  $5.5\text{ V}$  @  $1\text{ MHz}$  to  $16\text{ MHz}$

**Remarks** 1.  $f_{MX}$ : High-speed system clock frequency (X1 clock oscillation frequency or external main system clock frequency)

2.  $f_{IH}$ : high-speed on-chip oscillator clock frequency

3. Temperature condition of the TYP. value is  $T_A = 25^\circ\text{C}$ .

## (2) 30-pin products

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

(2/2)

Parameter	Symbol	Conditions				MIN.	TYP.	MAX.	Unit
Supply current <small>Note 1</small>	I <sub>DD2</sub> <small>Note 2</small>	HALT mode	HS (High-speed main) mode <small>Note 6</small>	f <sub>IH</sub> = 24 MHz <small>Note 4</small>	V <sub>DD</sub> = 5.0 V		440	2300	μA
					V <sub>DD</sub> = 3.0 V		440	2300	
				f <sub>IH</sub> = 16 MHz <small>Note 4</small>	V <sub>DD</sub> = 5.0 V		400	1700	μA
					V <sub>DD</sub> = 3.0 V		400	1700	
				f <sub>MX</sub> = 20 MHz <small>Note 3</small> , V <sub>DD</sub> = 5.0 V	Square wave input		280	1900	μA
					Resonator connection		450	2000	
				f <sub>MX</sub> = 20 MHz <small>Note 3</small> , V <sub>DD</sub> = 3.0 V	Square wave input		280	1900	μA
					Resonator connection		450	2000	
				f <sub>MX</sub> = 10 MHz <small>Note 3</small> , V <sub>DD</sub> = 5.0 V	Square wave input		190	1020	μA
					Resonator connection		260	1100	
				f <sub>MX</sub> = 10 MHz <small>Note 3</small> , V <sub>DD</sub> = 3.0 V	Square wave input		190	1020	μA
					Resonator connection		260	1100	
I <sub>DD3</sub> <small>Note 5</small>	STOP mode	T <sub>A</sub> = −40°C					0.18	0.50	μA
		T <sub>A</sub> = +25°C					0.23	0.50	
		T <sub>A</sub> = +50°C					0.30	1.10	
		T <sub>A</sub> = +70°C					0.46	1.90	
		T <sub>A</sub> = +85°C					0.75	3.30	
		T <sub>A</sub> = +105°C					2.94	15.30	

**Notes 1.** Total current flowing into  $V_{DD}$ , including the input leakage current flowing when the level of the input pin is fixed to  $V_{DD}$  or  $V_{SS}$ . The values below the MAX. column include the peripheral operation current. However, not including the current flowing into the A/D converter, LVD circuit, I/O port, and on-chip pull-up/pull-down resistors and the current flowing during data flash rewrite.

**2.** During HALT instruction execution by flash memory.

**3.** When high-speed on-chip oscillator clock is stopped.

**4.** When high-speed system clock is stopped.

**5.** Not including the current flowing into the 12-bit interval timer and watchdog timer.

**6.** Relationship between operation voltage width, operation frequency of CPU and operation mode is as follows.

HS (High speed main) mode:  $V_{DD} = 2.7\text{ V}$  to  $5.5\text{ V}$  @  $1\text{ MHz}$  to  $24\text{ MHz}$

$V_{DD} = 2.4\text{ V}$  to  $5.5\text{ V}$  @  $1\text{ MHz}$  to  $16\text{ MHz}$

**Remarks 1.**  $f_{MX}$ : High-speed system clock frequency (X1 clock oscillation frequency or external main system clock frequency)

**2.**  $f_{IH}$ : high-speed on-chip oscillator clock frequency

**3.** Except STOP mode, temperature condition of the TYP. value is  $T_A = 25^\circ\text{C}$ .



**(3) Peripheral functions (Common to all products)****( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )**

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Low-speed onchip oscillator operating current	$I_{FIL}$ <sup>Note 1</sup>				0.20		$\mu\text{A}$
12-bit interval timer operating current	$I_{TMKA}$ <sup>Notes 1, 2, 3</sup>				0.02		$\mu\text{A}$
Watchdog timer operating current	$I_{WDT}$ <sup>Notes 1, 2, 4</sup>	$f_{IL} = 15\text{ kHz}$			0.22		$\mu\text{A}$
A/D converter operating current	$I_{ADC}$ <sup>Notes 1, 5</sup>	When conversion at maximum speed	Normal mode, $AV_{REFP} = V_{DD} = 5.0\text{ V}$		1.30	1.70	mA
			Low voltage mode, $AV_{REFP} = V_{DD} = 3.0\text{ V}$		0.50	0.70	mA
A/D converter reference voltage operating current	$I_{ADREF}$ <sup>Note 1</sup>				75.0		$\mu\text{A}$
Temperature sensor operating current	$I_{TMPS}$ <sup>Note 1</sup>				75.0		$\mu\text{A}$
LVD operating current	$I_{LVD}$ <sup>Notes 1, 6</sup>				0.08		$\mu\text{A}$
Self-programming operating current	$I_{FSP}$ <sup>Notes 1, 8</sup>				2.00	12.20	mA
BGO operating current	$I_{BGO}$ <sup>Notes 1, 7</sup>				2.00	12.20	mA
SNOOZE operating current	$I_{SNOZ}$ <sup>Note 1</sup>	ADC operation	The mode is performed <sup>Note 9</sup>		0.50	1.10	mA
			The A/D conversion operations are performed, Low voltage mode, $AV_{REFP} = V_{DD} = 3.0\text{ V}$		1.20	2.04	mA
		CSI/UART operation			0.70	1.54	mA

**Notes** 1. Current flowing to the  $V_{DD}$ .

2. When high speed on-chip oscillator and high-speed system clock are stopped.

3. Current flowing only to the 12-bit interval timer (excluding the operating current of the low-speed on-chip oscillator). The current value of the RL78 microcontrollers is the sum of  $I_{DD1}$ ,  $I_{DD2}$  or  $I_{DD3}$ , and  $I_{FIL}$  and  $I_{TMKA}$  when the 12-bit interval timer operates.4. Current flowing only to the watchdog timer (including the operating current of the low-speed on-chip oscillator). The current value of the RL78 microcontrollers is the sum of  $I_{DD1}$ ,  $I_{DD2}$  or  $I_{DD3}$  and  $I_{WDT}$  when the watchdog timer operates.5. Current flowing only to the A/D converter. The current value of the RL78 microcontrollers is the sum of  $I_{DD1}$  or  $I_{DD2}$  and  $I_{ADC}$  when the A/D converter operates in an operation mode or the HALT mode.6. Current flowing only to the LVD circuit. The current value of the RL78 microcontrollers is the sum of  $I_{DD1}$ ,  $I_{DD2}$  or  $I_{DD3}$  and  $I_{LVD}$  when the LVD circuit operates.

7. Current flowing only during data flash rewrite.

8. Current flowing only during self programming.

9. For shift time to the SNOOZE mode, see **17.3.3 SNOOZE mode**.**Remarks** 1.  $f_{IL}$ : Low-speed on-chip oscillator clock frequency2. Temperature condition of the TYP. value is  $T_A = 25^\circ\text{C}$

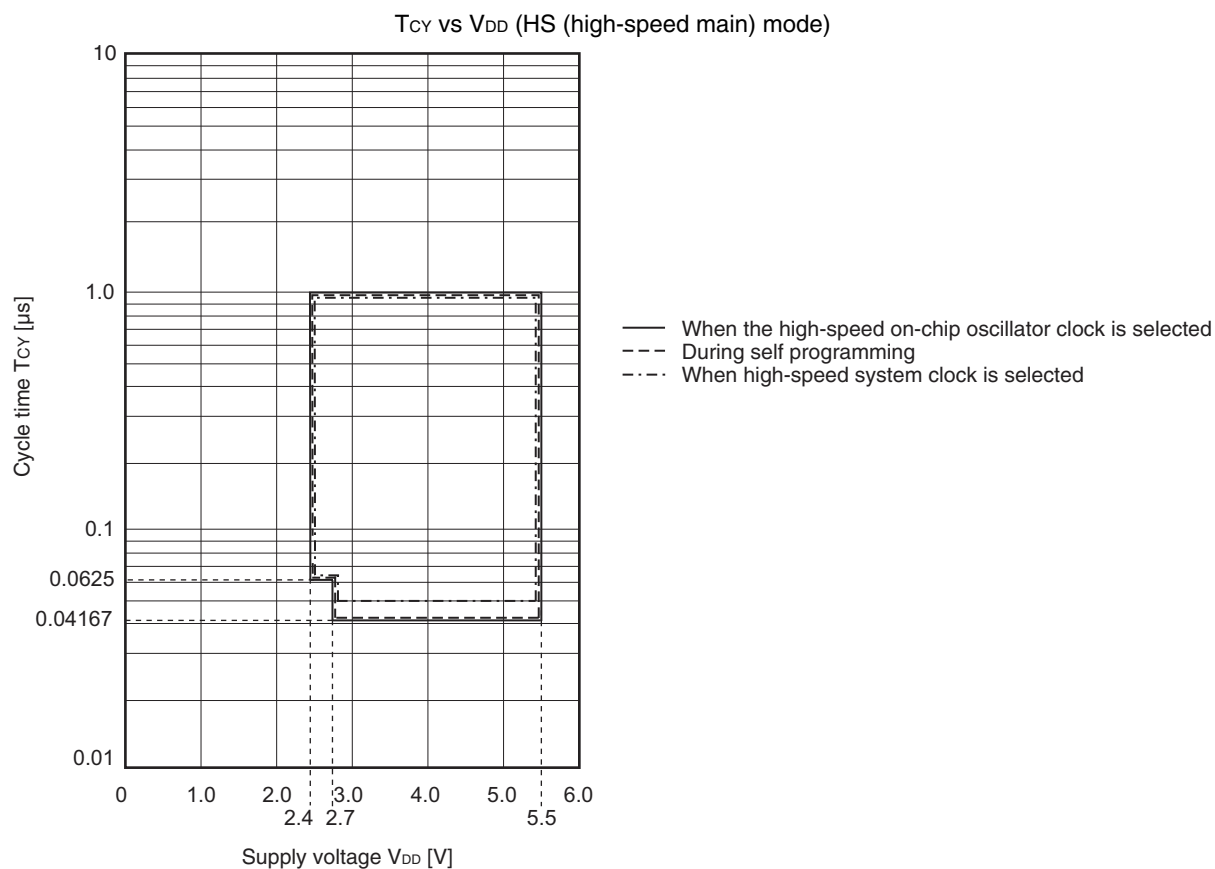
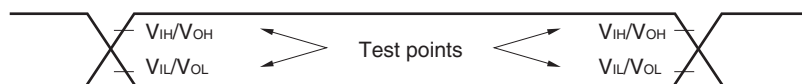
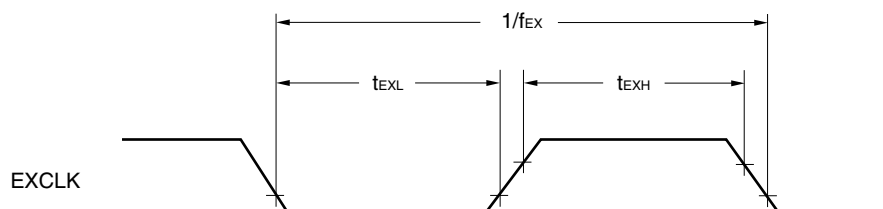
## 3.4 AC Characteristics

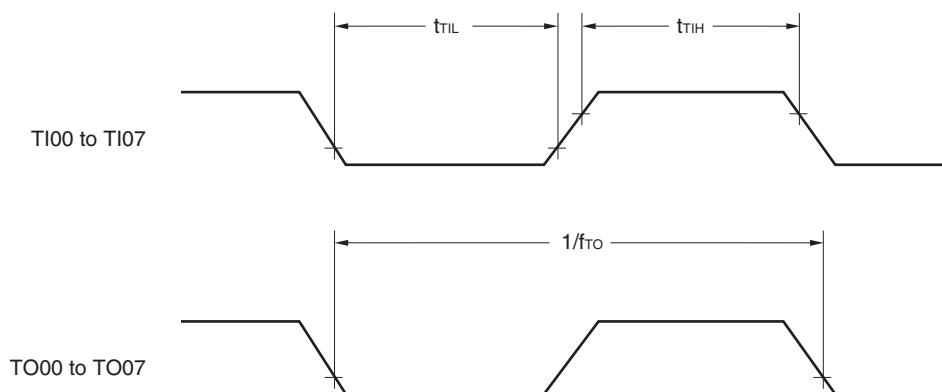
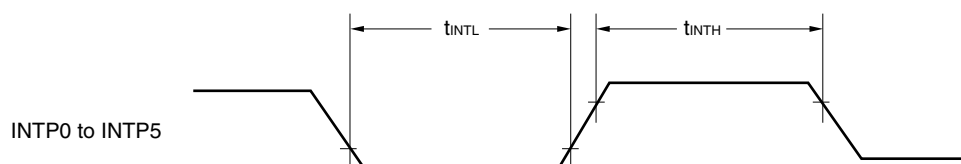
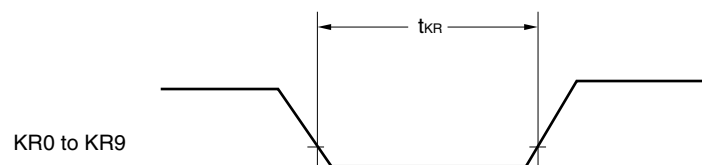
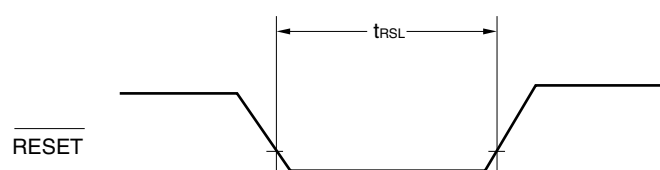
(TA = -40 to +105°C, 2.4 V ≤ VDD ≤ 5.5 V, VSS = 0 V)

Items	Symbol	Conditions			MIN.	TYP.	MAX.	Unit
Instruction cycle (minimum instruction execution time)	T <sub>CY</sub>	Main system clock (f <sub>MAIN</sub> ) operation	HS (High-speed main) mode	2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V	0.04167		1	μs
				2.4 V ≤ V <sub>DD</sub> < 2.7 V	0.0625		1	μs
		During self programming	HS (High-speed main) mode	2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V	0.04167		1	μs
				2.4 V ≤ V <sub>DD</sub> < 2.7 V	0.0625		1	μs
External main system clock frequency	f <sub>EX</sub>	2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V			1.0		20.0	MHz
		2.4 V ≤ V <sub>DD</sub> < 2.7 V			1.0		16.0	MHz
External main system clock input high-level width, low-level width	t <sub>EXH</sub> , t <sub>EXL</sub>	2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V			24			ns
		2.4 V ≤ V <sub>DD</sub> < 2.7 V			30			ns
TI00 to TI07 input high-level width, low-level width	t <sub>TIH</sub> , t <sub>TIL</sub>				1/f <sub>MCK</sub> + 10			ns
TO00 to TO07 output frequency	f <sub>TO</sub>	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V					12	MHz
		2.7 V ≤ V <sub>DD</sub> < 4.0 V					8	MHz
		2.4 V ≤ V <sub>DD</sub> < 2.7 V					4	MHz
PCLBUZ0, or PCLBUZ1 output frequency	f <sub>PCL</sub>	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V					16	MHz
		2.7 V ≤ V <sub>DD</sub> < 4.0 V					8	MHz
		2.4 V ≤ V <sub>DD</sub> < 2.7 V					4	MHz
INTP0 to INTP5 input high-level width, low-level width	t <sub>INTH</sub> , t <sub>INTL</sub>				1			μs
KR0 to KR9 input available width	t <sub>KR</sub>				250			ns
RESET low-level width	t <sub>RSL</sub>				10			μs

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

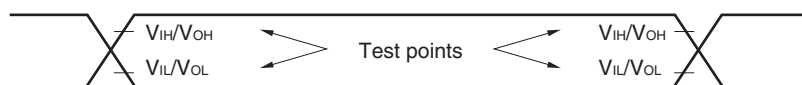
(Operation clock to be set by the timer clock select register 0 (TPS0) and the CKS0n bit of timer mode register 0n (TMR0n). n: Channel number (n = 0 to 7))

**Minimum Instruction Execution Time during Main System Clock Operation****AC Timing Test Point****External Main System Clock Timing**

**TI/TO Timing****Interrupt Request Input Timing****Key Interrupt Input Timing****RESET Input Timing**

### 3.5 Peripheral Functions Characteristics

#### AC Timing Test Point



#### 3.5.1 Serial array unit

##### (1) During communication at same potential (UART mode)

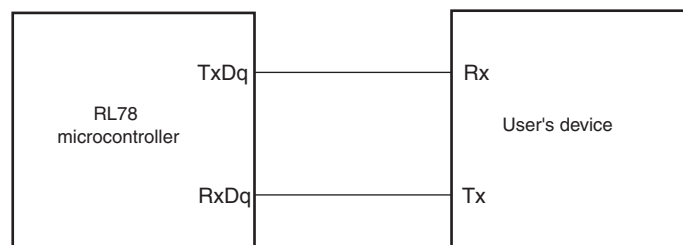
( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )

Parameter	Symbol	Conditions	HS (high-speed main) Mode		Unit
			MIN.	MAX.	
Transfer rate <small>Note 1</small>		Theoretical value of the maximum transfer rate $f_{CLK} = f_{MCK}$ <small>Note2</small>		$f_{MCK}/12$	bps
				2.0	Mbps

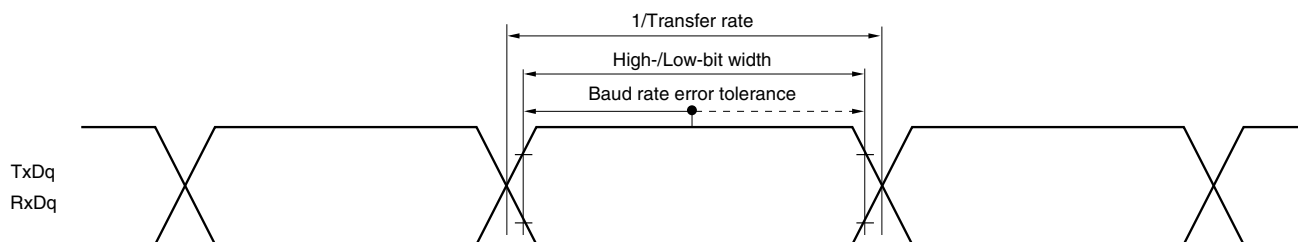
- Notes**
1. Transfer rate in the SNOOZE mode is 4800 bps only.
  2. The maximum operating frequencies of the CPU/peripheral hardware clock ( $f_{CLK}$ ) are:  
 HS (high-speed main) mode:  $24\text{ MHz}$  ( $2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ )  
 $16\text{ MHz}$  ( $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ )

**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).

#### UART mode connection diagram (during communication at same potential)



#### UART mode bit width (during communication at same potential) (reference)



- Remarks**
1. q: UART number (q = 0 to 2), g: PIM, POM number (g = 0, 1)
  2.  $f_{MCK}$ : Serial array unit operation clock frequency  
 (Operation clock to be set by the serial clock select register m (SPSm) and the CKSmn bit of serial mode register mn (SMRmn).  
 m: Unit number, n: Channel number (mn = 00 to 03, 10, 11))

**(2) During communication at same potential (CSI mode) (master mode, SCKp... internal clock output)****( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )**

Parameter	Symbol	Conditions	HS (high-speed main) Mode		Unit
			MIN.	MAX.	
SCKp cycle time	$t_{KCY1}$	$t_{KCY1} \geq 4/f_{CLK}$	$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	334	ns
			$2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	500	ns
SCKp high-/low-level width	$t_{KH1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	$t_{KCY1}/2-24$		ns
	$t_{KL1}$	$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	$t_{KCY1}/2-36$		ns
		$2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	$t_{KCY1}/2-76$		ns
Slp setup time (to SCKp $\uparrow$ ) <sup>Note 1</sup>	$t_{SIK1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	66		ns
		$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	66		ns
		$2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	113		ns
Slp hold time (from SCKp $\uparrow$ ) <sup>Note 2</sup>	$t_{KSI1}$		38		ns
Delay time from SCKp $\downarrow$ to SOp output <sup>Note 3</sup>	$t_{KSO1}$	$C = 30\text{ pF}$ <sup>Note 4</sup>		50	ns

- Notes**
1. When  $DAPmn = 0$  and  $CKPmn = 0$ , or  $DAPmn = 1$  and  $CKPmn = 1$ . The Slp setup time becomes “to SCKp $\downarrow$ ” when  $DAPmn = 0$  and  $CKPmn = 1$ , or  $DAPmn = 1$  and  $CKPmn = 0$ .
  2. When  $DAPmn = 0$  and  $CKPmn = 0$ , or  $DAPmn = 1$  and  $CKPmn = 1$ . The Slp hold time becomes “from SCKp $\downarrow$ ” when  $DAPmn = 0$  and  $CKPmn = 1$ , or  $DAPmn = 1$  and  $CKPmn = 0$ .
  3. When  $DAPmn = 0$  and  $CKPmn = 0$ , or  $DAPmn = 1$  and  $CKPmn = 1$ . The delay time to SOp output becomes “from SCKp $\uparrow$ ” when  $DAPmn = 0$  and  $CKPmn = 1$ , or  $DAPmn = 1$  and  $CKPmn = 0$ .
  4. 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 and SCKp pins by using port input mode register 1 (PIM1) and port output mode registers 0, 1, 4 (POM0, POM1, POM4).

- Remarks**
1. p: CSI number (p = 00, 01, 11, 20), m: Unit number (m = 0, 1), n: Channel number (n = 0, 1, 3)
  2.  $f_{MCK}$ : Serial array unit operation clock frequency  
(Operation clock to be set by the serial clock select register m (SPSm) and the CKSmn bit of serial mode register mn (SMRmn). m: Unit number (m = 0, 1), n: Channel number (n = 0, 1, 3))

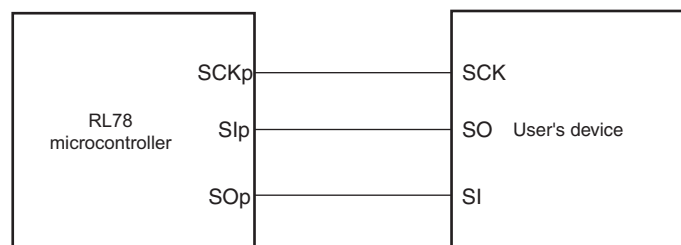
**(3) During communication at same potential (CSI mode) (slave mode, SCKp... external clock input)**  
**( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )**

Parameter	Symbol	Conditions		HS (high-speed main) Mode		Unit
				MIN.	MAX.	
SCKp cycle time <sup>Note 4</sup>	$t_{KCY2}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	$20\text{ MHz} < f_{MCK}$	$16/f_{MCK}$		ns
			$f_{MCK} \leq 20\text{ MHz}$	$12/f_{MCK}$		ns
		$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	$16\text{ MHz} < f_{MCK}$	$16/f_{MCK}$		ns
			$f_{MCK} \leq 16\text{ MHz}$	$12/f_{MCK}$		ns
		$2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		$12/f_{MCK}$ and 1000		ns
SCKp high-/low-level width	$t_{KH2}$ , $t_{KL2}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		$t_{KCY2}/2-14$		ns
		$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		$t_{KCY2}/2-16$		ns
		$2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		$t_{KCY2}/2-36$		ns
Slp setup time (to SCKp $\uparrow$ ) <sup>Note 1</sup>	$t_{SIK2}$	$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		$1/f_{MCK} + 40$		ns
		$2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		$1/f_{MCK} + 60$		ns
Slp hold time (from SCKp $\uparrow$ ) <sup>Note 2</sup>	$t_{KSI2}$			$1/f_{MCK} + 62$		ns
Delay time from SCKp $\downarrow$ to SOp output <sup>Note 3</sup>	$t_{KSO2}$	$C = 30\text{ pF}$ <sup>Note 4</sup>	$2.7\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		$2/f_{MCK} + 66$	ns
			$2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		$2/f_{MCK} + 113$	ns

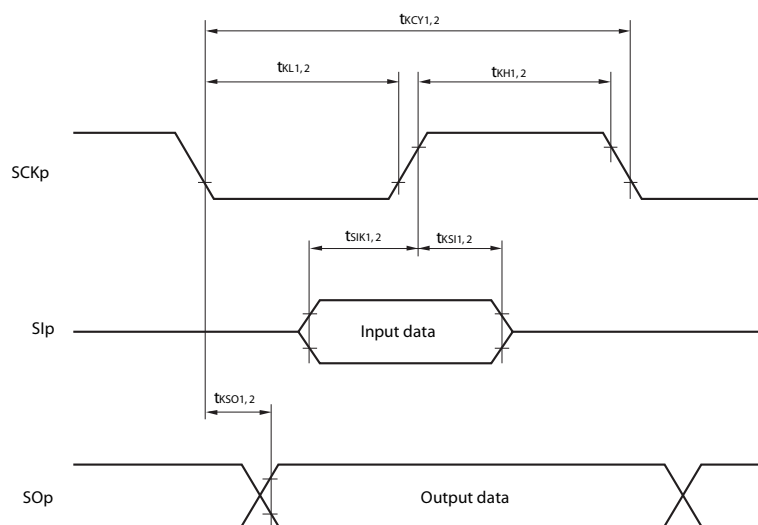
- Notes**
1. When  $DAPmn = 0$  and  $CKPmn = 0$ , or  $DAPmn = 1$  and  $CKPmn = 1$ . The Slp setup time becomes “to SCKp $\downarrow$ ” when  $DAPmn = 0$  and  $CKPmn = 1$ , or  $DAPmn = 1$  and  $CKPmn = 0$ .
  2. When  $DAPmn = 0$  and  $CKPmn = 0$ , or  $DAPmn = 1$  and  $CKPmn = 1$ . The Slp hold time becomes “from SCKp $\downarrow$ ” when  $DAPmn = 0$  and  $CKPmn = 1$ , or  $DAPmn = 1$  and  $CKPmn = 0$ .
  3. When  $DAPmn = 0$  and  $CKPmn = 0$ , or  $DAPmn = 1$  and  $CKPmn = 1$ . The delay time to SOp output becomes “from SCKp $\uparrow$ ” when  $DAPmn = 0$  and  $CKPmn = 1$ , or  $DAPmn = 1$  and  $CKPmn = 0$ .
  4. C is the load capacitance of the SOp output lines.
  5. Transfer rate in the SNOOZE mode: MAX. 1 Mbps

**Caution** Select the normal input buffer for the Slp and SCKp pins and the normal output mode for the SOp pin by selecting port input mode register 1 (PIM1) and port output mode registers 0, 1, 4 (POM0, POM1, POM4).

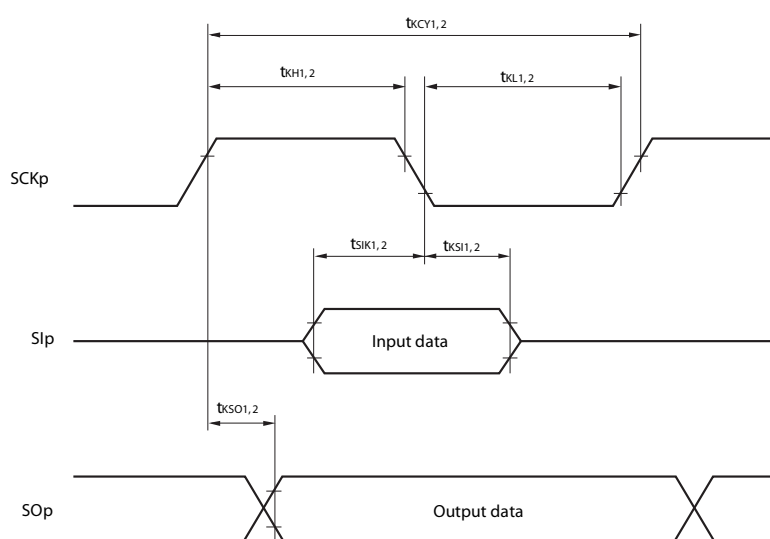
**CSI mode connection diagram (during communication at same potential)**



**CSI mode serial transfer timing (during communication at same potential)**  
**(When DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1.)**



**CSI mode serial transfer timing (during communication at same potential)**  
**(When DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.)**

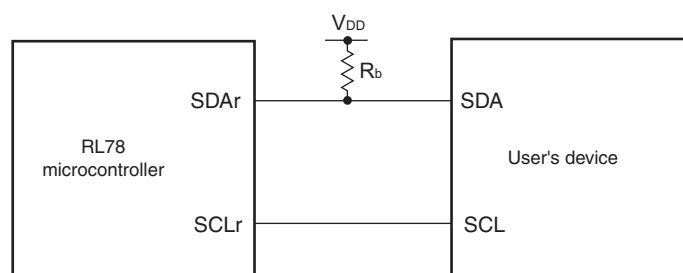
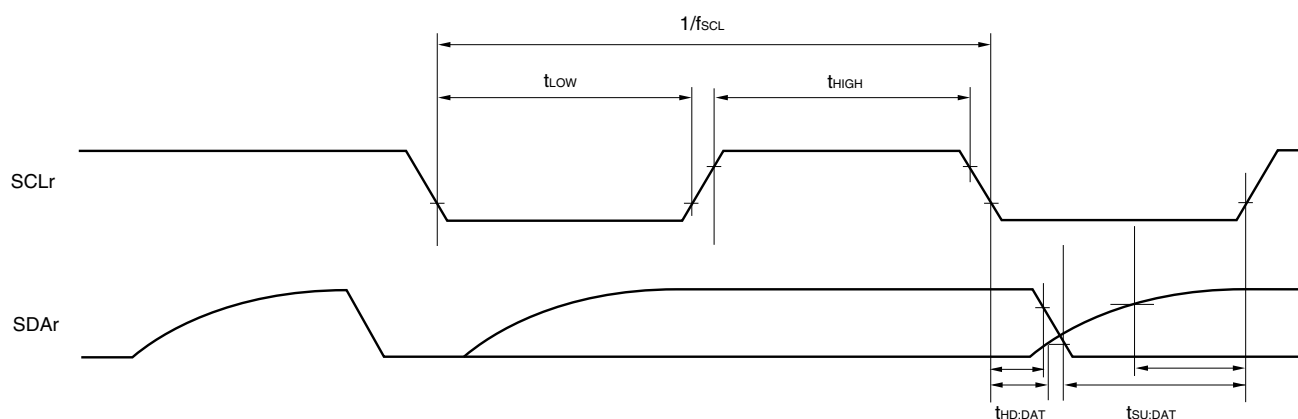


- Remarks**
1. p: CSI number (p = 00, 01, 11, 20), m: Unit number (m = 0, 1), n: Channel number (n = 0, 1, 3)
  2.  $f_{\text{MCK}}$ : Serial array unit operation clock frequency  
 (Operation clock to be set by the serial clock select register m (SPSm) and the CKSmn bit of serial mode register mn (SMRmn). m: Unit number (m = 0, 1), n: Channel number (n = 0, 1, 3))



**(4) During communication at same potential (simplified I<sup>2</sup>C mode)****( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )**

Parameter	Symbol	Conditions	HS (high-speed main) Mode		Unit
			MIN.	MAX.	
SCLr clock frequency	$f_{\text{SCL}}$	$C_b = 100\text{ pF}$ , $R_b = 3\text{ k}\Omega$		100 <sup>Note 1</sup>	kHz
Hold time when SCLr = "L"	$t_{\text{LOW}}$	$C_b = 100\text{ pF}$ , $R_b = 3\text{ k}\Omega$	4600		ns
Hold time when SCLr = "H"	$t_{\text{HIGH}}$	$C_b = 100\text{ pF}$ , $R_b = 3\text{ k}\Omega$	4600		ns
Data setup time (reception)	$t_{\text{SU:DAT}}$	$C_b = 100\text{ pF}$ , $R_b = 3\text{ k}\Omega$	$1/f_{\text{MCK}} + 580$ <sup>Note 2</sup>		ns
Data hold time (transmission)	$t_{\text{HD:DAT}}$	$C_b = 100\text{ pF}$ , $R_b = 3\text{ k}\Omega$	0	1420	ns

**Notes 1.** The value must also be equal to or less than  $f_{\text{MCK}}/4$ .**2.** Set  $t_{\text{SU:DAT}}$  so that it will not exceed the hold time when SCLr = "L" or SCLr = "H".**Caution** Select the N-ch open drain output ( $V_{DD}$  tolerance) mode for SDAr by using port output mode register h (POMh).**Simplified I<sup>2</sup>C mode connection diagram (during communication at same potential)****Simplified I<sup>2</sup>C mode serial transfer timing (during communication at same potential)****Remarks 1.**  $R_b$  [ $\Omega$ ]: Communication line (SDAr) pull-up resistance $C_b$  [F]: Communication line (SCLr, SDAr) load capacitance**2.** r: IIC number (r = 00, 01, 11, 20), h: = POM number (h = 0, 1, 4, 5)**3.**  $f_{\text{MCK}}$ : Serial array unit operation clock frequency

(Operation clock to be set by the serial clock select register m (SPSm) and the CKSmn bit of serial mode register mn (SMRmn).

m: Unit number (m = 0, 1), n: Channel number (0, 1, 3))

**(5) Communication at different potential (1.8 V, 2.5 V, 3 V) (UART mode)****(T<sub>A</sub> = -40 to +105°C, 2.4 V ≤ V<sub>DD</sub> ≤ 5.5 V, V<sub>SS</sub> = 0 V)**

Parameter	Symbol	Conditions		HS (high-speed main) Mode		Unit
				MIN.	MAX.	
Transfer rate <small>Note 4</small>		Reception	4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V, 2.7 V ≤ V <sub>b</sub> ≤ 4.0 V		f <sub>MCK</sub> /12 <small>Note 1</small>	bps
			Theoretical value of the maximum transfer rate f <sub>MCK</sub> = f <sub>CLK</sub> <small>Note 2</small>		2.0	Mbps
			2.7 V ≤ V <sub>DD</sub> < 4.0 V, 2.3 V ≤ V <sub>b</sub> ≤ 2.7 V		f <sub>MCK</sub> /12 <small>Note 1</small>	bps
			Theoretical value of the maximum transfer rate f <sub>MCK</sub> = f <sub>CLK</sub> <small>Note 2</small>		2.0	Mbps
		Transmission	2.4 V ≤ V <sub>DD</sub> < 3.3 V, 1.6 V ≤ V <sub>b</sub> ≤ 2.0 V		f <sub>MCK</sub> /12 <small>Note 1</small>	bps
			Theoretical value of the maximum transfer rate f <sub>MCK</sub> = f <sub>CLK</sub> <small>Note 2</small>		2.0	Mbps
			4.0 V ≤ V <sub>DD</sub> ≤ 5.5 V, 2.7 V ≤ V <sub>b</sub> ≤ 4.0 V		<b>Note 3</b>	bps
			Theoretical value of the maximum transfer rate C <sub>b</sub> = 50 pF, R <sub>b</sub> = 1.4 kΩ, V <sub>b</sub> = 2.7 V		2.0 <small>Note 4</small>	Mbps
			2.7 V ≤ V <sub>DD</sub> < 4.0 V, 2.3 V ≤ V <sub>b</sub> ≤ 2.7 V		<b>Note 5</b>	bps
			Theoretical value of the maximum transfer rate C <sub>b</sub> = 50 pF, R <sub>b</sub> = 2.7 kΩ, V <sub>b</sub> = 2.3 V		1.2 <small>Note 6</small>	Mbps
			2.4 V ≤ V <sub>DD</sub> < 3.3 V, 1.6 V ≤ V <sub>b</sub> ≤ 2.0 V		<b>Notes 2, 7</b>	bps
			Theoretical value of the maximum transfer rate C <sub>b</sub> = 50 pF, R <sub>b</sub> = 5.5 kΩ, V <sub>b</sub> = 1.6 V		0.43 <small>Note 8</small>	Mbps

**Notes 1.** Transfer rate in the SNOOZE mode is 4800 bps only.**2.** The maximum operating frequencies of the CPU/peripheral hardware clock (f<sub>CLK</sub>) are:HS (high-speed main) mode: 24 MHz (2.7 V ≤ V<sub>DD</sub> ≤ 5.5 V)16 MHz (2.4 V ≤ V<sub>DD</sub> ≤ 5.5 V)**3.** The smaller maximum transfer rate derived by using f<sub>MCK</sub>/12 or the following expression is the valid maximum transfer rate.Expression for calculating the transfer rate when 4.0 V ≤ V<sub>DD</sub> ≤ 5.5 V and 2.7 V ≤ V<sub>b</sub> ≤ 4.0 V

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

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

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

4. This value as an example is calculated when the conditions described in the “Conditions” column are met. Refer to **Note 3** above to calculate the maximum transfer rate under conditions of the customer.
5. The smaller maximum transfer rate derived by using f<sub>MCK</sub>/12 or the following expression is the valid maximum transfer rate.

Expression for calculating the transfer rate when 2.7 V ≤ V<sub>DD</sub> < 4.0 V and 2.3 V ≤ V<sub>b</sub> ≤ 2.7 V

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

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

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

6. This value as an example is calculated when the conditions described in the “Conditions” column are met. Refer to **Note 5** above to calculate the maximum transfer rate under conditions of the customer.
7. The smaller maximum transfer rate derived by using f<sub>MCK</sub>/12 or the following expression is the valid maximum transfer rate.

Expression for calculating the transfer rate when 2.4 V ≤ V<sub>DD</sub> < 3.3 V, 1.6 V ≤ V<sub>b</sub> ≤ 2.0 V

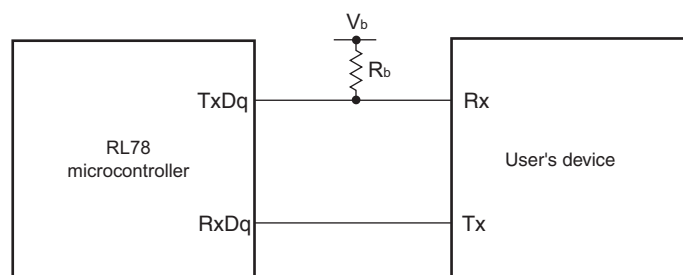
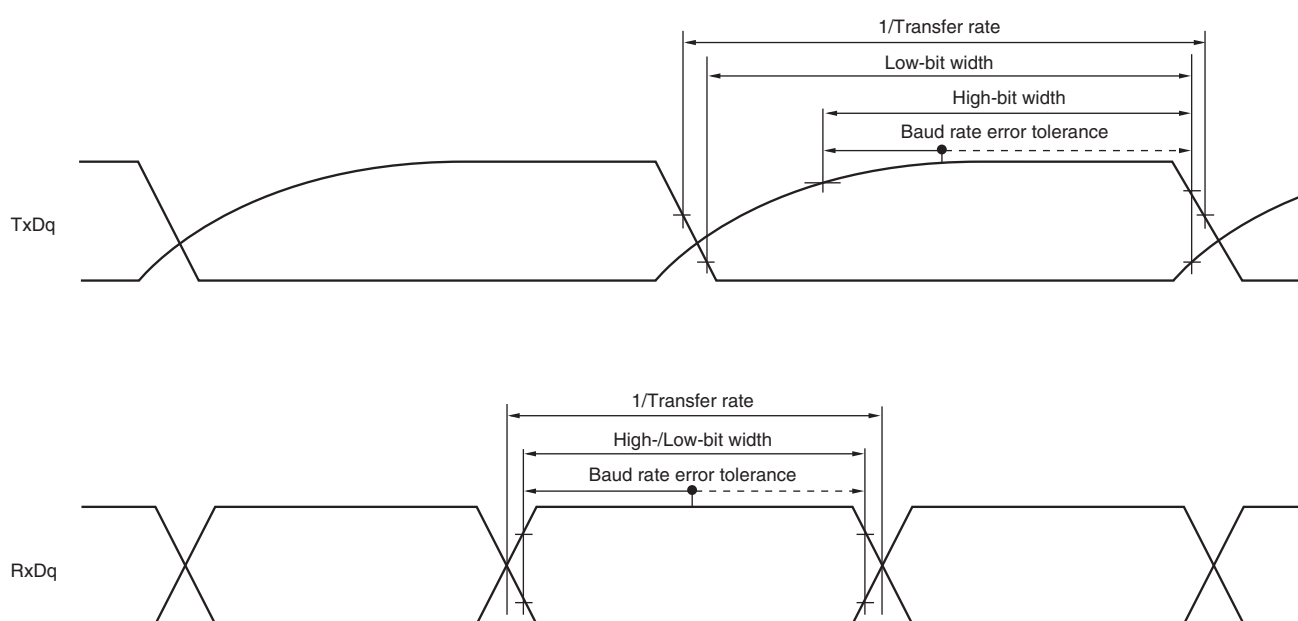
$$\text{Maximum transfer rate} = \frac{1}{\{-C_b \times R_b \times \ln(1 - \frac{1.5}{V_b})\} \times 3} \quad [\text{bps}]$$

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

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

8. This value as an example is calculated when the conditions described in the “Conditions” column are met. Refer to **Note 7** 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 (V<sub>DD</sub> tolerance) mode for the TxDq 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.**

**UART mode connection diagram (during communication at different potential)****UART mode bit width (during communication at different potential) (reference)**

- Remarks**
1.  $R_b[\Omega]$ : Communication line (TxDq) pull-up resistance,  $C_b[F]$ : Communication line (TxDq) load capacitance,  $V_b[V]$ : Communication line voltage
  2. q: UART number (q = 0 to 2), g: PIM and POM number (g = 0, 1)
  3.  $f_{MCK}$ : Serial array unit operation clock frequency  
(Operation clock to be set by the serial clock select register m (SPSm) and the CKSmn bit of serial mode register mn (SMRmn).  
m: Unit number, n: Channel number (mn = 00 to 03, 10, 11))
  4. UART0 of the 20- and 24-pin products supports communication at different potential only when the peripheral I/O redirection function is not used.

**(6) Communication at different potential (1.8 V, 2.5 V, 3 V) (CSI mode) (master mode, SCKp... internal clock output) (1/3)****( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $2.4\text{ V} \leq V_{DD} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )**

Parameter	Symbol	Conditions		HS (high-speed main) Mode		Unit
				MIN.	MAX.	
SCKp cycle time	$t_{KCY1}$	$t_{KCY1} \geq 4/f_{CLK}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$	600		ns
			$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$	1000		ns
			$2.4\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$	2300		ns
SCKp high-level width	$t_{KH1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$		$t_{KCY1}/2 - 150$		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$		$t_{KCY1}/2 - 340$		ns
		$2.4\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$		$t_{KCY1}/2 - 916$		ns
SCKp low-level width	$t_{KL1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$		$t_{KCY1}/2 - 24$		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$		$t_{KCY1}/2 - 36$		ns
		$2.4\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$		$t_{KCY1}/2 - 100$		ns

- Cautions 1.** Select the TTL input buffer for the SIp pin and the N-ch open drain output ( $V_{DD}$  tolerance) mode for the SOp pin and SCKp pin by using port input mode register 1 (PIM1) and port output mode register 1 (POM1). For  $V_{IH}$  and  $V_{IL}$ , see the DC characteristics with TTL input buffer selected.
- 2.** CSI01 and CSI11 cannot communicate at different potential.

- Remarks 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
- 2.** p: CSI number (p = 00, 20)

**(6) Communication at different potential (1.8 V, 2.5 V, 3 V) (CSI mode) (master mode, SCKp... internal clock output) (2/3)****( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )**

Parameter	Symbol	Conditions	HS (high-speed main) Mode		Unit
			MIN.	MAX.	
Slp setup time (to SCKp $\uparrow$ ) <small>Note</small>	$t_{SIK1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$	162		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$	354		ns
		$2.4\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$	958		ns
Slp hold time (from SCKp $\uparrow$ ) <small>Note</small>	$t_{KSI1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$	38		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$	38		ns
		$2.4\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$	38		ns
Delay time from SCKp $\downarrow$ to SOp output <small>Note</small>	$t_{KSO1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$		200	ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$		390	ns
		$2.4\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$		966	ns

**Note** When DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1.

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

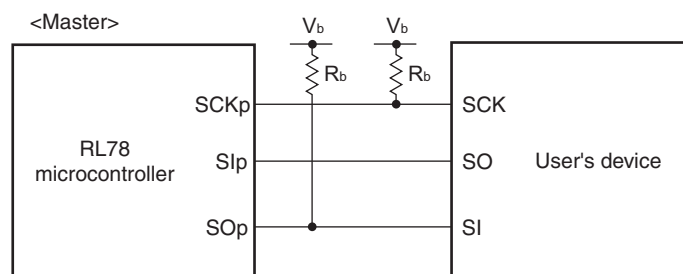
**(6) Communication at different potential (1.8 V, 2.5 V, 3 V) (CSI mode) (master mode, SCKp... internal clock output) (3/3)****( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )**

Parameter	Symbol	Conditions	HS (high-speed main) Mode		Unit
			MIN.	MAX.	
Slp setup time (to SCKp↓) <small>Note</small>	$t_{SIK1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$	88		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$	88		ns
		$2.4\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$	220		ns
Slp hold time (from SCKp↓) <small>Note</small>	$t_{KSI1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$	38		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$	38		ns
		$2.4\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$	38		ns
Delay time from SCKp↑ to SOp output <small>Note</small>	$t_{KSO1}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$		50	ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$		50	ns
		$2.4\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$		50	ns

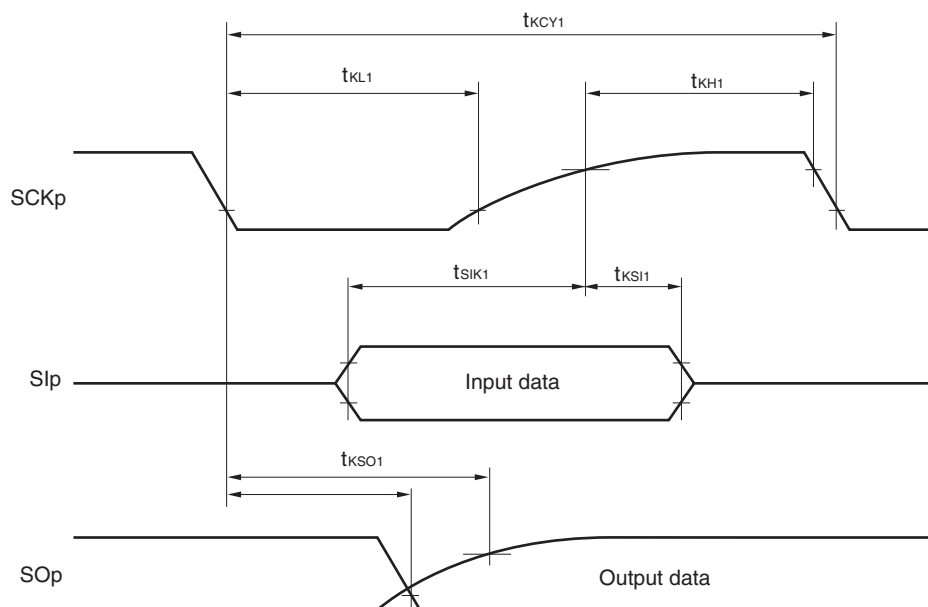
**Note** When  $DAPmn = 0$  and  $CKPmn = 1$ , or  $DAPmn = 1$  and  $CKPmn = 0$ .

- Cautions 1.** Select the TTL input buffer for the Slp pin and the N-ch open drain output ( $V_{DD}$  tolerance) mode for the SOp pin and SCKp pin by using port input mode register 1 (PIM1) and port output mode register 1 (POM1). For  $V_{IH}$  and  $V_{IL}$ , see the DC characteristics with TTL input buffer selected.
- 2.** CSI01 and CSI11 cannot communicate at different potential.

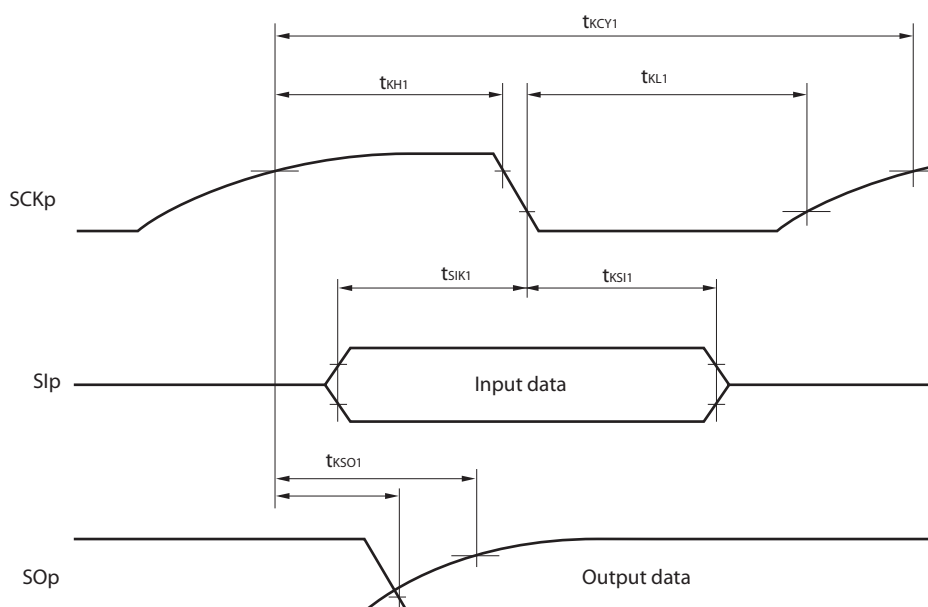
- Remarks 1.**  $R_b$  [ $\Omega$ ]: Communication line (SCKp, SOp) pull-up resistance,  $C_b$  [F]: Communication line (SCKp, SOp) load capacitance,  $V_b$  [V]: Communication line voltage
- 2.** p: CSI number (p = 00, 20), m: Unit number (m = 0, 1), n: Channel number (n = 0)

**CSI mode connection diagram (during communication at different potential)**

**CSI mode serial transfer timing (master mode) (during communication at different potential)**  
**(When DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1)**



**CSI mode serial transfer timing (master mode) (during communication at different potential)**  
**(When DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.)**



**Remark** p: CSI number (p = 00, 20), m: Unit number (m = 0, 1), n: Channel number (n = 0)



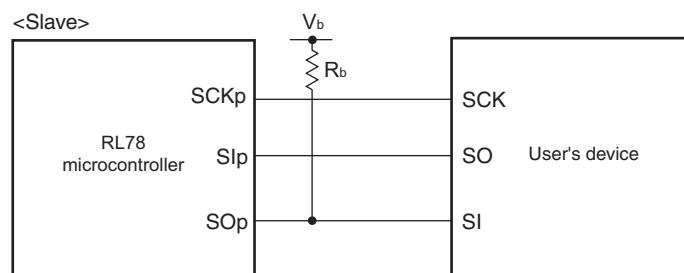
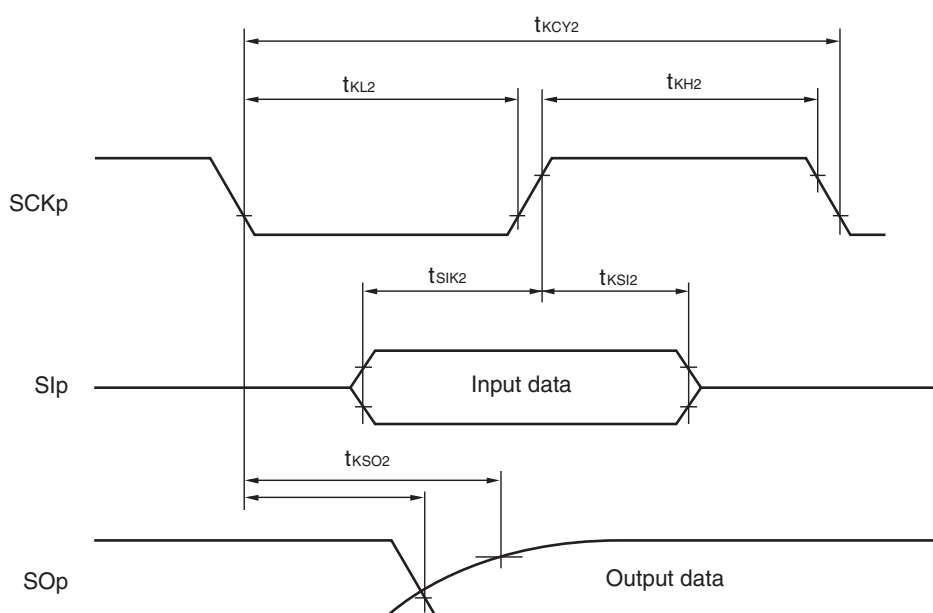
**(7) Communication at different potential (1.8 V, 2.5 V, 3 V) (CSI mode) (slave mode, SCKp... external clock input)**  
**( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )**

Parameter	Symbol	Conditions		HS (high-speed main) Mode		Unit
				MIN.	MAX.	
SCKp cycle time <sup>Note 1</sup>	$t_{KCY2}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$	$20\text{ MHz} < f_{MCK} \leq 24\text{ MHz}$	$24/f_{MCK}$		ns
			$8\text{ MHz} < f_{MCK} \leq 20\text{ MHz}$	$20/f_{MCK}$		ns
			$4\text{ MHz} < f_{MCK} \leq 8\text{ MHz}$	$16/f_{MCK}$		ns
			$f_{MCK} \leq 4\text{ MHz}$	$12/f_{MCK}$		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$	$20\text{ MHz} < f_{MCK} \leq 24\text{ MHz}$	$32/f_{MCK}$		ns
			$16\text{ MHz} < f_{MCK} \leq 20\text{ MHz}$	$28/f_{MCK}$		ns
			$8\text{ MHz} < f_{MCK} \leq 16\text{ MHz}$	$24/f_{MCK}$		ns
			$4\text{ MHz} < f_{MCK} \leq 8\text{ MHz}$	$16/f_{MCK}$		ns
			$f_{MCK} \leq 4\text{ MHz}$	$12/f_{MCK}$		ns
		$2.4\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$	$20\text{ MHz} < f_{MCK} \leq 24\text{ MHz}$	$72/f_{MCK}$		ns
			$16\text{ MHz} < f_{MCK} \leq 20\text{ MHz}$	$64/f_{MCK}$		ns
			$8\text{ MHz} < f_{MCK} \leq 16\text{ MHz}$	$52/f_{MCK}$		ns
			$4\text{ MHz} < f_{MCK} \leq 8\text{ MHz}$	$32/f_{MCK}$		ns
			$f_{MCK} \leq 4\text{ MHz}$	$20/f_{MCK}$		ns
SCKp high-/low-level width	$t_{KH2}$ , $t_{KL2}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$		$t_{KCY2}/2 - 24$		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$		$t_{KCY2}/2 - 36$		ns
		$2.4\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$		$t_{KCY2}/2 - 100$		ns
Slp setup time (to SCKp $\uparrow$ ) <sup>Note 2</sup>	$t_{SIK2}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_{DD} \leq 4.0\text{ V}$		$1/f_{MCK} + 40$		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$		$1/f_{MCK} + 40$		ns
		$2.4\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_{DD} \leq 2.0\text{ V}$		$1/f_{MCK} + 60$		ns
Slp hold time (from SCKp $\uparrow$ ) <sup>Note 3</sup>	$t_{KSI2}$			$1/f_{MCK} + 62$		ns
Delay time from SCKp $\downarrow$ to SOp output <sup>Note 4</sup>	$t_{KSO2}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 1.4\text{ k}\Omega$			$2/f_{MCK} + 240$	ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$			$2/f_{MCK} + 428$	ns
		$2.4\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ , $C_b = 30\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$			$2/f_{MCK} + 1146$	ns

**Notes** 1. Transfer rate in the SNOOZE mode: MAX. 1 Mbps

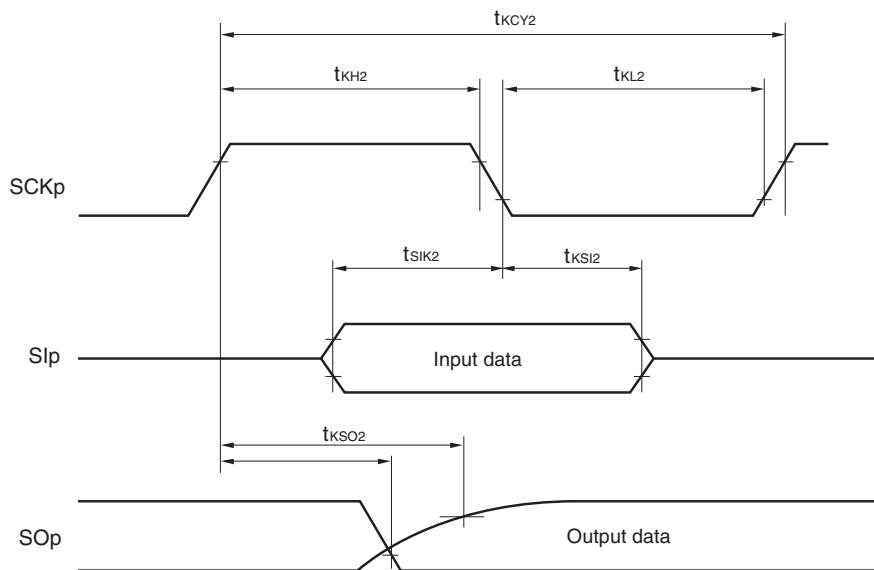
- When DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1. The Slp setup time becomes "to SCKp $\downarrow$ " when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.
- When DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1. The Slp hold time becomes "from SCKp $\downarrow$ " when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.
- When DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1. The delay time to SOp output becomes "from SCKp $\uparrow$ " when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.

- Cautions**
- Select the TTL input buffer for the Slp and SCKp pins and the N-ch open drain output ( $V_{DD}$  tolerance) mode for the SOp pin by using port input mode register 1 (PIM1) and port output mode register 1 (POM1). **For  $V_{IH}$  and  $V_{IL}$ , see the DC characteristics with TTL input buffer selected.**
  - CSI01 and CSI11 cannot communicate at different potential.

**CSI mode connection diagram (during communication at different potential)**
**CSI mode serial transfer timing (slave mode) (during communication at different potential)**  
 (When  $DAPmn = 0$  and  $CKPmn = 0$ , or  $DAPmn = 1$  and  $CKPmn = 1$ .)


- Remarks**
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
  2. p: CSI number ( $p = 00, 20$ ), m: Unit number ( $m = 0, 1$ ), n: Channel number ( $n = 0$ )
  3.  $f_{MCK}$ : Serial array unit operation clock frequency  
(Operation clock to be set by the serial clock select register m (SPS<sub>m</sub>) and the CKS<sub>mn</sub> bit of serial mode register mn (SMR<sub>mn</sub>))

**CSI mode serial transfer timing (slave mode) (during communication at different potential)**  
**(When DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.)**



**Remark** p: CSI number (p = 00, 20), m: Unit number (m = 0, 1), n: Channel number (n = 0)

**(8) Communication at different potential (1.8 V, 2.5 V, 3 V) (simplified I<sup>2</sup>C mode)****( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )**

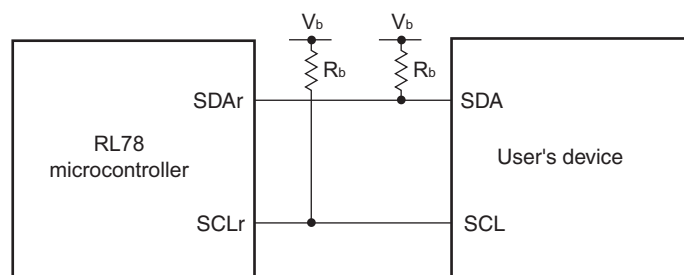
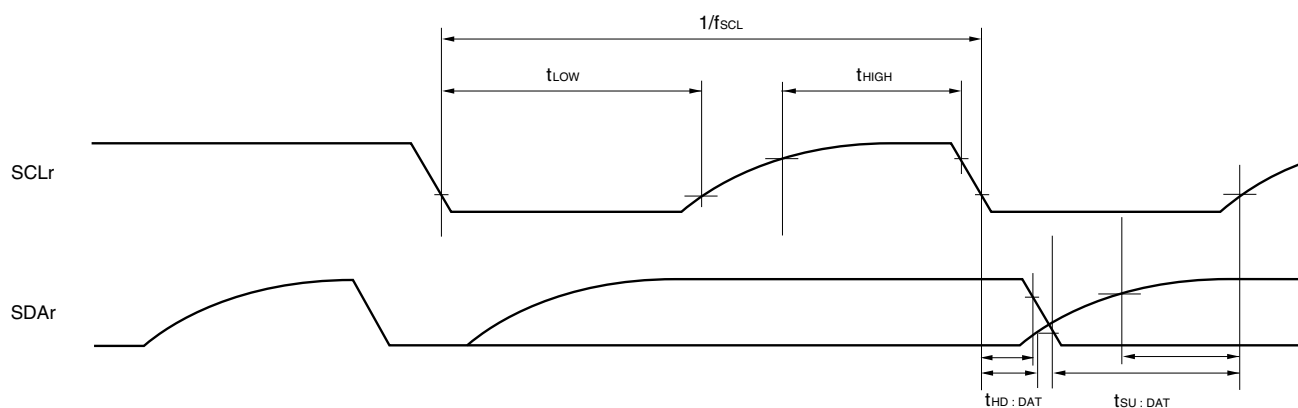
Parameter	Symbol	Conditions	HS (high-speed main) Mode		Unit
			MIN.	MAX.	
SCLr clock frequency	$f_{SCL}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 2.8\text{ k}\Omega$		$100^{\text{Note1}}$	kHz
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$		$100^{\text{Note1}}$	kHz
		$2.4\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$		$100^{\text{Note1}}$	kHz
Hold time when SCLr = "L"	$t_{LOW}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 2.8\text{ k}\Omega$	4600		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$	4600		ns
		$2.4\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$	4650		ns
Hold time when SCLr = "H"	$t_{HIGH}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 2.8\text{ k}\Omega$	2700		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$	2400		ns
		$2.4\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$	1830		ns
Data setup time (reception)	$t_{SU:DAT}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 2.8\text{ k}\Omega$	$1/f_{MCK}$ + 760 <sup>Note3</sup>		ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$	$1/f_{MCK}$ + 760 <sup>Note3</sup>		ns
		$2.4\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$	$1/f_{MCK}$ + 570 <sup>Note3</sup>		ns
Data hold time (transmission)	$t_{HD:DAT}$	$4.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ , $2.7\text{ V} \leq V_b \leq 4.0\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 2.8\text{ k}\Omega$	0	1420	ns
		$2.7\text{ V} \leq V_{DD} < 4.0\text{ V}$ , $2.3\text{ V} \leq V_b \leq 2.7\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 2.7\text{ k}\Omega$	0	1420	ns
		$2.4\text{ V} \leq V_{DD} < 3.3\text{ V}$ , $1.6\text{ V} \leq V_b \leq 2.0\text{ V}$ , $C_b = 100\text{ pF}$ , $R_b = 5.5\text{ k}\Omega$	0	1215	ns

**Notes** 1. The value must also be equal to or less than  $f_{MCK}/4$ .2. Set  $t_{SU:DAT}$  so that it will not exceed the hold time when SCLr = "L" or SCLr = "H".

**Cautions** 1. Select the TTL input buffer and the N-ch open drain output ( $V_{DD}$  tolerance) mode for the SDAr pin and the N-ch open drain output ( $V_{DD}$  tolerance) mode for the SCLr pin by using port input mode register 1 (PIM1) and port output mode register 1 (POM1). For  $V_{IH}$  and  $V_{IL}$ , see the DC characteristics with TTL input buffer selected.

2. IIC01 and IIC11 cannot communicate at different potential.

(Remarks are listed on the next page.)

**Simplified I<sup>2</sup>C mode connection diagram (during communication at different potential)****Simplified I<sup>2</sup>C mode serial transfer timing (during communication at different potential)**

- Remarks 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
- 2.**  $r$ : IIC Number ( $r = 00, 20$ )
- 3.**  $f_{MCK}$ : Serial array unit operation clock frequency  
(Operation clock to be set by the serial clock select register  $m$  (SPS $m$ ) and the CKS $m$  $n$  bit of serial mode register  $m$  $n$  (SMR $m$  $n$ ).  
 $m$ : Unit number ( $m = 0, 1$ ),  $n$ : Channel number ( $n = 0$ ))

## 3.5.2 Serial interface IICA

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

Parameter	Symbol	Conditions	HS (high-speed main) mode				Unit
			Standard Mode		Fast Mode		
			MIN.	MAX.	MIN.	MAX.	
SCLA0 clock frequency	f <sub>SCL</sub>	Fast mode: f <sub>CLK</sub> ≥ 3.5 MHz			0	400	kHz
		Normal mode: f <sub>CLK</sub> ≥ 1 MHz	0	100			kHz
Setup time of restart condition	t <sub>SU:STA</sub>		4.7		0.6		μs
Hold time <sup>Note 1</sup>	t <sub>HD:STA</sub>		4.0		0.6		μs
Hold time when SCLA0 = “L”	t <sub>LOW</sub>		4.7		1.3		μs
Hold time when SCLA0 = “H”	t <sub>HIGH</sub>		4.0		0.6		μs
Data setup time (reception)	t <sub>SU:DAT</sub>		250		100		ns
Data hold time (transmission) <sup>Note 2</sup>	t <sub>HD:DAT</sub>		0	3.45	0	0.9	μs
Setup time of stop condition	t <sub>SU:STO</sub>		4.0		0.6		μs
Bus-free time	t <sub>BUF</sub>		4.7		1.3		μs

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

<R> 2. The maximum value (MAX.) of  $t_{HD:DAT}$  is during normal transfer and a wait state is inserted in the ACK (acknowledge) timing.

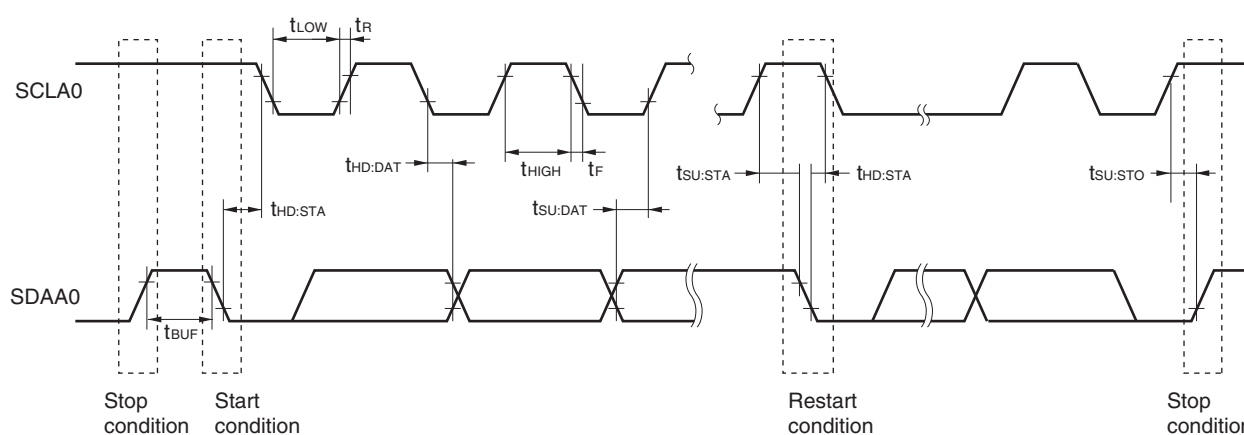
**Caution** Only in the 30-pin products, the values in the above table are applied even when bit 2 (PIOR2) in the peripheral I/O redirection register (PIOR) is 1. At this time, the pin characteristics ( $I_{OH1}$ ,  $I_{OL1}$ ,  $V_{OH1}$ ,  $V_{OL1}$ ) must satisfy the values in the redirect destination.

**Remark** The maximum value of  $C_b$  (communication line capacitance) and the value of  $R_b$  (communication line pull-up resistor) at that time in each mode are as follows.

Normal mode:  $C_b = 400\text{ pF}$ ,  $R_b = 2.7\text{ k}\Omega$

Fast mode:  $C_b = 320\text{ pF}$ ,  $R_b = 1.1\text{ k}\Omega$

IICA serial transfer timing



### 3.6 Analog Characteristics

#### 3.6.1 A/D converter characteristics

##### Classification of A/D converter characteristics

Input channel	Reference Voltage		
	Reference voltage (+) = $AV_{REFP}$ Reference voltage (-) = $AV_{REFM}$	Reference voltage (+) = $V_{DD}$ Reference voltage (-) = $V_{SS}$	Reference voltage (+) = $V_{BGR}$ Reference voltage (-) = $AV_{REFM}$
ANI0 to ANI3	Refer to 29.6.1 (1).	Refer to 29.6.1 (3).	Refer to 29.6.1 (4).
ANI16 to ANI22	Refer to 29.6.1 (2).		
Internal reference voltage Temperature sensor output voltage	Refer to 29.6.1 (1).		—

(1) When reference voltage (+) =  $AV_{REFP}/ANI0$  ( $ADREFP1 = 0$ ,  $ADREFP0 = 1$ ), reference voltage (-) =  $AV_{REFM}/ANI1$  ( $ADREFM = 1$ ), target pin: ANI2, ANI3, internal reference voltage, and temperature sensor output voltage

( $T_A = -40$  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 (-) =  $AV_{REFM} = 0\text{ V}$ )

Parameter	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>		1.2	$\pm 3.5$	LSB
Conversion time	$t_{CONV}$	10-bit resolution Target pin: ANI2, ANI3	$3.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	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 Target pin: Internal reference voltage, and temperature sensor output voltage (HS (high-speed main) mode)	$3.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	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 $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>			$\pm 0.25$	%FSR
Full-scale error <sup>Notes 1, 2</sup>	EFS	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>			$\pm 0.25$	%FSR
Integral linearity error <sup>Note 1</sup>	ILE	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>			$\pm 2.5$	LSB
Differential linearity error <sup>Note 1</sup>	DLE	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>			$\pm 1.5$	LSB
Analog input voltage	$V_{AIN}$	ANI2, ANI3	0		$AV_{REFP}$	V
		Internal reference voltage (HS (high-speed main) mode)	$V_{BGR}$ <sup>Note 4</sup>			V
		Temperature sensor output voltage (HS (high-speed main) mode)	$V_{TMPS25}$ <sup>Note 4</sup>			V

(Notes are listed on the next page.)

**Notes** 1. Excludes quantization error ( $\pm 1/2$  LSB).

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

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

Overall error: Add  $\pm 1.0$  LSB to the MAX. value when  $AV_{REFP} = V_{DD}$ .

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

Integral linearity error/ Differential linearity error: Add  $\pm 0.5$  LSB to the MAX. value when  $AV_{REFP} = V_{DD}$ .

4. Refer to **29.6.2 Temperature sensor/internal reference voltage characteristics**.

(2) When reference voltage (+) =  $AV_{REFP}/ANI0$  ( $ADREFP1 = 0$ ,  $ADREFP0 = 1$ ), reference voltage (–) =  $AV_{REFM}/ANI1$  ( $ADREFM = 1$ ), target pin: ANI16 to ANI22

( $T_A = -40$  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 (–) =  $AV_{REFM} = 0\text{ V}$ )

Parameter	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>		1.2	$\pm 5.0$	LSB
Conversion time	$t_{CONV}$	10-bit resolution Target ANI pin: ANI16 to ANI22	$3.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	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>			$\pm 0.35$	%FSR
Full-scale error <sup>Notes 1, 2</sup>	EFS	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>			$\pm 0.35$	%FSR
Integral linearity error <sup>Note 1</sup>	ILE	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>			$\pm 3.5$	LSB
Differential linearity error <sup>Note 1</sup>	DLE	10-bit resolution $AV_{REFP} = V_{DD}$ <sup>Note 3</sup>			$\pm 2.0$	LSB
Analog input voltage	$V_{AIN}$	ANI16 to ANI22	0		$AV_{REFP}$ and $V_{DD}$	V

**Notes** 1. Excludes quantization error ( $\pm 1/2$  LSB).

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

3. When  $AV_{REFP} \leq V_{DD}$ , the MAX. values are as follows.

Overall error: Add  $\pm 4.0$  LSB to the MAX. value when  $AV_{REFP} = V_{DD}$ .

Zero-scale error/Full-scale error: Add  $\pm 0.20\%$ FSR to the MAX. value when  $AV_{REFP} = V_{DD}$ .

Integral linearity error/ Differential linearity error: Add  $\pm 2.0$  LSB to the MAX. value when  $AV_{REFP} = V_{DD}$ .



(3) When reference voltage (+) =  $V_{DD}$  (ADREFP1 = 0, ADREFP0 = 0), reference voltage (–) =  $V_{SS}$  (ADREFM = 0), target pin: ANI0 to ANI3, ANI16 to ANI22, internal reference voltage, and temperature sensor output voltage

( $T_A = -40$  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 (–) =  $V_{SS}$ )

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Resolution	RES		8		10	bit
Overall error <sup>Note 1</sup>	AINL	10-bit resolution		1.2	$\pm 7.0$	LSB
Conversion time	t <sub>CONV</sub>	10-bit resolution Target pin: ANI0 to ANI3, ANI16 to ANI22	$3.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	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	$\mu\text{s}$
Conversion time	t <sub>CONV</sub>	10-bit resolution Target pin: internal reference voltage, and temperature sensor output voltage (HS (high-speed main) mode)	$3.6\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	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			$\pm 0.60$	%FSR
Full-scale error <sup>Notes 1, 2</sup>	EFS	10-bit resolution			$\pm 0.60$	%FSR
Integral linearity error <sup>Note 1</sup>	ILE	10-bit resolution			$\pm 4.0$	LSB
Differential linearity error <sup>Note 1</sup>	DLE	10-bit resolution			$\pm 2.0$	LSB
Analog input voltage	V <sub>AIN</sub>	ANI0 to ANI3, ANI16 to ANI22	0		$V_{DD}$	V
		Internal reference voltage (HS (high-speed main) mode)	V <sub>BGR</sub> <sup>Note 3</sup>			V
		Temperature sensor output voltage (HS (high-speed main) mode)	V <sub>TMPS25</sub> <sup>Note 3</sup>			V

**Notes** 1. Excludes quantization error ( $\pm 1/2$  LSB).

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

3. Refer to **29.6.2 Temperature sensor/internal reference voltage characteristics**.

(4) When reference voltage (+) = Internal reference voltage (ADREFP1 = 1, ADREFP0 = 0), reference voltage (–) =  $AV_{REFM}$  (ADREFM = 1), target pin: ANI0, ANI2, ANI3, and ANI16 to ANI22

( $T_A = -40$  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, HS (high-speed main) mode)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Resolution	RES		8			bit
Conversion time	$t_{CONV}$	8-bit resolution	17		39	$\mu\text{s}$
Zero-scale error <sup>Notes 1, 2</sup>	EZS	8-bit resolution			$\pm 0.60$	%FSR
Integral linearity error <sup>Note 1</sup>	ILE	8-bit resolution			$\pm 2.0$	LSB
Differential linearity error <sup>Note 1</sup>	DLE	8-bit resolution			$\pm 1.0$	LSB
Analog input voltage	$V_{AIN}$		0		$V_{BGR}$ <sup>Note 3</sup>	V

**Notes** 1. Excludes quantization error ( $\pm 1/2$  LSB).

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

3. Refer to **29.6.2 Temperature sensor/internal reference voltage characteristics**.

4. When reference voltage (–) =  $V_{SS}$ , the MAX. values are as follows.

Zero-scale error: Add  $\pm 0.35\%$ FSR to the MAX. value when reference voltage (–) =  $AV_{REFM}$ .

Integral linearity error: Add  $\pm 0.5$  LSB to the MAX. value when reference voltage (–) =  $AV_{REFM}$ .

Differential linearity error: Add  $\pm 0.2$  LSB to the MAX. value when reference voltage (–) =  $AV_{REFM}$ .

## 3.6.2 Temperature sensor/internal reference voltage characteristics

**( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ , HS (high-speed main) mode)**

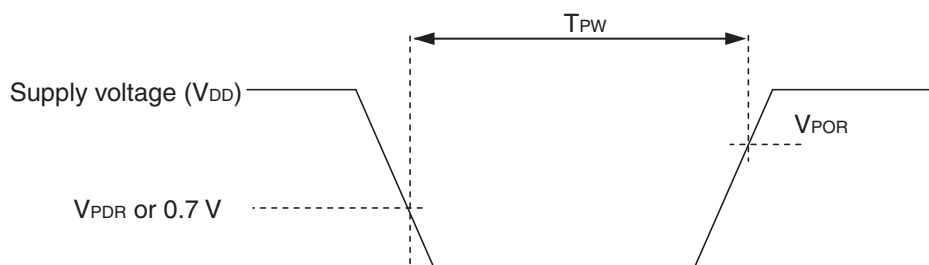
Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Temperature sensor output voltage	$V_{TMS25}$	Setting ADS register = 80H, $T_A = +25^\circ\text{C}$		1.05		V
Internal reference voltage	$V_{BGR}$	Setting ADS register = 81H	1.38	1.45	1.50	V
Temperature coefficient	$F_{VTMS}$	Temperature sensor output voltage that depends on the temperature		-3.6		mV/ $^\circ\text{C}$
Operation stabilization wait time	$t_{AMP}$		5			$\mu\text{s}$

## 3.6.3 POR circuit characteristics

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

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Detection voltage	$V_{POR}$	Power supply rise time	1.45	1.51	1.57	V
	$V_{PDR}$	Power supply fall time	1.44	1.50	1.56	V
Minimum pulse width <sup>Note</sup>	$T_{PW}$		300			$\mu\text{s}$

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



## 3.6.4 LVD circuit characteristics

**LVD Detection Voltage of Reset Mode and Interrupt Mode****( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $V_{PDR} \leq V_{DD} \leq 5.5$  V,  $V_{SS} = 0$  V)**

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Detection supply voltage	$V_{LVD0}$	Power supply rise time	3.90	4.06	4.22	V
		Power supply fall time	3.83	3.98	4.13	V
	$V_{LVD1}$	Power supply rise time	3.60	3.75	3.90	V
		Power supply fall time	3.53	3.67	3.81	V
	$V_{LVD2}$	Power supply rise time	3.01	3.13	3.25	V
		Power supply fall time	2.94	3.06	3.18	V
	$V_{LVD3}$	Power supply rise time	2.90	3.02	3.14	V
		Power supply fall time	2.85	2.96	3.07	V
	$V_{LVD4}$	Power supply rise time	2.81	2.92	3.03	V
		Power supply fall time	2.75	2.86	2.97	V
	$V_{LVD5}$	Power supply rise time	2.70	2.81	2.92	V
		Power supply fall time	2.64	2.75	2.86	V
	$V_{LVD6}$	Power supply rise time	2.61	2.71	2.81	V
		Power supply fall time	2.55	2.65	2.75	V
	$V_{LVD7}$	Power supply rise time	2.51	2.61	2.71	V
		Power supply fall time	2.45	2.55	2.65	V
Minimum pulse width	$t_{LW}$		300			$\mu\text{s}$
Detection delay time					300	$\mu\text{s}$

**LVD detection voltage of interrupt & reset mode****( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $V_{PDR} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )**

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Interrupt and reset mode	V <sub>LVDD0</sub>	V <sub>POC2</sub> , V <sub>POC1</sub> , V <sub>POC1</sub> = 0, 1, 1, falling reset voltage		2.64	2.75	2.86	V
	V <sub>LVDD1</sub>	LVIS1, LVIS0 = 1, 0	Rising reset release voltage	2.81	2.92	3.03	V
			Falling interrupt voltage	2.75	2.86	2.97	V
	V <sub>LVDD2</sub>	LVIS1, LVIS0 = 0, 1	Rising reset release voltage	2.90	3.02	3.14	V
			Falling interrupt voltage	2.85	2.96	3.07	V
	V <sub>LVDD3</sub>	LVIS1, LVIS0 = 0, 0	Rising reset release voltage	3.90	4.06	4.22	V
			Falling interrupt voltage	3.83	3.98	4.13	V

**3.6.5 Power supply voltage rising slope characteristics****( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $V_{SS} = 0\text{ V}$ )**

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Power supply voltage rising slope	S <sub>VDD</sub>				54	V/ms

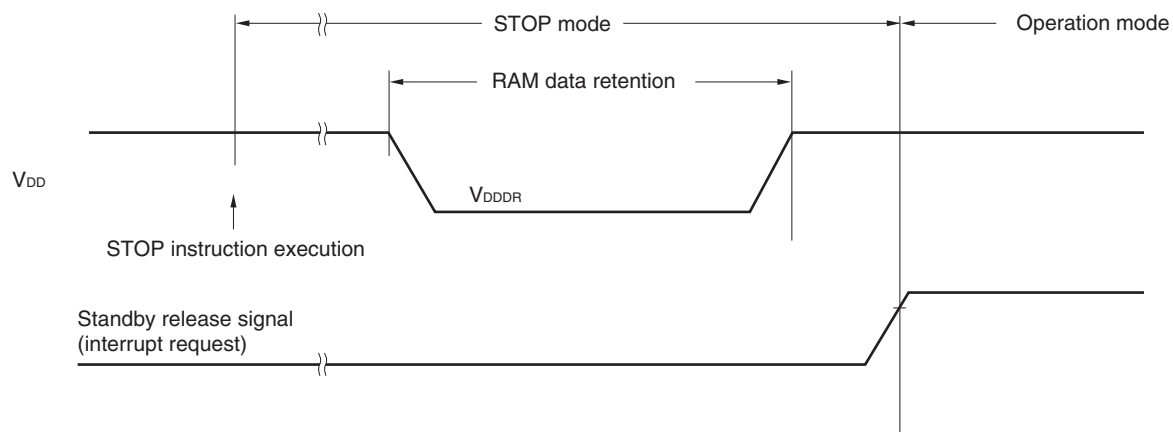
**Caution** Make sure to keep the internal reset state by the LVD circuit or an external reset until  $V_{DD}$  reaches the operating voltage range shown in 29.4 AC Characteristics.

## &lt;R&gt; 3.7 RAM Data Retention Characteristics

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

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Data retention supply voltage	$V_{DDDR}$		1.44 <sup>Note</sup>		5.5	V

<R> Note This depends on the POR detection voltage. For a falling voltage, data in RAM are retained until the voltage reaches the level that triggers a POR reset but not once it reaches the level at which a POR reset is generated.



## 3.8 Flash Memory Programming Characteristics

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

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
System clock frequency	$f_{CLK}$		1		24	MHz
Code flash memory rewritable times <small>Notes 1, 2, 3</small>	$C_{erwr}$	Retained for 20 years $T_A = 85^\circ\text{C}$ <small>Notes 4</small>	1,000			Times
Data flash memory rewritable times <small>Notes 1, 2, 3</small>		Retained for 1 year $T_A = 25^\circ\text{C}$ <small>Notes 4</small>		1,000,000		
		Retained for 5 years $T_A = 85^\circ\text{C}$ <small>Notes 4</small>	100,000			
		Retained for 20 years $T_A = 85^\circ\text{C}$ <small>Notes 4</small>	10,000			

- Notes**
- 1 erase + 1 write after the erase is regarded as 1 rewrite. The retaining years are until next rewrite after the rewrite.
  2. When using flash memory programmer and Renesas Electronics self programming library
  3. These are the characteristics of the flash memory and the results obtained from reliability testing by Renesas Electronics Corporation.
  4. This temperature is the average value at which data are retained.

## 3.9 Dedicated Flash Memory Programmer Communication (UART)

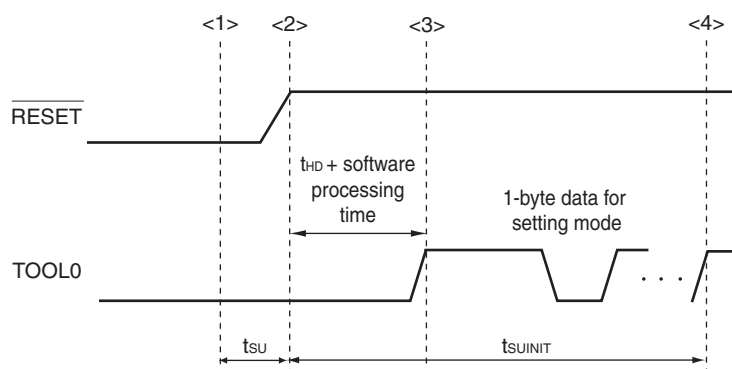
**( $T_A = -40$  to  $+105^\circ\text{C}$ ,  $2.4\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )**

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Transfer rate		During serial programming	115,200		1,000,000	bps

## 3.10 Timing of Entry to Flash Memory Programming Modes

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

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Time to complete the communication for the initial setting after the external reset is released	$t_{\text{SUNIT}}$	POR and LVD reset are released before external release			100	ms
Time to release the external reset after the TOOL0 pin is set to the low level	$t_{\text{SU}}$	POR and LVD reset are released before external release	10			$\mu\text{s}$
Time to hold the TOOL0 pin at the low level after the external reset is released (excluding the processing time of the firmware to control the flash memory)	$t_{\text{HD}}$	POR and LVD reset are released before external release	1			ms



- <1> The low level is input to the TOOL0 pin.
- <2> The external reset is released (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**  $t_{\text{SUNIT}}$ : Communication for the initial setting must be completed within 100 ms after the external reset is released during this period.

$t_{\text{SU}}$ : Time to release the external reset after the TOOL0 pin is set to the low level

$t_{\text{HD}}$ : Time to hold the TOOL0 pin at the low level after the external reset is released (excluding the processing time of the firmware to control the flash memory)

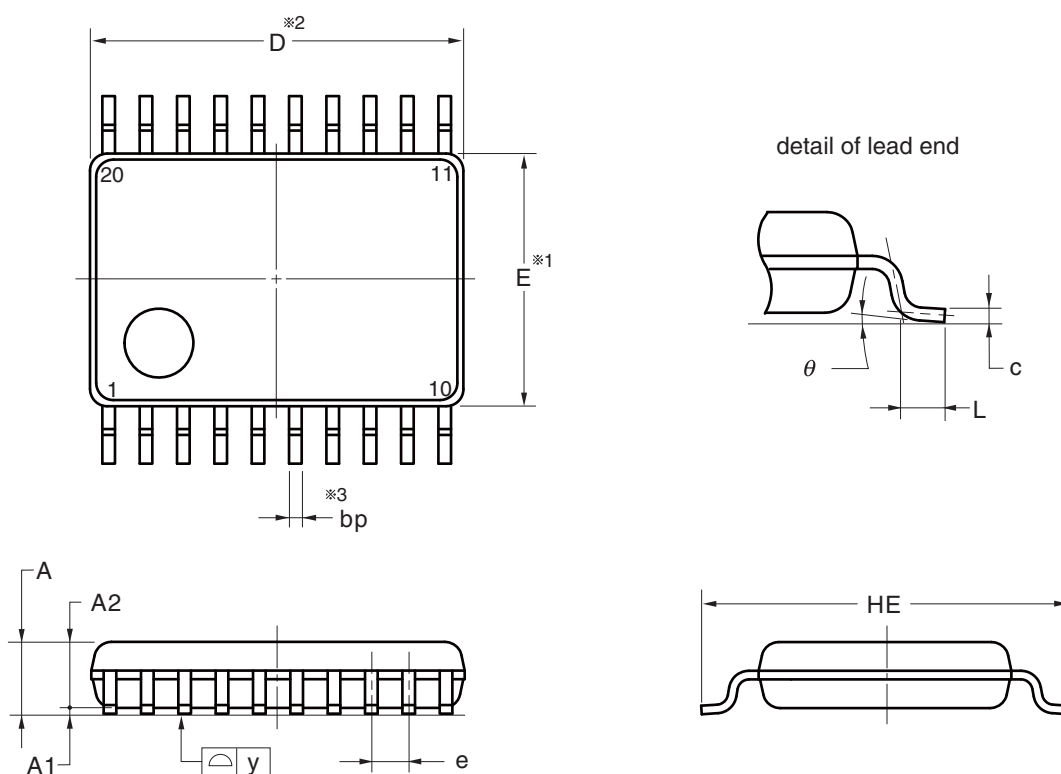
## 4. PACKAGE DRAWINGS

### 4.1 20-pin products

R5F1026AASP, R5F10269ASP, R5F10268ASP, R5F10267ASP, R5F10266ASP  
 R5F1036AASP, R5F10369ASP, R5F10368ASP, R5F10367ASP, R5F10366ASP  
 R5F1026ADSP, R5F10269DSP, R5F10268DSP, R5F10267DSP, R5F10266DSP  
 R5F1036ADSP, R5F10369DSP, R5F10368DSP, R5F10367DSP, R5F10366DSP  
 R5F1026AGSP, R5F10269GSP, R5F10268GSP, R5F10267GSP, R5F10266GSP

<R>

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.

(UNIT:mm)

ITEM	DIMENSIONS
D	6.50±0.10
E	4.40±0.10
HE	6.40±0.20
A	1.45 MAX.
A1	0.10±0.10
A2	1.15
e	0.65±0.12
bp	0.22 <sup>+0.10</sup> <sub>-0.05</sub>
c	0.15 <sup>+0.05</sup> <sub>-0.02</sub>
L	0.50±0.20
y	0.10
θ	0° to 10°

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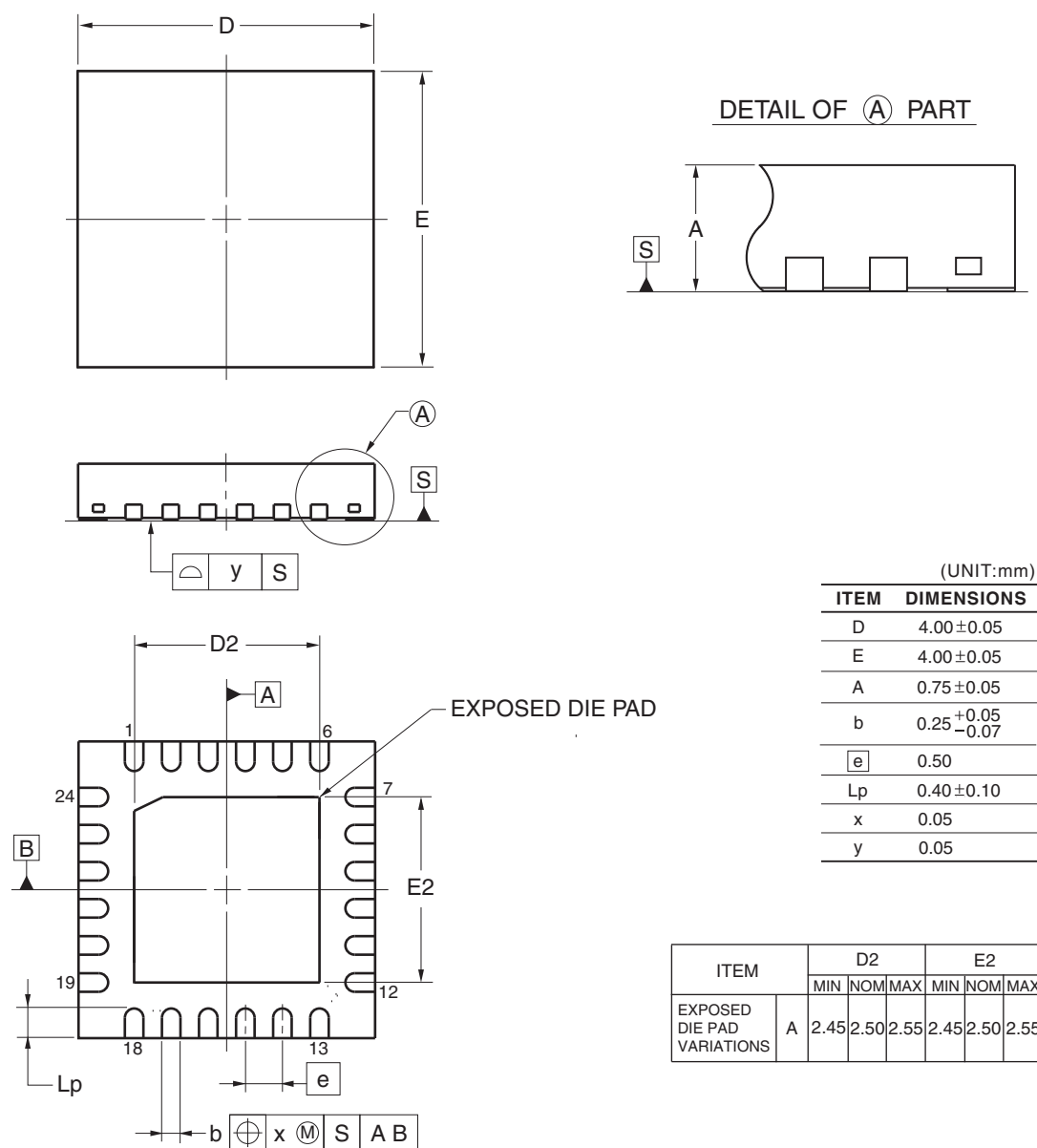


## 4.2 24-pin products

R5F1027AANA, R5F10279ANA, R5F10278ANA, R5F10277ANA  
 R5F1037AANA, R5F10379ANA, R5F10378ANA, R5F10377ANA  
 R5F1027ADNA, R5F10279DNA, R5F10278DNA, R5F10277DNA  
 R5F1037ADNA, R5F10379DNA, R5F10378DNA, R5F10377DNA  
 R5F1027AGNA, R5F10279GNA, R5F10278GNA, R5F10277GNA

&lt;R&gt;

JEITA Package Code	RENESAS Code	Previous Code	MASS (TYP.) [g]
P-HWQFN24-4x4-0.50	PWQN0024KE-A	P24K8-50-CAB-1	0.04



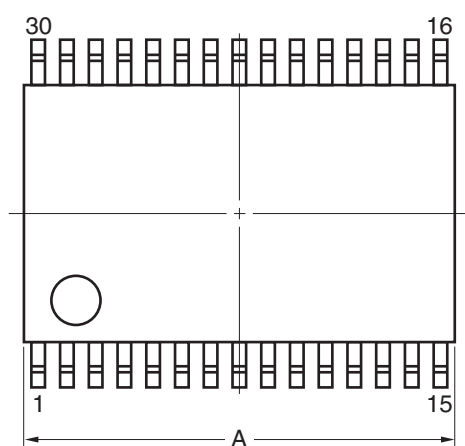
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## 4.3 30-pin products

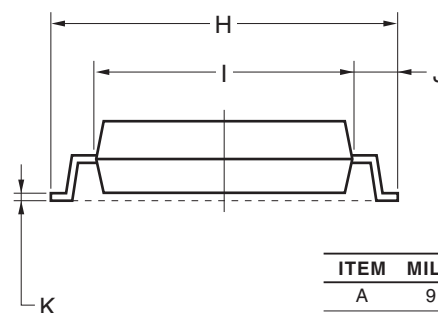
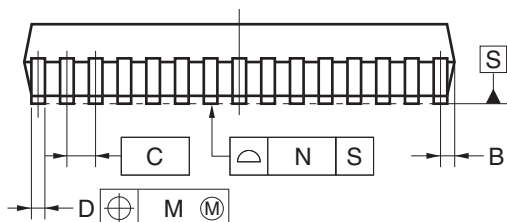
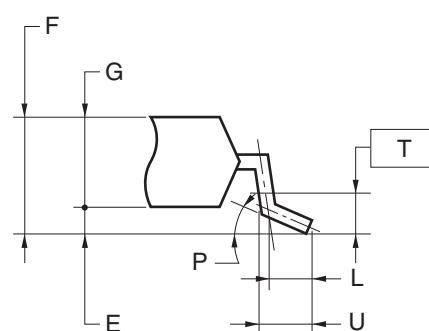
R5F102AAASP, R5F102A9ASP, R5F102A8ASP, R5F102A7ASP  
 R5F103AAASP, R5F103A9ASP, R5F103A8ASP, R5F103A7ASP  
 R5F102AADSP, R5F102A9DSP, R5F102A8DSP, R5F102A7DSP  
 R5F103AADSP, R5F103A9DSP, R5F103A8DSP, R5F103A7DSP  
 R5F102AAGSP, R5F102A9GSP, R5F102A8GSP, R5F102A7GSP

&lt;R&gt;

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



detail of lead end

**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

<b>Revision History</b>	<b>RL78/G12 Data Sheet</b>
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Rev.	Date	Description	
		Page	Summary
1.00	Dec 10, 2012	-	First Edition issued
2.00	Sep 06, 2013	1	Modification of 1.1 Features
		3	Modification of 1.2 List of Part Numbers
		4	Modification of Table 1-1. List of Ordering Part Numbers, Note, and Caution
		7 to 9	Modification of package name in 1.4.1 to 1.4.3
		14	Modification of tables in 1.7 Outline of Functions
		17	Modification of description of table in 2.1 Absolute Maximum Ratings (TA = 25°C)
		18	Modification of table, Note, and Caution in 2.2.1 X1 oscillator characteristics
		18	Modification of table in 2.2.2 On-chip oscillator characteristics
		19	Modification of Note 3 in 2.3.1 Pin characteristics (1/4)
		20	Modification of Note 3 in 2.3.1 Pin characteristics (2/4)
		23	Modification of Notes 1 and 2 in (1) 20-, 24-pin products (1/2)
		24	Modification of Notes 1 and 3 in (1) 20-, 24-pin products (2/2)
		25	Modification of Notes 1 and 2 in (2) 30-pin products (1/2)
		26	Modification of Notes 1 and 3 in (2) 30-pin products (2/2)
		27	Modification of (3) Peripheral functions (Common to all products)
		28	Modification of table in 2.4 AC Characteristics
		29	Addition of Minimum Instruction Execution Time during Main System Clock Operation
		30	Modification of figures of AC Timing Test Point and External Main System Clock Timing
		31	Modification of figure of AC Timing Test Point
		31	Modification of description and Note 2 in (1) During communication at same potential (UART mode)
		32	Modification of description in (2) During communication at same potential (CSI mode)
		33	Modification of description in (3) During communication at same potential (CSI mode)
		34	Modification of description in (4) During communication at same potential (CSI mode)
		36	Modification of table and Note 2 in (5) During communication at same potential (simplified I <sup>2</sup> C mode)
		38, 39	Modification of table and Notes 1 to 9 in (6) Communication at different potential (1.8 V, 2.5 V, 3 V) (UART mode)
		40	Modification of Remarks 1 to 3 in (6) Communication at different potential (1.8 V, 2.5 V, 3 V) (UART mode)
		41	Modification of table in (7) Communication at different potential (2.5 V, 3 V) (CSI mode)
		42	Modification of Caution in (7) Communication at different potential (2.5 V, 3 V) (CSI mode)
		43	Modification of table in (8) Communication at different potential (1.8 V, 2.5 V, 3 V) (CSI mode) (1/3)
		44	Modification of table and Notes 1 and 2 in (8) Communication at different potential (1.8 V, 2.5 V, 3 V) (CSI mode) (2/3)
		45	Modification of table, Note 1, and Caution 1 in (8) Communication at different potential (1.8 V, 2.5 V, 3 V) (CSI mode) (3/3)
		47	Modification of table in (9) Communication at different potential (1.8 V, 2.5 V, 3 V) (CSI mode)
		50	Modification of table, Note 1, and Caution 1 in (10) Communication at different potential (1.8 V, 2.5 V, 3 V) (simplified I <sup>2</sup> C mode)
		52	Modification of Remark in 2.5.2 Serial interface IICA
		53	Addition of table to 2.6.1 A/D converter characteristics
		53	Modification of description in 2.6.1 (1)
		54	Modification of Notes 3 to 5 in 2.6.1 (1)
		54	Modification of description and Notes 2 to 4 in 2.6.1 (2)

Rev.	Date	Description	
		Page	Summary
2.00	Sep 06, 2013	55	Modification of description and Notes 3 and 4 in 2.6.1 (3)
		56	Modification of description and Notes 3 and 4 in 2.6.1 (4)
		57	Modification of table in 2.6.2 Temperature sensor/internal reference voltage characteristics
		57	Modification of table and Note in 2.6.3 POR circuit characteristics
		58	Modification of table in 2.6.4 LVD circuit characteristics
		59	Modification of table of LVD detection voltage of interrupt & reset mode
		59	Modification of number and title to 2.6.5 Power supply voltage rising slope characteristics
		61	Modification of table, figure, and Remark in 2.10 Timing of Entry to Flash Memory Programming Modes
		62 to 103	Addition of products of industrial applications (G: T <sub>A</sub> = -40 to +105°C)
		104 to 106	Addition of products of industrial applications (G: T <sub>A</sub> = -40 to +105°C)
2.10	Mar 25, 2016	6	Modification of Figure 1-1 Part Number, Memory Size, and Package of RL78/G12
		7	Modification of Table 1-1 List of Ordering Part Numbers
		8	Addition of product name (RL78/G12) and description (Top View) in 1.4.1 20-pin products
		9	Addition of product name (RL78/G12) and description (Top View) in 1.4.2 24-pin products
		10	Addition of product name (RL78/G12) and description (Top View) in 1.4.3 30-pin products
		15	Modification of description in 1.7 Outline of Functions
		16	Modification of description, and addition of target products
		52	Modification of note 2 in 2.5.2 Serial interface IICA
		60	Modification of title and note, and addition of caution in 2.7 RAM Data Retention Characteristics
		60	Modification of conditions in 2.8 Flash Memory Programming Characteristics
		62	Modification of description, and addition of target products and remark
		94	Modification of note 2 in 3.5.2 Serial interface IICA
		102	Modification of title and note in 3.7 RAM Data Retention Characteristics
		102	Modification of conditions in 3.8 Flash Memory Programming Characteristics
		104 to 106	Addition of package name

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- (1) **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, etc., 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).
- (2) **HANDLING OF UNUSED INPUT PINS:** Unconnected CMOS device inputs can be cause of malfunction. If an input pin is unconnected, it is possible that an internal input level may be generated due to noise, etc., causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using pull-up or pull-down circuitry. Each unused pin should be connected to VDD or GND via a resistor if there is a possibility that it will be an output pin. All handling related to unused pins must be judged separately for each device and according to related specifications governing the device.
- (3) **PRECAUTION AGAINST ESD:** A strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it when it has occurred. Environmental control must be adequate. When it is dry, a humidifier should be used. It is recommended to avoid using insulators that 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 should be grounded. The operator should be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with mounted semiconductor devices.
- (4) **STATUS BEFORE INITIALIZATION:** Power-on does not necessarily define the initial status of a MOS device. Immediately after the power source is turned ON, devices with reset functions have not yet been initialized. Hence, power-on does not guarantee output pin levels, I/O settings or contents of registers. A device is not initialized until the reset signal is received. A reset operation must be executed immediately after power-on for devices with reset functions.
- (5) **POWER ON/OFF SEQUENCE:** In the case of a device that uses different power supplies for the internal operation and external interface, as a rule, switch on the external power supply after switching on the internal power supply. When switching the power supply off, as a rule, switch off the external power supply and then the internal power supply. Use of the reverse power on/off sequences may result in the application of an overvoltage to the internal elements of the device, causing malfunction and degradation of internal elements due to the passage of an abnormal current. The correct power on/off sequence must be judged separately for each device and according to related specifications governing the device.
- (6) **INPUT OF SIGNAL DURING POWER OFF STATE :** Do not input signals or an I/O pull-up power supply while the device is not powered. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Input of signals during the power off state must be judged separately for each device and according to related specifications governing the device.

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