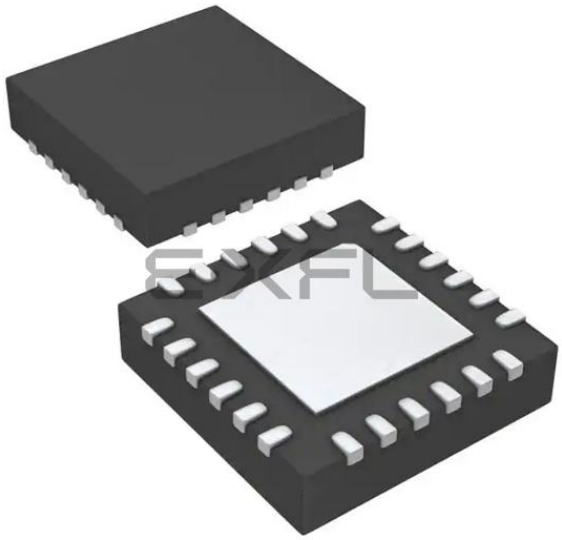

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What is "Embedded - Microcontrollers"?

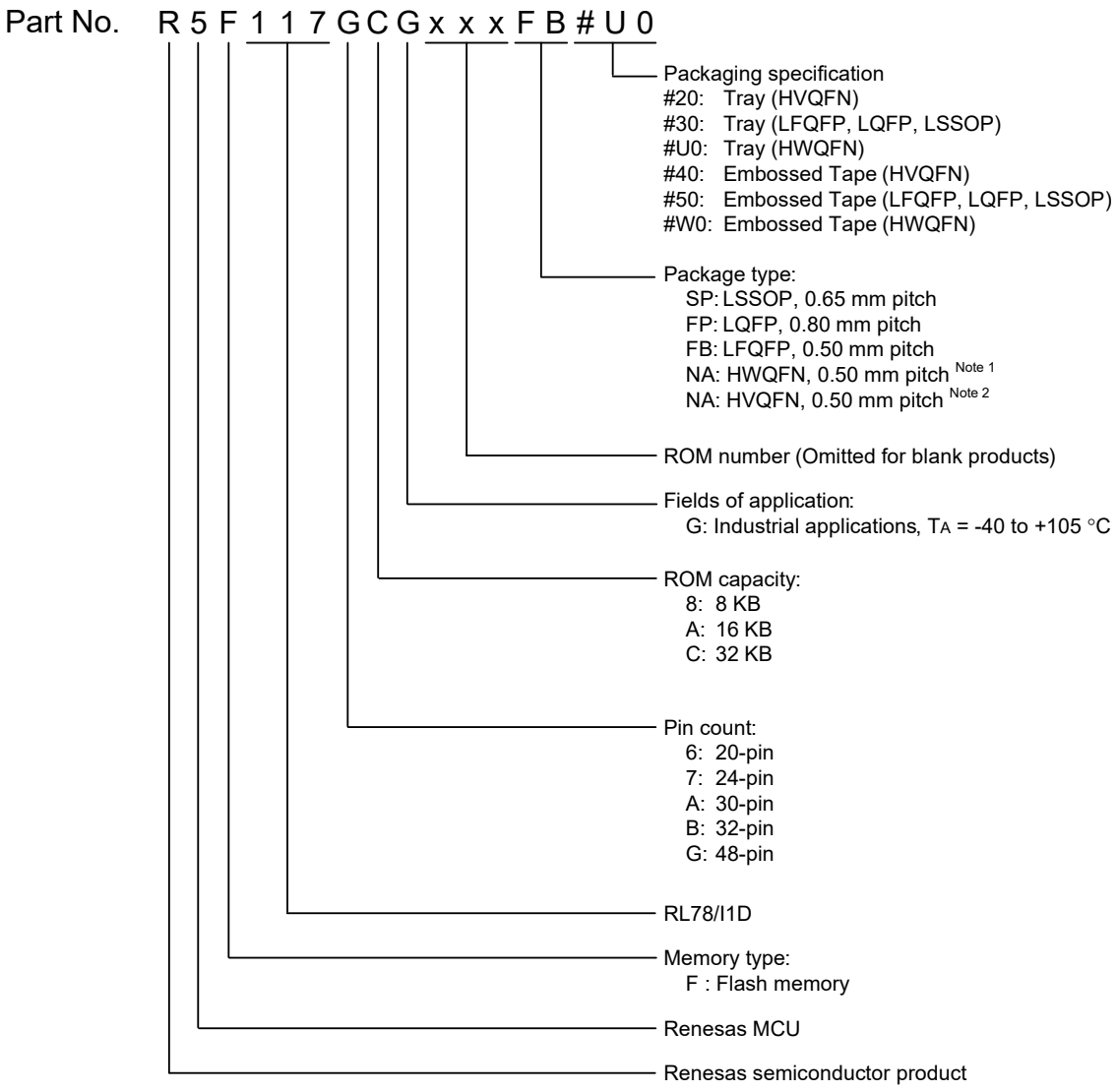
"Embedded - Microcontrollers" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable input/output peripherals. They are called "embedded" because they are embedded within electronic devices to control various functions, rather than serving as standalone computers. Microcontrollers are crucial in modern electronics, providing the intelligence and control needed for a wide range of applications.

Applications of "Embedded - Microcontrollers"

Details	
Product Status	Obsolete
Core Processor	RL78
Core Size	16-Bit
Speed	24MHz
Connectivity	CSI, I²C, UART/USART
Peripherals	LVD, POR, WDT
Number of I/O	15
Program Memory Size	8KB (8K x 8)
Program Memory Type	FLASH
EEPROM Size	2K x 8
RAM Size	768 x 8
Voltage - Supply (Vcc/Vdd)	1.6V ~ 3.6V
Data Converters	A/D 6x8/12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 105°C (TA)
Mounting Type	Surface Mount
Package / Case	24-WFQFN Exposed Pad
Supplier Device Package	24-HWQFN (4x4)
Purchase URL	https://www.e-xfl.com/product-detail/renesas-electronics-america/r5f11778gna-u0

1.2 Ordering Information

Figure 1 - 1 Part Number, Memory Size, and Package of RL78/I1D



Note 1. 24-pin products
Note 2. 32-pin products

Absolute Maximum Ratings **(2/2)**

Parameter	Symbols	Conditions		Ratings	Unit
Output current, high	I_{OH1}	Per pin	P00 to P04, P30 to P33, P40, P50 to P57, P130	-40	mA
		Total of all pins -170 mA	P00 to P04, P40, P130	-70	mA
			P30 to P33, P50 to P57	-100	mA
	I_{OH2}	Per pin	P10 to P17, P20 to P25	-0.1	mA
		Total of all pins		-1.4	mA
Output current, low	I_{OL1}	Per pin	P00 to P04, P30 to P33, P40, P50 to P57, P60 to P63, P130	40	mA
		Total of all pins 170 mA	P00 to P04, P40, P130	70	mA
			P30 to P33, P50 to P57, P60 to P63	100	mA
	I_{OL2}	Per pin	P10 to P17, P20 to P25	0.4	mA
		Total of all pins		5.6	mA
Operating ambient temperature	T_A	In normal operation mode		-40 to +105	°C
		In flash memory programming mode			
Storage temperature	T_{stg}			-65 to +150	°C

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

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

(T_A = -40 to +85°C, 1.6 V ≤ AV_{DD} = V_{DD} ≤ 3.6 V, V_{SS} = AV_{SS} = 0 V)

(T_A = +85 to +105°C, 2.4 V ≤ AV_{DD} = V_{DD} ≤ 3.6 V, V_{SS} = AV_{SS} = 0 V) **(2/5)**

Items	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Output current, low Note 1	I_{OL1}	Per pin for P00 to P04, P30 to P33, P40, P50 to P57, P130	T_A = -40 to +85°C			20.0 Note 2	mA
			T_A = +85 to +105°C			8.5 Note 2	mA
		Per pin for P60 to P63				15.0 Note 2	mA
		Total of P00 to P04, P40, P130 (When duty ≤ 70% Note 3)	2.7 V ≤ V_{DD} ≤ 3.6 V			15.0	mA
			1.8 V ≤ V_{DD} < 2.7 V			9.0	mA
			1.6 V ≤ V_{DD} < 1.8 V			4.5	mA
		Total of P30 to P33, P50 to P57, P60 to P63 (When duty ≤ 70% Note 3)	2.7 V ≤ V_{DD} ≤ 3.6 V			35.0	mA
			1.8 V ≤ V_{DD} < 2.7 V			20.0	mA
			1.6 V ≤ V_{DD} < 1.8 V			10.0	mA
		Total of all pins (When duty ≤ 70% Note 3)				50.0	mA
	I_{OL2}	Per pin for P10 to P17, P20 to P25				0.4 Note 2	mA
		Total of all pins (When duty ≤ 70% Note 3)	1.6 V ≤ V_{DD} ≤ 3.6 V			5.6	mA

Note 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.

Note 2. Do not exceed the total current value.

Note 3. Specification under conditions where the duty factor ≤ 70%.
The output current value that has changed to the duty factor > 70% the duty ratio can be calculated with the following expression (when changing the duty factor from 70% to n%).

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

<Example> Where n = 80% and I_{OL} = 10.0 mA
Total output current of pins = (10.0 × 0.7)/(80 × 0.01) ≈ 8.7 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.

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

(T_A = -40 to +85°C, 1.6 V ≤ AV_{DD} = V_{DD} ≤ 3.6 V, V_{SS} = AV_{SS} = 0 V)

(T_A = +85 to +105°C, 2.4 V ≤ AV_{DD} = V_{DD} ≤ 3.6 V, V_{SS} = AV_{SS} = 0 V) **(5/5)**

Items	Symbol	Conditions			MIN.	TYP.	MAX.	Unit
Input leakage current, high	I_{LIH1}	P00 to P04, P30 to P33, P40, P50 to P57, P60 to P63, P130, P137	$V_I = V_{DD}$				1	μA
	I_{LIH2}	$\overline{\text{RESET}}$	$V_I = V_{DD}$				1	μA
	I_{LIH3}	P121 to P124 (X1, X2, EXCLK, XT1, XT2, EXCLKS)	$V_I = V_{DD}$	In input port or external clock input			1	μA
				In resonator connection			10	μA
	I_{LIH4}	P10 to P17, P20 to P25	$V_I = AV_{DD}$				1	μA
Input leakage current, low	I_{LIL1}	P00 to P04, P30 to P33, P40, P50 to P57, P60 to P63, P130, P137	$V_I = V_{SS}$				-1	μA
	I_{LIL2}	$\overline{\text{RESET}}$	$V_I = V_{SS}$				-1	μA
	I_{LIL3}	P121 to P124 (X1, X2, EXCLK, XT1, XT2, EXCLKS)	$V_I = V_{SS}$	In input port or external clock input			-1	μA
				In resonator connection			-10	μA
	I_{LIL4}	P10 to P17, P20 to P25	$V_I = AV_{SS}$				-1	μA
On-chip pull-up resistance	R_U	P00 to P04, P30 to P33, P40, P50 to P57, P130	$V_I = V_{SS}$, In input port		10	20	100	kΩ

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

Peripheral Functions (Common to all products)

(T_A = -40 to +85°C, 1.6 V ≤ AV_{DD} = V_{DD} ≤ 3.6 V, V_{SS} = AV_{SS} = 0 V)

(T_A = +85 to +105°C, 2.4 V ≤ AV_{DD} = V_{DD} ≤ 3.6 V, V_{SS} = AV_{SS} = 0 V) **(1/2)**

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Low-speed on-chip oscillator operating current	I_{FIL} Note 1				0.20		μA
RTC operating current	I_{RTC} Notes 1, 2, 3	f_{SX} = 32.768 kHz			0.02		μA
12-bit interval timer operating current	I_{TMKA} Notes 1, 2, 4	f_{SX} = 32.768 kHz			0.04		μA
8-bit interval timer operating current	I_{TMT} Notes 1, 9	f_{SX} = 32.768 kHz f_{MAIN} stopped (per unit)	8-bit counter mode × 2-channel operation		0.12		μA
			16-bit counter mode operation		0.10		μA
Watchdog timer operating current	I_{WDT} Notes 1, 2, 5	f_{IL} = 15 kHz			0.22		μA
A/D converter operating current	I_{ADC} Notes 6, 10	During maximum-speed conversion	AV_{DD} = 3.0 V		420	720	μA
$AV_{REF(+)}$ current	I_{AVREF} Note 11	AV_{REFP} = 3.0 V, ADREFP1 = 0, ADREFP0 = 1			14.0	25.0	μA
Internal reference voltage (1.45 V) current	I_{ADREF} Notes 1, 12				85.0		μA
Temperature sensor operating current	I_{TMPS} Note 1				85.0		μA
Comparator operating current	I_{CMP} Notes 8, 10	AV_{DD} = 3.6 V, Regulator output voltage = 2.1 V	Comparator high-speed mode Window mode		12.5		μA
			Comparator low-speed mode Window mode		3.0		
			Comparator high-speed mode Standard mode		6.5		
			Comparator low-speed mode Standard mode		1.7		
		AV_{DD} = 3.6 V, Regulator output voltage = 1.8 V	Comparator high-speed mode Window mode		8.0		
			Comparator low-speed mode Window mode		2.2		
			Comparator high-speed mode Standard mode		4.0		
			Comparator low-speed mode Standard mode		1.3		
Operational amplifier operating current	I_{AMP} Notes 10, 13	Low-power consumption mode	One operational amplifier unit operates Note 14		2.5	4.0	μA
			Two operational amplifier units operate Note 14		4.5	8.0	
			Three operational amplifier units operate Note 14		6.5	11.0	
			Four operational amplifier units operate Note 14		8.5	14.0	
		High-speed mode	One operational amplifier unit operates Note 14		140	220	
			Two operational amplifier units operate Note 14		280	410	
			Three operational amplifier units operate Note 14		420	600	
			Four operational amplifier units operate Note 14		560	780	
LVD operating current	I_{LVD} Notes 1, 7				0.10		μA

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

(4) During communication at same potential (CSI mode) (slave mode, SCKp... external clock input)

(T_A = +85 to +105°C, 2.4 V ≤ AV_{DD} = V_{DD} ≤ 3.6 V, V_{SS} = AV_{SS} = 0 V) **(1/2)**

Parameter	Symbol	Conditions		HS (high-speed main) Mode		Unit
				MIN.	MAX.	
SCKp cycle time Note 5	t_{KCY2}	2.7 V ≤ V_{DD} < 3.6 V	f_{MCK} > 16 MHz	16/f_{MCK}		ns
			f_{MCK} ≤ 16 MHz	12/f_{MCK}		ns
		2.4 V ≤ V_{DD} < 2.7 V		12/f_{MCK} and 1000		ns
SCKp high-/low-level width	t_{KH2}, t_{KL2}	2.7 V ≤ V_{DD} ≤ 3.6 V		t_{KCY2}/2 - 16		ns
		2.4 V ≤ V_{DD} < 2.7 V		t_{KCY2}/2 - 36		ns
SIp setup time (to SCKp↑) Note 1	t_{SIK2}	2.7 V ≤ V_{DD} ≤ 3.6 V		1/f_{MCK} + 40		ns
		2.4 V ≤ V_{DD} < 2.7 V		1/f_{MCK} + 60		ns
SIp hold time (from SCKp↑) Note 2	t_{KSI2}			1/f_{MCK} + 62		ns
Delay time from SCKp↓ to SOp output Note 3	t_{KSO2}	C = 30 pF Note 4	2.7 V ≤ V_{DD} ≤ 3.6 V		2/f_{MCK} + 66	ns
			2.4 V ≤ V_{DD} < 2.7 V		2/f_{MCK} + 113	ns

Note 1. When DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1. The SIp setup time becomes “to SCKp↓” when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.

Note 2. When DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1. The SIp hold time becomes “from SCKp↓” when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.

Note 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.

Note 4. C is the load capacitance of the SOp output lines.

Note 5. The maximum transfer rate when using the SNOOZE mode is 1 Mbps.

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

Remark 1. p: CSI number (p = 00), m: Unit number (m = 0), n: Channel number (n = 0), g: PIM and POM numbers (g = 5)

Remark 2. f_{MCK}: Serial array unit operation clock frequency
(Operation clock to be set by the CKSmn bit of serial mode register mn (SMRmn). m: Unit number, n: Channel number (mn = 00, 01))

(8) Communication at different potential (1.8 V, 2.5 V) (CSI mode) (master mode, SCKp... internal clock output)

(T_A = -40 to +85°C, 1.8 V ≤ AV_{DD} = V_{DD} ≤ 3.6 V, V_{SS} = AV_{SS} = 0 V) (1/2)

Parameter	Symbol	Conditions		HS (high-speed main) Mode		LS (low-speed main) Mode		LP (Low-power main) mode		LV (low-voltage main) Mode		Unit
				MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	
SCKp cycle time	t_{KCY1}	$t_{KCY1} \geq f_{CLK}/4$	2.7V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 30 pF, R_b = 2.7 kΩ	500		1150		1150		1150		ns
			1.8 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V Note, C_b = 30 pF, R_b = 5.5 kΩ	1150		1150		1150		1150		ns
SCKp high-level width	t_{KH1}	2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 30 pF, R_b = 2.7 kΩ		t_{KCY1}/2 - 170		t_{KCY1}/2 - 170		t_{KCY1}/2 - 170		t_{KCY1}/2 - 170		ns
		1.8 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V Note, C_b = 30 pF, R_b = 5.5 kΩ		t_{KCY1}/2 - 458		t_{KCY1}/2 - 458		t_{KCY1}/2 - 458		t_{KCY1}/2 - 458		ns
SCKp low-level width	t_{KL1}	2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 30 pF, R_b = 2.7 kΩ		t_{KCY1}/2 - 18		t_{KCY1}/2 - 50		t_{KCY1}/2 - 50		t_{KCY1}/2 - 50		ns
		1.8 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V Note, C_b = 30 pF, R_b = 5.5 kΩ		t_{KCY1}/2 - 50		t_{KCY1}/2 - 50		t_{KCY1}/2 - 50		t_{KCY1}/2 - 50		ns

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

Caution 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 g (PIMg) and port output mode register g (POMg). For V_{IH} and V_{IL}, see the DC characteristics with TTL input buffer selected.

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

(8) Communication at different potential (1.8 V, 2.5 V) (CSI mode) (master mode, SCKp... internal clock output)

(T_A = -40 to +85°C, 1.8 V ≤ AV_{DD} = V_{DD} ≤ 3.6 V, V_{SS} = AV_{SS} = 0 V) **(2/2)**

Parameter	Symbol	Conditions	HS (high-speed main) Mode		LS (low-speed main) Mode		LP (Low-power main) mode		LV (low-voltage main) Mode		Unit
			MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	
SIp setup time (to SCKp↑) Note 1	t_{SIK1}	2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 30 pF, R_b = 2.7 kΩ	177		479		479		479		ns
		1.8 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V Note 3, C_b = 30 pF, R_b = 5.5 kΩ	479		479		479		479		ns
SIp hold time (from SCKp↑) Note 1	t_{KSI1}	2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 30 pF, R_b = 2.7 kΩ	19		19		19		19		ns
		1.8 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V Note 3, C_b = 30 pF, R_b = 5.5 kΩ	19		19		19		19		ns
Delay time from SCKp↓ to SOp output Note 1	t_{KSO1}	2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 30 pF, R_b = 2.7 kΩ		195		195		195		195	ns
		1.8 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V Note 3, C_b = 30 pF, R_b = 5.5 kΩ		483		483		483		483	ns
SIp setup time (to SCKp↓) Note 2	t_{SIK1}	2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 30 pF, R_b = 2.7 kΩ	44		110		110		110		ns
		1.8 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V Note 3, C_b = 30 pF, R_b = 5.5 kΩ	110		110		110		110		ns
SIp hold time (from SCKp↓) Note 2	t_{KSI1}	2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 30 pF, R_b = 2.7 kΩ	19		19		19		19		ns
		1.8 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V Note 3, C_b = 30 pF, R_b = 5.5 kΩ	19		19		19		19		ns
Delay time from SCKp↑ to SOp output Note 2	t_{KSO1}	2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 30 pF, R_b = 2.7 kΩ		25		25		25		25	ns
		1.8 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V Note 3, C_b = 30 pF, R_b = 5.5 kΩ		25		25		25		25	ns

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

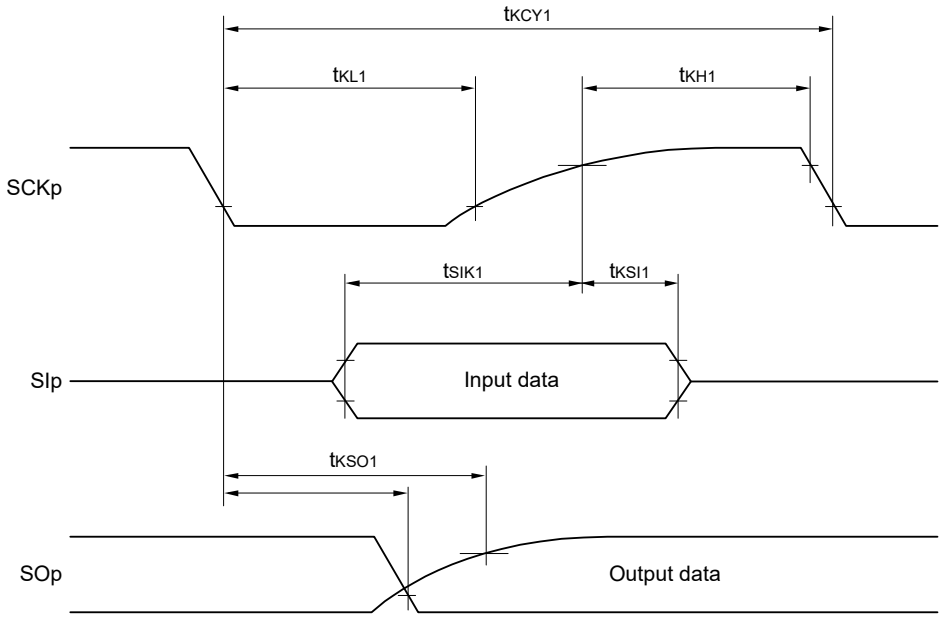
Note 2. When DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.

Note 3. Use it with V_{DD} ≥ V_b.

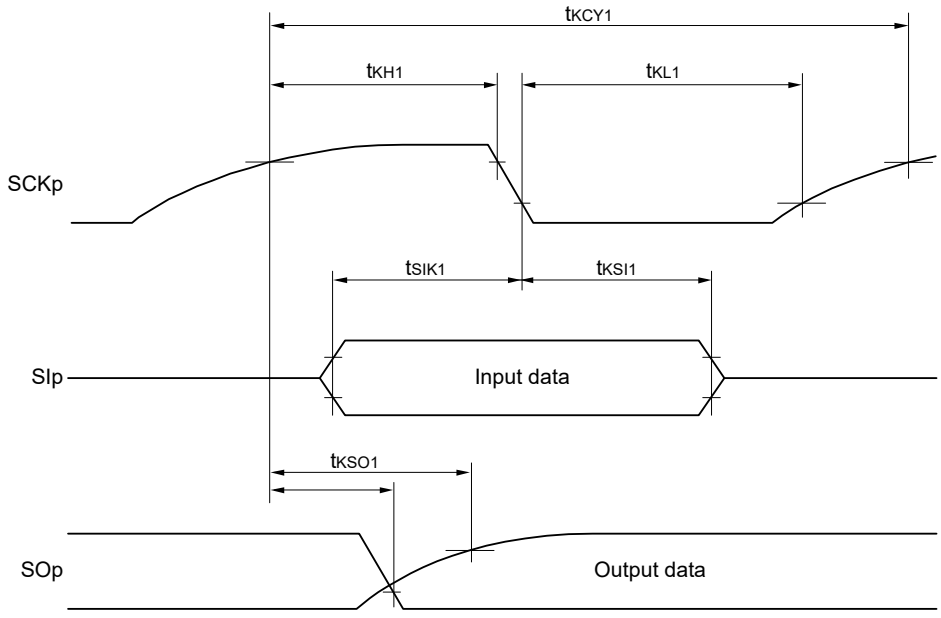
Caution Select the TTL input buffer for the SIp pin and the N-ch open drain output (V_{DD} tolerance) mode for the SOp pin and SCKp pin by using port input mode register g (PIMg) and port output mode register g (POMg). For V_{IH} and V_{IL}, see the DC characteristics with TTL input buffer selected.

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

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

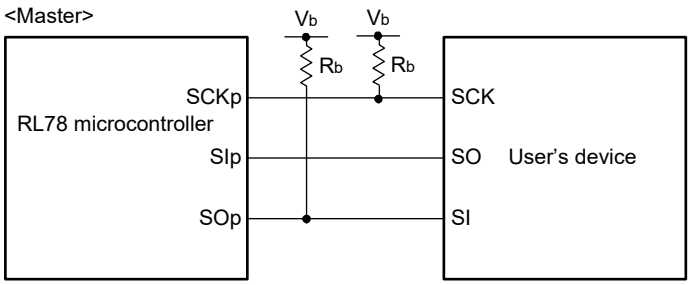


CSI mode serial transfer timing (master mode) (during communication at different potential)
(When DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.)



Remark p: CSI number (p = 00, 01), m: Unit number (m = 0), n: Channel number (n = 0, 1), g: PIM and POM numbers (g = 5)

CSI mode connection diagram (during communication at different potential)



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

Remark 2. p: CSI number (p = 00, 01), m: Unit number (m = 0), n: Channel number (n = 0, 1), g: PIM and POM numbers (g = 5)

Remark 3. f_{MCK}: Serial array unit operation clock frequency
(Operation clock to be set by the CKSmn bit of serial mode register mn (SMRmn). m: Unit number, n: Channel number (mn = 00, 01))

(9) Communication at different potential (1.8 V, 2.5 V) (CSI mode) (slave mode, SCKp... external clock input)

(T_A = +85 to 105°C, 2.4 V ≤ AV_{DD} = V_{DD} ≤ 3.6 V, V_{SS} = AV_{SS} = 0 V)

Parameter	Symbol	Conditions		HS (high-speed main) Mode		Unit
				MIN.	MAX.	
SCKp cycle time Note 1	t_{KCY2}	2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V	20 MHz < f_{MCK} ≤ 24 MHz	32/f_{MCK}		ns
			16 MHz < f_{MCK} ≤ 20 MHz	28/f_{MCK}		ns
			8 MHz < f_{MCK} ≤ 16 MHz	24/f_{MCK}		ns
			4 MHz < f_{MCK} ≤ 8 MHz	16/f_{MCK}		ns
			f_{MCK} ≤ 4 MHz	12/f_{MCK}		ns
		2.4 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V Note 2	20 MHz < f_{MCK} ≤ 24 MHz	72/f_{MCK}		ns
			16 MHz < f_{MCK} ≤ 20 MHz	64/f_{MCK}		ns
			8 MHz < f_{MCK} ≤ 16 MHz	52/f_{MCK}		ns
			4 MHz < f_{MCK} ≤ 8 MHz	32/f_{MCK}		ns
			f_{MCK} ≤ 4 MHz	20/f_{MCK}		ns
SCKp high-/low-level width	t_{KH2}, t_{KL2}	2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V		t_{KCY2}/2 - 36		ns
		2.4 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V Note 2		t_{KCY2}/2 - 100		ns
SIp setup time (to SCKp↑) Note 3	t_{SIK2}	2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V		1/f_{MCK} + 40		ns
		2.4 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V Note 2		1/f_{MCK} + 60		ns
SIp hold time (from SCKp↑) Note 4	t_{KSI2}			1/f_{MCK} + 62		ns
Delay time from SCKp↓ to SOp output Note 5	t_{KSO2}	2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V C_b = 30 pF, R_b = 2.7 kΩ			2/f_{MCK} + 428	ns
		2.4 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V Note 2 C_b = 30 pF, R_b = 5.5 kΩ			2/f_{MCK} + 1146	ns

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

Note 1. Transfer rate in the SNOOZE mode: MAX. 1 Mbps

Note 2. Use it with $V_{DD} \geq V_b$.

Note 3. When DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1. The SIp setup time becomes “to SCKp↓” when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.

Note 4. When DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1. The SIp hold time becomes “from SCKp↓” when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.

Note 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.

Caution Select the TTL input buffer for the SIp pin and SCKp pin and the N-ch open drain output (V_{DD} tolerance) mode for the SOp 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.

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

(10) Communication at different potential (1.8 V, 2.5 V) (simplified I²C mode)

(T_A = +85 to 105°C, 2.4 V ≤ AV_{DD} = V_{DD} ≤ 3.6 V, V_{SS} = AV_{SS} = 0 V)

Parameter	Symbol	Conditions	HS (high-speed main) Mode		Unit
			MIN.	MAX.	
SCLr clock frequency	f_{SCL}	2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 50 pF, R_b = 2.7 kΩ		400 Note 1	kHz
		2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 100 pF, R_b = 2.7 kΩ		100 Note 1	kHz
		2.4 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V Note 2, C_b = 100 pF, R_b = 5.5 kΩ		100 Note 1	kHz
Hold time when SCLr = "L"	t_{LOW}	2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 50 pF, R_b = 2.7 kΩ	1200		ns
		2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 100 pF, R_b = 2.7 kΩ	4600		ns
		2.4 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V Note 2, C_b = 100 pF, R_b = 5.5 kΩ	4650		ns
Hold time when SCLr = "H"	t_{HIGH}	2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 50 pF, R_b = 2.7 kΩ	500		ns
		2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 100 pF, R_b = 2.7 kΩ	2400		ns
		2.4 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V Note 2, C_b = 100 pF, R_b = 5.5 kΩ	1830		ns
Data setup time (reception)	$t_{SU:DAT}$	2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 50 pF, R_b = 2.7 kΩ	1/f_{MCK} + 340 Note 3		ns
		2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 100 pF, R_b = 2.7 kΩ	1/f_{MCK} + 760 Note 3		ns
		2.4 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V Note 2, C_b = 100 pF, R_b = 5.5 kΩ	1/f_{MCK} + 570 Note 3		ns
Data hold time (transmission)	$t_{HD:DAT}$	2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 50 pF, R_b = 2.7 kΩ	0	770	ns
		2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 100 pF, R_b = 2.7 kΩ	0	1420	ns
		2.4 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V Note 2, C_b = 100 pF, R_b = 5.5 kΩ	0	1215	ns

Note 1. The value must also be equal to or less than f_{MCK}/4.

Note 2. Use it with V_{DD} ≥ V_b.

Note 3. Set the f_{MCK} value to keep the hold time of SCLr = "L" and SCLr = "H".

Caution 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 g (PIMg) and port output mode register g (POMg). For V_{IH} and V_{IL}, see the DC characteristics with TTL input buffer selected.

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

(4) When reference voltage (+) = AVDD (ADREFP1 = 0, ADREFP0 = 0), reference voltage (-) = AVSS (ADREFM = 0), conversion target: ANI16 to ANI18, internal reference voltage, temperature sensor output voltage

(TA = -40 to +85°C, 1.6 V ≤ AVDD = VDD ≤ 3.6 V, VSS = 0 V, AVSS = 0 V, Reference voltage (+) = AVDD, Reference voltage (-) = AVSS = 0 V)

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Resolution	RES		2.4 V ≤ AVDD ≤ 3.6 V	8		12	bit
			1.8 V ≤ AVDD ≤ 3.6 V	8		10 Note 1	
			1.6 V ≤ AVDD ≤ 3.6 V	8 Note 2			
Overall error Note 3	AINL	12-bit resolution	2.4 V ≤ AVDD ≤ 3.6 V			±8.5	LSB
		10-bit resolution	1.8 V ≤ AVDD ≤ 3.6 V			±6.0	
		8-bit resolution	1.6 V ≤ AVDD ≤ 3.6 V			±3.5	
Conversion time	tCONV	ADTYP = 0, 12-bit resolution	2.4 V ≤ AVDD ≤ 3.6 V	4.125			µs
		ADTYP = 0, 10-bit resolution Note 1	1.8 V ≤ AVDD ≤ 3.6 V	9.5			
		ADTYP = 0, 8-bit resolution Note 2	1.6 V ≤ AVDD ≤ 3.6 V	57.5			
		ADTYP = 1, 8-bit resolution	2.4 V ≤ AVDD ≤ 3.6 V	3.3125			
			1.8 V ≤ AVDD ≤ 3.6 V	7.875			
			1.6 V ≤ AVDD ≤ 3.6 V	54.25			
Zero-scale error Note 3	EZS	12-bit resolution	2.4 V ≤ AVDD ≤ 3.6 V			±8.0	LSB
		10-bit resolution	1.8 V ≤ AVDD ≤ 3.6 V			±5.5	
		8-bit resolution	1.6 V ≤ AVDD ≤ 3.6 V			±3.0	
Full-scale error Note 3	EFS	12-bit resolution	2.4 V ≤ AVDD ≤ 3.6 V			±8.0	LSB
		10-bit resolution	1.8 V ≤ AVDD ≤ 3.6 V			±5.5	
		8-bit resolution	1.6 V ≤ AVDD ≤ 3.6 V			±3.0	
Integral linearity error Note 3	ILE	12-bit resolution	2.4 V ≤ AVDD ≤ 3.6 V			±3.5	LSB
		10-bit resolution	1.8 V ≤ AVDD ≤ 3.6 V			±2.5	
		8-bit resolution	1.6 V ≤ AVDD ≤ 3.6 V			±1.5	
Differential linearity error Note 3	DLE	12-bit resolution	2.4 V ≤ AVDD ≤ 3.6 V			±2.5	LSB
		10-bit resolution	1.8 V ≤ AVDD ≤ 3.6 V			±2.5	
		8-bit resolution	1.6 V ≤ AVDD ≤ 3.6 V			±2.0	
Analog input voltage	VAIN			0		AVDD	V
		Internal reference voltage (1.8 V ≤ VDD ≤ 3.6 V)		VBGR Note 4			
		Temperature sensor output voltage (1.8 V ≤ VDD ≤ 3.6 V)		VTMP25 Note 4			

Note 1. Cannot be used for lower 2 bits of ADCR register

Note 2. Cannot be used for lower 4 bits of ADCR register

Note 3. Excludes quantization error (±1/2 LSB).

Note 4. Refer to **2.6.2 Temperature sensor, internal reference voltage output characteristics**.

Caution Always use AVDD pin with the same potential as the VDD pin.

(5) When reference voltage (+) = Internal reference voltage (1.45 V) (ADREFP1 = 1, ADREFP0 = 0), reference voltage (-) = AVSS (ADREFM = 0), conversion target: ANI0 to ANI13, ANI16 to ANI18

(T_A = -40 to +85°C, 1.8 V ≤ AV_{DD} = V_{DD} ≤ 3.6 V, V_{SS} = 0 V, AV_{SS} = 0 V, Reference voltage (+) = internal reference voltage, Reference voltage (-) = AV_{SS} = 0 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Resolution	RES			8		bit
Conversion time	tCONV	8-bit resolution	16			µs
Zero-scale error Note	EZS	8-bit resolution			±4.0	LSB
Integral linearity error Note	ILE	8-bit resolution			±2.0	LSB
Differential linearity error Note	DLE	8-bit resolution			±2.5	LSB
Analog input voltage	VAIN		0		V_{BGR}	V

Note Excludes quantization error (±1/2 LSB).

Caution Always use AV_{DD} pin with the same potential as the V_{DD} pin.

(6) When reference voltage (+) = AV_{REFP}/ANI0 (ADREFP1 = 0, ADREFP0 = 1), reference voltage (-) = AV_{REFM}/ANI1 (ADREFM = 1), conversion target: ANI2 to ANI13

(T_A = +85 to +105°C, 2.4 V ≤ AV_{REFP} ≤ AV_{DD} = V_{DD} ≤ 3.6 V, V_{SS} = 0 V, AV_{SS} = 0 V, Reference voltage (+) = AV_{REFP}, Reference voltage (-) = AV_{REFM} = 0 V)

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Resolution	RES		2.4 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V	8		12	bit
Overall error Note	AINL	12-bit resolution	2.4 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V			±6.0	LSB
Conversion time	tCONV	ADTYP = 0, 12-bit resolution	2.4 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V	3.375			µs
Zero-scale error Note	EZS	12-bit resolution	2.4 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V			±4.5	LSB
Full-scale error Note	EFS	12-bit resolution	2.4 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V			±4.5	LSB
Integral linearity error Note	ILE	12-bit resolution	2.4 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V			±2.0	LSB
Differential linearity error Note	DLE	12-bit resolution	2.4 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V			±1.5	LSB
Analog input voltage	VAIN			0		AV_{REFP}	V

Note Excludes quantization error (±1/2 LSB).

Caution Always use AV_{DD} pin with the same potential as the V_{DD} pin.

(9) When reference voltage (+) = AVDD (ADREFP1 = 0, ADREFP0 = 0), reference voltage (-) = AVSS (ADREFM = 0), conversion target: ANI16 to ANI18, internal reference voltage, temperature sensor output voltage

(T_A = +85 to +105°C, 2.4 V ≤ AVDD = VDD ≤ 3.6 V, VSS = 0 V, AVSS = 0 V, Reference voltage (+) = AVDD, Reference voltage (-) = AVSS = 0)

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Resolution	RES		2.4 V ≤ AVDD ≤ 3.6 V	8		12	bit
Overall error Note 1	AINL	12-bit resolution	2.4 V ≤ AVDD ≤ 3.6 V			±8.5	LSB
Conversion time	tCONV	ADTYP = 0, 12-bit resolution	2.4 V ≤ AVDD ≤ 3.6 V	4.125			µs
Zero-scale error Note 1	EZS	12-bit resolution	2.4 V ≤ AVDD ≤ 3.6 V			±8.0	LSB
Full-scale error Note 1	EFS	12-bit resolution	2.4 V ≤ AVDD ≤ 3.6 V			±8.0	LSB
Integral linearity error Note 1	ILE	12-bit resolution	2.4 V ≤ AVDD ≤ 3.6 V			±3.5	LSB
Differential linearity error Note 1	DLE	12-bit resolution	2.4 V ≤ AVDD ≤ 3.6 V			±2.5	LSB
Analog input voltage	VAIN			0		AVDD	V
		Internal reference voltage (2.4 V ≤ VDD ≤ 3.6 V)		VBGR Note 2			
		Temperature sensor output voltage (2.4 V ≤ VDD ≤ 3.6 V)		VTMP25 Note 2			

Note 1. Excludes quantization error (±1/2 LSB).

Note 2. Refer to **2.6.2 Temperature sensor, internal reference voltage output characteristics**.

Caution Always use AVDD pin with the same potential as the VDD pin.

2.6.4 Operational amplifier characteristics

(T_A = -40 to +85°C, 1.8 V ≤ AV_{DD} = V_{DD} ≤ 3.6 V, V_{SS} = AV_{SS} = 0 V)

(T_A = +85 to +105°C, 2.4 V ≤ AV_{DD} = V_{DD} ≤ 3.6 V, V_{SS} = AV_{SS} = 0 V)

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Common mode input range	Vicm1	Low-power consumption mode		0.2		AV_{DD} - 0.5	V
	Vicm2	High-speed mode		0.3		AV_{DD} - 0.6	V
Output voltage range	Vo1	Low-power consumption mode		0.1		AV_{DD} - 0.1	V
	Vo2	High-speed mode		0.1		AV_{DD} - 0.1	V
Input offset voltage	Vioff			-10		10	mV
Open gain	Av			60	120		dB
Gain-bandwidth (GB) product	GBW1	Low-power consumption mode			0.04		MHz
	GBW2	High-speed mode			1.7		MHz
Phase margin	PM	CL = 20 pF		50			deg
Gain margin	GM	CL = 20 pF		10			dB
Equivalent input noise	Vnoise1	f = 1 kHz	Low-power consumption mode		230		nV/√Hz
	Vnoise2	f = 10 kHz			200		nV/√Hz
	Vnoise3	f = 1 kHz	High-speed mode		90		nV/√Hz
	Vnoise4	f = 2 kHz			70		nV/√Hz
Power supply reduction ratio	PSRR				90		dB
Common mode signal reduction ratio	CMRR				90		dB
Operation stabilization wait time	Tstd1	CL = 20 pF Only operational amplifier is activated Note	Low-power consumption mode	650			µs
	Tstd2		High-speed mode	13			µs
	Tstd3	CL = 20 pF Operational amplifier and reference current circuit are activated simultaneously	Low-power consumption mode	650			µs
	Tstd4		High-speed mode	13			µs
Settling time	Tset1	CL = 20 pF	Low-power consumption mode			750	µs
	Tset2		High-speed mode			13	µs
Slew rate	Tslew1	CL = 20 pF	Low-power consumption mode		0.02		V/µs
	Tslew2		High-speed mode		1.1		V/µs
Load current	Iload1	Low-power consumption mode		-100		100	µA
	Iload2	High-speed mode		-100		100	µA
Load capacitance	CL					20	pF

Note When the operational amplifier reference current circuit is activated in advance.

2.6.6 LVD circuit characteristics

(1) LVD Detection Voltage of Reset Mode and Interrupt Mode

(T_A = -40 to +85°C, $V_{PDR} \leq AV_{DD} = V_{DD} \leq 3.6$ V, $V_{SS} = AV_{SS} = 0$ V)

Parameter		Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Detection voltage	Supply voltage level	V_{LVD2}	Power supply rise time	3.07	3.13	3.19	V
			Power supply fall time	3.00	3.06	3.12	V
		V_{LVD3}	Power supply rise time	2.96	3.02	3.08	V
			Power supply fall time	2.90	2.96	3.02	V
		V_{LVD4}	Power supply rise time	2.86	2.92	2.97	V
			Power supply fall time	2.80	2.86	2.91	V
		V_{LVD5}	Power supply rise time	2.76	2.81	2.87	V
			Power supply fall time	2.70	2.75	2.81	V
		V_{LVD6}	Power supply rise time	2.66	2.71	2.76	V
			Power supply fall time	2.60	2.65	2.70	V
		V_{LVD7}	Power supply rise time	2.56	2.61	2.66	V
			Power supply fall time	2.50	2.55	2.60	V
		V_{LVD8}	Power supply rise time	2.45	2.50	2.55	V
			Power supply fall time	2.40	2.45	2.50	V
		V_{LVD9}	Power supply rise time	2.05	2.09	2.13	V
			Power supply fall time	2.00	2.04	2.08	V
		V_{LVD10}	Power supply rise time	1.94	1.98	2.02	V
			Power supply fall time	1.90	1.94	1.98	V
		V_{LVD11}	Power supply rise time	1.84	1.88	1.91	V
			Power supply fall time	1.80	1.84	1.87	V
		V_{LVD12}	Power supply rise time	1.74	1.77	1.81	V
			Power supply fall time	1.70	1.73	1.77	V
		V_{LVD13}	Power supply rise time	1.64	1.67	1.70	V
			Power supply fall time	1.60	1.63	1.66	V
Minimum pulse width		t_{LW}		300			µs
Detection delay time						300	µs

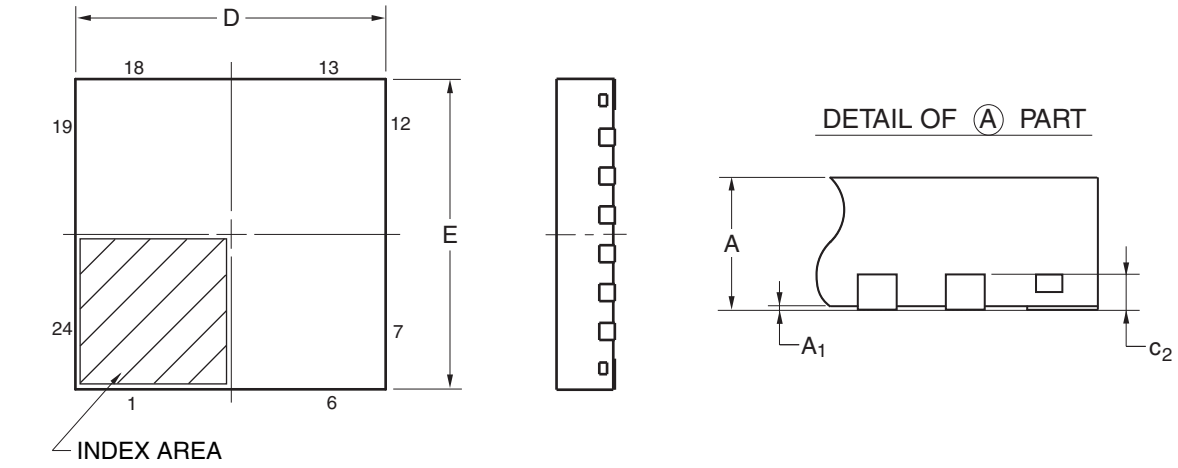
(T_A = +85 to +105°C, $V_{PDR} \leq AV_{DD} = V_{DD} \leq 3.6$ V, $V_{SS} = AV_{SS} = 0$ V)

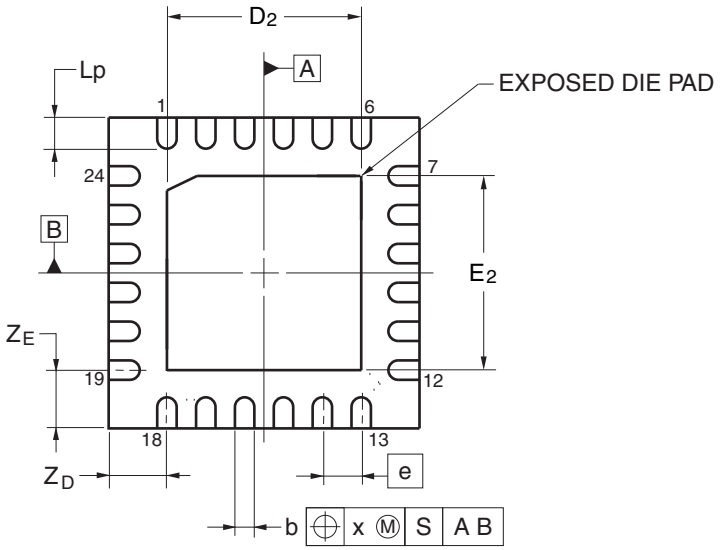
Parameter		Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Detection voltage	Supply voltage level	V_{LVD2}	Power supply rise time	3.01	3.13	3.25	V
			Power supply fall time	2.94	3.06	3.18	V
		V_{LVD3}	Power supply rise time	2.90	3.02	3.14	V
			Power supply fall time	2.85	2.96	3.07	V
		V_{LVD4}	Power supply rise 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	2.71	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			µs
Detection delay time						300	µs

3.2 24-pin products

R5F1177AGNA, R5F11778GNA

JEITA Package code	RENESAS code	Previous code	MASS(TYP.)[g]
P-HWQFN24-4x4-0.50	PWQN0024KE-A	P24K8-50-CAB-3	0.04





Referance Symbol	Dimension in Millimeters		
	Min	Nom	Max
D	3.95	4.00	4.05
E	3.95	4.00	4.05
A	—	—	0.80
A_1	0.00	—	—
b	0.18	0.25	0.30
e	—	0.50	—
Lp	0.30	0.40	0.50
x	—	—	0.05
y	—	—	0.05
Z_D	—	0.75	—
Z_E	—	0.75	—
c_2	0.15	0.20	0.25
D_2	—	2.50	—
E_2	—	2.50	—

REVISION HISTORY	RL78/I1D Datasheet

Rev.	Date	Description	
		Page	Summary
1.00	Aug 29, 2014	—	First Edition issued
2.00	Jan 16, 2015	24, 25, 27	Addition of note 7 in 2.3.2 Supply current characteristics
		24, 26	Addition of description in 2.3.2 Supply current characteristics
		26, 28	Modification of description in 2.3.2 Supply current characteristics
		28	Correction of error in 2.3.2 Supply current characteristics
		95	Modification of package drawing in 3.2 24-pin products
2.20	Feb 20, 2017	ALL	The function name changed from real-time clock to real-time clock 2
		5	Addition of product name in 1.3.1 20-pin products
		6	Addition of product name in 1.3.2 24-pin products
		7	Addition of product name in 1.3.3 30-pin products
		8	Addition of product name in 1.3.4 32-pin products
		9	Change of description and addition of product name in 1.3.4 32-pin products
		10	Addition of product name in 1.3.5 48-pin products
		13, 14	Change of description in 1.6 Outline of Functions
		16	Change of 2.1 Absolute Maximum Ratings
		22	Change of 2.3.1 Pin characteristics
		24	Change of conditions in 2.3.2 Supply current characteristics
		25, 27, 28	Change of note 1 in 2.3.2 Supply current characteristics
		26	Change of conditions and unit in 2.3.2 Supply current characteristics
		30	Change of note 3 in 2.3.2 Supply current characteristics
		31	Addition of note 5 in 2.3.2 Supply current characteristics
		92	Change of table in 2.8 Flash Memory Programming Characteristics
		92	Addition of note 4 in 2.8 Flash Memory Programming Characteristics
		99	Change of package drawing in 3.5 48-pin products