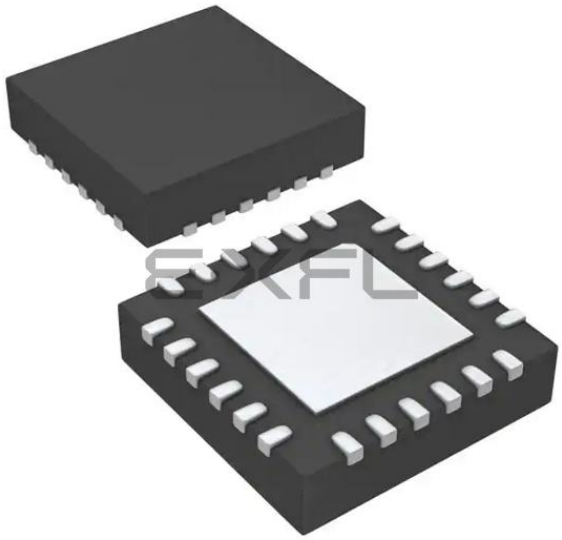
Renesas Electronics America Inc - R5F1037AANA#W0 Datasheet



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"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, PWM, WDT
Number of I/O	18
Program Memory Size	16KB (16K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	1.5K x 8
Voltage - Supply (Vcc/Vdd)	1.8V ~ 5.5V
Data Converters	A/D 11x8/10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°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/r5f1037aana-w0

○ 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 Note 1	R5F1027A Note 1	—
	—		R5F1036A Note 1	R5F1037A Note 1	—
12 KB	2KB	1 KB	R5F10269 Note 1	R5F10279 Note 1	R5F102A9
	—		R5F10369 Note 1	R5F10379 Note 1	R5F103A9
8 KB	2 KB	768 B	R5F10268 Note 1	R5F10278 Note 1	R5F102A8
	—		R5F10368 Note 1	R5F10378 Note 1	R5F103A8
4 KB	2KB	512 B	R5F10267	R5F10277	R5F102A7
	—		R5F10367	R5F10377	R5F103A7
2 KB	2 KB	256 B	R5F10266 Note 2	—	—
	—		R5F10366 Note 2	—	—

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

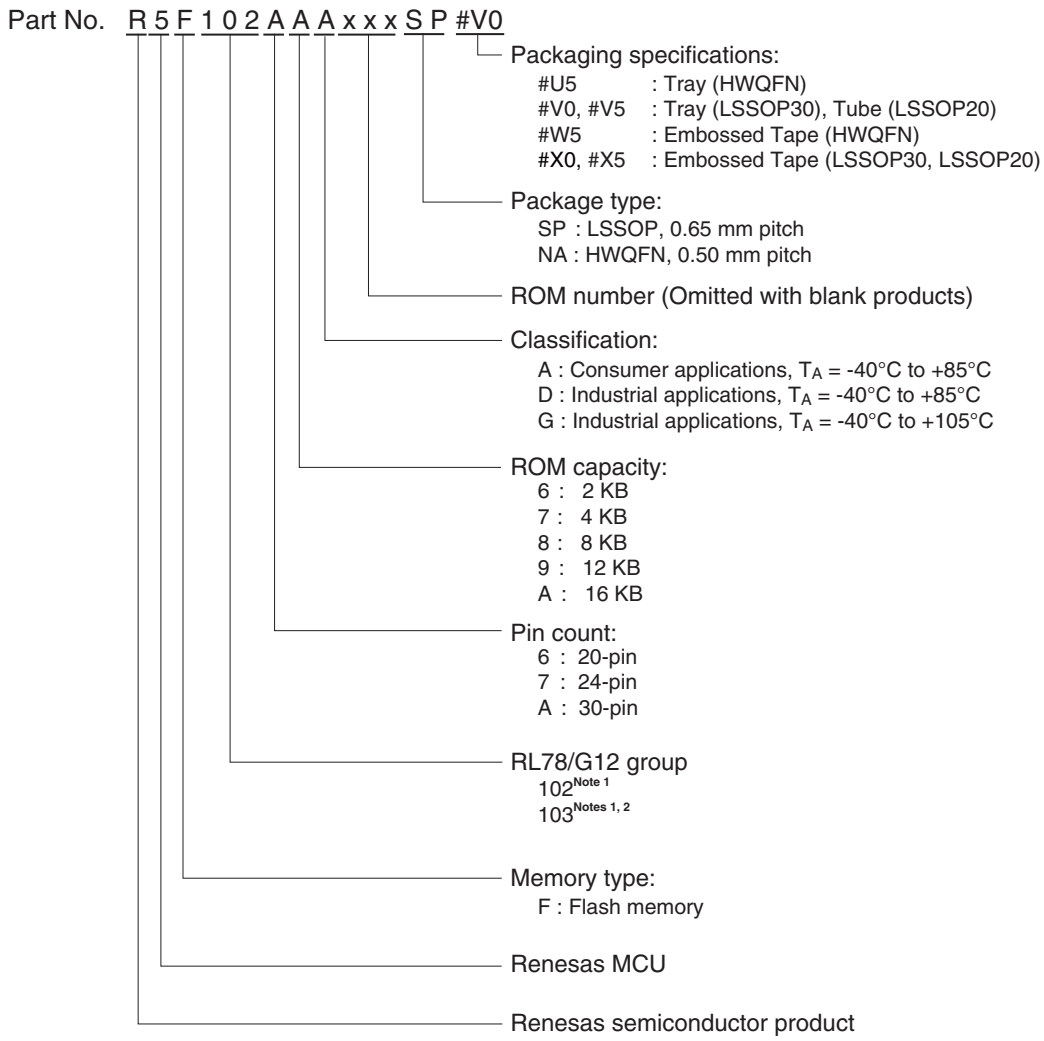
2. The self-programming function cannot be used for R5F10266 and R5F10366.

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

<R>



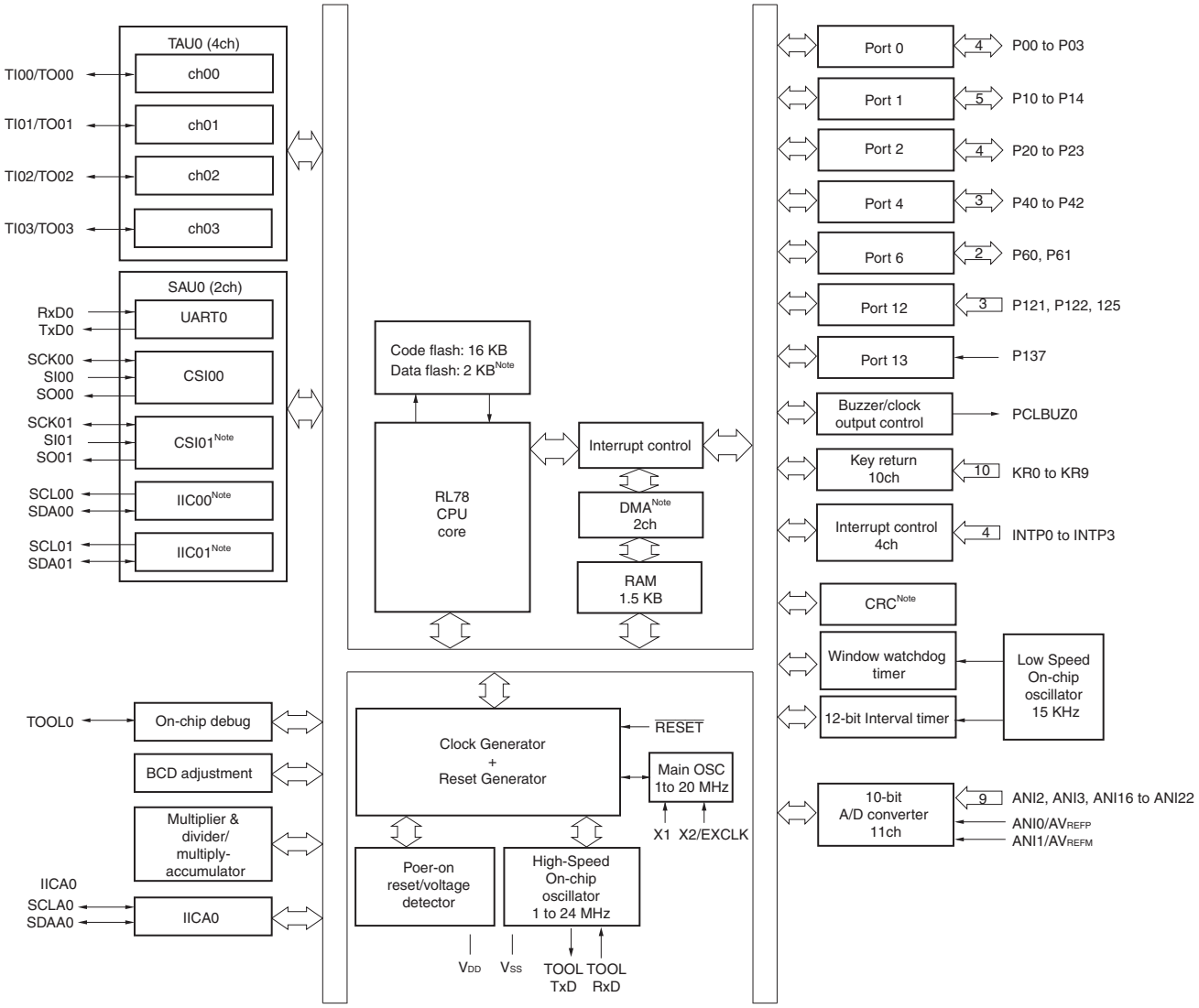
Notes 1. For details about the differences between the R5F102 products and the R5F103 products of RL78/G12, see **1.1 Differences between the R5F102 Products and the R5F103 Products**.

2. Products only for "A: Consumer applications (T_A = -40 to +85°C)" and "D: Industrial applications (T_A = -40 to +85°C)"

1.5 Pin Identification

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

1.6.2 24-pin products



Note Provided only in the R5F102 products.

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)

Item		20-pin		24-pin		30-pin	
		R5F1026x	R5F1036x	R5F1027x	R5F1037x	R5F102Ax	R5F103Ax
Code flash memory		2 to 16 KB Note 1		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					
<R> 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_{DD} = 2.7 to 5.5 V), HS (High-speed main) mode : 1 to 16 MHz (V_{DD} = 2.4 to 5.5 V), LS (Low-speed main) mode : 1 to 8 MHz (V_{DD} = 1.8 to 5.5 V)					
	High-speed on-chip oscillator clock	HS (High-speed main) mode : 1 to 24 MHz (V_{DD} = 2.7 to 5.5 V), HS (High-speed main) mode : 1 to 16 MHz (V_{DD} = 2.4 to 5.5 V), LS (Low-speed main) mode : 1 to 8 MHz (V_{DD} = 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_{IH} = 24 MHz operation)					
		0.05 μs (High-speed system clock: f_{MX} = 20 MHz operation)					
Instruction set		• Data transfer (8/16 bits) • Adder and subtractor/logical operation (8/16 bits) • Multiplication (8 bits × 8 bits) • Rotate, barrel shift, and bit manipulation (set, reset, test, and Boolean operation), etc.					
I/O port	Total	18		22		26	
	CMOS I/O	12 (N-ch O.D. I/O [V_{DD} withstand voltage]: 4)		16 (N-ch O.D. I/O [V_{DD} withstand voltage]: 5)		21 (N-ch O.D. I/O [V_{DD} 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 Note 3)				8 channels (PWM outputs: 7 Note 3) Note 2	

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.

2.1 Absolute Maximum Ratings

Absolute Maximum Ratings (T_A = 25°C)

Parameter	Symbols	Conditions		Ratings	Unit
Supply Voltage	V_{DD}			−0.5 to + 6.5	V
REGC terminal input voltage[Note1]	V_{IREGC}	REGC		−0.3 to +2.8 and −0.3 to V_{DD} + 0.3 [Note 2]	V
Input Voltage	V_{I1}	Other than P60, P61		−0.3 to V_{DD} + 0.3[Note 3]	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[Note 3]	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[Notes 3, 4]	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[Note 5], 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[Note 5], 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 +85	°C
Storage temperature	T_{stg}			−65 to +150	°C

Notes 1. 30-pin product only.

2. Connect the REGC pin to V_{SS} 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 $AV_{REF}(+)$ + 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. $AV_{REF}(+)$: + side reference voltage of the A/D converter.

3. V_{SS} : Reference voltage

(T_A = −40 to +85°C, 1.8 V ≤ V_{DD} ≤ 5.5 V, V_{SS} = 0 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[Note 2], 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 V ≤ V_{DD} ≤ 5.5 V	2.2		V_{DD}	V
			3.3 V ≤ V_{DD} < 4.0 V	2.0		V_{DD}	V
			1.8 V ≤ V_{DD} < 3.3 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
	V_{IH5}	P121, P122, P125[Note 1], P137, EXCLK, $\overline{\text{RESET}}$		0.8V_{DD}		V_{DD}	V
Input voltage, low	V_{IL1}	Normal input buffer 20-, 24-pin products: P00 to P03[Note 2], 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 V ≤ V_{DD} ≤ 5.5 V	0		0.8	V
			3.3 V ≤ V_{DD} < 4.0 V	0		0.5	V
			1.8 V ≤ V_{DD} < 3.3 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[Note 1], P137, EXCLK, $\overline{\text{RESET}}$		0		0.2V_{DD}	V
Output voltage, high	V_{OH1}	20-, 24-pin products: P00 to P03[Note 2], P10 to P14, P40 to P42 30-pin products: P00, P01, P10 to P17, P30, P31, P40, P50, P51, P120, P147	4.0 V ≤ V_{DD} ≤ 5.5 V, I_{OH1} = −10.0 mA	V_{DD}−1.5			V
			4.0 V ≤ V_{DD} ≤ 5.5 V, I_{OH1} = −3.0 mA	V_{DD}−0.7			V
			2.7 V ≤ V_{DD} ≤ 5.5 V, I_{OH1} = −2.0 mA	V_{DD}−0.6			V
			1.8 V ≤ V_{DD} ≤ 5.5 V, I_{OH1} = −1.5 mA	V_{DD}−0.5			V
	V_{OH2}	P20 to P23	I_{OH2} = −100 μA	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.

(3) Peripheral functions (Common to all products)

(T_A = –40 to +85°C, 1.8 V ≤ V_{DD} ≤ 5.5 V, V_{SS} = 0 V)

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

2. Temperature condition of the TYP. value is T_A = 25°C

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^2C mode)

(T_A = −40 to +85°C, 1.8 V ≤ V_{DD} ≤ 5.5 V, V_{SS} = 0 V)

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

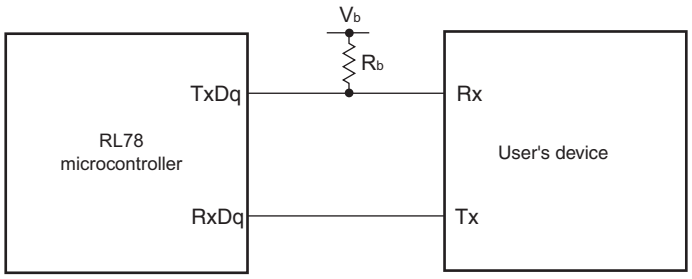
Notes 1. The value must also be equal to or less than f_{MCK}/4.

2. Set $t_{SU:DAT}$ so that it will not exceed the hold time when SCLr = "L" or SCLr = "H".

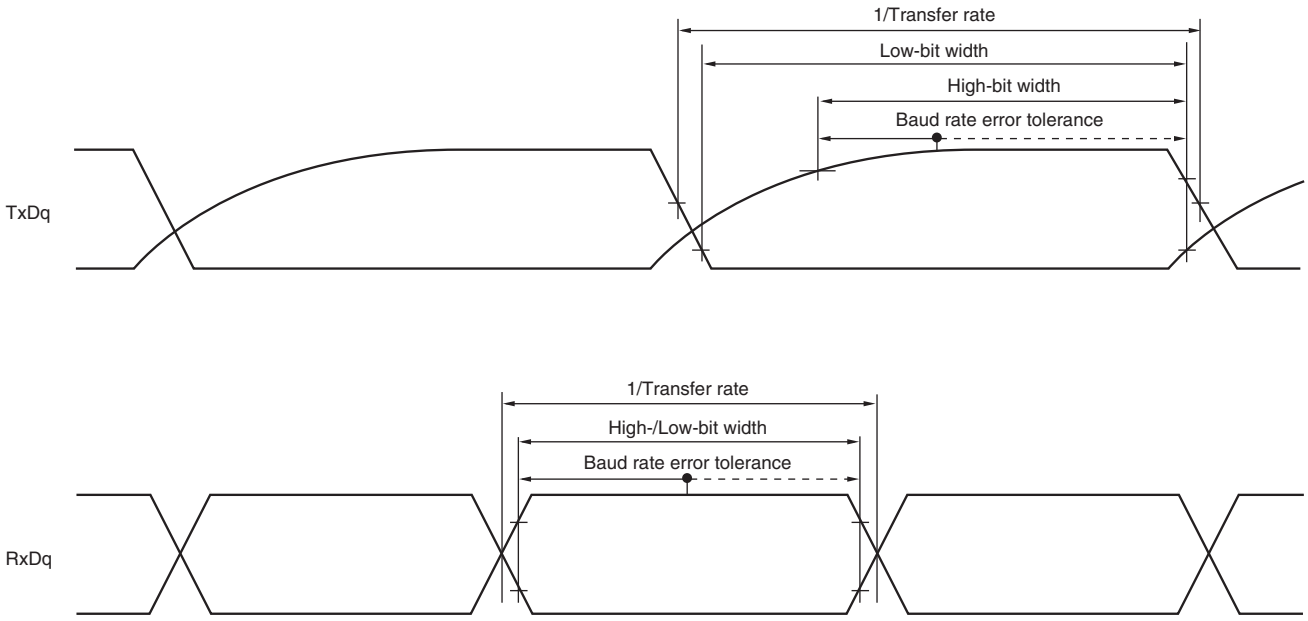
Caution Select the N-ch open drain output (V_{DD} tolerance) mode for SDAr by using port output mode register h (POMh).

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

UART mode connection diagram (during communication at different potential)



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



Remarks 1. R_b[Ω]: 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.

(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°C, 1.8 V ≤ V_{DD} ≤ 5.5 V, V_{SS} = 0 V)

Parameter	Symbol	Conditions	HS (high-speed main) Mode		LS (low-speed main) Mode		Unit
			MIN.	MAX.	MIN.	MAX.	
SIp setup time (to SCKp↓) Note 1	t_{SIK1}	4.0 V ≤ V_{DD} ≤ 5.5 V, 2.7 V ≤ V_b ≤ 4.0 V, C_b = 30 pF, R_b = 1.4 kΩ	44		110		ns
		2.7 V ≤ V_{DD} < 4.0 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 30 pF, R_b = 2.7 kΩ	44		110		ns
		1.8 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	110		110		ns
SIp hold time (from SCKp↓) Note 1	t_{KSI1}	4.0 V ≤ V_{DD} ≤ 5.5 V, 2.7 V ≤ V_b ≤ 4.0 V, C_b = 30 pF, R_b = 1.4 kΩ	19		19		ns
		2.7 V ≤ V_{DD} < 4.0 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 30 pF, R_b = 2.7 kΩ	19		19		ns
		1.8 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	19		19		ns
Delay time from SCKp↑ to SOp output Note 1	t_{KSO1}	4.0 V ≤ V_{DD} ≤ 5.5 V, 2.7 V ≤ V_b ≤ 4.0 V, C_b = 30 pF, R_b = 1.4 kΩ		25		25	ns
		2.7 V ≤ V_{DD} < 4.0 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 30 pF, R_b = 2.7 kΩ		25		25	ns
		1.8 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		25		25	ns

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

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

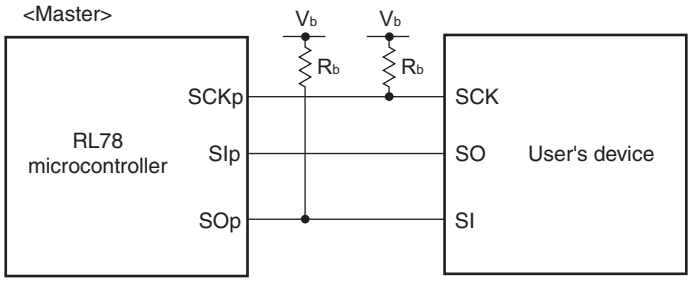
Cautions 1. Select the TTL input buffer for the SIp pin and the N-ch open drain output (V_{DD} tolerance) mode for the SOp pin and SCKp pin by using port input mode register 1 (PIM1) and port output mode register 1 (POM1). For V_{IH} and V_{IL}, see the DC characteristics with TTL input buffer selected.

2. CSI01 and CSI11 cannot communicate at different potential.

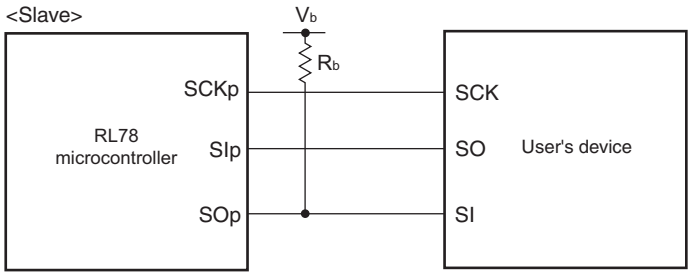
Remarks 1. R_b [Ω]: Communication line (SCKp, SOp) pull-up resistance, C_b [F]: Communication line (SCKp, SOp) load capacitance, V_b [V]: Communication line voltage

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 connection diagram (during communication at different potential)

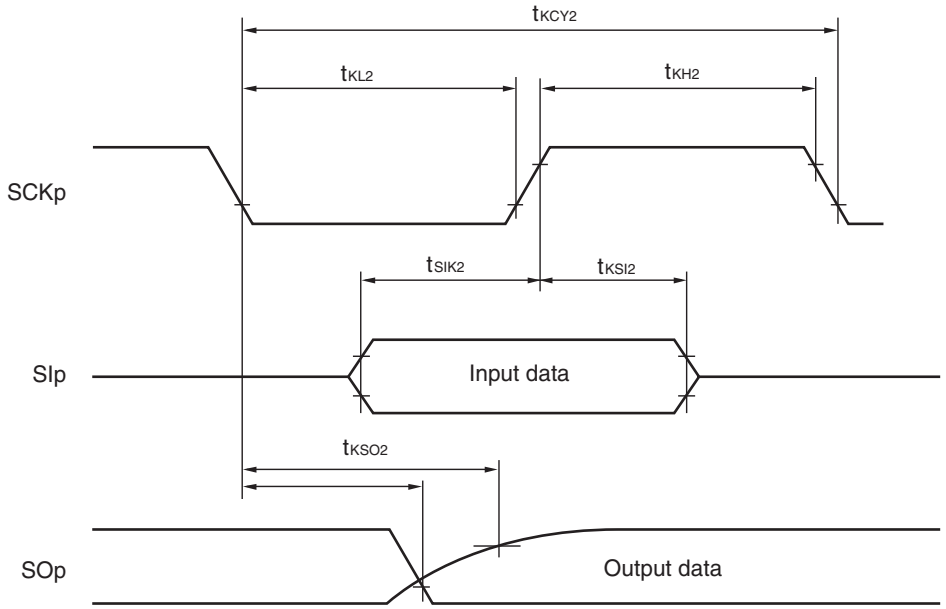


Remarks 1. R_b [Ω]: Communication line (SOp) pull-up resistance, C_b [F]: Communication line (SOp) load capacitance, V_b [V]: Communication line voltage

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.)



(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 +85°C, 2.4 V ≤ V_{DD} ≤ 5.5 V, V_{SS} = 0 V, Reference voltage (+) = V_{BGR} Note 3, Reference voltage (–) = AV_{REFM} Note 4 = 0 V, HS (high-speed main) mode)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Resolution	R_{ES}			8		bit
Conversion time	t_{CONV}	8-bit resolution	17		39	μs
Zero-scale error Notes 1, 2	EZS	8-bit resolution			±0.60	%FSR
Integral linearity error Note 1	ILE	8-bit resolution			±2.0	LSB
Differential linearity error Note 1	DLE	8-bit resolution			±1.0	LSB
Analog input voltage	V_{AIN}		0		V_{BGR} Note 3	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_{SS}, the MAX. values are as follows.
Zero-scale error: Add ±0.35%FSR to the MAX. value when reference voltage (–) = AV_{REFM}.
Integral linearity error: Add ±0.5 LSB to the MAX. value when reference voltage (–) = AV_{REFM}.
Differential linearity error: Add ±0.2 LSB to the MAX. value when reference voltage (–) = AV_{REFM}.

2.6.4 LVD circuit characteristics

LVD Detection Voltage of Reset Mode and Interrupt Mode

(T_A = –40 to +85°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	3.98	4.06	4.14	V
		Power supply fall time	3.90	3.98	4.06	V
	V_{LVD1}	Power supply rise time	3.68	3.75	3.82	V
		Power supply fall time	3.60	3.67	3.74	V
	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
Minimum pulse width	t_{LW}		300			μs
Detection delay time					300	μs

3.2 Oscillator Characteristics

3.2.1 X1 oscillator characteristics

(T_A = –40 to +105°C, 2.4 V ≤ V_{DD} ≤ V_{DD} ≤ 5.5 V, V_{SS} = 0 V)

Parameter	Resonator	Conditions	MIN.	TYP.	MAX.	Unit
X1 clock oscillation frequency (f_X)Note	Ceramic resonator / crystal oscillator	2.7 V ≤ V_{DD} ≤ 5.5 V	1.0		20.0	MHz
		2.4 V ≤ V_{DD} < 2.7 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°C, 2.4 V ≤ V_{DD} ≤ 5.5 V, V_{SS} = 0 V)

Oscillators	Parameters	Conditions		MIN.	TYP.	MAX.	Unit
High-speed on-chip oscillator clock frequency Notes 1, 2	f_{IH}			1		24	MHz
High-speed on-chip oscillator clock frequency accuracy		R5F102 products	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	%
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) During communication at same potential (CSI mode) (master mode, SCKp... internal clock output)

(T_A = –40 to +105°C, 2.4 V ≤ V_{DD} ≤ 5.5 V, V_{SS} = 0 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 V ≤ V_{DD} ≤ 5.5 V	334		ns
			2.4 V ≤ V_{DD} ≤ 5.5 V	500		ns
SCKp high-/low-level width	t_{KH1}, t_{KL1}	4.0 V ≤ V_{DD} ≤ 5.5 V		t_{KCY1}/2–24		ns
		2.7 V ≤ V_{DD} ≤ 5.5 V		t_{KCY1}/2–36		ns
		2.4 V ≤ V_{DD} ≤ 5.5 V		t_{KCY1}/2–76		ns
SIp setup time (to SCKp↑) Note 1	t_{SIK1}	4.0 V ≤ V_{DD} ≤ 5.5 V		66		ns
		2.7 V ≤ V_{DD} ≤ 5.5 V		66		ns
		2.4 V ≤ V_{DD} ≤ 5.5 V		113		ns
SIp hold time (from SCKp↑) Note 2	t_{KSI1}			38		ns
Delay time from SCKp↓ to SOp output Note 3	t_{KSO1}	C = 30 pF Note4			50	ns

Notes 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.

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.

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 SIp 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))

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

* 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_{MCK}/12 or the following expression is the valid maximum transfer rate.
Expression for calculating the transfer rate when 2.7 V ≤ V_{DD} < 4.0 V and 2.3 V ≤ V_b ≤ 2.7 V

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

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

* 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_{MCK}/12 or the following expression is the valid maximum transfer rate.
Expression for calculating the transfer rate when 2.4 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V

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

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

* 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_{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.**

(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°C, 2.4 V ≤ V_{DD} ≤ 5.5 V, V_{SS} = 0 V)

Parameter	Symbol	Conditions	HS (high-speed main) Mode		Unit
			MIN.	MAX.	
SIp setup time (to SCKp↑) Note	t_{SIK1}	4.0 V ≤ V_{DD} ≤ 5.5 V, 2.7 V ≤ V_b ≤ 4.0 V, C_b = 30 pF, R_b = 1.4 kΩ	162		ns
		2.7 V ≤ V_{DD} < 4.0 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 30 pF, R_b = 2.7 kΩ	354		ns
		2.4 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V, C_b = 30 pF, R_b = 5.5 kΩ	958		ns
SIp hold time (from SCKp↑) Note	t_{KSI1}	4.0 V ≤ V_{DD} ≤ 5.5 V, 2.7 V ≤ V_b ≤ 4.0 V, C_b = 30 pF, R_b = 1.4 kΩ	38		ns
		2.7 V ≤ V_{DD} < 4.0 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 30 pF, R_b = 2.7 kΩ	38		ns
		2.4 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V, C_b = 30 pF, R_b = 5.5 kΩ	38		ns
Delay time from SCKp↓ to SOp output Note	t_{KSO1}	4.0 V ≤ V_{DD} ≤ 5.5 V, 2.7 V ≤ V_b ≤ 4.0 V, C_b = 30 pF, R_b = 1.4 kΩ		200	ns
		2.7 V ≤ V_{DD} < 4.0 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 30 pF, R_b = 2.7 kΩ		390	ns
		2.4 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V, C_b = 30 pF, R_b = 5.5 kΩ		966	ns

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

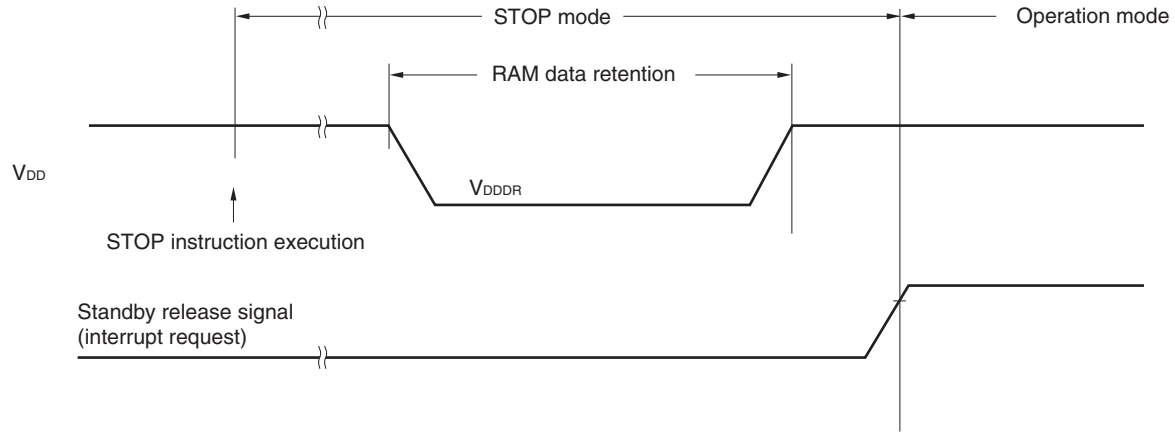
(**Cautions** and **Remarks** are listed on the next page.)

<R> 3.7 RAM Data Retention Characteristics

(T_A = –40 to +105°C, V_{SS} = 0 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Data retention supply voltage	V_{DDDR}		1.44 Note		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°C, 2.4 V ≤ V_{DD} ≤ 5.5 V, V_{SS} = 0 V)

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

Notes 1. 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.

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