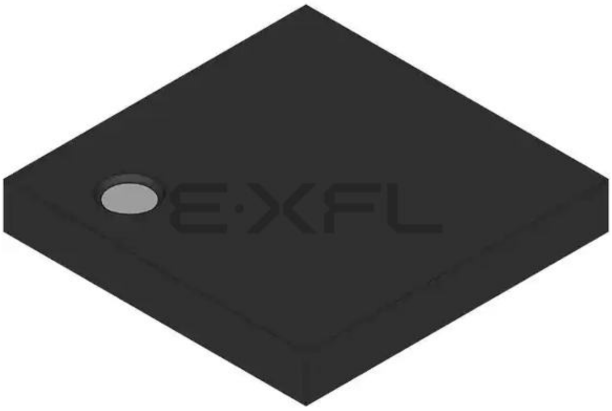
Renesas Electronics America Inc - R5F1027AANA#U5 Datasheet



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	Active
Core Processor	RL78
Core Size	16-Bit
Speed	24MHz
Connectivity	CSI, I²C, UART/USART
Peripherals	DMA, LVD, POR, PWM, WDT
Number of I/O	18
Program Memory Size	16KB (16K x 8)
Program Memory Type	FLASH
EEPROM Size	2K x 8
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/r5f1027aana-u5

○ 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]	—	—

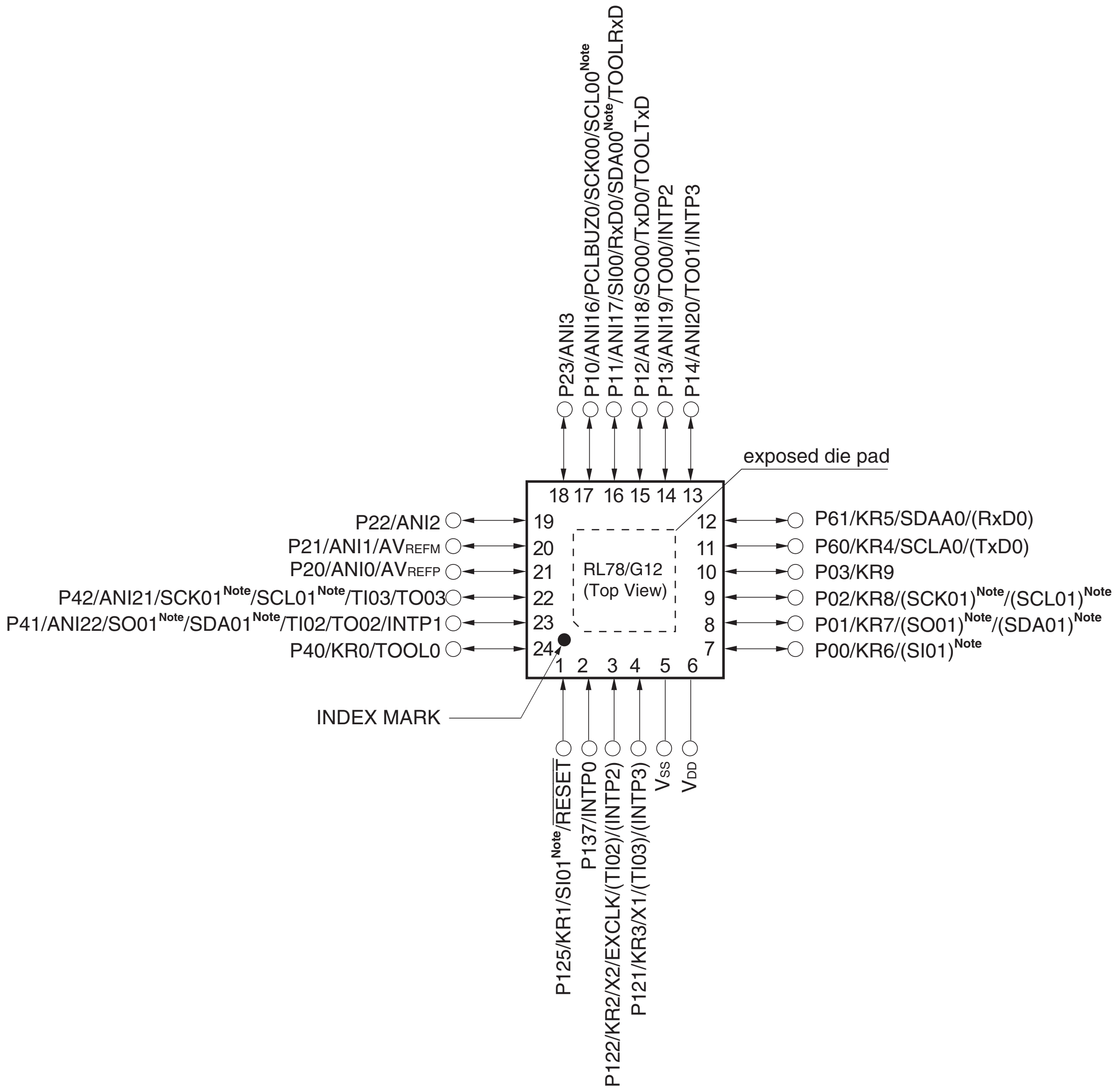
Notes 1. This is 640 bytes when the self-programming function or data flash function is used. (For details, see **CHAPTER 3 CPU ARCHITECTURE**.)

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.

1.4.2 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**.

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)**.

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

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.

2.2 Oscillator Characteristics

2.2.1 X1 oscillator characteristics

(T_A = –40 to +85°C, 1.8 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
		1.8 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**.

2.2.2 On-chip oscillator characteristics

(T_A = –40 to +85°C, 1.8 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	%
		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.

(3) During communication at same potential (CSI mode) (master mode, SCKp... internal clock output)
(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.	
SCKp cycle time	t_{KCY1}	t_{KCY1} ≥ 4/f_{CLK}	2.7 V ≤ V_{DD} ≤ 5.5 V	167		500		ns
			2.4 V ≤ V_{DD} ≤ 5.5 V	250		500		ns
			1.8 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}/2–12		t_{KCY1}/2–50		ns
		2.7 V ≤ V_{DD} ≤ 5.5 V		t_{KCY1}/2–18		t_{KCY1}/2–50		ns
		2.4 V ≤ V_{DD} ≤ 5.5 V		t_{KCY1}/2–38		t_{KCY1}/2–50		ns
		1.8 V ≤ V_{DD} ≤ 5.5 V		–		t_{KCY1}/2–50		ns
SIp setup time (to SCKp↑) Note 1	t_{SIK1}	4.0 V ≤ V_{DD} ≤ 5.5 V		44		110		ns
		2.7 V ≤ V_{DD} ≤ 5.5 V		44		110		ns
		2.4 V ≤ V_{DD} ≤ 5.5 V		75		110		ns
		1.8 V ≤ V_{DD} ≤ 5.5 V		–		110		ns
SIp hold time (from SCKp↑) Note 2	t_{KSI1}			19		19		ns
Delay time from SCKp↓ to SOp output Note 3	t_{KSO1}	C = 30 pF Note4			25		25	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.

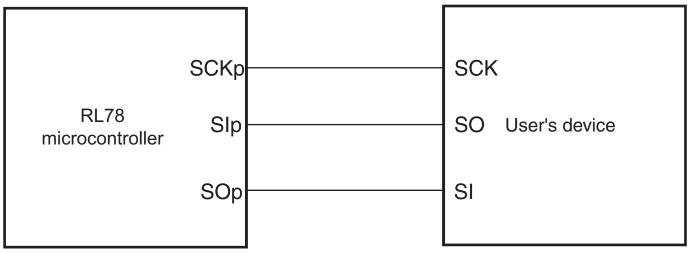
4. C is the load capacitance of the SCKp and SOp output lines.

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).

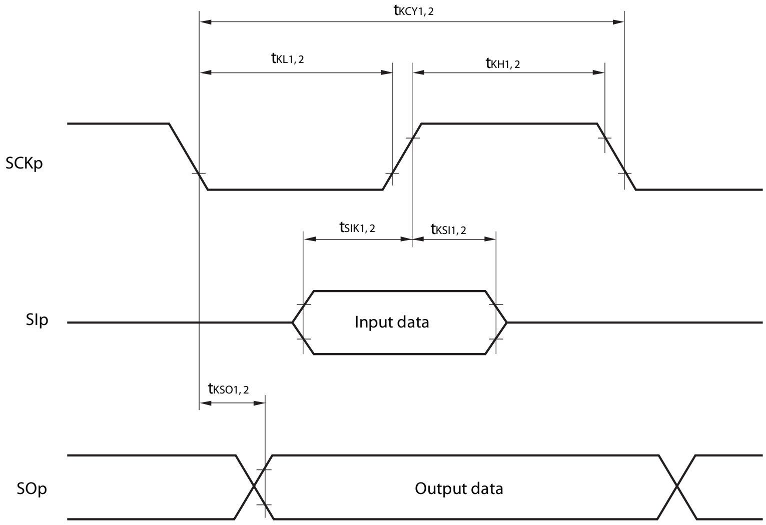
Remarks 1. p: CSI number (p = 00, 01, 11, 20), m: Unit number (m = 0, 1), n: Channel number (n = 0, 1, 3: “1, 3” is only for the R5F102 products)

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.))

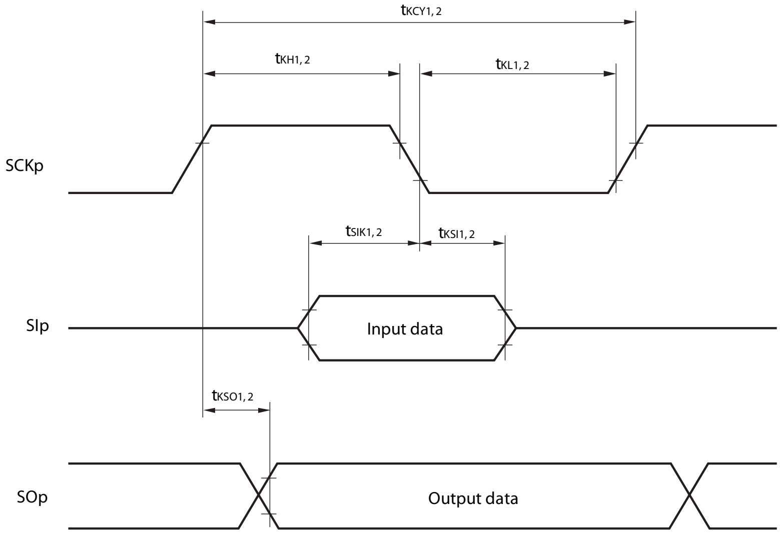
CSI mode connection diagram (during communication at same potential)



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.)

(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°C, 1.8 V ≤ V_{DD} ≤ 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.	
SCKp cycle time	t_{KCY1}	t_{KCY1} ≥ 4/f_{CLK}	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	300		1150		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	500		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		ns
SCKp high-level width	t_{KH1}	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		t_{KCY1}/2 –75		t_{KCY1}/2–75		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		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		ns
SCKp low-level width	t_{KL1}	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		t_{KCY1}/2 –12		t_{KCY1}/2–50		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		t_{KCY1}/2 –18		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		ns

Note Use it with V_{DD} ≥ 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)

(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↓) $^{\text{Note 1}}$	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 $^{\text{Note 2}}$, C_b = 30 pF, R_b = 5.5 kΩ	110		110		ns
SIp hold time (from SCKp↓) $^{\text{Note 1}}$	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 $^{\text{Note 2}}$, C_b = 30 pF, R_b = 5.5 kΩ	19		19		ns
Delay time from SCKp↑ to SOp output $^{\text{Note 1}}$	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 $^{\text{Note 2}}$, 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 $V_{DD} \geq V_b$.

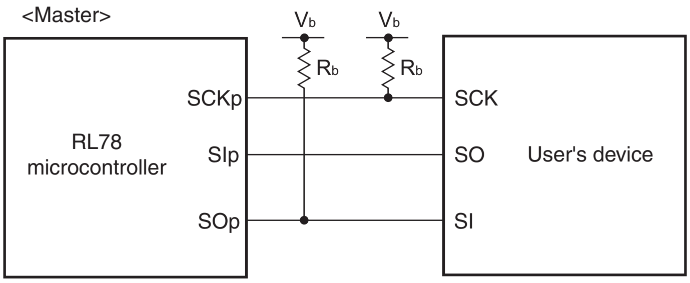
Cautions 1. Select the TTL input buffer for the SIp pin and the N-ch open drain output (V_{DD} tolerance) mode for the SOp pin and SCKp pin by using port input mode register 1 (PIM1) and port output mode register 1 (POM1). For V_{IH} and V_{IL}, see the DC characteristics with TTL input buffer selected.

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)



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

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Resolution	R_{ES}			8		10	bit
Overall error Note 1	AINL	10-bit resolution			1.2	±7.0	LSB
					1.2	±10.5 Note 3	LSB
Conversion time	t_{CONV}	10-bit resolution Target pin: ANI0 to ANI3, ANI16 to ANI22	3.6 V ≤ V_{DD} ≤ 5.5 V	2.125		39	μs
			2.7 V ≤ V_{DD} ≤ 5.5 V	3.1875		39	μs
			1.8 V ≤ V_{DD} ≤ 5.5 V	17		39	μs
				57		95	μs
Conversion time	t_{CONV}	10-bit resolution Target pin: internal reference voltage, and temperature sensor output voltage (HS (high-speed main) mode)	3.6 V ≤ V_{DD} ≤ 5.5 V	2.375		39	μs
			2.7 V ≤ V_{DD} ≤ 5.5 V	3.5625		39	μs
			2.4 V ≤ V_{DD} ≤ 5.5 V	17		39	μs
Zero-scale error Notes 1, 2	EZS	10-bit resolution				±0.60	%FSR
						±0.85 Note 3	%FSR
Full-scale error Notes 1, 2	EFS	10-bit resolution				±0.60	%FSR
						±0.85 Note 3	%FSR
Integral linearity error Note 1	ILE	10-bit resolution				±4.0	LSB
						±6.5 Note 3	LSB
Differential linearity error Note 1	DLE	10-bit resolution				±2.0	LSB
						±2.5 Note 3	LSB
Analog input voltage	V_{AIN}	ANI0 to ANI3, ANI16 to ANI22		0		V_{DD}	V
		Internal reference voltage (2.4 V ≤ V_{DD} ≤ 5.5 V, HS (high-speed main) mode)		V_{BGR} Note 4			V
		Temperature sensor output voltage (2.4 V ≤ V_{DD} ≤ 5.5 V, HS (high-speed main) mode)		V_{TMPS25} Note 4			V

Notes **1.** Excludes quantization error (±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 μs (min.) and 95 μs (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_{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}.

2.9 Dedicated Flash Memory Programmer Communication (UART)

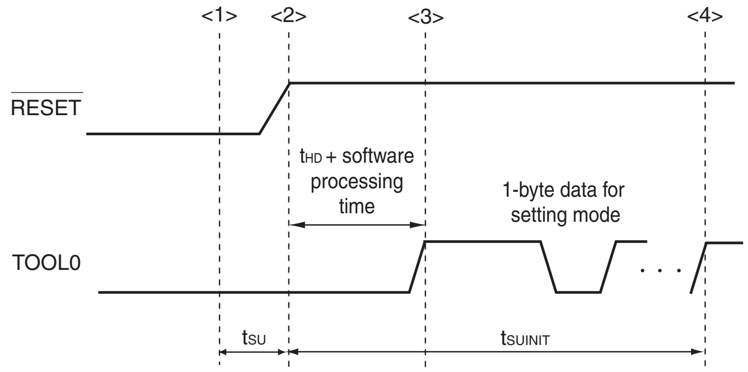
(T_A = –40 to +85°C, 1.8 V ≤ V_{DD} ≤ 5.5 V, V_{SS} = 0 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
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°C, 1.8 V ≤ V_{DD} ≤ 5.5 V, V_{SS} = 0 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Time to complete the communication for the initial setting after the external reset is released	t_{SUINIT}	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_{SU}	POR and LVD reset are released before external reset release	10			μs
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_{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_{SUINIT}: Communication for the initial setting must be completed within 100 ms after the external reset is released during this period.

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

t_{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)

(T_A = –40 to +105°C, 2.4 V ≤ V_{DD} ≤ 5.5 V, V_{SS} = 0 V) (2/4)

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

4. 24-pin products only.

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

(2) 30-pin products

(T_A = –40 to +105°C, 2.4 V ≤ V_{DD} ≤ 5.5 V, V_{SS} = 0 V) **(1/2)**

Parameter	Symbol	Conditions					MIN.	TYP.	MAX.	Unit
Supply current[Note 1]	I_{DD1}	Operating mode	HS (High-speed main) mode[Note 4]	f_{IH} = 24 MHz[Note 3]	Basic operation	V_{DD} = 5.0 V		1.5		mA
						V_{DD} = 3.0 V		1.5		
					Normal operation	V_{DD} = 5.0 V		3.7	5.8	mA
						V_{DD} = 3.0 V		3.7	5.8	
				f_{IH} = 16 MHz[Note 3]		V_{DD} = 5.0 V		2.7	4.2	mA
						V_{DD} = 3.0 V		2.7	4.2	
				f_{MX} = 20 MHz[Note 2], V_{DD} = 5.0 V		Square wave input		3.0	4.9	mA
						Resonator connection		3.2	5.0	
				f_{MX} = 20 MHz[Note 2], V_{DD} = 3.0 V		Square wave input		3.0	4.9	mA
						Resonator connection		3.2	5.0	
				f_{MX} = 10 MHz[Note 2], V_{DD} = 5.0 V		Square wave input		1.9	2.9	mA
						Resonator connection		1.9	2.9	
				f_{MX} = 10 MHz[Note 2], V_{DD} = 3.0 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 V to 5.5 V @1 MHz to 24 MHz
V_{DD} = 2.4 V to 5.5 V @1 MHz to 16 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°C.

(3) Peripheral functions (Common to all products)

(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
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	1.10	mA
			The A/D conversion operations are performed, Low voltage mode, AV_{REFP} = V_{DD} = 3.0 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.

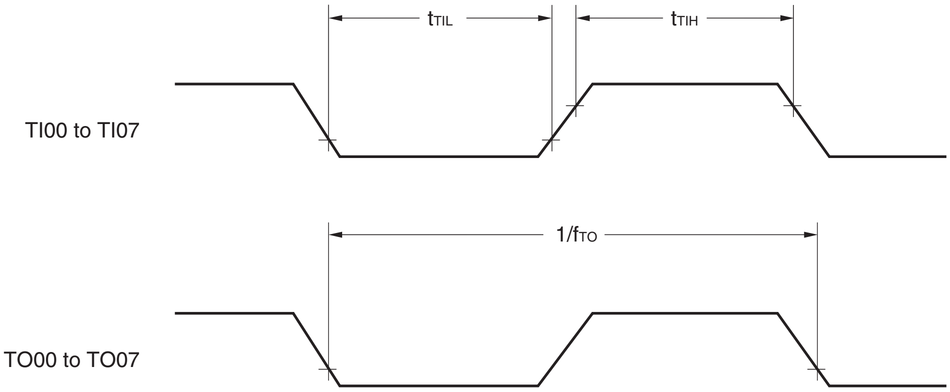
8. Current flowing only during self programming.

9. For shift time to the SNOOZE mode, see **17.3.3 SNOOZE mode**.

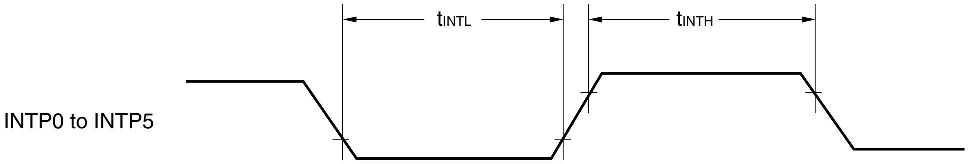
Remarks 1. f_{IL}: Low-speed on-chip oscillator clock frequency

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

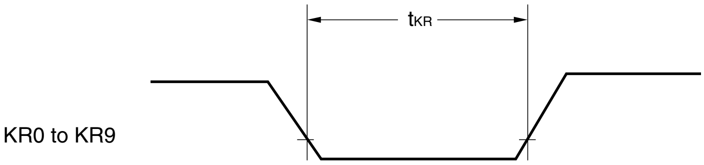
TI/TO Timing



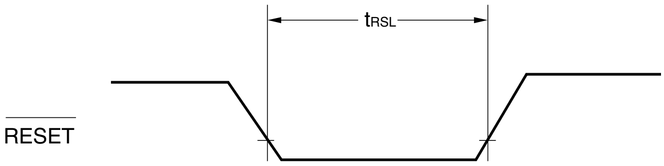
Interrupt Request Input Timing



Key Interrupt Input Timing



$\overline{\text{RESET}}$ Input Timing



(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°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 [Note 1]	t_{KCY2}	4.0 V ≤ V_{DD} ≤ 5.5 V, 2.7 V ≤ V_b ≤ 4.0 V	20 MHz < f_{MCK} ≤ 24 MHz	24/f_{MCK}		ns
			8 MHz < f_{MCK} ≤ 20 MHz	20/f_{MCK}		ns
			4 MHz < f_{MCK} ≤ 8 MHz	16/f_{MCK}		ns
			f_{MCK} ≤ 4 MHz	12/f_{MCK}		ns
		2.7 V ≤ V_{DD} < 4.0 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	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}	4.0 V ≤ V_{DD} ≤ 5.5 V, 2.7 V ≤ V_b ≤ 4.0 V		t_{KCY2}/2 – 24		ns
		2.7 V ≤ V_{DD} < 4.0 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		t_{KCY2}/2 – 100		ns
SIp setup time (to SCKp↑) [Note 2]	t_{SIK2}	4.0 V ≤ V_{DD} ≤ 5.5 V, 2.7 V ≤ V_{DD} ≤ 4.0 V		1/f_{MCK} + 40		ns
		2.7 V ≤ V_{DD} < 4.0 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_{DD} ≤ 2.0 V		1/f_{MCK} + 60		ns
SIp hold time (from SCKp↑) [Note 3]	t_{KSI2}			1/f_{MCK} + 62		ns
Delay time from SCKp↓ to SOp output [Note 4]	t_{KSO2}	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			2/f_{MCK} + 240	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			2/f_{MCK} + 428	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			2/f_{MCK} + 1146	ns

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

2. 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.

3. 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.

4. 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 SIp 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.**

2. CSI01 and CSI11 cannot communicate at different potential.

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°C, 2.4 V ≤ AV_{REFP} ≤ V_{DD} ≤ 5.5 V, V_{SS} = 0 V, Reference voltage (+) = AV_{REFP}, Reference voltage (–) = AV_{REFM} = 0 V)

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Resolution	RES			8		10	bit
Overall error[Note 1]	AINL	10-bit resolution AV_{REFP} = V_{DD} [Note 3]			1.2	±3.5	LSB
Conversion time	t_{CONV}	10-bit resolution Target pin: ANI2, ANI3	3.6 V ≤ V_{DD} ≤ 5.5 V	2.125		39	μs
			2.7 V ≤ V_{DD} ≤ 5.5 V	3.1875		39	μs
			2.4 V ≤ V_{DD} ≤ 5.5 V	17		39	μs
		10-bit resolution Target pin: Internal reference voltage, and temperature sensor output voltage (HS (high-speed main) mode)	3.6 V ≤ V_{DD} ≤ 5.5 V	2.375		39	μs
			2.7 V ≤ V_{DD} ≤ 5.5 V	3.5625		39	μs
			2.4 V ≤ V_{DD} ≤ 5.5 V	17		39	μs
Zero-scale error[Notes 1, 2]	EZS	10-bit resolution AV_{REFP} = V_{DD} [Note 3]				±0.25	%FSR
Full-scale error[Notes 1, 2]	EFS	10-bit resolution AV_{REFP} = V_{DD} [Note 3]				±0.25	%FSR
Integral linearity error[Note 1]	ILE	10-bit resolution AV_{REFP} = V_{DD} [Note 3]				±2.5	LSB
Differential linearity error [Note 1]	DLE	10-bit resolution AV_{REFP} = V_{DD} [Note 3]				±1.5	LSB
Analog input voltage	V_{AIN}	ANI2, ANI3		0		AV_{REFP}	V
		Internal reference voltage (HS (high-speed main) mode)		V_{BGR} [Note 4]			V
		Temperature sensor output voltage (HS (high-speed main) mode)		V_{TMPS25} [Note 4]			V

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

3.9 Dedicated Flash Memory Programmer Communication (UART)

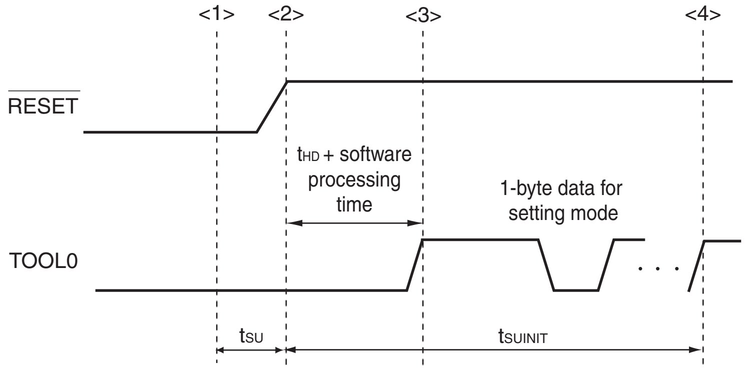
(T_A = −40 to +105°C, 2.4 V ≤ V_{DD} ≤ 5.5 V, V_{SS} = 0 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
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°C, 2.4 V ≤ V_{DD} ≤ 5.5 V, V_{SS} = 0 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Time to complete the communication for the initial setting after the external reset is released	t_{SUINIT}	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_{SU}	POR and LVD reset are released before external release	10			µs
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_{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_{SUINIT}: Communication for the initial setting must be completed within 100 ms after the external reset is released during this period.

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

t_{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)

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 (T_A = 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^{2}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^{2}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)

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