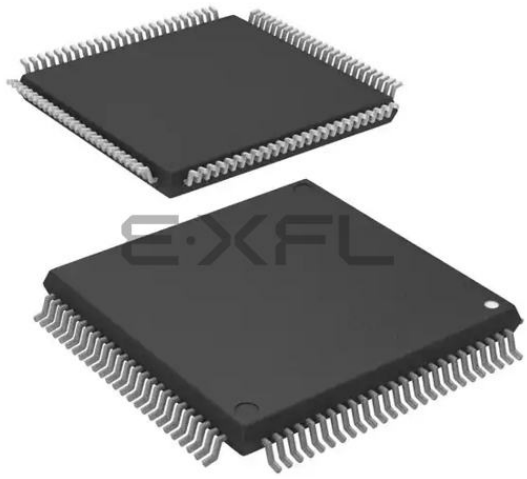
Renesas Electronics America Inc - R5F111PJAFB#30 Datasheet



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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	Active
Core Processor	RL78
Core Size	16-Bit
Speed	24MHz
Connectivity	CSI, I²C, LINbus, UART/USART
Peripherals	LCD, LVD, POR, PWM, WDT
Number of I/O	73
Program Memory Size	256KB (256K x 8)
Program Memory Type	FLASH
EEPROM Size	8K x 8
RAM Size	16K x 8
Voltage - Supply (Vcc/Vdd)	1.6V ~ 3.6V
Data Converters	A/D 13x8/12b; D/A 2x8b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	100-LQFP
Supplier Device Package	100-LFQFP (14x14)
Purchase URL	https://www.e-xfl.com/product-detail/renesas-electronics-america/r5f111pjafb-30

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

Items	Symbol	Conditions			MIN.	TYP.	MAX.	Unit
Input leakage current, high	I_{LIH1}	P00 to P07, P10 to P17, P20 to P27, P30 to P37, P40 to P46, P50 to P57, P60, P61, P70 to P77, P80 to P83, P125 to P127, P137, P140 to P143, $\overline{RESET}$	V_I = V_{DD}				1	μA
	I_{LIH2}	P20, P21, P140 to P143	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}	P150 to P156	V_I = AV_{DD}				1	μA
Input leakage current, low	I_{LIL1}	P00 to P07, P10 to P17, P20 to P27, P30 to P37, P40 to P46, P50 to P57, P60, P61, P70 to P77, P80 to P83, P125 to P127, P137, P140 to P143, $\overline{RESET}$	V_I = V_{SS}				-1	μA
	I_{LIL2}	P20, P21, P140 to P143	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}	P150 to P156	V_I = AV_{SS}				-1	μA
On-chip pull-up resistance	R_{U1}	P00 to P07, P10 to P17, P20 to P27, P30 to P37, P50 to P57, P70 to P77, P140 to P143, P125 to P127	V_I = V_{SS}	2.4 V ≤ V_{DD} ≤ 3.6 V	10	20	100	kΩ
				1.6 V ≤ V_{DD} ≤ 2.4 V	10	30	100	
	R_{U2}	P40 to P46, P80 to P83	V_I = V_{SS}		10	20	100	kΩ

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

Note 1. Current flowing to V_{DD}.

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

Note 3. Current flowing only to the real-time clock 2 (excluding the operating current of the low-speed on-chip oscillator and the XT1 oscillator). The supply current of the RL78 microcontrollers is the sum of the values of either I_{DD1} or I_{DD2}, and I_{RTC}, when the real-time clock 2 operates in operation mode or HALT mode. When the low-speed on-chip oscillator is selected, I_{FIL} should be added. I_{DD2} subsystem clock operation includes the operational current of the real-time clock 2.

Note 4. Current flowing only to the 12-bit interval timer (excluding the operating current of the low-speed on-chip oscillator and the XT1 oscillator). The supply current of the RL78 microcontrollers is the sum of the values of either I_{DD1} or I_{DD2}, and I_{TMKA}, when the 12-bit interval timer operates in operation mode or HALT mode. When the low-speed on-chip oscillator is selected, I_{FIL} should be added. I_{DD2} subsystem clock operation includes the operational current of the 12-bit interval timer.

Note 5. 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 in STOP mode.

Note 6. Current flowing only to the A/D converter. The supply current of the RL78 microcontrollers is the sum of I_{DD1} or I_{DD2} and I_{ADC}, I_{AVREF}, I_{ADREF} when the A/D converter operates in an operation mode or the HALT mode.

Note 7. Current flowing to the AV_{DD}.

Note 8. Current flowing from the reference voltage source of A/D converter.

Note 9. Operation current flowing to the internal reference voltage.

Note 10. Current flowing to the AV_{REFP}.

Note 11. Current flowing only to the D/A converter. The current value of the RL78 microcontrollers is the sum of I_{DD1} or I_{DD2} and I_{DA} when the D/A converter operates in an operation mode or the HALT mode.

Note 12. Current flowing only to the comparator circuit. The current value of the RL78 microcontrollers is the sum of I_{DD1}, I_{DD2} or I_{DD3} and I_{CMP} when the comparator circuit operates in the Operating, HALT or STOP mode.

Note 13. 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_{LVI} when the LVD circuit operates in the Operating, HALT or STOP mode.

Note 14. Current flowing only during self-programming.

Note 15. Current flowing only during data flash rewrite.

Note 16. For shift time to the SNOOZE mode, see **23.3.3 SNOOZE mode** in the RL78/L1C User's Manual.

Note 17. Current flowing only to the LCD controller/driver (V_{DD} pin). The current value of the RL78 microcontrollers is the sum of the LCD operating current (I_{LCD1}, I_{LCD2} or I_{LCD3}) to the supply current (I_{DD1}, or I_{DD2}) when the LCD controller/driver operates in an operation mode or HALT mode. Not including the current that flows through the LCD panel.

Note 18. Not including the current that flows through the external divider resistor divider resistor.

Note 19. Current flowing to the UV_{BUS}.

Note 20. Including the operating current when f_{PLL} = 48 MHz.

Note 21. Including the current supplied from the pull-up resistor of the UDP pin to the pull-down resistor of the host device, in addition to the current consumed by this MCU during the suspended state.

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

Remark 2. f_{SUB}: Subsystem clock frequency (XT1 clock oscillation frequency)

Remark 3. f_{CLK}: CPU/peripheral hardware clock frequency

Remark 4. Temperature condition of the TYP. value is T_A = 25°C

(3) During communication at same potential (CSI mode) (master mode, SCKp... internal clock output)

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

Parameter	Symbol	Conditions		HS (high-speed main) Mode		LS (low-speed main) Mode		LV (low-voltage main) Mode		Unit
				MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	
SCKp cycle time	t_{KCY1}	$t_{KCY1} \geq f_{CLK}/4$	2.7 V ≤ V_{DD} ≤ 3.6 V	167		500		1000		ns
			2.4 V ≤ V_{DD} ≤ 3.6 V	250		500		1000		ns
			1.8 V ≤ V_{DD} ≤ 3.6 V	—		500		1000		ns
			1.6 V ≤ V_{DD} ≤ 3.6 V	—		—		1000		ns
SCKp high-/low-level width	t_{KH1}, t_{KL1}	2.7 V ≤ V_{DD} ≤ 3.6 V		t_{KCY1}/2 - 18		t_{KCY1}/2 - 50		t_{KCY1}/2 - 50		ns
		2.4 V ≤ V_{DD} ≤ 3.6 V		t_{KCY1}/2 - 38		t_{KCY1}/2 - 50		t_{KCY1}/2 - 50		ns
		1.8 V ≤ V_{DD} ≤ 3.6 V		—		t_{KCY1}/2 - 50		t_{KCY1}/2 - 50		ns
		1.6 V ≤ V_{DD} ≤ 3.6 V		—		—		t_{KCY1}/2 - 100		ns
SIp setup time (to SCKp↑) Note 1	t_{SIK1}	2.7 V ≤ V_{DD} ≤ 3.6 V		44		110		110		ns
		2.4 V ≤ V_{DD} ≤ 3.6 V		75		110		110		ns
		1.8 V ≤ V_{DD} ≤ 3.6 V		—		110		110		ns
		1.6 V ≤ V_{DD} ≤ 3.6 V		—		—		220		ns
SIp hold time (from SCKp↑) Note 2	t_{KSI1}	2.4 V ≤ V_{DD} ≤ 3.6 V		19		19		19		ns
		1.8 V ≤ V_{DD} ≤ 3.6 V		—		19		19		ns
		1.6 V ≤ V_{DD} ≤ 3.6 V		—		—		19		ns
Delay time from SCKp↓ to SOp output Note 3	t_{KSO1}	C = 30 pF Note 4	2.7 V ≤ V_{DD} ≤ 3.6 V		25		50		50	ns
			2.4 V ≤ V_{DD} ≤ 3.6 V		25		50		50	ns
			1.8 V ≤ V_{DD} ≤ 3.6 V		—		50		50	ns
			1.6 V ≤ V_{DD} ≤ 3.6 V		—		—		50	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.

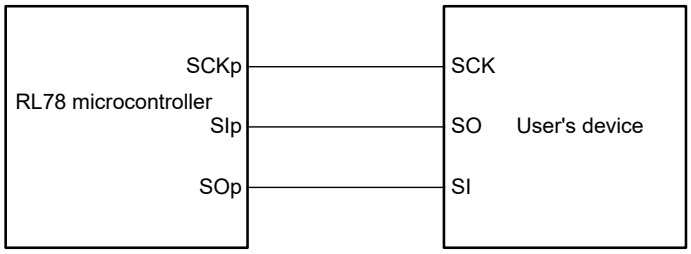
Note 4. C is the load capacitance of the SCKp and SOp output lines.

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

Remark 1. p: CSI number (p = 00, 10, 20, 30), m: Unit number (m = 0, 1), n: Channel number (n = 0 to 3), g: PIM number (g = 0 to 3)

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 to 03, 10 to 13))

CSI mode connection diagram (during communication at same potential)



Remark 1. p: CSI number (p = 00, 10, 20, 30)

Remark 2. m: Unit number, n: Channel number (mn = 00 to 03, 10 to 13)

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

(T_A = -40 to +85°C, 2.7 V ≤ V_{DD} ≤ 3.6 V, V_{SS} = 0 V)

Parameter	Symbol	Conditions		HS (high-speed main) Mode		LS (low-speed main) Mode		LV (low-voltage main) Mode		Unit
				MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	
SCKp cycle time	t_{KCY1}	$t_{KCY1} \geq f_{CLK}/2$	2.7V ≤ V_{DD} < 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 20 pF, R_b = 2.7 kΩ	300		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 = 20 pF, R_b = 2.7 kΩ		t_{KCY1}/2 - 120		t_{KCY1}/2 - 120		t_{KCY1}/2 - 120		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 = 20 pF, R_b = 1.4 kΩ		t_{KCY1}/2 - 10		t_{KCY1}/2 - 50		t_{KCY1}/2 - 50		ns
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 = 20 pF, R_b = 2.7 kΩ		121		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 = 20 pF, R_b = 1.4 kΩ		10		10		10		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 = 20 pF, R_b = 1.4 kΩ			130		130		130	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 = 20 pF, R_b = 2.7 kΩ		33		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 = 20 pF, R_b = 2.7 kΩ		10		10		10		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 = 20 pF, R_b = 2.7 kΩ			10		10		10	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.

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.

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), m: Unit number (m = 0),
n: Channel number (n = 0), g: PIM and POM number (g = 2)

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))

(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 ≤ V_{DD} ≤ 3.6 V, V_{SS} = 0 V) **(2/2)**

Parameter	Symbol	Conditions	HS (high-speed main) Mode		LS (low-speed main) Mode		LV (low-voltage main) Mode		Unit
			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		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		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		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		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	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	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		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		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		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		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	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	ns

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

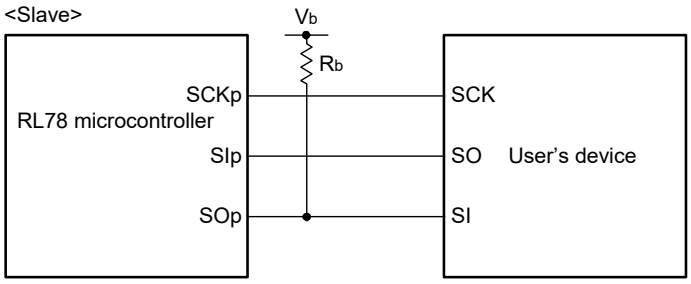
Note 2. When DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.

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 connection diagram (during communication at different potential)



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

Remark 2. p: CSI number (p = 00, 10, 20, 30), m: Unit number (m = 0, 1), n: Channel number (n = 0 to 3), g: PIM and POM number (g = 0 to 3)

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, 02, 10, 12))

2.5.2 Serial interface IICA

(1) I²C standard mode

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

Parameter	Symbol	Conditions		HS (high-speed main) Mode		LS (low-speed main) Mode		LV (low-voltage main) Mode		Unit
				MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	
SCLA0 clock frequency	f_{SCL}	Standard mode: f_{CLK} ≥ 1 MHz	2.7 V ≤ V_{DD} ≤ 3.6 V	0	100	0	100	0	100	kHz
			1.8 V ≤ V_{DD} ≤ 3.6 V	—	—	0	100	0	100	kHz
			1.6 V ≤ V_{DD} ≤ 3.6 V	—	—	—	—	0	100	kHz
Setup time of restart condition	$t_{SU: STA}$	2.7 V ≤ V_{DD} ≤ 3.6 V		4.7		4.7		4.7		µs
		1.8 V ≤ V_{DD} ≤ 3.6 V		—		4.7		4.7		µs
		1.6 V ≤ V_{DD} ≤ 3.6 V		—		—		4.7		µs
Hold time Note 1	$t_{HD: STA}$	2.7 V ≤ V_{DD} ≤ 3.6 V		4.0		4.0		4.0		µs
		1.8 V ≤ V_{DD} ≤ 3.6 V		—		4.0		4.0		µs
		1.6 V ≤ V_{DD} ≤ 3.6 V		—		—		4.0		µs
Hold time when SCLA0 = “L”	t_{LOW}	2.7 V ≤ V_{DD} ≤ 3.6 V		4.7		4.7		4.7		µs
		1.8 V ≤ V_{DD} ≤ 3.6 V		—		4.7		4.7		µs
		1.6 V ≤ V_{DD} ≤ 3.6 V		—		—		4.7		µs
Hold time when SCLA0 = “H”	t_{HIGH}	2.7 V ≤ V_{DD} ≤ 3.6 V		4.0		4.0		4.0		µs
		1.8 V ≤ V_{DD} ≤ 3.6 V		—		4.0		4.0		µs
		1.6 V ≤ V_{DD} ≤ 3.6 V		—		—		4.0		µs
Data setup time (reception)	$t_{SU: DAT}$	2.7 V ≤ V_{DD} ≤ 3.6 V		250		250		250		ns
		1.8 V ≤ V_{DD} ≤ 3.6 V		—		250		250		ns
		1.6 V ≤ V_{DD} ≤ 3.6 V		—		—		250		ns
Data hold time (transmission) Note 2	$t_{HD: DAT}$	2.7 V ≤ V_{DD} ≤ 3.6 V		0	3.45	0	3.45	0	3.45	µs
		1.8 V ≤ V_{DD} ≤ 3.6 V		—	—	0	3.45	0	3.45	µs
		1.6 V ≤ V_{DD} ≤ 3.6 V		—	—	—	—	0	3.45	µs
Setup time of stop condition	$t_{SU: STO}$	2.7 V ≤ V_{DD} ≤ 3.6 V		4.0		4.0		4.0		µs
		1.8 V ≤ V_{DD} ≤ 3.6 V		—		4.0		4.0		µs
		1.6 V ≤ V_{DD} ≤ 3.6 V		—		—		4.0		µs
Bus-free time	t_{BUF}	2.7 V ≤ V_{DD} ≤ 3.6 V		4.7		4.7		4.7		µs
		1.8 V ≤ V_{DD} ≤ 3.6 V		—		4.7		4.7		µs
		1.6 V ≤ V_{DD} ≤ 3.6 V		—		—		4.7		µs

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

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

Remark The maximum value of C_b (communication line capacitance) and the value of R_b (communication line pull-up resistor) at that time in each mode are as follows.
Standard mode: C_b = 400 pF, R_b = 2.7 kΩ

(2) When reference voltage (+) = AV_{REFP}/ANI0 (ADREFP1 = 0, ADREFP0 = 1), reference voltage (-) = AV_{REFM}/ANI1 (ADREFM = 1), conversion target: ANI2 to ANI6

(T_A = -40 to +85°C, 1.6 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
			1.8 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V	8		10 Note 1	
			1.6 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V	8 Note 2			
Overall error Note 3	AINL	12-bit resolution	2.4 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V			±6.0	LSB
		10-bit resolution	1.8 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V			±5.0	
		8-bit resolution	1.6 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V			±2.5	
Conversion time	t_{CONV}	ADTYP = 0, 12-bit resolution	2.4 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V	3.375			µs
		ADTYP = 0, 10-bit resolution Note 1	1.8 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V	6.75			
		ADTYP = 0, 8-bit resolution Note 2	1.6 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V	13.5			
		ADTYP = 1, 8-bit resolution	2.4 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V	2.5625			
			1.8 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V	5.125			
			1.6 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V	10.25			
Zero-scale error Note 3	E_{ZS}	12-bit resolution	2.4 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V			±4.5	LSB
		10-bit resolution	1.8 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V			±4.5	
		8-bit resolution	1.6 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V			±2.0	
Full-scale error Note 3	E_{FS}	12-bit resolution	2.4 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V			±4.5	LSB
		10-bit resolution	1.8 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V			±4.5	
		8-bit resolution	1.6 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V			±2.0	
Integral linearity error Note 3	ILE	12-bit resolution	2.4 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V			±2.0	LSB
		10-bit resolution	1.8 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V			±1.5	
		8-bit resolution	1.6 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V			±1.0	
Differential linearity error Note 3	DLE	12-bit resolution	2.4 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V			±1.5	LSB
		10-bit resolution	1.8 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V			±1.5	
		8-bit resolution	1.6 V ≤ AV_{REFP} ≤ AV_{DD} ≤ 3.6 V			±1.0	
Analog input voltage	V_{AIN}			0		AV_{REFP}	V

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

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

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

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

3.1 Absolute Maximum Ratings

Absolute Maximum Ratings (T_A = 25°C) **(1/3)**

Parameter	Symbols	Conditions	Ratings	Unit
Supply voltage	V_{DD}		-0.5 to + 6.5	V
	UV_{BUS}		-0.5 to + 6.5	V
	AV_{DD}	$AV_{DD} \leq V_{DD}$	-0.5 to + 4.6	V
REGC pin input voltage	V_{IREGC}	REGC	-0.3 to + 2.8 and -0.3 to V_{DD} + 0.3 Note 1	V
U_{REGC} pin input voltage	V_{IUREGC}	U_{REGC}	-0.3 to UV_{BUS} + 0.3 Note 2	V
Input voltage	V_{I1}	P00 to P07, P10 to P17, P20 to P27, P30 to P37, P40 to P46, P50 to P57, P70 to P77, P80 to P83, P125 to P127, P137, P140 to P143, EXCLK, EXCLKS, $\overline{\text{RESET}}$	-0.3 to V_{DD} + 0.3 Note 3	V
	V_{I2}	P60, P61 (N-ch open-drain)	-0.3 to + 6.5	V
	V_{I3}	UDP, UDM	-0.3 to + 6.5	V
	V_{I4}	P150 to P156	-0.3 to AV_{DD} + 0.3 Note 4	V
Output voltage	V_{O1}	P00 to P07, P10 to P17, P20 to P27, P30 to P37, P40 to P46, P50 to P57, P60, P61, P70 to P77, P80 to P83, P125 to P127, P130, P140 to P143	-0.3 to V_{DD} + 0.3 Note 3	V
	V_{O2}	P150 to P156	-0.3 to AV_{DD} + 0.3 Note 3	V
	V_{O3}	UDP, UDM	-0.3 to + 3.8	V
Analog input voltage	V_{AI1}	ANI16 to ANI21	-0.3 to V_{DD} + 0.3 and $AV_{REF(+)}$ + 0.3 Notes 3, 5	V
	V_{AI2}	ANI0 to ANI6	-0.3 to AV_{DD} + 0.3 and $AV_{REF(+)}$ + 0.3 Notes 3, 5	V

Note 1. Connect the REGC pin to V_{SS} via a capacitor (0.47 to 1 μF). This value regulates the absolute maximum rating of the REGC pin. Do not use this pin with voltage applied to it.

Note 2. Connect the U_{REGC} pin to Vss via a capacitor (0.33 μF). This value regulates the absolute maximum rating of the U_{REGC} pin. Do not use this pin with voltage applied to it.

Note 3. Must be 6.5 V or lower.

Note 4. Must be 4.6 V or lower.

Note 5. Do not exceed $AV_{REF(+)}$ + 0.3 V in case of A/D conversion target pin.

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

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

Remark 2. $AV_{REF(+)}$: + side reference voltage of the A/D converter.

Remark 3. V_{SS}: Reference voltage

(T_A = -40 to +105°C, 2.4 V ≤ AV_{DD} = V_{DD} ≤ 3.6 V, V_{SS} = 0 V)

Items	Symbol	Conditions			MIN.	TYP.	MAX.	Unit
Input leakage current, high	I_{LIH1}	P00 to P07, P10 to P17, P20 to P27, P30 to P37, P40 to P46, P50 to P57, P60, P61, P70 to P77, P80 to P83, P125 to P127, P137, P140 to P143, $\overline{RESET}$	V_I = V_{DD}				1	μA
	I_{LIH2}	P20, P21, P140 to P143	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}	P150 to P156	V_I = AV_{DD}				1	μA
Input leakage current, low	I_{LIL1}	P00 to P07, P10 to P17, P20 to P27, P30 to P37, P40 to P46, P50 to P57, P60, P61, P70 to P77, P80 to P83, P125 to P127, P137, P140 to P143, $\overline{RESET}$	V_I = V_{SS}				-1	μA
	I_{LIL2}	P20, P21, P140 to P143	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}	P150 to P156	V_I = AV_{SS}				-1	μA
On-chip pull-up resistance	R_{U1}	P00 to P07, P10 to P17, P20 to P27, P30 to P37, P50 to P57, P70 to P77, P140 to P143, P125 to P127	V_I = V_{SS}	2.4 V ≤ V_{DD} ≤ 3.6 V	10	20	100	kΩ
	R_{U2}	P40 to P46, P80 to P83	V_I = V_{SS}		10	20	100	kΩ

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

Note 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 LCD controller/driver, A/D converter, D/A converter, comparator, LVD circuit, USB 2.0 function module, I/O port, and on-chip pull-up/pull-down resistors and the current flowing during data flash rewrite.

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

Note 3. When high-speed system clock and subsystem clock are stopped.

Note 4. When high-speed on-chip oscillator and high-speed system clock are stopped. When AMPHS1 = 1 (Ultra-low power consumption oscillation). However, not including the current flowing into the real-time clock 2, 12-bit interval timer, and watchdog timer.

Note 5. Relationship between operation voltage width, operation frequency of CPU and operation mode is as below.
HS (high-speed main) mode: 2.7 V ≤ V_{DD} ≤ 3.6 V@1 MHz to 24 MHz
2.4 V ≤ V_{DD} ≤ 3.6 V@1 MHz to 16 MHz

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

Remark 2. f_{HOCO}: High-speed on-chip oscillator clock frequency (48 MHz max.)

Remark 3. f_{IH}: Main system clock source frequency when the high-speed on-chip oscillator clock divided 1, 2, 4, or 8, or the PLL clock divided by 2, 4, or 8 is selected (24 MHz max.)

Remark 4. f_{SUB}: Subsystem clock frequency (XT1 clock oscillation frequency)

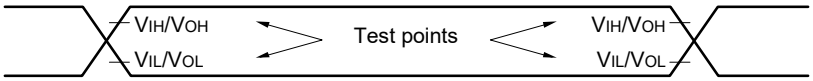
Remark 5. Except subsystem clock operation, temperature condition of the TYP. value is T_A = 25°C

(T_A = -40 to +105°C, 2.4 V ≤ V_{DD} ≤ 3.6 V, V_{SS} = 0 V)

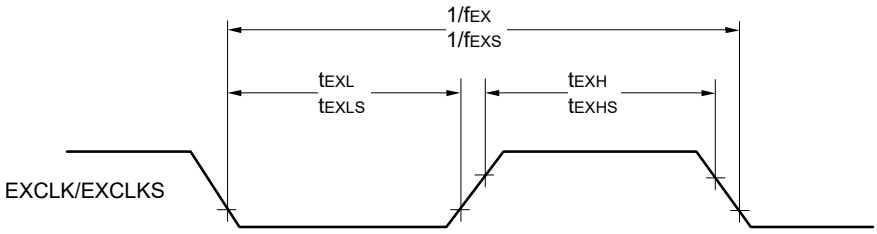
Parameter	Symbol	Conditions				MIN.	TYP.	MAX.	Unit
Low-speed on-chip oscillator operating current	I_{FIL} Note 1						0.20		μA
RTC2 operating current	I_{RTC} Notes 1, 3						0.02		μA
12-bit interval timer operating current	I_{TMKA} Notes 1, 2, 4						0.02		μA
Watchdog timer operating current	I_{WDT} Notes 1, 2, 5	f_{IL} = 15 kHz					0.22		μA
A/D converter operating current	I_{ADC} Notes 6, 7	AV_{DD} = 3.0 V, when conversion at maximum speed					422	720	μA
$AV_{REF(+)}$ current	I_{AVREF} Note 8	AV_{DD} = 3.0 V, ADREFP1 = 0, ADREFP0 = 0 Note 7					14.0	25.0	μA
		AV_{REFP} = 3.0 V, ADREFP1 = 0, ADREFP0 = 1 Note 10					14.0	25.0	
		ADREFP1 = 1, ADREFP0 = 0 Note 1					14.0	25.0	
A/D converter reference voltage current	I_{ADREF} Notes 1, 9	V_{DD} = 3.0 V					75.0		μA
Temperature sensor operating current	I_{TMPS} Note 1						78		μA
D/A converter operating current	I_{DAC} Notes 1, 11	Per D/A converter channel					0.53	1.5	mA
Comparator operating current	I_{CMP} Notes 1, 12	V_{DD} = 3.6 V, Regulator output voltage = 2.1 V	Window mode				12.5		μA
			Comparator high-speed mode				4.5		μA
			Comparator low-speed mode				1.2		μA
LVD operating current	I_{LVD} Notes 1, 13						0.06		μA
Self-programming operating current	I_{FSP} Notes 1, 14						2.50	12.20	mA
BGO operating current	I_{BGO} Notes 1, 15						1.68	12.20	mA
SNOOZE operating current	I_{SNOZ} Note 1	ADC operation	The mode is performed Note 16				0.34	1.10	mA
			The A/D conversion operations are performed, Low voltage mode, AV_{REFP} = V_{DD} = 3.0 V				0.53	2.04	
		CSI/UART operation					0.70	1.54	mA
LCD operating current	I_{LCD1} Notes 17, 18	External resistance division method	f_{LCD} = f_{SUB} LCD clock = 128 Hz	1/3 bias 4-time slice	V_{DD} = 3.6 V, V_{L4} = 3.6 V		0.14		μA
	I_{LCD2} Note 17	Internal voltage boosting method	f_{LCD} = f_{SUB} LCD clock = 128 Hz	1/3 bias 4-time slice	V_{DD} = 3.0 V, V_{L4} = 3.0 V (VLCD = 04H)		0.61		μA
	I_{LCD3} Note 17	Capacitor split method	f_{LCD} = f_{SUB} LCD clock = 128 Hz	1/3 bias 4-time slice	V_{DD} = 3.0 V, V_{L4} = 3.0 V		0.12		μA
USB current Note 19	I_{USB} Note 20	Operating current during USB communication					4.88		mA
	I_{USB} Note 21	Operating current in the USB suspended state					0.04		mA

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

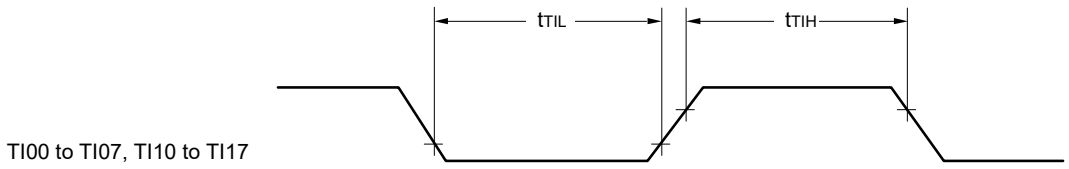
AC Timing Test Points

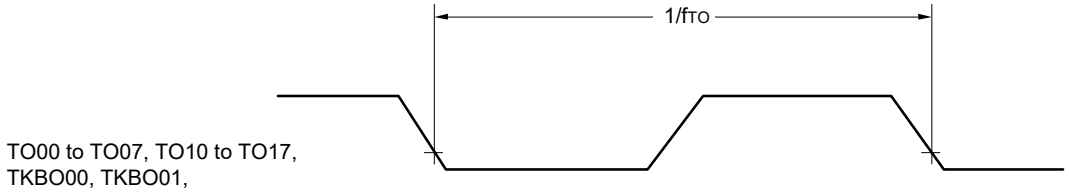


External System Clock Timing

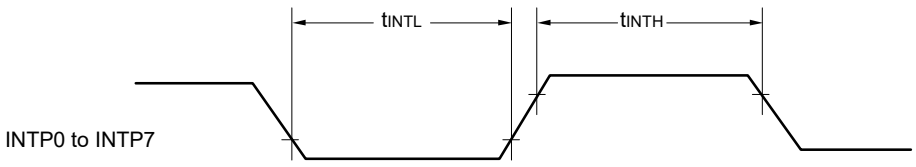


TI/TO Timing

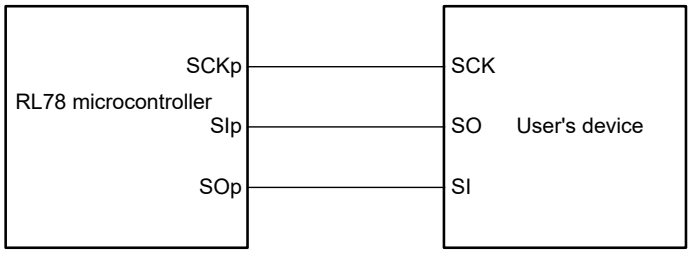




Interrupt Request Input Timing



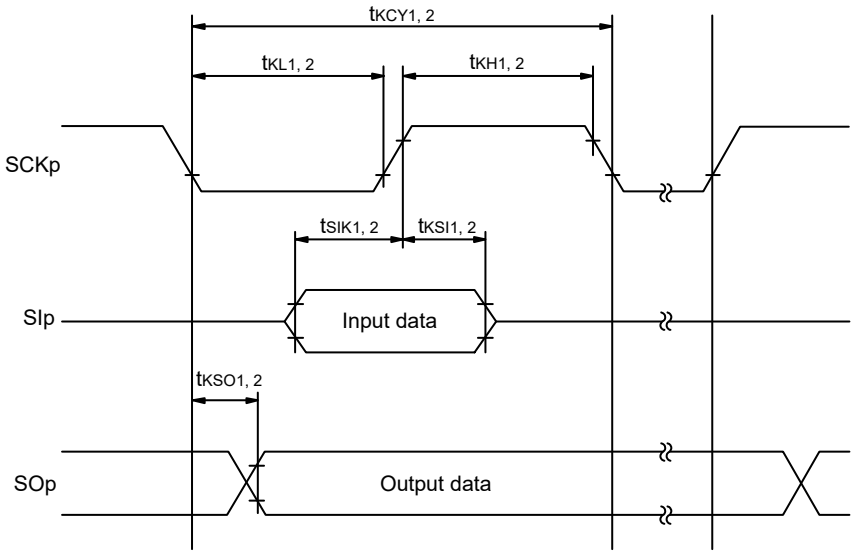
CSI mode connection diagram (during communication at same potential)



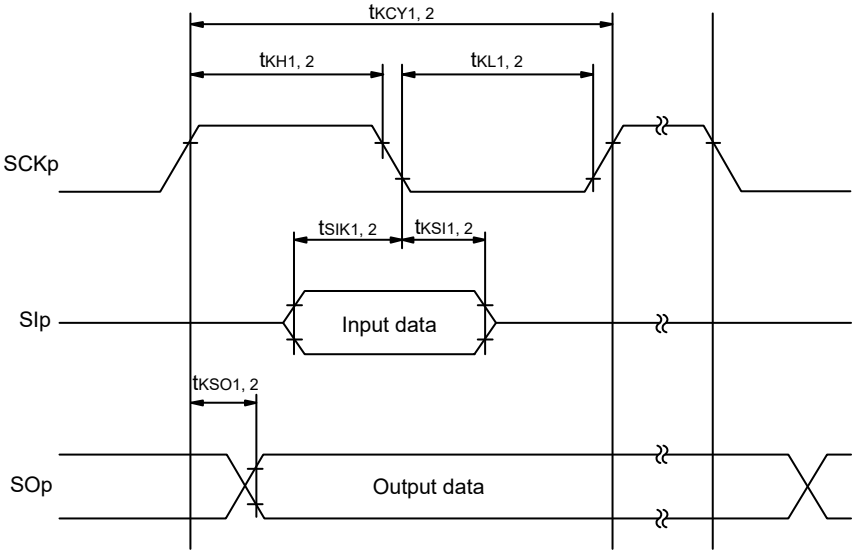
Remark 1. p: CSI number (p = 00, 10, 20, 30)

Remark 2. m: Unit number, n: Channel number (mn = 00 to 03, 10 to 13)

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

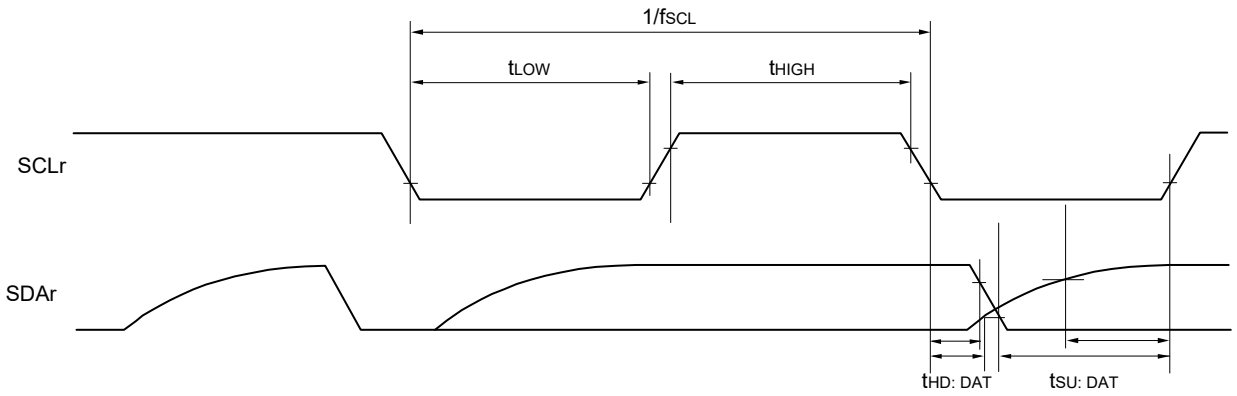


CSI mode serial transfer timing (during communication at same potential)
(When DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.)



Remark 1. p: CSI number (p = 00, 10, 20, 30)
Remark 2. m: Unit number, n: Channel number (mn = 00 to 03, 10 to 13)

Simplified I²C mode serial transfer timing (during communication at same potential)

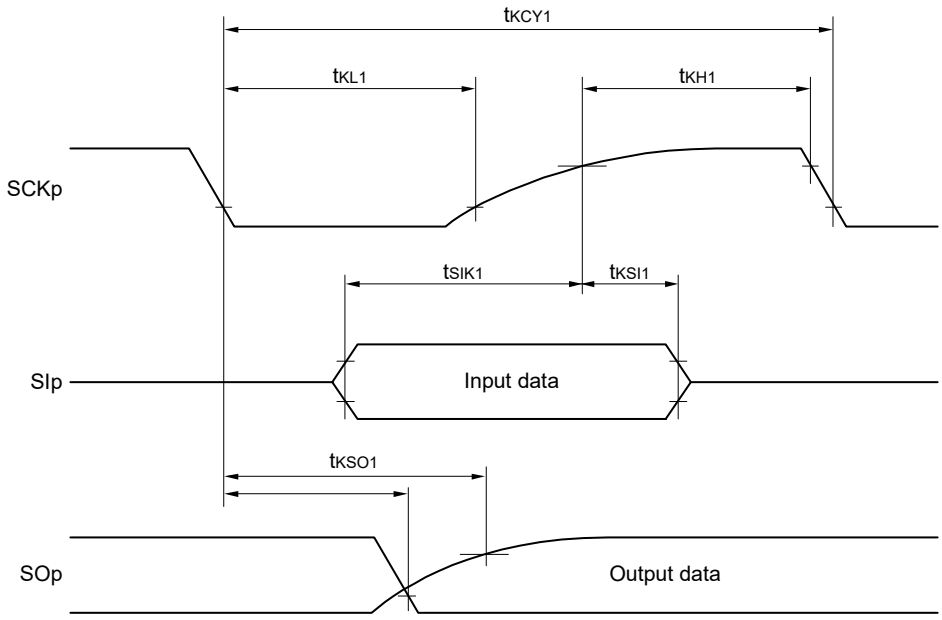


Remark 1. R_b[Ω]: Communication line (SDAr) pull-up resistance, C_b[F]: Communication line (SDAr, SCLr) load capacitance

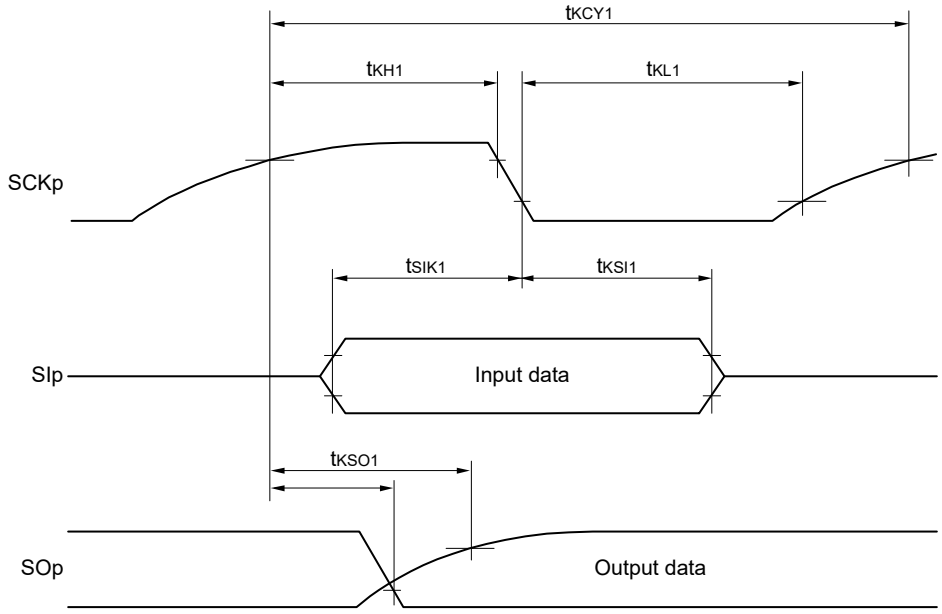
Remark 2. r: IIC number (r = 00, 10, 20, 30), g: PIM number (g = 0 to 3),
h: POM number (h = 0 to 3)

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 (m = 0, 1),
n: Channel number (n = 0 to 3), mn = 00 to 03, 10 to 13)

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

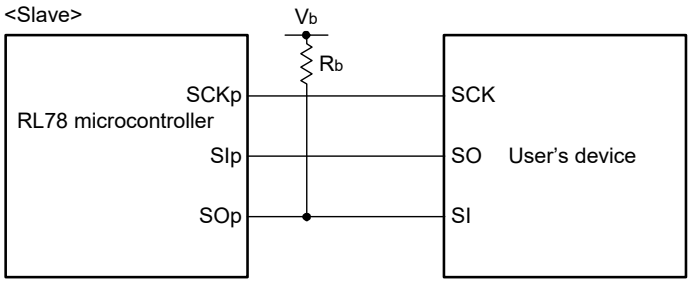


CSI mode serial transfer timing (master mode) (during communication at different potential)
(When DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.)



Remark p: CSI number (p = 00, 10, 20, 30), m: Unit number (m = 0, 1), n: Channel number (n = 0 to 3),
g: PIM and POM number (g = 0 to 3)

CSI mode connection diagram (during communication at different potential)



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

Remark 2. p: CSI number (p = 00, 10, 20, 30), m: Unit number (m = 0, 1), n: Channel number (n = 0 to 3), g: PIM and POM number (g = 0 to 3)

Remark 3. fMCK: 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, 02, 10, 12))

(8) Communication at different potential (1.8 V, 2.5 V) (simplified I^2C mode)

(T_A = -40 to +105°C, 2.4 V ≤ V_{DD} ≤ 3.6 V, V_{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 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.)