Renesas Electronics America Inc - R5F110NGALA#U0 Datasheet

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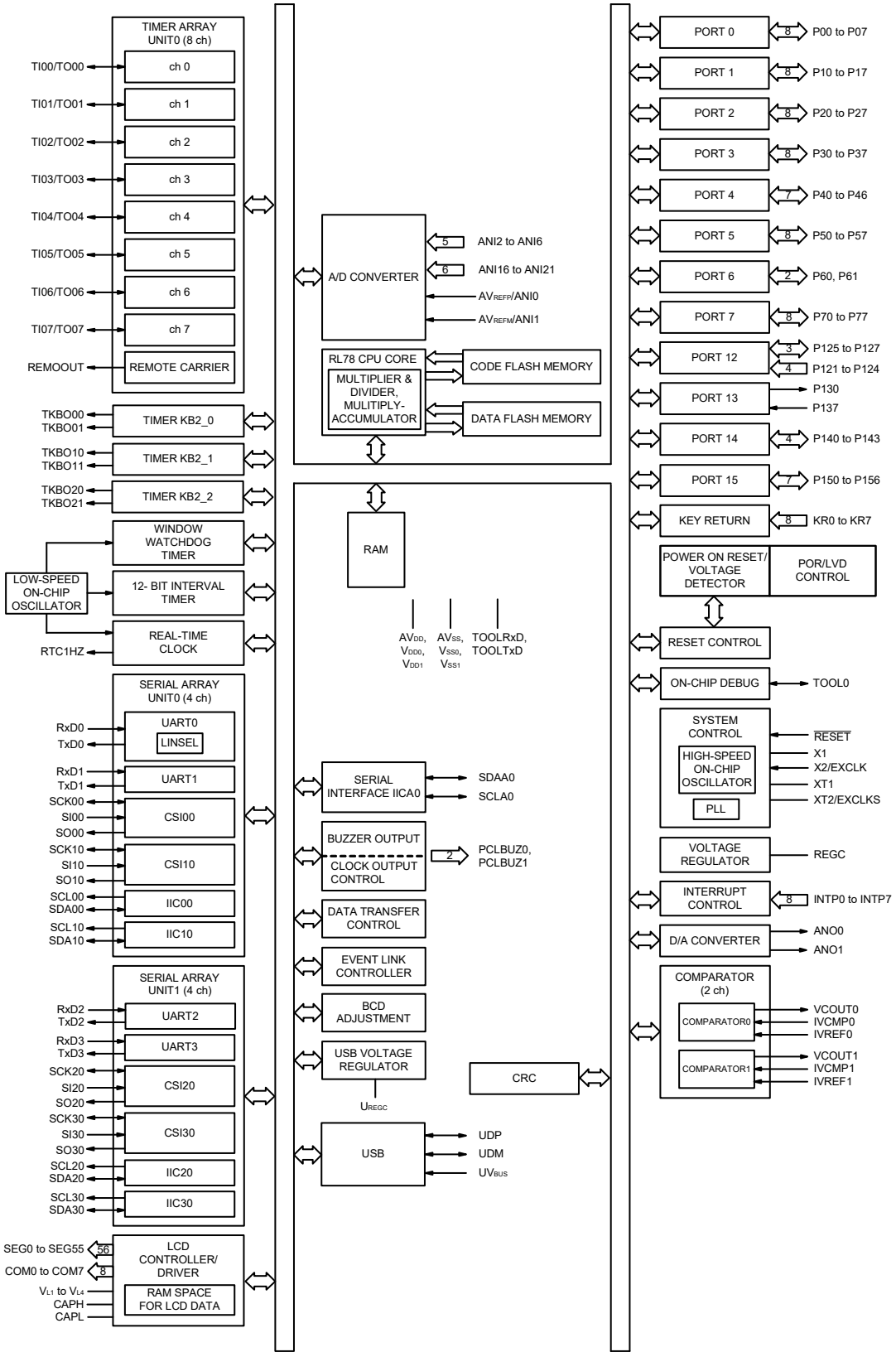
What is "Embedded - Microcontrollers"?

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

Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	RL78
Core Size	16-Bit
Speed	24MHz
Connectivity	CSI, I²C, LINbus, UART/USART, USB
Peripherals	LCD, LVD, POR, PWM, WDT
Number of I/O	51
Program Memory Size	128KB (128K x 8)
Program Memory Type	FLASH
EEPROM Size	8K x 8
RAM Size	12K x 8
Voltage - Supply (Vcc/Vdd)	1.6V ~ 3.6V
Data Converters	A/D 9x8/12b; D/A 2x8b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	85-VFLGA
Supplier Device Package	85-VFLGA (7x7)
Purchase URL	https://www.e-xfl.com/product-detail/renesas-electronics-america/r5f110ngala-u0

1.5.3 100-pin products (with USB)



Absolute Maximum Ratings (T_A = 25°C) (2/3)

Parameter	Symbols	Conditions		Ratings	Unit
LCD voltage	V_{LI1}	V_{L1} input voltage Note 1		-0.3 to +2.8	V
	V_{LI2}	V_{L2} input voltage Note 1		-0.3 to +6.5	V
	V_{LI3}	V_{L3} input voltage Note 1		-0.3 to +6.5	V
	V_{LI4}	V_{L4} input voltage Note 1		-0.3 to +6.5	V
	V_{LI5}	CAPL, CAPH input voltage Note 1		-0.3 to +6.5	V
	V_{LO1}	V_{L1} output voltage		-0.3 to +2.8	V
	V_{LO2}	V_{L2} output voltage		-0.3 to +6.5	V
	V_{LO3}	V_{L3} output voltage		-0.3 to +6.5	V
	V_{LO4}	V_{L4} output voltage		-0.3 to +6.5	V
	V_{LO5}	CAPL, CAPH output voltage		-0.3 to +6.5	V
	V_{LO6}	COM0 to COM7 SEG0 to SEG55 output voltage	External resistance division method	-0.3 to V_{DD} + 0.3 Note 2	V
			Capacitor split method	-0.3 to V_{DD} + 0.3 Note 2	V
			Internal voltage boosting method	-0.3 to V_{LI4} + 0.3 Note 2	V

Note 1. This value only indicates the absolute maximum ratings when applying voltage to the V_{L1}, V_{L2}, V_{L3}, and V_{L4} pins; it does not mean that applying voltage to these pins is recommended. When using the internal voltage boosting method or capacitance split method, connect these pins to V_{SS} via a capacitor (0.47 ± 30%) and connect a capacitor (0.47 ± 30%) between the CAPL and CAPH pins.

Note 2. Must be 6.5 V or lower.

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.

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

Parameter	Symbols	Conditions		Ratings	Unit
Output current, high	I_{OH1}	Per pin	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, P130, P140 to P143	-40	mA
		Total of all pins -170 mA	P40 to P46	-70	mA
			P00 to P07, P10 to P17, P20 to P27, P30 to P37, P50 to P57, P70 to P77, P80 to P83, P125 to P127, P130, P140 to P143	-100	mA
	I_{OH2}	Per pin	P150 to P156	-0.1	mA
		Total of all pins		-0.7	mA
	I_{OH3}	Per pin	UDP, UDM	-3	mA
Output current, low	I_{OL1}	Per pin	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	40	mA
		Total of all pins 170 mA	P40 to P46	70	mA
			P00 to P07, P10 to P17, P20 to P27, P30 to P37, P50 to P57, P70 to P77, P80 to P83, P125 to P127, P130, P140 to P143	100	mA
	I_{OL2}	Per pin	P150 to P156	0.4	mA
		Total of all pins		2.8	mA
	I_{OL3}	Per pin	UDP, UDM	3	mA
Operating ambient temperature	T_A	In normal operation mode		-40 to +85	°C
		In flash memory programming mode			
Storage temperature	T_{stg}			-65 to +150	°C

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

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

(T_A = -40 to +85°C, 1.6 V ≤ V_{DD} ≤ 3.6 V, V_{SS} = 0 V) **(2/2)**

Parameter	Symbol	Conditions				MIN.	TYP.	MAX.	Unit
Supply current Note 1	I_{DD2} Note 2	HALT mode	HS (high-speed main) mode Note 7	f_{HOCO} = 48 MHz Note 4, f_{IH} = 24 MHz Note 4	V_{DD} = 3.6 V		0.77	2.70	mA
					V_{DD} = 3.0 V		0.77	2.70	
				f_{HOCO} = 24 MHz Note 4, f_{IH} = 24 MHz Note 4	V_{DD} = 3.6 V		0.55	1.91	
					V_{DD} = 3.0 V		0.55	1.90	
				f_{HOCO} = 16 MHz Note 4, f_{IH} = 16 MHz Note 4	V_{DD} = 3.6 V		0.48	1.41	
					V_{DD} = 3.0 V		0.47	1.41	
			LS (low-speed main) mode Note 7	f_{HOCO} = 8 MHz Note 4, f_{IH} = 8 MHz Note 4	V_{DD} = 3.0 V		300	770	μA
					V_{DD} = 2.0 V		300	770	
			LV (low-voltage main) mode Note 7	f_{HOCO} = 4 MHz Note 4, f_{IH} = 4 MHz Note 4	V_{DD} = 3.0 V		440	770	μA
					V_{DD} = 2.0 V		440	770	
			HS (high-speed main) mode Note 7	f_{MX} = 20 MHz Note 3, V_{DD} = 3.6 V	Square wave input		0.35	1.63	mA
					Resonator connection		0.51	1.68	
				f_{MX} = 20 MHz Note 3, V_{DD} = 3.0 V	Square wave input		0.34	1.63	
					Resonator connection		0.51	1.68	
				f_{MX} = 16 MHz Note 3, V_{DD} = 3.6 V	Square wave input		0.30	1.22	
					Resonator connection		0.45	1.39	
				f_{MX} = 16 MHz Note 3, V_{DD} = 3.0 V	Square wave input		0.29	1.20	
					Resonator connection		0.45	1.38	
				f_{MX} = 10 MHz Note 3, V_{DD} = 3.6 V	Square wave input		0.23	0.82	
					Resonator connection		0.30	0.90	
				f_{MX} = 10 MHz Note 3, V_{DD} = 3.0 V	Square wave input		0.22	0.81	
					Resonator connection		0.30	0.89	
			LS (low-speed main) mode Note 7	f_{MX} = 8 MHz Note 3, V_{DD} = 3.0 V	Square wave input		120	510	μA
					Resonator connection		170	560	
				f_{MX} = 8 MHz Note 3, V_{DD} = 2.0 V	Square wave input		130	520	
					Resonator connection		170	570	
			HS (High-speed main) mode (PLL operation)	f_{MX} = 48 MHz, f_{CLK} = 24 MHz Note 3	V_{DD} = 3.6 V		0.99	2.89	mA
					V_{DD} = 3.0 V		0.99	2.88	
				f_{MX} = 48 MHz, f_{CLK} = 12 MHz Note 3	V_{DD} = 3.6 V		0.89	2.48	
					V_{DD} = 3.0 V		0.89	2.47	
				f_{MX} = 48 MHz, f_{CLK} = 6 MHz Note 3	V_{DD} = 3.6 V		0.84	2.27	
					V_{DD} = 3.0 V		0.84	2.27	
			Subsystem clock operation	f_{SUB} = 32.768 kHz Note 5 T_A = -40°C	Square wave input		0.32	0.61	μA
					Resonator connection		0.51	0.80	
				f_{SUB} = 32.768 kHz Note 5 T_A = +25°C	Square wave input		0.41	0.74	
					Resonator connection		0.62	0.91	
				f_{SUB} = 32.768 kHz Note 5 T_A = +50°C	Square wave input		0.52	2.30	
					Resonator connection		0.75	2.49	
				f_{SUB} = 32.768 kHz Note 5 T_A = +70°C	Square wave input		0.82	4.03	
					Resonator connection		1.08	4.22	
				f_{SUB} = 32.768 kHz Note 5 T_A = +85°C	Square wave input		1.38	8.04	
					Resonator connection		1.62	8.23	
	I_{DD3} Note 6	STOP mode Note 8	T_A = -40°C				0.18	0.52	μA
			T_A = +25°C				0.25	0.52	
			T_A = +50°C				0.34	2.21	
			T_A = +70°C				0.64	3.94	
			T_A = +85°C				1.18	7.95	

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

(T_A = -40 to +85°C, 1.6 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
		V_{DD} = 3.6 V, Regulator output voltage = 1.8 V	Window mode				7.05		μA
			Comparator high-speed mode				2.2		μA
			Comparator low-speed mode				0.9		μA
LVD operating current	I_{LVI} 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, L_{V4} = 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, L_{V4} = 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, L_{V4} = 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.)

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

(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 Note 5	t_{KCY2}	2.7 V ≤ V_{DD} < 3.6 V	f_{MCK} > 16 MHz	8/f_{MCK}		—		—		ns
			f_{MCK} ≤ 16 MHz	6/f_{MCK}		6/f_{MCK}		6/f_{MCK}		ns
		2.4 V ≤ V_{DD} < 3.6 V		6/f_{MCK} and 500		6/f_{MCK} and 500		6/f_{MCK} and 500		ns
		1.8 V ≤ V_{DD} < 3.6 V		—		6/f_{MCK} and 750		6/f_{MCK} and 750		ns
		1.6 V ≤ V_{DD} < 3.6 V		—		—		6/f_{MCK} and 1500		ns
SCKp high-/low-level width	t_{KH2}, t_{KL2}	2.7 V ≤ V_{DD} ≤ 3.6 V		t_{KCY2}/2 - 8		t_{KCY2}/2 - 8		t_{KCY2}/2 - 8		ns
		1.8 V ≤ V_{DD} ≤ 3.6 V		—		t_{KCY2}/2 - 18		t_{KCY2}/2 - 18		ns
		1.6 V ≤ V_{DD} ≤ 3.6 V		—		—		t_{KCY1}/2 - 66		ns
SIp setup time (to SCKp↑) Note 1	t_{SIK2}	2.7 V ≤ V_{DD} ≤ 3.6 V		1/f_{MCK} + 20		1/f_{MCK} + 30		1/f_{MCK} + 30		ns
		2.4 V ≤ V_{DD} ≤ 3.6 V		1/f_{MCK} + 30		1/f_{MCK} + 30		1/f_{MCK} + 30		ns
		1.8 V ≤ V_{DD} < 3.6 V		—		1/f_{MCK} + 30		1/f_{MCK} + 30		ns
		1.6 V ≤ V_{DD} < 3.6 V		—		—		1/f_{MCK} + 40		ns
SIp hold time (from SCKp↑) Note 2	t_{KSI2}	2.4 V ≤ V_{DD} < 3.6 V		1/f_{MCK} + 31		1/f_{MCK} + 31		1/f_{MCK} + 31		ns
		1.8 V ≤ V_{DD} < 3.6 V		—		1/f_{MCK} + 31		1/f_{MCK} + 31		ns
		1.6 V ≤ V_{DD} < 3.6 V		—		—		1/f_{MCK} + 250		ns
Delay time from SCKp↓ to SOp output Note 3	t_{KSO2}	C = 30 pF Note 4	2.7 V ≤ V_{DD} ≤ 3.6 V		2/f_{MCK} + 44		2/f_{MCK} + 110		2/f_{MCK} + 110	ns
			2.4 V ≤ V_{DD} < 3.6 V		2/f_{MCK} + 75		2/f_{MCK} + 110		2/f_{MCK} + 110	ns
			1.8 V ≤ V_{DD} < 3.6 V		—		2/f_{MCK} + 110		2/f_{MCK} + 110	ns
			1.6 V ≤ V_{DD} < 3.6 V		—		—		2/f_{MCK} + 220	ns

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

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

Note 3. When DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1. The delay time to SOp output becomes "from SCKp↑" when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.

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

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

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

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

(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) (1/2)

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.	
SCKp cycle time	t_{KCY1}	t_{KCY1} ≥ f_{CLK}/4	2.7V ≤ V_{DD} < 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 30 pF, R_b = 2.7 kΩ	500 Note		1150		1150		ns
			1.8 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 1.8 V, C_b = 30 pF, R_b = 5.5 kΩ	1150 Note		1150		1150		ns
SCKp high-level width	t_{KH1}	2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 30 pF, R_b = 2.7 kΩ		t_{KCY1}/2 - 170		t_{KCY1}/2 - 170		t_{KCY1}/2 - 170		ns
		1.8 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V, C_b = 30 pF, R_b = 5.5 kΩ		t_{KCY1}/2 - 458		t_{KCY1}/2 - 458		t_{KCY1}/2 - 458		ns
SCKp low-level width	t_{KL1}	2.7 V ≤ V_{DD} ≤ 3.6 V, 2.3 V ≤ V_b ≤ 2.7 V, C_b = 30 pF, R_b = 2.7 kΩ		t_{KCY1}/2 - 18		t_{KCY1}/2 - 50		t_{KCY1}/2 - 50		ns
		1.8 V ≤ V_{DD} < 3.3 V, 1.6 V ≤ V_b ≤ 2.0 V, C_b = 30 pF, R_b = 5.5 kΩ		t_{KCY1}/2 - 50		t_{KCY1}/2 - 50		t_{KCY1}/2 - 50		ns

Note 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 page after the next page.)

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

(T_A = -40 to +85°C, 1.8 V ≤ 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.)

(3) BC option standard

(T_A = -40 to +85°C, 4.35 V ≤ UV_{BUS} ≤ 5.25 V, 2.4 V ≤ V_{DD} ≤ 3.6 V, V_{SS} = 0 V, HS (High-speed main) mode only)

Parameter			Symbol	Conditions	MIN.	TYP.	MAX.	Unit
UDP/UDM input reference voltage (UV_{BUS} divider ratio) (Function)	VDSELi [3: 0] (i = 0, 1)	0000	V_{DDET0}		27	32	37	%UVBUS
		0001	V_{DDET1}		29	34	39	%UVBUS
		0010	V_{DDET2}		32	37	42	%UVBUS
		0011	V_{DDET3}		35	40	45	%UVBUS
		0100	V_{DDET4}		38	43	48	%UVBUS
		0101	V_{DDET5}		41	46	51	%UVBUS
		0110	V_{DDET6}		44	49	54	%UVBUS
		0111	V_{DDET7}		47	52	57	%UVBUS
		1000	V_{DDET8}		51	56	61	%UVBUS
		1001	V_{DDET9}		55	60	65	%UVBUS
		1010	V_{DDET10}		59	64	69	%UVBUS
		1011	V_{DDET11}		63	68	73	%UVBUS
		1100	V_{DDET12}		67	72	73	%UVBUS
		1101	V_{DDET13}		71	76	81	%UVBUS
		1110	V_{DDET14}		75	80	85	%UVBUS
		1111	V_{DDET15}		79	84	89	%UVBUS

(4) When reference voltage (+) = AVREFP/ANI0 (ADREFP1 = 0, ADREFP0 = 1), reference voltage (-) = AVREFM/ANI1 (ADREFM = 1), conversion target: ANI16 to ANI21, internal reference voltage, temperature sensor output voltage

(T_A = -40 to +85°C, 1.6 V ≤ V_{DD} ≤ 3.6 V, 1.6 V ≤ AVREFP ≤ AVDD = V_{DD} ≤ 3.6 V, V_{SS} = 0 V, AVSS = 0 V, Reference voltage (+) = AVREFP, Reference voltage (-) = AVREFM = 0 V)

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Resolution	RES		2.4 V ≤ AVREFP ≤ AVDD ≤ 3.6 V	8		12	bit
			1.8 V ≤ AVREFP ≤ AVDD ≤ 3.6 V	8		10 Note 1	
			1.6 V ≤ AVREFP ≤ AVDD ≤ 3.6 V	8 Note 2			
Overall error Note 3	AINL	12-bit resolution	2.4 V ≤ AVREFP ≤ AVDD ≤ 3.6 V			±7.0	LSB
		10-bit resolution	1.8 V ≤ AVREFP ≤ AVDD ≤ 3.6 V			±5.5	
		8-bit resolution	1.6 V ≤ AVREFP ≤ AVDD ≤ 3.6 V			±3.0	
Conversion time	tCONV	ADTYP = 0, 12-bit resolution	2.4 V ≤ AVREFP ≤ AVDD ≤ 3.6 V	4.125			µs
		ADTYP = 0, 10-bit resolution Note 1	1.8 V ≤ AVREFP ≤ AVDD ≤ 3.6 V	9.5			
		ADTYP = 0, 8-bit resolution Note 2	1.6 V ≤ AVREFP ≤ AVDD ≤ 3.6 V	57.5			
		ADTYP = 1, 8-bit resolution	2.4 V ≤ AVREFP ≤ AVDD ≤ 3.6 V	3.3125			
			1.8 V ≤ AVREFP ≤ AVDD ≤ 3.6 V	7.875			
			1.6 V ≤ AVREFP ≤ AVDD ≤ 3.6 V	54.25			
Zero-scale error Note 3	EZS	12-bit resolution	2.4 V ≤ AVREFP ≤ AVDD ≤ 3.6 V			±5.0	LSB
		10-bit resolution	1.8 V ≤ AVREFP ≤ AVDD ≤ 3.6 V			±5.0	
		8-bit resolution	1.6 V ≤ AVREFP ≤ AVDD ≤ 3.6 V			±2.5	
Full-scale error Note 3	EFS	12-bit resolution	2.4 V ≤ AVREFP ≤ AVDD ≤ 3.6 V			±5.0	LSB
		10-bit resolution	1.8 V ≤ AVREFP ≤ AVDD ≤ 3.6 V			±5.0	
		8-bit resolution	1.6 V ≤ AVREFP ≤ AVDD ≤ 3.6 V			±2.5	
Integral linearity error Note 3	ILE	12-bit resolution	2.4 V ≤ AVREFP ≤ AVDD ≤ 3.6 V			±3.0	LSB
		10-bit resolution	1.8 V ≤ AVREFP ≤ AVDD ≤ 3.6 V			±2.0	
		8-bit resolution	1.6 V ≤ AVREFP ≤ AVDD ≤ 3.6 V			±1.5	
Differential linearity error Note 3	DLE	12-bit resolution	2.4 V ≤ AVREFP ≤ AVDD ≤ 3.6 V			±2.0	LSB
		10-bit resolution	1.8 V ≤ AVREFP ≤ AVDD ≤ 3.6 V			±2.0	
		8-bit resolution	1.6 V ≤ AVREFP ≤ AVDD ≤ 3.6 V			±1.5	
Analog input voltage	VAIN			0		AVREFP	V
		Internal reference voltage (2.4 V ≤ V_{DD} ≤ 3.6 V, HS (high-speed main) mode)		V_{BGR} Note 4			
		Temperature sensor output voltage (2.4 V ≤ V_{DD} ≤ 3.6 V, HS (high-speed main) mode)		V_{TMP25} Note 4			

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

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

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

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

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

(5) When reference voltage (+) = AV_{DD} (ADREFP1 = 0, ADREFP0 = 0), reference voltage (-) = AV_{SS} (ADREFM = 0), conversion target: ANI16 to ANI21, internal reference voltage, temperature sensor output voltage

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

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Resolution	RES		2.4 V ≤ AV_{DD} ≤ 3.6 V	8		12	bit
			1.8 V ≤ AV_{DD} ≤ 3.6 V	8		10 Note 1	
			1.6 V ≤ AV_{DD} ≤ 3.6 V	8 Note 2			
Overall error Note 3	AINL	12-bit resolution	2.4 V ≤ AV_{DD} ≤ 3.6 V			±8.5	LSB
		10-bit resolution	1.8 V ≤ AV_{DD} ≤ 3.6 V			±6.0	
		8-bit resolution	1.6 V ≤ AV_{DD} ≤ 3.6 V			±3.5	
Conversion time	t_{CONV}	ADTYP = 0, 12-bit resolution	2.4 V ≤ AV_{DD} ≤ 3.6 V	4.125			µs
		ADTYP = 0, 10-bit resolution Note 1	1.8 V ≤ AV_{DD} ≤ 3.6 V	9.5			
		ADTYP = 0, 8-bit resolution Note 2	1.6 V ≤ AV_{DD} ≤ 3.6 V	57.5			
		ADTYP = 1, 8-bit resolution	2.4 V ≤ AV_{DD} ≤ 3.6 V	3.3125			
			1.8 V ≤ AV_{DD} ≤ 3.6 V	7.875			
			1.6 V ≤ AV_{DD} ≤ 3.6 V	54.25			
Zero-scale error Note 3	E_{ZS}	12-bit resolution	2.4 V ≤ AV_{DD} ≤ 3.6 V			±8.0	LSB
		10-bit resolution	1.8 V ≤ AV_{DD} ≤ 3.6 V			±5.5	
		8-bit resolution	1.6 V ≤ AV_{DD} ≤ 3.6 V			±3.0	
Full-scale error Note 3	E_{FS}	12-bit resolution	2.4 V ≤ AV_{DD} ≤ 3.6 V			±8.0	LSB
		10-bit resolution	1.8 V ≤ AV_{DD} ≤ 3.6 V			±5.5	
		8-bit resolution	1.6 V ≤ AV_{DD} ≤ 3.6 V			±3.0	
Integral linearity error Note 3	ILE	12-bit resolution	2.4 V ≤ AV_{DD} ≤ 3.6 V			±3.5	LSB
		10-bit resolution	1.8 V ≤ AV_{DD} ≤ 3.6 V			±2.5	
		8-bit resolution	1.6 V ≤ AV_{DD} ≤ 3.6 V			±1.5	
Differential linearity error Note 3	DLE	12-bit resolution	2.4 V ≤ AV_{DD} ≤ 3.6 V			±2.5	LSB
		10-bit resolution	1.8 V ≤ AV_{DD} ≤ 3.6 V			±2.5	
		8-bit resolution	1.6 V ≤ AV_{DD} ≤ 3.6 V			±2.0	
Analog input voltage	V_{AIN}			0		AV_{DD}	V
		Internal reference voltage (2.4 V ≤ V_{DD} ≤ 3.6 V, HS (high-speed main) mode)		V_{BGR} Note 4			
		Temperature sensor output voltage (2.4 V ≤ V_{DD} ≤ 3.6 V, HS (high-speed main) mode)		V_{TMP25} Note 4			

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

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

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

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

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

2.6.6 LVD circuit characteristics

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

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

Caution Set the detection voltage (V_{LVD}) to be within the operating voltage range. The operating voltage range depends on the setting of the user option byte (000C2H/010C2H). The following shows the operating voltage range.

HS (high-speed main) mode: V_{DD} = 2.7 to 3.6 V at 1 MHz to 24 MHz
V_{DD} = 2.4 to 3.6 V at 1 MHz to 16 MHz
LS (low-speed main) mode: V_{DD} = 1.8 to 3.6 V at 1 MHz to 8 MHz
LV (low-voltage main) mode: V_{DD} = 1.6 to 3.6 V at 1 MHz to 4 MHz

2.8 LCD Characteristics

2.8.1 Resistance division method

(1) Static display mode

(T_A = -40 to +85°C, V_{L4} (MIN.) ≤ V_{DD} ≤ 3.6 V, V_{SS} = 0 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
LCD drive voltage	V_{L4}		2.0		V_{DD}	V

(2) 1/2 bias method, 1/4 bias method

(T_A = -40 to +85°C, V_{L4} (MIN.) ≤ V_{DD} ≤ 3.6 V, V_{SS} = 0 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
LCD drive voltage	V_{L4}		2.7		V_{DD}	V

(3) 1/3 bias method

(T_A = -40 to +85°C, V_{L4} (MIN.) ≤ V_{DD} ≤ 3.6 V, V_{SS} = 0 V)

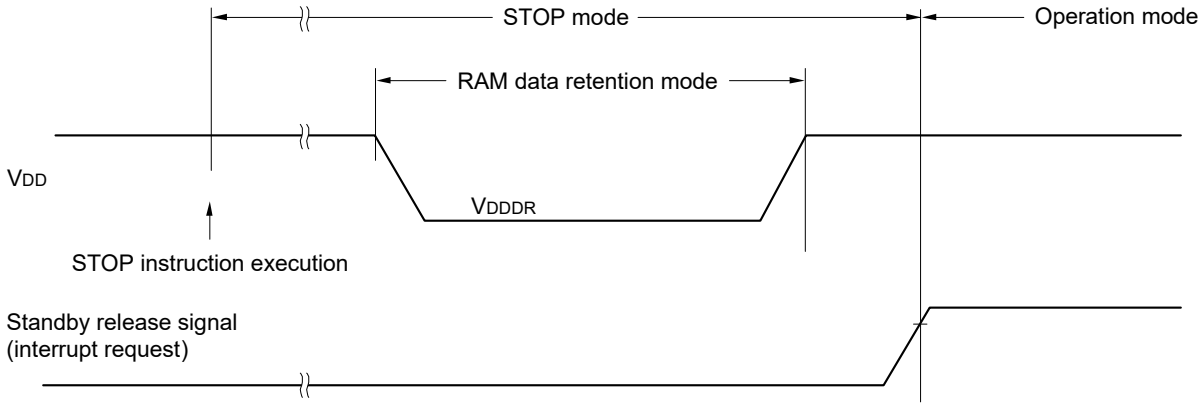
Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
LCD drive voltage	V_{L4}		2.5		V_{DD}	V

2.9 RAM Data Retention Characteristics

(T_A = -40 to +85°C, V_{SS} = 0 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Data retention supply voltage	V_{DDDR}		1.46 Note		3.6	V

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



2.10 Flash Memory Programming Characteristics

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

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
CPU/peripheral hardware clock frequency	f_{CLK}	2.4 V ≤ V_{DD} ≤ 3.6 V	1		24	MHz
Number of code flash rewrites Notes 1, 2, 3	C_{erwr}	Retained for 20 years T_A = 85°C	1,000			Times
Number of data flash rewrites Notes 1, 2, 3		Retained for 1 year T_A = 25°C		1,000,000		
		Retained for 5 years T_A = 85°C	100,000			
		Retained for 20 years T_A = 85°C	10,000			

Note 1. 1 erase + 1 write after the erase is regarded as 1 rewrite. The retaining years are until next rewrite after the rewrite.

Note 2. When using flash memory programmer and Renesas Electronics self programming library

Note 3. These are the characteristics of the flash memory and the results obtained from reliability testing by Renesas Electronics Corporation.

2.11 Dedicated Flash Memory Programmer Communication (UART)

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

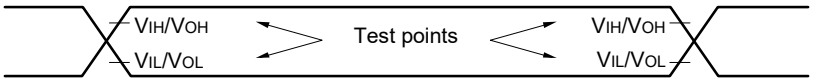
Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Transfer rate		During serial programming	115,200		1,000,000	bps

(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.)

3.5 Peripheral Functions Characteristics



3.5.1 Serial array unit

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

(TA = -40 to +105°C, 2.4 V ≤ VDD ≤ 3.6 V, VSS = 0 V)

Parameter	Symbol	Conditions	HS (high-speed main) Mode		Unit
			MIN.	MAX.	
Transfer rate Note 1		2.4 V ≤ VDD ≤ 3.6 V		fMCK/12 Note 2	bps
		Theoretical value of the maximum transfer rate fMCK = fCLK Note 3		2.0	Mbps

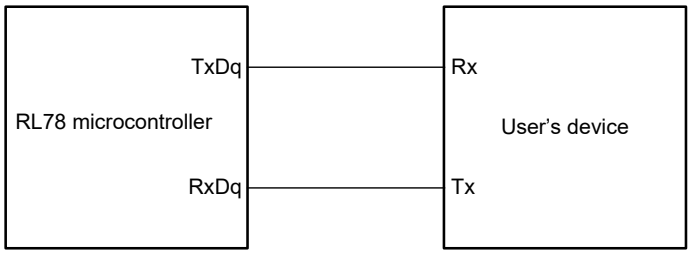
Note 1. Transfer rate in the SNOOZE mode is 4800 bps only.

Note 2. The following conditions are required for low voltage interface.
2.4 V ≤ VDD < 2.7 V: MAX. 1.3 Mbps

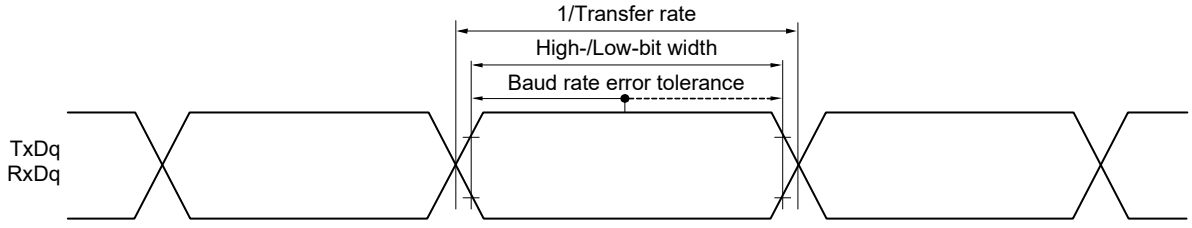
Note 3. The maximum operating frequencies of the CPU/peripheral hardware clock (fCLK) are:
HS (high-speed main) mode: 24 MHz (2.7 V ≤ VDD ≤ 3.6 V)
16 MHz (2.4 V ≤ VDD ≤ 3.6 V)

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

UART mode connection diagram (during communication at same potential)



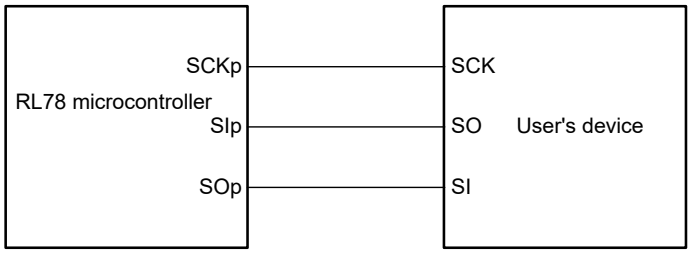
UART mode bit width (during communication at same potential) (reference)



Remark 1. q: UART number (q = 0 to 3), g: PIM and POM number (g = 0 to 3)

Remark 2. 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 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 (1.8 V, 2.5 V) (CSI mode) (slave mode, SCKp... external clock input)

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

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

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

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

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

Note 5. When DAPmn = 0 and CKPmn = 0, or DAPmn = 1 and CKPmn = 1. The delay time to SOp output becomes “from SCKp↑” when DAPmn = 0 and CKPmn = 1, or DAPmn = 1 and CKPmn = 0.

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

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

(5) When reference voltage (+) = Internal reference voltage (1.45 V) (ADREFP1 = 1, ADREFP0 = 0), reference voltage (-) = AVSS (ADREFM = 0), conversion target: ANI0 to ANI6, ANI16 to ANI21

(T_A = -40 to +105°C, 2.4 V ≤ V_{DD} ≤ 3.6 V, 2.4 V ≤ V_{DD}, 2.4 V ≤ AV_{DD} = V_{DD}, V_{SS} = 0 V, AV_{SS} = 0 V, Reference voltage (+) = internal reference voltage, Reference voltage (-) = AV_{SS} = 0 V, HS (high-speed main) mode)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Resolution	RES			8		bit
Conversion time	tCONV	8-bit resolution	16.0			µs
Zero-scale error Note	EZS	8-bit resolution			±4.0	LSB
Integral linearity error Note	ILE	8-bit resolution			±2.0	LSB
Differential linearity error Note	DLE	8-bit resolution			±2.5	LSB
Reference voltage (+)	$AV_{REF(+)}$	= Internal reference voltage (V_{BGR})	1.38	1.45	1.5	V
Analog input voltage	VAIN		0		V_{BGR}	V

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

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

3.6.2 Temperature sensor, internal reference voltage output characteristics

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

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Temperature sensor output voltage	V_{TMPS25}	Setting ADS register = 80H, T_A = +25°C		1.05		V
Internal reference voltage	V_{BGR}	Setting ADS register = 81H	1.38	1.45	1.5	V
Temperature coefficient	F_{VTMPS}	Temperature sensor output voltage that depends on the temperature		-3.6		mV/°C
Operation stabilization wait time	tAMP		10			µs

3.6.3 D/A converter characteristics

(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
Resolution	RES					8	bit
Overall error	AINL	Rload = 4 MΩ	2.4 V ≤ V_{DD} ≤ 3.6 V			±2.5	LSB
		Rload = 8 MΩ	2.4 V ≤ V_{DD} ≤ 3.6 V			±2.5	LSB
Settling time	tSET	Cload = 20 pF	2.7 V ≤ V_{DD} ≤ 3.6 V			3	µs
			2.4 V ≤ V_{DD} < 2.7 V			6	µs

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Renesas Electronics America Inc.
2801 Scott Boulevard Santa Clara, CA 95050-2549, U.S.A.
Tel: +1-408-588-6000, Fax: +1-408-588-6130

Renesas Electronics Canada Limited
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3
Tel: +1-905-237-2004

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-585-100, Fax: +44-1628-585-900

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
Room 1709, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100191, P.R.China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, P. R. China 200333
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852 2886-9022

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics India Pvt. Ltd.
No.777C, 100 Feet Road, HAL II Stage, Indiranagar, Bangalore, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.
12F., 234 Teheran-ro, Gangnam-Gu, Seoul, 135-080, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141

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