

RL78/G2x

Hardware Design Guide

Introduction

This document provides hardware-specific information and recommendations for using RL78/G2x microcontrollers. It should be used in conjunction with the applicable Hardware User's Manual, which includes the electrical characteristics.

Contents

1. Typical Circuit Schematic.....	2
1.1 Power Supply Circuit	4
1.1.1 Power Supply Pin	4
1.1.2 Power Supply Timing	5
1.2 REGC Pin	6
1.3 RESET Pin	7
1.4 Oscillator Circuit	8
1.4.1 Oscillator Input/Output Pin	8
1.4.2 Main System Clock.....	9
1.4.3 Subsystem Clock.....	9
1.4.4 Common Note for Oscillator Circuit.....	10
1.5 Note for I/O Port	12
1.5.1 Output Characteristics of I/O Port	12
1.5.2 Recommended Connection of Unused Pins	15
1.5.3 Peripheral I/O Redirection Function	16
1.6 Note for A/D Converter	17
1.6.1 Input Range of ANIn Pins	17
1.6.2 Notes on Board Design	17
1.6.3 Noise Countermeasures.....	18
1.6.4 Analog Input Pins (ANIn).....	18
1.6.5 Input Impedance of Analog Input (ANIn) Pins.....	18
1.6.6 Internal Equivalent Circuit	19
1.7 Note for Capacitive Sensing Unit	20
1.7.1 TSCAP Pin	20
1.7.2 Capacitive Touch Sensing Unit Electrodes	20
1.8 On-chip Debug Circuit	22
Revision History.....	25

1. Typical Circuit Schematic

Figure 1 shows a typical circuit schematic for the RL78/G23, and Table 1 lists the minimum external components shown in Figure 1.

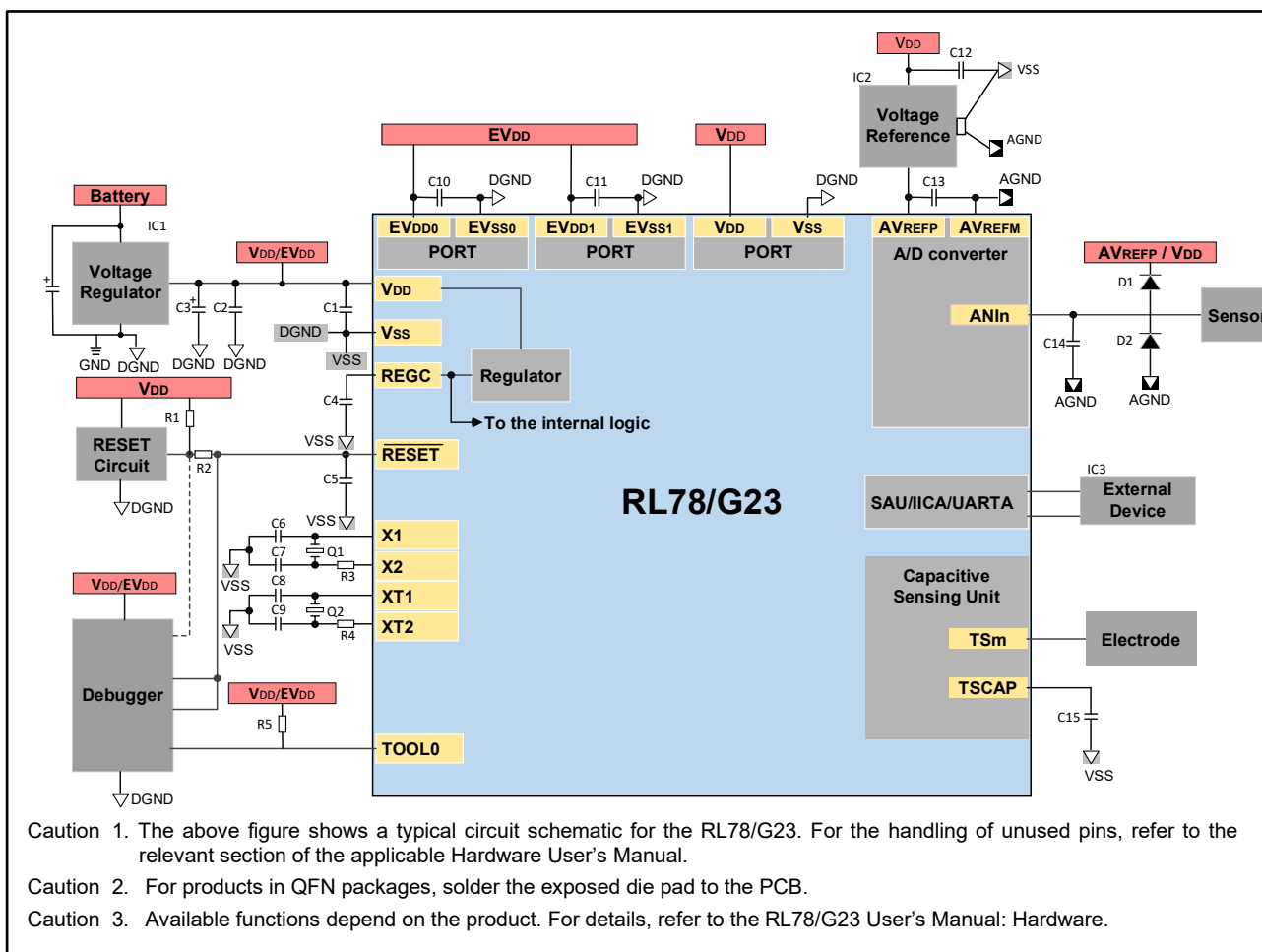


Figure 1: Typical Circuit Schematic for the RL78/G23

Table 1: Minimum External Components List

Category	Components	Value (Typ.)	Purpose	Remark	Supplement
Power supply	IC1	No recommended IC	Generating power supply for V _{DD}	Depends on the user system.	1.1
	C1	0.1 μ F	Bypass capacitor	Reference value. Place it as short and equidistant from the V _{DD} and V _{SS} pins as possible.	
	C2, C3	No recommended value	Stabilizing the output voltage of the voltage regulator	Follow the recommendation of the data sheet of the voltage regulator IC.	
	C4	0.47 μ F to 1.0 μ F	Stabilizing the internal regulator output voltage	Connect the capacitor between the REGC and V _{SS} pins using the shortest possible wiring.	1.2
	C10	0.1 μ F	Bypass capacitor	Reference value. Place it as short and equidistant from the EV _{DD0} , EV _{SS0} pins as possible.	–
	C11	0.1 μ F	Bypass capacitor	Reference value. Place it as short and equidistant from the EV _{DD1} , EV _{SS1} pins as possible.	
RESET	R1	1.0 k Ω	Pull-up resistor	Depends on the external reset circuit.	1.3
	C5	0.1 μ F	Stabilizing the reset output voltage level	Reference value. Place RESET and V _{SS} pins as short as possible.	
Oscillator circuit (Main system clock)	Q1	1.0 MHz to 20.0 MHz	Generating clock signal source for the main system clock	Customers are requested to consult the resonator manufacturer to select an appropriate resonator and to determine the proper oscillation constant. Connect the GND side of C6 and C7 to the V _{SS} pin as short as possible.	1.4.1 1.4.2
	C6, C7	No recommended value			
	R3	No recommended value			
Oscillator circuit (Subsystem clock)	Q2	32.768 kHz	Generating clock signal source for the subsystem clock	Customers are requested to consult the resonator manufacturer to select an appropriate resonator and to determine the proper oscillation constant. Connect the GND side of C8 and C9 to the V _{SS} pin as short as possible.	1.4.1 1.4.3
	C8, C9	No recommended value			
	R4	No recommended value			
A/D converter	IC2	No recommended IC	Voltage reference	Depends on the user system.	1.6
	C12	No recommended value	Bypass capacitor	Depends on the external voltage reference IC.	
	C13	0.1 μ F	Bypass capacitor	Place AV _{REFP} and AV _{REFM} pins as short as possible.	
	D1, D2	V _F $\leq$ 0.3 V	Noise protection	Depends on the user system.	
	C14	10 pF to 0.1 μ F	Stabilizing the sampling operation	Depends on the user system. Place the ANIn and V _{SS} pins as short as possible.	
Debug	R2	10 k Ω	Current limit between Reset circuit and Debugger	Depends on the external reset circuit.	1.8
	R5	1.0 k Ω	Pull-up resistor	Be sure to pull-up this pin externally when on-chip debugging is enabled (pulling it down is prohibited).	
SAU/IICA	IC3	No recommended IC	Controlling external device	Depends on the user system.	–
Capacitive Sensing Unit	C15	10 nF	Stabilizing the measurement secondary power	Connect the capacitor between the TSCAP and V _{SS} pins using the shortest possible wiring.	1.7

1.1 Power Supply Circuit

1.1.1 Power Supply Pin

Connect the power supply pin to GND via a bypass capacitor. For the bypass capacitor, use a capacitor with good frequency characteristics such as a ceramic capacitor. Also, wire the power supply pin (+ side), bypass capacitor, and paired power supply pin (- side) as short and equidistant as possible. Bypass capacitors should always be connected to pairs of power supply pins. For example, the V_{DD} and V_{SS} pins, the EV_{DD0}/EV_{DD1} and EV_{SS0}/EV_{SS1} pins, and the AV_{REFP} and AV_{REFM} pins form a pair. Wire the pattern of the power supply pin with a pattern that is thicker than the other signal lines. Also, please design the product equipped with $EV_{DD0/1}$ and $EV_{SS0/1}$ pins so that $EV_{DD0} = EV_{DD1}$ and $V_{SS} = EV_{SS0}/EV_{SS1}$, as shown in "Figure 1 Typical Circuit Schematic for the RL78/G23".

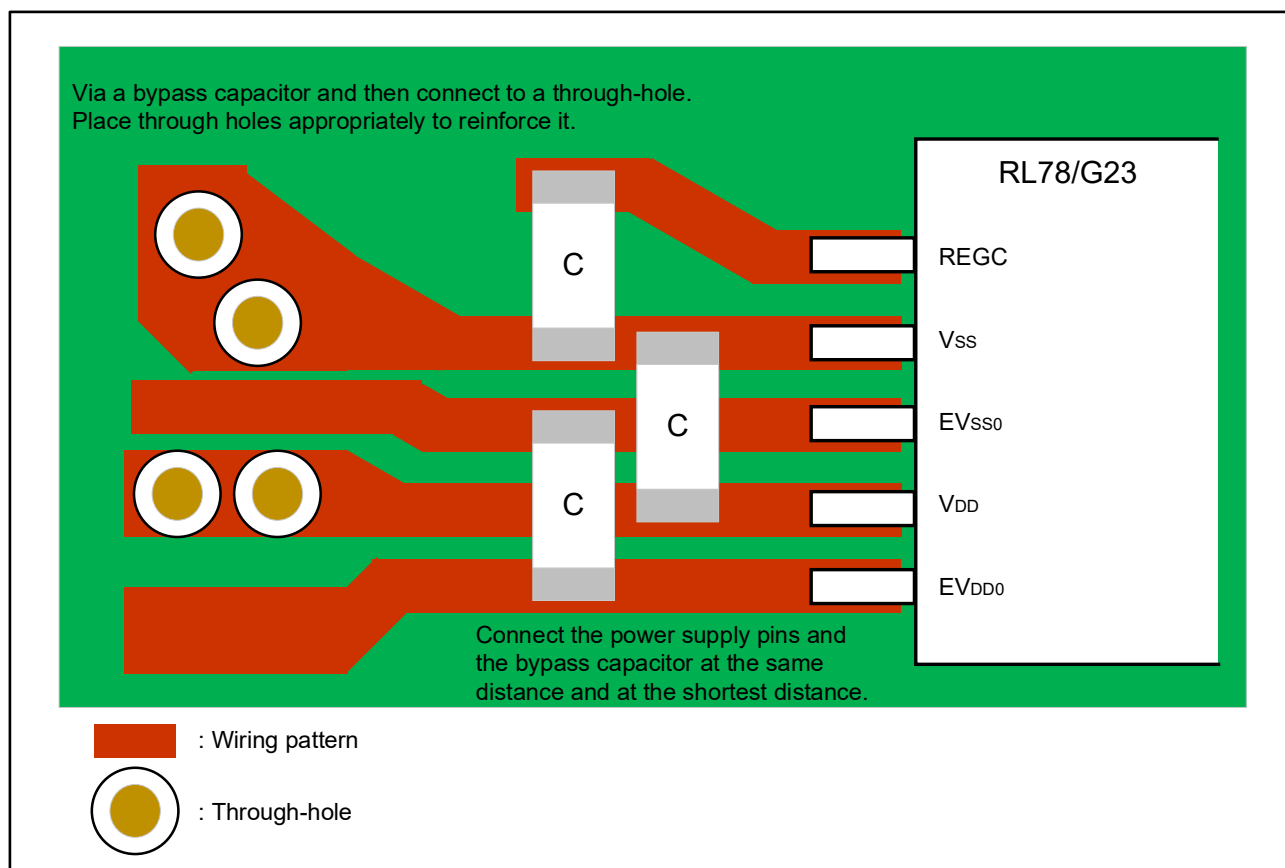


Figure 2: Connection Example of Power Supply Pin and Bypass Capacitor

1.1.2 Power Supply Timing

Please note that power supply timing according to the following use case.

- (1) When the externally input reset signal on the RESET pin is used.

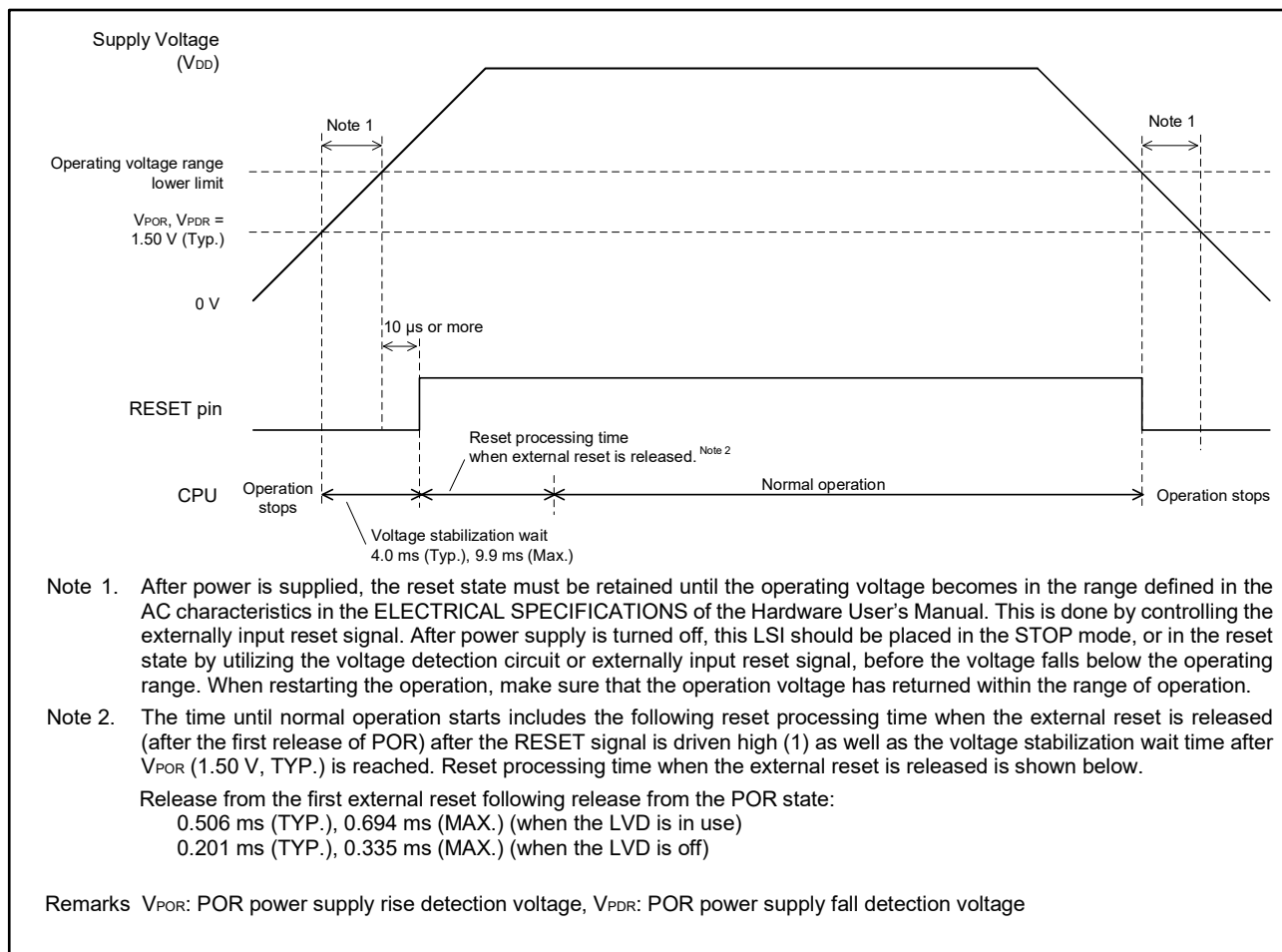


Figure 3: Power Supply Timing using the Externally RESET Circuit

(2) When LVD0 is in use (reset mode).

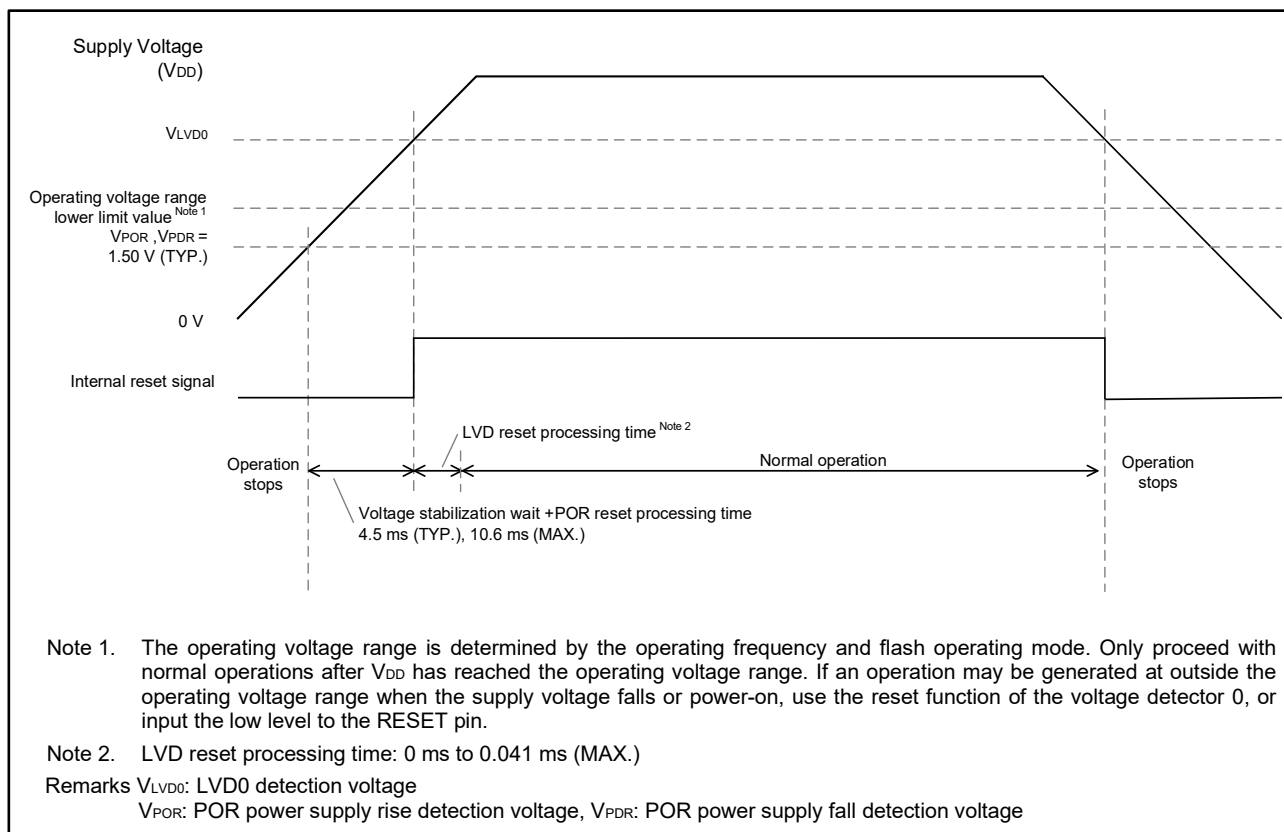


Figure 4: Power Supply Timing using LVD0

1.2 REGC Pin

RL78/G2x microcontrollers contain a circuit for operating the microcontrollers with a constant voltage. At this time, in order to stabilize the regulator output voltage, connect the REGC pin to V_{SS} via a capacitor (0.47 μF to 1 μF). Also, use a capacitor with good characteristics, since it is used to stabilize internal voltage. It is recommended that the capacitor's ESR be 1 Ω or less. The REGC pin can be used as a reference voltage for an external circuit. An external circuit for connection to the REGC pin for this purpose must have an input impedance of at least 1.5 $\text{M}\Omega$.

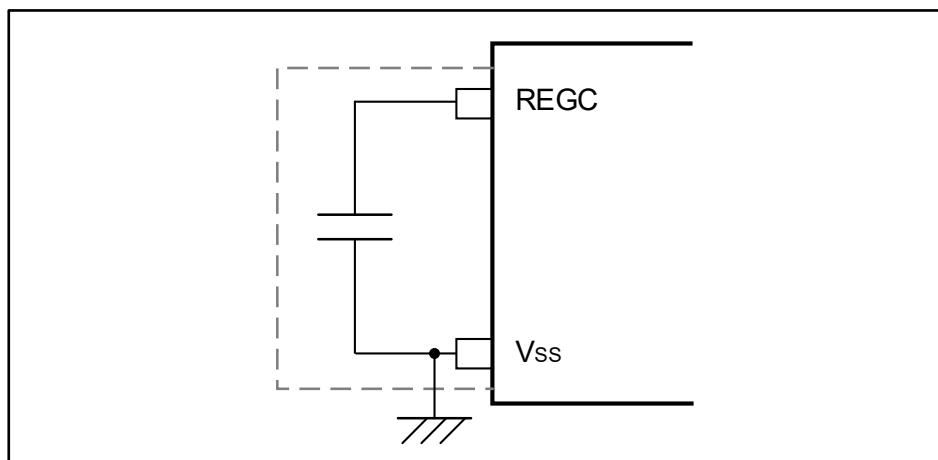


Figure 5: REGC Pin Connection

Caution Keep the wiring length as short as possible for the broken-line part in the above figure.

1.3 RESET Pin

RL78/G2x microcontrollers have the on-chip voltage detection circuit. Therefore, a specific external RESET circuit is not required, and the minimum requirement of the RESET circuit is a pull-up resistor R1 (1 k Ω to 10 k Ω) to V_{DD} .

It depends on user system if RESET IC with external WDT function is necessary for a safety reason.

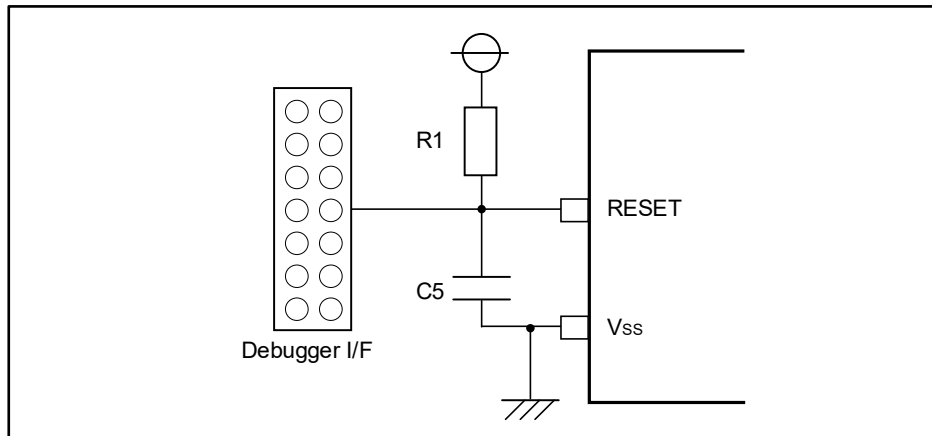


Figure 6: Minimum RESET Pin Connection (Minimum Circuit Image)

1.4 Oscillator Circuit

1.4.1 Oscillator Input/Output Pin

Wire the oscillator input/output pins (X1, X2, XT1, XT2) as short as possible, including the peripheral circuits. Also, guard the oscillator input/output pin pattern with a stable V_{SS} pattern so that it is not adjacent to other patterns (signal lines that carry high alternating current or signal lines that switch at high speed). See “1.4.4 Common Note for Oscillator Circuit” for details.

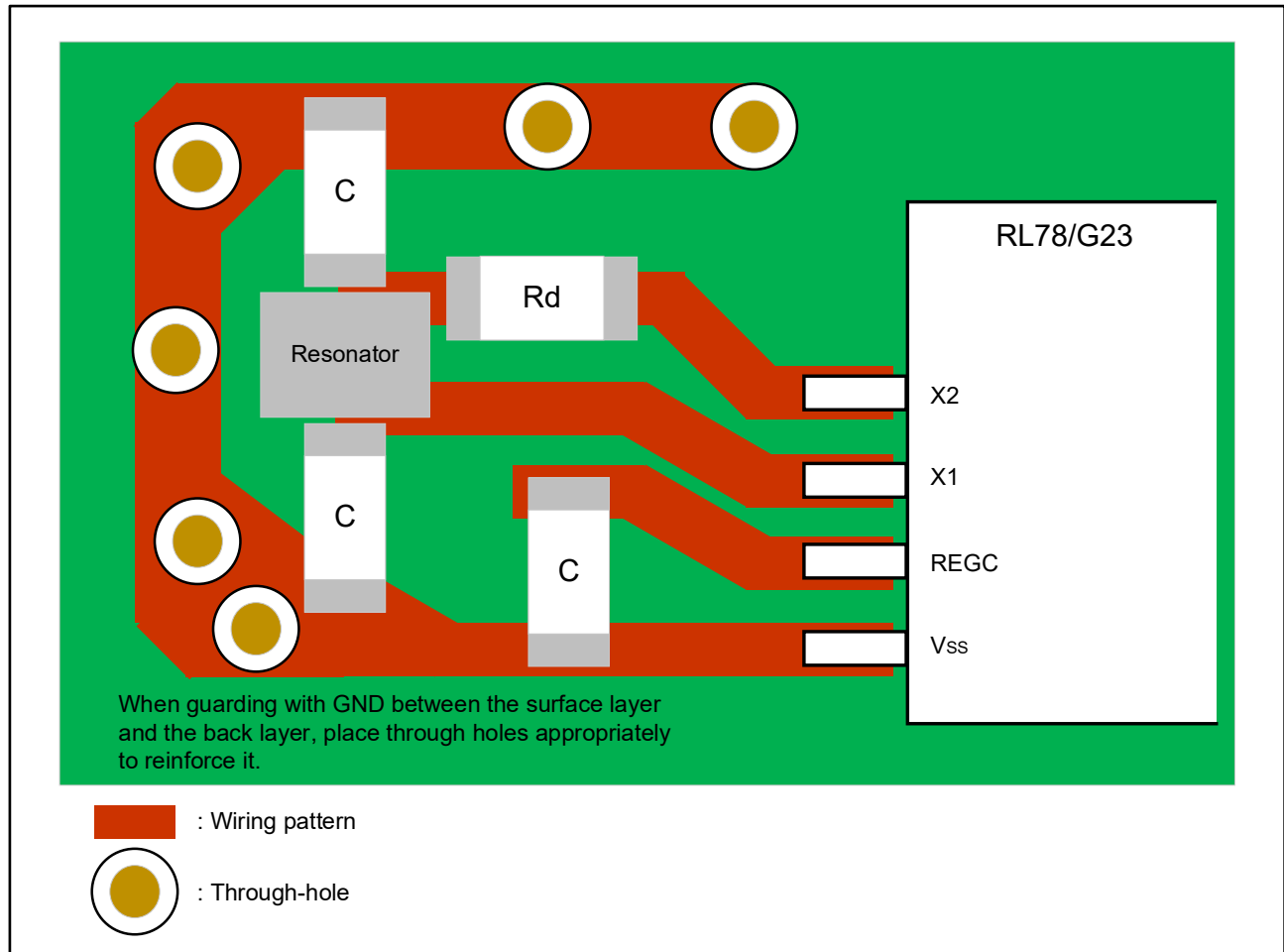


Figure 7: Connection Example of Oscillator Input/Output Circuit

1.4.2 Main System Clock

Typical circuit for the external oscillator circuit of the main system clock is illustrated below. The X1 oscillator oscillates with a crystal resonator or ceramic resonator (1 MHz to 20 MHz) connected to the X1 and X2 pins. Please check with the manufacturer of the resonator used for the resistance and capacitance values that make up the circuit.

An external clock can also be input. In this case, input the clock signal to the EXCLK pin.

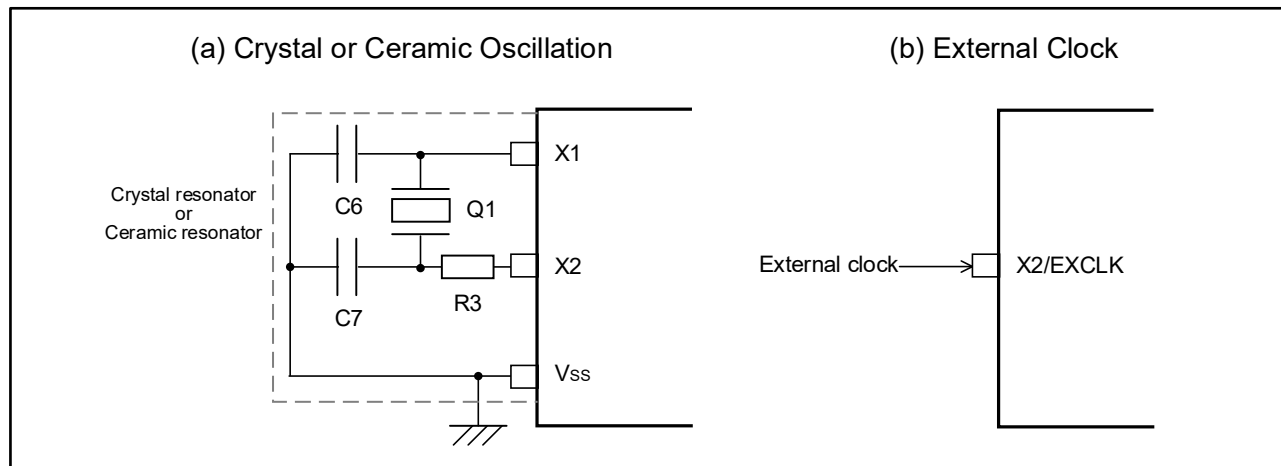


Figure 8: Main System Clock Connection

1.4.3 Subsystem Clock

Typical circuit for the external oscillator circuit of the subsystem clock is illustrated below. The XT1 oscillator oscillates with a crystal resonator (standard: 32.768 kHz) connected to the XT1 and XT2 pins.

Please check with the manufacturer of the resonator used for the resistance and capacitance values that make up the circuit.

An external clock can also be input. In this case, input the clock signal to the EXCLKS pin.

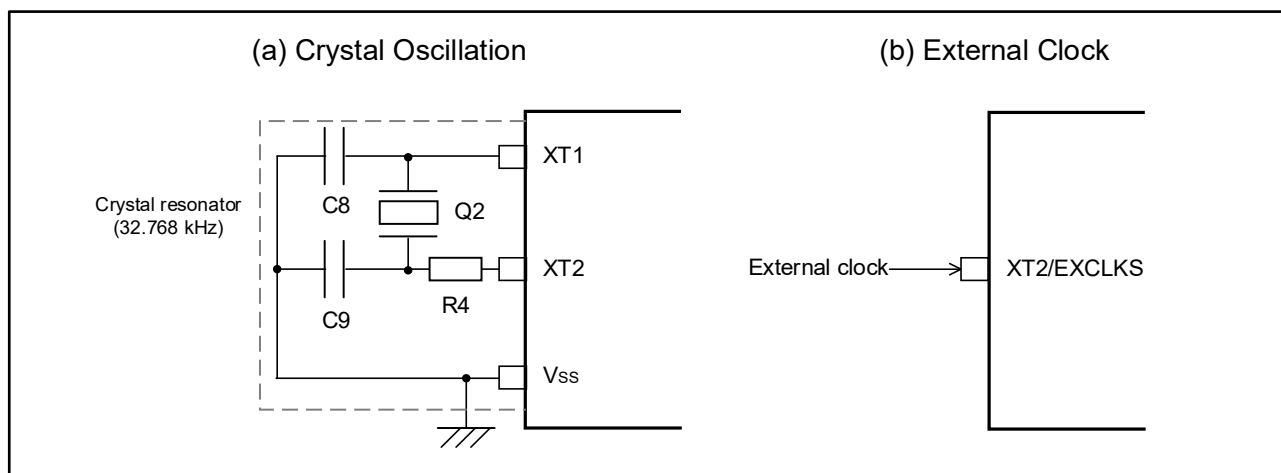


Figure 9: Subsystem Clock Connection

1.4.4 Common Note for Oscillator Circuit

Customers are requested to consult the resonator manufacturer to select an appropriate resonator and to determine the proper oscillation constant.

When using the X1 oscillator and XT1 oscillator, wire as follows in the area enclosed by the broken lines in Figure 8 and Figure 9 to avoid an adverse effect from wiring capacitance.

- Keep the wiring length as short as possible.
- Do not cross the wiring with the other signal lines. Do not route the wiring near a signal line through which a high fluctuating current flow.
- Always make the ground point of the oscillator capacitor the same potential as V_{SS} . Do not ground the capacitor to a ground pattern through which a high current flow.
- Do not fetch signals from the oscillator.

The XT1 oscillator is a circuit with low amplification in order to achieve low-power consumption.

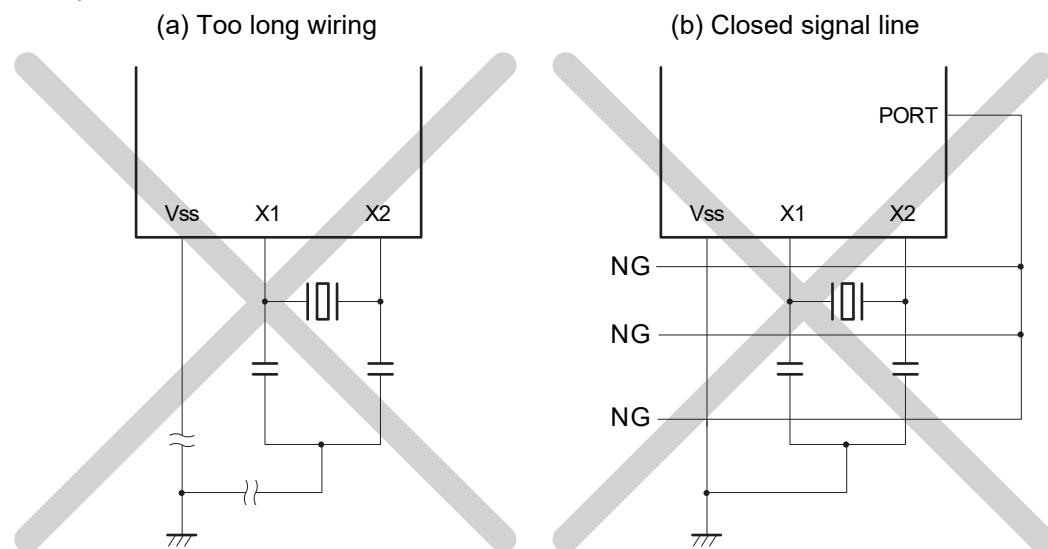
Note the following points when designing the circuit.

- Pins and circuit boards include parasitic capacitance. Therefore, perform oscillation evaluation using a circuit board to be actually used and confirm that there are no problems.
- Make the wiring between the XT1 and XT2 pins and the resonators as short as possible, and minimize the parasitic capacitance and wiring resistance. Note this particularly when the low power consumption oscillation 2 (AMPHS1, AMPHS0 = 1, 0) or low power consumption oscillation 3 (AMPHS1, AMPHS0 = 1, 1) is selected.
- Configure the circuit of the circuit board, using material with little wiring resistance.
- Place a ground pattern that has the same potential as V_{SS} as much as possible near the XT1 oscillator.
- Be sure that the signal lines between the XT1 and XT2 pins, and the resonators do not cross with the other signal lines.

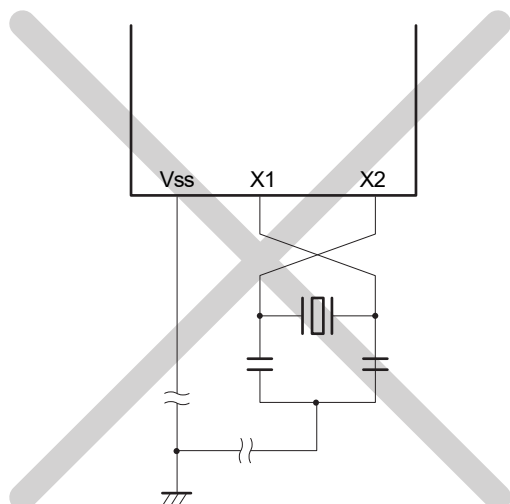
Do not route the wiring near a signal line through which a high fluctuating current flow.

- The impedance between the XT1 and XT2 pins may drop and oscillation may be disturbed due to moisture absorption of the circuit board in a high-humidity environment or dew condensation on the board. When using the circuit board in such an environment, take measures to damp-proof the circuit board, such as by coating.
- When coating the circuit board, use material that does not cause capacitance or leakage between the XT1 and XT2 pins.

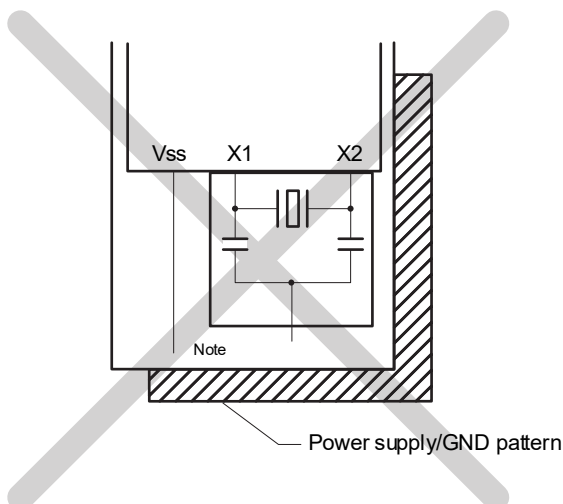
Examples of bad connection in oscillator circuit are shown below.



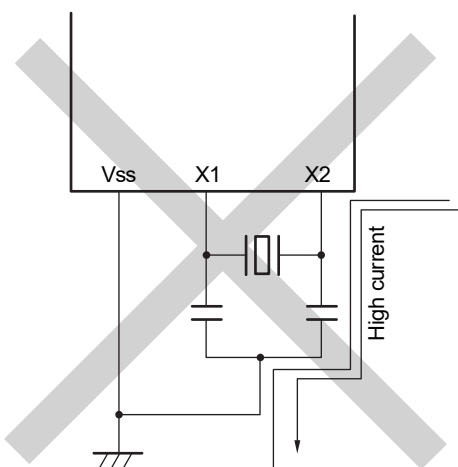
(c) The X1 and X2 signal line wires cross



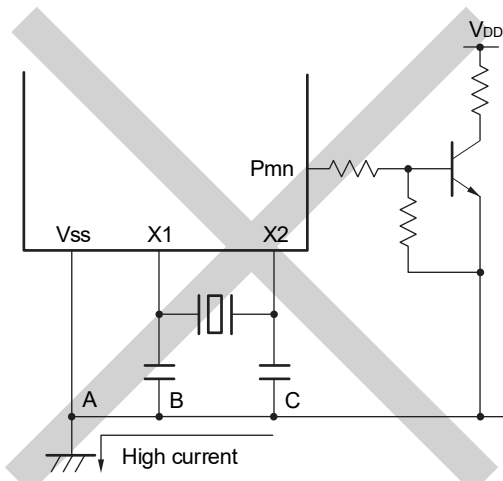
(d) A power supply/GND pattern exists under the X1 and X2 wires



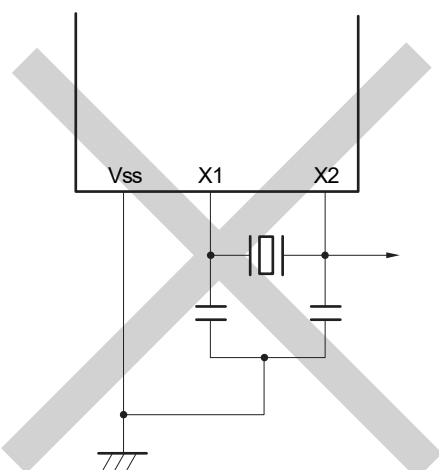
(e) Wiring near high alternating current



(f) Current flowing through ground of oscillator (potential at points A, B, and C fluctuates)



(g) Signals are fetched



Caution: When X2 and XT1 are wired in parallel, the crosstalk noise of X2 may increase with XT1, resulting in malfunctioning.

Remark: When using the subsystem clock, replace X1 and X2 with XT1 and XT2, respectively. Also, insert resistors in series on the XT2 side.

1.5 Note for I/O Port

1.5.1 Output Characteristics of I/O Port

Table 2 shows the output characteristics of the ports on RL78/G23 products. The general purpose I/O of RL78/G23 products have VDD-type I/O and EVDD-type I/O. Note that port drive current capability is different according to I/O type. For other products, please refer to the "Pin Characteristics" section in the Hardware User's Manual of the respective product.

Table 2. IOH and IOL Characteristics

- Consumer application products

Port Type	Applicable General Purpose I/O	Conditions	Port Characteristics (IOH and IOL)	
VDD-type	Per pin for P20-P27, P121, P122, P150-P156	$4.0V \leq V_{DD} \leq 5.5V$	IOH2: -3.0 mA IOL2: 8.5 mA	
		$2.7V \leq V_{DD} < 4.0V$	IOH2: -1.0 mA IOL2: 1.5 mA	
		$1.8V \leq V_{DD} < 2.7V$	IOH2: -1.0 mA IOL2: 0.6 mA	
		$1.6V \leq V_{DD} < 1.8V$	IOH2: -0.5 mA IOL2: 0.4 mA	
	Total of all VDD-type pins (when duty $\leq 70\%$)	$4.0V \leq V_{DD} \leq 5.5V$	IOH2: -20.0 mA IOL2: 20 mA	
		$2.7V \leq V_{DD} < 4.0V$	IOH2: -10.0 mA IOL2: 20 mA	
		$1.8V \leq V_{DD} < 2.7V$	IOH2: -5.0 mA IOL2: 15 mA	
		$1.6V \leq V_{DD} < 1.8V$	IOH2: -5.0 mA IOL2: 10 mA	
	EVDD-type	Per pin for P00-P07, P10-P17, P30-P37, P40-P47, P50-P57, P64-P67, P70-P77, P80-P87, P90-P97, P100-P106, P110-P117, P120, P125-P127, P130, P140-P147	$1.6V \leq V_{DD} \leq 5.5V$	IOH1: -10.0 mA IOL1: 20 mA
		Per pin for P60-P63	$1.6V \leq V_{DD} \leq 5.5V$	IOL1: 15 mA
Total of P00-P04, P07, P32-P37, P40-P47, P102-P106, P120, P125-P127, P130, P140-P145 (when duty $\leq 70\%$)		$4.0V \leq V_{DD} \leq 5.5V$	IOH1: -55.0 mA IOL1: 70.0 mA	
		$2.7V \leq V_{DD} < 4.0V$	IOH1: -10.0 mA IOL1: 15.0 mA	
		$1.8V \leq V_{DD} < 2.7V$	IOH1: -5.0 mA IOL1: 9.0 mA	
		$1.6V \leq V_{DD} < 1.8V$	IOH1: -2.5 mA IOL1: 4.5 mA	
Total of P05, P06, P10-P17, P30, P31, P50-P57, P60-P67, P70-P77, P80-P87, P90-P97, P100, P101, P110-P117, P146, P147 (when duty $\leq 70\%$)		$4.0V \leq V_{DD} \leq 5.5V$	IOH1: -80.0 mA IOL1: 80.0 mA	
		$2.7V \leq V_{DD} < 4.0V$	IOH1: -19.0 mA IOL1: 35.0 mA	
		$1.8V \leq V_{DD} < 2.7V$	IOH1: -10.0 mA IOL1: 20.0 mA	
		$1.6V \leq V_{DD} < 1.8V$	IOH1: -5.0 mA IOL1: 10.0 mA	
Total of all EVDD-type pins (when duty $\leq 70\%$)		$1.6V \leq V_{DD} \leq 5.5V$	IOH1: -135.0 mA IOL1: 150.0 mA	

● Industrial application products ($T_A = -40$ to $+85^\circ\text{C}$)

Port Type	Applicable General Purpose I/O	Conditions	Port Characteristics (IOH and IOL)
VDD-type	Per pin for P20-P27, P121, P122, P150-P156	$4.0\text{V} \leq V_{DD} \leq 5.5\text{V}$	IOH2: -3.0 mA IOL2: 8.5 mA
		$2.7\text{V} \leq V_{DD} < 4.0\text{V}$	IOH2: -1.0 mA IOL2: 1.5 mA
		$1.8\text{V} \leq V_{DD} < 2.7\text{V}$	IOH2: -1.0 mA IOL2: 0.6 mA
		$1.6\text{V} \leq V_{DD} < 1.8\text{V}$	IOH2: -0.5 mA IOL2: 0.4 mA
	Total of all VDD-type pins (when duty $\leq 70\%$)	$4.0\text{V} \leq V_{DD} \leq 5.5\text{V}$	IOH2: -20.0 mA IOL2: 20 mA
		$2.7\text{V} \leq V_{DD} < 4.0\text{V}$	IOH2: -10.0 mA IOL2: 20 mA
		$1.8\text{V} \leq V_{DD} < 2.7\text{V}$	IOH2: -5.0 mA IOL2: 15 mA
		$1.6\text{V} \leq V_{DD} < 1.8\text{V}$	IOH2: -5.0 mA IOL2: 10 mA
EVDD-type	Per pin for P00-P07, P10-P17, P30-P37, P40-P47, P50-P57, P64-P67, P70-P77, P80-P87, P90-P97, P100-P106, P110-P117, P120, P125-P127, P130, P140-P147	$1.6\text{V} \leq V_{DD} \leq 5.5\text{V}$	IOH1: -10.0 mA IOL1: 20 mA
	Per pin for P60-P63	$1.6\text{V} \leq V_{DD} \leq 5.5\text{V}$	IOL1: 15 mA
	Total of P00-P04, P07, P32-P37, P40-P47, P102-P106, P120, P125-P127, P130, P140-P145 (when duty $\leq 70\%$)	$4.0\text{V} \leq V_{DD} \leq 5.5\text{V}$	IOH1: -55.0 mA IOL1: 70.0 mA
		$2.7\text{V} \leq V_{DD} < 4.0\text{V}$	IOH1: -10.0 mA IOL1: 15.0 mA
		$1.8\text{V} \leq V_{DD} < 2.7\text{V}$	IOH1: -5.0 mA IOL1: 9.0 mA
		$1.6\text{V} \leq V_{DD} < 1.8\text{V}$	IOH1: -2.5 mA IOL1: 4.5 mA
	Total of P05, P06, P10-P17, P30, P31, P50-P57, P60-P67, P70-P77, P80-P87, P90-P97, P100, P101, P110-P117, P146, P147 (when duty $\leq 70\%$)	$4.0\text{V} \leq V_{DD} \leq 5.5\text{V}$	IOH1: -80.0 mA IOL1: 80.0 mA
		$2.7\text{V} \leq V_{DD} < 4.0\text{V}$	IOH1: -19.0 mA IOL1: 35.0 mA
		$1.8\text{V} \leq V_{DD} < 2.7\text{V}$	IOH1: -10.0 mA IOL1: 20.0 mA
		$1.6\text{V} \leq V_{DD} < 1.8\text{V}$	IOH1: -5.0 mA IOL1: 10.0 mA
	Total of all EVDD-type pins (when duty $\leq 70\%$)	$1.6\text{V} \leq V_{DD} \leq 5.5\text{V}$	IOH1: -100.0 mA IOL1: 150.0 mA

● Industrial application products ($T_A = -40$ to $+105^\circ\text{C}$)

Port Type	Applicable General Purpose I/O	Conditions	Port Characteristics (IOH and IOL)
VDD-type	Per pin for P20-P27, P121, P122, P150-P156	$4.0\text{V} \leq V_{DD} \leq 5.5\text{V}$	IOH2: -3.0 mA IOL2: 8.5 mA
		$2.7\text{V} \leq V_{DD} < 4.0\text{V}$	IOH2: -1.0 mA IOL2: 1.5 mA
		$1.8\text{V} \leq V_{DD} < 2.7\text{V}$	IOH2: -1.0 mA IOL2: 0.6 mA
		$1.6\text{V} \leq V_{DD} < 1.8\text{V}$	IOH2: -0.5 mA IOL2: 0.4 mA
	Total of all VDD-type pins (when duty $\leq 70\%$)	$4.0\text{V} \leq V_{DD} \leq 5.5\text{V}$	IOH2: -20.0 mA IOL2: 20 mA
		$2.7\text{V} \leq V_{DD} < 4.0\text{V}$	IOH2: -10.0 mA IOL2: 20 mA
		$1.8\text{V} \leq V_{DD} < 2.7\text{V}$	IOH2: -5.0 mA IOL2: 15 mA
		$1.6\text{V} \leq V_{DD} < 1.8\text{V}$	IOH2: -5.0 mA IOL2: 10 mA
EVDD-type	Per pin for P00-P07, P10-P17, P30-P37, P40-P47, P50-P57, P64-P67, P70-P77, P80-P87, P90-P97, P100-P106, P110-P117, P120, P125-P127, P130, P140-P147	$1.6\text{V} \leq V_{DD} \leq 5.5\text{V}$	IOH1: -10.0 mA IOL1: 20 mA
	Per pin for P60-P63	$1.6\text{V} \leq V_{DD} \leq 5.5\text{V}$	IOL1: 15 mA
	Total of P00-P04, P07, P32-P37, P40-P47, P102-P106, P120, P125-P127, P130, P140-P145 (when duty $\leq 70\%$)	$4.0\text{V} \leq V_{DD} \leq 5.5\text{V}$	IOH1: -30.0 mA IOL1: 40.0 mA
		$2.7\text{V} \leq V_{DD} < 4.0\text{V}$	IOH1: -10.0 mA IOL1: 15.0 mA
		$1.8\text{V} \leq V_{DD} < 2.7\text{V}$	IOH1: -5.0 mA IOL1: 9.0 mA
		$1.6\text{V} \leq V_{DD} < 1.8\text{V}$	IOH1: -2.5 mA IOL1: 4.5 mA
	Total of P05, P06, P10-P17, P30, P31, P50-P57, P60-P67, P70-P77, P80-P87, P90-P97, P100, P101, P110-P117, P146, P147 (when duty $\leq 70\%$)	$4.0\text{V} \leq V_{DD} \leq 5.5\text{V}$	IOH1: -50.0 mA IOL1: 40.0 mA
		$2.7\text{V} \leq V_{DD} < 4.0\text{V}$	IOH1: -19.0 mA IOL1: 35.0 mA
		$1.8\text{V} \leq V_{DD} < 2.7\text{V}$	IOH1: -10.0 mA IOL1: 20.0 mA
		$1.6\text{V} \leq V_{DD} < 1.8\text{V}$	IOH1: -5.0 mA IOL1: 10.0 mA
	Total of all EVDD-type pins (when duty $\leq 70\%$)	$1.6\text{V} \leq V_{DD} \leq 5.5\text{V}$	IOH1: -60.0 mA IOL1: 80.0 mA

Remarks: Some general purpose I/O may not be mounted depending on the product.
P123 to P124 and P137 are input-only pins.

1.5.2 Recommended Connection of Unused Pins

Table 3 shows the recommended connections of unused pins for RL78/G23 products. For other products, please refer to the “Connection of Unused Pins” section in the Hardware User’s Manual of the respective product.

Table 3: Recommended Connection of Unused Pins

Port Type	Pin Name	Recommended Connection of Unused Pin
VDD-type	P123 to P124 (Input-only pin)	Independently connect V_{DD} or V_{SS} via a resistor. Alternatively, set the EXCLKS and OSCSELS bits in the clock operation mode control register (CMC) to 0 and 1, respectively. Set the XTSTOP bit in the clock operation status control register (CSC) to 1, and leave the pins open-circuit ^{Note1} .
	P137 (Input-only pin)	Independently connect V_{DD} or V_{SS} via a resistor. Alternatively, set the PDIDIS137 bit in the port digital input disable register (PDIDIS13) to 1, and leave the pin open-circuit.
	All VDD-type pins except P123 to P124 and P137	Input: Independently connect to V_{DD} or V_{SS} via a resistor. [Reference resistance value: Pull-up with 20 k Ω resistor] Output: Leave open.
	RESET	Connect to V_{DD} directly or via a resistor.
EVDD-type	P40 ^{Note2}	Input: Independently connect to EV_{DD} via a resistor. [Reference resistance value: 1.0 k Ω] Output: Leave open.
	P130 (Output-only pin)	Leave open.
	All EVDD-type pins except P40 and P130	Input: Independently connect to EV_{DD} or EV_{SS} via a resistor. [Reference resistance value: 10 k Ω] Output: Leave open.

Note 1: When the low-speed on-chip oscillator clock (f_{IL}) is selected for the CPU/peripheral hardware clock frequency (f_{CLK}), the current may increase approximately by 1 μ A.

Note 2: TOOL0 (On-chip debugger/Flash memory programmer interface pin) function is assigned to P40. When using TOOL0 function on the board, select an input mode and connect to EV_{DD} via a resistor (1.0 k Ω).

1.5.3 Peripheral I/O Redirection Function

Table 4 provides an overview of the peripheral I/O pin redirection functions available in RL78/G23 products. Peripheral I/O pin of RL78/G23 products can be assigned using the PIOR register. For other products, please refer to the “Peripheral I/O redirection register (PIOR)” section in the Hardware User’s Manual of the respective product.

Table 4: Peripheral I/O Redirection Function

Register	Bit Symbol	Assignable Peripheral I/O Function
PIOR	PIOR5	INTP1, INTP3, INTP4, INTP6 to INTP9 (External interrupt input pin)
		SI10/SDA10/RXD1, SO10/TXD1, SCK10/SCL10 (Serial array unit I/O pin)
	PIOR4	INTP5 (External interrupt input pin)
		PCLBUZ1 (Clock output/buzzer output pin)
	PIOR3	PCLBUZ0 (Clock output/buzzer output pin)
	PIOR2	SCLA0, SDAA0 (Serial interface IICA I/O pin)
	PIOR1	INTP10, INTP11 (External interrupt input pin)
		SI00/SDA00/RXD0, SO00/TXD0, SCK00/SCL00, SI20/SDA20/RXD2, SO20/TXD2, SCK20/SCL20 (Serial array unit I/O pin)
	PIOR0	TI02/TO02 to TI07/TO07 (I/O pin of timer array unit)

1.6 Note for A/D Converter

1.6.1 Input Range of ANIn Pins

Observe the rated range of the ANIn pins input voltage. If a voltage higher than V_{DD} and AV_{REFP} and less than V_{SS} and AV_{REFM} (even in the range of absolute maximum ratings) is input to an analog input channel, the converted value of that channel becomes undefined. In addition, the converted values of the other channels may also be affected.

When internal reference voltage (1.48 V) is selected reference voltage source for the + side of the A/D converter, do not input a voltage higher than the internal reference voltage to a pin selected by the ADS register. However, it is no problem that a voltage higher than the internal reference voltage is input to a pin not selected by the ADS register.

1.6.2 Notes on Board Design

- Separate the digital power supply pattern (V_{DD} , EV_{DD0} , EV_{DD1} , V_{SS} , EV_{SS0} , EV_{SS1}) and the analog reference power supply pattern (AV_{REFP} , AV_{REFM}) and layout them with the possible thick wiring patterns.
- By preparing separate analog power supply sources (AV_{REFP} , AV_{REFM}) and digital power supply sources (V_{DD} , EV_{DD0} , EV_{DD1} , V_{SS} , EV_{SS0} , EV_{SS1}), the effects of digital power supply noise can be reduced.
- When using the analog power (AV_{REFP} , AV_{REFM}) and digital power (V_{DD} , EV_{DD0} , EV_{DD1} , V_{SS} , EV_{SS0} , EV_{SS1}) as a common power supply, separate the analog and digital power supplies at the output section of the power supply source.
- Connect the analog ground (AV_{REFM}) pattern to the stable digital ground (V_{SS}) pattern on the board at only one point to prevent a noise from the digital ground.

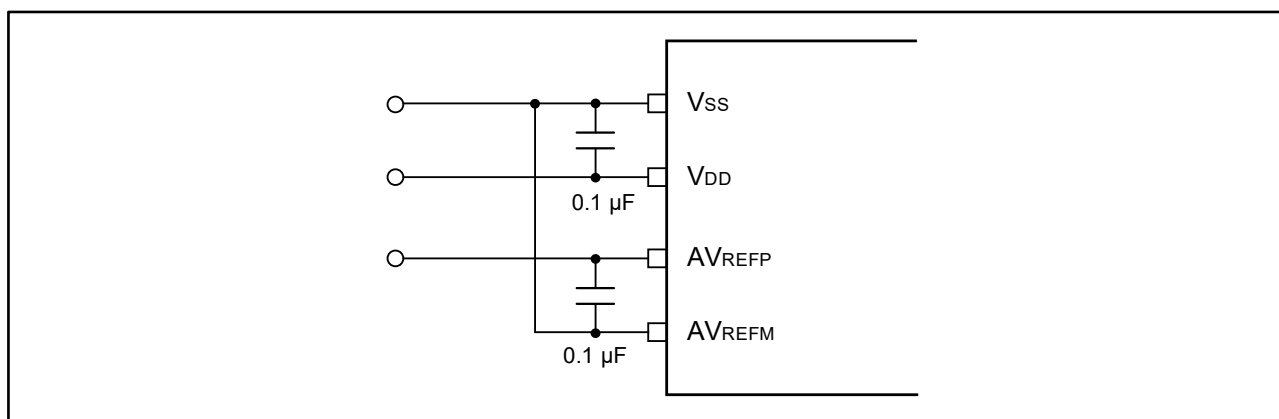


Figure 10: Power Supply Pin Connection Example

1.6.3 Noise Countermeasures

To maintain the 12-bit/10-bit resolution, attention must be paid to noise input to the AV_{REFP} , V_{DD} , $ANIn$ pins.

- (1) Connect a capacitor with a low equivalent resistance and a good frequency response to the power supply.
- (2) The higher the output impedance of the analog input source, the greater the influence. To reduce the noise, connecting external capacitor as shown in Figure 11 is recommended.
- (3) Do not switch these pins with other pins during conversion.
- (4) The accuracy is improved if the HALT mode is set immediately after the start of conversion.

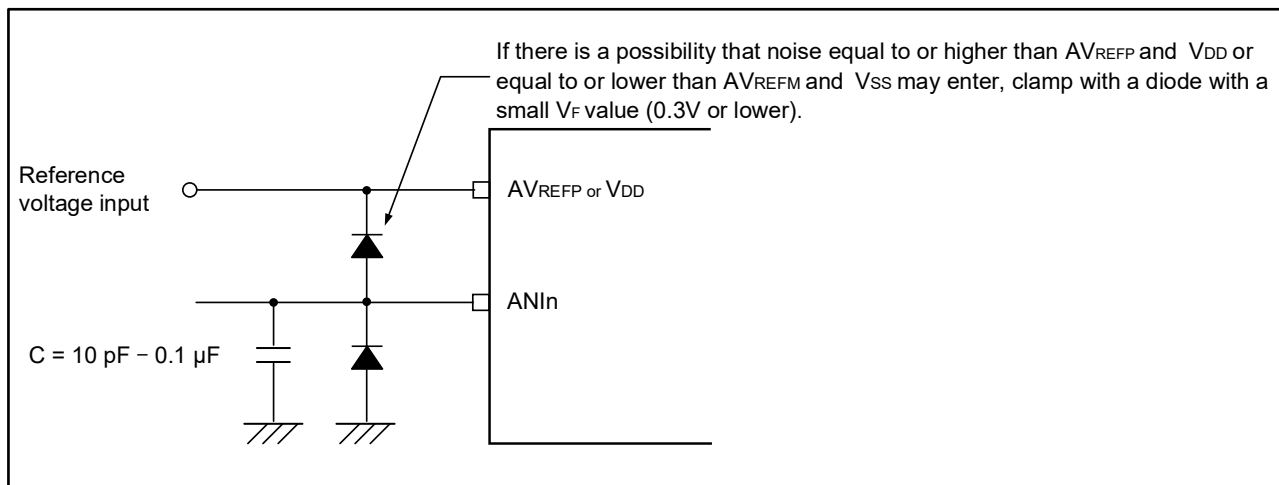


Figure 11: Sample Protection Circuit for Analog Inputs

1.6.4 Analog Input Pins (ANIn)

- (1) The analog input pins ($ANIn$) are shared with input port pins.

Do not change the output values for the shared port-pin functions while A/D conversion of the signals on the $ANIn$ pins is selected and conversion is in progress, since doing so may lower the precision of the results of conversion.

- (2) When a pin adjacent to one on which A/D conversion is in progress is used as a digital I/O port pin, coupling may lead to noise that causes the results of A/D conversion to differ from the expected values. Be sure to prevent the input or output of pulses on such pins while conversion is in progress.

1.6.5 Input Impedance of Analog Input ($ANIn$) Pins

This A/D converter charges a sampling capacitor for sampling during sampling time. Therefore, only a leakage current flows when sampling is not in progress, and a current that charges the capacitor flows during sampling. Consequently, the input impedance fluctuates depending on whether sampling is in progress, and on the other states.

To make sure that sampling is effective, however, it is recommended to keep the output impedance of the analog input source to within 1 k Ω , and to connect a capacitor of about 0.1 μ F to the $ANIn$ pins (Figure 11).

1.6.6 Internal Equivalent Circuit

Figure 12 shows the equivalent circuit of the analog input section. Table 5 shows the reference values for resistance and capacitance in the equivalent circuit of RL78/G23 products. For other products, please refer to the “Points for Caution when the A/D Converter is to be Used” section in the Hardware User’s Manual of the respective product.

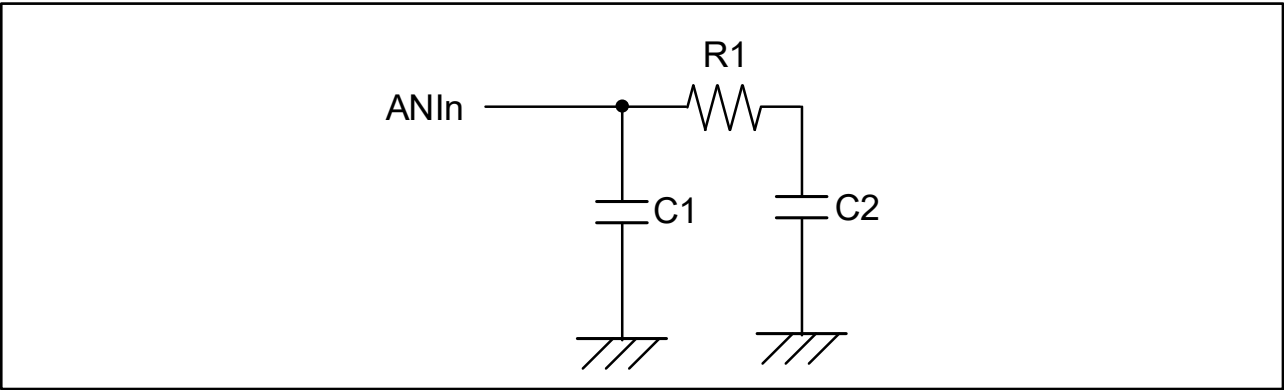


Figure 12: Equivalent Circuit of ANIn Pins

Table 5: Example of the Specifications of the Internal Equivalent Circuit

AVREFP, VDD	ANIn	R1 [kΩ]	C1 [pF]	C2 [pF]
2.4 V ≤ VDD ≤ 5.5 V	ANI0 to ANI14	11	8	9
	ANI16 to ANI26	12	8	10
1.8 V ≤ VDD < 2.4 V	ANI0 to ANI14	55	8	9
	ANI16 to ANI26	60	8	10
1.6 V ≤ VDD < 1.8 V	ANI0 to ANI14	110	8	9
	ANI16 to ANI26	120	8	10

Note: The values of these parameters are for reference only and are not guaranteed.

1.7 Note for Capacitive Sensing Unit

1.7.1 TSCAP Pin

A capacitor must be connected to the TSCAP pin to stabilize the internal voltage of the CTSU. Make sure the wiring between the TSCAP pin and the capacitor, and between the capacitor and GND, is as thick and as short as possible.

Use a multilayer ceramic capacitor with a stated capacitance of 10 nF and a capacitance tolerance no greater than $\pm 10\%$. Select from among those with a capacitance change limited to $\pm 15\%$ in accord with the usage environment, such as X7R as specified by the EIA standard.

1.7.2 Capacitive Touch Sensing Unit Electrodes

(1) Self-capacitance method

We recommend using a 2- or more layer board and placing a shield guard of a cross-hatched GND pattern (referred to as “cross-hatched GND shield” herein) around the touch electrodes and on the area directly underneath the touch electrodes to suppress parasitic capacitance fluctuations due to the surrounding environment and noise factors as well as a measure to handle external noise. We also recommend using an ESD countermeasure by shielding the outer circumference of the board with a solid GND pattern.

- <1> Electrode shape: square or circle
- <2> Electrode size: 10mm to 15mm
- <3> Electrode proximity: Electrodes should be placed with ample distance so that they do not react simultaneously to the target human interface, (referred to as “finger” in this document); suggested interval: button size x 0.8 or more
- <4> Wire width: approx. 0.15mm to 0.20mm for printed board
- <5> Wiring length: Make the wiring as short as possible. On corners, form a 45-degree angle, not a right angle.
- <6> Wiring spacing: (A) Make spacing as wide as possible to prevent false detection by neighboring electrodes. (B) 1.27mm pitch
- <7> Cross-hatched GND pattern width: 5mm
- <8> Cross-hatched GND pattern and button/wiring spacing area around electrodes: 5mm (B) area around wiring: 3mm or more
Cover the electrode area as well as the wiring and opposite surface with a cross-hatched pattern. Also place a cross-hatched pattern in the empty spaces, and connect the 2 surfaces of cross-hatched patterns through vias.
- <9> Electrode + wiring capacitance: 49 pF or less
- <10> Electrode + wiring resistance: 1k Ω or less (including damping resistor with reference value of 560 Ω)
Place the damping resistor as close as possible to the TS pin.

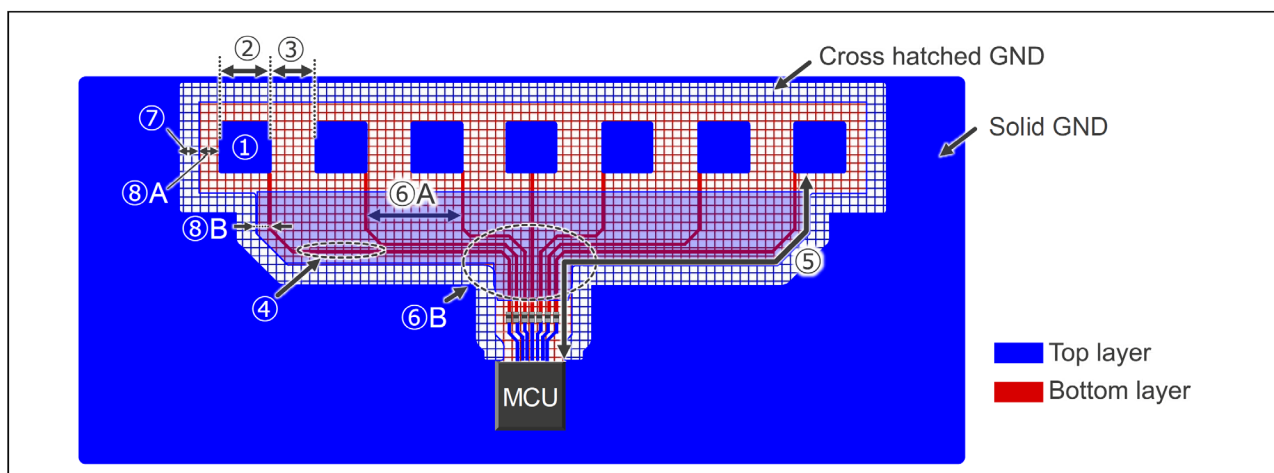


Figure 13: Example of Layout Pattern for Self-capacitance Method

(2) Mutual-capacitance method

We recommend placing a cross-hatched pattern GND shield guard around the electrodes. We also recommend using an ESD countermeasure by shielding the outer circumference of the board with a GND plane pattern.

- <1> Electrode shape: square (combined transmitter electrode TX and receiver electrode RX)
- <2> Electrode size: 10mm or larger
- <3> Electrode proximity: Electrodes should be placed with ample distance so that they do not react simultaneously to the touch object (finger, etc.), (suggested interval: button size x 0.8 or more)
- <4> Wire width: The thinnest wire achievable through mass production; approx. 0.15mm to 0.20mm for a printed board
- <5> Wiring length: Make the wiring as short as possible. On corners, form a 45-degree angle, not a right angle.
- <6> Wiring spacing:
 - (A) Make spacing as wide as possible to prevent false detection by neighboring electrodes.
 - (B) When electrodes are separated: 1.27mm pitch
 - (C) 20mm or more to prevent coupling capacitance generation between Tx and Rx.
- <7> Cross-hatched GND pattern width: 2mm or more
- <8> Cross-hatched GND pattern (shield guard) proximity
 - Because the pin parasitic capacitance in the recommended button pattern is comparatively small, parasitic capacitance increases the closer the pins are to GND.
 - A: 4mm or more around electrodes
 - We also recommend approx. 2-mm wide cross-hatched GND plane pattern between electrodes.
 - B: 1.27mm or more around wiring
- <9> Tx, Rx parasitic capacitance: 20pF or less (including overlay panel and TS pin capacitance)
- <10> Electrode + wiring resistance: 560Ω to 1kΩ (including damping resistor with reference value of 560Ω)
- <11> Do not place GND pattern directly under the electrodes or wiring.

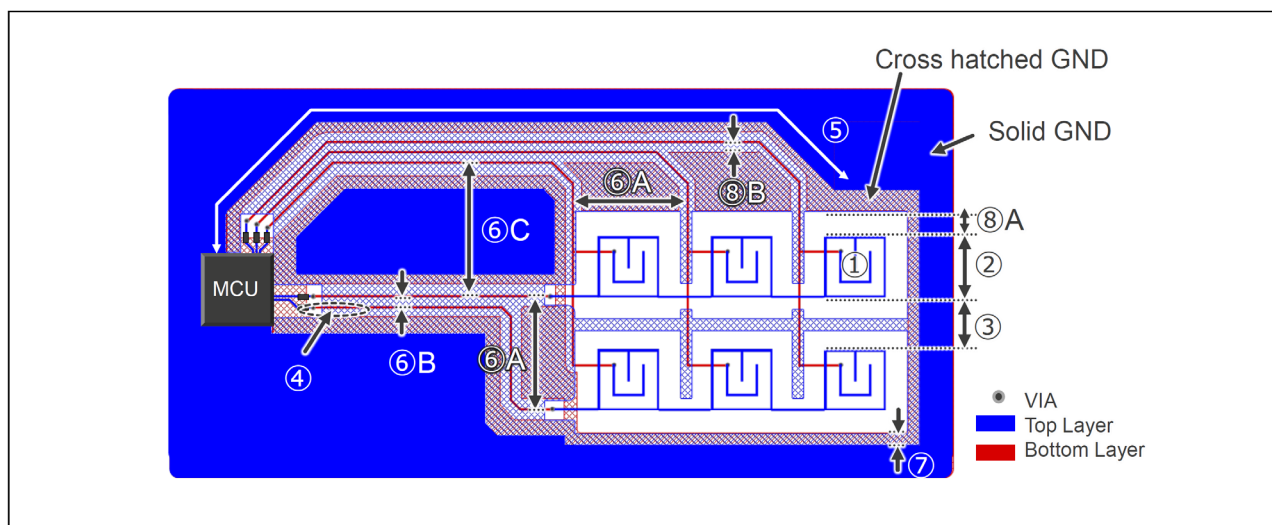


Figure 14: Example of Layout Pattern for Mutual-capacitance Method

1.8 On-chip Debug Circuit

RL78/G2x microcontrollers use the V_{DD}, EV_{DD0}, RESET, TOOL0, and V_{SS} pins to communicate with the host machine via an E2/E2 Lite on-chip debugging emulator. Serial communication is performed by using a single-line UART that uses the TOOL0 pin. For details, refer to “E1/E20/E2 Emulator, E2 Emulator Lite Additional Document for User’s Manual (Notes on Connection of RL78)” (Document No. R20UT1994E).

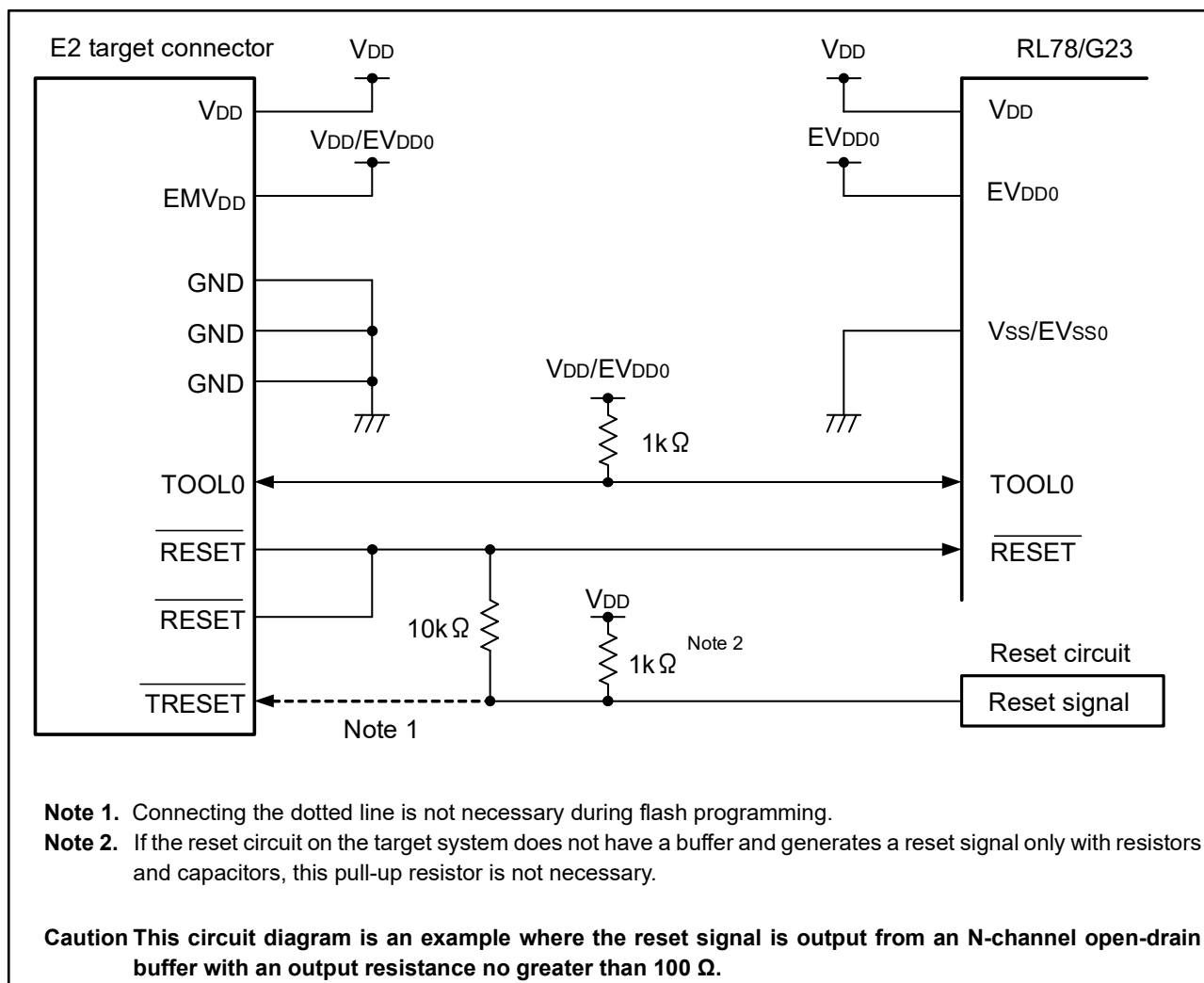


Figure 15: Connection Example between RL78/G23 and the E2 Emulator

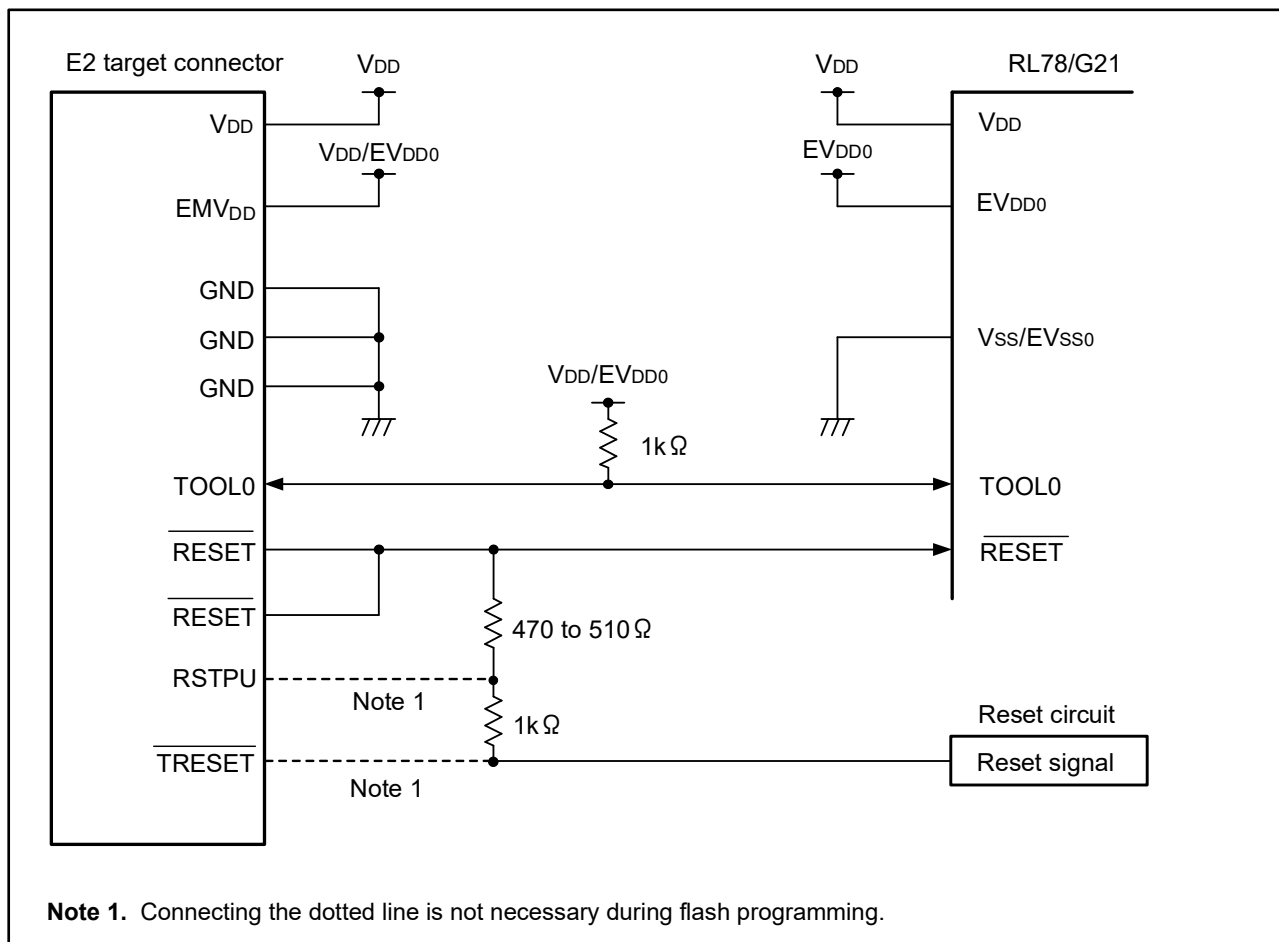


Figure 16: Connection Example between RL78/G21 and the E2 Emulator

Related Documents

Document Name	Document No
RL78/G21 User's Manual: Hardware	R01UH1177E
RL78/G22 User's Manual: Hardware	R01UH0978E
RL78/G23 User's Manual: Hardware	R01UH0896E
RL78/G24 User's Manual: Hardware	R01UH0961E
Capacitive Sensor Microcontrollers CTSU Capacitive Touch Electrode Design Guide	R30AN0389E
Capacitive Sensor MCU Capacitive Touch Noise Immunity Guide	R30AN0426E
Capacitive Sensor MCU Capacitive Touch Ripple Noise Prevention Guide	R30AN0453E
E1/E20/E2 Emulator, E2 Emulator Lite Additional Document for User's Manual (Notes on Connection of RL78)	R20UT1994E

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Mar 13, 2024	—	First issue
2.00	Dec 1, 2025	—	Changed the title from "RL78/G23 Hardware Design Guide" to "RL78/G2x Hardware Design Guide". Updated the entire document accordingly.
2.10	Oct 21, 2026	Page 7	Corrected the description in Section "1.3 RESET Pin."
		Page 23	Added Figure 16: Connection Example between RL78/G21 and the E2 Emulator.

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)

A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity.

Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.

2. Processing at power-on

The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.

3. Input of signal during power-off state

Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.

4. Handling of unused pins

Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.

5. Clock signals

After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.

6. Voltage application waveform at input pin

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).

7. Prohibition of access to reserved addresses

Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.

8. Differences between products

Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall be responsible for determining what licenses are required from any third parties, and obtaining such licenses for the lawful import, export, manufacture, sales, utilization, distribution or other disposal of any products incorporating Renesas Electronics products, if required.
5. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
6. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.

"Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.

"High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.

7. No semiconductor product is absolutely secure. Notwithstanding any security measures or features that may be implemented in Renesas Electronics hardware or software products, Renesas Electronics shall have absolutely no liability arising out of any vulnerability or security breach, including but not limited to any unauthorized access to or use of a Renesas Electronics product or a system that uses a Renesas Electronics product. RENESAS ELECTRONICS DOES NOT WARRANT OR GUARANTEE THAT RENESAS ELECTRONICS PRODUCTS, OR ANY SYSTEMS CREATED USING RENESAS ELECTRONICS PRODUCTS WILL BE INVULNERABLE OR FREE FROM CORRUPTION, ATTACK, VIRUSES, INTERFERENCE, HACKING, DATA LOSS OR THEFT, OR OTHER SECURITY INTRUSION ("Vulnerability Issues"). RENESAS ELECTRONICS DISCLAIMS ANY AND ALL RESPONSIBILITY OR LIABILITY ARISING FROM OR RELATED TO ANY VULNERABILITY ISSUES. FURTHERMORE, TO THE EXTENT PERMITTED BY APPLICABLE LAW, RENESAS ELECTRONICS DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THIS DOCUMENT AND ANY RELATED OR ACCOMPANYING SOFTWARE OR HARDWARE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE.
8. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
12. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
13. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
14. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

(Note2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.5.0-1 October 2020)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.

Contact information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit:

www.renesas.com/contact/.