RL78/F22

Hardware Design Guide

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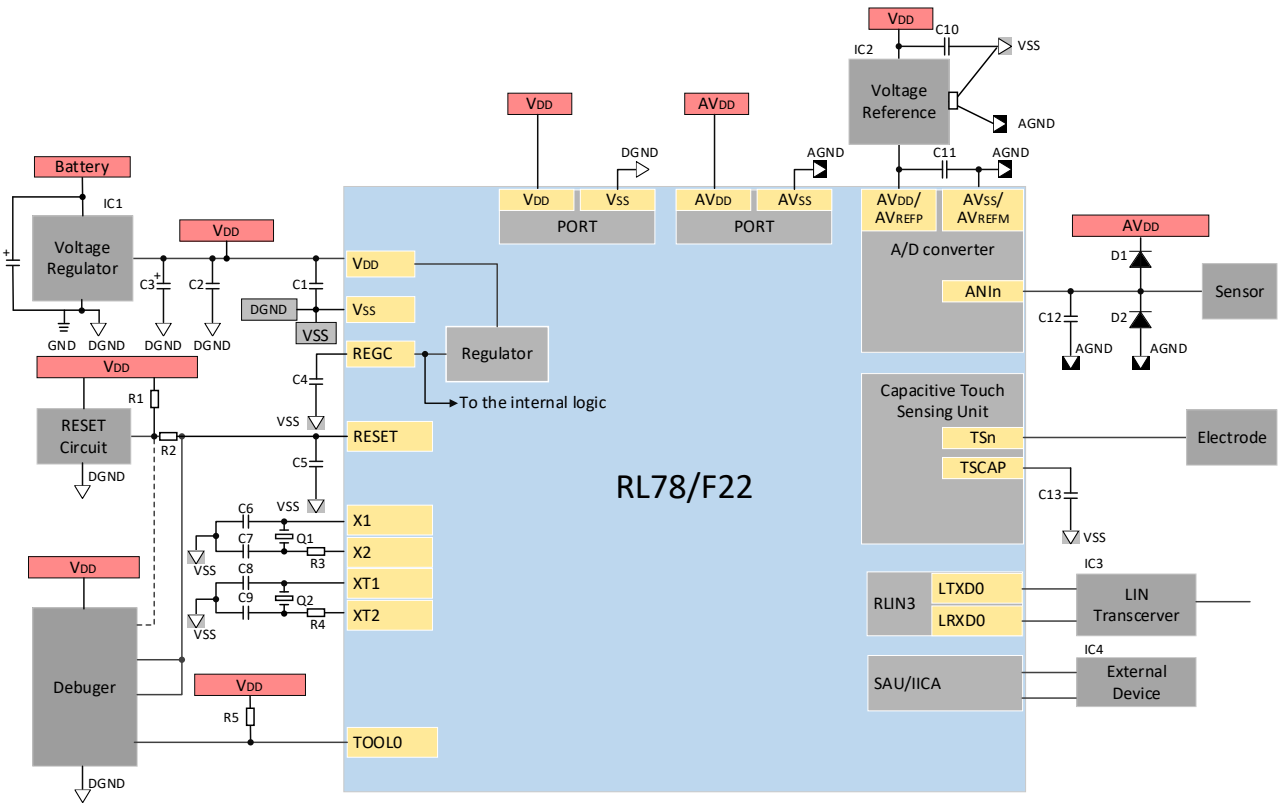
Introduction

This document is intended to provide the hardware specific information and recommendations on RL78/F22 usage. It should be used in conjunction with the corresponding Hardware User's Manual (includes the electrical characteristics).

Contents

1. Typical Circuit Schematic

Figure 1 shows the typical circuit schematic for the RL78/F22 product. And Table 1 shows minimum external components list on Figure 1.



Notes 1. The above figure illustrates the major circuit schematic for the target device (RL78/F22). For unused pins, follow the section related to the recommended connection of unused pins in each hardware user's manual.

2. For the QFN package product, solder the exposed die pad to the PCB. The potential of the exposed die pad is recommended to design as electrically open.

3. Available functions depend on the product. For details, check RL78/F22, F25 hardware user's manual.

Figure 1: Typical Circuit Schematic for the RL78/F22

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 µF	Bypass capacitor	Reference value. Connect 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 µF to 1.0 µF	Stabilizing the internal regulator output voltage	Connect the REGC and V_{SS} pins as short as possible.	1.2
RESET	R1	1.0 kΩ	Pull-up resistor	Depends on the external reset circuit.	1.3
	C5	0.1 µF	Capacitor	Reference value. Connect the RESET and V_{SS} pins as short as possible.	
Oscillator circuit (Main system clock)	Q1	2.0 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.	1.4.2 1.4.4
	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.	1.4.3 1.4.4
	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
	C10	No recommended value	Bypass capacitor	Depends on the external voltage reference IC.	
	C11	0.1 µF	Bypass capacitor	Connect the AV_{DD} and AV_{SS} pins as short as possible.	
	D1, D2	$V_F \leq 0.3$ V	Noise protection	Depends on the user system.	
	C12	100 pF to 0.1 µF	Stabilizing the sampling operation	Depends on the user system. Connect the ANIn and AV_{SS} pins as short as possible.	
Debug	R2	10 kΩ	Current limit between Reset circuit and Debugger	Depends on the external reset circuit.	1.8
	R5	10 kΩ	Pull-up resistor	Be sure to pull-up this pin externally when on-chip debugging is enabled (pulling it down is prohibited).	
LIN	IC3	No recommended IC	LIN transceiver	Depends on the user system.	–
SAU/IICA	IC4	No recommended IC	Controlling external device	Depends on the user system.	–
Cap. touch	C13	10 nF	Stabilizing the CTSU regulator	Connect the TSCAP and VSS pins as short as possible.	1.7

Caution Pins and peripheral functions vary depending on the product. For details, refer to the User's Manual: Hardware of the product used.

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, and the AV_{DD}/AV_{REFP} and AV_{SS}/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.

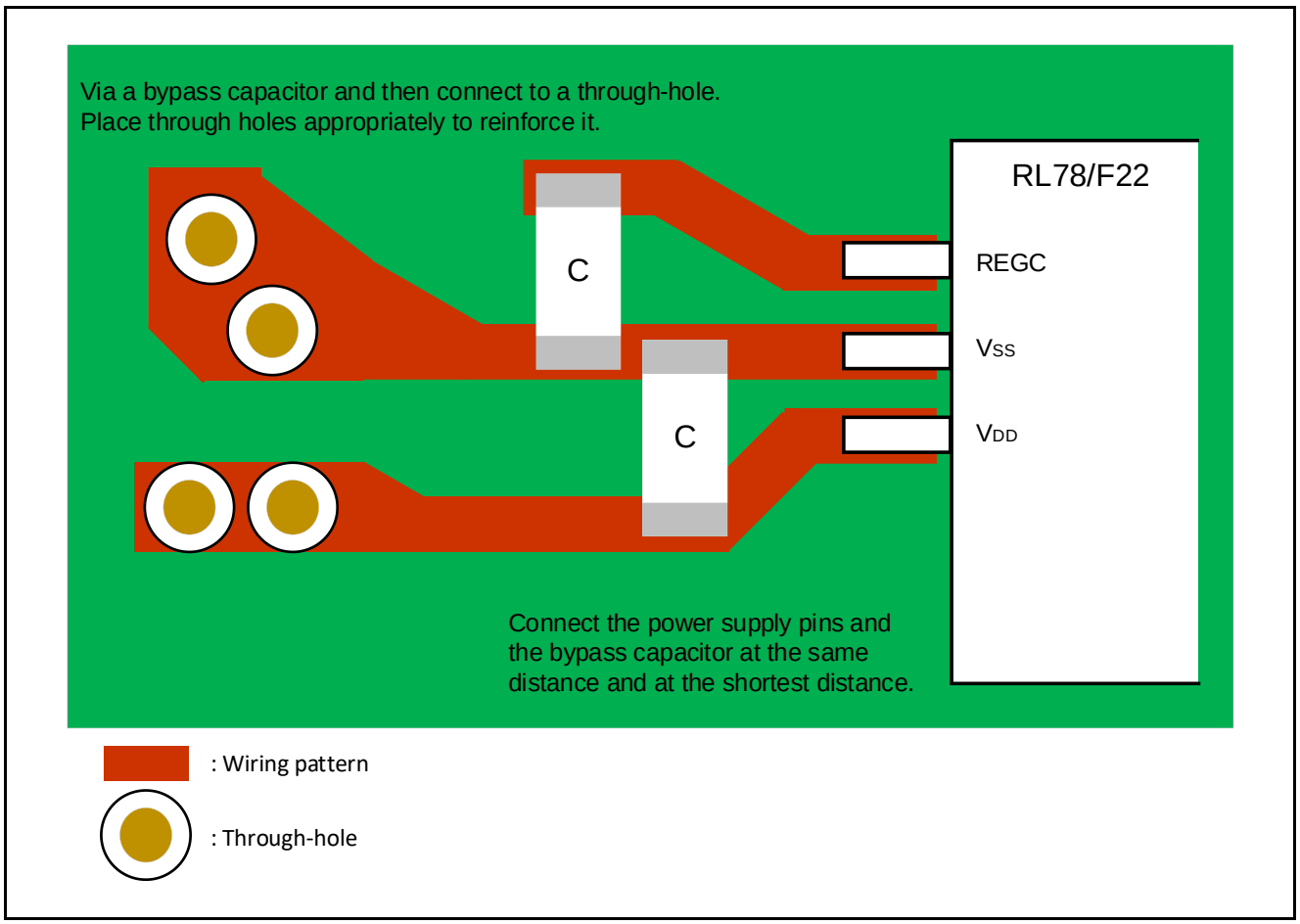
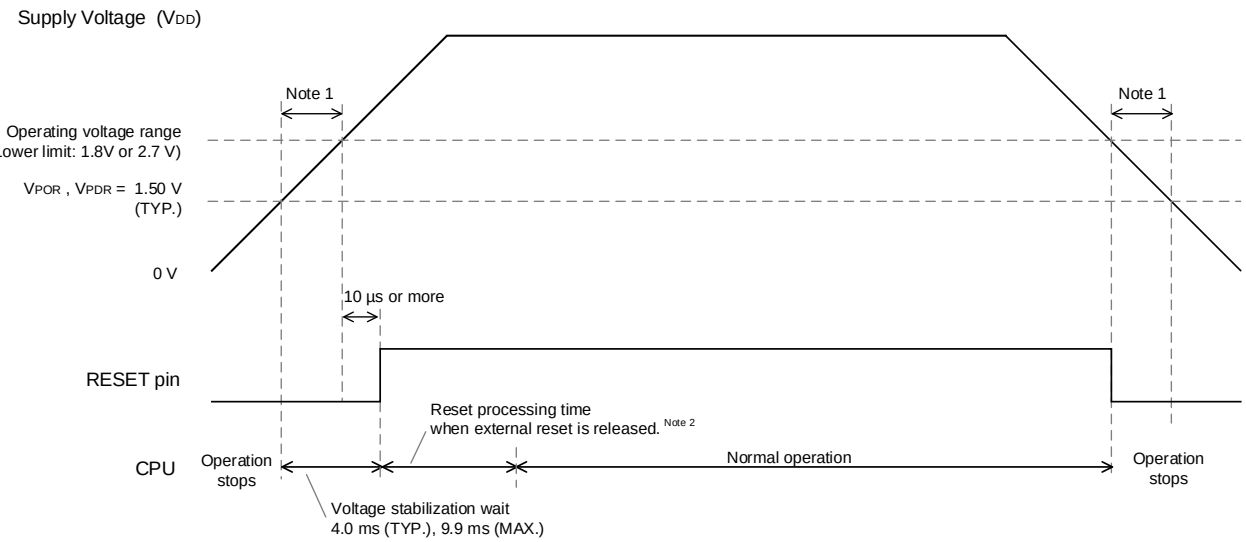


Figure 2: Connection Example of Power Supply Pin and Bypass Capacitor

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.



Notes 1. After power is supplied, the reset state must be retained until the operating voltage becomes in the range defined in the Electrical Specifications of User's Manual. This is done by using the LVD0 or controlling the externally input reset signal. After the power supply is turned off, this LSI should be entered in the STOP mode, or placed in the reset state by using the LVD0 or controlling the externally input reset signal before the supply voltage falls below operating range.

2. The time until normal operation starts includes the following reset processing time when the external reset is released (release from the first external reset following release from the POR state) after the RESET signal is driven high (1) as well as the voltage stabilization wait time after V_{POR} (1.50 V, TYP.) is reached.

   Release from the first external reset following release from the POR state:

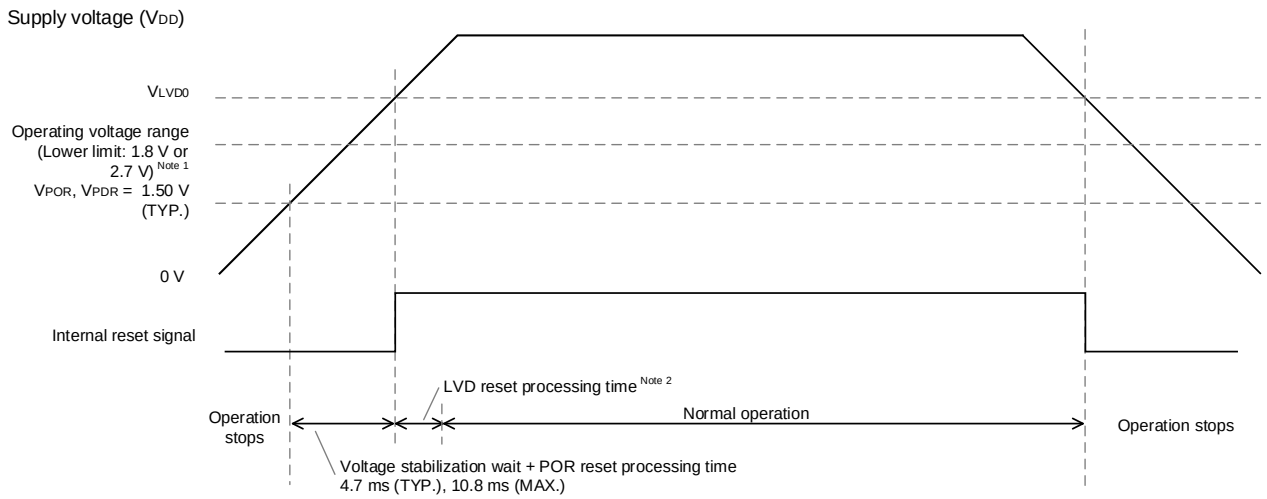
   0.674 ms (TYP.), 0.871 ms (MAX.) (when the LVD is use)

   0.401 ms (TYP.), 0.557 ms (MAX.) (when the LVD is off)

Remarks V_{POR}: POR power supply rise detection voltage, V_{PDR}: POR power supply fall detection voltage

Figure 3: External Power Supply Timing using the RESET pin

(2) When using LVD (LVD0 reset)



Notes 1. The guaranteed range for operation is 1.8 V ≤ V_{DD} ≤ 5.5 V (grade-3 product) and 2.7 V ≤ V_{DD} ≤ 5.5 V (grade-4 product). Only proceed with normal operations after V_{DD} has reached or exceeded operating voltage range. If an operation may be generated at lower than operating voltage range when the supply voltage falls or power-on, use the reset function of the voltage detector, or input the low level to the RESET pin.

2. LVD reset processing time: 0 ms to 0.12 ms (MAX.)

Remarks V_{POR}: POR power supply rise detection voltage, V_{PDR}: POR power supply fall detection voltage, V_{LVD0}: LVD0 detection voltage

Figure 4: Power Supply Timing using LVD

1.2 REGC Pin

RL78/F22 contains a circuit for operating the device 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.

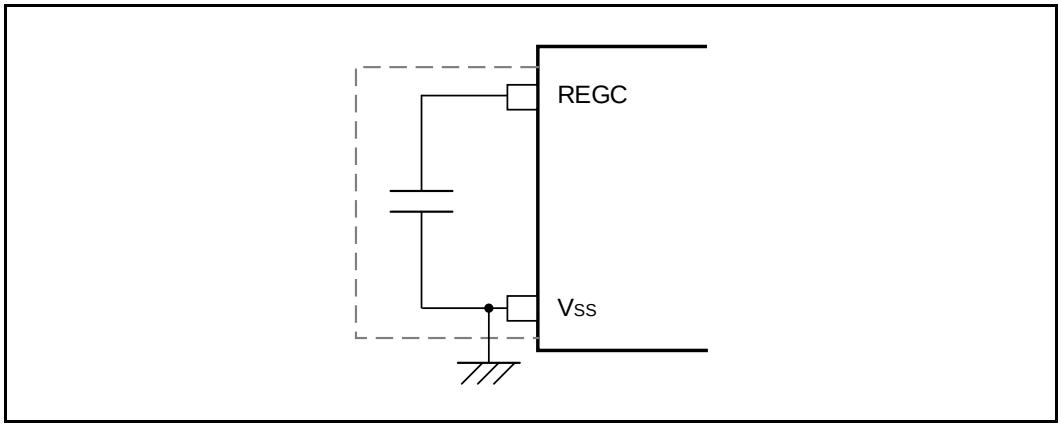


Figure 5: REGC Pin Connection

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

1.3 RESET Pin

RL78/F22 has the on-chip Power-on reset circuit (POR). Therefore, a specific external RESET circuit is not required, and the minimum requirement of the RESET circuit is a pull-up resistor R1 (1 kΩ to 10 kΩ) to V_{DD}. When using the hot plug-in, place a ceramic capacitor C5 (about 0.1 µF) close to the RESET pin to suppress noise to the RESET pin when the emulator is connected.

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

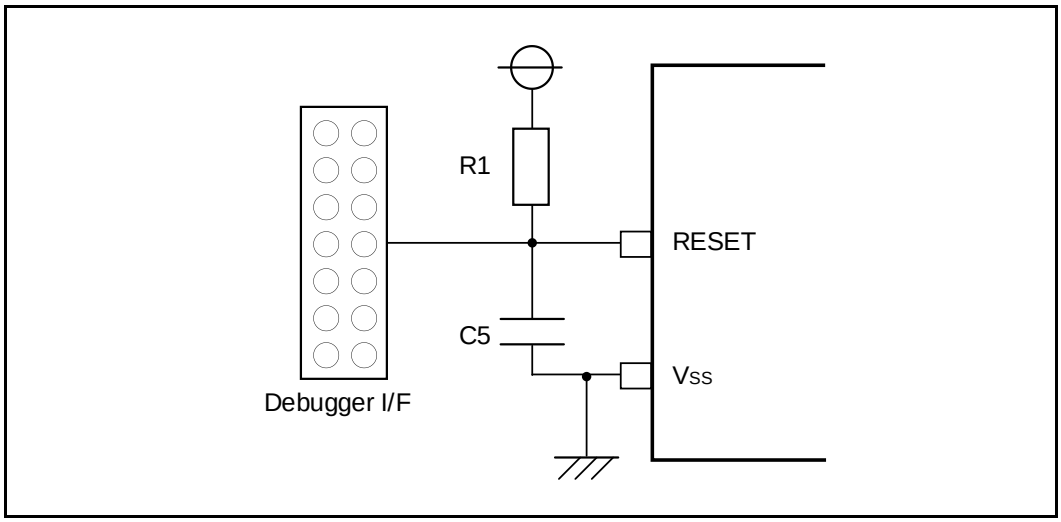


Figure 6: RESET Pin Connection (Minimum Circuit Image)

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 shows an example of the oscillation circuit pattern. When using the subsystem clock, replace X1 and X2 with XT1 and XT2, respectively.

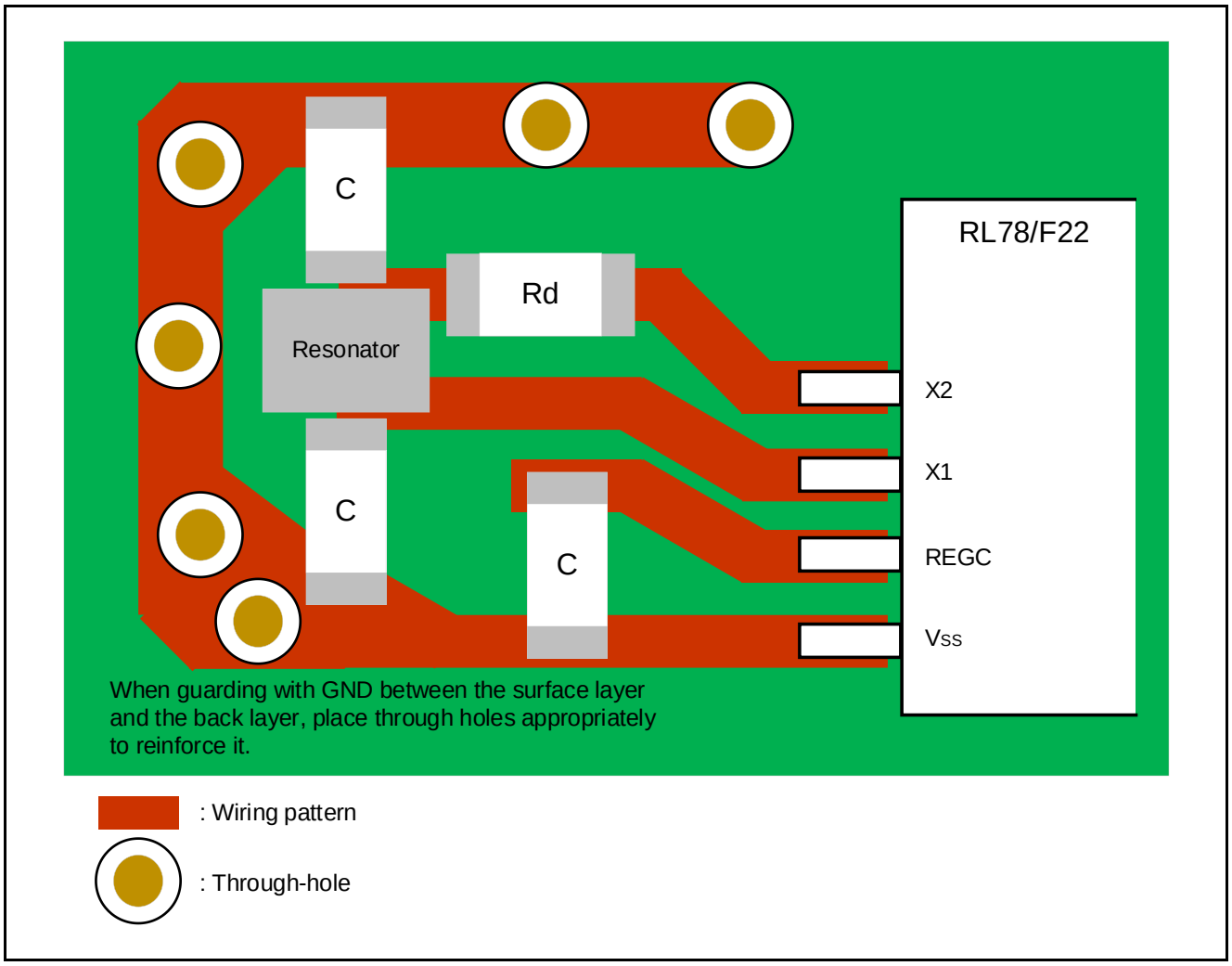


Figure 7: Connection Example of Oscillator Input/Output Circuit

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 (2 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.

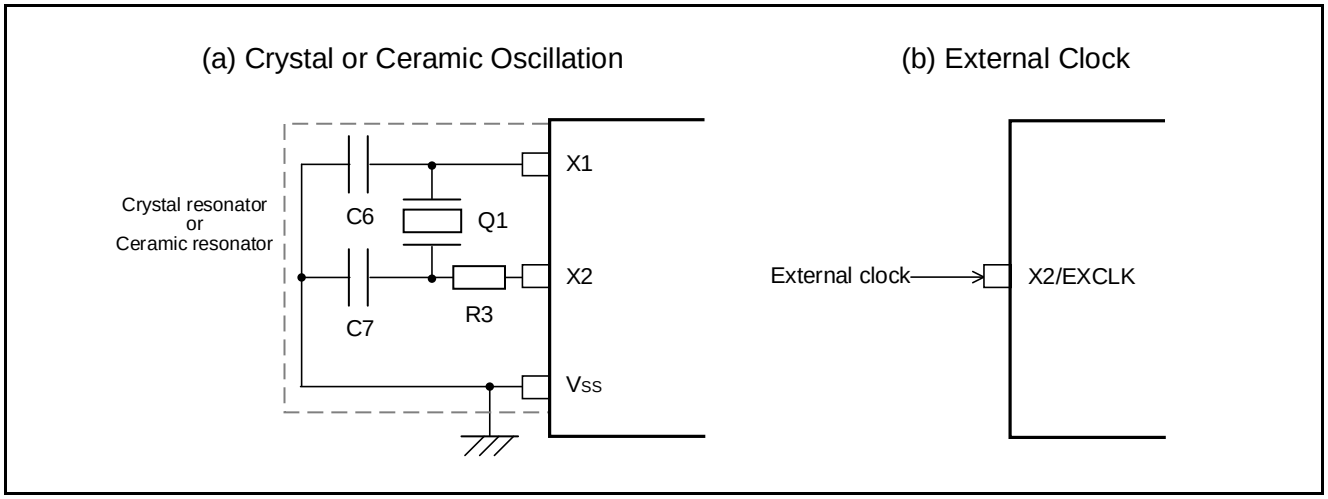


Figure 8: Main System Clock Connection

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.

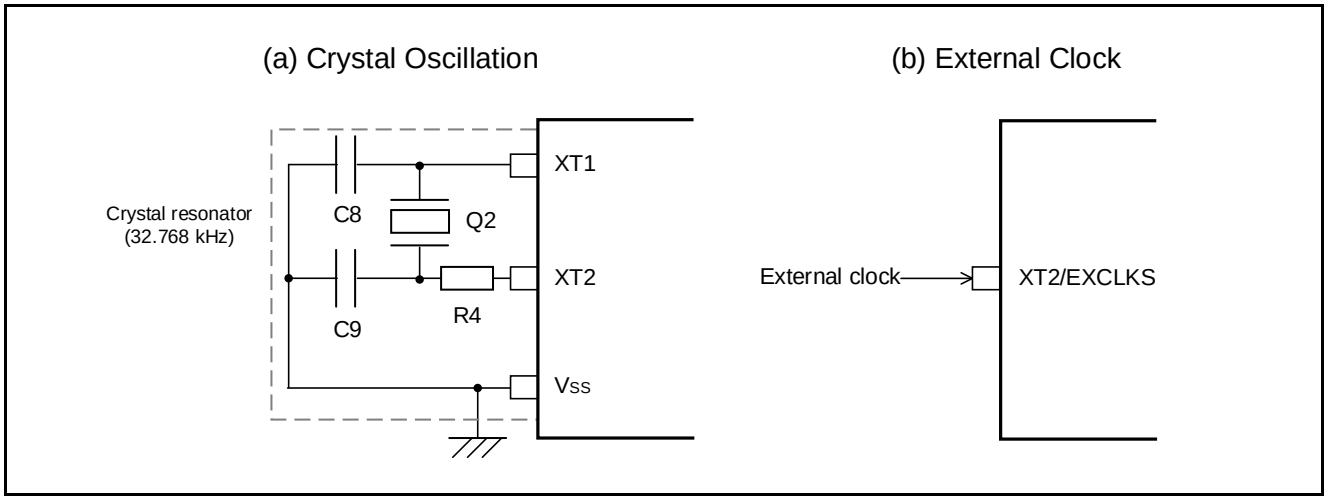


Figure 9: Subsystem Clock Connection

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.

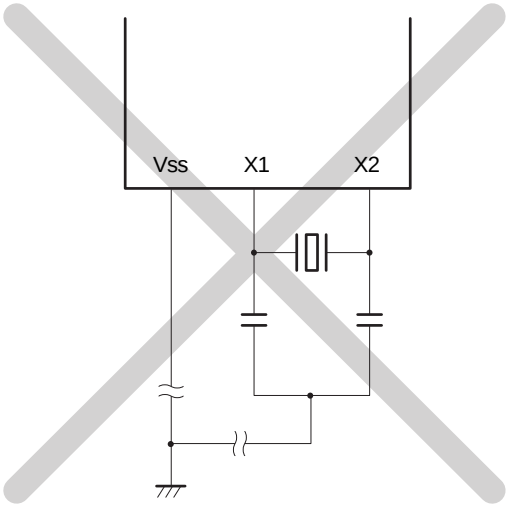
The XT1 oscillator is a circuit with low amplification in order to achieve low-power consumption.

Note the following points when designing the circuit.

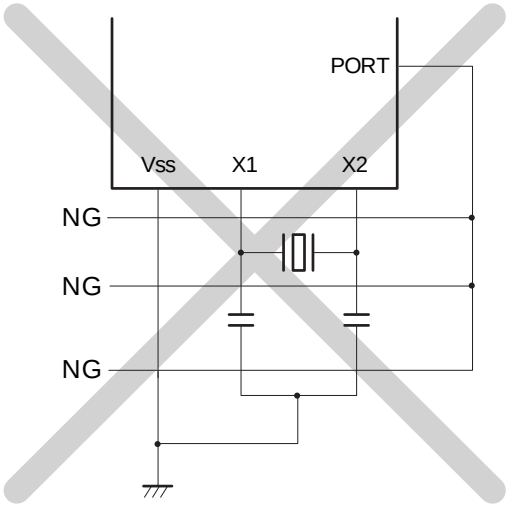
- Pins and circuit boards include parasitic capacitance. Therefore, perform oscillation evaluation using a circuit board to be actually used and confirm that there are no problems.
- Make the wiring between the XT1 and XT2 pins and the resonators as short as possible, and minimize the parasitic capacitance and wiring resistance. Note this particularly when the ultralow power consumption oscillation (AMPHS1, AMPHS0 = 1, 0) 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 VSS 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.

Please avoid the following PCB layout for the external OSC circuit.

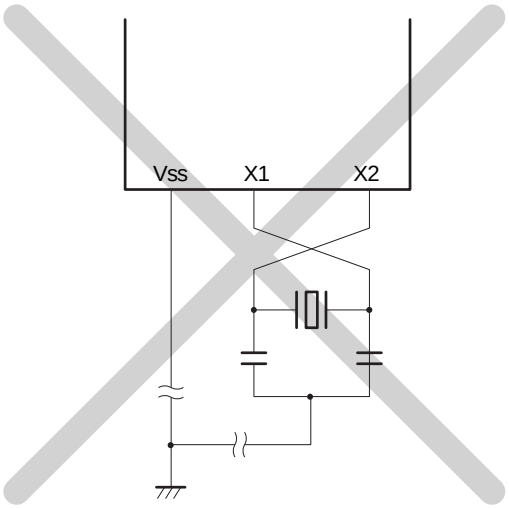
(a) Too long wiring



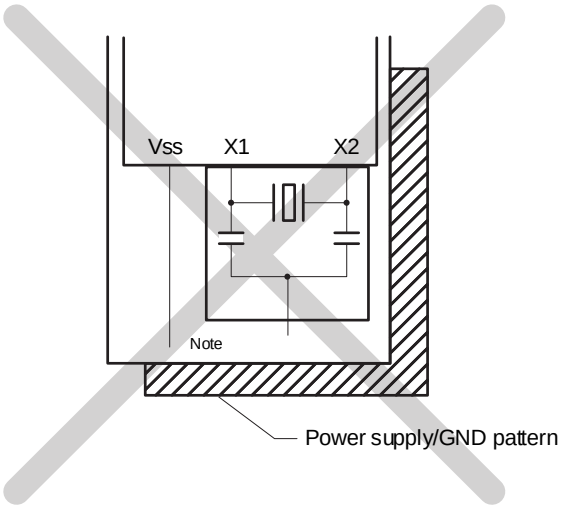
(b) Closed signal line



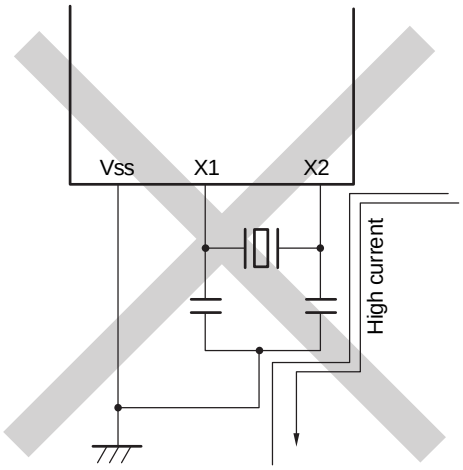
(c) The X1 and X2 signal line wires cross



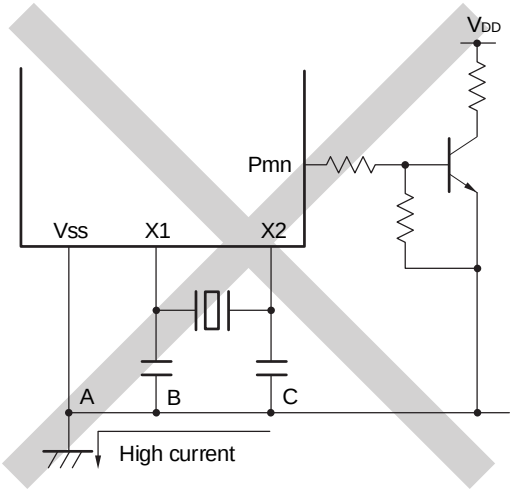
(d) A power supply / GND pattern exists under the X1 and X2 wires



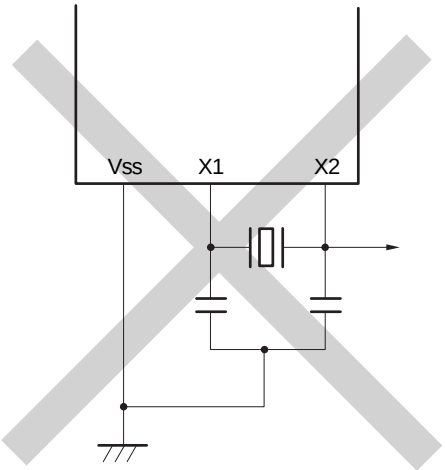
(e) Wiring near high alternating current



(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

The general purpose I/O of RL78/F22 product has AVDD-type I/O and EVDD-type I/O.
Note that port drive current capability is different according to I/O type.

Table 2: IOH and IOL Characteristics for Grade-3 Products

Port Type	Applicable General Purpose I/O	Conditions	Port Characteristics (IOH and IOL)
AVDD-type	Per pin for P80 to P87, P90 to P92	1.8V ≤ AV_{DD} ≤ 5.5V	IOH2: -0.1 mA IOL2: 0.4 mA
	Total of all AVDD-type pins	1.8V ≤ AV_{DD} ≤ 5.5V	IOH2: -2.0 mA IOL2: 5.0 mA
EVDD-type	Per pin for P00, P10 to P17, P30 to P32, P40, P41, P60 to P63, P70 to P73, P120, P125, P130, P140	4.0V ≤ V_{DD} ≤ 5.5V	IOH1: -5.0 mA IOL1: 8.5 mA
		2.7V ≤ V_{DD} < 4.0V	IOH1: -3.0 mA IOL1: 4.0 mA
		1.8V ≤ V_{DD} < 2.7V	IOH1: -0.5 mA IOL1: 0.6 mA
	Total of all EVDD-type pins	4.0V ≤ V_{DD} ≤ 5.5V	IOH1: -50.0 mA IOL1: 65.0 mA
		2.7V ≤ V_{DD} < 4.0V	IOH1: -29.0 mA IOL1: 50.0 mA
		1.8V ≤ V_{DD} < 2.7V	IOH1: -15.0 mA IOL1: 29.0 mA

Table 3: IOH and IOL Characteristics for Grade-4 Products

Port Type	Applicable General Purpose I/O	Conditions	Port Characteristics (IOH and IOL)
AVDD-type	Per pin for P80 to P87, P90 to P92	2.7V ≤ AV_{DD} ≤ 5.5V	IOH2: -0.1 mA IOL2: 0.4 mA
	Total of all AVDD-type pins	2.7V ≤ AV_{DD} ≤ 5.5V	IOH2: -2.0 mA IOL2: 5.0 mA
EVDD-type	Per pin for P00, P10 to P17, P30 to P32, P40, P41, P60 to P63, P70 to P73, P120, P125, P130, P140	4.0V ≤ V_{DD} ≤ 5.5V	IOH1: -5.0 mA IOL1: 8.5 mA
		2.7V ≤ V_{DD} < 4.0V	IOH1: -3.0 mA IOL1: 4.0 mA
	Total of all EVDD-type pins	4.0V ≤ V_{DD} ≤ 5.5V	IOH1: -42.0 mA IOL1: 65.0 mA
		2.7V ≤ V_{DD} < 4.0V	IOH1: -29.0 mA IOL1: 50.0 mA

Remarks Some general purpose I/O may not be mounted depending on the product.
P121 to P124 and P137 are input-only pins.

1.5.2 Recommended Connection of Unused Pins

Table 4 shows the recommended connections of unused pins for RL78/F22 product.

Table 4: Recommended Connection of Unused Pins

Port Type	Pin Name	Recommended Connection of Unused Pin
VDD-type	P121 to P124, P137 (Input-only pin)	Independently connect V_{DD} or V_{SS} via a resistor.
	RESET	Connect to V_{DD} directly or via a resistor.
AVDD-type	P80 to P87, P90 to P92	Input: Independently connect to AV_{DD} or AV_{SS} via a resistor. [Reference resistance value: 20 kΩ] Output: Leave open.
EVDD-type	P40 Note	Input: Independently connect to V_{DD} via a resistor. [Reference resistance value: 10 kΩ] Output: Leave open.
	P130 (Output-only pin)	Leave open.
	All EVDD-type pins except P40 and P130	Input: Independently connect to V_{DD} or V_{SS} via a resistor. [Reference resistance value: 10 kΩ] Output: Leave open.

Note: 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 V_{DD} via a resistor (10 kΩ).

1.5.3 Peripheral I/O Redirection Function

Peripheral I/O pin of RL78/F22 products can be assigned using the PIORx register and STPSTC register.

Table 5: Peripheral I/O Redirection Function

Register	Bit Symbol	Assignable Peripheral I/O Function
PIOR0	PIOR00 to PIOR07	TI00 to TI07 (Input pin of timer array unit)
PIOR1	PIOR10 to PIOR17	TO00 to TO07 (Output pin of timer array unit)
PIOR2	PIOR20 to PIOR23	TI10 to TI13 (Input pin of timer array unit)
PIOR3	PIOR30 to PIOR33	TO10 to TO13 (Output pin of timer array unit)
PIOR4	PIOR40	SI00/SDA00/RXD0, SO00/TXD0, SCL00/SCK00, SSI00 (Serial array unit I/O pin)
	PIOR41	SI01, SO01, SCK01, SSI01, SCL01, SDA01 (Serial array unit I/O pin)
	PIOR42	SI10/RXD1, SO10/TXD1, SCK10, SSI10, SCL10, SDA10 (Serial array unit I/O pin)
	PIOR43	SI11, SO11, SCK11, SSI11, SCL11, SDA11 (Serial array unit I/O pin)
	PIOR44	LRXD0, LTXD0 (Serial data I/O pin of RLIN3 module)
PIOR5	PIOR50	KR0 to KR7 (Key return input pin)
	PIOR52	INTP2 (External interrupt input pin)
	PIOR53	INTP3 (External interrupt input pin)
PIOR6	PIOR60 to PIOR67	SNZOUT0 to SNZOUT7 (SNOOZE status output pin)
PIOR7	PIOR70	TRDIOA0/TRDCLK0 (Timer RDe I/O pin)
	PIOR71	TRDIOB0 (Timer RDe I/O pin)
	PIOR73	TRDIOD0 (Timer RDe I/O pin)
PIOR9	PIOR90	TO01, TO02, TO03, TO07 (Output pin of timer array unit)
	PIOR91	SI10/RXD1, SCK10 (Serial array unit I/O pin)
	PIOR92	SO11 (Serial data output pin of serial array unit)
	PIOR95	TO13 (Output pin of timer array unit)
STPSTC	STPSEL	STOPST (STOP status output pin)

Cautions

1. **TO01, TO02, TO03, and TO07 (Timer Array Unit output pins) are assigned pins with PIOR1 register and PIOR90 bit. The PIOR90 bit is a common bit, so be careful when pin assignments.**
2. **The CSI10 pin function of the Serial Array Unit are assigned with PIOR42 and PIOR91 bits. The CSI10 pin functions (SCK10, SI10, SO10, SSI10) are assigned together, so be careful when pin assignments. In addition, the UART1 pin functions (RXD1, TXD1) are also assigned together with PIOR42 and PIOR91 bits, so be careful when pins assignments.**
3. **The CSI11 pin function of the Serial Array Unit are assigned with PIOR43 and PIOR92 bits. The CSI11 pin functions (SCK11, SI11, SO11, SSI11) are assigned together, so be careful when pin assignments.**

1.5.4 Injected Current Input

This product supports injection current input.

Note that the characteristics differ depending on the pin.

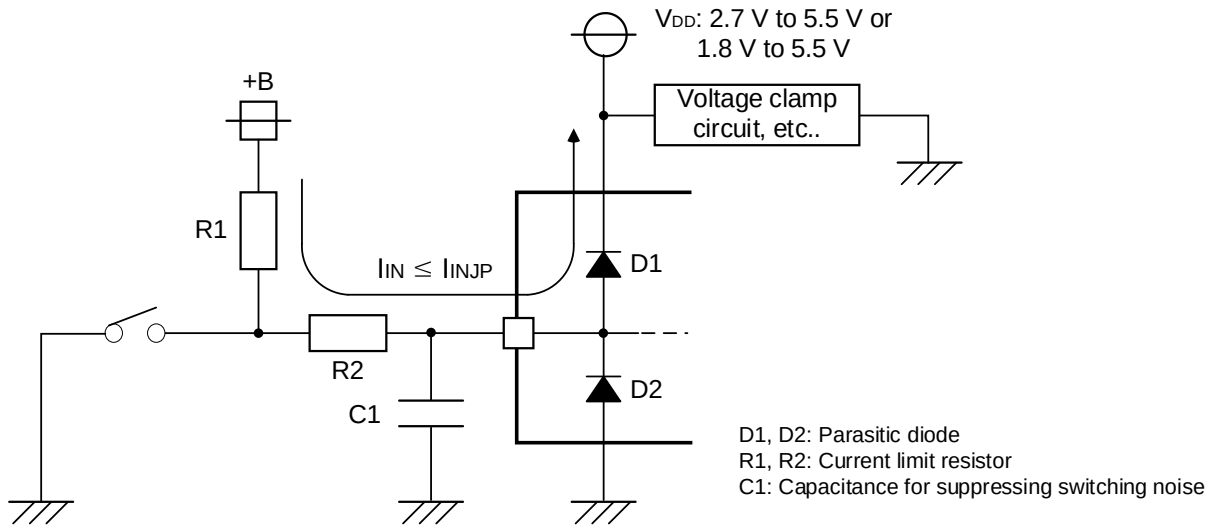


Figure 10: Example of Injected Current Input Circuit

Table 6: Injected Current Input Specifications

Item	Port Type	Conditions	Injected Current Specifications (MAX.)
Positive injected current ($V_{IN} \geq V_{DD}$)	EVDD-type	P12, P40, P130	Prohibition
		All EVDD-type pins except P12, P40, P70 to P73, P120, P125, and P130	0.4 mA (per pin), 4.0 mA (Total of EVDD-type pins)
		P70 to P73, P120, P125	0.15 mA (per pin), 1.0 mA (total of pins (including AVDD-type pins))
	VDD-type	P121 to P124, P137	Prohibition
	AVDD-type	P80, P83 to P87, P90 to P92	0.15 mA (per pin), 1.0 mA (total of pins (including EVDD-type pins (P70 to P73, P120, P125)))
		P81, P82	0.15 mA (per pin), 0.15 mA (total of pins)

Note The above specifications are not tested in the outgoing inspection, but they are specified based on the design rules and the device characterization.

1.6 Note for A/D Converter

1.6.1 Voltage Range of Analog Power Supply Pins

Observe the following conditions:

- Analog input voltage range
  Voltage applied to analog input pins ANIn: $AV_{SS}/AV_{REFM} \leq V_{AIN} \leq AV_{DD}/AV_{REFP}$
  Reference voltage range applied to the AV_{REFP} pin: $AV_{DD}/AV_{REFP} \leq V_{DD}$
- Relationship between power supply pin pairs ($AV_{DD}/AV_{REFP} – AV_{SS}/AV_{REFM}$)
  Connect a capacitor with a low equivalent resistance and a good frequency response to the power supply. When performing A/D conversion of analog input pin ANIn (n = 0 to 10, 22 to 27), a capacitor should be connected between each pair of power supply pins to create a closed loop with the shortest route possible as shown in Figure 11, and connection should be made so that the following conditions are satisfied at the supply side.
  $AV_{SS}/AV_{REFM} = V_{SS}$
  When the 12-bit A/D converter is not used, the following conditions should be satisfied.
  $AV_{DD}/AV_{REFP} = V_{DD}$ and $AV_{SS}/AV_{REFM} = V_{SS}$

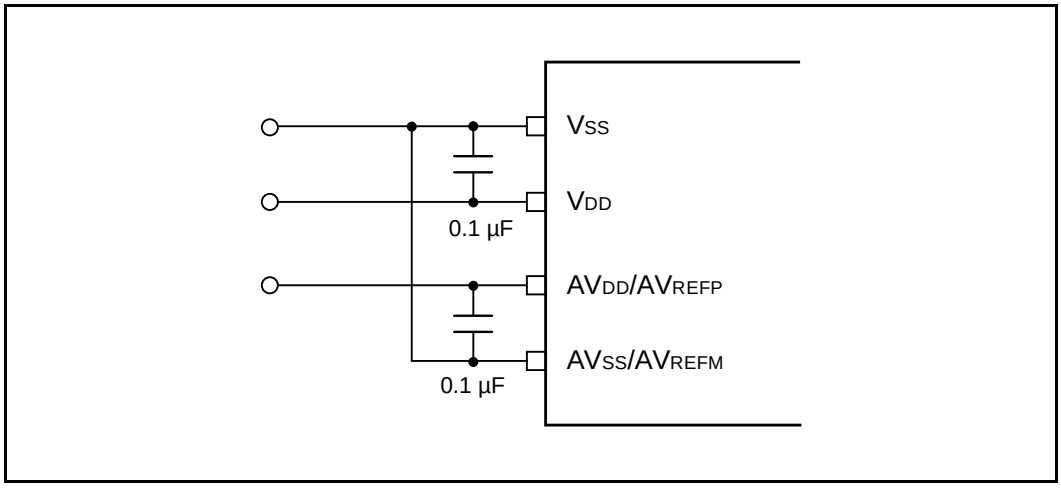


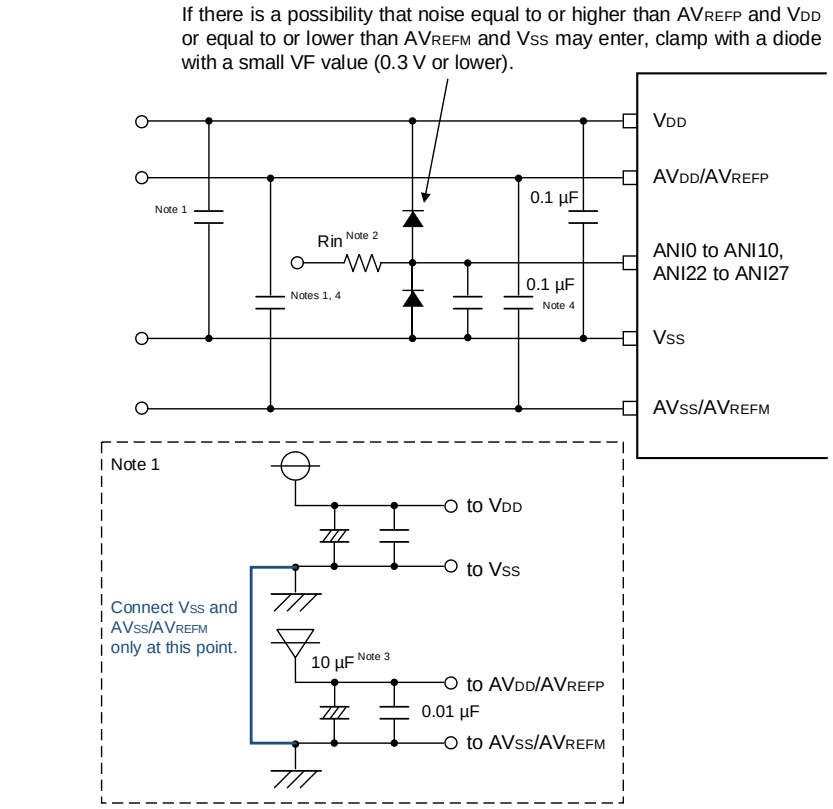
Figure 11: Power Supply Pin Connection Example

1.6.2 Notes on Board Design

- Separate the digital power supply pattern (V_{DD}, V_{SS}) and the analog power supply/reference power supply pattern (AV_{DD}/AV_{REFP}, AV_{SS}/AV_{REFM}) and layout them with the possible thick wiring patterns.
- Individually prepare the voltage supply sources for the digital power supply (V_{DD}, V_{SS}) and the analog power supply/reference power supply (AV_{DD}/AV_{REFP}, AV_{SS}/AV_{REFM}) for the 12-bit A/D converter.
- When using the single voltage supply source, branch off from the vicinity of the output terminal on the voltage supply source and supply it to the digital power supply (V_{DD}, V_{SS}) and the analog power supply/reference power supply (AV_{DD}/AV_{REFP}, AV_{SS}/AV_{REFM}) of the 12-bit A/D converter.
- Connect the analog ground/reference ground (AV_{SS}/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.

1.6.3 Notes on Noise Prevention

- To prevent the analog input pins (ANI0 to ANI10, ANI22 to ANI27) from being destroyed by abnormal voltage such as excessive surge, a capacitor should be inserted between V_{DD} and V_{SS} and between AV_{DD}/AV_{REFP} and AV_{SS}/AV_{REFM}, and a protection circuit should be connected to protect the analog input pins (ANI0 to ANI10, ANI22 to ANI27) as shown in Figure 12
- The A/D conversion result may vary due to fluctuations of the power supply voltage which is caused by changing of a port output current, large current consumption changes by erasing or writing operation of the flash memory, or the effects of noise. Also, if there is noise on the analog input pin (ANIn), power supply voltage/reference voltage input pin (AV_{DD}/AV_{REFP}, AV_{SS}/AV_{REFM}), the conversion result may vary. Apply software processing to avoid negative influence by variations of the results of A/D conversion to the system. Examples of software processing are described below.
  - Use averaged values from several rounds of A/D conversion
  - Execute A/D conversion for several time and rule out extreme results
- The accuracy is improved if the HALT mode is set immediately after the start of conversion.
- When A/D conversion of the signal on any channel (ANIn) is selected, do not change the levels output on P70 to P74, P80 to P87, P90 to P92, P120, and P125 during conversion, since doing so may decrease accuracy.
- When a pin adjacent to a pin on which A/D conversion is in progress is used as a digital I/O port pin, the result of A/D conversion may differ from the accurate value due to noise coupling. Take care to avoid pulses which change dramatically, like digital signals, being input or output through adjacent pins during A/D conversion.



Notes 1. The values indicated in the figure are reference values.
2. Rin: Signal source impedance
3. Connect a 10 µF capacitor between the AV_{DD}/AV_{REFP} and AV_{SS}/AV_{REFM} pins.
It is recommended that the capacitor be placed adjacent to the reference pins of the A/D converter.
4. Connect a capacitor between the AV_{REFP} and AV_{REFM} pins.

Figure 12: Sample Protection Circuit for Analog Inputs

1.6.4 Internal Equivalent Circuit

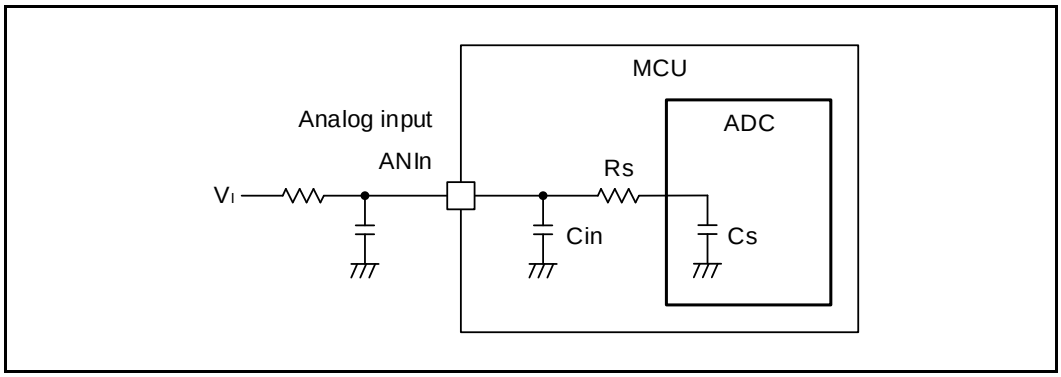


Figure 13: Equivalent Circuit of ANIn Pins

Table 7: Example of the Specifications of the Internal Equivalent Circuit

ANIn	Cin [pF]	Rs [kΩ]	Cs [pF]
ANI0, ANI3 to ANI10	8	2.5	8
ANI1, ANI2 (without channel dedicated S&H circuit)	8	2.5	8
ANI1, ANI2 (with channel dedicated S&H circuit)	8	10.5	3
ANI22 to ANI27	8	6.7	9

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

1.7 Note for Capacitive Sensing Unit (CTSU2SLa)

1.7.1 TSCAP Pin

Connect the TSCAP pin to V_{SS} via a capacitor (10 nF) to stabilize the internal voltage of the CTSU. Use a capacitor with good characteristics within the capacitance range of 10 nF ±10%, including the temperature range in which it will be used and the wiring capacitance of the board.

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 around the electrodes to suppress parasitic capacitance fluctuations due to the surrounding environment and noise factors. We also recommend shielding the outer circumference of the board with a GND plane pattern as an ESD countermeasure.

<1> Electrode shape: square or circle
<2> Electrode size: 10 mm to 15 mm
<3> Electrode proximity: button size × 0.8 or more
<4> Wire width: approx. 0.15 mm to 0.20 mm 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: Make spacing as wide as possible to prevent false detection by neighboring electrodes. (1.27 mm pitch or more)
<7> Cross-hatched GND pattern width: 5 mm
<8> Cross-hatched GND pattern and button/wiring spacing, around electrodes: 5 mm, around wiring: 3 mm 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: 50 pF or less
<10> Electrode + wiring resistance: 2 kΩ or less (including damping resistor with reference value of 560 Ω)

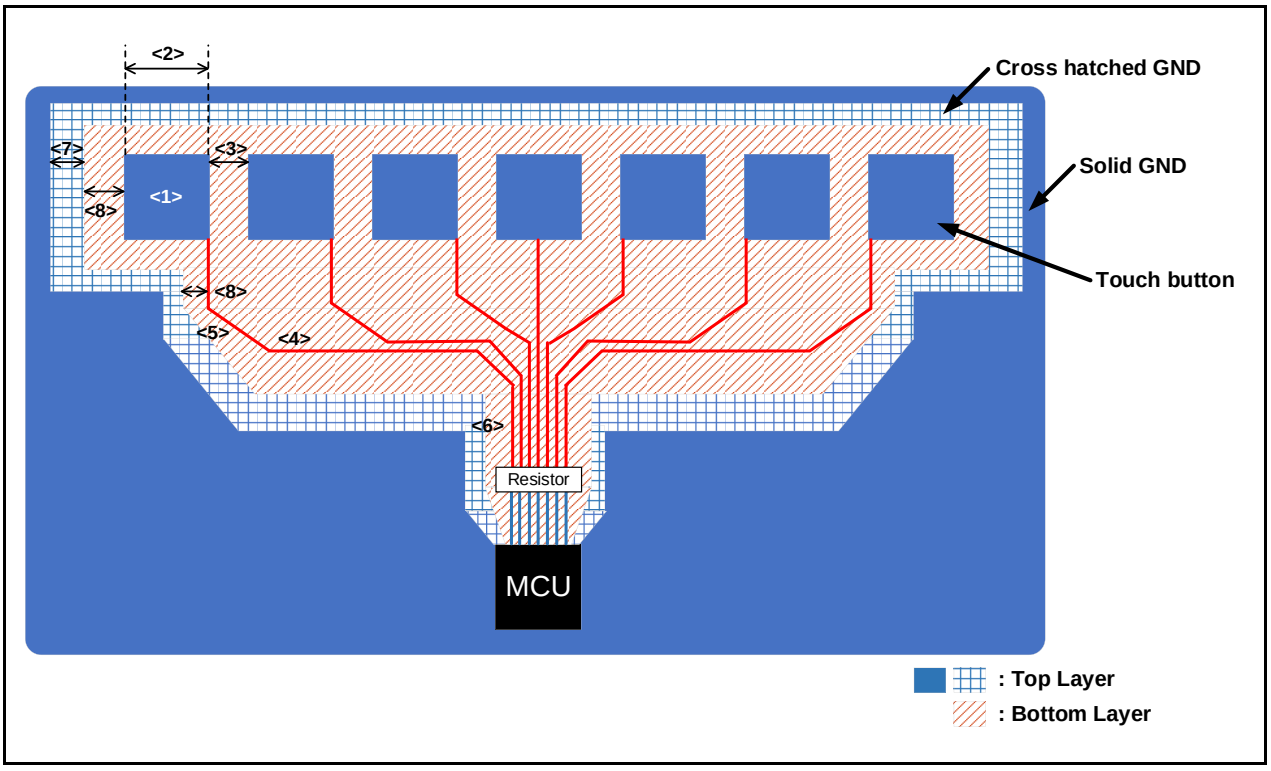


Figure 14: Example of Layout Pattern for Self-capacitance Method

(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: 10 mm or larger
<3> Electrode proximity: button size × 0.8 or more
<4> Wire width: approx. 0.15 mm to 0.20 mm 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: Make spacing as wide as possible to prevent false detection by neighboring electrodes. (1.27 mm pitch or mode). No coupling capacitance occurs between Tx and Rx (20 mm or more).
<7> Cross-hatched GND pattern (shield guard) proximity: The pin parasitic capacitance of the recommended button pattern is comparatively small, but the closer the pin is to GND, the greater the parasitic capacitance becomes. (around electrodes: 4 mm or more, We also recommend approx. 2 mm wide cross-hatched GND plane pattern between electrodes (around wiring: 1.27 mm or more))
<8> Tx, Rx parasitic capacitance: 20 pF or less
<9> Electrode + wiring resistance: 2 kΩ or less (including damping resistor with reference value of 560 Ω)
<10> Do not place GND pattern directly under the electrodes or wiring.

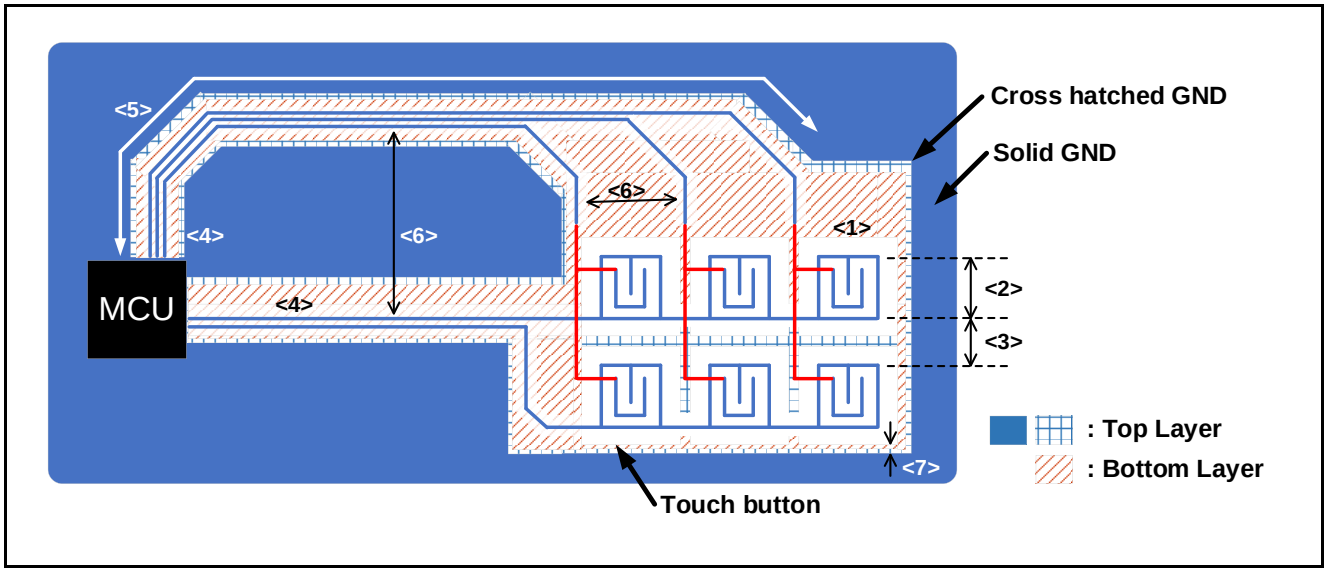


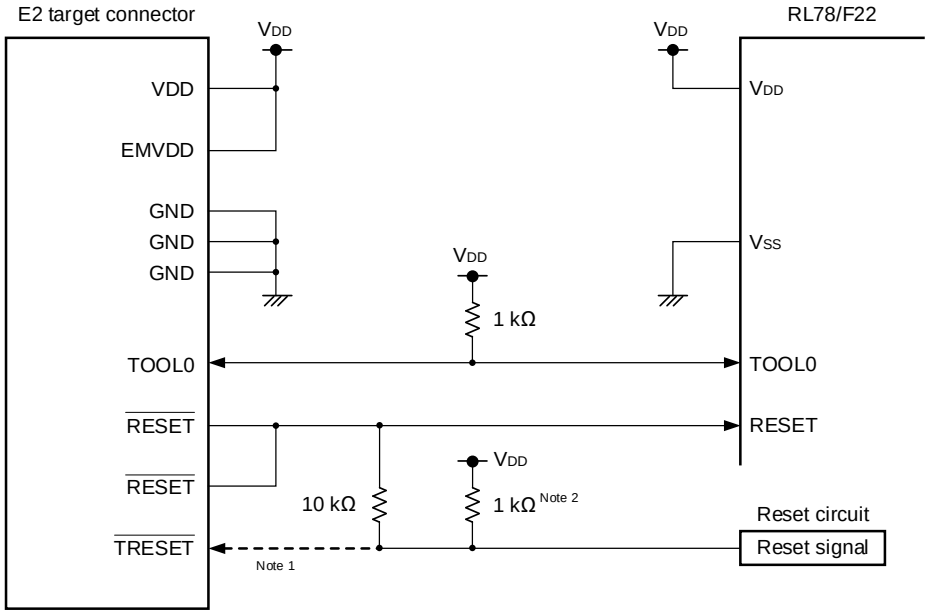
Figure 15: Example of Layout Pattern for Mutual-capacitance Method

1.7.3 Notes on Noise Prevention

If the V_{DD} power supply fluctuates due to noise or other causes, the measurement results may vary. Also, if ripple noise is applied to the V_{DD} power supply, the control current of the capacitance sensor unit may change (decrease) depending on the frequency band of the ripple noise, resulting in a decrease in the measured capacitance value. Please take care when designing the power supply for your board.

1.8 On-chip Debug Circuit

RL78/F22 uses the V_{DD}, 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 detail, refer “E1/E20/E2 Emulator, E2 Emulator Lite Additional Document for User’s Manual (Notes on Connection of RL78)” (Document No. R20UT1994).



Notes 1. Connecting the dotted line is not necessary during flash programming.
2. If the reset circuit on the target system does not have a buffer and generates a reset signal only with resistors and capacitors, this pull-up resistor is not necessary.

Caution This circuit diagram is assumed that reset signal outputs from an N-ch O.D. buffer (output resistor: 100 Ω or less).

Figure 16: Connection Example of E2 On-chip Debugging Emulator and RL78/F22

Related Documents

Document Name	Document No
RL78/F22, F25 User's Manual: Hardware	R01UH1061E
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	Jul 31, 2025	–	First issue

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.

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