

## RL78/G13, 78K0/Kx2

### Migration Guide from 78K0 to RL78: 8-Bit Timers H0 and H1 to Timer Array Unit

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#### Introduction

This application note describes how to migrate the 8-bit timers H0 and H1 of the 78K0/Kx2 to the timer array unit (TAU) of the RL78/G13.

#### Target Device

RL78/G13, 78K0/Kx2

When using this application note with other Renesas MCUs, careful evaluation is recommended after making modifications to comply with the alternate MCU.

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## 1. Functions of 8-Bit Timers H0 and H1 and Timer Array Unit

Table 1.1 shows the functions of the 8-Bit Timers H0 and H1, and Table 1.2 shows the functions of the timer array unit (TAU).

Table 1.1 Functions of 8-Bit Timers H0 and H1

機能	説明
Interval timer	Each timer can be used as a reference timer for generating interrupts (INTTMHn) at fixed intervals.
Square-wave output	Each timer outputs a square wave with a duty factor of 50% from the timer output pin (TOHn) by toggling the output signal at every occurrence of an INTTMHn interrupt.
PWM output	Pulse with an arbitrary duty and arbitrary cycle can be output.
Carrier generator operation (8-bit timer H1 only)	In carrier generator mode, the output of the 8-bit timer H1 carrier pulse is controlled by the 8-bit timer/event counter 51, and the carrier pulse is output from the TOH1 output.

Table 1.2 Functions of Timer Array Unit

Function	Explanation
Interval timer	Each timer of a unit can be used as a reference timer that generates an interrupt (INTTMmn) at fixed intervals.
Square wave output	A toggle operation is performed each time INTTMmn interrupt is generated and a square wave with a duty factor of 50% is output from a timer output pin (TOmn).
External event counter	Each timer of a unit can be used as an event counter that generates an interrupt when the number of the valid edges of a signal input to the timer input pin (TImn) has reached a specific value.
Divider	A clock input from a timer input pin (TI00) is divided and output from an output pin (TO00).
Input pulse interval measurement	Counting is started by the valid edge of a pulse signal input to a timer input pin (TImn). The count value of the timer is captured at the valid edge of the next pulse. In this way, the interval of the input pulse can be measured.
Measurement of high-/low-level width of input signal	Counting is started by a single edge of the signal input to the timer input pin (TImn), and the count value is captured at the other edge. In this way, the high-level or low-level width of the input signal can be measured.
Delay counter	Counting is started at the valid edge of the signal input to the timer input pin (TImn), and an interrupt is generated after any delay period.
One-shot pulse output	Two channels are used as a set to generate a one-shot pulse with a specified output timing and a specified pulse width.
PWM output	Two channels are used as a set to generate a pulse with a specified period and a specified duty factor.
Multiple PWM output	By extending the PWM function and using one master channel and two or more slave channels, up to seven types of PWM signals that have a specific period and a specified duty factor can be generated.

Remark. For 78K0/Kx2, n = 0, 1

For RL78/G13, m: Unit number (m = 0, 1), n: Channel number (n = 0 to 7)

The 8-bit timers H0 and H1 incorporated in the 78K0/Kx2 have two timer compare registers and one output pin per timer counter register.

Figure 1.1 shows a block diagram of the 8-Bit timers H0 and H1.

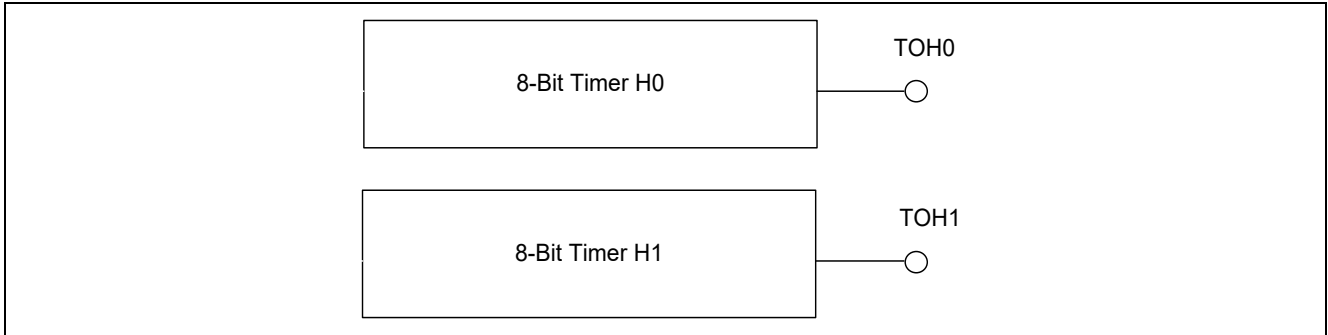


Figure 1.1 Block diagram of the 8-Bit timers H0 and H1

The timer array unit (TAU) incorporated in the RL78/G13 has eight 16-bit timers. Each 16-bit timer is called a channel and can be used as an independent timer. In addition, two or more channels can be combined to serve as a higher-accuracy timer.

Each channel has one timer counter register, one timer data register, one input pin, and one output pin.

Figure 1.2 shows a block diagram of the timer array unit (TAU).

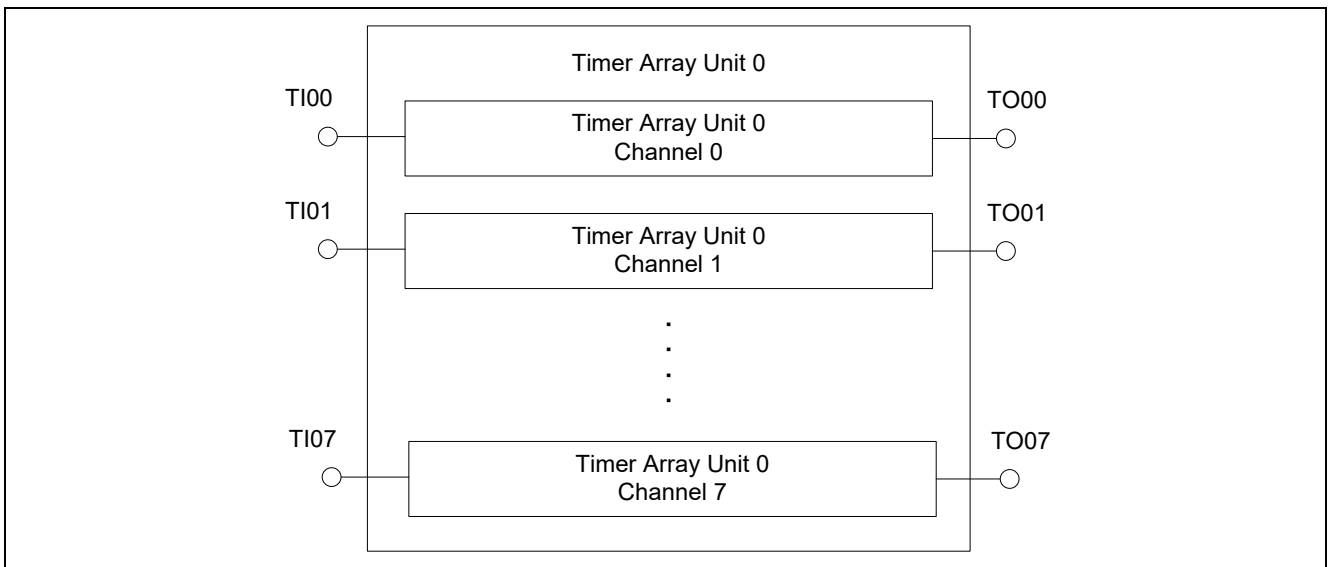


Figure 1.2 Block Diagram of Timer Array Unit

Table 1.3 shows the TAU functions corresponding to the 8-bit timers H0 and H1.

The 8-bit timers H0 and H1 can implement various operations such as interval timer and square-wave output operations. The timer array unit (TAU) can implement the functions equivalent to those provided in the 8-bit timers H0 and H1 by using each channel independently or a combination of multiple channels simultaneously.

Table 1.3 Correspondence between Functions

78K0/Kx2 8-Bit timers H0 and H1	RL78/G13 Timer Array Unit (TAU)	
	Operation function	Channel operation
Interval timer	Interval timer	Independent
Square-wave output	Square wave output	Independent
PWM output	PWM	Simultaneous
Carrier generator (8-bit timer H1 only)	The waveform of a remote controller signal can be generated by using the PWM function (for example, operation with a carrier frequency of 38 kHz and duty factor of 1/3) and interval timer interrupts of the TAU with the settings of the timer output pins controlled by software.	Both independent and simultaneous operations used together

The interval timers of the 8-bit timers H0 and H1 correspond to the interval timer function of the TAU.

The square-wave output of the 8-bit timers H0 and H1 corresponds to the square-wave output function of the TAU.

The PWM output function of the 8-bit timers H0 and H1 corresponds to the PWM function of the TAU.

The waveform equivalent to the output signal of the carrier generator in the 8-bit timer H1 can be generated by the interval timer function and the PWM output function using the timer output enable register m (TOEm) and timer output register m (TOM) in the TAU. For example, set up the PWM function so that the remote controller carrier frequency is 38 kHz and the duty factor is 1/3. For the high-level output period of the remote controller signal, enable PWM output (TOEmn = 1). For the low-level output period of the remote controller signal, disable PWM output (TOEmn = 0) and then set the output from the TOMn pin to the low level. Use the interval timer to generate the timings for switching between the high-level and low-level periods of the remote controller signal.

## 2. Differences between 8-Bit timers H0 and H1 and Timer Array Unit

### 2.1 Summary of Differences between Functions

Table 2.1 summarizes the differences between the functions of the 8-Bit timers H0 and H1 and TAU.

Table 2.1 Summary of Differences between Functions

Item	78K0/Kx2 8-Bit timers H0 and H1	RL78/G13 Timer Array Unit (TAU)
Configuration	8-bit timer	16-bit timer <sup>(Note1)</sup>
Count clock	8-Bit timers H0: $f_{CNT} = f_{PRS}, f_{PRS}/2, f_{PRS}/2^2, f_{PRS}/2^6, f_{PRS}/2^{10},$ TM50 output 8-Bit timers H1: $f_{CNT} = f_{PRS}, f_{PRS}/2^2, f_{PRS}/2^4, f_{PRS}/2^6, f_{PRS}/2^{12},$ $f_{RL}, f_{RL}/2^7, f_{RL}/2^9$	$f_{TCLK}$ ( $f_{CLK}$ to $f_{CLK}/2^{15}$ ), $f_{SUB}$ <sup>(Note2)</sup> , $f_{IL}$ <sup>(Note2)</sup>
Counter	Hn register	TCRmn register
Count setting value	CMP0n, CMP1n register	TDRmn register
Count Mode	Count up	Count up, Count down <sup>(Note3)</sup>
Operation Mode	<ul style="list-style-type: none"> <li>Interval timer</li> <li>Square-wave output</li> <li>PWM output</li> <li>Carrier generator (8-bit timer H1 only)</li> </ul>	<ul style="list-style-type: none"> <li>Interval timer</li> <li>Square wave output</li> <li>External event counter</li> <li>Frequency divider (channel 0 of unit 0 only)</li> <li>Input pulse interval measurement</li> <li>Input signal high-/low-level width measurement</li> <li>Delay counter</li> <li>One-shot pulse output function <sup>(Note4)</sup></li> <li>PWM output <sup>(Note4)</sup></li> <li>Multiple PWM output <sup>(Note4)</sup></li> </ul>
Simultaneous channel operation function	Not applicable	Applicable <sup>(Note4)</sup>
Timer input	None	TI00-TI07, TI10-TI17
Timer output	TOHn	TO00-TO07, TO10-TO17

Note1. Channels 1 and 3 can be each used in 2-channel 8-bit timer configuration.

Note2. Channel 5 only

Note3. Depends on the mode.

Note4. Realized by combining master and slave channels.

Remarks 1. For 78K0/Kx2, n = 0, 1

For RL78/G13, m: Unit number (m = 0, 1), n: Channel number (n = 0 to 7)

Remarks 2. Different products are provided with different functions. For details, refer to the appropriate user's manuals (hardware).

## 2.2 Differences between Interval Timers

The interval timers of the 8-Bit timers H0 and H1 of the 78K0/Kx2 correspond to the interval timer of the TAU of the RL78/G13. Table 2.2 shows the differences between the interval timers.

Table 2.2 Differences between Interval Timers

Item	78K0/Kx2 8-Bit timers H0 and H1	RL78/G13 Timer Array Unit (TAU)
Count clock	8-Bit timers H0: $f_{CNT} = f_{PRS}, f_{PRS}/2, f_{PRS}/2^2, f_{PRS}/2^6,$ $f_{PRS}/2^{10}, TM50$ output 8-Bit timers H1: $f_{CNT} = f_{PRS}, f_{PRS}/2^2, f_{PRS}/2^4, f_{PRS}/2^6,$ $f_{PRS}/2^{12}, f_{RL}, f_{RL}/2^7, f_{RL}/2^9$	$f_{TCLK} (f_{CLK} \sim f_{CLK}/2^{15}), f_{SUB}^{(Note)}, f_{IL}^{(Note)}$
Enable supplying the clock to the timer array unit	None	Setting the TAUmEN bit in the PER0 register to 1
Count mode	Count up	Count down
Generation period of interrupt	(Set value of CMP0n + 1) / $f_{CNT}$	(Set value of TDRmn + 1) × Period of count clock
Interrupt occur timing	When the value of the 8-bit timer counter Hn matches the value of the CMP0n register, generates an interrupt request signal (INTTMHn)	- When TCRmn reaches 0000H and then the next count clock pulse (fMCK) is generated - When count operation starts (only if MDmn0 bit in the TMRmn register is set to 1)
Starts count operation	Setting the TMHEn bit in the TMHMDn register to 1. The count clock starts counting no more than 1 clock after the operation is enabled.	Setting the TSmn bit in the TSm register to 1
Stops count operation	Setting the TMHEn bit in the TMHMDn register to 0	Setting the TTmn bit in the TTm register to 1
Counter value initialization timing	- When count operation stops - When an interrupt occurs	- When count operation starts - When an interrupt occurs
Acquires timer counter value	None	Reading the TCRmn register

Note. Channel 5 only

Remarks 1. For 78K0/Kx2, n = 0, 1

For RL78/G13, m: Unit number (m = 0, 1), n: Channel number (n = 0 to 7)

Remarks 2. Different products are provided with different functions. For details, refer to the appropriate user's manuals (hardware).

## 2.3 Differences between Square-Wave Output

The square-wave output of the 8-Bit timers H0 and H1 of the 78K0/Kx2 correspond to the square-wave output function of the TAU of the RL78/G13. Table 2.3 shows the differences between the square-wave output.

Table 2.3 Differences between Square-Wave Output

Item	78K0/Kx2 8-Bit timers H0 and H1	RL78/G13 Timer Array Unit (TAU)
Count clock	8-Bit timers H0: $f_{CNT} = f_{PRS}, f_{PRS}/2, f_{PRS}/2^2, f_{PRS}/2^6, f_{PRS}/2^{10}$ , TM50 output 8-Bit timers H1: $f_{CNT} = f_{PRS}, f_{PRS}/2^2, f_{PRS}/2^4, f_{PRS}/2^6, f_{PRS}/2^{12}$ , $f_{RL}, f_{RL}/2^7, f_{RL}/2^9$	$f_{CLK}$ ( $f_{CLK} \sim f_{CLK}/2^{15}$ ), $f_{SUB}$ <sup>(Note1)</sup> , $f_{IL}$ <sup>(Note1)</sup>
Enable supplying the clock to the timer array unit	None	Setting the TAUmEN bit in the PER0 register to 1
Count mode	Count up	Count down
Square wave frequency	Frequency of count clock / { (Set value of CMP0n + 1) x 2 }	Frequency of count clock / { (Set value of TDRmn + 1) x 2 }
Interrupt occur timing	When the 8-bit timer counter Hn value matches the CMP0n register value and then the next count clock pulse is generated	- When TCRmn reaches 0000H and then the next count clock pulse (fMCK) is generated - When count operation starts (only if MDmn0 bit in TMRmn register is set to 1)
Starts count operation	Setting the TMHEn bit in the TMHMDn register to 1. (The count clock starts counting no more than 1 clock after the operation is enabled.)	Setting the TSmn bit in the TSm register to 1
Stops count operation	Setting the TMHEn bit in the TMHMDn register to 0.	Setting the TTmn bit in the TTm register to 1
Counter value initialization timing	- When count operation stops - When an interrupt occurs	- When count operation starts - When an interrupt occurs
Acquires timer counter value	None	Reading the TCRmn register
Output level when timer output is disabled	Fixed to low (TOE0n = 0). Can also be fixed to high by setting 1 to the port latch of the multiplexed pin. Set 0 to the above latch at the start of timer output.	TOmn bit setting in the TOM register. Valid only when TOEmn = 0.
Output level when timer operation starts	TOLEVn bit setting in the TMHMDn register. Output level is inverted upon match between the 8-bit timer counter Hn value and CMP0n register value. Valid only when PM15 = P15 = 0, and PM16 = P16 = 0.	TOmn bit setting in the TOM register after port output is enabled. When MDmn0 = 1, output level is inverted after timer operation starts. When MDmn0 = 0, output level is not inverted after timer operation starts. Valid only when PMxx = Pxx = 0, and PMCxx = 0. <sup>(Note2)</sup>
Output pin	TOHn pin	TOmn pin

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



Note1. Channel 5 only

Note2. Refer to tables, Setting Examples of Registers and Output Latches When Using Alternate Function, in the RL78/G13 User's Manual: Hardware.

Remarks1. For 78K0/Kx2, n = 0, 1

For RL78/G13, m: Unit number (m = 0, 1), n: Channel number (n = 0 to 7)

Remarks2. Different products are provided with different functions. For details, refer to the appropriate user's manuals (hardware).

## 2.4 Differences between PWM output

The PWM output of the 8-Bit timers H0 and H1 of the 78K0/Kx2 corresponds to the PWM function of the TAU of the RL78/G13.

Table 2.4 and Table 2.5 shows the differences between the PWM output.

Table 2.4 Differences between PWM output (1/2)

Item	78K0/Kx2 8-Bit timers H0 and H1	RL78/G13 Timer Array Unit (TAU)
Count clock	8-Bit timers H0: $f_{CNT} = f_{PRS}, f_{PRS}/2, f_{PRS}/2^2, f_{PRS}/2^6, f_{PRS}/2^{10},$ TM50 output 8-Bit timers H1: $f_{CNT} = f_{PRS}, f_{PRS}/2^2, f_{PRS}/2^4, f_{PRS}/2^6, f_{PRS}/2^{12},$ $f_{RL}, f_{RL}/2^7, f_{RL}/2^9$	$f_{CLK}$ ( $f_{CLK}$ to $f_{CLK}/2^{15}$ ), $f_{SUB}$ (Note1), $f_{IL}$ (Note1)
Enable supplying the clock to the timer array unit	None	Setting the TAUmEN bit in the PER0 register to 1
Count mode	Count up	Count down
Period of output waveform (Note2) (Note3)	Period of count clock × (Set value of CMP0n + 1)	Period of count clock × {Set value of TDRmn (Master) + 1}
High-level width of output waveform (Note4)	- When TOLEVn = 0 Period of count clock × (set value of CR01n register + 1) - When TOLEVn = 1 Period of count clock × {(set value of CR00n register) - (set value of CR01n register)}	- When TOLm = 0 (active high) Period of count clock × {Set value of TDRmp (Slave)} - When TOLm = 1 (active low) Period of count clock × [ {Set value of TDRmn (Master) + 1} - {Set value of TDRmp (Slave)}]
Interrupt occur timing	When the 8-bit timer counter Hn value matches the CMP0n register value and then the next count clock pulse is generated	- When count operation starts (master) - When TCRmn reaches 0000H and then the next count clock pulse (fMCK) is generated (master) - When TCRmp reaches 0000H and then the next count clock pulse (fMCK) is generated (slave)
Compare register update timing (software)	When INTMHn is generated	When INTTMmn is generated by master channel
Compare register setting	CMP1n setting is changed only when the high-level width is to be changed. However, this takes a duration of three operating clock cycles (signal selected by the CKSn2 to CKSn0 bits of the TMHMDn register) from when the value of the CMP1n register is changed until the value is transferred to the register.	- TDRmn (master) setting is changed only when the period is to be changed. - TDRmp (slave) setting is changed only when the high-level width (TOLm = 0) or low-level width (TOLm = 1) is to be changed.

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

Note1. Channel 5 only

Note2. The 78K0/Kx2 outputs an inactive level after counting begins and until a count clock pulse is applied after the value of the 8-bit timer counter  $H_n$  matches the value of the compare register  $0_n$  (CMP0n).

Note3. Rewriting the CMP0n register during timer operation is prohibited.

Note4.  $00H \leq \text{CMP1n} < \text{CMP0n} \leq \text{FFH}$

Remarks1. For 78K0/Kx2,  $n = 0, 1$

For RL78/G13, m: Unit number ( $m = 0, 1$ ), n: Channel number ( $n = 0, 2, 4, 6$ )

p: Slave channel number ( $n < p \leq 7$ )

Remarks2. Different products are provided with different functions. For details, refer to the appropriate user's manuals (hardware).

Table 2.5 Differences between PWM output (2/2)

Item	78K0/Kx2 8-Bit timers H0 and H1	RL78/G13 Timer Array Unit (TAU)
Starts count operation	Setting the TMHE <sub>n</sub> bit in the TMHMD <sub>n</sub> register to 1.	Setting the TSm <sub>n</sub> bit in the TSm register to 1
Stops count operation	Setting the TMHE <sub>n</sub> bit in the TMHMD <sub>n</sub> register to 0.	Setting the TTm <sub>n</sub> bit in the TTm register to 1
Acquires timer counter value	None	Reading the TCRm <sub>n</sub> register Reading the TCRmp register
Output level when timer output is disabled	Fixed to low (TOE0 <sub>n</sub> = 0). Can also be fixed to high by setting 1 to the port latch of the multiplexed pin. Set 0 to the above latch at the start of timer output.	TOm <sub>n</sub> bit setting in the TOM register. Valid only when TOEm <sub>n</sub> = 0.
Output level when timer operation starts	TOLEV <sub>n</sub> bit setting in the TMHMD <sub>n</sub> register. Output level is inverted upon match between the 8-bit timer counter H <sub>n</sub> value and CMP0 <sub>n</sub> register value. Valid only when PM15 = P15 = 0, and PM16 = P16 = 0.	TOm <sub>n</sub> bit setting in the TOM register after port output is enabled. When MDm <sub>n</sub> 0 = 1, output level is inverted after timer operation starts. When MDm <sub>n</sub> 0 = 0, output level is not inverted after timer operation starts. Valid only when PM <sub>xx</sub> = P <sub>xx</sub> = 0, and PMC <sub>xx</sub> = 0. (Note)
Output pin	TOH <sub>n</sub> pin	TOmp pin

Note. Refer to tables, Setting Examples of Registers and Output Latches When Using Alternate Function, in the RL78/G13 User's Manual: Hardware.

Remarks1. For 78K0/Kx2, n = 0, 1

For RL78/G13, m: Unit number (m = 0, 1), n: Channel number (n = 0, 2, 4, 6)  
p: Slave channel number (n < p ≤ 7)

Remarks2. Different products are provided with different functions. For details, refer to the appropriate user's manuals (hardware).

### 3. Sample Code for Timer Array Unit

The sample code for the timer array unit is explained in the following application notes.

- RL78/G13 Timer Array Unit (Interval Timer) CC-RL (R01AN2576)
- RL78/G13 Timer Array Unit (PWM Output) CC-RL (R01AN2589)

### 4. Documents for Reference

User's Manual:

- RL78/G13 User's Manual: Hardware (R01UH0146)
- 78K0/Kx2 User's Manual: Hardware (R01UH0008)

The latest versions can be downloaded from the Renesas Electronics website.

Technical Update/Technical News:

The latest information can be downloaded from the Renesas Electronics website.

**Revision History**

Rev.	Date	Description	
		Page	Summary
1.00	Mar. 29, 2019	-	First edition issued

## 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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