RL78/G16

Measuring Distance to an Object with Ultrasonic Sensor

Introduction

This application note describes an example to measure distance to an object with ultrasonic sensor. The ultrasonic sensor is controlled by the timer array unit of the RL78/G16 and connected to the LCD module using the serial interface IICA.

Target Device

RL78/G16

When applying the sample program covered in this application note to another microcomputer, modify the program according to the specifications for the target microcomputer and conduct an extensive evaluation of the modified program.

Contents

1. Specifications

1.1 Overview of Specifications

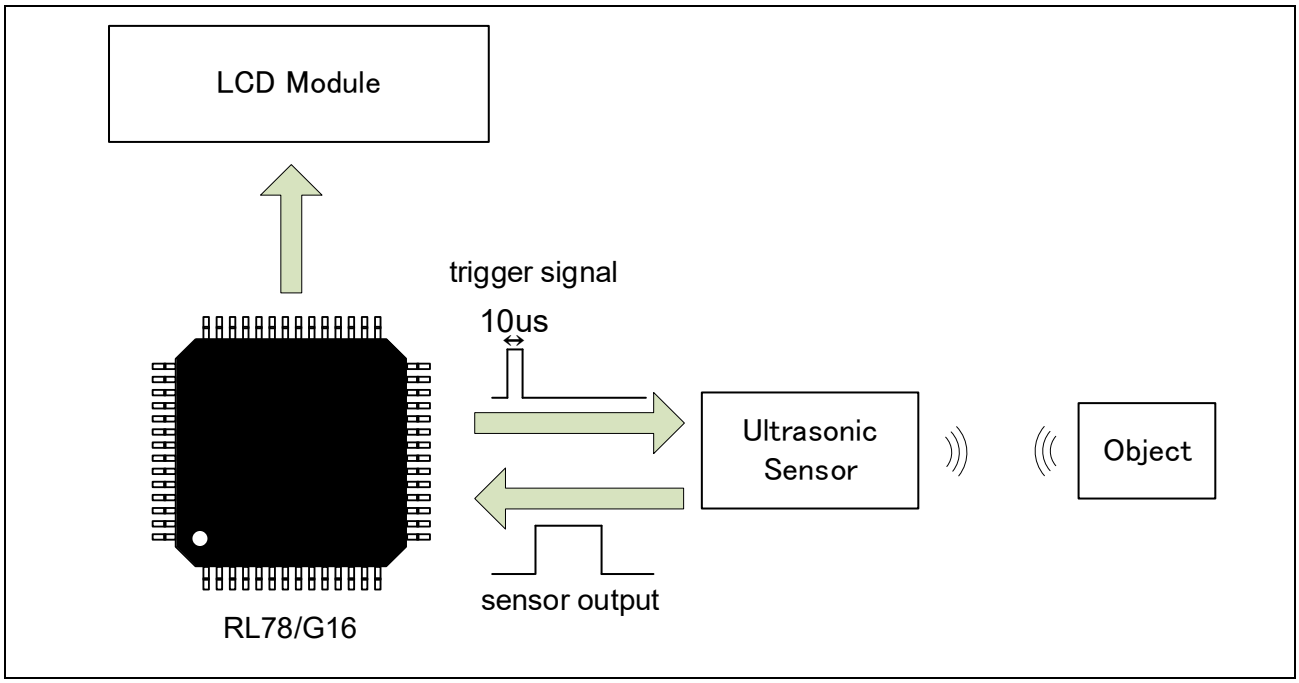
In this application note, measure distance to an object with ultrasonic sensor in each interval time. The Timer Array Unit (TAU) is used to control ultrasonic sensor. Time-of-Flight (TOF) value output by ultrasonic sensor is converted to distance. The distance is displayed on the LCD character display with Serial Interface IICA.

Table 1.1 lists peripheral functions to be used and Figure 1.1 shows an overview of sample code operation.

Table 1.1 Used Peripheral Functions and Purposes

Peripheral Functions	Use
P05	Output of Trigger Waveform for Ultrasonic Sensor Control
TAU01	Measurement of Ultrasonic Sensor Output Signal
TAU02	1us measurement timer
TAU03	1ms measurement timer
Serial Interface IICA0 P60/SCLA0, P61/SDAA0	I2C communication with the LCD module
RESET	External reset input

Figure 1.1 Outline of Distance Measuring System



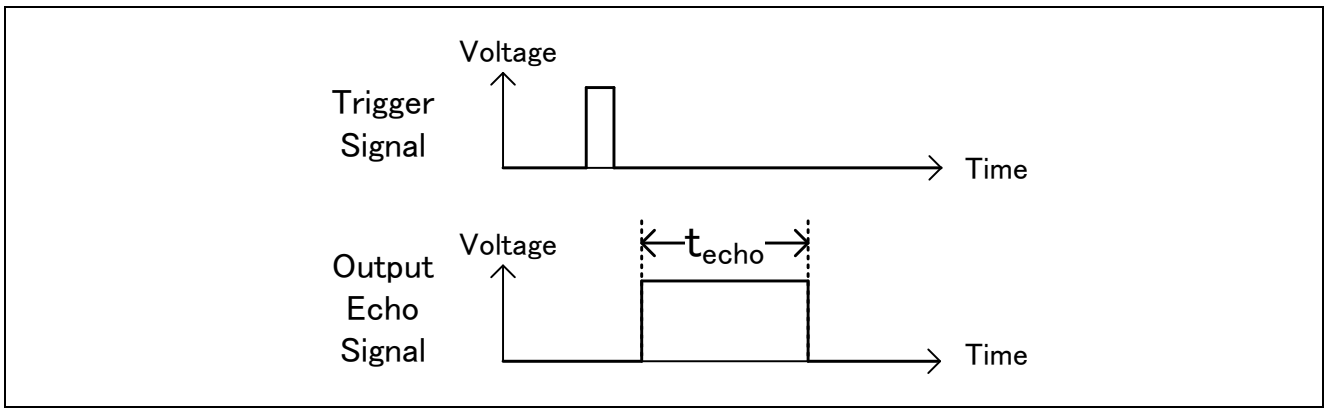
1.2 Method of Controlling an Ultrasonic Sensor.

An ultrasonic sensor used in this application note consists of a transmitting speaker and a receiving microphone. The sensor outputs the time sound travels between the sensor and an object.

For example, when a trigger signal is input to the sensor as shown in Figure 1.2, the sensor outputs an output signal which width has proportional to the distance to the object.

The control signal output uses P05. And to measure the high-level width output by the sensor, the "input signal high-/low-level width measurement" function is used. Also, to reduce noise, calculate moving average of the measurement result.

Figure 1.2 Trigger Signal and Output Echo Signa



1.3 Converting Time to Distance

The Euclidean distance between the ultrasonic sensor and the target surface $d\ [m]$ can be obtained by converting $t_{echo}\ [s]$ using following expressions (1.1) and (1.2). The sound velocity c is assumed to be constant at $340.29\ [m/s]$.

$$d\ [\mathrm{m}] = \frac{t_{echo}\ [s]}{2}\ c, \qquad c = 340.29\ [m/s] \tag{1.1}$$

$$t_{echo}\ [s] = \frac{TDR01}{f_{TCLK}\ [Hz]} \tag{1.2}$$

1.4 Format of LCD Character Display

For the LCD character display, I2C connection and 16 × 2 display ACM1602NI-FLM-FBW-M01 compatible products are used.

The distance measured by the sensor is displayed in the format shown in Figure 1.3. (display range is 0 to 999.9 cm)

Figure 1.3 Display Pattern of the LCD Character Display.

D	I	S	T	A	N	C	E	:								
1	2	3	.	4	c	m										

1.5 Outline of operation

In this application note, after initializing (I/O ports, Timer Array Unit (TAU), Serial Interface IICA), Enable for Timer Array Unit Channel 1 (TAU01) operation and wait for measurement completion in HALT mode.

After returning from HALT mode (INTTM01: after detecting the ultrasonic sensor output signal), display the distance to the target object on the LCD module. If the distance to the object exceeds 10 m, "OVER 999.9 cm" will be displayed on the LCD module.

(1) Initialize the I/O ports.

- Set P06 to the output port. (Initial value: Low level)

(2) Initialize the timer array unit

<Channel 1 (TAU01) settings>

- Set operating mode to capture mode.
- Set the measurable pulse interval to 1 us < TI01 < 131.071 ms.
- Use noise filter on TI01 terminal input signal.
- Set the signal level of measurement terminal TI01 to high level.

<Channel 2 (TAU02) settings>

- Set operating mode to Interval Timer.
- Set interval time to 1us.
- Disable INTTM02 interrupt generation at start of count.

<Channel 3 (TAU03) settings>

- Set operating mode to Interval Timer.
- Set interval time to 1ms.
- Disable INTTM03 interrupt generation at start of count.

(3) Initialize the serial interface IICA

- Use IICA0 (P60 set to SCLA0 and P61 set to SDAA0).
- Set the local address to 0x10.
- Set the standard mode as the operation mode.
- Set the transfer clock to 80 kbps.
- Enable INTIICA0 interrupt.

(4) Sends a command to initialize the LCD module.

(5) Enable the operation of Timer Array Unit Channel 1 (TAU01).

(6) Turn on the ultrasonic sensor control trigger (P05: High Level) and wait for a 10us using the 1us measurement timer (TAU02). After 10us, turn off the ultrasonic sensor control trigger (P05: High Level).

(7) Shift to HALT mode and wait for the end of measurement (INTTM01: capture completion interrupt).

(8) Stops operation of Timer Array Unit Channel 1 (TAU01) after INTTM01 occurs.

(9) Add the high level width of the input signal to the variable.

(10) Add the high level width of the input signal to the variable.

(11) Repeat (5) ~ (9) five times to calculate the distance using the average of the five measured high level widths.

(12) Wait 60 ms for ultrasonic sensor restart interval with 1 ms measurement timer (TAU03).

Thereafter, repeat (5) ~ (12).

Note 1. Refer to the RL78/G16 User's Manual: Hardware for usage notes concerning this device.

2. Operation Confirmation Conditions

The sample code with this application note runs properly under the conditions below.

Table 2.1 Used Peripheral Functions and Purposes

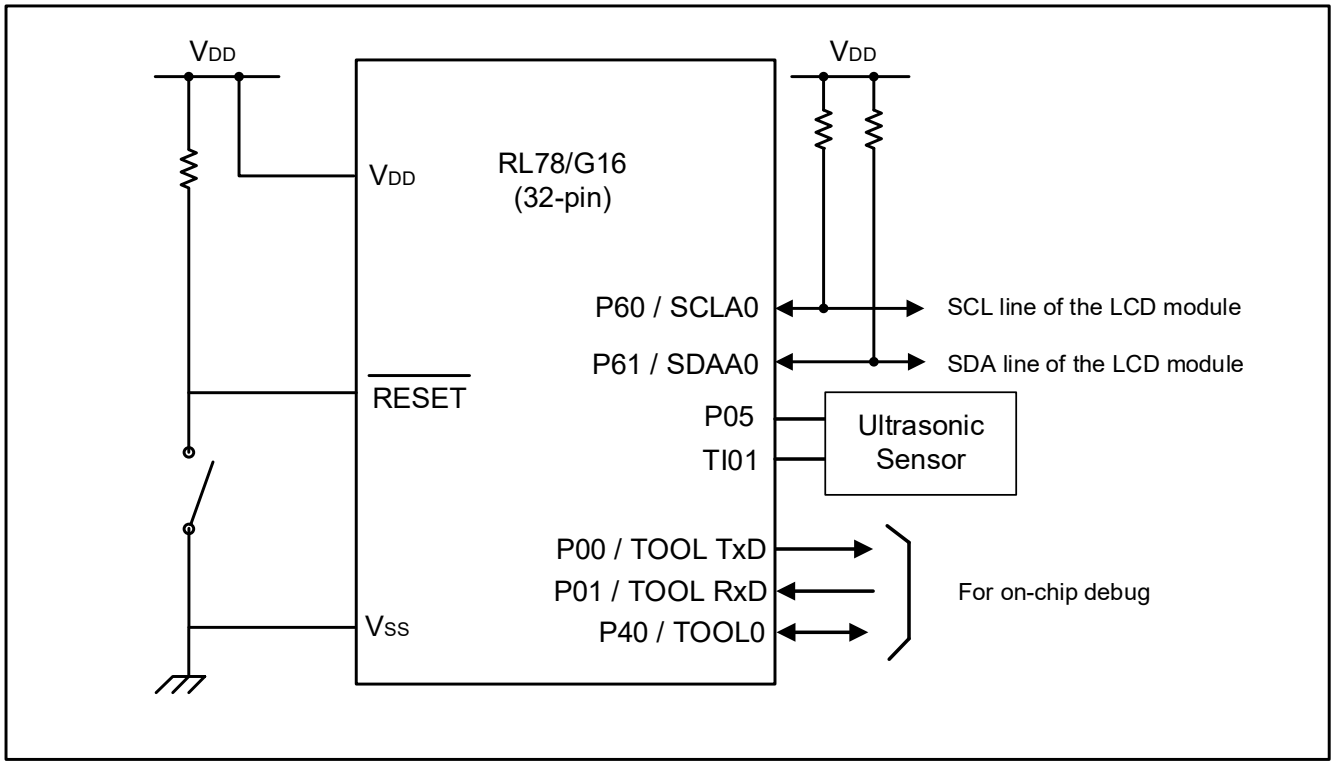
Item	Description
MCU used	RL78/G16 (R5F121BCAFP)
Board used	RL78/G16 Fast Prototyping Board (RTK5RLG160C00000BJ)
Operating frequency	High-speed on-chip oscillator clock (f_{IH}): 16 MHz
Operating voltage	5.0 V (can be operated at 2.4 V to 5.5 V) SPOR operations (VSPOR) At rising edge TYP. 2.57V (2.44 V to 2.68 V) At falling edge TYP. 2.52V (2.40 V to 2.62 V)
Integrated development environment (CS+)	CS+ for CC E8.10.00 from Renesas Electronics Corp.
C compiler (CS+)	CC-RL V1.12.01 from Renesas Electronics Corp.
Integrated development environment (e2studio)	e2studio V2023-10 (23.10.0) from Renesas Electronics Corp.
C compiler (e2studio)	CC-RL V1.12.01 from Renesas Electronics Corp.
Integrated development environment (IAR)	IAR Embedded Workbench for Renesas RL78 V5.10.1 from IAR Systems Corp.
C compiler (IAR)	IAR C/C++ Compiler for Renesas RL78 V5.10.1.2260 from IAR Systems Corp.
SmaRTC2onfigurator (SC)	V1.8.0 from Renesas Electronics Corp.
Board support package (BSP)	V1.60 from Renesas Electronics Corp.
LCD module	ACM1602NI-FLW-FBW-M01

3. Hardware Descriptions

3.1 Example of Hardware Configuration

Figure 3.1 shows an example of the hardware configuration used in this application note.

Figure 3.1 Hardware Configuration



Note 1. This simplified circuit diagram was created to show an overview of connections only. When actually designing your circuit, make sure the design includes sufficient pin processing and meets electrical characteristic requirements. (Connect each input-only port to V_{DD} or V_{SS} through a resistor.)

Note 2. VDD must not be lower than the reset release voltage (VSPOR) that is specified for the SPOR.

3.2 List of Pins to be Used

Table 3.1 shows list of used Pins and assigned functions.

Table 3.1 List of Pins and Functions

Pin Name	I/O	Function
P05	Output	Output of Trigger Waveform for Ultrasonic Sensor Control
TI01	Output	Measurement of Ultrasonic Sensor Output Signal
P60 / SCLA0, P61 / SDAA0	Input/Output	I2C communication with the LCD module
RESET	Input	External reset input

Caution In this application note, only the used pins are processed. When actually designing your circuit, make sure the design includes sufficient pin processing and meets electrical characteristic requirements.

4. Software Explanation

4.1 Option Byte Settings

Table 4.1 lists the option byte settings.

Table 4.1 Option Byte Settings

Address	Setting Value	Contents
000C0H	11101111B	Disables the watchdog timer. (Counting stopped after reset)
000C1H	11111011B	5.0 V (can be operated at 2.4 V to 5.5 V) SPOR operations (VSPOR) At rising edge TYP. 2.57V (2.44 V to 2.68 V) At falling edge TYP. 2.52V (2.40 V to 2.62 V)
000C2H	11111001B	High-speed on-chip oscillator clock: 16 MHz
000C3H	10000101B	On-chip debugging enabled

4.2 Constants

Table 4.2 and Table 4.3 lists the constants that are used in this sample code.

Table 4.2 Constants in the Sample Program (1/2)

Constant Name	Setting Value	Contents
_0x20_TRIGGER_ON	0x20	Ultrasonic Sensor Control Trigger On Flag
_0xDF_TRIGGER_OFF	0xDF	Ultrasonic Sensor Control Trigger OFF Flag
_0xA0_LCM_SLAVE_ADDR	0xA0	Slave address for LCD module
_0x00_LCM_SLAVE_ADDR_RW_LOW	0x00	Write flag for LCD module
_0x80_LCM_CONTROL_BYTE_RS_HIGH	0x80	Data transfer flag for LCD module
_0x00_LCM_CONTROL_BYTE_RS_LOW	0x00	Command transfer flag for LCD module
_0x00_LCM_COMMAND_CLEAR_DISPLAY	0x01	Clear display flag
_0x04_LCM_COMMAND_ENTRY_MODE_SET	0x04	Display position setting flag
_0x02_LCM_COMMAND_ENTRY_MODE_SET_ID_HIGH	0x02	Shift the display position to the right (increment)
_0x00_LCM_COMMAND_ENTRY_MODE_SET_S_LOW	0x00	Display shift off flag
_0x08_LCM_COMMAND_DISPLAY_ONOFF	0x08	Display enable flag
_0x04_LCM_COMMAND_DISPLAY_ONOFF_D_HIGH	0x04	Display on flag
_0x00_LCM_COMMAND_DISPLAY_ONOFF_C_LOW	0x00	Cursor display disable flag
_0x00_LCM_COMMAND_DISPLAY_ONOFF_B_LOW	0x00	Cursor blinking disable flag
_0x20_LCM_COMMAND_FUNCTION_SET	0x20	Function enable flag
_0x10_LCM_COMMAND_FUNCTION_SET_DL_HIGH	0x10	Transfer bit unit to LCD module: 8-bit
_0x08_LCM_COMMAND_FUNCTION_SET_N_HIGH	0x08	Display Lines: 2 lines
_0x00_LCM_COMMAND_FUNCTION_SET_F_LOW	0x00	Font display: 5x8 dots
_0x80_LCM_COMMAND_SET_DDRAM_ADDRESS	0x80	Font display position setting

Table 4.3 Constants in the Sample Program (2/2)

Constant Name	Setting Value	Contents
LCM_COMMAND_EXEC_WAIT	26600	LCD module command execution wait time 10 ms (16 MHz operation)
LCM_CONFIG_FUNCTION_SET_ PARAMS	0x18	Parameters for function set _0x10_LCM_COMMAND_FUNCTION_SET_DL_HIGH | _0x08_LCM_COMMAND_FUNCTION_SET_N_HIGH | _0x00_LCM_COMMAND_FUNCTION_SET_F_LOW
LCM_CONFIG_ENTRY_MODE_ SET_PARAMS	0x20	Parameters for entry mode set _0x02_LCM_COMMAND_ENTRY_MODE_SET_ID_HIGH | _0x00_LCM_COMMAND_ENTRY_MODE_SET_S_LOW
LCM_CONFIG_DISPLAY_ ONOFF_PARAMS	0x40	Display ON/OFF control command parameters _0x04_LCM_COMMAND_DISPLAY_ONOFF_D_HIGH | _0x00_LCM_COMMAND_DISPLAY_ONOFF_C_LOW | _0x00_LCM_COMMAND_DISPLAY_ONOFF_B_LOW
LCM_CONFIG_MAX_CHAR_ PER_LINE	16	Maximum number of characters per line
LCM_CONFIG_WAIT_COUNT	13	IIIA0 wait count
LCM_POSITION_TOP	0x80	LCD module display line (top)
LCM_POSITION_BOTTOM	0xC0	LCD module display line (bottom)

4.3 Global Variables

Table 4.4 lists the global variables.

Table 4.4 Global Variables

Type	Variable Name	Contents	Functions used
uint32_t	g_tau0_ch1_width	The variable to temporarily store the high-level width of the signal input from TI01.	main(), r_Config_TAU0_1_interrupt()

4.4 List of Functions

Table 4.5 lists the functions.

Table 4.5 Functions

Function Name	Outline
Calc_Distance()	Process to convert high level width measurement results to distance
Display_Distance()	Process to send drawing data to LCD module
r_Config_IICA0_callback_master_sendend()	IICA0 send end callback processing
r_Config_IICA0_callback_master_error()	IICA0 error callback processing
r_LCM_init()	LCD module initialization
r_LCM_clear()	LCD module display clear processing
r_LCM_send_string()	LCD module character string transmission processing
r_LCM_send_command()	LCD module command transmission processing
r_LCM_send_data()	LCD module data transmission processing
r_LCM_turn_sendend_on()	LCD module communication end flag setting
r_LCM_wait_sendend()	LCD module communication end wait processing
wait_us	us unit time wait processing
wait_ms	ms unit time wait processing
r_Config_TAU0_2_interrupt	Timer Array Unit Channel 2 interrupt processing
r_Config_TAU0_3_interrupt	Timer Array Unit Channel 3 interrupt processing

4.5 Specifications of Function

This part describes function specifications of the sample code.

Calc_Distance()	
Outline	Process to convert high level width measurement results to distance.
Header	-
Declaration	static uint8_t Calc_Distance(uint32_t result);
Description	After measuring the high level width 5 times, the average value is converted to distance to generate the drawing data for the LCD module.
Arguments	result: Total of the high-level width measurement results taken five times.
Return value	0: Distance to the object is shorter than 10 m 1: Distance from the object is more than 10 m

Display_Distance()	
Outline	Process to send drawing data to LCD module
Header	-
Declaration	static void Display_Distance(uint8_t more_than_10ms_flag);
Description	Transfers the drawing data generated by Calc_Distance() to the LCD module.
Arguments	more_than_10m_flag = 0: Distance to the object is shorter than 10 m more_than_10m_flag = 1: Distance from the object is more than 10 m
Return value	None

r_Config_IICA0_callback_master_sendend()	
Outline	IICA0 send end callback processing.
Header	r_cg_macrodriver.h, Config_IICA0.h, LCM_driver.h
Declaration	static void r_Config_IICA0_callback_master_receiveend(void);
Description	Callback function called when an IICA0 transmission completion interrupt is generated. Generate stop conditions, and then call the LCD module communication end flag setting function.
Arguments	None
Return value	None

r_Config_IICA0_callback_master_error()	
Outline	IICA0 error callback processing.
Header	r_cg_macrodriver.h, Config_IICA0.h, LCM_driver.h
Declaration	static void r_Config_IICA0_callback_master_error(MD_STATUS flag);
Description	Callback function called when an IICA0 transmission error interrupt is generated Call the LCD module communication end flag setting function.
Arguments	MD_STATUS flag : error type
Return value	None

r_LCM_init()	
Outline	LCD module Initialization
Header	LCM_driver.h, Config_IICA0.h
Declaration	void r_LCM_init(void);
Description	Initializes LCD module.
Arguments	None
Return value	None

r_LCM_clear()	
Outline	LCD module display clear processing
Header	LCM_driver.h, Config_IICA0.h
Declaration	void r_LCM_clear(void);
Description	Transmit the display clear command to the LCD module.
Arguments	None
Return value	None

r_LCM_send_string()	
Outline	LCD module character string transmission processing
Header	LCM_driver.h, Config_IICA0.h
Declaration	void r_LCM_send_string(uint8_t * const str, lcm_position_t pos);
Description	Display the character string transferred with str on the LCD module. The line to display the character string is specified by pos.
Arguments	uint8_t * const str: Character string to be displayed lcm_position_t pos: LCM_POSITION_TOP: Displayed at the top LCM_POSITION_BOTTOM: Displayed at the bottom
Return value	None

r_LCM_send_command()	
Outline	LCD module command transmission processing
Header	LCM_driver.h, Config_IICA0.h
Declaration	void r_LCM_send_command(uint8_t command);
Description	Send the command transferred with command to the LCD module.
Arguments	uint8_t command: Command to be sent to the LCD module
Return value	None

r_LCM_send_data()	
Outline	LCD module data transmission processing
Header	LCM_driver.h, Config_IICA0.h
Declaration	void r_LCM_send_data(uint8_t data);
Description	Send the data transferred with data to the LCD module.
Arguments	uint8_t data: Data to be sent to the LCD module
Return value	None

r_LCM_turn_sendend_on()	
Outline	LCD module communication end flag setting
Header	LCM_driver.h, Config_IICA0.h
Declaration	void r_LCM_turn_sendend_on(void);
Description	Set the I2C communication (with the LCD module) end flag for g_LCM_is_sendend.
Arguments	None
Return value	None

r_LCM_wait_sendend()	
Outline	LCD module communication end wait processing
Header	LCM_driver.h, Config_IICA0.h
Declaration	static void r_LCM_wait_sendend(void);
Description	Wait until the I2C communication (with the LCD module) ends, and then perform wait processing during the command execution wait time period (10 ms).
Arguments	None
Return value	None

wait_us()	
Outline	us unit time wait processing
Header	Config_TAU0_2.h
Declaration	void wait_us(uint16_t wait_time);
Description	Wait for the time (us unit) specified by the argument.
Arguments	Wait time
Return value	None

wait_ms()	
Outline	ms unit time wait processing
Header	Config_TAU0_3.h
Declaration	void wait_ms(uint16_t wait_time);
Description	Wait for the time (ms unit) specified by the argument.
Arguments	Wait time
Return value	None

r_Config_TAU0_2_interrupt()	
Outline	Timer Array Unit Channel 2 interrupt processing
Header	-
Declaration	static void __near r_Config_TAU0_2_interrupt(void);
Description	Timer Array Unit Interrupt processing for channel 2.
Arguments	None
Return value	None

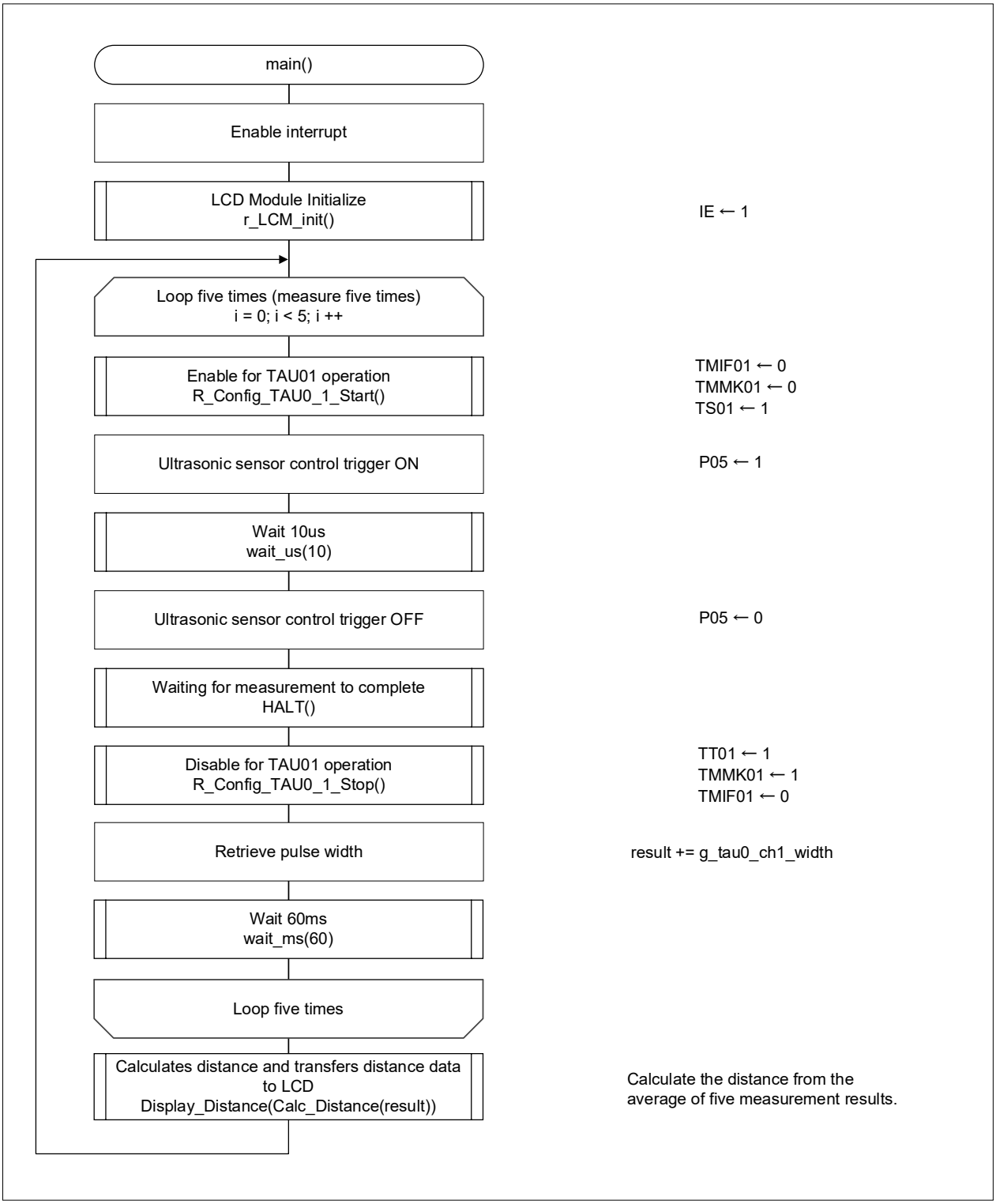
r_Config_TAU0_3_interrupt()	
Outline	Timer Array Unit Channel 3 interrupt processing
Header	-
Declaration	static void __near r_Config_TAU0_3_interrupt(void);
Description	Timer Array Unit Interrupt processing for channel 3.
Arguments	None
Return value	None

4.6 Flowcharts

4.6.1 Main Processing

Figure 4.1 Shows the flowchart of main processing.

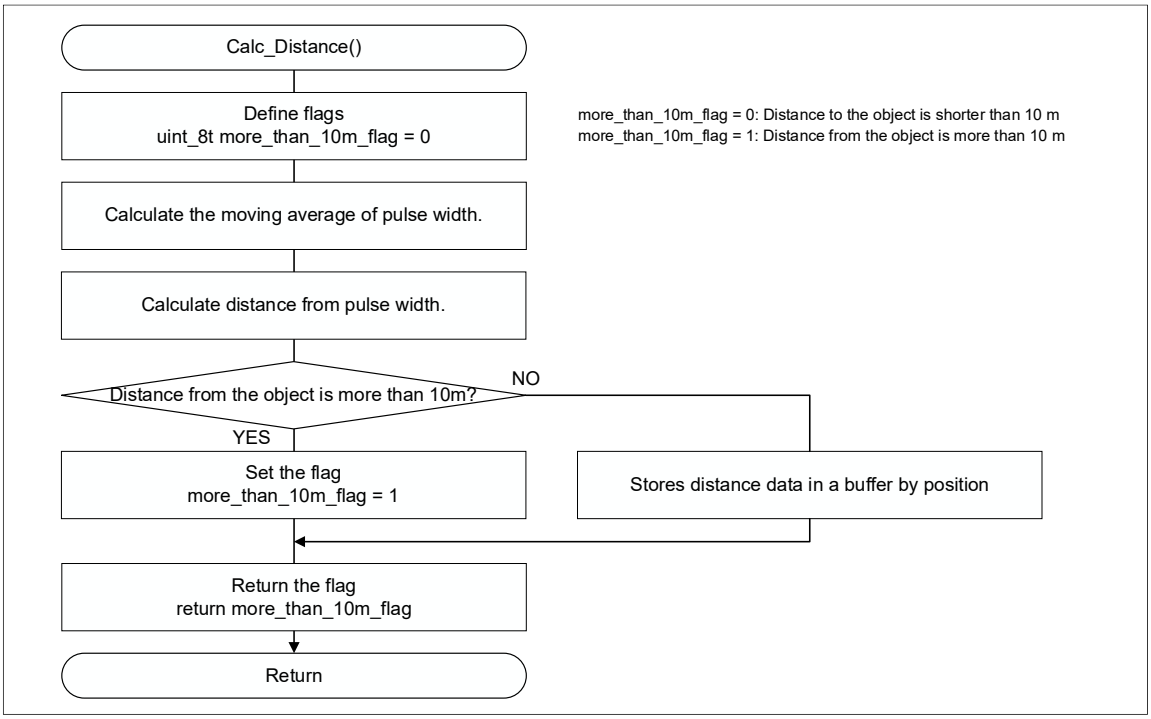
Figure 4.1 Main Processing



4.6.2 Process to Convert High Level Width Measurement Results to Distance

Figure 4.2 shows the flowchart of Process to convert high level width measurement results to distance.

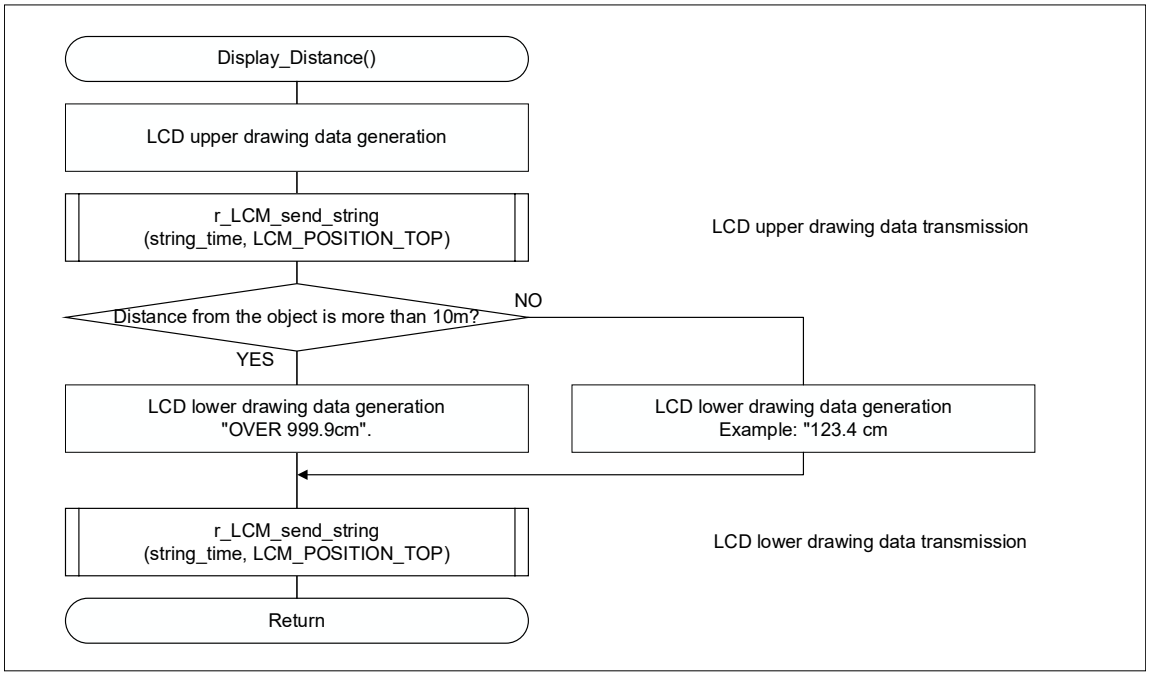
Figure 4.2 Process of Converting High level Width Measurement Results into Distance.



4.6.3 Process to Send Drawing Data to LCD Module

Figure 4.3 shows the flowchart of LCD character display initialization function.

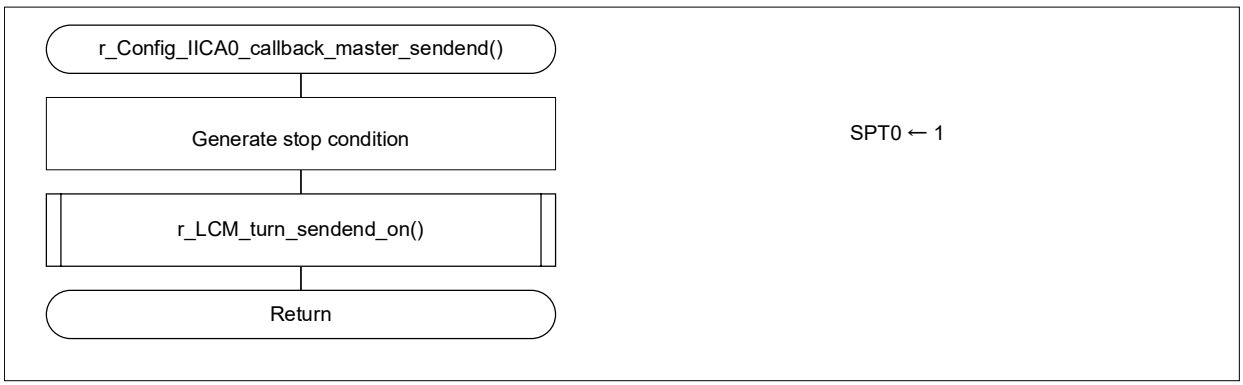
Figure 4.3 Process to Send Drawing Data to LCD Module.



4.6.4 IICA0 Send End Callback Processing

Figure 4.4 shows the flowchart of IICA0 send end callback processing.

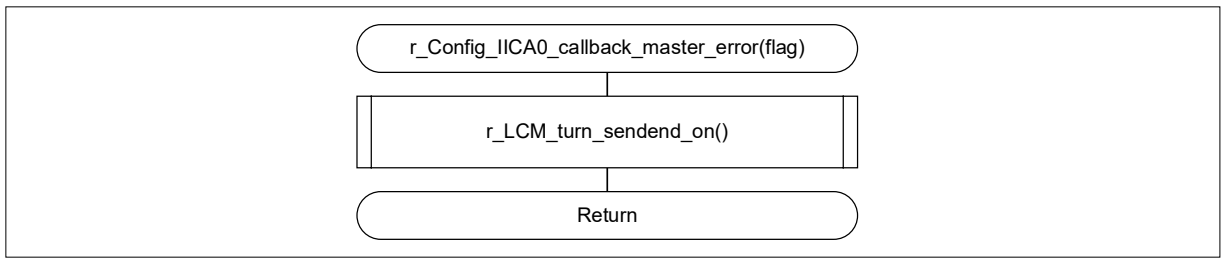
Figure 4.4 IICA0 Send End Callback Processing.



4.6.5 IICA0 Error Callback Processing

Figure 4.5 shows the flowchart of the IICA0 error callback processing.

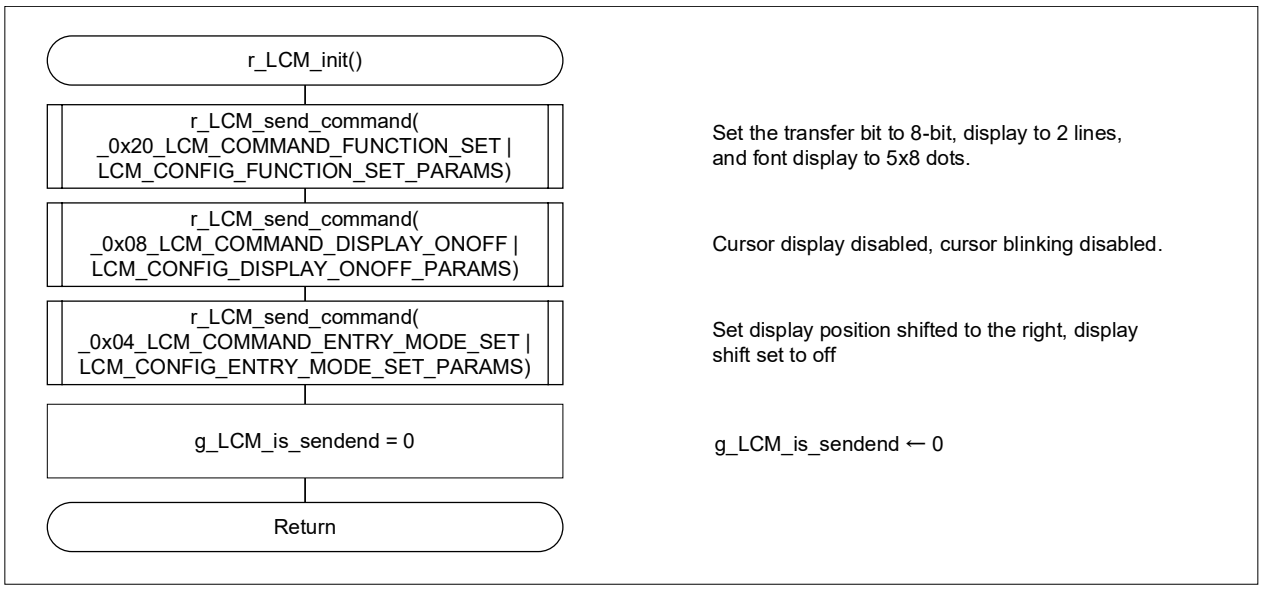
Figure 4.5 IICA0 Error Callback Processing



4.6.6 LCD Module Initialization

Figure 4.6 show the flowchart of the LCD module initialization.

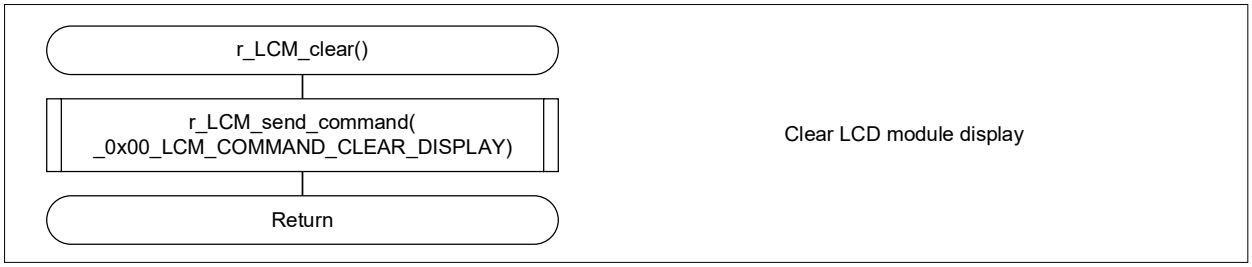
Figure 4.6 IICA0 Error Callback Processing



4.6.7 LCD Module Display Clear Processing

Figure 4.7 shows the flowchart of TAU00 operation start function.

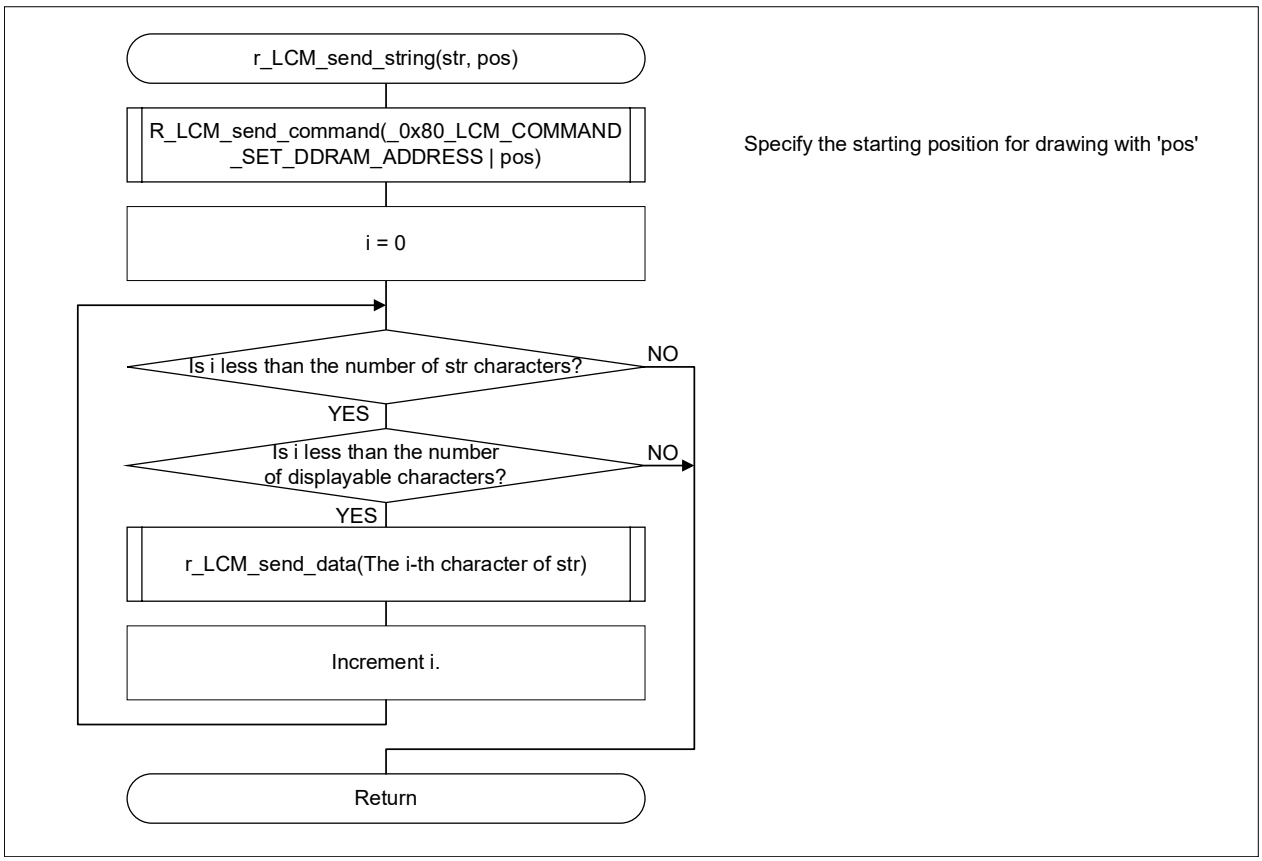
Figure 4.7 LCD Module Display Clear Processing



4.6.8 LCD Module Character String Transmission Processing

Figure 4.8 shows the flowchart of LCD Module Character String Transmission Processing

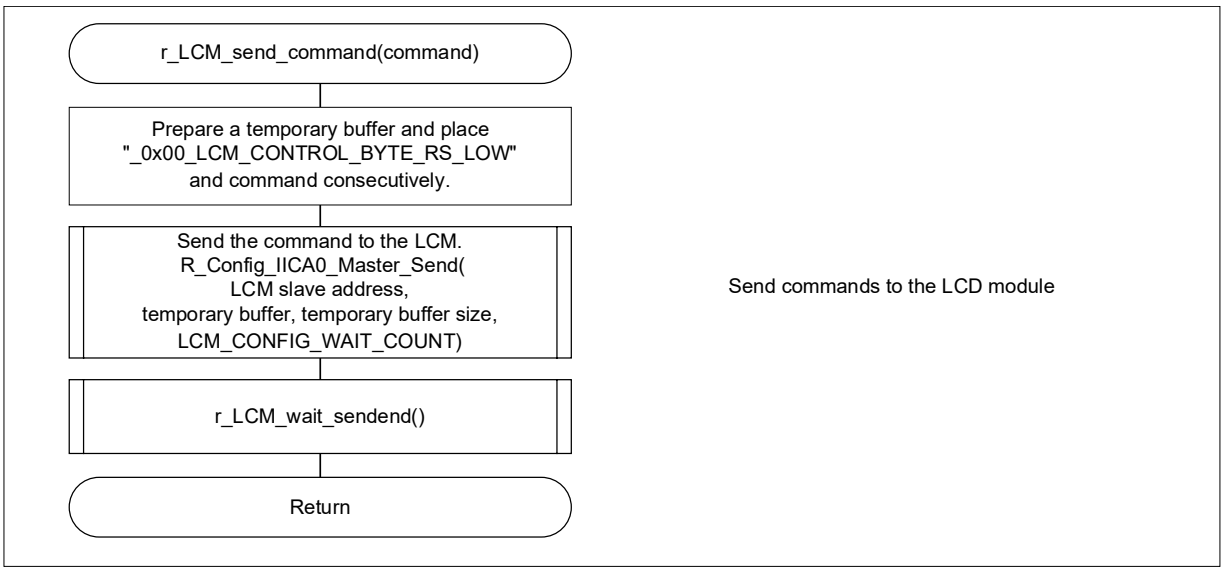
Figure 4.8 LCD Module Character String Transmission Processing



4.6.9 LCD Module Command Transmission Processing

Figure 4.9 shows the flowchart of the command transmission processing for the LCD module.

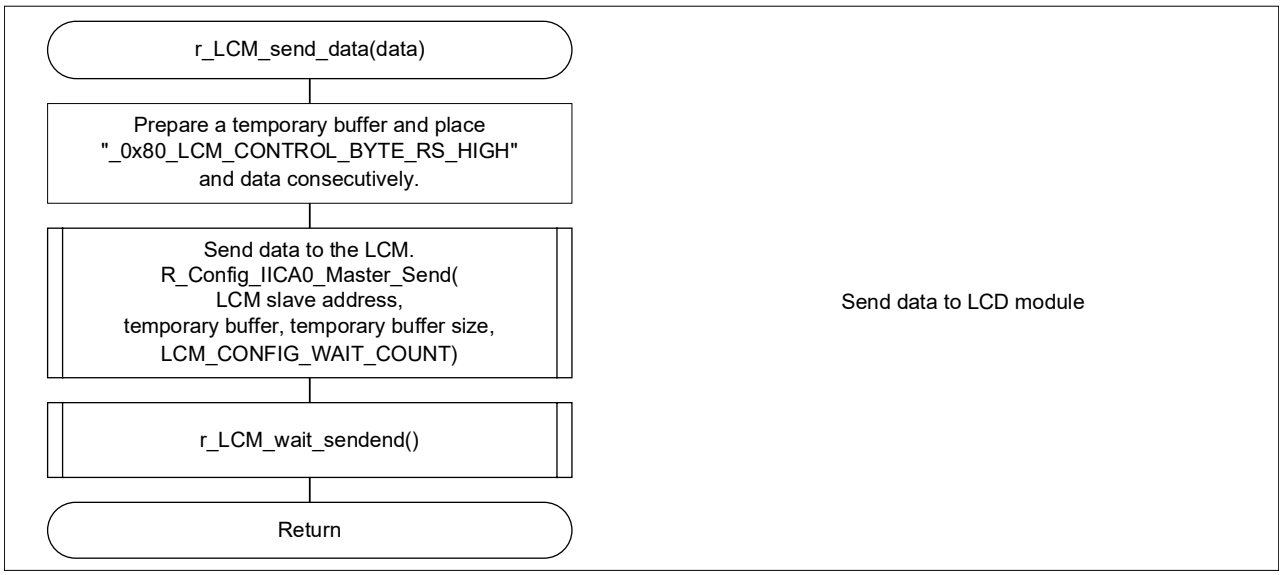
Figure 4.9 LCD Module Command Transmission Processing



4.6.10 LCD Module Data Transmission Processing

Figure 4.10 shows the flowchart of TAU00 interrupt function

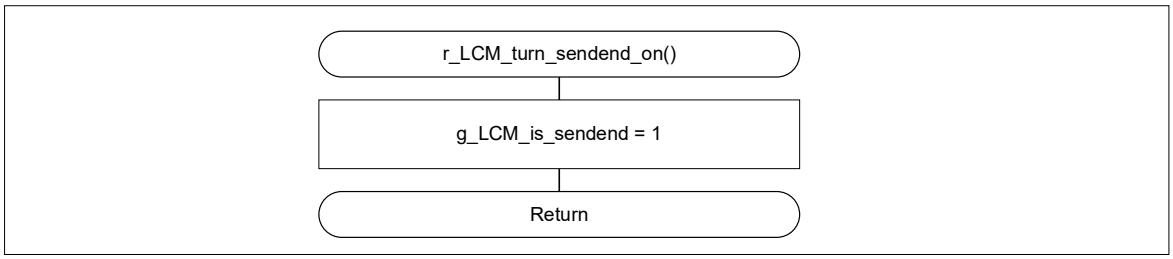
Figure 4.10 LCD Module Data Transmission Processing



4.6.11 LCD Module Communication End Flag Setting

Figure 4.11 shows the flowchart of TAU00 interrupt function

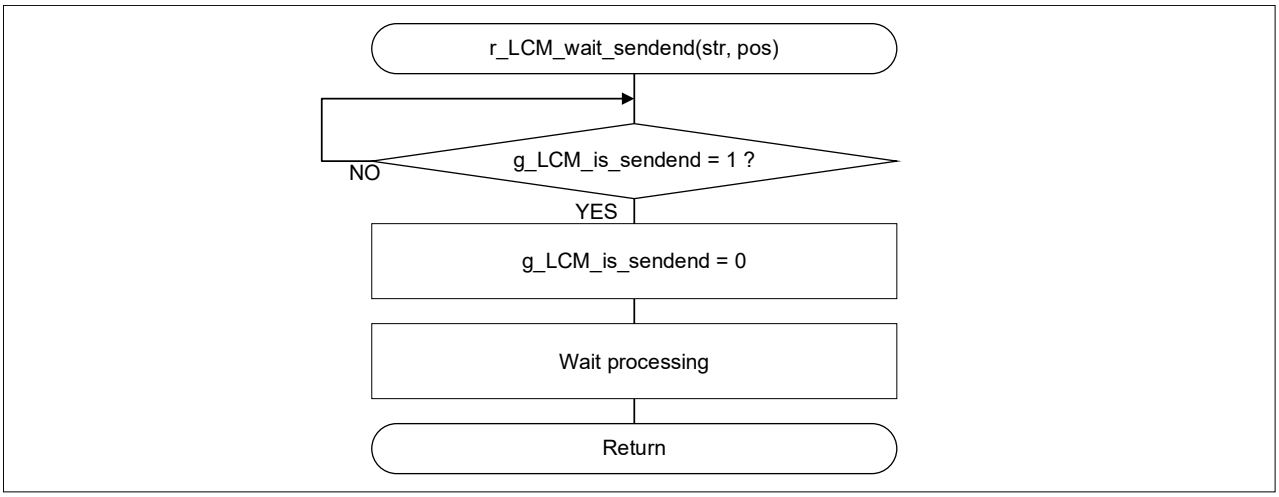
Figure 4.11 LCD Module Communication End Flag Setting



4.6.12 LCD Module Communication End Wait Processing

Figure 4.12 shows the flowchart of TAU00 interrupt function

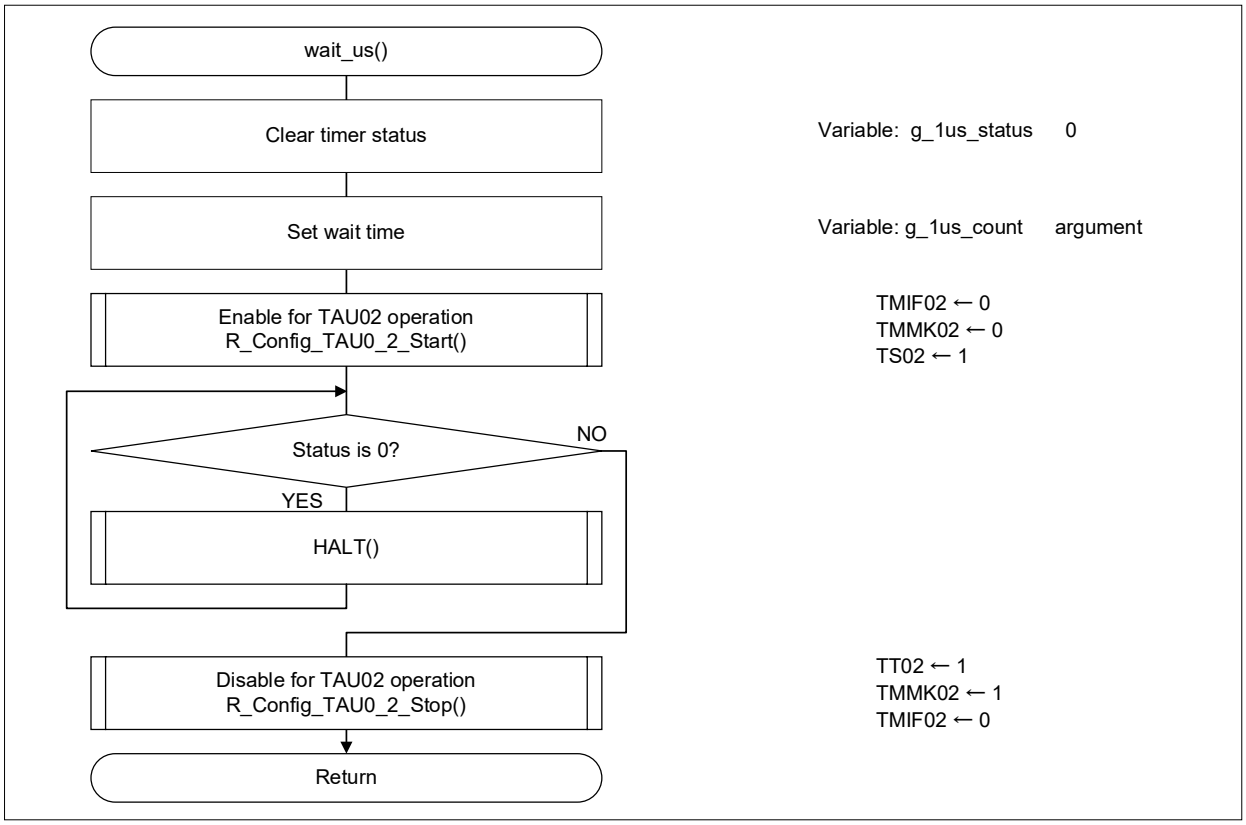
Figure 4.12 LCD Module Communication End Wait Processing



4.6.13 Time Wait Processing in us units

Figure 4.13 shows the flowchart of the time wait processing in us units.

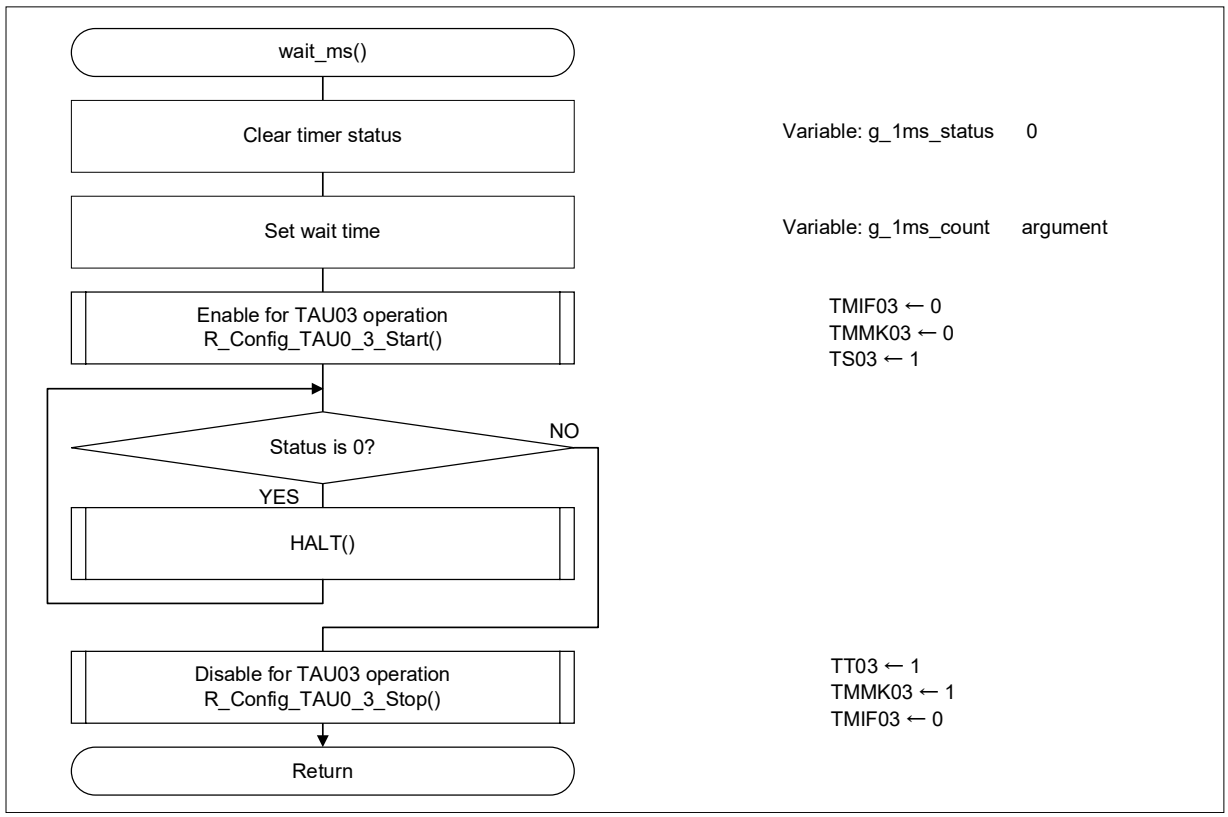
Figure 4.13 Time Wait Processing in us units



4.6.14 Time Wait Processing in ms units

Figure 4.14 shows the flowchart of the time wait processing in ms units.

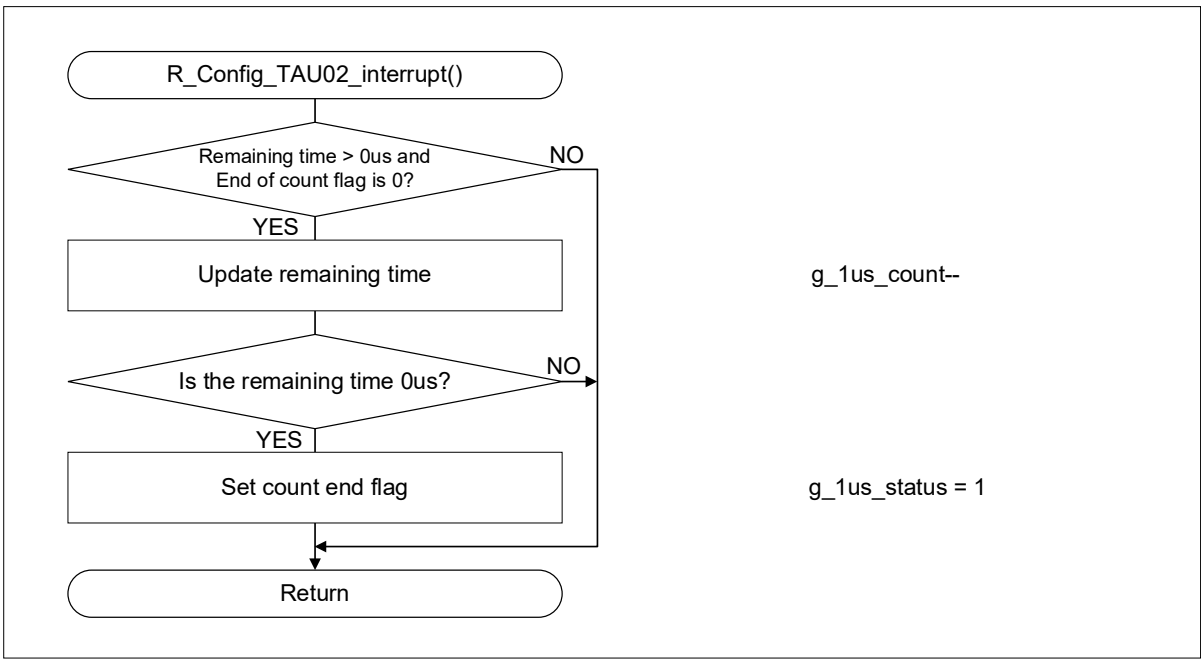
Figure 4.14 Time Wait Processing in ms units



4.6.15 Time Array Unit Channel2 Interrupt Processing

Figure 4.15 shows the flowchart of the time array unit channel2 interrupt processing.

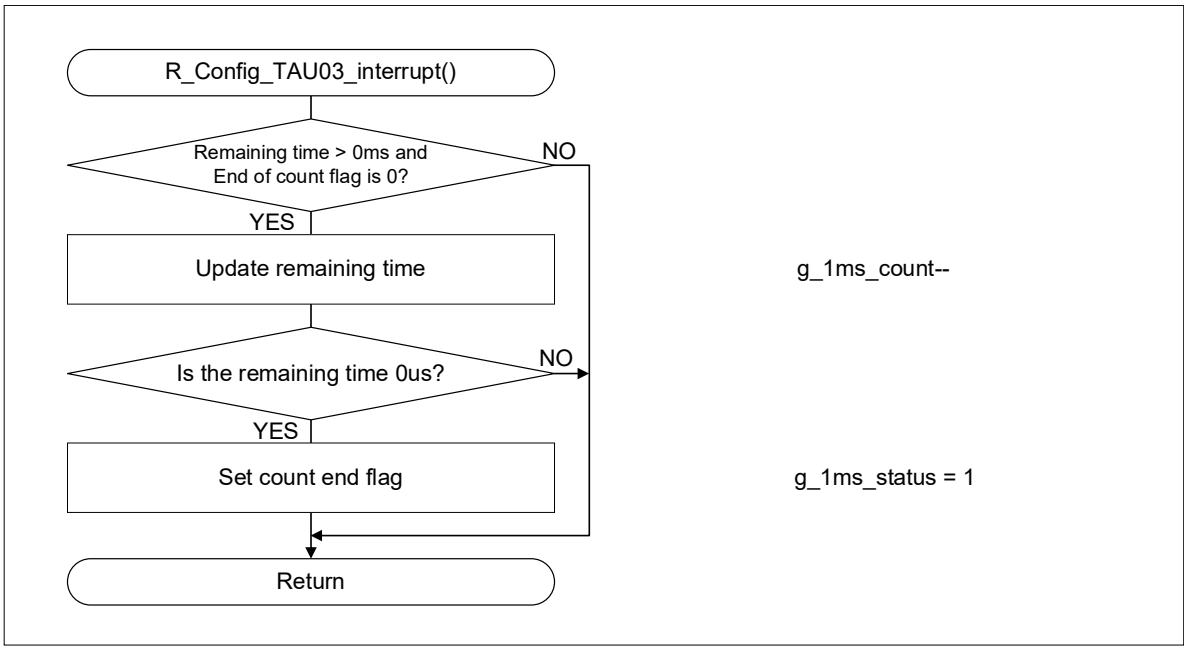
Figure 4.15 Time Array Unit Channel2 Interrupt Processing



4.6.16 Time Array Unit Channel3 Interrupt Processing

Figure 4.16 shows the flowchart of the time array unit channel3 interrupt processing.

Figure 4.16 Time Array Unit Channel3 Interrupt Processing



5. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

6. Reference Documents

RL78/G16 User’s Manual: Hardware (R01UH0980E)
RL78 family user's manual software (R01US0015E)
RL78 Smart Configurator User’s Guide: CS+ (R20AN0580E)
RL78 Smart Configurator User’s Guide: e2 studio (R20AN0579E)
The latest versions can be downloaded from the Renesas Electronics website.

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

LCD module datasheet
(ACM1602NI-FLW-FBW-M01 (ZETTLER DISPLAYS) CHARACTER MODULE VER1.4)

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Nov.20.2023	-	First edition

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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Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu, Koto-ku, Tokyo 135-0061, Japan

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