RL78/G15

Digital angle meter using I2C communication

Introduction

This application note explains how to receive acceleration data from a gyro sensor (BMX055), convert it into angle data, and display the sensor's tilt information on an LCD (ACM1602NI-FLW-FBW-M01) using I2C communication.

Target Device

RL78/G15

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.

Content

1. Specifications

1.1 Basic specifications as a master on the I2C bus

The specifications for the I2C bus are as follows;

- Standard mode (transfer clock 85 kbps)

  Target slaves (LCD display, gyro sensor)

- LCD display (ACM1602NI-FLW-FBW-M01) address : 0b1010000 (0x50)
- Gyro sensor (BMX055) address : 0b1101001 (0x69)

Table 1-1 shows the peripheral functions used and their use.

Table 1-1 Peripheral functions used and their use

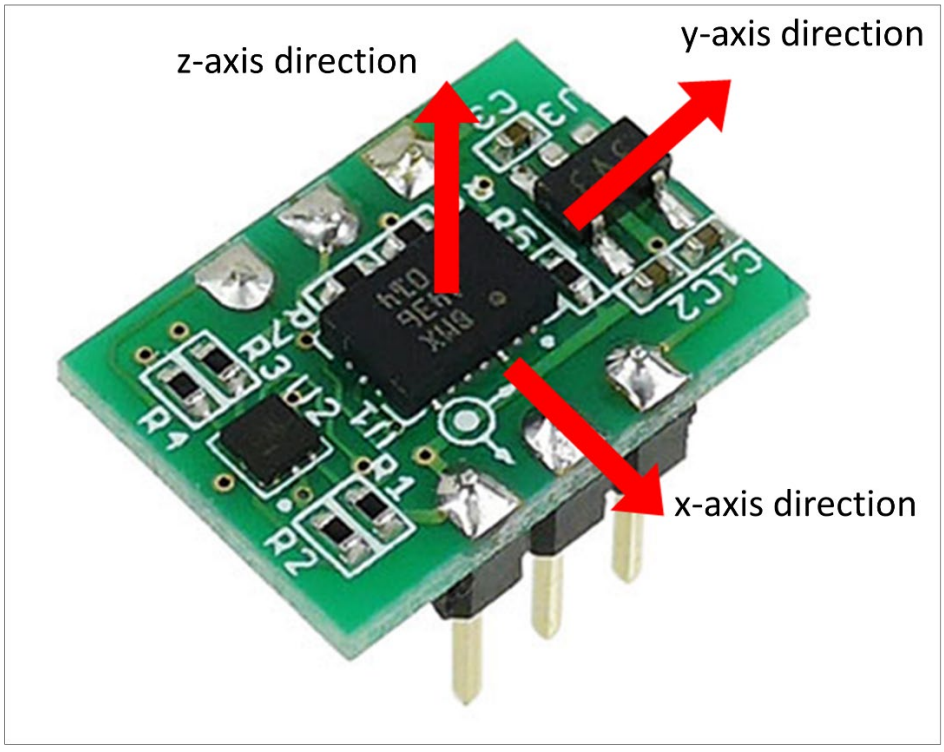
Peripheral function	Use
IICA0	Operation as a master function on the I2C bus
TAU0	1ms *interval timer interrupt

1.2 Overview of Operation

Specify the registers of the gyro sensor (BMX055) and read the acceleration data one byte at a time. Convert that data into angles and send it to the LCD display (ACM1602NI-FLW-FBW-M01) to visualize the angles in the x and y directions.

Below, the axis directions (Figure 1-1) and the method for calculating angles for the gyro sensor (BMX055) are described.

Figure 1-1 The axis direction of the gyro sensor (BMX055)



<Method for calculating angles>

The data sent from the gyro sensor (BMX055) is 16-bit acceleration data, but it is initially configured with a full scale of ±125 (degree/s). To convert it to units of degrees/s, you can use the following calculation.

Angular Velocity (degree/s) = Gyro × 0.0038

*The LSB of the 16-bit data is approximately 0.0038 (since 250/65536 ≈ 0.0038).

Next, you can convert the angular velocity (degree/s) obtained from the above formula to angles (degree).

Since you are receiving data from the gyro sensor (BMX055) every 100 milliseconds, you can calculate the angle using the following formula.

Angle (degree) = ((Angular Velocity (degree/s)) + (Previous Angular Velocity (degree/s))) × 0.1 (s) ÷ 2

Below are the initial settings for each function, the gyro sensor, and the LCD display.

(1) IICA0 initialization

＜Setting conditions＞

- Use the P06 pin as the SCLA0 pin.
- Use the P07 pin as the SDAA0 pin.
- Set the operation mode to standard mode and the transfer clock (f_{SCL}) to 85 kbps.
- For the interrupt priority level, select “Level 3 lowest priority (default)”.

(2) TAU0 initialization

＜Setting conditions＞

- Set the operating clock to CK00.
- Set the clock source to f_{CLK} (16000 kHz).
- Set the interval time to 1ms. (Do not generate INTTM0 interrupt at the start of counting.)
- For the interrupt priority level, select “Level 0 highest priority”.

(3) LCD display (ACM1602NI-FLW-FBW-M01) initialization

＜Setting conditions＞

- The address is set to 0x50.
- Display the angle in the x-axis direction on the first line and the angle in the y-axis direction on the second line.

(4) Gyro sensor (BMX055) initialization

＜Setting conditions＞

- The address is set to 0x69.
- Set the measurement range to ±125 (degree/s).
- Set the output rate to 100 (Hz).
- Set the power mode to Normal mode (default).

2. Operation Evaluate Conditions

The sample code contained in this application note has been checked under the conditions listed in the table below.

Table 2-1 Operation Check Conditions

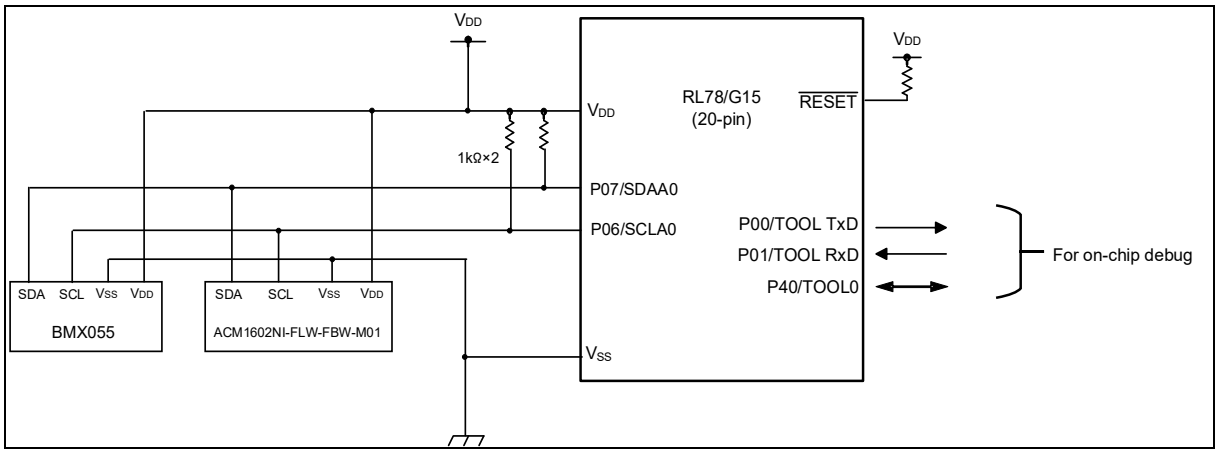
Item	Description
Microcontroller used	RL78/G15 (R5F12608ASP)
Board to be used	RL78/G15-20p Fast Prototyping Board (RTK5RLG150C00000BJ)
Operating frequency	HOCO (f_{IH}) : 16MHz
Operating voltage	5.0V (Operation is possible over a voltage range of 2.4 to 5.5V.)
Integrated development environment(CS+)	CS+ for CC V8.09.00 from Renesas Electronics Corp.
Assembler (CS+)	CC-RL V1.12.00 from Renesas Electronics Corp.
Integrated development environment (e2studio)	e2studio V2023-04(23.4.0) from Renesas Electronics Corp.
Assembler(e2studio)	CC-RL V1.12.00 from Renesas Electronics Corp.
Integrated development environment (IAR)	IAR Embedded Workbench for Renesas RL78 V5.10.1 from IAR Systems.
Assembler(IAR)	IAR C/C++ Compiler for Renesas RL78 V5.10.1 from IAR Systems.
Smart Configurator (SC)	V1.6.0
Board Support Package(BSP)	V1.60

3. Description of the Hardware

3.1 Hardware Configuration Example

Figure 3-1 shows an example hardware configuration used in this application note.

Figure 3-1 Hardware Configuration



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

3.2 List of Pins to be Used

Table 3-1 lists the pins to be used and their functions.

Table 3-1 Pins to be Used and their Functions

Pin Name	I/O	Description
P06/SCLA0	Output	Serial Clock
P07/SDAA0	Output	Serial Data Bus

Note. This application note only demonstrates the handling of the used pins. When creating an actual circuit, please ensure appropriate pin handling and design the circuit to meet electrical characteristics.

4. Description of the Software

4.1 List of Option Byte Settings

Table 4-1 summarizes the settings of the option bytes.

Table 4-1 Option Byte Settings

Address	Value	Description
000C0H	11101111B	Disables the watchdog timer. (Stops counting after the release from the reset state.)
000C1H	11110111B	At Rising: TYP. 2.90V At Falling: TYP.2.84V
000C2H	11111001B	HOCO：16MHz
000C3H	10000101B	Enables the on-chip debugger

4.2 List of functions

Table 4-2 shows the list of functions.

Table 4-2 List of functions

Function Name	Overview
main()	Main processing
R_init_LCD()	LCD initialization function
R_init_sensor()	Gyro sensor initialization function
R_IICA0_start_condition()	Start condition generation function
R_IICA0_stop_condition()	Stop condition generation function
R_IICA0_transmit()	I2C transmission function
send_command_LCD()	Command transmission function (LCD)
send_data_LCD()	Data transmission function (LCD)
send_range_sensor()	Function for setting the measurement range for the gyro sensor
send_rate_sensor()	Function for setting the output rate for the gyro sensor
send_powermode_sensor()	Function for setting the power mode for the gyro sensor
send_register_select_sensor()	Function for setting registers in the gyro sensor
R_IICA0_receive_sensor_data()	I2C receive function
R_gyrodata_angle()	Angle calculation function
wait_3ms()	3ms delay function
Gyro_modify	Gyro drift correction function
r_Config_TAU0_0_interrupt()	1ms interval timer interrupt processing function

4.3 Function Specifications

Below are the function specifications for the sample code.

main()	
Overview	Main processing
Header	r_smc_entry.h
Declaration	void main(void)
Explanation	Initialize the LCD and gyro sensor, and perform periodic tasks.
Arguments	—
Return value	—

R_init_LCD()	
Overview	LCD initialization function
Header	r_smc_entry.h
Declaration	void R_init_LCD(void)
Explanation	Use the serial data bus to send initial data to the LCD.
Arguments	—
Return value	—

R_init_sensor()	
Overview	Gyro sensor initialization function
Header	r_smc_entry.h
Declaration	void R_init_sensor(void)
Explanation	Use the serial data bus to set the measurement range, output rate, and power mode of the gyro sensor.
Arguments	—
Return value	—

R_IICA0_start_condition()	
Overview	Start condition generation function
Header	r_smc_entry.h
Declaration	void R_IICA0_start_condition(uint8_t addr)
Explanation	Generate a start condition and send the address and address direction.
Arguments	uint8_t addr
Return value	—

R_IICA0_stop_condition()	
Overview	Stop condition generation function
Header	r_smc_entry.h
Declaration	void R_IICA0_stop_condition(void)
Explanation	Generating a stop condition.
Arguments	uint8_t addr
Return value	—

R_IICA0_transmit()	
Overview	I2C transmission function
Header	r_smc_entry.h
Declaration	void R_IICA0_transmit(uint8_t data)
Explanation	Assign the transmit data to the shift register and transmit the data.
Arguments	uint8_t data
Return value	—

send_command_LCD()	
Overview	Command transmission function (LCD)
Header	r_smc_entry.h
Declaration	void send_command_LCD(uint8_t comcode)
Explanation	Send the command value represented by the variable comcode to the LCD.
Arguments	uint8_t comcode
Return value	—

send_data_LCD()	
Overview	Data transmission function (LCD)
Header	r_smc_entry.h
Declaration	void send_data_LCD(uint8_t datacode)
Explanation	Send the data represented by the variable datacode to the LCD.
Arguments	uint8_t datacode
Return value	—

send_range_sensor()	
Overview	Function for setting the measurement range for the gyro sensor
Header	r_smc_entry.h
Declaration	void send_range_sensor(uint8_t datacode)
Explanation	Send the Measurement Range Setting Register address (0x0F) and the setting value represented by the variable datacode to the gyro sensor.
Arguments	uint8_t datacode
Return value	—

send_rate_sensor()	
Overview	Function for setting the output rate for the gyro sensor
Header	r_smc_entry.h
Declaration	void send_rate_sensor(uint8_t datacode)
Explanation	Send the Output Rate Setting Register address (0x10) and the setting value represented by the variable datacode to the gyro sensor.
Arguments	uint8_t datacode
Return value	—

send_powermode_sensor()	
Overview	Function for setting the power mode for the gyro sensor
Header	r_smc_entry.h
Declaration	void send_powermode_sensor(uint8_t datacode)
Explanation	Send the Power Mode Setting Register address (0x11) and the setting value represented by the variable datacode to the gyro sensor.
Arguments	uint8_t datacode
Return value	—

send_register_select_sensor()	
Overview	Function for setting registers in the gyro sensor
Header	r_smc_entry.h
Declaration	void send_register_select_sensor(uint8_t datacode)
Explanation	Send the register address value represented by the variable datacode to the gyro sensor.
Arguments	uint8_t datacode
Return value	—

R_IICA0_receive_sensor_data()	
Overview	I2C receive function
Header	r_smc_entry.h
Declaration	void R_IICA0_receive_sensor_data(void)
Explanation	Read data from the gyro sensor.
Arguments	—
Return value	—

R_gyrodata_angle()	
Overview	Angle calculation function
Header	r_smc_entry.h
Declaration	void R_gyrodata_angle(void)
Explanation	Convert the data received from the gyro sensor into angle data.
Arguments	—
Return value	—

wait_3ms()	
Overview	3ms delay function
Header	r_smc_entry.h
Declaration	void wait_3ms(void)
Explanation	Count for 3 milliseconds.
Arguments	—
Return value	—

Gyro_modify()	
Overview	Gyro drift correction function
Header	r_smc_entry.h
Declaration	void Gyro_modify(void)
Explanation	Correct the angle by 1 degree for the X-axis every 12 seconds and for the Y-axis every 6.8 seconds.
Arguments	—
Return value	—

r_Config_TAU0_0_interrupt()	
Overview	1ms interval timer interrupt processing function
Header	r_cg_macrodriver.h、r_cg_userdefine.h、Config_TAU0_0.h
Declaration	static void __near r_Config_TAU0_0_interrupt(void)
Explanation	Perform a 1 ms interval timer interrupt processing.
Arguments	—
Return value	—

4.4 List of constants

Table 4-3 lists the constants that are used in this sample program.

Table 4-3 Constants for the Sample Program

Constant	Setting	Description
CLRDISP	0x01	Clearing the LCD display
LCD_Mode	0x38	Setting values for the operation mode
DISPON	0x0C	Processing for turning on the display
ENTRY_Mode	0x06	Processing for the entry mode
slaveaddr_lcd	0xA0	Address value of the LCD
slaveaddr_sensor_W	0xD2	Gyro sensor address value + transfer direction (Write)
slaveaddr_sensor_R	0xD3	Gyro sensor address value + transfer direction (Read)

4.5 List of variables

Table 4-4 lists the global variables that are used in this sample program.

Table 4-4 Global Variables for the Sample Program

Type	Variable Name	Contents	Function Used
uint8_t	lcd_number_data[]	LCD display patterns for numbers 0 to 9	main()
uint8_t	counter_3ms	3ms counter	r_Config_TAU0_0_interrupt()
uint8_t	flag_3ms_start	3ms count start flag	r_Config_TAU0_0_interrupt(), wait_3ms()
uint8_t	counter_100ms	100ms counter	main() r_Config_TAU0_0_interrupt()
uint8_t	flag_100ms	100ms count flag	main() r_Config_TAU0_0_interrupt()
uint8_t	counter_12s	12s counter	main() r_Config_TAU0_0_interrupt()
uint8_t	flag_12s	12s count flag	main() r_Config_TAU0_0_interrupt()
uint8_t	counter_6800ms	6.8s counter	main() r_Config_TAU0_0_interrupt()
uint8_t	flag_6800ms	6.8s count flag	main() r_Config_TAU0_0_interrupt()
float	xGyro	x-axis gyro data	R_gyrodata_angle()
float	yGyro	y-axis gyro data	R_gyrodata_angle()
float	xGyro_past	x-axis gyro past data	main(), R_gyrodata_angle()
float	yGyro_past	y-axis gyro past data	main(), R_gyrodata_angle()
float	xAngle	x-axis angle	R_gyrodata_angle()
int	xAngle_disp	x-axis angle (for LCD display)	main(), R_gyrodata_angle()
float	yAngle	y-axis angle	R_gyrodata_angle()
int	yAngle_disp	y-axis angle (for LCD display)	main(), R_gyrodata_angle()
uint8_t	data_receive_counter	Indicating the number of data receptions	main()

4.6 Flowchart

4.6.1 Main Processing

Figure 4-1 through Figure 4-3 show the flowchart for the main processing.

Figure 4-1 Main Processing (1/3)

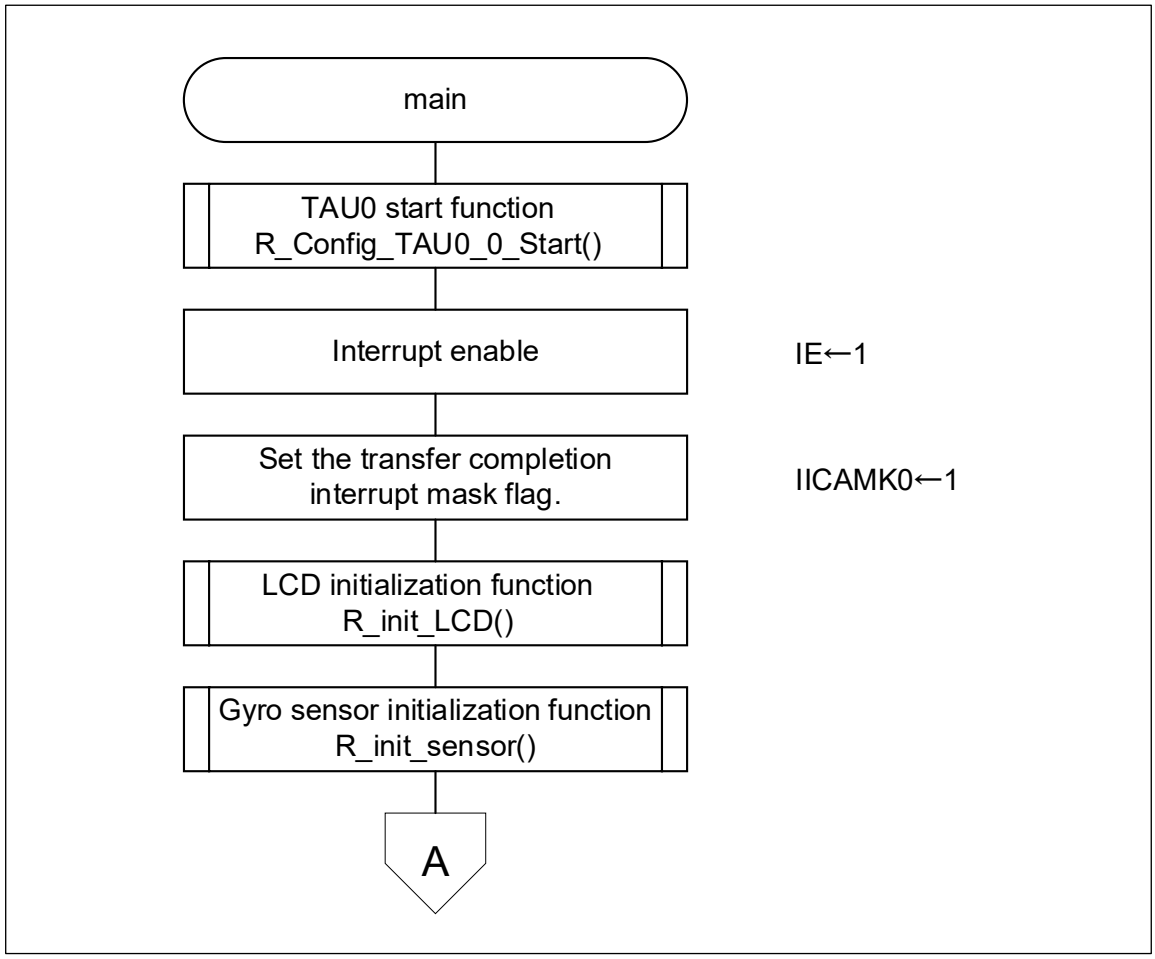


Figure 4-2 Main Processing (2/3)

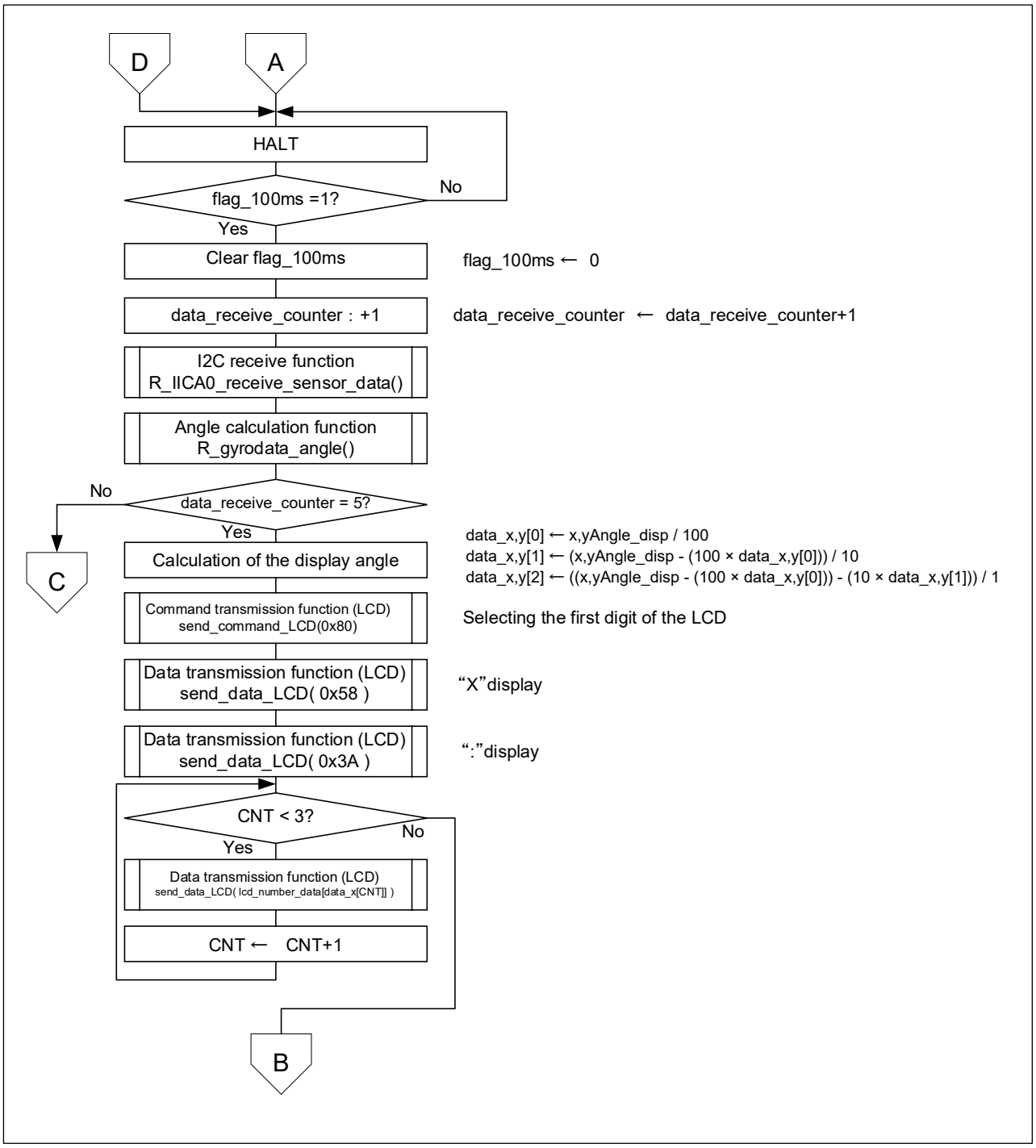
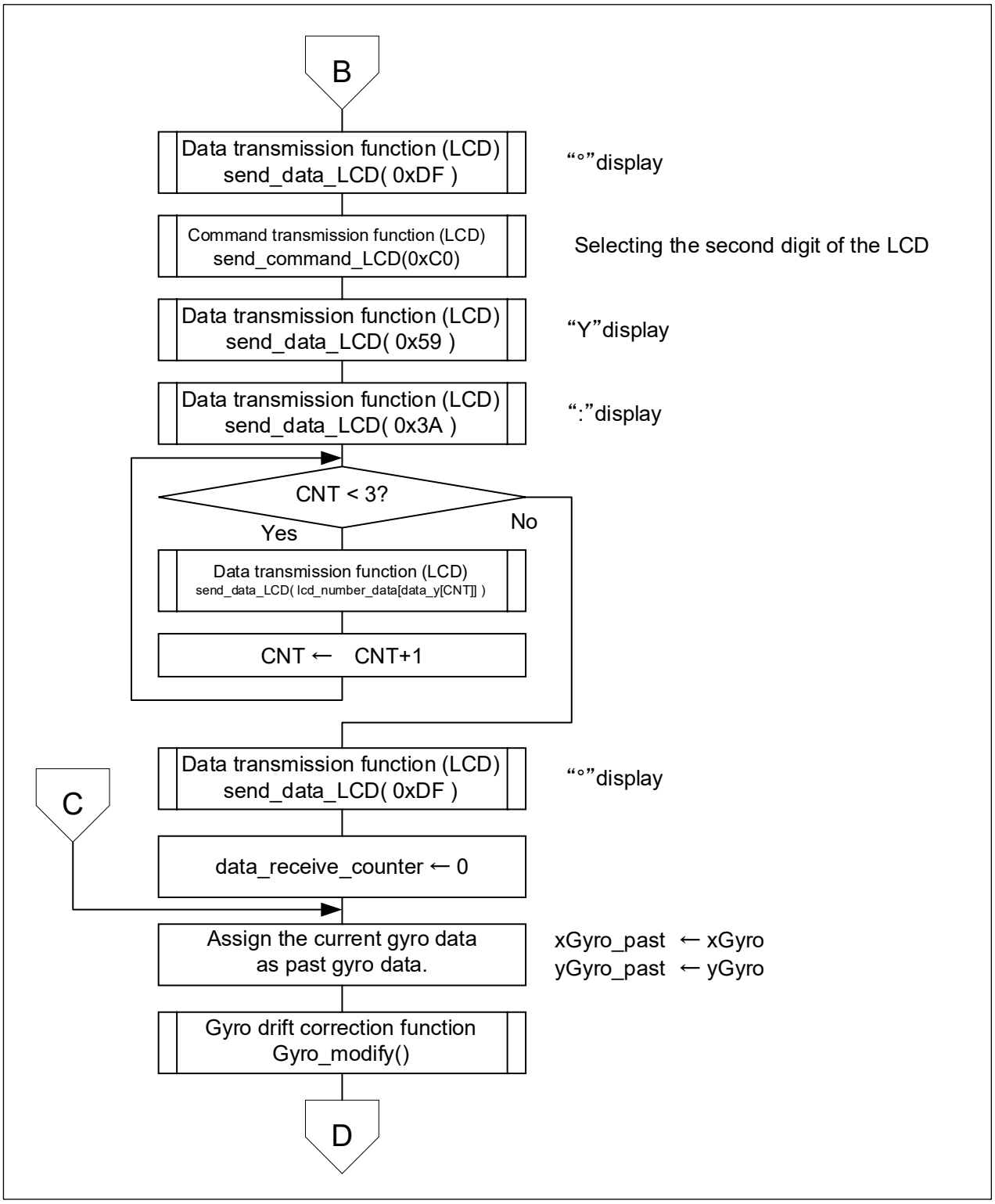


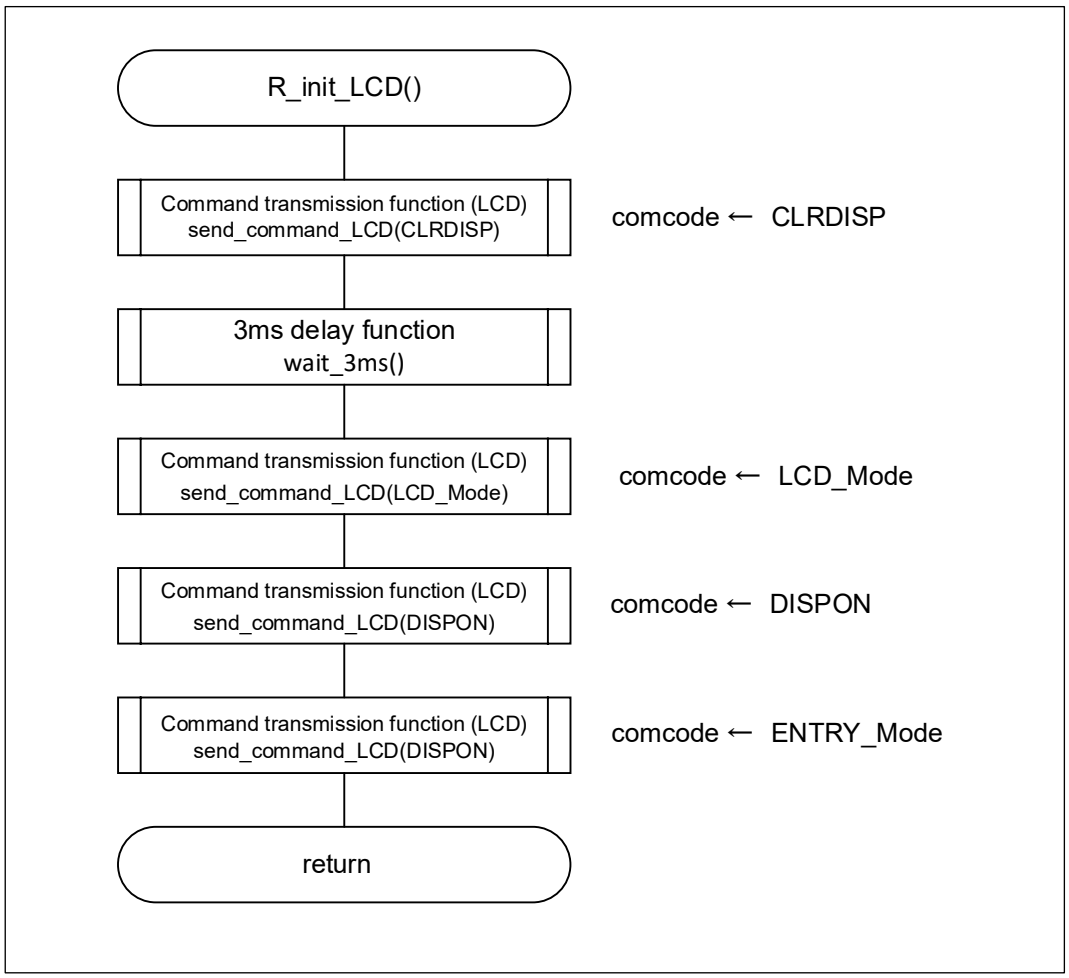
Figure 4-3 Main Processing (3/3)



4.6.2 LCD initialization function

Figure 4-4 show the flowchart for LCD initialization function.

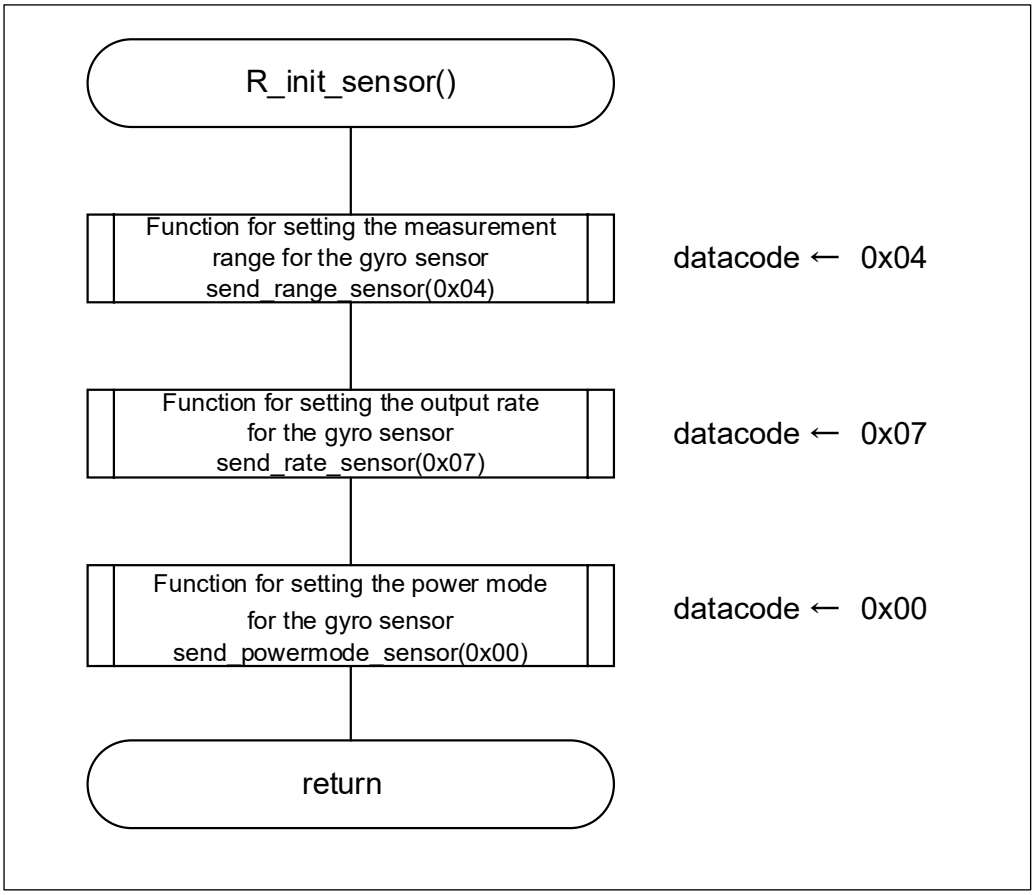
Figure 4-4 LCD initialization function



4.6.3 Gyro sensor initialization function

Figure 4-5 show the flowchart for Gyro sensor initialization function.

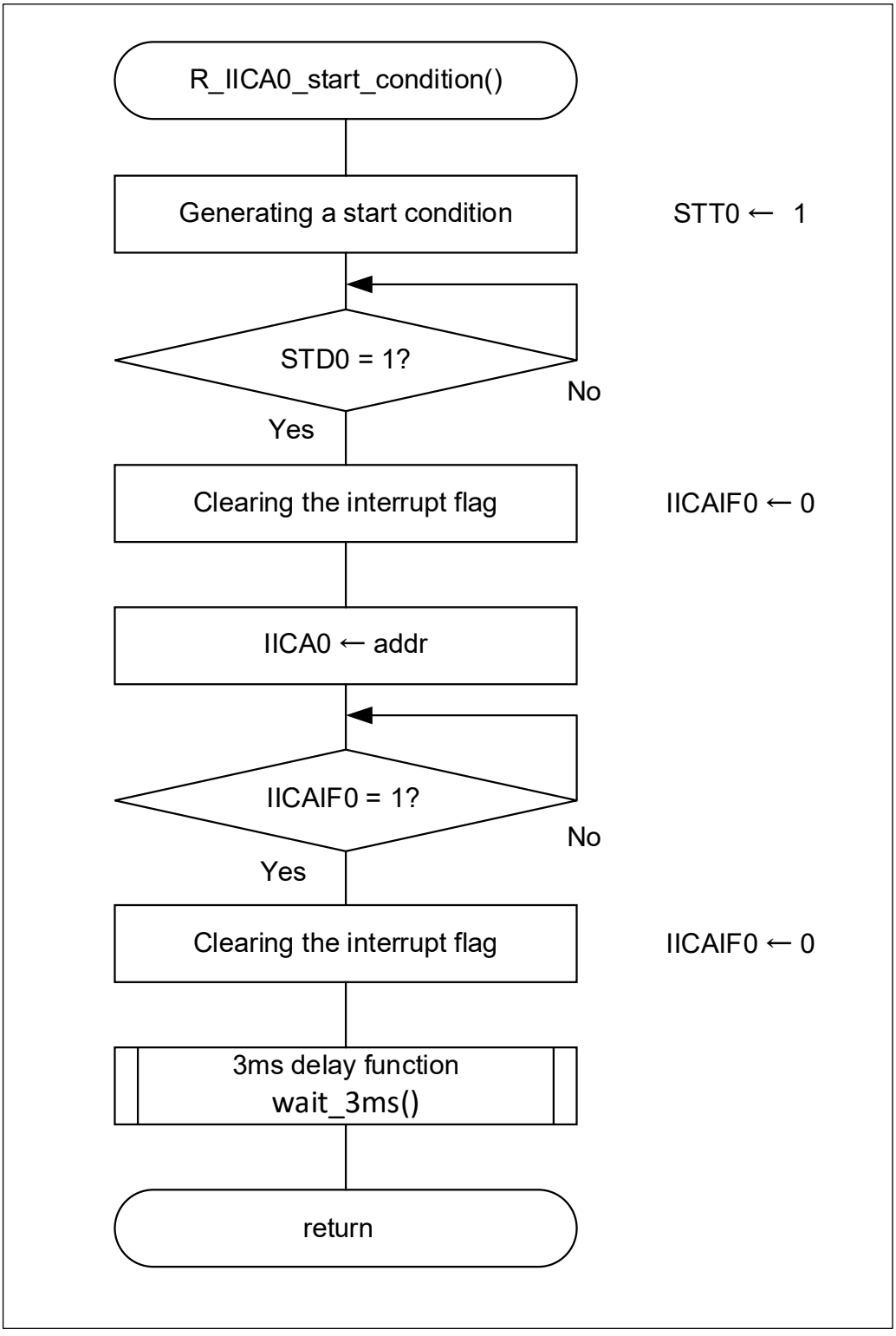
Figure 4-5 Gyro sensor initialization function



4.6.4 Start condition generation function

Figure 4-6 show the flowchart for Start condition generation function.

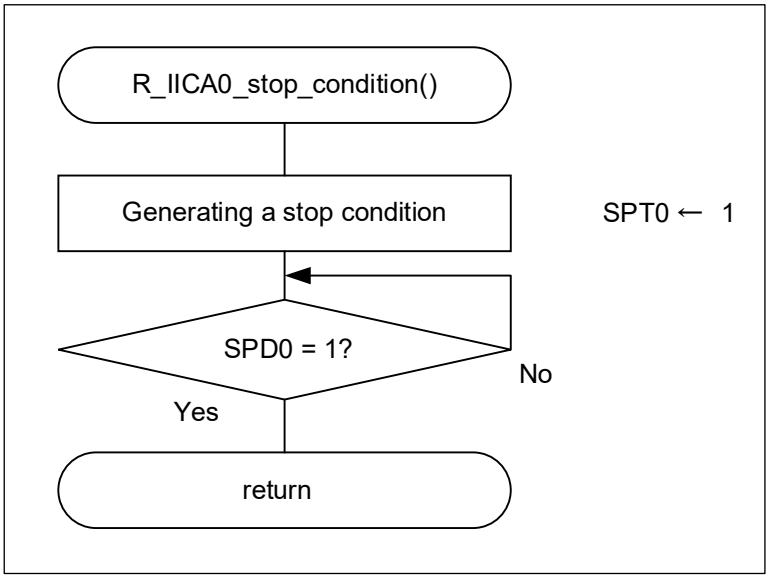
Figure 4-6 Start condition generation function



4.6.5 Stop condition generation function

Figure 4-7 show the flowchart for Stop condition generation function.

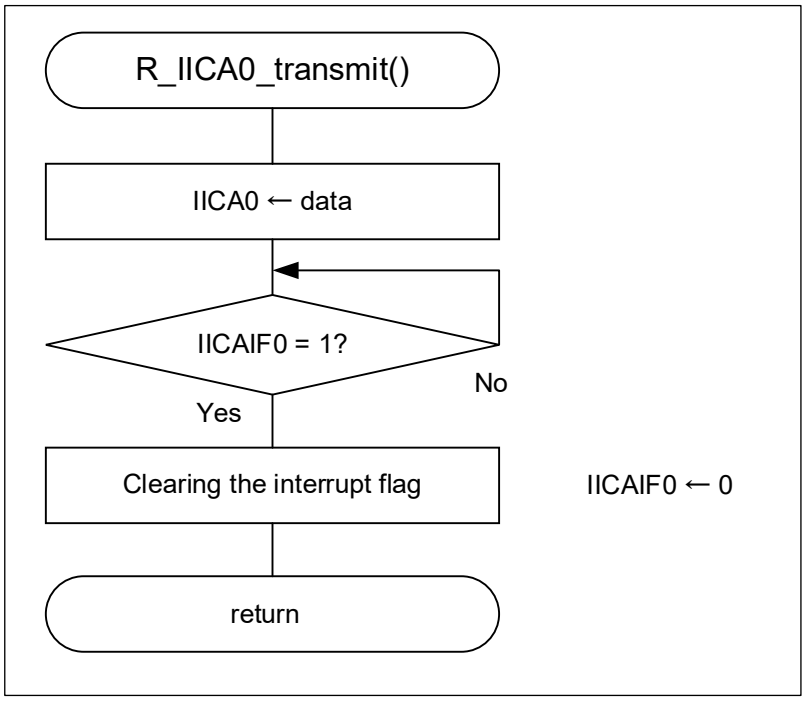
Figure 4-7 Stop condition generation function



4.6.6 I2C transmission function

Figure 4-8 show the flowchart for I2C transmission function.

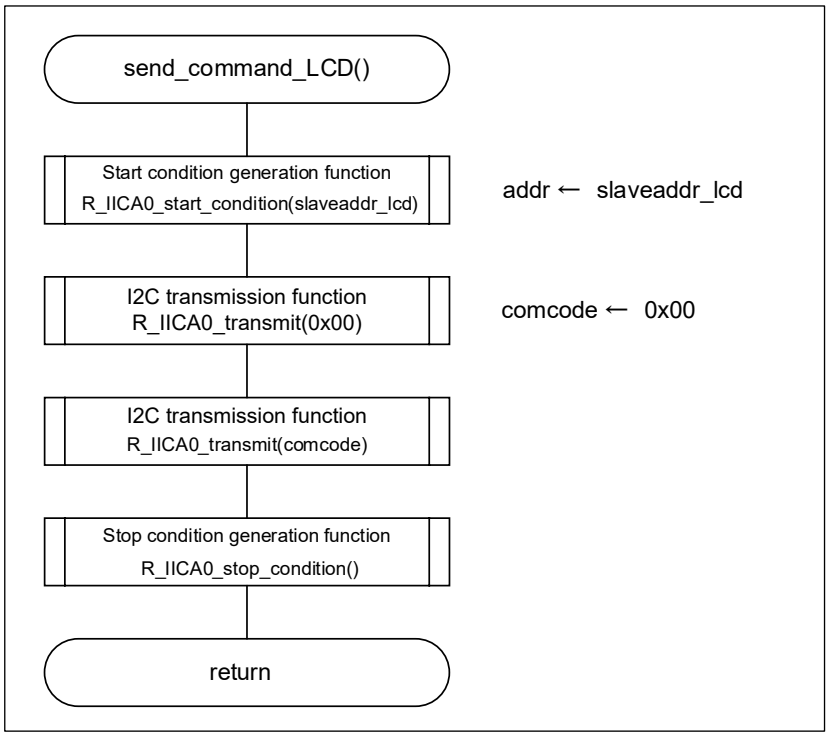
Figure 4-8 I2C transmission function



4.6.7 Command transmission function (LCD)

Figure 4-9 show the flowchart for Command transmission function (LCD).

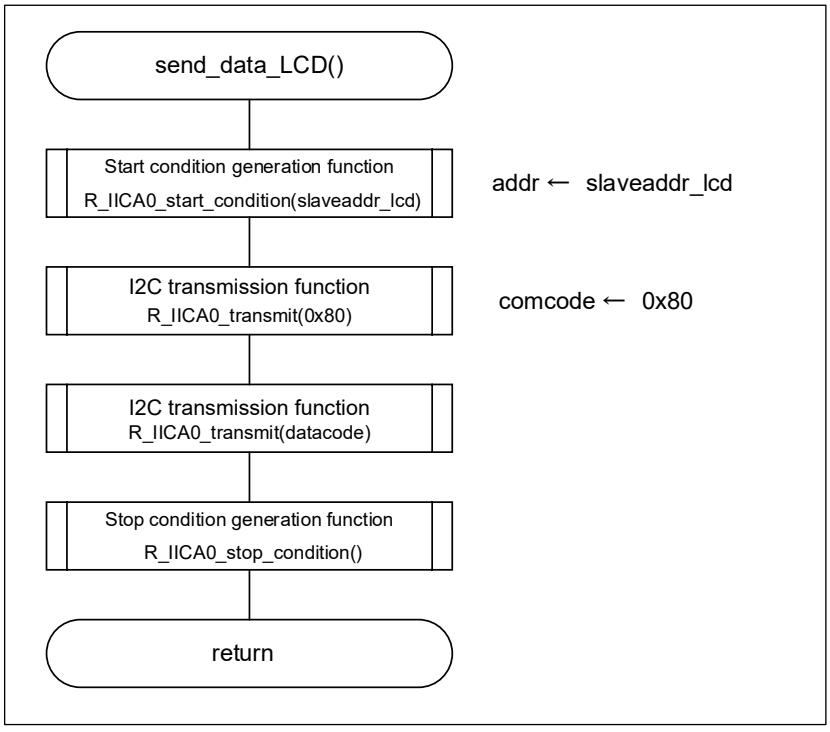
Figure 4-9 Command transmission function (LCD)



4.6.8 Data transmission function (LCD)

Figure 4-10 show the flowchart for Data transmission function (LCD).

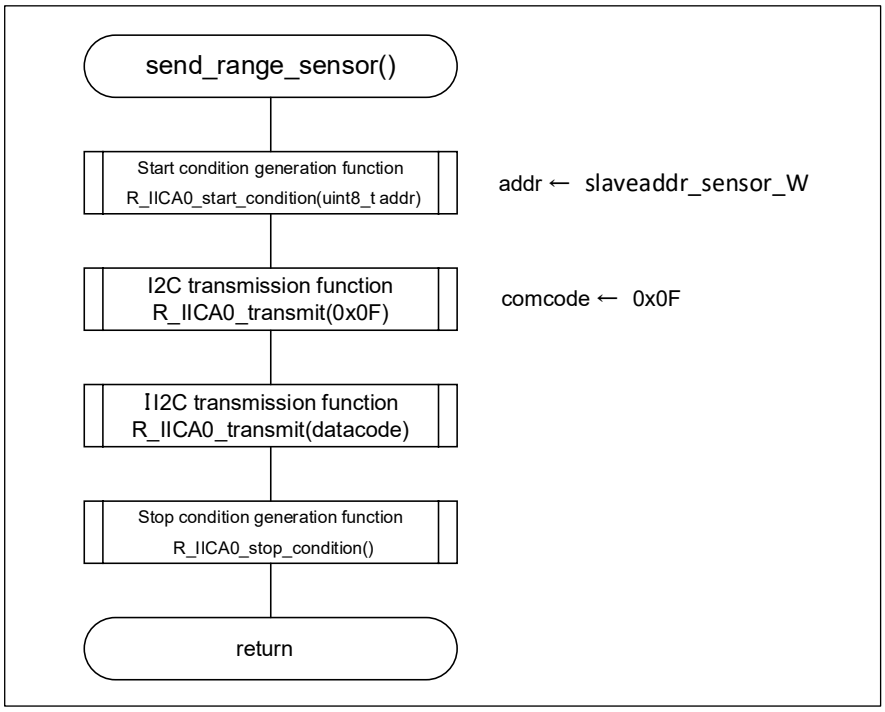
Figure 4-10 Data transmission function (LCD)



4.6.9 Function for setting the measurement range for the gyro sensor

Figure 4-11 show the flowchart for Function for setting the measurement range for the gyro sensor.

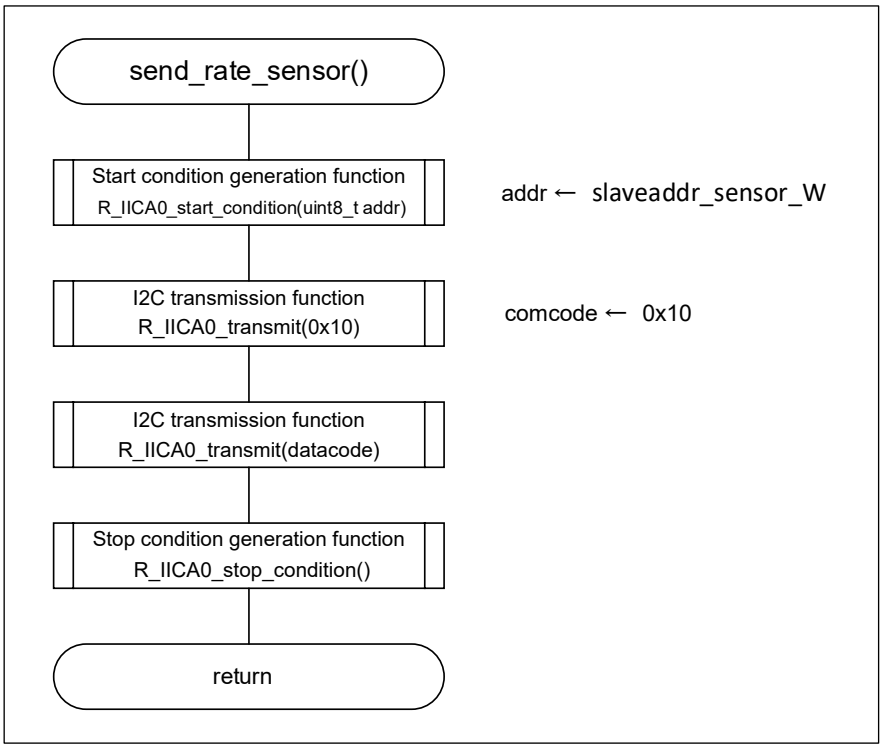
Figure 4-11 Function for setting the measurement range for the gyro sensor



4.6.10 Function for setting the output rate for the gyro sensor

Figure 4-12 show the flowchart for Function for Function for setting the output rate for the gyro sensor.

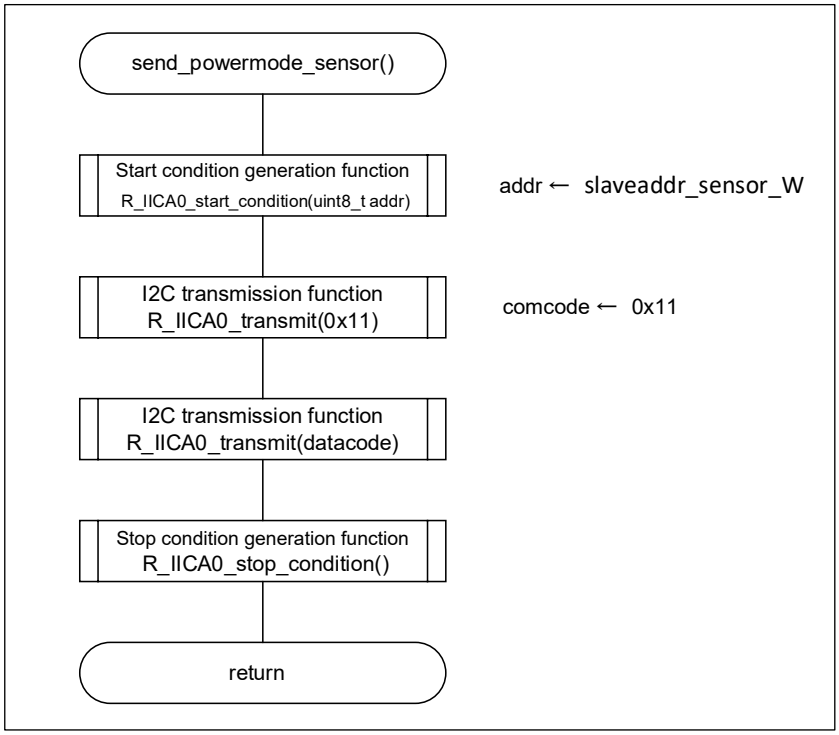
Figure 4-12 Function for setting the output rate for the gyro sensor



4.6.11 Function for setting the power mode for the gyro sensor

Figure 4-13 show the flowchart for Function for Function for setting the power mode for the gyro sensor.

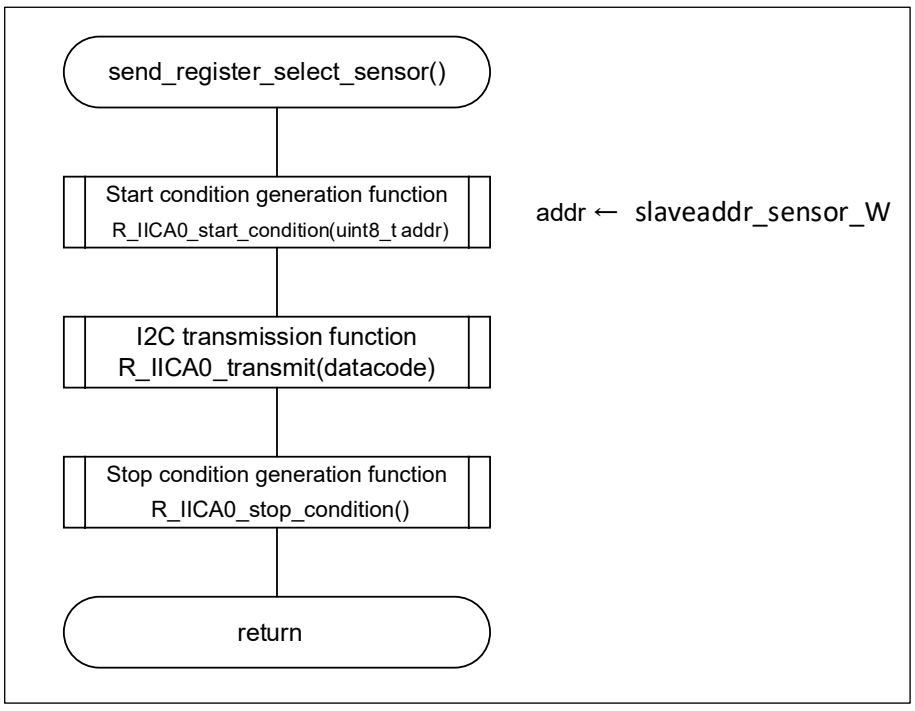
Figure 4-13 Function for setting the power mode for the gyro sensor



4.6.12 Function for setting registers in the gyro sensor

Figure 4-14 show the flowchart for Function for Function for setting the power mode for the gyro sensor.

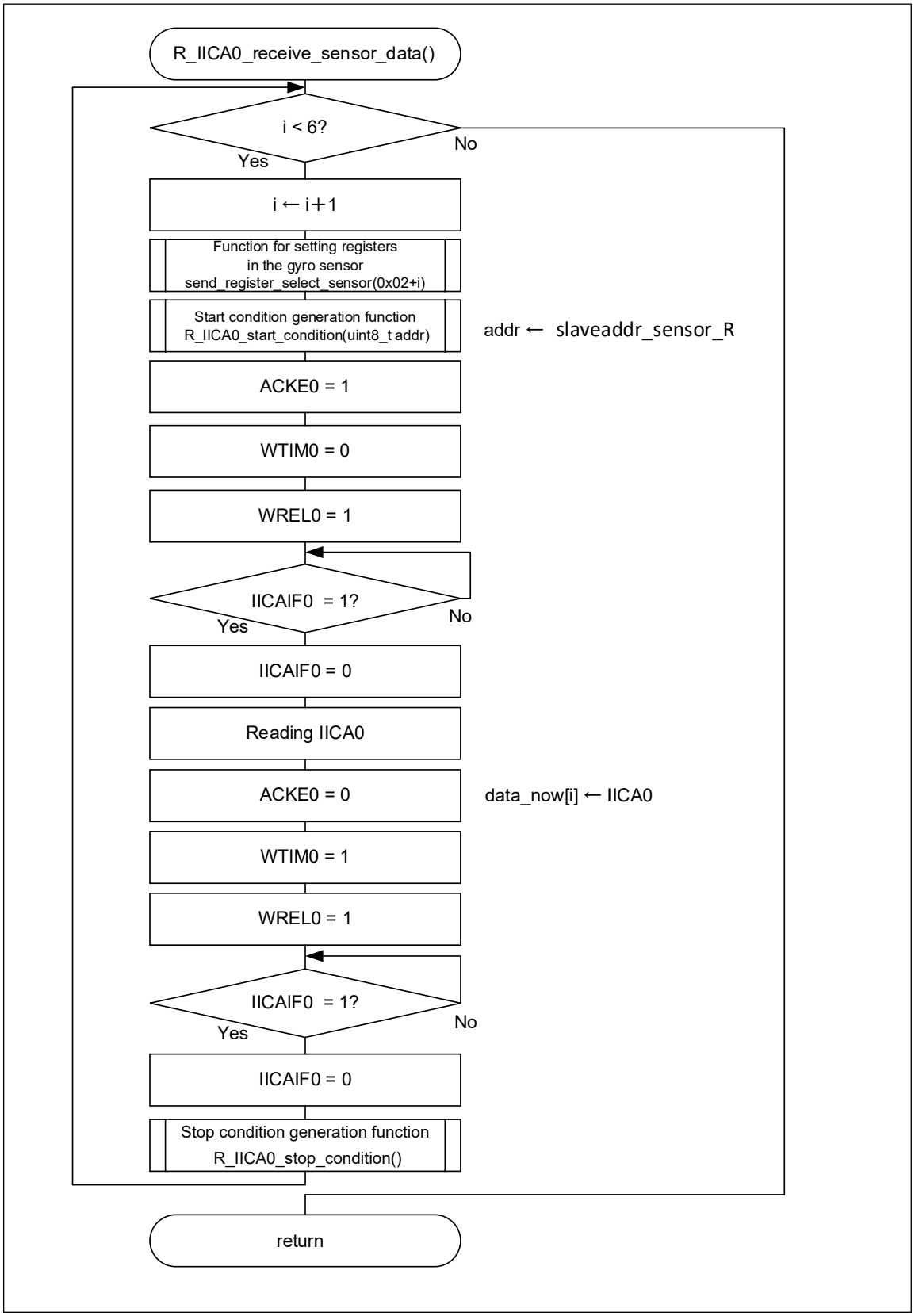
Figure 4-14 Function for setting registers in the gyro sensor



4.6.13 I2C receive function

Figure 4-15 show the flowchart for I2C receive function.

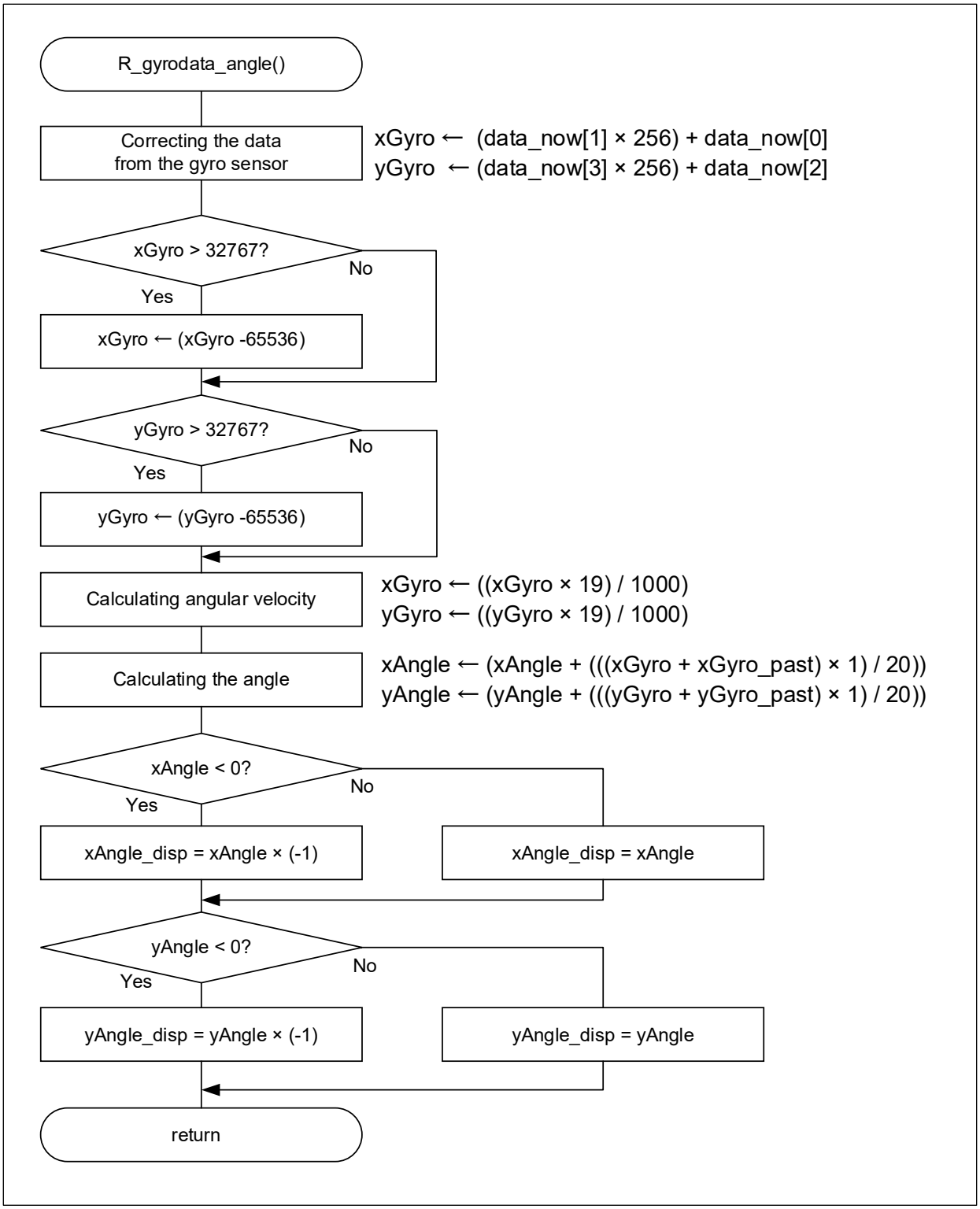
Figure 4-15 I2C receive function



4.6.14 Angle calculation function

Figure 4-16 show the flowchart for Angle calculation function.

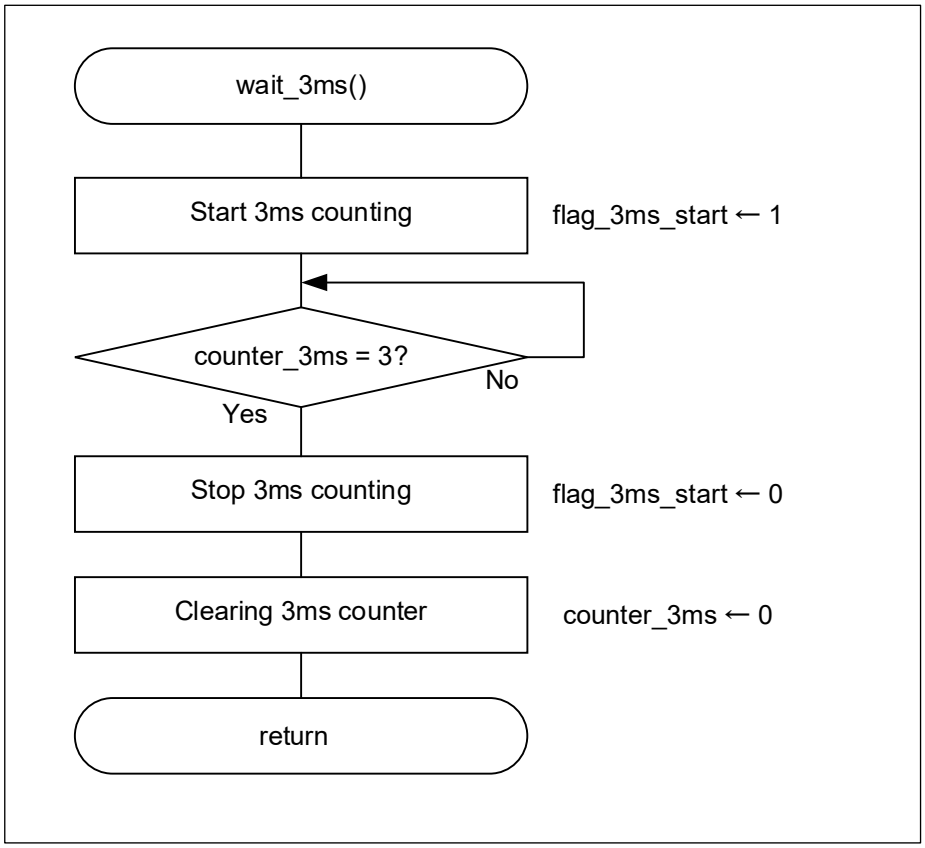
Figure 4-16 Angle calculation function



4.6.15 3ms delay function

Figure 4-17 show the flowchart for 3ms delay function.

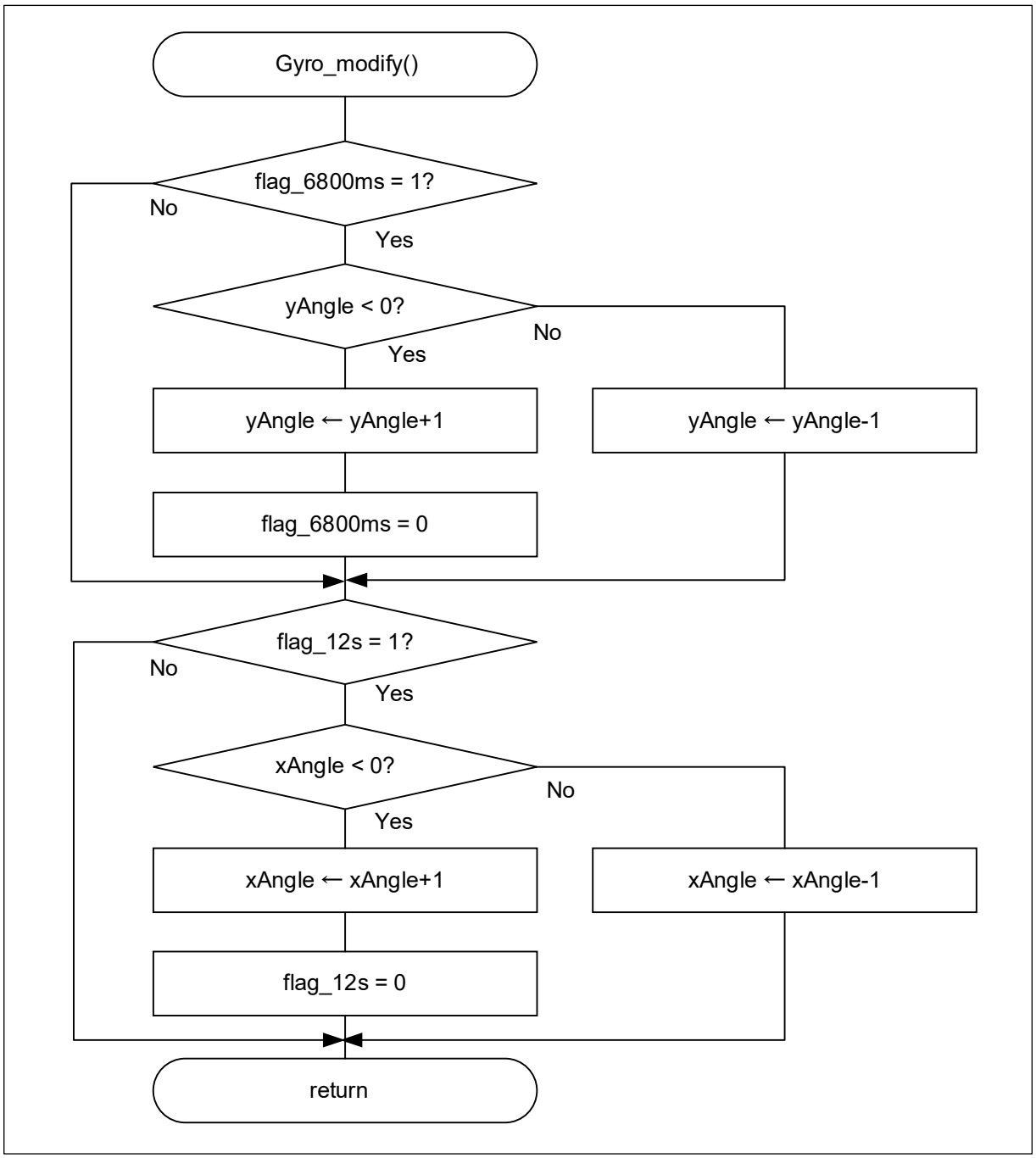
Figure 4-17 3ms delay function



4.6.16 Gyro drift correction function

Figure 4-18 show the flowchart for Gyro drift correction function.

Figure 4-18 Gyro drift correction function

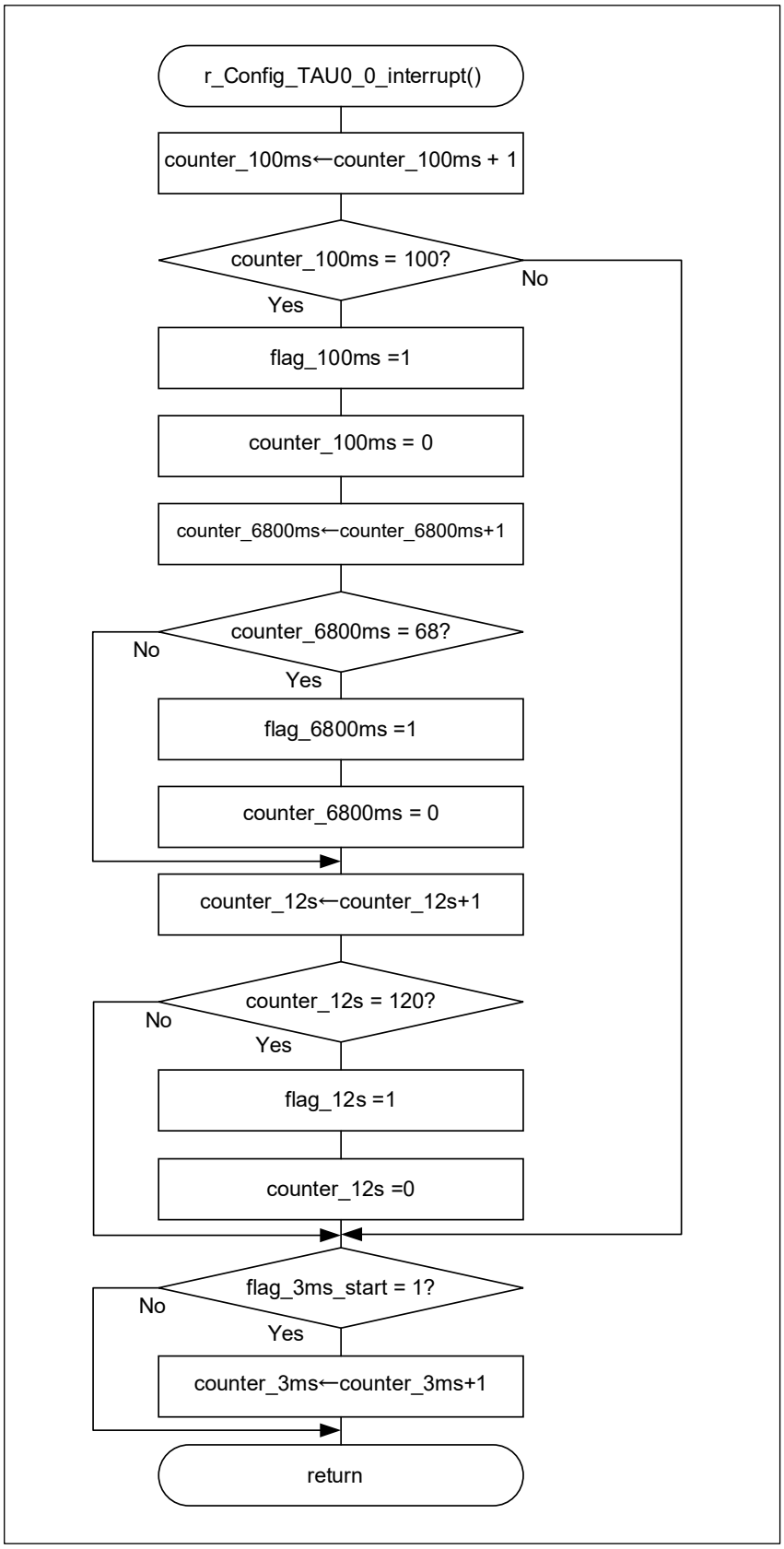


Note. Gyro drift characteristics may vary between individual sensors, so please perform calibration according to the gyro drift of your specific sensor.

4.6.17 1ms interval timer interrupt processing function

Figure 4-19 show the flowchart for 1ms interval timer interrupt processing function.

Figure 4-19 1ms interval timer interrupt processing function



5. Sample Code

Please obtain the sample code from the Renesas Electronics website.

6. Documents for Reference

User's Manual:

RL78/G15 User's Manual: Hardware (R01UH0959EJ)

RL78 Family User's Manual: Software(R01US0015JJ)

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

Technical Updates/Technical News

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

Revision History

Rev.	Date	Description	
		Page	Summary
1.00		—	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.

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall be responsible for determining what licenses are required from any third parties, and obtaining such licenses for the lawful import, export, manufacture, sales, utilization, distribution or other disposal of any products incorporating Renesas Electronics products, if required.
5. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
6. Renesas Electronics products are classified according to the following two quality grades: “Standard” and “High Quality”. The intended applications for each Renesas Electronics product depends on the product’s quality grade, as indicated below.
   "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.
   "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.
   Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user’s manual or other Renesas Electronics document.
7. No semiconductor product is absolutely secure. Notwithstanding any security measures or features that may be implemented in Renesas Electronics hardware or software products, Renesas Electronics shall have absolutely no liability arising out of any vulnerability or security breach, including but not limited to any unauthorized access to or use of a Renesas Electronics product or a system that uses a Renesas Electronics product. RENESAS ELECTRONICS DOES NOT WARRANT OR GUARANTEE THAT RENESAS ELECTRONICS PRODUCTS, OR ANY SYSTEMS CREATED USING RENESAS ELECTRONICS PRODUCTS WILL BE INVULNERABLE OR FREE FROM CORRUPTION, ATTACK, VIRUSES, INTERFERENCE, HACKING, DATA LOSS OR THEFT, OR OTHER SECURITY INTRUSION (“Vulnerability Issues”). RENESAS ELECTRONICS DISCLAIMS ANY AND ALL RESPONSIBILITY OR LIABILITY ARISING FROM OR RELATED TO ANY VULNERABILITY ISSUES. FURTHERMORE, TO THE EXTENT PERMITTED BY APPLICABLE LAW, RENESAS ELECTRONICS DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THIS DOCUMENT AND ANY RELATED OR ACCOMPANYING SOFTWARE OR HARDWARE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE.
8. When using Renesas Electronics products, refer to the latest product information (data sheets, user’s manuals, application notes, “General Notes for Handling and Using Semiconductor Devices” in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
12. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
13. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
14. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

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

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

(Rev.5.0-1 October 2020)

Corporate Headquarters

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

Trademarks

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

Contact information

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