RL78/I1A

Lighting Communications Using RL78/I1A (Transmission)

R01AN3193EJ0100
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Introduction

The application note explains the control program to be implemented in RL78/I1A Lighting Communication Master Evaluation Board. Refer to the "RL78/I1A Lighting Communication Master Evaluation Board User's manual" for the handling of the evaluation board.

Target Devices

MCU: RL78/I1A [38-pin]

Evaluation board: RL78/I1A Lighting Communication Master Evaluation Board

When applying this application note to other microcontrollers, make the necessary changes according to the specifications of the microcontroller and verify them thoroughly.

Contents

Overview

This program[Note] controls lighting communication master evaluation board using RL78/I1A.

Figure 1 shows the System configuration of evaluation board.

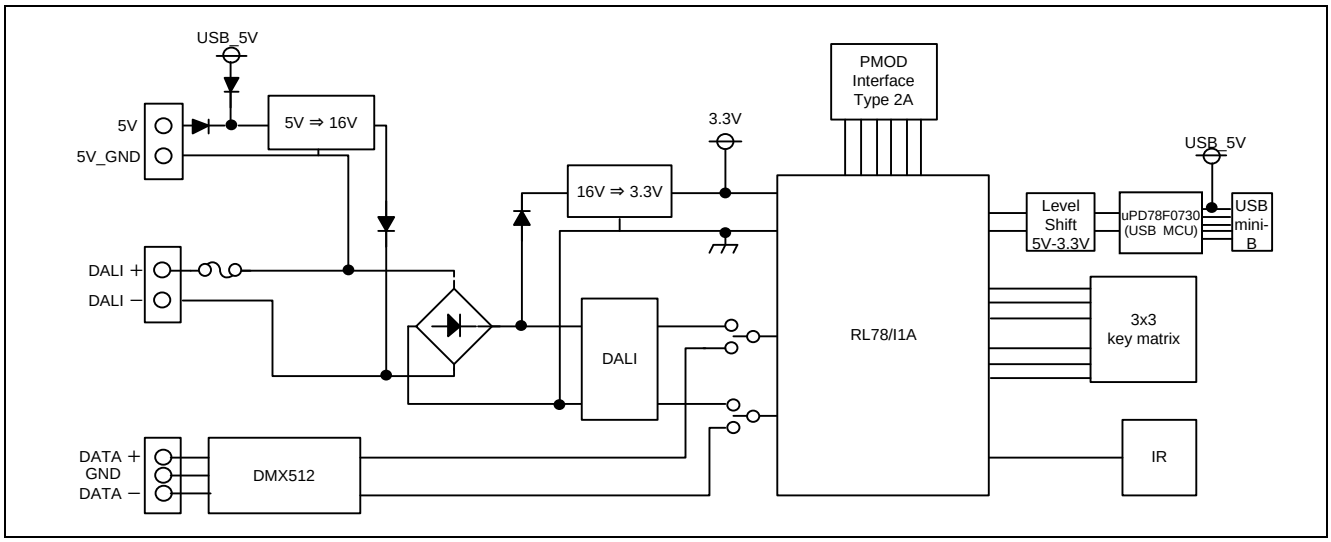


Figure 1 System configuration

This evaluation board can be used as a communication master board for controlling various lighting evaluation board. This evaluation board supports four kinds of dimming interfaces of the DALI communication /DMX512 communication / infrared transmission / PMOD.

Note The program to be described in this application note targets a one output by Applilet EZ for HCD Ver9.0. Refer to Applilet EZ for HCD Ver9.0 User's Manual for the way to output the program.

1. DALI Communication

DALI (Digital Addressable Lighting Interface) is an international open communication protocol for lighting control and is mainly used for controlling multiple fluorescent lights and LED lamps. DALI is a standard used to achieve communication between products of different manufacturers.

RL78 / I1A supports the DALI as a feature of the serial array unit 4, it is possible to transmit and receive data in the hardware as the master and the slave. This program achieves DALI communication using this feature.

For details about DALI communication and a protocol, refer to "Lighting Communications Using RL78/I1A (Reception) (R01AN1115EJ0300)".

1.1 DALI standard configuration

DALI is prescribed in IEC62386.

In this application note, unless otherwise noted, it targets IEC62386-101 ed.2.0, IEC62386-102 ed.2.0 and IEC62386-103 ed.1.0.

1.1.1 Configuration overview

The standard configuration of the DALI is shown below.

Several Part called a series is included in IEC62386.

-Part 101 General requirements about the System component

-Part 102 General requirements for Control Gear (slave)

-Part 103 General requirements for Control Device (master)

-Part2xx Extended feature peculiar to a source of light about Control Gear (slave)

-Part3xx Extended feature peculiar to Input Device about Control Device (master)

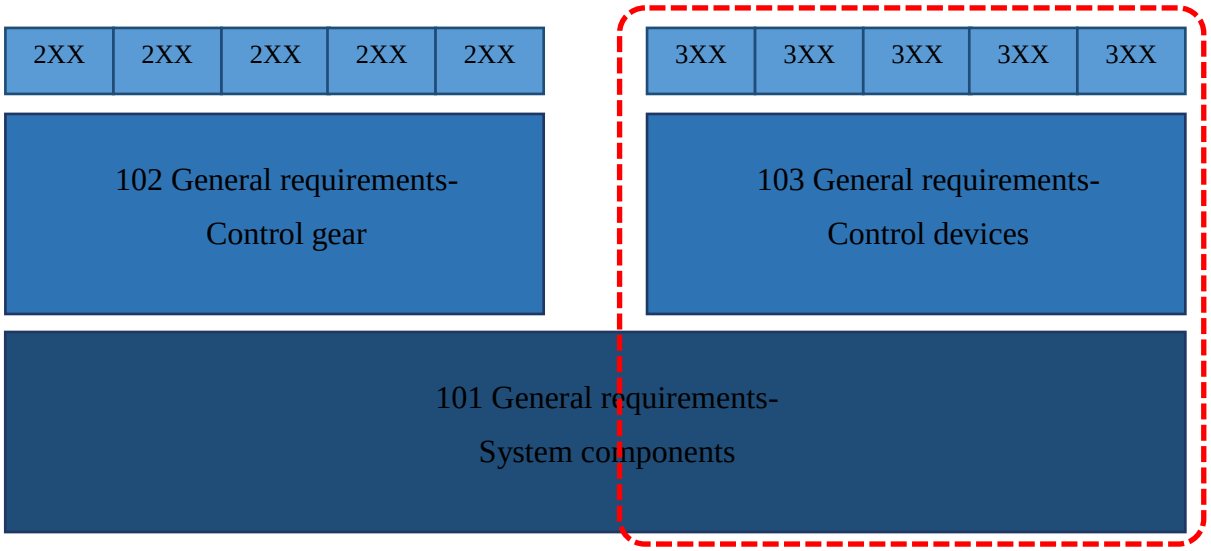


Figure 1-1 figure of summary of IEC62386

* The red frame is within a range targeted for this application note.

1.1.2 Extended feature overview

The Extended feature overview to Part102 and Part103 is shown on the following table.

Table 1-1 Part2xx overview

Part number	Contents
201	Fluorescent lamp (device type 0)
202	Built-in emergency lighting (device type 1)
203	Vapor lamp (except for fluorescent lamp) (device type 2)
204	Low voltage halogen lamp (device type 3)
205	Power supply voltage controller for white lamps (device type 4)
206	Conversion to the DC voltage of the digital signal (device type 5)
207	LED model (device type 6)
208	Switching feature (device type 7)
209	Color control (device type 8)
210	Sequencer (device type 9)

Table 1-2 Part3xx overview

Part number	Contents
301	Push button
302	Switch & Slider
303	Presence detector
304	Optical sensor
305	Color sensor
306	IP interface
307	Rotary
332	Feedback
333	Manual setting

1.2 DALI system configuration

DALI system configuration is indicated below.

1.2.1 System configuration

Table 1-3 shows the system in accordance with DALI standard must be comprised of a component.

Table 1-3 System component

Component	The number	Reference of the detailed information
Bus power supply	≥ 1	IEC62386-101
Control gear	≥ 0	IEC62386-102
Application controller	≥ 1	IEC62386-103
Input device	≥ 0	IEC62386-103
Bus	1	IEC62386-101

Figure 1-2 shows a configuration example of the system.

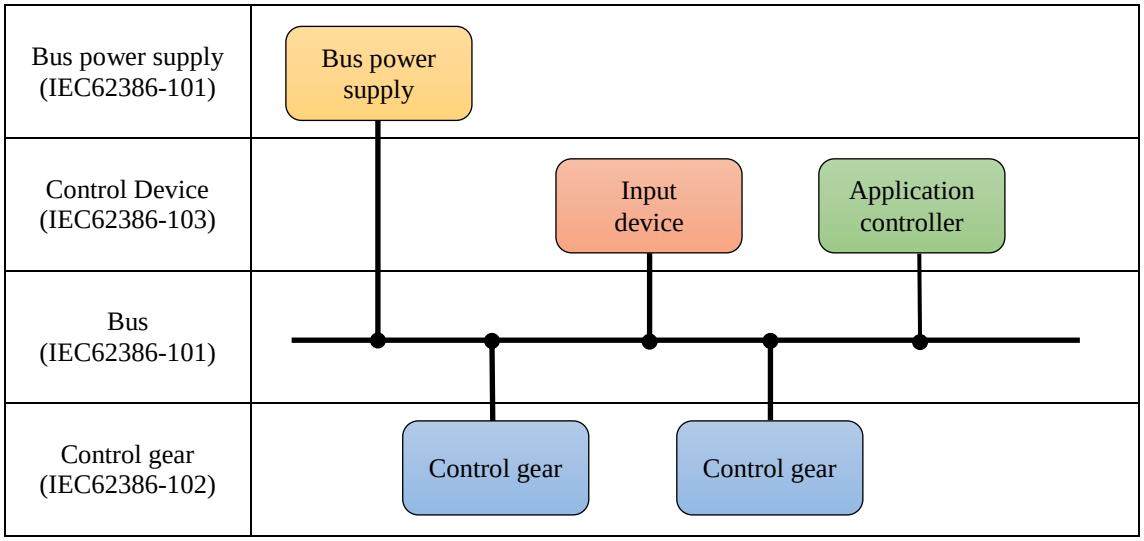


Figure 1-2 configuration example of the system

It is divided into a single master system configuration and a multi master system configuration according to the number of Control device (Input device, Application device) on Bus.

1.2.2 Single Master

The single master system configuration example is shown.

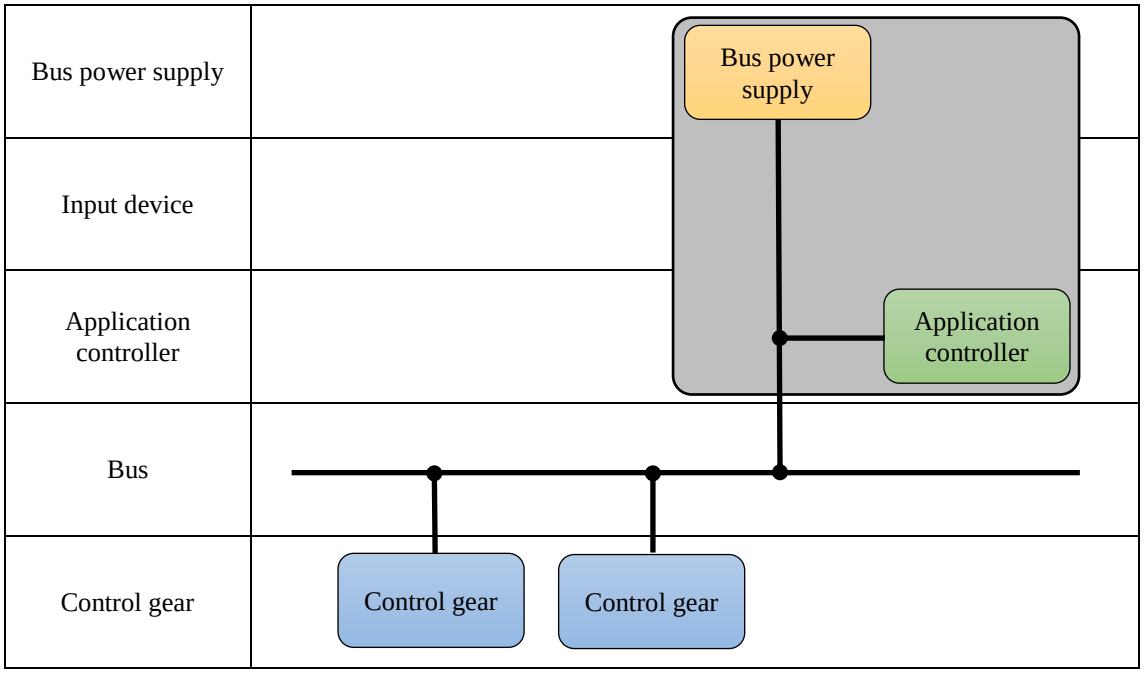


Figure 1-3 configuration example of Single master

The single master configuration contents are shown below.

- Bus power supply
- Single master application controller
- Even at least one Control gear
- No Input device or Input device that does not have the Event message

The single master configuration is not intended to share the Bus with other Control device, Application Controller does not have a Multi-master Transmitter features for collision measures.

1.2.3 Multi Master

The multi master system configuration example is shown.

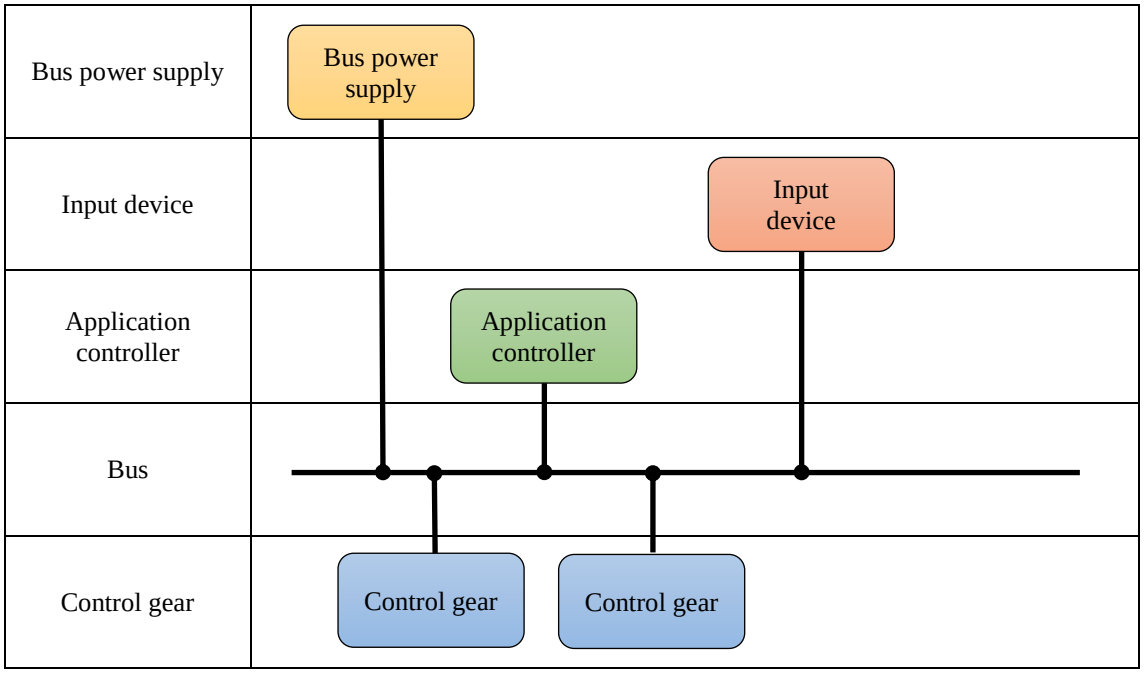


Figure 1-4 configuration example of Multi master

The multi master configuration contents are shown below.

- Bus power supply
- Multi master application controller
- The other at least one of the Control device
- At least one of the Control gear

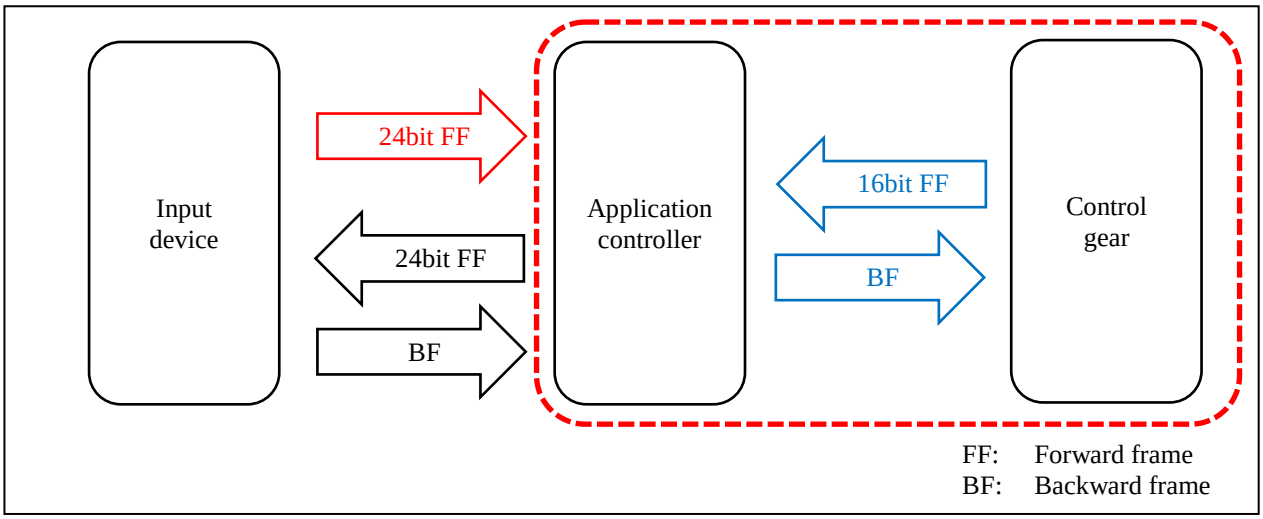
The multi master configuration is intended to share the Bus with other Control device, Application Controller has a Multi-master Transmitter features for collision measures.

Collision is an impact phenomenon of the signal generated by the multiple of Control device to transmit at approximately the same time. When signal collision occurred, an abnormal signal occurs and data is damaged. When a transmitted device detected abnormality by collision, it is necessary to implement features of cancellation of the transmission and reception, confirmation of the recovery of the transmission channel, retransmitting after the recovery.

In multi-master configuration, use the Multi-master application controller that implements the Multi-master Transmitter feature for collision measures. (See IEC62386-103)

1.3 Flow of DALI system information

A frame used between Bus Unit in the system is shown below.



* The red frame is within a range targeted for this application note.

In this program, reception of 24bit Event message from the Input device, transmission of 24bit Messsage to Input device is not currently supported. Even when installing Input device on the same bus, it isn't possible to communicate with the Input device and this program (Application controller). Application controller assumes only more than one of configuration for the multi-master configuration in this program.

The multi-master configuration corresponding to this program assumes the following configuration.

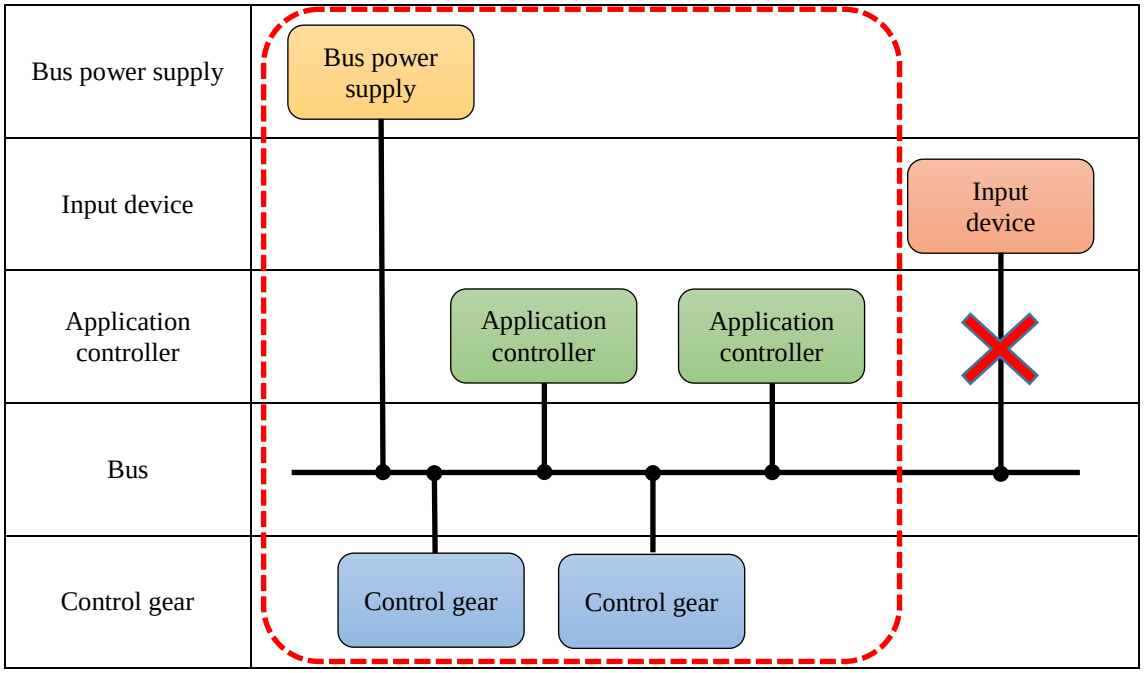


Figure 1-5 Multi-master configuration example supporting to this program

1.4 Multi-master support

This program supports the collision detection, which is defined in the DALI standard, and can operate as a multi-master.

1.4.1 Necessity of collision detection

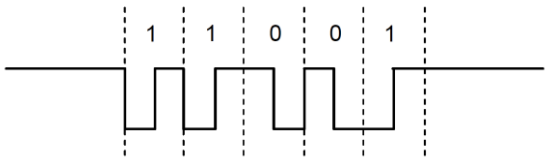
As for the DALI communication, it is in the multi-master specifications that can communicate with plural masters connected on the same bus for one slave.

In a multi-master, if more than one master transmits at the same time, there is that a bus collision that overlaps the transmission signal on the bus occurs. When a collision occurs, it isn't ordinarily possible to communicate with a slave. Therefore master has to detect a presence of collision occurrence and return from a collision.

1.4.2 The collision detection standard

A bit data of a DALI communication signal is Manchester code, and one bit data consists of the half bit of 2, H and L.

Figure 1-6 shows the description of the Manchester code.



*The definition of bit 1 or 0 expresses it in the edge of the voltage change not a battery level such as H/L.

*A falling edge is bit-defined as “0” and a rising edge as “1”,

Figure 1-6 Manchester code

For collision detection standard of DALI communication, it is defined in the DALI standard, it can be divided into two determination time pattern by the bit sequence of frames to be transmitted from the master.

Table 1-4 shows the condition of collision judgment time, Table 1-5 and Table 1-6 show the judgment time of each pattern. When half bit time of a transmission frame is in the range of destroy area defined by Table 1-5 and Table 1-6, it'll be collision detection.

Further, judgment of collision detection applies to only the forward frame master transmits and it doesn’t apply to the backward frame a slave transmits.

Table 1-4 The condition of collision judgment time

The condition of the judgment range	The pattern of judgment time
From the start of the bit which starts from an edge to the neutrality.	Pattern 1
From the middle of the bit to the next edge	Pattern 2

Table 1-5 Pattern 1 definition of the collision judgment time

Minimum time	Maximum time	Definition
	< 100 us	grey area
100 us	356.7 us	destroy area
> 356.7 us	< 400.0 us	grey area
400.0 us	433.3 us	valid half bit
> 433.3 us	< 476.7 us	grey area
476.7 us		destroy area (Time out condition. only L level)

Table 1-6 Pattern 2 definition of the collision judgment time

Minimum time	Maximum time	Definition
	< 100 us	grey area
100 us	356.7 us	destroy area
> 356.7 us	< 400.0 us	grey area
400.0 us	433.3 us	valid half bit
> 433.3 us	< 476.7 us	grey area
476.7 us	723.3 us	destroy area
> 723.3 us	< 800.0 us	grey area
800.0 us	866.7 us	2 valid half bits
> 866.7 us	< 943.3 us	grey area
943.3 us		destroy area (Time out condition. only L level)

1.4.3 Return after collision detection

The master recognizes that it was not transmitted definitely by the collision detection and transmits a forward frame again. However, if another master transmits in a state which is transmitting continuously to fail to recognize collision, collision occurs again. Therefore the master makes a bus an active state (L level) during constant Break time period, and it is necessary to make other master recognize collision occurrence.

Collision continuation with other master is judged and restore operation is performed by the state of the bus when master released the active position after Break time passage.

Table 1-7 shows the method of collision return judgment.

Table 1-7 Collision return judgment

Level of bus	Condition of collision	Operation after the judgment
H level (idle state)	Return	Retransmit after Recovery time progress.
L level (active state)	Continue	Retransmit after Settling time progress.

Table 1-8 shows regulation time of Break time, Recovery time and Settling time.

Time range of Settling time is prescribed by five of priority. It is intended to suppress occurrence of a collision in a minimum by setting Settling time of the priority different depending on frames.

Table 1-8 Regulation at the timing of collision return

Regulation at the timing	Minimum time	Maximum time
Break time	1.2 ms	14.0 ms
Recovery time	4.0 ms	4.6 ms
Settling time(Any frame and forward frame(priority 1))	12.7 ms	13.8 ms
Settling time(Any frame and forward frame(priority 2))	14.0 ms	15.1 ms
Settling time(Any frame and forward frame(priority 3))	15.3 ms	16.5 ms
Settling time(Any frame and forward frame(priority 4))	16.7 ms	18.1 ms
Settling time(Any frame and forward frame(priority 5))	18.3 ms	19.7 ms

1.5 How to realize the collision detection in the RL78/I1A

1.5.1 Bus monitoring by TAU

It's needed to be able to recognize an edge of master transmit signal on the DALI bus line and to be able to recognize the elapsed time from the edge to detect a collision.

Collision detection is achieved to input master transmit signal on the DALI bus line (=DALIRxD4 terminal) to a TI terminal and measure the H/L level width by using an input pulse interval measurement feature of TAU (timer array unit) put on RL78/I1A, and to judge whether acquired time is in the destroy area indicated in Table 1-5 and Table 1-6.

In addition, for the Time out conditions shown in Table 1-5 and Table 1-6, it's judged using the interval timer feature of TAU because it can't be judged by the input pulse interval measurement feature which a change in an edge is needed.

1.5.2 Control of a collision return timer by TAU

After detecting a collision, it's necessary to do collision return processing at the timing prescribed as Break time, Recovery time and Settling time (see Table 1-8). An interval timer of TAU is used to generate these timings.

2. DMX512 communication

This program realizes DMX512 communication using an interval timer of the timer array unit of the RL78/I1A, an input pulse interval measurement feature and the UART feature of the serial array unit 4. For DMX512 communication details and protocol, see "Lighting Communications Using RL78/I1A (Reception) (R01AN1115EJ0300)".

3. Infrared transmission

This program realizes the infrared remote control wave pattern transmission using an interval timer of timer array unit of RL78/I1A and a square pulse output feature. For infrared remote control wave pattern transmission details and protocol, please refer to the "Lighting Communications Using RL78/I1A (Reception) (R01AN1115EJ0300)".

4. USB communication

This program realizes USB communication using the UART feature of the serial array unit 0. It is possible to request the operation of the DALI/DMX512 communication from the DALI/DMX512 master controller GUI on the PC by connecting to a PC via USB.

Download the DALI/DMX512 master controller GUI V2.0 from Renesas Electronics website.

5. Software Configuration

5.1 Overview

Figure 5-1 shows the Overview of software configuration.

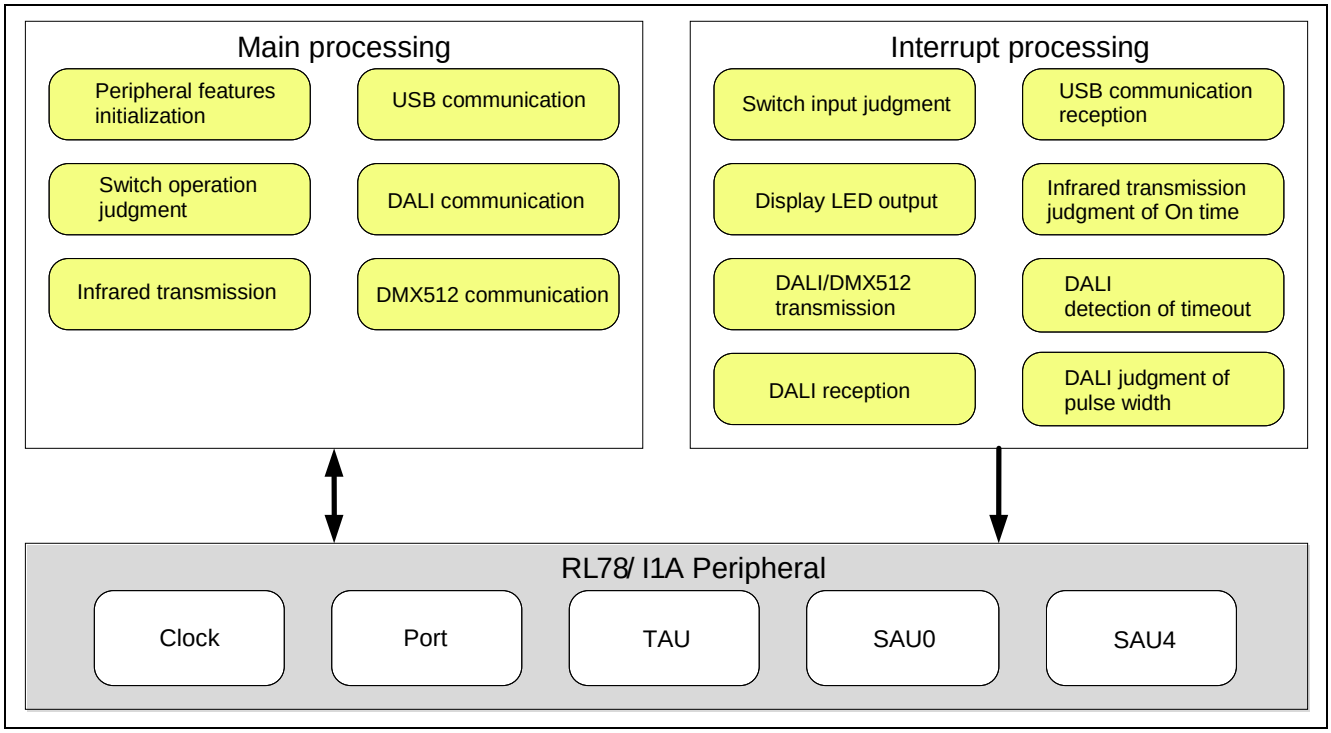


Figure 5-1 Overview of software configuration

This software consists of Main processing, interrupt processing and I/F to peripheral device.

Main processing carries out initialization of the surrounding feature, operation judgment of the switch and each communication processing.

Input judgment of the switch, output processing of an LED for display and communication judgment of DALI/DMX512/ infrared rays are performed using timer interrupt, USB reception is performed using reception interrupt of a serial array unit 0 and DALI/DMX512 transmission / reception processing are performed using a serial array unit 4 transmission / reception interrupt.

5.2 Settings of peripheral features

Table 5-1,Table 5-2 and Table 5-3 show the settings list of peripheral features to be used in this software. For information about how to set each feature, see "RL78/I1A User's Manual: Hardware".

Table 5-1 Settings of peripheral features (1)

Peripheral features	Settings
Clock	CPU clock：f_{CLK} = 32 MHz
I/O port	[Input] P75 : Key scan output 1 P76 : Key scan output 2 P77 : Key scan output 3 [Output] P25 : Key scan output 1 P26 : Key scan output 2 P27 : Key scan output 3 P200 : Power supply LED output P201 : Communication state LED output P202 : Switch ON LED output
Timer array unit (TAU0)	[Mode commonness] Channel 1 (TM01): Timer for 1 ms period processing • Operation mode ... Interval timer • Count clock ... 32 MHz / 1 (f_{CLK} / 1) • Period ... 1 ms • Completion interrupt ... Permit [At the time of DALI communication] Channel 6 (TM06): For collision detection (for pulse interval measurement) • Operation mode ... Input pulse interval measurement • Count clock ... 32 MHz / 1 (f_{CLK} / 1) • Completion interrupt ... Permit Channel 7 (TM07): For collision detection (for elapsed time judgment) • Operation mode ... Interval timer • Count clock ... 32 MHz / 16 (f_{CLK} / 16) • Period ... 943 us • Completion interrupt ... Permit [At the time of DMX512 communication] Channel 6 (TM06): (Only at the time of reception) for Break signal input • Operation mode ... Input pulse interval measurement • Count clock ... 32 MHz / 1 (f_{CLK} / 1) • Completion interrupt ... Permit Channel 6 (TM06): (Only at the time of transmission) for Break signal output • Operation mode ... Interval timer • Count clock ... 32 MHz / 1 (f_{CLK} / 1) • Period ... 88 us • Completion interrupt ... Prohibit

Table 5-2 Settings of peripheral features (2)

Peripheral features	Settings
Timer array unit (TAU0)	[At the time of the infrared transmission] Channel 2 (TM02): Output time Measurement • Operation mode ... Interval timer • Count clock ... 32 MHz / 1 (f_{CLK} / 1) • Period ... 562.5 us • Completion interrupt ... Permit Channel 3 (TM03): Pulse output • Operation mode ... Interval timer • Count clock ... 32 MHz / 1 (f_{CLK} / 1) • Period ... 13.157 us (= 38 kHz / 2) • Completion interrupt ... Prohibit [At the time of USB communication] Channel 3 (TM03): Communication time-out judgment • Operation mode ... Interval timer • Count clock ... 32 MHz / 16 (f_{CLK} / 16) • Period ... 9.17 ms • Completion interrupt ... Permit
Serial array unit4 (DALI/UART4)	[At the time of DALI communication] Channel 0: DALI Transmission • Operation mode ... DALI mode • Serial clock ... 62.5 kHz • Baud rate ... 1202 bps • Data length ... 16 bit • Data phase ... Default H level • Data direction ... MSB first • Transmit interrupt ... Permit • Interrupt source ... Transfer completion Channel 1: DALI Reception • Operation mode ... DALI mode • Serial clock ... 62.5 kHz • Baud rate ... 1202 bps • Data length ... 8 bit • Data phase ... Default H level • Data direction ... MSB first • Receive interru ... Permit • Interrupt source ... Transfer completion • Noise filter ... ON

Table 5-3 Settings of peripheral features (3)

Peripheral features	Settings
Serial array unit 4 (DALI/UART4)	[At the time of DMX512communication] Channel 0: DMX512 Transmission • Operation mode ... UART mode • Serial clock ... 32 MHz / 1 • Baud rate ... 250 kbps • Data direction ... MSB first • Transmit interrupt ... Permit
Serial array unit 0 (UART0)	[Common] Channel 2: USB Transmission • Operation mode ... UART mode • Serial clock ... 32 MHz / 1 • Baud rate ... 250 kbps • Transmit interrupt ... Prohibit Channel 3: USB Reception • Operation mode ... UART mode • Serial clock ... 32 MHz / 1 • Baud rate ... 250 kbps • Receive interrupt ... Permit

5.3 File structure

Table 5-4 shows a List of program files which this software uses.

Table 5-4 List of program files

Folder Name	File Name	Contents
src	r_main.c	Main function, Key operation, Main function for DALI communication
	r_userinit.c	Initialization function for the user
	r_systeminit.c	System initialization function
	r_timer	Timer initialization function, Timer interrupt function
	r_keyscan.c	Key input reading function
	r_leddisp.c	LED output function for display
	r_dali.c	DALI communication control function
	r_dmx.c	DMX512 communication control function
	r_ir.c	Infrared transmission control function
	r_guicom.c	USB communication control function
	Init.asm	RL78/I1A option byte definition
include	r_userdefine.h	User-defined
	r_macrodriver.h	Common macro definition
	r_system.h	Definition for r_systeminit.c
	r_timer.h	Definition for r_timer.c
	r_keyscan.h	Definition for r_keyscan.c
	r_leddisp.h	Definition for r_leddisp.c
	r_dali.h	Definition for r_dali.c
	r_dmx.h	Definition for r_dmx.c
	r_ir.h	Definition for r_ir.c
	r_guicom.h	Definition for r_guicom.c
	r_keydefine.h	Switch operation definition

5.4 List of Functions

Table 5-5 shows a List of Functions of sample program.

Table 5-5 List of Functions

Function Name	Overview
main	Main process
key_operation	Key operation process
user_init	Initialization process for the user
timer_init	Timer control initialization process
int_tm01	1 ms period process
int_tm02	562.5μs period process
KEYSCAN_Init	Key input read initialization process
KEYSCAN_CheckInterval	Key input 1 ms period process
LEDDISP_Init	LED display initialization process
LEDDISP_CheckInterval	LED display 1 ms period process
DALI_Init	DALI communication initialization process
DALI_Loop	DALI communication control process
int_stdl4	DALI/DMX512 communication transmission completion interrupt process
int_srdl4	DALI communication reception completion interrupt process
int_tm06	DALI communication collision detection pulse measurement timer process
int_tm07	DALI communication collision detection elapsed time determination timer process
DMX_Init	DMX512 communication initialization process
DMX_Loop	DMX512 communication control process
DMX_CheckInterval	DMX512 communication 1 ms period process
IR_Init	Infrared transmission initialization process
IR_Send	Infrared transmission process
GUICOM_Init	USB communication initialization process
int_sr1	USB communication reception completion interrupt process
int_tm04	USB communication reception timeout process

5.5 Function specifications

This section describes the detailed specifications of the software function.

5.5.1 Main process

main

Overview	Main process
Declaration	void main(void)
Description	This is the main routine of the program. It performs initialization process, key operation process, DALI / DMX512 / infrared communication request monitoring, and communication control process.
Parameter	None
Return value	None
Remark	None

Figure 5-2 shows the flow of Main process.

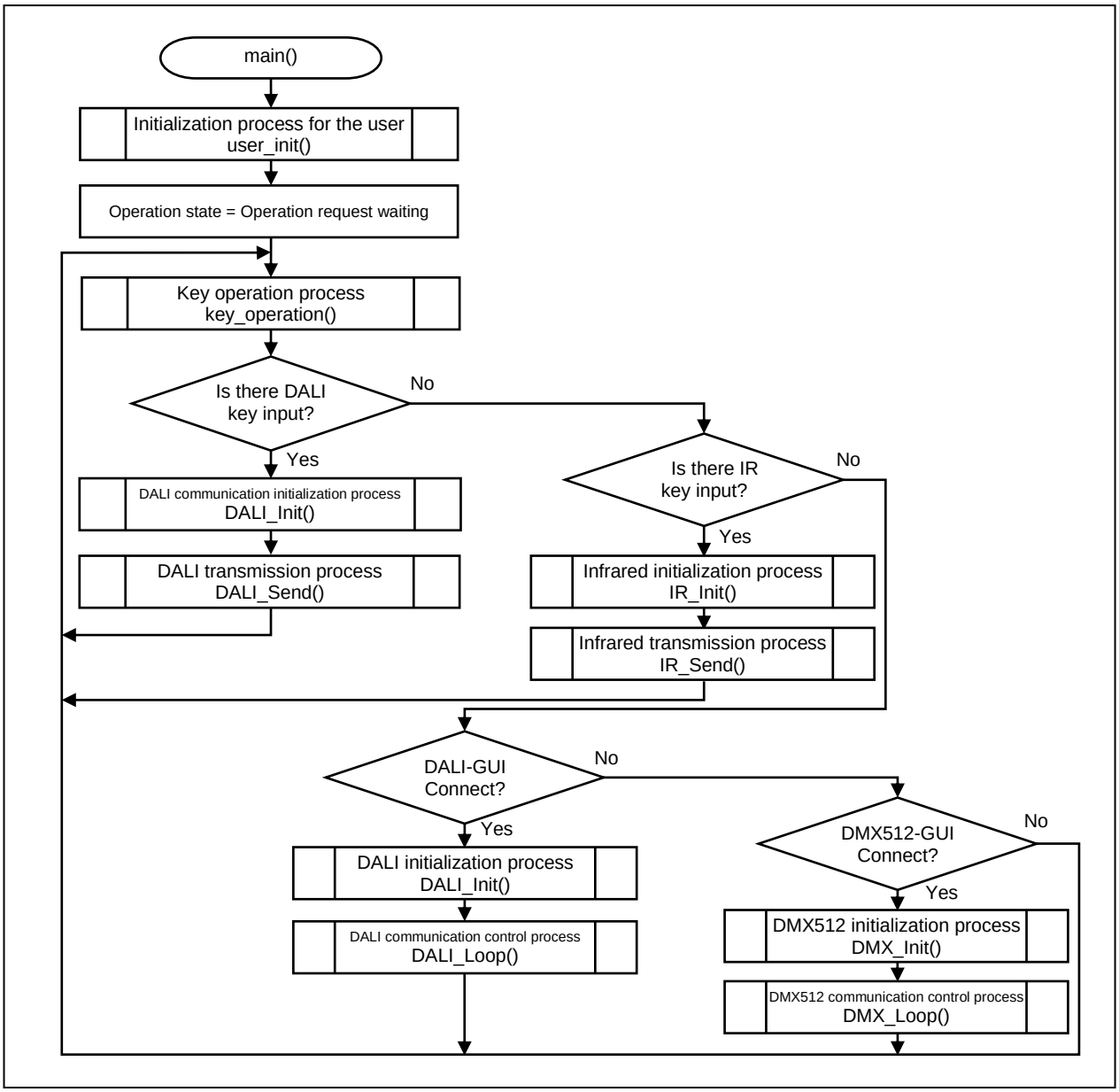


Figure 5-2 Main process

After MCU starts, the peripheral features and user use variables are initialized. Then, it enters Main loop processing, judges an input key and requests operation of each mode. According to the judgment result ,after the initialization of a operation state of the request, the specified operation is carried out.

5.5.2 Key operation process

key_operation

Overview	Key operation process
Declaration	void key_operation(uint8_t inputkey)
Description	A key operation request is watched and it's processed according to the input key. In this program, default operation that is assigned to each key is as follows. SW2 : DALI communication Broadcast MAX command SW3 : DALI communication Broadcast MIN command SW4 : DALI communication Broadcast OFF command SW5 : DALI communication Broadcast UP command (resend) SW6 : DALI communication Broadcast DOWN command (resend) SW7 : DALI communication Broadcast SCENE0 command SW8 : DALI communication Broadcast ON AND STEP UP command SW9 : DALI communication Broadcast STEP DOWN AND OFF command SW10 : Infrared transmission custom code (0x0000) + specified channel data (resend)
Parameter	inputkey Input key
Return value	None
Remark	The default value can be changed at Applilet EZ for HCD. The command with the resend specified retransmits the command by continuing pushing the key.

Figure 5-3, Figure 5-4 and Figure 5-5 show the flow of key operation process.

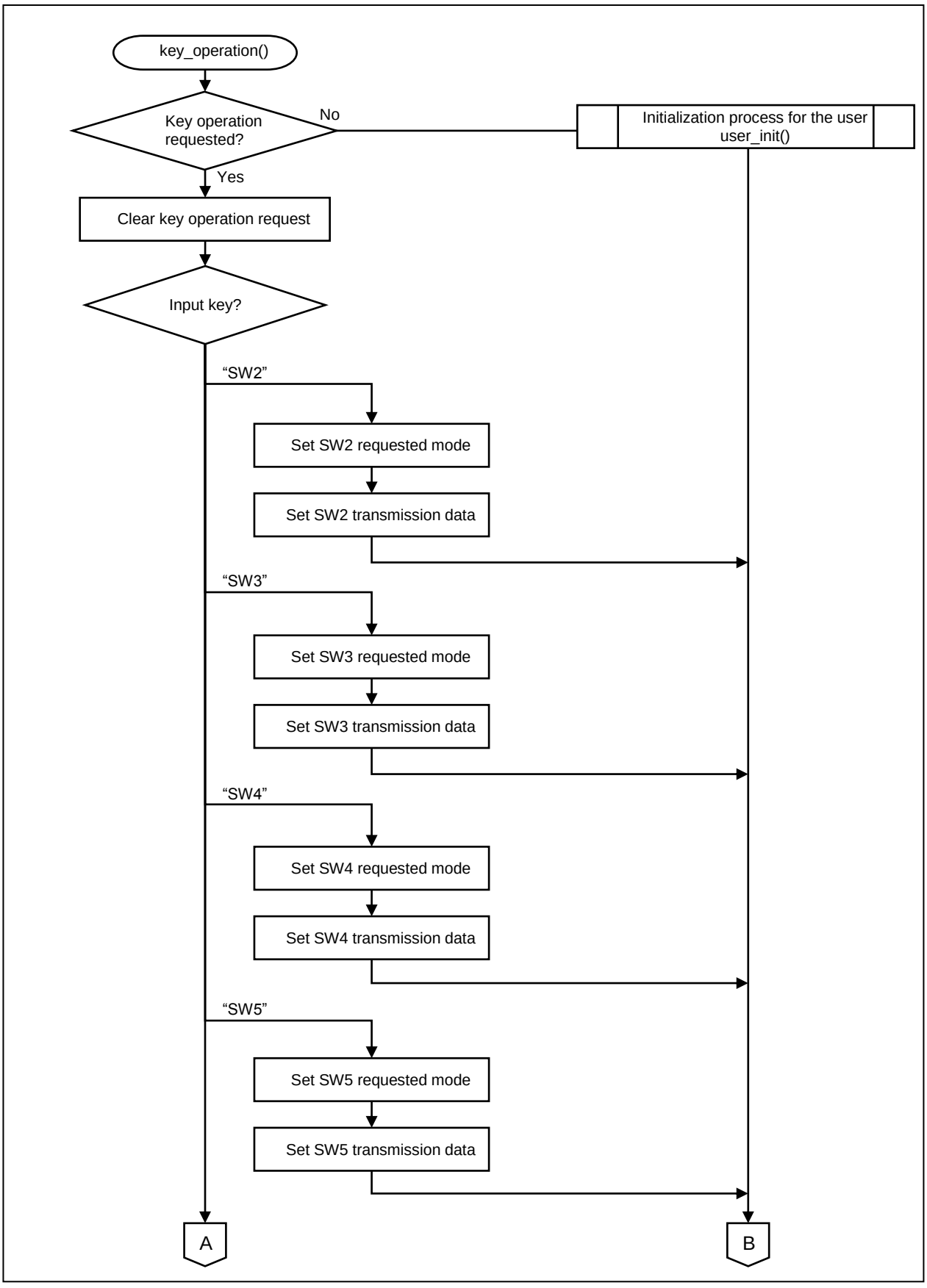


Figure 5-3 Key operation process (1)

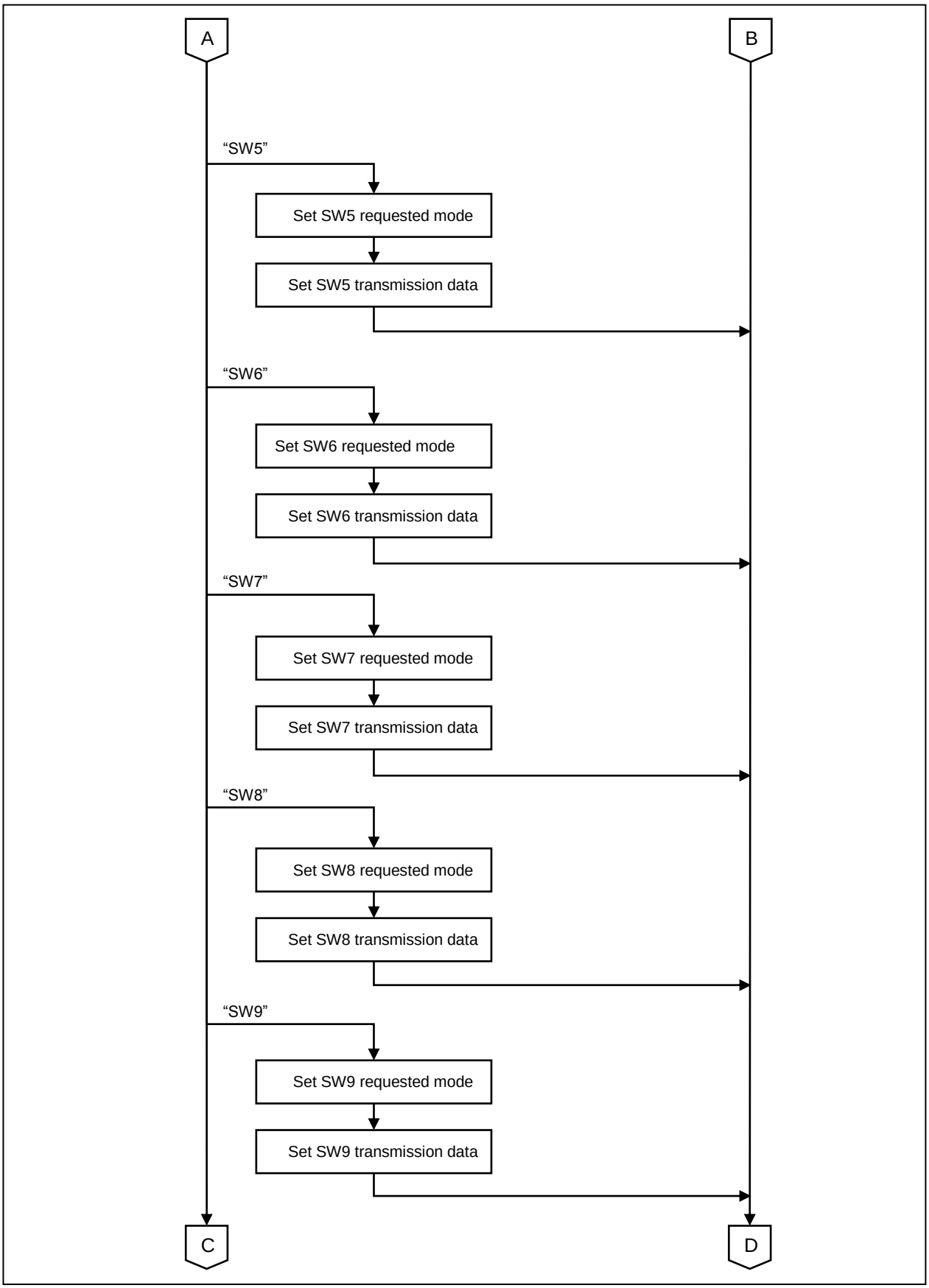


Figure 5-4 Key operation process (2)

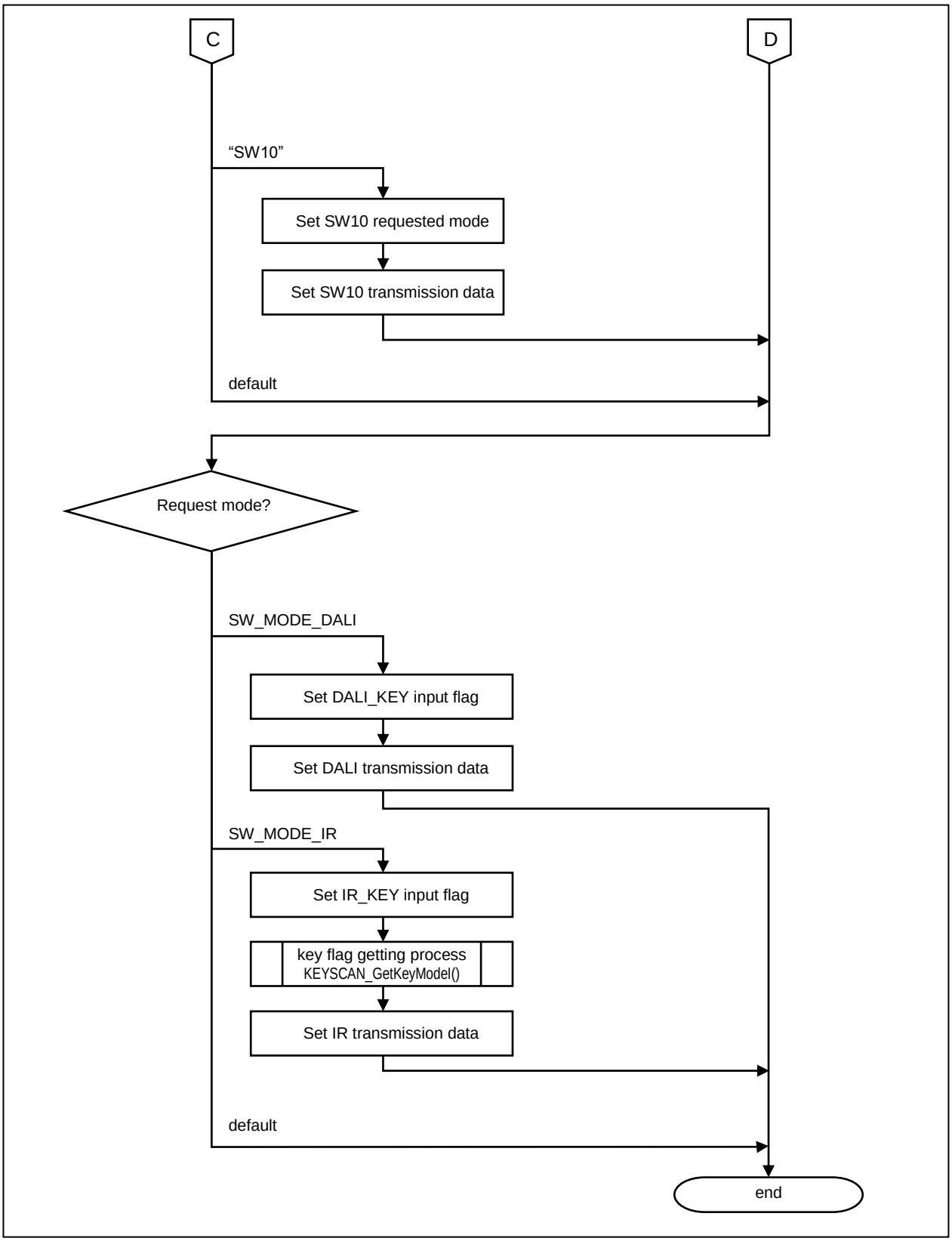


Figure 5-5 Key operation process (3)

It performs to request the operation and to set transmission data at the time of communication depending on the input key.

5.5.3 Initialization process for the user

user_init

Overview	Initialization process for the user
Declaration	void user_init(void)
Description	It initializes the features used in this program. The features initialized by this function are as follows. * Timer control * LED display * Key input read * USB communication When adding the features, add an initializing process in this function.
Parameter	None
Return value	None
Remark	None

Figure 5-6 shows the flow of Initialization process for the user.

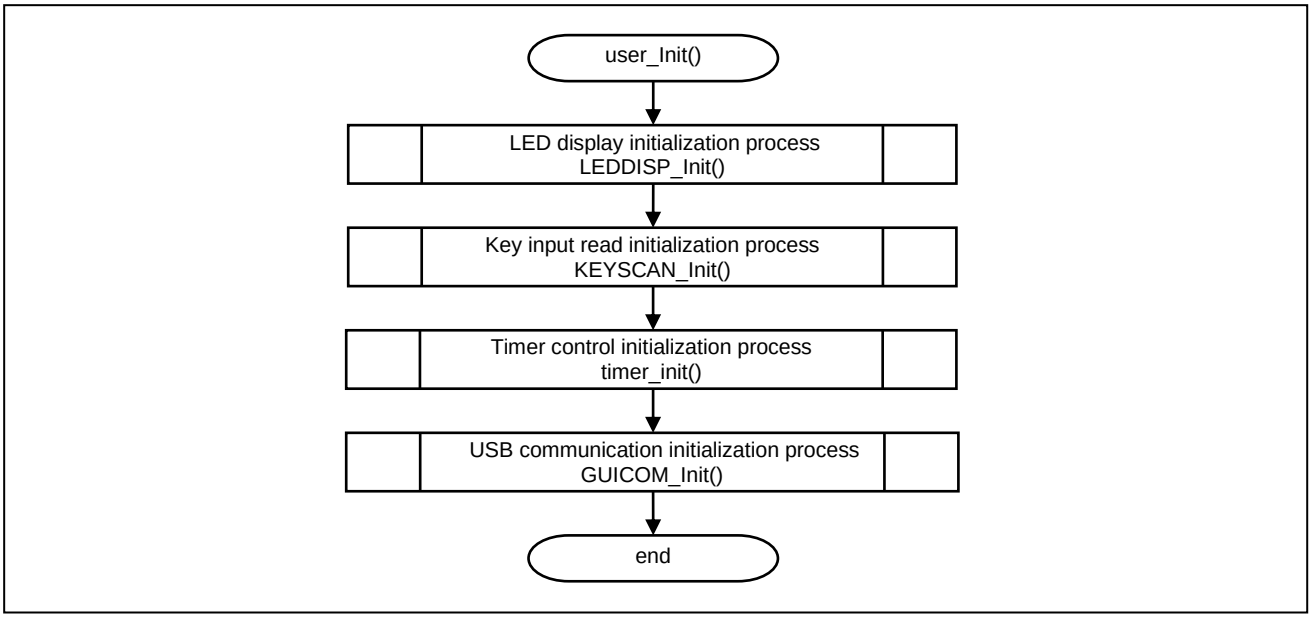


Figure 5-6 Initialization process for the user

The peripheral features and use variables are initialized.

5.5.4 Timer control initialization process

timer_init

Overview	Timer control initialization process
Declaration	void timer_init(void)
Description	It initializes the registers and variables associated with the timer control. For the initial settings of the TAU, see Section 5.2.
Parameter	None
Return value	None
Remark	None

Figure 5-7 shows the flow of Timer control initialization process.

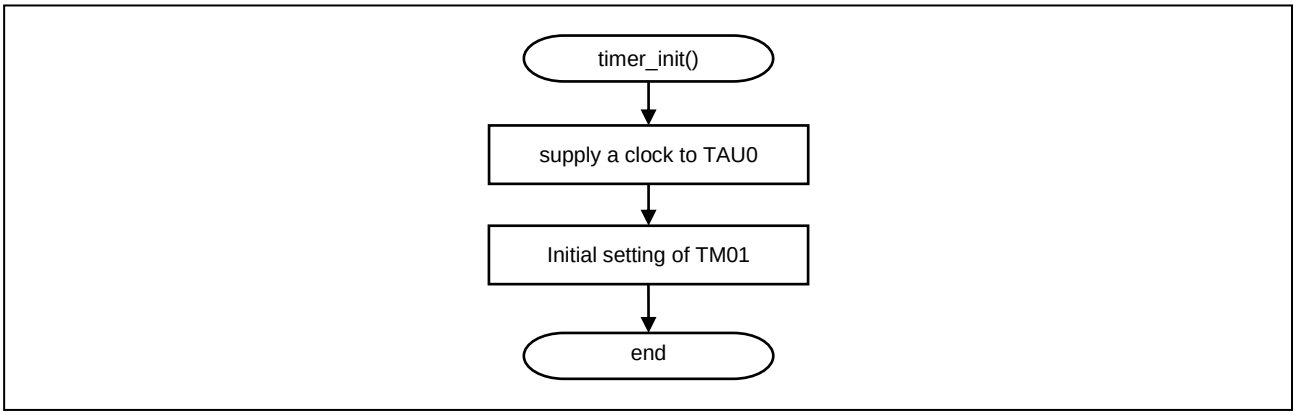


Figure 5-7 Timer control initialization process

It initializes the timer array unit to be used in the 1 ms period process.

For the initial settings, see Section 5.2.

5.5.5 1 ms period process

int_tm01

Overview	1 ms period process
Declaration	void int_tm01(void)
Description	This function processes at the time of channel 1 (TM01) count completion interrupt of the timer array unit. TM01 operates as an interval timer of 1 ms period. Content to be processed by this function is as follows. * Key input 1 ms period process * LED display 1 ms period process * DMX512 communication 1 ms period process (Only DMX512 communication mode)
Parameter	None
Return value	None
Remark	None

Figure 5-8 shows the flow of 1 ms period process.

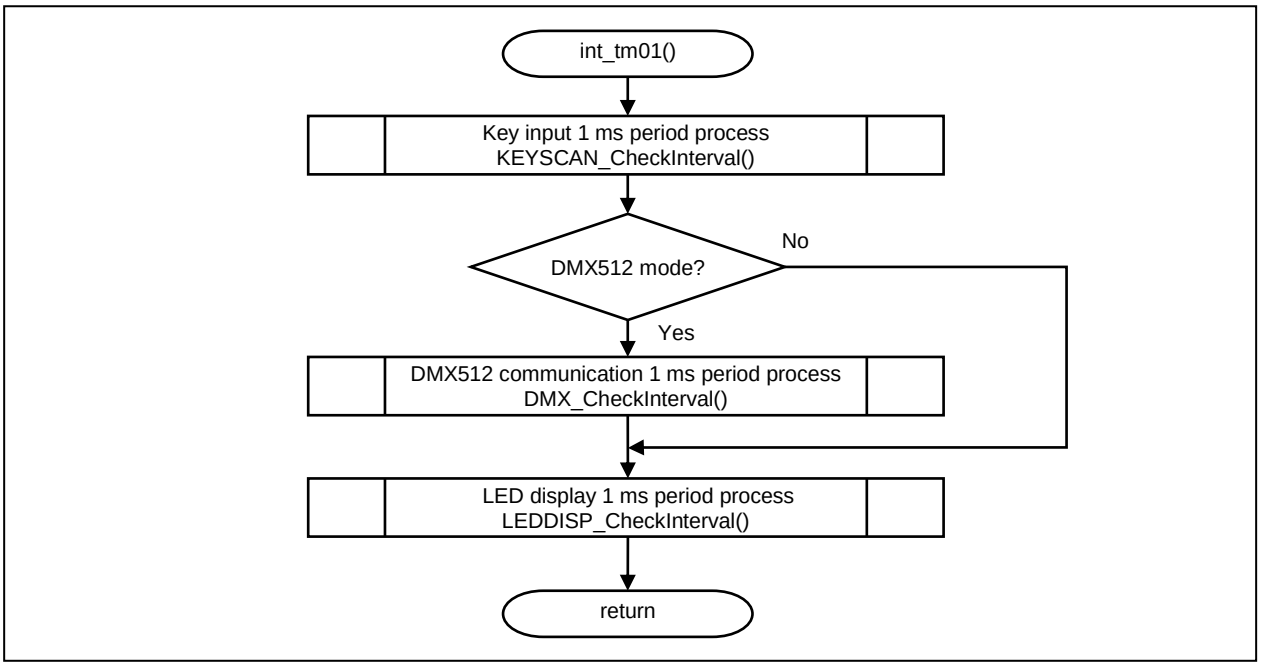


Figure 5-8 1 ms period process

1 ms period process is performed by the channel 1 (TM01) count complete interrupt of the timer array unit. Call the 1 ms period process function of each module and then process it.

5.5.6 562.5µs period process

int_tm02

Overview	562.5µs period process
Declaration	void int_tm02(void)
Description	This function processes at the time of channel 2 (TM02) count completion interrupt of the timer array unit. TM02 operates as an interval timer of 562.5µs period, starts at the time of IR transition. This interrupt timing is the burst timing of the carrier frequency and is used as a carrier frequency output change timing of the IR data transmission.
Parameter	None
Return value	None
Remark	None

Figure 5-9 shows the flow of 562.5µs period process.

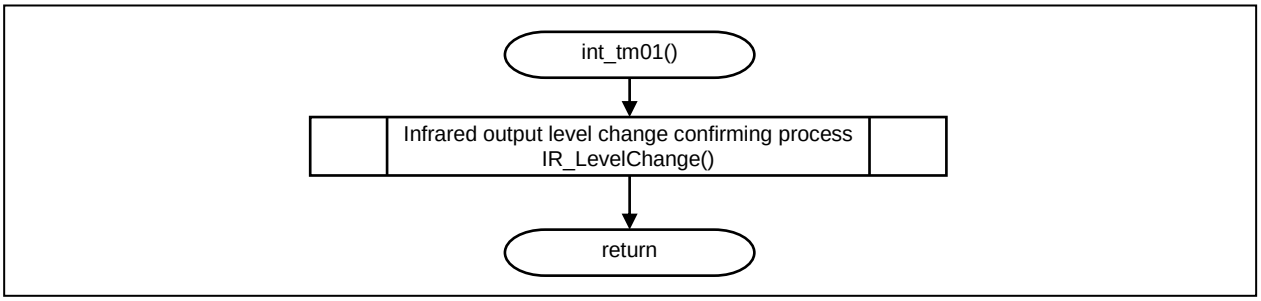


Figure 5-9 562.5µs period process

562.5µs period process is performed by the channel 2 (TM02) count complete interrupt of the timer array unit. Call the Infrared output level change confirming process function and then process it.

5.5.7 Key input read initialization process

KEYSCAN_Init	
Overview	Key input read initialization process
Declaration	void KEYSCAN_Init(void)
Description	It initializes the registers and variables associated with the key input read. For the initial settings of the associated registers (port), see Section 5.2.
Parameter	None
Return value	None
Remark	None

Figure 5-10 shows the flow of Key input read initialization process.

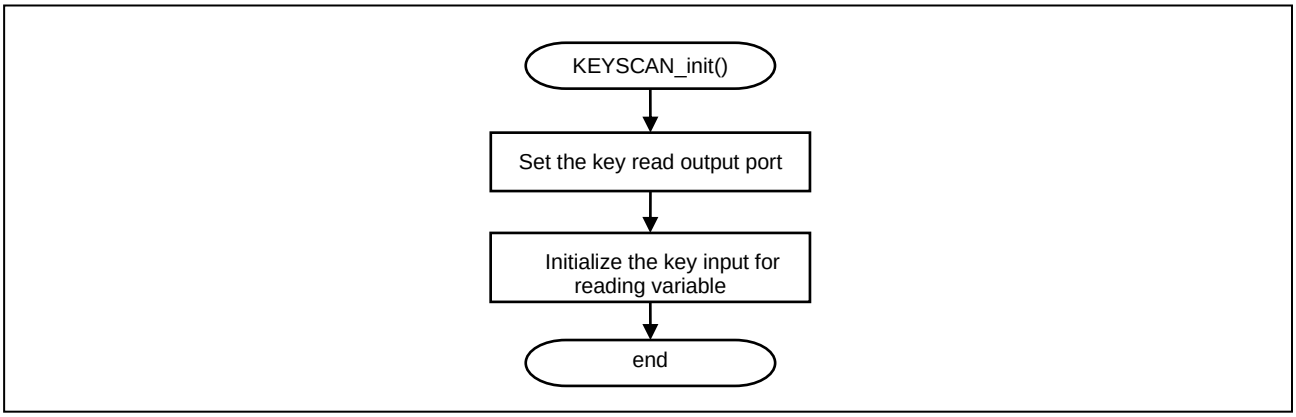


Figure 5-10 Key input read initialization process

It initializes the I / O port to be used for key input read and use variables.

For the initial settings, see Section 5.2.

5.5.8 Key input 1 ms period process

KEYSCAN_CheckInterval

Overview	Key input 1 ms period process
Declaration	void KEYSCAN_CheckInterval(void)
Description	It watches the key input period 10 ms and gets the key input in every 10ms. When there is a valid key input, it sets key operation request and LED4 lighting request. Even if there is a valid key input, if an input of the same key that is continuous from the previous input, a single operation key invalidates the input. For continuous operation key, when there is a valid key, continuous input operation is fixed if the same key as the last time was entered 15 times(150ms), and set the key operation request and LED4 lighting request. This function runs every 1 ms period.
Parameter	None
Return value	None
Remark	None

Figure 5-11 and Figure 5-12 show the flow of Key input 1 ms period process (1).

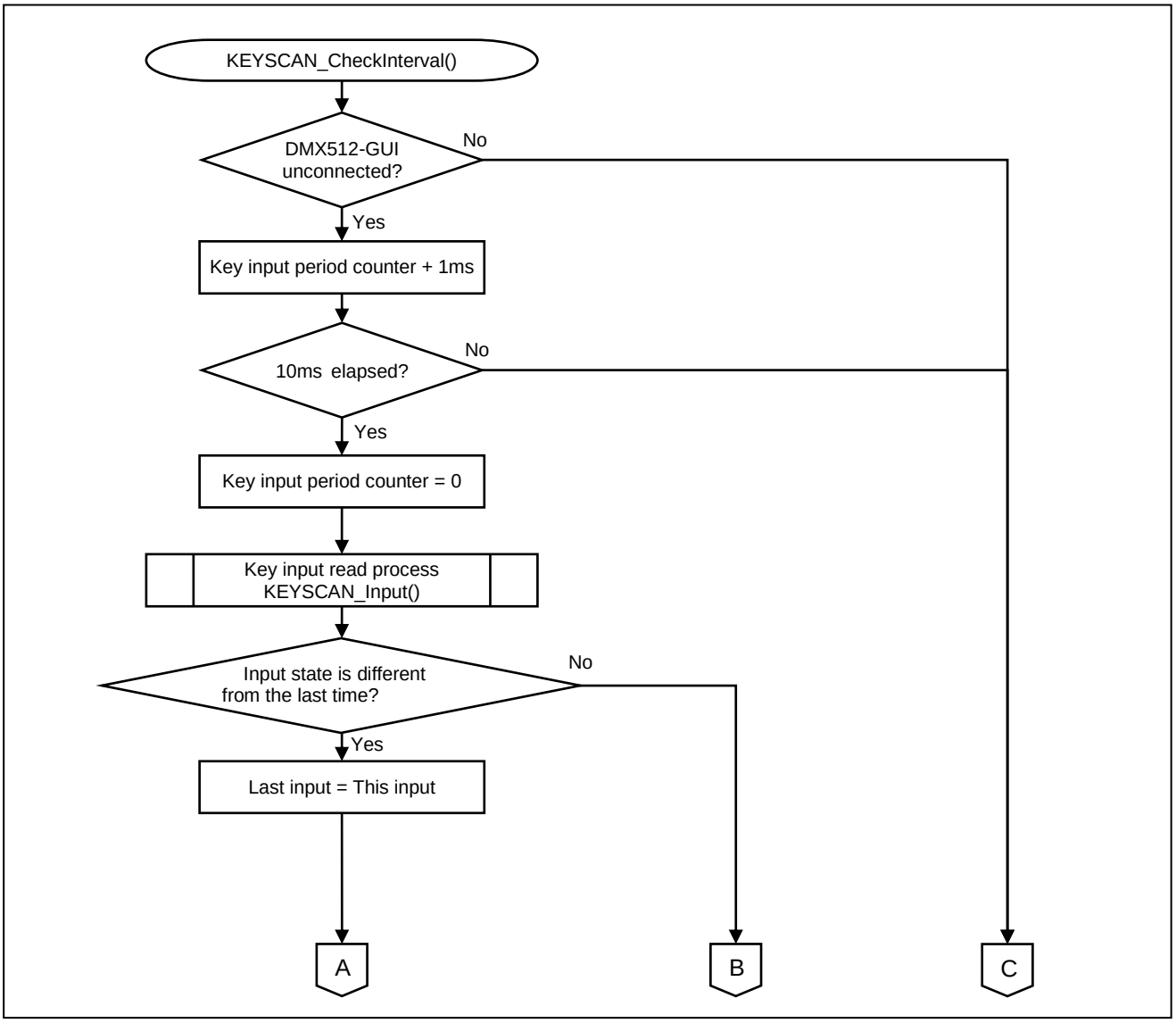


Figure 5-11 Key input 1 ms period process (1)

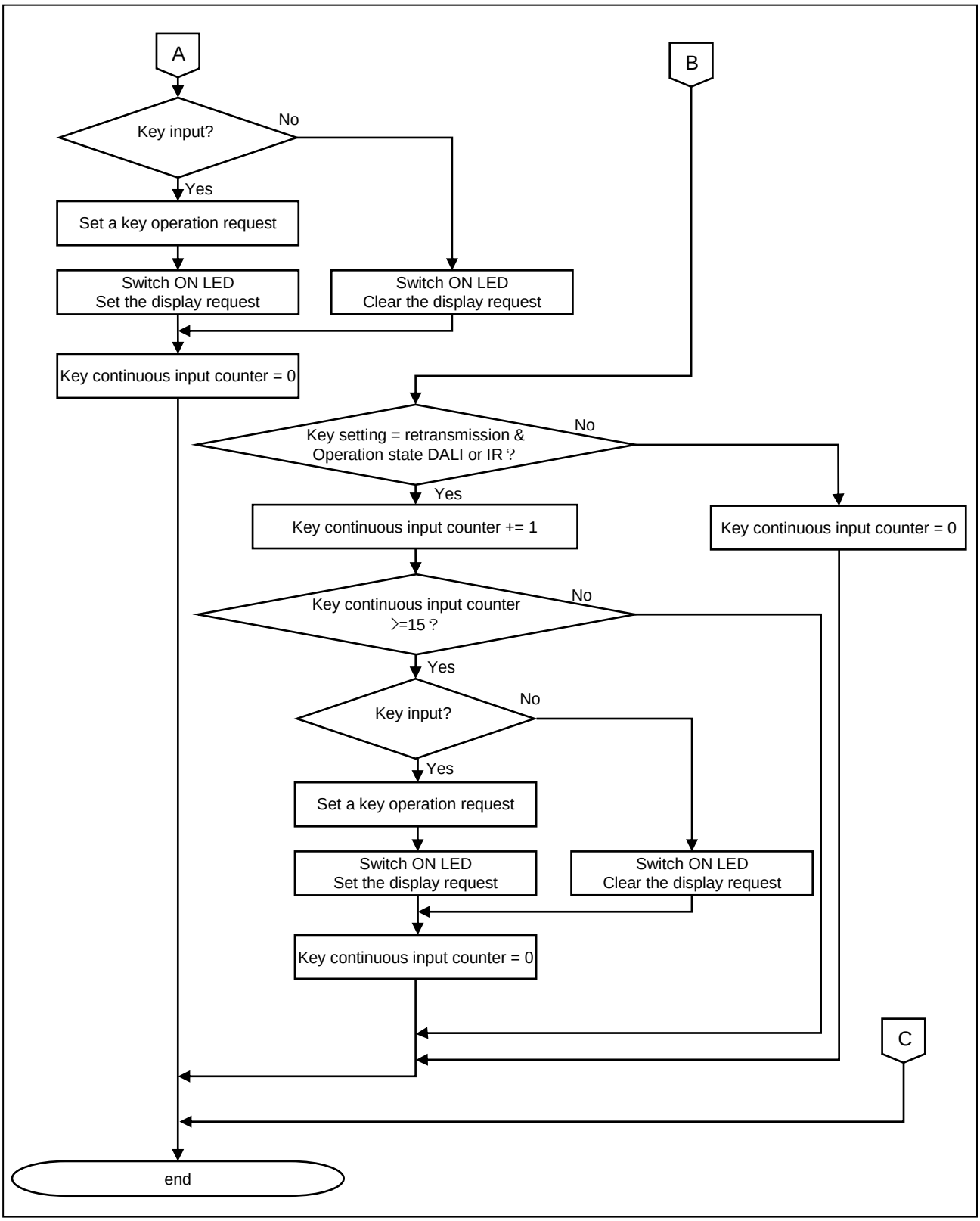


Figure 5-12 Key input 1 ms period process (2)

It watches the key input every 10 ms periods and confirms an input key by five times of agreement judgments in key input judgment process function. Continuous push operation of a key is prevented by judgment about a single operation key. For continuous operation key, if the same key is determined to match 15 times the previous enter key to confirm a continuous operation. If the confirmation key is valid, it performs the key operation request and the switch ON LED display request.

5.5.9 LED display initialization process

LEDDISP_Init	
Overview	LED display initialization process
Declaration	void LEDDISP_Init(void)
Description	It initializes the registers and variables associated with the LED display. For the initial settings of the associated registers (port), see Section 5.2.
Parameter	None
Return value	None
Remark	None

Figure 5-13 shows the flow of LED display initialization process.

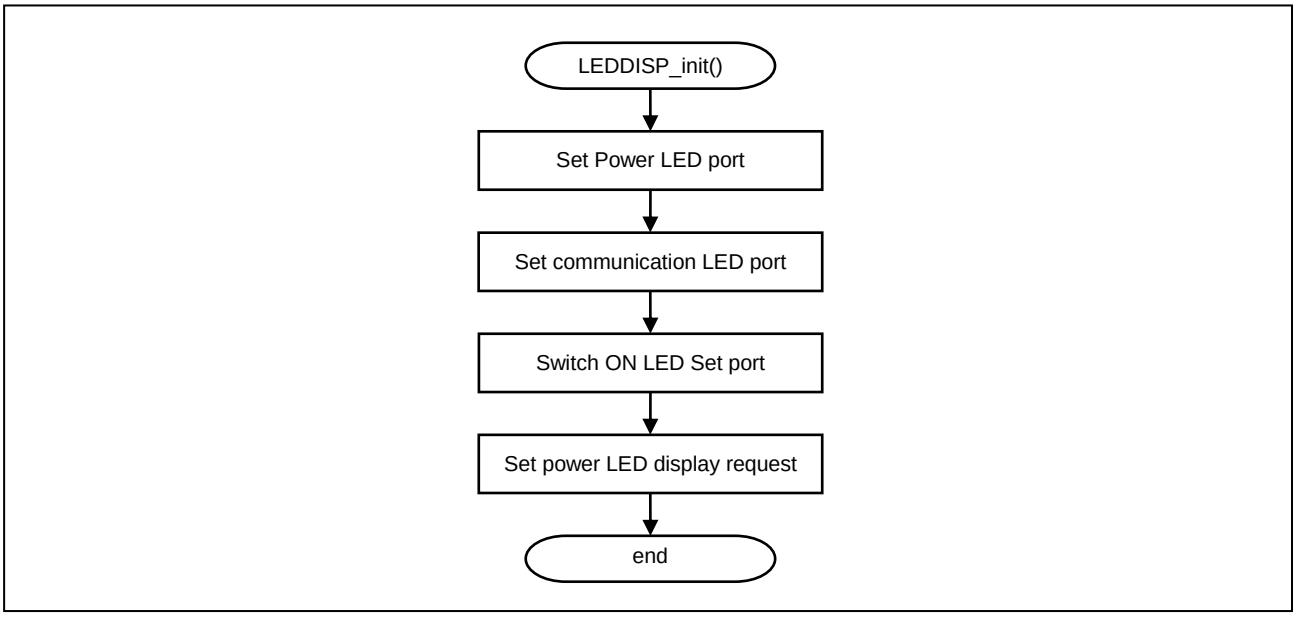


Figure 5-13 LED display initialization process

It initializes the I / O port to be used for the LED display. Also, it makes a request to display the power LED.

For the initial settings, see Section 5.2.

5.5.10 LED display 1 ms period process

LEDDISP_CheckInterval

Overview	LED display 1 ms period process
Declaration	void LEDDISP_CheckInterval(void)
Description	It watches each LED display request of the power supply LED / communication LED / switch ON LED, and make the turn on and off control of each LED by the request content. This function runs every 1 ms period.
Parameter	None
Return value	None
Remark	None

Figure 5-14 shows the flow of LED display 1 ms period process.

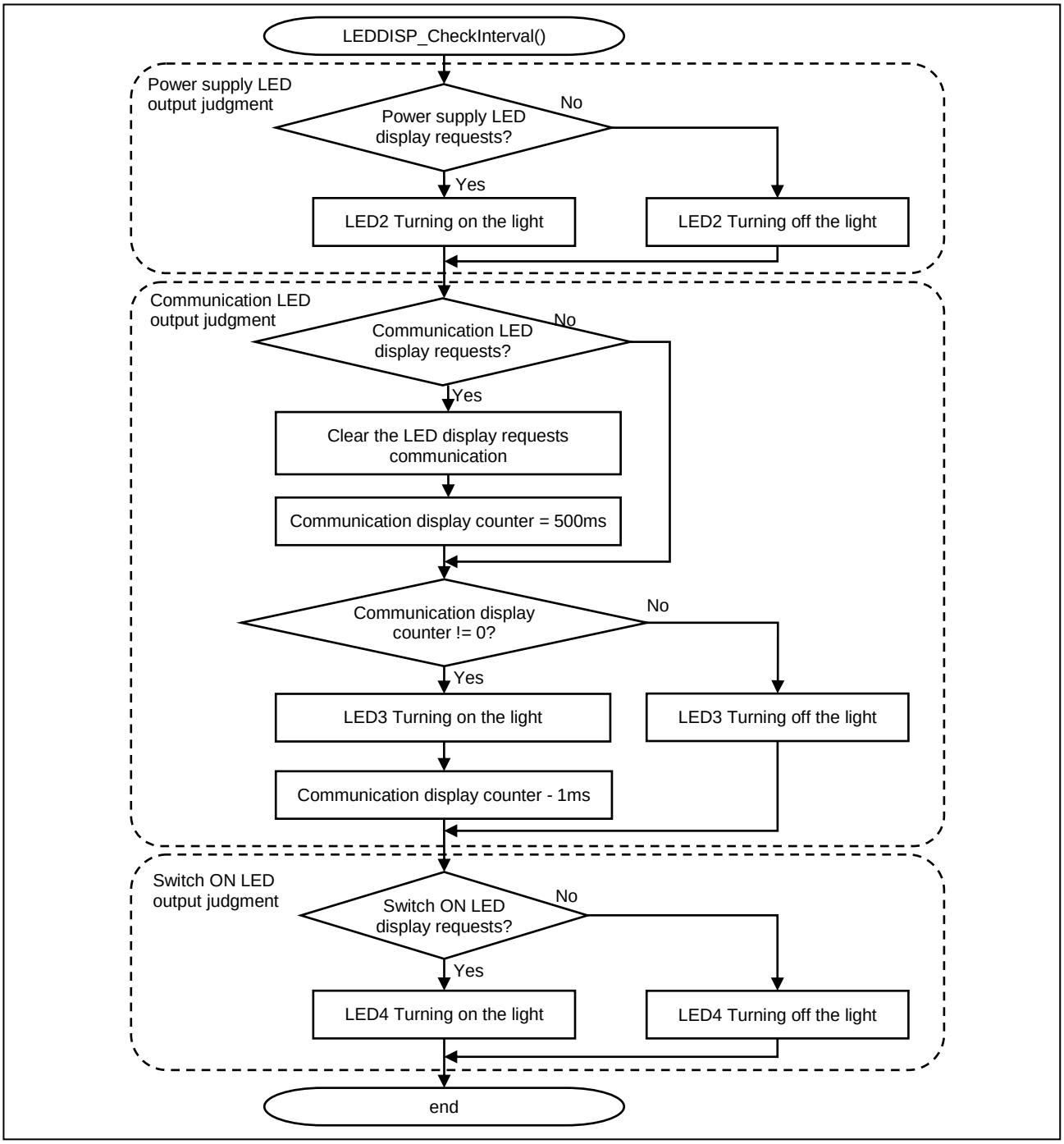


Figure 5-14 LED display 1 ms period process

It watches each LED display request of the power supply LED / communication LED / switch ON LED, and make the turn on and off control of each LED by the request content.

Communication LED lights up continuously for 500ms from accepting a request to display, and then turns off.

Switch ON LED continues to light up while pushing a key on the evaluation board.

5.5.11 DALI communication initialization process

DALI_Init

Overview	DALI communication initialization process
Declaration	void DALI_Init(void)
Description	It initializes the registers and variables associated with DALI communication. For the initial settings of the associated registers (DALI/UART4, TAU), see Section 5.2.
Parameter	None
Return value	None
Remark	None

Figure 5-15 shows the flow of DALI communication initialization process.

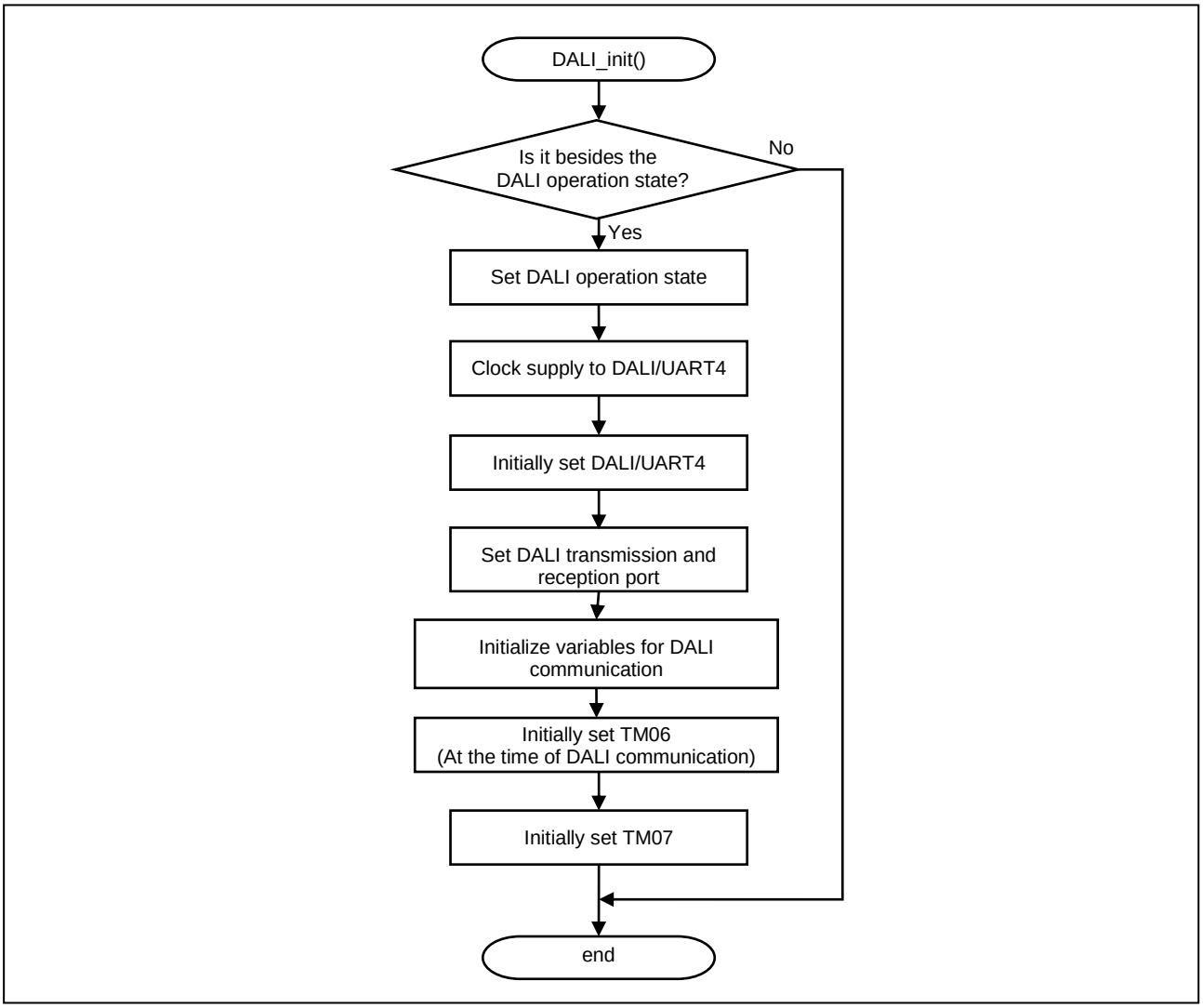


Figure 5-15 DALI communication initialization process

It initializes serial array unit and timer array unit to be used for DALI communication control.

For the initial settings, see Section 5.2.

5.5.12 DALI communication control

DALI_Loop

Overview	DALI communication control
Declaration	void DALI_Loop(void)
Description	It performs the DALI transmission depending on DALI communication request by USB communication or the key input. It performs the DALI reception after the command transmission when the response from a slave is a necessary command. In addition, it performs judgment pattern of the collision detection judgment time and timer setting for collision detection at the time of the transmission, and start collision watching. When there is key input during communication process, it stops a using timer (TM06, TM07) after communication and pass through this function.
Parameter	None
Return value	None
Remark	None

Figure 5-16, Figure 5-17, Figure 5-18 and Figure 5-19 show the flow of DALI communication control (1).

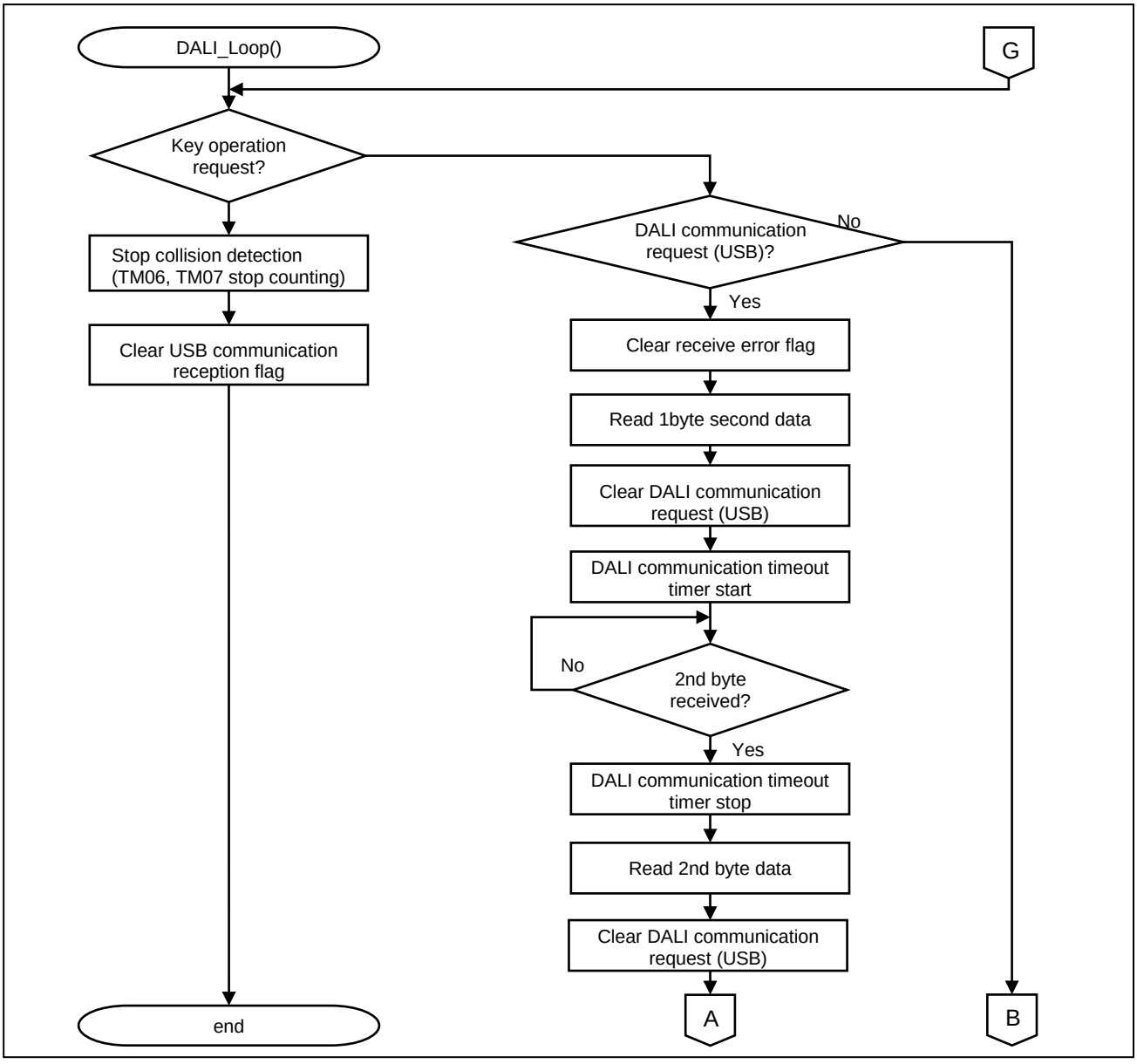


Figure 5-16 DALI communication control (1)

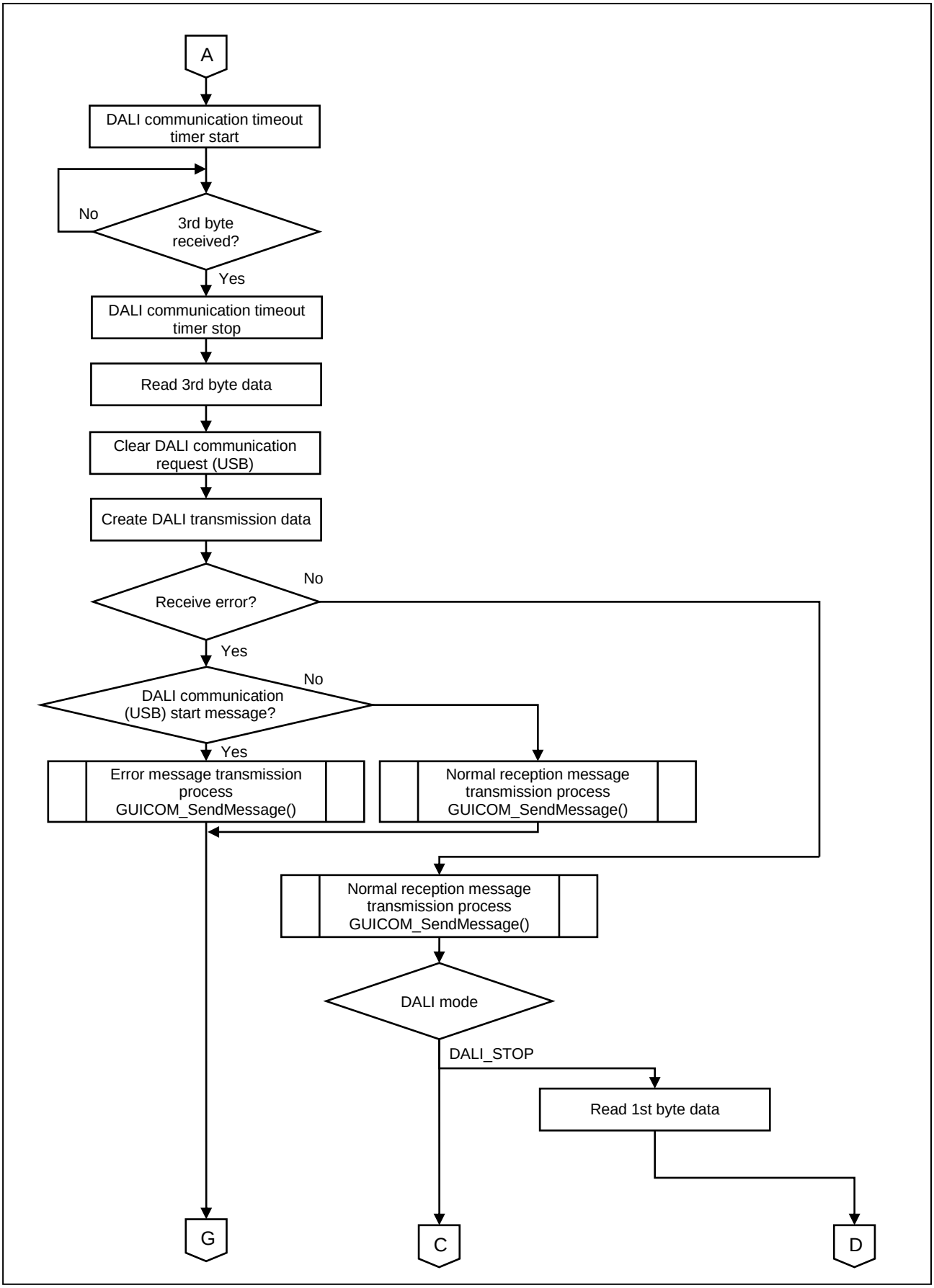


Figure 5-17 DALI communication control (2)

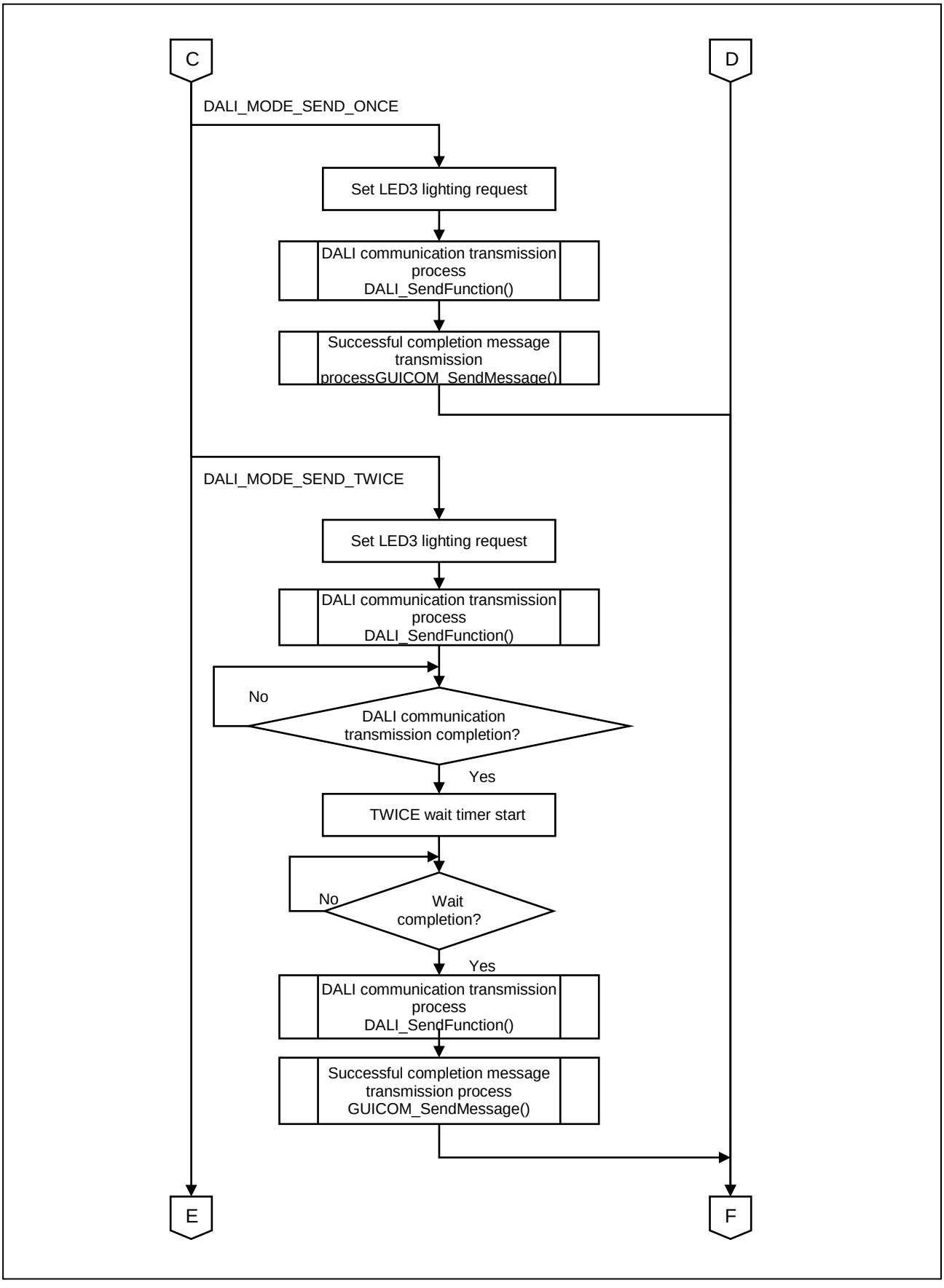


Figure 5-18 DALI communication control (3)

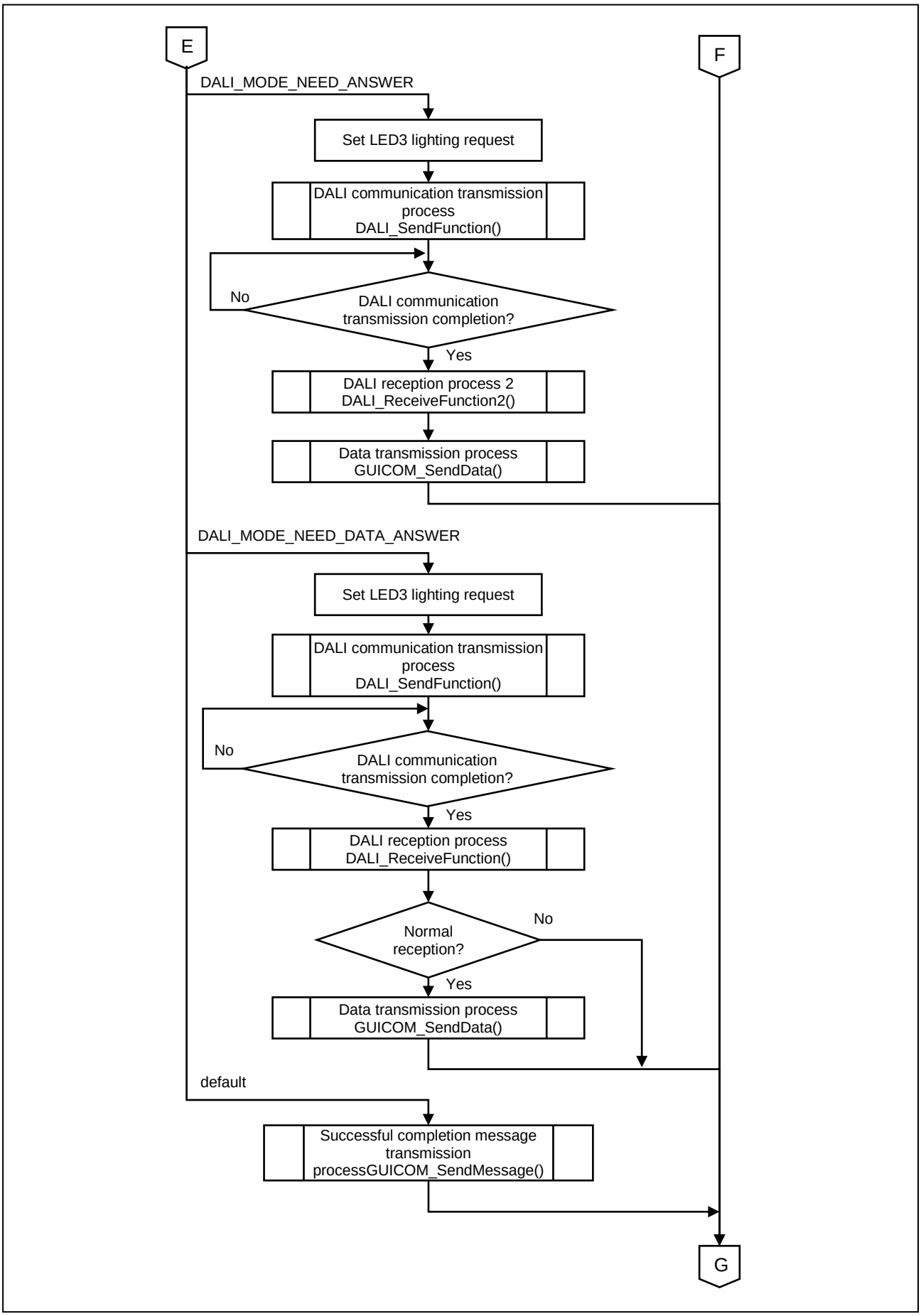


Figure 5-19 DALI communication control (4)

DALI communications control is performed according to the DALI communication request.

If there is a DALI communication request by the USB communication, 3 performs a USB communication waiting until the byte reception is completed, and then performs DALI transmission of received data to the slave based on. When there are the instructions of the command that a reply is needed, it performs reception waiting for from the slave after DALI transmission, it transmissions a response data received by the USB communication.

When there is DALI communication request by the key input, it performs DALI transmission of data set depending on the key which had the input to a slave. At the time of transmission start, the count of the TM06 as for collision detection starts.

In addition, regardless of the request by the USB communication and the key input, a communication LED display request is performed at the time of DALI transmission.

After DALI communication end, when there is a key input, it stops the timer that use, then exits from the control function.

5.5.13 DALI/DMX512 communication transmission completion interrupt process

int_stdl4

Overview	DALI/DMX512 communication transmission completion interrupt process
Declaration	void int_stdl4(void)
Description	Transmission completion interrupt process is performed at the time of DALI/DMX512 communication mode. In the DALI communication mode, it performs the stop of the timer for the collision detection and the stop of the DALI communication in DALI transmission completion process function. In the DMX512 communication mode, it confirms the number of transmission data and judge to continue or stop transmission.
Parameter	None
Return value	None
Remark	None

Figure 5-20 shows the flow of DALI/DMX512 communication transmission completion interrupt process.

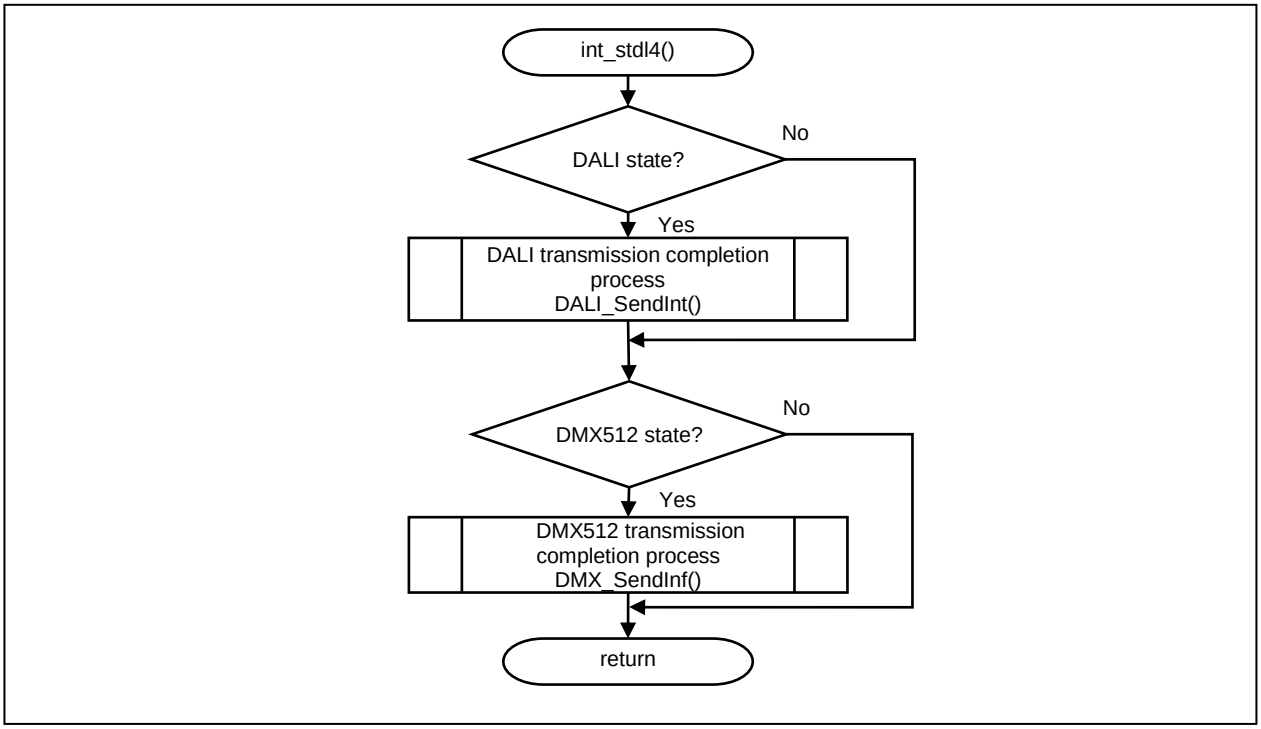


Figure 5-20 DALI/DMX512 communication transmission completion interrupt process

When receiving the transmission completion interrupt while operating in DALI mode, it will be distributed to DALI communication interrupt completion process, when receiving the transmission completion interrupt while operating in DMX512 mode, it will be distributed to DMX512 communication interrupt completion process.

5.5.14 DALI communication reception completion interrupt process

int_srdl4

Overview	DALI communication reception completion interrupt process
Declaration	void int_srdl4(void)
Description	In DALI communication mode, it performs reception completion interrupt process. In DALI communication mode, it performs error check and getting received data process in the DALI reception complete processing function.
Parameter	None
Return value	None
Remark	None

Figure 5-21 shows the flow of DALI communication reception completion interrupt process.

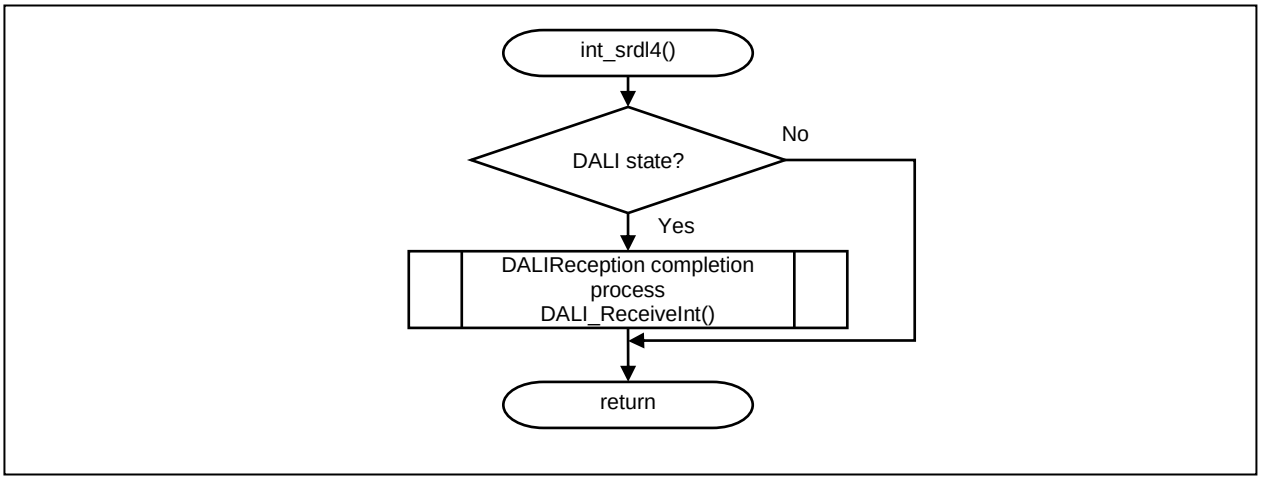


Figure 5-21 DALI communication reception completion interrupt process

When receiving a reception completion interrupt while operating in DALI mode, it performs getting received data, checking error and setting already received, and clears the interrupt source.

5.5.15 DALI communication collision detection pulse measurement timer process

int_tm06

Overview	DALI communication collision detection pulse measurement timer process
Declaration	void int_tm06(void)
Description	In DALI communication mode, it performs judging process of collision detection by the pulse interval measurement. In DMX512 communication mode, it performs judging Break signal process at the time of DMX512 reception.
Parameter	None
Return value	None
Remark	None

Figure 5-22 shows the flow of DALI communication collision detection pulse measurement timer process.

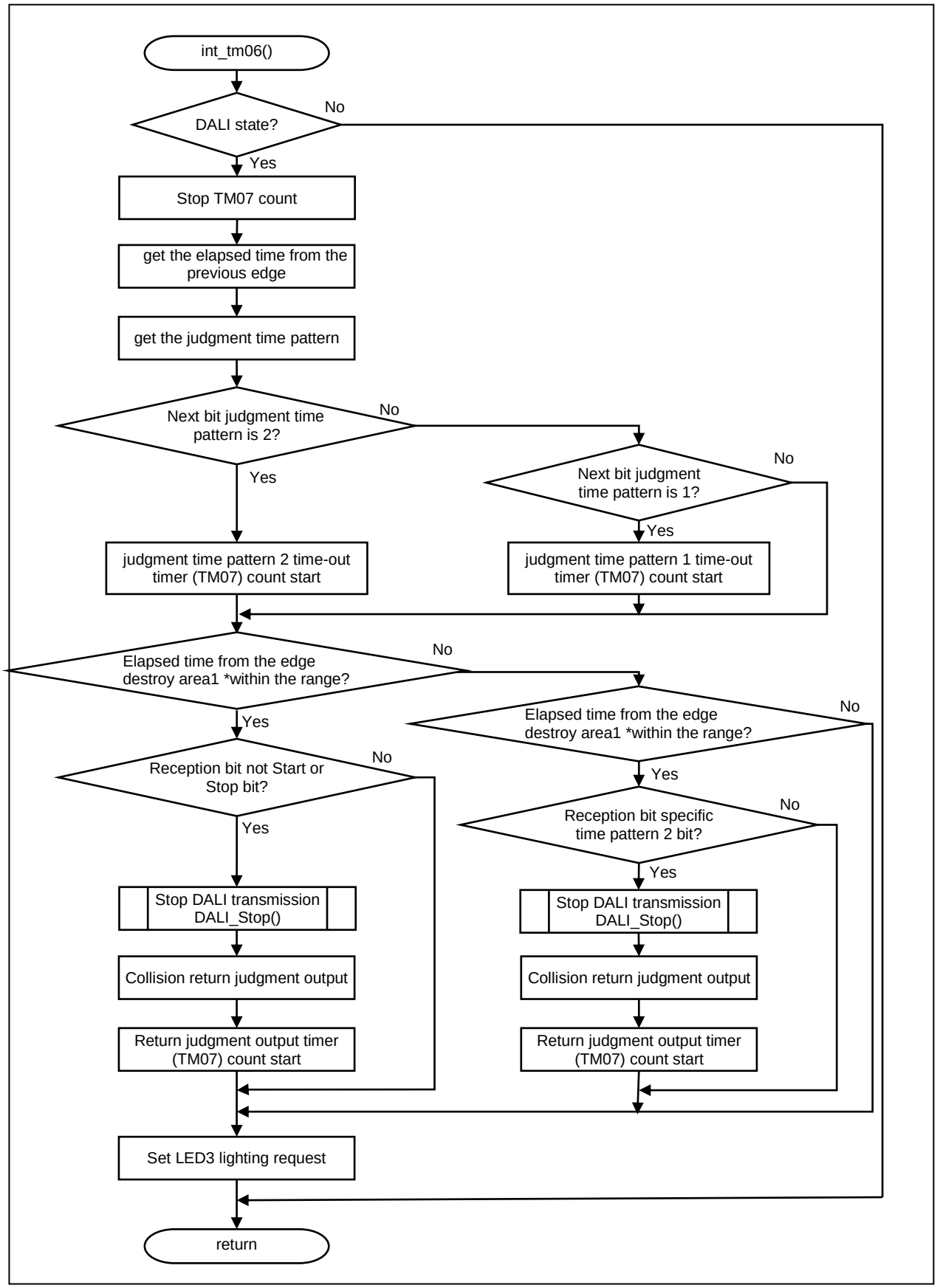


Figure 5-22 DALI communication collision detection pulse measurement timer process

This function is carried out at the time of channel 6 (TM06) of the timer array unit count completion interrupt.

It operates differently in the DALI communication mode and DMX512 communication mode.

a. DALI communication mode

In DALI communication mode, it operates as a collision detection judgment process by the pulse interval measurement.

In this program, it operates TM06 as an input pulse distance measurement mode just before the DALI transmission and starts edge monitoring of the bus line. Then, an interrupt occurs by detecting an edge and it begins the process of this function. (The edge detection in the first time is invalid.)

At the time of DALI transmission start, time of the bit which should be received by transmission bit pattern set in advance and time of the bit received just before are compared and collision judgment is performed. In addition, similarly, it decides the Time out time (see Table 1-5and Table 1-6) of the bit to transmit next by transmission bit pattern and starts a count of time-out timer (TM07).

When it is a collision detection by the result of the collision judgment, DALI transmission is stopped and collision restore operation is begun. (For judgment standard of collision, see Section 1.4.2. For collision return, see Section 1.4.3.)

5.5.16 DALI communication collision detection elapsed time determination timer process int_tm07

Overview	DALI communication collision detection elapsed time determination timer process
Declaration	void int_tm07(void)
Description	In DALI communication mode, it performs the collision detection judgment process by the time elapsed. After collision detection, elapsed time judgment process for collision return is performed.
Parameter	None
Return value	None
Remark	None

Figure 5-23 and Figure 5-24 show the flow of DALI communication collision detection elapsed time determination timer process.

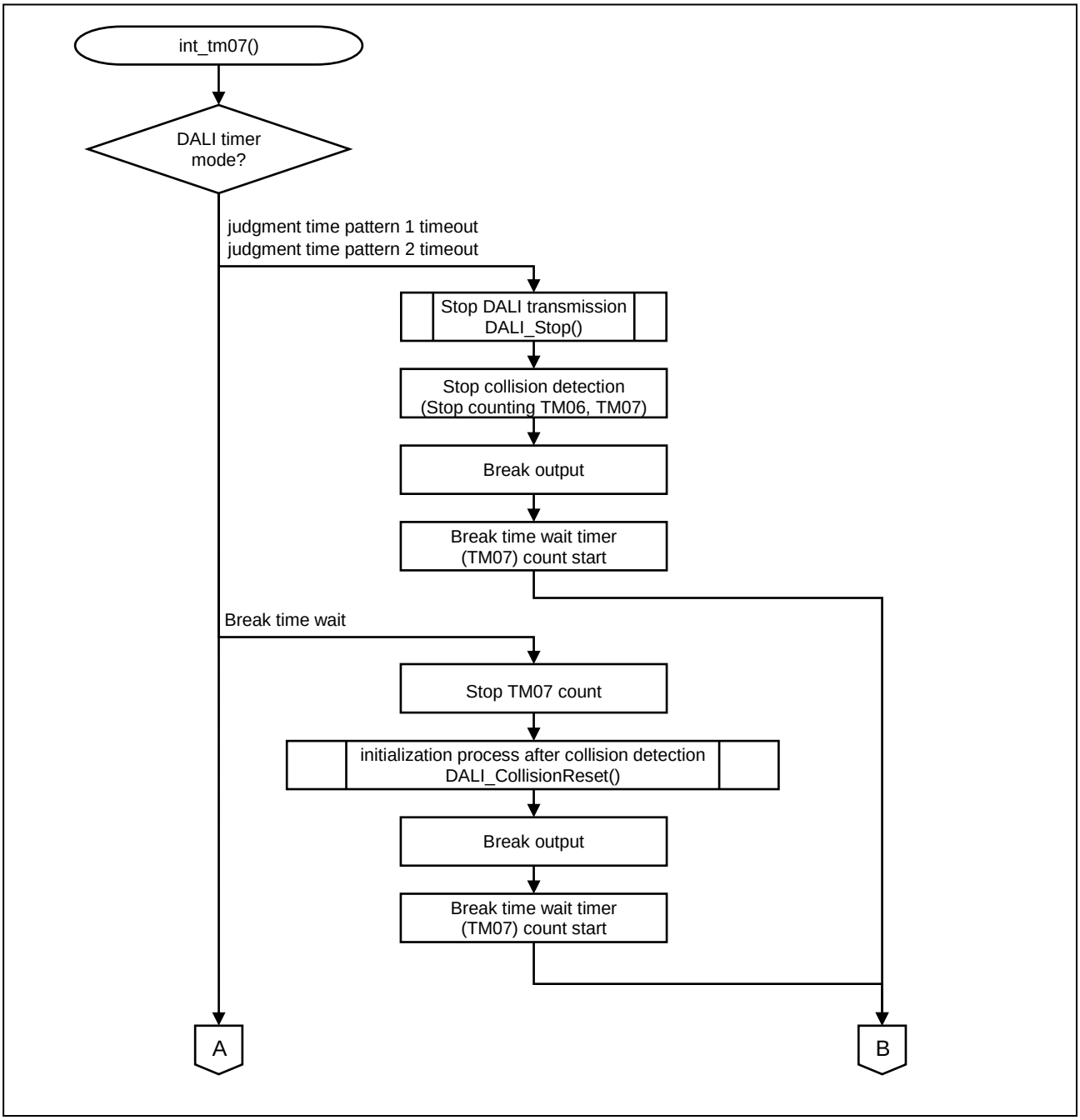


Figure 5-23 DALI communication collision detection elapsed time determination timer process (1)

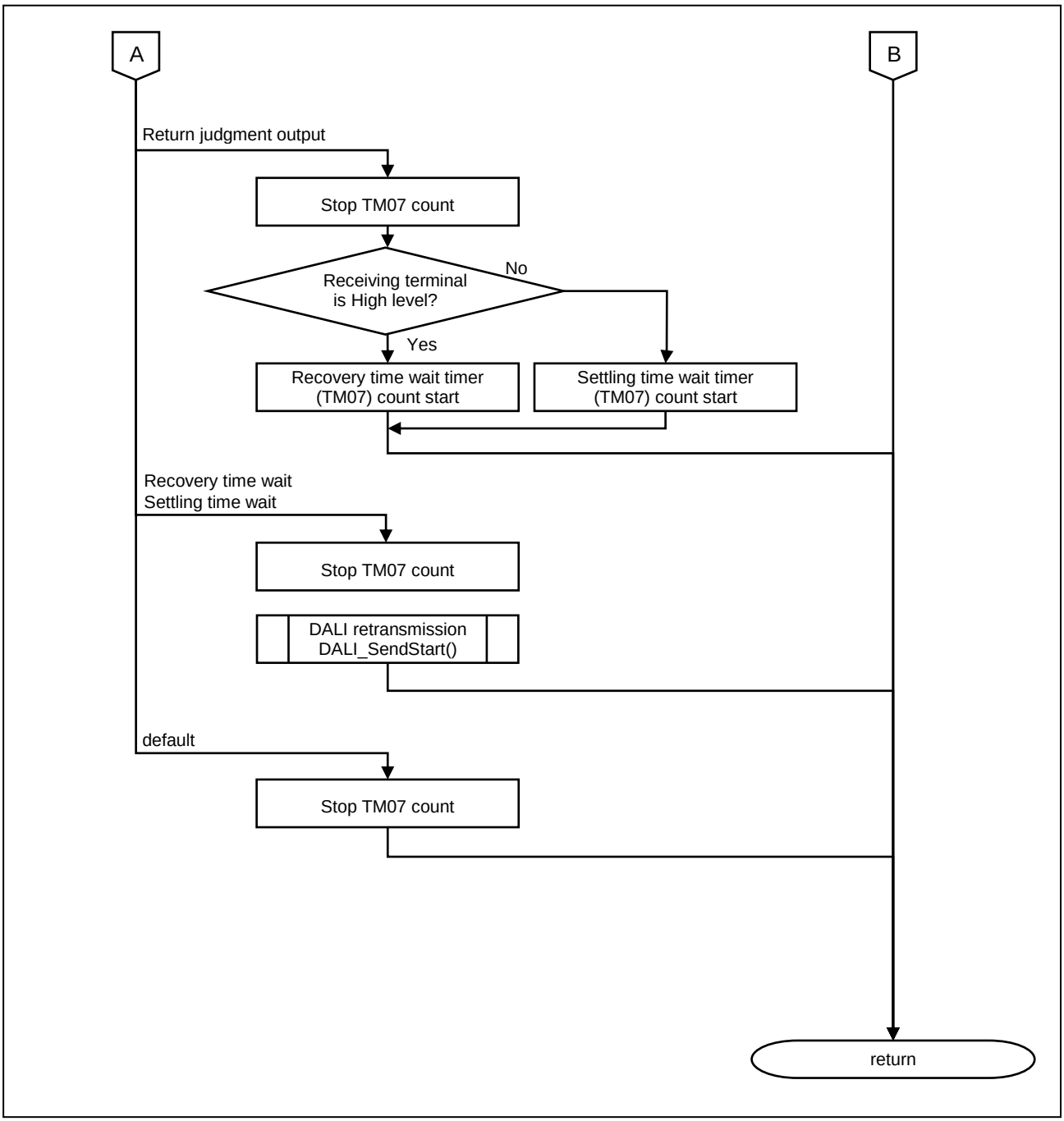


Figure 5-24 DALI communication collision detection elapsed time determination timer process (2)

This function is carried out at the time of channel 7 (TM07) of the timer array unit count completion interrupt.

In DALI communication mode, it operates judgment process of the elapsed time for the collision detection and return.

At the time of normal transmission, it operates as a time-out timer, which is set in the DALI communication collision detection pulse measurement timer process (see Section 5.5.15), performs collision detection and judgment.

After the collision detection, it operates as a timer waiting Break time, a return judgment output timer, a timer waiting Recovery time, a timer waiting Settling time for collision return process. About a procedure of the return movement and the timing, see Section 5.6.

5.5.17 DMX512 communication initialization process

DMX_Init

Overview	DMX512 communication initialization process
Declaration	void DMX_Init(void)
Description	It initializes the registers and variables associated with DMX512 communication. For the initial settings of the associated registers (DALI/UART4, TAU), see Section 5.2.
Parameter	None
Return value	None
Remark	None

Figure 5-25 shows the flow of DMX512 communication initialization process.

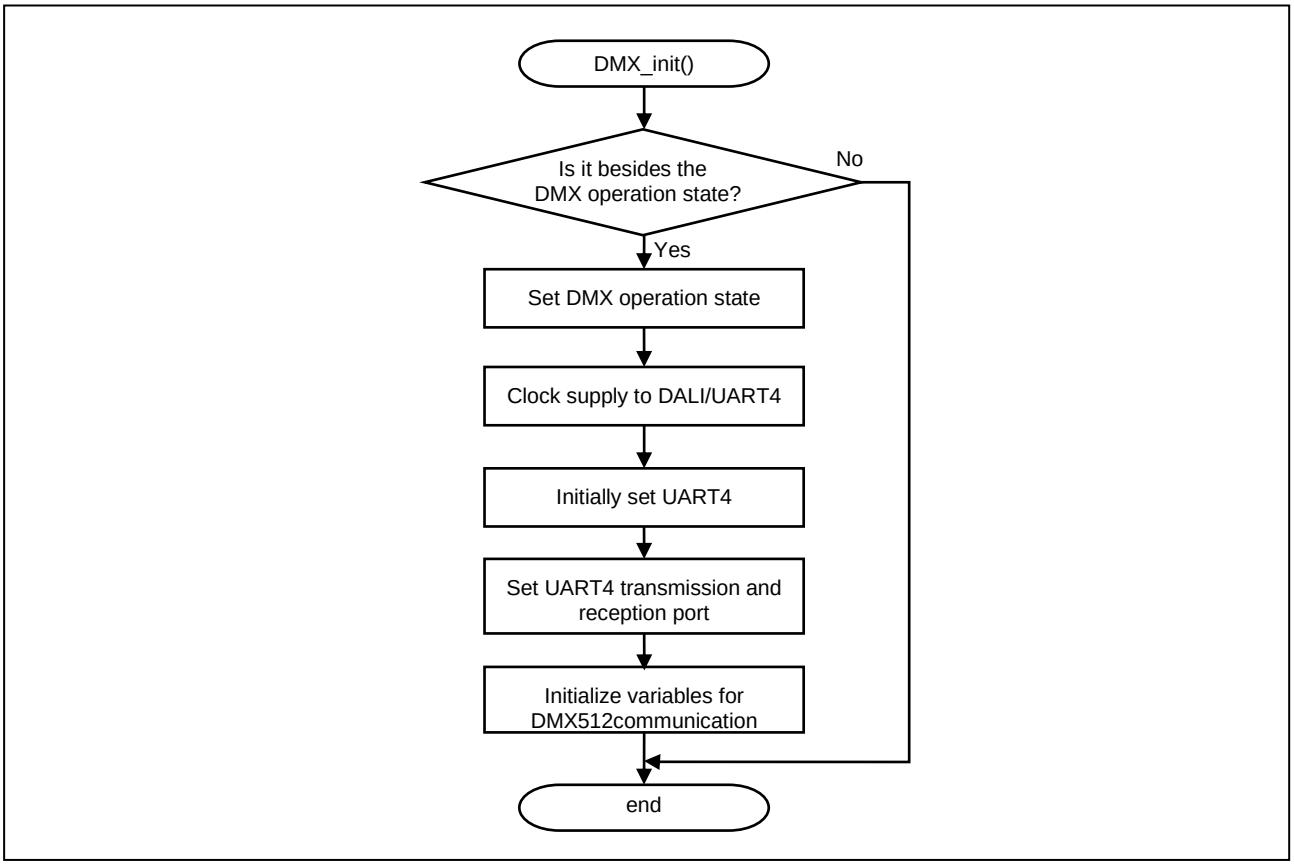


Figure 5-25 DMX512 communication initialization process

It initializes serial array unit to be used for DMX512 communication control.

For the initial settings, see Section 5.2.

5.5.18 DMX512 communication control process

DMX_Loop

Overview	DMX512 communication control process
Declaration	void DMX_Loop(void)
Description	It performs the DMX512 transmission depending on DMX512 communication request by USB communication or the key input. It becomes the DMX512 reception wait state after the transmission. When there is key input during communication process, it passes through this function after communication.
Parameter	None
Return value	None
Remark	None

Figure 5-26 shows the flow of DMX512 communication control process.

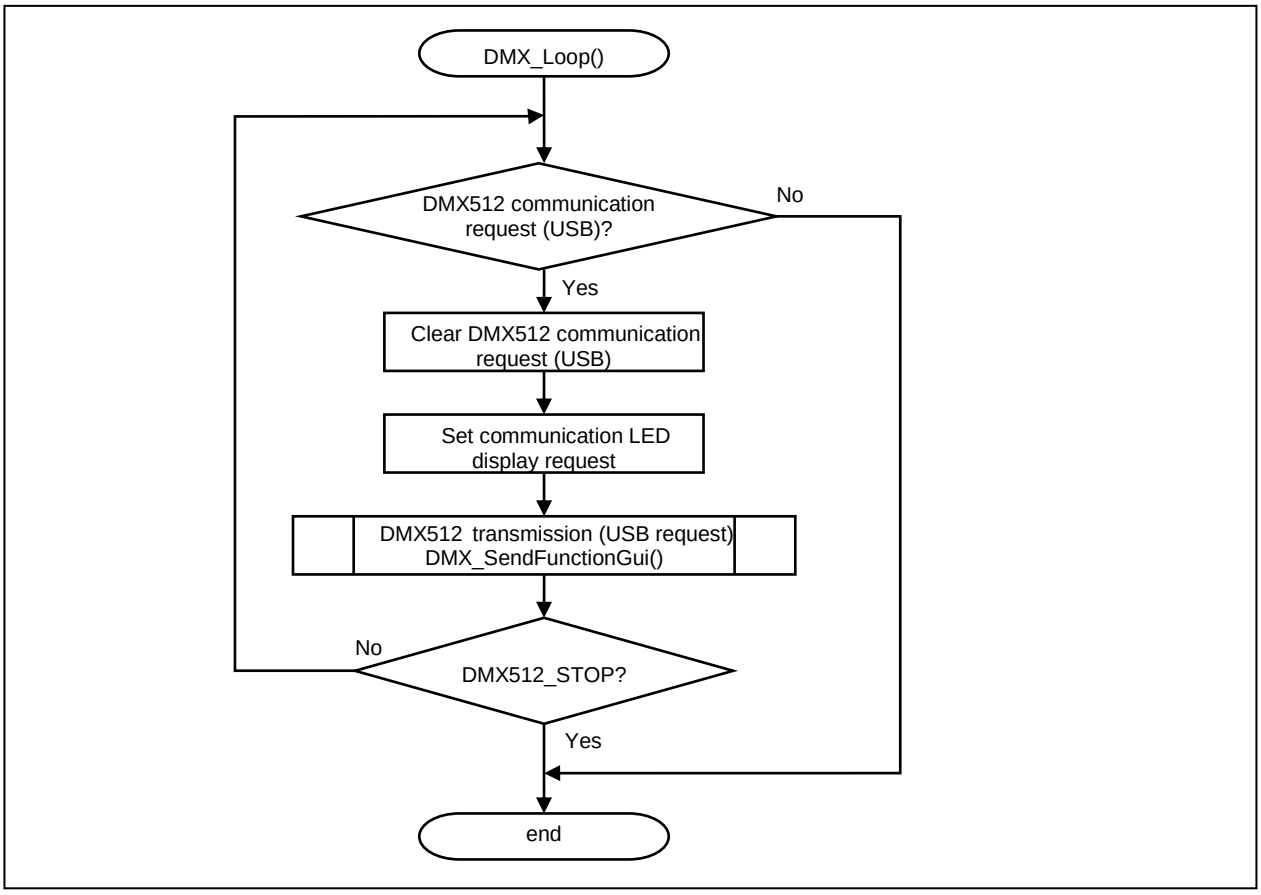


Figure 5-26 DMX512 communication control process

If there is a DMX512 communication request by the USB communication, DMX512 transmission is carried out to a slave based on the received data.

A communication LED display request is performed at the time of DMX512 transmission.

5.5.19 DMX512 communication 1 ms period process

DMX_CheckInterval

Overview	DMX512 communication 1 ms period process
Declaration	void DMX_CheckInterval(void)
Description	Time-out judgment of DMX512 communication is performed. Transmission time-out : 50 ms This function runs every 1 ms period.
Parameter	None
Return value	None
Remark	None

Figure 5-27 shows the flow of DMX512 communication 1 ms period process.

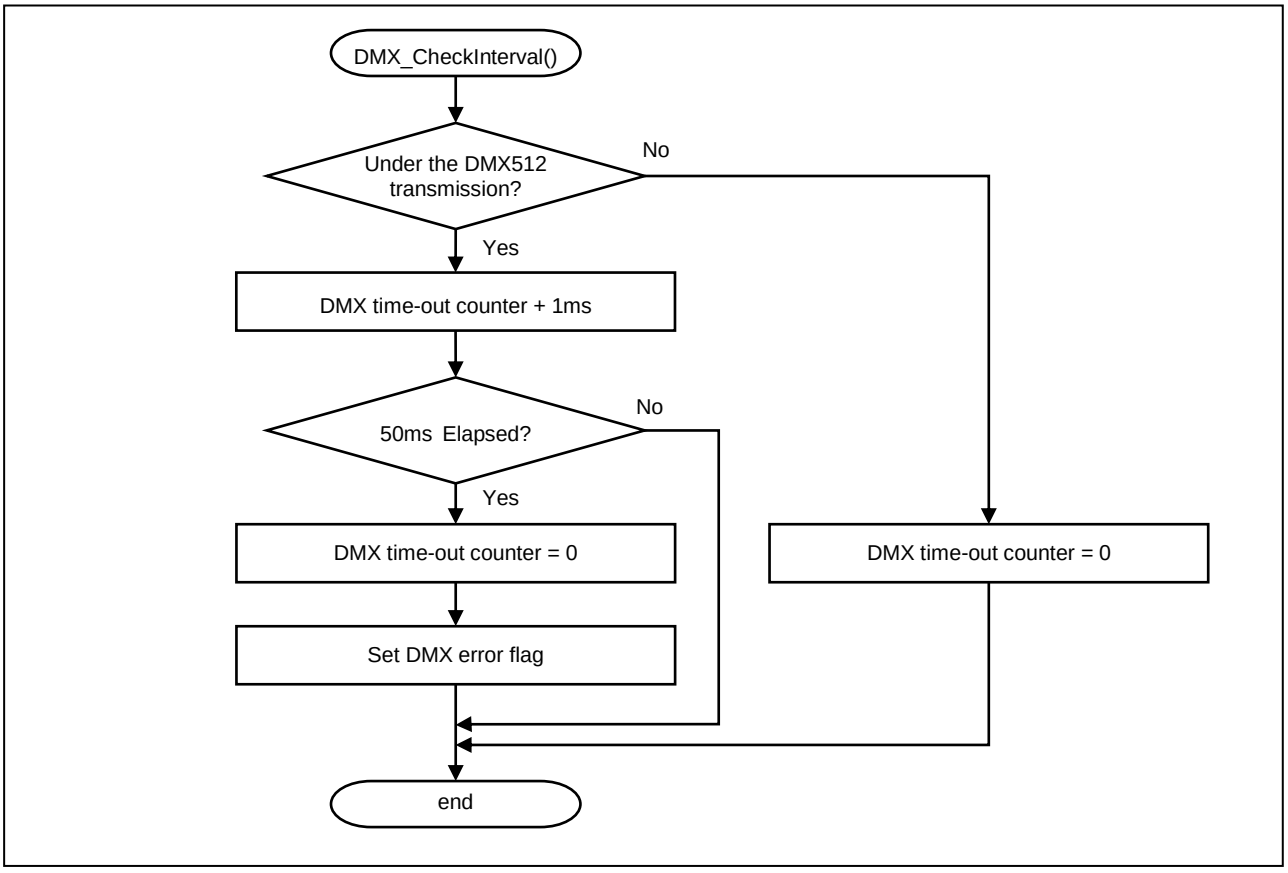


Figure 5-27 DMX512 communication 1 ms period process

Time-out judgment of DMX512 communication is performed. When 50 ms has passed during DMX512 transmission to a slave, it judges transmission time-out and set the error flag to transmit error flag by USB communication.

5.5.20 Infrared transmission initialization process

IR_Init

Overview	Infrared transmission initialization process
Declaration	void IR_Init(void)
Description	It initializes the registers and variables associated with Infrared transmission. For the initial settings of the associated registers (TAU), see Section 5.2.
Parameter	None
Return value	None
Remark	None

Figure 5-28 shows the flow of Infrared transmission initialization process.

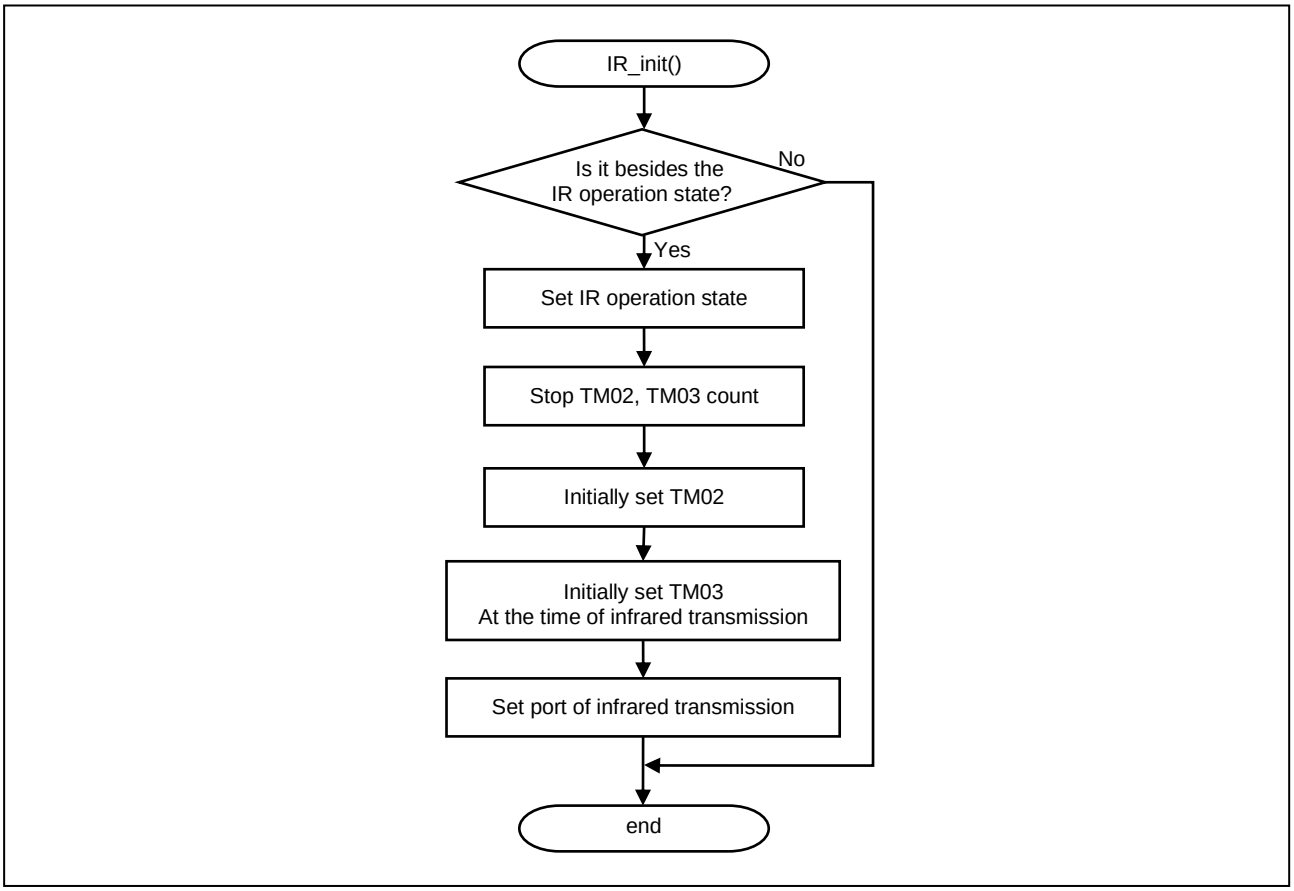


Figure 5-28 Infrared transmission initialization process

It initializes timer array unit to be used for infrared transmission control.

For the initial settings, see Section 5.2.

5.5.21 Infrared transmission process

IR_Send

Overview	Infrared transmission process
Declaration	void IR_Send(void)
Description	An infrared transmission is performed according to the infrared transmission request by key input.
Parameter	None
Return value	None
Remark	None

Figure 5-29 shows the flow of Infrared transmission process.

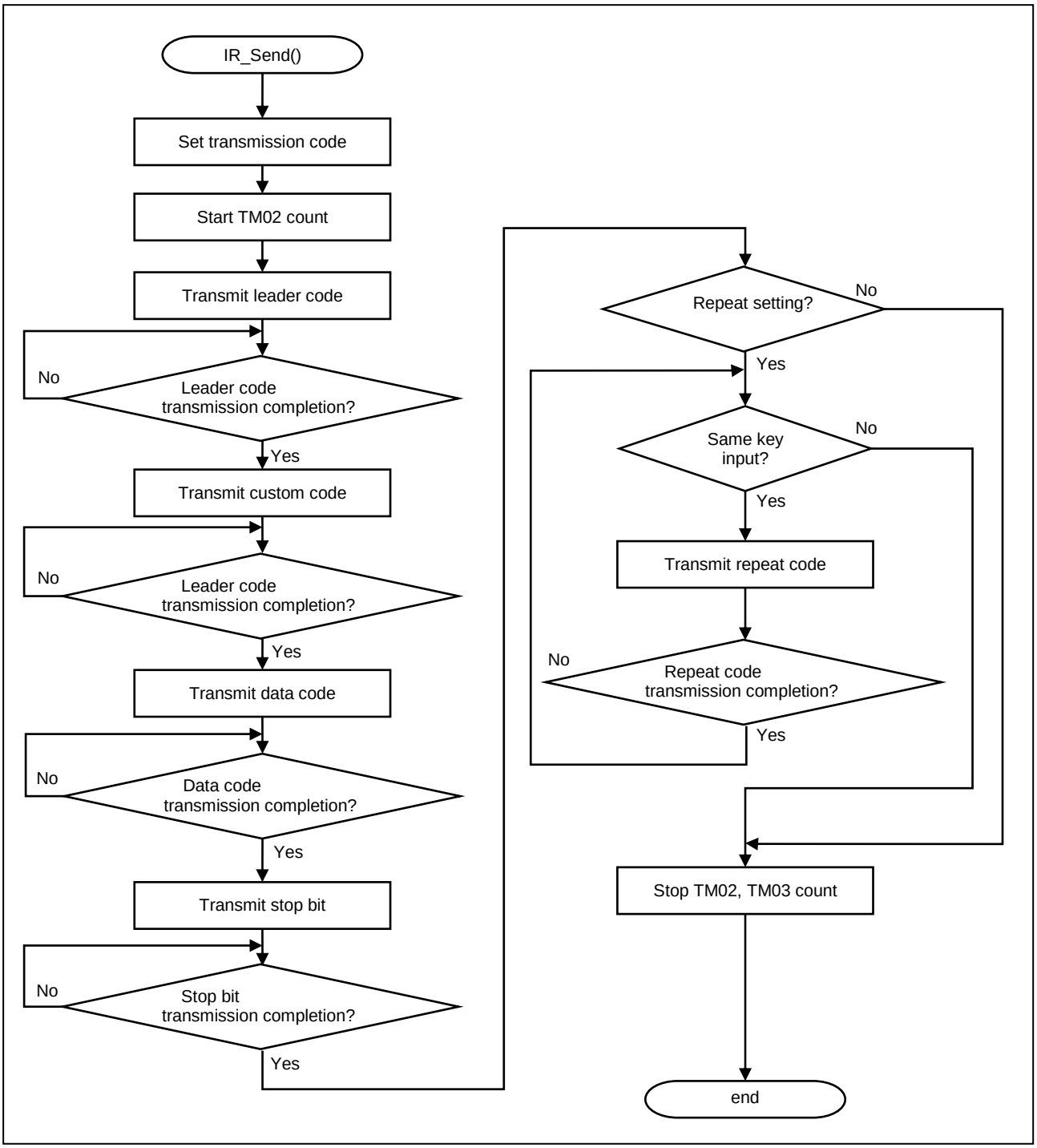


Figure 5-29 Infrared transmission process

A custom code according to SW1 setting and the data code set at the time of operation request are transmitted by infrared communication. When key input is continued after a custom code and a data code transmission, repeat code is transmitted repeatedly.

5.5.22 USB communication initialization process

GUICOM_Init

Overview	USB communication initialization process
Declaration	void GUICOM_Init(void)
Description	It initializes the registers and variables associated with USB communication. For the initial settings of the associated registers (UART0, TAU), see Section 5.2.
Parameter	None
Return value	None
Remark	None

Figure 5-30 shows the flow of USB communication initialization process.

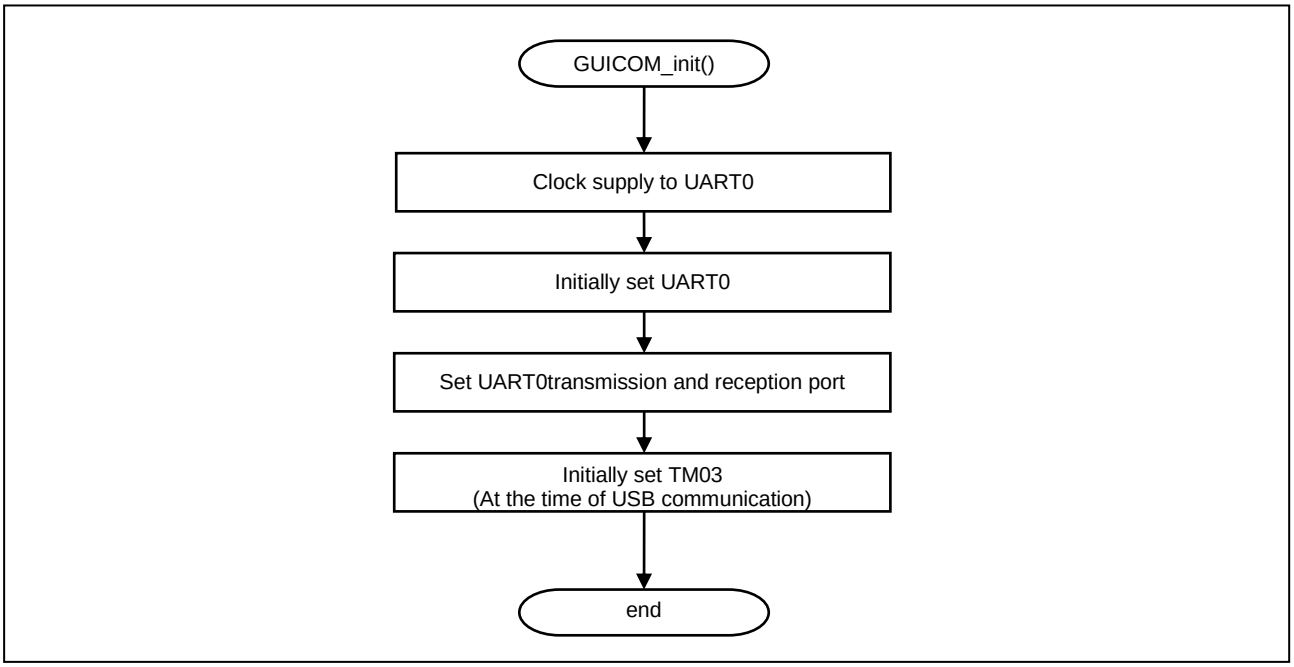


Figure 5-30 USB communication initialization process

It initializes serial array unit and timer array unit to be used for USB communication control.

For the initial settings, see Section 5.2.

5.5.23 USB communication reception completion interrupt process

ins_sr1

Overview	USB communication reception completion interrupt process
Declaration	void int_sr1(void)
Description	It performs USB communication reception completion interrupt process.
Parameter	None
Return value	None
Remark	None

Figure 5-31 shows the flow of USB communication reception completion interrupt process.

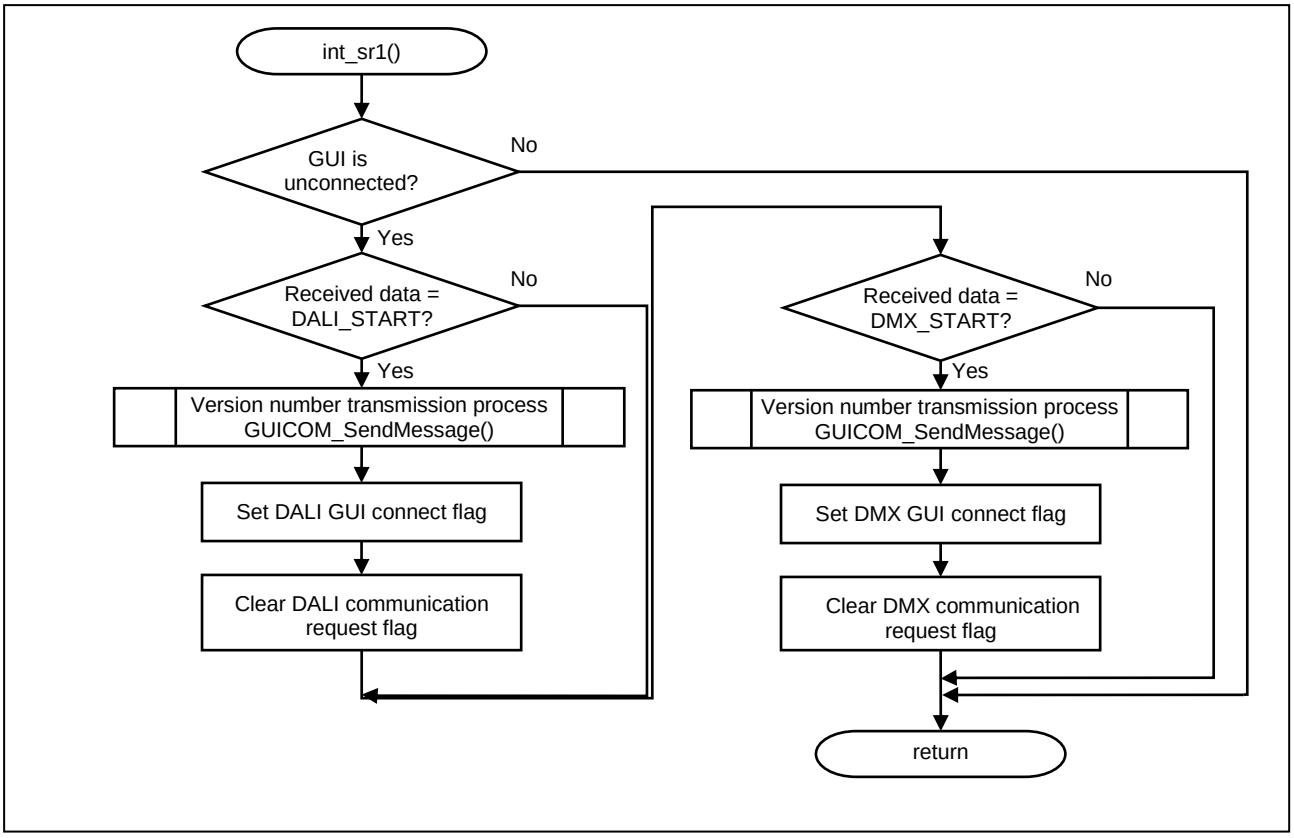


Figure 5-31 USB communication reception completion interrupt process

It performs USB communication reception completion interrupt process.

When receiving a DALI_START or DMX_START command while the GUI is not connected, it transmits the version number to the GUI, and shifts to GUI connection state.

5.5.24 USB communication timeout process

ins_sr1

Overview	USB communication timeout process
Declaration	void int_tm04(void)
Description	It performs timeout timer interrupt process at the time of USB communication.
Parameter	None
Return value	None
Remark	None

Figure 5-32 shows the flow of USB communication timeout process.

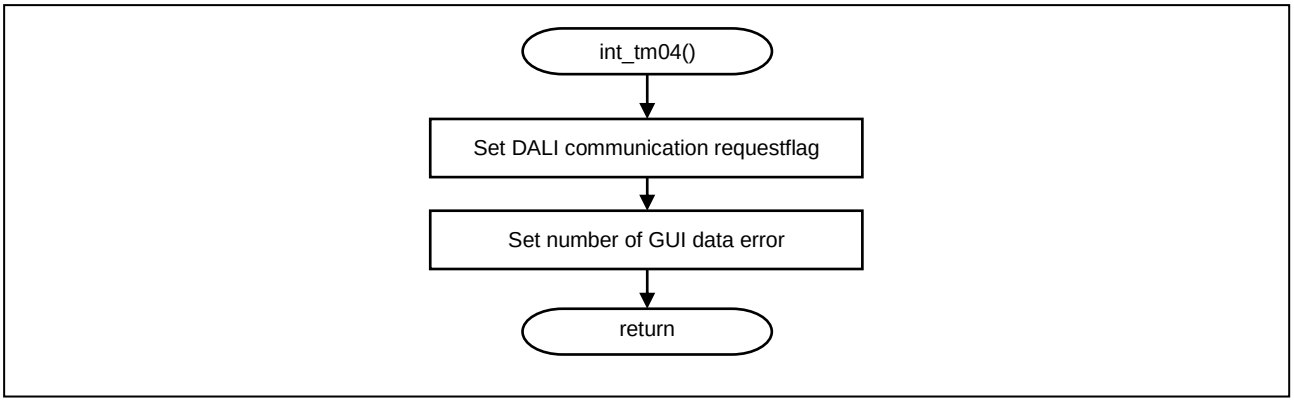


Figure 5-32 USB communication timeout process

It performs USB communication reception timeout process.

If the data sent from the GUI has not been transmitted the specified time, it is judged that the time-out, and set the number of data errors.

5.6 Overview of the collision detection operation of DALI communication

This section describes the collision detection overview of the operation of this program.

For collision detection, as described in Section 1.4.2, a pattern of the collision judgment time differs according to the bit sequence of the transmission frame. Table 5-6 shows Pattern judgment condition of the collision judgment time. In this program, it decides pattern order of the judgment time by applying all 17 bits including Start bit of transmission data to the condition of the Table 5-6 before the frame transmission.

Then it starts transmission, and performs collision detection for each timing that edge is input to the TI06 terminal.

Table 5-6 Pattern judgment condition of the collision judgment time

Previous Bit Data	Bit Data	Pattern of judgment time	
		The first half of the half-bit	The second half of the half-bit
-	Start bit	Pattern 1	Pattern 2
1	1	Pattern 1	Pattern 2
1	0	Continue the pattern 2 judgment of previous bit	Pattern 2
0	1	Continue the pattern 2 judgment of previous bit	Pattern 2
0	0	Pattern 1	Pattern 2
-	Stop Condition	No judgment	

Figure 5-33 shows Pattern application examples of the collision judgment time.

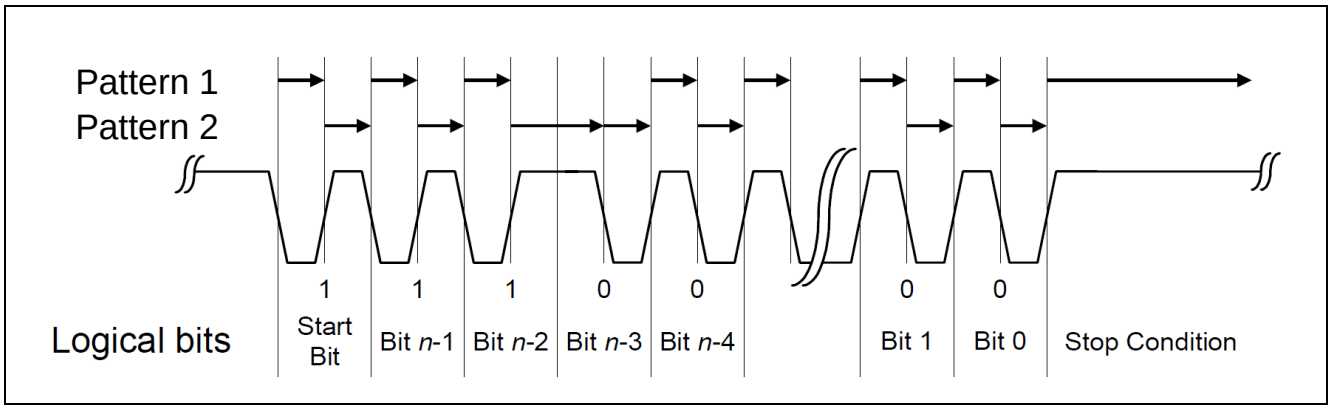


Figure 5-33 Pattern application examples of the collision judgment time

Table 5-7 shows Setting of collision return timing. Timing adjustment time at the time of collision return is set the Table 5-7 from the range specified in the DALI standard.

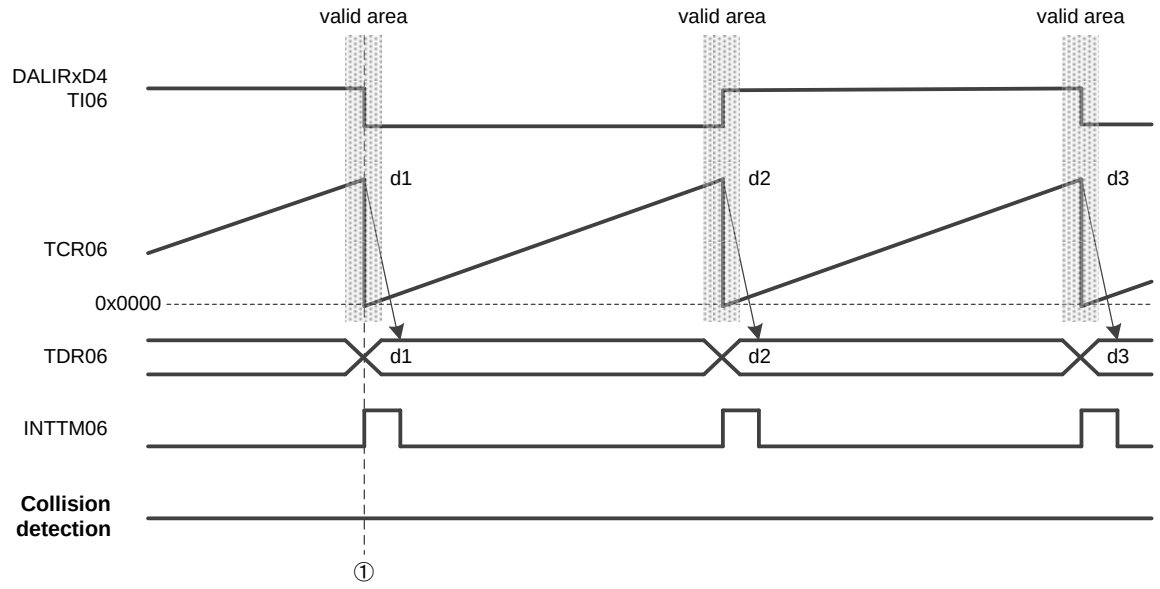
Table 5-7 Setting of collision return timing

Timing type	Set time	Remarks
Break time	1.3 ms	Set to an intermediate value of the specified range 12.0 ~ 14.0 ms
Recovery time	4.3 ms	Set to an intermediate value of the specified range 4.0 ~ 4.6 ms
Settling time	12.7 ms	Set to minimum value of the Any frame and forward frame(priority 1) specified range 12.7 ~ 13.8 ms

Thereafter figures of timing of the collision detection and the return operation are shown in this program.

5.6.1 Collision detection operation timing (no collision occurs)

Figure 5-34 shows Figure of collision detection operation timing (no collision occurs).



① Check the value of the TDR06 (d1)

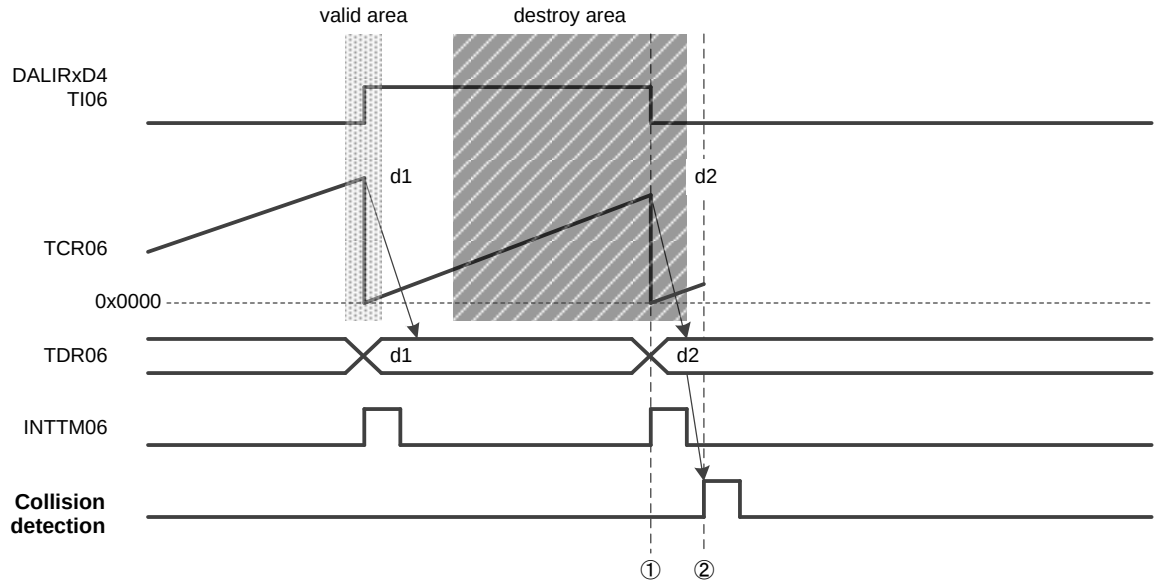
at the timing of the TI06 terminal of the edge detection = INTTM06 (TAU06 interrupt)

Because there is value (d1) of TDR06 in the effective range (valid area) of the DALI transmission bit, continue DALI communication

Figure 5-34 Figure of collision detection operation timing (no collision occurs)

5.6.2 Collision detection operation timing (collision occurs)

Figure 5-35 shows Figure of collision detection operation timing (collision occurs).



① Check the value of the TDR06 (d2)

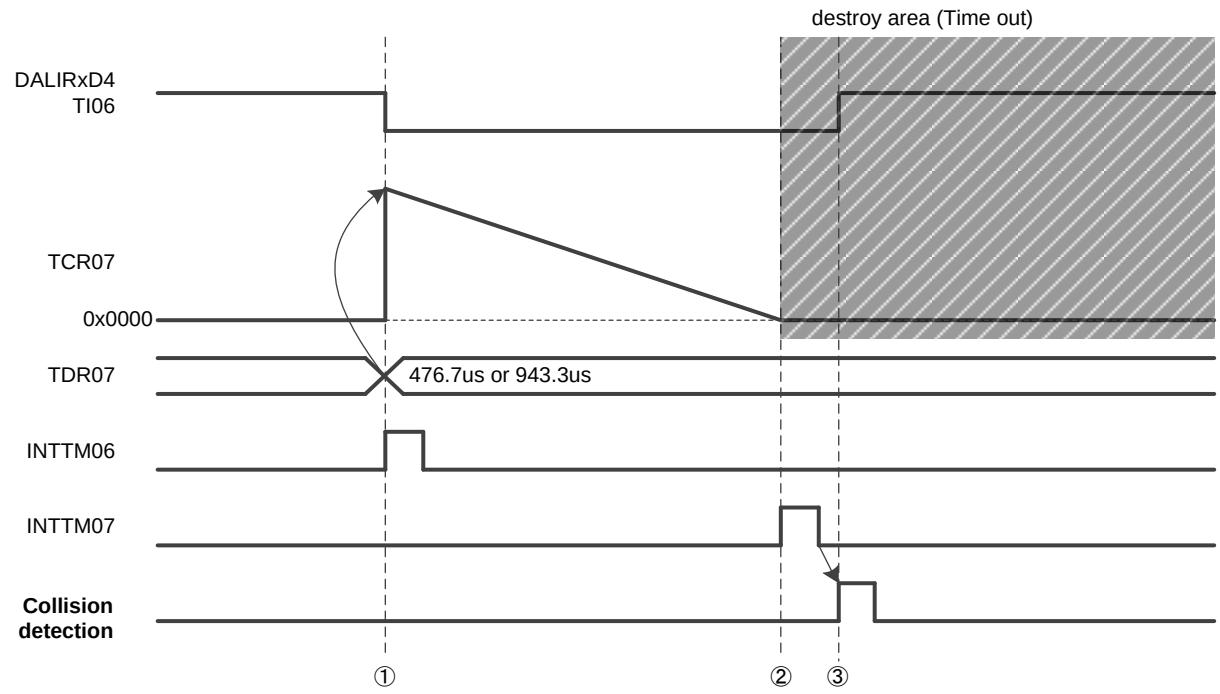
at the timing of the TI06 terminal of the edge detection = INTTM06 (TAU06 interrupt)

② Because there is value of TDR06 (d2) in the invalid range (destroy area) of the DALI transmission bit, detect collision and stop DALI communication

Figure 5-35 Figure of collision detection operation timing (collision occurs)

5.6.3 Collision detection operation timing (time-out judgment)

Figure 5-36 shows Figure of collision detection operation timing (time-out judgment).



① The signal to be transmitted next at the timing of the TI06 terminal of the edge detection = INTTM06 (TAU06 interrupt) is L, set the Time out time to TDR07, TAU07 count start

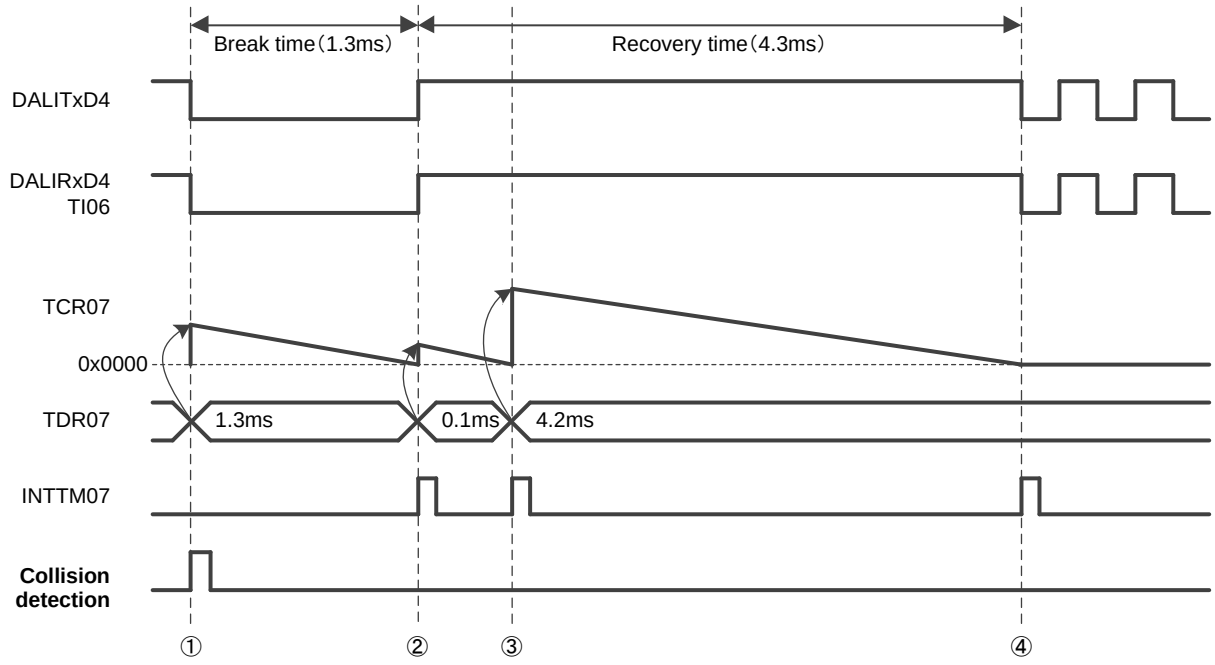
② Time out time has elapsed while there is no edge change in the TI06 terminal, INTTM07 (TAU07 interrupt) occurs

③ It's judged as Time out by collision occurrence and stops DALI communication is suspended.

Figure 5-36 Figure of collision detection operation timing (time-out judgment)

5.6.4 Collision return operation timing (collision return)

Figure 5-37 shows Figure of collision return operation (collision return) timing.



① After the collision detection, output TxD at L level (active state)
Set the Break time to TDR07, TAU07 count start

② After Break time elapsed, output TxD at H level (idle state)
Set 0.1ms to TDR07, TAU07 count start

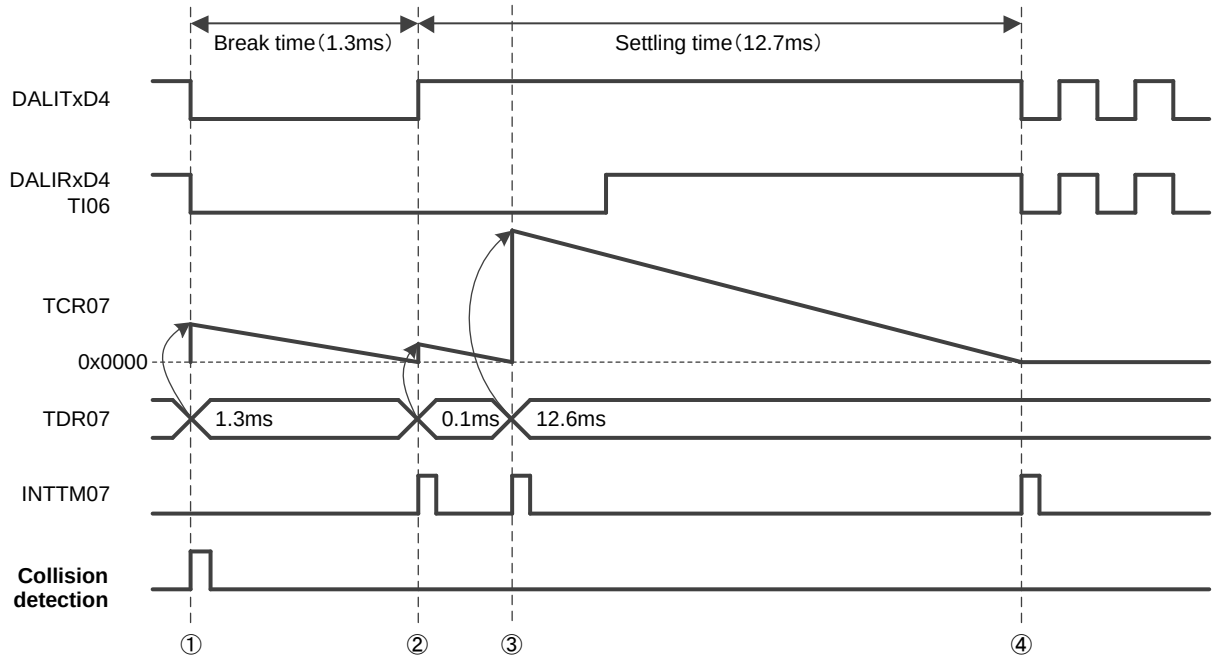
③ As a result of reading the RxD, because it was at the H level (idle state), judged to be return from collision
Set (Recovery time - 0.1 ms) to TDR07, TAU07 count start

④ After Recovery time elapsed, re-transmit the forward frame from TxD

Figure 5-37 Figure of collision return operation (collision return) timing

5.6.5 Collision return operation timing (collision continue)

Figure 5-38 shows Figure of collision return operation (collision continue) timing.



① After the collision detection, output TxD at L level (active state)
Set the Break time to TDR07, TAU07 count start

② After Break time elapsed, output TxD at H level (idle state)
Set 0.1ms to TDR07, TAU07 count start

③ As a result of reading the RxD, because it was at the L level (active state), judged to continue collision
Set (Settling time - 0.1 ms) to TDR07, TAU07 count start

④ After Settling time elapsed, re-transmit the forward frame from TxD

Figure 5-38 Figure of collision return operation (collision continue) timing

5.7 Restrictions

In this program, the following restrictions apply.

1. Registers of serial array unit 4 is initialized at the time of DALI communication collision detection.
   In the process of returning after the collision detection, all registers used in serial array unit 4 (see Hardware manual "Registers Controlling Serial Array Unit 4 (DALI/UART4)") are initialized. For the initial settings, see Section 5.2.

2. Don’t change interrupt priority of INTTM06(TAU06 interrupt)
   If the timing of INTTM06 process was delayed by other interrupt process, collision detection of DALI communication may not be done.

6. Reference Documents

- User's Manual: Hardware
  RL78/I1A User's Manual: Hardware (R01UH0169EJ)
  (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.)

- User's Manual: Development Tools
  (The latest versions can be downloaded from the Renesas Electronics website.)

- Evaluation board User's Manual
  RL78/I1A Lighting Communication Master Evaluation Board User's Manual

- Communication protocol
  Lighting Communications Using RL78/I1A (Reception) Application Note (R01AN1115EJ0300)

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Revision History

Rev.	Date	Description	
		Page	Summary
1.00	August 31, 2016	-	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. 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 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. Unused pins should be handled as described under Handling of Unused Pins in the manual.

2. Processing at Power-on

   The state of the product is undefined at the moment 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 moment 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 moment 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 moment when power is supplied until the power reaches the level at which resetting has been specified.

3. Prohibition of Access to Reserved Addresses

   Access to reserved addresses is prohibited.

   — The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.

4. Clock Signals

   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has 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. Moreover, 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.

5. Differences between Products

   Before changing from one product to another, i.e. to a product with a different part number, confirm that the change will not lead to problems.

   — The characteristics of Microprocessing unit or Microcontroller unit products in the same group but having a different part number may differ in terms of the 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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