

RL78/G12 Visible Light Beacon Transmission Program

[Development Environments: CubeSuite, IAR, and e2studio]

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Introduction

This application note explains the sample program for using the RL78/G12 to control transmission through a visible light communications beacon system.

The visible light beacon system is compliant with the JEITA CP-1223 standard.

Target Device

RL78/G12

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1. Specification

The sample program covered in this application note can be used to control turning an LED on and off to transmit signals in a visible light beacon system compliant with the JEITA CP-1223 standard. The data being transmitted can be switched by pressing a button on the target board.

http://www.renesas.com/products/tools/introductory_evaluation_tools/cpu_board/qb_r5f1026a_tb/index.jsp

2. Operation Check Conditions

The sample code described 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/G12 (R5F1026A)
Operating frequency	Main clock (OSC1): 20 MHz
Operating voltage	3.0 V (Operation is possible within the range of voltage from 2.7 V to 3.0 V.)
Integrated development environment (CubeSuite+)	CubeSuite+ V2.00.00
C compiler (CubeSuite+)	CA78K0 4.00.00.09
Integrated development environment (e2studio)	e2studio V3.0.0.22
C compiler (e2studio)	KPIT GNURL78-ELF Toolchain V14.01
Integrated development environment (IAR)	IAR Embedded Workbench for Renesas RL78 V1.40.1
C compiler (IAR)	IAR C/C++ Compiler for Renesas RL78 V1.40

3. System Overview

The system consists of a transmitter (subsequently referred to as the simple RL78/G12 transmitter) using the RL78/G12 target board (QB-R5F1026A-TB), a visible light beacon system reception module (separately sold), and a PC. The sample program covered in this application note handles the sending of visible light beacon signals from the simple RL78/G12 transmitter, and the received signals can be checked through a GUI on the PC.

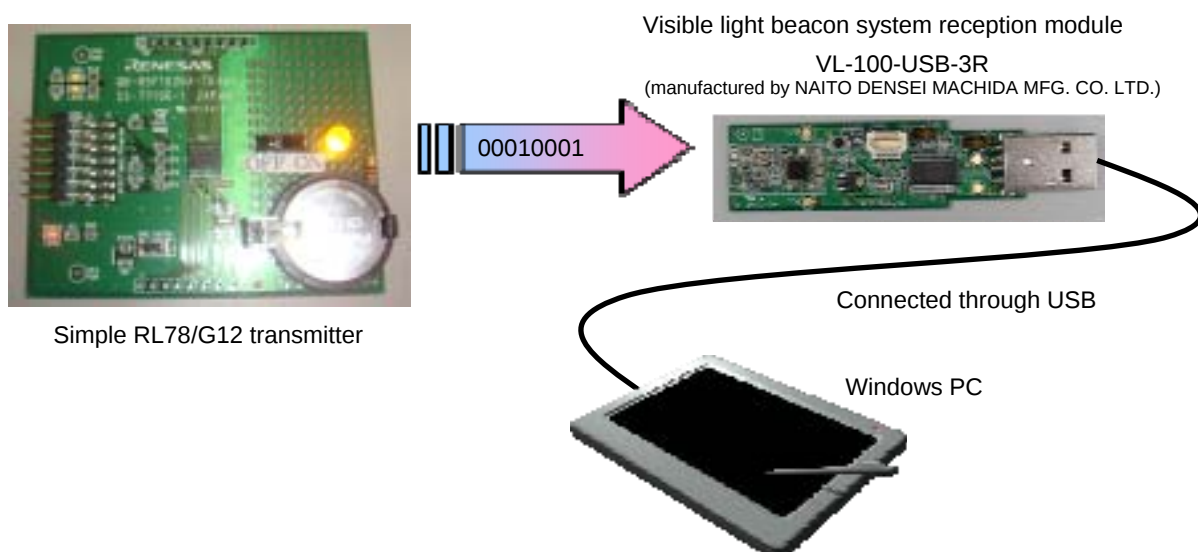


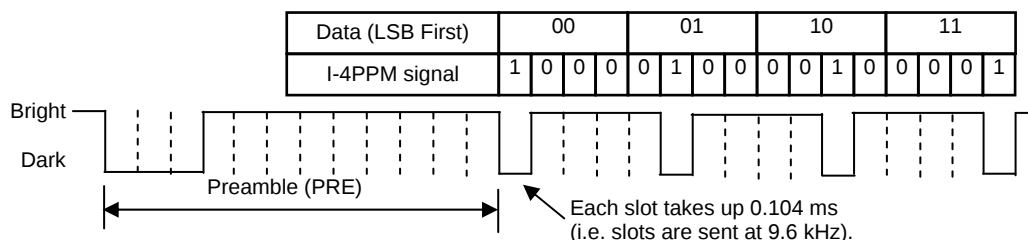
Figure 3-1 System Overview

4. Characteristics of the Visible Light Beacon System

This section describes the format used in the visible light communications. For details, see the specifications of the visible light beacon system as defined in Japan Electronics and Information Technology Industries Association (JEITA) standard CP-1223.

Data rate: 4.8[Kb/s]

Method of transmission: I-4PPM (inverted 4-slot pulse-position modulation)



Frame configuration:

SOF (Start of Frame)		Payload	EOF (End of Frame)
PRE (6 bits)	F-TYPE (8 bits)	ID/DATA (128 bits)	CRC-16 (16 bits)

4.1 Preamble (PRE)

The PRE field defines the starting position of a frame and is not 4-PPM encoded. It consists of three ones followed by nine zeros (12-slot symbol: 111 000 000 000).

4.2 Frame Type (F-TYPE)

The frame type field holds an 8-bit code that indicates the type of payload. The value is 0x00 in the sample program, since this indicates a payload for use in testing and development.

4.3 ID/DATA

The length of the ID/DATA field is 128 bits and may be used to hold an ID code and data, or any desired data.

4.4 CRC Field

The CRC field is 16 bits long and is used on the receiving side to determine whether reception of the frame was successful. The CRC field holds the result calculated by the following generating polynomial.

$$X^{16}+X^{15}+X^2+1$$

5. Description of the Transmitter Board

The simple RL78/G12 transmitter mainly consists of an RL78/G12 target board (QB-R5F1026A-TB) manufactured by Renesas Electronics Cooperation, with a button-battery holder, switch, and super-bright LED added to the universal version of the target board. Figure 5-1 is the hardware configuration of the simple transmitter board.

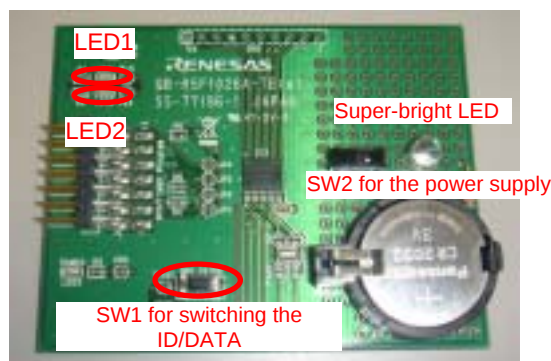


Figure 5-1 RL78/G12 Simple Transmitter

5.1 List of Pins to be Used

Table 5-1 Pins to be Used and their Functions

Pin Name	Input/Output	Description
P10	Output	Control pin for the LED used in visible light communications
P13	Output	Control pin for an indicator LED (LED1)
P14	Output	Control pin for an indicator LED (LED2)
X1	Input	Pin for connection to the 20-MHz resonator
X2	Input	Pin for connection to the 20-MHz resonator
P137	Input	Input for SW1 used to switch the ID/DATA field

5.2 Operation Procedure

5.2.1 Connection to Power Source

Setting the CR-2032 and turning on the power switch enables the visible light beacon system to transmit the signals through the super-bright LED.

5.2.2 Switching of IDs

Pressing SW1 enables switching of the transmitted ID/DATA field.

Table 5-2 Transmitted ID/DATA Values

Number of Times SW1 is Pressed	F-Type	IDs	LED1	LED2
0	0	"Renesas.Renesas."	On	On
1	0	"0356853N1393715E"	Off	On
2	0	"ABCDEFGHJKLMNOP"	On	Off
3	0	"VisibleLightComm"	Off	Off
Further pressing of the switch causes the sequence to be repeated.				

5.3 Description of the Components

Table 0-1 List of Components to be Used

Name	Manufacturer	Type Number
Button-battery holder	COMFORTABLE ELECTRONIC	CH74-2032LF
SW2 for power source	SWITRONIC	SS12D01G4
Super-bright LED	Avago Technologies	HLMP-EL1A-Z1KDV
Fixed resistor of 62 Ω	—	—

5.4 Circuit Diagram

The circuit diagram implemented on the universal RL78/G12 target board is shown below.

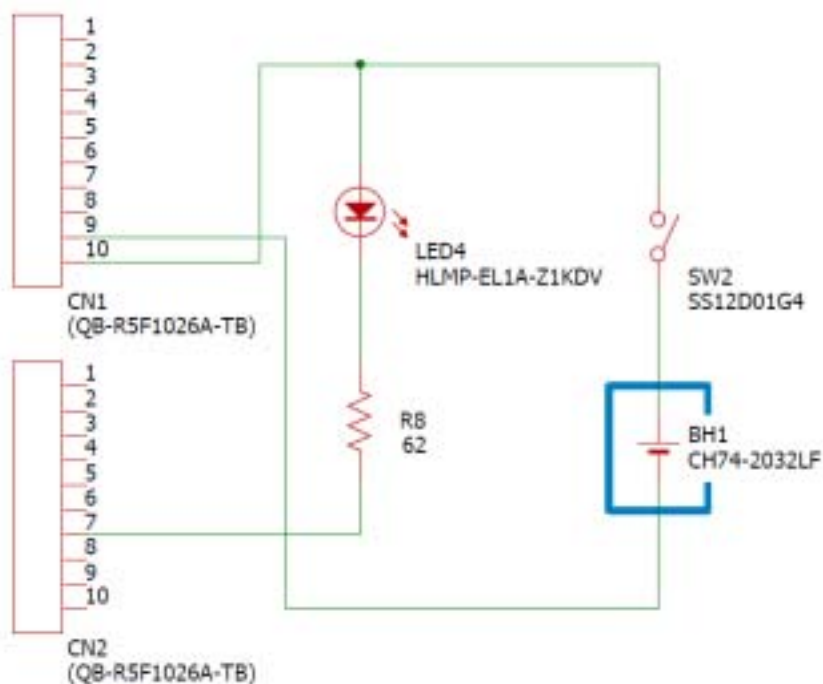


Figure 5-2 Circuit Diagram

6. Description of the Software

6.1 Outline of the Software Processing

The sample program covered in this application note switches the transmitted ID/DATA field in response to SW1 being pressed. It also uses an interval timer interrupt that is generated every 104 μ sec to turn the LED on and off with timing in accord with the standard for visible light communications.

Figure 6-1 is a schematic view of the system.

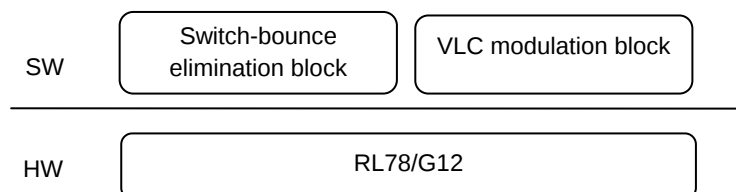


Figure 6-1 Schematic View of the System

6.2 List of Option Byte Settings

Table 6-1 summarizes the settings of the option bytes.

Table 6-1 Option Byte Settings

Address	Value	Description
000C0H/010C0H	11100000B	Disables the watchdog timer (counting stops after release from the reset state).
000C1H/010C1H	10000001B	LVD OFF
000C2H/010C2H	11100000B	HS mode, HOCO: 24 MHz
000C3H/010C3H	10000100B	Enables the on-chip debugger.

6.3 List of Functions

Function Name	Outline	File Name
main	Eliminates switch bounce in the signal from SW1.	main.c
CPU_Init	Initializes the clock pulse generator.	main.c
TIMER_Init	Initializes the timers.	main.c
PORT_Init	Sets port pins.	main.c
VLC_Timer	Handler for timer interrupts (104 μ sec).	main.c
VLC_InitFrame	Generates the visible light frame for transmission.	vlc.c
VLC_GetPulse	Acquires information on the state of the LED (i.e. whether it is on or off).	vlc.c
VLC_PulseUpdate	Updates the LED state information (i.e. determines whether it is to be switched on or off).	vlc.c
VLC_Encode4ppm	Handles 4-PPM encoding.	vlc.c
VLC_GetCrc	Generates CRC code.	vlc.c

6.4 Function Specifications

This section describes the specifications for the functions that are used in the sample program.

[Function Name] main

Synopsis Eliminates switch bounce in the signal from SW1.

Declaration void main(void)

Explanation This function calls the initialization function of the hardware and its main loop handles elimination of switch bounce. It also sets a flag to indicate the ID/DATA field currently being transmitted and switches the indicator LEDs on detection of the falling edge of SW1.

Arguments None

Return value None

[Function Name] CPU_Init

Synopsis Initializes the clock pulse generator.

Declaration void CPU_Init(void)

Explanation This function sets the clock operating mode to the X1 oscillation mode, sets the high-speed system clock (f_{MX}) as the system clock, enables operation of the X1 oscillation circuit, and disables the high-speed on-chip oscillator clock.

Arguments None

Return value None

[Function Name] TIMER_Init

Synopsis Initializes the timers.

Declaration void TIMER_Init(void)

Explanation This function activates the timer array unit to measure intervals of 104.15 μ s and 10 ms.

Arguments None

Return value None

[Function Name] PORT_Init

Synopsis Sets port pins.

Declaration void PORT_Init(void)

Explanation This function makes the port register (Px), port mode register (PMx), port mode control register (PMCx), pull-up resistor option register (PUx), port input mode register (PIMx), port output mode register (POMx), and A/D port configuration register (ADPC) settings for the respective pins.

Arguments None

Return value None

[Function Name] VLC_Timer

Synopsis Handler for timer interrupts (104 μ sec).

Declaration void VLC_Timer(void)

Explanation This function is the handler for the 104- μ s interval interrupts and determines whether the LED for visible light transmission is to be turned on or off, or to be left in its current state, as each 104- μ s interval elapses. When the ID/DATA field is to be switched in response to SW1 being pressed, the frame updating function (VLC_InitFrame) is also called from within the interrupt handler.

Arguments None

Return value None

[Function Name] VLC_InitFrame

Synopsis Generates the visible light frame for transmission.

Declaration void VLC_InitFrame(unsigned char frame_type, unsigned char *payload)

Explanation This function generates the visible light frame for transmission in an internal buffer.

Arguments frame_type : Frame type
Payload: 16-byte ID data

Return value None

[Function Name] VLC_GetPulse

Synopsis Acquires information on the state of the LED (i.e. whether it is on or off).

Declaration unsigned char VLC_GetPulse(void)

Explanation This function acquires information on the state of the LED (i.e. whether it is on or off).

Arguments None

Return value 0: LED is on. 1: LED is off.

[Function Name] VLC_PulseUpdate

Synopsis Updates the LED state information (i.e. determines whether it is to be switched on or off).

Declaration unsigned char VLC_PulseUpdate(void)

Explanation This function updates the LED state information (i.e. determines whether it is to be switched on or off) in accordance with the frame being transmitted.

Arguments None

Return value 0: In the midst of frame transmission 1: At the end of the frame

[Function Name] VLC_Encode4ppm

Synopsis Handles 4-PPM encoding.

Declaration unsigned short VLC_Encode4ppm(unsigned char data)

Explanation This function converts 8-bit data to 4-PPM data (taking up 16 slots).

Arguments 8-bit data

Return value 16 slots of 4-PPM data

[Function Name] VLC_GetCrc

Synopsis Generates CRC code.

Declaration unsigned short VLC_GetCrc(unsigned char *buff, int size)

Explanation This function generates the CRC code.

Arguments buff: Address where the buffer for storing the CRC code starts.
Size: Buffer size

Return value CRC code

6.5 List of Constants

Constant	Setting	Description
vlc_payload[4][16]	"Renesas.Renesas." "0356853N1393715E" "ABCDEFGHJKLMNOP" "VisibleLightComm"	ID/DATA fields for transmission
led_table[4][2]	{LED_ON,LED_ON} {LED_OFF,LED_ON} {LED_ON,LED_OFF} {LED_OFF,LED_OFF}	Information on the states of the indicator LEDs (sequence of whether they are to be on or off)
crc16_table[256]	See the source code.	Table information for generating CRC16 ($X^{16}+X^{15}+X^2+1$)
bitrev_table[256]	See the source code.	Table for acquiring 1-byte of bit-inverted data
vlc_4ppm_table[4]	{0x08U, 0x02U, 0x04U, 0x01U}	Table of 4-PPM slot-level sequences

6.6 List of Variables

Table 6-2 lists the global variables that are used in this sample program.

Table 6-2 Global Variables

Type	Variable Name	Contents	Function Used
chattering	chat	SW information from sampling three times at 10-ms intervals	main
unsigned char	id_change	Flag to indicate timing of ID/DATA switching	main VLC_Timer
unsigned char	id_sel	Index of ID/DATA field currently being transmitted (0 to 3)	main VLC_Timer
unsigned char	sw1	SW1 information after bounce is eliminated	main
unsigned char	tx_buff[]	Frame of data for visible light transmission	VLC_InitFrame VLC_PulseUpdate
unsigned char	tx_buff_ptr	Index information on the buffer holding the frame of data for visible light transmission	VLC_PulseUpdate
int	state	Current internal state	VLC_PulseUpdate
int	next_state	Next internal state to be entered	VLC_PulseUpdate
unsigned short	slot_pattern	Slot data for 4-PPM symbols	VLC_PulseUpdate
unsigned short	slot_num	The number of slots that have been updated	VLC_PulseUpdate
unsigned char	vlc_pulse	Information on the state of the LED (i.e. whether it is on or off)	VLC_GetPulse VLC_PulseUpdate

6.7 Flowcharts

Figure 6-2 shows the flow of the main routine of the sample program.

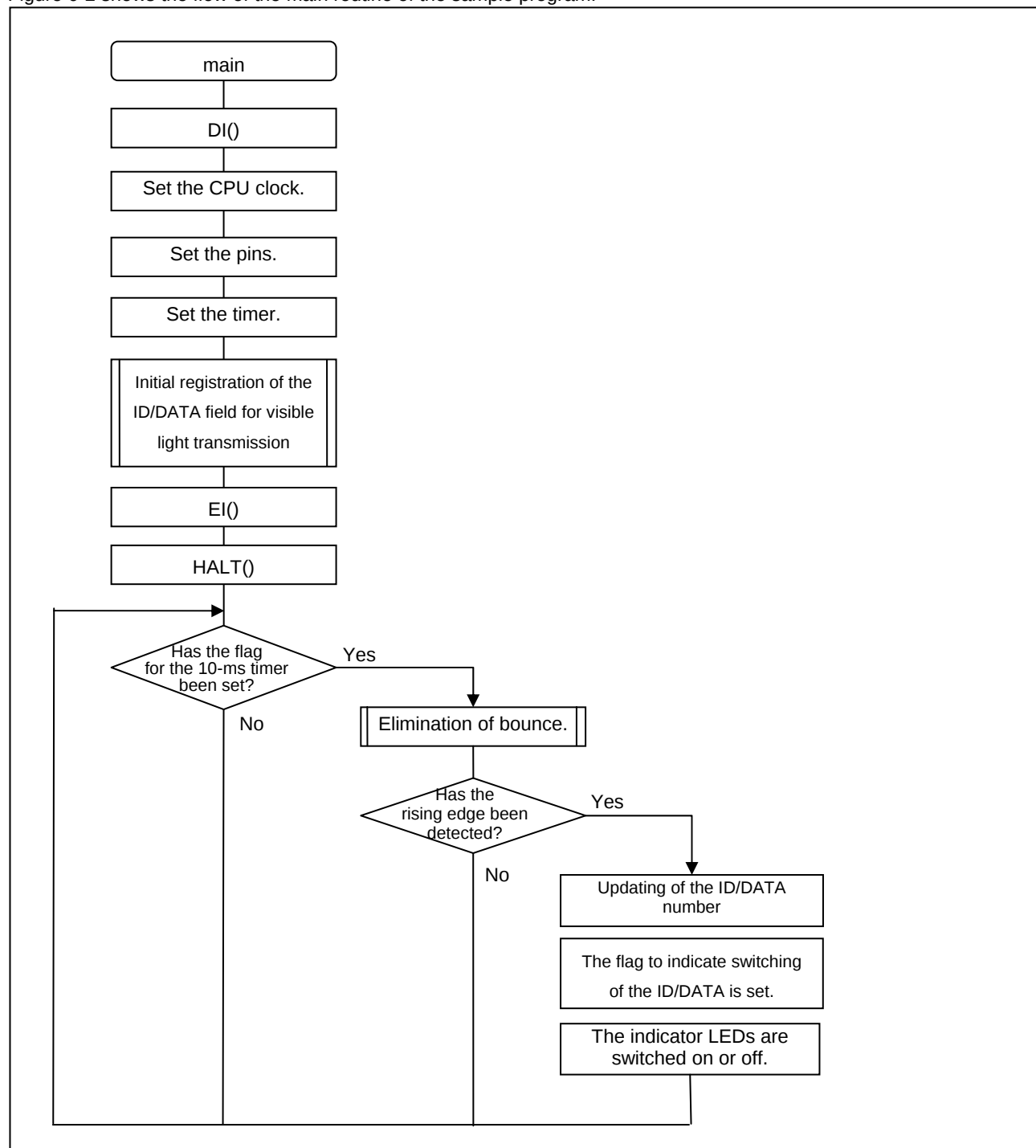


Figure 6-2 Flow of Main

6.7.1 Timer Interrupt Function

Figure 6-3 shows the flow of the timer interrupt function.

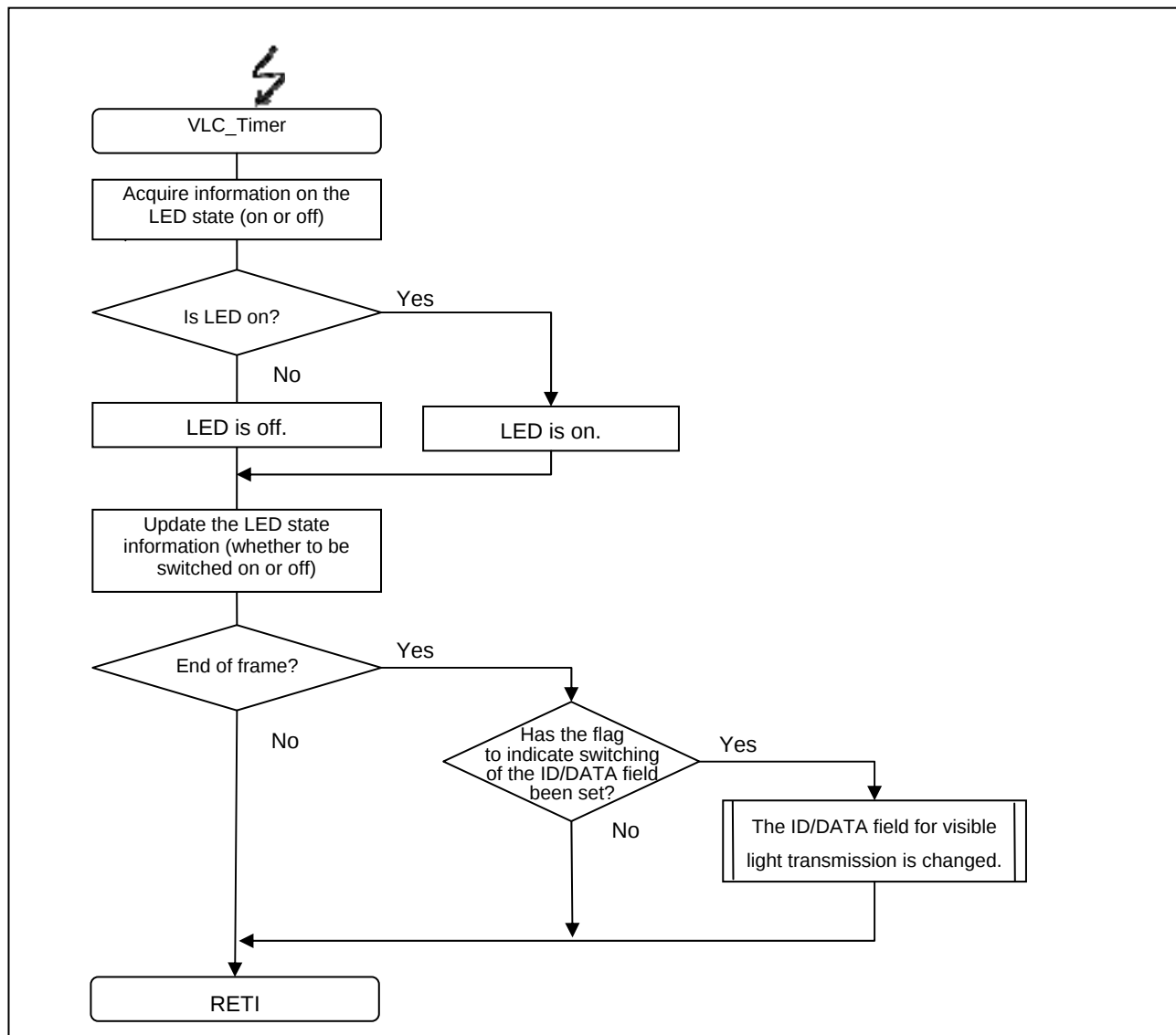


Figure 0-1 Timer Interrupt Function

6.7.2 Function to Update the LED State Information (Whether to be Switched On or Off)

Figure 6-4 shows the flow of processing by the function to update the LED state information (i.e. whether it is to be switched on or off).

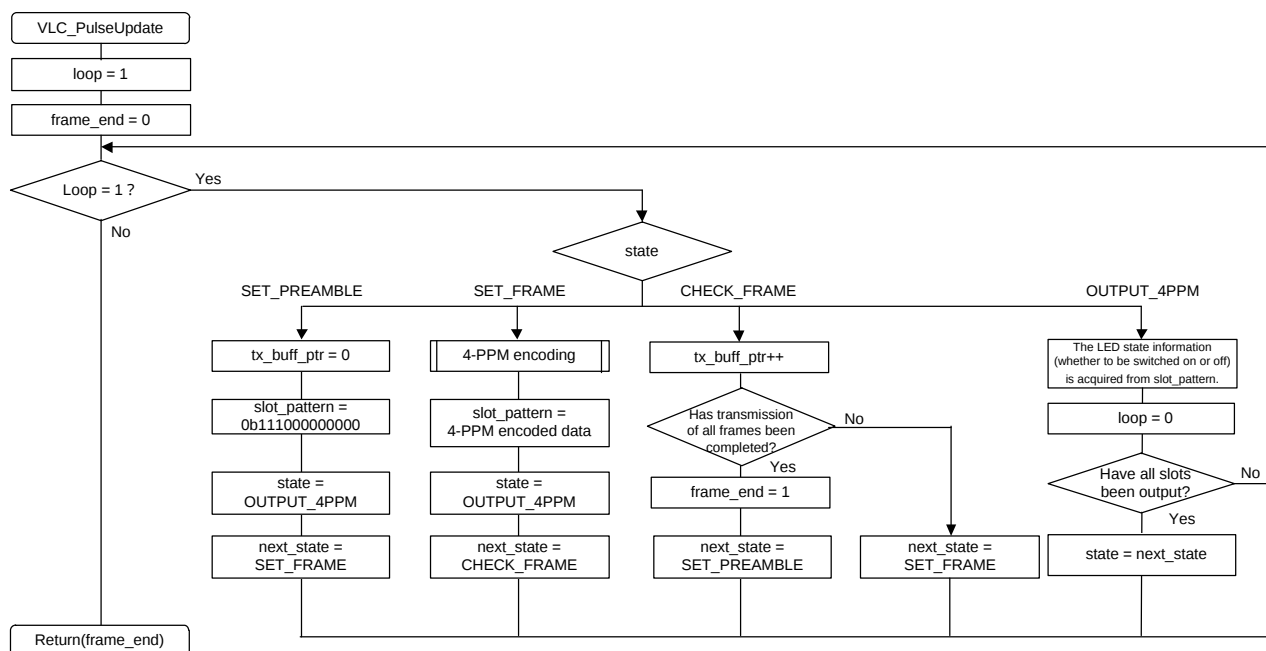


Figure 6-4 Updating of LED State Information (On or Off)

7. Sample Program

The sample program is available on the Renesas Electronics Website.

8. Documents for Reference

RL78/G12 User's Manual: Hardware (R01UH0200E)

RL78 Family User's Manual: Software (R01US0015E)

(The latest versions of the documents are available on the Renesas Electronics Website.)

Technical Updates/Technical Brochures

(The latest versions of the documents are available on the Renesas Electronics Website.)

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Revision Record	RL78/G12 Visible Light Beacon Transmission Program
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Rev.	Date	Description	
		Page	Summary
1.00	Aug 06, 2014	—	First edition issued

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Access to reserved addresses is prohibited.

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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.

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