

RL78/G14

Onboard LED Flashing Control (Arduino API)

Introduction

This application note describes a method for controlling flashing of LEDs mounted on an RL78/G14 Fast Prototyping Board (FPB) using a program written in an Arduino language using the FPB.

Target Device

RL78/G14 Fast Prototyping Board

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.

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1. Specifications

In this application note, the flashing of LEDs (LED0 and LED1) mounted on an FPB is controlled by a program written in an Arduino language using the FPB. The time (wait time) until the change to the next operation is modified using a switch (SW_USR).

After turning on power, LED0 and LED1 are lit. Initially, this program extinguishes LED0 and LED1. Next, each time the wait time elapses, LED0 is lit, LED1 is lit, and LED0 is extinguished. Thereafter, operations Nos. 1 to 4 shown below are repeated.

No.	Operation	LED1	LED0
0	Both lit	ON	ON
1	Both extinguished	OFF	OFF
2	LED0: lit	OFF	ON
3	LED1: lit	ON	ON
4	LED0: lit	ON	OFF

The wait time is initially set to 1 second. Each time the switch (SW_USR) is pressed the setting is modified, to 0.75 seconds, 0.5 seconds, 0.25 seconds, and then to 1 second.

Table 1.1 shows peripheral functions used in this program and their uses.

Table 1.1 Peripheral functions used and their uses

Peripheral Function	Use
Digital input	Reading the state of the switch (SW_USR)
Digital output	Control of the LEDs (LED0, LED1)
Timer Array Unit (TAU)	Measurement of the wait time

1.1 Program Execution Environment

In this application note, a program in an Arduino language is executed in a development environment specific to the RL78 family. A conceptual diagram of the program execution environment is shown in Figure 1.1.

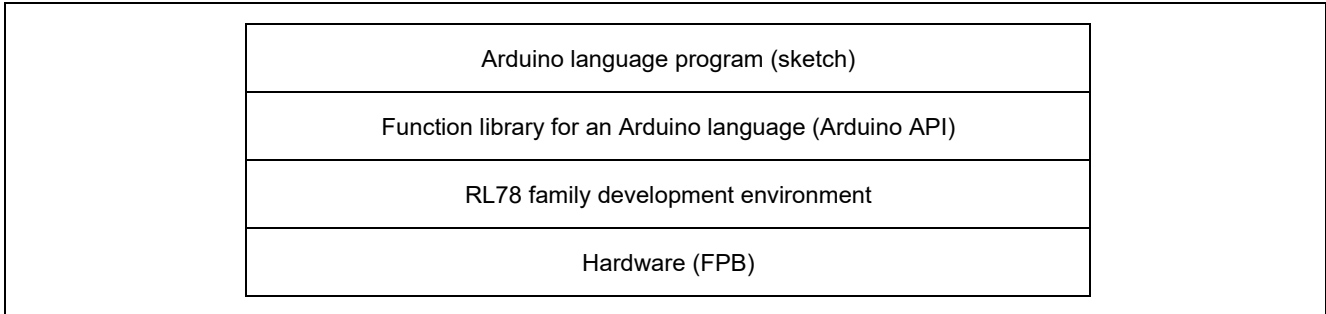


Figure 1.1 Program execution environment

Library functions that can be used in this application note are shown in Table 1.2.

Table 1.2 Library functions

Item	Library Function	Function
Digital I/O	pinMode(pin, mode)	Specifies the operation mode (input mode/output mode/input mode with internal pull-up resistor enabled) for the pin specified by pin.
	digitalWrite (pin, value)	Sets the pin specified by pin to the state specified by value (high level/low level).
	digitalRead(pin)	Reads out the state of the pin specified by pin
Time control	millis()	Returns, in millisecond units, the time from the start of program execution to the present time.
	micros()	Returns, in microsecond units, the time from the start of program execution to the present time.
	delay (ms)	Stops the program for the specified time in millisecond units.
	delayMicroseconds (us)	Stops the program for the specified time in microsecond units.

1.2 Program (Sketch) Configuration

Subfolders are prepared for each integrated development environment below the folder (workspace) in which the project is stored. In the folders for each of the integrated development environments the files are stored that are used in the RL78 family development environment.

In each sketch subfolder, AR_SKETCH.c is stored which is the Arduino language program (sketch). When viewing or modifying sketch, the "AR_SKETCH.c" file in the sketch subfolder is used.

1.3 Preparations for Project Startup

Preparations for project startup are different depending on the integrated development environment used. For details, refer to the following application note.

RL78 Family Arduino API Introduction Guide (R01AN5413)

1.4 Definitions in the Program (sketch)

Definitions in the program (sketch) are indicated in Figure 1.2.

```

/*-----↓
  Definition area. Write pin definition here. ↓
-----*/↓
1) int ledPin1 = 16;           // assign D16 pin to ledPin1 for LED0. ↓
   int ledPin2 = 17;         // assign D17 pin to ledPin2 for LED1. ↓
   int swPin = 18;           // assign D18 pin to swPin for SW_USER. ↓
2) const int TIME_TABLE[] = ↓
   {                          // interval definition ↓
     100, 75, 50, 25 ↓
   }; ↓
3) int sw_flag = 0xFF;        // SW status flag ↓
   int f_edge_count = 0;     // falling edge count ↓
   void wait(void);          // delay with SW check ↓
   void setup(void);         // initialisation procedure ↓
   void loop(void);          // main function of sketch ↓

```

Figure 1.2 Program definition details

First, digital input and output pins to be used are defined. The ledPin1 pin, which controls LED0, is assigned the value 16 and allocated to D16. The ledPin2 pin, which controls LED1, is assigned 17 and allocated to D17. The swPin pin, which controls the switch (SW_USR), is assigned 18 and allocated to D18. These functions are installed on the FPB, and so cannot be changed.

Next, four times (in 10 millisecond units) are defined in the array TIME_TABLE, which specifies the intervals in LED control.

Next, the variables sw_flag and f_edge_count used to manage the state of the switch (SW_USR) are defined. sw_flag stores the state of the switch (SW_USR) at intervals of approximately 10 milliseconds. f_edge_count counts (using values from 0 to 3) the number of times the switch (SW_USR) has been pressed. The value of f_edge_count determines the value to reference in the array TIME_TABLE, to determine the interval of LED control.

2. Operating Conditions

The operation of the sample code provided with this application note has been tested under the following conditions.

Table 2.1 Operating conditions

Item	Description
Microcontroller used	RL78/G14 (R5F104MLAFB)
Operating frequency	<ul style="list-style-type: none"> ● High-speed on-chip oscillator clock (f_{IH}): 32 MHz ● CPU/peripheral hardware clock: 32 MHz
Operating voltage	3.3V (can be operated at 2.75 V to 5.5 V) LVD operation: Reset mode LVD detection voltage (V_{LVD}) At rising edge: 2.81 V typ. (2.76 V to 2.87 V) At falling edge: 2.75 V typ. (2.70 V to 2.81 V)
Integrated development environment	Renesas Electronics CS+ for CC V8.03.00 Renesas Electronics e ² studio V7.7.0 IAR Systems IAR Embedded Workbench for RL78
C compiler	Renesas Electronics CC-RL V1.09.00 IAR Systems IAR C/C++ Compiler v4.20.1 for RL78

3. Related Application Notes

The application notes related to this application note are shown below.

Refer to these together with this application note.

RL78 Family Arduino API Introduction Guide (R01AN5413)

RL78/G14 7-Segment LED Lighting Control (Arduino API) (R01AN5387)

4. Hardware

4.1 Example of Hardware Configuration

Figure 4.1 shows the hardware (FPB) that is used in this application note.

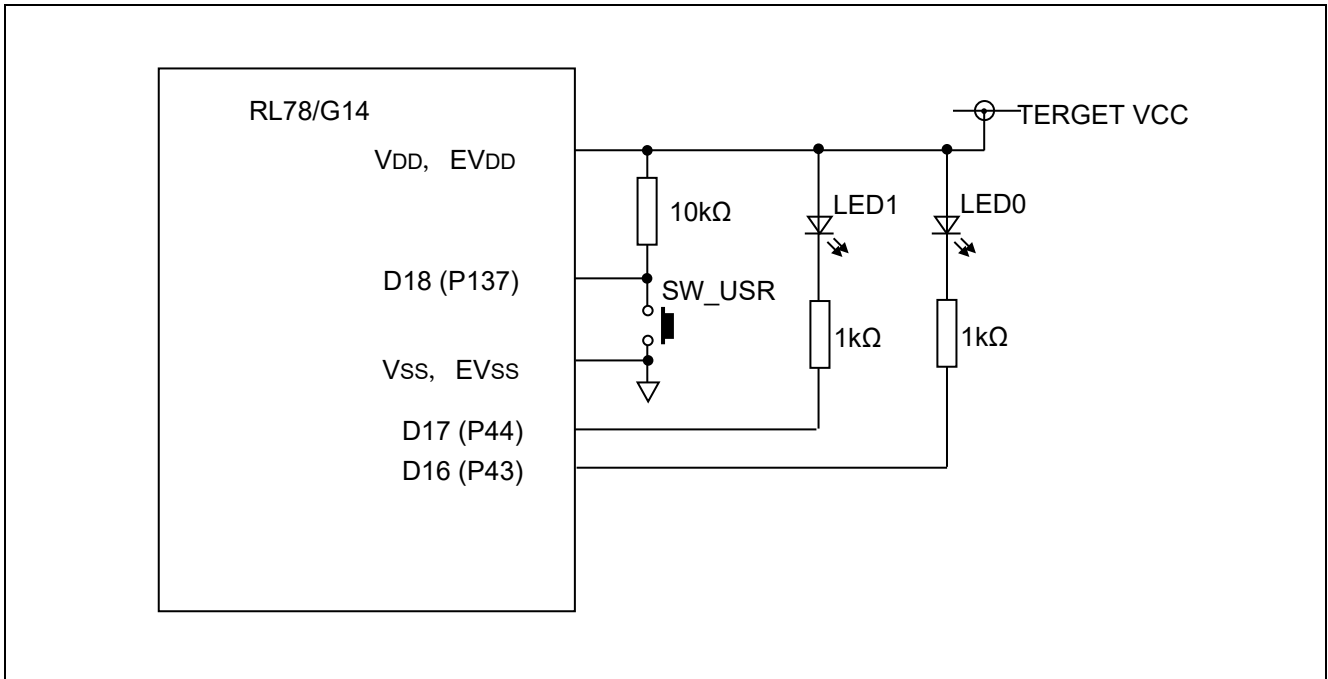


Figure 4.1 Hardware configuration example

Note: This conceptual diagram is simplified in order to summarize the connections.
As the power supply voltage, 3.3 V is supplied via USB.

4.2 List of Pins Used

Table 4.1 shows the pins used and their functions.

Table 4.1 Pins used and their functions

Pin	Port Name	I/O	Function
D16	P43	Output	Control of LED0
D17	P44	Output	Control of LED1
D18	P137	Input	Switch (SW_USR) input

5. Software

5.1 Summary of Operation

In this application note, when the initial settings (pin settings) are completed and the main processing (loop) is started, the lit states of the LED0 and LED1 mounted on the FPB change every 1 second. Upon pressing the SW_USR switch, the timing with which the lit states change is modified to 0.75 second, and then to 0.5 second, 0.25 second, and then 1 second.

Details are explained in (1) to (3) below.

(1) Pins to be used are set in the setup function.

- The drive pin for LED0 (ledPin1) is set for digital output.
- The drive pin for LED1 (ledPin2) is set for digital output.
- The read pin for the SW_USR switch (swPin) is set for digital input.

(2) The main processing is performed in the loop function.

- ledPin1 is set to HIGH to extinguish LED0.
- ledPin2 is set to HIGH to extinguish LED1.
- The poll_sw function confirms the state of the SW_USR switch, and waits for the wait time to elapse.
- ledPin1 is set to LOW to light LED0.
- The poll_sw function confirms the state of the SW_USR switch, and waits for the wait time to elapse.
- ledPin2 is set to LOW to light LED1
- The poll_sw function confirms the state of the SW_USR switch, and waits for the wait time to elapse.
- ledPin1 is set to HIGH to extinguish LED0.
- The poll_sw function confirms the state of the SW_USR switch, and waits for the wait time to elapse.

(3) In the poll_sw function, the state of the SW_USR switch is confirmed every 10 milliseconds, and the number of times the switch is pressed is counted.

- The state of the SW_USR switch is read in.
- Processing waits for 10 milliseconds. (Chattering countermeasure)
- A check as to whether the SW_USR switch has been pressed is performed.
- If the SW_USR switch has been pressed, a flag (e_flag) is set.
- Processing from the beginning is repeated the number of times specified in the TIME_TABLE array.
- When processing for the specified number of times has been completed, the flag (e_flag) is checked.
- If the flag (e_flag) is set, the number of presses is counted.

5.2 List of Constants

Table 5.1 shows constants that are used in the sample code.

Table 5.1 Constants used in sample code

Constant Name	Setting Value	Description
ledPin1	16	Number of the pin that controls LED0
ledPin2	17	Number of the pin that controls LED1
swPin	18	Number of the pin that reads SW_USR
TIME_TABLE	100, 75, 50, 25	Wait time (10 millisecond units)

5.3 List of Variables

Table 5.2 lists global variables.

Table 5.2 Global variables

Type	Variable Name	Description	Function used
Int	sw_flag	Stores state changes of SW_USR.	poll_sw()
Int	f_edge_count	Counts the number of times SW_USR has been pressed.	poll_sw()

5.4 List of Functions

Table 5.3 shows a list of functions.

Table 5.3 List of functions

Function Name	Overview
loop	Main processing (sketch)
setup	Initialization function (sketch)
poll_sw	SW_USR state confirmation and wait processing (10 millisecond units)
pinMode	Specifies the operation mode of a pin (input mode/output mode/input mode with internal pull-up resistor enabled)
digitalWrite	Outputs data to a pin
digitalRead	Read the state of a pin
micros	Returns the time, in microsecond units, from the start of program execution until the present time
millis	Returns the time, in millisecond units, from the start of program execution until the present time
delay	Stops the program for the specified time, in millisecond units
delayMicroseconds	Stops the program for the specified time, in microsecond units

5.5 Specification of Functions

The function specifications of the sample code are shown below.

[Function name] loop	
Overview	Main function
Header	AR_LIB_PORT.h, AR_LIB_TIME.h, r_cg_macrodriver.h, AR_SKETCH.h, r_cg_userdefine.h
Declaration	void loop(void)
Description	Upon starting, with the specified time interval, LED0 and LED1 are both extinguished →LED0 is lit→LED1 is lit→LED1 is extinguished
Argument	None
Return value	None
[Function name] setup	
Overview	Initialization function
Header	AR_LIB_PORT.h, r_cg_macrodriver.h r_cg_userdefine.h
Declaration	void setup(void);
Description	Pins used by the program (sketch) are set
Argument	None
Return value	None
[Function name] poll_sw	
Overview	SW_USR check and time wait function
Header	AR_LIB_PORT.h, AR_LIB_TIME.h, r_cg_macrodriver.h, r_cg_userdefine.h
Declaration	void poll_sw(void);
Description	Every 10 milliseconds the state of SW_USR is checked. This operation is repeated a specified number of times and the number of presses of SW_USR is counted.
Argument	None
Return value	None
[Function name] pinMode	
Overview	Function to set the pin function
Header	AR_LIB_PORT.h, r_cg_macrodriver.h, r_cg_userdefine.h
Declaration	void pinMode(uint8_t pin, uint8_t mode)
Description	The pin indicated by the first argument is set to the mode indicated by the second argument
Argument	uint8_t pin : Number of the pin to be specified uint8_t mode : Specifies the pin mode with OUTPUT/INPUT/INPUT_PULLUP
Return value	None

[Function name] digitalWrite

Overview	Function for digital data output to a pin	
Header	AR_LIB_PORT.h, r_cg_macrodriver.h, r_cg_userdefine.h	
Declaration	void digitalWrite(uint8_t pin, uint8_t value);	
Description	The data indicated by the second argument is output to the pin indicated by the first argument	
Argument	uint8_t pin	: Number of the pin for data output
	uint8_t value	: Data to output (HIGH/LOW)
Return value	None	

[Function name] digitalRead

Overview	Function for digital data read out from a pin	
Header	AR_LIB_PORT.h, r_cg_macrodriver.h, r_cg_userdefine.h	
Declaration	uint8_t digitalRead(uint8_t pin);	
Description	The state of the pin specified by the argument is read out	
Argument	uint8_t pin	: Number of the pin to be read out
Return value	uint8_t	: Data that was read out (HIGH/LOW)

[Function name] delay

Overview	Wait function in millisecond units	
Header	AR_LIB_TIME.h, r_cg_macrodriver.h, r_cg_userdefine.h	
Declaration	void delay(uint32_t time);	
Description	Processing waits for the time specified by the argument, in millisecond units	
Argument	uint32_t time	: Wait time (in millisecond units)
Return value	None	

5.6 Flowcharts

5.6.1 Initial setting function

Figure 5.1 shows a flowchart of the initial setting.

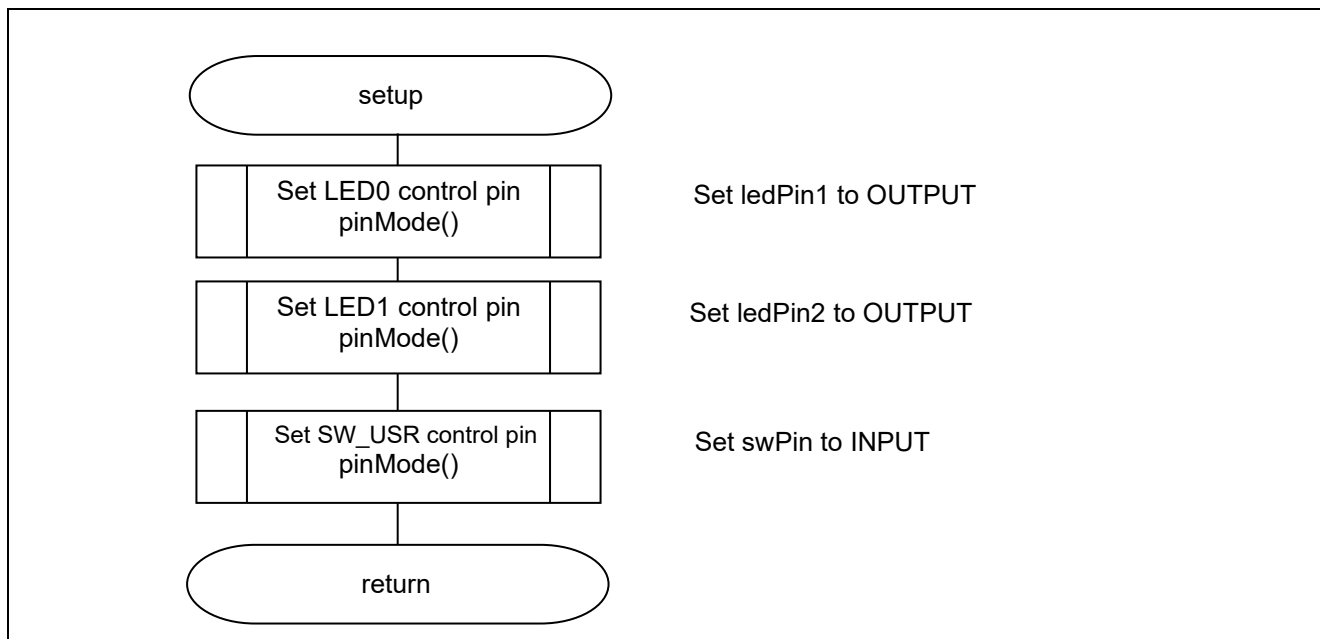


Figure 5.1 Initial setting function

5.6.2 Main Processing Function

Figure 5.2 shows a flowchart of the main processing function.

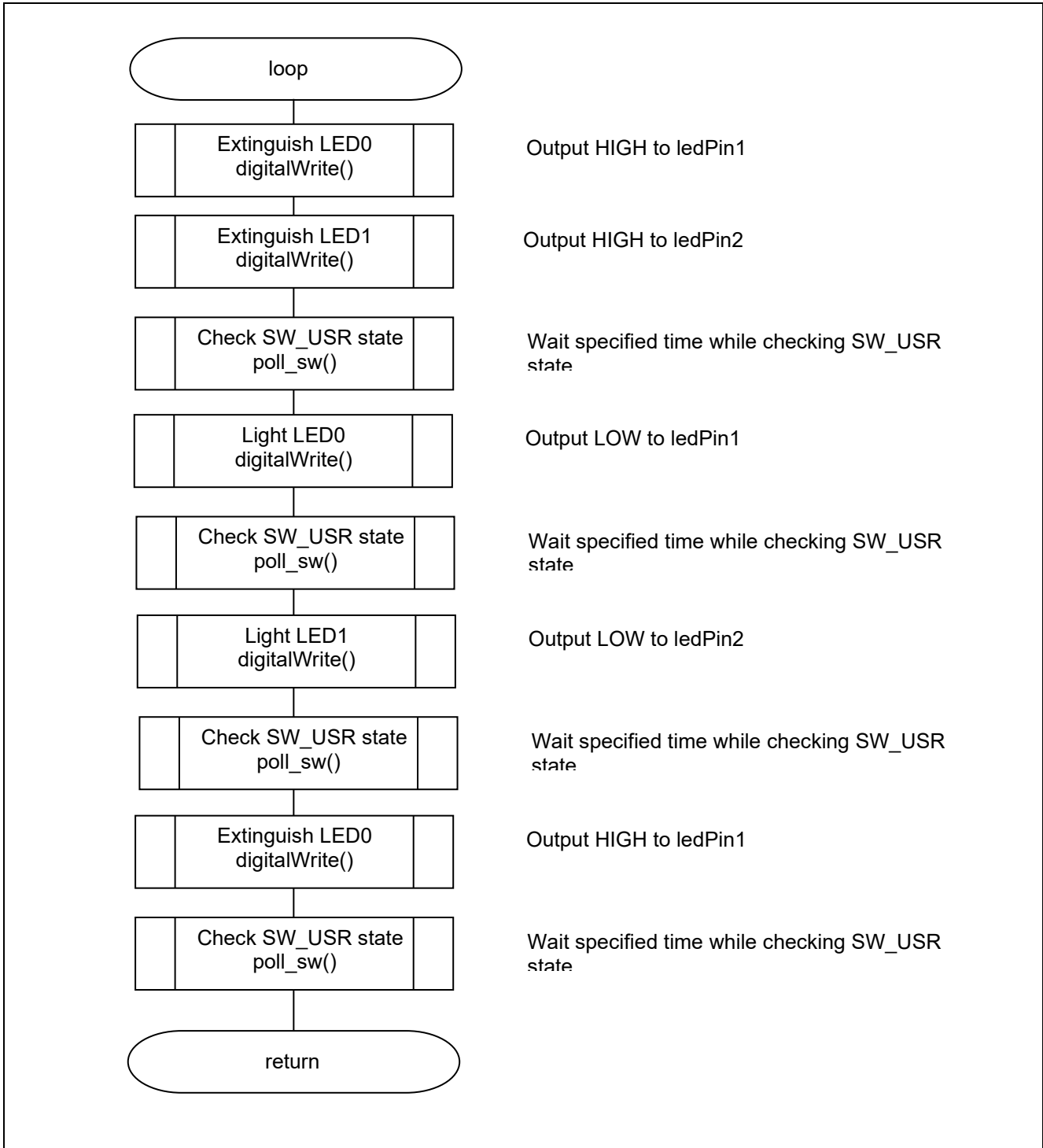


Figure 5.2 Main processing function

5.6.3 SW_USR check and wait time function

Figure 5.3 shows flowcharts of the SW_USR check and wait time functions.

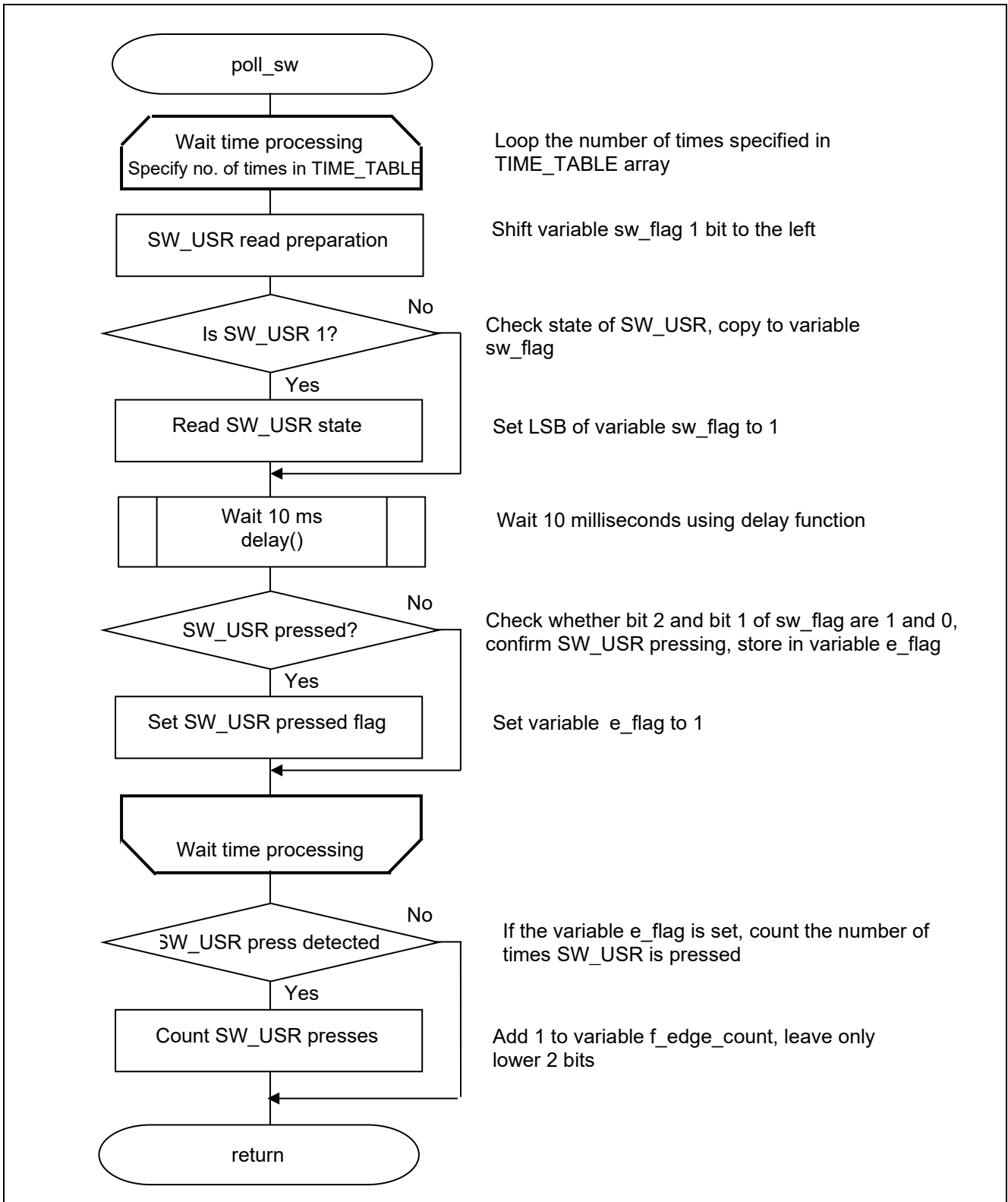


Figure 5.3 SW_USR check and wait time function

6. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

7. Reference Documents

RL78/G14 User's Manual: Hardware (R01UH0186)

RL78 family User's Manual: Software (R01US0015)

RL78/G14 Fast Prototyping Board User's Manual (R20UT4573)

RL78 Family Arduino API Introduction Guide (R01AN5413)

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

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Revision History

Rev.	Date	Description	
		Page	Summary
1.00	June.30.20	—	First Edition

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

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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.).

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