RL78 Family

MIDI Performance Control Sample Software Using SIS

Introduction

This application note provides examples of using communication control with MIDI devices by using the MIDI interface SIS (Software Integration System) module.

The LED matrix display is controlled in accordance with NoteOn messages (MIDI messages) generated by hexadecimal keyboard input. MIDI messages can also be transferred to the sound module to play sounds by using the MIDI interface SIS module.

The compliant standard is as follows.

• MIDI 1.0

For details on the MIDI standard, refer to the preceding specification.

Target Devices

RL78/G16

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

Contents

1. Specification

1.1 Overview of Specification

This sample program provides examples of using the MIDI message output function by using the MIDI interface SIS (Software Integration System) module.

The LED matrix display is controlled in accordance with NoteOn messages (MIDI messages) generated by hexadecimal keyboard input. MIDI messages can be transferred from the MIDIOUT pin to the sound module to play sounds by using the transmission function.

Table 1-1 lists the peripheral functions for use and their application. Figure 1-1 shows an overview of the sample program operation.

Table 1-1 Peripheral Functions for Use and Their Application

Peripheral Function	Application
Serial interface UART0 P03/TxD0	UART communication with MIDI devices
A/D converter P05/ANI4	Volume switch input for volume selection
Serial interface CSI20 P13/SCK20, P16/GPIO, P15/SO20	SPI communication with the LED matrix module
P10/GPIO, P21/GPIO, P60/GPIO, P61/GPIO, P11/GPIO, P43/GPIO, P137/GPIO, P12/GPIO	Key matrix input to the hexadecimal keyboard

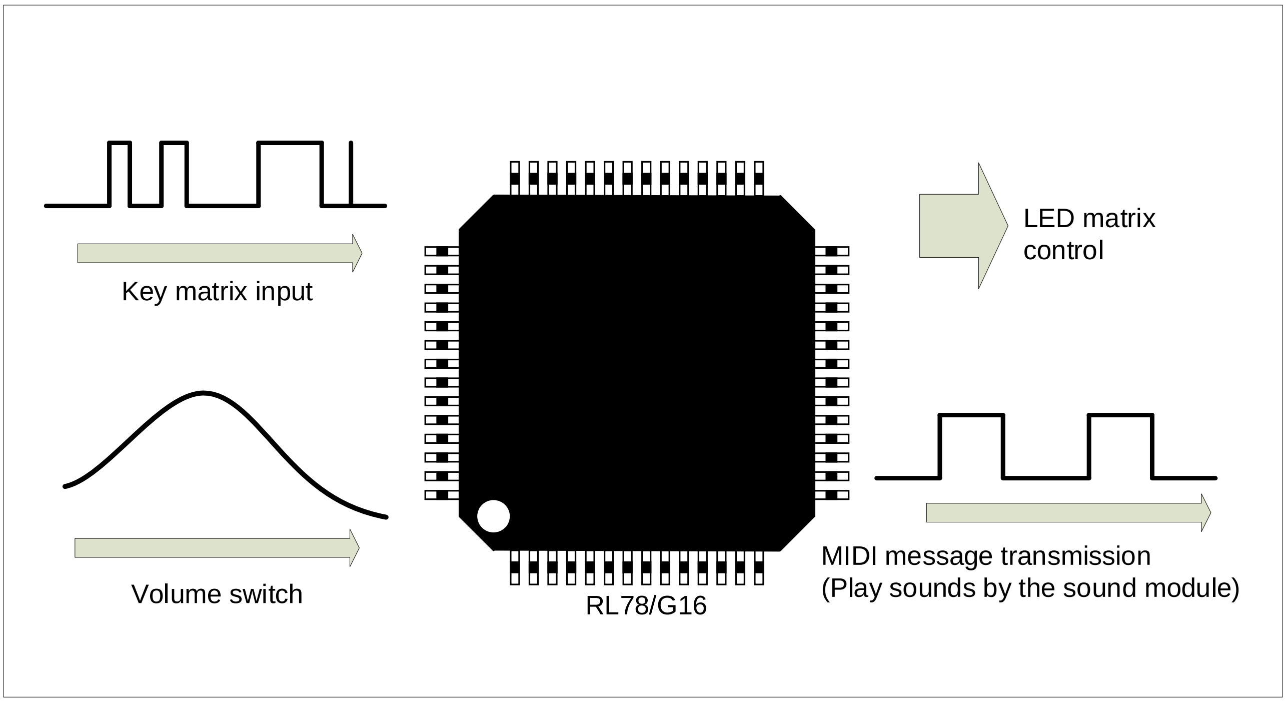


Figure 1-1 Overview of Sample Program Operation

1.1.1 Communication specifications

The following describes the MIDI standard data configuration used in this sample program.

As shown in Figure 1-2, the MIDI data column is a bit column for unidirectional asynchronous communication of 31.25 Kb/sec. Each byte to be sent consists of ten bits (one start bit, eight data bits, and one stop bit).

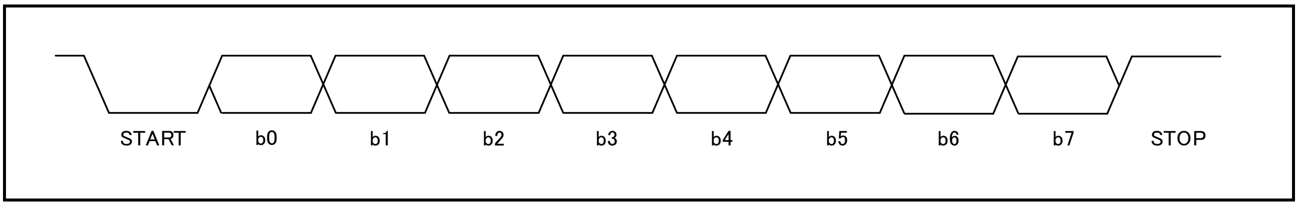


Figure 1-2 MIDI Data Column

As shown in Figure 1-3, a MIDI message consists of a status byte and data bytes, and is roughly categorized as a channel message or a system message according to the status byte.

Status byte

Channel Message Structure

b7	b6	b5	b4	b3	b2	b1	b0
1	Type of msg			Channel#			

System Message Structure

b7	b6	b5	b4	b3	b2	b1	b0
1	1	1	1	Type of msg			

Data byte

b7	b6	b5	b4	b3	b2	b1	b0
0	Data						

Figure 1-3 MIDI Data Structure

The following describes the NoteOn (keystroke) message, which is a channel message used by this sample program to control the LED matrix.

As shown in Figure 1-4, the NoteOn (keystroke) message consists of the status byte followed by two data bytes.

The status byte contains the channel number (Channel#).

Data byte 1 contains the note number (Note#), indicating the note.

Data byte 2 contains “Velocity”, indicating the velocity of the sound.

Status byte

Channel Message Structure

b7	b6	b5	b4	b3	b2	b1	b0
1	0	0	1	Channel#			

Data byte 1

b7	b6	b5	b4	b3	b2	b1	b0
0	Note#						

Data byte 2

b7	b6	b5	b4	b3	b2	b1	b0
0	Velocity						

Figure 1-4 NoteOn (Keystoke) Message

The following describes the program change message used to specify the tone for a MIDI channel.

As shown in Figure 1-5, the message consists of a status byte followed by one data byte.

The status byte contains the channel number (Channel#).

Data byte 1 contains the program number (Prog#), indicating the tone.

Status byte

Channel Message Structure

b7	b6	b5	b4	b3	b2	b1	b0
1	1	0	0	Channel#			

Data byte 1

b7	b6	b5	b4	b3	b2	b1	b0
0	Prog#						

Figure 1-5 Program Change Message

The following describes the control change message used to expand the number of tones for a MIDI channel.

The bank settings for MSB and LSB provide 16,384 choices for a program number specified in the program change message.

As shown in Figure 1-6, the message consists of a status byte followed by two data bytes.

The status byte contains the channel number (Channel#).

Data byte 1 contains the controller number (Controller#), indicating the target bank.

The controller number must be set to 0 for Bank Select MSB and 32 for Bank Select LSB.

Data byte 2 contains the bank number (Bank#), indicating the bank set value.

Status byte

Channel Message Structure

b7	b6	b5	b4	b3	b2	b1	b0
1	0	1	1	Channel#			

Data byte 1

b7	b6	b5	b4	b3	b2	b1	b0
0	Controller#						

Data byte 2

b7	b6	b5	b4	b3	b2	b1	b0
0	Bank#						

Figure 1-6 Control Change Message (Bank Select)

The following describes the control change message used to specify the volume for a MIDI channel.

As shown in Figure 1-7, the message consists of a status byte followed by two data bytes.

The status byte contains the channel number (Channel#).

Data byte 1 contains the controller number (Controller#), indicating the channel volume.

Specify 7 for the controller number.

Data byte 2 contains the volume (Volume#).

Status byte

Channel Message Structure

b7	b6	b5	b4	b3	b2	b1	b0
1	0	1	1	Channel#			

Data byte 1

b7	b6	b5	b4	b3	b2	b1	b0
0	Controller#						

Data byte 2

b7	b6	b5	b4	b3	b2	b1	b0
0	Volume#						

Figure 1-7 Control Change Message (Channel Volume)

1.2 Operation Details

This sample program assumes a hexadecimal keyboard as a piano keyboard and turns on the LED matrix according to the key information generated by key input. When a key is pressed, the sample program sends the NoteOn (keystroke) message of the note corresponding to the key to the sound module to play a sound. While the key is held down, the LED stays lit and sounding might continue depending on the instrument assigned to the MIDI channel. When the key is released, the LED is turned off and a NoteOff message is sent to stop the sound.

(1) Input on the hexadecimal keyboard

- The hexadecimal keyboard is a keypad having 16 keys (0 to F). The keys are arranged in a matrix with 4 rows and 4 columns. Key pressing status is read in units of columns.
- This sample program is placed in melody mode immediately after a reset. In this mode, as shown in Figure 1-8, notes are assigned to 0 to 9, F, and E keys as keyboard keys. Pressing a key turns on the LED matrix and plays a sound from the MIDI sound source.
- Pressing the “A” key changes the mode between melody mode and MIDI channel change mode.
- Pressing the “C” or “D” key changes the pitch by one octave.

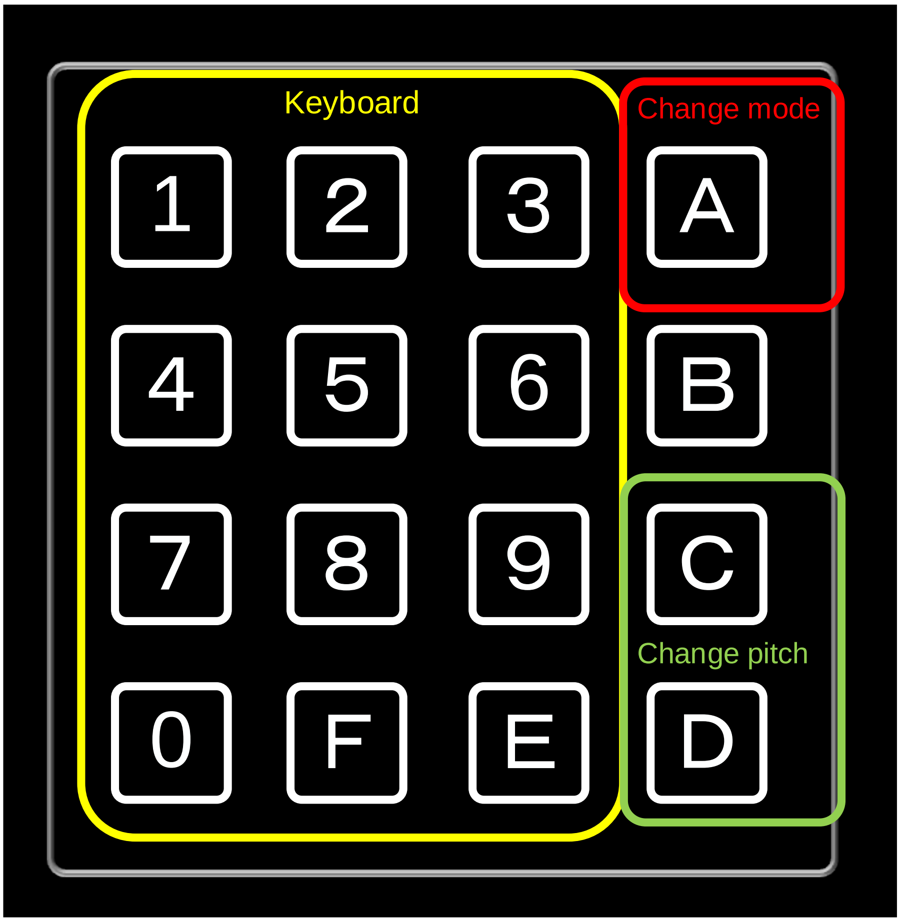


Figure 1-8 Assignment on Hexadecimal Keyboard

(2) Specifying and changing sound target MIDI channels

- The MIDI standard defines 1 to 16 channels (denoting "instruments"), which are referred to as MIDI channels.
- One of the tones that are preset for each MIDI channel can be selected to play sounds.
- MIDI channels are changed by using the hexadecimal keyboard in MIDI channel change mode.
- Pressing the A key in melody mode, as shown in Figure 1-9, causes transition to MIDI channel change mode.
- The current MIDI channel is displayed immediately after transition to MIDI channel change mode. This display also waits for input of a tens place digit of the MIDI channel number, where the valid input value is 0 or 1. When you enter a tens place digit, the display changes and waits for input of a ones place digit. In this state, 0 to 9 are valid input values for the MIDI channel. Enter a ones place digit so that the two digit number is within the range from 01 to 16.
- Pressing the "A" key in channel change mode returns to melody mode. If a two digit number is displayed at this time, that number is set for the MIDI channel. If the display still waits for input of a ones place digit, the current MIDI channel will be used without change.
- Figure 1-10 shows how the display target channels are displayed on the LED matrix. (Black is off. Red and green are lit.)

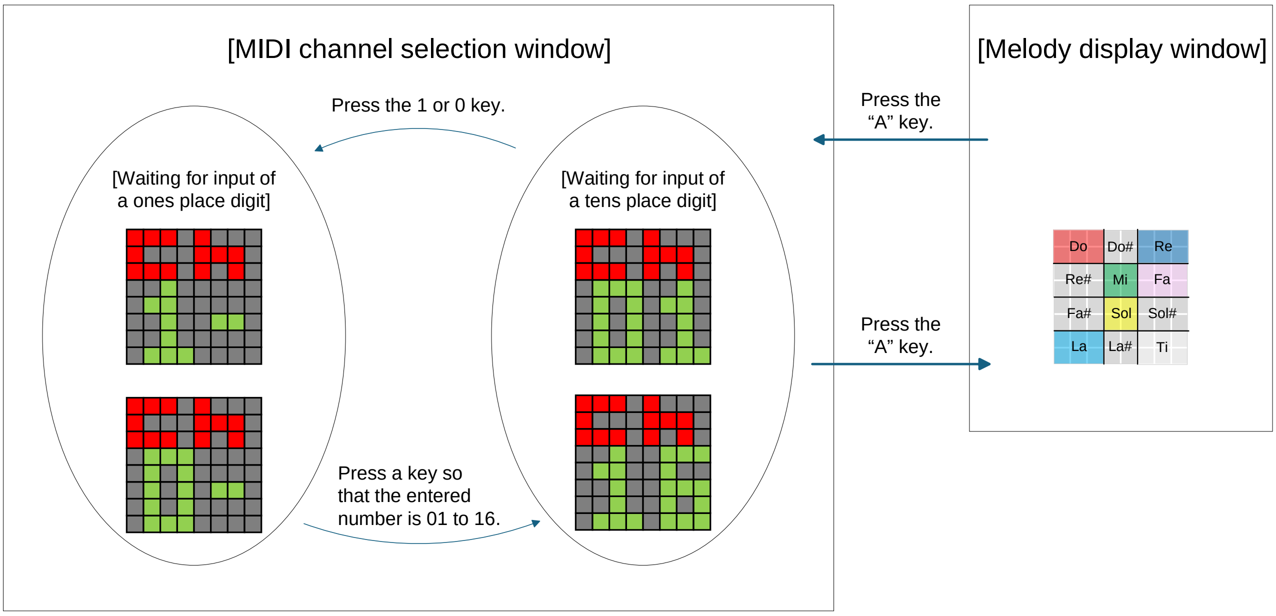


Figure 1-9 State Transition of Setting and Changing the Target MIDI Channel for Sound Output

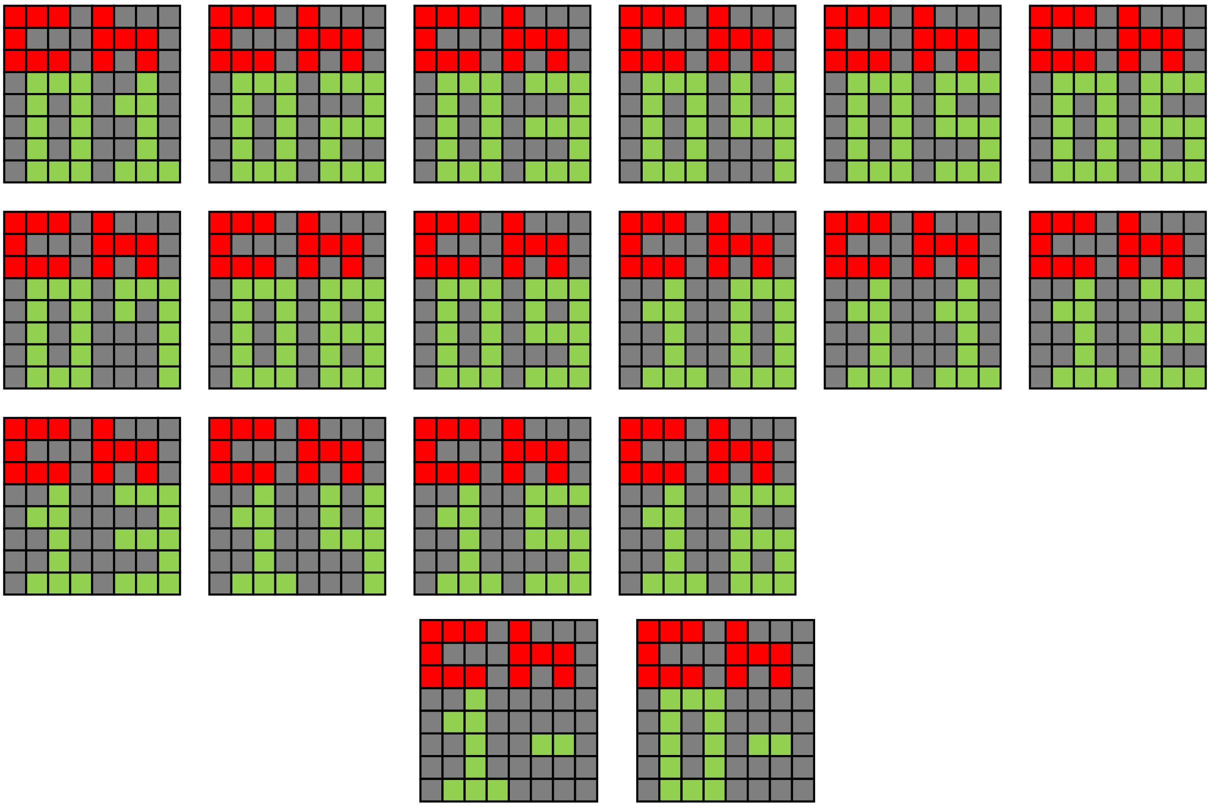


Figure 1-10 MIDI Channel Displays

(3) Specifying and changing the pitch

- The 4 × 4 hexadecimal keyboard can play sounds only in the range of one octave. However, the pitch can be changed in the range from -5 to +5 by one octave, assuming that the pitch is set to ±0 immediately after reset.
- The user can change the pitch by pressing the “C” or “D” key. (Change is possible even while sound is being played.)
- Pressing the “C” key increments the current pitch by 1, and pressing the “D” key decrements the current pitch by 1. In both cases, pitch information is displayed on the LED matrix for one second.
- Figure 1-11 shows how the pitch information is displayed on the LED matrix. (Black is off. Green is lit.)

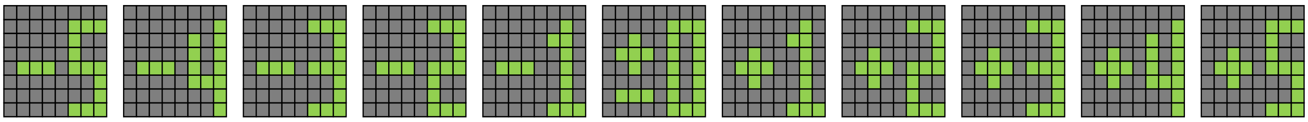


Figure 1-11 Pitch Information Display

(4) LED matrix display during melody display

- Assuming the hexadecimal keyboard as a piano keyboard, NoteOn (keystroke) messages are sent and the LED matrix is turned on according to the scale information based on the positions of pressed keys. That is, the LED matrix is turned on at the beginning of the sound.
- Figure 1-12 shows the correspondence between the hexadecimal keyboard and piano keyboard. Figure 1-13 shows the notes and LED matrix lighting positions.

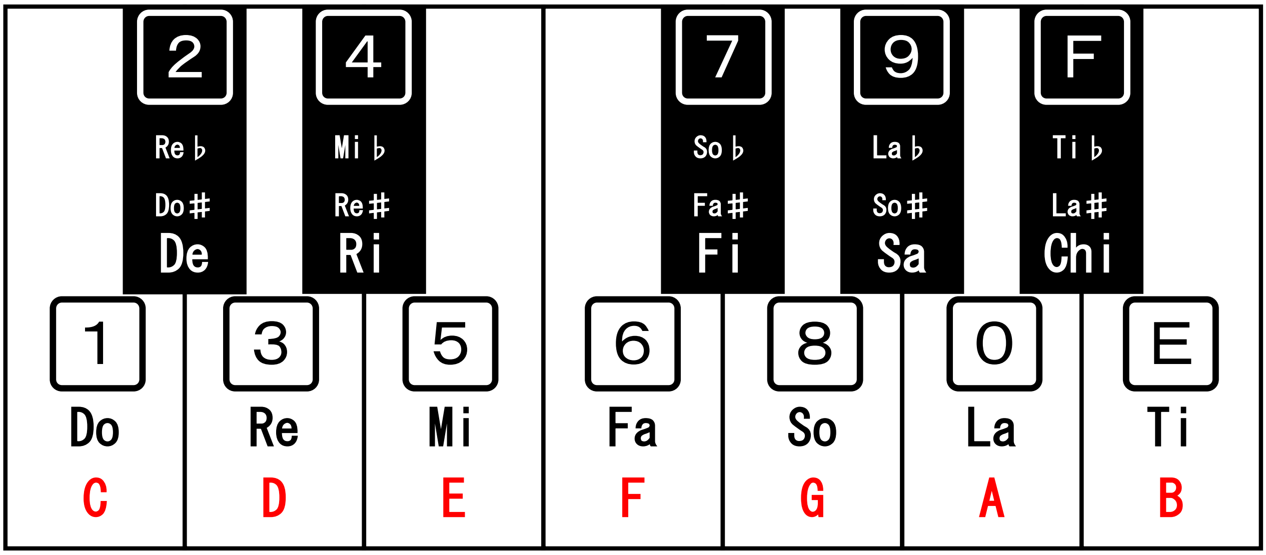


Figure 1-12 Correspondence Between the Hexadecimal Keyboard and Piano Keyboard

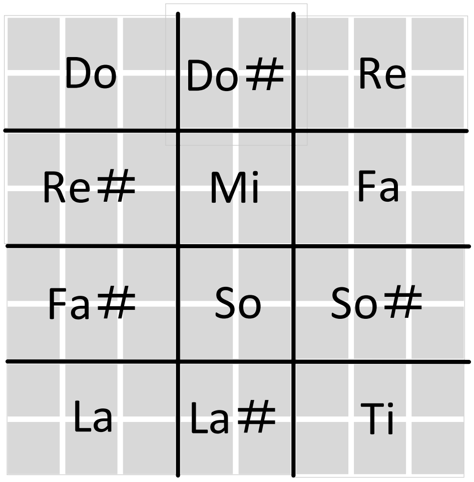


Figure 1-13 Correspondence Between the Notes and LED Matrix Lighting Positions

- Colors are assigned to each note (do, re, mi, fa, so, la, ti) as shown in Figure 1-14.As an example, for piano keyboard, the received keystroke messages are shown in a single color for the white keys and in two colors for the black keys.
- The LED stays lit while the key is held down. Also, sounding might continue depending on the instrument assigned to the MIDI channel.

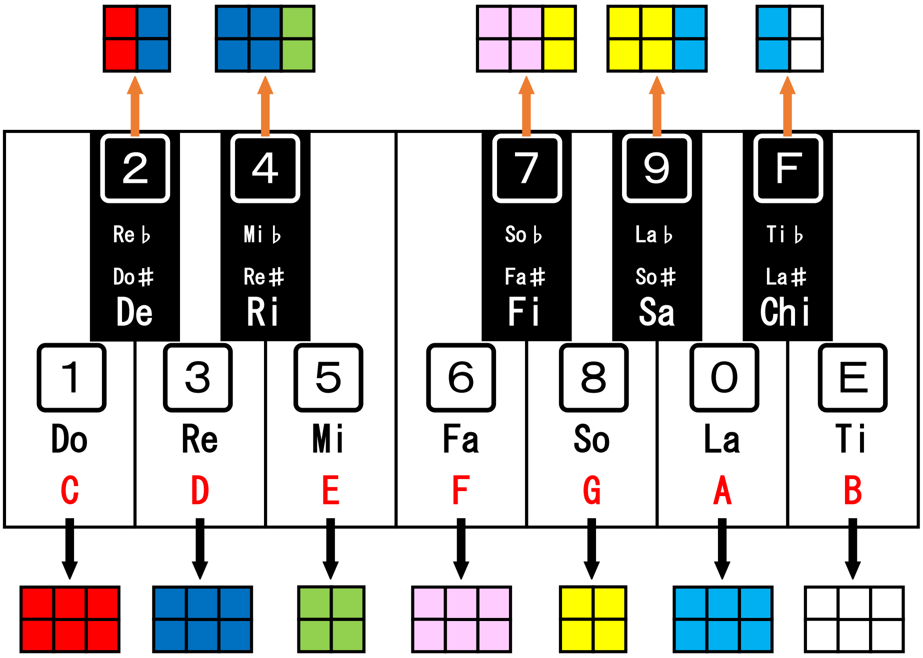


Figure 1-14 Display Color for Each Note

(5) Specifying and changing the volume

- Setting values in the range from 1 to 127, excluding 0 (mute), are converted to eight volume levels.
- The user can change the volume by turning Volume(A0). (Change is possible even while sound is being played.)
- When Volume(A0) is turned, volume information is displayed on the LED matrix for 1 second.
- The volume level is indicated by the width of the yellow band. The leftmost column is lit for minimum (level 1), and all eight columns in a row are lit for maximum (level 8).
- Figure 1-15 shows how the volume information is displayed on the LED matrix. (Black is off. Red, blue, green, and yellow are lit.)

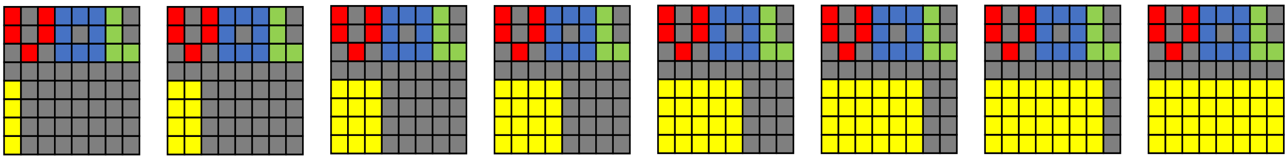


Figure 1-15 Volume Information Display

2. Hardware Description

2.1 Hardware Configuration

Table 2-1 describes the hardware used in this sample program.

Table 2-1 Hardware List

Hardware	Application
Board used	Manufactured by Renesas Electronics RL78/G16 Fast Prototyping Board (RTK5RLG160C00000BJ)
MCU used	RL78/G16 (R5F121BCAFP)
Operating frequency	High-speed on-chip oscillator clock (fHOCO): 16 MHz
Operating voltage	5.0V
MIDI shield board	SparkFun MIDI Shield
MIDI to MIDI (male-to-male) cable	SANWA SUPPLY KB-MID01-18K
MIDI sound module	Roland SOUND Canvas SC-88 Pro
LED matrix module	52pi EP-0075 RPI-RGB-LED-Matrix
Hexadecimal keyboard	digilent Pmod KYPD 16-button Keypad

Figure 2-1 and Figure 2-2 show the configurations used in this application note.

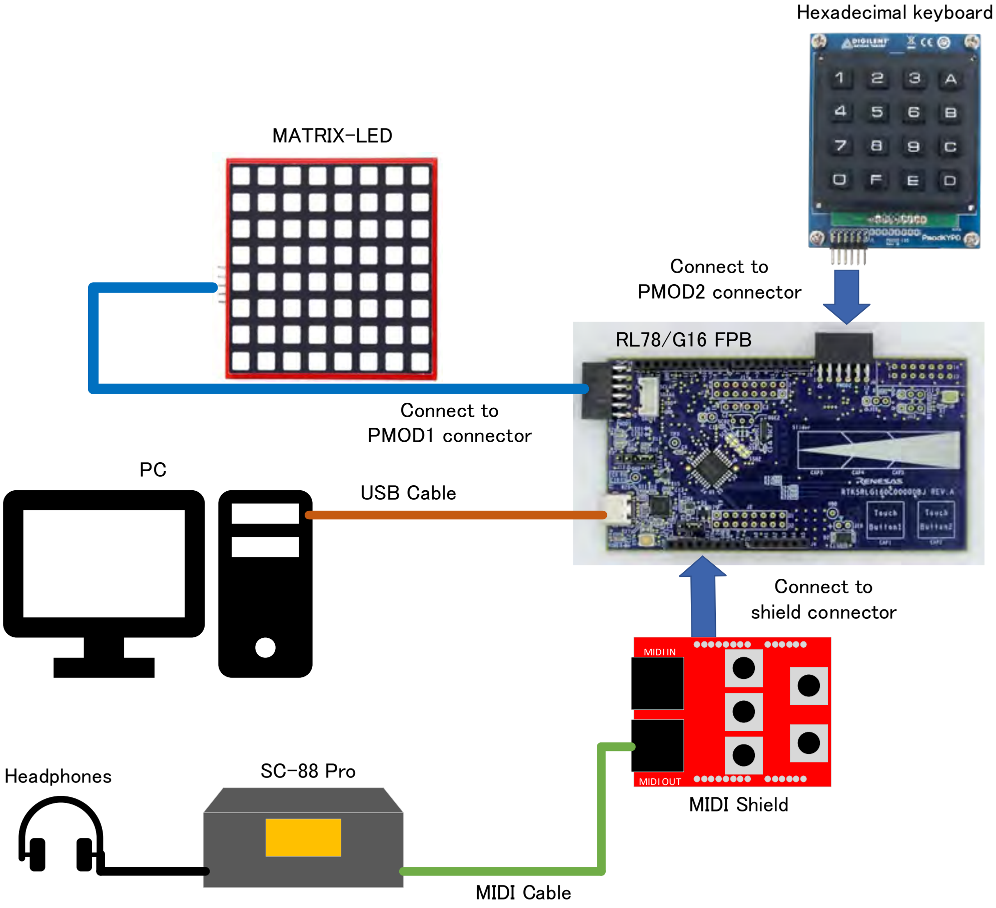


Figure 2-1 Hardware Configuration

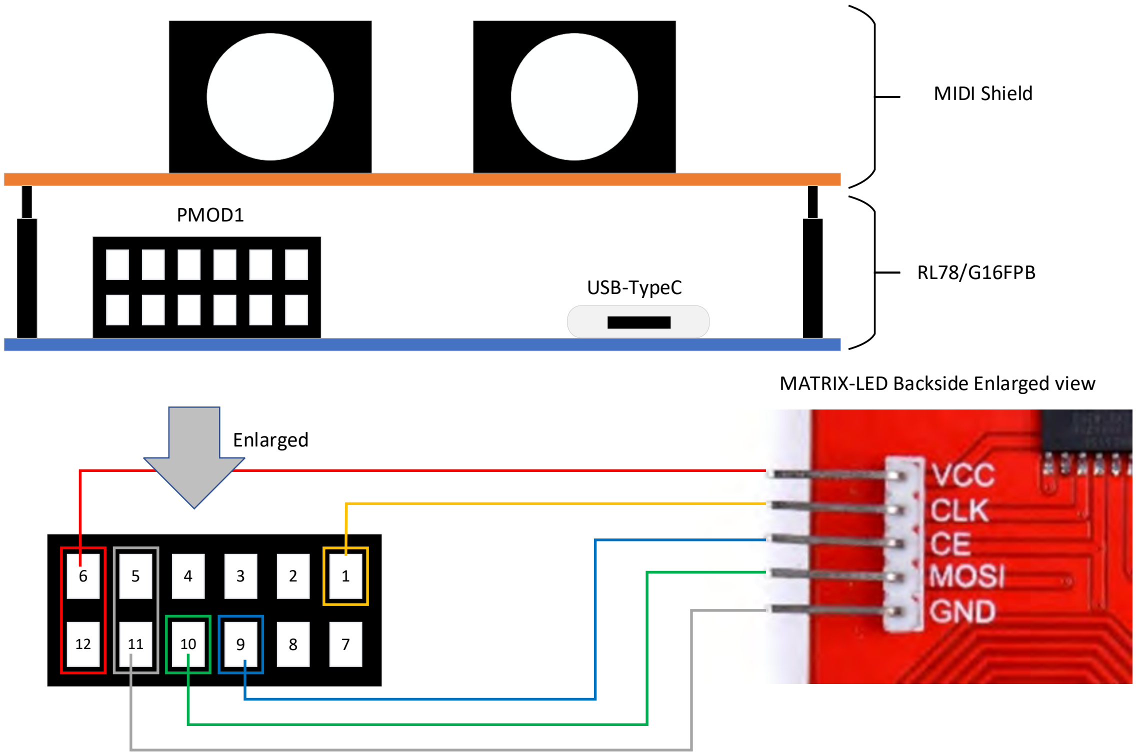


Figure 2-2 Wiring Between PMOD1 and MATRIX-LED

2.2 Pin Connection Diagrams

Figure 2-3 shows a pin connection diagram between the RL78/G16 FPB and the MIDI Shield. Figure 2-4 shows a pin connection diagram between the RL78/G16 FPB and the MATRIX-LED. Figure 2-5 shows a pin connection diagram between the RL78/G16 FPB and the hexadecimal keyboard.

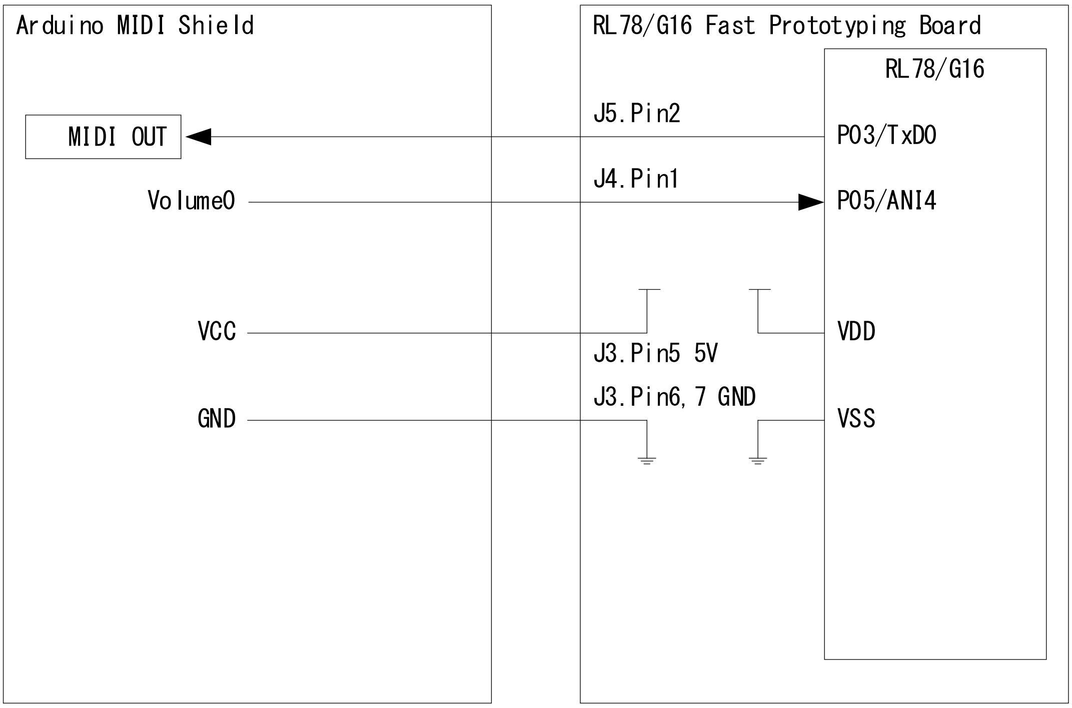


Figure 2-3 Pin Connection Diagram Between RL78/G16 FPB and MIDI Shield

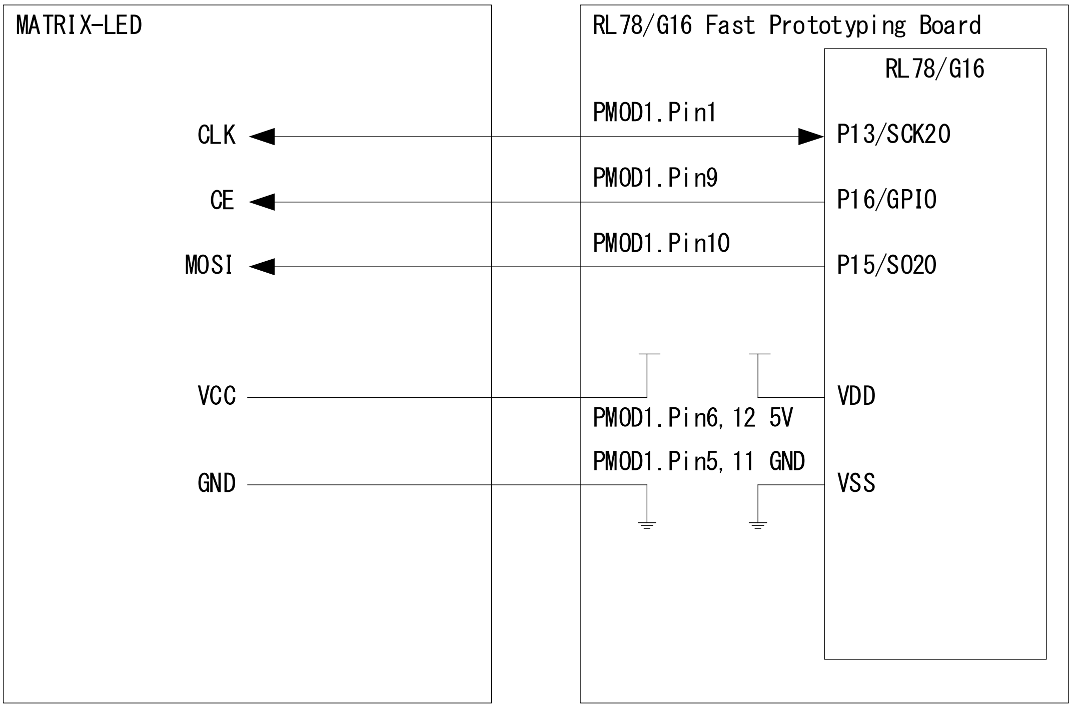


Figure 2-4 Pin Connection Diagram Between RL78/G16 FPB and MATRIX-LED

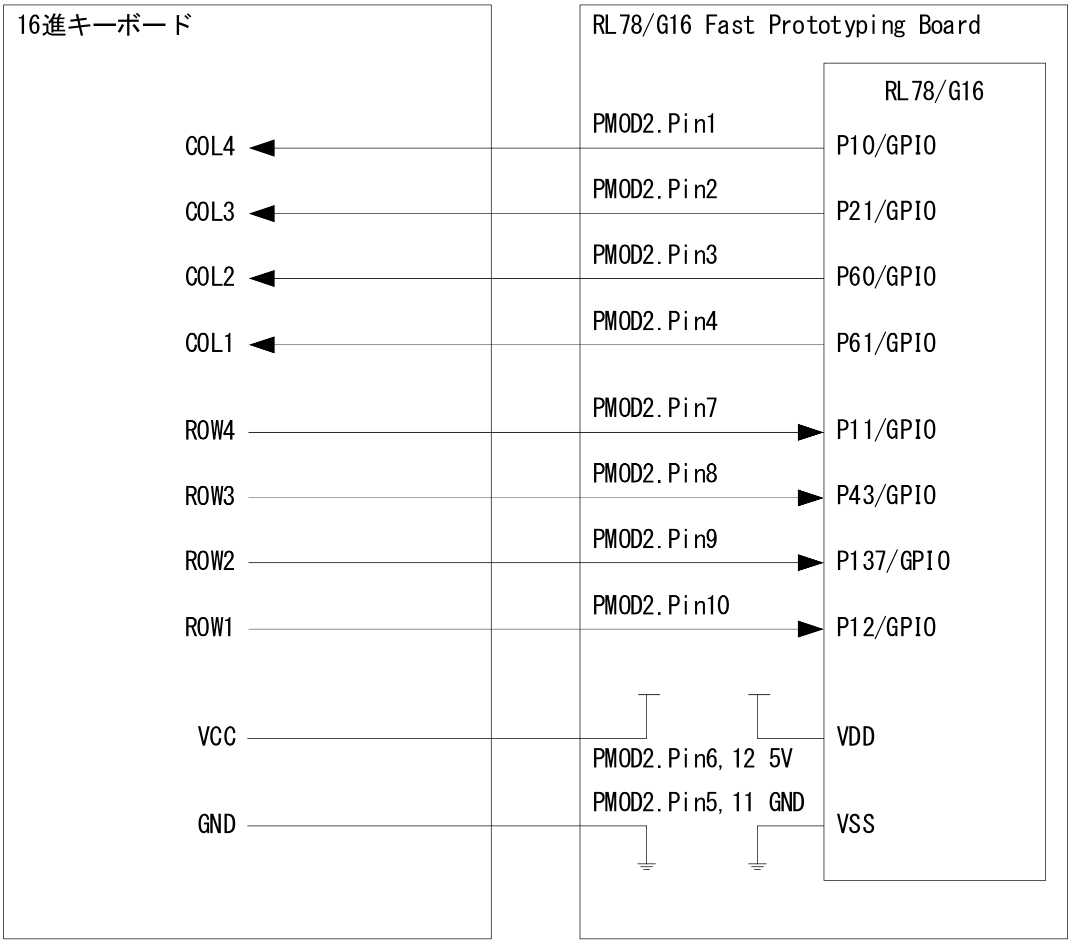


Figure 2-5 Pin Connection Diagram Between RL78/G16 FPB and Hexadecimal Keyboard

2.3 List of Used Pins

Table 2-2 lists the used pins and their functions.

Table 2-2 Used Pins and Functions

Pin Name	I/O	Description
P03/TxD0	Output	MIDI message transmission
P05/ANI4	Input	Sound volume setting
P13/SCK20	Output	MATRIX-LED SPI clock
P16/GPIO	Output	MATRIX-LED SPI chip selection
P15/SO20	Output	MATRIX-LED SPI MOSI
P61/GPIO	Output	Hexadecimal keyboard COL1
P60/GPIO	Output	Hexadecimal keyboard COL2
P21/GPIO	Output	Hexadecimal keyboard COL3
P10/GPIO	Output	Hexadecimal keyboard COL4
P12/GPIO	Input	Hexadecimal keyboard ROW1
P137/GPIO	Input	Hexadecimal keyboard ROW2
P43/GPIO	Input	Hexadecimal keyboard ROW3
P11/GPIO	Input	Hexadecimal keyboard ROW4

Note: Only the used pins are connected in this application note. When creating a circuit, refer to section 2.3 Connection of Unused Pins in the RL78/G16 User's Manual: Hardware (R01UH0980) and appropriately handle the pins not used in this application note so that the circuit design satisfies the electrical characteristics.

3. Software Description

3.1 Software Environment

Table 3-1 shows the software used in this sample program.

Table 3-1 Software

Software	Application
Integrated development environment	Manufactured by Renesas Electronics e[2] studio 2024-07
C compiler	Manufactured by Renesas Electronics C Compiler Package for RL78 Family [CC-RL] V1.14.00
Smart Configurator (SC)	Smart Configurator for RL78 V1.10.0
Board Support Package (BSP)	Manufactured by Renesas Electronics V1.70

3.2 Peripheral Function Settings

Figure 3-1 shows the settings of the 1-ms interval timer.

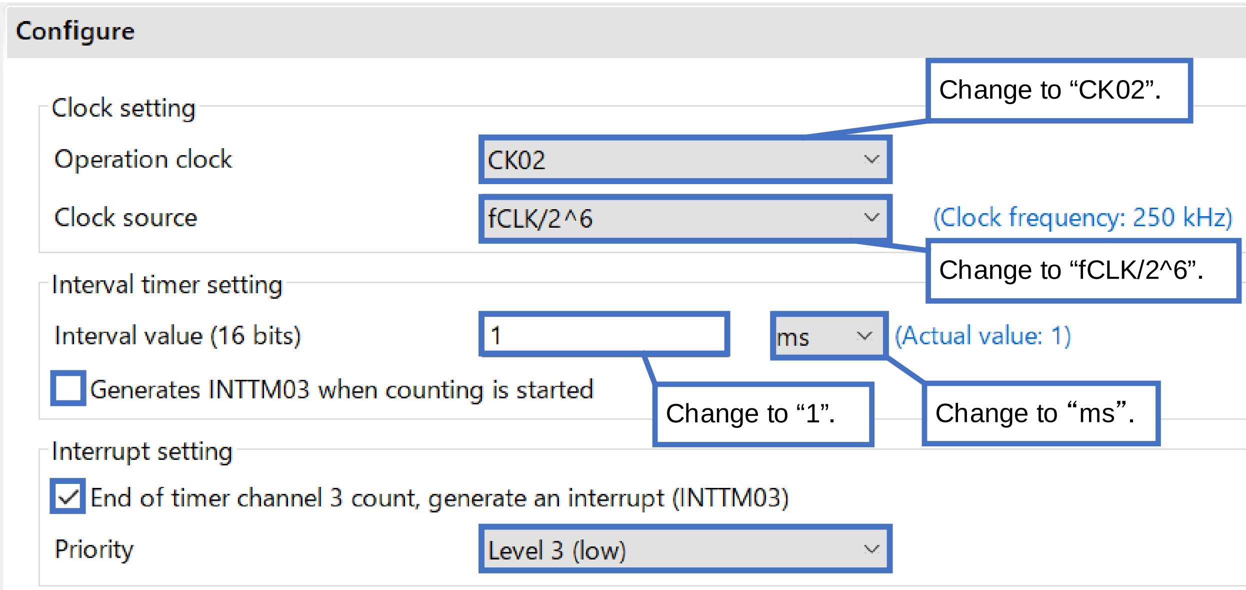


Figure 3-1 1-ms Interval Timer Settings

Figure 3-2 shows the A/D converter settings to select analog input channel 4 and specify 10-bit data for conversion results.

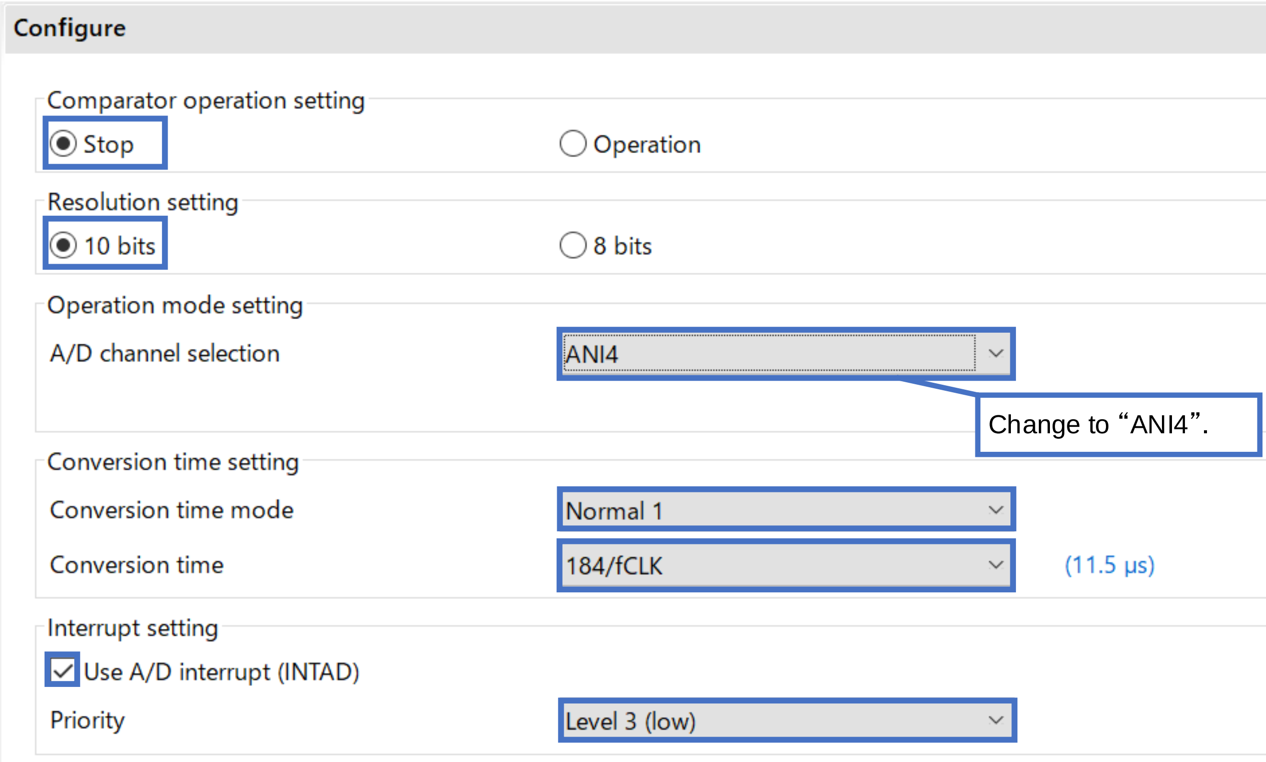


Figure 3-2 Analog Input Settings

Figure 3-3 shows the SPI communication settings to specify MSB first for the data transfer direction and 4 Mbps for the communication speed.

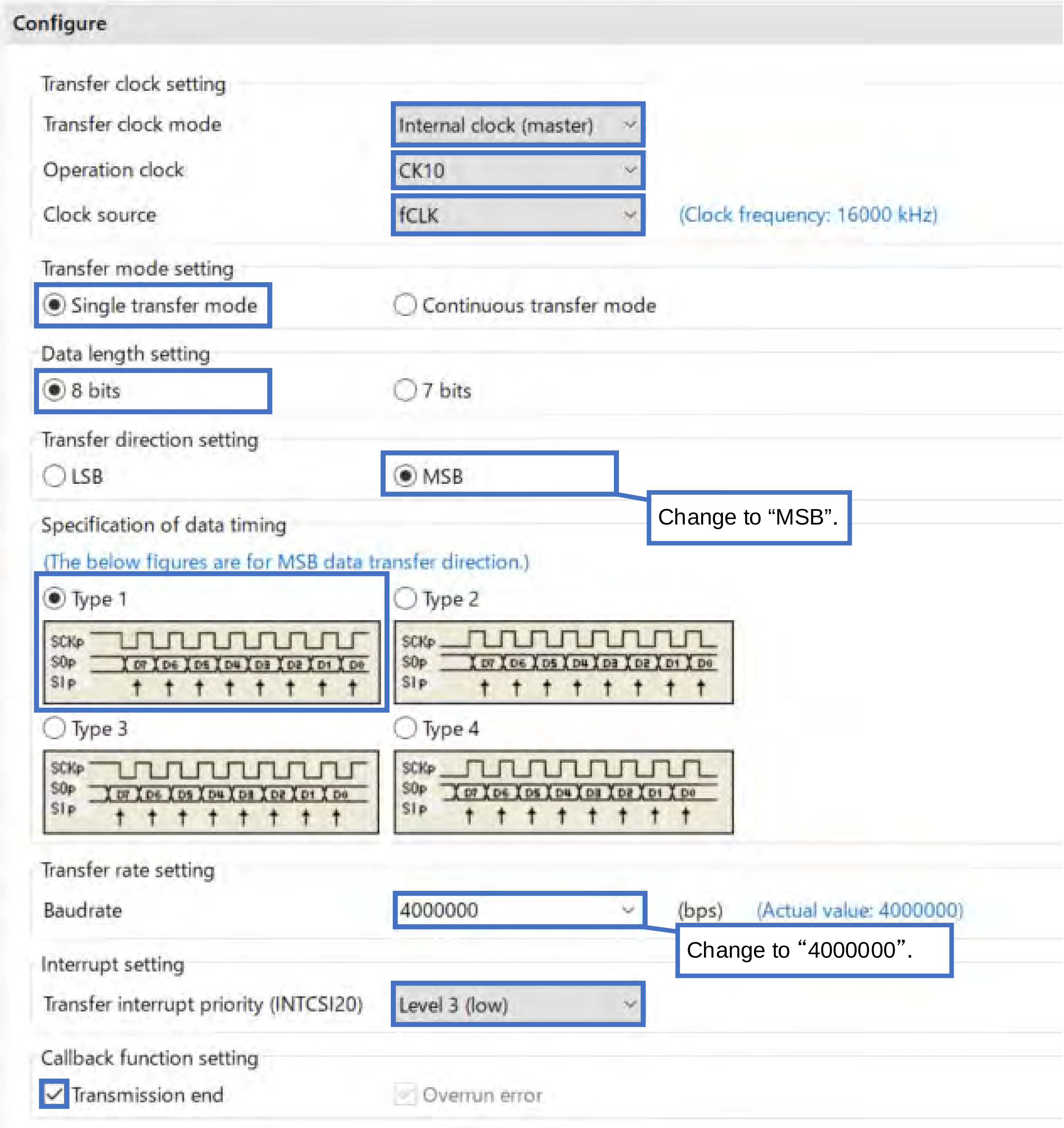


Figure 3-3 SPI Communication Settings

Figure 3-4 shows the communication settings for UART transmission that comply with the MIDI communication standard.

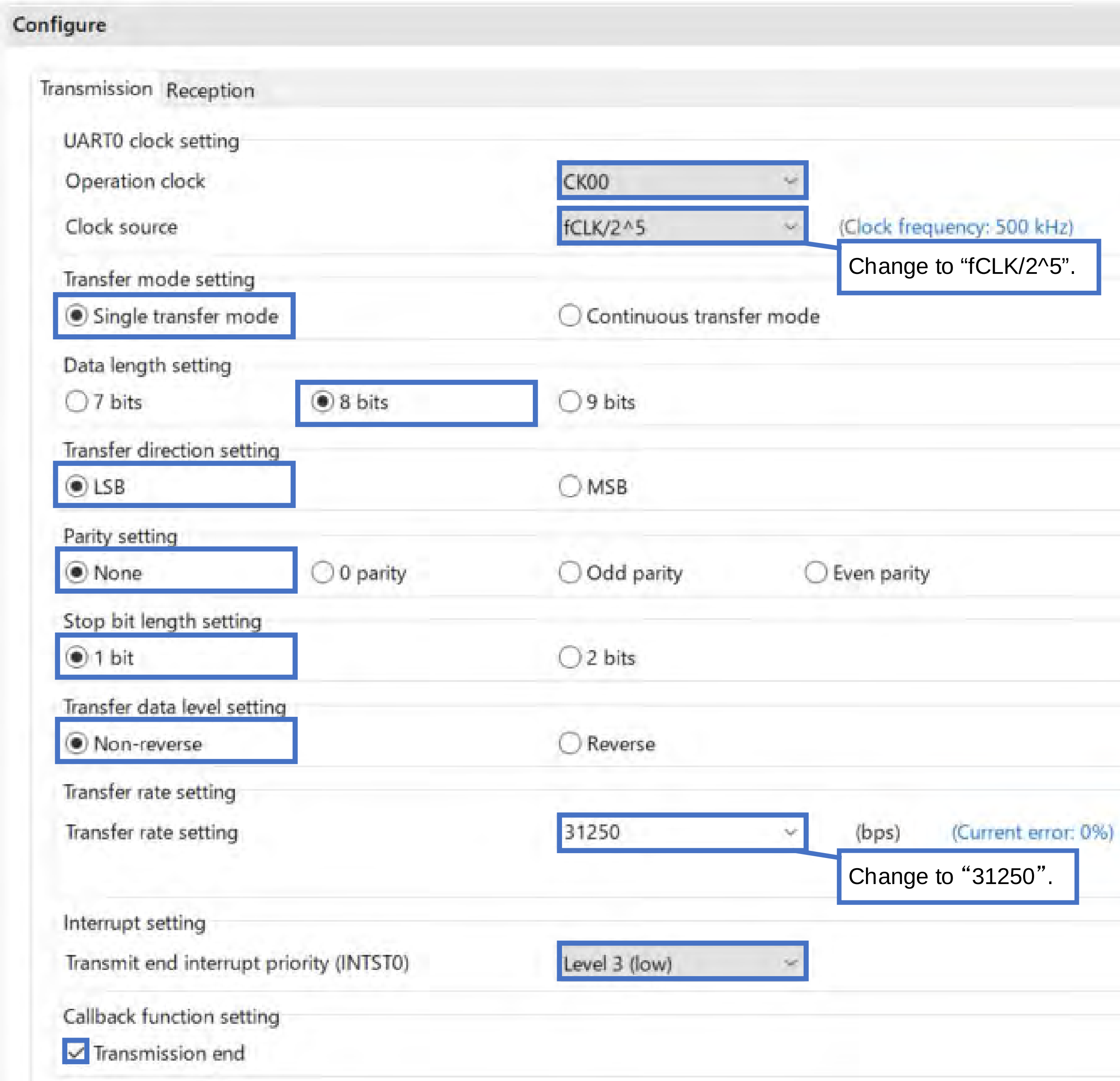


Figure 3-4 Communication Settings for MIDI Transmission

Figure 3-5 shows the communication settings for UART reception that comply with the MIDI communication standard.

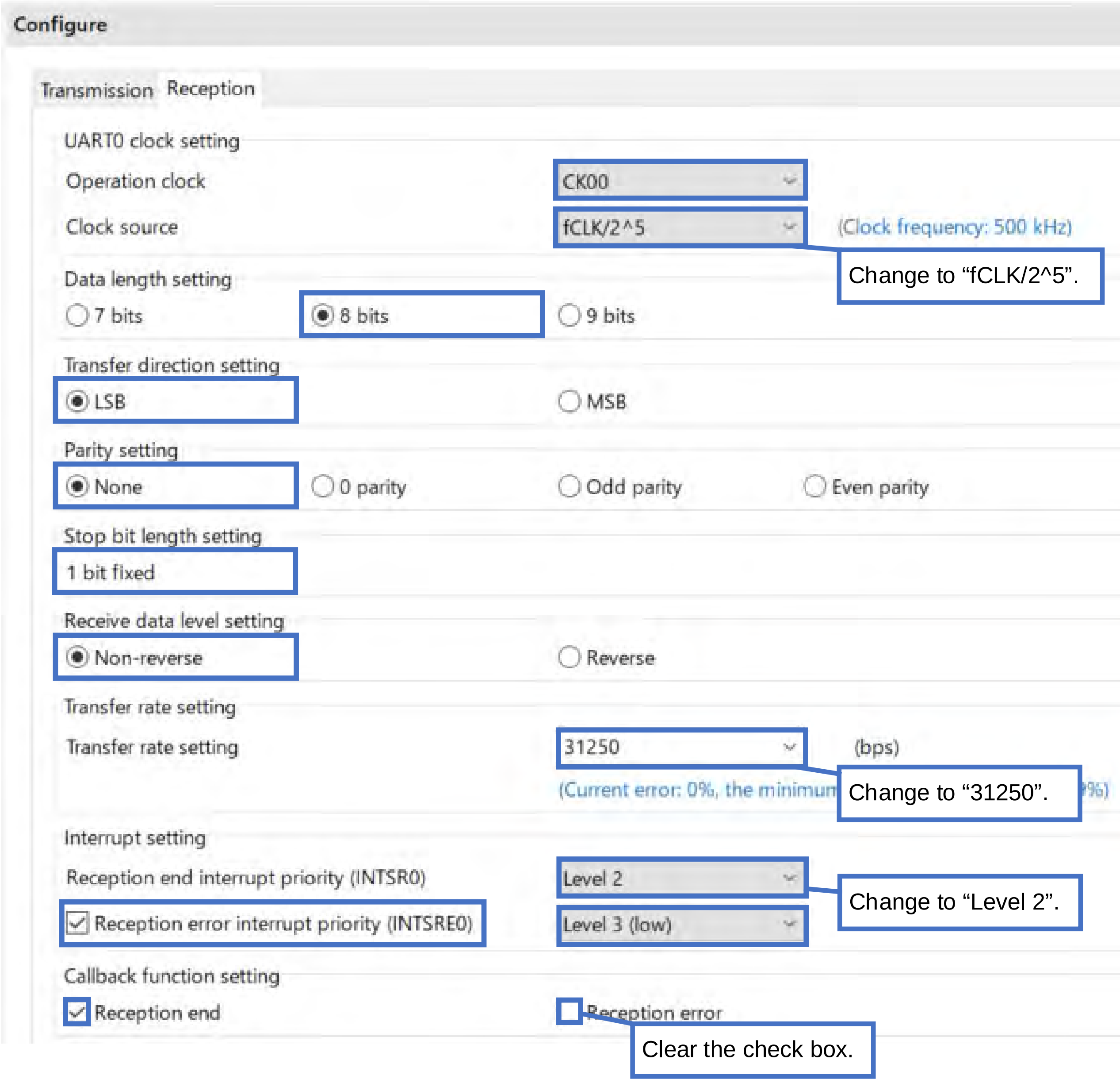


Figure 3-5 Communication Settings for MIDI Reception

3.3 Setting of Option Byte

Table 3-2 shows the option byte settings.

Table 3-2 Setting of Option Byte

Address	Setting Value	Contents
000C0H	11101111B	Disables the watchdog timer. (Counting stopped after reset)
000C1H	11110111B	SPOR operations (VSPOR) At rising edge TYP. 2.90V (2.76 V ～ 3.02 V) At falling edge TYP. 2.84V (2.70 V ～ 2.96 V)
000C2H	11111001B	High-speed on-chip oscillator clock: 16MHz
000C3H	10000101B	Enables on-chip debugging

3.4 List of Macros

Table 3-3 lists the macros used in the sample program.

Table 3-3 Macros Used in Sample Program (1/2)

Macro Name	Set Value	Description
DEMO_MIDI_NOTE_MAX	127	Maximum MIDI note value
DEMO_MIDI_PITCH_NUM	12	Number of notes in one octave
DEMO_MIDI_DISPlAY_VOL_MAX	8	Maximum MIDI volume
DEMO_MIDI_CH_MAX	16	Maximum MIDI channel number
DEMO_MIDI_CH_MIN	1	Minimum MIDI channel number
DEMO_MIDI_MIDDLE_C	60	Medium MIDI note value
DEMO_MIDI_VELOCITY	127	Velocity in NoteOn messages
DEMO_ADC_DATA_DIVISION	1024	Volume switch input resolution
DEMO_ADC_BUFF_SIZE	4	Number of volume switch data buffers
DEMO_ADC_INPUT_DIFFERENCE	8	Volume switch input threshold
DEMO_DISPLAY_MODE_MELODY	0	Display information type: Note display
DEMO_DISPLAY_MODE_CH_SET	1	Display information type: Channel display
DEMO_DISPLAY_MODE_COLOR_VOL_SET	2	Display information type: Volume display
DEMO_DISPLAY_MODE_OCTAVE_SHIFT_SET	3	Display information type: Pitch display
DEMO_DISPLAY_VOL_SET_TIME	1000	Volume display period [ms]
DEMO_DISPLAY_OCTAVE_SHIFT_SET_TIME	1000	Octave display period [ms]
DEMO_MATRIX_CATHODE_COLOR	3	Number of LED color elements: Red, Blue, Green
DEMO_MATRIX_DIGIT	8	Number of LED rows
DEMO_SOUND_VOLUME_PATTERN	8	Number of volume levels: 8
DEMO_KYPD_OCTAVE_SHIFT_NONE	5	Initial pitch adjustment value (±0)
DEMO_KYPD_OCTAVE_SHIFT_MIN	0	Minimum pitch adjustment value (-5)
DEMO_KYPD_OCTAVE_SHIFT_MAX	10	Maximum pitch adjustment value (+5)
KYPD_SET_MODE_OUTPUT	0	Mode register output mode set value
KYPD_SET_MODE_INPUT	1	Mode register input mode set value
DEMO_SYSTEM_TIMER_START_FUNC	-	Alias of R_Config_TAU0_3_Start
DEMO_MATRIX_LED_SPI_CSPIN	-	Alias of CSI20 chip selection (P1_bit.no6)
DEMO_MATRIX_LED_SPI_START_FUNC	-	Alias of R_Config_CSI20_DEMO_MATRIX_LED_Start
DEMO_MATRIX_LED_SPI_SEND_FUNC	-	Alias of R_Config_CSI20_DEMO_MATRIX_LED_Send
DEMO_ANALOG_VOLUME_INPUT_START_FUNC	-	Macro that sequentially calls R_Config_ADC_DEMO_VOLUME_Set_OperationOn() and R_Config_ADC_DEMO_VOLUME_Start() to prepare for starting AD conversion
DEMO_KYPD_MATRIX_ROW1_PIN	-	Alias of key matrix input ROW1 (P1_bit.no2)
DEMO_KYPD_MATRIX_ROW2_PIN	-	Alias of key matrix input ROW2 (P13_bit.no7)

Table 3-4 Macros Used in Sample Program (2/2)

マクロ名	Set Value	Description
DEMO_KYPD_MATRIX_ROW3_PIN	-	Alias of key matrix input ROW3 (P4_bit.no3)
DEMO_KYPD_MATRIX_ROW4_PIN	-	Alias of key matrix input ROW4 (P1_bit.no1)
DEMO_KYPD_MATRIX_COL1_PIN	-	Alias of key matrix output COL1 (P6_bit.no1)
DEMO_KYPD_MATRIX_COL2_PIN	-	Alias of key matrix output COL2 (P6_bit.no0)
DEMO_KYPD_MATRIX_COL3_PIN	-	Alias of key matrix output COL3 (P2_bit.no1)
DEMO_KYPD_MATRIX_COL4_PIN	-	Alias of key matrix output COL4 (P1_bit.no0)
DEMO_KYPD_MATRIX_COL1_PINMODE	-	Alias of key matrix output COL1 mode register (PM6_bit.no1)
DEMO_KYPD_MATRIX_COL2_PINMODE	-	Alias of key matrix output COL2 mode register (PM6_bit.no0)
DEMO_KYPD_MATRIX_COL3_PINMODE	-	Alias of key matrix output COL3 mode register (PM2_bit.no1)
DEMO_KYPD_MATRIX_COL4_PINMODE	-	Alias of key matrix output COL4 mode register (PM1_bit.no0)

3.5 List of Constants

Table 3-5 list global variables.

Table 3-5 Constants

Type	Constant Name	Description	Used Functions
const uint8_t	g_anti_blur	Anti-blur LED data	demo_display_main
const uint8_t	g_disp_scale	Scale data table by lighting position for the LED matrix	demo_display_main
const uint8_t	g_color_table_tone	LED data table by note in melody mode	demo_display_main
const uint8_t	g_display_ch_graph	LED data table to display channel settings when changing channels	demo_display_main
const uint8_t	g_color_table_vol	LED data table to display the volume level when changing the volume	demo_display_main
const uint8_t	g_sound_volume_msk	Mask data table to display the volume level when changing the volume	demo_display_main
const uint8_t	g_display_octave_shift_graph	LED data table to display the pitch adjustment value when changing the pitch	demo_display_main
const uint8_t	g_kypd_tenkey	Hexadecimal keyboard input value table for MIDI channel change mode	main
const uint8_t	g_disp_volume	Volume data table by volume level	main
const timbre_tone_t	g_demo_timbre	Tone setting information table by MIDI channel	main

3.6 List of Variables

Table 3-6 through Table 3-8 list global variables.

Table 3-6 Global Variables (1/3)

Type	Variable Name	Description	Used Functions
uint8_t	g_demo_adc_finish	Flag indicating that AD conversion with the volume switch ends	main、r_Config_ADC_DEMO_VOLUME_interrupt、demo_volume_input
uint16_t	g_demo_adc_data	AD value of the volume switch	main、r_Config_ADC_DEMO_VOLUME_interrupt、demo_volume_input
uint16_t	g_demo_adc_buff	AD value buffer of the volume switch	main、demo_volume_monitor_main、demo_volume_input
uint16_t	g_demo_adc_average	Average AD value of the volume switch	main、demo_volume_monitor_main
uint16_t	g_demo_adc_average_bak	Previous average AD value of the volume switch	main、demo_volume_monitor_main
uint8_t	g_demo_adc_step	State of AD conversion processing of the volume switch: 0 (conversion stopped), 1 (conversion in progress)	main、demo_volume_monitor_main、demo_volume_input
uint8_t	g_demo_adc_input_index	Index of the AD value buffer of the volume switch	demo_volume_input
pitch_blink_t	g_demo_matrix_ch_info	Display information by note	main、demo_display_main
uint8_t	g_demo_kypd_buff	Hexadecimal keyboard input status buffer	demo_kypd_matrix_main、demo_display_main
uint8_t	g_demo_spi_sending_flag	Flag indicating LED data transmission in progress: 0 (transmission end), 1 (transmission in progress)	main、r_Config_CSI20_DEMO_MATRIX_LED_callback_sendend、demo_matrix_led_data_send、demo_matrix_led_send_busy_check

Table 3-7 Global Variables (2/3)

Type	Variable Name	Description	Used Functions
uint32_t	g_demo_display_vol_start_time	Volume display start time when changing the volume	main、
uint32_t	g_demo_display_octave_shift_start_time	Pitch information display start time when changing the pitch	main、 demo_display_main
uint8_t	g_demo_display_mode	LED display mode: DEMO_DISPLAY_MODE_MELODY (Melody mode), DEMO_DISPLAY_MODE_CH_SET (MIDI channel change mode), DEMO_DISPLAY_MODE_COLOR_VOL_SET (Volume change mode), DEMO_DISPLAY_MODE_OCTAVE_SHIFT_SET (Pitch change mode)	main、 demo_display_main
uint8_t	g_demo_last_display_mode	Return destination LED display mode: The LED display mode to be resumed after a given period since the volume change mode or pitch change mode was displayed. Either DEMO_DISPLAY_MODE_MELODY (melody mode) or DEMO_DISPLAY_MODE_CH_SET (MIDI channel change mode) can be specified.	main、 demo_display_main
uint8_t	g_demo_display_ch	Display target channel: 0 to 15 = Ch1 to Ch16, 16 = Display “0”- and wait for entry of the first digit, 17 = Display “1-“ and wait for entry of the first digit	main、 demo_display_main
uint8_t	g_demo_current_ch	Sound target channel: 0 to 15 = Ch1 to Ch16	main、 demo_volume_monitor_main
uint8_t	g_demo_display_vol	Volume: 0 to 7 = Volume level 1 to 8	main、 demo_volume_monitor_main 、 demo_display_main
uint32_t	g_demo_timer	System timer value of the sample program [ms]	demo_time_now、 demo_timer_cycle
uint8_t	g_demo_matrix_led_send_buff	Buffer for sending LED display data	demo_display_main
uint16_t	g_digit_now	Update target LED index	demo_display_main
uint8_t	g_demo_kypd_matrix_keys	Confirmation information for the input status for each key of the hexadecimal keyboard	main

Table 3-8 Global Variables (3/3)

Type	Variable Name	Description	Used Functions
uint8_t	g_demo_kypd_key_chg_timer	Retention time of the status change for each key of the hexadecimal keyboard	demo_kypd_timer_cycle、demo_kypd_start_key_chg_timer、demo_kypd_get_keys_chg_timer_cnt、
uint8_t	g_demo_octave_shift	Pitch adjustment value	main、demo_display_main

3.7 List of Functions

Table 3-9 lists the functions.

Table 3-9 Functions

Function Name	Overview
demo_volume_monitor_main()	Volume setting update processing
demo_volume_input()	Processing to acquire the volume switch status
demo_display_main()	LED data update processing
demo_time_now()	Acquires the time elapsed from the start of the program.
demo_timer_cycle()	Called from a TAU0_3 periodic interrupt to update the time elapsed from the start of the program.
demo_matrix_led_data_send()	LED data transmission processing
demo_matrix_led_send_busy_check()	Processing to monitor the end of LED data transmission
R_Config_TAU0_3_Start()	TAU0_3 timer start processing
r_Config_TAU0_3_interrupt()	Callback processing for a TAU0_3 periodic interrupt
R_Config_ADC_DEMO_VOLUME_Start()	Clears the AD conversion end interrupt flag, enables AD conversion end interrupts, and enables AD conversion operation.
R_Config_ADC_DEMO_VOLUME_ Set_OperationOn()	Enables AD voltage comparator operations.
R_Config_ADC_DEMO_VOLUME_Get_Result_10bit()	Processing to acquire AD conversion results
r_Config_ADC_DEMO_VOLUME_interrupt()	Callback processing when INTAD AD conversion ends
R_Config_CSI20_DEMO_MATRIX_LED_Start()	CSI20 start processing
R_Config_CSI20_DEMO_MATRIX_LED_Send()	CSI20 data transmission processing
r_Config_CSI20_DEMO_MATRIX_LED_ callback_sendend()	Callback processing when CSI20 transmission ends
r_Config_CSI20_DEMO_MATRIX_LED_interrupt()	CSI20 transfer end interrupt processing
R_Config_UART0_Send()	UART0 transmission processing
R_Config_UART0_Receive()	UART0 reception processing
r_Config_UART0_callback_sendend()	UART0 transmission end processing
r_Config_UART0_callback_receiveend()	UART0 reception end processing
r_Config_UART0_interrupt_send()	UART0 transmission interrupt processing
r_Config_UART0_interrupt_receive()	UART0 reception interrupt processing
r_Config_UART0_interrupt_error()	Communication error interrupt processing in UART0 reception
demo_kypd_timer_cycle()	Called from a TAU0_3 periodic interrupt to update the key input confirmation timer count for the hexadecimal keyboard
demo_kypd_start_key_chg_timer()	Processing to start the key input change confirmation timer
demo_kypd_matrix_sense()	Processing to determine the confirmed key input status
demo_kypd_matrix_main()	Main processing of hexadecimal keyboard input
demo_kypd_matrix_col_read()	Processing to read the hexadecimal keyboard column status
demo_kypd_get_keys_chg_timer_cnt()	Processing to acquire the value of the key input change confirmation timer

3.8 Function Specifications

This section describes the function specifications of the sample program.

demo_volume_monitor_main()	
Overview	Volume setting update processing
Header	-
Declaration	uint8_t demo_volume_monitor_main(void);
Description	This function updates the volume according to the change in the volume switch.
Arguments	None
Return values	0: The volume is not changed. 1: The volume is changed.

demo_volume_input()	
Overview	Processing to acquire the status of the volume switch
Header	-
Declaration	uint8_t demo_volume_input(void);
Description	This function acquires the status of the volume switch.
Arguments	None
Return values	0: Volume switch input is being acquired. 1: Volume switch input is acquired.

demo_display_main()	
Overview	Processing to update the LED matrix display
Header	-
Declaration	void demo_display_main(void);
Description	This function updates the contents of the LED matrix display.
Arguments	None
Return values	None

demo_time_now()	
Overview	Acquisition of the current time
Header	-
Declaration	uint32_t demo_time_now(void);
Description	This function returns the time elapsed from the start of the sample program.
Arguments	None
Return values	uint32_t: Time elapsed from the start of the sample program

demo_timer_cycle()	
Overview	Time update
Header	-
Declaration	void demo_timer_cycle(void);
Description	This function is called from within periodic interrupt processing to update the time elapsed from the start of the sample program.
Arguments	None
Return values	None

demo_matrix_led_data_send()	
Overview	LED data transmission
Header	-
Declaration	void demo_matrix_led_data_send(uint8_t * data, uint16_t len);
Description	This function sends data to the LED matrix.
Arguments	uint8_t * data: Send data address uint16_t len: Send data size
Return values	None

demo_matrix_led_send_busy_check()	
Overview	LED data transmission end monitoring
Header	-
Declaration	uint8_t demo_matrix_led_send_busy_check(void);
Description	This function references the communication-in-progress flag (g_demo_spi_sending_flag) and returns the transmission status.
Arguments	None
Return values	0: Transmission end 1: Transmission in progress

r_Config_TAU0_3_interrupt()	
Overview	Interval timer interrupt processing
Header	r_cg_macrodriver.h, r_cg_userdefine.h, Config_TAU0_3.h, r_midi_rl78_if.h
Declaration	static void __near r_Config_TAU0_3_interrupt(void);
Description	This is a TAU0_3 count end interrupt function. This function calls a MIDI 1-ms interval notification function. It also calls a system timer count function. It also calls a timer count function for hexadecimal keyboard input confirmation.
Arguments	None
Return values	None

r_Config_ADC_DEMO_VOLUME_interrupt()	
Overview	AD conversion end interrupt processing
Header	r_cg_macrodriver.h, r_cg_userdefine.h, Config_ADC_DEMO_VOLUME.h
Declaration	static void __near r_Config_ADC_DEMO_VOLUME_interrupt(void);
Description	This is an A/D conversion end interrupt function. This function reads the AD conversion results and then saves them in the buffer (g_demo_adc_data). It sets the AD conversion end flag (g_demo_adc_finish).
Arguments	None
Return values	None

r_Config_CSI20_DEMO_MATRIX_LED_callback_sendend()	
Overview	Callback processing when CSI20 transmission ends
Header	r_cg_macrodriver.h, r_cg_userdefine.h, Config_CSI20_DEMO_MATRIX_LED.h, midi_matrixled_demo.h
Declaration	static void r_Config_CSI20_DEMO_MATRIX_LED_callback_sendend(void);
Description	This callback function is called when CSI20 transmission ends. This function sets the SPI CS pin to High. Then, this function resets the communication-in-progress flag (g_demo_spi_sending_flag).
Arguments	None
Return values	None

r_Config_UART0_callback_sendend()	
Overview	UART0 transmission end callback processing
Header	r_cg_macrodriver.h, r_cg_userdefine.h, Config_UART0.h, r_midi_rl78_if.h
Declaration	static void r_Config_UART0_callback_ sendend(void);
Description	This function is called to perform callback processing when UART0 transmission ends. This function calls (R_MIDI_NotifyEvent) to notify the MIDI interface SIS (Software Integration System) module of the end of transmission.
Arguments	None
Return values	None

r_Config_UART0_callback_receiveend()	
Overview	UART0 transmission end callback processing
Header	r_cg_macrodriver.h、r_cg_userdefine.h、Config_UART0.h、r_midi_rl78_if.h
Declaration	static void r_Config_UART0_callback_ sendend(void);
Description	This function is called to perform callback processing when UART0 transmission ends. This function calls (R_MIDI_NotifyEvent) to notify the MIDI interface SIS (Software Integration System) module of the end of transmission.
Arguments	None
Return values	None

demo_kypd_timer_cycle()	
Overview	Update of the key input confirmation timer count
Header	midi_matrixled_kypd_demo.h
Declaration	void demo_kypd_timer_cycle(void);
Description	This function is called from within periodic interrupt processing to update the key input confirmation timer count.
Arguments	None
Return values	None

demo_kypd_start_key_chg_timer()	
Overview	Starting the input confirmation timer
Header	midi_matrixled_kypd_demo.h
Declaration	void demo_kypd_start_key_chg_timer(uint8_t index);
Description	This function sets the time (10 ms) after which the change of the target key will be confirmed.
Arguments	Index of the target key
Return values	None

demo_kypd_matrix_sense()	
Overview	Processing to determine the confirmed key input status
Header	midi_matrixled_kypd_demo.h
Declaration	uint8_t demo_kypd_matrix_sense(uint8_t *key);
Description	This function determines whether pressing or releasing of a specific key is confirmed, and then returns the result.
Arguments	Address of the key to be determined
Return values	0: No change in the key status DEMO_KYPD_KEYMAK E: Key-pressing confirmed DEMO_KYPD_KEYBREAK: Key-releasing confirmed DEMO_KYPD_KEYMAKE + DEMO_KYPD_KEYBREAK: Key-pressing and key-releasing confirmed

demo_kypd_matrix_main()	
Overview	Processing to update confirmation information of hexadecimal keyboard input
Header	midi_matrixled_kypd_demo.h
Declaration	void demo_kypd_matrix_main(uint8_t keys[][4]);
Description	A single call of this function updates input information for one column of the hexadecimal keyboard. If any change is found in the hexadecimal keyboard input, this function sets a timer for how long the status must continue before confirmation. If the key input status continues until the timer expires, the key input is confirmed and a confirmation flag indicating that the key is pressed or released is set in confirmation information.
Arguments	Address of confirmation information of hexadecimal keyboard input
Return values	None

demo_kypd_matrix_col_read()	
Overview	Input processing for one column of the hexadecimal keyboard
Header	midi_matrixled_kypd_demo.h
Declaration	uint8_t demo_kypd_matrix_col_read(uint8_t col);
Description	This function returns key pressing information for one column of the hexadecimal keyboard. Each bit In this information is set to 0 (key not pressed) or 1 (key pressed). BIT3: Key pressing status of row 1 BIT2: Key pressing status of row 2 BIT1: Key pressing status of row 3 BIT0: Key pressing status of row 4
Arguments	Column number
Return values	Input status of the column of the hexadecimal keyboard specified by the argument

demo_kypd_get_keys_chg_timer_cnt()	
Overview	Processing to acquire the count value of the key input confirmation timer
Header	midi_matrixled_kypd_demo.h
Declaration	uint8_t demo_kypd_get_keys_chg_timer_cnt(uint8_t index);
Description	This function returns the count value of the input confirmation timer for the target key
Arguments	Index of the target key
Return values	Count value of the key input confirmation timer

3.9 Flowcharts

3.9.1 Main processing

Figure 3-6、Figure 3-7 and Figure 3-8 show the flowchart for the main processing.

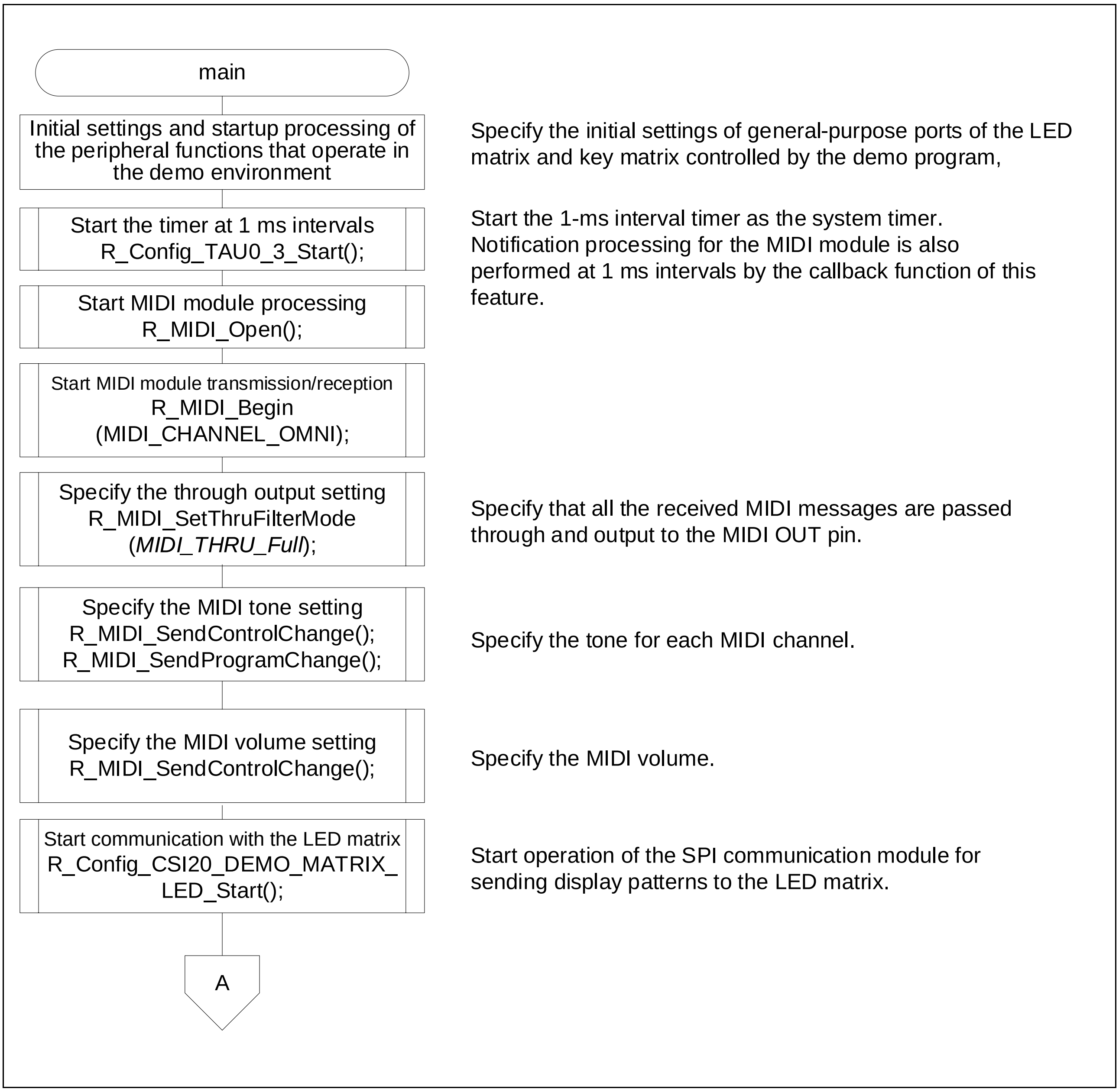
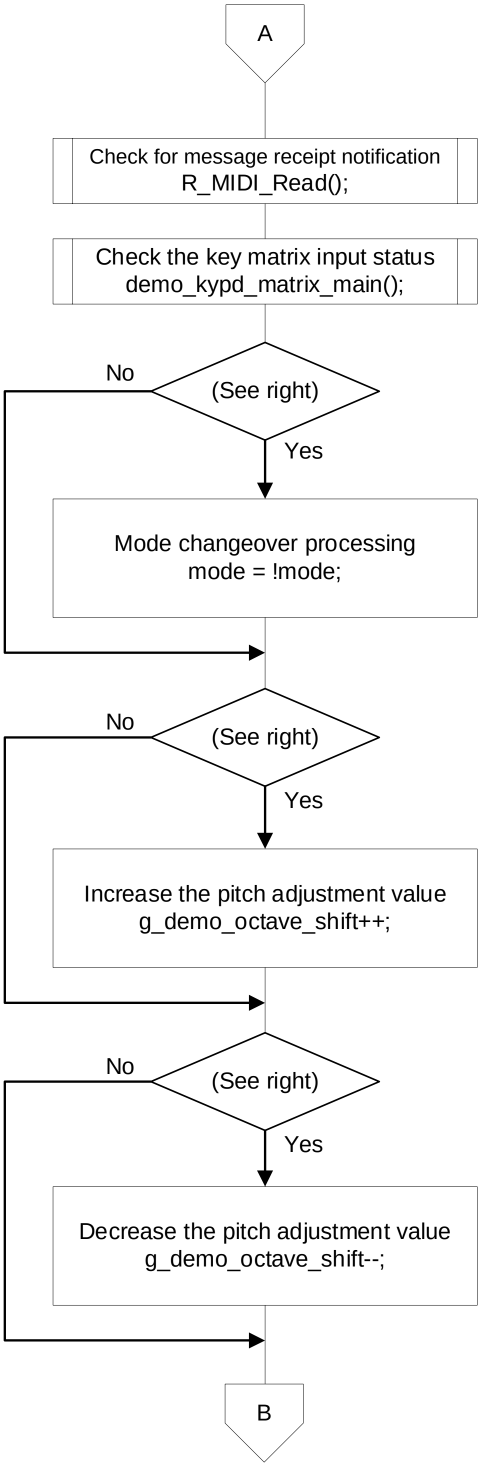


Figure 3-6 Main Processing (1/3)



Determine whether the input key meets the following condition:
・Is the input key type mode changeover switch?

Use the mode changeover switch to change the mode between melody mode and MIDI channel change mode.
・In melody mode, a NoteOff message is sent to the sound module to turn off the LED light.
・In MIDI channel change mode, a control change message for the changed MIDI channel is sent to set the volume.

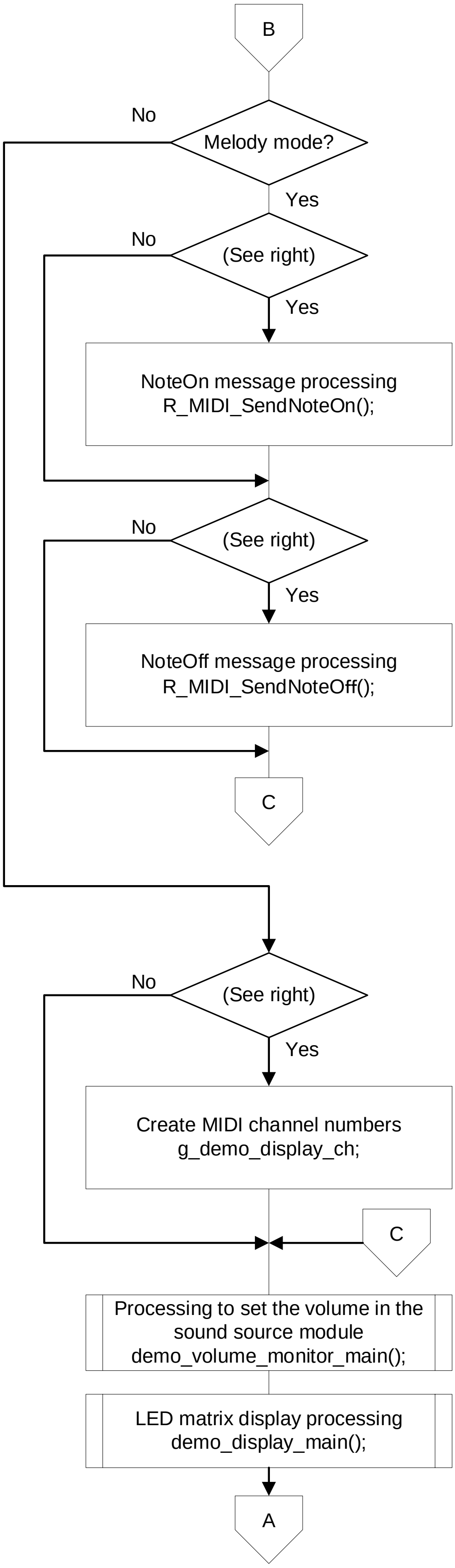
Determine whether the input key meets the following condition:
・Is the input key type pitch-up switch?

・If the pitch adjustment value is equal to or smaller than the upper limit (+5), add 1 to the pitch adjustment value.

Determine whether the input key meets the following condition:
・Is the input key type is pitch-down switch?

・If the pitch adjustment value is equal to or greater than the lower limit (-5), subtract 1 from the pitch adjustment value.

Figure 3-7 Main Processing (2/3)



Determine whether the current mode is melody mode.
In melody mode, you can play music by using key input.

Determine whether the input key meets the following condition:
・Is pressing of the key with a note assigned confirmed?

A sound is played when key-pressing is confirmed.
・Add the pitch adjustment value to the note number of the NoteOn message.
・Pitch adjustment values are given by one octave.
・Specify the scale information used to turn on the LED matrix lights corresponding to keys.

Determine whether the input key meets the following condition:
・Is releasing of the key with a note assigned confirmed?

The sound stops when key-releasing is confirmed.
・The note number of the NoteOff message is the note number specified for the NoteOn message.
・Specify the scale information used to turn off the LED matrix lights corresponding to keys.

If the current mode is not melody mode, it must be MIDI channel change mode.
In MIDI channel change mode, you can change MIDI channels by using key input.

Determine whether the input key meets the following condition:
・Is pressing of a numeric key confirmed?

Create MIDI channel numbers based on the order in which numeric keys are pressed.
・In MIDI channel change mode, the mode changeover switch is also used to confirm MIDI channels and updates channels if the entered two-digit number is within the range from 01 to 16.

Acquire the A/D conversion value from Volume0 and determine the volume to be set in the sound source module.

The volume level is displayed for 1 second immediately after Volume0 is turned. The pitch adjustment value is displayed for 1 second immediately after the pitch-up or pitch-down switch is pressed. In any other case, melody mode or MIDI channel change mode is displayed according to the mode setting.

Figure 3-8 Main Processing (3/3)

3.9.2 Volume setting update processing

Figure 3-9 shows the flowchart for volume setting update processing.

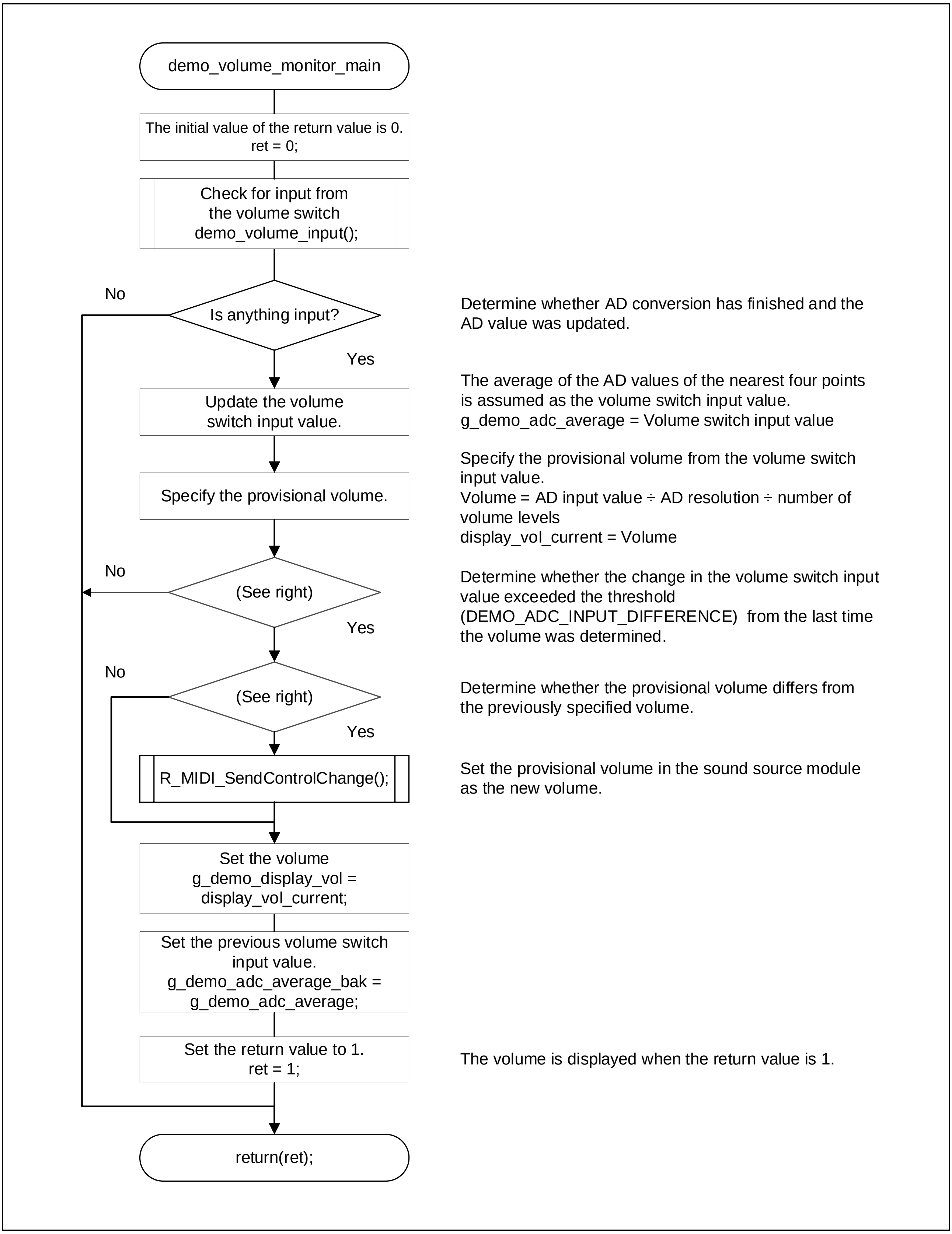


Figure 3-9 Volume Setting Update Processing

3.9.3 Processing to acquire volume switch input

Figure 3-10 shows the flowchart for processing to acquire volume switch input.

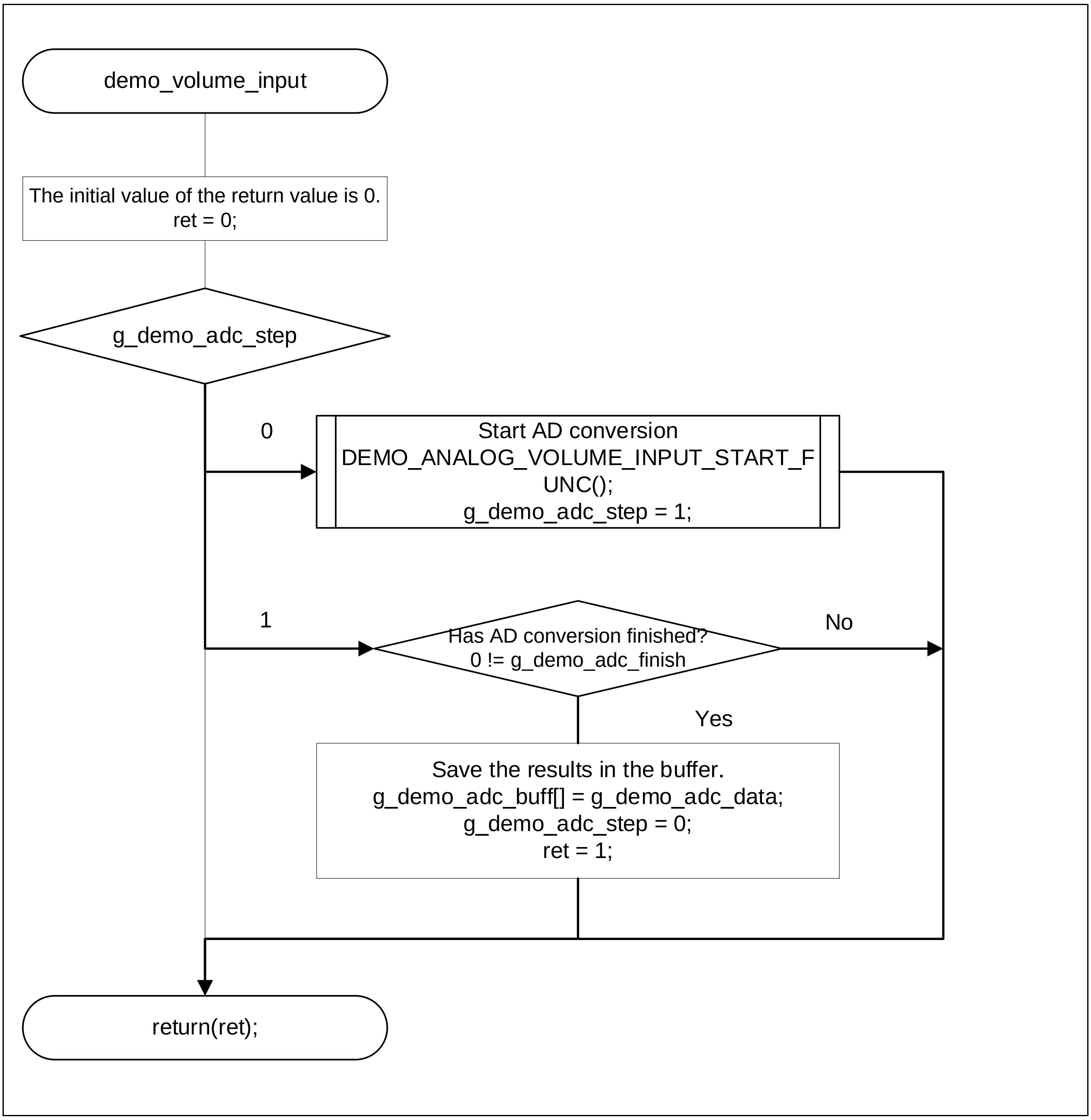


Figure 3-10 Processing to Acquire Volume Switch Input

3.9.4 LED matrix display processing

Figure 3-11 shows the flowchart for LED matrix display processing.

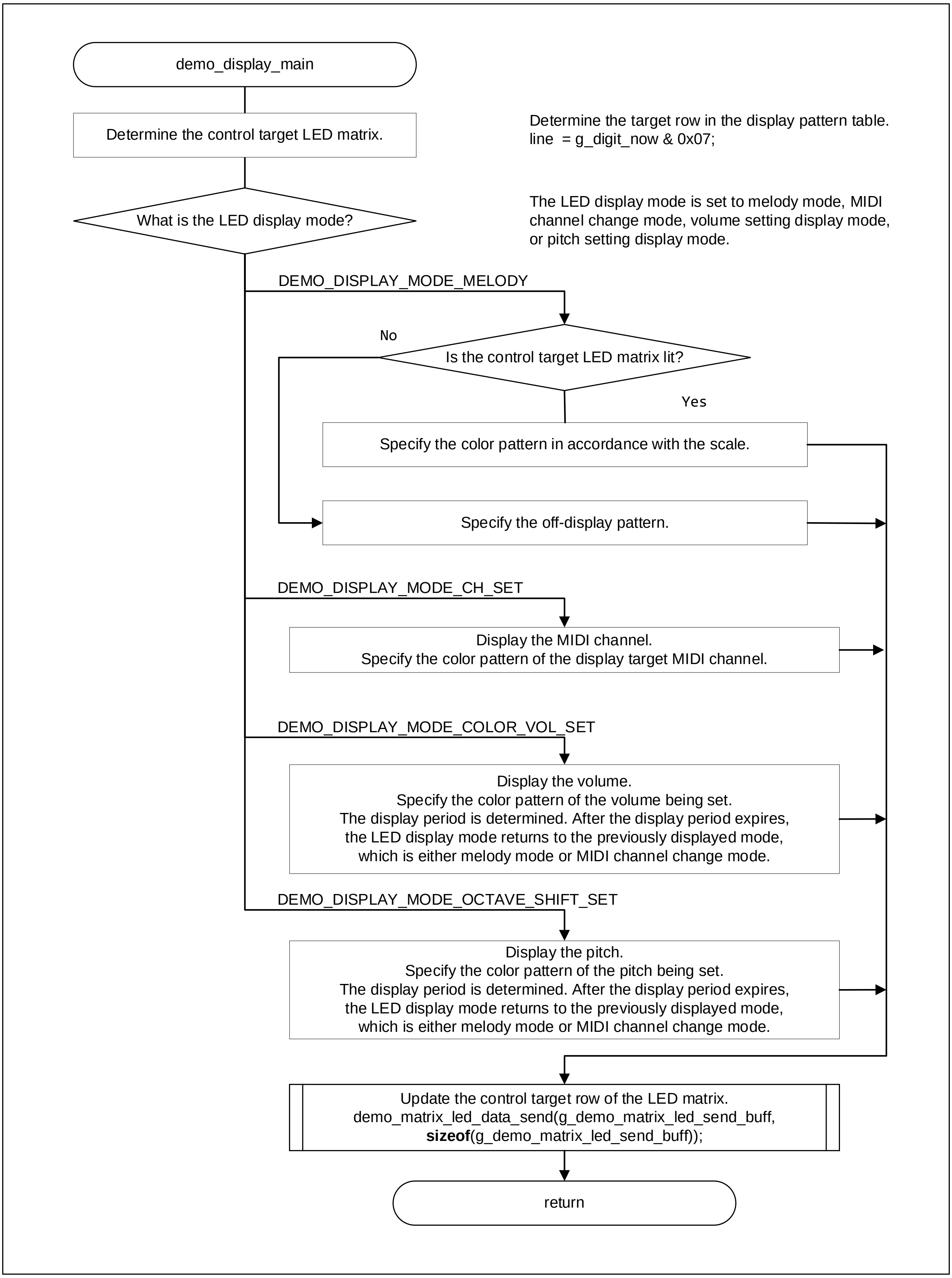


Figure 3-11 LED Matrix Display Processing.

3.9.5 System timer acquisition processing

Figure 3-12 shows the flowchart for system timer acquisition processing.

Note: This function simply returns a global variable that can be referenced from multiple locations. This function is provided to clearly indicate that the same variable is being referenced.

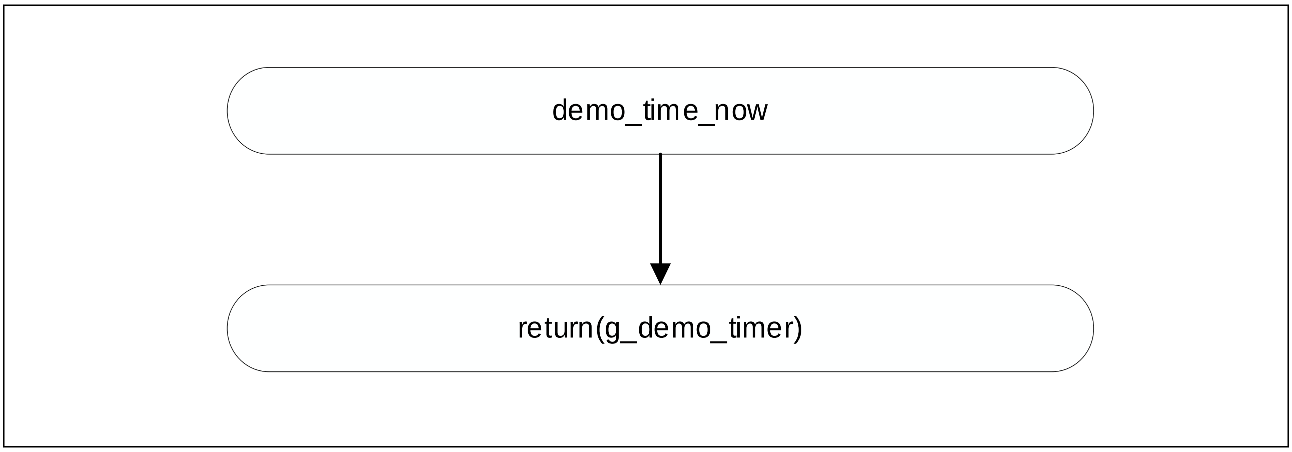


Figure 3-12 System Timer Acquisition Processing

3.9.6 System timer count processing

Figure 3-13 shows the flowchart for system timer count processing.

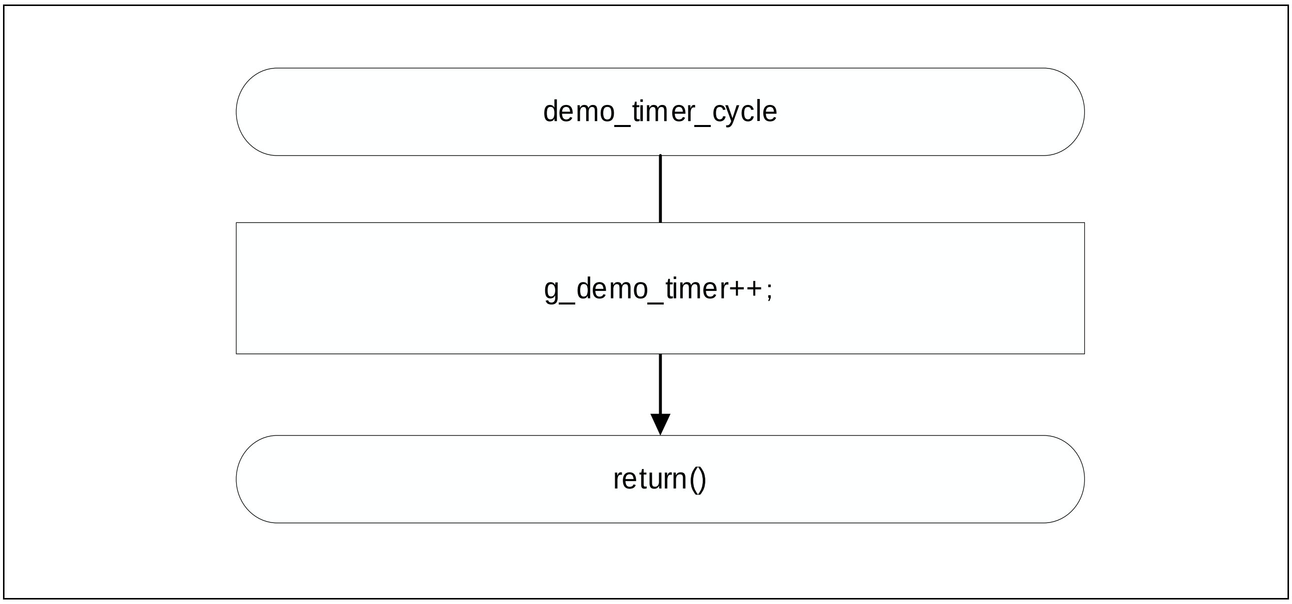


Figure 3-13 System Timer Count Processing

3.9.7 LED matrix data transmission processing

Figure 3-14 shows the flowchart for LED matrix data transmission processing.

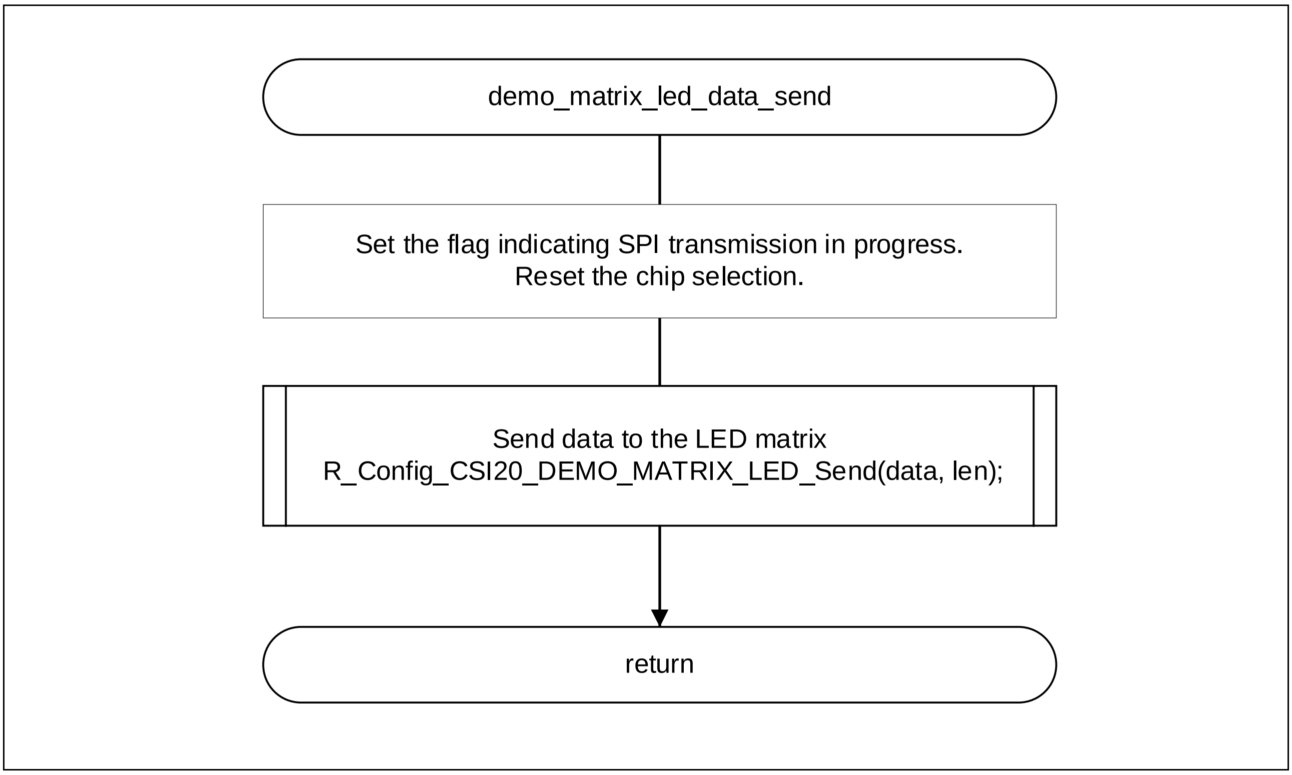


Figure 3-14 LED Matrix Data Transmission Processing

3.9.8 Processing to check the end of LED matrix data transmission

Figure 3-15 shows the flowchart for processing to check the end of LED matrix data transmission.

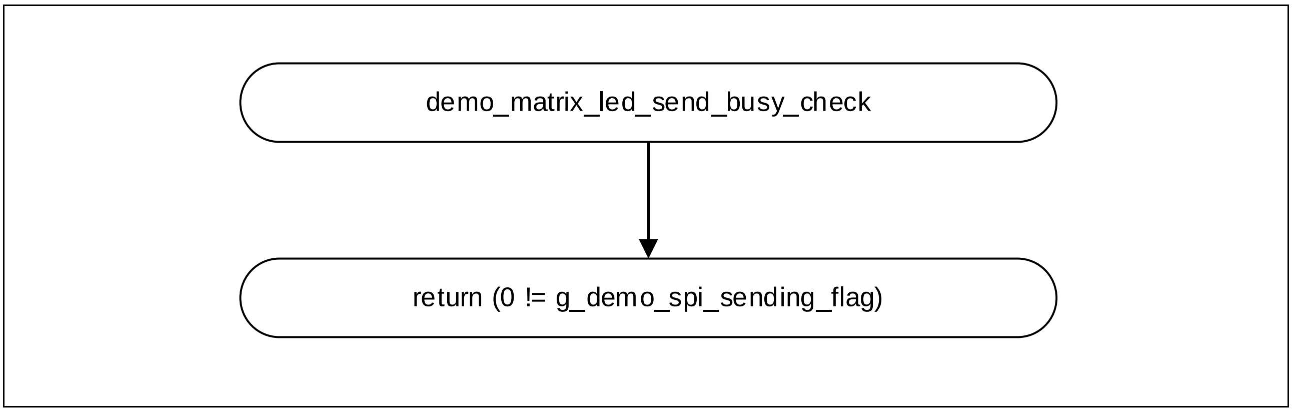


Figure 3-15 Processing to Check the End of LED Matrix Data Transmission

3.9.9 TAU0_3 interrupt processing

Figure 3-16 shows the flowchart for TAU0_3 interrupt processing.

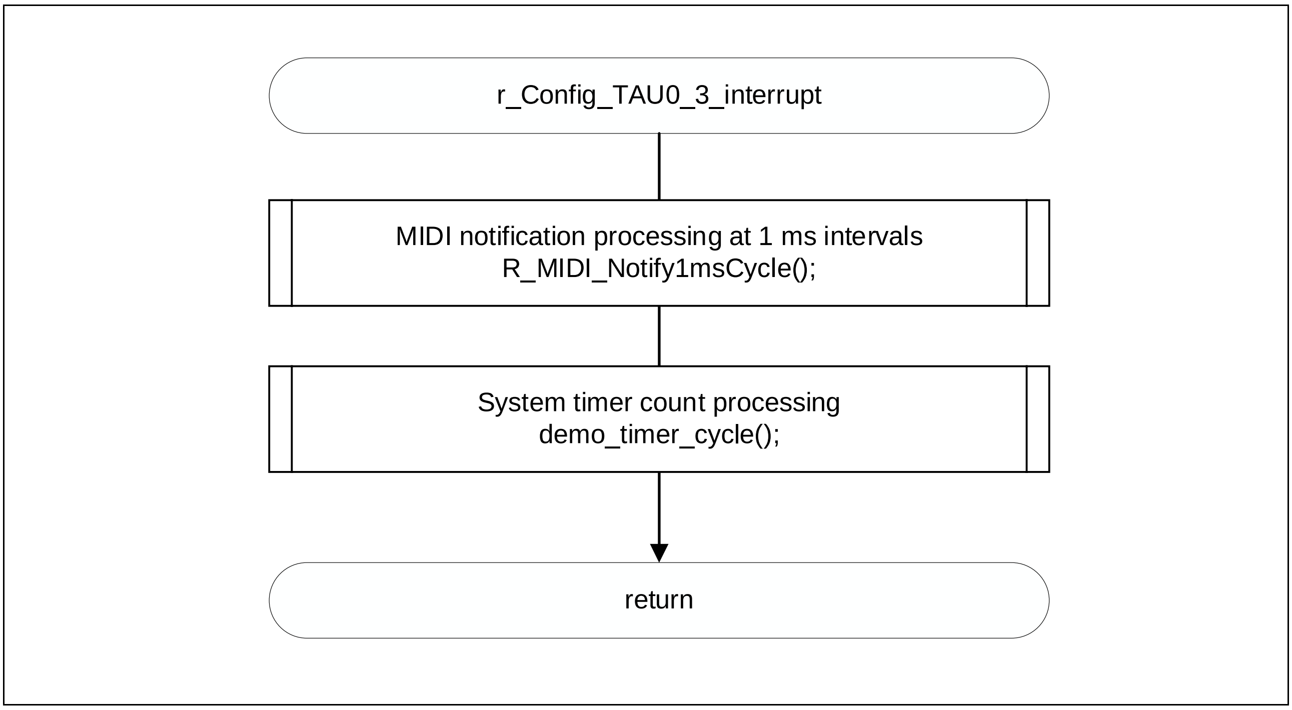


Figure 3-16 TAU0_3 Interrupt Processing

3.9.10 AD conversion end interrupt processing

Figure 3-17 shows the flowchart for AD conversion end interrupt processing.

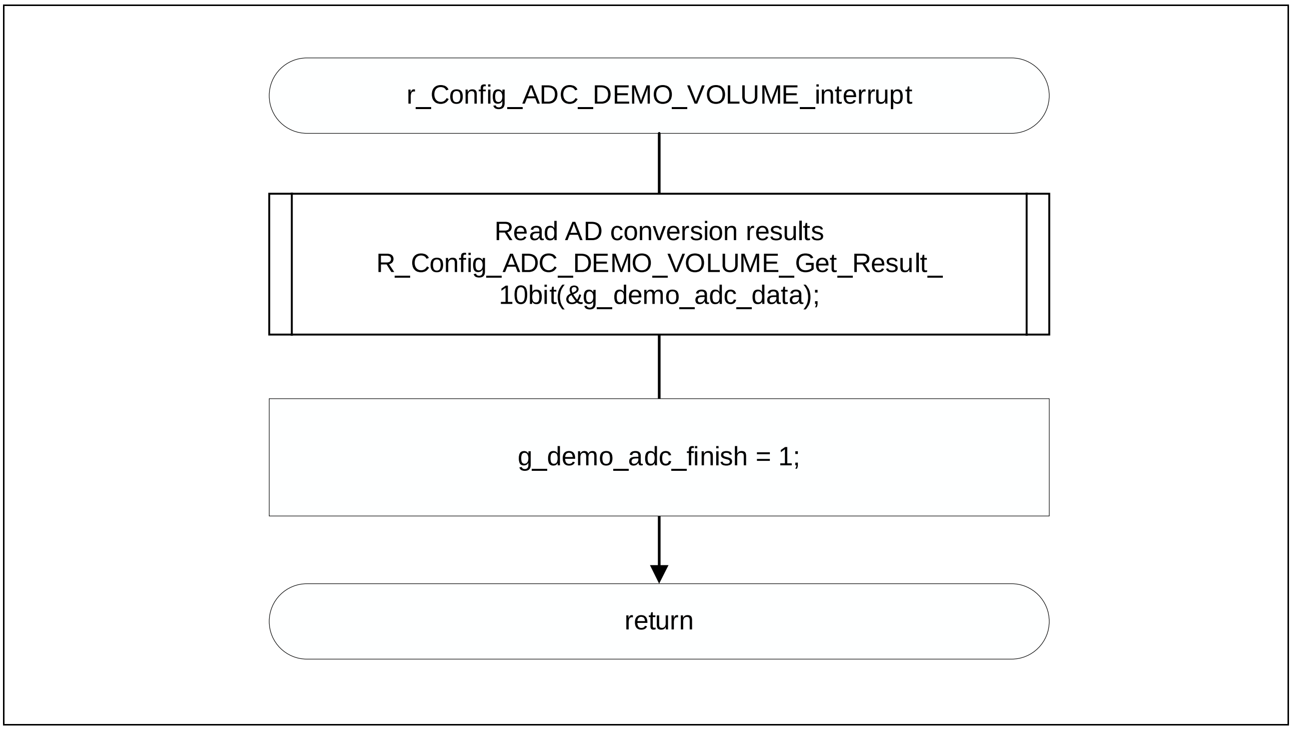


Figure 3-17 AD Conversion End Interrupt Processing

3.9.11 LED matrix data CSI transmission end processing

Figure 3-18 shows the flowchart for CSI transmission end processing for LED matrix data.

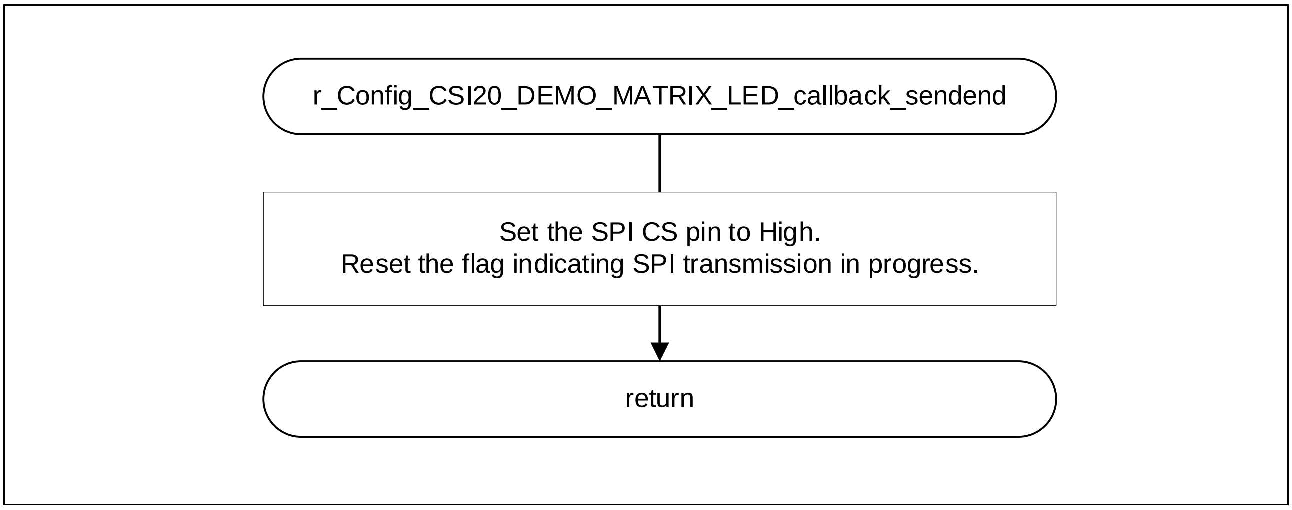


Figure 3-18 LED Matrix Data CSI Transmission End Processing

3.9.12 UART0 transmission end processing

Figure 3-19 shows the flowchart for UART0 transmission end processing.

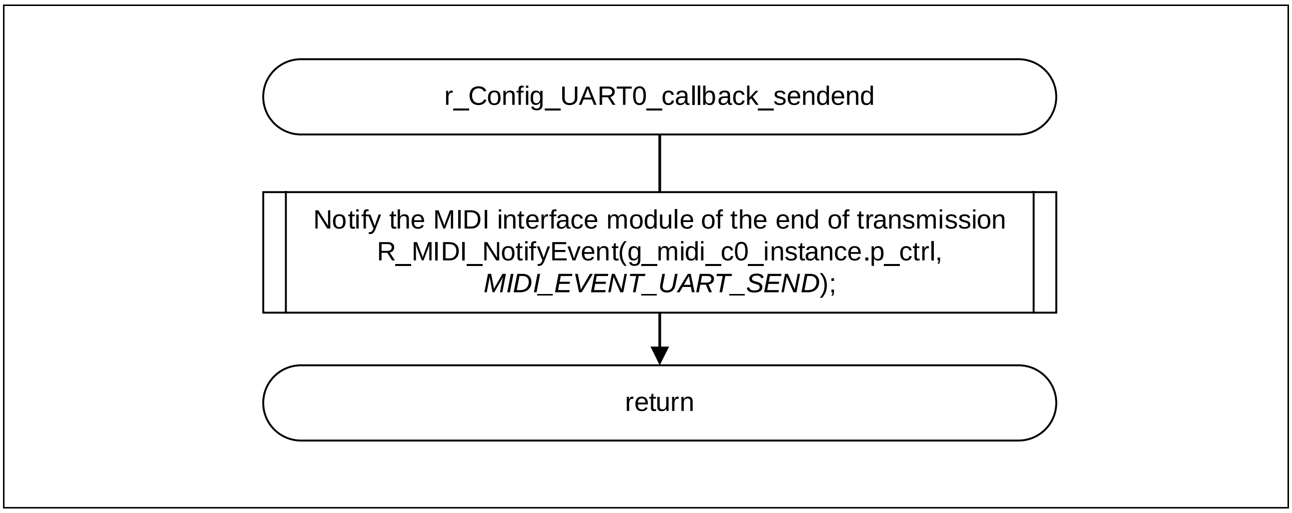


Figure 3-19 UART0 Transmission End Processing

3.9.13 UART0 reception end processing

Figure 3-20 shows the flowchart for UART0 reception end processing.

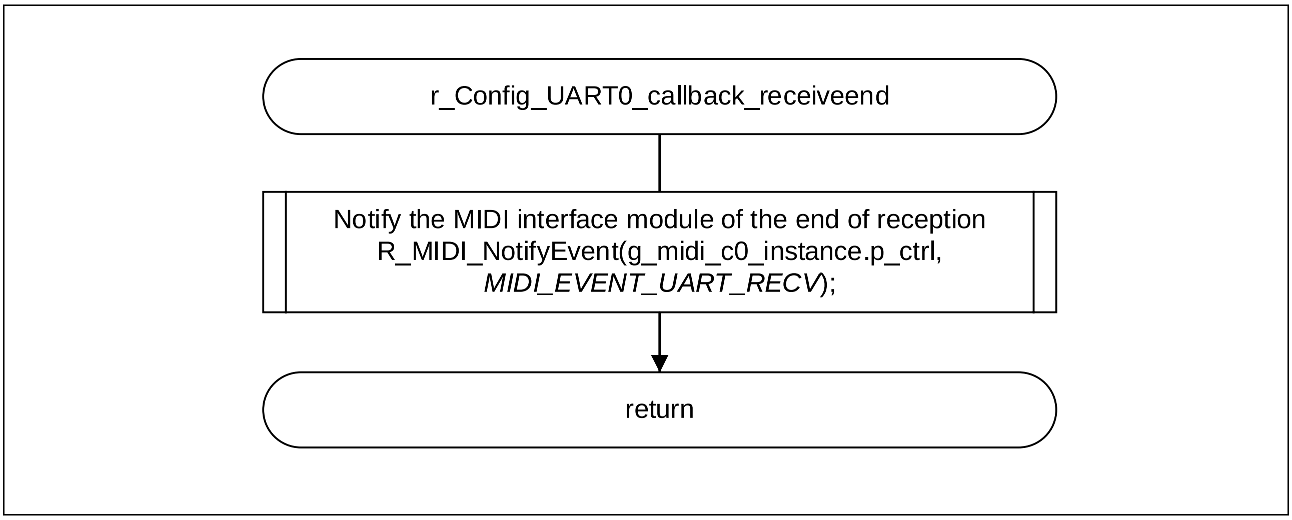


Figure 3-20 UART0 Reception End Processing

3.9.14 Hexadecimal keyboard key input processing

Figure 3-21 shows the flowchart for hexadecimal keyboard key input processing.

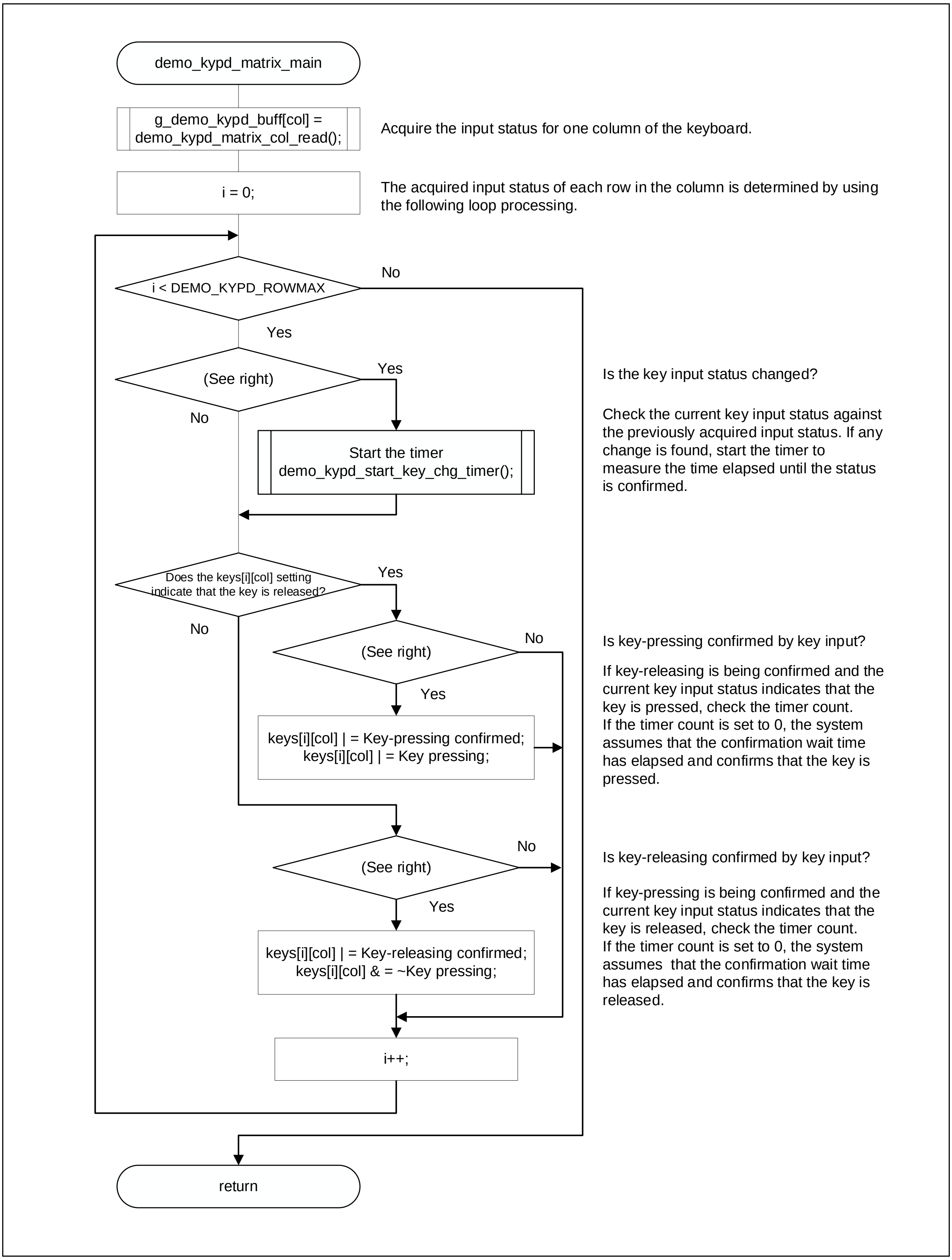


Figure 3-21 Hexadecimal Keyboard Input Processing

3.9.15 Input processing for one column of the hexadecimal keyboard

Figure 3-22 shows the flowchart for input processing for one column of the hexadecimal keyboard.

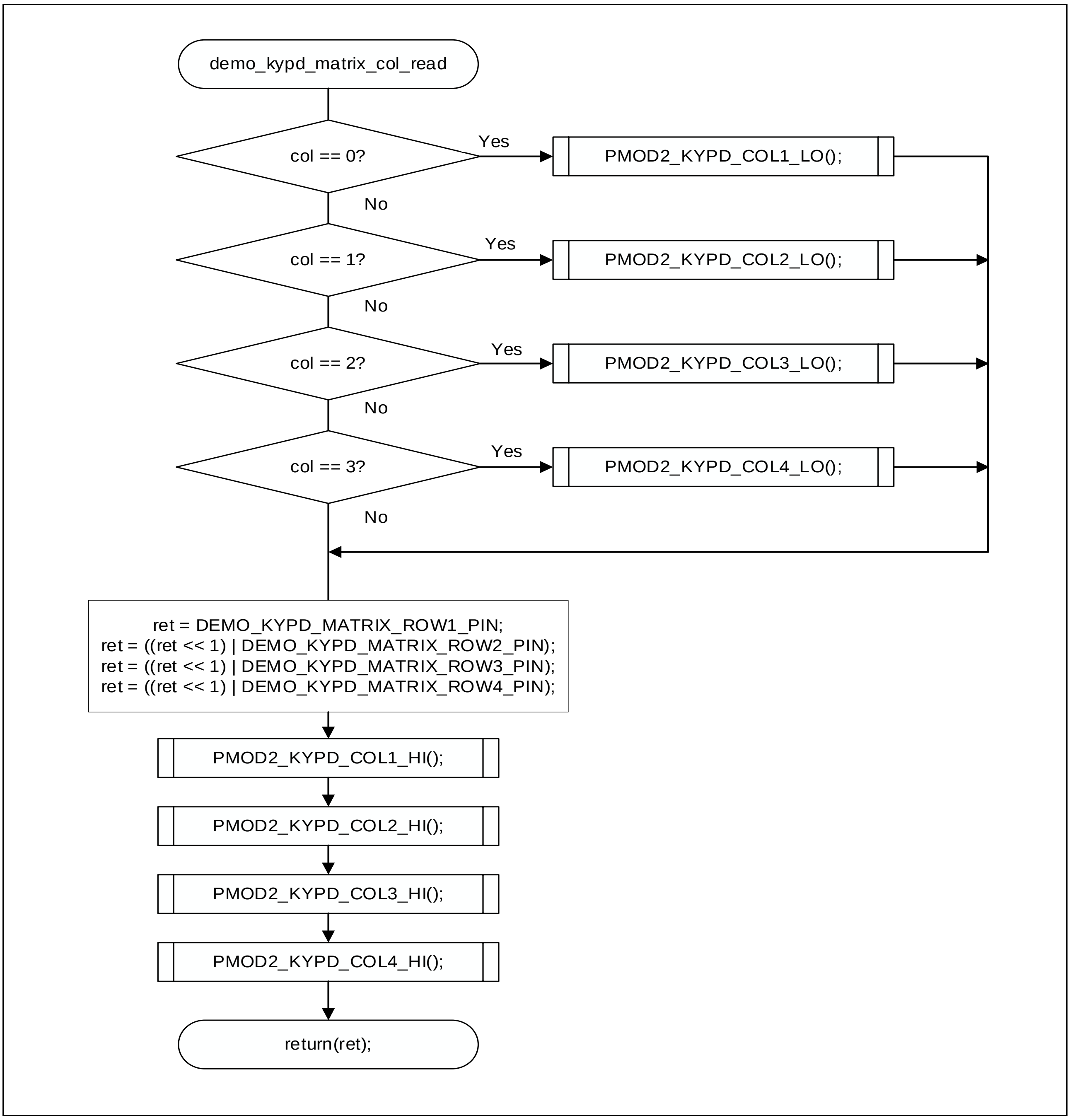


Figure 3-22 Input Processing for One Column of the Hexadecimal Keyboard

3.9.16 Key input determination processing

Figure 3-23 shows the flowchart for key input determination processing.

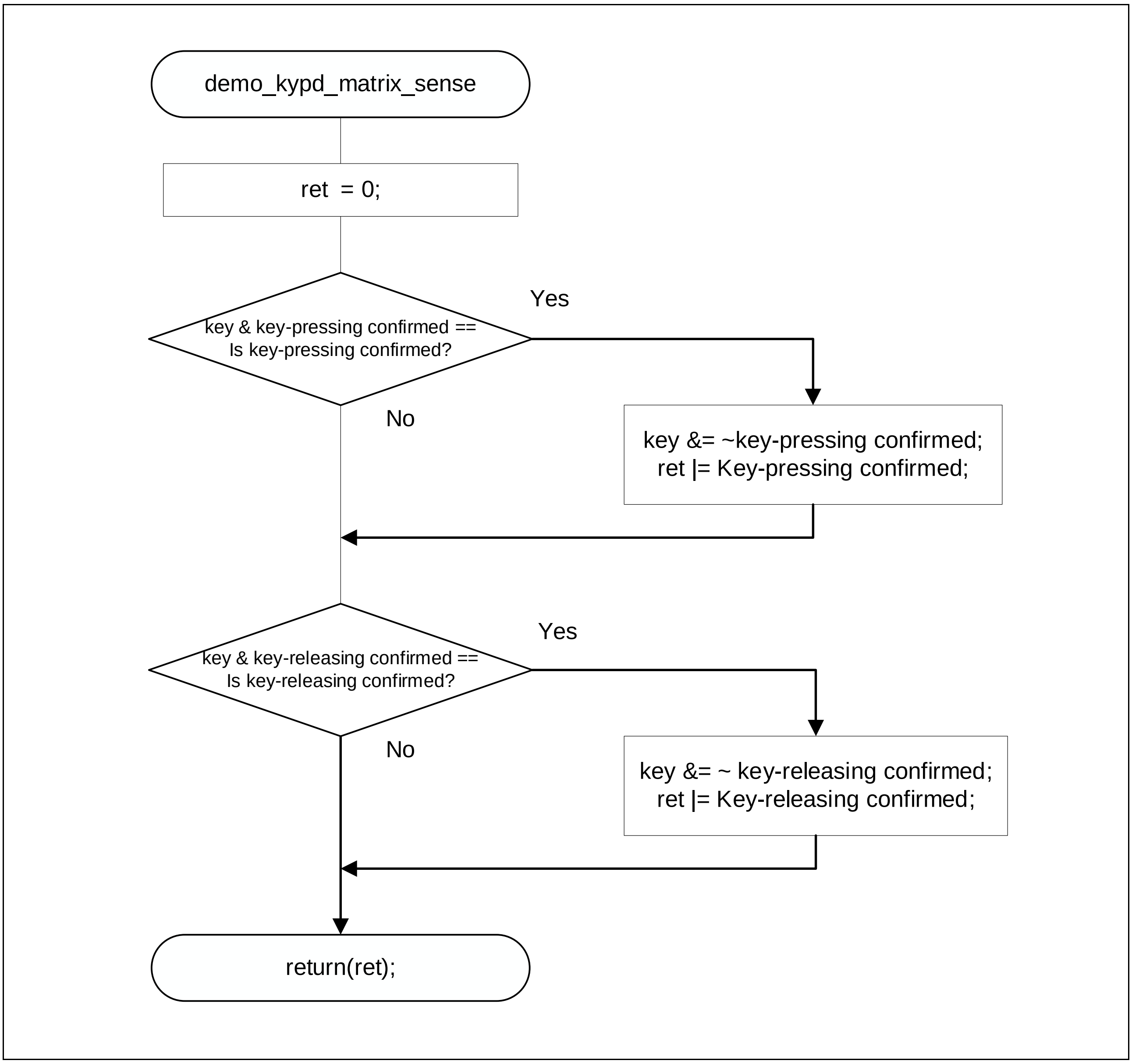


Figure 3-23 Key Input Determination Processing

3.9.17 Count processing for the key input confirmation timer

Figure 3-24 shows the flowchart for count processing for the key input confirmation timer.

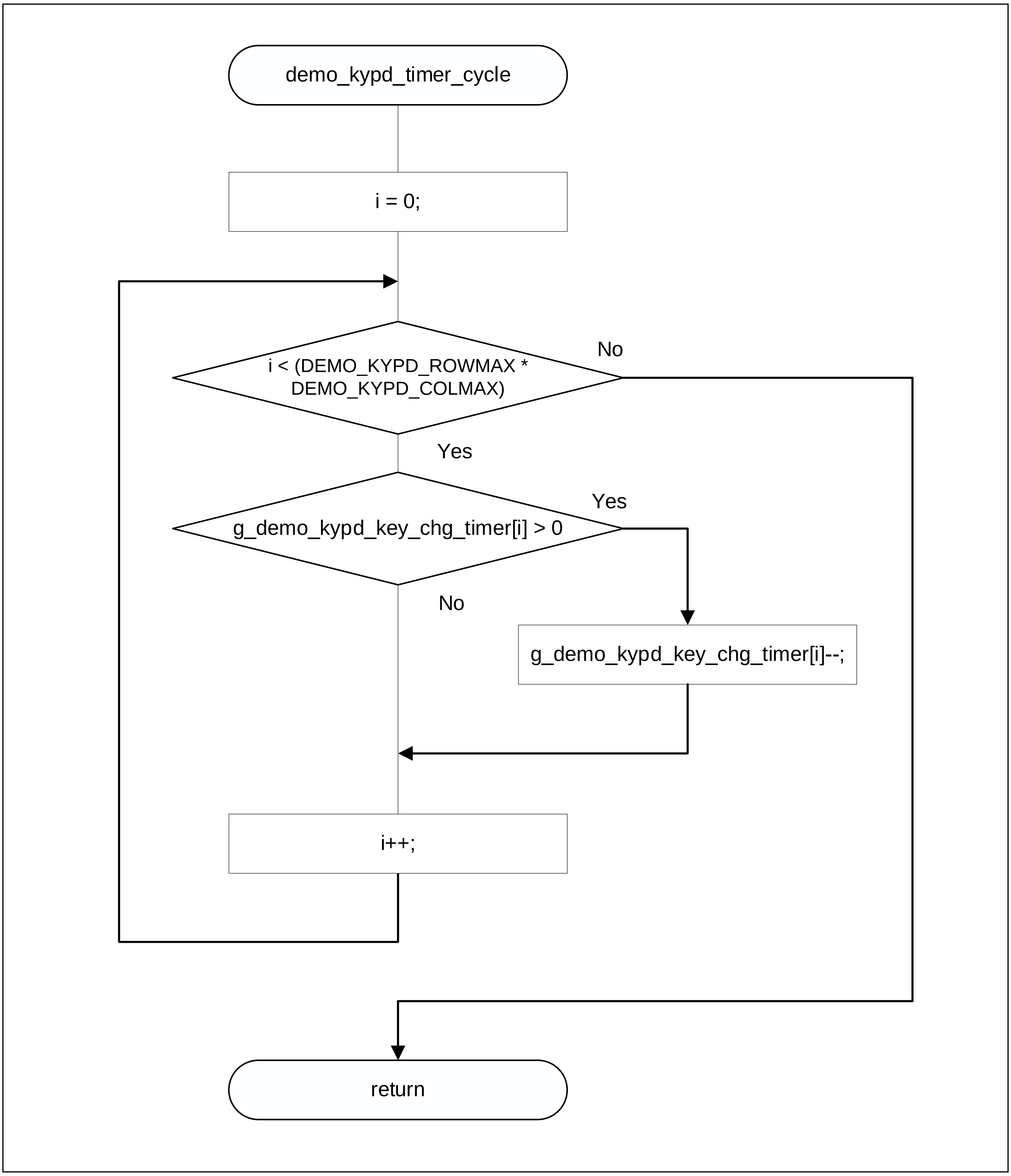


Figure 3-24 Count Processing for the Key Input Confirmation Timer

3.9.18 Processing to start the key input confirmation timer

Figure 3-25 shows the flowchart for processing to start the key input confirmation timer.

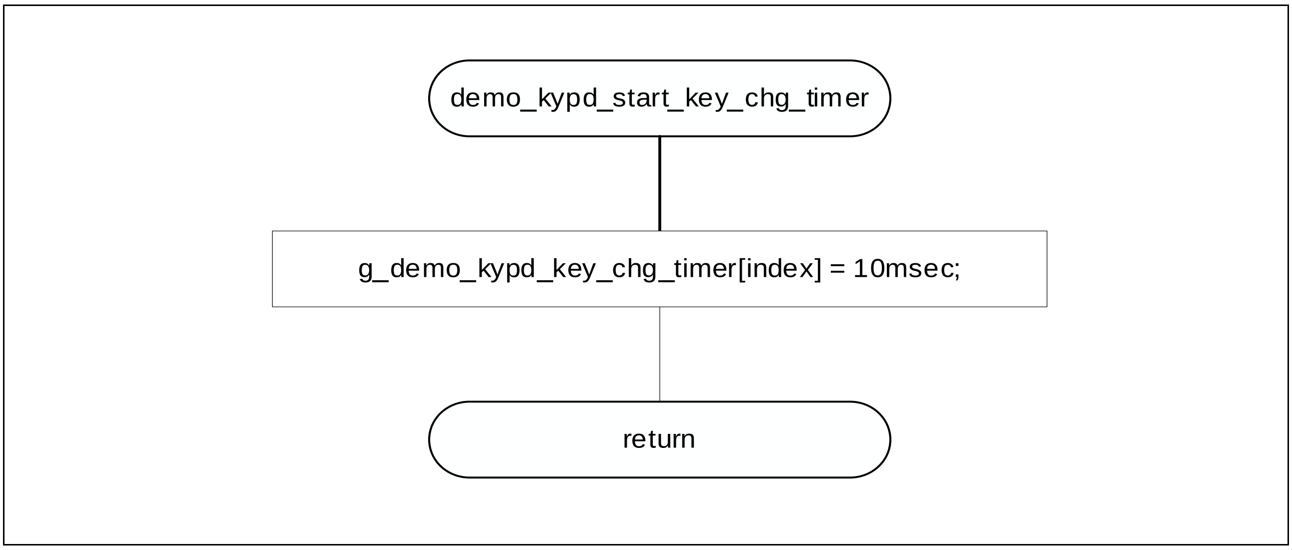


Figure 3-25 Processing to Start the Key Input Confirmation Timer

3.9.19 Processing to acquire the key input confirmation timer count

Figure 3-26 shows the flowchart for processing to acquire the key input confirmation timer count.

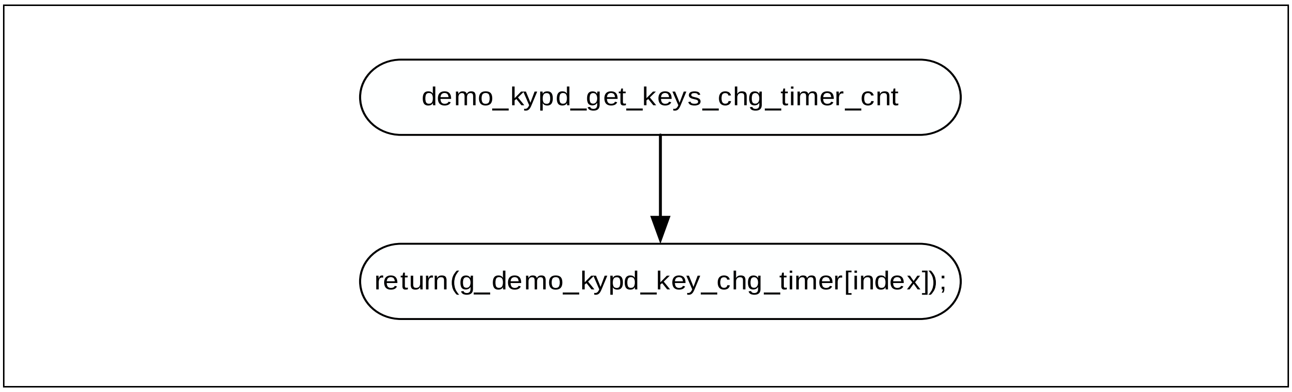


Figure 3-26 Processing to Acquire the Key Input Confirmation Timer Count

4. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

5. Notes

5.1 Operation of the Hexadecimal Keyboard

Due to the specifications of the hexadecimal keyboard used in this sample program, pressing two or more keys at the same time might result in unexpected value input. To prevent problems, press one key at a time.

6. Reference Documents

RL78 Family MIDI Interface Module Software Integration System (R01AN7265E)
RL78 Family MIDI Linked Illumination Control Sample Software Using SIS (R01AN7463E)
RL78/G16 User's Manual: Hardware (R01UH0980E)
RL78 family user's manual: software (R01US0015E)
RL78/G16 Fast Prototyping Board User's Manual (R12UM0048E)
(The latest versions can be downloaded from the Renesas Electronics website.)

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

MIDI Shield (SparkFun MIDI Shield)

https://www.sparkfun.com/products/12898

LED matrix

https://wiki.52pi.com/index.php?title=EP-0075

Hexadecimal keyboard

https://digilent.com/reference/pmod/pmodkypd/start

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	2024.12.04	—	First Edition

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

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)
   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on
   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.
3. Input of signal during power-off state
   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.
4. Handling of unused pins
   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.
5. Clock signals
   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.
6. Voltage application waveform at input pin
   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).
7. Prohibition of access to reserved addresses
   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products
   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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