R7F0C809

4-Digit 8-Segment LED Display with Key Read

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Introduction

This application note describes a method of using the high-current pin to control 4-digit 8-segment LED with reading the key code by A/D converter of R7F0C809 microcontroller.

Target Device

• R7F0C809

When applying the sample program covered in this application note to another microcomputer with the same SFR (Special Function Register), modify the program according to the specifications for the target microcomputer and conduct an extensive evaluation of the modified program.

Contents

1. Specifications

This application note introduces the way of controlling 4-digit 8-segment LED display with Timer Array Unit (TAU) and high current pin according to the input of A/D key board. The scanning period of LED depends on the interval of TAU0 Channel 0. Timing of 1 second is achieved with TAU Channel 1.

Table 1.1 lists the peripheral functions and their applications.

Table 1.1 Peripheral Functions and Their Applications

Peripheral Function	Use
P02~P05	Control the COM pins of LED
P06~P07, P10~P15	Control the SEG pins of LED
P16	Set the initial status of A/D keyboard input
TAU0 Chanel 0	Control the scanning period of LED
TAU0 Chanel 1	Control the interval of updating LED
A/D converter	Identify the key pressed by sampling the voltage on A/D input pin

2. Operating Conditions

The sample code contained in this application note has been tested under the conditions below.

Table 2.1 Operation Confirmation Conditions

Item	Contents
MCU used	R7F0C809
Operating frequency	•High-speed on-chip oscillator clock (f_{HOCO}): 20 MHz (typ.) •CPU/peripheral hardware clock (f_{CLK}): 20 MHz
Operating voltage	5.0 V (operation enabled from 4.5 to 5.5 V) SPOR detection operation (V_{SPOR}):rising edge 4.28V(typ.), falling edge 4.00V(min.)
Integrated development environment	Renesas Electronics Corporation CubeSuite+ V2.01.00
C compiler	Renesas Electronics Corporation CA78K0R V1.60

3. Related Application Note

The application notes that are related to this application note are listed below for reference.

- R7F0C809 6-Digit 8-Segment LED Display (R01AN2005E) Application Note
- R7F0C809Key Matrix Input and 4-Digit 8-Segment LED Display (R01AN2006E) Application Note

4. Description of the Hardware

4.1 Hardware Configuration Example

Figure 4.1 shows an example of hardware configuration that is used for this application note.

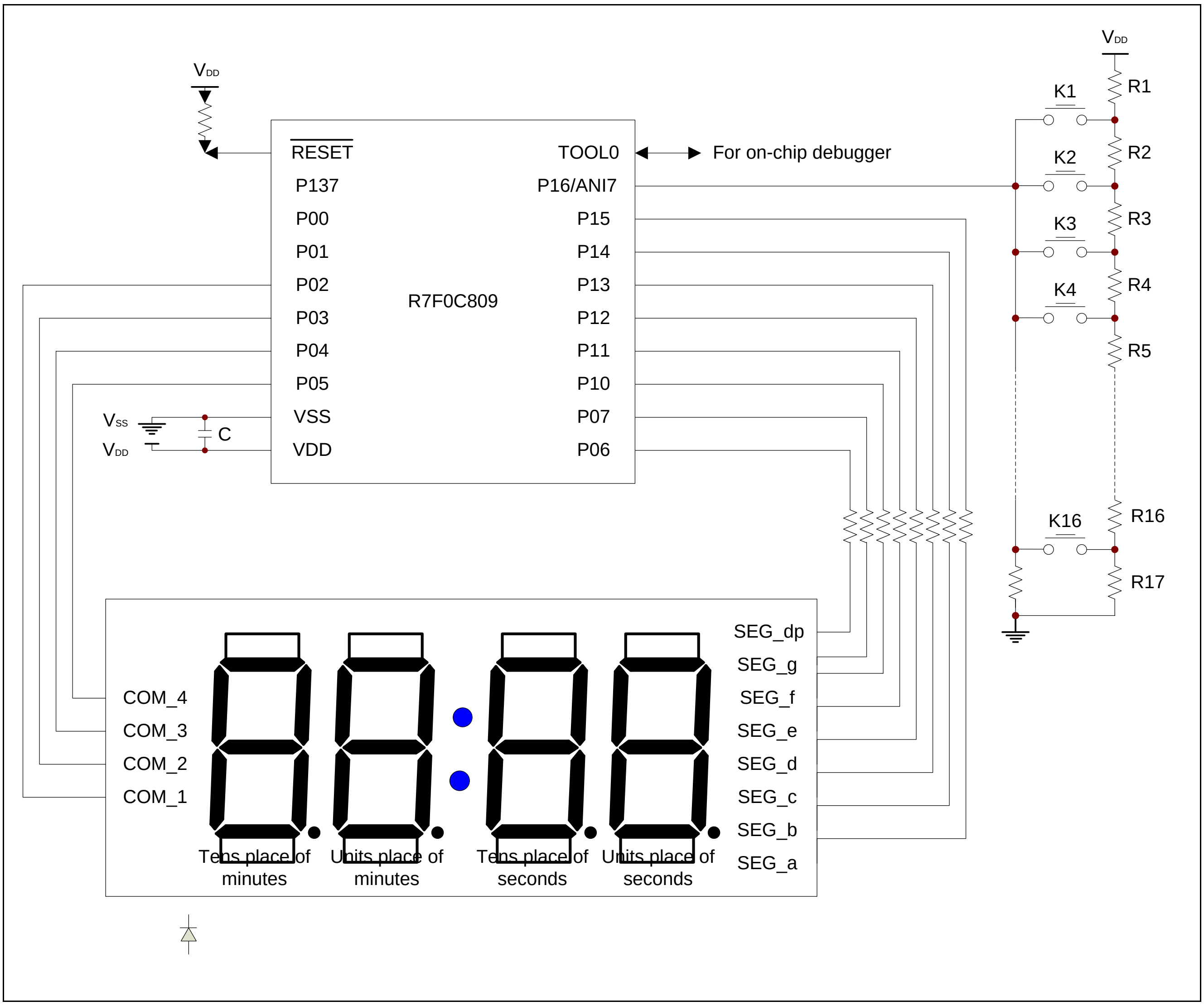

Figure 4.1 Hardware Configuration

Notes: 1. The purpose of this circuit is only to provide the connection outline and the circuit is simplified accordingly. When designing and implementing an actual circuit, provide proper pin treatment and make sure that the hardware's electrical specifications are met (connect the input-only ports separately to V_{DD} or V_{SS} via a resistor).

2. V_{DD} must be held at not lower than the reset release voltage (V_{SPOR}) that is specified as SPOR.

Table 4.1 lists the keys used and LED display contents.

Table 4.1 Keys Used and LED Display Contents

Key Name	Function	Description
K1	Set the tens place of minutes	The counting time can be set by K1~K4 and displayed on LED. Tens places of minutes and seconds can be set from 0 to 5. Units places of minutes and seconds can be set from 0 to 9. Attention: Setting of K1 to K4 is ineffective when counting is started or paused.
K2	Set the units place of minutes	
K3	Set the tens place of seconds	
K4	Set the units place of seconds	
K15	Start function key	After counting value is set, once start key is pressed, the down-counting with 1 second as unit is started until the counting value is down to 0. After the counting is finished, all the LEDs are turned off.
K16	Pause / Stop function key	After down-counting is started, the first pressing of K16 pauses the present counting operation and the counting value is maintained. A second pressing of K16 stops the current counting and the counting value is cleared. All the LEDs are turned off to indicate the stop of counting.
Other Keys	Reserved	Please append functions according to application requirements.

4.2 List of Pins to be Used

Table 4.2 lists the pins to be used and their function.

Table 4.2 Pins to be Used and Their Function

Pin Name	I/O	Description
P02	Output	Control COM_1
P03	Output	Control COM_2
P04	Output	Control COM_3
P05	Output	Control COM_4
P06	Output	Control SEG_dp
P07	Output	Control SEG_g
P10	Output	Control SEG_f
P11	Output	Control SEG_e
P12	Output	Control SEG_d
P13	Output	Control SEG_c
P14	Output	Control SEG_b
P15	Output	Control SEG_a
P16/ANI7	Analog Input	Input pin of scanning key

5. Description of the Software

5.1 Operation Overview

This application introduces the way of using P-ch/N-ch open-drain high current port to control LED and identifying the external input key with A/D converter.

5.1.1 Display control for 4-Digit 8-Segment LED

4-Digit 8-segment LED is connected in common anode way. The content displayed depends on the key status. All the control ports of LED are accessed by I/O port of MCU (in high current mode).

Display mode of LED:

Dynamic scanning: Frequency of cyclical scanning the 4-digit LED is 60Hz.

The period of scanning is: 1/60Hz/4≈4.17ms.

5.1.2 Sampling control for A/D key input

Key code is identified by sampling voltage value divided by external resistors using A/D converter.

Figure 5.1 shows an example of A/D key input hardware configuration.

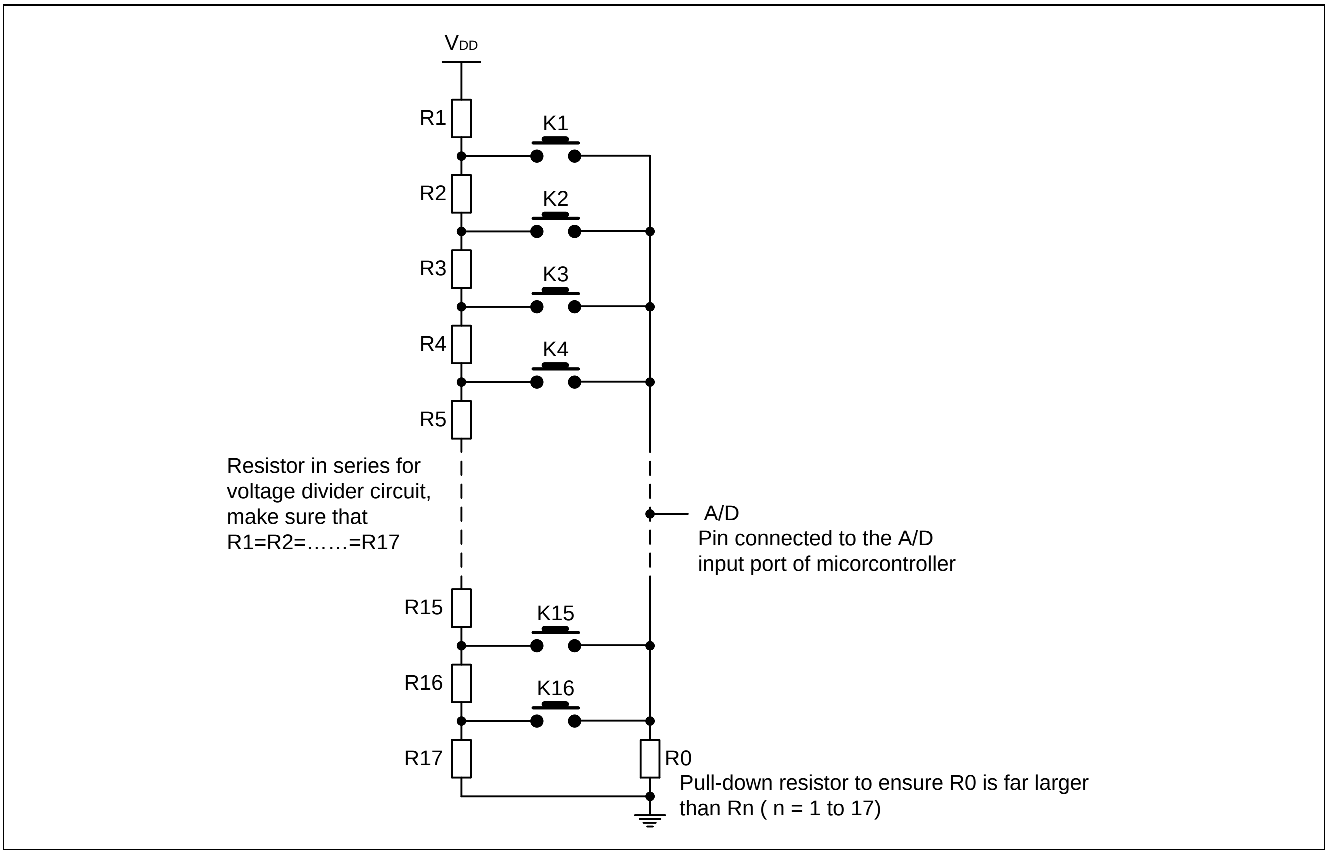

Figure 5.1 A/D Key Input Hardware Configuration

The way of A/D key sampling is shown below.

(1)Multiple pins are connected to the A/D input port. The key pressed is reflected in the voltage obtained by external divider resistors. The key code of each key is mapped to the unique voltage range on A/D input port.

(2)The interval of A/D sampling (A/D conversion of the analog input pin - ANIx) is the same as that of LED scanning that is 4.17ms.

(3)Sample the voltage of analog input pin 6 times, get the average value after removing the maximum and minimum data. If the average values are equal twice, the key input is confirmed. As a result, 4.17 x 6 x 2≈50ms is necessary for confirming the key pressed.

Table 5.1 lists the values and key codes for key determination.

Table 5.1 Values and Key Codes for Key Determination

Key pressed	None	K16	K15	K14	K13	K12	K11	K10	K9
Theoretical value of A/D sample voltage	0V	0.29V	0.59V	0.88V	1.41V	1.47V	1.76V	2.06V	2.35V
Theoretical value of A/D converter result	0	60	120	181	241	301	361	421	481
Area of A/D value corresponding to key	0~29	30~89	90~149	150~210	211~270	271~330	331~390	391~450	451~510
Key code	17	16	15	14	13	12	11	10	9

Key pressed	K8	K7	K6	K5	K4	K3	K2	K1	-
Theoretical value of A/D sample voltage	2.65V	2.94V	3.24V	3.53V	3.82V	4.12V	4.41V	4.71V	5V
Theoretical value of A/D converter result	541	602	662	722	782	842	903	962	1023
Area of A/D value corresponding to key	511~570	571~631	632~691	692~751	752~811	812~871	872~931	932~991	992~1023
Key code	8	7	6	5	4	3	2	1	-

Note: V_{DD} = 5V

5.1.3 Timing

Figure 5.2 shows the timing of LED display and A/D key input sample.

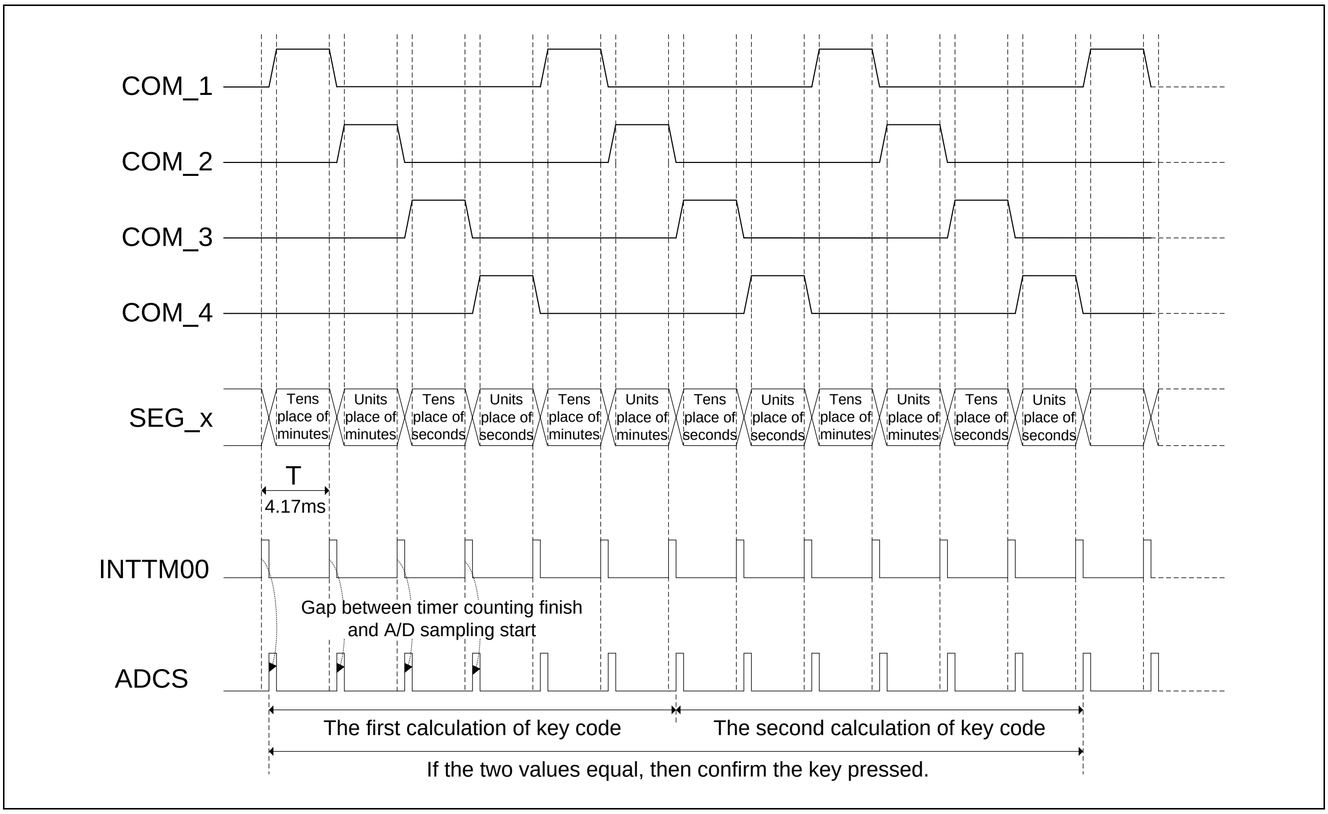

Figure 5.2 LED Display and A/D Key Input Sample

5.1.4 Operation Outline

(1) Initialize PORT

- Configure the ports for LED display as digital I/O ports and that for A/D key input sample as analog port.
- Configure the ports for SEG end of LED as N-ch open-drain and those for COM end as P-ch open-drain.
- Configure the initial status of LED as none display mode in which both SEG and COM ends are set to invalid level.
- Configure the A/D key input port as input pin.

(2) Initialize TAU

- Configure the TAU in interval timer mode.
- Configure the interval of TAU0 channel 0 is 4.7ms.
- Configure the interval of TAU0 channel 1 is 100ms.
- Enable the interrupt of channel 1 (INTTM01).

(3) Initialize A/D converter

- Configure conversion clock of A/D as f_{CLK}/8.
- Configure the resolution of A/D conversion as 10-bit.
- Configure the target of A/D conversion as ANI7.

(4) Initialize variables.

- Initialize the flag of 1second being up.
- Initialize the operating status flag of LED.

(5) Start the counting of TAU0 channel 0.

(6) Wait for the interrupt flag of TAU0 channel 0 (TMIF00) to become 1.

(7) Clear the interrupt flag after interrupt flag of TAU0 channel 0 is set to 1.

(8) Process the LED display.

- Update the LED display content according to the array of LED display.
- If the flag of 1 second timing up is 1, then update the array of LED display.

(9) Process the key sample.

- Obtain the current A/D value. After 6 times of sampling, calculate the average value of A/D conversion.
- Confirm the current key code.
- Key process according to the key code.

(10)Return to step (6).

5.2 List of Option Byte Settings

Table 5.2 summarizes the settings of the option bytes.

Table 5.2 Option Byte Settings

Address	Value	Description
000C0H	11101110B	Watchdog timer operation is stopped. (Count is stopped after reset.)
000C1H	11110011B	SPOR detection voltage: rising edge 4.28V(typ.), falling edge 4.00V(min.) P125/KR1/$\overline{\text{RESET}}$ pin: RESET input
000C2H	11111001B	HOCO: 20 MHz
000C3H	10000101B	On-chip debugging is enabled.

5.3 List of Constants

Table 5.3 lists the constants that are used in this sample code.

Table 5.3 Constants that are Used in this Sample Code

Constant	Value	Description
SEG_A	0xdf	Set low level to SEG_a
SEG_B	0xef	Set low level to SEG_b
SEG_C	0xf7	Set low level to SEG_c
SEG_D	0xfb	Set low level to SEG_d
SEG_E	0xfd	Set low level to SEG_e
SEG_F	0xfe	Set low level to SEG_f
SEG_G	0x7f	Set low level to SEG_g
SEG_DOT	0xbf	Set low level to SEG_dp
uint16_t ad_key_data[17]	992, 932, 872, 812, 752, 692, 632, 571, 511, 451, 391, 331, 271, 211, 150, 90, 30	The boundary value of voltage on ANI7 pin when one of K16~K1 is pressed or none of them is pressed
uint8_t c_SEG_DataP0[10]	0xff, 0xff, 0xff&SEG_G, 0xff&SEG_G, 0xff&SEG_G, 0xff&SEG_G, 0xff&SEG_G, 0xff, 0xff&SEG_G, 0xff&SEG_G	The value of P07~P06 when '0' to '9' is displayed on LED
uint8_t c_SEG_DataP1[10]	0xff&SEG_A&SEG_B&SEG_C&SEG_D&SEG_E&SEG_F, 0xff&SEG_B&SEG_C, 0xff&SEG_A&SEG_B&SEG_D&SEG_E, 0xff&SEG_A&SEG_B&SEG_C&SEG_D, 0xff&SEG_B&SEG_C&SEG_F, 0xff&SEG_A&SEG_C&SEG_D&SEG_F, 0xff&SEG_A&SEG_C&SEG_D&SEG_E&SEG_F, 0xff&SEG_A&SEG_B&SEG_C&SEG_F, 0xff&SEG_A&SEG_B&SEG_C&SEG_D&SEG_E&SEG_F, 0xff&SEG_A&SEG_B&SEG_C&SEG_D&SEG_F	The value of P15~P10 when '0' to '9' is displayed on LED

5.4 List of Variables

Table 5.4 lists the variables that are used in this sample code.

Table 5.4 Variables that are Used in this Sample Code

Type	Variable	Description	Function Used
uint8_t	g_COM_Data[4]	Control data for COM end of LED	Minute10_Add() Minute1_Add() Second10_Add() Second1_Add() Start() Pause_Stop() LED_Display() LED_Refresh()
uint16_t	g_SEG_Data[4]	Control data for SEG end of LED(0~9 is allowed to be set)	
uint8_t	g_AD_Key_Code	Present key code input	AD_Key_In() Key_Process()
uint8_t	g_Last_AD_Key_Code	Previous key code input	
uint16_t	g_AD_Fix	Present A/D value calculated	AD_In() AD_Key_In()
uint8_t	g_Cnt100ms	100ms counting value	TAU0_Channel1_Interrupt() Pause_Stop()
boolean	g_Flag_AD_Fix	Complete flag of A/D value calculation	AD_In() AD_Key_In()
boolean	g_Flag1s	Flag of 1 second timing up	Variable_Init() LED_Handle() TAU0_Channel1_Interrupt()
st_sp_flag_union	g_StSpFlag	The union of LED display status	Variable_Init() Key_Process() Start() Pause_Stop() LED_Refresh()
static uint8_t	s_COM	Count value of LED display	LED_Display()

5.5 List of Functions

Table 5.5 lists the functions that are used in this sample code.

Table 5.5 Functions that are Used in This Sample Code

Function	Outline
main()	Main processing
System_Init()	System initialization
PORT_Init()	Port initialization
TAU_Init()	TAU initialization
AD_Init()	A/D initialization
TAU0_Channel1_Interrupt()	Interrupt process of TAU0 channel 1
LED_Handle()	Handle LED
LED_Display()	Handle LED display
LED_Refresh()	Handle update of LED display array
Key_Handle()	Key handle
AD_In()	Start A/D conversion, calculate A/D value
AD_Key_In()	Identify the input key code
Key_Process()	Key process
Minute10_Add()	Tens place of minutes setting
Minute1_Add()	Units place of minutes setting
Second10_Add()	Tens place of seconds setting
Second1_Add()	Units place of seconds setting
Start()	Process of Start key
Pause_Stop()	Process of Pause/Stop key

5.6 Function Specifications

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

[Function Name] main

Synopsis	Main processing
Header	userdefine.h tau.h ad.h led.h key.h
Declaration	void main(void)
Explanation	Perform main processing.
Arguments	None
Return value	None
Remarks	None

[Function Name] System_Init

Synopsis	System initialization
Header	userdefine.h tau.h ad.h led.h key.h
Declaration	void System_Init(void)
Explanation	Perform initialization to PORT, TAU and A/D converter, enable interrupt.
Arguments	None
Return value	None
Remarks	None

[Function Name] PORT_Init

Synopsis	Port initialization
Header	userdefine.h tau.h ad.h led.h key.h
Declaration	void Port_Init(void)
Explanation	Perform port initialization.
Arguments	None
Return value	None
Remarks	None

[Function Name] TAU_Init

Synopsis	TAU initialization
Header	userdefine.h tau.h
Declaration	void TAU_Init(void)
Explanation	Perform TAU initialization.
Arguments	None
Return value	None
Remarks	None

[Function Name] AD_Init

Synopsis	A/D initialization
Header	userdefine.h ad.h
Declaration	void AD_Init(void)
Explanation	Perform A/D initialization.
Arguments	None
Return value	None
Remarks	None

[Function Name] TAU0_Channel1_Interrupt

Synopsis	Interrupt process of TAU0 channel 1
Header	userdefine.h tau.h
Declaration	__interrupt void TAU0_Channel1_Interrupt(void)
Explanation	Interrupt occurs once per 100ms. The counter of 100ms is increased by 1 every time interrupt occurs and when the counter equals to 10, the flag of 1 second is set to 1.
Arguments	None
Return value	None
Remarks	None

[Function Name] LED_Handle

Synopsis	Handle LED
Header	userdefine.h led.h
Declaration	void LED_Handle(void)
Explanation	Call the LED_Display function and the LED_Refresh function.
Arguments	None
Return value	None
Remarks	None

[Function Name] LED_Display

Synopsis	Handle LED display
Header	userdefine.h led.h
Declaration	void LED_Display(void)
Explanation	Update the display of 1-digit according to the current digit bit value.
Arguments	None
Return value	None
Remarks	None

[Function Name] LED_Refresh

Synopsis	Handle update of LED display array
Header	userdefine.h led.h
Declaration	void LED_Refresh(void)
Explanation	In down-counting mode, update the display array every second.
Arguments	None
Return value	None
Remarks	None

[Function Name] Key_Handle

Synopsis	Key handle
Header	userdefine.h key.h
Declaration	void Key_Handle(void)
Explanation	Start A/D conversion. Then confirm the conversion result, and process the input key.
Arguments	None
Return value	None
Remarks	None

[Function Name] AD_In

Synopsis	Start A/D conversion, calculate A/D value
Header	userdefine.h key.h
Declaration	void AD_In(void)
Explanation	Start A/D conversion and obtain the present A/D value by averaging the 4 samples with removing the maximum and minimum value.
Arguments	None
Return value	None
Remarks	None

[Function Name] AD_Key_In

Synopsis	Identify the input key code
Header	userdefine.h key.h
Declaration	void AD_Key_In(void)
Explanation	Identify the key pressed according to the present A/D value. If present pressed key is the same as last pressed key, this key is identified.
Arguments	None
Return value	None
Remarks	None

[Function Name] Key_Process

Synopsis	Key process
Header	userdefine.h key.h
Declaration	void Key_Process(void)
Explanation	If key input changes, process according to the new input key.
Arguments	None
Return value	None
Remarks	None

[Function Name] Minute10_Add

Synopsis	Tens place of minutes setting
Header	userdefine.h
	key.h
Declaration	void Minute10_Add(void)
Explanation	Set the tens place of minutes. 0~5 is available.
Arguments	None
Return value	None
Remarks	None

[Function Name] Minute1_Add

Synopsis	Units place of minutes setting
Header	userdefine.h
	key.h
Declaration	void Minute1_Add(void)
Explanation	Set the units place of minutes. 0~9 is available.
Arguments	None
Return value	None
Remarks	None

[Function Name] Second10_Add

Synopsis	Tens place of seconds setting
Header	userdefine.h
	key.h
Declaration	void Second10_Add(void)
Explanation	Set the tens place of seconds. 0~5 is available.
Arguments	None
Return value	None
Remarks	None

[Function Name] Second1_Add

Synopsis	Units place of seconds setting.
Header	userdefine.h
	key.h
Declaration	void Second1_Add(void)
Explanation	Set the units place of seconds. 0~9 is available.
Arguments	None
Return value	None
Remarks	None

[Function Name] Start

Synopsis	Process of Start key
Header	userdefine.h key.h
Declaration	void Start(void)
Explanation	In down-counting mode, start the down counting by 1 second.
Arguments	None
Return value	None
Remarks	None

[Function Name] Pause_Stop

Synopsis	Process of Pause/Stop key
Header	userdefine.h key.h
Declaration	void Pause_Stop(void)
Explanation	Pause or stop the down counting by 1 second.
Arguments	None
Return value	None
Remarks	None

5.7 Flowcharts

5.7.1 System Function

Figure 5.3 shows the flowchart for System Function.

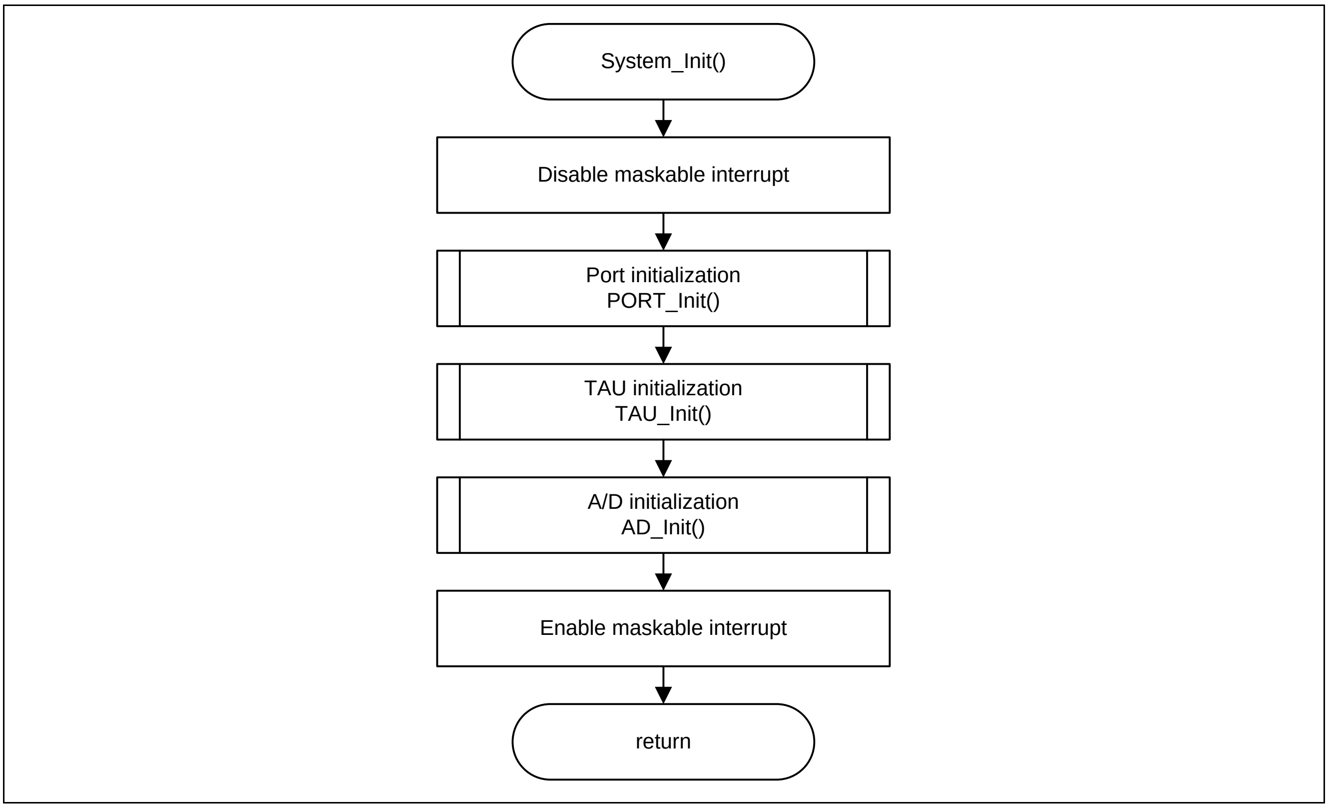

Figure 5.3 System Function

5.7.2 Port Initialization

Figure 5.4 shows the flowchart for Port Initialization.

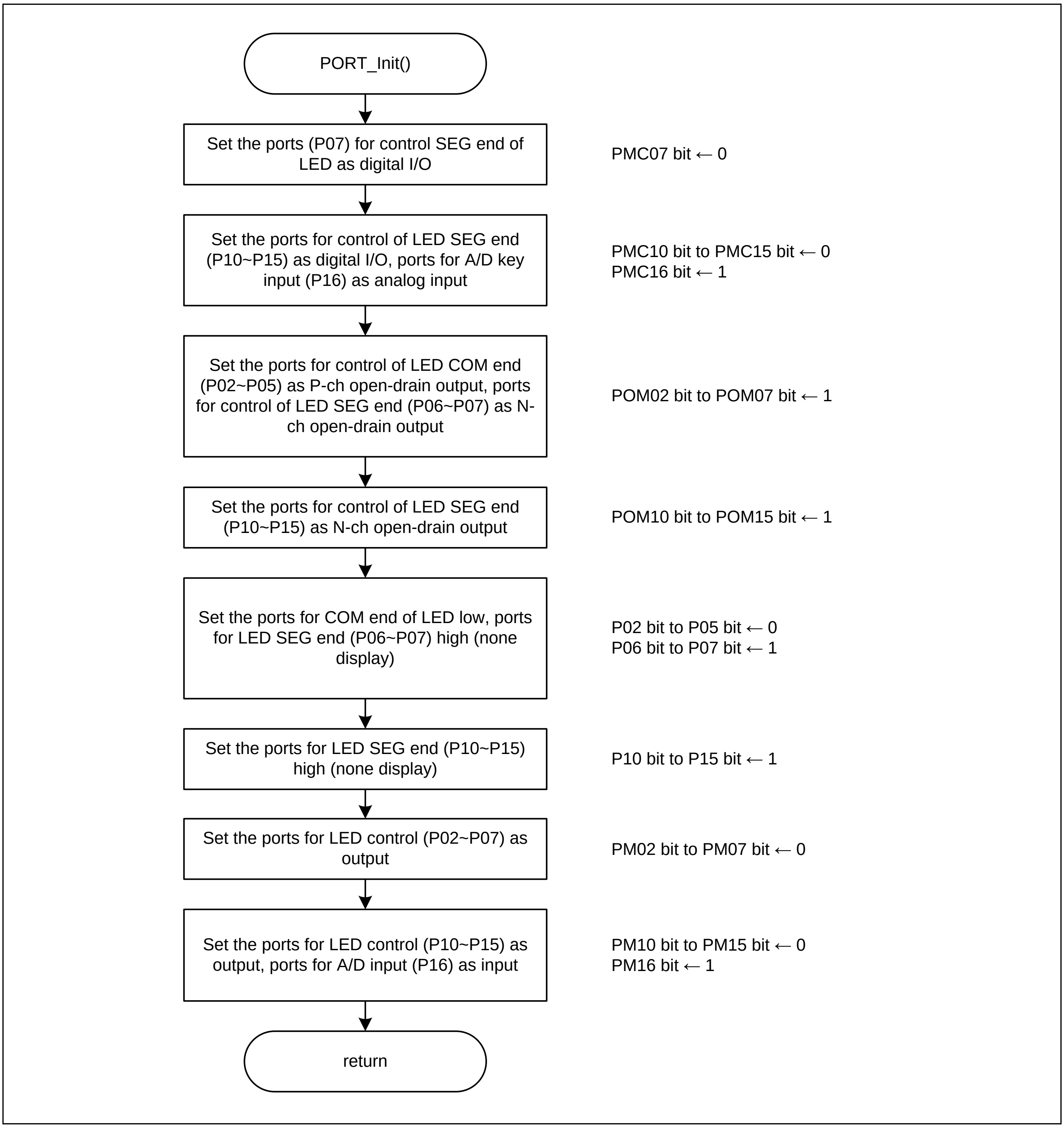

Figure 5.4 Port Initialization

Note: Provide proper treatment for unused pins so that their electrical specifications are observed. Connect each of any unused input-only ports to V_{DD} or V_{SS} via separate resistors.

Setting of ports for LED control

- Port Mode Control Register 0 (PMC0)
  Set P07 as digital I/O.
- Port Mode Control Register 1(PMC1)
  Set P10 to P15 as digital I/O.
  Set P16 as analog input.

Symbol: PMC0

7	6	5	4	3	2	1	0
PMC07	1	1	1	1	1	1	1
0	–	–	–	–	–	–	–

Bit 7

PMC07	P07 pin digital I/O/analog input selection
0	**Digital I/O (alternate function other than analog input)**
1	Analog input

Symbol: PMC1

7	6	5	4	3	2	1	0
1	PMC16	PMC15	PMC14	PMC13	PMC12	PMC11	PMC10
–	**1**	**0**	**0**	**0**	**0**	**0**	**0**

Bits 5 to 0

PMC1n	P1n pin digital I/O/analog input selection(n = 0 to 5)
0	**Digital I/O (alternate function other than analog input)**
1	Analog input

Bit 6

PMC16	P16 pin digital I/O/analog input selection
0	Digital I/O (alternate function other than analog input)
1	**Analog input**

Refer to the R7F0C806-809 user’s manual (hardware) for details on individual registers.
Initial values of individual bits
x: Bits not used in this application; blank spaces: bits that do not change; -: reserved bits or bits that have nothing assigned.

- Port Output Mode Register 0 (POM0)
  Set P02 to P05 as P-ch open-drain output mode. Set P06 to P07 as N-ch open-drain output mode.
- Port Output Mode Register 1(POM1)
  Set P10 to P15 as N-ch open-drain output mode.

Symbol: POM0

7	6	5	4	3	2	1	0
POM07	POM06	POM05	POM04	POM03	POM02	POM01	POM00
1	**1**	**1**	**1**	**1**	**1**	x	x

Bits 7 to 2

POM0n	P0n pin output mode selection(n = 2 to 7)
0	Normal output mode
1	**N-ch open-drain output (V_{DD} tolerance) mode (P06~P07 pin)** **P-ch open-drain output (V_{DD} tolerance) mode (P02~P05 pin)**

Symbol: POM1

7	6	5	4	3	2	1	0
0	0	POM15	POM14	POM13	POM12	POM11	POM10
–	–	**1**	**1**	**1**	**1**	**1**	**1**

Bits 5 to 0

POM1n	P1n pin output mode selection (n = 0 to 5)
0	Normal output mode
1	**N-ch open-drain output (V_{DD} tolerance) mode (P10~P15 pin)**

Refer to the R7F0C806-809 user's manual (hardware) for details on individual registers.
Initial values of individual bits
x: Bits not used in this application; blank spaces: bits that do not change; -: reserved bits or bits that have nothing assigned.

- Port Register 0 (P0)
  Set the output latch value of P02 to P05 to 0. Set the output latch value of P06 and P07 to 1.
- Port Register 1(P1)
  Set the output latch value of P10 to P15 to 1.

Symbol: P0

7	6	5	4	3	2	1	0
P07	P06	P05	P04	P03	P02	P01	P00
1	**1**	**0**	**0**	**0**	**0**	x	x

Bits 5 to 2

P0n	Output data control (in output mode)	Input data read (in input mode)
0	**Output 0**	**Input low level**
1	Output 1	Input high level

Bits 7 to 6

P0n	Output data control (in output mode)	Input data read (in input mode)
0	Output 0	Input low level
1	**Output 1**	**Input high level**

Symbol: P1

7	6	5	4	3	2	1	0
0	P16	P15	P14	P13	P12	P11	P10
–	x	**1**	**1**	**1**	**1**	**1**	**1**

Bits 5 to 0

P1n	Output data control (in output mode)	Input data read (in input mode)
0	Output 0	Input low level
1	**Output 1**	**Input high level**

Refer to the R7F0C806-809 user's manual (hardware) for details on individual registers.
Initial values of individual bits
x: Bits not used in this application; blank spaces: bits that do not change; -: reserved bits or bits that have nothing assigned.

- Port Mode Register 0 (PM0)
  Specify the output mode of P02 to P07.
- Port Mode Register 1(PM1)
  Specify the output mode of P10 to P15. Specify the input mode of P16.

Symbol: PM0

7	6	5	4	3	2	1	0
PM07	PM06	PM05	PM04	PM03	PM02	PM01	PM00
0	**0**	**0**	**0**	**0**	0	x	x

Bits 7 to 2

PM0n	P0n pin I/O mode selection (n = 2 to 7)
0	**Output mode (output buffer on)**
1	Input mode (output buffer off)

Symbol: PM1

7	6	5	4	3	2	1	0
1	PM16	PM15	PM14	PM13	PM12	PM11	PM10
–	**1**	**0**	**0**	**0**	**0**	**0**	**0**

Bits 5 to 0

PM1n	P1n pin I/O mode selection (n = 0 to 5)
0	**Output mode (output buffer on)**
1	Input mode (output buffer off)

Bit6

PM16	P16 pin I/O mode selection
0	Output mode (output buffer on)
1	**Input mode (output buffer off)**

Refer to the R7F0C806-809 user’s manual (hardware) for details on individual registers.
Initial values of individual bits
x: Bits not used in this application; blank spaces: bits that do not change; -: reserved bits or bits that have nothing assigned.

5.7.3 TAU Initialization

Figure 5.5shows the flowchart for TAU initialization.

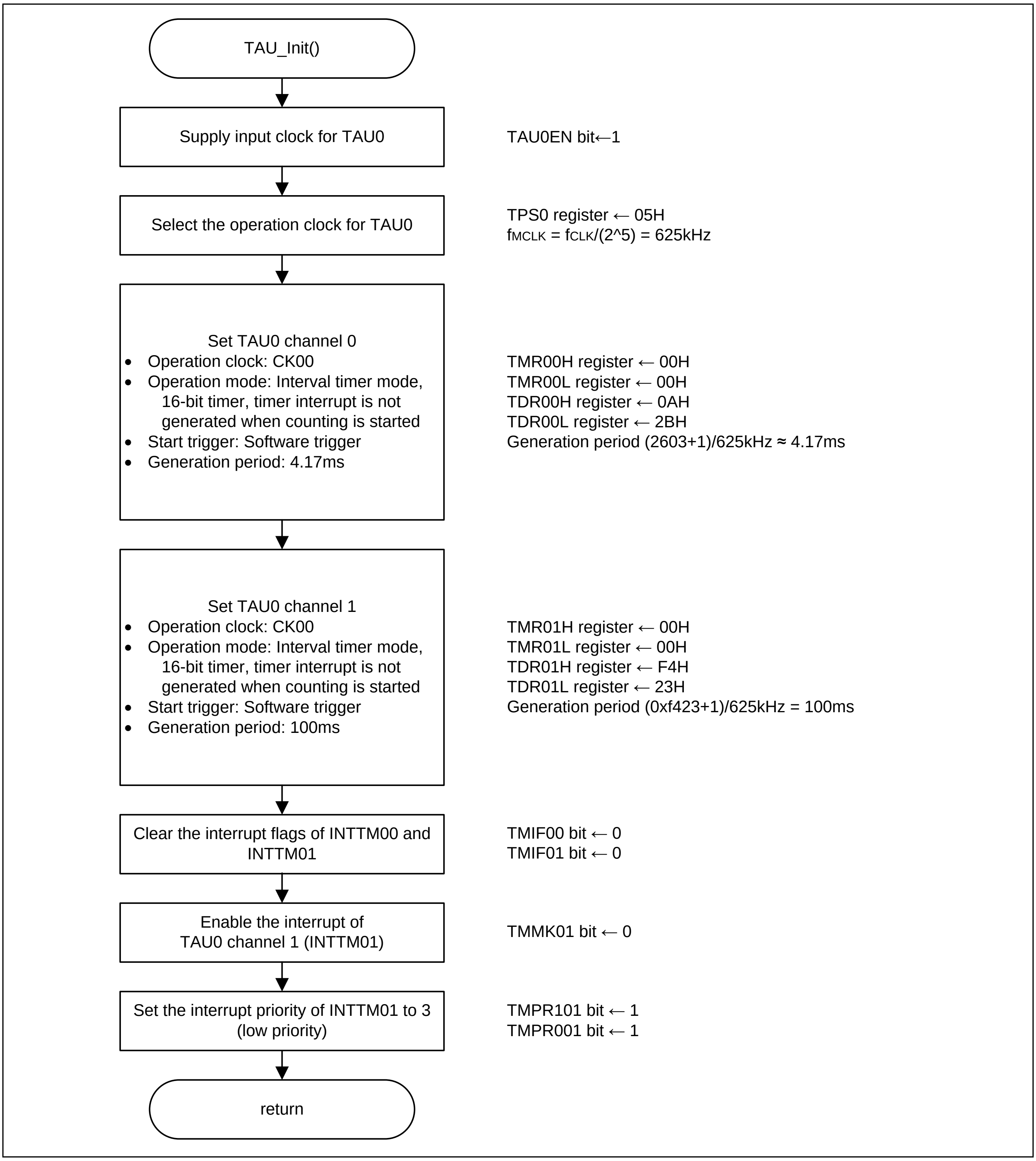

Figure 5.5 TAU Initialization

Enabling input clock supply to Timer Array Unit 0.

- Peripheral Enable Register 0 (PER0)
  Supply input clock for Timer Array Unit 0.

Symbol: PER0

7	6	5	4	3	2	1	0
TMKAEN	RTOEN	ADCEN	0	0	SAU0EN	0	TAU0EN
x	x	x	–	–	x	–	**1**

Bit 0

TAU0EN	Control of timer array unit input clock supply
0	Stops input clock supply. ·SFR used by timer array unit cannot be written. ·Timer array unit is in the reset status.
1	**Enables input clock supply.** **·SFR used by timer array unit can be read and written.**

Refer to the R7F0C806-809 user's manual (hardware) for details on individual registers.
Initial values of individual bits
x: Bits not used in this application; blank spaces: bits that do not change; -: reserved bits or bits that have nothing assigned.

Configuring the operation clock of Timer Array Unit 0

- Timer Clock Select Register 0 (TPS0)
  Select an operation clock for timer array unit 0.

Symbol: TPS0

7	6	5	4	3	2	1	0
PRS013	PRS012	PRS011	PRS010	PRS003	PRS002	PRS001	PRS000
x	x	x	x	**0**	**1**	**0**	**1**

Bits 3 to 0

PRS 003	PRS 002	PRS 001	PRS 000	Selection of operation clock (CK00)					
					f_{CLK}= 1.25 MHz	f_{CLK}= 2.5 MHz	f_{CLK}= 5 MHz	f_{CLK}= 10 MHz	f_{CLK}= 20 MHz
0	0	0	0	$f_{CLK}/2^0$	1.25 MHz	2.5 MHz	5 MHz	10 MHz	20 MHz
0	0	0	1	$f_{CLK}/2^1$	625 kHz	1.25 MHz	2.5 MHz	5 MHz	10 MHz
0	0	1	0	$f_{CLK}/2^2$	313 kHz	625 kHz	1.25 MHz	2.5 MHz	5 MHz
0	0	1	1	$f_{CLK}/2^3$	156 kHz	313 kHz	625 kHz	1.25 MHz	2.5 MHz
0	1	0	0	$f_{CLK}/2^4$	78.1 kHz	156 kHz	313 kHz	625 kHz	1.25 MHz
0	**1**	**0**	**1**	$\mathbf{f_{CLK}/2^5}$	**39.1 kHz**	**78.1 kHz**	**156 kHz**	**313 kHz**	**625 kHz**
0	1	1	0	$f_{CLK}/2^6$	19.5 kHz	39.1 kHz	78.1 kHz	156 kHz	313 kHz
0	1	1	1	$f_{CLK}/2^7$	9.77 kHz	19.5 kHz	39.1 kHz	78.1 kHz	156 kHz
1	0	0	0	$f_{CLK}/2^8$	4.88 kHz	9.77 kHz	19.5 kHz	39.1 kHz	78.1 kHz
1	0	0	1	$f_{CLK}/2^9$	2.44 kHz	4.88 kHz	9.77 kHz	19.5 kHz	39.1 kHz
1	0	1	0	$f_{CLK}/2^{10}$	1.22 kHz	2.44 kHz	4.88 kHz	9.77 kHz	19.5 kHz
1	0	1	1	$f_{CLK}/2^{11}$	610 Hz	1.22 kHz	2.44 kHz	4.88 kHz	9.77 kHz
1	1	0	0	$f_{CLK}/2^{12}$	305 Hz	610 Hz	1.22 kHz	2.44 kHz	4.88 kHz
1	1	0	1	$f_{CLK}/2^{13}$	153 Hz	305 Hz	610 Hz	1.22 kHz	2.44 kHz
1	1	1	0	$f_{CLK}/2^{14}$	76.3 Hz	153 Hz	305 Hz	610 Hz	1.22 kHz
1	1	1	1	$f_{CLK}/2^{15}$	38.1 Hz	76.3 Hz	153 Hz	305 Hz	610 Hz

Refer to the R7F0C806-809 user's manual (hardware) for details on individual registers.
Initial values of individual bits
x: Bits not used in this application; blank spaces: bits that do not change; -: reserved bits or bits that have nothing assigned.

Set the operation mode of Timer Array Unit 0

- Timer Mode Register 0n (TMR00H, TMR00L, TMR01H, TMR01L)
  Select the operation clock (f_{MCK})
  Select the count clock (f_{TCLK})
  Set software trigger start valid
  Set the operation mode

Symbol: TMR00H

7	6	5	4	3	2	1	0
CKS001	0	0	CCS00	0	STS002	STS001	STS000
0	**-**	**-**	**0**	**-**	**0**	**0**	**0**

Bit7

CKS001	Selection of operation clock (f_{MCK}) of channel 0
0	**Operation clock CK00 set by timer clock select register 0 (TPS0)**
1	Operation clock CK01 set by timer clock select register 0 (TPS0)

Bit4

CCS00	Selection of count clock (f_{TCLK}) of channel 0
0	**Operation clock (f_{MCK}) specified by the CKS001 bit**
1	Valid edge of input signal input from the TI00 pin

Bits 2 to 0

STS002	STS001	STS000	Setting of start trigger or capture trigger of channel 0
0	**0**	**0**	**Only software trigger start is valid (other trigger sources are unselected).**
0	0	1	Valid edge of the TI00 pin input is used as the start trigger and capture trigger.
0	1	0	Both the edges of the TI00 pin input are used as a start trigger and a capture trigger.
1	0	0	When the channel is used as a slave channel with the one-shot pulse output, PWM output function, or multiple PWM output function: The interrupt request signal of the master channel (INTTM00) is used as the start trigger.
1	1	0	When the channel is used as a slave channel in two-channel input with one-shot pulse output function: The interrupt request signal of the master channel (INTTM00) is used as the start trigger. A valid edge of the TI03 pin input of the slave channel is used as the end trigger.
Other than above			Setting prohibited

Refer to the R7F0C806-809 user’s manual (hardware) for details on individual registers.
Initial values of individual bits
x: Bits not used in this application; blank spaces: bits that do not change; -: reserved bits or bits that have nothing assigned.

Symbol: TMR01H

7	6	5	4	3	2	1	0
CKS011	0	0	CCS01	SPLIT01	STS012	STS011	STS010
0	**-**	**-**	**0**	**0**	**0**	**0**	**0**

Bit7

CKS011	Selection of operation clock (f_{MCK}) of channel 1
0	**Operation clock CK00 set by timer clock select register 0 (TPS0)**
1	Operation clock CK01 set by timer clock select register 0 (TPS0)

Bit4

CCS01	Selection of count clock (f_{TCLK}) of channel 1
0	**Operation clock (f_{MCK}) specified by the CKS011 bit**
1	Valid edge of input signal input from the TI01 pin

Bit3

SPLIT01	Selection of 8 or 16-bit timer operation for channel 1
0	**Operates as 16-bit timer.**
1	Operates as 8-bit timer.

Bits 2 to 0

STS012	STS011	STS010	Setting of start trigger or capture trigger of channel 1
0	**0**	**0**	**Only software trigger start is valid (other trigger sources are unselected).**
0	0	1	Valid edge of the TI01 pin input is used as the start trigger and capture trigger.
0	1	0	Both the edges of the TI01 pin input are used as a start trigger and a capture trigger.
1	0	0	When the channel is used as a slave channel with the one-shot pulse output, PWM output function, or multiple PWM output function: The interrupt request signal of the master channel (INTTM01) is used as the start trigger.
1	1	0	When the channel is used as a slave channel in two-channel input with one-shot pulse output function: The interrupt request signal of the master channel (INTTM01) is used as the start trigger. A valid edge of the TI03 pin input of the slave channel is used as the end trigger.
Other than above			Setting prohibited

Refer to the R7F0C806-809 user’s manual (hardware) for details on individual registers.
Initial values of individual bits
x: Bits not used in this application; blank spaces: bits that do not change; -: reserved bits or bits that have nothing assigned.

Symbol: TMR00L, TMR01L

7	6	5	4	3	2	1	0
CIS0n1	CIS0n0	0	0	MD0n3	MD0n2	MD0n1	MD0n0
x	x	-	-	**0**	**0**	**0**	**0**

Bits 3 to 0

MD0n3	MD0n2	MD0n1	MD0n0	Setting of operation mode of channel n	Corresponding function	Count operation of TCR
0	**0**	**0**	**1/0**	**Interval timer mode**	**Interval timer/Square wave output/Divider function/PWM output (master)**	**Down count**
0	1	0	1/0	Capture mode	Input pulse interval measurement/Two channel input with one-shot pulse output function (slave)	Up count
0	1	1	0	Event counter mode	External event counter	Down count
1	0	0	1/0	One-count mode	Delay counter/One-shot pulse output/Two-channel input with one-shot pulse output function (master)/PWM output (slave)	Down count
1	1	0	0	Capture & one-count mode	Measurement of high-/low-level width of input signal	Up count
Other than above				Setting prohibited		

The operation of each mode changes depending on the operation of MD0n0 bit (see the table below).

Operation mode (Value set by the MD0n3 to MD0n1 bits)	MD0n0	Setting of starting counting and interrupt
Interval timer mode(0,0,0) Capture mode(0,1,0)	**0**	**Timer interrupt is not generated when counting is started (timer output does not change, either).**
	1	Timer interrupt is generated when counting is started (timer output also changes).
Event counter mode(0,1,1)	0	Timer interrupt is not generated when counting is started (timer output does not change, either).
One-count mode(1,0,0)	0	Start trigger is invalid during counting operation. At that time, a timer interrupt is not generated.
	1	Start trigger is valid during counting operation [Note]. At that time, a timer interrupt is not generated.
Capture & one-count mode(1,1,0)	0	Timer interrupt is not generated when counting is started (timer output does not change, either). Start trigger is invalid during counting operation. At that time, a timer interrupt is not generated.
Other than above		Setting prohibited

Note: n = 0 to 1

Refer to the R7F0C806-809 user's manual (hardware) for details on individual registers.
Initial values of individual bits
x: Bits not used in this application; blank spaces: bits that do not change; -: reserved bits or bits that have nothing assigned.

Set the period of interval timer

- Timer Data Register 0n (TDR00H, TDR00L, TDR01H, TDR01L)
  Set the compare value of interval timer

Symbol: TDR00H

7	6	5	4	3	2	1	0
0	0	0	0	1	0	1	0

Symbol: TDR00L

7	6	5	4	3	2	1	0
0	0	1	0	1	0	1	1

Generation period of INTTM00 (timer interrupt) = Period of count clock × (Set value of TDR00 + 1)

= 1 /625kHz×(2603+1) = 4.17ms

Symbol: TDR01H

7	6	5	4	3	2	1	0
1	1	1	1	0	1	0	0

Symbol: TDR01L

7	6	5	4	3	2	1	0
0	0	1	0	0	0	1	1

Generation period of INTTM01 (timer interrupt) = Period of count clock × (Set value of TDR01 + 1)

= 1 /625kHz × (62499+1) = 100ms

Refer to the R7F0C806-809 user's manual (hardware) for details on individual registers.
Initial values of individual bits
x: Bits not used in this application; blank spaces: bits that do not change; -: reserved bits or bits that have nothing assigned.

Timer channel start

- Timer Channel Start Register 0 (TS0)
  Operation start

Symbol: TS0

7	6	5	4	3	2	1	0
0	0	0	0	TS03	TS02	TS01	TS00
-	-	-	-	x	x	**1**	**1**

Bits 1 to 0

TS0n	Operation enable (start) trigger of channel n (n=0 to 1)
0	No trigger operation
1	**The TE0n bit is set to 1 and the count operation becomes enabled.**

Symbol: TT0

7	6	5	4	3	2	1	0
0	0	0	0	TT03	TT02	TT01	TT00
-	-	-	-	x	x	**1**	

Bit1

TT01	Operation stop trigger of channel 1
0	No trigger operation
1	**The TE01 bit is cleared to 0 and count operation is stopped.**

Refer to the R7F0C806-809 user's manual (hardware) for details on individual registers.
Initial values of individual bits
x: Bits not used in this application; blank spaces: bits that do not change; -: reserved bits or bits that have nothing assigned.

Interrupt setting

- Interrupt Request Flag Register (IF0L, IF0H)
  Clear interrupt request flag
- Interrupt Mask Flag Register (MK0H)
  Clear interrupt mask
- Interrupt Priority Specification Flag Register (PR00H, PR10H)
  Set interrupt priority level

Symbol: IF0L

7	6	5	4	3	2	1	0
TMIF00	TMIF01H	SREIF0	SRIF0	STIF0 CSIIF00	PIF1	PIF0	WDTIIF
0	x	x	x	x	x	x	x

Bit7

TMIF00	Interrupt request flag
0	**No interrupt request signal is generated**
1	Interrupt request is generated, interrupt request status

Symbol: IF0H

7	6	5	4	3	2	1	0
TMIF02	0	TMIF03H	PIF3	PIF2	KRIF	ADIF	TMIF01
x	-	x	x	x	x	x	**0**

Bit0

TMIF01	Interrupt request flag
0	**No interrupt request signal is generated**
1	Interrupt request is generated, interrupt request status

Refer to the R7F0C806-809 user's manual (hardware) for details on individual registers.
Initial values of individual bits
x: Bits not used in this application; blank spaces: bits that do not change; -: reserved bits or bits that have nothing assigned.

Symbol: MK0H

7	6	5	4	3	2	1	0
TMMK02	1	TMMK03H	PMK3	PMK2	KRMK	ADMK	TMMK01
x	-	x	x	x	x	x	**0**

Bit0

TMMK01	Interrupt servicing control
0	**Interrupt servicing enabled**
1	Interrupt servicing disabled

Symbol: PR00H

7	6	5	4	3	2	1	0
TMPR002	1	TMPR003H	PPR03	PPR02	KRPR0	ADPR0	TMPR001
x	-	x	x	x	x	x	**1**

Symbol: PR10H

7	6	5	4	3	2	1	0
TMPR102	1	TMPR103H	PPR13	PPR12	KRPR1	ADPR1	TMPR101
x	-	x	x	x	x	x	**1**

Priority level varies depending on the value of PR00H and PR10H (see table below).

TMPR001	TMPR101	Priority level selection
0	0	Specify level 0 (high priority)
0	1	Specify level 1
1	0	Specify level 2
1	**1**	**Specify level 3 (low priority)**

Refer to the R7F0C806-809 user's manual (hardware) for details on individual registers.
Initial values of individual bits
x: Bits not used in this application; blank spaces: bits that do not change; -: reserved bits or bits that have nothing assigned.

5.7.4 A/D Converter Initialization

Figure 5.6 shows the flowcharts of A/D converter initialization.

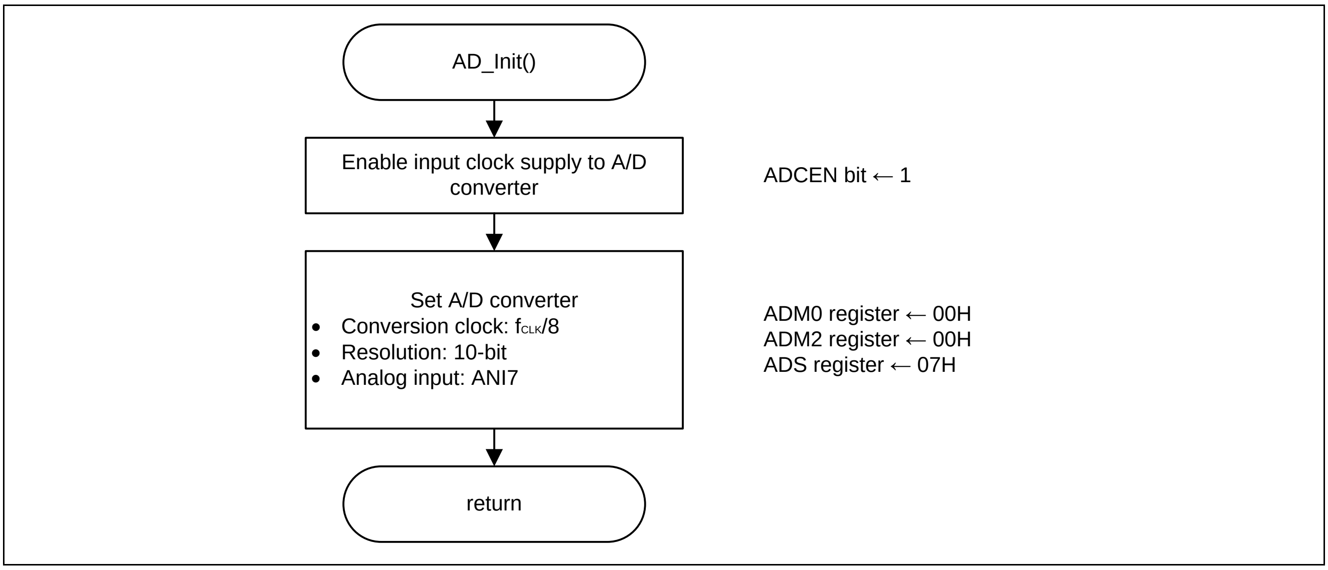

Figure 5.6 A/D Converter Initialization

Enable input clock supply of A/D converter

- Peripheral Enable Register 0 (PER0)
  Enable input clock supply of A/D converter.

Symbol: PER0

7	6	5	4	3	2	1	0
TMKAEN	RTOEN	ADCEN	0	0	SAU0EN	0	TAU0EN
x	x	**1**	-	-	x	-	

Bit5

ADCEN	Control of A/D converter input clock supply
0	Stop input clock supply.
1	**Enable input clock supply.**

Refer to the R7F0C806-809 user's manual (hardware) for details on individual registers.
Initial values of individual bits
x: Bits not used in this application; blank spaces: bits that do not change; -: reserved bits or bits that have nothing assigned.

Set conversion time and operation mode

- A/D Converter Mode Register 0 (ADM0)
  A/D conversion operation control
  A/D voltage comparator operation control
  A/D conversion time select

Symbol: ADM0

7	6	5	4	3	2	1	0
ADCS	0	0	FR1	FR0	0	LV0	ADCE
0	-	-	**0**	**0**	-	**0**	**0**

Bit7

ADCS	A/D conversion operation control
0	**Stops A/D conversion operation(conversion stopped/standby status)**
1	Enables A/D conversion operation(conversion operation status)

Bit4, Bit3 and Bit1 (10-bit resolution)

A/D Converter Mode Register 0 (ADM0)			Conversion clock	Number of Conversion clock	Conversion time	Conversion Time Selection (us)				
FR1	FR0	LV0				f_{CLK} =1.25 MHz	f_{CLK} =2.5 MHz	f_{CLK} =5 MHz	f_{CLK}=10 MHz	f_{CLK} =20MHz[Note]
0	**0**	**0**	**f_{CLK}/8**	**23 f_{AD}(Number of sampling clock: 9 f_{AD})**	**184/ f_{CLK}**	**Setting prohibited**	**Setting prohibited**	**Setting prohibited**	**18.4**	**9.2**
0	1		f_{CLK}/4		92/ f_{CLK}			18.4	9.2	4.6
1	0		f_{CLK}/2		46/ f_{CLK}		18.4	9.2	4.6	Setting prohibited
1	1		f_{CLK}		23/ f_{CLK}	18.4	9.2	4.6	Setting prohibited	
0	0	1[Note]	f_{CLK}/8	17 f_{AD}(Number of sampling clock: 3 f_{AD})	136/ f_{CLK}	Setting prohibited	Setting prohibited	Setting prohibited	13.6	6.8
0	1		f_{CLK}/4		68/ f_{CLK}			13.6	6.8	3.4
1	0		f_{CLK}/2		34/ f_{CLK}		13.6	6.8	3.4	Setting prohibited
1	1		f_{CLK}		17/ f_{CLK}	13.6	6.8	3.4	Setting prohibited	

Note: Setting prohibited when 2.4 V ≤ V_{DD}< 2.7 V. Can be selected when 2.7 V ≤ V_{DD}≤ 5.5 V.

Bit0

ADCE	A/D voltage comparator operation control
0	**Stops A/D voltage comparator operation**
1	Enables A/D voltage comparator operation

Refer to the R7F0C806-809 user's manual (hardware) for details on individual registers.
Initial values of individual bits
x: Bits not used in this application; blank spaces: bits that do not change; -: reserved bits or bits that have nothing assigned.

Set A/D conversion mode

- A/D Converter Mode Register 2 (ADM2)
  Set A/D conversion resolution

Symbol: ADM2

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	ADTYP
-	-	-	-	-	-	-	**0**

Bit0

ADTYP	Resolution of A/D conversion
0	**10-bit resolution**
1	8-bit resolution

Specify analog input channel

- Analog Input Channel Specification Register (ADS)
  Specify the input channel of the analog voltage to be A/D converted.

Symbol: ADS

7	6	5	4	3	2	1	0
0	0	0	0	0	ADS2	ADS1	ADS0
-	-	-	-	-	**1**	**1**	**1**

Bits 2 to 0

ADS2	ADS1	ADS0	Analog input channel	Input source
0	0	0	ANI0	P07/ANI0 pin
0	0	1	ANI1	P10/ANI1 pin
0	1	0	ANI2	P11/ANI2 pin
0	1	1	ANI3	P12/ANI3 pin
1	0	0	ANI4	P13/ANI4 pin
1	0	1	ANI5	P14/ANI5 pin
1	1	0	ANI6	P15/ANI6 pin
1	**1**	**1**	**ANI7**	**P16/ANI7 pin**

Refer to the R7F0C806-809 user's manual (hardware) for details on individual registers.
Initial values of individual bits
x: Bits not used in this application; blank spaces: bits that do not change; -: reserved bits or bits that have nothing assigned.

5.7.5 Main Processing

Figure 5.7 shows the flowchart of main processing.

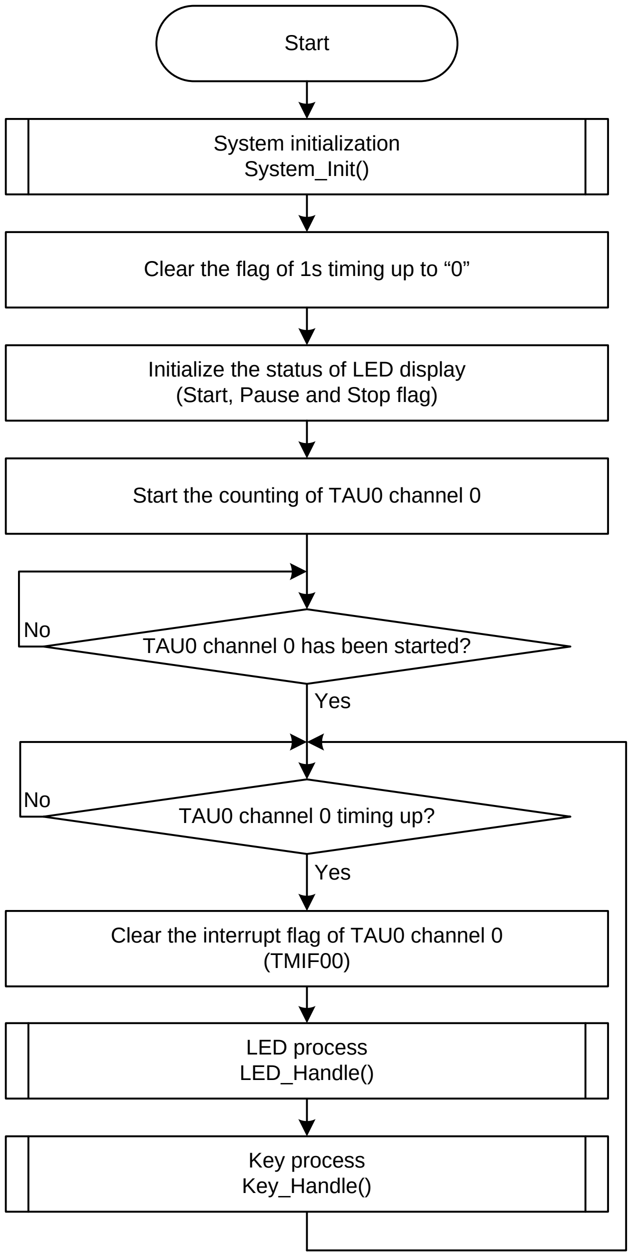

Figure 5.7 Main Processing

5.7.6 TAU0 channel 1 Interrupt Processing

Figure 5.8 shows the flowchart of TAU0 channel 1 interrupt processing.

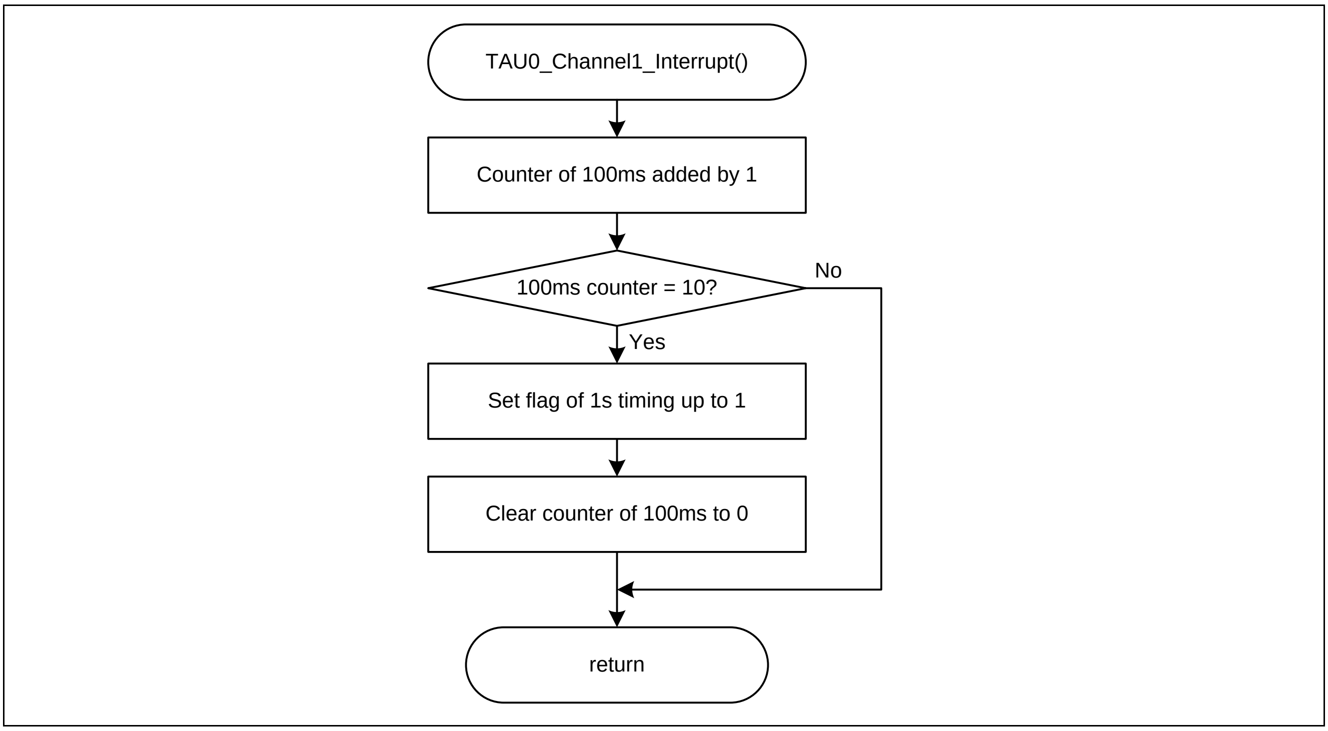

Figure 5.8 TAU0 channel 1 Interrupt Processing

5.7.7 LED Control Processing

Figure 5.9 shows the flowchart of LED Control Processing.

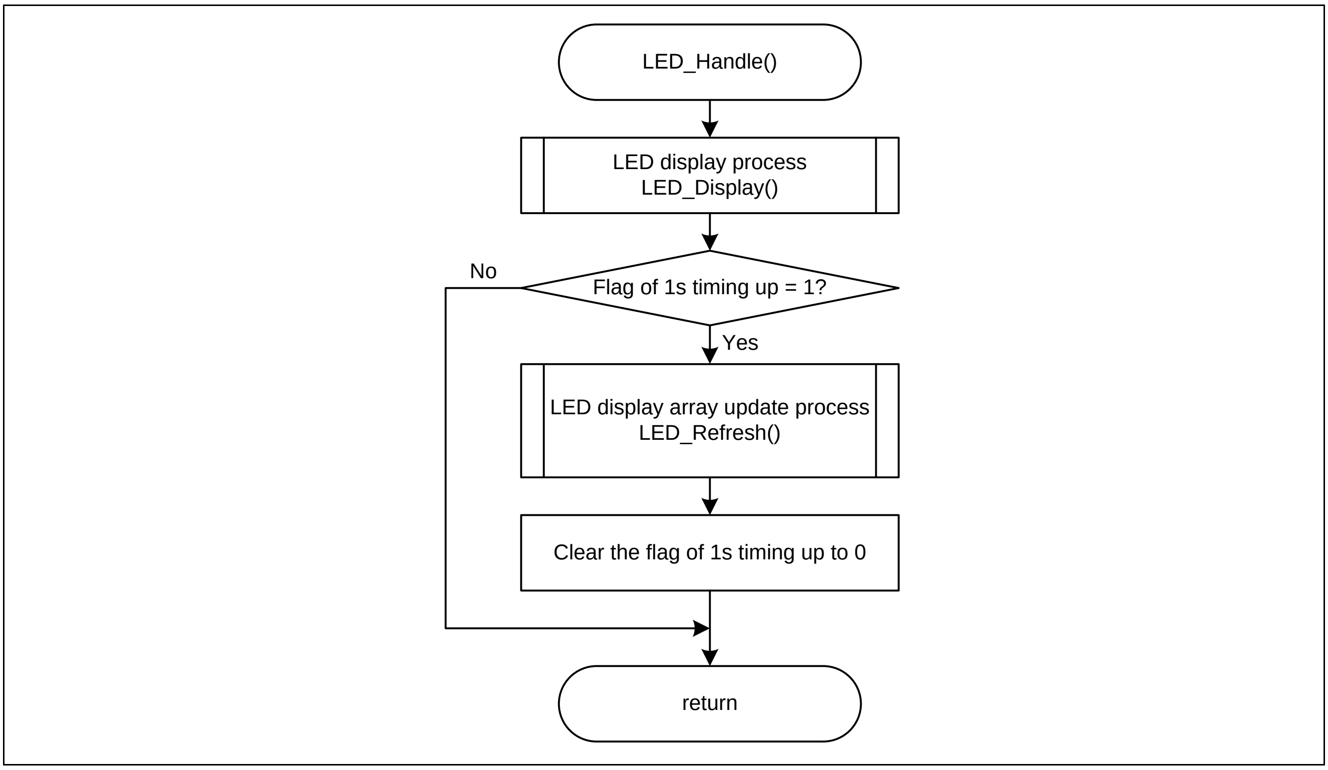

Figure 5.9 LED Control Processing

5.7.8 LED Display Processing

Figure 5.10 shows the flowchart of LED display processing.

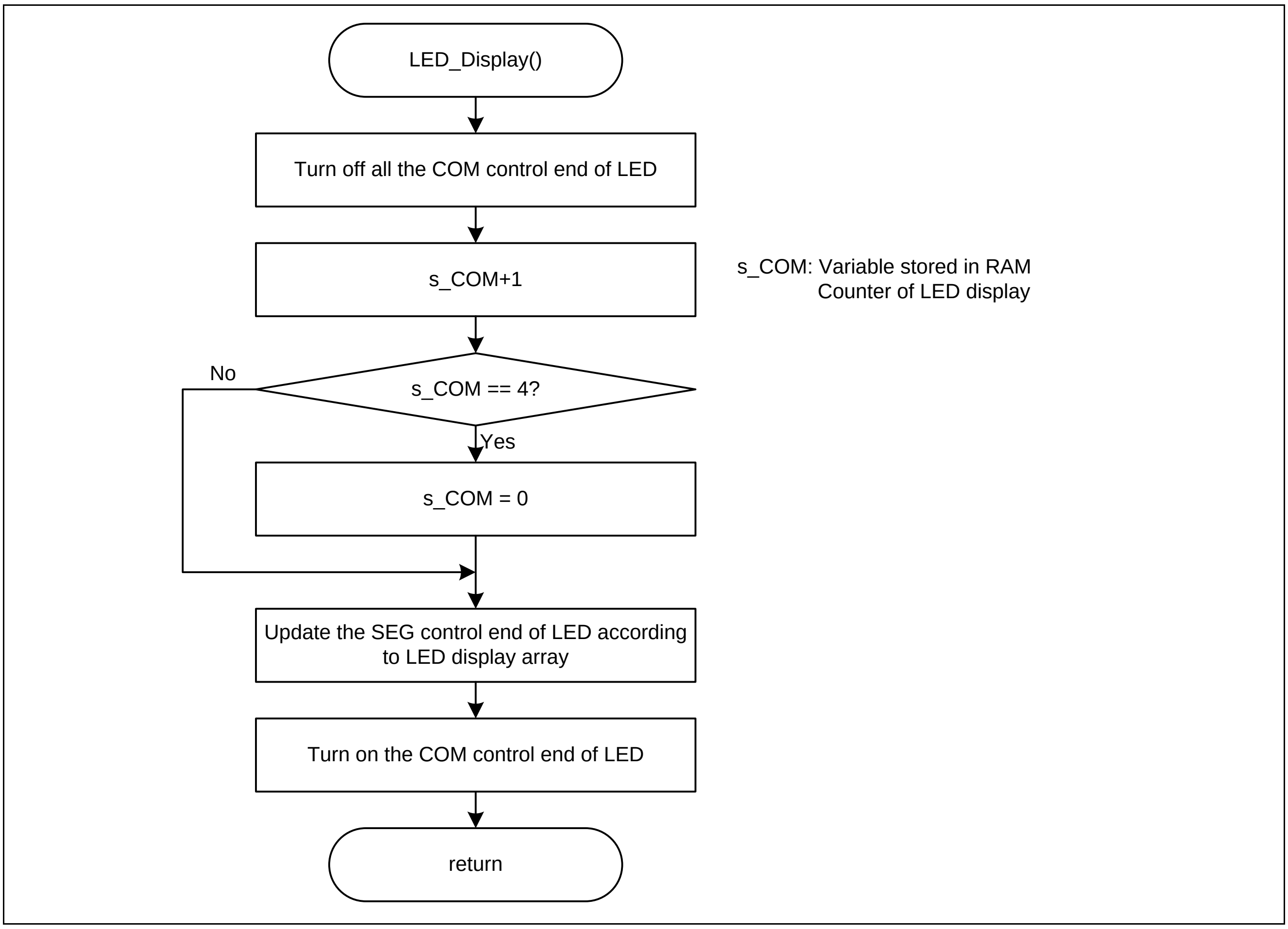

Figure 5.10 LED Display Processing

5.7.9 LED Display Array Update Processing

Figure 5.11 shows the flowchart of LED display array update processing.

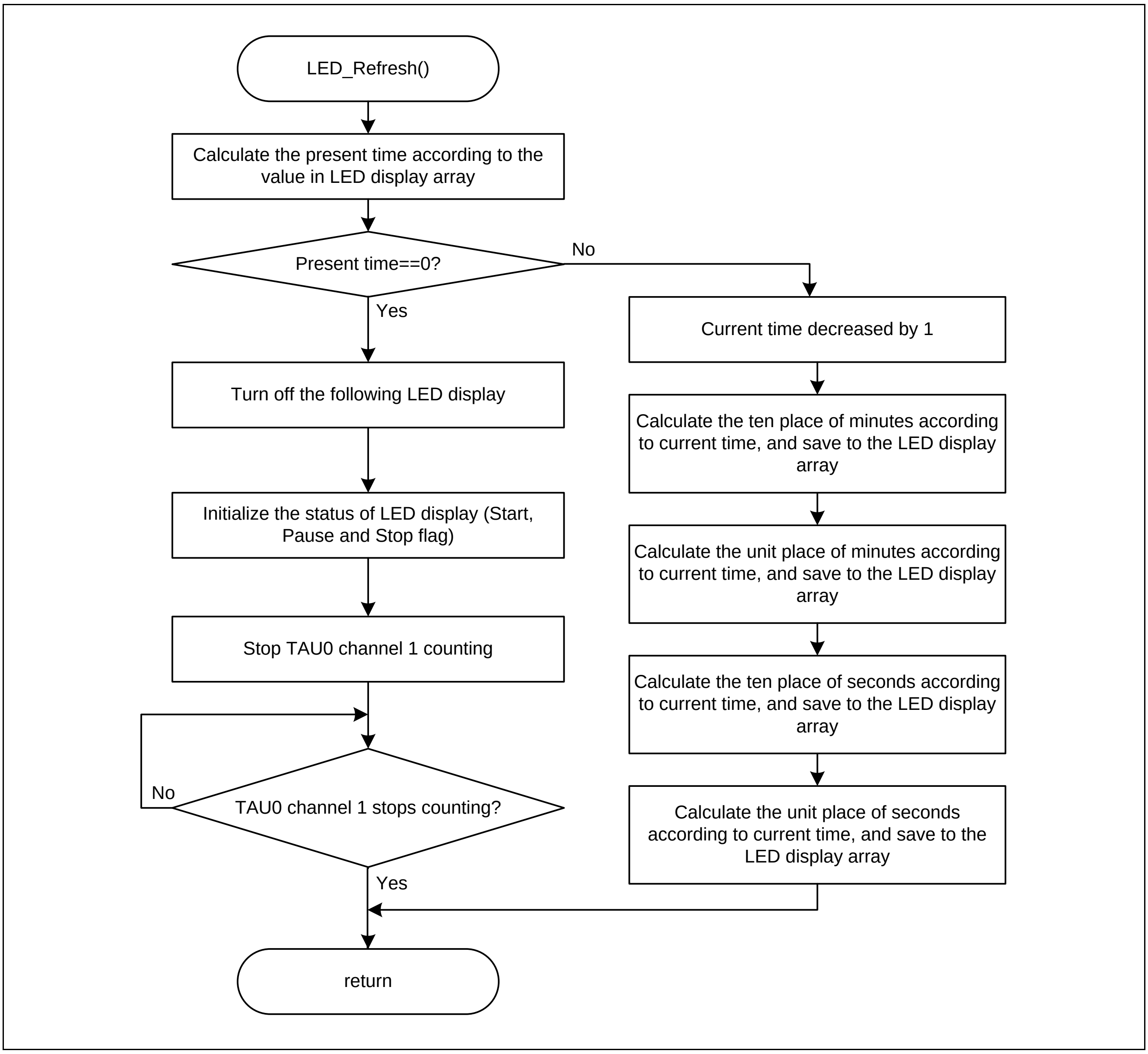

Figure 5.11 LED Display Array Update Processing

5.7.10 Key Handling

Figure 5.12 shows the flowchart of key handling.

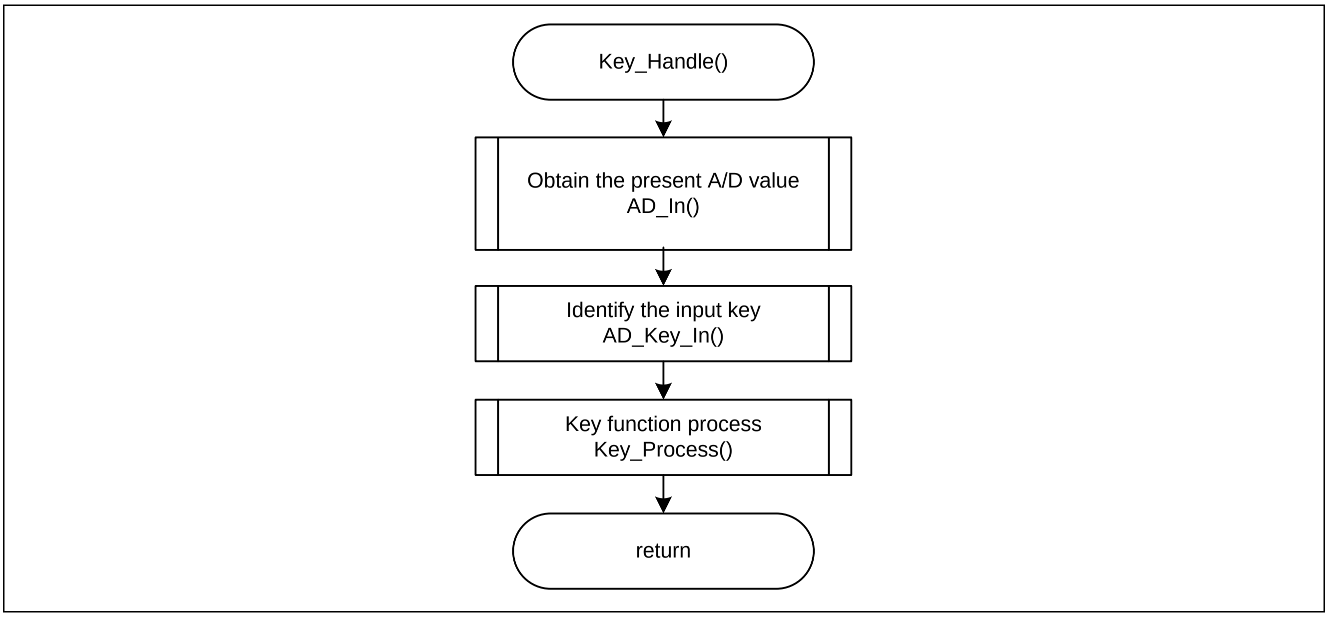

Figure 5.12 Key Handling

5.7.11 A/D Conversion Result Processing

Figure 5.13 shows the flowchart of A/D conversion result processing.

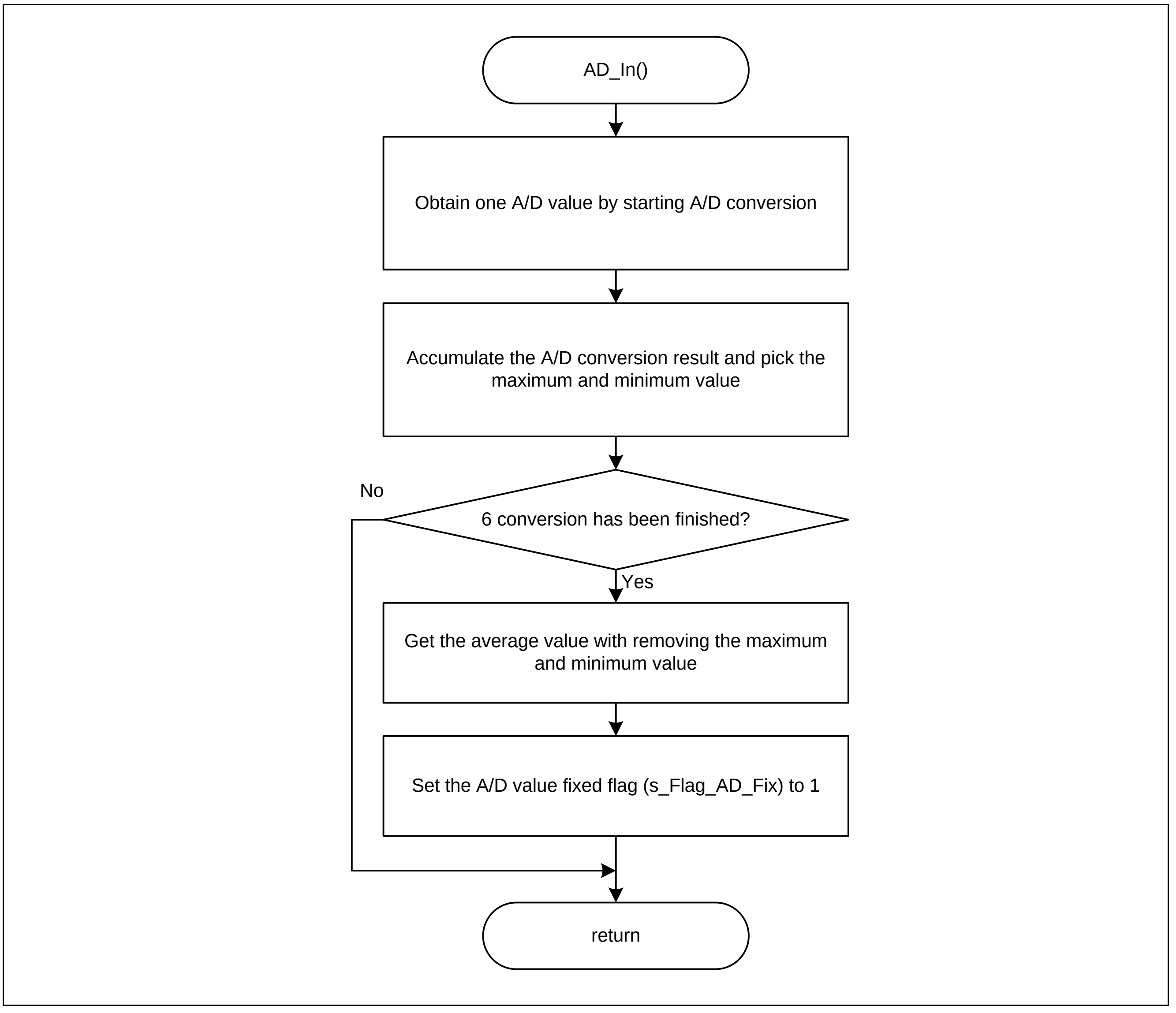

Figure 5.13 A/D Conversion Result Processing

5.7.12 Key Code Processing

Figure 5.14 shows the flowchart of key code processing.

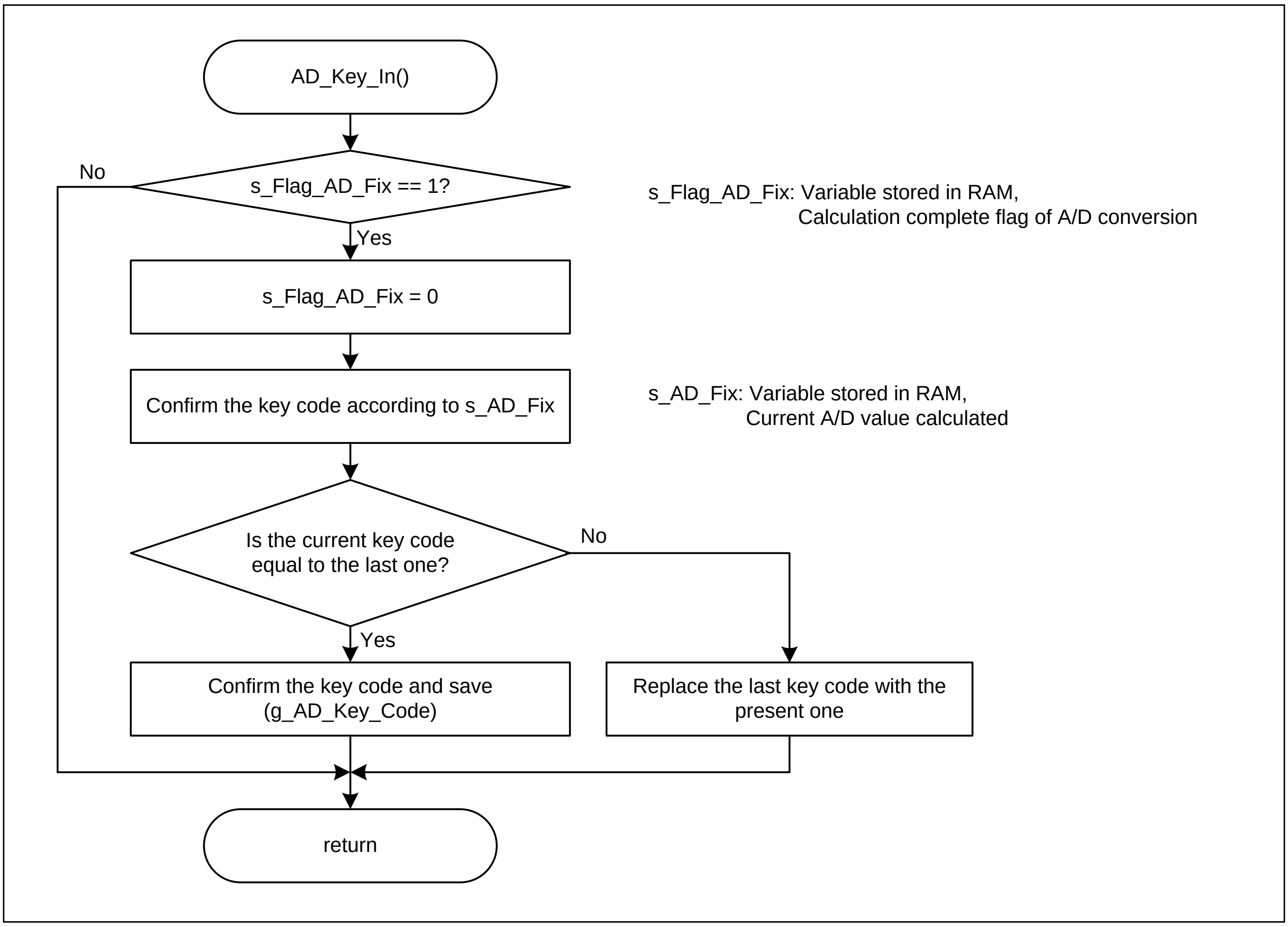

Figure 5.14 Key Code Processing

5.7.13 Key Processing

Figure 5.15 shows the flowchart of key processing.

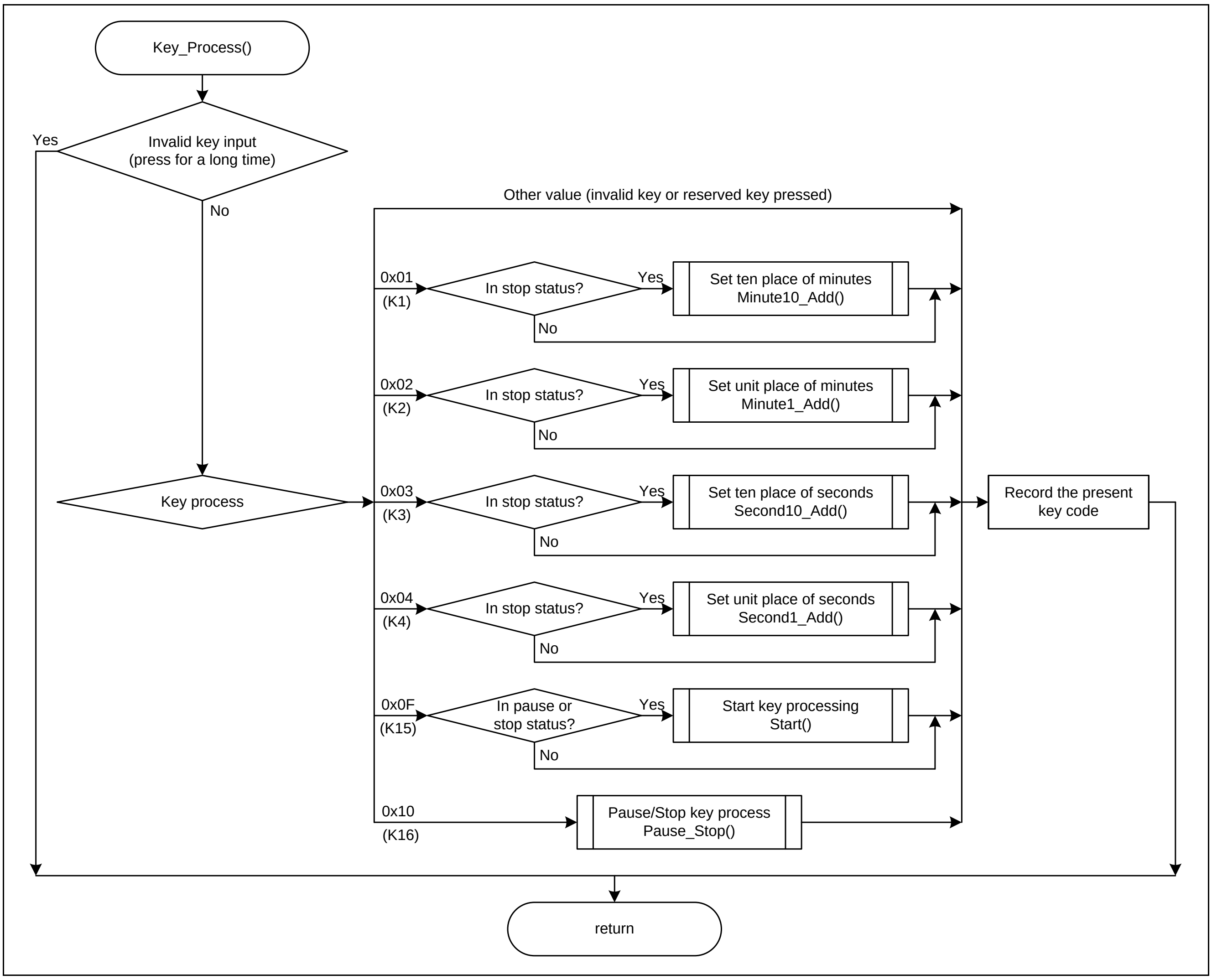

Figure 5.15 Key Processing

Note: During a key is in long-pressed, no duplicate process is executed.

5.7.14 Minutes and Seconds Set Processing

Figure 5.16 and figure 5.17 show the flowchart of minutes and seconds set processing.

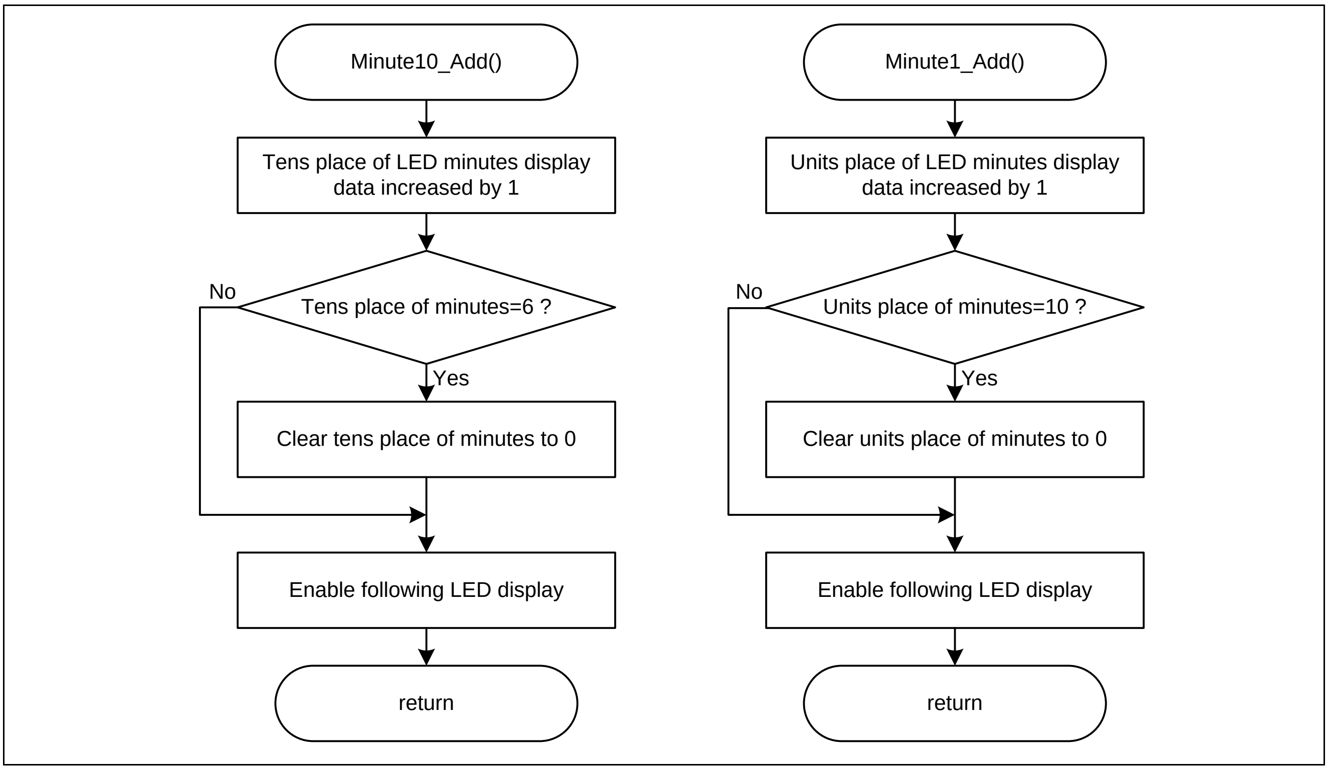

Figure 5.16 Minutes Set Processing

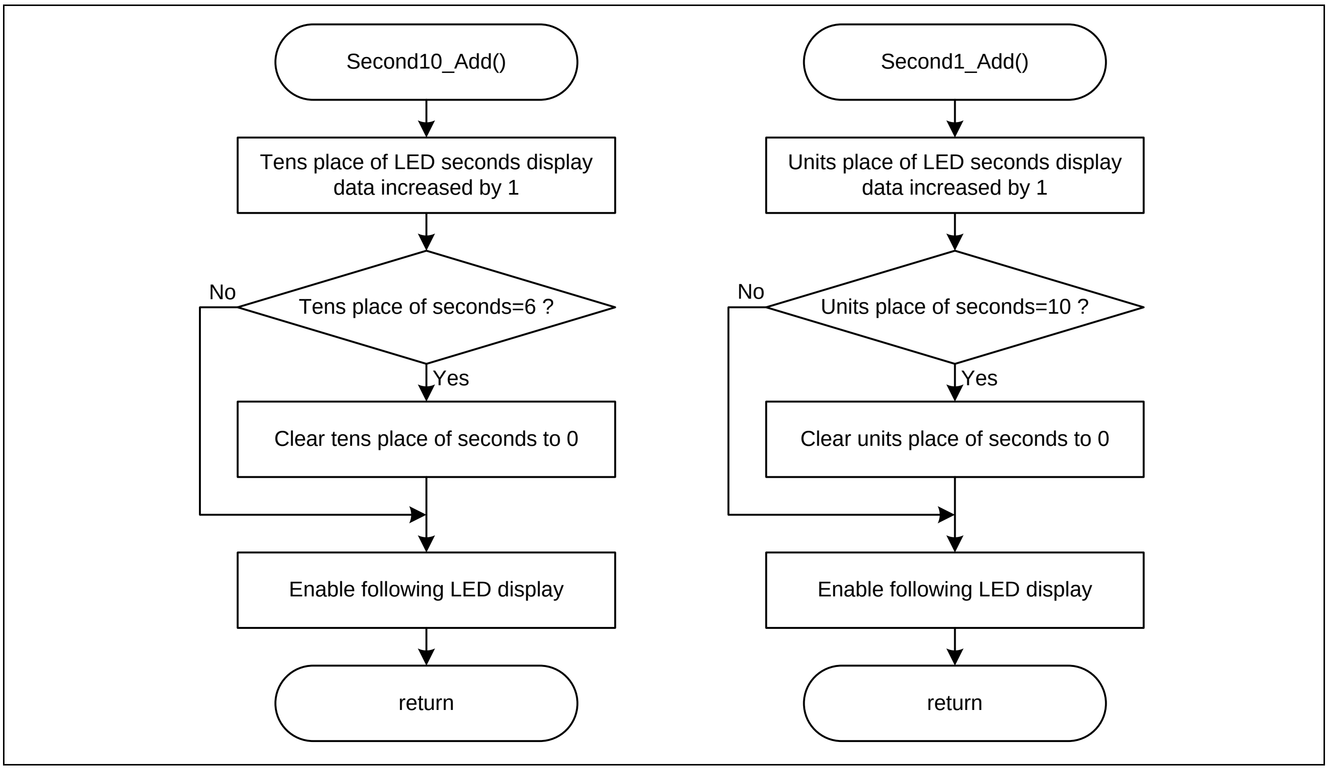

Figure 5.17 Seconds Set Processing

5.7.15 Start, Pause / Stop Key of Down-counting Process

Figure 5.18 and figure 5.19 show the flowchart of Start, Pause / Stop key down-counting process.

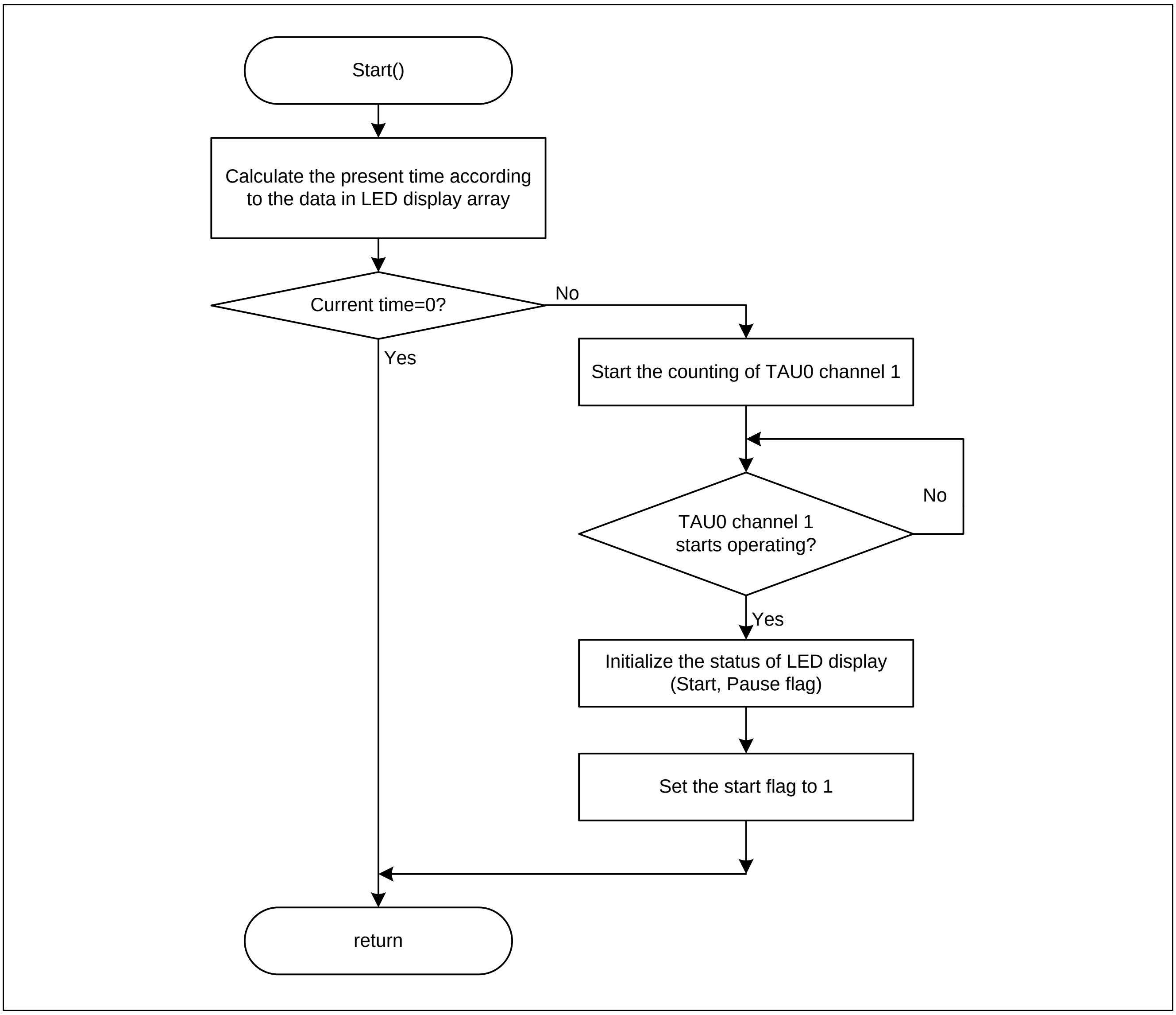

Figure 5.18 Start Key of Down-counting Process

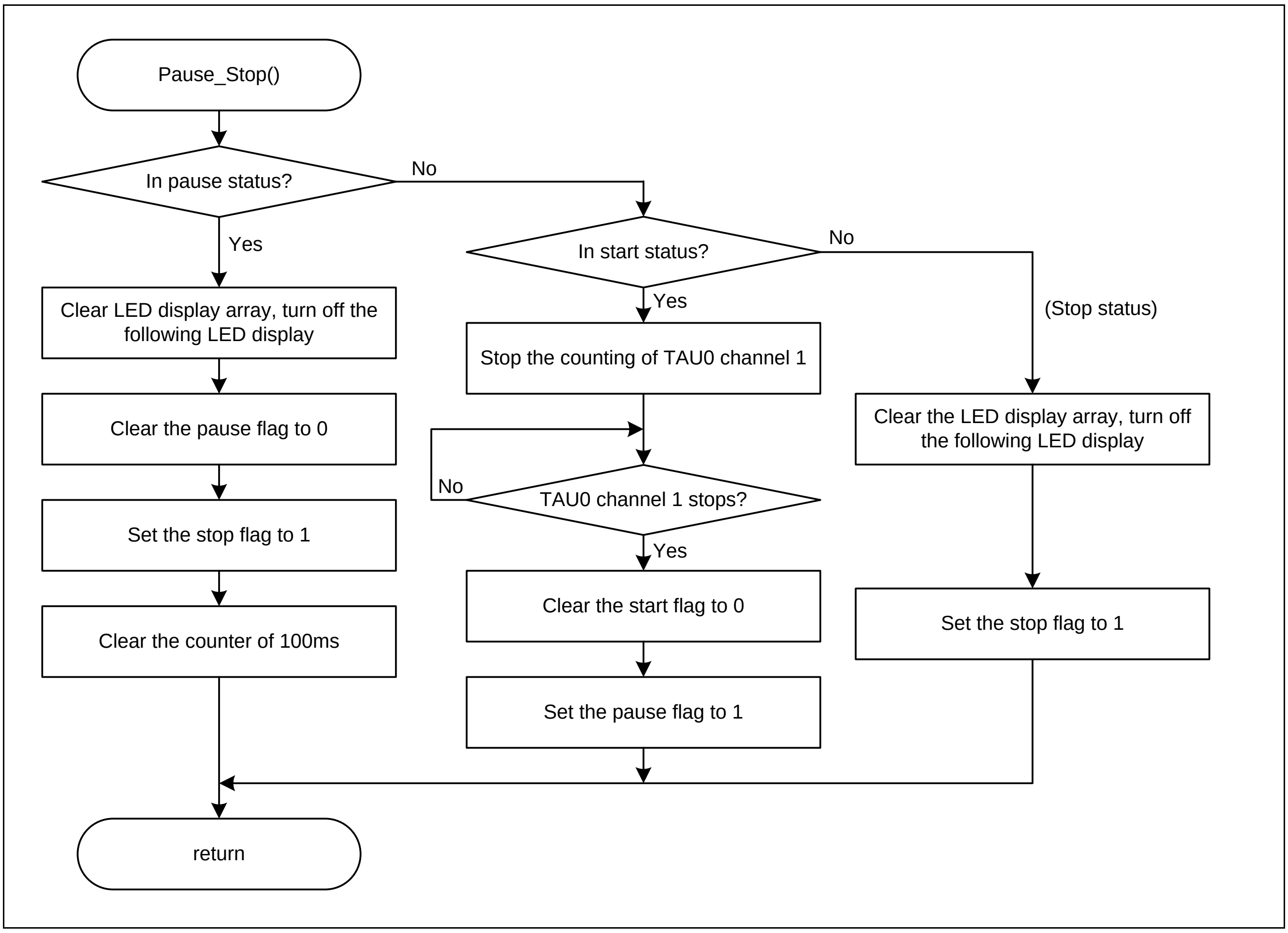

Figure 5.19 Pause / Stop Key of Down-counting Process

6. Sample Code

The sample code is available on the Renesas Electronics Website.

7. Reference Documents

User's Manual:

R7F0C806-809 User's Manual: Hardware (R01UH0481E)
RL78 Family User's Manual: Software (R01US0015E)
The latest versions of the documents are available on the Renesas Electronics Website.

Technical Updates/Technical News

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

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Revision History

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General Precautions in the Handling of MPU/MCU Products

The following usage notes are applicable to all MPU/MCU 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 an MPU or MCU 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.

SALES OFFICES Renesas Electronics Corporation http://www.renesas.com

Refer to "http://www.renesas.com/" for the latest and detailed information.

Renesas Electronics America Inc.
2801 Scott Boulevard Santa Clara, CA 95050-2549, U.S.A.
Tel: +1-408-588-6000, Fax: +1-408-588-6130

Renesas Electronics Canada Limited
1101 Nicholson Road, Newmarket, Ontario L3Y 9C3, Canada
Tel: +1-905-898-5441, Fax: +1-905-898-3220

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-585-100, Fax: +44-1628-585-900

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
Room 1709, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100191, P.R.China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, P. R. China 200333
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited
Unit 1601-1613, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852 2886-9022/9044

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 906, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics Korea Co., Ltd.
12F., 234 Teheran-ro, Gangnam-Ku, Seoul, 135-920, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141

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