M3H Group(1)
Application Note
12-bit Analog to Digital Converter
(ADC-A)

Outlines

This application note is a reference material for developing products using the 12-bit analog to digital converter (ADC) function of M3H Group(1).
This document helps the user check operation of the product and develop its program

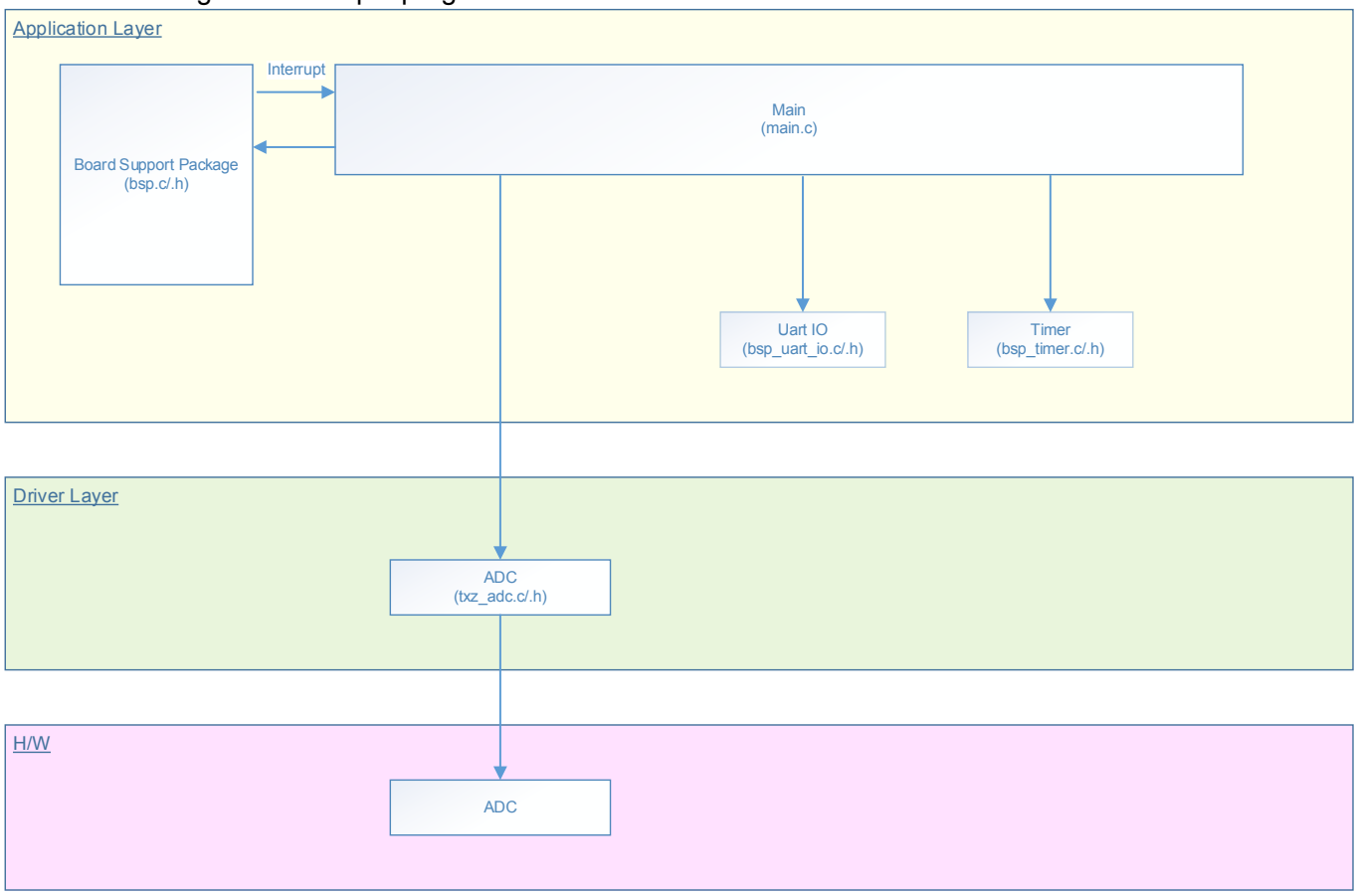
Target sample program: ADC_UART

Table of Contents

1. Preface

This sample program is used to measure the thermistor output voltage using the ADC, convert the ADC result to a temperature value using the CPU, and display it on the terminal software.

Structure diagram of Sample program



2. Reference Document

- Datasheet
  TMPM3H group (1) datasheet Rev2.0 (Japanese edition)
- Reference manual
  12-bit analog to digital converter (ADC-A) Rev2.0 (Japanese edition)
- Reference manual
  TMPM3H Group Peripheral Driver User Manual (Doxygen)

3. Function to Use

IP	channel	port	Function / operation mode
ADC	ch2	PD2 (AIN02)	Single conversion
Asynchronous serial communication circuit	ch0	PA1 (UT0TXDA) PA2 (UT0RXD)	Asynchronous communication with PC

4. Target Device

The target devices of application note are as follows.

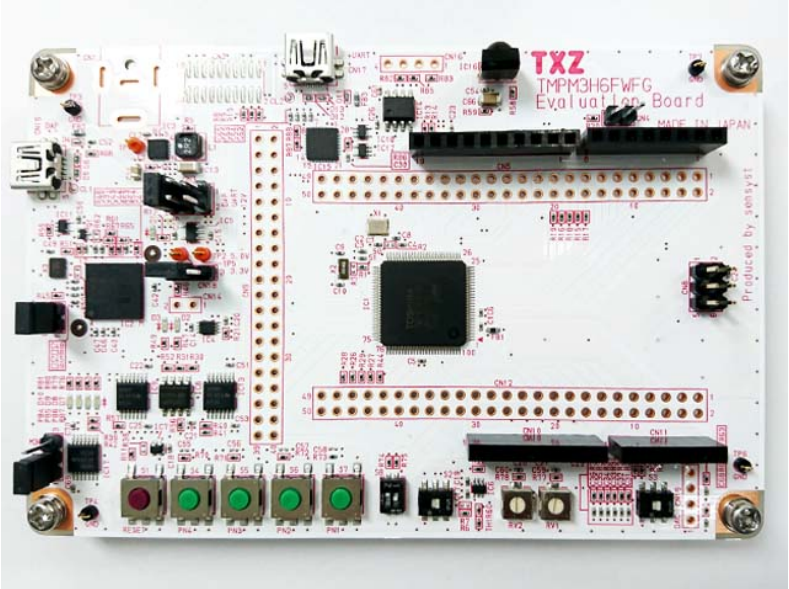
TMPM3H6FWFG	TMPM3H6FUFG	TMPM3H6FSFG
TMPM3H6FWDFG	TMPM3H6FUDFG	TMPM3H6FSDFG
TMPM3H5FWFG	TMPM3H5FUFG	TMPM3H5FSFG
TMPM3H5FWDFG	TMPM3H5FUDFG	TMPM3H5FSDFG
TMPM3H4FWUG	TMPM3H4FUUG	TMPM3H4FSUG
TMPM3H4FWFG	TMPM3H4FUFG	TMPM3H4FSFG
TMPM3H3FWUG	TMPM3H3FUUG	TMPM3H3FSUG
TMPM3H2FWDUG	TMPM3H2FUDUG	TMPM3H2FSDUG
TMPM3H2FWQG	TMPM3H2FUQG	TMPM3H2FSQG
TMPM3H1FWUG	TMPM3H1FUUG	TMPM3H1FSUG
TMPM3H1FPUG	TMPM3H0FSDUG	TMPM3H0FMDUG

* This sample program operates on the evaluation board of TMPM3H6FWFG.
If other function than the TMPM3H6 one is checked, it is necessary that CMSIS Core related files (C startup file and I/O header file) should be changed properly.
The BSP related file is dedicated to the evaluation board (TMPM3H6). If other function than the TMPM3H6 one is checked, the BSP related file should be changed properly.

5. Operation Confirmation Condition

Used microcontroller TMPM3H6FWFG
Used board TMPM3H6FWFG Evaluation Board (Product of Sensyst)
Unified development environment IAR Embedded Workbench for ARM 8.11.2.13606
Unified development environment μVision MDK Version 5.24.2.0
Terminal software Tera Term V4.96
Sample program V1100

Evaluation board (TMPM3H6FWFG Evaluation Board) (Top view)



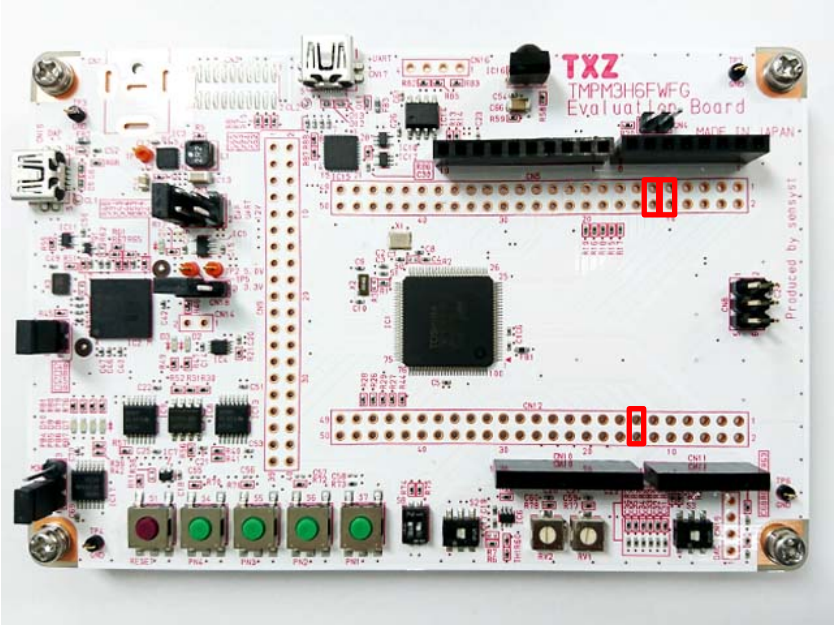
For purchasing the board, refer to the following homepage. (http://www.chip1stop.com/)

6. Evaluation Board Setting

The following pin connections should be done on the evaluation board.

CN5		
Use	Through-hole No.	Setting
UART	9-10	Connection
UART	11-12	Connection

CN12		
Use	Through-hole No.	Setting
ADC Input	13-14	Connection



7. Outline of 12-bit Analog to Digital Converter (ADC) Function

The ADC is a successive-approximation analog-to-digital converter. It supports maximum 16 analog inputs. When you use ADC, please set an applicable clock enable bit to "1" (clock supply) in fsys supply stop register A or B (***[CGFSYSENA]***, ***[CGFSYSENB]***), fc supply stop registers (***[CGFCEN]***), and Clock Supply for ADC and TRACE register(***[CGSPCLKEN]***). Please refer to "Clock Control and Operation Mode" of the reference manual for the clock enable bit.

8. Sample Program

The ADC measures the thermistor output voltage.
The ADC result is converted to a temperature value by the CPU, and the value is displayed on the terminal software.

8.1. Initialization

The following initialization is done after power is supplied.
The PORT setting is executed after the initialization of each clock setting and the clock setting.

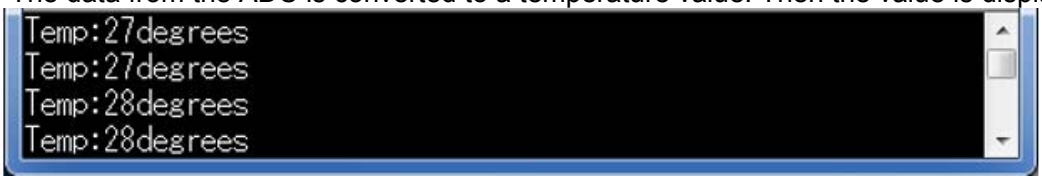
8.2. Sample program main operation

This sample program executes the setting of the ADC driver after the initialization settings.
The timer setting, the UART setting, and the thermistor setting are done to execute the operation.
ADIN02 pin is used as the AD input pin.
The application starts to operate after every setting completes.
The sample program works with single conversion of ADC.

The ADC result is converted to a temperature value by the CPU, and the value is displayed on the terminal software.
The interval of the output to the terminal software is defined by timer_interval_handler.
The output interval is set by the macro definition CFG_OUTPUT_INTERVAL, and the initial value is 5 seconds.

8.3. Output Example of Sample Program

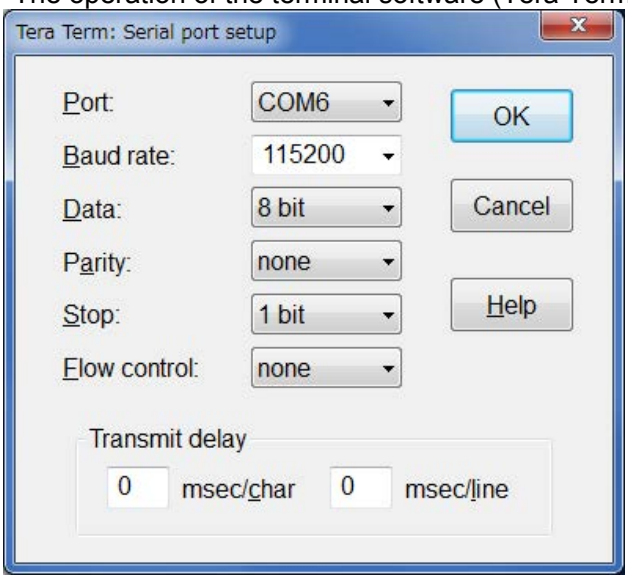
The data from the ADC is converted to a temperature value. Then the value is displayed.

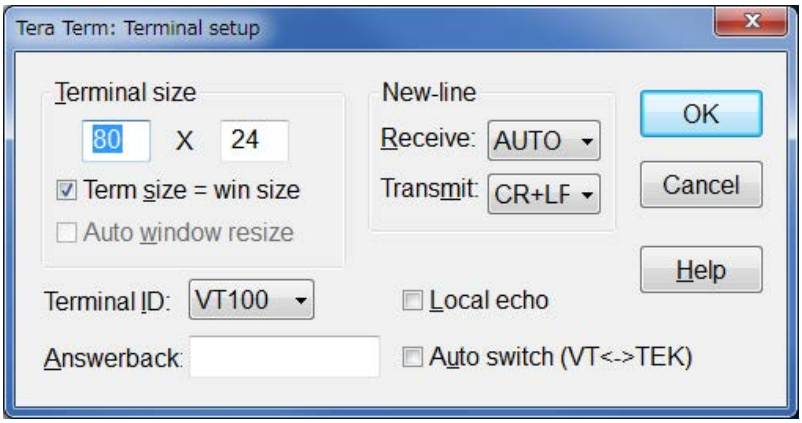


The updated temperature value is displayed every 5 seconds.

8.3.1. Setting Example of Terminal Software

The operation of the terminal software (Tera Term) has been checked with the following settings.





8.4. ADC Setting Change

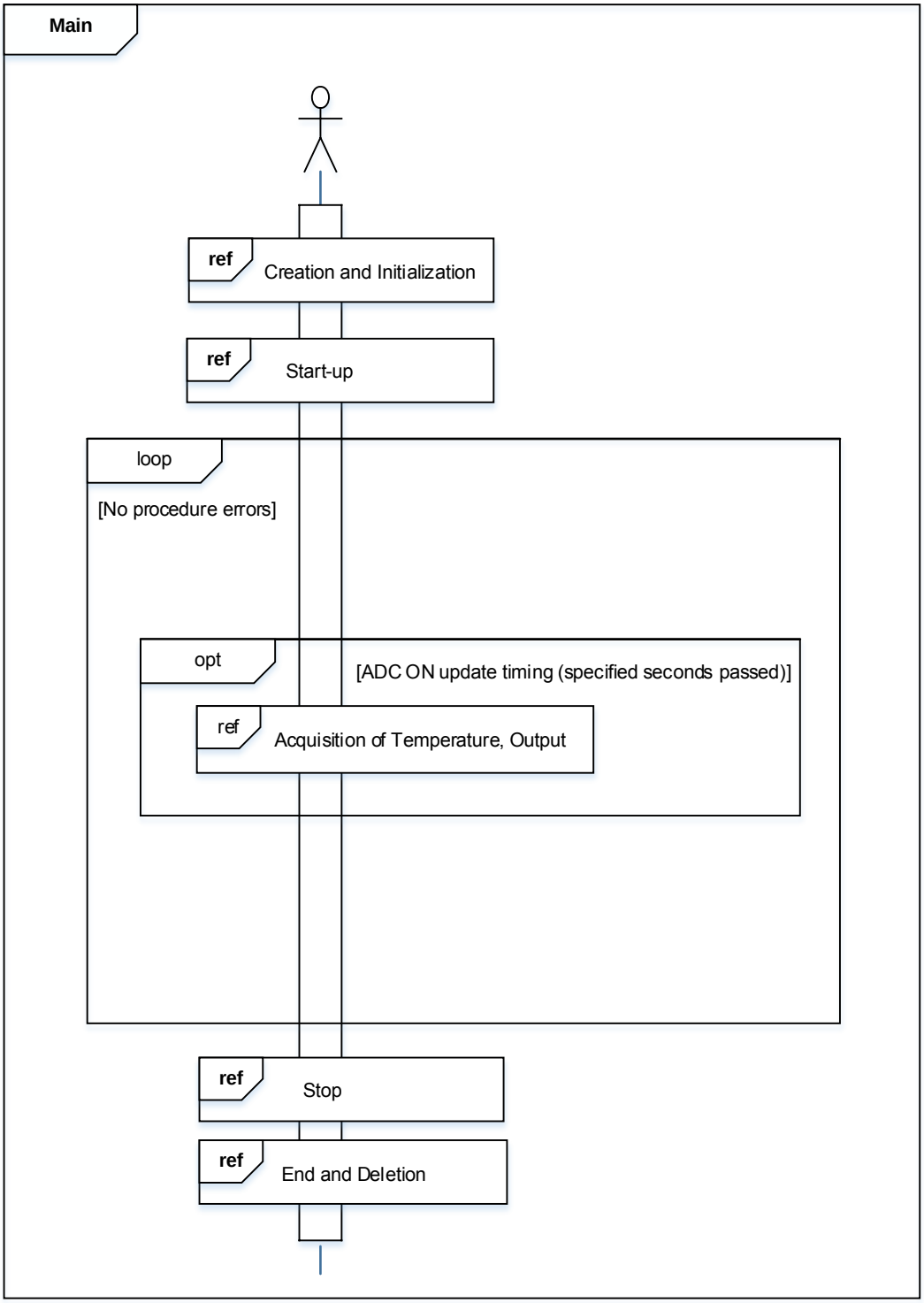
The ADC is initialized depending on the evaluation board.
The channel of the ADC can be changed by bps.c.

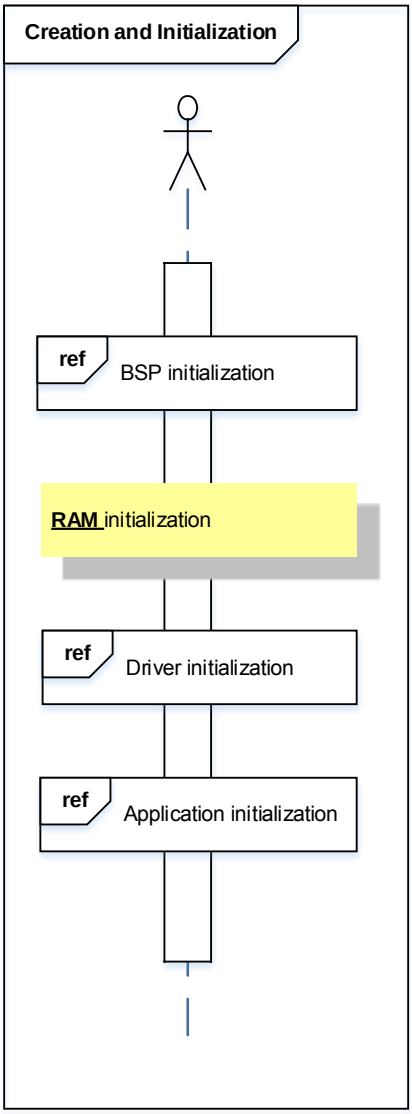
```
static const uint32_t thermistorsTbl[BSP_THERMISTORS_MAX][5] =
{
    {(uint32_t)GPIO_PORT_D, (uint32_t)GPIO_PORT_2, (uint32_t)(2), (uint32_t)(2), (uint32_t)(16)},
    {(uint32_t)GPIO_PORT_D, (uint32_t)GPIO_PORT_1, (uint32_t)(1), (uint32_t)(1), (uint32_t)(16)},
    {(uint32_t)GPIO_PORT_D, (uint32_t)GPIO_PORT_0, (uint32_t)(0), (uint32_t)(0), (uint32_t)(16)}
};
```

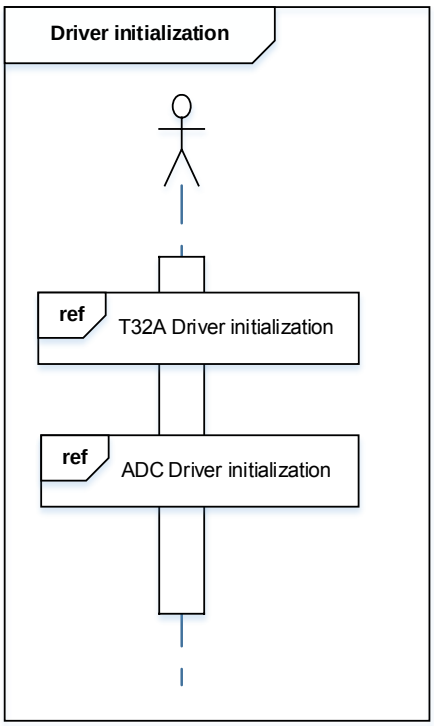
The above settings define Group of the ADC, PORT number, ADIN, AD ch, and the channel of DMAC.
The used ADC can be changed by the update of the above settings.
The third item sets the AD input channel.
The fourth item sets the AD channel.

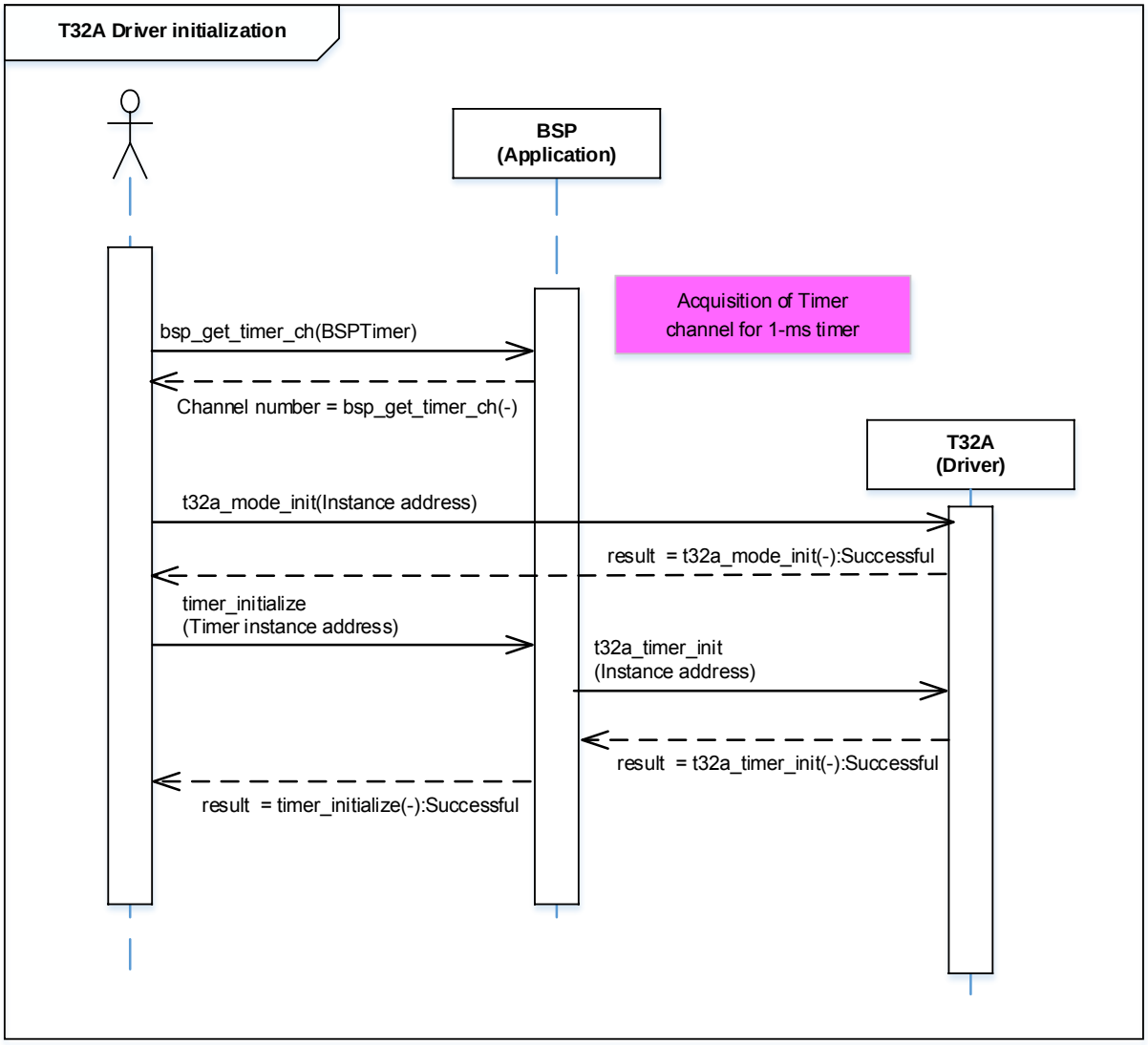
8.5. Operating Flow of Sample Program

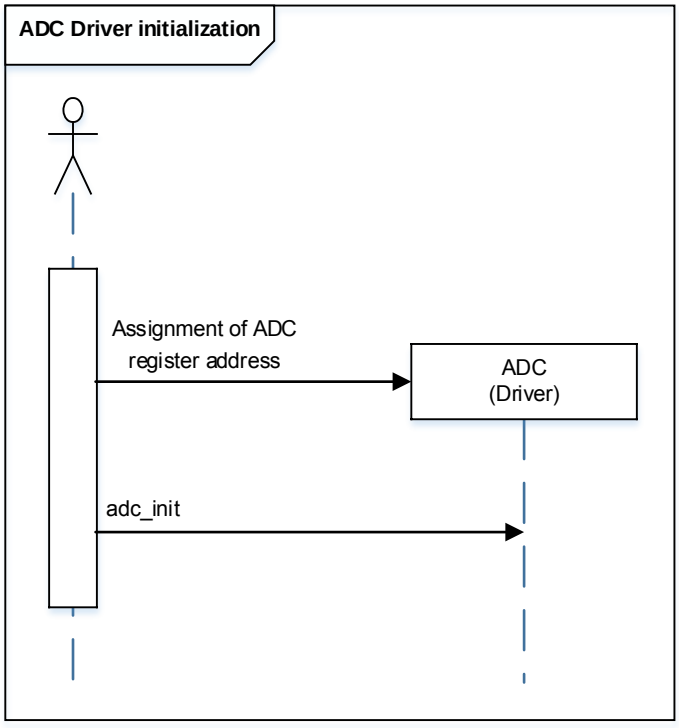
The operating flows of the sample program are shown as follows.

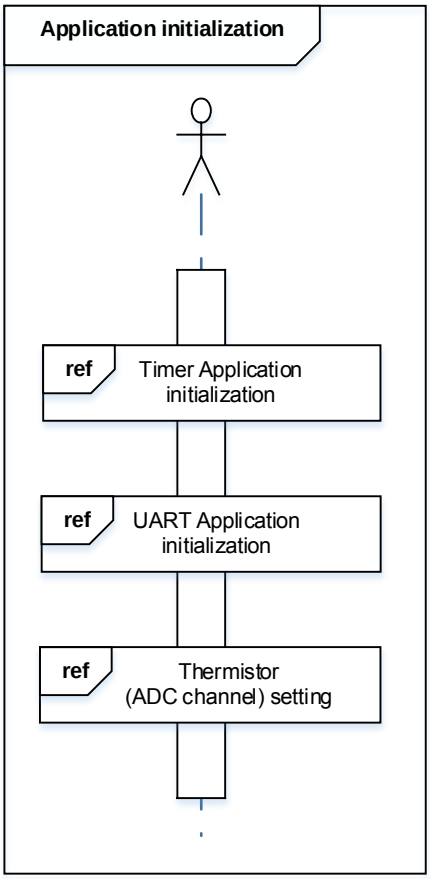


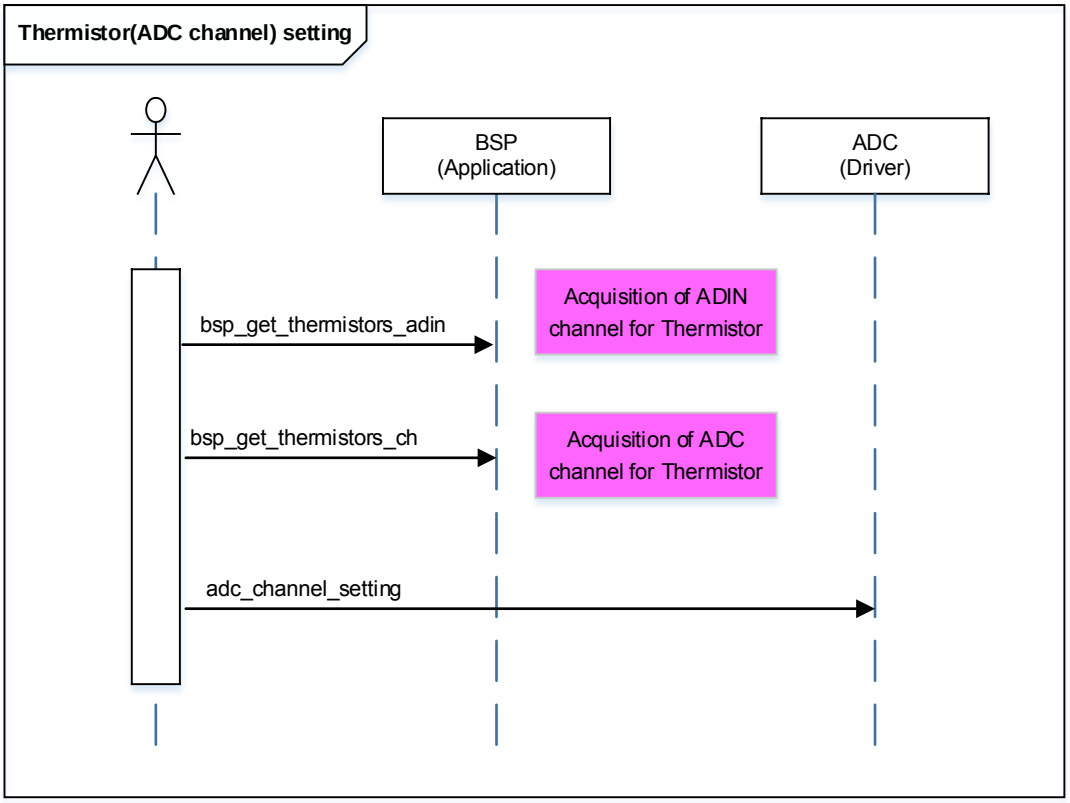

Creation and Initialization
ref
BSP initialization
RAM initialization
ref
Driver initialization
ref
Application initialization

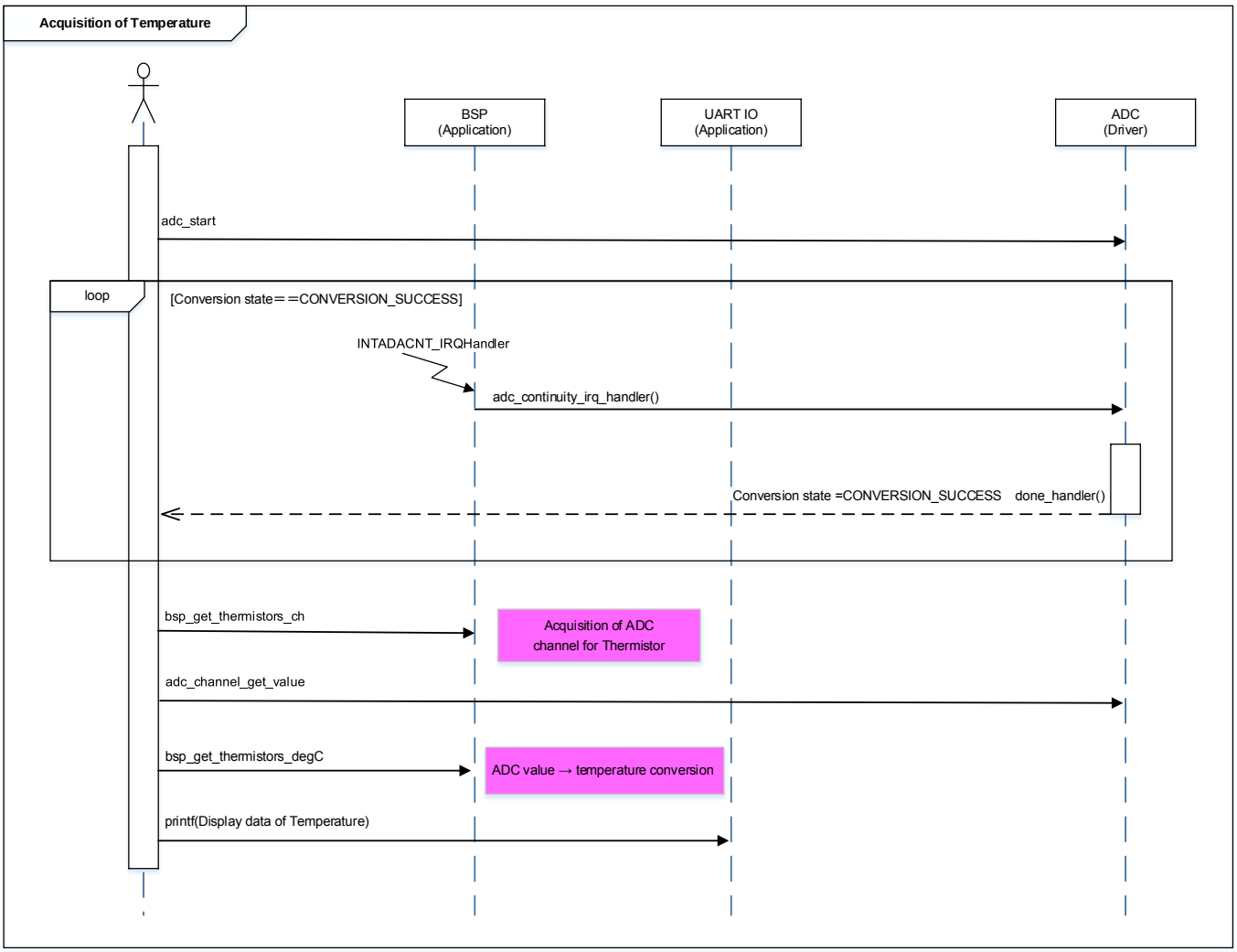

Driver initialization
ref
T32A Driver initialization
ref
ADC Driver initialization

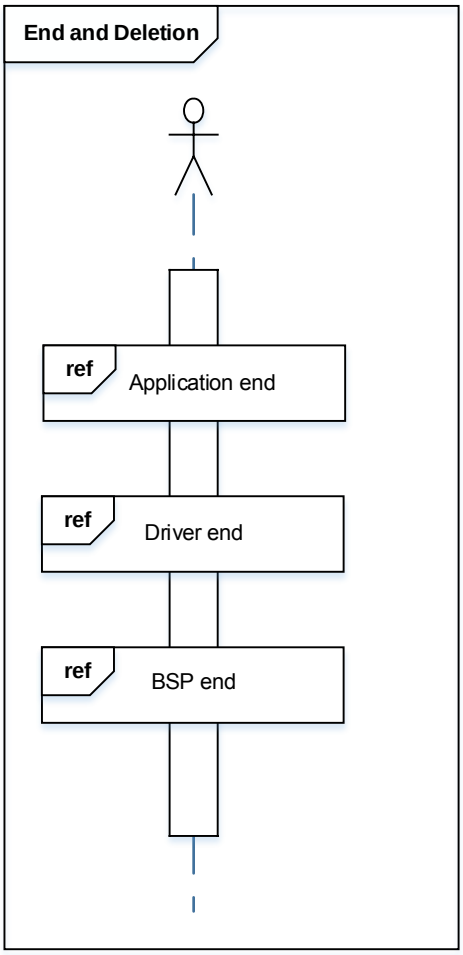

T32A Driver initialization
BSP
(Application)
Acquisition of Timer
channel for 1-ms timer
bsp_get_timer_ch(BSPTimer)
Channel number = bsp_get_timer_ch(-)
T32A
(Driver)
t32a_mode_init(Instance address)
result = t32a_mode_init(-):Successful
timer_initialize
(Timer instance address)
t32a_timer_init
(Instance address)
result = t32a_timer_init(-):Successful
result = timer_initialize(-):Successful

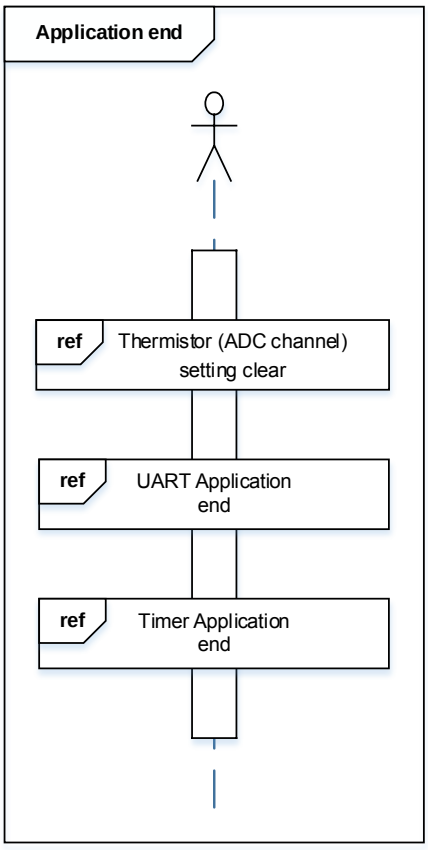

ADC Driver initialization
Assignment of ADC
register address
ADC
(Driver)
adc_init

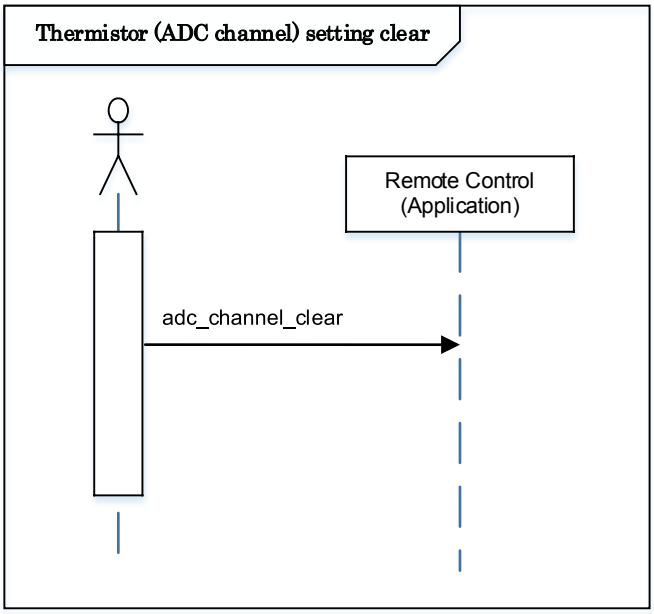

Application initialization
ref
Timer Application initialization
ref
UART Application initialization
ref
Thermistor (ADC channel) setting

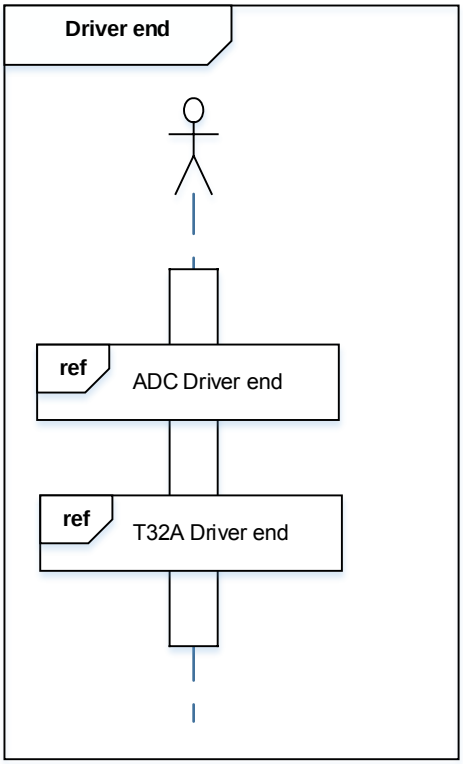

Thermistor(ADC channel) setting
BSP (Application)
ADC (Driver)
Acquisition of ADIN channel for Thermistor
bsp_get_thermistors_adin
Acquisition of ADC channel for Thermistor
bsp_get_thermistors_ch
adc_channel_setting

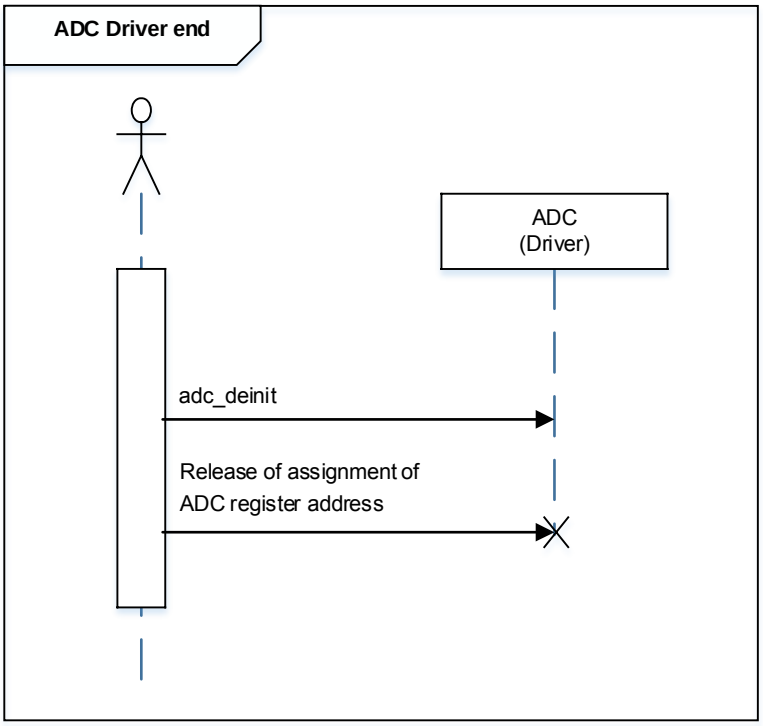

Acquisition of Temperature
BSP
(Application)
UART IO
(Application)
ADC
(Driver)
adc_start
loop
[Conversion state==CONVERSION_SUCCESS]
INTADACNT_IRQHandler
adc_continuity_irq_handler()
Conversion state =CONVERSION_SUCCESS
done_handler()
bsp_get_thermistors_ch
Acquisition of ADC
channel for Thermistor
adc_channel_get_value
bsp_get_thermistors_degC
ADC value → temperature conversion
printf(Display data of Temperature)

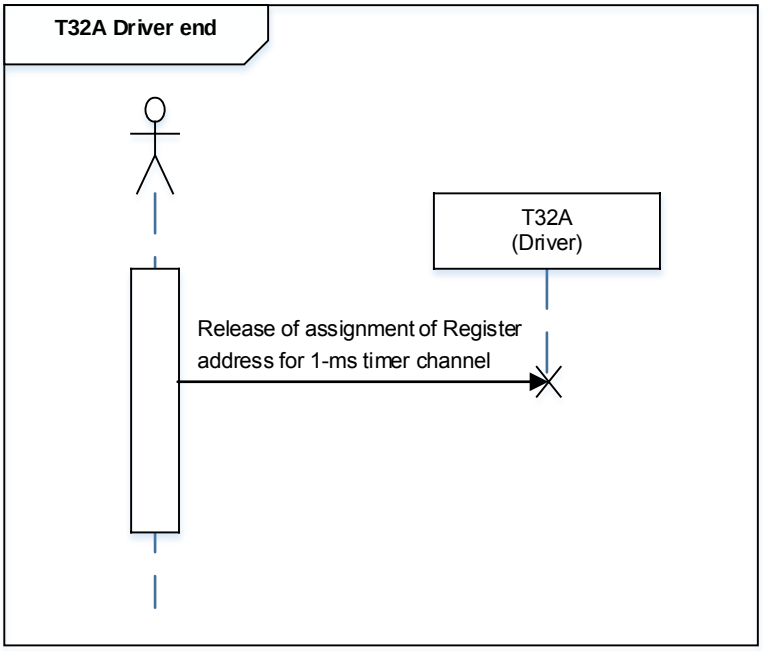

End and Deletion
ref
Application end
ref
Driver end
ref
BSP end


Application end
ref
Thermistor (ADC channel) setting clear
ref
UART Application end
ref
Timer Application end


Thermistor (ADC channel) setting clear
Remote Control
(Application)
adc_channel_clear


Driver end
ref
ADC Driver end
ref
T32A Driver end


ADC Driver end
ADC
(Driver)
adc_deinit
Release of assignment of
ADC register address


T32A Driver end
T32A
(Driver)
Release of assignment of Register
address for 1-ms timer channel

9. Precaution

When using the sample program with CPU other than TMPM3H6, please check operation sufficiently.

10. Revision History

Rev	Date	Page	Description
1.0	2018-03-22	-	First release

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