M4K Group (1)
Application Note
12-bit Analog to Digital Converter
(ADC-B)

Outlines

This application note is a reference material for developing products using the 12-bit analog to digital converter (ADC) function of M4K Group (1).
This document helps the user check operation of the product and develop its program.

Target sample program: ADC_VersionB_UART

Table of Contents

1. Preface

This sample program converts a voltage value generated by a variable resistor using the ADC. And the program can also display the converted digital value on the terminal software.

2. Reference Document

1. Datasheet
   TMPM4K Group (1) Datasheet Rev2.0 (Japanese edition)
2. Reference manual
   12-bit Analog to Digital Converter (ADC-B) Rev2.0 (Japanese edition)
   Asynchronous Serial Communication Circuit (UART-C) Rev3.0 (Japanese edition)
   32-bit Timer Event Counter (T32A-B) Rev3.0 (Japanese edition)
3. Application note
   M4K Group (1) Application Note Startup (CMSIS System & Clock Configuration) Rev1.0
4. Other reference document
   TMPM4KxA Group Peripheral Driver User Manual (Doxygen) V1.0.4.0

3. Function to Use

IP	Channel	Port	Function/Operation mode
Asynchronous Serial Communication Circuit	ch0	PK0 (UT0RXD) PK1 (UT0TXDA)	UART mode
12-bit Analog to Digital Converter	ch14 (Note)	PE4 (AINA14)	AD conversion (Single conversion operation mode)
	ch15 (Note)	PE5 (AINA15)	
32-bit Timer Event Counter	ch0	—	Interval timer

(Note) The ADC channel is the channel which is defined in the sample program.

4. Target Device

The target devices of this application note are as follows;

TMPM4K4FYAUG	TMPM4K4FWAUG	TMPM4K4FUAUG	TMPM4K4FSAUG
TMPM4K4FYAFG	TMPM4K4FWAFG	TMPM4K4FUAFG	TMPM4K4FSAFG
TMPM4K2FYADUG	TMPM4K2FWADUG	TMPM4K2FUADUG	TMPM4K2FSADUG
TMPM4K1FYAUG	TMPM4K1FWAUG	TMPM4K1FUAUG	TMPM4K1FSAUG
			TMPM4K0FSADUG

* This sample program operates on the evaluation board of TMPM4K4FYAUG.
If other function than the TMPM4K4 one is checked, it is necessary that CMSIS Core related files (the startup file and I/O header file) should be changed properly.
Additionally, the name of microcontroller which is set to the project should be changed.
The BSP related file is dedicated to the evaluation board (TMPM4K4FYAUG). If other function than the TMPM4K4 one is checked, the BSP related file should be changed properly.

5. Operation Confirmation Condition

Used microcontroller	TMPM4K4FYAUG
Used board	TMPM4K4 evaluation board (Product of ESP-kikaku Co. Ltd.)
Integrated development environment	IAR Embedded Workbench for ARM 8.22.2
Integrated development environment	Arm® Keil® MDK Version 5.24.2.0
Terminal software	Tera Term V4.96
Sample program	v1.0.0

6. Operation of Evaluation Board

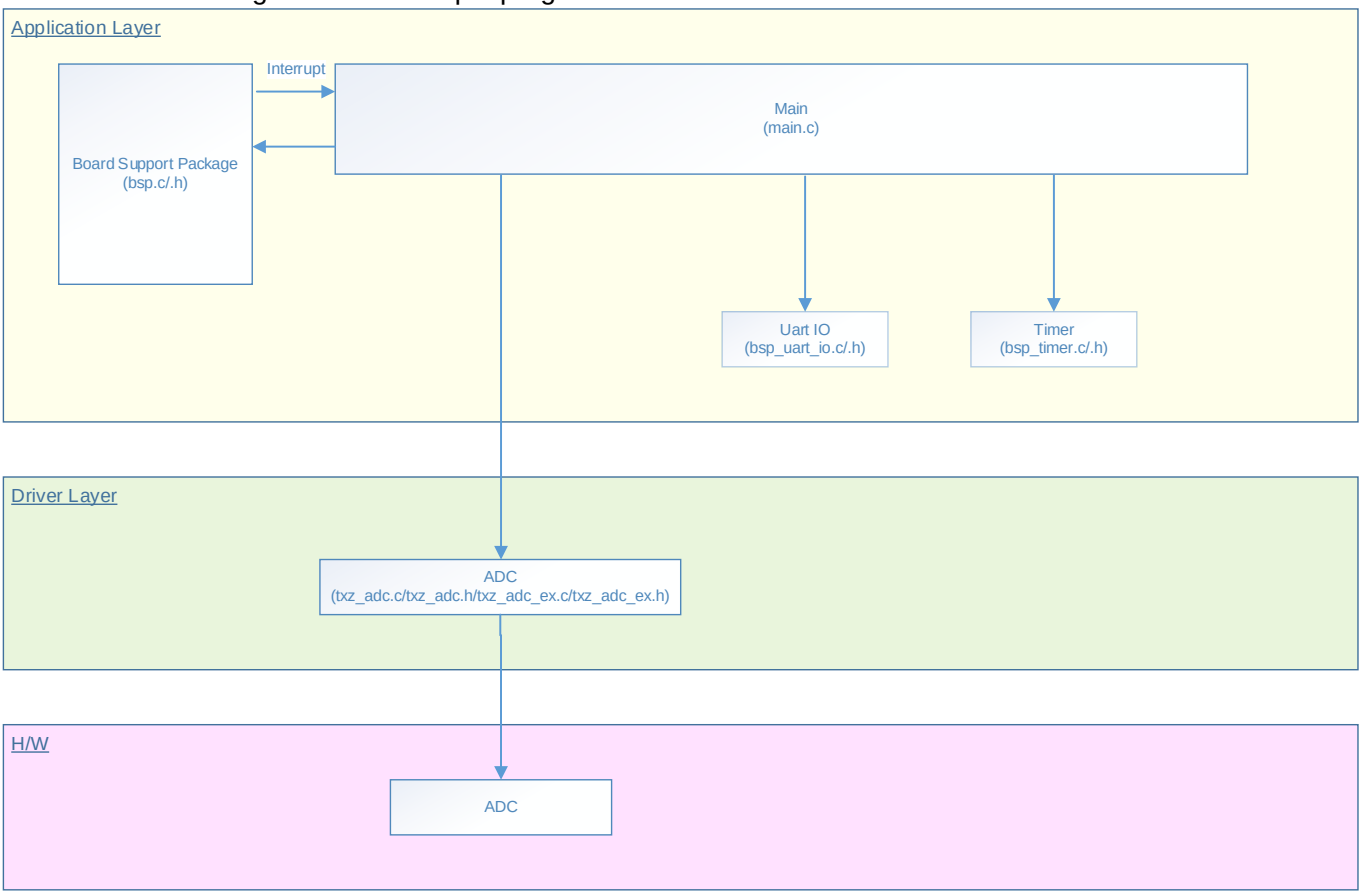
The USB_UART connecter should be connected to a PC for communication with the terminal software.
The output of the AD converted value is displayed on the terminal software every interval set in the terminal software.

This sample program can use 2 channels of the ADC.
The other input pin of the ADC (PE5) is connected to VDD.

7. Sample Program

7.1. Structure Diagram of Sample Program

The structure diagram of the sample program is shown below.



7.2. Startup Routine

The following initialization is done after power is supplied.
The initialization of each clock setting and the initialization of the watchdog timer setting are done.

7.3. Main Operation

The initialization of the BSP is done.
The initialization of the variables is done.
The initialization of the driver is done.
The initialization of the timer, the initialization of the USB_UART, and the initialization of the AD input are done as the initialization of the application software.

The Timer starts.
The input voltage from the ADIN input pin is converted.
The converted result is displayed on the Tera Term via the UART.

7.4. Setting of AIN Channels of ADC

When the used AIN input pin is changed, the following in the bsp.c file should be modified properly.

```
static const uint32_t potentiometersTbl[BSP_POTENTIOMETERS_MAX][4] =
{
    {(uint32_t)GPIO_PORT_E, (uint32_t)GPIO_PORT_4, (uint32_t)(14), (uint32_t)(14)},
    {(uint32_t)GPIO_PORT_E, (uint32_t)GPIO_PORT_5, (uint32_t)(15), (uint32_t)(15)},
};
```

The setting of 2 channel inputs of the ADC is available in this sample program as shown above.
It, however, should be noted that the only one ADC input is available on the evaluation board in the operation confirmation condition.
PE5 is connected to VDD. The input voltage on the PE5 pin is converted to “FFF”.

7.5. Setting of Interval Time

The interval time of the display update of the converted output can be modified by changing CFG_OUTPUT_INTERVAL in the main.c.

```
#define CFG_OUTPUT_INTERVAL             ((uint32_t)5000)
```

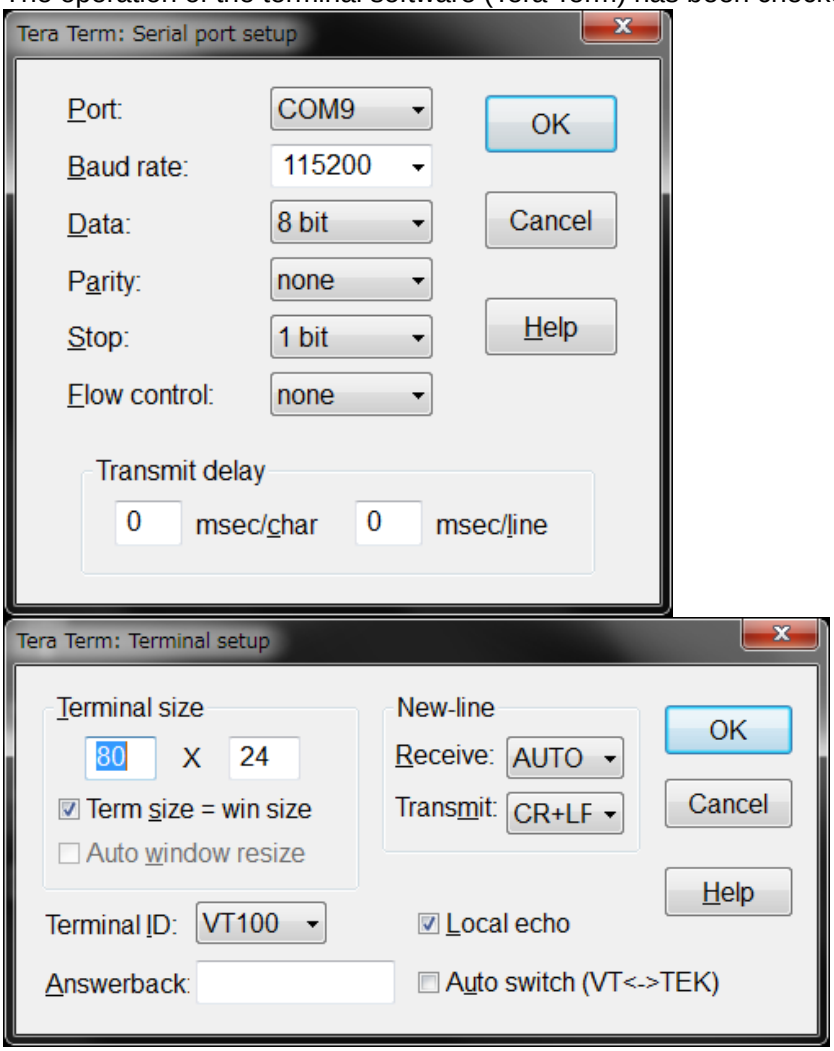
When the value “5000” is modified to another proper value, the interval time of the display update is changed.

7.6. Output Example of Terminal Software

When the sample program is executed, the output value of the ADC is displayed.
The display is updated frequently (every 5 seconds as default).

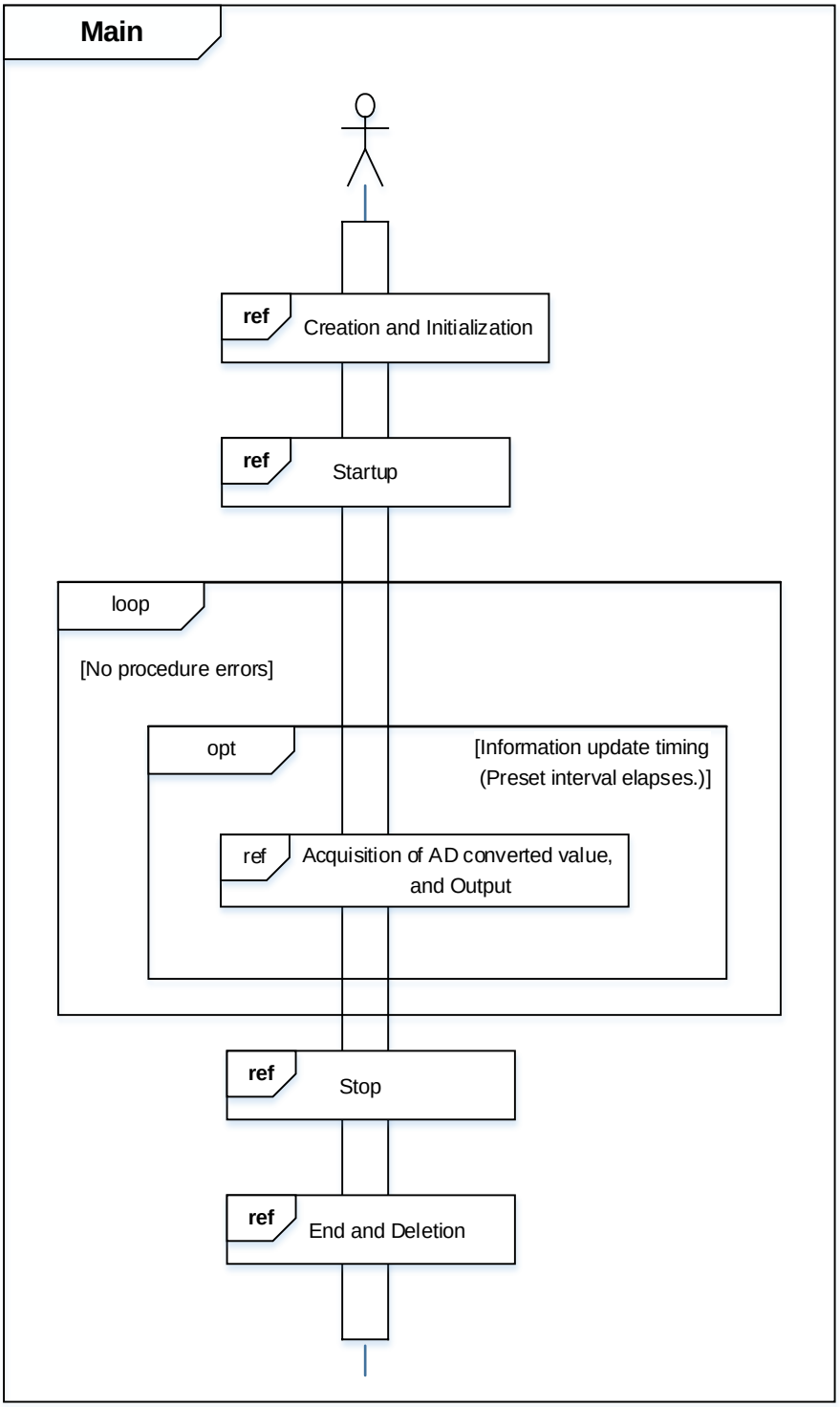
7.6.1. Setting Example of Terminal Software

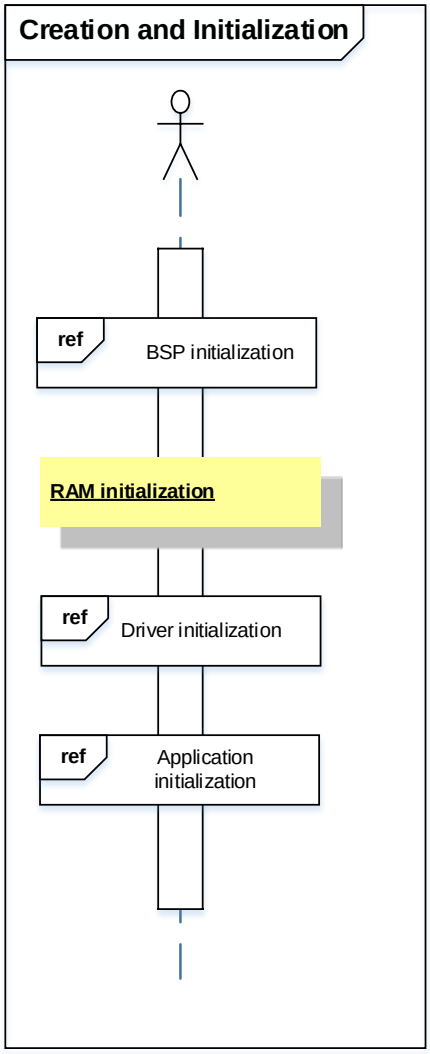
The operation of the terminal software (Tera Term) has been checked with the following settings.

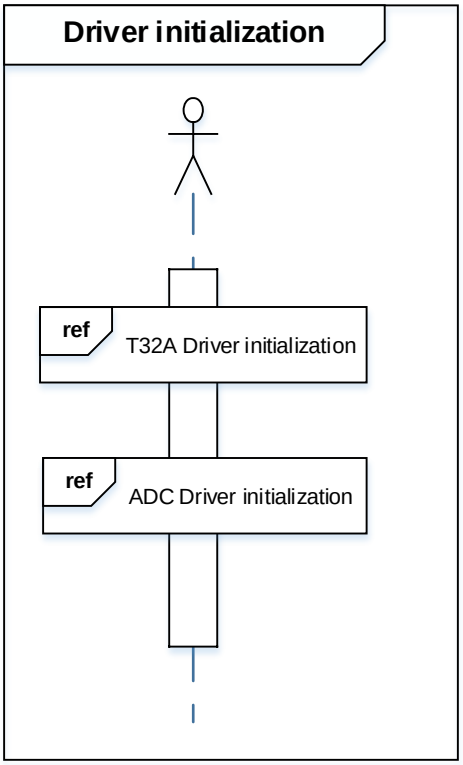


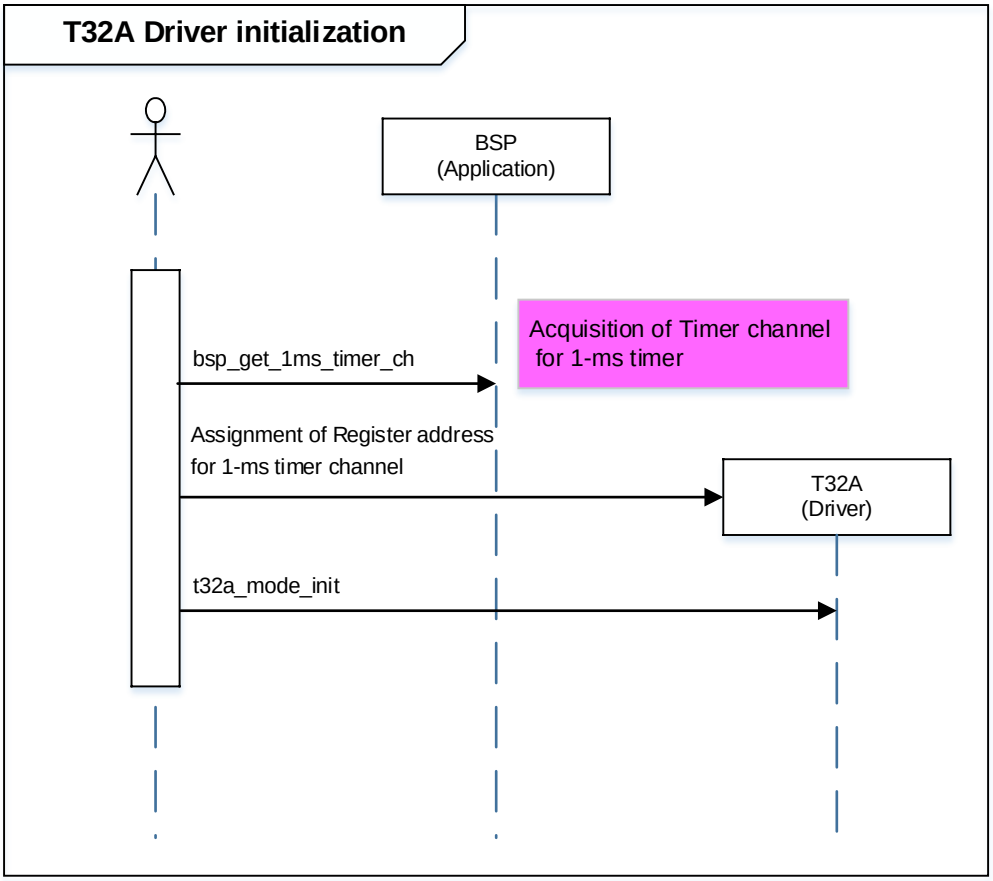
7.7. Operating Flow of Sample Program

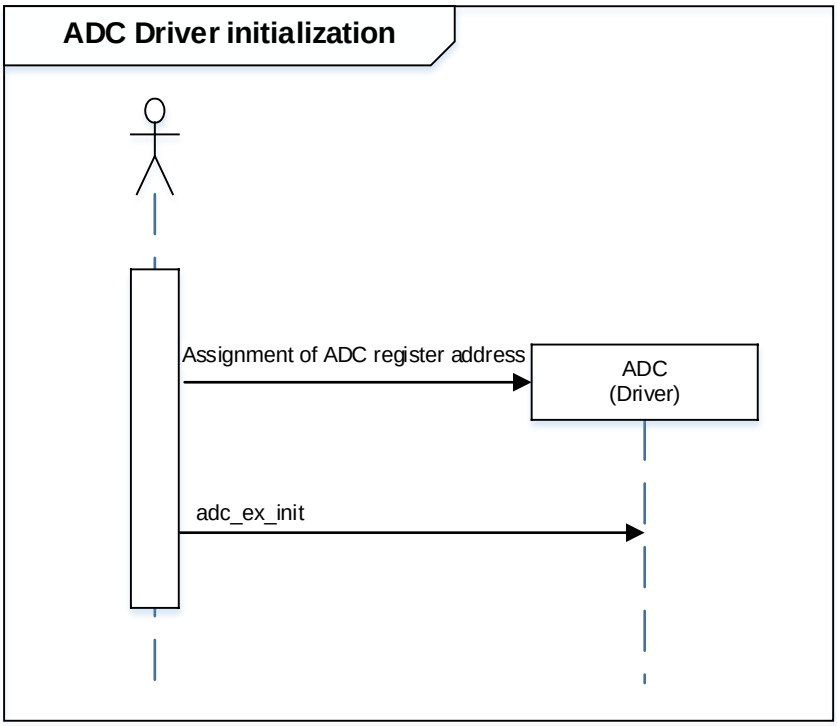
The basic operating flows of the sample program are shown in the following;

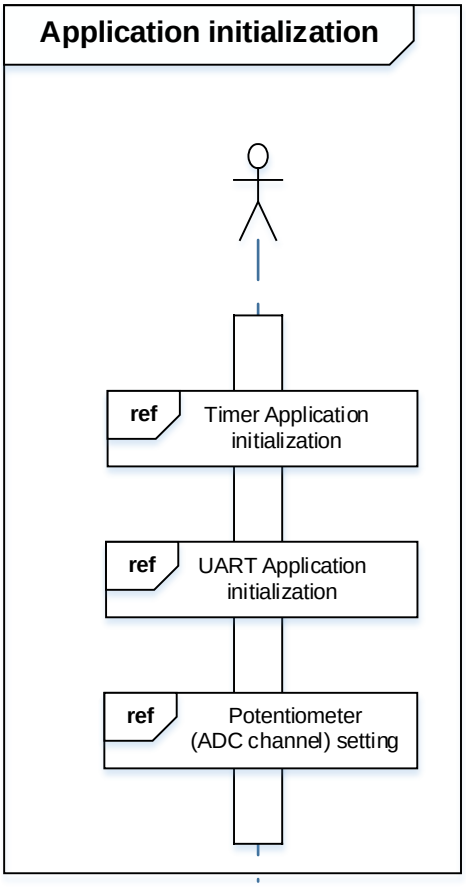


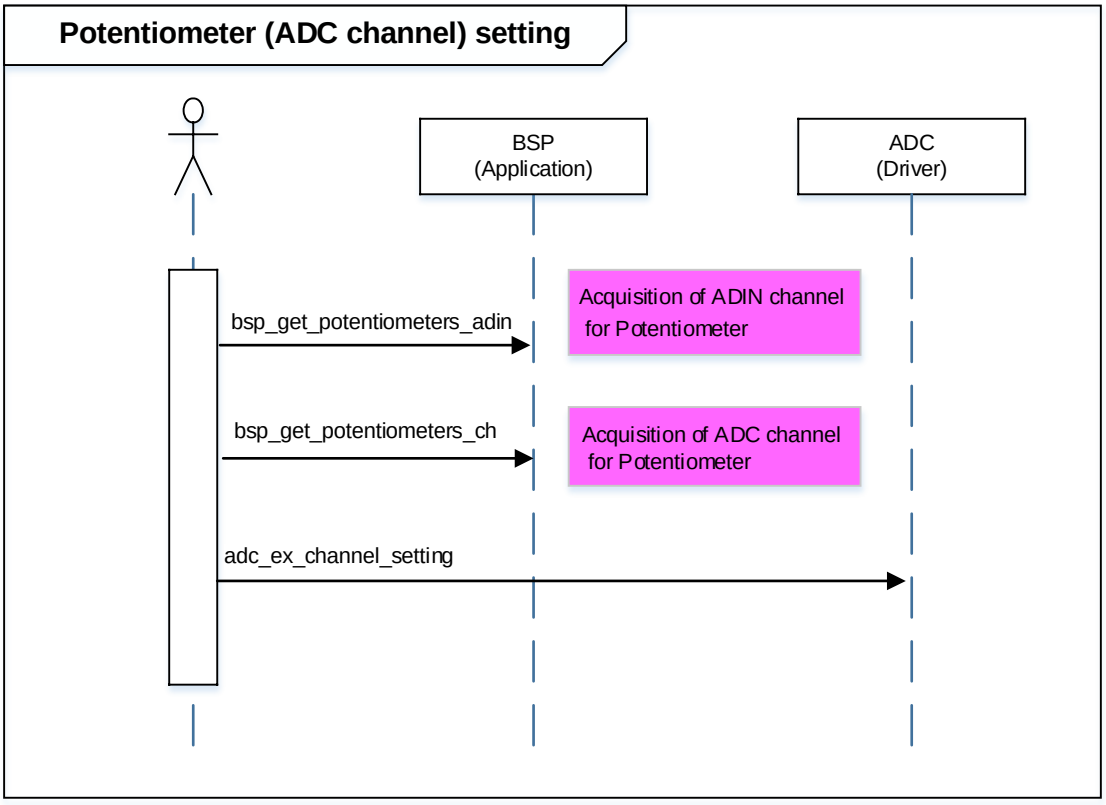

Creation and Initialization
ref
BSP initialization
RAM initialization
ref
Driver initialization
ref
Application initialization

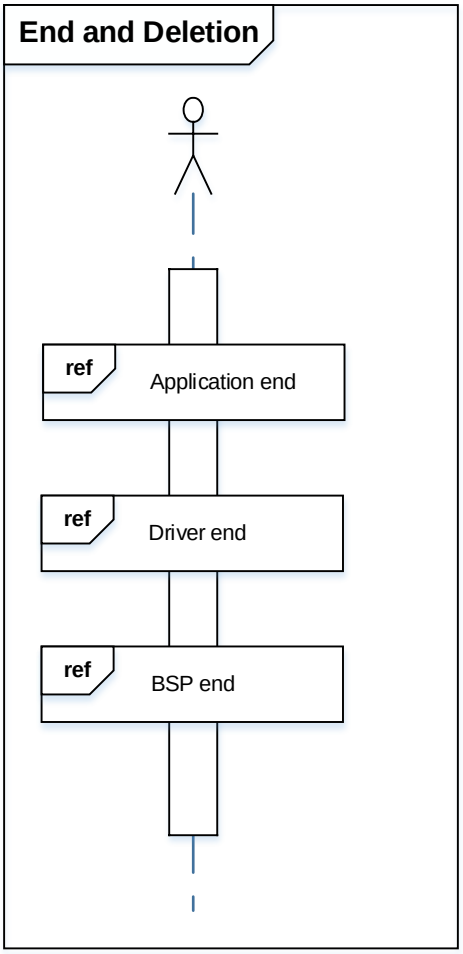

Driver initialization
ref
T32A Driver initialization
ref
ADC Driver initialization

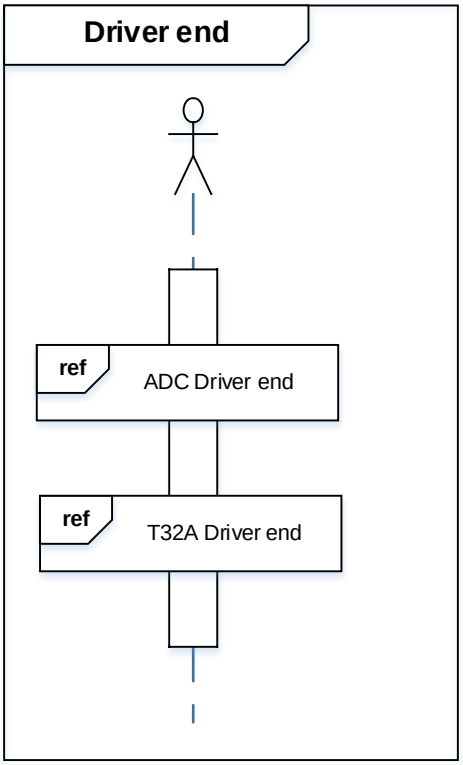

T32A Driver initialization
BSP
(Application)
Acquisition of Timer channel
for 1-ms timer
bsp_get_1ms_timer_ch
Assignment of Register address
for 1-ms timer channel
T32A
(Driver)
t32a_mode_init

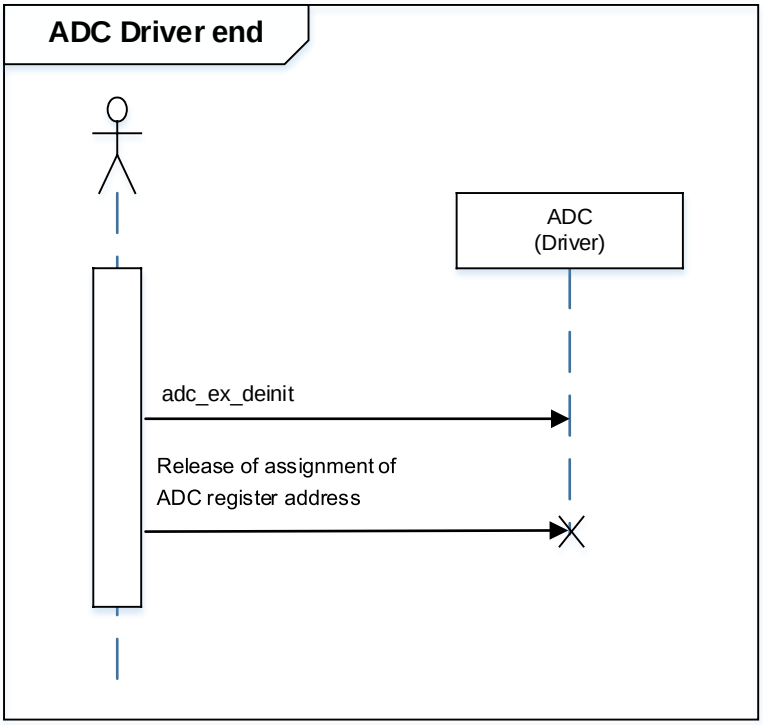

ADC Driver initialization
Assignment of ADC register address
ADC
(Driver)
adc_ex_init

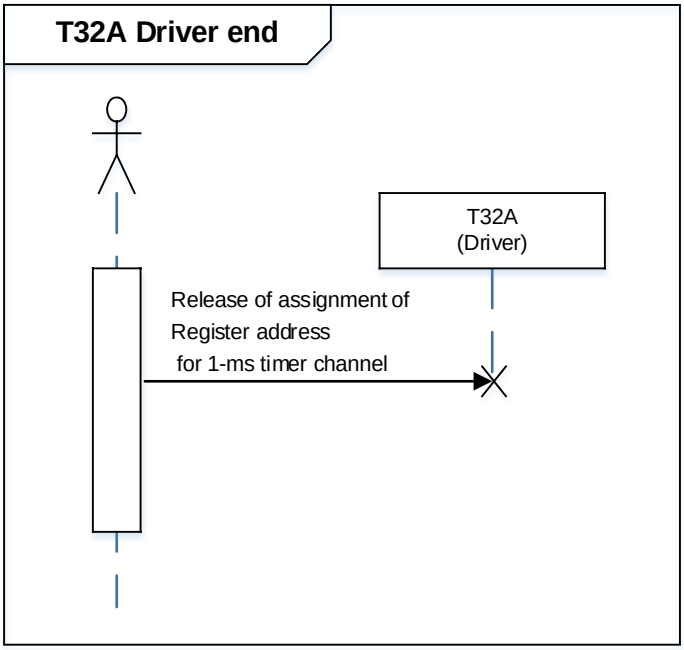

Application initialization
ref
Timer Application initialization
ref
UART Application initialization
ref
Potentiometer (ADC channel) setting

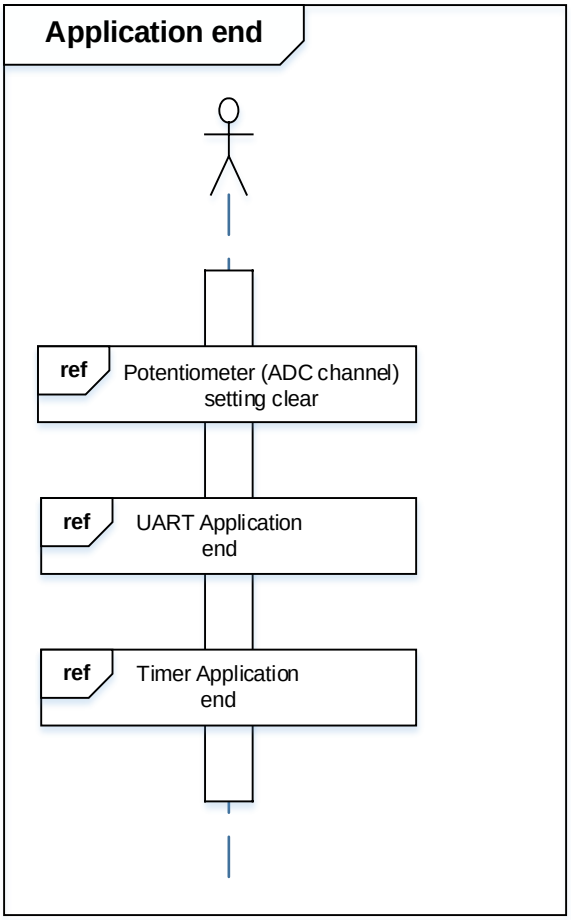

Potentiometer (ADC channel) setting
BSP (Application)
ADC (Driver)
Acquisition of ADIN channel for Potentiometer
bsp_get_potentiometers_adin
Acquisition of ADC channel for Potentiometer
bsp_get_potentiometers_ch
adc_ex_channel_setting

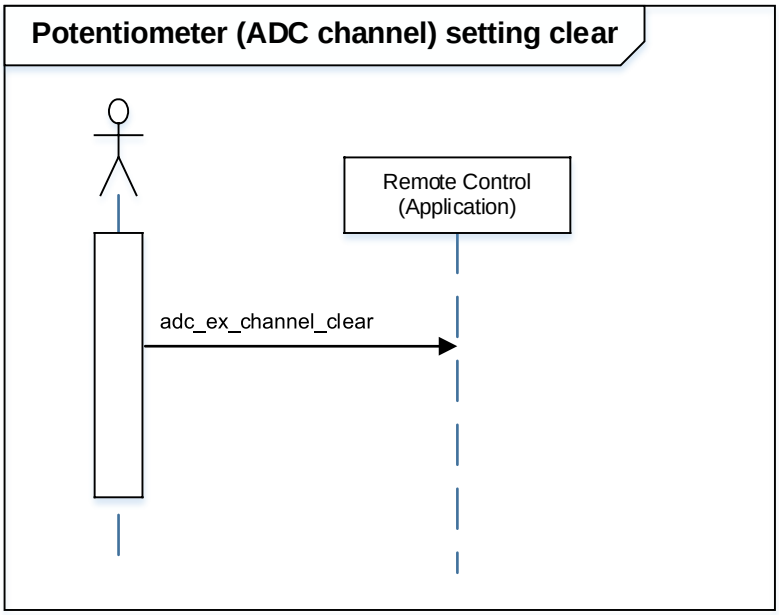

End and Deletion
ref
Application end
ref
Driver end
ref
BSP end

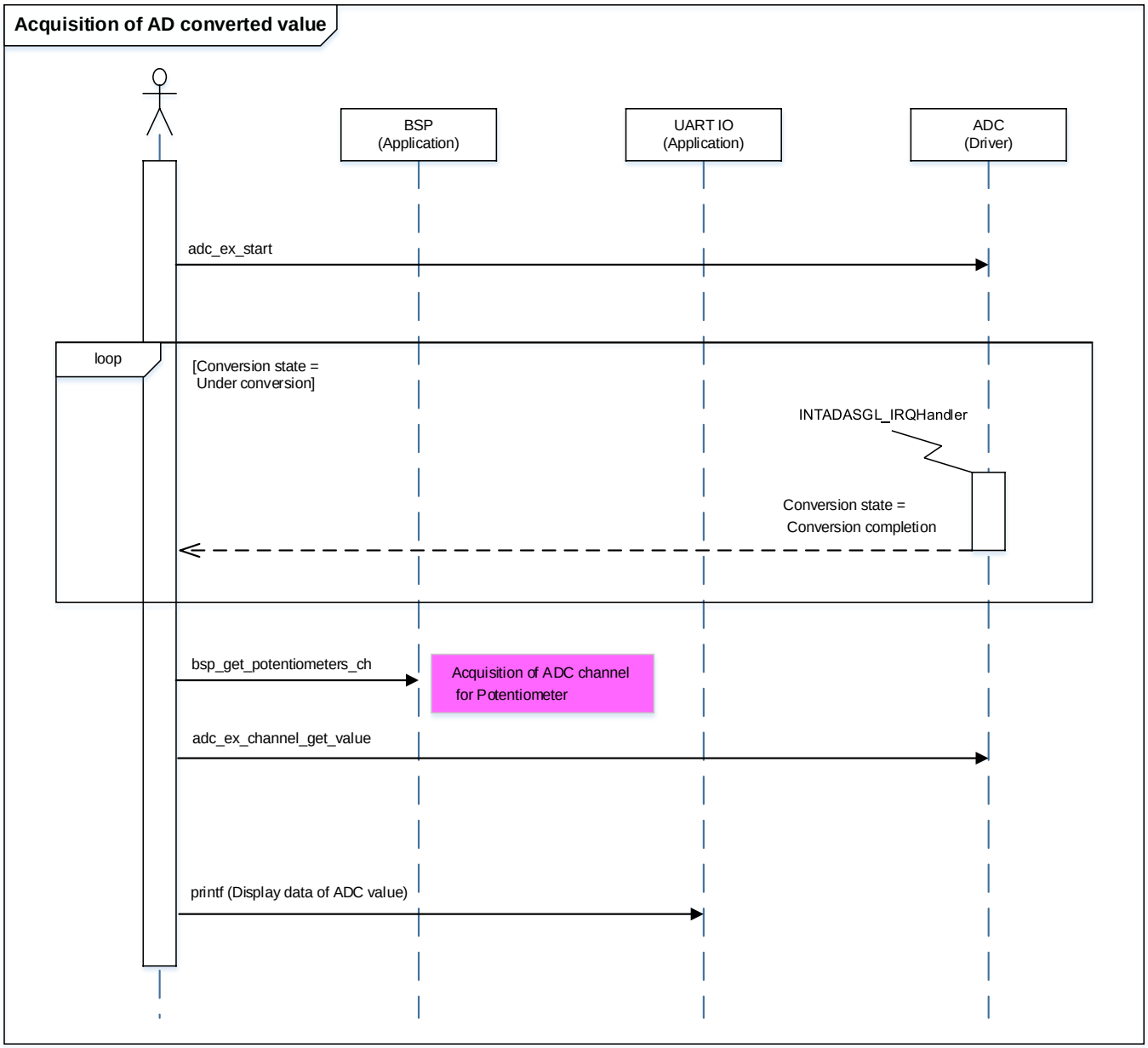

Driver end
ref
ADC Driver end
ref
T32A Driver end


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


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


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


Potentiometer (ADC channel) setting clear
Remote Control (Application)
adc_ex_channel_clear


Acquisition of AD converted value
BSP
(Application)
UART IO
(Application)
ADC
(Driver)
adc_ex_start
loop
[Conversion state =
Under conversion]
INTADASGL_IRQHandler
Conversion state =
Conversion completion
bsp_get_potentiometers_ch
Acquisition of ADC channel
for Potentiometer
adc_ex_channel_get_value
printf (Display data of ADC value)

8. Points to Remember on Handling of Sample Programs

When using the sample program with other than “Operation Confirmation Condition“, please check the operation sufficiently.

9. Revision History

Revision	Date	Description
1.0	2019-10-08	First release

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