M4K Group (1)
Application Note
Asynchronous Serial Communication Circuit (UART-C)
DMA

Outlines

This application note is a reference material for developing products using the Asynchronous serial communication circuit (UART with DMA) function of M4K Group (1).
This document helps the user check operation of the product and develop its program.

Target sample program: UART Echo DMA

Table of Contents

1. Preface

This sample program is use to check the operation of the UART communication function using the DMA. Data input from the terminal software on a PC is stored to the memory via the USB-UART interface. The data stored in the memory is transferred and echoed back by the DMAC control.

2. Reference Document

1. Datasheet
   TMPM4K Group (1) datasheet Rev2.0 (Japanese edition)
2. Reference manual
   Asynchronous Serial Communication Circuit (UART-C) Rev3.0 (Japanese edition)
   DMA Controller (DMAC-B) Rev2.0 (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
DMA Controller	ch8 ch9	–	Unit normal transfer

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

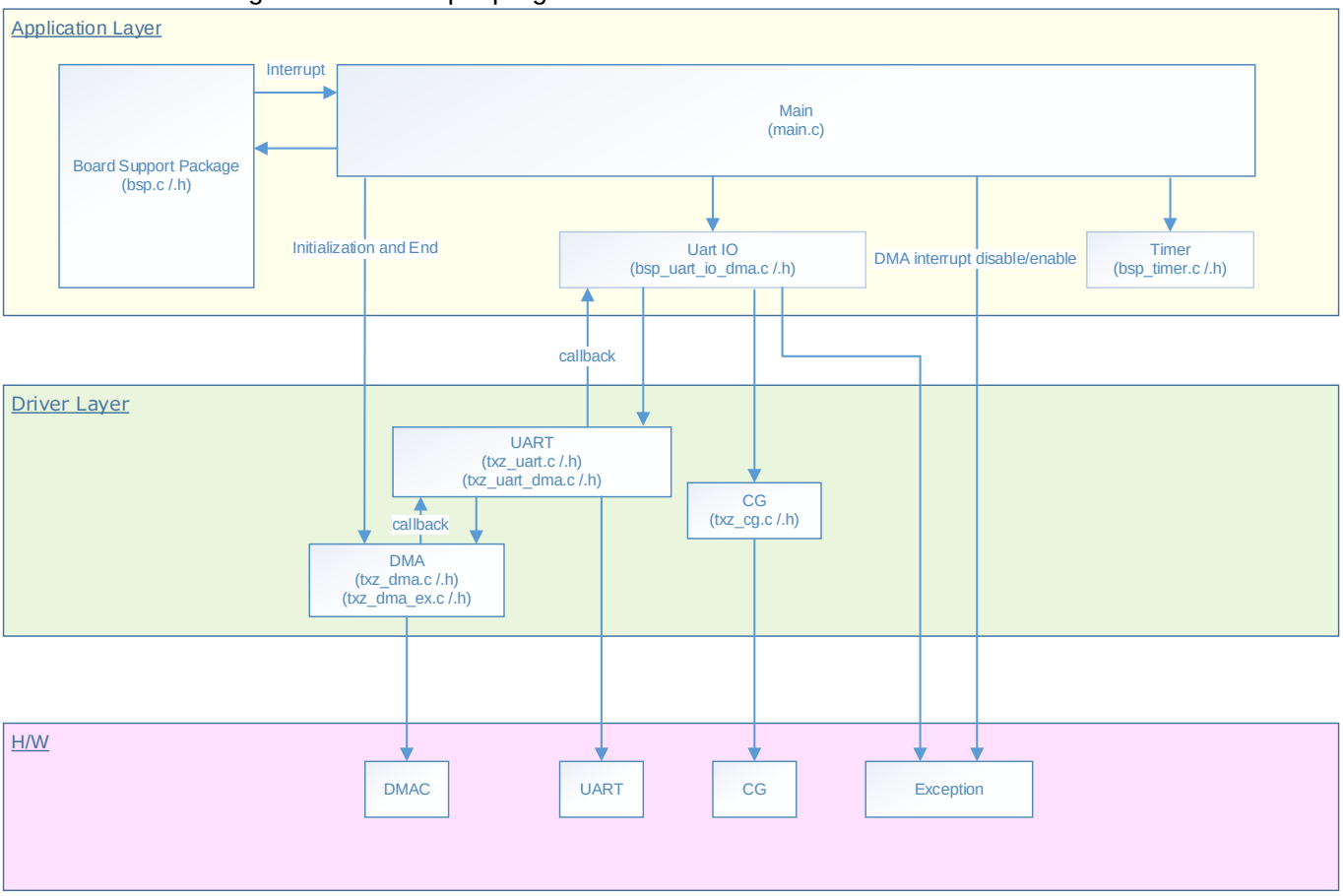
6. Evaluation Board Operation

A PC should be connected with the USB_UART connector to communicate with the terminal software. When a character is input to the terminal software, the input character is echoed back to the terminal software.

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 should be done.
The initialization of the variables should be done.
The initialization of the T32A driver and the initialization of the DMA driver should be done as the initialization of the drivers.
The initialization of the Timer and the initialization of the USB_UART should be done as the initialization of the application software.
The interrupt of the DMA should be enabled.

The Timer is started.
"Input =" is displayed on the terminal software on the PC. The sample program waits for an input.
When a line feed code is detected, an input character is displayed after “Echo =” as the echo-back character.
After that, the sample program waits for an input. The operations above repeat.

The DMA is used for the data transmission and reception.
The reception is done as a single transmission. The transmission is done as a burst transmission.
The maximum size of the input data is 32 bytes.
When the size of the input characters exceeds the maximum value, “Input Error !!" is displayed.

7.4. Output Example of Terminal Software

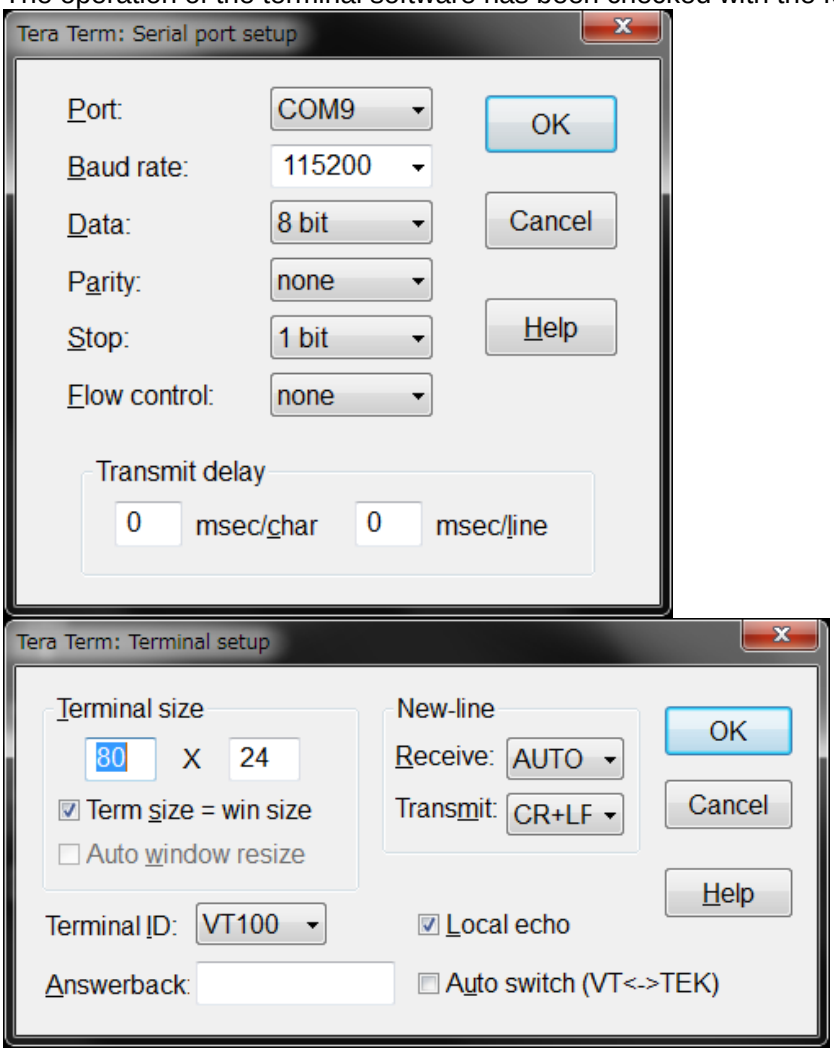
When the sample program is executed, the command result is displayed as follows;

```
Input = 012345
 Echo = 012345
Input = 01234567890123456789012345678 9
 Echo = 01234567890123456789012345678 9
Input = 012345678901234567890123456789 01

 Input Error !!
Input =  Echo =
Input =
```

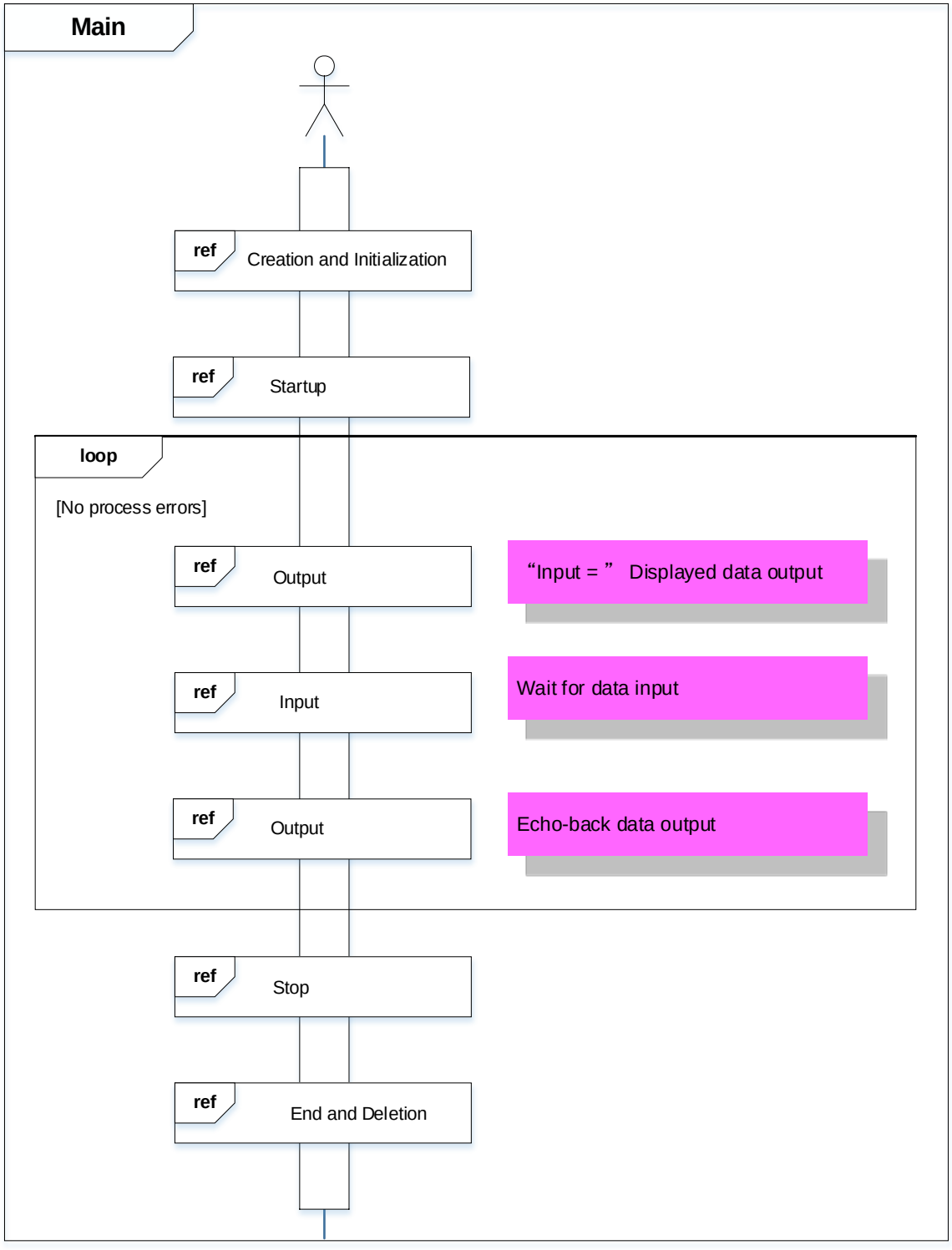
7.4.1. Setting Example of Terminal Software

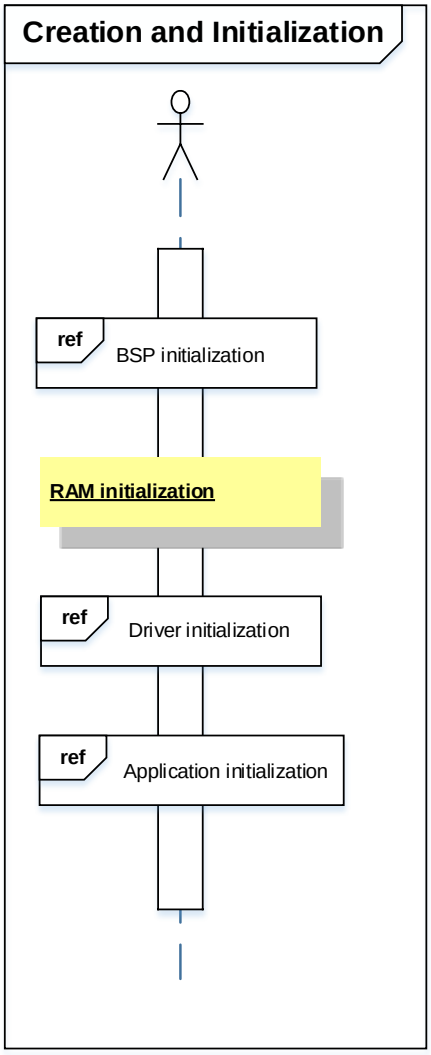
The operation of the terminal software has been checked with the following settings.

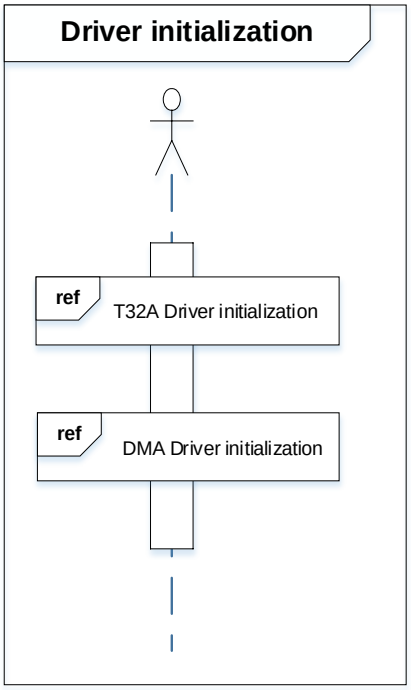


7.5. Operating Flow of Sample Program

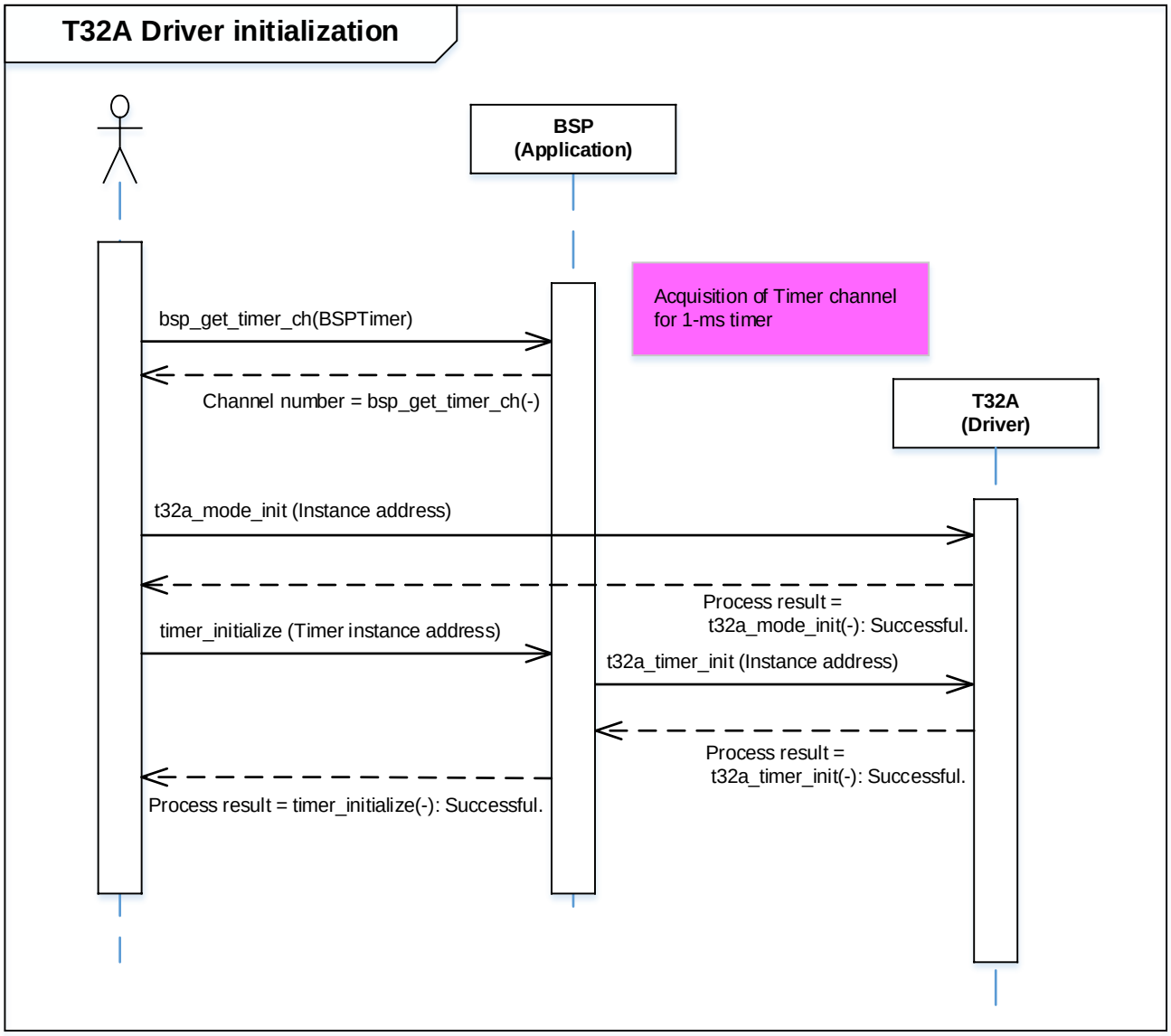
The basic operating flows of the sample program are shown in the following;

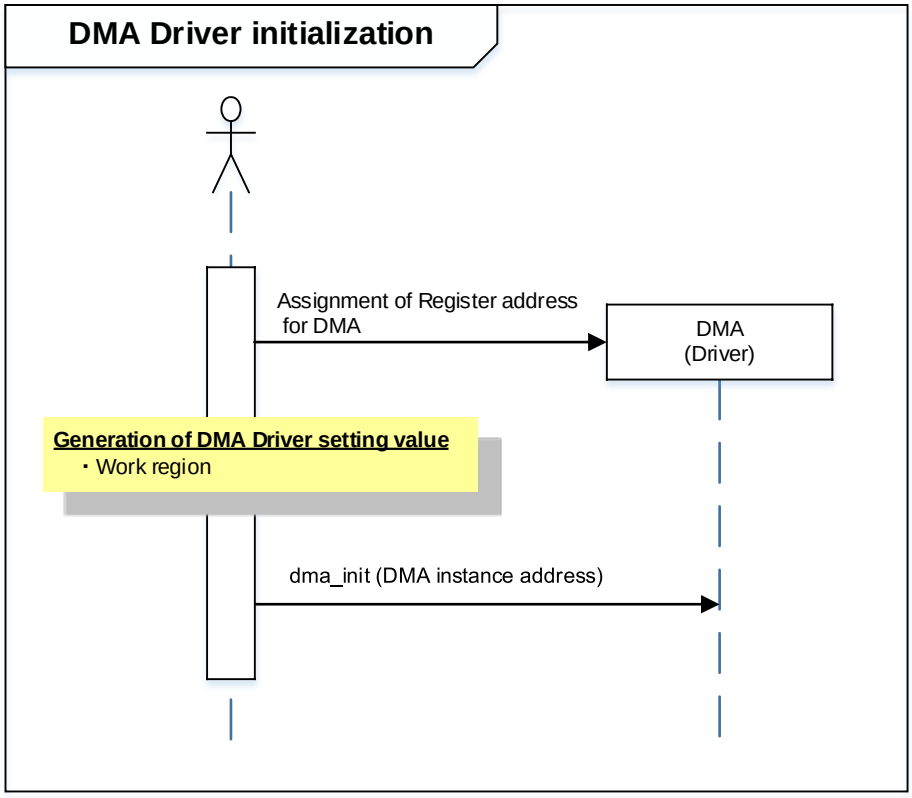


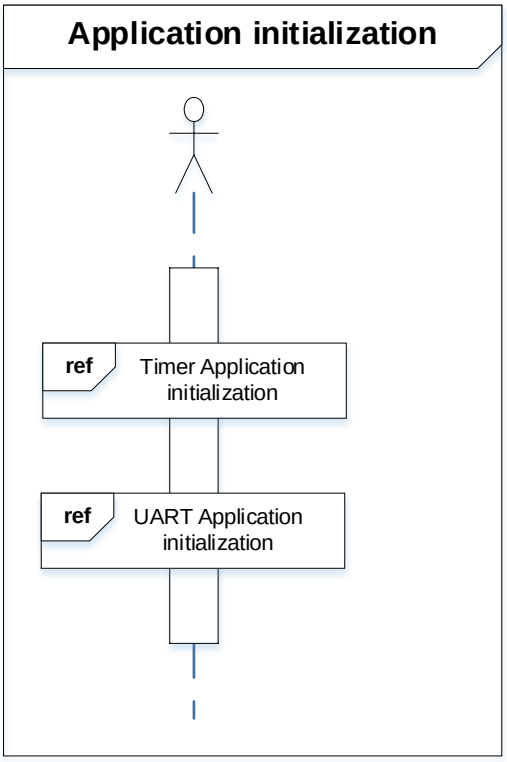

Creation and Initialization
ref
BSP initialization
RAM initialization
ref
Driver initialization
ref
Application initialization

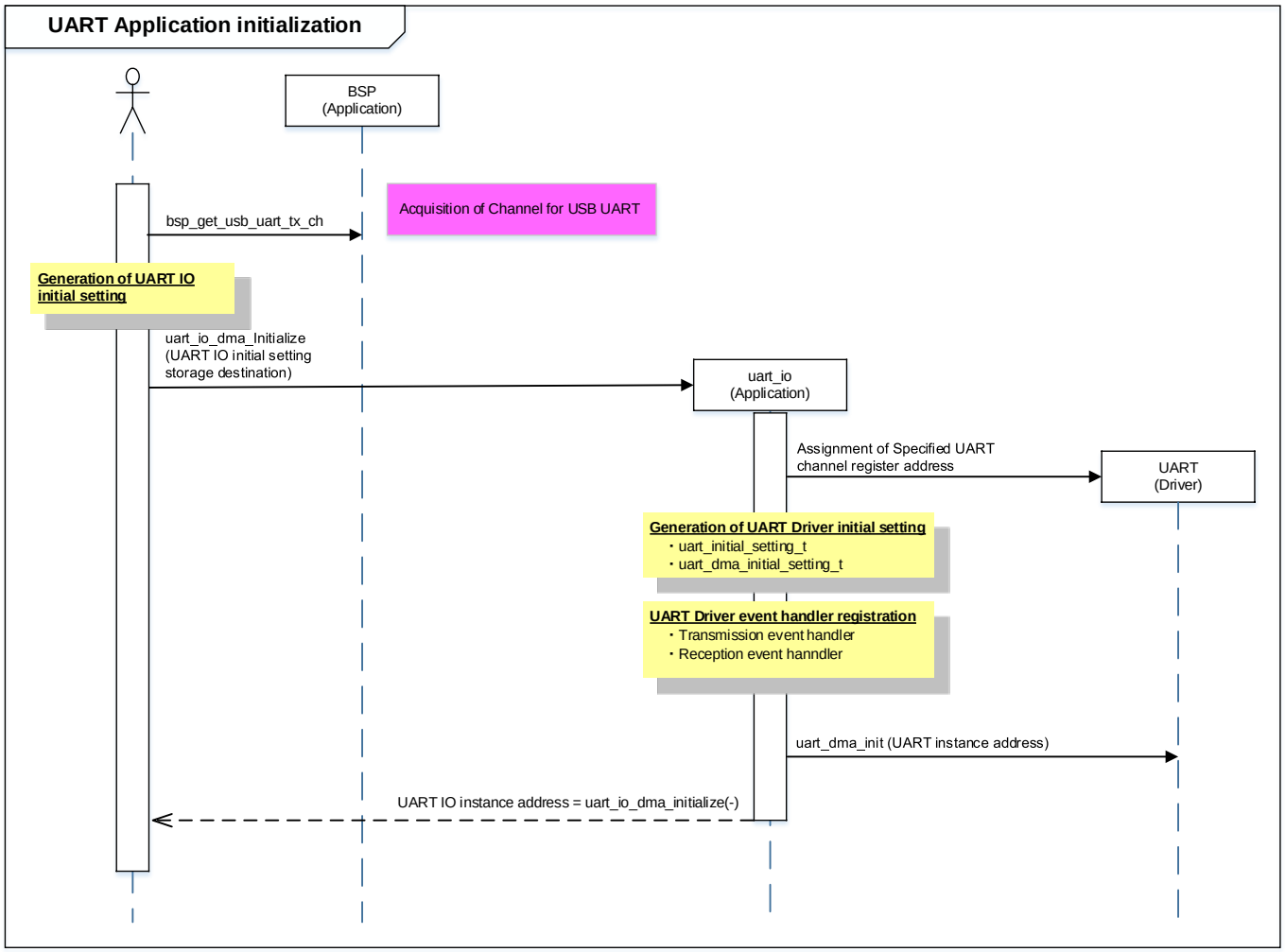

Driver initialization
ref
T32A Driver initialization
ref
DMA Driver initialization

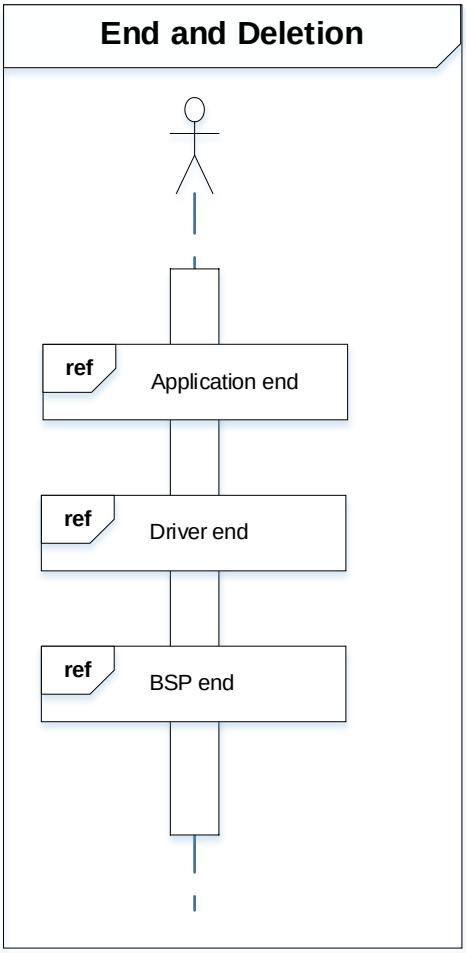
The 32-bit timer event counter of TMPM4K4A is running, but processing using timer count is not performed.

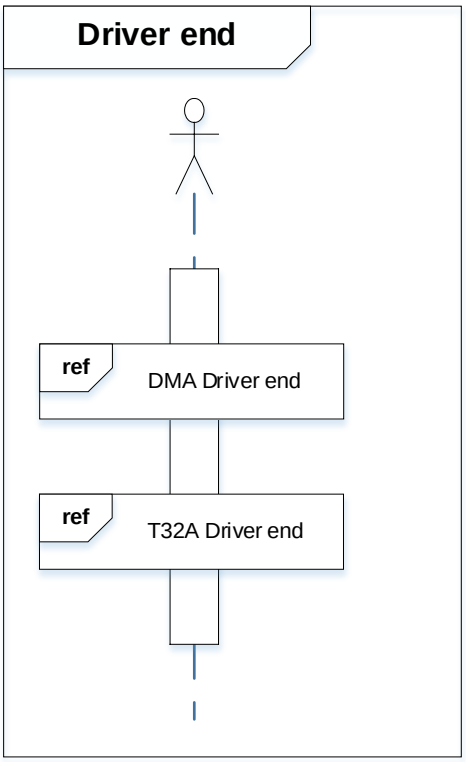


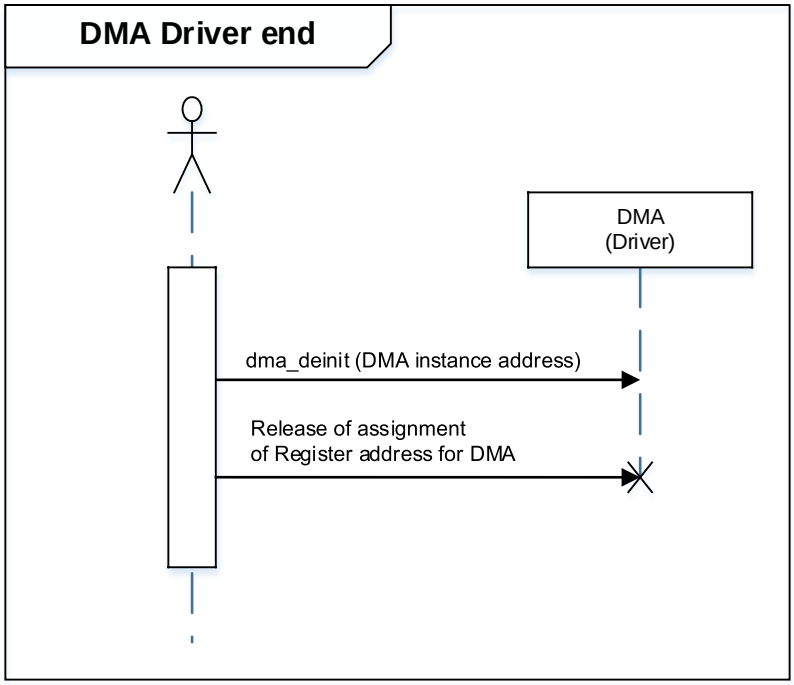

DMA Driver initialization
Assignment of Register address for DMA
DMA (Driver)
Generation of DMA Driver setting value
・Work region
dma_init (DMA instance address)

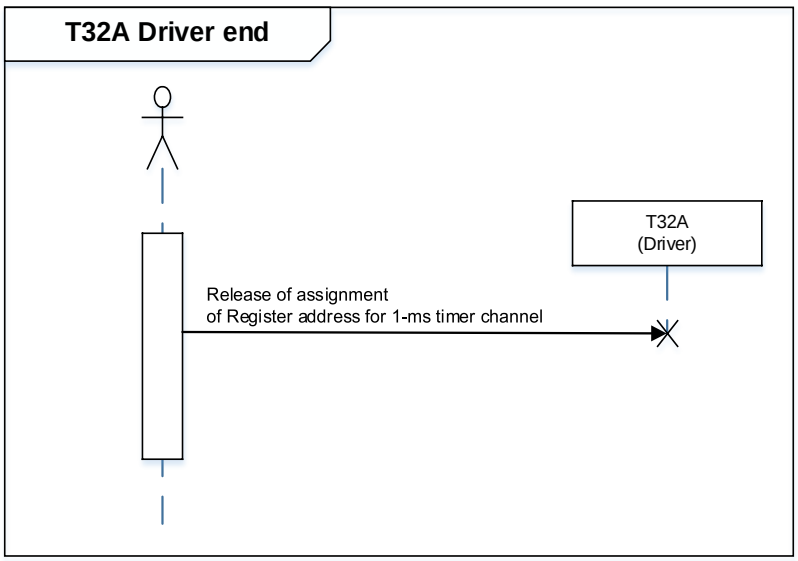

Application initialization
ref
Timer Application initialization
ref
UART Application initialization

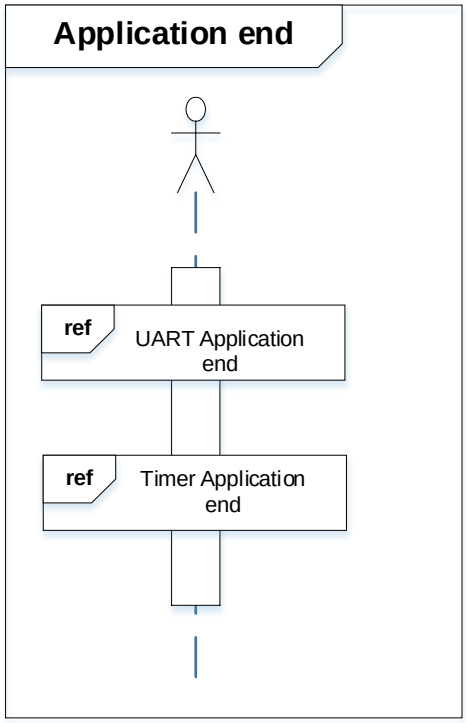

UART Application initialization
BSP
(Application)
Acquisition of Channel for USB UART
bsp_get_usb_uart_tx_ch
Generation of UART IO
initial setting
uart_io_dma_Initialize
(UART IO initial setting
storage destination)
uart_io
(Application)
Assignment of Specified UART
channel register address
UART
(Driver)
Generation of UART Driver initial setting
・uart_initial_setting_t
・uart_dma_initial_setting_t
UART Driver event handler registration
・Transmission event handler
・Reception event hanndler
uart_dma_init (UART instance address)
UART IO instance address = uart_io_dma_initialize(-)

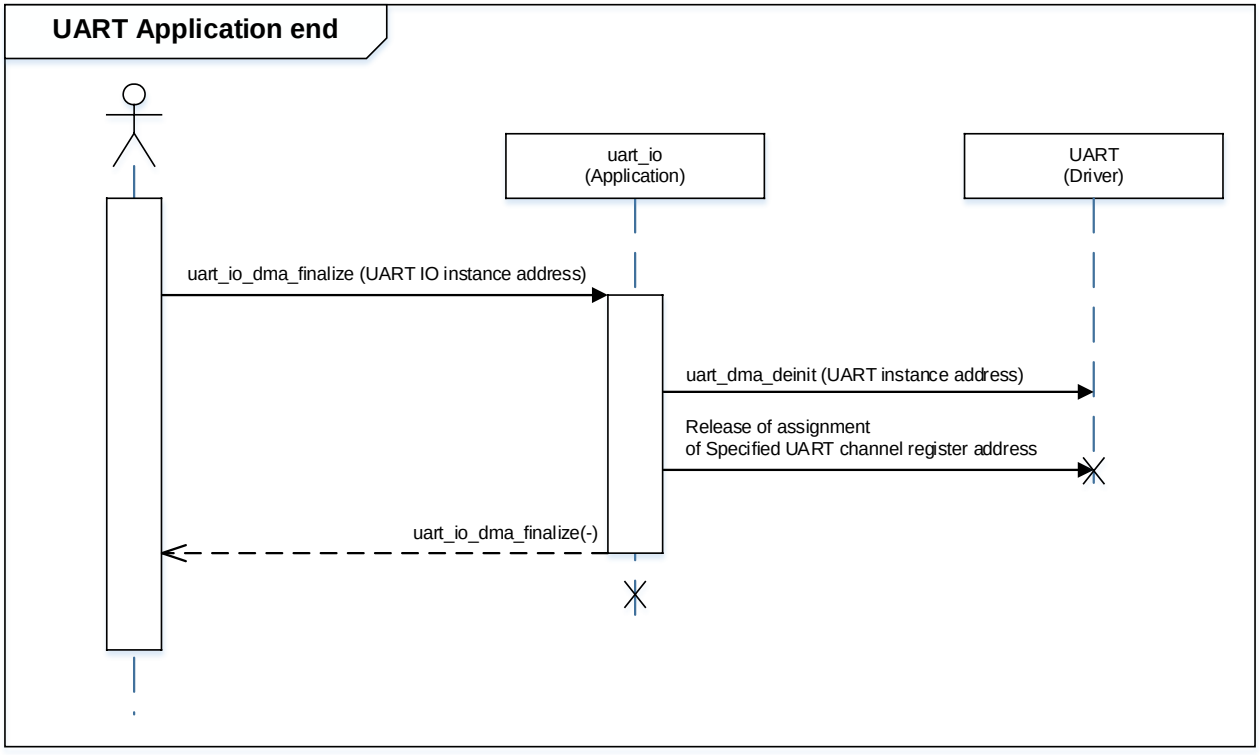

End and Deletion
ref
Application end
ref
Driver end
ref
BSP end

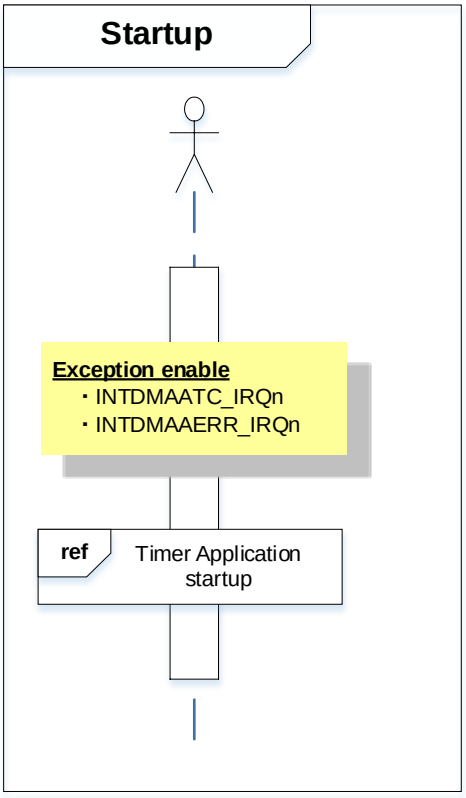

Driver end
ref
DMA Driver end
ref
T32A Driver end

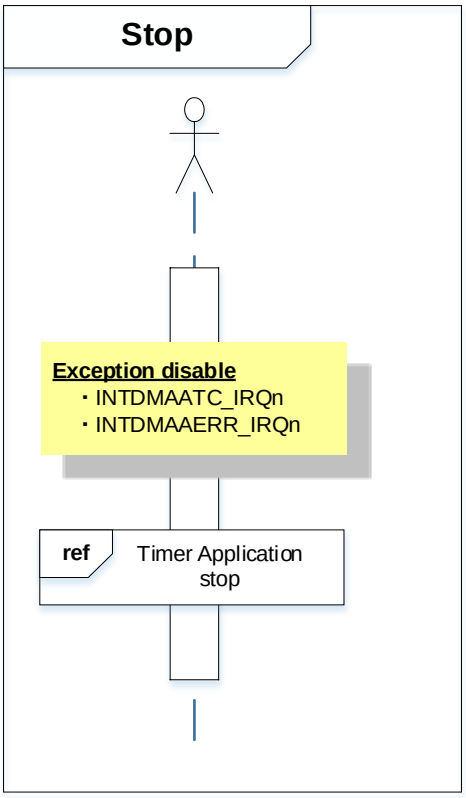

DMA Driver end
DMA
(Driver)
dma_deinit (DMA instance address)
Release of assignment
of Register address for DMA

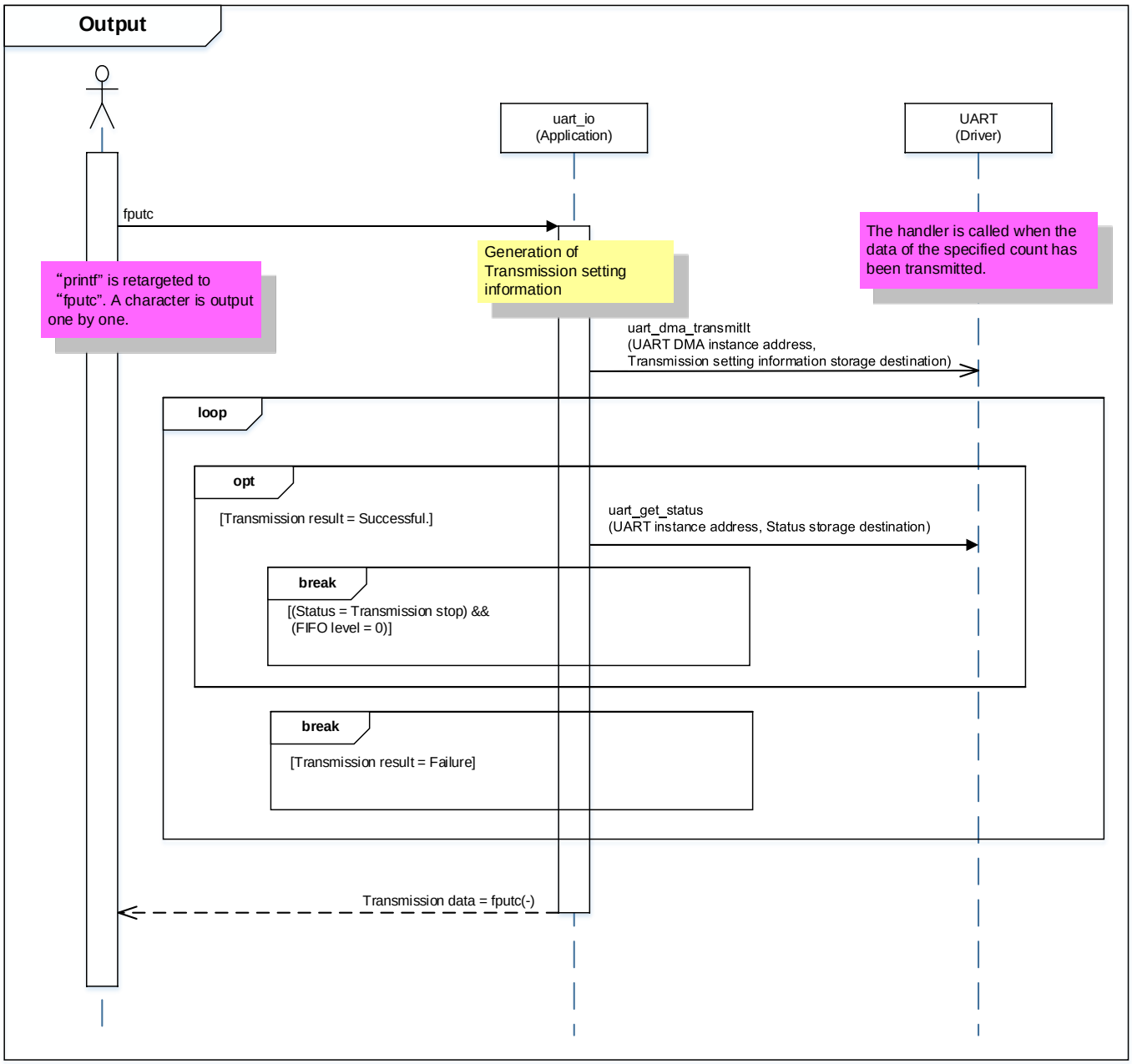

T32A Driver end
T32A
(Driver)
Release of assignment
of Register address for 1-ms timer channel

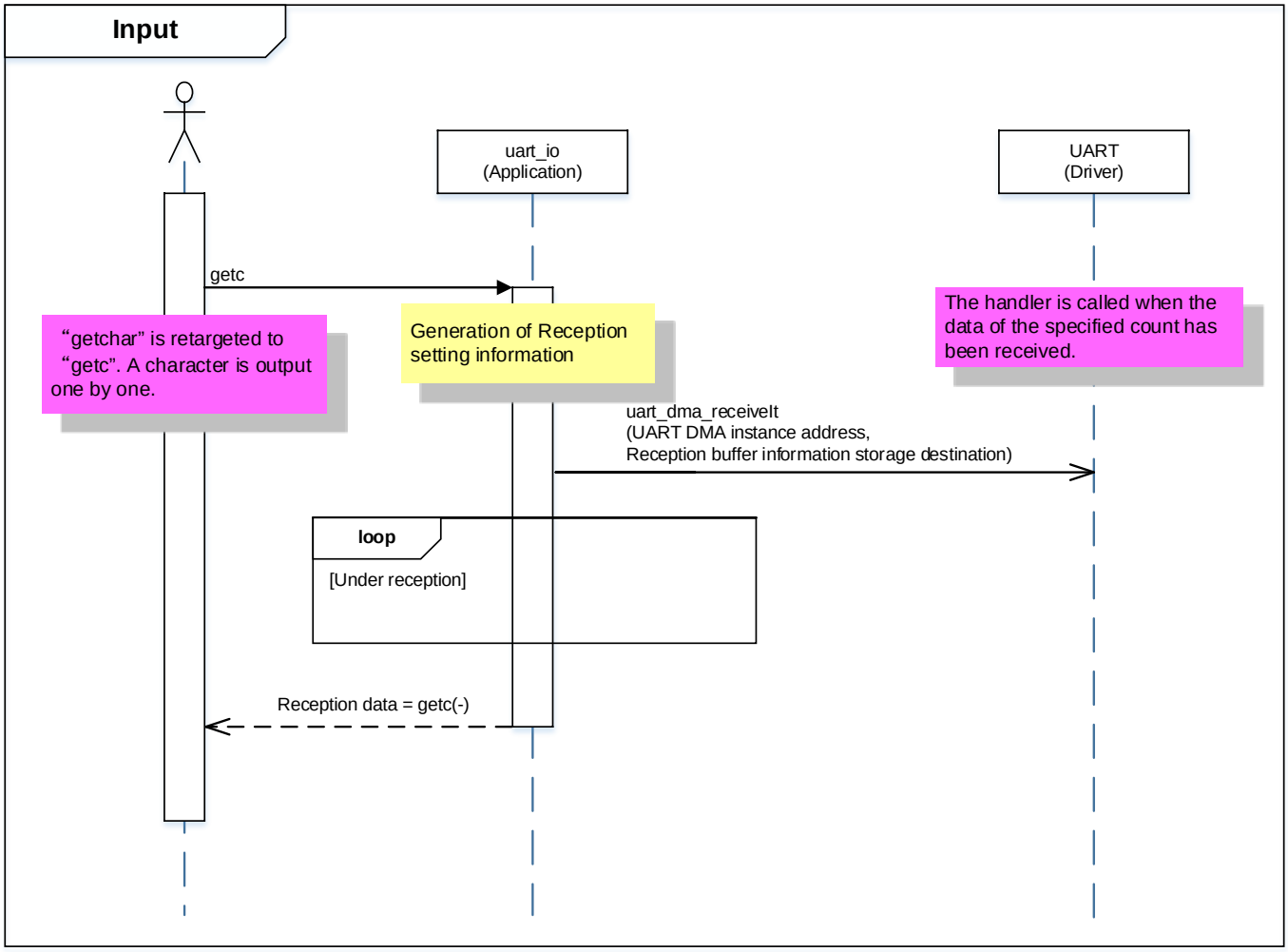

Application end
ref
UART Application end
ref
Timer Application end

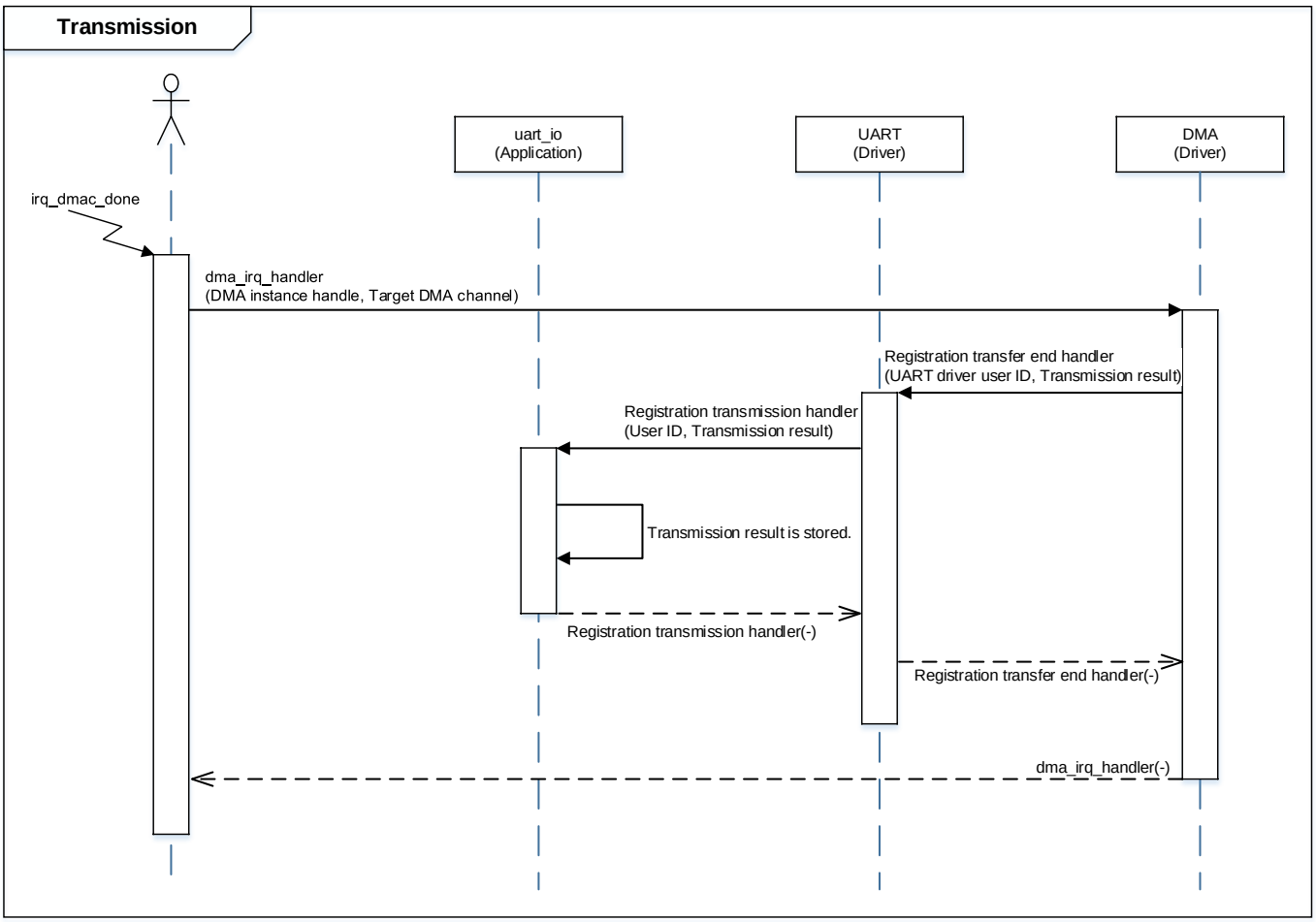

UART Application end
uart_io (Application)
UART (Driver)
uart_io_dma_finalize (UART IO instance address)
uart_dma_deinit (UART instance address)
Release of assignment of Specified UART channel register address
uart_io_dma_finalize(-)

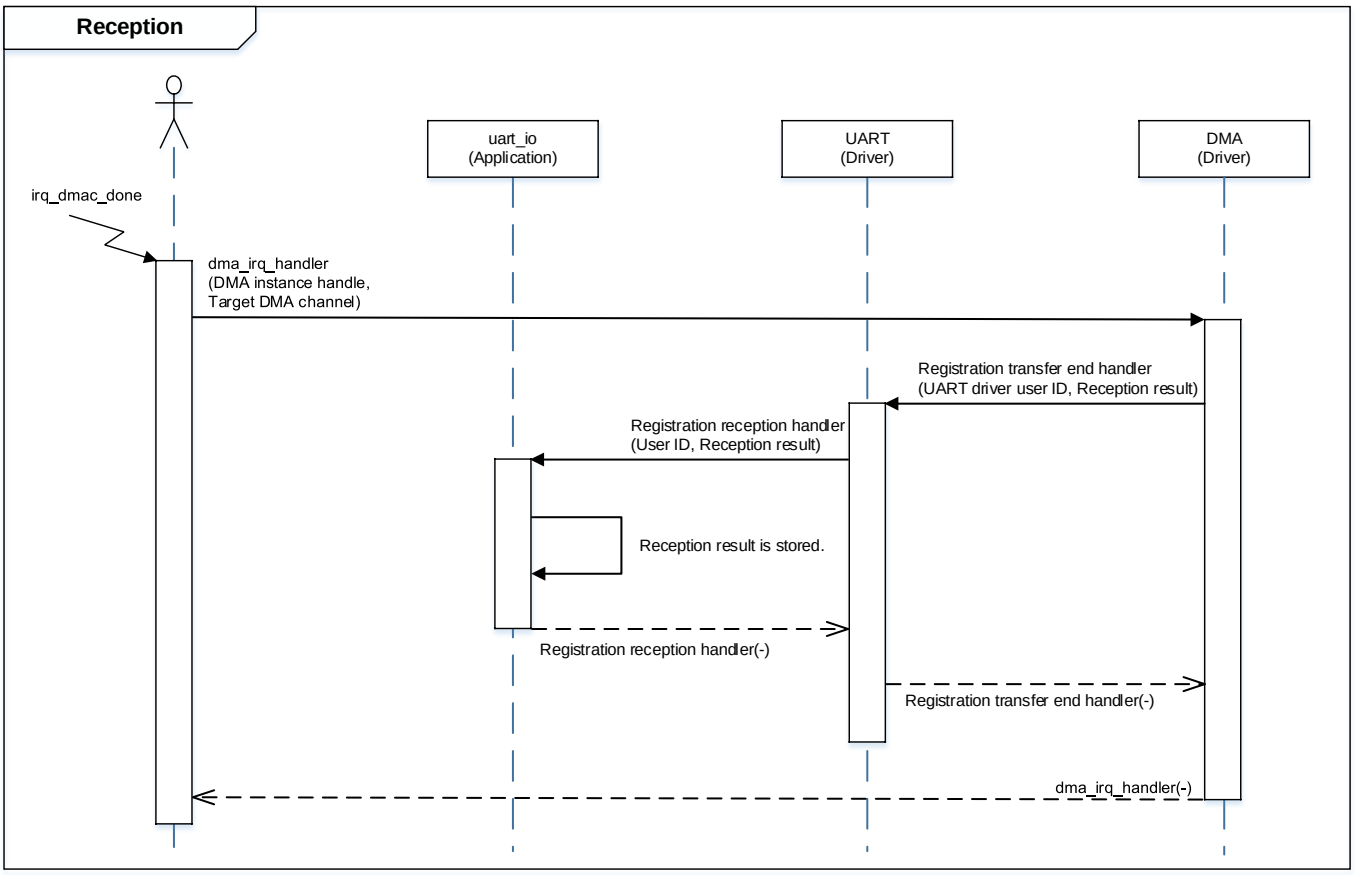

Startup
Exception enable
・INTDMAATC_IRQn
・INTDMAAERR_IRQn
ref
Timer Application startup


Stop
Exception disable
・INTDMAATC_IRQn
・INTDMAAERR_IRQn
ref
Timer Application stop


Output
uart_io
(Application)
UART
(Driver)
fputc
"printf" is retargeted to "fputc". A character is output one by one.
Generation of Transmission setting information
The handler is called when the data of the specified count has been transmitted.
uart_dma_transmitIt
(UART DMA instance address,
Transmission setting information storage destination)
loop
opt
[Transmission result = Successful.]
uart_get_status
(UART instance address, Status storage destination)
break
[(Status = Transmission stop) &&
(FIFO level = 0)]
break
[Transmission result = Failure]
Transmission data = fputc(-)


Input
uart_io
(Application)
UART
(Driver)
getc
"getchar" is retargeted to "getc". A character is output one by one.
Generation of Reception setting information
The handler is called when the data of the specified count has been received.
uart_dma_receiveIt
(UART DMA instance address,
Reception buffer information storage destination)
loop
[Under reception]
Reception data = getc(-)


Transmission
uart_io
(Application)
UART
(Driver)
DMA
(Driver)
irq_dmac_done
dma_irq_handler
(DMA instance handle, Target DMA channel)
Registration transfer end handler
(UART driver user ID, Transmission result)
Registration transmission handler
(User ID, Transmission result)
Transmission result is stored.
Registration transmission handler(-)
Registration transfer end handler(-)
dma_irq_handler(-)


Reception
uart_io
(Application)
UART
(Driver)
DMA
(Driver)
irq_dmac_done
dma_irq_handler
(DMA instance handle,
Target DMA channel)
Registration transfer end handler
(UART driver user ID, Reception result)
Registration reception handler
(User ID, Reception result)
Reception result is stored.
Registration reception handler(-)
Registration transfer end handler(-)
dma_irq_handler(-)

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	2019-10-21	First release

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