M4G Group (1)
Application Note
8-bit Digital to Analog Converter
(DAC-A)

Outlines

This application note is a reference material for developing products using 8-bit digital to analog converter (DAC) function of M4G Group (1).
This document helps the user check operation of the product and develop its program

Target sample program: DAC-UART

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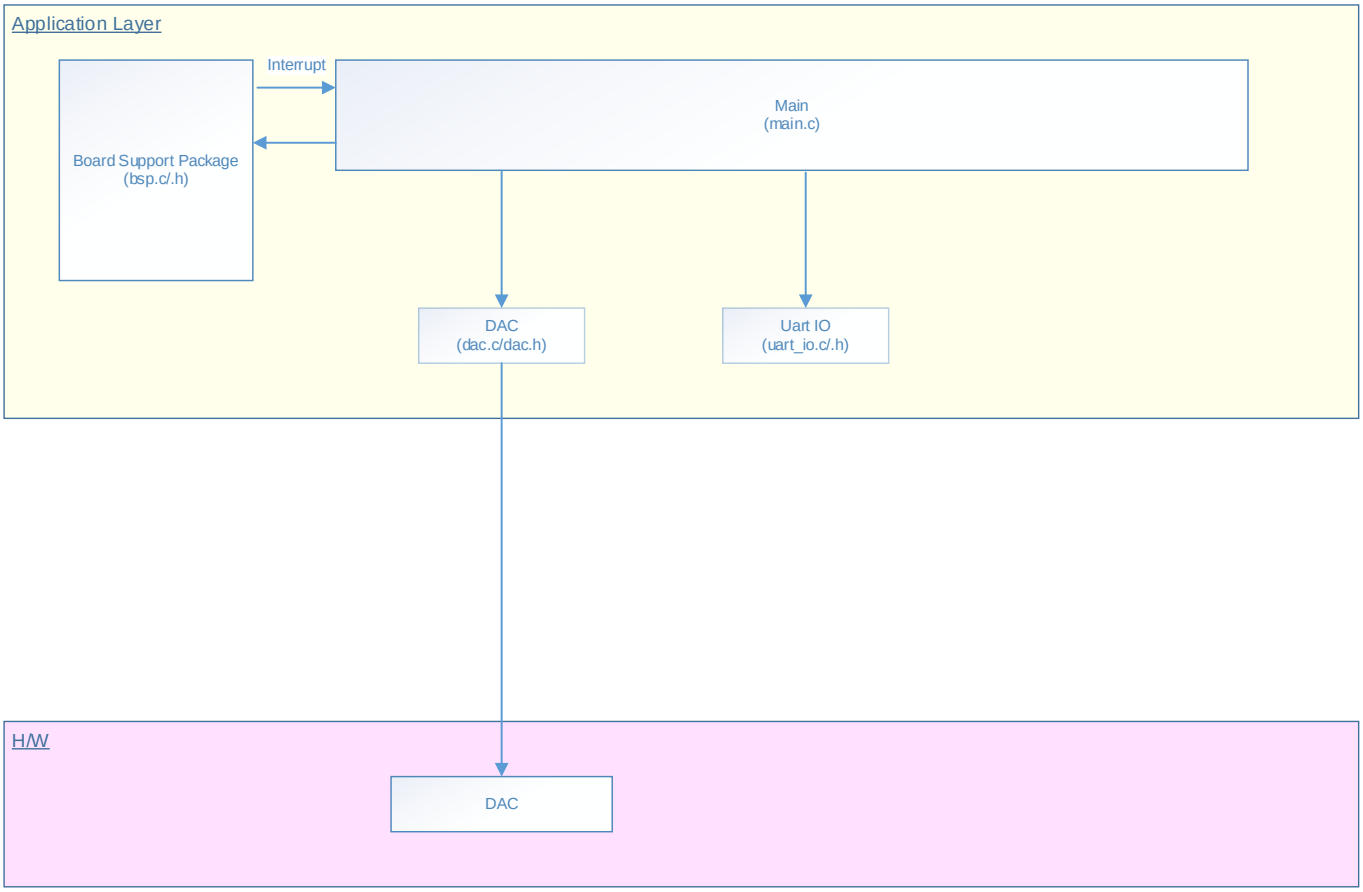
1. Preface

This sample program is used to check the operation of the DAC function.
A received digital data is converted to an analog data, and its corresponding voltage is output.

Structure diagram of Sample program



2. Reference Document

- Datasheet
  TMPM4G Group (1) datasheet Rev1.0 (Japanese edition)
- Reference manual
  8-bit Digital to Analog Converter (DAC-A) Rev2.1 (Japanese edition)
  Asynchronous Serial Communication Circuit (UART-C) Rev3.0 (Japanese edition)
- Application Note
  M4G Group (1) Application Note Startup (CMSIS System & Clock Configuration) Rev1.0
- Other reference document
  TMPM4G Group Peripheral Driver User Manual (Doxygen)

3. Function to Use

IP	Channel	Port	Function/Operation mode
Asynchronous Serial Communication Circuit	ch0	PE2 (UT0RXD) PE3 (UT0TXDA)	UART mode
8-bit Digital to Analog Converter	ch0	PT0 (DAC0)	DAC output

4. Target Device

The target devices of this application note are as follows;

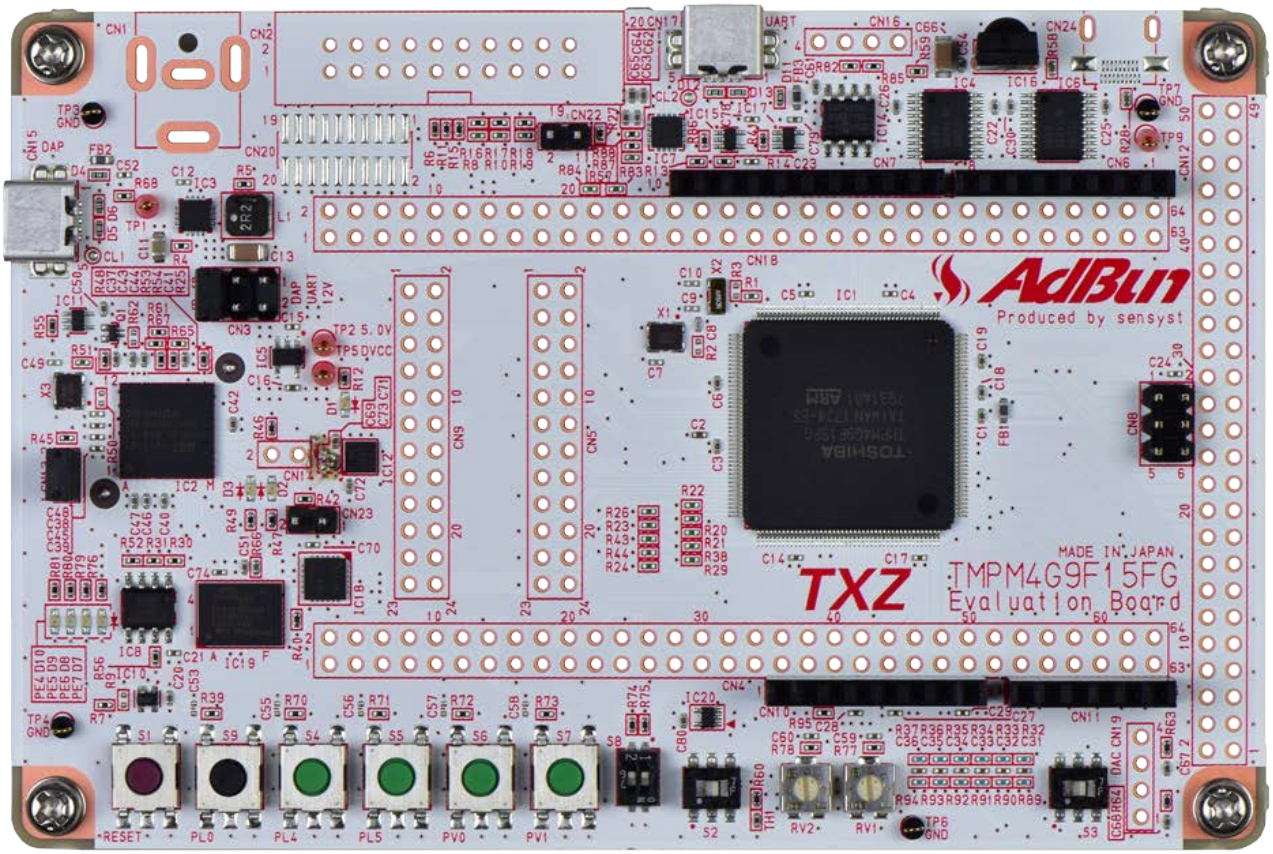
TMPM4G9F15FG	TMPM4G9F10FG	TMPM4G9FEFG	TMPM4G9FDFG
TMPM4G9F15XBG	TMPM4G9F10XBG	TMPM4G9FEXBG	TMPM4G9FDXBG
TMPM4G8F15FG	TMPM4G8F10FG	TMPM4G8FEFG	TMPM4G8FDFG
TMPM4G8F15XBG	TMPM4G8F10XBG	TMPM4G8FEXBG	TMPM4G8FDXBG
	TMPM4G7F10FG	TMPM4G7FEFG	TMPM4G7FDFG
	TMPM4G6F10FG	TMPM4G6FEFG	TMPM4G6FDFG

* This sample program operates on the evaluation board of TMPM4G9F15FG.
If other function than the TMPM4G9F15 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 (TMPM4G9F15). If other function than the TMPM4G9F15 one is checked, the BSP related file should be changed properly.

5. Operation Confirmation Condition

Used microcontroller TMPM4G9F15FG
Used board TMPM4G9F15FG Evaluation Board by 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 V1000

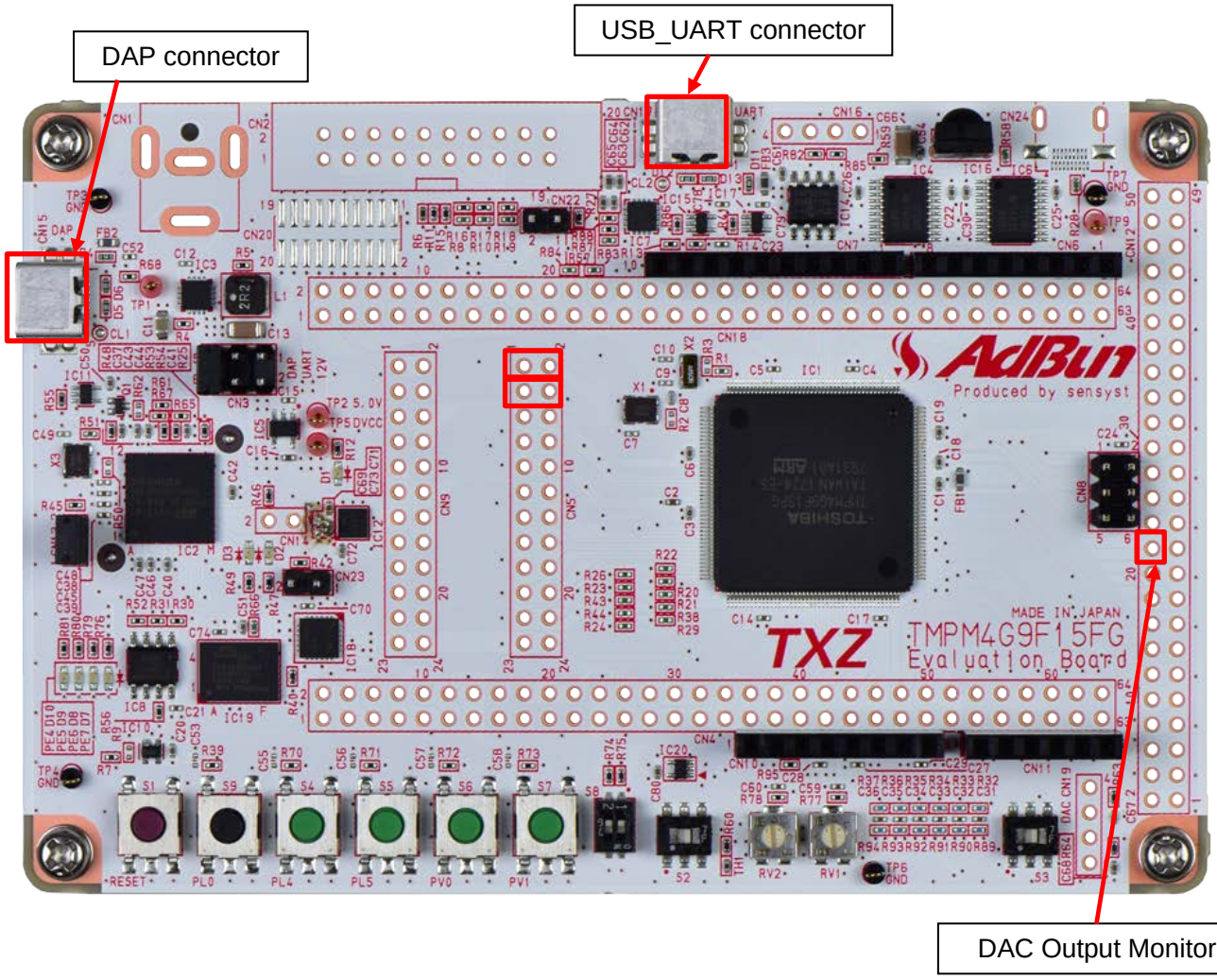
Evaluation board (TMPM4G9F15FG Evaluation Board) Top view



6. Evaluation Board Setting

The following pin connections should be done on the evaluation board

CN5		
Board function	Through-hole No.	Through-hole No.
USB UART conversion	1: USB_UT_RX	2: PE2
USB UART conversion	3: USB_UT_TX	4: PE3



7. Operation of Evaluation Board

PC and the USB_UART are connected for communication with the terminal software.
255 or a less number should be input to the terminal software.
The input digital value is converted to an analog data, and its corresponding voltage is output on PT0.

8. Outline of DAC Function

8-bit digital / analog converter (DAC) builds in the DAC output circuit of one channel (DACx) per 1 unit.
The main functions are as follows

Function category	Function	Description
DAC output	Conversion system	R-2R Resistance rudder type
	Resolution	8 bits
	Buffer amplifier	Un-built-in

9. Sample Program

The digital data which is transmitted by the terminal software using the UART interface is converted to analog data.
The voltage corresponding to the analog data is output on the port of DAC0.

9.1. Initialization

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

9.2. Sample Program Main Operation

The initialization of BSP is executed.
The initialization of application is executed.

After data clearing is done, it becomes input state by “Input =” display.
When entering a value in terminal software, it will receive the value entered via UART.
When the input data is within the setting range, the DAC is enabled.
When it is processed normally, it returns to the input state.

If the received value is 255 or less, perform digital-to-analog conversion and output voltage.
If the received value is 256 or more, an error message is displayed in the terminal software.

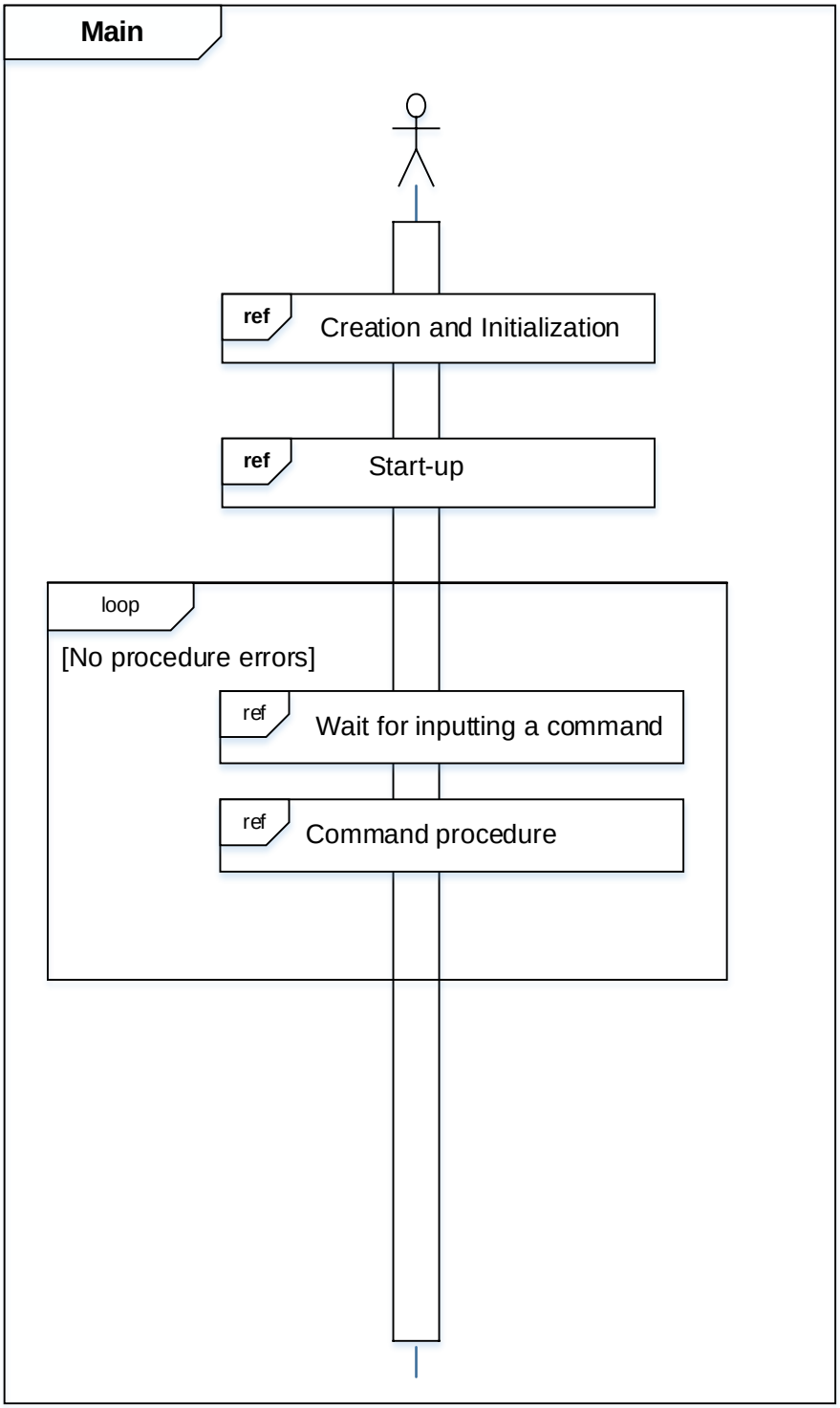
9.3. Example of DAC output

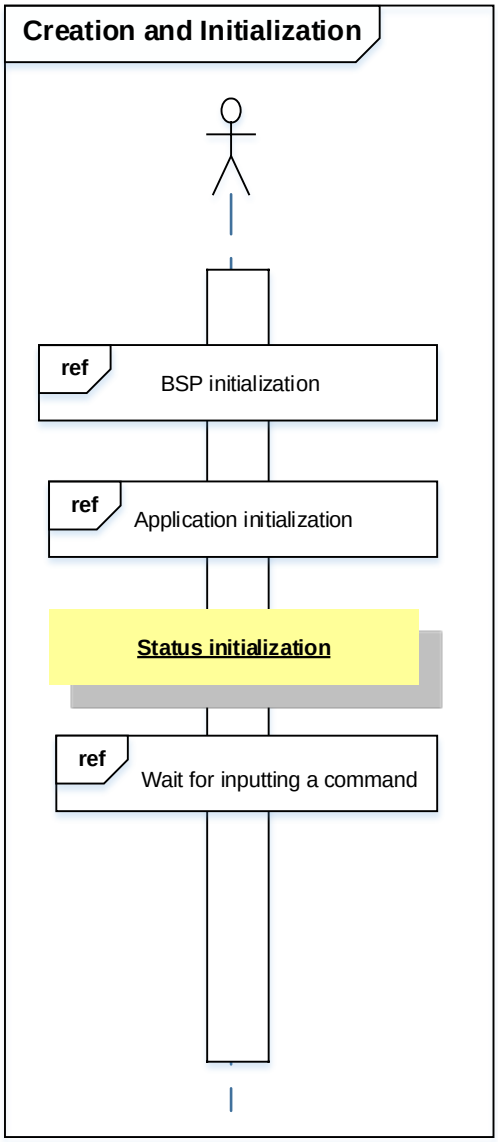
The voltage value obtained by DA converting the digitally input value can be monitored with PT0.
When the reference voltage is 3.3 V, the theoretical value is as follows.

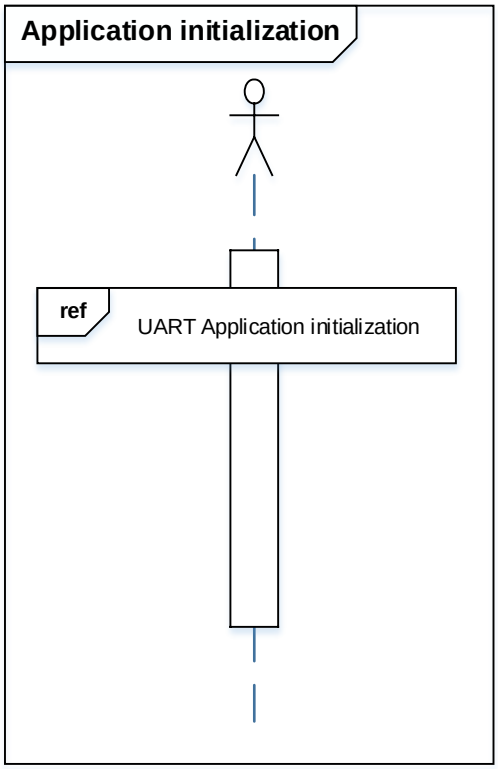
Input value	Converted voltage (Theoretical value)
0	0
63	0.812
127	1.637
192	2.475
255	3.287
256 or more	Error

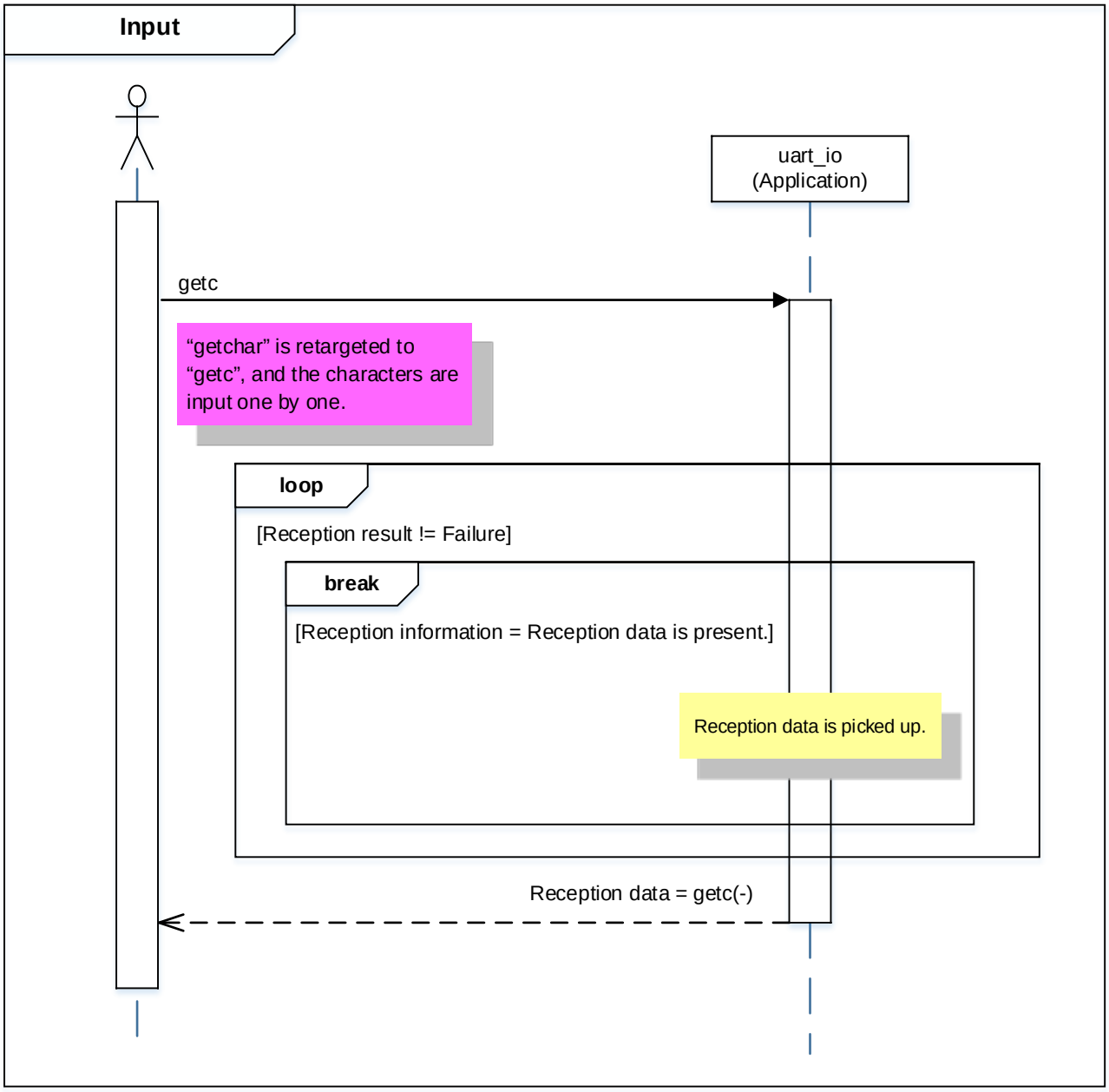
9.4. Operating Flow of Sample Program

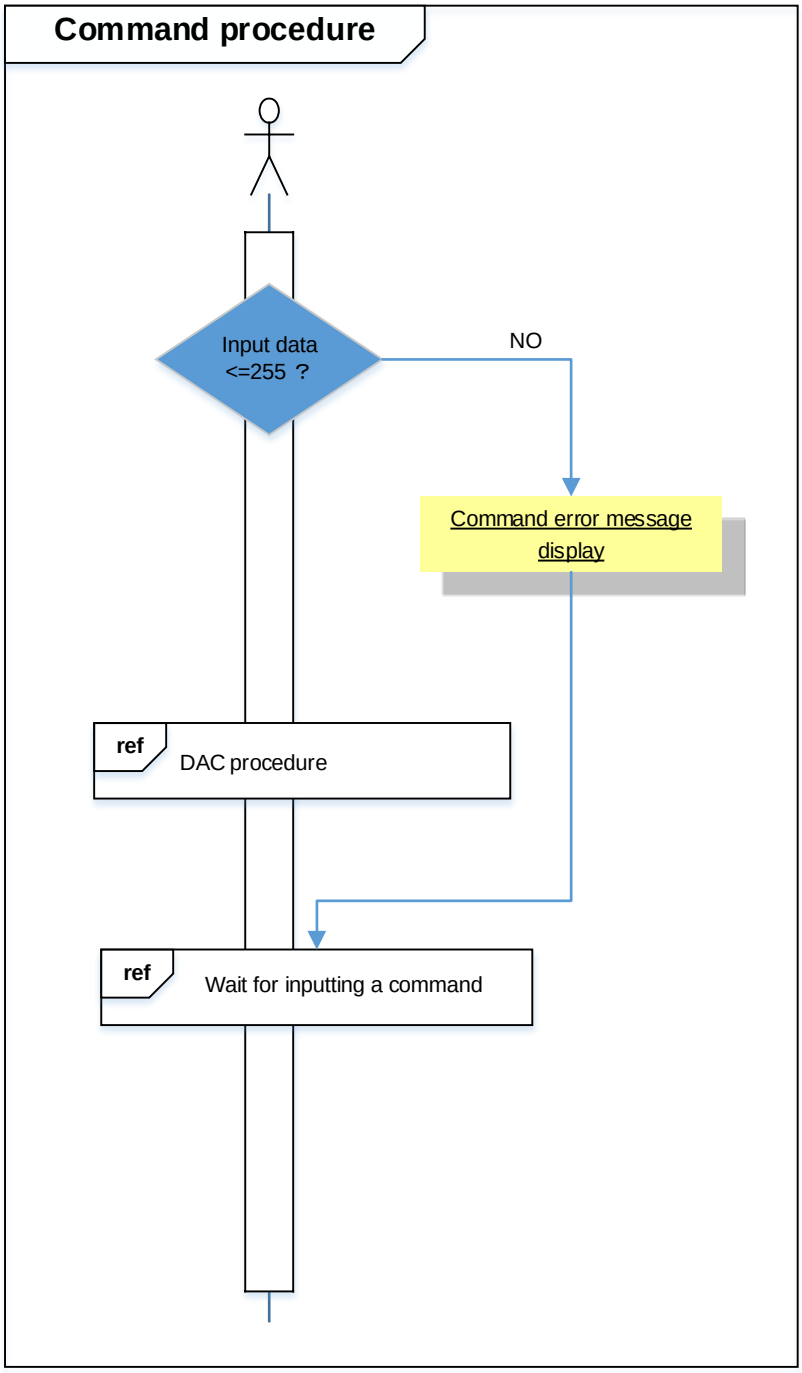
The basic operating flows of the sample program are shown in the following;

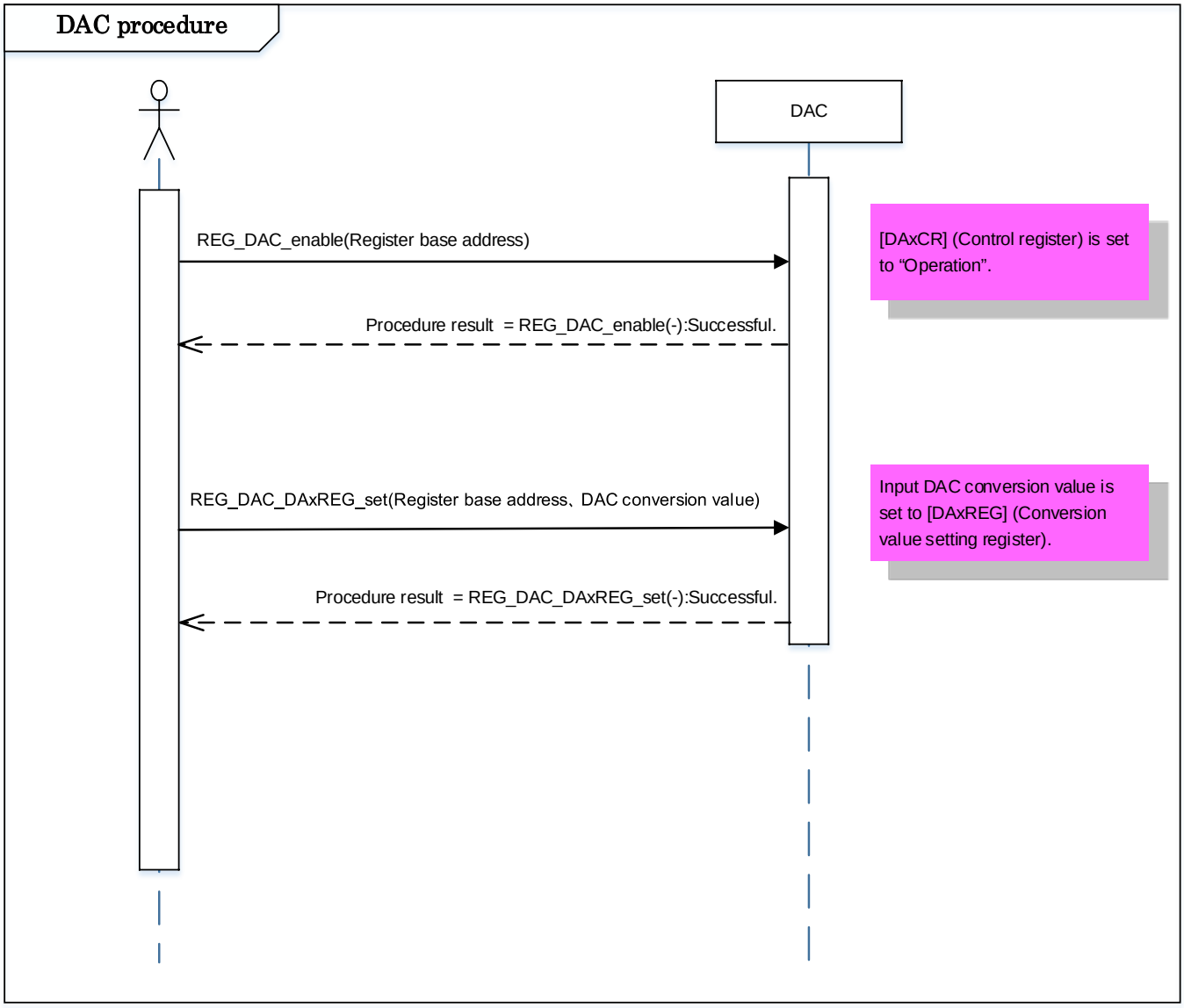



Creation and Initialization
ref
BSP initialization
ref
Application initialization
Status initialization
ref
Wait for inputting a command


Application initialization
ref
UART Application initialization


Input
uart_io
(Application)
getc
“getchar” is retargeted to “getc”, and the characters are input one by one.
loop
[Reception result != Failure]
break
[Reception information = Reception data is present.]
Reception data is picked up.
Reception data = getc(-)


Command procedure
Input data
<=255 ?
NO
Command error message
display
ref
DAC procedure
ref
Wait for inputting a command


DAC procedure
DAC
REG_DAC_enable(Register base address)
[DAxCR] (Control register) is set to “Operation”.
Procedure result = REG_DAC_enable(-):Successful.
REG_DAC_DAxREG_set(Register base address、DAC conversion value)
Input DAC conversion value is set to [DAxREG] (Conversion value setting register).
Procedure result = REG_DAC_DAxREG_set(-):Successful.

10. Precaution

When using the sample program with CPU other than TMPM4G9F15, please check operation sufficiently.

11. Revision History

Rev	Date	Description
1.0	2018-11-27	First release

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