

**M4G Group (1)**  
**Application Note**  
**32-bit Timer Event Counter**  
**(T32A-B)**  
**Interval Timer Function**

**Outlines**

This application note is a reference material for developing products using interval timer functions in the 32-bit timer event counter (T32A) function of M4G Group (1).

This document helps the user check operation of the products and develop its programs.

Target sample program: Timer\_LED

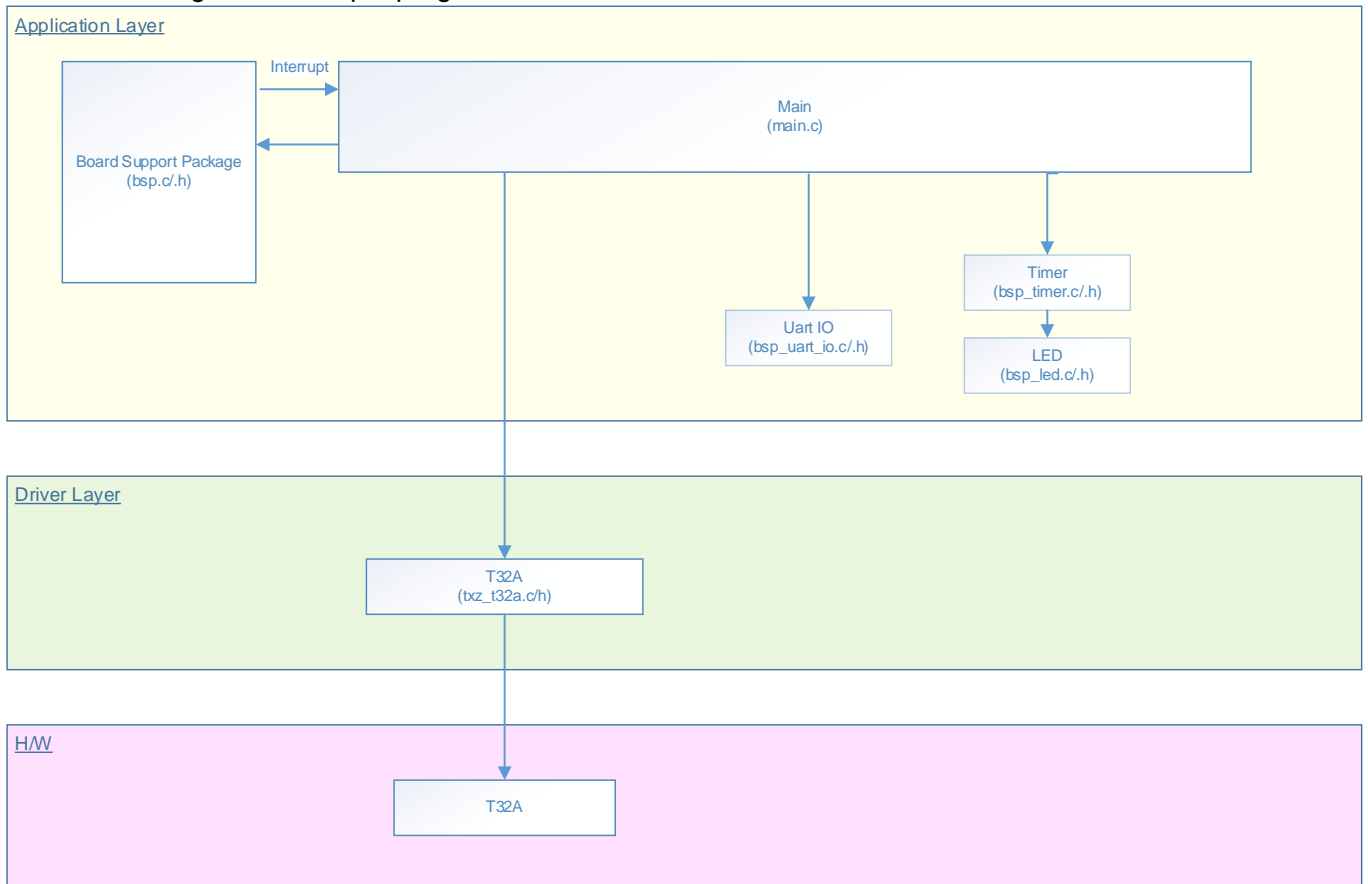
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### 1. Preface

This sample program uses the 32-bit timer event counter to control LEDs' blinking. To stop and re-start of LEDs' blinking can be switched by push switch.

Structure diagram of Sample program



### 2. Reference Document

- Datasheet  
TMPM4G Group (1) datasheet Rev.1.0 (Japanese edition)
- Reference manual  
32-bit Timer Event Counter (T32A-B) Rev2.1 (Japanese edition)  
Asynchronous Serial Communication Circuit (UART-C) Rev3.0 (Japanese edition)  
Input/Output Ports (PORT-M4G(1)) Rev1.0 (Japanese edition)  
Exception (EXCEPT-M4G(1) Rev1.0 (Japanese edition)
- Application Note  
M4G Group (1) Application Note Startup (CMSIS System &Clock Configuration) Rev1.0
- Other reference document  
TMPM4G (1) 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
Input/Output Ports	-	PE4(Output Port)	Output
	-	PE5(Output Port)	
	-	PE6(Output Port)	
	-	PE7(Output Port)	
	-	PL4(INT12b)	External interrupt
-	PL5(INT13b)		
32-bit Timer Event Counter	ch0	-	Interval timer

### 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.

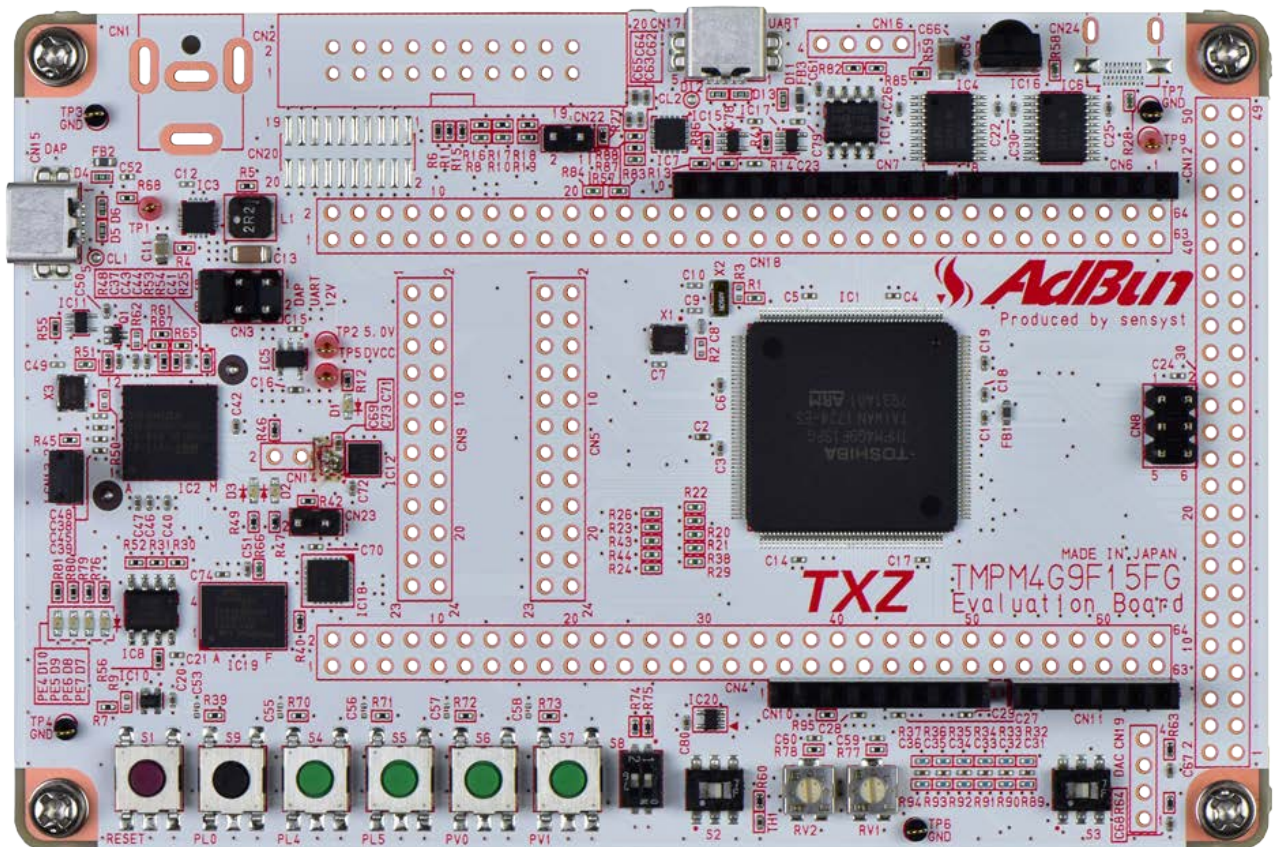
If other function than the TMPM4G9F15 one is checked, it is necessary that CMSIS Core related files (C startup file and I/O header file) should be changed properly.

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	TMPM4G9F15FGEvaluation 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



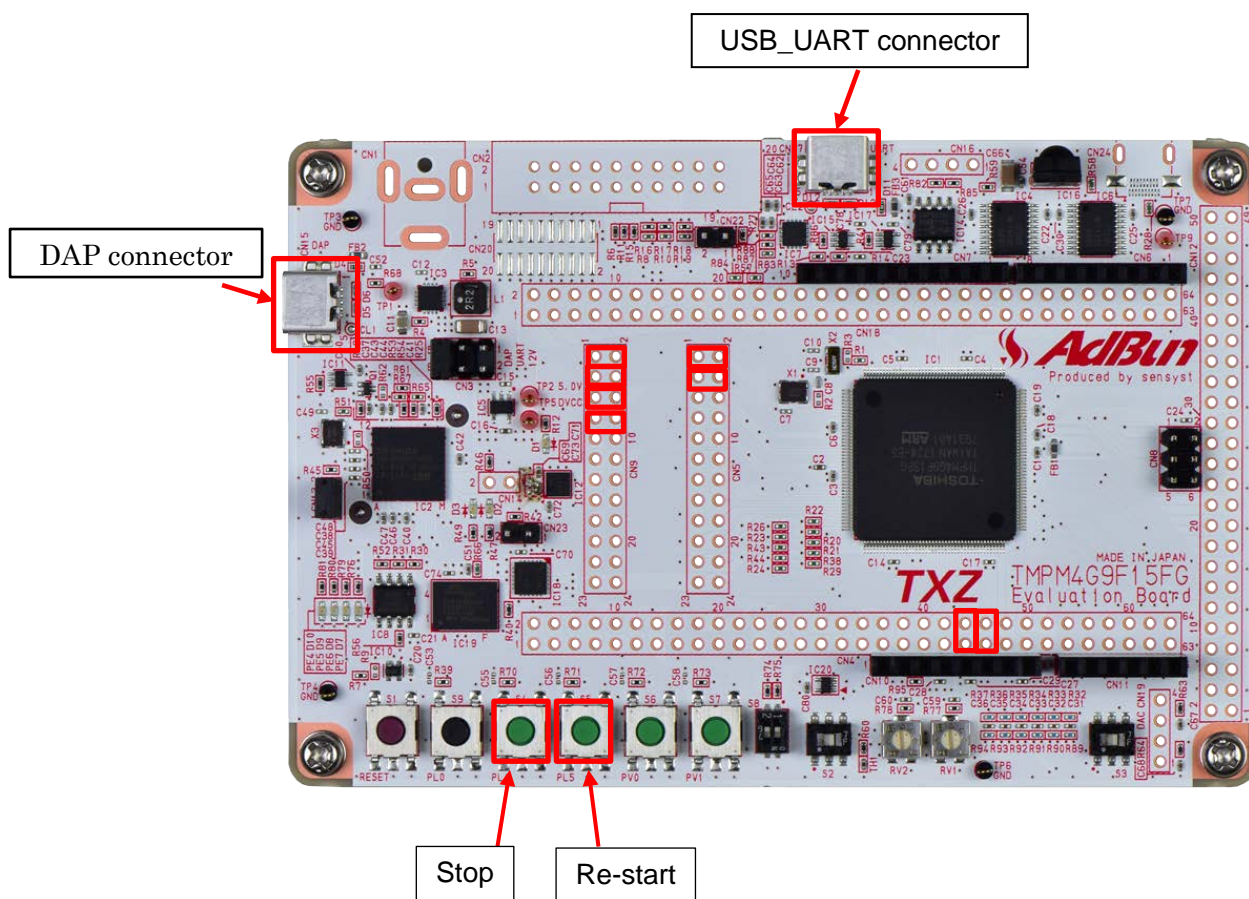
### 6. Evaluation Board Setting

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

CN9		
Board function	Through-hole No.	Through-hole No.
LED(D10)	1: LED0	2: PE4
LED(D9)	3: LED1	4: PE5
LED(D8)	5: LED2	6: PE6
LED(D7)	7: LED3	8: PE7

CN4		
Board function	Through-hole No.	Through-hole No.
Push switch (S5)	43: SW_INT1	44: PL5
Push switch (S4)	45: SW_INT0	46: PL4



### 7. Operation of Evaluation Board

PC and the USB\_UART are connected for communication with the terminal software. When the sample program is started, the timer interval is displayed on the terminal software. After that, all LEDs ((LED (D7) to LED (D10)) will repeat lighting ON/OFF with a set interval.

When the Push switch S4 is pushed down, all LEDs are fixed to the state at that time. Then, when the Push switch S5 is pushed down, all LEDs restart repeating the lights ON/OFF.

### 8. Outline of T32A Function

T32A can work as a 16-bit timer (timer A, timer B) of 2ch or a 32-bit timer (timer C) of 1ch by 1UNIT circuit unit. The function list is shown in the following.

Function Classification		Function		A Functional Description or the range
16-bit timer Timer A	Time control	Interval timer		This function generates interrupt to CPU at set interval time.
	Measurement control	Event counter		Up counting or down counting or up/down counting can be selected as count operation. And when the count value matches the timer register, you can generate timer interrupt.
		Capture	Frequency measurement	Capture count value on rising edge and falling edge of input pulse. You can calculate frequency from difference of capture data.
			Pulse width measurement	Capture count value on rising edge and falling edge of input pulse. You can calculate Pulse Width from difference of capture data.
			Time difference measurement	Capture count value on rising edge or falling edge of input pulse. You can calculate Time difference from difference of capture data.
	Rectangular wave output	PPG		Can output rectangular wave of arbitrary frequency or arbitrary duty.
	Synchronous Operation	Counter start		Timer counter start the count in synch with count start of master timer counter.
		Counter stop		Timer counter stop the count in synch with count stop of master timer counter.
		Counter reload		Timer counter is reloaded in synch with reload of master timer counter.
	16-bit timer Timer B	Time control	Interval timer	
Measurement control		Event counter		Up counting or down counting or up/down counting can be selected as count operation. And when the count value matches the timer register, you can generate timer interrupt.
		Capture	Frequency measurement	Capture count value on rising edge and falling edge of input pulse. You can calculate frequency from difference of capture data.
			Pulse width measurement	Capture count value on rising edge and falling edge of input pulse. You can calculate Pulse Width from difference of capture data.
			Time difference measurement	Capture count value on rising edge or falling edge of input pulse. You can calculate Time difference from difference of capture data.
Rectangular wave output		PPG		Can output rectangular wave of arbitrary frequency or arbitrary duty.
Synchronous Operation		Counter start		Timer counter start the count in synch with count start of master timer counter.
		Counter stop		Timer counter stop the count in synch with count stop of master timer counter.
		Counter reload		Timer counter is reloaded in synch with reload of master timer counter.

Function Classification		Function		A Functional Description or the range
32-bit timer Timer C	Time control	Interval timer		This function generates interrupt to CPU at set interval time.
	Measurement control	Event counter		Up counting or down counting or up/down counting can be selected as count operation. And when the count value matches the timer register, you can generate timer interrupt.
		Pulse count	1-phase pulse count	The counter counts up or counts down according to the level of input pulse to T32AxINC0 or T32AxINC1.
			2-phase pulse count	The counter counts up or down according to the change of the signal level input to T32AxINC0/T32AxINC1.
		Capture	Frequency measurement	Capture count value on rising edge and falling edge of input pulse. You can calculate frequency from difference of capture data.
			Pulse width measurement	Capture count value on rising edge and falling edge of input pulse. You can calculate Pulse Width from difference of capture data.
			Time difference measurement	Capture count value on rising edge or falling edge of input pulse. You can calculate Time difference from difference of capture data.
	Rectangular wave output	PPG		Can output rectangular wave of arbitrary frequency or arbitrary duty.
	Synchronous Operation	Counter start		Timer counter start the count in synch with count start of master timer counter.
		Counter stop		Timer counter stop the count in synch with count stop of master timer counter.
Counter reload		Timer counter is reloaded in synch with reload of master timer counter.		



## 9. Sample Program

This sample program repeats the light ON / OFF of LED with a set interval. Furthermore, the timer stop/re-start can be switched by pushing down the Push switch.

### 9.1. Initialization

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

### 9.2. Sample Program Main Operation

The initialization of BSP (Board Support Package) is executed.  
As an initialization of the application, the initialization of UART, LED and Push switch are executed.  
The timer initialization and 1-ms timer setting are executed as the driver initialization, then external interrupt and the timer interrupt are enabled.  
Timer starts.

In this sample program, "General Timer Period: 1sec" of the timer initial setting is displayed to terminal software and start operation.

The light of LED is ON in the initial state, and the light of LED is OFF after the lapse of the set time (1 second by default).  
The light of LED is ON after lapse of the re-set time. After that, the light ON/OFF of LED repeat with the set interval.

When the Push switch S4 is pushed down, the timer operation stops and the light of LED is fixed to the state at that time.  
Then, when the Push switch S5 is pushed down, the timer operation starts and the light ON/OFF of LED restarts repeating.

### 9.3. Timer Interval Setting

The interval duration setting of the timer can be adjusted by changing the timer interval. In the sample program, "driver\_initialize" in the line 413 in main.c is used for setting the interval.  
The default setting is 1000 $\mu$ s.

(e.g.) `p_timer->init.interval = 2000;`  
The timer interval is changed by changing the value "interval" of the above timer initial setting structure.  
In the example, the timer interruption interval is doubled by changing it from 1000 to 2000.

However, since the terminal software display is fixedly displayed by the printf statement, the display result does not change from "1 sec".

When changing the display, change the following program line:  
460th line of main.c : `if (printf("General Timer Period : 1sec\n") < 0)`

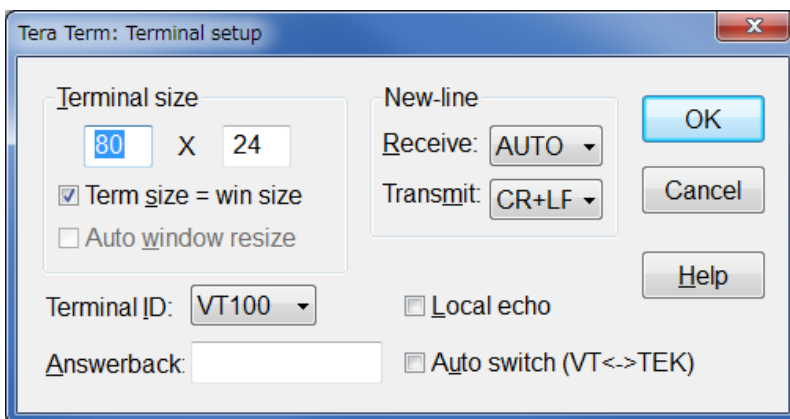
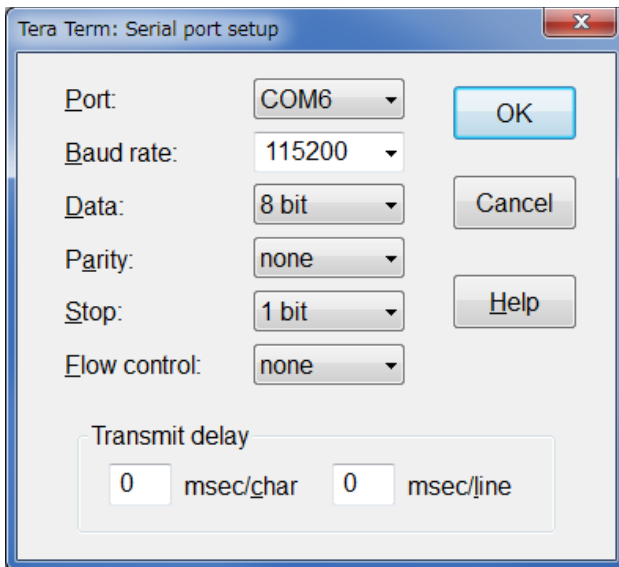
### 9.4. Output Example of Sample Program

The timer interval is displayed as below when the sample program is started:



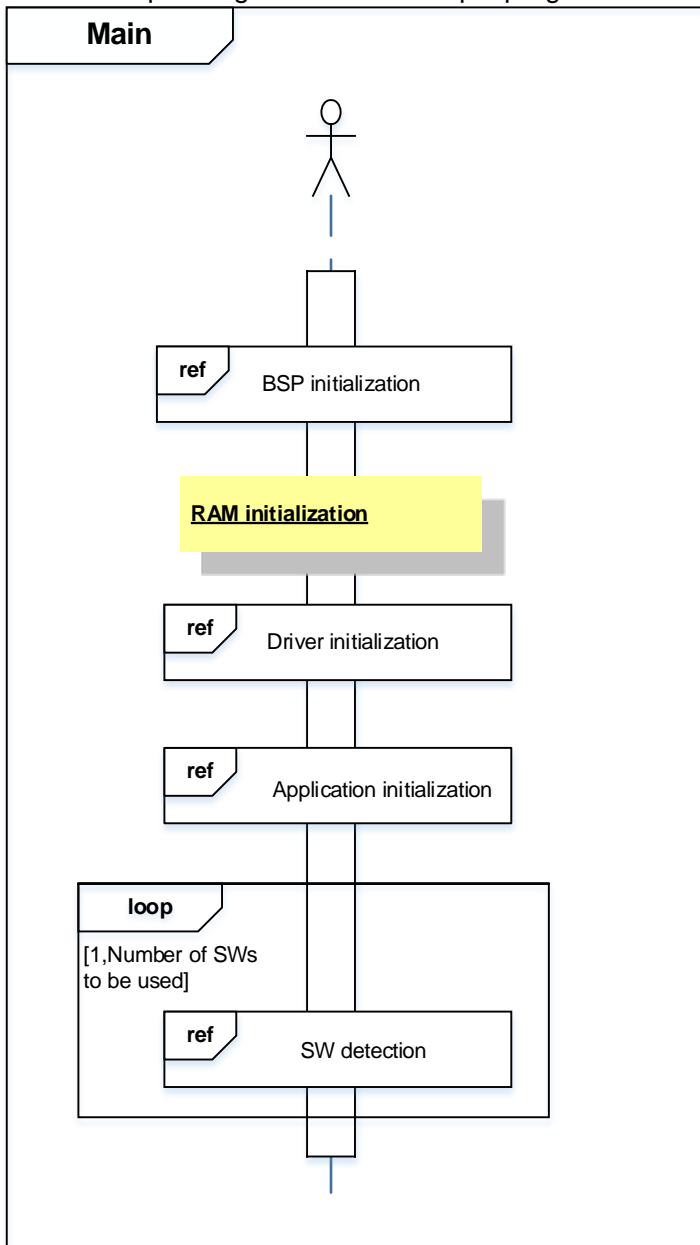
#### 9.4.1. Setting Example of Terminal Software

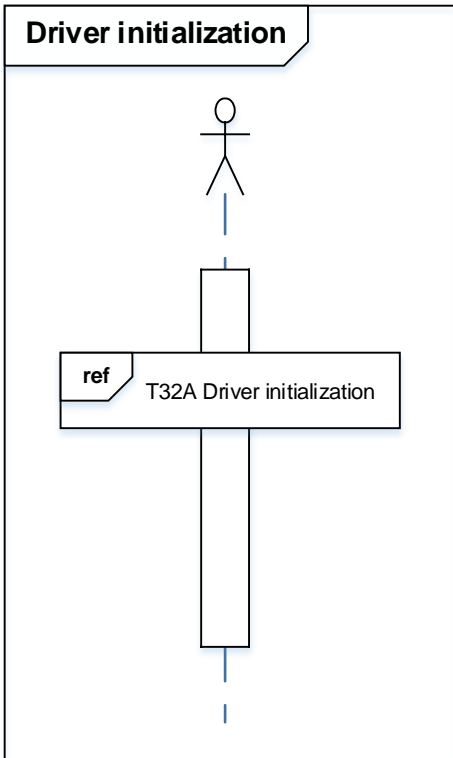
The operation of the terminal software (Tera Term) has been checked with the following settings.

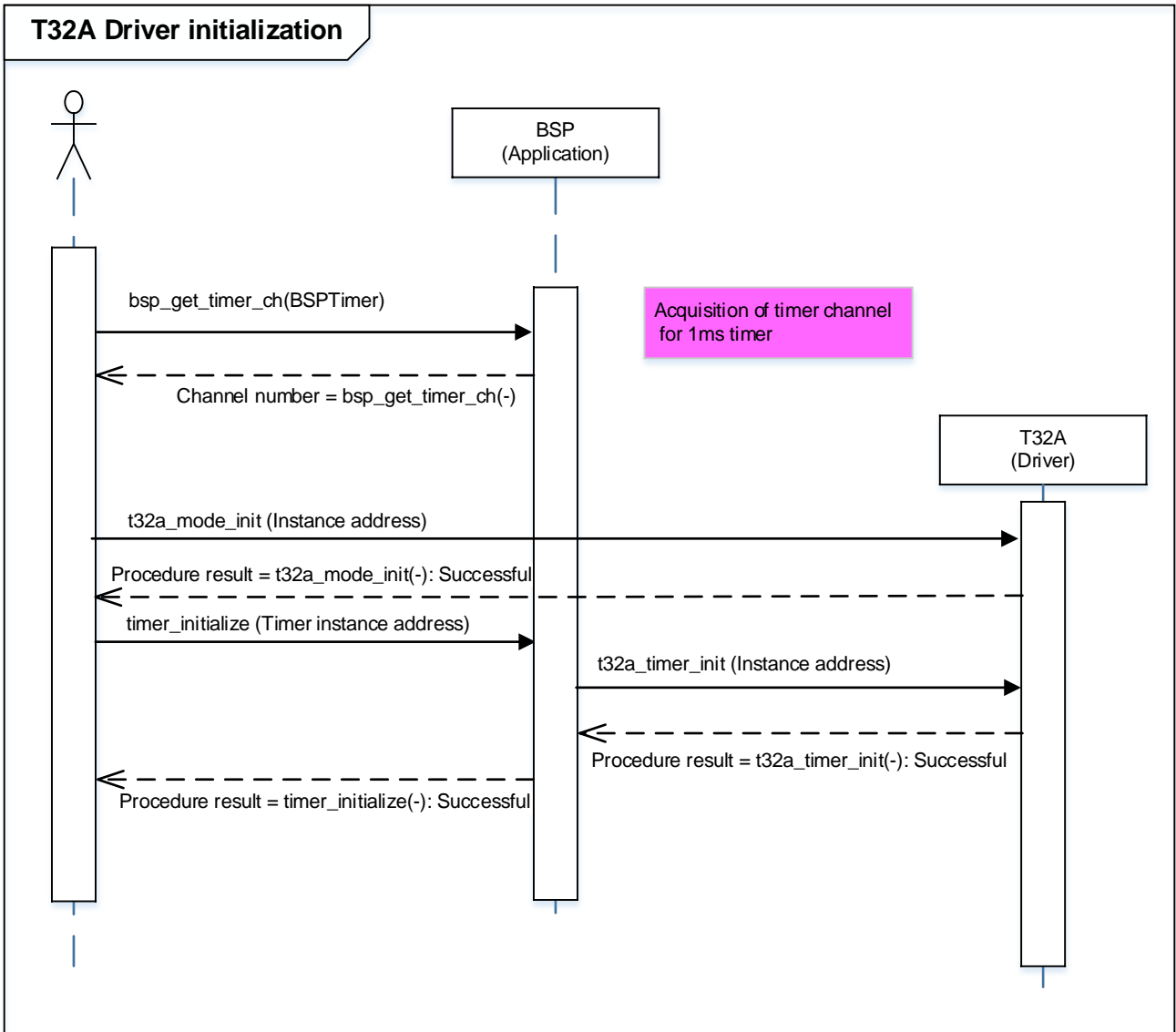


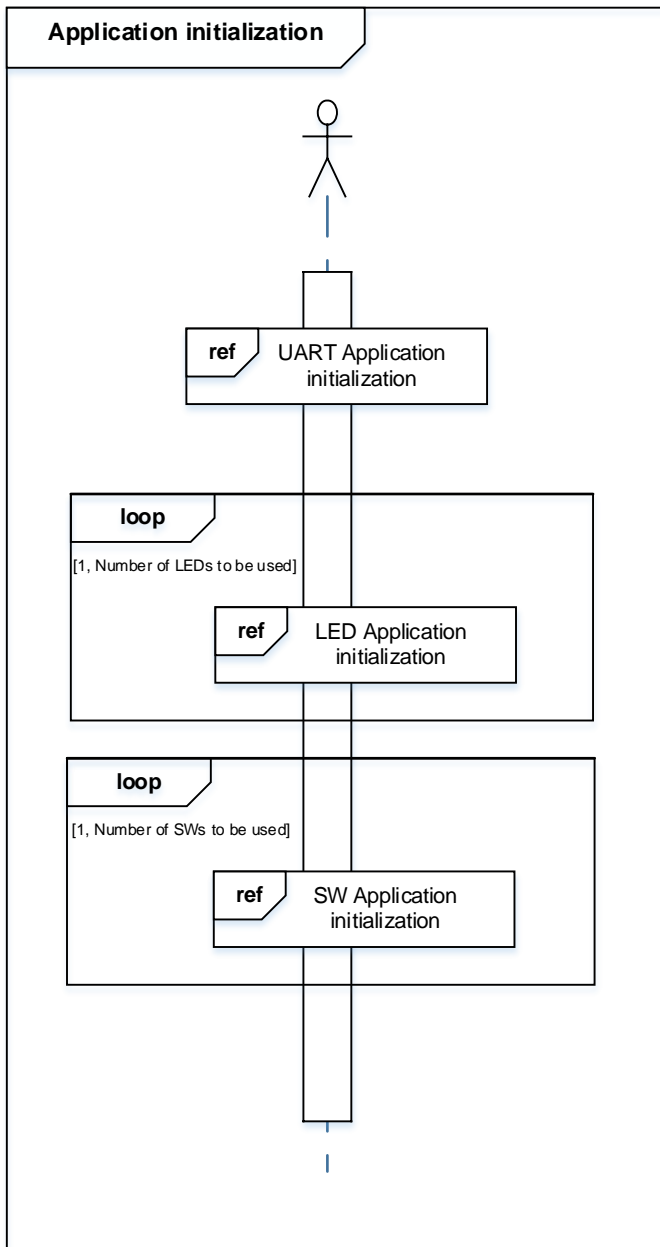
### 9.5. Operating Flow of Sample Program

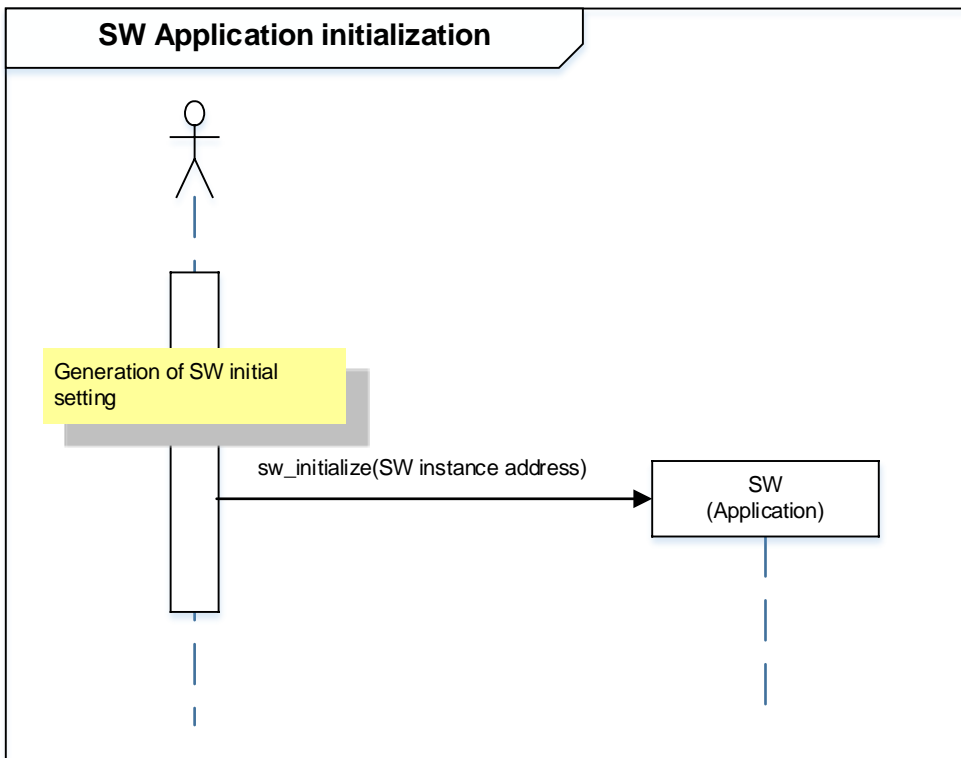
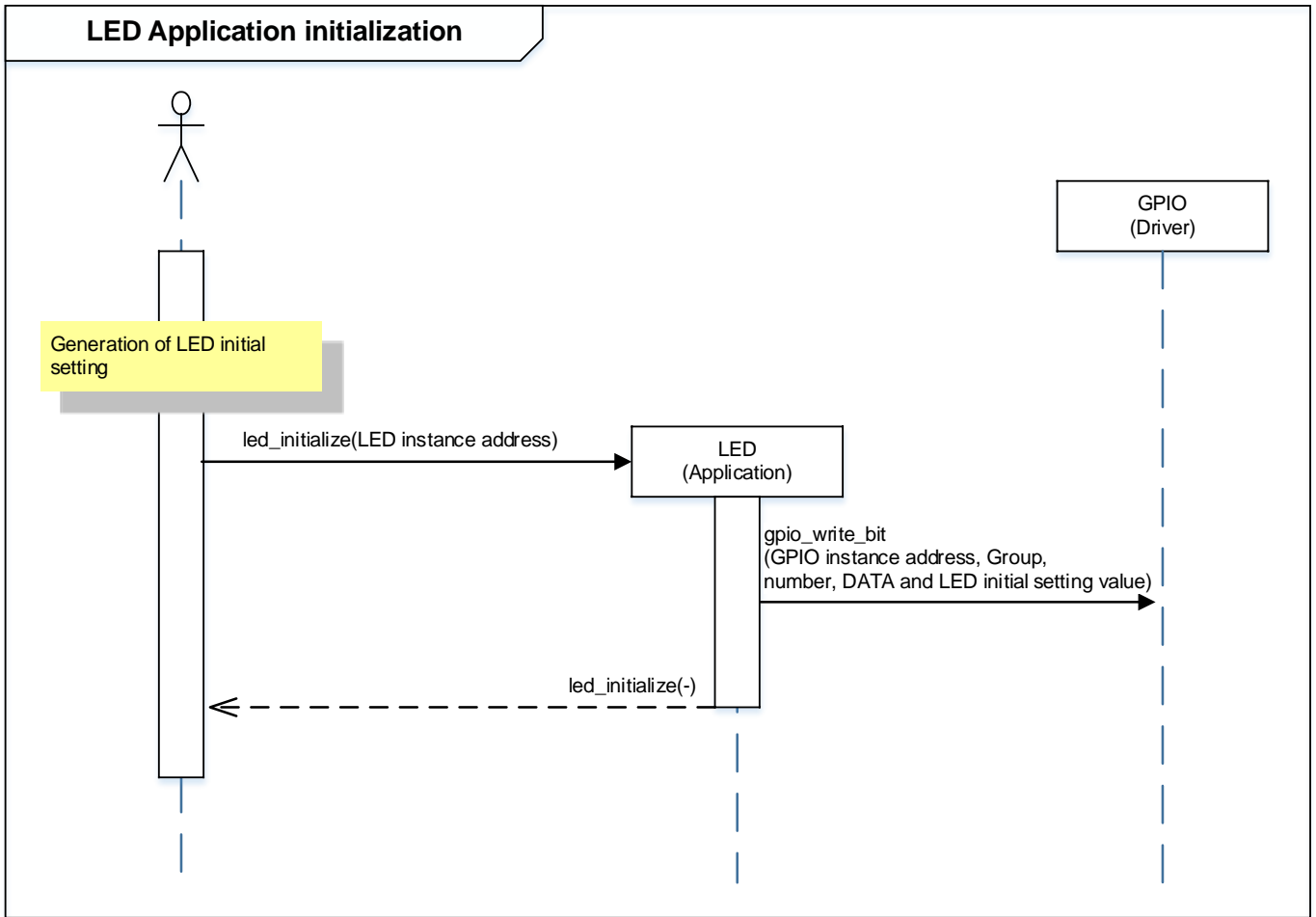
The basic operating flows of the sample program are shown in the following.

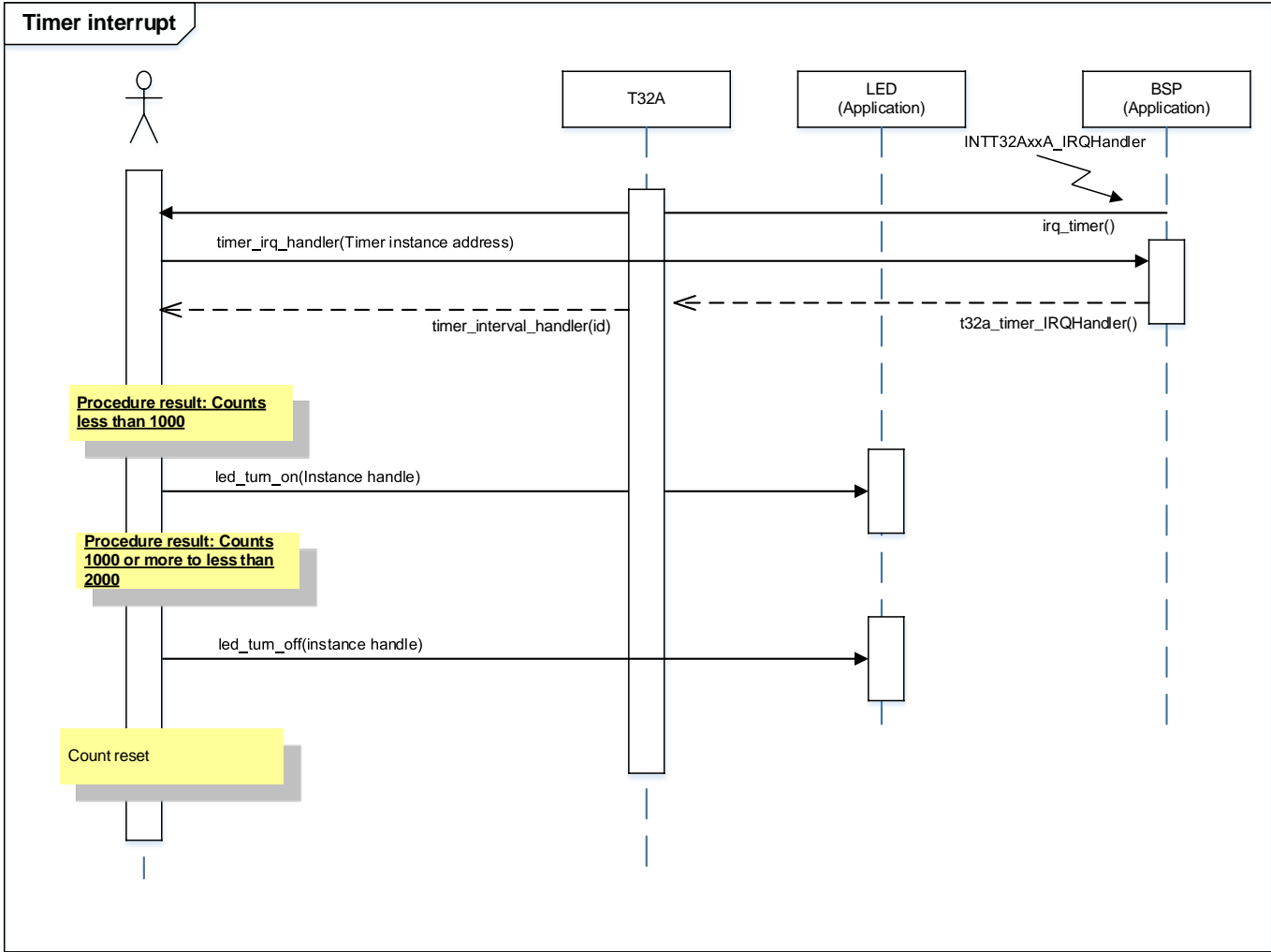




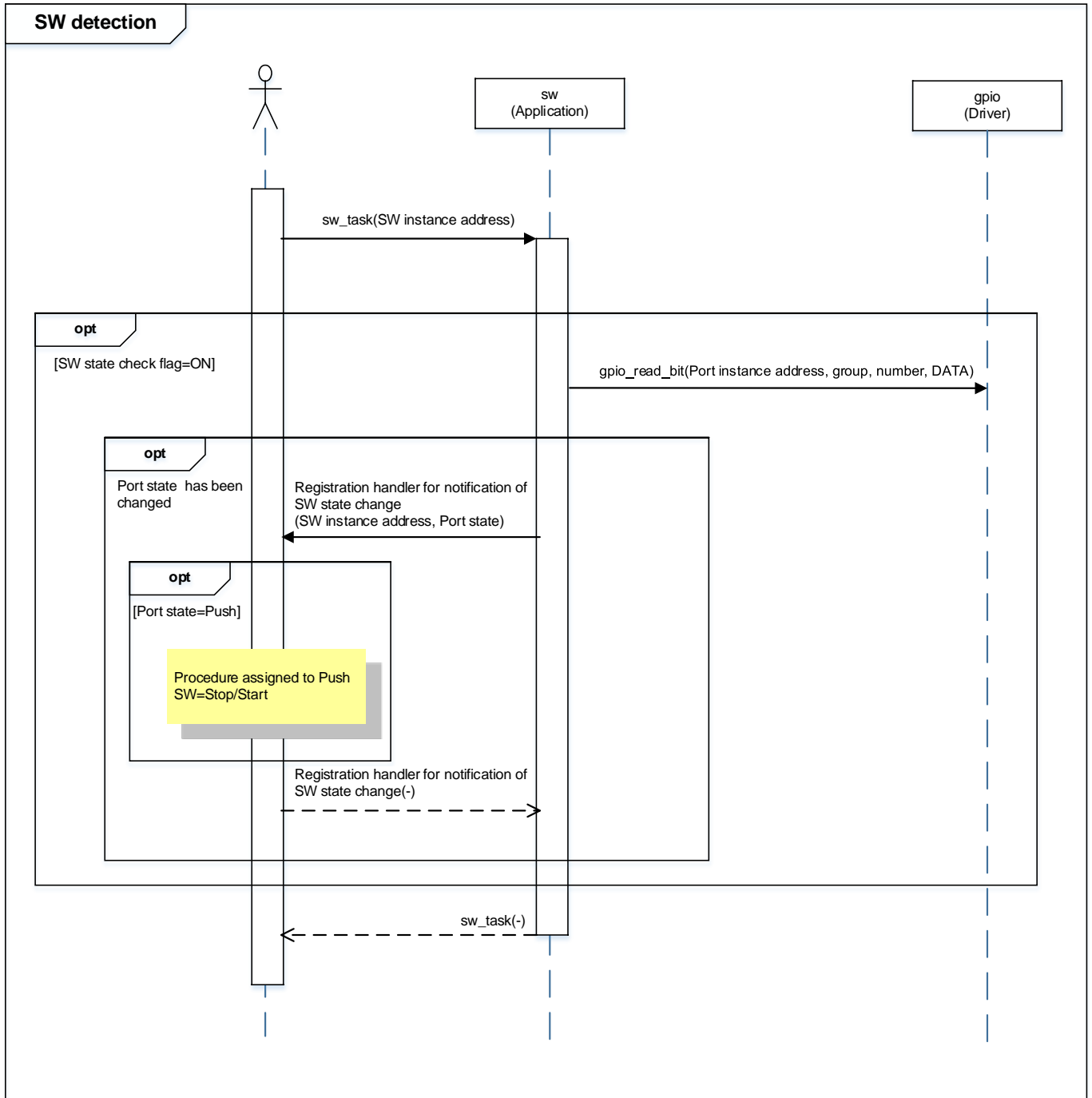












**10. Precaution**

When using the sample program with CPU other than TPM4G9F15, please check operation sufficiently.

**11. Revision History**

Rev	Date	Page	Description
1.0	2018-12-13	-	First release

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