Outlines

This application note is a reference material for developing products using the programmable pulse output (PPG) function in the 32-bit timer event counter (T32A) of M3H Group(2). This document helps the user check operation of the product and develop its program.

Target sample program: Timer_PPG
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1. Preface

This sample program executes to start the PPG output of the timer function when the PV0 Push Switch is pushed down.

Structure diagram of Sample program
2. Reference Document

- Datasheet
  TMPM3H group (2) datasheet Rev2.0 (Japanese edition)
- Reference manual
  32-bit timer/event counter (T32A-B) Rev2.1 (Japanese edition)
- Other reference document
  TMPM3H(2) Group Peripheral Driver User Manual (Doxygen)

3. Function to Use

<table>
<thead>
<tr>
<th>IP</th>
<th>Channel</th>
<th>Port</th>
<th>Function/Operation mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>32-bit timer event counter</td>
<td>Timer A ch3</td>
<td>PJ0 (T32A03OUTA)</td>
<td>PPG operation</td>
</tr>
<tr>
<td></td>
<td>Timer A ch0</td>
<td>-</td>
<td>Timer interrupt</td>
</tr>
<tr>
<td>Input or output port</td>
<td>-</td>
<td>PV0 (Input Port)</td>
<td>Input</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PV1 (Input Port)</td>
<td></td>
</tr>
<tr>
<td>Asynchronous serial communication circuit</td>
<td>ch0</td>
<td>PA1 (UT0TXDA) PA2 (UT0RXD)</td>
<td>Asynchronous communication with PC</td>
</tr>
</tbody>
</table>

4. Target Device

The target devices of application note are as follows.

<table>
<thead>
<tr>
<th>TMPM3HQFDFG</th>
<th>TMPM3HQFZFG</th>
<th>TMPM3HQFYFG</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMPM3HPFDFG</td>
<td>TMPM3HPFZFG</td>
<td>TMPM3HPFYFG</td>
</tr>
<tr>
<td>TMPM3HNFDFFG</td>
<td>TMPM3HNFDZFG</td>
<td>TMPM3HNFYDFG</td>
</tr>
<tr>
<td>TMPM3HMFDFFG</td>
<td>TMPM3HMFDZFG</td>
<td>TMPM3HMFYFG</td>
</tr>
</tbody>
</table>

* This sample program operates on the evaluation board of TMPM3HQFDFG.
If other function than the TMPM3HQ 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 (TMPM3HQ). If other function than the TMPM3HQ one is checked, the BSP related file should be changed properly.
5. Operation confirmation condition

- **Used microcontroller**: TMPM3HQFDFG
- **Used board**: TMPM3HQFDFG 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

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

![Evaluation board (TMPM3HQFDFG Evaluation Board) (Top view)](image-url)
6. Evaluation Board Setting

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

<table>
<thead>
<tr>
<th>CN5</th>
<th>Board function</th>
<th>Through hole No.</th>
<th>Through hole No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CN5</td>
<td>Board function</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Push SW (S4)</td>
<td>PV0</td>
<td>49: PORT_PSW0</td>
<td>50: PV0</td>
</tr>
<tr>
<td>Push SW (S5)</td>
<td>PV1</td>
<td>51: PORT_PSW1</td>
<td>52: PV1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CN12</th>
<th>Board function</th>
<th>Through hole No.</th>
<th>Through hole No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CN12</td>
<td>Board function</td>
<td></td>
<td></td>
</tr>
<tr>
<td>USB UART conversion</td>
<td>PA1</td>
<td>53: PA1</td>
<td>54: USB_TXD</td>
</tr>
<tr>
<td>USB UART conversion</td>
<td>PA2</td>
<td>55: PA2</td>
<td>56: USB_RXD</td>
</tr>
</tbody>
</table>

7. Operation of Evaluation Board

PPG output and duty ratio can be switch with Push Switch.

<table>
<thead>
<tr>
<th>Key</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Push SW (S4) : PV0</td>
<td>PPG output</td>
</tr>
<tr>
<td>Push SW (S5) : PV1</td>
<td>Duty change / PPG stop</td>
</tr>
</tbody>
</table>

The duty ratios preset in this sample program are 10 %, 25 %, 50 %, 75 %, and 90 %.
The PPG output can be monitored at PJ0 (T32A03OUTA). (It can be monitored at CN5: 18 pin.)
8. Outline of Timer Event Counter (T32A) Function

T32A is composed two 16-bit timer that can be used Timer A and Timer B. Also it can use Timer C that is connected Timer A and Timer B as 32-bit timer. When use Timer C, Timer A and Timer B cannot be used.

The T32A have an interval timer, event counter, input capture, 2-phase counter input, PPG output, Synchronous Start, and Trigger start/stop functions.

The timer has the following functions;
16-bit timer: Timer A and Timer B
32-bit timer: Timer C
9. Sample Program

When Low input is detected at PortV0, the PPG output starts. When Low input is detected at PortV1, the PPG output stops. And the duty ratio is changed. The terminal software can display the duty ratio value.

The pulse width has been set to 500μs in this sample program. 5 values are defined for the duty ratio of the PPG output (50μs, 125μs, 250μs, 375μs, and 450μs) Those values generate 5 duty ratios, 10 %, 25 %, 50 %, 75 %, and 90 %, respectively.

9.1. Initialization

The following initialization is done after power is supplied. The initialization of each clock setting is done. The duty ratio of the PPG output is set after System clock setting. Then, the GPIO setting is done. Perform initialization setting of port for pulse output. Timer A ch0 is initialized for the timer driver setting. Timer A ch3 is initialized for the pulse driver setting.
9.2. Sample Program Main Operation

The timer setting is done to use the timer for PPG operation.
Timer A ch0 has been selected for Switch polling in this sample program.
1-ms timer interrupt checks Switch status.
Timer A ch3 has been selected as the timer for the output pulse.

When the value in Timer A counter matches the values in Timer registers ([T32AxRGA0] and [T32AxRGA1]),
the timer output is set or cleared, respectively, which a pulse with an arbitrary width can be generated.
And it is output from T32A03OUTA pin.

The setting condition can be displayed by the terminal software.
UART setting should be done, and the setting condition is displayed.

The following is an example of the output signal with 25-% duty.
9.3. Output Example of Sample Program
When the sample program operates, the command results are shown as follows;

<table>
<thead>
<tr>
<th>Command</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change to Duty</td>
<td>25%</td>
</tr>
<tr>
<td>Change to Duty</td>
<td>50%</td>
</tr>
<tr>
<td>Change to Duty</td>
<td>75%</td>
</tr>
<tr>
<td>Change to Duty</td>
<td>90%</td>
</tr>
<tr>
<td>FPG Output</td>
<td>10%</td>
</tr>
<tr>
<td>FPG Output</td>
<td>90%</td>
</tr>
<tr>
<td>FPG Output</td>
<td>10%</td>
</tr>
</tbody>
</table>

9.3.1. Setting Example of Terminal Software
The operation of the terminal software (Tera Term) has been checked with the following settings.

![Terminal Software Settings](image)
9.4. Duty Setting Change

When the duty is changed, the following setting should be modified.

```c
```

5 values are available from 10 % to 90 % in the above setting.

For example, 10 % duty is calculated by the following formula;
Pulse width setting;

```c
  p_pulse->init.pulse_trailing = 500U;  
```

500-μs pulse width is defined above.

Duty setting;

```c
  RisingTimingus[i] = tgtRisingTiming[i] * 5U;  
```

The rising time is set above.
The duty ratios of 10 %, 25 %, 50 %, 75 %, and 90 % are defined in tgtRisingTiming[i].
The rising times are calculated to 50, 125, 250, 375, and 450μs, respectively.
The pulse width is supposed to be 500μs to calculate the duty ratios.

If the duty ratio is changed, the corresponding set value should be changed in the following.

```c
```
9.5. Operating Flow of Sample Program

The operating flows of the sample program are shown in the following:
Driver initialization

**Driver initialization**

- **ref** T32A Driver initialization

---

**T32A Driver initialization**

- **BSP (Application)**
  - bsp_get_timer_ch(BSPTimer)
    - Channel number = bsp_get_timer_ch()
  - t32a_mode_init(Instance address)
  - timer_initialize(Timer instance address)
    - result = timer_initialize(-):Successful
  - t32a_timer_init(Instance address)
    - result = t32a_timer_init(-):Successful

---

Acquisition of Timer channel for 1-ms timer
PPG Driver initialization

ref T32A PPG Driver initialization

T32A PPG Driver initialization

BSP (Application)

 BSP

 Acquisition of Timer channel for Pulse output

 t32a_mode_init(Instance address)

 result = t32a_mode_init(-): Successful

 t32a_timer_init(Instance address)

 result = t32a_timer_init(-): Successful

 pulse_initialize(Pulse instance address)

 result = pulse_initialize(-): Successful

 bsp_get_output_pulse_ch(BSPulse)

 Channel number = bsp_get_output_pulse_ch(-)

 Acquisition of Timer channel for Pulse output
Application initialization

ref

UART Application initialization

loop

[1, Count of used SW’s]

ref

SW Application initialization

SW Application initialization

Generation of SW initial settings

sw_initialize(SW instance address)

SW (Application)
Condition monitoring

Condition monitoring

sw_task(SW instance address)

sw (Application)

gpio (Driver)

SW status check flag = ON

Port status has changed

Registration handler for SW status change notification (SW instance address and Port status)

Process assigned to Push SW's
= Duty change/PPG output

Registration handler for SW status change notification (-)

sw_task(-)

gpio_read_bit(-): Successful

Result = gpio_read_bit(): Successful

Result = gpio_read_bit(): Successful

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Port status has changed

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Duty change

Timer for Pulse output stops.

pulse_timer_stop
(Pulse instance address)

pulse_timer_finalize
(Pulse instance address)

Rise timing value is changed.

Initialization of T32A Driver for PPG

rising_timing_change_display()

t32a_timer_stopIT(Instance)

result = t32a_timer_stopIT(-): Successful

t32a_deinit(Instance and Timer type)

result = t32a_deinit(-): Successful

uart_io

Changed duty value is displayed.

T32A
(Driver)

BSP
(Application)
PPG output

BSP (Application)

T32A (Driver)

uart_io

rising_timing_display()

pulse_timer_start
(Pulse instance address)

t32a_timer_startIT
(Instance, Timer type)

result = t32a_timer_startIT(): Successful

t32a_SWcounter_start
(Instance, Timer type)

result = t32a_SWcounter_start(): Successful

Duty value of the output signal is displayed.
10. Precaution

When using the sample program with CPU other than TMPM3HQ, please check operation sufficiently.

11. Revision History

<table>
<thead>
<tr>
<th>Rev</th>
<th>Date</th>
<th>Page</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>2018-05-18</td>
<td>-</td>
<td>First release</td>
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