Customer training workshop:
Device Configurator_Timer configuration

TRAVEO™ T2G CYT4BF series Microcontroller Training
V1.0.0 2022-12

Scope of work

- This document helps application developers understand how to use the Timer configuration of the Device Configurator as part of creating a ModusToolbox™ (MTB) application
  - The Device Configurator is part of a collection of tools included with the MTB software. It provides a GUI to configure the target device.

- ModusToolbox™ tools package version
  - 3.0.0
- Device Configurator version
  - 4.0
- Device
  - The TRAVEO™ T2G CYT4BFBCH device is used in this code example.
- Board
  - The TRAVEO™ T2G KIT_T2G-B-H_EVK board is used for testing.

Introduction

- **TCPWM has the following features:**
  - Supports up to four counter groups (device-specific)
  - Each counter group consists of up to 256 counters (counter group-specific)
  - Each counter can run in one of the following seven function modes:
    - Timer-counter with compare
    - Timer-counter with capture
    - Quadrature decoding
    - Pulse-width modulation/stepper motor control (SMC) for pointer instruments
    - PWM with dead time/three-phase motor control (Brushless-DC, BLDC)
    - Pseudo-random PWM
    - Shift register mode
  - 16-bit or 32-bit counters (counter group-specific)
  - Up, down, and up/down counting modes
  - Clock prescaling (division by 1, 2, 4, ... 64, 128)

Introduction (contd.)

TCPWM has the following features:

- Up to two capture and compare functions (counter group-specific)
- Double buffering of all compare/capture and period registers
- Two output trigger signals for each counter to indicate underflow, overflow, and capture/compare events; they can also directly connects with the line output signal
- Supports interrupt on:
  - Terminal count - Depends on the mode; typically occurs on overflow or underflow
  - Capture/compare - The count has been captured in the capture registers or the counter value equals the value in the compare register
- Line out selection feature for stepper motor application including two complementary output lines with dead time insertion
- Selectable start, reload, stop, count, and two capture event signals for each TCPWM with the rising edge, falling edge, both edges, and level trigger options
- Each counter with up to 254 (device-specific) synchronized input trigger signals and two constant input signals: '0' and '1'.

Introduction (contd.)

- **TCPWM has the following features:**
  - Two types of input triggers for each counter:
    - General-purpose triggers used by all counters
    - One-to-one triggers for specific counter
  - Synchronous operation of multiple counters
  - Debug mode support

Introduction (contd.)

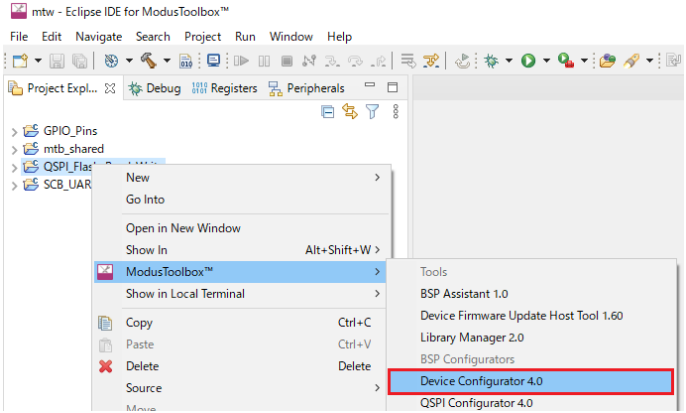
- **Timer configuration in Device Configurator:**
  - Function mode (PWM, timer counter compare/capture, Quadrature decoder, Shift register)
  - Input clock prescaler
  - Alignment (left, right, center, asymmetric)
  - Run mode (Continuous/One Shot)
  - Count direction (Up, Down, Up and Down)
  - Select Run mode (Continuous/One Shot)
  - Programmable period, compare, and capture register
  - Interrupt generation
  - Start, Reload, Stop, Swap (Capture), and Count Inputs
  - Event generation
  - GPIO connection

Launch the Device Configurator

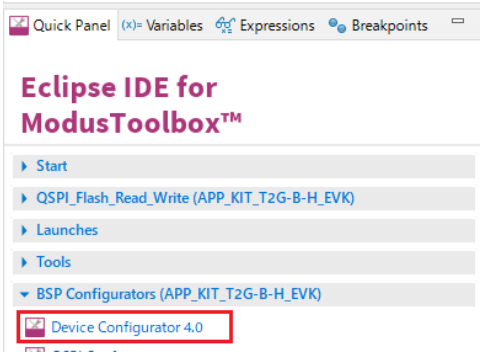
› From Eclipse IDE

You can launch the Device Configurator by either of the following methods:

a) Right-click on the project in the Project Explorer and select **ModusToolbox™** > **Device Configurator** <version>



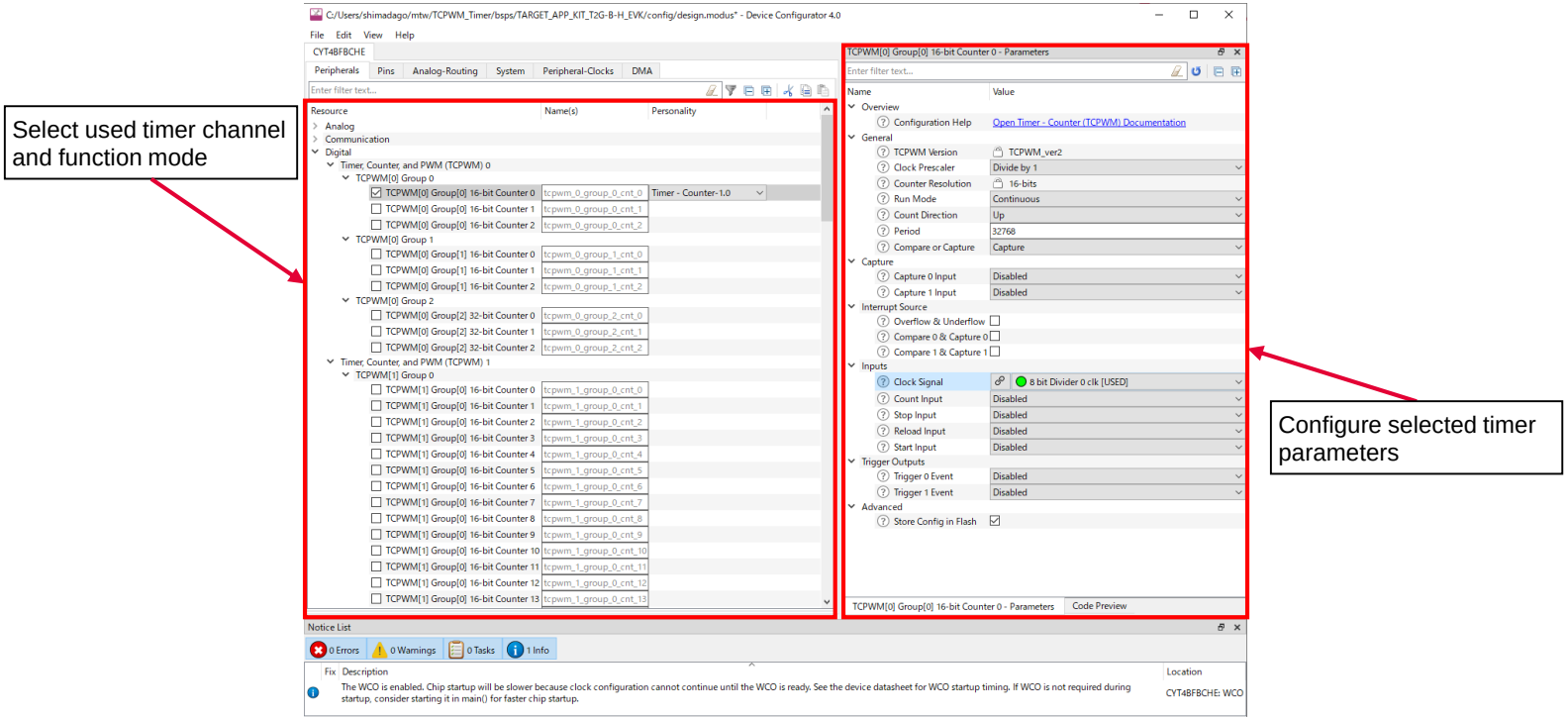
b) Click the Device Configurator link in the Quick Panel



Device configurator view for timer config

› Peripherals tab

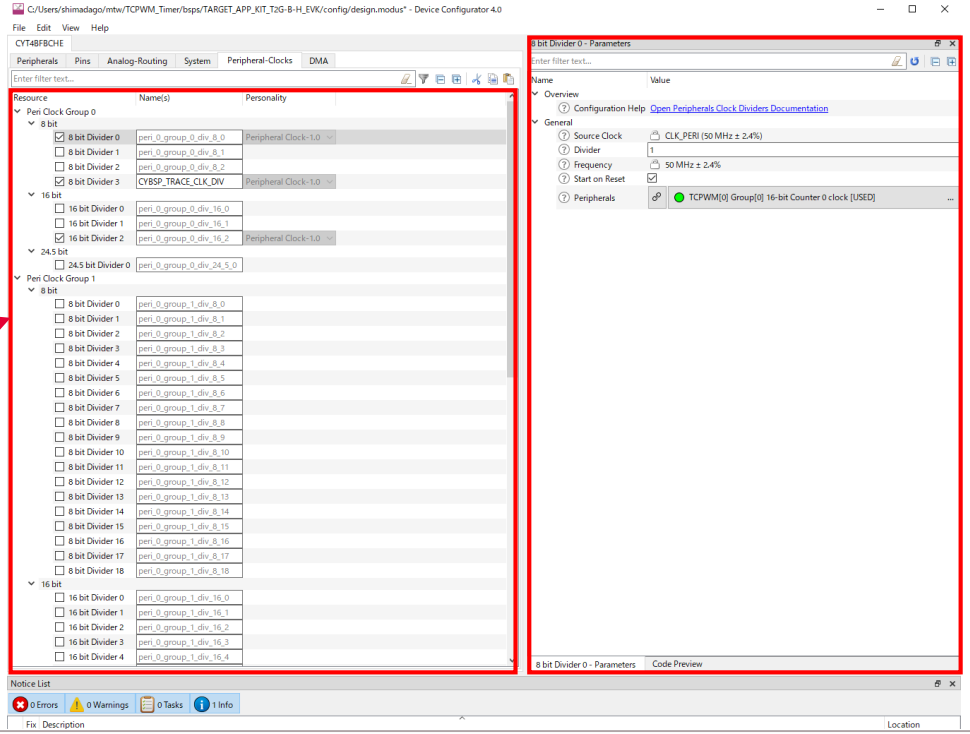
- Set each timer on the Peripheral tab



Device configurator view for timer config (contd.)

› Peripheral-Clocks tab

- Set peripheral clock (PCLK) on the Peripheral-Clocks tab.



Quick start

To use the Device configurator for Timer setting

- Launch the Device configurator.
- Use the various pull-down menus to configure signals. Refer to the descriptions in the Routing tab section for more details.
- Save the file to generate source code.
- The Device Configurator generates code into a "GeneratedSource" directory in your Eclipse IDE application, or in the same location you saved the *.modus file for non-IDE applications. That directory contains the necessary source (.c) and header (.h) files for the generated firmware, which uses the relevant driver APIs to configure the hardware.
- Use the generated structures as input parameters for Timer configuration functions in your application.

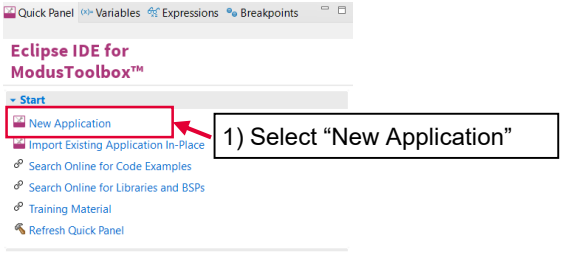
Use case

- CLK_PERI frequency set to 50 MHz
- TCPWM [0] Group [0] 16-bit Counter 1 operates as PWM mode (TCPWM_PWM)
  - It works at 50 MHz and the period is set to 9999
  - It outputs the PWM waveform to start TCPWM_COUNTER
  - Use an 8-bit Divider 1 clock (TCPWM_COUNTER_CLK) to generate 50 MHz
- TCPWM [0] Group [0] 16-bit Counter 0 operates as Counter mode (TCPWM_COUNTER)
  - It works at 200 kHz and the period is set to 60000
  - Compare value is set to 50000 (Generate compare match interrupt)
  - Use an 8-bit Divider 0 clock (TCPWM_COUNTER_CLK) to generate 200 kHz
  - It starts counting by the TCPWM_PWM event
- See the TCPWM_Counter application for operation

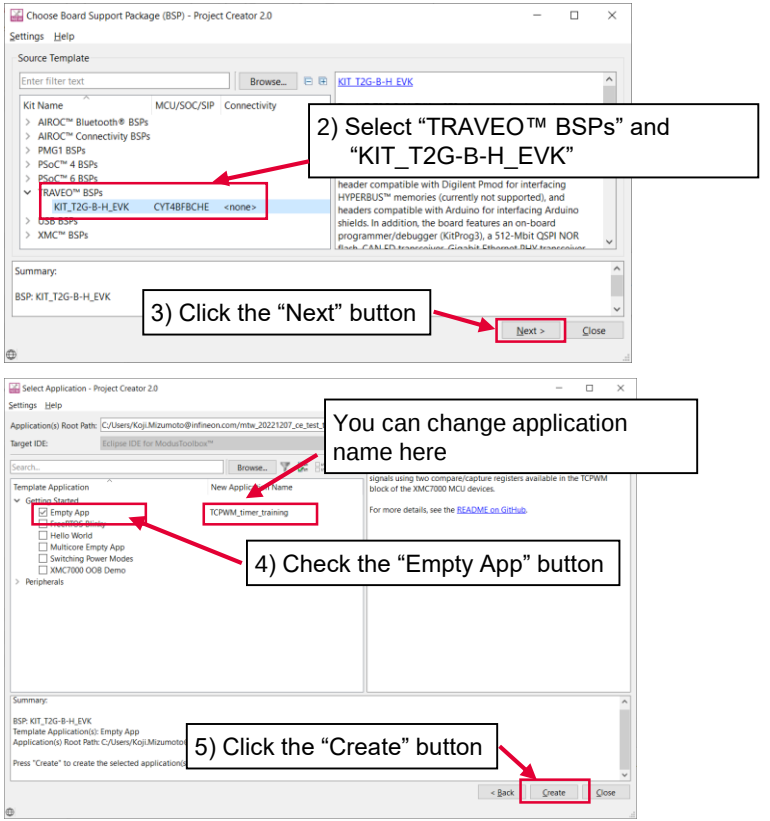
Timer configuration

› Create project

1) Click **New Application** in the Quick Panel and open the **Choose Board Support Package (BSP)** window



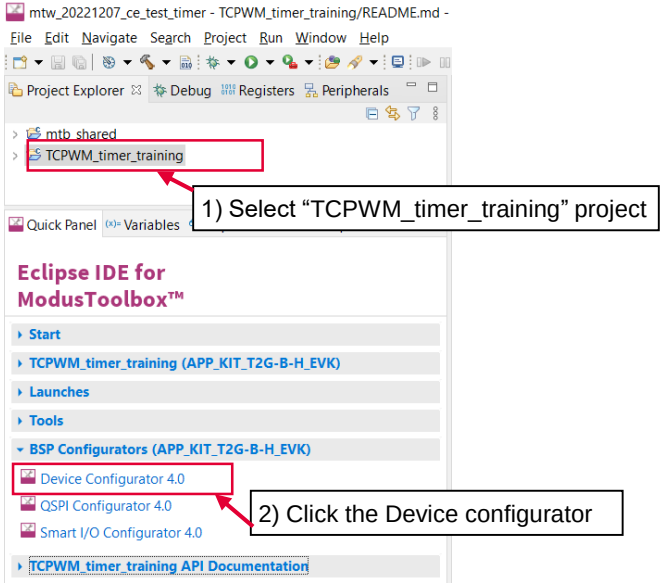
2) Select **TRAVEO™ BSPs** and **KIT_T2G-B-H_EVK**
3) Click the **Next** button and open the Application window
4) In this use case, it changes to “TCPWM_timer_training”
5) Click the **Create** button, and then start application creation

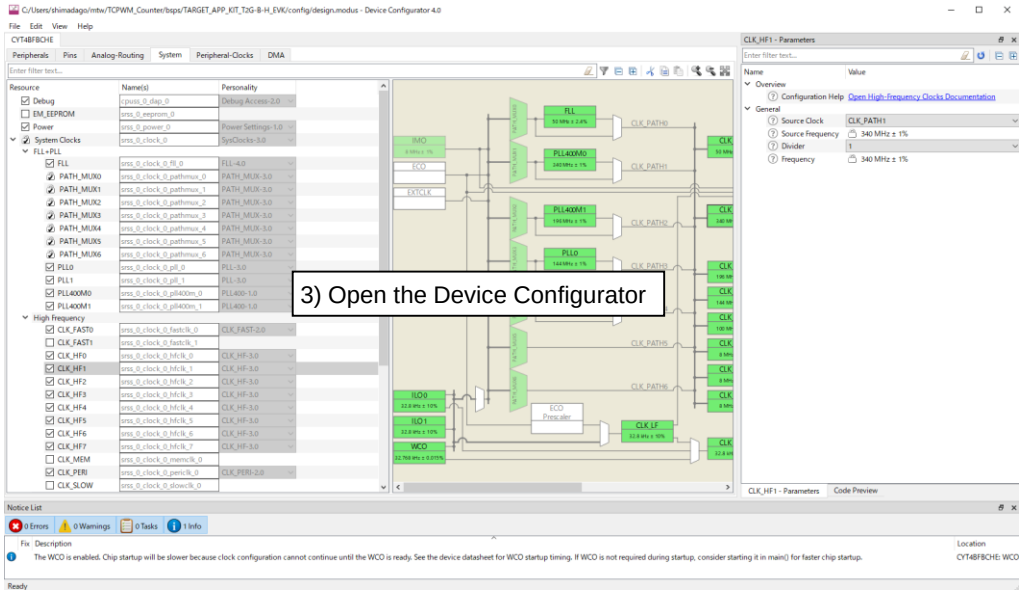


Timer configuration (contd.)

› Launch the Device configurator

1) Select the **TCPWM_timer_training** project.
2) Click the Device configurator in the Quick Panel
3) Then, open the Device Configurator window





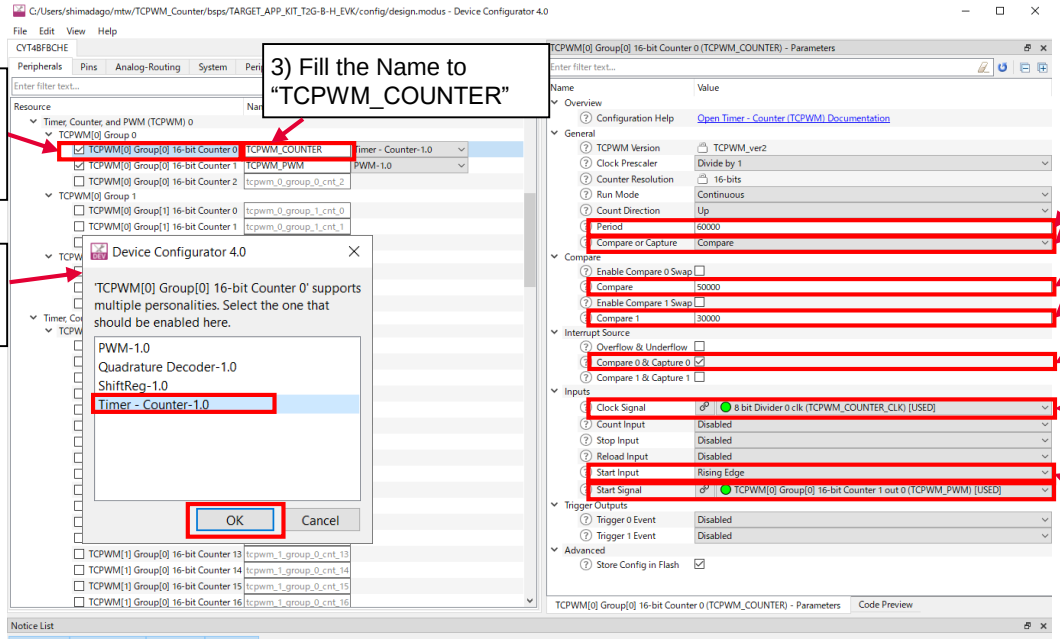
Timer configuration (contd.)

› Configure TCPWM_COUNTER

- Open the Peripherals tab and make the following settings
- The values without description are default settings. You should set them only if needed.

1) Select TCPWM [0] Group [0] 16-bit Counter 0, then open the function mode window

2) Select Timer – Counter – 1.0, then, click “OK” button



Set Period to 60000

Select to Compare

Set Compare to 50000, and Compare 1 to 30000

Check Compare 0 to generate compare match interrupt

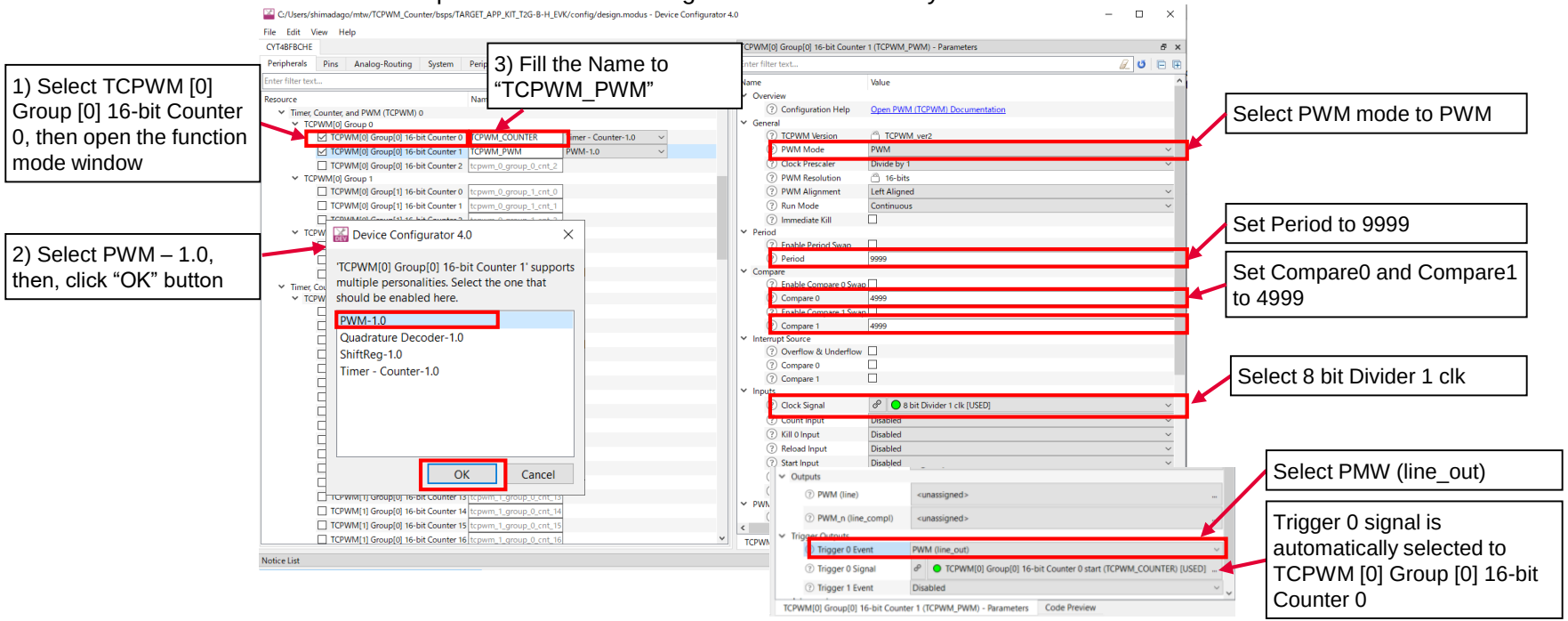
Select 8 bit Divider 0 as Input clock

Select Start Input to Rising Edge, then, select Start Signal to TCPWM [0] / Group [0] / 16-bit Counter 1.

Timer configuration (contd.)

› Configure TCPMW_PWM

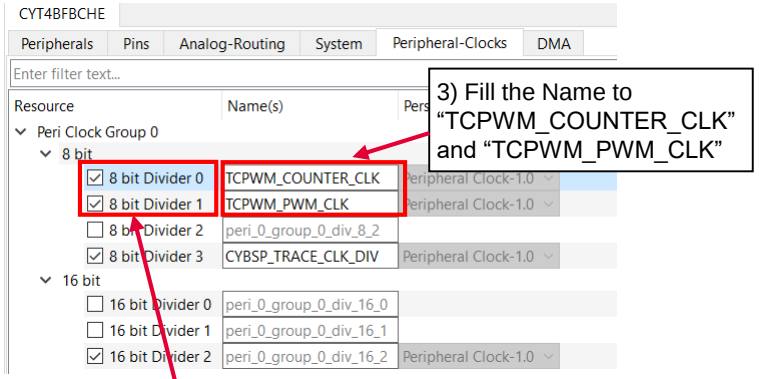
- Open the Peripherals tab and make the following settings.
- The values without description are default settings. You should set only if needed.



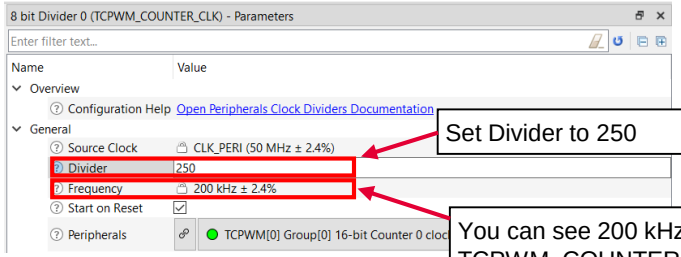
Timer configuration (contd.)

› Configure Peripheral clock divider

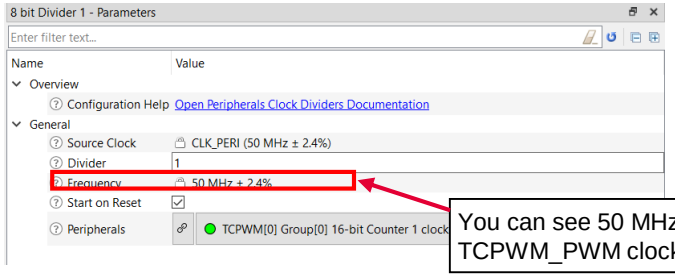
- Open the Peripheral-clocks tab and make the following dividers settings.



TCPWM_COUNTER_CLK



TCPWM_PWM_CLK

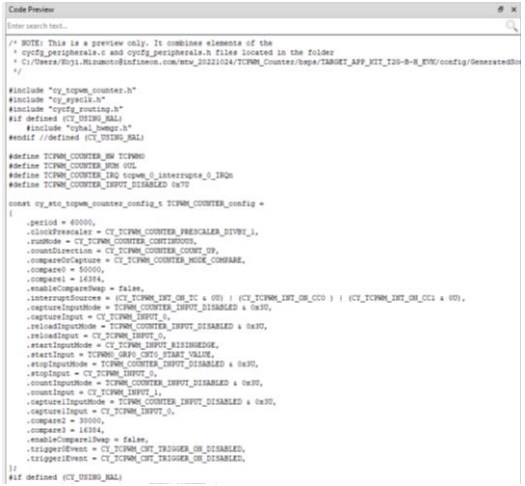


Timer configuration (contd.)

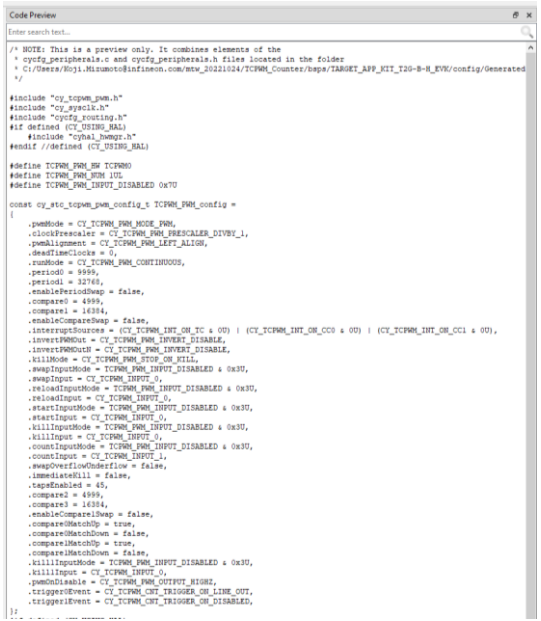
› Confirm configuration result

- You can check the configuration result in the “Code Preview” tab of the Device Configurator

TCPWM_COUNTER



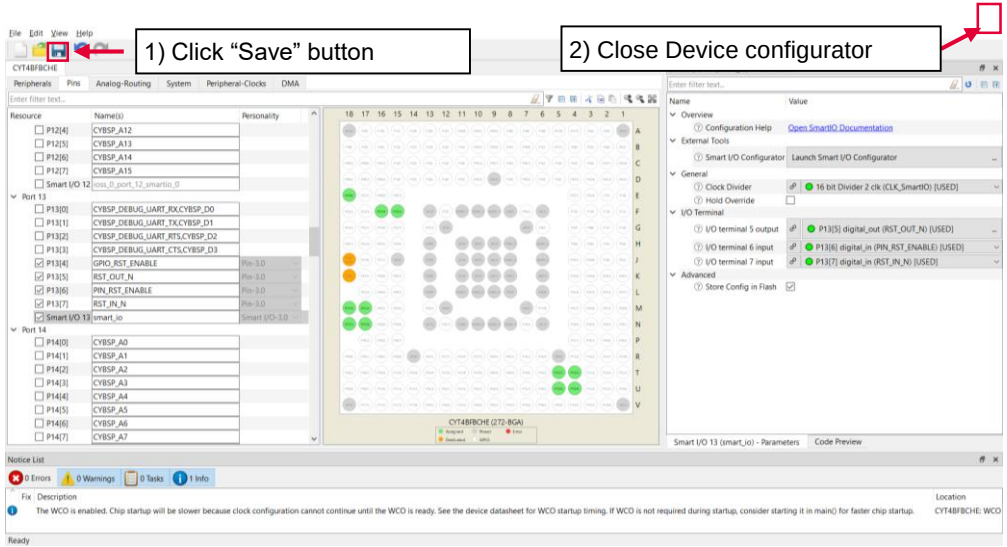
TCPWM_PWM



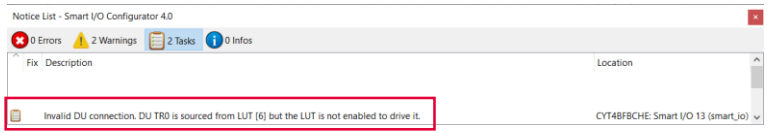
Timer configuration (contd.)

› Close Device configurator

- Click the **Save** button after completing all settings, then close the Device configurator



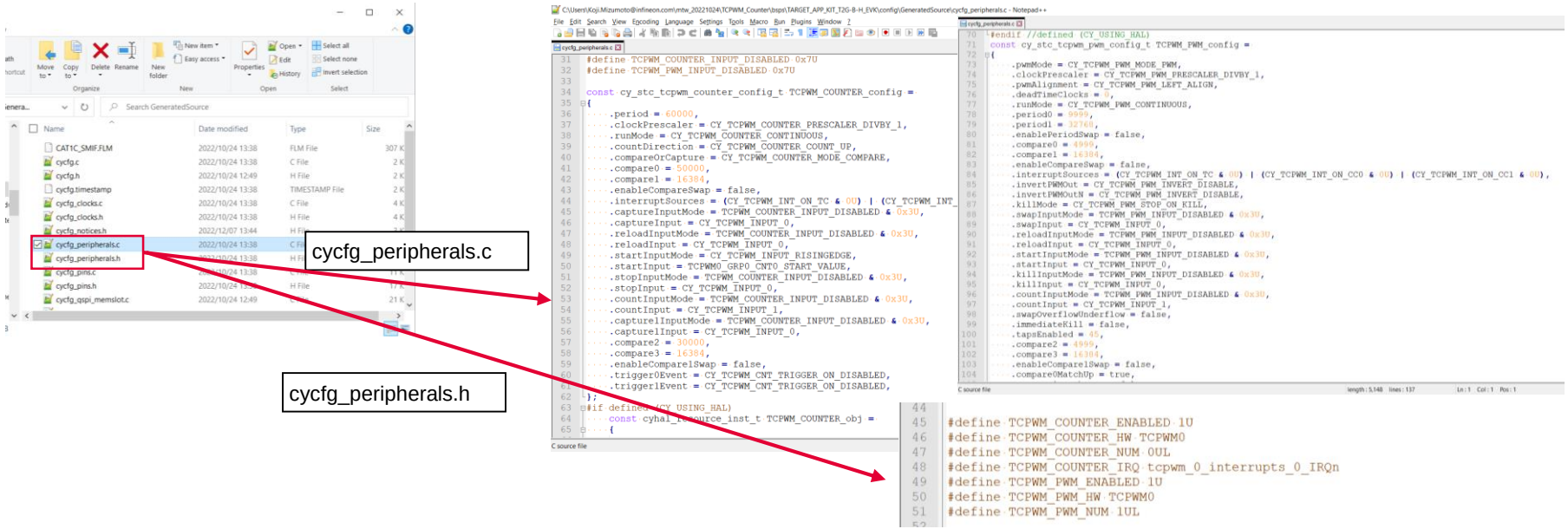
- If an **Errors/Tasks** message appears, it should be resolved according to the instructions



Timer configuration (contd.)

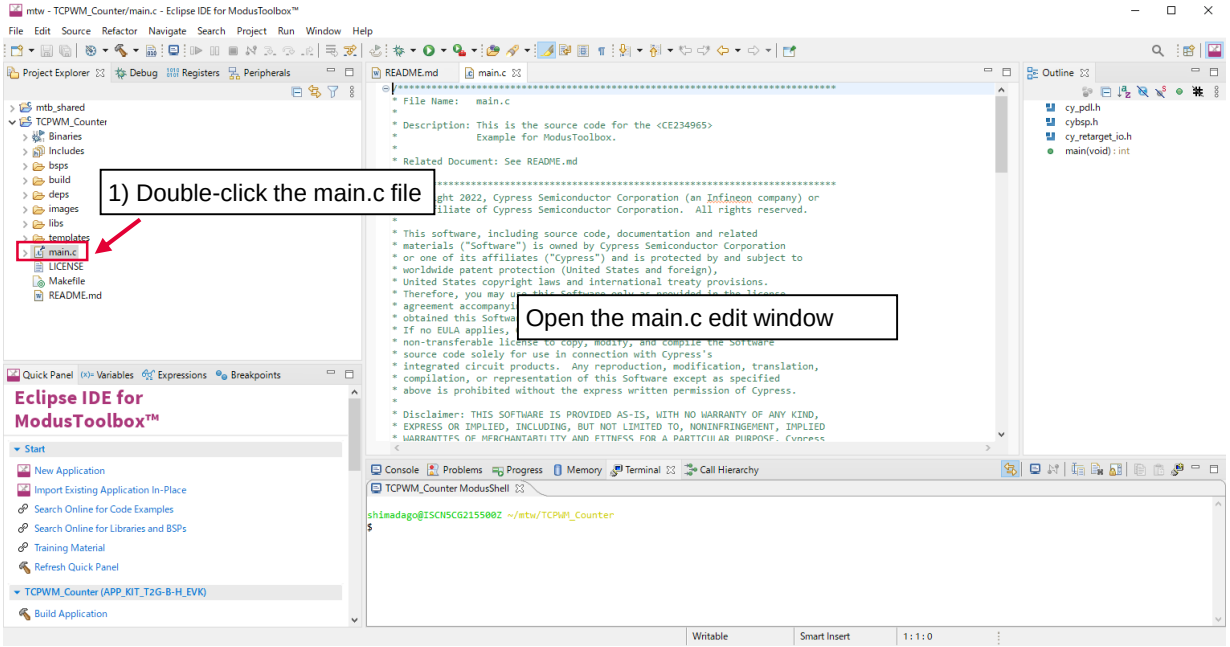
› Configuration file

- The Device Configurator generates code into a "GeneratedSource" directory in your Eclipse IDE application, or in the same location you saved the *.modus file for non-IDE applications.
- In this example, the following code is generated:



Implementation

› The structure generated by the Device Configurator can be used by implementing the following function in your application code.



Implementation (contd.)

› Add include file

README.md | main.c

```
 * reserves the right to make changes to the Software without notice. Cypress
 * does not assume any liability arising out of the application or use of the
 * Software or any product or circuit described in the Software. Cypress does
 * not authorize its products for use in any products where a malfunction or
 * failure of the Cypress product may reasonably be expected to result in
 * significant property damage, injury or death ("High Risk Product"). By
 * including Cypress's product in a High Risk Product, the manufacturer
 * of such system or application assumes all risk of such use and in doing
 * so agrees to indemnify Cypress against all liability.
 *******************************************************************************/

#include "cy_pdl.h"
#include "cybsp.h"
#include "cy_retarget_io.h"

/*******************************************************************************
 * Macros
 *******************************************************************************/
```

Add include file in main.c

Implementation (contd.)

› Add TCPWM_PWM initialization enable function

README.md | main.c

```
int main(void)
{
    cy_rslt_t result;
    uint32_t intrMask;

    /* Initialize the device and board peripherals */
    result = cybsp_init() ;
    if (result != CY_RSLT_SUCCESS)
    {
        CY_ASSERT(0);
    }

    /* Enable global interrupts */
    __enable_irq();

    /*Initialize the User LED*/
    Cy_GPIO_Pin_Init(CYBSP_USER_LED1_PORT, CYBSP_USER_LED1_PIN, &CYBSP_USER_LED1_config );

    /*TCPWM PWM Mode initial*/
    if (CY_TCPWM_SUCCESS != Cy_TCPWM_PWM_Init(TCPWM_PWM_HW, TCPWM_PWM_NUM, &TCPWM_PWM_config))
    {
        CY_ASSERT(0);
    }

    /* Enable the initialized PWM */
    Cy_TCPWM_PWM_Enable(TCPWM_PWM_HW, TCPWM_PWM_NUM);

    /* Then start the PWM */
    Cy_TCPWM_TriggerReloadOrIndex_Single(TCPWM_PWM_HW, TCPWM_PWM_NUM);

    /*TCPWM Counter Mode initial*/
    if (CY_TCPWM_SUCCESS != Cy_TCPWM_Counter_Init(TCPWM_COUNTER_HW, TCPWM_COUNTER_NUM, &TCPWM_COUNTER_config))
    {
        CY_ASSERT(0);
    }
    /* Enable the initialized counter */
    Cy_TCPWM_Counter_Enable(TCPWM_COUNTER_HW, TCPWM_COUNTER_NUM);

    /* Then start the counter, the counter will be trigger by PWM signal */

    for (;;)
    {
        /*get the counter CC0 compare interrupt mask*/
        intrMask = Cy_TCPWM_GetInterruptStatusMasked(TCPWM_COUNTER_HW, TCPWM_COU
        if (intrMask == CY_TCPWM_INT_ON_CC0)
        {
            /*toggle user LED1*/
            Cy_GPIO_Inv(CYBSP_USER_LED1_PORT, CYBSP_USER_LED1_PIN);

            /*clear the counter CC0 compare interrupt*/
            Cy_TCPWM_ClearInterrupt(TCPWM_COUNTER_HW, TCPWM_COUNTER_NUM, CY_TCPWM_INT_ON_CC0);
        }
    }
}
```

There is structure to configure TCPWM_PWM in the cycfg_peripherals.c file

Add TCPWM_PWM initialization function

Add TCPWM_PWM enable function

Add TCPWM_PWM start function (Software reload event generation)

README.md | main.c | cycfg_peripherals.c

```
#endif //defined (CY_USING_HAL)
const cy_stc_tcpwm_pwm_config_t TCPWM_PWM_config =
{
    .pwmMode = CY_TCPWM_PWM_MODE_PWM,
    .clockPrescaler = CY_TCPWM_PWM_PRESCALER_DIVBY_1,
    .pwmAlignment = CY_TCPWM_PWM_LEFT_ALIGN,
    .deadTimeClocks = 0,
    .runMode = CY_TCPWM_PWM_CONTINUOUS,
    .period0 = 9999,
    .period1 = 32768,
    .enablePeriodSwap = false,
    .compare0 = 4999,
    .compare1 = 16384,
    .enableCompareSwap = false,
    .interruptSources = (CY_TCPWM_INT_ON_TC & 0U) | (CY_TCPWM_INT_ON_CC0 & 0U) | (CY_TCPWM_INT_ON_CC1 & 0U),
    .invertPWMOut = CY_TCPWM_PWM_INVERT_DISABLE,
    .invertPWMOutN = CY_TCPWM_PWM_INVERT_DISABLE,
    .killMode = CY_TCPWM_PWM_STOP_ON_KILL,
    .swapInputMode = TCPWM_PWM_INPUT_DISABLED & 0x3U,
    .swapInput = CY_TCPWM_INPUT_0,
    .reloadInputMode = TCPWM_PWM_INPUT_DISABLED & 0x3U,
    .reloadInput = CY_TCPWM_INPUT_0,
    .startInputMode = TCPWM_PWM_INPUT_DISABLED & 0x3U,
    .startInput = CY_TCPWM_INPUT_0,
    .killInputMode = TCPWM_PWM_INPUT_DISABLED & 0x3U,
    .killInput = CY_TCPWM_INPUT_0,
    .countInputMode = TCPWM_PWM_INPUT_DISABLED & 0x3U,
    .countInput = CY_TCPWM_INPUT_1,
    .swapOverflowUnderflow = false,
    .immediateKill = false,
    .tapsEnabled = 45,
    .compare2 = 4999,
    .compare3 = 16384,
    .enableCompare1Swap = false,
    .compare0MatchUp = true,
    .compare0MatchDown = false,
    .compare1MatchUp = true,
    .compare1MatchDown = false,
    .killInputMode = TCPWM_PWM_INPUT_DISABLED & 0x3U,
    .killInput = CY_TCPWM_INPUT_0,
    .pwmOnDisable = CY_TCPWM_PWM_OUTPUT_HIGHZ,
    .trigger0Event = CY_TCPWM_CNT_TRIGGER_ON_LINE_OUT,
    .trigger1Event = CY_TCPWM_CNT_TRIGGER_ON_DISABLED,
};
#if defined (CY_USING_HAL)
    const cyhal_resource_inst_t TCPWM_PWM_obj =
    {
        .type = CYHAL_RSC_TCPWM,
        .block_num = 0U,
        .channel_num = 1U,
    };
#endif //defined (CY_USING_HAL)

void init_cycfg_peripherals(void)
{
    Cy_SysClk_PeriphAssignDivider(PCLK_TCPWM0_CLOCKS0, CY_SYSCLK_DIV_8_BIT, 0U);
    Cy_SysClk_PeriphAssignDivider(PCLK_TCPWM0_CLOCKS1, CY_SYSCLK_DIV_8_BIT, 1U);
}

void reserve_cycfg_peripherals(void)
{
#if defined (CY_USING_HAL)
```

You can use the “TCPWM_PWM_HW” (TCPWM#0) and “TCPWM_PWM_NUM” (Counter#1) to specify the hardware

```
#define TCPWM_COUNTER_ENABLED 1U
#define TCPWM_COUNTER_HW TCPWM0
#define TCPWM_COUNTER_NUM 0UL
#define TCPWM_COUNTER_IRQ tcpwm_0_interrupts_0_IRQn
#define TCPWM_PWM_ENABLED 1U
#define TCPWM_PWM_HW TCPWM0
#define TCPWM_PWM_NUM 1UL
```

Implementation (contd.)

› Add TCPWM_COUNTER initialization enable function

README.md | main.c

```
int main(void)
{
    cy_rslt_t result;
    uint32_t intrMask;

    /* Initialize the device and board peripherals */
    result = cybsp_init() ;
    if (result != CY_RSLT_SUCCESS)
    {
        CY_ASSERT(0);
    }

    /* Enable global interrupts */
    __enable_irq();

    /*Initialize the User LED*/
    Cy_GPIO_Pin_Init(CYBSP_USER_LED1_PORT, CYBSP_USER_LED1_PIN, &CYBSP_USER_LED1_config );

    /*TCPWM PWM Mode initial*/
    if (CY_TCPWM_SUCCESS != Cy_TCPWM_PWM_Init(TCPWM_PWM_HW, TCPWM_PWM_NUM, &TCPWM_PWM_config))
    {
        CY_ASSERT(0);
    }

    /* Enable the initialized PWM */
    Cy_TCPWM_PWM_Enable(TCPWM_PWM_HW, TCPWM_PWM_NUM);

    /* Then start the PWM */
    Cy_TCPWM_TriggerReloadOrIndex_Single(TCPWM_PWM_HW, TCPWM_PWM_NUM);

    /*TCPWM Counter Mode initial*/
    if (CY_TCPWM_SUCCESS != Cy_TCPWM_Counter_Init(TCPWM_COUNTER_HW, TCPWM_COUNTER_NUM, &TCPWM_COUNTER_config))
    {
        CY_ASSERT(0);
    }
    /* Enable the initialized counter */
    Cy_TCPWM_Counter_Enable(TCPWM_COUNTER_HW, TCPWM_COUNTER_NUM);

    /* Then start the counter, the counter will be trigger by PWM signal */

    for (;;)
    {
        /*get the counter CC0 compare interrupt mask*/
        intrMask = Cy_TCPWM_GetInterruptStatusMasked(TCPWM_COUNTER_HW, TCPWM_COUNTER
        if (intrMask == CY_TCPWM_INT_ON_CC0)
        {
            /*toggle user LED1*/
            Cy_GPIO_Inv(CYBSP_USER_LED1_PORT, CYBSP_USER_LED1_PIN);

            /*clear the counter CC0 compare interrupt*/
            Cy_TCPWM_ClearInterrupt(TCPWM_COUNTER_HW, TCPWM_COUNTER_NUM, CY_TCPWM_INT_ON_CC0);
        }
    }
}
```

README.md | main.c | cycfg_peripherals.c

```
#include "cycfg_peripherals.h"

#define TCPWM_COUNTER_INPUT_DISABLED 0x7U
#define TCPWM_PWM_INPUT_DISABLED 0x7U

const cy_stc_tcpwm_counter_config_t TCPWM_COUNTER_config =
{
    .period = 60000,
    .clockPrescaler = CY_TCPWM_COUNTER_PRESCALER_DIVBY_1,
    .runMode = CY_TCPWM_COUNTER_CONTINUOUS,
    .countDirection = CY_TCPWM_COUNTER_COUNT_UP,
    .compareOrCapture = CY_TCPWM_COUNTER_MODE_COMPARE,
    .compare0 = 30000,
    .compare1 = 16384,
    .enableCompareSwap = false,
    .interruptSources = (CY_TCPWM_INT_ON_TC & 0U) | (CY_TCPWM_INT_ON_CC0 ) | (CY_TCPWM_INT_ON_CC1 & 0U),
    .captureInputMode = TCPWM_COUNTER_INPUT_DISABLED & 0x3U,
    .captureInput = CY_TCPWM_INPUT_0,
    .reloadInputMode = TCPWM_COUNTER_INPUT_DISABLED & 0x3U,
    .reloadInput = CY_TCPWM_INPUT_0,
    .startInputMode = CY_TCPWM_INPUT_RISINGEDGE,
    .startInput = TCPWM0_GRP0_CNT0_START_VALUE,
    .stopInputMode = TCPWM_COUNTER_INPUT_DISABLED & 0x3U,
    .stopInput = CY_TCPWM_INPUT_0,
    .countInputMode = TCPWM_COUNTER_INPUT_DISABLED & 0x3U,
    .countInput = CY_TCPWM_INPUT_1,
    .capture1InputMode = TCPWM_COUNTER_INPUT_DISABLED & 0x3U,
    .capture1Input = CY_TCPWM_INPUT_0,
    .compare2 = 30000,
    .compare3 = 16384,
    .enableCompare1Swap = false,
    .trigger0Event = CY_TCPWM_CNT_TRIGGER_ON_DISABLED,
    .trigger1Event = CY_TCPWM_CNT_TRIGGER_ON_DISABLED,
};
#if defined (CY_USING_HAL)
    const cyhal_resource_inst_t TCPWM_COUNTER_obj =
    {
        .type = CYHAL_RSC_TCPWM,
        .block_num = 0U,
        .channel_num = 0U,
    };
#endif //defined (CY_USING_HAL)
```

There is structure to configure TCPWM_COUNTER in the cycfg_peripherals.c file

Add TCPWM_COUNTER initialization function

Add TCPWM_COUNTER enable function

You can use the “TCPWM_COUNTER_HW” (TCPWM#0) and “TCPWM_COUNTER_NUM” (Counter#0) to specify the hardware

```
#define TCPWM_COUNTER_ENABLED 1U
#define TCPWM_COUNTER_HW TCPWM0
#define TCPWM_COUNTER_NUM 0UL
#define TCPWM_COUNTER_IRQ tcpwm_0_interrupts_0_IRQn
#define TCPWM_PWM_ENABLED 1U
#define TCPWM_PWM_HW TCPWM0
#define TCPWM_PWM_NUM 1UL
```

In this example, TCPWM_COUNTER starts with a TCPWM_PWM trigger. So you don't use the start function.

Implementation (contd.)

TCPWM_PWM initialization:

› Call the ***Cy_TCPWM_PWM_Init()*** function to initialize TCPWM_PWM
  – Configure TCPWM with parameters in the ***TCPWM_PWM_config*** structure

TCPWM_PWM enable:

› Call the ***Cy_TCPWM_PWM_Enable()*** function to enable TCPWM_PWM

TCPWM_PWM start:

› Call the ***Cy_TCPWM_TriggerReloadOrIndex_Single()*** function to start TCPWM_PWM
  – Triggers a software reload event on the specified TCPWM

Implementation (contd.)

TCPWM_COUNTER initialization:

› The ***Cy_TCPWM_Counter_Init()*** function initializes TCPWM as a counter mode

  – Configure TCPWM with parameters in ***TCPWM_COUNTER_config*** structure

TCPWM_COUNTER enable:

› Call the ***Cy_TCPWM_Counter_Enable()*** function to enable the TCPWM counter

References

Datasheet

› CYT4BF datasheet 32-bit Arm® Cortex®-M7 microcontroller TRAVEO™ T2G family

Architecture Technical reference manual

› TRAVEO™ T2G automotive body controller high family architecture technical reference manual

Registers Technical reference manual

› TRAVEO™ T2G Automotive body controller high registers technical reference manual

PDL/HAL

› PDL

› HAL

Training

› TRAVEO™ T2G Training

Revision History

Revision	ECN	Submission Date	Description of Change
**	7847266	2022/12/13	Initial release

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