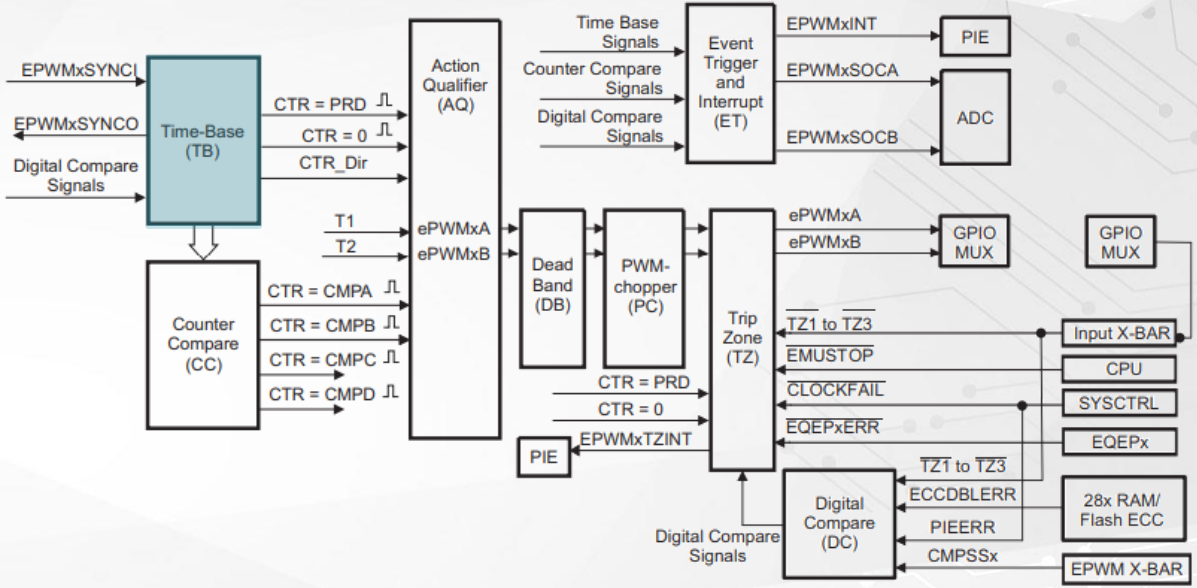
ePWM Time-Base Submodule

C2000 Enhanced Pulse Width Modulator (ePWM) Series

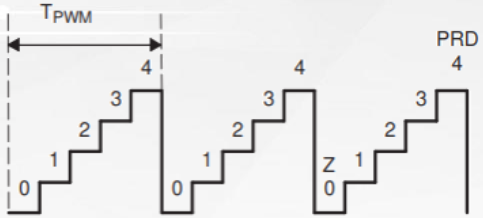
Time-Base (TB) Submodule

- Configure the PWM time-base counter frequency & period
- Set the mode for the time-base counter (up, down, or up-down)
- Configure the phase & synchronization

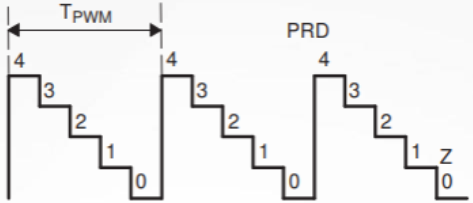


Time-Base Submodule: Equations for Period and Frequency

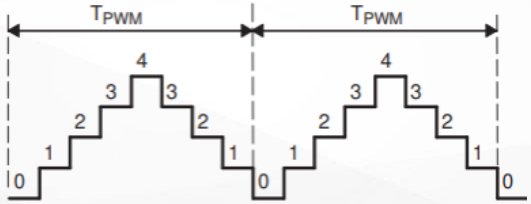
Up-Count Mode



Down-Count Mode



Up-Down-Count Mode



For Up-Count and Down-Count

$$T_{PWM} = (TBPRD + 1)T_{TBCLK}$$

$$F_{PWM} = \frac{1}{T_{PWM}}$$

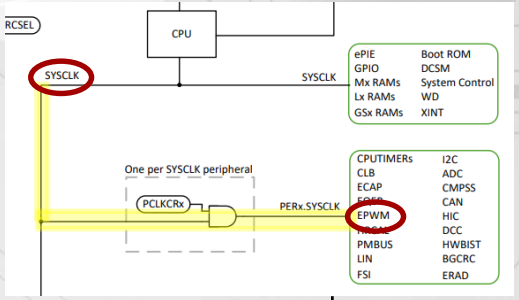
For Up-and-Down-Count

$$T_{PWM} = 2 * TBPRD * T_{TBCLK}$$

$$F_{PWM} = \frac{1}{T_{PWM}}$$

*TBPRD, HSPCLKDIV, and CLKDIV are configurable

*Refer to the 'Clocking' section of the TRM for EPWMCLK (usually = SYSCLK)



$$TBCLK = \frac{EPWMCLK}{HSPCLKDIV * CLKDIV}$$

$$T_{TBCLK} = \frac{1}{TBCLK}$$

Time-Base Submodule: Calculating Frequency and Period

Example: If I want a 50KHz output, what value do I set for TBPRD?

Step 1) Calculate T_{PWM}

$$F_{PWM} = \frac{1}{T_{PWM}} = 50KHz \rightarrow T_{PWM} = 20usec$$

Step 2) Calculate TBCLK and T_{TBCLK}

$$TBCLK = \frac{EPWMCLK}{HSPCLKDIV * CLKDIV} = \frac{100MHz}{2 * 1} = 50MHz$$

$$T_{TBCLK} = \frac{1}{TBCLK} = \frac{1}{50MHz} = 20nsec$$

* Values of HSPCLKDIV and CLKDIV are configurable through the HSPCLKDIV and CLKDIV bits of the TBCTL register

Step 3) Calculate TBPRD for Up − Count Mode

$$T_{PWM} = (TBPRD + 1)T_{TBCLK} = 20usec$$

$$TBPRD = \frac{T_{PWM}}{T_{TBCLK}} - 1 = \frac{20usec}{20nsec} - 1 = 999$$

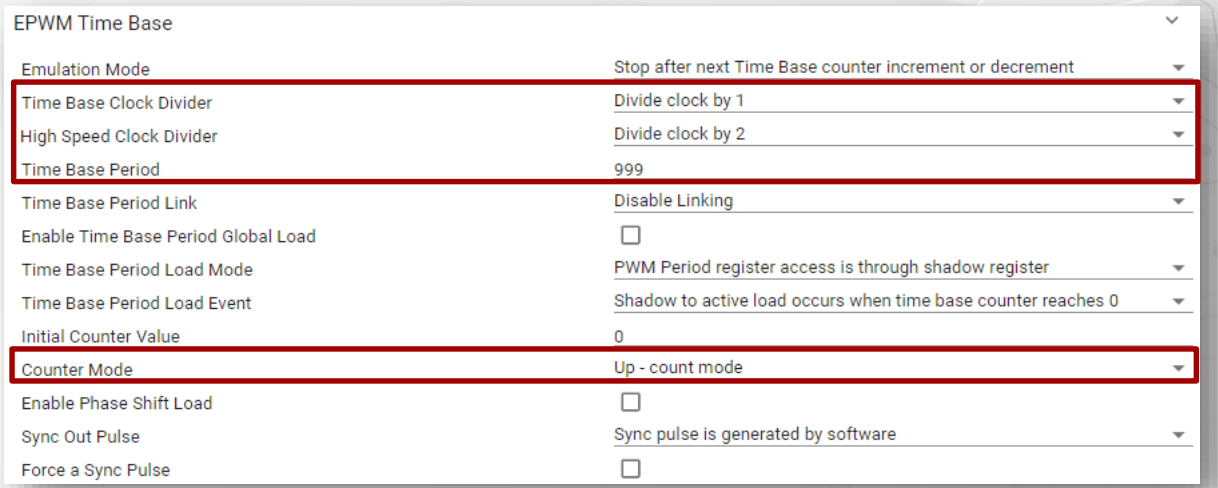
Step 3) Calculate TBPRD for Up − Down − Count Mode

$$T_{PWM} = 2 * TBPRD * T_{TBCLK} = 20usec$$

$$TBPRD = \frac{T_{PWM}}{2 * T_{TBCLK}} = \frac{20usec}{2 * 20nsec} = 500$$

Time-Base Submodule: Programming Frequency and Period

From the previous example, we learned that in order to generate a 50KHz output, TBPRD needs to be 999 for Up or Down Count mode or 500 for Up-and-Down-Count mode. How do we program this?
Below is an example for the Up-Count counter mode:



Time-Base Submodule: Calculating Phase Shift Value

Example: How do I get two ePWM modules with a 90 degree phase shift? TBPRD is 500

The phase value is set through the TBPHS register

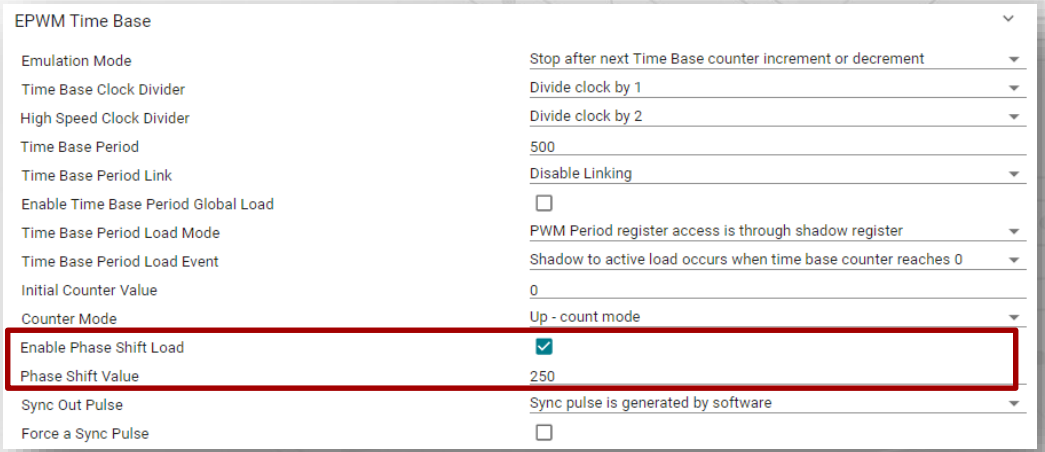
$$\text{TBPHS} = \frac{\text{TBPRD} * \text{Desired Phase Degree}}{180}$$

$$\text{TBPHS} = \frac{500 * 90}{180} = 250$$

Therefore:

- first ePWM module would have a TBPHS value of 0
- second ePWM module would have a TBPHS value of 250

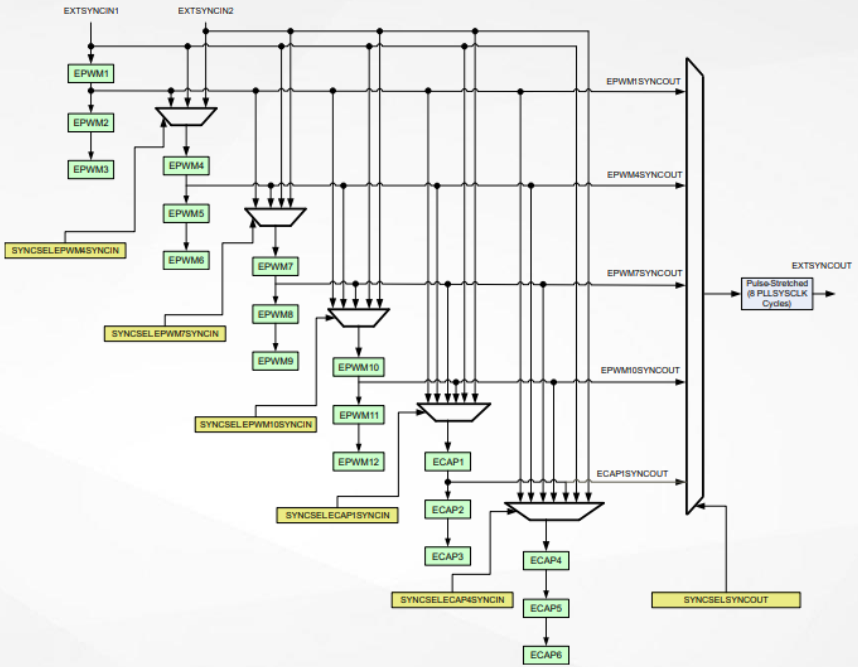
SysConfig



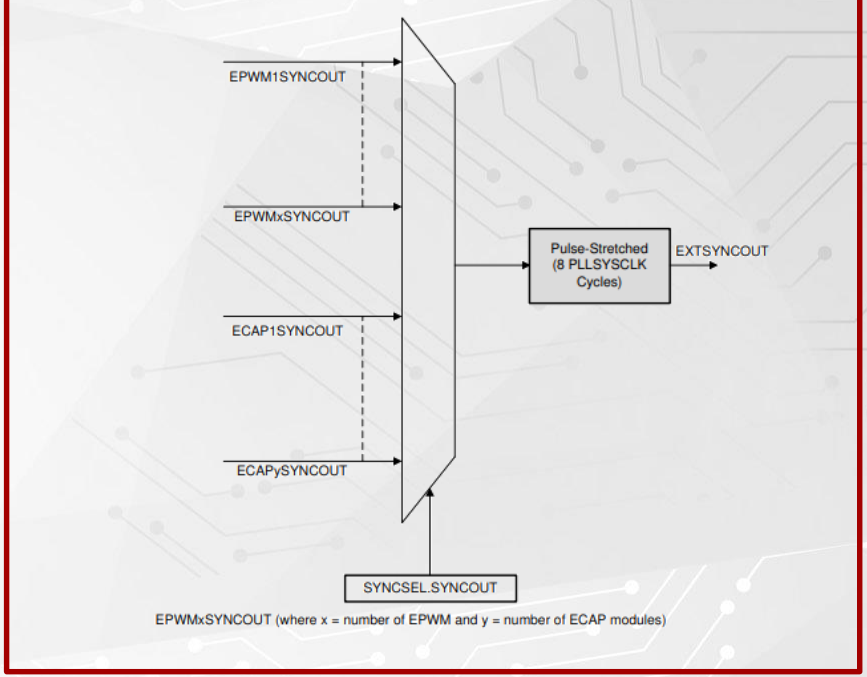
Time-Base Submodule: Synchronization

There are two synchronization schemes for ePWM Type 4:

1

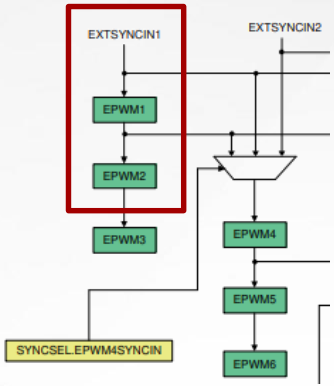


2



Time-Base Submodule: Synchronization Example

Example: How do I synchronize EPWM2, EPWM4, and EPWM5 to EPWM1?



EPWM 1

- The SYNC Source
  - This EPWM module will drive the sync pulse of the other modules
- Its SYNCIN comes from EXTSYNCIN1
- The SYNCOUT signal can be configured to be any of the following:
  - A software trigger, zero event, CMPB/C/D match, or the SYNCIN pulse.

In this example, let's choose a SYNCOUT when TBCTR = ZRO

```
EPWM_setSyncOutPulseMode(EPWM1_BASE,EPWM_SYNC_OUT_PULSE_ON_COUNTER_ZERO);
```

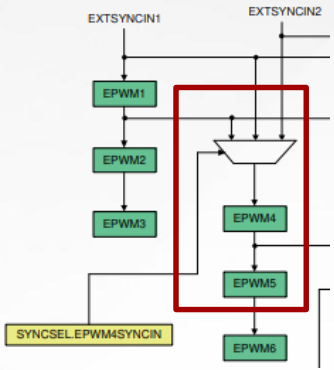
EPWM 2

- The SYNCIN will be EPWM1's SYNCOUT
- Its SYNCOUT will be SYNCIN (pass through of the sync signal)

```
EPWM_setSyncOutPulseMode(EPWM2_BASE, EPWM_SYNC_OUT_PULSE_ON_EPWMxSYNCIN);
```

Time-Base Submodule: Synchronization Example

Example: How do I synchronize EPWM2, EPWM4, and EPWM5 to EPWM1?



EPWM4

- The SYNCIN is configured through SYNCSEL.EPWM4SYNCIN
- The SYNCOUT of EPWM4 will be its own SYNCIN

In this example, we are going to choose the SYNCOUT of EPWM1 as the SYNCIN for EPWM4

```
SysCtl_setSyncInputConfig(SYSCTL_SYNC_IN_EPWM4,SYSCTL_SYNC_IN_SRC_EPWM1SYNCOUT);
EPWM_setSyncOutPulseMode(EPWM4_BASE,EPWM_SYNC_OUT_PULSE_ON_EPWMxSYNCIN);
```

EPWM5

- EPWM5's SYNCIN is EPWM4's SYNCOUT
- EPWM5's SYNCOUT will be its own SYNCIN

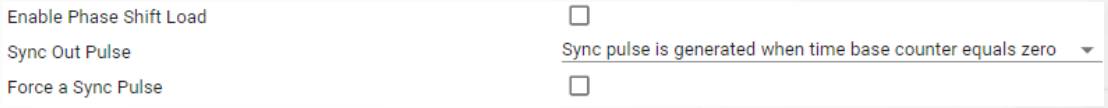
```
EPWM_setSyncOutPulseMode(EPWM5_BASE,EPWM_SYNC_OUT_PULSE_ON_EPWMxSYNCIN);
```

Time-Base Submodule: Synchronization Example – Programming

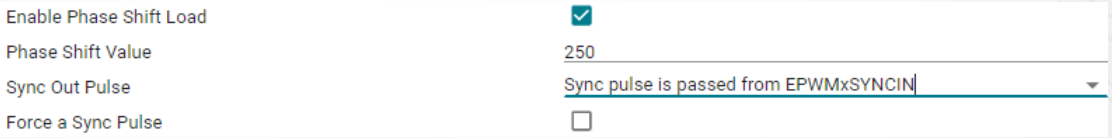
Example: How do I synchronize EPWM2, EPWM4, and EPWM5 to EPWM1?

Within the ‘SYNC’ module of Control, EPWM1 & EPWM4 SYNCIN sources are selected:

Within the Time-Base submodule of the EPWM module, for EPWM1:



Within the Time-Base submodule of the EPWM module, for EPWM2, 4, and 5:



Sync Source:
- Disable phase shift

Sync Receivers:
- Provide phase shift
- Enable phase shift

Additional ePWM Resources

- C2000 Academy with Hands-on Labs
- TI Precision Labs: PWM Basics Overview
- TI Precision Labs: Motor Interfaces and PWM Frequencies

- ePWM Application Reports
  - Flexible PWMs Enable Multi-Axis Drives, Multi-Level Inverters
  - Using PWM Output as a Digital-to-Analog Converter
  - Using the ePWM Module for 0% - 100% Duty Cycle Control
  - Leverage New Type ePWM Features for Multiple Phase Control

Check Video Description for Additional Resources