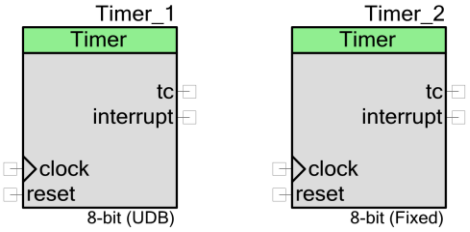
Timer
2.80



Features

- Universal Digital Block (UDB) implementation for all devices
- Fixed-function (FF) implementation for PSoC 3 and PSoC 5LP devices
- 8-, 16-, 24-, or 32-bit timer
- Optional capture input
- Enable, trigger, and reset inputs, for synchronizing with other Components
- Continuous or one shot run modes

General Description

The Timer Component provides a method to measure intervals. It can implement a basic timer function and offers advanced features such as capture with capture counter and interrupt/DMA generation.

For PSoC 3 and PSoC 5LP devices, the Component can be implemented using FF blocks or UDB. PSoC 4 devices support only the UDB implementation. A UDB implementation typically has more features than a FF implementation. If the design is simple enough, consider using FF and save UDB resources for other purposes.

Note For PSoC 4 devices, there is also a Timer/Counter/Pulse Width Modulator (TCPWM) Component available for use. Refer to the TCPWM Component datasheet.

The following table shows the major feature differences between FF and UDB. There are also many specific functional differences between the FF and UDB implementations and differences between the FF implementation in different devices. See the Configurations section for detailed timing waveforms for the various implementations.

Feature	FF	UDB
Number of bits	8 or 16	8, 16, 24, or 32
Run mode	Continuous or one shot	Continuous, one shot, or one shot halt on interrupt
Count mode	Down only	Down only
Enable input	Yes (hardware or software enable)	Yes (hardware or software enable)

Feature	FF	UDB
Capture input	Yes	Yes
Capture mode	Rising edge only	Rising edge, falling edge, either edge, or software controlled
Capture FIFO	No (one capture register)	Yes (up to four captures)
Trigger input	No	Yes
Trigger mode	None	Rising edge, falling edge, either edge, or software controlled
Reset input	Yes	Yes
Terminal count output	Yes	Yes
Interrupt output	Yes	Yes
Interrupt conditions	TC, capture	TC, capture, and FIFO full
Capture output	No	Yes
Period register	Yes	Yes
Period reload	Yes (always reload on reset or TC)	Yes (always reload on reset or TC)
Clock input	Limited to digital clocks in the clock system	Any signal

When to Use a Timer

The default use of the Timer is to generate a periodic event or interrupt signal. However, there are other potential uses:

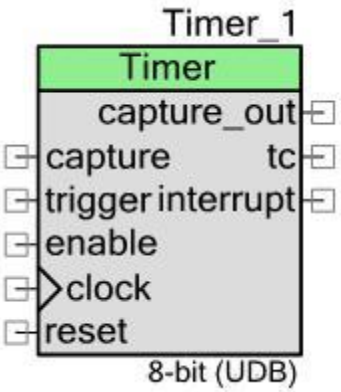
- Create a clock divider by driving a clock into the clock input and using the terminal count output as the divided clock output.
- Measure the length of time between hardware events by driving a clock into the clock input and driving the test signal to the enable or capture input.

Note A Counter Component is better used in situations focused on counting events. A PWM Component is better used in situations requiring multiple compare outputs with more control features like center alignment, output kill, and dead band outputs.

A Timer is typically used to record the number of clock cycles between events. An example of this is measuring the number of clocks between two rising edges as might be generated by a tachometer sensor. A more complex use is to measure the period and duty cycle of a PWM input. For PWM measurement, the Timer Component is configured to start on a rising edge, capture the next falling edge, and then capture and stop on the next rising edge. An interrupt on the final capture signals the CPU that all of the captured values are ready in the FIFO.

Input/Output Connections

This section describes the various input and output connections for the Timer. Some I/Os may be hidden on the symbol under the conditions listed in the description of that I/O.



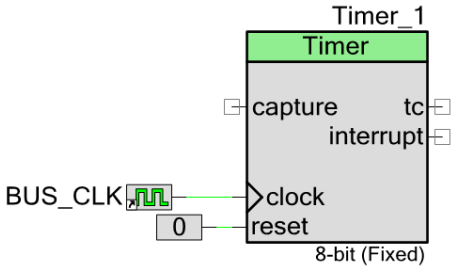
Note All signals are active high unless otherwise specified.

Input	May Be Hidden	Description
clock	N	The clock input defines the operating frequency of the Timer Component. That is, the timer period counter value is decremented on the rising edge of this input while the Timer Component is enabled.
reset	N	This input is a synchronous reset. It requires at least one rising edge of the clock to implement the resets of the counter value and the capture counter. It resets the period counter to the period value and also resets the capture counter. For the fixed-function implementation the reset signal forces the counter to load from the period register in active mode only. Namely if timer is started by call the Timer_Start() function.
enable	Y	This input is the Timer hardware enable. This connection enables the period counter to decrement on each rising edge of the clock. If this input is low the outputs are still active but the Timer Component does not change states. This input is visible when the **Enable Mode** parameter is set to **Hardware Only** or **Software and Hardware**.
capture	Y	The capture input captures the current count value to a capture register or FIFO. The input is visible if the **Capture Mode** parameter is set to any mode other than **None**. Capture may take place on a rising edge, falling edge, or either edge applied to this input, depending on the **Capture Mode** setting. The capture input is sampled on the clock input. No values are captured if the Timer is disabled. The capture input may be left floating with no external connection. If nothing is connected to the capture line, the Component will assign it a constant logic 0.
trigger	Y	The trigger input enables the timer to start counting based on configurable hardware events. The input is visible if the **Trigger Mode** parameter is set to any mode other than **None**. It causes the Timer to delay counting until the appropriate edge is detected. The trigger edge is not captured nor does it generate an interrupt.

Output	May Be Hidden	Description
tc	N	Terminal count is a synchronous output that indicates that the count value equals zero. The output is synchronous to the clock input of the Timer. The exact timing of this output depends on the device and whether a UDB or FF implementation is used.
interrupt	N	The interrupt output is driven by the interrupt sources configured in the hardware. All sources are ORed together to create the final output signal. The sources of the interrupt can be: Terminal Count, Capture, or FIFO full. After an interrupt is triggered, the interrupt output remains asserted until the status register is read.
capture_out	Y	The capture_out output is an indicator of when a hardware capture has been triggered. This signal is available for the UDB implementation only. This output is synchronized to the clock input of the Timer.

Schematic Macro Information

The default Timer in the Component Catalog is a schematic macro using a Timer Component with default settings. It is connected to bus clock and a Logic Low Component.



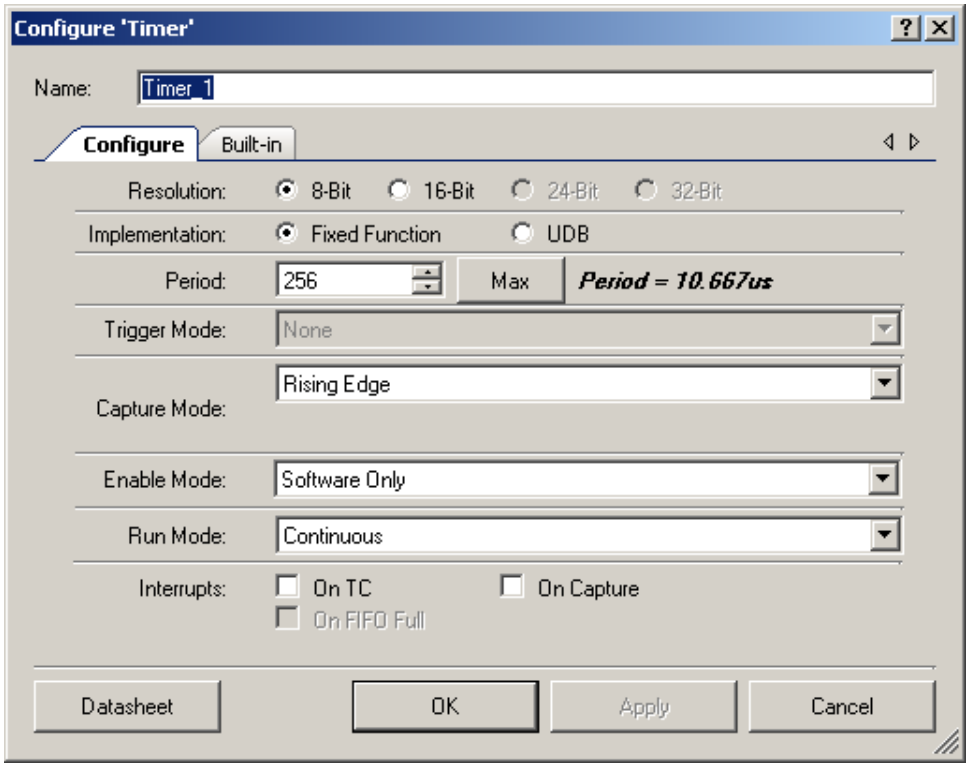
Component Parameters

Drag a Timer onto your design and double-click it to open the **Configure** dialog.

Hardware versus Software Configuration Options

Hardware configuration options change the way the project is synthesized and placed in the hardware. You must rebuild the hardware if you make changes to any of these options. Software configuration options do not affect synthesis or placement. When setting these parameters before build time you are setting their initial values. These may be modified at any time with the APIs provided. Most parameters described in the next sections are hardware options. The software options are noted as such.

Configure Tab



Resolution

The **Resolution** parameter defines the bit-width resolution of the Timer. This value may be set to 8, 16, 24, or 32 for maximum count values of 255, 65535, 16777215, and 4294967295 respectively. For FF implementations, the resolution is limited to 8 or 16 bits.

Implementation

The **Implementation** parameter allows you to choose between a fixed-function block implementation and a UDB implementation of the Timer. If FF is selected, UDB functions are disabled.

Period (Software Option)

The **Period** parameter defines the period of the counter. The max count value (or rollover point) for the Timer Component is equal to the **Period** minus one. The **Period** minus one is the initial value loaded into the period register. The software can change this register at any time with the Timer_WritePeriod() API. To get the equivalent result using this API, the **Period** value from the customizer, minus one, must be used as the argument in the function.

The limits of this value are defined by the **Resolution** parameter. For 8-, 16-, 24-, and 32-bit **Resolution**, the **Period** is: 2^8, 2^16, 2^24, and 2^32 or 256, 65536, 16777216, and 4294967296 respectively.

Trigger Mode (Software Option)

The **Trigger Mode** parameter configures the implementation of the trigger input. This parameter is only active when **Implementation** is set to **UDB**.

Trigger Mode can be set to any of the following values:

- **None** (default) – No trigger implemented and the trigger input pin is hidden
- **Rising Edge** – Trigger (enable) counting on the first rising edge of the trigger input
- **Falling Edge** – Trigger (enable) counting on the first falling edge of the trigger input
- **Either Edge** – Trigger (enable) counting on the first edge (rising or falling) of the trigger input
- **Software Controlled –** The trigger mode can be set during run time, to one of the four trigger modes listed above, using the Timer_SetTriggerMode() API call. The default trigger is **None** until another value is set using this API.

Capture Mode (Software Option)

The Capture Mode section contains three parameters: **Capture Mode Value**, **Enable Capture Counter**, and **Capture Count**.

Capture Mode

The **Capture Mode** parameter configures when a capture takes place. The capture input is sampled on the rising edge of the clock input. This mode can be set to any of the following values (for the fixed-function implementation, only **None** and **Rising Edge** are available):

- **None** – No capture implemented and the capture input pin is hidden
- **Rising Edge** – Capture the counter value on a rising edge of the capture input with respect to the clock input.
- **Falling Edge** – Capture the counter value on a falling edge of the capture input with respect to the clock input.
- **Either Edge** – Capture the counter value on either edge of the capture input with respect to the clock input.
- **Software Controlled** – The capture mode can be set during run time, to one of the four capture modes listed above, using the Timer_SetCaptureMode() API call. The default trigger is **None** until another value is set using this API.

Enable Capture Counter (Software Option)

The **Enable Capture Counter** parameter is used to define how many capture events happen before the counter is actually captured. For example, it may be necessary to capture every third event, in which case the capture counter must be set to a value of 3. This parameter is only available for a UDB implementation.

Capture Count (Software Option)

The **Capture Count** parameter sets the initial number of capture events that occur before the counter is actually captured. It can be set to a value from 2 to 127. The capture count value may be modified at run time by calling the API function Timer_SetCaptureCount(). This parameter is only available for a UDB implementation.

Enable Mode

The **Enable Mode** parameter configures the enable implementation of the Timer. The enable input is sampled on the rising edge of the clock input. This mode can be set to any of the following values:

- **Software Only** – The Timer is enabled based on the enable bit of the control register only.
- **Hardware Only** – The Timer is enabled based on the enable input only. (UDB only)
- **Software and Hardware** – The Timer is enabled if both hardware and software enables are true.

Run Mode

The **Run Mode** parameter is used to configure the Timer Component to run continuously or in a one-shot mode:

- **Continuous** – The Timer runs continuously while it is enabled.
- **One Shot** – The Timer starts counting and stops counting when zero is reached. After it is reset, it begins another cycle. On stop, it reloads **Period** into the count register.
- **One Shot (Halt on Interrupt)** – The Timer starts counting and stops counting when zero is reached or an interrupt occurs. After it is reset, it begins another cycle. On stop, for a UDB Timer, it reloads **Period** into the count register (UDB only).

Note In order to be sure that One Shot mode does not start prematurely, use a **Trigger Mode** to control the start time, or use some form of software enable mode (**Software Only** or **Software and Hardware**).

Interrupt (Software Option)

The **Interrupt** parameters is used to configure the initial interrupt sources. An interrupt is generated when one or more of the following selected events occur. The software can reconfigure this mode at any time; this parameter defines an initial configuration.

- **On TC** –This parameter is always active; it is cleared by default.
- **On Capture (1-4) –** Allows you to interrupt on a given number of captures; it is cleared by default.
- **On FIFO Full –** Allows you to interrupt when the capture FIFO is full; it is cleared by default.

Clock Selection

Fixed-Function Components

When configured to use the FF block in the device, the Timer Component has the following restrictions:

- The clock input must be a digital clock from the clock system.
- If the frequency of the clock is to be the same as bus clock, then the clock must actually be the bus clock.

Open the **Configure** dialog of the appropriate Clock Component to configure the **Clock Type** parameter as **Existing** and the **Source** parameter as **BUS_CLK**. A clock at this frequency cannot be divided from any other source, such as the master clock, IMO, and so on.

For UDB-based Components

Any digital signal from any source can be connected to the clock input. The frequency of that signal is limited to the frequency range defined in the DC and AC Electrical Characteristics (UDB Implementation) section of this datasheet.

Application Programming Interface

Application Programming Interface (API) routines allow you to configure the Component using software. The following table lists and describes the interface to each function. The subsequent sections cover each function in more detail.

By default, PSoC Creator assigns the instance name “Timer_1” to the first instance of a Component in a given design. You can rename it to any unique value that follows the syntactic rules for identifiers. The instance name becomes the prefix of every global function name, variable, and constant symbol. For readability, the instance name used in the following table is “Timer”.

Functions

Function	Description
Timer_Start()	Sets the initVar variable, calls the Timer_Init() function, and then calls the Enable function.
Timer_Stop()	Disables the Timer.
Timer_SetInterruptMode()	Enables or disables the sources of the interrupt output.
Timer_ReadStatusRegister()	Returns the current state of the status register.
Timer_ReadControlRegister()	Returns the current state of the control register.
Timer_WriteControlRegister()	Sets the bit-field of the control register.
Timer_WriteCounter()	Writes a new value directly into the counter register. (UDB only)
Timer_ReadCounter()	Forces a capture, and then returns the capture value.
Timer_WritePeriod()	Writes the period register.
Timer_ReadPeriod()	Reads the period register.
Timer_ReadCapture()	Returns the contents of the capture register or the output of the FIFO.
Timer_SetCaptureMode()	Sets the hardware or software conditions under which a capture will occur.
Timer_SetCaptureCount()	Sets the number of capture events to count before capturing the counter register to the FIFO.
Timer_ReadCaptureCount()	Reports the current setting of the number of capture events.
Timer_SoftwareCapture()	Forces a capture of the counter to the capture FIFO
Timer_SetTriggerMode()	Sets the hardware or software conditions under which a trigger will occur.
Timer_EnableTrigger()	Enables the trigger mode of the timer.
Timer_DisableTrigger()	Disables the trigger mode of the timer.
Timer_SetInterruptCount()	Sets the number of captures to count before an interrupt is triggered.
Timer_ClearFIFO()	Clears the capture FIFO.

Function	Description
Timer_Sleep()	Stops the Timer and saves its current configuration.
Timer_Wakeup()	Restores the Timer configuration and re-enables the Timer.
Timer_Init()	Initializes or restores the Timer per the Configure dialog settings.
Timer_Enable()	Enables the Timer.
Timer_SaveConfig()	Saves the current configuration of the Timer.
Timer_RestoreConfig()	Restores the configuration of the Timer.

void Timer_Start(void)

Description: This is the preferred method to begin Component operation. Timer_Start() sets the initVar variable, calls the Timer_Init() function, and then calls the Timer_Enable() function.

Side Effects: If the initVar variable is already set, this function only calls the Timer_Enable() function.

void Timer_Stop(void)

Description: For fixed-function implementations this disables the Timer and powers it down. For UDB implementations the Timer is disabled only in software enable modes.

Side Effects: Because fixed-function Timers are powered down by this function, the TC output will be driven low.

void Timer_SetInterruptMode(uint8 interruptMode)

Description: Enables or disables the sources of the interrupt output.

Parameters: uint8: Interrupt sources. For bit definitions, refer to the Mode Register section of this datasheet.

Side Effects: The bit locations are different between FF and UDB. Mask #defines are provided to encapsulate the differences.

uint8 Timer_ReadStatusRegister(void)

Description: Returns the current state of the status register.

Return Value: uint8: Current status register value
For bit definitions, refer to the Status Register section of this datasheet.

Side Effects: Some of these bits are cleared when status register is read. Clear-on-read bits are defined in the Status Register section of this datasheet.

uint8 Timer_ReadControlRegister(void)

Description: Returns the current state of the control register. This API is not available in the special case when the control register is not required (UDB implementation, enable mode is hardware only, capture mode not software controlled, and trigger mode not software controlled).

Return Value: uint8: Control register bit field

For bit definitions, refer to the Control Register section of this datasheet.

void Timer_WriteControlRegister(uint8 control)

Description: Sets the bit field of the control register. This API is not available in the special case when the control register is not required (UDB implementation, enable mode is hardware only, capture mode not software controlled, and trigger mode not software controlled).

Parameters: uint8: Control register bit field

For bit definitions, refer to the Control Register section of this datasheet.

void Timer_WriteCounter(uint8/16/32 counter)

Description: Writes a new value directly into the counter register. This function is available only for the UDB implementation.

Parameters: uint8/16/32: New counter value. For 24-bit Timers, the parameter is uint32.

Side Effects: Overwrites the counter value. This can cause undesired behavior on the terminal count output or period width. This is not an atomic write and the function may be interrupted. The Timer should be disabled before calling this function.

uint8/16/32 Timer_ReadCounter(void)

Description: Forces a capture and then returns the capture value.

Return Value: uint8/16/32: Current counter value. For 24-bit Timers, the return type is uint32.

Side Effects: Returns the contents of the capture register or the output of the FIFO (UDB only).

void Timer_WritePeriod(uint8/16/32 period)

Description: Writes the period register.

Parameters: uint8/16/32: New period value. For 24-bit Timers, the parameter is uint32.

Side Effects: The period of the Timer does not change until the counter is reloaded from the period register.

uint8/16/32 Timer_ReadPeriod(void)

Description: Reads the period register.

Return Value: uint8/16/32: Current period value. For 24-bit Timers, the return type is uint32.

uint8/16/32 Timer_ReadCapture(void)

Description: Returns the contents of the capture register or the output of the FIFO (UDB).

Return Value: uint8/16/32: Current capture value. For 24-bit Timers, the return type is uint32.

Side Effects: In the UDB implementation, the value is removed from the FIFO.

void Timer_SetCaptureMode(uint8 captureMode)

Description: Sets the capture mode. This function is available only for the UDB implementation and when the **Capture Mode** parameter is set to **Software Controlled**.

Parameters: uint8: Enumerated capture mode. Refer also to the Control Register section:

```
Timer__B_TIMER__CM_NONE
Timer__B_TIMER__CM_RISINGEDGE
Timer__B_TIMER__CM_FALLINGEDGE
Timer__B_TIMER__CM_EITHEREDGE
Timer__B_TIMER__CM_SOFTWARE
```

void Timer_SetCaptureCount(uint8 captureCount)

Description: Sets the number of capture events to count before a capture is performed. This function is available only for the UDB implementation and when the **Enable Capture Counter** parameter is selected in the Configure dialog.

Parameters: uint8 captureCount: The number of capture events you want to count before capturing the counter value to the capture FIFO. A value from 2 to 127 is valid.

uint8 Timer_ReadCaptureCount(void)

Description: Reads the current value setting for the captureCount parameter as set in the Timer_SetCaptureCount() function. This function is only available for the UDB implementation and when the **Enable Capture Counter** parameter is selected in the Configure dialog.

Return Value: uint8: Current capture count

void Timer_SoftwareCapture(void)

Description: Forces a software capture of the current counter value to the FIFO. This function is available only for UDB implementation.

void Timer_SetTriggerMode(uint8 triggerMode)

Description: Sets the trigger mode. This function is available only for UDB implementation and when Trigger Mode parameter is set to Software Controlled.

Parameters: uint8: Enumerated capture mode. Refer also to the Control Register section.

```
Timer__B_TIMER__TM_NONE
Timer__B_TIMER__TM_RISINGEDGE
Timer__B_TIMER__TM_FALLINGEDGE
Timer__B_TIMER__TM_EITHEREDGE
Timer__B_TIMER__TM_SOFTWARE
```

void Timer_EnableTrigger(void)

Description: Enables the trigger. This function is available only when **Trigger Mode** is set to **Software Controlled**.

void Timer_DisableTrigger(void)

Description: Disables the trigger. This function is available only when **Trigger Mode** is set to **Software Controlled**.

void Timer_SetInterruptCount(uint8 interruptCount)

Description: Sets the number of captures to count before an interrupt is generated for the InterruptOnCapture source. This function is available only when InterruptOnCaptureCount is enabled.

Parameters: uint8 interruptCount: The number of capture events to count before the interrupt on capture is generated. A value from 0 to 3 is valid.

void Timer_ClearFIFO(void)

Description: Clears the capture FIFO. This function is available only for the UDB implementation. Refer to the UDB FIFOs section of this datasheet.

void Timer_Sleep(void)

Description: This is the preferred routine to prepare the Component for sleep. Timer_Sleep() saves the current Component state. Then it calls the Timer_Stop() function and calls Timer_SaveConfig() to save the hardware configuration.

Call the Timer_Sleep() function before calling the CyPmSleep() or the CyPmHibernate() function. Refer to the PSoC Creator *System Reference Guide* for more information about power-management functions.

Side Effects: For the FF implementation, all registers are retained across low-power modes. For the UDB implementation, the control register and counter value register are saved and restored. Additionally when calling Timer_Sleep(), the enable state is stored in case you call Timer_Sleep() without calling Timer_Stop().

void Timer_Wakeup(void)

Description: This is the preferred routine to restore the Component to the state when Timer_Sleep() was called. The Timer_Wakeup() function calls the Timer_RestoreConfig() function to restore the configuration. If the Component was enabled before the Timer_Sleep() function was called, the Timer_Wakeup() function also re-enables the Component.

Side Effects: Calling the Timer_Wakeup() function without first calling the Timer_Sleep() or Timer_SaveConfig() function may produce unexpected behavior.

void Timer_Init(void)

Description: Initializes or restores the Component according to the customizer Configure dialog settings. It is not necessary to call Timer_Init() because the Timer_Start() routine calls this function and is the preferred method to begin Component operation..

Side Effects: All registers will be set to values according to the customizer Configure dialog.

void Timer_Enable(void)

Description: Activates the hardware and begins Component operation. It is not necessary to call Timer_Enable() because the Timer_Start() routine calls this function, which is the preferred method to begin Component operation. This function enables the Timer for either of the software controlled enable modes.

Side Effects: If the **Enable Mode** parameter is set to **Hardware Only**, this function has no effect on the operation of the Timer.

void Timer_SaveConfig(void)

Description: This function saves the Component configuration and nonretention registers. It also saves the current Component parameter values, as defined in the Configure dialog or as modified by appropriate APIs. This function is called by the Timer_Sleep() function.

void Timer_RestoreConfig(void)

Description: This function restores the Component configuration and nonretention registers. It also restores the Component parameter values to what they were before calling the Timer_Sleep() function.

Side Effects: Calling this function without first calling the Timer_Sleep() or Timer_SaveConfig() function may produce unexpected behavior.

Global Variables

Variable	Description
Timer_initVar	Indicates whether the Timer has been initialized. The variable is initialized to 0 and set to 1 the first time Timer_Start() is called. This allows the Component to restart without reinitialization after the first call to the Timer_Start() routine. If reinitialization of the Component is required, then the Timer_Init() function can be called before the Timer_Start() or Timer_Enable() function.

Sample Firmware Source Code

PSoC Creator provides many example projects that include schematics and example code in the Find Example Project dialog. For Component-specific examples, open the dialog from the Component Catalog or an instance of the Component in a schematic. For general examples, open the dialog from the Start Page or **File** menu. As needed, use the **Filter Options** in the dialog to narrow the list of projects available to select.

Refer to the “Find Example Project” topic in the PSoC Creator Help for more information.

MISRA Compliance

This section describes the MISRA-C:2004 compliance and deviations for the Component. There are two types of deviations defined:

- project deviations – deviations that are applicable for all PSoC Creator Components
- specific deviations – deviations that are applicable only for this Component

This section provides information on Component-specific deviations. Project deviations are described in the MISRA Compliance section of the *System Reference Guide* along with information on the MISRA compliance verification environment.

The Timer Component does not have any specific deviations.

API Memory Usage

The Component memory usage varies significantly, depending on the compiler, device, number of APIs used and Component configuration. The following table provides the memory usage for all APIs available in the given Component configuration.

The measurements have been done with the associated compiler configured in Release mode with optimization set for Size. For a specific design the map file generated by the compiler can be analyzed to determine the memory usage.

Configuration[1]	PSoC 3 (Keil_PK51)		PSoC 4 (GCC)		PSoC 5LP (GCC)	
	Flash Bytes	SRAM Bytes	Flash Bytes	SRAM Bytes	Flash Bytes	SRAM Bytes
8-bit UDB Timer	255	5	440	5	448	5
8-bit FF Timer	264	2	N/A	N/A	376	2
16-bit UDB Timer	296	6	440	7	448	7
16-bit FF Timer	266	2	N/A	N/A	380	2
24-bit UDB Timer	286	8	448	7	456	13
32-bit UDB Timer	286	8	440	13	448	13
8-bit UDB Timer One Shot	255	5	440	5	444	5
16-bit UDB Timer One Shot	296	6	440	7	448	7

Functional Description

As described previously, the Timer Component can be configured for multiple uses. This section describes those configurations in more detail.

General Operation

On each rising edge of the clock input, the Timer Component always counts down. It reloads the counter register from the period register on the next clock edge after the counter reaches a value of zero.

The timer remains disabled until enabled by hardware or software, depending on the configuration setting. The Component cannot be used until Timer_Start() is called because this function sets the registers for the defined configuration.

Timer Outputs

The counter register can be monitored and reloaded. The tc output is available to monitor the current value of the counter register; it is asserted for 1 clock cycle when the counter is zero.

1. For all configurations the common settings are: Enable mode = Software only, Capture mode = None, Interrupt = On TC

Timer Inputs

A capture operation can be done in either hardware or firmware. The current value in the counter register is copied into either a capture register or a FIFO. Firmware can then read the captured value at a later time.

Reset and enable features allow the Timer Component to be synchronized to other Components. The Timer Component counts only when enabled and not held in reset. Counting can also be initiated on a trigger input event. It can be reset or enabled by either hardware or firmware. All triggering is hardware.

Note All of the inputs for the FF Timer implementations (capture, reset, and enable) are double synchronized in the FF Timer. The synchronizer is run at BUS_CLK speed. This results in a delay between when these signals are applied and when they take effect. The delay depends on the ratio between BUS_CLK and the clock that runs the Timer. All waveforms shown for the FF implementations show the signal after it has been synchronized.

Timer Interrupt

An interrupt output is available to communicate event occurrences to the CPU or to other Components. You can set the interrupt to be active on a combination of one or more events. You should design the interrupt handler carefully so that you can determine the source of the interrupt and whether it is edge- or level-sensitive, and clear the source of the interrupt.

Timer Registers

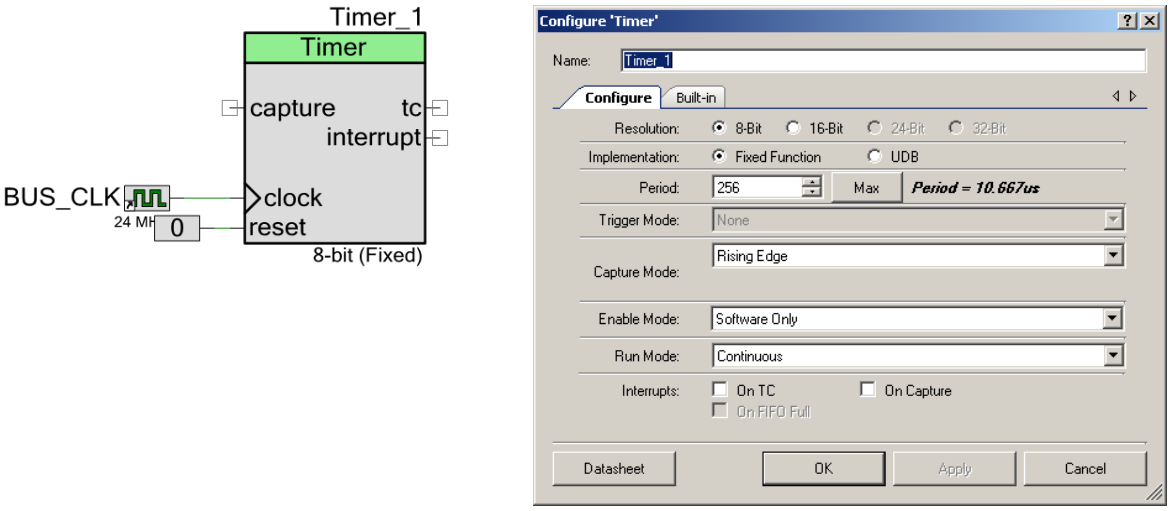
There are three registers: mode, status, and control. Refer to the Registers section.

Configurations

Default Configuration

When you drag a Timer Component onto a PSoC Creator schematic, the default configuration is an 8-bit, FF timer that decrements the counter register on a rising edge at the clock input. Figure 1 shows the default schematic macro and Configure dialog settings.

Figure 1. Default Timer Configuration



The exact functionality of this timer differs for different implementations. The following figures show the functionality of this timer with the UDB implementation and for the FF implementation.

The functionality of the default configuration when configured for the UDB implementation is shown in Figure 2.

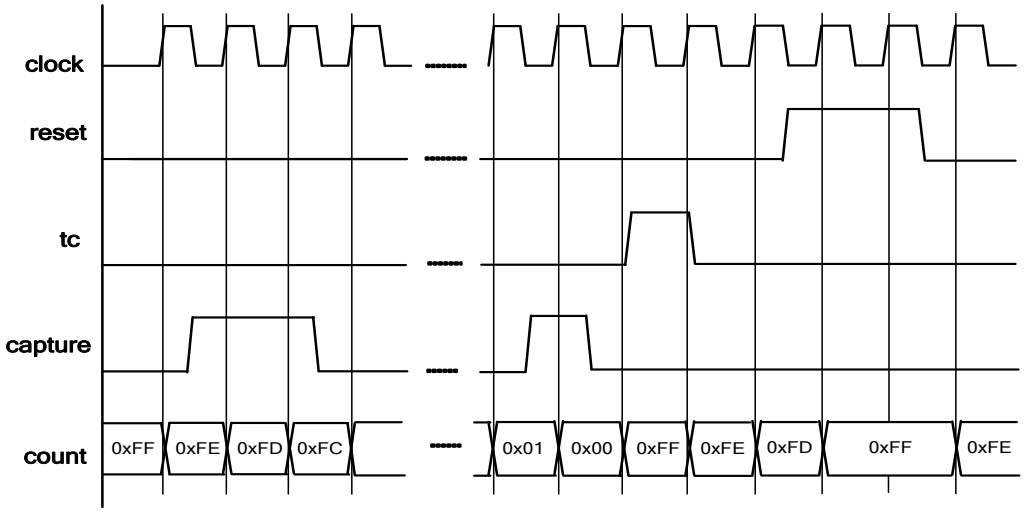
The counter is preloaded during Timer configuration and it is reloaded each time the counter reaches zero. In the default configuration, the **Period** is set to 256. This results in 0xFF being loaded into the counter because counting from 0xFF through 0 yields a period of 256.

The reset signal forces the counter to reload from its period register. The counter is held at this state until the reset signal is removed.

Terminal count indicates that the timer has counted down to zero. It is active on the clock cycle that follows the clock cycle where the count value has reached zero. The terminal count signal is not generated based on a reset event.

By default, the capture functionality is configured to capture on every rising edge of the capture input. Regardless of the width of the capture pulse, a single value is captured. In this example, the values 0xFE and 0x01 are captured and can be read by the CPU.

Figure 2. Default UDB Timer Implementation Example Waveform



The functionality of the default configuration when configured for the fixed-function implementation on PSoC 3/PSoC 5LP is shown in Figure 3.

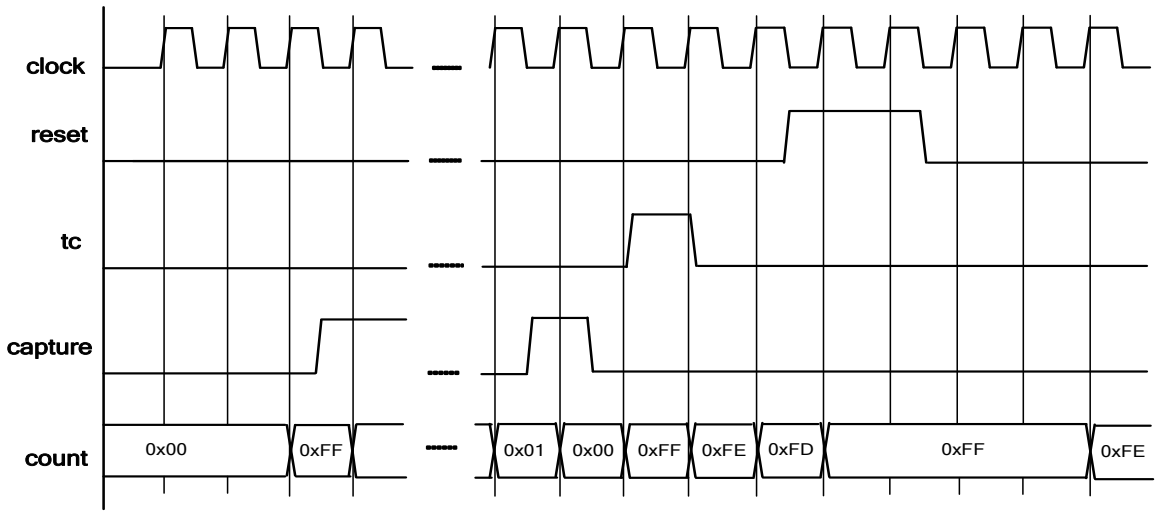
For the fixed-function implementations, the counter value is not preloaded during configuration time; instead, the counter starts with a value of zero. For PSoC 3/PSoC 5LP this results in a three-cycle initial lag time for the FF implementation versus the UDB implementation. This is a two-cycle delay before the Timer starts counting and one cycle to load the counter from the period register. After the Timer is running, the period is the same as the UDB implementation.

The reset signal forces the counter to load from the period register and remain at that count until reset is removed. Once reset is removed, there is a two-cycle lag before the counter begins counting down.

Terminal count indicates that the timer has counted down to zero. It is active on the clock cycle that follows the clock cycle where the count value has reached zero. The terminal count signal is not generated based on a reset event or because of the initial counter value of zero.

By default, the capture functionality is configured to capture on every rising edge of the capture input. Regardless of the width of the capture pulse, a single value is captured. In this example, the values 0xFF and 0x01 are captured and can be read by the CPU. This functionality is the same as the UDB implementation.

Figure 3. Default PSoC 3/PSoC 5LP FF Timer Implementation Example Waveform

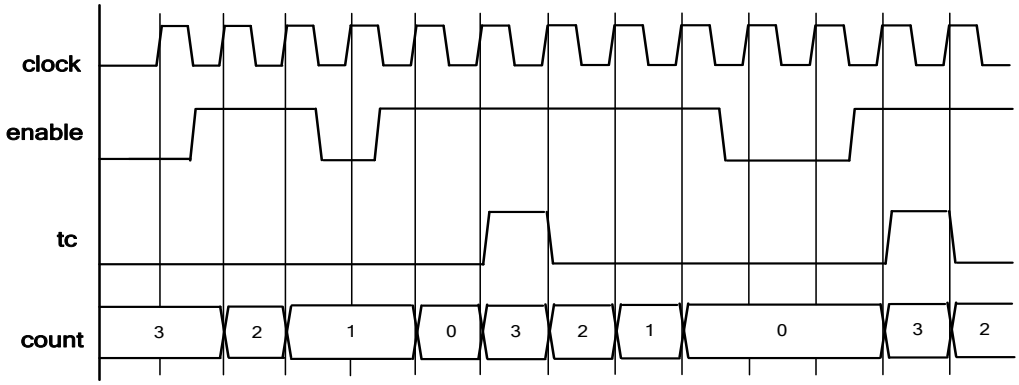


Software and Hardware Enable Configuration

The functionality of the hardware enable varies based on the specific implementation. The functionality of the Timer when configured for Software and Hardware enable with the UDB implementation is shown in Figure 4.

The counter is decremented on every cycle when the Timer is enabled. During the cycle when the counter is reloaded from its period register, a single cycle terminal count pulse is generated. The TC signal will always be a single clock cycle pulse. Note that it occurs during the reload cycle. If the reload is delayed because the counter was disabled as it hit a zero count, the TC pulse is also delayed until the counter is re-enabled and the counter is reloaded. If the counter is forced to reload because of a reset signal, the TC pulse is not generated.

Figure 4. SW and HW Enable UDB Timer Implementation Example Waveform

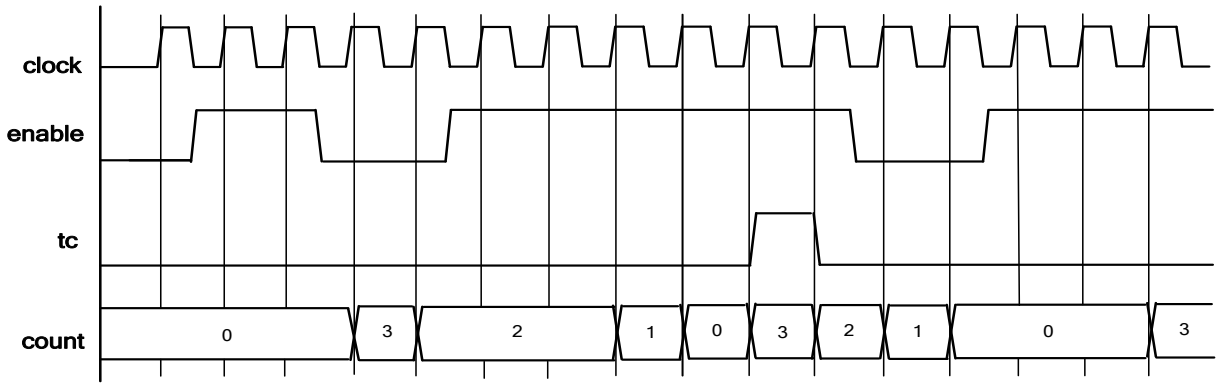


The functionality of the Timer when configured for Software and Hardware enable with the PSoC 3/PSoC 5LP FF implementation is shown in Figure 5.

There is a two-clock-cycle lag between the hardware enable and the effective enable of the counter. The result is that the counter decrements if the enable signal two clock cycles earlier was high. This lag applies for both enabling and disabling the counter. During the cycle when the counter is reloaded from its period register, a single-cycle terminal count pulse is generated. The TC signal is always a single clock cycle pulse.

Note If the Timer has the enable signal low during the two cycles before the counter reaches zero, the TC output pulse is not generated for this period of the Timer. When the Timer is re-enabled it is reloaded without the generation of the TC signal. This is shown in the example waveform.

Figure 5. SW and HW Enable PSoC 3/PSoC 5LP FF Timer Implementation Example Waveform



One Shot Configuration

The functionality of the One Shot Run Mode varies based on the specific implementation. The functionality of the Timer when configured for One Shot operation with the UDB implementation is shown in Figure 6.

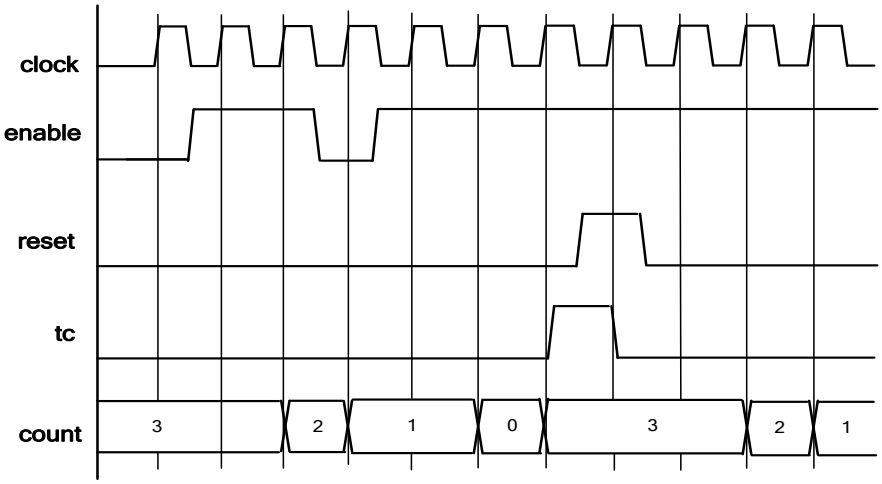
There is a one-clock-cycle lag between the hardware enable and the effective enable of the counter. The result is that the counter decrements if the enable signal one clock cycle earlier was high. This lag applies for both enabling and disabling the counter. This is a different behavior than in Continuous Run Mode, which counts without lag.

The TC signal is always a single-clock-cycle pulse. Note that it occurs during the reload cycle. If the reload is delayed because the counter was disabled as it hit a zero count, the TC pulse is also delayed until the counter is re-enabled and the counter is reloaded. If the counter is forced to reload because of a reset signal, the TC pulse is not generated.

After the One Shot period has completed, the Timer can be set up to run for another period by using a hardware reset. The hardware reset reloads the counter from the period register. One

cycle after reset is removed, the Timer is enabled to count down again after the hardware enable is also active.

Figure 6. One Shot Operation UDB Timer Implementation Example Waveform



The functionality of the Timer when configured for One Shot operation with the FF implementation on PSoC 3/PSoC 5LP is shown in Figure 7.

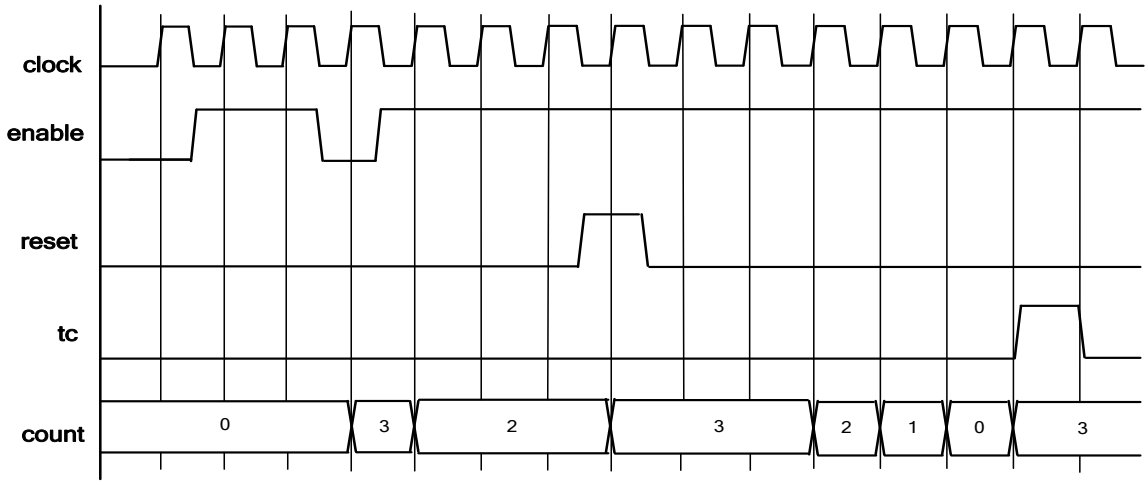
There is a two-clock-cycle lag between the hardware enable and the effective enable of the counter. The result is that the counter decrements if the enable signal two clock cycles earlier was high. This lag applies for both enabling and disabling the counter. During the cycle when the counter is reloaded from its period register, a single-cycle terminal count pulse is generated. The TC signal is always a single-clock-cycle pulse. This is identical to the operation in Continuous Run Mode.

An extra feature of the One Shot mode, for this implementation only, is that once the Timer starts counting, the first time that the enable signal goes low stops the counter at that value. To start counting again, the Timer must be reset.

After the One Shot period has completed or it has stopped because of the enable signal being disabled, the Timer can be set up to run for another period by using a hardware reset. The hardware reset reloads the counter from the period register. There is a two-cycle lag from releasing reset until the Timer is enabled to count down again.

Note For this implementation, only the Timer can be restarted by using the Timer_Stop() API followed by the Timer_Start() API. This allows the counter to continue to count, but it does not reload the counter value, so this method only should be used in the case where the counter has already completed a period and been reloaded.

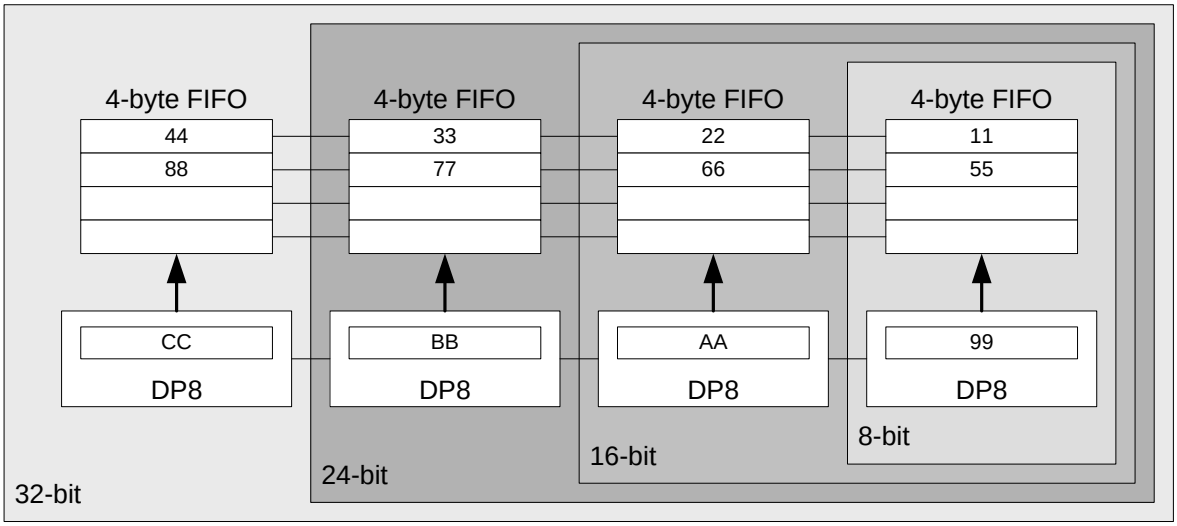
Figure 7. One Shot Operation FF PSoC 3/PSoC 5LP Timer Implementation Example Waveform



UDB FIFOs

The UDB datapath FIFOs are used to capture the counter value. Each FIFO is four bytes deep. For multi-byte configurations, each byte of the counter is captured simultaneously in the FIFO of the associated UDB. Therefore, up to four captures can be done before the CPU must read the capture register to avoid losing data.

If the FIFO is full, and subsequent writes occur (overflow), the new data overwrites the front of the FIFO (the data currently being output, the next data to read).



Capture Value #1 = 0x44332211
Capture Value #2 = 0x88776655
Accumulator = 0xCCBBAA99

DMA Support

The Timer Component supports Direct Memory Access (DMA) transfers. The Component may transfer to/from the following sources.

Name of DMA Source / Destination	Length	Direction	DMA Req Signal	DMA Req Type	Description
Timer_1_PERIOD_LSB_PTR	8/16/32-bit depending on **Resolution** for **UDB** or 16-bit for **FF implementation**	Destination	tc	Derived	Writes new value to the period register

Registers

Status Register

The status register is a read-only register that contains the status bits defined for the Timer. Use the Timer_ReadStatusRegister() function to read the status register value. All operations on the status register must use the following defines for the bit fields because these bit fields may be different between FF and UDB implementations.

Some bits in the status register are sticky, meaning that after they are set to 1, they retain that state until they are cleared when the register is read. The status data is registered at the input clock edge of the Timer, which gives all sticky bits the timing resolution of the Timer. All nonsticky bits are transparent and read directly from the inputs to the status register.

Timer_Status (UDB Implementation)

Bits	7	6	5	4	3	2	1	0
Name	RSVD	RSVD	RSVD	RSVD	FIFO Not Empty	FIFO Full	Capture	TC
Sticky	N/A	N/A	N/A	N/A	FALSE	FALSE	TRUE	TRUE

Timer_Status (Fixed Function Implementation)

Bits	7	6	5	4	3	2	1	0
Name	TC	Capture	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD
Sticky	TRUE	TRUE	N/A	N/A	N/A	N/A	N/A	N/A

Bit Name	#define in header file	Description
TC	Timer_STATUS_TC	This bit goes to 1 when the counter value is equal to zero.

Bit Name	#define in header file	Description
Capture	Timer_STATUS_CAPTURE	This bit goes to 1 whenever a valid capture event is triggered. This does not include software capture.
FIFO Full	Timer_STATUS_FIFOFULL	This bit goes to 1 when the UDB FIFO reaches the full state defined as four entries.
FIFO Not Empty	Timer_STATUS_FIFONEMP	This bit goes to 1 when the UDB FIFO contains at least one entry.

Mode Register

The mode register is a read/write register that contains the interrupt mask bits defined for the counter. Use the Timer_SetInterruptMode() function to set the mode bits. All operations on the mode register must use the following defines for the bit fields because these bit fields may be different between FF and UDB implementations.

The Timer Component interrupt output is an OR function of all interrupt sources. Each source can be enabled or masked by the corresponding bit in the mode register.

Timer_Mode (UDB Implementation)

Bits	7	6	5	4	3	2	1	0
Name	RSVD	RSVD	RSVD	RSVD	RSVD	FIFO Full	Capture	TC

Timer_Mode (Fixed-Function Implementation)

Bits	7	6	5	4	3	2	1	0
Name	RSVD	RSVD	RSVD	RSVD	TC	Capture	RSVD	RSVD

Bit Name	#define in header file	Enables Interrupt Output On
TC	Timer_STATUS_TC_INT_MASK	Counter register equals 0
Capture	Timer_STATUS_CAPTURE_INT_MASK	Capture
FIFO Full	Timer_STATUS_FIFOFULL_INT_MASK	UDB FIFO full

Control Register

The Control register is used to control the general operation of the counter. This register is written with the Counter_WriteControlRegister() function call and read with the Counter_ReadControlRegister() function. All operations on the control register must use the following defines for the bit fields as these bit fields may be different between FF and UDB implementations.

Note When writing to the control register, you must not change any of the reserved bits. All operations must be read-modify-write with the reserved bits masked.

Timer_Control (UDB Implementation)

Bits	7	6	5	4	3	2	1	0
Name	Enable	Capture Mode [1:0]		Trigger Enable	Trigger Mode [1:0]		Interrupt Count [1:0]	

Timer_Control1 (Fixed-Function Implementation)

Bits	7	6	5	4	3	2	1	0
Name	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	RSVD	Enable

Bit Name	#define in header file	Description / Enumerated Type
Interrupt Count	Timer_CTRL_INTCNT_MASK	The interrupt count bits define the number of capture events to count before an interrupt is fired.
Trigger Mode	Timer_CTRL_TRIG_MODE_MASK	The trigger mode control bits define the expected trigger input functionality. This bit field is configured at initialization with the trigger mode defined in the **Trigger Mode** parameter. ▪ Timer__B_TIMER__TM_NONE ▪ Timer__B_TIMER__TM_RISINGEDGE ▪ Timer__B_TIMER__TM_FALLINGEDGE ▪ Timer__B_TIMER__TM_EITHEREDGE ▪ Timer__B_TIMER__TM_SOFTWARE
Trigger Enable	Timer_CTRL_TRIG_EN	The Trigger Enable bit allows for software control of when to prepare for a trigger event.

Bit Name	#define in header file	Description / Enumerated Type
Capture Mode	Timer_CTRL_CAP_MODE_MASK	The capture mode control bits are a two-bit field used to define the expected capture input operation. This bit field is configured at initialization with the capture mode defined in the **Capture Mode** parameter. ▪ Timer__B_TIMER__CM_NONE ▪ Timer__B_TIMER__CM_RISINGEDGE ▪ Timer__B_TIMER__CM_FALLINGEDGE ▪ Timer__B_TIMER__CM_EITHEREDGE ▪ Timer__B_TIMER__CM_SOFTWARE
Enable	Timer_CTRL_ENABLE	Enables counting under software control. This bit is valid only if the **Enable Mode** parameter is set to **Software Only** or **Software and Hardware**.

Counter (8-, 16-, 24-, or 32-bit Based on Resolution)

The counter register contains the current counter value. This register is decremented in response to the rising edge of all clock inputs. This register may be read at any time with the Timer_ReadCounter() function call.

Capture (8-, 16-, 24-, or 32-bit Based on Resolution)

The capture register contains the captured counter value. Any capture event copies the counter register to this register. In the UDB implementation, this register is actually a FIFO. See the UDB FIFOs section for details.

Period (8-, 16-, 24-, or 32-bit Based on Resolution)

The period register contains the period value set with the Timer_WritePeriod() function call and defined by the **Period** parameter at initialization. The period register is copied into the counter register on a reload event.

Component Debug Window

The Timer Component supports the PSoC Creator Component debug window. The following registers are displayed in the debug window. Some registers are available in the UDB implementation (indicated by *) and some registers are only available in the fixed-function Implementation (indicated by **). All other registers are available for either configuration.

Register: Timer_CONTROL

Name: Control Register

Description: Refer to the Timer_Control register description earlier in this datasheet for bit-field definitions.

Register: Timer_CONTROL2 **

Name: Fixed-Function Control Register #2

Description: The fixed-function Timer block has a second configuration register. Refer to the Technical Reference Manual for bit field definitions.

Register: Timer_STATUS_MASK *

Name: Status Register Interrupt Mask Configuration

Description: Allows you to enable any status bit as an interrupt source at the interrupt output pin of the Component. Refer to the Timer_Status register description earlier in this datasheet for one-to-one correlation of bit-field definitions.

Register: Timer_STATUS_AUX_CTRL *

Name: Auxiliary Control Register for the Status Register

Description: Allows you to enable the interrupt output of the internal status register through the bit field INT_EN. Refer to the Technical Reference Manual for bit-field definitions.

Register: Timer_PERIOD

Name: Timer Period Register

Description: Defines the period value reloaded into the period counter at the beginning of each cycle of the Timer.

Register: Timer_COUNTER

Name: Timer Counter Register

Description: Indicates the current counter value (in clock cycles from **Period** down to zero) of the current timer period cycle.

Register: Timer_GLOBAL_ENABLE **

Name: Fixed Function Timer Global Enable Register

Description: Enables the Fixed-Function Timer for operation. Refer to the Technical Reference Manual for bit-field definitions.

Resources

The Timer Component is placed in the device based on the **Implementation** parameter. If it is set to **Fixed Function**, this Component uses a FF counter/timer block. If it is set to **UDB**, the Component uses the following resources.

Configuration[2]	Resource Type					
	Datapath Cells	Macrocells	Status Cells	Control Cells	DMA Channels	Interrupts
8-bit UDB Timer Trigger mode = Rising edge	1	6	1	1	–	–
16-bit UDB Timer Trigger mode = Rising edge	2	6	1	1	–	–
24-bit UDB Timer Trigger mode = Rising edge	3	6	1	1	–	–
32-bit UDB Timer Trigger mode = Rising edge	4	6	1	1	–	–
8-bit UDB Timer One Shot Trigger mode = Rising edge	1	9	1	1	–	–
16-bit UDB Timer One Shot Trigger mode = Rising edge	2	9	1	1	–	–

2. For all configurations the common settings are: Enable mode = Software only, Capture mode = None, Interrupt = On TC

DC and AC Electrical Characteristics PSoC 3 (FF Implementation)

Specifications are valid for –40 °C ≤ TA ≤ 85 °C and TJ ≤ 100 °C, except where noted.
Specifications are valid for 1.71 V to 5.5 V, except where noted.

DC Characteristics

Parameter	Description	Conditions	Min	Typ	Max	Units
	16-bit timer block current consumption	Input clock frequency – 3 MHz	–	15	–	µA
		Input clock frequency –12 MHz	–	60	–	µA
		Input clock frequency – 48 MHz	–	260	–	µA
		Input clock frequency – 67 MHz	–	350	–	µA

AC Characteristics

Parameter	Description	Conditions	Min	Typ	Max	Units
	Operating frequency		DC	–	67.01	MHz
	Capture pulse width (internal)		15	–	–	ns
	Capture pulse width (external)		30	–	–	ns
	Timer resolution		15	–	–	ns
	Enable pulse width		15	–	–	ns
	Enable pulse width (external)		30	–	–	ns
	Reset pulse width		15	–	–	ns
	Reset pulse width (external)		30	–	–	ns

DC and AC Electrical Characteristics for PSoC 5LP (FF Implementation)

Specifications are valid for –40 °C ≤ T_A ≤ 85 °C and T_J ≤ 100 °C, except where noted.
Specifications are valid for 2.7 V to 5.5 V, except where noted.

DC Characteristics

Parameter	Description	Conditions	Min	Typ	Max	Units
	16-bit timer block current consumption	Input clock frequency – 3 MHz	–	65	–	µA
		Input clock frequency –12 MHz	–	170	–	µA
		Input clock frequency – 48 MHz	–	650	–	µA
		Input clock frequency – 67 MHz	–	900	–	µA

AC Characteristics

Parameter	Description	Conditions	Min	Typ	Max[3]	Units
	Operating frequency		DC	–	80.01	MHz
	Capture pulse width (internal)		15	–	–	ns
	Capture pulse width (external)		30	–	–	ns
	Timer resolution		15	–	–	ns
	Enable pulse width		15	–	–	ns
	Enable pulse width (external)		30	–	–	ns
	Reset pulse width		15	–	–	ns
	Reset pulse width (external)		30	–	–	ns

3 Refer to the device-specific datasheet to determine the maximum frequency for a particular device.

DC and AC Electrical Characteristics (UDB Implementation)

Specifications are valid for –40 °C ≤ T_A ≤ 85 °C and T_J ≤ 100 °C, except where noted.
Specifications are valid for 1.71 V to 5.5 V, except where noted.

DC Characteristics

Parameter	Description[4]	Min	Typ[5]	Max	Units
I_{DD}	Component current consumption				
	8-bits UDB, Continuous, Trigger = None	–	6	–	µA/MHz
	8-bits UDB, One shot, Trigger = None	–	5	–	µA/MHz
	16-bits UDB, Continuous, Trigger = Rising edge	–	8	–	µA/MHz
	16-bits UDB, One Shot, Trigger = Rising edge	–	8	–	µA/MHz
	24-bits UDB, Continuous, Trigger = Either Edge	–	10	–	µA/MHz
	32-bits UDB, Continuous, Trigger = Software Controlled	–	13	–	µA/MHz

AC Characteristics

Parameter	Description[6]	Min	Typ	Max[7]	Units
f_{CLOCK}	Component clock frequency				
	8-bits UDB, Continuous, Trigger = None	–	–	44	MHz
	8-bits UDB, One shot, Trigger = None	–	–	44	MHz
	16-bits UDB, Continuous, Trigger = Rising edge	–	–	33	MHz
	16-bits UDB, One Shot, Trigger = Rising edge	–	–	33	MHz
	24-bits UDB, Continuous, Trigger = Either Edge	–	–	28	MHz
	32-bits UDB, Continuous, Trigger = Software Controlled	–	–	25	MHz

4. For all configurations the common settings are: Enable mode = Software only, Capture mode = None, Interrupt = On TC
5. Device IO and clock distribution current not included. The values are at 25 °C.
6. For all configurations the common settings are: Enable mode = Software only, Capture mode = None, Interrupt = On TC
7. The values provide a maximum safe operating frequency of the Component. The Component may run at higher clock frequencies, at which point validation of the timing requirements with STA results is necessary.

Component Changes

This section lists the major changes in the Component from the previous version.

Version	Description of Changes	Reason for Changes / Impact
2.80	Improved GUI functionality. Fixed controls greying out in GUI.	The parameter value change doesn't trigger other parameters changes. The validation mechanism was changed. The user can leave any control at any time. An error provider is shown when the control has wrong data. The message box was replaced with a warning icon.
	Updated the datasheet.	Added **DMA Support** subsection to the Functional description section
2.70.a	Updated the datasheet.	Clarified Functional Description section for Timer Outputs. Updated DC and AC Electrical Characteristics for PSoC 5LP section.
2.70	Updated SoftwareCapture() API function	Improved forces a capture of the counter to the capture FIFO in the UDB Implementation for PSoC 5LP with 24- and 32-bit resolution.
2.60	Updated ReadCounter() API function	Fixed read current counter value in the UDB Implementation for PSoC 5LP with 24- and 32-bit resolution.
	Updated the datasheet.	Updated Run Mode parameter in the Component Parameters section
2.50.b	Updated the datasheet.	Updated Input / Output Connections section. Clarified Functional Description section for PSoC 5LP. Added a note to the FIFO section for clarity, and updated a few numbers in the Characteristics section for accuracy.
2.50.a	Edited datasheet to remove references to PSoC 5.	PSoC 5 was replaced by PSoC 5LP.
2.50	Updated datasheet with memory usage for PSoC 4	Support for new device.
2.40	Added MISRA Compliance section.	The Component does not have any specific deviations.
2.30	Added PSoC 5LP support.	
	Updated customizer to remove warning pop-up in One shot hardware enable mode.	
	Updated DC and AC Electrical characteristics. Updated Resource and API memory usage sections.	

Version	Description of Changes	Reason for Changes / Impact
	Removed silicon revision enumerations from symbol file. Added description for formal parameters.	
2.20	Verilog change for UDB implementation	To fix a case where the TC output could be missed under certain conditions when the hardware enable signal was being used
	Document that the interrupt signal is not available for PSoC 5 FF implementation	This feature was removed because it could not be supported by the silicon
	Customizer updated to make Cancel button always available	Under some error conditions the Cancel button had not been available
	Extensive datasheet updates	The implementation of the Timer is different for each of the implementations (UDB, PSoC 3 FF, PSoC 5 FF) and these differences were not adequately described. Particularly. see the waveforms provided in the Configurations section of the Functional Description.
2.10	Verilog update and customizer related updates	To fix a minor issue with Trigger logic and GUI related issues
	"Interrupt on Capture" is disabled when Capture Mode is set to None	"Interrupt on Capture" check box option was available even when Capture Mode is set to "None" and should not be made available
2.0	Synchronized inputs	All inputs are synchronized in the fixed-function implementation, at the input of the block.
	Timer_GetInterruptSource() function was converted to a Macro	The Timer_GetInterruptSource() function is exactly the same implementation as the Timer_ReadStatusRegister() function. To save code space this was converted to a macro substitution of the Timer_ReadStatusRegister() function.
	Outputs are now registered to the Component clock	To avoid glitches on the outputs of the Component it is required that all outputs be synchronized. This is done inside of the datapath when possible, to avoid excess resource use.
	Implemented critical regions when writing to Aux Control registers.	CyEnterCriticalSection and CyExitCriticalSections functions are used when writing to Aux Control registers so that it is not modified by any other process thread.
	Incorrect masking rectified while setting capture mode using SetCaptureMode() API.	Masking used for setting capture mode has erroneous value.
	Added characterization data to datasheet	
	Minor datasheet edits and updates	