XMC1000, XMC4000

Microcontroller Series
for Industrial Applications

Migration from CCU6 to CCU4/CCU8/POSIF

Migration Guide

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1 Overview

The CCU6 (Capture Compare Unit6) module found in the Infineon XC800 8-bit, XC2000/XE166 16-bit and some TriCore™ 32-bit MCUs is often used for motor control and power supply applications. In the XMC1000 and XMC4000 family of products from Infineon, the CCU4s, CCU8s and POSIF peripherals are designed for these applications and provide features that are similar to those of the CCU6.

When combined, the CCU4, CCU8 and POSIF offer all the functionality of the CCU6 together with many extra features and performance enhancements.

1.1 Intended audience

This document is intended for users that are already familiar with the CCU6 and want to know how to implement similar functionality in the XMC1000 or XMC4000 products.

1.2 Scope and purpose

We focus specifically on the following CCU6 features:

- Half-Bridge PWM
- Multi-Channel Mode
- Hall Effect Mode
- Input Capture Modes
- Trap Features

Although the CCU4, CCU8 and POSIF support all of CCU6 peripheral functionality, it is not possible to create a simple formula or table for one-to-one conversion between peripherals. For example, it is not possible to say: “If bit x is set in the CCU6, set bit y in the CCU8 to achieve the same functionality”. Instead we focus on a feature comparison between the CCU6 and the CCU4, CCU8, and POSIF modules, with references to specific User Guides that describe the detail of how to implement the required feature.

1.3 References

For the complete list of available documents, please refer to the XMC web pages:

- **XMC1000** (See the ‘User Guide’ section for peripheral Device Guides)
- **XMC4000** (See the ‘User Guide’ section for peripheral Device Guides)
- **www.infineon.com/xmc**

2 Half-Bridge PWM

2.1 CCU6 features

The CCU6 can generate PWM to control up to 3 half-bridges with dead-time. The basic features and restrictions that the CCU6 places on half-bridge PWM generation are:

- All 3 channels use Timer 12 (T12) as a time base (unless Multi-Channel or Hall Effect Modes are used). This means that the 3 PWM signals must all have the same frequency.
- The CCU6 can insert a programmable dead-time in the half-bridges, but the dead time must be the same for the rising and falling edges. The dead-time counter is a 5-bit timer that counts at the same frequency as T12.
- There is only one compare register per channel so the PWM must be symmetric when T12 is in the center aligned (up/down) counting mode.

2.2 Using CCU8

The CCU8 can be used to create PWM that is identical to that produced by the CCU6, however the structure of the CCU8 is a bit different.

The CCU8 consists of 4 slices, and each slice has 2 compare channels and can generate PWM to control up to 2 half-bridges with dead-time. In total up to 8 half-bridges can be controlled per CCU8 module.

2.3 CCU8 versus CCU6 features

Compared to the CCU6, the CCU8 has the following interesting features:

- Each slice has its own 16-bit timer, so a CCU8 module can produce PWM with up to 4 different frequencies. The timers and the shadow register updates can be synchronized if fewer than 4 different frequencies are required.
- Each channel of each slice has a programmable dead-time for both the falling and rising edges of the PWM, so asymmetric dead-time is supported. The dead-time counters are 8-bits wide and can be clocked by the slice clock with a programmable prescaler (f_{tclk}, $f_{tclk}/2$, $f_{tclk}/4$ or $f_{tclk}/8$) so much longer dead-times can be achieved compared with the CCU6.
- The 2 compare channels of each slice can be combined to create a single PWM output with one compare register controlling the rising edge and the other compare channel controlling the falling edge when the timer is in the center aligned (up/down) counting mode. This allows asymmetric PWM in center aligned mode (with or without dead-time)
- The CCU8 supports dithered PWM.
- The CCU8 timers can be concatenated to create 32, 48 or 64-bit timers.

2.4 Document references

For more information about the CCU8 features described and how to use them, please see the following chapters of the document **Device Guide – CCU8** (See the ‘User Guide’ section of the **XMC1000** or **XMC4000** Infineon web pages):

- Introduction to the Basic Features
- Output Pattern Generation using the Compare Mode
- Signal Quantification & Quality Enhancement by Dithering
- Dead Time Generation
- Asymmetric PWM

3 Multi-Channel Mode

3.1 CCU6 features

The CCU6 Multi-Channel Mode is a subset of the Hall Effect Mode that is often used for BLDC or Stepper motor control.

The Multi-Channel Mode allows one register (MCMOUT) to control which of the six T12 outputs are active or passive. When an output pin is active, the MODCTR register controls which pins get PWM from either T12 or T13.

MCMOUT register updates can be synchronized to PWM edges and/or a Correct Hall Event (CHE). See the section on **Hall Effect Mode** for further details on CHE.

3.2 Using CCU4 and CCU8

The CCU4 and CCU8 both have a Multi-Channel Mode. Generally speaking, the CCU4 can be used for multi-channel PWM that does not require synchronous rectification, and the CCU8 can be used when synchronous rectification (with or without dead-time) is required. The output pattern is located in the MCMP bit-field of the MCM register of the POSIF peripheral. So the POSIF works together with the CCU4 or CCU8 to achieve Multi-Channel Mode.

The CCU4 and CCU8 peripherals do not have MODCTR registers. When the output pin is Active (i.e. there is a '1' in the corresponding MCMP bit) the PWM from that slice will be gated to the pin, unless a trap, modulation event or override event prevents this. If it is a requirement to have a pin that is always high or low, the appropriate compare value must be set. The Multi-Channel Mode of CCU4 and CCU8 is similar to that of the CCU6 with the T12 related MODCTR bits set.

3.3 Document references

A detailed description of how to setup and use the Multi-Channel Mode can be found in the following chapters of the respective User Guides (See the 'User Guide' section of the **XMC1000** or **XMC4000** Infineon web pages):

- **Device Guide – CCU4**
  - Multi-Phase Output control using the Multi-Channel Mode
- **Device Guide – CCU8**
  - Multi-Phase Output control using the Multi-Channel Mode
- **Device Guide - POSIF**
  - Multi-Channel Multi-Phase Control

4 Hall Effect Mode

4.1 Description

The CCU6 has a special Hall Effect Mode to simplify control of a 3 phase BLDC motor using trapezoidal (6-step or 12-step) control. There is also a “Reduced Hall Mode” that offers additional functionality (mainly synchronous rectification) at the expense of automatic speed measurement and angle based delays.

To achieve the same or enhanced functionality, the CCU4 and/or CCU8 are implemented in combination with the POSIF peripheral. The initial setup of these peripherals is more complex than setting up the Hall Effect Mode of the CCU6, but there are User Guides and DAVE™ Apps available for free download from the Infineon website to help ease the setup.

4.2 CCU6 features

The basic features of the CCU6 Hall Effect Mode are:

- Three input Signals from latched Hall Effect sensors are monitored for any change in state. When any sensor changes state, the dead-time counter delays a programmable amount of time and the senor state is re-evaluated to see if the original transition was real or noise.
- The noise filtered sensor state is compared to the next expected state (contained in the MCMOUT register) to see if the motor is spinning as expected. If the sensor state does not match the expected state this is a Wrong Hall Event (WHE). The sensors can be ignored or the CCU6 can be placed in IDLE mode where the outputs are placed in the passive state.
- If the sensor state matches the expected state a Correct Hall Event (CHE) internal signal is generated and the value of T12 is captured into the capture/compare register 0. T12 is reset to zero and continues counting. Capture/Compare register 0 therefore indicates the speed of the motor.
- The MCMOUTS shadow register contains a bit-field for the next output pattern. This bit-field indicates which of the 6 outputs will be “active”. Whether the “active” outputs receive PWM from T13 is determined by the MODCTR register. The transfer from the shadow register to the actual register can be triggered by one of several events including a CHE (for immediate commutation) or when T12 equals the value of compare register 1 (for a phase delay).

4.3 Using CCU4, CCU8 and POSIF

The CCU6 functionality can be implemented with the combination of the CCU4, CCU8 and POSIF peripherals, but the implementation is quite different:

- The three Hall Effect sensors are connected to the POSIF. When the POSIF detects a change on the sensors, it triggers a CCU4 (typical) or CCU8 timer in single shot mode to perform a noise filtering delay. This is similar to how the CCU6 dead-timer counter is used. When the CCU4 or CCU8 timer expires, the POSIF samples the three inputs again.
- The POSIF contains registers that have the current and expected sensors state and can trigger a CHE or WHE similar to the CCU6. These events can then be connected to the CCU4 or CCU8 running in Multi-Channel Mode to trigger updates of the actual output states, or further delays (phase delays).
- In the XMC family there is no MODCTR register so the active outputs are always gated by the PWM signal. For an output to be high or low all of the time, the duty appropriate compare value should be used.
- The output pattern shadow transfer occurs after the following 2 events
  - After the CHE has become active a phase delay (MSET signal of the POSIF) is required before the output pattern can be updated. The delay can be small, but must be at least several clock cycles. The delay also clears the internal CHE signal.
  - The update of the output pattern (MCMP) must also be synchronized to another signal (e.g. PWM synchronization) after the phase delay, for the shadow transfer to occur. This is achieved via the MSYNC input of the POSIF. If PWM synchronization is not required, then an additional CCU4 or CCU8 slice can be setup to generate a high frequency MSYNC signal so that the delay between CHE and the output pattern update is minimized.

4.4 Document references

For more information about using the CCU4, CCU8 and POSIF peripherals to achieve the Hall Effect mode found with CCU6, please refer to the following chapters of the respective User Guides (See the 'User Guide' section of the **XMC1000** or **XMC4000** Infineon web pages):

- **Device Guide – CCU4**
  - Multi-Phase Output control using the Multi-Channel Mode
- **Device Guide – CCU8**
  - Multi-Phase Output control using the Multi-Channel Mode
- **Device Guide - POSIF**
  - Triple-Hall Commutation Control for BLDC motor

5 Input Capture Modes

5.1 CCU6 features

In the CCU6:

- 9 capture modes are supported for each of the 3 input channels.
- Each of the capture modes are selected using the MSEL6x bit-fields of the T12MSEL register.
- Four of the capture modes use one input per channel (CC6xIN).
- The remaining five capture modes use 2 inputs per channel (CC6xIN and CCPOSx).
- Each channel of input capture can store the T12 contents (or previously captured value) into the CC6xR or CC6xSR register.
- All of the channels use T12 as the time base.

5.2 Using CCU4 and CCU8

The CCU6 Input Capture Modes functionality is reproducible in the CCU4 and CCU8, however the implementation is different and additional features are also available.

In CCU4 and CCU8:

- Each slice supports up to 2 inputs for capture and up to 4 registers to store the captured timer values.
- Since each slice has its own timer, and many more time bases can be used.
- The timers can be concatenated for capturing 32, 48 or 64-bit time values.
- The Floating Prescaler mode can be used to capture signals with unknown or highly dynamic timing.
- Hardware low pass filtering can, if required, be performed on the capture inputs.

5.3 Document references

For more information on how to setup and use the Input Capture features of the CCU4 and CCU8, please refer to the following chapters of the respective User Guides (See the ‘User Guide’ section of the **XMC1000** or **XMC4000** Infineon web pages):

- **Device Guide – CCU4**
  - Advanced Signal Measurement using the Capture Mode
  - External Events Control
  - Autonomic Signal Measurement Range Adaption using the Floating Prescaler
- **Device Guide – CCU8**
  - Advanced Signal Measurement using the Capture Mode
  - External Events Control
  - Autonomic Signal Measurement Range Adaption using the Floating Prescaler

6 Trap Features

6.1 CCU6 features

The CCU6 module has an input signal that, when pulled low, can put any or all of the output pins into a programmable “passive” state. The signal is connected to a /CTRAP pin and on some devices it is also connected to internal sources such as an out of range comparator or ADC boundary flag.

This Trap feature is generally used for over current/voltage protection in a motor control or power supply type of application. One Trap signal is used for the whole CCU6 module and the Trap signal is always active low. It is possible to leave the Trap state via hardware or software, and it can be optionally synchronized to PWM events to prevent glitches.

6.2 Using CCU4 and CCU8

Features

The CCU4 and CCU8 support Trap functions with all of the same capability as the CCU6, but also with these additional features:

- One Trap input is available per slice
- The Trap signal can be active high or low
- An optional hardware low pass filter can be used on the signal
- The Trap signals can come from many more internal or external sources

Implementation

- The Trap input always uses input Event 2 on each slice.
- The Trap is cleared via software using the CC4yINTS.E2AS or CCU8yINTS.E2AS bit.
- Hardware clearing of the Trap and synchronization to PWM events is setup in the CC4yTC or CCU8yTC registers.
- The reference manual for each device describes the Trap feature in detail.

6.3 Document references

The following chapters of the respective User Guides describe how to setup the input signals (See the ‘User Guide’ section of the **XMC1000** or **XMC4000** Infineon web pages):

- **Device Guide – CCU4**
  - External Events Control
- **Device Guide – CCU8**
  - External Events Control

7 Conclusion

The CCU4, CCU8 and POSIF peripherals found in the XMC1000 and XMC4000 products offer all of the functionality of the CCU6 peripheral found in other Infineon devices, but with significant additional features that reduce software overhead and increase accuracy and performance. These peripherals are designed with repetitive structures that make automatic code generation easier.

The DAVE™ 3 tool with the DAVE™ Apps can be used to handle the most common use cases for the CCU4, CCU8 and POSIF. Additionally, example projects, and Users Guides are available for download to ease the learning curve and help speed-up development and implementation.

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