CCU8: Capture and Compare Unit 8

XMC™ microcontrollers
September 2016

Agenda

1. Overview
2. Key feature: modular timer approach
3. Key feature: flexible PWM generation
4. Key feature: flexible capture scheme
5. System integration
6. Application examples

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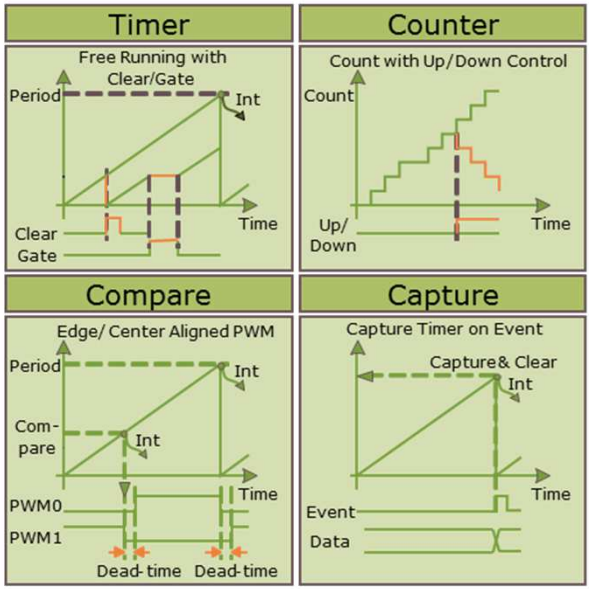
CCU8
Capture/Compare Unit 8



Highlights

One timer architecture serves any use case. The regular and repetitive slice structure allows portable software and use of code generators.

Two compare channels enable the generation of up to 4 complementary PWM signals per timer (16 per CCU8).

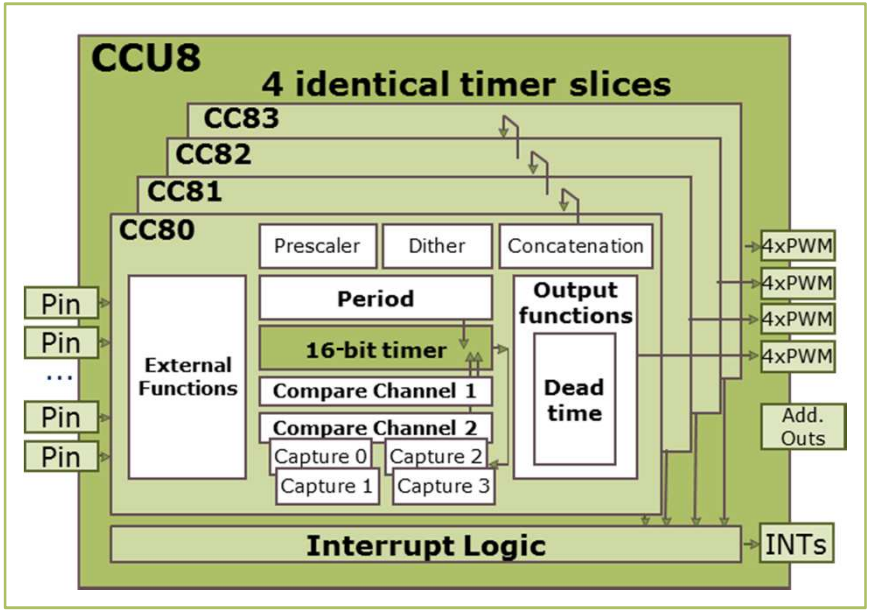
Key feature

- CCU8 serves as timer, counter, capture, compare
- Shadow and buffer mechanism for coherency
- Dead-time insertion

Customer benefits

- Adjust the timer to the wanted application
- Synchronize hardware events to software timing for real-time control
- Generating complementary PWM signals

CCU8
Capture/Compare Unit 8



Highlights

The CCU8 is a flexible timer module, comprised with 4 identical timer slices tailored for multi-phase PWM generation and signal conditioning.
Several input functions can be controlled externally (via pins or other modules) enabling a powerful resource arrangement for each application.

Key feature

- Modular timer approach
- Flexible PWM generation
- Flexible capture scheme

Customer benefits

- Each specific application function can be ported to any of the 4 timers
- Each timer slice can generate up to 4 PWM signals (2 x complementary)
- Parallel capture and compare modes

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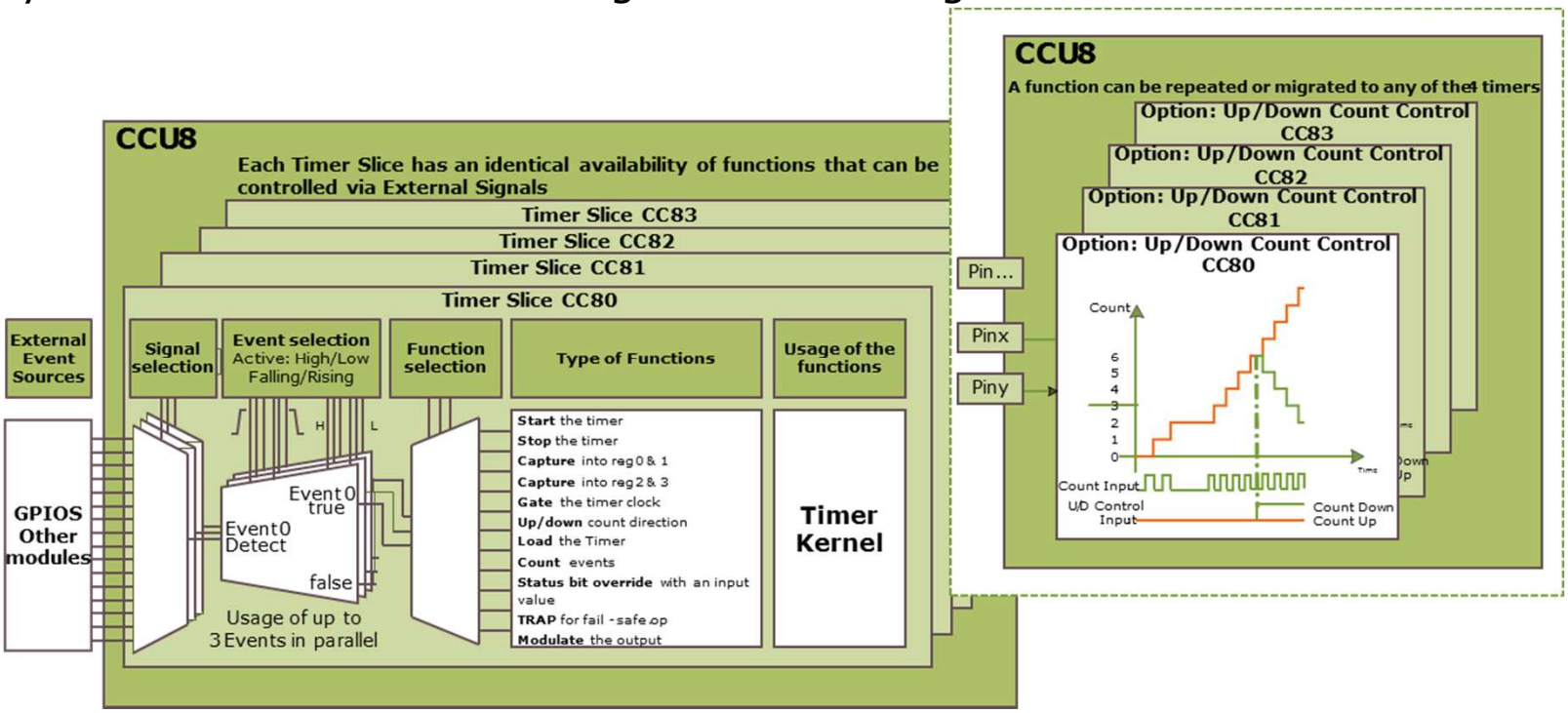
CCU8
Modular timer approach

- Equal structure and same availability of features for each of the 4 timer slices
- Functions controllable via external signals do not depend on the selected signal
- Portability of code is not dependent on the used timer slice
- High amount of configurable external functions (11), make each timer slice a very flexible HW resource for signal conditioning



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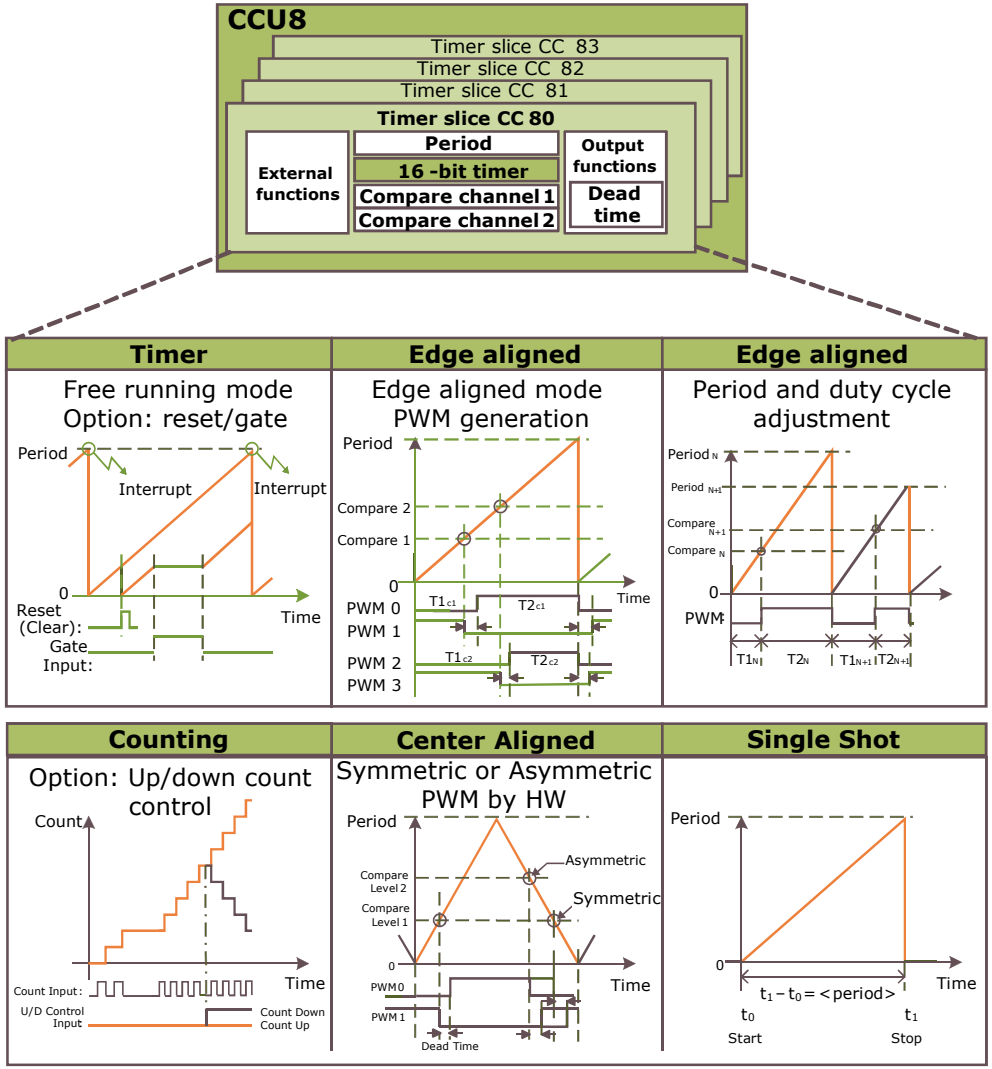
CCU8
Flexible PWM generation

- Each timer slice of the CCU8 can operate in center aligned or edge aligned mode
- Additional operation modes like single shot, counting or dithering modes are also available
- Complementary PWM signal generation with dead time
- HW asymmetric PWM generation
- Additional external controllable functions give another degree of PWM manipulation (e.g. timer gate, timer load, timer clear, etc.)



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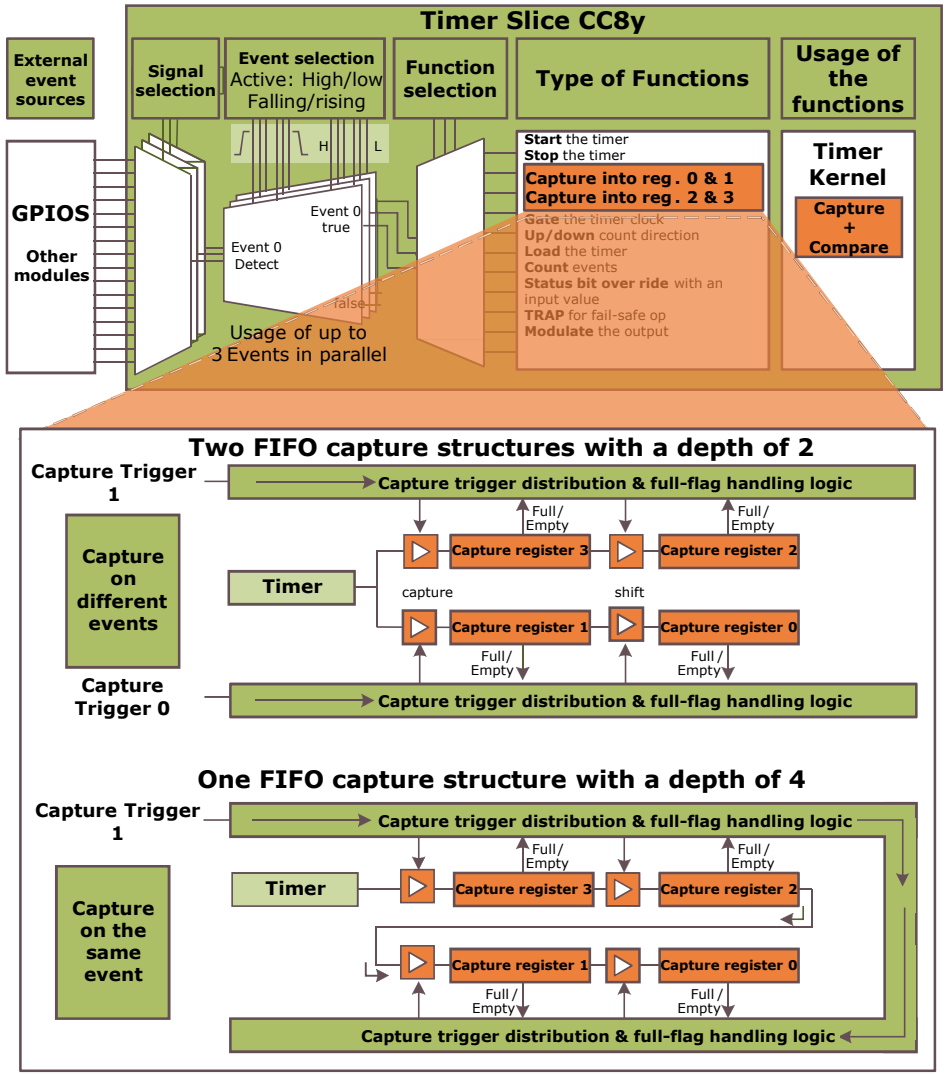
CCU8
Flexible capture scheme

- Each timer slice of the CCU8 can operate in compare and/or capture mode
- Possibility of using the available 4 capture registers in two modes:
  - 2 capture triggers
  - 1 capture trigger
- A FIFO structure, with a full/empty control, decreases the load on the CPU when reading back fast capture trigger info:
  - Depth of 2
  - Depth of 4
- FIFO structure will always return the oldest captured value



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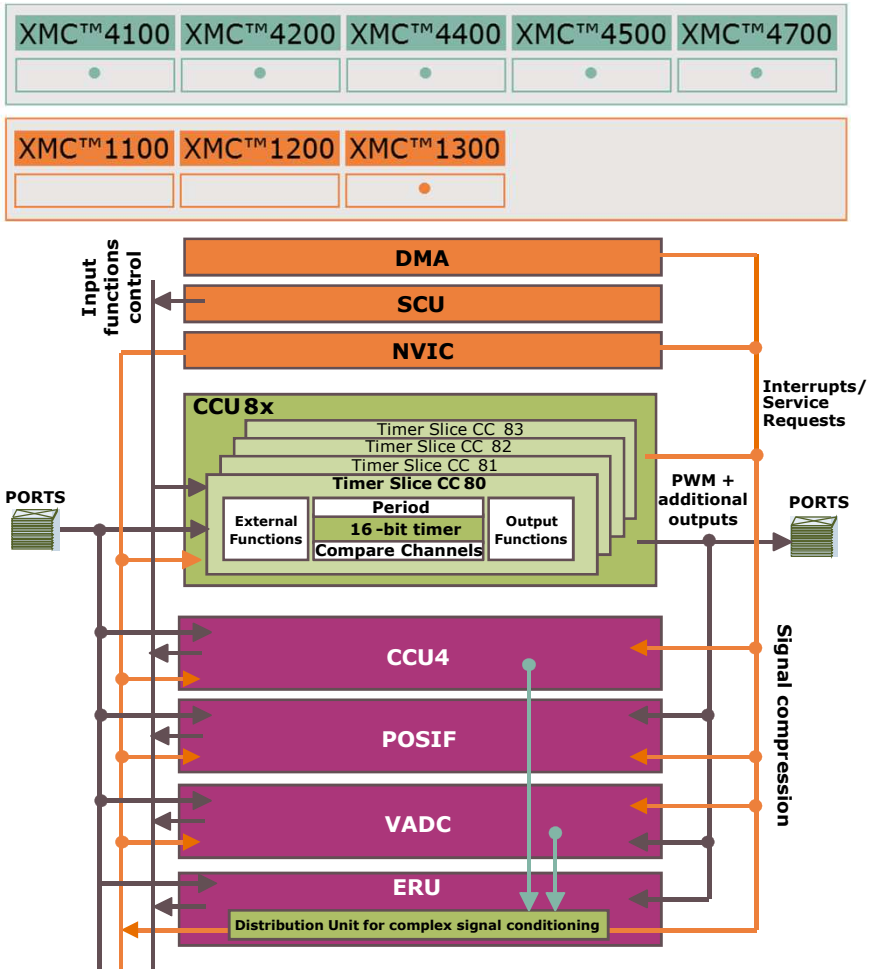
CCU8
System integration



Several components may be present or not depending on the device

The CCU8 system integration offers several advantages:

- Distribution bus over the ERU for complex signal conditioning application cases
- Usage of interrupts/service requests as flexible connection for ADC conversion triggering (signal compression)
- Synchronous control over several timers via the SCU
- The CCU8 is agnostic to the type of signal (feature and type: level, edge)
- Target applications
  - Motor control
  - Power conversion
  - Human machine interface
  - Connectivity
  - General purpose

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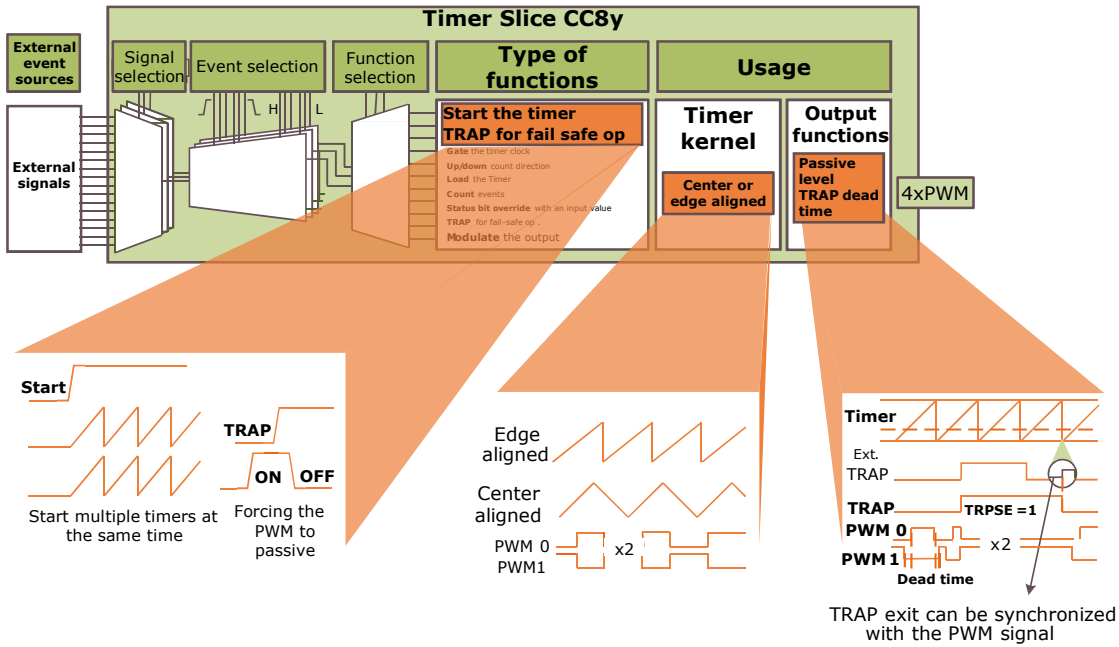
Application example
PWM for generic purpose (1/2)



In Brief

Standard functions for generic PWM generation.

Overview

For a standard PWM generation application, four major functions can be controlled in each CCU8 timer slice:

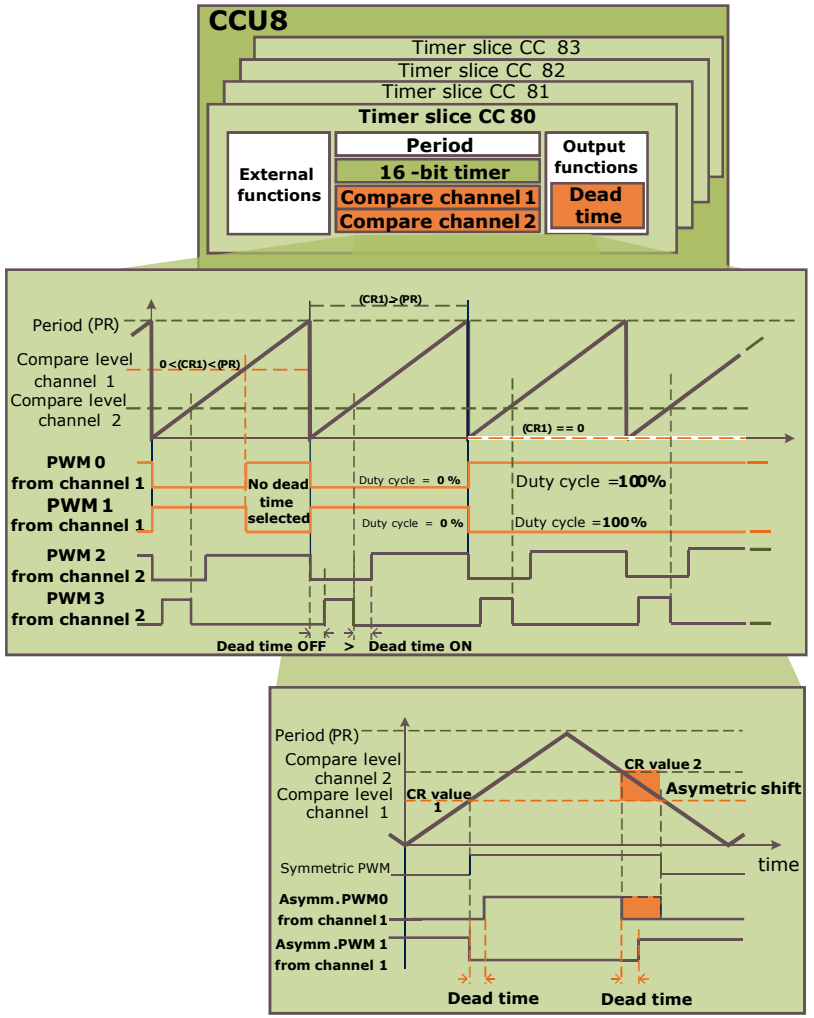
- Start PWM generation
- Type of counting scheme (edge or center aligned)
- Passive level of the PWM
- Dead time insertion for complementary signals

The start of the PWM can be applied to any combination of timers.

Additionally a TRAP signal can be configured to set the PWM in a pre-configured passive state.

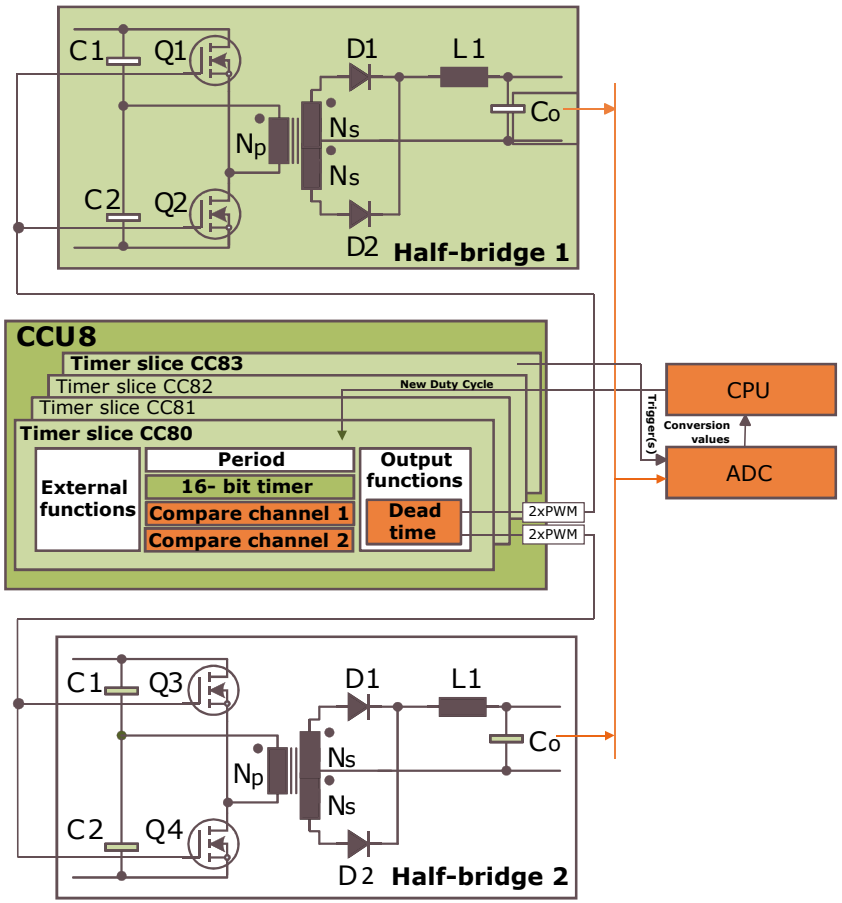
Application example
PWM for generic purpose (2/2)

- For the two available counting schemes: edge and center aligned, different dead times can be programmed for the ON and OFF thresholds
- In a straightforward PWM generation it is possible to output up to 4 PWM signals from the same timer slice: controlling up to two complementary switches
- It is possible to combine the two compare channels and generate an asymmetric complementary PWM signal by HW
- Dead time is programmable for both compare channels. Different dead-time for ON and OFF transition is also available for each channel



Application example PWM generation: detailed timing diagram

Application example
PWM for power conversion (1/4)



In brief

Controlling half-bridges

Overview

With each CCU8 timer slice, it is possible to control up to two half-bridges with the same switching frequency.

Each of the compare channels is generating 2 complementary PWM signals with configurable dead time.

Dead time values for half-bridge 1 can be different from the dead time values of half-bridge 2.

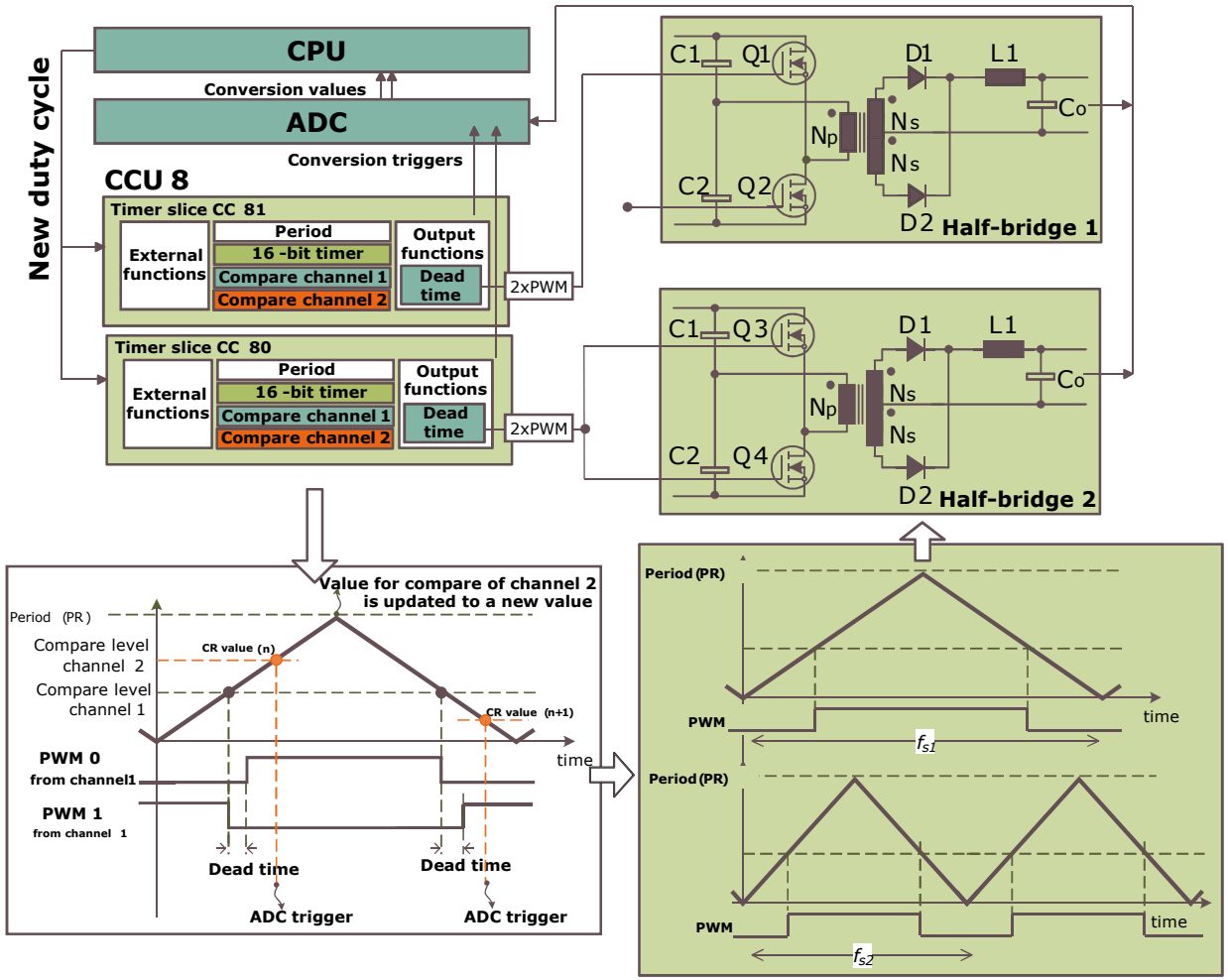
In this application example, a second timer slice (CC83), is being used to generate the needed ADC conversion triggers.

Application example
PWM for power conversion (2/4)

When several half-bridges do not have the same f_S, one timer slice per bridge is needed.

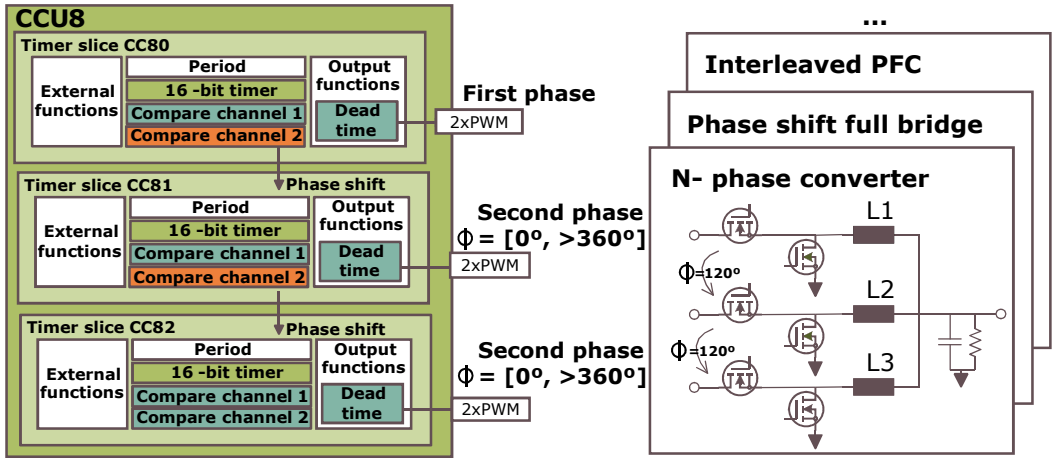
In this application case, the second compare channel is used to generate the conversion trigger(s) for the ADC. With this a very good resource utilization is guaranteed.

Different trigger stamp can be used for ON and OFF time frame.



Application example two half-bridges with different f_S: detailed block diagram

Application example
PWM for power conversion (3/4)



- **Compare channel 2 controls the phase shift: it can be a fixed phase shift or updated on a cycle-by-cycle way**
- **Each timer can then generate the appropriate phase shifted signals with dead-time**

In brief

- Phase shift control

Overview

There are several power converter topologies that implement phase shift between one or more signals (complementary or not).

A known topology is the 2 or 3 phase buck converter or a phase shift full bridge.

While for a 3 phase buck converter the phase shift is fixed, this is not true for a phase shift full bridge.

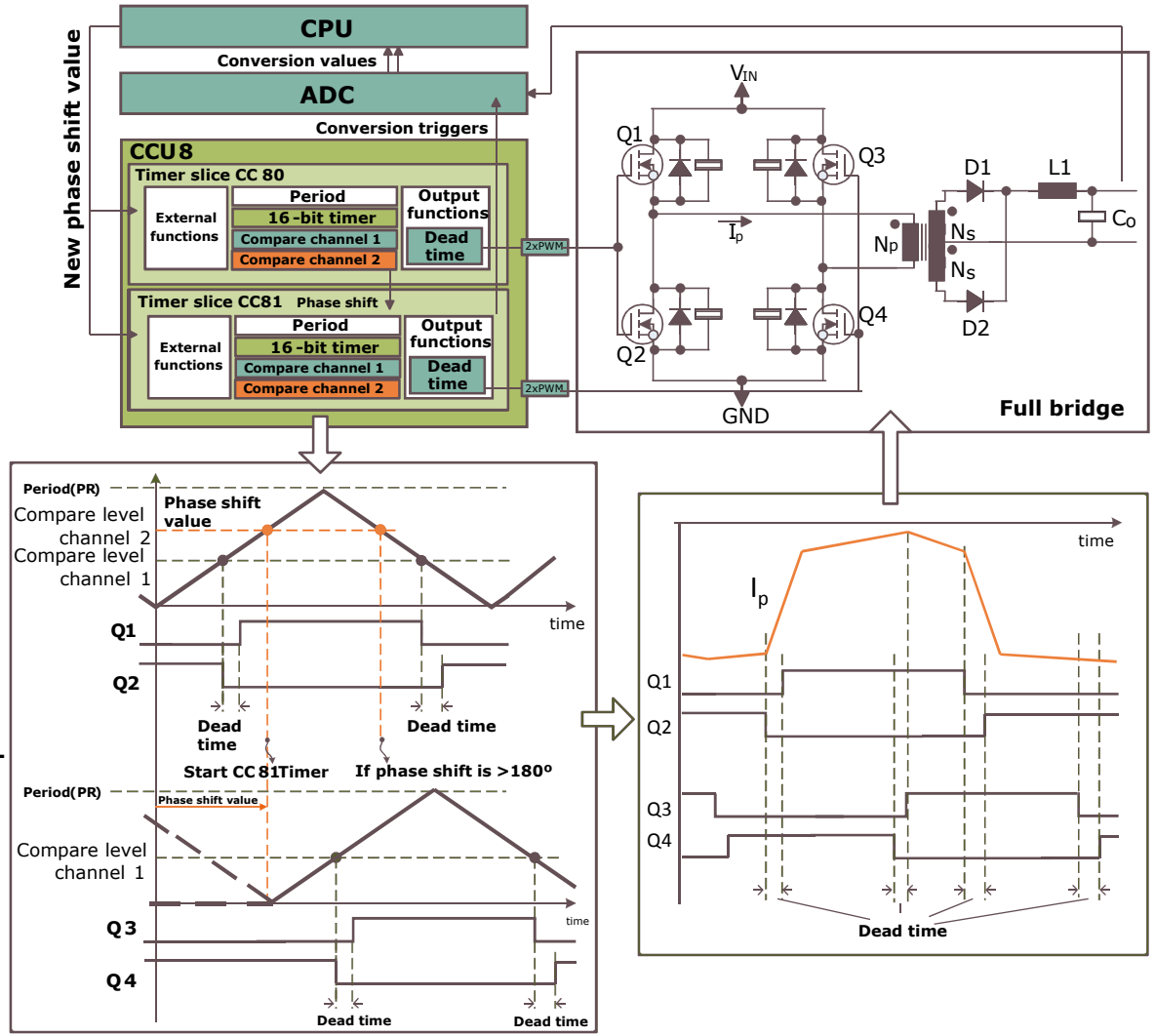
With the CCU8 timers it is easier to control a phase shift mechanism, for fixed and/or variable phase shift.

Application example
PWM for power conversion (4/4)

CC80 timer is generating the PWM signals for Q1 and Q2 switches. These are complementary signals with dead time.

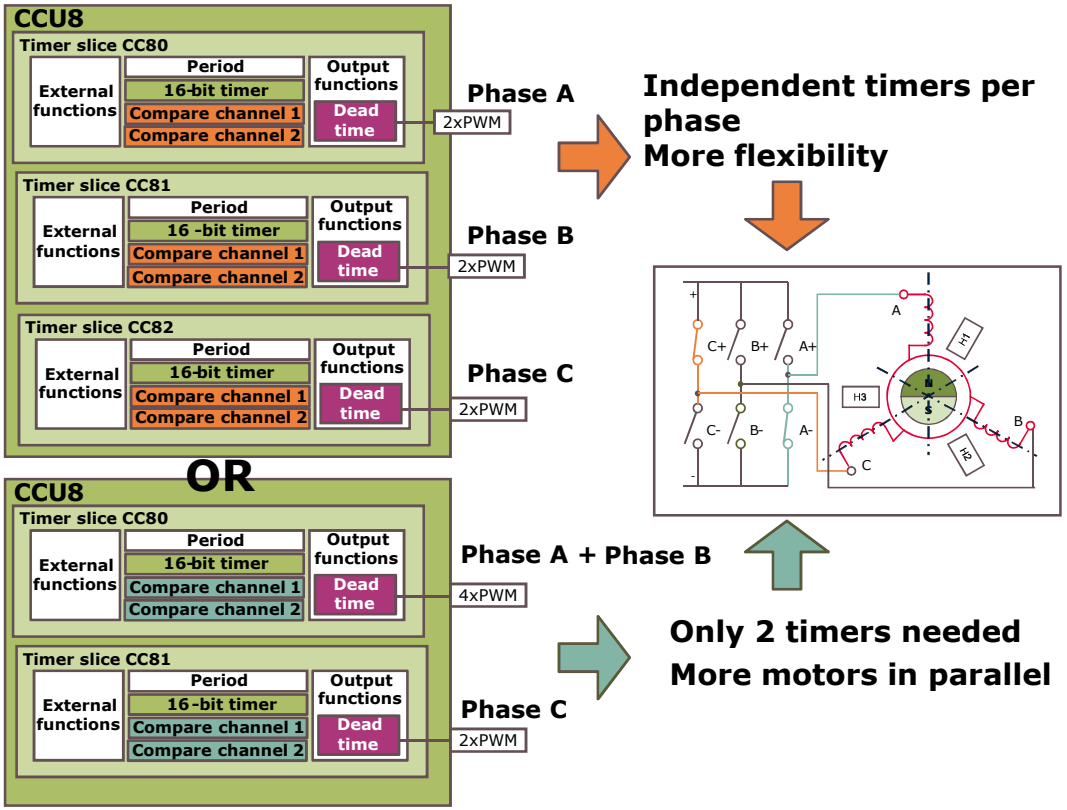
With compare channel 2 of the CC80 timer it is possible to start the CC81 timer. **This will dictate then the phase shift of CC81 regarding to CC80**.

Due to the fact that it is possible to update the compare channel 2 value on-the-fly, **the phase shift can be from 0 to > 360°.**



Application example phase shift full bridge: timing diagram

Application example
PWM for motor control (1/3)



In brief

- Motor control PWM

Overview

Controlling a 3-phase motor is a common application within the motor control world, that can be simply done by the CCU8.

Each CCU8 timer can control a motor phase with complementary switches.

If a higher resource utilization density is needed, **it is possible to control with just one timer, two phases in parallel.**

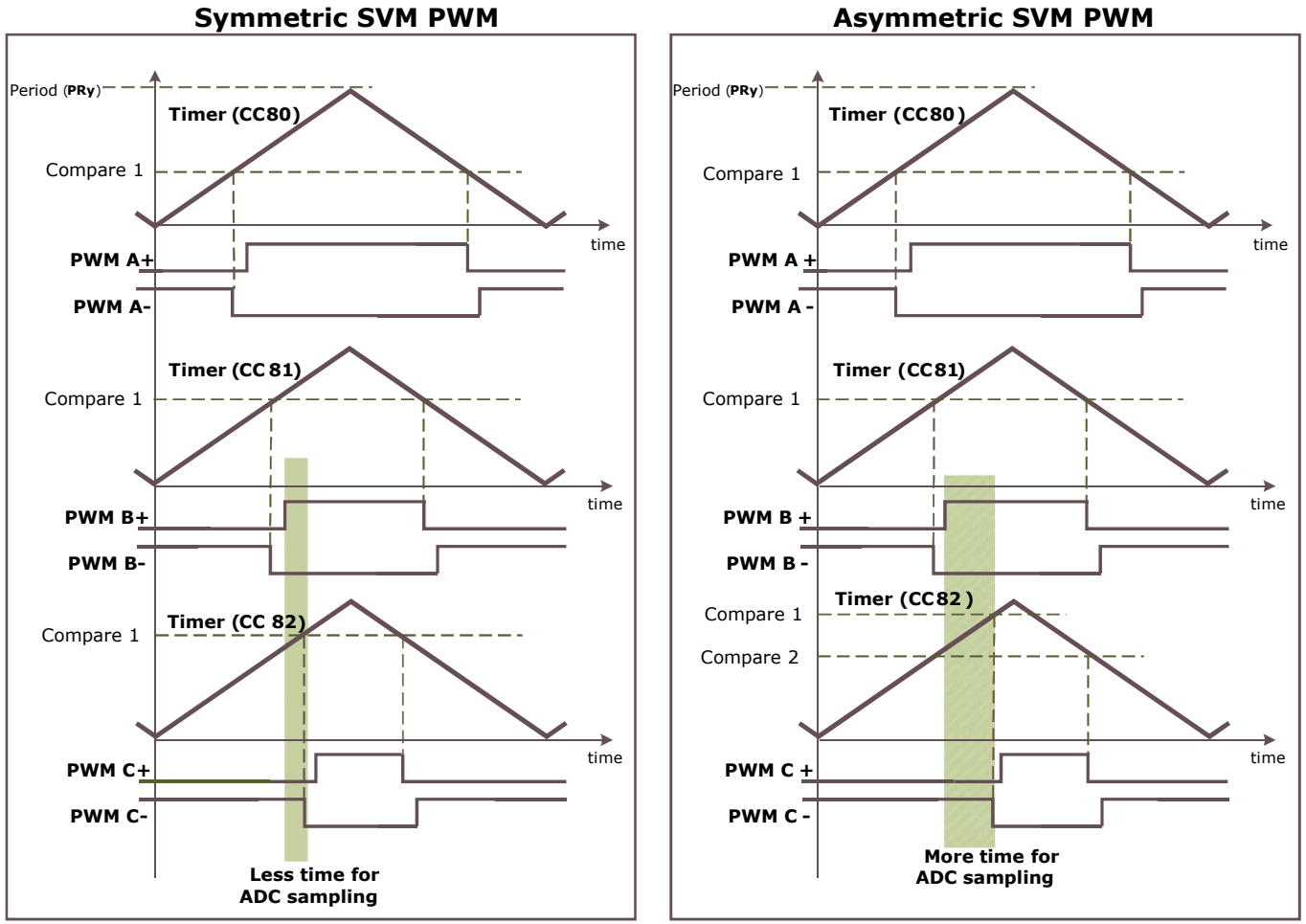
The CCU8 timers are able to generate the proper PWM patterns for **SVM** and **block commutation**.

Application example
PWM for motor control (2/3)

SVM pattern generation can be done in a **symmetric or asymmetric way.**

In asymmetric fashion one timer per phase is needed.

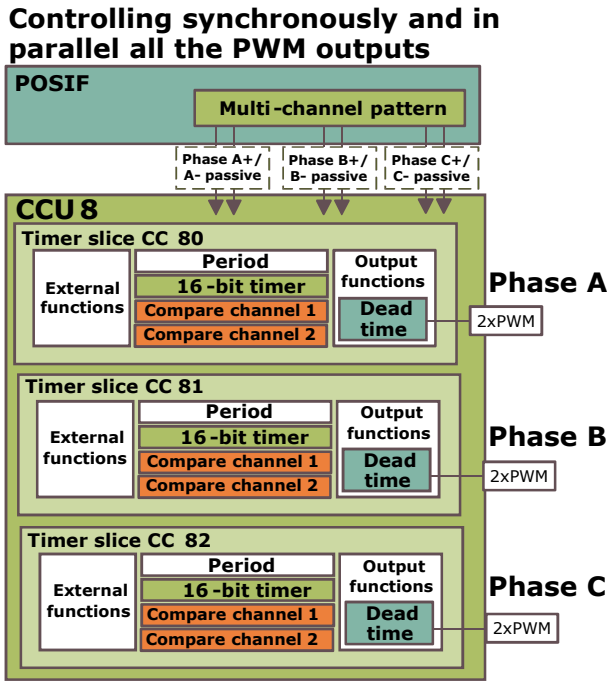
Asymmetric way gives more flexibility for sampling shunt currents via the ADC.

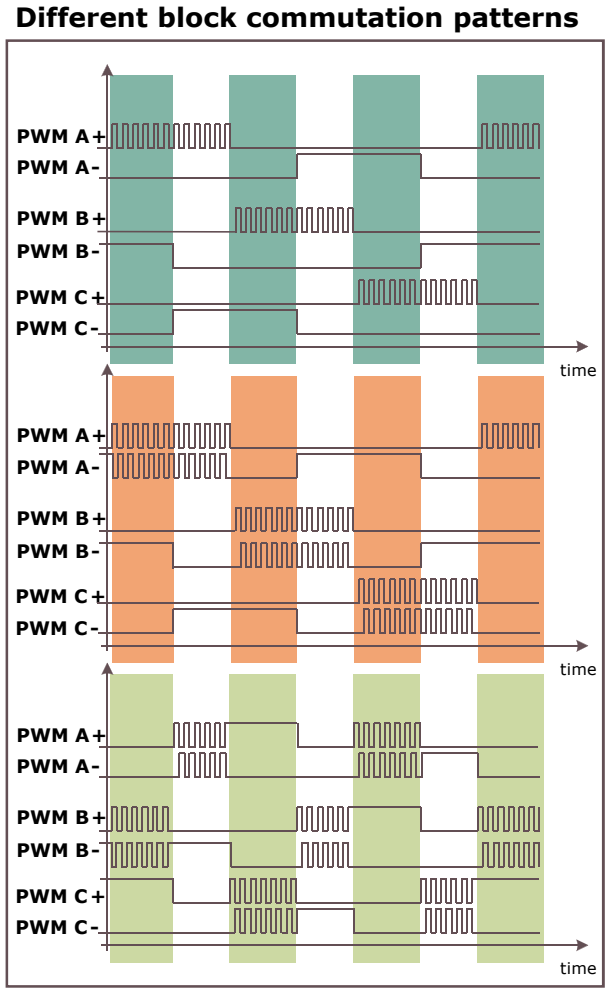


Application example SVM pattern generation: timing diagram

Application example
PWM for motor control (3/3)

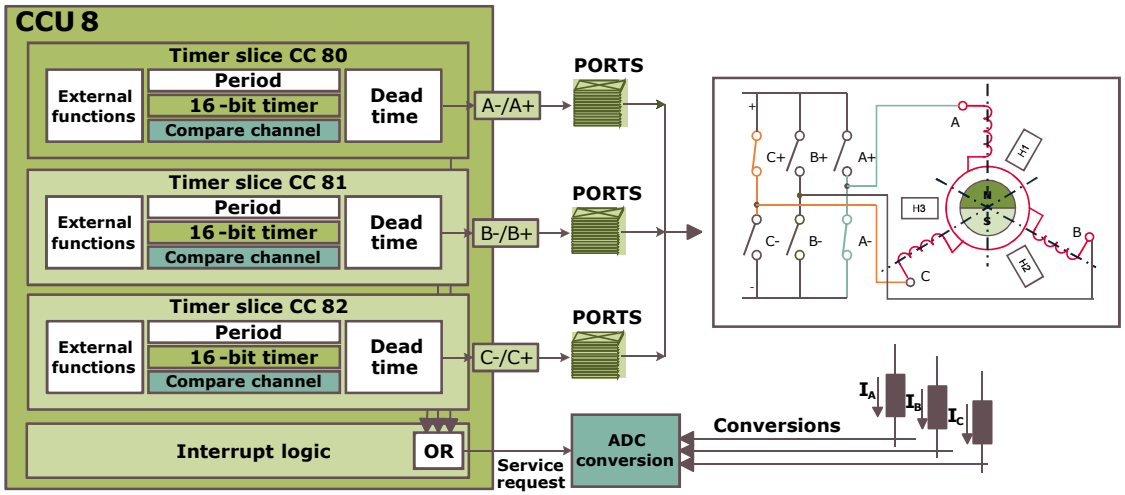
- Several block commutation pattern schemes can be controlled by the CCU8
- Link between CCU8 and POSIF interface gives flexibility for any type of output pattern generation.





Application example block commutation PWM generation: timing diagram

Application example
ADC triggering with service requests (1/2)



Overview

It may be necessary in some applications to generate several ADC conversion triggers synchronized with a PWM signal.

In a motor control application it may be necessary to measure several shunt currents in each PWM cycle.

The CCU8 offers a way to compress all the conversion triggers to the ADC via just one signal. This enables a better optimization of resources and connectivity.

In brief

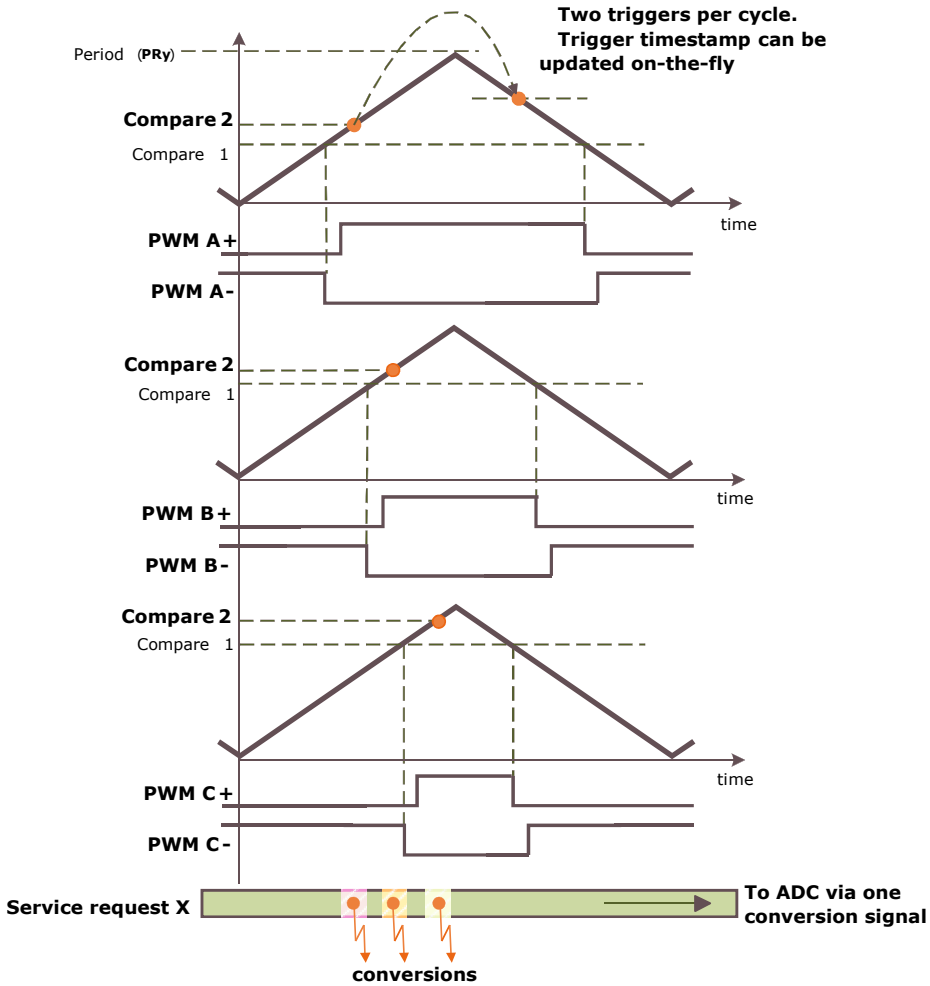
- Using the service requests to compress ADC triggers

Application example: signal compression with service requests (2/2)

In this example, we are using **the second compare of each timer slice to trigger a delayed conversion trigger** to the ADC.

All the triggers are grouped together in a service request line.

Additionally, **the conversion timestamp for the second 180° part of the signals can also be used to trigger a conversion**. This timestamp can be different from the first one.



Application example grouped conversion triggers: timing diagram

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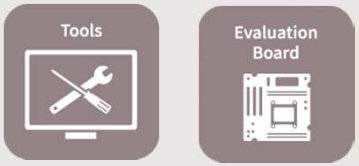
Technical Material 	– Application Notes – Technical Articles – Simulation Models – Datasheets, MCDS Files – PCB Design Data	– www.infineon.com/XMC – Kits and Boards – DAVE™ – Software and Tool Ecosystem
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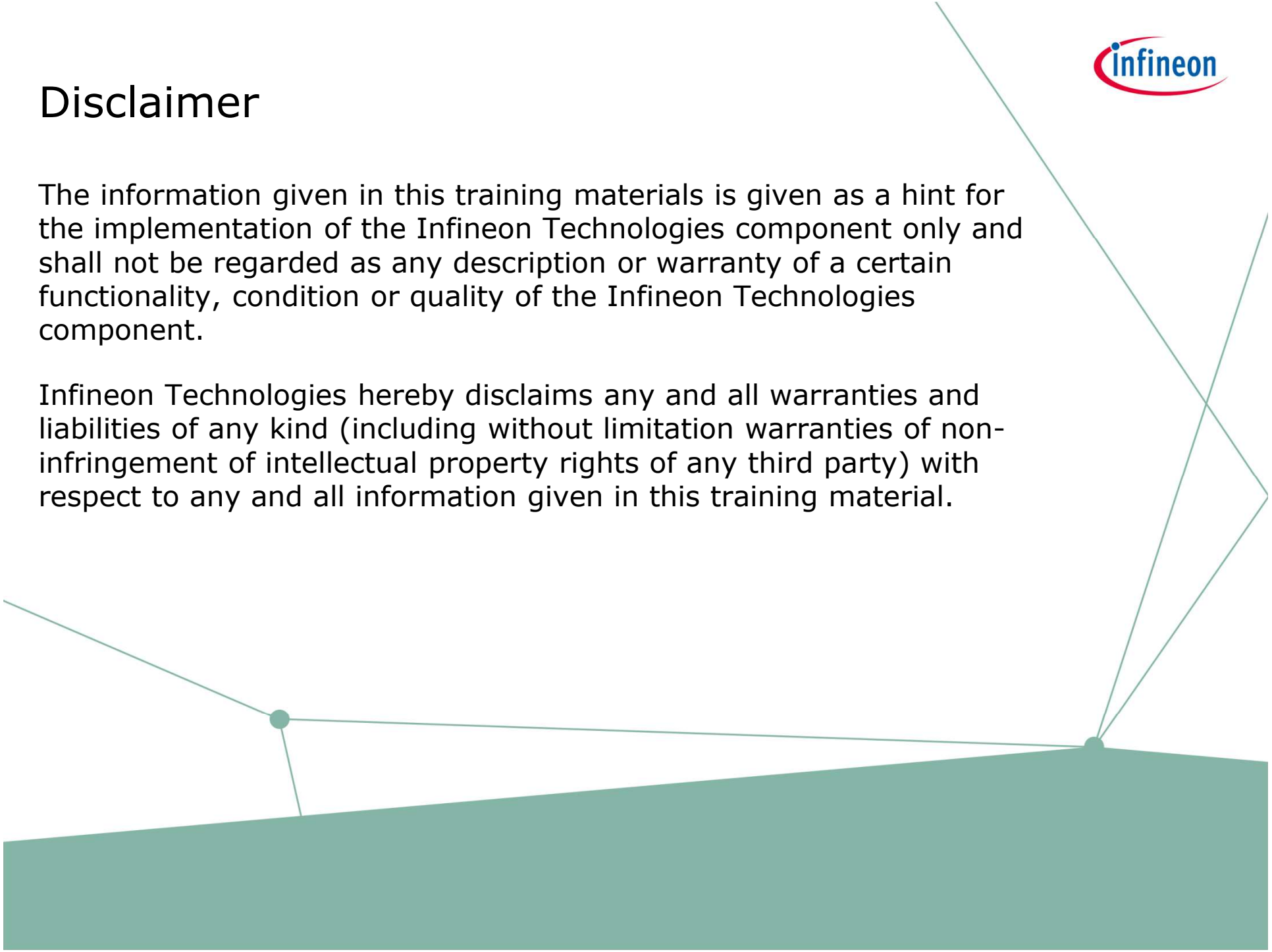

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