XMC4000

XMC4500 Family

CCU4 and External Modulation

Output Level Modulation on External Events

User Guide

Device Guide

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1 Output Level Modulation on External Events

Each CAPCOM4 (CCU40/../43) is a multi-purpose timer unit for many use cases. It is designed with repetitive structures with multiple timer slices that have all the same base functionalities. This allows the development of re-usable SW low level drivers. The main function blocks of 1 of the 4 CC4y slices on a CCU4x are shown here. See Figure 1.

1.1 Output Level Modulation Basics

A slice may have its output pin modulated by *external events*. This function (and the *active level* of the event source) should be mapped to one of the 3 inputs of the slice in the **CC4yCMC** and **CC4yINS** registers. Modulation alternatives can be selected in **CC4yTC** for either *Status Bit Clear* or just *Output Gating* on events.

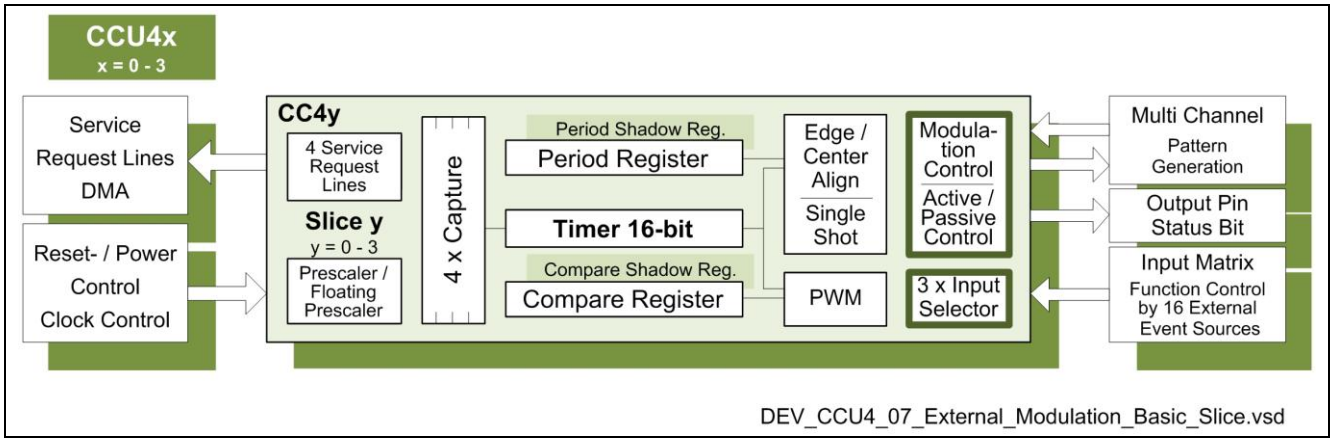

Figure 1 Timer Slice in Status Bit or Output Pin Modulation by External Events Control

1.2 Use Cases

Use cases for external modulation can be found in e.g. motor drive and control applications, such as BLDC. The PWM signals that control motor currents by duty cycle are activated and passivated alternately according to the commutation event sequence – which is an *external modulation*, controlled by commutation logic and sensors.

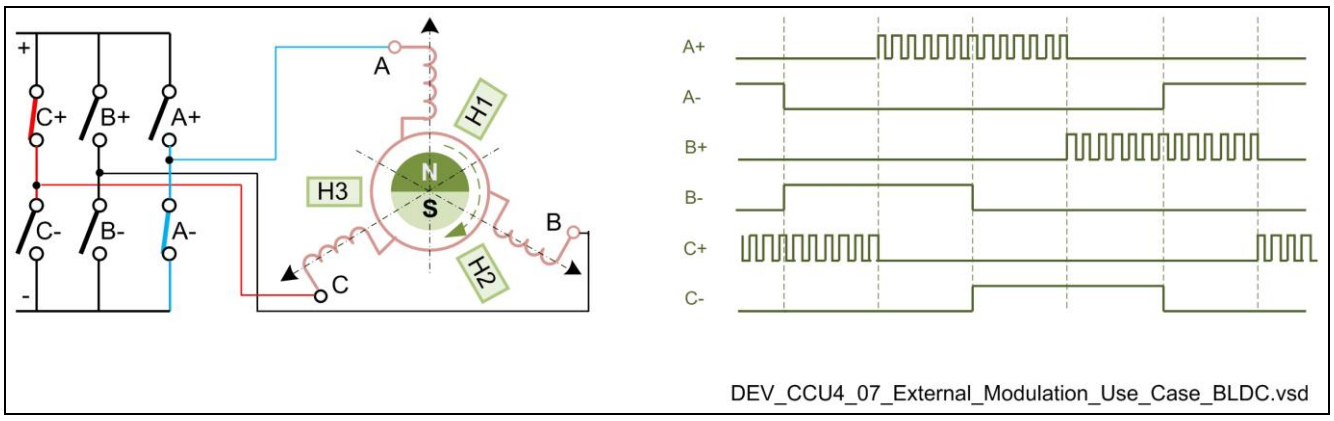

Figure 2 PWM signals in External modulation by BLDC Commutation Event Sequences Control

2 External Events Control of a Timer Status Bit or Output Pin State

An External Event Control request is a *considered edge* or *level event* signal from a peripheral unit or a GPIO. It can be linked to CCU4xCC4y slices input selection stages via a comprehensive matrix. A slice that by any of its 3 events setups detects a *considered source-event profile* can be Status Bit or Output Pin modulated this way!

2.1 External Events Control of Timer Input Functions in general

There are 11 Timer Input Functions (as e.g. *Modulate Output*), controlable by external events via 3 selectable input lines with configurable *source-event profile* conditions to the Timer Slices CC4y (y=0-3) of a CCU4x unit (x=0-3) for *Start, Stop, Capture0-3, Gate, Up/Down, Load, Count, Bit Override, Trap & Modulate Output* control.

See Figure 3.

2.2 Selection of External Events Control Sources and Input Functions

The *Modulate Output* function can be linked to external trigger requests – from such as the following sources: *GPIO, ERU, POSIF, CAN, CCU4x, USIC, ADC, CCU8x or SCU*. **Pin Connections** are given by the **Top-Level Interconnect** matrix and the **CC4yINS**[P:A] *Input Select* vector - and *Function Select* by the **CC4yCMC** register.

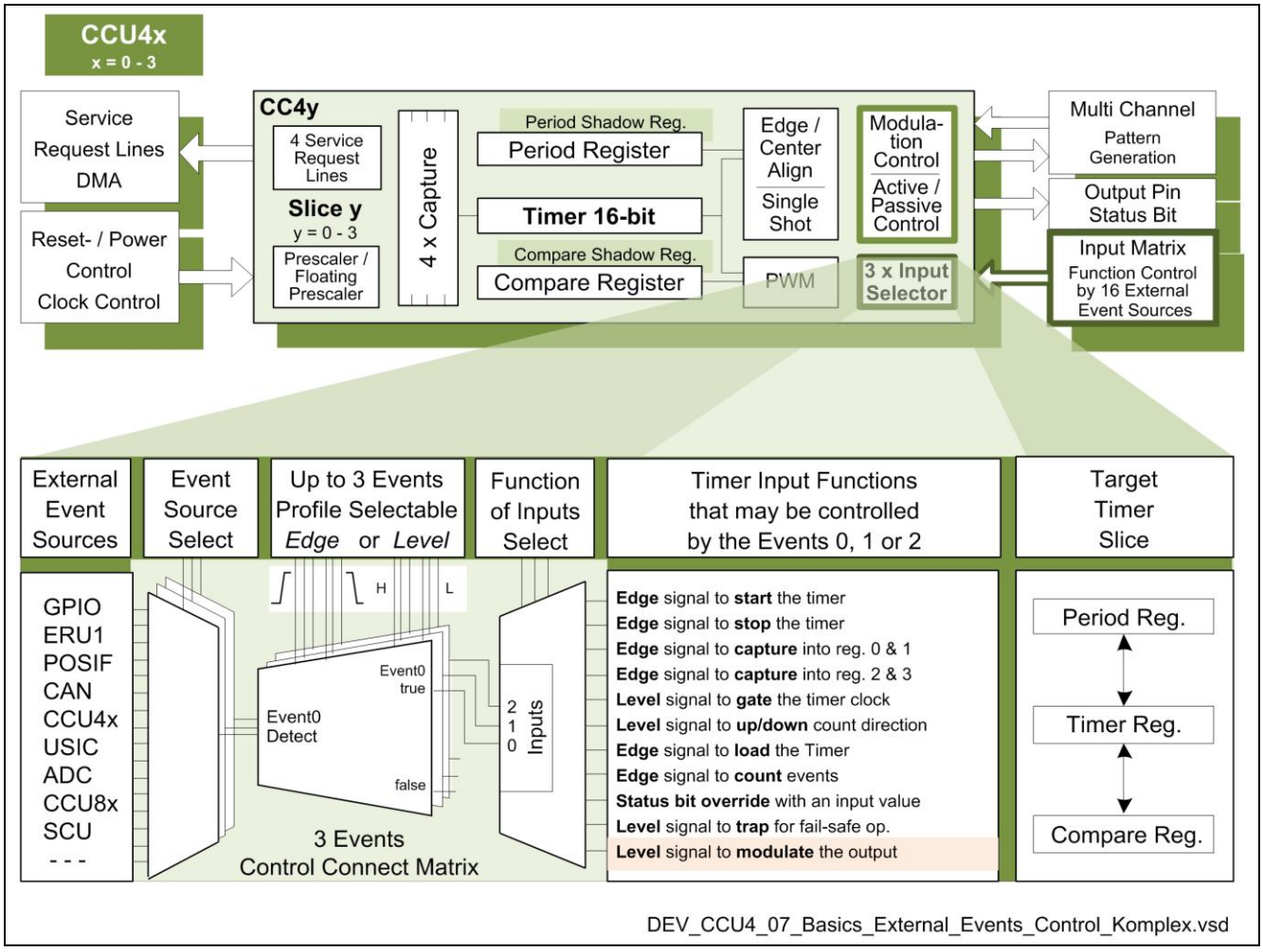

Figure 3 External Events Control of a Timer Slice Input Functions

3 Output Level Modulation Principle

A timer slice may have its status bit or output pin modulated by an *external event* signal. The modulation alternatives can be setup for either *Status Bit Clear* (*including* influence on the Output Pin) - or just *Output Gating* (i.e. *without* influence on the Status Bit). The Output PASSIVE/ACTIVE LEVEL rules are still due.

See Figure 4.

3.1 Output Pin PASSIVE / ACTIVE Level Control

The PASSIVE/ACTIVE state of a slice *internal* output **CCUxSTy** (i.e. status bit **CC4yST)** is controlled by the compare level and the External Modulation Mode. Wether the *external* output pin state **CCU4xOUTy** (e.g. the PWM) should be *Passive Low / Active High* or vice versa, is controlled by the **CC4yPSL** *Passive/Active* bit **PSL**.

3.2 Synchronized or Unsynchronized Output Level Modulation Schemes

By “synchronized” should be understood that the output pin signal keeps its pulse width until it returns into passive state (i.e. there is no shortening of any active pulse length due to the External Modulation signal) So the entering into inactive state can be synchronized with the PWM period instead of the External Modulation period.

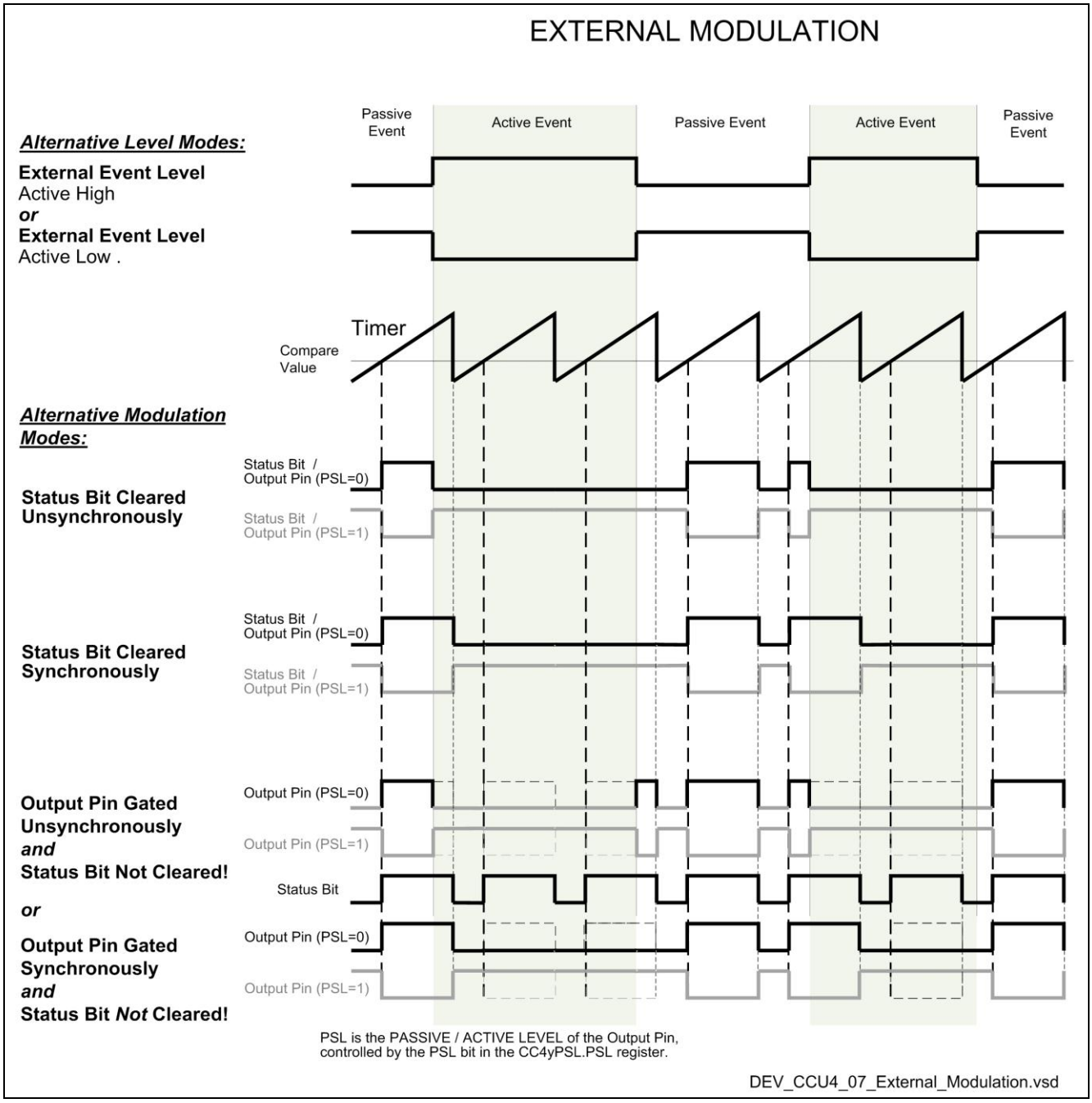

Figure 4 External Modulation by Events Control

4 Getting Started with CCU4 and External Modulation

4.1 Ultimate Initialization Sequence

Before start and execution of a timer slice SW first time, the CAPCOM4 must have been initialized appropriately according to a specific **CAPCOM4 Initialization Sequence:** 1. *Apply Reset*, 2. *Release Reset*, 3. *Enable Clock*, 4. *Enable Prescaler Block*, 5. *Configure Global Control*, 6. *Configure Slice(s) Functions*, *Interrupts* and *Start-up*.

4.1.1 Ultimate Start-Up Enable

In the last part of the ultimate CAPCOM4 **Initialization Sequence** the startup value(s) for a specific Compare Channel Status of the Timer Slice(s) may be configured by the respective **GCSS.SyTS** bit. After that the default *IDLE mode has to be removed* from the Timer Slice(s) in register **GIDLC** and Start or Global Start can be done!

All these topics are covered in detail by the Reference Manual: <<< Link to 23.6.1 Initialization Sequence >>>

4.2 External Events Control Setup Registers

The *Input Selection* register **CC4yINS** maps *External-Event-Sources* and *Edge/Level Mode* conditions to the *Event[2:0] Input Lines*. In turn the *Connection Matrix Control* register **CC4yCMC** maps the three *Event[2:0] Input Lines* to any of the 11 *Input Functions*. The *Timer Control* register **CC4yTC** enables different *Mode Alternatives*.

4.2.1 Using the External Modulation Control Register Bitfields

1. **CC4yCMC.**MOS — Input Function Selection and Event Number x=0-2 Input Line Selection bitfield
2. **CC4yINS.**<Event-*x* bitfields> — Event-x Source EVxIS (**CC4yINS**[P:A]) and Level Mode EVxLM bitfields
3. **CC4yTC.**EMT — Timer Control bit for Status Bit Clear or Output Gating Only
4. **CC4yTC.**EMS — Timer Control bit for Unsynchronized or Synchronized modulation

Note: When using the index 'x' in event nomenclature, it should be understood as 'Actual Event[2:0] Number '.

Note: When using the index 'x' in CCU4x nomenclature, it should be understood as 'Actual CCU4 Unit Number'.

Note: The Ultimate Event Number 'x' for the MOS Input Function is always x == <MOS>-1 (when <MOS> != 0).

Note: By "Synchronization" should be understood that the Modulated Signal keeps its pulse width when active (i.e. there is no shortening or cut of any active pulses by the Modulation Signal edges).

4.2.2 Pseudo Code for the External Modulation Setup

```
// This is an independent 32-bit based Pseudo Code, regarding that there are no
connections to a certain CAPCOM4 Unit (CCU4x) nor specific Variable Declarations.
// step1
// Make a MASK OPERATION first for bitfield focusing – if not first time – else:
CC4yCMC |= MOS_FUNCTION_AND_EVENT_NUMBER_BITFIELD //Initialize External Modulation
// step 2
CC4yINS &= MOS_SOURCE_AND_EVENT_MODE_BITFIELDS_MASK; //Focus on Source1 events
CC4yINS |= MOS_SOURCE_AND_EVENT_MODE_BITFIELDS_PATTERN;  //Paste setup pattern
// step 3
EMT = TC_STATUS_BIT_CLEAR_OR_OUTPUT_GATING_ONLY; // Set or Clear this bit
// step 4
EMS = TC_UNSYNCHRONOUS_OR_SYNCHRONOUS; // Set or Clear this bit

// Manipulation of the Output Pin PASSIVE/ACTIVE LEVEL control bit (PSL) if needed
// CC4yPSL = ACTUAL_PASSIVE_LEVEL // Use for LOW: 0x00000000 or HIGH: 0x00000001
// (There are no other bits but the PSL bit (CC4yPSL.PSL) in this register!)
```

4.3 Setting Up External Modulation (Illustration)

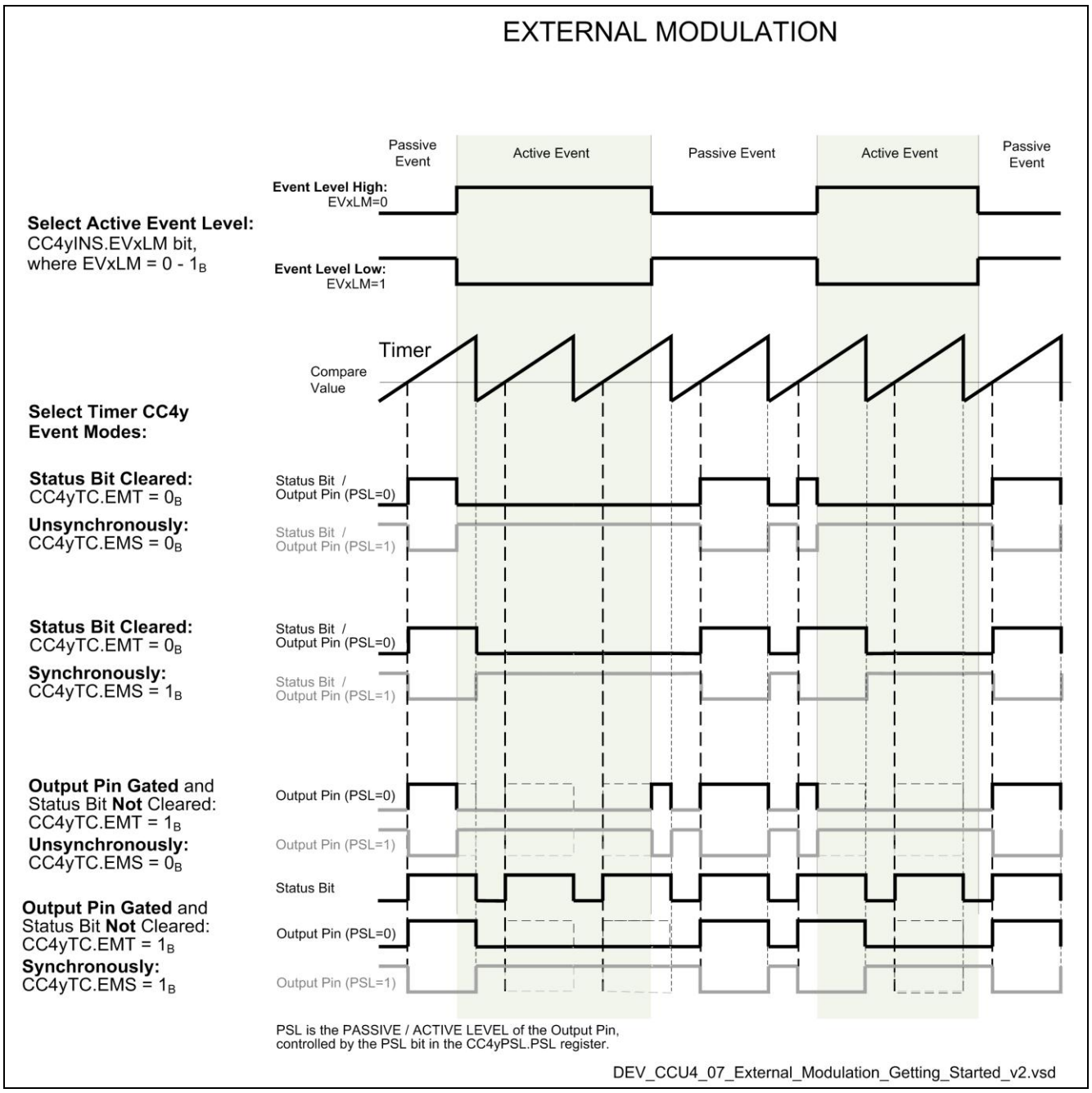

Figure 5 Setting Up External Modulation Event Control Source and Operation Modes

5 Example Application for CCU4 and External Modulation

5.1 Application External Modulation with Current Limitation by Output State Override

See Figure 6.

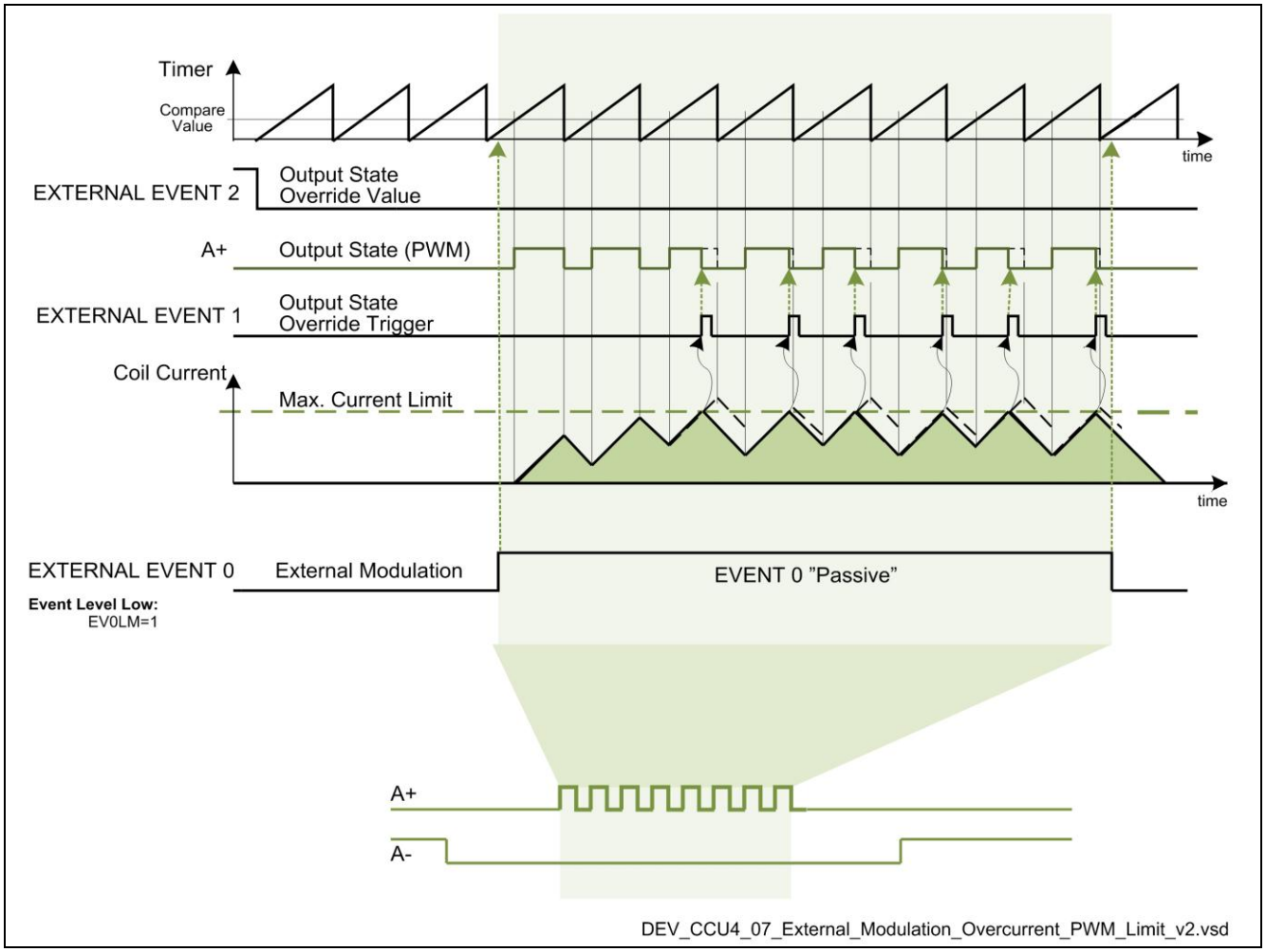

Figure 6 Application External Modulation with Current Limitation by Output State Override

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