XMC MCU

dabo Corporation

Infineon

Agenda

- Key XMC1000 Features
- Lighting Power Supply Topologies
- PFC and QR with XMC1000
- CCM Buck with XMC1000

Digital Control Benefits – Benefits of Digital Control

Flexibility

- Adjustable voltage reference
- Adjustable tuning parameter
- Non-linear control methods
- Reusable in next platform/projects

Linearity

- Controller is not sensitive to temperature, aging, drifting
- Linear softstart with lesser components

Security

- Source code encryption preventing piracy

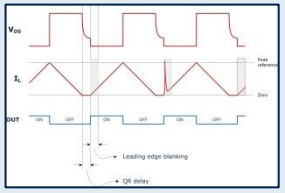
Communication

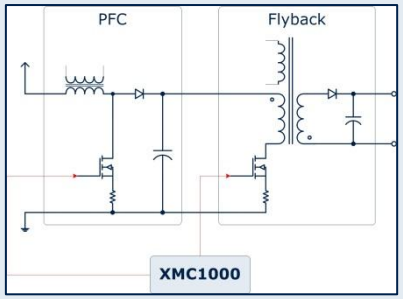
- Housekeeping: diagnostics & reporting
- Programmable: define maximum power, output voltage
- Error/Fault handling capability

LED Lighting with XMC1000 Power Conversion

Several ACDC topologies supported

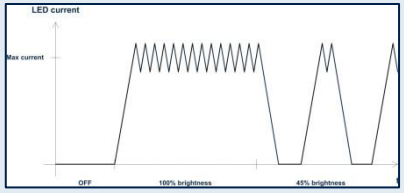
- Single-stage flyback
- Boost PFC + QR Flyback
- Boost PFC + LLC HB

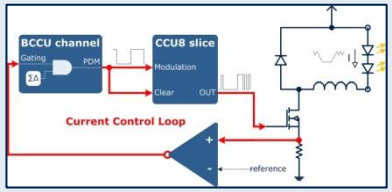


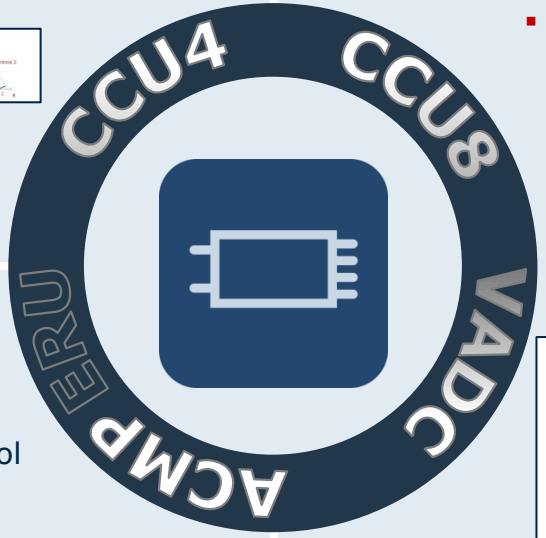


DCDC Buck

- Ultra-fast current control loop
- Up to 3.5MHz switching frequency
- Modulation dimmed peak-current control
- No CPU load

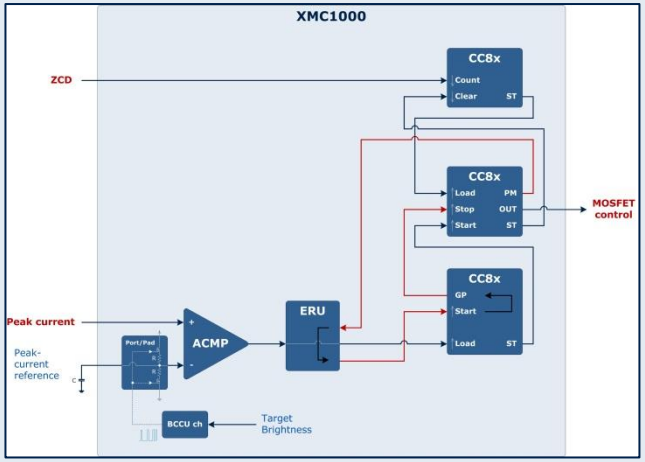






Tightly interconnected peripherals support various digital power conversion techniques

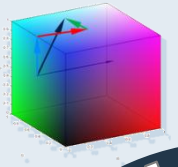
- PFC: CCM/CrCM/DCM, quasi resonance
- Synchronous buck, half bridge
- **Generic flexible timer structure**
  - Zero crossing detection
  - Peak current control
  - Constant on-time control
  - Leading-edge blanking
  - Valley switching

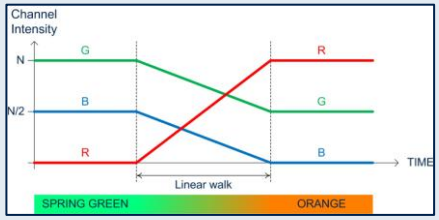


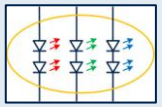
LED Lighting with XMC1000
Dimming and Color Control

Automatic smooth color change

- Straight transition in orthogonal color space (e.g. RGB)
- Automatic timed transitions
- No CPU Load
- Independent of lamp brightness

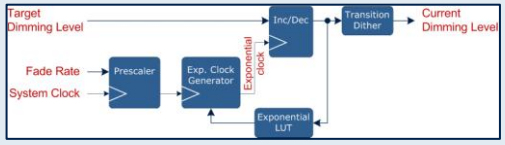


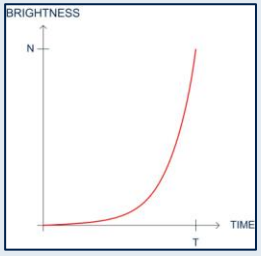




Automatic exponential dimming

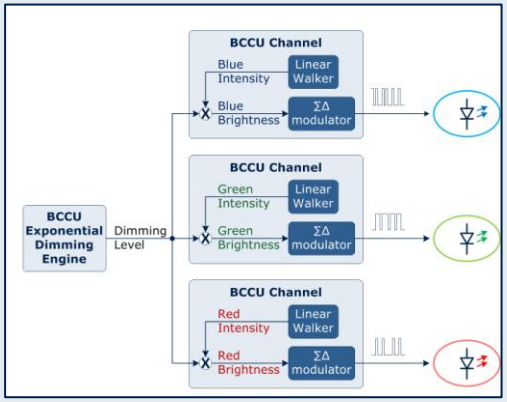
- Eye-friendly dimming
- Changes in brightness appear natural
- Dithered piece-wise exponential curve
- Automatic timed transitions
- No CPU load
- Lamp color remains unaffected

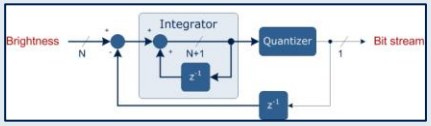


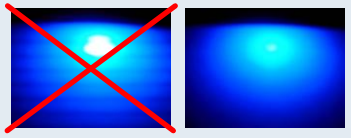


Dedicated Brightness and Color Control Unit (BCCU)

- Designed to automatically control multi-channel LED lights
- Automatic and configurable high frequency brightness control using pulse-density modulation (PDM) enables **flicker-free dimming**



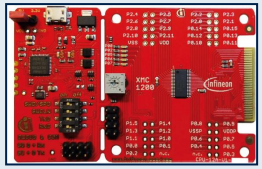




LED Lighting with XMC1000 Connectivity

DALI and DMX512 demo stacks available

- Capture-Compare Unit for easy Manchester decoding
- Flexible UART interface with slot counting and break detection
- EEPROM emulation
- DAVE™ Apps
- Evaluation kit



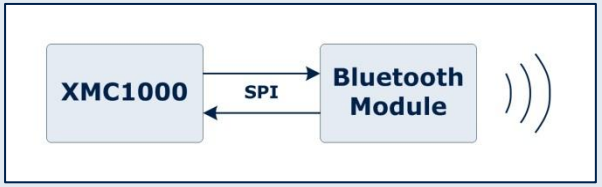
Easy-to-program standard core for 3rd party connectivity stacks

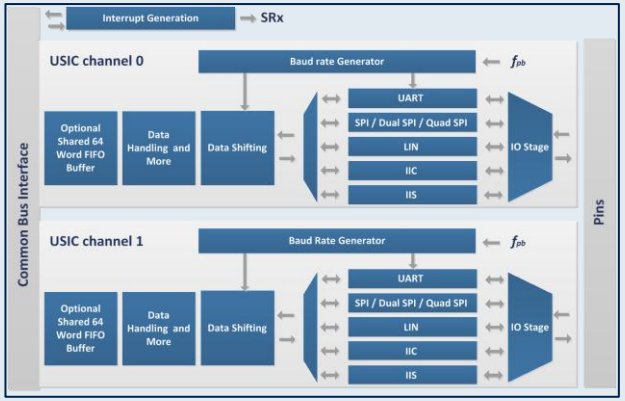
- DALI, KNX, RDM
- Bluetooth, ZigBee, 6LoWPAN
- 16KB RAM, up to 200KB Flash!

RDM KNX DALI Bluetooth ZigBee

General purpose interfaces to external communication ICs

- Universal serial interface module with two independent channels and 64-word FIFO buffer (USIC)
  - UART
  - SPI
  - I²C





LED Lighting with XMC1000
DAVE™ – Free of charge Eclipse based IDE

XMC Lib
CMSIS / MISRA 2004-compliant low level driver library for peripherals (APIs)

DAVE™
Free Eclipse-based integrated development environment (IDE) including GNU C-compiler, debugger and code generation plug-in

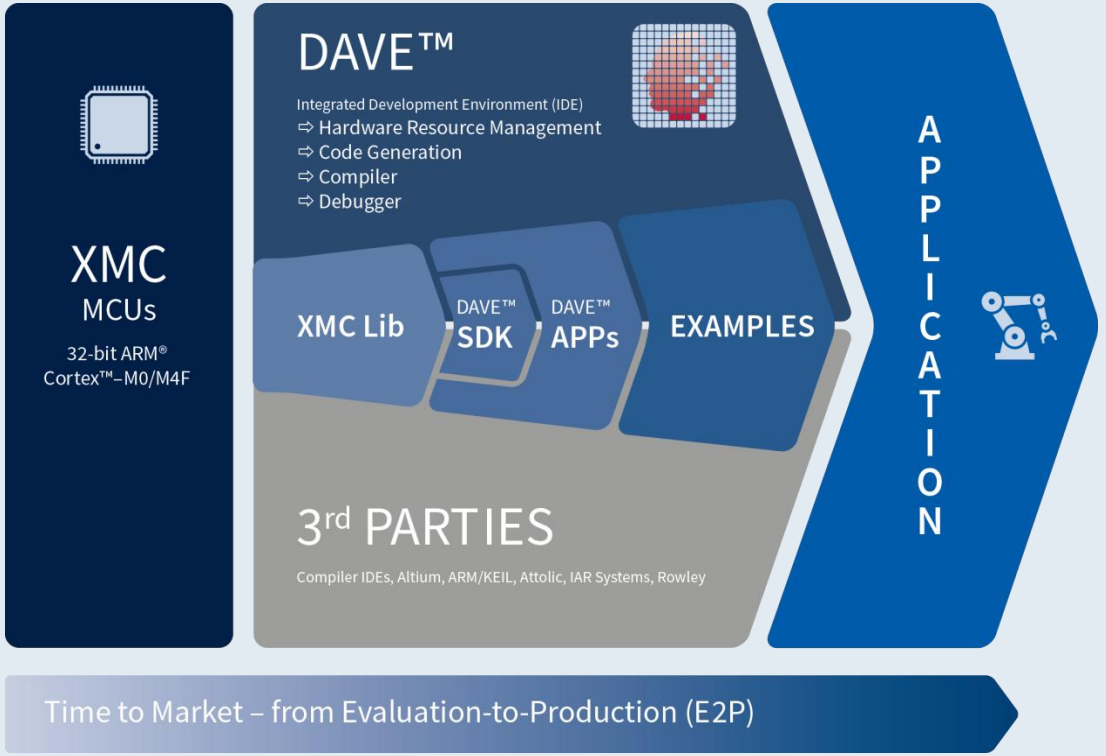
DAVE™ APPs
GUI-configurable application-oriented software components using XMC Lib; arranged in a library (APIs)

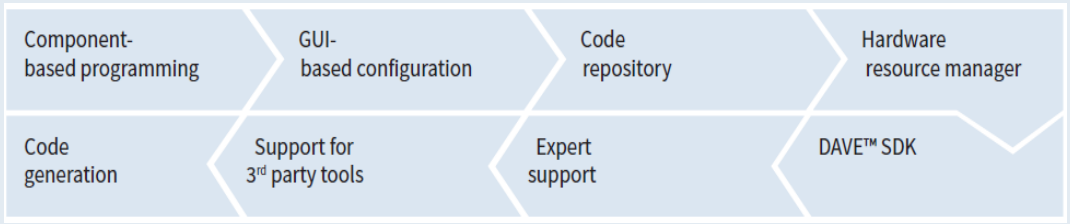
DAVE™ SDK
Software development kit to modify, enhance, and develop new DAVE™ APPs

EXAMPLES
XMC Lib and DAVE™ APPs composed to create applications

3rd PARTIES
XMC Lib and DAVE™ APPs are tested with GCC, ARM® and TASKING compilers; released for Altium, Atollic, ARM/KEIL, DAVE™, IAR Systems, and Rowley compiler IDEs

www.infineon.com/dave





XMC Portfolio Line-up

ARM Cortex™ - M4 (with FPU)

- CPU Frequency up to 120MHz
- Timers CCU4, CCU8, POSIF
- USB / Up to 3x CAN / Up to 6x Serial Channels
- **High Resolution PWM**
- **Interconnect Matrix**
- 2x 12Bit ADC / 2x DAC
- **TA = -40C to 125C**

XMC4100/4200
Up to 256kB Flash / 40kB RAM
QFN48, TQFP64

XMC4400
Up to 512kB Flash / 80kB RAM
TQFP64 / TQFP100
+ **120MHz Core**
+ **Ethernet**
+ **ΔΣ Demodulator**

XMC4500
Up to 1MB Flash / 160kB RAM
TQFP100 / TQFP144 / BGA144
+ **EBU**
+ **SD Card**

XMC4700
Up to 2MB Flash / 352kB RAM
TQFP100 / TQFP144 / **BGA196**
+ **144MHz Core**
+ **6ch CAN FD**

XMC4800
Up to 2MB Flash / 352kB RAM
TQFP100 / TQFP144 / **BGA196**
+ **Industrial Connectivity**

ARM Cortex™ - M0

- Core 32MHz / Peripherals up to 64MHz
- Capture Compare Units (CCU4)
- 2x Serial Channels
- **12Bit ADC**
- **Interconnect Matrix**
- **Secure Bootloader**
- **1,8V – 5,5V Supply Voltage Range**
- **TA = -40C to 105C**

XMC1100
Up to 64kB Flash
TSOP16/38, VQFN24/40

XMC1200
Up to 200kB Flash
TSOP16/28/38, VQFN24/40
+ **9ch LED Control (BCCU)**
+ **3x Analog Comparators**

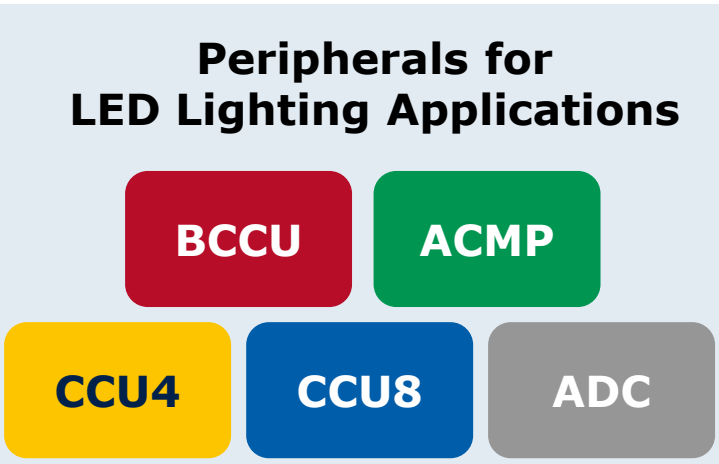
XMC1300
Up to 200kB Flash
TSOP16/28/38, VQFN24/40
+ **Math Co-Processor**
+ **CCU8 PWM Timer**
+ **Hall & Encoder I/F**

XMC1400
Up to 200kB Flash
VQFN40/48/64, TQFP64
+ **48MHz Core / 96MHz Peripherals**
+ **2x CAN FD**
+ **2x CCU8 / Up to 4 Serial Channels**

High Volume Production

Sampling 2H 2015

Key Microcontroller Features



Highlights

BCCU dedicated for modulation dimming and color mixing enables users to develop high quality lighting solutions with little user code.

Tightly interconnected analog and PWM peripherals enable fast SMPS control for high efficiency.

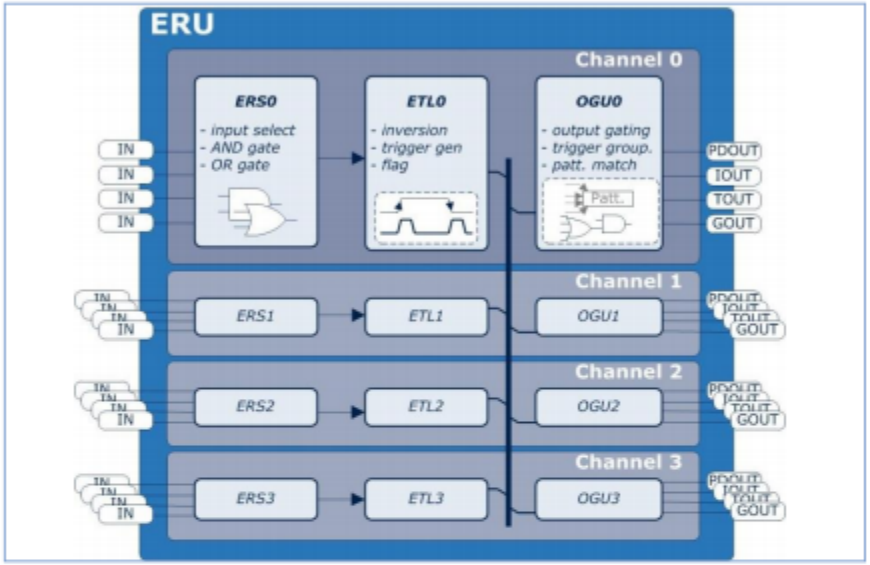
Key Feature

- Dedicated Brightness and Color Control Unit
- Interconnected analog and PWM peripherals
- Internal comparator reference generation with external capacitor

Customer Benefits

- Automatic pulse-density modulated dimming and color control
- Control fast SMPSs with high power density and high dimmability
- Simple DAC solution without output pin required

ERU
Event Request Unit



Highlights

The ERU module can be used to expand the P-to-P connections of the device: ports-to-peripherals, peripherals-to-peripherals and ports-to-ports. It also offers configurable logic, that allows the generation of triggers, pattern detection and real-time signal monitoring.

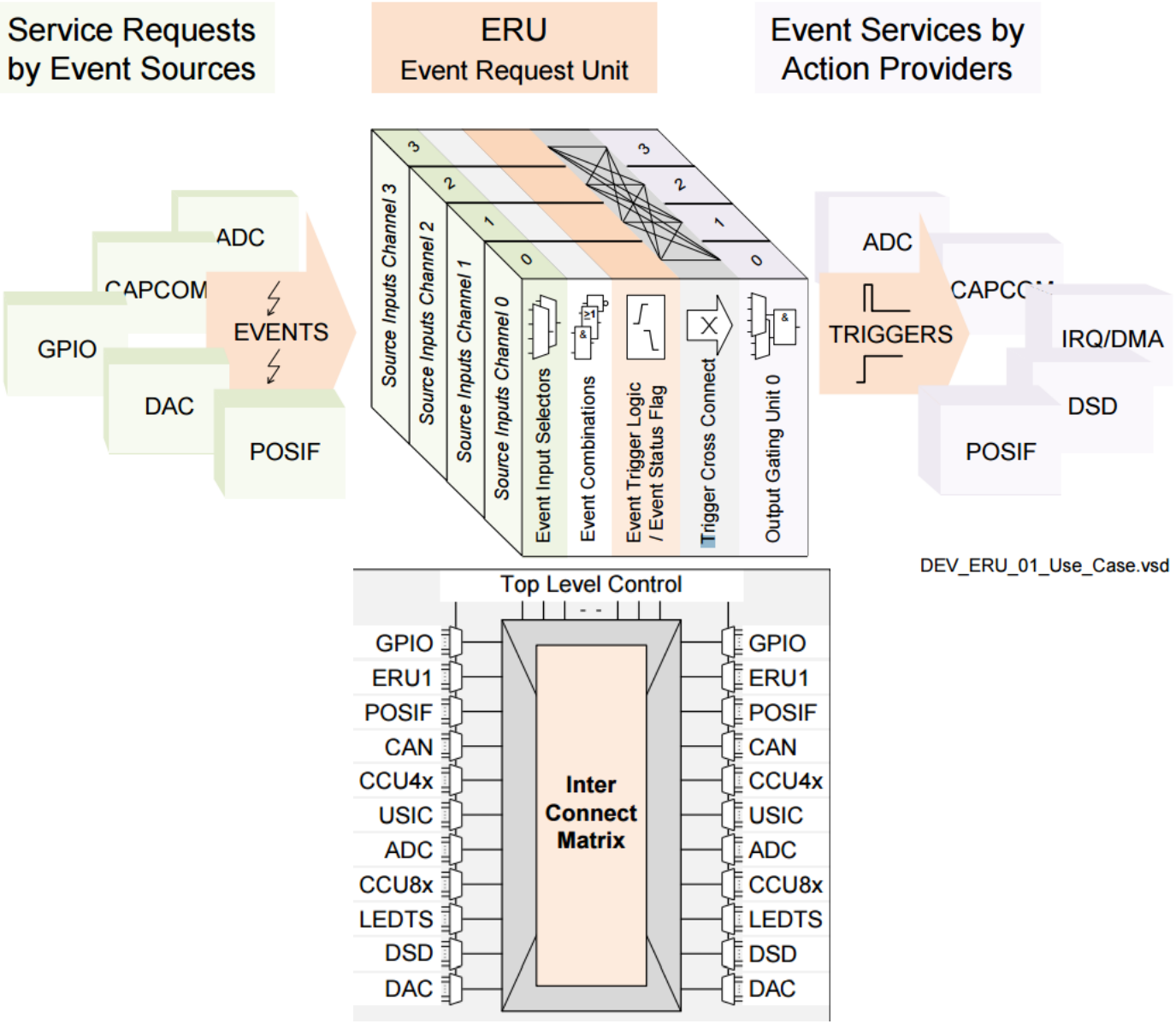
Key Feature

Connection flexibility
External Interrupt Generation
Configurable logic

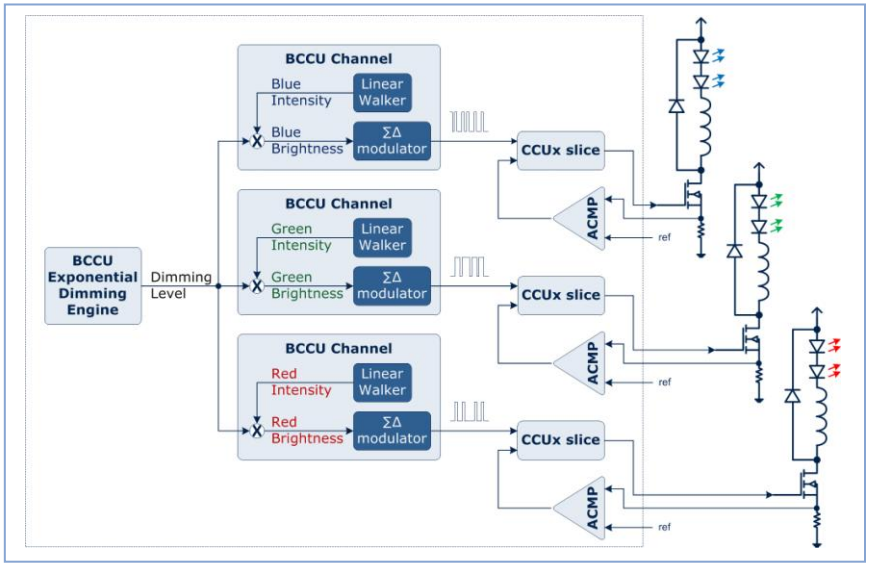
Customer Benefits

Connection expansion for small packages; Increased application case coverage for motor control, power conversion, etc; Peripheral/Port-to-Peripheral/Port;
Multiple and parallel interrupt generation from port pins; Conditioning of interrupts with internal signals;
Real-time conditioning of external signals; Logical functions between peripherals, e.g AND, OR;

ERU
Event Request Unit



Application Example
RGB Lamp Control with switched-mode current control



In Brief

Automatic smooth color and dimming control

Easy on the human eye

Flicker elimination and smoothened dimming steps

Low-cost high-quality multi-channel DCDC LED driver solution

Overview

BCCU provides color control with 12-bit precision. Color transitions can be immediate or gradual by a linear walk.

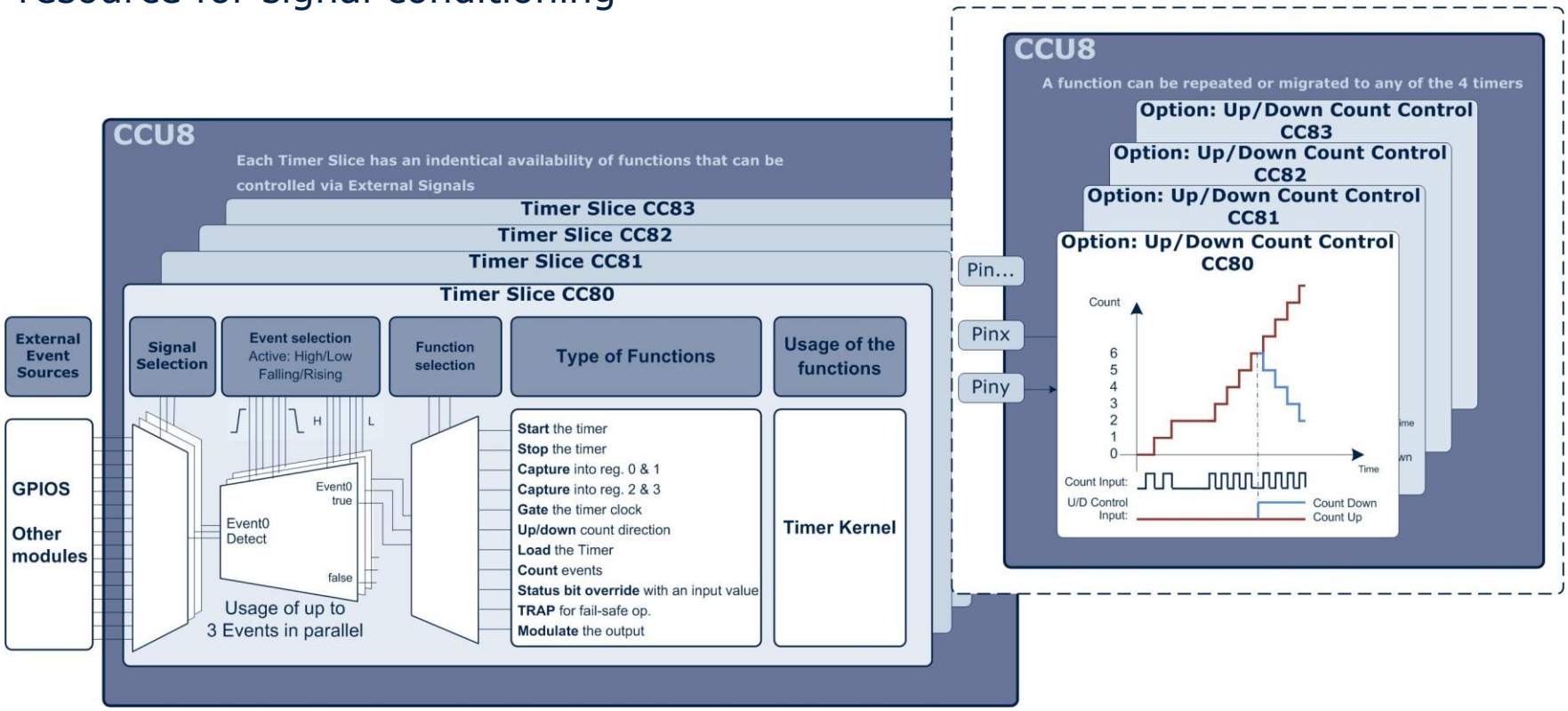
Lamp dimming level is separately controlled from lamp color, also with 12-bit precision. Dimming level can change exponentially over time to appear natural to the human eye.

Flickering due to low switching rate and visible steps due to slow dimming at low intensity levels can be automatically eliminated.

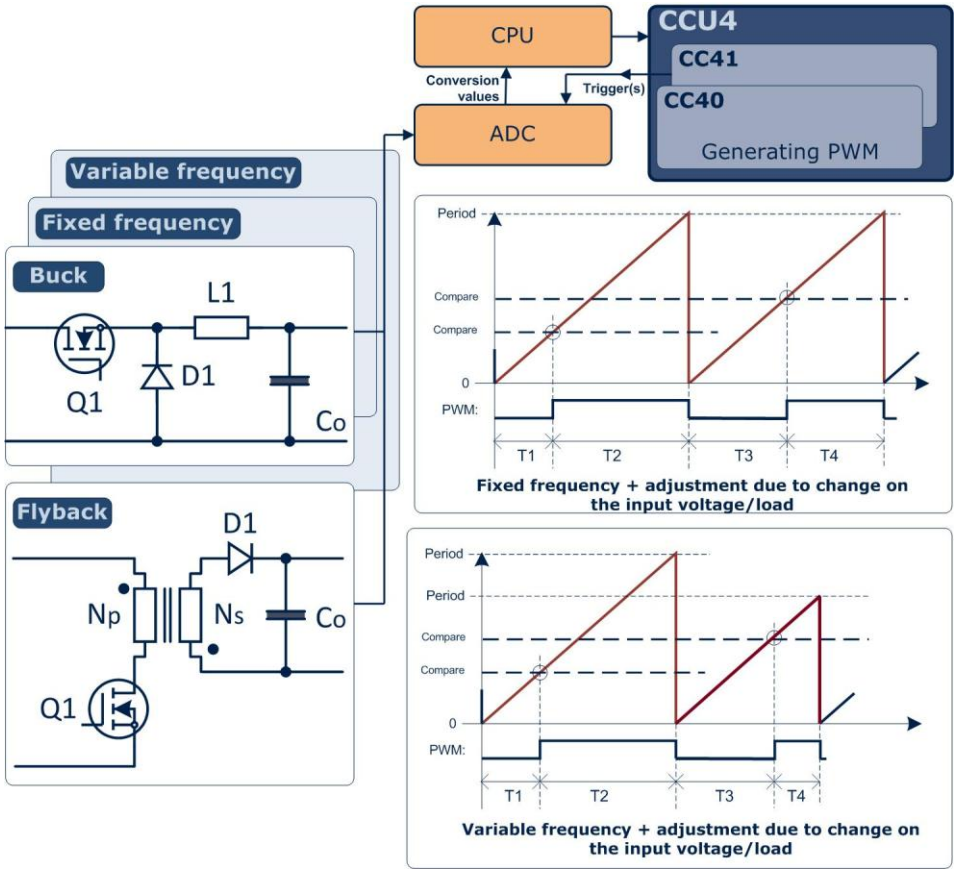
Fast current control possible by well-interconnected switching and analog peripherals.

Flexible PWM Unit
CCU4/8 – Modular Timer Approach

- Equal structure and same availability of features in each Timer Slice
- Functions controllable via external signals
- Portability of code not dependent on used Timer Slice
- 11 configurable external functions make each Timer Slice a very flexible HW resource for signal conditioning



Application Example
PWM for Power Conversion (1/2)



In Brief

Controlling different types of single phase power converter topologies

Overview

Inside the power conversion application domain, one has different type of topologies that may request different type of control methods.

With each CCU4 Timer Slice it is possible to implement all the needed requirements, such as: variable duty cycle, variable switching frequency and a combination of both.

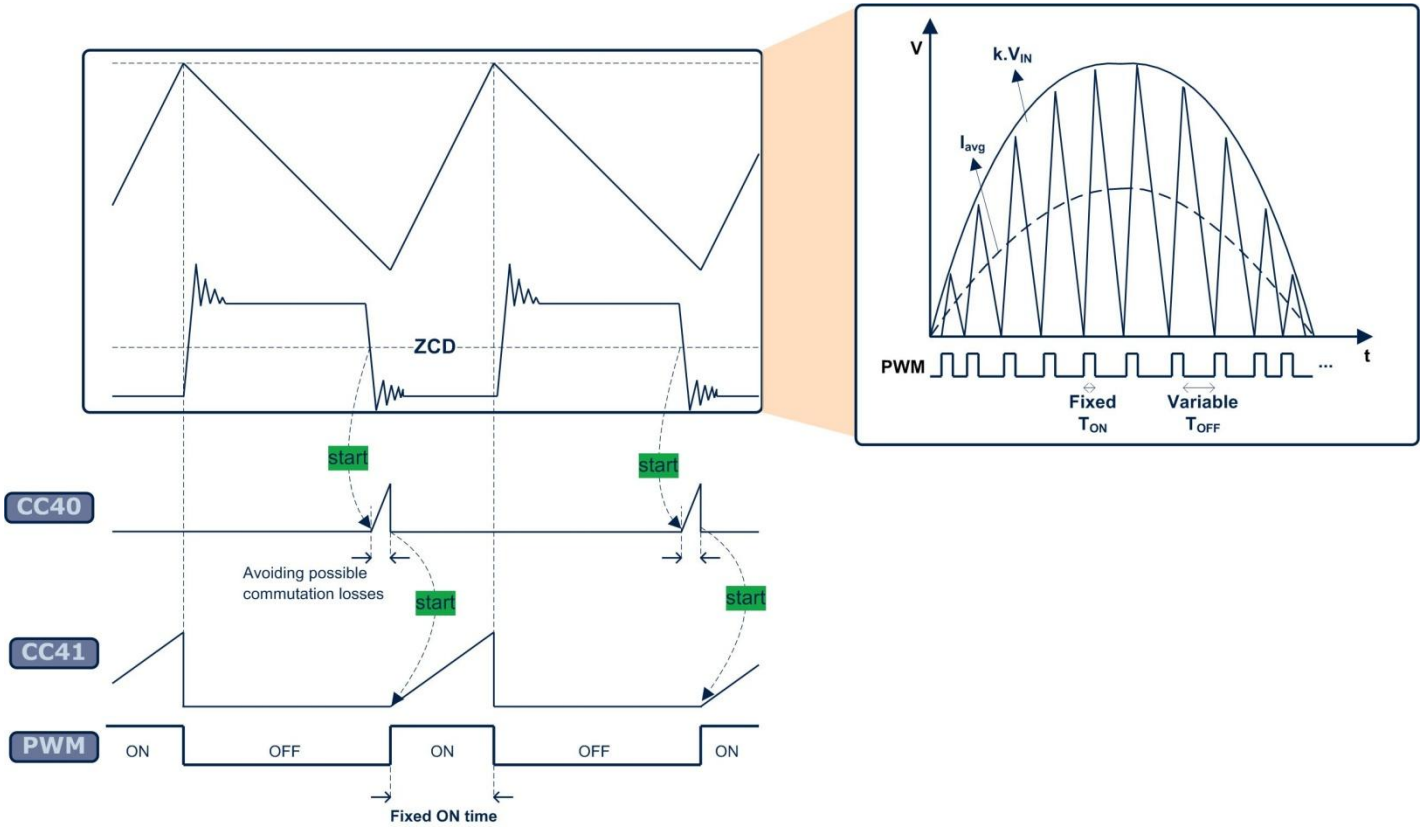
The flexible connections between the CCU4 and additional modules, e.g. ADC, will simplify the task of controlling and generation conversion triggers for each application.

Application Example
PWM for Power Conversion (2/2)

With the extra functions controllable by external signal, it is possible to implement easily a PFC stage.

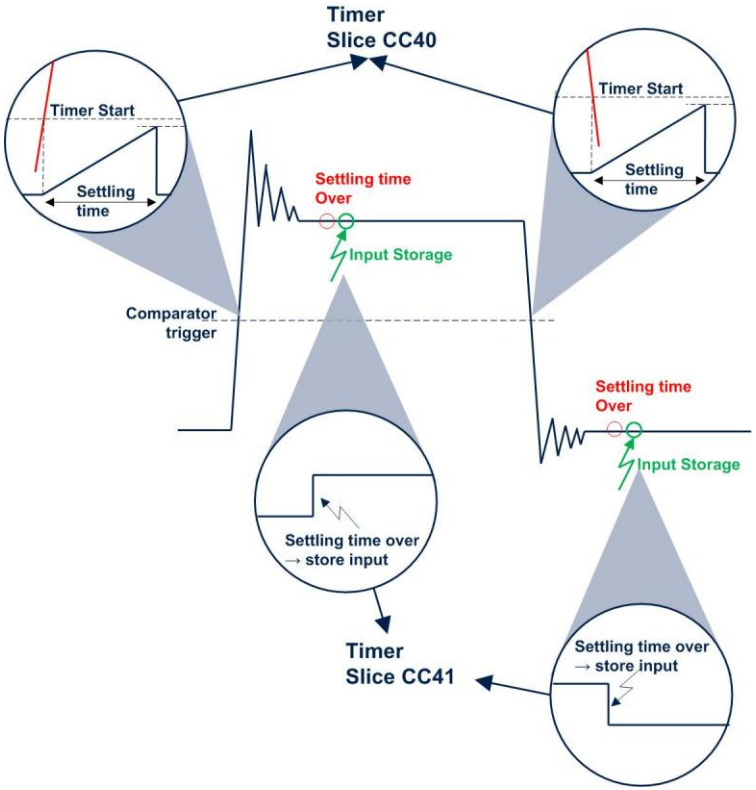
The CC40 slice is used for noise suppression.

The CC41 slice is used for PWM generation with fixed ON time.



Application Example PFC in Critical Conduction Mode: Detailed Timing Diagram

Application Example
Sampling Control with Noise Rejection (1/2)



In Brief

- Storage of an external signal level after noise suppression

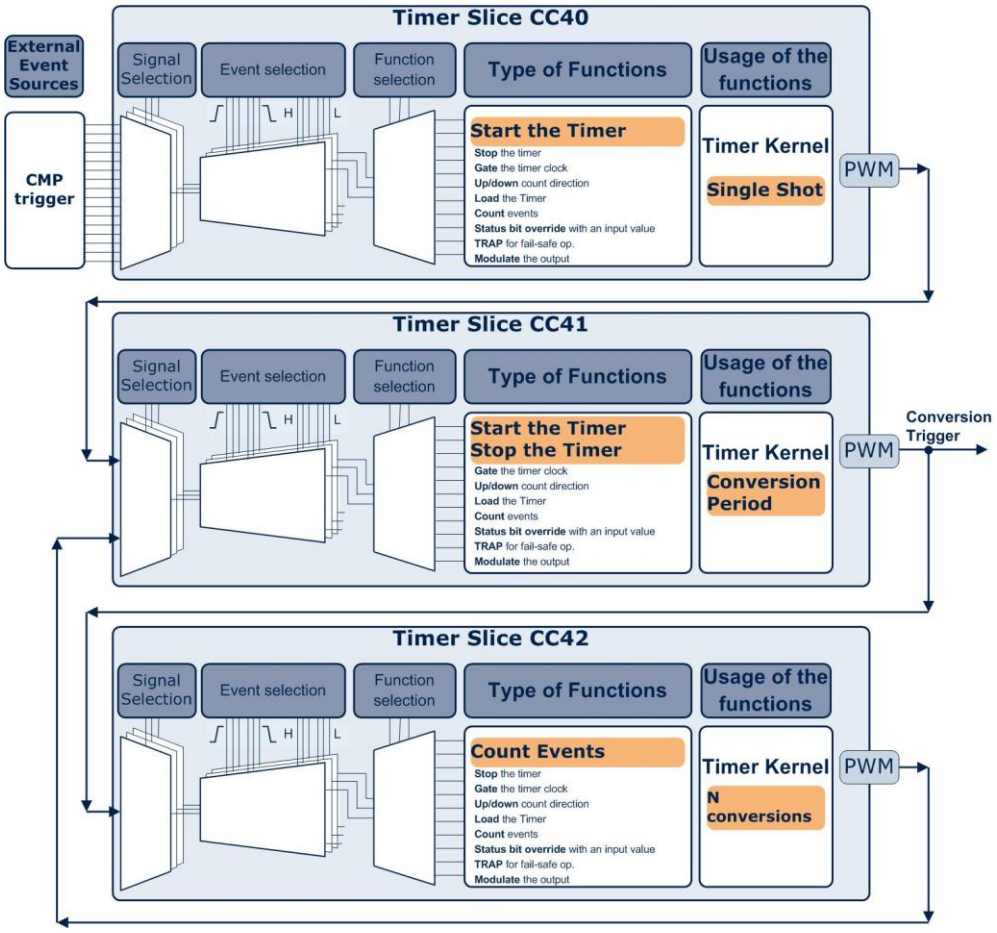
Overview

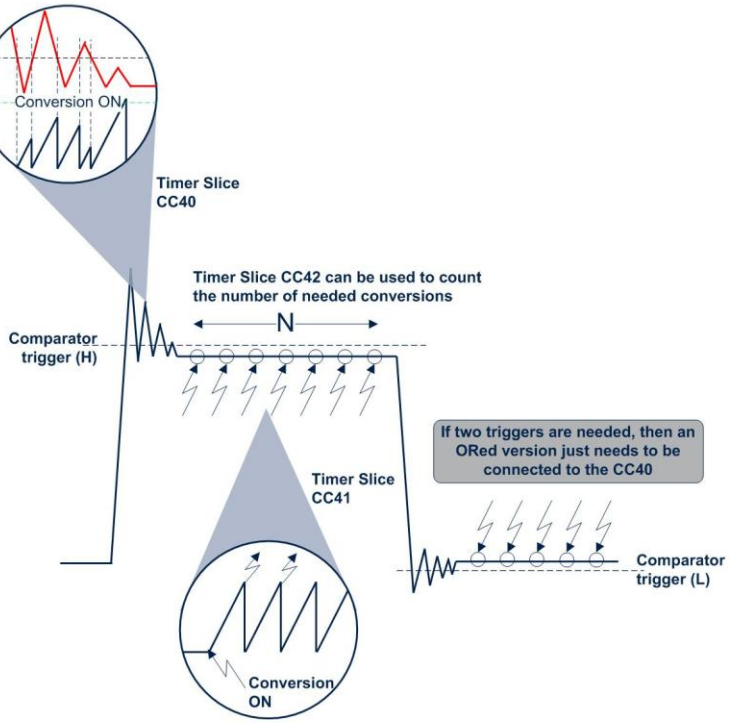
A lot of signal conditioning application cases involve not only noise rejection as also sampling control.

Noise rejection is normally needed when the sampled signal comes from a noisy environment. Sampling control can impose several requirements, e.g. ADC periodic triggers, controllable number of conversions, etc.

CCU4 modularity and huge set of external functions, provide a huge flexibility for this type of signal conditioning.

Application Example
Sampling Control with Noise Rejection (2/2)





Application Example Noise Rejection + ADC conversion: Block Diagram

Feedback Peripherals

- XMC offers a wide range of feedback peripherals:
  - 30ns Analog Comparators
  - ADC:
    - 12-bit resolution and 2 Msamples/second
    - Synchronous sampling and flexible sequencing
    - OVP/OCP through band detection and TRAP triggering to Timers
    - Fast Compare Mode allows 150ns-1 bit conversion. This can be used very efficiently as a comparator.
  - Out-of-Range Comparators (ORC)
  - More sophisticated comparators available in XMC4000 (CSG) with a DAC for slope generation

Agenda

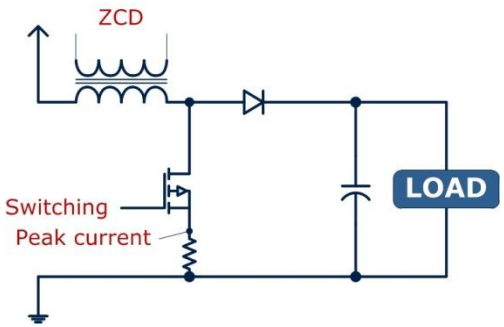
- Key XMC1000 Features
- Lighting Power Supply Topologies
- PFC and QR with XMC1000
- CCM Buck with XMC1000

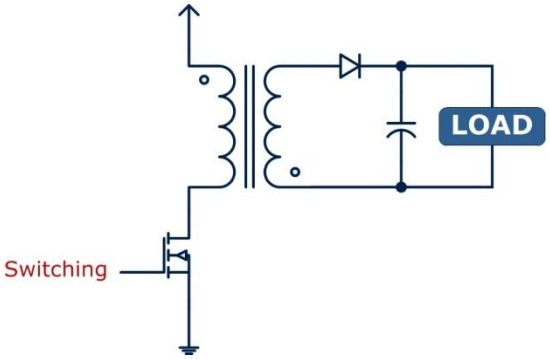
Common Building Blocks

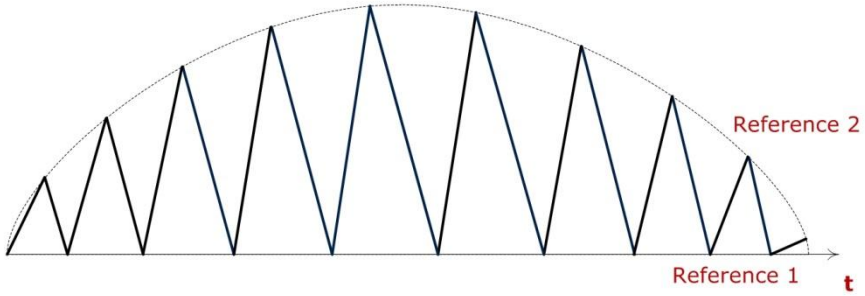
- Buck Converter
  - Continuous Conduction Mode (CCM)
    - Peak-current control with constant off-time
    - Hysteretic control
  - Critical Conduction Mode (CrCM) / Quasi Resonant (QR)
    - Constant on-time control with zero crossing detection
    - Peak-current control with zero crossing detection
- Boost Converter
  - Critical Conduction Mode (CrCM) / Quasi Resonant (QR)
    - Constant on-time control with zero crossing detection
    - Peak-current control with zero crossing detection
- Flyback Converter
  - Critical Conduction Mode (CrCM) / Quasi Resonant (QR)
    - Constant on-time control with zero crossing detection
    - Peak-current control with zero crossing detection
- Resonant Converter
  - LLC
  - FBPS

Power Factor Correction

- Boost topology
- Flyback topology
- Discontinuous or Critical Conduction Mode
  - ON-time control
    - Peak current detection
  - OFF-time control
    - Zero current detection
  - Detection blanking

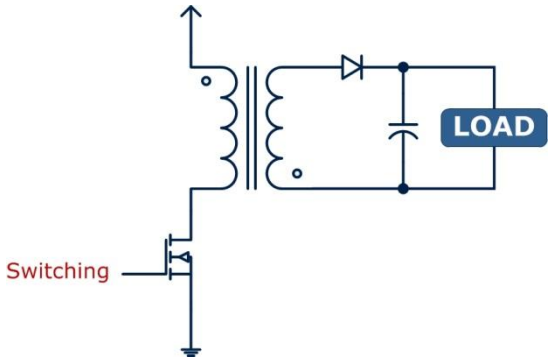


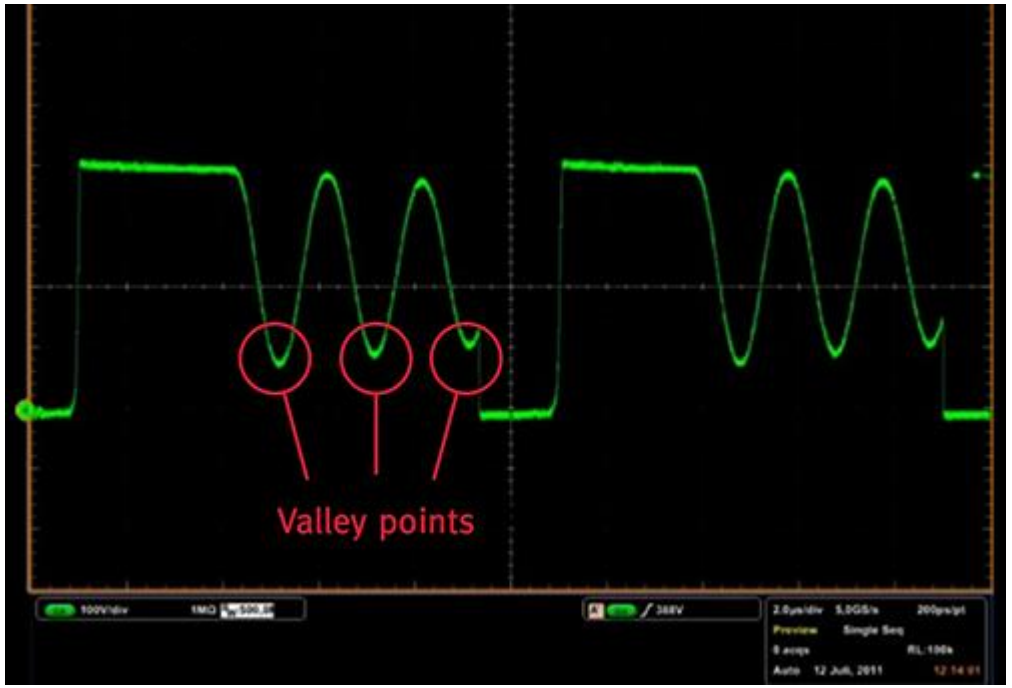




Quasi Resonance

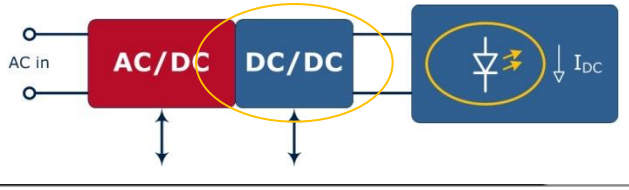
- ON-time control
  - Peak current detection
- OFF-time control
  - Zero current detection
  - Valley switching
- Detection blanking

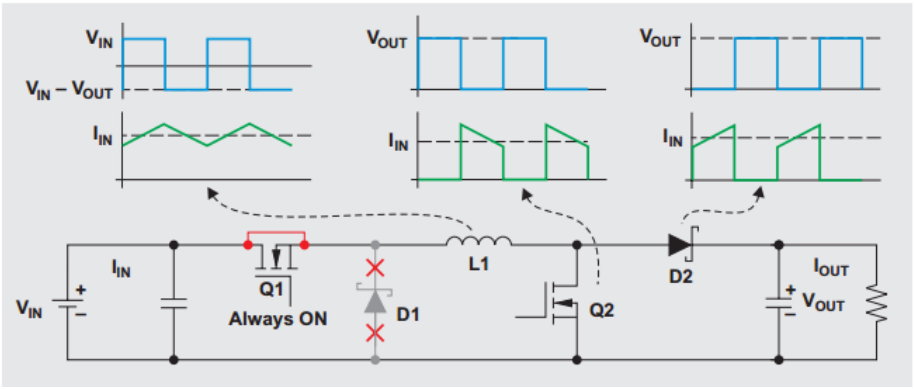


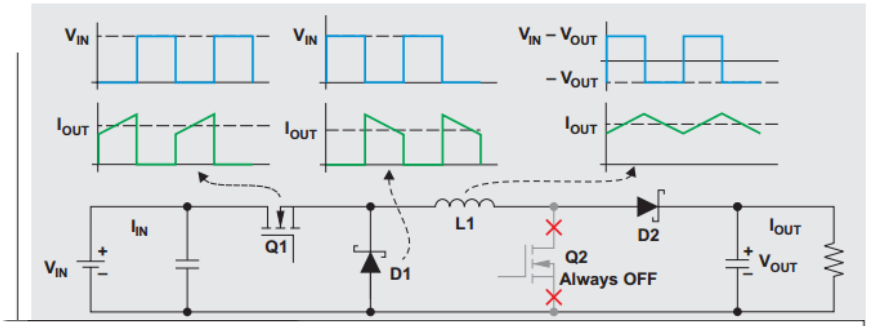


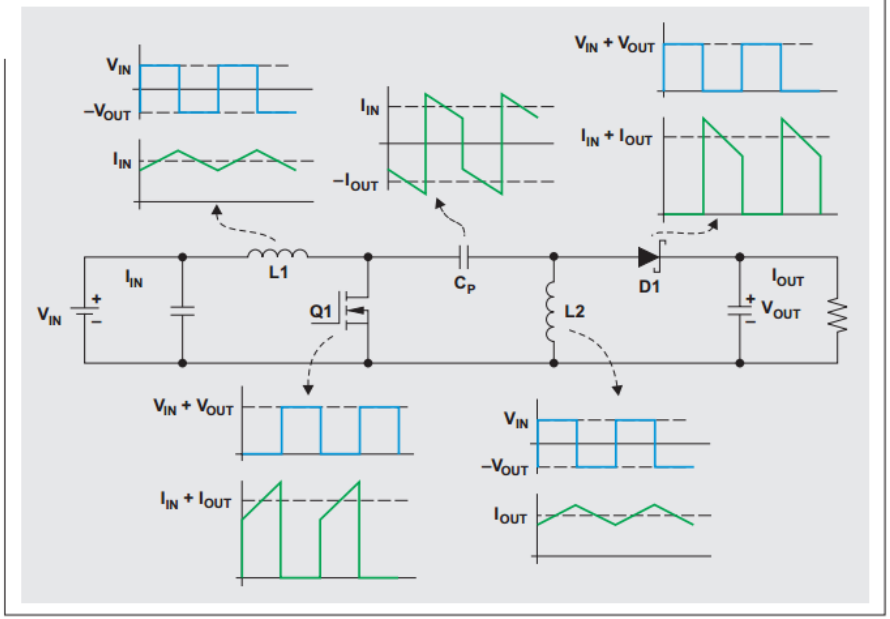
DC/DC

- Buck Converter
  Invertive Buck Converter
- Boost Converter
- Sepic





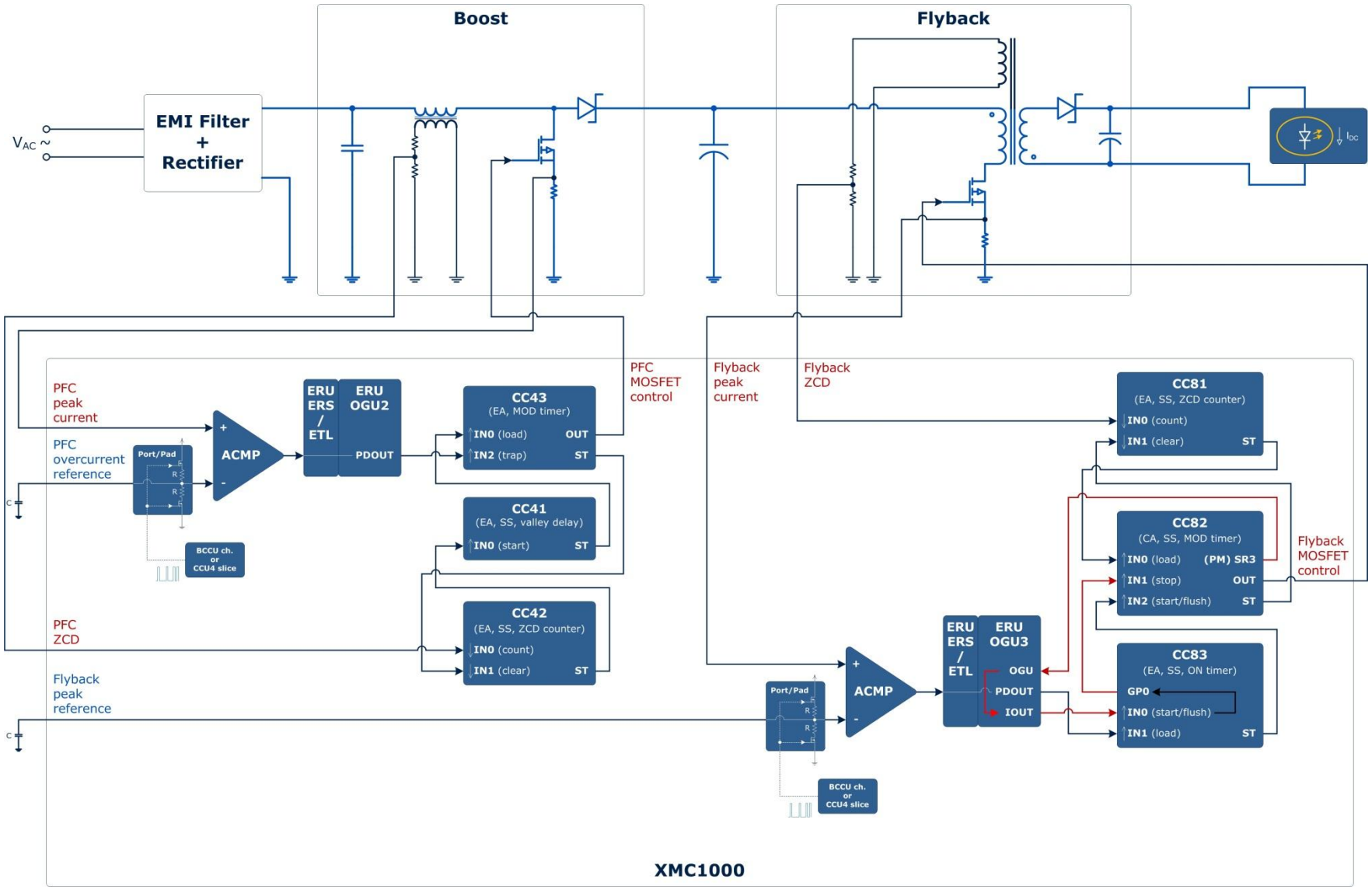




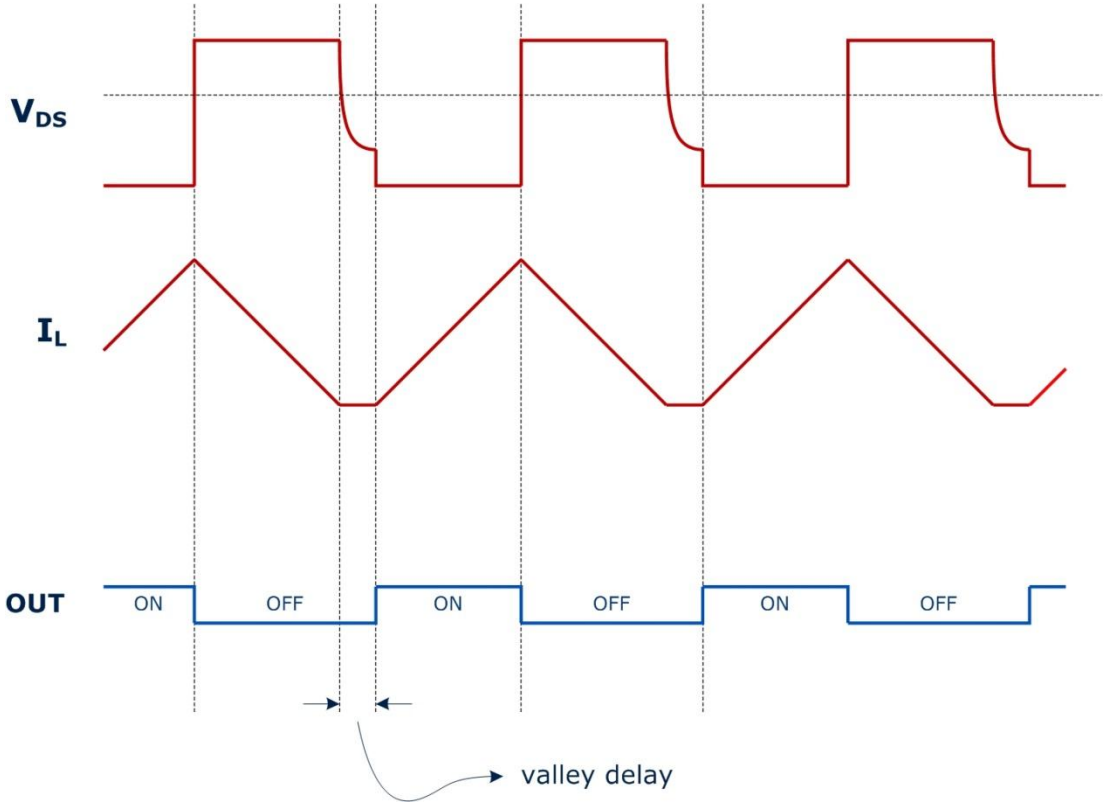
Agenda

- Key XMC1000 Features
- Lighting Power Supply Topologies
- **PFC and QR with XMC1000**
- CCM Buck with XMC1000

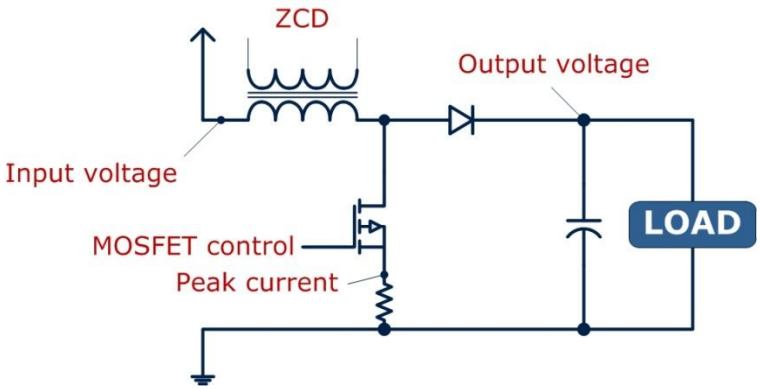
This is how complex it can get



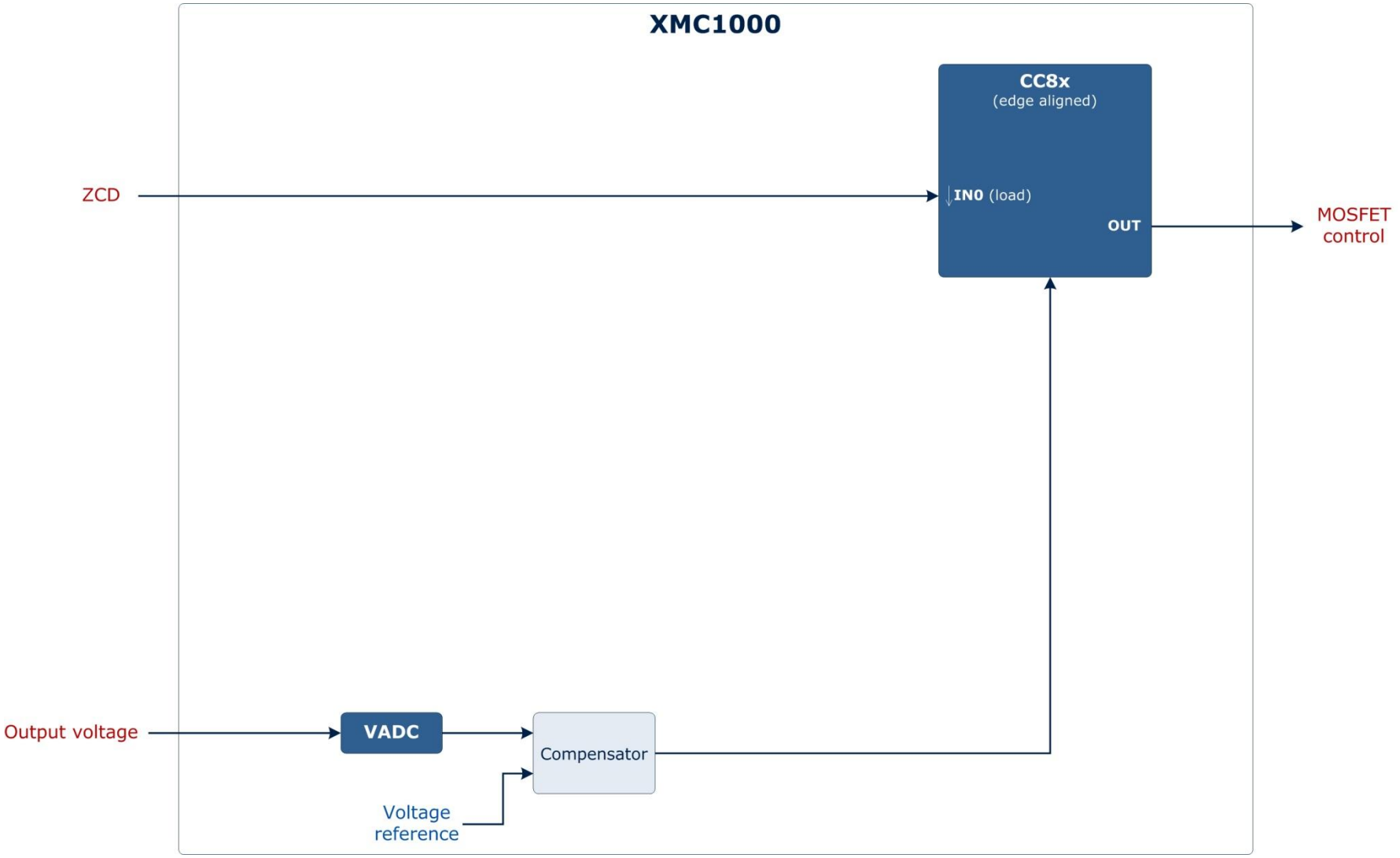
Simple PFC/QR Target Waveforms



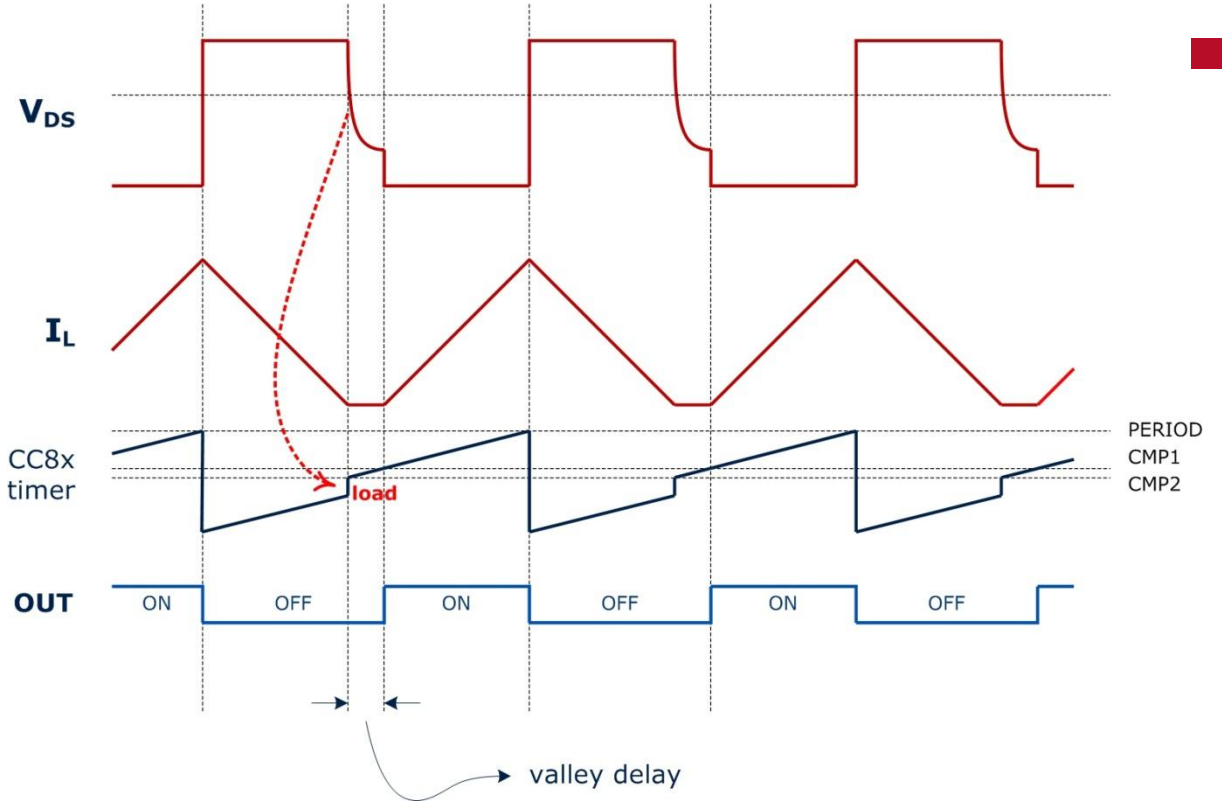
- Zero crossing detection
- Switching in first valley
- Constant on-time



Simple PFC/QR
Constant on-time control



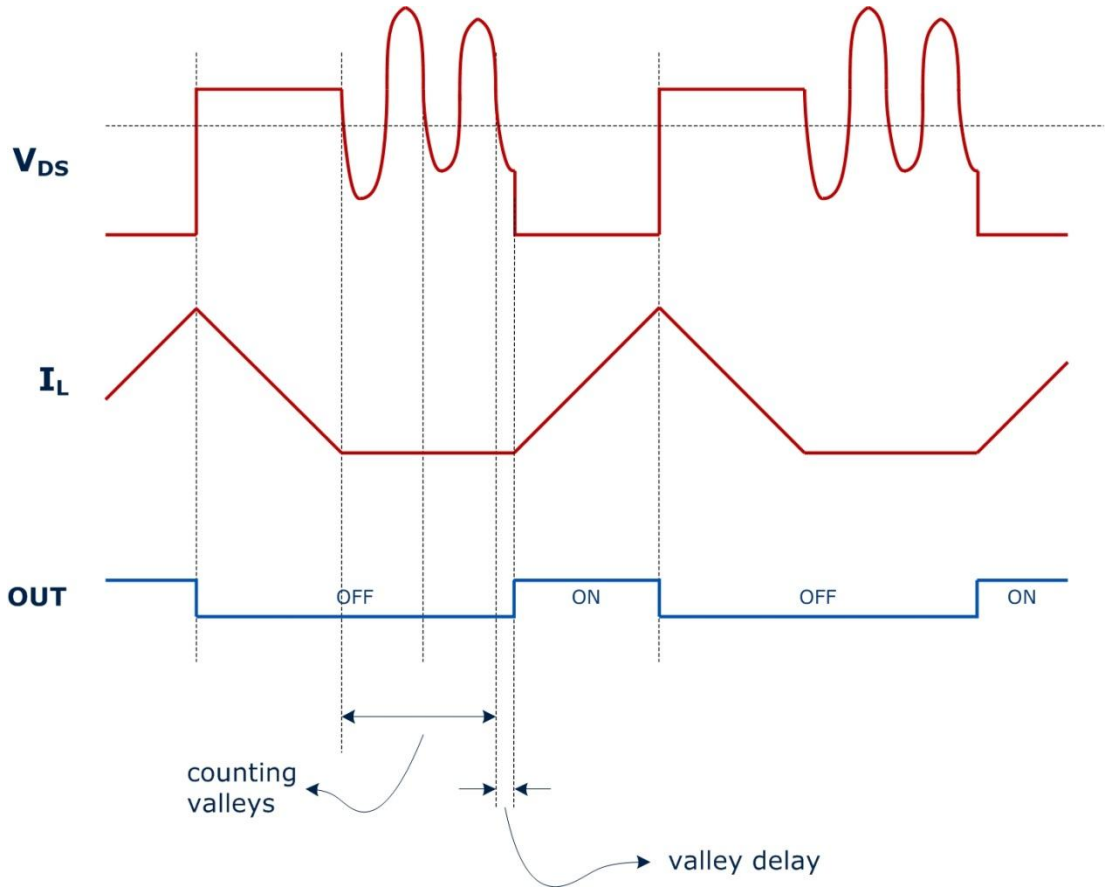
Simple PFC/QR
Signals and waveforms



- Delayed switching in first valley after zero crossing detection

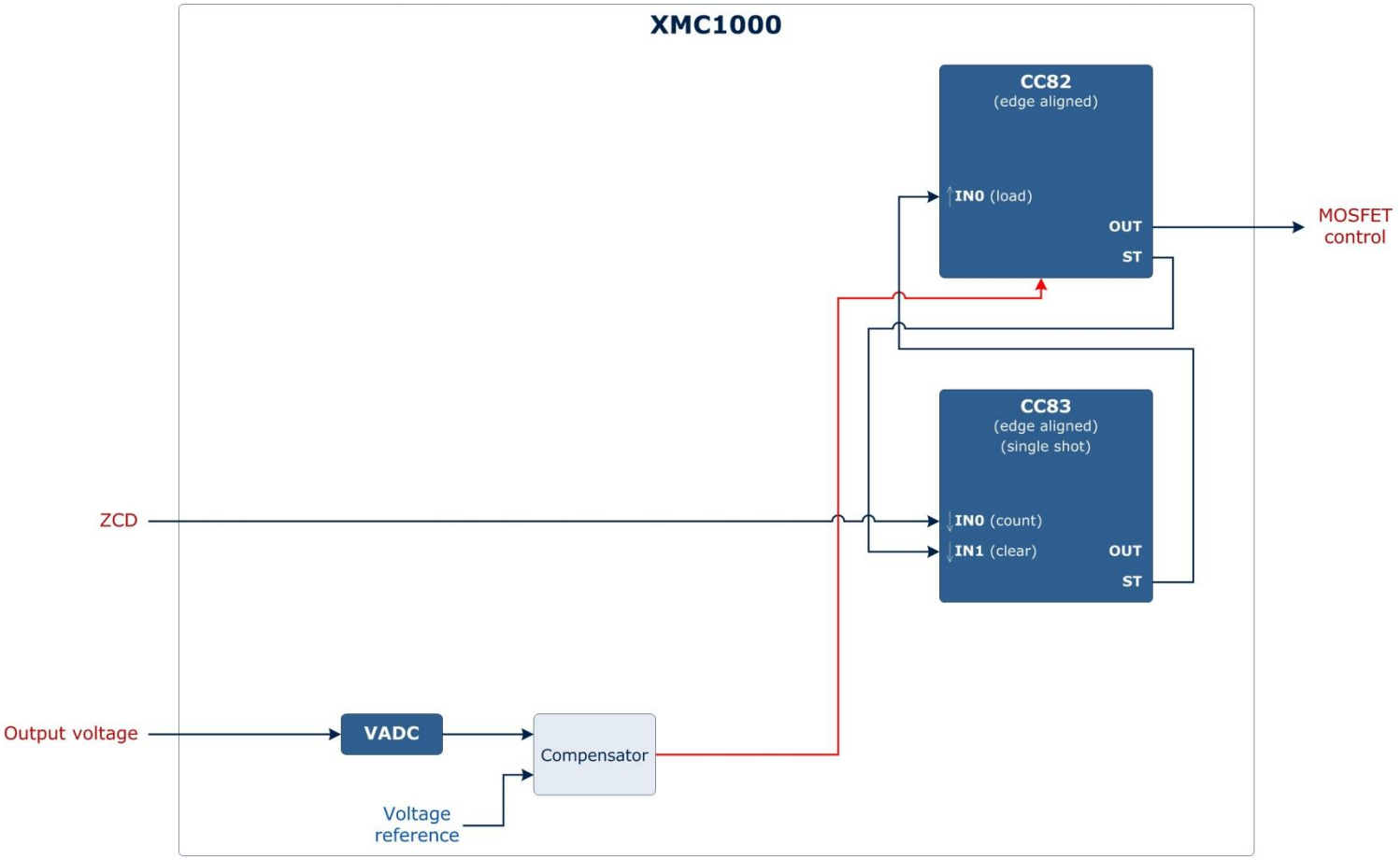
- On-time: PER-CMP1
- Valley delay: CMP1-CMP2
- Max off-time: CMP1

PFC/QR with frequency limit
Target waveforms

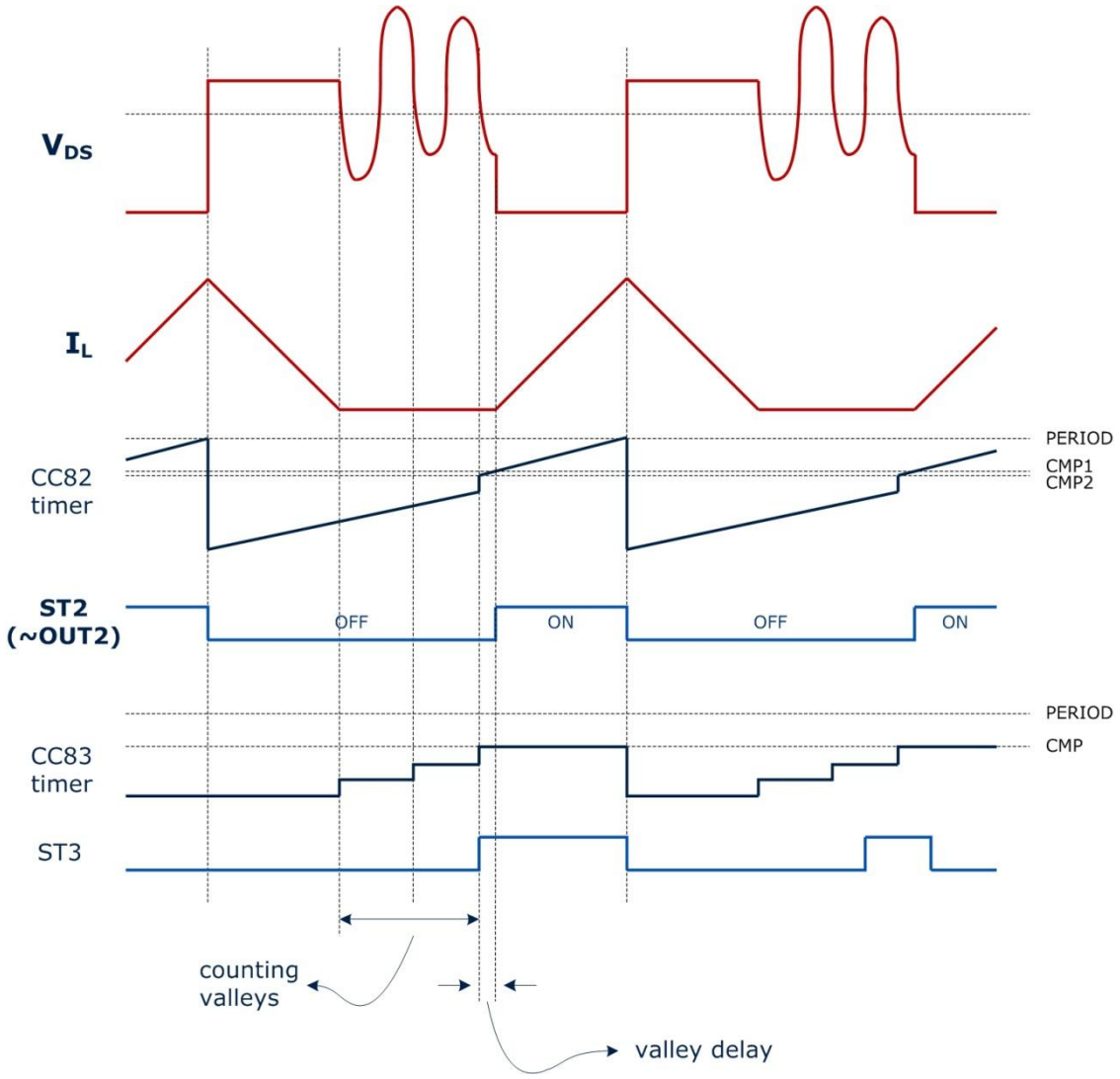


- Zero crossing detection
- Switching in any valley we want to
- Constant on-time

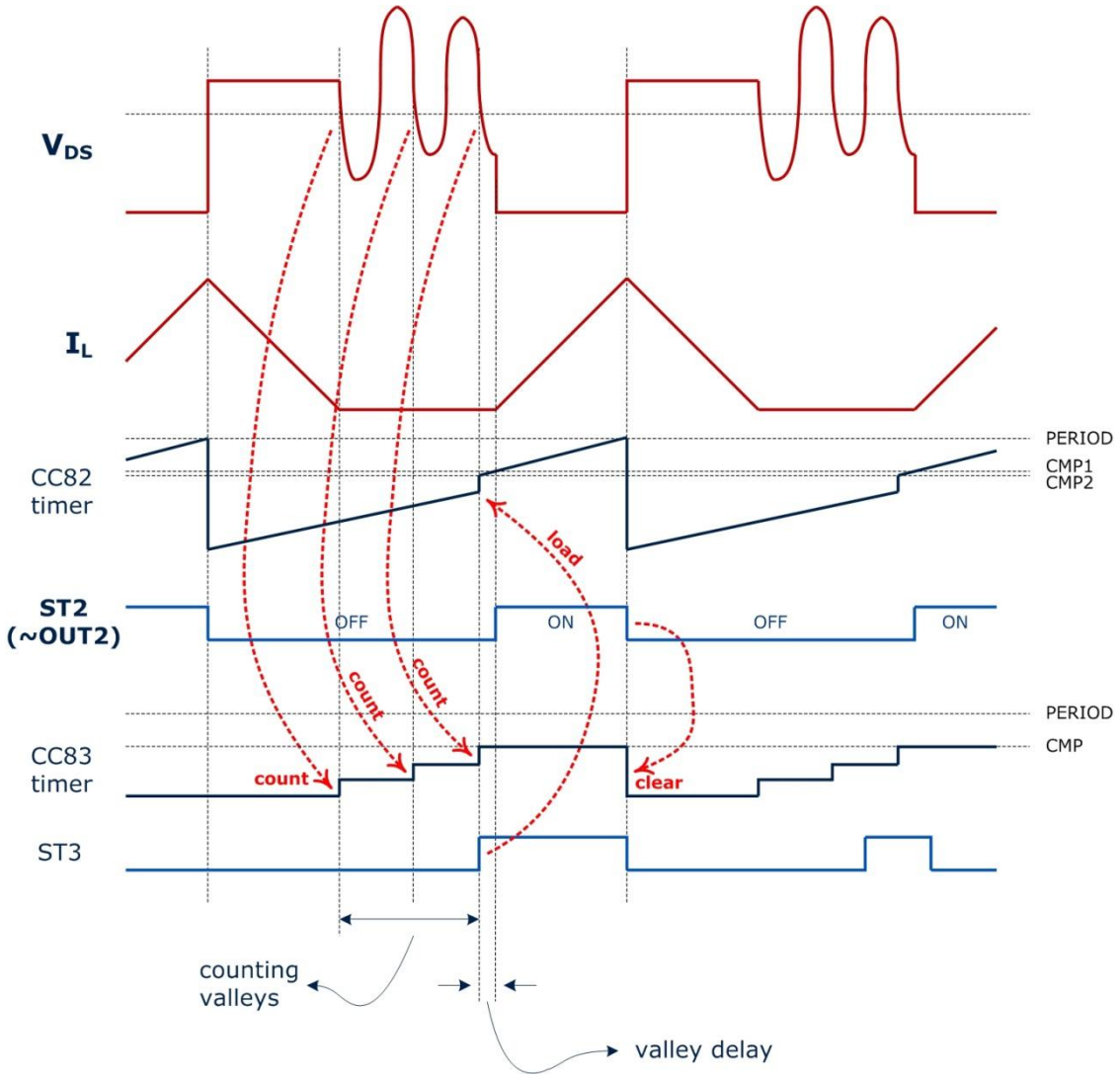
PFC/QR with frequency limit
Constant on-time control and valley counting



PFC/QR with frequency limit
Signals and waveforms



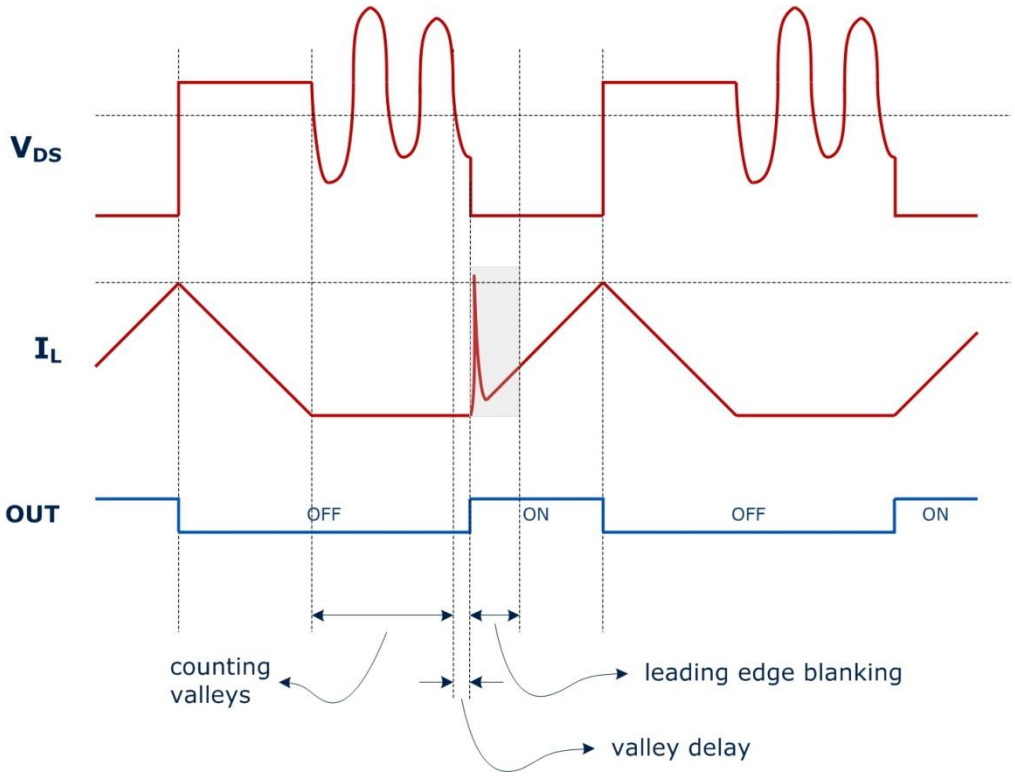
PFC/QR with frequency limit
Signals and waveforms



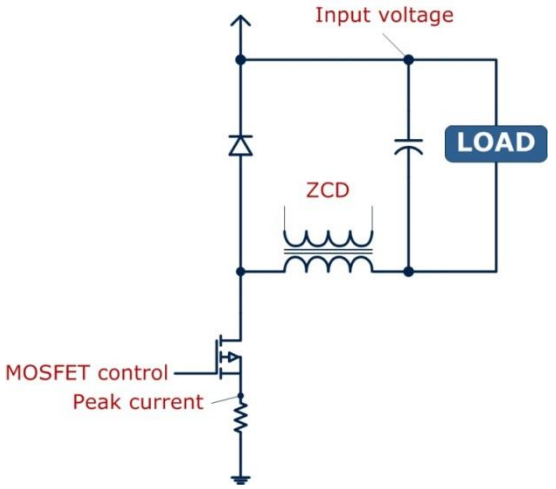
- Oscillations counted by additional timer slice
- Delayed switching in right valley

- On-time: PER-CMP1
- Valley delay: CMP1-CMP2
- Max off-time: CMP1

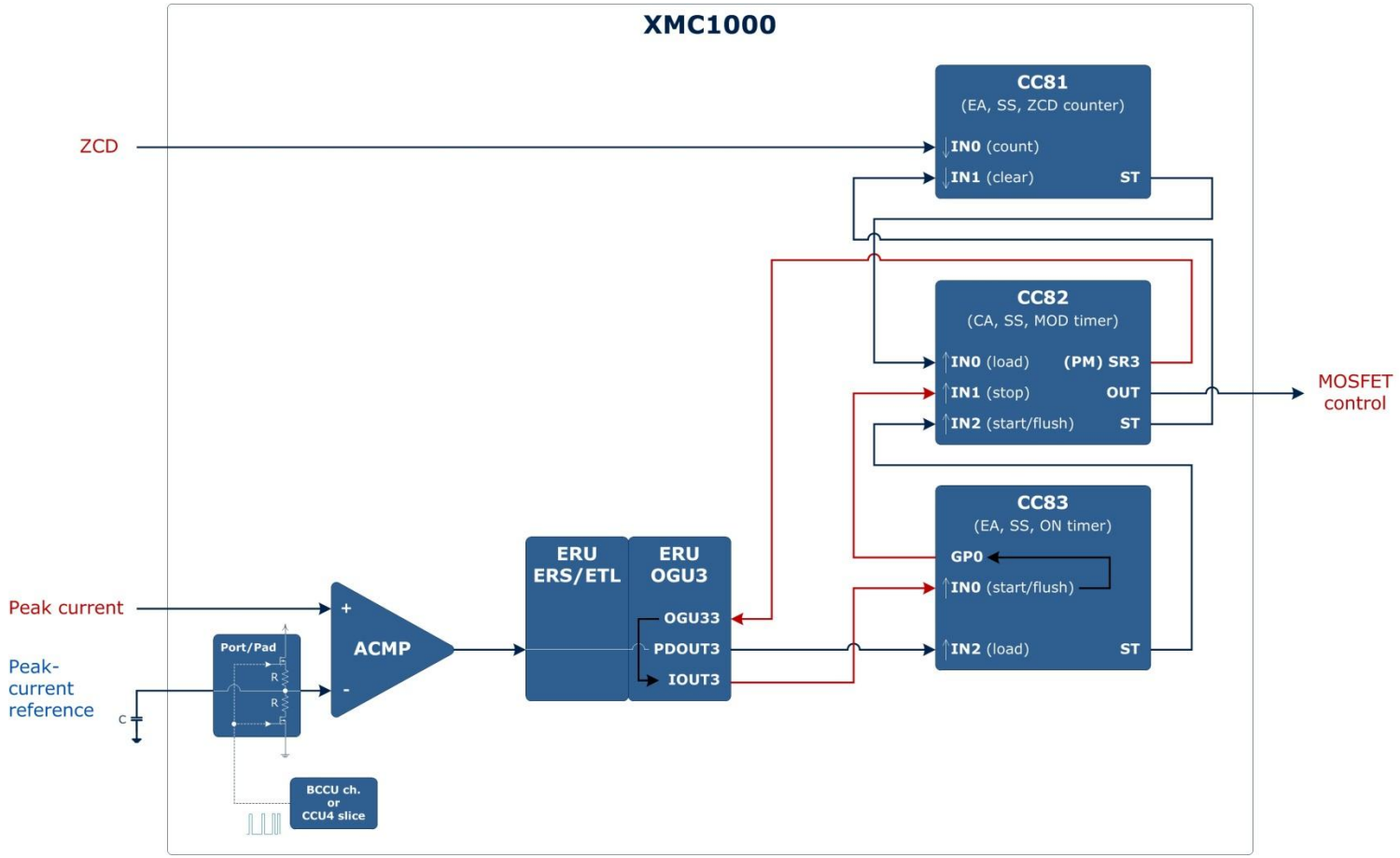
PFC/QR with peak-current control
Target waveforms



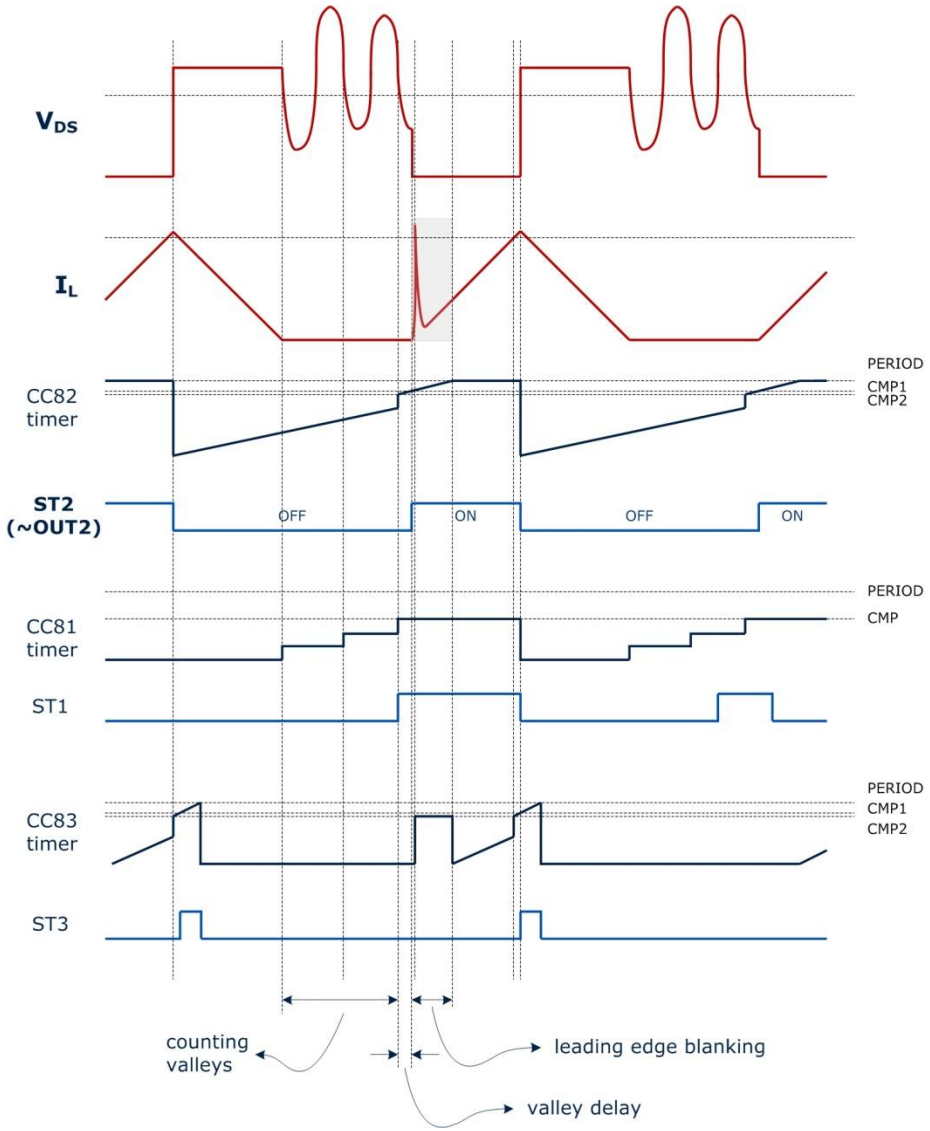
- Zero crossing detection
- Switching in any valley we want to
- Peak-current detection
- Leading edge blanking



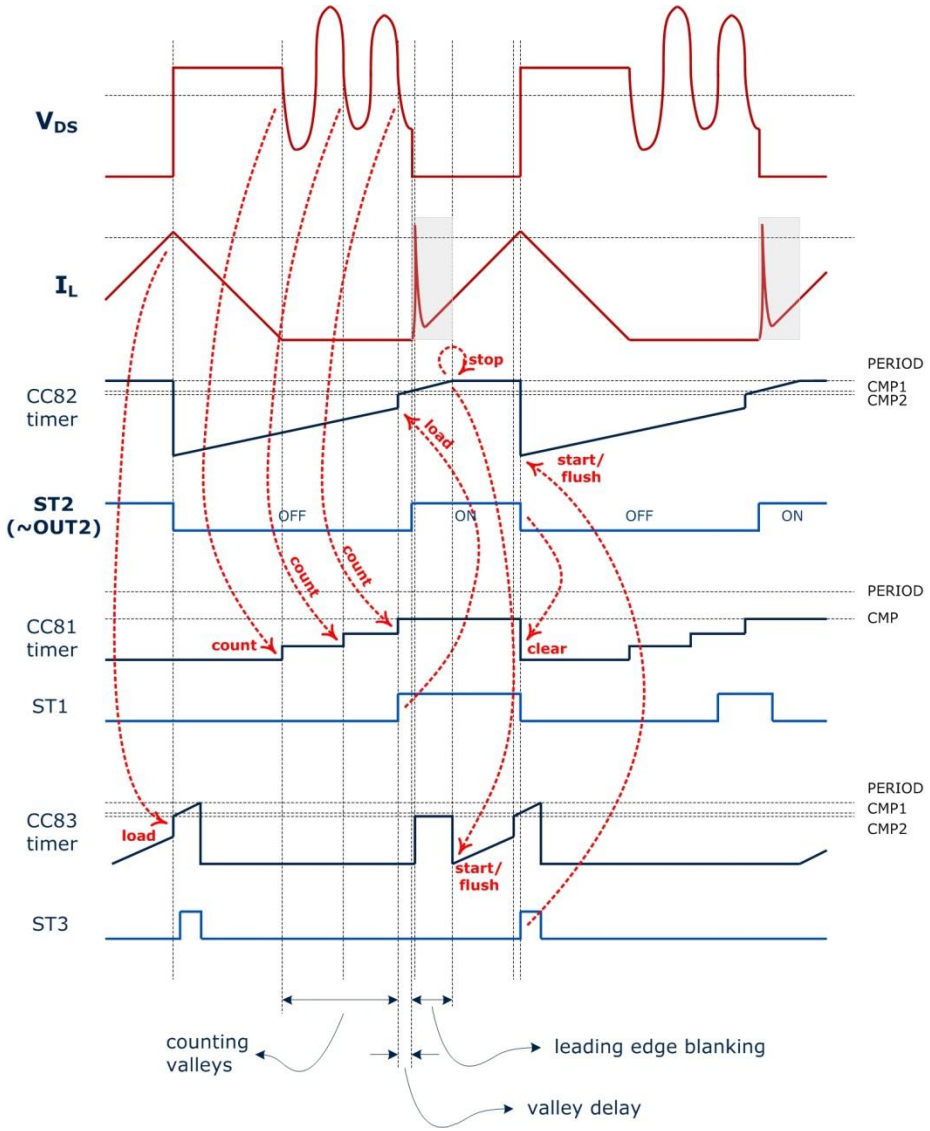
PFC/QR with peak-current control
Peak-current control and valley counting



PFC/QR with peak-current control
Signals and waveforms



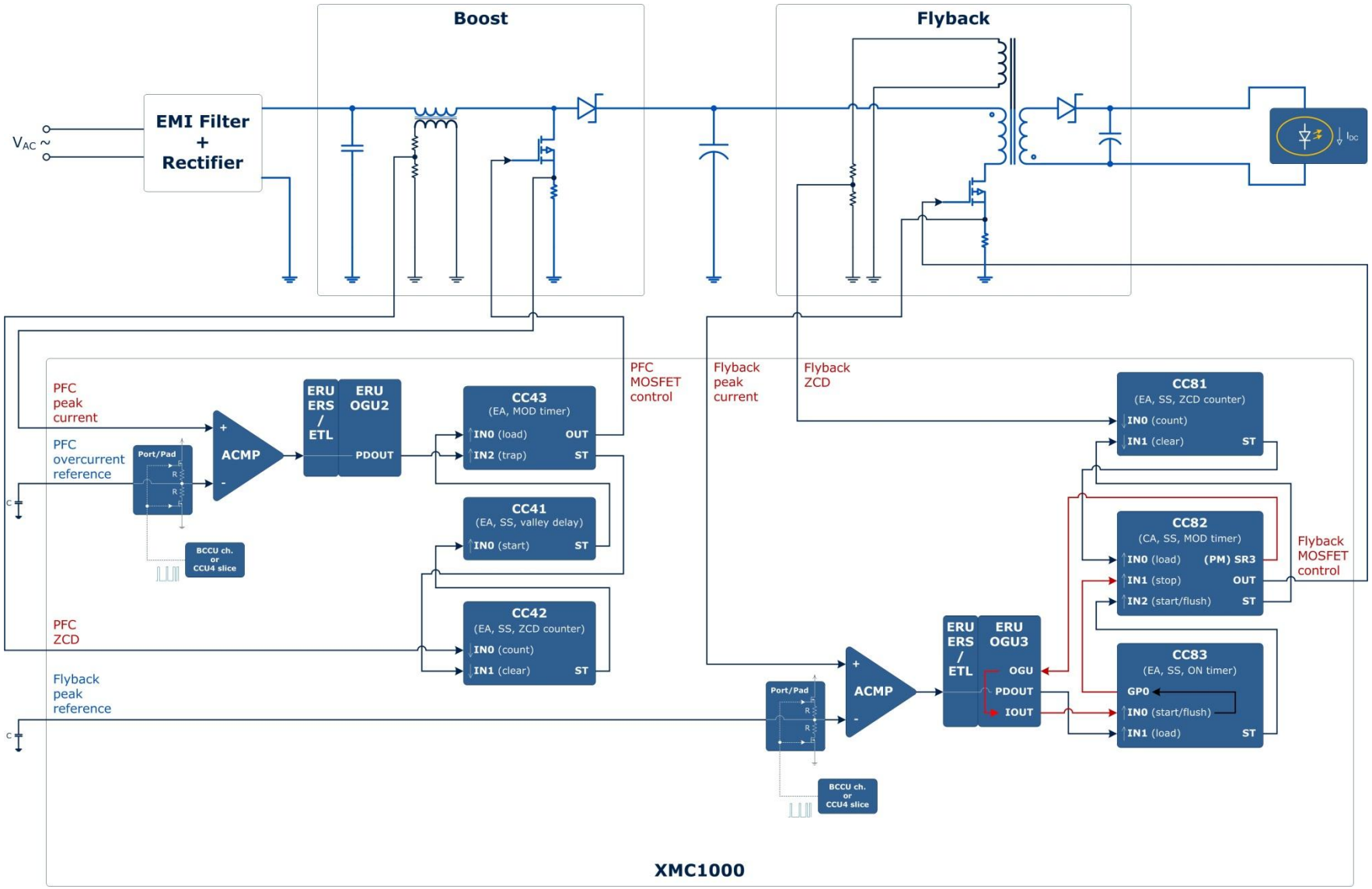
PFC/QR with peak-current control
Signals and waveforms



- Oscillations counted by additional timer slice
- Delayed switching in the right valley
- On-time controlled separately by additional timer to enable peak-current control

- Max off-time: $CMP1_2$
- Valley delay: $CMP1_2$-$CMP2_2$
- LEB: PER_2-$CMP1_2$
- Max on-time: $CMP1_3$+PER_2-$CMP1_2$

Boost PFC + DCDC Flyback
With overcurrent protection

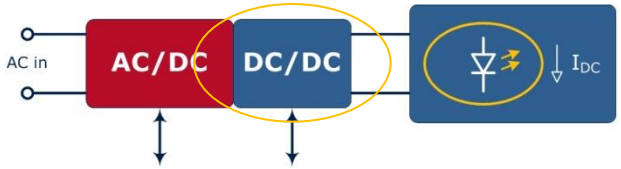


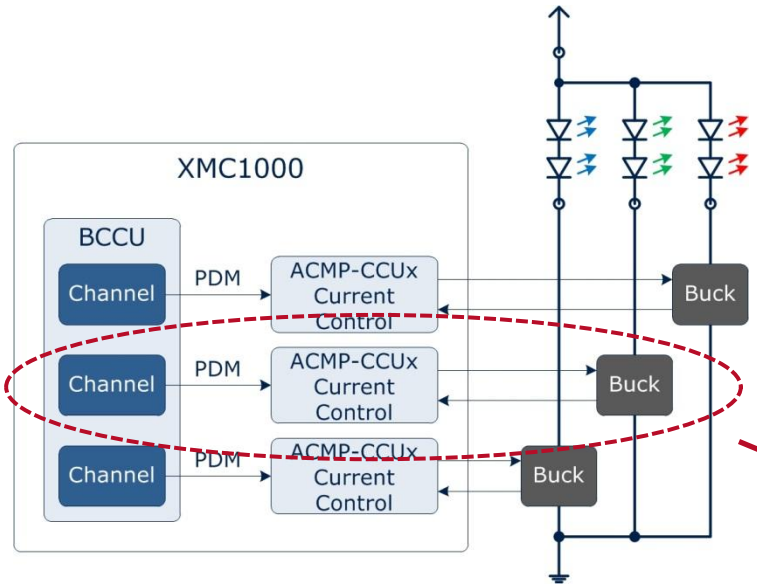
Agenda

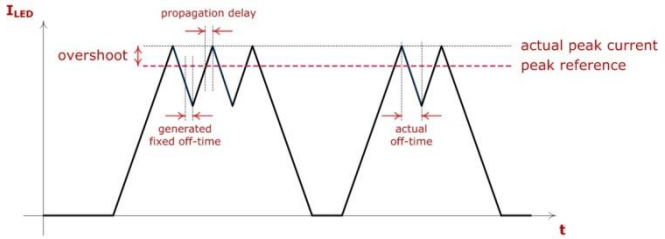
- Key XMC1000 Features
- Lighting Power Supply Topologies
- PFC and QR with XMC1000
- CCM Buck with XMC1000

Modulation Dimmable CCM Buck

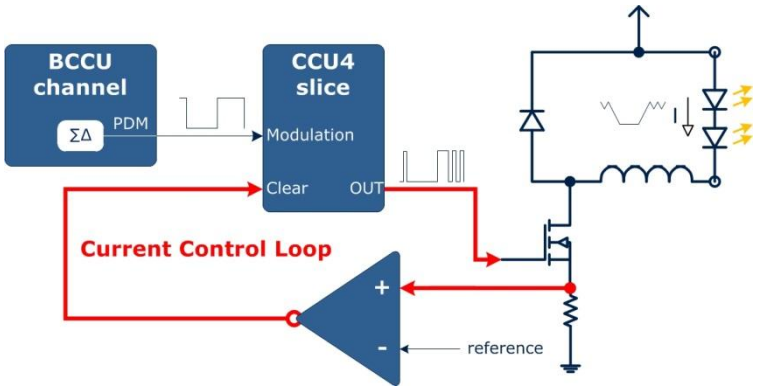
- LED strings in parallel
- High frequency switching enables high speed modulaton dimming



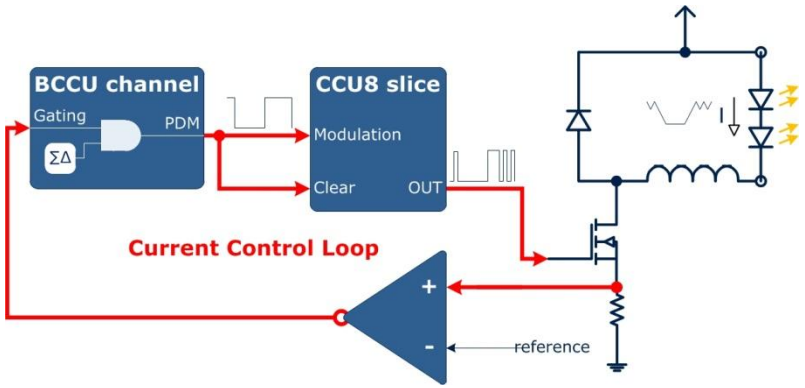




ZOOM

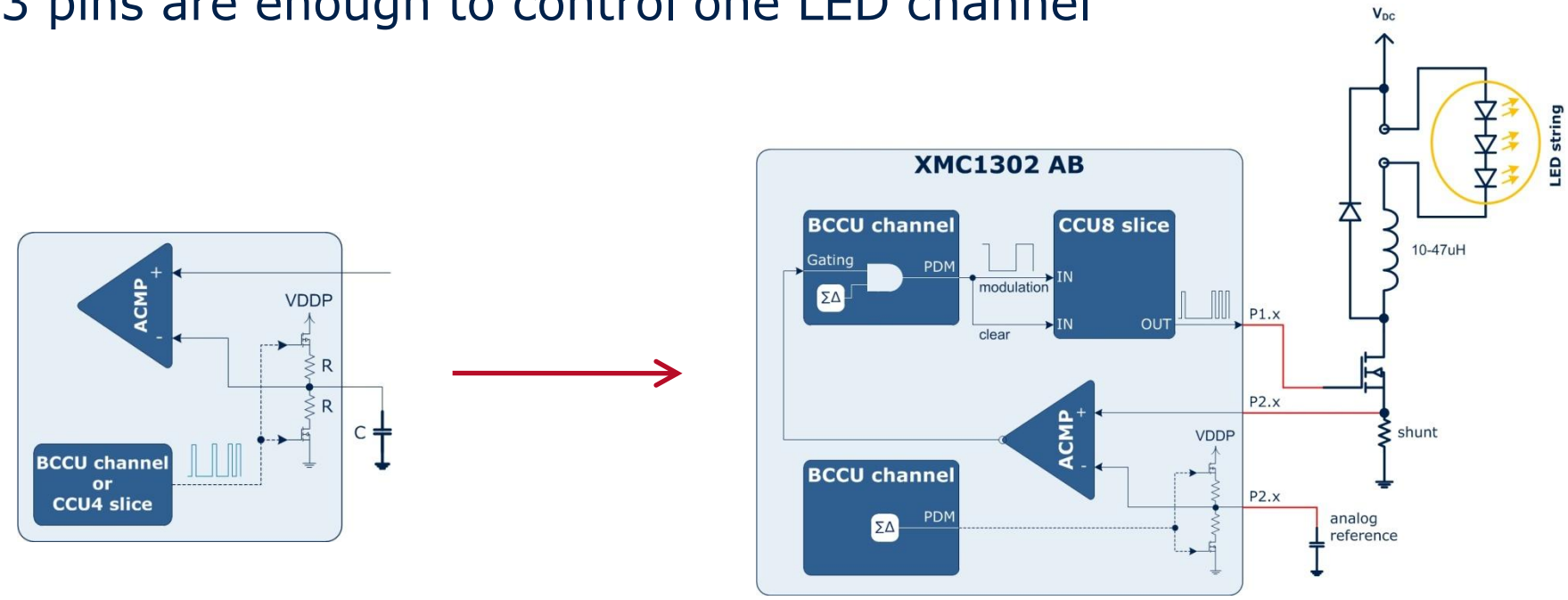


ZOOM

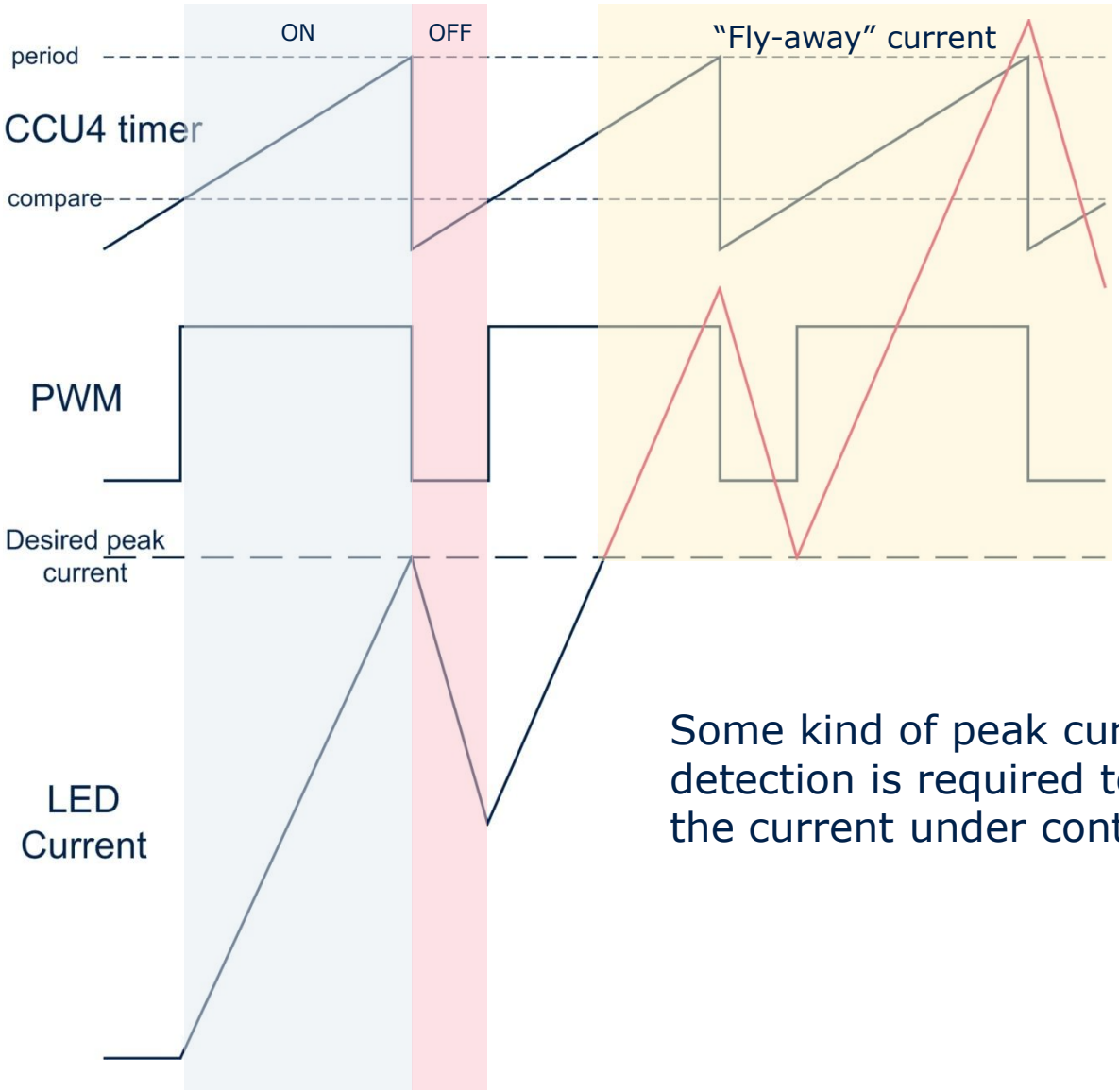


Internal comparator reference generation with external capacitor

- Internal pull resistor control by BCCU channels or CCU4 slices
- RC filter with internal R and external C
- Pin configured as analog input
- Easily adjustable current reference
- 3 pins are enough to control one LED channel



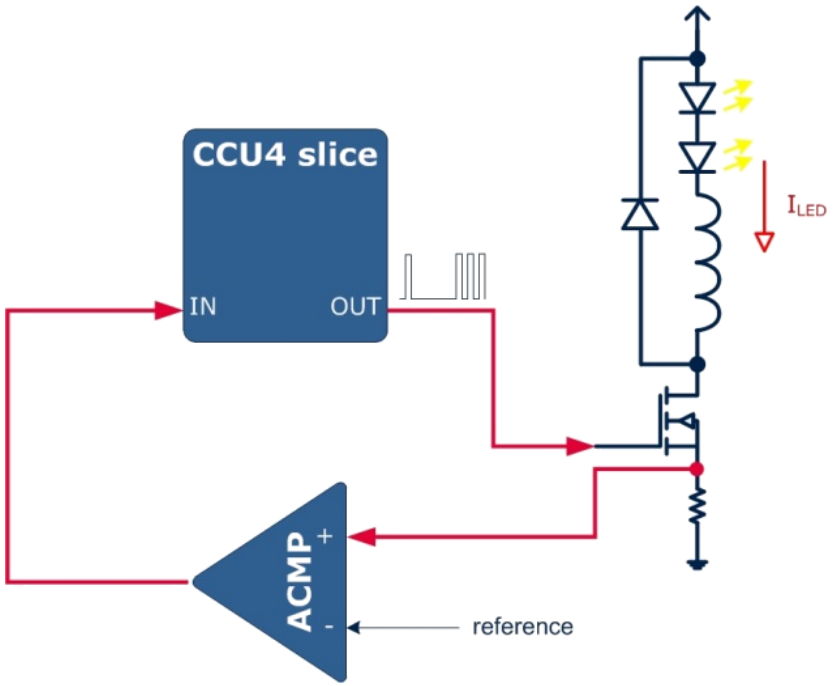
“Fly-away” current



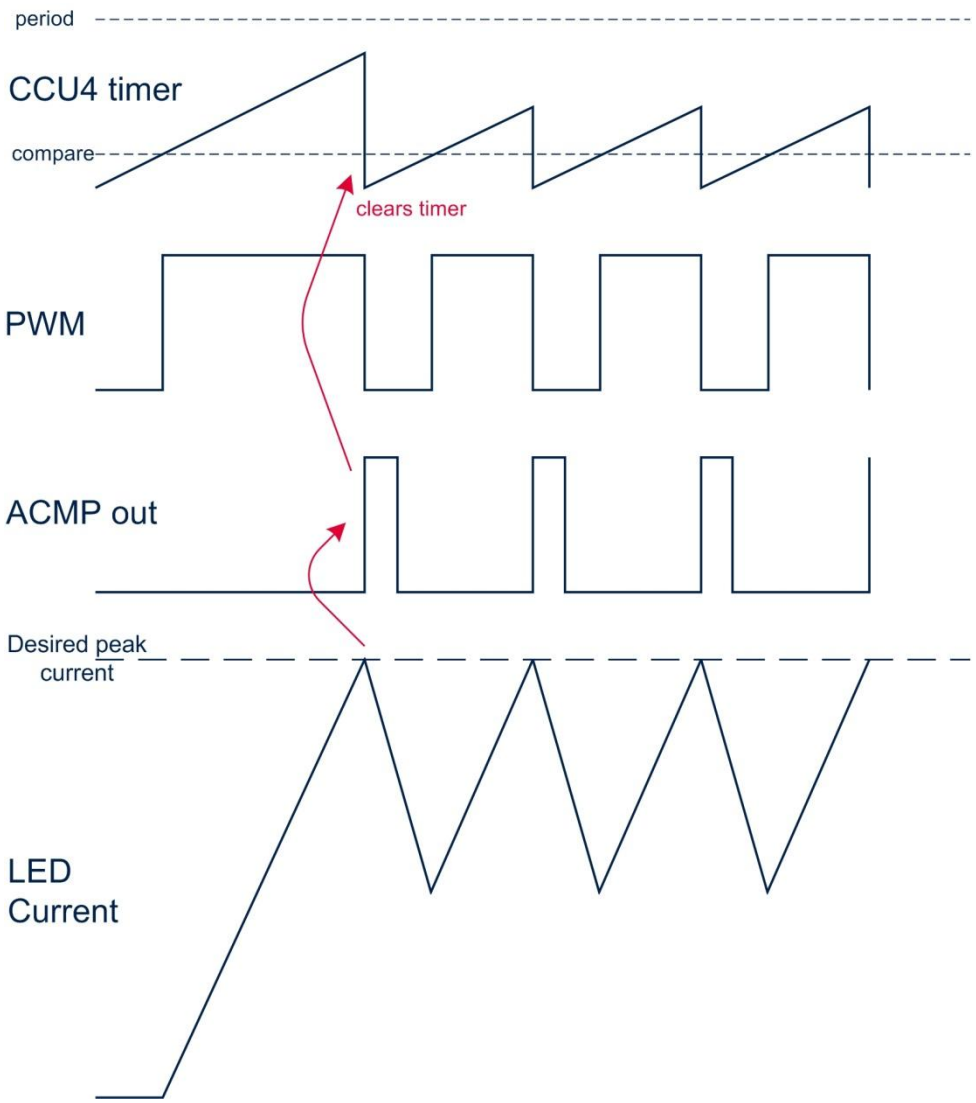
Some kind of peak current detection is required to keep the current under control

Peak-Current Detection (1/2)

- Analog comparator (ACMP)
  - Detects when desired peak level is reached
  - Sends a trigger signal to CCU4 to turn MOSFET OFF
- CCU4
  - Upon receiving trigger signal from ACMP, clears its timer and starts counting up again

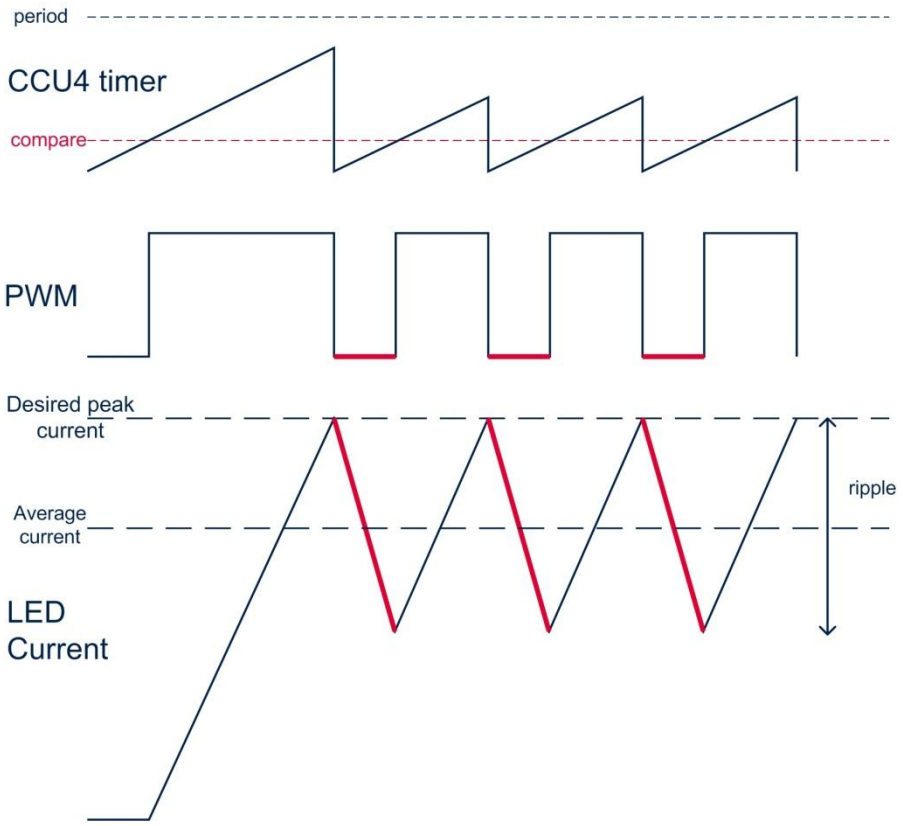


Peak-Current Detection (2/2)



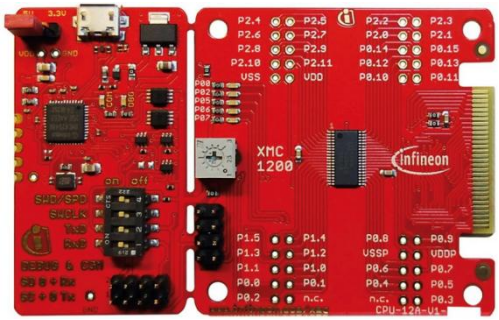
Controlling Average Current

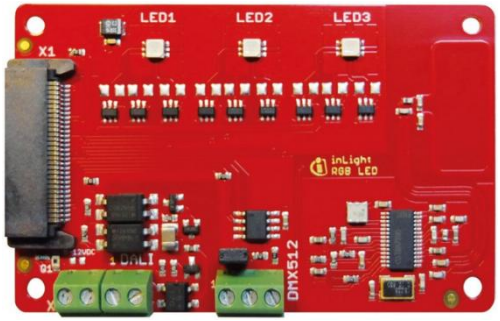
- CCU4 timer compare value affects the MOSFET off-time
  - This affects the size of the current ripple (amount of current drop)
- LED average current is approximately half of the current ripple
- Higher compare value = Larger ripple = lower average current value

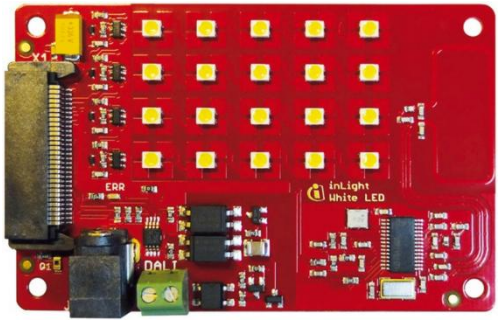


Kits and Boards
LED Lighting Application Kit

- Features
  - XMC1200 Microcontroller with 200KB Flash
  - Detachable SEGGER J-Link
  - Colour LED Card
    - 3 RGB LEDs, 10mA
    - Connectivity: DALI, DMX512, RF
    - Ambient light sensor
    - Linear LED drivers
  - White LED Card
    - 20 LEDs in 4 strings, 20mA
    - Connectivity: DALI, RF
    - Ambient light sensor
    - Temperature sensor
    - Linear LED drivers
  - Compatible with XMC1400 Boot Kit

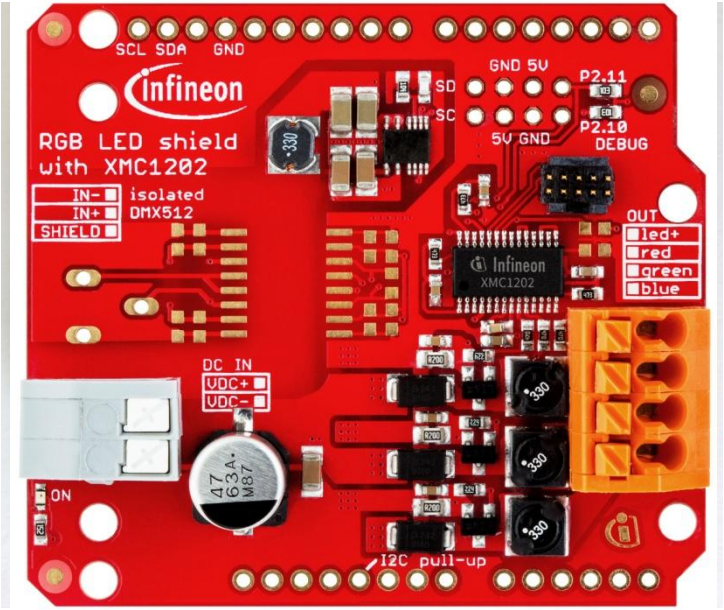




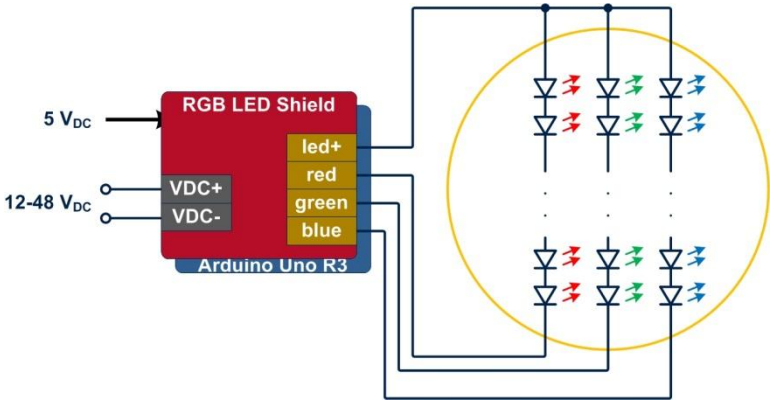


Kits and Boards
RGB LED Lighting Shield for Arduino

- Features
  - XMC1202 Microcontroller with 16K Flash
  - 3 independent output channels
  - Up to 48V DC input
  - Up to 700mA output on each channel
  - Connectivity: I^2C, isolated DMX512 (n.m.)
  - Compatible with Arduino Uno R3 and XMC1100 Boot Kit

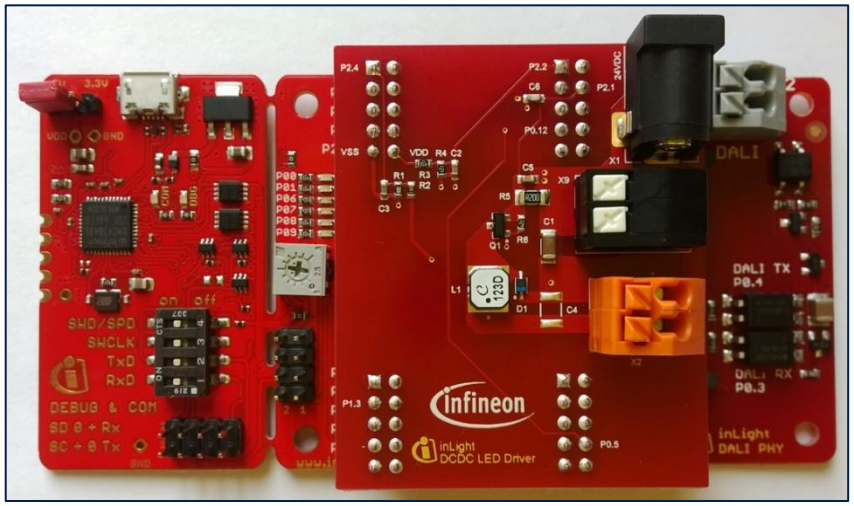


- Current control scheme
  - Peak-current control with fixed off-time
  - Pulse density modulation



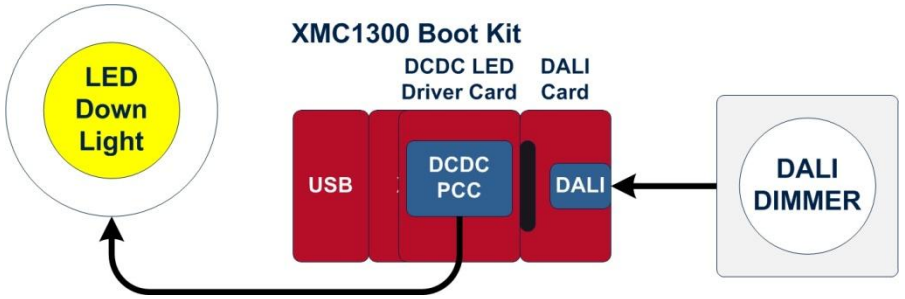
Kits and Boards
Single-Ch. DCDC LED Driver w. DALI

- DCDC LED Driver Card
  - Up to $30V_{DC}$ input voltage
  - Up to 700mA average output current
  - Up to 1A peak current
  - High-speed dimmable DCDC buck



- DALI Card
  - Isolated DALI interface

- Boot Kit
  - XMC1200, XMC1302 or XMC1403 microcontroller
  - Programmable ripple
  - DALI stack



영업문의 : 황혜성 차장(hs.hwang@dabo-corp.com)
윤상원 대리(sw.yoon@dabo-corp.com)

기술문의 : 조용규 과장(yg.cho@dabo-corp.com)
권혁준 사원(hj.kwon@dabo-corp.com)

ENERGY EFFICIENCY
MOBILITY
SECURITY

Innovative semiconductor solutions for energy efficiency, mobility and security.