

Peak current control in XMC4

XMC™ Microcontrollers
February 2015



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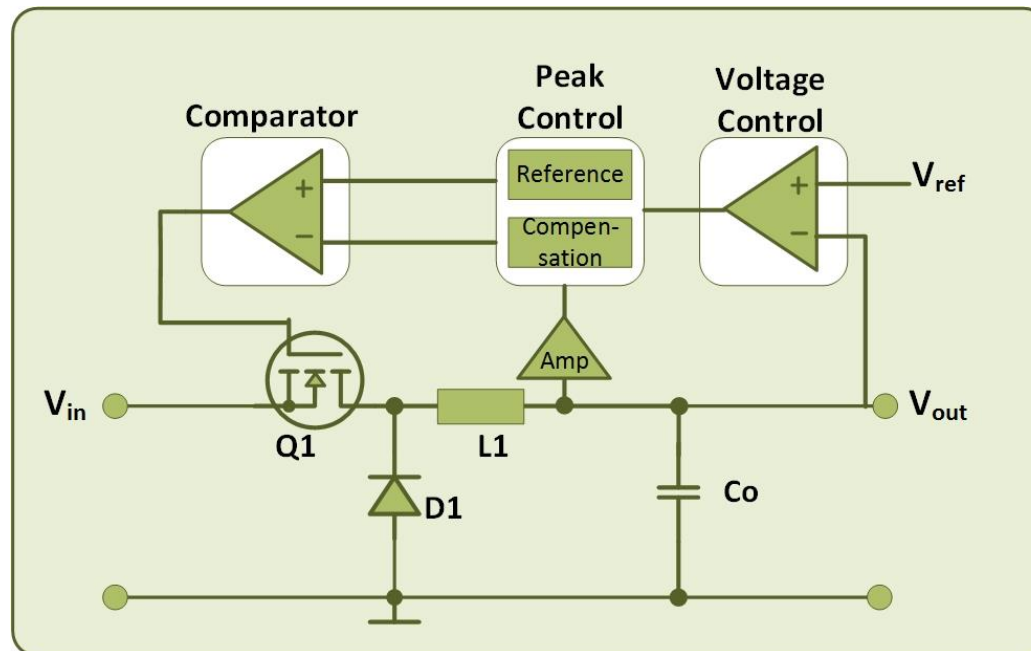
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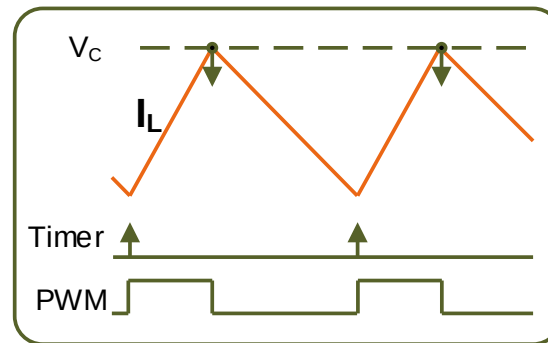
Peak current control in XMC4 – Overview (1/5)

- › The purpose of the training slides is to learn how to utilize HRPWM peripheral in XMC4000 family for peak current control scheme
- › The XMC™ Digital Power Explorer Kit is used to present the concepts on a real application



Peak current control in XMC4 – Overview (2/5)

- › Peak current control is a common control technique for buck converter; this control technique comprises of two loops: current and voltage
- › A comparator is used to track the inductor current; when this current reaches the peak value, the MOSFET will be switched off; consequently the inductor current starts decreasing



- › Blanking mechanism is needed to avoid premature switching off the MOSFET because of noise that is induced when it is turned on

-
- The diagram shows four signals over time:
- V_c**: A dashed horizontal line representing the capacitor voltage, which remains constant at a high level.
  - I_L**: An orange sawtooth waveform representing the inductor current. It ramps up during the 'on' time of the PWM and ramps down during the 'off' time. The peaks of the current are marked with green dots and labeled V_c , indicating that the inductor voltage is zero at those points.
  - Timer**: A green square wave that is high during the 'on' time and low during the 'off' time.
  - PWM**: A green square wave that is high during the 'on' time and low during the 'off' time.



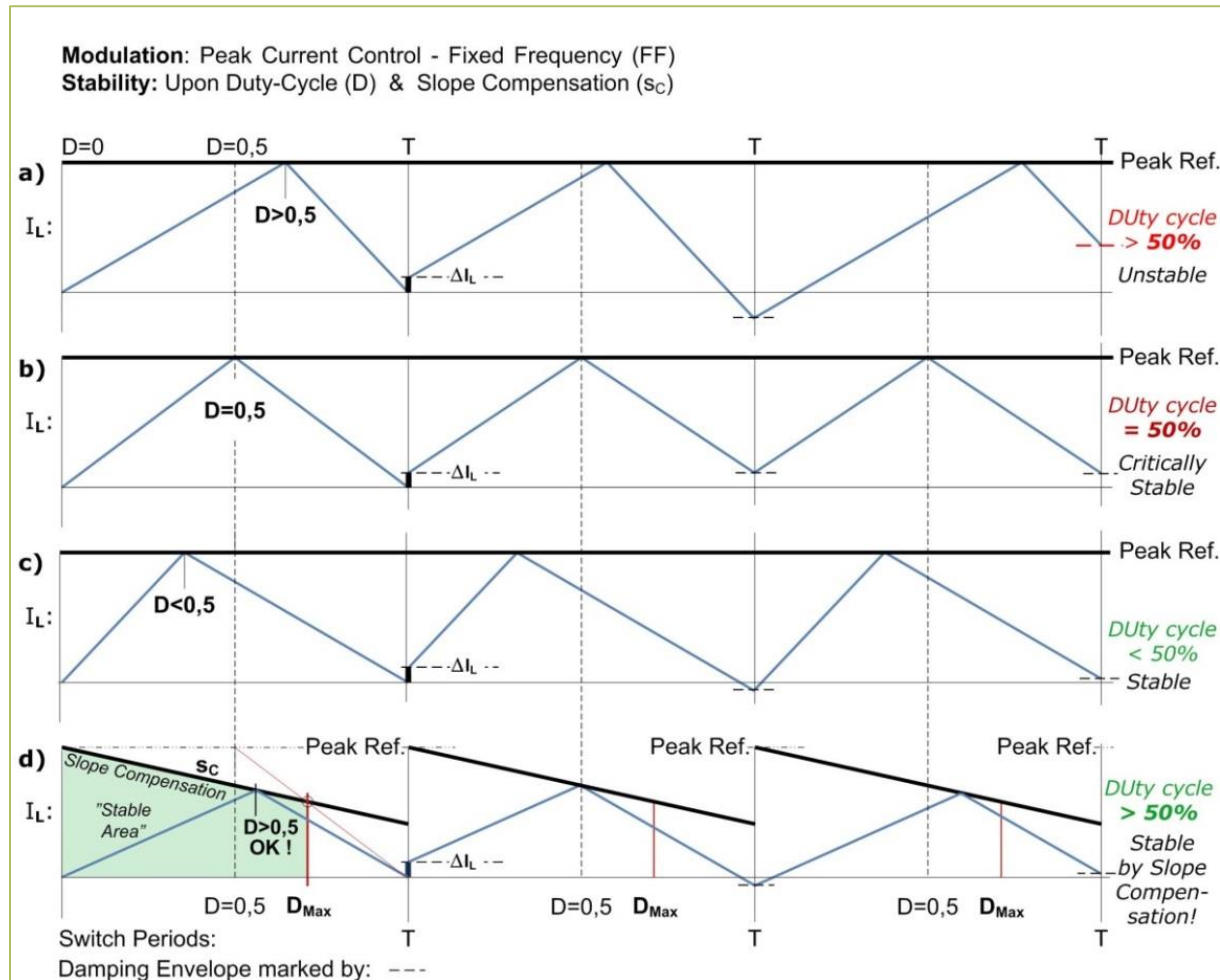
Why need slope compensation?

- › Peak current control tends to have sub-harmonic oscillations due to disturbances in the current sensing
  - Below 50% duty cycle: disturbances die out gradually
  - Above 50% duty cycle: disturbances grow gradually

- › Slope compensation can be used to avoid this, which has two other advantages:
  - Inherent average current control without increasing CPU load
  - Customized closed loop response with a damping factor that is adjustable by slope compensation

Peak current control in XMC4 – Overview (5/5)

Why need slope compensation?



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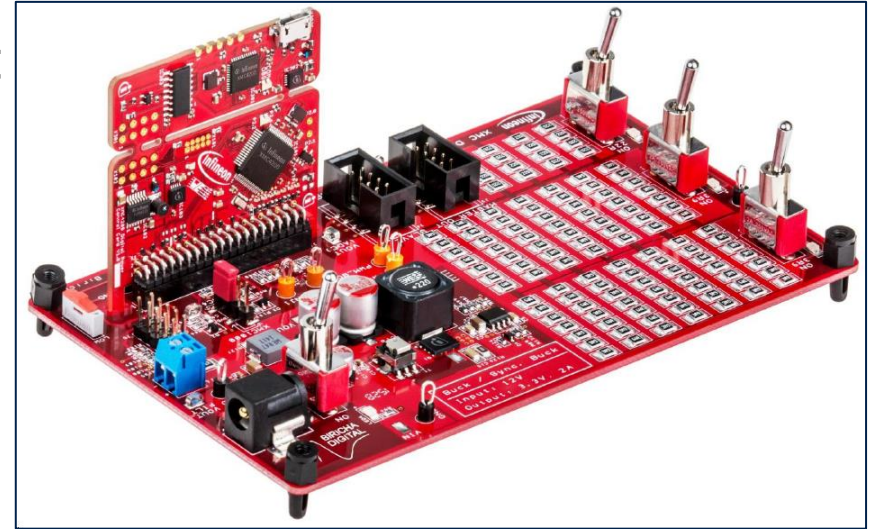
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Peak current control in XMC4 – Key features

Target application

- › XMC™ Digital Power Explorer Kit



Key features

- › Peak current control scheme
  - Analog comparator – 20 ns bandwidth
  - Filtering, blanking and clamping capabilities
  - DAC for comparator reference
  - Slope generation

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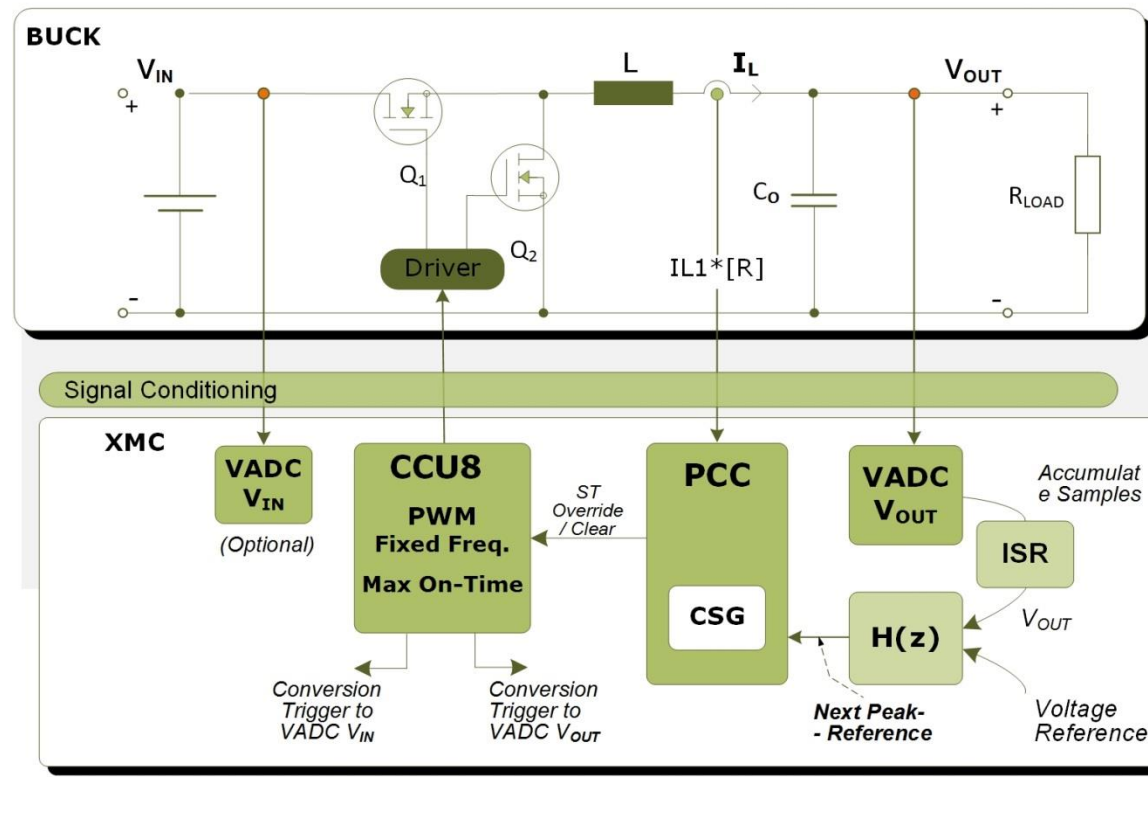
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Peak current control in XMC4 – System block diagram



System block diagram: Peak current control with XMC4 in buck converter

Peak current control in XMC4 – System block diagram



- › With the XMC4400, XMC4200 or XMC4100 device, the peak current control loop can be realized in a cost effective way
- › This is due to integrated comparator, slope generator and blanking functionality in these devices
  - Bill of material cost is reduced
  - No DMA / data transfer required for slope generation

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Peak current control in XMC4 – Hardware overview



- › XMC™ Digital Power Explorer Kit is used to demonstrate the peak current control in XMC4000; the kit comprises of
  - XMC4200 Control Card
  - XMC™ Digital Power Explorer Board

- › Kit schematics, documentation
  - www.infineon.com/xmc-dev

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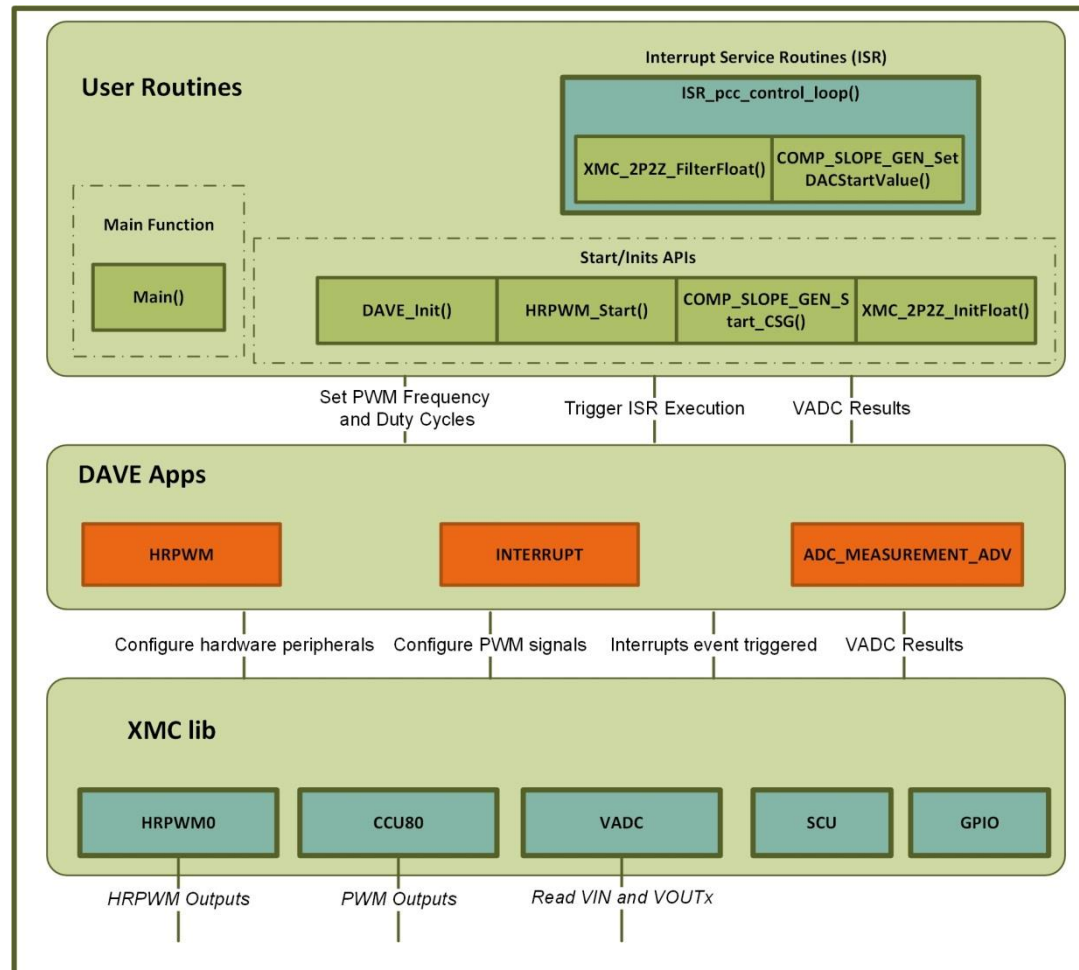
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Peak current control in XMC4 – Software overview



Software overview: Peak current control

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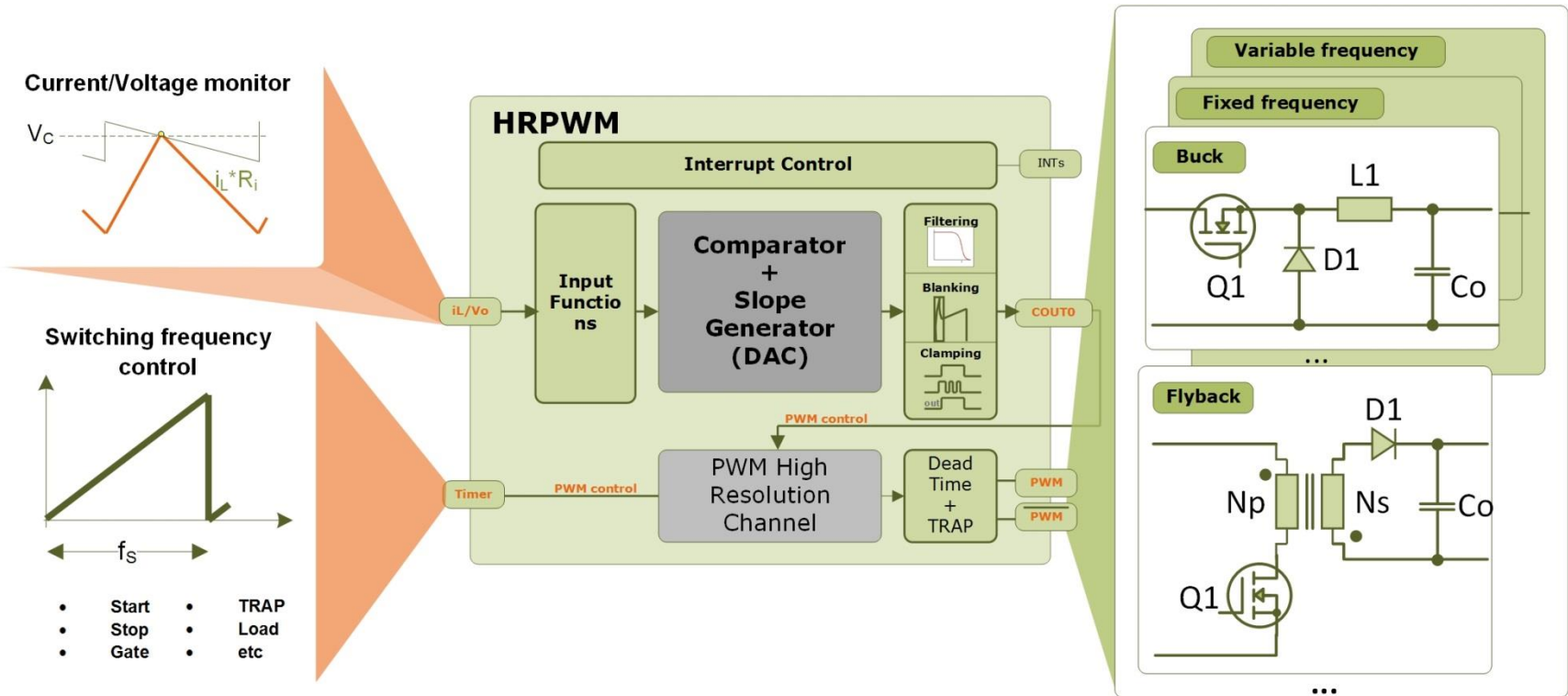
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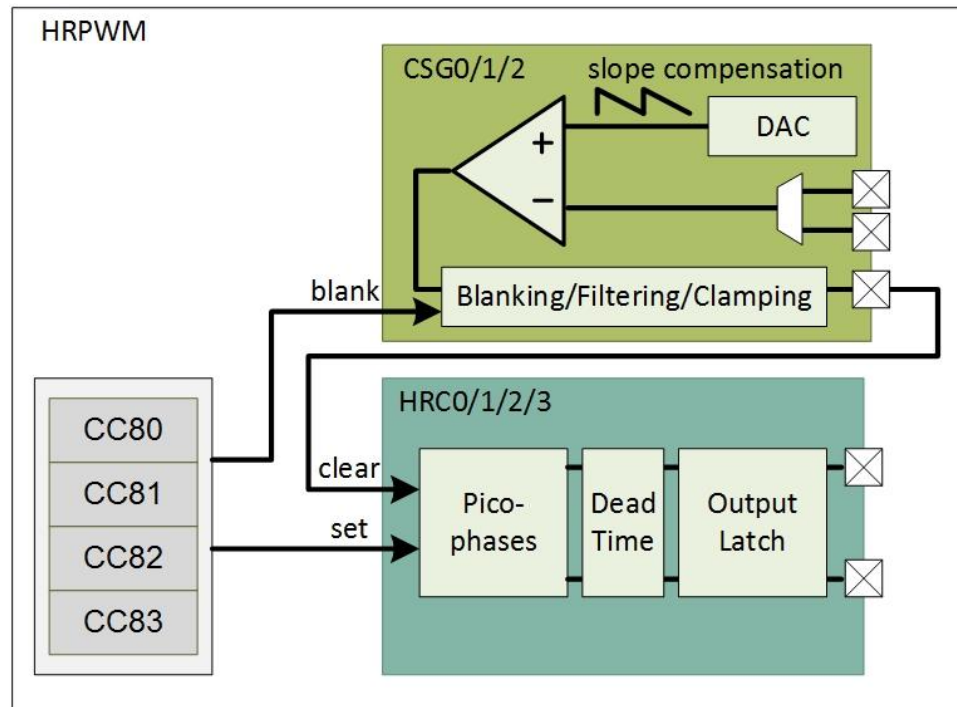
Peak current control in XMC4 – Highlight MCU features: CSG

- › HRPWM Comparator and Slope Generator Unit (CSG)
  - Include **filtering, blanking and clamping** capabilities as well as a **DAC** for automatic reference or slope generation



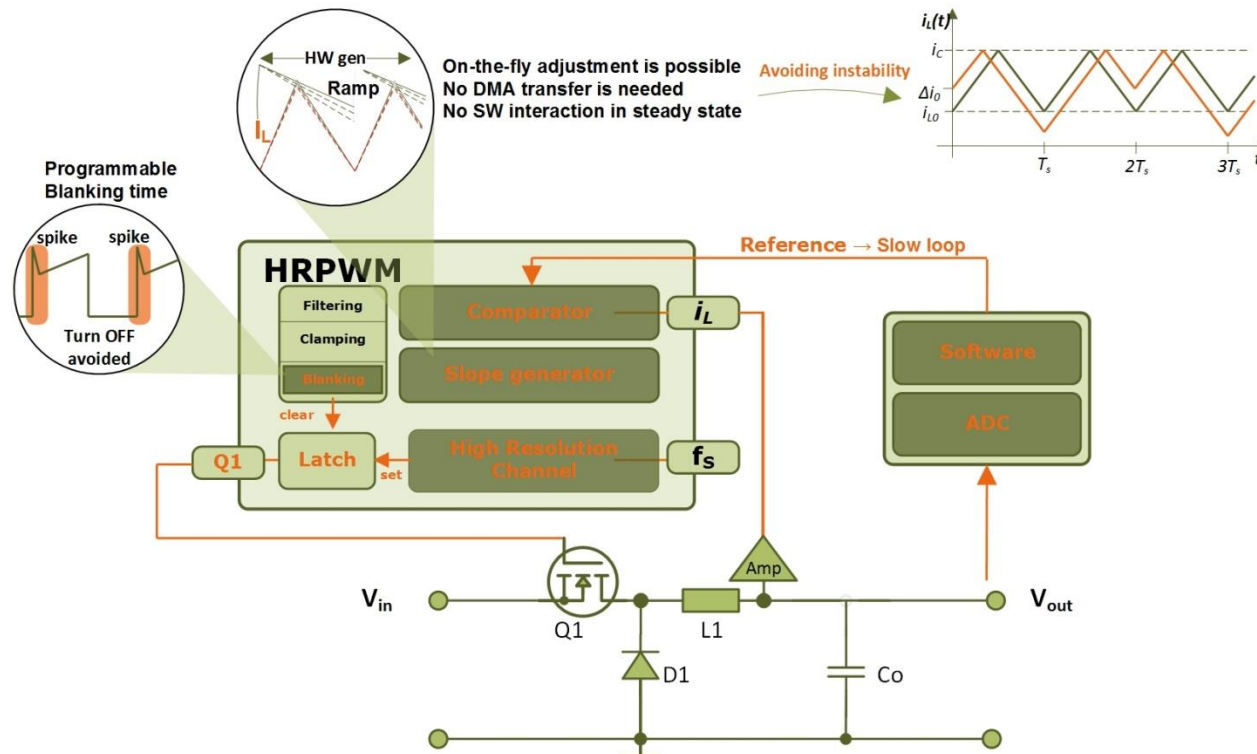
Peak current control in XMC4 – Highlight MCU features: CSG

- › Can easily and efficiently perform:
  - **Voltage control**
  - **Current control**
  - **Customized controls**
- › Analog frontend digitally controlled; best of both worlds:
  - **Analog performance**
  - **Programmability/flexibility**



Peak current control in XMC4 – Overview

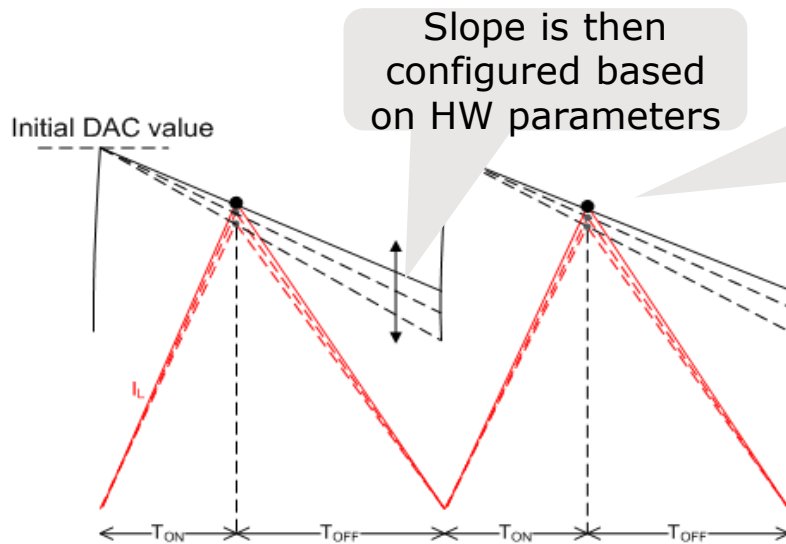
- › The blanking stage is programmed with the wanted value to avoid premature turn OFF of the switch
- › External signal, e.g. PWM status signal, could be used to trigger the start of the blanking time



Peak current control in XMC4 – Slope compensation

› HRPWM slope generation

- No DMA/data transfers
- Slope is dictated by the **initial value of DAC reference** + **conversion rate** (conversion clock, step gain, and the number of clock pulse to swallow)
- Update to new slope can be done by just updating 2 parameters (on-the-fly)
  - DAC reference value
  - Number of clock pulse to swallow



The user configures:

- › The conversion clock
- › The conversion ratio, e.g:
  - 1x per clock
  - 1x per 2 clocks
  - 3x per 4 clocks
  - ...
  - 12x per 16 clocks
  - ...

Peak current control in XMC4 – Highlight MCU features



› CCU PWM

- Generate synchronous PWM outputs
- Trigger ADC conversion via hardware interconnection
- Dead time control
- Can be controlled from external events, e.g. external start

› ADC

- 12 bit resolution
- Fast Compare Mode allows 150 ns - 1 bit conversion, this can be used very efficiently as a comparator
- Synchronous sampling and flexible sequencing
- Full connectivity with CCU8 and CCU4 for event synchronisation
- Result handling and filtering, boundaries detection
- Event and interrupt generation
- Used to sense output voltage as feedback to the system

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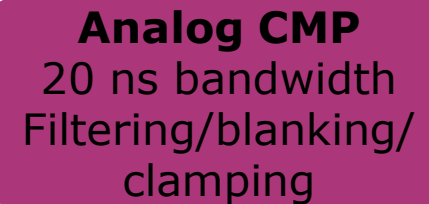
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Peak current control in XMC4 – Get started



- › Key feature – Peak current control scheme

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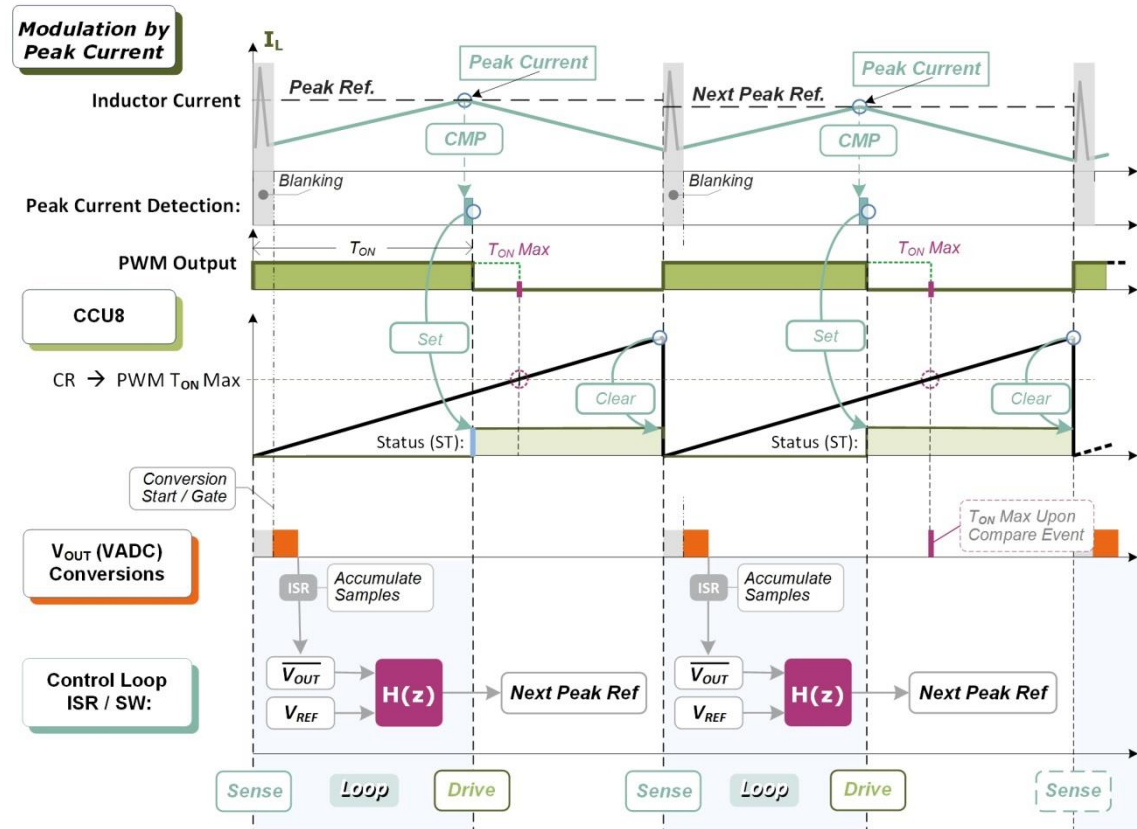


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Peak current control in XMC4 – Peak current control scheme - Timing scheme

› Peak current control at fixed frequency

- The peak current is detected by means of fast comparator; the comparator output signal will reset the PWM
- The voltage control loop compares output voltage with the reference value and update the peak current reference value



Applying the
filter to the
ADC measured
value



Set new DAC start
value

Software: Control loop interrupt service routine

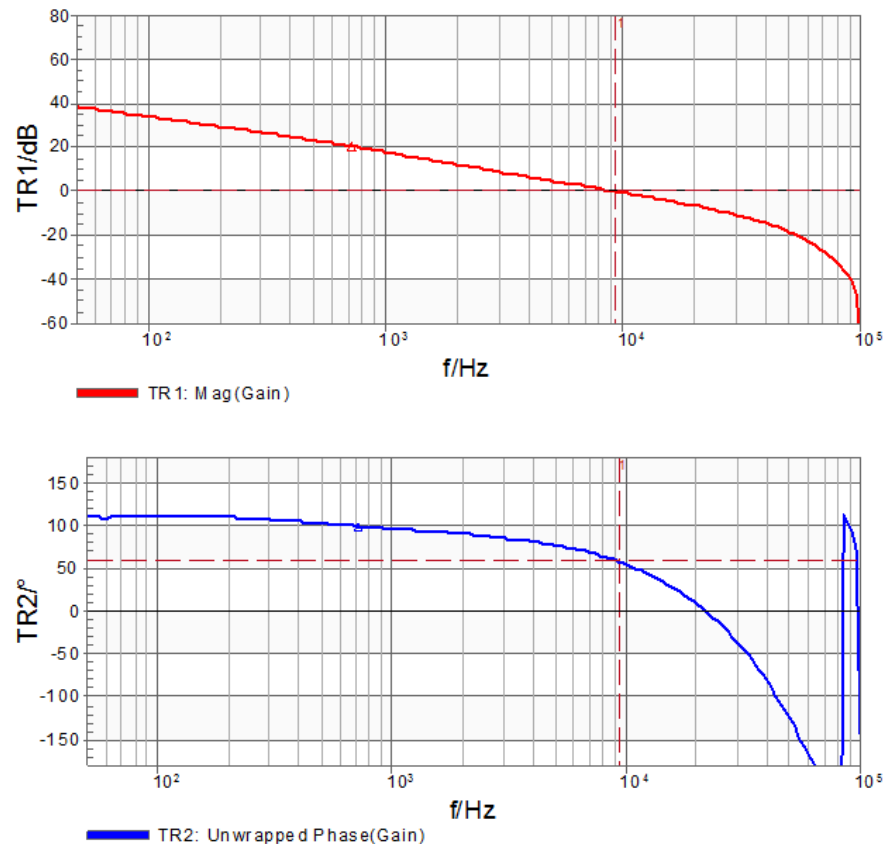
Schematic: Buck converter – Peak current control

List of DAVE™ APPs

- › HRPWM
  - Supports synchronous buck PWM outputs
  - Set PWM frequency to 200 KHz
- › COM_SLOPE_GEN
  - Comparator setup
  - Enable slope generation, set blanking time
- › ADC_MEASUREMENT_ADV
  - Read output (V_{out}) and input (V_{in}) voltage value

Peak current control in XMC4 – Peak current control scheme – Bode plot

- › Stability of the peak current control is checked using OMICRON Bode 100; phase margin is about 60° and cross over frequency 10 kHz



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- › Where to buy kit

<http://www.infineon.com/xmc-dev>

- › For latest updates, please refer to

<http://www.infineon.com/xmc4000>

- › For support

<http://www.infineonforums.com>

- › XMC4 peak current control DAVE™ project

http://www.infineon.com/cms/en/product/promopages/aim-mc/dave_downloads.html

Q & A

Support material:

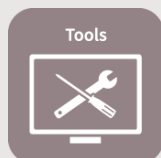
Collaterals and Brochures



- › Product Briefs
- › Selection Guides
- › Application Brochures
- › Presentations
- › Press Releases, Ads

› www.infineon.com/XMC

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](#)

Videos



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- › Product Information Videos

› [Infineon Media Center](#)

› [XMC Mediathek](#)

Contact



- › Forums
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› [Infineon Forums](#)

› [Technical Assistance Center \(TAC\)](#)

Glossary abbreviations

- › ADC Analog Digital Converter
- › CCU Capture and Compare Unit
- › CSG Comparator and Slope Generator Unit
- › DAC Digital to Analog Converter
- › DAVE™ Free development IDE for XMC™
- › DMA Direct Memory Address peripheral
- › HRPWM High Resolution Pulse Width Modulation
- › PWM Pulse Width Modulation

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