XMC™ in power conversion applications

XMC™ microcontrollers

September 2016

Agenda

1. Why XMC™ for digital power control?
2. Key microcontroller features
3. Kits and reference design
4. Development tool and software

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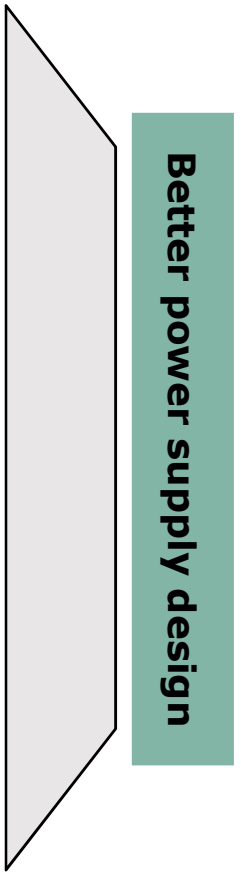
Why XMC™ for digital power control?

Key factors in power supply design	Counter measure	XMC™
Efficiency at all conditions	Sophisticated/ flexible control schemes	Cortex® M0/M4 + dedicated peripherals (analog performance + digital programmability)
Power density	Increase switching frequency	High Resolution PWM (150 ps) and analog peripherals
Time to market	Ecosystem and examples	DAVE™ APPs and ARM® ecosystem (Keil/IAR/open source)
Reliability and security	Great technology + security solution	125°C technology Security technology



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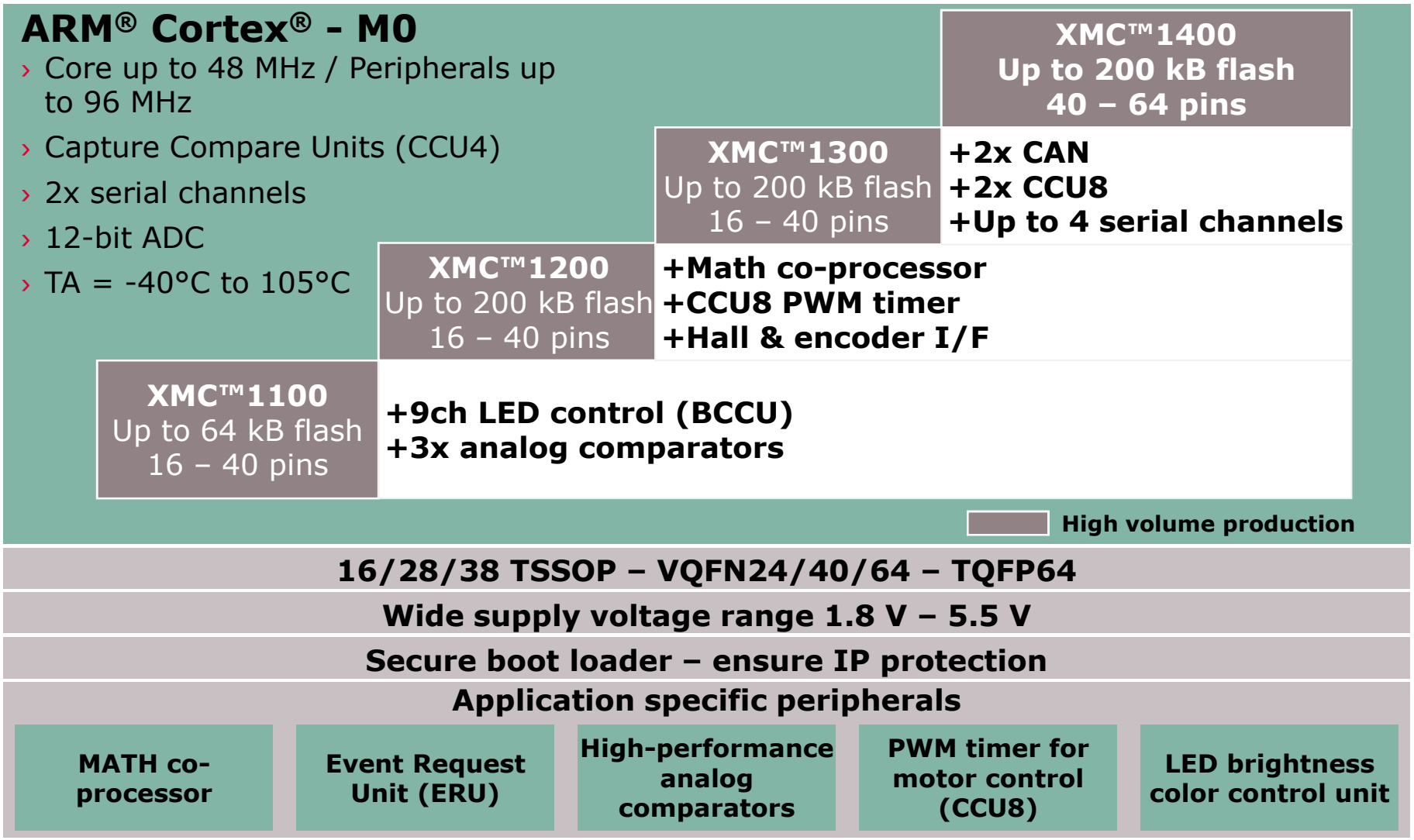
Product portfolio XMC™
XMC™1000 family overview



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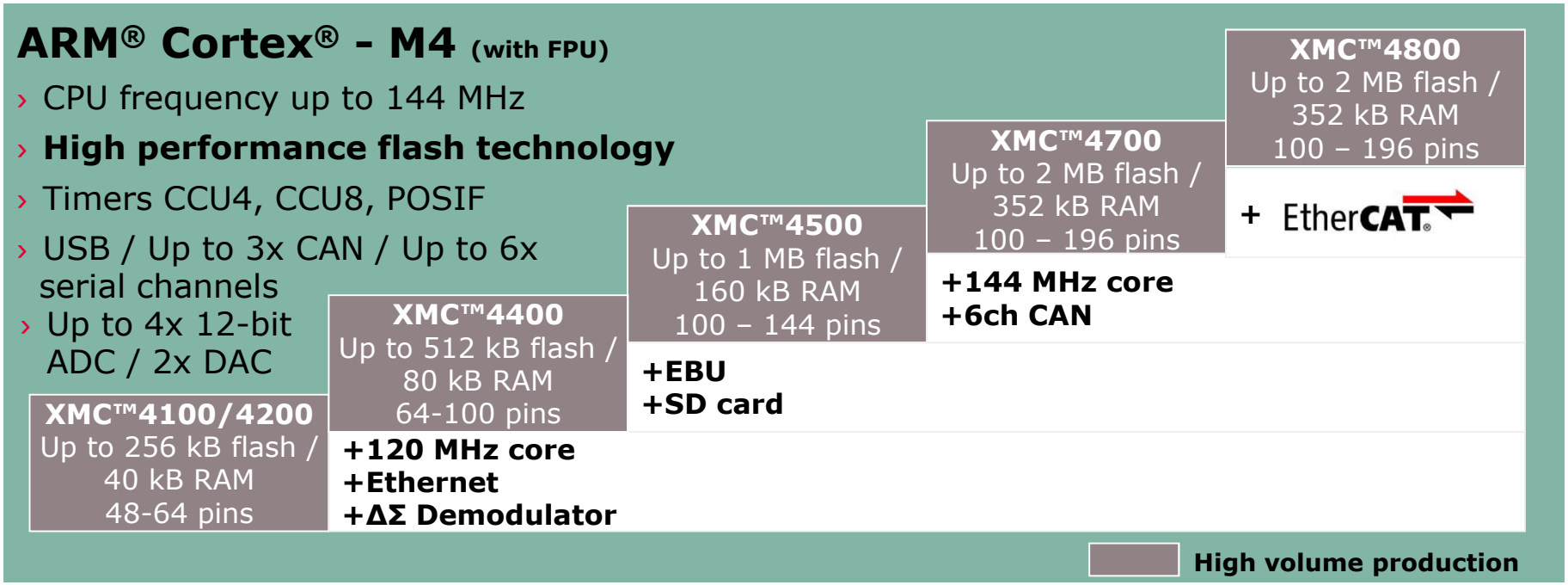
Product portfolio XMC™
XMC™4000 family overview



48 QFN – 64-144 LQFP – 196 BGA

Long product life cycle (min. 2027)

Extended temperature range – up to T_A 125°C + continues up time of 20a@T_J 110°C

Application specific peripherals

High Resolution PWM	Event Request Unit (ERU)	High-speed analog comparators + slope generation	Timer for inverter control (CCU8)	Delta Sigma Demodulator

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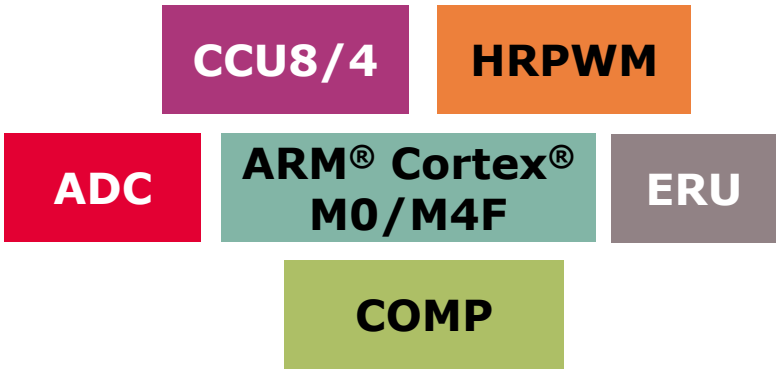
Key features

Peripherals for power conversion applications



Highlights

Analog front end together with full configurability allows most advanced power supply control.
With the support of ARM® Cortex® cores and high Resolution PWM (150 ps), accurate and fast control loops execution are possible for improved figure of merits in power supply design.

Key feature

- High Resolution PWM (150 ps)
- Smart analog comparators
- Fast and flexible ADC and timers

Customer benefits

- Regulate voltages/current with higher accuracy
- Analog comparators with smart features such as slope compensation
- Permit complex PWM patterns and sophisticated measure sequences

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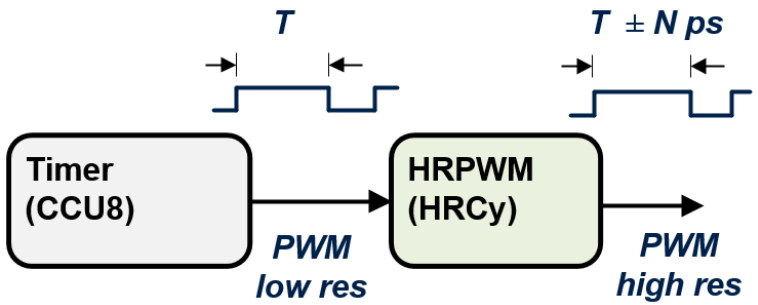
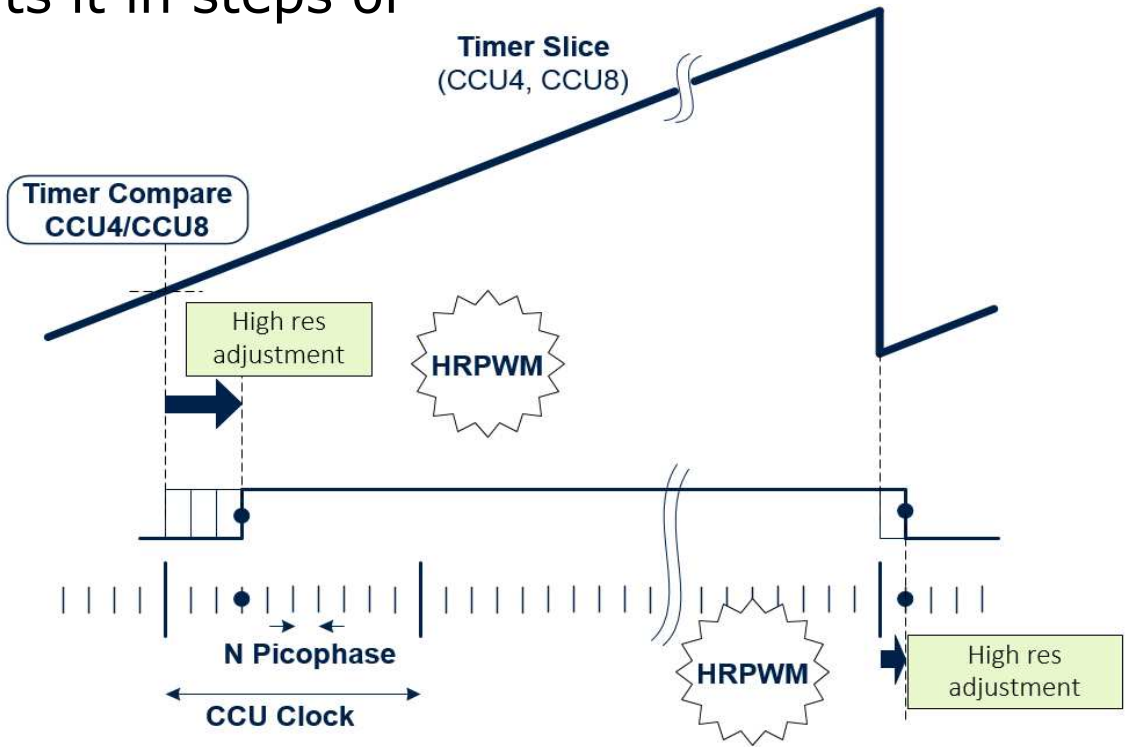
High Resolution PWM (150 ps) (1/3)

- High Resolution PWM receives a signal from other peripherals like CCU8 module
- HRPWM (HRC) takes this signal and shifts it in steps of 150 ps





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High Resolution PWM (150 ps) (2/3)

› Resolutions in bits achieved with and without HRPWM by different conditions : switching frequency of PWM and duty cycle of PWM

Switching frequency	Duty cycle	Resolution w/o HRPWM @ 80 MHz	Resolution w/o HRPWM @ 120 MHz	Resolution w/ HRPWM
200 KHz	50%	7,6-bit	8,2-bit	14-bit
	20%	6,3-bit	6,9-bit	12,7-bit
	10%	5,3-bit	5,9-bit	11,7-bit
500 KHz	50%	6,3-bit	6,9-bit	12,7-bit
	20%	5-bit	5,5-bit	11,3-bit
	10%	4-bit	4,5-bit	10,3-bit
1,5 MHz	50%	4,7-bit	5,3-bit	11,1-bit
	20%	3,4-bit	4-bit	9,8-bit
	10%	2,4-bit	3-bit	8,8-bit

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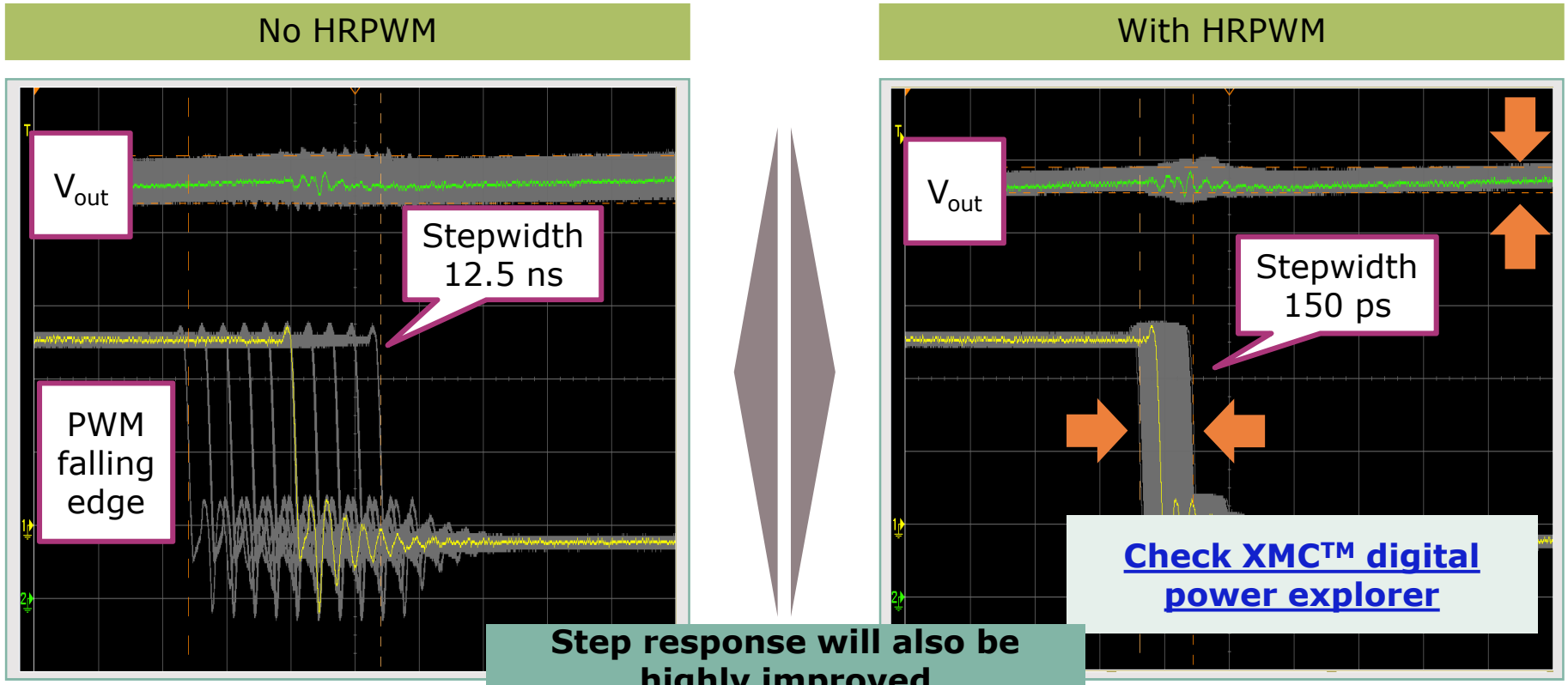
High Resolution PWM (150 ps) (3/3)

› Example: thanks to a finer adjustment of the duty cycle, the output voltage (in this example in a buck converter), is regulated much more accurately. This reduces the output voltage ripple significantly



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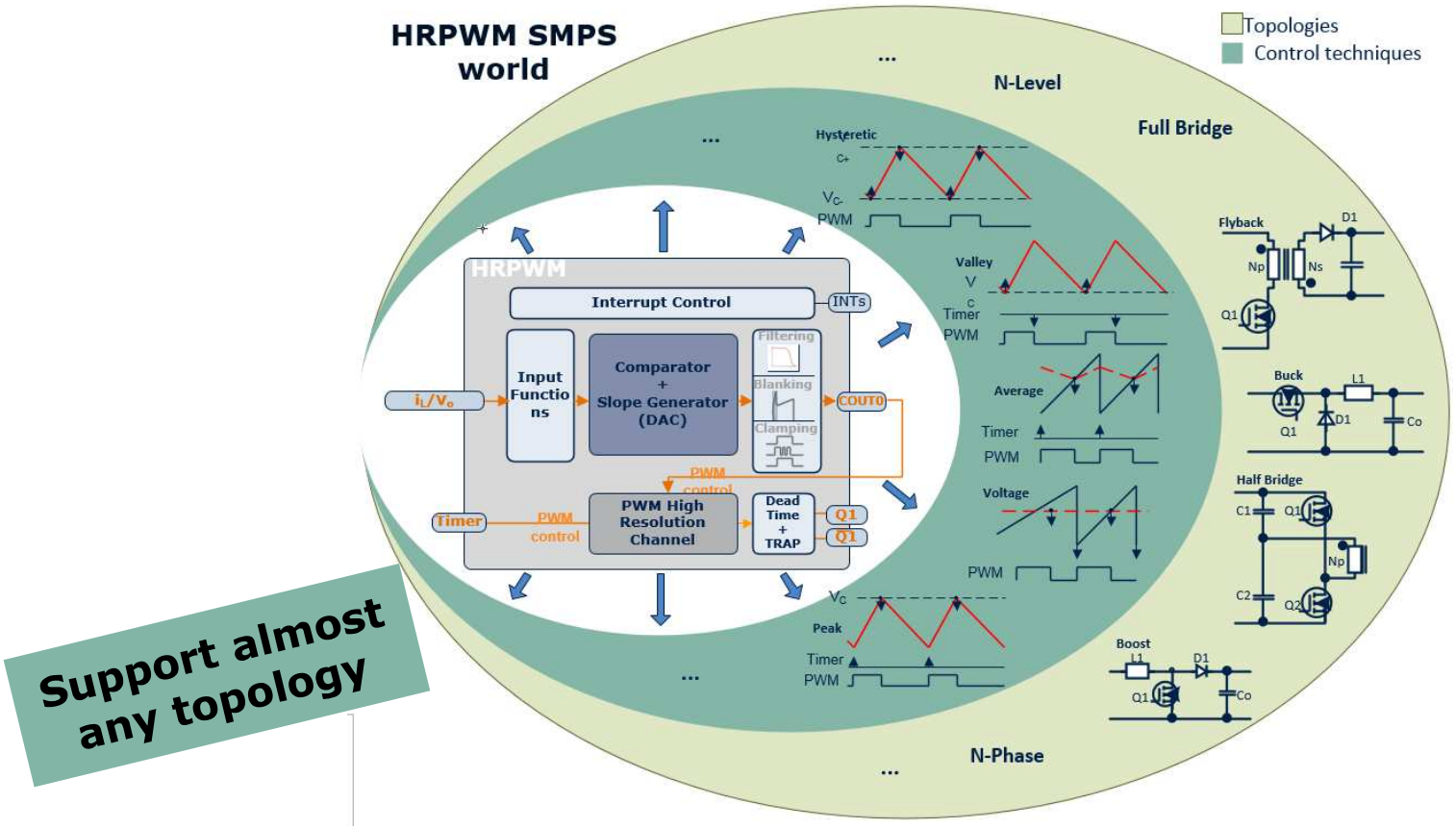
Smart analog comparators (1/3)

- XMC™4000 comparators include **filtering, blanking and clamping** capabilities as well as a **DAC** for automatic reference or slope generation
- XMC™1000 comparators can configure **hysteresis** and output **filtering**



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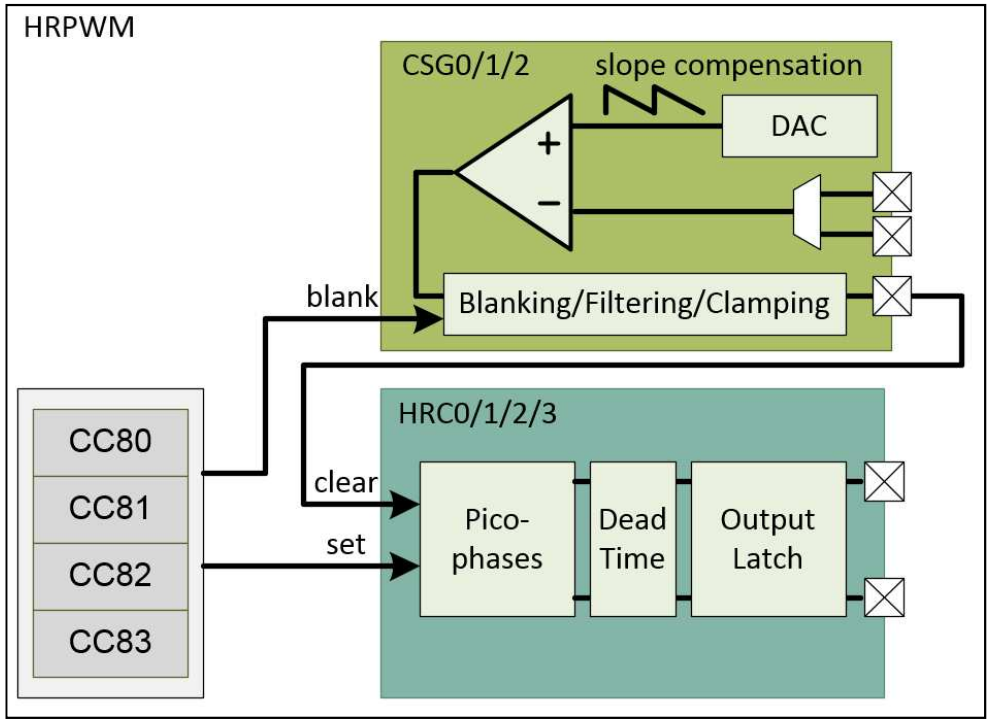
Smart analog comparators (2/3)

- Analog frontend digitally controlled. Best of both worlds:
  - **Analog performance**
  - **Programmability/flexibility**
- Can easily and efficiently perform:
  - **Voltage control**
  - **Current control**
  - **Customized controls**
- **Supports almost any topology and combinations**:
  - LLC/LCC
  - PSFB
  - PFC stages
  - Flybacks/forwards
  - Buck-boost, sepic
  - Inverters
  - Etc…



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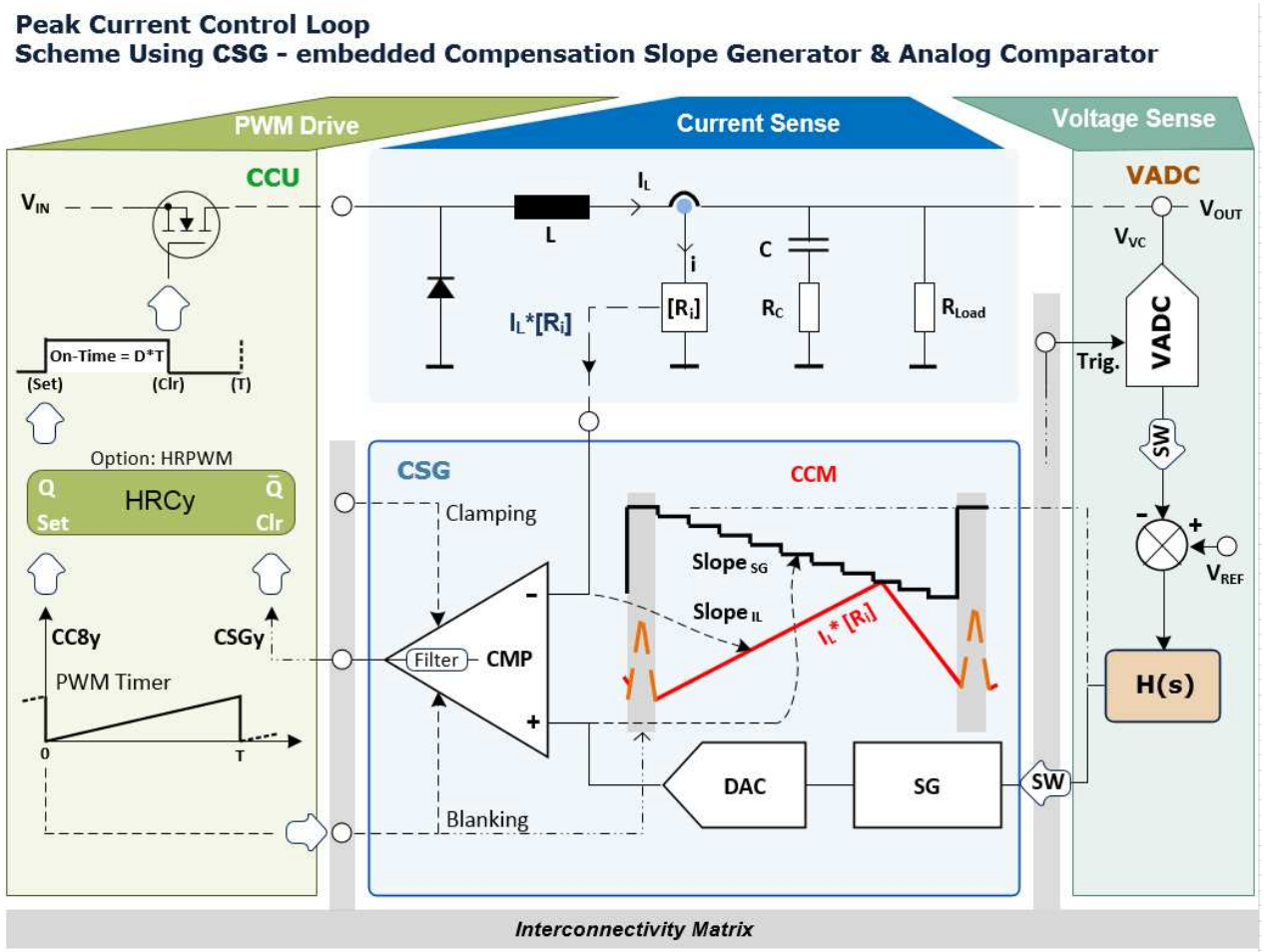
Smart analog comparators (3/3)

› Advanced peak current mode control is possible by making use of HRPWM peripheral, resulting in low CPU load

Internal DAC
10-bits resolution
30 Msamples/sec
Auto-waveform

Analog comp
20 ns bandwidth
Filtering/blanking/
clamping

Check XMC™ Digital Power Explorer



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Fast and flexible ADC and timers (1/4)

- In order to cover the exigent requirements of power supplies, it is needed to provide:
  - Flexible and safe PWM patterns
  - Fast ADC sampling
  - Flexible ADC sequencing and synchronization to PWM
  - Post processing of conversions including
    - Filtering (FIR/IIR), FIFO, subtraction (for offset compensation), etc.
  - Resolution in sampling signal and in PWM for accurate control:
    - 12-bits ADC
    - 150 ps resolution PWM in XMC™4 and 15,6 ns in XMC™1000

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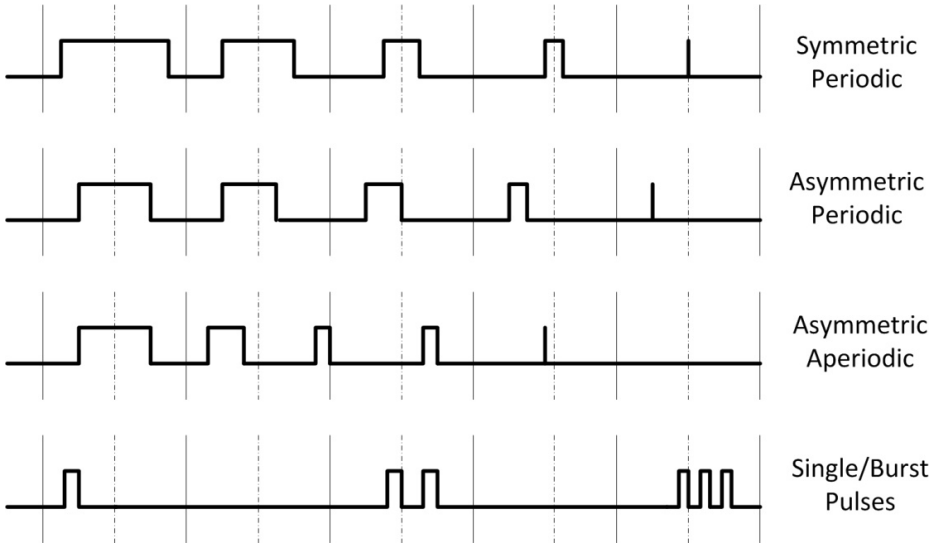
Fast and flexible ADC and timers (2/4)

- For power conversion continues and discontinues PWM signals have to be generated – switching between the two modes is needed to get efficiency over a wide load range
- CCU4/CCU8 supports any kind of pulse generation like
  - Asymmetric PWM
  - Aperiodic PWM
  - Single events and pulses
- CCU4/CCU8 can be controlled from external or internal events
  - External start/stop
  - Emergency trap
  - Override/modulation
  - Count gating
  - Capturing



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Fast and flexible ADC and timers (3/4)

- Multimode power supplies are very common in order to help with stringent requirements on THD, PF and efficiency at many different conditions of the load, input voltage and temperature
  - → The way the power supply is controlled varies depending on the load or the input voltage
- For example:
  - PFCs than change between CCM and CrCM when reducing the load and even to DCM when load is lower
  - Normal mode to burst mode in both ACDC and DCDC power supplies

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Fast and flexible ADC and timers (3/4)

- Main issue in this idea, is how to switch the control scheme
  - Usually controllers are specific for one or the other, making impossible this
  - Others can switch the mode but during switching, the PWM is unpredictable and can create overcurrent and overvoltage situations damaging permanently the system
- In order to support a seamless switch between modes, HRPWM peripheral introduces a new switch event based
  - This switch is connected to 2 different sets of timers and/or comparators that defines the 2 control schemes and links those to the output stage that is connected finally to the necessary pins
  - Should the event occur, then HRPWM peripheral will swap the set of timers and/or comparators connected to the output
  - In this way, the HRPWM will immediately and safely → synchronized to the PWM pattern, move to the alternate control scheme

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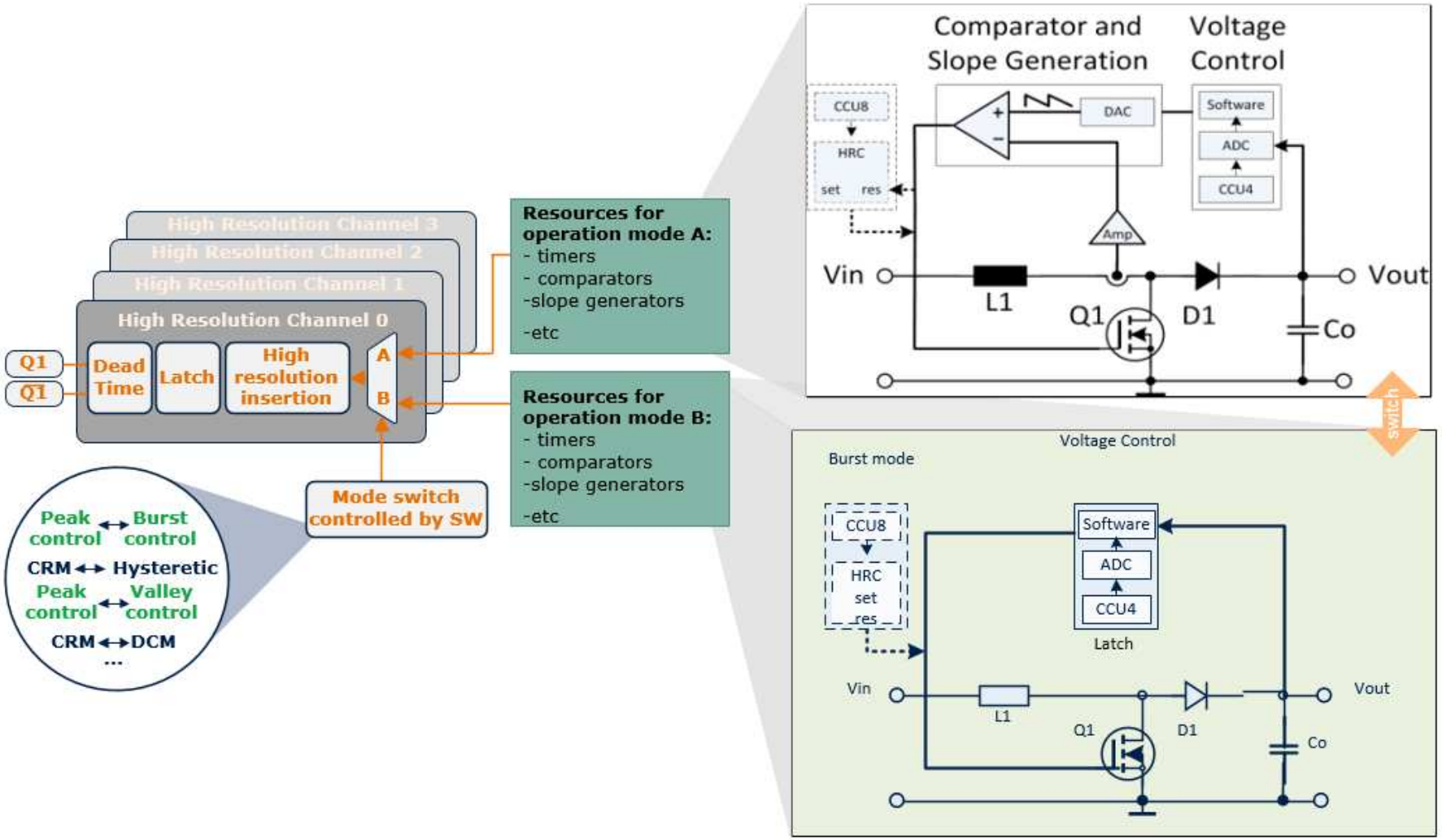
Fast and flexible ADC and timers (4/4)



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Additional features

- ERU module allows very flexible connections in the XMC™. This is helpful in cases such as:
  - Detect a peak current with a comparator and send the signal to a timer → usually signal is directly connected
  - But if the comparator signal needs to be OR-ed with another one, this can be done with the available logic functions in ERU module
- Serial communications, like I2C for PMBus™, and CAN supported

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Kits and reference design

Development boards		Order number/ISAR order (SP)	Kit/ demo
XMC™4200 digital power control card		**KIT_XMC4200_DP_CC_01** *SP001343128*	KIT
XMC™1300 digital power control card		**KIT_XMC1300_DP_CC_01** *SP001343134*	KIT
XMC™ digital power explorer		**KIT_XMC_DP_EXP_01** *SP001343072*	KIT
800 W PFC boost CCM XMC™1300		**EVAL_800W_130PFC_C7** *SP001360062*	DEMO
600 W LLC eval kit		**EVAL-600W-12V-LLC-D** *SP001293818*	DEMO
3 kW LLC dual phase XMC™4400 eval kit		**EVAL_3KW_2LLC_C7_47 (_20)** *SP001360064(/SP001360066)*	DEMO

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XMC™4200 digital power control card

Link to Web



Infineon components	
MCU	XMC™4200 (LQFP64)
Supply	IFX54441LDV IFX90121ELV50
ESD protections	ESD8V0L2B-03L
Debugger MCU	XMC™4200 (QFN48)

Key features:

- Detachable isolated Jlink debugger integrated and isolated UART to USB channel
- 8 PWMs outputs, 8 ADCs and 3 CMP inputs. 2 communication channels and up to 4 general purpose pins
- Only 28 mm height vertically fits 1U rack standards (without debugger part)

Customer benefits:

- Fast evaluation of XMC™ power conversion applications
  - No need to design debuggers, isolations, XMC™ supply concepts
- Same interface as other XMC™ control cards permit 1 to 1 comparison of different XMC™ devices in customer´s application

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XMC™1300 digital power control card

Link to Web



Infineon components	
MCU	XMC™1302 (TSSOP38)
Supply	IFX54441LDV
ESD protections	ESD8V0L2B-03L
Debugger MCU	XMC™4200 (QFN48)

Key features:

- Detachable isolated Jlink debugger integrated and isolated UART to USB channel
- 8 PWMs outputs, 8 ADCs and 3 CMP inputs. 2 communication channels and up to 4 general purpose pins
- Only 25 mm height vertically fits 1U rack standards (without debugger part)

Customer benefits:

- Fast evaluation of XMC™ power conversion applications
  - No need to design debuggers, isolations, XMC™ supply concepts
- Same interface as other XMC™ control cards permit 1 to 1 comparison of different XMC™ devices in customer's application

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XMC™ digital power explorer kit (1/2)

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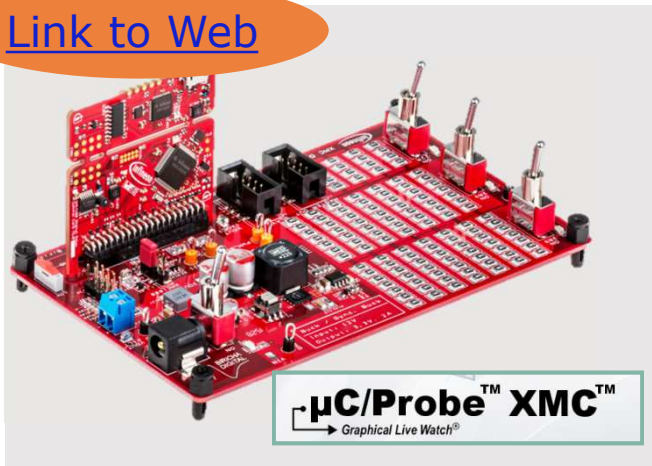

Specification	
V_{in}	12 V_{DC}
V_{out_nom}	3,3 V_{DC}
I_{out}	2 A
P_{out}	6 W

Infineon components	
MCU	XMC™4200 or XMC™1300
MOSFETs	OptiMOS™ BSC0924NDI
MOSFET HB Driver	IRS2011S (IRF)

Key features:

- Synchronous buck converter with XMC™4200 and XMC™1300 in collaboration with Biricha and Würth Elektronik
  - To be used in Biricha trainings
- Different control schemes possible
  - Voltage mode control
  - Peak current mode control

Customer benefits:

- Learn digital control with XMC™ by the hand of Biricha
- Understand the advantages of voltage/ peak current control and how to extract the maximum of XMC™ devices
- Compatible with XMC™4200 and XMC™1300 dig. power control cards

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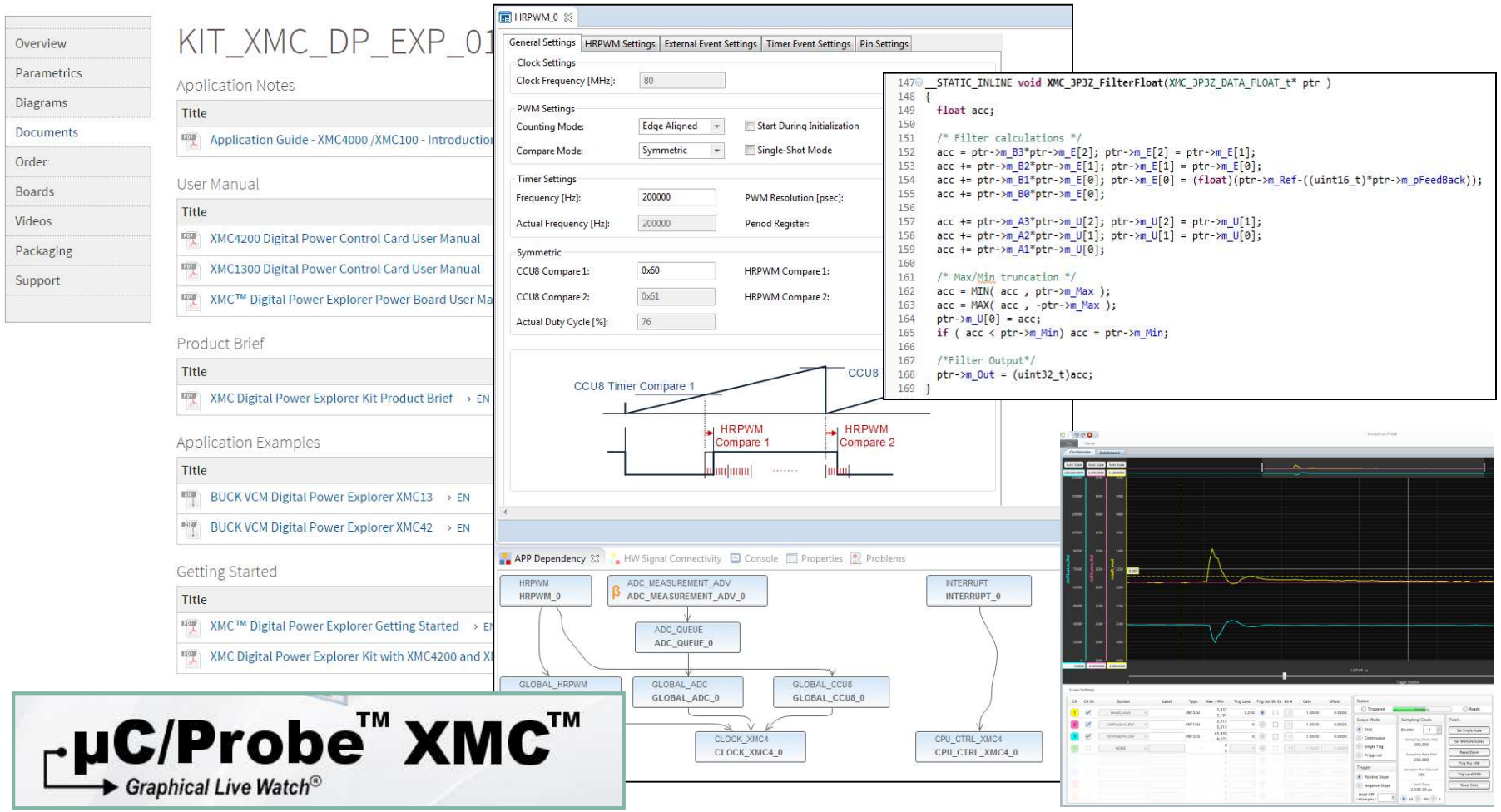
XMC™ digital power explorer kit (2/2)

- Website populated with plenty of support material



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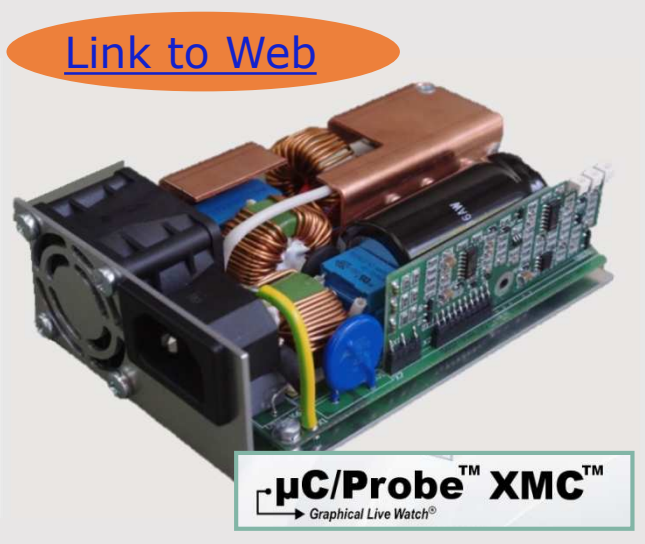
Digital power
800 W PFC boost CCM with XMC™1302



Specification	
V_{in}	90-265 V_{AC}
V_{out_nom}	380 V_{DC}
I_{out}	2.1 A
PWM freq	130 kHz
THD	<10%
Power Factor	>0.9 from 20% load
Efficiency	>96% from 20% load

Infineon components	
MCU	XMC™1302 (TSSOP38)
MOSFET	CoolMOS™ C7 600 V
MOSFET driver	2EDN7524F non isolated
Diode	SiC Gen 5 650 V
Auxiliary PSU	ICE2QR4780Z

Key features:

- Classic PFC boost stage digitally controlled with XMC™1302 including voltage and current loops
- Protections, including cycle by cycle current protection
- Run time debug with isolated UART to PC interface and PC software

Customer benefits:

- High efficient PFC stage with a complete system solution from Infineon
  - HW and SW available
- Use MATH co-processor to accelerate calculations like divisions
- Higher switching frequency permits higher power density

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600 W LLC digital control with XMC™4200

Link to Web



Specification	
V_{in}	350-410 VDC
V_{out_nom}	12 VDC
I_{out}	50 A
P_{out}	600 W
Peak eff.	97.8% @ 50% load
Eff.	>95% @ 10% load

Infineon components	
MCU	XMC™4200 (VQFN48)
MOSFET SR	BSC010N04LS
HB driver	2EDL05N06PF
LLC HB MOSFET	CoolMOS™ IPP60R190P6
Auxiliary PSU	ICE2QR2280Z

Key features:

- 600 W LLC half bridge stage with Sync Rectification (SR)
- All controlled with XMC™4200 including:
  - Adaptive dead time and capacitive mode detection
  - No hard commutation at any condition

Customer benefits:

- Learn LLC topology with a complete system solution from Infineon
- Close to customer solution
  - High efficiency → 97,8%
  - Reliability and power density

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3 kW dual phase LLC converter using XMC™4400

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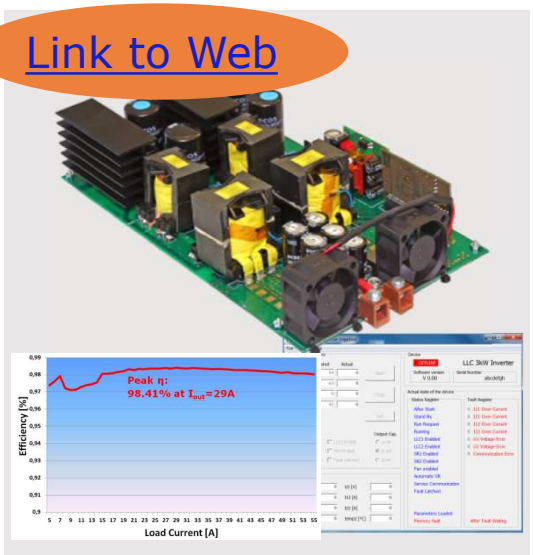

Specification	
V_{in}	350-410 V_{DC}
V_{out_nom}	54,3 V_{DC}
I_{out_max}	55 A
P_o	3 kW
Peak efficiency	>98,5%
Efficiency	>97.2% in all load range

Infineon components	
MCU	XMC™4400 (LQFP64)
MOSFETs SR	OptiMOS™ 5 BSC093N15NS5
Gate drivers	2EDN7524R 1EDI60N12AF
LLC MOSFET	CoolMOS™ P6/C7- IPP(W)60R040C7
Auxiliary PSU	ICE2QR2280Z

Key features:

- 3 kW dual phase LLC with Sync Rectification
  - **Full digital control by XMC™4400 on secondary side**
  - Digital current sharing with phase shedding
  - Accurate algorithm able to prevent hard commutation and capacitive load mode in LLC operation

Customer benefits:

- Highly sophisticated HW and SW design available → very flat efficiency curve
  - Efficiency peak 98.5% and >97.2% in the entire load range thanks to current balancing algorithm (Cortex® M4 core at 120 MHz)
  - Improved performance thanks to adaptive dead time implemented with HRWPM

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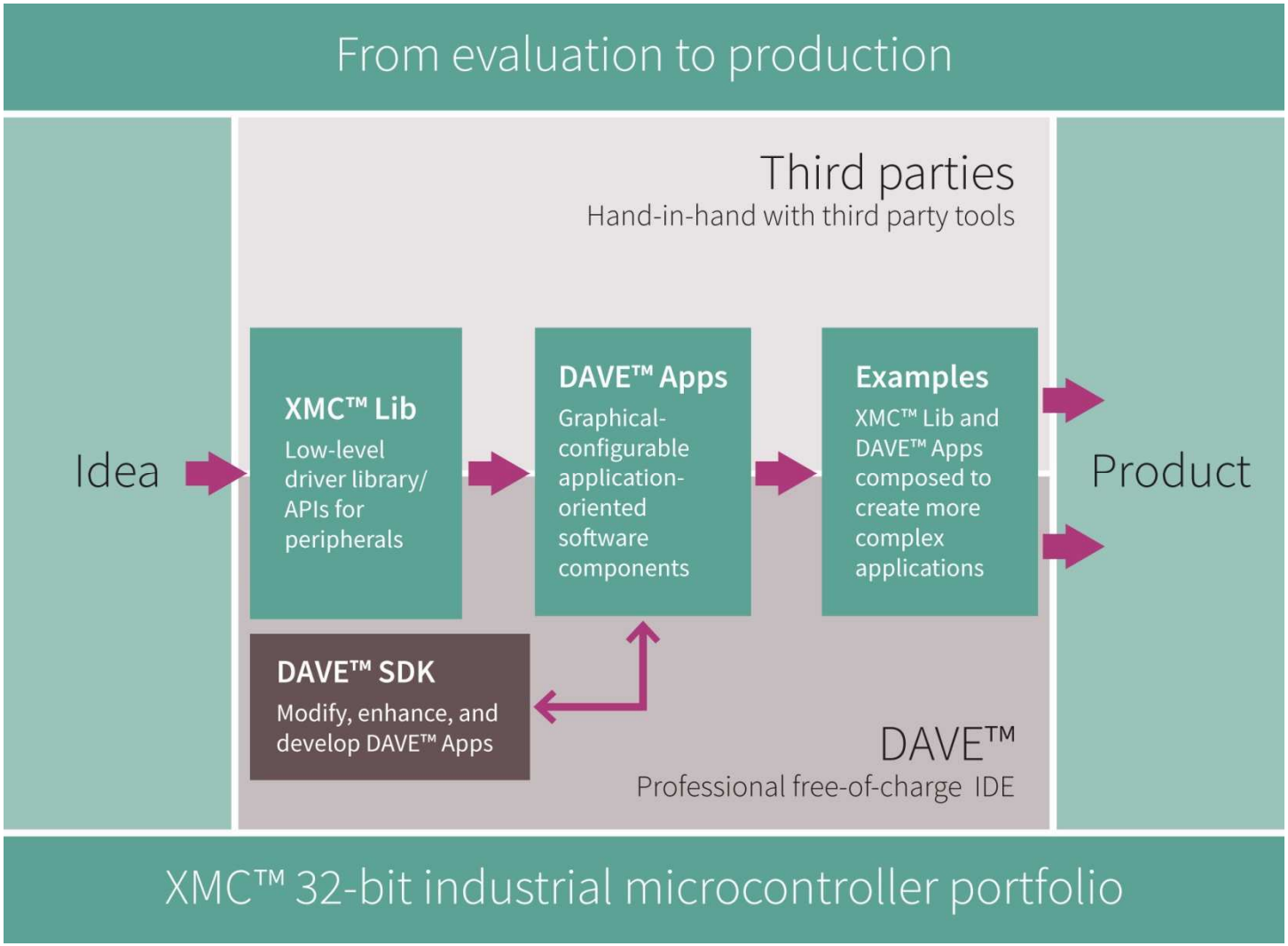
Development tools and software
DAVE™– software development made easy



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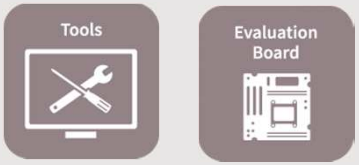
Support material

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 	– Technical Videos – Product Information Videos	– Infineon Media Center – XMC Mediathek
Contact 	– Forums – Product Support	– Infineon Forums – Technical Assistance Center (TAC)

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Glossary abbreviations

VADC	Versatile Analog Digital Converter
CCM	Continuous Conduction Mode
CMP	Comparator
DAC	Digital to Analog Converter
DAVE™	Free development IDE for XMC™
HRPWM	High Resolution PWM
LLC	Power stage topology built with 2 inductors (L) and 1 capacitor (C)
PFC	Power Factor Correction
PWM	Pulse Width Modulation

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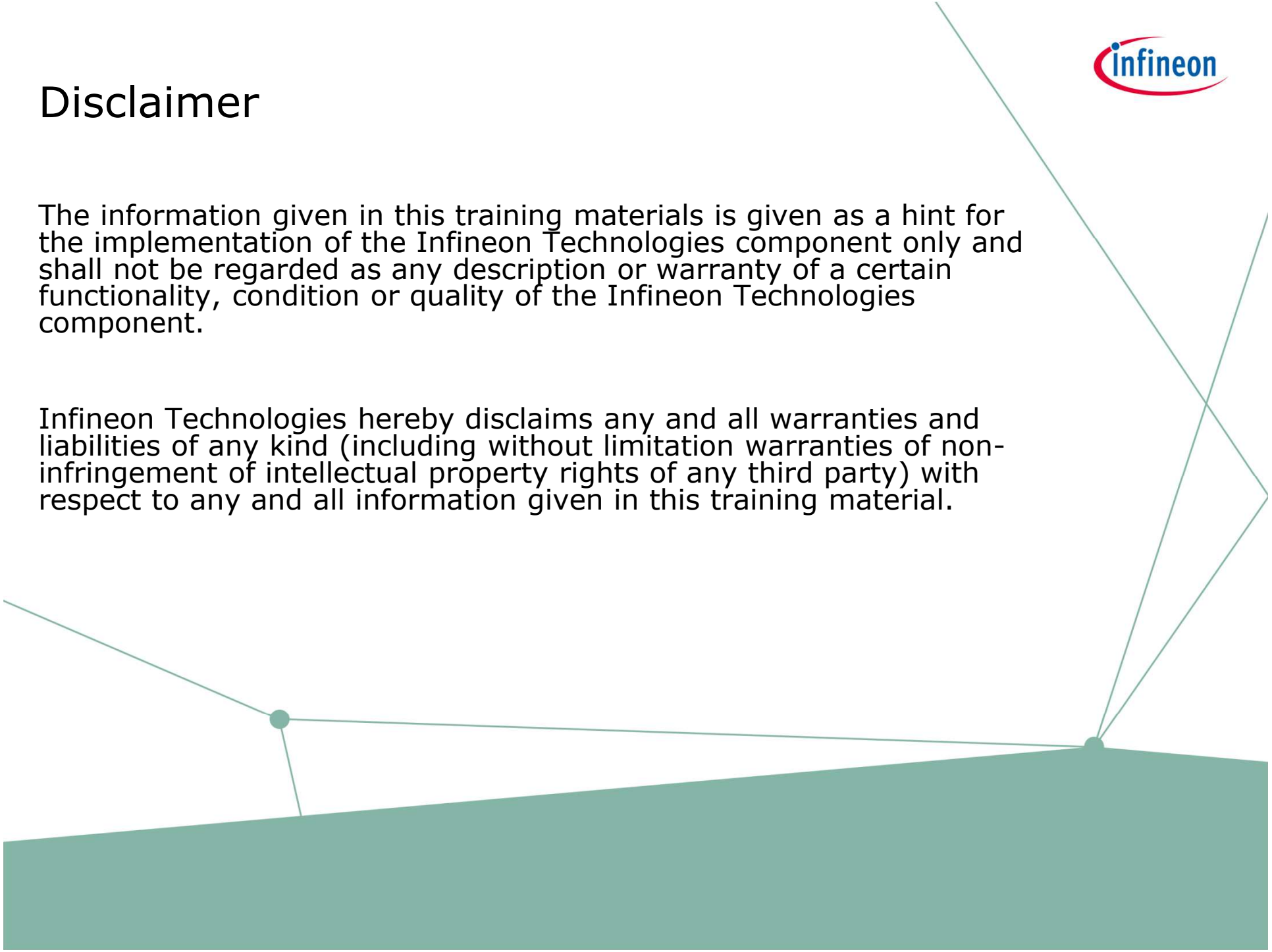



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