XMC
The Industrial and Multimarket MCU

March 2015

Rev 1.2

XMC - Key Segment Care Abouts

Factory Automation

- High through-put and up-time
- Remote monitoring
- Reliability & Quality
- Lifetime
- Security & Safety
- Interoperability

Power & Energy

- Energy efficiency
- Robustness for harsh environment
- Up-time

Trans-portation

- Robustness for harsh environment
- Functional safety
- Reliability and quality
- Lifetime

Building Automation

- Energy efficiency
- Ease of use
- Remote monitoring
- Appealing design and form factors
- Interoperability

Home & Professional

- Form factor, size and weight
- Platform concept
- Copy protection
- Fast ramp-up

XMC Family / DAVE™

XMC - Key Segment Differentiators

Factory Automation

- Fast execution
- Powerful sense and control
- Industrial connectivity
- Memory interfaces
- Flash with ECC
- -40 to 125°C

Power & Energy

- High-Resolution PWM
- Powerful sense and control
- Industrial connectivity
- Flash with ECC
- -40 to 125°C

Trans-portation

- Flash with ECC
- -40 to 125°C
- Fast execution
- Scalability
- Shipping till 2027

Building Automation

- Flicker-free LED dimming
- Robust sensor-less motor control
- Flexible serial communication

Home & Professional

- Low pin count packages
- Software IP protection
- Software compatibility
- DAVE™ Apps shorten development time

XMC Family / DAVE™

XMC – Basic Facts

XMC1000

System
- ARM® Cortex™-M0, 32MHz
- 8KB to 200KB Flash
- 16kB RAM
- up to 40pin packages

Highlights
- 64MHz MATH Co-processor for advanced control loops (CORDIC / DIVIDE)
- Advanced PWM and Timers
- Rich serial communication including SPI, UART and I2C
- LED color control engine for automatic RGB mixing and flicker free dimming
- Position Interface for motor control applications

Operating Conditions
- Temperature: up to 105°C
- Voltage: 1.8 to **5.5V**

XMC4000

System
- ARM® Cortex™-M4, up to 120MHz
- DSP and Floating Point Unit (FPU)
- Up to 1 MB Flash with ECC
- Up to 160kB RAM and 4kB Cache
- FPU and up to 12ch DMA
- up to 144pin packages

Highlights
- Advanced PWM, Timers and four 12-bit ADC with 3.5Msps for efficient drives
- High-resolution PWM and control logic for digital power applications
- ΔΣ-Demodulator to save an ASIC
- Real-time optimized and powerful peripherals working autonomously
- Complete set of industrial standard connectivity peripherals including Ethernet, USB, SD/MMC, CAN, SPI, UART, I^2C

Operating Conditions
- Temperature: **up to 125°C**

XMC - Key Segment Differentiators

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**

+ **140MHz 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**

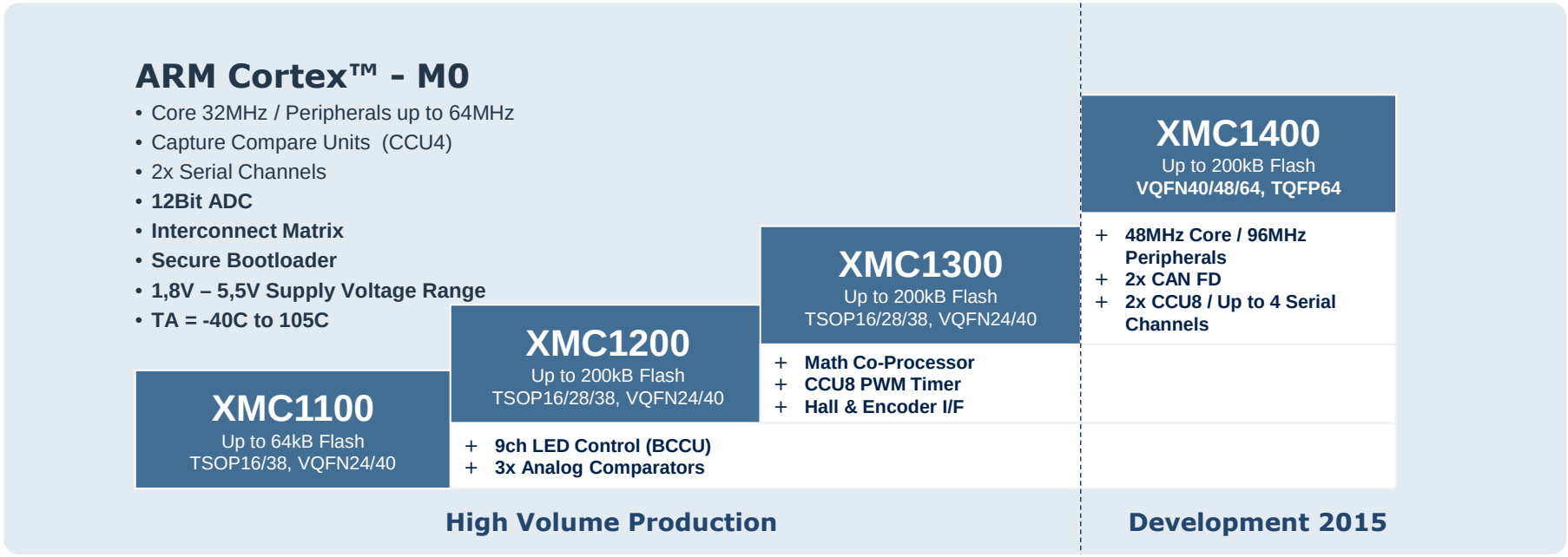
XMC1400
Up to 200kB Flash
VQFN40/48/64, TQFP64

+ **48MHz Core / 96MHz Peripherals**
+ **2x CAN FD**
+ **2x CCU8 / Up to 4 Serial Channels**

High Volume Production

Development 2015

XMC MCUs powered by ARM® Cortex™-M0
– One Microcontroller Platform. Countless Solutions



PRODUCT DIFFERENTIATORS

MATH co-processor

speed up your arithmetic calculations by up to 94% - enables FOC motor control

Event Request Unit (ERU)

enables interconnection between analog, PWM and sensor interface peripherals

High-performance analog comparators

with 30ns propagation delay, enables zero current crossing detection for AC/DC PFC.

Supply Voltage Range

wide Supply Voltage Range from 1.8V – 5.5V

Secure boot loader

embedded code can be programmed to flash memory in a protected way using AES 128-bit cryptography. Protect IP if manufacturing is outsource

XMC MCUs powered by ARM® Cortex™-M4
– One Microcontroller Platform. Countless Solutions

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

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

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Up to 1MB Flash / 160kB RAM
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+ **EBU**
+ **SD Card**

High Volume Production

XMC4700
Up to 2MB Flash / 352kB RAM
TQFP100 / TQFP144 / **BGA196**

+ **140MHz Core**
+ **6ch CAN FD**

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

+ **Industrial Connectivity**

Development 2015

PRODUCT DIFFERENTIATORS

125°C ambient temperature

for highest robustness in harsh environments.

Event Request Unit (ERU)

enables interconnection between analog, PWM and sensor interface peripherals

Flexible Timers / ADCs and Position Interfaces

enable deterministic behavior and full application control.

Delta Sigma demodulator

with integrated filters for **cost- and size-efficient** galvanic isolated current measurement.

Extended Technology Life Time

allows continues up time of 20a@110C

XMC – Areas of Competence

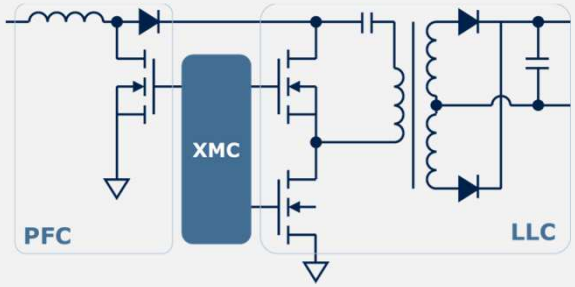
Factory Automation	Power & Energy	Trans-portation	Building Automation	Home & Professional
				
				
				
				
				

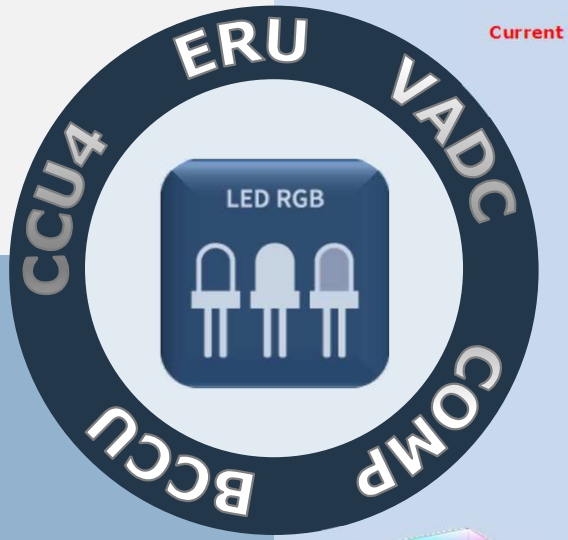
XMC1000 Lighting

be flexible without hurting system costs…

Lighting Power AC/DC Stage

- Fast analog comparators (30ns propagation delay)
- Event Request Unit (ERU) enables peripheral interconnection
- Flexible use of CCU4 (Timer module with 4 independent Timer Slices) as power converter control timer





Smart Lighting

Offloading the CPU by Integrated Hardware Control Unit for LED control allows adding communication and sensor control within the same MCU.

DALI √

DMX512 √

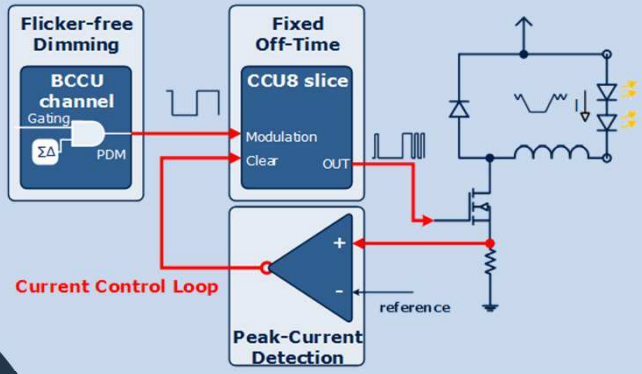
RF
with external PHY

Motion Sensors

Ambient light sensing

√Software stack available

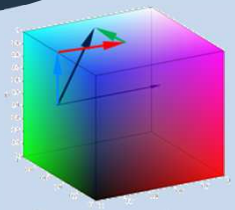
Adaptive LED control schemes



Support of **different topologies** (DCDC, Linear, …)

High frequency brightness modulation (PDM) results in completely **flicker free dimming**

Automatic exponential dimming results in smooth and natural level or color changes → **human eye friendly**



Automatic smooth color change
Straight transition in the orthogonal color space (e.g. RGB)

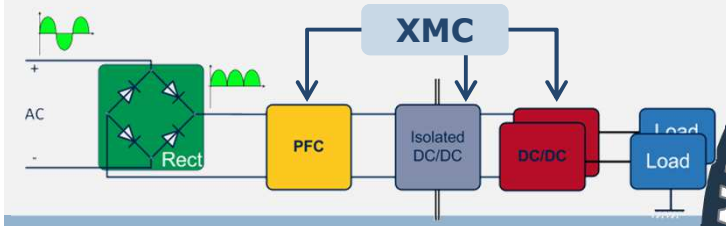
Everything in Hardware → CPU offload + Code Space Savings

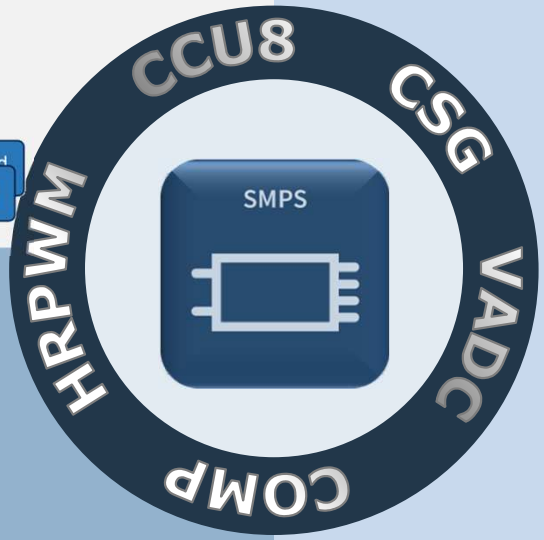
XMC1000/4000 Power Conversion

flexibility and high efficiency at any load condition…

XMC supports many Digital Power Conversion topologies/techniques

- PFC control: CCM/CrCM/DCM/valley QR…
- DC/DC: Buck, boost, flyback, LLC, LCC, ZVS-PSFB (+synchronous rectification)
- AC/DC: PFC+LLC, PFC+Buck
- DC/AC: Solar inverters, UPS





Communication and sensing

Use XMC's extra bandwidth and communication interfaces to enhance SPMS systems by adding communication and sensor control capability.

DALI √

DMX512 √

PMBus *

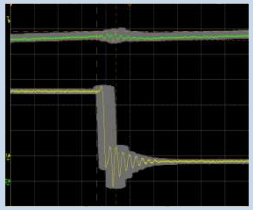
Motion Sensors

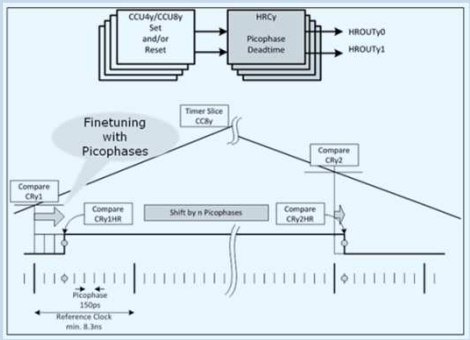
Ambient light sensing

*Limited software stack available

√Software stack available

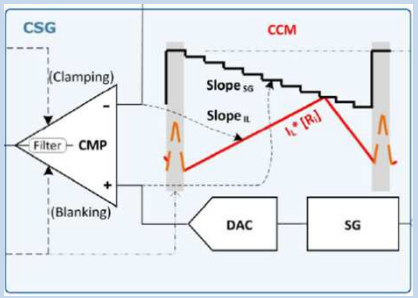
High Resolution PWM Module





HRPWM with 150ps resolution allows for reaching analog control performance with all the flexibility of digital control

CSG Module



Easy **Peak Current Control mode** with **CSG Module:**

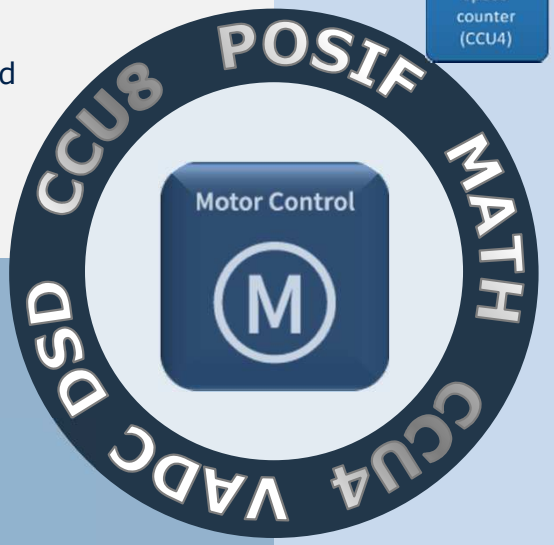
- Integrated slope compensation circuitry
- Integrated Blanking, Filtering and Clamping circuitry

XMC1000/4000 Motor Control

beyond standard core…

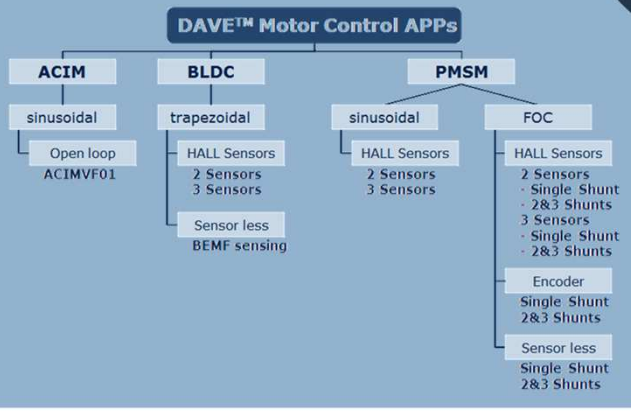
Dedicated Motor Control peripherals for various control and feedback schemes

- Fast and sophisticated 12-bit ADC (up to 2MSPS)
- Position Interfaces for HALL sensors, incremental encoders and resolvers for higher integration
- PWM unit tailored for sinusoidal and trapezoidal commutation pattern
- Event Request Unit (ERU) enables interconnection between analog, PWM and sensor interface peripherals
- Ideal for FOC control, both low-end and high-performance

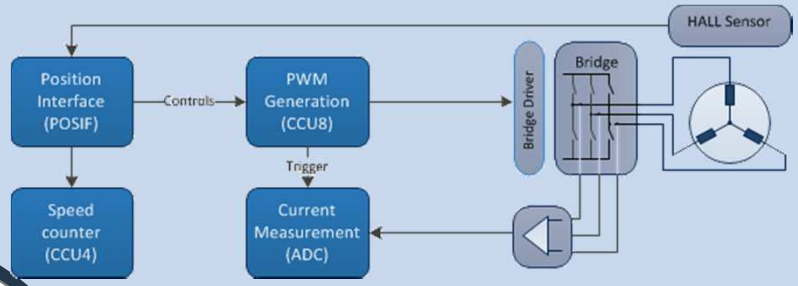


DAVE™ APPs Support

Comprehensive and growing APPs support for different types of motors and motor control schemes.



Robust and Intelligent Motor Control systems with XMC



BLDC Power Tools Block Diagram

Additional HW/SW features bring your Motor Control system to the next level:

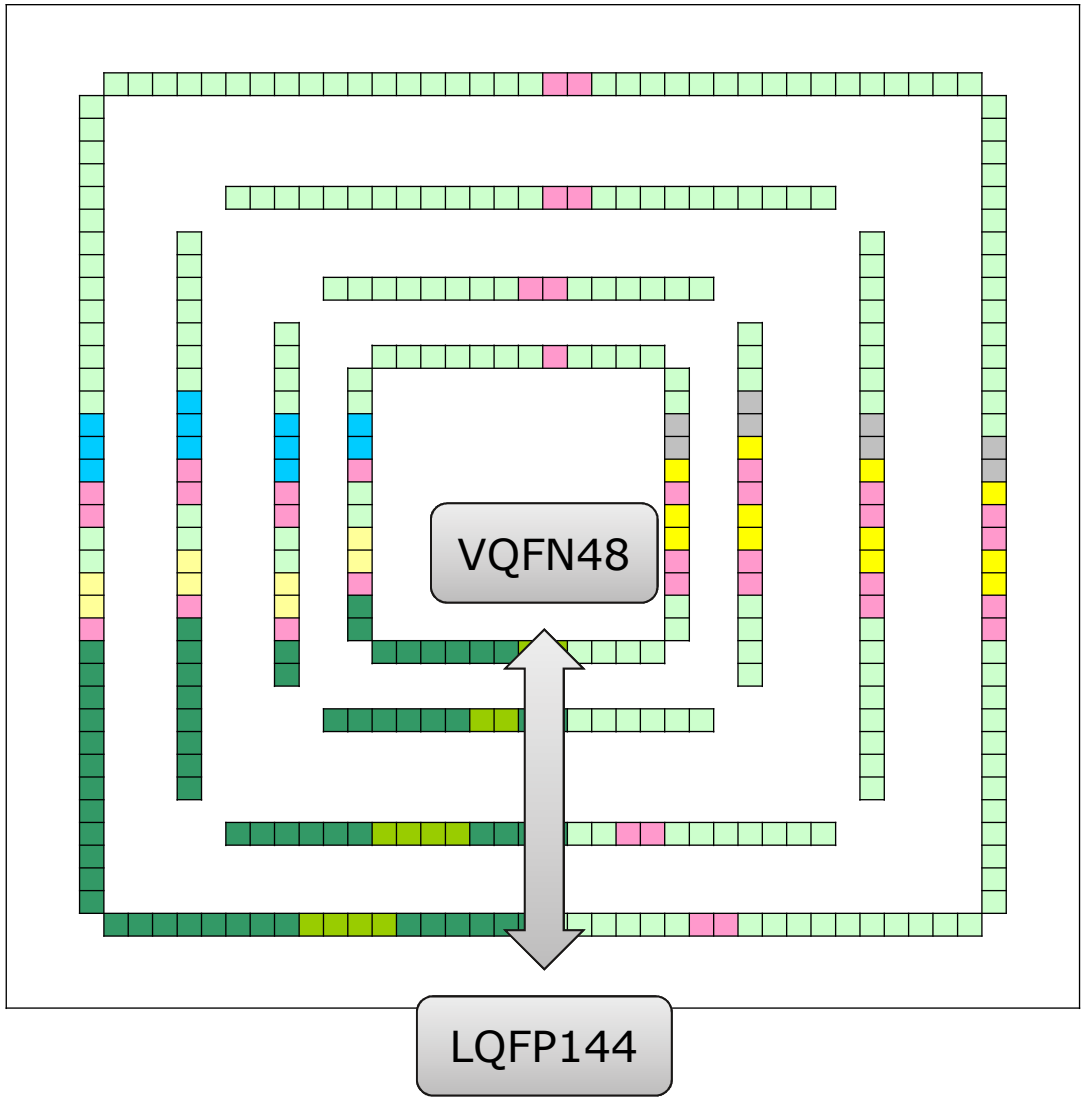
- Ethernet, CAN, CAN-FD (XMC1400) and serial communication
- Over-current Protection (OCP) and Overvoltage Protection (OVP) with fast reaction times using ADC Fast Compare mode (150ns conversion time)
- Over-temperature protection (w/ext. sensors)
- High temperature range (up to 125C, XMC4000) and automotive grade flash for most robust and reliable systems
- Sophisticated PWMs allow additional synchronous rectification to increase system efficiency

XMC4000 scalability
Pin Compatibility and Scalable Port Mapping

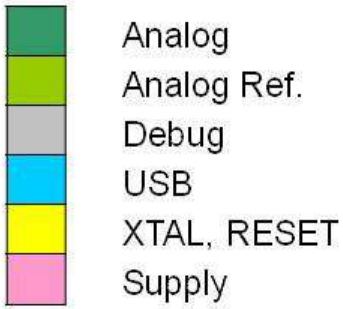
Clock	Flash	SRAM	VQFN48 (7x7)	LQFP64 (12x12) LFBGA64 *	LQFP100 (16x16)	LQFP144 (22x22)	LFBGA144 (10x10)	LFBGA196
144 MHz	2 MB	354 kB			XMC4800	XMC4800	XMC4800	XMC4800
144 MHz	2 MB	354 kB			XMC4700	XMC4700	XMC4700	XMC4700
120 MHz	1 MB	160 kB				XMC4500	XMC4500	
120 MHz	768 kB	160 kB			XMC4500			
120 MHz	512 kB	80 kB			XMC4400			
120 MHz	256 kB	80 kB		XMC4400				
80 MHz	256 kB	40 kB		XMC4200				
80 MHz	128 kB	20 kB	XMC4200	XMC4100				
80 MHz	64 kB	20 kB	XMC4100					

* Under definition

XMC4000 scalability
Scalable Port Mapping



- Late change during development & market introduction
- Easy layout generation for PCB variants with placement options

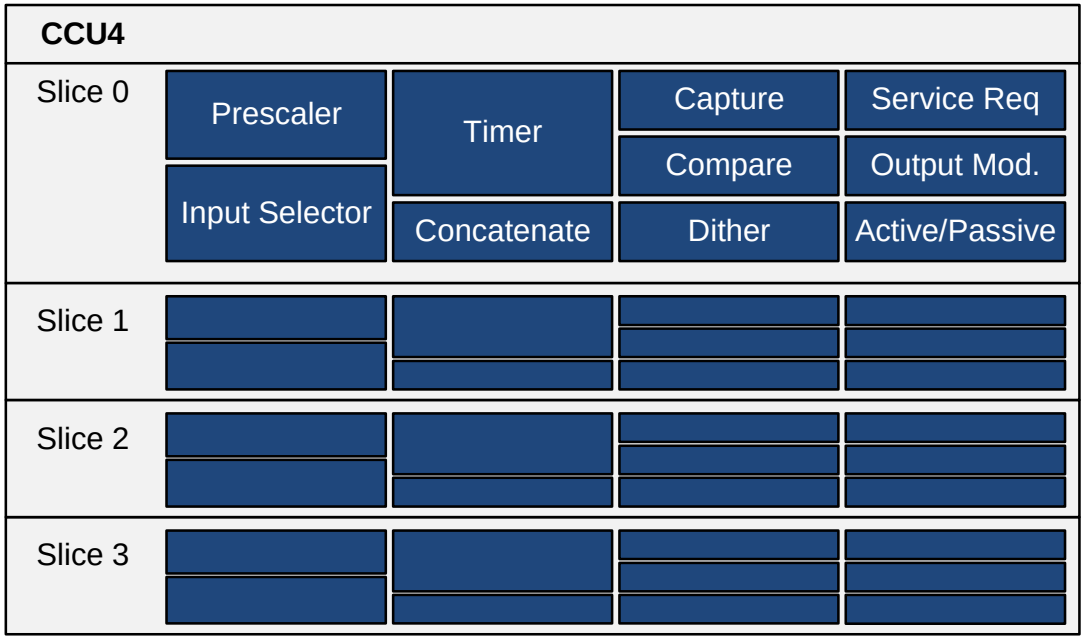


XMC4000 scalability
Scalable Port Mapping

- Extension of the XMC4500 144Ball LFBGA
- Overlapping ball out with XMC4500
  - The additional ball rows at the top and left side of the picture can be used for EtherCAT
- New Port 7/8/9 provides additional signals for USIC, CCU, CAN-FD

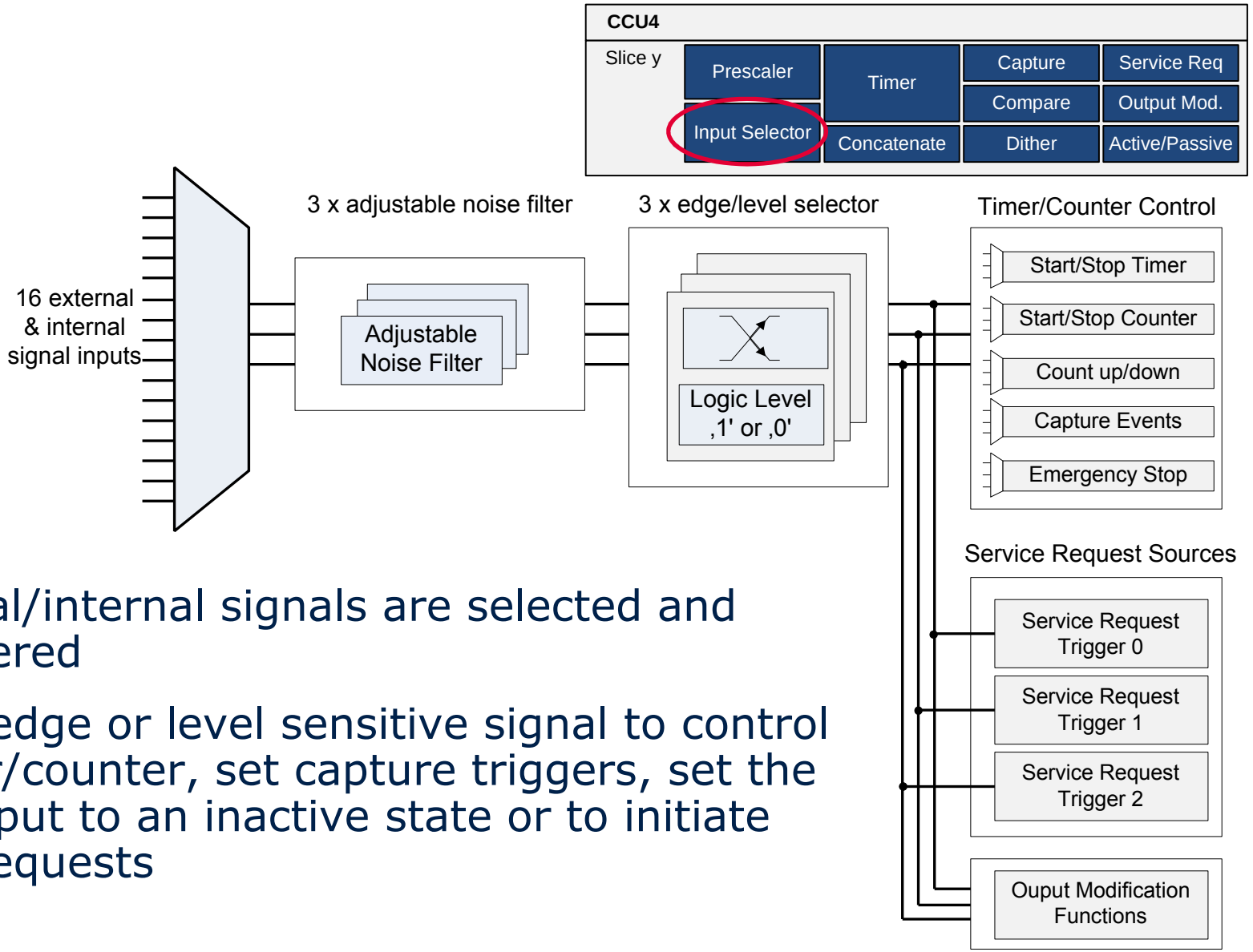
Multiple purpose timer module - CCU4

- Each CCU4 timer module comprises 4 identical timer slices
- Each timer slice comprises a
  - Prescaler to adjust the timer slice frequency
  - Input Selector for internal and external input signals
  - 16 Bit timer including concatenation to adjacent timer slices



- 4 Captures of the timer value
- Compare & Dither for PWM generation
- Service Requests to ERU and NVIC
- Output connection to pads

CCU4 – External and internal signals can control the timer behaviour, trigger an interrupt or set the output driver into a safe state

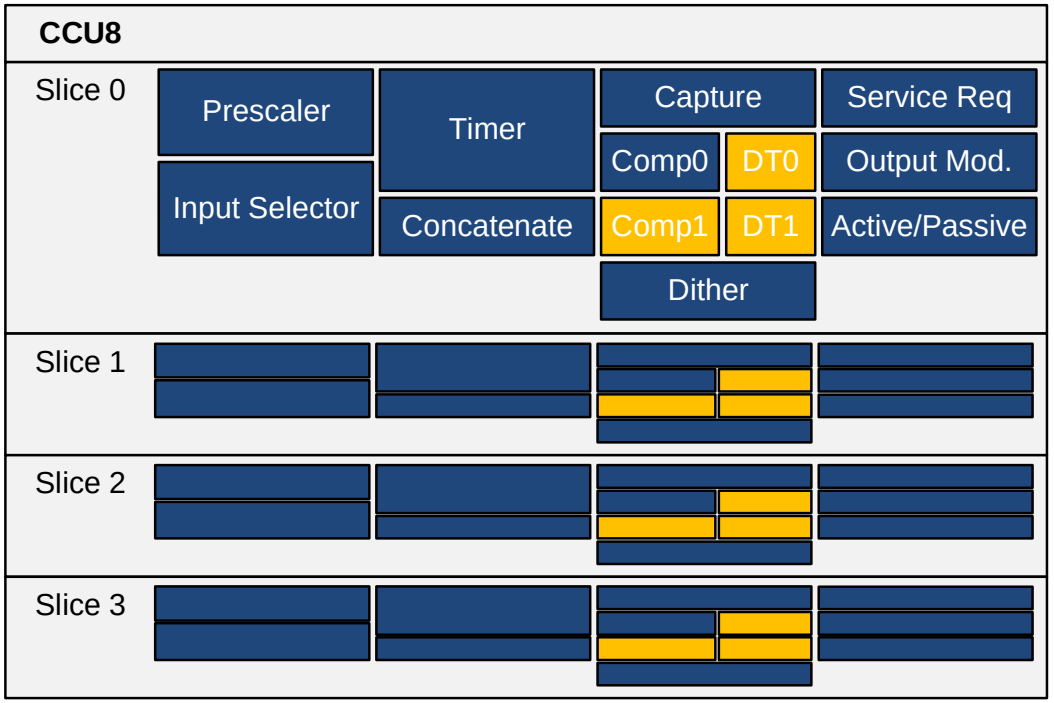


- 3 external/internal signals are selected and noise filtered
- Used as edge or level sensitive signal to control the timer/counter, set capture triggers, set the PWM output to an inactive state or to initiate service requests

Flexible PWM Generation– CCU8

- Flexible PWM Generation (Up to 32 PWM Outputs)
- Hardware Dead Time generation and Trap handling
- Simultaneous Duty Cycle update
- ADC/DSD Synchronization for noise free conversion

Minimal CPU Usage

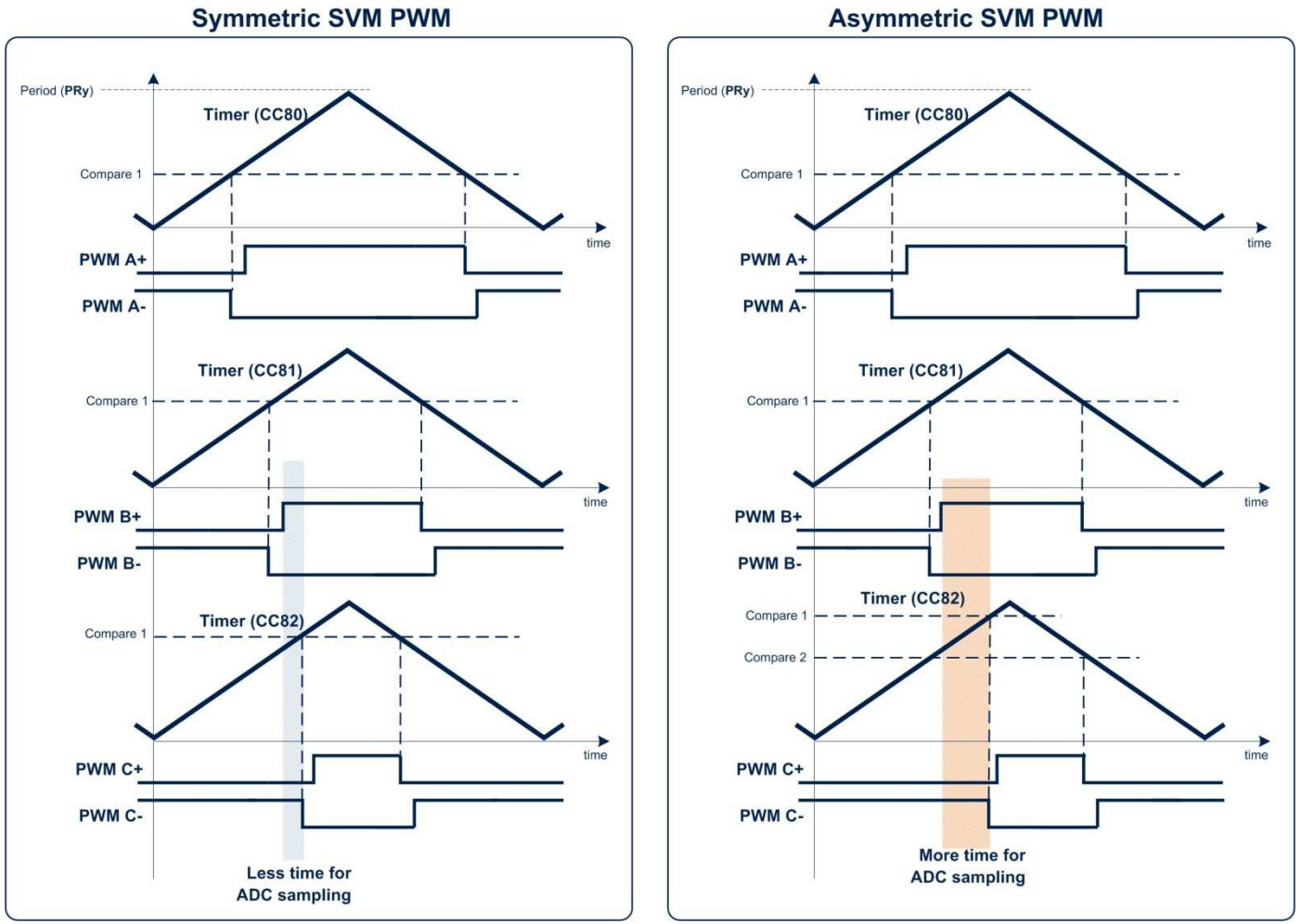


Application Example
PWM for Motor Control (2/3)

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.



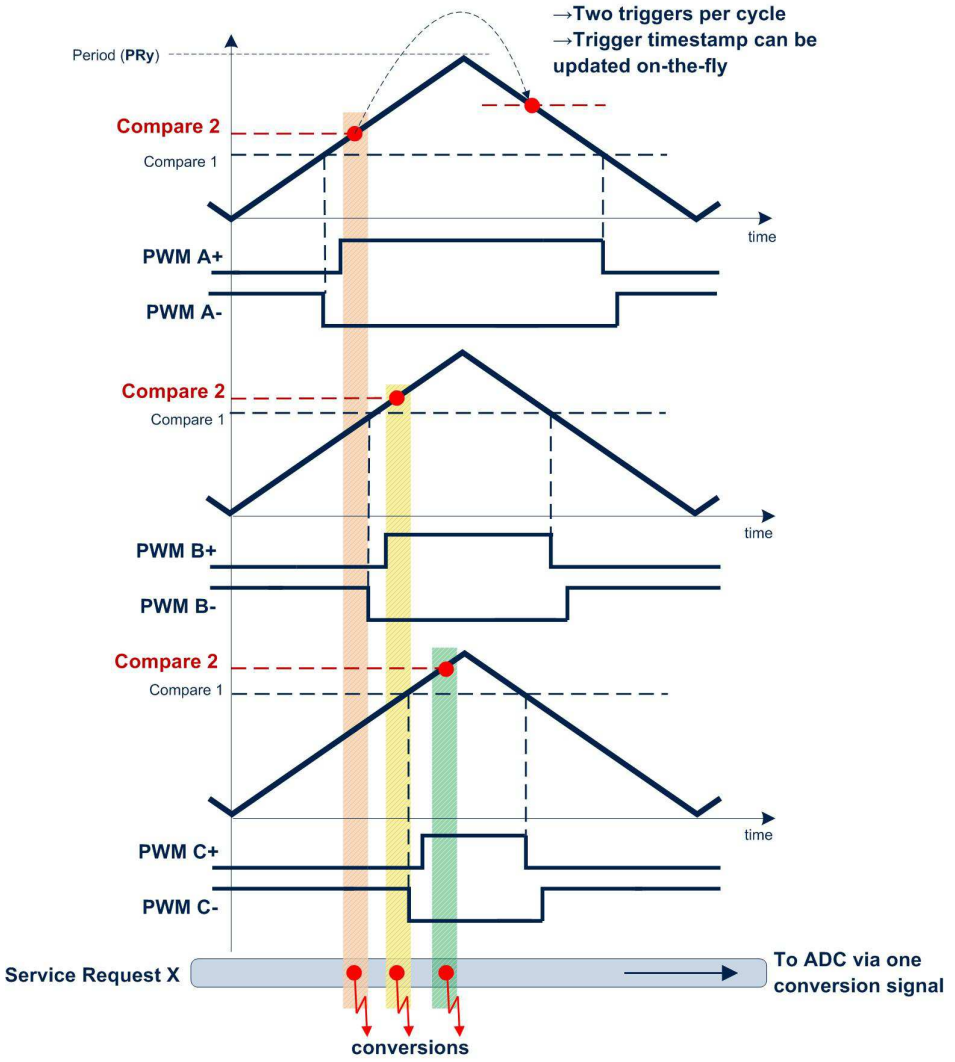
Application Example SVM Pattern Generation: Timing Diagram

Application Example
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.

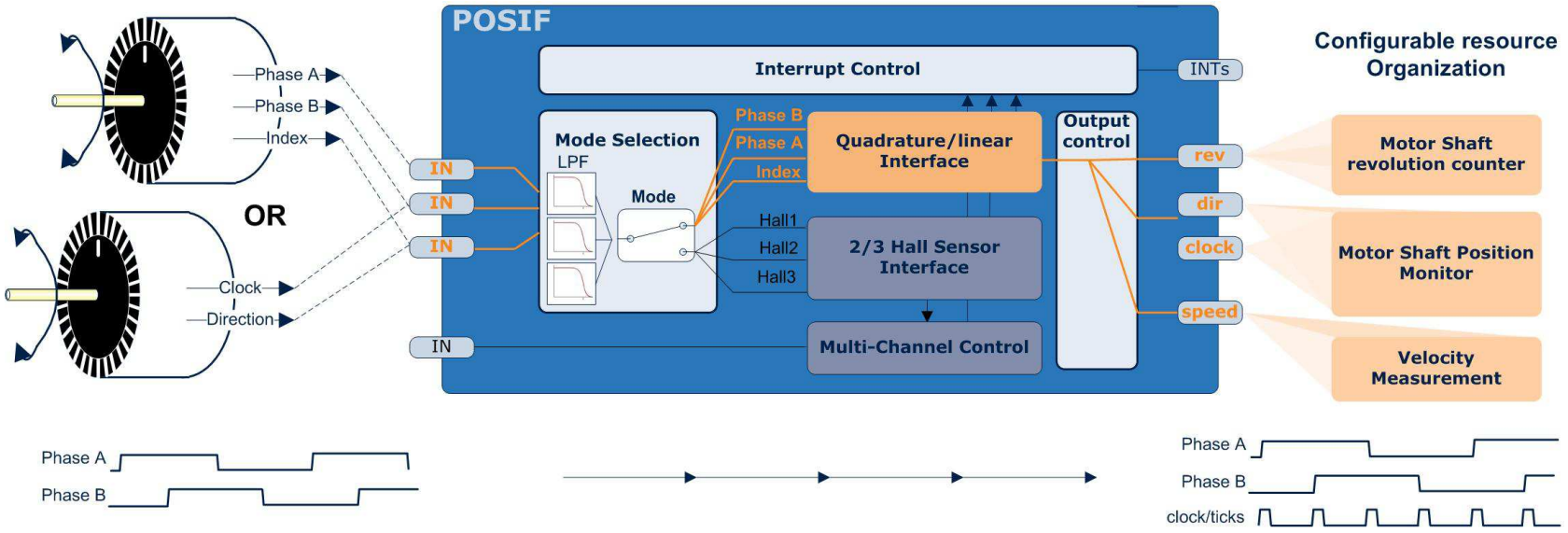
Additionally, **the conversion timestamp for the second 180° part of the signals can also be used to trigger a conversion**. This timestamp can be different from the first one.



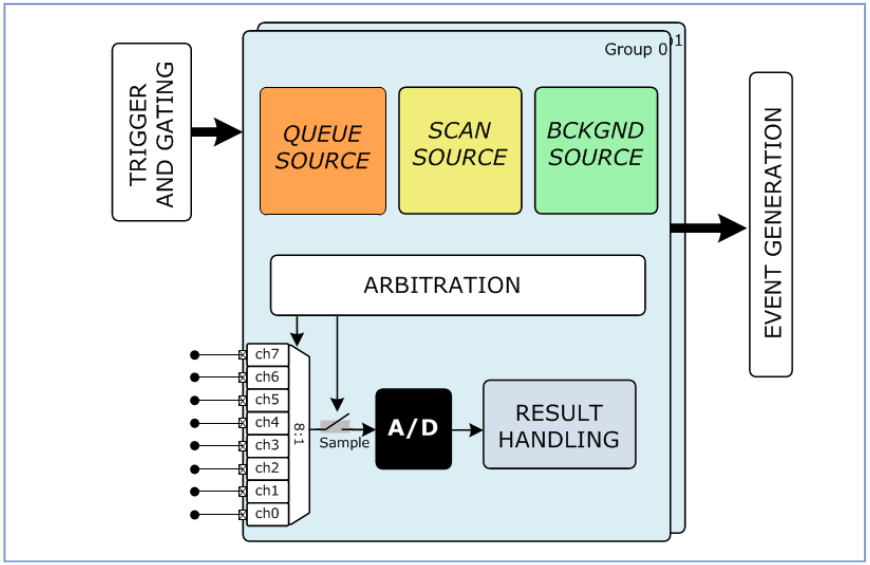
Application Example Grouped Conversion triggers: Timing Diagram

POSIF
Encoder Interface

- Linear or Quadrature Interface
- Input signal filtering
- Position monitoring (tick counting + direction)
- Velocity Monitoring (time between ticks or/and elapsed time for a number of ticks)
- Revolution Monitoring



VADC
Versatile Analog to Digital Converter (1/2)



Highlights

The VADC converts analog signals into digital values. Up to 12 bits resolution at 1 MSamples/sec enables highly accurate signal measurement for currents, voltages, temperatures, etc

Key Feature

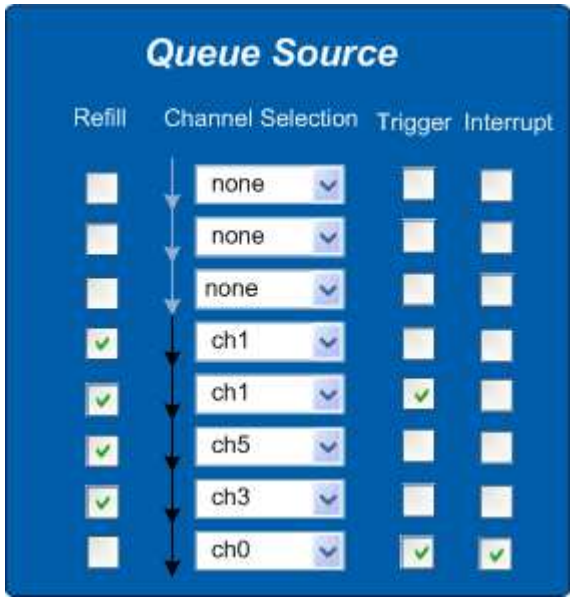
- Flexible sequencing scheme
- 2 independent sample and hold unit
- Triggering and gating conversions

Customer Benefits

- 3 sophisticated and flexible request sources for requesting conversions
- Simultaneous sampling
- External and deterministic triggering and gating of conversions

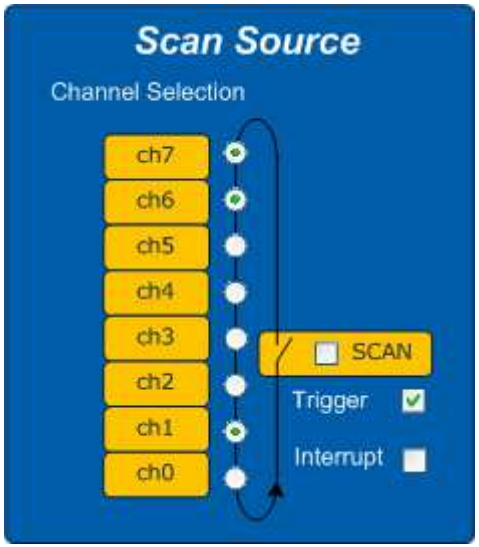
VADC
Flexible sequencing (1/2)

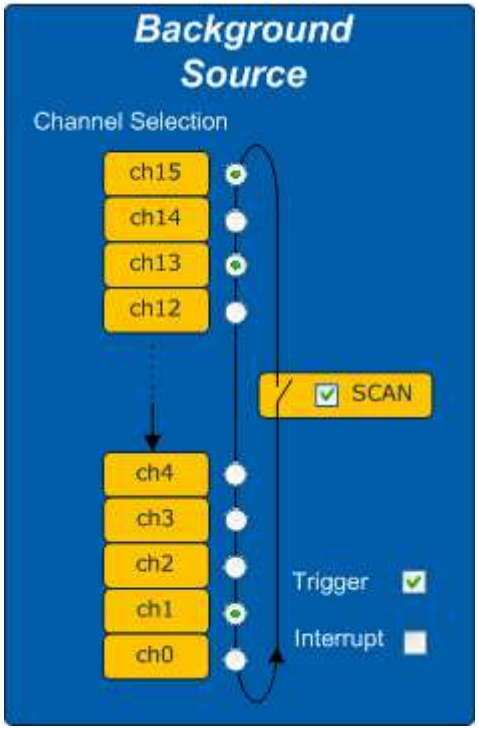
- 3 request sources allows a sophisticated sequencing
  - Queue source → up to 8 channels in 8 stages FIFO with any channel combination possible
  - Refill, source event generation and trigger can be configured individually for any entry in the queue

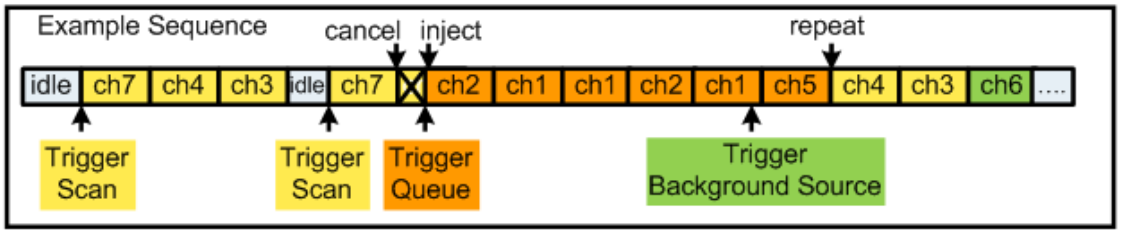


VADC
Flexible sequencing (2/2)

- Scan source → up to 8 channels. Converts from higher number selected until lowest channel number selected.
- Background source → a scan source that is able to request conversions in all channels in the microcontroller. It is typically the lowest priority source

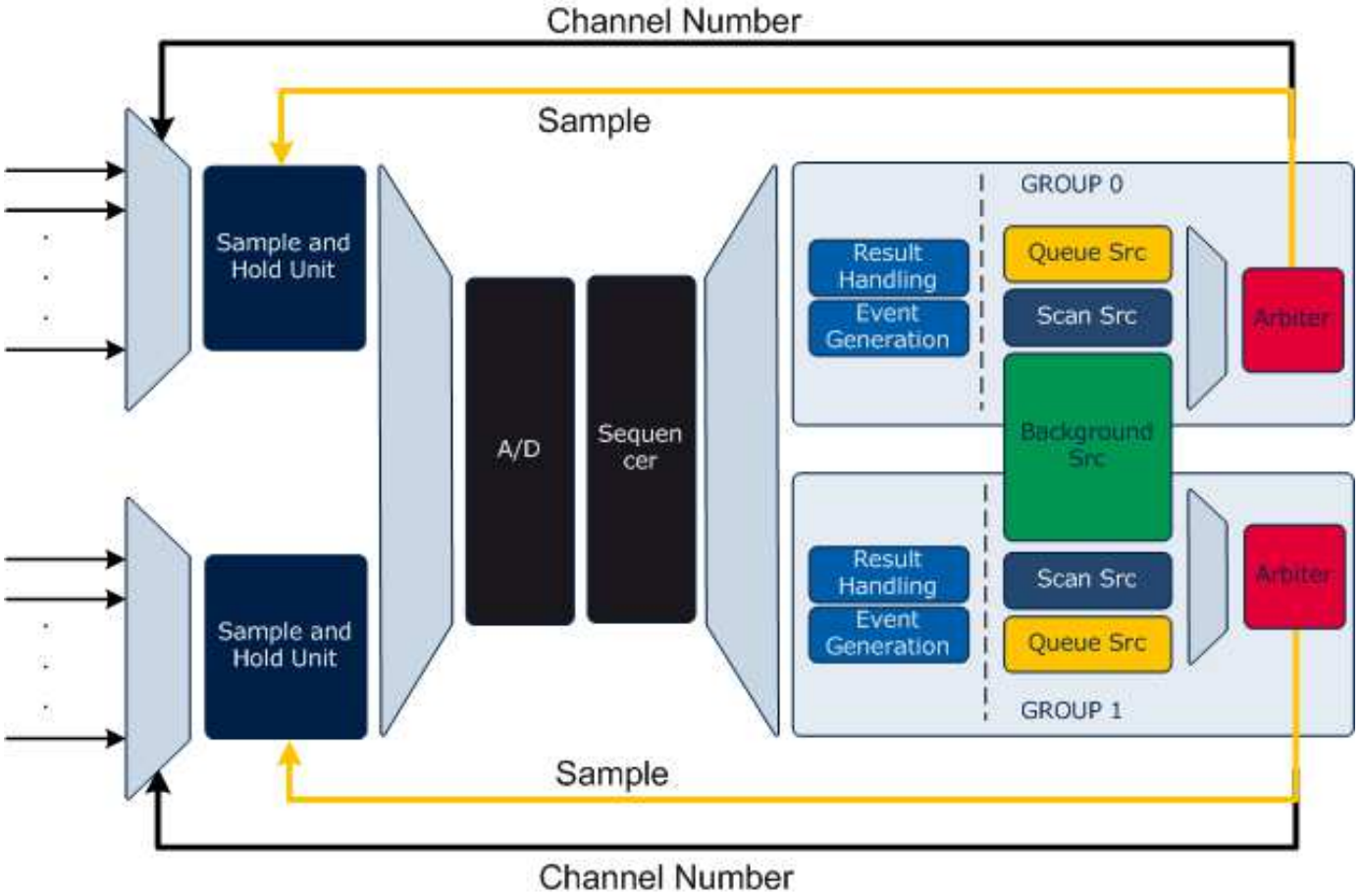






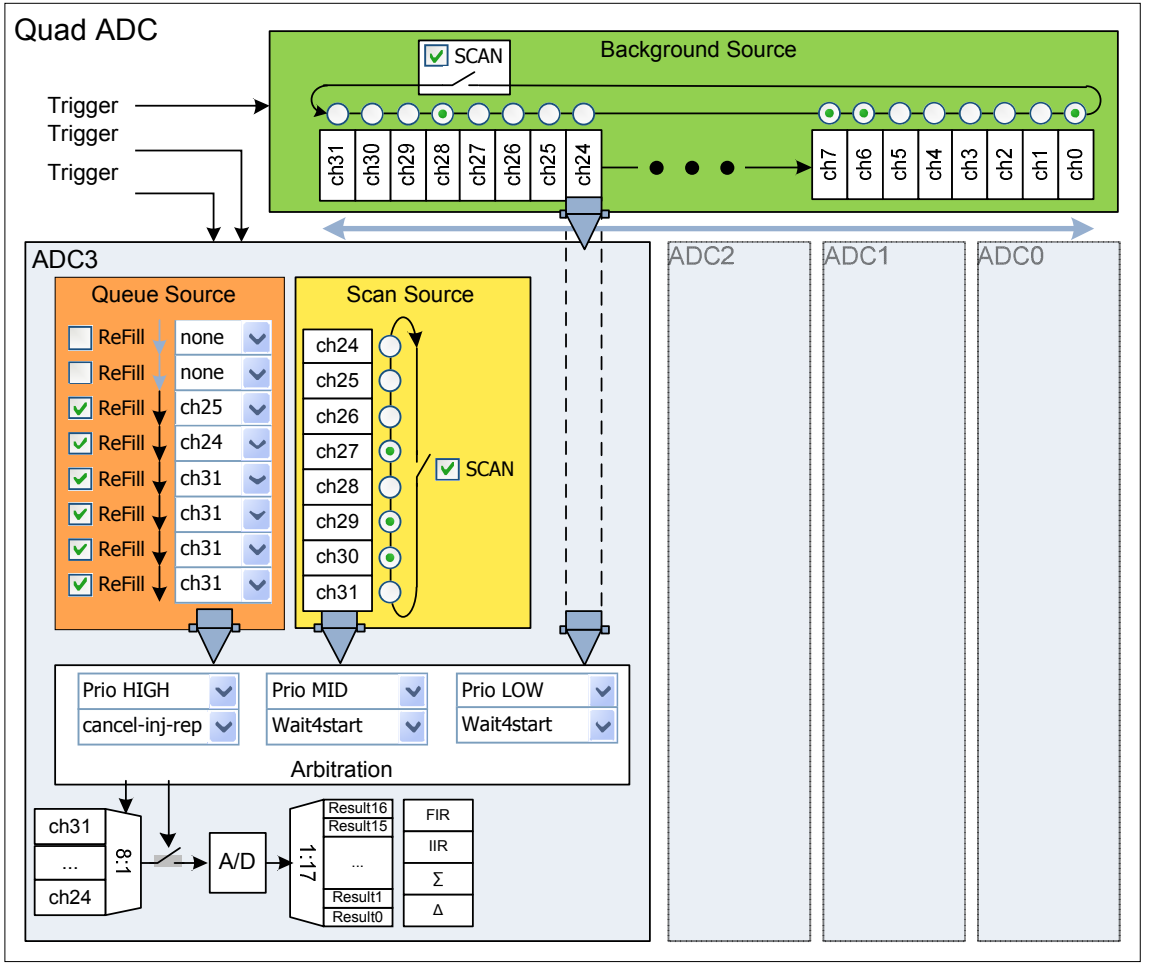
VADC
2 independent sample and hold units

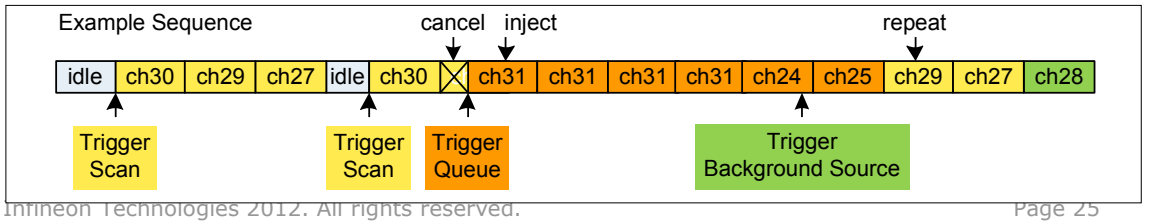
- The arbitration winner is sample in the A/D. The sequencer will recognize the group and will allocate in the corresponding result handling.



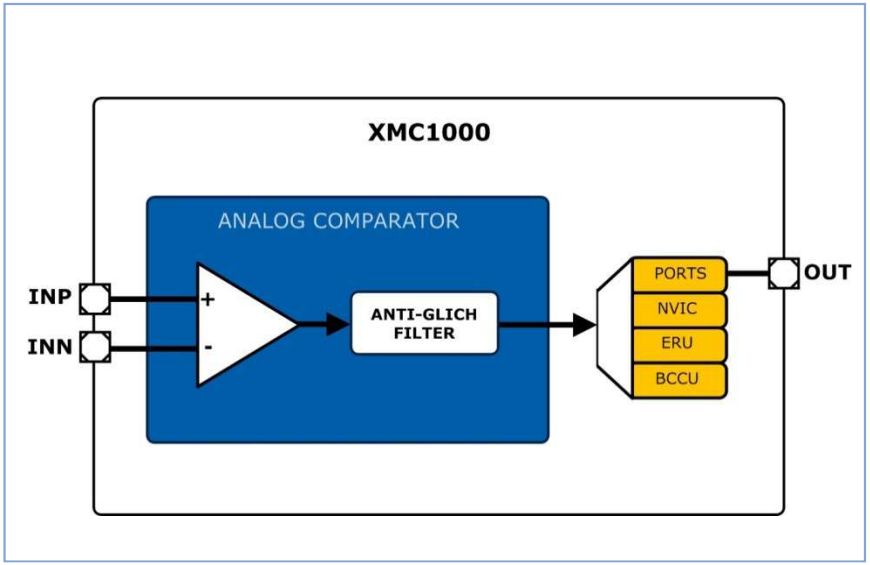
ADC: 3 trigger sources

- Queue Source
- Scan Source
- A Background Source
- Filtering for every adc
- Various priorities
- Sync in parallel or in a consecutive
- Boundaries for limit checking





ACMP
Analog Comparator



Highlights

XMC1000 provides up to three Analog Comparators.

Every analog comparator is realized with low input offset voltage (3mV) and short propagation delay (25ns).

The output signal can be routed to a port pin directly or used by the various peripherals of the MCU.

Key Feature

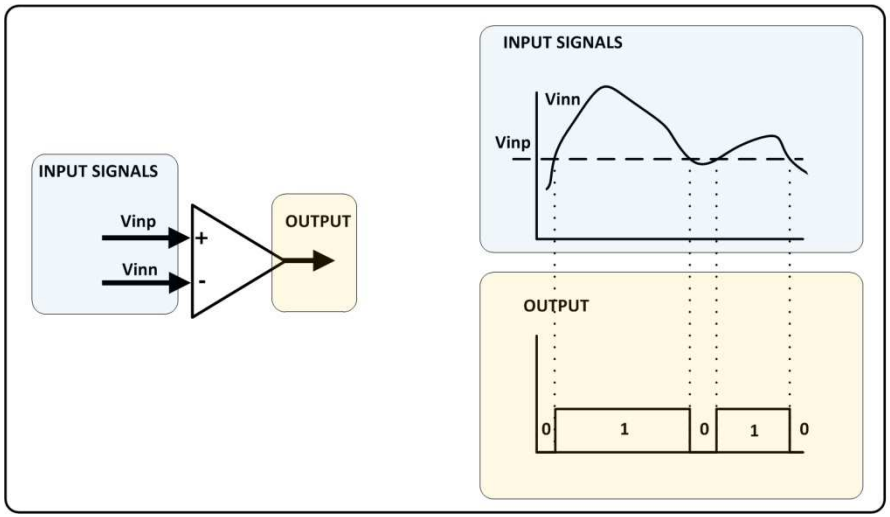
Fast and precise analog comparator (ACMP)
Anti-glitch filter
Define analog threshold and trigger interrupt

Customer Benefits

In power conversion, fast and precise response improves the control quality.
Prevents undefined states immediately after comparator enabling.
Reduced power consumption as no ADC is needed.

ACMP
Fast and precise analog comparator

- Fast and precise:
  - The Analog Comparator has a really short response time with a short propagation delay (25ns). It has also very low input offset voltage (3mV) making it highly accurate.
  - Those two features make the ACMP module ideal for Power Conversion applications, which need real-time and precise signal level comparisons.

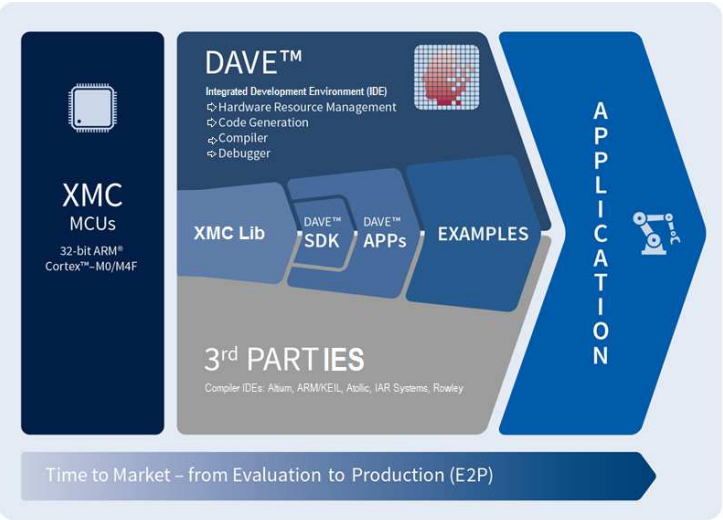


Meet Your Deadlines with DAVE™

Embedded SW developer's challenges

- Stiffer competition on time to market
- Profitability trough higher R&D efficiency
- End-customer expectations require usage of flexible peripherals
- Higher real-time demands drive all-to-all interconnectivity options

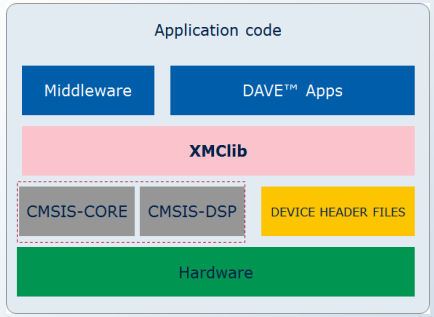
DAVE™ can manage those challenges because



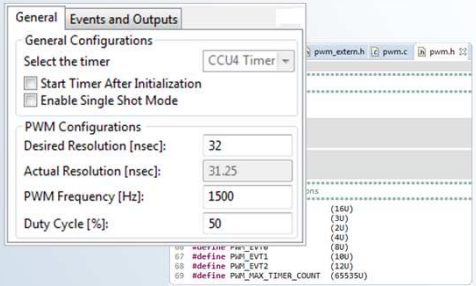
- DAVE™ generates the code tailored to the application
- DAVE™ is easy to use and free
- DAVE™ Apps make it easy to fully utilize flexible peripherals and interconnectivity
- The resource solver ensures conflict free mapping of chip resources

DAVE™ - What's new with Version4

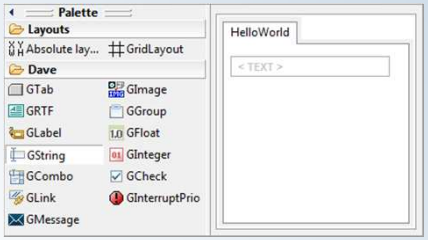
- Code library for peripherals
- Transparency of code
- CMSIS and MISRA 2004 complaint



Library of configurable (GUI) application oriented software components using XMC Lib. Growing repository System Control, General Purpose and Application Oriented APPS.



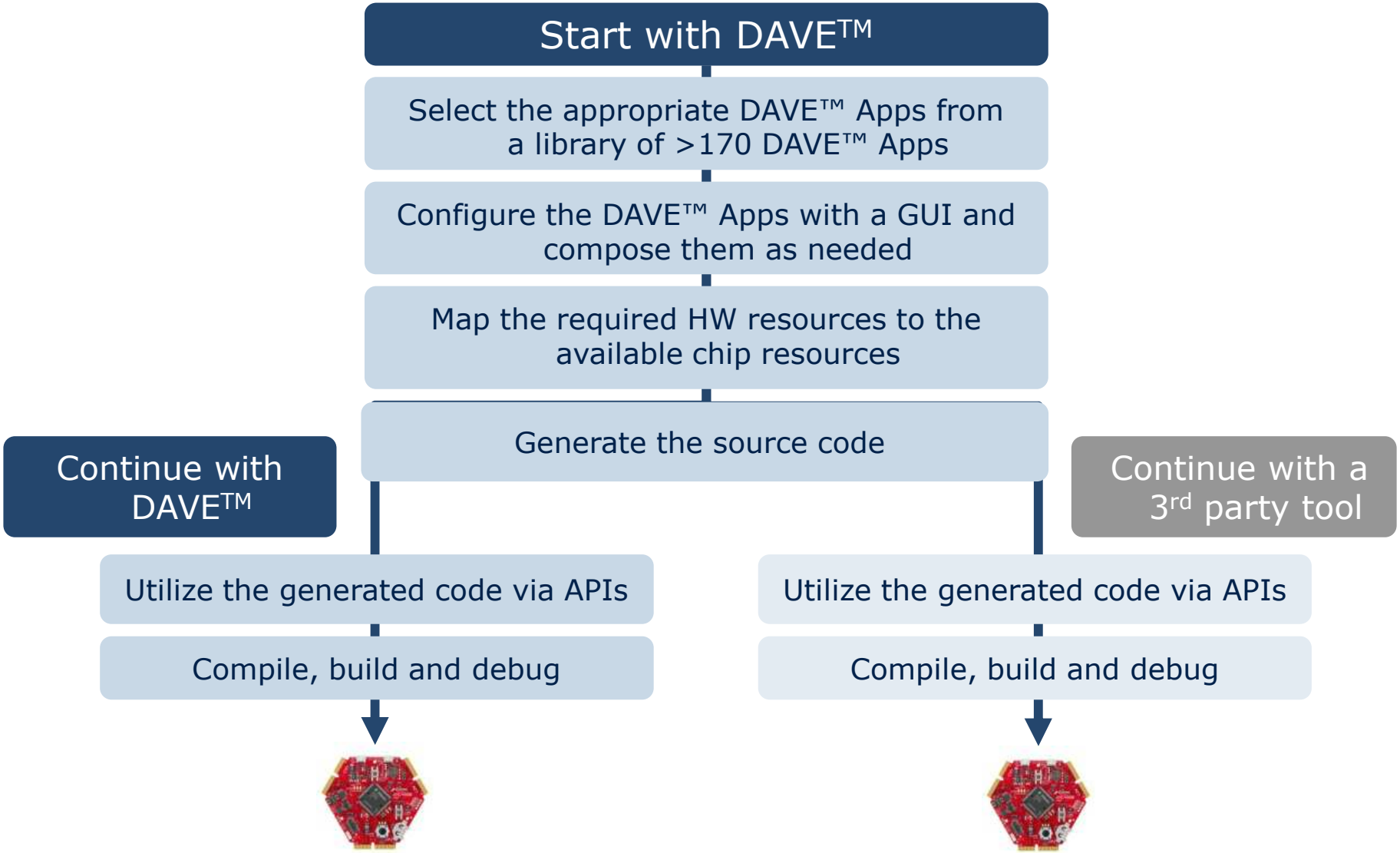
- Modify, extend, optimize or develop DAVE™ APPs using DAVE™ SDK (Software Development Kit)
- Based on Eclipse Java IDE extended with GROOVY plug-in



XMC Lib and DAVE™ APPs are tested with
- GCC compiler
- ARM® compiler
- TASKING compiler

And released for
- Altium
- ARM/KEIL
- Atollic
- IAR Systems
- Rowley

Straight Forward Development Flow



The World around XMC

Modeling, Simulation, Code Generation

MATLAB & SIMULINK · WILLERT. · SiSy

Libraries, RTOS, Middleware

CMX SYSTEMS · Micrium · FreeRTOS · expresslogic · HCC embedded · SEGGER www.segger.com · port · KEIL An ARM® Company · THESYCON · SEVENSTAX · interniche technologies, inc. · CODESYS · etas · IEC 60730 Class-B LIB

Compiler Tools, IDEs

atollic · IAR SYSTEMS · KEIL An ARM® Company · TASKING · SiSy

Debugging, Test, Verification, Analysis

hitex DEVELOPMENT TOOLS · SEGGER www.segger.com · pls Development Tools · Verifysoft TECHNOLOGY · LAUTERBACH · PARASOFT · iSYSTEM · atollic

Flash Programming

HI-LO SYSTEMS · hitex DEVELOPMENT TOOLS · XELTEK · pls Development Tools · Infineon Memtool · SEGGER www.segger.com

DAVE™ IDE, DAVE™ Apps

Training / Consulting

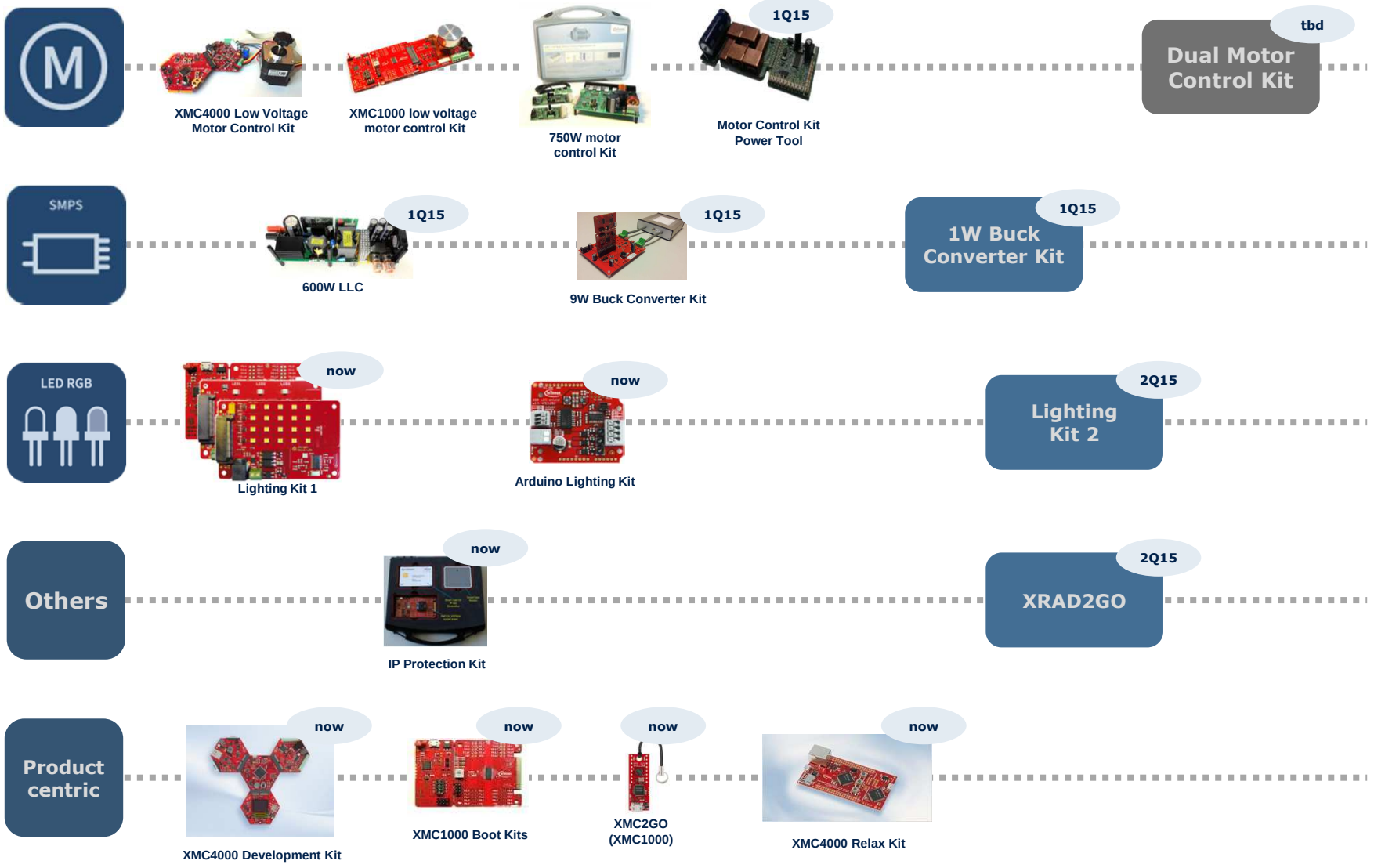
WILLERT. · MicroConsult · hitex DEVELOPMENT TOOLS · BLUE WIND

PCB Design / Test

GOPEL electronic · Altium

PRODUCT

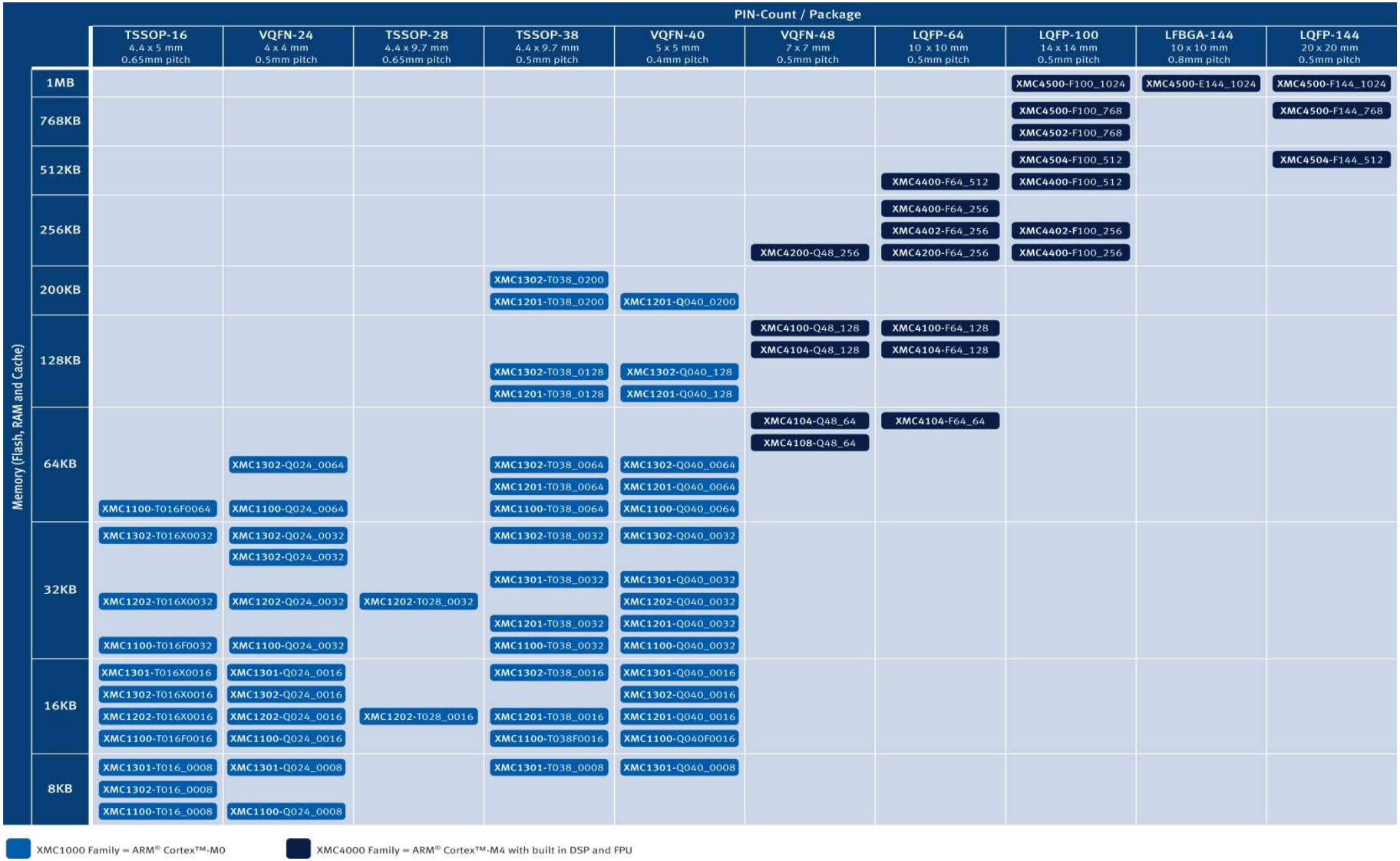
XMC KIT / D2D Roadmap



ENERGY EFFICIENCY
MOBILITY
SECURITY

Innovative semiconductor solutions for energy efficiency, mobility and security.

XMC Portfolio Line-Up



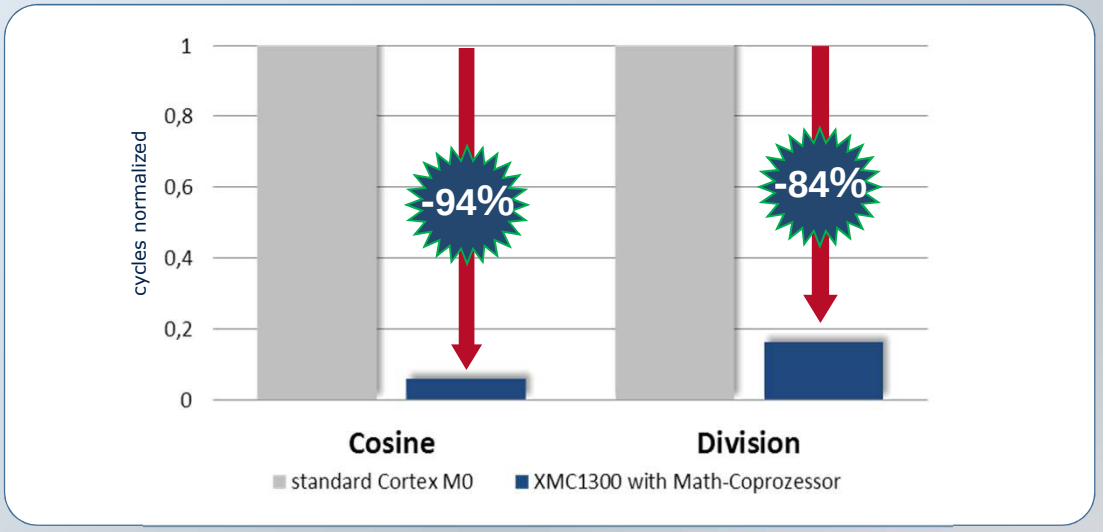
XMC MCU – Feature Overview

Numbers are 'UP TO'. For all details see Reference Manual.	XMC11x	XMC12x	XMC13x	XMC41x	XMC42x	XMC44x	XMC45x
ARM® Processor	Cortex™-M0			Cortex™-M4 with built in DSP			
[MHz]	32			80		120	
CO-Processor	–		Math-Co Processor (CORDIC)	Floating Point Unit (SPFPU)			
DMA/MPU	–			8ch / 8 Regions		8ch / 8 Regions	12ch / 8 Regions
Flash/RAM/Cache [KB]	8 ~ 200 /16 / no			128 ~ 256 / 20 ~ 40 / 1		256 ~ 512/ 80 / 4	512 ~ 1M/ 128 ~ 160 / 4
Packages (number of Pins)	16 / 28 /38			48 / 64		64 / 100	100 / 144
ETH/USB/EBU	–			no / FS DEV / no		IEEE1588 / FS OTG / no	IEEE1588 / FS OTG / yes
CAN/SD/MMC	–			2 nodes / no			3 nodes / yes
USIC (UART/LIN, IIC, IIS, Standard-/Dual-/Quad-SPI)	4ch (2 USICs)			8ch (4 USICs)			12ch (6 USICs)
High Resolution PWM (HRPWM) Delta Sigma Demodulator (DSD) Position Interface (POSIF)	– – –	– – –	no no 1x	1x no 1x		1x 4x 2x	no 4x 2x
ADC/DAC	12ch / no	12ch (2x Sample) / yes		9ch (2x Sample) / 2ch		26ch (4x Sample) / 4ch	
CMP	–	2x	3x	see HRPWM (with built in CMPs)			-
PWM Unit CCU4 (single side) PWM Unit CCU8 (high & low side)	4ch no		4ch 4ch	8ch 4ch	8ch 4ch	16ch 8ch	16ch 8ch
Touch & LED Display Matrix (Lighting) LED Diming (Lighting) LED Color Control Power LED	–	yes yes yes yes	no yes yes yes	8ch Touch 64 LEDs – –			
Operating Voltage	1.8 ~ 5.5 V			3.13 ~ 3.63 V			
Operating Temperature	-40°C ~ 85°C / 105°C			-40°C ~ 85°C / 125°C			
Status	In production (TSSOP packages)			In production			
Ecosystem & Enablement	Infineon DAVE™: FREE Eclipse based IDE, CMSIS and MISRA compliant, GCC with Debugger, DAVE™ APPs Code Generation, open for 3rd Party Tools like KEIL, IAR, ….						

Common peripherals and development tools across family for easy scalability

XMC1300 MATH Co-Processor

Tune Up your system



- Unload your main CPU and **save up to 94% cycles**
- **64MHz** computing power
- Arithmetic acceleration (trigonometric, multiply, divide and hyperbolic functions)
- Significant **Code space reduction**

Try it...

Supported *products*

- **XMC1300**

Development Kits

Example: FOC motor control - XMC1300 outperforms even a Cortex®M3.

- Try it within minutes...
- Motor Control Kit hardware
- Use Dave™ FOC App to spin your motor...

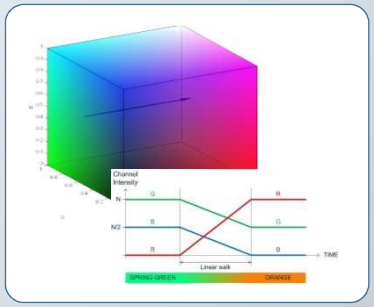
Software

DAVE™

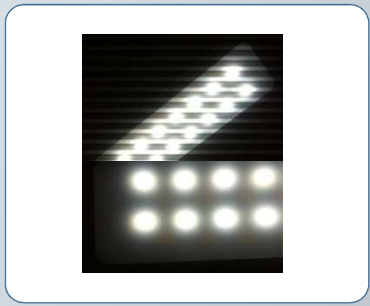
Get Your Free ARM KEIL Microcontroller Tools

XMC1200 Brightness Color Control Unit

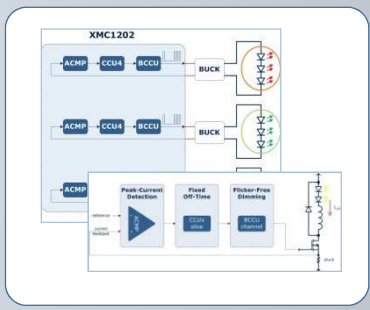
dedicated hardware for intelligent lighting



Automated RGB control mixing
- **linear walk principle**
- Very little use code and development effort – **CPU offload**



Smooth and automated dimming
- **flicker free**
- human eye friendly
- even at low dimming level



True System Approach
- Support **different topologies**
- Self-adaptive
- Expandability
  e.g. DALI/DMX, Radar

Try it…

Supported *products*
- **XMC1200**

Development Kits

LED Lighting Application Kit

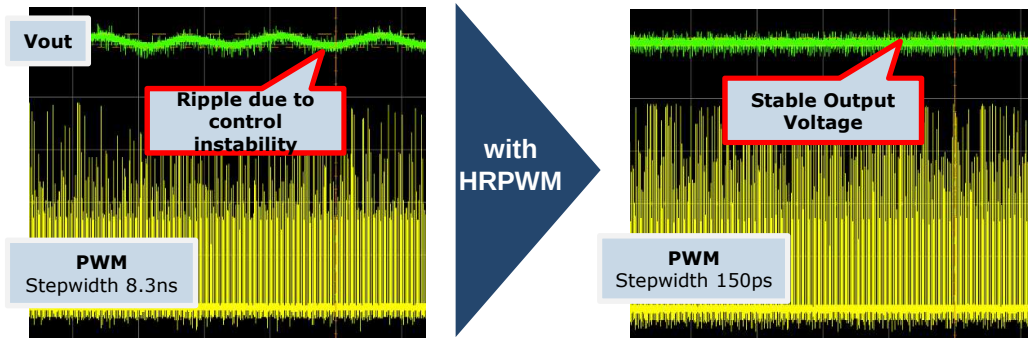
Software

DAVE™

Get Your Free ARM KEIL Microcontroller Tools

XMC4000 High Resolution PWM (HRPWM)

switch to digital power



* Measured on 280 KHz buck converter w/o HRPWM

HRPWM offers

- **High resolution PWM** w/o an increase of CPU frequency (equals 6,67 GHz)
- **Precise and stable output voltage** in digital power applications even at high switching frequencies
- **Cost reduction** potential due to less & cheaper external components

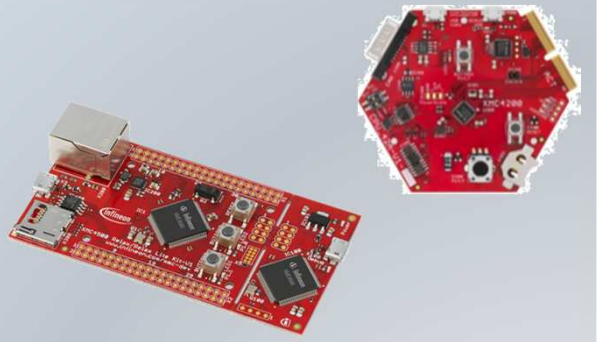
Try it…

Supported *products*

- **XMC4000**

Development Kits

XMC4000 Application Kit



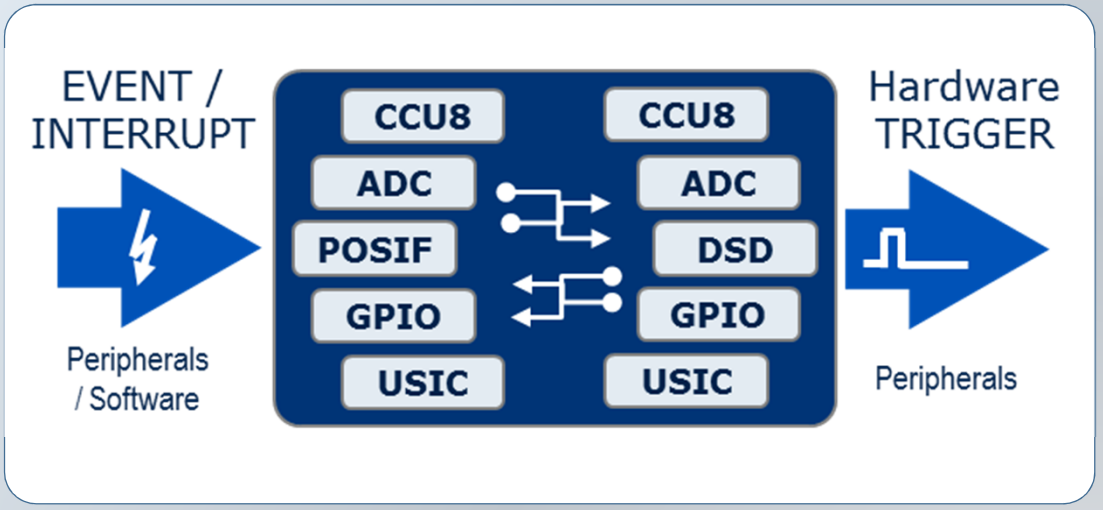
XMC4500 Relax Kit

Software

DAVE™

XMC Intelligent Interconnect Matrix

Interconnect your peripherals



- **Interconnect of events, interrupts and signals**
- **React on events w/o CPU**
- Process simultaneous, fast & **deterministic**
- **Save cycles, code and energy**

Try it…

Supported *products*

- **XMC1000**
- **XMC4000**

Development Kits

XMC 2Go

XMC4500 Relax Kit

Software

DAVE™

Get Your Free ARM KEIL Microcontroller Tools

ENERGY EFFICIENCY
MOBILITY
SECURITY

Innovative semiconductor solutions for energy efficiency, mobility and security.