

XMC1000 MCU PMSM

Infineon Technologies
2014

BLDC



XMC1000: 8-bit price for 32-bit power

www.infineon.com/XMC1000

www.infineon.com/XMC4000

Main Content

- Infineon Latest MCU portfolio
- System block, Key Features
- Supporting tool, Ecosystem
- BLDC Motor Driver Design Using XMC
- PMSM Motor Driver Design Using XMC

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Core Applications

Compressors

Robotics

Servo Drive

Pumps & Fans

General Purpose Drives

Aircon Sys

Process Control

Escalators

E Vehicle

Elevators

Traffic Lights

Battery Storage

Fork Lifts

Solar Inverter

GP Inverter

Micro Inverter

UPS

Wind Energy Converter

Monitor/CTV

Micro Turbines

Telecom

X-Ray

Power Supplies for Medical Equipment

Infineon new generation XMC families targeted for Industrial Market



Cortex-M4

Addressing
"32-bit/DSC" applications

MCU plus DSP
Accelerated SIMD, FP&DSP

Cortex-M0

Addressing
"8/16-bit" applications

Lowest cost
Optimised connectivity

XMC4000

Infineon first ARM Core released in Feb'2012
Target 32bit application from mid to high end
XMC4100, 4200, 4400, 4500
80~120MHz 64K~2.5M Flash, 48~256pin package

ARM

XMC1000

Infineon second ARM Core released
Officially Press-release today on 17.Jan.13.
Sample available Mar 2013

Target low end market with 32bit MCU
XMC1100, 1200, 1300
32Mhz, 8~200K Flash, 16~38pin package



Infineon ARM based industrial Microcontrollers



Flash	2.5MB	1MB	768kB	512kB	XMC4400	XMC4400	XMC4500	XMC4500	XMC4500		
2.5MB											
1MB							XMC4500	XMC4500	XMC4500		
768kB							XMC4500	XMC4500			
512kB				XMC4400	XMC4400		XMC4500	XMC4500			
256kB	XMC4200	XMC4200	XMC4400	XMC4400							
128kB	XMC4100	XMC4100									
64kB	XMC4100	XMC4100									
	VQFN48	LQFP64	LQFP64	LQFP100	LQFP100	LQFP144					
		LFBGA64 (in def.)							LFBGA 144		
TSSOP 16	TSSOP 28	TSSOP 38	XMC4100	XMC4200	XMC4400	XMC4500					

One microcontroller platform.
Countless solutions. XMC.



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www.infineon.com/XMC1000

Where XMC1000 makes the difference

Standard Core in Leading edge technology

65nm

300mm



32-bit ARM® Cortex™-M0
Industry standard for 8-bit replacement

AR

XMC Peripherals

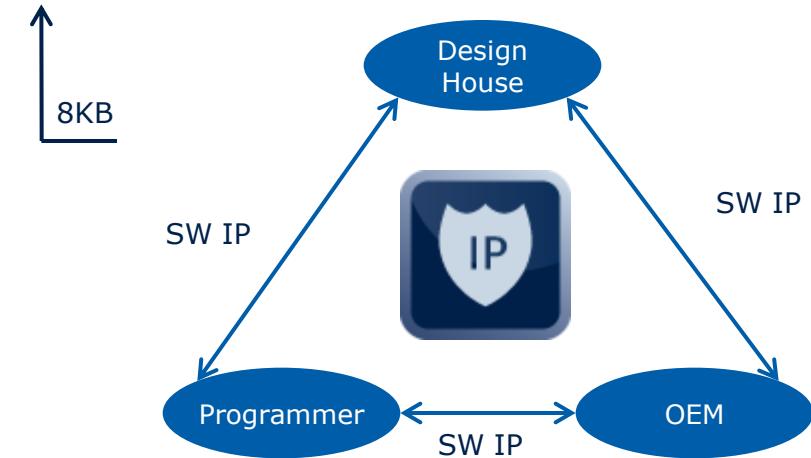
A/D
USIC
CCU8
CCU4

Scalable & user friendly

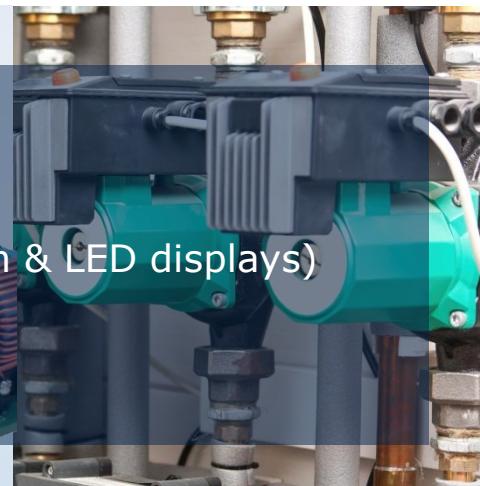
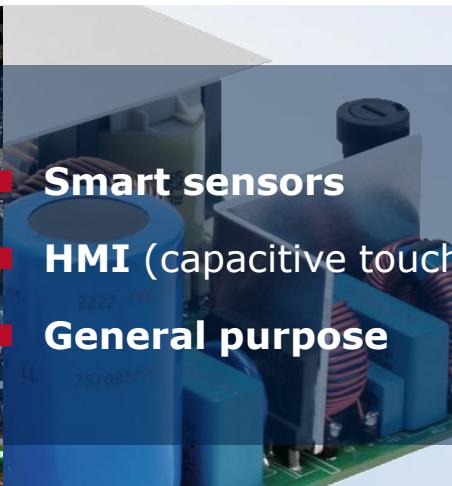


SW IP Protection

Flash IP From # 1 in security microcontrollers



XMC1000 Key Features inspired by Target Application Fields



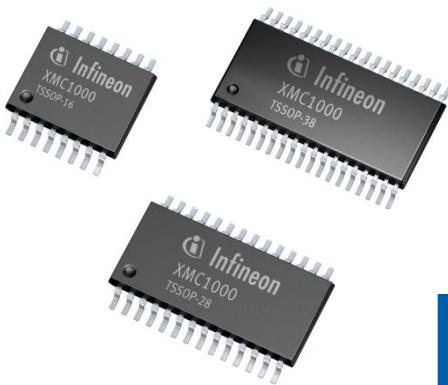
Key Features

- Most scalable **Flash** memory portfolio in Low-end: from **8KB** to **200KB**
- **AES 128-bit** secure loader for **SW IP protection**
- **LED lighting & color** control
- 32-bit **ARM® Cortex™-M0**, 32MHz
- Broadest supply range **1,8 - 5V**
- Leading edge **XMC** mixed signal and timer **peripherals**
- **64MHz MATH Co-processor** for advanced control loops (CORDIC / DIVIDE)
- **30ns analog comparators**
- **IEC 60730 Class B**
- Peripherals for **Touch** control and LED **display** control

XMC1000 (3 Product Series, 22 products, 5 packages)



+++ 22 products +++ 3 packages TSSOP-16, -28, -38 +++ 8KB to 200KB Flash +++
(VQFN-24, -40 available in Q1 2014)



XMC1100 Entry Series

- Basic feature set, state of the art
(16-bit timers, 12-bit ADC, serial communication)
- Simplified documentation

XMC1200 Feature Series

- Additional features
 - **Patented LED-lighting** and -color control peripheral (BCCU)
 - Capacitive **touch** and LED-**Display** control (LEDTS)
- Extended temperature range to **105°C**



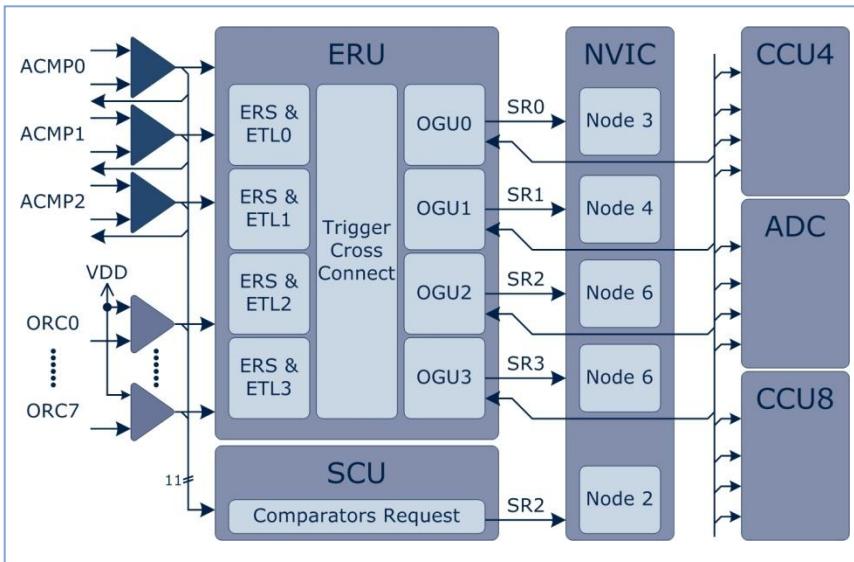
XMC1300 Control Series

- Special purpose **timers** for **motor control** & digital **power conversion** (CCU8)
- **MATH co-processor**
- **Motor position I/F** (POSIF)
- Extended temperature range to **105°C**

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ACMP and ORC System Integration



The output signals of ACMP as well as ORC are available at the input multiplexer of the event request unit ERU. As a result, they can be flexibly combined to logical signals that trigger interrupts, start timers or trigger ADC measurements.

It is the unique combination of fast analog signals and the powerful peripherals that provide a solution in various demanding control applications.

Both the fast ACMP as well as ORC comparators are functional in a wide supply voltage range (2.7V ... 5.5V).

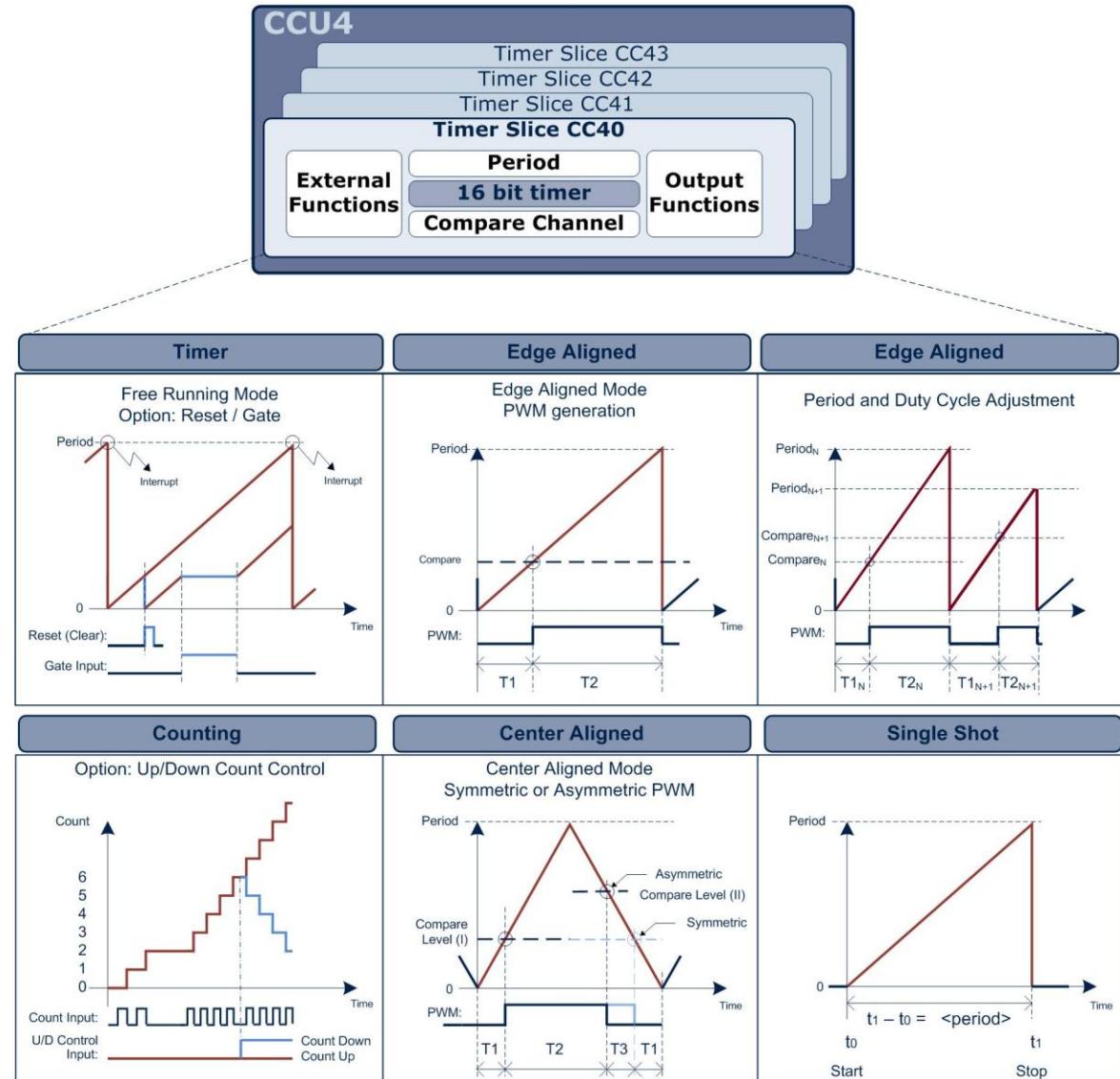
- Target applications
 - Motor Control
 - Intelligent Lighting
 - Power Conversion
 - General Purpose

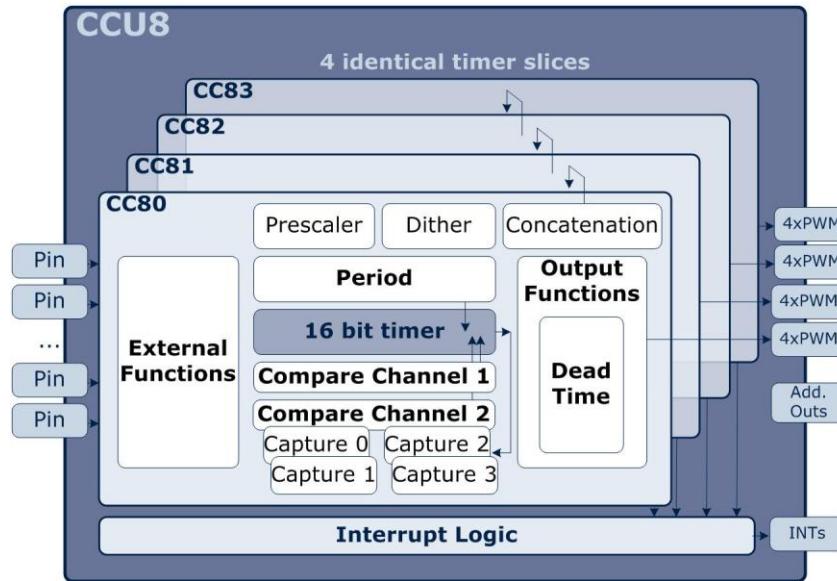
CCU4

Flexible PWM generation



- Each Timer Slice of the CCU4 can operate in center aligned or edge aligned mode
- Additional operation modes like single shot, counting or dithering modes are also available
- Update of the Duty Cycle and Period can be done on-the-fly to accommodate different operation requirements
- Additional external controllable functions give another degree of PWM manipulation (e.g. timer gate, timer load, timer clear, etc)





Key Feature

Modular timer approach with repeated external functions

Flexible PWM generation with on-the-fly duty cycle and period update plus dead time insertion

Flexible capture scheme

Highlights

The CCU8 is a flexible timer module, comprised of 4 identical timer slices tailored for multi-phase PWM generation and signal conditioning. Several input functions can be controlled externally (via pins or other modules) enabling a powerful resource arrangement for each application.

Customer Benefits

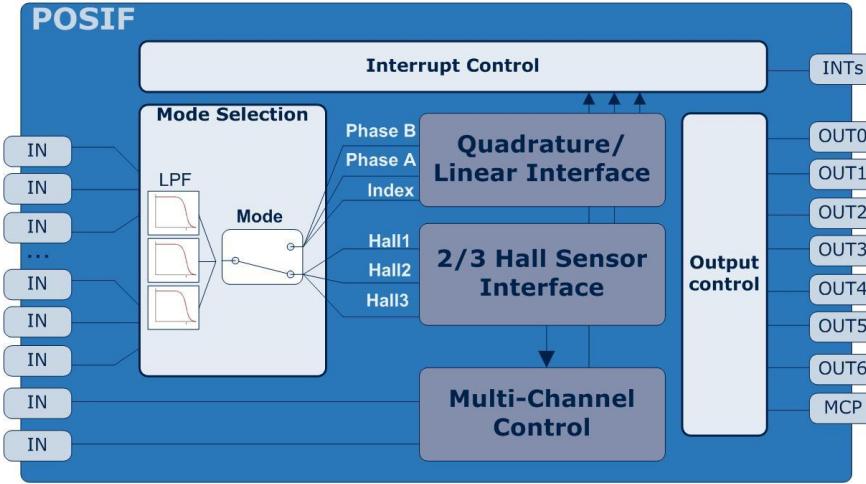
Each specific application function can be ported to any of the 4 Timers

Each Timer Slice can generate up to 4 PWM signals (2 pairs of complementary signals)

Parallel capture and compare modes

Position Interface Key Features

POSIF



Highlights

The POSIF module is the ideal solution for motor control applications using Hall Sensors and Quadrature Decoders. The user can configure freely the type and usage of the resources to perform an optimized mapping to the wanted application.

Key Feature

Interface for linear or quadrature rotary encoder

Interface for Hall Sensors

Stand-alone multi channel control

Customer Benefits

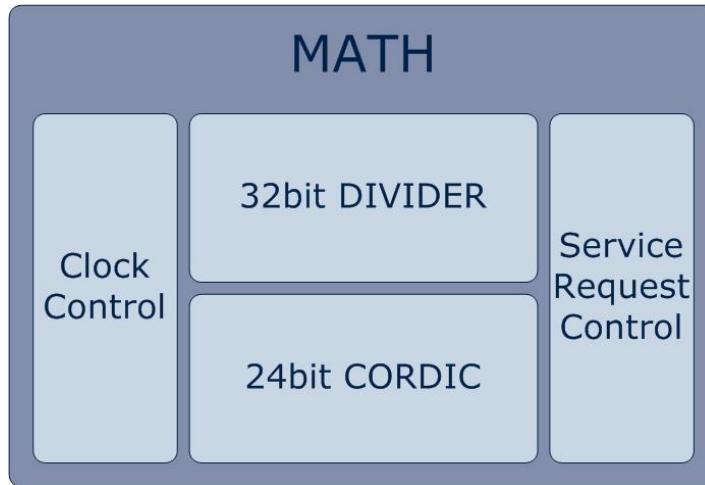
Application tailored motor position and velocity measurement.

Tailored solution for 2 or 3 Hall Sensor applications. Coupling with PWM generation.

Perform multi-level modulation for PWM. Tailored modulation development

MATH

MATH Co-Processor



Highlights

The math co-processor provides a 32bit signed or unsigned divider as well as a 24bit CORDIC for trigonometric calculations. Both DIVIDER and CORDIC can operate in parallel next to the CORTEX-M0 CPU core.

The MATH unit is connected to the PCLK which can be configured for 64MHz.

Key Feature

32bit divide for signed and unsigned long integer numbers

$\sin(x)$, $\cos(x)$, $\arctan(y/x)$ is executed in parallel to CPU operation

Vector rotation (PARK transform) is executed in 24bit resolution

Customer Benefits

The calculation time of a divide operation is reduced to ..%

Increase of computational power for real time critical tasks

Field oriented motor control algorithms are implemented with high resolution

ADC

Analog to Digital Converter



Highlights

The ADC in all XMC1000 series is based on a high speed 12-bit analog to digital converter which is clocked with 32MHz. Resulting in high maximum sample rates for 12-bit conversions:

- 1.28MSPS calibrated
 - 1.88MSPS un-calibrated
- Target values,
to be confirmed*

Key Feature

12-bit, 10-bit and 8-bit conversion modes as well as fast compare mode

Individually adjustable gain for each analog input channel

Two independent sigma delta loops increase ENOBs

Customer Benefits

This fast ADC can be made faster when configuring in lower resolution conversion modes.
The 10-bit fast compare mode just takes 62.5ns.

An adjustable gain factor of x1, x3, x6 or x12 together with the fast conversion speed make an operational amplifier obsolete in many applications.

The two sigma delta loops individually hold the quantization error of the previous conversion in order to consider this tiny amount in the next conversion.

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Tools and SW Partners for XMC Micro Controllers



Micrium



expresslogic



Thesycon
Thesycon® Systemsoftware & Consulting GmbH

port

EUROS

WIND RIVER

SEVENSTAX
EMBEDDED TECHNOLOGIES

- Commercial tools and SW solutions
 - Infineon cooperates with all major tool and SW vendors for ARM based microcontrollers to support XMC1000 as well as XMC4000
- Free tools and SW solutions
 - The development platform DAVE is provided by Infineon
 - Open source
 - FreeRTOS
 - Free evaluation versions

DAVE™ makes powerful hardware accessible

Free IDE and code generator



Integrated Development Environment (IDE)

- Eclipse based
- Free GNU Compiler, debugger, loader
- Free data visualization utilities
- Open for 3rd party tools (compiler, debugger) and software (operating systems, stacks) as plug-in

DAVE IDE - Project_ADC_LED/Main_Project_ADC_LED.c - DAVE 3

File Edit Navigate Search Project DAVE Debug Window Help

C/C++ Projects

Project_ADC_LED [Active - D]

- Binaries
- Includes
- Debug
- Startup
- GPIO.h
- Main_Project_ADC_LED.c
- ErrorLog.txt
- Project_ADC_LED.id
- Project_ADC_LED.simulator
- PWM_Generation

Main_Project_ADC_LED.c

```
int main(void)
{
    unsigned long adc_result;
    /* Setup the system */

    SysTick_Config(12000); // 0.1 ms = 100us

    /* Configure P3.9 (LED) */
    Control_P3_9(OUTPUT_PP_GP, STRONG);
    /* Initialize and start ADC */
    ADC0_Init();

    /* Infinite loop */
    while (1) {
        do{
            ...
        } while (1);
    }
}
```

Active Project Problems

CDT Build Console [Project_ADC_LED]

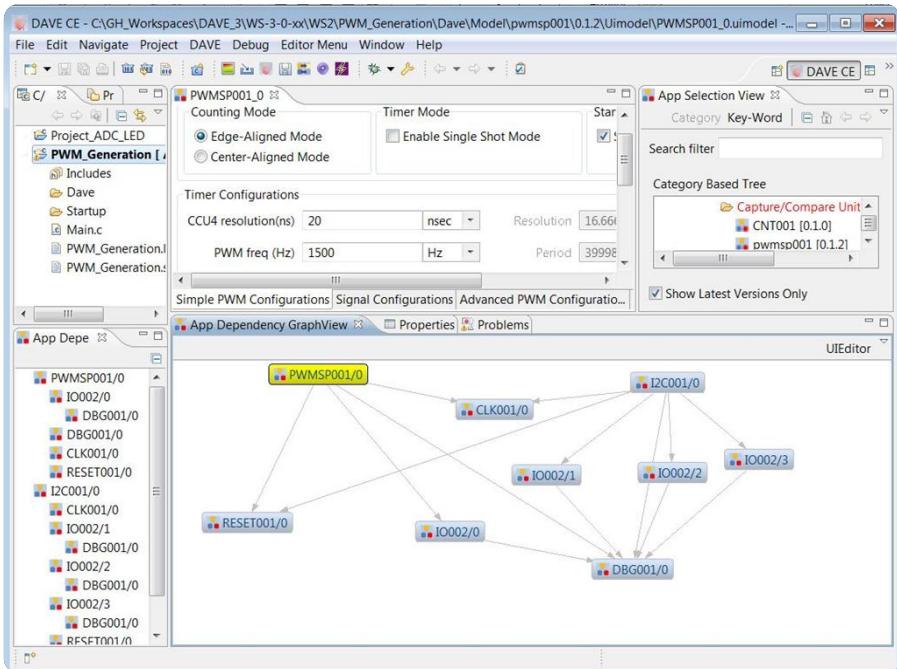
```
'Invoking: Sourcery G++ Lite Create Listing'
"C:\Tools_MCU\GCC_ARM\Rel-4-6-Dec11\bin/arm-none-eabi-objdump" -h -S
Project_ADC_LED.elf > "Project_ADC_LED.lst"
'Finished building: Project_ADC_LED.lst'
'

***** Build Finished *****
```

Writable Smart Insert 1:1

Auto-code generator (Code Engine)

- Easy selection of peripheral and application oriented DAVE™ Apps
- Configuration via graphical user interface
- Generated code can be used via well documented APIs (like a library)
- Extendable by user or 3rd party Apps



■ Website: www.infineon.com/dave3

Overview of available and planned DAVE™ Apps for the XMC Families



Service Apps

- Clock
- Reset
- SystemControl
- Power Mgmt.
- Watchdog
- DMA
- NVIC /Exception
- Request Unit
- I/O
- EBU
- Flash
- CRC
- AES
- SW/SysTimer
- Debug Log
- CMSIS RTOS
- Libraries

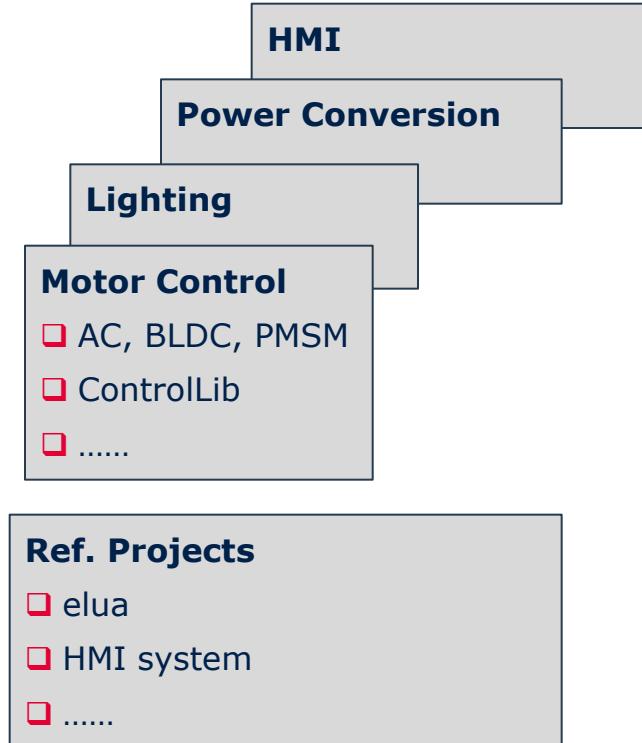
Middleware

- USB stack, class drivers, host and device
- TCP/IP stack plus HTTP, FTP, SNMP
- SD/MMC, file system,...
- GUI lib plus driver for intel. LCD
-

Basic Applications

- PWM, Capture, Timer, Counter
- Communication
- Analog
-

Application Specific Middleware



In total Infineon is providing 170+ DAVE Apps

Details about the latest released DAVE Apps can be found here:

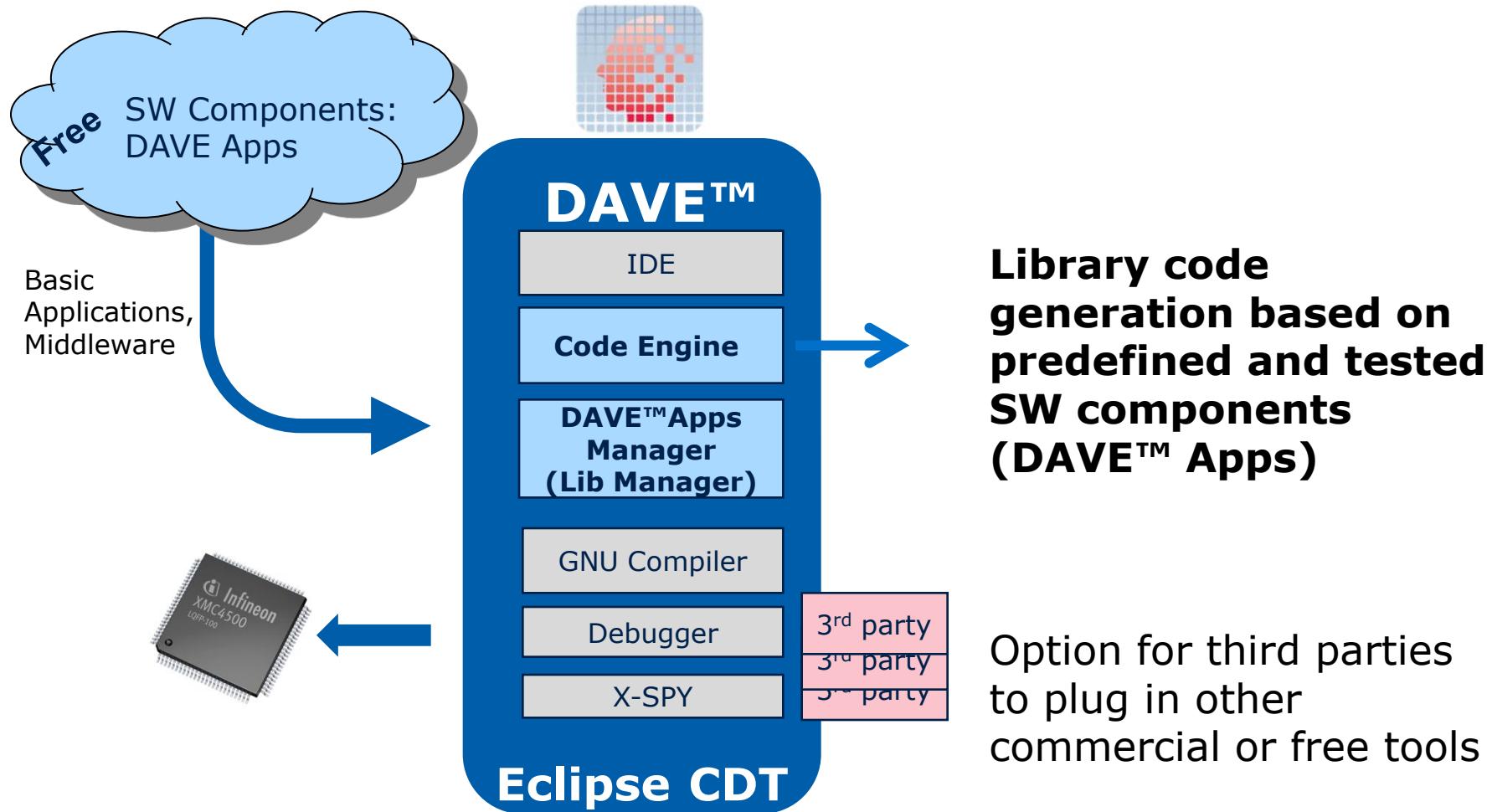
http://www.infineon.com/cms/en/product/promopages/aim-mc/DAVE_3_Support_Portal/Release_Note_update.html

App Support for Motor Control

- V/F for simple open loop
- Block Commutation for Hall Sensor
- Sinewave commutation for Hall Sensor
- Sensorless FOC

▲	📁	Motor Control
	■	ACIMVF01 [1.0.8]
	■	BLDCBCH02 [1.0.10]
	■	BLDCBCH03 [1.0.12]
	■	BLDCBCSL01 [1.0.4]
	■	PMSMFOCH02 [1.0.8]
	■	PMSMFOCH03 [1.0.6]
	■	PMSMFOCH04 [1.0.8]
	■	PMSMFOCH05 [1.0.8]
	■	PMSMFOCIE01 [1.0.6]
	■	PMSMFOCIE02 [1.0.6]
	■	PMSMFOCSL01 [1.0.12]
	■	PMSMFOCSL02 [1.0.6]
	■	PMSMSINH02 [1.0.10]
	■	PMSMSINH03 [1.0.12]
	■	POSHL001 [1.0.12]
	■	POSIFH01 [1.0.12]
	■	POSIFIE01 [1.0.4]
	■	POSIFMC01 [1.0.4]
	■	PWMBC01 [1.0.8]
	■	PWMSVM01 [1.0.36]

The DAVE™ Development Platform

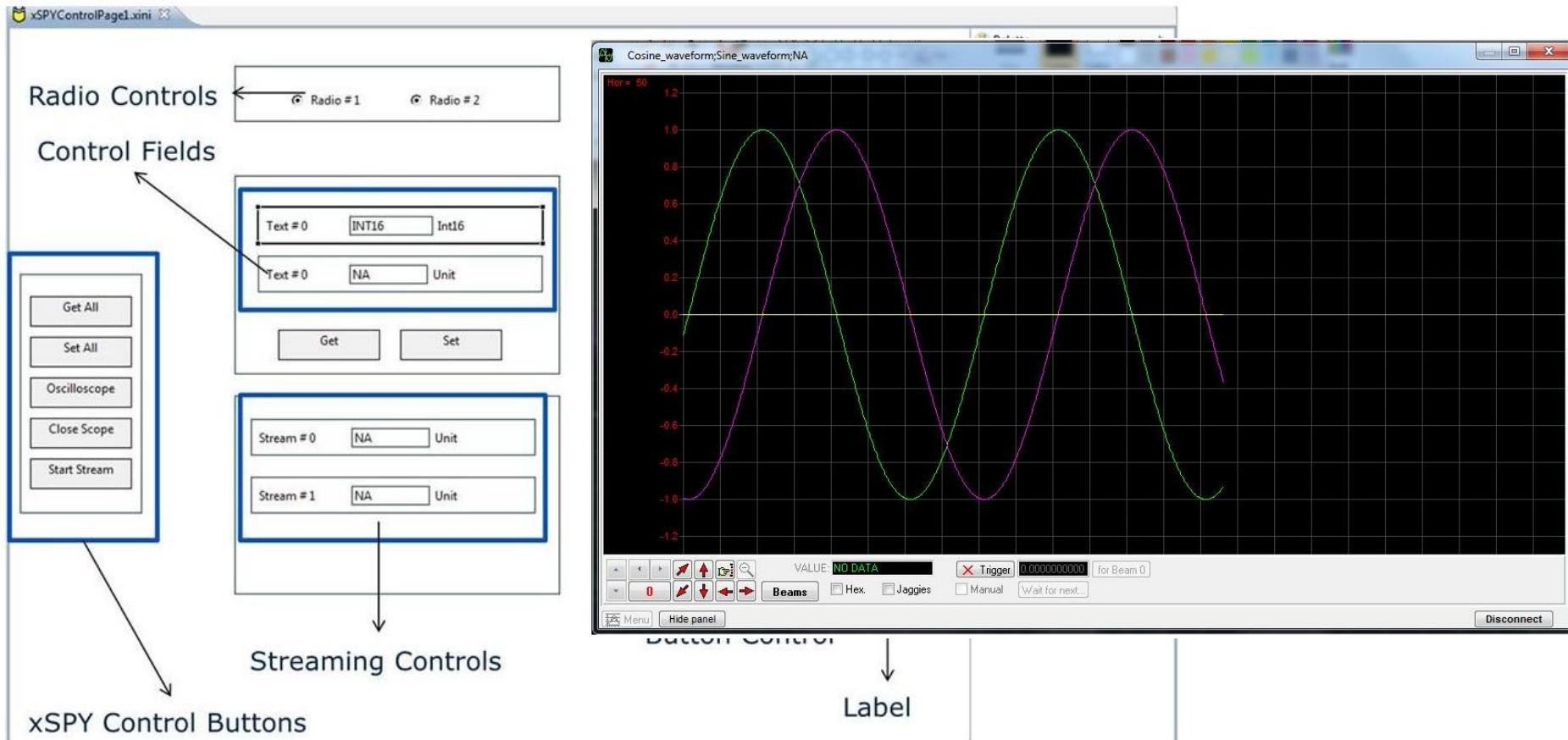


XSPY for PC Monitoring Program

- Using xSPY the user can easily define an UI to control and monitor the microcontroller from the PC.
- xSPY is a DAVE plugin used to visualize and analyze the tracing data generated by DBG002 App by means of software oscilloscopes and logging views.



XSPY for PC Monitoring Program

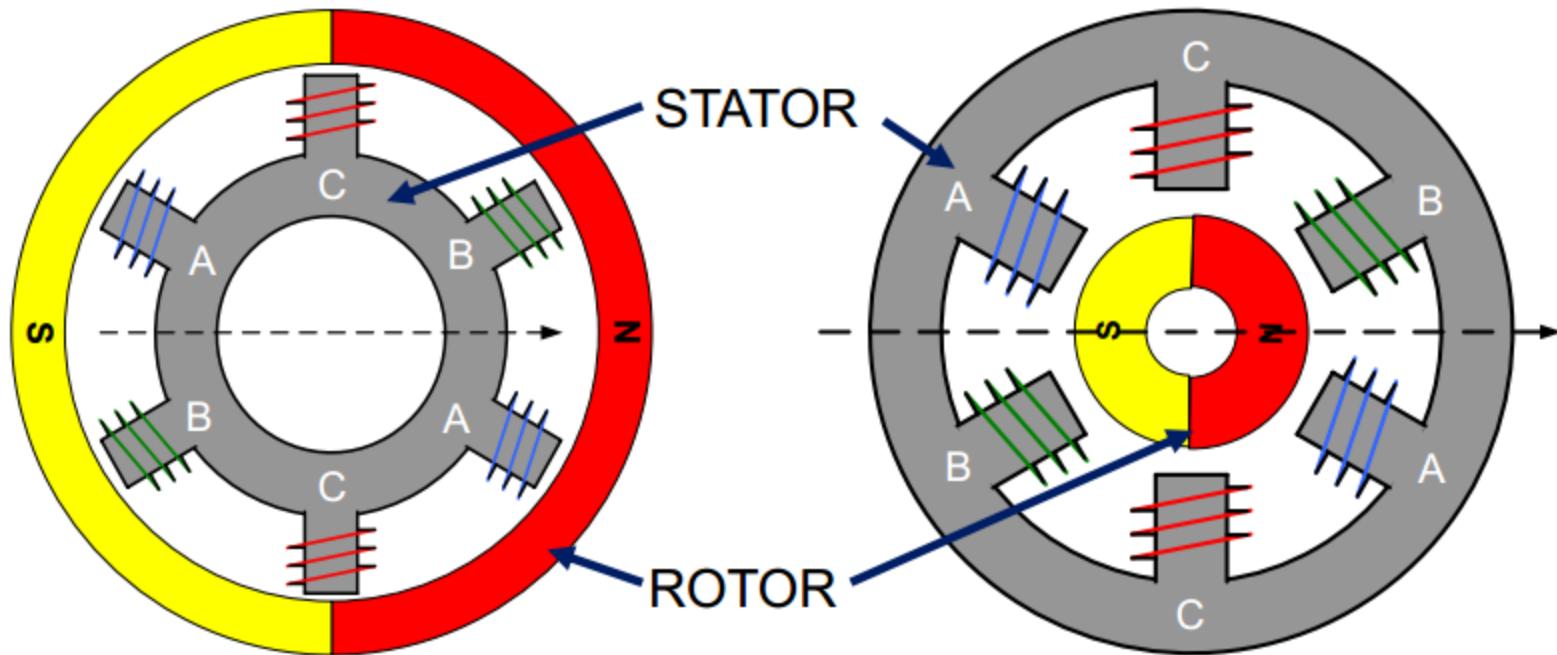


Main Content

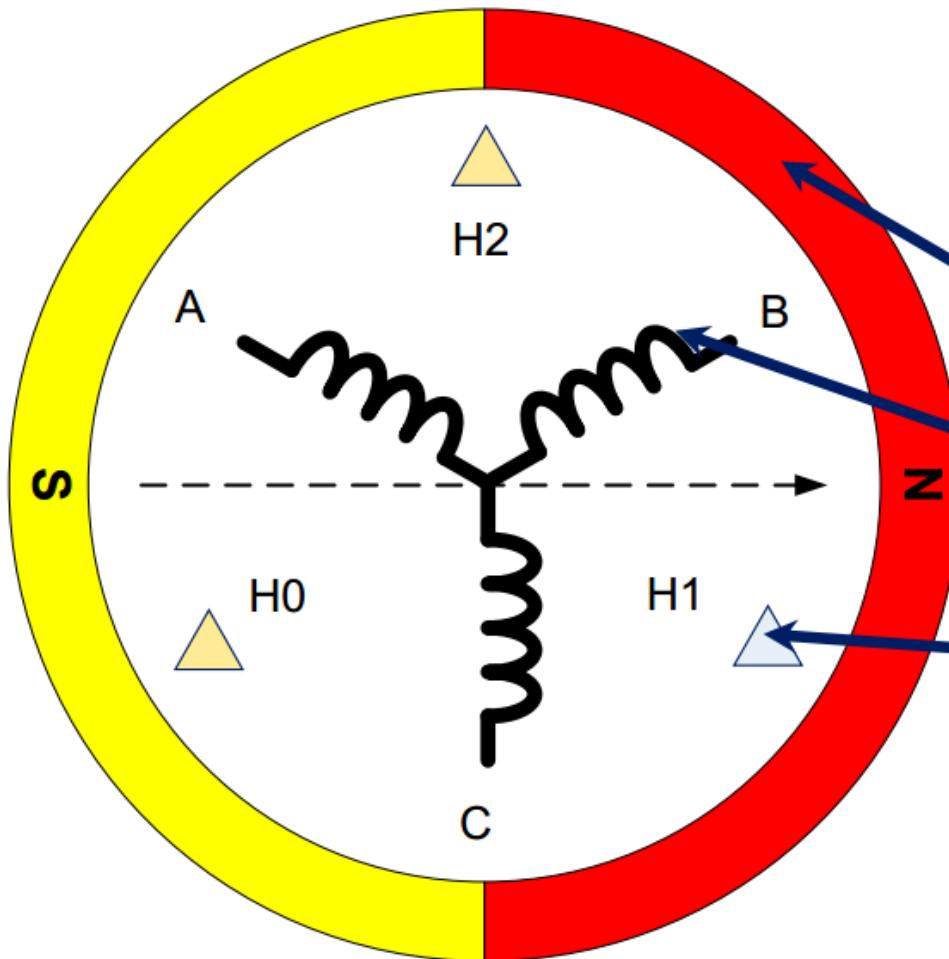
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Introduction to Brushless DC (BLDC) Motor

- Constructed with a permanent magnet rotor and a stator comprising of wire wound poles and stacked steel laminations.
- Electrical energy is converted to mechanical energy by the magnetic attractive force between permanent magnet and the rotating magnetic field induced in the wound stator poles

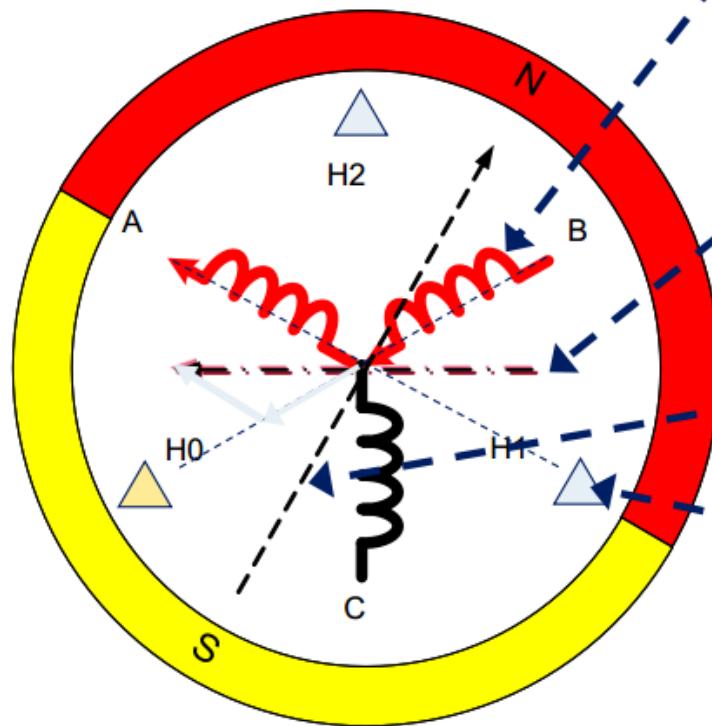
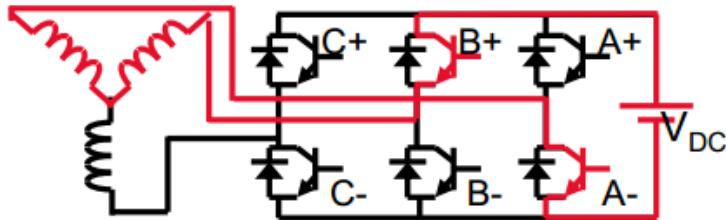


Introduction to Brushless DC (BLDC) Motor



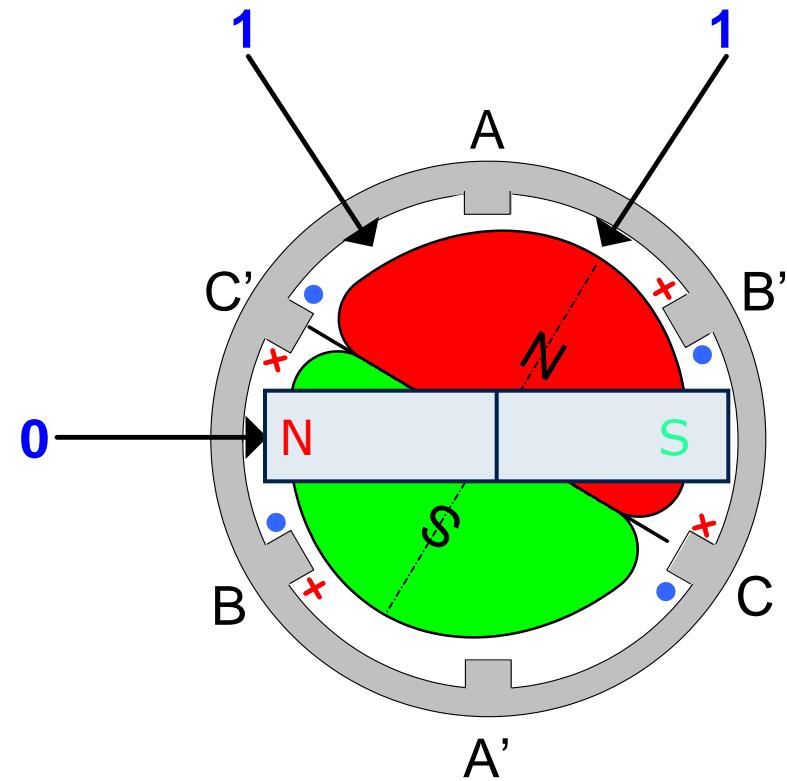
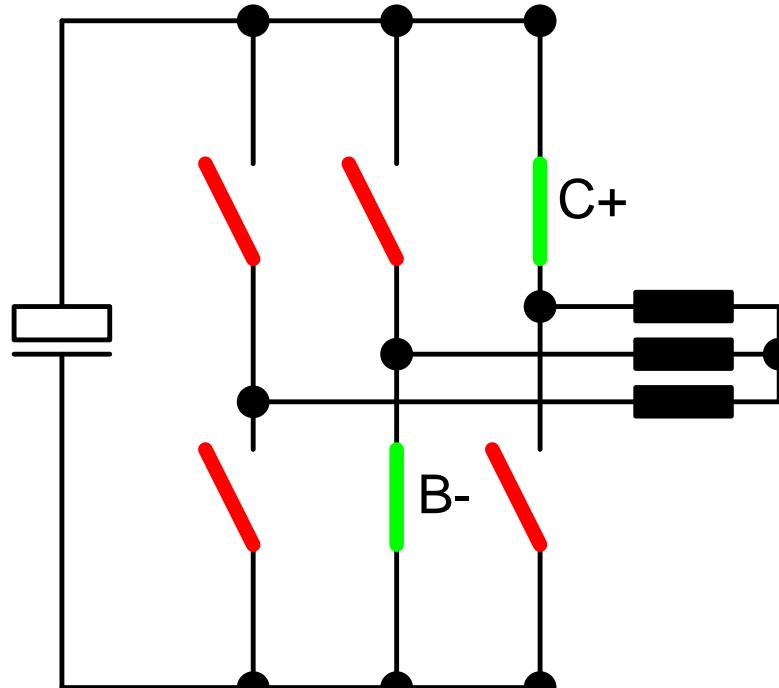
- This is a simplified and representational model of a single pole pair BLDC motor.
- Rotor – Made of permanent magnet.
- Stator - Three phase windings connected in star fashion.
- Hall Sensor – Devices that can detect magnetic field. In this case study, they are placed at 120 electrical degrees apart.

Introduction to Brushless DC (BLDC) Motor

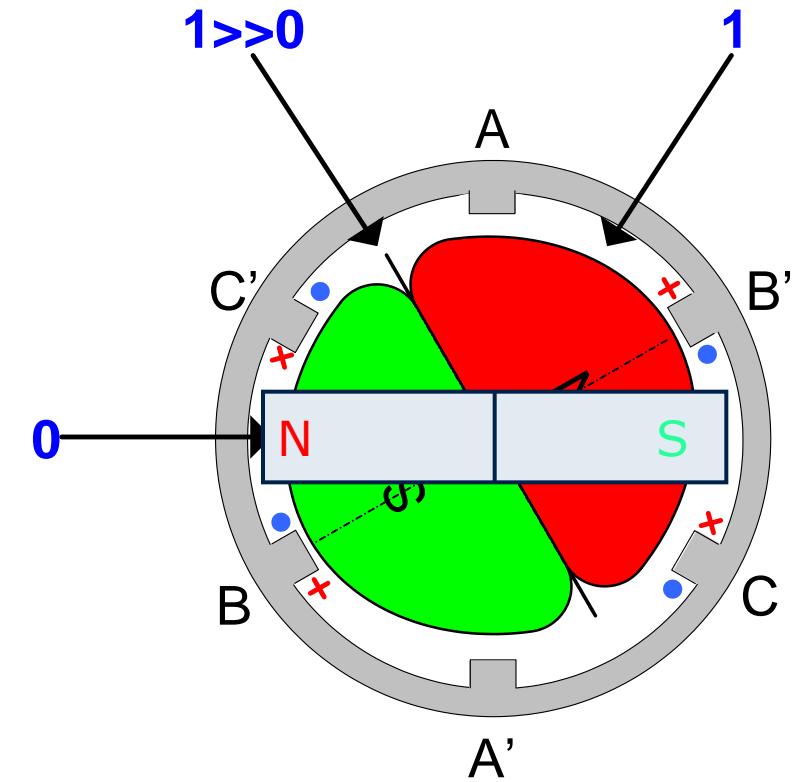
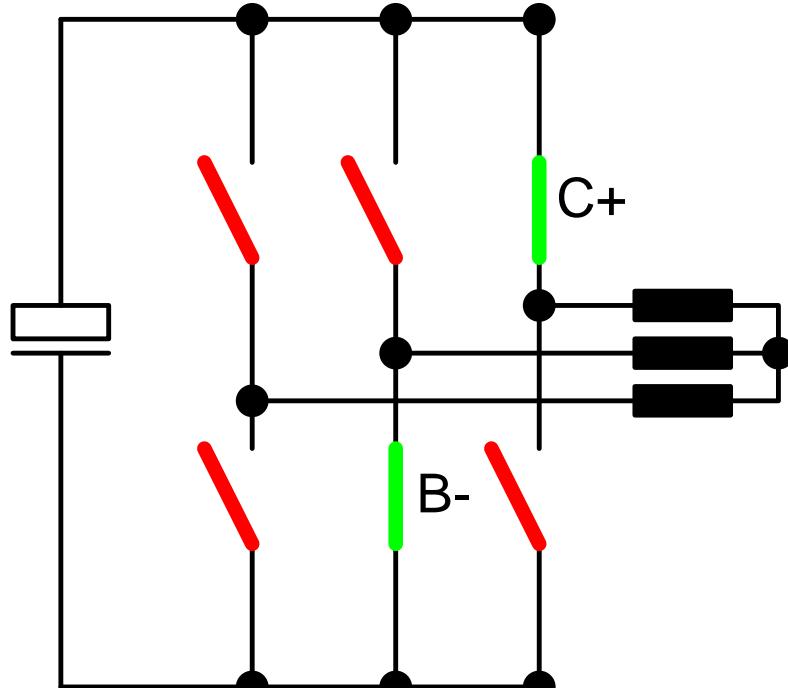


- For simplicity, the arrow that shows the direction of the energizing current also shows the direction of the magnetic field for each coil.
- Magnetic field of stator, it is a vector sum of the magnetic fields of the energized coils.
- Magnetic field of rotor (permanent magnet)
- Hall sensors output LOW when 'N' is sensed.

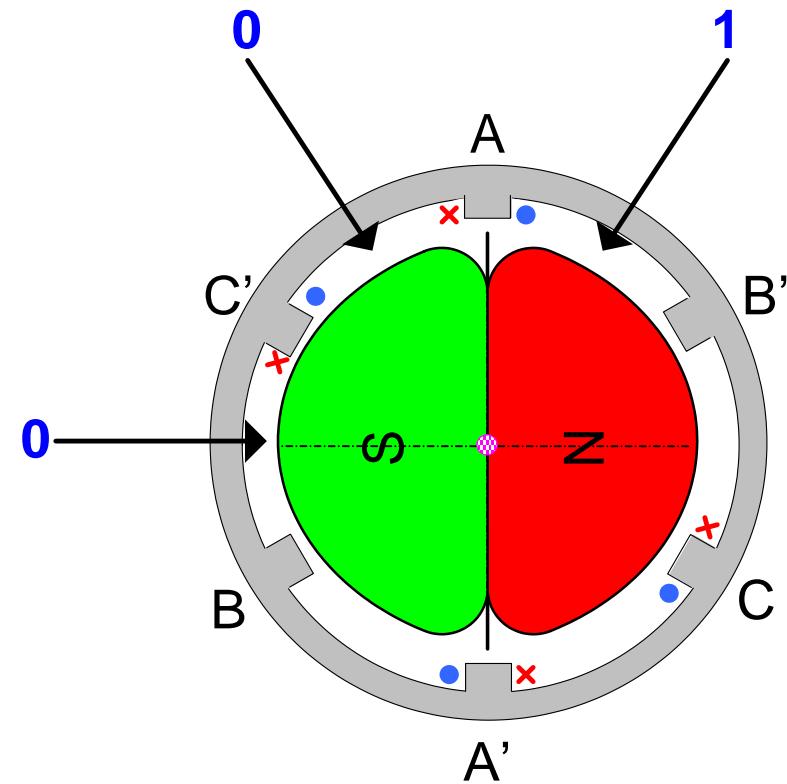
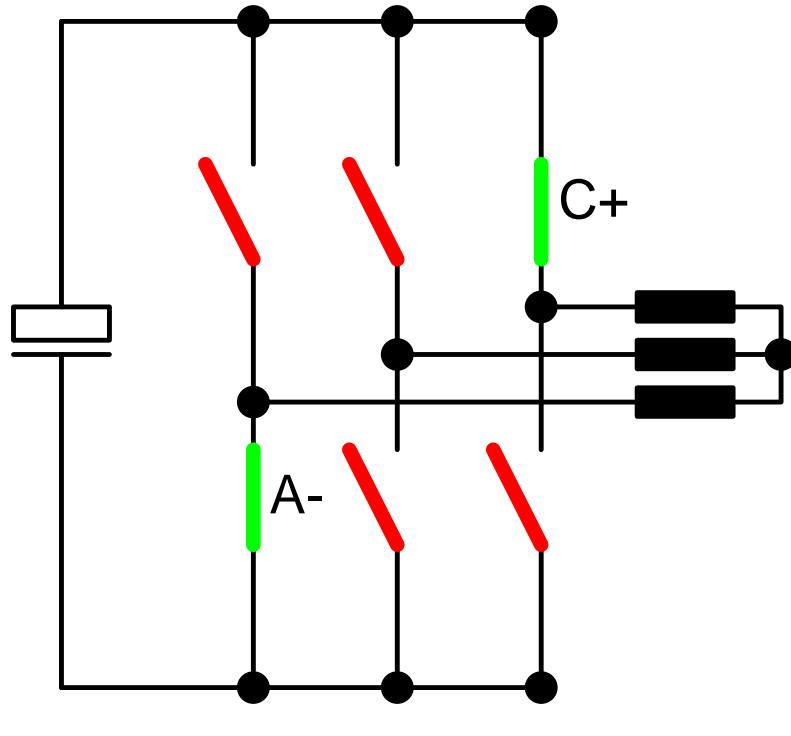
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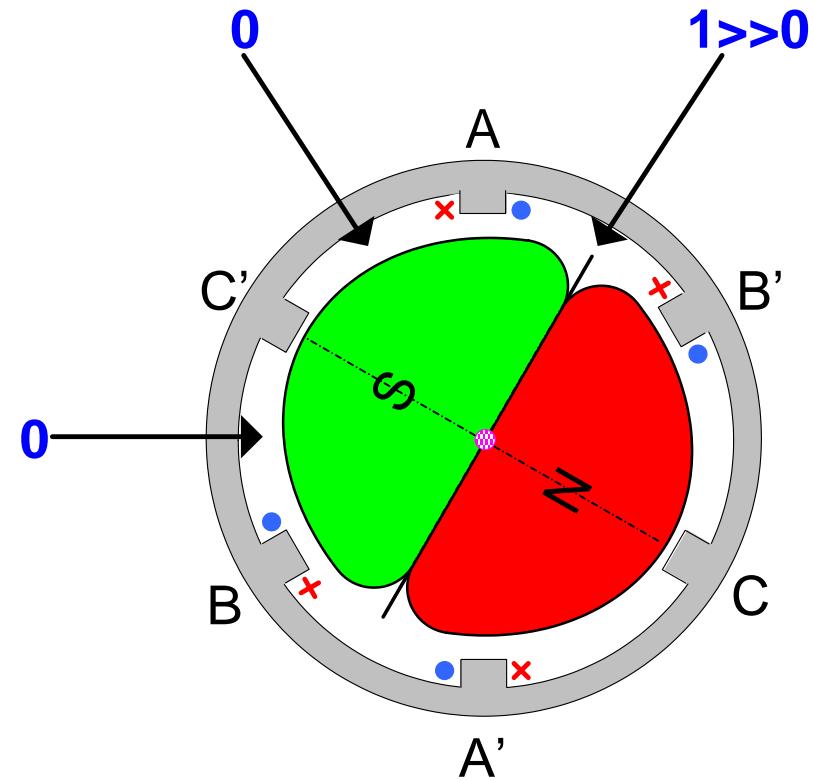
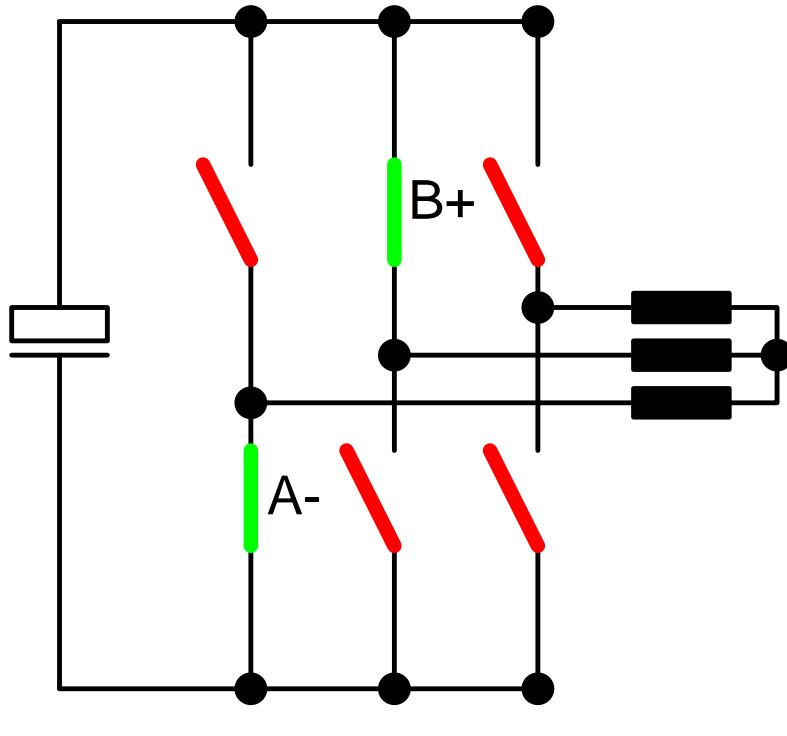
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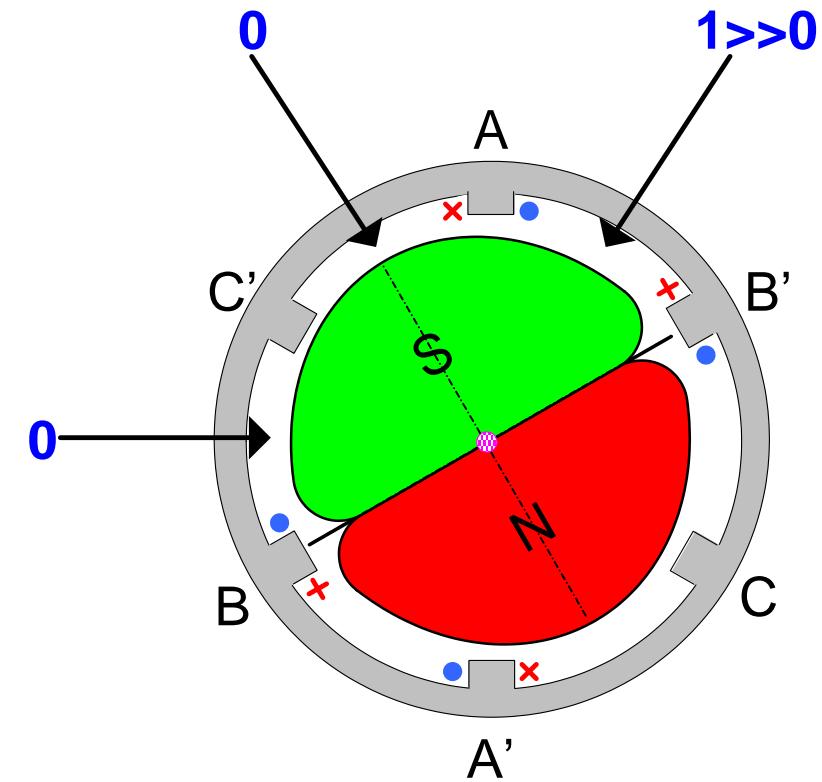
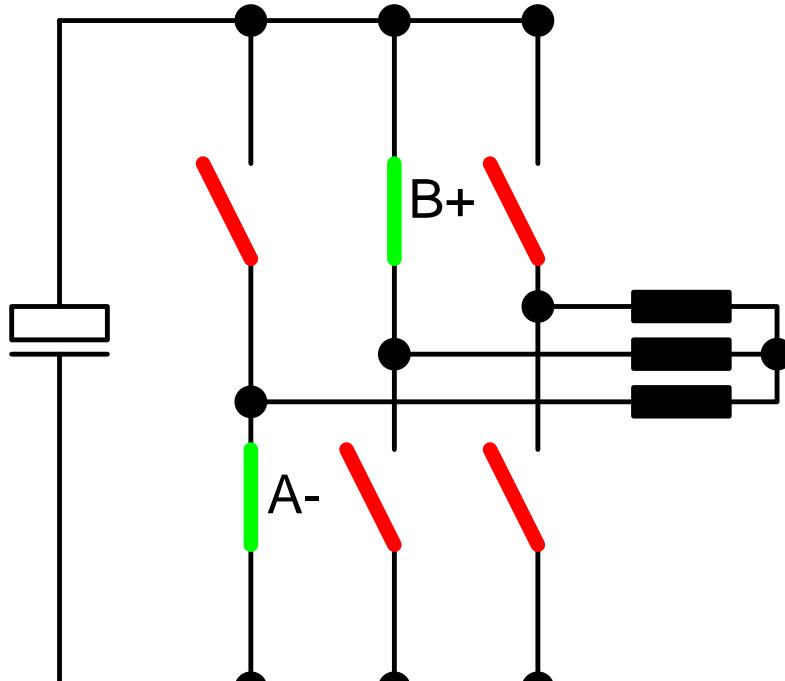
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Introduction to Brushless DC (BLDC) Motor



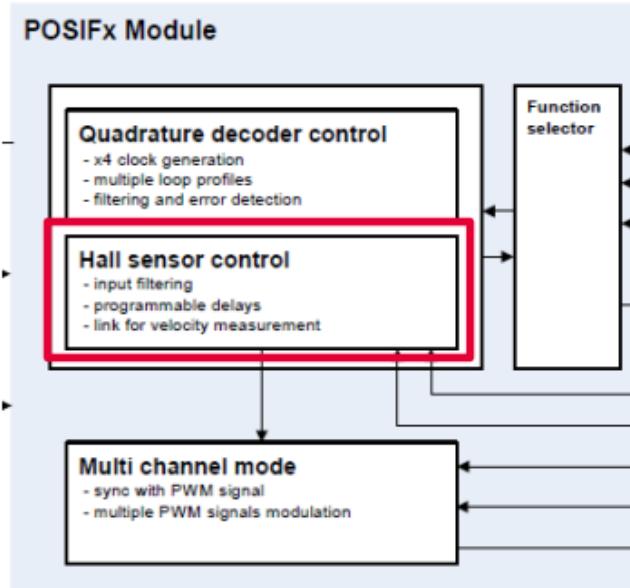
Introduction to Brushless DC (BLDC) Motor



POSIF Feature

Hall Sensor Mode

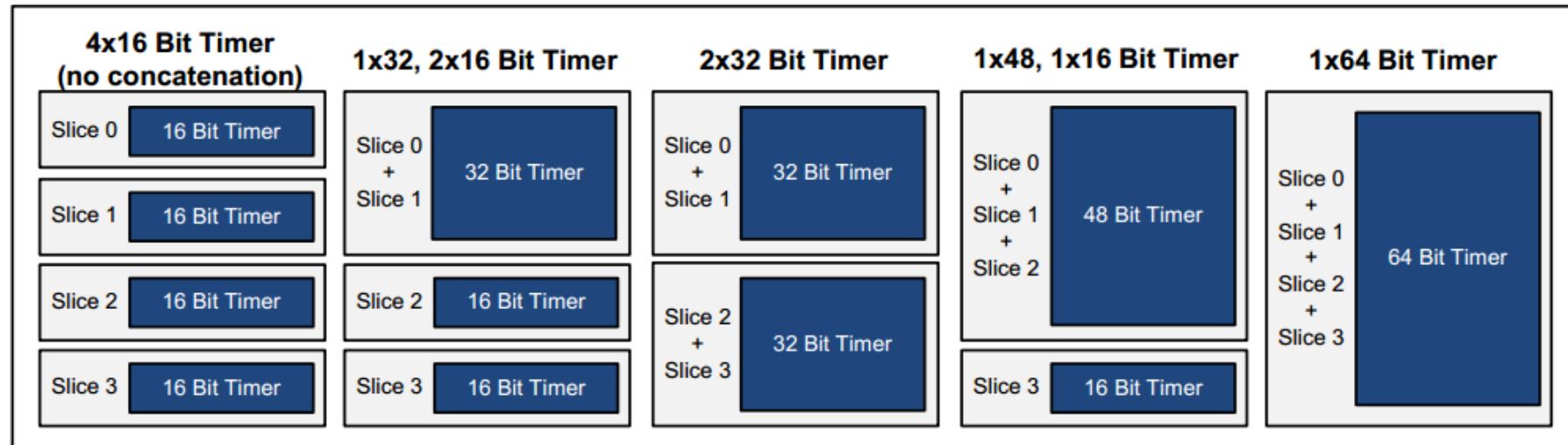
- Simple build-in mode for brushless DC motor control
- Shadow register for the multi-channel pattern
- Complete synchronization with the PWM signals and the multi-channel pattern update
- Interrupt sources for Correct Hall Event detection, Wrong Hall Event detection



CCU4 Feature

General Features

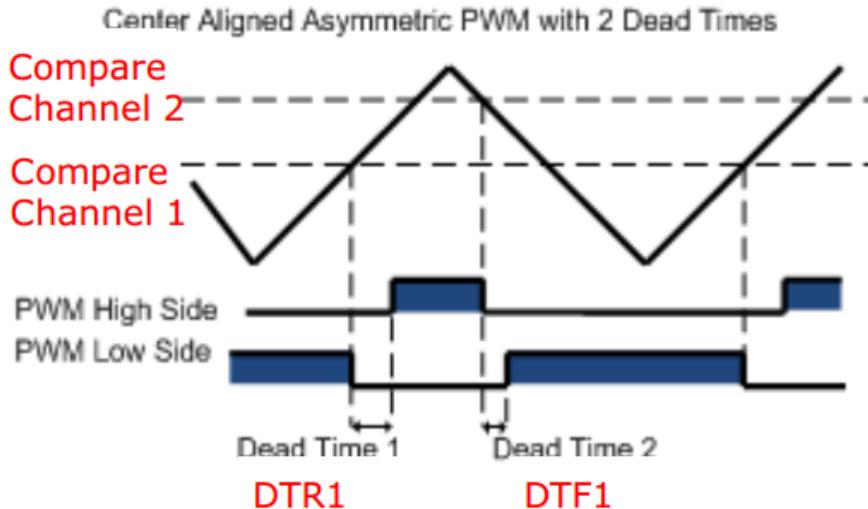
- Four identical 16-bit Capture/Compare Timer slices
- Concatenated timer cells
- Normal/Floating prescaler
- Linking with POSIF



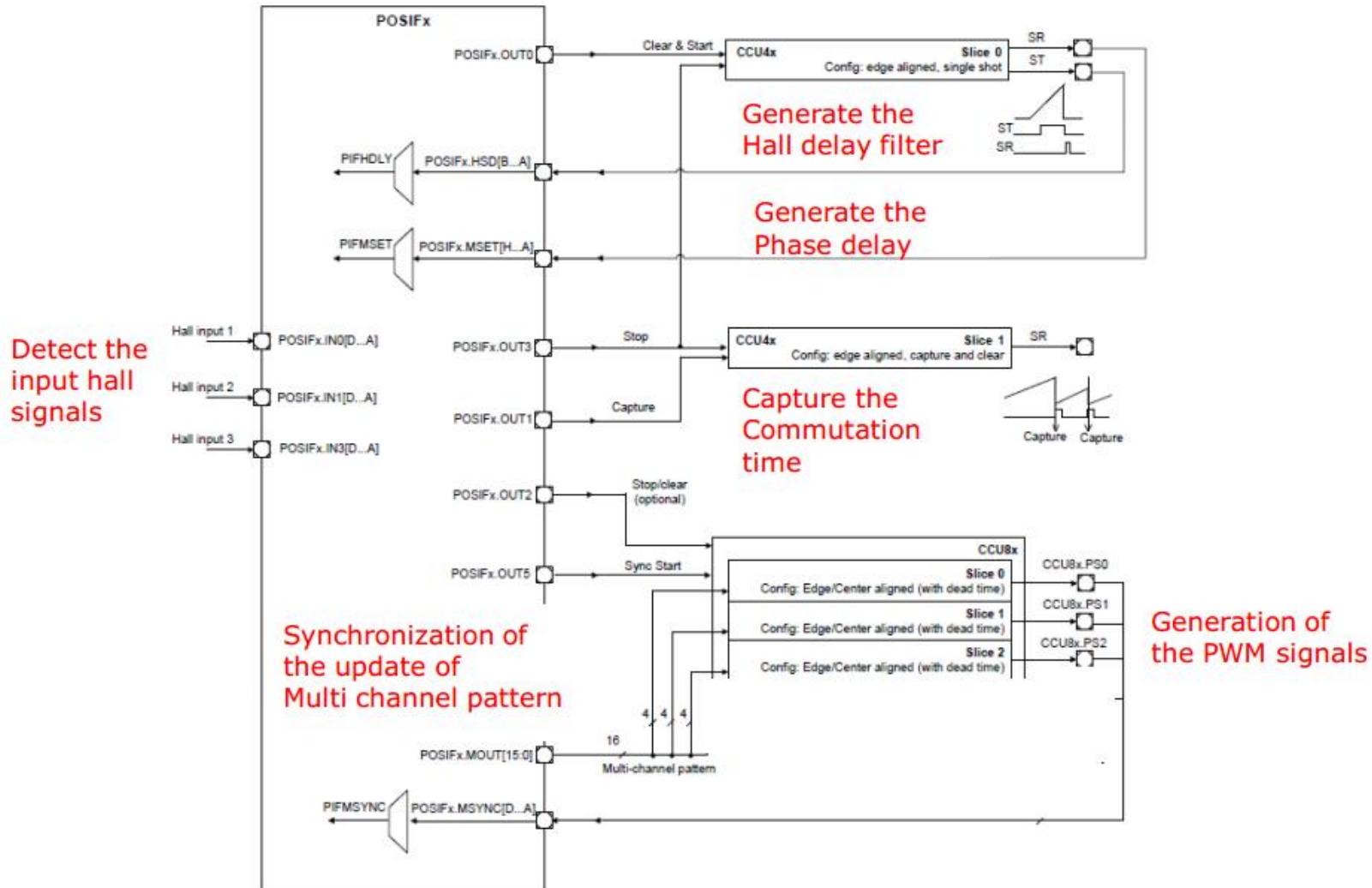
CCU8Feature

General Features

- Support Symmetric, Asymmetric, Periodic, Aperiodic PWM generation.
- Support different dead time values for rising and falling transition.

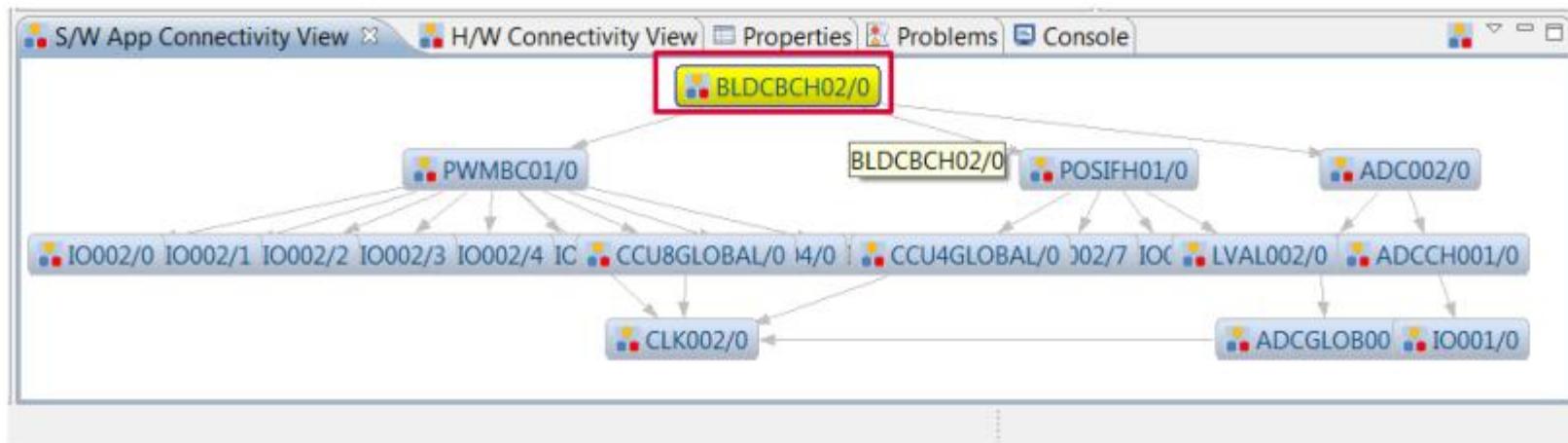


Overview of POSIF, CCU4 & CCU8 usage for Hall Sensor BLDC Motor control application



Hall Sensored Block Commutation

- Double click on “BLDCBCH02/0” in the S/W App Connectivity View.



Hall Sensored Block Commutation –Control Algorithm



BLDCBCH03_0

Control Techniques

Control Strategy: Block Commutation

Feedback Mechanism: Hall Sensor

Control Technique: Voltage Control

PWM frequency: 20000 Hz

Phase Advance: Enable, Angle: 60 Degree

Current Measurement Configuration

Current Measurement: Enable

Measurement Type: Average Current (selected)

Trigger Control: Software Trigger (selected)

Over Current Detection: Enable

Max Current Limit: 300 mA

Speed Control Via Pot: Enable

Trap: Enable

Voltage Compensation: Enable

Time Out: Enable

Time Out Count: 500 msec

Control Algorithm

Control Panel -VC

Motor Parameters

Power Board Configuration

Adaptive HallPattern Dete...

ADC Group Configuration

Interrupts

Control Technique: Voltage Control

Voltage Control (selected)

Speed Control

Current Control

Speed Inner Current Control

Hall Sensored Block Commutation – Control Panel



BLDCBCH03_0

Motor Direction

Forward Direction
 Reverse Direction

Control Parameters

Voltage Control Technique

Voltage Reference

Start Voltage 4 V End Voltage 24

Slew Rate 1 V/s

Control Algorithm Control Panel -VC Motor Parameters Power Board Config

BLDCBCH03_0

Motor Direction

Forward Direction
 Reverse Direction

Control Parameters

Speed Inner Current Control Technique

Speed Reference

Start Speed 1000 RPM End Speed 2000 RPM

Speed PI

Speed Kp 204 dec Speed Ki 20 dec

Speed PI Controller Limit

PI Output 0.6 A Integral Buffer 0.6 A

Current PI

Current Kp 307 dec Current Ki 1 dec

Current PI Controller Limit

PI Output 100 % Integral Buffer 100 %

Slew Rate 500 RPM/s

Configuration Options

Default
 User Defined

Hall Sensored Block Commutation – Motor Parameters



BLDCBCH03_0

Motor Parameters

Nominal Voltage*	24	V	Phase Resistance	39000	mOhm:
Nominal Current	3000	mA	Phase Inductance	199	mH
Nominal Speed*	3000	RPM	Pole Pairs*	2	dec
Nominal Torque	256	Nm			

Hall Sensor Configuration

Hall Pattern

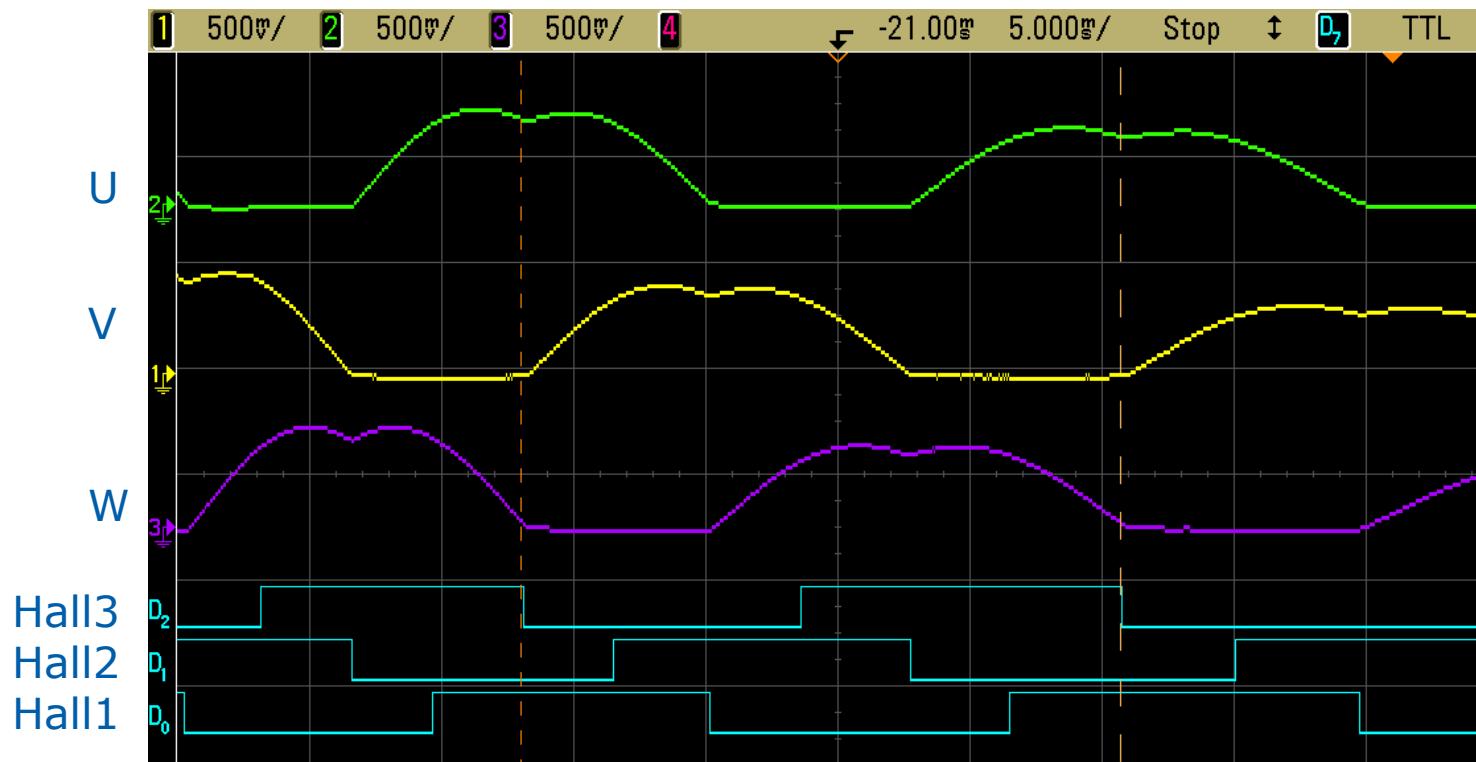
1	1	hex
2	3	hex
3	2	hex
4	6	hex
5	4	hex
6	5	hex

MultiChannel Pattern(PhW-PhV-PhU)

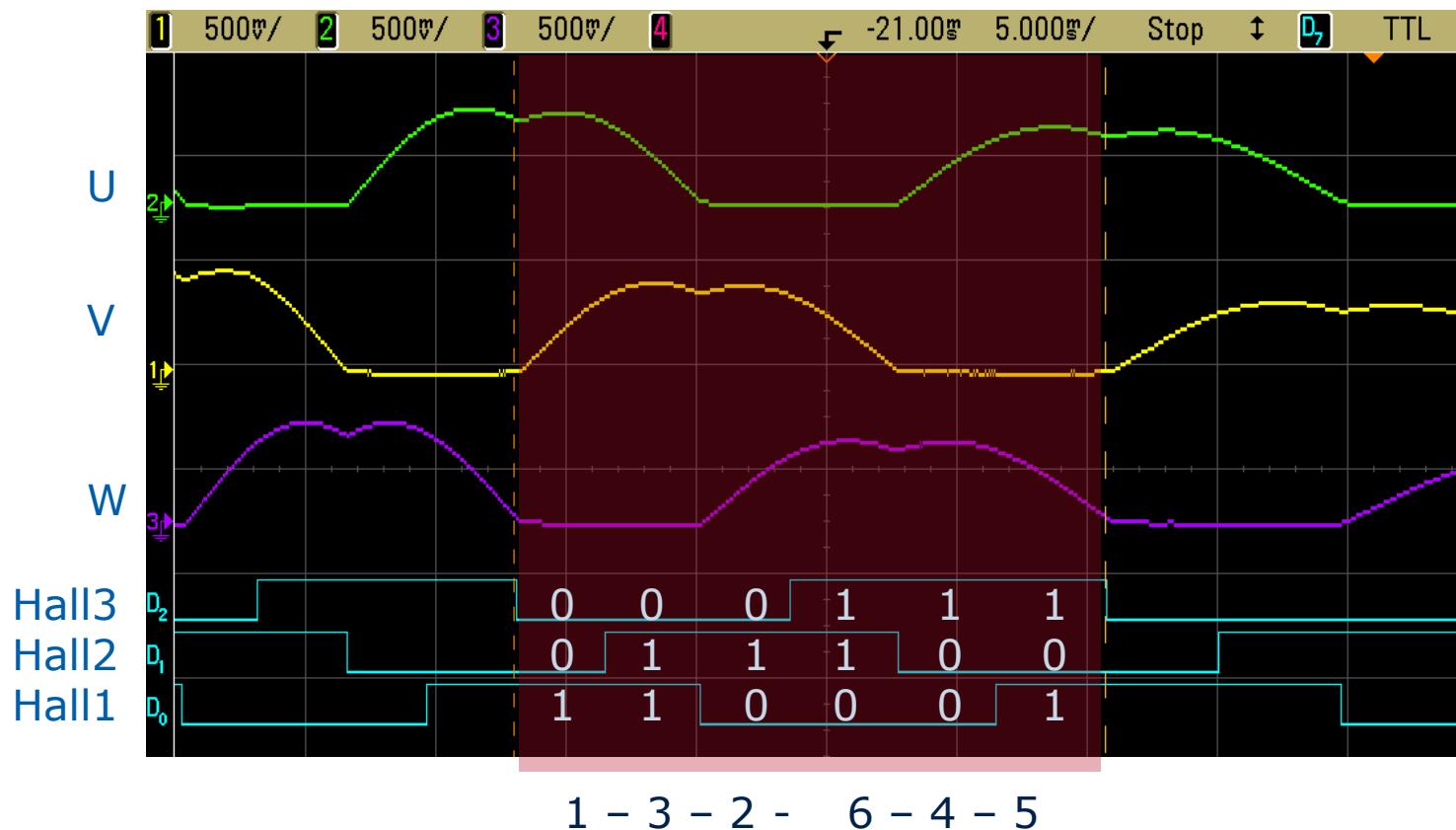
1	102	hex
2	120	hex
3	21	hex
4	201	hex
5	210	hex
6	12	hex

Control Algorithm | Control Panel - SCC | Motor Parameters | Power Board Configura... | Adaptive HallPattern ... | ADC Group Configuration | Interrupts

Hall Sensored Block Commutation – Motor Parameters



Hall Sensored Block Commutation – Motor Parameters



- The Hall Pattern for one electrical cycle is:
- 1 -> 3 -> 2 -> 6 -> 4 -> 5

Hall Sensored Block Commutation – Motor Parameters

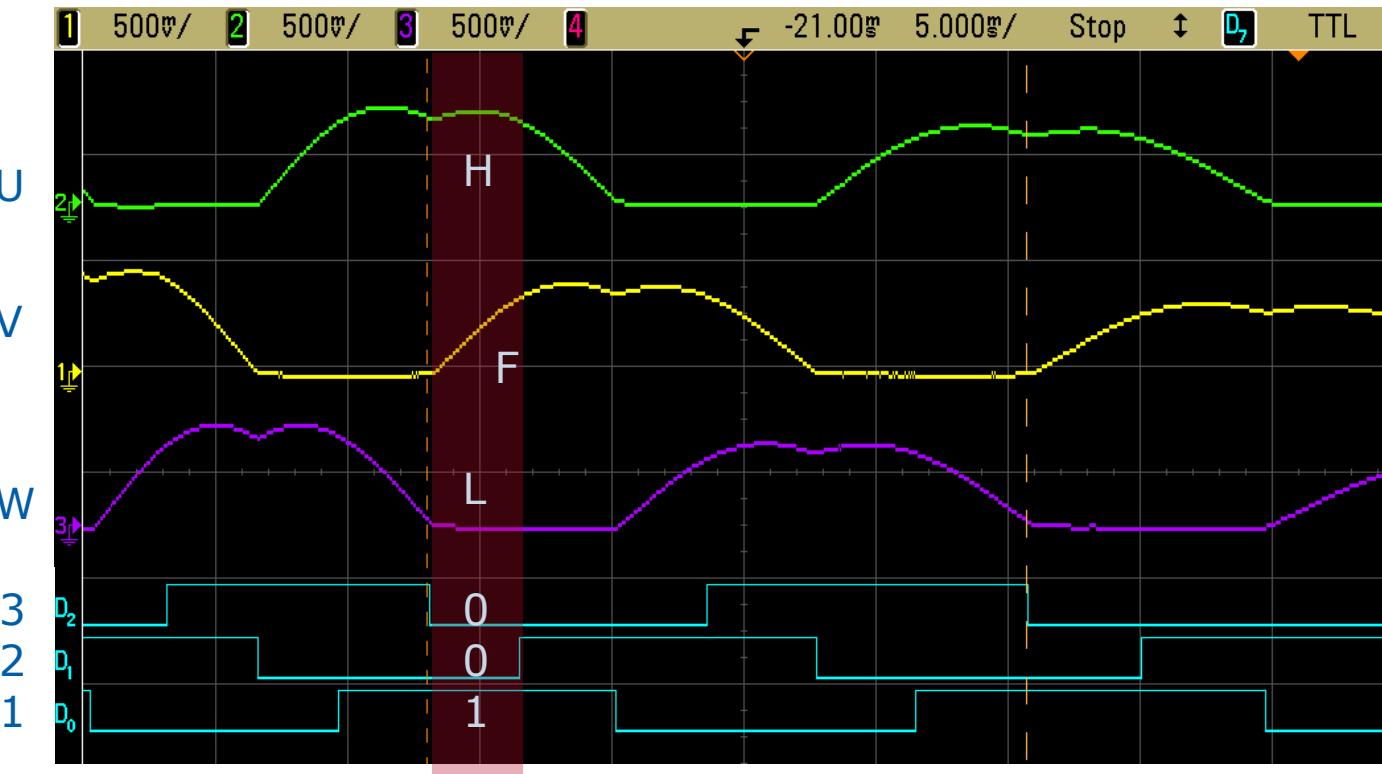


Hall Pattern (Clockwise)		
1	0001	bin
2	0011	bin
3	0010	bin
4	0110	bin
5	0100	bin
6	0101	bin
7	0000	bin
8	0000	bin

Hall Sensor Configurations Hall Pattern Interrupt

- The Hall Pattern for one electrical cycle is:
- 1 -> 3 -> 2 -> 6 -> 4 -> 5

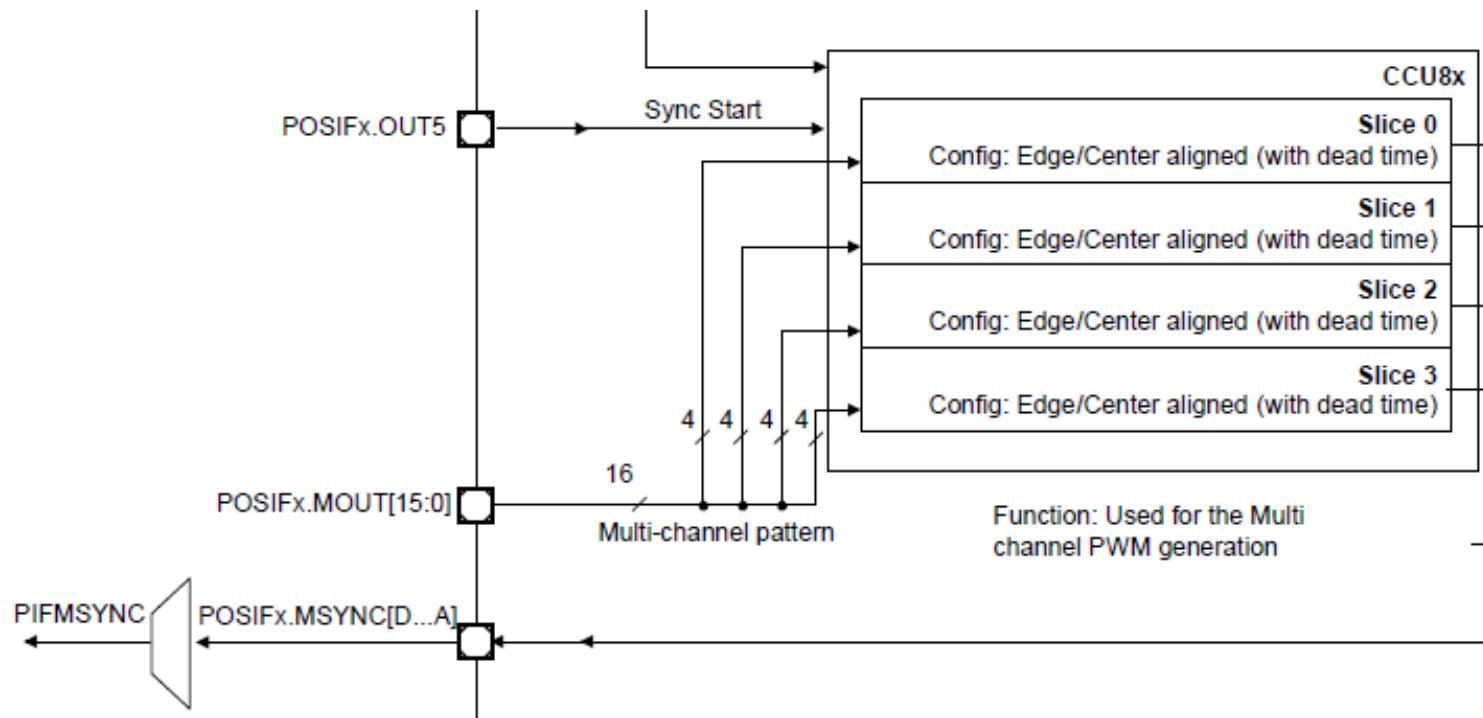
Hall Sensored Block Commutation – Motor Parameters



At Hall Position “1” :

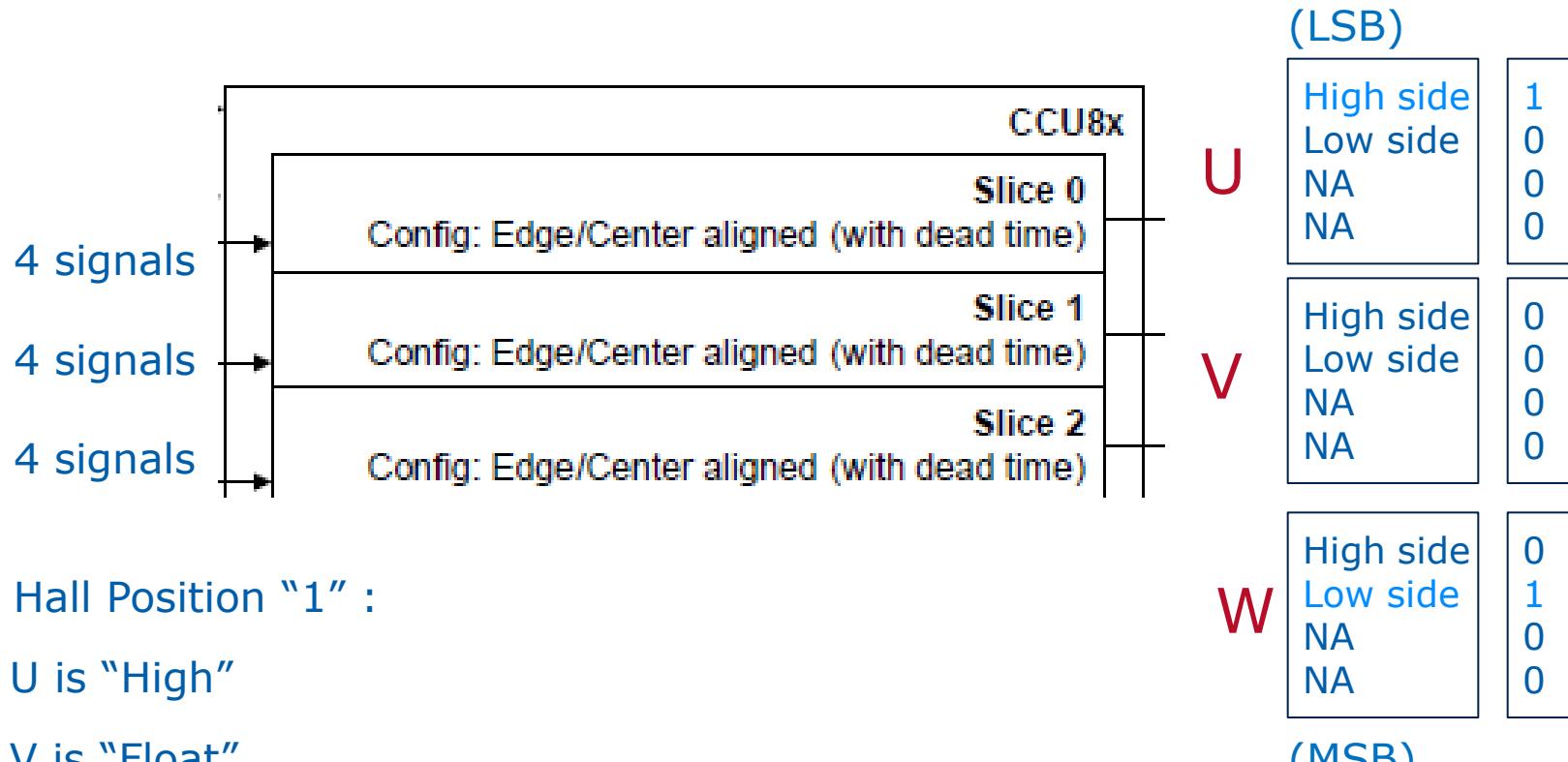
- U is “High”
- V is “Float”
- W is “Low”

Hall Sensored Block Commutation – Motor Parameters



- MOUT of the POSIF is used to control the PWM signal.

Hall Sensored Block Commutation – Motor Parameters



At Hall Position “1” :

- U is “High”
- V is “Float”
- W is “Low”

W V U
(MSB) (LSB)

The output pattern is “0010 0000 0001”.

The output pattern is “201” (hex).

Hall Sensored Block Commutation – Power Board Configuration



BLDCBCH03_0

Power Parameters

DC Link Voltage(Vdc) 24 V

ADC Configurations

VADC Reference 5000 mV

Current Measurement Parameters(DC Link)

Rshunt 50 mOhm

Gain 12 dec

Max Current 4.166666667 A

Amplifier Bias Voltage 2500 mV

Amplifier Bias Voltage Calibration

Enable

Stage Divide Ratio 9.79 %

Modulation Type

High Side Modulation

Modulation Type

High Side Modulation

Both Side Modulation

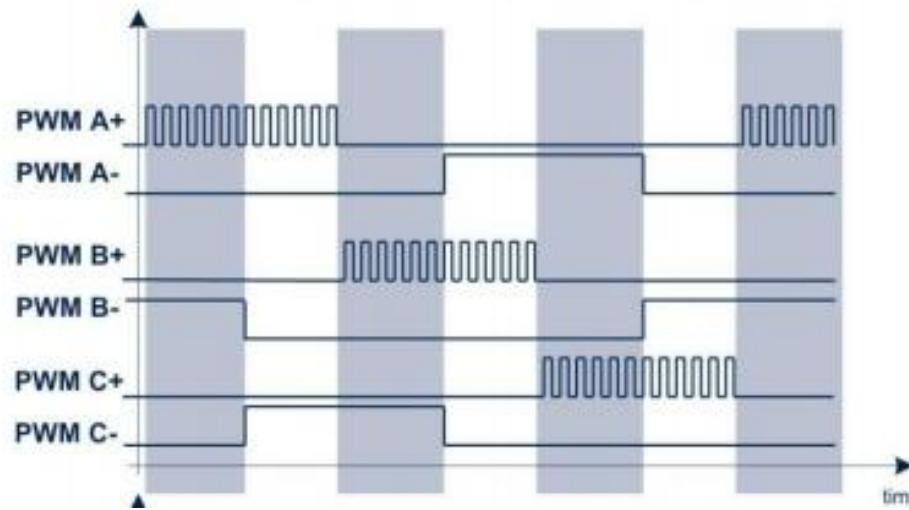
High Side Modulation

Low Side Modulation

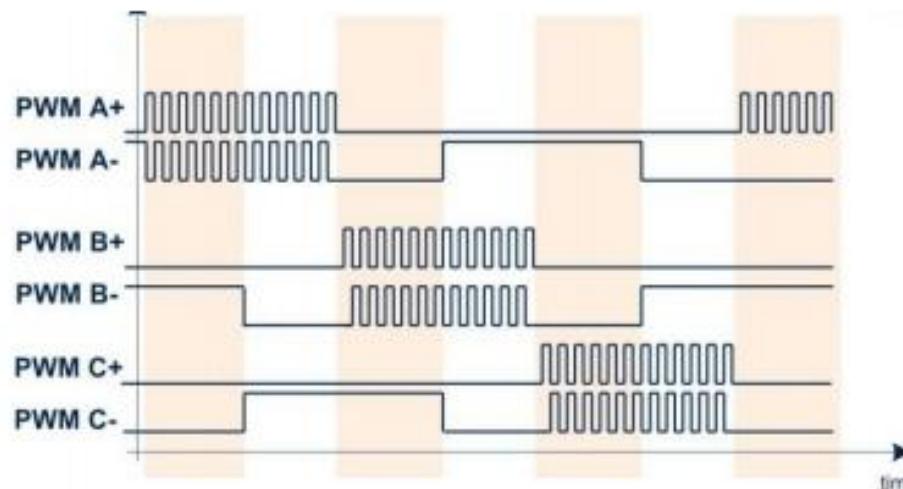
Meters Power Board Configuration Adaptive HallPattern ... ADC Group Configuration Interrupts

Hall Sensored Block Commutation – Motor Parameters

■ High Side PWM



■ Both Side PWM



Hall Sensored Block Commutation – Adaptive Hall Pattern



BLDCBCH03_0

Adaptive Hall Pattern Detection

Enable

Open Loop Speed 500 RPM

Open Loop Voltage 5 V

Control Algorithm | Control Panel - SCC | Motor Parameters | Power Board Configura... | Adaptive HallPattern ... | ADC Group Configuration | Interrupts

A screenshot of a software interface titled "BLDCBCH03_0". The main window is titled "Adaptive Hall Pattern Detection" and contains three configuration fields: "Enable" (checkbox), "Open Loop Speed" set to 500 RPM, and "Open Loop Voltage" set to 5 V. At the bottom of the window, there is a navigation bar with several tabs: "Control Algorithm", "Control Panel - SCC", "Motor Parameters", "Power Board Configura...", "Adaptive HallPattern ...", "ADC Group Configuration", and "Interrupts". The "Adaptive HallPattern ..." tab is currently selected, indicated by a blue border around its tab.

Hall Sensored Block Commutation – Interrupts

BLDCBCH03_0

Interrupt Configurations

Period Match Interrupt

Preemption Priority dec

User Function `BLDCBCH03_PWMPeriodMatchISR<AppInst>`

Pattern Update Interrupt

Preemption Priority dec

User Function `BLDCBCH03_PatternUpdateISR<AppInst>`

Trap Interrupt

Preemption Priority dec

User Function `BLDCBCH03_TrapISR<AppInst>`

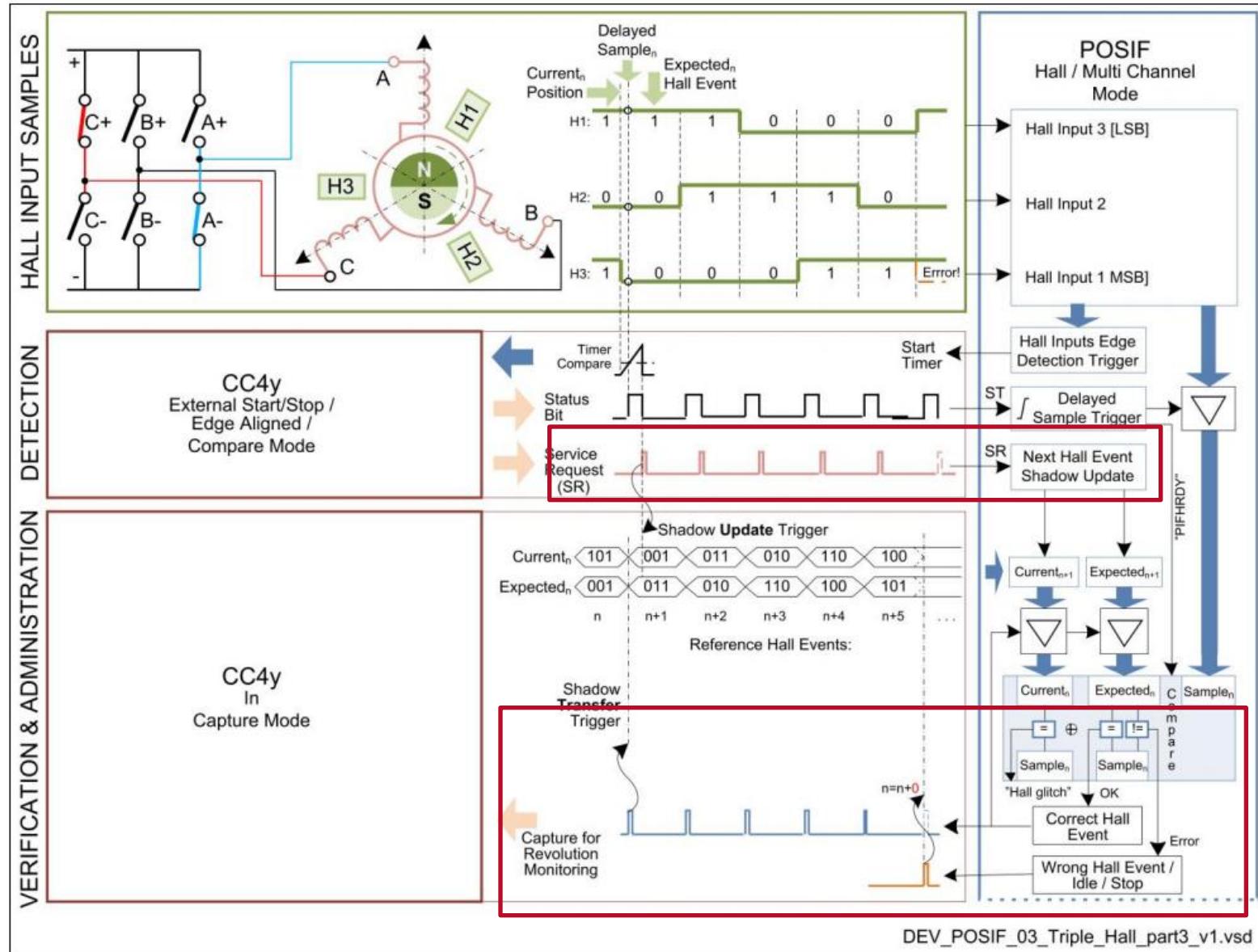
Wrong Hall Event Interrupt

Preemption Priority dec

User Function `BLDCBCH03_WrongHallEventISR<AppInst>`

Control Algorithm | Control Panel - SCC | Motor Parameters | Power Board Configura... | Adaptive HallPattern ... | ADC Group Configuration | **Interrupts**

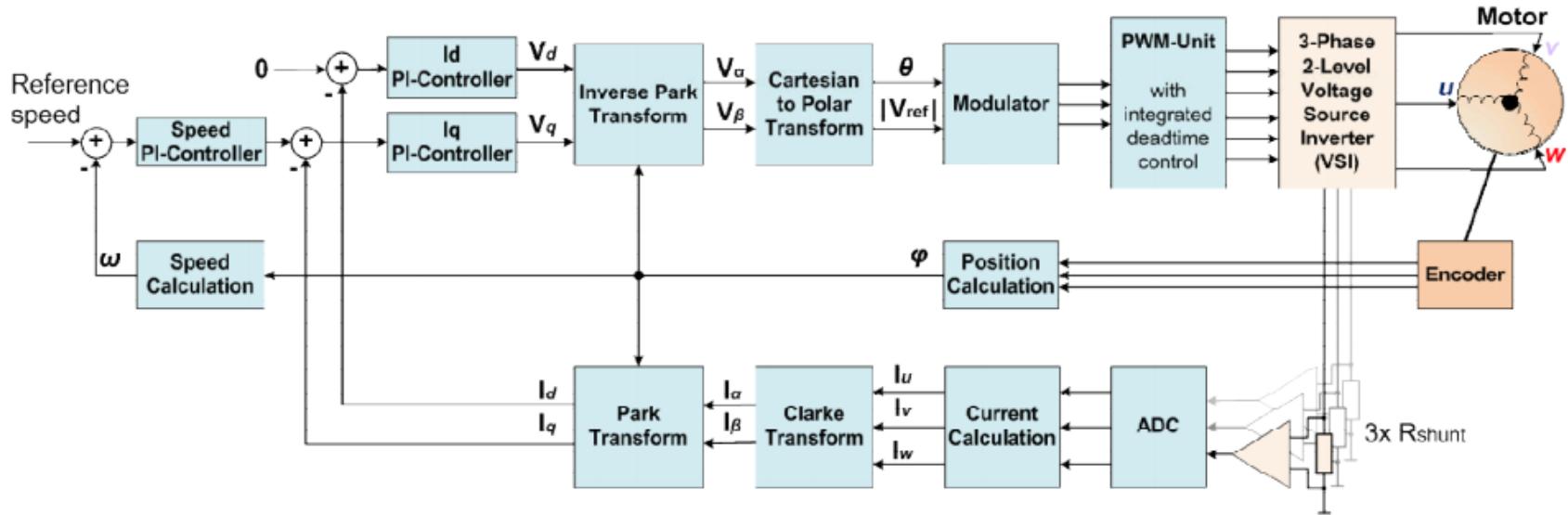
Hall Sensed Block Commutation – Interrupts



Main Content

- Infineon Latest MCU portfolio
- System block, Key Features
- Supporting tool, Ecosystem
- BLDC Motor Driver Design Using XMC
- PMSM Motor Driver Design Using XMC

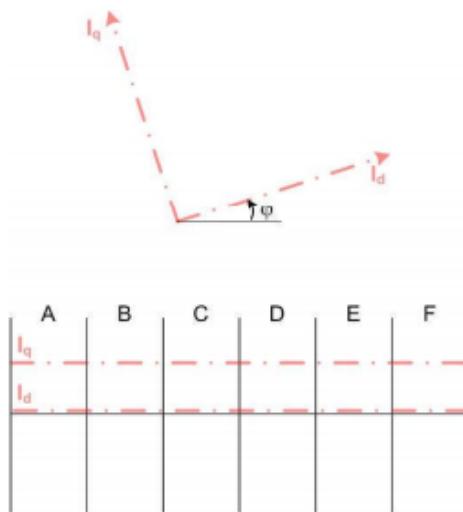
PMSM Field Oriented Control with Encoder



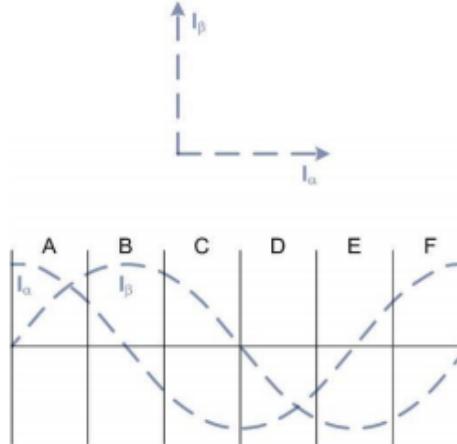
- FOC is a method to generate three phase sinusoidal signals which can easily be controlled in frequency and amplitude in order to minimize the current which means to maximize the efficiency
- The basic idea is the transform of three phase signals into two rotor-fix signals and vice versa

PMSM Field Oriented Control with Encoder

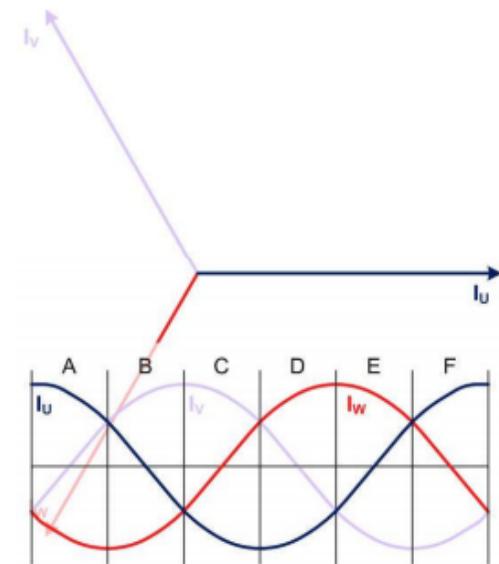
Rotating
orthogonal
reference frame



Two phase
orthogonal
reference frame



Three phase
120°
reference frame



Park Transform

Clarke Transform

Mathematical Consideration

■ Clarke Transform

$$i_\alpha = i_u$$

$$i_\beta = \frac{1}{\sqrt{3}} \cdot i_u + \frac{2}{\sqrt{3}} \cdot i_v = \frac{1}{\sqrt{3}} \cdot (i_u + 2 \cdot i_v)$$

$$i_u + i_v + i_w = 0$$

■ Park Transform

$$i_d = i_\alpha \cdot \cos(\varphi) + i_\beta \cdot \sin(\varphi)$$

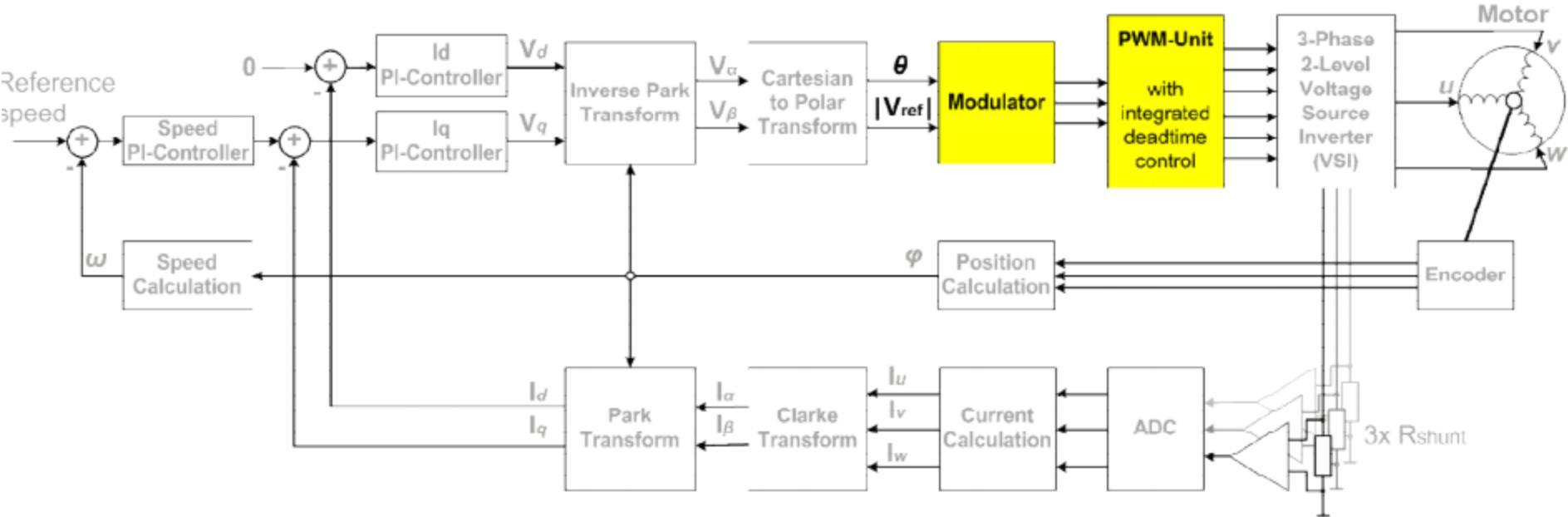
$$i_q = -i_\alpha \cdot \sin(\varphi) + i_\beta \cdot \cos(\varphi)$$

■ Inverse Park Transform

$$V_\alpha = V_d \cdot \cos(\varphi) - V_q \cdot \sin(\varphi)$$

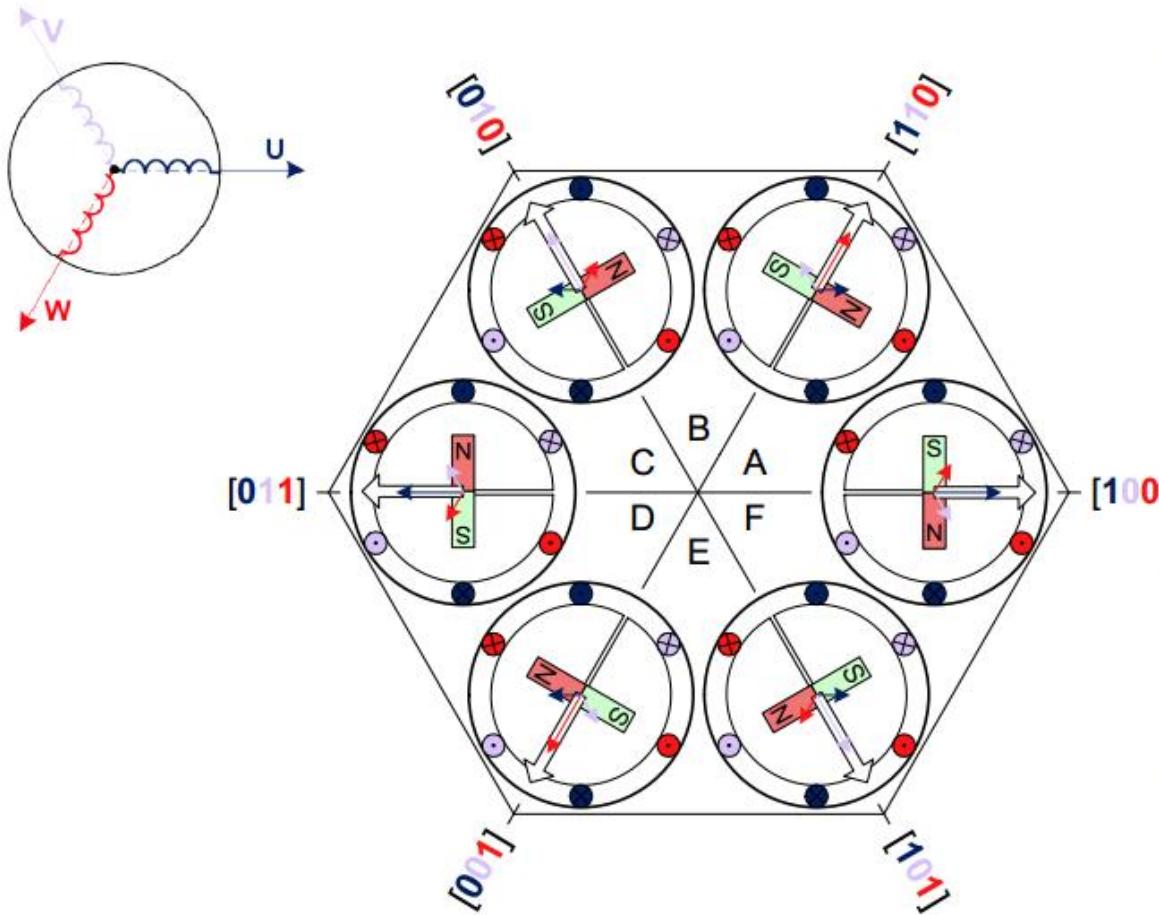
$$V_\beta = V_d \cdot \sin(\varphi) + V_q \cdot \cos(\varphi)$$

Space Vector Modulation



- Space Vector Modulation (SVM) is an algorithm for the control of Pulse Width Modulation (PWM)
- It is used for the creation of three phase sinusoidal waveforms

Space Vector Diagram



■ Active Vectors

- V1: 100
- V2: 110
- V3: 010
- V4: 011
- V5: 001
- V6: 101

■ Passive Vectors

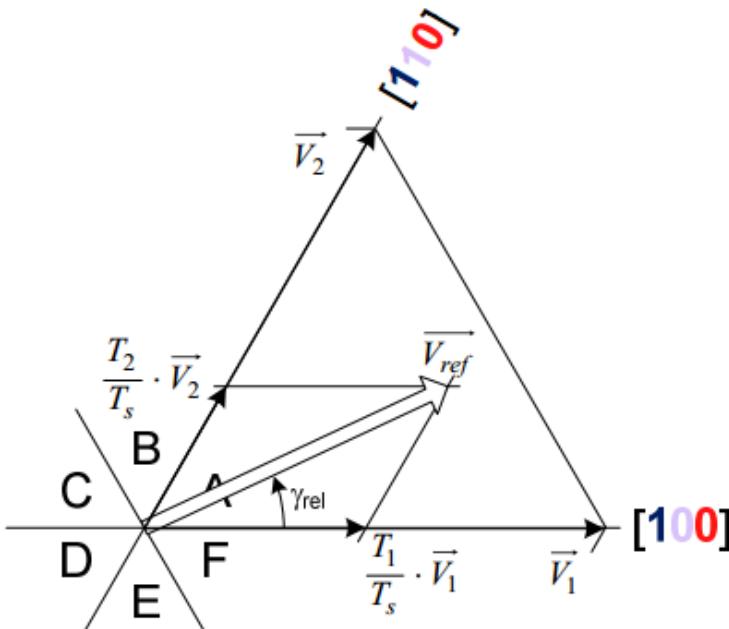
- V0: 000
- V7: 111

■ Six Sectors

- A, B, C, D, E, F

Space Vector Diagram

- V_{ref} is approximated by two adjacent active vectors (e.g. V_1, V_2) and one or both of the passive vectors (e.g. V_0 only)
- The plane is dissected in six sectors and the angle θ is transformed into the relative angle γ_{rel}
- T_1, T_2 and T_0 correspond with the active vectors and passive vector(s) (e.g.: V_1, V_2 and V_0 in Sector A)



$$\blacksquare T_1 = \frac{\sqrt{3} \cdot T_s \cdot |V_{ref}|}{V_{DC}} \sin\left(\frac{\pi}{3} - \gamma_{rel}\right)$$

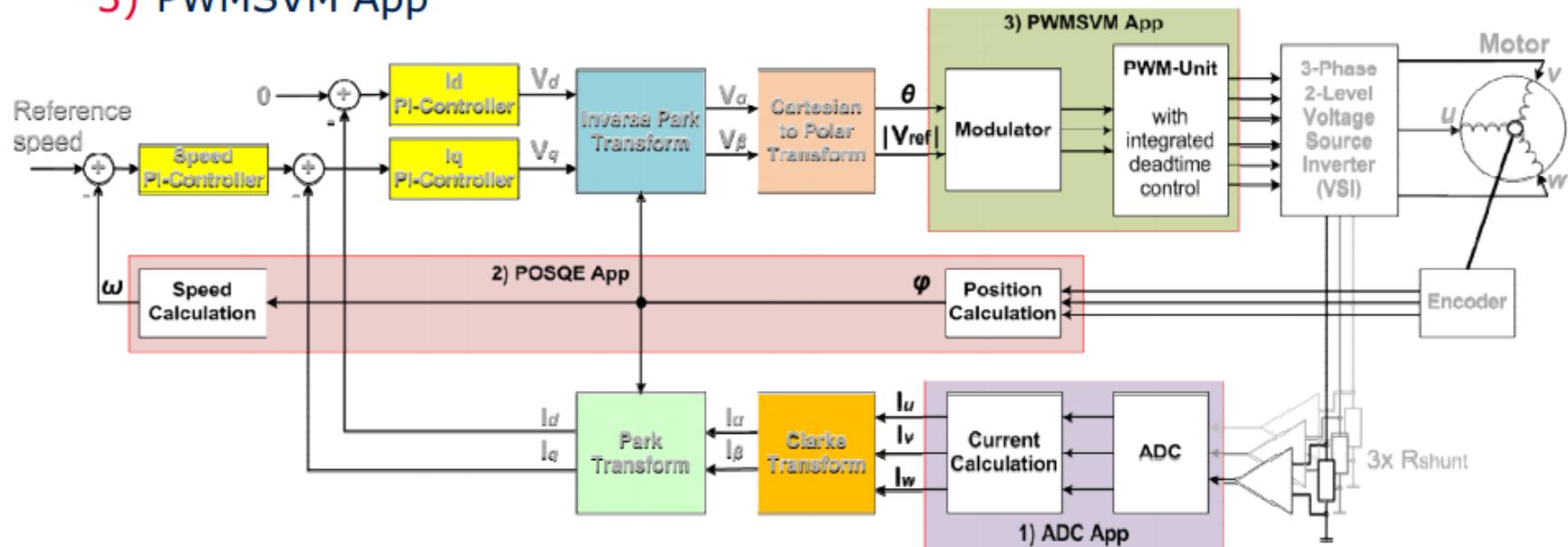
$$\blacksquare T_2 = \frac{\sqrt{3} \cdot T_s \cdot |V_{ref}|}{V_{DC}} \sin(\gamma_{rel})$$

$$T_0 = T_s - T_1 - T_2$$

FOC Example Project - Overview of Apps

- Three key peripheral-specific DAVE™ Apps are used for FOC Example Project

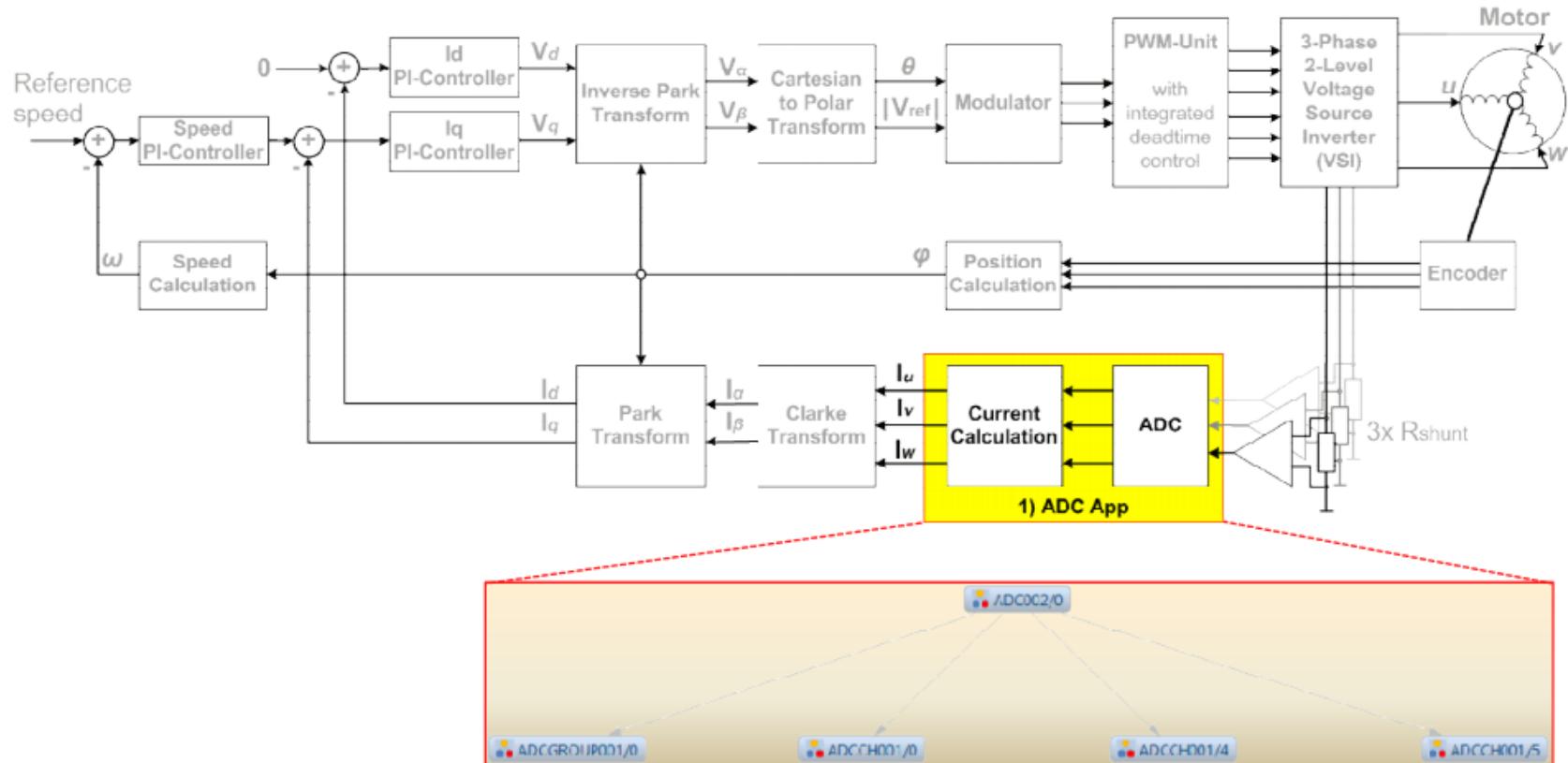
- 1) ADC App
- 2) POSQE App
- 3) PWMSVM App



- Other blocks of the algorithm use control library functions

ADC App

- ADC002 App configures queue request source of the ADC group.

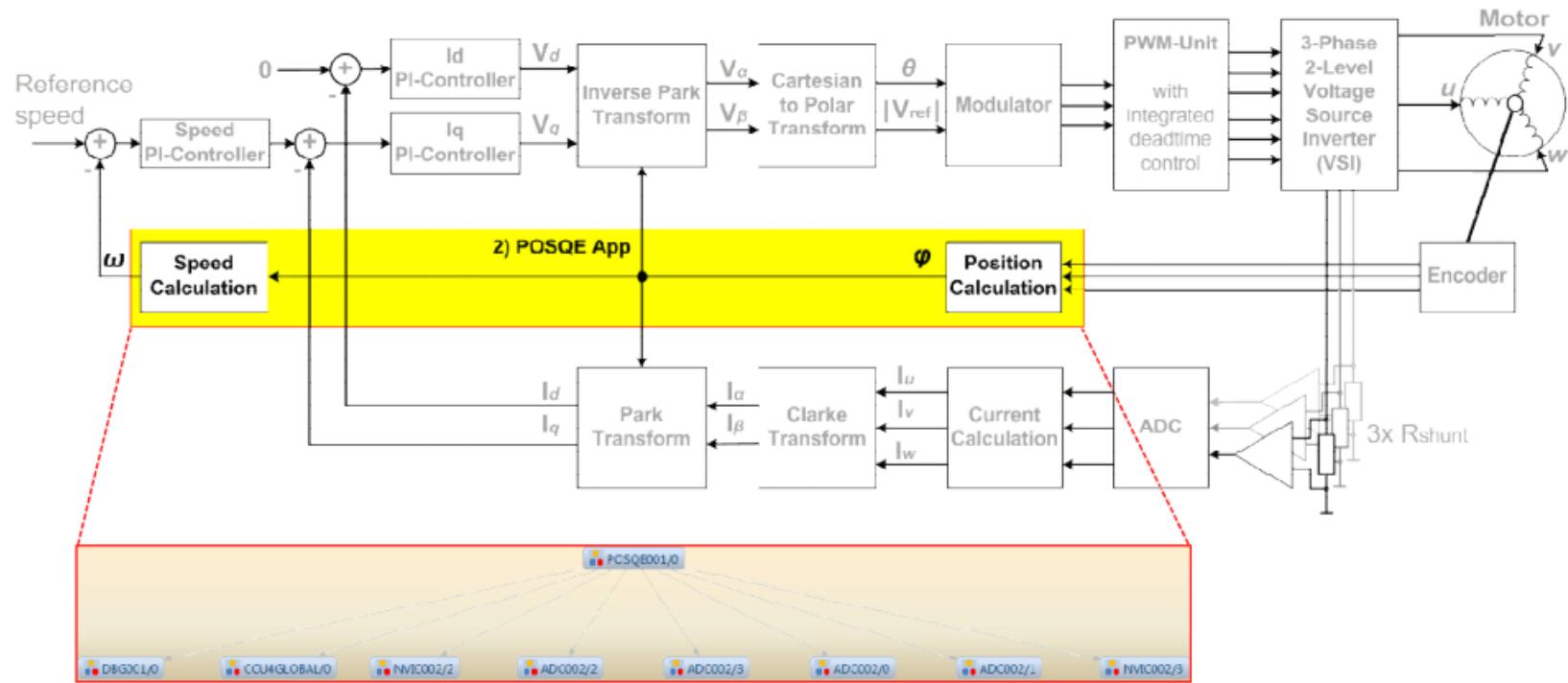


ADC App - Feature

- Consumes ADCGROUP001 App and a number of ADCCH001 Apps depending upon the number of channels configured
- Provides the following configurations
 - Number of channels (maximum 8 channels from the same ADC group)
 - Enable the queue request source
 - Request source priority configuration
 - External trigger mode
 - Gate mode configuration
 - Start mode configuration
 - Group input class 0 configuration
 - Queue entry configuration

POSQE App

- POSQE001 App is targeted to find the speed and position of a motor with quadrature encoder

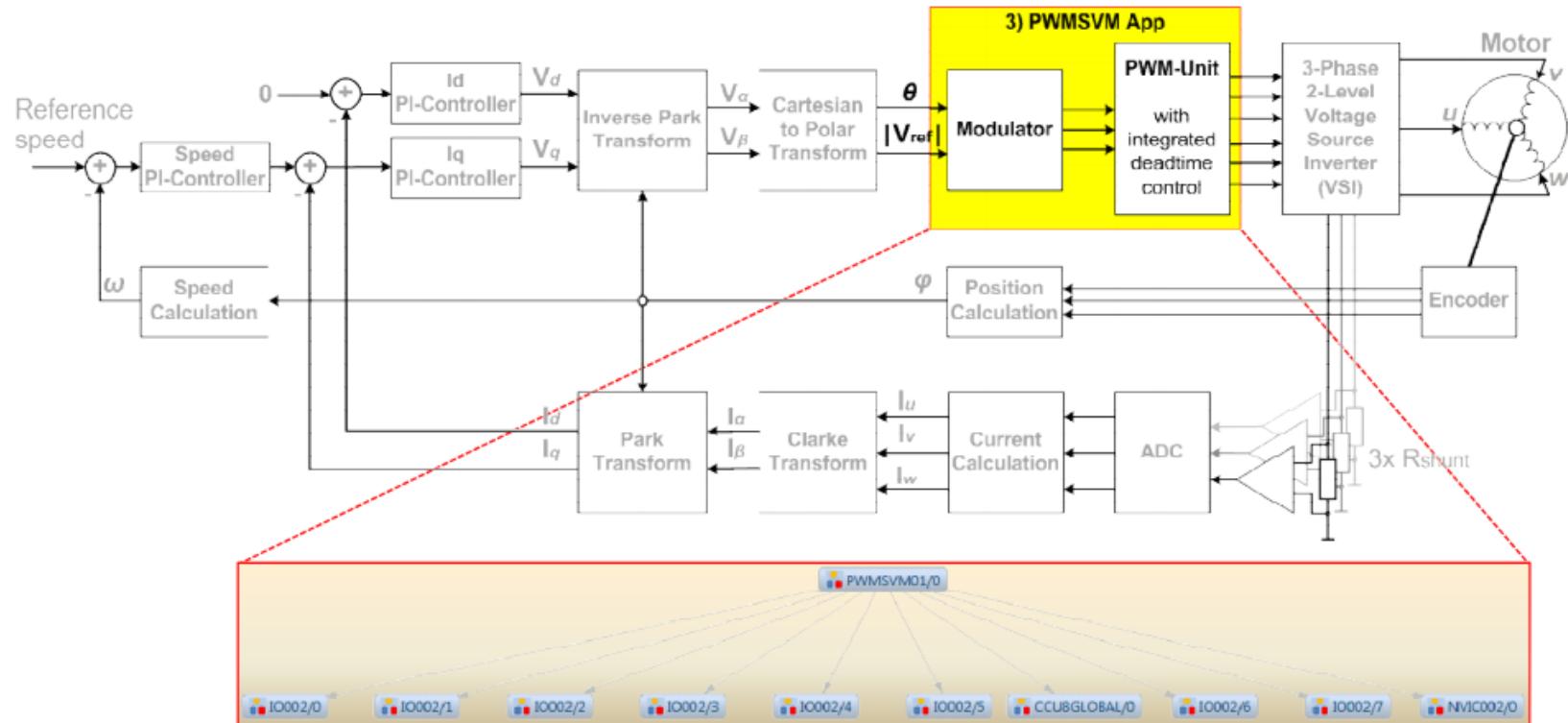


POSQE App - Feature

- Software controlled start and stop
- Get motor speed
- Get motor position:
 - Without interpolation
 - With interpolation (more precise position results)
- Get motor direction
- Get motor revolutions

PWMSVM App -

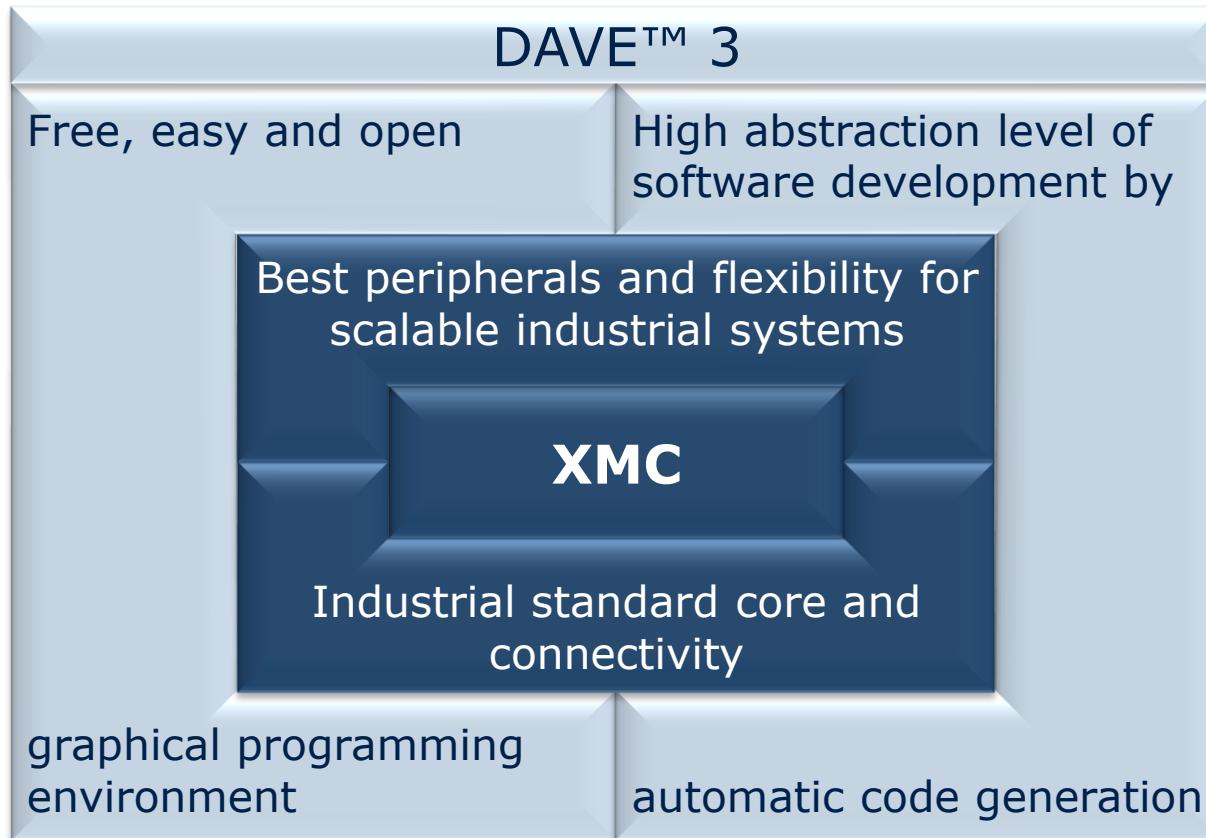
- PWMSVM01 App generates Space Vector Pulse Width Modulated output with deadtime to drive 3-phase 2-level voltage inverter



PWMSVM App - Feature

- Synchronous start of three phases of the 3-phase 2-level voltage inverter
- Symmetric and asymmetric SVM generation
- 7-segment and 5-segment SVM schemes
- Inverter enable pin configuration
- Trap feature
- Dead time generation

XMC family: 32-bit microcontroller family for industrial applications



Key differentiators of the Infineon XMC industrial microcontroller family



Combination of Infineon key IP and know-how with all the benefits of an industry standard core

Microcontroller Know-how

- >30 years automotive and industrial microcontroller experience
- Innovative application specific peripherals
- Highly configurable and flexible
- Fast flash

Quality and reliability

- High-performance Flash technology
- Extended temperature range on selected products (125 °C)
- Long product life time (min. 15 years)

SW Tool DAVE™ 3

- Next generation of DAVE™ with enhanced functionality
- Free tools
- Auto-code generation making powerful hardware easy to use
- Open to 3rd parties



Thank you!

ENERGY EFFICIENCY
MOBILITY
SECURITY

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