XMC™ in motor control applications

XMC™ microcontrollers
October 2016

Agenda

1	Why XMC™ for motor control?
2	Key microcontroller features
3	Kits and reference design
4	Development tool and software
5	General information

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Why XMC™ for motor control?

› Wide microcontroller portfolio

XMC1000 ARM® Cortex®-M0	XMC4000 ARM® Cortex®-M4

32 MHz 48 MHz	80 MHz 120 MHz 144 MHz
MATH Coprocessor	FPU and DSP instructions
Flash (kB): 16 32 64 128 200	64 128 256 512 1024 2048
Pins: 16 24 28 38 40 64	48 64 100 144 196

› Peripherals tailored for motor control

  – Fast 12-bit ADC

  – Position interfaces for Hall sensors, incremental encoders and resolvers

  – PWM units tailored for sinusoidal and trapezoidal commutation pattern

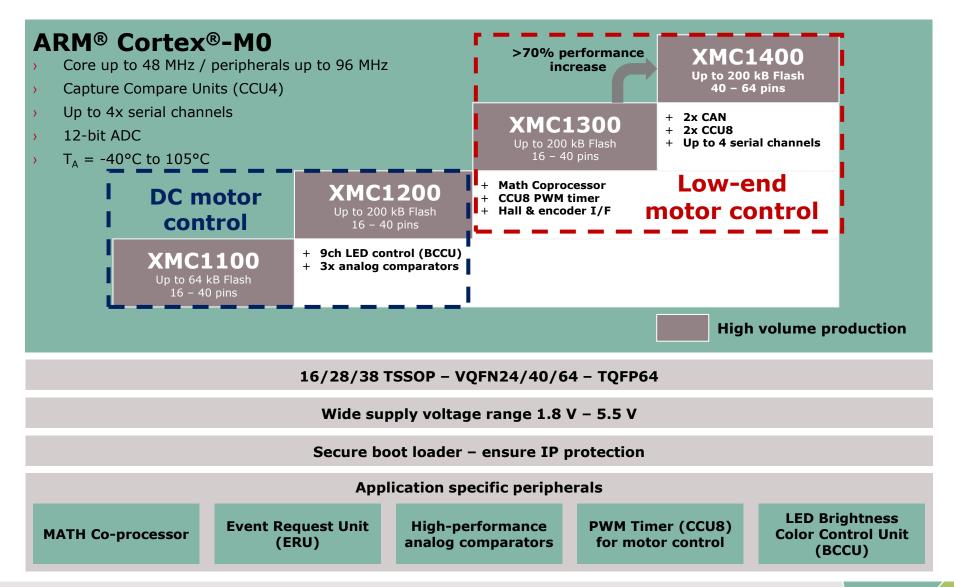› Ideal for Field-Oriented Control (FOC)

Motor control

M

Fans

Pumps

LEV

Power tools

Home & garden

Electric toys

Drives

Industrial automation

Home appliance

XMC™ product portfolio
- XMC1000 family overview

ARM® Cortex®-M0

› Core up to 48 MHz / peripherals up to 96 MHz

› Capture Compare Units (CCU4)

› Up to 4x serial channels

› 12-bit ADC

› T_A = -40°C to 105°C

>70% performance increase

XMC1400
Up to 200 kB Flash
40 – 64 pins

XMC1300
Up to 200 kB Flash
16 – 40 pins

+ **2x CAN**
+ **2x CCU8**
+ **Up to 4 serial channels**

+ **Math Coprocessor**
+ **CCU8 PWM timer**
+ **Hall & encoder I/F**

Low-end motor control

DC motor control

XMC1200
Up to 200 kB Flash
16 – 40 pins

XMC1100
Up to 64 kB Flash
16 – 40 pins

+ **9ch LED control (BCCU)**
+ **3x analog comparators**

High volume production

16/28/38 TSSOP – VQFN24/40/64 – TQFP64

Wide supply voltage range 1.8 V – 5.5 V

Secure boot loader – ensure IP protection

Application specific peripherals

| **MATH Co-processor** | **Event Request Unit (ERU)** | **High-performance analog comparators** | **PWM Timer (CCU8) for motor control** | **LED Brightness Color Control Unit (BCCU)** |

5

ARM® Cortex®-M4 (with FPU)

› CPU frequency up to 144 MHz
› High performance Flash technology
› Timers CCU4, CCU8, POSIF
› USB / up to 6x CAN / up to 6x serial channels
› Up to 4x 12-bit ADC / 2x DAC
› T_A = -40°C to 125°C

XMC4800
Up to 2 MB Flash / 352 kB RAM
100 – 196 pins
EtherCAT®

XMC4700
Up to 2 MB Flash / 352 kB RAM
100 – 196 pins
+ **144 MHz core**
+ **6ch CAN**

XMC4500
Up to 1 MB Flash / 160 kB RAM
100 – 144 pins
+ **EBU**
+ **SD card**

XMC4300
256 kB Flash / 128 kB RAM
100 pins
EtherCAT®

XMC4400
Up to 512 kB Flash / 80 kB RAM
64-100 pins
+ **120 MHz core**
+ **Ethernet**
+ **ΔΣ demodulator**

XMC4100/4200
Up to 256 kB Flash / 40 kB RAM
48-64 pins

High-end motor control

Mid-range motor control

High volume production

48 QFN – 64-144 LQFP – 196 BGA

Long product life cycle (min. 2031)

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

Application specific peripherals

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

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Key microcontroller features

Peripherals for motor control applications

ADC	CCU8	
CCU4	ARM® Cortex®-M	MATH
POSIF	DSD	

Highlights

XMC™ microcontrollers are well suited for various motor control applications and their specific control schemes

Well tailored and interconnected analog, PWM and sensor interface peripherals are scalable over the entire XMC™ family

Key feature

› Dedicated motor control peripherals for various control schemes and sensors
› Interconnected analog, PWM and sensor interface peripherals
› ARM® Cortex®-M CPU portfolio range from M0 with MATH to M4 with FPU

Customer benefits
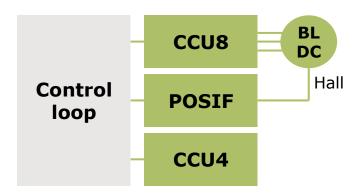
› Select and configure the peripherals with respect to the specific requirements
› Autonomous peripherals ensure precise control for high energy efficiency
› Easy cost and performance balancing within the entire XMC™ portfolio

Dedicated motor control peripherals for various control schemes and sensors
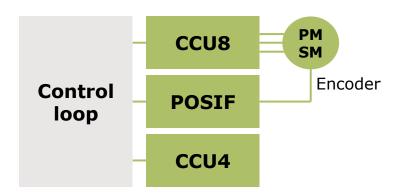
Feature rich peripherals with dedicated motor control features allow optimization of the system behaviour with respect to the specific application's requirements
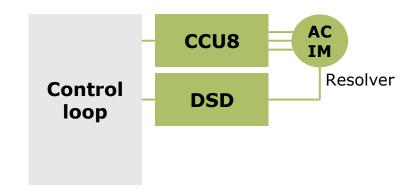
› BLDC control with Hall sensors

```
Control    ── CCU8 ──── BL
loop                    DC
           ── POSIF ──── Hall
           ── CCU4
```

› FOC control with encoder

```
Control    ── CCU8 ──── PM
loop                    SM
           ── POSIF ──── Encoder
           ── CCU4
```
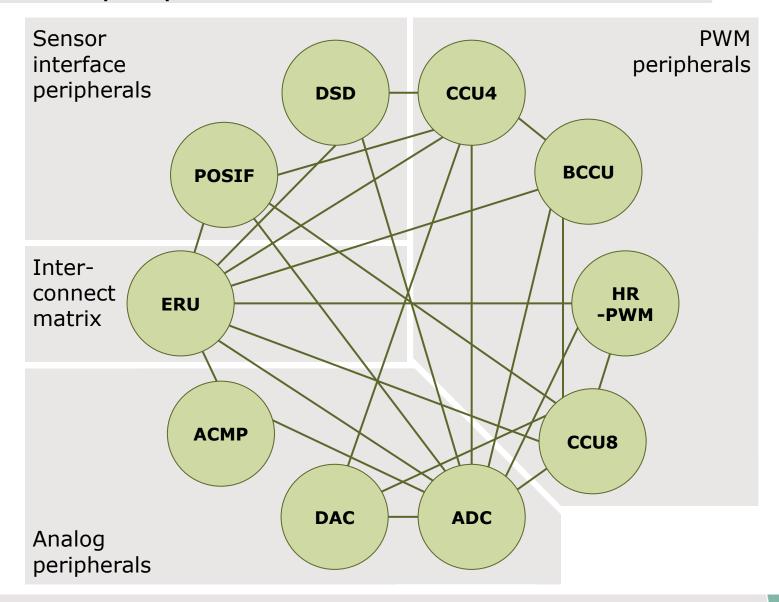
› FOC control with resolver

```
Control    ── CCU8 ──── AC
loop                    IM
           ── DSD ──── Resolver
```

Interconnected analog, PWM and sensor interface periperals

Sensor interface peripherals

PWM peripherals

Inter-connect matrix

Analog peripherals

DSD, CCU4, POSIF, BCCU, ERU, HR-PWM, ACMP, CCU8, DAC, ADC

XMC™ ARM® Cortex®-M0
- with MATH coprocessor

› XMC1300 series with 16 to 40 pins

– 32-bit ARM® Cortex®-M0 core running at 32 MHz

– MATH coprocessor running at 64 MHz

– 7x faster division compared to other Cortex®-M0 devices

– 38x faster sine, cosine and arctangent calculations

– High resolution Park/Inverse Park Transforms at 24-bit in less than 1 μs

– PWM units clocked at 64 MHz for precise modulation

› XMC1400 series with 40 to 64 pins

– 32-bit ARM® Cortex®-M0 core running at 48 MHz

– MATH coprocessor running at 96 MHz

– PWM units clocked at 96 MHz for precise modulation

– CAN bus connectivity

XMC™ ARM® Cortex®-M4
- with FPU and EtherCAT®

› XMC4000 Series with 48 to 196 pins

  – 32-bit ARM® Cortex®-M4 core with FPU running at 80 MHz to 144 MHz

  – DSP instruction set with saturation and MAC instructions

  – Wide temperature range from -40°C to 125°C

› As a highlight, XMC4300 and XMC4800 are the first-ever highly integrated ARM® Cortex®-M based microcontrollers with EtherCAT® integrated

  – Bringing real-time Ethernet communication into an unrivaled level

    – Ease of implementation
    – Cost effectiveness

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XMC™ motor control application kits
- for DC motors

Development boards		Order number	Kit/ref design
DC motor control shield with BTN8982TA for Arduino		DC-MOTORCONTR_BTN8982	Kit
24 V protected switch shield with BTT6030-2EKA and BTT6020-1EKA for Arduino		24V_SHIELD_BTT6030	Kit
H-bridge kit 2GO		HBRIDGEKIT2GO TOBO1	Kit

XMC™ motor control application kits
- for low voltage AC motors (1/2)

Development boards		Order number	Kit/ref design
XMC1000 motor control application kit		KIT_XMC1X_AK_MOTOR_001	Kit
XMC1300 boot kit		KIT_XMC13_BOOT_001	Kit
XMC1400 boot kit		KIT_XMC14_BOOT_001	Kit
XMC4400 motor control application kit		KIT_XMC44_AE3_001	Kit

XMC™ motor control application kits
- for low voltage AC motors (2/2)

Development boards		Order number	Kit/ref design
24 V, 250 W motor drive power card for XMC1000 and XMC4000		(coming soon)	Kit

XMC™ motor control application kits
- for high voltage AC motors (1/2)

Development boards		Order number	Kit/ref design
XMC™ 750 Watt motor control application kit		KIT_XMC750WATT_MC_AK_V1	Kit
XMC1300 drive card		KIT_XMC1300_DC_V1	Kit
XMC4400 drive card		KIT_XMC4400_DC_V1	Kit

XMC™ motor control application kits
- for high voltage AC motors (2/2)

Development boards		Order number	Kit/ref design
iMOTION™ modular application design kit (MADK)		EVALM11302056 5DTOBO1 EVALM11302058 4DTOBO1 EVALM11302364 5ATOBO1 EVALM11302368 4ATOBO1	Kit

XMC™ motor control reference designs and system demonstrators

System solution		Order number	Kit/ref design
BLDC power tool reference design 1 kW / 20 V_{DC}		On request OPN:EVALSSO81 KWBLDCTOBO1	Kit / Ref design
40mm server fan reference design with XMC1302 in VQFN24 package		-	Ref design
Modular 3-phase motor drive 100 W / 230 V_{AC}		-	Ref design
Multi-axis drive and motion control with XMC4400		-	demo

DC motor control shield
with BTN8982TA for Arduino

Application Diagram of the DC Motor Control Shield

Key features:
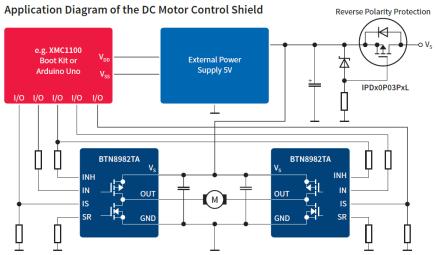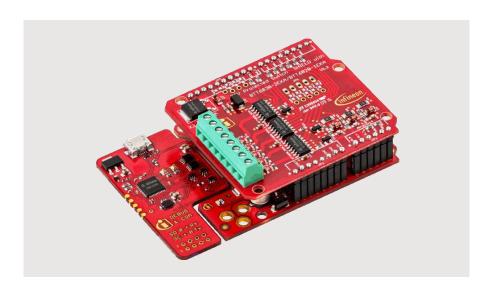
› Compatible with Arduino Uno R3 and XMC1100 boot kit from Infineon

› Capable of high frequency PWM, e.g. 30 kHz

› Diagnosis with current sense

› Protection e.g. against over-temperature and overcurrent

Customer benefits:

› Rapid prototyping of DC motor control in half and full bridge configuration

› Precise control and small current ripples

› Easy overload detection and current limitation by software control

› Robust design platform without hesitation
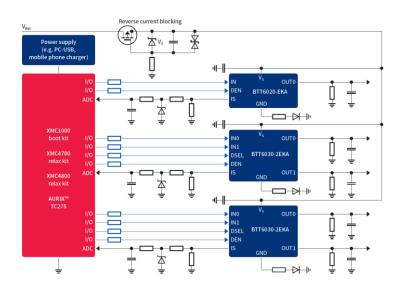
24 V protected switch shield with BTT6030-2EKA and BTT6020-1EKA for Arduino

Key features:

› Compatible with Arduino microcontroller boards and XMC™ microcontroller kits using the Arduino form factor (e.g.: XMC1100 boot kit)

› 8 V - 36 V input voltage (max. 5V - 48 V), current up to 5 A per channel

› Capable of PWM up to 400 Hz

› Driver circuit with logic level inputs

Customer benefits:

› Fast and inexpensive prototyping of 24 V load driving, e.g.: motors

› Load diagnosis with current sense capability

› Over temperature shut down with latch behaviour
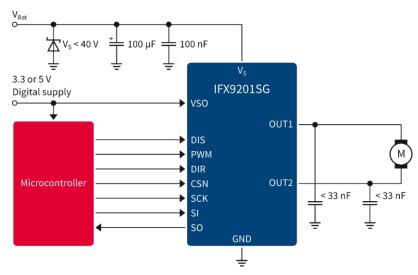
H-bridge kit 2GO

Key features:
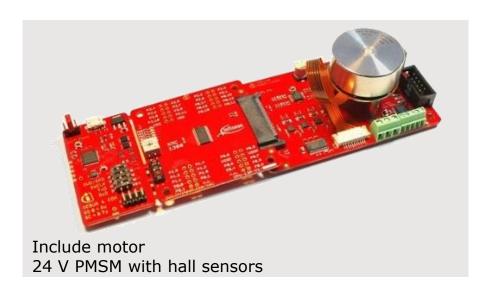
› Control of DC motors or other inductive loads up to 6 A or up to 36 V of supply

› General purpose H-bridge IFX9201 combined with XMC1100

› Outputs can be pulse width modulated at frequencies up to 20 kHz

› SPI enables for easy diagnosis

Customer benefits:

› Rapid prototyping of DC motor control in half and full bridge configuration

› Simple design with few external components

› Easy protection of over current and over temperature

XMC1000 motor control application kit

Include motor
24 V PMSM with hall sensors
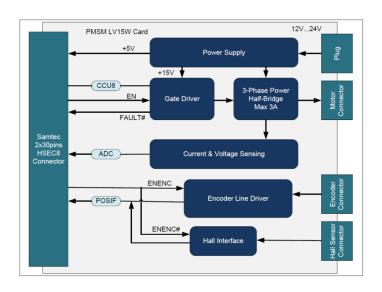
Key features:
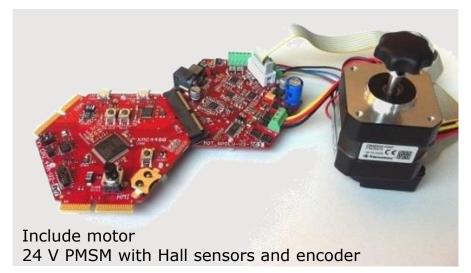
› Robust 12 V - 24 V 3-phase inverter for maximum 3 A

› Multiple position sensing interfaces

– Quadrature encoder interface

– Hall sensor interface

› Seamless connection to the XMC1300 or XMC1400 boot kits
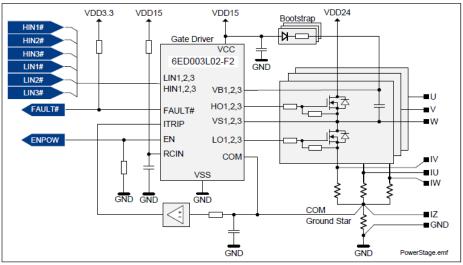
Customer benefits:

› Rapid prototyping of PMSM and BLDC motor control schemes with various position and current feedback sensors

› This modular system allows users to evaluate the XMC1302 or XMC1404 microcontrollers with respect to motor control feature set and performance

XMC4400 motor control application kit

Include motor
24 V PMSM with Hall sensors and encoder

Key features:
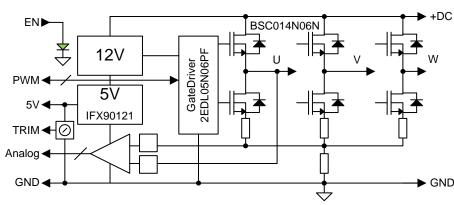
› Robust 3-phase 24 V inverter for nominal dc-link current 5 A (max. 7.5 A)

› Multiple position sensing interfaces

  – Inductive resolver interface
  – Quadrature encoder interface
  – Hall sensor interface

› Seamless connection to XMC4000 CPU boards (e.g. CPU_44A-V2, CPU_45A-V2)

Customer benefits:

› Rapid prototyping of PMSM and BLDC motor control schemes with various position and current feedback sensors

› This modular system allows to evaluate any XMC4000 microcontroller with respect to motor control feature set and performance

24 V, 250 W motor drive power card for XMC1000 and XMC4000

Key features:

› Robust 16 V - 42 V (60 V max) 3-phase motor drive bridge, equipped with 6x BSC014N06N OptiMOS™ 80 V, 1.4 mΩ

› Half-bridge gate driver 2EDL05N06PF EiceDRIVER™ in SO8 package with SOI technology

› Seamless connection to XMC1000 and XMC4000 drive cards

Customer benefits:

› Rapid prototyping of PMSM and BLDC motor control from low to middle-range power

› Allows evaluation of XMC1000 and XMC4000 in the same ecosystem

› Flexible to adopt many different control algorithms

XMC™ 750 watt motor control application kit

› Include two XMC™ drive cards with galvanic isolation to target device

› 3-phase inverter and analog or digital PFC

› Support with various sense & control techniques (including shunt, resolver, Hall sensors for FOC)
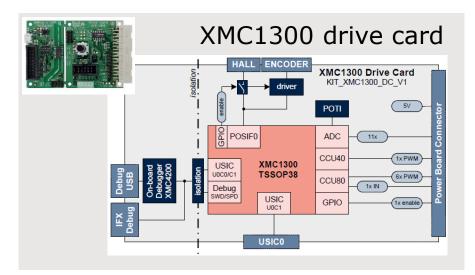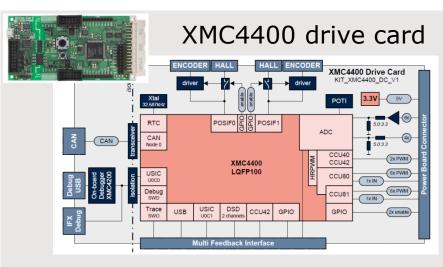
Key features:

› Ready to use 750 W power inverter with PFC with wide supply range (115 V_{AC} to 230 V_{AC}) and nominal 3 A motor current

› XMC1300 and XMC4400 drive cards included

› Isolated debug interface providing Cortex®-SWD channel and COM-port (UART) channel

Customer benefits:

› Gives jumpstart into evaluation of XMC™ microcontroller and motor control performance

› Allows evaluation of XMC1000 as well as XMC4000 in the same ecosystem

› Robust and non-hazardous control via standard tools for debugging, data analysis and control

XMC™ drive cards with galvanic isolation
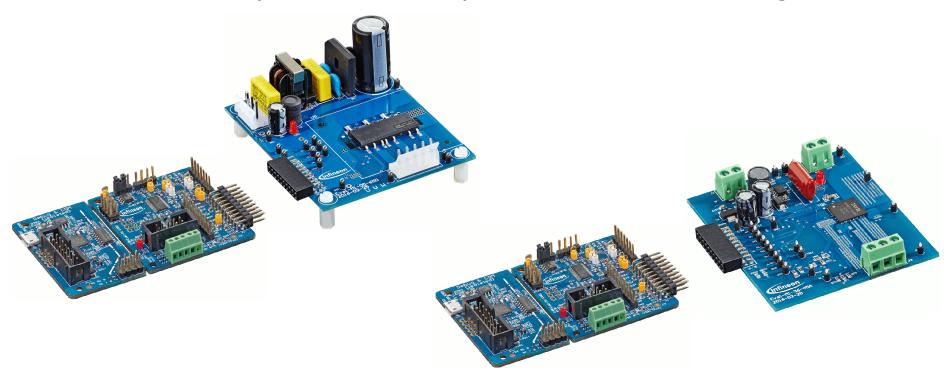

XMC1300 drive card

XMC4400 drive card

› On-board J-Link Lite debugger with galvanic isolation to target device

› Flexible and modular with clearly defined interfaces

› Isolated debug interfaces
  – SWD
  – UART
  – CAN (if applicable)

› Other interfaces
  – Hall Sensors
  – Encoder
  – UART/SPI/I2C
  – Others

iMOTION™ modular application design kit - introduction

› Compact and modular 3-phase motor drive system solution platform with scalable controller and IPM inverter board options

› Designed for sensorless or sensored motor control

› Spin your motor in less than 1 hour thanks to provided motor control software and easy-to-use GUI for parametrization and tuning

iMOTION™ modular application design kit
- available kits and boards overview (1/2)

Controller boards

Inverter boards

Individual board

EVAL-M1-099M
IRMCK099
control card
SP001591856

EVAL-M1-1302
XMC1302
control card
SP001591894

M1 platform interface

EVAL-M1-36-84A
µIPM™ power board
IRSM836-084MA 250 V
SP001592062

EVAL-M1-36-45A
µIPM™ power board
IRSM836-045MA 500 V
SP001592052

EVAL-M1-05-84D
µIPM™-DIP power board
IRSM505-084DA2 250 V
SP001591850

EVAL-M1-05-65D
µIPM™-DIP power board
IRSM505-065DA2 500 V
SP001591474

Kits

EVAL-M1-1302_36-84A
XMC1302 control card + Powerstage based on IRSM836-084MA, µIPM™, 250 V
SP001592044

EVAL-M1-1302_36-45A
XMC1302 control card + Powerstage based on IRSM836-045MA, µIPM™, 500 V
SP001592034

EVAL-M1-1302_05-84D
XMC1302 control card + Powerstage based on IRSM505-084DA2, µIPM™-DIP, 250 V
SP001591814

EVAL_M1-1302_05-65D
XMC1302 control card + Powerstage based on IRSM505-065DA2, µIPM™-DIP, 500 V
SP001591902

More iMOTION™ MADK controller and inverter boards coming soon…

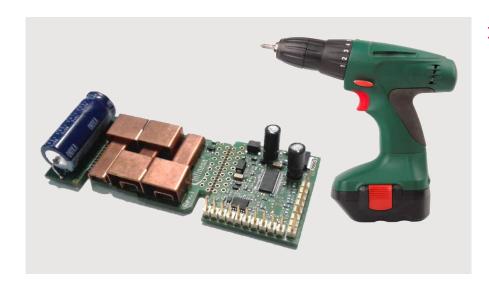# iMOTION™ modular application design kit - available kits and boards overview (2/2)

No.	Kit name	Kit description	Order number	Input voltage /output power
1	Eval-M1-1302_05-65D	Eval-M1-1302, Eval-M1-05-65D, USB cable	EVALM113020565DTOBO1	100 V_{AC} - 230 V_{AC} up to 250 W
2	Eval-M1-1302_05-84D	Eval-M1-1302, Eval-M1-05-84D, USB cable	EVALM113020584DTOBO1	100 V_{AC} – 120 V_{AC} up to 250 W
3	Eval-M1-1302_36-45A	Eval-M1-1302, Eval-M1-36-45A, USB cable	EVALM113023645ATOBO1	100 V_{AC} - 230 V_{AC} up to 80 W
4	Eval-M1-1302_36-84A	Eval-M1-1302, Eval-M1-36-84A, USB cable	EVALM113023684ATOBO1	100 V_{AC} – 120 V_{AC} up to 80 W

› For more details about individual board (control cards and µIPM™-based inverters), please check the additional documentation on www.infineon.com/MADK

Reference design / demo
- BLDC power tool 1 kW / 20 V$_{DC}$

› Key Infineon components:

   – Microcontroller:

      – XMC1302 in TSSOP38

   – Power stage:

      – OptiMOS™ 1.05 mΩ / 40 V BSC010N04LSI
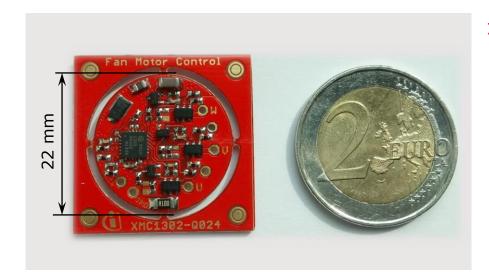
      – EiceDRIVER™ 2EDL05N06PF

Key features:

› 3-phase BLDC motor driver (6 V-24 V, 50 A continuous, 200 A peak) with Hall sensor based block commutation on XMC1302

› Synchronous PMW transitions

› Motor model based speed control

› MOSFET driver voltage boost control

› Over current, over load, over temperature protection

Customer benefits:

› Precise and efficient control of power tool motor with best in class OptiMOS™ power MOSFETs

› Minimized power losses

› Best tool performance

› Extended supply voltage range

› Maximum robustness by dedicated hardware and software features

› Key Infineon components:

– Microcontroller:

  – XMC1302 in VQFN24

– Power:

  – OptiMOS™ P + N channel BSL308C

  – 5 V LDO IFX20001MBV50

Key features:

› 3-phase motor driver (12 V, 1 A) with sensorless FOC based on XMC1302 in VQFN24

› Smooth start-up control of sinusoidal output voltage and closed loop speed control up to 25000 rpm

› Lock detection, over current protection, reverse polarity protection

› Control interface:
PWM speed input / FG speed output

Customer benefits:

› Maximum energy efficiency at lowest bill of material cost and smallest form factor

› Minimum audible noise at low speed and maximum performance at high speed

› Reliable operation under all circumstances

› Compatible to many fan control ASICs
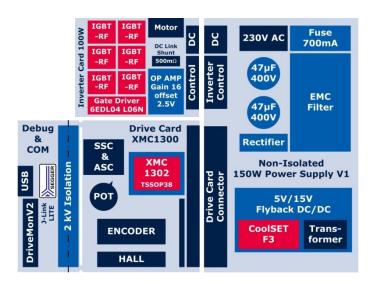
Reference design / demo
- modular 3-phase motor drive

Highlights:

› Modular concept:
  – Power supply for 325 V, 15 V and 5 V
  – Inverter card: 100 W with fast reverse conducting IGBT (DPAK)
  – XMC1300 drive card
› Applications:
  – Fridge compressor
  – Pump
  – Fan

Key features and benefits:

› Easy performance comparison of different IGBTs, MOSFETs and IPMs

› Fast adaptation to continuously growing IGBT, MOSFET and IPM portfolio

› Easy performance comparison of different XMC™ microcontrollers

› Software evaluation and development platform

System demonstrator with XMC4400 multi-axis drive and motion control

- › **Demonstrator for system integration of HMI, PLC, CAN and XMC4000**
- › **Multi-axis motion control**
  - Manual movement
  - Homing
  - Positioning
  - Hand-wheel ("electrical shaft")
- › **XMC4400 dual motor control**
  - Torque, speed & position loop
  - FOC with encoder

- › **XMC4400 tasks**
  - Dual FOC with torque, speed and position loop at 20 kHz cycle
  - Dual shunt current measurement with hardware synchronized ADC channels
  - CAN communication for speed and position control with PLC as well as parameter handling
- › **Software is based on DAVE™ 3 motor control APPs with only a few lines of user code**
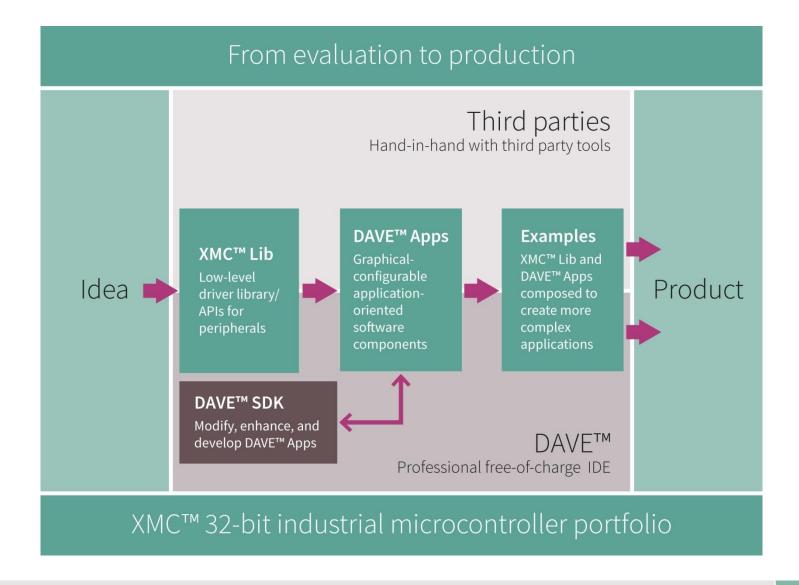
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Development tools and software
DAVE™ - software development made easy

From evaluation to production

Third parties
Hand-in-hand with third party tools

Idea

XMC™ Lib
Low-level driver library/ APIs for peripherals

DAVE™ Apps
Graphical-configurable application-oriented software components

Examples
XMC™ Lib and DAVE™ Apps composed to create more complex applications

Product

DAVE™ SDK
Modify, enhance, and develop DAVE™ Apps

DAVE™
Professional free-of-charge IDE

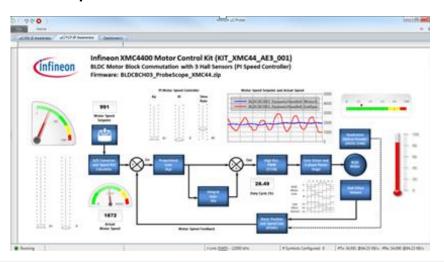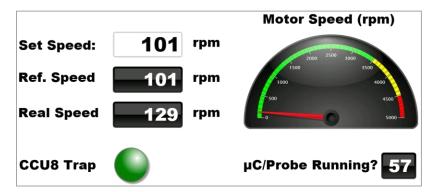XMC™ 32-bit industrial microcontroller portfolio

µC/Probe™ XMC™

› µC/Probe™ XMC™ - Windows based application that allows you to read and write the memory of XMC™ microcontrollers during run-time in a non-intrusive way and with a graphical dashboard to fine-tune your application
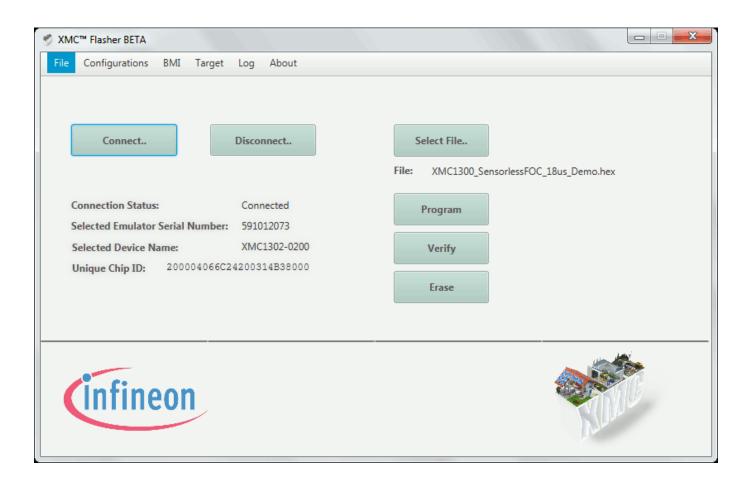

› Examples - motor control GUI

XMC™ Flasher

› XMC™ Flasher - programming tool for on-chip flash programming of XMC™ microcontrollers

Motor control example projects

› Users can download DAVE™ 4 motor control example projects from [Infineon website](#), e.g.:

Project	Description	Target MCU	Version	Last Update	Tool
BLDC_SCALAR _HALL_XMC13	This example project controls 3-phase BLDC motor with 3 hall sensor feedback using block commutation control algorithm. This is configured for Infineon low voltage motor control kit KIT_XMC1X_AK_MOTOR_001 with Maxon motor part number 267121	XMC1300	1.0.0	2016-05-25	DAVE™
PMSM_FOC_EX AMPLE_XMC13	This example demonstrates permanent magnet synchronous motor control using sensorless FOC algorithm. Speed of the motor is changed by potentiometer value	XMC1300	4.2.6	2016-04-28	DAVE™
PMSM_FOC_EX AMPLE_XMC44	This example demonstrates speed control of motor using V/f with smooth transition to FOC closed loop start up technique. Speed of the motor is changed by potentiometer input value	XMC4400	4.2.6	2016-04-28	DAVE™

Agenda

1   Why XMC™ for motor control?

2   Key microcontroller features

3   Kits and reference design

4   Development tool and software

5   General information

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)

Glossary abbreviations (1/2)

- › AC   Alternating Current
- › ADC   Analog-to-Digital Converter
- › BEMF   Back Electromotive Force
- › BLDC   Brushless DC Motor
- › CAN   Controller Area Network
- › CPU   Central Processing Unit
- › DAC   Digital-to-Analog Converter
- › DAVE™   Digital Application Virtual Engineer
- › DC   Direct Current
- › DSD   Delta Sigma ($\Delta\Sigma$) Demodulator
- › DSP   Digital Signal Processor
- › FOC   Field-Oriented Control

Glossary abbreviations (2/2)

- › FPU   Floating Point Unit

- › GUI   Graphical User Interface

- › HMI   Human-Machine Interface

- › IPM   Intelligent Power Modules

- › MADK   Modular Application Design Kit

- › MOSFET   Metal-Oxide-Semiconductor Field-Effect Transistor

- › PLC   Programmable Logic Controller

- › PMSM   Permanent Magnet Synchronous Motor

- › POSIF   Position Interface

- › PWM   Pulse Width Modulation

- › RAM   Random-Access Memory

- › XMC™   Cross-Market Microcontrollers

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