



AHEAD OF WHAT'S POSSIBLE™

Analog Devices Industrial Motor Control



AHEAD OF WHAT'S POSSIBLE™

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Industry Automation Segment Marketing Manager GC

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ADI Focus for Industry 4.0

Industry 4.0 Delivers on Increased Productivity

See where ADI is accelerating the transition to the secure connected enterprise



Flexibility

The shift to more flexible architectures allows for greater capacity and faster reconfiguration. Using universal analog I/O (input/output) brings integration, robustness, flexibility, and efficiency with significant time and cost savings. All of which create opportunities for virtualization utilizing AI and digital twin technologies.



Efficiency

Even a 1% reduction in energy use can bring tremendous savings to a factory operator. These savings can be realized through the adoption of inherently lower power solutions that are then augmented by condition-based machine monitoring analytics.



Communications

Central to the execution of Industry 4.0 is robust and secure wired and wireless communication that must support legacy standards and provide a clear path to Ethernet to the Edge and time sensitive networks (TSN).



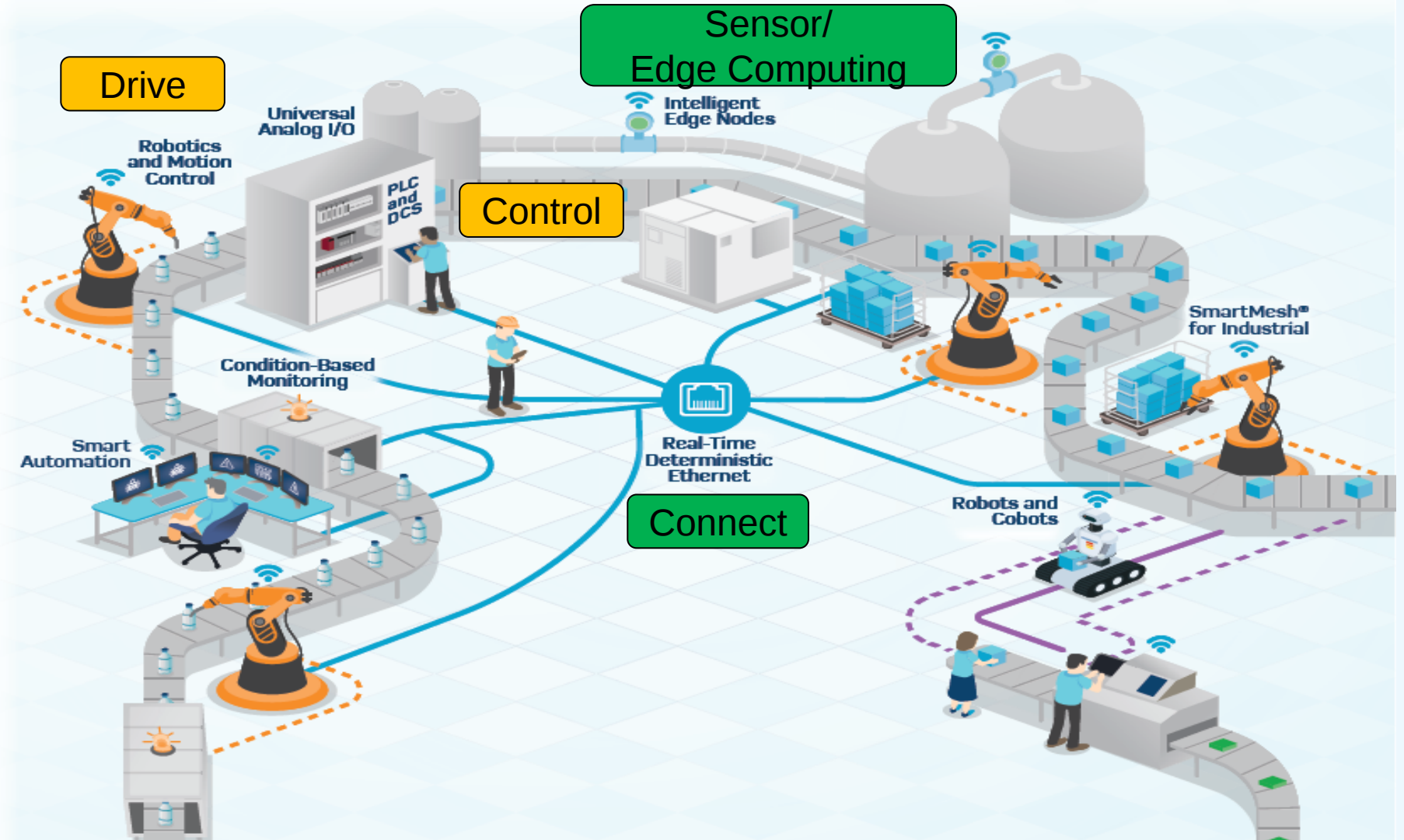
Safety

A system is not smart if it is not safe. Functional safety is ubiquitous in automation systems with strict standardization and certifications requirements.

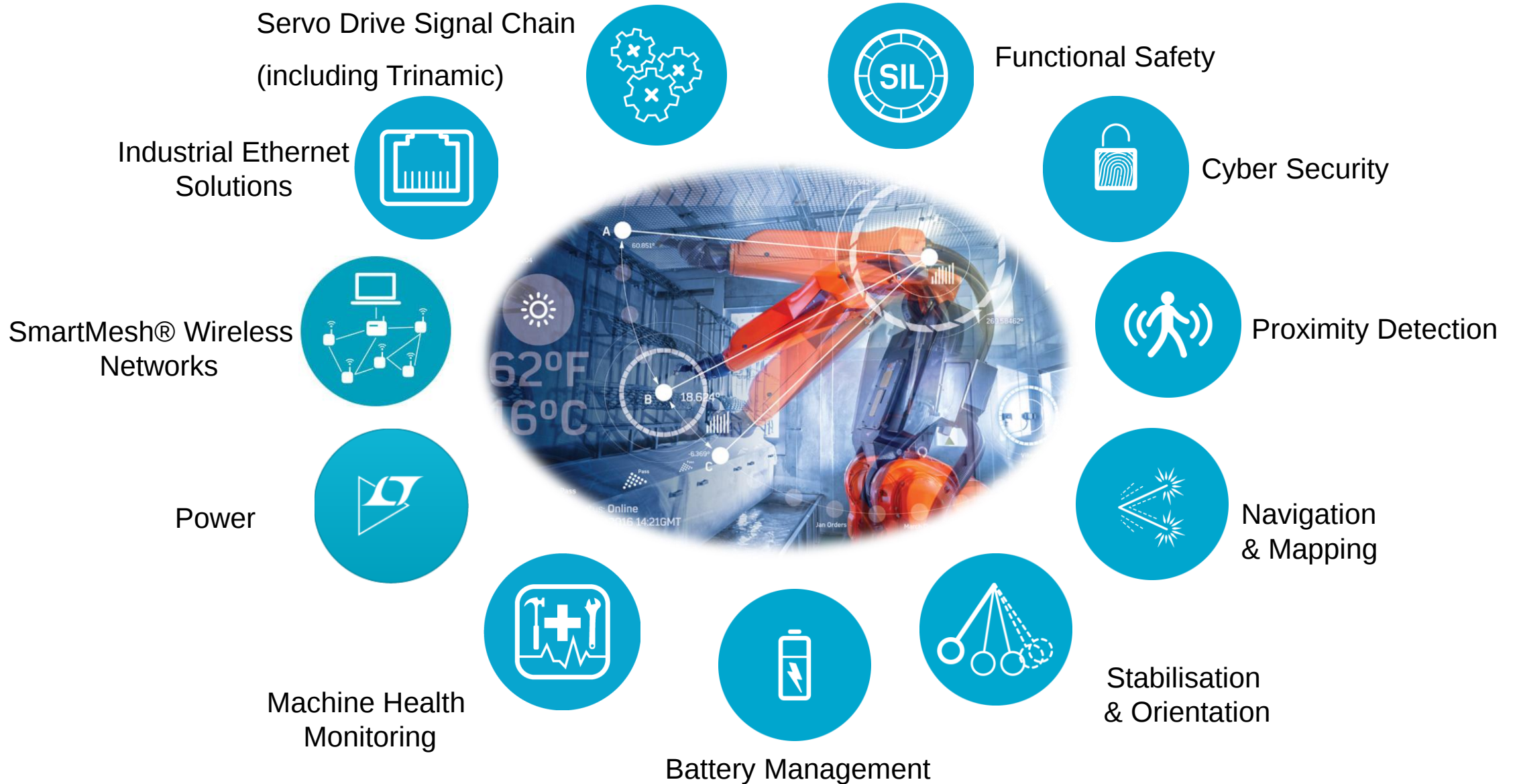


Security

Greater connectivity of smart machines with Industry 4.0 brings with it risks from cyber attacks. Factory operators and solution providers need to develop stronger cybersecurity strategies that are more vigilant and resilient to attack.



ADI Technologies Summary



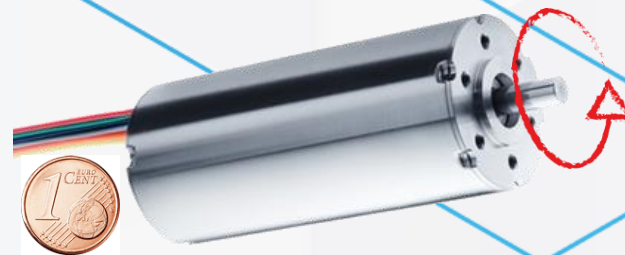
Content

- ▶ Industry robotic system architecture

- ▶ ADI Solutions Offer
 - Motor and motion control -- Trinamic
 - Current & Voltage sensing
 - Position
 - Power conversion
 - Interface
 - Networking
 - Sensor
 - ToF
 - iTMU
 - Power
 - Solution and platform

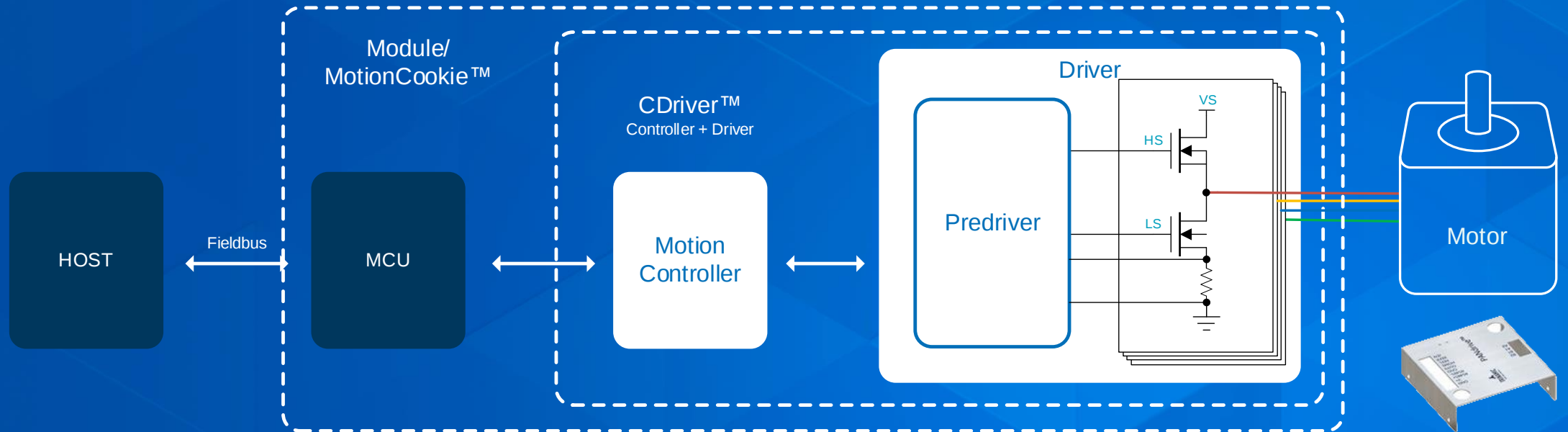
ADI Trinamic Stepper and BLDC

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1101000011100010101001  
0011101000011100010101  
0100100100011101000011  
0101000100100100100011
```

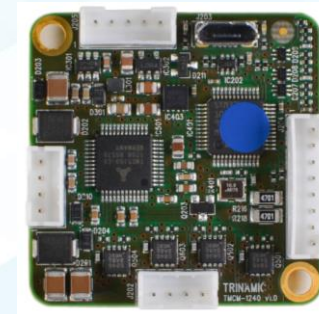


We Transform Digital Information Into Physical Motion

Motor & Motion Control



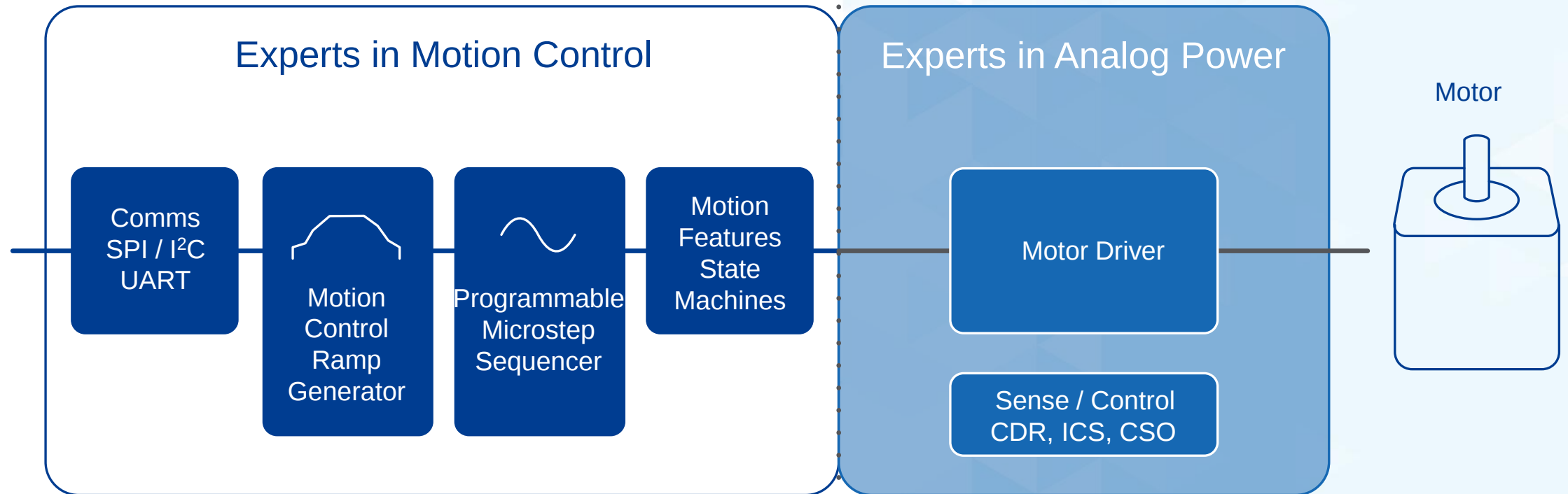
- ▶ Motor Types: Stepper, BLDC
- ▶ Motor Sizes: mW ... kW
- ▶ Voltage Range: 1.8...80V



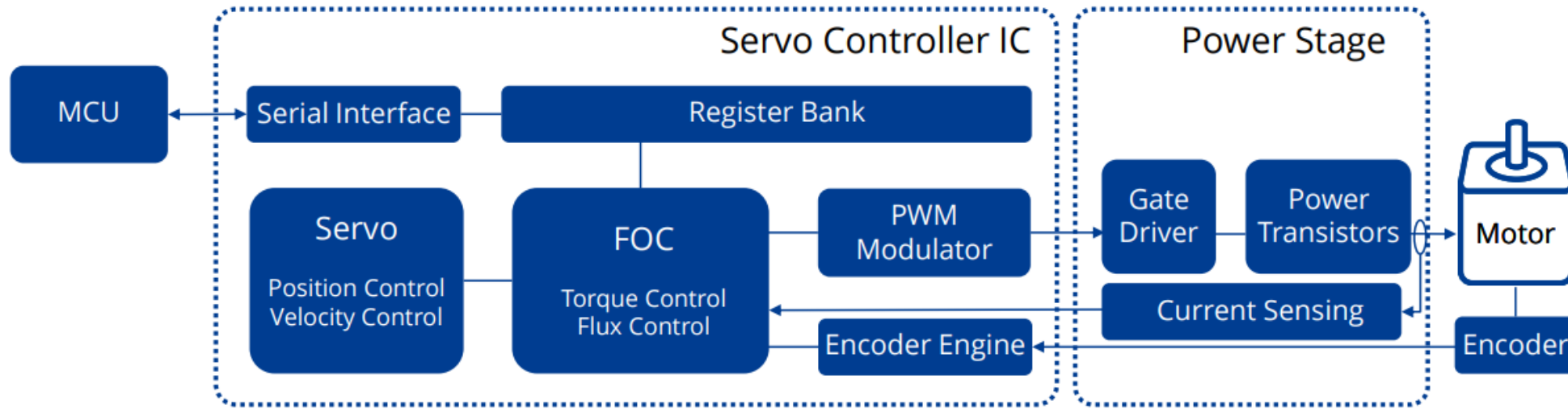
Problem Solving Differentiators

Energy consumption / heat and power dissipation Current control based on sensorless StallGuard™ values	CoolStep™
Pulsation in movement / vibrations High-resolution microstepping	SpreadCycle™
Audible noise / mechanical resonances Advanced current control	StealthChop™
Dynamic load changes / overload and pot. position loss Sensorless load monitoring	StallGuard2™
Jerky motion / position overshoot Advanced multi-segment / jerk-limiting acceleration ramps	SixPoint™

Analog Devices + Trinamic:



BLDC Servo Control System





TRINAMIC
MOTION CONTROL

► Camera Gimbal

...winning with **efficiency**
and **integration**

thanks to hardware FOC



► Respiration

...winning with **precision**
and **fast time to market**

thanks to closed-loop
reference designs



► AGVs

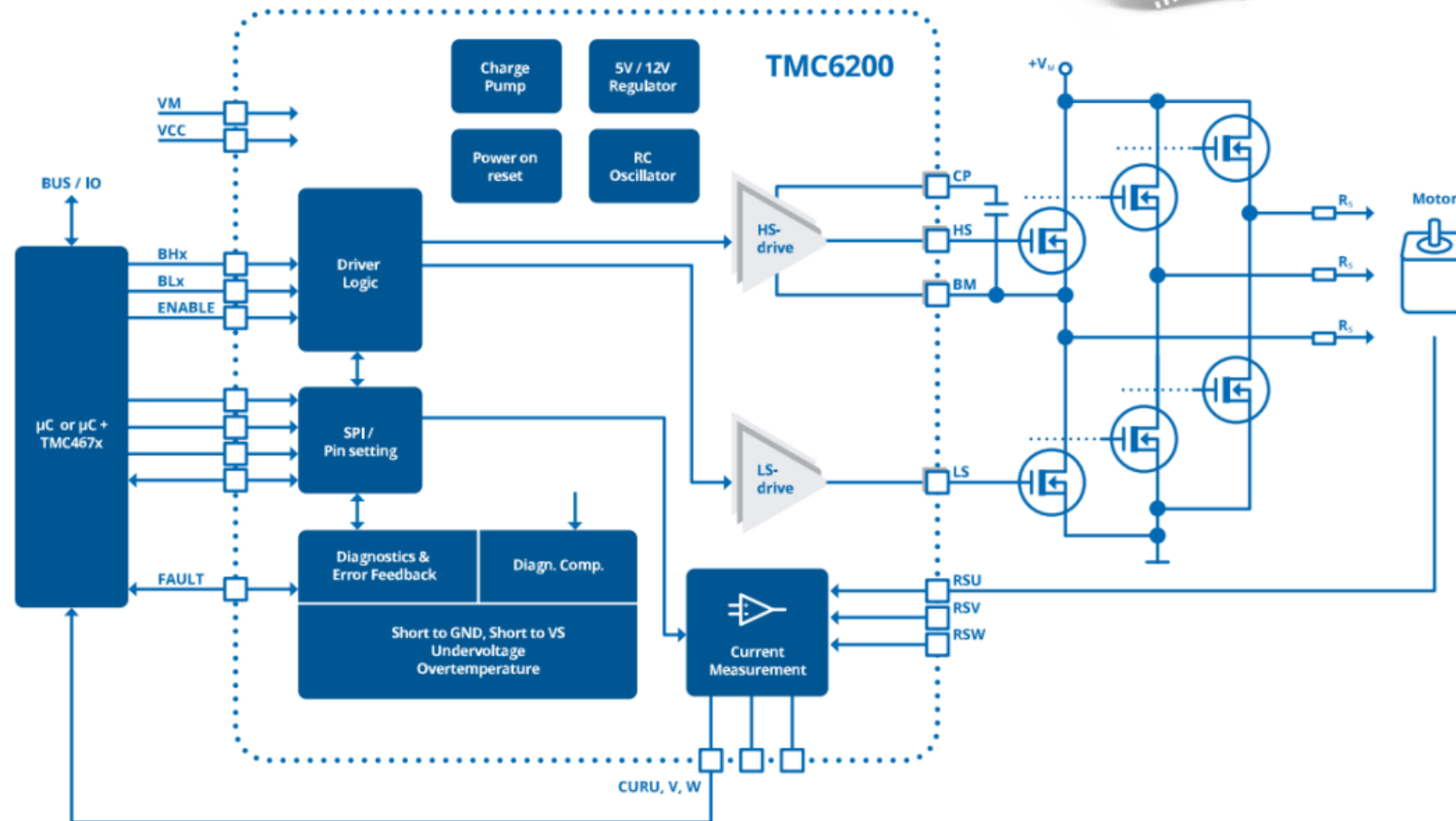
...winning with **efficiency** and
code-free building blocks

thanks to hardware FOC



Gate driver

BLOCK DIAGRAM



Gate Driver

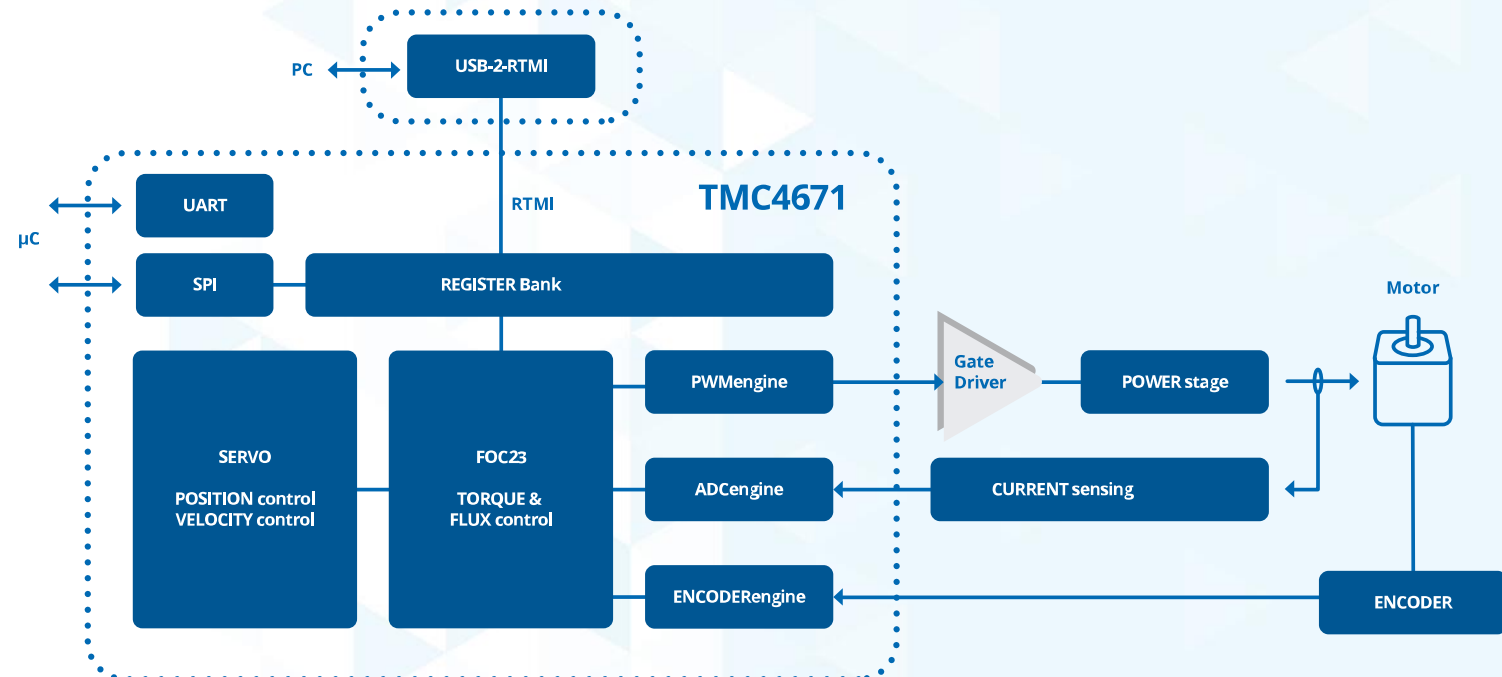
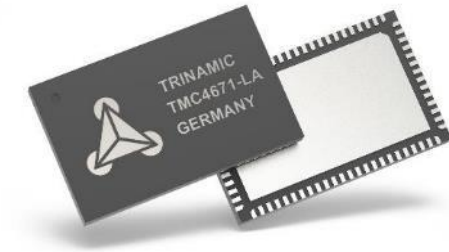


PRODUCT	TMC6100-LA	TMC6140-LA	TMC6200-TA	TMC6300-LA
Number of axes	1	1	1	1
Motor type	3-Phase BLDC, PMSM	3-Phase BLDC, PMSM	3-Phase BLDC, PMSM	3-Phase BLDC, PMSM
Gate current	0.5A / 1A / 1.5A	0.5A / 1A	0.5A / 1A / 1.5A	-
Motor supply voltage	8V...60V	6V...30V	8V...60V	2V (1.8V)...11V
Controller interface	3/6 line HS & LS, SPI	6 line HS & LS, UART-TxD	3/6 line HS & LS, SPI	6 line HS & LS
Shunt amplifier	-	triple	triple	-
Short to GND protection	✓	✓	✓	✓
Switching regulator	-	3.3 V, 500 mA	-	-
Linear regulator	5V, 12V	5V, 10V	5V, 12V	1.8V
Low side charge pump	-	✓	-	-
Break before make logic	✓	✓	✓	✓
Slope control	✓	✓	✓	-
MOSFET type	N	N	N	N
Package	QFN37 (7x7)	QFN36 (5x6)	eTQFP48 (7x7)	QFN20 (3x3)

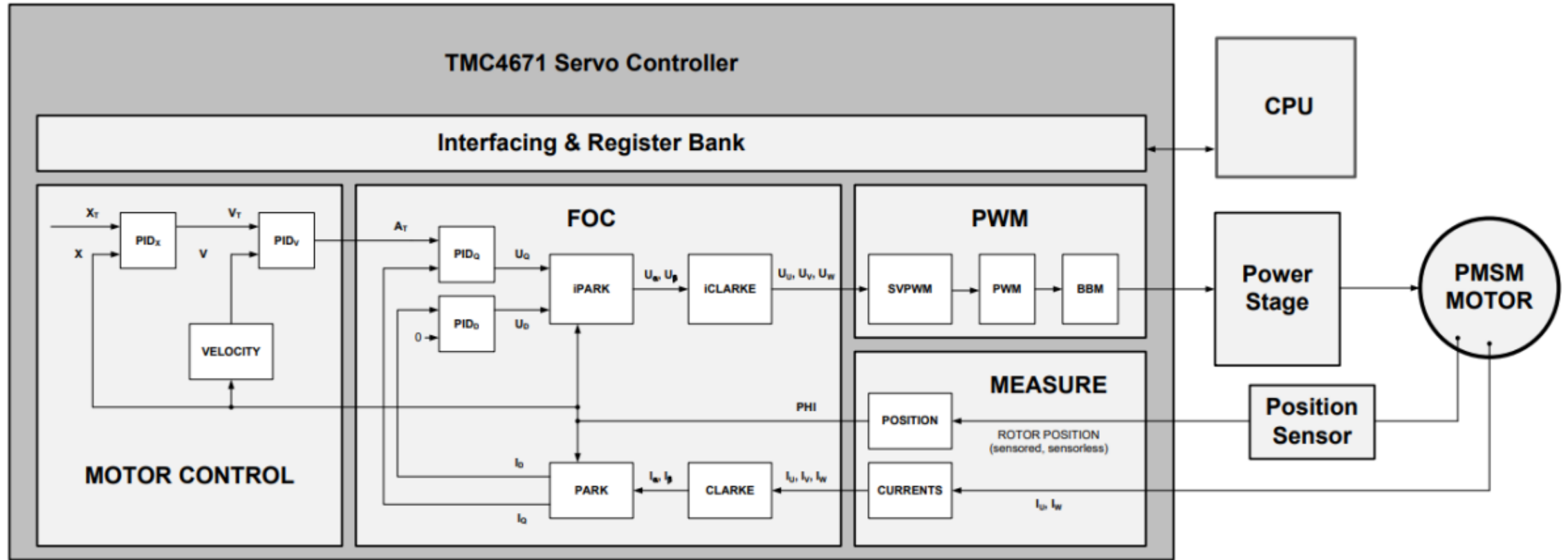
TMC4671-LA -- FOC in Hardware

Features:

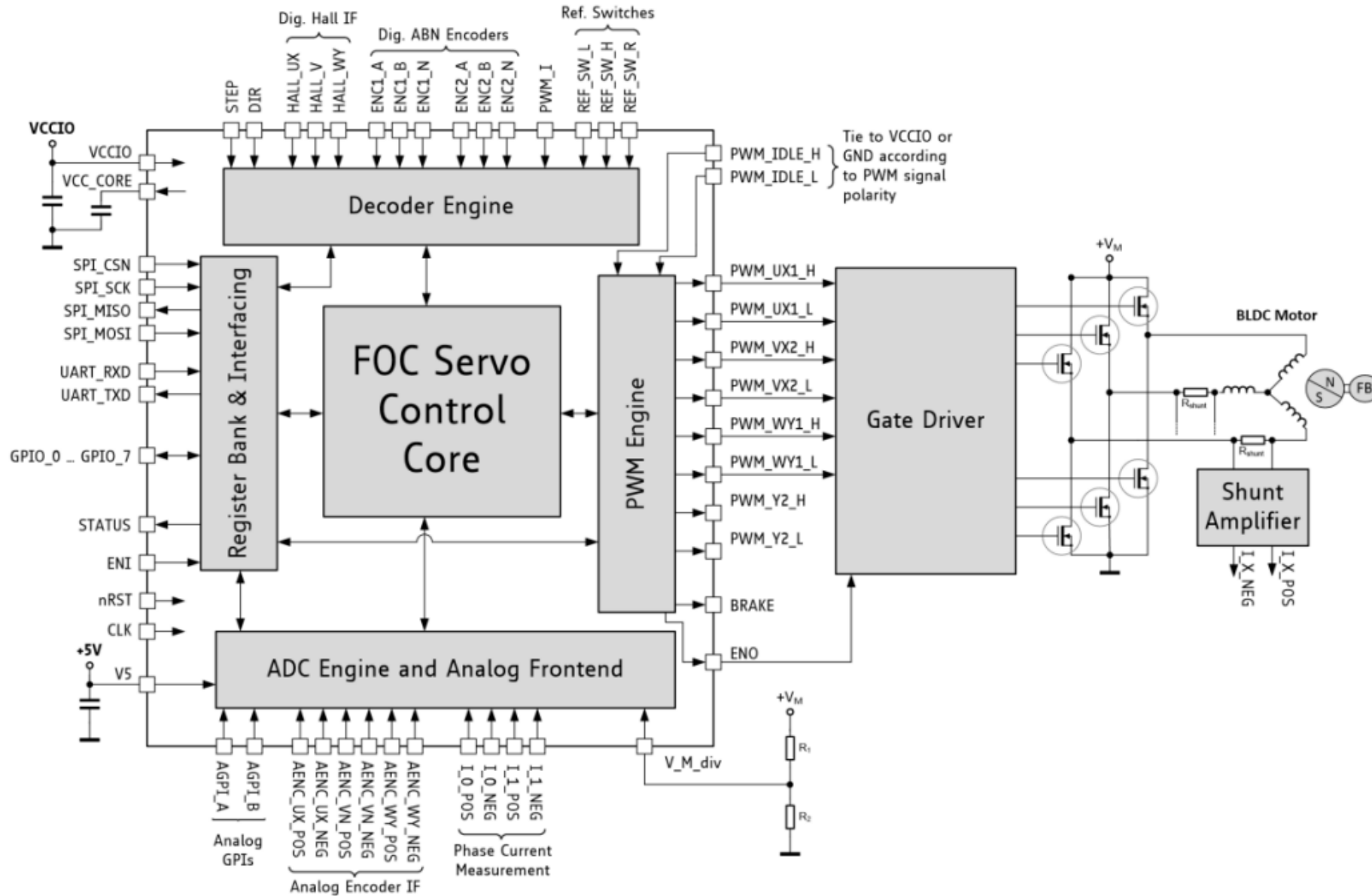
- Servo Controller w/ Field Oriented Control (FOC) • Torque Control (FOC), Velocity Control, Position Control
- Integrated ADCs, $\Delta\Sigma$ -ADC Frontend
- Encoder Engine: Hall analog/digital, Encoder analog/digital
- Supports 3-Phase PMSM/BLDC, 2-Phase Stepper Motors, and 1-Phase DC Motors •
- Fast PWM Engine (25kHz ... 100kHz)
- Application SPI + Debug (UART, SPI)
- Step-Direction Interface (S/D)
- QFN76 (10.5x6.5) package



TMC4671-LA -- FOC in Hardware

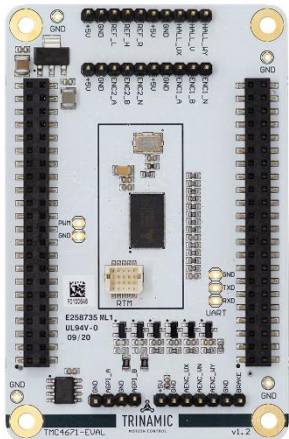


TMC4671 pin function for BLDC/PMSM

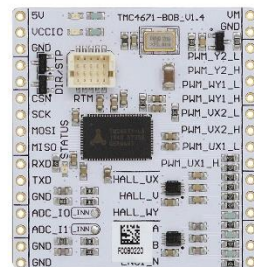


TMC4671 – Get Started

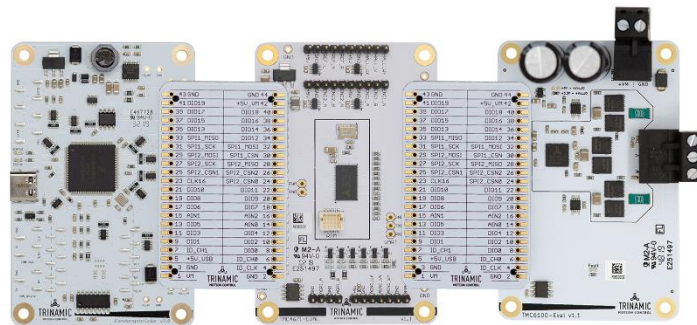
- ▶ Start your design easily using Trinamic's evaluation boards and kits
 - Open source: access to all registers using Trinamic's own software, allowing you to develop your own firmware
- ▶ Open-source breakout boards for rapid prototyping
 - Can be used on a breadboard or with flying wires
 - All sensitive signals are routed on the BOB itself



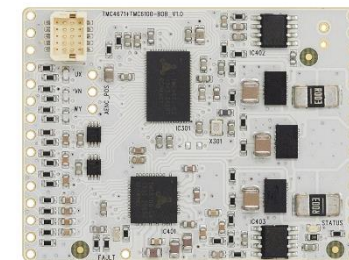
TMC4671-
EVAL



TMC4671-BOB



TMC6100+TMC4671-EVAL-KIT



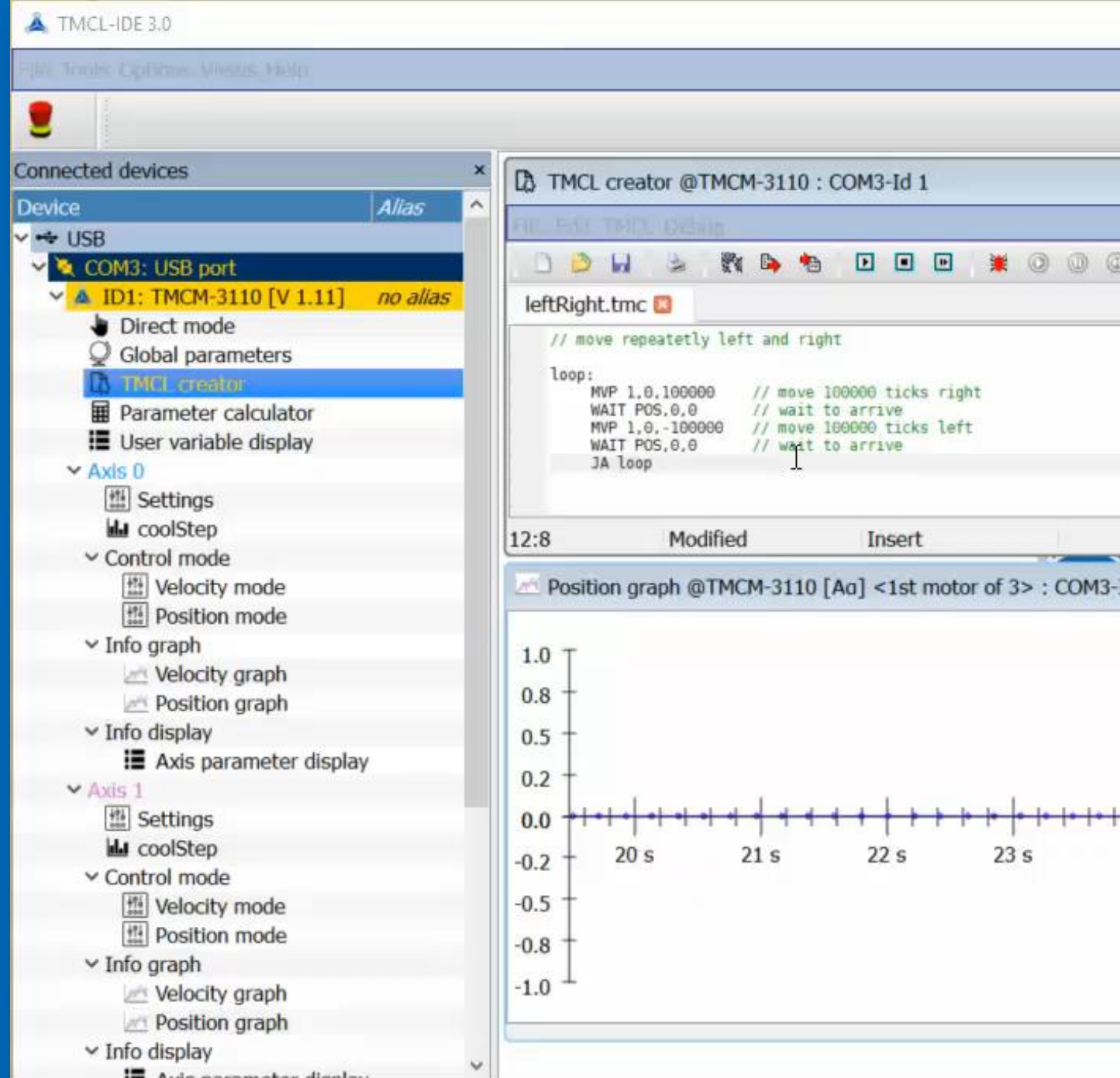
TMC4671+
TMC100-BOB

TMCL-IDE

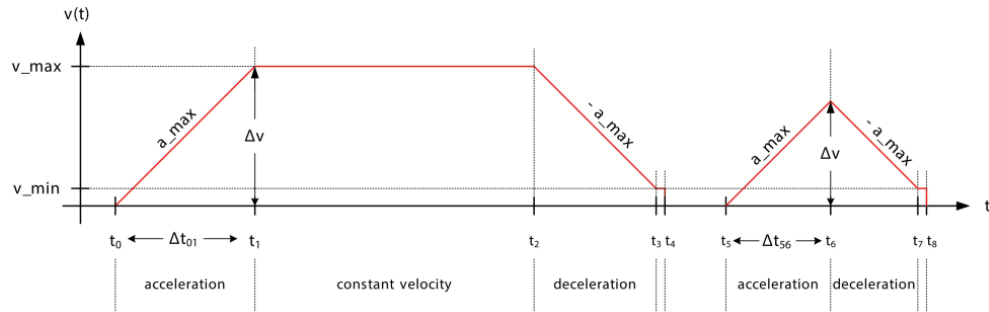
- ▶ Connect & get Started
- ▶ Parametrize & Program
- ▶ Analyze & Debug
- ▶ Intuitive

It's free to download & use!

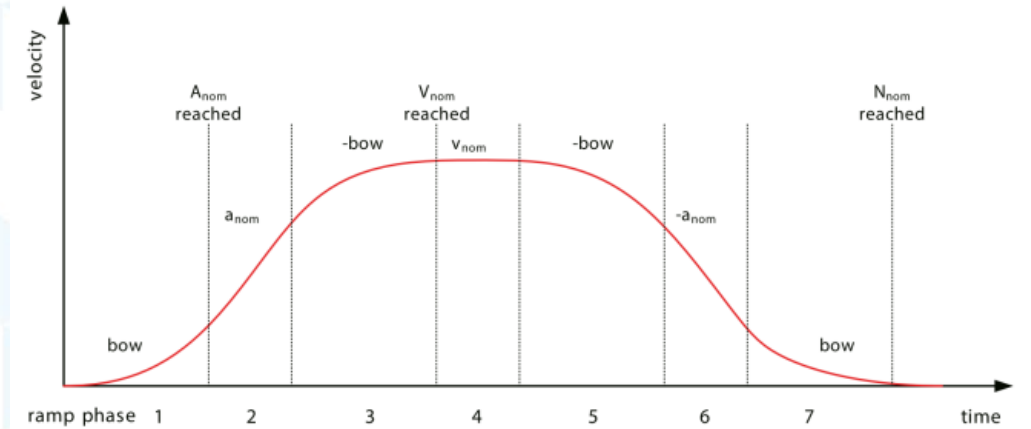
[TMCL-IDE page](#)



Motion Control

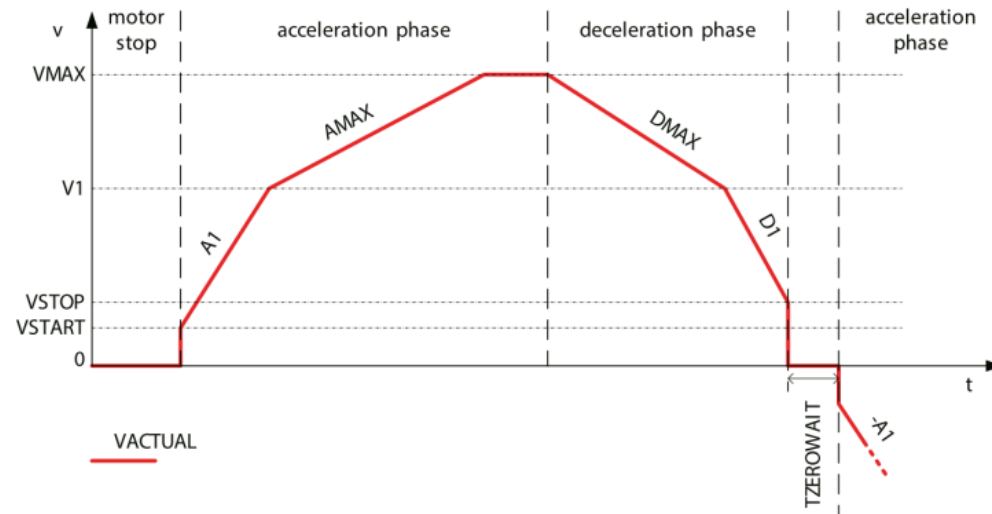


Linear ramping



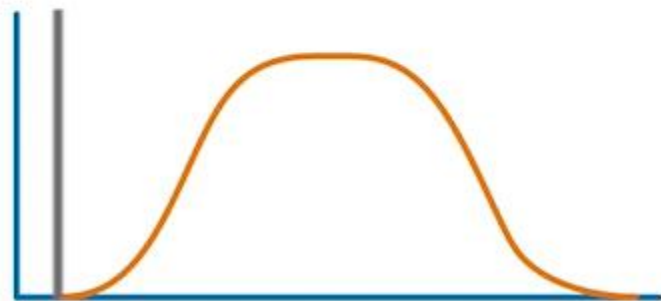
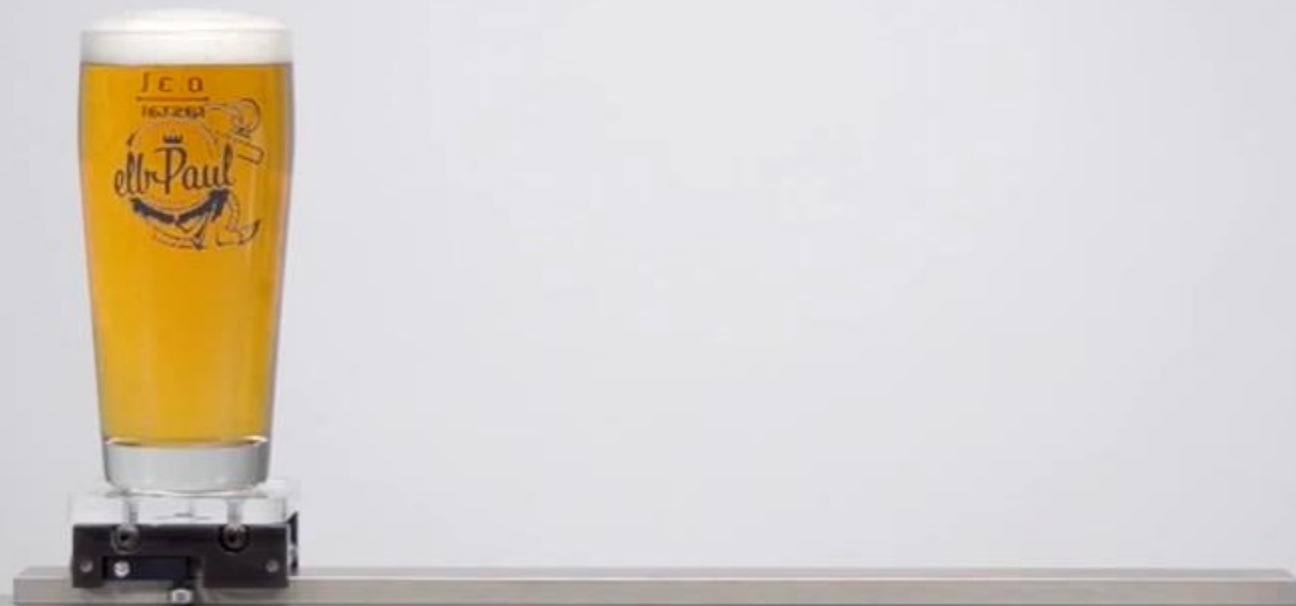
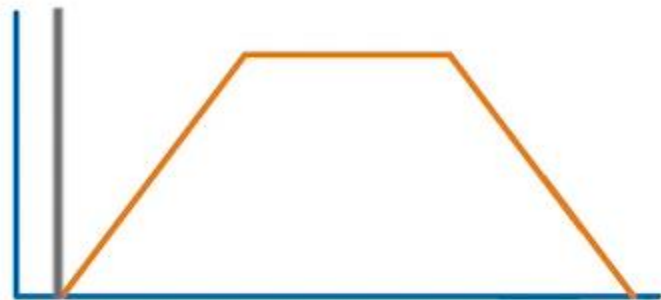
N_{nom} : number of steps
 A_{nom} : maximum acceleration
 V_{nom} : maximum velocity
 B : increase of acceleration (bow)

S-Shaped ramping



sixPoint™ ramping

ALL IN
HARDWARE!

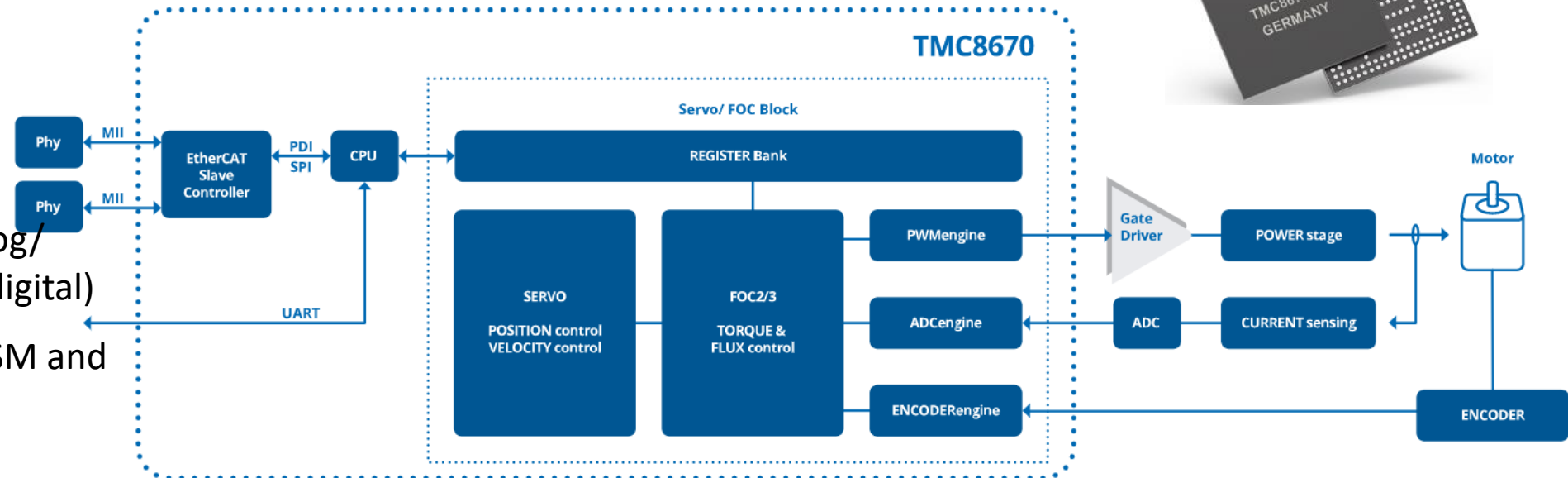


TMC8670 --- Most Integrated Part

Features

- ▶ Field Oriented Control (FOC) Servo Controller
 - Torque Control (FOC)
 - Velocity Control
 - Position Control
- ▶ Sensor Engine (Hall analog/digital, Encoder analog/digital)
- ▶ Support for 3-Phase PMSM and 2-Phase Stepper Motors
- ▶ PWM Engine including SVPWM
- ▶ Integrated EtherCAT Slave Controller, CoE protocol CiA 402 drive profile
- ▶ UART interface

Block Diagram (TMC8670-BI)

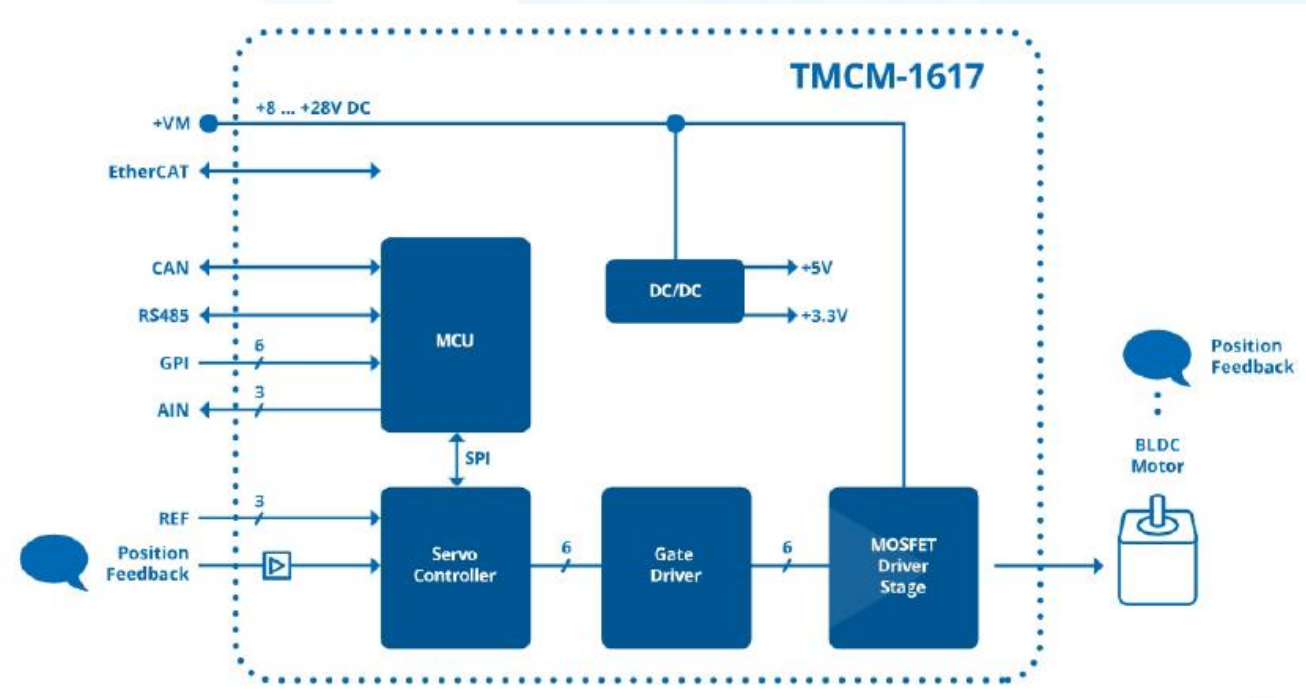


- Two MII interfaces to external Ethernet PHYs plus management interface
- Four Fieldbus Memory Management Units (FMMU)
- Four Sync Managers (SM)
- 4 Kbyte of Process Data RAM (PDRAM)
- 64-bit Distributed Clocks support
- IIC interface for an external SII-EEPROM for ESC configuration

TMCM1617 --- Custom Module Offer

Features

- ▶ • Servo drive for BLDC motors
- ▶ • +8...28V DC supply voltage
- ▶ • Up to 18A RMS max. motor current
- ▶ • RS485, CAN&EtherCAT® interfaces
- ▶ • Incremental encoder feedback
- ▶ • Digital HALL sensor feedback
- ▶ • Reference switch inputs
- ▶ • Cooling via aluminum housing
- ▶ • L/W/H: 36.8mm x 26.8mm x 11.1mm
- ▶ • Weight: ca. 24g
- ▶ • Customization options



TMCM-1617-GRIP-REF

► Features

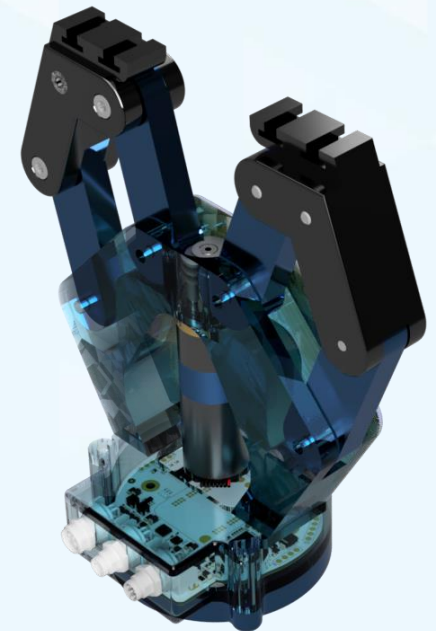
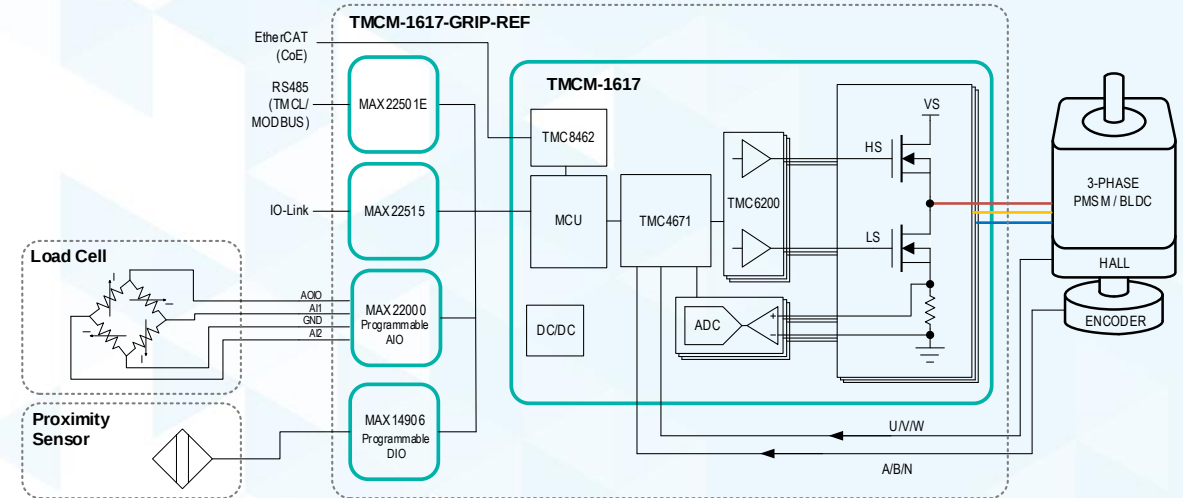
- Supply Voltage: 8...28V
- Phase Current: Up to 2.5A
- Interfaces: RS485, EtherCAT, IO-Link
- Fast, deterministic & High performance Motor Control
- Advanced Diagnostics
- 1x Precise configurable analog Output
- 1x Precise configurable analog Input (MAX22000)
- 4x configurable digital I/Os (MAX14906)
- Efficient Cooling

► Benefits

- No Software development required.
- Easy deployment using TMCL-IDE
- Small Formfactor
(to be mounted in a ISO 9409-1-50-4-M6 Flange)

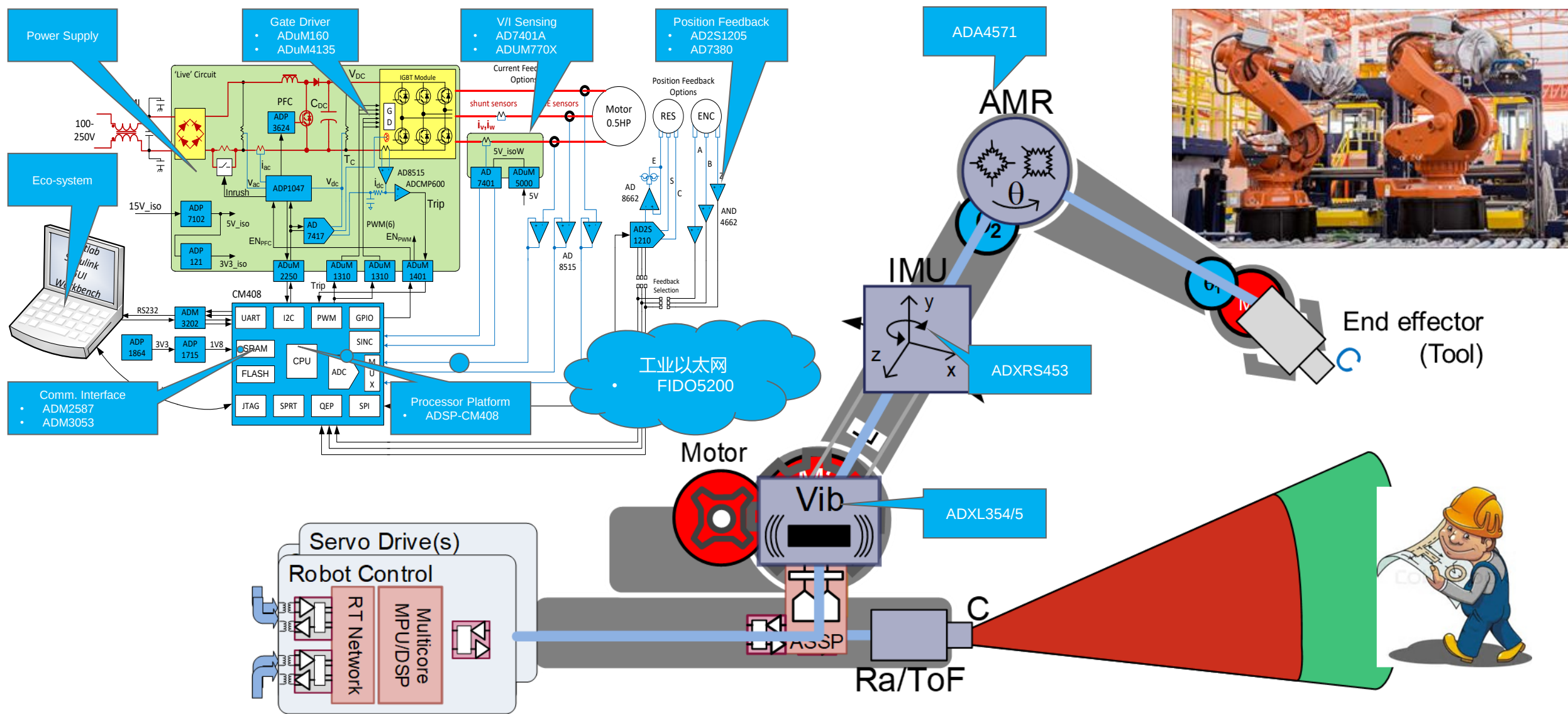
► Applications

- End of Arm tooling (EoAT)

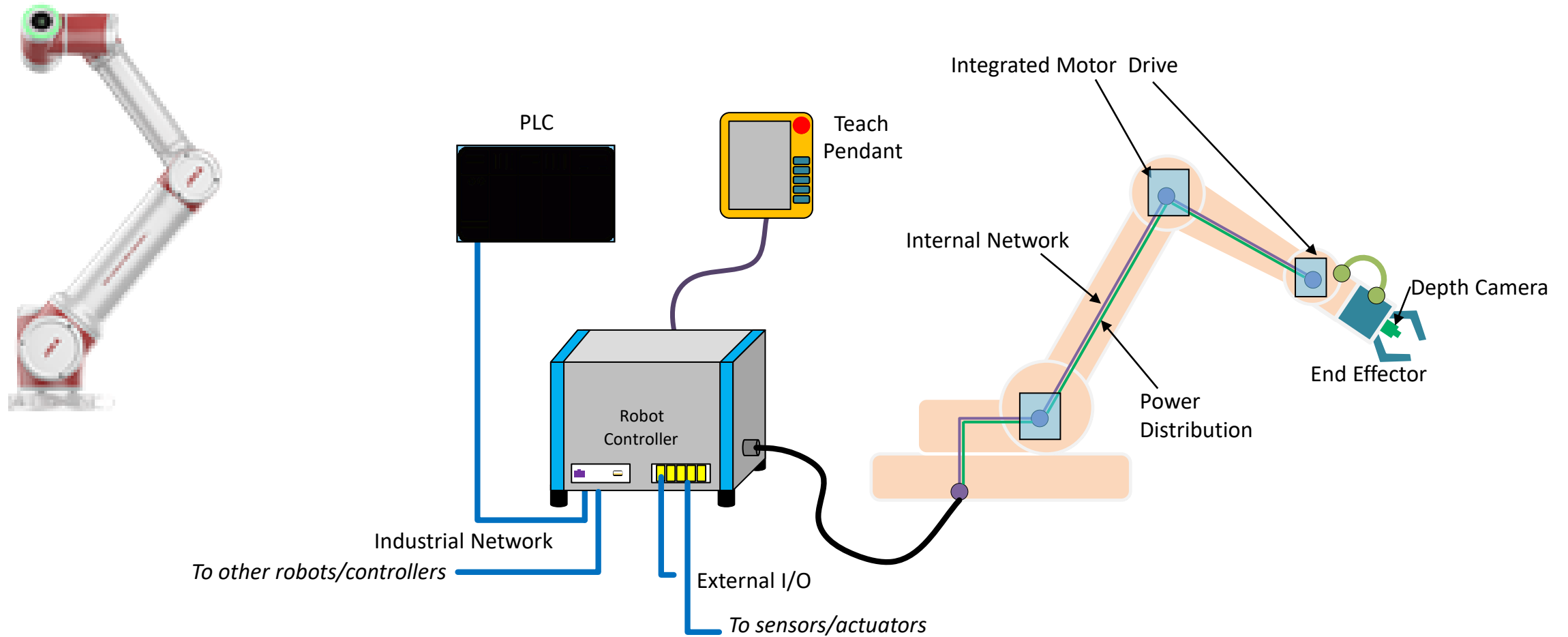


PMSM/AC Motors

Traditional Robot Diagram



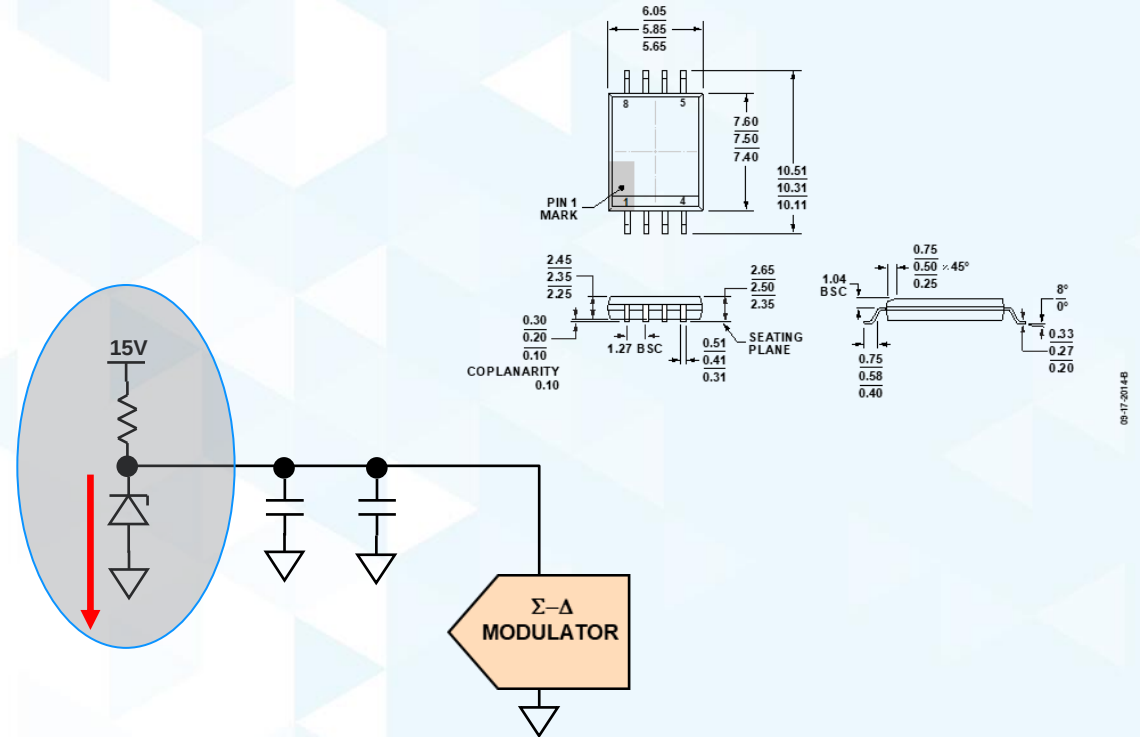
Cobot Diagram



Current/Voltage Sensing

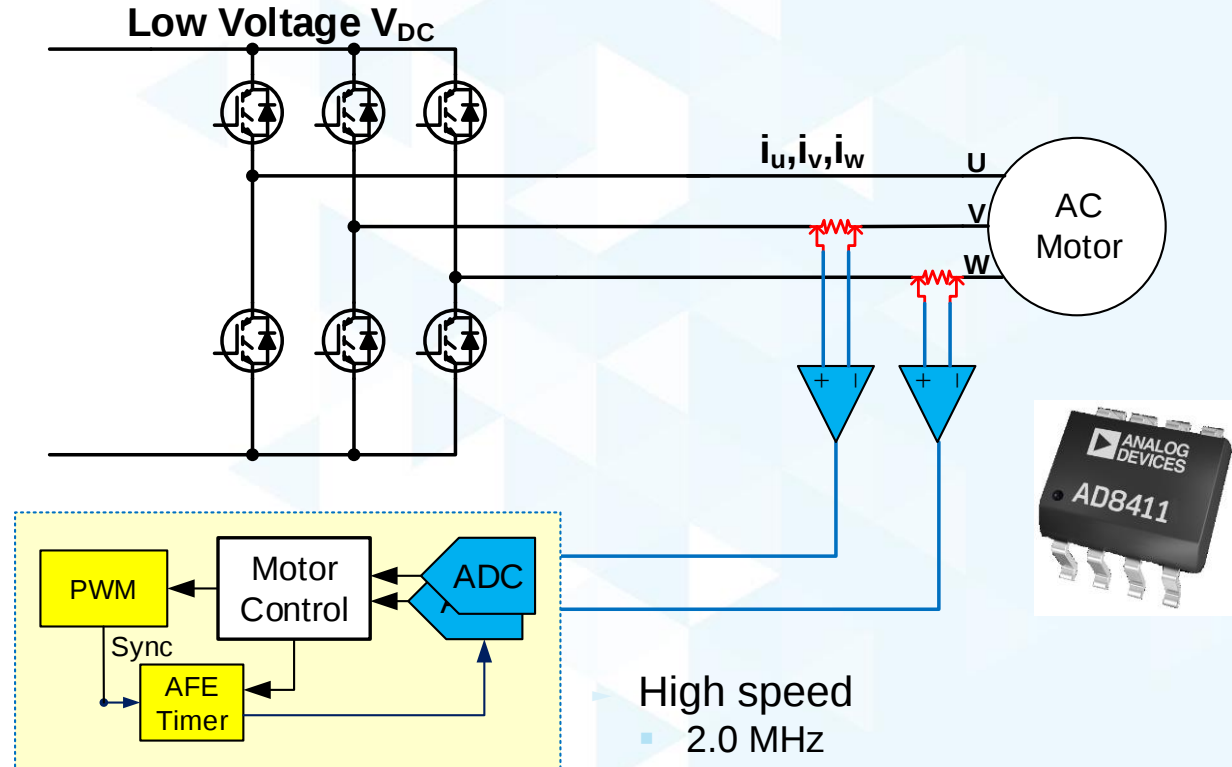
ADuM7703, Integrated LDO

- ▶ Space saving package RI-8, 8-lead wide body SOIC
- ▶ ADuM7703/04-8 only devices with integrated LDO in 8-lead package
- ▶ No external LDO or bootstrapping required
 - Delivering board area savings, fewer components
 - Bootstrap zener diode breakdown voltage varies vs. temperature adding additional offset error
 - Current loss through Zener
- ▶ **ADuM770x reduces system size, weight and cost compared to competition**



Low Voltage Current Sensing

- ▶ Low voltage DC bus option in cobots and light payload robots
 - Controller Box space saving
 - Wiring reduction
- ▶ Drives integrated into robot arms, joints
- ▶ Typically 48V – No isolation requirement
 - Shunt + High common mode amplifiers
- ▶ Isolated signal chain may still be used in LV systems for noise reduction

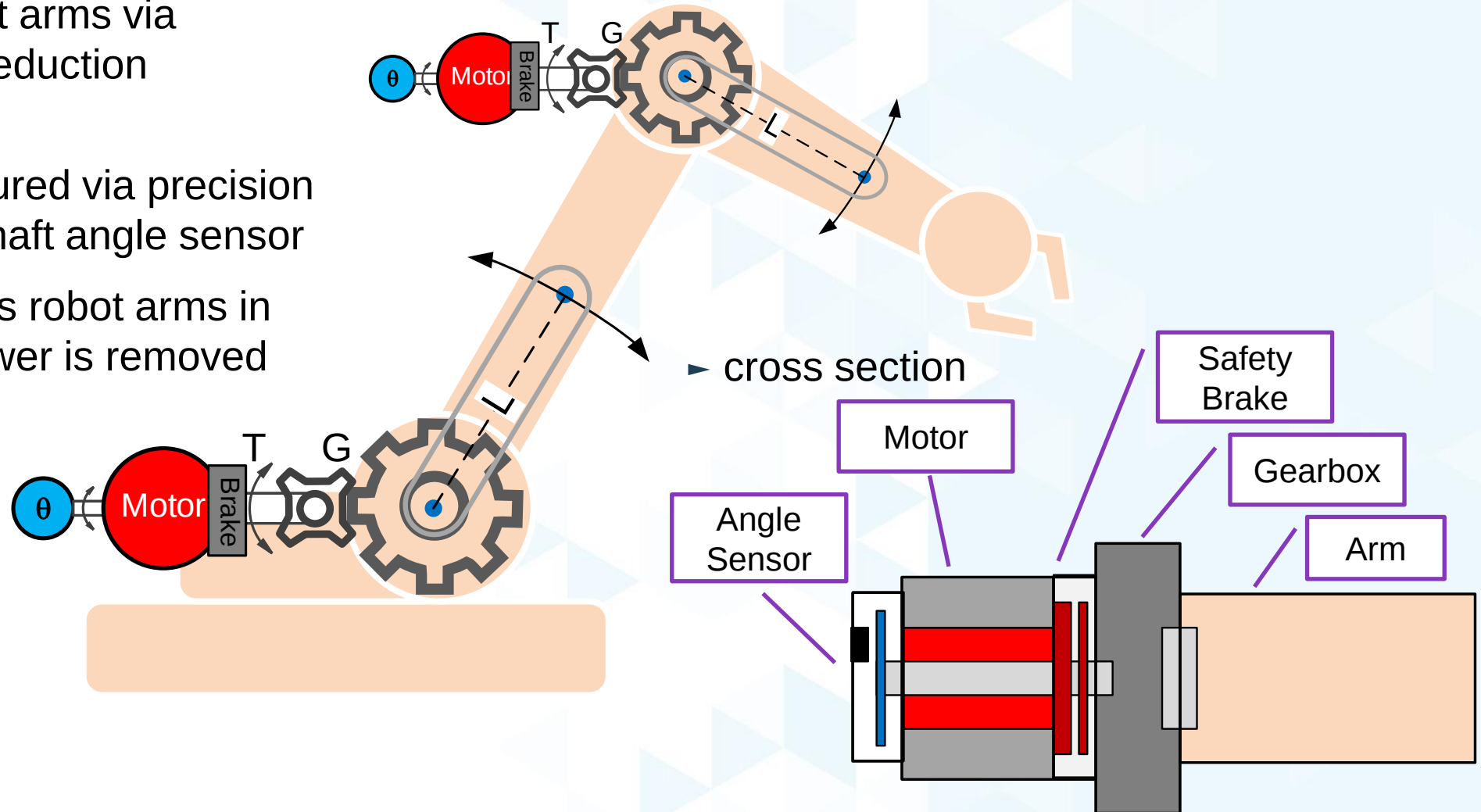


- ▶ High speed
 - 2.0 MHz
 - 9 V/ μ s slew rate
- ▶ High input common-mode voltage
 - -2V to +70V Continuous Operation
- ▶ Small packages for integration in robot joints
 - 8-lead SOIC_N
 - 8-lead MSOP
- ▶ Low drift: 1.0 μ V/ $^{\circ}$ C max

Positioning

Robot Electromechanical System

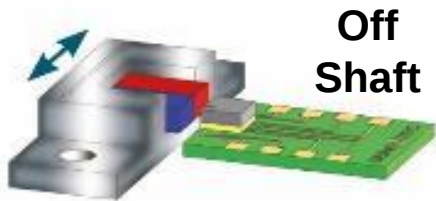
- ▶ Motors drive robot arms via precision speed reduction gearboxes
- ▶ Joint angle measured via precision motor mounted shaft angle sensor
- ▶ Safety brake holds robot arms in position when power is removed



xMR - Measurement arrangements



End of
Shaft



Off
Shaft

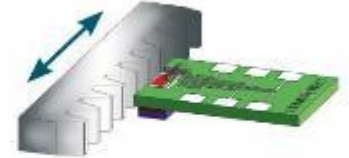
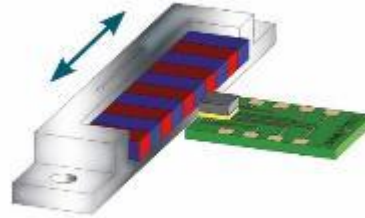
1

Absolute Position

ADA4570/1

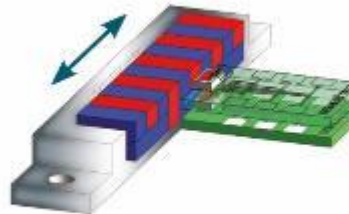
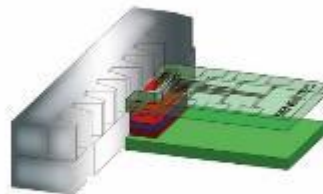
2

Incremental



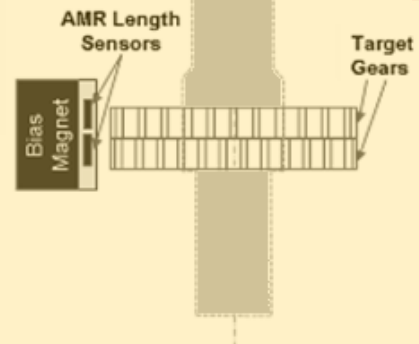
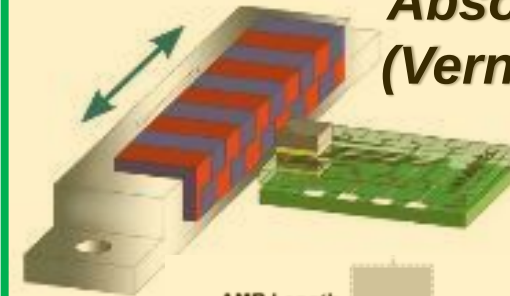
3

Incremental + Index



4

**AMR Length Sensor
Absolute Position
(Vernier or Nonius)**



xMR- Position Sensing

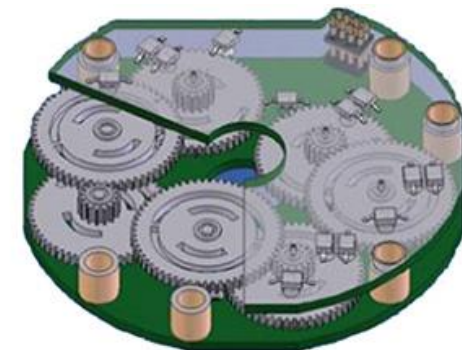
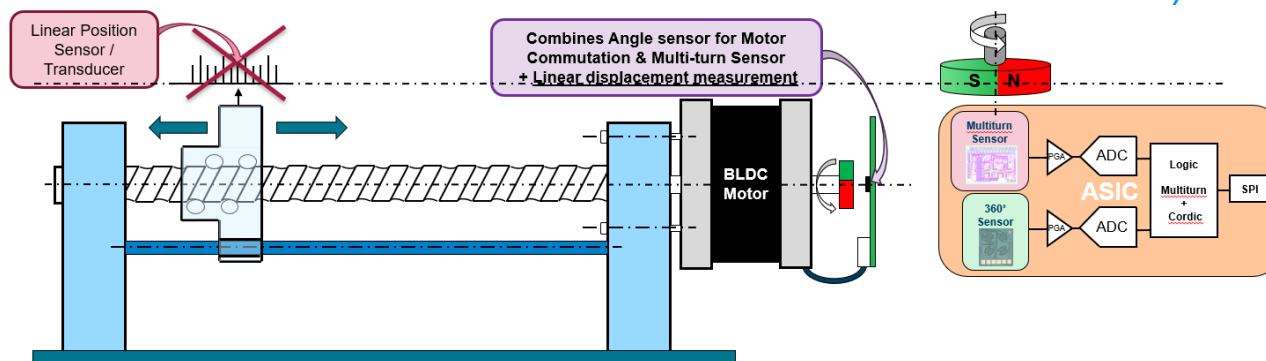
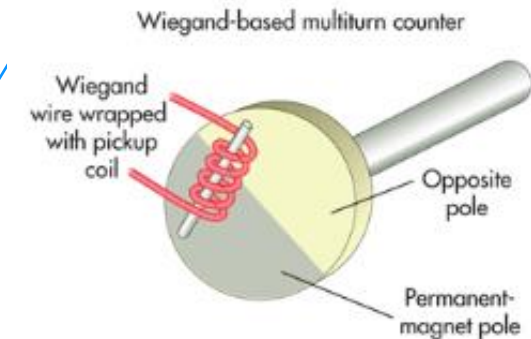
ADI xMR Multiturn can be the disruptive technology to replace existing solutions

- +Zero power, battery-less
- +Small formfactor
- +Can be combined with angular position sensors
- +Cost effective

Multi-Turn:

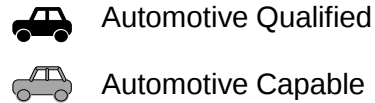
- 40T today
- Machine Tool Applications
- Short Range Linear Motion or Tracks
- ~~Closed Loop multi-turn still several years out~~

ADMT4000



Power Conversion

Gate Driver Companions



				Basic				Protecting			Programmable		
													
				ADuM4120	ADuM4121	ADuM4122	ADuM4221	ADuM4135	ADuM4136	ADuM4146*	ADuM4137	ADuM4138	ADuM4177*
1200V XM3 Module		400A, 425A, 450A	XM3 					C, E, T*	C		C	C	C, E*
1200V HM2 Module		325A	HM2 					C	C		C	C	C
1200V BM2 Module		120A, 300A	BM2 					C, E	C		C	C	C
1700V BM2 Module		300A	BM2 							V, E*			
1200V CM2 Module		20A, 50A	CM2 	C	C	C	H						
650V C3M MOSFET		15mΩ, 60mΩ	D, K, J 	C	C, E*	C	H, R	P	P	F	P	P	P, R*
900V C3M MOSFET		30mΩ, 65mΩ, 120mΩ, 280mΩ	D, K, J 	C	C	C	H	P	P	F	P	P	P
900V E3M MOSFET		65mΩ, 120mΩ, 280mΩ	D 	C	C	C	H	P	P	F	P	P	P
1000V C3M MOSFET		65mΩ, 120mΩ	J, K 	C	C	C	H	P	P	F	P	P	P
1200V C3M MOSFET		16mΩ, 21mΩ, 25mΩ, 32mΩ, 40mΩ, 49mΩ, 75mΩ, 80mΩ, 160mΩ, 280mΩ	D, J, K 	C	C	C	H	P	P	F	P	P	P
1700V C2M MOSFET		45mΩ, 80mΩ, 1000mΩ	D, P 							V			

* - In development
 E - Evaluation Board Exists
 T - Test Report Exists
 R - Reference Design Exists

C - General companion recommendation
 H - Preferred for Half Bridge Configurations
 F - Preferred for High Frequency Applications
 V - Preferred for High Voltage Applications
 P - Preferred when paralleling switches

CGD12HBXMP

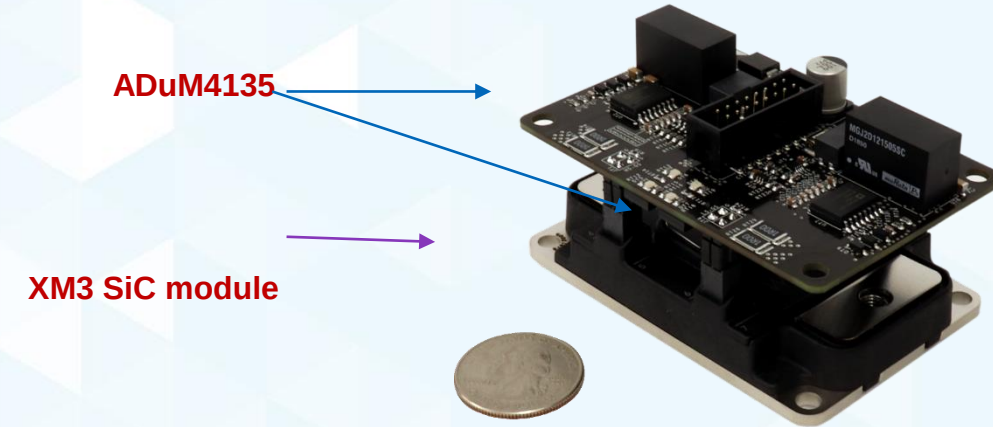
Evaluation Gate Driver Tool Optimized for the XM3 Module Platform

Specifications

- 2-Channel , Single Half Bridge
- Isolation Voltage of 1000 V
- 16-Pin Interface
- 10A Peak Gate Drive Current
- Direct low inductance mounting
- dV/dt capability of 100 kV/ μ s
- Maximum Switching Frequency of 80 kHz

Features:

- Optimized for Wolfspeed's XM3 SiC half bridge power module
- 2W isolated supplies support 80kHz switching frequency
- User configurable turn-on & turn-off gate resistors
- Overcurrent, shoot-through and reverse polarity protections
- Differential inputs for increased noise immunity
- Very low isolation capacitance (<5pF) and 100 kV/ μ s common mode transient immunity (CMTI)
- Fault and power LEDs



Wolfspeed Products	ADI Products
CAB450M12XM3 CAB450M12XM3 CAB450M12XM3 1200 V, Silicon Carbide Conduction-Loss Optimized XM3 Half-Bridge Modules	ADUM4135BRWZ 4A Gate Driver Magnetic Coupling 5000Vrms 1 Channel
	LT3015 50mA, 3V to 80V Low Dropout Micropower Linear Regulator

Application Note 

Schematic 

BOM 

Gerbers 

Force Torque Sensing

Force Sensing in Robotics

- ▶ Collaborative robot applications require force limiting by law
 - Contact with the robot should not cause pain

- ▶ Application level motivators
 - Precision assembly
 - Quality improvements in polishing & grinding
 - Tool damage prevention
 - Increase productivity

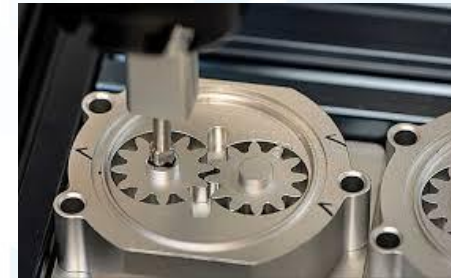
- ▶ Human safety, 65N limit
- ▶ **Precision applications, 0.1N resolution**



ISO/TS 15066:2016(E)

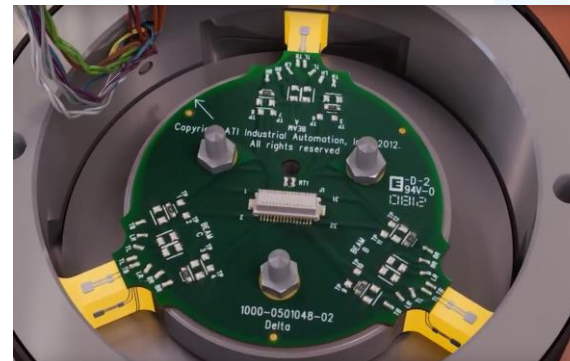
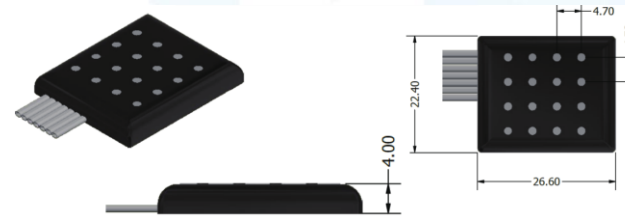
Table A.2 — Biomechanical limits

Body region	Specific body area	Quasi-static contact		Transient contact	
		Maximum permissible pressure ^a p_s N/cm ²	Maximum permissible force ^b F_s N	Maximum permissible pressure multiplier ^c P_T	Maximum permissible force multiplier ^c F_T
Skull and forehead ^d	1 Middle of forehead	130	130	not applicable	not applicable
	2 Temple	110		not applicable	
Face ^d	3 Masticatory muscle	110	65	not applicable	not applicable
Neck	4 Neck muscle	140	150	2	2
	5 Seventh neck muscle	210		2	
Back and shoulders	6 Shoulder joint	160	210	2	2
	7 Fifth lumbar vertebra	210		2	
Chest	8 Sternum	120	140	2	2
	9 Pectoral muscle	170		2	
Abdomen	10 Abdominal muscle	140	110	2	2
Pelvis	11 Pelvic bone	210	180	2	2
Upper arms and elbow joints	12 Deltoid muscle	190	150	2	2
	13 Humerus	220		2	
Lower arms and wrist joints	14 Radial bone	190	160	2	2
	15 Forearm muscle	180		2	
	16 Arm nerve	180		2	

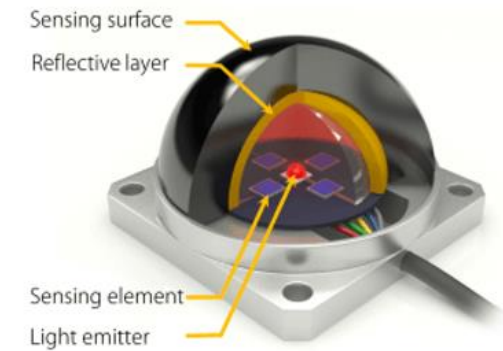


Force, Torque, Tactile Sensors

- ▶ Sensors can be placed in
 - Joints
 - Intermediate end effectors (wrist)
 - End effectors (grippers/tools)
- ▶ Multiple sensor types
 - Tactile
 - Mems
 - Resistive
 - Force & Torque
 - Current
 - Capacitive
 - Piezo
 - Optical
 - Strain gauge



3D Force Sensor (OMD)



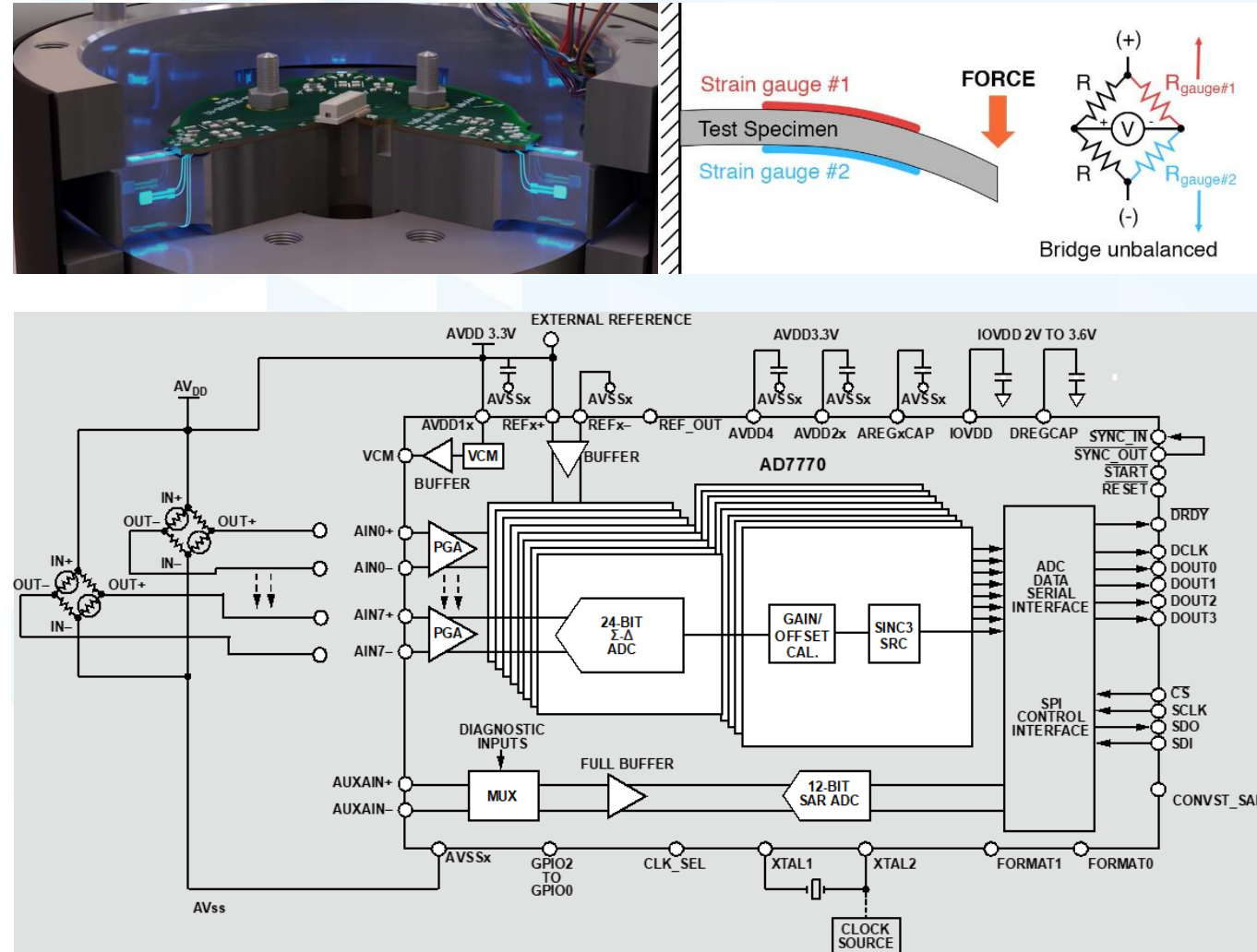
Force Sensing Solutions

- ▶ Typical wrist force and torque sensor
 - 3 stress beams
 - 4 strain gauges per beam
 - Typically 4mV/V to 80mV/V sensors
 - 6x simultaneous sampling half bridge channels
 - Sub 10kHz sampling

- ▶ Ideally suited to $\Sigma\Delta$ signal chain

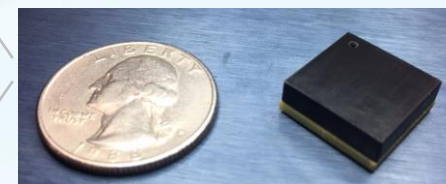
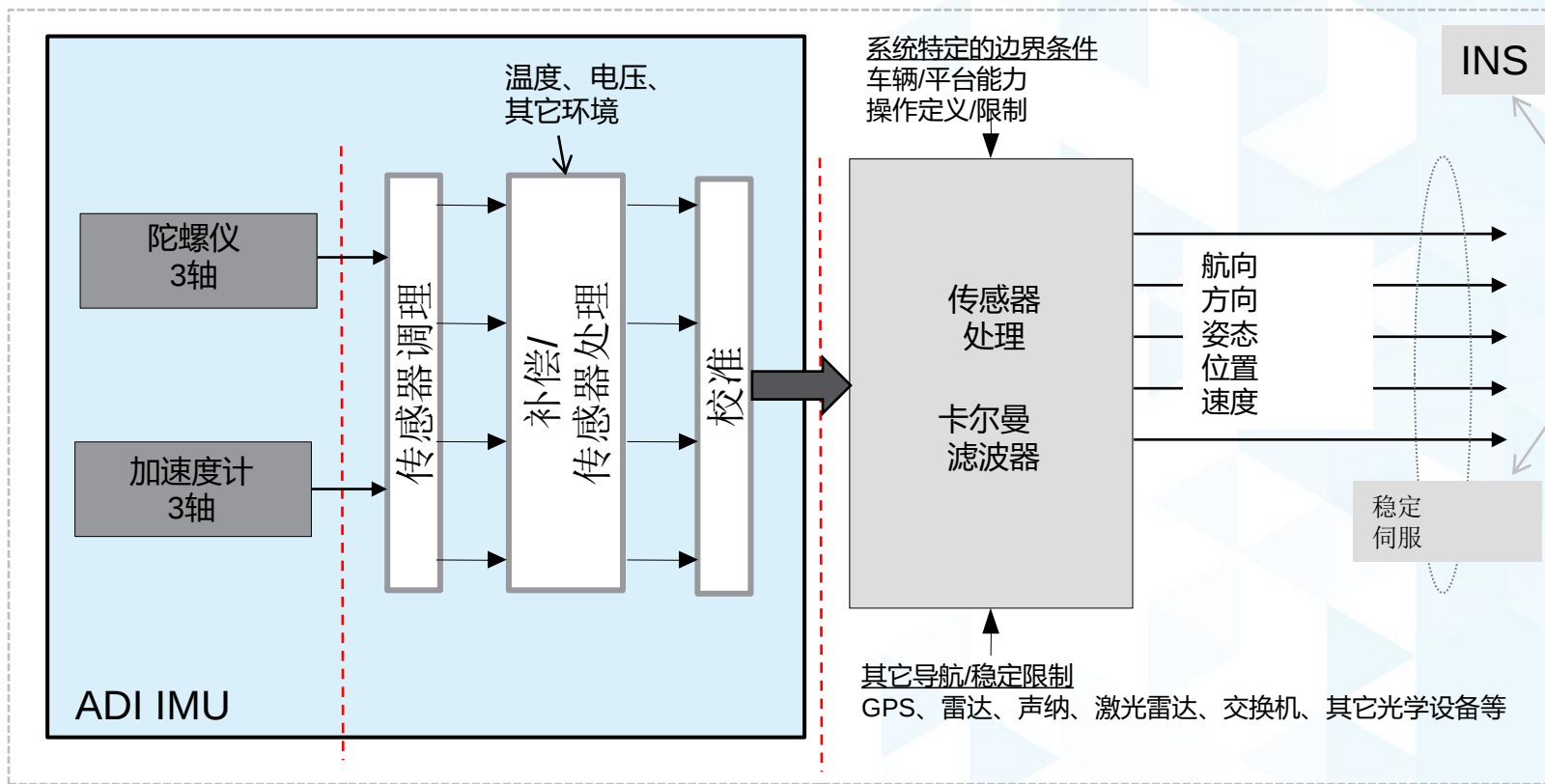
▶ AD777x

- 8x sim sampling
- Integrated PGAs, 1x, 2x, 4x, 8x
- Configurable filters



Stability and Navigation

What IMU Looks Like?



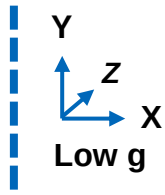
ADIS16500/ADIS16505/
ADIS16507 IMU



“传感器”与“导航引擎”的分际，代表：

- | | |
|-------------------|--------|
| ➤ 开发周期衡量单位： | 人-年 |
| ➤ 性能改进衡量单位： | 数量级 |
| ➤ 测试设备衡量单位： | 10万美元数 |
| ➤ 单台设备生产测试时间衡量单位： | 小时 |
| ➤ 传感器处理衡量单位： | 技术先进程度 |

ADIS16500
ADIS16505
ADIS16507



Yaw/Roll/Pitch
XYZ

Compact Performance
SMT IMU



✓ Compact Performance

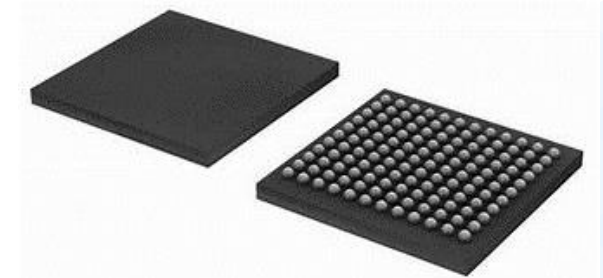
- In-run bias stability of 2.5°/hr and 3.6μg (industry leading)
- Lowest angular random walk (0.15°/√hr) and velocity random walk (0.012 m/sec/√hr)
- Gyro range: 500°/s, Accelerometer: 8g
- Achieved via extended factory calibration

✓ Industry-Leading Compact Footprint

- Much smaller than Fiber Optic Gyros (FOG) used in prototype vehicles today

✓ Robust performance in automotive testing environments

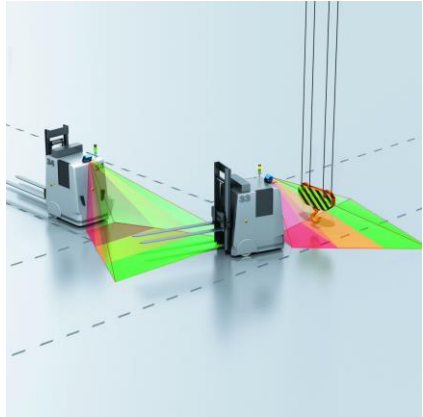
- High level of immunity to vibration (0.01°/s/g) and shock (2,000g) over -40 to 105C temperature range
- ADI's iSensor portfolio is already on the road in Autonomous Driving prototype systems



6-DoF IMU available
in planar BGA
(in development, not to scale)

Environmental Awareness Sensing

Application Examples of Environmental Sensing



Obstacle Avoidance

- AGV moves around an obstacle or another AGV
- Robot avoids a companion workpiece

Safety

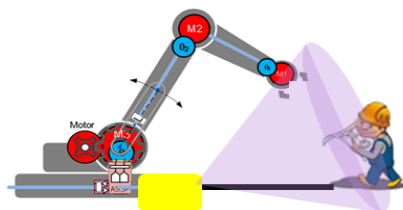
- AGV slows or stops near humans
- Robot slows or stops with human in vicinity

SLAM

- AGV uses sensors to map dynamic environment

Object ID

- Production system identifies different items by dimensions
- Robot picks randomly sorted objects



ADTF3175 – Crosby ToF Module

► Specs

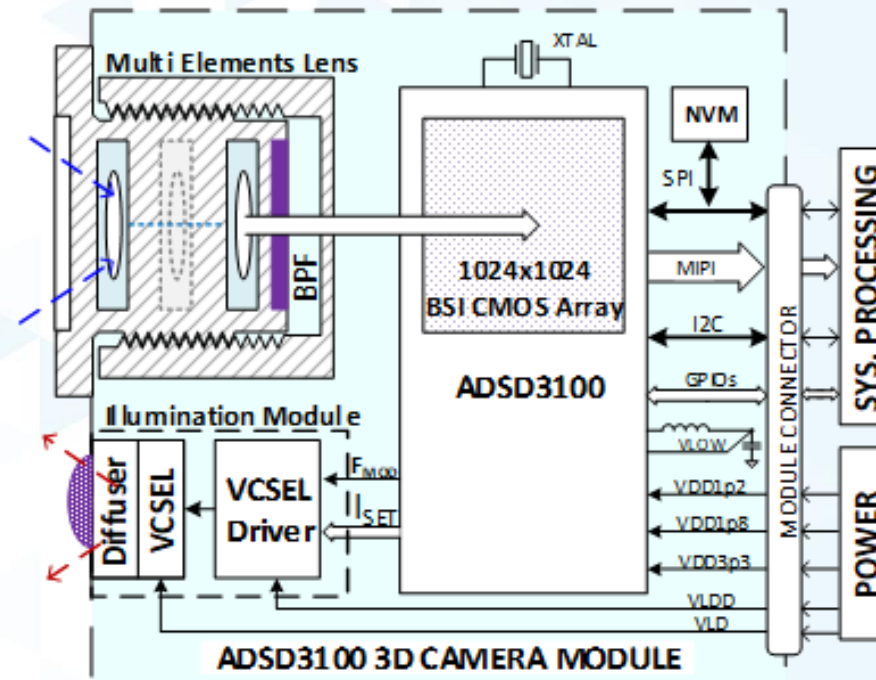
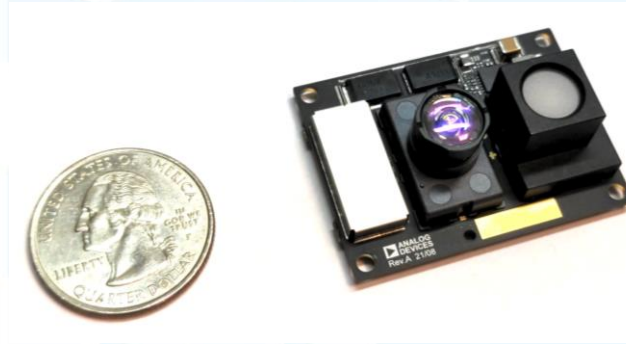
- Field of view (FOV): 75° x 75° @ 1024 x 1024
- 43mm x 31mm x 15.1mm

► Modes of operation

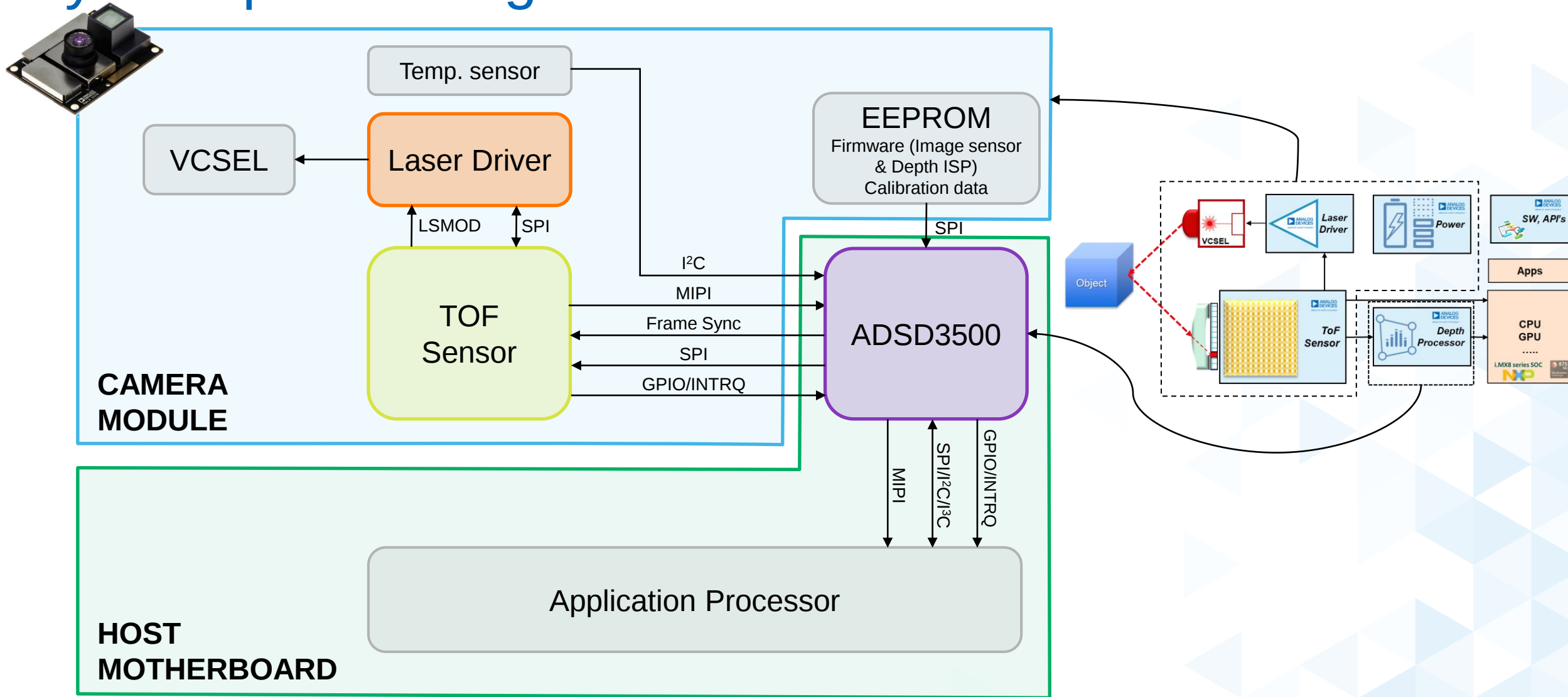
- QMP (512 x 512 binned)
 - short range (~0.1m - 1m)
 - long range (~ 0.4 - 5m)
- 1MP (1024 x 1024)
 - short range (~0.1m - 1m)
 - long range (~ 0.4 - 4m)

► Operating conditions

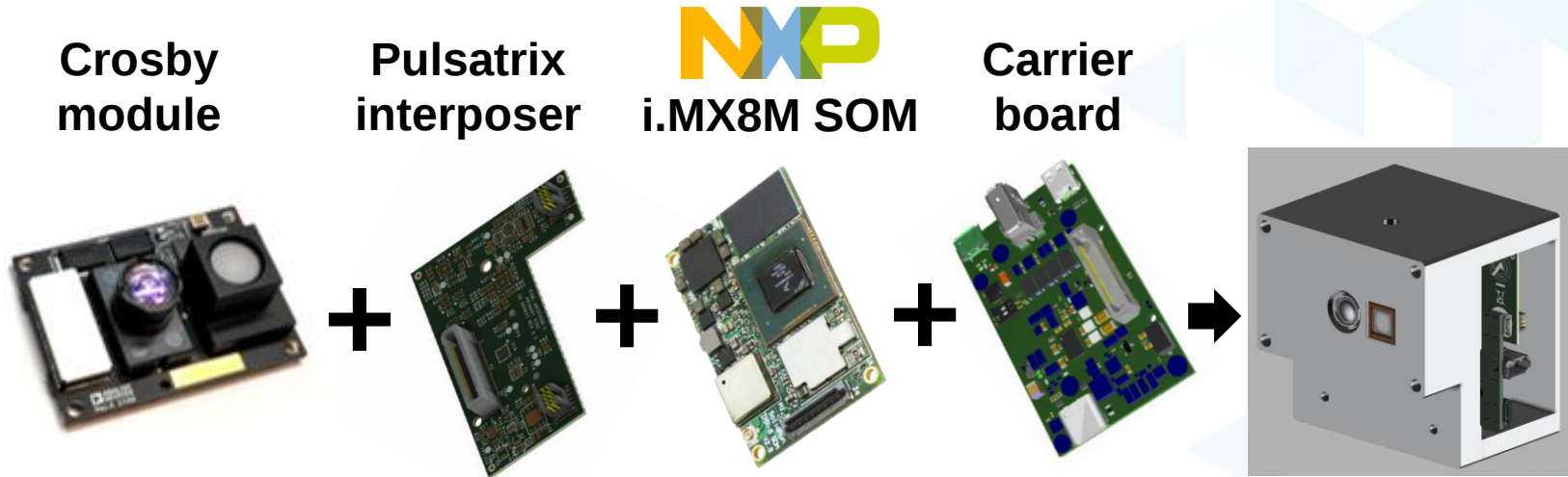
- Reflectance range: 15% - 90% (Lambertian)
- Ambient temperature -20°C to 65°C
- Ambient light < 5,000 lux
(~1 W/m² @ 940 nm +/- 25nm)



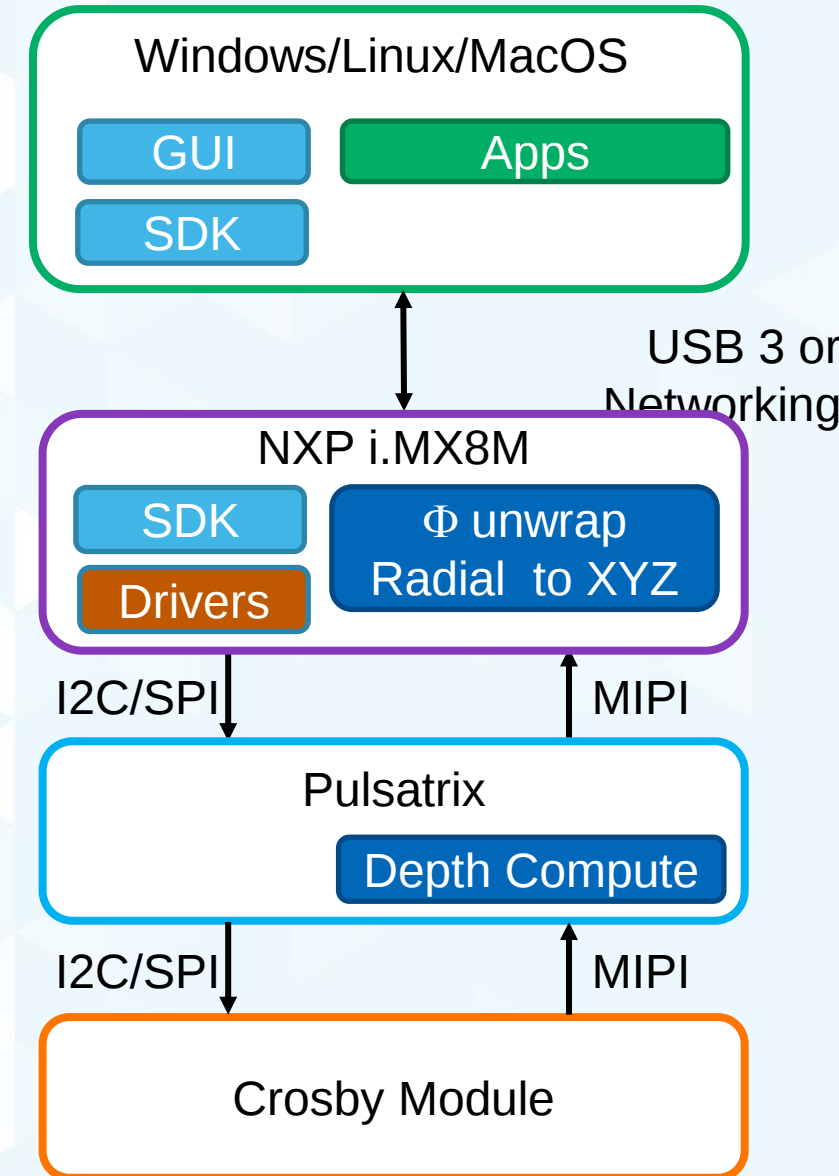
System partitioning – ISP on motherboard



1MP ToF Eval/Dev Platform: Condor



- ▶ Crosby 1MP ToF module
- ▶ Pulsatrix interposer: HW depth engine, module power support
- ▶ Reference Linux MIPI drivers
- ▶ SDK for both embedded and PC
- ▶ Enables customer product development
 - Crosby: ADI production module (RTS Aug '22)
 - Pulsatrix, Power, Host AP: Reference design collateral for 3rd party customization
- ▶ Shipping now in limited quantity (w/o Pulsatrix)
- ▶ Wider availability w/ Pulsatrix: June 2022



ROS Hardware/Software

ROS: A widely accepted robot system middleware that enables inter-operability between robotic subsystem components

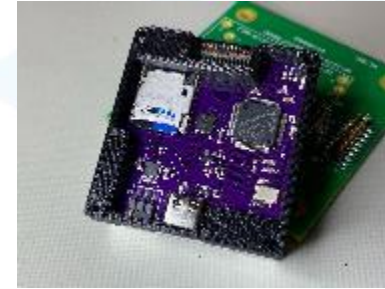
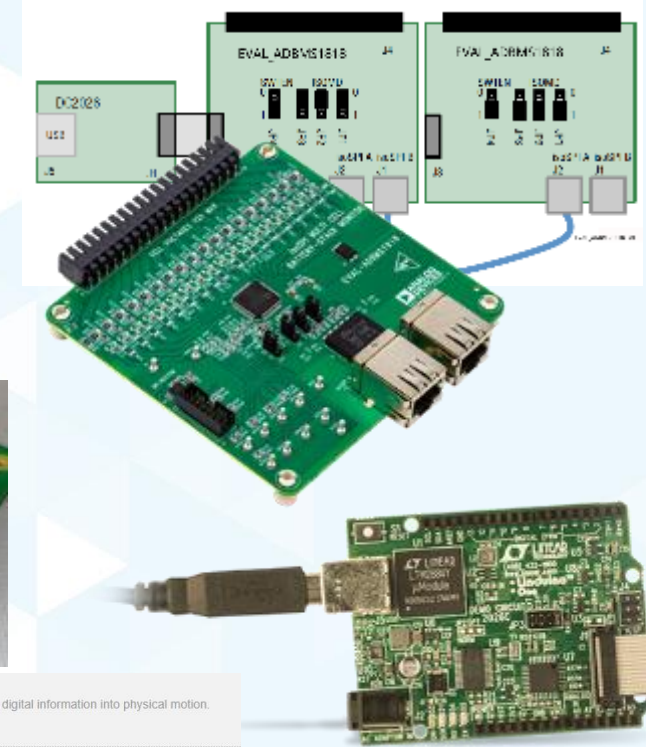
ADI Goal: Provide ROS drivers, standard HW interfaces (USB/Ethernet) and Gazebo plugins to relevant components and subsystems

► *In progress*

- IMU iSensor Buffer Board
- 3D ToF (Swan)
- ADI Github – Dec 2021
- Official ROS release – Jan 2022

► *Other Options*

- BMS
 - ADBMS1818 18-Cell Battery Stack Monitor
- Motor control
 - Maxim Trinamic Motor Control for LV Brushless motors

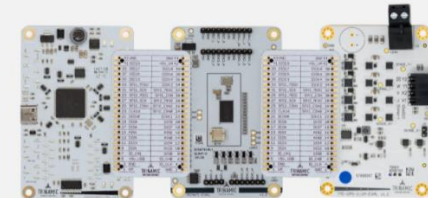


TRINAMIC BLOG

We transform digital information into physical motion.

[NEWSLETTER](#) | [BLOG ETHICS](#) | [LEGAL/IMPRESSUM](#) | [MAIN WEBSITE](#)

CONTROLLING BRUSHLESS MOTORS WITH ROS



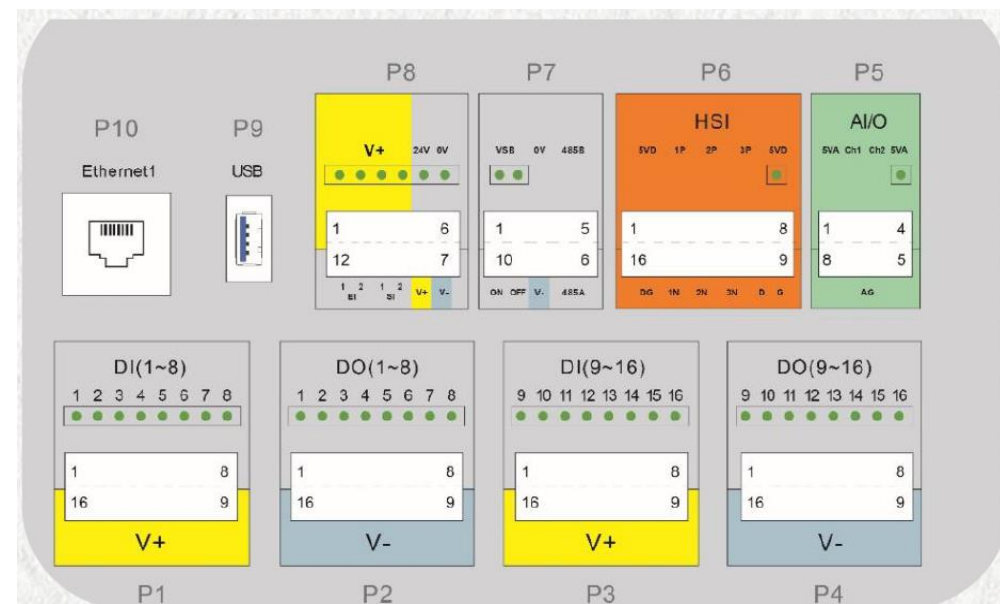
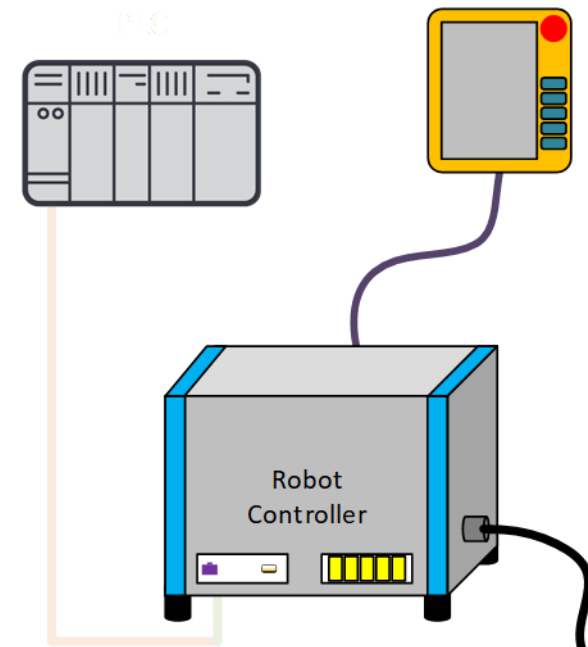
GAZEBO

Robot simulation made easy.

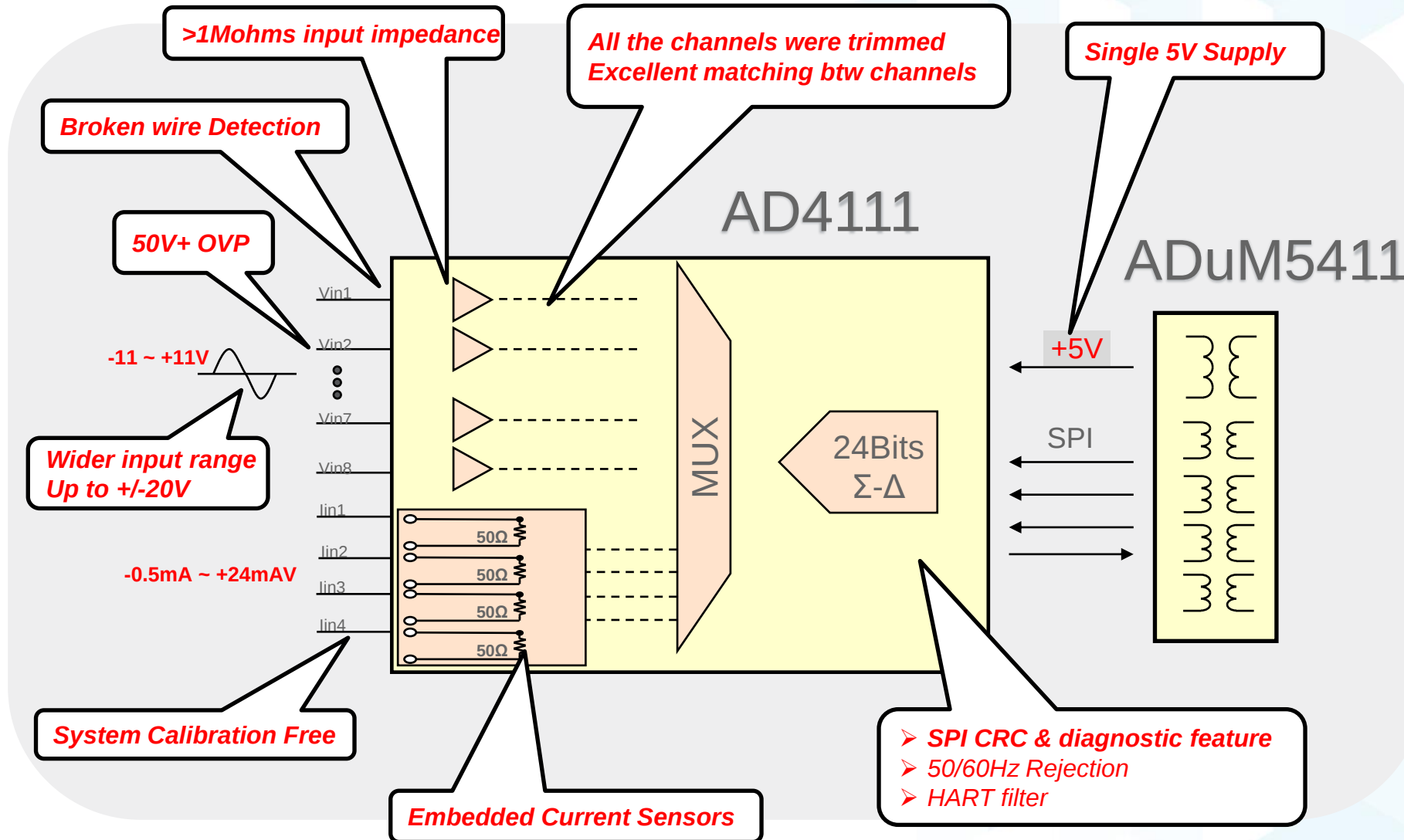
Interface and Networking

Signal Option Card

最大负载	7 kg	关节角度限制	Max. ± 220° (依据配置)
臂展	最大臂展 850 mm	重量	29 kg
	最大臂展 1000 mm (5 kg 负载时)		
视觉	集成2D视觉以及2个高功率LED光源	防护等级	IP 54 (本体和控制柜)
灵敏度	集成力矩传感器在每个关节	电源电压	200~253 VAC, 47~63 Hz
		平均功耗	250 W
机器学习及AI	集成神经处理单元 (NPU)	最大电流	8 A @ 230 VAC
重复定位精度	0.05 mm	环境条件	温度: 5~40 °C 湿度: 80 % RH (非冷凝)
TCP常规速度	1.2 m/s		
TCP最大速度	2.0 m/s	用户界面	基于浏览器的图形化机器人用户界面 集成 Python-API, 包括图形化用户界面编辑器 集成三个可自定义功能按钮的腕部工具接口
最大关节速度	关节 1: 141°/s		
	关节 2: 141°/s		
	关节 3: 169°/s		
	关节 4: 180°/s		
	关节 5: 180°/s		
安全功能 符合 EN ISO 10218-1 EN ISO 13849-1 PL d, Cat. 3	ES: 紧急停止包括 STO, SBC		
	ED: 使能装置		
	OM: 操作模式		
	SLDS: 安全限制的驱动速度		
	SLDP: 安全限制的驱动位置		
	SLDT: 安全限制的驱动力矩		
	SLRP: 安全限制的机器人功率		
	SLCP: 安全限制的笛卡尔坐标系位置		
	SLCO: 安全限制的笛卡尔坐标系方向		
	SLCS: 安全限制的笛卡尔坐标系速度		
	SLCF: 安全限制的笛卡尔坐标系力		
	PS: 保护性停止		
	可定制的安全多个I/O接口		
通讯协议 机器人控制	支持16 DI, 16 DO, 4 AI, 4 AO, 支持Ethernet通讯		
	支持8 SafeDI, 4 SafeDO (safe Ins- and Outs)		
	基于OPC UA的网关通讯 (SPS, Cloud等)		
通讯协议 末端执行器	最大电源供给: 2 A & 24 V		
	M8接口(8 Pin): 2 DI, 1 DO, 2 AI/ModbusRTU, 1DI/O/IOLink		
	弹性探针插头 (无需硬线链接): 2 DI, 3 DO, 2 AI/ Modbus RTU, 1DI/O/IOLink, 支持Modbus and IO Link		
手控器	M8接口(6 Pin): 总线接口、支持以太网通信		
	紧急停止		
	使能按钮		
	操作模式切换		
55	开机/关机 按钮		



AD4111/2 Simplify AI Design



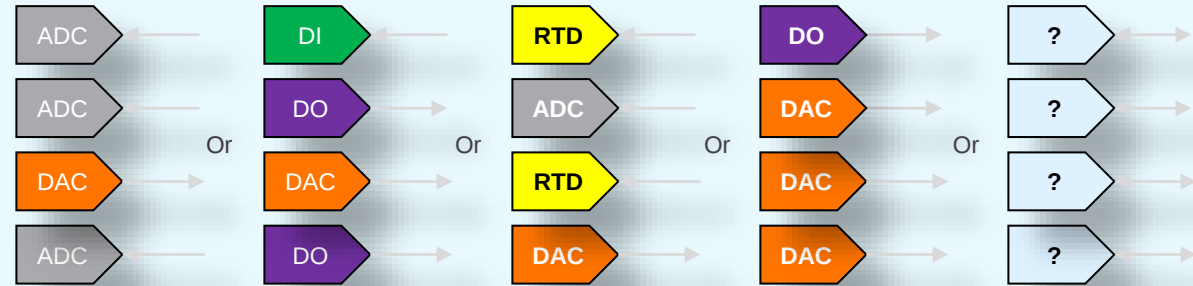
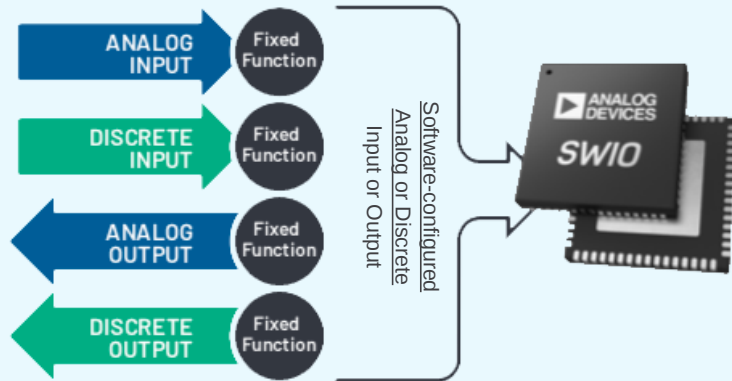
AD4111

- 4-dif/8-se channels
- 6.25kHz CH switching
- 1Mohms impedance
- w/ OWD feature
- 4-se Current channel

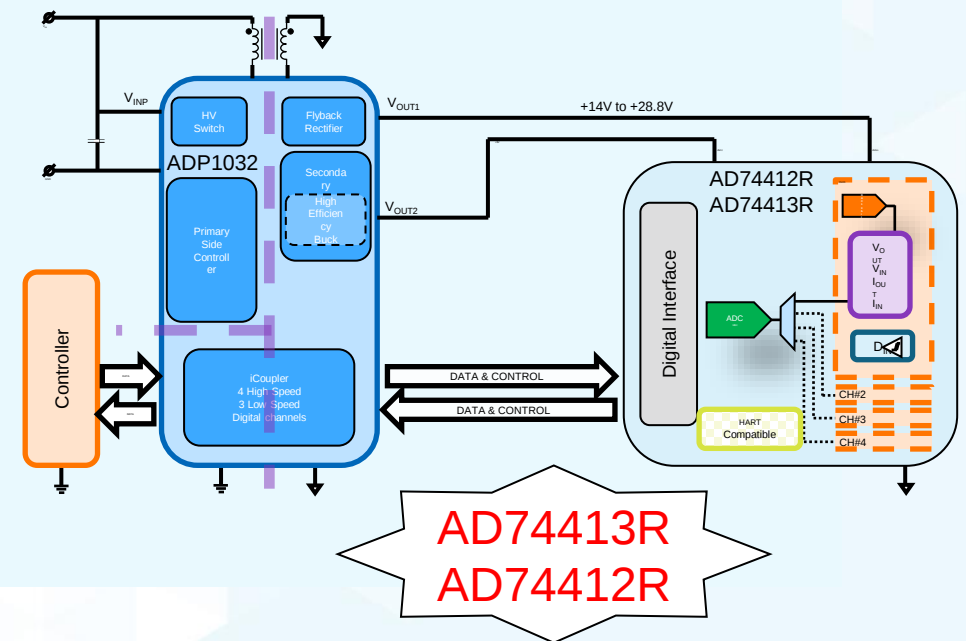
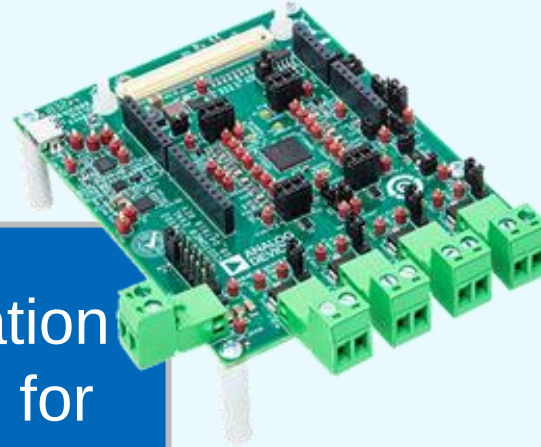
AD4112

- 4-dif/8-se channels
- 6.25kHz CH switching
- 1Mohms impedance
- w/o OWD feature
- 4-se Current channel

Software Configurable I/O - SWIO



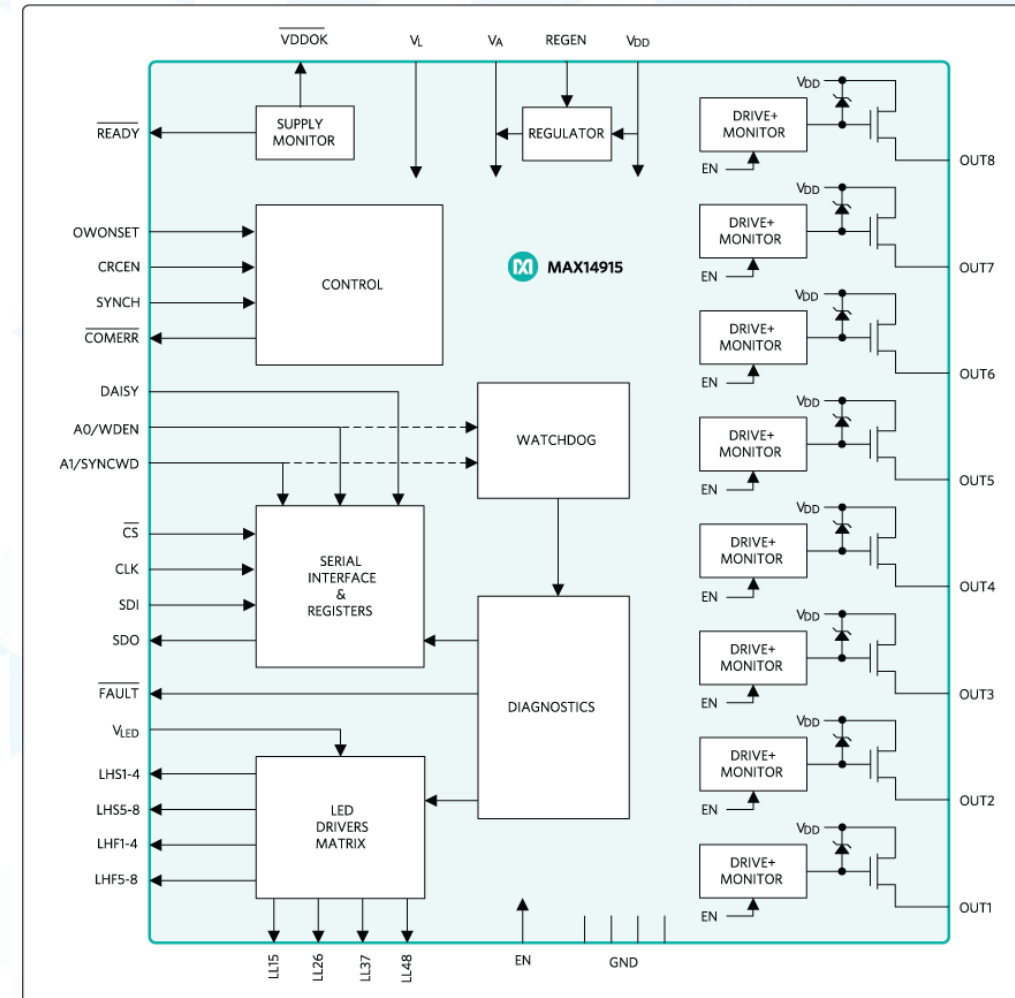
Any function, any combination
on any pin, no restrictions for
ultimate flexibility
Industrial IO on Demand



MAX14915, MAX14916, MAX14917

Industrial Octal High-Side Switch with Diagnostics

- ▶ **Robustness**
 - 65V ABS MAX Supply Range
 - Fast Demag for Inductive Load
 - Integrated 1kV surge protection per IEC 61000-4-5
- ▶ **Outputs**
 - Accurate Output Current Limiting (0.7A, min)
 - 250mΩ (max) On-Resistance at 125°C
- ▶ **Diagnostics**
 - Open Wire/Load Detection, with Switches On and Off
 - Overload and Current Limiting Detection
 - Over and Undervoltage Detection on VDD
 - Thermal Shutdown Protection
 - Loss of VDD or GND Protection
- ▶ **Interface/Control**
 - Addressable SPI allowing multiple MAX14915 sharing a common Chip Select
 - CRC Error Checking on SPI Interface
- ▶ Compact 6mm x 6mm QFN package



MAX14915, MAX14916, MAX14917

Industrial Octal High-Side Switch with Diagnostics

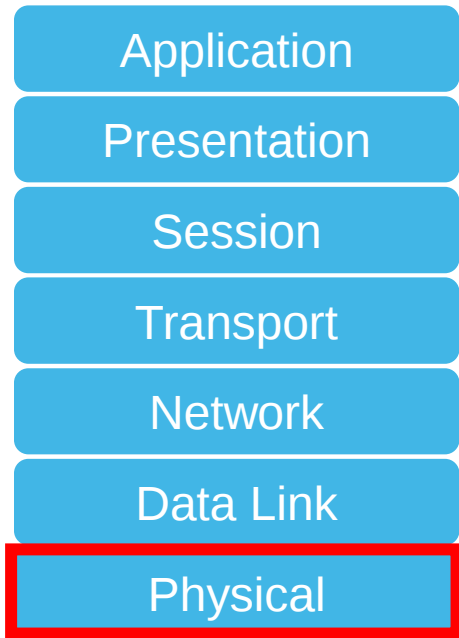
- ▶ Robustness
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 - Loss of VDD or GND Protection
- ▶ Interface/Control
 - Addressable SPI allowing multiple MAX14915 sharing a common Chip Select
 - CRC Error Checking on SPI Interface
- ▶ Compact 6mm x 6mm QFN package

	MAX14915	MAX14916	MAX14917
Octal Output Current Limit (A) (min)	0.7	1.1	0.7
Quad Output Current Limit (A) (min)	1.4	2.4	1.4
Addressable SPI	Yes	Yes	No
Enhanced Diagnostic	Yes	Yes	No
Daisy Chained SPI (limited diagnostic)	Yes	Yes	Yes
Budgetary Price @1k volume	\$4.18	\$4.53	\$3.88

* MAX14917 is pin compatible with the MAX14915 only in daisy chain configuration. It is a limited features, low-cost part for low-end application.

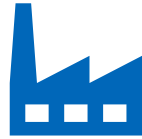
RS-485 in Industrial Connectivity

RS-485 (and RS-422)
are flexible
physical layer



OSI Model

Applications



**Industrial
Processing**
PROFIBUS, Interbus

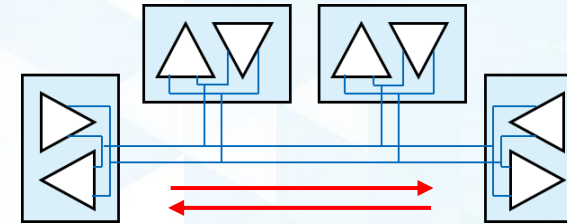


Motor Control
Hiperface DSL

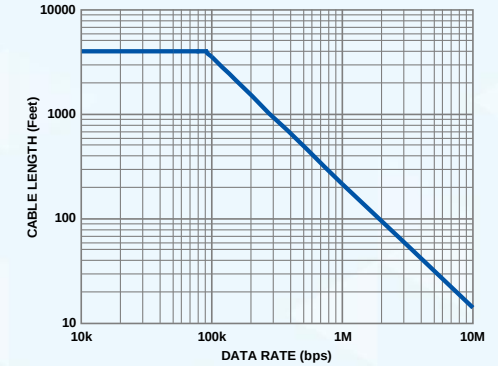


**Building
Automation**
Modbus RTU, BACNet

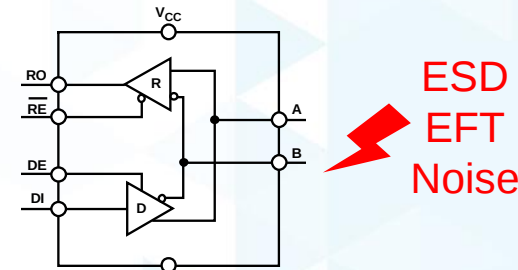
Multipoint



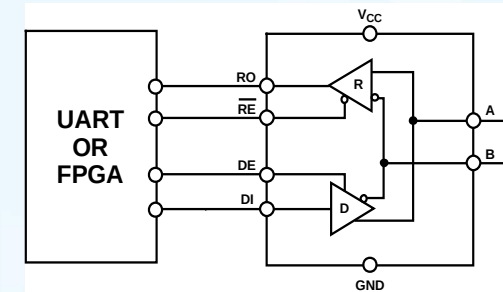
Reach ($\geq 1\text{km}$)



Robustness



Simplicity



ADM286xE/ADM256xE Family

3kV / 5.7kV Signal & Power Isolated RS-485

► Transceiver

- Half or Full duplex transceiver
- 500 kbps or 25 Mbps data rate over 192 nodes
- Level 4 IEC61000-4-2 ESD robustness on bus pins
- Smart cable invert feature

► Isolated DC to DC

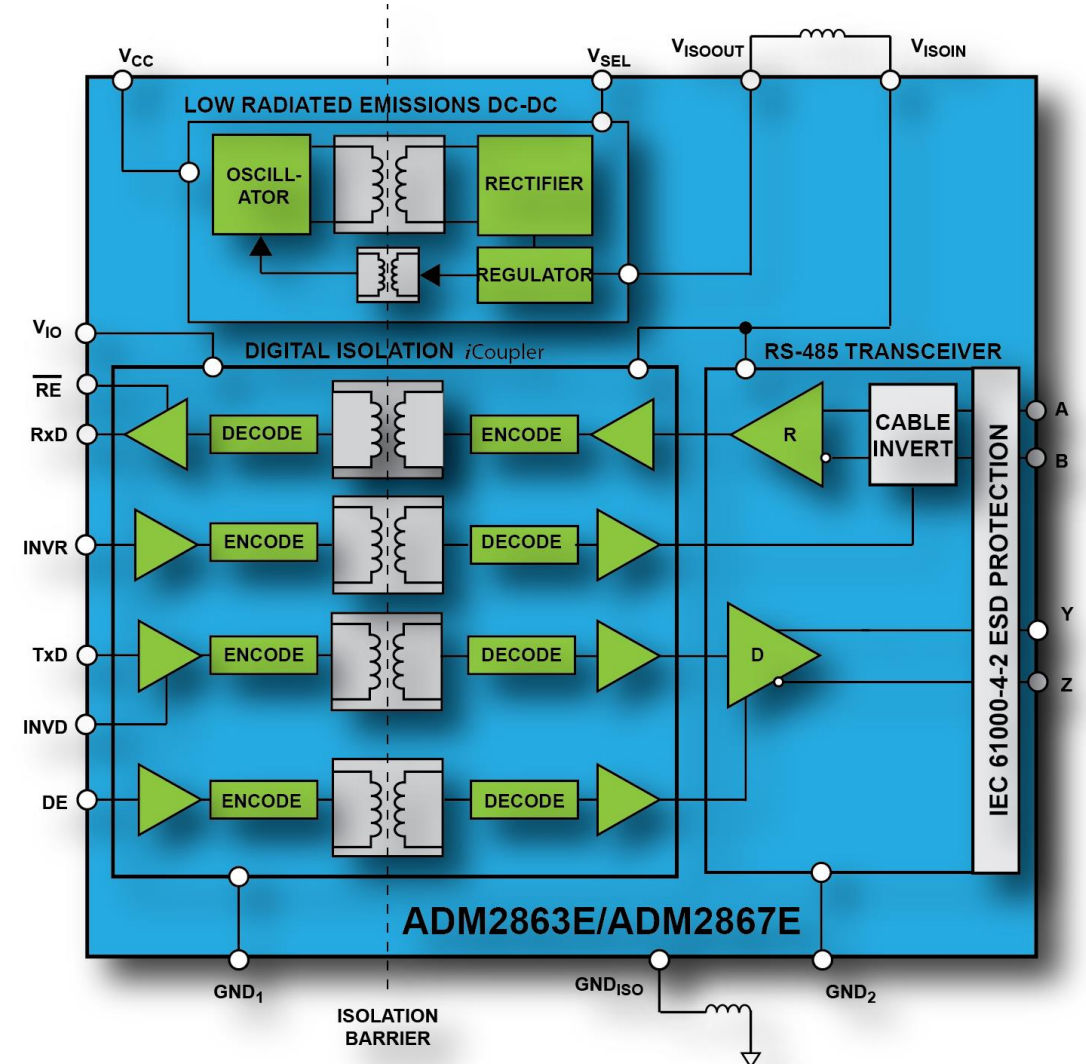
- Wide 3V to 5.5V input, 3.3V or 5V output
- 5V output for PROFIBUS DP
- Meet Class B Radiated Emissions on 2-layer PCB

► Isolator

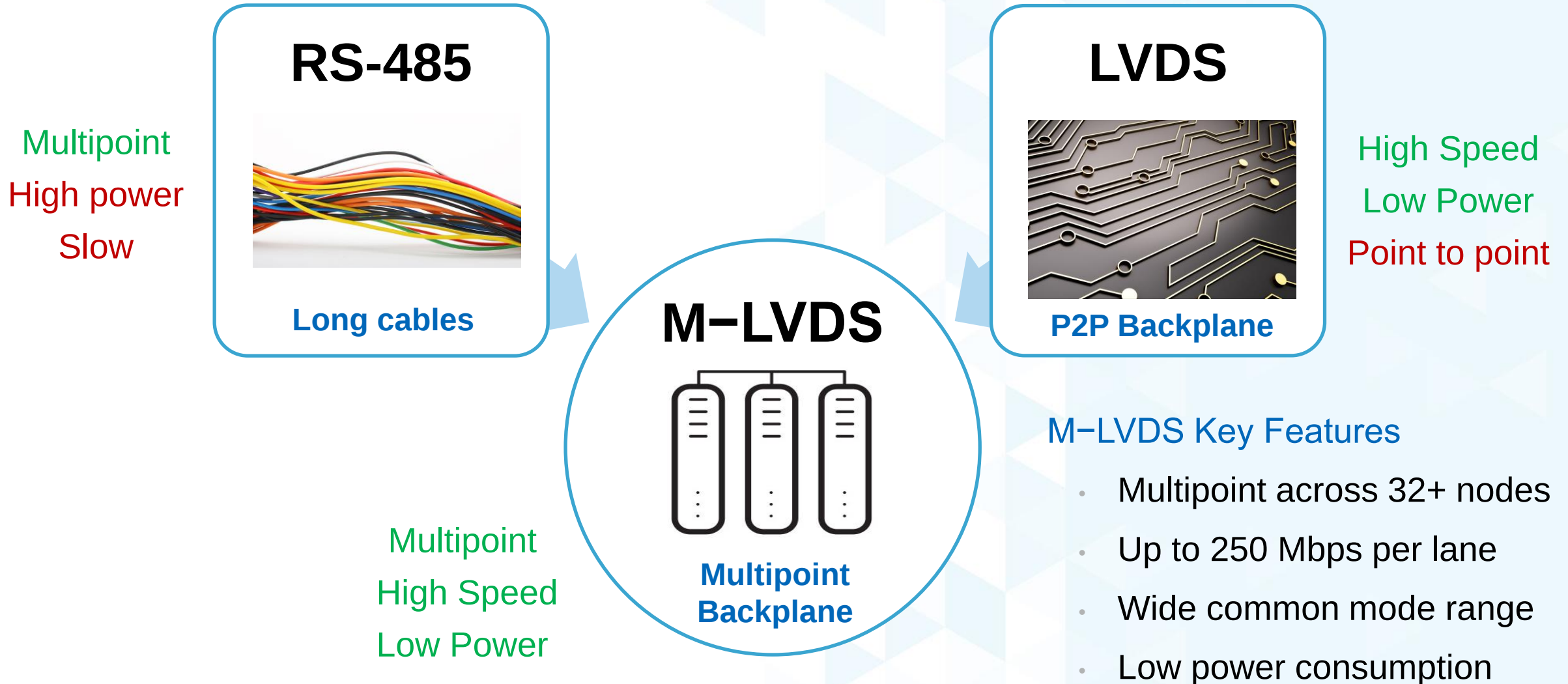
- Supports I/O from 1.7V – 5.5V
- 225kV/us common-mode transient immunity.

► Isolation / Package

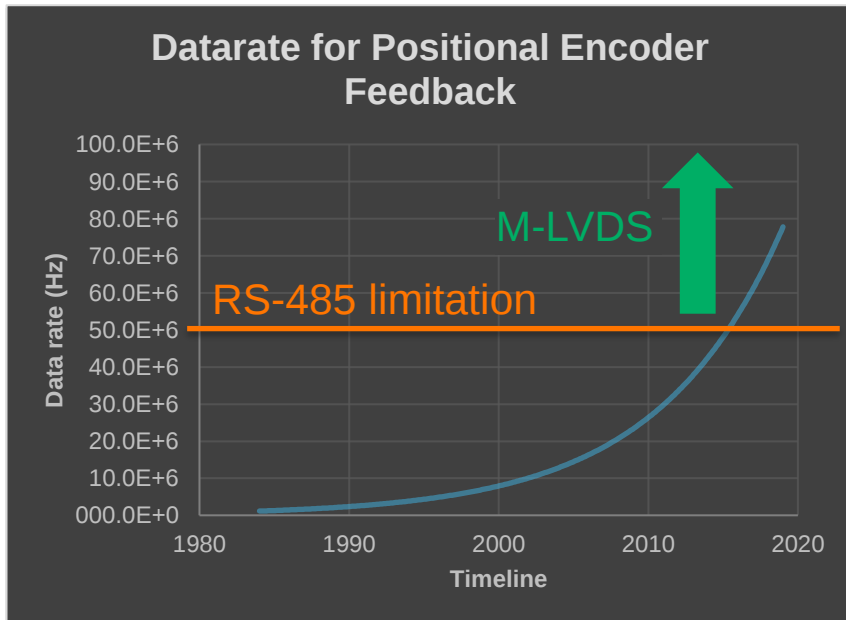
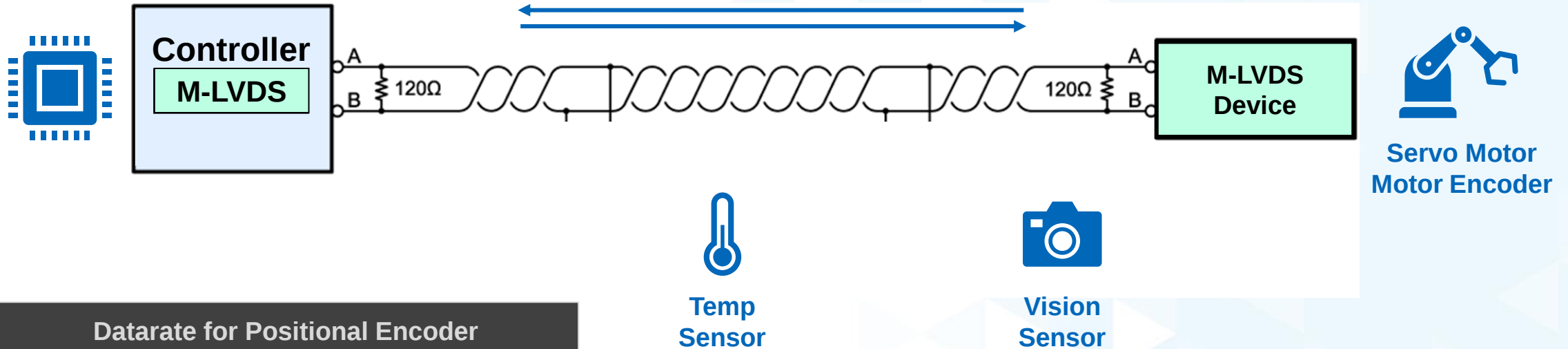
- Smallest form isoRS485 on 16L SOICW body size
- 5.7 kV, 8mm creepage, MG I for reinforced insulation



M-LVDS : Optimised Backplane Communication



Why M-LVDS for Motor Control



	RS-485 / RS-422	M-LVDS
Topology	Differential, Multipoint	Differential, Multipoint
Maximum Data Rate	50 Mbps	250 Mbps
Power Consumption	High, 165mW – 425mW	Low, ~ 60mW
Min Output Voltage	1.5 V	0.48V
# of Devices, Distance	Up to 256 over 1km+	Up to 32 over 30m+

High Density M-LVDS Transceivers

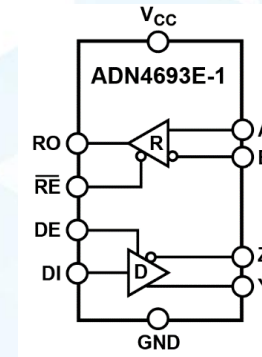
Value proposition

- ▶ Low power solution in a compact packages
- ▶ Low latency, skew and jitter performance for optimum SI
- ▶ Hot-swap and system level ESD for robust end systems

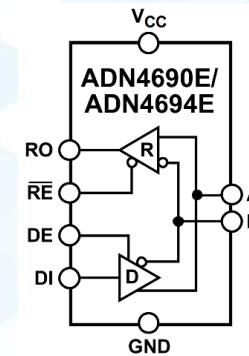
Key benefits

- ▶ Extended industrial temperature ranges
- ▶ Reduced dynamic power consumption
- ▶ Skew less than 5% of unit interval at 200 Mbps
- ▶ Level 4 IEC 61000-4-2 ESD on M-LVDS I/O

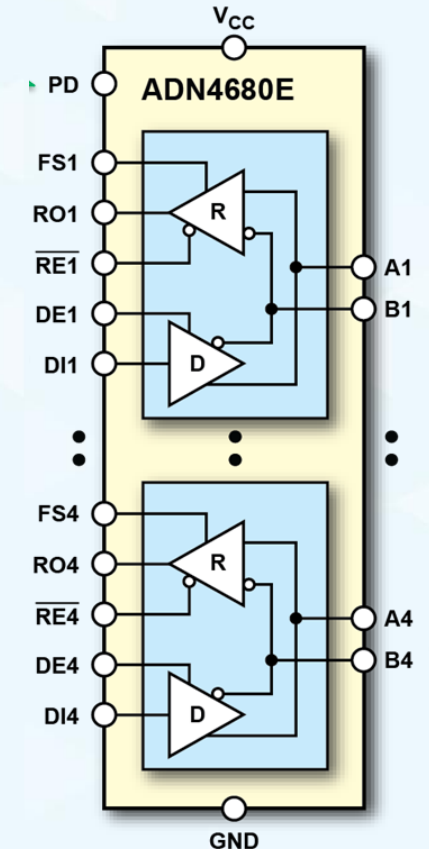
Full duplex



Half duplex



Quad half duplex



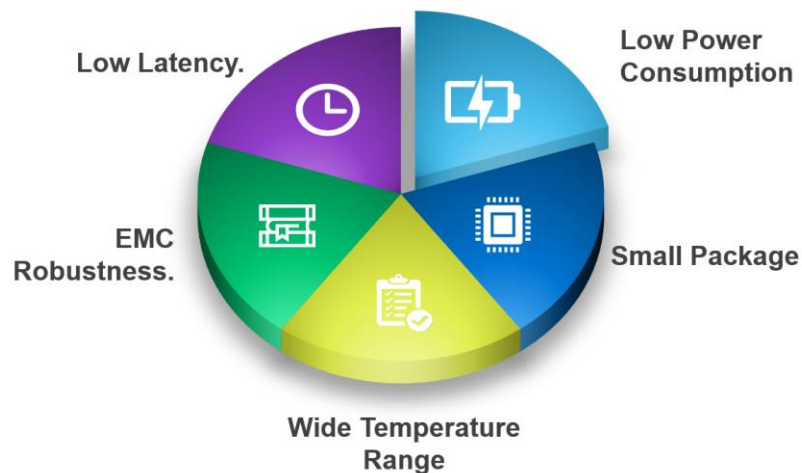
ADIN1300: 10/100/1000 Robust Industrial Ethernet PHY

ADIN1300 10/100/1000 gigabit PHY

- ▶ Small footprint: 6 x 6mm 40-LFCSP
- ▶ Low power: 330mW
- ▶ Low latency: 290ns Tx & Rx (RGMII)

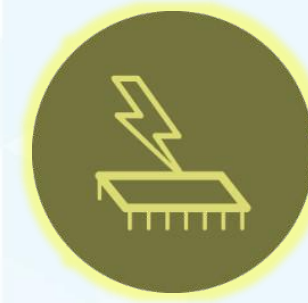
ADIN1200 10/100 fast ethernet PHY

- ▶ Small footprint: 5 x 5mm 32-LFCSP
- ▶ Low power: 139mW
- ▶ Low latency: 300ns Tx & Rx (MII)



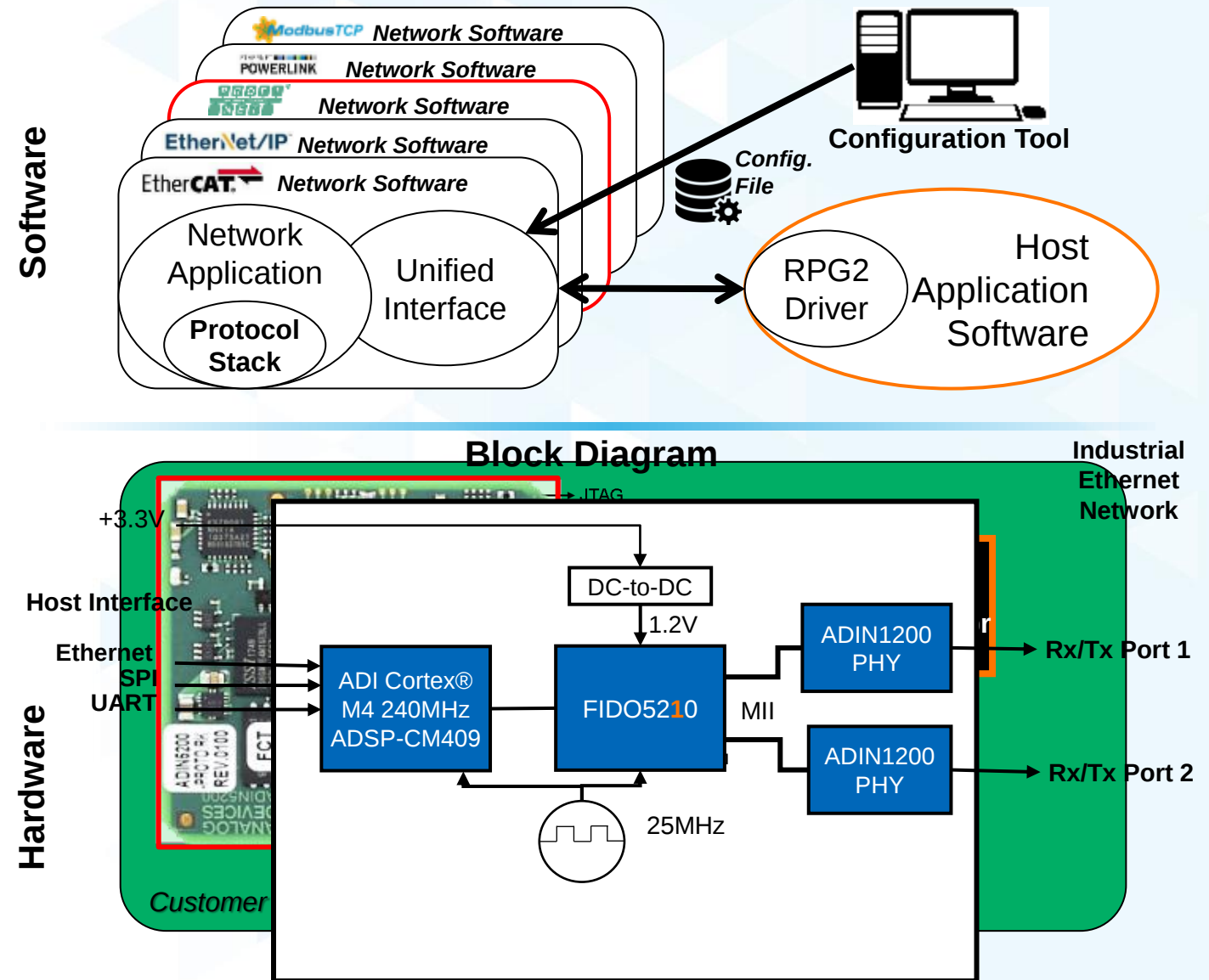
Extensive EMC/ robustness testing

- ▶ IEC 61000-4-5 surge (± 4 kV)
- ▶ IEC 61000-4-4 electrical fast transient (EFT) (± 4 kV)
- ▶ IEC 61000-4-2 ESD (± 6 kV contact discharge)
- ▶ IEC 61000-4-6 conducted immunity (10 V)
- ▶ EN55032 radiated emissions (Class A)
- ▶ EN55032 conducted emissions (Class A)



RapID Platform Generation 2 (RPG2) - 100BASE-Tx

- ▶ 2-Port multiprotocol platform
- ▶ Network software for each protocol
 - A module comes pre-installed with network software (PROFINET is shown here in RED)
- ▶ Driver provided for the host-side software to communicate with the network software
- ▶ Unified interface in the network software
 - Host application software does not have to change when the protocol changes



Network Interface Solutions: Two Options

- ▶ Pre-certified hardware with multiprotocol software
- ▶ Reduces development effort
- ▶ Speeds time to market

Module



ADIN2299

Complete off-the-shelf,
ready-to-use solution
Fully tested reducing
development risk

Embedded reference design



Pre-certified

Enables optimisation
of board design
Cost effective solution for
high volume applications

Isolated USB in Industrial Systems

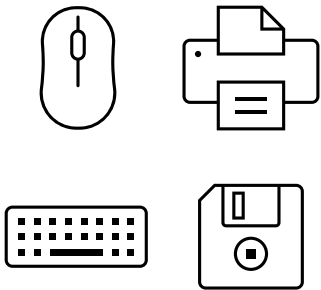


**Photo is from internet

- ▶ Debug Ports (RS-232 Replacement)
- ▶ Noise Immunity
- ▶ Electrical Safety for Operators

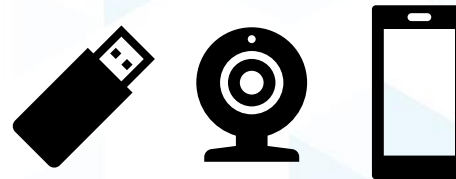
Gen 1 Isolator (USB 1.X)

Low Speed (0.5 Mbps)
Full Speed (12 Mbps)



Gen 2 Isolator (USB 2.0)

Low & Full Speed
High Speed (480 Mbps)

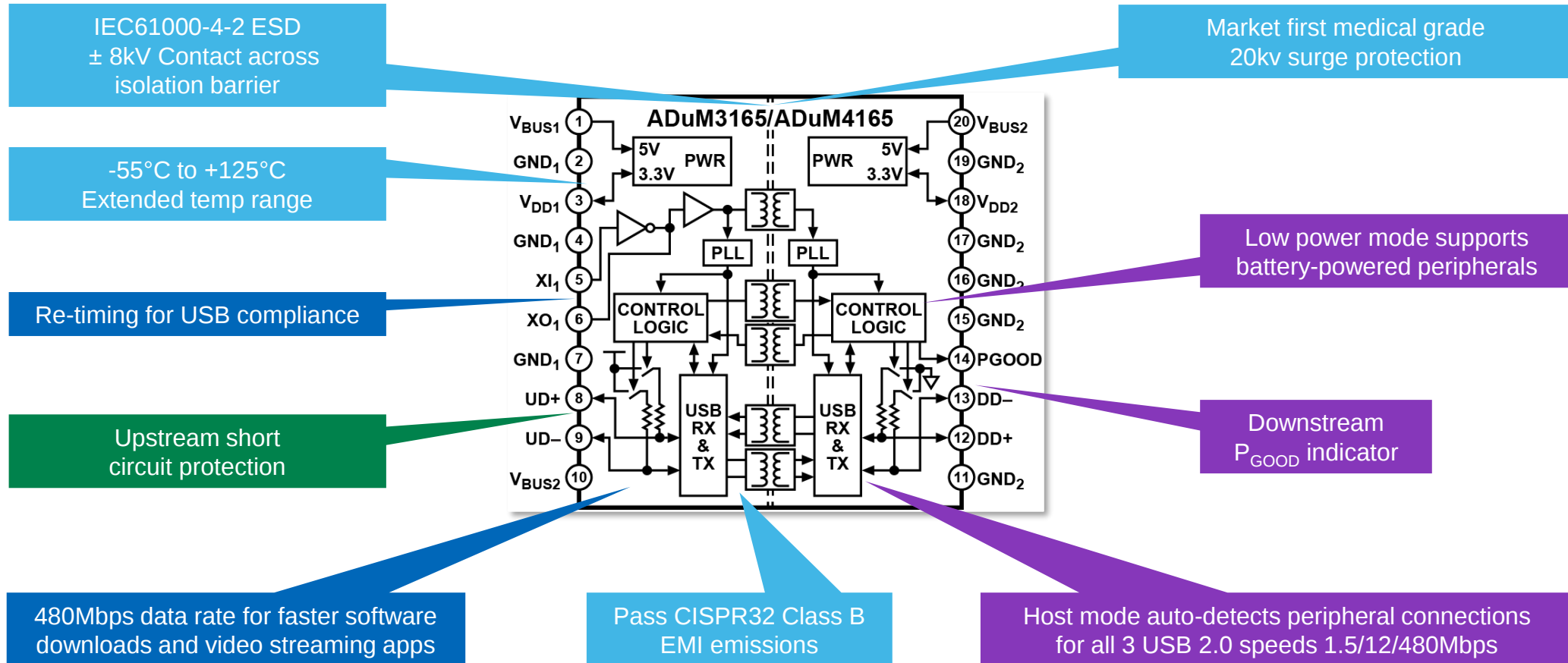


ADI 2nd Gen Isolated USB

- Faster Firmware Updates
- Supports video streams
- More flexible systems
- Enhanced robustness

Isolated USB Gen 2 Product Highlights

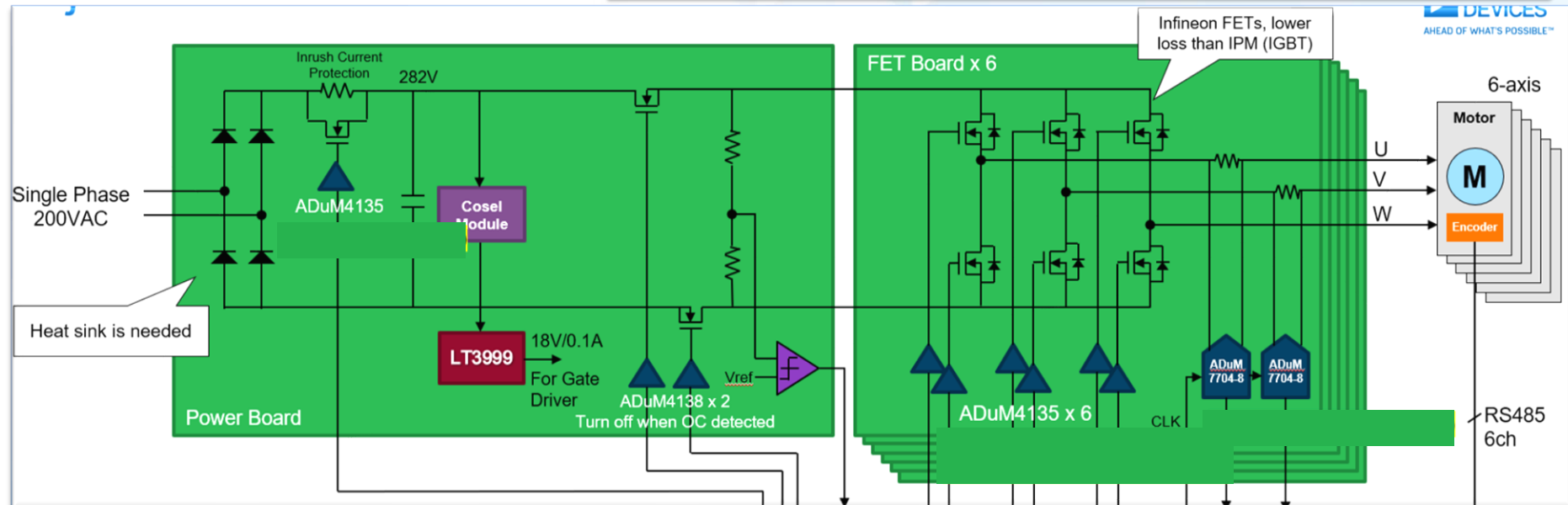
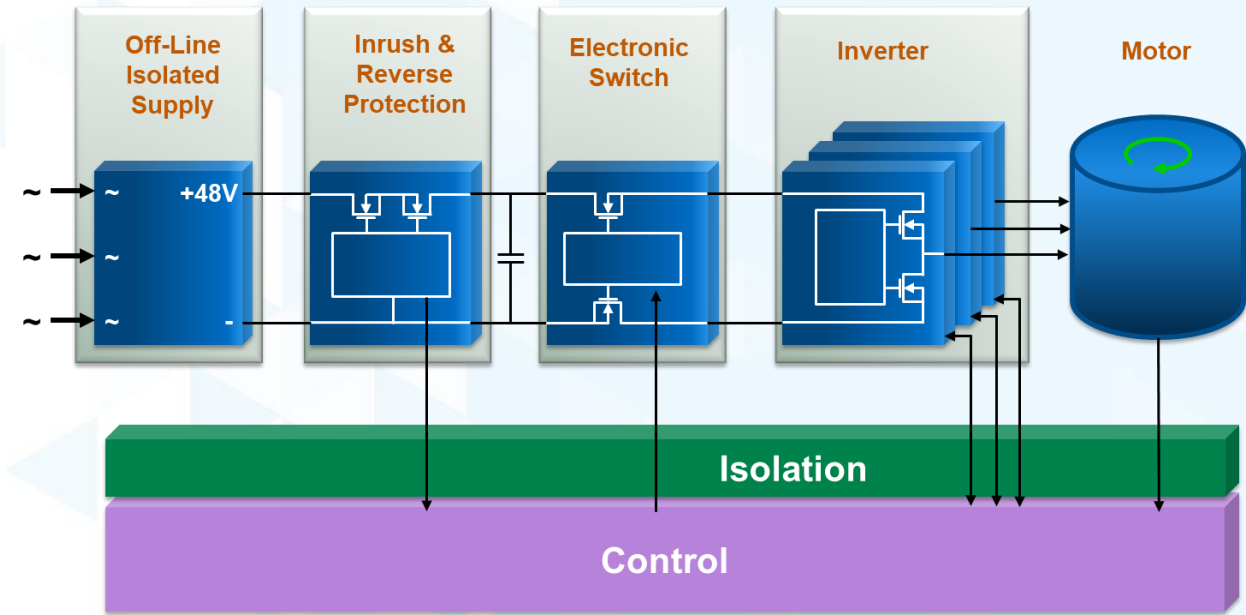
ADuM3165/ADuM3166/ADuM4165/ADuM4166



Power

Inrush Hot Swap

- ▶ Currently using wire wound cement resistors to inrush very large bulk capacitor
 - Relay or MOSFET switch closes after inrush
 - Input shorts can blow up Hot Swap relay or MOSFET
 - Solution size is too big and can get very hot during inrush
- ▶ ADI Solutions – Very small, very low heat and protects against input shorts
 - <100V
 - LTC4368 – Now
 - LTC4267 – Now



Q&A