



AHEAD OF WHAT'S POSSIBLE™

# Isolation Architectures in Motor Control Systems

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*Industrial Automation Team*

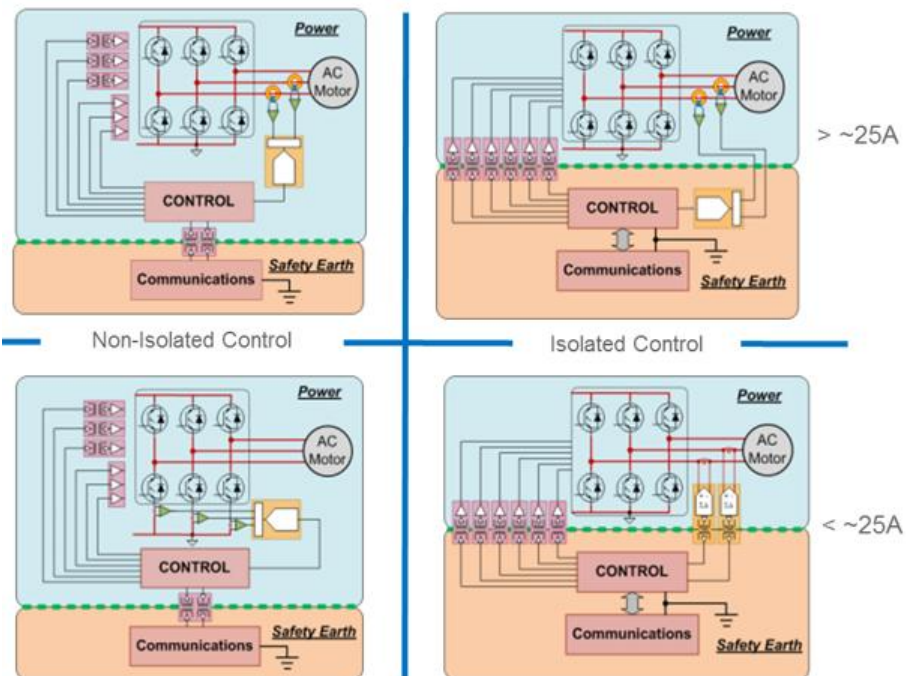
6/8/2015



# Isolation Architectures in Motor Control

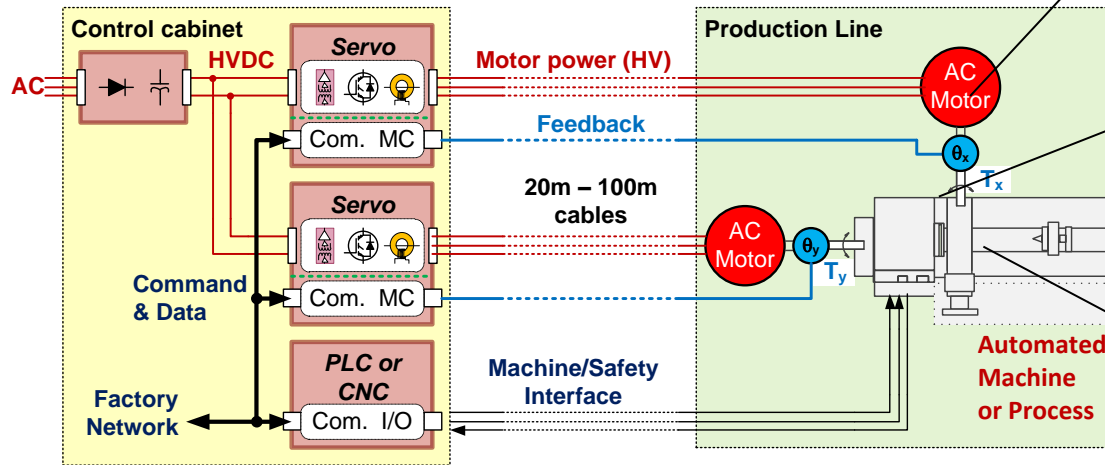
Topics and discussion areas

- ▶ System Partitioning
- ▶ External factors – influencing design
- ▶ System design considerations
- ▶ Analog Devices systems design offerings
- ▶ Design platforms
- ▶ Summary



# Trends in a Typical Digital Factory (Motor control focused)

Supporting Efficient, Productive and Connected systems



**Model based Design,  
multiple sensor nodes &  
Isolation**

**Higher Analog or  
Digital Precision  
"Single wire"**

**Motor to Motor  
Synchronized  
precision motion**



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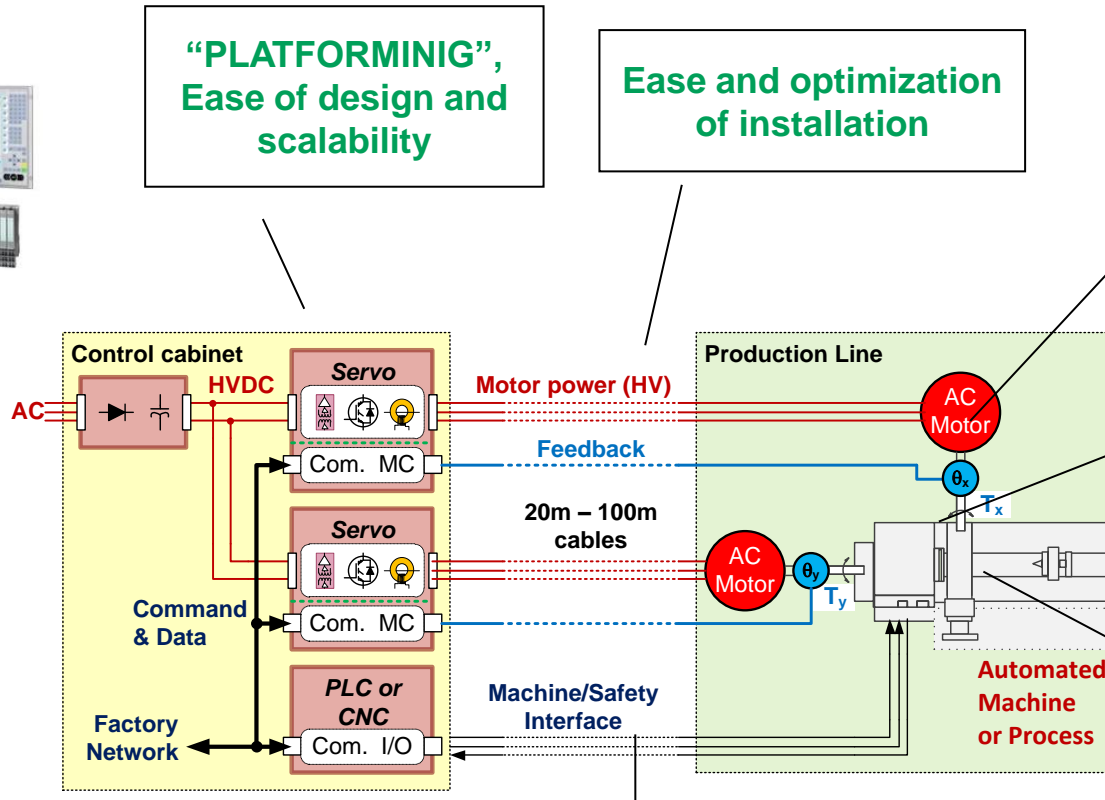
**“PLATFORMINIG”,  
Ease of design and  
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**Ease and optimization  
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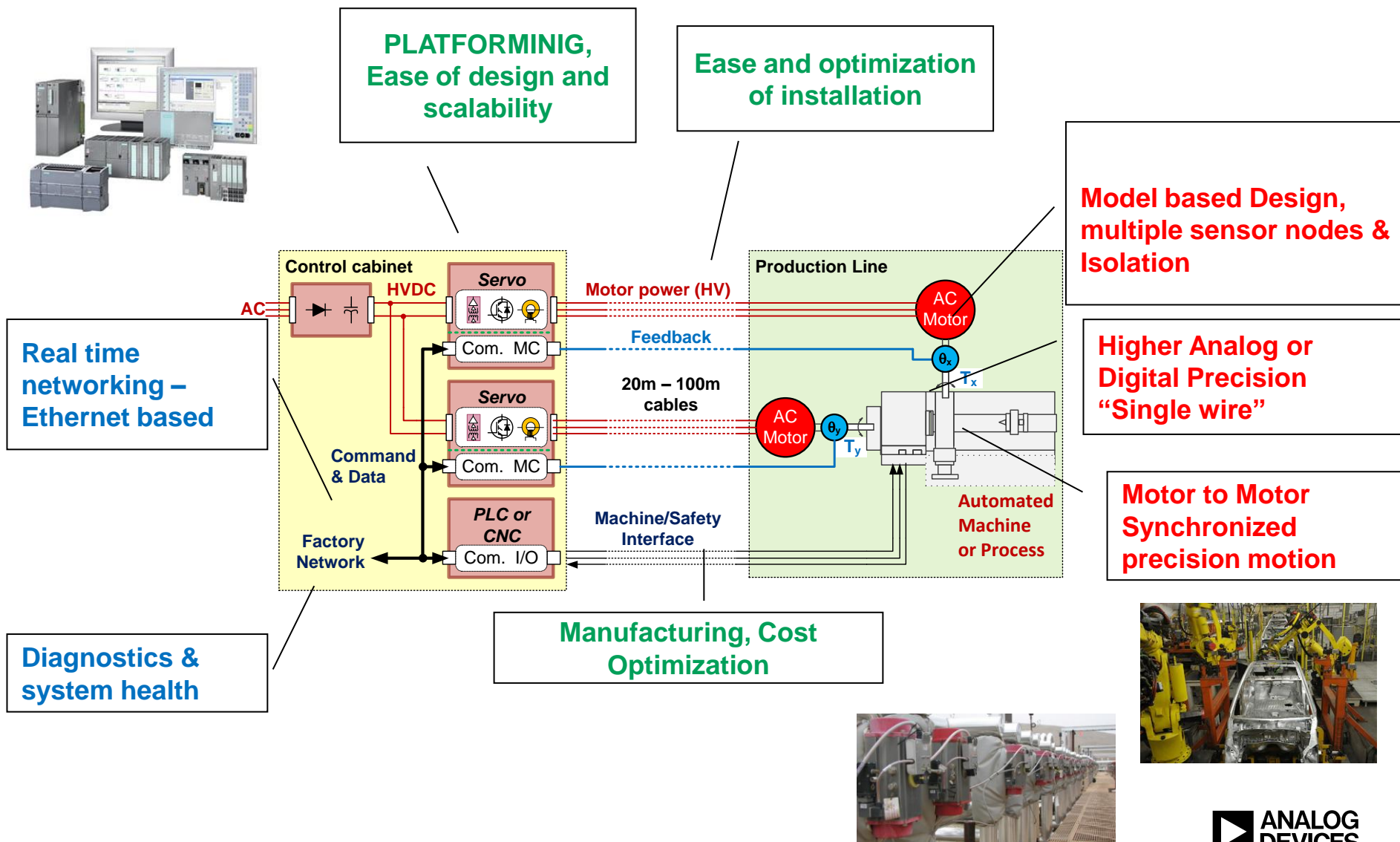


**Manufacturing, Cost  
Optimization**



# Trends in a Typical Digital Factory (Motor control focused)

Supporting Efficient, Productive and Connected systems



Real time networking – Ethernet based

Diagnostics & system health

PLATFORMING, Ease of design and scalability

Ease and optimization of installation

Model based Design, multiple sensor nodes & Isolation

Higher Analog or Digital Precision “Single wire”

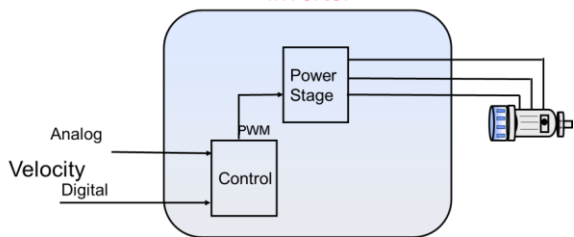
Motor to Motor Synchronized precision motion

Manufacturing, Cost Optimization

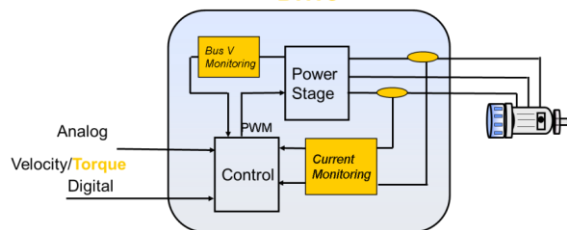
# Motor Control System Architectures

## Market Themes & End customer Requirements

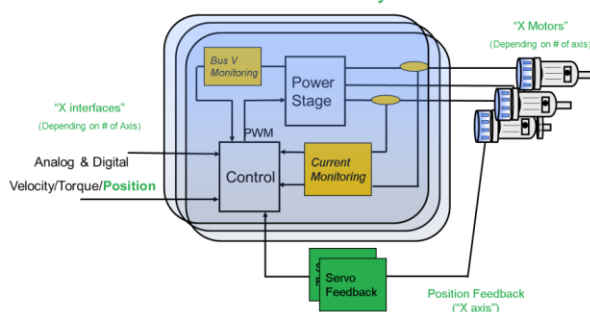
Inverter



Drive



Servo or "X" Axis Systems



### ▶ System Robustness



- ▶ Cost and Ease of installation
- ▶ Power scale of platforms
- ▶ Ease of Use

### ▶ Up-time of production



- ▶ Flexibility in installation / Wiring
- ▶ Highest efficiency of system
- ▶ Quality → enhancing productivity

### ▶ Shaft synchronization



- ▶ Miniaturization
- ▶ System optimization – installation
- ▶ Machine productivity

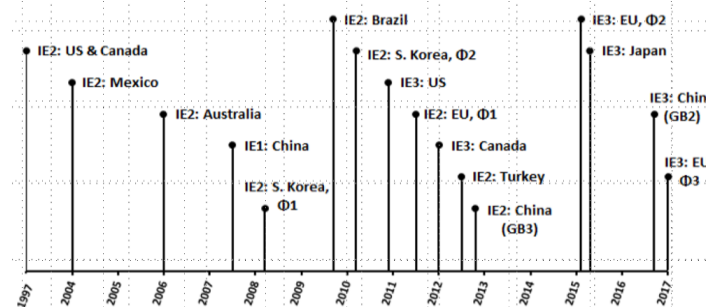
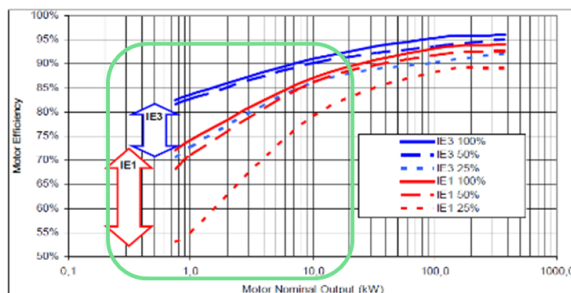
# Geographical Factors in the Motor Control Market

Efficiency legislation supporting lowest cost of production and smallest grid load.

- ▶ Motor Efficiency Classes (International Electrotechnical Commission (IEC) 60034-30)
  - 3-phase AC induction motor, 0.75–375kW, 2-4-6-poles, 50/60Hz, 200-700 Vin
  - 0.75–375kW motors consume 68% electric energy(3) of all motors from 1W to 100MW

	Motor Efficiency Classes	Comments
IE1	Standard efficiency	
IE2	High efficiency	For 50 Hz considerably higher than EFF2 of CEMEP and identical to the U.S. EPAAct for 60 Hz
IE3	Premium efficiency	New efficiency class in Europe for 50 Hz, higher than EFF1 on CEMEP and with some exceptions identical to NEMA Premium in the United States for 60 Hz.
IE4	Super Premium efficiency	Future improvements starting 2014

NEMA – National Electrical Manufacturers Association (US)  
CEMEP – Committee of European Manuf of Elect Machines & Pwr



Since June, 16, 2011, it is no longer permissible to market IE1 standard motors in the European economic arena. It is now a legal requirement that all standard motors that are marketed must comply, at a minimum, with the IE2 classification.

from January 1, 2015: The legally specified minimum efficiency IE3 will be mandatory for power ratings from 7.5 kW up to 375 kW – or as an alternative, an IE2 motor plus converter

Minimum effect on inorganic growth

from January 1, 2017: **The legally specified minimum efficiency IE3 will be mandatory for power ratings from 0.75 kW up to 375 kW – or as an alternative, an IE2 motor plus converter**

High effect on inorganic growth (market for motors high)

Power range >90% of EMEA Zone

Expecting 15-20% growth on these systems

IE4 – Super premium .... Strong expectation and driving PM and hybrid motor system types



# Architectural influencing the Motor Control Market

## isolation standardization strengthening ADIs system play



### 61800-5-1

- ▶ Companies works to “Adjustable speed electrical power drive systems” standard IEC61800-5-1 ( his supports all Motor control systems)
  - This standard establishes creepage and clearance based on IEC insulation coordination
  - This standards does not address component construction
  - No way to determine if a component meets Reinforced requirements
- ▶ Customers are and has requested that ADI obtain a certification under an IEC Product/Component standard to remove ambiguity

#### 1 Scope

The scope of this part of IEC 61800 does not include devices used as component parts of a *PDS* if they comply with the safety requirements of a relevant product standard for the same environment. For example, motors used in *PDS* shall comply with the relevant parts of IEC 60034.

##### 4.3.6.8 Solid insulation

###### 4.3.6.8.1 General

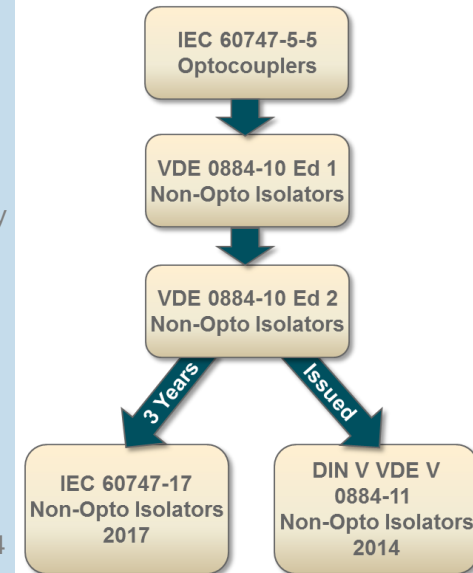
Materials selected for solid insulation shall be able to withstand the stresses occurring. These include mechanical, electrical, thermal and climatic stresses which are to be expected in normal use. Insulation materials shall also be resistant to ageing during the *expected lifetime* of the *PDS*.

Components that comply with a relevant product standard which provides equivalent requirements to those of this standard do not require separate evaluation. Assemblies containing such components shall be tested according to the requirements of this standard.



### VDE0884-11 → IEC 60747-5-17

- ▶ VDE developed a non-Opto version of the IEC60747-5 Optocoupler Safety standard
- ▶ VDE 0884-10 Ed 1
  - Approved 2006
  - Added Characterization
  - Reinforced Insulation Only
  - Unacceptable to IEC
  - Will be withdrawn in September 2017
- ▶ VDE 0884-10 Ed2
  - Approved July 2014
  - Changes based on IEC feedback
- ▶ DIN V VDE V 0884-11
  - Issued in September 2014
  - Applies to Germany only
  - Can be used as IEC equivalent
- ▶ IEC 60747-17 draft submitted
  - July 2014
  - 3 Year Approval Cycle



# Productivity and system extension (Trends/examples)

efficiency in the equipment processing node (more axis at the same time with high precision)

The new 5-axis production center from Chiron optimizes the production of compressor wheels. A Sinumerik 840D sl improves the fast and precise production by approximately ten percent.



With its new, highly dynamic milling machine, Chiron produces a complete compressor wheel in two minutes



By using the scalable products from Rockwell Automation, JANDA Company, Inc. was able to:

- Reduce design time by 25%
- Reduce commissioning time by 25%
- Improve installation time by 30%
- Improve tolerances from one-eighth inch to one-ten thousandth inch
- Reduced size of control panels by 50%
- Reduce maintenance time

■ Gleason-Pfauter GmbH, Germany

## A New Paradigm

■ Kraft Maschinenbau GmbH, Germany

### 5-Axis Milling in a Class of Its Own

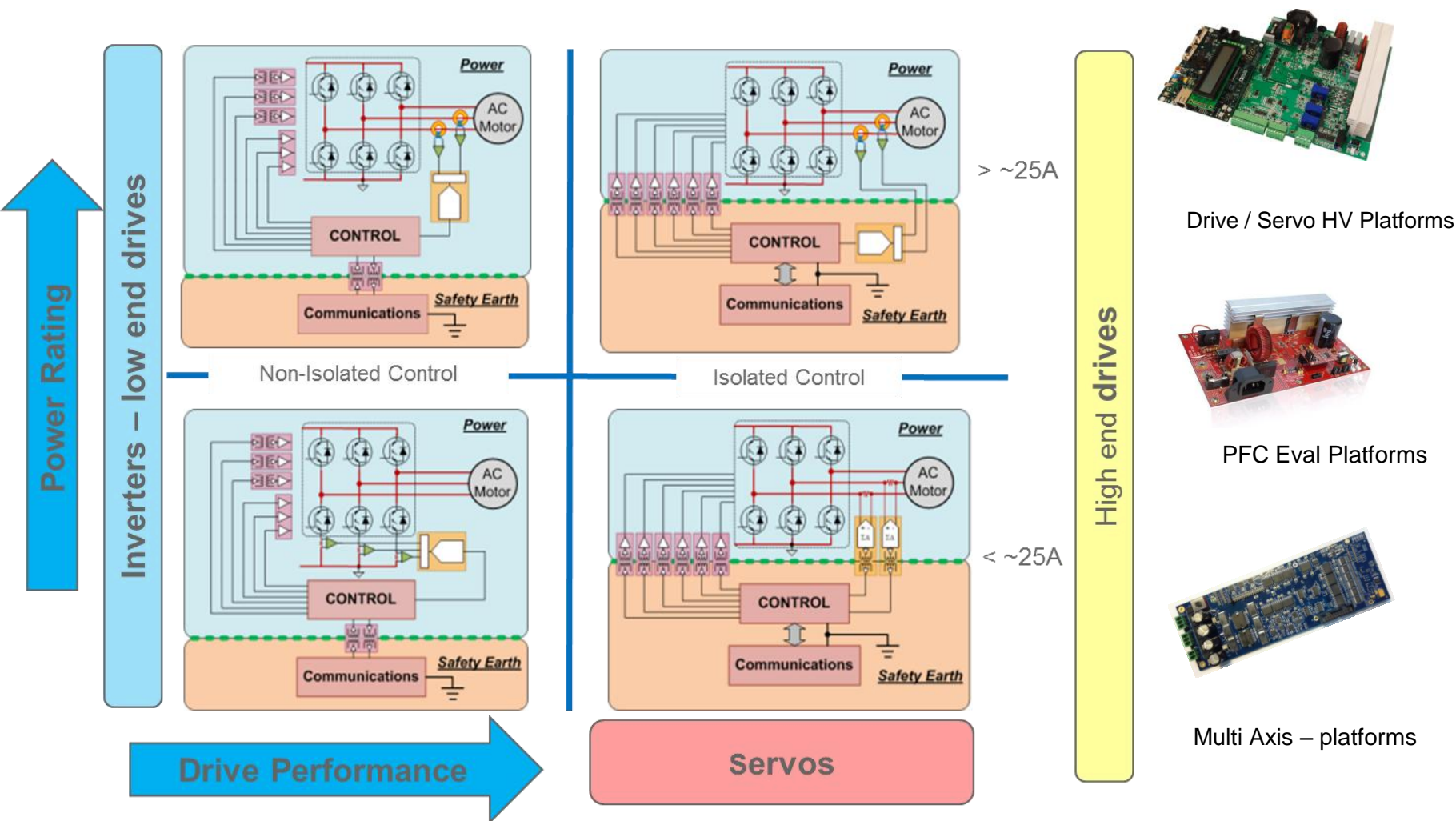
Sinumerik 840D ensures maximum productivity thanks to modern CNC features in a new 5-axis machining center for wood, plastic, and aluminum.



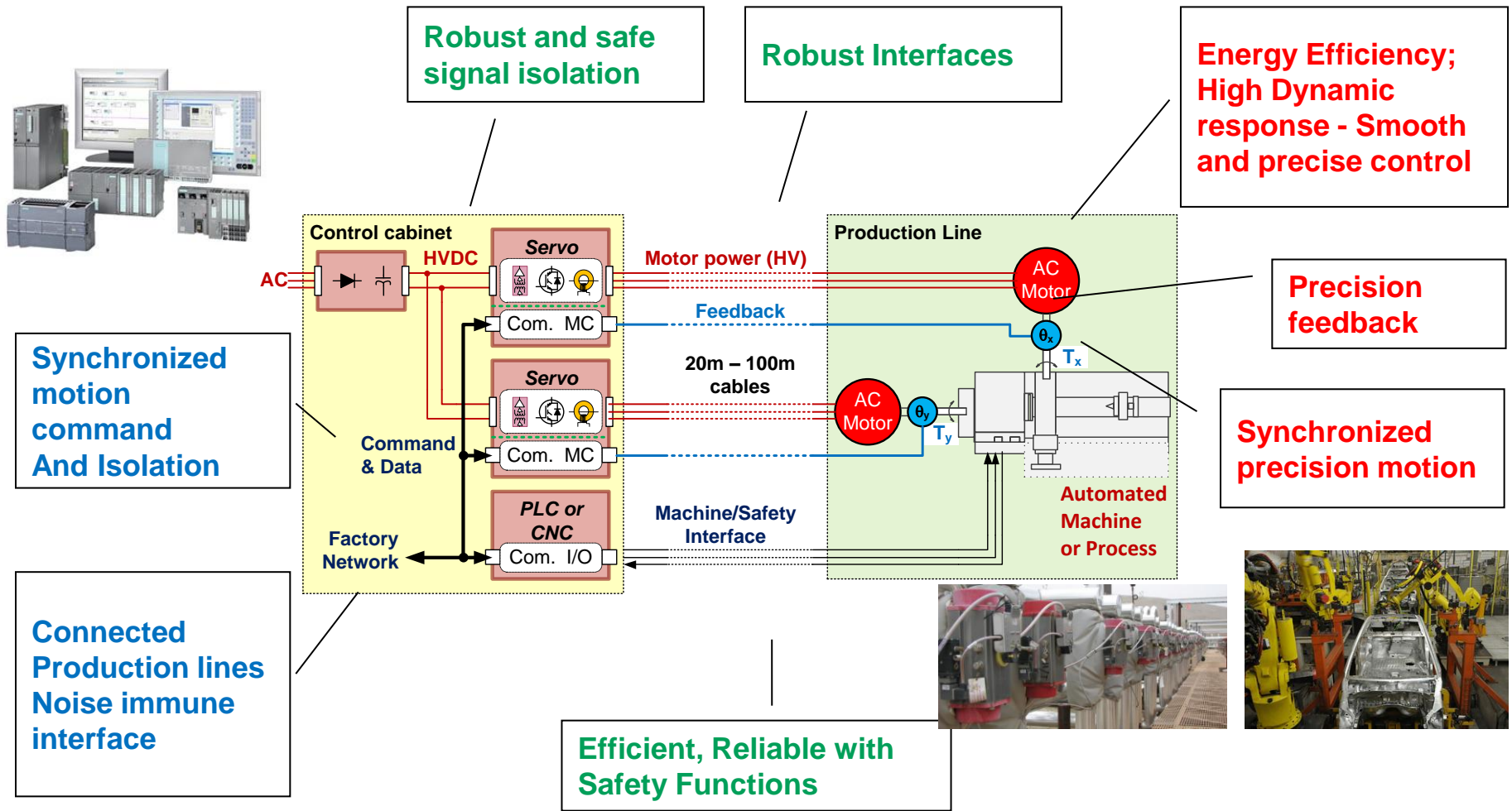
With its new Titan machine series, Gleason-Pfauter enters a new era in toothed gear grinding: An automatic tool changer, together with efficient CNC and the corresponding drives, enables large better-quality gear teeth to be used, thus ensuring a better surface finish with faster grinding of toothed gears.

# Defining the System Architecture to Cover end Applications

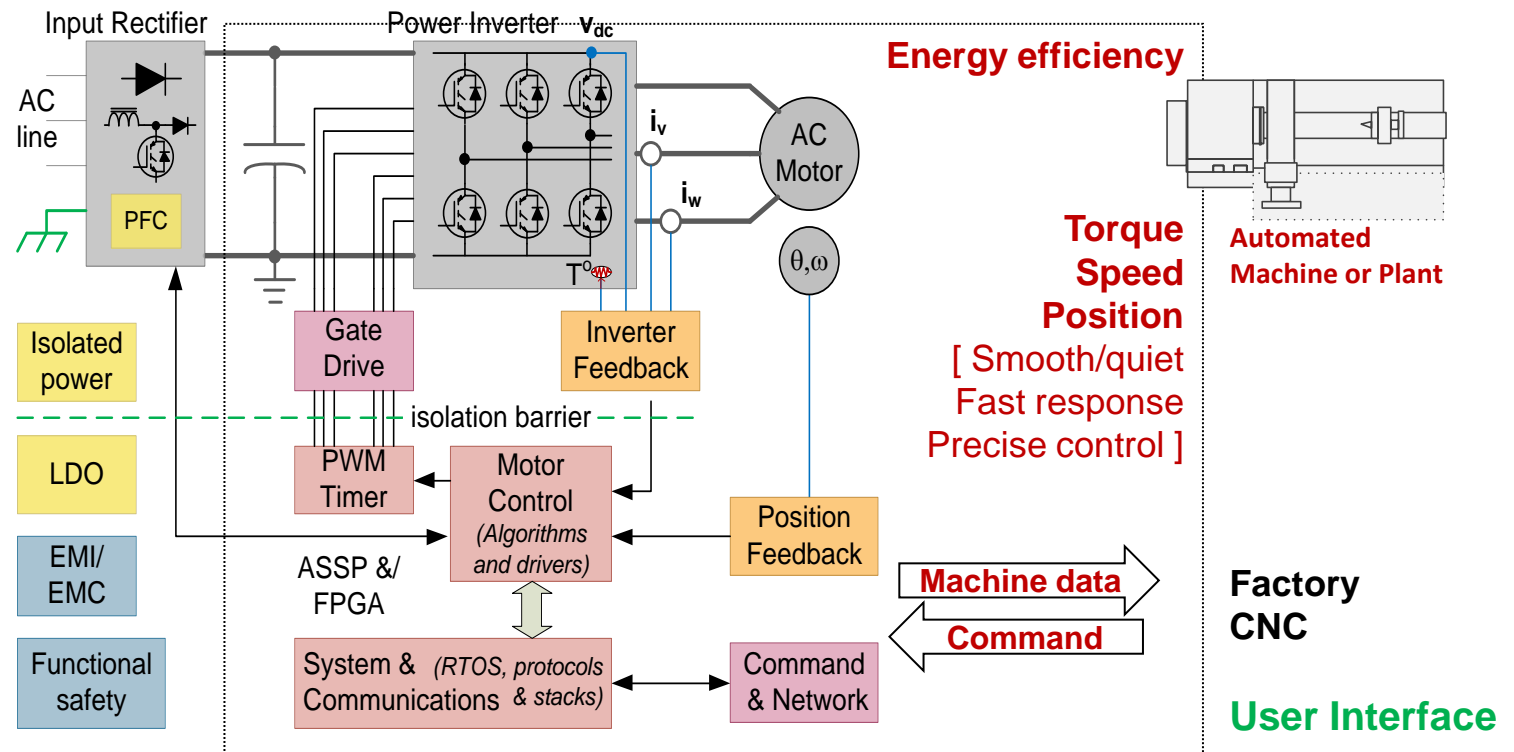
Architectures depends on power and performance levels



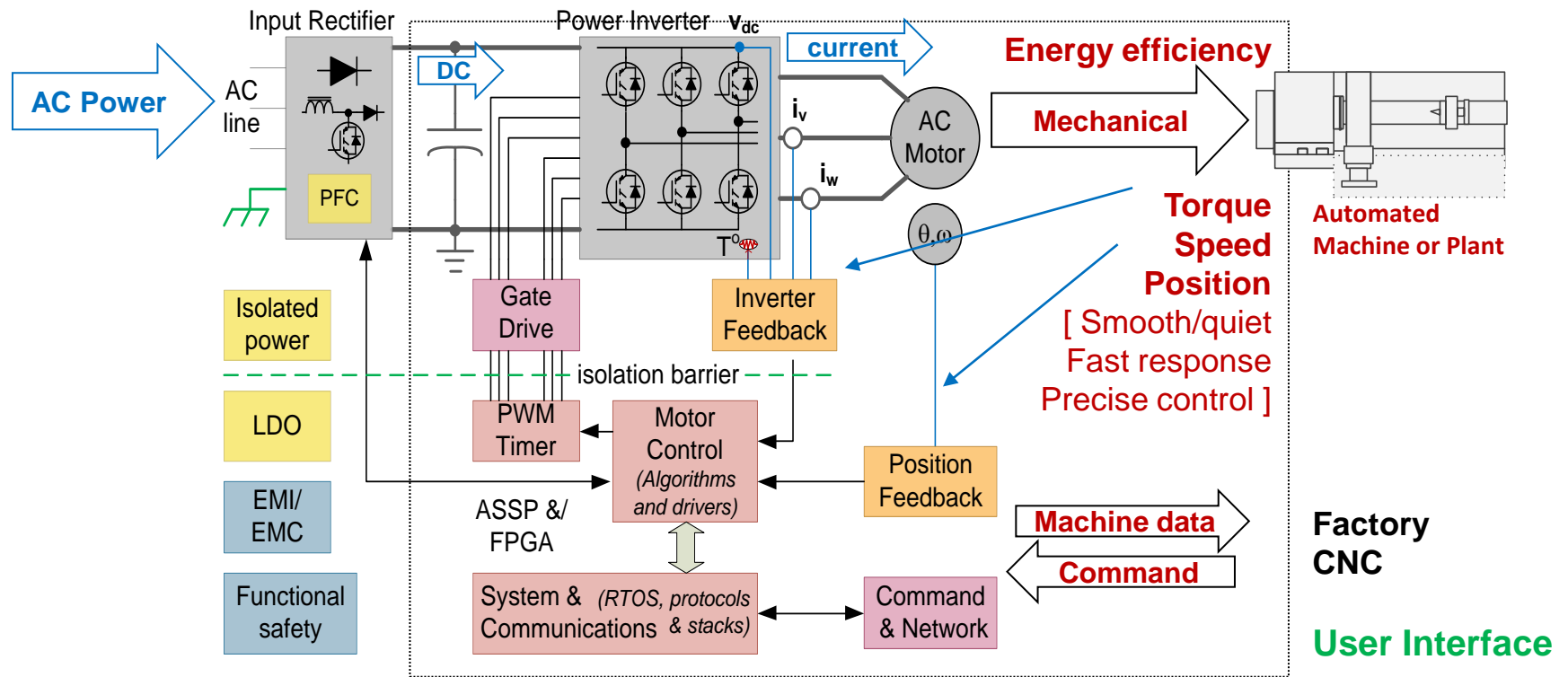
# Quality, Reliability and Productivity drivers in the Digital Factory



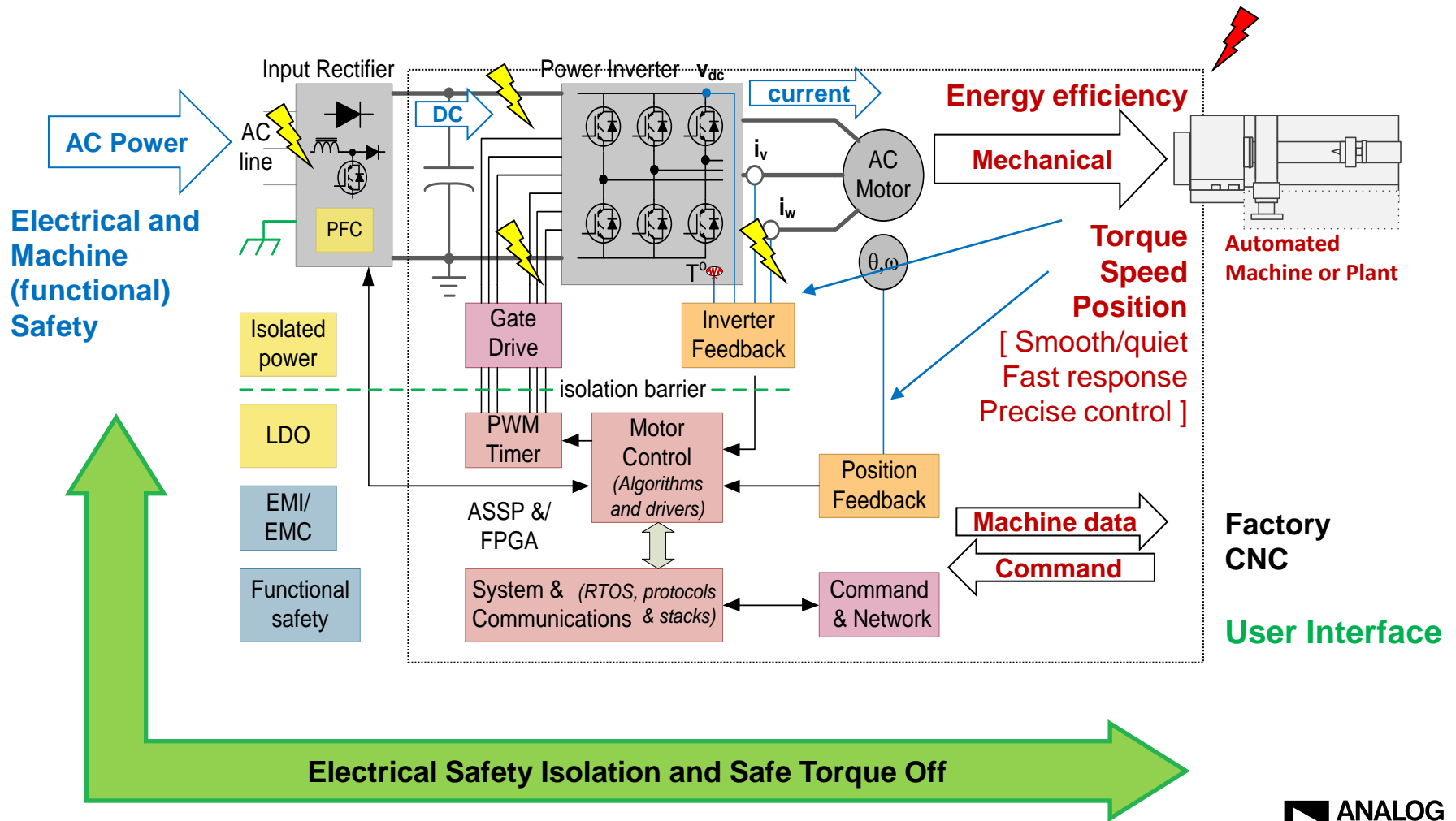
# Motor Drive Function: Control of Electrical power => Mechanical motion



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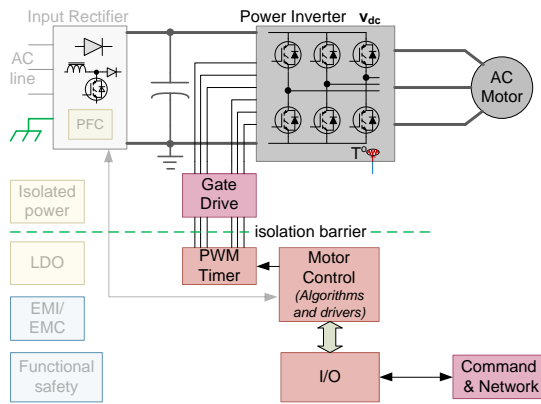


# Motor Drive Function: Control of Electrical power => Mechanical motion



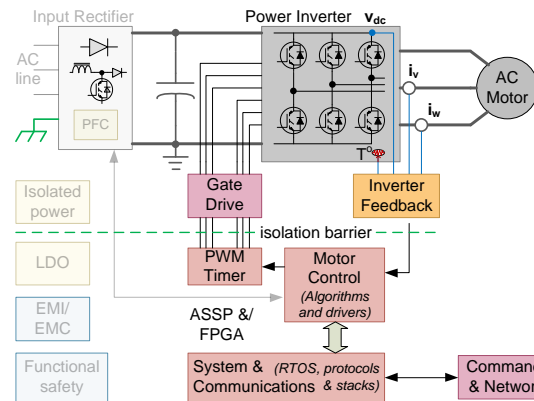
# Industrial Drive Control Architectures

## Open Loop - No Feedback



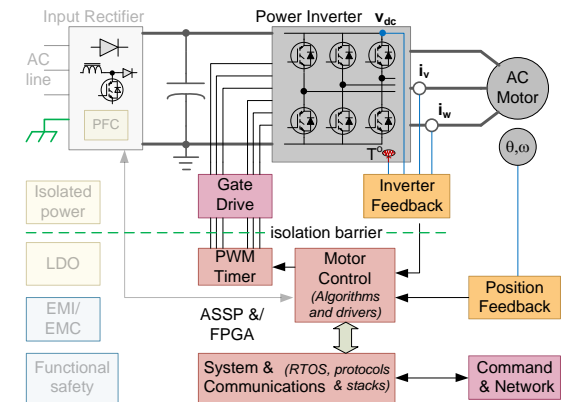
Typical Cranes or hoists with manual controls

## Closed Loop - some Feedback [current, voltage]

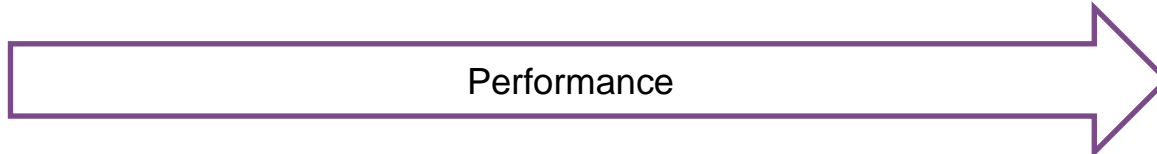


Typical Energy Efficient drives for process automation

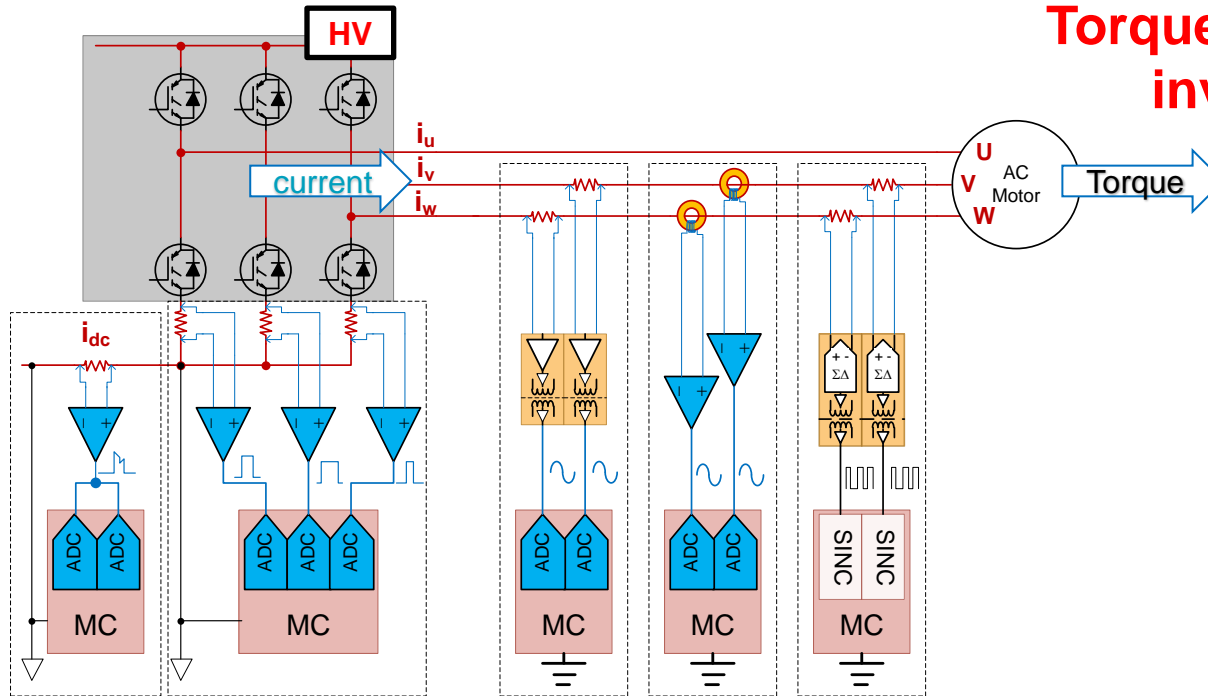
## Closed Loop - Full Feedback [Current, Velocity and Position]



Typical Automated Machine Control or CNCs



# Current Feedback Architectures and circuits

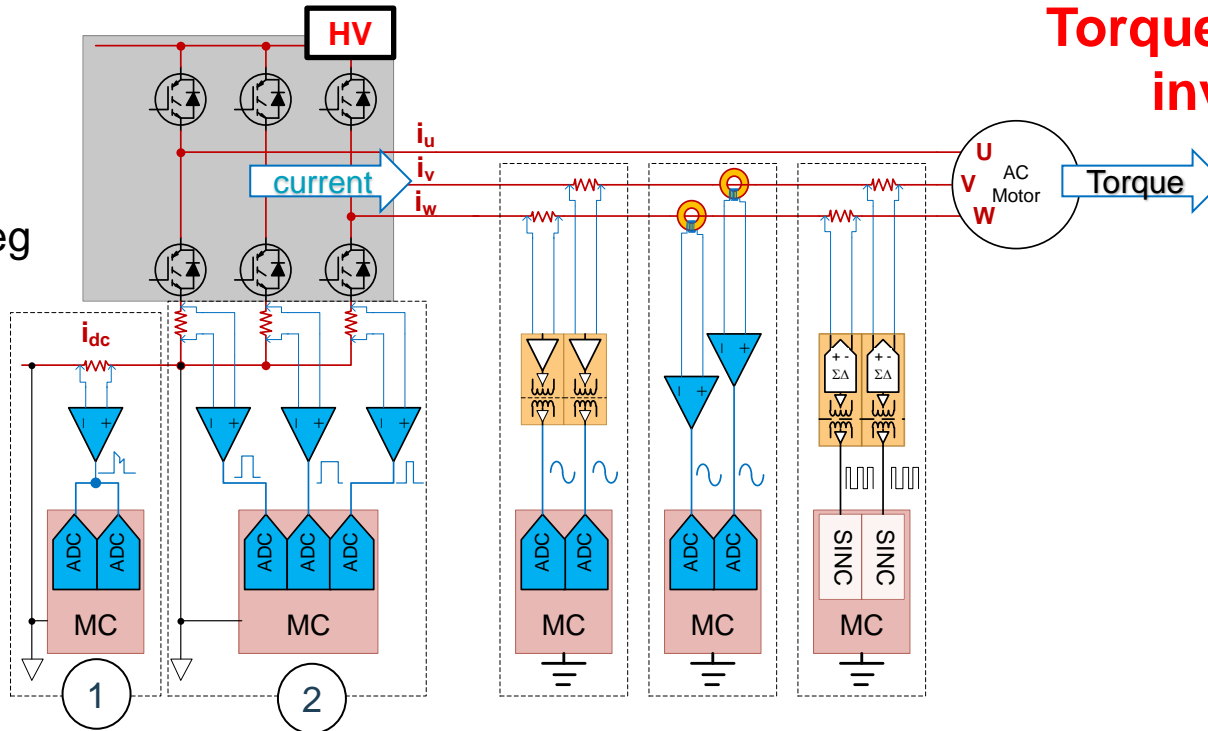


**Current feedback for  
Torque control and  
inverter switch  
protection**

# Current Feedback Architectures and circuits

## Non isolated current feedback:

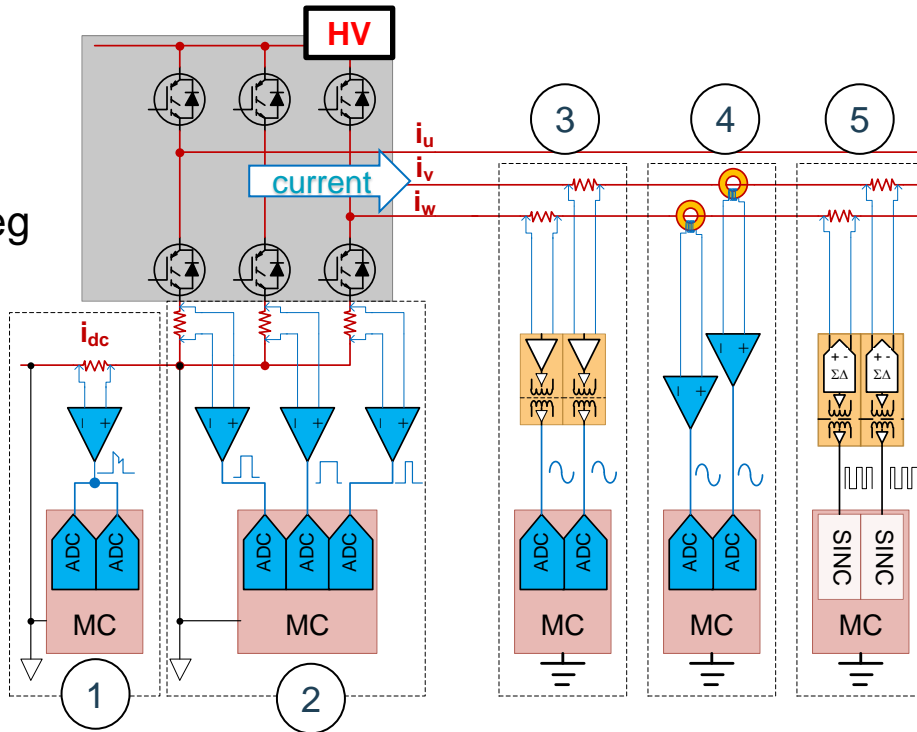
1. dc link shunt
2. inverter leg shunts



**Current feedback for Torque control and inverter switch protection**

# Current Feedback Architectures and circuits

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1. dc link shunt
  2. inverter leg shunts



**Current feedback for Torque control and inverter switch protection**

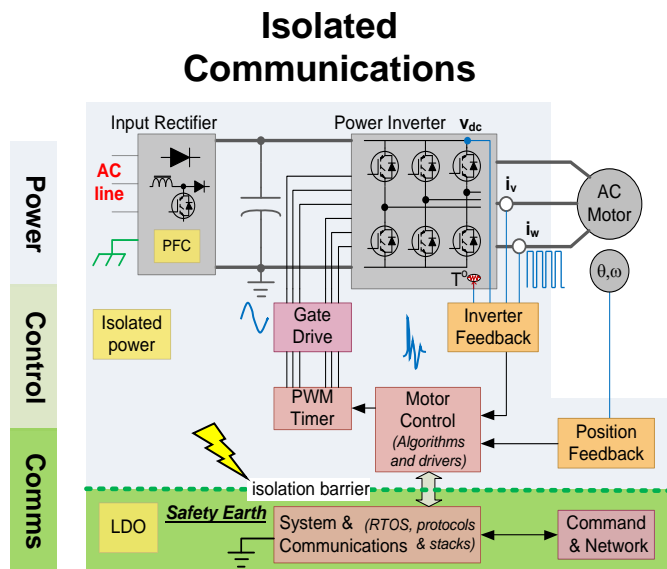
- Isolated current feedback:**
3. Current shunt with isolation amplifier
  4. Isolating magnetic current sensor
  5. Current shunt with isolating sigma delta modulator



Quality of signals and overall dynamics equal parameters driving **Torque** quality

# Isolation Architectures

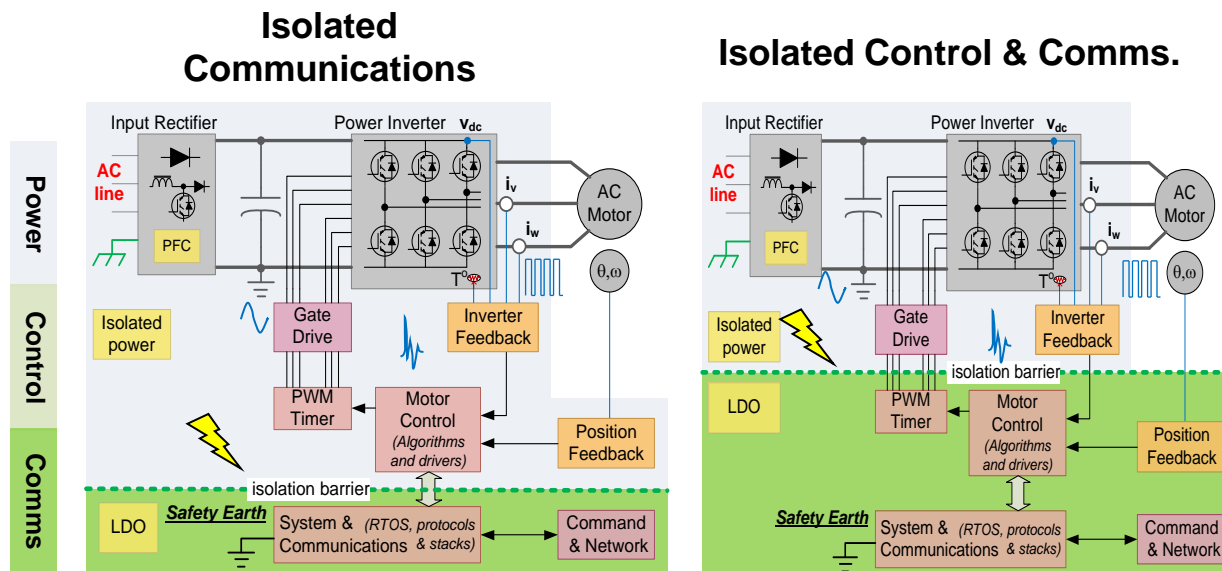
## Dependencies in Power, Control and Communications



- Simplifies inverter circuit interfaces
- Must isolate communications interfaces
- Preferred when using slow communications interfaces

# Isolation Architectures

## Dependencies in Power, Control and Communications



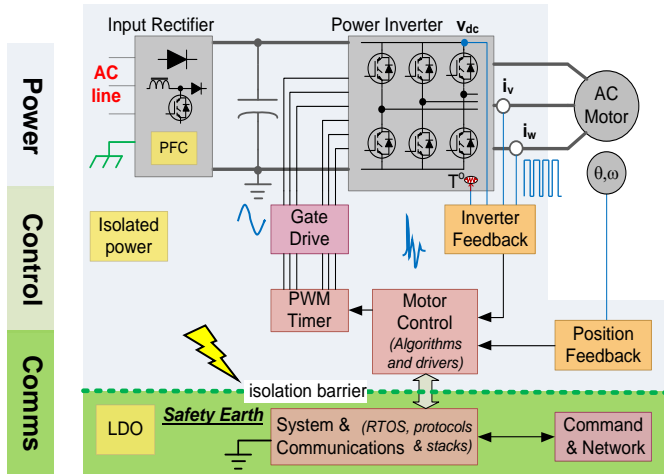
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- Must isolate inverter circuit signals
- Isolates power circuit noise from control
- Preferred when using fast communications interfaces

# Isolation Architectures

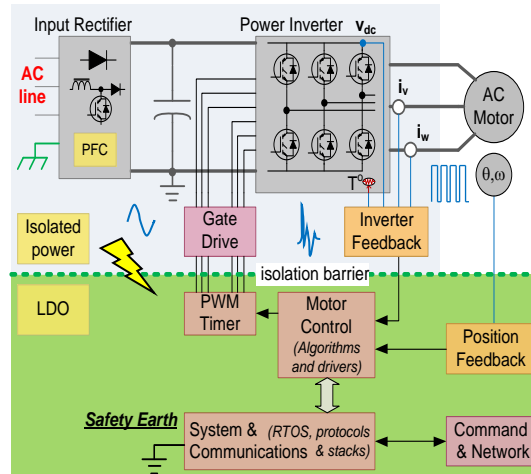
## Dependencies in Power, Control and Communications

### Isolated Communications



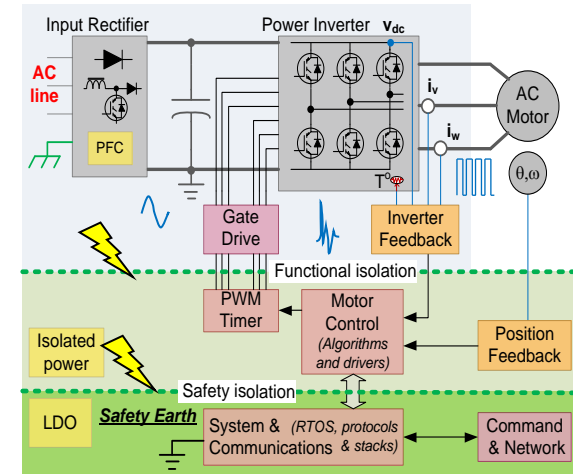
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### Isolated Control & Comms.



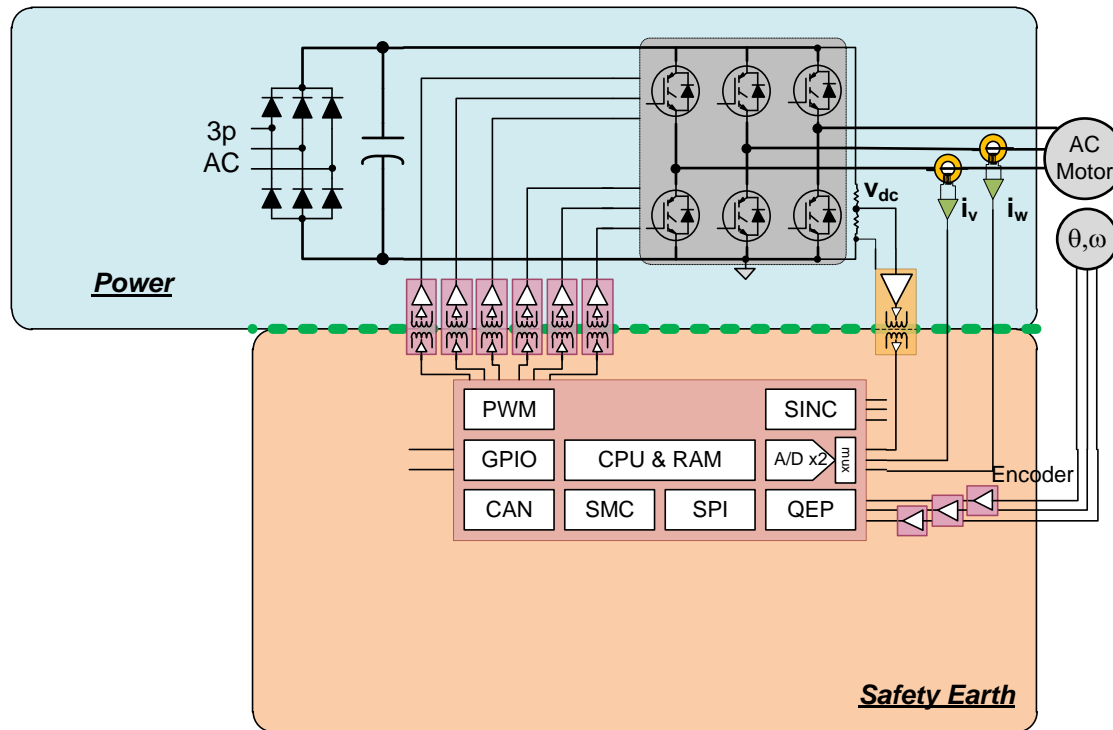
- Must isolate inverter circuit signals
- Isolates power circuit noise from control
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### Multiple Isolation domains



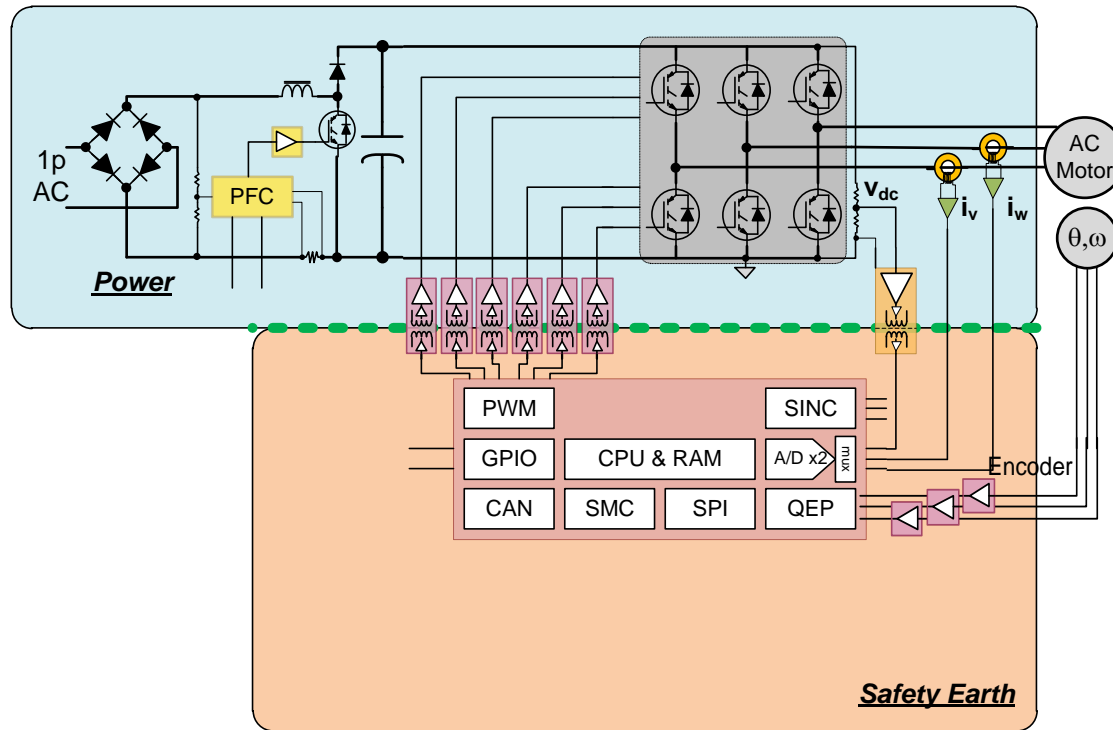
- Functionally isolate inverter signals [less difficult than safety isolation]
- Safety isolate communication interfaces
- Used in high performance systems to isolate power circuit noise from control

# System Solution options supported by Analog Devices

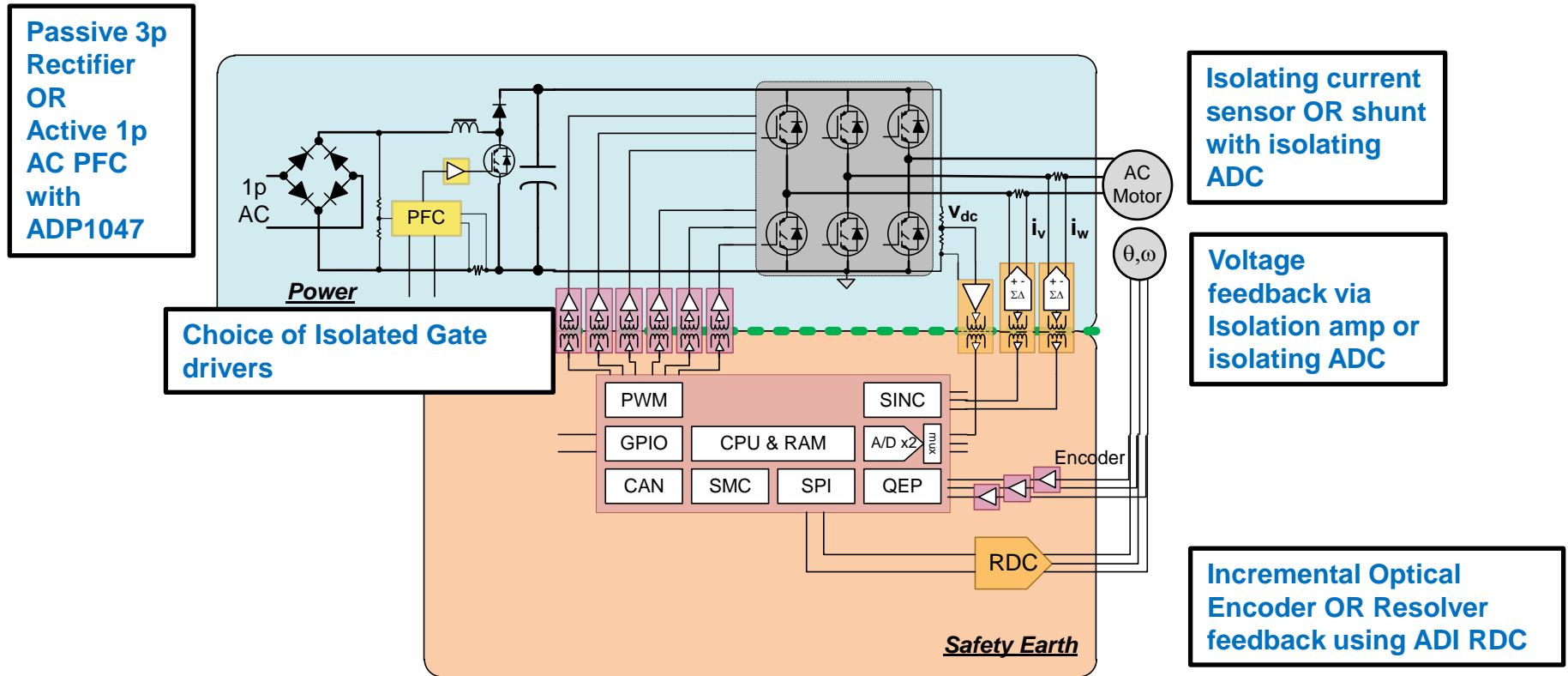


# System Solution options supported by Analog Devices

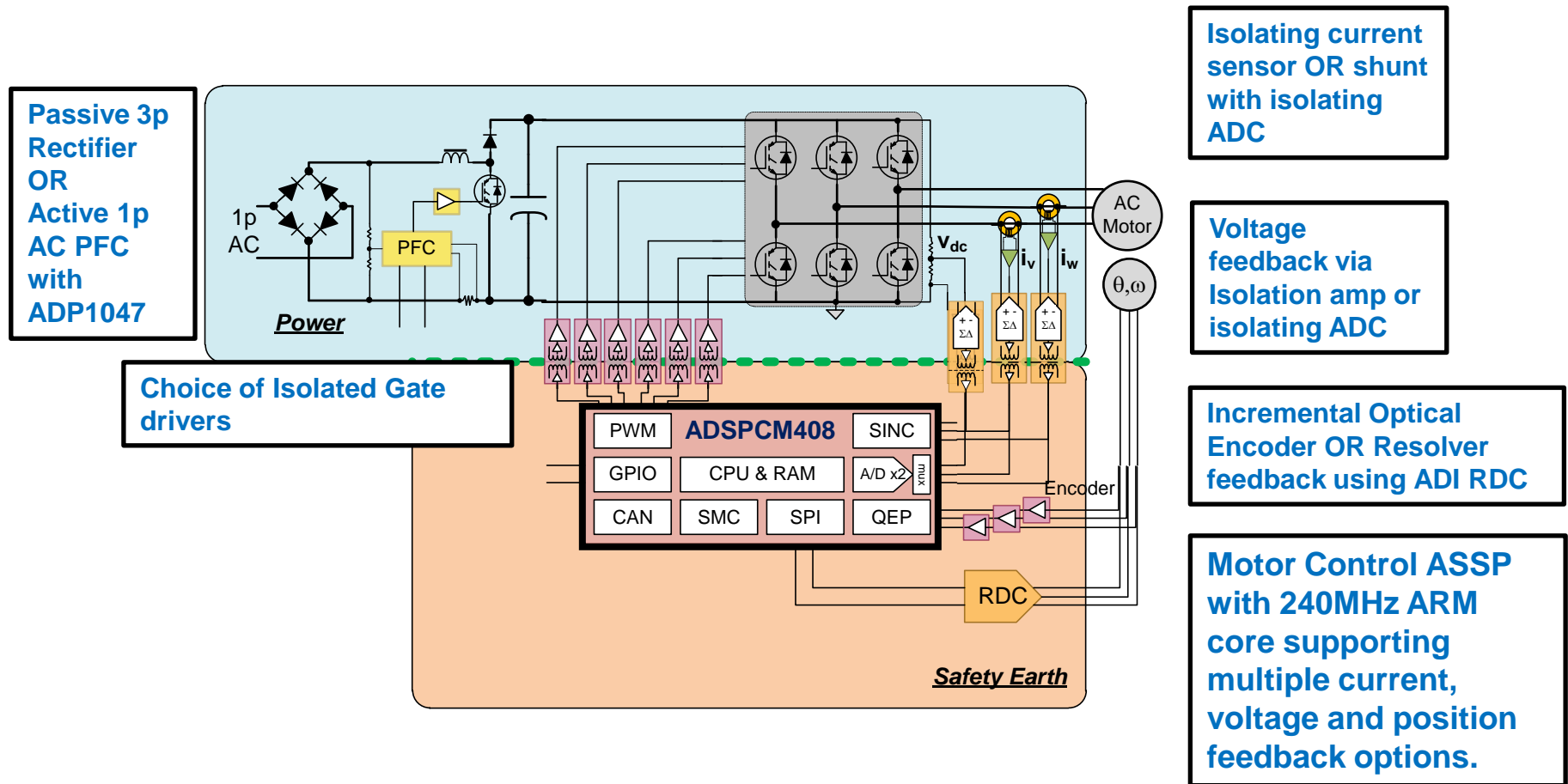
Passive 3p  
Rectifier  
OR  
Active 1p  
AC PFC  
with  
ADP1047



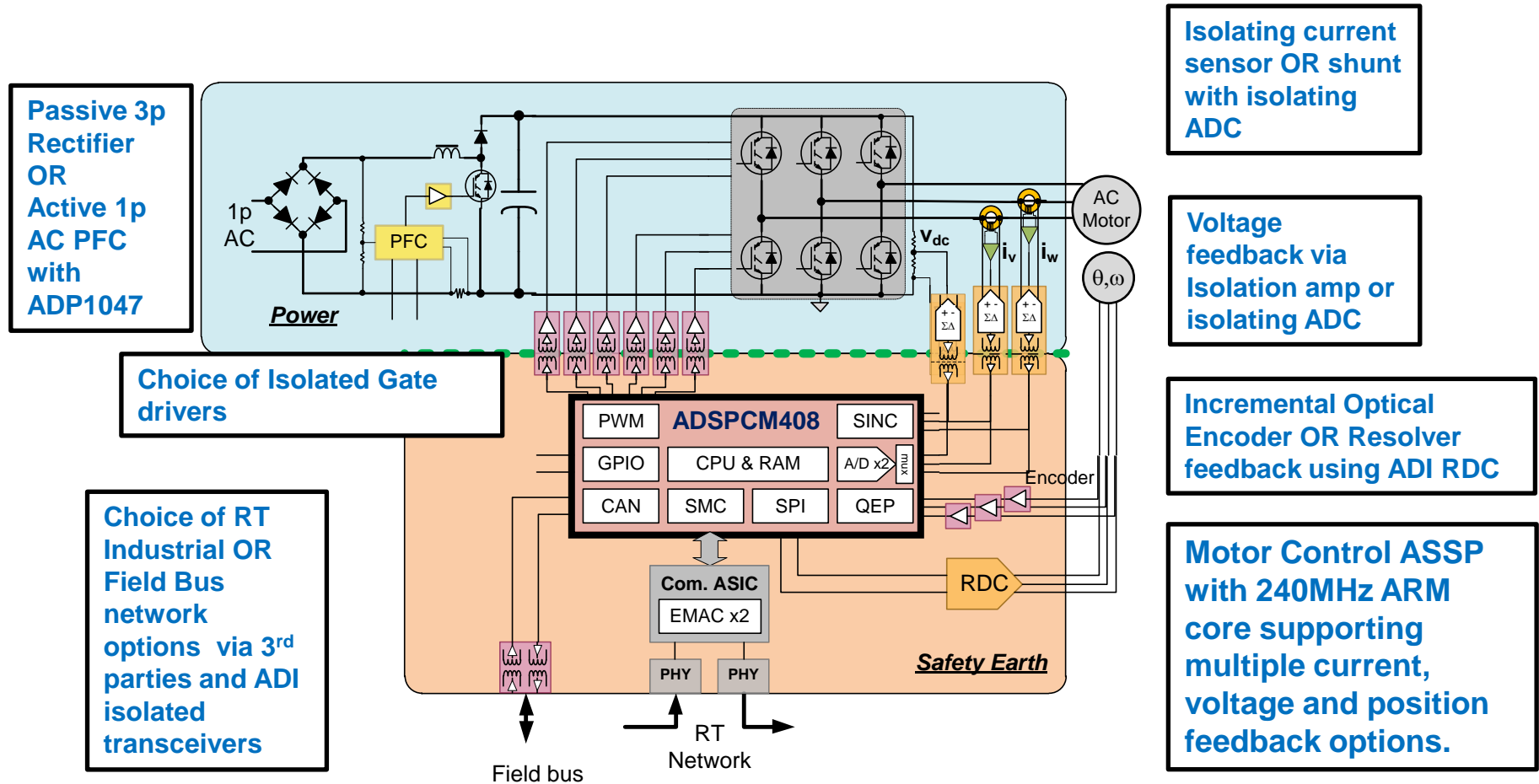
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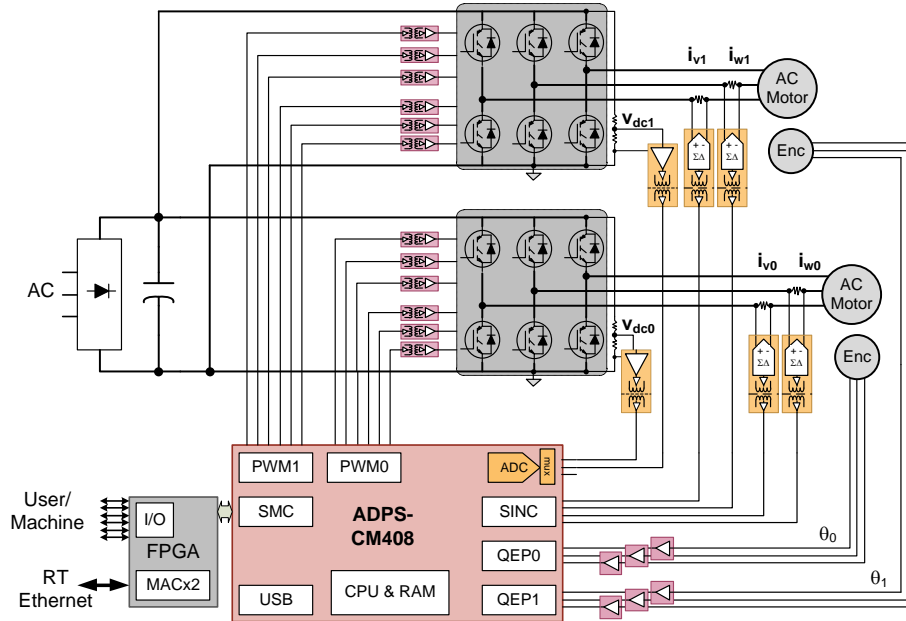


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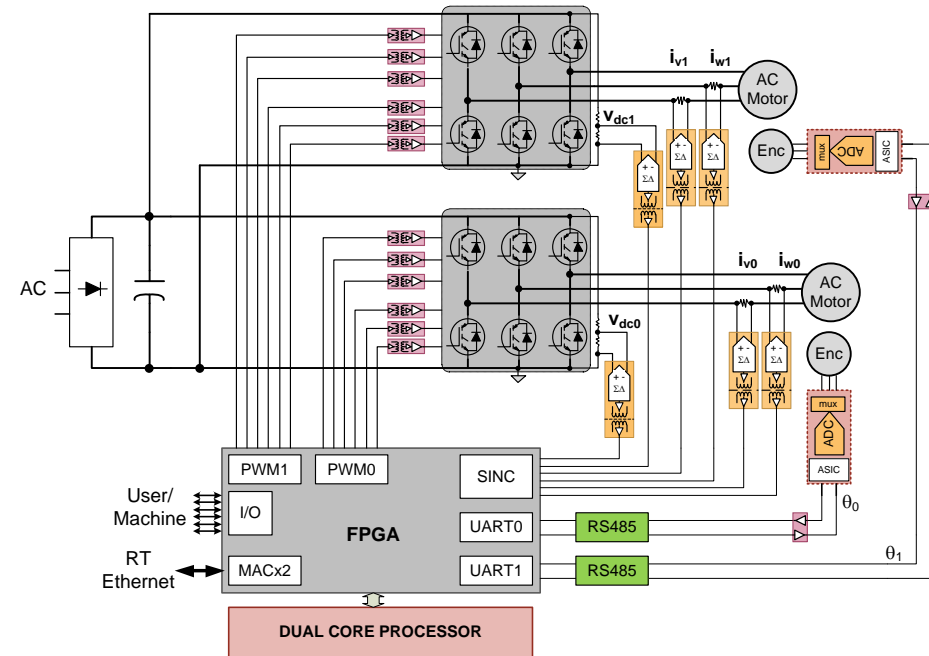


# ADI Processors .vs. FPGA for dual axis servo control

Example of different implementations



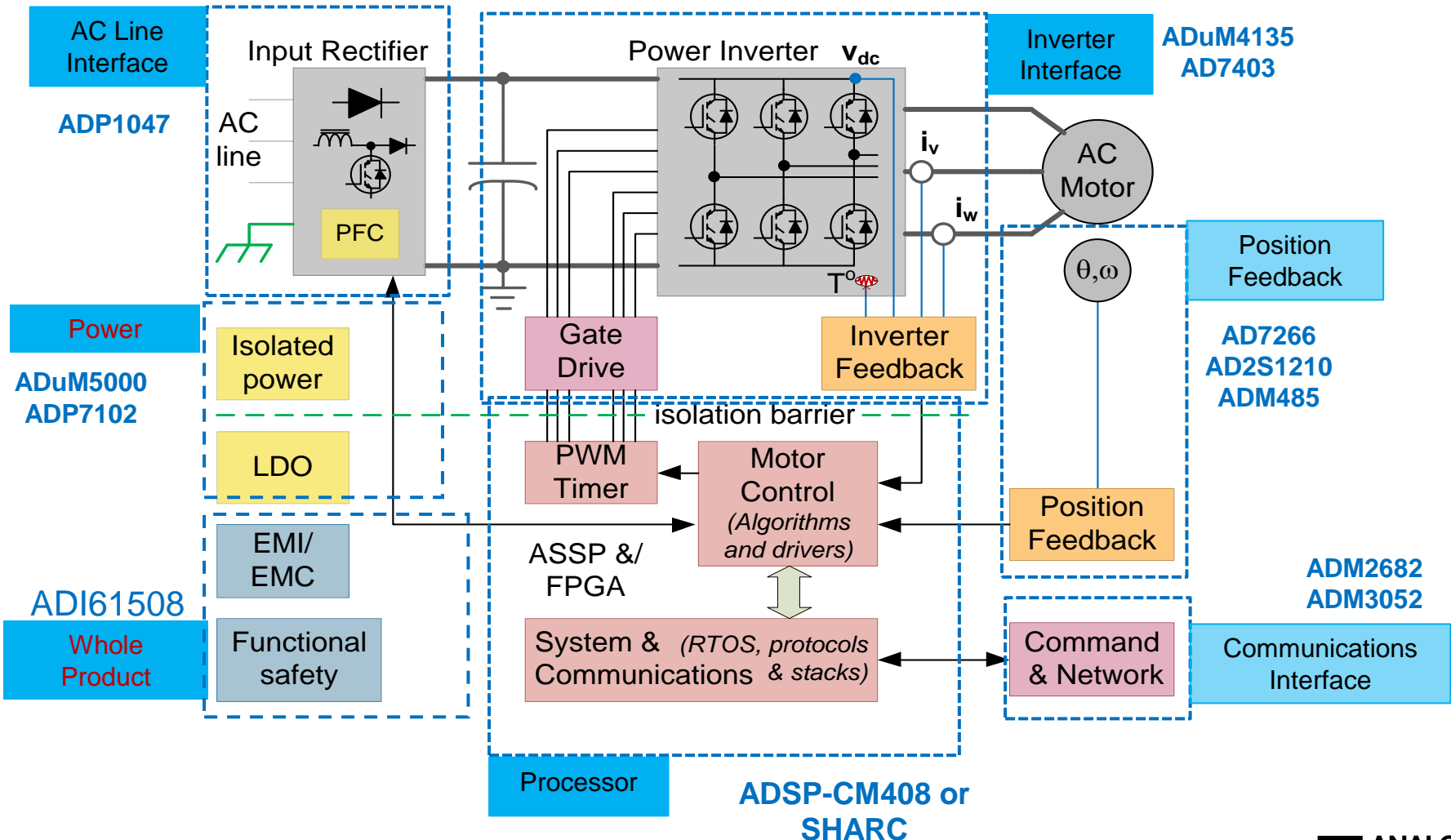
< 30% CM408  
resources for 2 x MC



Existing FPGA –  
Processor solution

# ADI Motor Drive Signal Chain Components Examples

## Complete system offering and categorization



# Moto Control System Platforms #1

## Simple evaluation

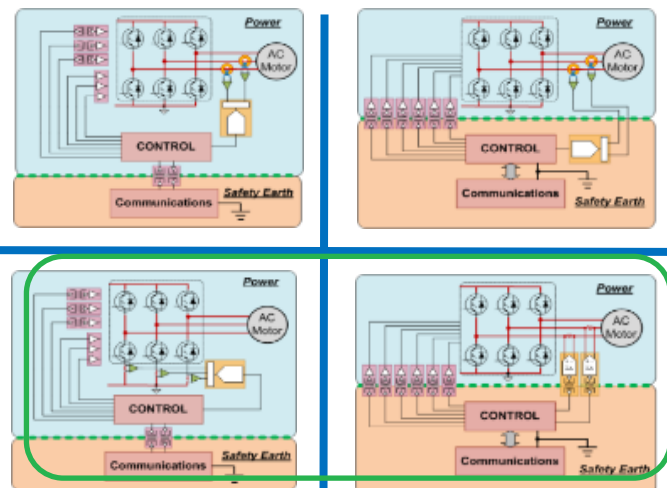
### ► Low Voltage Drive Platform

- More portable and safe
- Current feedback – phase shunt +  $\Sigma-\Delta$  → Embedded ADC
- DC bus current sensing
- Phase voltage sensing (e.g. for sensorless)
- Code development and evaluation
- Some LV signal chain components
- Available on SAP for **broad market order** (power board, motor, cables, PSU)
- Power board only version also available

### Ordering Information

Directly order from website

- EV-MCS-LVDRV-Z
- EV-MCS-LVBRD-Z



# Motor Control System Platforms #2

## Testing power and isolations functions

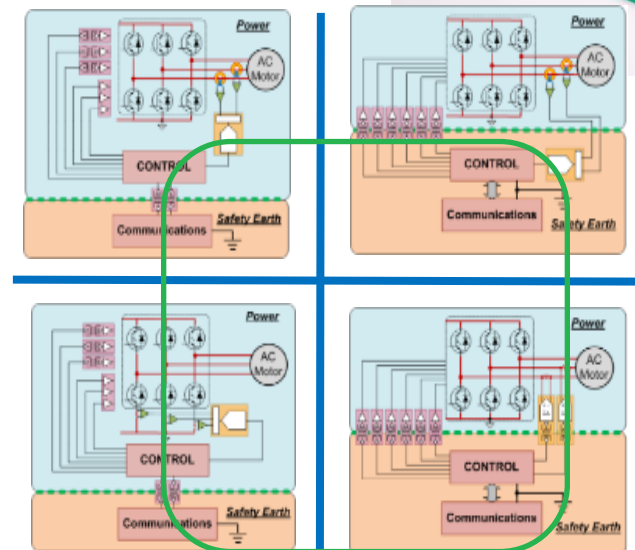
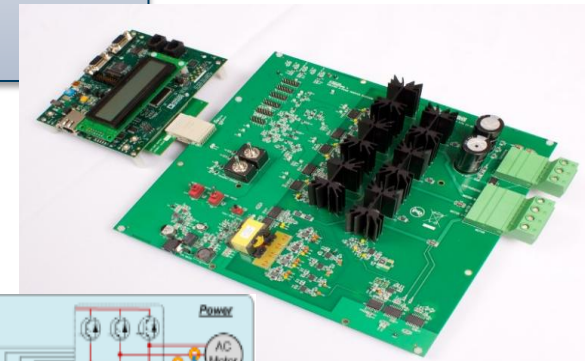
### ► Isolated Inverter Platform

- Flexible subsystem platform with greater connectivity and evaluation capability
- Isolated current and voltage measurement
- Open loop motor control starter project
- Isolated IGBT gate drivers – ADuM4223 (-ISOINV) and ADuM4135 (-ISOINVEP)
- Digital-only interface to ADSP-CM408
- Gate driver power supplies reference design
- HV platform without the risks/downside/human safety expectations of a 'plug-into-the-wall' platform
- Can also connect to AC input or use ADP1047 eval board
- Available for **broad market order** (power board, motor, cables, PSU)

### Ordering Information

Directly order from website

- EV-MCS-ISOINV-Z
- *EV-MCS-ISOINVEP-Z*



# Motor Control System Platforms #3

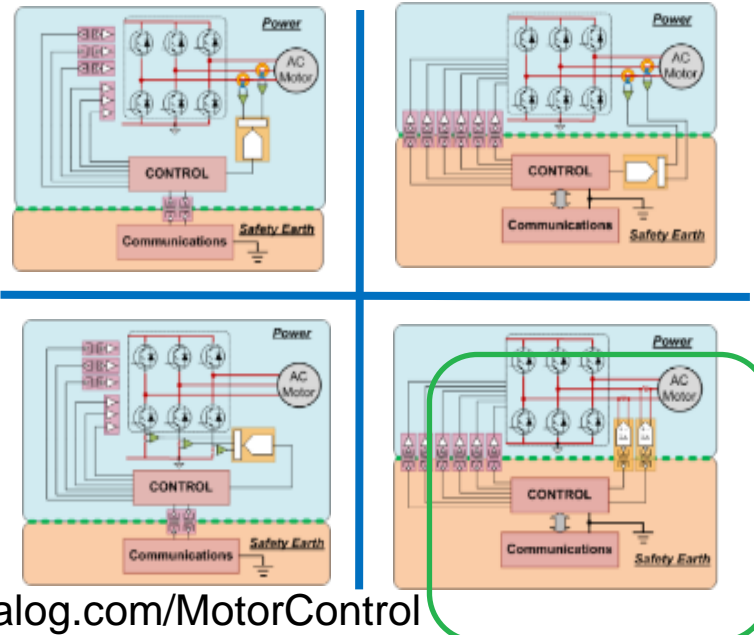
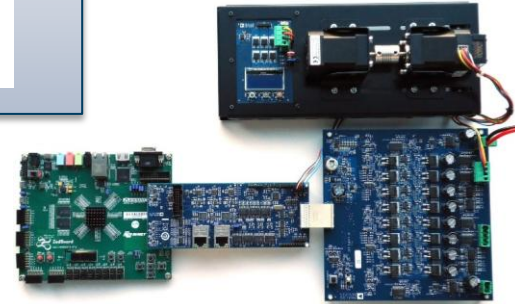
## High performance servos – multi axis

### ► Dual Axis FPGA-Based Platform

- Compatible with all Xilinx FPGA platforms with FMC LPC or HPC connectors
- FMC signals voltage adaptation interface for seamless operation on all FMC voltage levels
- 2 x Gbit Ethernet PHYs for high speed industrial communication
- Current and Voltage measurement using isolated ADCs
- BEMF zero cross detection for sensorless control of PMSM or BLDC motors
- Dynamometer for controllable load with external control using Analog Discovery and MathWorks Instrumentation Control Toolbox

### Ordering Information

Directly order from website



# “Platforming” and Systems solutions

Making it easy for engineers to design with ADI – System offering “a strong benefit”

## ▶ ADI WEBSITE

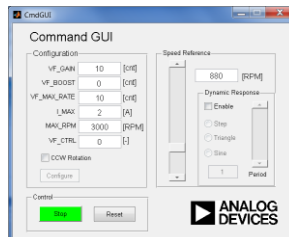
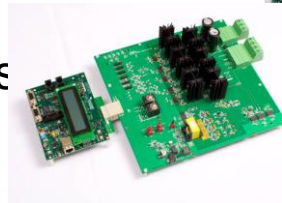
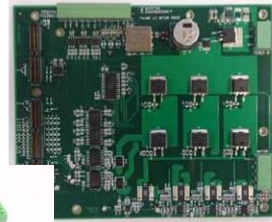
- [analog.com/motorcontrol](http://analog.com/motorcontrol)

## ▶ Engineering Zone

- Dedicated system forum – Software and hardware offering and systems

## ▶ 3rd Parties

- Regional 3rd parties in place supporting systems and solutions



## Motor Control Hardware Platforms

This is a discussion, FAQ and information forum related to the different motor control system platforms provided by Analog Devices. This specifically hardware-related forum covers the following platforms:

- FlexMC High Voltage Platform
- FlexMC Low Voltage Platform
- FCMCoton Low Voltage Drive

**MOTOR CONTROL SYSTEM DESIGN**

Design Motor Control Systems that are safer, more productive, and more efficient for energy efficiency.

Safer. More Productive. Energy Efficient.

Today's industrial motor control systems are required to meet the increasing energy efficiency and stringent safety demands while still addressing the ever-increasing productivity. Designing such systems can be further complicated by the differential control architectures in the factory operation environment.

We do enter the bar to meet the safety and productivity demands by providing the most advanced motor control architectures. Follow the steps of our process in the steps to our comprehensive technology, system development, safety and efficiency design that can help simplify your design process.

Category	Key Applications	Implementing Technologies	Key Features and Benefits	Operational Metrics
<ul style="list-style-type: none"> <li>• DC Motor Drives</li> <li>• AC Motor Drives</li> <li>• Servo Drives</li> <li>• Linear Motion</li> <li>• Fan/Blower</li> <li>• Compressor</li> <li>• Pump</li> <li>• Valve Actuator</li> </ul>	<ul style="list-style-type: none"> <li>• Industrial</li> <li>• Automotive</li> <li>• Marine</li> <li>• Aeronautics</li> <li>• Defense</li> <li>• Medical</li> <li>• Consumer</li> <li>• Industrial</li> </ul>	<ul style="list-style-type: none"> <li>• High Power Density</li> <li>• High Efficiency</li> <li>• High Reliability</li> <li>• High Safety</li> <li>• High Performance</li> <li>• High Precision</li> <li>• High Accuracy</li> <li>• High Speed</li> <li>• High Torque</li> <li>• High Power</li> <li>• High Voltage</li> <li>• High Current</li> <li>• High Frequency</li> <li>• High Temperature</li> <li>• High Humidity</li> <li>• High Vibration</li> <li>• High Shock</li> <li>• High Impact</li> <li>• High Radiation</li> <li>• High EMI/RFI</li> <li>• High EMC</li> <li>• High Immunity</li> <li>• High Security</li> <li>• High Integrity</li> <li>• High Availability</li> <li>• High Reliability</li> <li>• High Safety</li> <li>• High Performance</li> <li>• High Precision</li> <li>• High Accuracy</li> <li>• High Speed</li> <li>• High Torque</li> <li>• High Power</li> <li>• High Voltage</li> <li>• High Current</li> <li>• High Frequency</li> <li>• High Temperature</li> <li>• High Humidity</li> <li>• High Vibration</li> <li>• High Shock</li> <li>• High Impact</li> <li>• High Radiation</li> <li>• High EMI/RFI</li> <li>• High EMC</li> <li>• High Immunity</li> <li>• High Security</li> <li>• High Integrity</li> <li>• High Availability</li> </ul>	<ul style="list-style-type: none"> <li>• High Power Density</li> <li>• High Efficiency</li> <li>• High Reliability</li> <li>• High Safety</li> <li>• High Performance</li> <li>• High Precision</li> <li>• High Accuracy</li> <li>• High Speed</li> <li>• High Torque</li> <li>• High Power</li> <li>• High Voltage</li> <li>• High Current</li> <li>• High Frequency</li> <li>• High Temperature</li> <li>• High Humidity</li> <li>• High Vibration</li> <li>• High Shock</li> <li>• High Impact</li> <li>• High Radiation</li> <li>• High EMI/RFI</li> <li>• High EMC</li> <li>• High Immunity</li> <li>• High Security</li> <li>• High Integrity</li> <li>• High Availability</li> </ul>	



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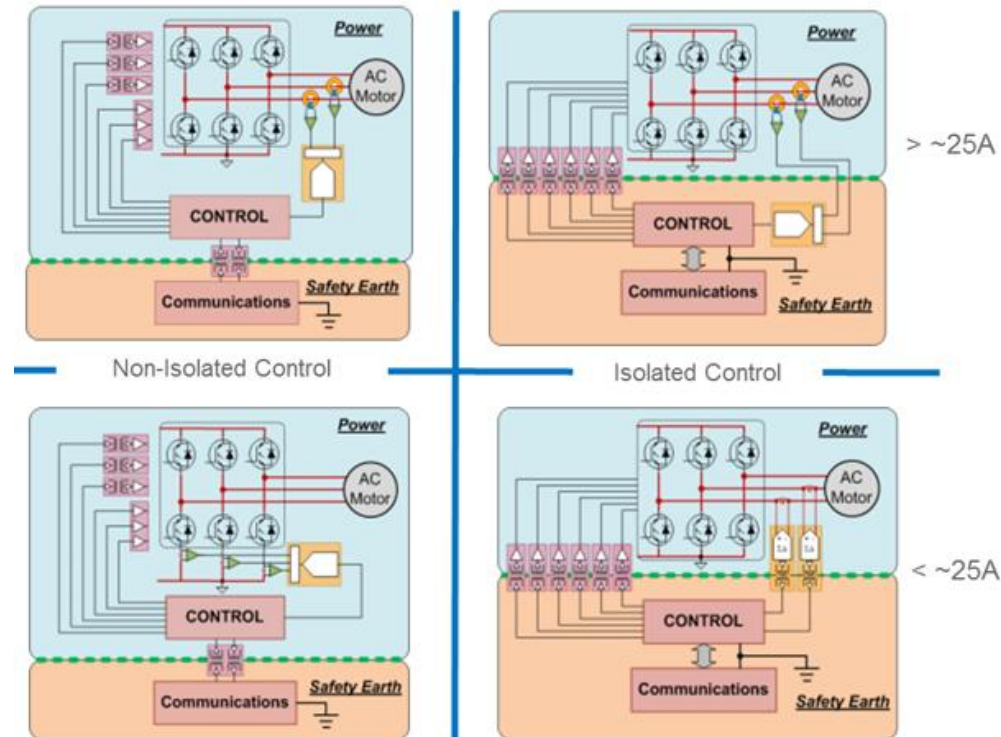
## Platform Overview: Isolated Inverter Platform

created by DOSulliz on Apr 13, 2015 6:28 AM, last modified by DOSulliz on May 5, 2015 6:



# Summary

- ▶ Depending on system performance – Isolation is one of the most critical design parameters.
- ▶ Analog Devices offer a wide range of system solutions to ensure best in class system partitioning. Performance and power ranges.
- ▶ Support, design guidance and ecosystem partners will enable end design quicker.



# Thank You For Watching!

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