Testing EV Motor Control Units
How Simulation is Vital to Your Success

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What does an MCU do in BEV?

Tasks and Features

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What does an MCU do in BEV?

(E)Motion

Efficiency

Safety

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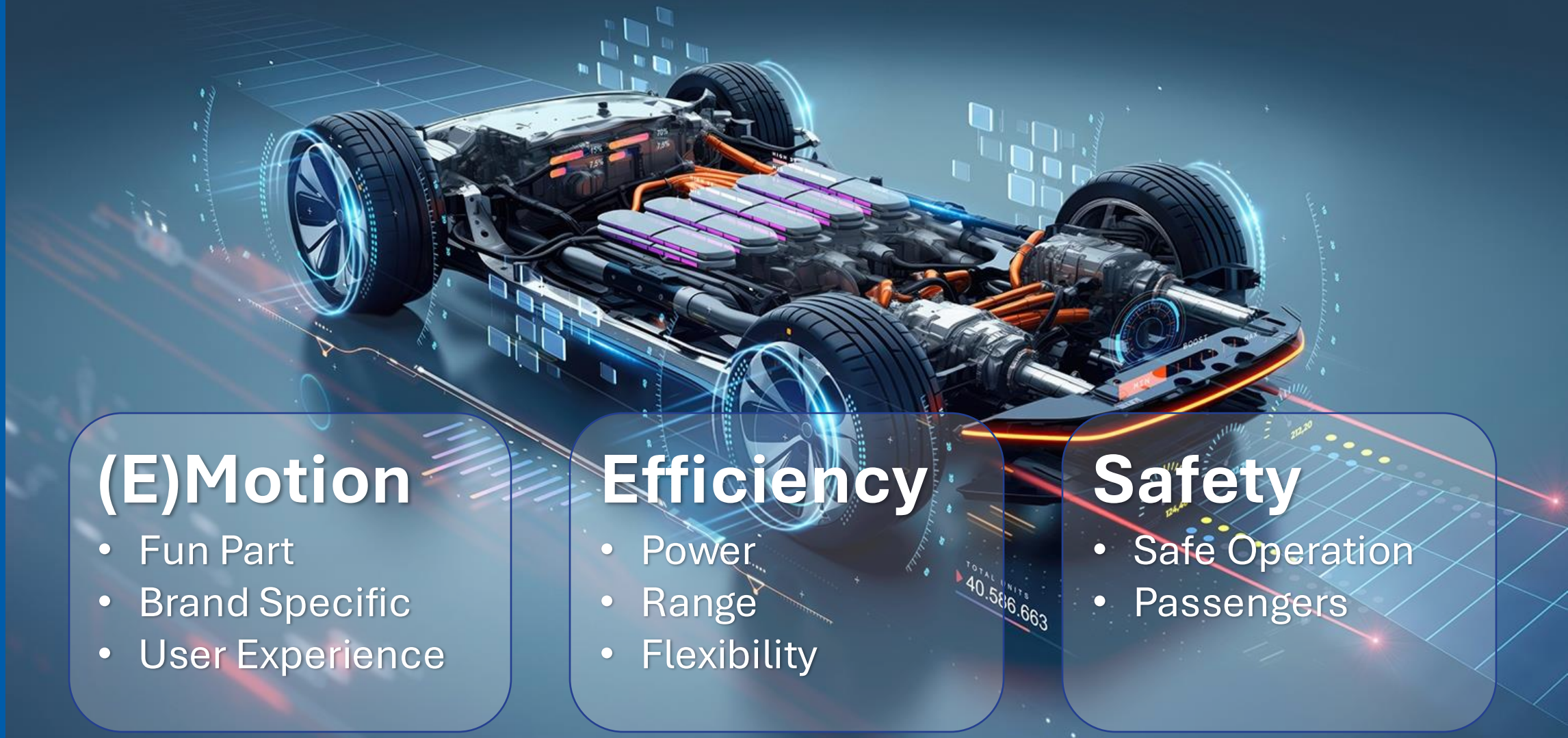
What does an MCU do in BEV?



(E)Motion

- Fun Part
- Brand Specific
- User Experience

Efficiency

- Power
- Range
- Flexibility

Safety

- Safe Operation
- Passengers

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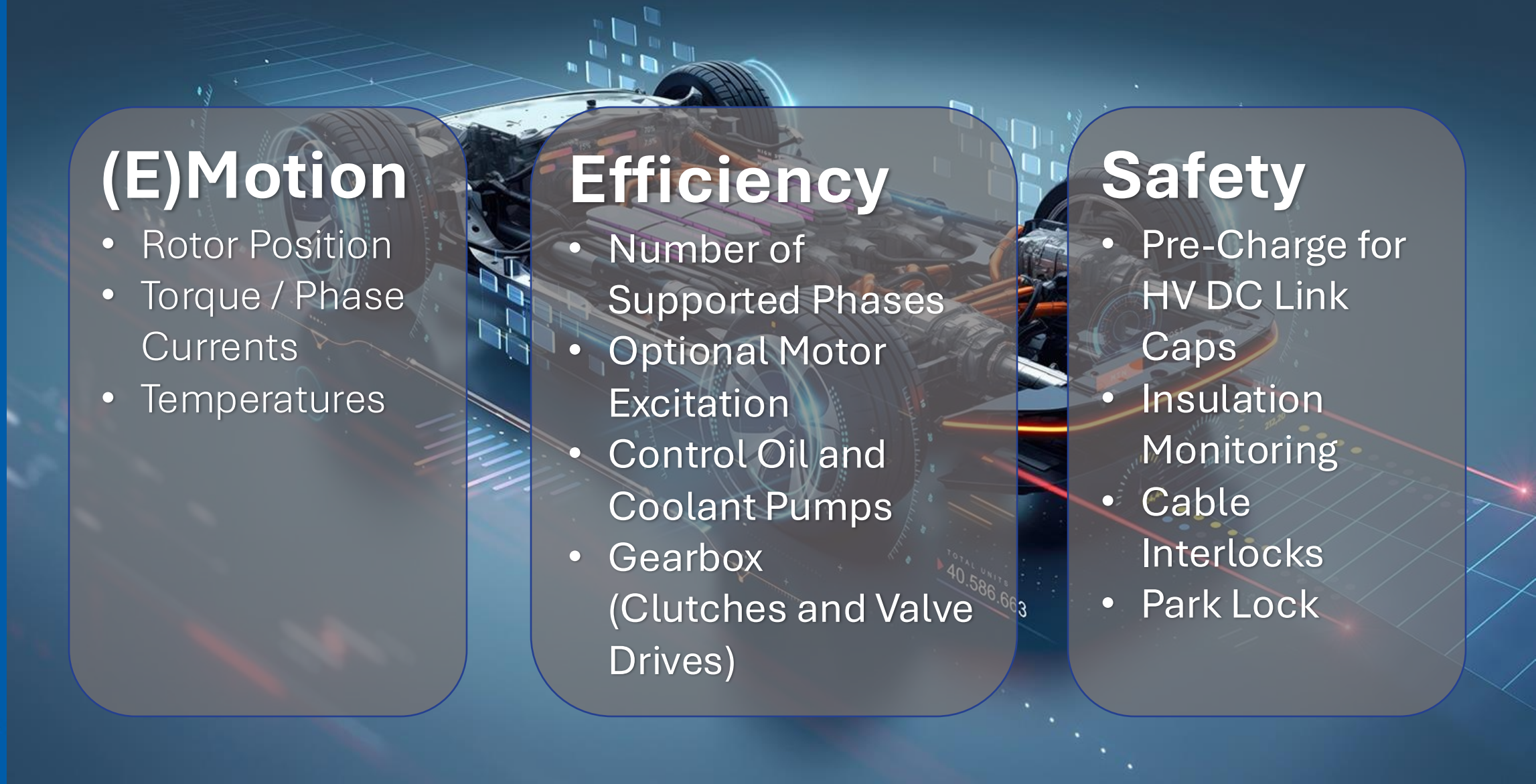
What does an MCU do in BEV?



(E)Motion

- Rotor Position
- Torque / Phase Currents
- Temperatures

Efficiency

- Number of Supported Phases
- Optional Motor Excitation
- Control Oil and Coolant Pumps
- Gearbox (Clutches and Valve Drives)

Safety

- Pre-Charge for HV DC Link Caps
- Insulation Monitoring
- Cable Interlocks
- Park Lock

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From Feature to Simulation

Pick your Instrument

(E)Motion

- Rotor Position
- Torque / Phase Currents
- Temperatures

Rotor Position

- Digital Output Signal with Variation in
  - Duty Cycle and Signal Level Changes

  e.g. Sensors with ABI Encoder Output

  => Multichannel Function Generators, Digital Outputs with Pattern Streaming

- Analog Output Signal with Variation in
  - Amplitude, Frequency and Phase

  e.g. Resolver with Sine-Cosine Signal Output

  => Resolver Emulator

Torque / Phase Currents

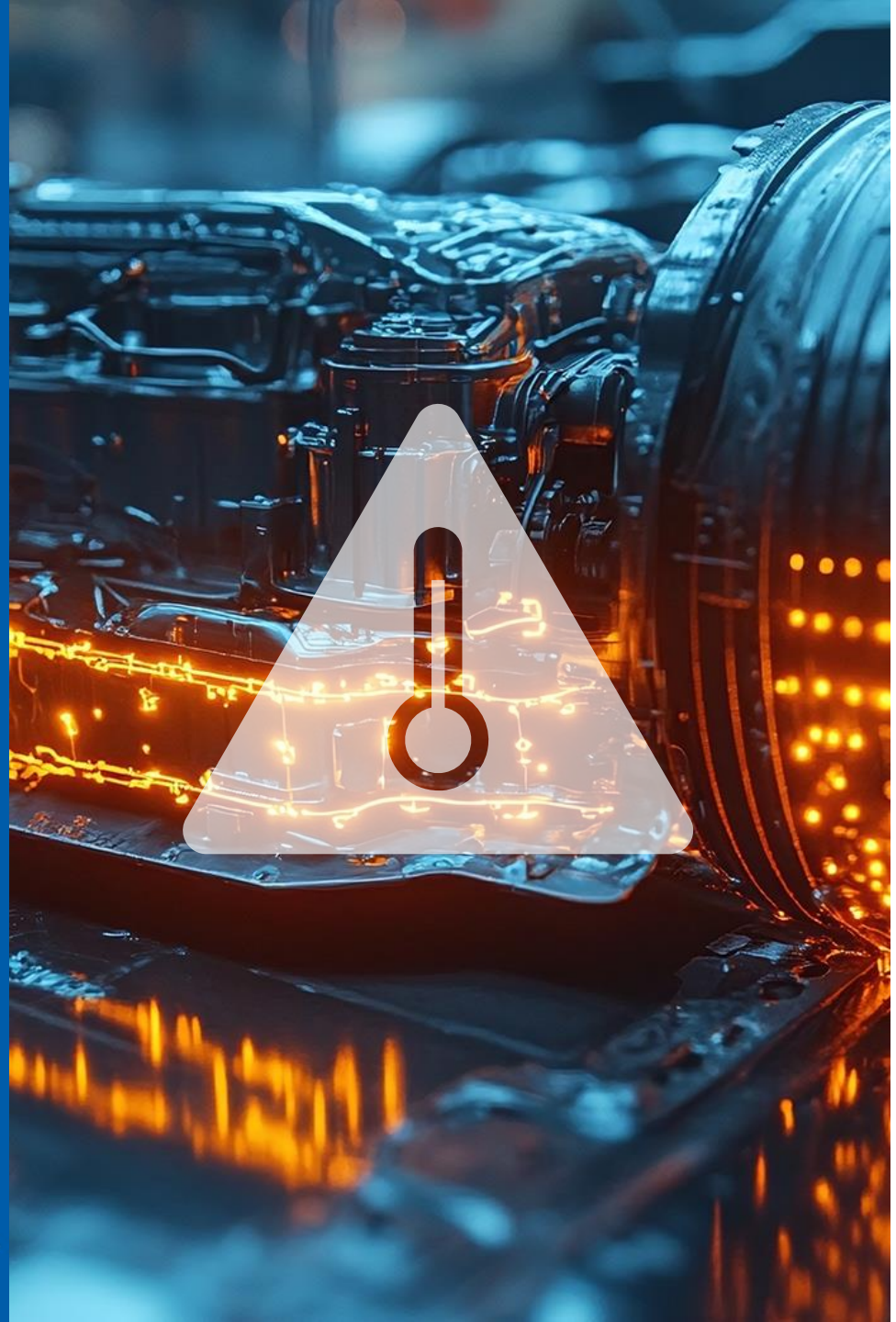
- Analog Output Signal with Variation in
  - Amplitude

  e.g. Shunts, HALL, Current Transformer

  => Function Generator, Analog Output

- Smart Sensors with Communication Protocol
  - CAN or LIN based

  => Communication Interface



Temperatures

- Analog Output Signal with Variation in
  - Amplitude, Resistance Value

  e.g. Diodes, PT100/1000 or Thermocouples

  => Analog Output, Resistance Emulator

- Smart Sensors with Communication Protocol
  - SPI, OneWire or LIN based

  => Communication Interface, Function Generator, Digital Outputs with Pattern Streaming

Efficiency

Control Oil and Coolant Pumps

Gearbox

(Clutches and Valve Drives)

Control Oil and Coolant Pumps

- Digital Output Signal with Variation in
  - Duty Cycle and Signal Level Changes

  e.g. Sensors with ABI Encoder Output

  => Fault Insertion Units to use a Component as Load and override Feedback Signal with Function Generator or Digital Outputs with Pattern Streaming

- Smart Pumps with Communication Protocol
  - CAN or LIN based

  => Communication Interface

Gearbox

- Analog Output Signal with Variation in
  - Amplitude, Resistance Value

  e.g. Position and Distance Sensors

  => Analog Output, Resistance Emulator

- Digital Signal with Variation in
  - Signal Level Changes

  e.g. End-Switches, Valve Drivers

  => Digital Output, Fault Insertion Units

Safety

- Pre-Charge for HV DC Link Caps
- Insulation Monitoring
- Cable Interlocks
- Park Lock

Pre-Charge for HV DC Link Caps

- Influence and check the Circuitry for Pre-charging and Safety Dis-charging the DC Link Caps
  - Inject HV Path with high resistance
  - Create Voltage Divider from Pack Voltage

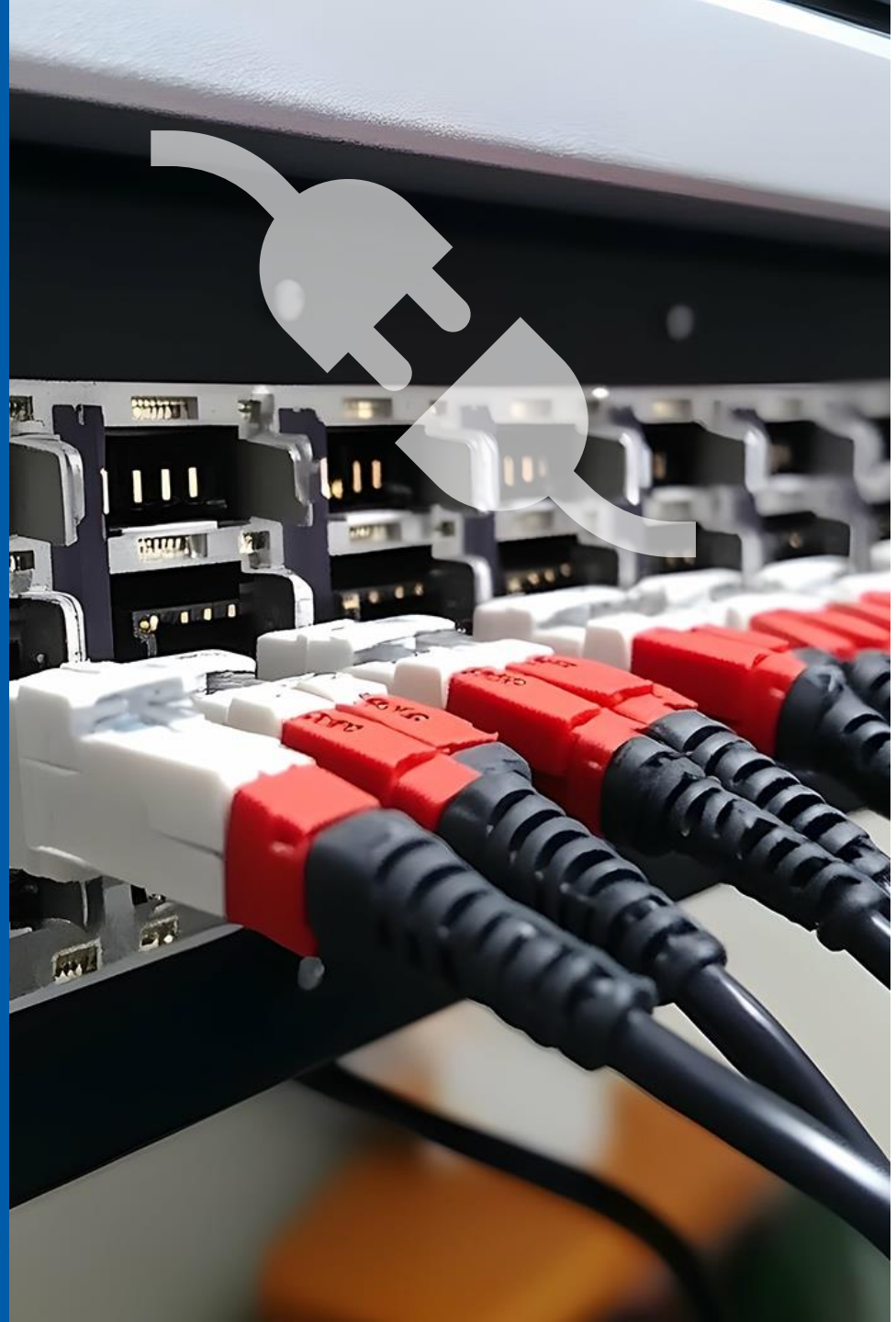
=> Fault Insertion Unit and Resistance Emulator

Insulation Monitoring

- Analog Output Signal with Variation in
  - Resistance

  e.g. Impedance between DUT and PE

  => Resistance Emulator



Cable Interlocks

- Digital Output Signal with Variation in
  - Signal Level Changes

  e.g. Loopback from MCU Output to Input

  => Fault Insertion Unit or Digital Output

- Analog Output Signal with Variation in
  - Resistance

  e.g. Resistors in Harness or Connector

  => Resistance Emulator

Park Lock

- Digital Output Signal with Variation in
  - Duty Cycle and Signal Level Changes

e.g. Sensors with ABI Encoder Output, End-Switched

=> Fault Insertion Units to use a Component as Load and override Feedback Signal with Function Generator or Digital Outputs with Pattern Streaming

Think Outside the Box

Digital Output

- Cable Interlock
- End-Switch

Digital Output with Pattern Streaming

- Position Sensor
- Speed Sensor
- Simple Communication Protocol

Analog Output

- Current Sensor
- Temperature Sensor
- Distance Sensor

Resolver Emulator

- Resolvers

Resistance Emulator

- Temperature Sensor
- Distance Sensor
- Insulation
- Pre-charging & Dis-charging

Function Generator

- Position Sensor
- Speed Sensor

Fault Insertion Unit

- Integrate Components and Override

Communication Interfaces

- Smart Sensor

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COTS Platform

from Validation to Manufacturing

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PCI eXtensions for Instrumentation (PXI)

- Industry standard for Test and Measurement
  - Very wide choice of products, with full compatibility between PXISA members' products
  - Continuously evolving specifications with backward compatibility ensure high performance and longevity
  - Original PXI products are still supported after 25 years
- Modularity, Scalability, Flexibility, Ease of Maintenance

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LAN extension for Instrumentation (LXI)

- Industry Standard for LAN based Test & Measurement Instrumentation
- Unlimited performance and power – no form factor limitations
- Lower test system cost using universal and inexpensive LAN components
- Simplified system integration – Plug & Play
- Every Pickering PXI module fits inside a Pickering LXI modular chassis

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The true meaning of Plug and Play

From validation to manufacturing

Think Outside the Box

Digital Output

- Cable Interlock
- End-Switch

Digital Output with Pattern Streaming

- Position Sensor
- Speed Sensor
- Simple Communication Protocol

Analog Output

- Current Sensor
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- Distance Sensor

Resolver Emulator

- Resolvers

Resistance Emulator

- Temperature Sensor
- Distance Sensor
- Insulation
- Pre-charging & Dis-charging

Function Generator

- Position Sensor
- Speed Sensor

Fault Insertion Unit

- Integrate Components and Override

Communication Interfaces

- Smart Sensor

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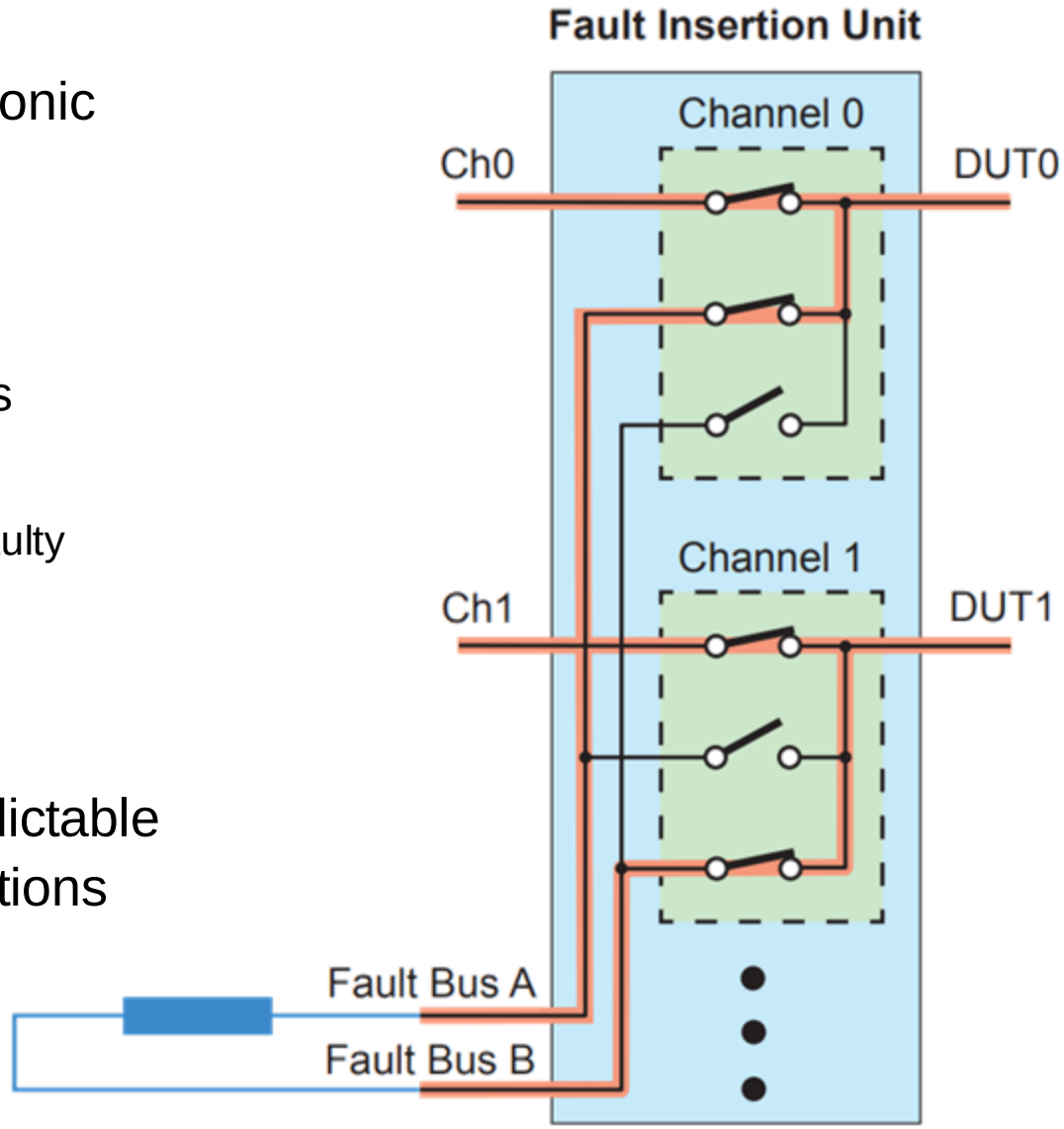
Fault Insertion Applications

- Introducing electrical faults into an electronic control system is an important aspect of automotive embedded software design validation:
  - Simulates potentially occurring conditions
    - Short/open/high resistance connections
    - Inherited through age, damage or even faulty installation
    - Firmware issues
- Verifies system reacts in a safe and predictable manner in the presence of faulty connections



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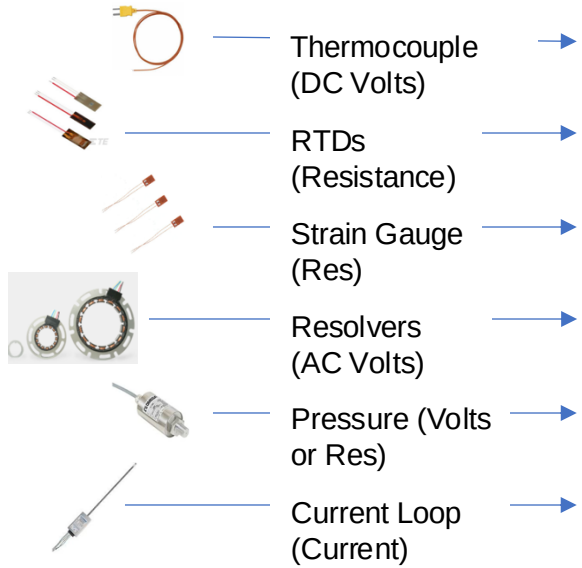
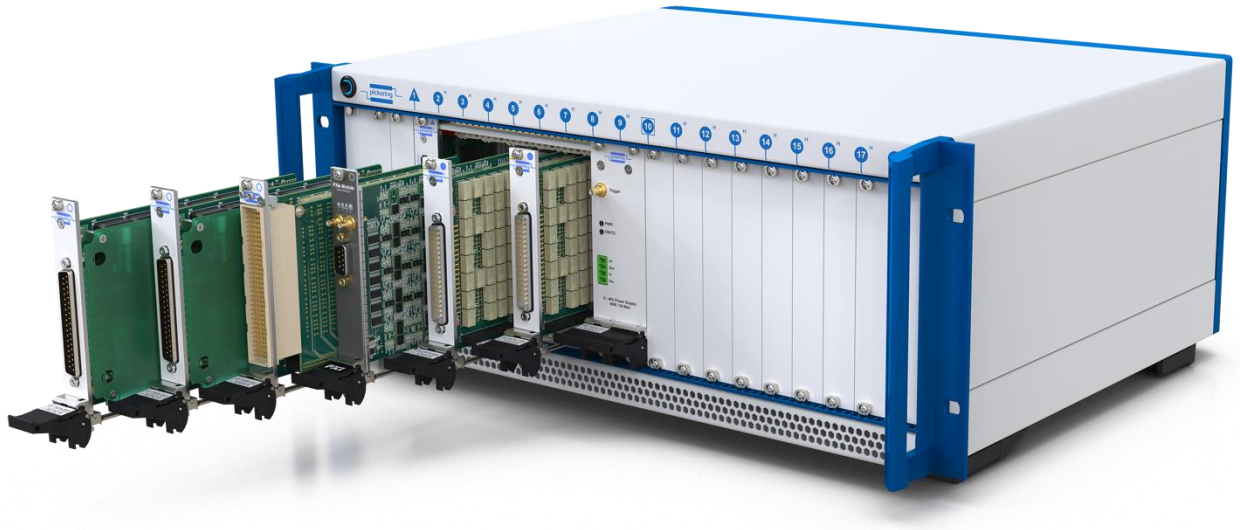
Advantages of HIL Simulation

- Time to Test
- Repeatability
- Cost
- Safety





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Pickering Capabilities Summary

- Long history in test and measurement, with deep core competency in automated switching and simulation solutions
  - 50+ years in relay design
  - 35+ years in ATE products and solutions
- Largest range of switching and sensor simulation in the industry
- Continued investment in new product development and innovation
- Flexible in addressing unique requirements
  - Customization and modification
- Only switching manufacturer with in-house reed relay and cable production
- Highly customer-centric with a commitment to providing best in class support
  - Automated self-test utilities
  - Cable design services
  - Application team (phone, email, & on-site)

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Q&A

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