

Testing ECUs of Electric Vehicles with the VT System

Vector Congress 2010, Stuttgart

> **Testing of Automotive Electronics**

VT System

Challenges in Testing EV/HEV Electronics

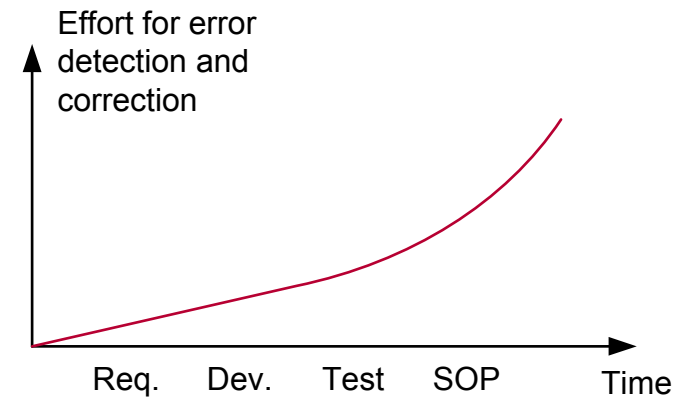
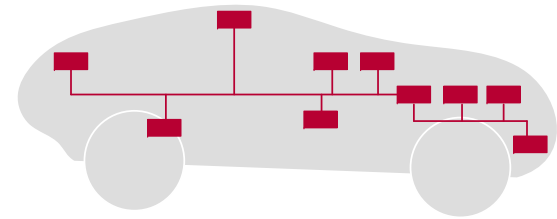
VT System and Electric Power Train Testing

Conclusion

Testing of Automotive Electronics

Motivation

- ▶ Situation of automotive electronics
 - ▶ Increasing number of ECUs
 - ▶ Increasing complexity of networks and SW
 - ▶ Highly distributed systems
 - ▶ Introduction of new technology (electric vehicles, hybrid)
- ▶ Impacts
 - ▶ High demands on testing process
 - ▶ Systematic and comprehensive tests are necessary in all phases of development
 - ▶ Early error detection and correction is much cheaper than errors found in late phases
 - ▶ Increasing relevance of testing methods and test tools



VT System Overview

VT System is a modular **test system** for functional tests of **automotive ECUs** with **CANoe**.



VT1004



VT2004



VT2516



VT7001



VT6104



Full rack with backplane VT8012

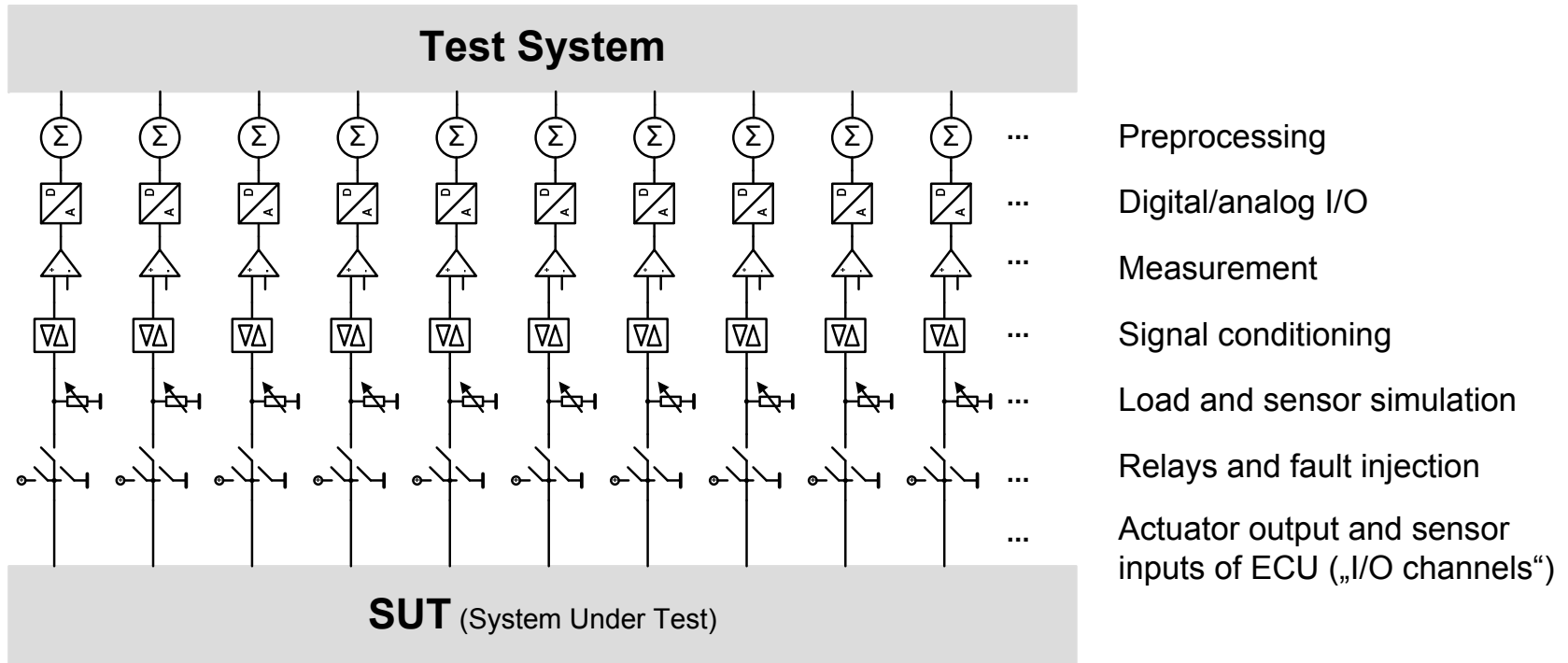


Small rack with backplane VT8006

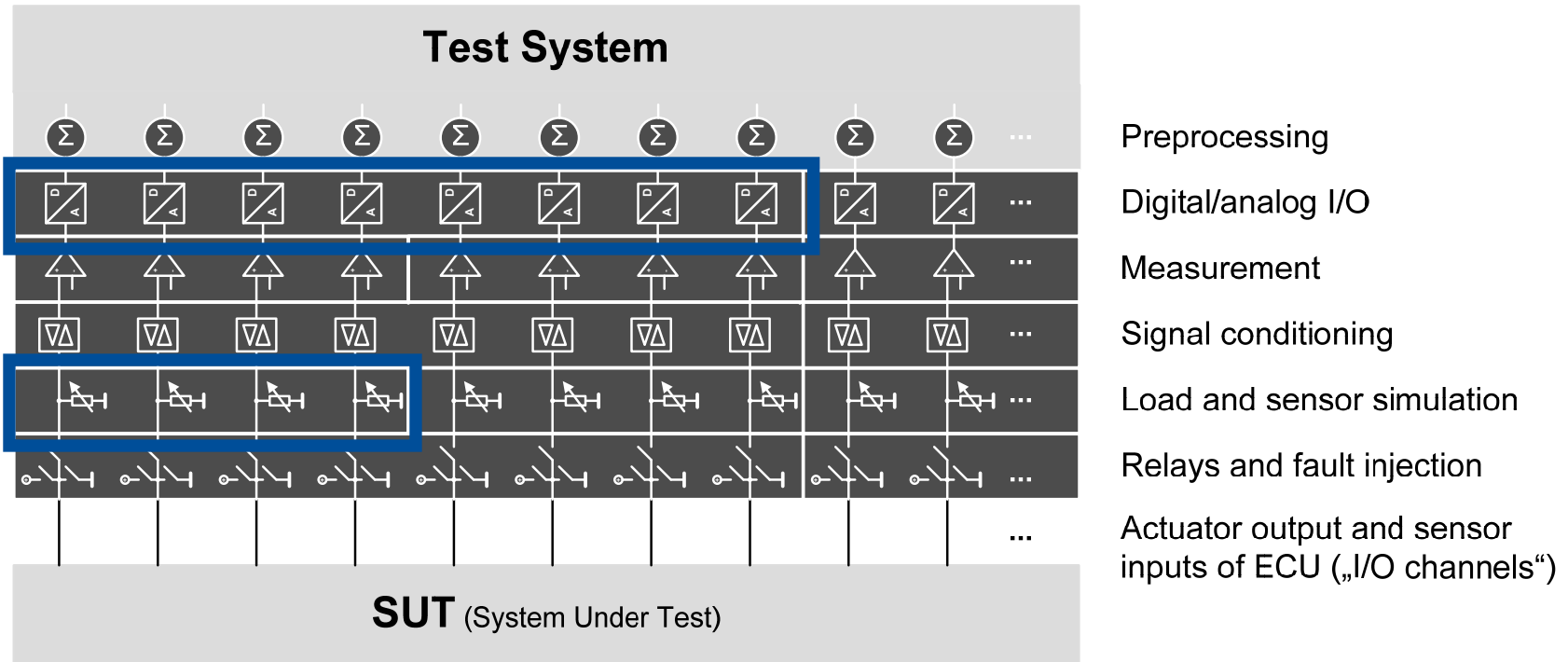


VT6010

- ▶ Several components needed for accessing each input/output channel



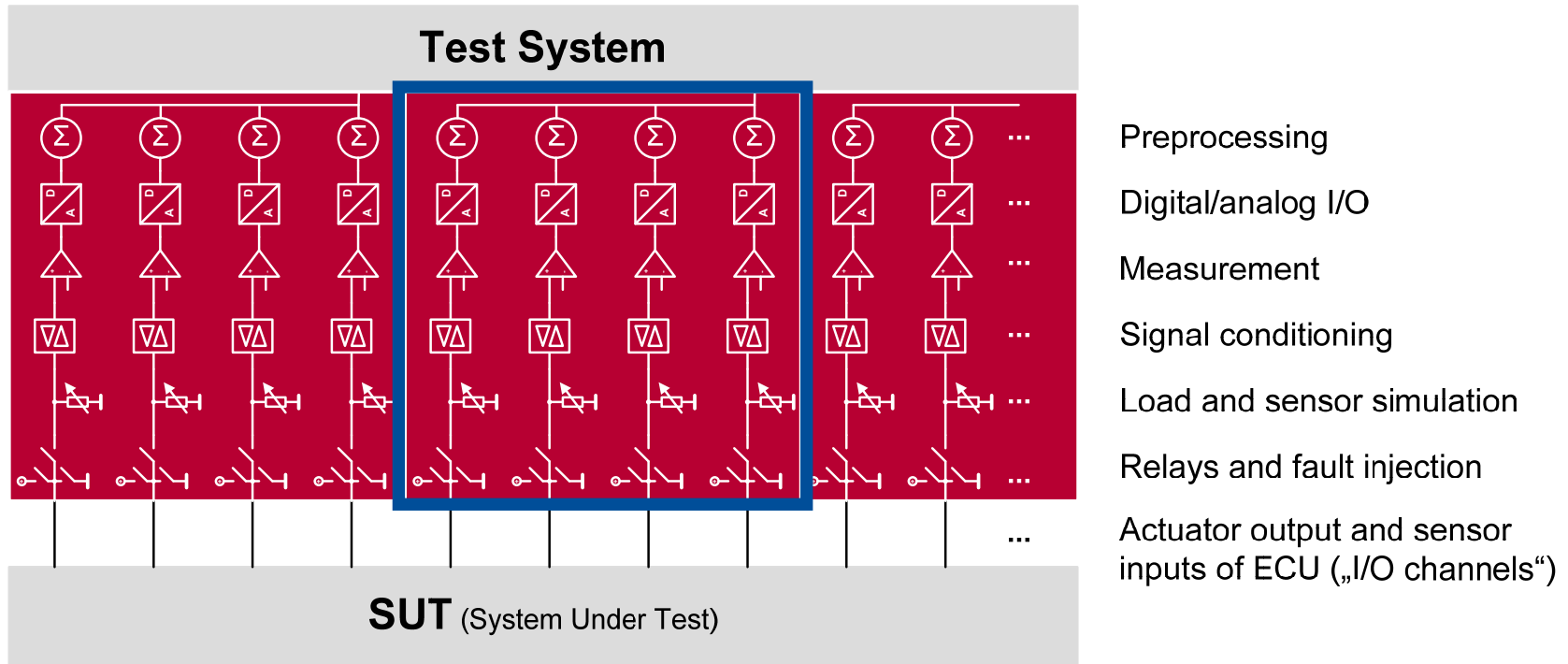
- ▶ Hardware Horizontal integration of test components on hardware modules
- ▶ Lots of modules and extensive wiring needed



VT System

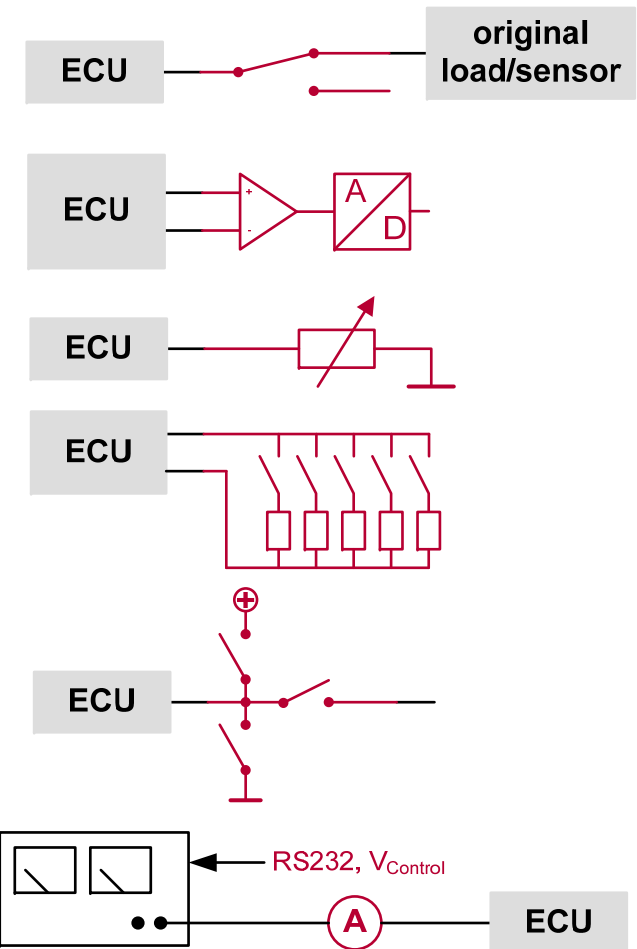
Setup of Test Hardware – VT System

- ▶ Vertical integration: All necessary functions for some ECU input or output channels are included on each module
- ▶ Simple test setup, minimized wiring
- ▶ Modular, off-the-shelf test system

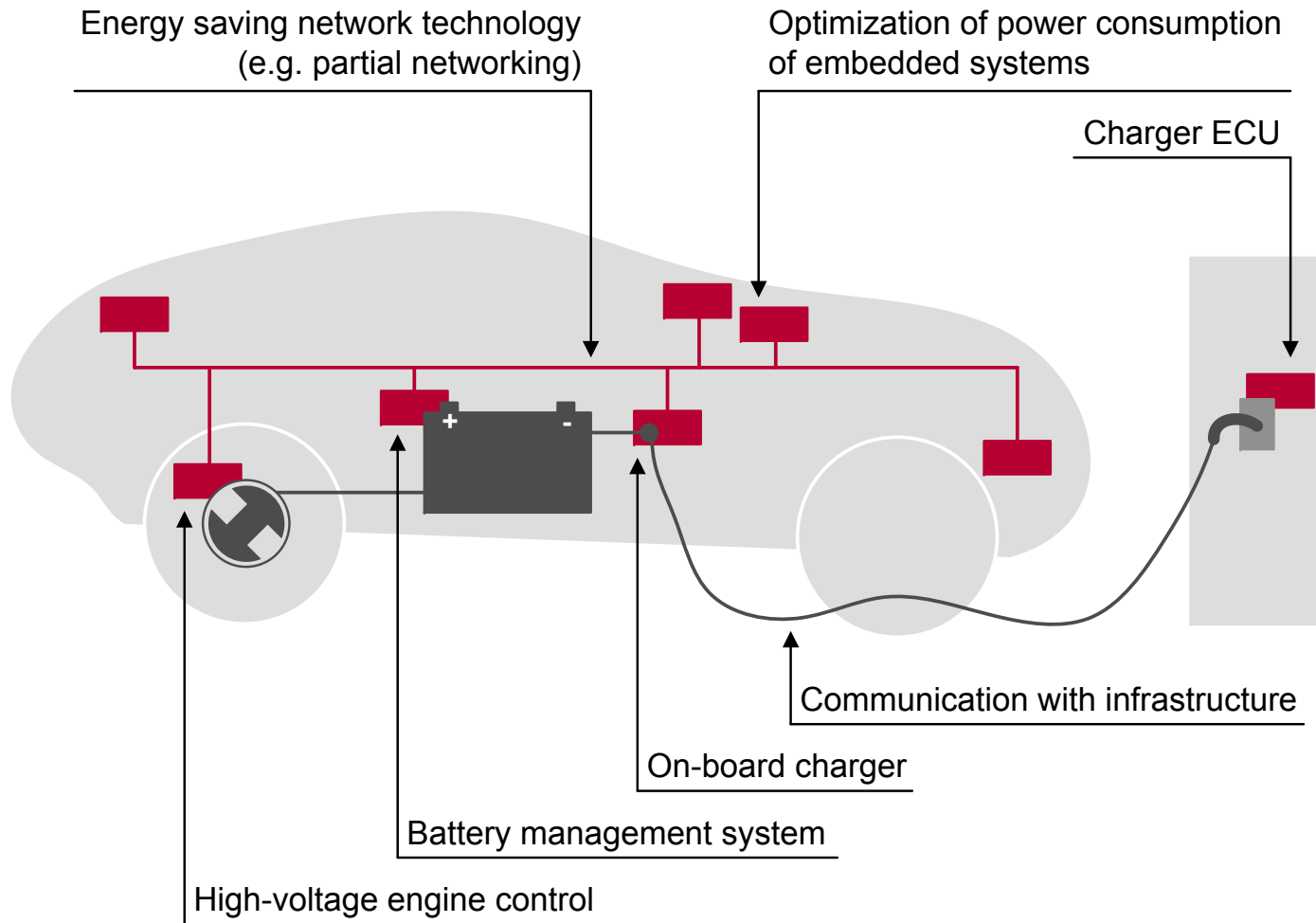


- ▶ Vertical integration of test functions
- ▶ All resources available exclusively for each channel → no multiplexing
 - ▶ Simple and highly flexible test setup
 - ▶ Easy to write test scripts
- ▶ Designed for testing automotive ECUs
 - ▶ Dedicated test functions for automotive loads and sensors (e.g. electronic load, decade resistor, ...)
 - ▶ Electrical characteristics laid out for automotive needs (e.g. voltage range $\pm 32 \dots \pm 40$ V, high currents up to 16 A on load channels)
- ▶ System strongly aims for testers
 - ▶ Status displayed at front
 - ▶ Plugs for manual measurement
 - ▶ Fully integrated in CANoe Test Feature Set

- ▶ **Switching** the signal path, e.g. to the original load or sensor
- ▶ **Measurement** of ECU output signals, including differential signals, average values, RMS, PWM parameters
- ▶ **Simulation of loads**
- ▶ **Stimulation of sensor** inputs (sensor simulation), including arbitrary signal generation and PWM output
- ▶ **Fault injection**, e.g. short circuits to ground or V_{bat} , short-circuits between ECU lines, broken wires
- ▶ **Control of supply power**, definition of input voltage and measurement of power consumption



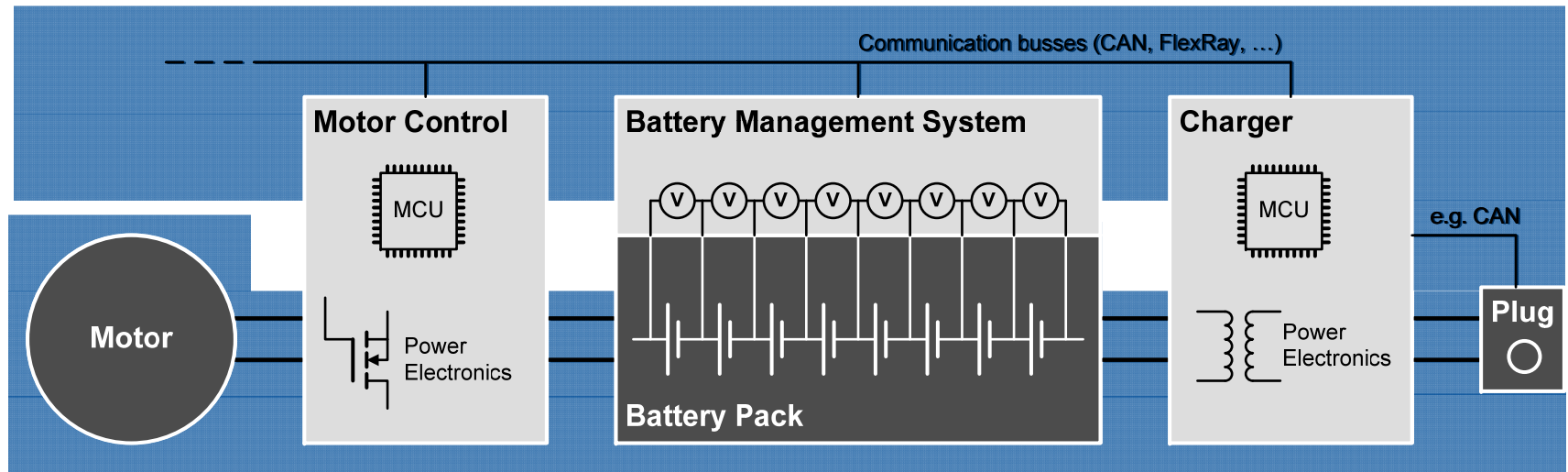
Challenges in Testing EV/HEV Electronics



VT System and Electric Power Train Testing

Situation

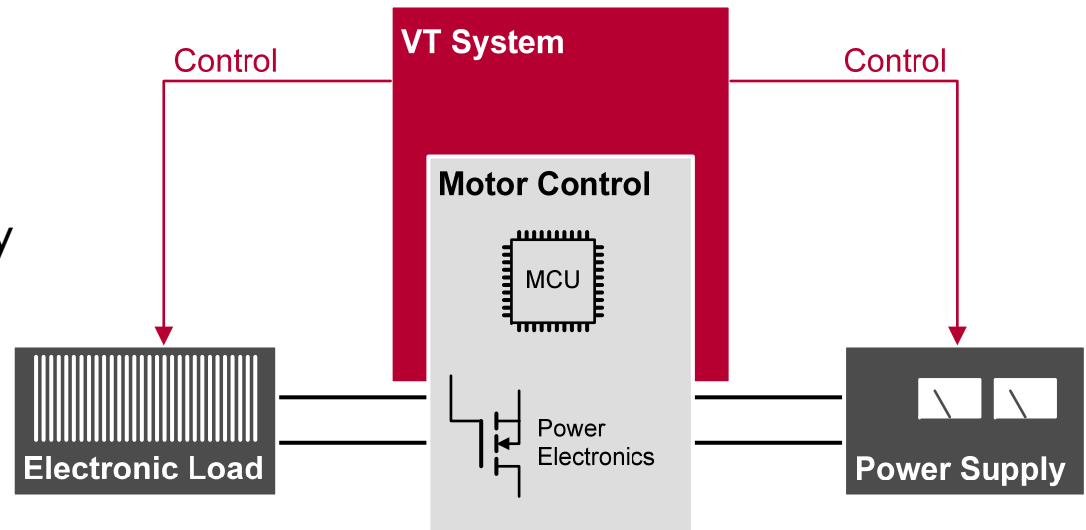
- ▶ ECUs in the electric power train contain
 - ▶ Conventional electronics (“logic” in 12 V technology)
 - ▶ High voltage/high power electronics
 - > New components, instead of external components for gasoline handling
 - > Now integrated into the ECUs



VT System and Electric Power Train Testing

Testing the Motor Control ECU

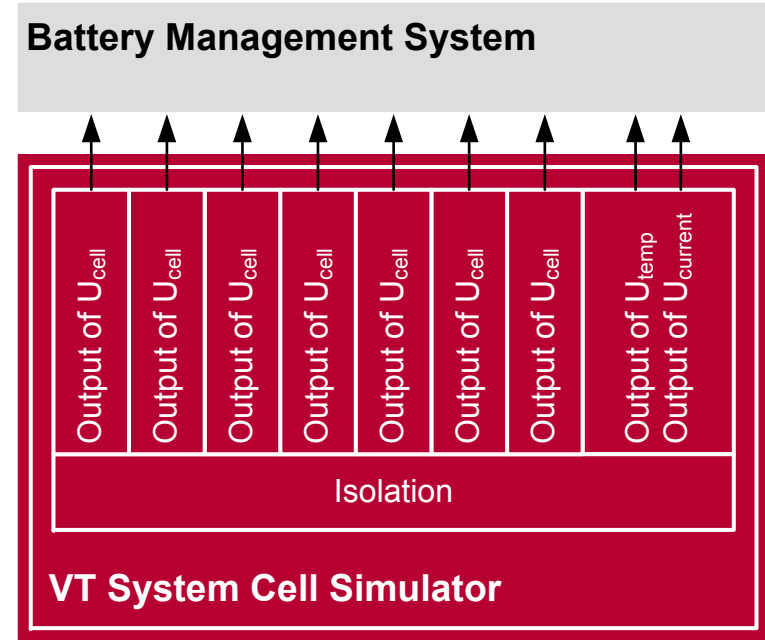
- ▶ Testing the “logic” of a electric motor control ECU
 - ▶ Behavior in the car network
 - ▶ Implementation of diagnostics protocol and functionality
 - ▶ Test of motor control algorithm
 - ▶ ... → same as for conventional engine control ECUs
- ▶ Testing the complete ECU
 - ▶ Covering also power electronics
 - ▶ But: high effort for battery and load simulation



VT System and Electric Power Train Testing

Testing the Battery Management System

- ▶ Goal: Testing behavior of battery management system ECU
 - ▶ Measurement of battery characteristics (U, I, Temperature)
 - ▶ Reaction on cell failures like overvoltage, cell short-circuit, ...
 - ▶ Charge state evaluation by BMS
 - ▶ Diagnostic functions
 - ▶ ...
- ▶ Test system has to
 - ▶ generate the battery voltages,
 - ▶ simulate the sensors (temperature, current),
 - ▶ but does not sink charging current or source power for the motor



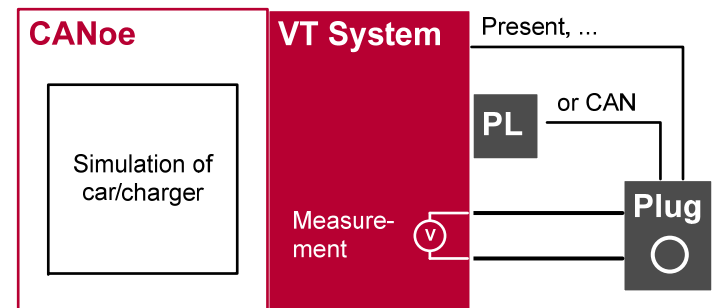
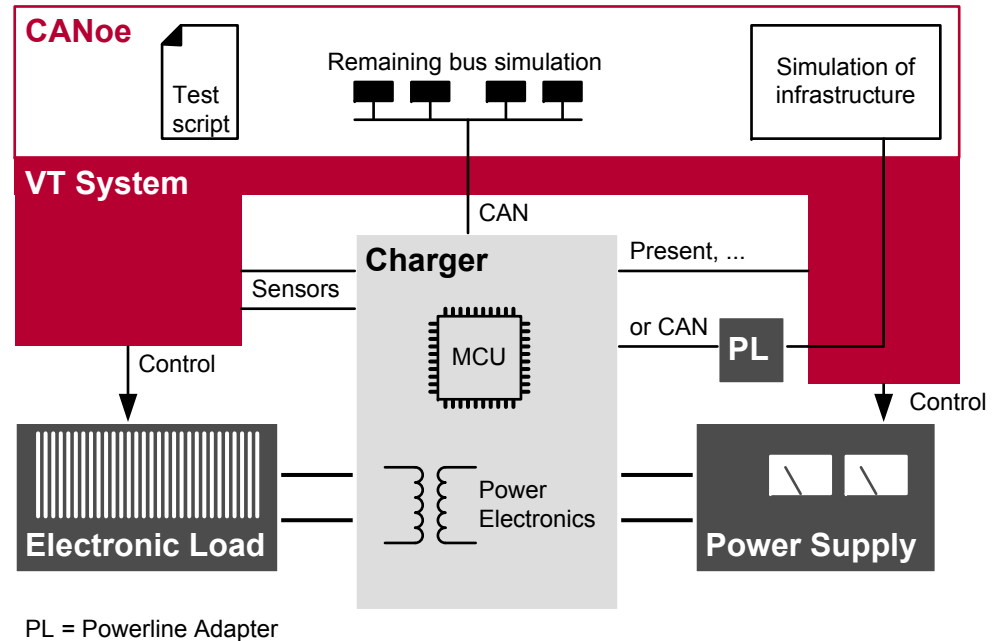
- ▶ Cell simulator = extension of VT System
 - ▶ Cell simulation cannot be provided by the existing VT modules
 - > Galvanic isolated outputs necessary
 - > Safety considerations (high voltages in sum)
 - ▶ Economical considerations
 - > 100 cells and more have to be simulated
 - > Short circuits, bus bars etc. are not wanted due to safety reasons
- ▶ Solution: Specific application board based on VT7900 extension module
 - ▶ General parts (communication, μ C, FPGA, form factor, ...) and CANoe integration already available on VT7900 extension module
 - ▶ Specific parts (only!) have to be implemented on application board



VT System and Electric Power Train Testing

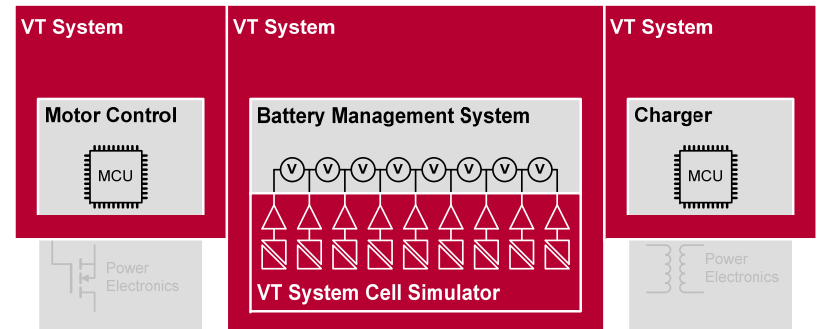
Testing the Charger

- ▶ Test of on-board charger
 - ▶ Simulation of car
 - > Remaining bus simulation
 - > Sensors
 - > Possibly battery (power sink)
 - ▶ Simulation of infrastructure
 - > Communication (e.g. CHAdeMO, ISO15118)
 - > Charger signal (PWM, ...)
- ▶ Test of infrastructure
 - ▶ Simulation of "remote station" (on-board charger and car)
 - ▶ Measurement of output



Conclusion

- ▶ New challenges by testing of electric vehicles
 - ▶ High relevance of new, **power saving technologies**
 - ▶ Demanding functional and safety requirements due to **high voltages**
 - ▶ Simulation of **battery cells** required
 - ▶ Motor control ECU contains **power electronics**
- ▶ VT System and CANoe is a **modular**, highly **integrated**, and **smart** testing solution for **automotive** ECUs from Vector
- ▶ VT System is **fit for testing electric vehicle** ECUs
 - ▶ Set of very flexible modules
 - ▶ Easily extensible for covering new requirements
 - > Control of external test hardware
 - > Battery simulator based on VT7900



Thank you for your attention.

For detailed information about Vector
and our products please have a look at:

www.vector.com

Author:

Dr. Stefan Krauß

Vector Informatik GmbH

Ingersheimer Str. 24

70499 Stuttgart