



## VT System Smart HIL Testing

## > ECU Testing

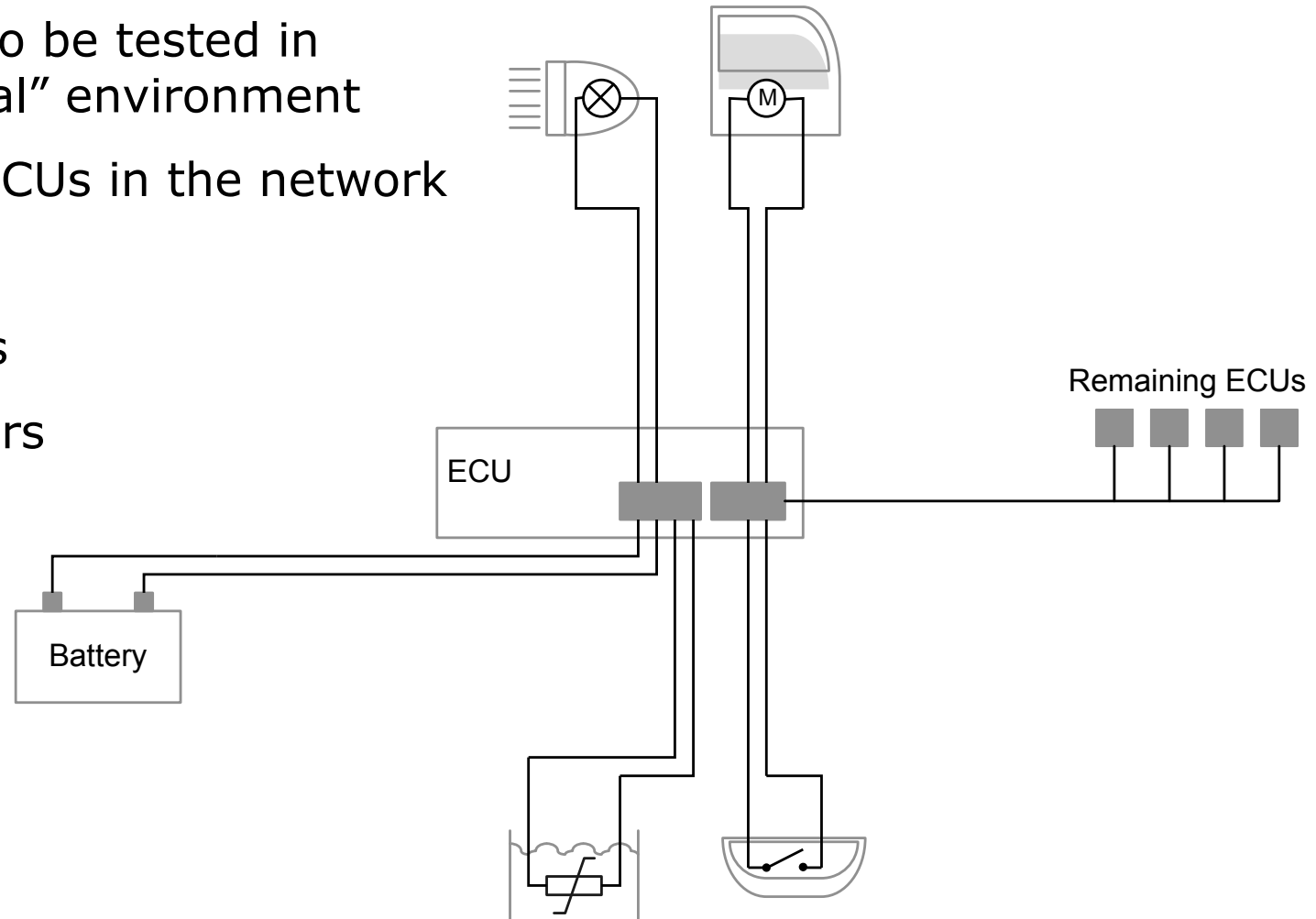
Testing a Door Control Unit

Summary and Outlook

# ECU Testing

## I/O Access for ECU Testing

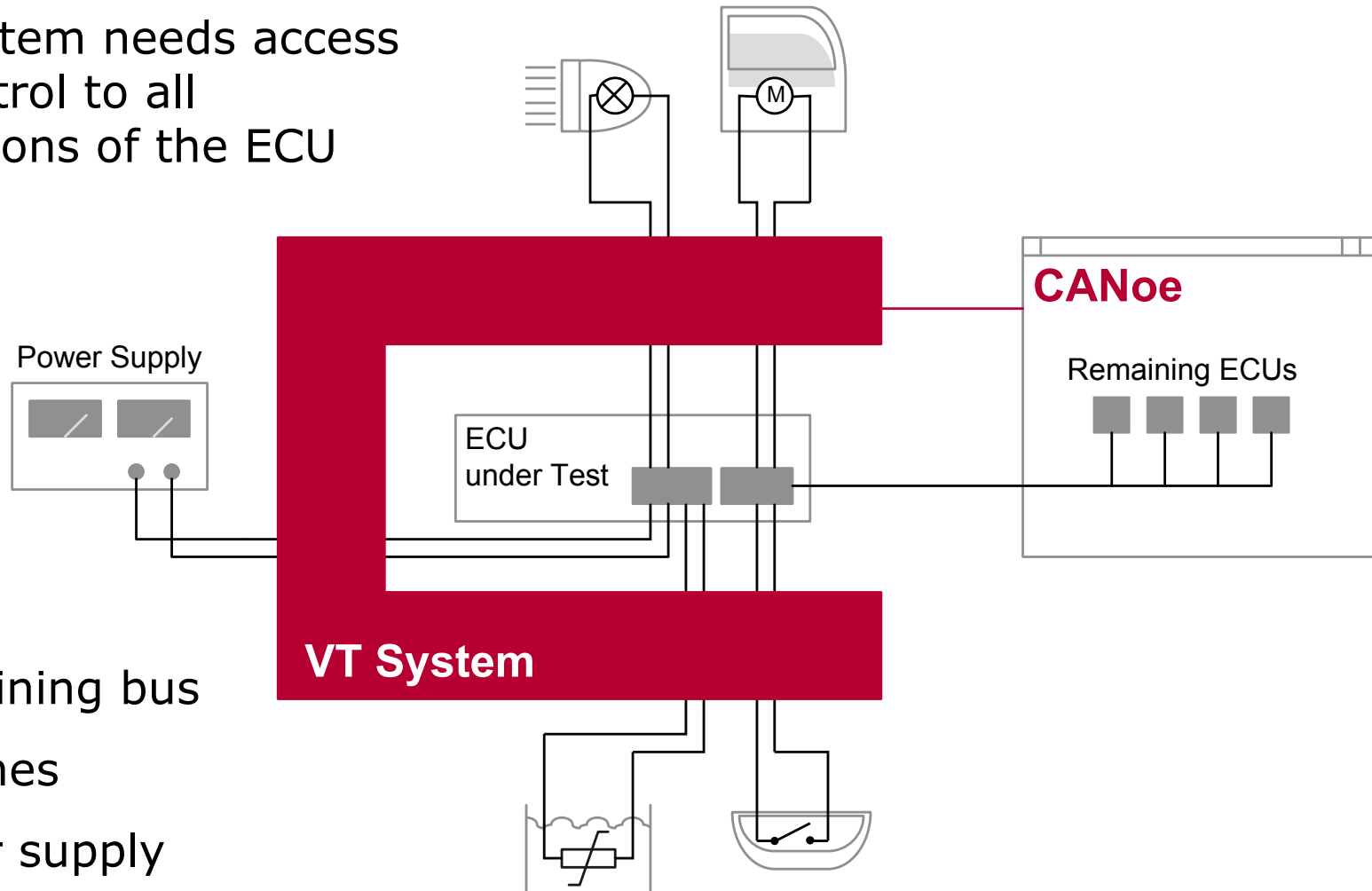
- ▶ ECU has to be tested in its “natural” environment
  - ▶ Other ECUs in the network
  - ▶ Battery
  - ▶ Sensors
  - ▶ Actuators



# ECU Testing

## I/O Access for ECU Testing

- ▶ Test system needs access and control to all connections of the ECU



- ▶ Remaining bus
- ▶ I/O lines
- ▶ Power supply

# ECU Testing

## VT System Concept

- ▶ Highly integrated modules to cover the complete testing requirements of an input or output channel
  - ▶ Stimulation
  - ▶ Measurement
  - ▶ Fault injection
- ▶ Minimal cabling, no additional hardware
  - ▶ Focus on test case development
- ▶ Modular and scalable
  - ▶ From developer's desk to dedicated HIL systems
- ▶ Electric characteristics suited to automotive requirements
- ▶ Connection to CANoe via EtherCAT®
  - ▶ Fulfills real-time requirements
  - ▶ Connection via standard Ethernet interface

EtherCAT®



# Agenda

ECU Testing

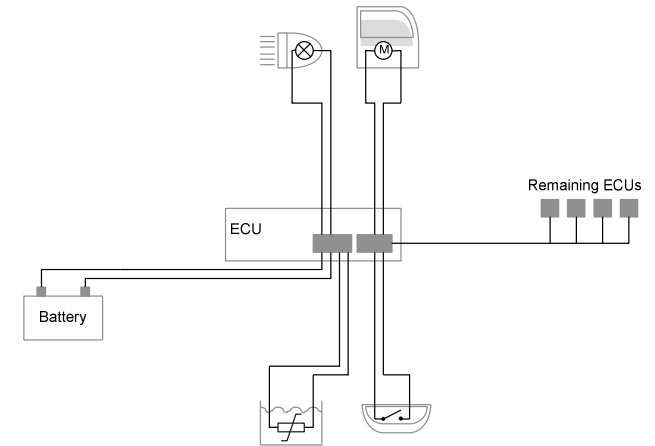
**> Testing a Door Control Unit**

Summary and Outlook

# Testing a Door Control Unit

## Motivation

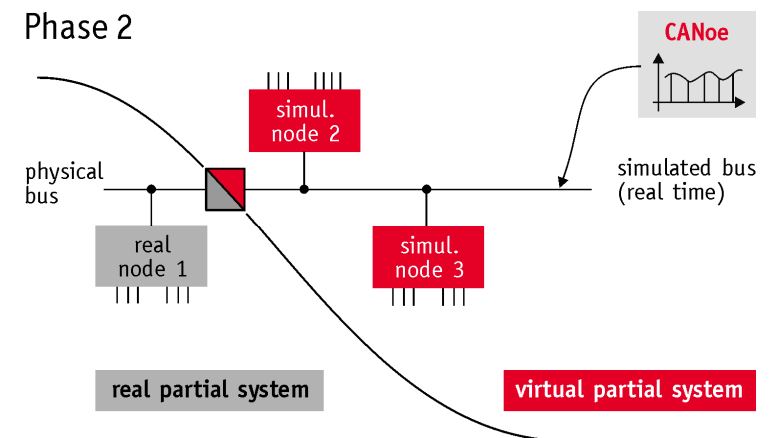
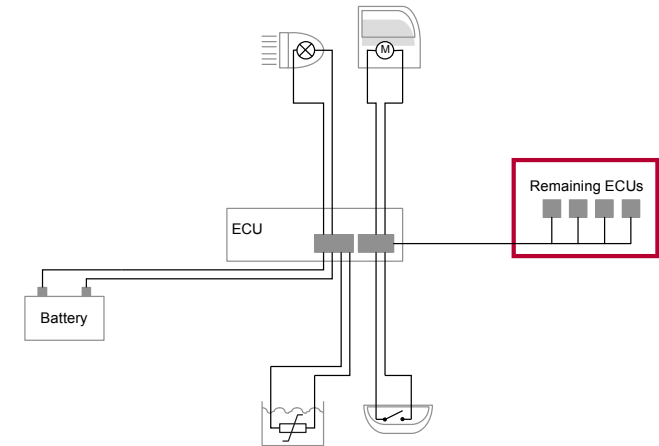
- ▶ Door control unit operates
  - ▶ Mirrors
  - ▶ Window lifts
  - ▶ Locking system
- ▶ Test requirements
  - ▶ Test of different use cases
  - ▶ Handling of failures
  - ▶ Monitoring of energy consumption
  - ▶ Test of diagnostic interface



# Testing a Door Control Unit

## Remaining bus simulation

- ▶ ECU needs communication with other ECUs
  - ▶ Central Locking System
  - ▶ Control of mirror and windows at other door
- ▶ CANoe provides means to simulate missing ECUs
  - ▶ Manual programming
  - ▶ MATLAB®/Simulink® integration
  - ▶ Generation from Communication Database

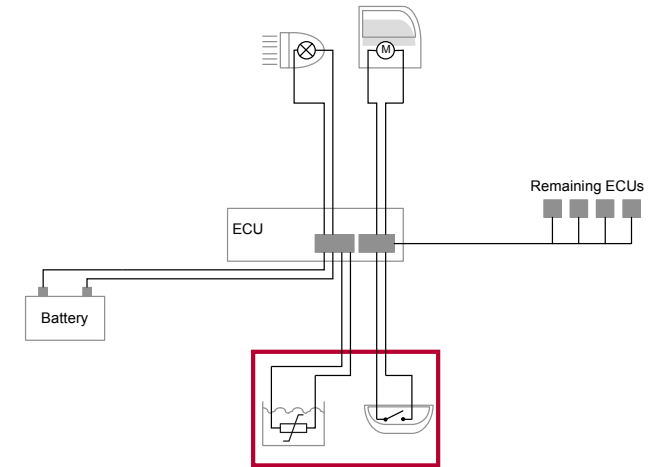




# Testing a Door Control Unit

## Sensors

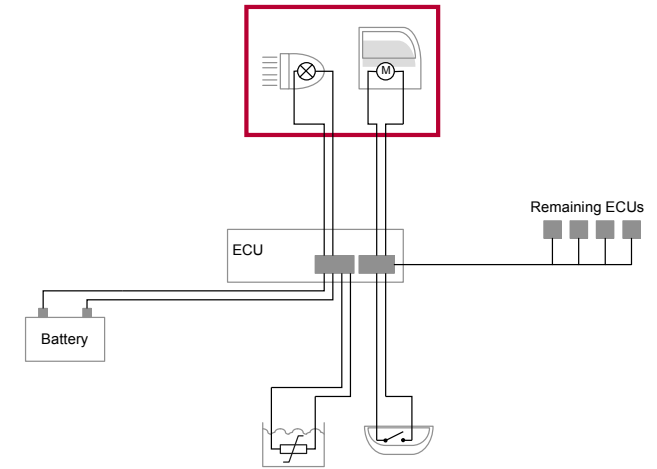
- ▶ Sensors provide information about environment and signal user requests
  - ▶ Doors closed?
  - ▶ Position of window
  - ▶ Control switches and buttons
  - ▶ ...
- ▶ Test requires generation of specified sensor signals
- ▶ VT System generates sensor input
  - ▶ Constant voltage, PWM, Wave form
  - ▶ Decade resistor
  - ▶ Faults like short circuits or open circuits
  - ▶ Directly controlled from CANoe



# Testing a Door Control Unit

## Actuators

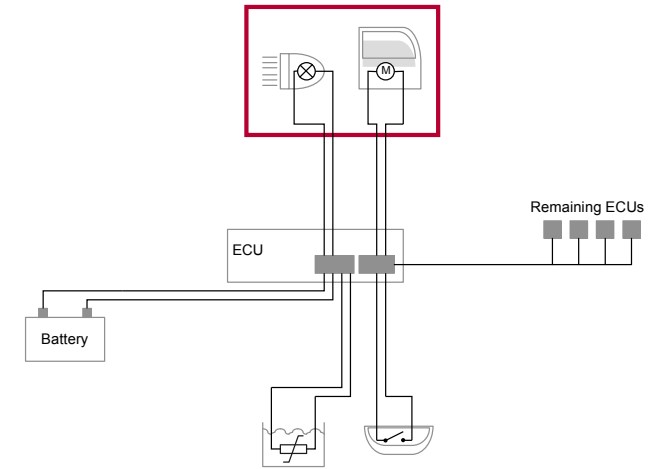
- ▶ Actuators are operated by ECU according to sensor input and internal state
  - ▶ Window lift motor
  - ▶ Mirror servo
  - ▶ Lock
- ▶ ECU detects missing actuators
- ▶ Test checks output for specified combinations of input signals



# Testing a Door Control Unit

## Actuators

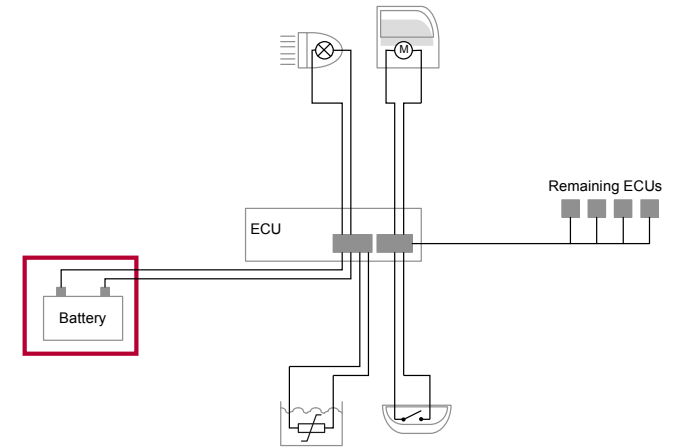
- ▶ VT System simulates actuators with electronic load
  - ▶ Original components not needed for test
  - ▶ Efficient simulation of different situations
- ▶ VT System measures ECU output
  - ▶ Plain voltage measurement
  - ▶ Averages and RMS computed on module
  - ▶ PWM frequency and duty cycle
  - ▶ Available for automatic tests in CANoe
  - ▶ Visualization in CANoe, e.g. as graph



# Testing a Door Control Unit

## Power Supply

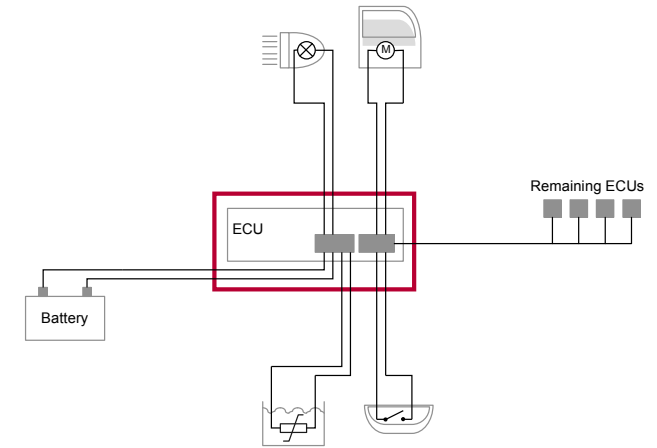
- ▶ Low energy consumption is an important requirement, especially for vehicles with electric drive
- ▶ ECU must be able to compensate certain fluctuations of supply voltage
- ▶ Handling of failures
- ▶ VT System measures supply voltage and current
  - ▶ Handles high currents up to 70A for one supply line
  - ▶ Low currents can be measured with  $\mu\text{A}$  resolution to check sleep states
- ▶ Simulation of different scenarios
  - ▶ Control of external power supply via analog signal or RS232 port



# Testing a Door Control Unit

## ECU Access and Test Control

- ▶ Test of diagnostic functions
- ▶ CANoe provides diagnostic framework
  - ▶ Support for CANdela and ODX databases
  - ▶ VT System can be used in automated diagnostic tests with DiVa e.g. for fault injection
- ▶ White Box testing with direct access to internal values of the ECU
  - ▶ CANoe provides CCP and XCP interface
- ▶ Test control with CANoe Test Feature Set
  - ▶ Test sequences can be created using XML, CAPL or .NET
- ▶ Automatic generation of test reports



The screenshot displays the Vector CANoe software interface. The main window shows a list of test cases under the heading "Central locking system test - Mecilla Firefox". The test cases are organized into sections: "Preparation of Test Module", "1. Test static requirements of the SUT", "2. Test velocity-dependent requirements of Central Locking System", and "3. Additional requirements of the Window System". The results for each test case are shown in a table format, with a green checkmark indicating a passed test and a red X indicating a failed test.

Test Case Name	Verdict
Central locking system test	All Passed
Test static requirements of the SUT	Passed
Lock statically	Passed
Statically open the window	Passed
Statically close the window	Passed
Unlock statically	Passed
Test velocity-dependent requirements of Central Loc.	All Passed
Lock by increasing velocity	Passed
Check no unlock when slowing down	Passed
Crash while engine is on	Passed
Apply crash while engine is off and not moving	Passed
Apply crash when engine is off but moving	Passed
Additional requirements of the Window System	Some Failed: 2
GAP: Check Request Response Timing	Failed
Ambiguous open and close	Failed
Open and control-close	Failed

Statistics:

Category	Count	Percentage
Overall number of test cases	12	
Executed test cases	12	100% of all test cases
Not executed test cases	0	0% of all test cases
Test cases passed	10	83% of executed test cases
Test cases failed	2	17% of executed test cases

Test Case Results:

Test Case Name	Verdict
1.1 TC101 Lock statically	passed
1.2 TC201 Statically open the window	passed
1.3 TC202 Statically close the window	passed
1.4 TC102 Unlock statically	passed
2.1 TC103 Lock by increasing velocity	passed
2.2 TC104 Check no unlock when slowing down	passed
2.3 TC105 Crash while engine is on	passed
2.4 TC106 Apply crash while engine is off and not moving	passed
2.5 TC107 Apply crash when engine is off but moving	passed
3.1 TC203 Timing check between Request and Response	passed
3.2 TC203 Ambiguous open and close	fail

# Agenda

ECU Testing

Testing a Door Control Unit

**> Summary and Outlook**

- ▶ Integrated all-in-one hardware interface for ECU I/O testing
  - ▶ All basic test components included (relays, decade resistor, ...)
  - ▶ Fills gap between standard I/O card and ECU under test
- ▶ Fulfills automotive test requirements concerning voltage, currents, latency, through-put, ...
- ▶ Simplifies wiring of even complex test stands
- ▶ Fully integrated in CANoe: direct and simple control of I/O for test, simulation, and analysis
- ▶ Scalable test solution: from compact off-the-shelf I/O box at developer's desk to component HIL racks in the lab

# Summary and Outlook

## Upcoming Extensions

- ▶ Dedicated PC Module for real-time part of CANoe
  - ▶ Atom or Core 2 Duo CPU on highly flexible COM Express module
  - ▶ Improvement of real-time capabilities
- ▶ Network Interface Module VT6104
  - ▶ 4 channel CAN, LIN
  - ▶ Based on well-established CANcard XLe technology
  - ▶ Contains relays for short circuit, open wire, termination
- ▶ Extension Module VT7900
  - ▶ Base board for the realization of application-specific VT System modules
  - ▶ Digital and analog I/Os allow simple application boards





Thank you for your attention.

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

[www.vector.com](http://www.vector.com)

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