ECU Measurement and Calibration in a Real-Time Test Environment

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Term Definitions

- What is ECU Calibration?
  - Software Optimization of ECU Algorithms
- When is ECU Calibration typically used?
  - ECU (rapid) Prototyping
  - ECU test
- Which Standards are used?
  - ASAM Standards
    - CCP (CAN Calibration Protokoll)
    - XCP (Universal Calibration Protocol)
    - ASAM Database configurations (*.a2l)

Calibration-Protocols

CCP – CAN Calibration Protocol

Supported Transport Protocols

CAN

Use Cases

- ECU Parameter Calibration(1D, 2D, 3D)
- ECU Data acquisition
  Asynchronous read from Master (Measurement)
  asynchronous or synchronous Event on ECU
- Flash Programmiing

XCP – Universal Measurement and Calibration Protocol

Supported Transport Protocols

TCP/IP, UDP, CAN, USB, FlexRay, LIN

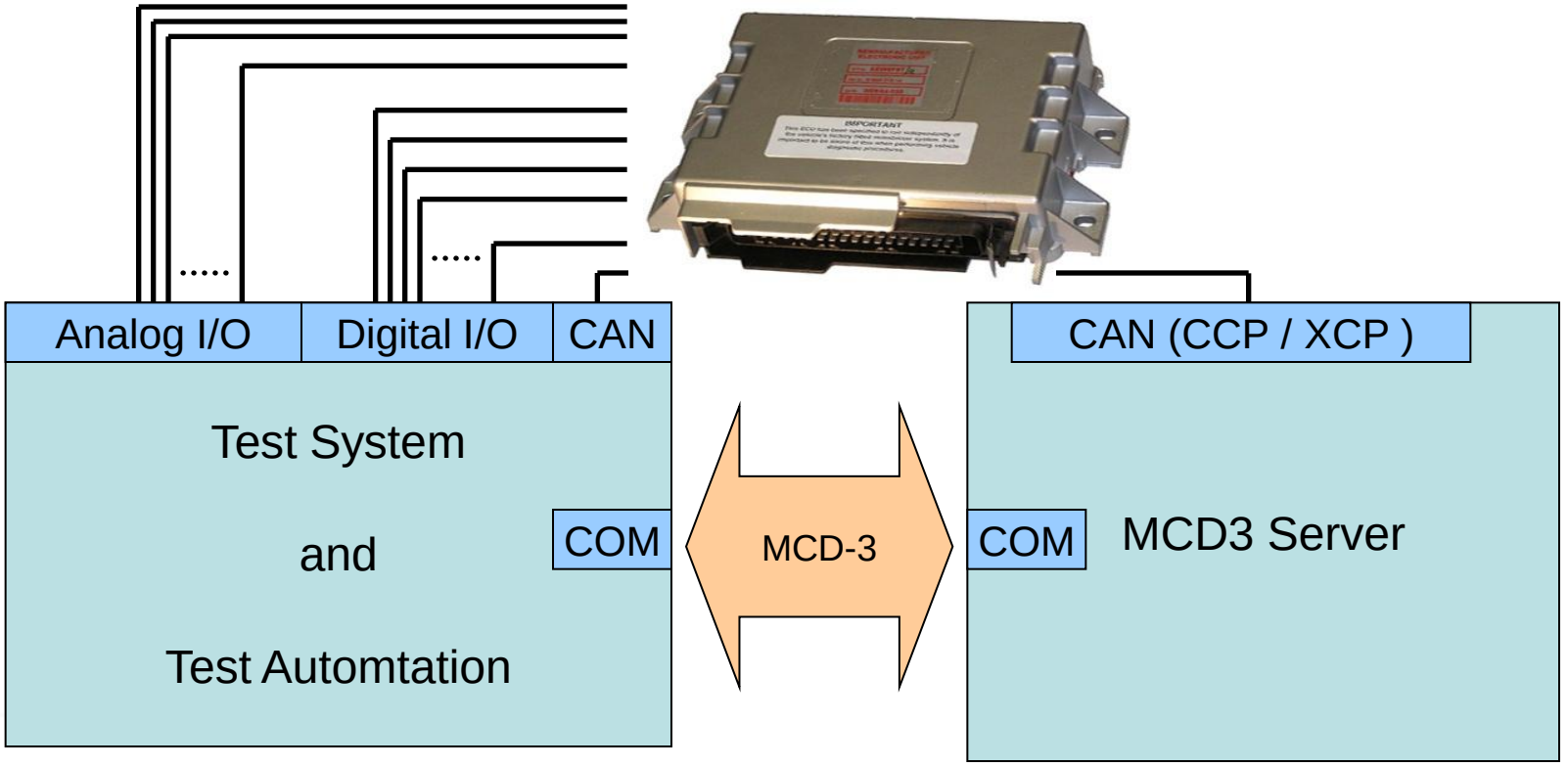
Use Cases

- ECU Parameter Calibration(1D, 2D, 3D)
- ECU Data acquisition
- Flash Programmiing
- ECU Stimulation (Sensor Simulation)
- Bypassing (run test algorithm on Master)

ASAM Database File: A2L

- Official Standard for describing ECU memory layout on an ECU target
- Information about all relevant ECU data objects
  - Measurements and Set points (1..3D)
  - Memory Addresses, Data Layout, Data Type, etc.
  - Conversion rules
- Database generated automatically at ECU Software-Compile time

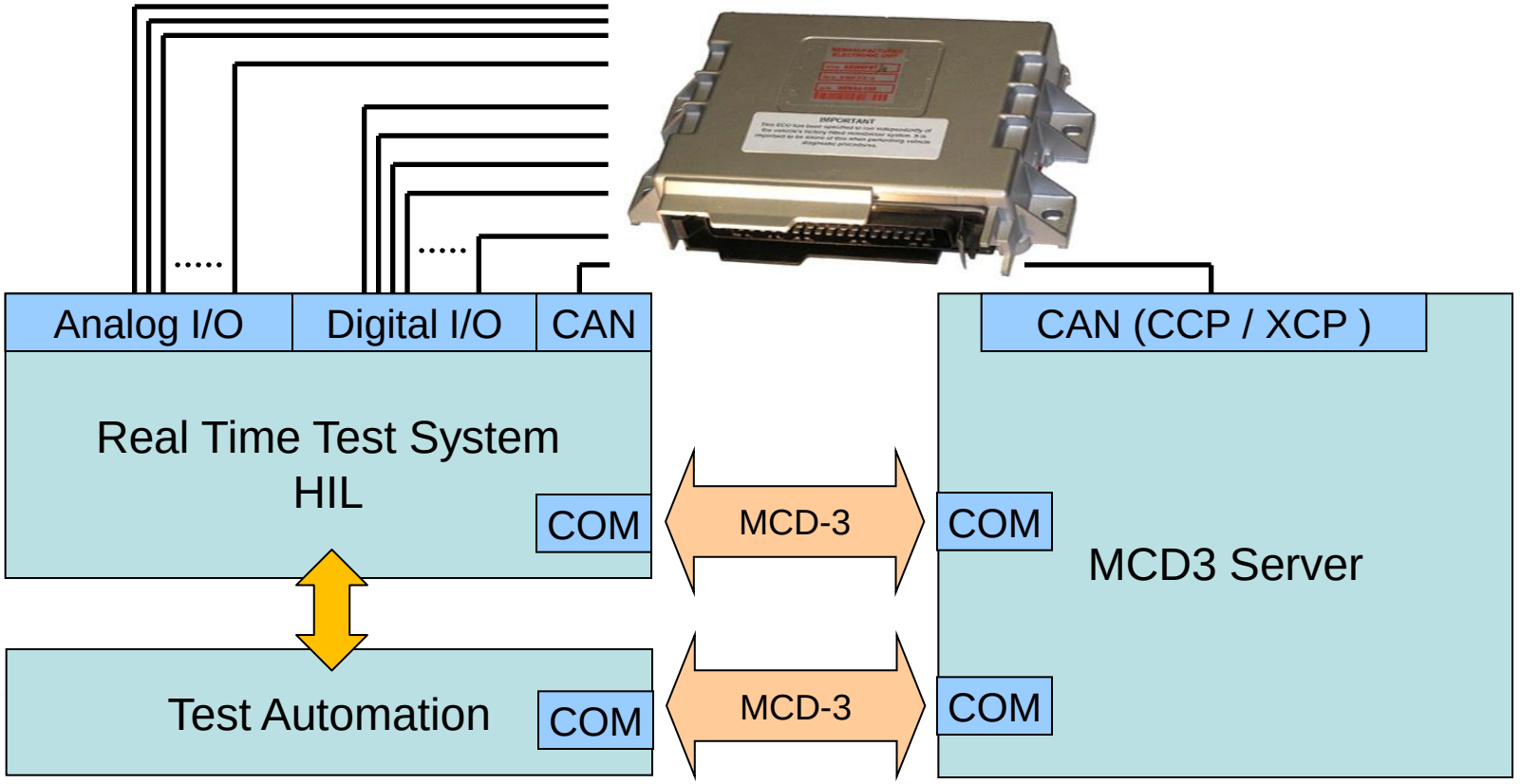
Historical Windows ECU Test System incl. ECU Measurements and Calibration (MC)



Test System Historical

- Test automation Server and Test Execution (HIL System)
  - Single Windows PC plus optional Embedded System (proprietary real time hardware)
- Calibration System
  - Windows PC connected to Test Automation via e.g. Ethernet / DCOM / MCD3
- Not deterministic

Historical Real Time Test System incl. ECU Measurements and Calibration (MC)



Real Time Test System Historical

- Test automation Server
  - Windows PC
- Real Time Test Execution / HIL System
  - Embedded Test System (proprietary real time hardware)
- Calibration System
  - Windows PC connected to Test Automation and Real Time System via e.g. Ethernet / DCOM / MCD3
- Disadvantage: non deterministic link between Test Automation / Test System and MC System
  - Complex System Integration

Test System Requirements Today

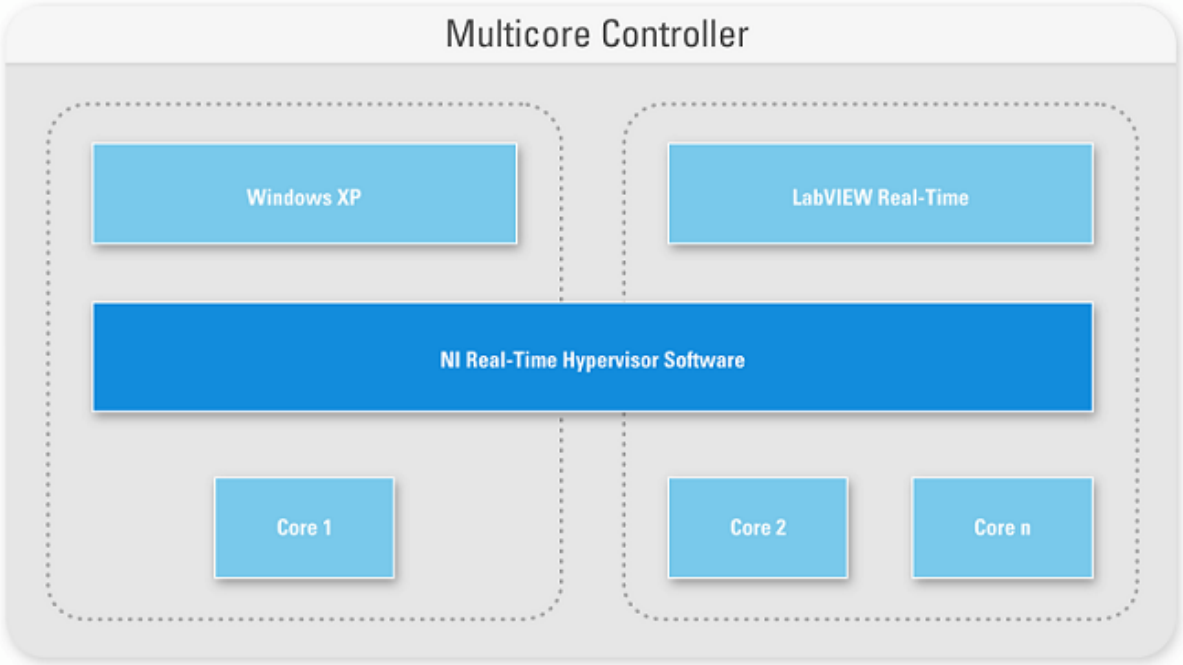
- Open Architecture
- Extendable
- Run-time Editable User Interface
- User Management
- Scalable
- Real-Time Stimulus Generation
- Data Logging in Real-Time
- Configurable I/O
- Closed-Loop Control
- Deterministic Execution

Real-Time Testing and Simulation Software

National Instrument: Test Systems

- Windows PC (LabVIEW, TestStand)
- Real Time (LabVIEW RT, NI-VeriStand)
  - Office/Lab: Desktop
  - Industrial: PXI
  - Embedded Target
    - FPGA (Compact RIO)
- Hybrid (Hypervisor)
  - Windows and Real Time System on same target
  - Windows: LabVIEW and/or TestStand
  - Real Time Target: LabVIEW RT or NI-VeriStand

NI Real-Time Hypervisor for PXI



Multicore PXI Controllers

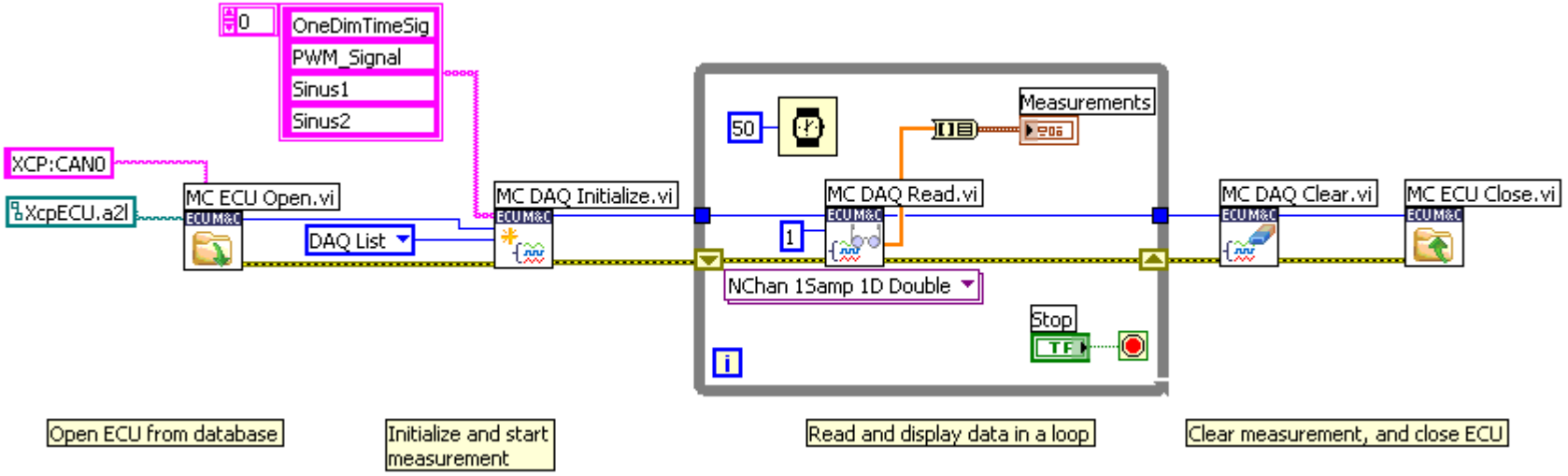
NI Industrial Controller

National Instrument: ECU Calibration

- **ECU Meaurement and Calibration Toolkit**
  - High-level API for Measurement and Calibration Applications
  - CCP and XCP Master
  - Access of ECU internal data
    - Measurements (DAQ-List)
    - Characteristics (1D, 2D, 3D)
  - Support of ASAM A2L database file configurations
  - Runtime Enviroments
    - Windows (C/C++, CVI, LabVIEW)
    - LV Real Time, LabVIEW FPGA (e.g.Compact RIO)
  - Supported Hardware
    - NI-CAN, NI-XNET, NI USB-CAN
    - XCP: Ethernet

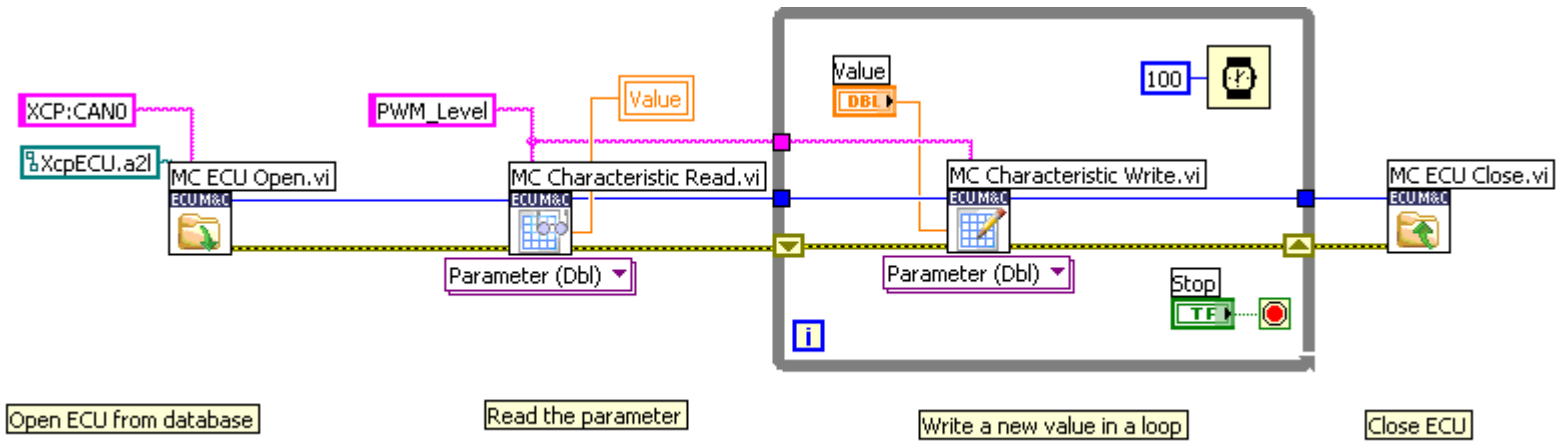
ECU MC Toolkit API for LabVIEW

- Easy to use API
  - Channel Name based
- Example: DAQ-List Read



ECU MC Toolkit API for LabVIEW

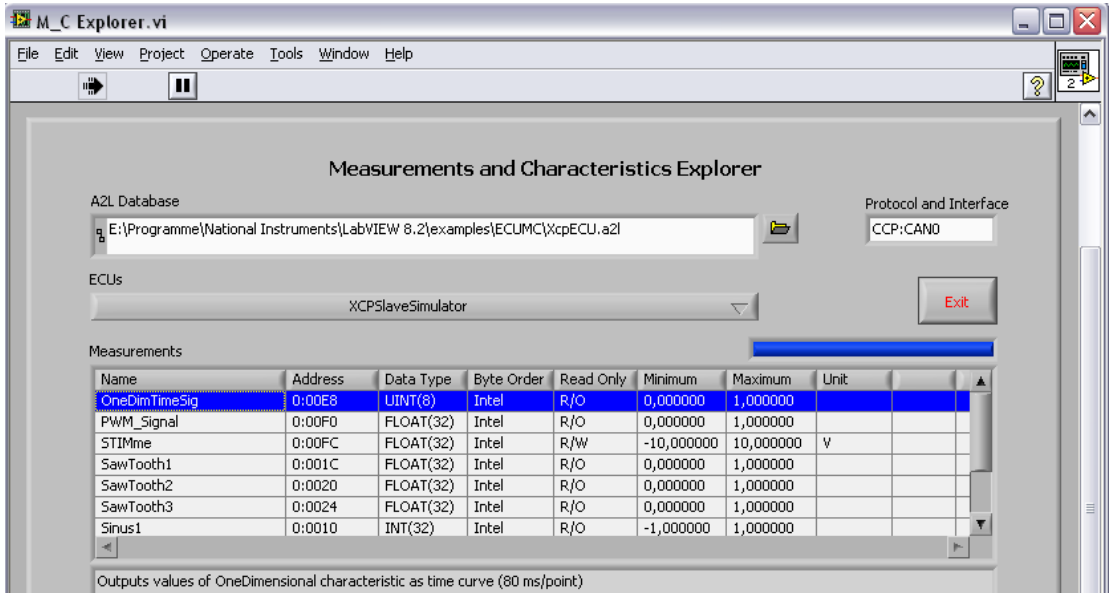
- Characteristic Read/Write



ECU MC Toolkit API

A2L Database Access

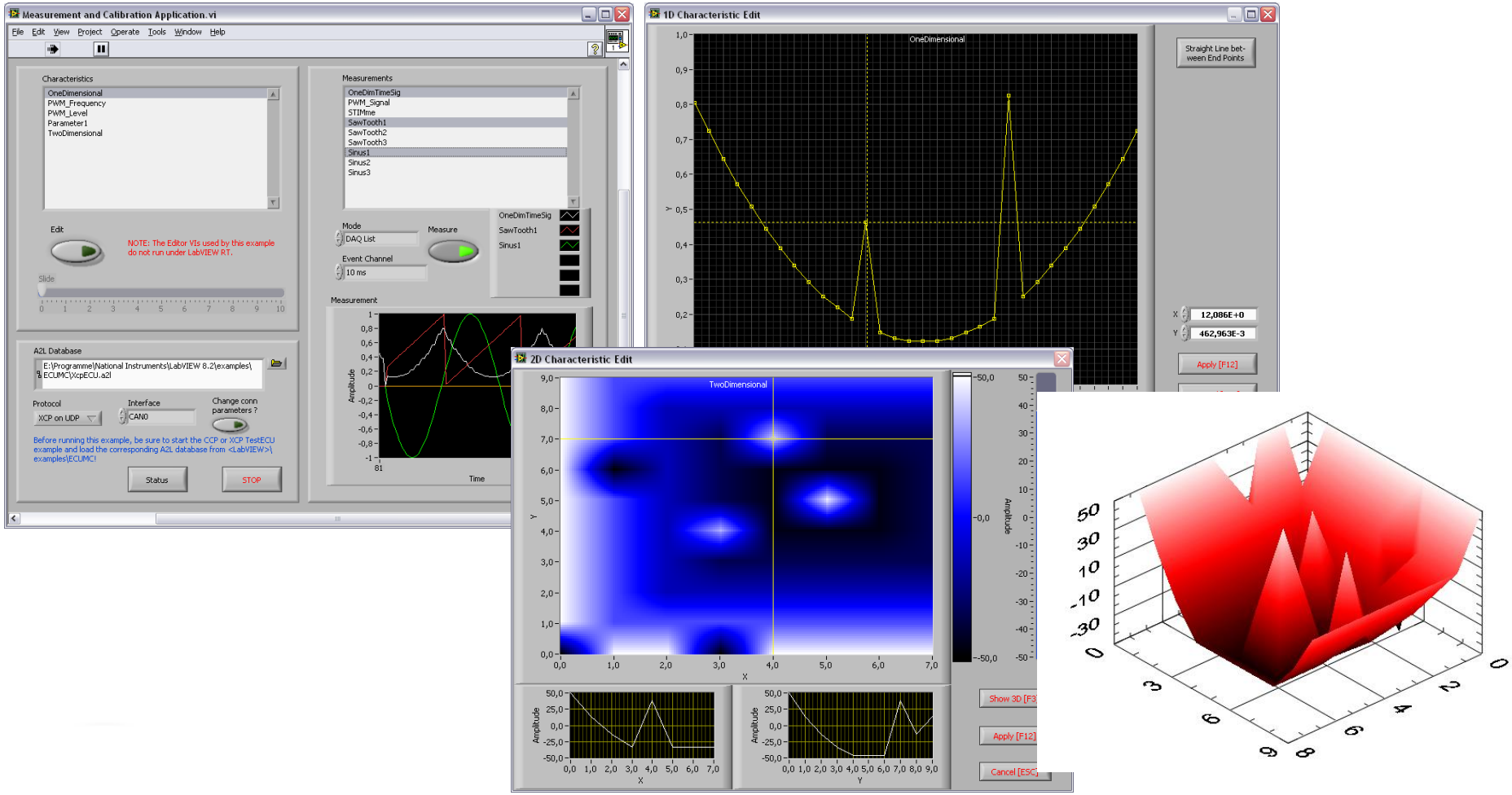
Example: Datenbase Browser



Characteristics

Name	Address	Data Type	Byte Order	Read Only	Minimum	Maximum	Dimension	Unit
OneDimensional	0:00C8	UINT(8)	Intel	R/W	0,000000	1,000000	32	
PWM_Frequency	0:00F4	FLOAT(32)	Intel	R/W	0,500000	2,000000	-	
PWM_Level	0:00F8	FLOAT(32)	Intel	R/W	0,000000	100,000000	-	%
Parameter1	0:00EC	INT(32)	Intel	R/W	0,000000	1000,000000	-	
TwoDimensional	0:0028	INT(16)	Intel	R/W	-50,000000	50,000000	8x10	

ECU Calibration with NI-LabVIEW



Integrated MC Test System with NI Components on Windows

CAN Bus

Analog I/O	Digital I/O	CAN	CAN (CCP / XCP)
NI DAQmx		NI-XNET	NI ECU MC Toolkit

Test System

Restbus Simulation, HIL

Integrated MC Test System with NI Components on Real Time Target

CAN Bus

Analog I/O	Digital I/O	CAN	CAN (CCP / XCP)
NI DAQmx		NI-XNET	NI ECU MC Toolkit

Real Time Test System

Restbus Simulation, HIL, Stimulation

Test Automation

LabVIEW RT

Windows

NI Hypervisor

Windows & LabVIEW RT

Summary

- High performant ECU Test Execution and ECU Calibration is possible on a single target
- Combine Real Time Test and ECU Calibration
  - Deterministic execution of test and calibration
  - Hybrid (NI Hypervisor)
    - Test Automation, Test Execution and ECU Calibration on same target
  - LabVIEW (RT) plus ECU Measurement Calibration Toolkit
    - Supports all various OS and Hardware targets