HIL
Hardware-in-the-loop system for Automotive ECU testing and validation
What we offer
Custome made Hardware-in-the-loop systems for Automotive ECU testing and validation, based on National Instruments hardware and in-house designed hardware and software solutions.

FEATURES
The HIL system is based on National Instruments VeriStand software platform. The typical hardware solution is based on NI PXI chassis and real-time controller with the addition of other I/O modules from National Instruments, third party manufacturers and Alma Automotive’s custom devices.

Exemplary list of features that can be modified based on specific user needs:
• Real time controller with last generation processing power (up to quad core CPUs)
• Easy system definition with VeriStand System Explorer interface
• Base system configuration (step-time, cpu allocation)
• HW channels definition (analog, digital, CAN)
• Model DLL import from any supported modeling environment
• User and calculated channels definition
• Channel mappings

SOFTWARE REQUIREMENTS
NI VeriStand Deployment or Full Development license.

• Custom devices setup
• Stimulus profile editor
• Data logging
• Flexible GUI for easy run-time customization of the workspace
• FPGA based engine simulation
• Fault insertion units:
  • 32 channels power FIU, with 2 general purpose buses + open circuit, 20A capable and current sensing capability
  • 64 channels sensors FIU, 2 general purpose busses with 4 general purpose buses + open circuit, 2A capable
  • Make-before-break switch operation
  • User selectable fault current limiting with feedback signals
• High resolution resistor simulation
• Lambda simulation (HEGO/UEGO)
• Standard communication bus (CAN, Ethernet, RS232, CCP, LIN)
• Rugged desktop rack enclosure
Supported modeling environments
Lists of supported modeling environments, tested and verified to be able to create compiled models that can be imported in NI VeriStand:

- LabVIEW
- LabVIEW Control Design and Simulation Module
- The MathWorks, Inc. Simulink® software
- SimulationX from ITI
- Dymola from Dynasim
- Esterel SCADE Suite Software
- C/C++
- GT-POWER from Gamma Technologies
- AMESim from LMS
- AVL BOOST
- AVL CRUISE
- Rational Rhapsody from IBM
- MapleSim from MapleSoft
- Dynacar from Tecnalia
- CarSim from Mechanical Simulation
- VI-CarRealTime from VI-Grade
- JMAG RT FEA models from JMAG
- TESIS DYNAware software
- Fortran
- MATRIXx SystemBuild
- Carmaker from IPG
- EcoSimPro from EA Internacional.

HIL Targets

VEHICLE ELECTRONICS TESTING

ECU SOFTWARE DEVELOPMENT

END OF LINE TESTING

ECU SOFTWARE VALIDATION

Alma Automotive’s custom HIL
Case Study: End-of-Line Test

THE CHALLENGE
Developing an End-of-Line system for functional validation of all ECU’s inputs and outputs
Case Study: End-of-Line Test

**THE SOLUTION**

- Full simulation of ECU input signals
- Full simulation of ECU electronic loads
- Fault insertion units over all channels
- Automated test procedure for the full ECU diagnosis

**SW**

- RT OS ✧ Pharlap
- RT execution and user interface ✧ NI VeriStand/LabVIEW
- Signals simulation ✧ NI VeriStand custom device: crankshaft and camshaft sensors, manifold air pressure, ION current signal
- ECU signals acquisition ✧ NI LabVIEW: ignition and injection tracking
- Fault Insertion Units boards ✧ NI VeriStand custom device
- Variable resistor boards ✧ NI VeriStand custom device
- Test report ✧ NI LabVIEW
- Vehicle model ✧ Matlab/Simulink.

**HW**

- Power supply ✧ SM52-AR-60 1500W-DC Delta Elektronika
- Controller ✧ PC desktop RT
- PXI Chassis ✧ NI PXI-1033 (7 Slot)
- FPGA Virtex-5 LX85 FPGA (8 AI 16bit), 8AO(16bit), 96 DIO ✧ NI PXI-7853R (signal processing 40 Mhz)
- Analog Input / Digital I0 ✧ NI PXI-6254 (32 AI 16bit, 48 DIO)
- Analog Output / Digital I0 ✧ NI PXI-6723 (32 AO 13bit, 8 DIO)
- CAN Interface ✧ NI PXI-8513/2
- LIN Interface ✧ NI PXI-8516/2

Custom boards

- AI conditioning (AI ±10V, ±40V, ±80V, ±400V)
- AO HV conditioning (±10V, ±40V)
- DI conditioning (5V-18V, programmable threshold (0-4V))
- DO conditioning (5-18V push pull)
- Signal FIU (3x 32ch, up to 2Ampere)
- Power FIU (2x 16ch, up to 20Ampere)
- Variable resistor (5ch(16bit), 0-655350hm).
Case Study: Vehicle electronics testing

THE CHALLENGE
Developing a system to simulate ECU fault conditions with the aim of developing recovery strategies and fault models of vehicle electronic components.
Case Study: Vehicle electronics testing

**THE SOLUTION:**
- Full simulation of ECU input signals with possible switching on real sensors
- Full simulation of ECU electronic loads with possible switching on real electronic loads
- Complete Breakout box for all ECU’s pins
- Fault insertion unit over all ECU channels
- Swappable electronic load boxes

**HW**
- Power supply → 2x TTI, CPX400DP, 420W DC
- Controller → NI PXI 8135
- PXI Chassis → NI PXI-1078 (7 Slot)
- MXI Express BUS → NI PXI-8364
- Variable resistor → NI PXI-2727
- CAN Interface → 3x NI PXI-8512/2
- Signal FIU → NI 2510 (2x 68ch, up to 2A)
- MXI Express expansion chassis → NI 9157 (14 slot)
  with FPGA LX85 (signal processing 40MHz)

**NI FPGA Modules**
- Analog Input → 2x NI 9205 (32ch, ±200mV to ±10V; 16 bit)
- Analog Input HV → NI 9221 (±60V, 800ks/s, 8ch)
- Analog Output ch-ch isolated → NI 9269 (±10V, 4ch)
- Analog Output → 2x NI 9264 (±10V, 25Ks/s 16ch)
- Differential Digital Input → 3x NI 9411 (±5 to 24 V; 6ch)
- Digital Input sinking → 2x NI 9437 (24 to 250 VDC, 8 ch)
- Digital IO → NI 9403 (5V TTL, 32ch)
- Digital Output sinking → NI 9477 (60V, 32ch).

**Custom boards**
- AO HV conditioning (±10V, ±40V)
- Power FIU (6x 8channels, up to 40Ampere + current sensing)
- Breakout box boards
- Lambda simulation

**SW**
- RT OS → Linux RT
- RT execution and user interface → NI VeriStand/LabVIEW
- Signals simulation → NI VeriStand custom device
- Fault Insertion Unit boards → NI VeriStand custom device
- Variable resistor boards → NI VeriStand custom device
- Target generation → stimulus profile editor
- Vehicle model → Matlab/Simulink.
Case Study: ECU SW DEVELOPMENT

THE CHALLENGE
Developing a compact system to simulate ECU input signals and monitor output signals status.
Case Study: ECU SW DEVELOPMENT

THE SOLUTION

• Full simulation of ECU input signals
• Complete monitoring of HIL outputs
• Power supply of the Device Under Test and electronic loads carried out separately through an external device
• Compactness required achieved thanks to NI cRIO platform

SW

• RT OS ➔ Linux RT
• RT execution with basic GUI for RT application visualization, with monitor directly connected to the HIL system ➔ NI LabVIEW
• Signals simulation ➔ NI LabVIEW: crankshaft and camshaft sensors, manifold air pressure, ION current signal
• ECU signals acquisition ➔ NI LabVIEW: ignition and injection tracking
• Data logging ➔ NI LabView
• Vehicle model ➔ Matlab/Simulink.

HW

• 4U rack mountable desktop chassis
• Controller ➔ cRIO 9035
• FPGA ➔ Xilinx Kintex-7 70T (signal processing 40MHz)

NI FPGA Modules

• Digital Output sinking ➔ NI 9477 (60V, 32ch)
• Analog Output ➔ NI 9264 (±10V, 25Ks/s 16ch)
• CAN ➔ NI 9860 (2-port CAN HS/FD and/or LIN interface)
• Digital IO ➔ NI 9403 (5V TTL, 32ch)
• Analog Input ➔ NI 9205 (32ch, ±200mV to ±10V; 16 bit)
• Resistance simulation Wireflow WF3144 (Range: 16-160 Ohm).

Custom boards

• AI conditioning (16ch RSE e 8ch diff with selectable gain ±8V, ±40V, ±200V e ±400V in high gain e ±400mV, ±2V, ±10V e ±20V in low gain)
• DI conditioning (selectable threshold, Hight voltage protection up tp 300V, galvanic isolation).
Case Study: ECU HW/SW VALIDATION

THE CHALLENGE
Developing a system to simulate nominal ECU working conditions, for software validation and fault conditions analysis.

CUSTOM HIL: TEST FAULT E COMPONENTI
- Engine Simulation
- Vehicle Simulation

SW Control

Input / Output HW

INPUT: STIMULUS PROFILE
OUTPUT: TEST LOG

ECU
Case Study: ECU SW DEVELOPMENT

THE SOLUTION
- Full simulation of ECU input signals
- Full simulation of ECU electronic loads
- Complete Breakout box for all ECU’s pins
- Fault insertion unit over all ECU channels
- Swappable electronic load boxes

SW
- RT OS ➔ Pharlap
- RT execution and user interface ➔ NI VeriStand/LabVIEW
- Signals simulation ➔ NI VeriStand custom device
- Fault Insertion Units boards ➔ NI VeriStand custom device
- Variable resistore boards ➔ NI VeriStand custom device
- Target generation ➔ stimulus profile editor
- Vehicle model ➔ Matlab/Simulink

HW
- Power supply ➔ SM 18-50 800W-DC Delta Elektronika
- Controller ➔ PC desktop RT
- PXI Chassis ➔ NI PXI-1033 (2x7 Slot)
- Analog Input / Digital IO ➔ NI PXI-6224 (32 AI 16bit, 48 DIO)
- Analog Output / Digital IO ➔ NI PXI-6723 (32 AO(13bit), 8 DIO)
- CAN Interface ➔ NI PXI-8512
- CAN Interface ➔ NI PXI-8512/2
- FPGA Virtex-5 LX85 FPGA (8 AI 16bit, 8AO 16bit), 96 DIO ➔ NI PXI-7842R; (signal processing 40MHz)
- Variable resistor ➔ Pickering 40-295-021-5/16 (5ch 16bit), 0-655350hm
- Signal FIU ➔ NI 2510 (2x68ch, up to 2A).

Custom boards
- AI conditioning (AI ±10V, ±40V)
- AO HV conditioning (±10V, ±40V)
- DI conditioning (5V-18V, programmable threshold (0-4V))
- DO conditioning (0-Vbatt)
- Power FIU (16ch, up to 20Ampere)
- Breakout box
Originally established as a spin-off of University of Bologna, Alma Automotive represents the synergy between knowledge acquired in academic research activities and years of experience in developing applied solutions. The company has now evolved to offer both ready-to-use products and engineering services supported by bespoke hardware and software solutions. Highly oriented towards new challenges, Alma Automotive’s mission is to provide innovative solutions and tools to help customers in the development of ever more efficient engines and powertrains. Our partnership with National Instruments and the strong relationship we have with top-tier automotive companies is testimonial to the high level of skill and quality of services offered to our clients.