HIL
Hardware-in-the-loop system for Automotive ECU testing and validation
What we offer

Custom 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 an NI MXI or cRIO 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
- 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:
  - Power FIU, with 2 general purpose buses + open circuit, up to 50A capable and current sensing capability independent for each channel
  - Signal FIU, 2 general purpose busses + open circuit, 5A 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

SOFTWARE REQUIREMENTS

NI VeriStand Deployment or Full Development license.
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
- END OF LINE TESTING
- ECU SOFTWARE DEVELOPMENT AND VALIDATION

Alma Automotive's custom HIL
Modular HIL platform

Modular HIL platform, built by four subsitems: the composing modules will be chosen to fit exactly your application.

- **LOAD RACK MODULE**
  - Fast LOAD RACK change to rearrange the application
  - Custom made

- **FIU MODULE**
  - Up to 256 channel per rack, multiple rack stackable
  - Up to 50A FIU channels
  - Independent current reading for each channel
  - 2 fault bus operation, no simultaneous fault limit

- **CORE MODULE**
  - Support signal conditioning & real-time calculation
  - Up to 400 channel per rack, multiple rack stackable
  - Wide range of conditioning modules available
  - Compact size for on-desk developers applications (3U chassis)

- **BOB MODULE**
  - Optional Break Out Box Module
All the signal conditioning you need

- Low Voltage Analog Input module: 32 ch. 16 bit up to 10 KS/s
- High Voltage Analog input module: 32 ch. up to 350V
- Analog output module: 16 ch. Signal generation
- VRS output module: ±40V up to 100 KS/s signal generation
- Digital Input Module: 32 ch. up to 350V
- Digital Output Module: 32 ch. Module
- Lambda simulation module: simulation of HEGO, UEGO sensors
- Resistance simulator: wide range simulation 0 Ω to 65 KΩ, 16 bit
- Current sensor simulation module: up to 4 ch 16 bit, 0 – 20 mA
- CAN / LIN communication module: CAN LS/FT, HS/FD an LIN communication bus
- Custom conditioning modules available on request

All the computational power you need

We can tune the computational power of the system on request.
The National Instruments multi-platform approach makes it possible to scale the real time processor, from Arm® based computers to the latest Intel® based platforms.
The system also includes a powerful FPGA to meet the harshest demands about the real time response.
Case Study: End-of-Line Test

THE CHALLENGE
Developing an End-of-Line system for functional validation of all ECU’s inputs and outputs.

CUSTOM HIL: EOL AUTOMATED TEST

- Engine Simulation
- Vehicle Simulation
- Control Software
- Input/Output Hardware

ECU

INPUT: TEST LIST

OUTPUT: TEST RESULT TEST LOG
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), 8A0(16bit), 96 DIO ➔ NI PXI-7853R (signal processing 40 Mhz)
- Analog Input / Digital IO ➔ NI PXI-6254 (32 AI 16bit, 48 DIO)
- Analog Output / Digital IO ➔ 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), 0-65535Ohm).
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

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.

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
Case study: ECU SW development and validation

THE CHALLENGE
Developing a compact system to simulate ECU input signals and monitor output signals status.
Case study: ECU SW development and validation

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, High voltage protection up tp 300V, galvanic isolation).
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.