

Hardware-In-the-Loop Test system for Driveline ECUs

Overview

Hardware-In-the Loop (HIL) testing has been an important part of design verification for many years.

A faster product development cycle makes the life expectancy of traditional turn-key solutions shorter and this requires a more open and flexible solution that more easily can adapt to future products testing demands.

The Challenge

- Develop a flexible HIL system based on an open architecture.
- It shall be able to emulate all sensors and actuators normally connected to the ECUs.
- It shall be able to generate all bus traffic normally flowing in a vehicle.
- It shall be capable of running dynamic models simulating the behaviour of the engine and gearbox as well as the rest of the vehicle and its environment.
- It shall be reconfigurable so that it can be changed to test a different type of engine or gearbox within minutes.

System Description

- Hardware built in a 19" rack based on our xMove concept and the open PC-based platform PXI.
- All software in the system is developed using LabVIEW.



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- The ECUs have 200 pins connected to the HIL system, with complete fault injection on each pin.
- All electrical loads are put in a separate load box for easy reconfiguration of the system.
- All I/O is implemented by C-series modules in expansion chassis connected to FPGA boards, ensuring galvanic isolation and flexibility.
- The FPGAs have 300 electrical I/O channels emulating all sensors and actuators on the ECUs.
- Four J1939/CAN buses and one J1587 bus have together over 350 signals in periodic frames.
- The Simulink model simulating the engine, gearbox and truck environment has 300 inputs and outputs and runs at a loop frequency of 1 kHz.
- The HIL system has over 1000 variables that handle scaling and routing between the FPGA/J1939/J1587 I/O and Simulink model inputs and outputs, all calculated every 1 ms.
- Custom sensor signals like camshaft, crankshaft, lambda, knock and several complex inductive sensors are generated by software in the FPGA.
- Complex actuator measurements like injector pulse length and filtered PWM frequency and duty cycle are implemented by software in the FPGA.
- The PXI PC runs a real-time OS and handles all I/O and model execution at a rate of 1 kHz.
- An external Windows PC connected via Ethernet is used for control and supervision, data logging, test case execution and GUIs.

Results

- Built with industrial off-the-shelf components on an open software platform and leveraging the latest PC technology, it is more flexible and has higher performance than the previous solution.
- Five HIL simulators are currently in Brazil, France, US and Sweden.

