MORE AUTOMATION for ECU testing

The latest fault-insertion tests enable engineers to run more test cases in less time.

by Keith Moore

Testing control software for driveline ECUs (BorgWarner transfer case shown) has been made more efficient using automated FIUs.

Testing safety-related Electronic Control Units (ECUs) is as much about software testing as hardware. Increased intelligence within ECUs to control braking, prevent rollovers and ensure that power is applied to the correct wheels is critical. Automotive Tier 1s such as **Delphi**, **Magna Powertrain** and **Continental** share these concerns.

Transfer cases for four-wheel-drive and all-wheel-drive vehicles are a mechanical/electronic device that monitors wheel slippage and ensures that torque is transferred to the wheels that are not slipping. A transfer case ECU connects to sensors and actuators, as well as interfaces with the vehicle's network. When a driver shifts into gear, the ECU determines if it can perform this shift. Upon completion, the ECU reports this to the network.

In operation, many different faults can occur. For example, consider that cable connections can fail open, short to adjacent conductors, and high-resistance connections. To ensure that the transfer case will operate safely under fault conditions, manufacturers simulate these faults.

In some cases, a driveline system supplier may develop a test fixture that allows engineers to manually inject faults into the transfer unit during testing. Such manual switching-in of faults is time-consuming and limits the number of tests that the engineers can run. It is also prone to operator error.

"As automotive ECUs get more complex and intelligent, our customers keep asking for newer fault-insertion switching scenarios," noted Paul Bovingdon, Simulation Product Manager at **Pickering Interfaces**, a U.K.-based provider of modular signal switching and simulation for electronic test and verification. "Clearly, there is a trend for more test automation to allow for more in-depth ECU testing in shorter time."

ECUs under development typically are exercised using Hardware-in-the-Loop (HIL) simulation, a test system that simulates the device that the unit will control. Stimulus instrumentation that simulates engine behavior, for example, is connected and controlled either by manual operation or by computer with measurement instrumentation used to capture analog and digital responses from the ECU. When it is necessary to inject faults, traditionally a patch panel, has often been used.

Such a solution has many inherent disadvantages including lack of repeatability, size, on-going maintenance issues, the need for significant knowledge on the part of the operator, potential human error and the labor cost required to execute the test and record results.

The way forward in HIL simulation is to use Fault Insertion Units (FIU), modules that introduce electrical faults, simulating issues like corrosion, short/open circuits and other electrical failures. Testing with the FIUs is more repeatable, comprehensive and finds problems earlier, Bovington claims.

Back to the transfer-case ECU testing, from an actual scenario. The test fixture was inserted between a transfer case and its ECU. A technician would manually switch faults in and out. This limited the number of tests cases that they could run because of slower test times, and was prone to operator error.

The test fixture had issues—the engineers could not insert resistive faults and it took up to eight minutes to run a single test case. Since the driveline supplier runs thousands of tests, it was clear they had to find a way to reduce test times.

Automating fault insertion

After evaluating several switching systems, the driveline-systems supplier purchased from Pickering a PXI chassis

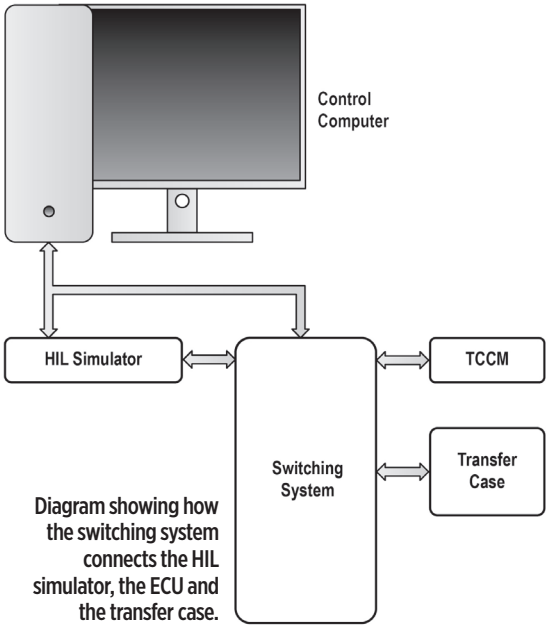
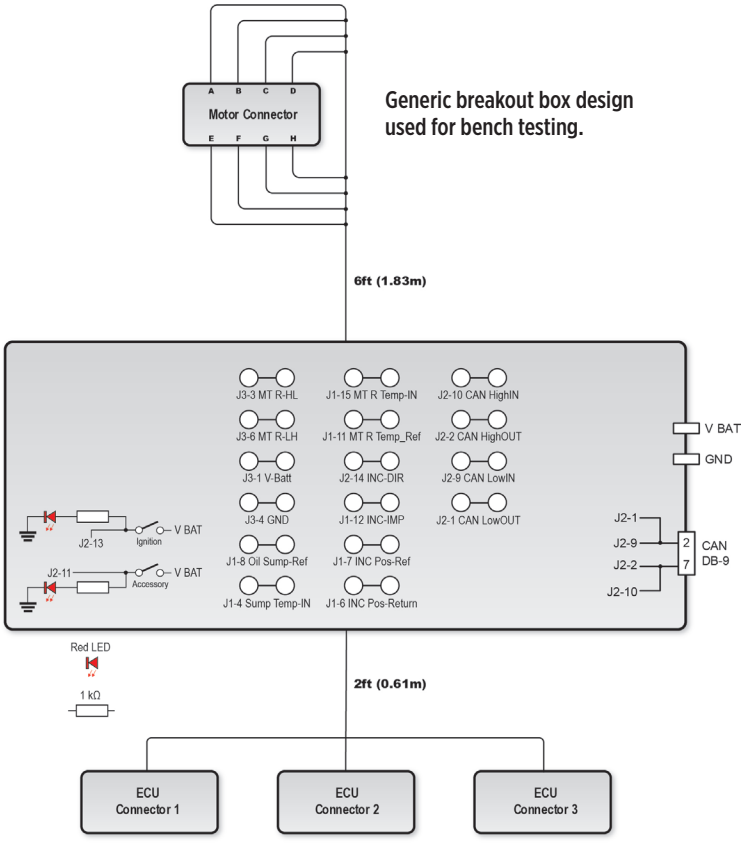


Diagram showing how the switching system connects the HIL simulator, the ECU and the transfer case.



Generic breakout box design used for bench testing.

populated with several 40-191 FIU Switch Modules to simulate shorts and opens. The 40-191 features solid-state switching elements and is capable of carrying 40A on single channel. The module allows each channel of the test system to send signals to the UUT or open-circuit.

Fault-insertion buses allow any channel to be shorted to any other channel. They also enable any channel to be connected to an external signal such as Power, Ignition or

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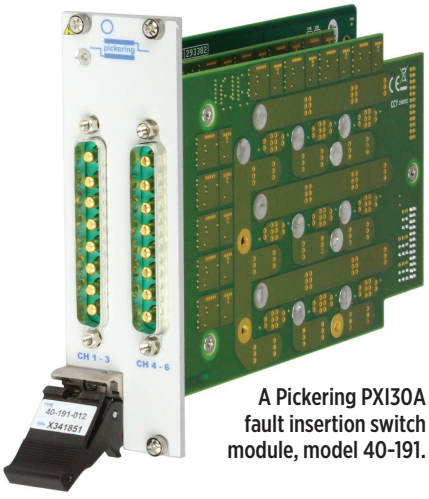
Ground to simulate fault conditions. A Programmable Resistor Module (40-295) made by Pickering was selected to simulate resistive faults.

To inject open faults, engineers simply open a line. To short two lines, they connect each of the two lines to one of the module's fault busses. To simulate a short to power or ground, they connect the signal line to one of the fault busses and then connect that bus to ground or to an external voltage.



A Pickering PXI30A fault insertion switch module, model 40-191.

To inject a resistance fault into one of the signal lines running between the transfer case and the transfer case ECU, the computer would switch in one of the variable resistors on the 40-295, then vary the resistance in steps until the line reacts like an open circuit.

Once a fault is inserted, engineers run one or more driving scenarios and gather test data. By automating the fault insertion, the time it takes to run a single test has been cut from eight minutes on average to around four minutes. Considering that the test might include 20,000 tests and take more than a month to run, the savings are clear.

Analyzing the test results

The first thing engineers look for is whether the test has caused any damage to the ECU. If no damage is found, they start analyzing the test data. Particularly interesting are the CAN signals and overall behavior. What they are looking for is data that would indicate unintentional changes as well as the appropriate diagnostic codes.

The supplier's engineering team was very pleased with the way that the Pickering switching system automated their test. Based on this success they are working on a "universal" test system for their transfer cases. Using a switching system, they feel that they can accomplish this. ■

Keith Moore is CEO of Pickering Interfaces