Testing for the Unexpected Using PXI

An Automated Method of Injecting Faults for Engine Management Development

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What will happen if a fault occurs in an automotive vehicle's electrical system? Similarly, and potentially on a more catastrophic scale, what will happen if this kind of fault were to occur in a military or commercial aircraft? Key questions, requiring straightforward answers. Fault simulation during the design and validation of Engine Control Units (ECUs) is one method of establishing solid predictions, ultimately ensuring the safety of driver/pilot and passengers. In this article, Shaun explains the need for fault insertion testing and how a switching solution is enhancing test capability in this domain.

High Reliability Requirement

Engine control units (ECUs) are present in many applications today, often involving safety-critical considerations demanding high predictability and reliability of operation in environments where unexpected behaviour cannot be tolerated! Typical applications include avionics, automotive and the operation of heavy machinery in freight terminals. These environments exhibit a high level safety sensitive aspect, where the failure of an ECU to act in an appropriate manner under emergency conditions could pose a threat to life and/or property, justifying any increased cost of test. There are many examples of where the safety-critical operation of an ECU is important.

For avionics, one such example is the design validation of a Full Authority Digital Electronic Controller (FADEC) for a jet aircraft engine. The FADEC is effectively a jet engine's brain, controlling all aspects of an aircraft's engine performance while providing complete redundancy for safety critical reliability. Understandably there are stringent government regulations concerning the testing of FADEC modules for commercial aircraft, requiring safe or controlled operation under a wide range of hardware fault conditions.

An example of where fault insertion is currently used in the automotive industry, is part of the overall testing of Powertrain Control Modules (PCMs). The PCM is one of the most complex electronic control units in the modern vehicle, requiring a rigorous and thorough testing of its functionality. The consequences of PCM failure will potentially have greater significance in X-by-Wire applications (a collective term for the addition of electronic systems into a vehicle to enhance and replace tasks that were previously accomplished via mechanical and hydraulic systems such as braking or steering), placing increased importance upon these test methods.

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Due to the high level of sophistication and complexity of today's ECU devices, special test methods are required. An important aspect of ECU testing involves the introduction of electrical faults into a system, simulating various conditions which could potentially occur because of corrosion, short/open circuits and other electrical failures inherited through age, damage or even faulty installation.

Fault insertion testing is an important aspect of ECU validation and the idea of testing for system failures is not new. Traditional test methods often involve the manual insertion and extraction of cables to and from a patch panel, which is far from ideal. Not only is this method of testing prone to human error, it is time consuming - and time is money. Targeting ECU validation, the Pickering Interfaces PXI Fault Insertion BRIC™ switching solution enables a far more sophisticated testing approach for these real-world scenarios.

Traditional Solution

Typically, ECUs under development are exercised by a test system which simulates the engine that the unit will control. Stimulus instrumentation simulating engine behaviour is connected and controlled either by manual operation or computer, with measurement instrumentation used to capture analogue and digital responses from the ECU.

When it is necessary to inject faults, most laboratories utilize a patch panel (an example is shown in Figure 1). The various cables shown may be used to connect any input/output (I/O) line on an ECU to stimulus or measurement instrumentation. The I/O lines may be disconnected to simulate an open-circuit or tied together to simulate short-circuits (to ground, voltage source or between I/O lines). An engineer would move the patch cables to simulate a desired fault and then measure the results. This type of solution has many inherent disadvantages.

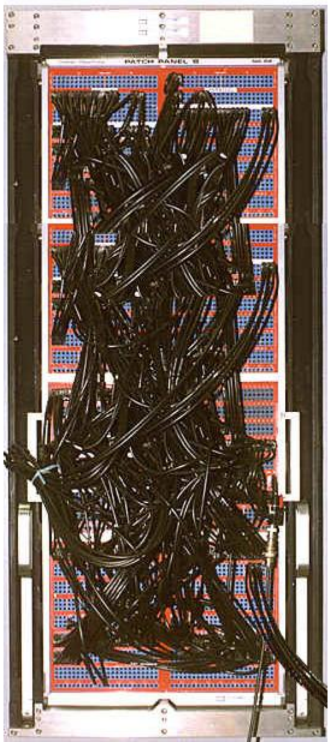

Figure 1

An immediately obvious disadvantage is size, i.e. patch panels tend to be large. Additionally, several ‘hidden cost’ issues also spring to mind such as; maintenance, knowledge, potential human error and the cost of labour required to accomplish the tests and record results. Over a period of time, patch panel maintenance issues are extremely likely to arise. Any such maintenance will often demand many hours of labour, not only to repair faults but also to correct mistakes. The patch panel style of solution requires a significant knowledge base, hence long periods of user training are associated with operation and maintenance. A very significant final disadvantage, is the lack of repeatability, which would otherwise be a major advantage in the repetition of various fault conditions (either for any corrective action that needs to be undertaken or for tests which need to be repeated as part of any ongoing verification or upgrade programme).

The ability to program under software control instrument signal routing combined with the real-time insertion of all types of electrical faults, would inevitably enhance both the testing process and the recording of the outcome. Although a standard crosspoint matrix with adequate specifications may be capable of handling the instrument routing, the fault insertion requirement typically demands additional capability.

New Thinking

Our design engineers were tasked with simplifying the above needs for a major aerospace customer, who wished to automate fault insertion via the use of a custom Pickering Interfaces switching solution, overcoming the disadvantages associated with traditional test methods. The approach we chose was to enhance our BRIC™ family of crosspoint matrices.

Fault Insertion BRIC™ Solution

The testing requirements of ECUs have grown significantly in recent years. Development of sophisticated ECUs require the engineer to test the unit, not only in a normal operating environment, but also to discover how the unit performs when things go wrong.

For such test requirements, Pickering Interfaces developed the Fault Insertion BRIC™, a scalable solution which may be used to switch signals between simulations and real-life devices in a multitude of hardware-in-the-loop (HIL) simulation and test systems. HIL testing enables the user to put an ECU through test scenarios identical to those carried out in ‘engine test stand’ testing, with substantial reductions in cost and risk, along with a lower burden on human and mechanical resources. The Fault Insertion BRIC™ switching solution can help to considerably simplify and accelerate the testing, diagnosis and integration work in HIL applications.

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Based upon the BRIC™ architecture, the Fault Insertion BRIC™ is available with maximum switching capacities of 1A and 10A. A typical Fault Insertion BRIC™ application is to assist in routing electrical fault simulation to high pin-count ECUs in automotive and aerospace applications, valuable to customers with rigorous fault testing requirements. These faults include those found in cable harnesses such as open-circuits and short-circuits (to ground, to battery or between I/O signal lines).

A simplified functional schematic of a Fault Insertion BRIC™ is shown in 'Figure 2'. Fault insertion and measurement are performed via the Y-axis, connection to the ECU via the X-axis. The X-axis also has a breakout facility (3-pin in this illustration), allowing the interruption of I/O signals to the ECU.

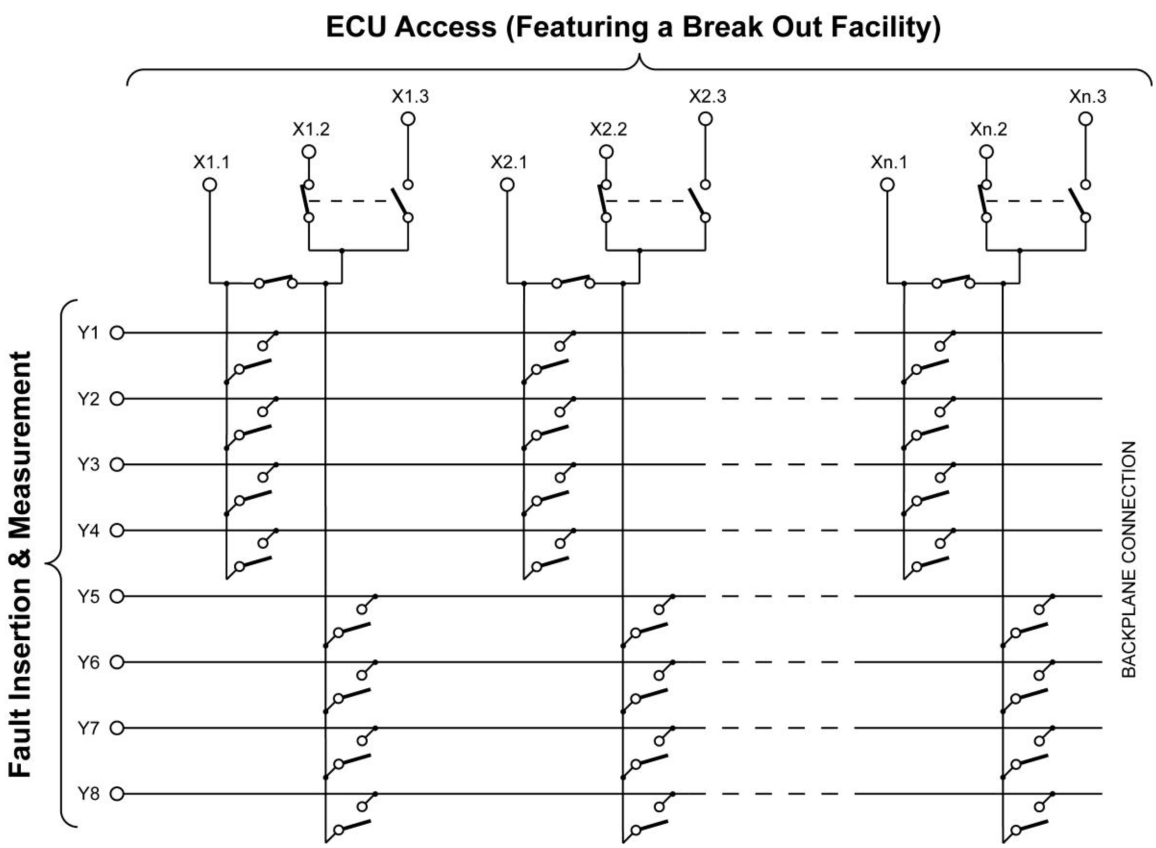

Figure 2

The Fault Insertion BRIC™ is intended to improve methods of error injection, monitoring and self-test in various test and simulation systems, requiring both manual and automatic access to each signal line connecting the test system with the ECU. The Fault Insertion BRIC™ provides the user with a powerful solution for routing simulated faults to the ECU with guaranteed repeatability, such as:

- Open-circuits simulating cable breaks between an ECU and it's sensors or actuators.
- Short-circuits to ground.
- Short-circuits to either a battery or an external voltage source.
- Short-circuits between I/O signal lines.

Conclusion

A Pickering Interfaces Fault Insertion BRIC™ switching solution enables faster, more flexible, repeatable & powerful fault insertion testing. The Fault Insertion BRIC™ advantages provide at least an order of magnitude improvement, compared with traditional test methods. Contact Pickering Interfaces to find out how the Fault Insertion BRIC™, along with a broad range of PXI solutions can assist in your product development programmes.

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Pickering Interfaces is a United Kingdom based company manufacturing advanced switching & instrumentation equipment for the electronics industry. Offering innovative modular test solutions, their products are used worldwide in many applications such as automotive, aerospace and defence.

For more information, please visit www.pickeringtest.com or contact Pickering Interfaces directly.