Application of a Fault Insertion BRIC Matrix

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Pickering Interfaces has designed a range of BRIC matrix modules whose architecture is specifically designed to aide the injection of faults on to a device under test. This application note explains why users need to simulate the insertion of faults and why the Fault Insertion BRIC's are an ideal solution.

Engine Control Units

Engine control units are present in many applications today, often involving safety-critical applications that demand highly predictable behaviour and reliable operation in environments where undesirable behaviour cannot be tolerated! Typical applications include avionics, automotive and the operation of heavy machinery in freight terminals. These environments are highly safety sensitive, the failure of an ECU (Electronic Control Unit) to act in an appropriate manner under emergency conditions could pose a threat to life and/or property. Ensuring these demands are met requires significant investment in test and documentation.

The ECU relies for information from a set of sensors and controls to decide what to do with the device it is managing. These sensors are themselves often working in a hostile environment (car engines, jet engines) exposed to the environment and to the engine being managed. Failures do occur, both in the sensors and the interconnecting system, so the control system has to respond appropriately when one or more sensors fail. It also has to respond appropriately when there is genuine fault. You want a jet engine to shut down if catches on fire, but you do not want it to shut down if it is clear there is a sensor fault.

Another 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 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.

Due to the high level of sophistication and complexity of today's ECU devices, special test methods are required. Fault insertion testing is an important aspect of ECU validation. The idea of testing for system failures is not new – it is an important aspect of ECU testing and involves the introduction of electrical faults into a system. The simulation typically duplicates various conditions which could occur because of corrosion, short/open circuits and other electrical failures inherited through age, damage or even faulty installation.

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 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 – this is sometimes called a hardware-in-the-loop (HIL) simulation test system. 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 many use a patch panel such as that 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 can move the patch cables to simulate a desired fault and then measure the results. This type of solution has many inherent disadvantages.

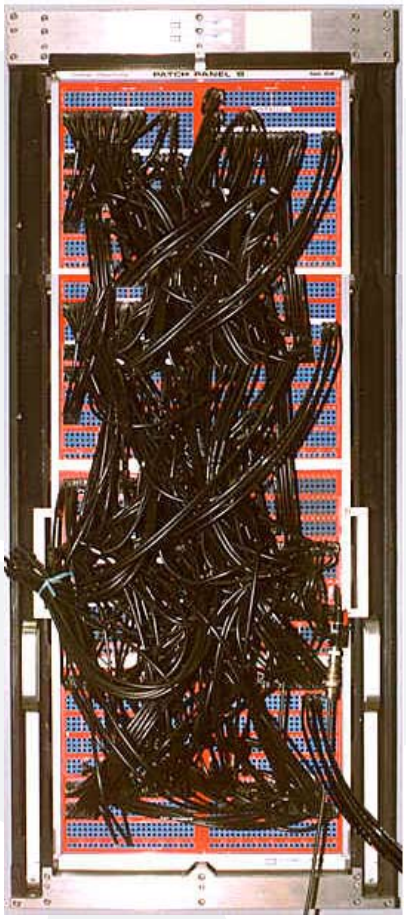

Figure 1. Using a Patch Panel to insert faults into a test system

An immediately obvious disadvantage is size, i.e. patch panels tend to be large. There are hidden costs such as maintenance, the need for knowledge on the part of the operator, potential human error and the cost of labour required to execute the test and record results. Over a period of time, patch panel maintenance issues are likely to arise through frequent use. 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 and user training.

Clearly a disadvantage of any manual method is the lack of repeatability. The ability to quickly reproduce a failed test condition is essential in a test system, either to aid development or to take corrective action. Being able to precisely reproduce the test procedure quickly is a major advantage in any upgrade or verification programme.

The ability to gain software control of both instrument routing and the insertion of real-time electrical faults enhances both the testing process and the recording of the outcome. However, although a standard crosspoint matrix with an adequate specification is capable of handling the instrument routing to the device under test, the insertion of faults requires a different switching architecture that was previously not available.

Fault Insertion BRIC™ Solution

For fault insertion test applications Pickering Interfaces has taken its experience with the BRIC and developed the Fault Insertion BRIC™, a scalable solution which may be used in place of a patch panel to switch signals from simulated and real-life devices in a HIL system. HIL testing enables the user to put an ECU through test scenarios identical to those carried out in ‘engine test stand’ testing. The Fault Insertion BRIC™ switching solution can help to considerably simplify and accelerate the testing, diagnosis and integration work in HIL applications.

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 ECU's in automotive and aerospace applications. Typical simulated 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 is performed via the Y-axis and connection to the ECU is via the X-axis. The X-axis has a breakout facility (3-pin in this illustration), allowing the interruption of I/O signals to the ECU.

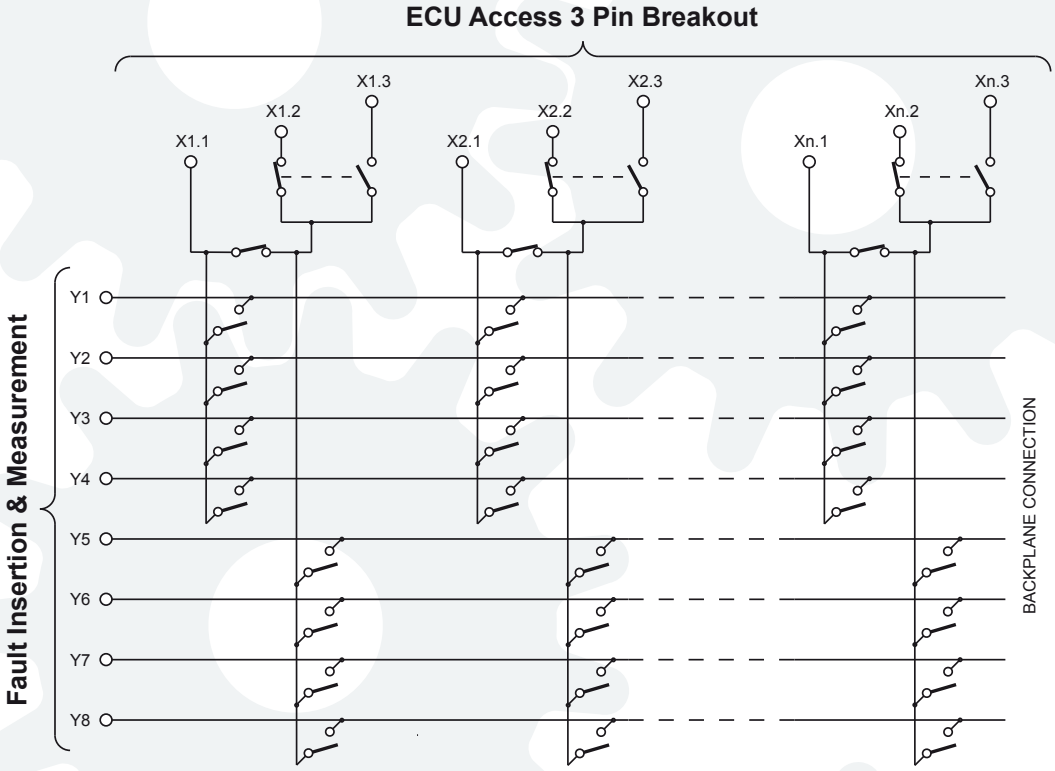

Figure 2 Functional diagram of a 3 pin breakout Fault Insertion BRIC.

The Fault Insertion BRIC™ improves the method of error injection, monitoring and self-test in various test and simulation systems Using the Fault Insertion BRIC both manual and programmatic access to each signal line can be provided. The Fault Insertion BRIC™ provides the user with a powerful solution for routing simulated faults to the ECU with guaranteed repeatability including faults 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.
- Partial connection between signal paths

Fault Insertion BRIC's can be used in a variety of ways to insert faults and example methods are shown in Figure 3 for a Fault Insertion BRIC with a 2 pin breakout connection. The architecture of the Fault Insertion BRIC makes it simple to add faults and to isolate the fault to the just one side of the system..

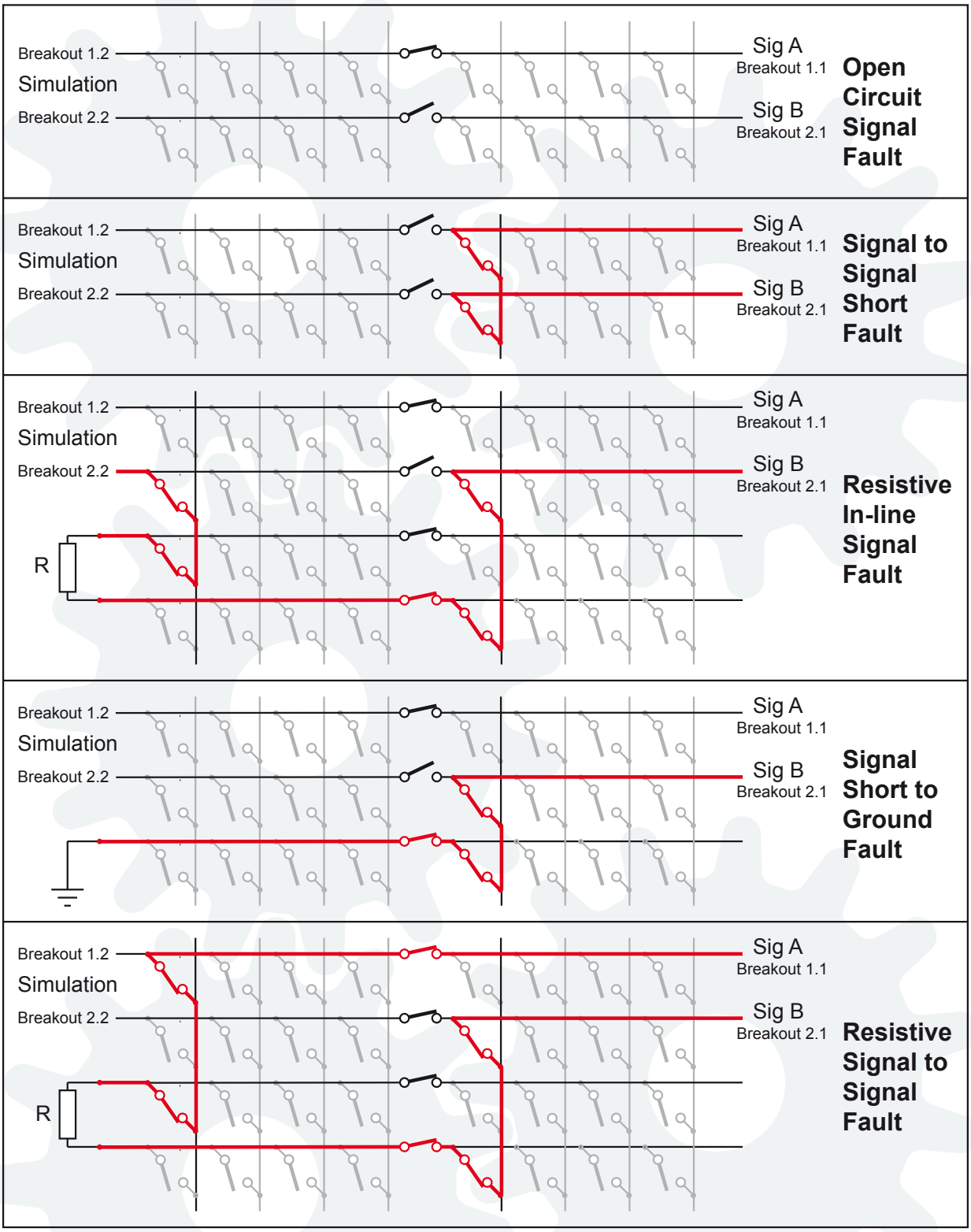

Figure 3. Using a 2 pin breakout Fault Insertion BRIC to insert a variety of different faults.

A Fault Insertion BRIC with three breakout pins can provide even more flexibility as shown in Figure 4. The three breakout connections permit the device line (the connection to or from the Device Under Test) to be connected to a simulation source or a real source. The simulated source can be instrumentation that either replicates the expected signal or provides a signal with some unexpected characteristics.

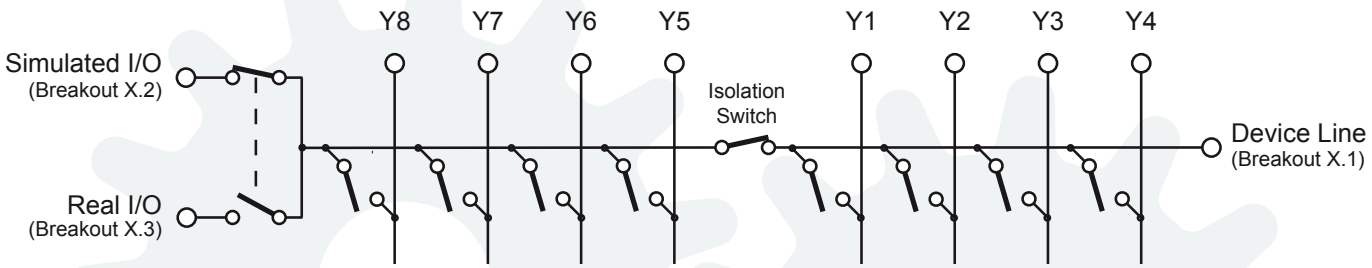

Figure 4.

Fault Insertion BRIC Models

The 40-592 is a very high density Fault Insertion BRIC™ solution, handling small to mid-range signals. Based on instrumentation grade ruthenium sputtered reed relays, this model has 1A (150Vdc/100Vac, 20W) switching capacity and long operating life. It is available in both 4-slot and 8-slot mechanical form factors. The 40-592 can be specified in a wide variety of matrix sizes to suit the intended application by having only some of the switching modules installed. A total of 24 configurations are available for the 40-592 with either 2-pin or 3-pin breakout options. Maximum matrix sizes are 248x8 for the 2-pin breakout option and 160x8 for the 3-pin breakout option. Larger matrices can be constructed by simply daisy-chaining modules.

The 40-595 is a high power Fault Insertion BRIC™ solution. Using high quality gold plated electromechanical relays, this model has 10A (125Vdc/250Vac, 240W/2000VA) switching capacity and occupies 8 slots of a 3U PXI chassis. It is provided with 3-pin breakout facility as standard and various configurations are offered up to a fully populated 30x8 matrix.

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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