

Case Study: System Integration Test Bench

Client: Caterpillar

NI Products Used:

[Software] VeriStand, LabVIEW, LabVIEW Real-Time, LabVIEW FPGA (Embedded & HIL Suite).

[Hardware] PXIe-1062Q - Quiet 8 slot PXI chassis, PXIe-8115 RT - Embedded Real-Time Controller (2.5 GHz Intel Core i5-2510E), PXI-6723 - DAQmx based - Static and Waveform Analog Output (13-Bit, 32 Channels), PXI-8512/2 - 2-Port High-Speed CAN Interface, PXI-7813R - R Series Digital RIO with Virtex-II 3M Gate FPGA, NI-9151 - R Series Expansion Chassis for C Series I/O, PXI-2569 - High-Density, General-Purpose SPST Relays, NI 9148 - Ethernet RIO 8slot chass, NI 9476 - 32ch Sourcing Digital Output modules.

Application Area: Automotive

Key Benefits:

- A new standardised HIL Test Bench – Caterpillar can deploy this across multiple departments.
- Standard software interface - for automation and custom plugins.
- Easy to use intuitive interface - reduces the requirement for in house training.
- **Reuse of customer's bespoke PCBs** - reduces development and build costs.
- Simplified maintenance - consolidates power supply and distribution eliminating multiple, distributed mains AC connections - swapping fuses previously used to Mini Circuit Breakers (MCBs), now quickly accessible from a removable panel - repackaging PCBs into a dedicated rack mount enclosure allowing a plug and play system.
- Pull out Fault Insertion Unit (FIU) drawers – allows for product specific customisation by the customer.
- Increased safety – due to a new safety relay and Emergency Stop button.

The Challenge

Caterpillar, Advanced Components and Systems Division look after full system integration testing for many of Caterpillar's popular product lines. This system integration activity involves linking up multiple Electronic Control Units (ECUs) and Electronic Control Modules (ECMs), alongside real displays, technician tools and other connected systems that form part of the internal infrastructure of a vehicle.

As the vehicles themselves get more and more complex, the full system tests are becoming more time consuming and a manual approach is becoming less viable due not only to reliance on human resource, but also due to differences in how these tests are performed (timing and interpretation). The previous testing process was very manual, as many of the tests involved setting an indicator and looking for a result either on a separate CAN tool or perhaps on a display.

Our Approach

Austin Consultants worked alongside the Caterpillar team to create a real-time hardware platform based on a PXI Real-Time controller, and with the addition of Caterpillar designed conditioning electronics (to bring signals level to a suitable format) to directly interface with the ECUs/ECMs and a custom built hardware platform.

The hardware design carried out by Austin Consultants involved a review of the existing Cat hardware and understanding the day to day challenges that the operators faced, such as maintenance and servicing. The end result was a double 24u floor standing rack. On one side was all the NI hardware and the signal conditioning PCBs/modules developed by the customer including all power supplies and safety circuits.



Austin Consultants focused on making these aspects easily maintainable with the following features:

- The use of pull-out slides/trays for faster access to components.
- **Relocation of interface connectors on the customer's' signal conditioning modules to allow** quicker replacement.
- Swapped Fuses to MCBs and made these easily accessible by having them all behind an easily removable panel.
- Removed all switch mode PSUs from the signal conditioning modules and created a low voltage distribution around the system, which not only increased safety but also reduced electrical noise.
- Integrated a safety system within the enclosure **that interfaces with the customers' existing safety** systems.
- Where possible kept all wiring and cabling within the rack which resulted in a much clearer finish.

The second rack is dedicated to Fault Insertion Units (FIUs). In this rack an FIU controller was supplied and fitted and the rest of the rack allowed for the customer to fit in product specific FIUs and load trays. This makes the system very versatile and means that one asset can be used to test a wide range of products.

From a hardware point of view this project was largely a refresh and repackage of existing Caterpillar systems. Where Austin Consultants were really able to add value was with the software aspects of the rig. By fitting a PXI Real-Time controller, and using our extensive knowledge of NI VeriStand we were able to offer a real-time test (HiL) engine that gives the customer a very flexible solution. Austin Consultants provided the hardware and software expertise to integrate this into a solution for the customer.

Our Solution

By exploiting the power of VeriStand and embedded real-time hardware, Austin Consultants delivered a system that has many benefits. Not only deterministic communications and simulated behaviour but also flexibility of using a deterministic targetable FPGAs for customisable measurements synchronised with the primary control loop rate. This gives the customer great flexibility and the capability to meet future, more complex design requirements, such as missing tooth cam/crank signals.

The VeriStand framework allowed Austin Consultants to concentrate on customer specific components, such as **the integration of hardware and other interfaces not supported 'off the shelf' as well as custom devices to talk to the ECM/ECUs via CANbus.**

The benefits of using VeriStand and some of the reasons behind its utilisation in this project were that:

- It is configurable - as new variants are introduced, the user can just update the configuration with ease **(or programmatically from Excel using Austin's automation code).**
- It has standard interfaces - VeriStand includes plugins (Custom Devices) for standard interfaces such as a NI Switching hardware or Lambda Low Noise Power Supplies.
- **It's ease of FPGA integration, giving direct access to FPGA variables from within the VeriStand configuration tool.**
- It comes with a built in test framework - the Stimulus Profile Editor (part of VeriStand) allows automated testing and pushes results to an Automatic Test Mark-up Language (ATML) report file 'out-of-the-box'.
- VeriStand runs a real-time engine on the PXI Real Time devices allowing deterministic testing, stimulation and logging.
- It has a Dynamic User Interface - the client can build extra features on-the-fly whilst running (such as adding in extra graphs or more controls for different variants). This also allows the client to add to the UI without any programming experience (drag and drop controls).



Austin Consultants have also provided custom functionality to translate Excel based configuration files to **specific 'system configurations', allowing easy selection of multiple types of product, which then configures** the system to test on the same hardware platform. This configuration-based approach allows the customer to easily extend the capability of the equipment on their own.

The built in stimulus profile and real-time sequence editors along with custom additions and training allow Caterpillar to run automated testing in a much more controlled manner and with much less operator input.

The hardware platform worked with Caterpillar to realise (on top of NI equipment) – FIU / FIU with load / Frequency generation / PWM generation (optical isolation) CAN. Use different harness rather than complete matrix channel switching.

Austin Consultants possess vast knowledge of Hardware in the Loop (HiL) test applications. Caterpillar extensively use HiL testing throughout their business. They approached Austin Consultants to help migrate their existing HiL Test Bench into a standardised platform that had the capabilities to be expanded to support current but also future Electronic Control Unit (ECU) products.

Caterpillar's Advanced Technologies and Solutions team are responsible for the electronic systems on a wide range of the Caterpillar products. Integration verification involves testing the entire electronic control system for a particular product as a system. This bench was designed specifically for the Material Handler product, however the intention is that the hardware is generic enough to be replicated and used for other product lines with simple re-configuration.



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