Electrical Tester for Wind Turbine Control Boards

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Category:
Prototype and Validation Test

Products Used:
LabVIEW 8.6
TestStand 4.1
NI-Switch
IVI
PXI-1045
PXI-MXI-4
PXI-6704 (5 EACH)
PXI-7833
PXI-4071
PXI-2530 (2 EACH)
PXI-5122
PXI-2547 (2 EACH)
PXI-2569
PXI-1050
PCI-GPIB

The Challenge:
Create a reliable diagnostic testing system for hardware in the loop testing of wind turbine control boards. Create a flexible and easily modifiable test framework with reporting and debugging.

The Solution:
DSA created a custom connection fixture to test the board using a dynamically configurable PXI test system to run Hardware in the Loop testing of the control boards using DAQmx and PXI RIO. An elegant, adaptable software solution was implemented using the many benefits of NI TestStand and LabVIEW that allowed the execution of a series of user defined tests.

Abstract:
Wind turbines are an important part of the worldwide power grid. While the mechanical aspects of the turbine system have their own challenges, the control system and its specialized boards require comprehensive failure analysis to ensure system reliability and product improvements.

The focus of this project was to create an entire test system for one of the wind turbine control boards. As these boards come back from the field, they are subjected to hardware in the loop (HIL) testing to identify their failure mode. These tests need to be flexible, yet efficient while producing good documentation of results.

Figure 1. A Wind Energy Turbine in the Field

Testing Needs

The HIL testing of a just one of the multiple control boards used to control the operation of the typical wind turbine (Figure 1) consists of over 700 measurements, including basic continuity, resistance, voltage, and current. In addition to these measurements, bi-directional communication to the board processor over Ethernet must be tested. Simulated signals to the board provide the full wind turbine control system operating environment. The range of the kinds of measurements and signals needed in this testing takes this HIL beyond any standard benchtop apparatus. We found an excellent solution in implementing a full PXI chassis connected to a PC running LabVIEW and TestStand. This allowed the expandability to the many types of hardware needed for the full system.

Test Implementation

While the PXI hardware covered the breadth of measurement types needed in this system, the large numbers of tests required a switching routine to enable dedicated measurement devices to be rapidly connected to a series of test points without the need for operator interaction. In addition, the flexibility of the NI Switch framework allowed simultaneous stimulus and response measurement. Since the test system currently supported other types of wind turbine control boards and would need to be able to support future boards, architecture was developed in LabVIEW that would accommodate future control boards while requiring minimal code development. Multi-functional VI's were developed that would be called by the test steps in a sequence for a given control board. These VI's, called Functional Test Blocks (FTBs), contained functionality for:

- interfacing with each of the PXI devices
- communicating with the device under test (DUT) processor
- controlling switching,
- simulating signals to the DUT,
- reading digital and analog inputs,
- measuring continuity and resistance using a digital multi-meter (DMM)
- performing Ethernet communication to the DUT.

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The specific functionality executed in the FTBs called by the test steps was determined by XML configuration files that existed for each model of control board. The XML files contained explicit operations that implement the test methodology for each portion of the test. The XML files were generated from user-generated Microsoft Excel spreadsheets. This enabled user-readable editing of the tests, without having to alter the overall program code. This test architecture extends the inherent flexibility of LabVIEW and TestStand even further in that the FTBs typically need very little modification when a new test sequence is developed. As a result, test procedures and parameters can be modified without modifying the code.

Due to the various other control boards that would need to be tested in the future, a main requirement of the system was that it remain modular. The system test rack is able to test many different boards, so we made the system test automation adapt to whichever board was connected to the system. The connector was a Virginia panel G12X receiver, tied directly to the National Instruments equipment to form an interface to the test fixture. The test fixture was designed by DSA to hold the control board and allow for access to the test points around the edge of the board.

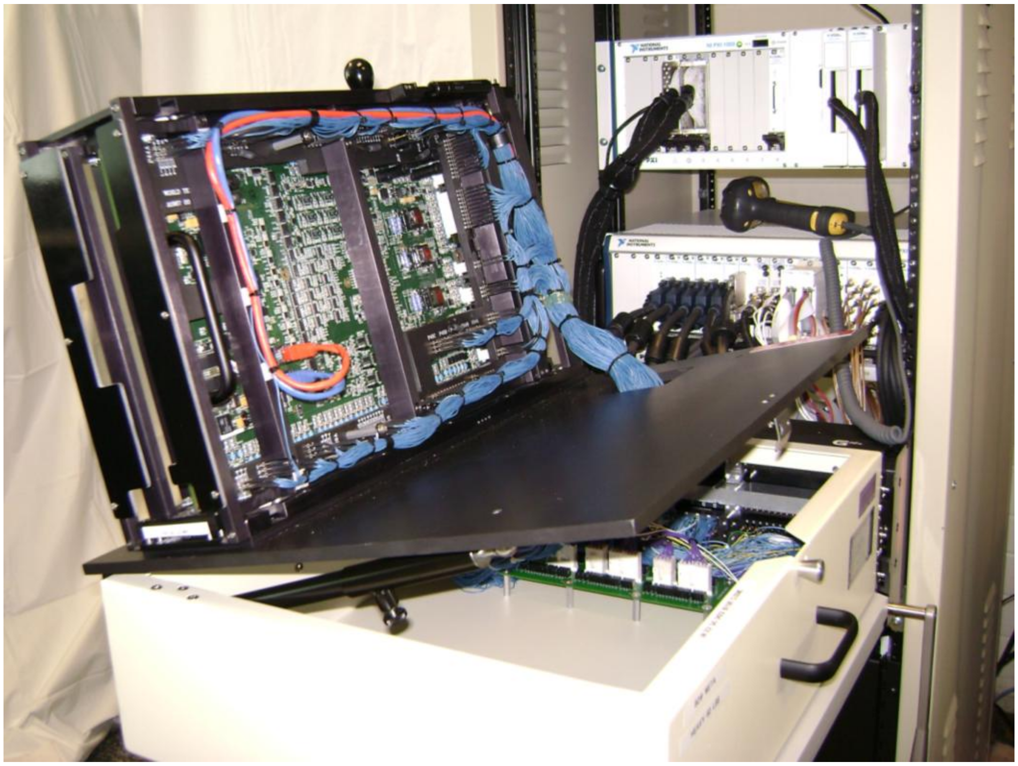

Figure 2. The Control Board Inserted Into the Fixture, Connected to the PXI Test System

Once the board is connected, the adaptive automation of the test protocol was used to make custom connections within the system. The operator used a TestStand Operator Interface (OI) developed in LabVIEW to select and execute a TestStand sequence file. The ability to use the TestStand API to tap into TestStand and display the real time results of each test on a front panel of the OI was a prime example of the customization factor that TestStand and LabVIEW provides.

Conclusion

There are many aspects of the TestStand test framework which made this project a success even with tight development timeline constraints. The flexibility benefits of TestStand really shown through with this project, one example being the ability to modify the sequential process model provided with TestStand. The fact that LabVIEW is able to easily interface to so many hardware devices, along with Ethernet data I/O and the reading and writing of multiple file types, including MS Excel and XML files, made it a perfect fit for this project. I could not envision completing this project with another hardware and software platform.