CASE STUDY: High-Speed Rotational Motor Test Platform

Author: Todd Kutzner, CLD


Industry: Structural Test of High Speed Motor Components.

Application Area: Machine Design and Structural Test

The Challenge: Add synchronized high-speed data acquisition, logging, and safety monitoring to a high-speed Motor Test Stand with sustained operating speeds as high as 25,000 revolutions per minute.

The Solution: Apply NI-DAQmx, LabVIEW on Windows, LabVIEW-RT, and LabVIEW FPGA to create an integrated test solution that accommodates existing design challenges with scalability for future expansion.

Overview:

Digalog Systems Inc. is an ISO 9001:2008-registered supplier of solutions for test and measurement applications across a broad spectrum of industries including medical, automotive, aerospace, power switching and distribution, transportation, and electronics manufacturing.

Digalog was selected to develop control software for a High Speed Motor Test Stand. Digalog was selected for this project because of Digalog’s status as a National Instruments Alliance Partner as well as their close geographical proximity with the customer, due to the requirement for extensive on-site development work and collaboration. In addition, Digalog was chosen for their ability to provide a high level of software application programming expertise. The engineers at Digalog hold multiple levels of LabVIEW certifications and have extensive experience in developing test and data acquisition solutions across multiple industries.

Technical Challenge:

The scope of the project consisted of designing a LabVIEW application capable of monitoring, controlling, and logging over 150 mixed-signal data acquisition (DAQ) channels at various sample rates, distributed across multiple hardware platforms. In addition, the application had to handle control and monitoring of Variable Frequency Drive (VFD) motor controllers and Vibration actuator controllers, with tight timing integration between the NI hardware and the LabVIEW software. The system required high reliability supervision of each data channel with user configurable limit and alarm conditions with automated system shutdown capability.
Solution:

The solution centered on NI Measurement and Automation Explorer (MAX) for configuration, scaling, testing, and calibration of each measurement resource channel, with changes in channel configuration automatically updated within the LabVIEW application. Signal types are grouped into NI-DAQmx Tasks, each with different sampling rates. High-speed Tasks include load cells, quadrature encoders, accelerometers, and displacement channels. Data with lower rates of change like pressures, flow rates, and temperatures are assigned to lower-speed tasks. Control signals that require extremely tight timing tolerances are handled by the LabVIEW-RT system and by a custom LabVIEW-FPGA application.

The FPGA application (the subject of its own case study) addresses the project’s unusually high-performance demands for data generation. Four synchronized user-programmable analog waveforms to a quadrature encoder signal with output voltage ranging from -10 to +10 volts, characterize the dynamic state of a rotating shaft driven by a motor which can reach sustained rotation speeds of 25,000 RPM. The real-time PXI-7841R reconfigurable I/O module with programmable FPGA hardware met the requirements for hardware performance and software programmability.

The platform hardware is served by two separate controllers, a Windows 7 PC with a MXI-Express link to a PXIe-1078 chassis, and a Real-Time system chassis based on the PXIe-8101 RT controller. The Windows PXI system incorporates X-Series DAQ cards including the PXIe-6358 for high-speed simultaneous acquisition and a PXIe-6363 for high-throughput measurements. It also includes PXIe-4353 thermocouple input channels. The Real-Time PXI system handles high-speed synchronized control of the dynamic vibration control system through a PXI-7841R (FPGA), and a PXI-4472B for vibration measurements.

![System Block Diagram](image-url)
LabVIEW NI-DAQmx was used to acquire channel data from the Windows system, as well as for recording and publishing data from the Real-Time system, with LabVIEW handling the synchronization of data across multiple sources. System requirements specified the ability to display live data in the user interface (UI) as well as maintain within memory, a high speed record of the last 10-20 seconds of data. The latter enables the high speed capture of pre-trigger data for logging of triggered system events without continuous storing to disc. Live data is utilized by the Safety Monitoring System to validate system health with reference to user-configurable channel limits and alarm conditions.

Logging requirements for the acquired data included:

- Maintain high-speed temporary data within memory (RAM).
- Display live (most recently acquired) data to the UI.
- Log periodic single-point data (TDMS) at low rates (all channels, one sample every 1-60 seconds).
- Log single synchronous waveform data (TDMS) at high speed, maintaining 10-20 seconds of temporary data.
- Continuously stream data at high speed (TDMS), using DAQmx logging modes.
- Support user-configurable time-based channel logging (TDMS) with on demand user selectable channel and sample rates.

**Advantages of Using the National Instruments Platform**

Digalog's status as a National Instruments Silver Alliance Partner, our demonstrated LabVIEW expertise, and our extensive experience with utilizing NI hardware and software products across a wide gamut of measurement applications, made the NI platform the obvious choice. LabVIEW and NI-DAQmx drivers facilitated a single software development platform, both for the main application on the Windows system as well as the FPGA and RT code development.

The common LabVIEW knowledge base between Digalog and their customer contributed substantially to the full and successful realization of this complex project with its highly demanding requirements for timing synchronization and multiple logging capabilities. To ensure the customer was able to confidently take ownership, Digalog provided full application documentation, source code, and on-site training.

**Contact Information**

Todd Kutzner  tkutzner@digalogsys.com  262-797-8000 X230  http://www.digalogsystems.com