

PORTABLE, RUGGED NATURAL GAS COMPRESSOR TESTER

The testing of compressor efficiency in the natural gas pipeline industry is essential. G Systems designed a lightweight, portable test system to automate testing, calculate performance parameters, and record data. This case study discusses the design and benefits of a portable, rugged NI CompactRIO-based system with LabVIEW Real-Time software used in the natural gas industry.

THE CHALLENGE

Design and implement a more cost effective, portable, and rugged data acquisition instrument (DAQ) to replace an existing DAQ. The DAQ is part of a data acquisition system used by the performance team of the mechanical testing group. The DAQ, in conjunction with a laptop computer, helps engineers evaluate the performance of the compressors thermodynamically and assists in creating compressor maps for the operation of compressor units.

The data acquired is used to aid engineers when validating compressor specifications, recommending ways of improving compressor efficiency, and estimating the cost involved with poor compressor performance.

THE SOLUTION

Create a compact, lightweight solution using two CompactRIOs and code written in LabVIEW Real-Time and LabVIEW FPGA software to synchronize analog data acquisition with a compressor's revolution relative to top dead center (TDC). Utilize commercial off-the-shelf (COTS) hardware and software for ease of maintenance and support.

PRODUCTS USED

- Two (2) NI cRIO controllers
- Two (2) NI cRIO 8-slot reconfigurable chassis
- Two (2) NI-9401 8-channel TTL DIO modules
- Eight (8) NI-9215 4-channel differential AI modules
- Five (5) NI-9217 100 ohm RTD AI modules
- One (1) NI-9205 AI module



INTRODUCTION

G Systems, a National Instruments (NI) Alliance Partner, is a privately held technical services and systems integration company specializing in designing and building turnkey test and measurement, data acquisition, and control systems. G Systems was able to rapidly develop a solution for a rugged, lightweight test system used for testing of natural gas pipeline compressors. This testing collects data to be analyzed and used in determining how the engines need to be adjusted to maximize efficiency. The customer's existing system had become difficult to manage and ship throughout the United States for testing at various locations, resulting in the need for G Systems to develop a new testing solution.

HARDWARE SYSTEM OVERVIEW

The size and weight of the existing system caused issues both in shipping and transporting within a test site. Designing the new system with NI CompactRIOs allowed G Systems not only to reduce the size and weight of the overall system, but the FPGA-based CompactRIO allowed for ease in managing and modifying the complex digital triggering and synchronization of the overall system. Because of the ruggedness of the design and the CompactRIOs, the system can be shipped to test sites via common carriers, such as UPS, without special handling fees. This ruggedness is not only necessary from a shipping standpoint, but also from a testing standpoint. Because of this, G Systems added customer-specified, circular connectors, and extra reinforcement within the box. Two fans were also added to aid in cooling of the box's interior. Furthermore, G Systems designed a customized faceplate for the system, with silk screening in an organized fashion to aid the operator in use. LEDs verify that the power is on, the CompactRIOs are running, and network connections have been established, alerting the operator that the system is ready to be used.



Figure 1: Customized Hardware Panel

The NI cRIO chassis's small footprint allowed G Systems to design a lightweight, compact system while achieving the high channel count needed. The NI-9401 module in one CompactRIO chassis totalizes the encoder's digital pulses over a set time period in order to measure the RPM of the compressor. The NI-9401 on the other NI CompactRIO chassis manages the synchronization of the digital inputs from the encoder with a digital pulse out to flash the strobe. This allows the user to find TDC of the compressor. Finally, the NI-9401 on each chassis is used to synchronize the simultaneous acquisition of 32 pressure channels using eight NI-9215 modules, across two different CompactRIO chassis, all relative to TDC. This, along with the acquisition of 19 temperature channels using five NI-9217 RTD modules, provides the data that is used to analyze engine efficiency.



Figure 2: Design of Compact System

SOFTWARE OVERVIEW AND ARCHITECTURE

The custom real-time software was designed to handle the simultaneous acquisition of pressure data triggered from a 512 pulse-per-revolution encoder that may be run at speeds up to 1500 RPM resulting in data acquisition rates of up to 12,800 S/s. Figure 3 illustrates the high level overview of the system architecture.



Figure 3: Software System Overview

The pressure and temperature data are acquired and transferred to the host using TCP/IP communication and displayed on a graph for the user to view and log to a file. The existing user interface is now expanded to allow for the viewing of data from multiple cylinders at once, for ease in troubleshooting or verifying the on-site test setup. Debugging and monitoring of the software was further enhanced with the use of G Systems' efficient and reusable software component, <u>G Systems Event Tracker</u>. This component timestamps incoming event messages to a millisecond resolution and displays them to the operator, while also logging the messages to disk. The incoming messages can be viewed using a standalone G Systems Event Tracker application or embedded within the custom application via an Active X Control.



Figure 4: User Interface

The most critical part of the system is ensuring that the pressure data acquired is truly relative to TDC of the compressor. The flexibility of the FPGA and CompactRIO platform aided G Systems in designing a solution that allows the operator to adjust the timing of a strobe flash in response to a varying analog input from a potentiometer and view this adjustment in real-time. The use of LabVIEW FPGA provided an incredibly intuitive way to manage challenging real-time timing schemes, which were required in this system. It also aided in the debugging of any timing-related issues, as the nature of dataflow programming allows the programmer to both see what's happening on a very low level and have complete control of the outputs.

Along with the FPGA complexity, the high channel count required multiple CompactRIOs to communicate with each other and the host. Leveraging the built-in network communication tools in LabVIEW, G Systems designed an advanced architecture to handle these network connections. This, along with the flexibility of being able to take the intuitive concept of data flow programming and apply it to programming the FPGA, allowed for quick development time of this system.

CONCLUSION

G Systems' use of NI CompactRIOs in a portable test system resulted in decreased development and debugging time, while greatly reducing the weight of an existing test system, thus providing increased ease-of-use, improved reliability, and cost savings during shipping.

Learn more about G Systems' approach to designing rugged custom test fixtures for the harshest environments by downloading <u>this white paper.</u>



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