Calibration and Test Platform for Flue Gas Analyzers

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NI Product(s) Used:
LabVIEW 2013
NI 9476 32-Ch Digital Output Module
NI-VISA for serial interface

Category:
Advanced Manufacturing and Control
Energy

The Challenge

A leading manufacturer of industrial process monitoring equipment needed an automated solution for calibrating and testing their new line of industrial flue gas analyzers.

The Solution

Data Science Automation has developed test software for controlling calibration gas inputs, adjusting flue gas analyzer settings through a serial interface, and recording results into Excel via ActiveX automation, fully automating their test and calibration process.

Introduction

Data Science Automation (DSA) is a premier National Instruments (NI) Alliance Partner that specializes in automating and educating the world leading companies. Clients choose DSA because of DSA's deep knowledge of National Instruments products, disciplined process of developing adaptive project solutions, staff of skilled Certified LabVIEW Architects and Certified Professional Instructors, and unique focus on empowerment through education and co-development.

A Bottleneck in Calibration and Testing Post-Production

Due to the sensitive, high-precision nature of their gas analyzers, our customer had previously expended a large amount of time an energy in manually calibrating and testing their product before shipping. First, technicians would manually take the analyzer through a laundry list of firmware functionality checks and setup steps, including checking the internal firmware version number, checking the device serial number and analyzer type, setting the firmware clock, and checking device analog outputs, inputs, and alarm settings. Next, the process of calibrating and validating the gas measurement hardware commenced over a period of several days.

The procedure for that calibration and verification proceeded as follows. First, a technician would connect tanks of methane, O_2, CO_2, or other gases of interest, and carefully apply valve settings to achieve a desired mixture of gas running to the analyzer. Then, the technician would enter the gas settings into the analyzer and trigger an internal calibration phase on the analyzer, during which it would measure voltages for the known gas concentration. Upon a signal from the device, the technician would change the valve settings and repeat the process so the device can internally record a calibration curve relating voltage measurements to gas concentrations. These calibration stages would run over a period of many hours to allow time for the device to stabilize for each gas concentration. After calibration, the technician would initiate several device readings over several days to verify that the spread and shift of the reading values did not exceed tolerances in their device specification. Finally the technician would take values recorded from that process and fill out a unit calibration certificate to be delivered to their customers with each device.

The process required an exhaustive and tedious manual effort, and led to a large amount of down-time where a given UUT might be idle between reading or calibration stages, waiting for technician input. As a result their entire production capability was limited by the rate at which they could calibrate and test units to their rigorous QA standards.

DSA Provides an Automated Test and Calibration Solution to Clear the Bottleneck
Based on previous positive experience with DSA on other projects, the manufacturer contracted once again with DSA to automate their post-production procedure of calibration and testing. DSA used the LabVIEW programming environment for this project because of LabVIEW's exceptional facility for communicating with a wide variety of NI and other third-party hardware. We employed NI-VISA for communicating directly with the customer's serial interface to their device, in order to trigger calibration stages and other actions which previously required manual intervention. In order to automatically control solenoid valves for adjusting calibration gas mixtures, we employed NI-DAQmx in our software for easy control of an NI 9476 32-ch digital output module.

The customer had previously used several Keithley 2700 meters and expressed a desire to utilize this existing hardware for acquisition of analog inputs to test the analog outputs of their device. Due to the flexibility of LabVIEW and the availability of certified LabVIEW drivers for those meters, the incorporation of that analog input module was efficient and seamless within our automated test application.

Our LabVIEW application utilized a central state machine for handling user events, which distributed commands to seven cloned sub-processes running in parallel, one for each of the units connected for testing (the limitation of seven was a result of channel limitations of the Keithley meters). The LabVIEW architecture segregated user-facing functionality such as click event processing from hardware-level processes, and also had the benefit of allowing easy extension and adaptability for more units added to a single test system, should hardware limitations be removed. A snapshot of the block diagram for the central state machine is shown in Figure 1. Commands are sent to unit-specific loops for each analyzer, or to all units (for instance for a pause-all command) via dynamic user events. An event structure (shown in Idle case) handles another dynamic event response from "consumers", as well as events such as user button clicks. The completed application was compiled into an executable with an installer so that it could be easily deployed on multiple test systems in different locations in their facility. An image of a calibration rack with seven mounted units is shown in Figure 2.

Our application also utilized LabVIEW's connectivity capabilities to create email notifications of test failures and completions to specific and configurable groups of users, running through the facility's existing SMTP server. DSA also designed a customized Excel report through ActiveX automation to generate and display calibration reports for the technicians to review and distribute with the units. Finally, we implemented a robust error handling module which handles any issues such as communication errors via configurable re-try settings. These allowed the technician to acknowledge and reconnect any cables that might be unplugged, or correct any physical defects in the unit, before picking up from where they left off in the test procedure without losing progress. We also included a number of diagnostic procedures to run from the test application, such as taking single readings, in order to help diagnose exactly what the problem might be with any failing gas sensor unit.

The Takeaway
Our customer was thrilled that we were able to eliminate a significant roadblock in their production and delivery line. A process that previously took many days of tedious, manual, hands-on adjustment and monitoring for each individual unit can now be completed with an hour or so of hands-on set-up, followed by a day or two of fully-automated, hands-off calibration and testing. The latter calibration wait time is driven only by their product's own sensor relaxation time. The customer reaffirmed their confidence in DSA and NI hardware/software as an easy choice for addressing their automation and systems integration needs.

Figures

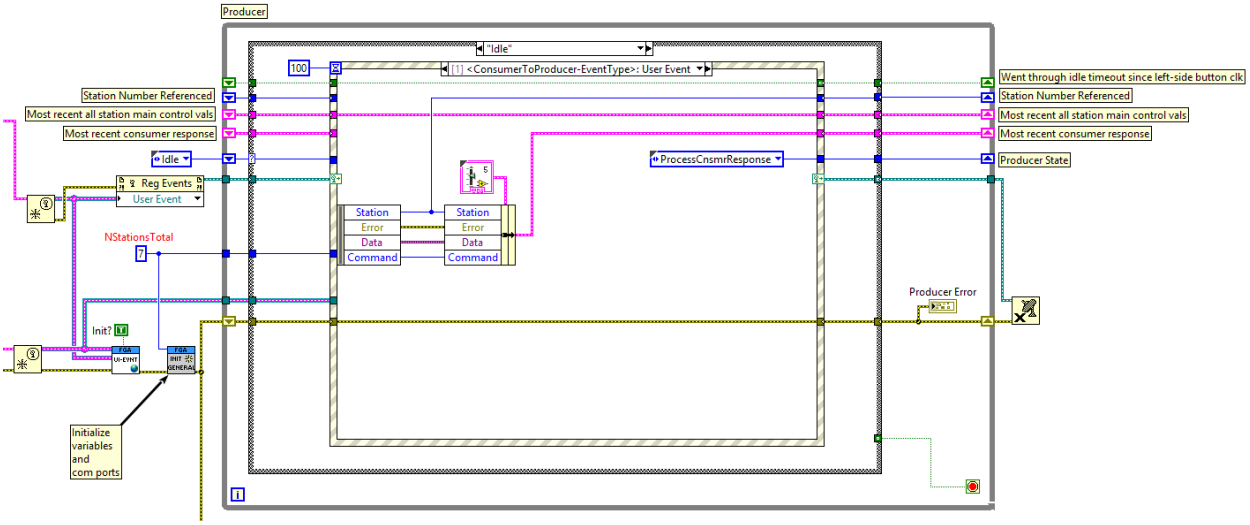

Figure 1. Central State Machine for Automating Calibration and Tests for Gas Analyzers.

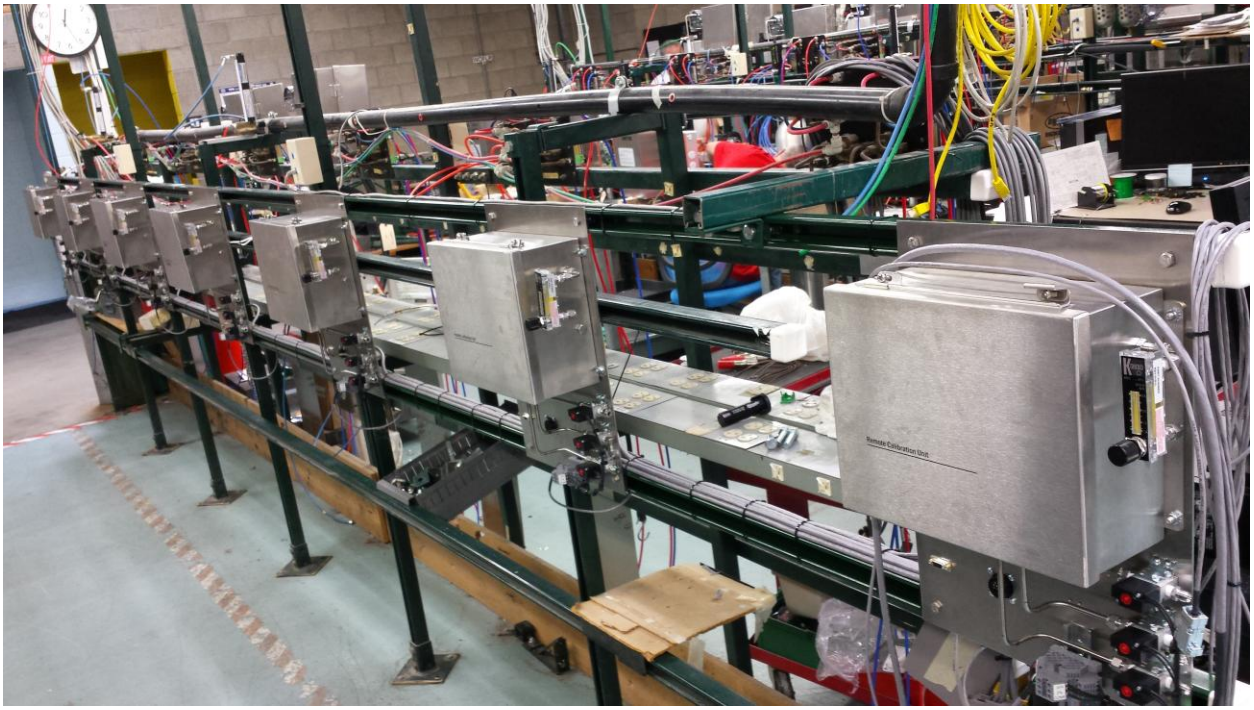

Figure 2. Seven Calibration Units for Gas Analyzers, Automated by a Single LabVIEW Program on a PC (Not Shown).

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