Soliton Creates Automated Instrument Cluster Calibration and Inspection System

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Category:
Automotive


The Challenge:
Developing, within eight weeks, a reliable and cost-effective system to perform multipoint calibration and inspection of multiple gauges in a modern electronic instrument cluster.

The Solution:
Using National Instruments LabVIEW and NI-IMAQ driver software to create a comprehensive and integrated computer-based solution.

Pull quote: Through the use of development tools such as LabVIEW and NI Vision Builder and NI products such as IEEE 1394 camera drivers, we were able to quickly develop, debug, and deploy a state-of-the-art, cost-effective system that satisfied the needs of our customer.

Designing an Automated Test
Our customer manufactures instrument clusters in collaboration with a renowned Japanese company. The instrument cluster comprises four gauges for indicating speed, fuel level, engine RPM, and temperature, and an LCD display. A microstepper motor, which is controlled by an onboard controller based on signals received from respective sensors, drives each gauge separately. For setup and test purposes, the instrument cluster establishes communication to the controller through a serial interface. We require a test system to perform initial checks on the controller, verify the LCD display operation, and calibrate the gauges at different ranges followed by a multipoint inspection to verify if the calibration is proper. Our customer desired an automated test system with the following requirements:

- Cost-effectiveness: The customer had the option of buying the test system from their Japanese collaborator but wanted a more cost-effective system.
- High throughput: The entire test time, including the loading and unloading of the cluster, had to last less than 55 seconds.
• Reliability/maintenance: Our customer needed high uptime because there was no backup test system. Maintenance requirements called for designs with little or no moving parts.
• Delivery: We needed an aggressive delivery schedule of eight weeks.
• Expandability: Future clusters would have controllers with CAN interfaces.
• Flexibility: Because new models were likely to be introduced in the future, flexibility and configurability were essential.

Our customer’s Japanese collaborator was already producing and testing these clusters, and hence, our customer had an option of purchasing the test system already developed for the Japanese line. The Japanese design used a single camera with high-speed motion control hardware to cover the four gauges. We presented a design that used multiple industrial FireWire cameras with no motion control elements in which each gauge could be tested in parallel to reduce cycle time. Our design stood out in terms of simplicity, reliability, throughput, and cost-effectiveness, and the customer did not hesitate in placing an order for an NI-based solution.

Using Digital I/O and DAQ to Implement the System

The system consisted of two P4, 2.4 GHz PCs to accommodate the many cards needed for the project. We derived the signals for exciting the speedometer and tachometer from two function generators controlled from an NI PCI-GPIB card that could provide square and sine wave signals with amplitudes of 20 V peak-to-peak at 20 mA and frequencies up to 15 MHz. The fuel and temperature gauges were excited from the pulse-width-modulation signals generated by counters on the NI PCI-6014 DAQ board or from resistors selected from a decade resistance box. The choice of signal types for the four gauges depended on the cluster model and if we could set the software.

We built the decade resistance box using standard resistors switched under software control through digital I/O boards (NI PCI-6503 and NI PCI-DIO-96). An algorithm selected appropriate resistances in the shortest possible time and provided closed-loop control over resistance within 0.1 Ω. We used four FireWire industrial color cameras (640 by 480 pixels at 30 fps) with motorized optics. The application software used the NI-IMAQ 1394 driver to configure all parameters such as zoom, focus, shutter speed, and filter. To accommodate different gauge-center distances, we mounted the outer cameras on manually operated slides equipped with rotary potentiometers that indicated position to the software through a PCI-6014 DAQ board. We used high-frequency florescent lighting switched under software control. A counter/timer device (NI PCI-6601) generated pulses and read responses for the four-pulse and eight-pulse check test.

The test process began with a series of checks, termed as initial data checks, that we performed by communicating with the cluster controller. We checked the LCD by sending commands to display characters on the LCD and imaging it with a camera.

We followed this with a zero point detection (ZPD) check on all four gauges in parallel. The system sent a command to the cluster controller to move the gauge pointer to the
initial position. The system acquired an image and sent respective pointer position offsets, if any, to the cluster controller.

After ZPD alignment, the system simultaneously calibrated all four gauges. The system calibrated the speedometer and tachometer by sending a pulse train at a specified shape (square or sine) and frequency to the cluster and imaging the gauge by the corresponding camera. The system compared pointer readings to standard input frequencies. Then the system sent offsets, if any, to the cluster controller, which stored them in an EEPROM and computed correction coefficients. The system calibrated fuel and temperature gauges in a similar fashion, except that the inputs were PWM signals or resistance values. We followed calibration with an inspection, during which the system gave the required inputs to the four gauges and checked the readings to ensure they were in range. The system performed the calibration and inspection process at several points for each gauge.

**Meeting Customer Needs with a Fully Automated, Flexible Test**

Within eight weeks, we built a fully automated flexible PC-based test system for automatic calibration and inspection of instrument clusters. The system was compact and highly reliable because it had no moving parts. We used NI-IMAQ vision software with multithreading capabilities to meet the throughput requirements by inspecting the gauges in parallel. Through the use of development tools such as LabVIEW and NI Vision Builder and NI products such as IEEE 1394 camera drivers, we were able to quickly develop, debug, and deploy a state-of-the-art, cost-effective system that satisfied the needs of our customer.

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