LabVIEW and GPIB Calibrate Cryogenic Thermometers for New CERN Large Hadron Collider

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The Challenge: Acquiring and conditioning calibration data from cryogenic thermometers.

The Solution: Using a LabVIEW program to drive GPIB instruments and communicating with a programmable logic controller (PLC), a database, and a mathematics program.

The large hadron collider (LHC), a new proton-proton accelerator at CERN of approximately 27 km circumference, uses superconducting magnets on a large-scale basis. These magnets, which provide a field of the order of 9 Tesla (T), maintain protons in orbit at energies up to 7 TeV. Super-fluid helium cools the magnets at an operating temperature of 1.9 Kelvin (K).

About 6,000 cryogenic thermometers control and monitor the temperature during operation, cool down, and warm up of the LHC machine. They must meet compelling demands, such as:

• High accuracy at operating temperature to avoid the heavy consequences of magnet quenching (transition of a magnet to its resistive state)
• Wide temperature range, from 1.6 to 300 K
• Long-term stability
• Radiation hardness
• Compatibility with industrial control equipment

Resistive temperature detectors (RTDs), sensors that change their resistance with the temperature, combined with special support developed at CERN, satisfy these constraints. To achieve the required accuracy, we must calibrate each thermometer individually.

Calibration Facility

The CERN cryogenic thermometer calibration facility consists of a liquid helium cryostat and an insert. The liquid helium cryostat is a vessel used to contain cryogens. The insert is an isothermal copper block on which we can mount up to 60 thermometers and four standard reference thermometers.

By fixing an enclosure surrounding the copper block and connecting a vacuum pumping unit to it, we can also perform calibrations under vacuum conditions.

We use a 4-wire technique to measure the resistance of the thermometers. The current and voltage signal transfers to a scanner connected to a current source and a digital voltmeter.

A bridge measures the four standard thermometers. GPIB links the instruments to the NI GPIB card plugged inside an Apple Macintosh, which runs the LabVIEW data acquisition program that we call ThermoCal.

Software for Calibration

Our LabVIEW program not only acquires and prepares data, but also controls the communication with the PLC, Mathematica, and an ORACLE database. We enter the set-up of a calibration, including thermometer serial number, location on the copper block, channel of the scanner, instruments used, and more, in an ORACLE database. LabVIEW reads this set-up via a file generated by this database and checks whether the corresponding GPIB instruments are available.

When the conditions are stable enough to perform a calibration, either the operator or the PLC, via RS-232, launches the LabVIEW data acquisition. As the voltmeter and scanner trigger each other, LabVIEW pauses until a service request wakes it again to read the data from the memory of the voltmeter.

The PLC sends the calibration parameters, including the liquid helium level, helium pressure, and electrical heating power, to LabVIEW.

History and Future

In 1993, we wrote the acquisition program ThermoCal under LabVIEW and also designed, developed, and constructed the calibration facility. The validation tests and upgrades were only possible because of the versatility of LabVIEW paired with the interchangeability of the self-written instrument drivers. These drivers have at...
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their base the same structure, the same measurement protocols, and have the same strictly defined VI nodes. Thanks to only a few carefully considered changes to the LabVIEW look and feel over the years, continuity of both the programmers’ and operators’ work are possible. With the third version of ThermoCal under LabVIEW, we perform not only routine calibrations of more than 1,000 thermometers per year, but also different tests concerning temperature measurement techniques.

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