A New Real-Time Monitoring System for the DC Field Power Supplies: Writing Software and Hardware Functionality

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Abstract

In 2018, the National High Magnetic Field Laboratory launched a new project that will create a more reliable control system for the DC Field Facility’s power supplies. This project will also stabilize the electrical current flow and increase the power to the resistive magnets, greatly improving the quality of their magnetic fields. In order to monitor the current and voltage flowing into the power supplies, an NI-DAQ (data acquisition) device reads the incoming signals, graphs them on a user interface, and saves them to a file on the local server. This device has remained in use for the past decade and uses an outdated version of the LabVIEW software. In recent months, it has failed to consistently deliver this critical information to the server. One part of the power supply project is to replace this monitor with a compactRIO, create a more informative system using the server. One part of the power supply project is to replace this and uses an outdated version of the LabVIEW software. In recent

LabVIEW Software

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NI-DAQ vs NI CompactRIO

NI-DAQ

• Hardware is not configurable.
• Programmer-defined code is limited to the application software.
• A crash affecting the operating system or driver API (application programming interface) may also interfere with the programmer-defined software for processing and logging data.

NI CompactRIO

• Contains a field programmable gate array (FPGA) as a major addition to its hardware architecture.
  – An FPGA is an integrated circuit that is programmable using a Hardware Description Language (HDL).
  – HDLs allow programmers to configure the circuit on an FPGA by creating a digital representation of the circuit.
  – FPGA programming has a higher reliability rate and is faster than a traditional DAQ device because the data processing takes place in hardware.
  – There is no operating system on the FPGA to interfere with the programmer-defined code.

LabVIEW Virtual Instrument Engineering Workbench (LabVIEW)

• LabVIEW is a development environment for graphical programming:
  – Graphical programming is a visual approach to text-based code that uses looped structures to perform different tasks.
  – The following image is a loop configured for the FPGA that continuously reads data from the input channels.
  – Loops can run parallel to each other so that different tasks are running at the same time.
  – Tasks that have a higher priority can be configured to perform operations regardless of the error status of another task.

Virtual Instruments (VIs) and Task Performing Loops

Behind the scenes

• The functionality of the new monitor will depend on three virtual instruments (VI):
  – A VI is a program containing any number of task performing loops or calculations.

1. FPGA VI

• Hosted on the FPGA hardware inside the compactRIO.
• Uses one loop to read measurements from the input channels.

2. Real-time (RT) VI

• Hosted on the cRIO’s Linux-based, real-time operating system.
• Uses six task performing loops to:
  – Communicate with the FPGA VI to obtain measurements and send them to the user interface VI to be graphed.
  – Log measurements to a file on the local server.
  – Log data to a backup file on the cRIO’s memory disk.
  – Monitor the health of the cRIO, including its temperature, CPU usage, and memory usage.
  – Monitor the network connection status of the cRIO.
  – Monitor the overall software performance and reboot the device if necessary.
• The loop responsible for FPGA interaction is deterministic (configured with a higher priority than the other loops).
  – A network connection failure in the data logging loop will inform workers of potential risks to the monitor, like over-heating or high CPU usage.

3. User interface VI

• Hosted over the network on a password protected server.
• Uses one loop to process incoming data and plot measurements.
• In contrast to the user interface on the right, the new interface will have additional tabs for monitoring the performance of the cRIO (CPU usage, memory usage, etc.). This will allow the cRIO to message workers and send them any power supply related updates.

Automatic Messaging

• LabVIEW can communicate with other applications through a variety of internet protocols.
• The HTTP protocol functions are used throughout the RT VI to establish a connection with Slack, a workplace messaging app.
• This will allow the cRIO to message workers and send them any power supply related updates.

Future Work

• Since the NI-DAQ is located in close range to the power supplies, the machine is not easily accessible to workers unless the power supplies are off.
• Once the cRIO functionality is complete, it will be connected to the power supplies and mounted in a more accessible location for future upgrades and maintenance.

Conclusions

The new power supply monitor will greatly reduce the risk of data loss and will provide a reliable platform for data communication. By monitoring the system health and performing automatic reboots, the cRIO will achieve a greater level of independence. Also, the new monitor will succeed the NI-DAQ device in reliability by utilizing the cRIO’s FPGA module, LabVIEW’s HTTP internet protocol functions, and LabVIEW’s priority configuration tools for different tasks.

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