DSG Note 2022-17

Hall A SoLID Magnet Control and Monitoring Status

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December 21, 2022

This note describes the development and implementation of the control and monitoring system for the CLEO magnet intended to be used in the Hall A Solenoidal Large Intensity Detector (SoLID).

The PLC program to control and monitor the entire instrumentation and operations of the solenoid has been developed using function block programming [1]. Routines and subroutines were developed to adapt the old and new instrumentation and sensors to the control and monitoring system.

For example, the PLC routine to monitor the power supply was changed for ramping the magnet to 100 A. The Lakeshore model 622 magnet power supply (±125 A, ±30 V, and 1 KVA) is to be used for the 100 A current test, using a PLC program to communicate with the power supply via serial RS-232 to remotely control and monitor the power supply. But the serial communication card in the power supply failed, so the program and hardware were modified to monitor the power supply via its analog output connector. Figure 1 shows real-time monitoring of the power supply during testing of readout signals.

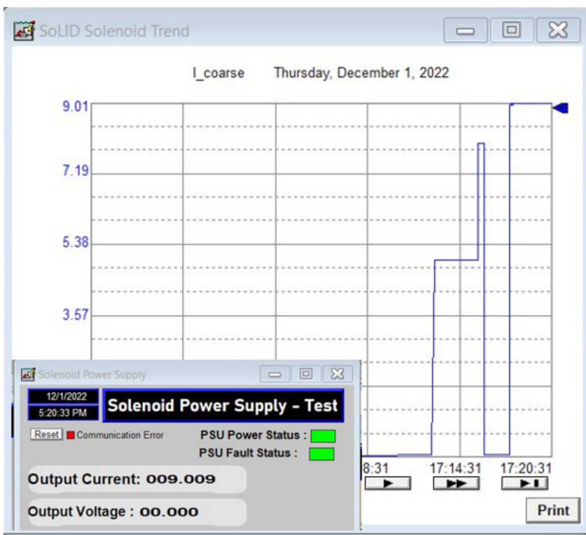

FIG. 1. Lakeshore power supply output current monitored during readout test.

To facilitate control and monitoring of the magnet, Human Machine Interface (HMI) systems, which consist of HMI server, clients, screens, and data archiving system [2], were developed. A total of 33 screens were developed and tested [3] for the low current testing of the magnet.

For use on the screens, NX 12, three-dimensional models based on actual dimensions shown in Oxford's manuals [4] were developed to facilitate the visualization of load sensors, temperature sensors, and voltage tap sensors [5]. For example, the *Solenoid Cryo Control Reservoir Expert* screen, Fig. 2, controls and monitors all instrumentation located in the cryogenic reservoir.

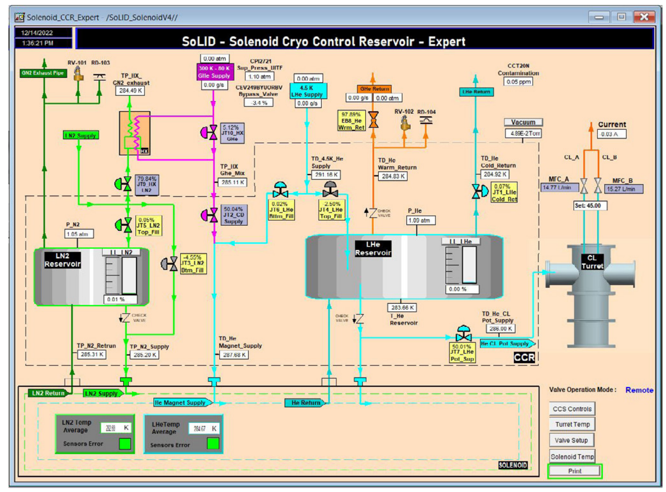

FIG. 2. *Solenoid Cryo Control Reservoir Expert* screen, showing real-time data from connected instrumentation, contains the NX 12 model of the CL turret.

A datalogger system based on FactoryTalk View software was configured and implemented as part of the HMI server to allow data archiving of the instrumentation and sensor readouts to provide the status of the magnet variables. The datalogger monitors and records data automatically to measure, analyze, document, and validate data. Figure 3 shows the datalogger system's archived data for a temperature sensor.

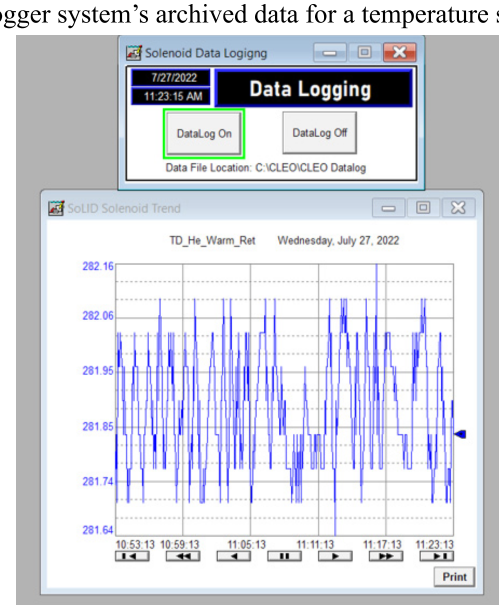

FIG. 3. Datalogger system shows data archived for a temperature sensor.

EPICS CCS-Phoebus screens were developed for EPICS control and monitoring. The Phoebus screens provide equivalent control and monitoring features as the HMI screens [6]. Figure 4 and Fig. 5 show examples of the Phoebus screens.

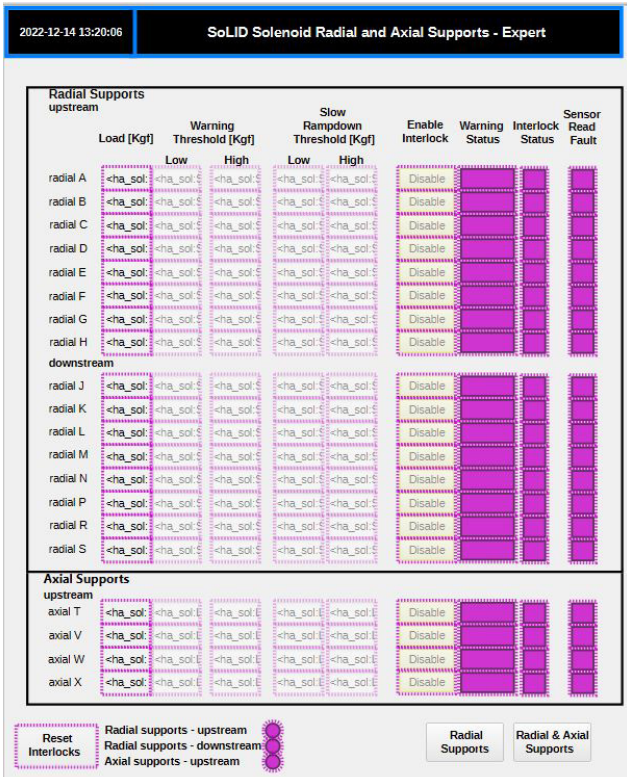

FIG. 4. *Radial and Axial Support Expert* Phoebus screen.

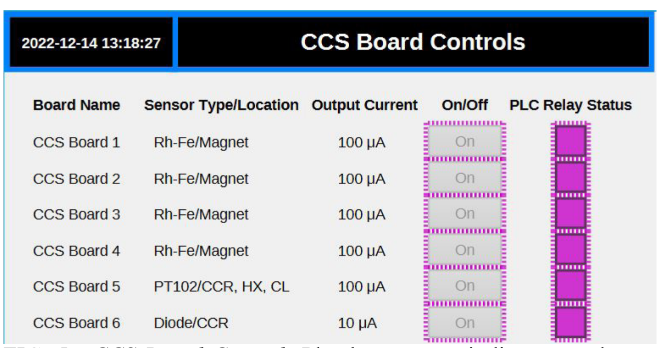

FIG. 5. *CCS Board Controls* Phoebus screen; indicators and controls shown in pink since process variables are disconnected.

Hardware tasks, such as design [7] and wiring of the control racks, Fig. 6, development of nine constant current source boards [8], two motor relay control boards [9], and procurement and fabrication of ~220 cables, were made to connect instrumentation with the control and monitoring system. Additionally, wiring issues were solved.

The disconnection of the instrumentation wiring of the turret flange connectors was done to allow the removal of contamination of mechanical components in the vacuum side of the turret [10]. Prior to re-connection, the wiring was checked, labeled, and repaired. Additional repairs, such as reconnecting a broken wire for a current lead voltage tap at turret vacuum side, Fig. 7, were done.

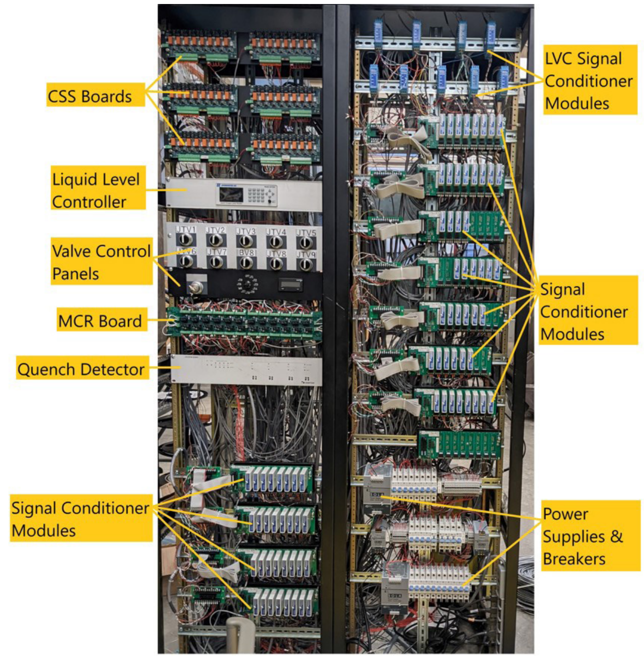

FIG. 6. Rack A and Rack B front sides.

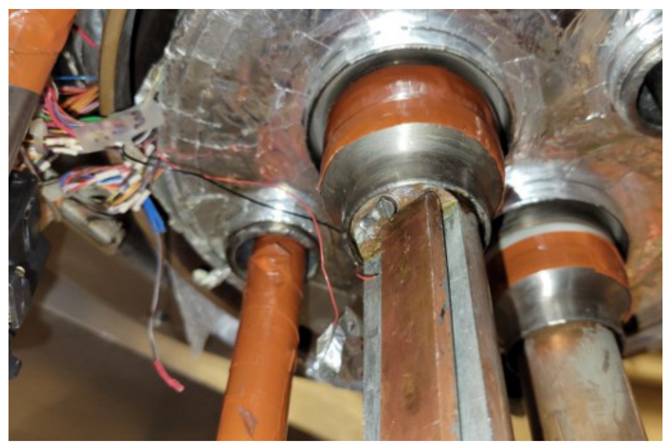

FIG. 7. Voltage tap sensor wire disconnected at the current lead inside the solenoid turret.

Documentation—drawings, control and monitoring diagrams, and spreadsheets with detailed information about mapping of cables and connectors—was developed. Fifty-eight electrical and control drawings were developed [11]. Multiple modifications to some drawings were required due to unexpected wiring changes in pinouts on instrument connectors. Drawings were reviewed and posted.

To conclude, for the low current test of the solenoid, the Detector Support Group (DSG) fabricated the hardware to control instrumentation, generated technical drawings and documentation for installation and troubleshooting, developed and implemented the control and monitoring system —the PLC programs and the HMI system to operate and to control and monitor, and a datalogger; in parallel to this work, DSG developed the EPICS Phoebus control and monitoring system.

[1] P. Campero, et al. *Hall A SoLID Magnet PLC Control System*, DSG Talk 2020-05, 2020.
[2] P. Campero, et al. *Hall A SoLID Magnet Controls & Monitoring System*, DSG Talk 2020-15, 2020.
[3] P.Campero, *SoLID Solenoid HMI and CSS Screens*, DSG technical document, 2022.
[4] *Operating Manual for Cleo II SuperConducting Magnet*, Oxford Instruments LTD, Oxford, England, 1987.
[5] P. Campero, et al., *Two-dimensional and Three-dimensional Models of SoLID Magnet's Structural Components*, DSG Note 2020-24, 2020.
[6] P. Campero, et al., *SoLID Solenoid HMI and CSS-BOY Screens for the Controls & Monitoring System*, DSG Talk 2020-38, 2020.
[7] P. Campero, et al., *SoLID Solenoid Instrumentation and Controls Rack Layouts*, DSG Talk 2020-31, October 2020.
[8] M. McMullen, et al., *Testing and Results for the Constant Current Source Board for the Hall A SoLID Solenoid*, DSG Note 2021-07, 2021.
[9] M. McMullen, et al., *Relay Board to Control JT Valve Motors of the SoLID Solenoid*, DSG Note 2020-29, 2020.
[10] P. Campero, et al., *SoLID Turret Work Status*, DSG Talk 2022-19, 2022.
[11] M. Antonioli, et al., *Drawings for Wiring of Hall A SoLID Instrumentation*, DSG Note 2021-38, 2021.