HMI and CSS-BOY Screens for SoLID Magnet Coils and Radiation Shield Temperatures

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The Detector Support Group (DSG) is contributing to the development of the SoLID magnet [1]. This note presents the development of the Human Machine Interface (HMI) and Control System Studio Best OPI Yet (CSS-BOY) screens to display temperature sensor readings of the SoLID magnet's coils and radiation shields for the controls and monitoring system [2].

During cooldown and steady state operations of the solenoid, it is imperative to monitor the temperature sensors located on the coil shell and the radiation shields; to do so, HMI and CSS-BOY *Coils and Radiation Shields Temperatures* screens were developed.

The HMI and CSS-BOY screens monitor, in real time, the temperature of the coils (~4.5 K in steady state), and the temperature of the inner and outer radiation shields (~80 K).

Thermal insulation of the coil is provided by the radiation shields, which are insulated from room temperature by 100 layers of aluminized mylar super-insulation. The radiation shields consist of two cylinders—inner and outer radiation screens, each of which is made from eight panels of aluminum honeycomb. Internal aluminum cooling pipes bonded to the radiation screens' skin flows LN_2 to handle a heat load of ~50 W, generated by the current in the coil and absorbed from the ambient environment.

The screens are developed in three stages: generation of graphics used to show an approximate location of the temperature sensors, HMI and CSS-BOY layout and programming of the screen, and finally, testing of the screens.

For the first stage, based on 1986 drawings made by the magnet manufacturer Oxford Instruments, a 3D model of the coil shell and radiation shields was developed with the NX12 CAD program. Advanced NX12 features such as coloring and shading were implemented to get a realistic view of the radiation shields and coil shell to be displayed in the HMI and CSS-BOY screens.

In the second stage, layout and programming, the developed NX12 3D model was inserted as an image file and indicator lines are used to point to the approximate sensor locations over the inserted image. The basic functions of the screen are to display values of 21 temperature sensors installed in the magnet, and alarms that occur when readout faults for temperature sensors are present.

The HMI screen [2], Fig. 1, was generated with Factory Talk View Studio software; for the CSS-BOY screen [3], Fig. 2, Control System Studio software was used.

Twelve temperature sensors (TS1–TS6 and TS21–TS26) located on the coil shell measure helium temperature. These sensors are distributed along the length of the coil shell—three sensors each at 2:00, 5:00, 7:00, and 11:00 o'clock positions, and are embedded in the shell (bonded in blinds holes) to monitor temperature in the superconducting coil. Another two sensors (TS33 and TS34) are bonded in blocks and at-
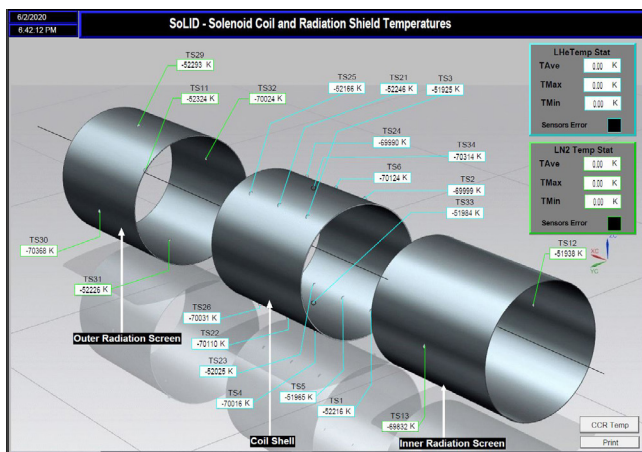

FIG. 1. SoLID Solenoid Coil Shell and Radiation Shield Temperatures HMI screen. Note, the values shown in the picture are arbitrary as the screen has not yet been deployed.
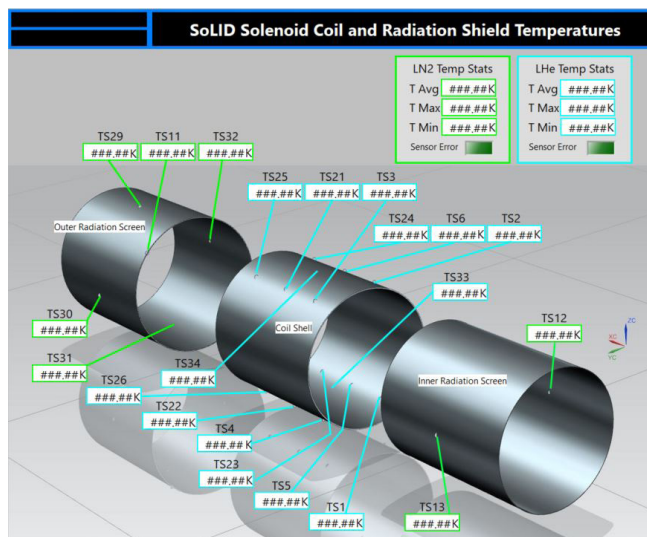

FIG. 2. SoLID Solenoid Coil Shell and Radiation Shield Temperatures CSS-BOY screen.

tached by screws to the baseplate.

Two sensors (TS12 and TS13) located on the inner radiation screen are bonded on blocks, which are screwed onto the outside of the inner skin of the radiation screen. Four temperature sensors (TS29–TS32) on the outer radiation shield are also bonded on blocks, which are screwed onto the outer skin of the outer radiation screen. Sensors on the radiation screens monitor the liquid nitrogen temperature.

Each indicator on the HMI screen will show the value of a PLC tag associated with temperature sensor readout. Indicators on the CSS-BOY screen will show the value of the EPICS process variables, which are associated with the PLC tags shown in the HMI screen. The labels used for each temperature sensor monitored in the HMI/CSS-BOY screen come from the original names issued by Oxford Instruments.

Temperature indicators are configured to blink red when a sensor fault is present, indicating that the faults are in real time. A fault is present when the resistance measured for the temperature sensor is out of range, typically 0 Ω–40 Ω, or the PLC ADC module channel indicates an error.

The two boxes in the upper right corner of the HMI/CSS-BOY screens show temperature statistics (minimum, maximum, and average) of the magnet. Sensor error indicators shown on the screen blink red when any of the temperature sensors located in the magnet has a fault.

Finally, the third stage, where the HMI and CSS-BOY screens are tested. The HMI screen is tested by reading the actual values from the PLC in running mode since the HMI system is linked with the PLC. Temperature values and faults are read from the PLC and can be monitored in real time for each indicator in the HMI screen. To test error conditions, test PLC tags are used, whose values can be changed without affecting the system. The CSS-BOY screen is tested by using local PVs generated by script that runs in the CSS environment [4 and 5].

The first version of the *Coils and Radiation Shield Temperatures* screens is complete [6]. Both HMI and CSS-BOY screens are ready to be deployed.

[1] P. Campero, et al., *Hall A SoLID Solenoid*, DSG Note 2020-05, 2020.
[2] P. Campero, *Hall A SoLID Magnet Instrumentation and Controls and Monitoring System*, DSG Talk 2020-05, 2020.
[3] M. A. Antonioli, *Generating CSS-BOY Screens*, DSG Talk 2020-20, 2020.
[4] T. Lemon, et al., *Test Operator Interface Creator Program,* DSG Note 2020-23, 2020.
[5] T. Lemon, *Test OPI Creator*, DSG Talk 2020-17, 2020.
[6] P, Campero, et al., *DSG SoLID Design and Development Highlights*, DSG Talk 2020-21, 2020.