

## Controls and Monitoring Screens for the Axial and Radial Supports of SoLID's Solenoid

Pablo Campero and Mary Ann Antonioli, Peter Bonneau, Aaron Brown, Brian Eng, George Jacobs, Mindy Leffel, Tyler Lemon, Marc McMullen, and Amrit Yegneswaran

*Physics Division, Thomas Jefferson National Accelerator Facility, Newport News, VA 23606*

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This note describes the development of the Human Machine Interface (HMI) and Control System Studio Best OPI Yet (CSS-BOY) screens to monitor the strain gauge load cell sensors located at the axial and radial supports of the solenoid.

To ensure safe operation of the solenoid, it is necessary to monitor the forces on the axial and radial supports, prior to and during cooldown, during steady state operations, as well as for the solenoid's move from the test lab to Hall A.

The HMI screens, Figs. 1 and 2, show the locations of the radial and axial supports, eight supports at each end of the solenoid. Supports A, B, C, D, E, F, G, and H, Fig. 1, are located at the solenoid's end surface located at  $x, y, -l/2$ , where  $l$  is the solenoid's length, with respect to a coordinate system whose origin is at the center of the solenoid. Supports J, K, L, M, N, P, R, and S are located at the other end of the solenoid,  $(x, y, +l/2)$ , Fig. 2. The support rods are attached to a geared jack unit that has a strain gauge load cell sensor, which is used to monitor the load [1].

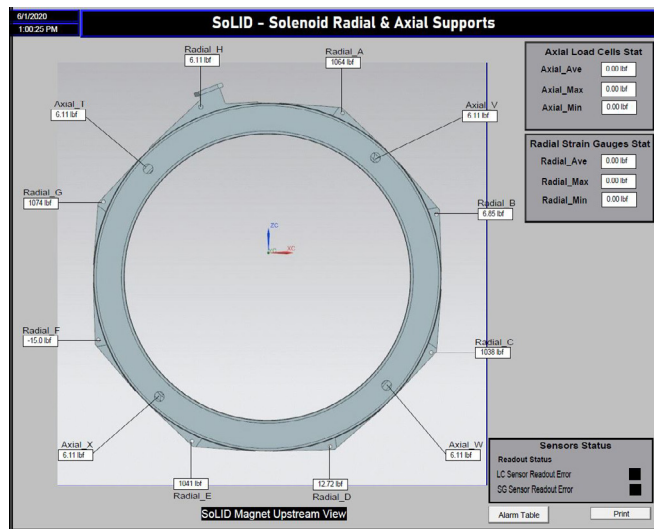


FIG. 1. HMI screen of the axial and radial supports at the  $(x, y, -l/2)$  plane of the solenoid.

There are four axial struts T, V, W and X, Fig. 1. These struts are bellows sealed through to the vacuum space and each strut is connected to an extension rod which terminates at the outer face of the coil collar [2] in an axial strain gauge load cell sensor. Measurement of the axial position of the coil is made at each of the four axial struts. Both axial and radial supports' sensors are read by the PLC control system [3].

Based on drawings made by the magnet manufacturer Oxford Instruments in 1986, two- and three-dimensional models of the axial and radial supports were developed with the NX12 Computer Aided Design (CAD) program; these models are used in the HMI and CSS-BOY screens [4]. The CAD

models are inserted as an image file and indicator lines are generated to point to the sensor locations.

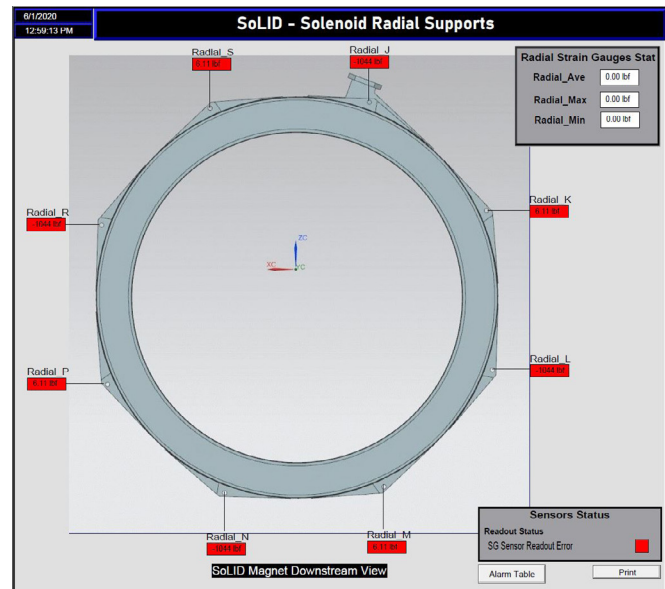


FIG. 2. HMI screen of the radial supports at the  $(x, y, +l/2)$  plane of the solenoid. Red indicators show PLC channel faults because radial support strain gauge load cell sensors are not connected to the PLC.

FactoryTalk View Studio software is used to generate the HMI screens [5]. The CSS-BOY screens, Figs. 3 and 4, are generated with Control System Studio software and are based on the HMI screens [6].

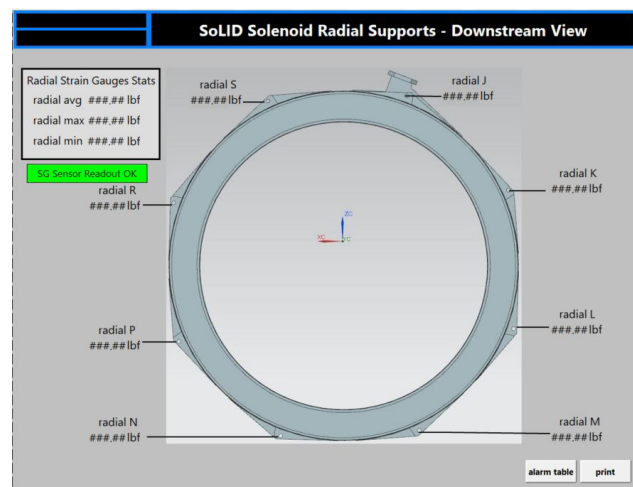


FIG. 3. SoLID Solenoid Radial Supports CSS-BOY screen.

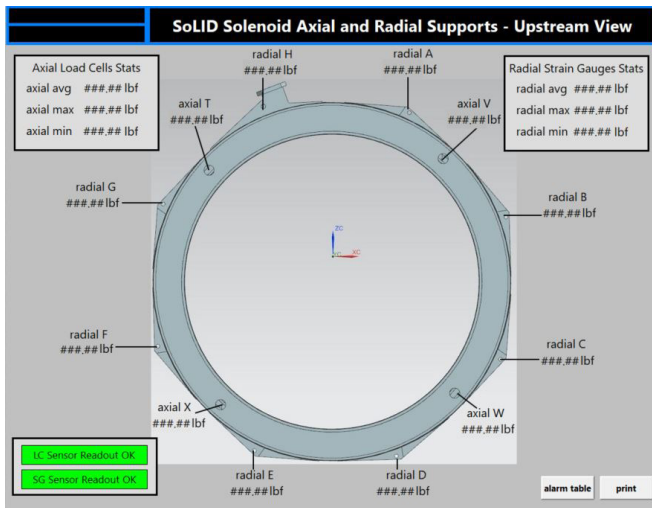


FIG. 4. SoLID Solenoid Axial and Radial Supports CSS-BOY screen.

Both types of screens show the specific locations of the axial and radial supports, display sensor readouts, sensors' or PLC channels' faults, and strain gauge load cell sensor statistics. Each indicator shown on the HMI screen shows the value of a PLC tag associated with a strain gauge load cell sensor readout. Indicators on the CSS-BOY screen show the value of the EPICS process variables that are associated with the PLC tags shown in the HMI screen.

Forces' indicators are configured to blink red when a sensor fault is present. A fault is present when the resistance measured for a force sensor is out of range or the PLC ADC module channel indicates an error, Fig. 2.

The boxes in the upper corners of both screen types show force readout statistics. LED indicators in the box located at the lower right corner (HMI), Fig. 2, and lower left corner (CSS-BOY), Fig. 4, blink red when any of the axial or radial support sensors have a fault.

All screens have a button named "Alarm Table" to enable navigation to the *Axial and Radial Expert* screen. The Print button allows a screenshot of the screen with the current values, a feature useful during the debugging process.

Since the HMI system is linked with the PLC, the HMI screen is tested by reading actual values from the PLC in running mode. Force values and faults are read from the PLC and can be monitored in real time for each indicator on the screen. To test error conditions, test PLC tags are used and values can be changed without affecting the system. Indicators' values, blinking features, navigation buttons, and screen format (text size, image quality and size, and colors) are tested by running FactoryTalk SE Client [5], which connects to the HMI server and allows real time monitoring to make the test more effective. CSS-BOY screens are tested by using local PVs generated by script that runs in the CSS environment [7].

To conclude, the first versions of the axial and radial HMI and CSS screens are completed. Both types of screens are ready to be implemented.

- [1] Oxford Instruments LTD, *Operating Manual for Cleo II Super Conducting Magnet*, Oxford England, 1987.
- [2] Y. Kubota, *The Cleo II Detector*, Elsevier Science Publishers, 1992.
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- [4] P. Campero, et al, *Two-dimensional and Three-dimensional Models of SoLID Magnet's Structural Components*, DSG Note 2020-24, 2020.
- [5] P. Campero, et al. *Steps to Install and Run the HMI System*, DSG Note 2020-21, 2020.
- [6] M. A. Antonioli, *Generating CSS-BOY Screens*, DSG Talk 2020-20, 2020.
- [7] T. Lemon, et al. *Test Operator Interface Creator Program*, DSG Note 2020-23, 2020.