Testing and Results for the Constant Current Source Board for the Hall A SoLID Solenoid

Marc McMullen, Peter Bonneau, Pablo Campero, and Mindy Leffel; Mary Ann Antonioli, Aaron Brown, Brian Eng, George Jacobs, Tyler Lemon, and Amrit Yegneswaran
Physics Division, Thomas Jefferson National Accelerator Facility, Newport News, VA 23606
April 14, 2021

The Constant Current Source (CCS) board [1, 2, 3] for the Hall A SoLID solenoid is designed to provide 100-µA current to temperature sensors [4]. This note describes the testing of the boards and presents the results.

Figure 1 shows the schematic of a single channel of the eight-channel CCS board. Using the three-pin selection header JPx02 (in this note, the range of x is 1–8, whenever x appears in a label name), each channel can be configured to power the temperature sensor either remotely (by shorting pin 1 and pin 2) or locally (by shorting pin 1 and pin 3). Each of the eight, normally-open relays Kx01 can be actuated by powering them from an external power supply. A single PLC channel controls all the relays via connector J2. The 24-V input connector PL101 provides power to the board's power plane, which distributes power to 10-V reference U1, eight JPx02, and eight operational amplifiers Ux01—used in the current compensation circuits which regulate the current flow of each channel via the 10-kΩ, 1% resistor Rx01. Eight temperature sensors can be connected to the CCS board via the 16-position connector J1; their return current is routed through a compensating circuit. Input current to the board is limited by the 1-A fuse F1 and each individual circuit has 120-mA thermal fuse Fx01.

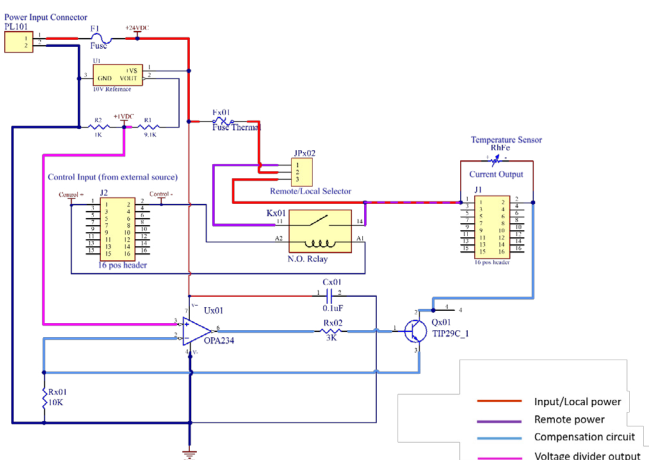

FIG. 1. A single channel of the CCS board circuit.

To test the relays, a 24-V benchtop power supply was connected to PL101, JP102 was set in remote mode and its output was connected to the bussed, odd-numbered pins of J2, Fig. 2. The bussed return, even-numbered pins of J1 were routed back to the power supply. To indicate the presence of power, an LED was connected to each odd-numbered pin of J1, Fig. 3. Upon turning on the power, the eight Kx01 closed. All LEDs lit up indicating the relays worked.

To determine whether current is a constant at ~100 µA, independent of the input voltage, a test was run in the local mode. Current resistors of known values were used as shunts, which in place of the temperature sensors, provided the load. DMM 1, Fig. 4, measured the input voltage to the circuit board and DMM 2 measured voltage across the shunt resistor.

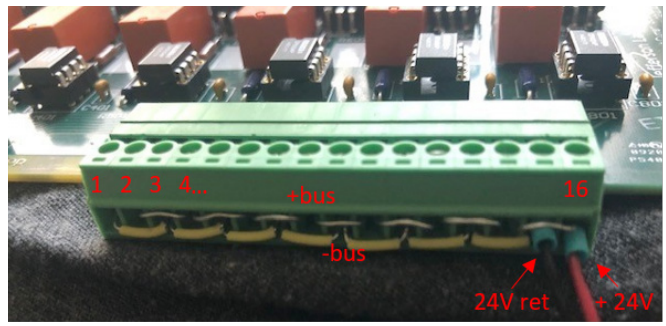

FIG. 2. Even and odd bussing of J2.

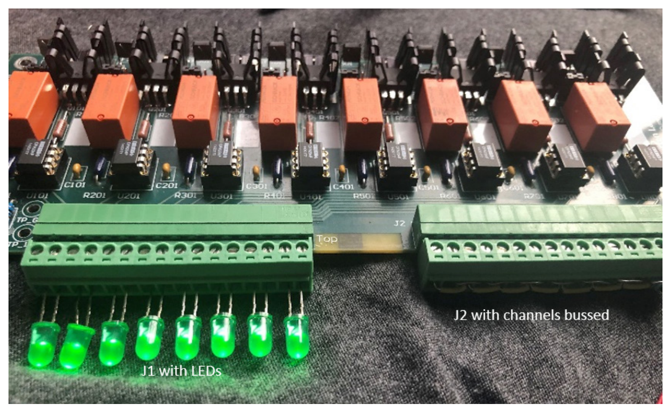

FIG. 3. CCS board with constant current connector J1 and controls input connector J2.

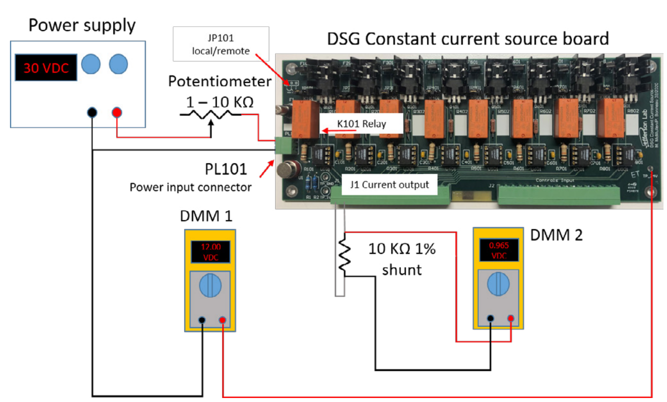

FIG. 4. Testing for constant current using a 10-kΩ resistor as the load.

A potentiometer was set to control the input voltage to the board. After the initial measurement across the shunt with the potentiometer set to its highest resistance of 10 kΩ, the potentiometer's resistance was reduced to increase the input voltage, in one volt steps, until the input voltage reached 30 V.

As the input voltage reached ~11 V, U1 started to provide 10 V to a divider circuit—a 1-kΩ resistor in series with a 9.1-kΩ resistor. The voltage drop across the 1-kΩ resistor, ~1 V, powered the noninverting input of Ux01. The output of Ux01 is connected via the 3-kΩ, Rx02 resistor to the base of an NPN transistor, whose collector-emitter junction is the return path. The current flowed from the emitter through Rx01 to the supply's return. Measurements were recorded at each voltage step. The current through the shunt resistor was calculated and plotted, Fig. 5.

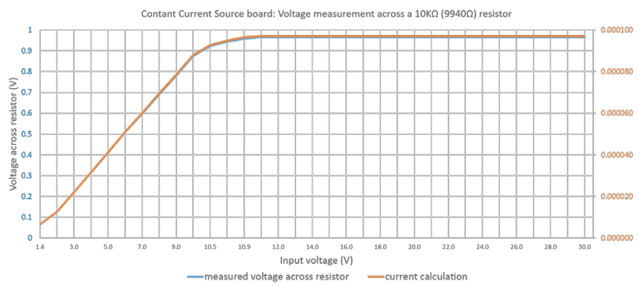

FIG. 5. Input voltage vs. current plot; current is constant at 97 µA.

The Constant Current Source board's relays and current output were tested; relays functioned and current was stable at ~100 µA. Eight boards have been assembled and tested.

[1] M. McMullen et al., *Constant Current Source Printed Circuit Board*, DSG Note 2020-07, 2020.

[2] M. McMullen et al., *Design and Routing of the Constant Current Source Board for SoLID*, DSG Talk 2019-35, 2019.

[3] M. McMullen et al., *DSG Modification to the Constant Current Source Board for SoLID*, DSG Talk 2020-04, 2020.

[4] P. Campero et al., *Temperature Controls and Monitoring System for the Hall A SoLID Solenoid*, DSG Note 2020-34, 2020.