Constant Current Source Printed Circuit Board

Marc McMullen, Mary Ann Antonioli, Peter Bonneau, Aaron Brown, Pablo Campero, Brian Eng, George Jacobs,
Mindy Leffel, Tyler Lemon, and Amrit Yegneswaran
Physics Division, Thomas Jefferson National Accelerator Facility, Newport News, VA 23606
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Rhodium-iron temperature sensors measure the temperature inside the SoLID solenoid; the measured temperature values are used in the safety interlocks. These sensors require a 100 µA constant current for operation. The Detector Support Group has developed an eight-channel constant current source (CCS) board.

The Hall A SoLID magnet requires constant current source boards that provide 100 µA to its rhodium-iron temperature sensors, which are crucial for the safe operation of the magnet. Figure 1 shows the schematic for a single channel of the eight-channel CCS board.

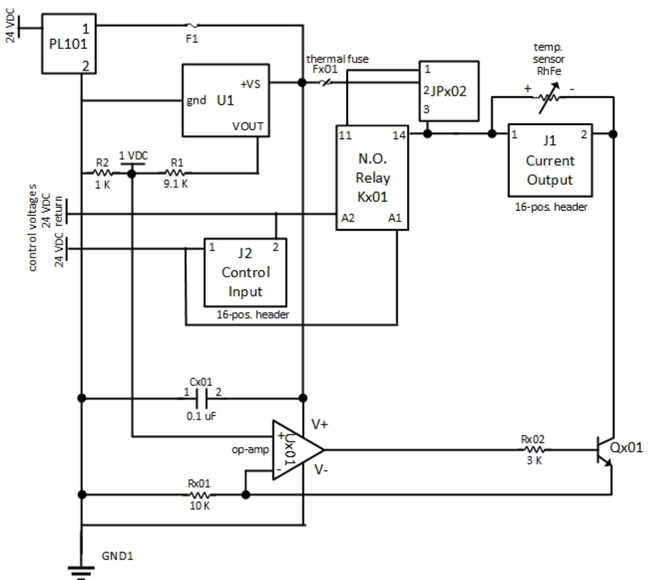

FIG. 1. Single channel electronic circuit of CCS.

Power to each channel is provided by the input connector PL101 and is routed via fuse F1 to the op-amp and to the rhodium-iron sensor—via the thermal fuse Fx01 (as there are eight channels on the board, $x \in [1, 8]$) and through a three-pin header (JPx02). The two positions on JPx02 enable operating each channel either in remote or in local mode.

If JPx02 is in remote mode (pins 1 and 2 jumpered together), the PLC controls the power to the temperature sensor. A 24 V, control voltage from the PLC through the control input connector J2 can be supplied to the normally open relay Kx01. When power is applied to Kx01, it closes the contact powering the sensor through the output connector J1. Current from the sensor flows through the collector to the emitter and is fixed to 100 µA by the 10 KΩ resistor Rx01.

The voltage regulator U1 outputs a 10 V reference voltage to the input of the voltage divider resistors R1 (9.1 KΩ) and R2 (1 KΩ). From the node between the two resistors, ~1 V is input to the op-amp's non-inverting input. The output of the op-amp controls the voltage via a 3 kΩ resistor to the base of the Tip29c transistor Qx01. Current supplied to the sensor is maintained at ~100 µA by the compensation circuit (op-amp and transistor). The error on the current on the resistor is dependent on the base current (~1 µA) of the transistor.

When JPx02 is in the local mode (pins 2 and 3 shorted), Kx01 is bypassed, and the current to the sensor is supplied directly via the J2 output pins. Current is still maintained at 100 µA by the compensation circuit.

The four layer CCS board measures 3" X 8" X 0.062". The cross-section of the board is shown in Fig. 2.

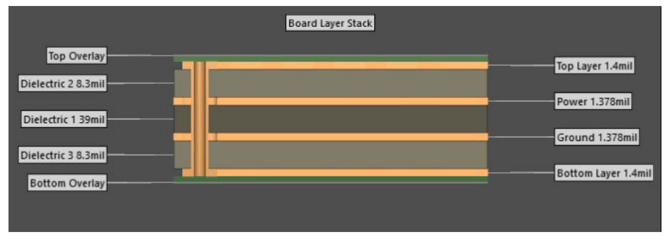

FIG. 2. CCS board cross-section drawing.

The top layer (Fig. 3) trace widths are ≥ 20 mils and connect the current output connector to the normally open contact of the relays and the transistor collector pins, and the thermal fuse to the remote/local selection header.

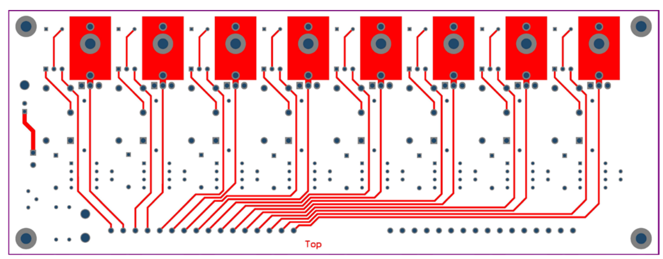

FIG. 3. Board layout, top layer.

Internal layer 1 (Fig. 4) is the power plane, which is split into two areas, separated by 40 mils. The upper area supplies 24 V to the regulator and the op-amps, the smaller bottom area supplies ~1 V to the non-inverting input of the op-amps.

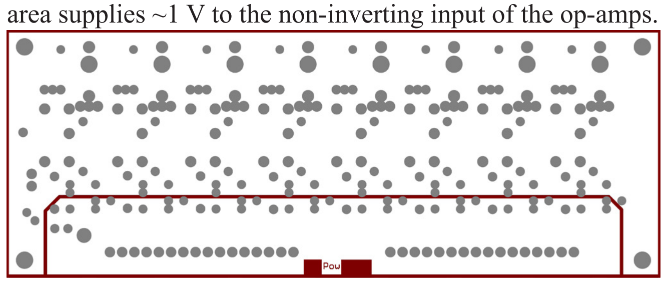

FIG. 4. Power plane.

Internal layer 2, Fig. 4, is a continuous ground plane and has a one ounce copper pour.

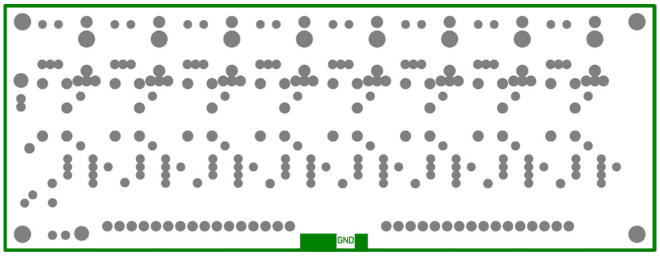

FIG. 4. Ground plane, internal layer 2.

The bottom layer (Fig. 5) has 20 mil traces that connect the controls input connector to the relay coils. A single, 50 mil trace, circled in Fig. 5, is routed from the voltage reference output to the input resistor of the voltage divider circuit.

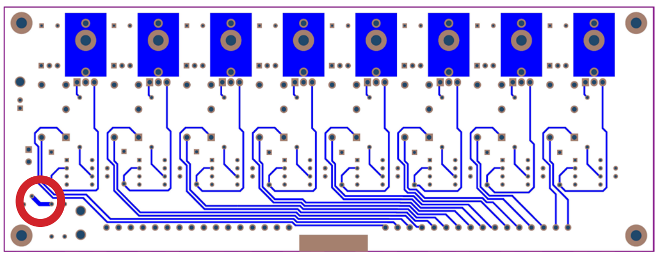

FIG. 5. Bottom layer.

Figure 6 shows an Altium 3-D rendering of the printed circuit board, showing all components on the top layer.

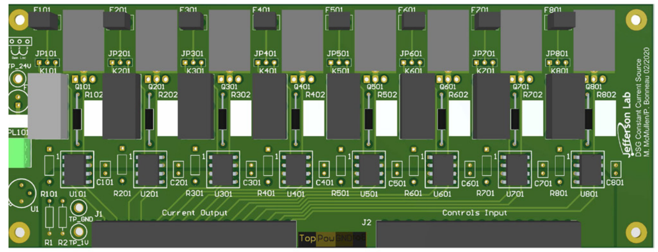

FIG. 6. Altium 3-D rendering of the CCS board.

To conclude, the routing of the CCS board has been completed. Components for the board have been procured. The board design is being reviewed.