Relay Board to Control JT Valve Motors of the SoLID Solenoid

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To actuate the Joule Thomson (JT) valve motors of the SoLID solenoid, the Detector Support Group has designed a 24-channel relay board, which can be controlled either manually or by the PLC. This note presents the design details of the relay board.

The relay board, part of the JT valve system, controls cryogenic flow, Fig. 1. Actuating the JT valve in either local or remote (PLC) mode is determined by the position of an actuator drive key selector. The position of the selector is monitored by a DC input module in the PLC system to determine whether to control the JT valve motors manually or by the PLC program.

Opening, closing, or maintaining the aperture can be performed manually through the use of a spring return switch, Fig. 1, which can be positioned to open, close, or hold position—the normal state of the switch. While in the hold position, the motor does not turn.

To open, close, or maintain the aperture for appropriate temperature during cooldown or steady state operations, the PLC program uses a proportional–integral–derivative (PID) loop to continuously control the JT valve aperture by using a macro sensor to monitor the secondary coil current in relation to the primary coil current of the linear variable differential transformer.

The macro sensor outputs current of 0 mA–20 mA to an ADC module in the PLC chassis. The read back ADC value is compared to the demand ADC value to determine whether to open or close the JT valve. To do so, the PLC energizes one of two relay coils, one to open and one to close, on the board that are connected to the motor. When one of the relays is activated, the relay switches the motor power connection from common return to +24 V, which drives the motor to either open or close the valve until that relay coil is de-energized, which stops the motor. If the PLC sends no signal to power either relay coil, the motor will not turn in either direction.

The relay board has 24 relay circuits, which are grouped in four sets of six relays. These sets can be configured in two arrangements by using jumpers—four sets of six relay channels or two sets of 12 relay channels, Fig. 2.

Each double-pole double-throw relay, Fig. 3, controls two sets (A and B) of relay contacts. Each set of contacts has a common contact that switches from a normally closed state to a normally opened state. Each set of six relays also has a two-position terminal header with a B relay common connection and a coil common connection.

FIG. 1. The JT valves control system, which features the 24-channel motor controller relay board.

FIG. 2. Relay board with 24 channels.

FIG. 3. Double-pole double-throw relay.
Each relay channel has a terminal that allows six connections—A normally open, A common (relay), A normally closed, B normally closed, B normally open, and coil.

Each relay has an indicator LED with a 3 KΩ resistor and a diode for the relay coil. The diode prevents damage to the circuits when power to the coil is removed, Fig. 4.

The Altium rendering of the relay board is shown in Fig. 5.

To conclude, the board has been reviewed and has been sent for manufacturing.