Development of Readout Electronics for Gas Flow Sensors for the Hall A GEM Detectors

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One of the components in the Hall A GEM detector gas distribution system [1] is an electronic flow sensor. After successful performance testing [2] of the Honeywell Zephyr series mass flow meter, along with a radiation test confirming no measurement errors up to 500 Gy, the Honeywell sensor was selected for use in the system. This note presents the PCB developed for these sensors.

There are ~50 gas lines for the GEM detector's gas distribution system. The flow of Ar/CO_2 (70%:30%) gas through these lines has to be monitored by a system that is easy to install and enables seamless integration with the existing controls setup. To this end, DSG designed a PCB to be populated with the Honeywell sensor HAFBLF0400C4AX5 and an RJ-11 6P4C connector. The RJ-11 connector uses the same pinout as existing PCBs in halls (A and C) to which the new PCB could be connected.

Figure 1 shows the circuit schematic. Using I2C communications protocol, data are transmitted between the master, a readout controller such as a Raspberry Pi, and slave, the sensor mounted to the board, via the serial data (SDA) line—RJ-11 connector pin 5 to sensor pin 4. Data are synchronized by the clock signal, which is transmitted on the serial clock (SCL) line, RJ-11 pin 4 to sensor pin 1. The RJ-11 connector supplies 5 V from pin 3 to pin 2 on the sensor, and ground from pin 2 to pin 3 of the sensor.

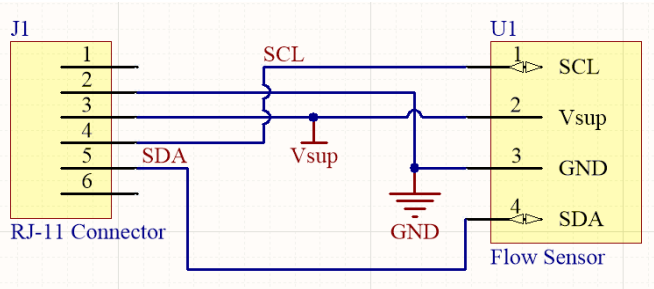

FIG. 1. Schematic of gas flow sensor PCB.

The PCB design has a small footprint of 2.3" x 2.1" x 0.062". The design has two layers, each with a 1-ounce copper pour covering most of the board. The copper pour clearance is 25 mils and the minimum clearance is set to 15 mils. The top layer has a single, 20 mil-wide trace that transmits the serial data and a connection to the top copper pour, which is connected to voltage supply return. Both components, the flow sensor and the connector, are through-hole, solder-mount components, which are mounted to the top side. The bottom layer has a single, 20 mil-wide trace for the clock signal and the connection for voltage supply. The board has four 0.150" mounting holes for 6/32 screws, clear of the ground and power planes.

Figure 2 shows a board populated with its components.

Using the I2C protocol, a single master component can communicate with several slave units on the same bus by using the address and acknowledgment bits to access registers and transfer data. Common data transfer rates are 100 Kb/s (standard) and 400 Kb/s.

FIG. 2. Populated gas flow PCB.

To be able to communicate with several slave units, DSG is developing an I2C multiplexer circuit board, which will communicate with up to eight flow sensors. The entire gas distribution system will require approximately eight multiplexer boards.

To conclude, the PCB has been designed, produced, and populated with the Honeywell sensor and RJ-11 connector.

[1] G. Jacobs, et al., *Design of the Gas Distribution System for the Hall A GEM Detectors*, DSG Note 2019-33, 2019.
[2] B. Eng, et al., *Comparison of MKS and Honeywell Zephyr Series Mass Flow Sensors for Hall A GEM Detectors*, DSG Note 2019-34.