Building of Gas Flow Monitor for GEM Detector

S. Sahu[1],* P. K. Sahu[1], S. Swain[1], and S. Biswas[2]
[1]*Institute of Physics, Sachivalaya Marg, P.O: Sainik School, Bhubaneswar - 751 005, Odisha, India and*
[2]*Bose Institute, Department of Physics and Centre for Astroparticle Physics and Space Science (CAPSS), EN-80, Sector V, Kolkata-700091, India*

Introduction

Now a days Gas Electron Multiplier (GEM) detector is one of the most promising detectors in High Energy Physics (HEP) experiments [1]. Since GEM detector is operated in flow mode at a positive pressure, the flow rate variation plays a significant role on the detector gain and other performances. ALICE (A Large Ion Collider Experiment) experiment at CERN will use GEM chambers as the readout of the TPC (Time Projection Chamber). CBM (Compressed Baryonic Matter) experiment at FAIR (Facility for Antiproton and Ion Research), Germany will use CEM modules for its muon chamber [2–4]. In both the experiments the number and size of the GEM chambers will be large and it needs gas in flow mode.

At IOP detector laboratory, we built and tested a gas flow monitor for obtaining flow rate of a given gas mixture. The gas flow monitor is incorporated with a mass flow sensor which converts the amount of gas flow into a voltage pulse. Later on, the voltage signal is fed into the appropriate electronics for getting a calibrated output. The details of the design, fabrication and calibration of the gas flow monitor is presented in this article.

Design principle

The gas flow monitor is designed with a mass flow sensor (Module number AWM2100), shown in FIG. 1 that can measure a maximum upto 200 SCCM (standard cubic centimetre per minute). The sensor is a balanced bridge type and operates on the principle of heat transfer. This is achieved by heating the four wire resistors suspended at the bridge arm through a constant current source upto a particular temperature where one of it's wire element is suspended in the air/gas stream.

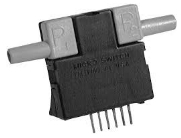

FIG. 1: Mass flow sensor AWM2100.

As all the elements are excited from a constant current source the temperature remains constant throughout the wire. So the resistance also remains constant and under this condition the bridge is balanced, showing no output voltage. The wire's electrical resistance increases as the temperature increases, which varies the current flowing through the circuit. When the gas flows through the sensor, it cause one of it's element to lose heat faster, as a result, the wire temperature decreases by reducing the resistance, in turn the bridge is unbalanced and a voltage output is obtained from the bridge. The equilibrium temperature of the bridge element depends upon the gas flow rate and the specific heat of the type of gas mixture.

The voltage pulse of the sensor is fed into a integrated electronic circuit which converts the signal into a calibrated one. The electronic circuit is basically composed of a buffer and a low pass filter. The total flow monitoring setup is shown in FIG. 2.

The signals are fed to the ADC of the controller. Atmel SAM3X8E, 32-Bit ARM

*Electronic address: `ssahu@iopb.res.in`, `sahusanjib69@gmail.com`

Cortex-M3 Microcontroller is programmed to read the two ADCs i.e.ADC0 and ADC1. As the sensor output is very low, even 1 mV noise may affect the readings. So the statistical and DSP Algorithms are implemented to remove the glitches and errors. The processed data for flow rate in l/h are transferred to the PC by using an USB interface in a hand shake mode. The Data can be displayed locally using a LCD/LED Panel.

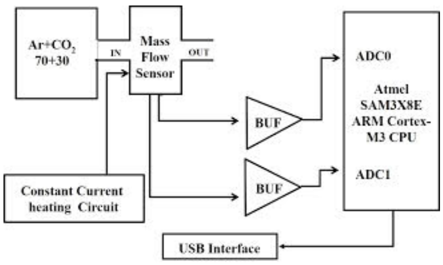

FIG. 2: Set-up for gas flow monitor.

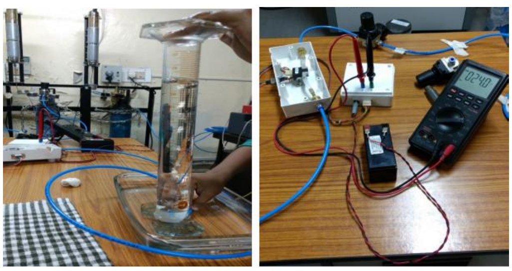

FIG. 3: Calibration with water displacement method.

Calibration

The sensor was calibrated only for pure and single gases. But in our case, we are using a gas mixture (Argon and CO_2 in 70/30 ratio) we have to recalibrate the sensor output voltage (in mV) with the flow rate (in SCCM). So the calibration was done manually by water displacement method. The set-up for calibration is given in FIG. 3.

At the beginning, a measuring cylinder is filled with water and kept inverted inside a half filled glass tray. One end of the gas-outlet tube from the flow sensor is now gently put into the measuring cylinder. At a constant flow rate, displacement of a fixed volume (30 ml) of the gas inside the cylinder is measured and the time interval (t in minute) is also recorded using a stop-watch. The gas flow rate is calculated by dividing the volume of water displaced to time taken in SCCM and the corresponding output voltage (in mV) of the sensor is noted from a multi-meter. This procedure is repeated for different ranges of gas flow starting from 10 SCCM to 200 SCCM. The plot is obtained for flow rate as a function of the output voltage which is then fitted with a second order polynomial function as shown in FIG. 4. The fitted function is then used to calculate the accurate flow rate. The flow rate increases with increasing voltage and acquires a maximum of 180 SCCM at 39 mV.

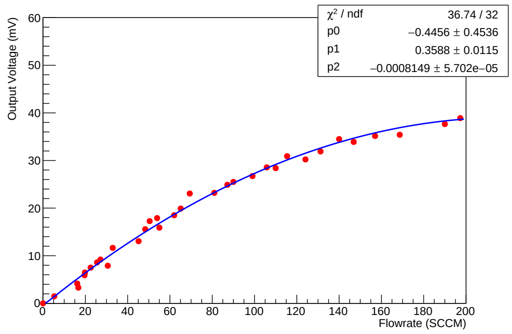

FIG. 4: The calibration curve.

Summary

One microcontroller based gas flow monitor is built and calibrated for Argon and CO_2 mixture in 70/30 ratio. It is found that the output voltage increases with increasing flow rate. The linearity is observed upto a flow rate of 100 SCCM. The accuracy and the measurement resolution are found to be ± 3.5% and 4 SCCM, respectively.

References

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