Gas Flux System

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Abstract

In this report, we will go through the importance of adding a gas flux system in the CMS "RPC" LAB's as well as the process of creating said system. For this design we will use the esp32 microcontroller in conjunction with the D6F-P0010A2 flow sensor. This system will mainly be used in order to monitor and control the gas flow within the RPC chambers in the laboratory. We will discuss the importance of reducing these gas emissions, the purpose of doing so and some of the effects that these emissions might have on the environment. Lastly this report will discuss some results and data collected using said system.

Key words: Gas Flux, RPC, Sensor, Microcontroller

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1 Introduction

What is the universe made of? What are the internal forces that it is subject to? These crucial concerns have been the focus of research by scientists worldwide. In order to answer these questions, we must first recreate the circumstances that existed billions of years ago, beginning with the “Big Bang” when the cosmos was extremely hot and dense. After that, it cooled down and the conditions for the creation of the fundamental building blocks of matter, quarks and leptons started.

Scientist are using many types of gas detectors at CERN in order to detect a wide variety of particles that are produced by the collisions in the accelerators. The main accelerator is the LHC, where the results of the collisions are collected by the experiments: ATLAS, ALICE, LHCB and CMS. CMS is a multipurpose experiment which uses RPC’s (Resistive Plate Chambers) that contain a mixture of gas that can have some effect on the environment (greenhouse gas).

2 Gas Flux System Function and Design

When muon particles pass through RPC chambers, they ionize and the electrons from the gas are accelerated at energies allowing them to collide with other atoms creating an avalanche of electrons. After that, the signal is picked up by metallic strips for further analysis.

Greenhouse gasses are typically known as any gas that is capable of absorbing the infrared radiation which traps or holds in the heat in the atmosphere.

These gas chambers use a gas mixture containing greenhouse gases, the main of them being TFE (Tetrafluoroethylene) gas, in a proportion of about 90% which causes immense harm to the environment and has a high global warming contribution.

This is where our design the gas flux system comes in, this designs main purpose is to detect gas flux or rather whether there is any gas leakage occurring or not. Also, the design serves as a way to monitor the amount of gas flux within these gas chambers.

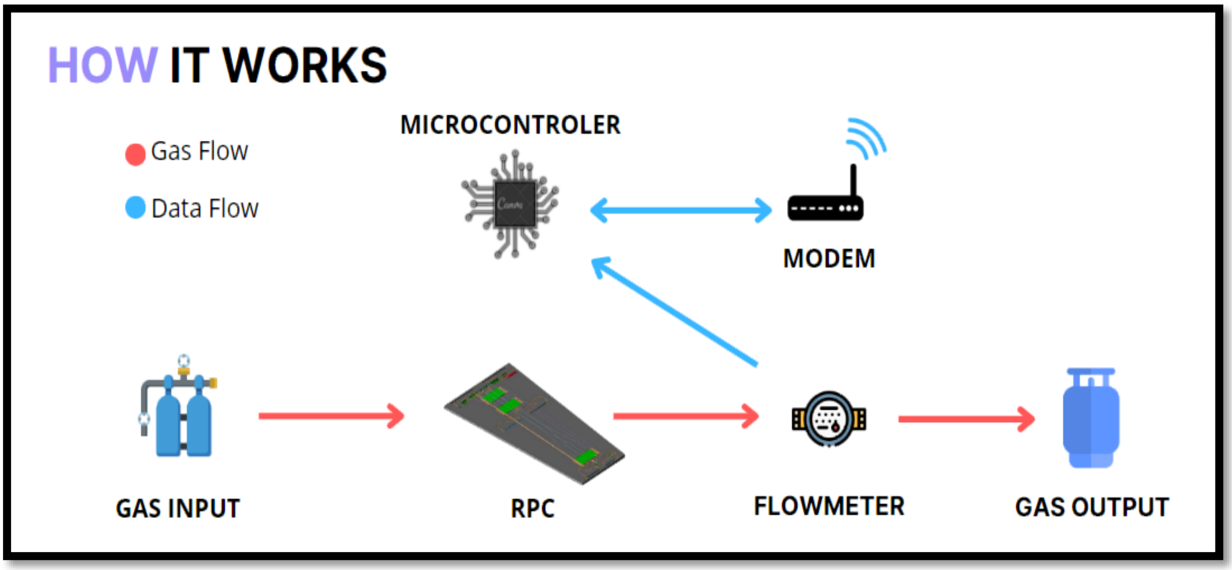


Figure 1: How the Design Works

From The Above Figure We See That The System Works As Follows:

1. Gas enters as an input
2. Gas goes through the ”RPC” chamber
3. Gas enters the flow-meter and exits through the other side returning to the gas system
4. Data is sent from the flow-meter to the micro-controller where the sensor can be controlled
5. Data is exchanged between the modem and micro-controller and is sent to the internet or (WebDCS site) via WIFI.

2.1 System Circuit Diagram

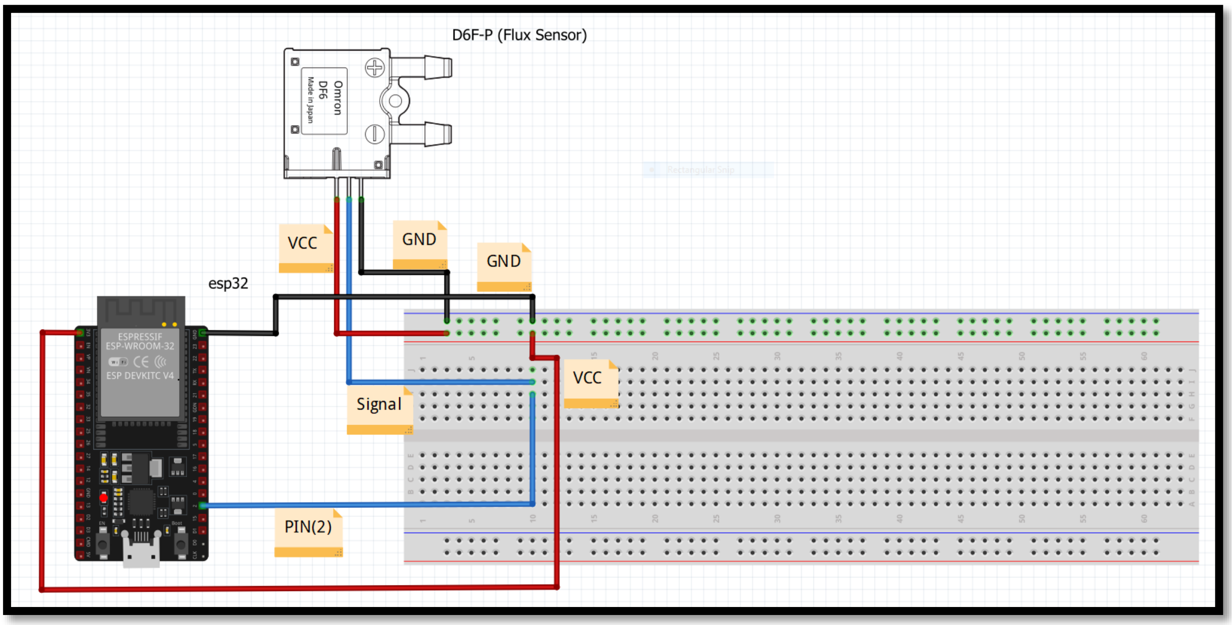


Figure 2: Circuit Diagram of the System

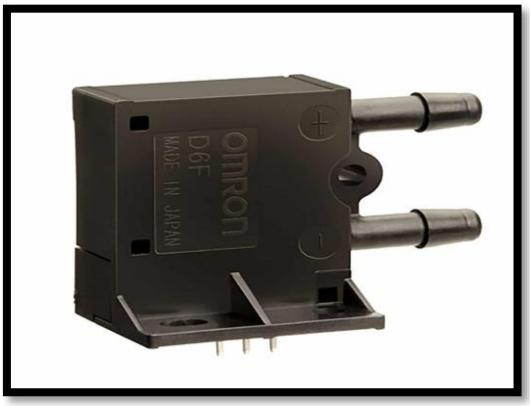
This System is comprised of a microcontroller (esp32) and a gas flux sensor (D6F-P0010A2) connected together using a breadboard. We used pin (2) as the Signal pin to control the sensor. The connections are made using regular male to male wires. The VCC pin is connected to the (+) side of the breadboard whereas the GND is connected to the (-) side. Then the VCC is connected from the breadboard to the (3V) pin on the (esp32). For the GND pin it is connected to the GND pin on the (esp32). Finally for the Signal pin it is connected from the breadboard to pin (2) on the (esp32).

2.2 Gas Flux Sensor

This sensor essentially has 3 main inputs which are the VCC, Vout and GND connections. It also has a source (+) and return (-) for the gas to pass through and out the other side. However this sensor outputs the flow in L/min, we needed to convert that to L/h since the gas system at CERN uses L/h measurement (multiply by 60). However, this sensor is an "Air Flow Sensor" so we need to make the right calculations in order to measure the gas flow as well as the different gas mixtures. We also need a calibration function that converts the output voltage of the sensor (mV) to the corresponding flow rate (L/h).

Some Advantages of The D6F-P Sensor Are:

- Temperature Compensation Circuit
- Stabilization of Air Flow
- Anti-Dust Performance
- Percentage of Reading (±3%RD)



2.3 Microcontroller (esp32)

Figure 3: D6F-P Flow Sensor

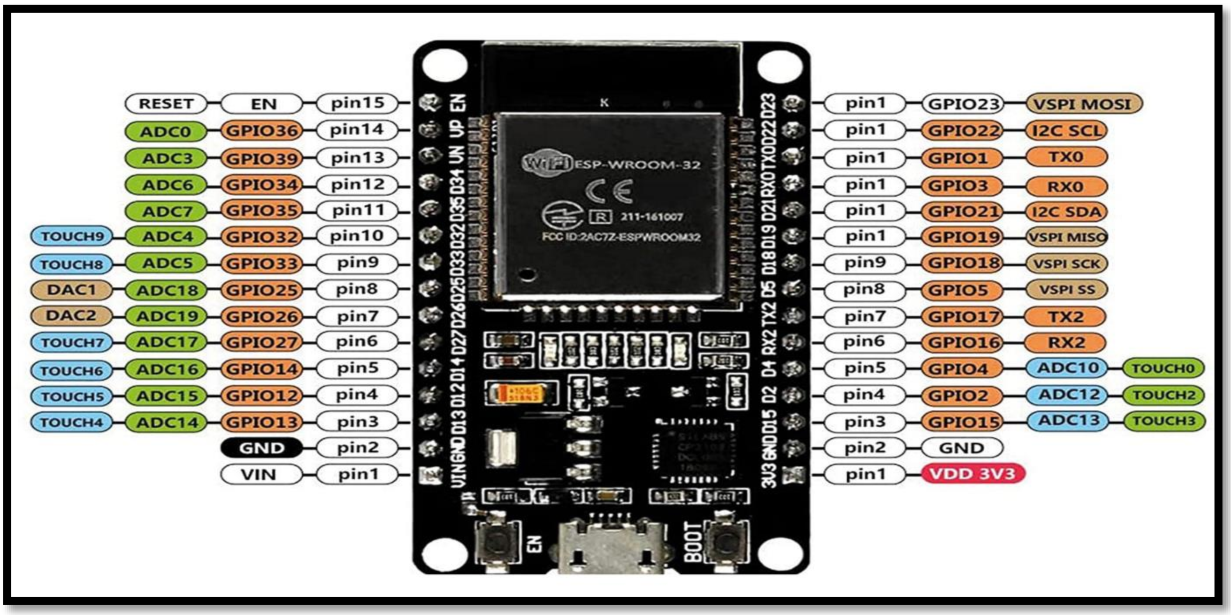


Figure 4: esp32 Microcontroller

This microcontroller has 48 pins in total, it also has a network and Bluetooth chip. This is where the main code is uploaded in order to control the flow sensor. Here pin (2) is used as the signal pin as mentioned earlier. This sensor operates very well for monitoring the environment that has a good or stable WIFI connection.

Some Advantages of The esp32 Microcontroller are:

- WIFI and Bluetooth Support
- Data Encryption Support
- 520KB of RAM
- 34 Programmable GPIO's

3 Results and Data Analysis

The main goal of the device is to detect the gas leakage, that way we can prevent or avoid any further leakage as well as control the damage. The sensor also is used to measure the amount of flux within the "RPC" chambers as mentioned earlier, this is mainly to see whether the amount of gas flux within the chambers is above or below a certain range.

With variation in the amount of flux rate the chambers can ultimately be effected negatively, this can lead to efficiency degradation as well as damaging the chambers in the long run.

3.1 Process of Data Taking

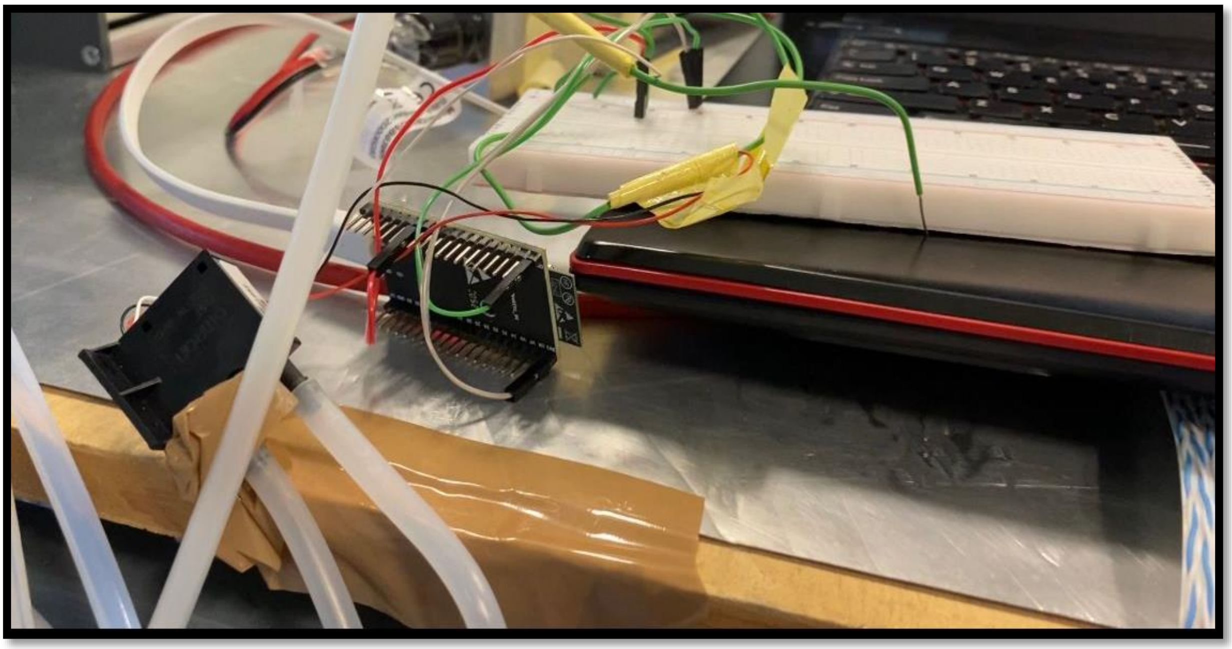


Figure 5: This is how the sensor is connected and prepared for data taking

Steps of the Data Taking Process with the D6F-P Sensor (Using Arduino IDE):

- First, we make sure that everything is connected (Microcontroller, Sensor etc.)
- Next we connect the system to the device using a USB connection
- Then we make sure that the correct port and board is connected to the Arduino IDE
- After that we start Collecting the data for each flow point (From 1-10Lh using the Rotameter in 904's CERN lab)
- About 200 lines of data was taken to use for analysis. (Can be less or more depending on the application and how much data is needed.)
- Finally the data is stored in separate text files for each of the flow points (in order to organize the data and make it easier to use and plot in the future)

3.2 Data Analysis

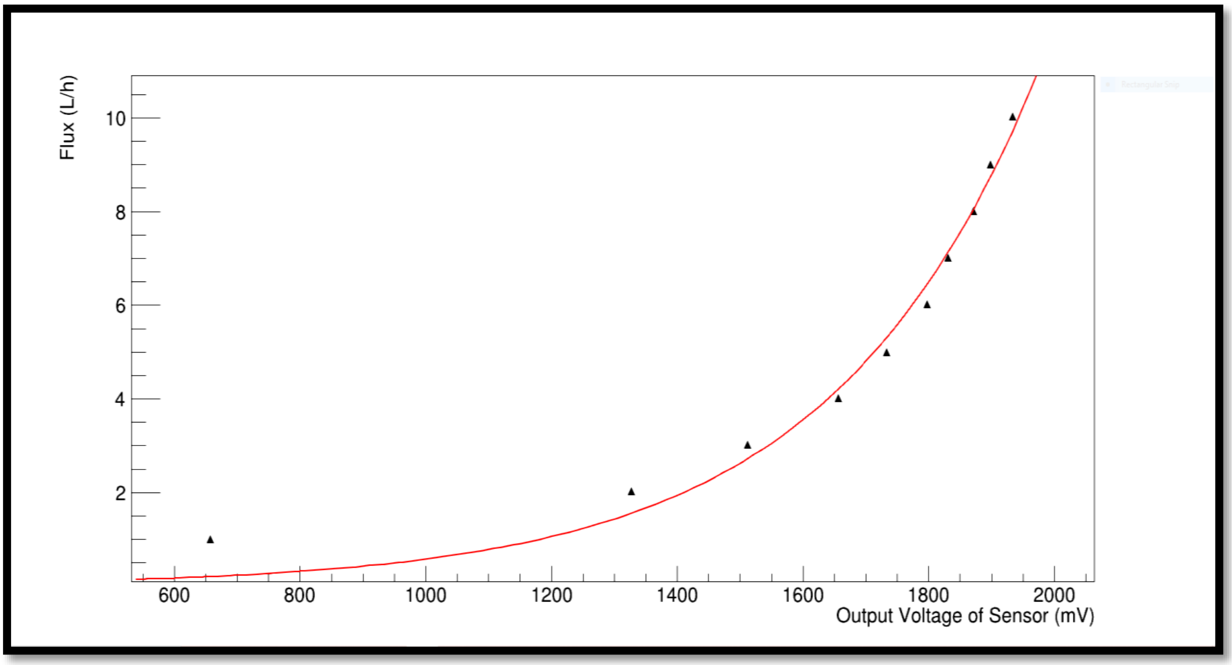


Figure 6: The plot above was made using the CERN "Root" program, it shows the Flux Vs Output Sensor Voltage

The above graph shows the Flux rate (L/h) vs Voltage (mV). For this plot, it should be voltage Vs Flux however since we got the inverse function to use as a calibration function. We represented the data in this form.

We notice that with the increase in flux rate the voltage is also increasing exponentially, the graph points we see here are basically the points of most interest as they are the "Mean Value" of the values within that certain flow rate (since we are taking multiple data points, reducing them was the best option for making sense of the big amount of data and understanding the plot).

Exponential Function used: a*exp(b*x)

However, this function did not best suit the data. So we needed to try to find a better function that best represents this data.

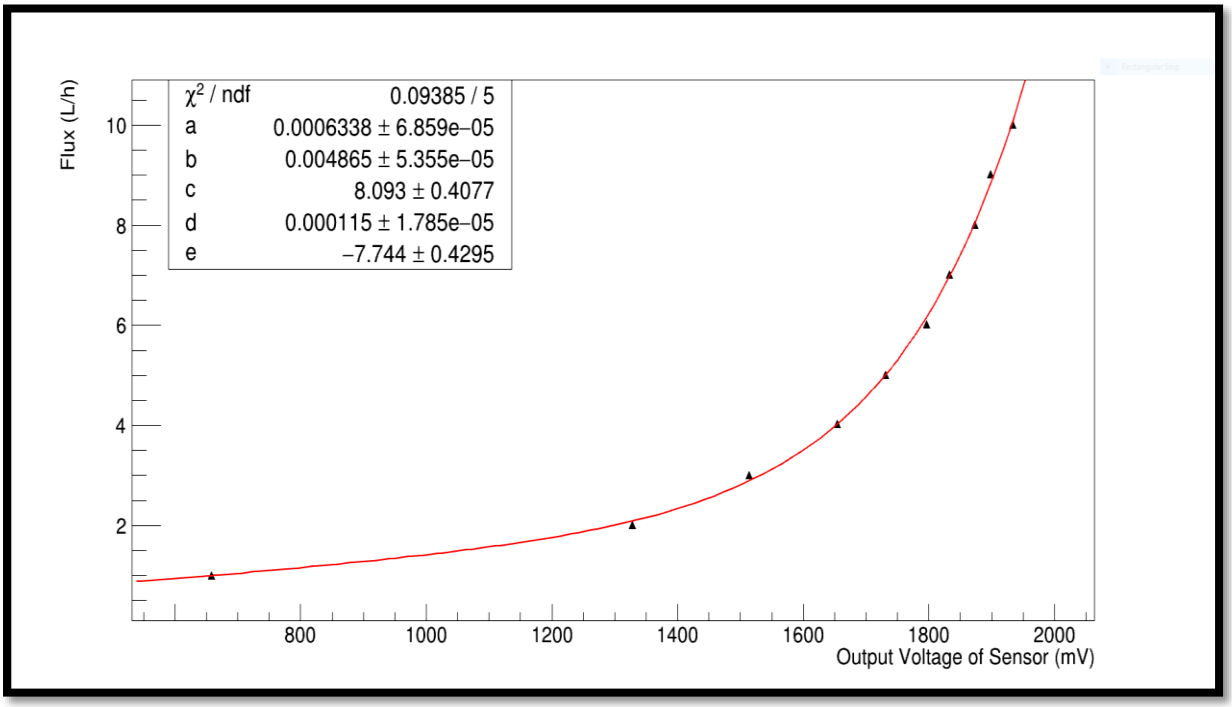


Figure 7: The plot above was made using the CERN "Root" program, it shows the Flux Vs Output Sensor Voltage

The above graph shows the Flux rate (L/h) vs Voltage (mV). Using the new exponential function we were able to reconstruct a plot that best suits the data that we collected.

The exponential function used is: [a]*exp([b]*x)+[c]*exp([d]*x)+[e]

For this new function we added some parameters using trial and error in order to best fit the given data. Here we see that the new function best represents the given data and that there are not many shifts with the given points (More points are passing through the given function). The next step is to use this function to convert the voltage and get the calculated flux. Then we use this new data to plot and make sure that the function is giving the correct values in order to implement it in the actual design for accurate results.

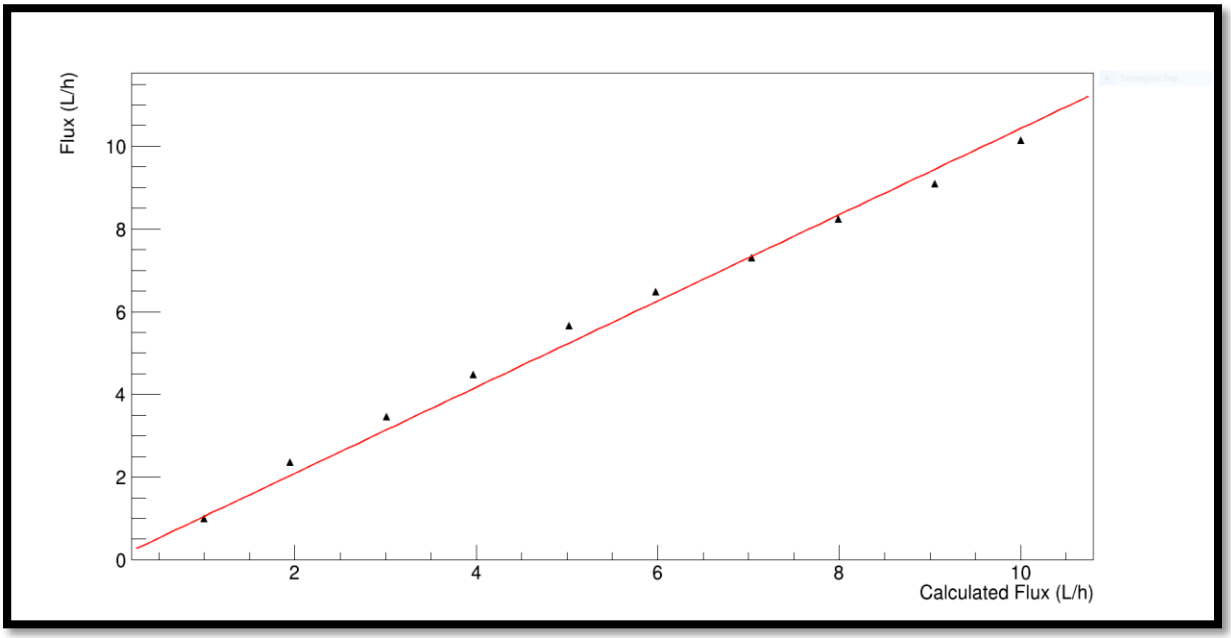


Figure 8: The plot above was made using the CERN "Root" program, it shows the Flux Vs Calculated Flux

The above plot shows the Flux rate (L/h) Vs Calculated Flux (L/h). This shows that our exponential function's behavior is as similar to the datasheet of the sensor, we see that the function acts in a linear or polynomial way which is expected.

Note: Since the data was taken using the "Rotameter" gas system in 904 (CERN's lab) which is not a very accurate device with many errors in giving constant values (Values may not be accurately represented meaning that 1L/h might be 1.1 or 1.2L/h etc.). This is why we see some shifts in the points after plotting.

4 Conclusion

In this report we were able to design and test our system “Gas Flux System” using the “Rotameter” as a gas flux reference. We were also able to find a calibration function that best suits our given data that was collected. However, in the future we will need to take into consideration the different gas mixtures as well as using a better device or method in order to take the data accurately (without using the Rotameter) in order to avoid any errors or misrepresentations of the given data. We will also need to consider using different calibration functions for different gas mixtures as well. There are alternative combinations of gases that the “RPC” chambers in CMS may use and each of them will need a different calibration function to use in order to convert the output voltage of the sensor (mV) to the flow rate (L/h).

5 References

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