# Gas Autoregulatory System Project

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# Summary

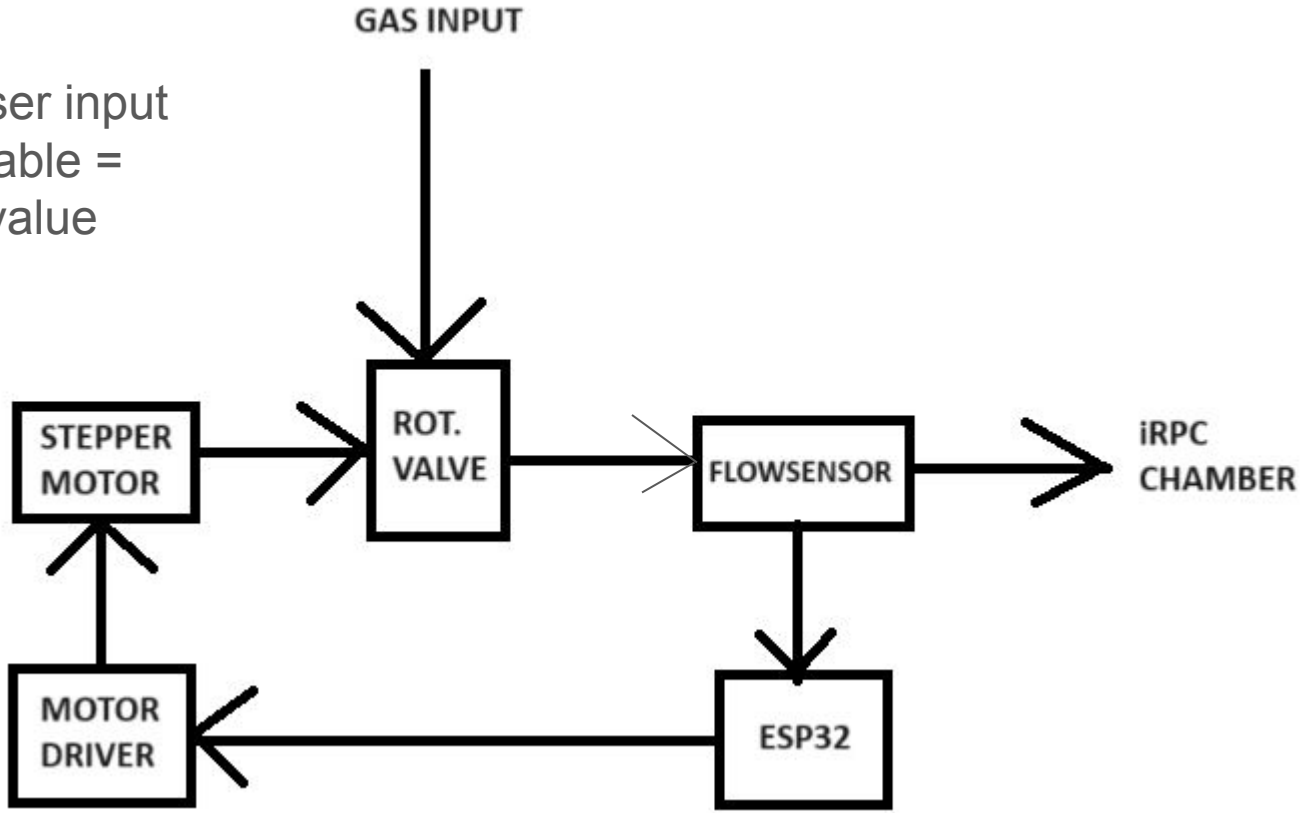
The design of a two channel autoregulated gas system using Proportional-Integral (PI) control and user input.

Integrating the system into gas chromatography to examine the proportions of each gas after mixing at GIF++

Low cost and transportable system

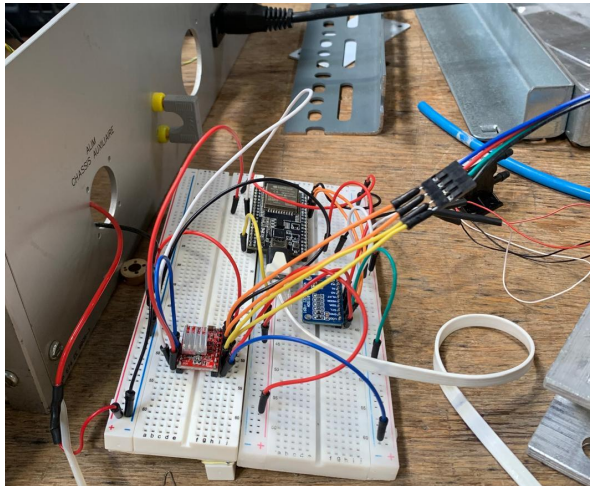
Use of air, Ar, $CO_2$, N

PI control
Setpoint = user input
Process variable =
flow sensor value



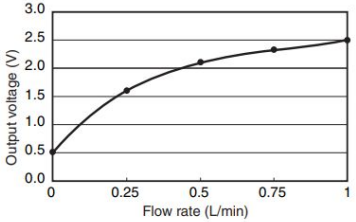
# Experimental Setup





# D6F Omron Flow sensor

**D6F-P0010A1/-P0010A2/-P0010AM2**




| Flow rate L/min (normal) | 0 | 0.25 | 0.50 | 0.75 | 1.00 |
|---|---|---|---|---|---|
| Output voltage V | 0.50 ±0.10 | 1.60 ±0.10 | 2.10 ±0.10 | 2.31 ±0.10 | 2.50 ±0.10 |

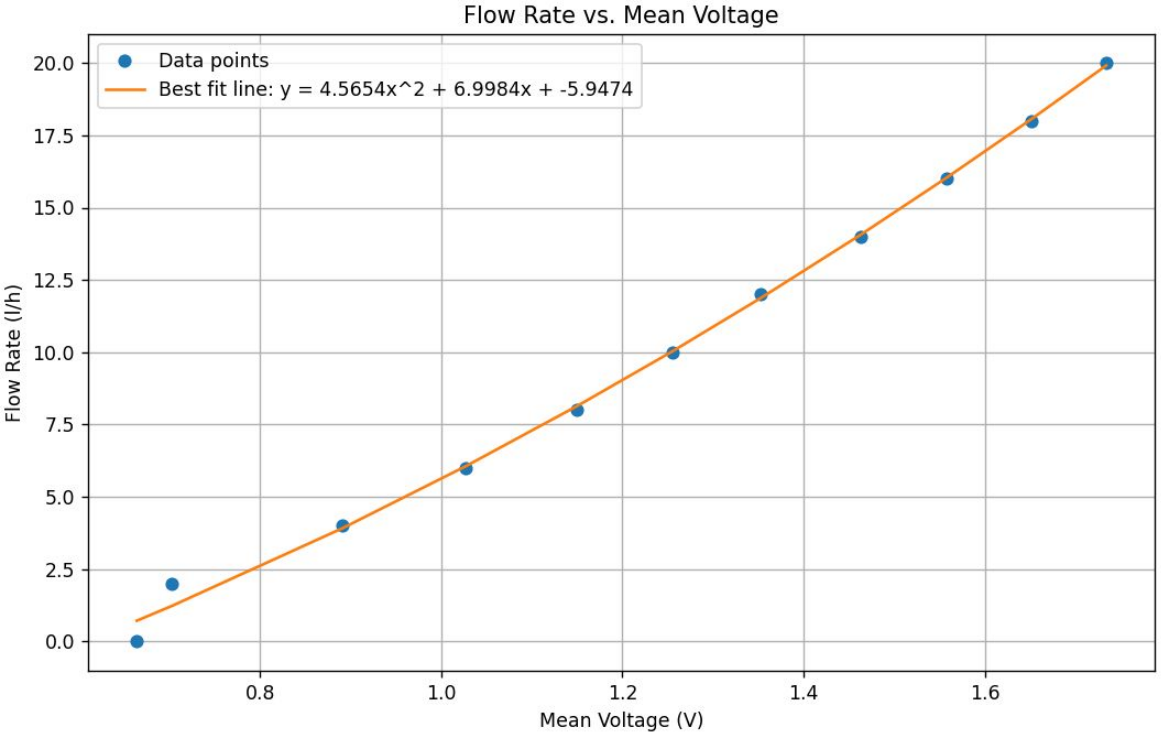
Measurement conditions: Power supply voltage of 5.0±0.1 VDC, ambient temperature of 25±5°C, and ambient humidity of 35% to 75%.

Sensor is used by EPDT to date

<u>Calibration method</u>

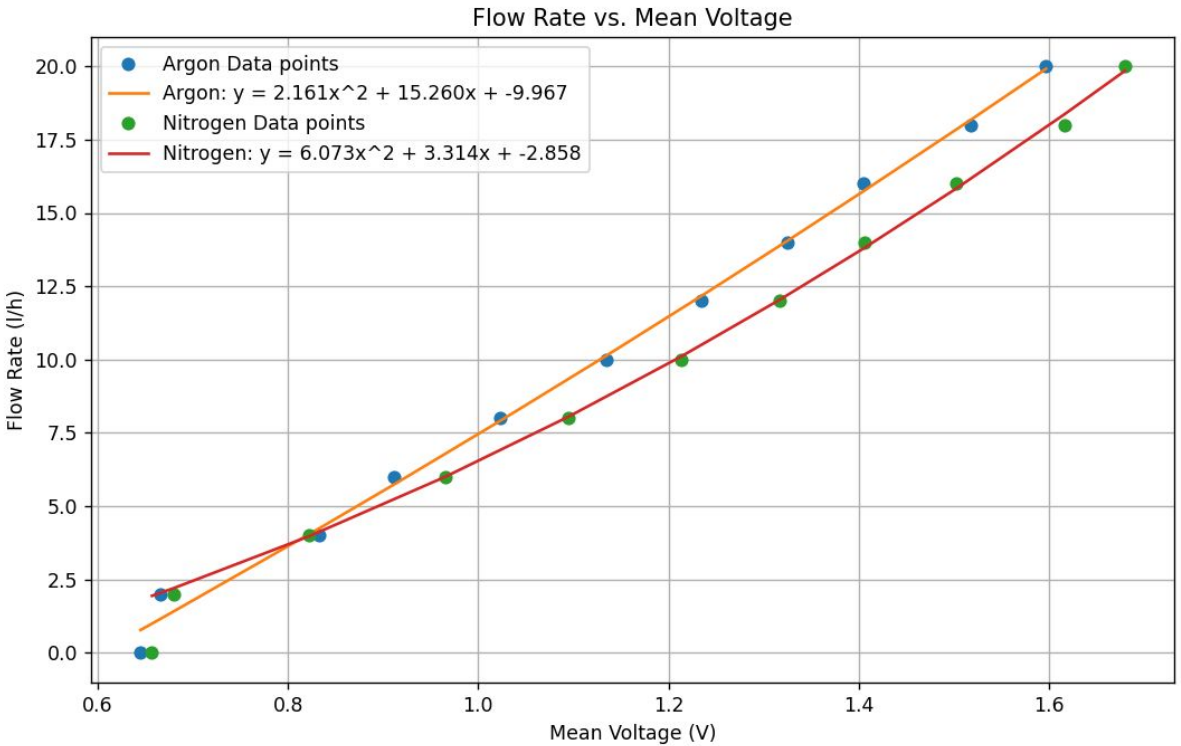
Increasing analog rotameter every 2l/h from 0-20l/h.
Proportional relationship between flowrate and voltage.
C++ program used to read voltage value from sensor.
Excel used to record data in the table
Python program to create calibration plot and formula - 2nd degree polynomial
PI controller process variable
Real time flow rate presented on LCD display

# Air Calibration at 904

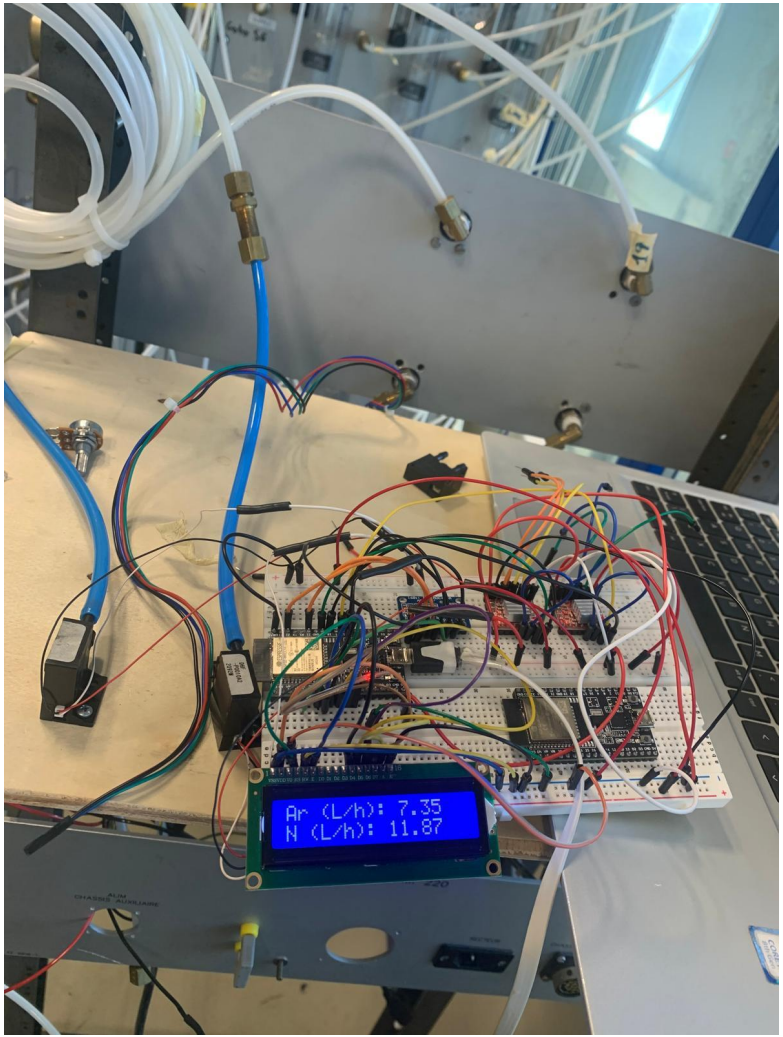


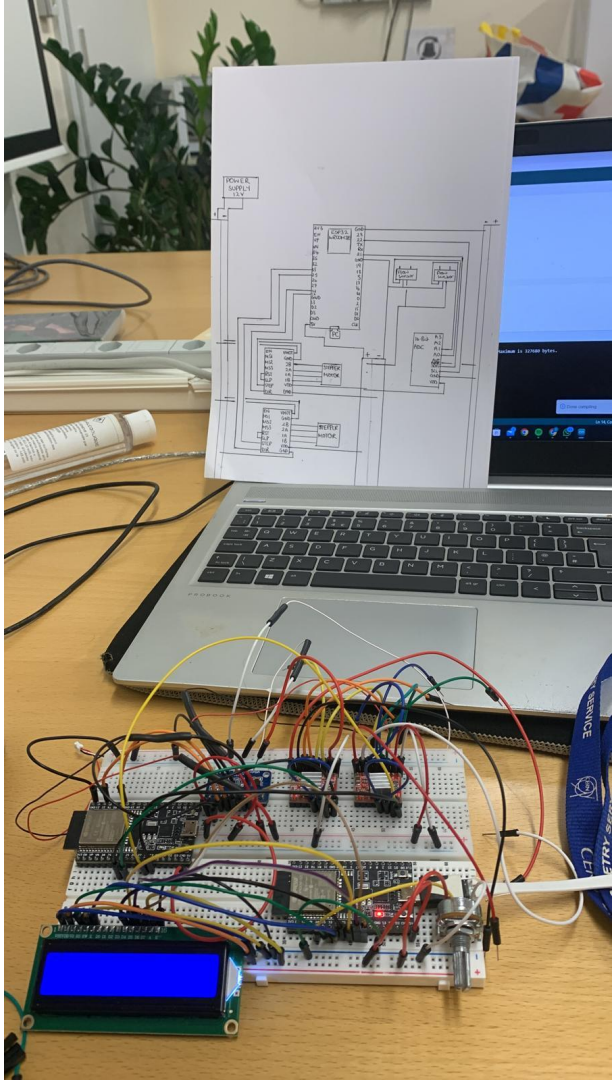

Calibration 1

# Argon and Nitrogen Calibration at 904




Calibration 2


Ar (L/h): 7.35
N (L/h): 11.87

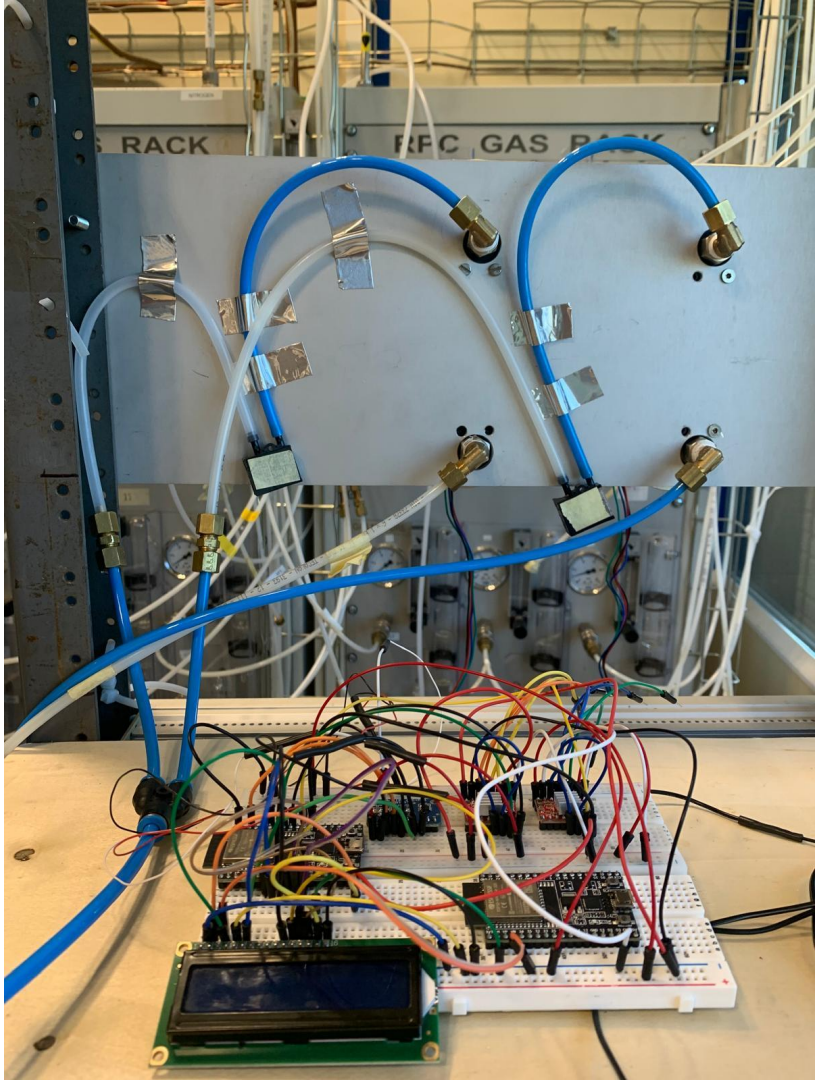


# Final Test Setup at 904

Channel 1 - Argon

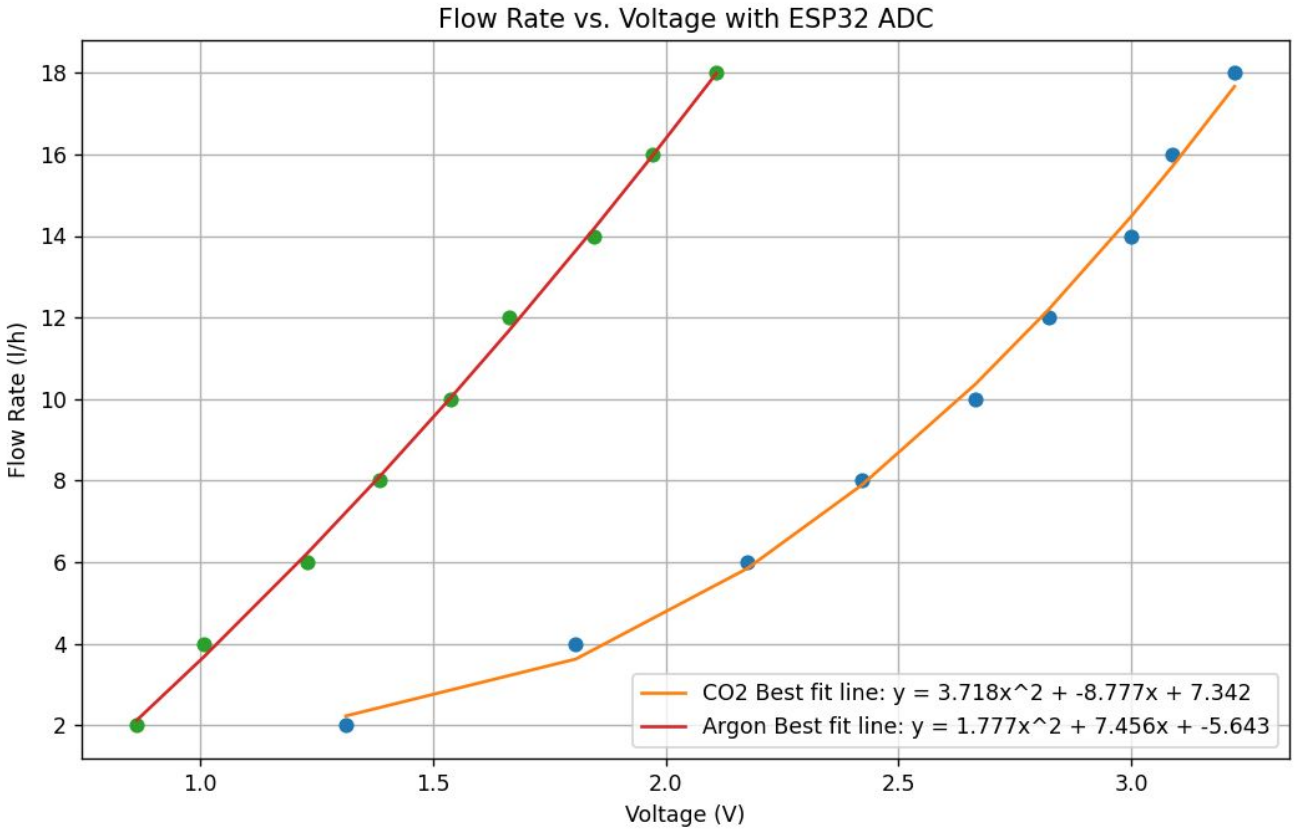
Channel 2 - Nitrogen

Transportation to GIF++



# Gas Chromatography

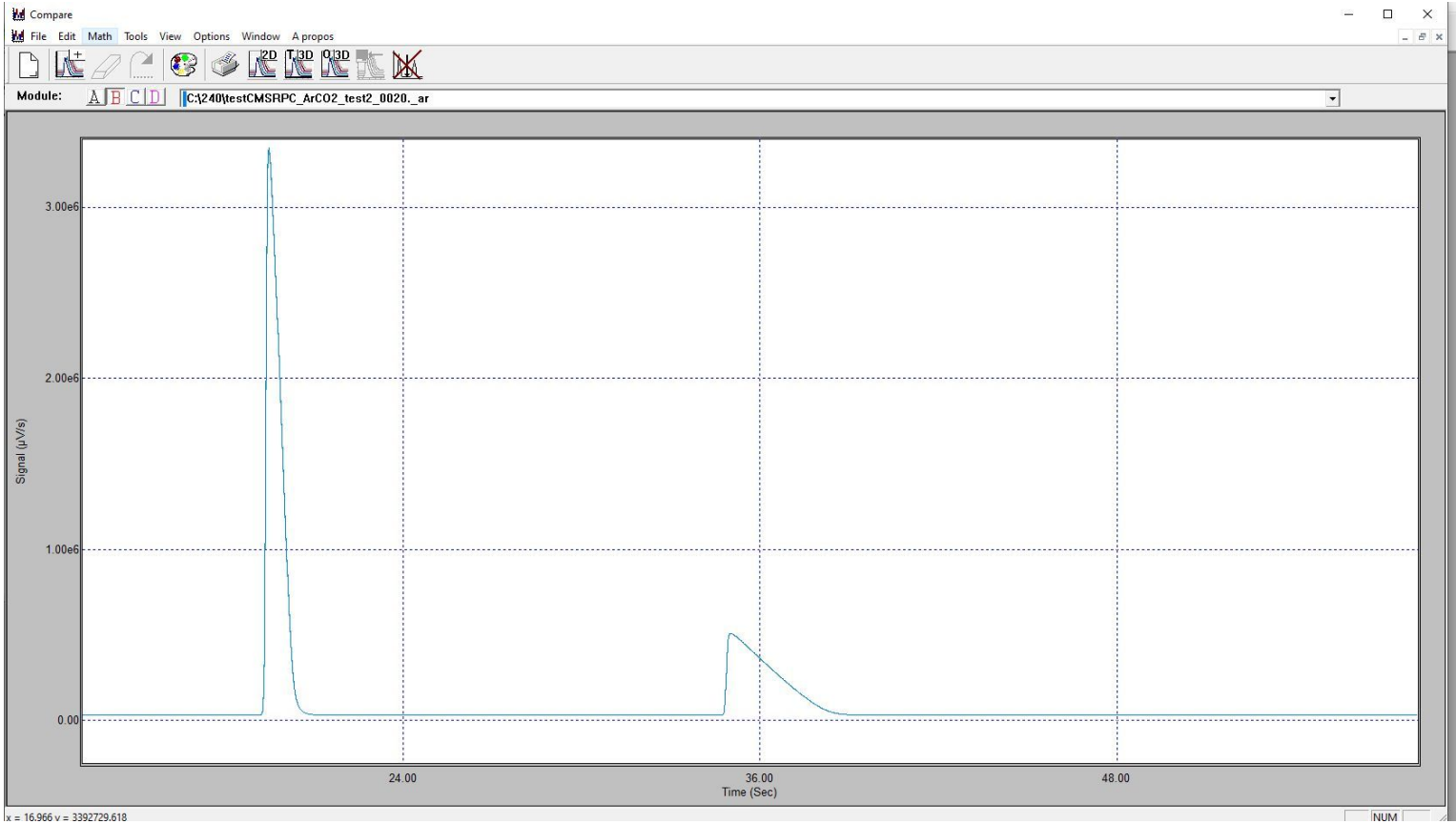
Permission to connect to CMS DT line (Ar & $CO_2$) and CSC line (calibration gas)



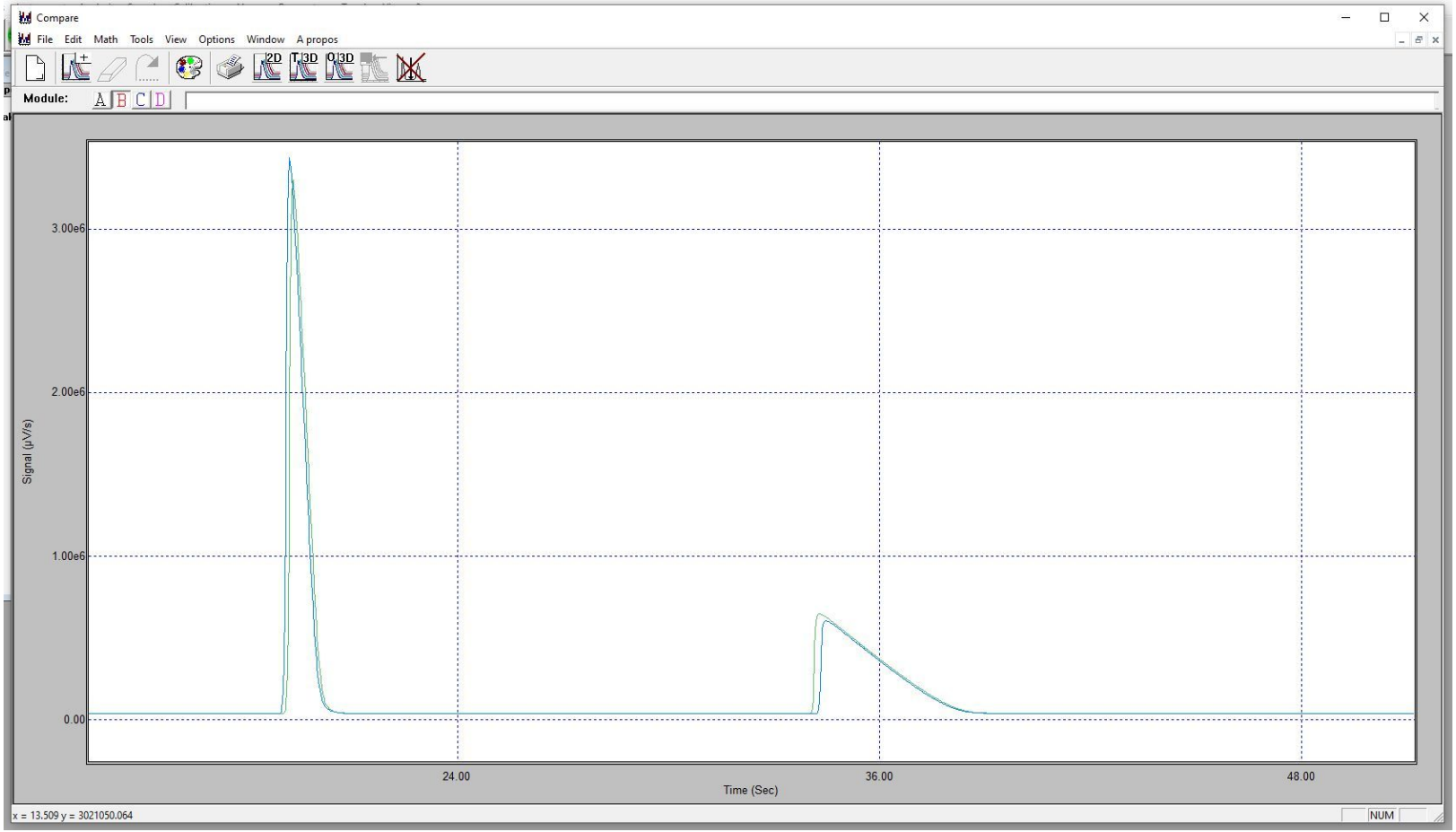

Calibration 2

# GC Calibration

70% Ar, 30% CO2 mix



# Integrated System GC



# Special Thanks

Ian Crotty

Iuri B

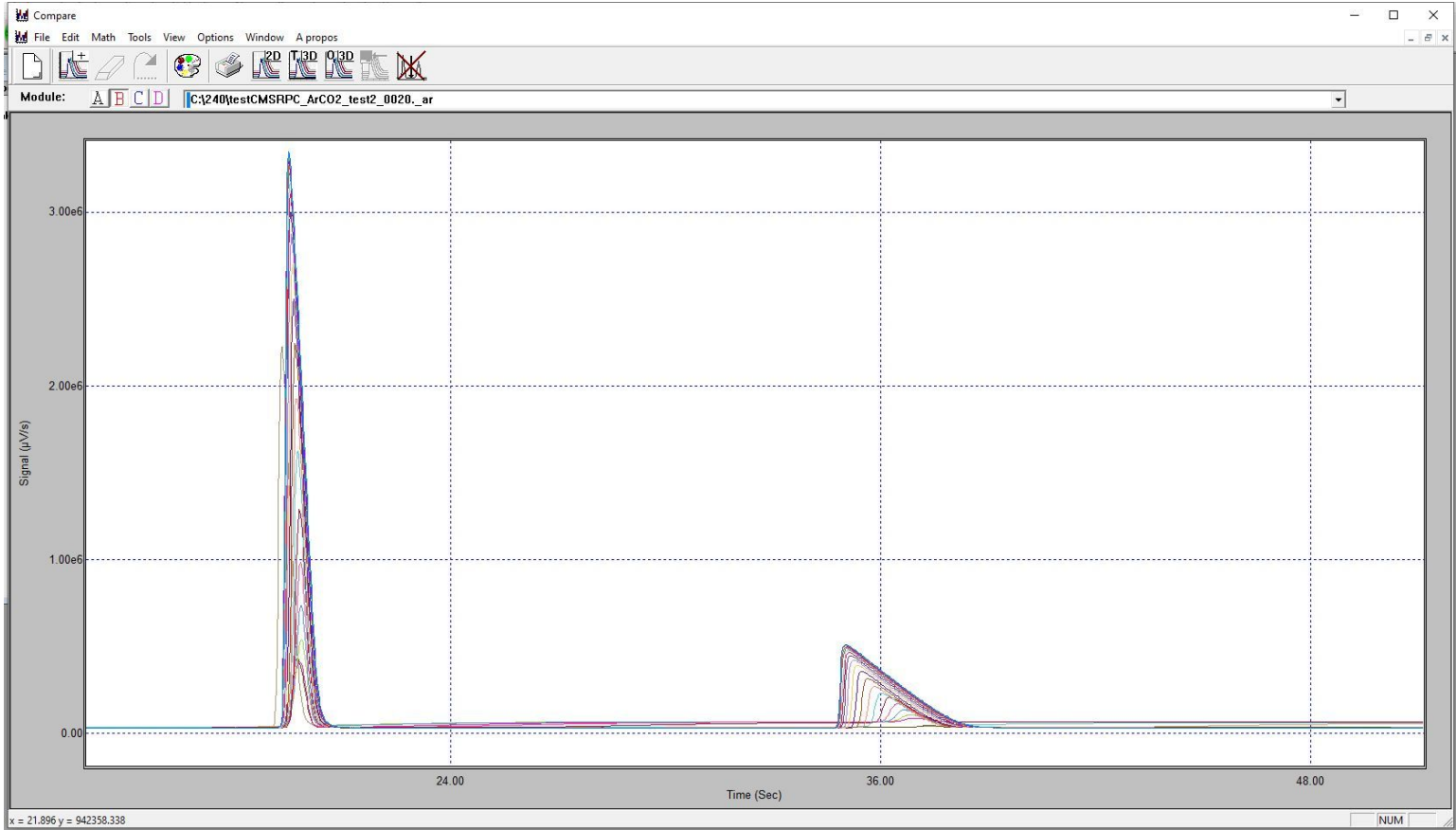
# Components

| | |
|---|---|
| Stepper Motor | 25.02 CHF |
| Motor Driver x5pks | 9.97 CHF |
| ESP32 | 3.59 CHF |
| D6F Flow sensor | 44.89 CHF |
| Arduino Box - Male Jumper Wires, breadboard, lcd display… | 25 CHF |
| Motor - Valve Connecter x2 | 5 CHF |
| Pipes | Lab |
| External ADC | 2 CHF |

# GC Calibration

70% Ar, 30% CO2 mix

Calibration 3



# Project Potential

Fine Tuning

Electrical System

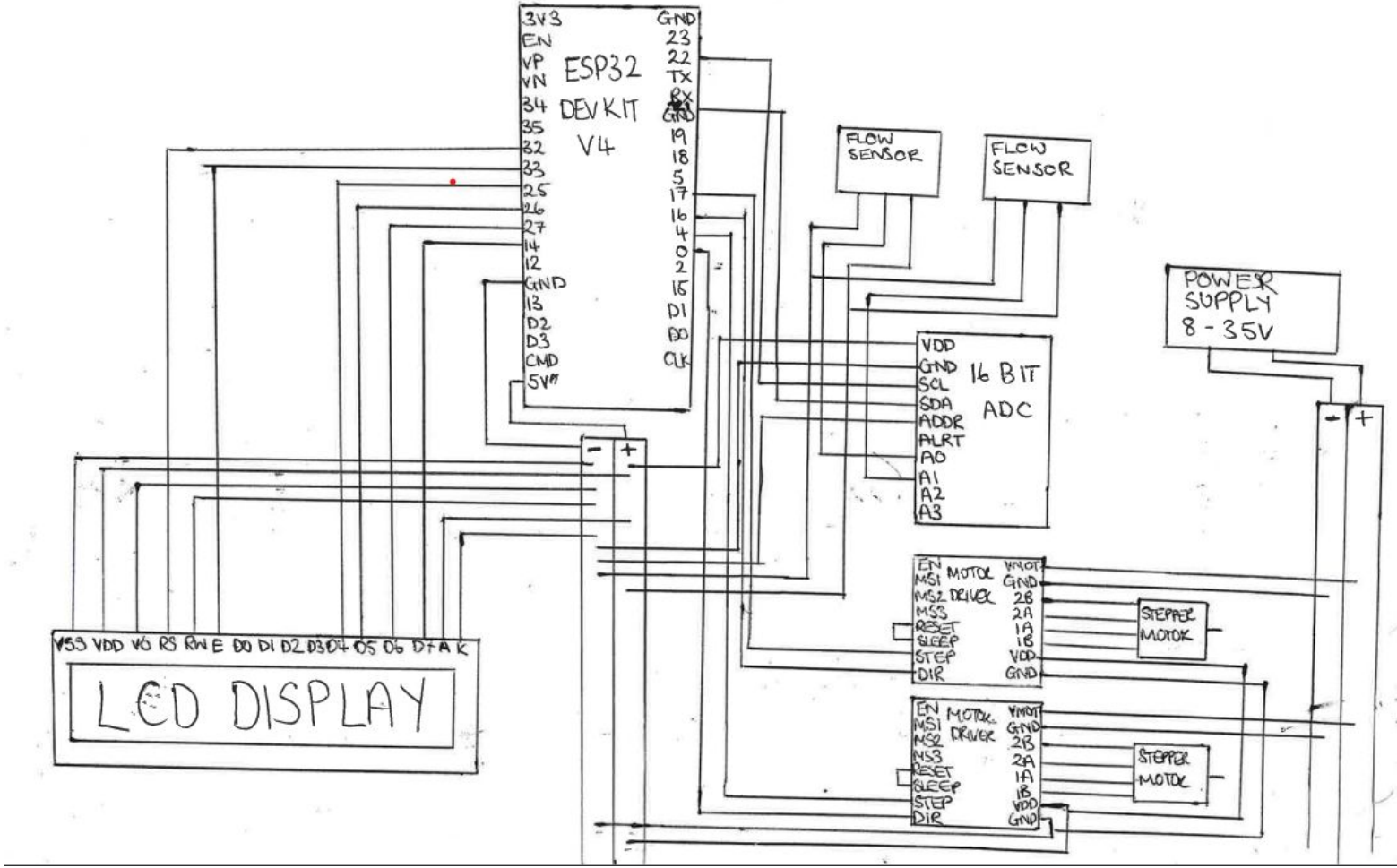
Improved electrical connections

More time at GIF++

More electronic schematics

Webdcs integration

# Electronic Schematic



# Main Programs

Arduino IDE - C++, Python

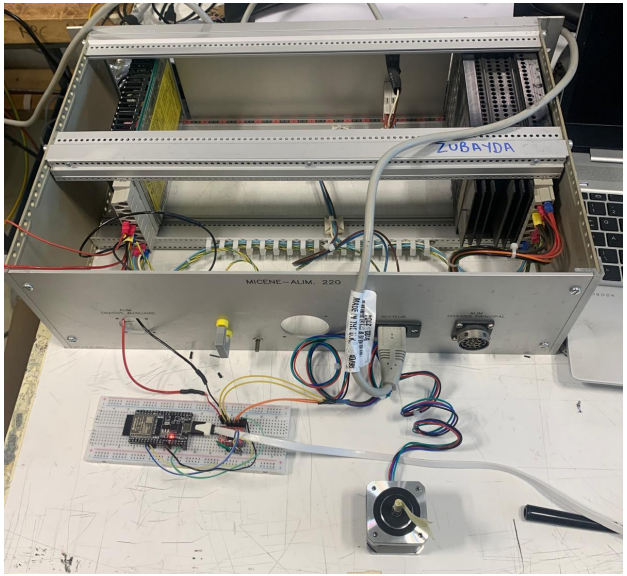
Many programs made/adapted.

Code Types:

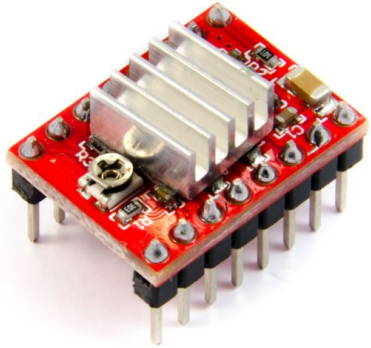
1. manual motor test
2. single/double flow sensor reading
3. single/double calibration formula
4. single/double flow sensor calibration
5. single/double P control
6. single/double PI control
7. troubleshooting

# Start Up

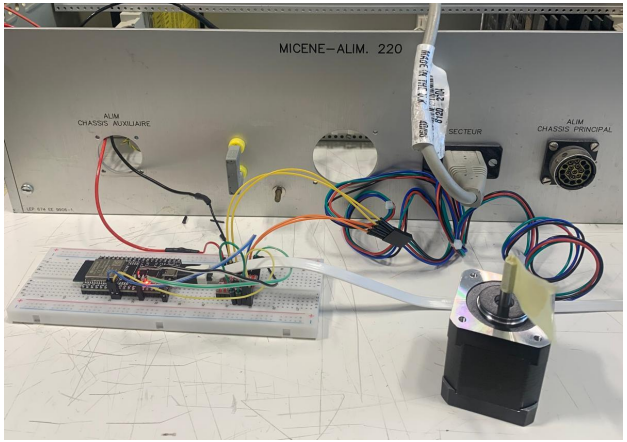
## Power supply modification - 12V




## Motor driver tuning



## Manual motor test



# What is it?

Gas chromatography (GC) is an analytical technique used to separate, identify, and quantify components in a mixture. It is widely used in chemistry for analyzing volatile substances, including gases and liquids that can be vaporized without decomposing. This process was investigated further to look at the quantity of each gas supply after mixing, and seeing if it.