ELECOMP CAPSTONE
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THE UNIVERSITY OF RHODE ISLAND

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Automated Response Time Measurement for Gas Detection Equipment

FM Approvals
Member of the FM Global Group

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Project Motivation

FM Approvals tests and certifies gas detectors that are used for the protection of personnel and property by detecting the presence of either combustible or toxic gases, to several national and international standards. These standards all require measuring the response time of the gas detectors when presented with a specific gas. This is done by exposing the detector, initially in clean air, to a step change of a known quantity of a specific test gas. The output of the gas detector must reach 50% of the final reading within 20 seconds and 90% of the final reading within 60 seconds, according to FM's own response/recovery report.

This process is being done manually with the current test apparatus. It is time consuming and requires two people, therefore making it challenging to create repeatable data. The motivation of the project is to automate this test apparatus to save time and improve the repeatability of the results.

Key Accomplishments

Arduino:

Serving as the conductor of the operation, the Arduino creates a repeatable and automated testing process. To replicate the manual testing process in an automated manner, a finite state machine (FSM) had been implemented into the Arduino code. To describe the overall structure of the FSM, a flow chart has been created **(Fig. 1)**. The FSM uses multiple states to control gas flow and allocate data from the gas detector under examination. The Arduino sorts the raw data into an array that is suitable for an FM Approvals employee to work with. The Arudino also sends signals to the relays, allowing the solenoid valves to open and close at the appropriate times.

Graphical User Interface (GUI):

The GUI has working components to start the process and graph the test results in real time. It contains options for the user to enter the information related to the test that will be used for creating the test pass/fail report. The GUI also exports a csv and/or a xlsx file, based on user input (with auto-generated file name) when done with the test run. The GUI also has a running stopwatch to verify the timing of the test. **(Fig. 4)**

System Test:

The establishment of communication between the Arduino and GUI had been verified through various tests. The Arduino successfully controlled the components **(Figure 3)** in accordance with the derived flow chart and returned accurate test results to the GUI for processing. This achievement was an extraordinary benchmark for the team, being that the hardware had finally been able to work in harmony with the software.

Automated Valves:

To automate the test process, a pneumatic knife gate valve and smaller solenoid valves were chosen. The pneumatic knife gate valve was chosen to control the flow of gas out of the lower chamber and up to the gas detector. The solenoid valves were chosen to control the flow of test gas into the lower chamber, as well as supply compressed air to operate the pneumatic valve. With these components working in unison, controlling the flow of test gas to the lower chamber and then to the gas detector proved to be far more efficient in comparison to an electric valve. The pneumatic valve has a much faster cycle time, meaning that it can open and close much quicker. This is a key feature to the design, ensuring that the test gas will flow at a constant rate, up to the gas detector, as soon as the valve is opened. The choice of a pneumatic knife gate valve and smaller solenoid valves proved to be effective after individual tests. **(Fig. 3)**

Printed Circuit Board:

To control the hardware using the software, a schematic and PCB was designed. The design allows for consolidation of all of the components into a neat, small board with easy-to-use terminal connections. This board holds all of the electronics needed to operate the solenoid valves, including relays, an Ardunio Nano, snubber diodes, the BME280 breakout board, and circuitry to read the 4-20 mA output of the gas detector. **(Fig. 2)**

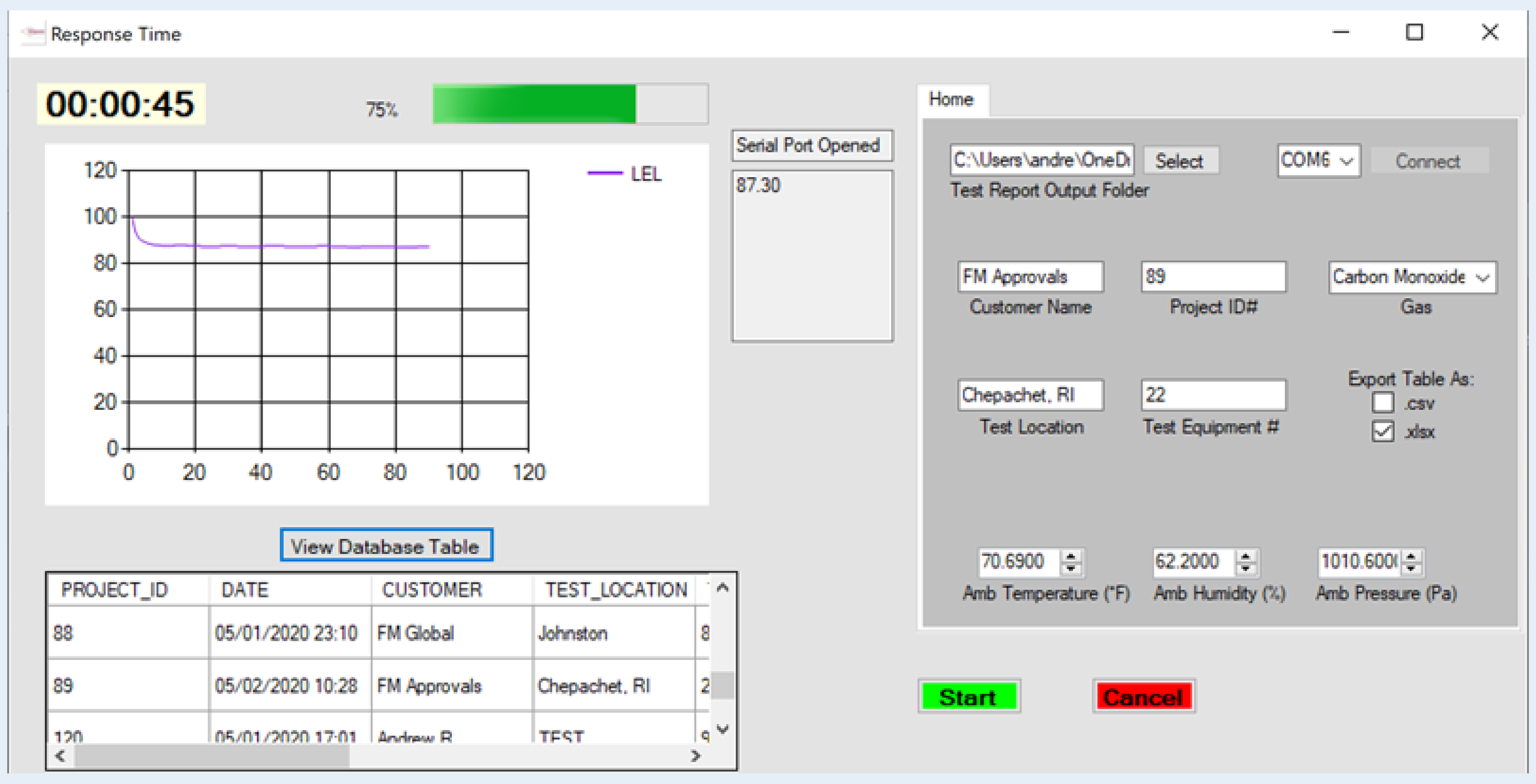

Fig.4 - Graphical User Interface

Anticipated Best Outcome

The Anticipated Best Outcome is a system with the following features:

- Automated system for filling the apparatus with test gas.
- Automated system for exposing the gas detector to the test gas.
- Integrated data acquisition system to record the response time of the gas detector.

Project Outcome

The Anticipated Best Outcome was achieved and exceeded by including a small form factor and stopwatch into the design.

Figures

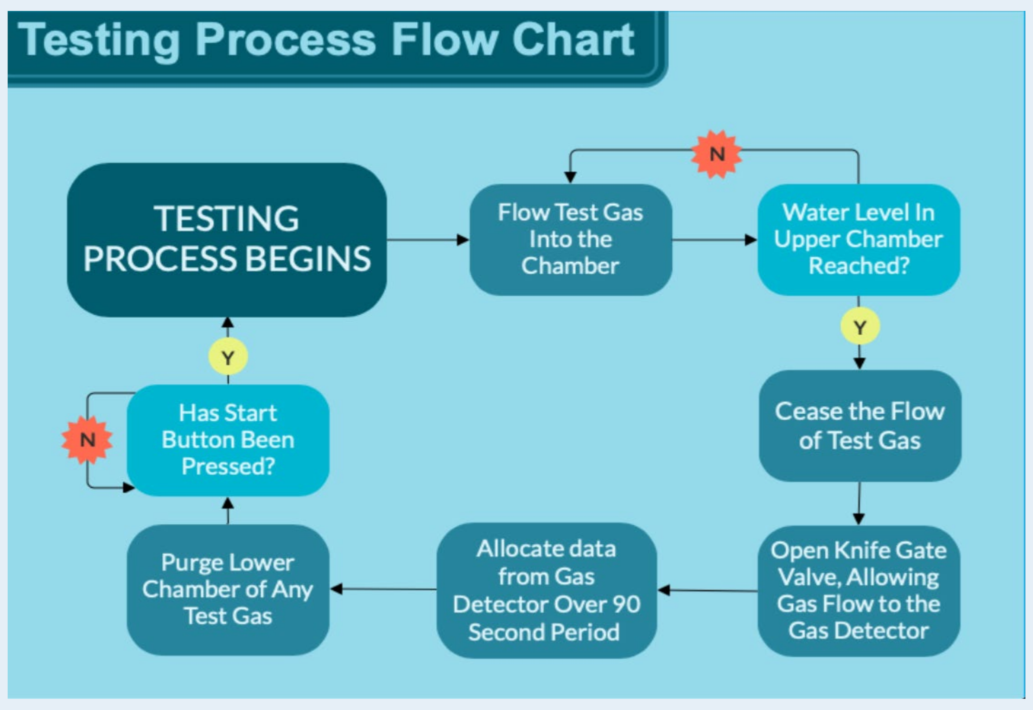

Fig.1 - System Diagram including the Arduino, GUI, and test apparatus connections.

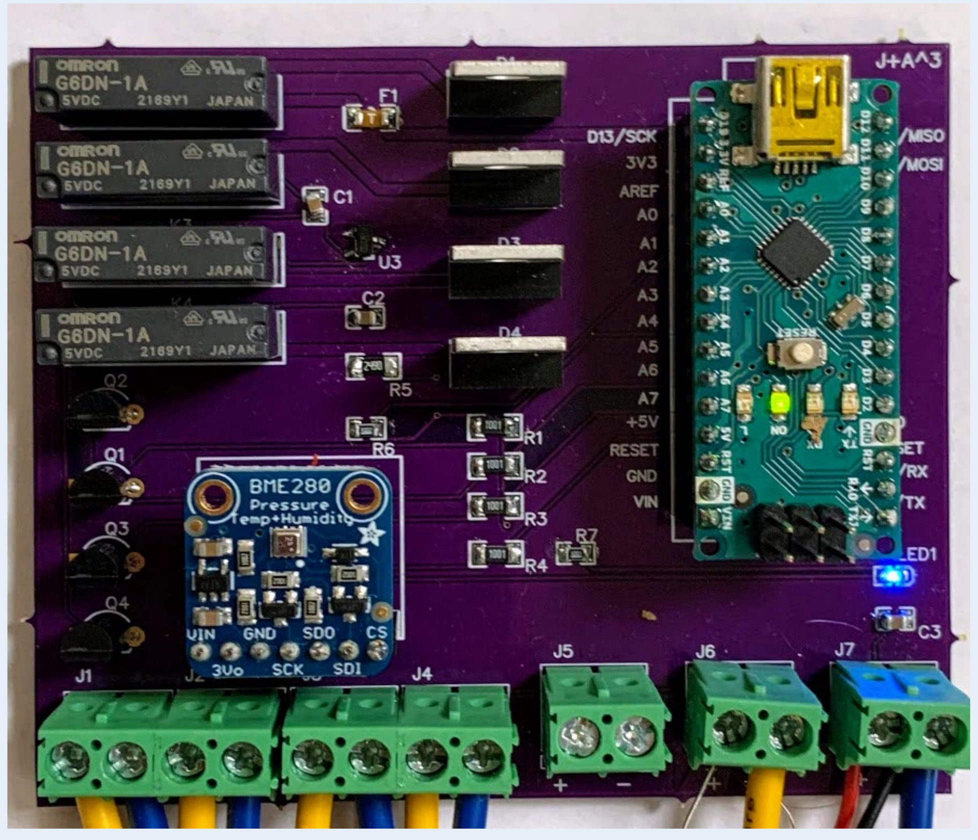

Fig.2 - Printed Circuit Board

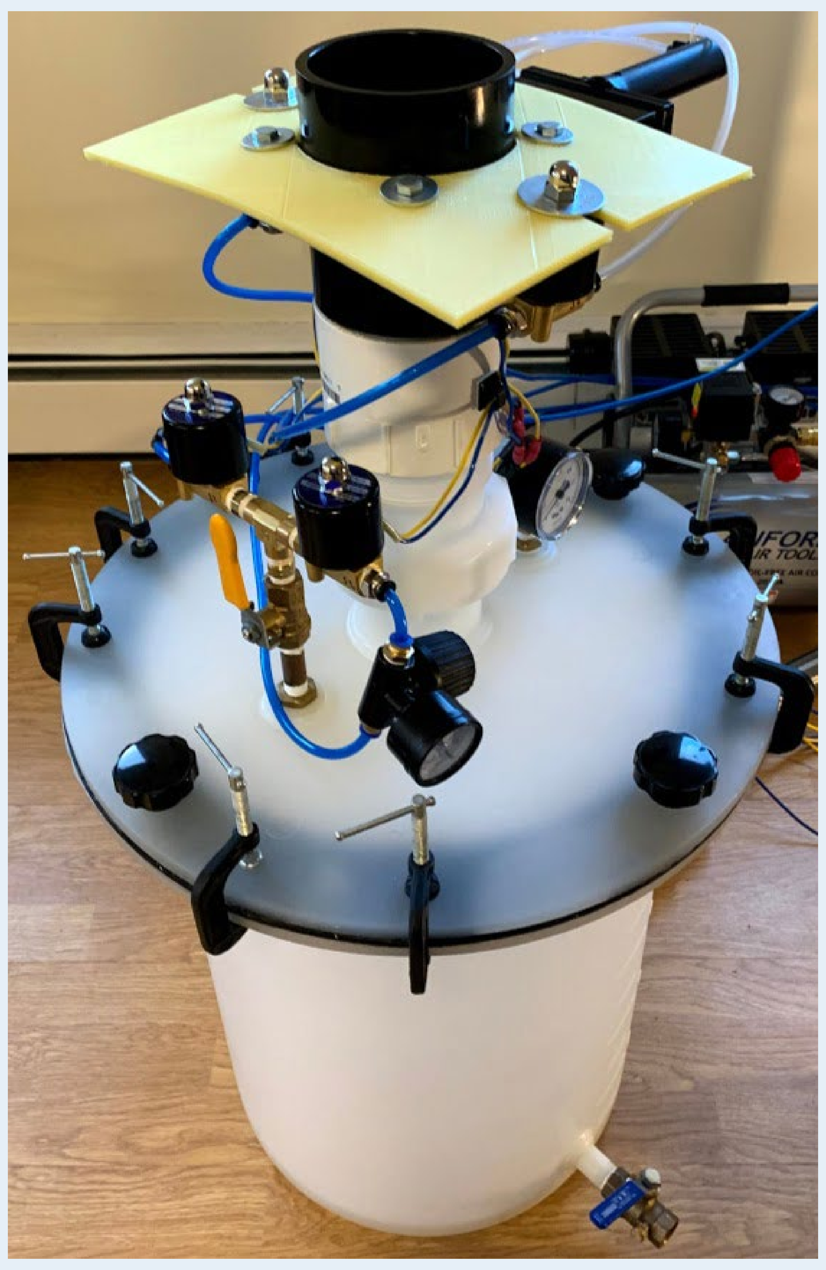

Fig.3 - View of the test apparatus with newly integrated components

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