ET SENIOR DESIGN PROJECT REPORT

Automated Test Cell for Compressed Gas

Submitted to

Dr. Goodman
Engineering Technology Program
Engineering Technology Department

by

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Title

ABSTRACT

This report details the components, decisions, and functionality to modify a manual system designed to gather data to create equations that correlate pressure and ultrasonic dB to flow. Our modifications turn the entirely manual system into a system that will automatically gather data from each sensor and write them to an Excel file. The data collected can then be used to create the equations.

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REVISION HISTORY

Version	Date	Revised by	Description
1.0	12/11/2018	Thomas Pereira	Initial version, added Problem statement and System Overview
2.0	12/12/2018	Thomas Pereira	Added **SYSTEM-WIDE DESIGN DECISIONS**
2.5	3/30/2019	Thomas Pereira	Updated 1.1 and 1.2
3.0	04/02/2019	Emma Griffith	Revised hardware and software
3.2	04/03/2019	Ani Meni	Updated abstraction and section 4
4.0	04/04/2019	Emma Griffith	Interface, interface design, concept of execution, and system components.
4.1	04/04/2019	Thomas Pereira	Revised everything
4.2	04/04/2019	Ani Meni	Revised conclusion and added interface design
5.0	04/29/2019	Thomas Pereira	Added schematics and pictures to the appendix, prof read
5.1	04/29/2019	Ani Meni	Added schematics and pictures to the appendix
5.2	04/29/2019	Emma Griffith	Added schematics and pictures to the appendix

1. INTRODUCTION

1.1 Problem Statement

Dr. Goodman currently had a manual system that was very slow and wasted a lot of gas, which can become costly. His system used analog temperature and pressure meters, as well as digital flow meters and a digital ultrasonic decibel gun. He needed a mostly automated system to decrease the test time and conserve gas, as well as easily record the data needed.

1.2 System Overview

The system shall comprise of a gas canister, which if it's a high-pressure gas will go into a manual high-pressure regulator and will be turned down to 120 PSI. The 120 PSI section will have a relief valve for safety, where it will the go into a pressure regulator connected to a stepper motor which will control the pressure using feedback from pressure sensors. After the low-pressure regulator, the gas will interact with an inserted ultrasonic flow meter, a thermocouple, and a pressure transducer.

After some tubing the gas will flow past an uninserted ultrasonic flow meter, a thermocouple, and a pressure transducer. The gas will then flow out through a pre-sized hole and an ultrasonic decibel meter will be used to record the dB of the ultrasonic flow.

Tests will be conducted using a LabVIEW VI; all test parameters will be set there. There is a section to manually control the pressure, as well as outputs listed inside LabVIEW so the testing can be watched live. All data will be exported to an excel file for easy data access.

2. REFERENCED DOCUMENTS

Table 1: Reference Documents

Title	Document Reference Number	Comment
Instructions for Flexim G601 Ultrasonic Flow Meter	Flexim.G601	Manual for setting up and using the G601 Flow Meter
LabVIEW Manual	Manual.LV01	Manual for running the LabVIEW program

3. SYSTEM-WIDE DESIGN DECISIONS

3.1 Hardware

The sensor requirements are based off the previous equipment that was in the system, as well as some new requirements set by Dr. Goodman. Both flow meters were already in the system and will be used because they meet Dr. Goodmans requirements and have 4-20 mA outputs. The two pressure sensors had a range of 0-150 PSI with an accuracy of +/- 1%. The two temperature sensors had a range of 0-300°F with an accuracy of +/- 2.5°F. The Pressure transducers and flow meters are wired to a NI 9203 4-20 mA input module. The temperature sensors are T type pipe plug thermocouples and are wired to a NI 9211 thermocouple module.

A stepper motor is coupled to a low-pressure regulator to provide pressures ranging from 10 to 110 PSI. The stepper motor is connected to a NI 9401 digital output module. A relief valve rated for 125 PSI is used to ensure the low-pressure regulator doesn't over pressurize. The system mainly uses ¼" NPT standard pipe and fittings throughout the entire system. This allows for easier replacement of components. PVC tubing is used for the Flexim Ultrasonic flow meter. After talking with the head engineer at Flexim, the only way to measure pressures lower than 60 PSIG is to use PVC. Everywhere else there are metal fittings and tubes to minimize contact corrosion.

There are two power supplies: one for the stepper motor and another for powering all of the sensors. A function generator is used create the pulses needed to turn the stepper motor as LabVIEW is incapable of generating a fast-enough signal.

3.2 Software

For this project LabVIEW-2017 is being used to create the software for our project. LabVIEW is being used because it was required by our sponsor. Our software is capable of receiving signals from every sensor using a DAQ. To control the pressure, a stepper motor turns the low-pressure regulators shaft the direction necessary to increase or decrease pressure. Once the pressure is within +/- 1psi, the stepper motor disables and the pressure will stay set, if the pressure changes the stepper motor gets reenabled and the pressure is reset. The stepper motor also has manual controls just in case something malfunctions.

3.3 Interface

The user interface displays the readings from every sensor as well as manual controls for the stepper motor. Every VI for the program will need to be downloaded for the main program to function properly. A disable stepper motor button can be used to immediately stop the stepper motor from functioning.

4. SYSTEM ARCHITECTURAL DESIGN

4.1 System components

In this system the 6 sensors are connected to DAQ modules. The pressure sensors and flow meters are connected to a NI 9203 and the temperature sensors are connected to a NI 9211. The stepper motor is connected to a NI 9401. There are 2 power supplies in the system. One power supply is used for the stepper motor and the other is used for the pressure sensors and flow meter.

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4.2 <u>Concept of execution</u>

Each sensor will be inserted into a fitting connected to the main flow path, with an exception of the Flexim ultrasonic flow meter. For the Flexim meter "Flexim.G601" should be read and followed to set up and use the meter. When the 6 sensors are connected to the proper DAQ modules, data can be read from them and saved to an Excel file. It then can be used to form graphs and equations. The program will run through 11 different pressures starting at 10 psi to 110 psi. At each pressure, 3 tests will be collected to get 3 different data collections at that pressure. The stepper motor will then increase the pressure 10 PSI.

4.3 <u>Interface design</u>

As stated earlier, the entire system will be using LabVIEW. The pressure, flow, and temperature sensor programs are in LabVIEW VI file and the stepper motor is in another LabVIEW VI. This will allow the main program to be less cluttered. The program consists of DAQmx instead of DAQ assistant. DAQ assistant can become hard to work with when a computer uses multiple DAQs. The DAQmx is hard coded specifically to use the chosen sensors.

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5. CONCLUSIONS AND RECOMMENDATIONS

For this project our team upgraded an existing system by replacing the old sensors with new electrical ones, as well as wiring the outputs on the existing flow meters. Six sensors were use: 2 flow meters, 2 pressure transducers, and 2 type T thermocouples. A stepper motor was added to regulate the pressure. In the original design the user had to manually change the pressure for the system. Instead of walking to the regulator to change the pressure or writing down the readings from the sensors and then taking the decibel readings, the user can now sit at a computer, run the program, and get the sensors data. The only manual entry in our system is the decibel reading and orifice size. Our team made the system faster and more efficient.

Title

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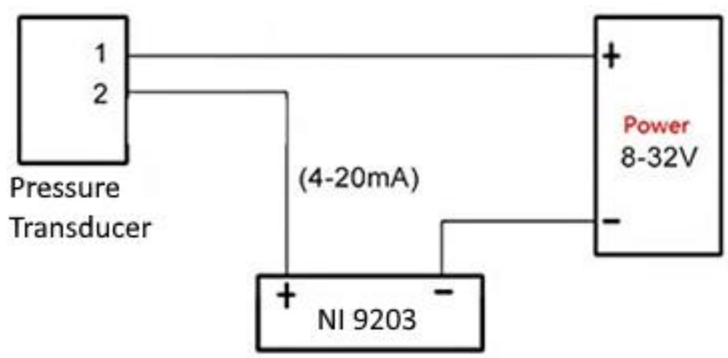
APENDIXES

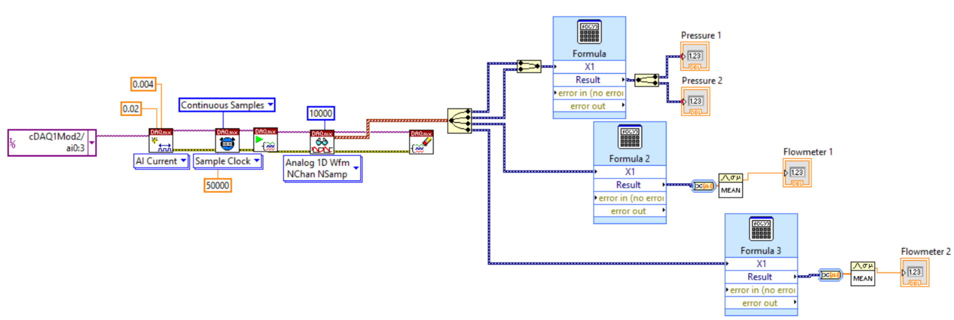
1. Pressure Sensor

1.1 Schematics

Title



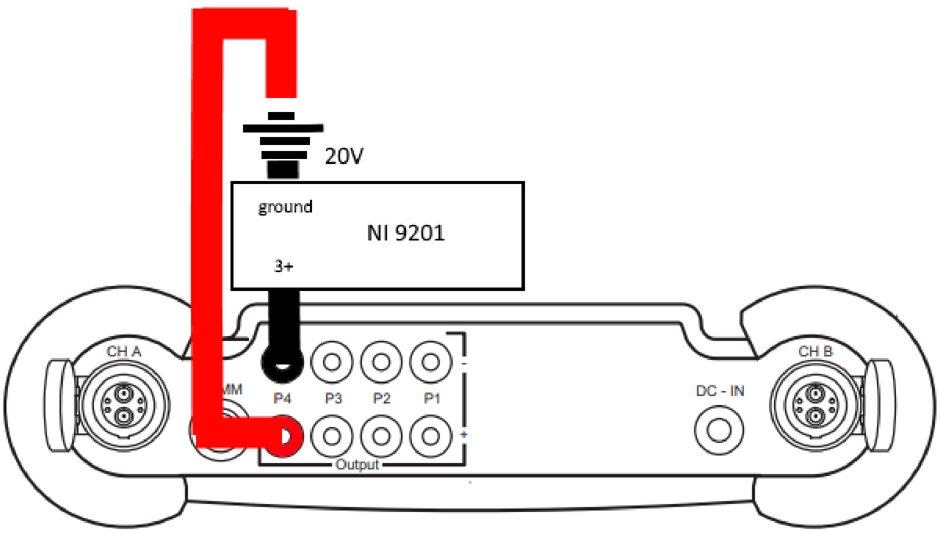
1.2 Code

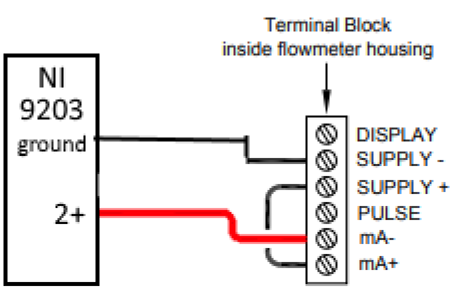


2. Flow meters

2.1 Schematics

Title





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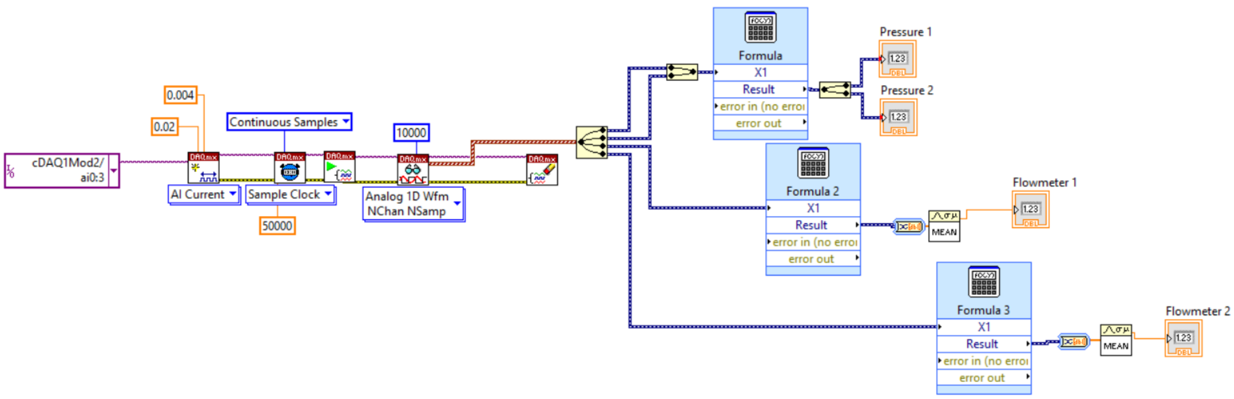
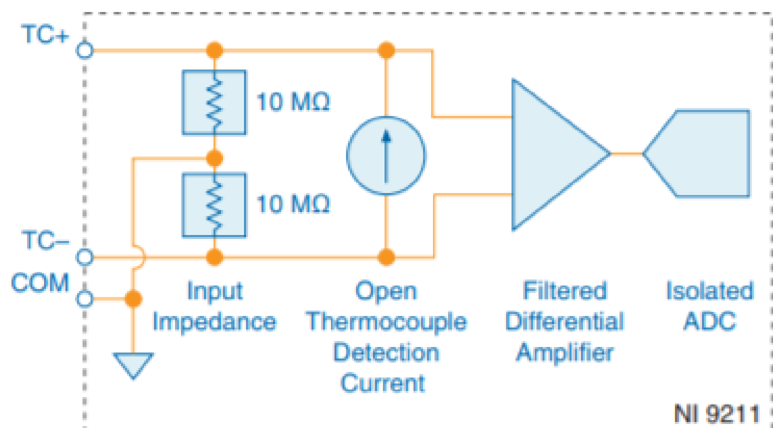


3. Temperature Sensors

3.1 Schematics

Figure 1. Input Circuitry for One Channel of the NI 9211



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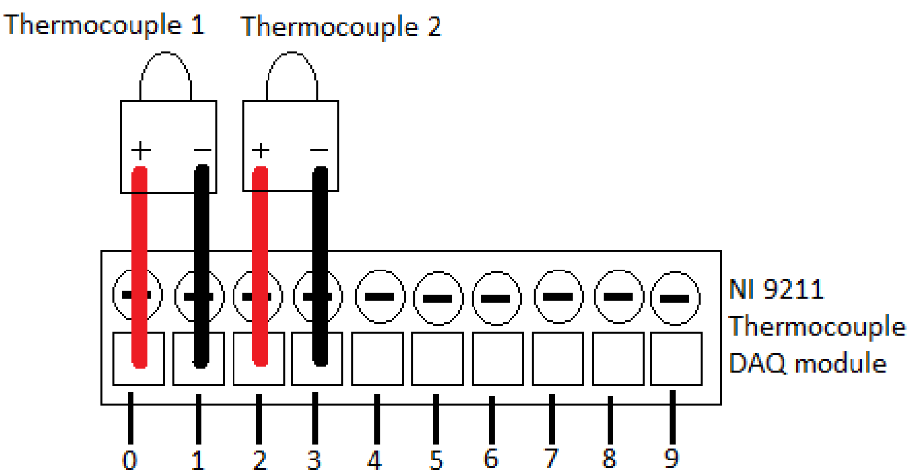

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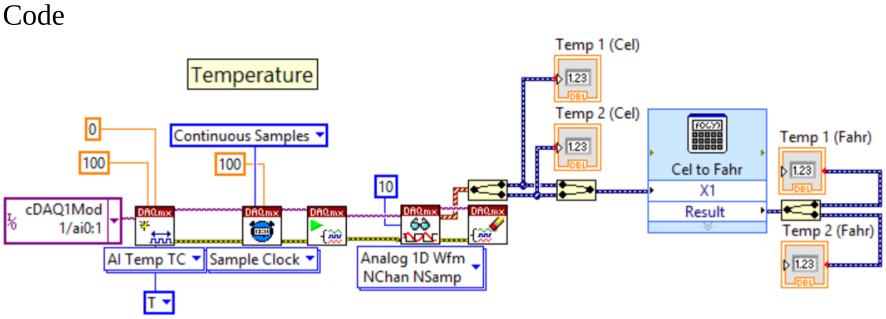

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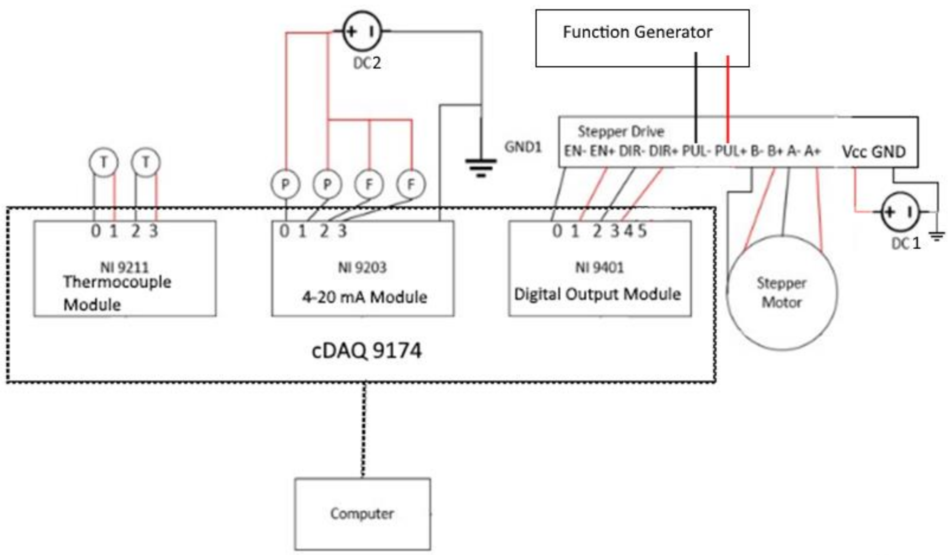
4. Stepper motor

4.1 Schematics



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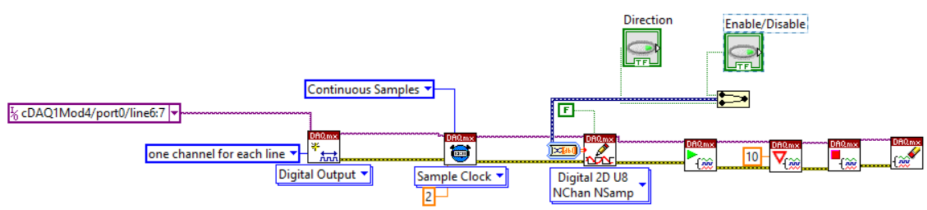

5. Main Program

5.1 Code

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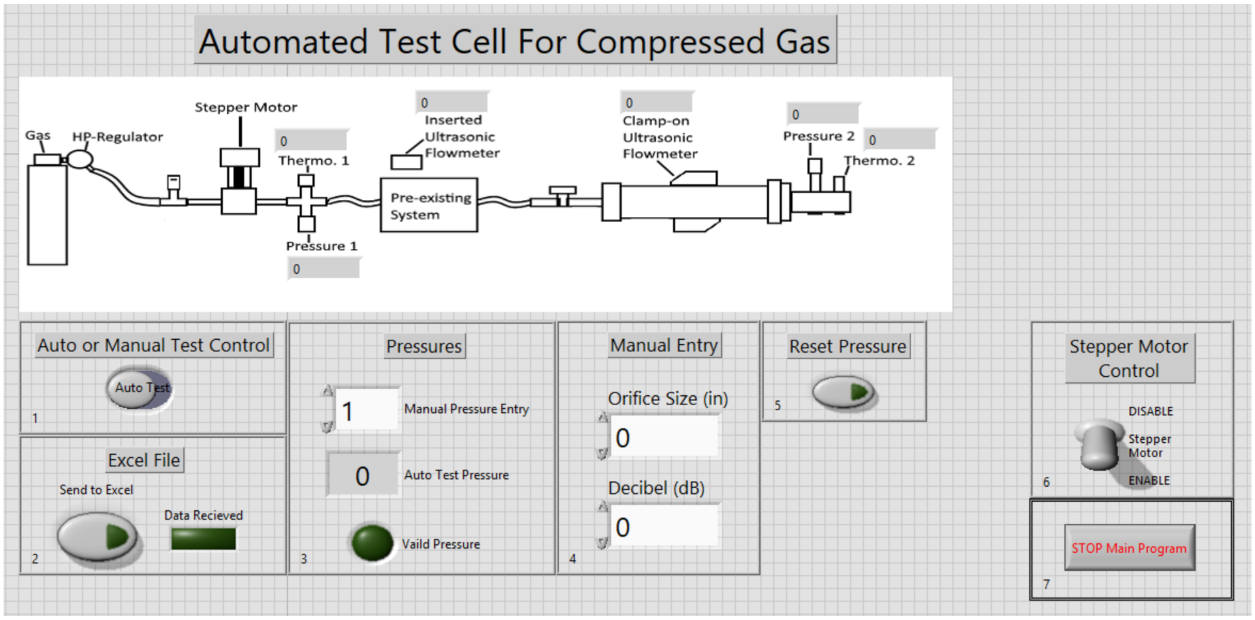

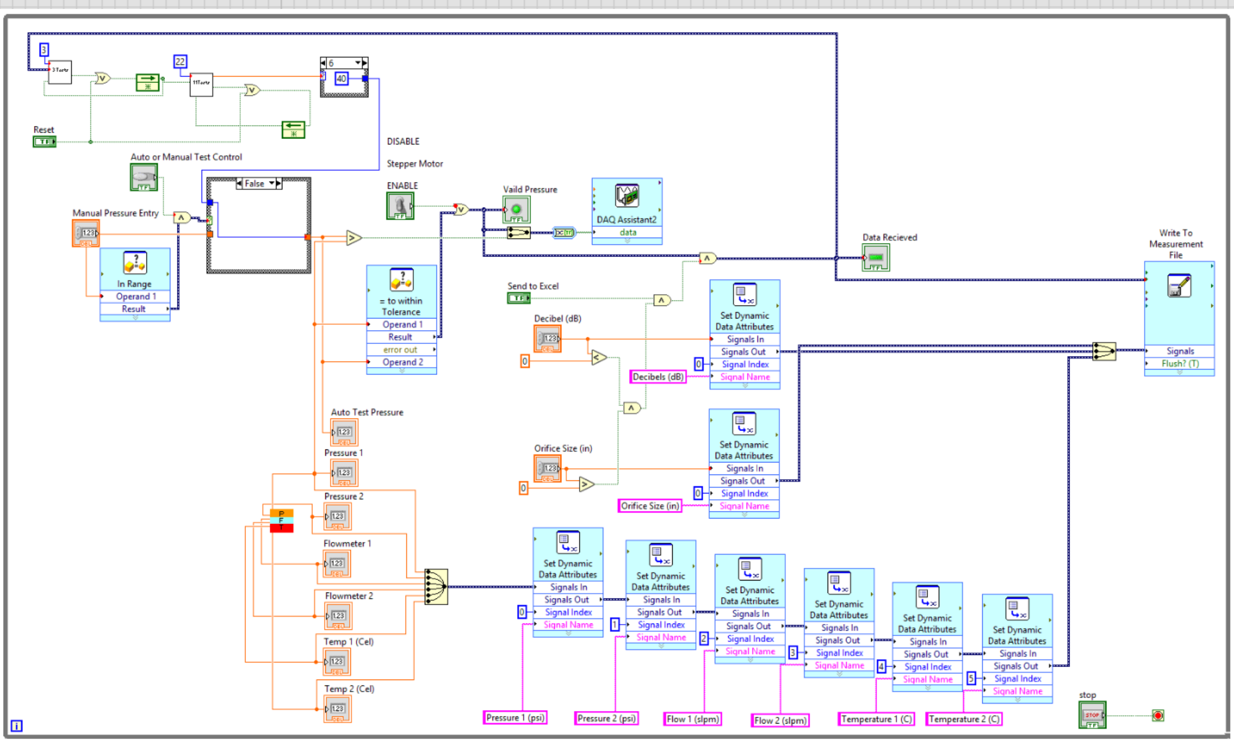

6. Physical Design

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6.1 Parts

1	High-Pressure Brass Pipe Fitting Cross Connector, 1/4 NPT Female 50785K233	1 Each	9.57 Each
2	ASME-Code Fast-Acting Pressure-Relief Valve for Air, Silicone Seal, 1/4 NPT, 125 PSI Set Pressure 48435K72	1 Each	5.26 Each
3	Zinc-Plated Steel Barbed Hose Fitting 3/8" Hose ID, 1/4 NPT Male End 5350K36	3 Packs of 1 each	1.98 Packs of 1 each
4	Industrial-Shape Hose Coupling Size 1/4, Zinc-Plated Steel Plug, 3/8" Hose ID 6534K67	1 Each	2.21 Each
5	Industrial-Shape Twist-Disconnect Air Hose Socket Coupling Size 1/4, 1/4 NPT Female End 9582K33	2 Each	22.09 Each
6	Standard-Wall PVC Pipe Fitting for Water Bushing Adapter with Hex, 1 Socket Male x 1/4 NPT Female 4880K825	1 Each	1.10 Each
7	Thick-Wall PVC Pipe Nipple for Water Threaded on Both Ends, 1/4 NPT, 1-1/2" Long 4882K21	1 Each	1.81 Each
8	Thread Sealant Tape 0.0032" Thick, 3/8" Wide, 14 Yard Long 6802K18	1 Each	2.58 Each
9	High-Pressure Brass Pipe Fitting Tee Connector, 1/4 NPT Female 50785K72	1 Each	6.00 Each
10	Standard-Wall Unthreaded PVC Pipe for Water 1 Pipe Size, 5 Feet Long 48925K93	1 Each	5.28 Each
11	Corrosion-Resistant On/Off Valve, Lever Handle Chrome-Plated Brass Body, 1/4 NPT Female x 1/4 NPT Female 33325K21	1 Each	9.29 Each
12	Standard-Wall PVC Pipe Fitting for Water Bushing Adapter with Hex, 1-1/4 Socket Male x 1 NPT Female 4880K206	1 Each	1.25 Each
13	Standard-Wall PVC Pipe Fitting for Water Reducer, 1-1/4 Socket Female x 1 Socket Female	1 Each	1.44 Each

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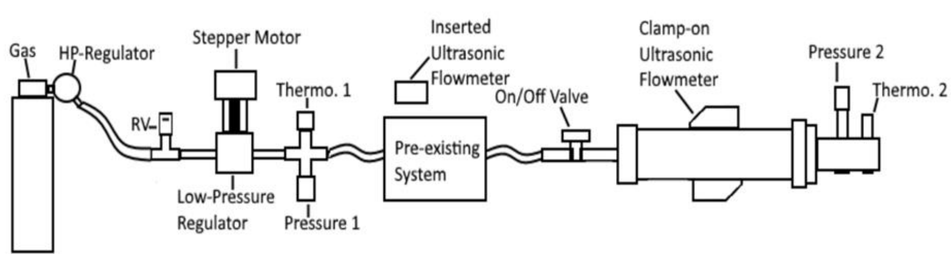
	4880K683		
14	Medium-Pressure Brass Threaded Pipe Fitting Straight Adapter, 1/4 BSPP Female x 1/4 NPT Male 1786N121	2 Each	7.56 Each
15	High-Pressure Brass Pipe Fitting Straight Connector, 1/4 NPT Female 50785K92	1 Each	1.50 Each
16	Standard-Wall Brass Pipe Nipple Threaded on Both Ends, 1/4 NPT, 2" Long 4568K133	1 Each	2.14 Each
17	Standard-Wall Brass Pipe Nipple Threaded on Both Ends, 1/4 NPT, 1-1/2" Long 4568K132	2 Each	1.91 Each
18	Standard-Wall PVC Pipe Fitting for Water Straight Connector, White, 1 Socket-Connect Female 4880K73	1 Each	0.48 Each
19	Primer for Pipe Cement for Plastic Pipe Clear, 8 oz. Brush-Top Can 18815K51	1 Each	6.07 Each
20	Pipe Cement for Plastic Pipe for 6" Maximum Diameter PVC Plastic Pipe, 8 oz. 74605A14	1 Each	5.27 Each

6.2 Schematic



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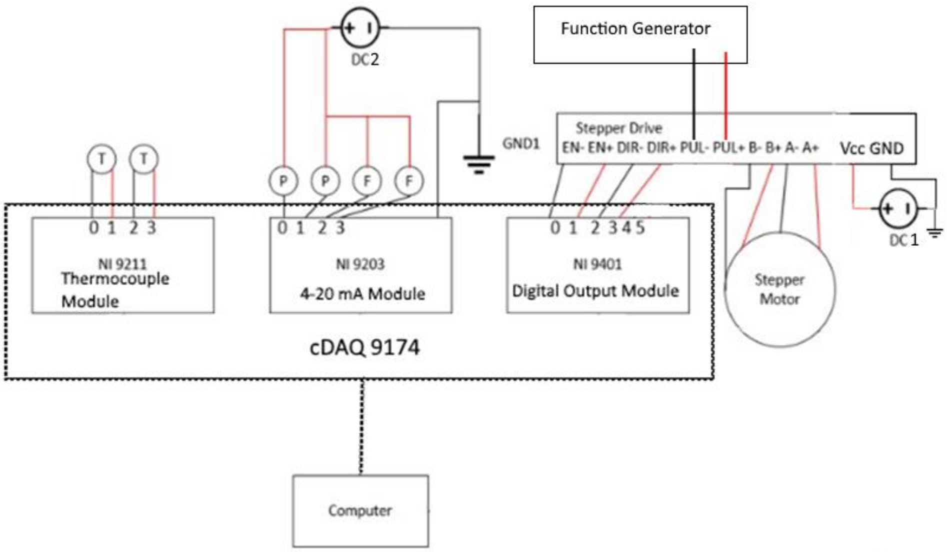

Function Generator
DC2
GND1
Stepper Drive
EN- EN+ DIR- DIR+ PUL- PUL+ B- B+ A- A+
Vcc GND
DC1
T
T
P
P
F
F
0 1 2 3
NI 9211
Thermocouple Module
0 1 2 3
NI 9203
4-20 mA Module
0 1 2 3 4 5
NI 9401
Digital Output Module
Stepper Motor
cDAQ 9174
Computer