Tech Expo, Spring 2026 – Team 7

Digital Pressure Regulator

Team: Nick Eynon, Thomas Copeland, Kaiden Miller, Ethan Bowlby

Mentors: Jose Garcia-Bravo

PURDUE UNIVERSITY
Polytechnic Institute

PROPORTION-AIR

Problem Statement

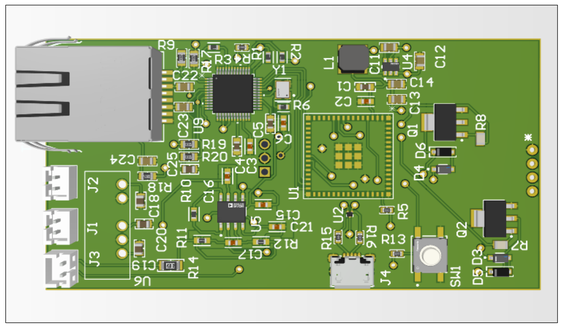
The problem that we aimed to resolve for proportion-air was to aid them to move away from the analog control and feedback mechanisms and move to integrate digital communication capabilities to the QB electronic pressure regulator using Ethernet.

Customer Background

Founded in 1985 by Daniel E. Cook, Proportion-Air, Inc. is a global leader in proportional electro-pneumatic pressure and flow control. The company, headquartered in McCordsville, Indiana, specializes in air pressure regulators and flow valves built with superior accuracy, resolution, and repeatability. Their product portfolio spans electronic and mechanical pressure regulators and air flow control valves, serving demanding industries such as aerospace, semiconductors, medical, pharmaceutical, and manufacturing.

Requirements

This project aims to develop an Ethernet/IP communication interface and a digital version for Proportion-Air's QBX electronic pressure regulator, enabling seamless integration into modern industrial automation networks. The new digital pressure regulator is built around an open-source microcontroller with ADC capabilities housed in a new, custom PCB designed to fit within the existing QBX housing. By including Ethernet/IP support, this solution brings legacy pneumatic hardware into compliance with today's industrial standards. This new system needs to meet, or exceed, the previous and demanding QBX specifications, with accuracy within ±0.1% Full Scale (FS), meaning that the error is only ±0.175 PSI when operating at the high-end of its pressure range of 175 PSI.



3D rendering of the partially populated PCB

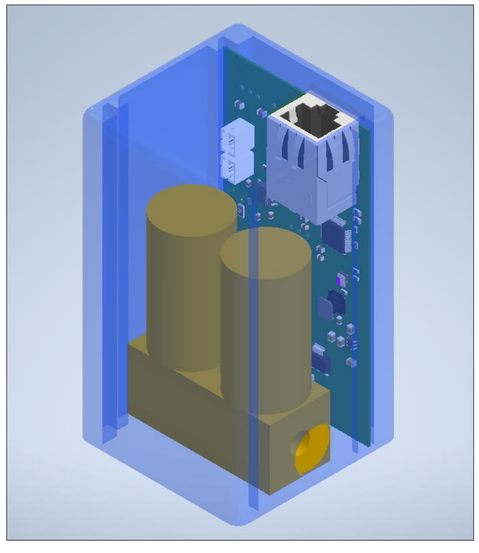
Experimentation and Concepts

Experimentation consisted of applying consistent pressure to the sensor over extended periods of time, measuring the PSI and then comparing it to the digital regulator pressure output. Initial attempts at this were done using a 3D printed chamber to hold the sensor in place and seal it shut using automotive gasket maker. Pressure was then applied with a fluid syringe. These attempts proved less than fruitful. The gasket maker would give way where the wires connected the sensor under high pressure impulses. Future attempts were done in the fluid lab where compressed air is on tap. This was fed through a pressure gauge and into the normally open side of a pressure regulator with our digital sensor inserted into it. This design catered positive results from the flowing pressure, resulting in a linear coalition. The biggest source of error was from the gauge that measured PSI in increments of 5.

Final Design

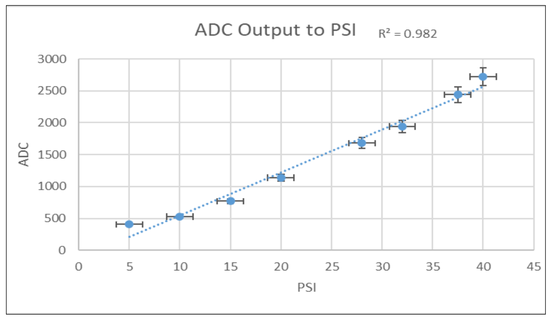
The final design will be a standalone pressure regulator that can send statistics over ethernet and receive a new setpoint over ethernet. Electronically, there will be four main parts of the pressure regulator. The first part will be the pressure sensor reading system. To maintain adequate resolution the pressure sensor's analog signal will be converted to digital with a 12-bit ADC. The second part of the regulator is the MCU that is responsible for communication with the other parts of the regulator. We will be using an ESP32 to communicate with the other parts of the regulator. A W5500 will be used as the heart of the third part of the regulator the ethernet / wireless control section. Lastly the fourth part of the regulator is the valve control. The required software will be written in C and will adjust the pressure based on the setpoint given. It will also send out the current pressure to be displayed on a control dashboard.

3D rendering of the valve construction with PCB



Transparent rendering of the new assembly

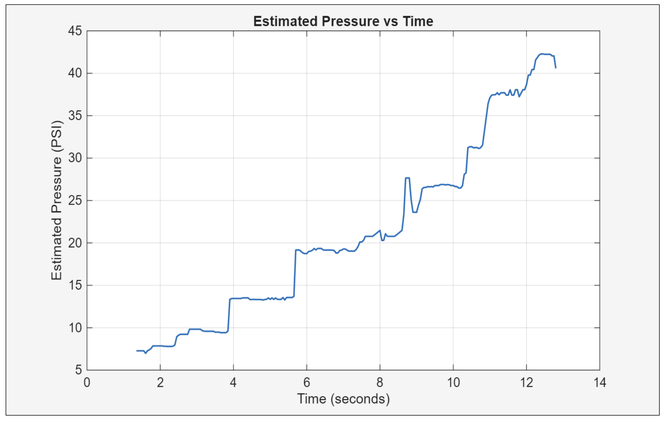
Testing and Results



Graph of ADC output vs PSI

To test our prototype digital pressure regulator, we had the following setup. We had an air compressor hooked up to a pressure Gadge that allowed us to control the pressure going to the sensor. The sensor was held in a mock setup utilizing the valves from a proportion QBX Regulator. Data was then recorded for each pressure and graphed in the figure shown above.

Our results strongly suggested that we are able to linearly and accurately read pressure in order to control a set point. Our web dashboard that was made in node read accurately displayed the pressure and adjusted our simulated set point based on input from the dashboard. The pressure gage that we used was analog and so there was a slight inaccuracy in some of our measurements. That inaccuracy is represented by the 1PSI error bars on our graph.



Graph of pressure value over time