ELECOMP CAPSTONE
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THE UNIVERSITY OF RHODE ISLAND

THINK BIG WE DO℠

Voltage to PWM Converter

A Translational Controller Between American-Design Boilers and European-Design Pumps

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Project Motivation

In North America, the typical speed control signaling method for pumps and valves is a 0-10 V, 2-10 V, or 4-20 mA control scheme. Taco International currently has a pump that is controlled with a pulse width modulation (PWM) signal. To take advantage of this pump in North America, Taco Comfort Solutions proposes developing a voltage to PWM converter module, which is capable of performing the proper control scheme transformation. In doing this, Taco Comfort Solutions will be enabling itself to reap the cost saving benefits of using such pumps, at a minimal cost to upgrade.

Key Accomplishments

Development Hardware: The hardware for the VPWMC involves multiple points of design which heighten the ability of the microcontroller to produce certain signals and work over certain communication protocols. The baseline hardware for the device involves the processor linked to a special active filter - gain stage pair, allowing the 5V microprocessor to produce up to 10V analog signals without the use of a specialized DAC or digital potentiometer.

PWM to Analog Voltage: One major challenge of this project was the generation of 10V analog from the microcontroller. Our solution to this problem was to implement an active filter which removes all frequency components of the PWM signal, leaving only the DC component. We achieve control of this level via an input PWM mimicking routine.

Proposed BAO Firmware: Firmware which implements all of the functions present in the originally proposed Best Anticipated Outcome (BAO). In doing this, we have implemented bi-directional Analog Signal to Pulse Width Modulation conversion across three different modes of voltage or current signal inputs.

Power On Safety Diagnostics: Additionally to the originally proposed BAO Firmware, we have implemented important power on safety diagnostics procedures similar to those found in the IEC 60730 application safety certification. In doing so, Taco can easily verify that a VPWMC device is working properly and ensure the safety of the end user.

Production Line Testing: We have also implemented production line testing via Taco Comfort Solutions' proprietary cyclical redundancy check based communication protocol: TacoBusLite. In doing so, Taco can not only write device specific Serial Numbers to the device with the ease of a comprehensive Graphical User Interface, but also control the inputs and outputs to the device remotely in order to verify that the device is working correctly before it is sent off to the end user.

Near Field Communication (NFC): An important reach goal was to implement an interface for Near Field Communication on the device. Using the STMicroelectronics ST25DV chip, and an onboard PCB antenna, Team Taco provided this capability, along with writing comprehensive firmware which can be expanded into desired functionality by Taco Comfort Solutions. Doing this has opened the door for this technology to be used in many future Taco products.

Printed Circuit Board: The printed circuit boards for the project have been received and tested. Two boards have been produced; a development board which has additional I/O and is larger, and then a small production style board which will fit in the provided Taco enclosure. The production style board is a 2-layer printed circuit board and contains a 2-layer NFC antenna for the dynamic NFC tag. The production printed circuit boards have very limited space available for components due to the way the existing enclosure is designed. We managed to fit the NFC antenna well and have verified that the design enables such communication. (Figures 1 and 2)

Production Ready Firmware: The last goal of Team Taco was updating the firmware of the VPWMC to eliminate transient bugs and fortify the existing processes against noise and other concerns. Through Alpha testing, Team Taco was able to find and eliminate a few crucial errors, which allowed us to expand into a newer, more capable processor family, and ensure clean signal analysis and production. After more discussed desirables, Team Taco finally completed the production ready firmware revision 2.1.5, meaning Taco can now go through the process of selling this device.

Bootloading Compatibility: One of the stretch goals provided by Taco on this project was to begin and attempt to finally implement the capability to program the VPWMC without use of an external debugger device. With desire to do this wirelessly via the NFC module onboard, crucial steps were taken by Team Taco to expand the interface into the module, and build out functions which lay the groundwork for such an interface, rarely seen on the market, to be implemented on not just this, but many of Taco's future products.

Anticipated Best Outcome

Device which possesses the following capabilities or traits

- Conversion of input analog signal to output PWM and input PWM signal to output analog, thus performing the two-way translation.
- Power on safety diagnostics based on those found in IEC 60730 Class B
- Production line testing via Taco's proprietary packet-based protocol TacoBusLite
- Hardware developed to fit a previously designed Taco enclosure and built on a PCB
- Device ready for production as one of Taco Comfort Solutions' many products

Project Outcome

The Anticipated Best Outcome was achieved.

Team Taco was able to excell past our goals for this project, achieving the Anticipated Best Outcome by the end of Fall Semester, and achieving our Extended Outcome Goals in the Spring.

Figures

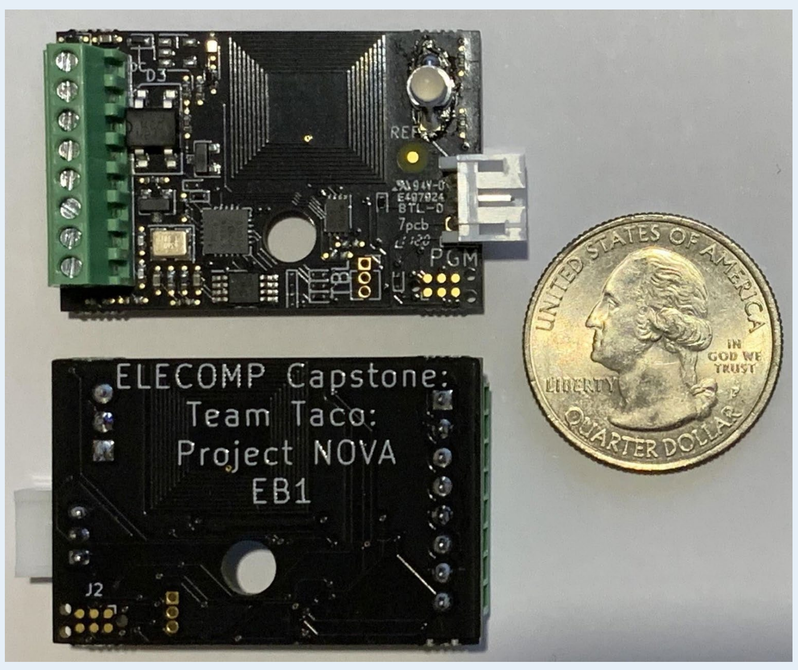

Figure 1 - Photo of the Revision 2.0 VPWMC production boards with U.S. quarter for scale

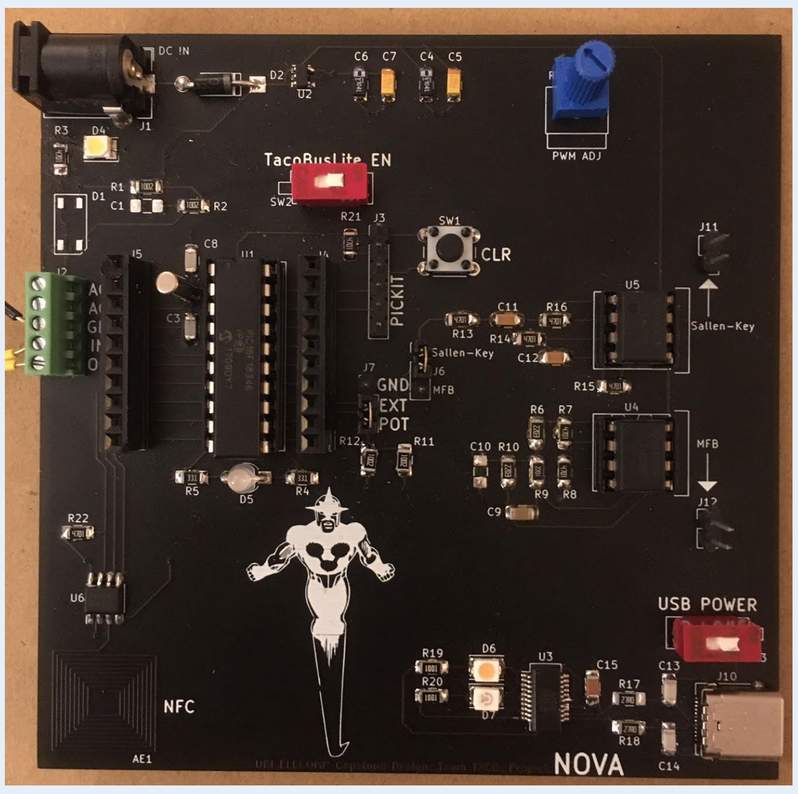

Figure 2 - Photo of the Revision 1.0 VPWMC development hardware used to facilitate alpha testing for the VPWMC

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