Developing a Graphical User Interface for Nanosecond Pulsers

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Purpose

Eagle Harbor Technologies'(EHT) Nanosecond Pulser (NSP) is a precision pulsed power solution to drive capacitive loads with applications in research and industrial fields. The original user interface employs a combination of analog knobs to adjust voltage, pulse width, and frequency of the output pulses. The analog system has worked well for EHT's customers in the past but as they expand into new markets there is increased demand for a more streamlined user interface with higher-precision controls. The goal was to redesign and prototype an updated NSP controller using a rotary encoder, button system, and screen interface. We began with an STM32, a 32-bit microcontroller, then researched compatible button systems, and lastly developed a graphical user interface (GUI). The screen and sensor readouts provide more accurate controls than the original knob system.

Background

The NSP produces high-frequency pulses with rise times on the nanosecond scale and has applications including plasma jets, sterilization, UV light production, underwater plasma, dielectric-barrier discharge, rapid capacitor charging, and medical diagnostic equipment. As the capabilities of NSPs continue to advance to include higher voltages for higher power applications, EHT desires to modernize and improve the user controls beyond the original design.

Figure 1 depicts the layout of the knobs, switches, and indicator lights on the original interface of the NSP-LP (low power) and NSP-HP (high power). The existing knobs control the pulse properties: pulse width, peak voltage, and frequency. The pulse width and voltage are adjusted using pairs of coarse and fine adjustment knobs to output the desired values. Pulse repetition frequency is adjusted using a pair of base and multiplier knobs.

Some customers, particularly in the medical field, desire touchscreen controls with a seamless interface due to ease of control and cleaning. However, high-voltage applications of the NSP will produce electromagnetic interference (EMI); this can induce noise across the screen that causes unwanted touch detection if the screen remains un-shielded.

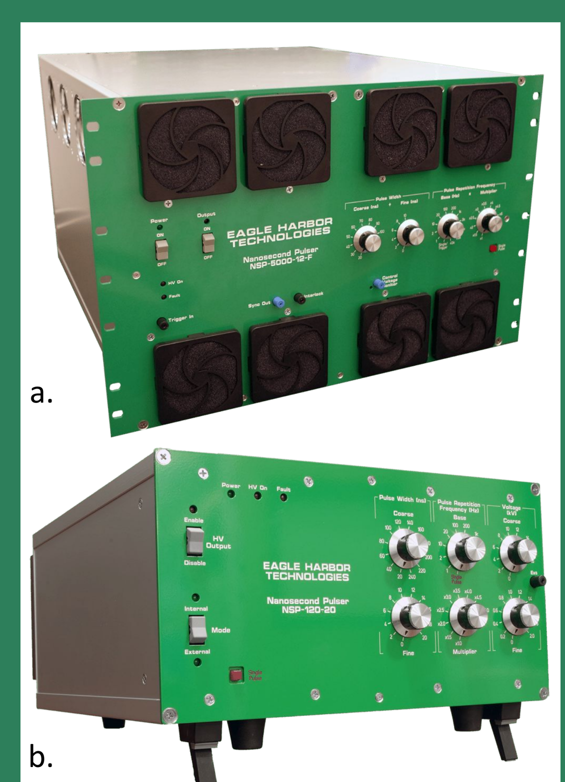

Figure 1: Front panel layouts of a. NSP-HP and b. NSP-LP

Concept

We received the STM32 microcontroller integrated-circuit chip on a NUCLEO144 development board and then we researched all the necessary compatible components: buttons, knobs, and screens. Based on the voltage variability, we aimed to develop a system that could flip between digital and analog controls to fit individual consumer needs. Our system will allow for precise control of the pulse width, voltage, and pulse repetition frequency by providing more readouts and feedback through the screen with a custom GUI. The digital interface using the touchscreen controls will only be viable for lower-power applications; the analog interface will employ one knob and 4 push button switches to control selections on the screen in higher-power applications.

Methods

Our initial step in the process of completing the digital interface to determine the amount of space on the chassis to accommodate a screen. We found that the chassis could accommodate up to a 7-inch screen, but we decided that a 5-inch screen would be sufficient. When we picked a screen, we deprioritized touchscreens due to the relatively high EMI of the NSP.

We selected the EVE3 screen model and followed the manufacturer's instructions. However, it was necessary to use 8-bit packets and a lower clock rate to ensure that the backlight function of the EVE3 worked. After we got the screen to turn on, we completed a demo project before assembling the circuit and having the components interface with the screen. The STM32 includes a rotary encoder, pushbutton switches, and a piezoelectric buzzer for the audio. Once we tested the analog circuit, we moved on to designing the GUI on the EVE3 screen editor.

Figure 2: Initial layout of screen

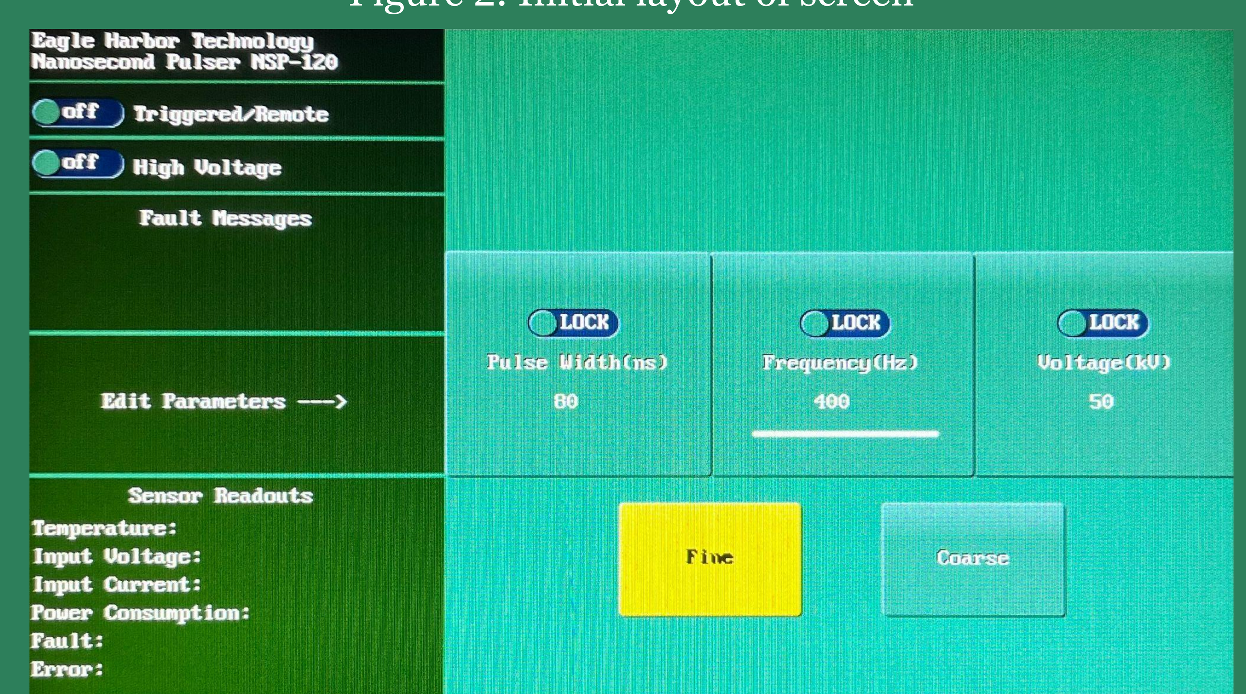

Figure 3: Finial layout of screen

The requirements for the GUI included a working menu that swaps between screens for pulse adjustment, system information, sensor readouts, and digitization of the analog knobs for pulse width, frequency, and voltage from the original interface. We first created a static GUI screen, seen in Figure 2. Then, we programmed the buttons and switches to animate on the screen when pressed. Finally, we spent time debugging code, troubleshooting hardware issues, familiarizing ourselves with the library, understanding the limits of the microcontroller, and gathering design feedback to improve the final build.

Results

The overall finding of our work on this project was that a screen with analog and touchscreen controls is compatible with the NSP and will help advance the product. We interfaced the EVE3 screen with the STM32 and determined this screen is a viable option for a digital interface on the NSP. We designed a screen layout and digital button system that carried over the original controls for pulse adjustment while improving the precision of the inputs. We also programmed the screen to respond to analog knob and touch control; this will be useful in medical and other sterile environments and when precise control of the output is required.

While our findings lay the groundwork for future implementation of screens into EHT's product line, we observed some hardware elements that should be improved for the final prototype, as the pushbutton switches are mechanically noisy, and the knob of the rotary encoder has small spaces in between each turn-click which can make it difficult to control the turns.

Future Work

While we made significant progress in the design and testing of the screen interface, we still need to conduct tests, streamline the GUI, and implement the system into the NSP. Future testing includes studying touchscreen models in high EMI environments to check their touch capabilities. Our circuit and code must be reviewed by an EHT Safety Officer to ensure it won't damage any components or the user and all overrides and shut offs function properly. To physically implement our concept into the existing NSP, we need to modify the front panel to accommodate the screen and updated control board. We can't modify the internal circuitry of the NSP, so the new chassis should be designed with as few modifications as possible. The final step is to build a working prototype with our screen and GUI integrated into the NSP chassis then test at low and high voltages.

Acknowledgements

This work is supported by TaiSheng Yeager, Huatsern Yeager, Kevin Muggli, Jacob Hagen, and others at Eagle Harbor Technologies, and the Washington NASA Space Grant Consortium.