Introduction

COVID-19 created a situation where students were not able to access the lab equipment provided by the school. As electrical engineers, the most important lab equipment is arguably the lab bench equipment (oscilloscope, function generator, etc.). Industrial grade lab equipment usually costs a couple thousand dollars altogether. Without access to the high performance equipment and a lack of a budget to purchase them for all EE students to use individually, a need for reliable and cheap lab equipment arose. Our project aims to create a reliable function generator that generates a square wave, sine wave, triangle wave, and sawtooth wave with adjustable frequency and amplitude.

Methodology

There are three approaches to completing the function generator: analog, digital, and a combination. An analog approach relies on the use of a timing chip, such as the 555 timer IC, to generate a square waveform and then use filters to create the other waveforms. In our attempt to build the function generator through analog components, we created a square wave using 555 IC with adjustable frequency. The signal was passed through several low-pass filters to create a ramp, triangle and sine wave.

The output of the 555 timer is then adjusted to remove DC offset and then amplified before reaching the multiplexer stage where the user can then select which output they want. Our analog approach to the function generator was then laid out in LTspice to test the proposed methodology. LTspice is a tool used for building and testing schematic designs which can be used prior to building physical prototypes.

The multiplexer is an electronic version of a mechanical switch allowing users to switch between any of the desired waveforms with a single button press. This is controlled by the microcontroller as it reduces the number of button presses or switches that users must input.

LTspice helped to provide simulations results for our design which was then implemented on a breadboard. Digital approaches such as the Arduino and NRF52840 showcased better flexibility and a wider range of frequencies. Therefore the initial design evolved to utilize these microcontrollers.

Analysis and Results

Overall, the initial concept and approach for the function generator needed several iterations and debugging sessions to complete. The final product is one that fulfills all the requirements our team had initially set at the beginning of fall [3]. However, the design could use additional tweaking to ensure users receive the highest fidelity signals possible for their endeavors at San Jose State University.

Key References


Acknowledgements

Thank you to Professor Hamedi-Hagh for being our advisor, providing us with our project idea, and guiding us when we needed it.