Digital/Analog Synthesizer

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Abstract

The Digital/Analog Poly Synthesizer is a compact, power efficient instrument that combines digital tone generation with analog processing in a single package. At its core is a 12-bit DAC deliver sub-millisecond voice response. A universal keypad interface accommodates 2- to 36-key controller. Dual-channel outputs feed either built-in speakers or balanced line-level jacks. This project not only showcases embedded audio design but also offers a fully functional prototype ready for performance and further development.
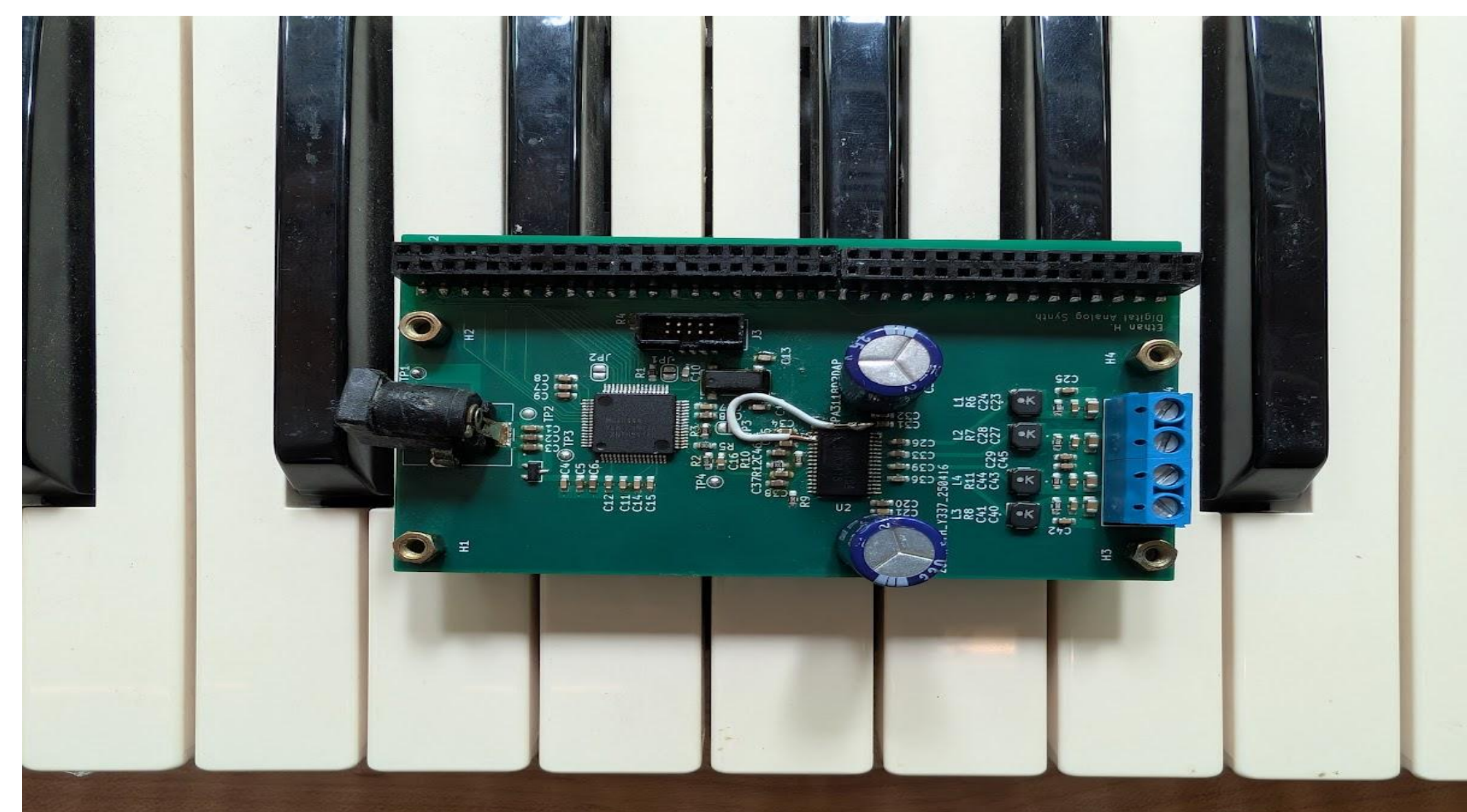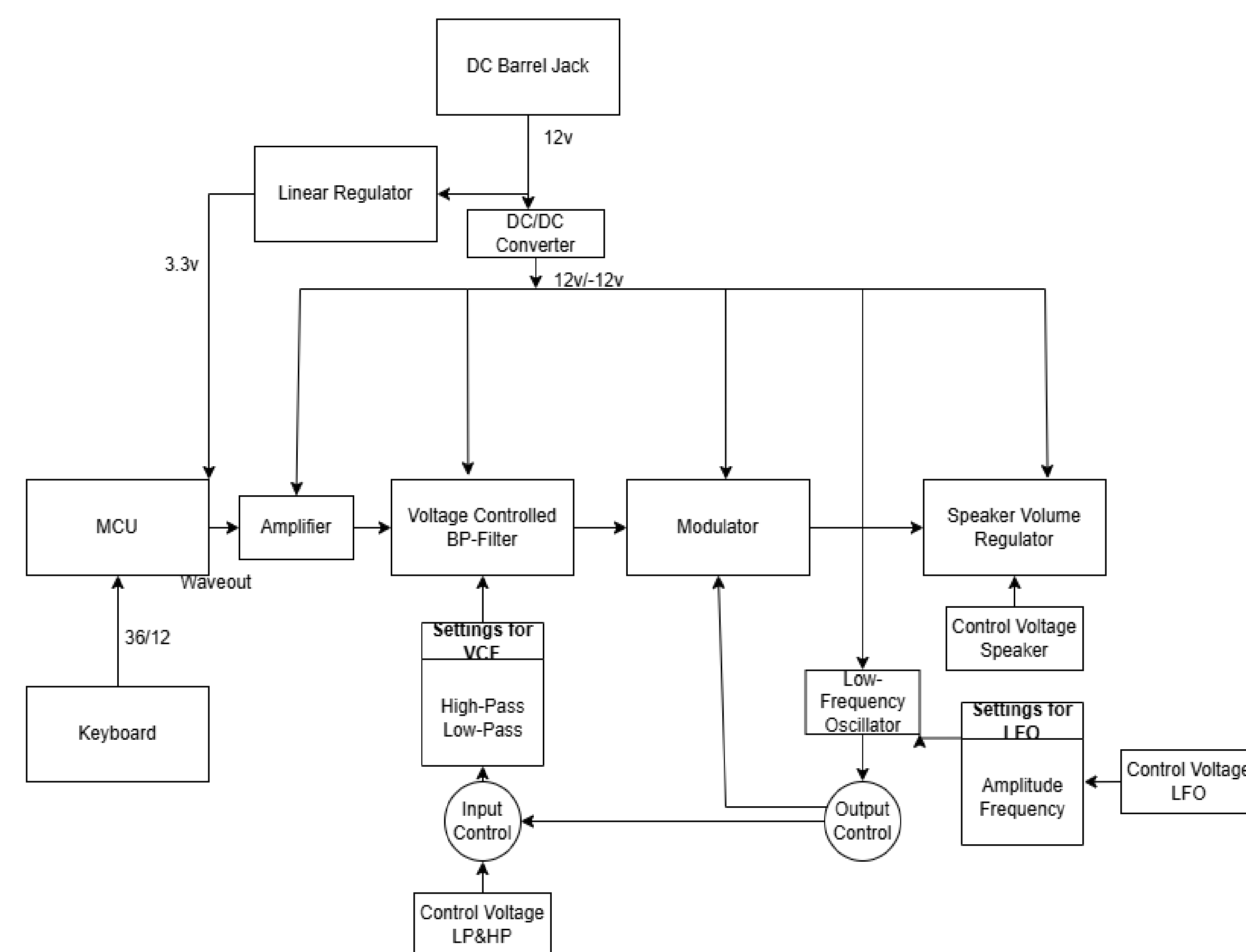
Methods and Materials

The end product that that you see today is quite slimmed down from the original design. In this version, it only contains the microcontroller used to create the piano sounds, and an amplifier so boost the signal and have the output ready to attach to a pair of speakers. The Microcontroller is an MCXC444VLH which is cheap and low power letting this product be compact and cheap. The amplifier is a TPA3118D2DAP which takes the signal from the Digital to Analog converter and boosts it up by ~20dB making it much easier to hear. The keyboard is a Yamaha original that I took from an old keyboard that wasn't in use anymore. The PCB was design using KICAD and the microcontroller was coded in C using MCUXpresso. Bellow is an example of how The wave is output. Because the audio output needs to stay at a high frequency to keep it sounding nice, lower frequency waves need a different way to be output. Rather than keeping track of the regular index, the phase is kept track of instead.

Example DDS Oscillator output (red), with phase value (green)
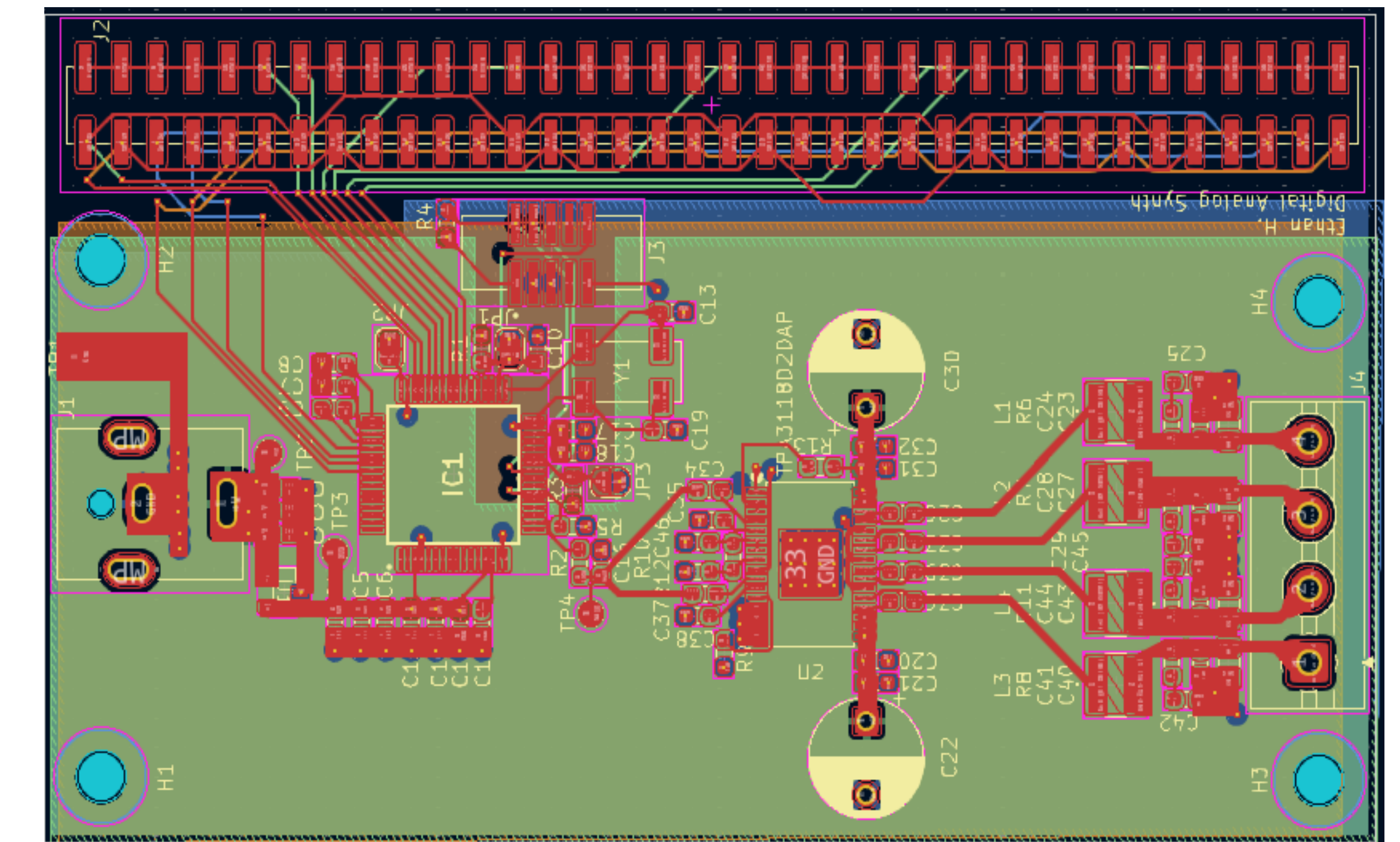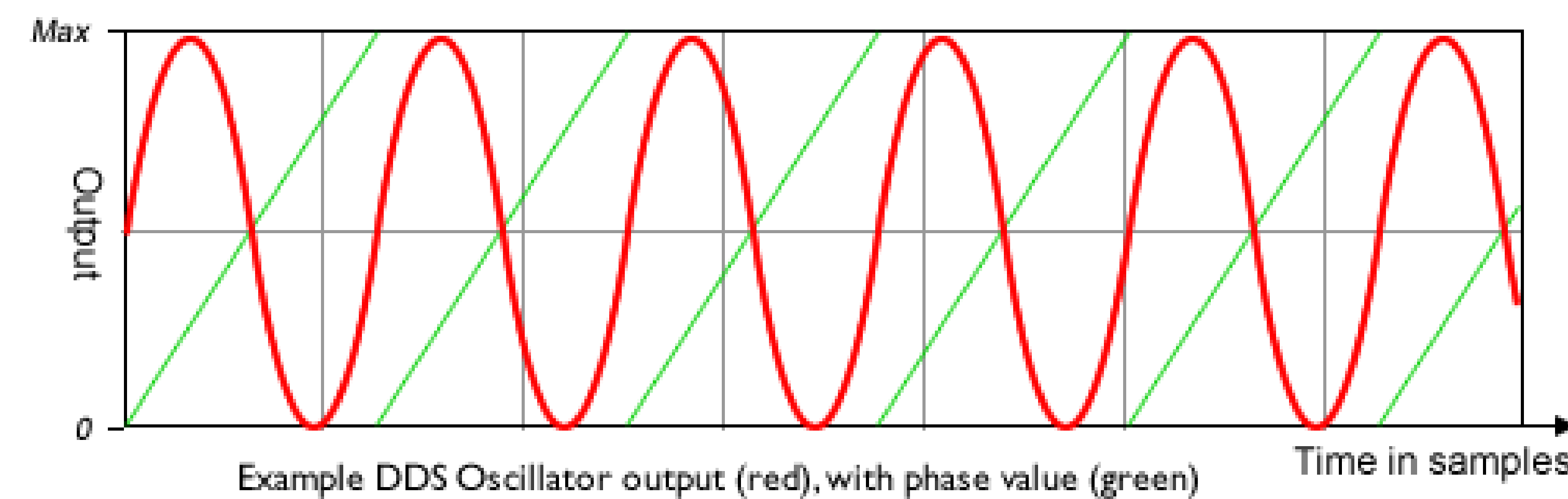
Results

The product that came out of the design process is a compact Poly-synthesizer that, although lacking the original effects that were intended, is still a capable poly-synthesizer. On the right is oscilloscope screenshots of C4, C4+E4, and a GPIO slice. This keyboard is able to reliable create 3 note combinations for playing chords and other note combinations. It can be observed that as more keys are pressed the bottom wave (This is the GPIO scan) becomes less frequent as more keys are pressed. This reveals the weakness of the design that's been implemented. The CPU load grows when more notes need to be mixed together which eventually leads to the underfilling of the output buffer, Once that happens it's no longer creating accurate sounds.
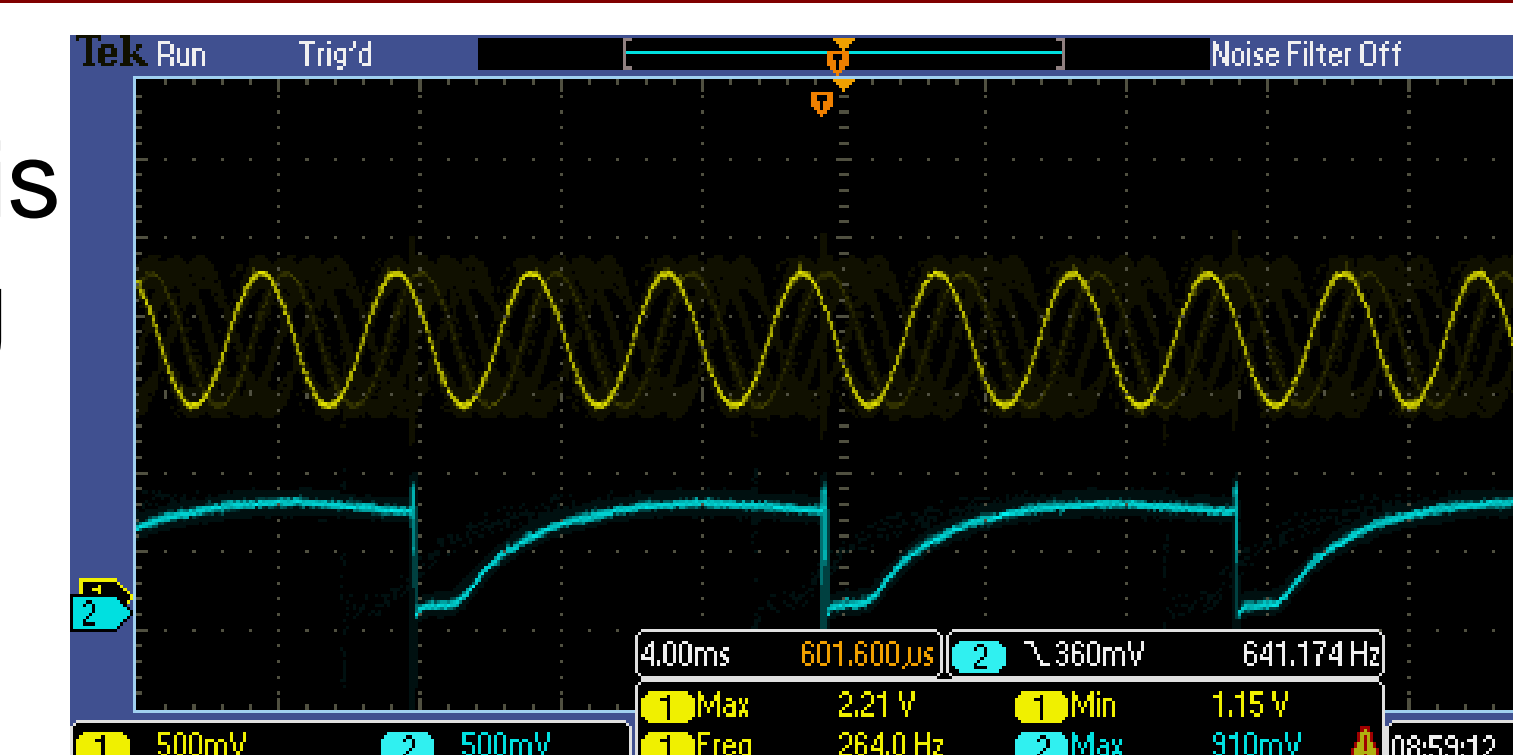
C Note
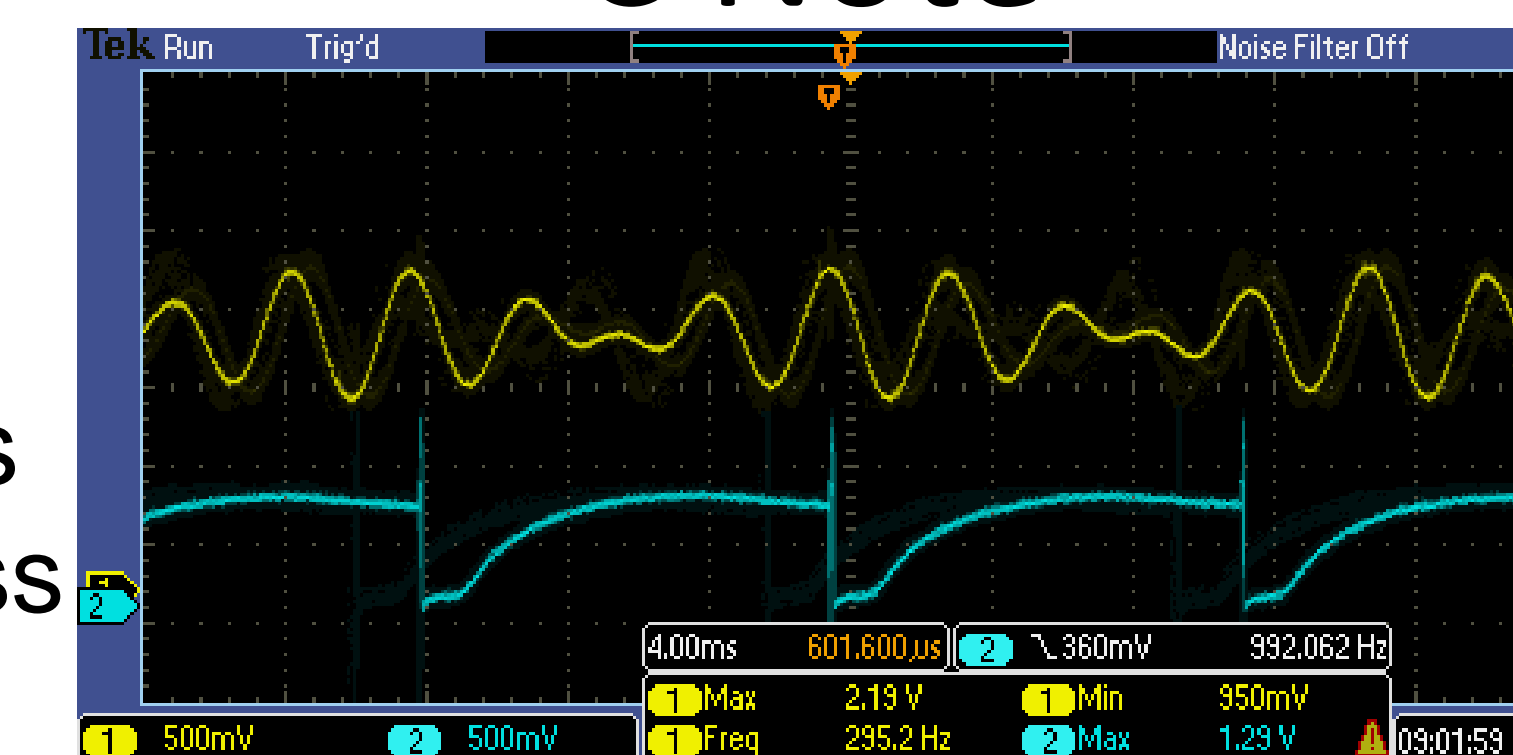
C+E Note
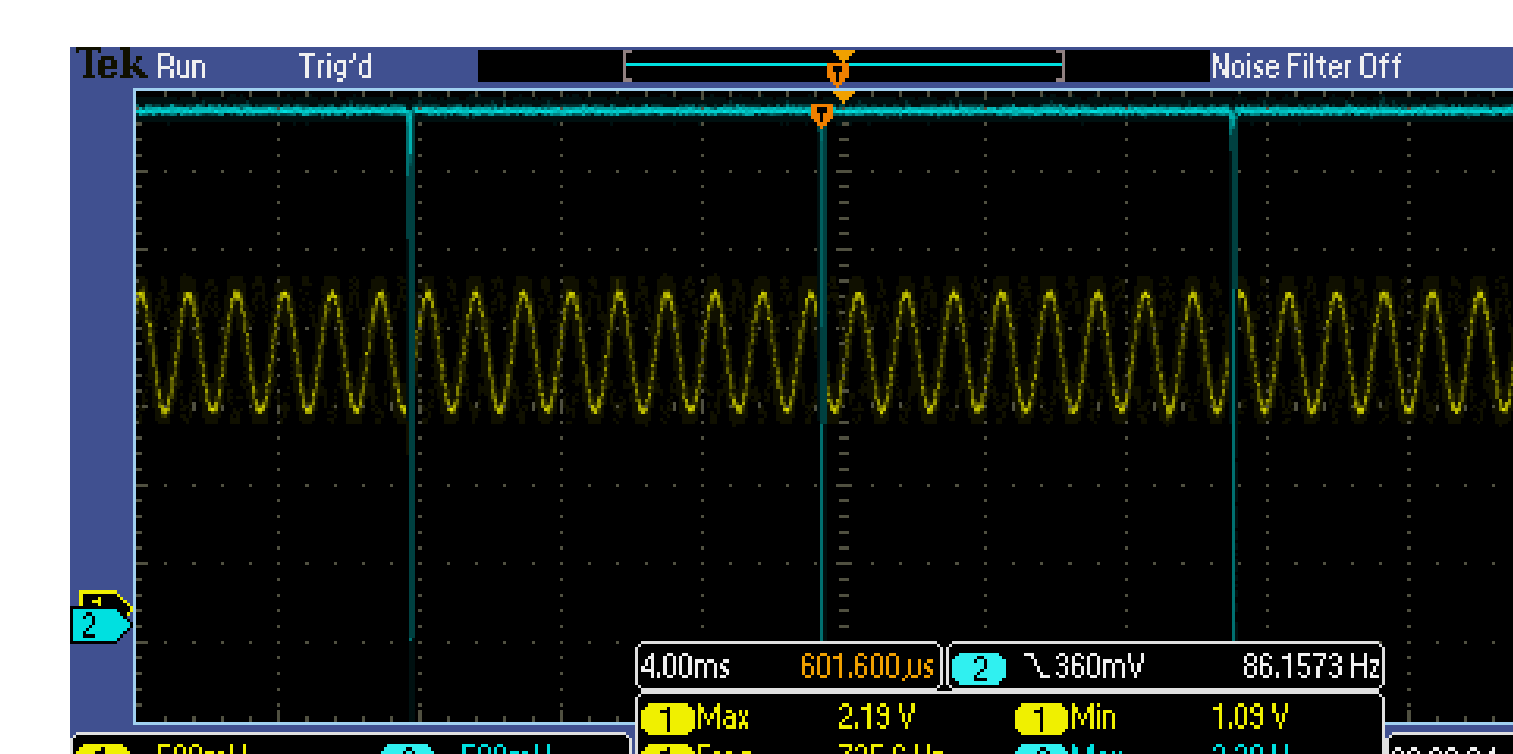
GPIO of pressed key

Future Direction

Originally this product was designed with significantly more analog effects to add the piano sounds. This design still could allow for adding those effects after the power amplifier. Effects such as moveable filters, low frequency oscillators, and amplitude modulation are all things that could be added to the product in the future.
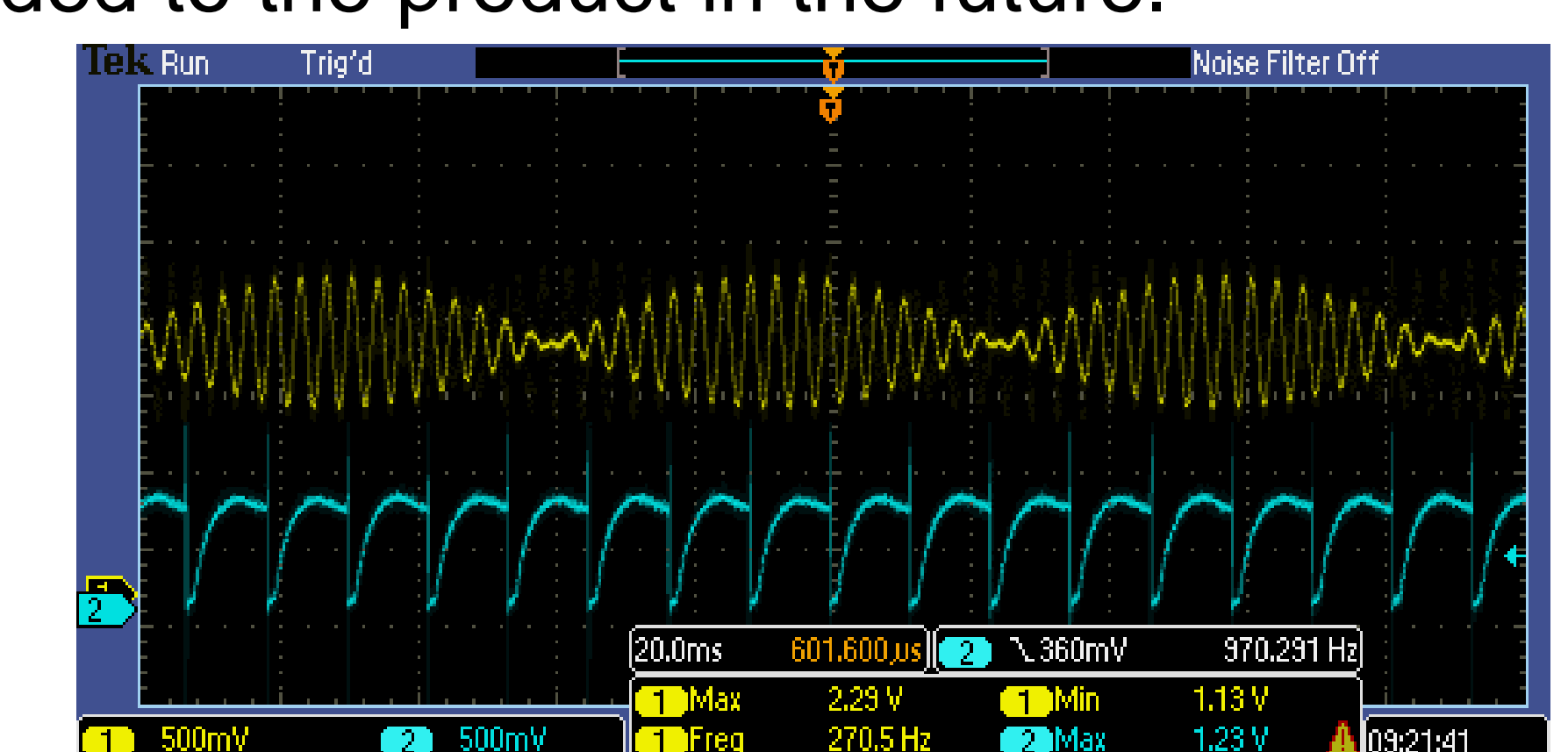
AM modulation

Acknowledgements

References

Western Washington
NXP
Texas Instruments

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