Design of Prototype PZT Long Distance Communication PCB

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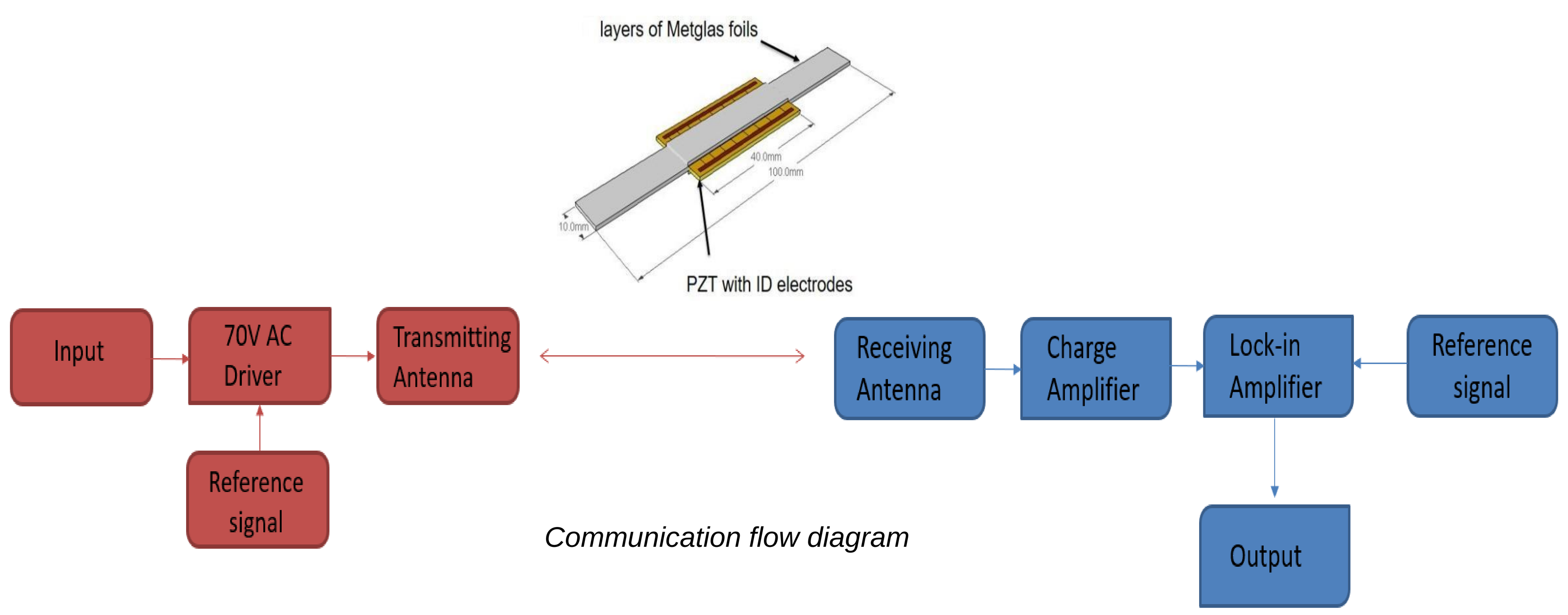
Introduction

Current communication devices transmit on radio frequencies (RF) which are becoming overused and have issues traveling through certain mediums. More reliable long distance communication can be achieved using Very Low Frequency (VLF) and Ultra Low Frequency (ULF) band devices. Lead zirconate titanate (PZT) antennas use the piezoelectric effect to produce low frequency signals with low bandwidth, making it ideal for quick message data. This method, is highly reliable as they are difficult to interrupt and can transmit in areas that most RF communications have difficulty reaching; such as underwater or underground locations. This research focuses on development of AC Driver and Lock-in Amplifier printed circuit board designs (PCB) for transmitter-receiver system.

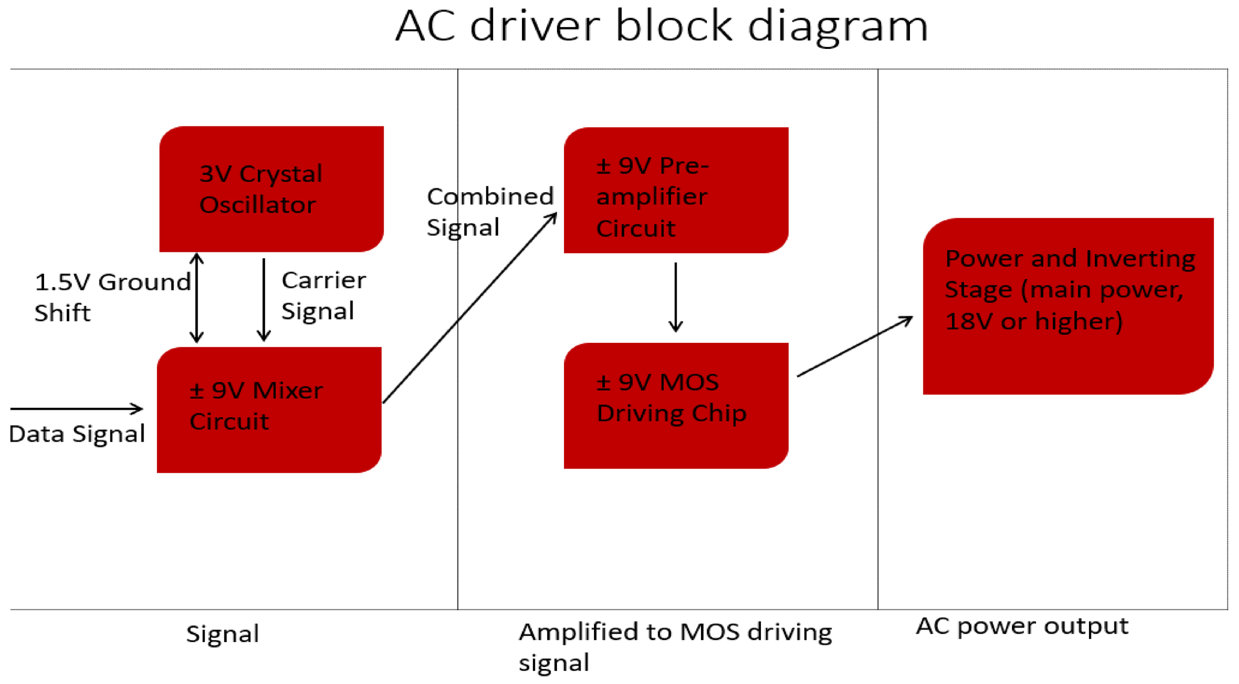


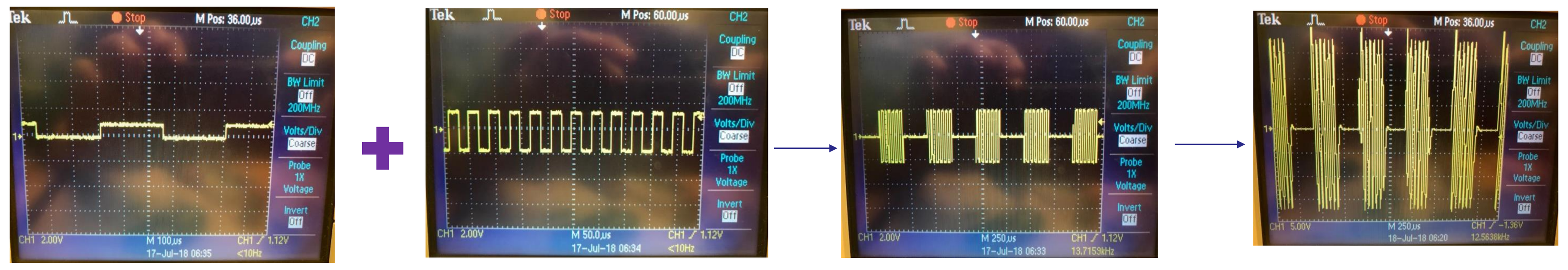
Communication flow diagram

AC Driver

-AC Driver inverts input DC signal to AC signal with frequency tunable using trimmer resistor in timer circuit.
-Used to allow signal to be modulated for transmission
-Achieved in three steps:
  -Signal frequency generated by crystal oscillator
  -amplification of signal
  -inverting to AC power output

AC driver block diagram



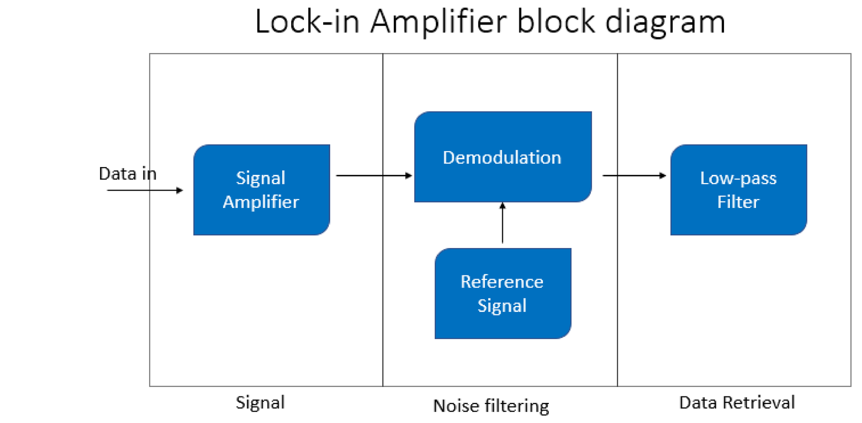


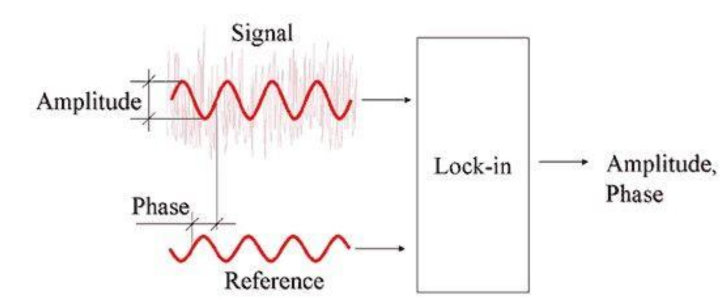
Data Signal generated by function generator; 2kHz | *Carrier Signal generated by AC Driver; 23.5kHz* | Output signal of mixer circuit (square wave output) | Output signal of AC driver (sin wave output)

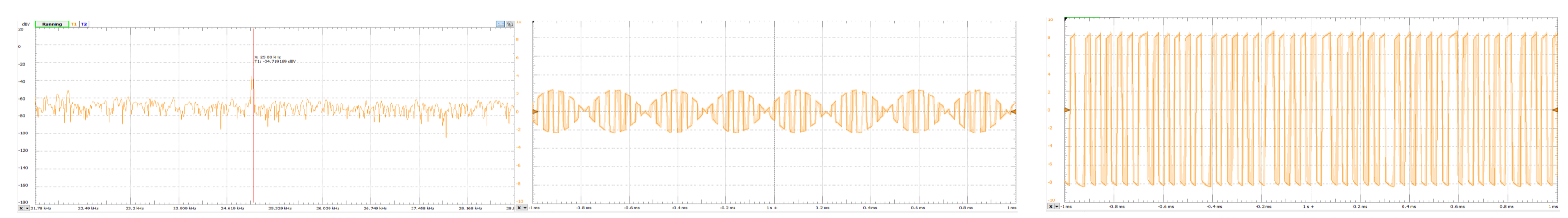
Lock-In Amplifier

-Used to tune in to signal of known carrier frequency while ignoring noise outside of band. Signals must be in phase to operate correctly
-Deciphers data sent by transmitting antenna
-Achieved in three steps:
  -Amplification of received signal
  -Demodulation of signal to remove noise
  -Low pass active filter to convert signal to original DC

Lock-in Amplifier block diagram



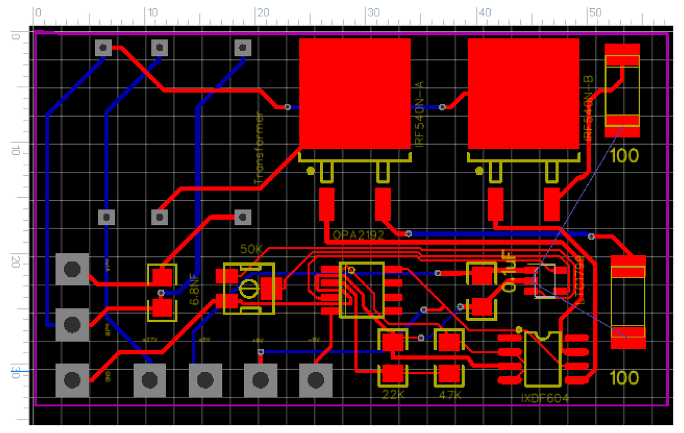




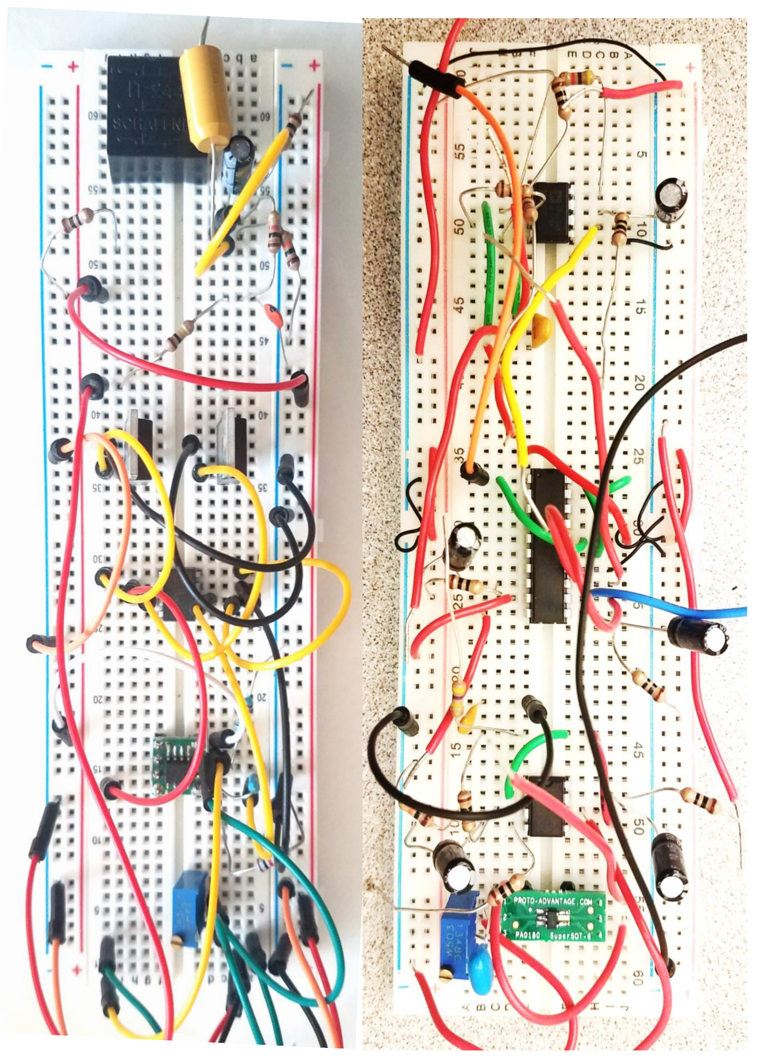
Received signal, amplified | *Demodulated signal, noise filtered* | *Low pass filter, original data retrieved*

Prototyping

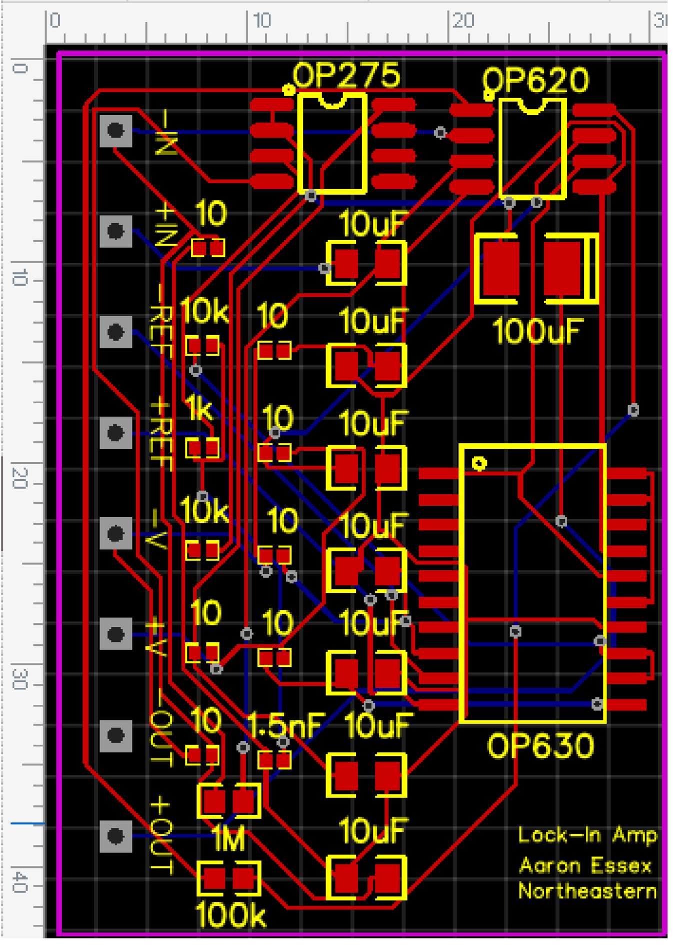
Schematics were imported into JLCEDA software to begin design. PCB was made to be compact and accept Surface Mounted Devices (SMD) to keep production cost low and take little space. Precision editing tools allow for custom component footprints



AC Driver circuit designed in JLCEDA software



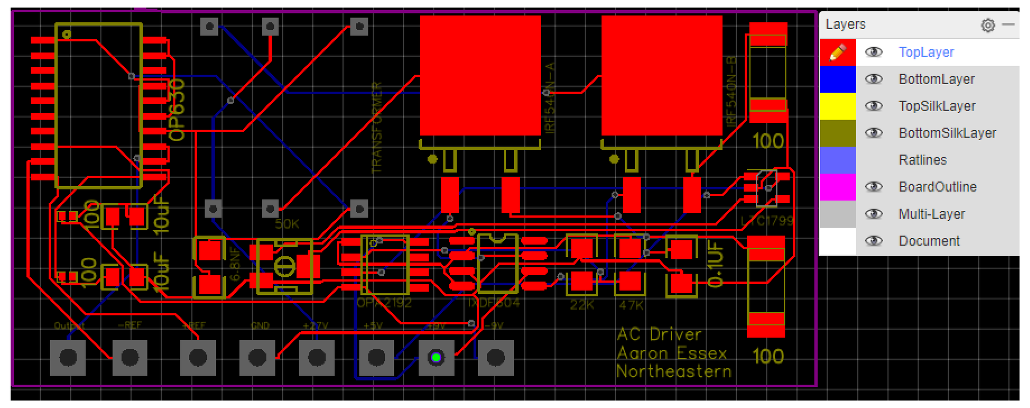
AC Driver (left) and Lock-in Amplifier (right) initial test circuits on breadboard



Lock-in Amplifier circuit designed in JLCEDA software

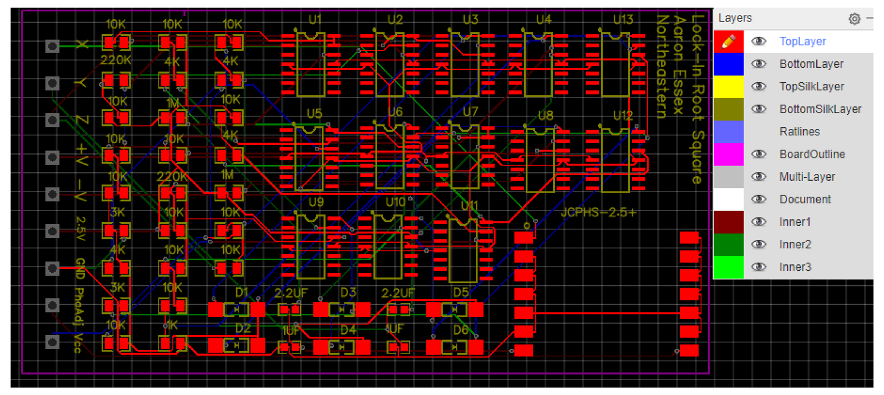
Refinements

Early models of AC Driver PCB become hot while operating and eventually burn out. Literature advises wider tracks on PCB and avoiding 90 degree track placement to circumvent issues. Modulator was added for data carry.

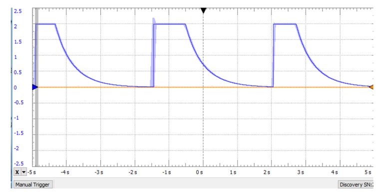


AC Driver with modulator, improved track geometry

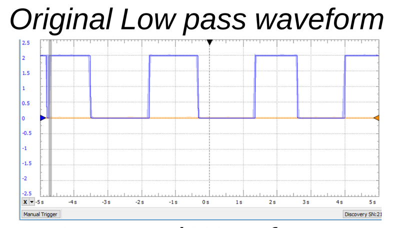
Phase independency circuit was added to Lock-In Amplifier reference signal input to make fine adjustments when necessary. Low pass filter time constant decreased to improve switching speed and thus improve data rates.



Lock-in Amplifier phase independency circuit

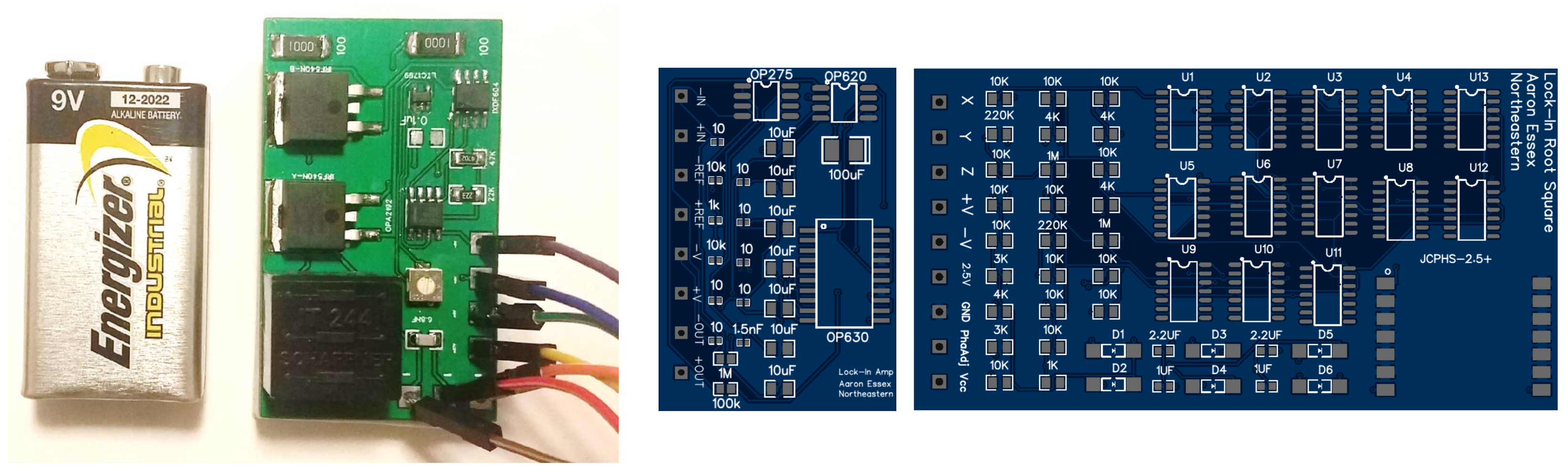


Original Low pass waveform



Improved Waveform

Product



Current prototypes of AC Driver (left) and Lock-In Amplifier (right)

References

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