Coffee Can Radar System

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## Background:

- <u>Ra</u>dio <u>De</u>tection <u>a</u>nd <u>R</u>anging uses electromagnetic waves to detect and extract target information
- Delay and Doppler can be extracted from received signal
- Delay = time for signal to reach target and return = τ
- Doppler = frequency shift of received signal vs. transmitted signal = F_D

Key Equations

Doppler:

$$\text{Transmit Monotone}: s(t) = A\cos(2\pi F_c t + \theta) \qquad F_C = 2.45\,GHz$$
$$\text{Mixer Output } m(t) = A'\cos(2\pi F_D t + \theta') \qquad F_D : 245\,Hz$$
$$Velocity = \frac{\lambda F_D}{2} = 33.5\,MPH$$

Range:
$$\text{Transmit Linear FM} = A\cos(2\pi F_c + \pi K t^2 + \theta); \; K = 5\,GHz/sec$$
$$\text{Mixer Output } m(t) = A'\cos(2\pi K\tau t + \theta') \qquad Freq.\,shift = 3kHz \; \therefore \tau = 0.6\,\mu sec$$
$$Range = \frac{c\tau}{2} = 90\,meters$$

Introduction:

Overview of Process

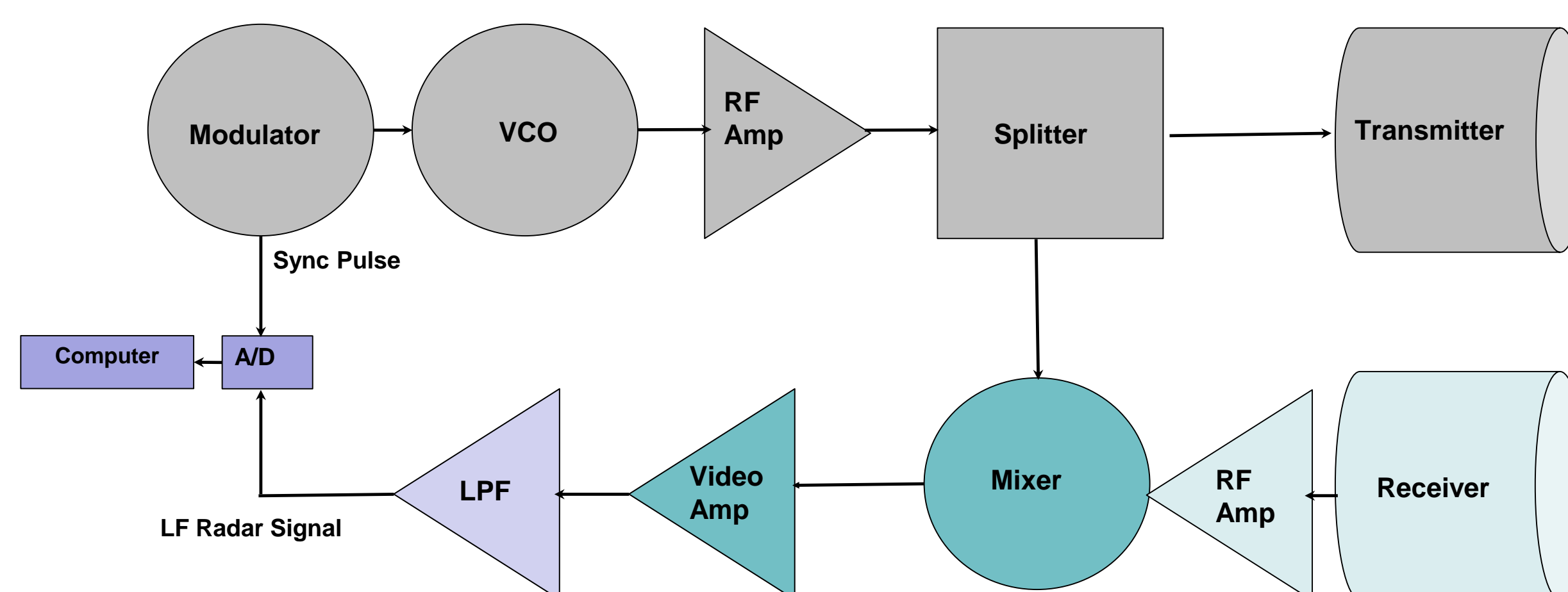**Target** → **Radar** → **Matlab** → **Doppler / Range**
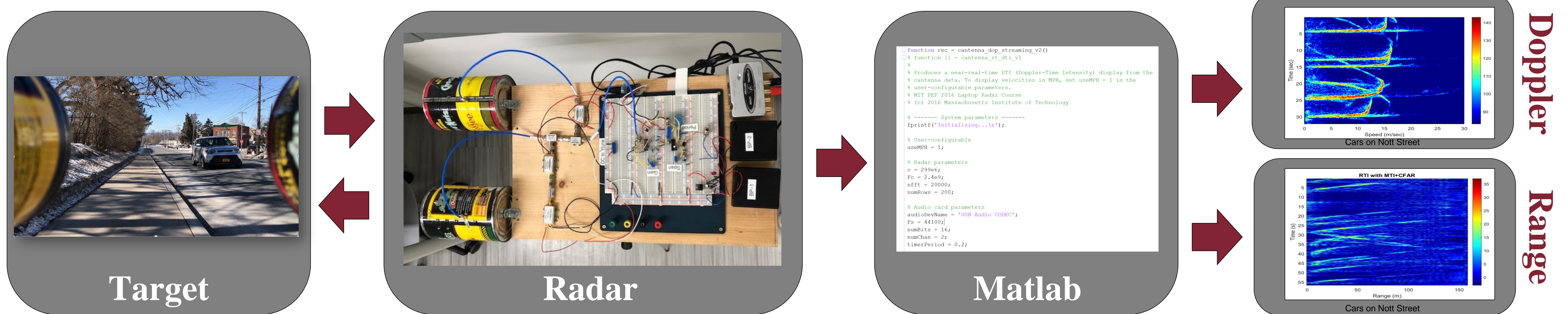
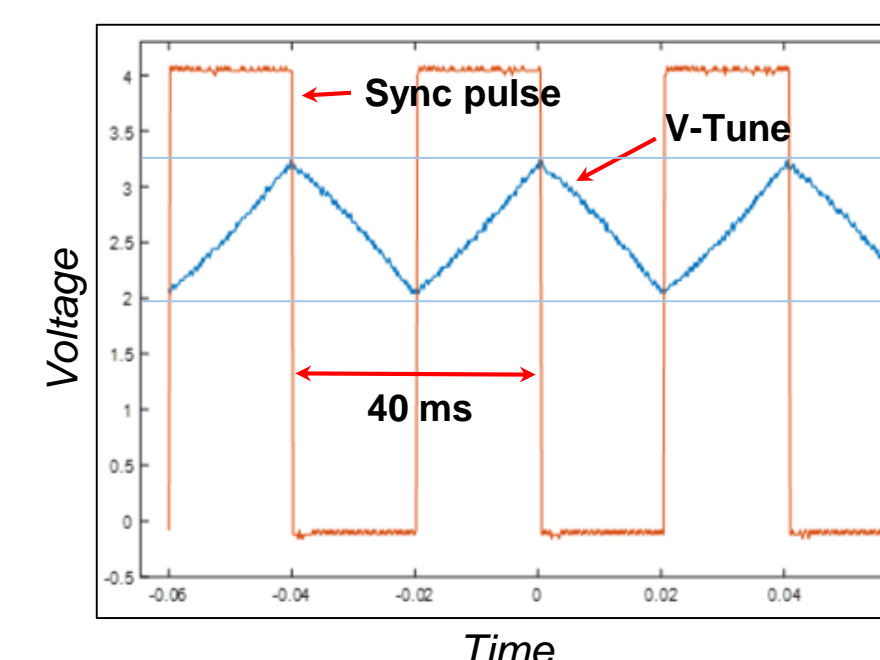## Design Goal: Determine the range and velocity of target

Design Goals:

Key Characteristics:
- *2.4 GHz* ISM Band
- Bandwidth *100 MHz*
- Transmit Power < *20 mW*
- Monopole Antennas
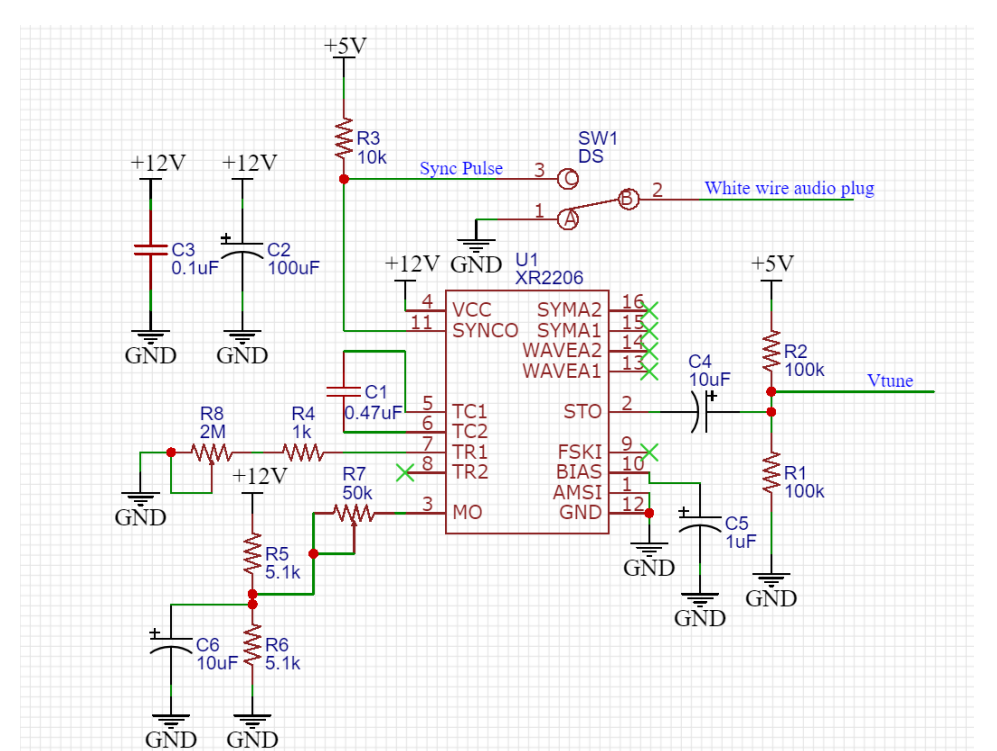- AA Battery Power Supply
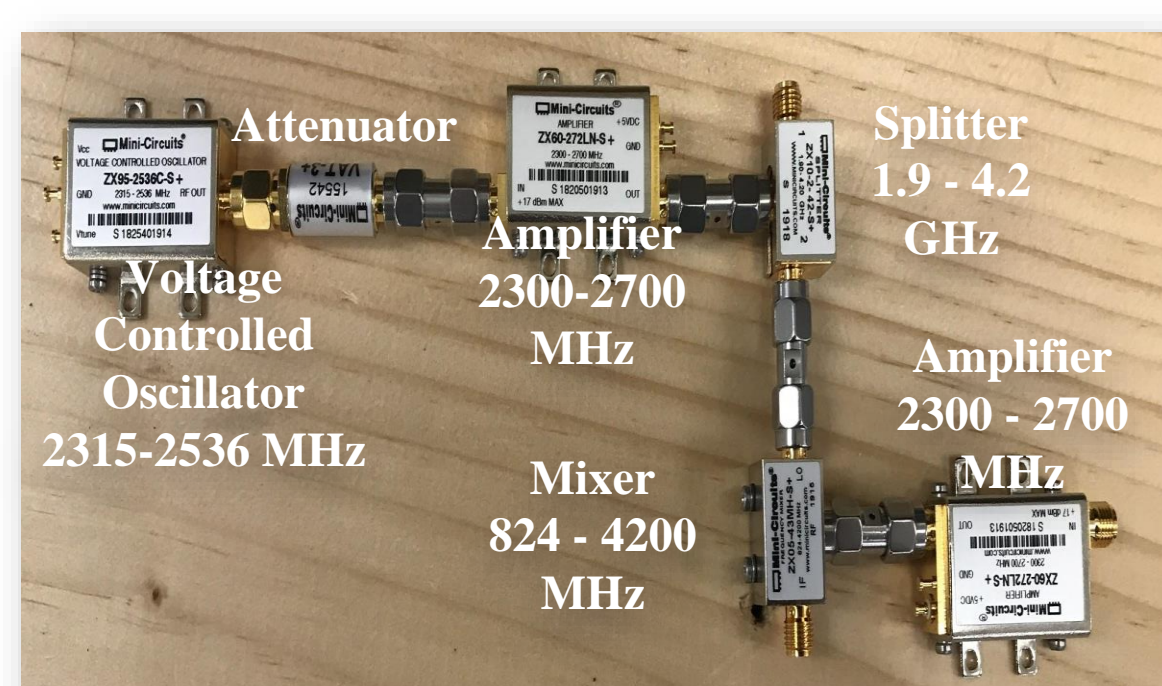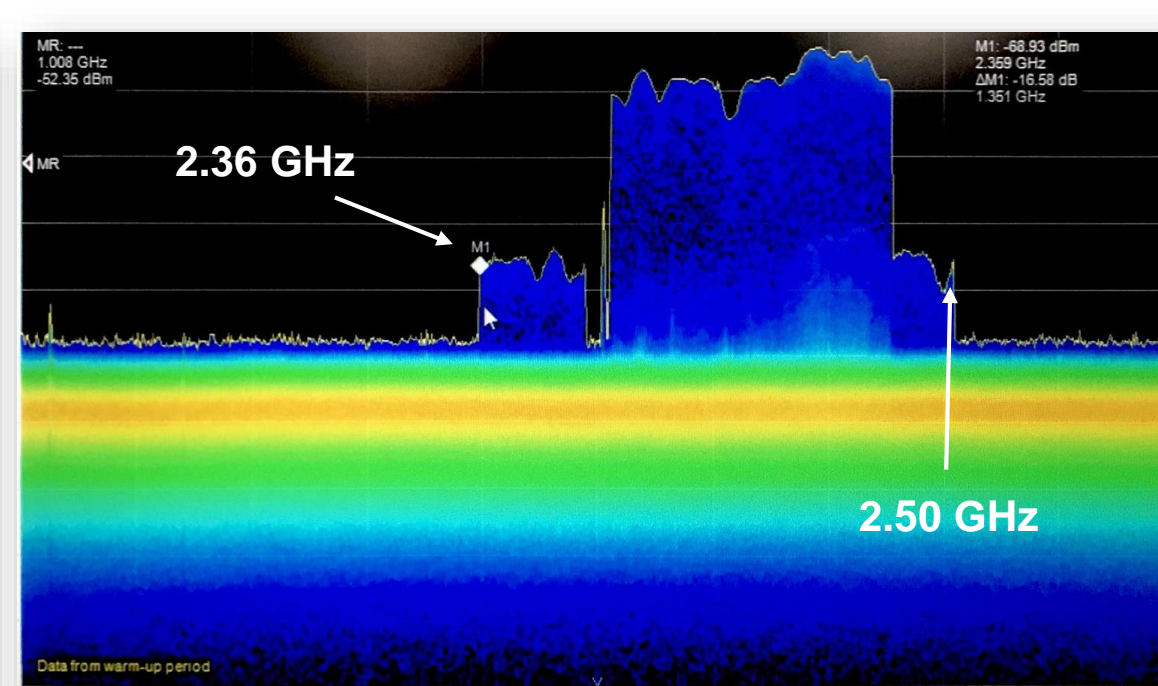- Cost Under $500

Block Diagram of System

Modulator

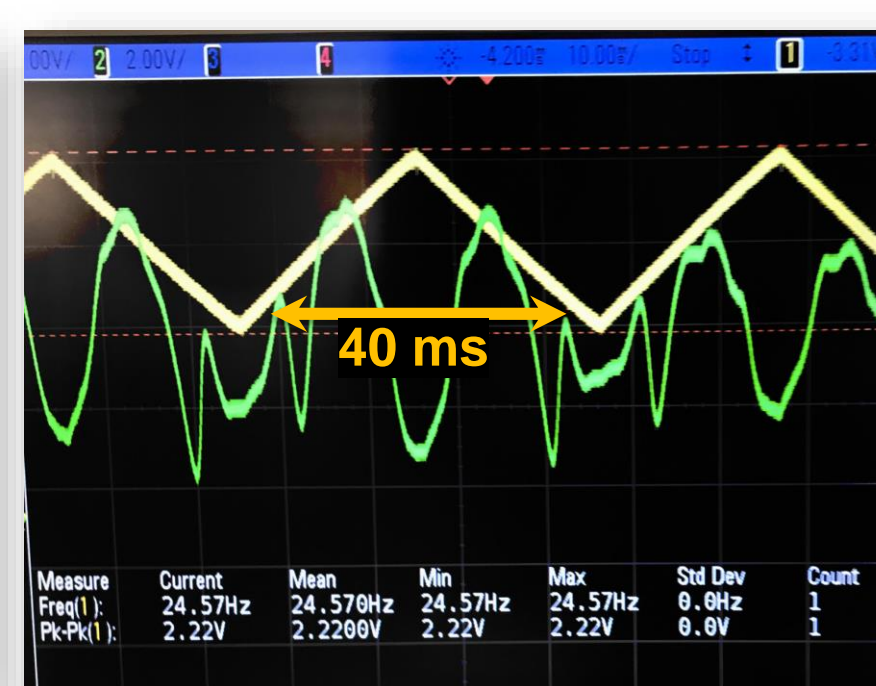### Modulator Circuit

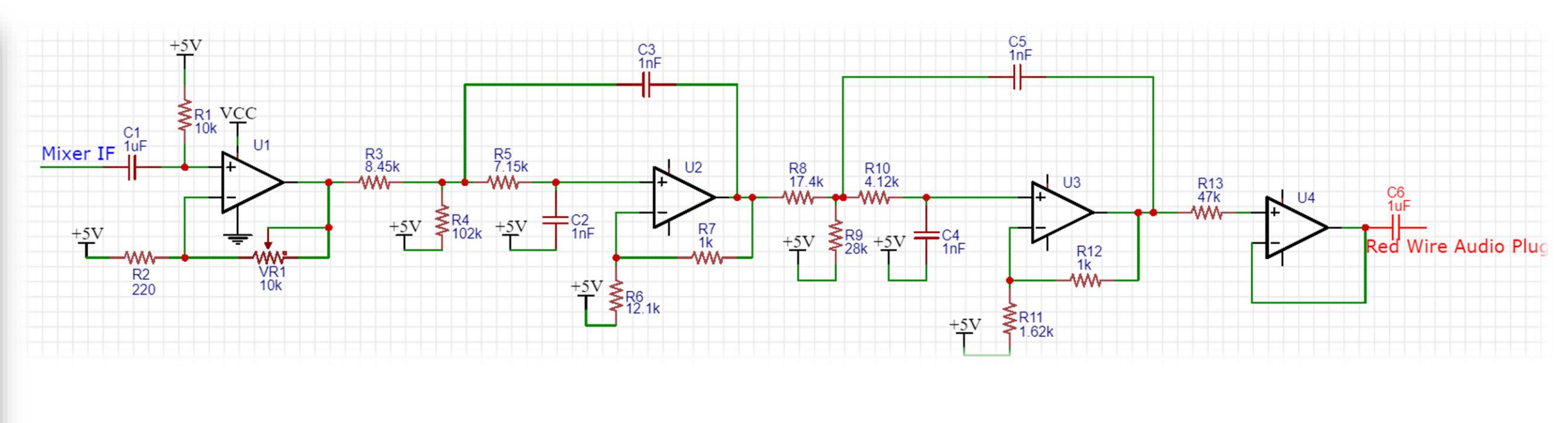### Key Components

Spectrum

Video Amp. Output

Video Amplifier

Testing and Results:

- RF power meter verified transmit power was under *20 mW*
- BW was measured to be approx. *100 MHz*
- .wav files were collected in *Audacity®* for Range and Doppler
- .wav files provided Range and Doppler information in MATLAB
- Doppler live streaming produced results within expected values
- Detected targets with a dynamic range of over *200 meters*.

Future Work:

- Implement Synthetic Aperture Radar (SAR)
- Incorporate chaotic oscillator in place of V-tune
- Conduct shakedown testing of Range streaming
- Replace Proto Board with Printed Circuit Board
- Test radar system when system is in motion and target is stationary

Conclusions:

- System demonstrates key radar principles. (LFM, CW, RF Electronics…etc.)
- Signal processing (MATLAB) of raw waveforms yields Range and Doppler information from .wav files and in real time.
- The radar system was built under budget approximate *$300*.

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