

Laboratory 5: Treble Boost Effects Box

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Transfer Function & Component Values

Transfer Function:

$$H(\omega) = 12 C_3 R_5 \cdot \frac{(j\omega)(1 + j\frac{\omega}{1/916.7C_2})}{(1 + j\frac{\omega}{1/R_5C_3})(1 + j\frac{\omega}{1/11000C_2})}$$

$$\frac{V_{out}}{V_{in}} = \frac{R_2 + R_4 + R_1(1 + j\omega C_2(R_2 + R_4)) \cdot j\omega C_3 R_5}{R_1(1 + j\omega C_2(R_2 + R_4)) \cdot j\omega C_3 R_5 + 1}$$

Component Values:

- $C_2 = 2.3\text{nF}$
- $R_3 = 10\text{k ohms}$
- $C_3 = 53\text{nF}$

Design Choice (didn't have exact capacitance values):

- Used 2nF instead
- Used 47nF instead

We want 10x gain between 300-15000 Hz

$$\omega_{c1} = \frac{1}{916.7C_2}$$

$$f_{c1} = \frac{\omega_{c1}}{2\pi}$$

$$300\text{Hz} = \frac{1}{2\pi R_5 C_3}$$

set $R_5 = 10\text{k}\Omega \rightarrow C_3 = 53\text{nF}$

$$\omega_{c2} = \frac{1}{R_5 C_3}$$

$$\omega_{c3} = \frac{1}{11000C_2}$$

$$f_{c2} = \frac{\omega_{c2}}{2\pi}$$

$$15000 = \frac{1}{2\pi(916.7C_2)}$$

$$C_2 = 2.3\text{nF}$$

$$V_1 = V_{in}$$

$$V_2 = V_{in} \left(\frac{R_3}{R_3 + \frac{1}{j\omega C_3}} \right)$$

$$V_4 = V_{in} \left(\frac{j\omega C_3 R_5}{j\omega C_3 R_5 + 1} \right) = V_{out}$$

$$V_4 = V_{out} \left(\frac{R_1}{R_1 + Z_x} \right)$$

$$V_4 = V_{out} \left(\frac{1\text{k}\Omega}{1\text{k}\Omega + \frac{11\text{k}\Omega}{11\text{k}\Omega j\omega C_2 + 1}} \right) \rightarrow V_4 = \left(\frac{R_1}{R_1 + \frac{R_2 + R_4}{1 + j\omega C_2(R_2 + R_4)}} \right)$$

$$V_4 = V_{out} \left(\frac{1\text{k}\Omega}{1 + \frac{11\text{k}\Omega j\omega C_2 + 1}{11\text{k}\Omega j\omega C_2 + 1}} \right)$$

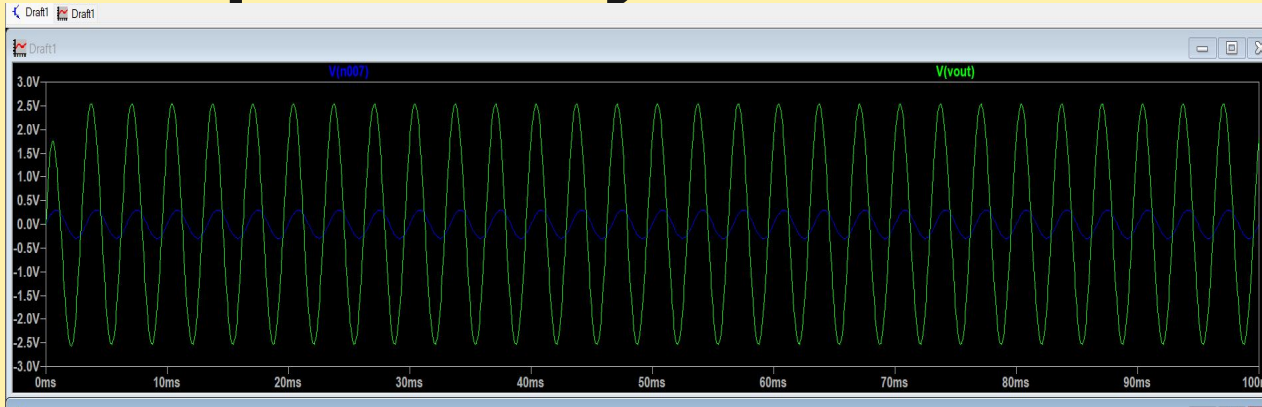
$$V_4 = V_{out} \left(\frac{(11 \times 10^3) j\omega C_2 + (10^3)}{(11 \times 10^3) j\omega C_2 + (10^3)} \right)$$

$$V_{in} \left(\frac{j\omega C_3 R_5}{j\omega C_3 R_5 + 1} \right) = V_{out} \left(\frac{(11 \times 10^3) j\omega C_2 + (10^3)}{(11 \times 10^3) j\omega C_2 + (10^3)} \right)$$

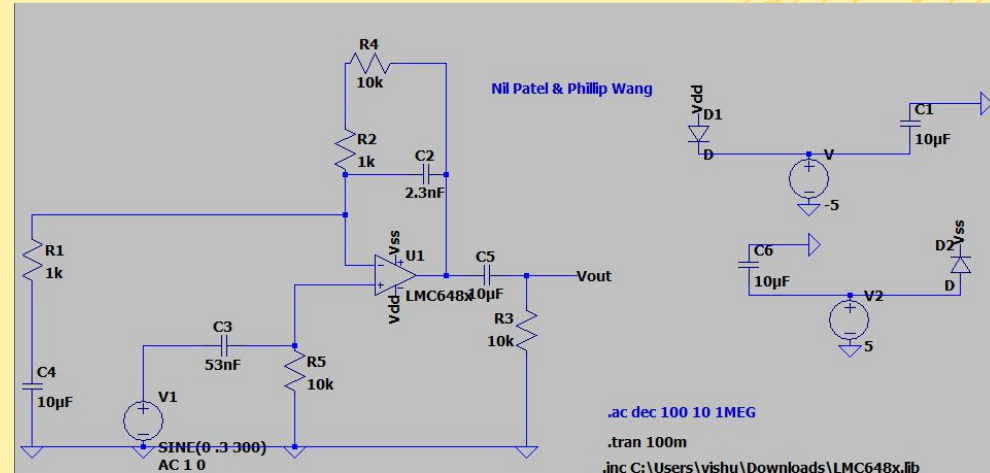
$$H(\omega) = \frac{V_{out}}{V_{in}} = \frac{(11 \times 10^3) j\omega C_2 + (10^3)}{(11 \times 10^3) j\omega C_2 + (10^3)} \cdot \frac{j\omega C_3 R_5}{j\omega C_3 R_5 + 1}$$

$$= \frac{(12 \times 10^3) (j\omega(916.7C_2) + 1)}{10^3 (j\omega(11000C_2) + 1)} \cdot \frac{j\omega C_3 R_5}{j\omega C_3 R_5 + 1}$$

LTSpice Analysis - Transient Response



Vin = Blue
V(out) = Green
Frequency = 300 Hz



LTSpice Analysis - Frequency Response

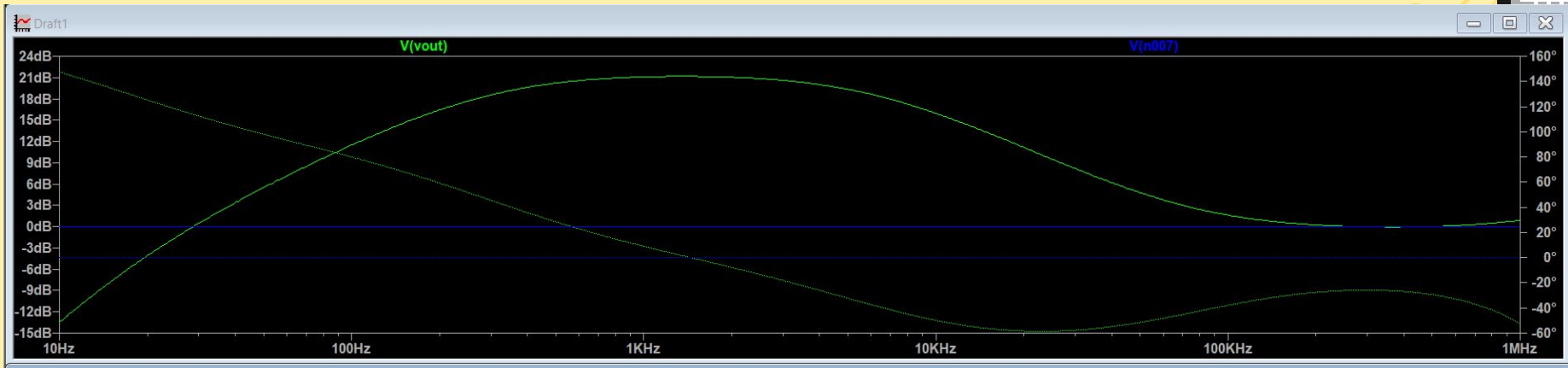
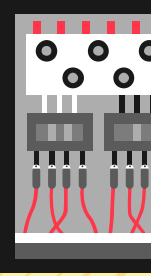
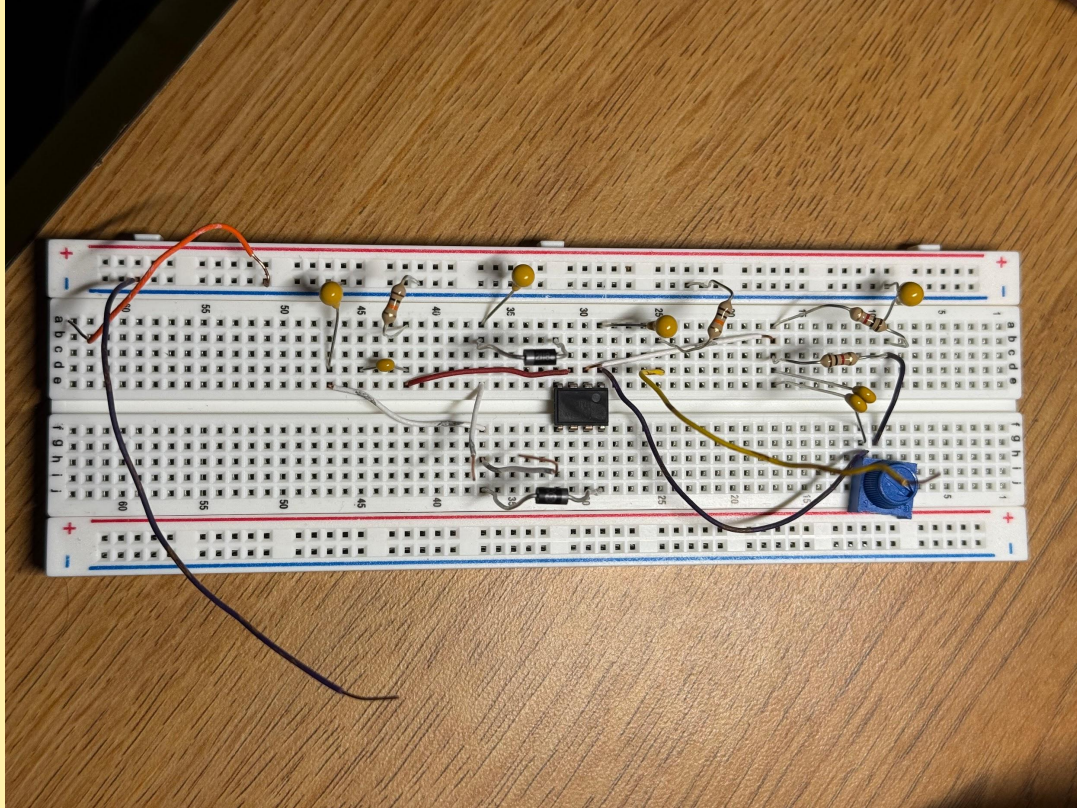
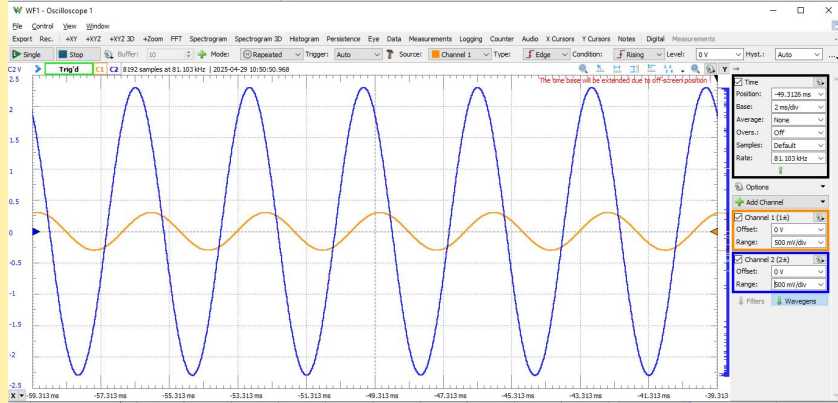


Photo of Breadboard

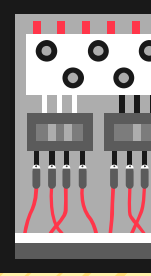
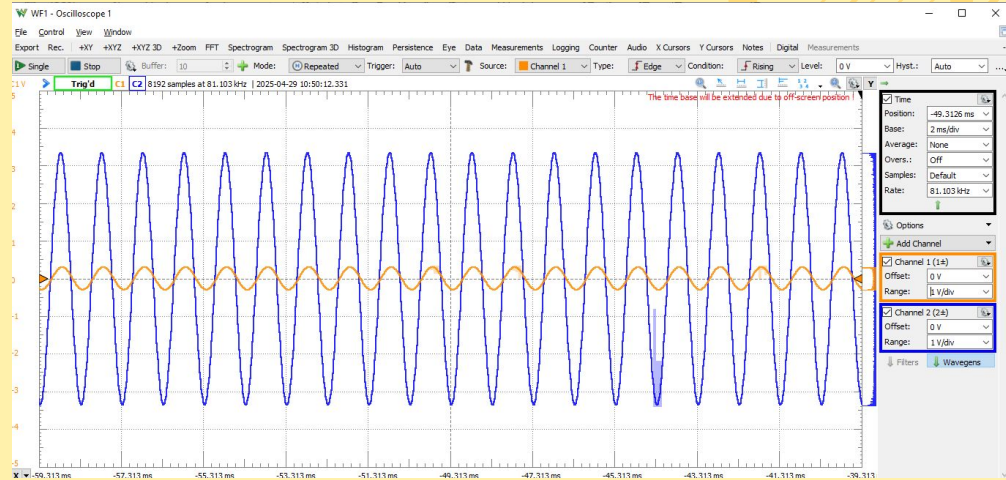


Measured time domain plots - Oscilloscope

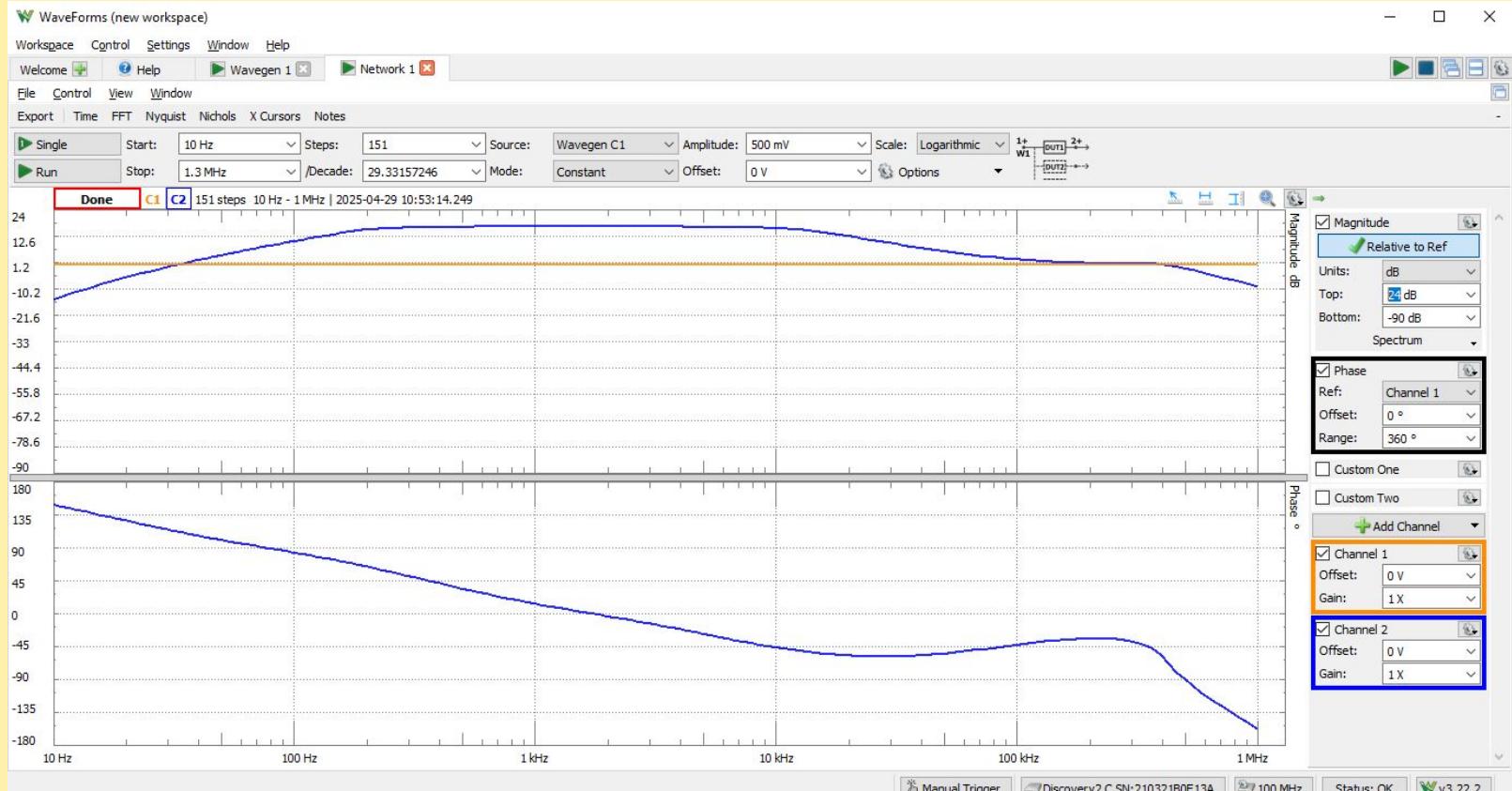


299 Hz

1kHz



Measured Frequency Domain Plots



Designed VS. Achieved

Component Selection:

- Used 2nF instead of 2.3nF
- Used 47nF instead of 53nF
- (Didn't have exact values that we needed)

	Symbolic Expression	Simulation (<i>low, high</i>)	Measurement
Cutoff Frequencies	$(1 / 2\pi R_5 C_3) = 300 \text{ Hz}$ $(1 / 2\pi 916.7 C_2) = 15.1 \text{ kHz}$	300 Hz, 15 kHz	200 Hz, 13 KHz
Gain (<i>inside boosted range</i>)	21.5dB	21dB	18.5dB

