Experiment 28

Monday, April 17, 2023 2:54 PM

Lillian Tucker

Pre-Lab:

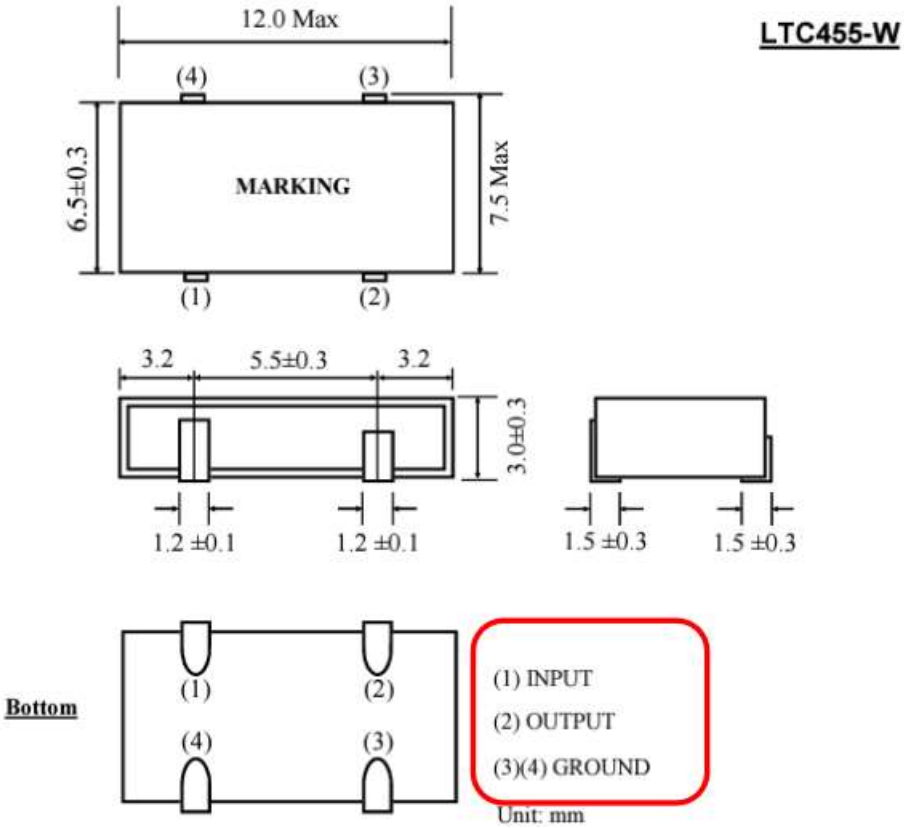


Figure 1: Schematic of ceramic filter

Ceramic Filter Specifications:
- Digikey Part No. LTC455FW
- Center Frequency = 455 ± 1.5 kHz
- Bandwidth = 8 kHz
- Max passband ripple = 2 dB
- Input / Output Impedance = 1.5 kΩ
- 4 lead surface mount device (SMD)

Harmonic equation for the circuit design in Figure 2:

$$y = V_o + 4V_p/\pi[\sin \omega t + (\sin 3\omega t)/3 + (\sin 5\omega t)/5 + (\sin 7\omega t)/7 + \cdots]$$

Procedure:

Step 1:

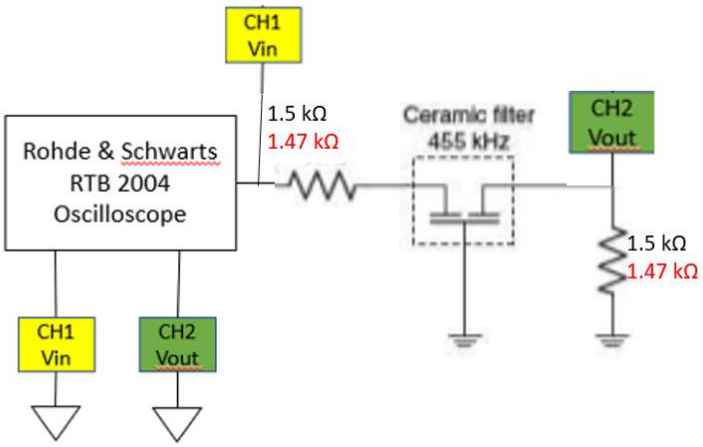


Figure 2: Circuit schematic of ceramic bandpass filter

Step 2-5:

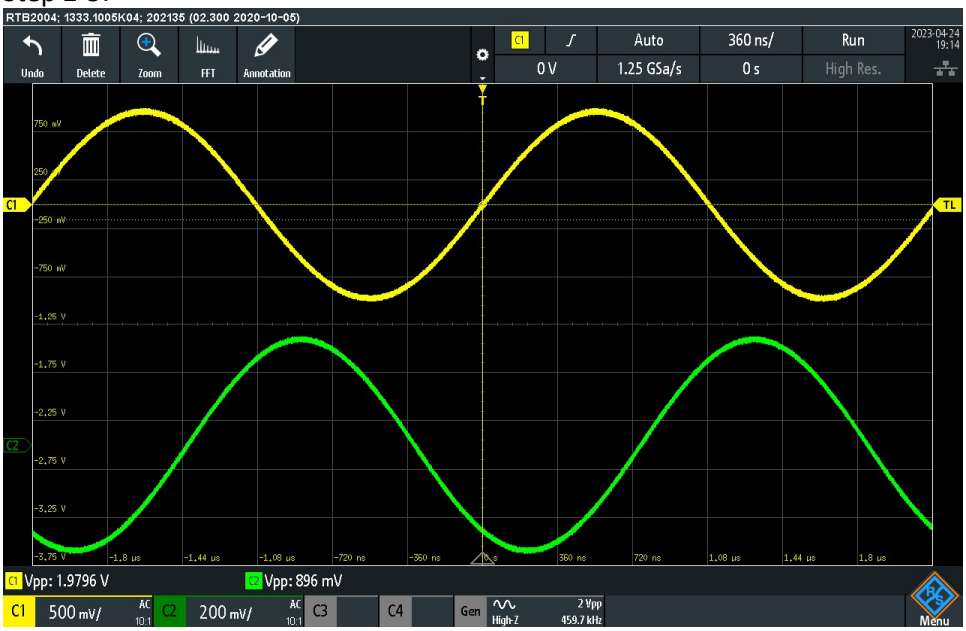


Figure 3: Oscilloscope image of circuit from Figure 2 at the center frequency of 459.7 kHz where CH1(yellow) = Vin = sine wave and CH2(green) = Vo

Table 1: Data for the circuit in Figure 2 and input and output corresponding to Figure 3	Frequency [kHz]	Vin [Vpp]	Vo [mVpp]	Attenuation [V/V]
Real	459.7	2.0	895	0.448
Predicted	455	2	849	0.425

Step 6-8:

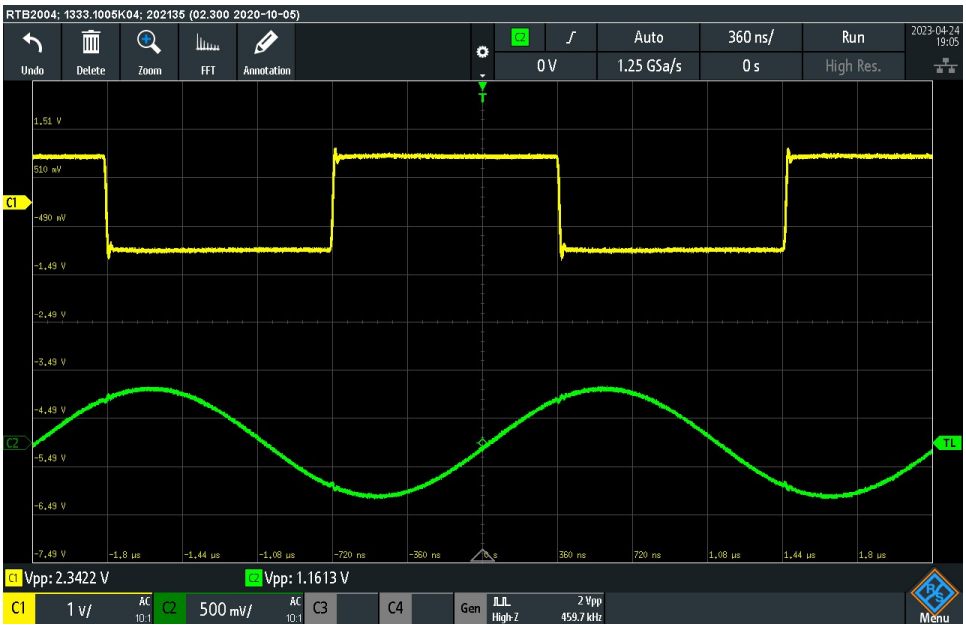
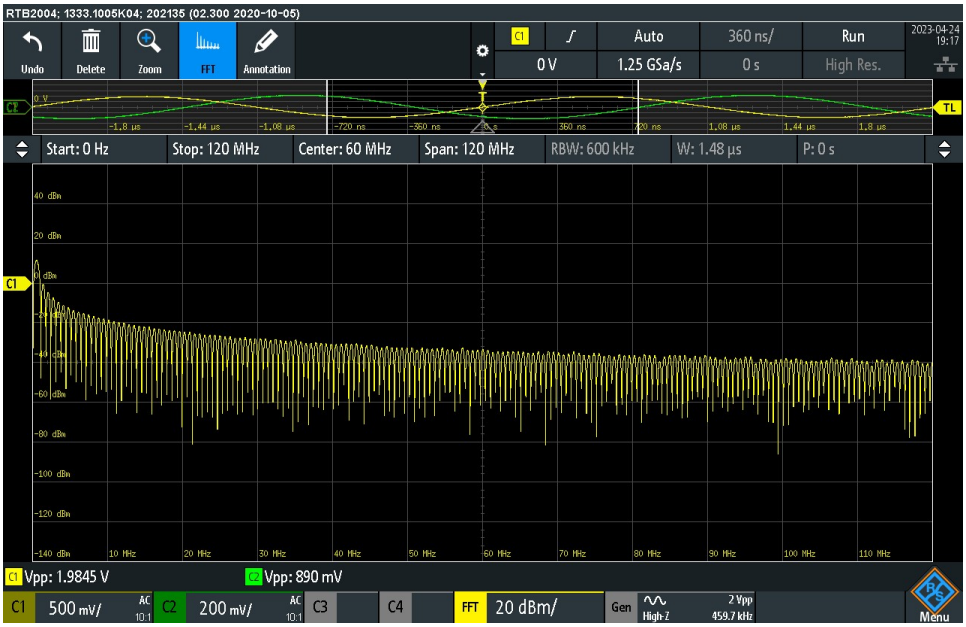
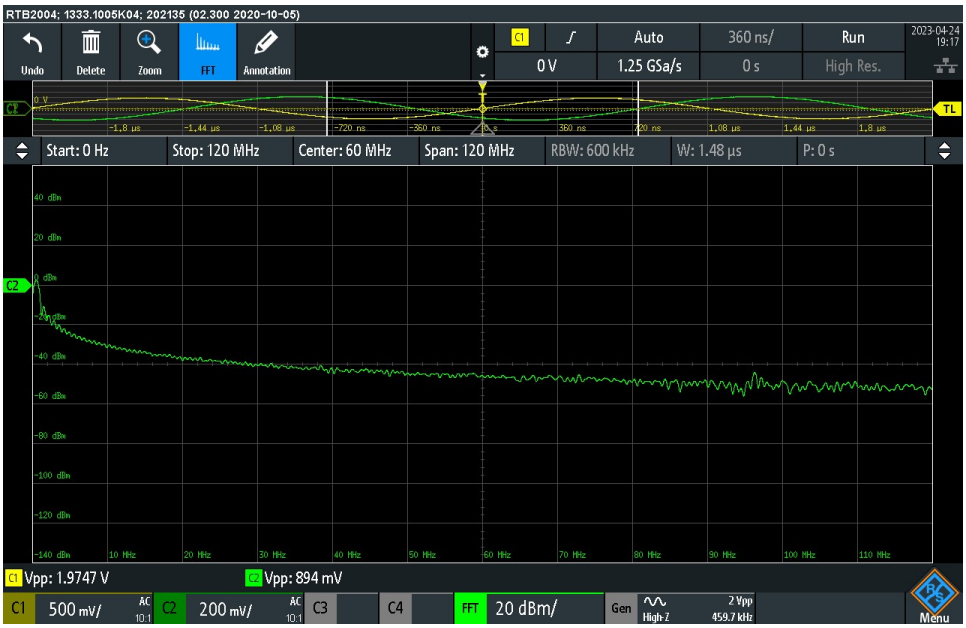


Figure 4: Oscilloscope image of circuit from Figure 2 at the center frequency of 459.7 kHz where CH1(yellow) = Vin = DC square wave and CH2(green) = Vo

Table 2: Data for the circuit in Figure 2 and input and output corresponding to Figure 4	Frequency [kHz]	Vin [Vpp]	Vo [Vpp]	Attenuation [V/V]
Real	459.7	2.2	1.17	0.532
Predicted	455	2	0.849	0.425

Measured average DC output voltage via DMM:
4.2 mV





Step 9-10:

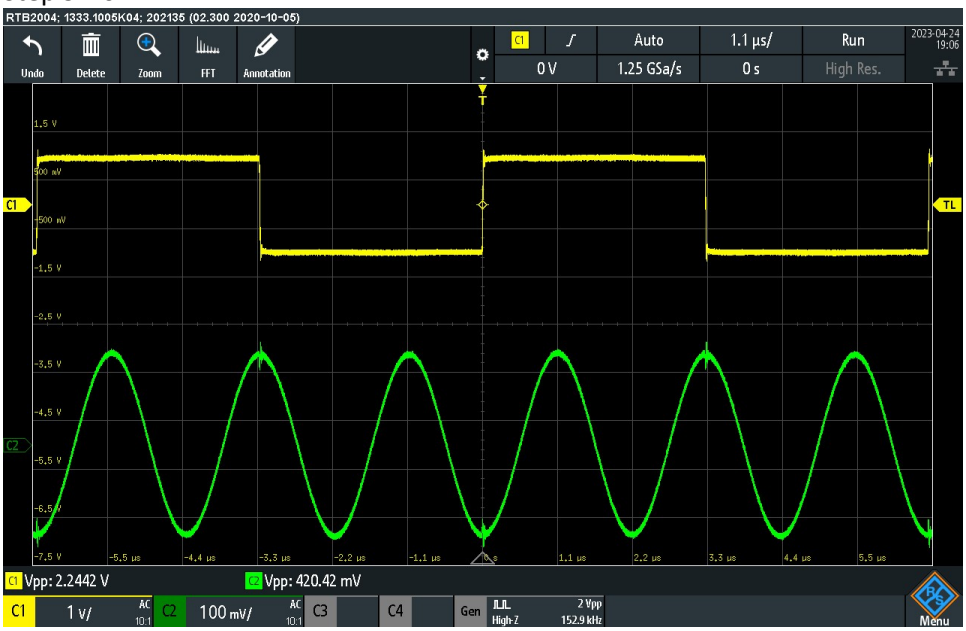


Figure 7: Oscilloscope image of circuit from Figure 2 at 1/3 the center frequency of 152.9 kHz where CH1(yellow) = Vin = DC square wave and CH2(green) = Vo

Table 3: Data for the circuit in Figure 2 and input and output corresponding to Figure 7	Frequency [kHz]	Vin [Vpp]	Vo [mVpp]	Attenuation [V/V]
Real	152.9	2.2	420	0.191
Predicted	151.7	2	509	0.255

Step 11:

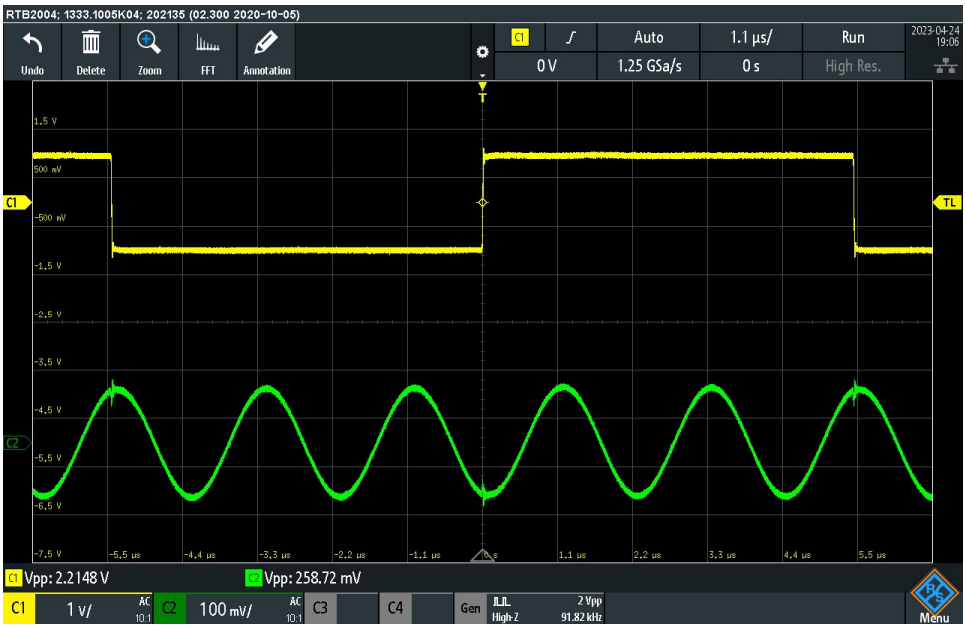


Figure 8: Oscilloscope image of circuit from Figure 2 at 1/5 the center frequency of 98.82 kHz where CH1(yellow) = Vin = DC square wave and CH2(green) = Vo

Table 4: Data for the circuit in Figure 2 and input and output corresponding to Figure 8	Frequency [kHz]	Vin [Vpp]	Vo [mVpp]	Attenuation [V/V]
Real	91.82	2.2	259	0.118
Predicted	91	2	364	0.182

Step 12:

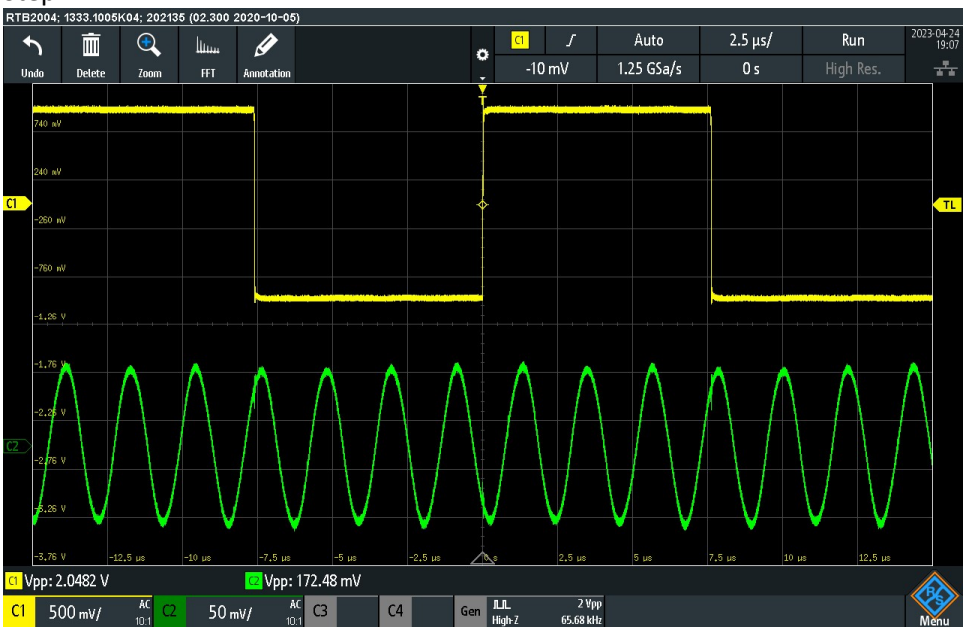


Figure 9: Oscilloscope image of circuit from Figure 2 at 1/7 the center frequency of 65.68 kHz where CH1(yellow) = Vin = DC square wave and CH2(green) = Vo

Table 5: Data for the circuit in Figure 2 and input and output corresponding to Figure 9	Frequency [kHz]	Vin [Vpp]	Vo [mVpp]	Attenuation [V/V]
Real	65.68	2.0	172	0.086
Predicted	65	2	283	0.142

Questions:

1. What would you expect to measure at the filter output if the input frequency were set to an even fraction (2, 4, 6, etc.) of 455 kHz?
    - Even center frequencies experience no harmonics. This is because the harmonic equation for this filter is odd therefore harmonics only occur at the odd fractions of the peak center frequency.

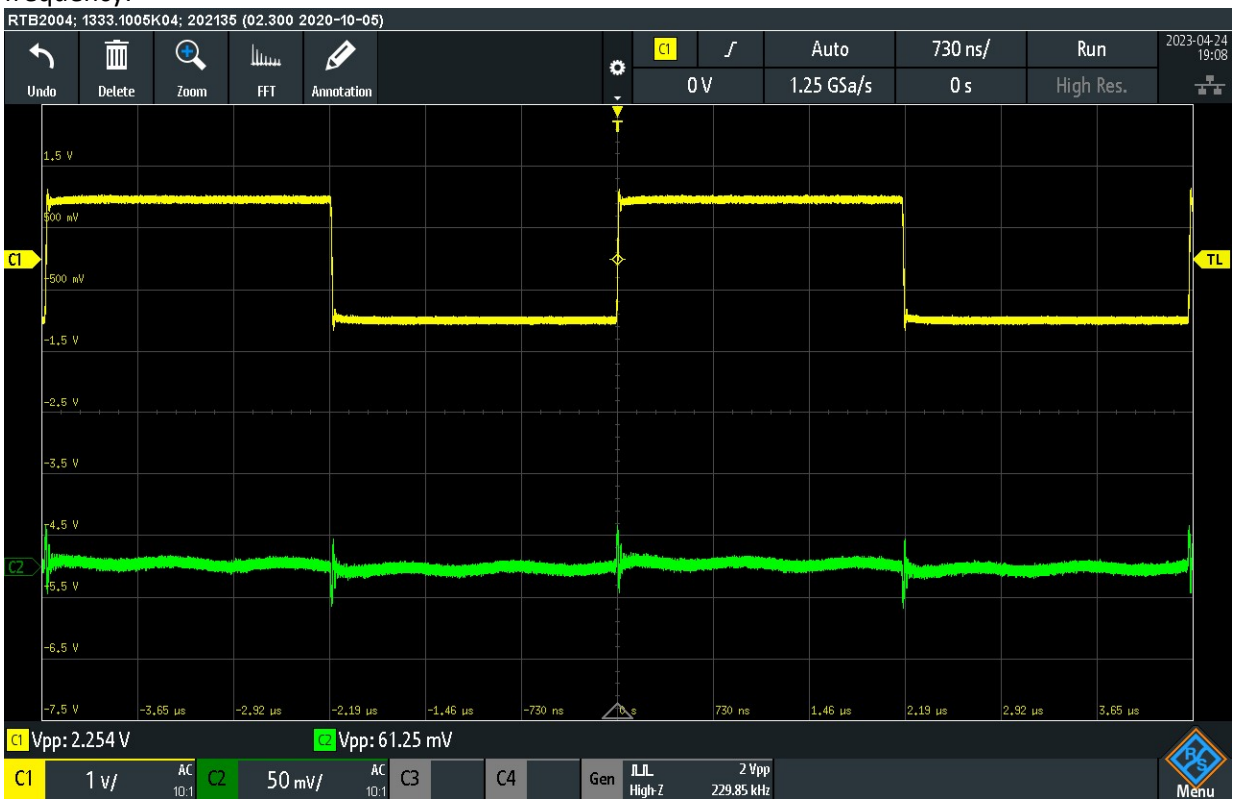


Figure 10: Oscilloscope image of circuit from Figure 2 at 1/2 the center frequency of 229.85 kHz where CH1(yellow) = Vin = DC square wave 2 Vpp and CH2(green) = Vo

2. Explain any discrepancies between your calculated and measured values of voltages.
    - The calculated and measure value of the output voltages had approximately 5% error. This discrepancy could be caused by frequency noise from lights as well as frequency noise from external devices from the electronics bench

3. What is the expected harmonic content of a triangular wave? If you wish, switch the function generator output to a triangular wave and experiment with finding odd and even harmonics

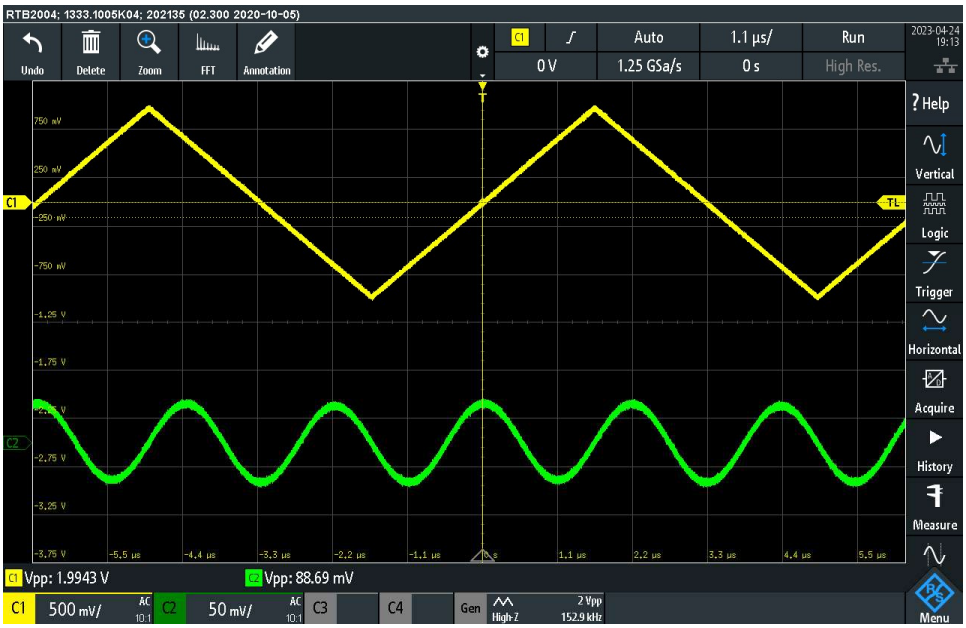


Figure 11: Oscilloscope image of circuit from Figure 2 at 1/3 the center frequency of 152.9 kHz where CH1(yellow) = Vin = triangular wave 2 Vpp and CH2(green) = Vo

Figure 12: Oscilloscope image of circuit from Figure 2 at 1/2 the center frequency of 229.85 kHz where CH1(yellow) = Vin = triangular wave 2 Vpp and CH2(green) = Vo

The triangular wave behave similarly to the sine and square waves with similar results in output as well. The center frequency occurs at the same frequency as well as harmonics do not occur at even fractions of the center frequency