EE 308: Advanced Analog Techniques
Discrete Analog Function Generator

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1 Analog Function Generator

1.1 Performance Summary

The following table summarizes the design specification targets and the achieved performance in the final design. Example scope plots for each waveform in the six different frequency bands are highlighted in Section 1.3. For the full design report, including detailed breakdown of each function generator block, please see the full report @ https://www.linkedin.com/in/austinrosh/details/projects/.

Output Amplifier		
Parameter	***Design Specification***	***Achieved***
Output Resistance	50 Ω, +/- 5 Ω	52.39 Ω
Input Resistance	> 1 kΩ	10.6 kΩ
Unloaded Voltage Gain	Adjustable from << 1 to 10	✅
Output-referred DC Offset	<100 mV	✅
Small-Signal Bandwidth	DC to >20 MHz (output terminated)	26 MHz
Output Overshoot 100 mV Input Step	< |10|%	-4.47%
Output Slew Rate	> 100 V/us	126.69 V/us
Sinusoidal Outout Distortion	< 3% up to 2 MHz and up to 5Vpp across 50 Ohm load. Consider up to 5th harmonic.	0.79%
50 ohm Drive Capability	+/- 3.2V	+/-3.65
Ability to withstand output shorts	-	✅
Supply Voltages	+/- 12V	+/- 12V
Schmitt Trigger		
Parameter	***Design Specification***	***Achieved***
Input Resistance	> 1 kΩ	4.05 kΩ
Trigger Thresholds	+/- 0.5V nominal, with each independently adjustable by +/- 0.15V	✅
Square Wave Output	+/- 1.0V peak-to-peak centered around 0.0V w/ amplifier loading	✅
Square Wave Output Rise/Fall Time	< 20 ns, output node w/ amplifier loading, rising edge	6.4 ns @ f = 100 kHz
		5.4 ns @ f = 2.0 MHz
	< 20 ns, output node w/ amplifier loading, falling edge	7.0 ns @ f = 100 kHz
		5.2 ns @ f = 2.0 MHz
	< 10 ns, switch core node, rising edge	9.2 ns @ f = 100 kHz
		7.6 ns @ f = 2.0 MHz
	< 10 ns, switch core node, falling edge	10.0 ns @ f = 100 kHz
		8.8 ns @ f = 2.0 MHz
Square Wave Output Overshoot	< 2%, rising edge	1.22%
	< 2%, falling edge	0.62%
Trigger Latency	< 10 ns, rising edge	4 ns
	< 10 ns, falling edge	3.8 ns
Triangle Wave Generator		
Parameter	***Design Specification***	***Achieved***
Frequency Coverage	2 Hz to 2 MHz, in six bands	1.7 Hz to 2.3 MHz (in spec) (4.4 MHz max operation)
Frequency Range Per Band	> 11:1	19.4:1 (average)
Duty Cycle Error	When adjusted to zero @ 10 kHz, does not exeed 2% at any other frequency	✅
Triangle Wave Quality	Ratio of max amplitude to min amplitude does not exceed 1.1 over entire frequency range	✅
Feedthrough	< 2 % shift at the triangle wave peaks over entire frequency range	✅
Sine Shaper		
Parameter	***Design Specification***	***Achieved***
THD	< 3 % across all frequency bands	Peak: 2.5% @ 2 MHz

Figure 1: Design specifications and achieved performance.

1.2 Schematics & Layout

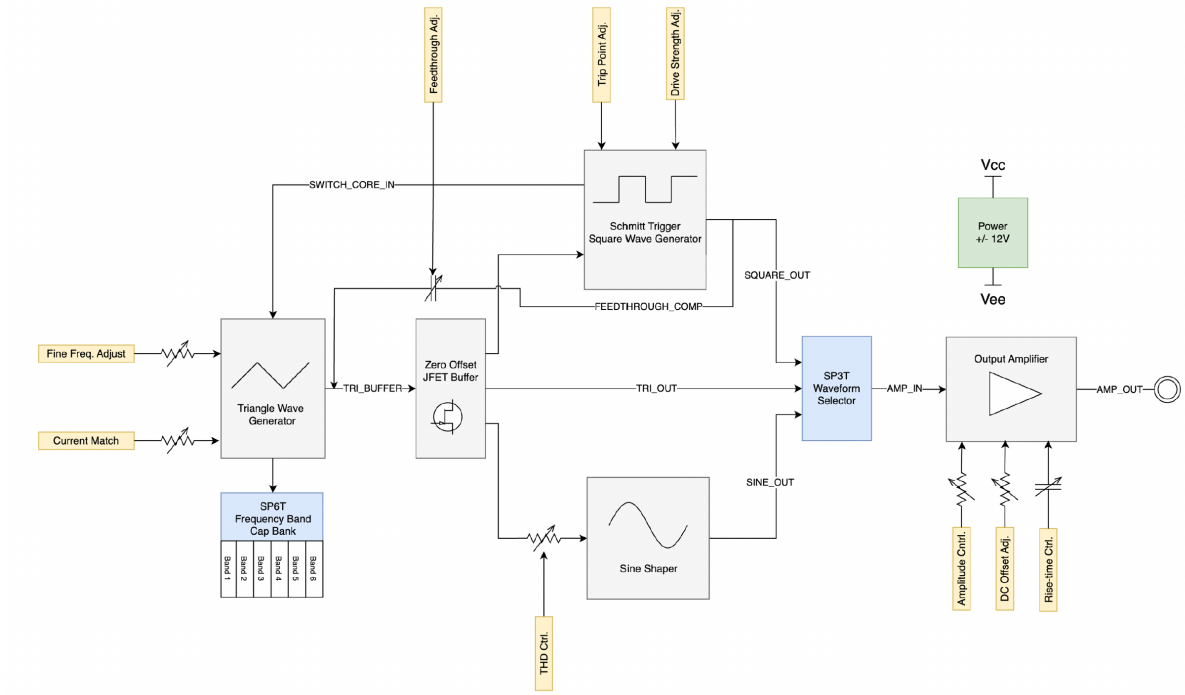


Figure 2: Block diagram.

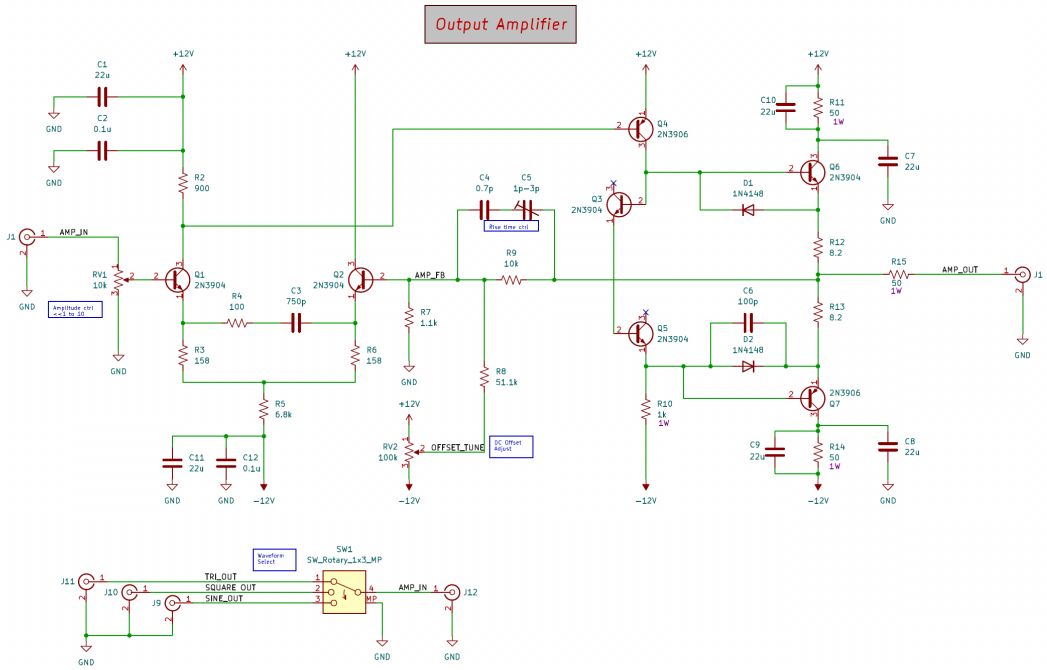


Figure 3: Amplifier

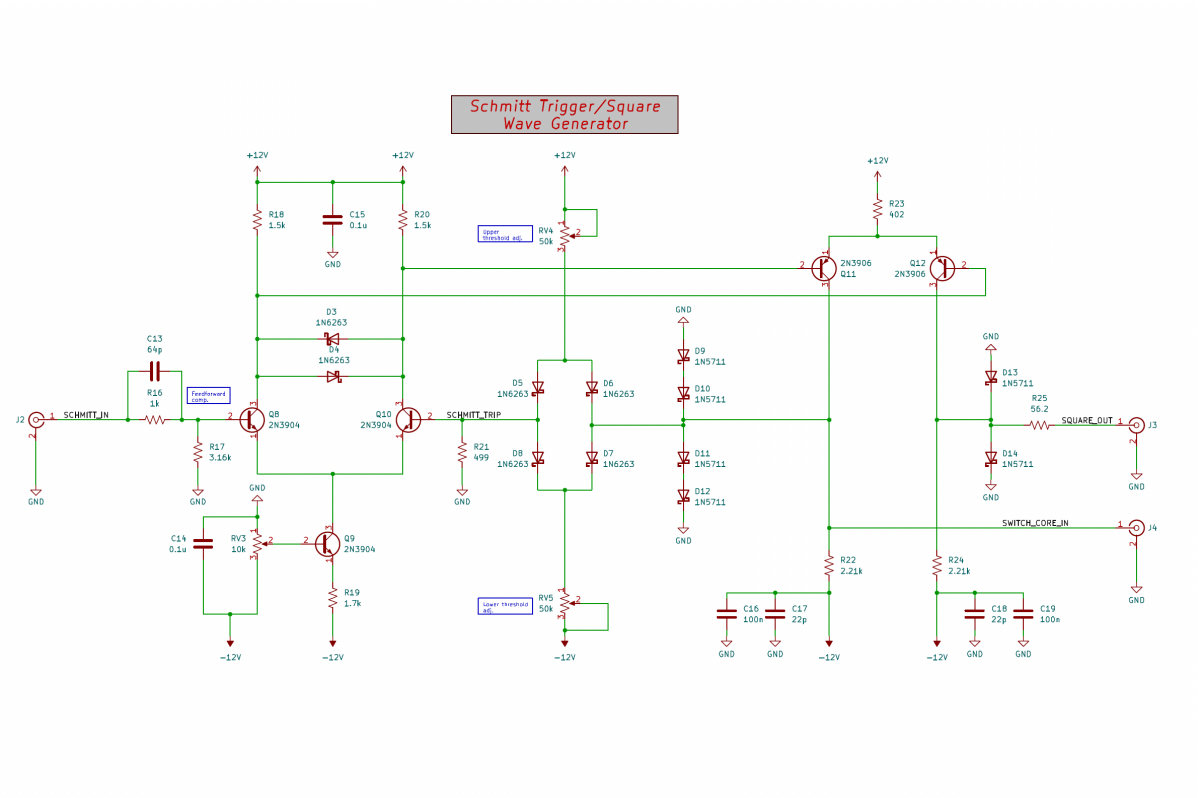


Figure 4: Schmitt Trigger

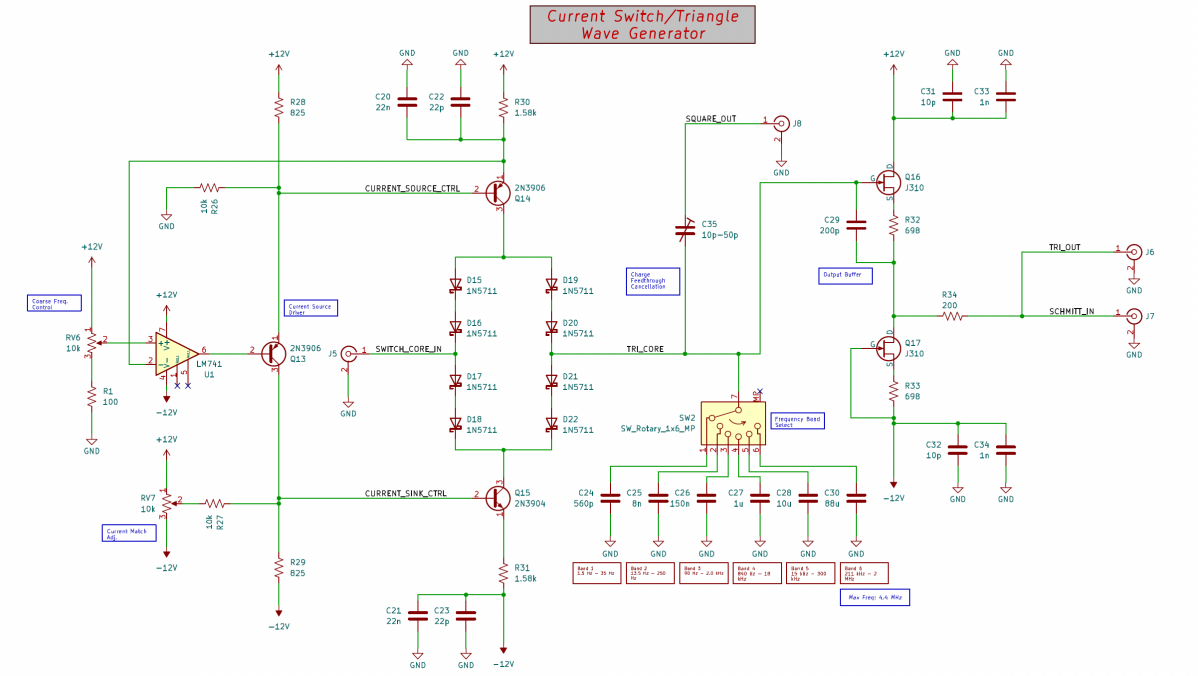


Figure 5: Triangle Wave Generator

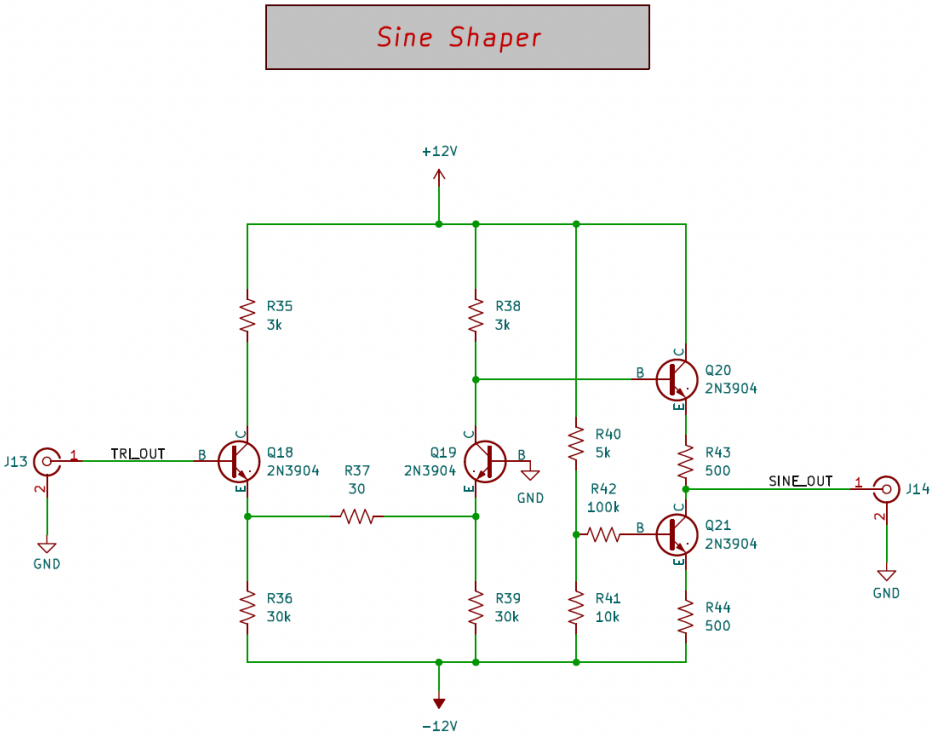


Figure 6: Sine Wave Generator

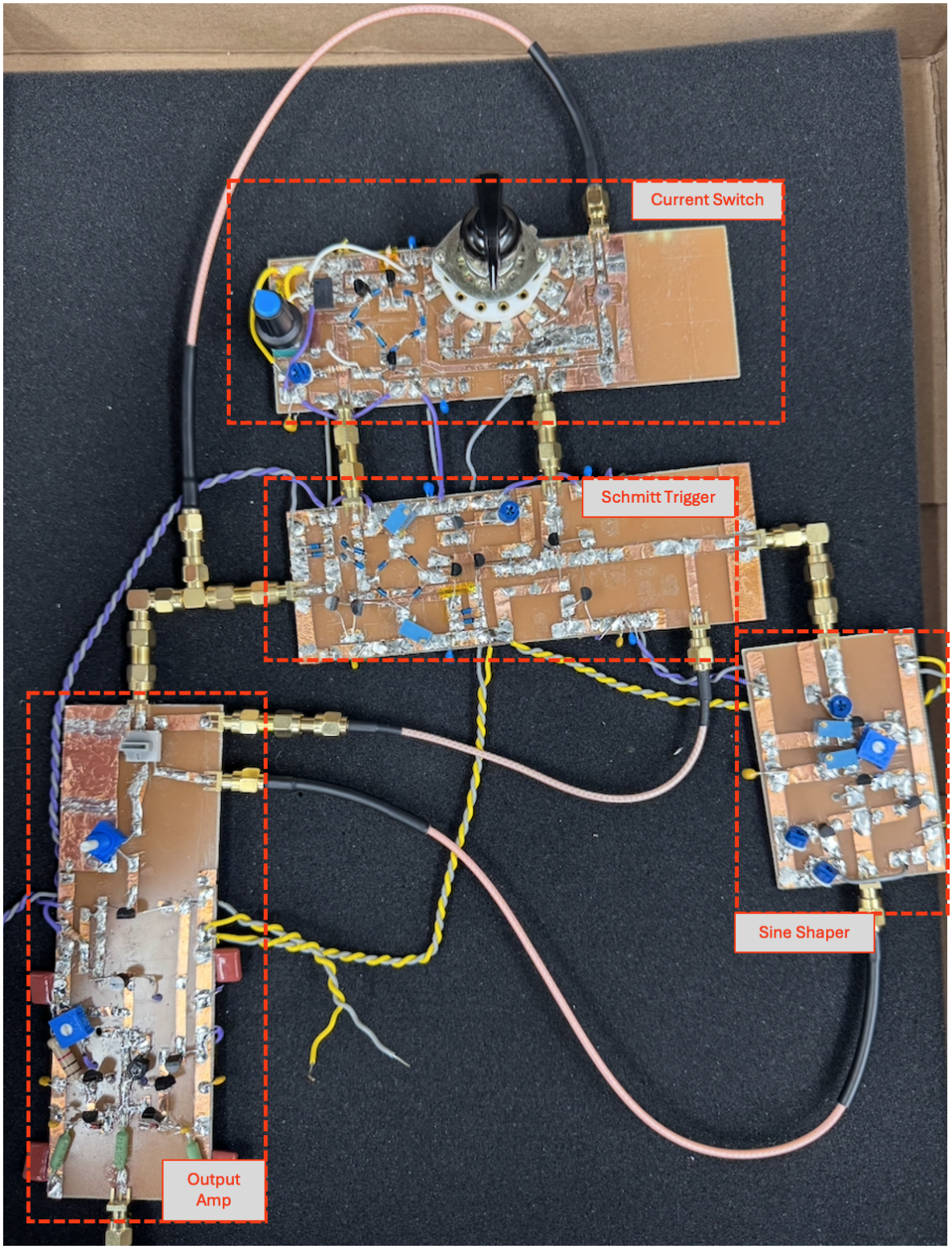


Figure 7: Final Design Layout

1.3 Example Scope Captures

The following contains scope captures of the final design waveform in each frequency band from the output amplifier. All waveforms are configured such that they have the maximum specified design peak-to-peak amplitude of:

- Square wave: 5.0 Vpp
- Triangle Wave: 4.0 Vpp
- Sine Wave: 4.0 Vpp

1.3.1 Square Wave

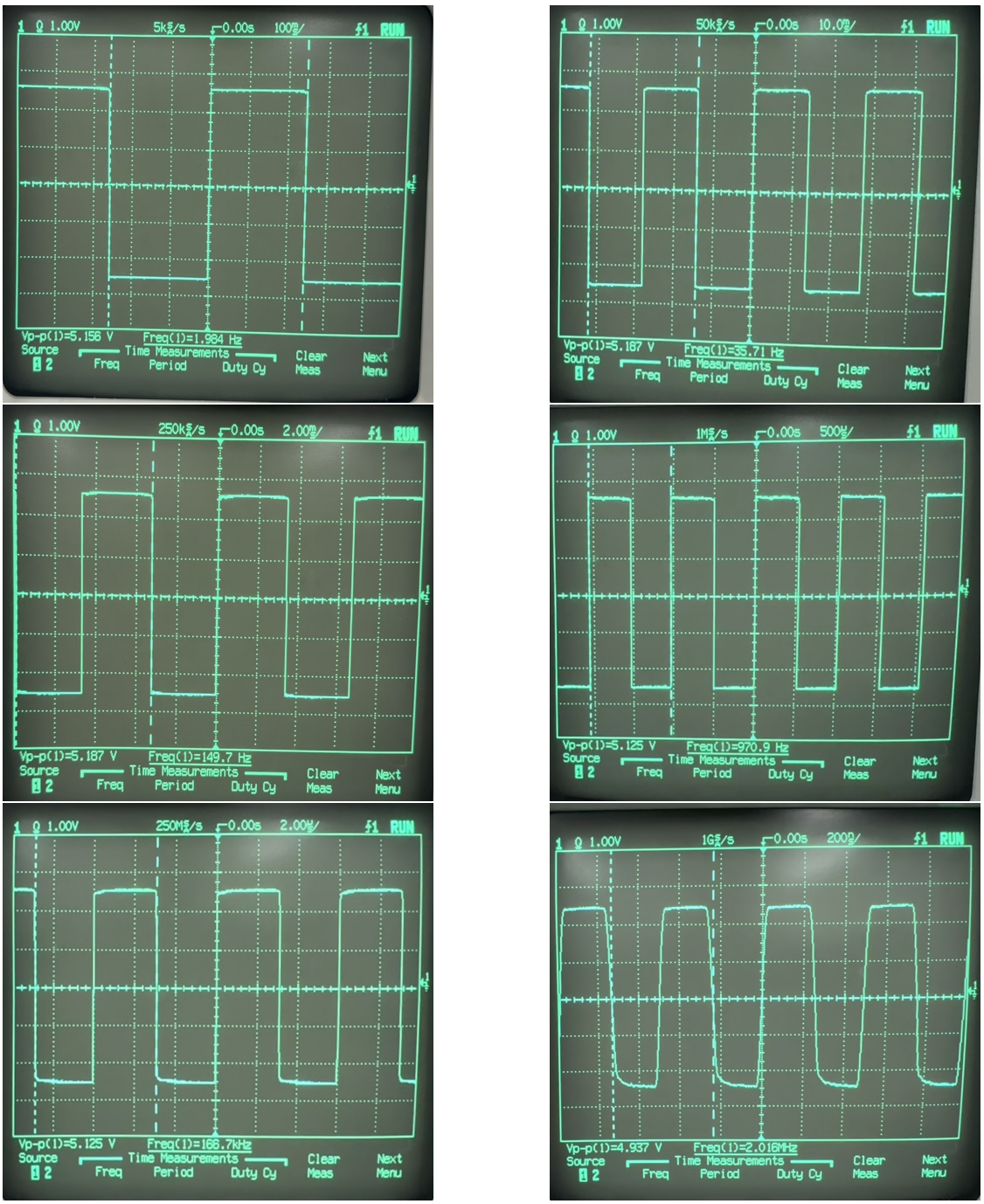


Figure 8: Square wave scope captures.

1.3.2 Triangle Wave

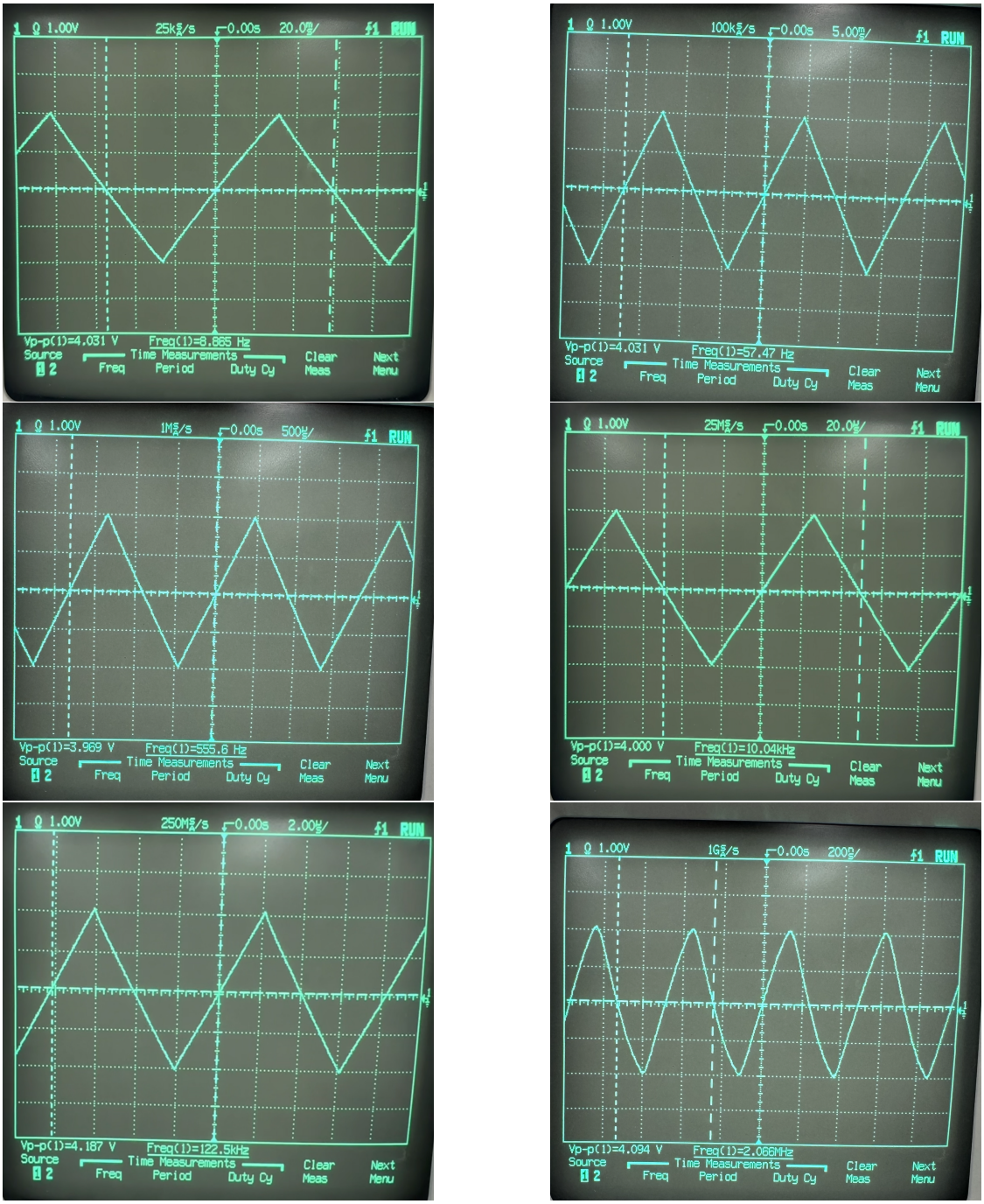


Figure 9: Triangle wave scope captures.

1.3.3 Sine Wave

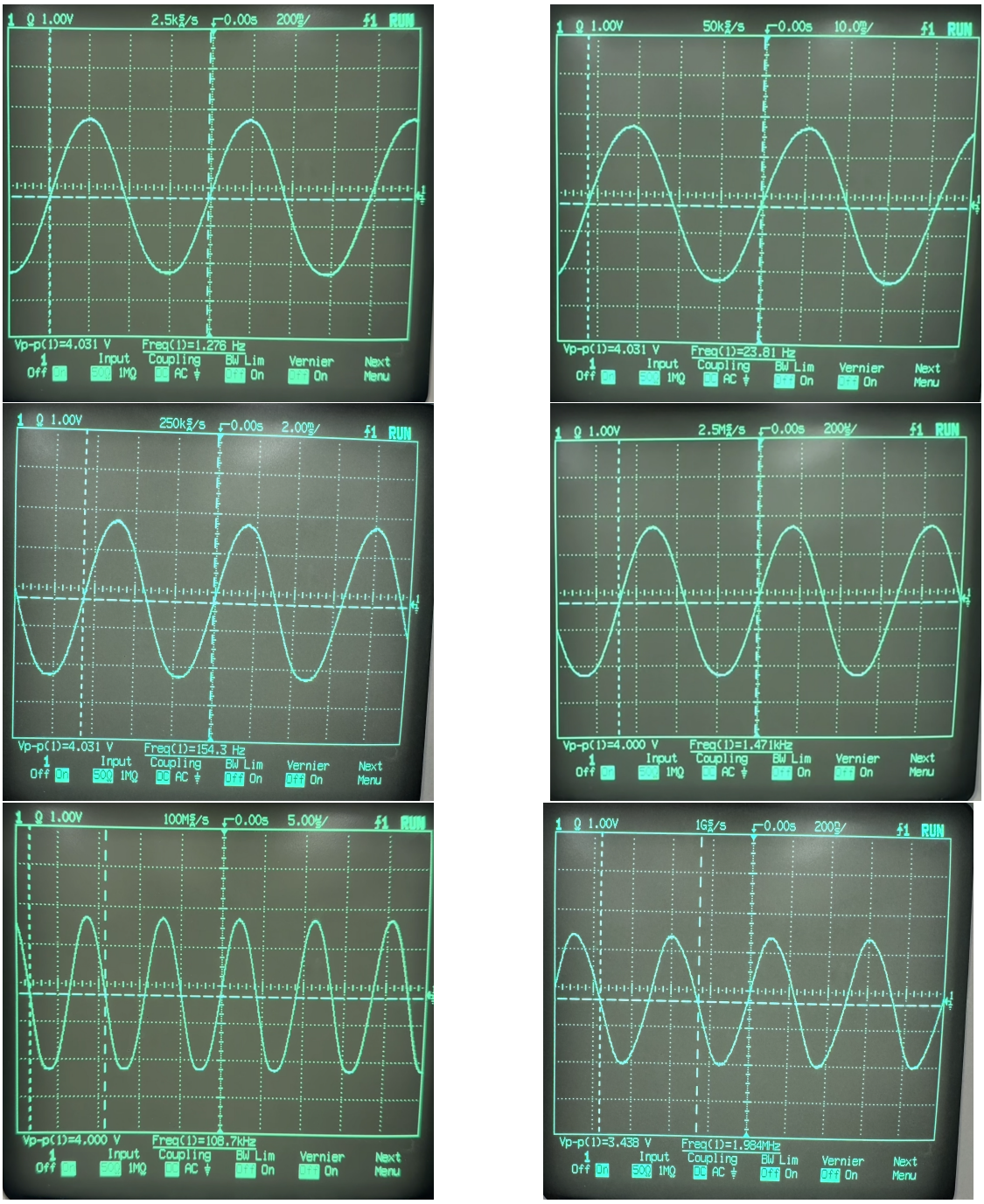


Figure 10: Sine wave scope captures.