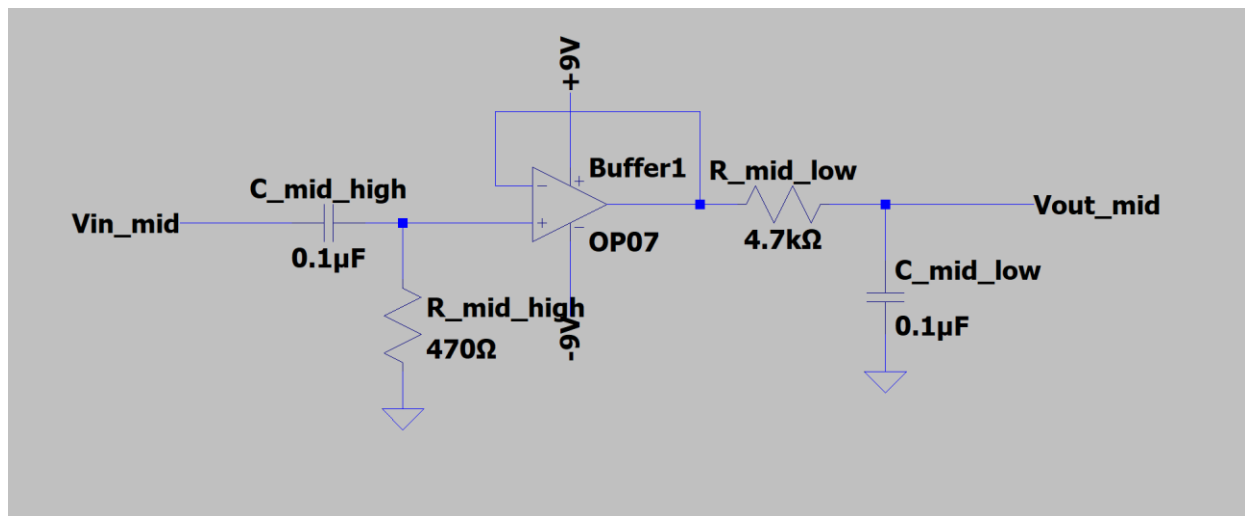
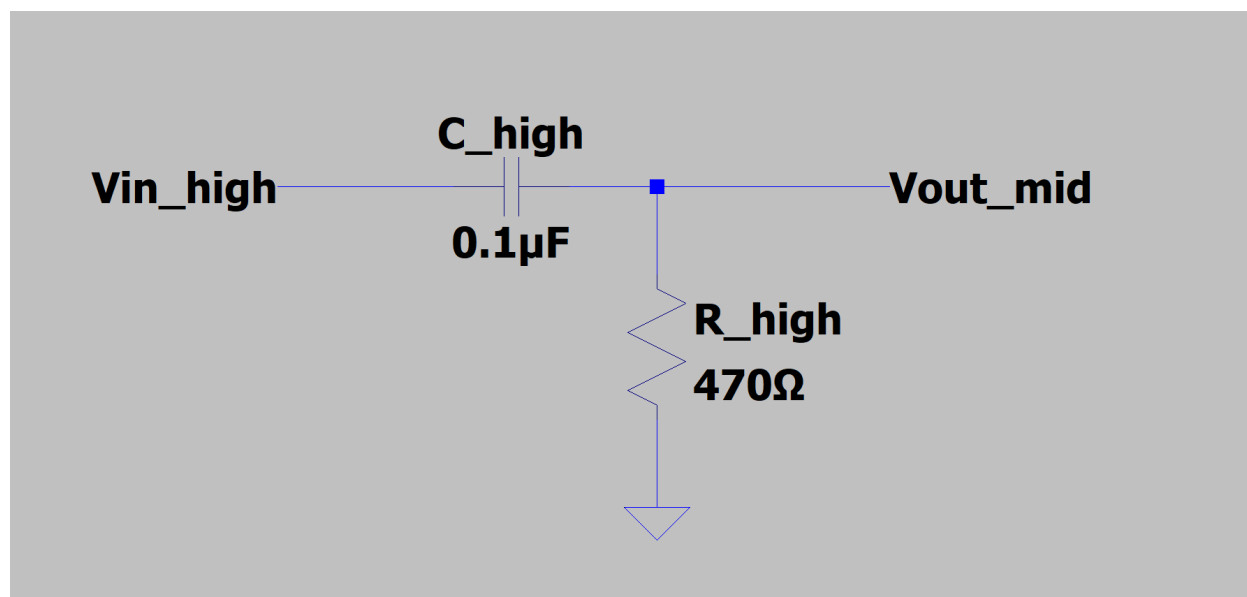


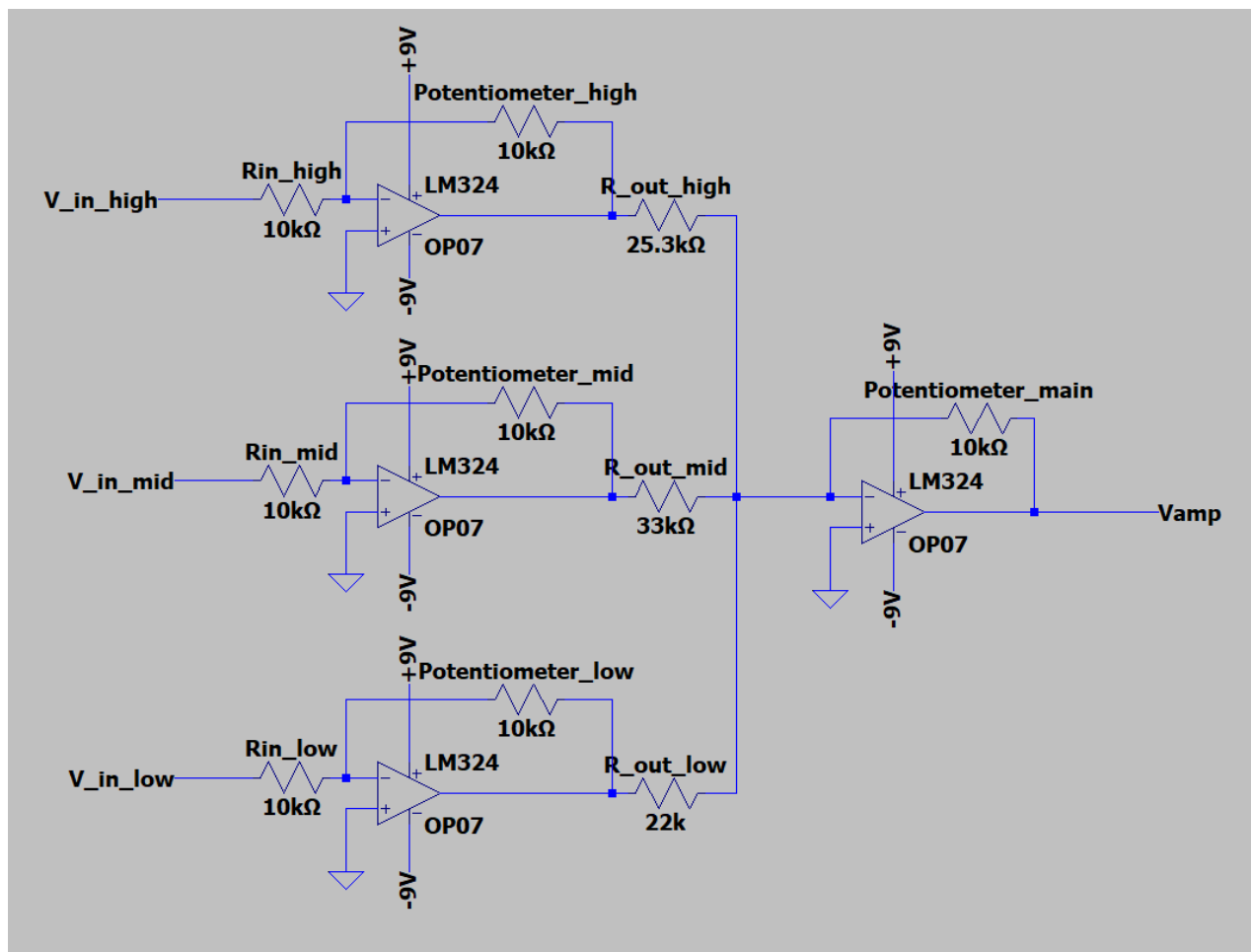
Low-Pass Filter Circuit Schematic



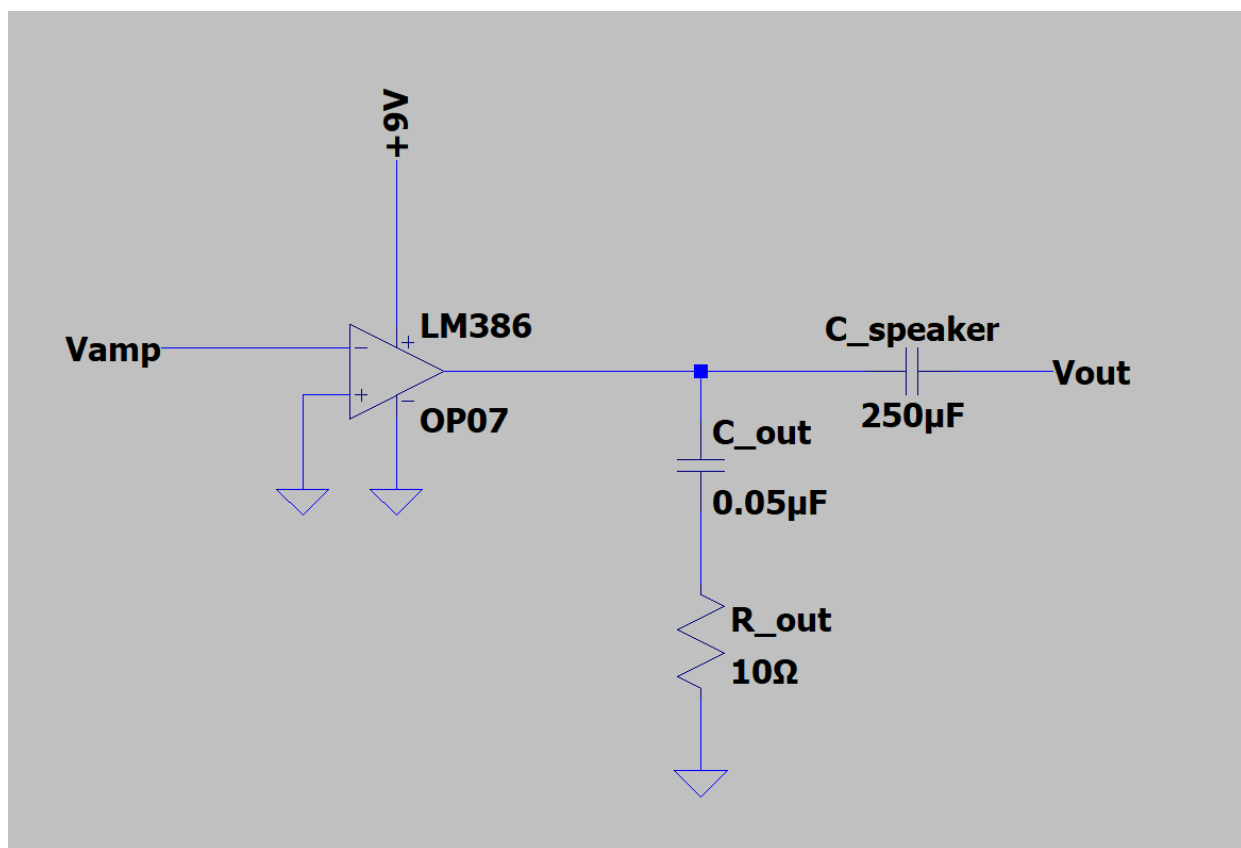
Band-Pass Filter Circuit Schematic



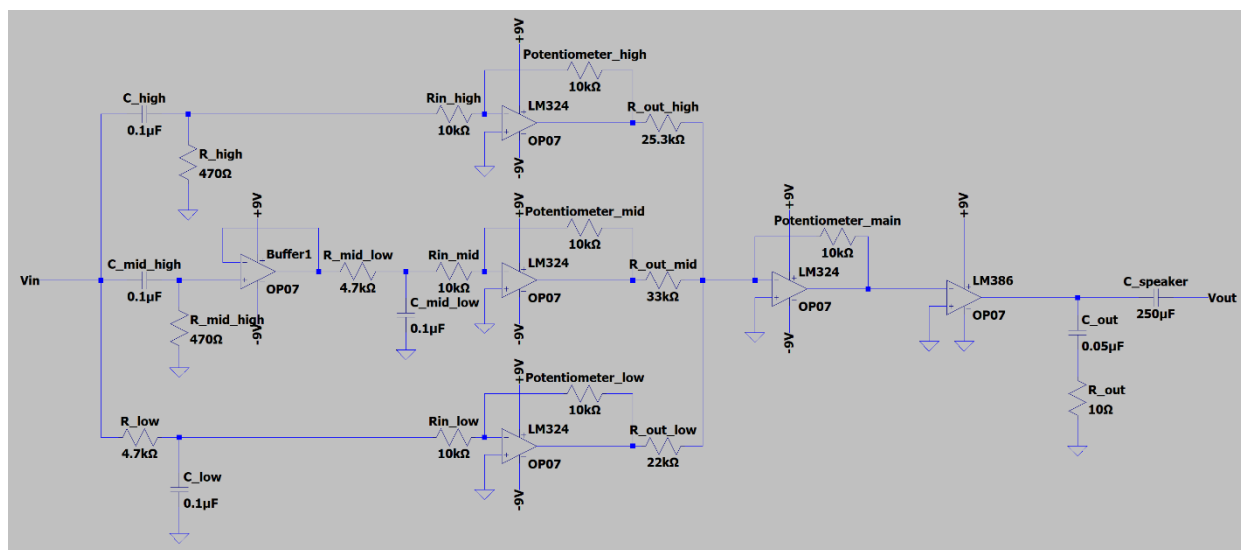
High-Pass Filter Circuit Schematic



Operational Amplifiers Circuit Schematic



Power Amplifier Circuit Schematic



Audio Equalizer Circuit Schematic

Audio Equalizer Design Parameter Calculations:

1. Filter Parameters

a. High Pass (>3200 Hz \pm 10%)

Parameter	Calculated Value	Equation/ Reasoning
R_{high}	470 Ω	$f = \frac{1}{2\pi RC} = 3386 \text{ Hz}$
C_{high}	0.1 μF	$f = \frac{1}{2\pi RC} = 3386 \text{ Hz}$

b. Band Pass (320-3200 Hz \pm 10%)

Parameter	Calculated Value	Equation/ Reasoning
$R_{\text{mid_high}}$	470 Ω	$f = \frac{1}{2\pi RC} = 3386 \text{ Hz}$
$C_{\text{mid_high}}$	0.1 μF	$f = \frac{1}{2\pi RC} = 3386 \text{ Hz}$
$R_{\text{mid_low}}$	4.7 k Ω	$f = \frac{1}{2\pi RC} = 338.6 \text{ Hz}$
$C_{\text{mid_low}}$	0.1 μF	$f = \frac{1}{2\pi RC} = 338.6 \text{ Hz}$

c. Low Pass (<320 Hz \pm 10%)

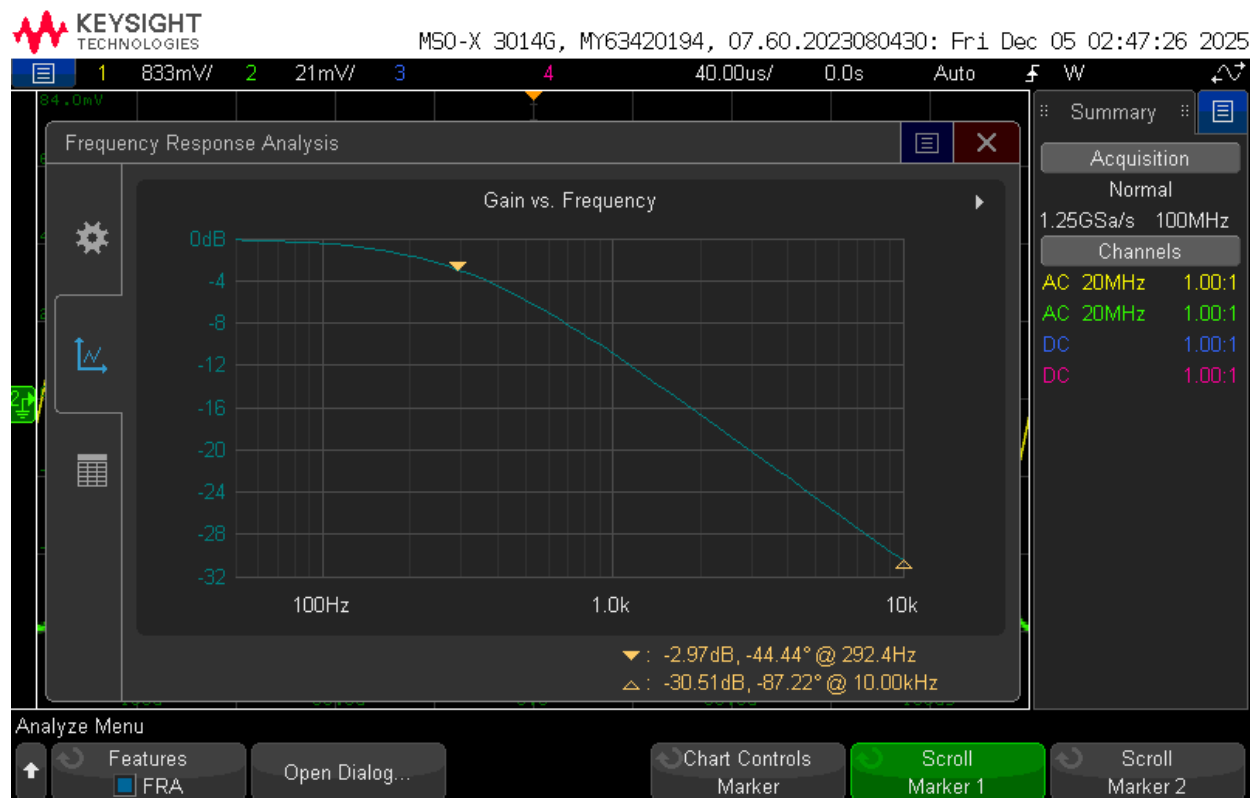
Parameter	Calculated Value	Equation/ Reasoning
R_{low}	4.7 k Ω	$f = \frac{1}{2\pi RC} = 338.6 \text{ Hz}$
C_{low}	0.1 μF	$f = \frac{1}{2\pi RC} = 338.6 \text{ Hz}$

2. Volume Control

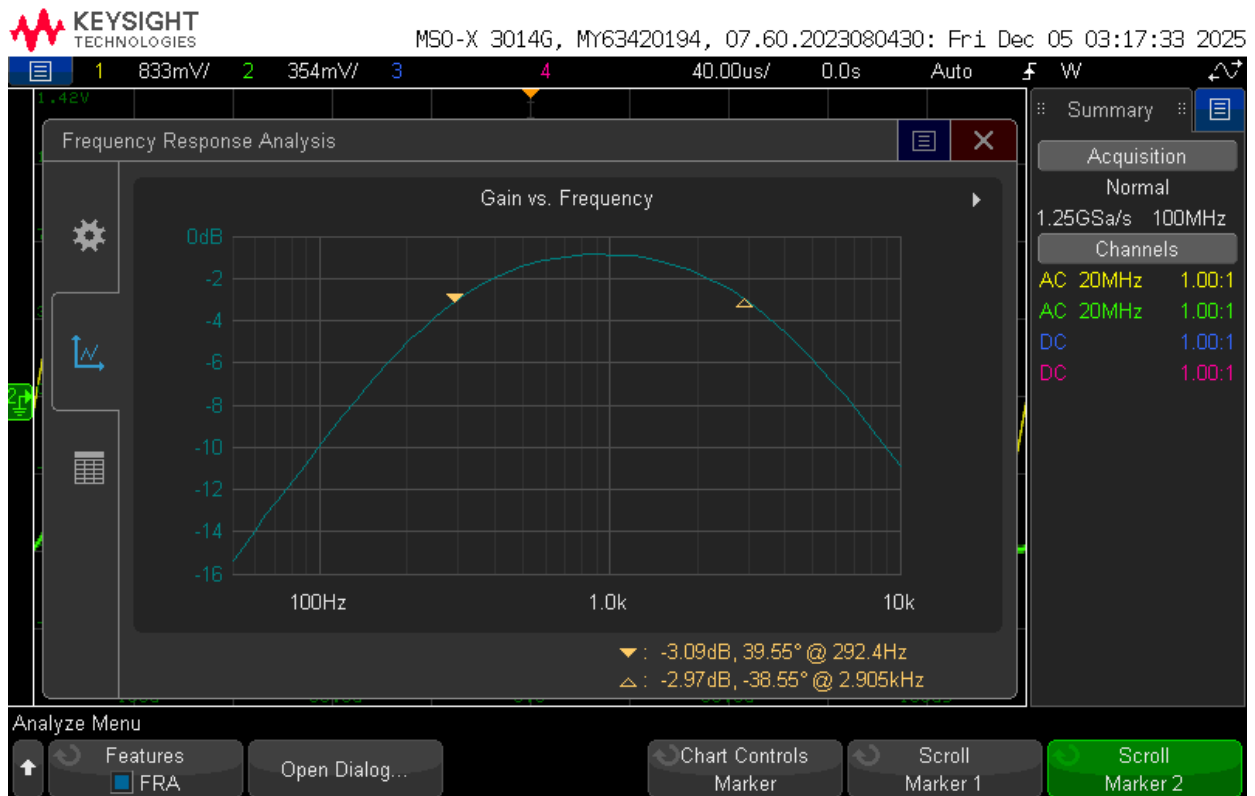
Parameter	Calculated Value	Equation/ Reasoning
R_{in} (3x for all filters)	10k Ω	$A_v = -R_f/R_{\text{in}} = 0 \rightarrow 1$ Stage gain of amplifier ranges from 0 \rightarrow 1
R_f (3x for all filters)	10 k Ω Potentiometer	$A_v = -R_f/R_{\text{in}} = 0 \rightarrow 1$ Stage gain of amplifier ranges from 0 \rightarrow 1

3. Signal Recombination

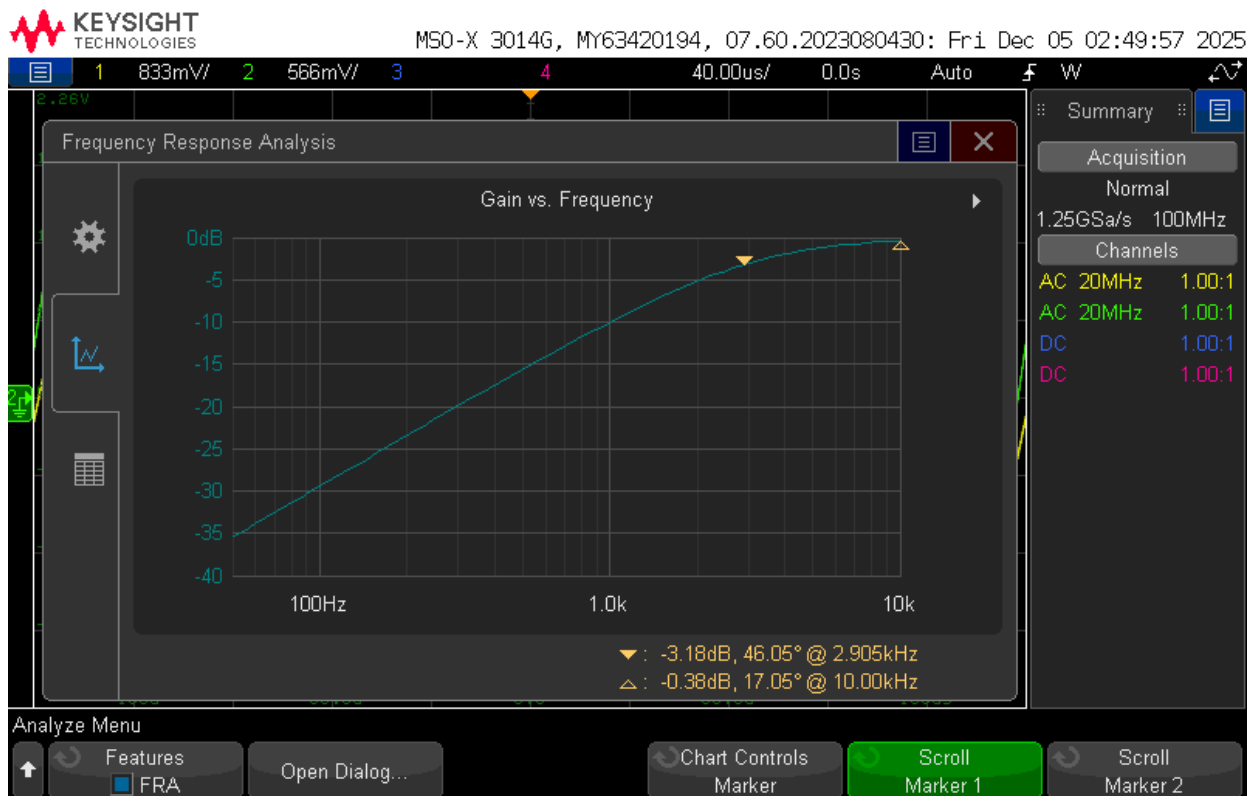
Parameter	Calculated Value	Equation/ Reasoning
R_{out_high}	25.3 k Ω (22 k Ω + 3.3 k Ω)	Provides isolation & weighting into summing node
R_{out_mid}	33 k Ω	Provides isolation & weighting into summing node
R_{out_low}	22 k Ω	Provides isolation & weighting into summing node
Potentiometer_main	10 k Ω Potentiometer	Changes the total Vamp output after recombination of low, medium, and high amplifiers. This demonstrates overall volume control.



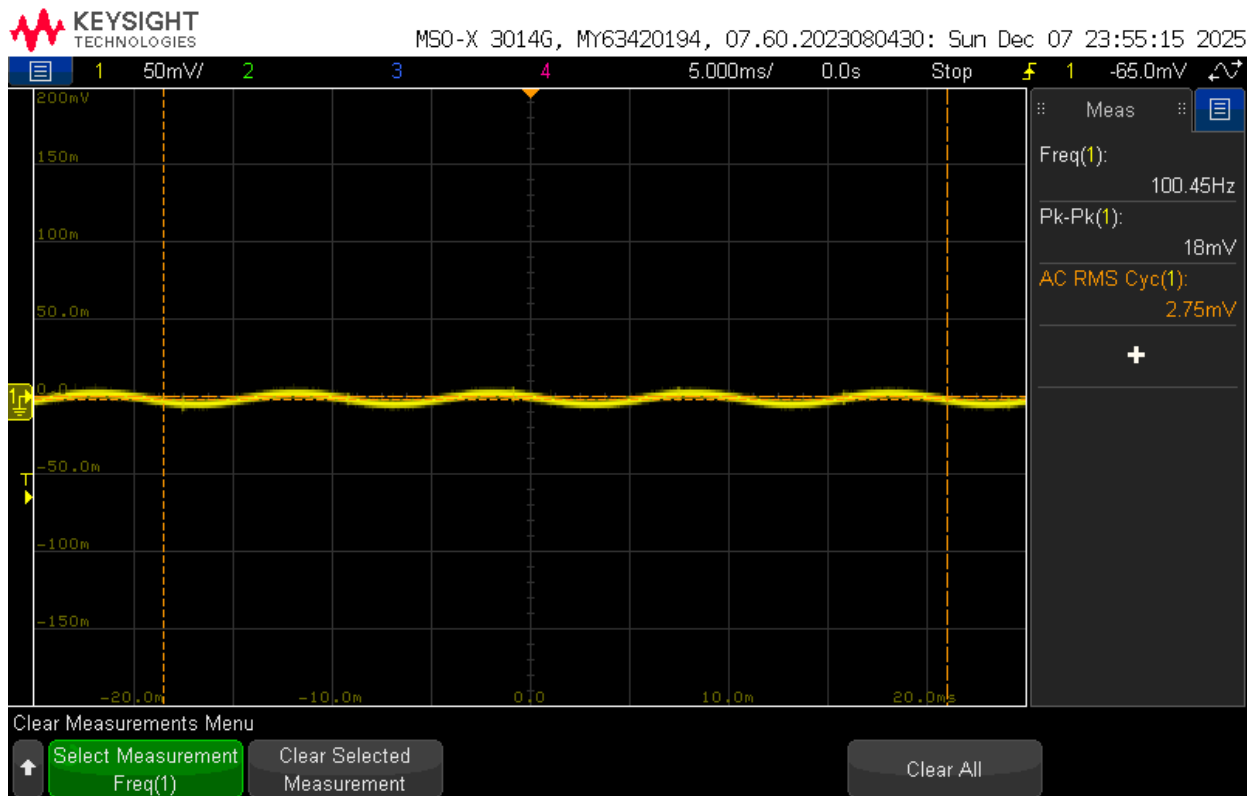
Low-Pass Filter Frequency Response Analysis Plot



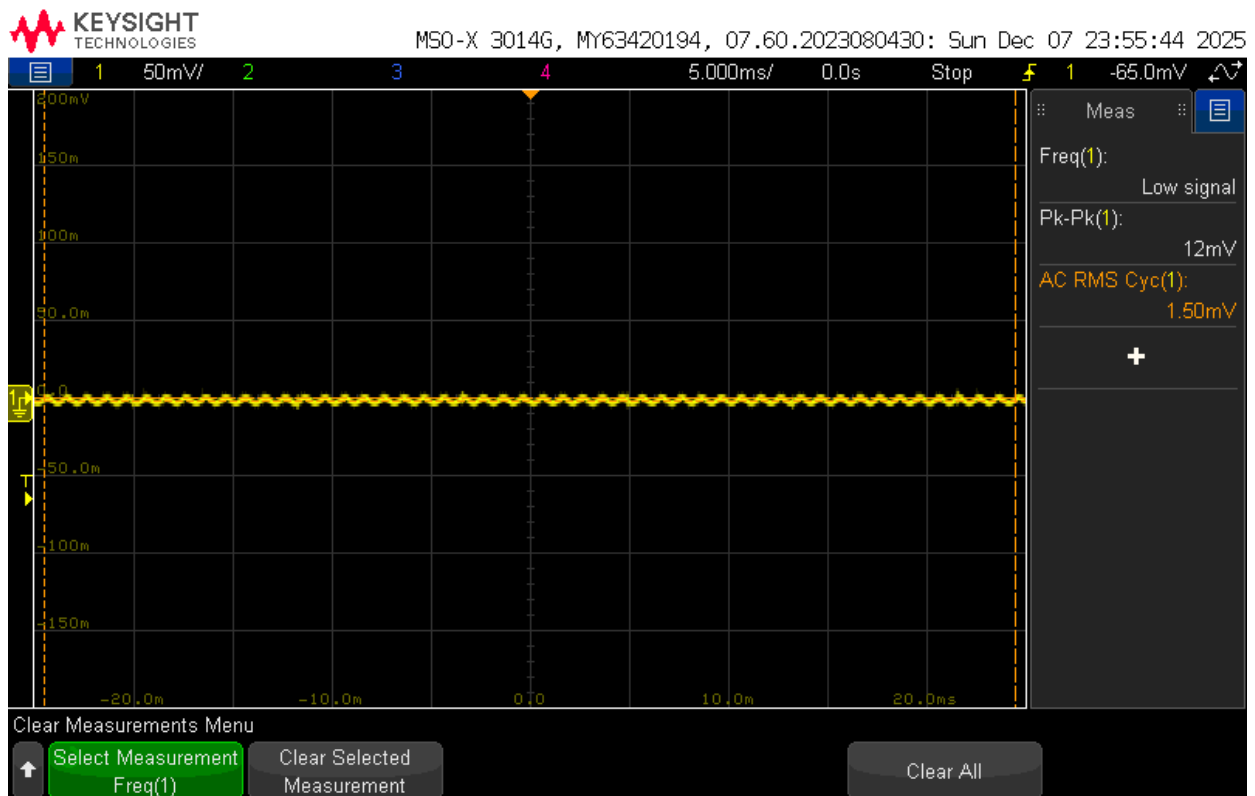
Band-Pass Filter Frequency Response Analysis Plot



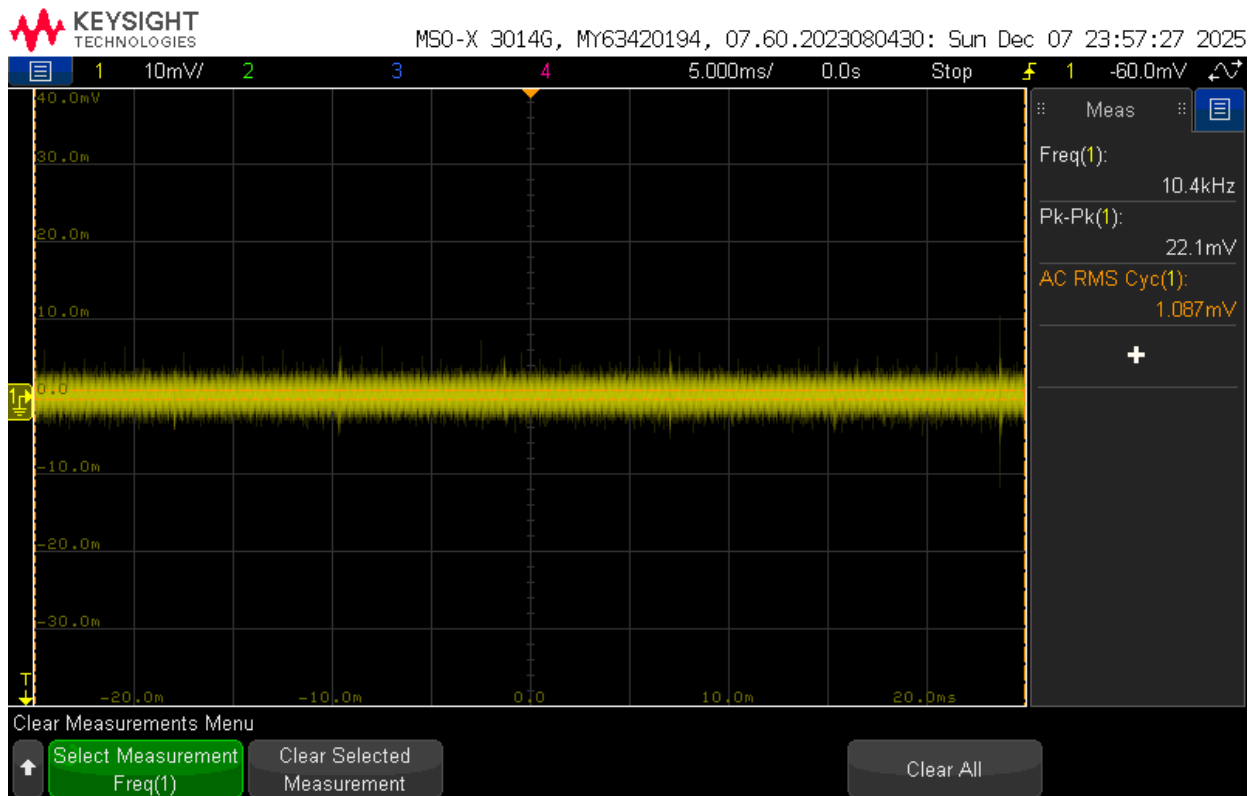
High-Pass Filter Frequency Response Analysis Plot



V_{amp} Plot on Minimum Settings at 100 Hz



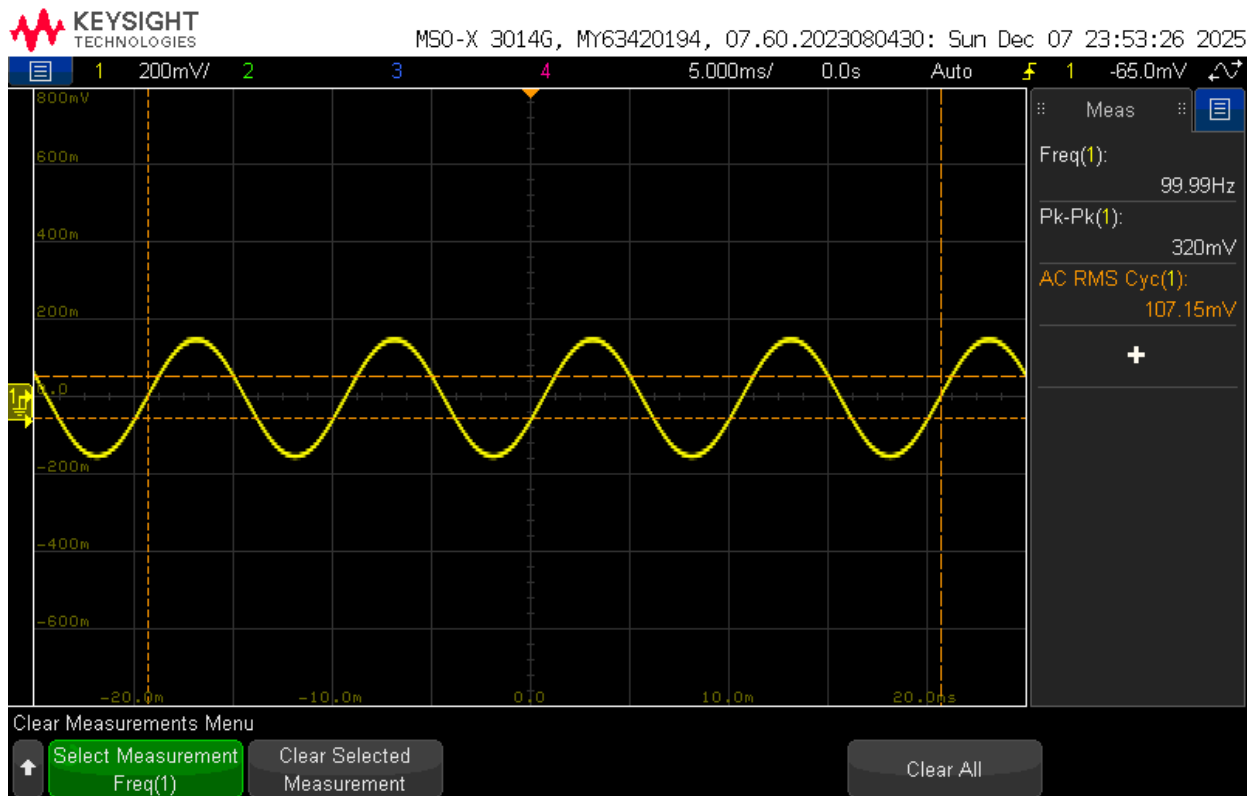
V_{amp} Plot on Minimum Settings at 1 kHz



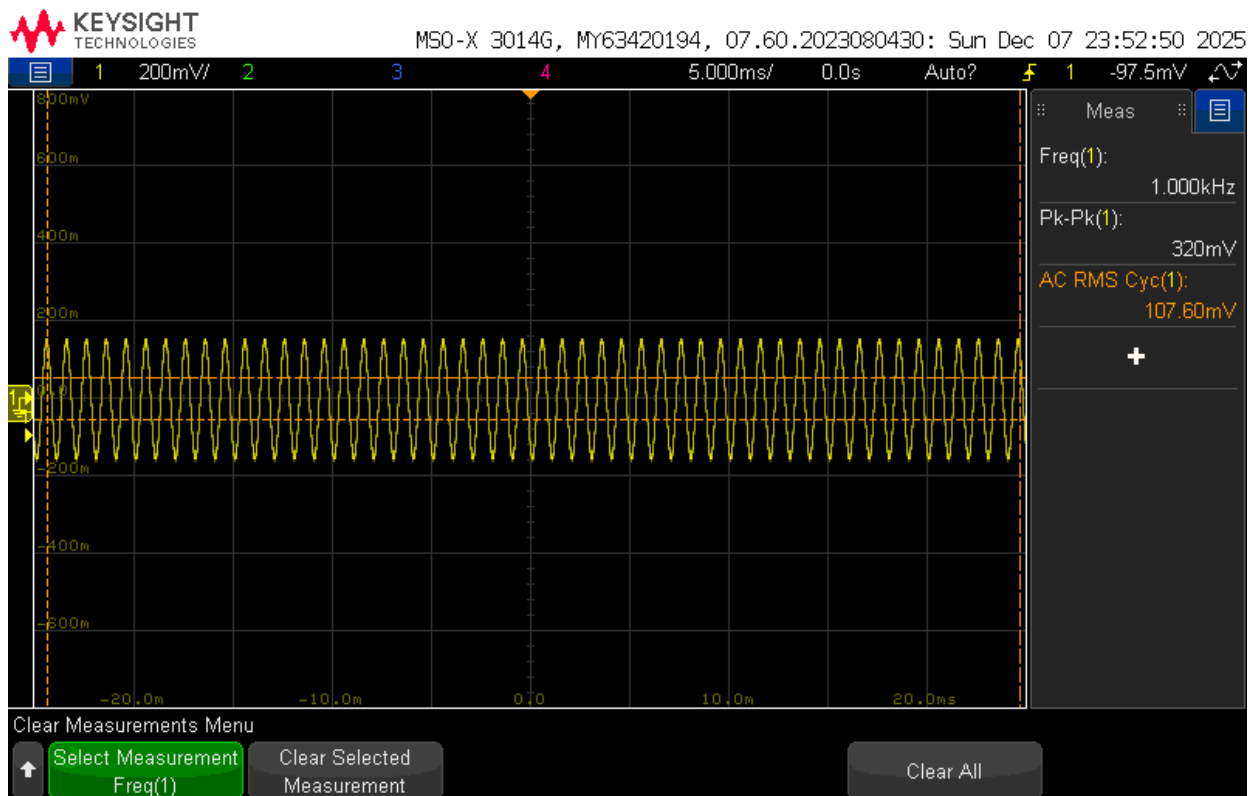
V_{amp} Plot on Minimum Settings at 10 kHz

Frequency (Hz)	V_{amp} (mV _{rms})	$V_{amp} < 15$ mV _{rms}
100	2.75	Yes
1000	1.50	Yes
10000	1.087	Yes

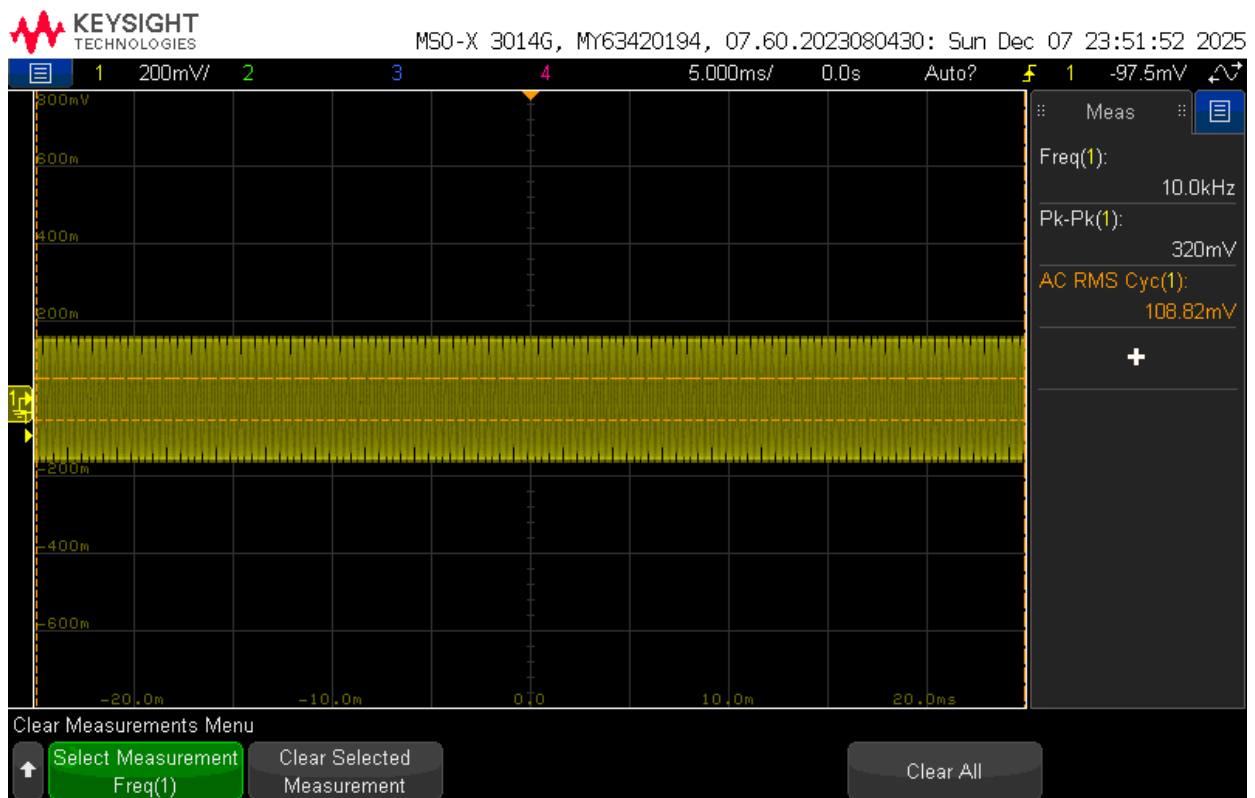
V_{amp} on Minimum Settings



V_{amp} Plot on Maximum Settings at 100 Hz



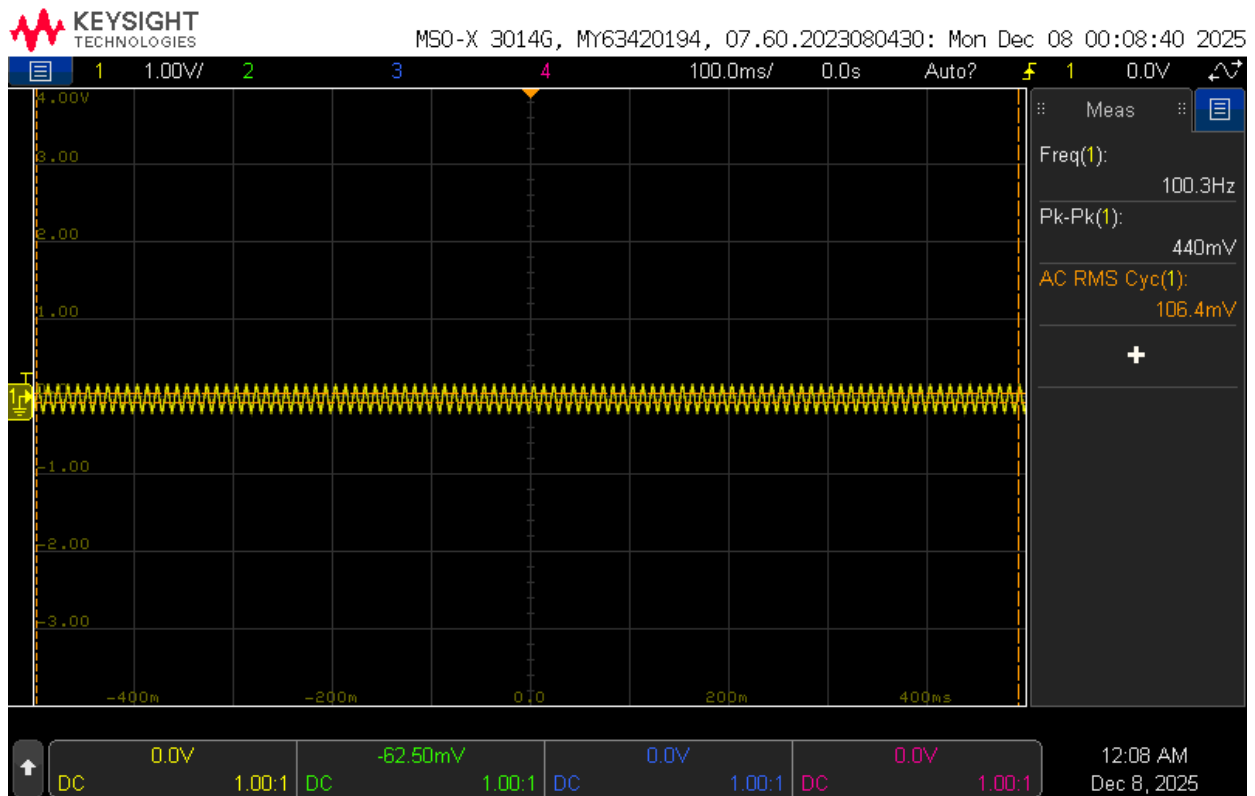
V_{amp} Plot on Maximum Settings at 1 kHz



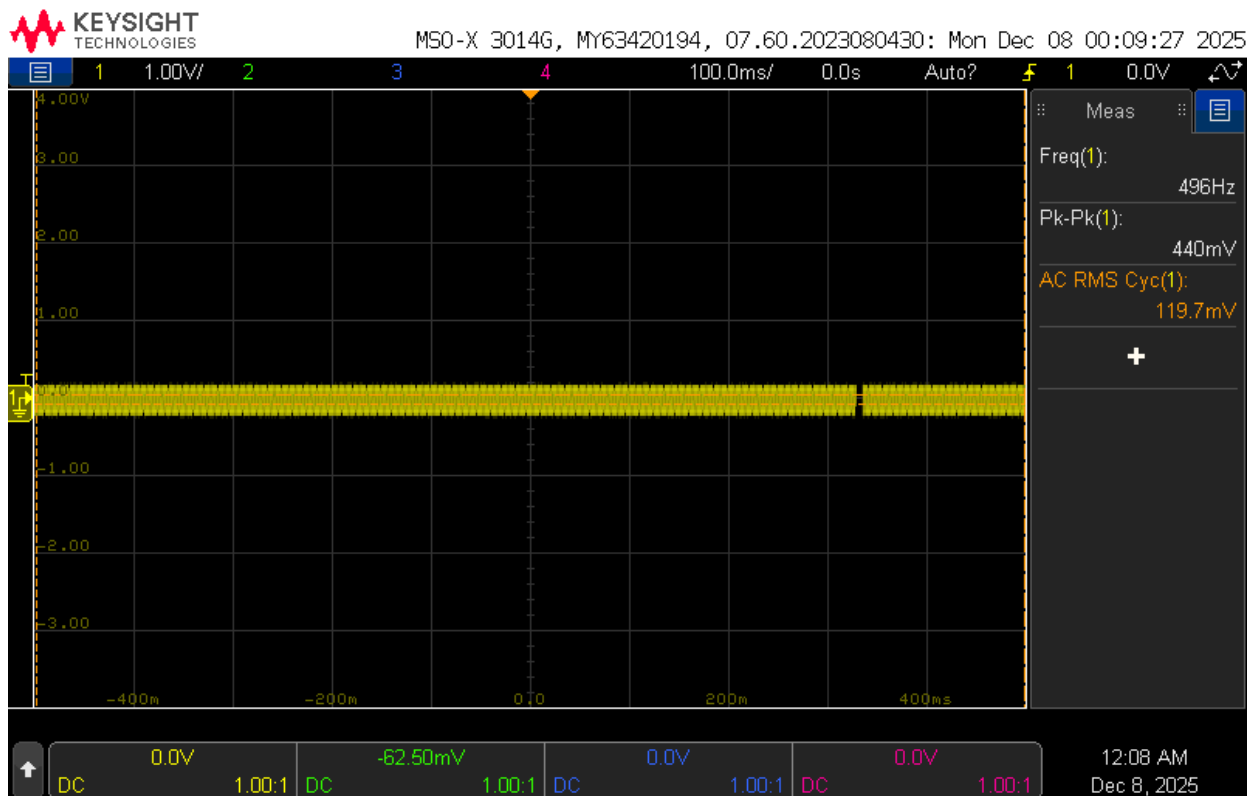
V_{amp} Plot on Maximum Settings at 10 kHz

Frequency (Hz)	V_{amp} (mV _{rms})	$V_{amp} = 100 \text{ mV}_{rms} \pm 10\%$
100	107.15	Yes
1000	107.60	Yes
10000	108.82	Yes

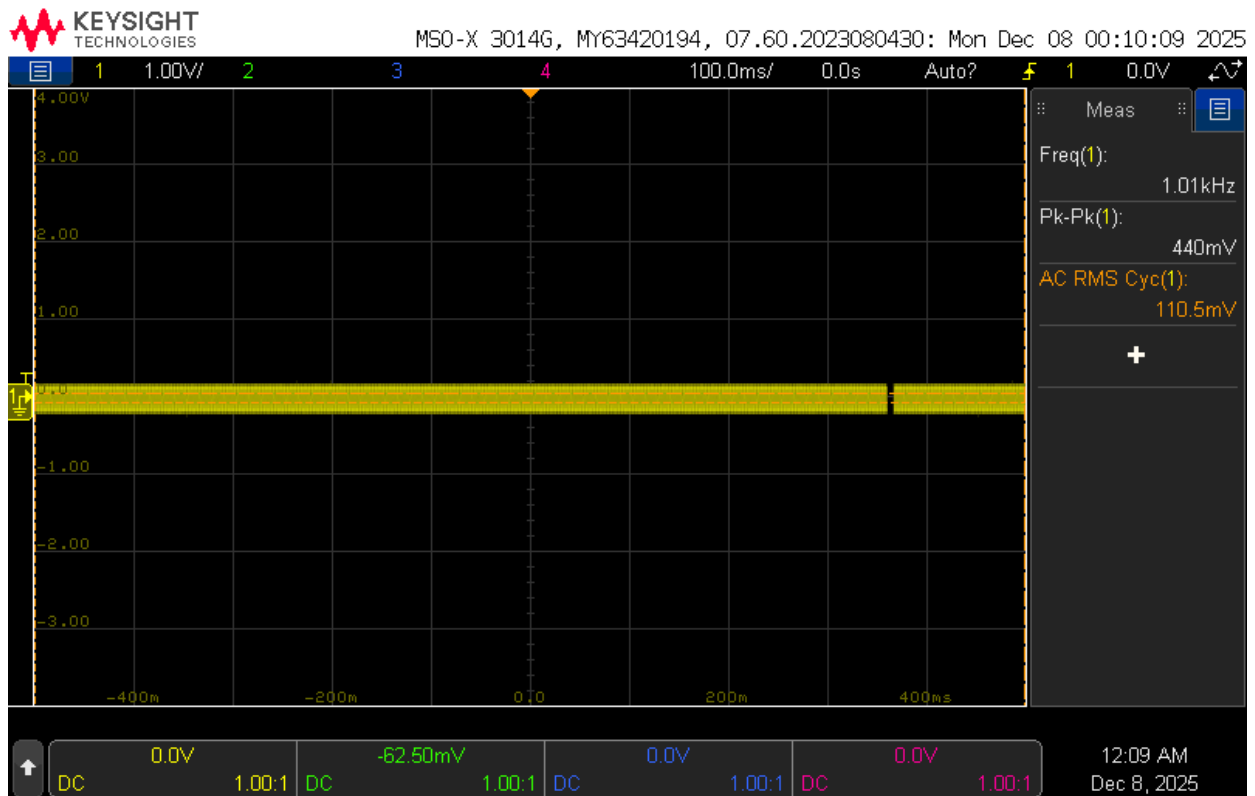
V_{amp} on Maximum Settings



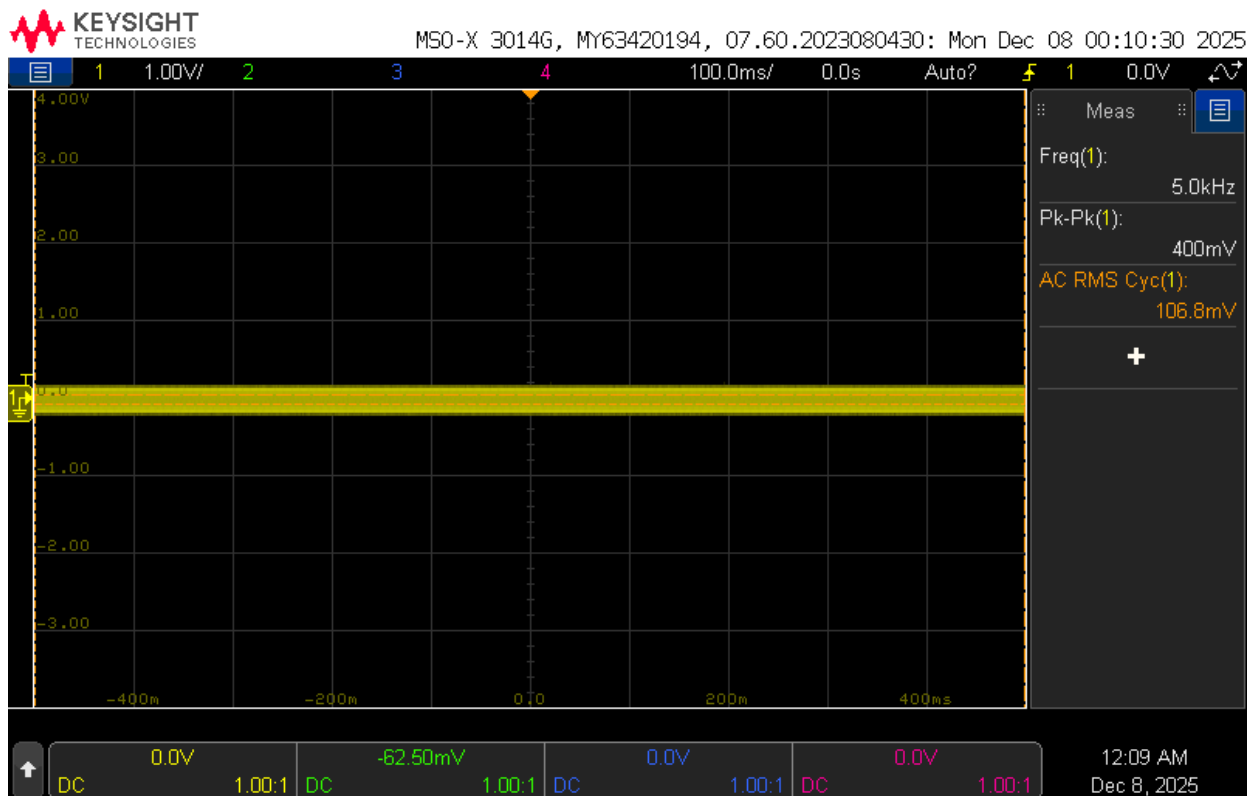
V_{amp} Plot at 100 Hz for Ripple Measurement



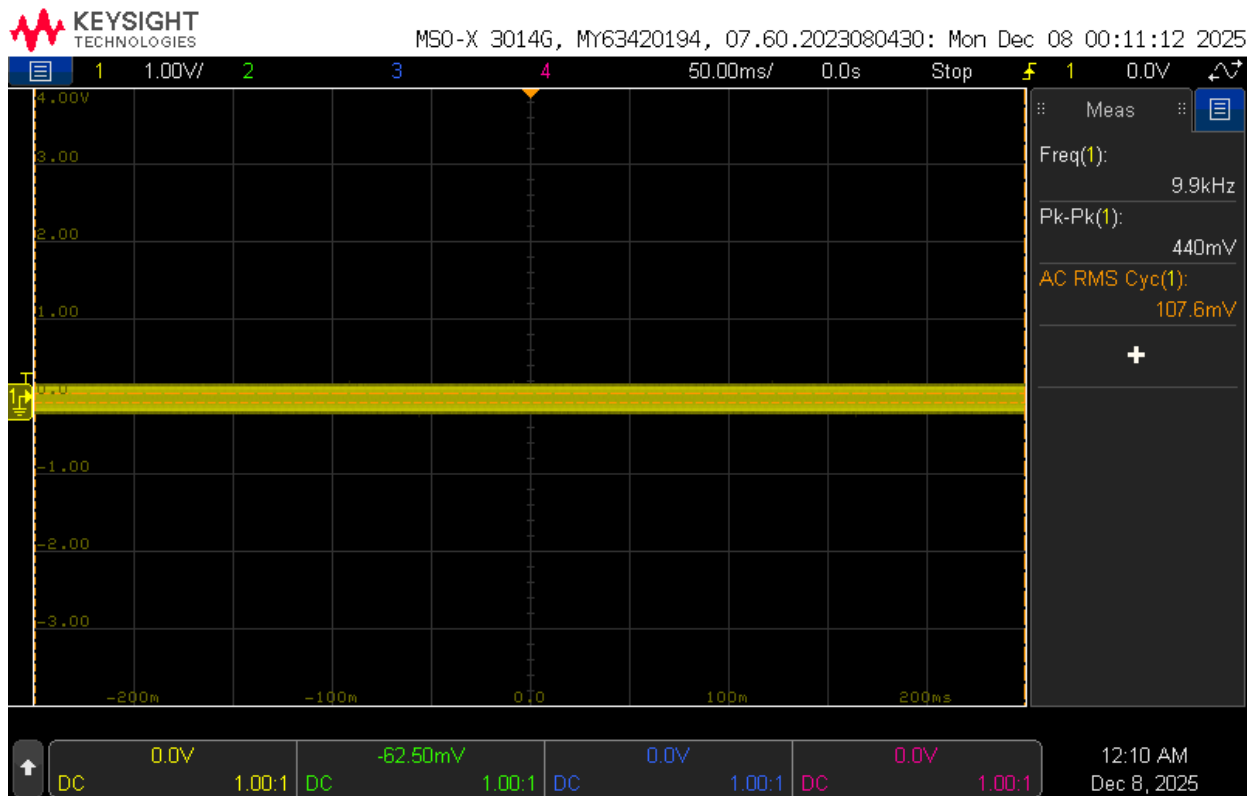
V_{amp} Plot at 500 Hz for Ripple Measurement



V_{amp} Plot at 1 kHz for Ripple Measurement



V_{amp} Plot at 5 kHz for Ripple Measurement



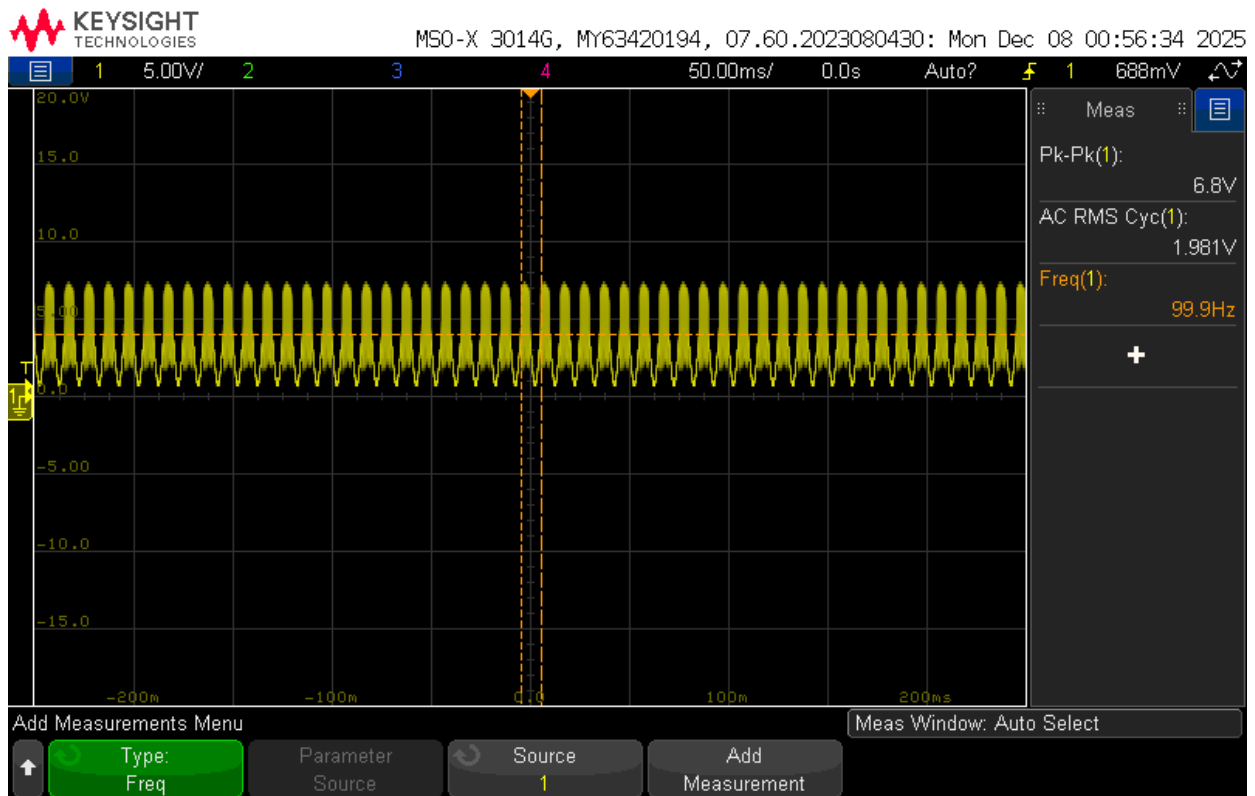
V_{amp} Plot at 10 kHz for Ripple Measurement

Ripple Measurement Calculations:

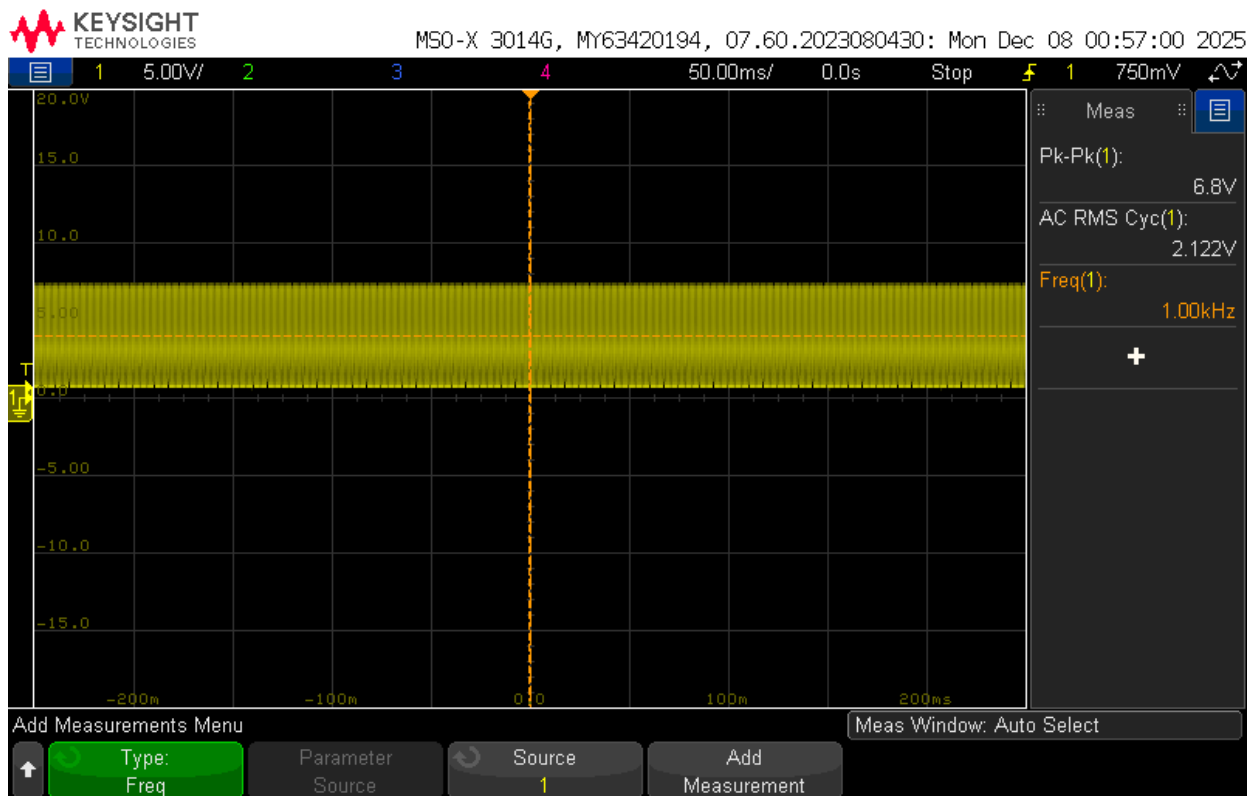
Frequency (Hz)	V_{amp} (mVrms)
100	106.4
500	119.7
1000	110.5
5000	106.8
10000	107.6

Maximum Ripple = $mV_{rms} (max) - mV_{rms} (min) = 119.7 - 106.4 = 13.3 mV_{rms} \approx 15 mV$ (Expected value)

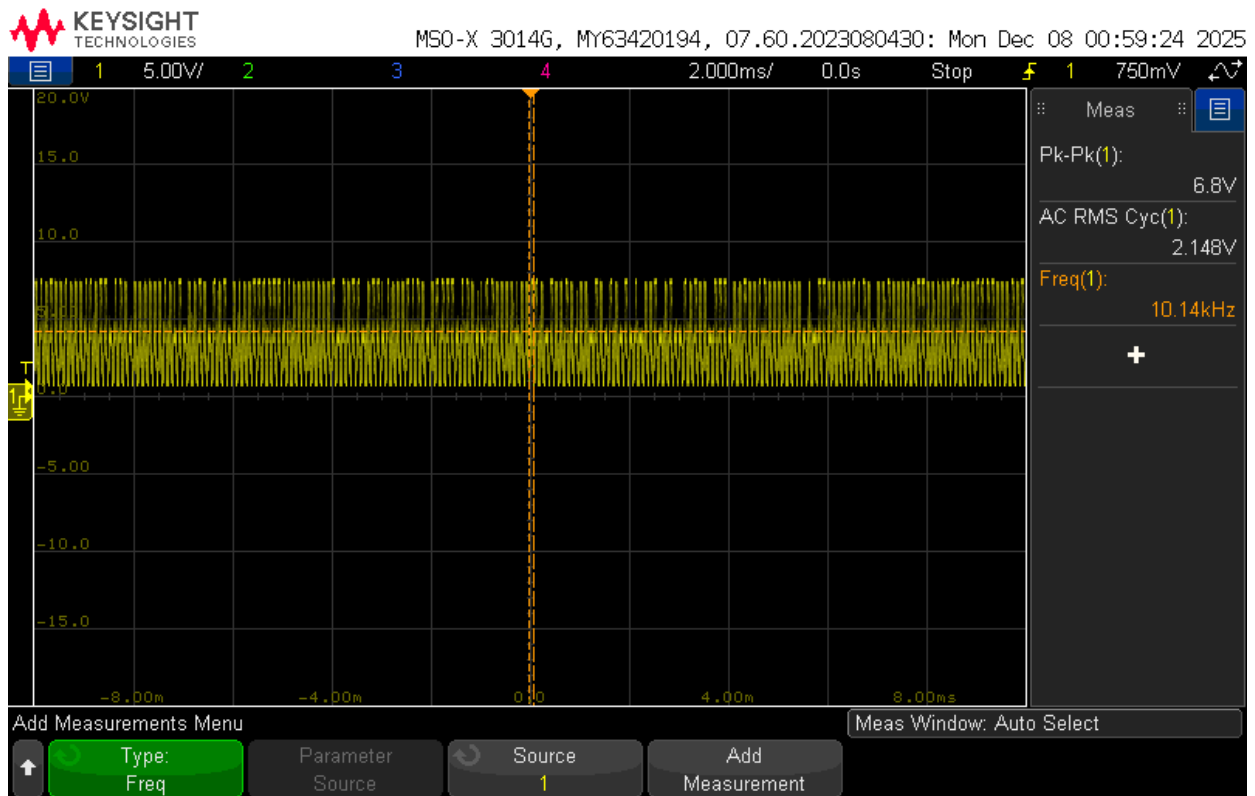
% Error = $|15 mV - 13.3 mV| \div 15 mV \times 100 = 11.3\%$



Power Amplifier Output at 100 Hz



Power Amplifier Output at 1 kHz

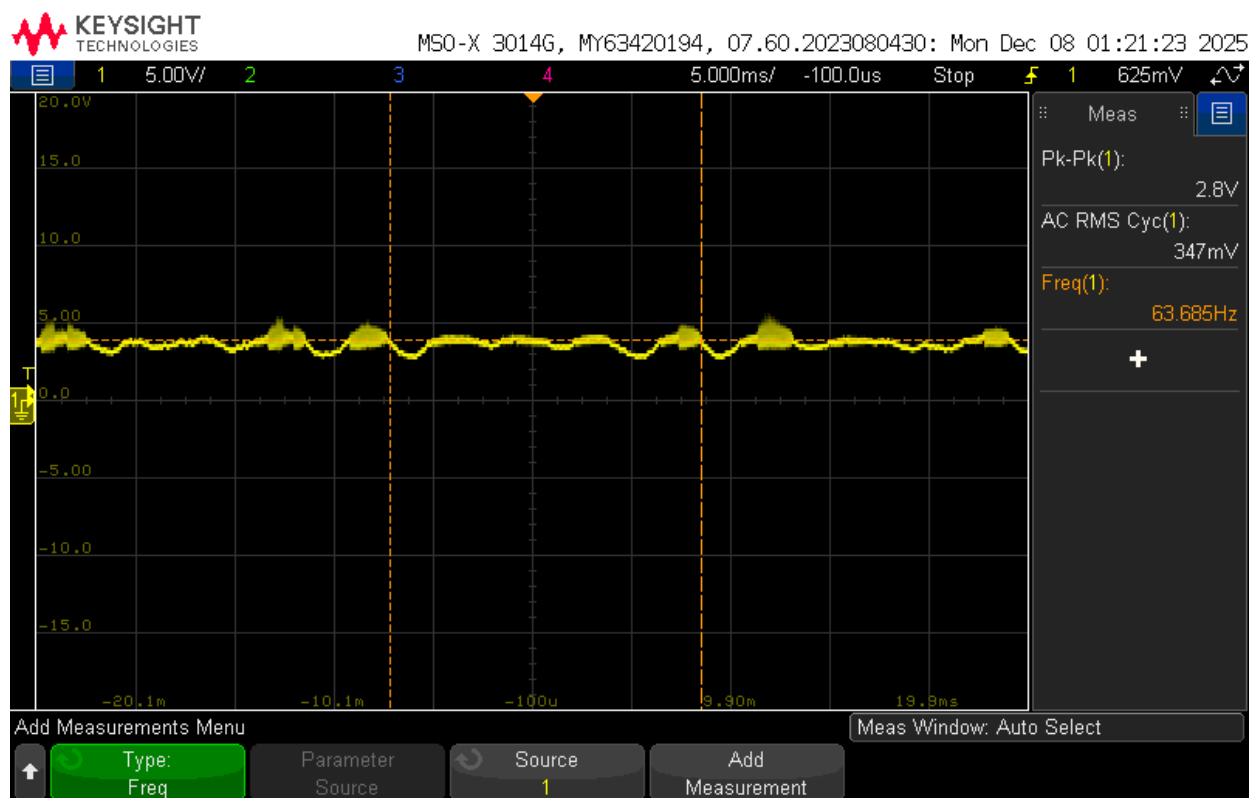


Power Amplifier Output at 10 kHz

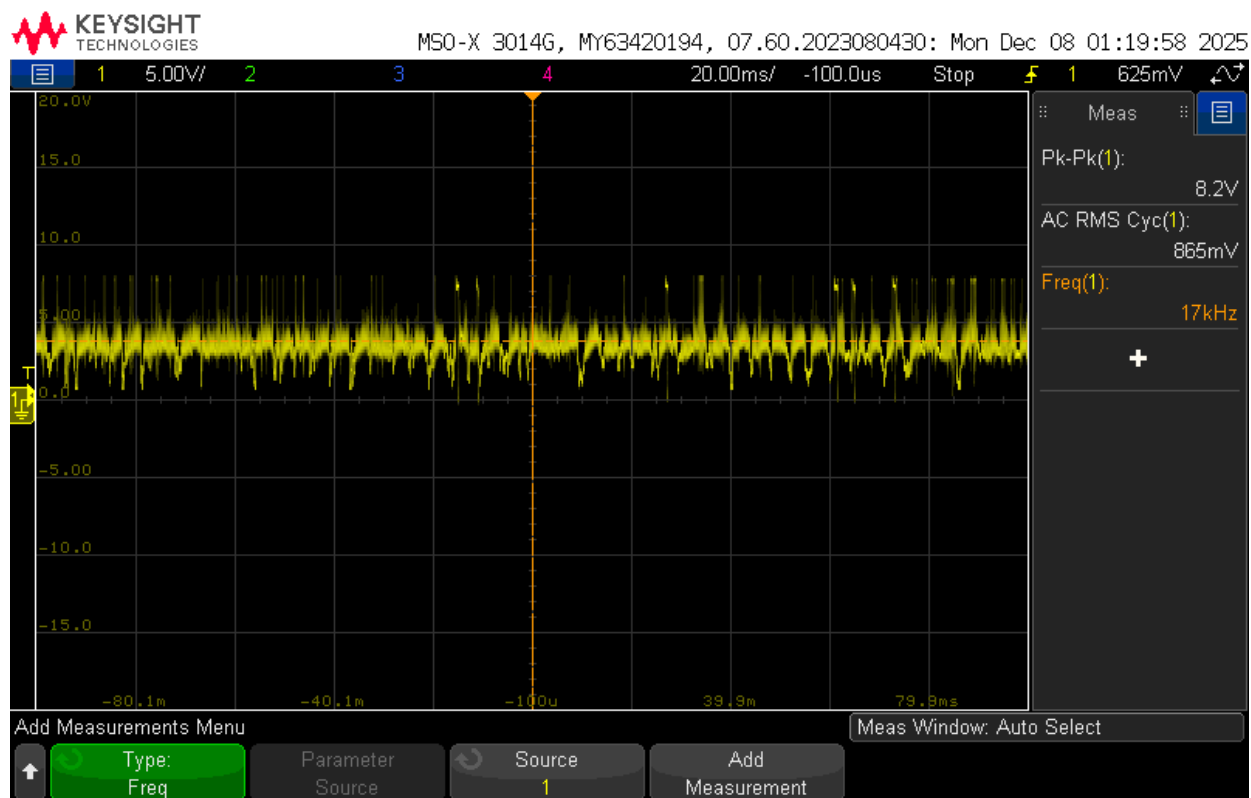
Power Output Calculations:

$$P_{avg} = \frac{V_{rms}^2}{R} = \frac{V_{rms}^2}{8}$$

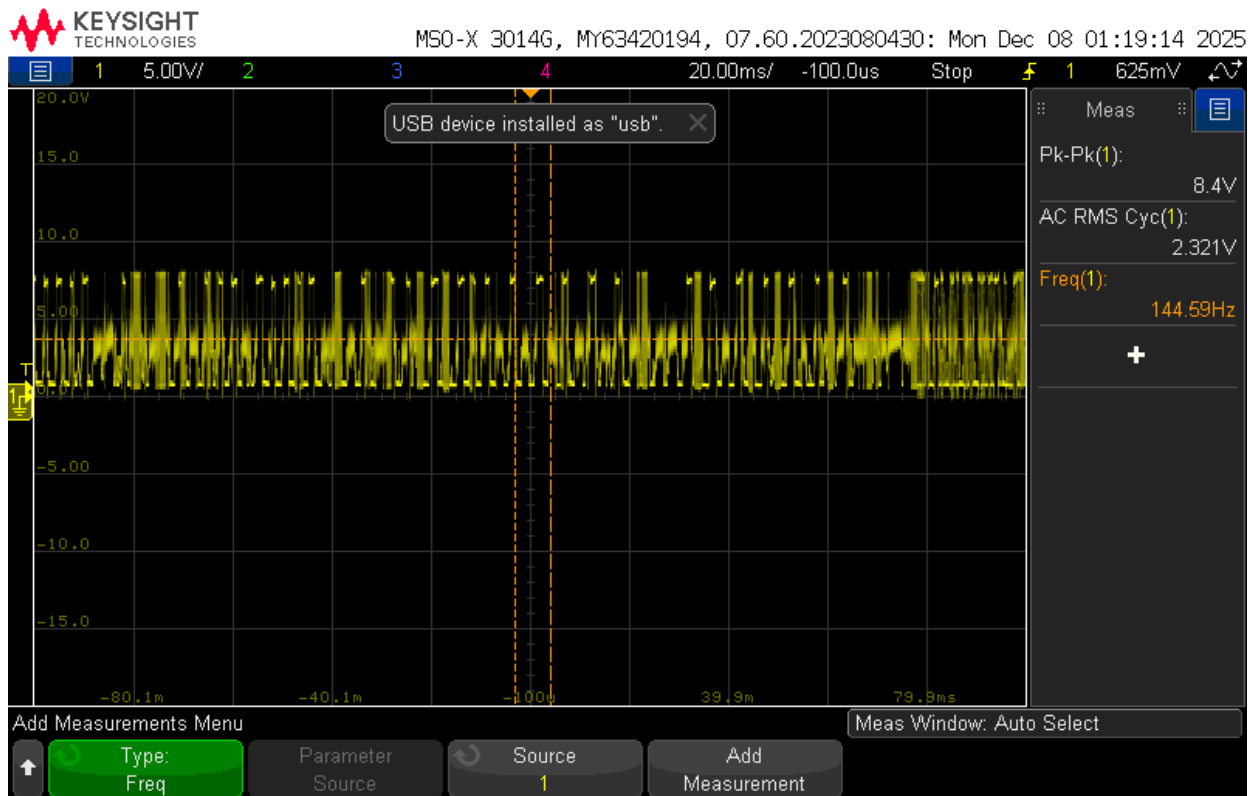
Frequency (Hz)	Vrms (V)	Power Output (mW)	$P_{avg} > 400 \text{ mW?}$
100	1.981	492.0	Yes
1000	2.122	562.9	Yes
10000	2.148	576.7	Yes



Low Volume Plot when an Audio Signal is Applied



Medium Volume Plot when Audio Signal is Applied



High Volume Plot when Audio Signal is Applied