ECEN 325 - 512

Operational Amplifiers - Part 3

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Contributors:

Dominic Treadwell | UIN: 720004254

Joaquin Salas | UIN: 731000141

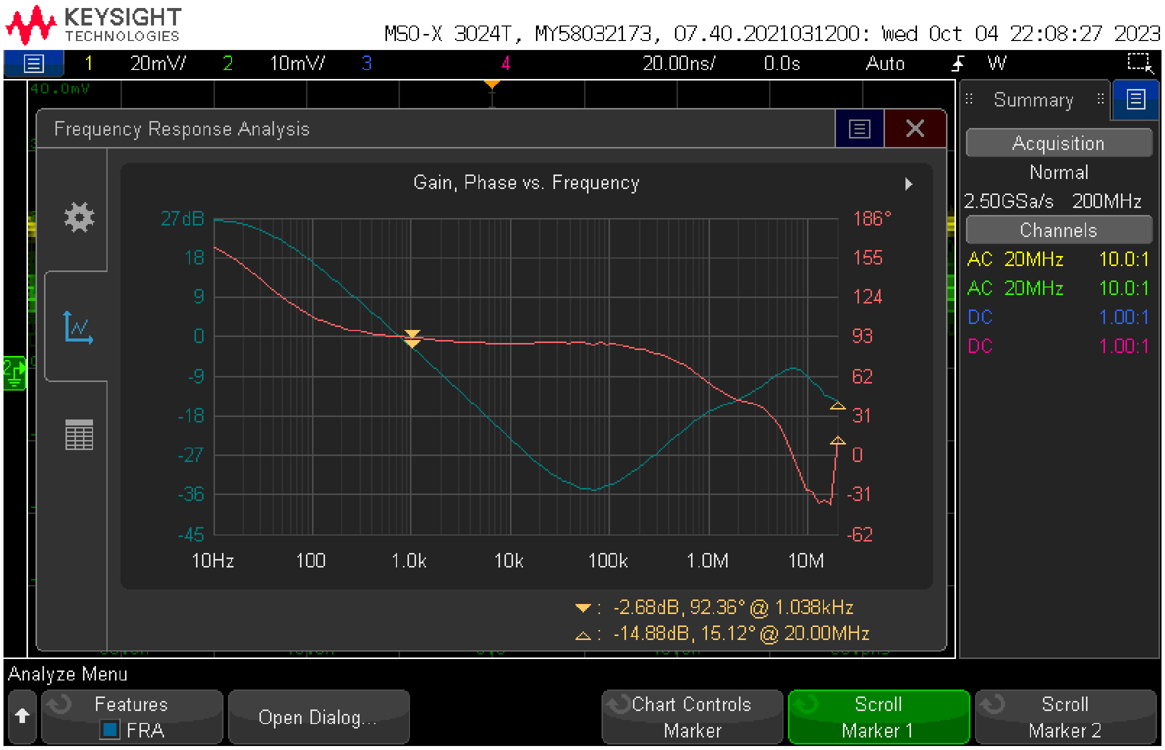
Measurements

Lossy Integrator

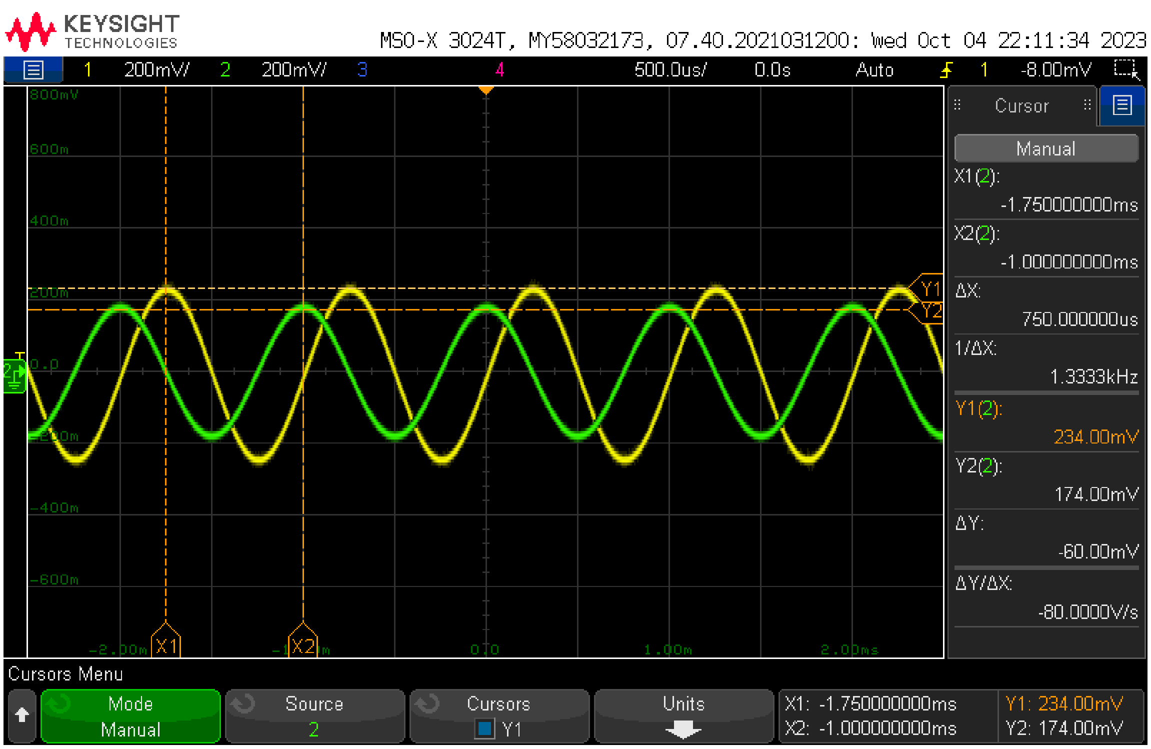
2a. Low Frequency Gain

2b. 3-dB Frequency

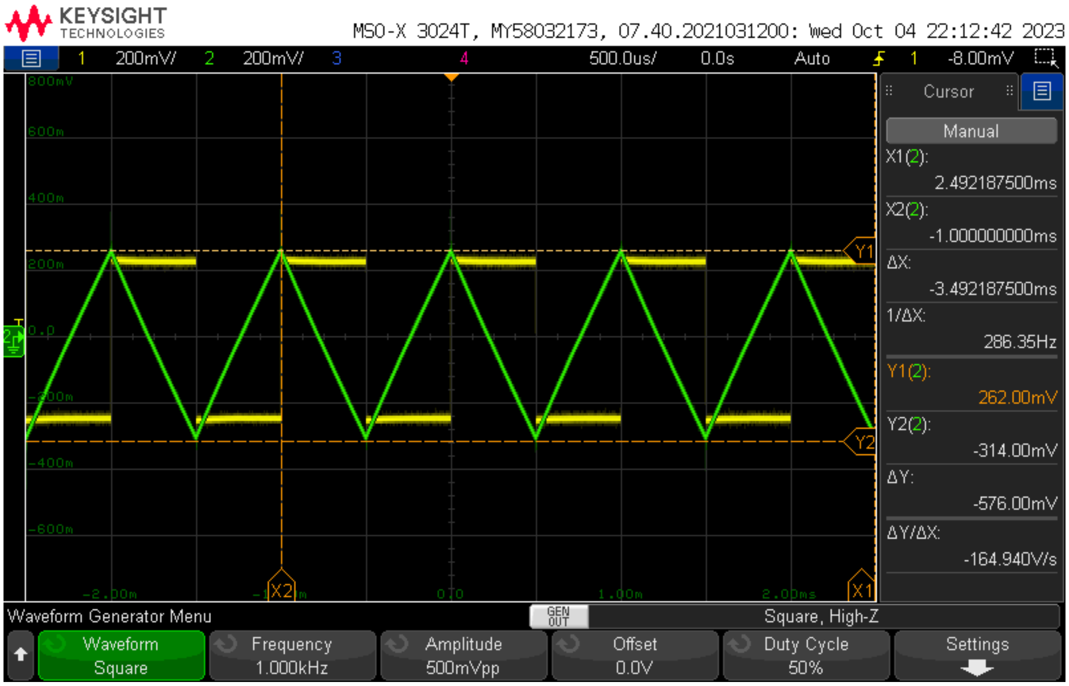
2c. Magnitude and Phase of Transfer Function at 1kHz



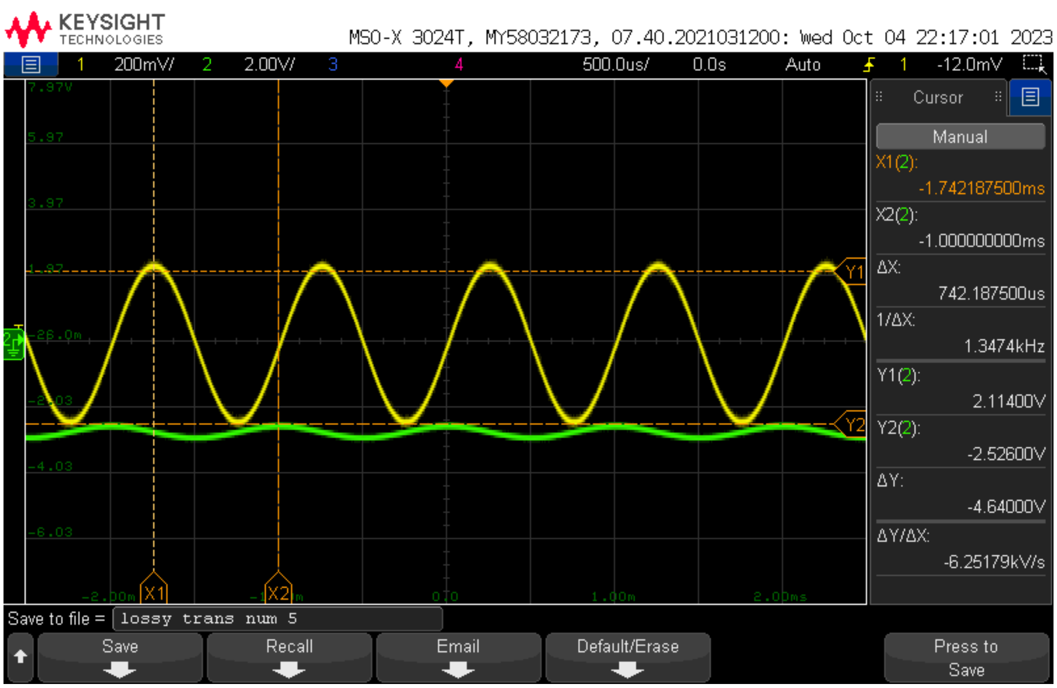
3. Time-domain waveforms



4. Square wave signal time-domain waveform



5. Remove the resistor R_2 and observe what happens to the output signal. Comment on the result.



When R_2 is removed, you can see the capacitor charging and discharging with respect to time.

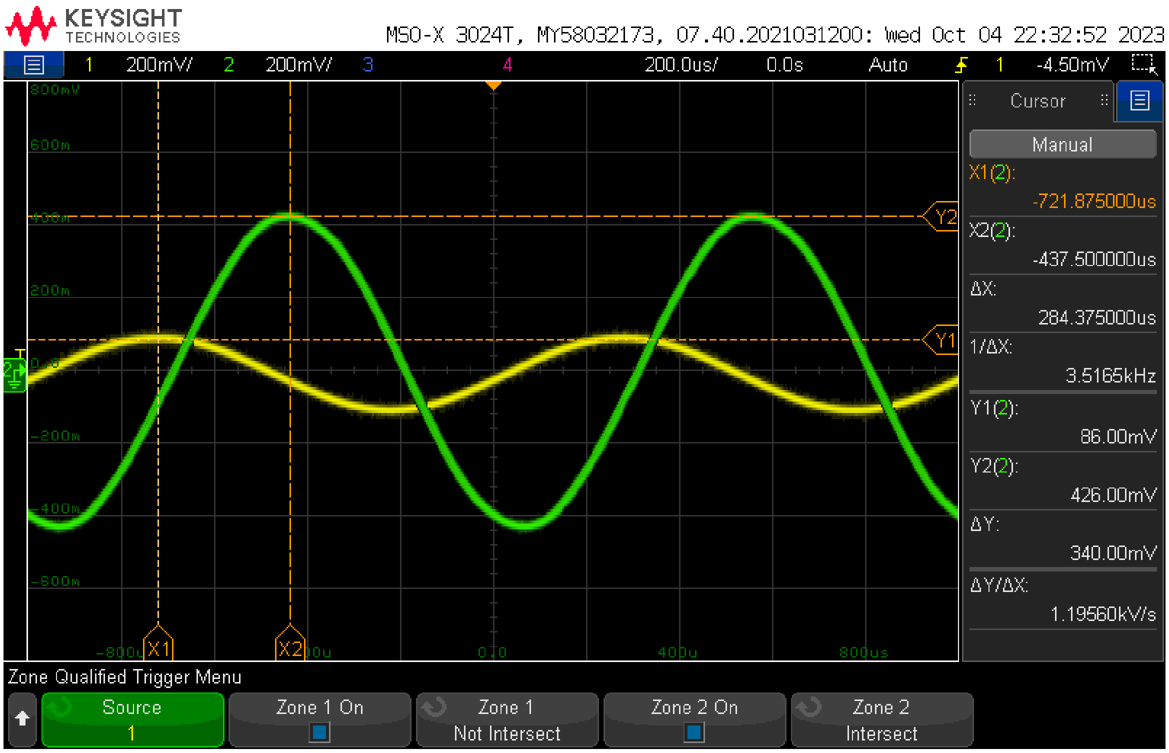
The sine wave is much smaller than the input signal, it only becomes an integrator circuit, since there is no resistor to alter the circuit.

Pseudo Differentiator

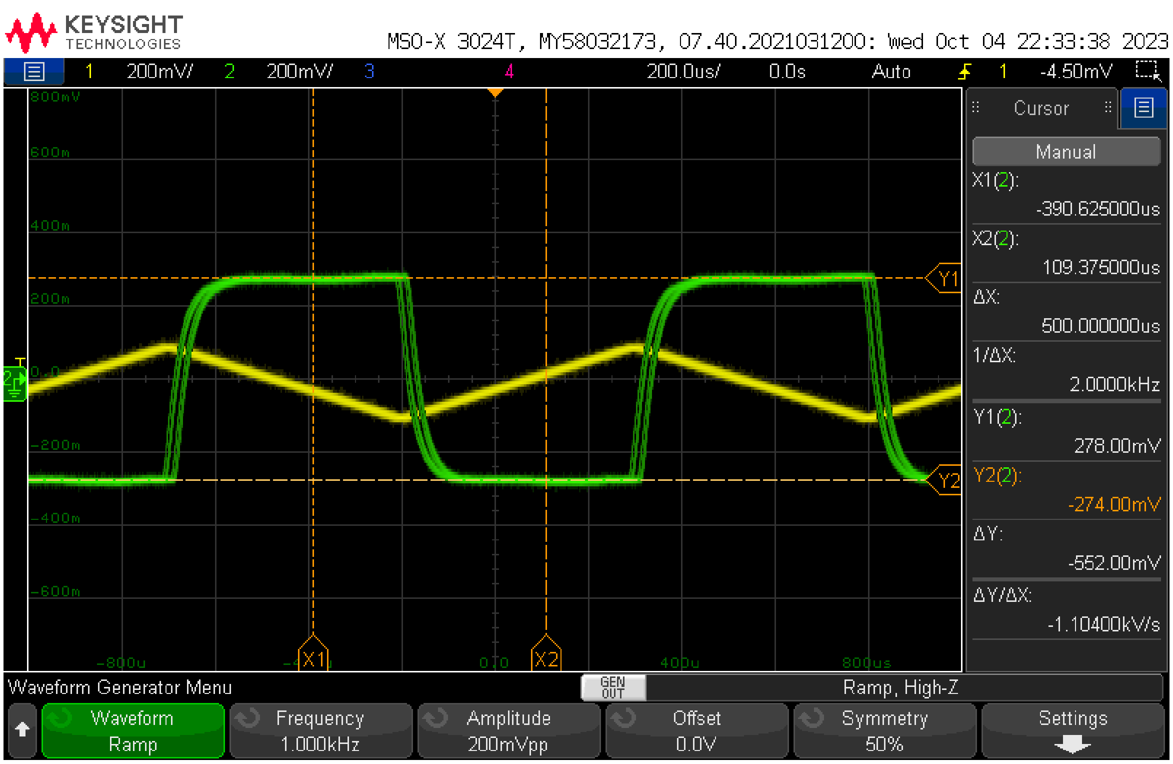
2a. Low frequency gain

2b. 3-dB frequency

3. Sine wave signal time-domain waveform

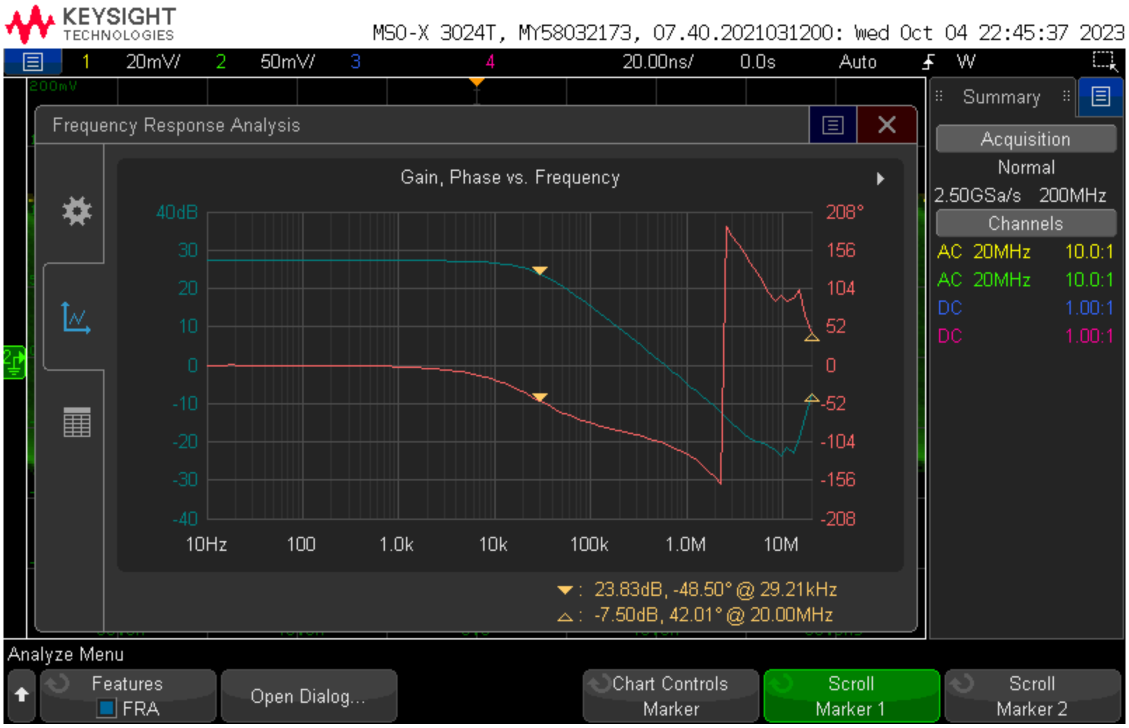


4. Triangular wave signal time-domain waveform

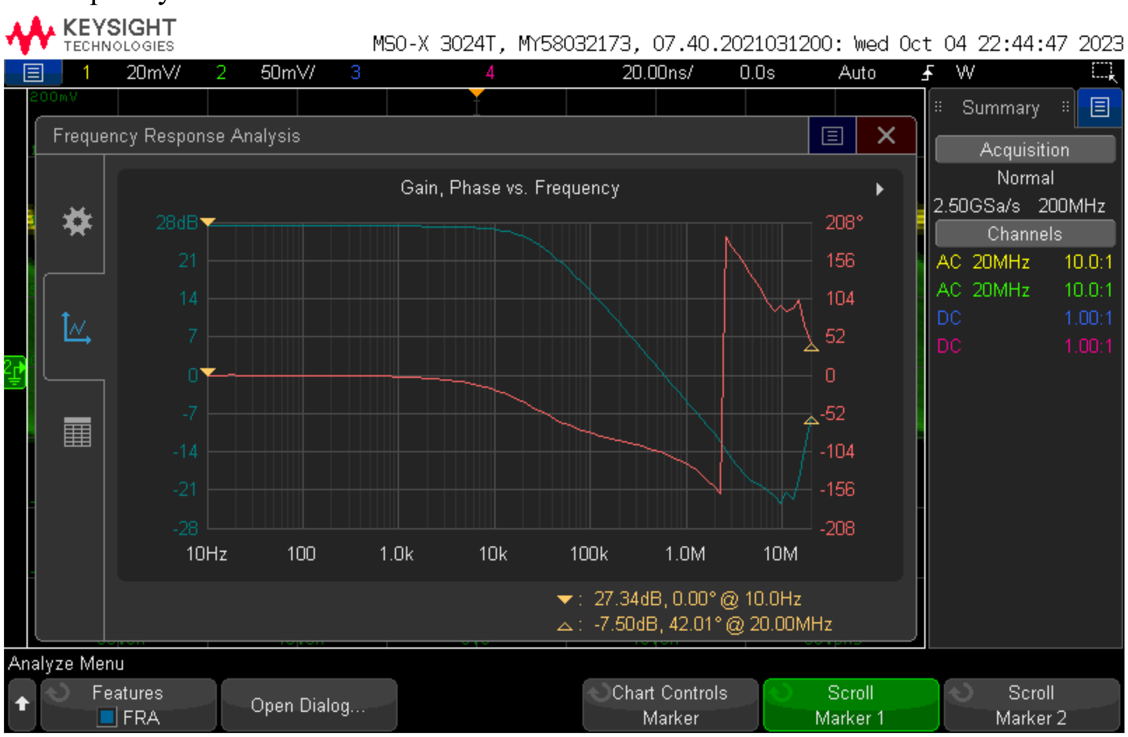


Finite GBW Limitations

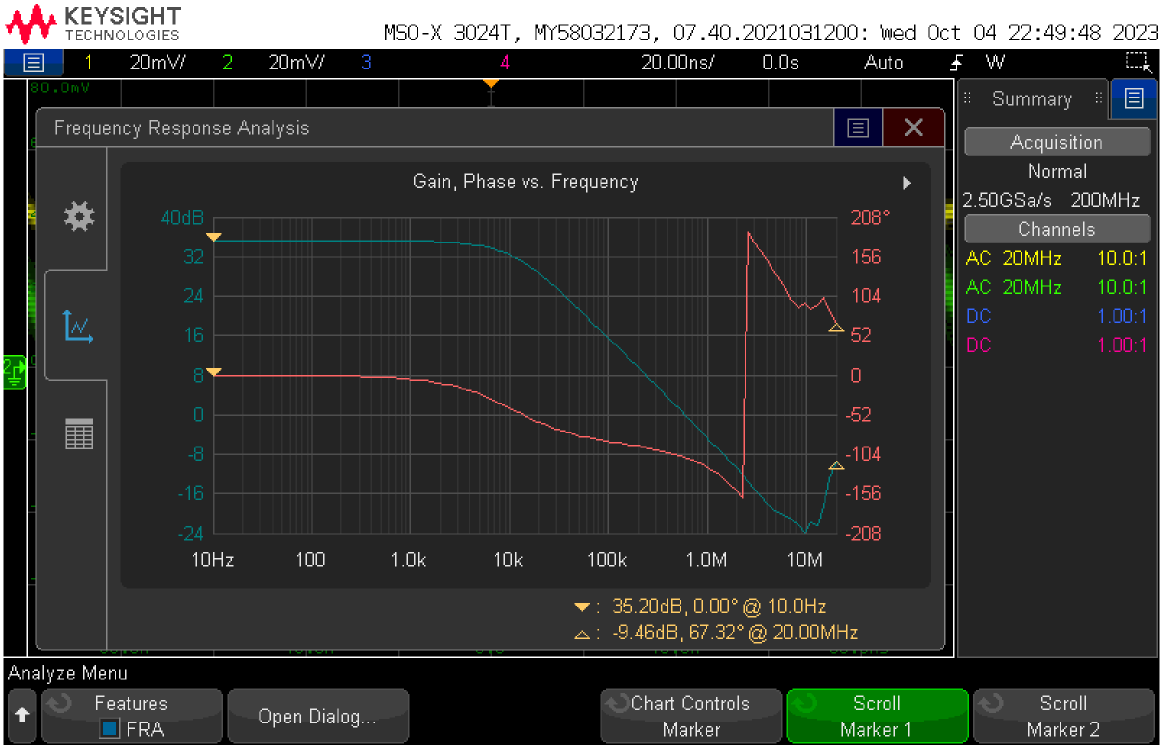
2. Magnitude and phase Bode Plots

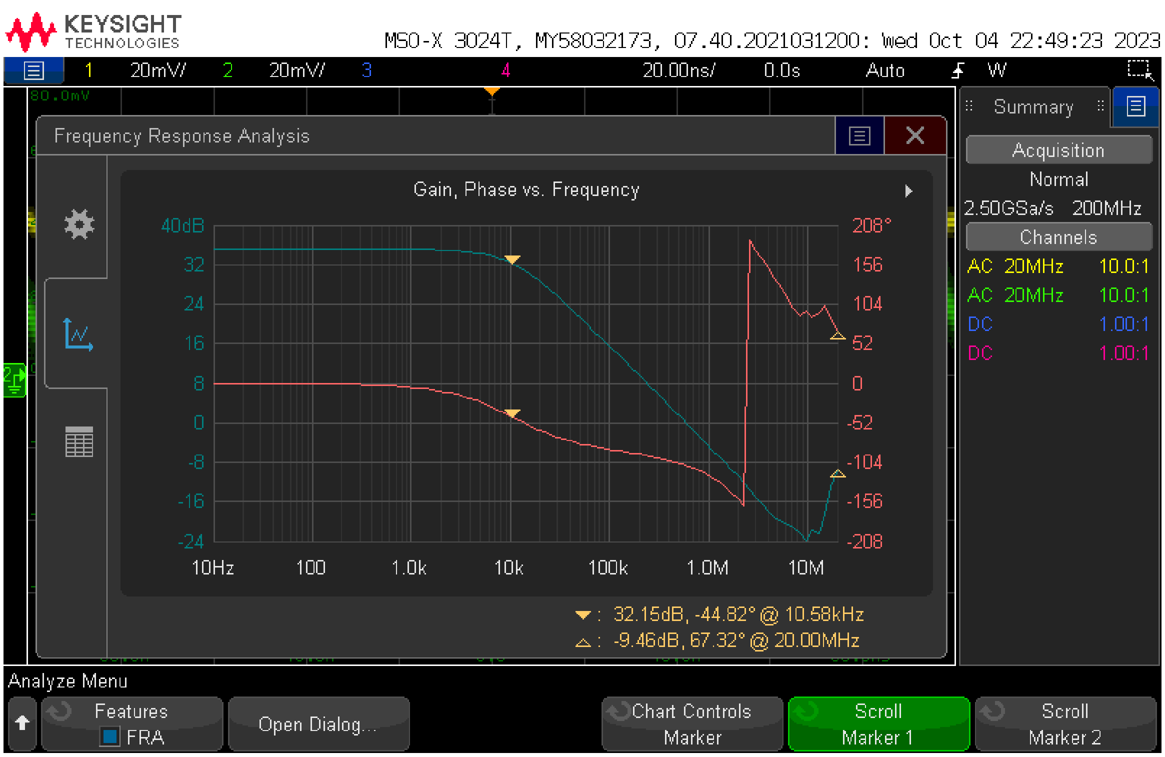


3. Low Frequency Gain

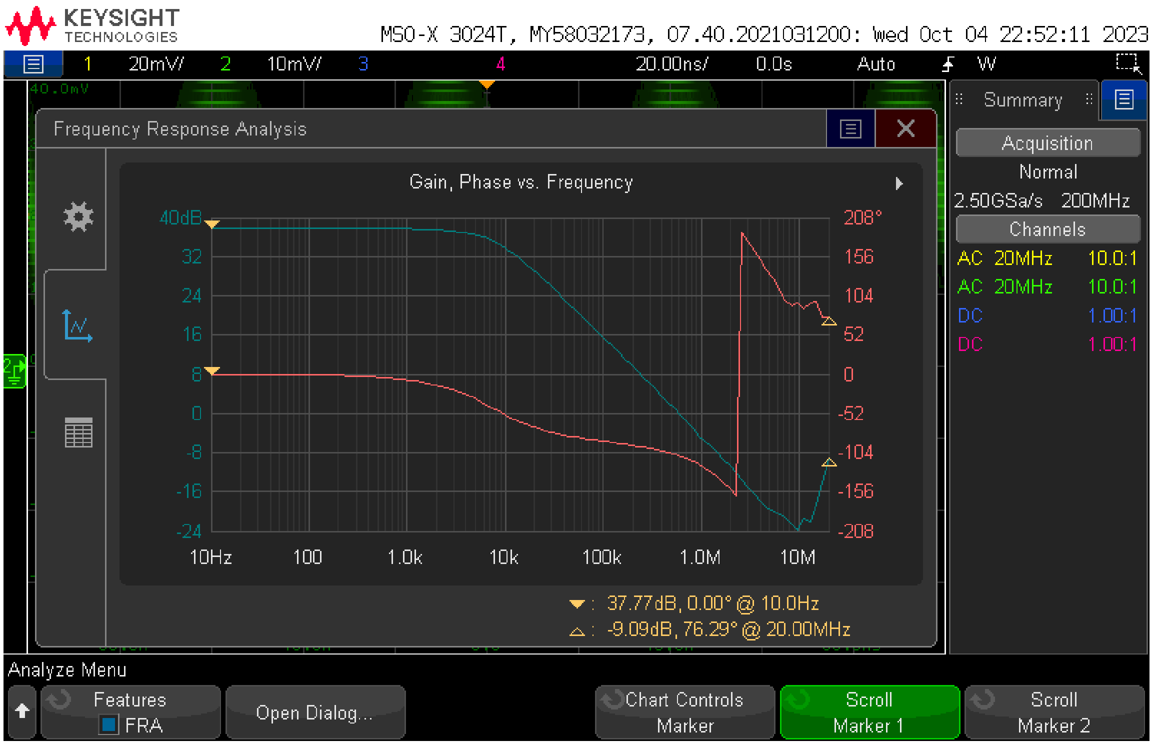


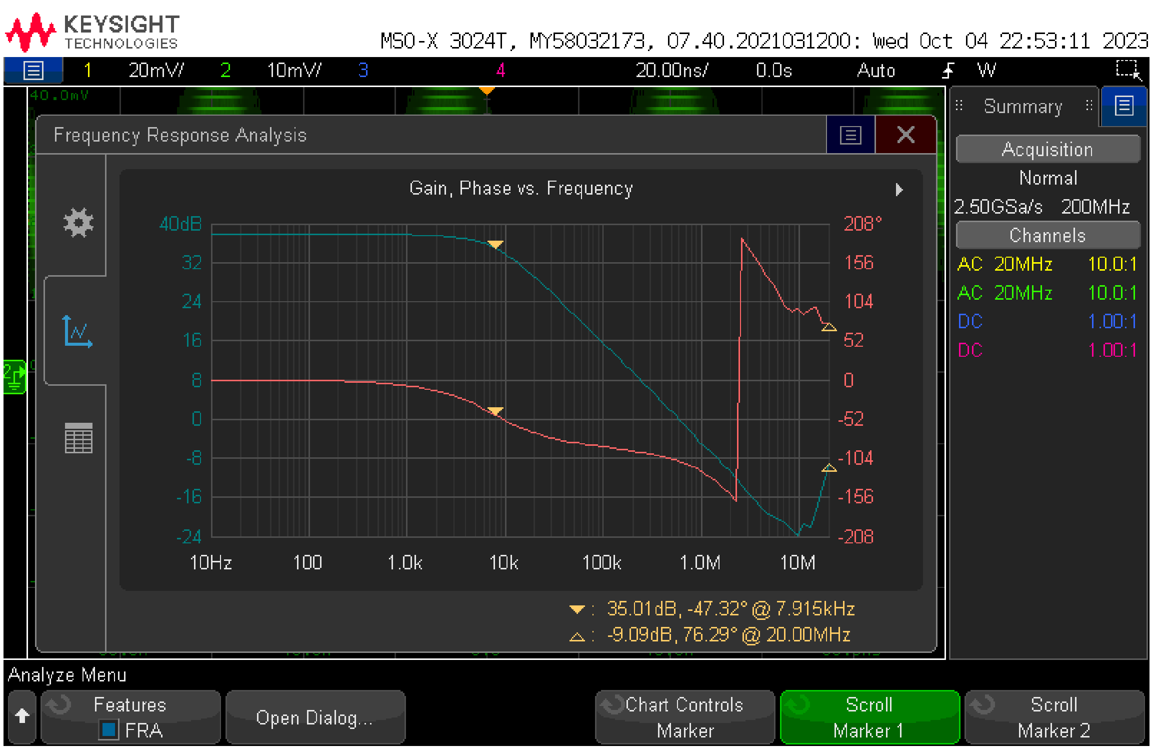
4a. Parts repeated for 57 gain





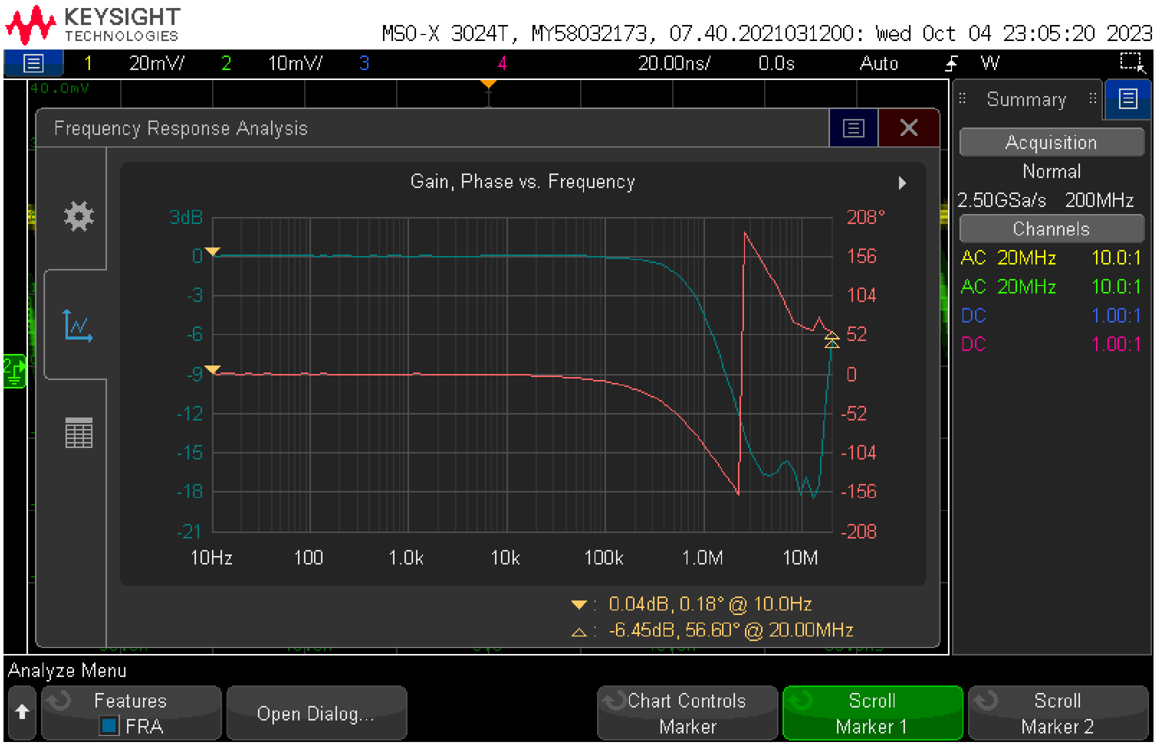
4b. Parts repeated for 83 gain



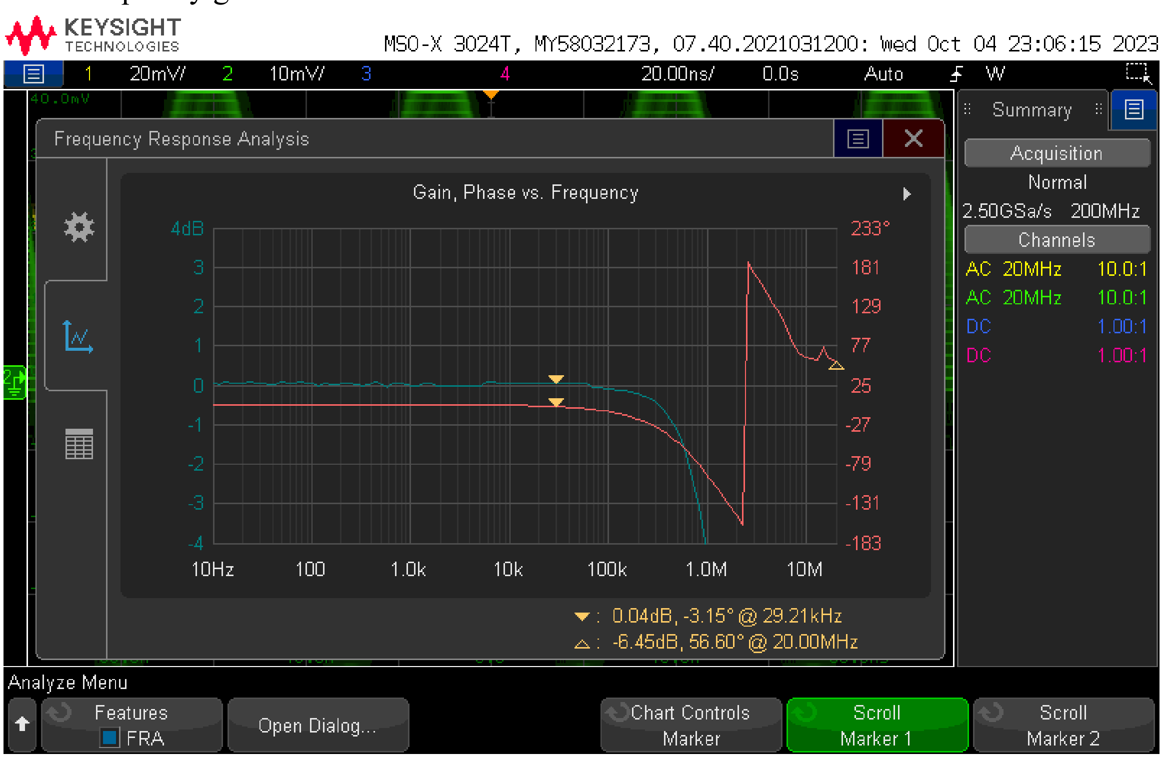


Slew Rate Limitations

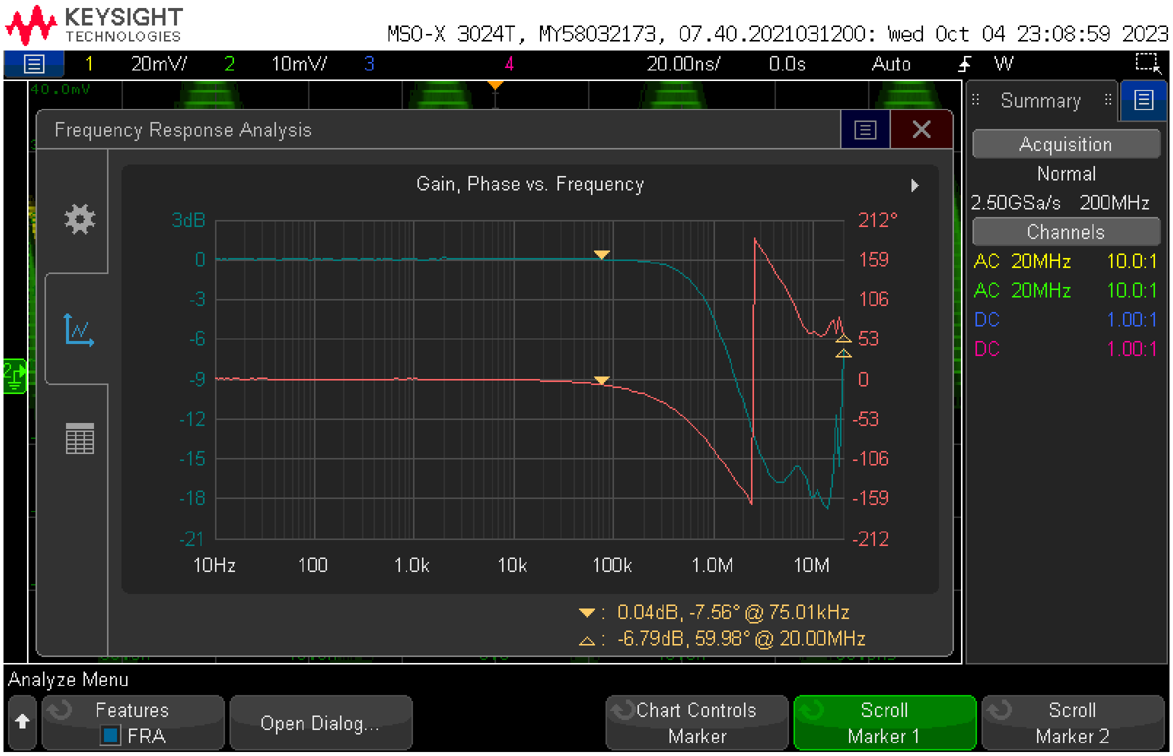
2a. Low-frequency gain

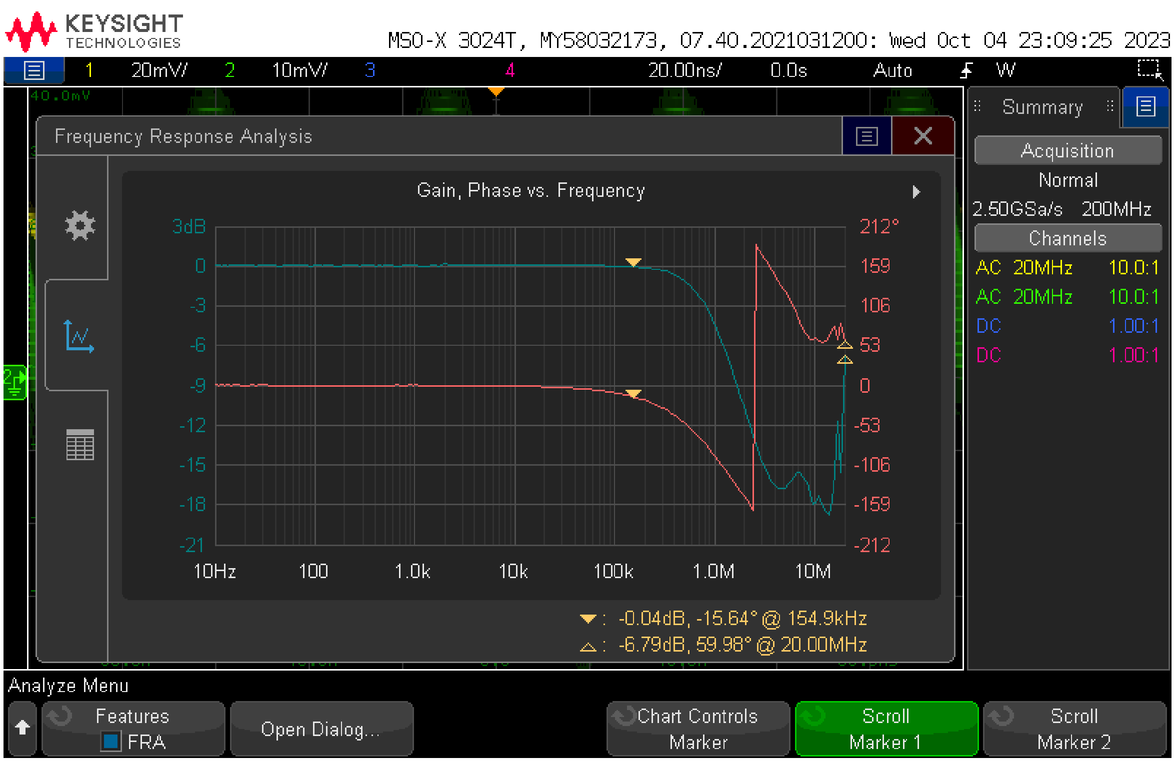


2b. 3-dB frequency gain

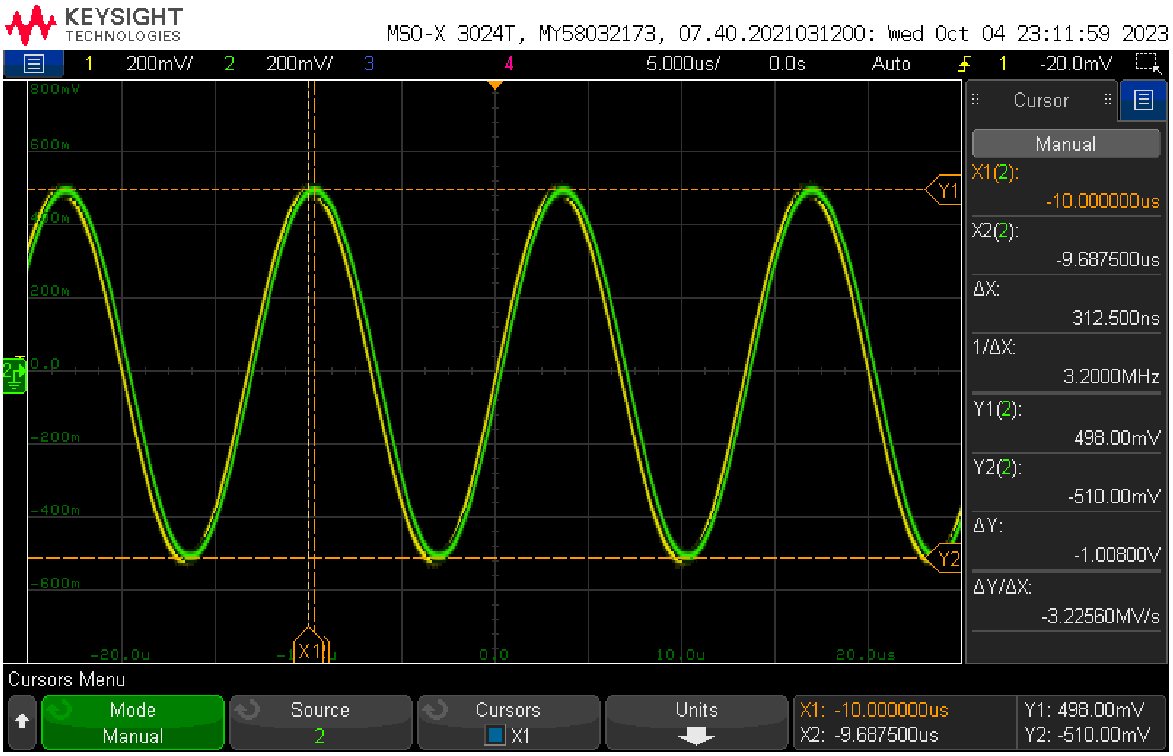


2c. Magnitude of Transfer Function

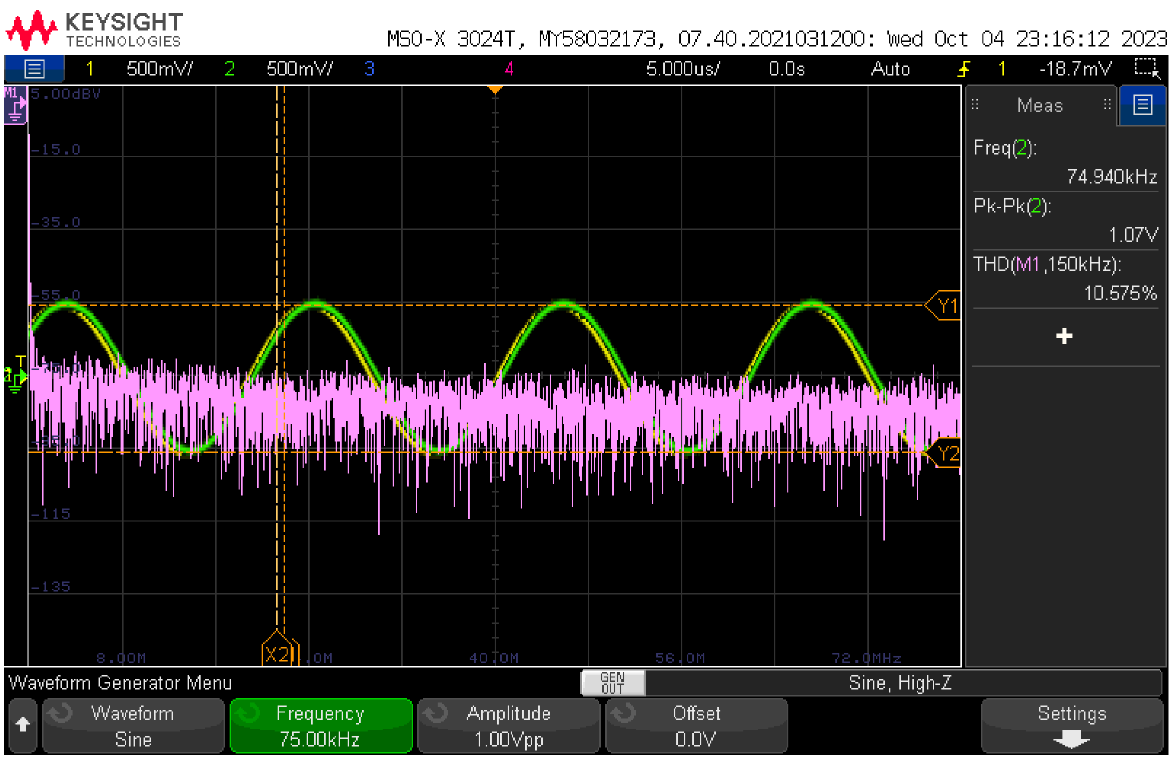




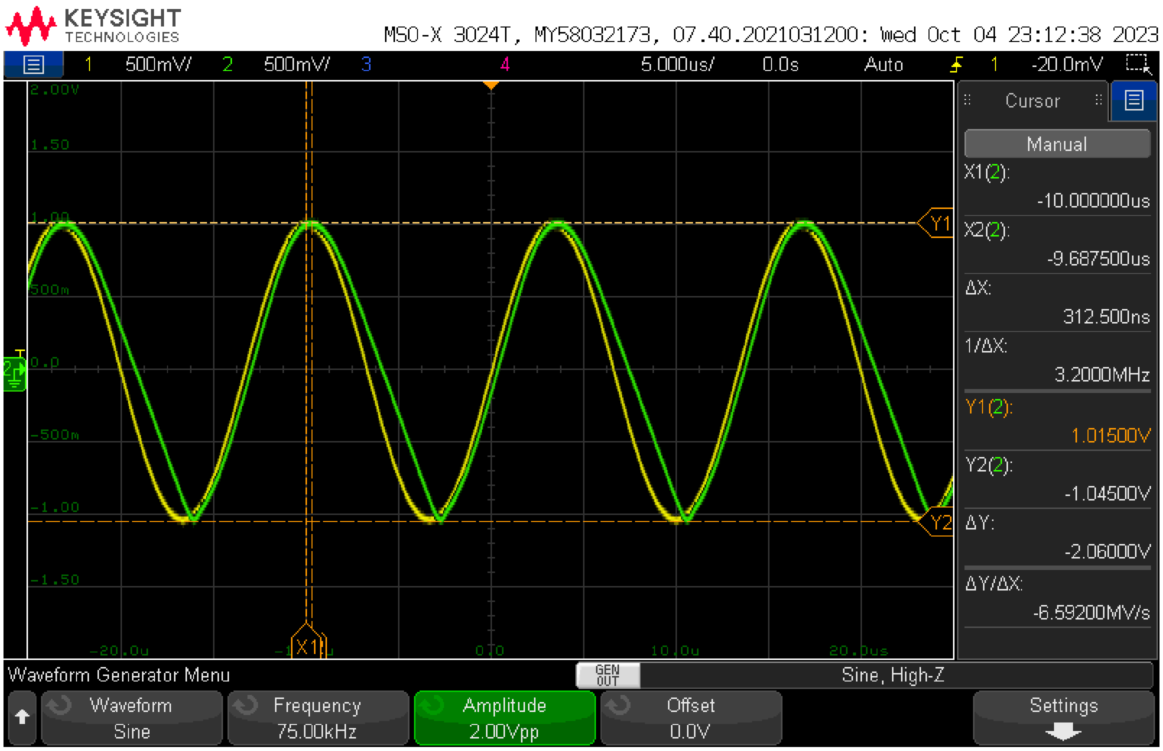
3a. 75kHz 1V sine wave time-domain waveform



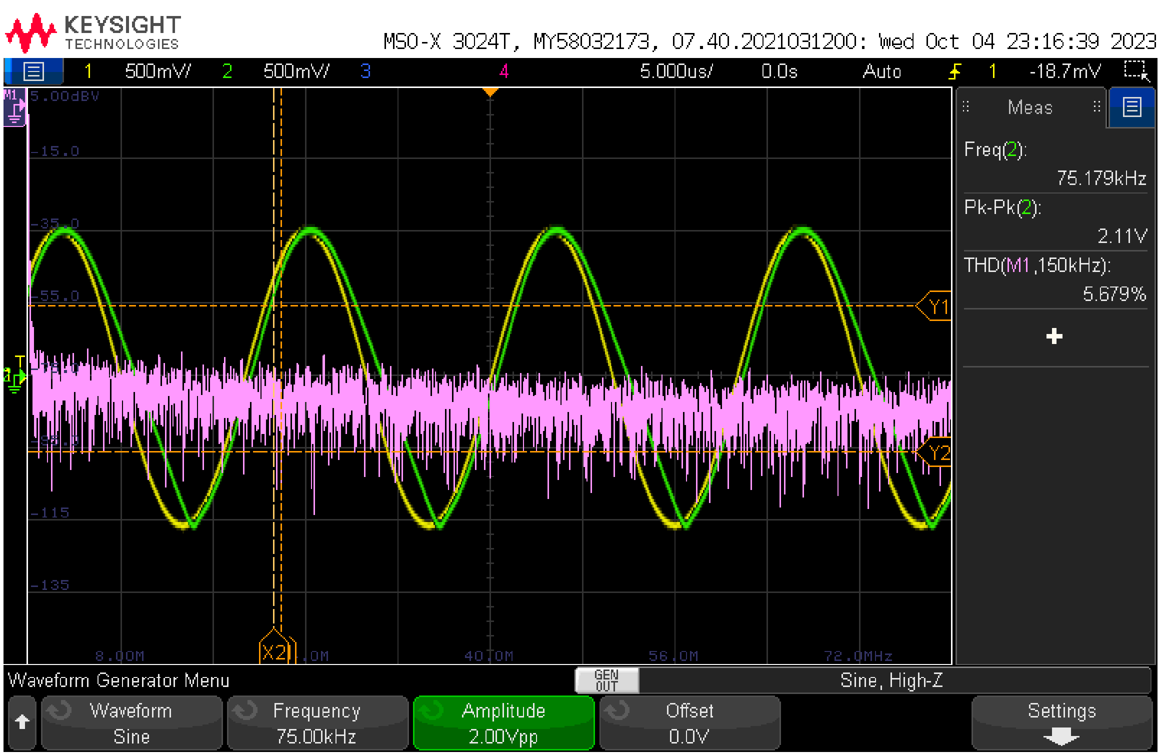
3b. 75kHz 1V sine wave total harmonic distortion



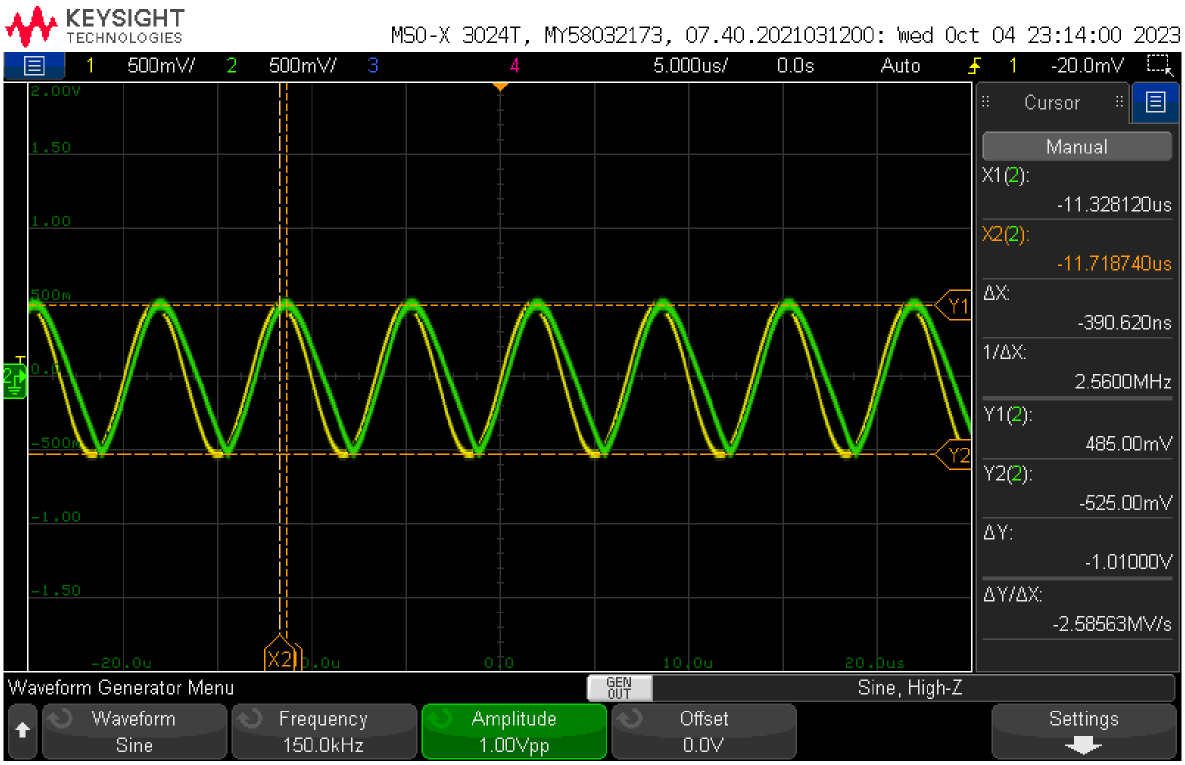
3c. 75kHz 2V sine wave time-domain waveform



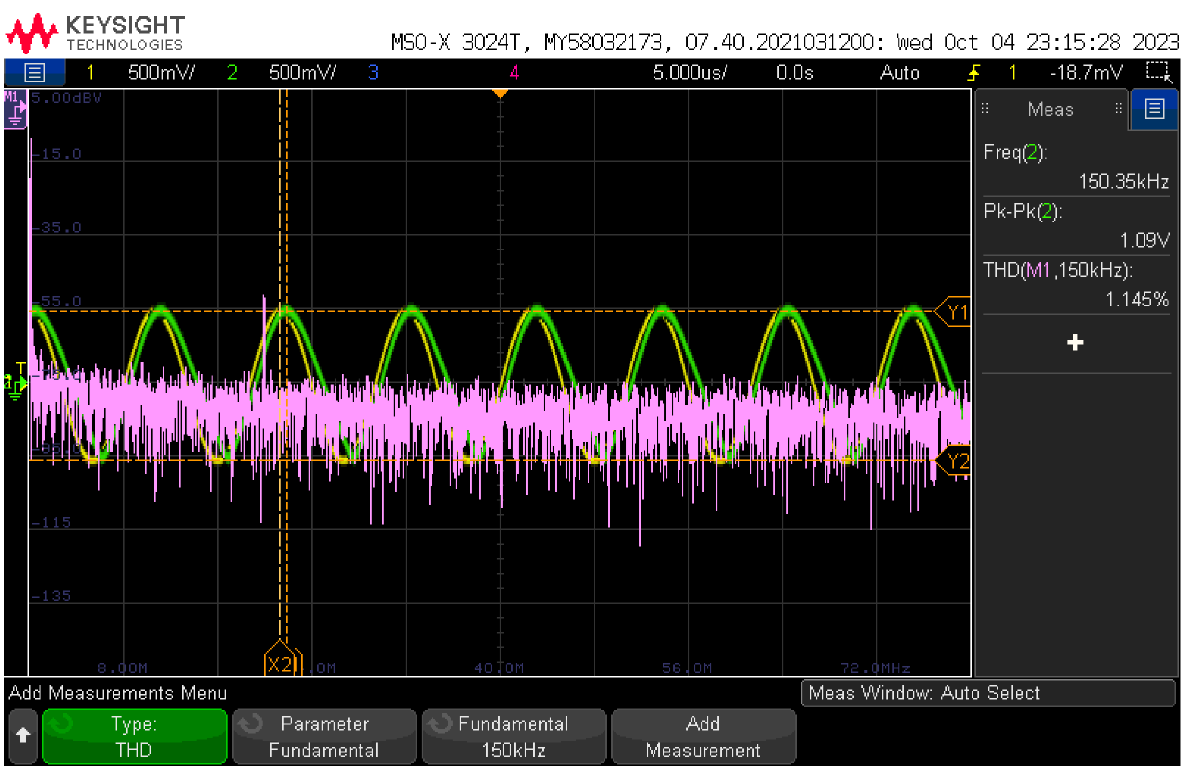
3d. 75kHz 2V total harmonic distortion



3e. 150kHz 1V time-domain waveform



3f. 150kHz 1V total harmonic distortion



Data Table:

The provided data table is a good way to organize and present our range of simulated and measured values. It is divided into three distinct sections: Lossy Integrator, Pseudo Differentiator, Finite GBW, and Slew Rate which correspond to different stages and aspects of the experiment or analysis. This format simplifies the detection of inconsistencies, allows for easy comparison of results across different methods or frequency domains, and ensures transparency and data integrity. By structuring data in this manner, we can efficiently manage and reference our findings, enhancing the clarity and reliability of our work.

	Simulated	Measured
Lossy Integrator low-frequency gain	26.78 dB	27 dB
Lossy Integrator 3 dB frequency	36.55 kHz	37 kHz
Lossy Integrator magnitude at 1kHz	-3.11 dB	-3 dB
Lossy Integrator phase at 1kHz	91.75 degrees	92 degrees
Lossy Integrator sine wave input voltage	497.598 mV	234 mV
Lossy Integrator sine wave output voltage	68.40 mV	174 mV
Lossy Integrator sine wave phase	91.6 degrees	270°
Lossy Integrator square wave peak to peak voltage	556.37 mV	262 mV
Pseudo Differentiator low-frequency gain	-60 dB	-25 dB
Pseudo Differentiator 3 dB frequency	58.71 kHz	33.77 kHz
Pseudo Differentiator magnitude at 1kHz	13.61 dB	14 dB
Pseudo Differentiator phase at 1kHz	-101.96 degrees	-100 degrees
Pseudo Differentiator sine	99.86 mV	86 mV

wave input voltage		
Pseudo Differentiator sine wave output voltage	449.25 mV	426 mV
Pseudo Differentiator sine wave phase	106.5 degrees	102.24°
Pseudo Differentiator triangular wave peak to peak voltage	290.4 mV	278 mV
Finite GBW Low frequency R2 = 23	27.21 dB	27.34 dB
Finite GBW 3-dB frequency R2 = 23	47.58 kHz	29.21 kHz
Finite GBW Low frequency R2 = 57	35.08 dB	35.2 dB
Finite GBW 3-dB frequency R2 = 57	19.64 kHz	10.58 kHz
Finite GBW Low frequency R2 = 83	38.31 dB	37.77 dB
Finite GBW 3-dB frequency R2 = 83	13.21 kHz	7.915 kHz
Slew Rate low frequency	0 dB	0 dB
Slew Rate 3-dB frequency	1.55 Mhz	0.99 MHz
Slew Rate magnitude 75kHz	36.5 uV	498 mV
Slew Rate magnitude 150kHz	447.43 uV	485 mV
Slew Rate 75kHz 1V sine wave THD	0.656%	10.575%
Slew Rate 75kHz 2V sine wave THD	11.66%	5.679%
Slew Rate 150kHz 1V sine wave THD	11.15%	1.145%

Lossy Integrator sine wave phase

$$|H| = \frac{V_{out}}{V_{in}} = \frac{234mV}{174mV} = 1.345$$

$$\Delta t = (-1mS - (-1.75mS) = 750\mu S \Rightarrow T = \frac{1}{f} = \frac{1}{1000} = 0.001S,$$

$$\angle H = \frac{\Delta t}{T} \times 360^{\circ} = \frac{750\mu S}{0.001S} \times 360^{\circ} = 270^{\circ}$$

Pseudo Differentiator sine wave phase

$$|H| = \frac{V_{out}}{V_{in}} = \frac{86mV}{426mV} = 0.202$$

$$\Delta t = (-437.5\mu S - (-721.9\mu S) = 284\mu S \Rightarrow T = \frac{1}{f} = \frac{1}{1000} = 0.001S,$$

$$\angle H = \frac{\Delta t}{T} \times 360^{\circ} = \frac{284\mu S}{0.001S} \times 360^{\circ} = 102.24^{\circ}$$

Results:

In summary, this lab experiment demonstrated a strong correlation between our theoretical predictions and real-world measurements, affirming our understanding of circuit concepts. There were a few discrepancies found within our data when compared to prelab. While the exact causes remains unclear,the error serves as a reminder of the complexities in practical circuits, influenced by factors like environmental interference and component variations. Future experiments should explore error mitigation strategies. This experience emphasizes the importance of bridging theory and practice in electrical engineering education.