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Date: 08.12.2024

EEE 313 Electronic Circuit Design
Lab #4 Experimental Report
Wide-Band Amplifier with Feedback

1)Introduction

The objective of this lab is to design a two-stage amplifier with feedback to achieve both a low output impedance and a flat gain across the operating range. The preliminary phase involves the design process, while the experimental phase focuses on hardware implementation. While the use of BJTs, MOSFETs, or a combination of both was permitted, I have used BJT's for this lab. This choice was based on BJTs' relatively simpler parameter set, which offers more predictable current control compared to MOSFETs.

In the hardware implementation phase, the design from the preliminary work was directly applied, ensuring consistency between theoretical and practical results. Standard resistor values were incorporated as recommended for ease of assembly and procurement. The design specifications were meticulously followed to meet the stated objectives. Additional considerations included ensuring stability, maintaining consistent biasing across both stages, and evaluating the frequency response to ensure the amplifier meets performance requirements across its intended operating range. Design Specifications can be observed as:

- Source impedance: 500Ω
- Load impedance: 47Ω
- Mid band voltage Gain: 20 dB±0.5dB
- Bandwidth (−3dB): at least 2KHz to 2MHz (by CNTL-Click in AC analysis)
- Supply voltage: 12V (single supply)
- Maximum current consumption: 70mA from the supply voltage
- Undistorted peak-to-peak output voltage: 2Vpp at 200KHz.

- Distortion at the output: Harmonics less than −30dBc at 200KHz 2Vpp output voltage (the difference between the fundamental and the highest harmonic in FFT window)

In order to accomplish the lab we need to met these requirements:

1. The current consumption is less than 70mA

2. The bandwidth is at least 2KHz-2MHz while the mid-band gain is 20dB±0.5dB (measure at 2KHz, 200KHz and 2MHz). Adjust the signal generator to 50mV peak (meaning it generates 200mV peak-to-peak) and insert a 470Ω resistor in series with the signal generator to simulate RS=500Ω. The output voltage across RL=47Ω should be 2V peak-to-peak.

3. The harmonic content of the output voltage is better than −30dBc at 200KHz.

To further gain insight about the amplifier we should determine:

4. The small-signal input impedance of the amplifier at 200KHz (with RL=47Ω, adjusted value of RS until the voltage gain drops to half its value compared to RS=0)

5. The small-signal output impedance of the amplifier at 200KHz (with RS=500 Ω, adjusted value of RL until the voltage gain drops to half its value compared to RL=∞ while applying the smallest signal of the signal generator. Use EXT SYNC for problem-free oscilloscope measurement.)

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2)Hardware Implementation and Results

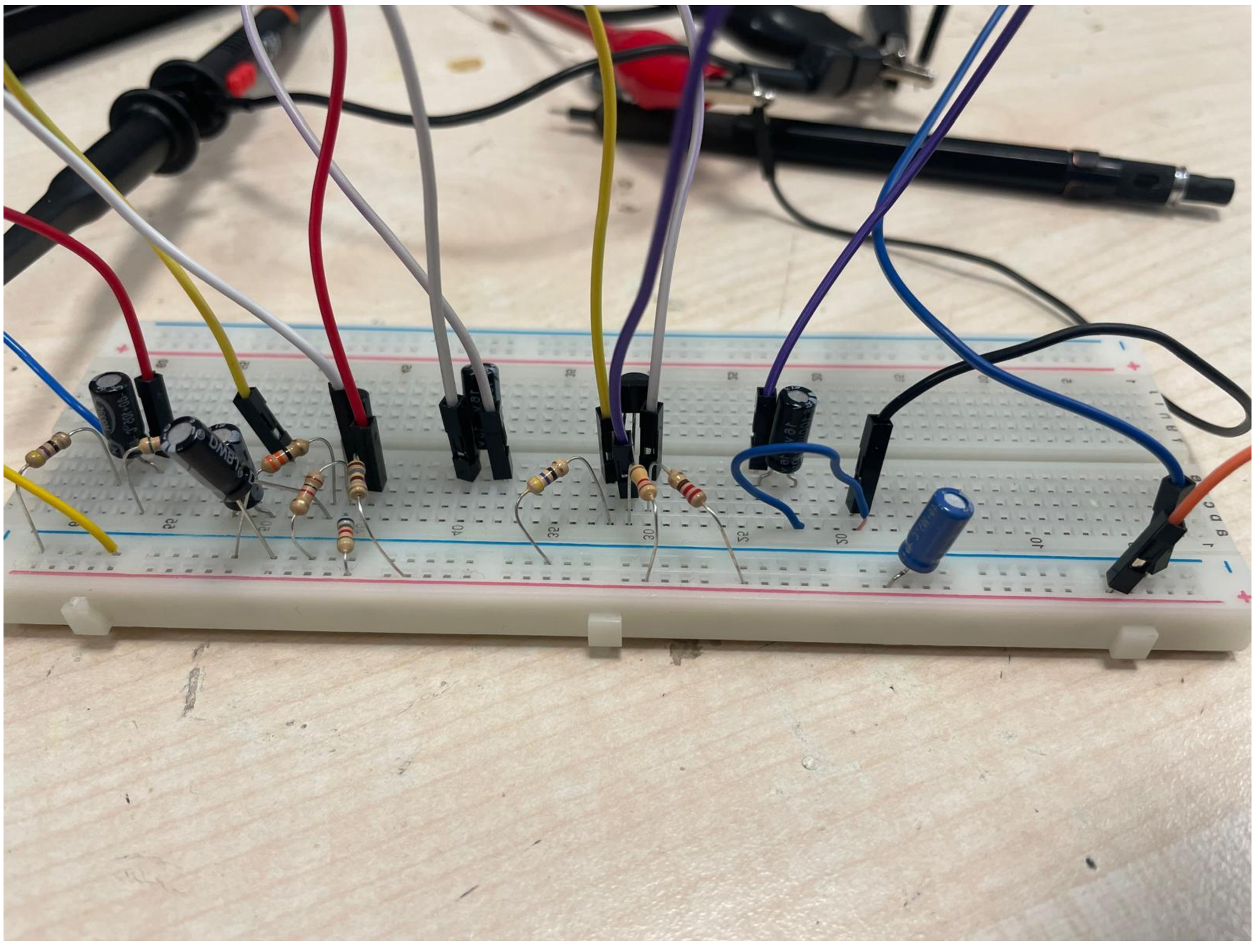

Fig.1 : Constructed Circuit

2.1) The current consumption is less than 70mA

In the software part we have found that total current consumption was around 61mA (Fig.2).

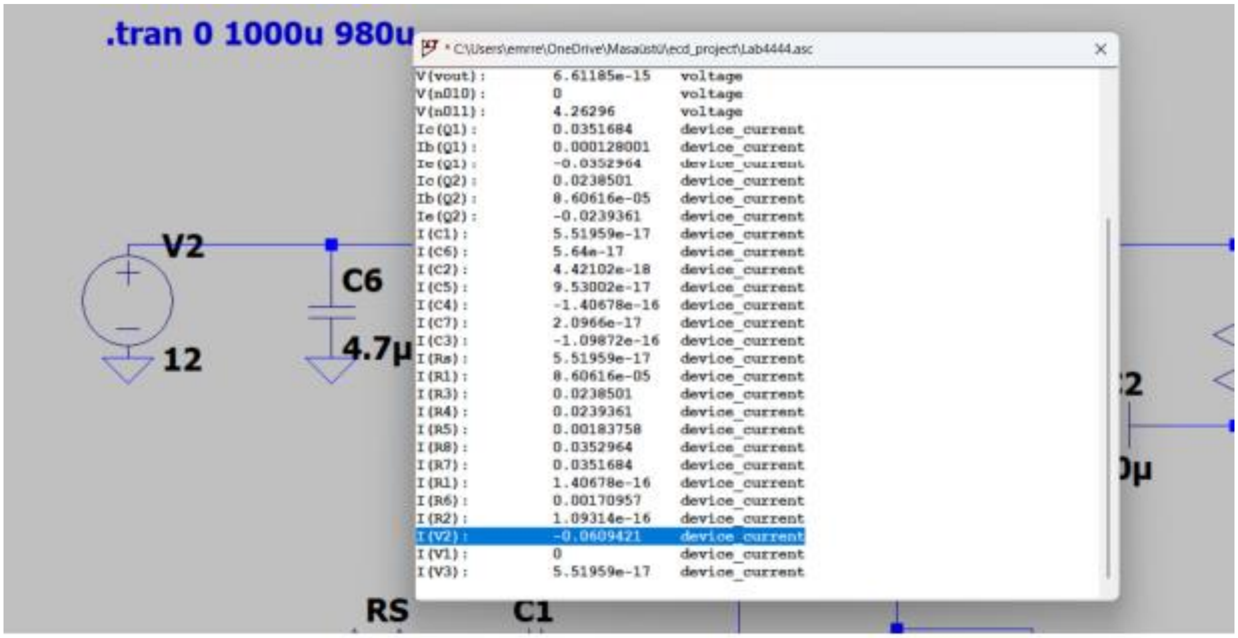

Fig.2: Current Consumption of Circuit

Hardware result was considerably close to the software value as it can be seen in Fig.3

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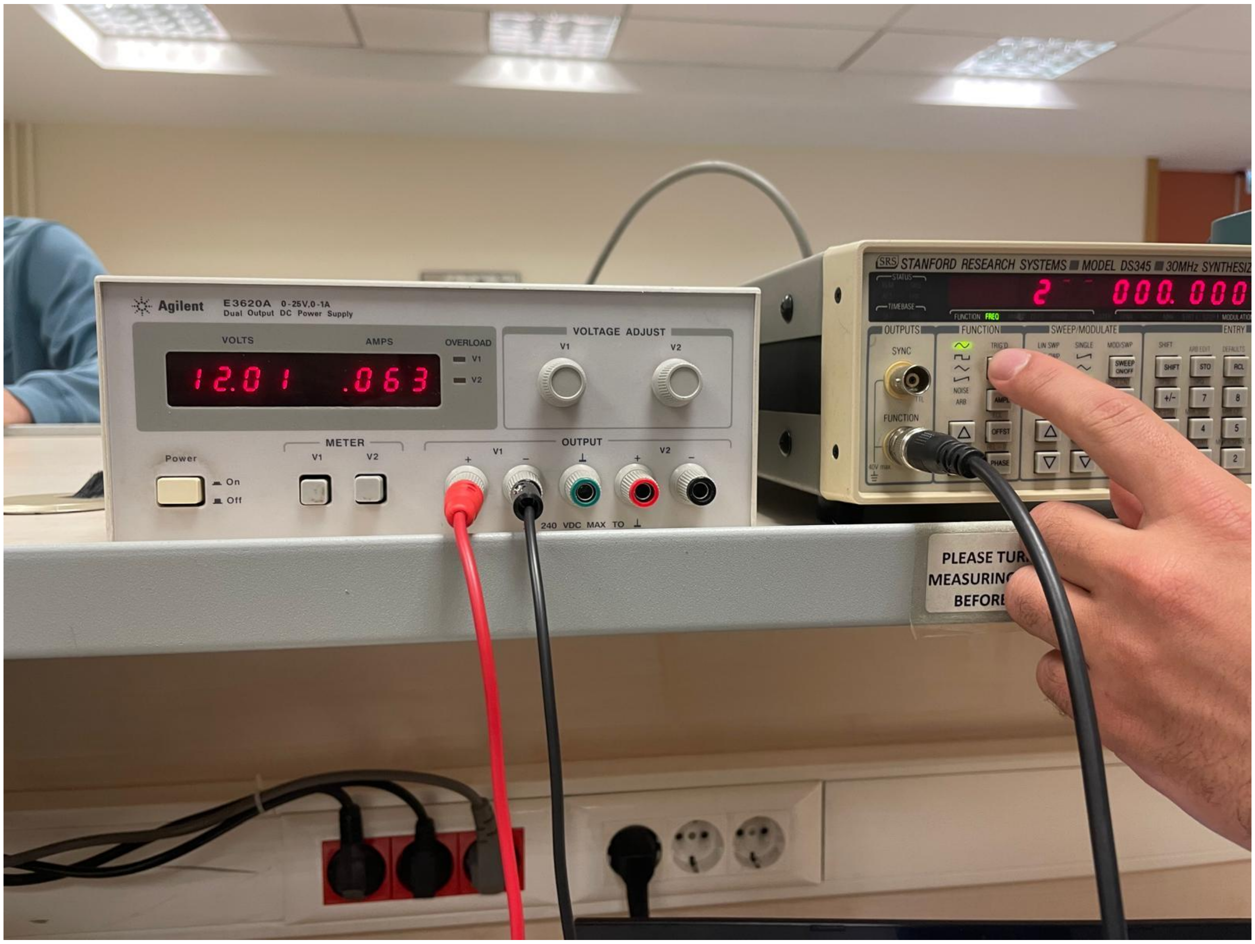

Fig.3: Current consumption of constructed circuit

Therefore, we met the first requirement. This requirement is especially important in battery powered systems. Since our power supply is not infinite we should keep the consumption as low as possible like this circuit.

2.2) The bandwidth is at least 2KHz-2MHz while the mid-band gain is 20dB±0.5dB (measure at 2KHz, 200KHz and 2MHz). Adjust the signal generator to 50mV peak (meaning it generates 200mV peak-to-peak) and insert a 470Ω resistor in series with the signal generator to simulate RS=500Ω. The output voltage across RL=47Ω should be 2V peak-to-peak.

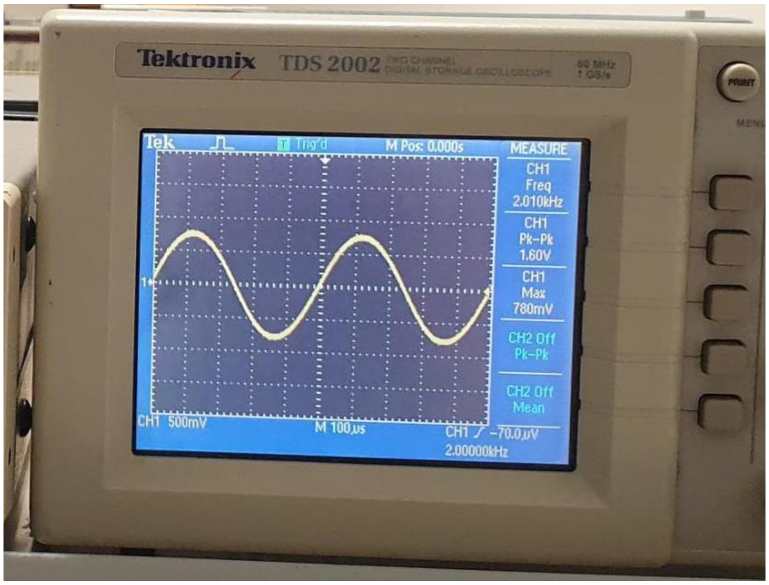

Fig.4: Output at 2KHz

As mentioned above the gain should be between (20±3) dB. Gain can be calculated as 20log(1.6/0.2)= 18.7dB which is inside the –3dB corner so the lower bound of the bandwidth is okay.

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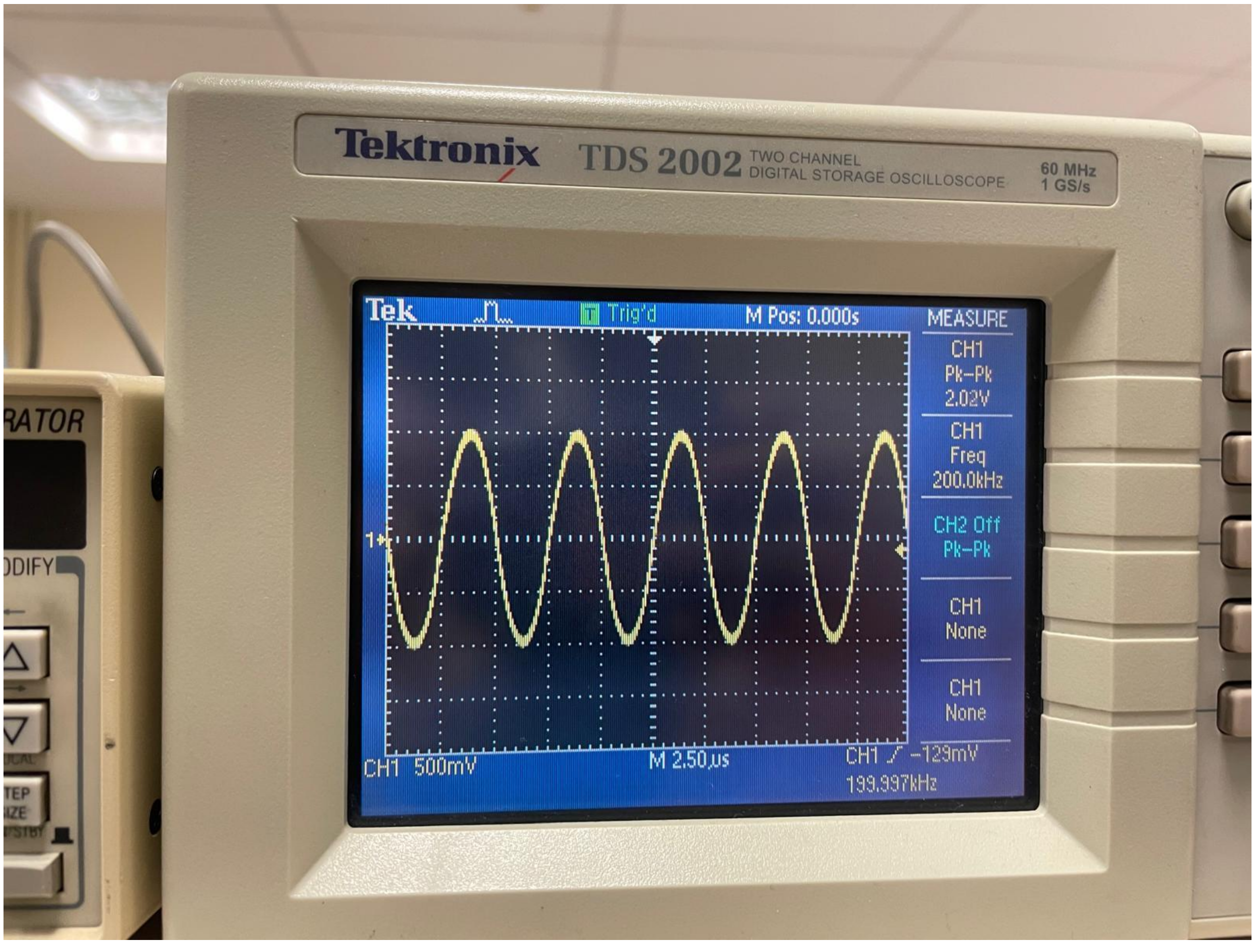

Fig.5: Output at 200KHz

As mentioned above the gain should be between (20) dB. Gain can be calculated as 20log(2.02/0.2)= 20.086 dB.

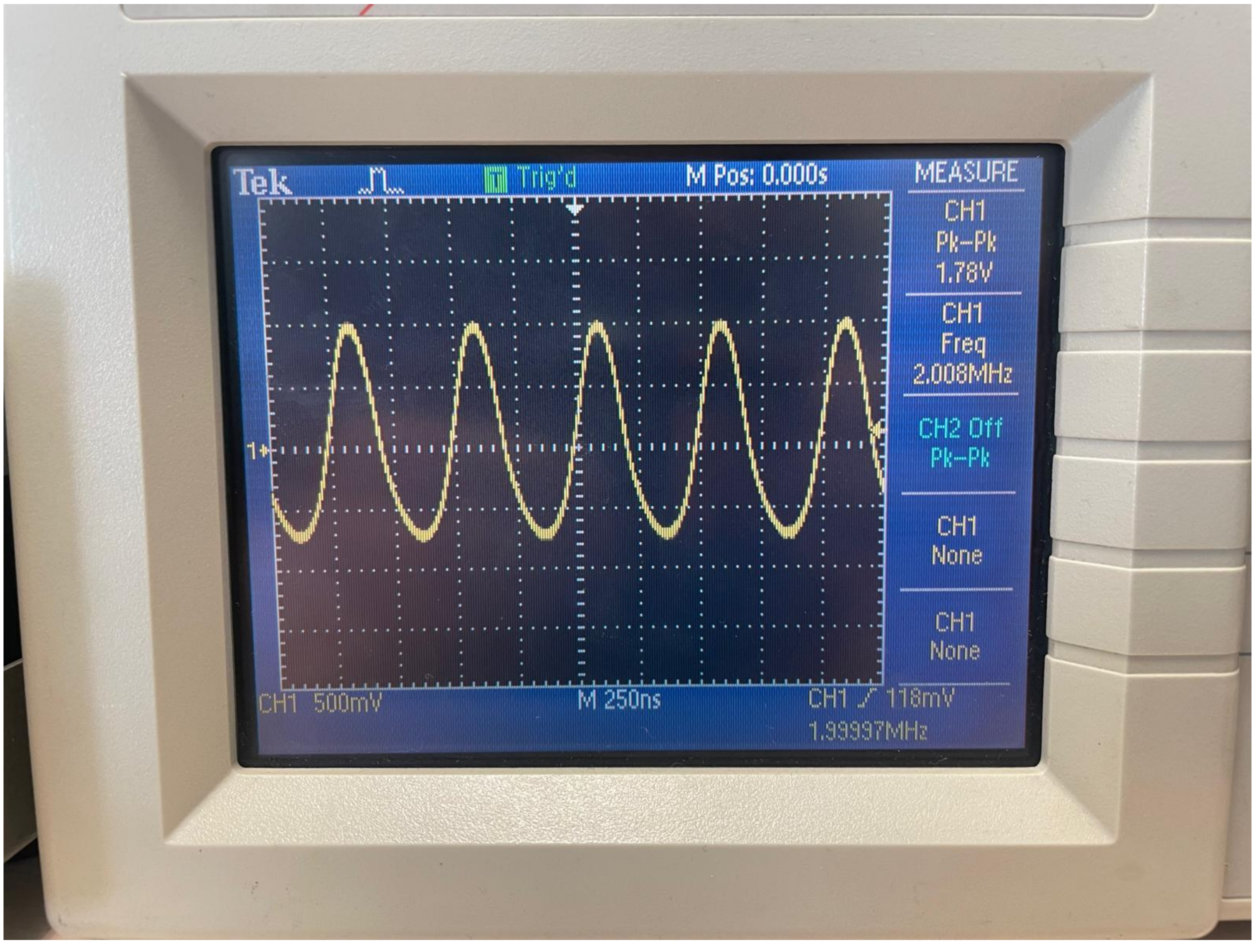

Fig.6: Output at 2Mhz

As mentioned above the gain should be between (20±3) dB. Gain can be calculated as 20log(1.78/0.2)= 18.99 dB which is inside the –3dB corner so the upper bound of the bandwidth is okay too. Therefore, criterion is met.

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2.3) The harmonic content of the output voltage is better than −30dB at 200KHz.

The FFT measurement feature of the oscilloscope was used to analyze the output signal at 200 kHz. The harmonic content was evaluated by measuring the difference between the amplitude of the fundamental frequency and the largest harmonic. The results are presented in Fig.X

Harmonics are essential to ensure signal integrity and reduce distortion in the amplifier's output. Harmonics introduce unwanted frequencies that can interfere with the desired signal, degrading overall performance. The requirement for harmonic content to be at least 30 dB lower than the fundamental helps us with getting a clean output while getting a gain in wide band.

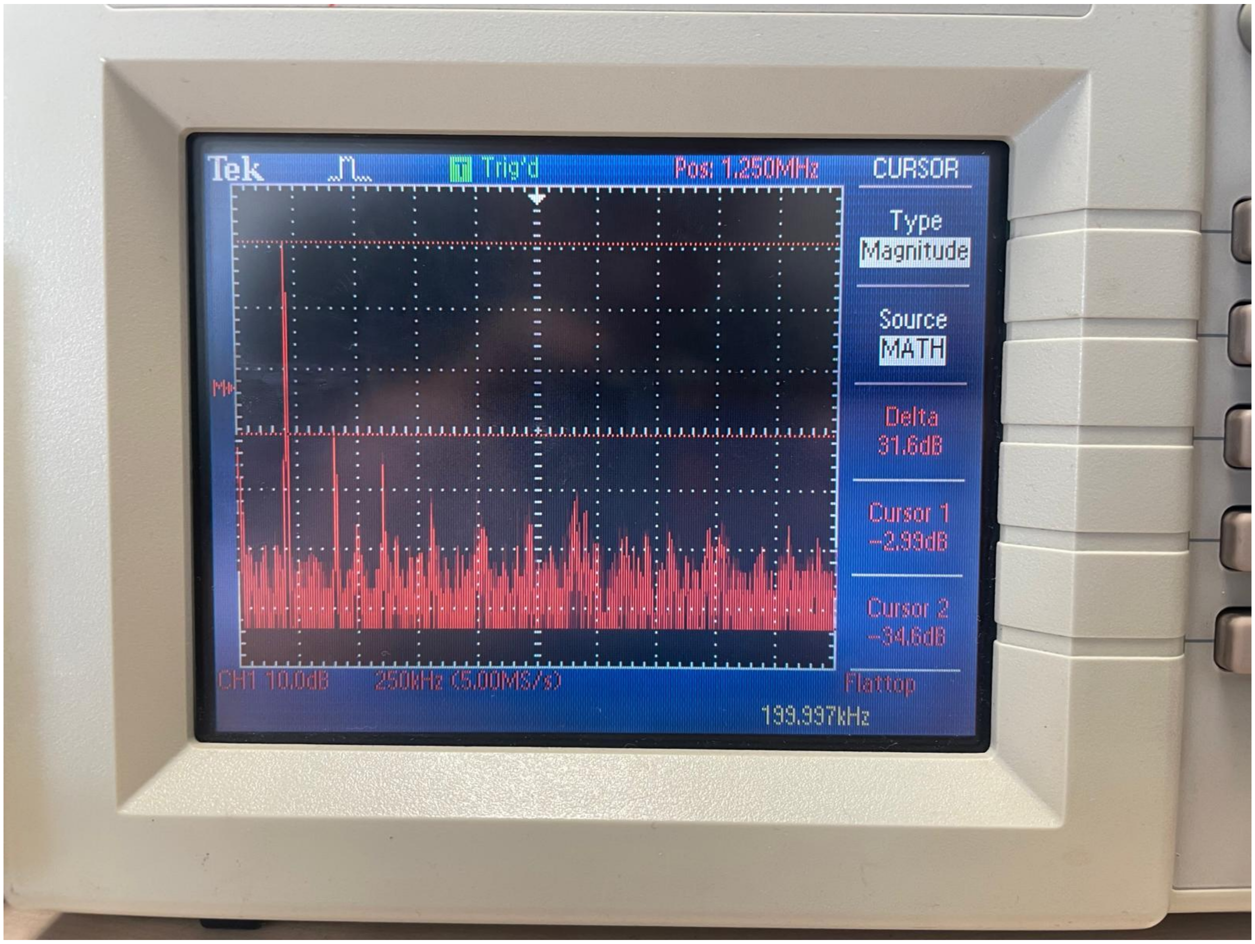

Fig.7: FFT Result

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2.4) The small-signal input impedance of the amplifier at 200KHz (with RL=47Ω, adjusted value of RS until the voltage gain drops to half its value compared to RS=0Ω)

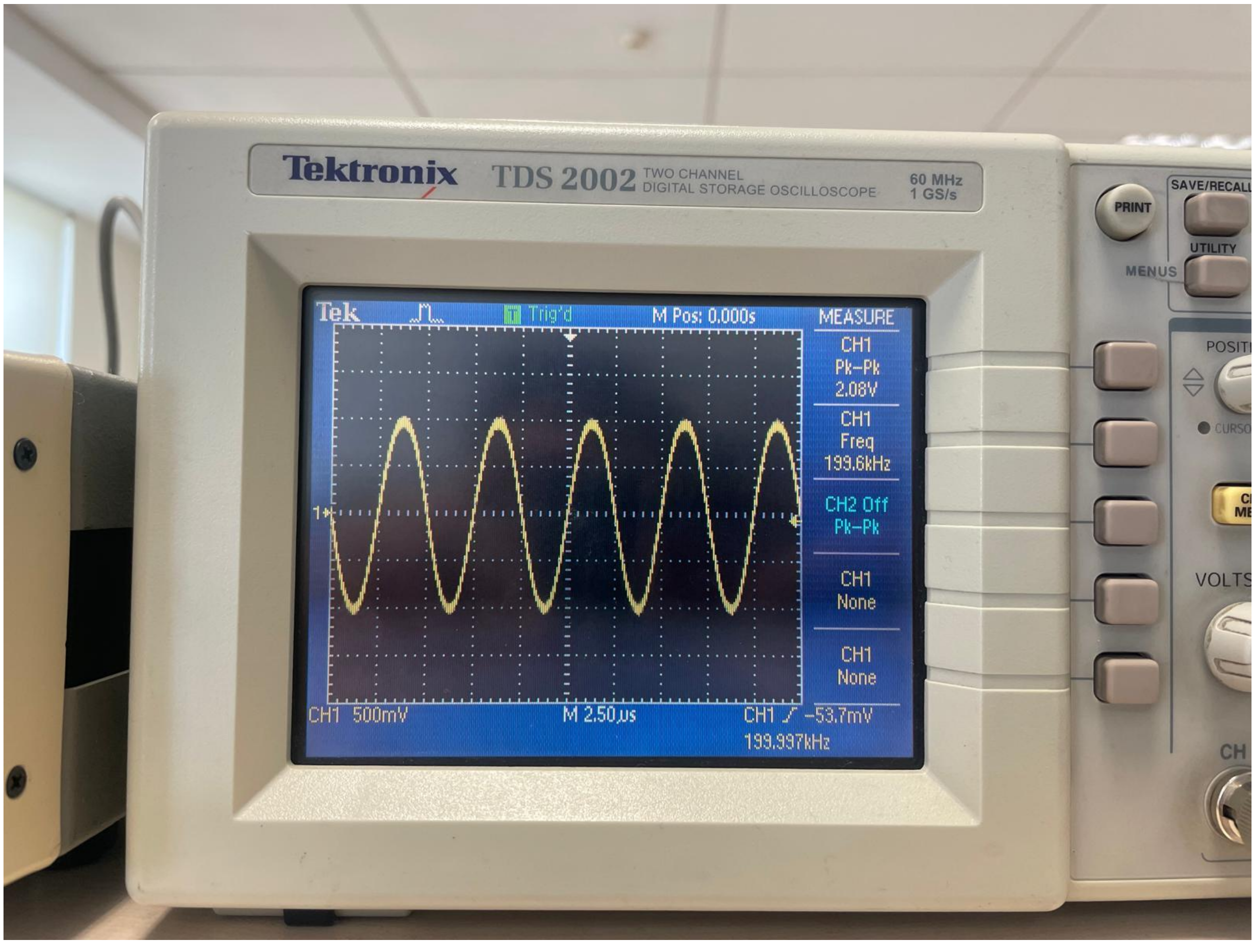

Fig.8: Output When Rs=0

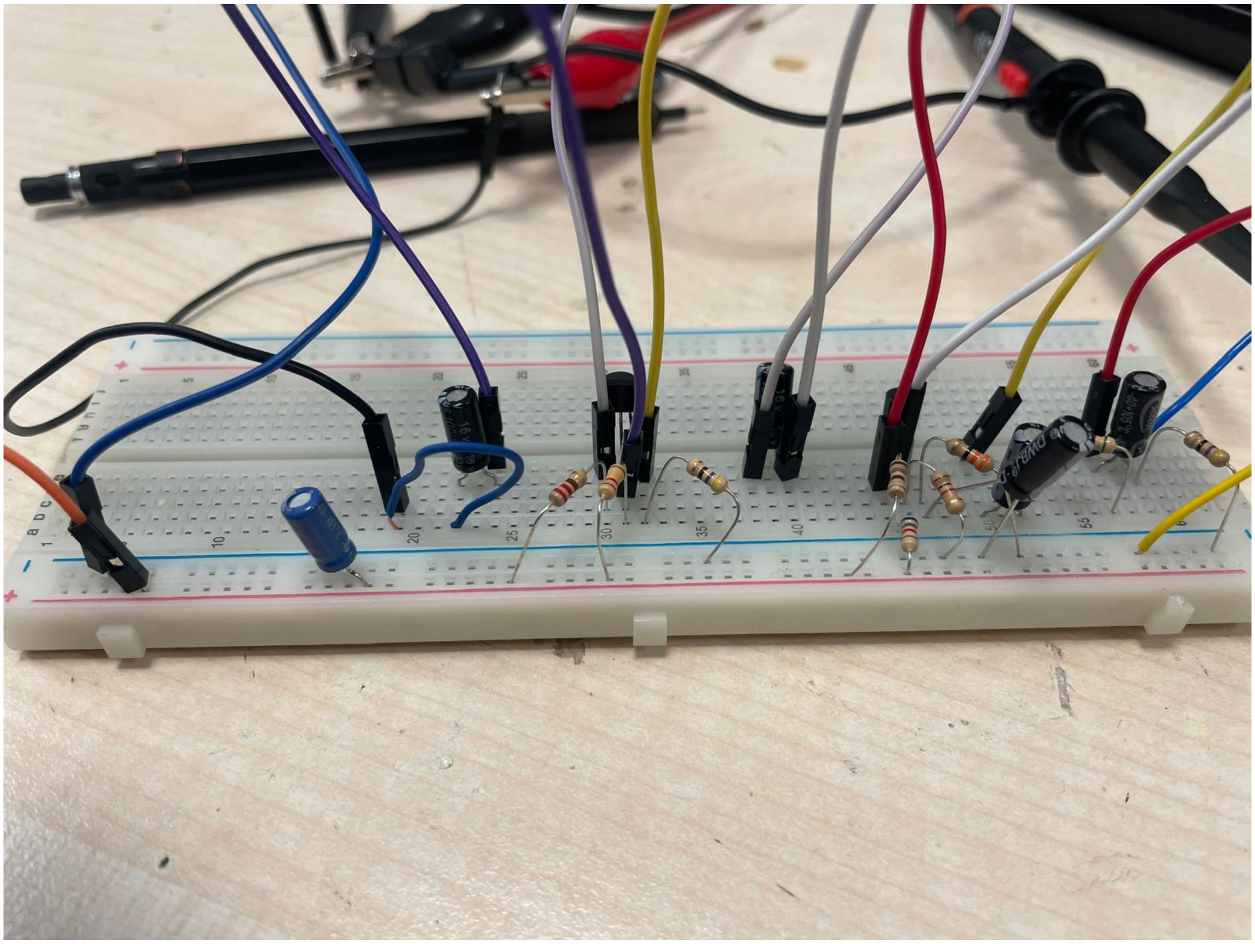

Fig.9: Rs is shorted

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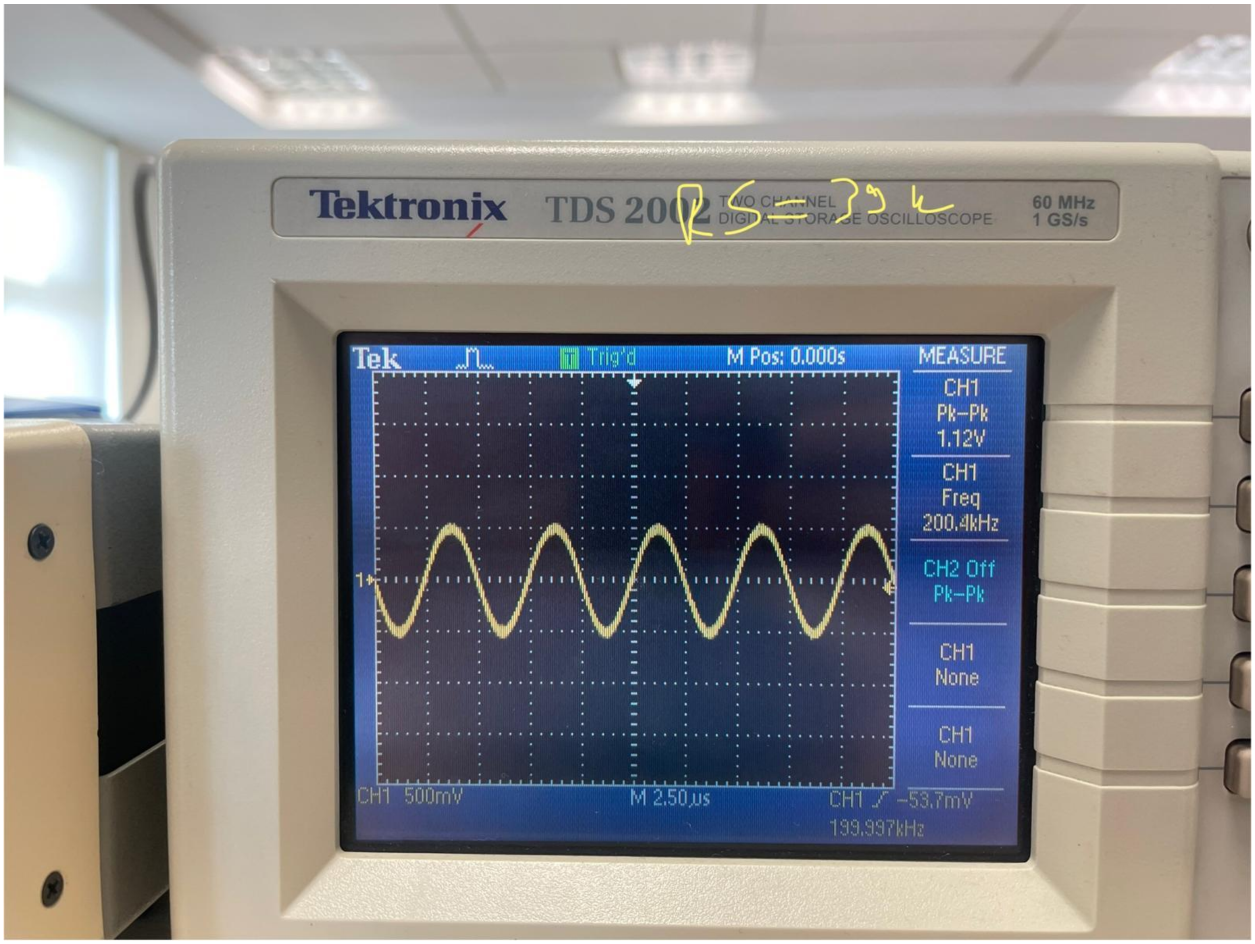

Fig.10: Output When Rs=39K

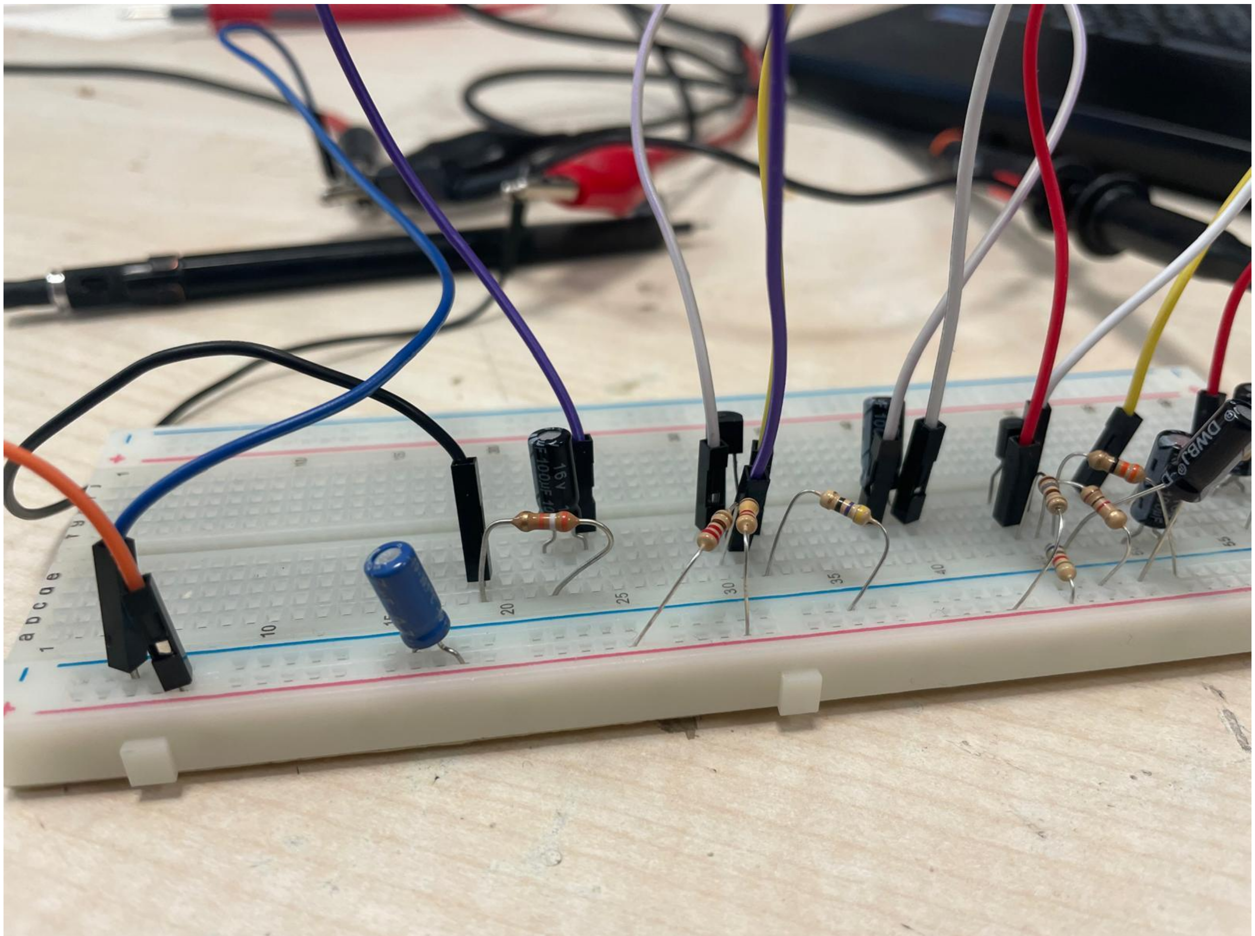

Fig.11: Rs is 39 K ohm

2.5) The small-signal output impedance of the amplifier at 200KHz (with RS=500 Ω, adjusted value of RL until the voltage gain drops to half its value compared to RL=∞

The values obtained are observed when given input signal is 0.1 V_{pp} as before not 0.01V.

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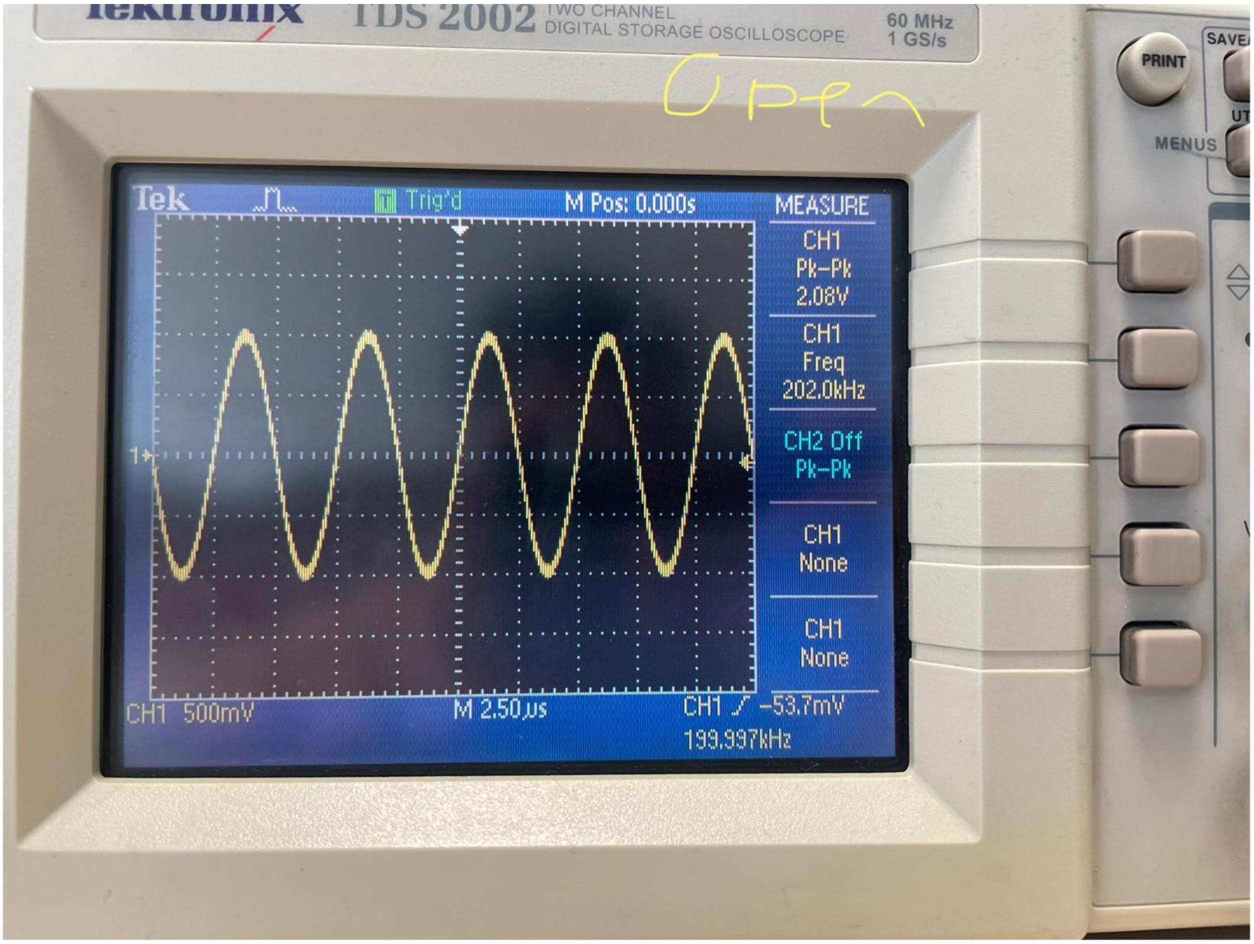

Fig.12: Output when RL is open circuited

Calculated gain is around 20.1 dB

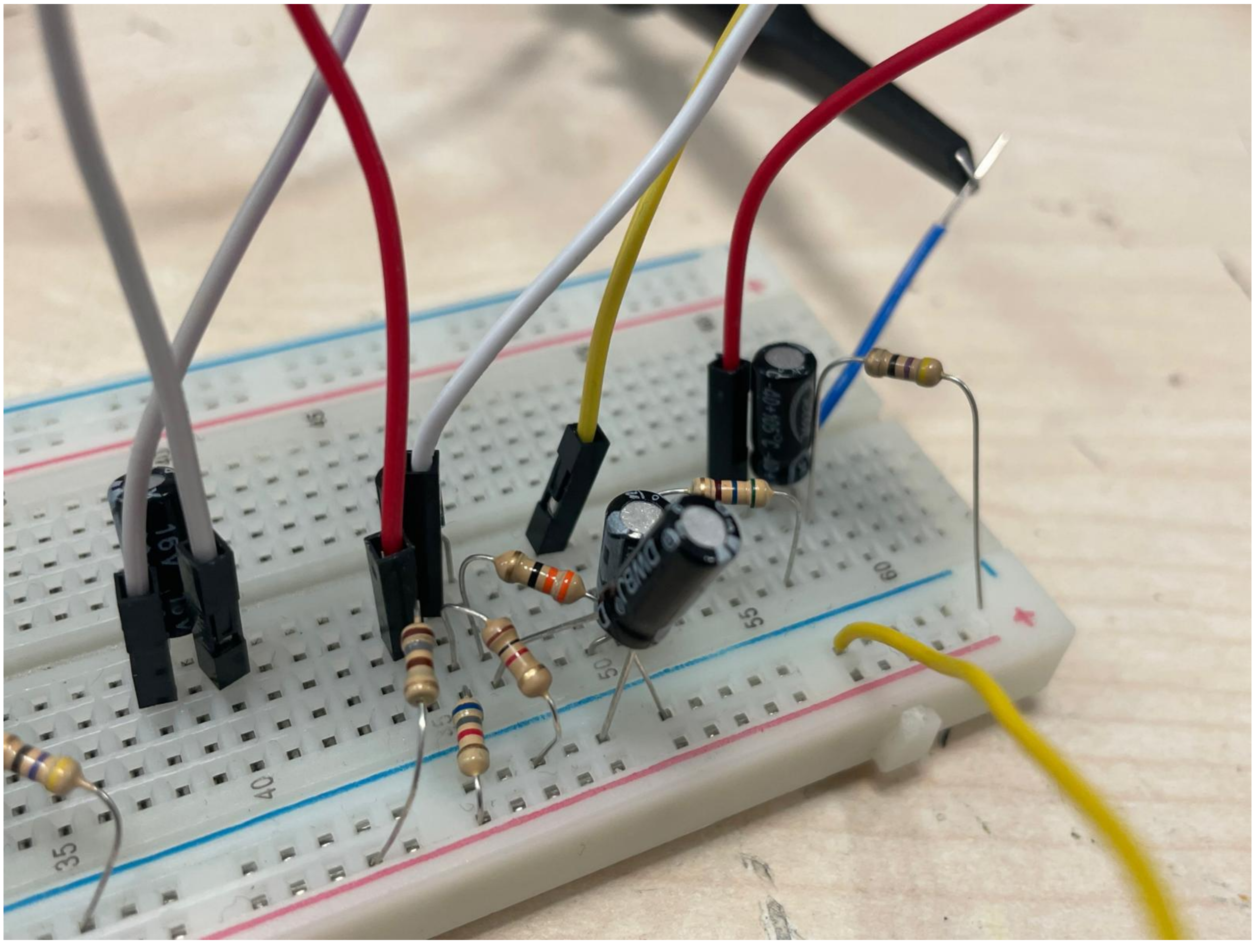
Fig.13: Open circuited R_L

Output when R_L= 10 Ω is around 630 mV but I forgot to take a photo but the calculated gain is 9.96 dB which is nearly the half.

Conclusion

The experiment successfully achieved its objective of designing and implementing a two-stage wide-band amplifier with feedback to ensure a low output impedance and a flat gain across a the required bandwidth which from 2KHz to 2MHz . Circuit created, fully met

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the required specifications, demonstrating the effectiveness of feedback in stabilizing both gain and output impedance.

While the experimental results were closely aligned with the simulation outcomes, some deviations were observed, as expected. These discrepancies stem from real-world factors such as the non-ideal characteristics of components, potential defects in the breadboard, environmental variations in the laboratory (e.g., temperature fluctuations), and the inherent possibility of human error during circuit assembly. Unlike simulations, which assume ideal conditions, real-world implementations bring to light these practical challenges.

Despite these differences, the amplifier's performance was well within acceptable limits, and minor adjustments to standard component values successfully satisfied design requirements.

The experiment turned out to be a great success since all the measurements and calculated values fell well within expected ranges. In addition to achieving technical goals, it also provided useful hands-on experience in wide-band amplifier design and a better understanding of feedback systems in practical uses. This theory gives students a predominant base to equip themselves better in future complex design realities of advanced electronics.