Electronics Laboratory

Winter semester 2025

Lab 4 – Op Amps

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Score and comments (only for tutors, please leave blank)

Please fill out this cover sheet and submit it with your lab report.

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Electronics Laboratory
WS 25/26
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Lab 4 - MOSFETs

11. Januar 2025

4.2 Non-inverting amplifier

4.2.1 Simulation

Introduction

In this section, we simulated a non-inverting amplifier circuit shown in Figure 5. We ran two simulations, one with $R_1 = 2$ kΩ connected to the feedback loop and the other with it disconnected, effectively setting its value to infinity. For both setups we ran an ac frequency sweep from 5 kHz to 5 MHz with 500 points per decade and plotted both results in Figure 2.

Circuit Diagrams:

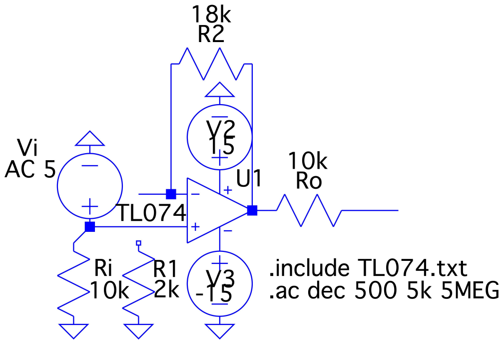

Figure 1: LTSpice *non-inverting amplifier* circuit diagram[1]

Plots:

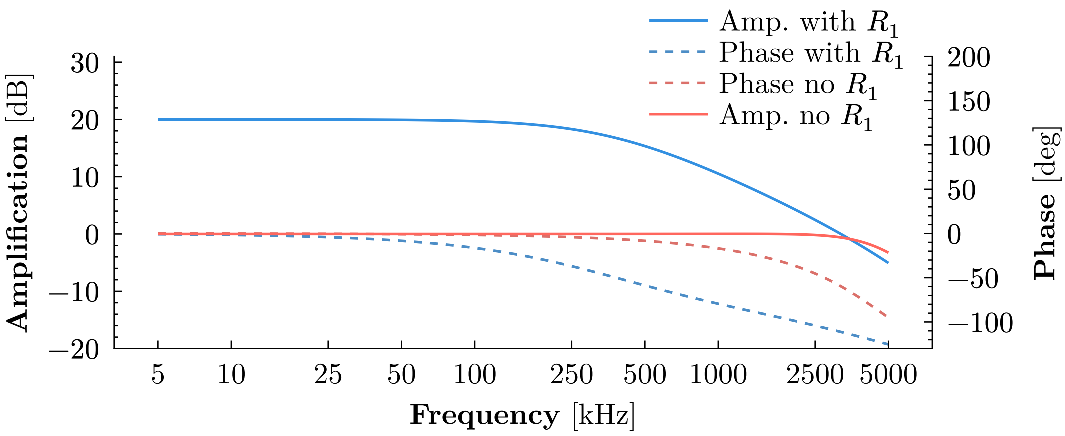

Figure 2: Simulated phase and amplification of the non-inverting amplifier for a frequency of 5kHz-5MHz on a logarithmic scale. R_1= 2 kΩ

[1]We changed `AC 5` to `AC 1` (we originally tried to do 15 mV as in the real measurement, but with 1 V we got very similar values to 15 mV so we decided on that.)

Text Questions:

With R_1 in the circuit, it reaches 0 dB amplification at $f \approx 3184$ kHz

Conclusion:

We successfully simulated the non-inverting amplifier. With R_1 connected, we got amplification values of approx 20 dB for frequencies under 150 kHz. We got a gain-bandwith of 3184 kHz. The phase shift is 0° at the beginning but linearly decreases to $\approx -120°$ at the end.

Without R_1, the amplification was ≈ 0 dB under 3 MHz with a phase shift of $\varphi < 25°$ for frequencies under 1 MHz, so very little phase sjift

4.2.2. Measurement

Introduction

Circuit Diagrams:

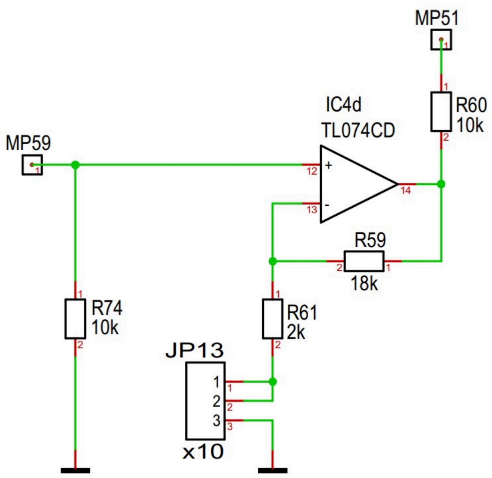

Figure 3: Schematic of the *non-inverting amplifier* circuit

Plots:

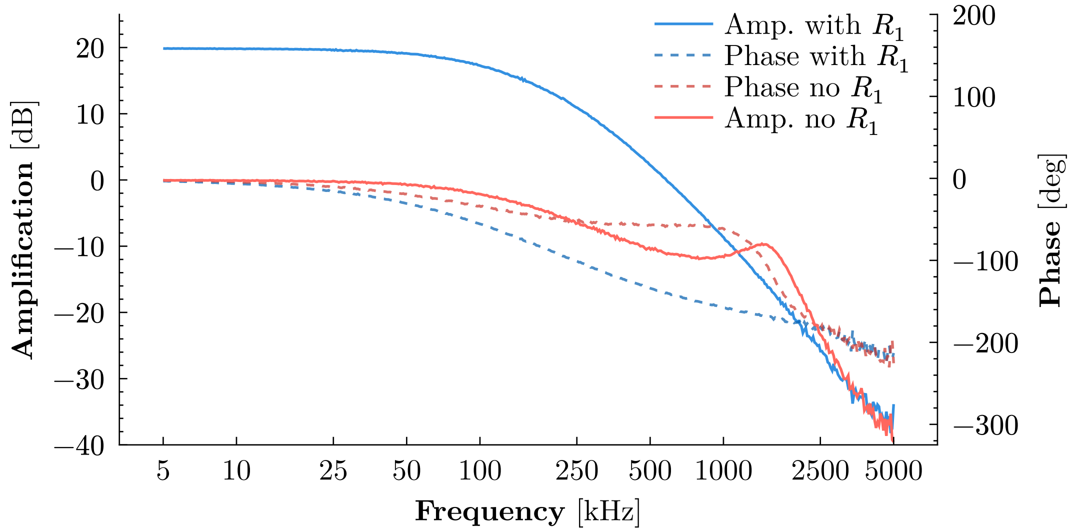

Figure 4: Simulated phase and amplification of the non-inverting amplifier for a frequency of 5kHz-5MHz on a logarithmic scale. R_1= 2 kΩ

Text Questions:

Conclusion

4.3 Voltage-to-current converter

4.3.1 Simulation

Introduction

Circuit Diagrams:

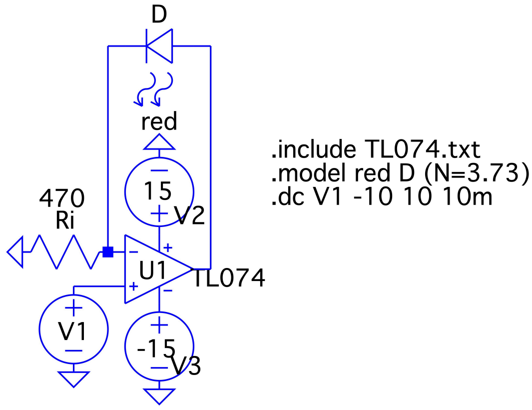

Figure 5: LTSpice *voltage-to-current converter* circuit diagram

Plots:

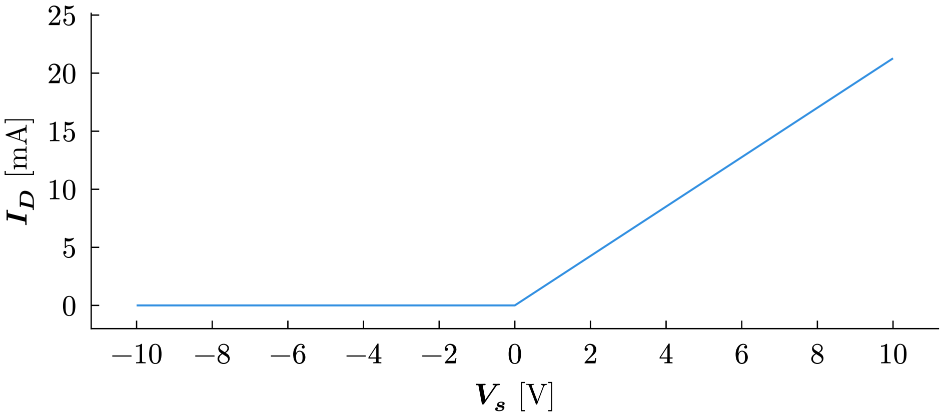

Figure 6: Simulated LED current

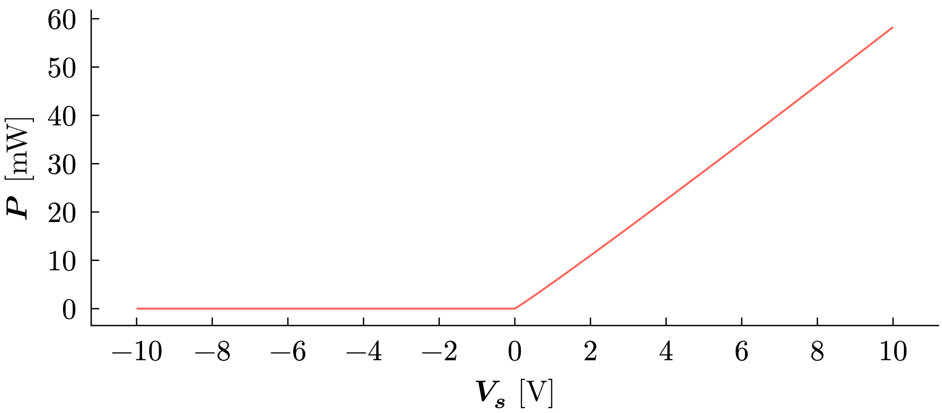

Figure 7: Simulated LED power

Text Questions:

Conclusion:

4.3.2. Measurement

Introduction

Circuit Diagrams:

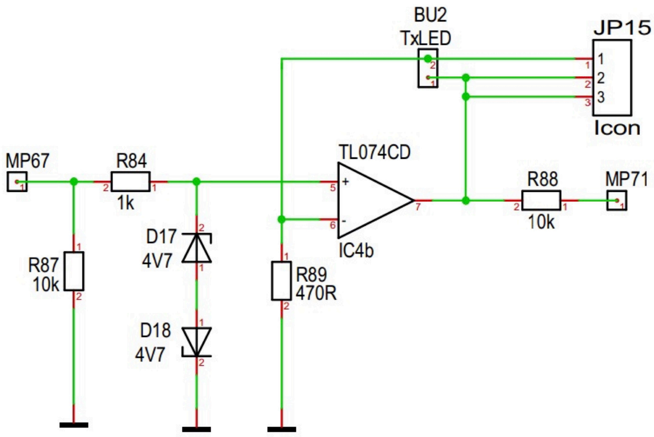

Figure 8: Schematic of the *voltage-to-current converter* circuit

Plots:

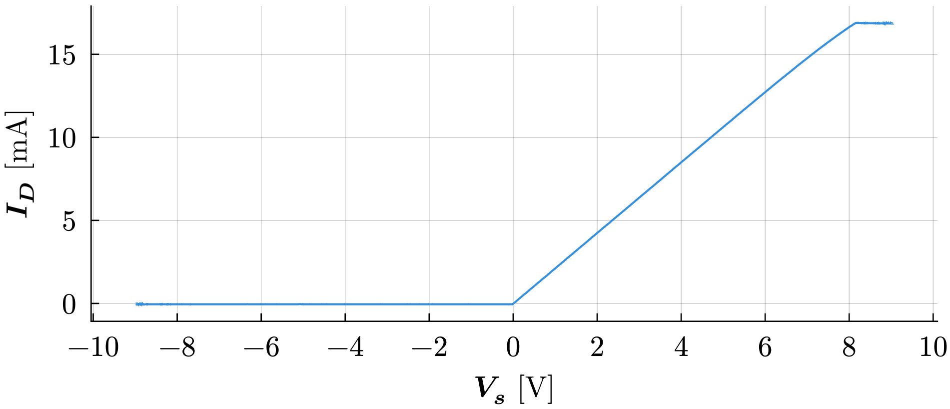

Figure 9: Measured LED current

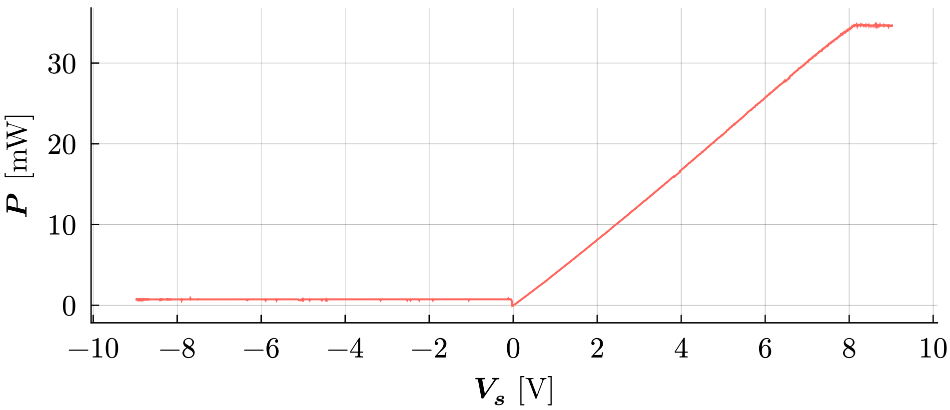

Figure 10: Measured LED power

Text Questions:

The current through the LED was measured as the voltage drop over $R_{89} = 470\Omega$ at `Pin1` of `JP15` and calculated by $I_D = \frac{V_{Pin1}}{R_{89}}$.

The voltage drop of the LED was calculated by taking the difference of the voltage between `Pin1` and `Pin2`

$V_{s(max)} \approx 8.1$ V

Conclusion

4.4 Transimpedance Amplifier

4.4.1 Simulation

Introduction

In this section the goal is to simulate a transimpedance amplifier, but used a current source in place of a photodiode.

Circuit Diagrams:

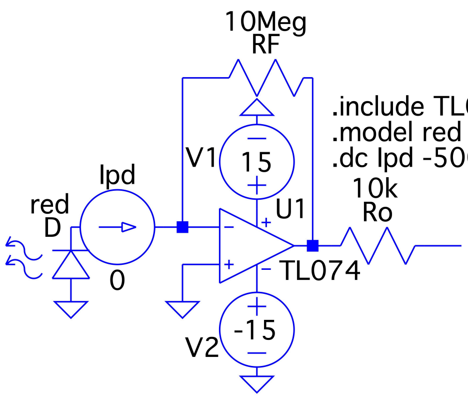

Figure 11: LTSpice *transimpedance amplifier* circuit diagram

Plots:

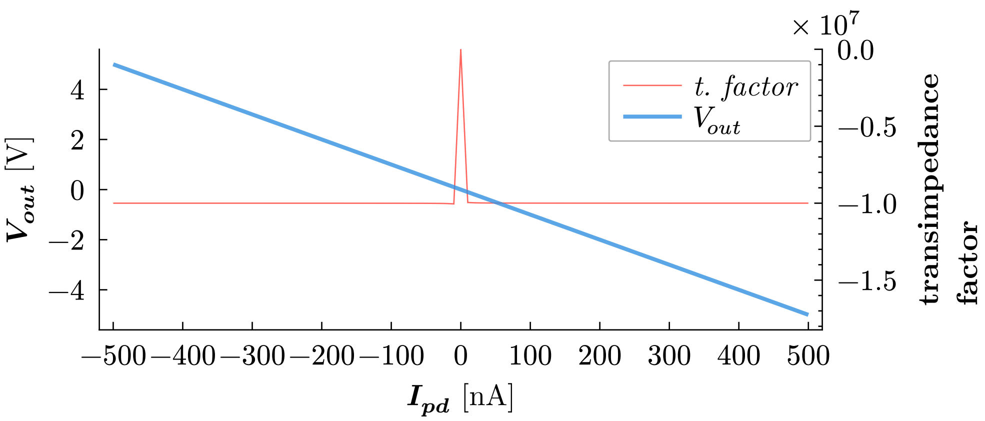

Figure 12: Simulated transimpedance amplifier

Text Questions:

Figure 12 shows the relation of V_{out} and I_{pd}. They are linearly dependant. As the transimpedance factor is $\frac{V_{out}}{I_{pd}}$ the transimpedance factor is roughly $-1 * 10^7$. The factor is mainly determined by the resist R_f.

Conclusion:
The transimpedance amplifier can be used to transform a current into a voltage source with a factor determined by the resist in the feedback loop.

4.4.2. Measurement

Introduction
In this section we use a transimpedance amplifier to calculate the current generated by a photodiode by means of output voltage.

Circuit Diagrams:

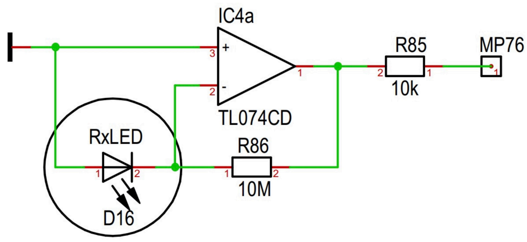

Figure 13: Schematic of the *transimpedance amplifier* circuit

Plots:

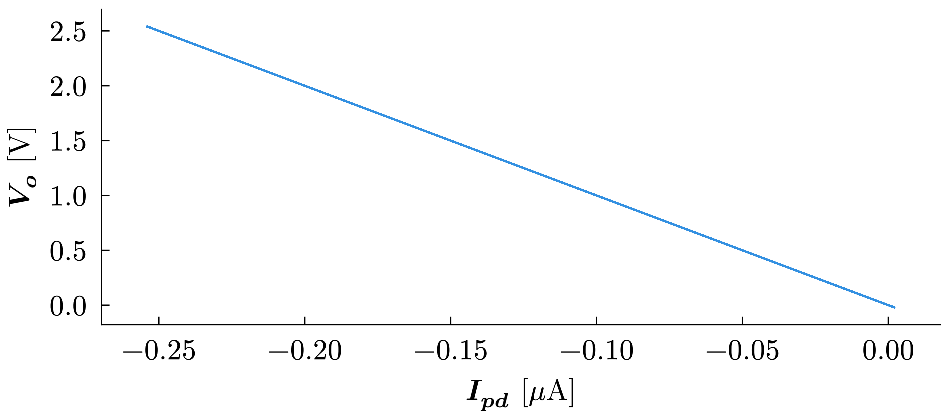

Figure 14: Measured transimpedance amplifier

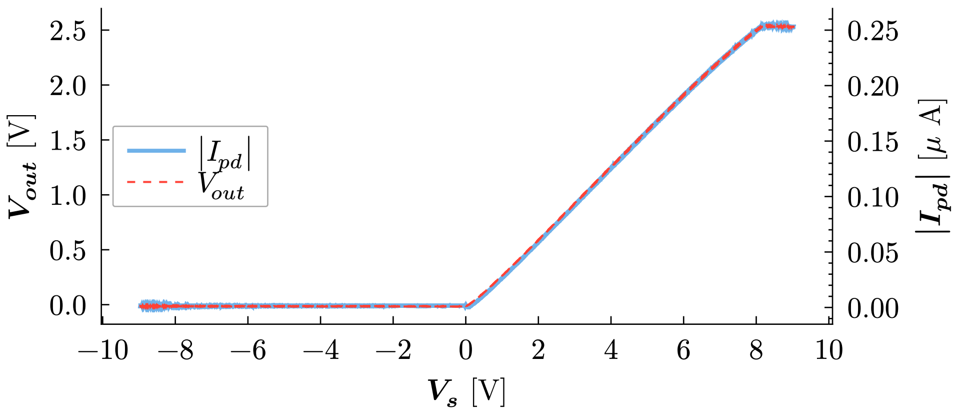

Figure 15: Measured transimpedance amplifier over V_s

Text Questions:
(c) to estimate the current over D16, we use the relation $U = -R * I$ where R is R88 as it is inside the feedback loop of the amplifier circuit. This leads to $I = -\frac{U}{R}$

(d) The current flows in the opposite direction of the input current, because the photodiode is in the same direction as the red LED but used to generate the current.

(f) The output voltage of the transimpedance amplifier is the input voltage $\frac{V_s}{1} * 10^6$ because the resist R88 is 1MΩ. this is shown in the data, as V_o is the same as I_{pd} just different by a factor of 1M. The data for $V_s > 0$ is explained by the means of current generation. As the current is generated via a photodiode, which in turn is powered by a LED. The LED only turns on for currents greater than the forward voltage of the diode. This leads to the circuit of the transimpedance amplifier only being powered while the LED is on making measurement below V_{fwd} pointless.

Conclusion

The measurement data showed the characteristics of the transimpedance amplifier to transform current into voltage. It also showcased the direct relation of the two, as well as the ability of a LED to function as a photodiode.