

6 (2. Halbttag) | Operationsverstärker

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1 Introduction

In this experiment, 6 groups will construct 6 different circuits and connect them to one big circuit. The result will look like this.

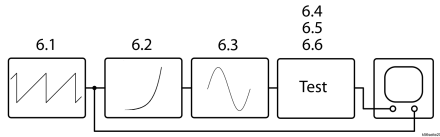


Figure 1: Circuit built from 6 individual smaller circuits; Abb. 6.14[1]

This resulting circuit will show different usecases of the opamp, for example, demonstrate different configurations of high- and lowpass filters as well as working as a resonanz amplifier.

2 Theory

The six different circuits are

- 1 Ramp generator: The ramp generator will input a ramp signal to the whole circuit. The signal will be generated via the astable multivibrator. This circuit utilises a condensator which charges and discharges in a certain time interval.
- 2 Exponentiator: The inverting exponentiator has a very high input impedance compared to the non-inverting exponentiator, which makes it more suitable for this task.

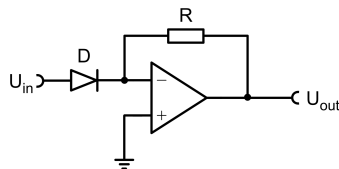


Figure 2: Inverting exponentiator; Abb. 6.4[1]

- 3 Voltage-frequency changer: This circuit produces a triangle signal with constant amplitude by charging and discharging a capacitor. The current is proportional to the input voltage.

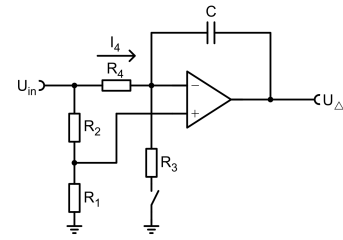


Figure 3: Reversible integrator; Abb. 6.6[1]

If the switch is open, the circuit behaves like a normal integrator and produces a constant decreasing output signal with current I_4 . If the switch is closed, a current across R_3 flows into the circuit which changes the sign of I_4 because both currents add. This results in a constant increasing output signal. For later use, the triangle signal will be modified into a sinusoidal signal.

- 4 High- and low-pass: For this circuit a third order low-pass is used, by connecting three low-passes in a row all separated by an opamp with $\nu = 1$.

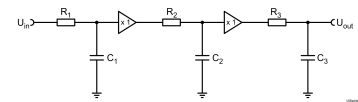


Figure 4: Third order low-pass; Abb. 6.10[1]

In this configuration, their frequency response is multiplied.

- 5 Band-elimination filter and resonance amplifier: In this circuit a signal is sent through two low- and high-passes connected in row. The two output signals are then added via an opamp. This results in a band-elimination filter.

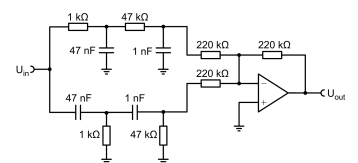


Figure 5: Band-elimination filter; Abb. 6.12[1]

- 6 Band-pass: The last part is a band-pass.

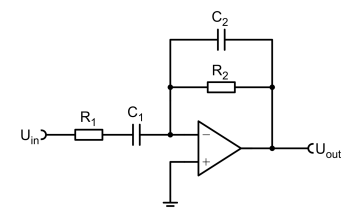


Figure 6: Band-pass; Abb. 6.13[1]

3 Analysis

3.1 Inverting Exponentiater

Firstly we have a look at the inverting exponentiater shown in fig. 2. From here we see that $U_- = 0$, since it is connected to ground. Furthermore we know from the first golden rule, that $U_- = U_+$, so U_+ is also 0. The second golden rule sais $I_+ = I_- = 0$. To calculate the current through the diode we now see

$$\begin{aligned} I_D &= -I_R + I_- \\ &= -I_R \\ &= -\frac{U_R}{R} \\ &= -\frac{U_{out}}{R}. \end{aligned}$$

Here we have to take the negative of I_R , since we are feeding the positiv output to the negativ input. From here we assume

$$I_D = I_0 e^{\alpha U_{in}}$$

with $\alpha :=$ diod specific paramter.

If we equate the equations and rearrange them, we get

$$U_{out} = -A \cdot e^{\frac{U_{in}}{B}}$$

with $A = I_R \cdot R$ and $B = \frac{1}{\alpha}$.

We allready see, that the circuit is designed to emplify our signal with an op amp with feedback, after it has been exponentiated by our diode. Our circuit is, because of our diod, only working, when the polarity is so that for positiv input voltages the diode is in pass through direction. If we switch the polarity we see, that only the negativ voltages will be exponentiated and inverted. It is advisable to use FET op amps, since FETs have a high resitance.

Building the circuit and powering it with a triangle wave singal, we get fig. 7.

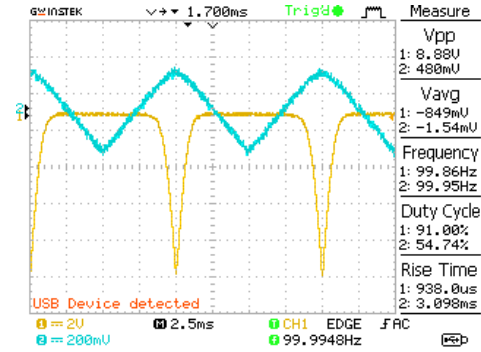


Figure 7: Inverted Exponentiater oscillogramm

Here we can observe the exponential-like amplification for positiv voltages.

3.2 The grand circuit

After we have assambled our non-inverting exponentiater with a potentiometer we plug the Sawtooth-Generator infront of our circuit and plug our circuit in the voltage-frequency-changer. After some debugging we hear a singal from the speaker thats plugged into the the voltage-frequency-changer. Todays lab course was a very pleasend one, since in comparisson to the last ones we had not to do as meany meassuremnts or analysis. It was a nice experimete to see the diffrent use cases for an op amp.

4 Conclusion

In the lab course we constructed a inverting and non-inverting exponentiater with diffrent resistors and a potantiometer. We saw from fig. 7 the amplification with an exponential behaviour.

At the end we connected all the diffrent kinds of circuits to achieve a sound from a speaker connected at the end.

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Source

[1] Fabian Hügging. *Elektronik-Praktikum Versuchsanleitung*. Universität Bonn, kurs b edition, 2024.