

# exercise\_sheet\_1

## Student Group

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# Exercise Sheet 1

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### Exercise 1.1.1 Microphone amplifier I

An amplifier circuit shall amplify a microphone signal so that a loudspeaker ( $R_{\text{LS}} = 8.0 \, \Omega$ ) can be driven. The **rms value** of the desired voltage across the loudspeaker shall be  $U_{\text{RMS, LS}} = 10 \, \text{V}$ . It is assumed that a sinusoidal signal is to be output. The power is supplied by two voltage sources, with  $V_{\text{S+}} = 15 \, \text{V}$  and  $V_{\text{S-}} = -15 \, \text{V}$ . For understanding (especially for tasks 2. and 3.), look at the simulation under the subchapter **equivalent circuit** in chapter "1. amplifier basics". This example shows a realistic amplifier, and the idealized current flow can be guessed from this.

Draw a labeled sketch of the circuit with the amplifier as a black box.

1. What power (P) does the loudspeaker consume?

2. From this, how can we determine the RMS current  $I_{\text{RMS, S}}$  of the power supply at which the above-desired voltage  $U_{\text{RMS, LS}}$  is output at the loudspeaker?

3. Determine from the previous task the maximum current  $I_{\text{max, S}}$  for which the two power supplies must be designed at least.  
(Note that for simple amplifiers, the output current  $I_{\text{O}}$  is always less than or equal to the current  $I_{\text{S}}$  of the power supply.)

### Exercise 1.1.2 Microphone amplifier II

A voltage amplifier circuit is given, which shall amplify a microphone signal in such a way that a loudspeaker ( $R_{\text{LS}} = 8.0 \text{ } \Omega$ ) can be driven. Neither amplification nor the desired voltage at the loudspeaker is known. This amplifier circuit is internally protected against over-currents above  $I_{\text{max, amplifier}} = 5.0 \text{ A}$  by a fast fuse. It is known that no over-currents occur in the allowed voltage operation of  $8.0 \text{ } \Omega$  loudspeakers.

1. By what factor does the current change if a  $4.0 \text{ } \Omega$  loudspeaker is used instead of an  $8.0 \text{ } \Omega$  loudspeaker?

2. What effect does this have on the fuse?

### Exercise 1.1.3 Wheatstone bridge circuit

Fig. 1: Wheatstone bridge circuit with a temperature sensor



Imagine that you work in the company “HHN Mechatronics & Robotics”. You are developing an IoT system that will be used in a harsh environment and will contain a rechargeable battery. The temperature of the battery must be monitored during operation and charging. If the temperature is too high, charging must be aborted or a warning issued. For the temperature measurement at the housing of the used lithium-ion cell [NCR18650](#) a measuring circuit is to be built up. A suggestion for the circuit is as follows:

1. Wheatstone bridge circuit with  $R_1 = R_2 = R_3 = R_4 = 1.0 \text{ k}\Omega$ .
2. Let the resistor  $R_4$  be a PT1000 with a temperature coefficient  $\alpha = 3850 \frac{\text{ppm}}{\text{K}}$ .
3. For the other resistors, two components are chosen, that have an unknown temperature coefficient. According to the datasheet, the temperature coefficient is within  $\alpha = \pm 100 \frac{\text{ppm}}{\text{K}}$ .
4. The voltage source of the system generates a voltage of  $5 \text{ V}$  with sufficient accuracy.
5. The determined voltage  $\Delta U$  is amplified by a factor of 20 through another amplifier circuit, output as  $U_{\text{O}}$ , and further used by an analog-to-digital converter in a microcontroller <sup>1)</sup>.

A short report is to be created; Tina TI is to be used as the analysis tool.

1. Create a problem description.



2. Rebuild the circuit in TINA TI and add this here. Take the following hint into account.

### Hint

Use a simple resistor for the PT1000 in the simulation. With Tina TI,  $27^{\circ}\text{C}$  (room temperature) is selected as the reference temperature for the temperature curve. For the PT1000, the reference temperature is often  $0^{\circ}\text{C}$  (in practical applications, this should be checked in the datasheet). With Tina TI, the reference temperature can be changed by entering the value 27 under Temperature [C] in the properties (double-click on Resistor).

3. From the datasheet linked above, determine in what range from  $T_{\text{min}}$  to  $T_{\text{max}}$  may be charged and what temperature  $T_{\text{lim}}$  may not be exceeded in any of the states.

4. First, for temperature invariant  $R_1 = R_2 = R_3 = 1.0 \text{ k}\Omega$  and a temperature variable resistor  $R_4$ , determine the voltage change  $\Delta U$  over the temperature of  $-30 \dots 70 \text{ }^\circ\text{C}$  in TINA TI. To do this, create a plot with  $\Delta U$  as a function of temperature.  
Read  $\Delta U^0(T_{\text{min}})$ ,  $\Delta U^0(T_{\text{max}})$ ,  $\Delta U^0(T_{\text{lim}})$ , from the diagram and check the plausibility of the values by calculation.

5. Determine  $\Delta U$  when the temperature dependence of  $R_1$ ,  $R_2$  and  $R_3$  is taken into account. To do this, create a suitable diagram with  $\Delta U$  as a function of temperature in TINA TI.  
At what voltages  $U_O(T_{\text{min}})$ ,  $U_O(T_{\text{max}})$  must the microcontroller intervene and disable charging?  
At what value  $U_A(T_{\text{lim}})$  must a warning be issued?

6. Discuss the results.

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<sup>1)</sup> In real systems, an analog-to-digital converter would most likely not be used because of its relatively large power consumption for IoT applications. For Atmel chips, this is a few  $10^{-6}$  A, which adds up to a rapid battery drain over time.

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