

exercise_sheet_1

Student Group

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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_{O} is always less than or equal to the current I_{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 ($R_{\text{LS}} = 8.0 \, \Omega$) 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 $8.0 \, \Omega$ loudspeakers.

1. By what factor does the current change if a $4.0 \, \Omega$ loudspeaker is used instead of an $8.0 \, \Omega$ 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 $\alpha = 3850 \text{ ppm/K}$.
3. For the other resistors, two components are chosen, that have an unknown temperature coefficient. According to the datasheet, the temperature coefficient is within $\alpha = \pm 100 \text{ ppm/K}$.
4. The voltage source of the system generates a voltage of 5 V with sufficient accuracy.
5. The determined voltage ΔU is amplified by a factor of 20 through another amplifier circuit, output as U_{O} , and further used by an analog-to-digital converter in a microcontroller ¹⁾.

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°C (room temperature) is selected as the reference temperature for the temperature curve. For the PT1000, the reference temperature is often 0°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_{min} to T_{max} may be charged and what temperature T_{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 ΔU over the temperature of $-30 \dots 70 \text{ }^\circ\text{C}$ in TINA TI. To do this, create a plot with ΔU 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 ΔU when the temperature dependence of R_1 , R_2 and R_3 is taken into account. To do this, create a suitable diagram with ΔU 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.

¹⁾ 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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