exercise_sheet_1

Student Group

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Exercise Sheet 1

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Tools für Lehr/Lern-Veranstaltungen

Name	**First Name**	**Matrikelnumber**
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Exercise 1.1.1 Microphone amplifier I

An amplifier circuit shall amplify a microphone signal so that a loudspeaker ($R_{\rm LS}= 8.0 ~\Omega$) can be driven. The rms value of the desired voltage across the loudspeaker shall be $U_{\rm RMS, LS} = 10 ~\rm V$. It is assumed that a sinusoidal signal is to be output. The power is supplied by two voltage sources, with $V_{\rm S+} = 15 ~\rm V$ and $V_{\rm S-} = - 15 ~\rm V$. 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.

What power (P) does the loudspeaker consume?

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

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

Exercise 1.1.2 Microphone amplifier II

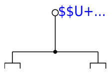
A voltage amplifier circuit is given, which shall amplify a microphone signal in such a way that a loudspeaker ($R_{\rm LS}= 8.0 ~\Omega$) can be driven. Neither amplification nor the desired voltage at the loudspeaker is known. This amplifier circuit is internally protected against over-currents above $I_{\rm max, amplifier}= 5.0 ~\rm A$ 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 ~\rm k \Omega $.
2. Let the resistor R_4 be a PT1000 with a temperature coefficient $\alpha = 3850 ~\rm \frac{ppm}{K}$.
3. For the other resistors, two components are chosen, that have an unknown temperature coefficient. According to the datasheet, the temperature coefficient is within $\alpha = \pm 100 ~\rm \frac{ppm}{K}$.
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 $U_{\rm O}$, 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 $T_{\rm min}$ to $T_{\rm max}$ may be charged and what temperature $T_{\rm lim}$ may not be exceeded in any of the states.

4. First, for temperature invariant $R_1 = R_2 = R_3 = 1.0 ~\rm k \Omega$ and a temperature variable resistor R_4, determine the voltage change ΔU over the temperature of $-30...70 ~°C$ in TINA TI. To do this, create a plot with ΔU as a function of temperature.
   Read $\Delta U^0 (T_{\rm min})$, $\Delta U^0 (T_{\rm max})$, $\Delta U^0 (T_{\rm lim})$, 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 $U_O (T_{\rm min})$, $U_O (T_{\rm max})$ must the microcontroller intervene and disable charging?
   At what value $U_A (T_{\rm lim})$ 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 $10 ~\rm µA$, which adds up to a rapid battery drain over time.