Assignment 2

1 Design Exercises

1.1 (5 points)

Find a relationship between V_{th}, V_{out}, I_{out}, and Z_{Th} that does not depend on R_{Load} in the Thévenin equivalent circuit.

1.2 (5 points)

Prove that the power transfer from a power supply with Thévenin resistance, R_{Th}, to a load resistor, R_{Load}, is maximum when $R_{Th} = R_{Load}$.

1.3 (10 points)

Use Kirchhoff's laws to determine the resistance of the Wheatstone bridge depicted in figure 1 circuit.

- 7 points will be awarded if you set your equations correctly. Do not go for the fully symbolic solution, it is very bulky and hard to grasp.
- 3 points. What is the Wheatstone bridge resistance for $R_1 = R_2 = 10$ kΩ, $R_3 = 12$ kΩ, $R_4 = 15$ kΩ, and $R_5 = 2$ kΩ.

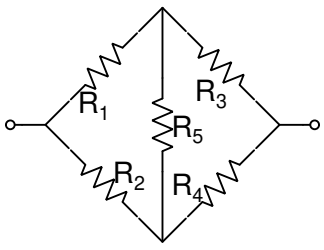

Figure 1: A Wheatstone bridge circuit.

2 Lab: Kirchhoff, Thévenin, and Impedance Matching

Always start with a circuit diagram and only then build it in hardware.

Your notebooks must be complete, understandable, and address all activities, design exercises, observations, and questions noted in the laboratory's procedures. Remember to use your notebook as a laboratory journal and record your data, design calculations, notes and scratch work. *Make sure to write a conclusion for each exercise and each week.*

Task 1 (20 points)

- Grab a resistor (R_1) in 1 kΩ to 10 kΩ range, measure it with Ω-meter.
- Set a power supply to about 5 V output (it should be in constant voltage output setting).
- Connect the resistor to the positive output of the power supply
- The other end of the resistor and the negative terminal of the power supply are outputs of a "black box", i.e. you have access only to these terminals.

Before you power on your circuit with multimeters connected, make sure that either a TA or an instructor check your circuit! If you blow a fuse, you have to replace it. This will put you at least 15 minutes behind the schedule.

- use several different R_{load} resistors, and plot V_{out} vs I_{out}
- does this plot follows your equation from the exercise assignment 1.1?
- From the slope of V_{out} vs I_{out} you can find R_{Th}. Make sure that you tried small enough R_{Load} to observe V_{out} smaller than the maximum by factor of 2 or 3.
- How is R_{Th} related to R_1. Can you say anything about inner R_{th} of the power supply. Is it larger or smaller than R_1, can you be more precise?

Task 2 (20 points)

Build a voltage divider from 2 resistors in the range 10 kΩ to 100 kΩ.

- Find Thévenin resistance of this voltage divider.
- Does it match your expectations?

Task 3 (10 points)

Build the Wheatstone bridge and measure its resistance. Chose resistors in the range 10 kΩ to 100 kΩ.

Task 4 extra for Tuesday section

The Wheatstone bridge was commonly used before Ω-meters became wide spread. The bridge would be constructed from two well calibrated resistors R_1 and R_3, a tunable and labeled resistor R_2, and unknown resistor R_4. The value of resistor R_5 could be any but generally kept small. To measure R_4 the bridge was connected to a power source and current passing through R_5 was measured, while R_2 was tuned. When the $I_5 = 0$, the following is true $R_3/R_1 = R_4/R_2$.

- Use simulator and plot I_5 as a function of R_4/R_2, keep R_1, R_3, R_4 constant.
- Do your observations confirm above statements?