Westsächsische Hochschule Zwickau
University of Applied Sciences

Faculty of Electrical Engineering

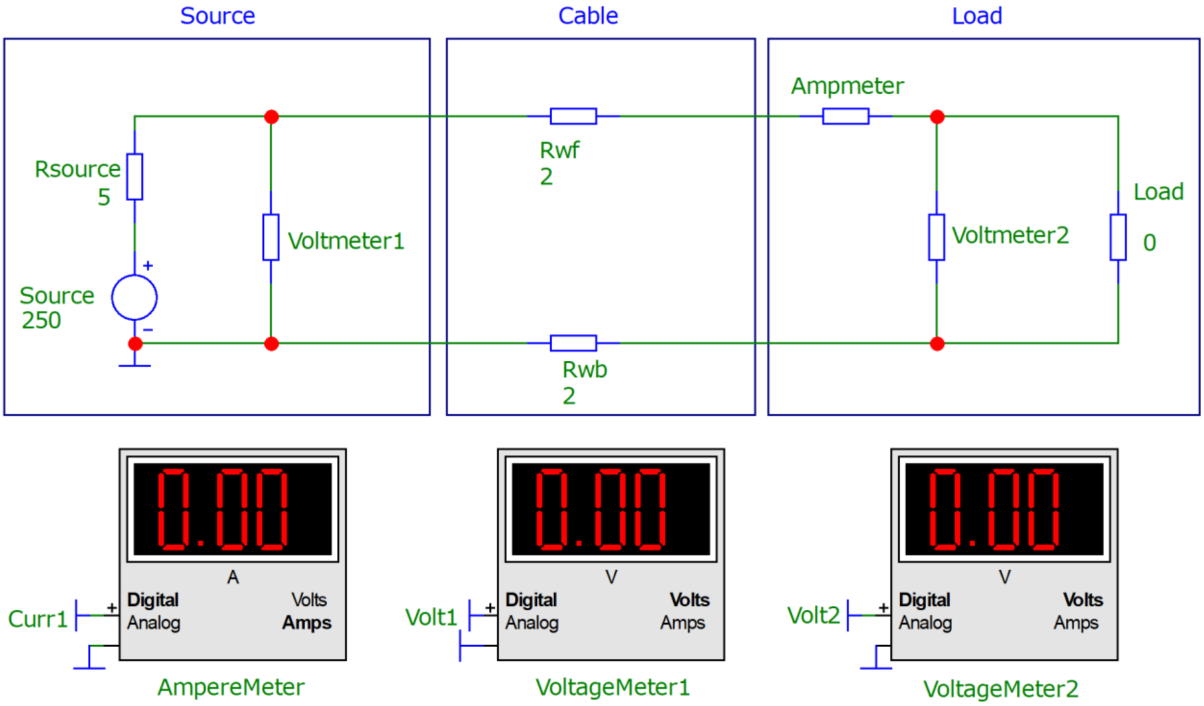
Engineering of Electrical Systems (ELT10150)
Assignment for Final Presentation (Master)

Task

Prepare **presentation slides** as if you were to personally present results covering all aspects and subtasks described in the following. Hand in the slides as a **PDF file** via the OPAL platform.

Simulation Setup

Attached to this document, you will find the following Micro-Cap circuit, which is a simple model for transmission of electrical energy from a voltage source to a load. Your task is to examine the influence of a varying load (in form of a load resistor) on losses in the power supply (voltage source) and transmission lines (cable), as well as to find the point of maximum power transfer to the load. The circuit simulation software Micro-Cap can also be downloaded from OPAL.



Simulation Experiments

1. Customize your circuit.
    a. Set the **source voltage** from 250 V to the value (70 V + $x \cdot 20$ V), with x being the fifth digit of your student ID number ("Matrikelnummer").
    Example: Student ID = 4567**8** → x = **8** → Voltage = (70 + **8** · 20) V = 230 V.
    b. Set the **source resistance** from 5 Ω to the value (5 Ω + $y \cdot 2.5$ Ω), with y being the fourth digit of your student ID number.
    Example: Student ID = 456**7**8 → y = **7** → Resistance = (5 + **7** · 2.5) Ω = 22.5 Ω.
    c. Set both **wire resistance** values Rwf and Rwb from 2 Ω to (2 Ω + $z \cdot 2$ Ω), with z being the third digit of your student ID number.
    Example: Student ID = 45**6**78 → z = **6** → Resistance = (2 + **6** · 2) Ω = 14 Ω.
2. Measure the **open-circuit voltage** with VoltMeter2 after setting the load resistance to 10 MΩ. Also write down the other two meter readings.
3. Measure the **short-circuit current** after setting the load resistance to 0 Ω. Also write down the other two meter readings.
4. Adjust the load resistance such that the current is **5% of the short-circuit current**. Write down the required resistance value and all meter readings.
5. Continue to modify the load resistance so as to obtain current values of **10%, 15%, 20%, …, 90%, 95% of the short-circuit current**. Write down the load resistance and all meter readings for each current step.

As a result of these virtual measurements, you should now have a table with 21 rows, ranging from 0% to 100% of the short-circuit current in 5% increments. Each entry should consist of load current, load resistance, and the two measured voltages.

Analysis of Powers and Losses

1. For each row of the table, **compute the source power** provided by the *ideal* voltage source (not the linear source that also consists of the source resistance – only the ideal source).
2. For each row of the table, **compute the load power** consumed by the load resistance.
3. For each row of the table, **compute the power loss inside the source**, which is caused by the source resistance.
4. For each row of the table, **compute the power loss of the cable** caused by the total wire resistance.
5. For each row of the table, **compute the total power loss**. Hint: The sum of load power and total power loss values should equate to the source power.
6. Collect all measured and computed values in **one combined table** (see example below). Do not forget units of measurement!

Measurements					*Power*		*Power losses*		
#	I (A)	R_{Load} (Ω)	V_1 (V)	V_2 (V)	P_{Source} (W)	P_{Source} (W)	$P_{L,Source}$ (W)	$P_{L,Cable}$ (W)	$P_{L,Total}$ (W)
1	0 A	10 MΩ							
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
21		0 Ω							

7. Prepare three different **diagrams**, all with the current as x-coordinate, displaying:
   a. Source power (of the *ideal* voltage source) and load power in one first diagram;
   b. Measured voltages before and after the cable in a second diagram;
   c. All losses (i.e. three curves with power loss inside the source, power loss of the cable, total power loss) in a third diagram.

Further Analyses

1. Find the point of **maximum power transferred** to the load. At what percentage of the short-circuit current does it occur? How are load resistance and the other resistance values related in this point? How are load power and total loss power related?
2. Compute the **cross-section area of the wire**, if the cable length between source and load is 100 m, and **copper** is being used (conductivity $\kappa = 56\ \frac{\text{m}}{\Omega\cdot\text{mm}^2}$). The resistance of this cable shall match your wire resistance values.
3. Once more compute the cable cross section, this time for **aluminum** as cable material (conductivity $\kappa = 36\ \frac{\text{m}}{\Omega\cdot\text{mm}^2}$). Compare and briefly discuss these two results.

Presentation Slides

Your slides shall contain at least the following pages and contents:

1. Schematic of the circuit with your personalized values of all components.
2. Brief description of the simulation steps performed.
3. Equations required for the subsequent analysis steps (computation of power values), each with a brief description.
4. Results in tabular form.
5. Results in graphical form (diagrams).
6. Analysis of the maximum power transfer to the load.
7. Equations and results for cable cross sections.