Nonlinear characteristics and Wheatstone Bridge

Report History

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Final decision:

☐ o.k.
☐ not passed

Prof. .................................................................
Objectives

- Understand the characteristics of non-linear resistances, especially the differential resistance at the operating point.
- Become familiar with the presentation of measured data using linear and logarithmic scaling.
- Apply the Wheatstone bridge and gain a solid understanding of the balanced and unbalanced bridge equations, as well as sensitivity and linearity.
- Learn to critically analyse measured data and to compare it against theoretically derived values.

Preparation

Note:
This homework is to be prepared as group work before the lab session starts and to be presented at the beginning of the lab session by the team leader.

1. Non-linear current characteristic

Let: \( \frac{I}{mA} = a\left(\frac{U}{V}\right)^b \)

where \( a = 14.7 \) and \( b = 0.54 \)

Calculate the current for the following voltages: 0.1 V, 0.2 V, 0.5 V, 1 V, 2 V, 5 V and 10 V.

2. Unbalanced bridge

Let \( R_2 = 1 \, k\Omega; \ R_3 = R_4 = 10 \, k\Omega \) and \( U_B = 6 \, V \).

Calculate the bridge voltage \( U_{AB}(R_1) \) where \( R_1 \) is to be incremented from 500 \( \Omega \) to 1800 \( \Omega \) in steps of 100 \( \Omega \).

Present the calculated values on graph paper using the following scales:

- \( U_{AB} \) (ordinate): 100 mV/cm,
- \( R_1 \) (abscissa): 100 \( \Omega \)/cm.
Experiment 1: Measuring the characteristic diagram of non-linear components

Both current and voltage are simultaneously measured in incremental steps to obtain the characteristic diagram of an electrical component. The data is to be graphically presented. In order to fully exploit the range of the variable voltage source, the circuit is to be set up with a voltage divider. The specific setup has to be highlighted in the (prepared) circuit diagram.

Light bulb
Nominal values of the light bulb: 15 V / 82 mA

a) Measure the resistance of the cold light bulb and document both the measured value and the measurement device being used.

b) Measure the voltage across the light bulb and the current flowing through it within the range 0.1 V to 10 V. List the data in a table and consider that each decade should have at least 3 measurement points. Use the adjustable power supply to adjust the voltage.

c) Plot the characteristic function I = f(U) using lin-lin scaling, and graphically determine both the DC resistance R and the incremental resistance r at the operating points U = 0.1 V, 1.0 V and 10.0 V. Enter the results into the following table.

<table>
<thead>
<tr>
<th>U/V</th>
<th>I /mA</th>
<th>R /Ω</th>
<th>r /Ω</th>
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<tbody>
<tr>
<td>0.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.0</td>
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d) Plot the I = f(U) diagram using log-log scaling.

e) Within the voltage range 0.5V < U < 10V, the characteristic function is to be approximated by the expression in Equation 1. Present the pre-calculated values in a log-log diagram.

\[
\frac{I}{mA} = a \left( \frac{U}{V} \right)^b
\]  
(Equation 1)

f) Use a regression line (‘best linear fit’) to approximate the measured data in the log-log diagram within the range 0.5V < U < 10V.

g) Graphically determine the parameters a and b in Equation 1 from the regression line.

h) Prove the results obtained in g) by superimposing the graph of the calculated values on both the linear and the logarithmic diagram.
Experiment 2: Wheatstone bridge

a) Set up the circuit shown below. R₁ is a 10 kΩ potentiometer.
   Let: R₂ = 1 kΩ; R₃ = R₄ = 10 kΩ and U_B = 6 V.
   **Attention:** The resistance of the potentiometer can only be measured if it is disconnected from the circuit. Otherwise you risk damaging the measurement device. You have to disconnect the potentiometer before each measurement.

b) Determine the value of R₁ for which the bridge is balanced.
   Let this value be R₁,0.

c) Measure the voltage U_{AB} as a function of R₁ for the following values:
   R₁ = 550 Ω, 750 Ω, 1.0 kΩ, 1.25 kΩ, 1.4 kΩ, 1.7 kΩ and 2.0 kΩ.

d) Put all values into a table together with the relative unbalance r = ΔR/R₁,0 where ΔR = R₁ − R₁,0.

e) Draw the graph U_{AB} = f(R₁) and highlight the pre-calculated values in this diagram.

f) Draw the tangent of U_{AB} = f(R₁) in the balance point. Determine the bridge sensitivity E₀ at this point and compare it against the theoretical value.