Circuit Analyses. Laboration 1 how to measure Current and Voltage and Resistance

This booklet, signed by the teacher, serves as a receipt for passing the lab. Each student must have a booklet of his own with solid preparation and completed readings.

Name:
Confirmed (Teacher):

Objective In this lab, you will learn how to manage digital multimeters, power supplies and RCL meter and interpret technical data from the instruments' manuals. At the same time, you investigate how the measurement affects the measurement objects and with which accuracy and precision the measurement can be made.

Equipment

- **Digital multimeter (DMM) Fluke45**
- **Power supply**
- **RCL meter**
- **Breadoard and Components**

Write down your results, and report to the teacher during the laboration.

Preparation tasks F1…F5

F1: the colorcode

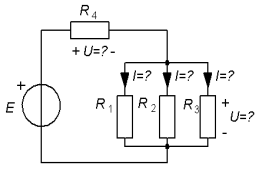
Write down the color code for resistors and explain how resistance marking is interpreted.

F2: Units and prefix

Make a table of prefix from 10^{-18} - 10^{18}**.**

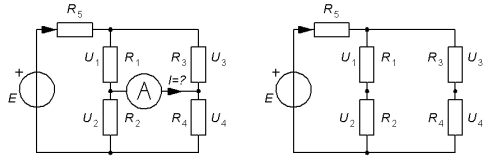
F3: Voltage and Current calculations for parallel operation

Calculate all currents and voltage drops across the resistors in Fig 1.
R_1 = 47Ω, R_2 = 100Ω, R_3 = 1kΩ och R_4 = 470Ω. E = 5V.



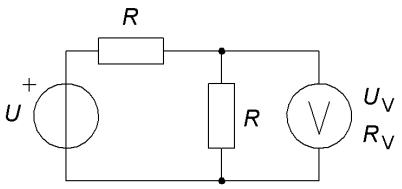
F4: Calculation of voltage for serial operation

Calculate the voltage drops for R_1, R_2, R_3 and R_4, in fig 3. How will the voltage change when the cable with the current I is removed?
R_1 = R_4 = 1kΩ, R_2 = R_3 = 100Ω, R_5 = 10Ω. E = 5V.



F5: Internal resistance

How can you calculate the internal resistance R_V of the voltmeter from the measured voltage in fig. 5? Develop a formula for R_V. $R_V = f(U, R, U_V) = ?$
ATTENTION! You must account for all steps of the derivation of the formula in the lab!



Measurements

M1: Parallel connection

F3: Voltage and Current calculations for parallel operation

Report the preparation task currents and voltage drops here (or on a separate sheet).
Connect components as in *fig 1* on a breadboard with R_1 = 47Ω, R_2 = 100Ω, R_3 = 1kΩ och R_4 = 470Ω.
Adjust the power supply to E = 5V.
Measure U_{R4} and $U_{R1,2,3}$. Measure I_{R2}.

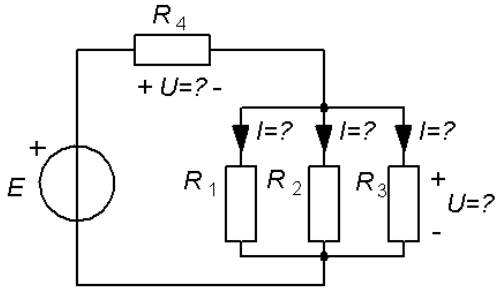


Fig 1

NOTE At all current measurements. Be sure to always first connect the ammeter to the 10A input to make sure the current is not too high (> 100 mA). Then change to the fused 100 mA range if the current value is low enough for this. If the fuse is broken it can be exchanged. Read the manual on how to do.

Table of calculated and measured values:

Calculated [V]:	**Calculated [mA]:**	**Measure [V]:**
U_{R1} =	I_{R1} =	U_{R4} =
U_{R2} =	I_{R2} =	$U_{R1,2,3}$ =
U_{R3} =	I_{R3} =	**Measure [mA]:**
U_{R4} =	I_{R4} =	I_{R2} =

Your comment:

- Are your calculations verified? Probably I_{R2} differs from the calculated value, what can be the reason?

M2: Serieal connection

Study *fig 2*. R_1 = 100Ω. E = 5V. You should make indirect measurments and calculate value of resistor R_X?
You will get the unknown R_X from the assistant at lab.
NOTE Measure R_1's exact value with the RCL meter and then use this value in calculations.Measure the voltage across the resistor R_1 and then measure the voltage across the power supply. Calculate the value of the resistor R_X.
Finally. Disconnect the resistor from the circuit and check the resistance of the resistor with the RCL meter

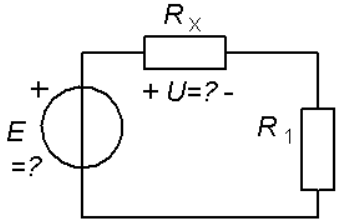


Fig 2

• Compare your measured and calculated value of $\boldsymbol{R_X}$ with the correct one from the RCL meter.

M3: Voltage division
F4: Calculation of voltage for serial operation

Connect as in *fig 3*. $R_1 = R_4 = 1\text{K}\Omega$, $R_2 = R_3 = 100\Omega$, $R_5 = 10\Omega$. $E = 5\text{V}$.
Connect the ammeter (DVM) as in the figure and measure the current *I*. Then replace the ammeter with a short cable to get the DVM free for the voltage measurements.

With the transverse cable. Measure the voltage over R_1 and R_3, R_2 and R_4.

- Explain, or show, why it runs a current through the transverse cable.
- Compare the measured values with the calculated values in the table.

Without the transverse cable. Remove the cable. (Don't reconnect the ammeter).

- How large is now the voltages across the resistors R_1, R_2, R_3 and. R_4.
- Compare the measured values with the calculated values in the table.

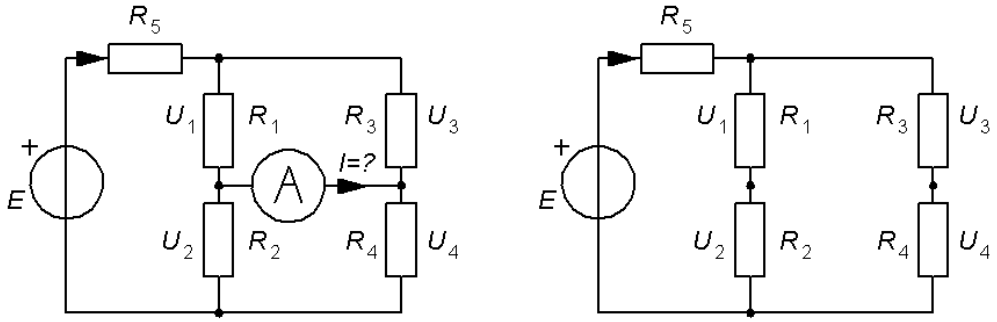


Fig 3
Show your voltage calculations here (or on a separate sheet):

Measure the current *I* [mA] $I =$
Which sig should you use, which **direction** has the current?

Table over calculated and mesured voltage values:

With the transverse cable		**Without the transverse cable**	
Calculated [V]:	**Mesured [V]:**	**Calculated [V]:**	**Mesured [V]:**
$U_1 =$	$U_1 =$	$U_1 =$	$U_1 =$
$U_2 =$	$U_2 =$	$U_2 =$	$U_2 =$
$U_3 =$	$U_3 =$	$U_3 =$	$U_3 =$
$U_4 =$	$U_4 =$	$U_4 =$	$U_4 =$

Your comment:

M4: Measuring resistances using the DVM and the error in the measurement.
Measure with RLC meter and DVM two resistors 1.2 kΩ and 4.7 MΩ and fill in the table below.
(Hint: How is the error in % based on the manual's data in Appendix A? consider the RCL meter values as close to the actual values. Are your DVM measured values within the manual's specified range?)

Resistor 1:

Value (nominal):	[Ω]	tolerance (color) +/-	[%]	Max and Min	[Ω]
reading DVM:	[Ω]	Tolerance (in manual) +/-		Max and Min	[Ω]
RCL-meter (= true value) :					[Ω]

Resistor 2:

Value (nominal):	[Ω]	tolerance (color) +/-	[%]	Max and Min	[Ω]
reading DVM:	[Ω]	Tolerance (in manual) +/-		Max and Min	[Ω]
RCL-meter (= true value) :					[Ω]

Your comment about the error in the measurements of resistances with DVM:

M5: Indirect measure of "low value" resistances
In M5 and M6 you will measure current and voltage simultaneously. Fluke45 has two displays so if the am-meterpart and the voltmeter-part can have a common connection (**COM**) this can be done. The additional measured variable is obtained by pressing the **2ND** button followed by the desired measuring function.

- Measure an unknowned resistor about 1Ω.

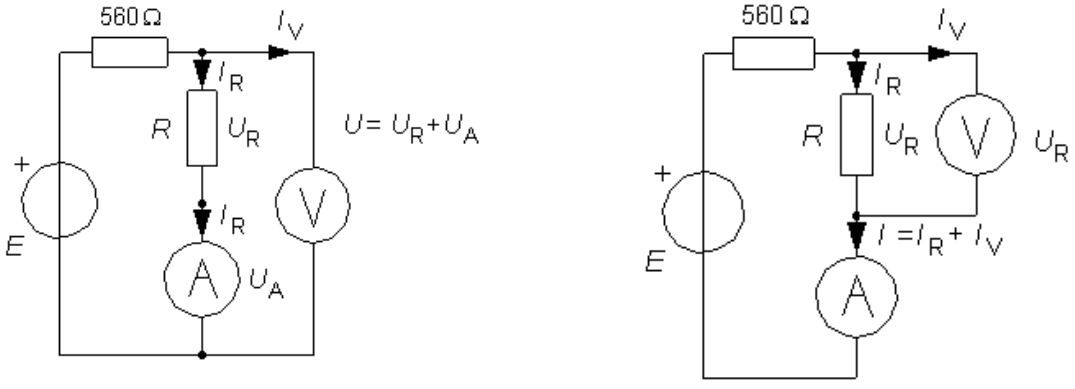


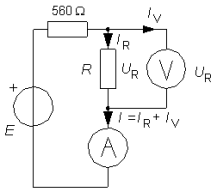
Fig 4

Correct current mesurement

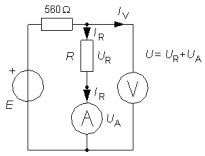
Correct voltage measurement

Use about **10V** as the voltage (*E*) and connect as in *fig 4*. First try with the ”correct current” connection (the voltmeterpart in parallell with *R* and the ammeterpart) and then with the “correct volt” connection (the voltmeterpart in parallell with only *R*).

Indirect measure of of ”low value” resistances *E* = 10 V



With “correct voltage” calculated value [Ω] :



With “correct current” calculated value [Ω]:

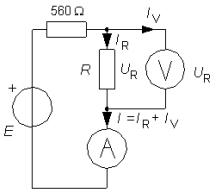
- What is the suitable connection to obtain the most accurate value of this resistance, “voltage correct” or “current correct”?

M6: Indirect measure of ”high value” resistances

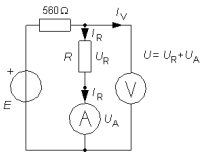
Now use **highest voltage** the power supply can deliver, and use *R* about 4.7 MΩ. Try again with the connections in *fig* 4 and measure the resistance the same way as in M5.
NOTE! If the currentmeasurement only gives you one single “digit” then you need to ask the labassistant for an even higer voltage source (*E*>100V) otherwise there will be no accuracy!

- What is the suitable connection to obtain the most accurate value of this resistance, “voltage correct” or “current correct”?

Indirect measure of of ”high value” resistances *E* = MAX



With “correct voltage” calculated value [MΩ] :



With “correct current” calculated value [Ω]:

M5 and M6: Your comment about using “voltage” or “current” correct connection when measuring resistance. Underline the correct options:

- Voltage correct connection should be used when *R* is greater/less than the Ammeter/Voltmeter inner resistance.
- Current correct connection should be used when *R* is greater/less than the Ammeter/Voltmeter inner resistance.

M7: Indirect measurement of the instruments internal resistance

F5: You must account for all steps of the derivation of the formula here

Connect as in *fig 5* with *R* = 4.7 MΩ and *U* = **5V**.
Measure the voltage with the DVM and calculate the internal resistance of the DVM-voltmeter.

$R_V = f(U, R, U_V) =$

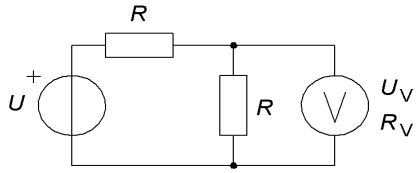


Fig 5

Calculation of the internal resistance:

• What is the value of the voltmeter internal resistance calculated by your formula?	[MΩ]
• How big is the internal resistance according to the manual (= the correct value)?	[MΩ]

You can use this page for your calculations.