Electronics I. laboratory measurement guide

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1. Measurement: Basic measurements

This measurement aims to improve skills of using laboratory instruments and breadboards. The measurement includes basic resistor networs and basic usage of power supply, multimeter and function generator. We can compare the theoretical knowledge and calculations of basic electricity theory with the practice.

Please refer to the instrument guide for detailed instructions of the lab instruments!

1.1 Measuring the characteristics of the power suppy:

For this measurement we need the power supply, a multimeter and a potentiometer.

The potentiometer is a variable resistor with three poles: two are the ends, between which the resistance if constant. The third is the wiper, which is connected to a sliding or rotating contact. Thus the resistance between an end and the wiper is adjustable. The wiper with the two ends forms an adjustable voltage divider. If only one end and the wiper is used, then we get a simple variable resistor, the resistance of which can in principle be continously changed from 0 to the nominal value. (For a visual description, please see figure 3.1 in the guide for the diode measurements.)

In this measurement we only use one end and the wiper, thus using it as a variable resistor (only these two connections will be found on the provided device).

The potentiometer (in short: potmeter) provided for this session has a value R=470Ω±20%. Thus the nominal value is 470 Ω and it can differ from it by 20% max, due to manufacturing variations.

1.1.1 First measure the maximum resistance of the potmeter. Turn the multimeter to resistance measurement mode and connect the two ends to the COM (black) and V/Ω (red) inputs, turn the wiper to maximum setting and measure the resistance in the maximum precision possible. Calculate the difference from the nominal value in absoute and relative terms.

1.1.2 Choose one of the variable output pairs of the power supply (left or right) and set its voltage to $\underline{V_0=15V}$. Connect the + and – outputs with a measuring cable (create a short circuit). Enable the power supply's output. A red LED will signal that the current limit is in effect. Change the display mode from V to mA for the actually used output and set up the current limit to be I_0=70mA. After this, we can disconnect the short circuit. (For each later laboratory sessions, you will have to setup a current limit in a similar way.)

1.1.3 Connect the potentiometer to the previously used output of the power supply. Enable the output. Start decreasing the potentiometer's resistance until the current limit (red) LED just turns on, stop at this point and write down the voltage and current from the power supply's display. Disable the power output; disconnect the potmeter and connect it to the multimeter and measure the precise resistance.

This resistance will be the R_0 value known from the power supply characteristisc (see the instrument guide!). Compare the value with calculation (using the V_0 and I_0 values).

1.1.4 Now set approximately 350Ω resistance on the potmeter (measure and note the precise value) and connect the potmeter to the power supply again. Enable power and write down the voltage and current values. As this R value is greater than R_0, the power supply will be in voltage generator mode.

1.1.5 Now setup about 150Ω value. This is smaller than R_0 and thus the power supply will be in current generator mode.

In the lab report, draw the characteristics of the power supply using the measured values and draw the operating line of the three load resistance values used.

1.2 Thévenin model of function generator:

The aim of this exercise is measuring the Thevenin circuit model of the function generator and proving its usability in practice. In addition to the banana plug wires, we need a banana to BNC plug wire for connecting to the function generator.

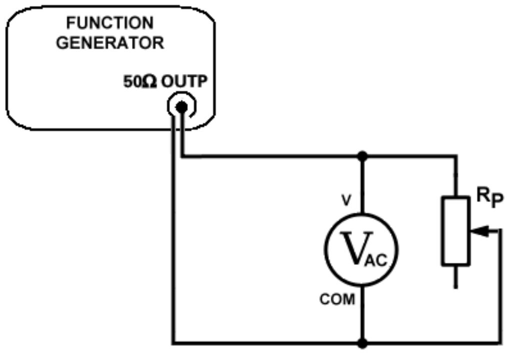


Figure 1.1 Measurement setup

1.2.1 First connect the analog output of the function generator with the multimeter (in voltage mode) using the BNC-to-banana wire. Turn the multimeter to AC voltage mode. (Use figure 1.1 but for now without the R_P potmeter!).

Setup f=1kHz sine wave on the function generator with $V=5V_{rms}$. Check the voltage with the multimeter in the most accurate range possible. As the internal resistance of the voltage meter is very large (10MΩ), the measured voltage can be viewed as the open circuit voltage (Thevenin voltage) of the model.

1.2.2 Connect the potmeter as the load of the function generator (see figure 1.1) while keeping the voltage meter connected (thus the generator, voltmeter and potmeter are parallel connected). Now change the potmeter's resistance until the voltage measured by the multimeter is half of the open circuit voltage. Do this with the best precision we can achieve. Write down the measured voltage.

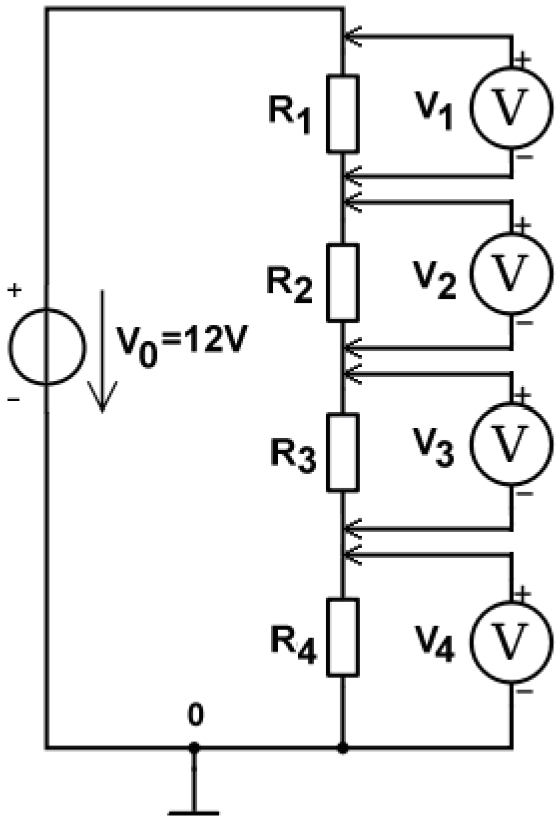
1.2.3 We know from the Thevenin model, that if the load resistor is equal to the internal resistance, the output voltage will be half of the open circuit voltage, as the two resistors form a voltage divider. Therefore after setting up the potmeter in the previous exercise, disconnect it from the generator and measure its resistance. Also write down the nominal output (internal) resistance of the function generator (find it written on the generator itself). Compare the two values.

1.3 Series resistor network:

The rest of the measurements need the **breadboard** that is introduced in the instrument guide. In the next exercise a simple, four resistor voltage divider is used.

Before creating the circuit, set up 50mA current limit on the power supply. Keep this limit for the rest of the laboratory session!

(The **+** and **–** symbols on the schematics indicate the V and COM inputs of the multimeter and the correct polarities.)



Parameters:

V_0 = 12V

R_1 = 2.2kΩ ±1%

R_2 = 1kΩ ±1%

R_3 = 620Ω ±1%

R_4 = 390Ω ±1%

Figure 1.2. Series network

1.3.1 After setting up the current limit, setup 12V output voltage on the power supply. Now measure and note the precise resistance of the four resistors.

R_1=	R_2=	R_3=	R_4=

1.3.2 Connect the four resistors in series as shown in figure 1.2. One voltmeter will be enough for this measurement. The points between each neighbouring resistor pair should be connected to one of to the banana sockets on the measuring panel for easy measurement.

	Calculated values with nominal R	**Calculated values with measured R (from 1.3.1)**	**Measured values**
V1			
V2			
V3			
V4			

Fill the first column with calculated voltages using the nominal R values, the second column with calculations using the R values measured in 1.3.1. The sum of the four voltages (in each column) should be equal to V_0.

1.3.3 Using the same circuit, now connect the COM input of the voltage meter to the reference point of the circuit indicated by a 0 (the negative pole of the power supply) as in figure 1.3.

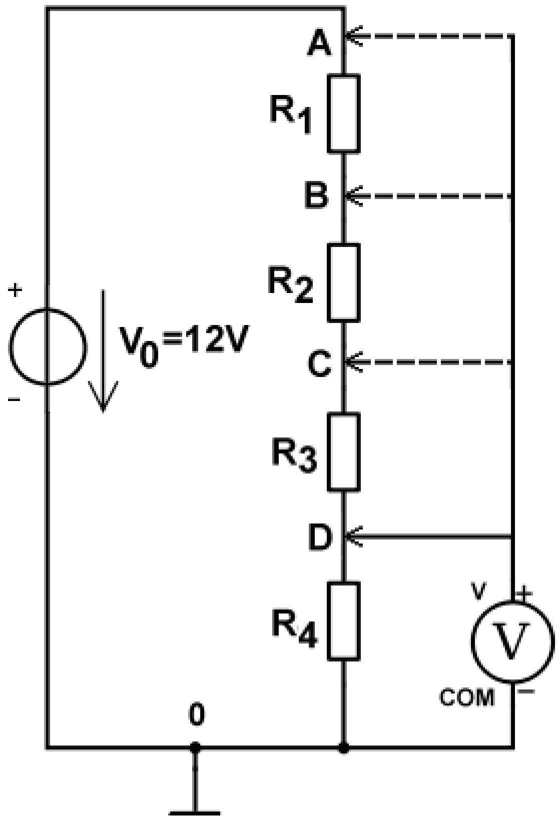


Figure 1.3

Leaving the COM input in place, use the V input on the four nodes (A to D) to measure four node potentials.

(V_A=V_0)	**Calculated**	**Calculated (1.3.1)**	**Measured**
V_A	-	-	
V_B			
V_C			
V_D			

Similarly to the previous exercise, fill the first column using nominal, the second column using measured R values.

In the lab report, include all calculations and check the validity of Kirchoff laws (eg. V_C=V_3+V_4 etc).

1.4 Measuring the internal resistance of the ampermeter

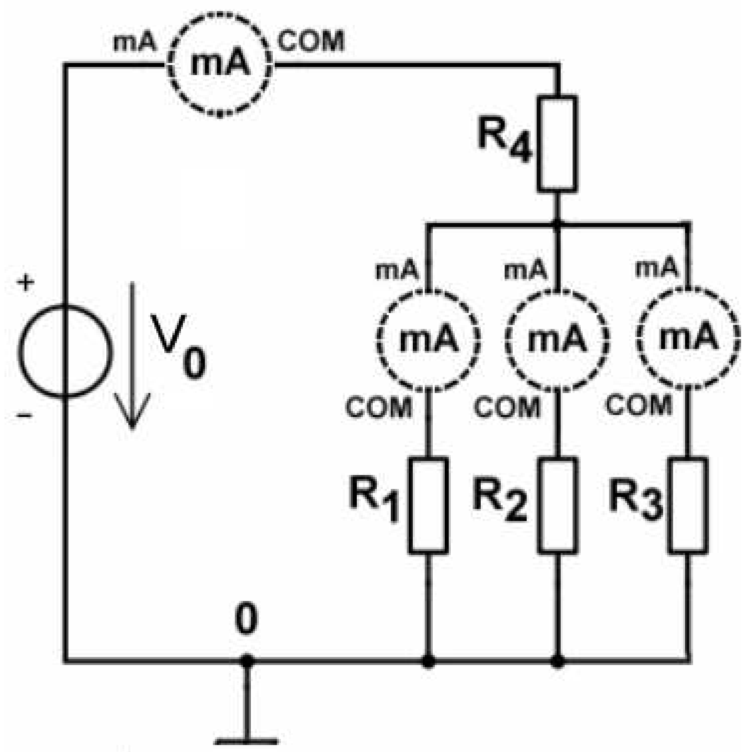
The internal resistance of the multimeter depends on the selected measurement range. In the case of the mA meter, it can cause significant error in our measurements. For this reason, we are going to measure it (because these values are not included in the instrument's manual).

Connect one of the multimeters in milliamper mode to the other multimeter in ohm mode. Select each mA measurement range in order and measure the internal resistance (using the most accurate ohm range possible.) The milliampermeter will show how much current the ohmmeter outputs (the ohmmeter acts as a current generator and measures the voltage across the resistor to calculate resistance). In this measurement, the resistance of the wires and contacts is not negligible. For this reason, first connect the two ends of the resistance measuring wires and note this value, later compensate all measurements with this value. (It is possible to use the Offset function of the Hameg multimeter for this; press the offset button when the two wires are connected, it will automatically compensate with this value until you switch off the offset mode.)

Range	L1	L2	L3	L4
$R_{internal}$				
$I_{ohmmeter}$				

1.5 Parallel resistor network:

1.5.1 Build the circuit seen in figure 1.4. We are going to need only one multimeters. In each turn, connect the current meter in series with one of the resistors, while connecting short circuit in its positions in the other branches.



Parameters:

V_0 = 1V

R_1 = 2.2kΩ ±1%

R_2 = 1kΩ ±1%

R_3 = 620Ω ±1%

R_4 = 390Ω ±1%

Figure 1.4

	Calculated value with nominal resistances	**Calculated value with measured resistances (1.3.1)**
I_1		
I_2		
I_3		
I_4		

Fill the first and second columns similarly to the previous exercises (suppose ampermeter to be ideal). If built correctly, the sum of the first three currents have to be equal to I_4.

We can also test what happens if we use the ampermeter in different measurement ranges. Measure the currents in all ranges. Compare these with the calculated values.

	L1	**L2**	**L3**	**L4**
I_1				
I_2				
I_3				
$I_4 = I_1 + I_2 + I_3$				

1.5 Test questions:

1. Describe the internal resistances of the ideal and real voltage meters!
2. Describe the internal resistances of the ideal and real current meters!
3. What does measurement range mean and how do you set it up when measuring an unknown quantity?
4. How do you connect a voltage and current meter to the measured two-pole (include drawing)?
5. How do you set up the current limit on a laboratory power supply?
6. Draw and describe the characteristic curve of a laboratory power supply!
7. Give a voltage divider formula for calculating the voltage of one of the resistors out of three connected in series!
8. Define what a potentiometer is and give its symbol!
9. Give the current divider formula for calculating the current of one of the resistors out of two connected in parallel!
10. Describe and draw the Thevenin model and a possible way of measuring the internal resistance!
11. Draw and describe a sinusoidal time-voltage function!
12. Define effective voltage (RMS voltage)!
13. Give a formula for a sinusoidal function with offset! Define the offset.