1. Voltage, Current and Ohm's Law

Introduction

A current runs through an electrical system and this current is the result of a voltage. How much current is running through it? How quickly will the battery discharge? How can the current be measured? What is the difference between a voltage source and a current source? A lamp has resistance, but is the relationship between the voltage and current linear?

In order to understand the working of the electrical installation and to be able to select components, we need knowledge. In this initial exercise, we will examine the principles that are generally valid, so that we can tackle many electrical engineering problems with our knowledge.

Objectives

1. Use of a multimeter for measuring DC voltage and direct current
2. Use of the reference direction of the voltage and the current
3. Use of the DC power as a current source and as a voltage source
4. Reading circuit diagrams
5. Organised/logical building of circuits
6. Verification of Ohm's Law
7. Describing electrical components (resistors, lamps and diodes) with diagrams

Terminology

DC	Direct current
Fine	Not coarse, small steps
Coarse	Not fine, large variation
DC supply	Supply device (but note: usually Voltage source)
Characteristic curve	A diagram that shows at a glance how an electrical network or an electronic component works
Diode	An electronic component that allows the current to pass through in only one direction
'Hard' voltage	Voltage from a source with low internal resistance
Measuring range	

Current runs <u>through</u> a resistor. Voltage goes <u>across</u> a resistor.

1. Preparatory exercise

a. Which meter has the highest resistance: a voltage or current meter?

b. Give Ohm's Law

c. Calculate: With a voltage of 12 volts and a resistance of 1000 ohms, there is a current of ..... Ampere.

I =

d. Calculate: With a voltage of 10 volts, there is a current of 20 micro ampere.
What is the resistance in the circuit?

R =

e. Calculate: With a current of 0.5 ampere, there is a voltage of 50 millivolts across a resistor.
What is the value of the resistance?

R =

f. With a voltage of 5 V, a current of – 0.1 Amps is measured. Calculate the resistance and draw the complete diagram.

R =

Draw the circuit, add all the known values.

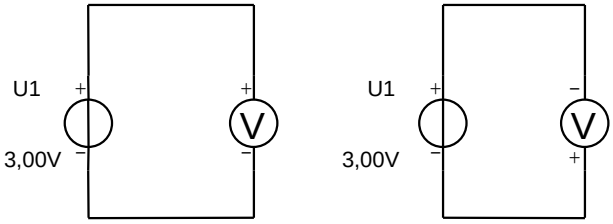
2. The DC supply as voltage source and current source

The DC supply can work both as a current source and as a voltage source. LEDs indicate whether the flow controller (CC = Constant Current) or the voltage controller (CV = Constant Voltage) is active.

The DC supply as a voltage source

To have the DC supply as a voltage source, the current control must be open far enough. When the DC supply is excessively loaded, the flow controller will restrict the output flow and the LED CC (= Constant Current) will turn on.

Regulate the voltage on the DC supply at exactly 3.00 V.
Next, connect a digital multimeter as shown in the measurement circuits A and B.



Circuit A Circuit B

a. Read the voltage for both diagrams.

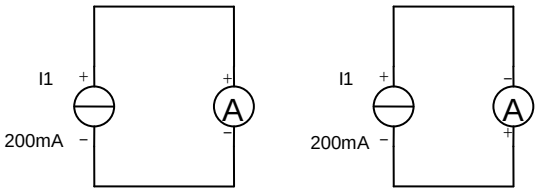
A: B:

b. How much current is running in the circuit? Read the ammeter of the DC supply.
(Remember that the final number of a digital reading can always be 1 more or 1 less.)

I =

DC supply as a current source

In order to use the DC supply as a current source, the voltage controller must be open far enough. With the current controller knob, the required current can be set. Consider that the current cannot travel through air and, in order to set the correct value, the output of the DC supply must be short-circuited with a wire for a moment.



Circuit C Circuit D

Set the flow controller at its lowest setting. Short-circuit the output with a wire.
Set the current source at exactly 0.200 A (200 mA). Remove the short-circuit wire.
Next, connect a digital multimeter as shown in the measurement circuits C and D.

c. Read the current for both measuring circuits.

C: D:

d. Make a note of the measuring range of the meter (question: what is this?)

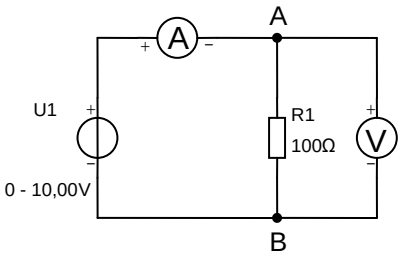
Meaning The measuring range is:

e. What is the voltage across the ammeter? Read the voltmeter of the DC supply or connect an extra voltmeter if necessary.

f. From the measurement data, calculate *the resistance of the multimeter as an ammeter* on this measuring range (compare the value with the readings of your peers!).

3. Verification of Ohm's Law

Draw measurement circuit E in your logbook and build it. Set the DC supply as a voltage source (current control at maximal).



Circuit E

a. For R1, use a 100 Ω resistor. Set the voltage across the resistor in stages at 2.00 V, 4.00 V, ... 10.00 V, and measure the current each time. Enter the measured values in the table. Ensure the correct units are used in the table.
Each time, calculate the expected value for the current and check whether the calculated and measured values match.

100 Ω	U (V)	I ( ) measured	I ( ) calculated
	2,		
	4,		
	6,		
	8,		
	10,		

b. Repeat the measurement, using a resistor of 470 Ω for R1.

470 Ω	U (V)	I ( ) measured	I ( ) calculated
	2,		
	4,		
	6,		
	8,		
	10,		

c. On squared paper, draw a diagram I =f(U) for both readings (R1=100 Ω, and R1= 470 Ω) in one figure and determine the measured resistance values by using the slope of the lines.

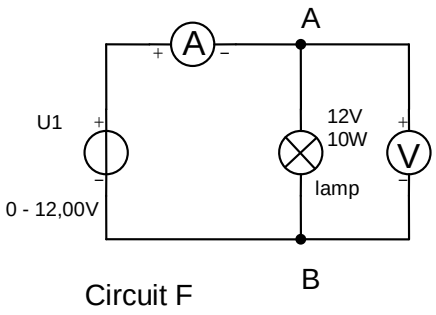
100 Ω	Measured resistor:
470 Ω	Measured resistor:

d. How much do these values deviate from the values given? Are they within the tolerance limits of the resistors?

4. Relation between voltage and current in a light bulb

Draw measurement circuit F in your logbook and build it. Set the DC supply as a voltage source (current control at maximal).
Use a 12 V halogen lamp.

a. Set the voltage on the lamp to 2.00 V, 4.00 V, ... 12.00 V, and measure the current each time.



Circuit F

U (V)	I ( )

b. On squared paper, draw a diagram I =f(U). From the diagram, determine the resistance of the lamp at 1, 3, 6 and 12 V.

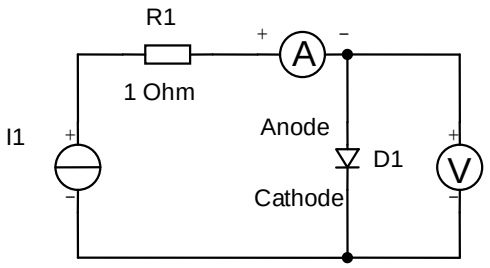
U (V)	I ( )	R ( )
1		
3		
6		
12		

c. Explain the course of the curve.

5. Relation between voltage and current in a diode

Draw measurement circuit G in your logbook and build it. For this measurement, use a 3 A diode in the experiment board. A diode may **never** be connected directly to a voltage source, which is why the measurement circuit is adjusted with a resistance of 1 Ohm.

A current is sent through the diode by a current source, while the voltage drop on the diode is measured, as can be seen in circuit G.



Circuit G

Set the source to 0 A at the beginning of the reading.

a. Increase the current in stages from 0 A to a maximum of 1.0 A. You will see that the voltage suddenly does not change much anymore. Select the current in such a way that you have measured sufficient voltage differences in the range from 0.3 to 0.7 V (also see assignment c).

I1 ()	U_{ac} ()

b. Also connect the diode in the other way (with the anode on the min. – of the supply) and measure the current at U_{ak} = -20 V. Calculate the resistance.

U_{ac} ( )	I1 ( )	R ( )

c. On squared paper, draw a diagram I = f (U_{ac}). From the diagram, determine the resistance of the diode at 0.3 V, 0.6 V and 0.9 V.

U_{ac} (V)	I1 ( )	R ( )
0.3		
0.6		
0.9		

6. Conclusion about the results

a. These tests concerned the linear and non-linear elements. Indicate which are linear, and which are not.

Resistor	
Halogen lamp	
Diode	

b. True or false:

I. If the voltage on a lamp is twice as much, the current is also twice as much.
II. If the current becomes twice as small through a diode, the voltage also becomes twice as small.
III. Ohm's law is a linear function.

Statement	True/false
I.	
II.	
III.	