Voltage division with a potentiometer

Aim of the experiment

- Investigation of a simple voltage divider
- Investigation of a loaded voltage divider
- Setup of a voltage divider with potentiometer

Foundations

Kirchhoff's voltage law states that the sum of all voltages in a closed loop is equal to zero.

With a voltage divider it is possible to divide up voltages and in particular tap lower partial voltages. A voltage divider generally consists of two resistors, between which the applied *U* is divided into two partial voltages (voltage drops). Voltage dividers are used for example in measuring probes or to set operating points (voltage conditions) for active components, e.g. with a transistor/amplifier circuit.

In an initial test a voltage divider is created from various resistors and the output voltages in particular are measured. In a second test the loaded voltage divider is tested. Finally, a voltage divider with a potentiometer is set up and the output voltage is measured.

Devices

1 plug-in board, DIN A4 .... 576 74
1 set 10 bridging plugs 501 48

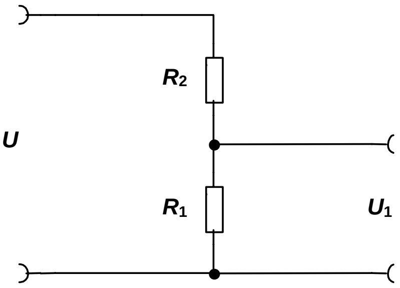
1 STE resistor 47 Ω 577 28
2 STE resistor 100 Ω 577 32
1 STE resistor 150 Ω, ... 577 34
1 STE resistor 470 Ω 577 40
1 STE potentiometer 220 Ω 577 90

1 DC power supply, 0…± 15 V 521 45
2 multimeter LD analog 20 .... 531 120

3 pairs of cables, 50 cm, red and blue.................. 501 45

JN/KEm 0908

Fig. 1: Simple voltage divider



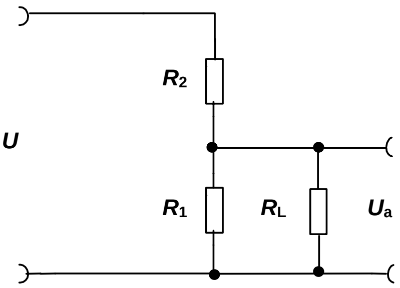
With non-loaded voltage dividers the current strength I results from the applied voltage U and the sum of the resistors R_1 und R_2:

$$I = \frac{U}{R_1 + R_2} \tag{1}$$

and thereby for the voltage drop, e.g. at resistor R_1

$$U_1 = I \cdot R_1 = U \cdot \frac{R_1}{R_1 + R_2} \tag{2}$$

Fig. 2: Loaded voltage divider



With a loaded voltage divider a current additionally flows via a load resistor R_L. This results in the current strength I increasing along with the voltage drop across resistor R_2 and thereby a drop in the output voltage U_a.

The following applies to resistor R_1^* (parallel connection of R_1 and R_L):

$$R_1^* = \frac{R_1 \cdot R_L}{R_1 + R_L} \tag{3}$$

and thereby to the current strength:

$$I = \frac{U}{R_2 + \frac{R_1 \cdot R_L}{R_1 + R_L}} \tag{4}$$

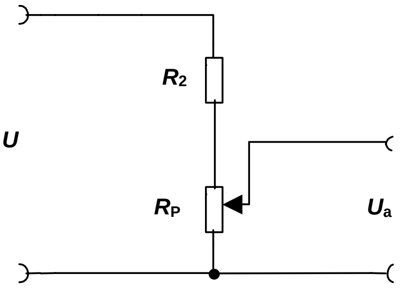
and for the voltage taken per (2):

$$U_a = U \cdot \frac{R_1^*}{R_1^* + R_2} \tag{5}$$

or

$$U_a = U \cdot \frac{R_1}{R_1 + R_2 + \frac{R_1 \cdot R_2}{R_L}} \tag{6}$$

Fig. 3: Voltage divider with potentiometer



With a potentiometer with a resistor R_P the voltage drop per (2) is

$$U_P = U \cdot \frac{R_P}{R_P + R_2} \tag{7}$$

This allows an accordant adjustment of the voltage U_a between 0 V and U_P via the respective component resistor.

The resistor R_2 serves here as a series resistor, so that no short circuit can be set.

Apparatus and method

Note: Observe the measurement quantities and polarities at the measuring devices with all tests.

a) Simple voltage divider

- Set up test in accordance with Fig. 1 with $R_2 = 100\ \Omega$. First apply no resistance for R_1 (i.e. $R_1 = \infty$).
- Set voltage U at the power supply to 15 V.
- Measure the current strength I and voltage U_1 and note these in Table 1.
- Set the resistances R_1 per Table and repeat the measurement each time.

b) Loaded voltage divider

- Set up test in accordance with Fig. 2 with $R_1 = 470\ \Omega$ and $R_2 = 100\ \Omega$. First apply no resistance to resistor R_L (i.e. $R_L = \infty$)
- Set voltage U at the power supply to 15 V.
- Measure the current strength I_L and voltage U_a and note these in Table 2.
- Set the load resistances R_L per Table 2 and repeat the measurement each time.

c) Voltage divider with potentiometer

- Set up the test per Fig. 3. First insert a bridging plug for resistor R_2 (i.e. $R_2 = 0\,\Omega$)
- Set voltage U at the power supply to 15 V.
- Actuate the potentiometer and observe voltage U_a. Measure the minimum and maximum voltage U_a each time and note these in Table 3.
- Set the (series) resistances R_2 per Table 3 and repeat the measurement each time.

Measurement examples and evaluation

a) Simple voltage divider

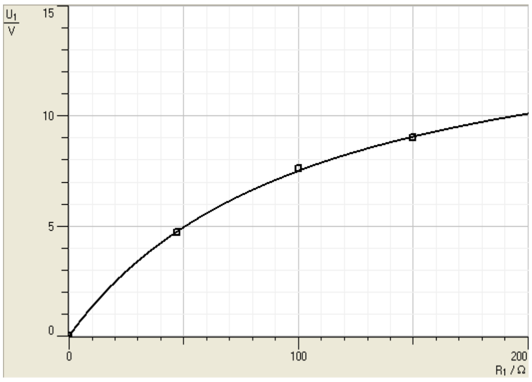
Tab. 1: Single voltage divider (R_2 = 100 Ω)

	Measured values		$\frac{U_1}{V}$ calculated with:	
$\frac{R_1}{\Omega}$	$\frac{I}{\text{mA}}$	$\frac{U_1}{V}$	$R_1 \cdot I$	$U \cdot \frac{R_1}{R_1 + R_2}$
∞	0	15.0	0	15*
150	60	9.0	9.0	9.0
100	73	7.6	7.3	7.5
47	100	4.7	4.7	4.8
0	150	0	0	0

(* through limit value evaluation)

– Calculate voltage U_1 and enter in Table 1.

– Enter the partial voltage U_1 in the graph against the resistance R_1:



– The output voltage U_1 depends on the size of the resistance R_1.

– The greater the resistance R_1 the greater the recorded voltage drop U_1.

b) Loaded voltage divider

Tab. 2: Loaded voltage divider
(R_1 = 470 Ω and R_2 = 100 Ω)

	Measured values		calculated with (4)	calculated with (6)
$\frac{R_L}{\Omega}$	$\frac{I}{\text{mA}}$	$\frac{U_a}{V}$	$\frac{I}{\text{mA}}$	$\frac{U_a}{V}$
∞	27	12.5	26*	12.4
150	71	7.9	70	8.0
100	83	6.7	82	6.8
47	105	4.4	105	4.5
0	150	0	150	0*

(* through limit value evaluation)

– The lower the load resistance, i.e. the more strongly the voltage divider is loaded, the lower the output voltage.

– Enter the output voltage U_a in the graph against the current strength I_L:

– The output voltage U_a drops with the current strength I_L.

– The maximum current strength is limited to 150 mA by the series resistor R_2.

c) Voltage divider with potentiometer

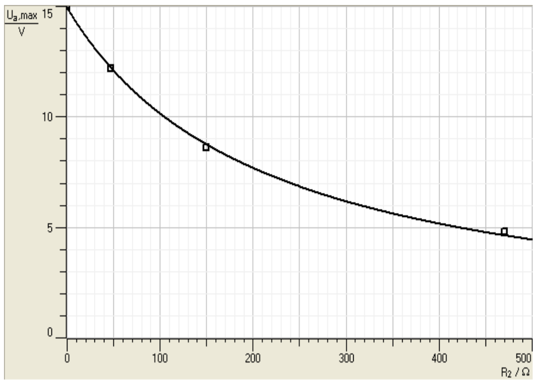
Tab. 3: Voltage divider with potentiometer R_P = 220 Ω

$\frac{R_2}{\Omega}$	$\frac{U_{a,min}}{V}$	$\frac{U_{a,max}}{V}$	$\frac{U \cdot \frac{R_P}{R_P + R_2}}{V}$
0	0	15.0	15.0
47	0	12.2	12.4
150	0	8.6	8.9
470	0	4.8	4.8

– Calculate voltage U_P and enter in Table 3.

– It is possible to set an infinitely variable >output voltage from 0 V to a max. U_P with the potentiometer.

– Enter the max. output voltage $U_{a,max}$ in the graph against the resistor *R2*:



– The greater the (series) resistance R_2 the lower the maximum recorded voltage drop $U_{a,max}$.

–