Wrocław University of Science and Technology

ELECTRIONIC MEASUREMENTS
LABORATORY REPORT

Chair of Electronic and Photonic Metrology
ELECTRIONIC MEASUREMENTS LABORATORY

Theme of class: MEASUREMET OF VOLTAGE AND CURRENT SOURCE PARAMETERS

Group no: 1

Students:
1. Paulina Nowak 251002
2. Ivan Melnyk 275510
3. Stanislav Kustov 275512

Date of class: 2023-01-09

Submission Date: 2023-01-16

Lab assistant: mgr inż. Krzysztof Adamczyk

Contents

1 Introduction

1.1 Theory

During this laboratory we explored the voltage and current source parameters, and their impact on a circuit. As we know, to get the most precise measurement, we should take into account every element in the circuit and power supplies are no exception. An ideal current source will maintain the chosen current despite the output voltage and the load resistance values. Similarly, an ideal voltage will always deliver the chosen voltage despite the current and the load resistance values. In reality, no device will ever behave like an ideal one, and both the voltage and the current source will lose the desired functionality after certain conditions are met.

1.2 Equipment

The following devices were used during the laboratory:

- power supply: DF1730SB3A;
- decade resistor: DR5b-16;
- digital meter: Agilent 34401A and UT803;
- oscilloscope;
- voltage sources;
- standard resistor.

2 Experiment

2.1 Measurement of voltage source parameters

The voltage source parameters were measured twice during this laboratory.

1st experiment

In the first experiment we connected an oscilloscope to the circuit (Fig. 1). Measurements were taken for varying load resistances and stopped once the $\frac{V}{V_o}$ ratio fell below 0.95. Current was calculated using the Ohm's Law and peak-to-peak voltage value was read from the oscilloscope. All measurements are shown in Table 1. Figure 2 shows the voltage-current characteristics of a voltage source.

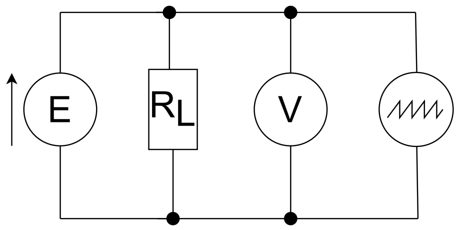


Figure 1: Voltage source parameters measurement (R_L – load resistance).

$R_L[\Omega]$	V[V]	$\frac{V}{V_o}$	V_{p-p}[mV]	I[mA]
10000	5.31131	0.99909	19.6	0.53113
9000	5.31236	0.99929	18	0.59026
8000	5.31491	0.99977	18.4	0.66436
7000	5.315501	0.99988	19.2	0.75936
6000	5.31475	0.99974	18.8	0.88579
5000	5.3145	0.99969	18	1.06290
4000	5.31252	0.99932	16.4	1.32813
3000	5.31252	0.99932	20.4	1.77084
2000	5.30828	0.99852	18.8	2.65414
1000	5.31172	0.99917	18	5.31172
900	5.31169	0.99916	19.6	5.90188
800	5.31252	0.99932	17.2	6.64065
700	5.31295	0.99940	19.6	7.58993
600	5.31366	0.99953	15.2	8.85610
500	5.31247	0.99931	17.6	10.62494
400	5.14929	0.96861	50.4	12.87323
300	4.92745	0.92688	100	16.42483

Table 1: Voltage source parameters measurements for $V_o = 5.316\,15\,\mathrm{V}$ (R_L – load resistance, V_o – measured voltage for $R_L = 0\,\Omega$, V_{p-p} – peak-to-peak voltage).

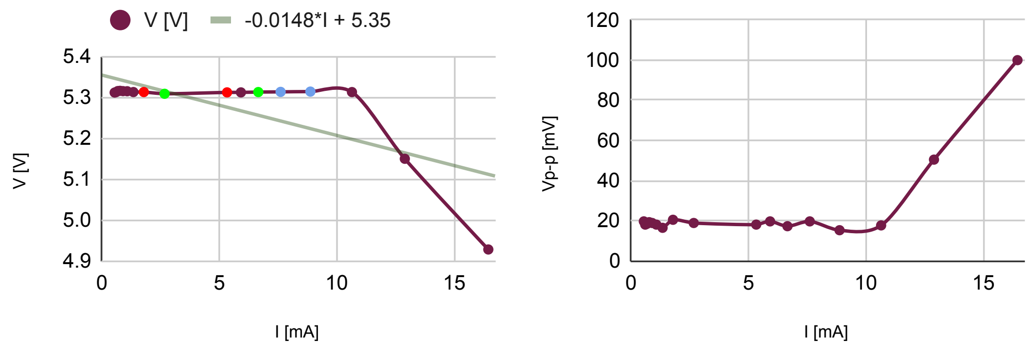


Figure 2: Voltage-current characteristics of a voltage source.

Using the $V = f(I)$ graph and the trend line defined by the equation $V = -I \cdot R_{int} + E$, the following values can be obtained:

- R_{int} (internal resistance defined as the slope of the trend line): 14.8 Ω;
- E (electromotive force): 5.35 V;
- I_{max} (maximal current for which the power supply works like an ideal one): ≈ 10 mA.

Table 2 shows the parameters calculated using the two-point method.

Points	V_1[V]	I_1[mA]	V_2[V]	I_2[mA]	R_{int}[Ω]	E[V]
Red	5.31252	1.77084	5.31172	5.31172	0.22593	5.31292
Green	5.30828	2.65414	5.31252	6.64065	−1.06359	5.30546
Blue	5.31295	7.58993	5.31366	8.85610	−0.56075	5.30869

Table 2: Voltage source parameters.

E and R_{int} were obtained using the formulas shown in Equation 3.

$$\begin{cases} E = I_1 \cdot R_{int} + V_1 \\ E = I_2 \cdot R_{int} + V_2 \end{cases} \quad \begin{cases} R_{int} = \frac{V_1 - V_2}{I_2 - I_1} \\ E = I \cdot R_{int} + V \end{cases} \tag{1}$$

2nd experiment

In the second experiment we disconnected the oscilloscope and added an ammeter to the circuit (Fig. 3). Measurements were made for varying load resistance values and stopped once the $\frac{V}{V_o}$ ratio fell below 0.95. All measurements are shown in Table 3. Figure 4 shows the voltage-current characteristics of a voltage source.

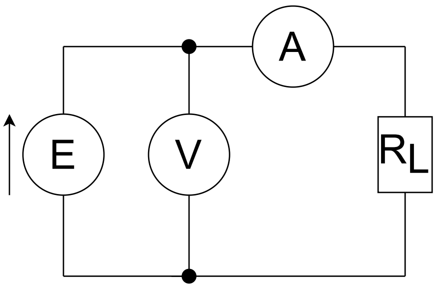


Figure 3: Voltage source parameters measurement (R_L – load resistance).

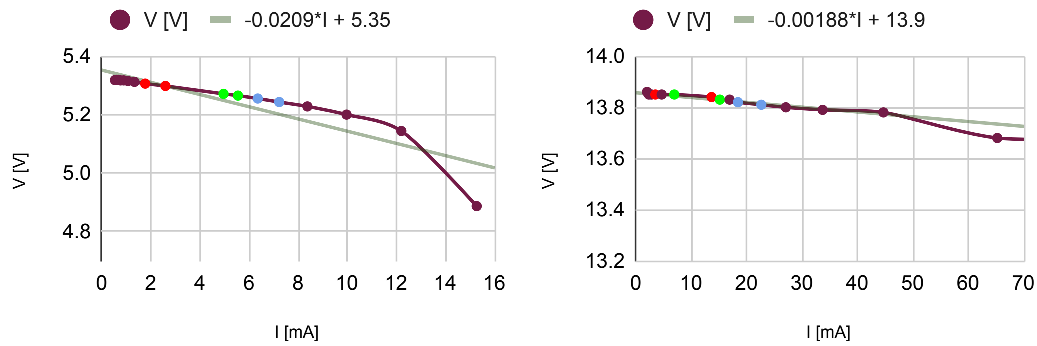
$R_L[\Omega]$	V[V]	$\frac{V}{V_o}$	I[mA]
10000	5.318	0.99906	0.53137
9000	5.319	0.99925	0.59025
8000	5.319	0.99925	0.66377
7000	5.317	0.99887	0.75821
6000	5.317	0.99887	0.88412
5000	5.315	0.99850	1.06036
4000	5.312	0.99793	1.3242
3000	5.306	0.99681	1.76291
2000	5.298	0.99530	2.58513
1000	5.271	0.99023	4.95231
900	5.265	0.98910	5.53997
800	5.255	0.98723	6.34545
700	5.243	0.98497	7.21971
600	5.228	0.98215	8.36787
500	5.200	0.97689	9.96317
400	5.144	0.96637	12.1929
300	4.887	0.91809	15.2643

(a) 1st voltage source: $V_o = 5.323\,\mathrm{V}$

$R_L[\Omega]$	V[V]	$\frac{V}{V_o}$	I[mA]
10000	13.86	0.99856	1.38284
9000	13.86	0.99856	1.51444
8000	13.86	0.99856	1.70754
7000	13.86	0.99856	1.95128
6000	13.85	0.99784	2.28445
5000	13.85	0.99784	2.76018
4000	13.85	0.99784	3.44949
3000	13.85	0.99784	4.59595
2000	13.85	0.99784	6.87844
1000	13.84	0.99712	13.6041
900	13.83	0.9940	15.0913
800	13.83	0.99640	16.8573
700	13.82	0.99568	18.3644
600	13.81	0.99496	22.5856
500	13.8	0.99424	27.0082
400	13.79	0.99352	33.6526
300	13.78	0.99280	44.6311
200	13.68	0.98559	65.1863
100	13.66	0.98415	132.8120
50	13.37	0.96326	251.9140

(b) 2nd voltage source: $V_o = 13.88\,\mathrm{V}$

Table 3: Voltage source parameters measurements (R_L – load resistance, V_o – measured voltage for $R_L = 0\,\Omega$)



(a) 1st voltage source (b) 2nd voltage source

Figure 4: Voltage-current characteristics of a voltage source.

Similarly as in the first experiment, the parameters can be obtained using the graph and the trend line. For the first voltage source we get:

- $R_{int} = 20.9\,\Omega$;
- $E = 5.35\,\mathrm{V}$;
- $I_{max} \approx 10\,\mathrm{mA}$.

And for the second voltage source:

- $R_{int} = 1.88\,\Omega$;
- $E = 13.9\,\mathrm{V}$;
- $I_{max} \approx 30\,\mathrm{mA}$.

Tables 4, 5 show the parameters calculated using the two-point method.

Points	V_1[V]	I_1[mA]	V_2[V]	I_2[mA]	R_{int}[Ω]	E[V]
Red	5.306	1.76291	5.298	2.58513	9.72976	5.32315
Green	5.271	4.95231	5.265	5.53997	10.20999	5.32156
Blue	5.255	6.34545	5.243	7.21971	13.72589	5.34210

Table 4: 1st voltage source parameters.

Points	V_1[V]	I_1[mA]	V_2[V]	I_2[mA]	R_{int}[Ω]	E[V]
Red	13.85	3.44949	13.84	13.6041	0.98477	13.85340
Green	13.85	6.87844	13.83	15.0913	2.43521	13.86675
Blue	13.82	18.3644	13.81	22.5856	2.36899	13.86351

Table 5: 2nd voltage source parameters.

E and R_{int} were obtained using the formulas shown in Equation 3.

2.2 Measurement of current source parameters

To measure current source parameters we added a $10\,\Omega$ standard resistor to the circuit (Fig.5). Measurements were taken for varying load resistances and stopped once the $\frac{V}{V_o}$ ratio fell below 0.99. All measurements are shown in Table 6. Figure 6 shows the current-voltage characteristics of a current source.

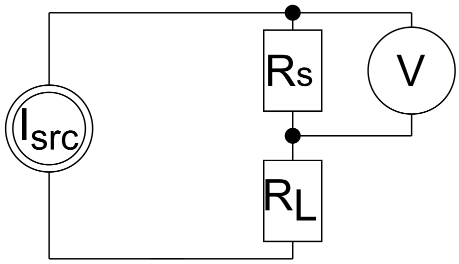


Figure 5: Current source parameters measurement (R_L – load resistance, R_s – standard resistor).

$R_L[\Omega]$	V_v[mV]	$\frac{V_v}{V_o}$	I[mA]	V[V]
0	19.3363	1.00000	1.93363	0.0193363
10	19.4437	1.00555	1.94437	0.0388874
20	19.4527	1.00602	1.94527	0.0583581
30	19.4569	1.00624	1.94569	0.0778276
40	19.4585	1.00632	1.94585	0.0972925
50	19.4607	1.00643	1.94607	0.1167642
60	19.4627	1.00654	1.94627	0.1362389
70	19.4633	1.00657	1.94633	0.1557064
80	19.4639	1.00660	1.94639	0.1751751
90	19.464	1.00660	1.9464	0.19464
100	19.4647	1.00664	1.94647	0.2141117
200	19.4199	1.00432	1.94199	0.4078179
500	19.4347	1.00509	1.94347	0.9911697
1000	19.4332	1.00501	1.94332	1.9627532
2000	19.4207	1.00436	1.94207	3.9035607
5000	19.3332	0.99984	1.93332	9.6859332
6000	16.8815	0.87305	1.68815	10.1457815

Table 6: Current source parameters measurements for $V_o = 19.3363\,\mathrm{mV}$ (R_L – load resistance, V_v – voltage drop on the standard resistor, V_o – measured voltage for $R_L = 0\,\Omega$).

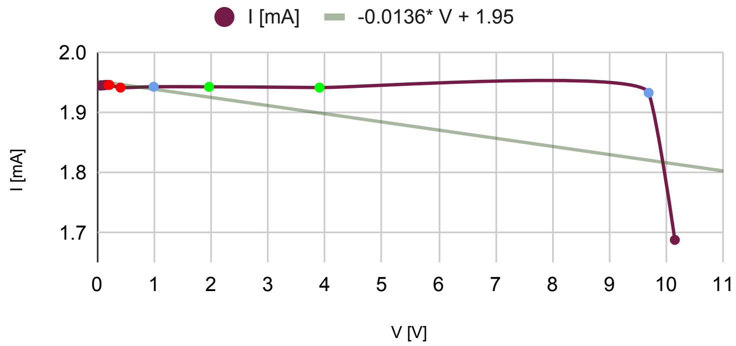


Figure 6: Current-voltage characteristics of a current source.

Looking at the graph, we estimated the maximal voltage to be about 9 V. Table 7 shows the parameters calculated using the two-point method.

Points	V_1[V]	I_1[mA]	V_2[V]	I_2[mA]	$R_{int}[\Omega]$	I_{src}[mA]
Red	0.21411	1.94647	0.40782	1.94199	43238.83929	1.94647
Green	1.96275	1.94332	3.90356	1.94207	1552648	1.94332
Blue	0.99117	1.94347	9.68593	1.93332	856626.60099	1.94347

Table 7: Current source parameters (R_{int}– internal resistance of the current source, I_{src}– nominal value).

Current I and voltage V were obtained using the following formulas:

$$\begin{cases} I = \frac{V_v}{R_s} \\ V = I \cdot (R_L + R_s) \end{cases} \tag{2}$$

And R_{int} and I_{src} were obtained using these:

$$\begin{cases} I_1 = I_{src} - \frac{V_1}{Rint} \\ I_2 = I_{src} - \frac{V_2}{Rint} \end{cases} \quad \begin{cases} R_{int} = \frac{V_1 - V_2}{I_2 - I_1} \\ I_{src} = I + \frac{V}{Rint} \end{cases} \tag{3}$$

3 Conclusion

All experiments confirmed the limitations of a power supply. It is not fully clear to us why the 1st experiment produced locally increasing voltage and, as a result, negative internal resistance values (Tab. 2); the most plausible explanations seem to be either human error or a device malfunction. Despite this unexpected behavior, it is still clearly visible in all graphs that power supplies are unable to perform as desired once their limits are reached.