جامعة بيرزيت
BIRZEIT UNIVERSITY

Physics Department
Physics 112

Experiment 2 :
Source Internal Resistance, Loading Problems And Circuit Impedance Matching

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Abstract :

The aim of experiment is to find the values of internal resistance and emf, and find the resistance that satisfies the condition of maximum power transfer.

The main result is: $R_{in} = 980\ \Omega$ **.**

note: the R_{in} calculated ~~is the~~ was supposed in Theory to be $r_{in} + R_{ext}$ but not the true value of r_{in}, also our result is accepted because it's in the Range of uncertainty of the external Resistance $\boxed{950\,\Omega - 1050\,\Omega}$

Theory :

All batteries in the world have an emf, this definition express the voltage difference between its terminals. An ideal voltage source is connected to a circuit with R~0 and by Ohm's Law V=IR it provides infinite current, and this will be impossible practically, so the battery should include an internal resistance that helps the voltage source to maintain most of its emf as voltage difference .

We use voltage sources to provide circuit components with power, and this components consume the power to produce useful work is called load.

$I = \frac{\varepsilon}{R_L + R_{in}}$ By ohm's law. (in the circuit shown below ⓐ) note: we suppose that $\boxed{R_{in} = r_{in} + R_{ex}}$

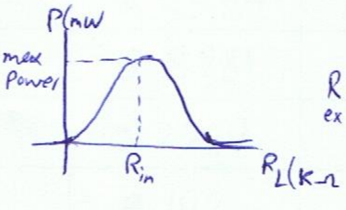
$Power = I^2 R = \frac{\varepsilon^2}{(R_L + R_{in})^2} R_L$ $\Rightarrow$ if we put P on y-axis and R_L on the x-axis we get the graph ⓑ

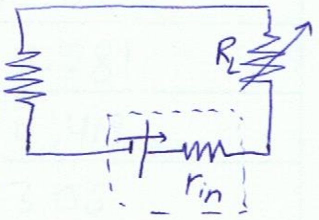
We get the maximum power by deriving the previous equation, and it will be equal zero at the max point >>> this give us the value of internal resistance.

by the differential rules

the extreme value can be found by deriving the power function

$\frac{dP}{dR_L} = 0 \Longrightarrow$ this statement will give us that $\boxed{R_L = R_{in}}$





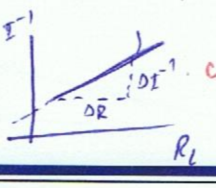
graph (a)

$I^{-1} = \frac{R_L + R_{in}}{\varepsilon}$

↓ x

$\underset{y}{I^{-1}} = \underbrace{\boxed{\frac{1}{\varepsilon}}}_{slop} \underset{x}{R_L} + \boxed{\frac{R_{in}}{\varepsilon}}$ constant the y-intercept

after that, if we plot I^{-1} on y-axis and R_L on x-axis we'll get linear graph



slop $= \frac{1}{\varepsilon}$ and y-intercept $= \frac{R_{in}}{\varepsilon}$

Physics 112 - Experiment Two

Impedance Matching and Internal Resistance

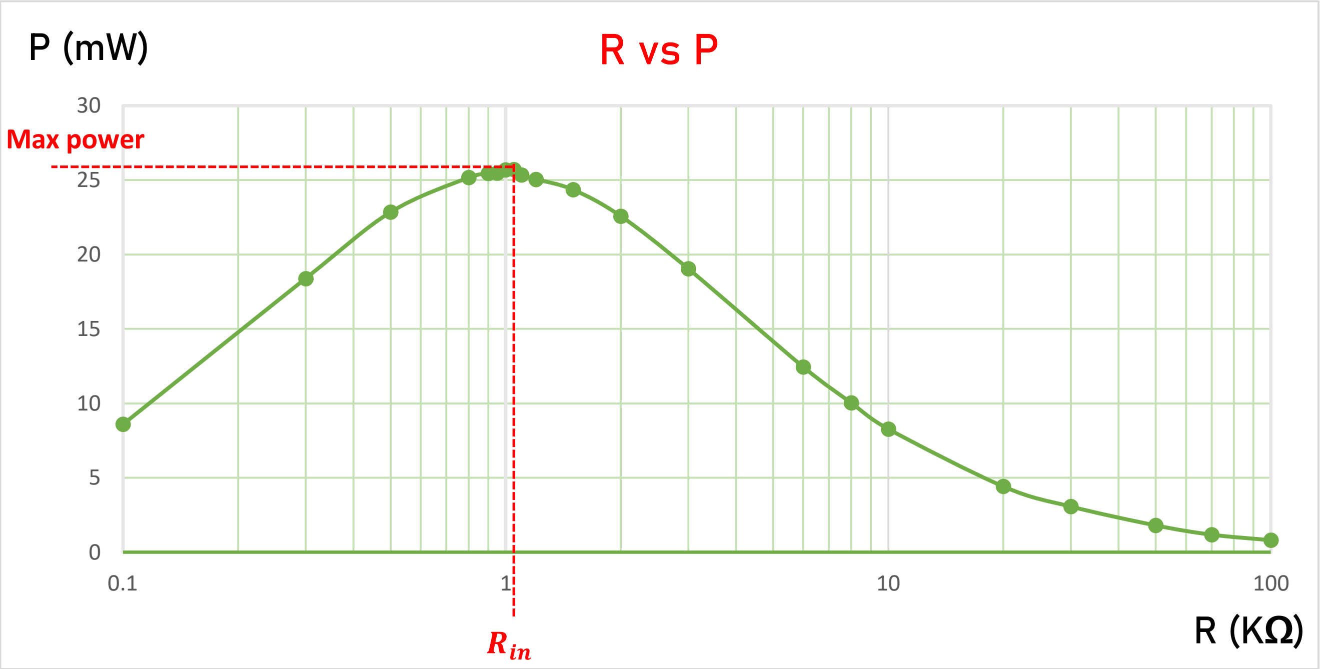
x y y

R_L (KΩ)	I(mA)	I^{-1} $(mA)^{-1}$	I^2 $(mA)^2$	$P_L = I^2 R_L$ (mW)
0.1	9.27	0.1078	85.932	8.593
0.3	7.83	0.1277	61.308	18.3924
0.5	6.76	0.1479	45.697	22.848
0.8	5.61	0.1782	31.472	25.177
0.9	5.32	0.1879	28.302	25.471
0.95	5.18	0.1930	26.832	25.4904
1.0	5.07		25.705	25.705
1.05	4.95		24.502	25.727
1.1	4.80		23.040	25.344
1.2	4.57		20.885	25.062
1.5	4.03		16.2409	24.3613
2.0	3.36		11.2896	22.579
3.0	2.52		6.350	19.05
6.0	1.44		2.074	12.444
8.0	1.12		1.2544	10.0352
10.0	0.91		0.8281	8.281
20.0	0.47		0.2209	4.418
30.0	0.32		0.102	3.06
50.0	0.19		0.0361	1.805
70.0	0.13		0.0170	1.19
100.0	0.09		0.008	0.8

21/7/2022

Graph 1 : $R_L vs P$

R(KΩ)	P(mW)
0.1	8.59329
0.3	18.39267
0.5	22.8488
0.8	25.17768
0.9	25.47216
0.95	25.49078
1	25.7049
1.05	25.72763
1.1	25.344
1.2	25.06188
1.5	**24.36135**
2	22.5792
3	19.0512
6	12.4416
8	10.0352
10	8.281
20	4.418
30	3.072
50	1.805
70	1.183
100	0.81



Graph 2 : $I^{-1} vs\ R_L$

R	I^{-1}
0.1	0.107875
0.3	0.127714
0.5	0.147929
0.8	0.178253
0.9	0.18797
0.95	0.19305
1	0.197239

$$I = \frac{\varepsilon}{R_L + r_{in} + R_{ex}} => I^{-1} = \frac{R_L + r_{in} + R_{ex}}{\varepsilon}$$

$$I^{-1} = \frac{1}{\varepsilon} \times R_L + \frac{r_{in} + R_{ex}}{\varepsilon}$$

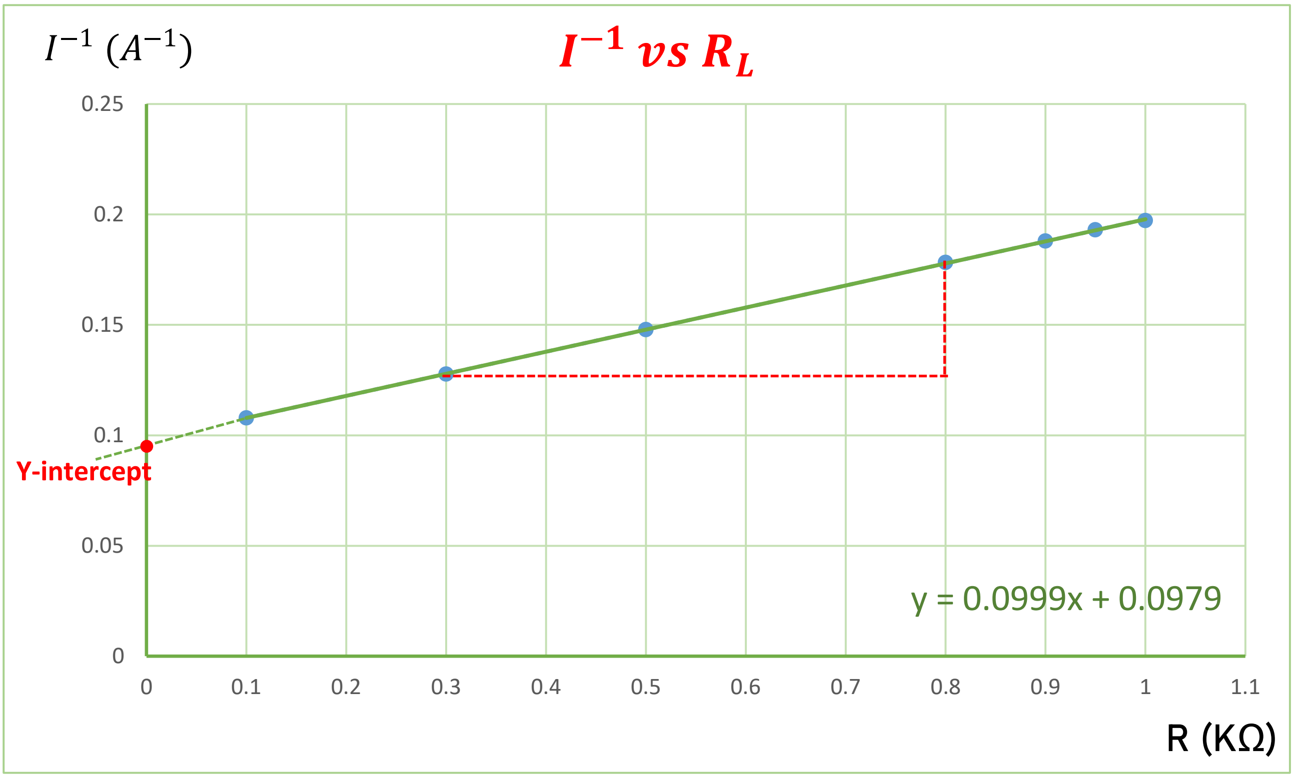
Slop y-intercept

$$\varepsilon = \frac{1}{slop} = \frac{1}{0.0999} = 10.01\ volt$$

$$y\ intercept = \frac{r_{in} + R_{ex}}{\varepsilon} => r_{in} + R_{ex} = \varepsilon . y\ int$$

$$= 10.01 * 0.0979 = 0.97998\ K\Omega$$

$$r_{in} = 980\ \Omega$$



Results and conclusion :

The value of internal resistance we found is 980Ω, but in fact, this value is the summation of internal and other external resistance with value 1 KΩ. We add this external resistance to produce the maximum power transfer condition for large values of R_L , also , it works as additional load resistance , all that because internal resistance is very small so that we can't calculate it alone experimentally .

In the above graphs. The first graph describes the power curve, and at the x-coordinate of the extreme value we have the value of internal resistance. The second graph present the linear relation between I^{-1} and R, from the slop we calculated the emf, and from the y-intercept we calculated the internal resistance.

The value calculated 980 ohm is accepted because it agrees with theory and included in the range of uncertainty of the external resistence 950-1050 ohm