Lab 2 Results – Circuit Theorems

ECE202: Fundamentals of Electrical Engineering

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2.1 Delta-Wye Transformations

Wye						
	R1(Ω)	**R2(Ω)**	**R3(Ω)**	**u-v(Ω)**	**v-w(Ω)**	**w-u(Ω)**
Measured	215.7	458.6	319.5	673	777	535.2
Calculated	209.5	461.4	314.7	978	1469	667
Delta						
	Ra(Ω)	**Rb(Ω)**	**Rc(Ω)**	**x-y(Ω)**	**y-z(Ω)**	**z-x(Ω)**
Measured	1469	667	978	672	777	525.6
Calculated	1457.4	685.5	983.9	983.9	1457.4	685.5

2.2 The Test Circuit

R_load	**Vb**	**Va**	**V_R1**	**V_R2**	**V_load**	**Ib**	**Ia**	**I_load**
(Ω)	(V)	(V)	(V)	(V)	(V)	(mA)	(mA)	(mA)
100	3.2538	5.0103	4.3062	2.9795	0.681	3.83	2.91	6.74
220	3.2578	5.0102	3.76	2.04	1.23	3.03	2.94	5.58
470	3.259	5.0107	3.08	1.36	1.9162	2.02	2.56	4.11
1000	3.2625	5.0106	2.388	0.6717	2.6097	1.01	2.02	2.62
2200	3.2656	5.0113	1.839	0.124	3.155	0.19	1.36	1.44

2.3 The Test Circuit

2.3.1 Vb Acting Alone

R_load	Vb	Va	V_R1	V_R2	V_load	Ib	Ia	I_load
(Ω)	(V)	(V)	(V)	(V)	(V)	(mA)	(mA)	(mA)
100	3.2545	0.0125	0.4116	2.8813	0.3822	4.25	0.26	3.98
220	3.2538	0.0133	0.733	2.5602	0.706	3.78	0.48	3.29
470	3.2583	0.0126	1.1355	2.1601	1.1162	3.17	0.76	2.41
1000	3.2589	0.0124	1.5419	1.7527	1.5175	2.58	1.03	1.54
2200	3.2600	0.0128	1.8662	1.4318	1.839	2.10	1.25	0.85

2.3.2 Va Acting Alone

R_load	Vb	Va	V_R1	V_R2	V_load	Ib	Ia	I_load
(Ω)	(V)	(V)	(V)	(V)	(V)	(mA)	(mA)	(mA)
100	0.009	5.0108	4.7344	0.2677	0.289	0.40	3.18	2.75
220	0.0108	5.0113	4.5101	0.4912	0.513	0.73	3.03	2.28
470	0.0095	5.011	4.2292	0.772	0.794	1.14	2.84	1.68
1000	0.0071	5.0109	3.947	1.0531	1.077	1.57	2.65	1.07
2200	0.0083	5.0104	3.7226	1.2752	1.3013	1.90	2.50	0.59

Superposition (Vb Acting Alone + Va Acting Alone)

R_load	Vb	Va	V_R1	V_R2	V_load	Ib	Ia	I_load
(Ω)	(V)	(V)	(V)	(V)	(V)	(mA)	(mA)	(mA)
100	3.2635	5.0233	5.146	3.149	0.6712	4.65	3.44	6.73
220	3.2646	5.0246	5.2431	3.0514	1.219	4.51	3.51	5.57
470	3.2678	5.0236	5.3647	2.9321	1.9102	4.31	3.6	4.09
1000	3.266	5.0233	5.4889	2.8058	2.5945	4.15	3.68	2.61

2200	3.2683	5.0232	5.5888	2.707	3.1403	4	3.75	1.44

2.4 Thevenin/Norton

2.4.1 Equivalent Parameters

V_th	(V)	3.82
I_norton	(mA)	8.2
R_th/R_norton	(Ω)	460.7

2.4.2 Thevenin Circuit

V_th (measured)	(V)	3.8345
R_th (measured)	(Ω)	458.7

R_load	V_load	I_load	P_source	P_load	η
(Ω)	(V)	(mA)	(mW)	(mW)	(%)
100	0.6512	6.73	32.05	4.38	13.7
220	1.195	5.56	32.05	6.64	20.7
470	1.8876	4.09	32.05	7.72	24.1
1000	2.5722	2.63	32.05	6.76	21.9
2200	3.1256	1.45	32.05	4.53	14.1

1) **Show your work for finding P_source, P_load and η for the case of R_load at 220 Ω for Thevenin Circuit.**

P_load= [V_th (measured)]^2/R_th (measured) = (3.8345 V)^2/458.7 Ω = 32.05 mW

P_load = V_load * I_load = 1.195 V * 5.56 mA = 6.64 mW

η =(P_load/P_load) * 100% = (6.64/32.05) * 100% = 20.7 %

2.4.3 Norton Circuit

I_{norton} (measured)	(mA)	8.64
R_norton (measured)	(Ω)	458.7

R_load	**V_load**	**I_load**	**P_source**	**P_load**	**η**
(Ω)	(V)	(mA)	(mW)	(mW)	(%)
100	0.68	7.08	34.2	4.81	14.1
220	1.25	5.83	34.2	7.29	21.3
470	1.975	4.27	34.2	8.43	24.6
1000	2.683	2.74	34.2	7.35	21.5
2200	3.252	1.51	34.2	4.91	14.4

2) What are the three different strategies described in the lab procedures for measuring R_th/R_norton.

Strategy 1: Calculate the Thevenin/Norton resistance by dividing the Thevenin-equivalent voltage by the Norton-equivalent current

Strategy 2: Adjust the load resistance R_load until the voltage across it equals half of the Thevenin-equivalent voltage. At this point, R_load is equal to both R_TH and R_NORTON.

Strategy 3: Replace all sources with their internal resistances (shorting voltage sources and opening current sources) and measure the resistance at the terminals.

3) Looking at both the Thevenin circuit and Norton circuit plot, what is the value of R_load which gives the maximum power? What is the efficiency at this operating point? Is this efficiency maximum?

In both Thevenin circuit and Norton circuit plot R_load = 470 Ω gives the maximum power. For Thevenin circuit efficiency is 24.1 % and for Norton circuit efficiency is 24.6% both of which are efficiency maximum respectively.

4) **Comparing the Thevenin I-V Characteristic Curve to the Norton Characteristic curve, would you say that these circuits perform equivalently?**

Yes, the Thevenin and Norton circuits perform equivalently in terms of their electrical characteristics. Both are two different ways of representing the same circuit, and their I-V characteristic curves are similar as can be seen by the plots on next few pages. This is because the Thevenin circuit uses a voltage source in series with a resistor, while the Norton circuit uses a current source in parallel with a resistor. When you convert between the two, the voltage and current relationships are preserved, which is why they show similar behavior.

Load I-V Characteristic Plot

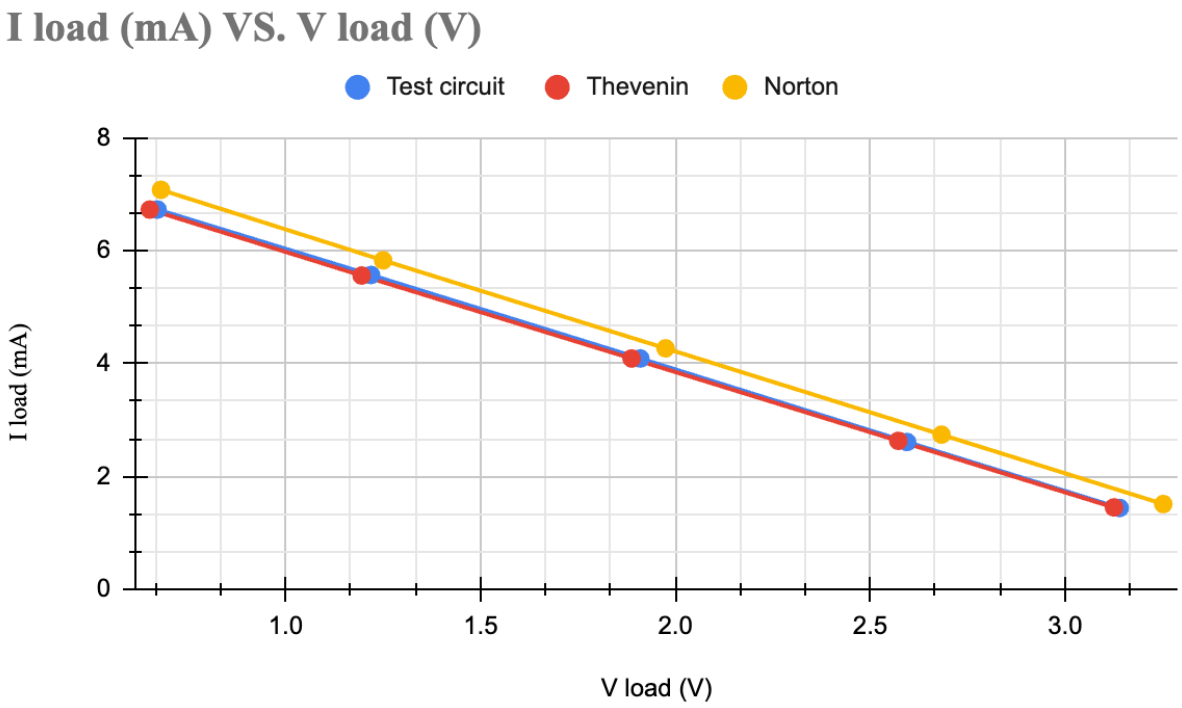
The following pages have been left for you to include the plots that you are required to create as part of your post-lab.

To create your plots you can use whichever software you would like (Excel, Matlab, etc), export your plot as an image and import it into your Lab 2 - Results sheet in the appropriate place.

Your plots should include:

- A Plot title
- Label your axes and show what unit of measure is used.
- Include a marking for your data-points.
- Include a line between your data-points in the same series.
- Include a legend.
- Make sure your scales are appropriate and visible.

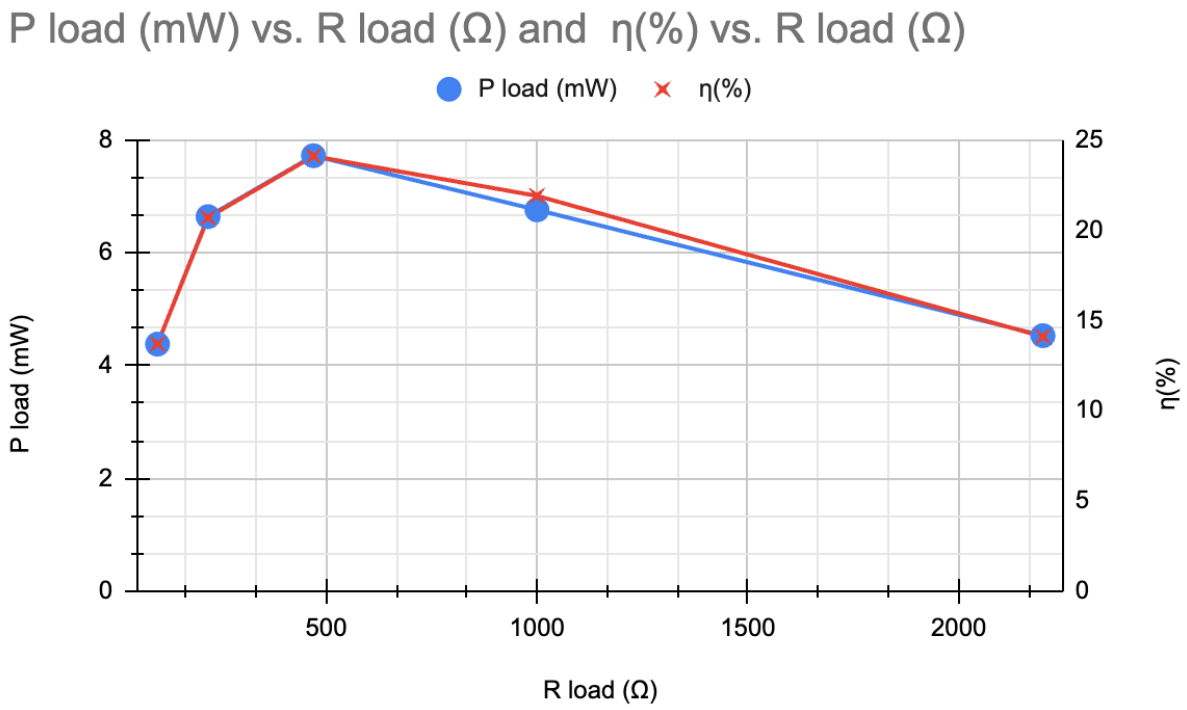
For each of these 3 circuits: The Test Circuit, Thevenin Circuit and Norton Circuit plot the load current vs. load voltage on the same plot.



Thevenin Circuit Plot

For your Thevenin Circuit results:

Plot the load power vs. load resistance as one series and the circuit efficiency vs. load resistance (R2) as a second series using a secondary y-axis scale.



Norton Circuit Plot

For your Norton Circuit results:

Plot the load power vs. load resistance as one series and the circuit efficiency vs. load resistance (R2) as a second series using a secondary y-axis scale.