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California State University, Northridge

Department of Electrical & Computer Engineering

Experiment 6
Network Theorems

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Introduction
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The purpose of the experiment is to understand how to design,build, and analyze complex

circuits by first simplifying them through Thevenin's, Norton's, Maximum Power and

Superposition theorem.

Equipment used:

Type	Model	Serial No.	Calibration Date
Power Supply	Tektronix PWS2323	MY48004846	N/A
Digital Multimeter	Tektronix CDM250	DM 250TWS2380	N/A

Parts Used:

QTY	Component	Value
1	Resistor	680Ω
1	Resistor	470Ω
1	Resistor	3.3kΩ
1	Resistor	10kΩ
1	Resistor	2.4kΩ
1	Resistor	2.7kΩ

1 Resistor 1kΩ

1 Resistor 4.7kΩ

Software
Used:

1. Google Docs
2. Krita
3. Snipping Tool
4. Google Sheets
5. Pspice

Theory
:

Thevenin's Theorem

Used to simplify a resistive circuit by replacing the original circuit with the open circuit voltage source and the series equivalent thevenin resistance.

a) Remove R_{load}. b) Compute voltage
across open terminals

c) remove all sources, short voltage sources, and compute the Thevenin resistance.

d) place the load back over the open terminal.

Norton's Theorem

Used to simplify a resistive circuit by replacing the original circuit with the short circuit current source and the equivalent parallel resistance.

Norton's theorem is related to Thevenin's theorem by ohm's law.

a) Remove R_{load} from the circuit that will equate to the Norton circuit.
b) Short the open terminals and evaluate I_{sc}. c) Eliminate all sources and find the equivalent resistance.

d) redraw the circuit with I_{sc} in parallel with R_N and R_{load} across the terminals.
If the circuit contains dependent sources, then R_{th} will be computed by the equation 6.2 rather than using step C.

Maximum Power Theorem

Used to simplify a circuit in which its load will consume max power.

For a Thevenin circuit to consume max power, the load resistance must be equal to the thevenin

resistance. To calculate the power of the thevenin circuit we use equation 6.3.

Superposition Theorem

Used to simplify circuits with multiple independent sources by calculating the voltage and

current across elements for each independent source and adding them together.

a) Eliminate all independent sources except one.

b) Find the currents & voltages desired and their directions.

c) repeat a & b for all independent sources.

d) add up all the results

Procedure & Results:

Part 1)

The Thevenin and Norton circuits were calculated for the circuit left of terminals a and b in

figure 6.4. Results were recorded in Table
6.1.

V_{oc} was found by removing the 3.3kΩ load, and open circuiting terminals a and b

I_{sc} was found by shorting terminals a and b

R_{TH} was found by shorting the voltage source.

V_{load} was calculated with the 3.3kΩ load back across terminals a and b

V_{ab} is the same as
V_{load}

Figure 6.4 was then constructed and simulated in Pspice and the results were recorded in table 6.1.

V_{oc} was simulated by putting a large resistor across terminals a and b.
Figure 6.4a

I_{sc} was simulated by putting a small resistor across terminals a and b.
Figure 6.4b

R_{TH} was calculated to be 1.937kΩ using Equation 6.2

$R_{TH} = V_{OC} / I_{SC} = 1.937\ k\Omega$
V_{LOAD} was simulated with a 3.3kΩ resistor.
Figure 6.4c

Figure 6.4 was then constructed and V_{OC}, I_{SC}, V_{LOAD}, and R_{TH} were all recorded with a DMM into table 6.1.

Table 6.1

	Calc	meas	Pspice	% error
V_{AB}	1.3406 v	1.339 v	1.341 v	2.6 %
V_{OC}	2.1277 v	2.12 v	2.128 v	0.36 %
I_{SC}	1.098 mA	1.10 mA	1.098 mA	1.8 %
R_{TH}	1.936 kΩ	1.904 kΩ	1.937 kΩ	1.7 %
V_{LOAD}	1.3406 v	1.339 v	1.341 v	2.6 %

The difference of the calculated and measured results are minimal and can be attributed to the tolerance values of the elements and the accuracy of our measuring tools. The similar results show an agreement with Norton's theorem and Thevenin's theorem.

Part 2)

R was evaluated for figure 6.5 using the maximum power theorem.

R_{TH} was found by shorting the voltage source and removing the load R.

Using maximum power theorem, $R = R_{TH}$. V_{OC} was calculated by removing the load R and calculating the voltage difference between the open terminals.
The power consumed by this resistor is calculated using Equation 6.3

P_{max} = 1.633 mw The circuit of Figure 6.5 was then constructed and V_{OC} ,R_{TH}, P_{max} were measured using a DMM and recorded in Table 6.2.

Table 6.2

	Meas	Calc	% error
P_{MAX}	1.638 mw	1.632 mw	0.4%

R_{TH} 2.43 kΩ 2.482 kΩ 2.1 %

V_{OC} 3.99 v 4.026 v 0.9% Minimal error in the results show that the experiment was a success in calculating the equivalent

resistance of the circuit.

5 resistors that have values in the neighborhood of R_{TH} were chosen to be R and be plotted in P vs R graph. The resistors were each input to the circuit built 1 by 1, their voltages across these

resistors were measured with a DMM, and recorded in Table 6.3.

The 5 resistors were simulated in simulations of figure 6.5a through figure 6.5e in PSpice, and

the voltages across the resistors were recorded in Table 6.3.

Figure 6.5a

Figure 6.5b

Figure 6.5c

Figure 6.5d

Figure 6.5e

Table 6.3

R	V_{Meas}	P_{Meas}	V_{pspice}	P_{pspice}	% error
0.200 kΩ	0.290 V	0.4205 mW	0.301 V	0.453 mW	6.6%
1 kΩ	1.14 V	1.300 mW	1.156 V	1.336 mW	2.7%
2.4 kΩ	2.6 V	1.438 mW	2.634 V	1.478 mW	2.9%
4.7 kΩ	3.20 V	1.024 mW	3.225 V	1.040 mW	2.6%
10 kΩ	1.95 V	1.584 mW	1.979 V	1.632 mW	1.54%

The results in table 6.3 have a minimal differences with the exception of the 200 Ω resistor. This can be attributed the resistors measured value being lower than expected and as such producing a lower slightly voltage than expected. The resistance is still within the 5% tolerance value expected.

The results were plotted in Graph 6.3.

Graph
6.3

The graph shows a curve and an expected maximum value around the thevenin resistance of

2.482 kΩ. Overall, the results of the experiment agree with the theorem that the maximum power can consumed by the load occurs when the resistance is equivalent to the thevenin resistance.

Conclusions:

The experiment covered the usage of Thevenin’s theorem, Norton’s theorem, and the Maximum power theorem. Throughout all parts, the experiments was a success in understanding how to convert complex circuits into a simpler form by calculating the Thevenin resistance of a circuit and a corresponding open circuit voltage or short circuit current. There was minimal differences in the calculated results and the measured results of the simplified circuit. Part 2 was a success in

showing the maximum power theorem and that to design a circuit that maximum power

consumed through its load, then its load has to be equivalent to the Thevenin resistance of the

rest of the circuit. The results were accurate and the required load for maximum power was

correctly identified. By graphing power vs resistance for the circuit, the results were verified.