Methods of Mesh Analysis

Lab 002

Electrical Networks

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CET 3525 Section E213
Report Submitted : February 26 2018
Laboratory Exercise Performed : February 19 2018

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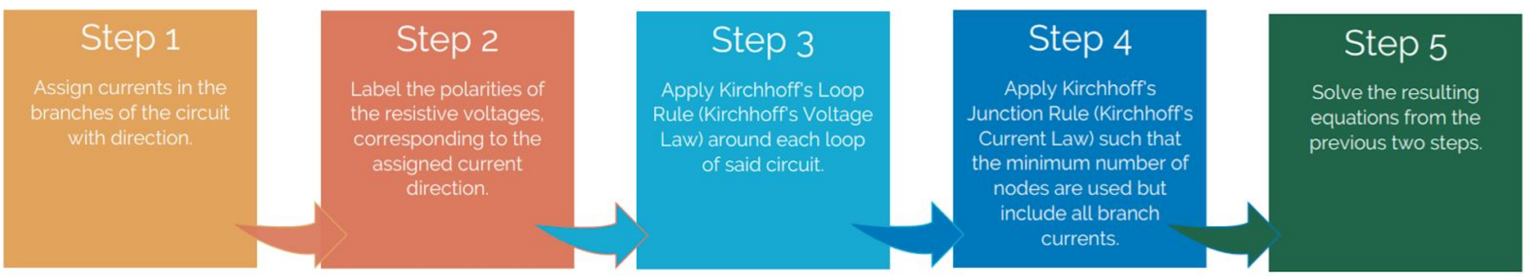
Objective

The primary goal of this laboratory exercise is to verify the validity of various circuit analysis techniques via comparison of theoretical and experimental results. This experiment will focus on the application of the following analytical techniques: *branch-current* , *mesh* (loop), and *nodal*.

Theory

Branch Current

This network analysis technique describes the relationship of currents using Kirchhoff's Law and the empirical Ohm's Law, under assumed directions (of current). Once an equation of every unknown current is formulated, the equations may be solved simultaneously - and one may deduce all the currents and voltage drops.



Mesh Current Analysis

The Mesh Current Analytical technique or "Maxwell's Circulating Currents method, uses the labeled currents circulating in a closed loop instead of labeling branch currents. Currents are assigned a direction (clockwise or counter-clockwise), and they are assumed to be flowing through all of the elements shared by that predetermined loop at least once.

Nodal Voltage Analysis

This analytical technique relies on Kirchhoff's Current to formulate equations describing the currents and related to the voltage potentials around each node of the circuit. So by adding together all these nodal voltages the net result will be equal to zero. Then, if there are "n" nodes in the circuit there will be "n-1" independent nodal equations and these alone are sufficient to describe and hence solve the circuit.

Materials

Resistors	External Variable DC Power Supply	Digital Multimeter
1kΩ	5 Volts	**Breadboard**
1.2 kΩ	10 Volts	**Jumper Wires**
2.2 kΩ	15 Volts	
3.3 kΩ	20 Volts	

Procedure

Upon construction of the circuits shown below, record measurements in regards to voltages and currents for each component and apply the assigned analytical technique. Compare the measured values to the theoretical & verify the validity of said analysis.

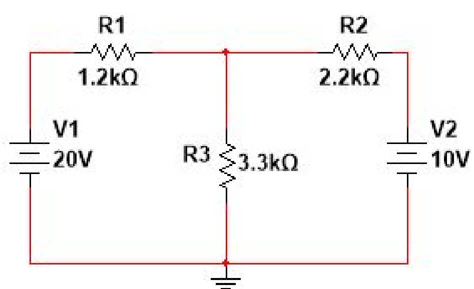


Figure 001

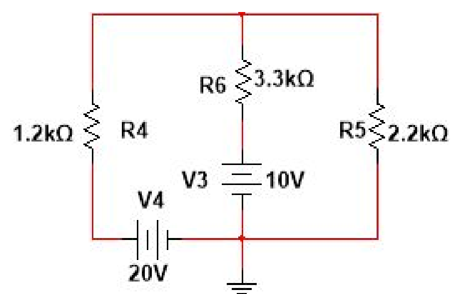


Figure 002

Procedure (cont.)

Part 001

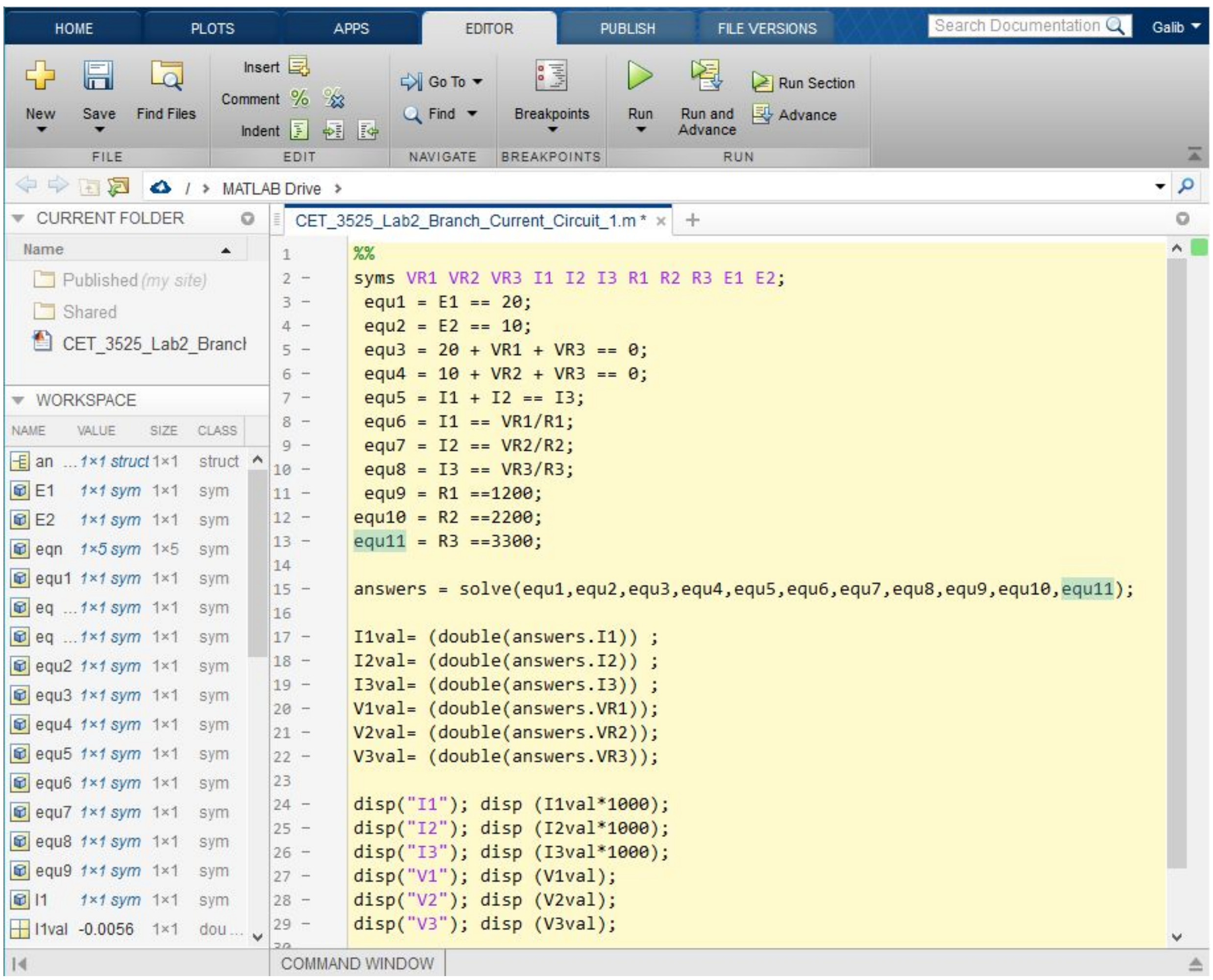
For the circuit shown in Figure 001, we applied the Branch Current Analysis - to deduce the theoretical values of the currents and potentials.

Upon formulation of the following equations we utilized MATLAB to solve these simultaneous linear equations.

$$20\,V + V_{R_1} + V_{R_3} = 0$$

$$10\,V + V_{R_2} + V_{R_3} = 0$$

$$I_1 + I_1 = I_3$$



Download MATLAB File here: http://bit.ly/CET3525Lab002

Procedure (cont.)

Part 002

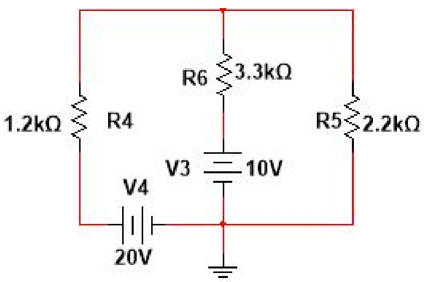


Figure 002

$eq.1: \quad 4.1(I_1) - 3.3(I_2) = 10$

$eq.2: \quad 3.3(I_1) - 5.5(I_2) = -10$

D = |4.5 -3.3| = -24.75-(-10.89) → D = -13.86

|3.3 -5.5|

$D_{I1} =$ | 10 -3.3| = -55-33 = -88 ; $I_1 = \frac{D_{I1}}{D} = \frac{-88}{-13.86} = 6.349\ mA$

|-10 -5.5|

$D_{I2} =$ |4.5 -3.3| = -45-33 = -78 ; $I_2 = \frac{D_{I2}}{D} = \frac{-78}{-13.86} = 5.63\ mA$

|3.3 -5.5|

$I_3 = I_2 - I_1 = 5.63 - 6.349 = -0.722\ mA$

Results

Table 14.1

Current		Calculated	Measured	% Difference
I_1		5.56 mA	5.67 mA	1.94%
I_2		1.52 mA	-1.55 mA	1.93%
I_3		-4 mA	4.12 mA	2.91%

Table 14.2

Voltage		Calculated	Measured	% Difference
V_1		-6.67 V	6.70 V	0.45%
V_2		3.33 V	3.37 V	1.1%
V_3		-13.33 V	13.41 V	0.6%

Table 14.3

Current		Calculated	Measured	% Difference
$I_{R1}=I_1$		6.35 mA	6.46 mA	1.70%
$I_{R2}=I_2$		5.63 mA	5.73 mA	1.75%
$I_{R3}=I_1-I_2$		-0.722 mA	-0.74 mA	2.43%

Table 14.4

Voltage		Calculated	Measured	% Difference
V_1		-6.67 V	6.70 V	0.45%
V_2		3.33 V	3.37 V	1..18%
V_3		-13.33 V	13.41 V	0.6%

Conclusion

Throughout these exercises, we have verified the validity of these various circuit analysis techniques and their proper usage. Mesh analysis and nodal analysis are two of the most fundamental techniques used in circuit analysis for various configurations between elements such as: Resistors, inductors and DC voltage/current sources in Parallel and/or Series. Being able to assign a mesh current in order to describe the behavior of a circuit simplifies the use of KVL (Kirchhoff's voltage law). Allowing for the solution of sizeable electrical networks with fewer unknown values. There is no limit to the amount of unknowns to be found, as long as we have a sufficient amount of equations to determine each value required for said circuit.

References

https://www.allaboutcircuits.com/textbook/direct-current/chpt-10/branch-current-method/
https://www.daenotes.com/electronics/basic-electronics/branch-current-method
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