SFU SIMON FRASER UNIVERSITY
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Faculty of Applied Science

School of Mechatronics Systems Engineering

MSE 211 - Computational Methods for Engineers

Instructor : Dr. Ahad Armin

Lab 3 - Linear Systems of Equations

Prepared By :

Lab Group 3 - Monday

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Due date:

March 20th, 2023

Introduction

The circuit in Figure 1 was constructed on a solderless breadboard and connected to a lab bench power supply and a digital multimeter was used to measure the voltages and currents throughout the network.

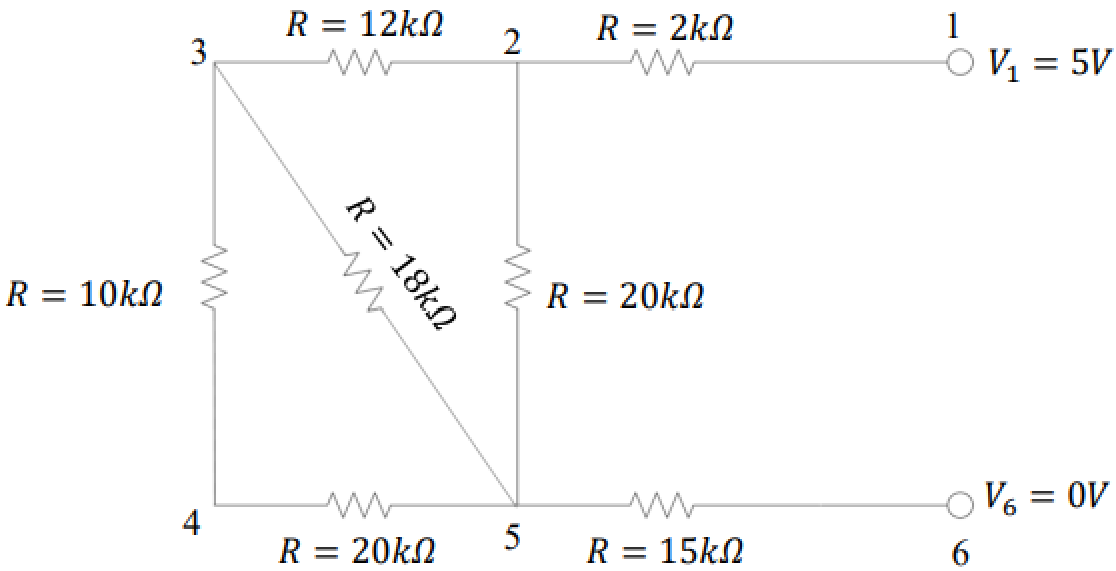

Fig 1: Electrical circuit

The primary objective of this lab is to model the currents and voltages in this resistor network as a system of linear equations. These equations can be derived using Ohm's Law and Kirchoff's Current and Voltage laws. Once derived, the system of equations is arranged in matrix form A**x** = **b**, where

$$\bar{x} = [V_2, V_3, V_4, V_5, i_{12}, i_{23}, i_{25}, i_{35}, i_{34}, i_{56}]$$

Solving for x yields the voltage at each node and the current through each resistor. This system can be modeled in MATLab, creating a convenient way to model different test cases for the same network model, such as replacing one of the resistors with a much larger resistor.

Results and Discussion

The system can be solved for **x** by multiplying the inverse of matrix A with **b.** This yields the following results.

Afterward, the error is calculated by first calculating **c** = A**x** - **b**, then calculating the magnitude of **c**. This yields a propagated error of 2.3189e-15.

Then, the Frobenius norm, the 1-norm, and the ∞-norm of A were all found to be in the 8th power, making this an ill-conditioned matrix. The interpretation of this result is that a small perturbation of the input conditions will lead to a large change in the output.

The 15kΩ resistor was then replaced with a 1MΩ resistor and the norms were recalculated. By adding the larger resistor, the norms jumped two orders of magnitude.

	Condition 1 (15kΩ)			Condition 2 (1MΩ)		
	Matlab	Lab Result	Absolute Error	Matlab	Lab Result	Absolute Error
V_2	4.64	4.54	2.20%	4.99	4.93	1.20%
V_3	3.64	3.51	2.47%	4.96	4.90	1.21%
V_4	3.33	3.21	3.60%	4.95	4.88	1.41%
V_5	2.70	2.58	4.44%	4.93	4.87	1.22%
i_{12}	0.000180	0.000183	1.66%	4.93e-06	0.00004	18.9%
i_{23}	8.33E-05	0.000084	0.840%	2.28e-06	0.00001	56.1%
i_{25}	9.69E-05	0.000098	1.13%	2.65e-06	0.00002	24.5%
i_{45}	5.21E-05	0.000053	1.73%	1.42e-06	0.00000	
i_{34}	3.12E-05	0.000031	0.641%	8.56e-07	0.00000	
i_{56}	0.000180	0.000182	1.11%	4.93e-06	0.00004	18.9%

Possible sources of error include manufacturing tolerances on the resistors and various microelectromechanical resistances in the breadboard and wires.

	k	k_1	k_∞
Condition 1 (15kΩ)	3.3693e8	6.3785e8	2.8314e8
Condition 2 (1MΩ)	2.3692e10	3.1189e10	2.2022e10

Conclusion

A linear system of equations was solved in Matlab. This was done through the use of two methods, the Frobenius norm and LU Decomposition. From the results of both methods, the values for the currents and voltages agree to some degree. The cause of the deviation from the actual values was due to experimental errors such as the tolerances of the resistors, and the resistances of other electronics used during the experiment.