

# Circuit Theory and Electronics Fundamentals 2020/2021

Integrated Masters in Aerospace Engineering, Técnico, University of Lisbon

First Laboratory Report

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## 1 Introduction

The objective of this laboratory assignment is to study a circuit containing a voltage source  $V_A$ , a current-controlled voltage source  $V_C$ , a current source  $I_D$  and a voltage-controlled current source  $I_B$  connected to different fixed value resistors  $R_1, R_2, R_3, R_4, R_5, R_6$  and  $R_7$ . The circuit can be seen in Figure 1.

In Section 2, a theoretical introduction is made in order to contextualize all the main principles that sustain our analysis of the circuit. This circuit is carefully analysed according to two of the most efficient ways to solve a circuit: the Mesh Current Method and the Node Voltage Method, both presented in Section ???. In Section 3, the circuit is analysed by simulation and the results are compared to the theoretical results obtained in Section ???. The conclusions of this study are outlined in the final part of the report, in Section 4.

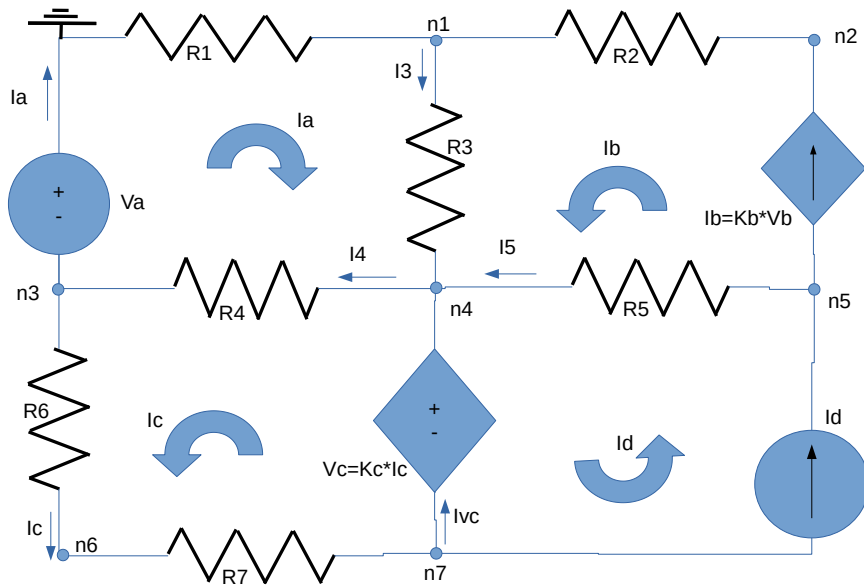


Figure 1: Second laboratory circuit.

## 2 Theoretical Introduction

The Mesh Current Method is a well-organized method for solving a circuit and is based on Kirchhoff's Voltage Law (KVL). To apply this method, we need to define what mesh current is. When we use the term mesh current, we are referring to an imagined current flowing around a loop. To apply this first step of this method, we first need to identify and distinguish a loop from a mesh. A loop corresponds to any closed path around the circuit and, to trace it, we start at any component terminal and trace a path through connected elements until we get back to the starting point. A loop is allowed to go through an element just one time. That leads us to the definition of a restricted kind of loop, a mesh, which contains no other loops.

The implementation of the Mesh Current Method to analyse the circuit was done following the common sequence of steps, summarized below.

- Identify the meshes.
- Assign a current variable to each mesh, using a consistent direction (clockwise or counterclockwise).
- Write Kirchhoff's Voltage Law equations around each mesh.
- Solve the resulting system of equations for all mesh currents.
- Solve for any element currents and voltages you want using Ohm's Law.

The Node Voltage Method is another way to analyze a circuit. This method is based on Kirchhoff's Current Law (KCL). To apply this method, we need to define what node voltage is. When we use the term node voltage, we are referring to the potential difference between two nodes of a circuit. We select one of the nodes in our circuit to be the reference node and, therefore, all the other node voltages are measured with respect to the referenced one. This reference node is called the ground node and, as it gets the ground symbol in Figure 1,

corresponds to the node between resistor  $R_1$  and voltage source  $V_A$ . The potential of the ground node is defined to be  $0V$  and the potentials of all the other nodes are measured relative to ground.

The implementation of the Node Voltage Method to analyse the circuit was done following the common sequence of steps, summarized below.

- Assign a reference node.
- Assign node voltage names to the remaining nodes.
- Solve the easy nodes first, the ones with a voltage source connected to the reference node.
- Write Kirchhoff's Current Law for each node.
- Solve the resulting system of equations for all node voltages.
- Solve for any currents you want to know using Ohm's Law.

## 3 Simulation Analysis

### 3.1 Topic I

### 3.2 Topic II

## 4 Conclusion

In this first laboratory assignment, all the major goals of the project were achieved. We concluded with success our first interaction with a new software (Ubuntu), with a simulation platform (Ngspice), with a computational language program (GNU Octave) and with a text report editor (LaTeX). The analysis of the circuit was also finished with success through simulation and theoretical interpretation.

The main objective of the report was completed with the study of a circuit containing a voltage source  $V_A$ , a current-controlled voltage source  $V_C$ , a current source  $I_D$  and a voltage-controlled current source  $I_B$  connected to different fixed value resistors  $R_1$ ,  $R_2$ ,  $R_3$ ,  $R_4$ ,  $R_5$ ,  $R_6$  and  $R_7$ . Mesh currents and node voltage were analysed both theoretically, using the Octave maths tool, and by circuit simulation, using the Ngspice tool. The simulation results matched the theoretical results precisely. This accuracy was confirmed by the mathematical calculation of relative errors, which were proved to be really small. The reason for this perfect match is the fact that this is a straightforward circuit containing only simple and linear components, so the theoretical and simulation models cannot differ. For more complex components, the theoretical and simulation models could differ. However, this is not the case of the analysis of this report, where the results are obtained successfully and with notorious precision.