

T1 - Introduction To Circuit Analysis

Integrated Master in Physics Engineering

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1 Introduction

The objective of this laboratory assignment is to study a circuit containing a various resistors, two voltage sources and two current sources. The circuit can be seen if Figure 1.

In Section 2, a theoretical analysis of the circuit is presented. In Section 3, the circuit is analysed by simulation, and the results are compared to the theoretical results obtained in Section 2. The conclusions of this study are outlined in Section 4.

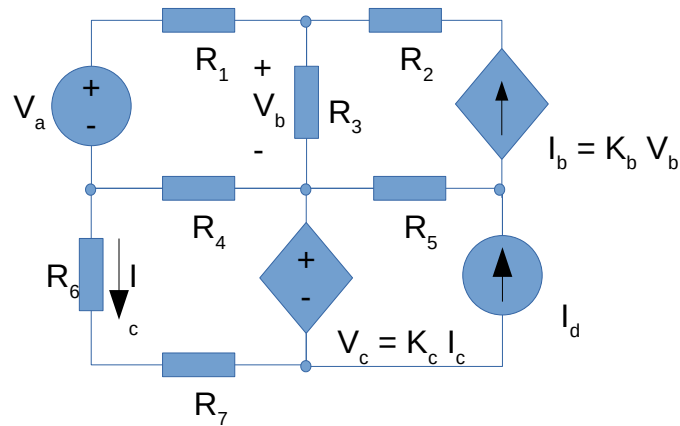


Figure 1: Circuit to be studied

2 Theoretical Analysis

In this section, the circuit shown in Figure 1 is analysed theoretically, first we approach the circuit using the mesh analysis, and later we analyse the circuit using the nodal analysis.

2.1 Mesh Analysis

As seen during theoretical lessons, we can use a mesh analysis to analyse the circuit. This method is built upon Kirchhoff's Voltage Law that states:

In a mesh, the sum of all voltages equals 0.

$$\sum_{i=0}^n V_i = 0 \quad (1)$$

The method consists of identifying every mesh, labeling its current and choosing the currents direction. Then the KVL equations are written for each mesh, and we can solve the system of equations, solving consequently the circuit.

As seen in in figure 2, there are four meshes, each with currents Y_a , Y_b , Y_c , Y_d , we will label each mesh as A, B, C, D respectively.

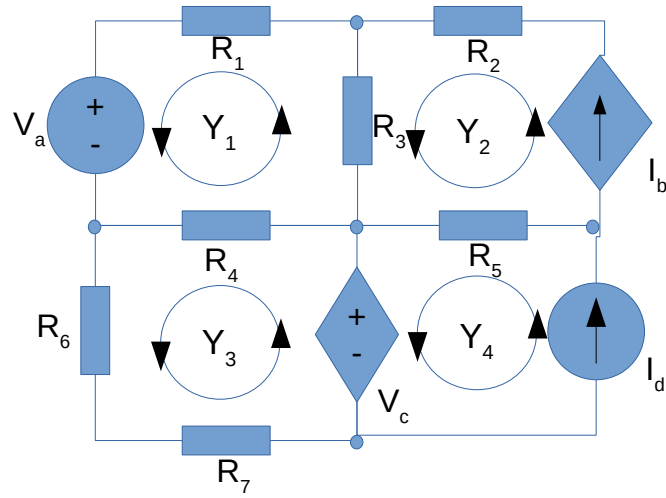


Figure 2: Current chosen for each mesh

The equations for each mesh are therefore:

$$\mathbf{E_A} : R_1 \cdot I_a + V_a + R_4 \cdot (I_a - I_c) + R_3 \cdot (I_a - I_b) = 0 \quad (2)$$

$$\mathbf{E_B} : R_2 \cdot I_b + R_3 \cdot (I_b - I_a) + R_5 \cdot (I_b - I_d) = 0 \quad (3)$$

$$\mathbf{E_C} : R_6 \cdot I_c + R_7 \cdot I_c - V_c + R_4 \cdot (I_c - I_a) = 0 \quad (4)$$

$$\mathbf{E_D} : V_c + R_5 \cdot (I_d - I_b) = 0 \quad (5)$$

Solving this system of equations, using the following values generated used the data generator python program using the number 93156:

R1	1.03919759193
R2	2.06836523173
R3	3.03375774261
R4	4.12779067183
R5	3.11985677803
R6	2.04513887844
R7	1.04289965713
Va	5.00439410964
Id	1.04536428769
Kb	7.25705461539
Kc	8.23640363075

Table 1: Data generated using number 93156

And the the following extra equations:

$$I_b = K_b \times V_b \quad (6)$$

where:

$$V_b = R_3 \times (I_b - I_a) \quad (7)$$

and

$$V_c = K_c \times I_c \quad (8)$$

We reach the following results, using octave:

Ia	-0.001880
Ib	-0.001970
Ic	-0.001076
Id	0.001045

Table 2: Results of Mesh Analysis using Octave

2.2 Nodal Analysis

V2	3.050285
V3	-1.024137
V5	12.728845
V7	3.321737

Table 3: Results of Nodal Analysis using Octave

3 Simulation Analysis

3.1 Operating Point Analysis

Table 4 shows the simulated operating point results for the circuit under analysis. Compared to the theoretical analysis results, one notices the following differences: describe and explain the differences.

Name	Value [A or V]
gib[i]	-1.96988e-03
id[current]	1.045364e-03
r1[i]	1.880402e-03
r2[i]	-1.96988e-03
r3[i]	8.947414e-05
r4[i]	-8.04723e-04
r5[i]	3.015240e-03
r6[i]	-1.07568e-03
r7[i]	-1.07568e-03
v(1)	5.004394e+00
v(2)	3.050285e+00
v(3)	-1.02414e+00
v(4)	3.321728e+00
v(5)	1.272885e+01
v(6)	2.199912e+00
v(7)	3.321737e+00
v(8)	2.199912e+00
v(10)	0.000000e+00

Table 4: Operating point. A variable preceded by @ is of type *current* and expressed in Ampere; other variables are of type *voltage* and expressed in Volt.

4 Conclusion

In this laboratory assignment the objective of analysing an RC circuit has been achieved. Static, time and frequency analyses have been performed both theoretically using the Octave maths tool and by circuit simulation using the Ngspice tool. The simulation results matched the theoretical results precisely. The reason for this perfect match is the fact that this is a straightforward circuit containing only linear components, so the theoretical and simulation models cannot differ. For more complex components, the theoretical and simulation models could differ but this is not the case in this work.

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