C & DS Assignment

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Download codes from

https://github.com/adyasa611/EE4013/tree/main/Assignment−1/codes

and latex-tikz codes from

https://github.com/adyasa611/EE4013/tree/main/Assignment−1/figures

1 Solving a circuit problem using Graph Theory

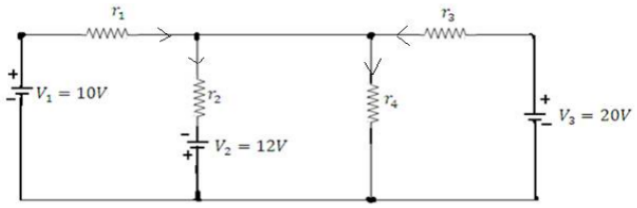

Fig. 0: Question

$r_1 = 2\Omega, r_2 = 5\Omega, r_3 = 1\Omega, r_4 = 10\Omega$

2 Theory

2.1 Fundamental Tie Set Matrix (Fundamental Loop Matrix)

1) We define the edges of the graph and remove all the elements like voltage source, resistor, capacitor from the circuit and the corresponding graph is formed.
2) The graph has loops, we define and number the edges and the non overlapping loops and give a direction for current flow in each loop.
3) We then form a matrix with n (number of edges) rows and m (number of loops) columns.
4) We check if an edge is a part of the loop or not, if it is not then we assign 0 in the respective cell.
5) If edge is part of the loop, we check the direction of loop and current flow. If they coincide we assign the value 1 in the cell, else -1.
6) This is the Fundamental Tie Set Matrix, denoted by B.

2.2 KVL & KCL

1) KVL states that for a closed loop series path the algebraic sum of all the voltages around any closed loop in a circuit is equal to zero.
2) In the matrix form it can be represented as B V_b=0 where V_b vector represents the total voltage drop in each branch of the circuit(edge).
3) $V_b = V_s + Z_b I_b$ where V_s, Z_b, I_b are matrices and vectors
4) V_s= Voltage Source, I_b= Current in that branch, Z_b= Impedance of that branch.
5) $B(V_s + Z_b I_b) = 0$
6) $B(Z_b I_b) = -BV_s$
7) From KCL we know that $I_b = B^T I_L$ where B^T is the transpose of B and I_L is the current in each loop.
8) So, $BZ_b B^T I_L = -BV_s$

3 Solution for given Circuit

1) The graph for the given circuit can be represented as:

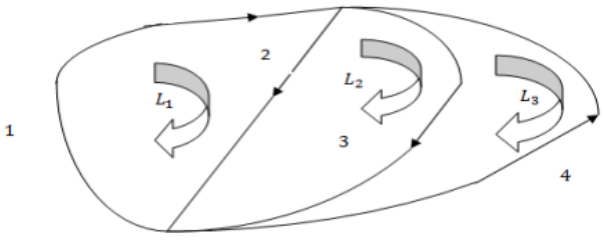

Fig. 1: Loops and Current Flow

2) We have to define the parameters

$$B = \begin{bmatrix} 1 & 1 & 0 & 0 \\ 0 & -1 & 1 & 0 \\ 0 & 0 & -1 & -1 \end{bmatrix}$$

$$Z_b = \begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 5 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 10 \end{bmatrix}$$

$$V_s = \begin{bmatrix} 10 \\ 12 \\ 0 \\ 20 \end{bmatrix}$$

$$I_L = \begin{bmatrix} \mathrm{I}_1 \\ \mathrm{I}_2 \\ \mathrm{I}_3 \end{bmatrix}$$

3) We put these parameters in the equation : $BZ_bB^T I_L = -BV_s$
4) We can solve this using pen and paper or using a basic code.
   Python code to solve the above equation.

   codes/Circuit.py

5) The current values are $I_L = \begin{bmatrix} \text{-3.72A} \\ \text{-0.8A} \\ \text{1.74A} \end{bmatrix}$
6) The negative sign indicates that our assumption of current flow direction was wrong.