Project: ECSE 343

In this project your task is to compute the DC solution of the circuit shown in Figure 1.

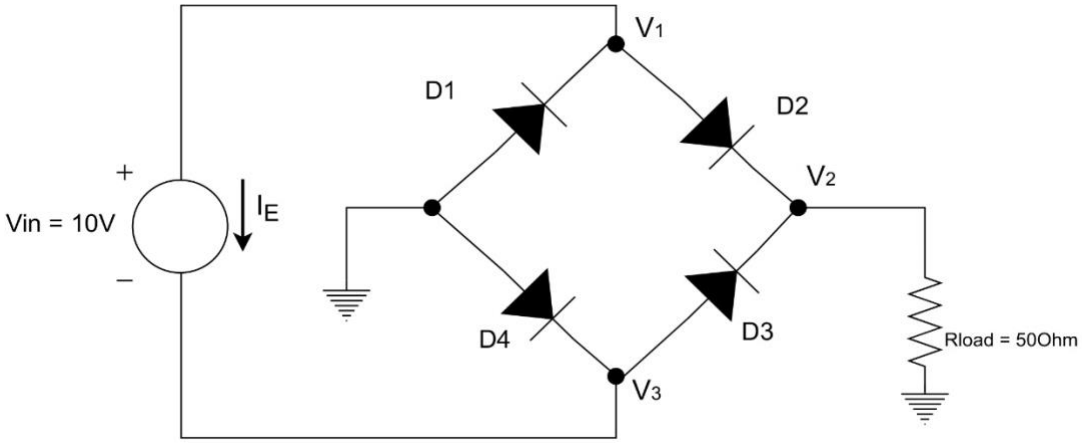

Figure 1: Full wave rectifier

We can write the nodal current equations of the above circuit as,

$$\boldsymbol{F(X)} = \boldsymbol{G\,X} + \boldsymbol{g(X)} - \boldsymbol{U} = \boldsymbol{0} \qquad (1)$$

where $\boldsymbol{X}$ is the unknown vector, it consists of nodal voltages, and the current.

$\boldsymbol{U}$ is the source vector, it contains the contribution of input sources. The matrix $\boldsymbol{G}$ mainly contains the contribution of the resistor. The vector $\boldsymbol{g(X)}$ consists of the diode currents and it is dependent on the vector $\boldsymbol{X}$.

The equation (1) can be further elaborated as,

$$\boldsymbol{F(X)} = \underbrace{\begin{bmatrix} 0 & 0 & 0 & 1 \\ 0 & 0.02 & 0 & 0 \\ 0 & 0 & 0 & -1 \\ 1 & 0 & -1 & 0 \end{bmatrix}}_{\boldsymbol{G}} \underbrace{\begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ I_E \end{bmatrix}}_{\boldsymbol{X}} + \underbrace{\begin{bmatrix} I_S\left(e^{\frac{V_1-V_2}{V_t}}-1\right) - I_S\left(e^{\frac{-V_1}{V_t}}-1\right) \\ -I_S\left(e^{\frac{V_1-V_2}{V_t}}-1\right) - I_S\left(e^{\frac{V_3-V_2}{V_t}}-1\right) \\ I_S\left(e^{\frac{V_3-V_2}{V_t}}-1\right) - I_S\left(e^{\frac{-V_3}{V_t}}-1\right) \\ 0 \end{bmatrix}}_{\boldsymbol{g(X)}} - \underbrace{\begin{bmatrix} 0 \\ 0 \\ 0 \\ V_{in} \end{bmatrix}}_{\boldsymbol{U}} = 0 \qquad (2)$$

The system, $\boldsymbol{F(X)}$, described in (2) contains nonlinear nodal equations of the circuit shown in Figure 2. Your task in this project is to implement a nonlinear solver to compute $\boldsymbol{X}$.

For your convenience you are provided with a Matlab function named *nonlinearFunc()* it takes $\boldsymbol{X}$ as an input and provides $\boldsymbol{F}(\boldsymbol{X})$ and $\frac{\partial \boldsymbol{F}(\boldsymbol{X})}{\partial \boldsymbol{X}}$. Note that the current function is hard-coded to compute $\boldsymbol{F}(\boldsymbol{X})$ and the jacobian for V_{in} = 10V. You may edit this function as needed in order to achieve your objectives.

PART 1

Design and implement a Matlab program that computes the solution for the output voltage V_2. For this part you may use built-in Matlab functions of your choice. Verify if the solutions obtained are correct, you may either use SPICE simulator or verify the solution analytically. Justify the choice of functions used as well as the choice of parameters and options used when running these functions.

PART 2

For this part implement a solver using an appropriate algorithm or combination of algorithms. Your algorithm should function without any meaningful initial guess provided by the user (i.e. it should determine its own initial guess or simply work for a trivial initial guess of all zeros). You may use the provided *nonlinearFunc()*. Do not hesitate to modify the *nonlinearFunc* method as per your requirements.

Note: You do not need to implement every algorithm use. If any of the following algorithms are needed you may use matlab functions/operators: '\' (backslash), *lu()* (LU decomposition), *qr()* (QR decomposition), *chol()* (Cholesky decomposition), *norm()*, and Forward/ Backward Substitution (provided in assignment 2).

PART 3

Design and implement a program that computes and plots the output V2 if Vin is a 60Hz sine wave with amplitude 5V. You may use any Matlab function of your choice including ones that you may have developed in this course.

Deliverables

1. You code (Matlab files): Provide your code for each part as well as a Matlab script that runs your code and displays the results.
2. Write a project report that includes:
    a. Detailed description of the implemented solver, the algorithms used as well as a pseudocode.
    b. Description of how you tested and validated your program and your results
    c. Justification of the algorithms and techniques that were chosen, and Matlab function used.
    d. Comparison between your algorithm and the Matlab methods (in parts 1 and 2) including insight into any differences in accuracy, number of iterations, speed etc.
3. Description of the contribution of each team member and how you shared the work.
4. A 10-minute presentation describing the project and going over the main points discussed above and any further insight you would like to add.
    a. Submit the PowerPoint/pdf of the presentation slides.
    b. Submit a recorded video (10min) of the presentation (you can use power point to record the presentation for example or any other similar tool of your choice). All team members should participate in the presentation.