# ECSE 343 Group Project

The main aim of this project is to write a software program for simulating the transient response of the circuit shown below using Modified Nodal Analysis (MNA) equations. The circuit shown in Figure 1 is called the Half-Wave Rectifier. The system of MNA equations for this circuit are provided to you (see equation (2)) . For this circuit you will compute the transient response for all the voltage nodes, namely, $V_1$, $V_2$, and $V_3$.

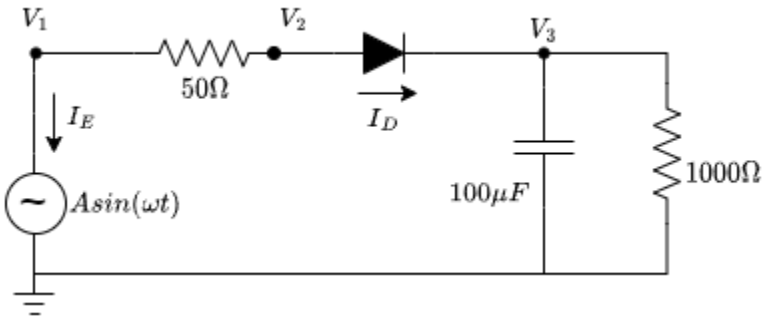


Figure 1: Half-Wave Rectifier.

The above circuit is connected to the sinusoidal voltage source and $I_E$ is the current passing into voltage source. $I_D$ is the diode current shown in (1)

$$I_D = I_S\left(e^{\frac{V_2-V_3}{V_T}} - 1\right) \tag{1}$$

$I_S$ is the saturation current of the diode and $V_T$ is the thermal voltage. The values for $I_S$ and $V_T$ are provided below. As we can see in (1), the diode current is a nonlinear function of the node voltages $V_2$ and $V_3$, this makes the nodal equations of the above circuit (shown in (2)) nonlinear.

$$\underbrace{\begin{bmatrix} \frac{1}{50} & -\frac{1}{50} & 0 & 1 \\ -\frac{1}{50} & \frac{1}{50} & 0 & 0 \\ 0 & 0 & \frac{1}{10^3} & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}}_{\boldsymbol{G}} \underbrace{\begin{bmatrix} V_1(t) \\ V_2(t) \\ V_3(t) \\ I_E(t) \end{bmatrix}}_{\boldsymbol{X}(t)} + \underbrace{\begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 10^{-4} & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}}_{\boldsymbol{C}} \underbrace{\begin{bmatrix} \dot{V}_1(t) \\ \dot{V}_2(t) \\ \dot{V}_3(t) \\ \dot{I}_E(t) \end{bmatrix}}_{\dot{\boldsymbol{X}}(t)} + \underbrace{\begin{bmatrix} 0 \\ I_S\left(e^{\frac{V_2(t)-V_3(t)}{V_T}} - 1\right) \\ -I_S\left(e^{\frac{V_2(t)-V_3(t)}{V_T}} - 1\right) \\ 0 \end{bmatrix}}_{\boldsymbol{D}(\boldsymbol{X}(t))} - \underbrace{\begin{bmatrix} 0 \\ 0 \\ 0 \\ A\sin(\omega t) \end{bmatrix}}_{\boldsymbol{B}(t)} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \tag{2}$$

The above equation can be written in compact Modified Nodal Analysis form as,

$$\boldsymbol{F}(\boldsymbol{X}(t)) = \boldsymbol{G}\,\boldsymbol{X}(t) + \boldsymbol{C}\,\dot{\boldsymbol{X}}(t) + \boldsymbol{D}(\boldsymbol{X}(t)) - \boldsymbol{B}(t) = \boldsymbol{0} \tag{3}$$

For the test circuit above use a transient voltage source with amplitude equal to 5V with the frequency of 60Hz. Use saturation current for the diode, $I_S = 10^{-13}$ and the thermal voltage of the diode, $V_T = 0.025$. Use the zero initial conditions ( i.e. $V_1(0) = 0,\ V_2(0) = 0, V_3(0) = 0,\ I_E(0) = 0$). Simulate, the circuit for the interval [0s, 0.5s]. Plot the obtained solution for $V_1$, $V_2$, and $V_3$.

**Specifications:**

1. Your software program should compute and plot the transient response of the example circuit provided over an interval [0s, 0.5s].
2. Your algorithm should prioritize both accuracy and cpu cost.
3. Your algorithm should be generalizable so that it can be easily modified to analyze other circuits as long as the MNA equations are provided.
4. Your algorithm should remain efficient as the size of the circuit increases.
5. You may use, any native matlab routine or functionality provided in the software package. However, you need to describe the algorithm used in it how it is suitable for your project.

**Deliverables**

Your deliverables will include three items. The first is a written report (maximum 5 pages, but no minimum as long as you explain the required content). The second is a recorded presentation of maximum 3min summarizing your work. The third is the matlab code that you developed. Make sure the code well commented. Your report should address at least the following points:

1. Identify and evaluate three possible approaches for obtaining the transient response, and implement and evaluate each one both theoretically and in practice.
2. Describe in detail the final algorithm chosen. Use equations to describe how you reached the final algorithm. Describe how the final algorithm was implemented (including source code).
3. Provide a justification for each numerical method chosen in your algorithm as well as for various design choices.
4. Describe how you tested and verified the final design and show the results of the simulation and testing.
5. Describe the contribution of each team member to the project.

Consult the file titled Grading Rubric to know what is expected for written report and recorded presentation.