The University of Windsor

ELEC4450: Power Electronics

Winter 2022

Lab #2

Theory & Computer Simulation for Diodes and Rectifiers

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Contents

OBJECTIVE

The objective of this lab is to get familiar with the SimPowerSystems' toolbox using MATLAB's graphical programming environment called Simulink. This will facilitate a better understanding for power electronic circuits by computer simulation. Lastly, it will contribute to the simulation models used in the final course project. To reach these objectives, six different circuit topologies will be simulated to examine the unique characteristics generated in the output and input.

INTRODUCTION

This report will cover simulation for six different circuit models related to power electronics. In doing so, a better understanding can be developed for components in these circuits including AC-power sources, diodes, resistors, inductors, and capacitors. Using SimPowerSystems' toolbox, six different circuit models will be created and tested. Once the circuits are built, a simulation will be run while capturing the input voltage or Vin, output voltage or Vout, and output current or Iout. This is performed by connecting scope probes to each respective node to examine the responses of different circuit topologies. By examining the response of the different circuit topologies with their fixed parameters, conclusions can be made for each topology and a high-level understanding can be developed for rectification.

THEORY & METHODOLOGY

Required theoretical knowledge related to the lab are limited to basic principles of circuits and components. Background knowledge includes how to connect current and voltage meter probes to a scope, how diodes and rectification works, and smoothening out rectification using inductor-capacitor pairs (LC). The theoretical knowledge listed is not necessary for completing the lab, but it is essential for understanding the concepts being demonstrated in the lab and throughout the power electronics course. The main piece of knowledge required for this lab is a background in using Simulink. This includes navigating component libraries, connecting and configuring components, running simulations, and viewing the simulation outputs.

CIRCUIT DIAGRAM

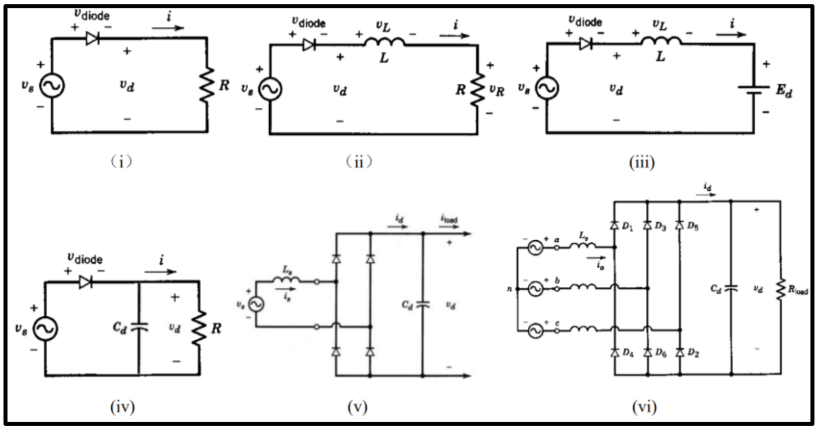

Figure 1 The six circuit diagrams for this experiment

The figure above contains the six circuit configuration that are used throughout this lab's simulations. The first four contain a combination of diodes and RLC (resistor – inductor – capacitor) circuit models while the last two contain rectification models. The fifth contains a full-bridge rectifier and the sixth contains a half-wave three-phase rectifier.

EQUIPMENT / APPARATUS

No physical equipment was used in this experiment; however, a list of simulated components are as follows:

1. AC power supplies with voltage peak or V_{peak} = 100V
2. DC source of 100V
3. Voltage meters
4. Current meters
5. Scope for viewing output of meters
6. Diodes with threshold voltage of 0.7V
7. Resistors of value 10 Ohms
8. Inductors of value 10 mH
9. Capacitors of value 900 uF

EXPERIMENTAL PROCEDURE

No physical aspect conducted as described in the “Power Electronics (ELEC4450 Lab) Report Guideline”.

RESULTS – SIMULATION

Part 1

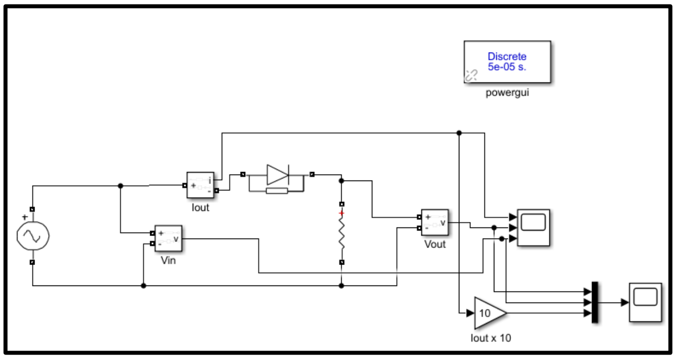

Figure 2 Simulink model for (i) diode resistor circuit

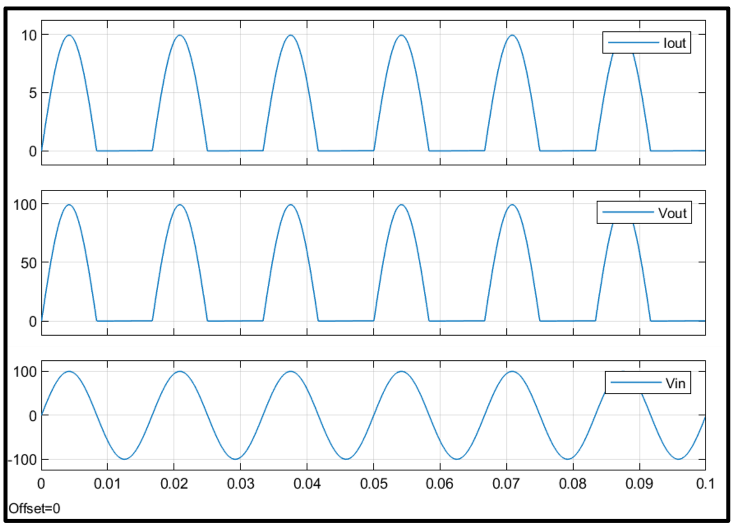

Figure 3 Response of circuit (i)

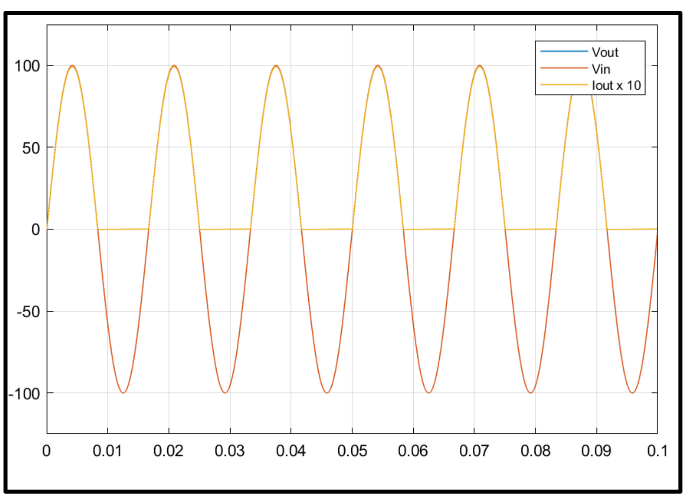

Figure 4 MUX response of circuit (i)

Part 2

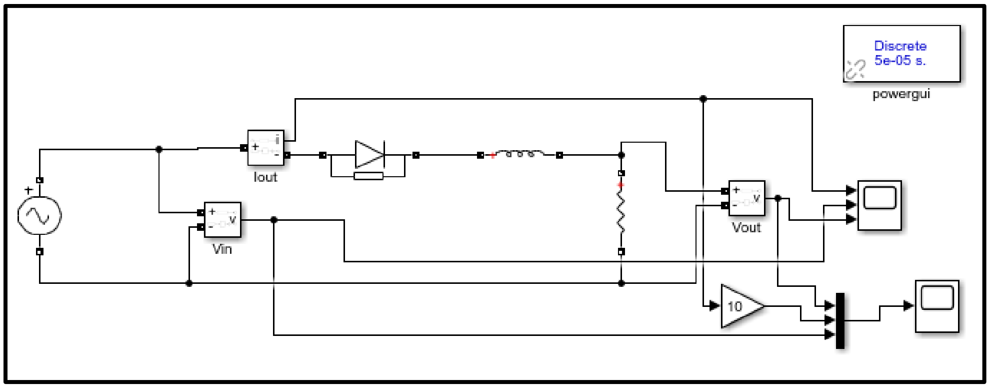

Figure 5 Simulink model for (ii) diode, inductor, and LR circuit

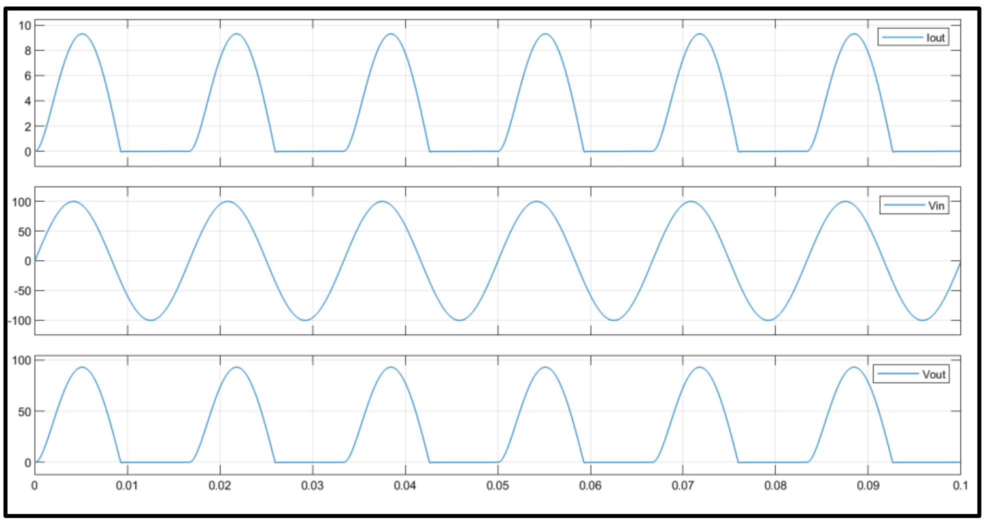

Figure 6 Response of circuit (ii)

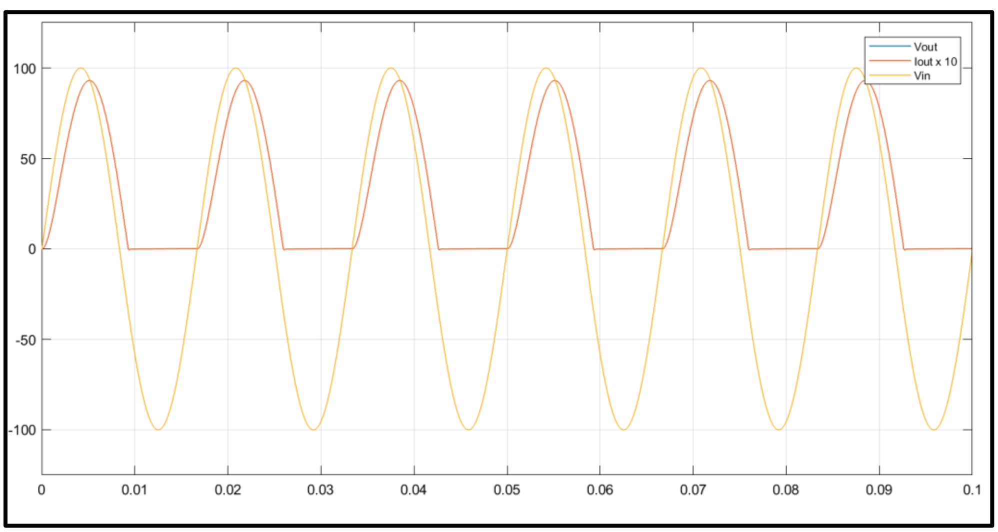

Figure 7 MUX response of circuit (ii)

Part 3

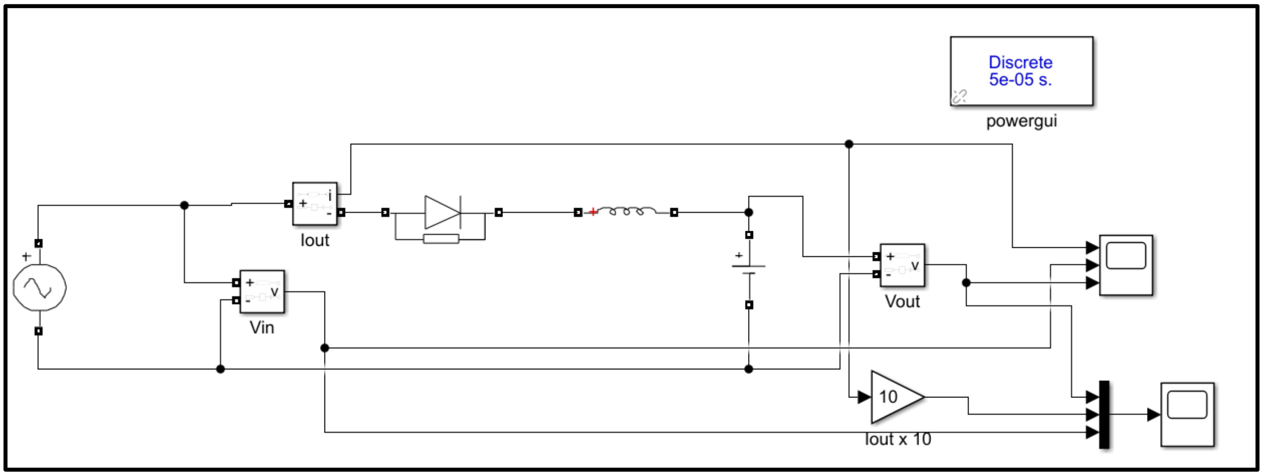

Figure 8 Simulink model for (iii) diode, inductor, and DC source circuit

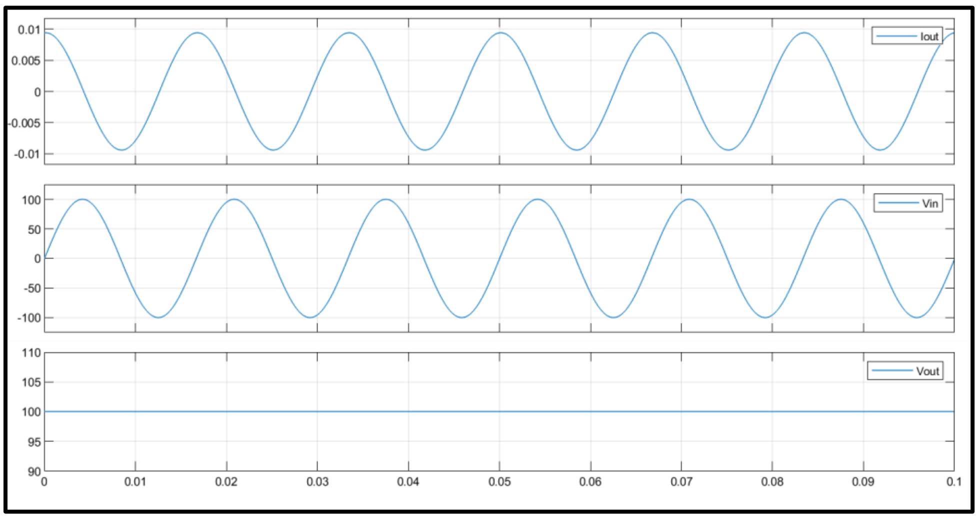

Figure 9 Response of circuit (iii)

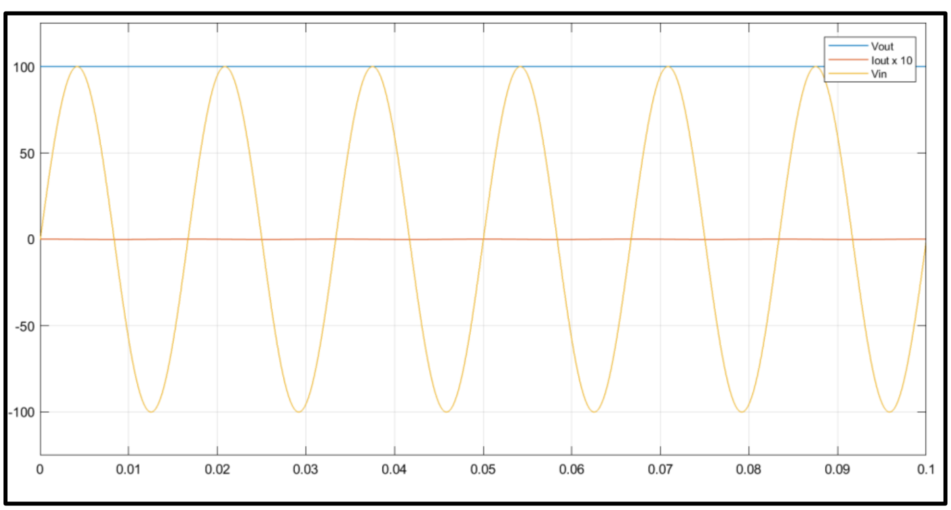

Figure 10 MUX response of circuit (iii)

Part 4

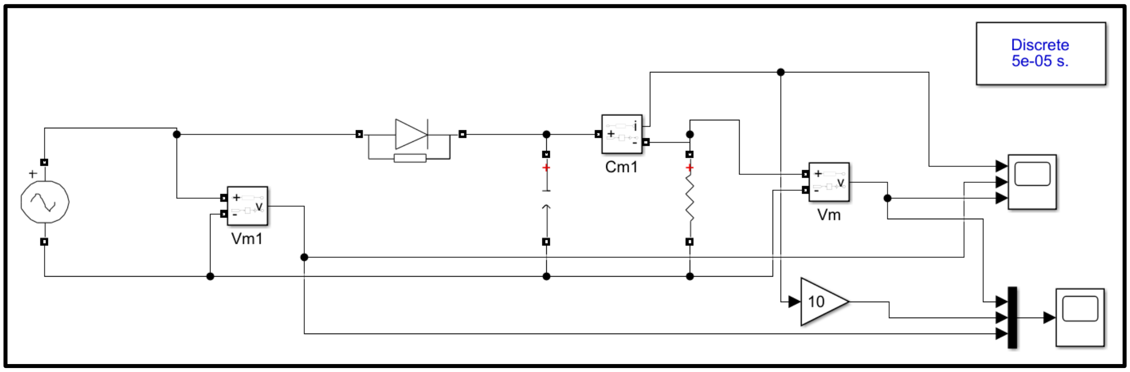

Figure 11 Simulink model for (iv) diode, and RC circuit

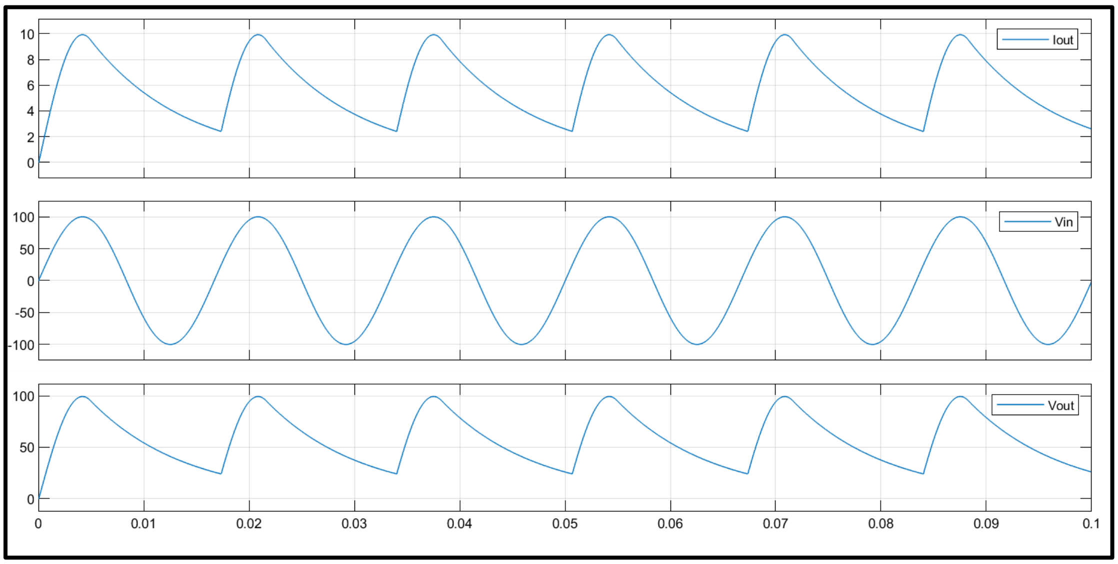

Figure 12 Response of circuit (iv)

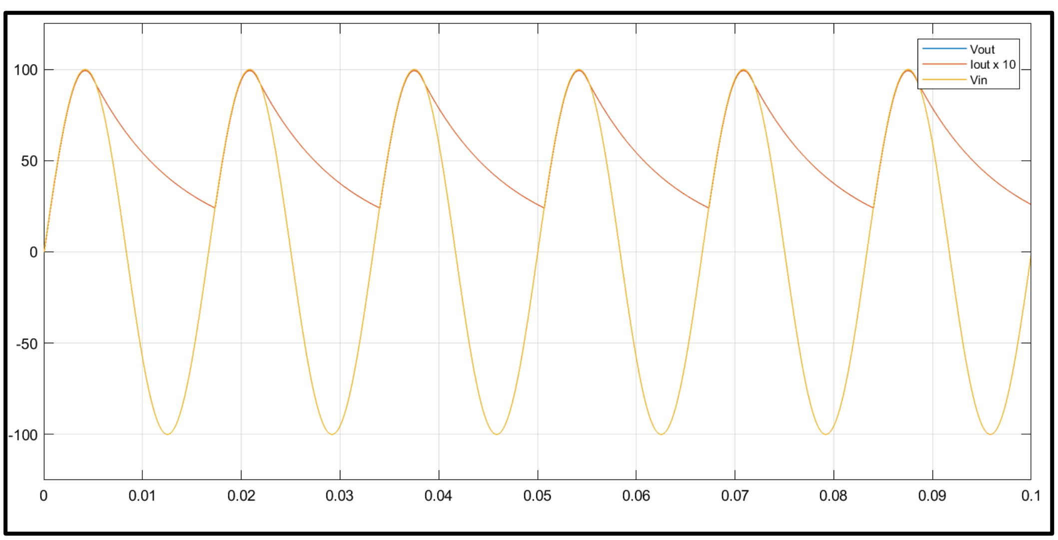

Figure 13 MUX response of circuit (iv)

Part 5

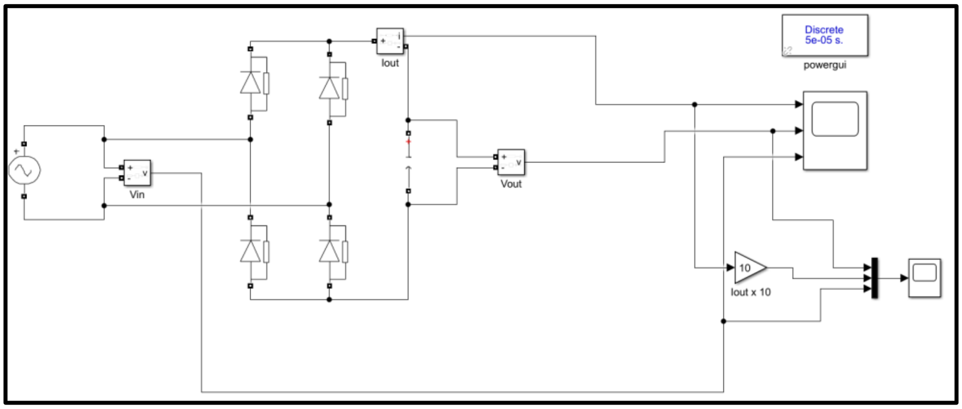

Figure 14 Simulink model for (v) full-bridge rectifier circuit

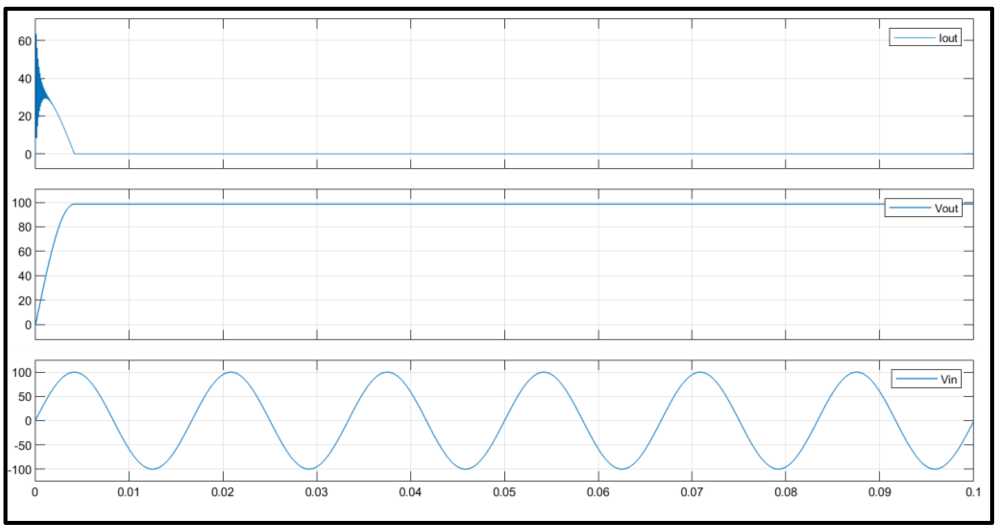

Figure 15 Response of circuit (v)

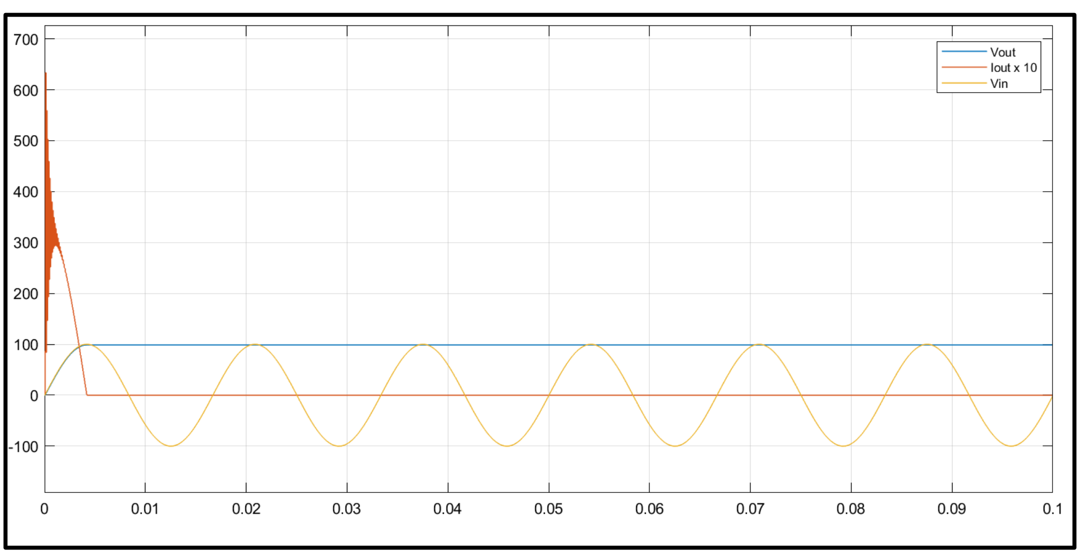

Figure 16 MUX response of circuit (v)

Part 6

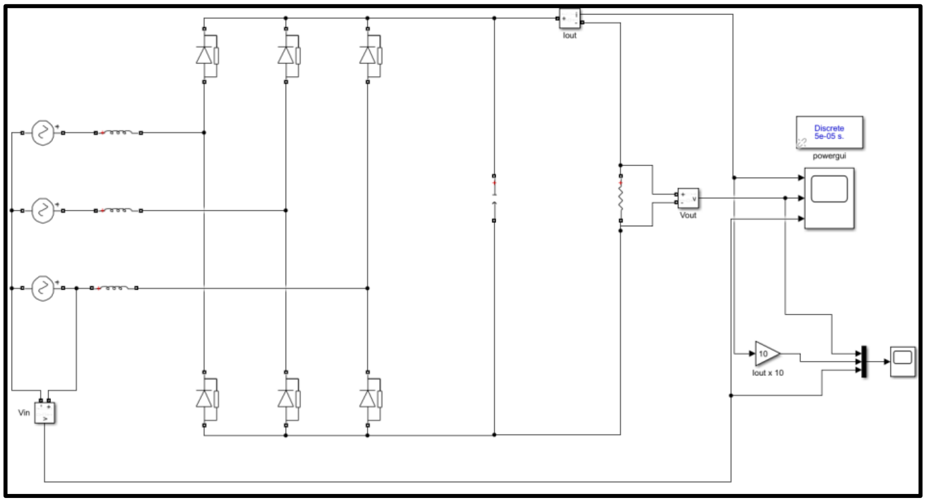

Figure 17 Simulink model for (vi) half-wave three-phase rectifier circuit

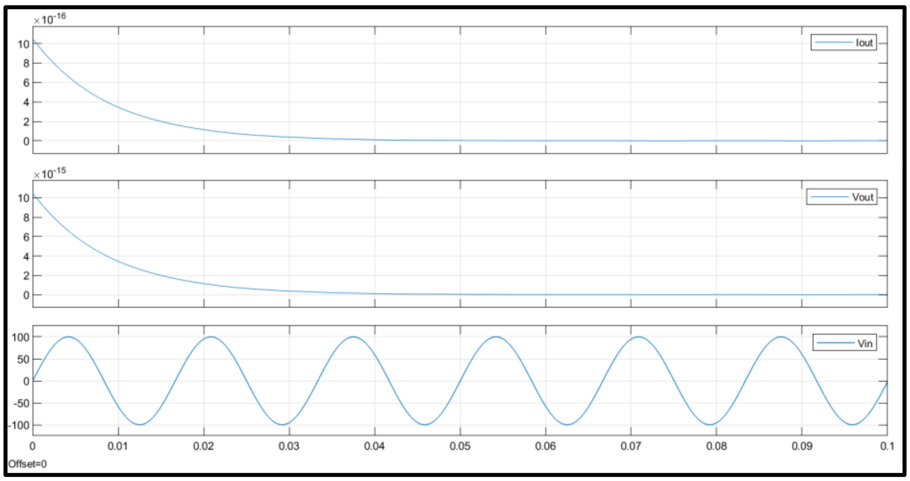

Figure 18 Response of circuit (vi)

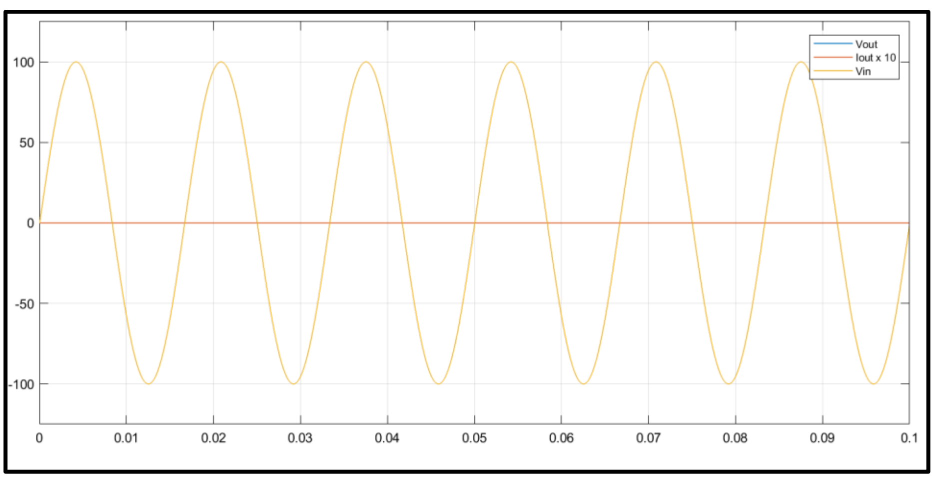

Figure 19 MUX response of circuit (vi)

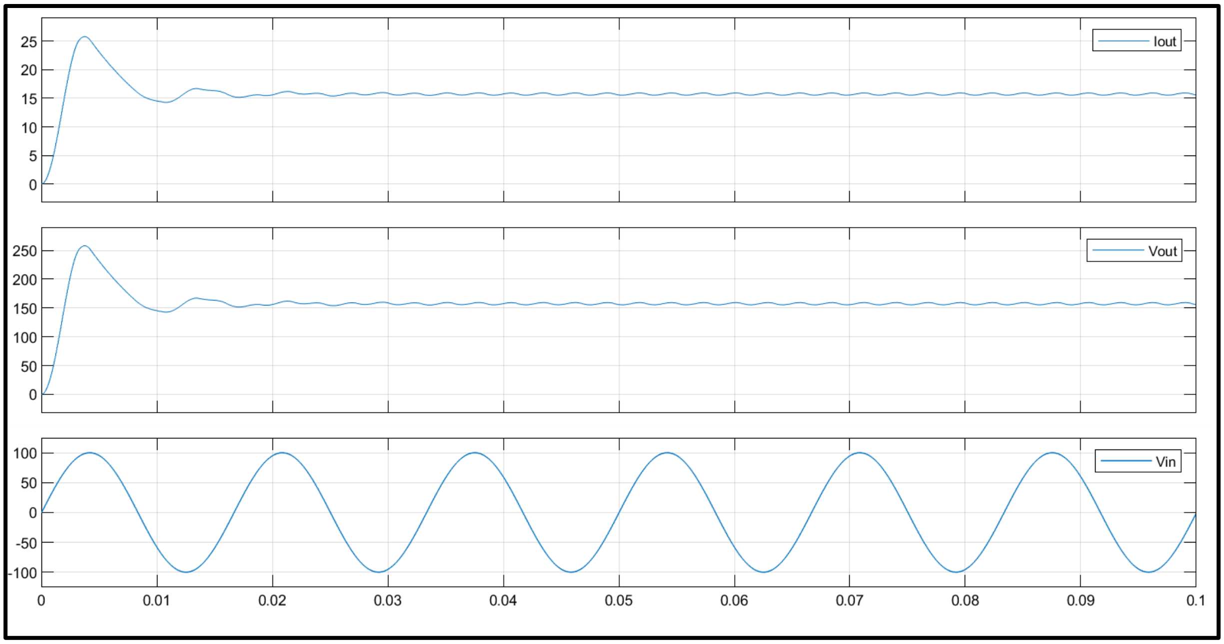

Figure 20 Phase shifted response of circuit (vi)

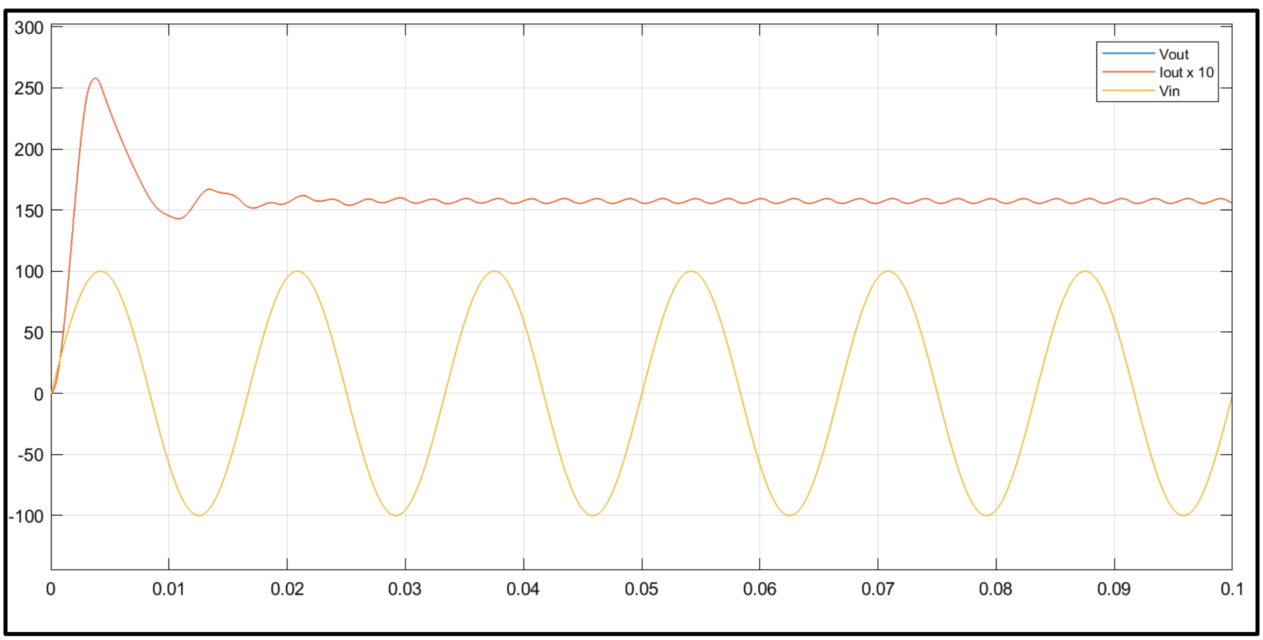

Figure 21 MUX phase shifted response of circuit (vi)

DISCUSSION & CONCLUSION

Throughout the six simulations, six very important and different responses can be observed. Part one's response demonstrates how the diode filters out the negative phase of the AC-input. Part two displays rectification and lag in the output. Part three demonstrates how current will not flow in a circuit if the potential on both sides are equal. This is also caused by the polarity of the diode which blocks bi-directional current flow. Circuit four's design demonstrates the steady state response of an RC circuit, giving sawtooth shaped output. Part five displays a very important output using a full-bridge rectifier, generating DC output! This occurs by rectifying AC-input and charging up a capacitor for ripples in the signal. Finally, part six shows a half-wave three-phase rectifier. Results can be observed for when a one-twenty-degree phase shift is applied (fig. 21) and without (fig. 19). When shifted, a near DC output is achieved. In conclusion, this lab helped demonstrate the importance and usefulness of different circuit designs and simulation using Simulink! It also touched upon the rectification process.