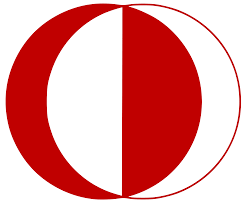
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**Middle East Technical University**

**Electrical and Electronics Department**

**EE463 - Static Power Conversion I**

**Simulation Project 1:**

**Diode Rectifiers**

**Project Group:** Team 13

**Group Members:** Burak Yalçın-

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1. **Introduction**

This report includes the Simulink simulation results for the first simulation project of the course: EE463 Static Power Conversion I. The topics of interest in this simulation assignment can be listed as: single & three phase half bridge and three phase full bridge diode rectifiers. The interpretations of the effects of line inductances, line resistances and also non ideal diodes, along with some calculations for a number of parameters such as: the output average voltage and input current THD, can be found in the following sections of this document.

The main purpose of this simulation project is to properly document our knowledge on diode rectifiers, get ourselves accustomed to the newer concepts and to be able to comment on the effects of some of the parameters which were presented in the lectures, with the help of a new simulating tool: Matlab Simulink.

1. **Question 1: Single Phase Half Bridge Rectifiers**
   1. **Plots obtained in Simulink for the Output Voltage with Different Time Steps**

The screenshot of the single phase half bridge rectifier constructed in Simulink along with the tools which help to obtain output average voltage value and the THD(%) value, can be found in Figure 1, below.

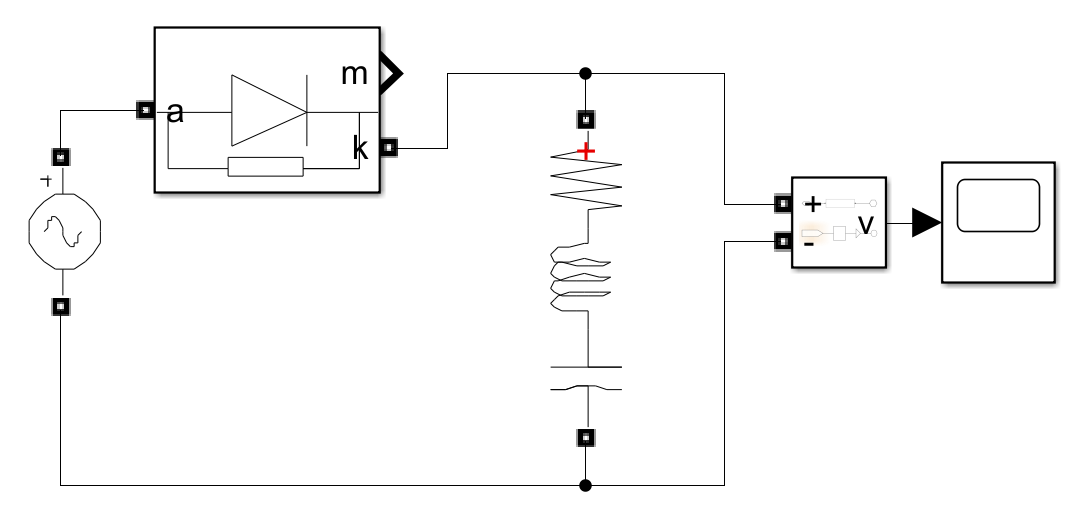


Figure . Simulink Schematic for the Single Phase Half Bridge Rectifier

The output voltage waveforms of the single phase bridge rectifier for step times of 1ns, 0.5ms and 5ms can be found in Figures 2,3 and 4, respectively.

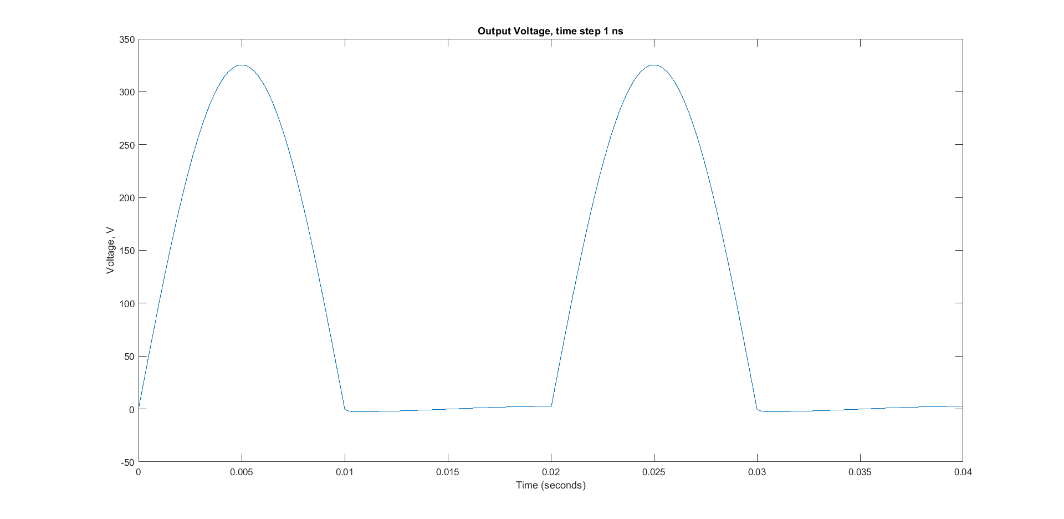


Figure . Output waveform of the single phase half bridge rectifier, when the time step = 1ns

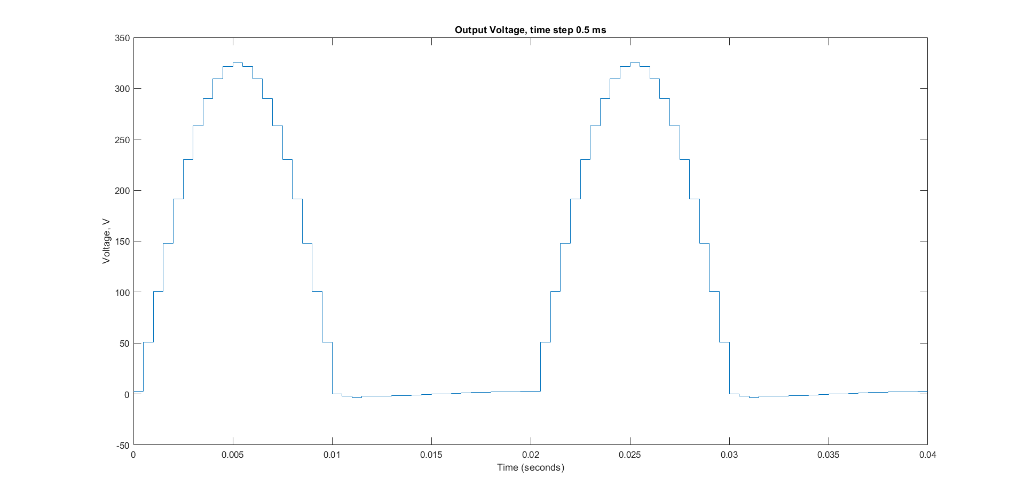


Figure . Output waveform of the single phase half bridge rectifier, when the time step = 0.5ms

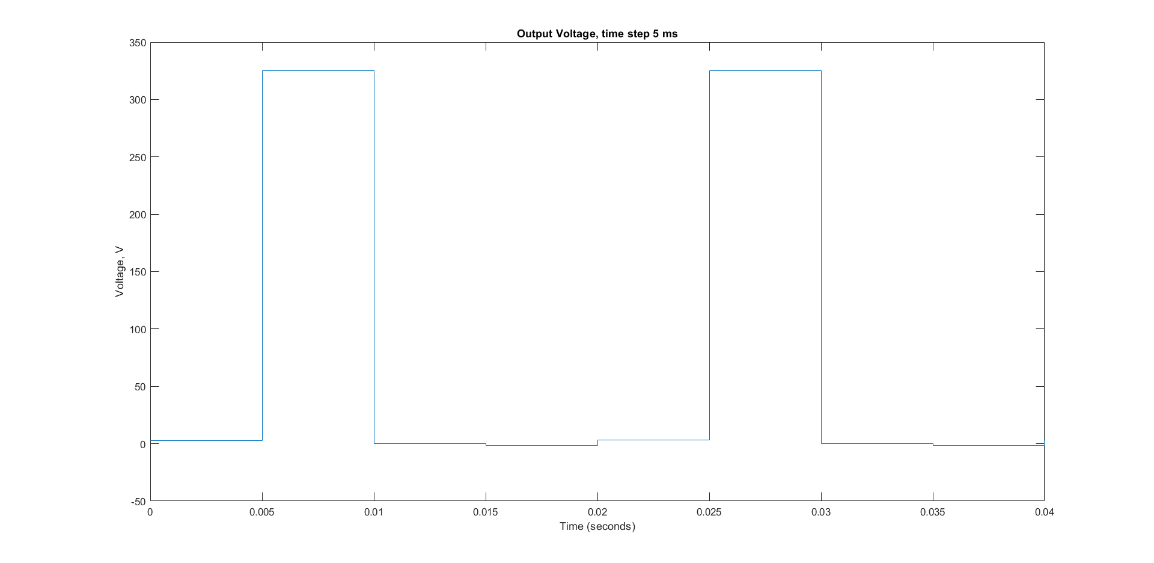


Figure . Output waveform of the single phase half bridge rectifier, when the time step = 5ms

* 1. **Significance of Step Time in Simulations**

As one can observe from the waveforms in the figures 2,3 and 4, the step time with which the simulation is executed, has a great effect on the resulting waveform.

The concept of the step time can be interpreted as the sampling rate at which the samples from the simulated signal is taken. Therefore, this parameter is directly linked with the shape of the outcome of the simulated waveform.

The sampling procedure is related with the sampling theorem, in which the minimum required sampling rate (in order to obtain the original signal without any changes in its frequency) is defined as the double of the frequency of the maximum frequency component that exists in the original signal.

If the step time is chosen too small, this corrupts the original curve of the signal, due to the existence of ‘aliasing’, which can be explained in other words as: the appeareance of a higher frequency signal as low frequency due to the lack of sampled points. An example for such a situation can be observed in Figure 4.

If the step time is chosen too large, theis would enable us to have an accurate representation of the original curve (an examplification of this situation can be seen in Figure 2), but unfotunately having too many sampled points would slow down the procedure and it would occupy quite a lot of storage room.

* 1. **Output Average Voltage and Input Current THD Calculations**

Output average voltage is calculated with the formula in equation 1, where the operation is basically sums the output voltage vd over its one period and obtaines the mean by dividing by the value of this time interval.

(1)

The analytical calculation for finding the output average voltage can be found below in equation 2, where the output function is taken as a sine and the integral is taken over (0,π).

(2)

The total harmonic distortion(THD) can be calculated from the formula in equation 3, where the operation is basically taking the ratio of RMS values of all of the signal’s harmonics (except the first one) to the RMS value of the first harmonic of the signal.

(3)

The analytical calculation for finding the input current THD can be found below in equation 7, where

(4)

Then the RMS value is equal to

??????????????? (5)

And the RMS value for the fundamental harmonic componenet is equal to

2.3 (6)

(7)

* 1. **Comparison of Analytical Results with Quantities Obtained Through Simulation Tools**

The calculation for the output average voltage, when one of the operational blocks in Simulink was utilized, namely ‘mean’ . After choosing the fundamental frequency as 50 Hz, which will indicate the length of the one cycle, and simulatneously the sampling time as 5 us, the average output voltage can be observed on the ‘Display1’ as: 103.5.

The calculation for the input curretn THD, when one of the operational blocks in Simulink was utilized, namely ‘THD’. After choosing the fundamental frequency as 50 Hz, which will indicate the length of the one cycle, and simulatneously the sampling time as 5 us, and finally measuring the input current by a ‘current measurement’ tool; the input current THD can be observed on the ‘Display’ as: 43.46.

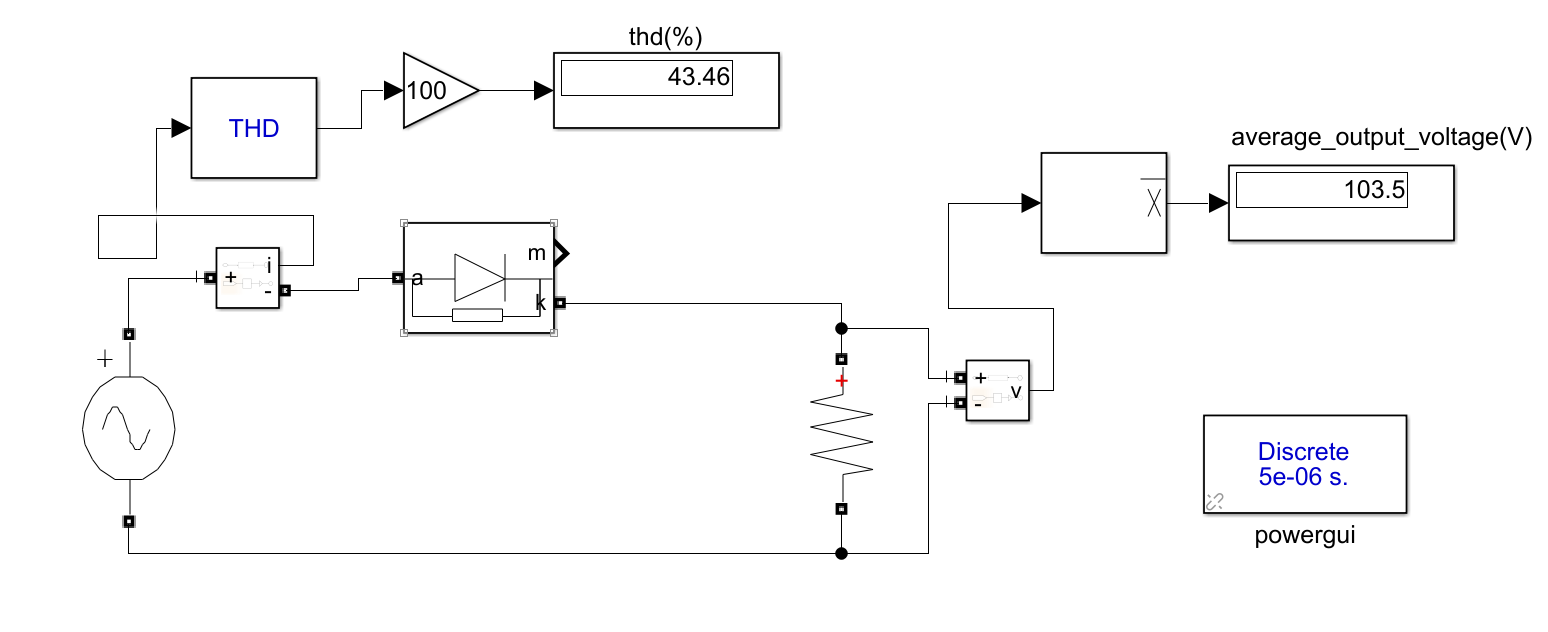


Figure . Simulink schematic of single phase half bridge rectifier with the calculator operators: THD and mean

1. **Question 2: Single Phase Full Bridge Rectifiers**
   1. **Ls and Rs in Practical Applications**

Ls and Rs, in this schematic of a single phase full bridge diode rectifier, represent the internal impedance of the voltage source vs, when combined. Ls serves to represent the inductive part of source impedance, while Rs seves to represent the resistive part.

* 1. **Finding Minimum Output Filter Capacitance**
  2. **Plots for Output Voltage, Input Current THD and Power Factor**
  3. **Measurments of Output Voltage, Input Current THD and Power Factor**
  4. **Simulation without Ls and Rs**
  5. **Stresses on the Diodes when DiodeXXX Is Used without the effects of Ls and Rs**
  6. **Rectifier Efficiency without the effects of Ls and Rs**

1. **Question 3: Three Phase Full Bridge Diode Rectifiers**
   1. **Plots of Output Voltage and Phase-A Input Current when Ls=0**
   2. **Output Average Voltage Calculations and Comparison with Simulated Results (Ls=0)**
   3. **Harmonic Analysis up to 30th Harmonic**
   4. **Plots of Output Voltage and Phase-A Input Current when Ls=1mH**
   5. **Output Average Voltage Calculations and Comparison with Simulated Results (Ls=1mH)**
   6. **Comparison of the Harmonic Content of the Input Current for Different Values of Ls**
2. **Question 4: Feedback**