Indian Institute of Technology Palakkad
भारतीय प्रौद्योगिकी संस्थान पालक्काड
Nurturing Minds For a Better World

Electrical Engineering

IIT Palakkad

Power Systems and Renewable Energy Lab

Power Quality and Harmonics

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Experiment number : 2

THEORY :

In this experiment, we study the effect of non-linear loads such as diode rectifiers on the power network.

Diode rectifiers transform ac voltage to dc voltage. However, apart from the dc voltage component, the dc side output voltage has other harmonics arising from this conversion.

Further, if a constant current sink is connected as load to the dc output, this reflects as a fundamental current along with harmonic current components on the ac side which will be drawn from the ac source. Furthermore, there typically exists a series or internal impedance associated with the ac source. Harmonic currents flowing through this impedance result in harmonic voltages drops. This, in turn, distorts the ac voltage at the common point or node where the diode rectifier is connected and perhaps another load or your neighbour's load is connected. This node is called the point of common coupling (PCC).

The voltage in the machine's lab to be distorted and not sinusoidal, is because, lot of nonlinear loads sitting in the other rooms (including computer power supplies) distort the voltage at the common coupling point at the grid to which other loads are also connected.

Circuit diagrams of different rectifiers

2-pulse rectifier

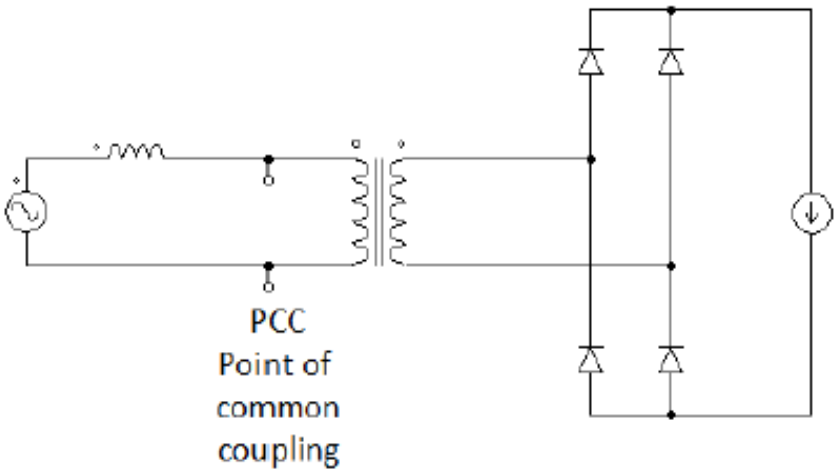

Fig.1

6-pulse rectifier

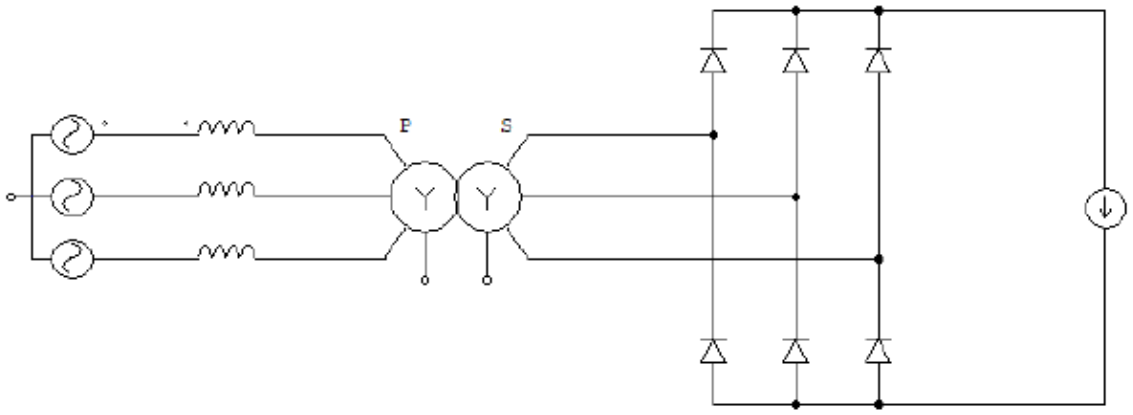

Fig.2

12-pulse rectifier

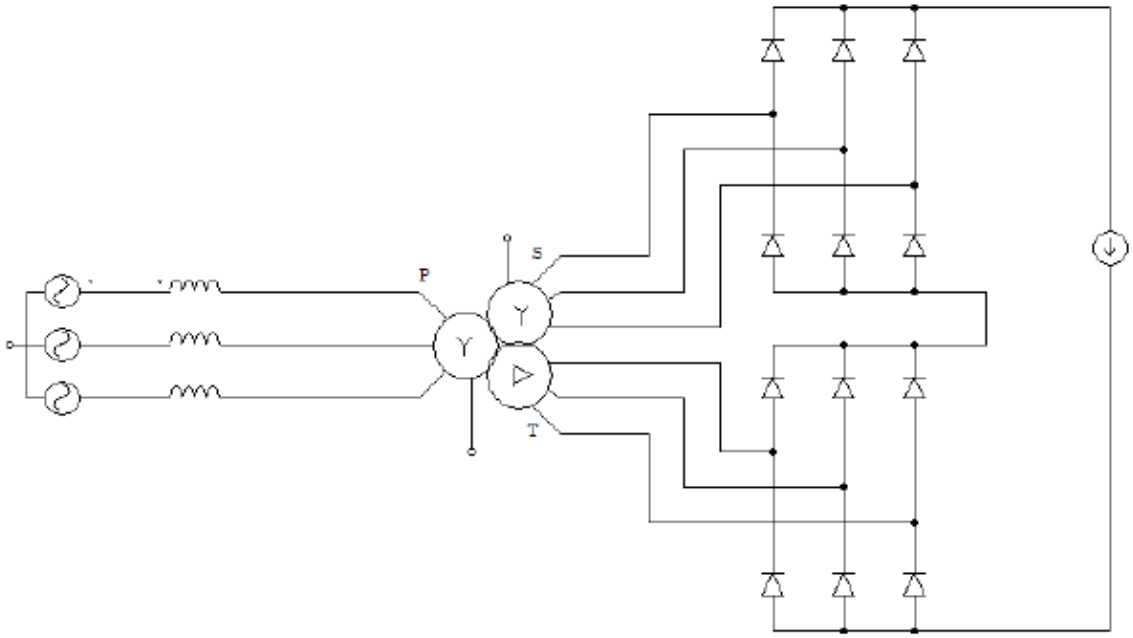

Fig.3

1 Question A - Single Pulse Rectifier (2 Pulse Rec-tifier)

1.1 The Model

The required simulink model for the 2 pulse rectifier is shown below:

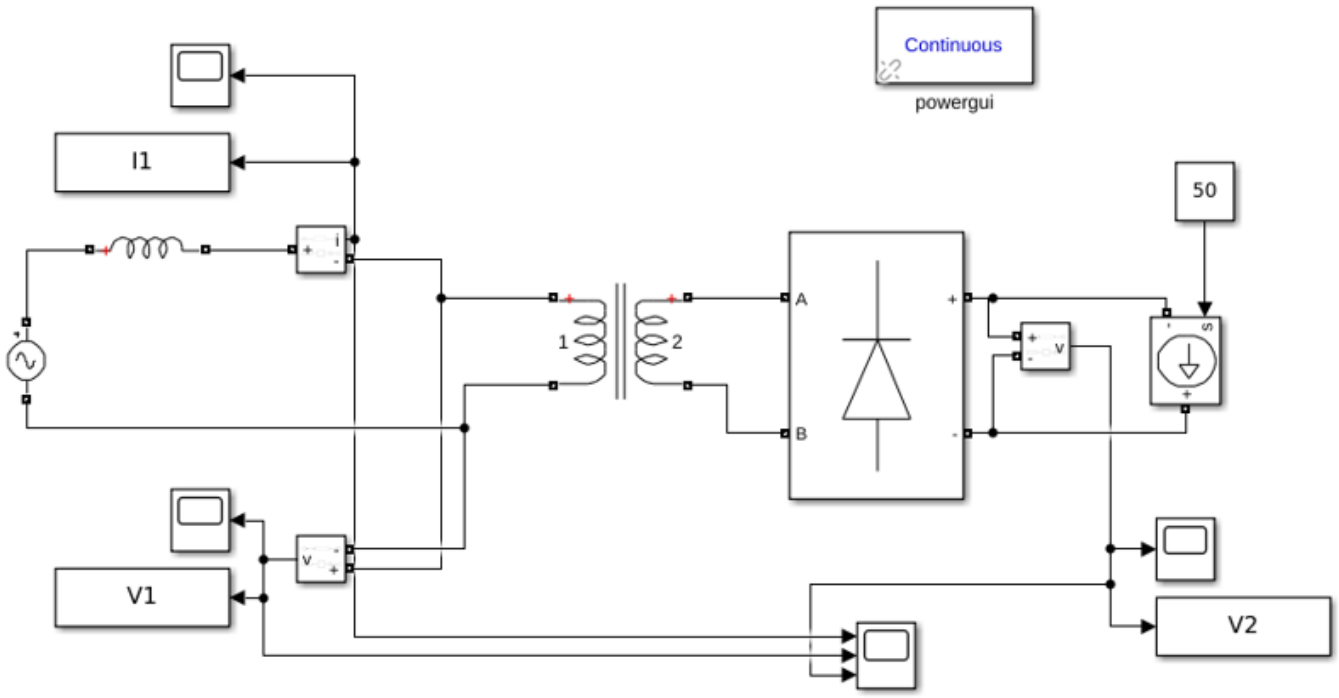

Figure 4: The simulink model for the 2 pulse rectifier.

1.2 The Output and Input Waveforms

1.2.1 The Inductance in series with the Voltage Source is 0.5 mH

The plots for the primary voltage, primary current and the output voltage is shown below:

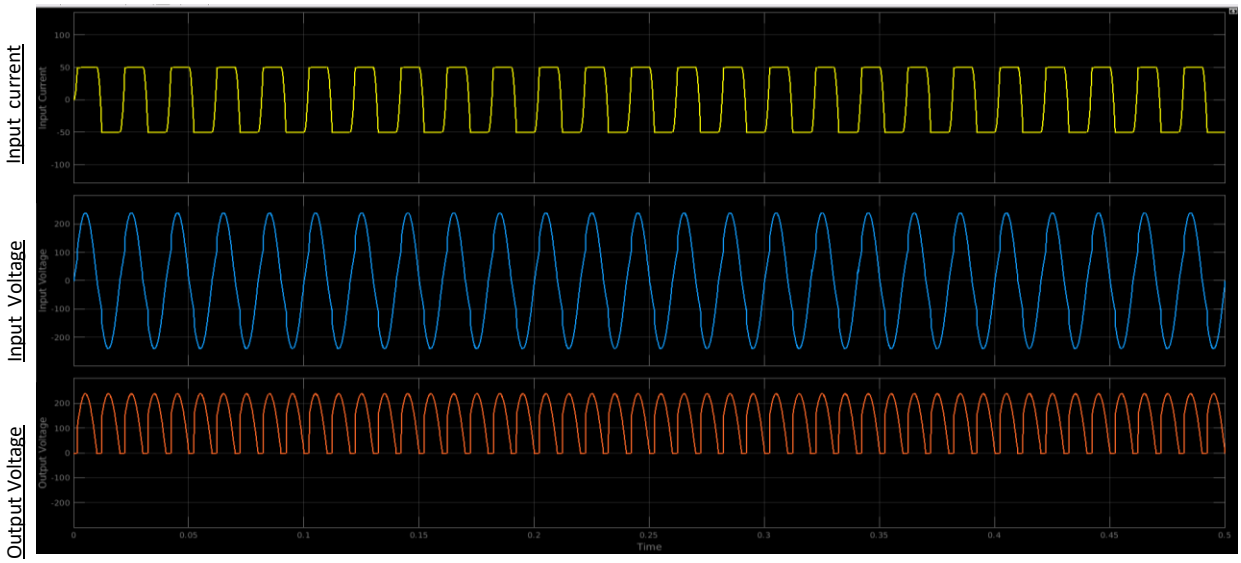

Figure 5: The output and input waveforms when L = 0.5mH.

1.2.2 The Inductance in series with the Voltage Source is 0.1 mH

The plots for the primary voltage, primary current and the output voltage is shown below:

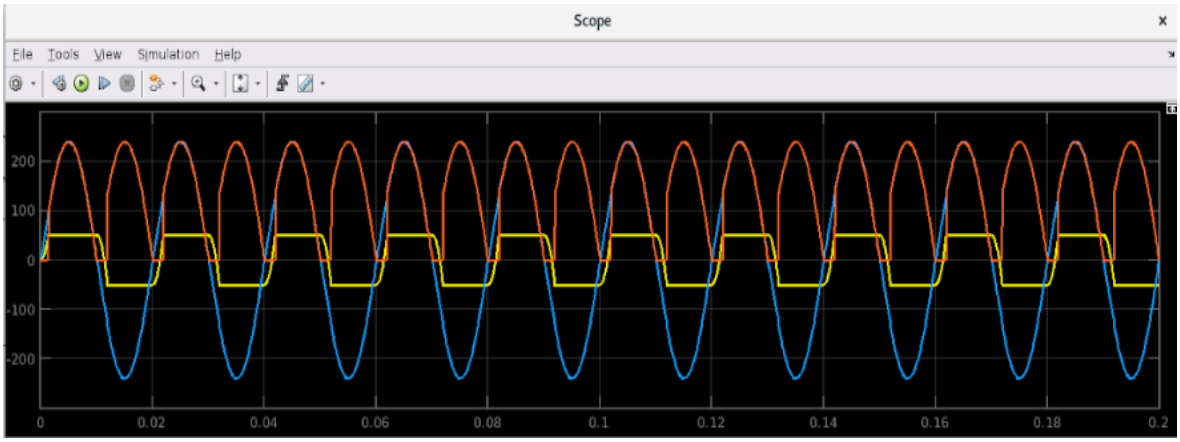

Figure 6: The output and input waveforms when L = 0.5mH.

Yellow - Input Current
Blue - Input Voltage
Red - Output Voltage

1.3 The Required FFT plots

1.3.1 The series Inductance, $L_{series} = 0.5$ mH

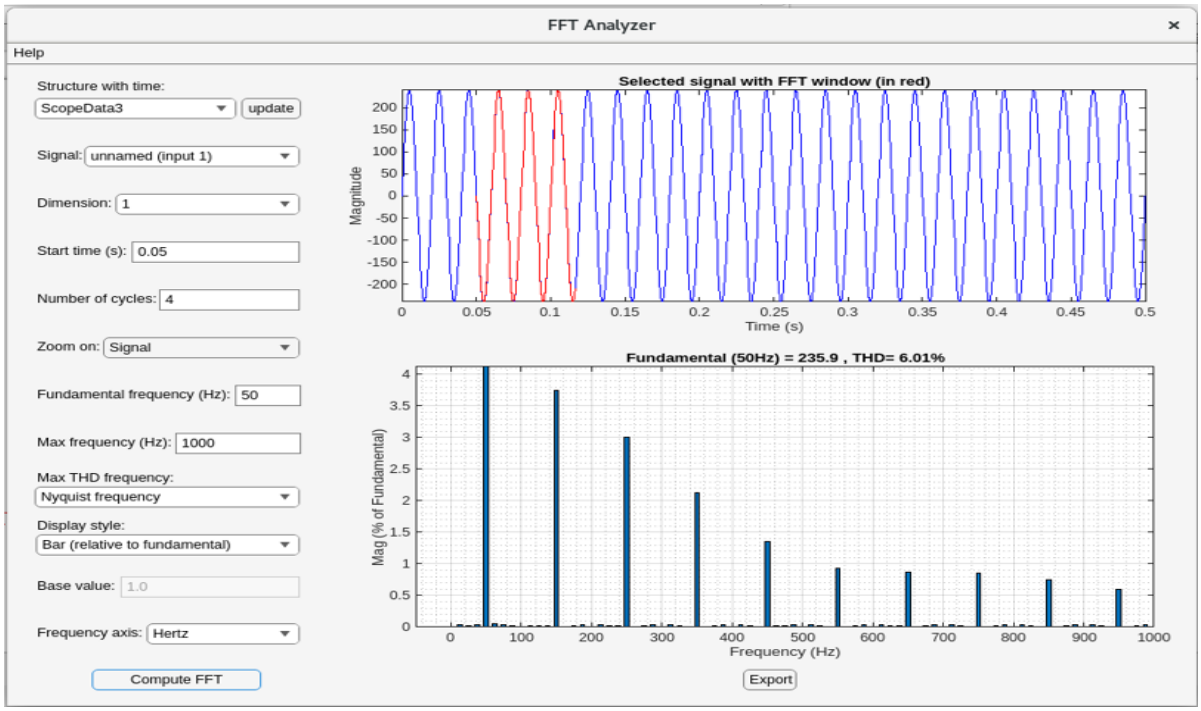

Figure 7: The FFT plot for the primary voltage when L_{series} = 0.5mH.

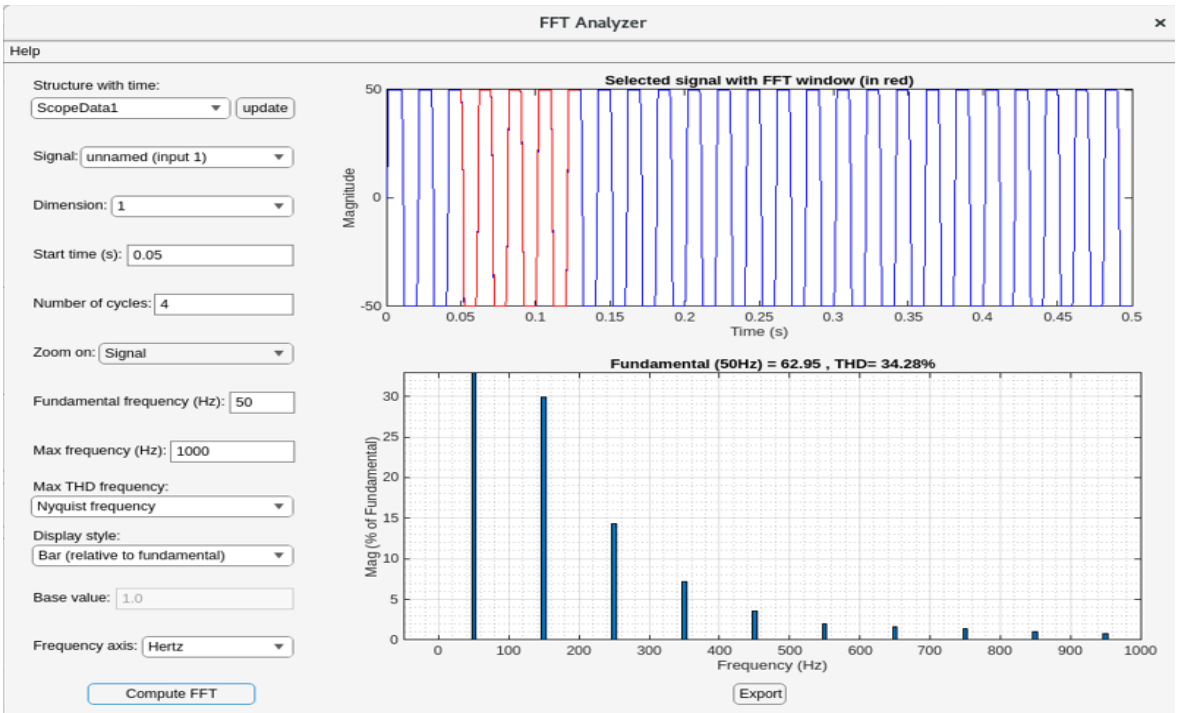

Figure 8: The FFT plot for the primary current when L_{series} = 0.5mH.

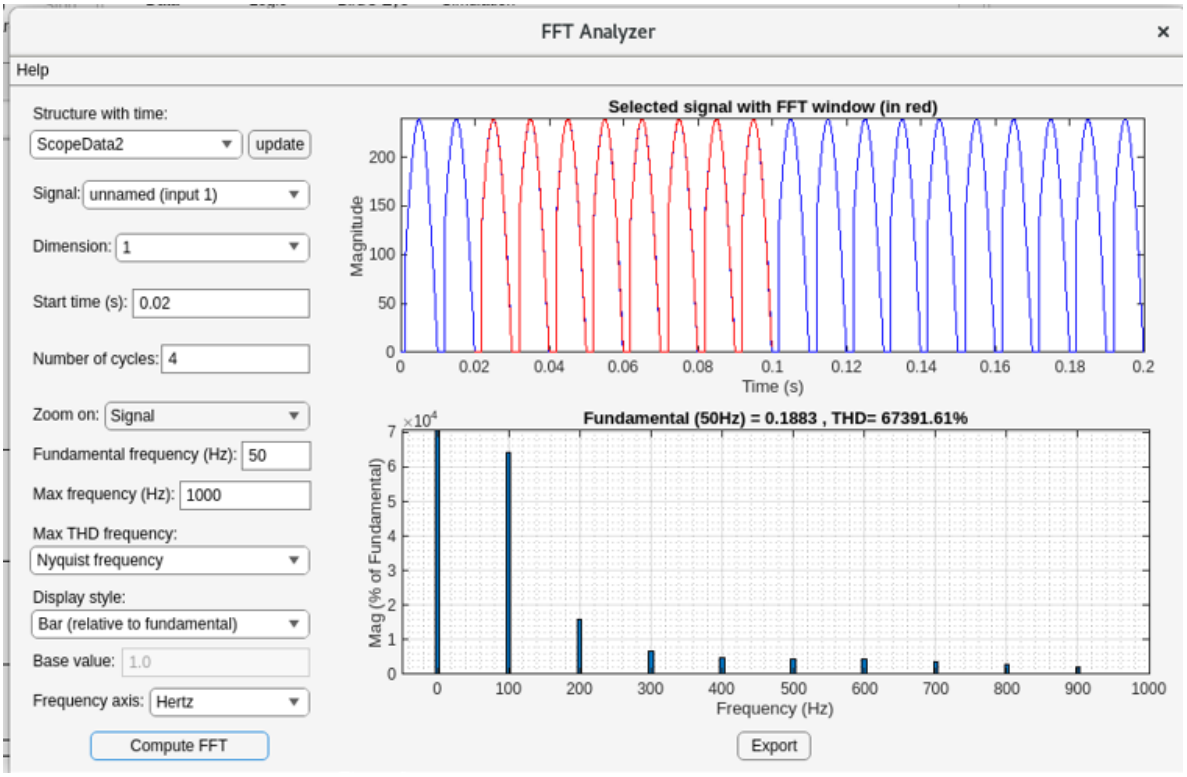

Figure 9: The FFT plot for the output voltage when L_{series} = 0.5 mH.

1.3.2 The series Inductance, L_{series} = 0.1 mH

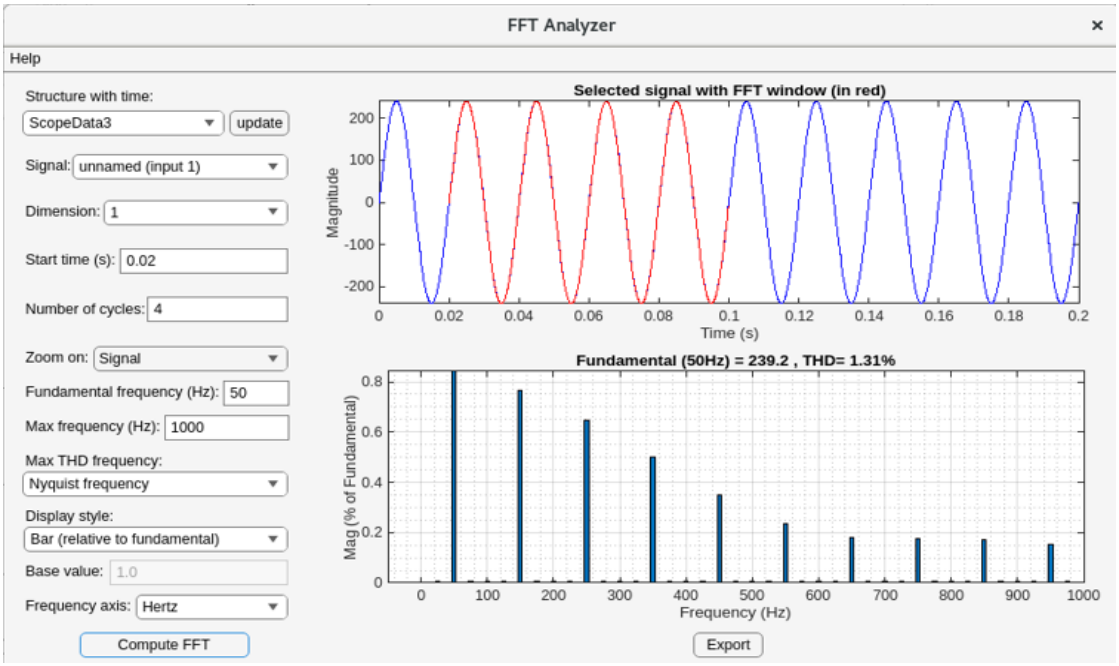

Figure 10: The FFT plot for the primary voltage when L_{series} = 0.1mH.

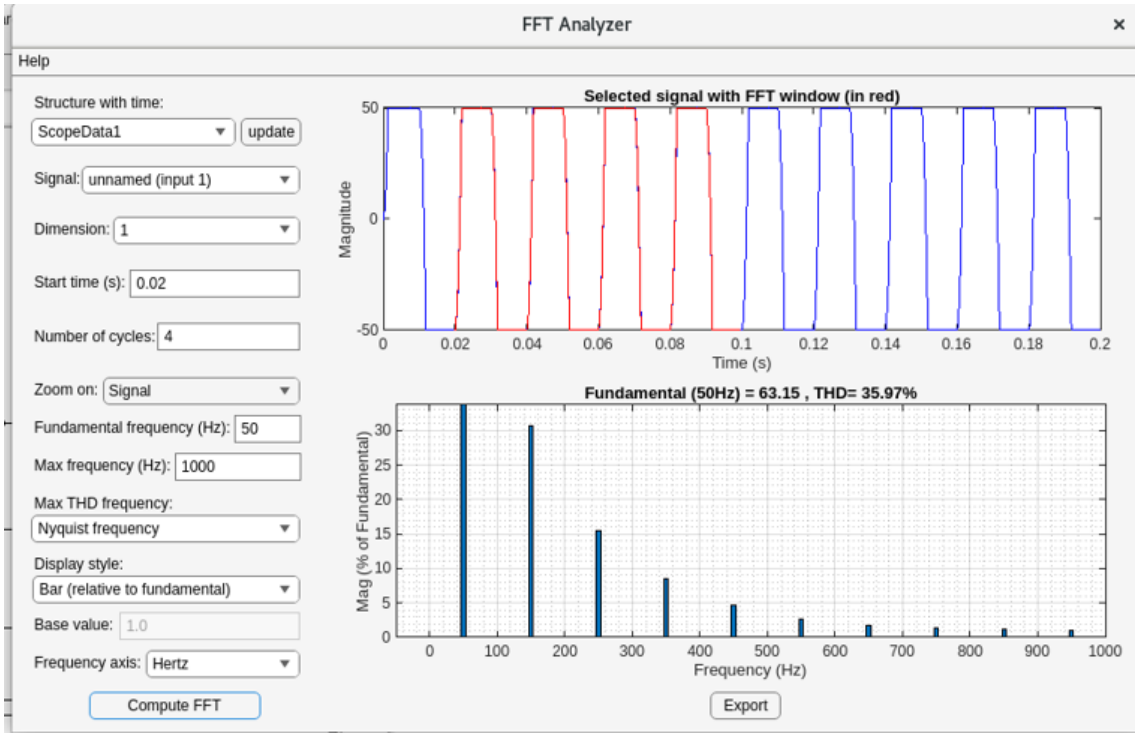

Figure 11: The FFT plot for the primary current when L_{series}=0.1mH.

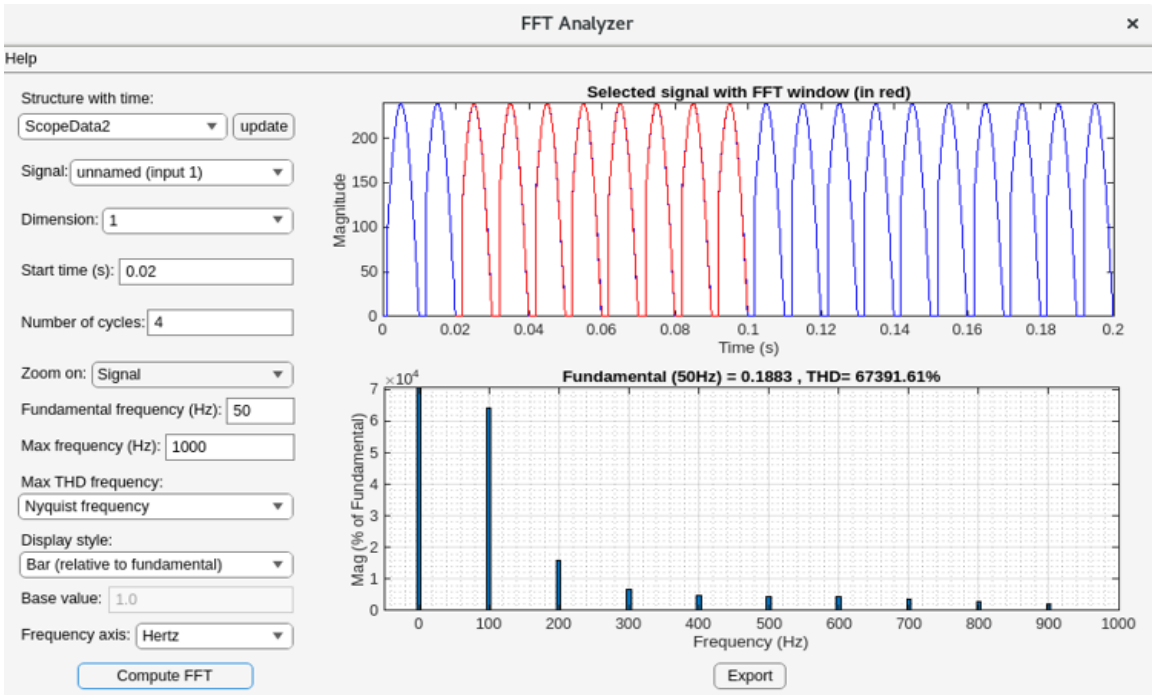

Figure 12: The FFT plot for the output voltage when L_{series} = 0.1 mH.

1.4 Observations

1. The Total Harmonic Distortion (THD) for the Primary current is 34.28 % when L_{series} = 0.5 mH and it is equal to 35.97 % when L_{series} = 0.1 mH.
2. The Total Harmonic Distortion (THD) for the Primary voltage is 6.01 % when L_{series} = 0.5 mH and it is equal to 1.31 % when L_{series} = 0.1 mH.
3. The dominant harmonics that are present in the primary current when:
   (a) L_{series} = 0.5 mH correspond to 150 Hz and 250 Hz.
   (b) L_{series} = 0.1 mH correspond to 150 Hz and 250 Hz.
4. The dominant harmonics that are present in the primary voltage when:
   (a) L_{series} = 0.5 mH correspond to 150 Hz and 250 Hz although their contribution in the THD is very low (< 10%).
   (b) L_{series} = 0.1 mH correspond to 150 Hz and 250 Hz although their contribution in the THD is less than 2%.

2 Question B - Three Phase 6 Pulse Rectifier

2.1 The Model

The required simulink model for the three phase 6 pulse rectifier is shown below:

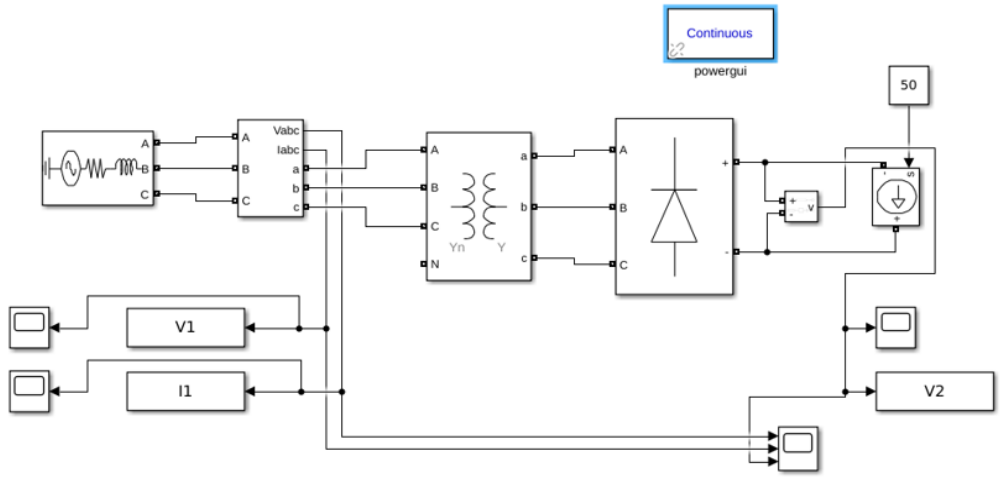

Figure 13: The simulink model for the three phase 3 pulse rectifier.

2.2 The Output and Input Waveforms

The plots for the primary voltage, primary current and the output voltage is shown:

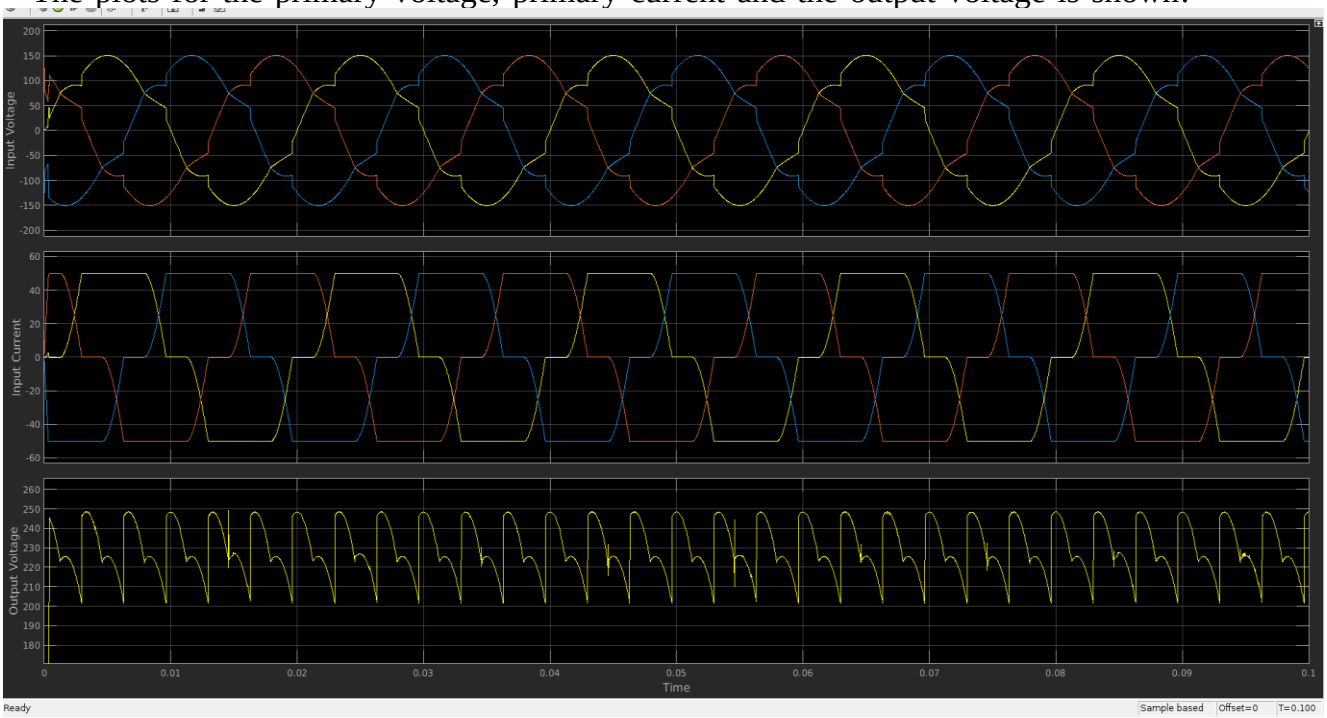

Figure 14: The output and input waveforms.

2.3 The Required FFT plots

The FFTs for the primary current, primary voltage and the DC voltage is shown below :

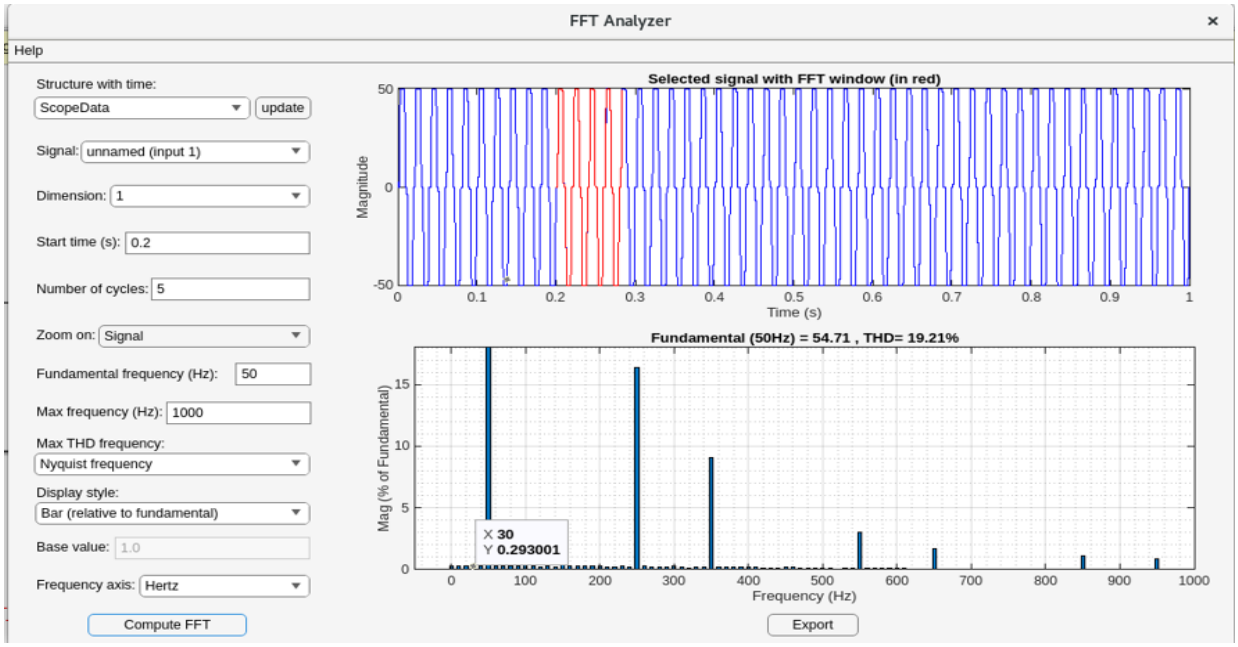

Figure 15: The FFT plot for the primary current.

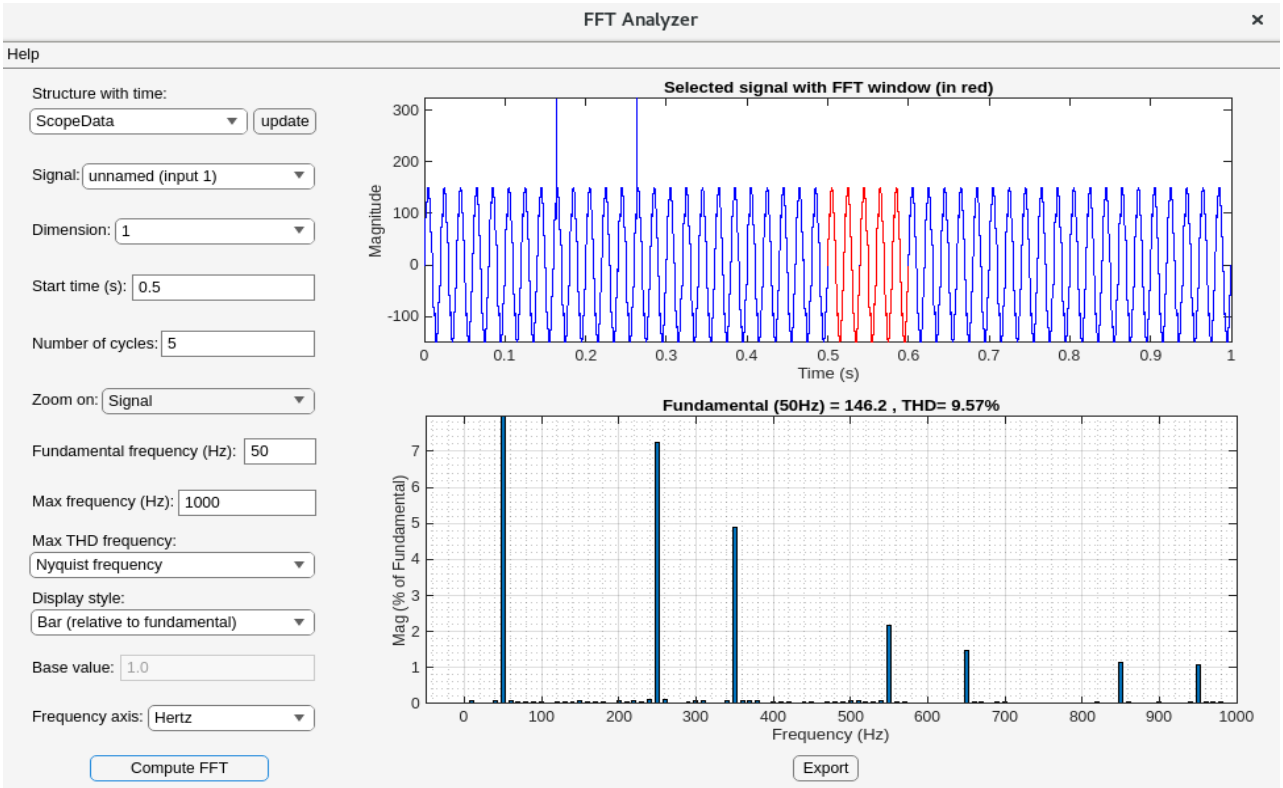

Figure 16: The FFT plot for the primary voltage.

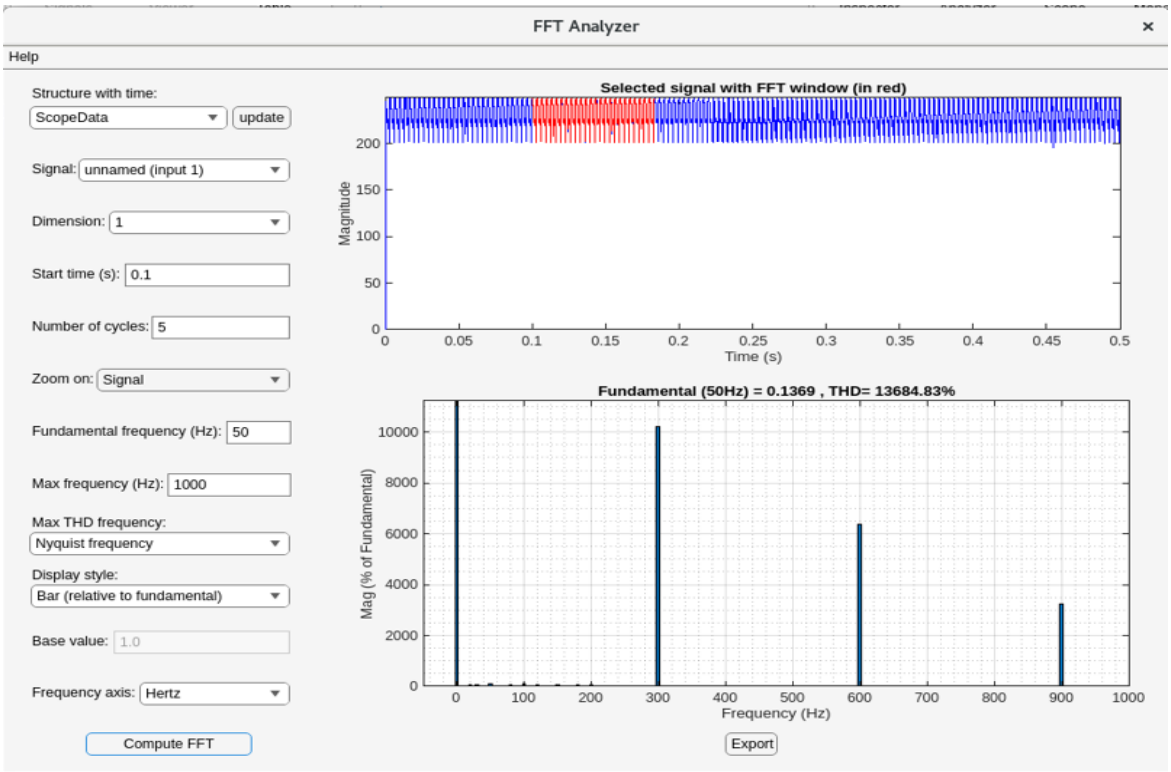

Figure 17: The FFT plot for the output voltage.

2.4 Observations

1. The Total Harmonic Distortion (THD) for the Primary current is 19.21 %.
2. The Total Harmonic Distortion (THD) for the Primary voltage is 9.57 %.
3. The dominant harmonics that are present in the primary current correspond to 250 Hz and 350 Hz (< 10%).
4. The dominant harmonics that are present in the primary voltage correspond to 250 Hz and 350 Hz.

3 Question C - Three Phase 12 Pulse Rectifier

3.1 The Model

The required simulink model for the three phase 12 pulse rectifier is shown below:

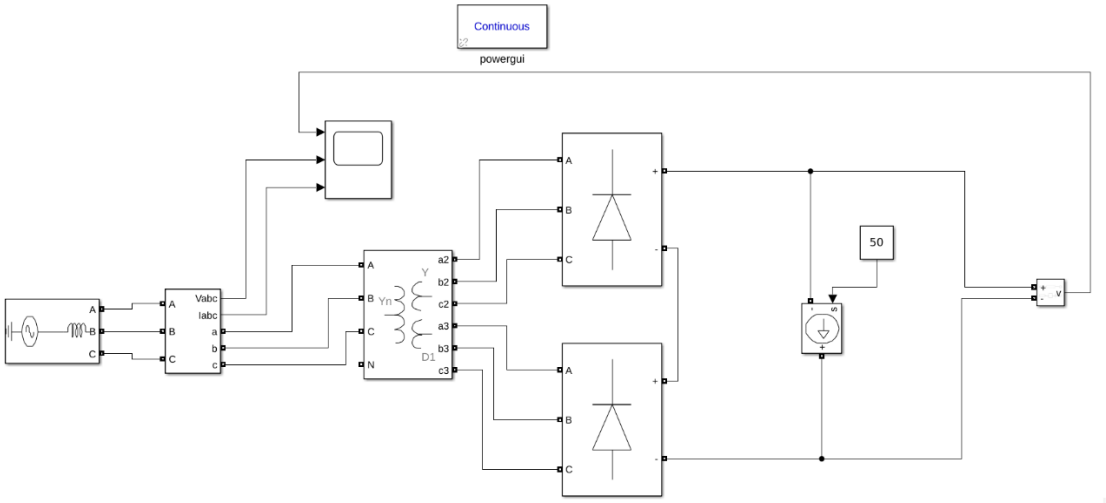

Figure 18: The simulink model for the three phase 12 pulse rectifier.

3.2 The Output and Input Waveforms

The plots for the primary voltage, primary current and the output voltage is shown below:

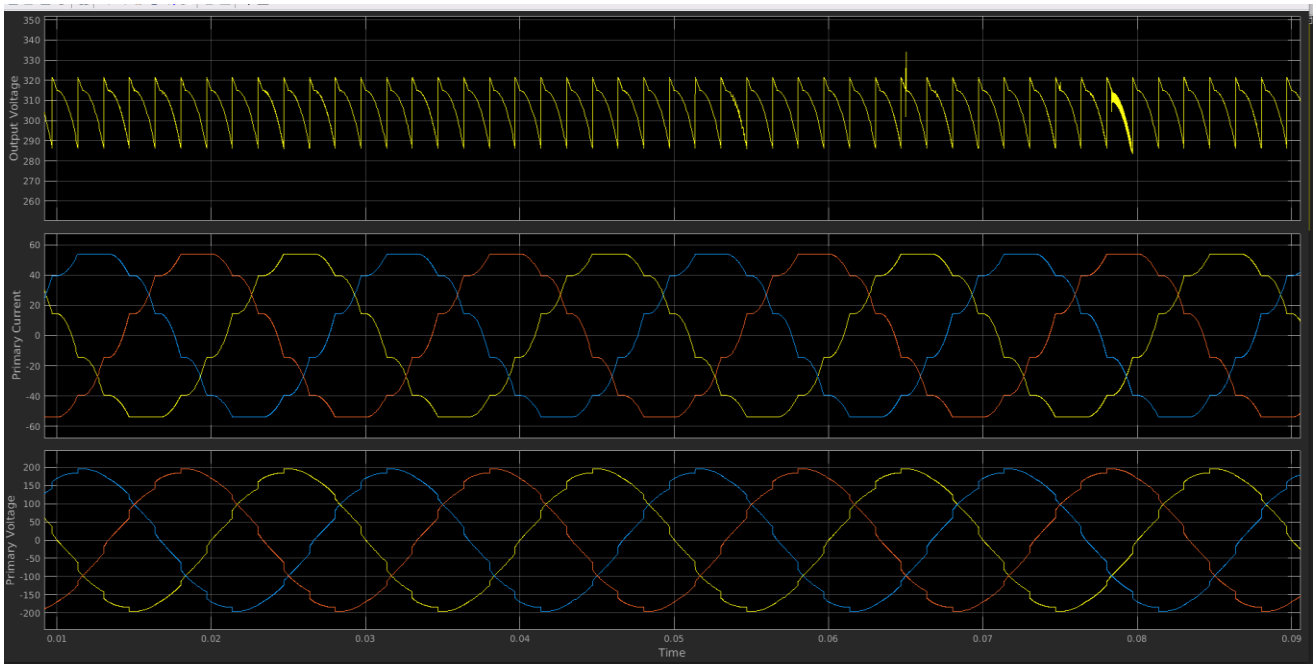

Figure 19: The output and input waveforms

3.3 The Required FFT plots

The FFTs for the primary current, primary voltage and the DC voltage is shown below

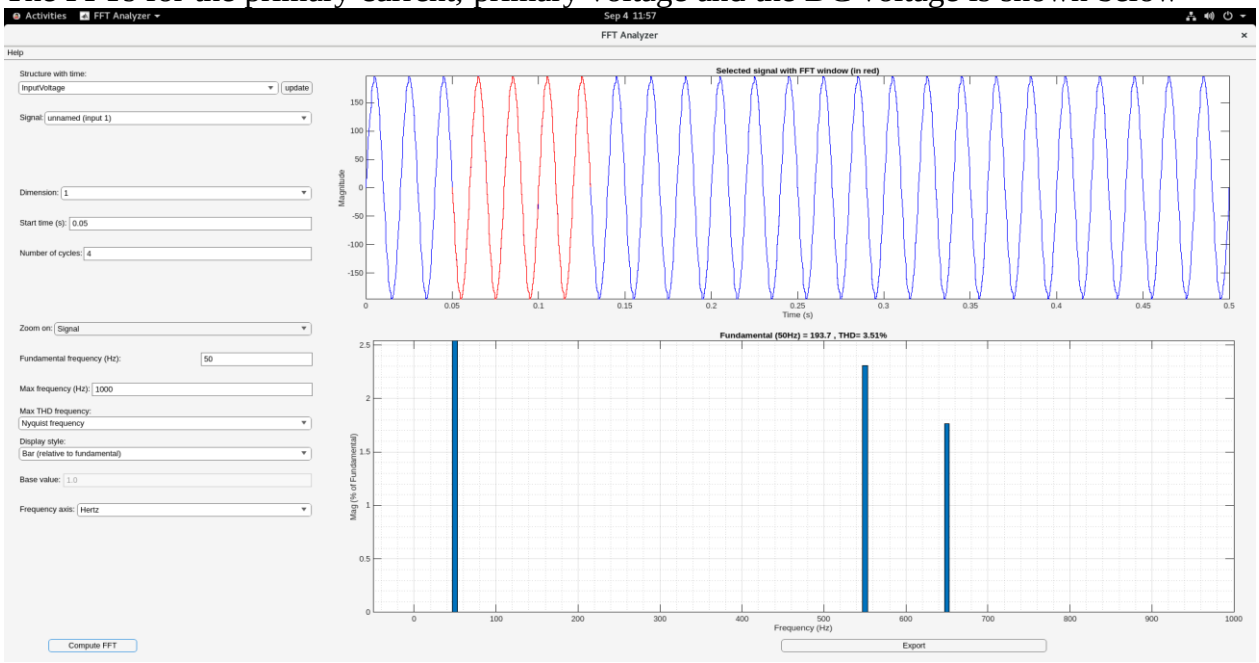

Figure 20: The FFT plot for the primary voltage.

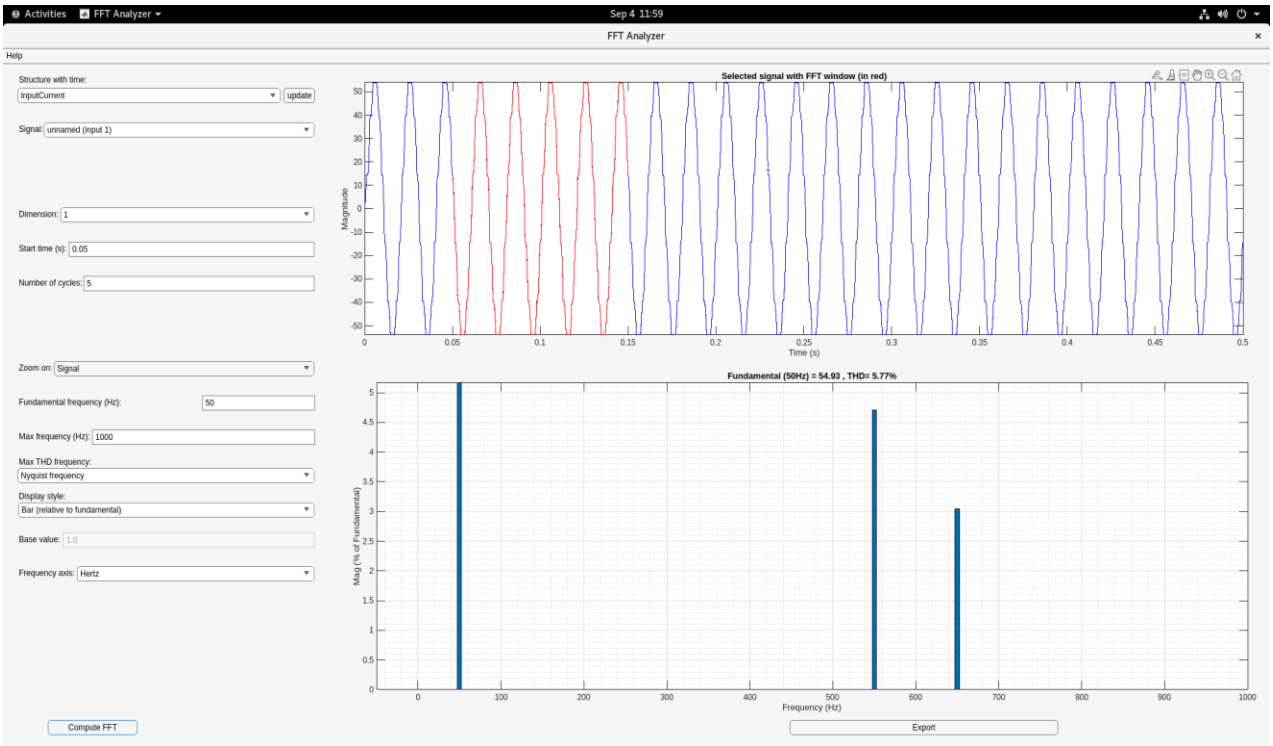

Figure 21: The FFT plot for the primary current.

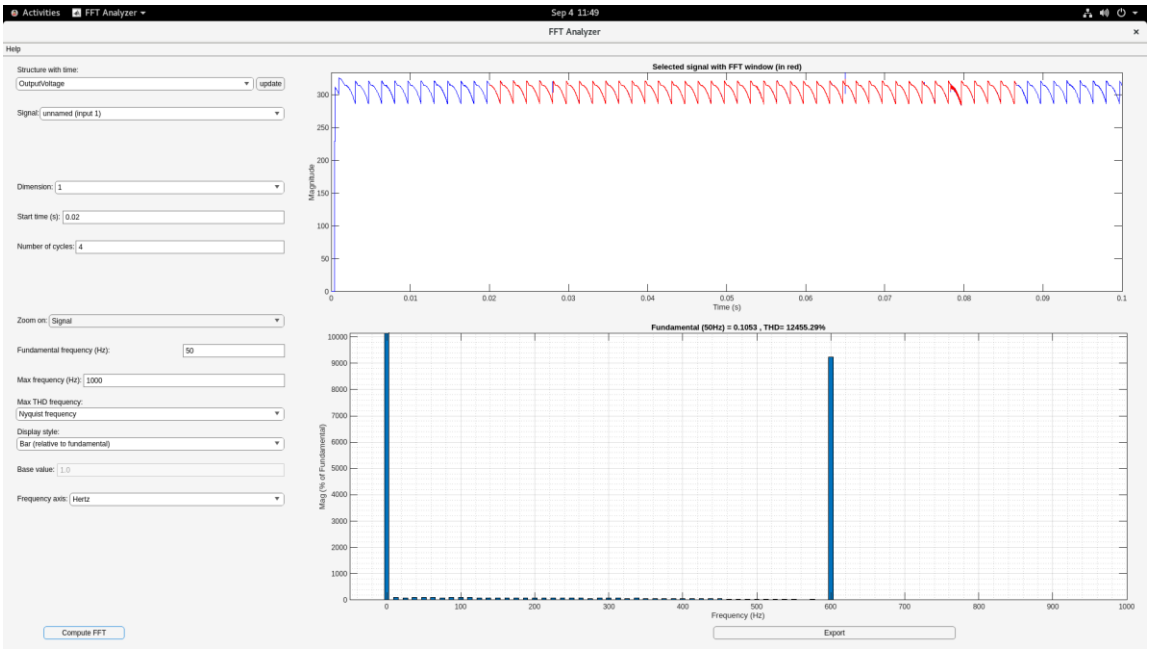

Figure 22: The FFT plot for the output voltage.

3.4 Observations

1. The Total Harmonic Distortion (THD) for the Primary current is 5.77 %.
2. The Total Harmonic Distortion (THD) for the Primary voltage is 3.51 %.
3. The dominant harmonics that are present in the primary current correspond to 550 Hz and 650 Hz (< 5%).
4. The dominant harmonics that are present in the primary voltage correspond to 550 Hz and 650 Hz (< 10%).

4 Inferences

The results are summarized in the below table:

Rectifier	Fundamental AC Source Current	Current THD	Fundamental Voltage on the Primary Side	Voltage THD
2 pulse	62.95 A peak 50 Hz	(L_{series}=0.5 mH) 34.28% (L_{series}=0.1 mH) 35.97 %	235.9 V peak 50 Hz	(L_{series}=0.5 mH) 6.01% (L_{series}=0.1 mH) 1.31%
6 pulse	54.71 A peak 50 Hz	19.21%	146.2 V peak 50 Hz	9.57%
12 pulse	54.93 A peak 50 Hz	5.77%	193.7 V peak 50 Hz	3.51%