EE605 Simulation Laboratory

Laboratory Report Submitted in Partial Fulfillment of the Requirements for the Degree of

Bachelor of Technology

in

Electrical and Electronic Engineering

Submitted by

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CERTIFICATE

This is to certify that Mr. RAJ P. NAIK DHULAPKAR bearing Roll. No. 20EEE1023, has submitted the **Laboratory Report** as a part of the Laboratory Course, "**Basic Electrical Science Lab (EE152)**" in the academic year 2020-2021 at the Institution of **National Institute of Technology Goa**.

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MARKSHEET

Sl. No	Name of the Experiment	Page No.	Date of Experiment	Date of submission	Marks
1	Verification of ohm's Law	2 - 3	4-05-2021	05-05-2021	
2	Verification of Kirchhoff's Law	2 - 3	4-05-2021	05-05-2021	
3	Verification of Network Theorems	2 - 3	4-05-2021	05-05-2021	
4	DC Transient Analaysis	23-28	20-06-2021	25-07-2021	
5	Power Calculation in AC Circuit	29-32	20-6-2021	25-06-2021	
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Half Wave Rectifier

1.1 Aim

Single Phase Half Wave Uncontrolled and Controlled Rectifier

1.2 Software Used

MATLAB R2020a

1.3 Theory

A rectifier is a device that converts alternating current (AC) to direct current (DC). It is done by using a diode or a group of diodes. A half wave rectifier is defined as a type of rectifier that only allows one half-cycle of an AC voltage waveform to pass, blocking the other half-cycle. Half-wave rectifiers are used to convert AC voltage to DC voltage, and only require a single diode to construct.

Single Phase Half Wave Uncontrolled Rectifier: This rectifier comprises of an AC source, a diode and a load. The diode gets forward biased during the positive half cycle of the AC source, and the circuit conducts. During the negative half cycle, the diode becomes reverse biased and blocks current.

Single Phase Half Wave Controlled Rectifier: This rectifier comprises of an AC source, a Thyristor/SCR and a load. The key difference here, is the presence of the thyristor/SCR, which conducts only when gate pulses at a firing angle α are applied to it. The SCR automatically turns off when its voltage is reverse biased for a period longer than the SCR turn off time and its current falls below holding current.

1.4 Theoretical Calculations

For an R load, average output voltage and current for a controlled half wave rectifier are given by:

$$V_{o,avg} = V_{phase}\sqrt{2(1 + cos\alpha)2\pi} = V_m(1 + cos\alpha)2\pi$$

$$I_{o,avg} = V_oR$$

Where α is the firing angle of the thyristor. For uncontrolled recti- fiers, the thyristor is replaced by a diode, and $\alpha = 0$.

For a single phase half wave uncontrolled rectifier

1.5 Single Phase Half Wave Uncontrolled Rectifier with R load

1.5.1 Circuit used for simulation

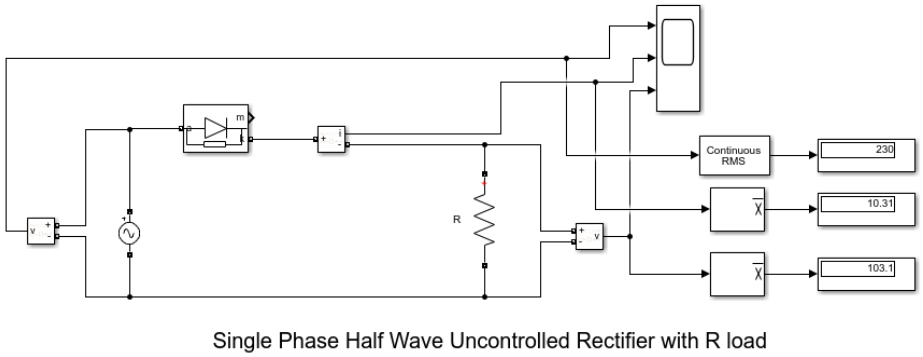

Figure 1.1: Circuit used for simulation

1.5.2 Components Required

Table 1.1: Components for Single Phase Half Wave Uncontrolled Rectifier with R load

Sr. No	Parameters	Ratings	Quantity
1	AC Single Phase Voltage Source	230V (V_{rms})	1
2	Resistor	10Ω	1
3	Diode	-	1
4	Voltmeter	-	2
5	Ammeter	-	1

1.5.3 Observations

Table 1.2: Observations for Single Phase Half Wave Uncontrolled Rectifier with R load

Parameters	Theoretical Values	Simulation Values
AC Input Voltage ($V_{in,rms}$)	230V	230V
Output Average Voltage ($V_{o,avg}$)	103.53V	103.5V
Output Average Current ($I_{o,avg}$)	10.35A	10.35A

It is observed that the simulated values accurately match the the- oretical values. As the load is resistive in nature, the output current is in phase with output voltage. From the output voltage and cur- rent waveforms, it can be deduced that the diode gets forward biased during the positive half cycle of the AC source.

1.5.4 Resultant Waveforms

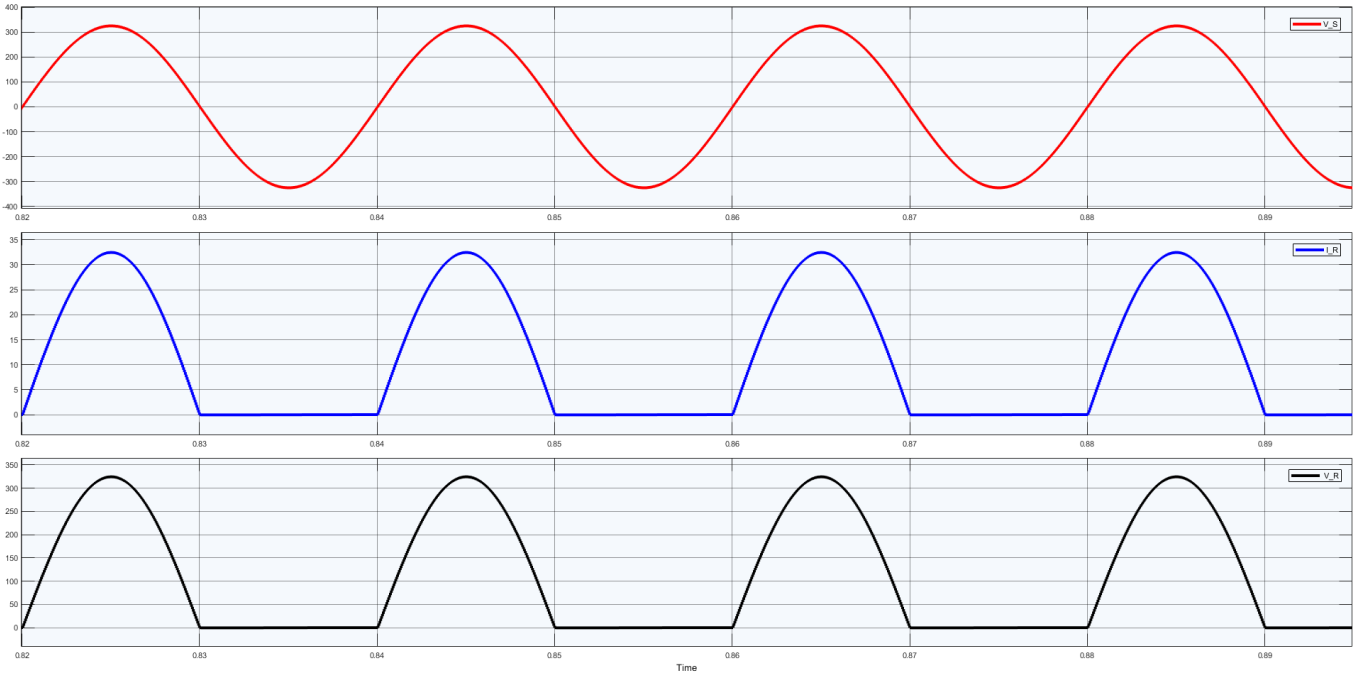

Figure 1.2: Scope Waveforms for Single Phase Half Wave Uncontrolled Rectifier with R load waveforms

1.6 Single Phase Half Wave Uncontrolled Rectifier with RL load

1.6.1 Circuit used for simulation

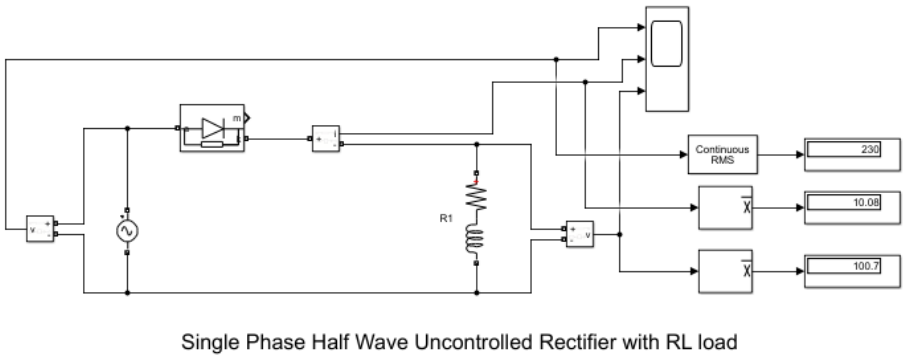

Figure 1.3: Circuit used for simulation

1.6.2 Components Required

Table 1.3: Components for Single Phase Half Wave Uncontrolled Rectifier with RL load

Sr. No	Parameters	Ratings	Quantity
1	AC Single Phase Voltage Source	230V (V_{rms})	1
2	Resistor	10Ω	1
3	Inductor	10mH	1
4	Diode	-	1
5	Voltmeter	-	2
6	Ammeter	-	1

1.6.3 Observations

Table 1.4: Observations for Single Phase Half Wave Uncontrolled Rectifier with RL load

Parameters	Theoretical Values	Simulation Values
AC Input Voltage ($V_{in,rms}$)	230V	230V
Output Average Voltage ($V_{o,avg}$)	103.53V	101.1V
Output Average Current ($I_{o,avg}$)	10.35A	10.11A

It is observed that the simulated values accurately match the the- oretical values. As the load is resistive in nature, the output current is in phase with output voltage. From the output voltage and cur- rent waveforms, it can be deduced that the diode gets forward biased during the positive half cycle of the AC source.

1.6.4 Resultant Waveforms

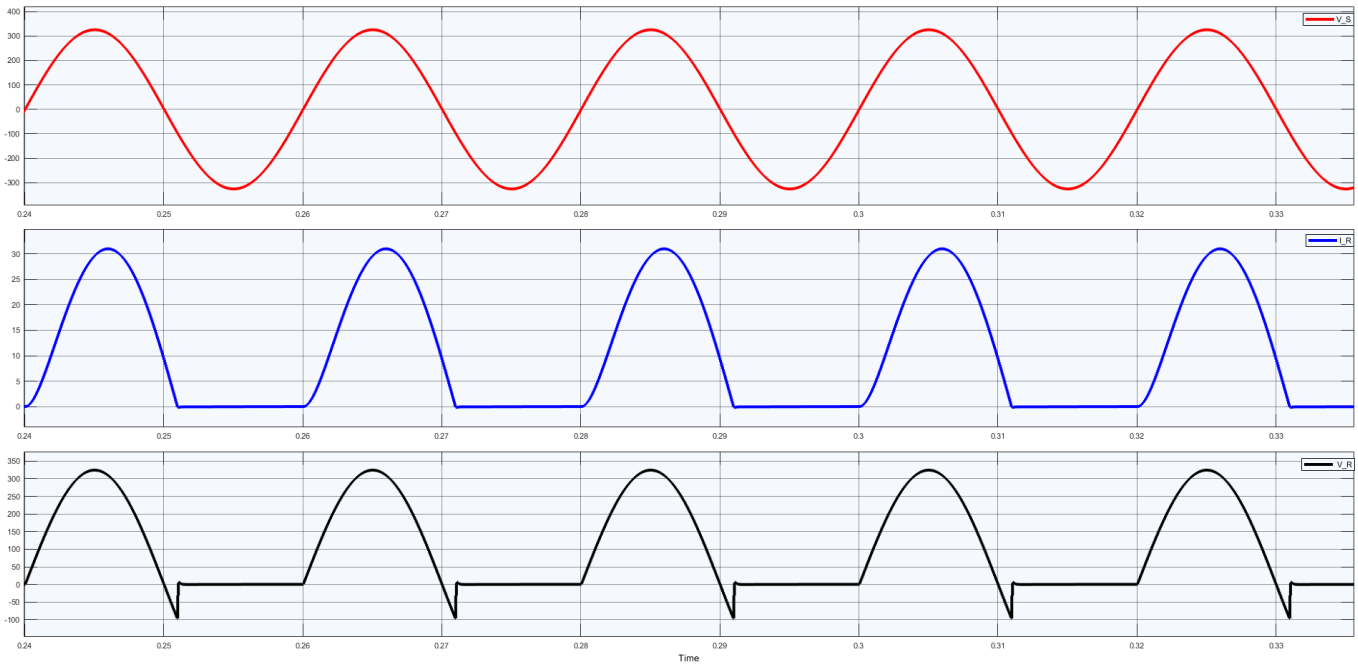

Figure 1.4: Scope Waveforms for Single Phase Half Wave Uncontrolled Rectifier with RL load

1.7 Single Phase Half Wave Uncontrolled Rectifier with RL load and Freewheeling Diode

1.7.1 Circuit used for simulation

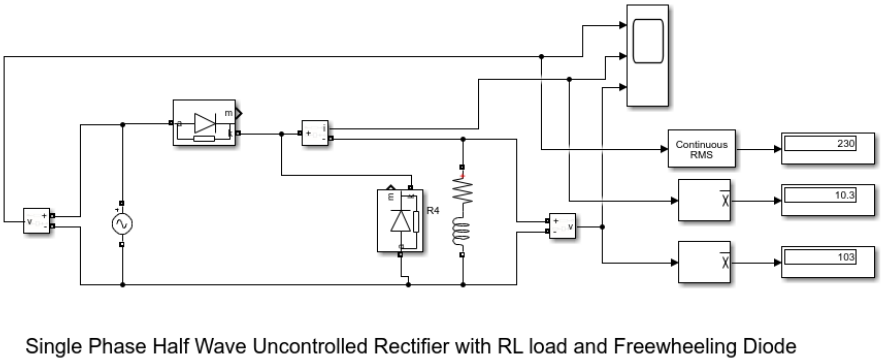

Figure 1.5: Circuit used for simulation

1.7.2 Components Required

Table 1.5: Components for Single Phase Half Wave Uncontrolled Rectifier with RL load and Freewheeling Diode

Sr. No	Parameters	Ratings	Quantity
1	AC Single Phase Voltage Source	230V (V_{rms})	1
2	Resistor	10Ω	1
3	Inductor	10mH	1
4	Diode	-	1
5	Voltmeter	-	2
6	Ammeter	-	1

1.7.3 Observations

Table 1.6: Observations for Single Phase Half Wave Uncontrolled Rectifier with RL load and Freewheeling Diode

Parameters	Theoretical Values	Simulation Values
AC Input Voltage ($V_{in,rms}$)	230V	230V
Output Average Voltage ($V_{o,avg}$)	103.53V	101.1V
Output Average Current ($I_{o,avg}$)	10.35A	10.11A

It is observed that the simulated values accurately match the the- oretical values. As the load is resistive in nature, the output current is in phase with output voltage. From the output voltage and cur- rent waveforms, it can be deduced that the diode gets forward biased during the positive half cycle of the AC source.

1.7.4 Resultant Waveforms

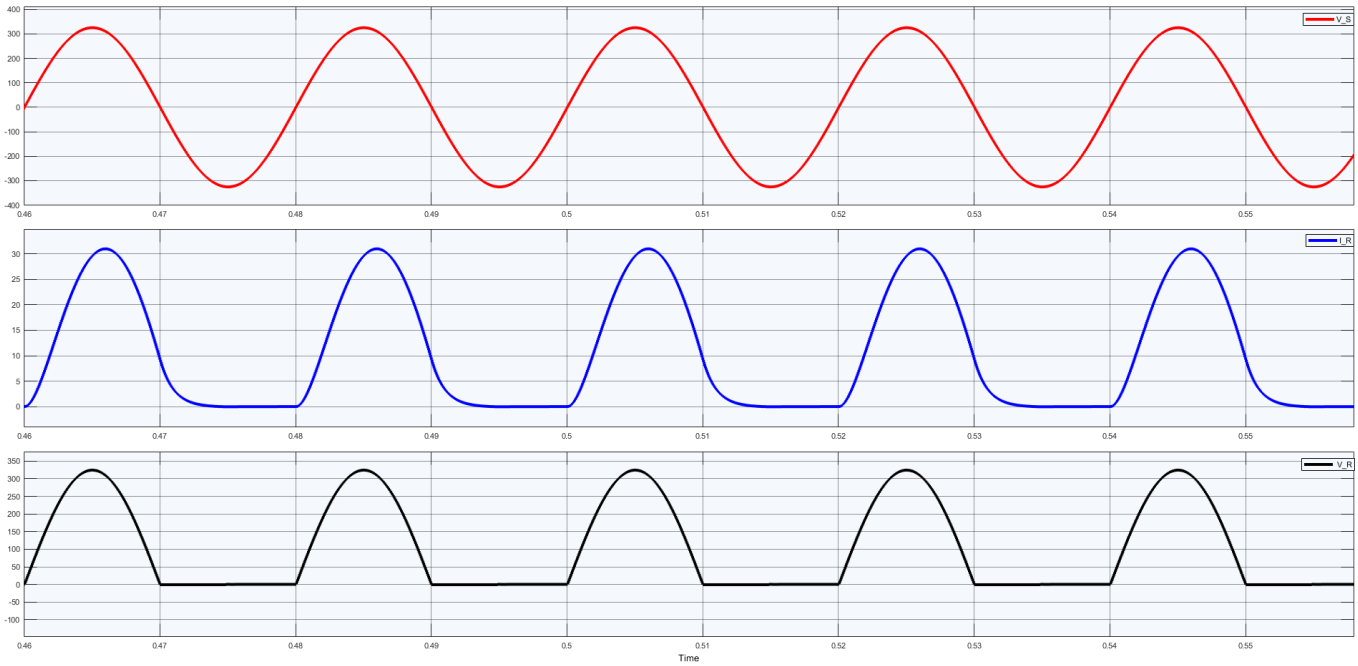

Figure 1.6: Scope Waveforms for Single Phase Half Wave Uncontrolled Rectifier with RL load and Freewheeling Diode

1.8 Single Phase Half Wave Uncontrolled Rectifier with RLE load

1.8.1 Circuit used for simulation

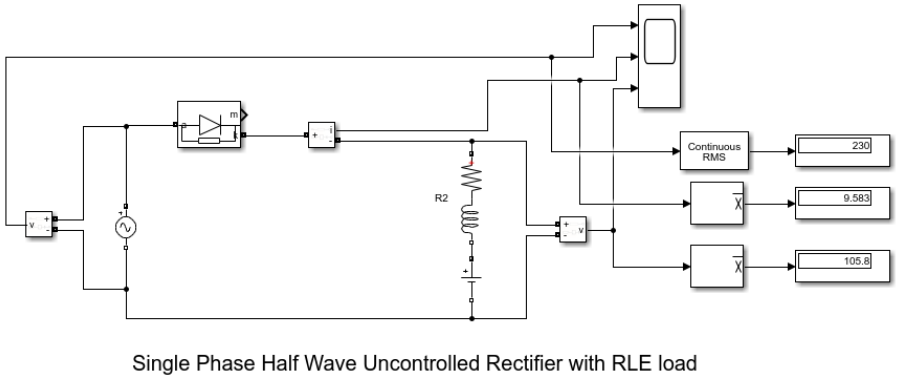

Figure 1.7: Circuit used for simulation

1.8.2 Components Required

Table 1.7: Components for Single Phase Half Wave Uncontrolled Rectifier with RLE load load

Sr. No	Parameters	Ratings	Quantity
1	AC Single Phase Voltage Source	230V (V_{rms})	1
2	Resistor	10Ω	1
3	Inductor	10mH	1
4	Diode	-	1
5	DC Source	100V	1
6	Voltmeter	-	2
7	Ammeter	-	1

1.8.3 Observations

Table 1.8: Observations for Single Phase Half Wave Uncontrolled Rectifier with R load

Parameters	Theoretical Values	Simulation Values
AC Input Voltage ($V_{in,rms}$)	230V	230V
Output Average Voltage ($V_{o,avg}$)	103.53V	101.1V
Output Average Current ($I_{o,avg}$)	10.35A	10.11A

It is observed that the simulated values accurately match the the- oretical values. As the load is resistive in nature, the output current is in phase with output voltage. From the output voltage and cur- rent waveforms, it can be deduced that the diode gets forward biased during the positive half cycle of the AC source.

1.8.4 Resultant Waveforms

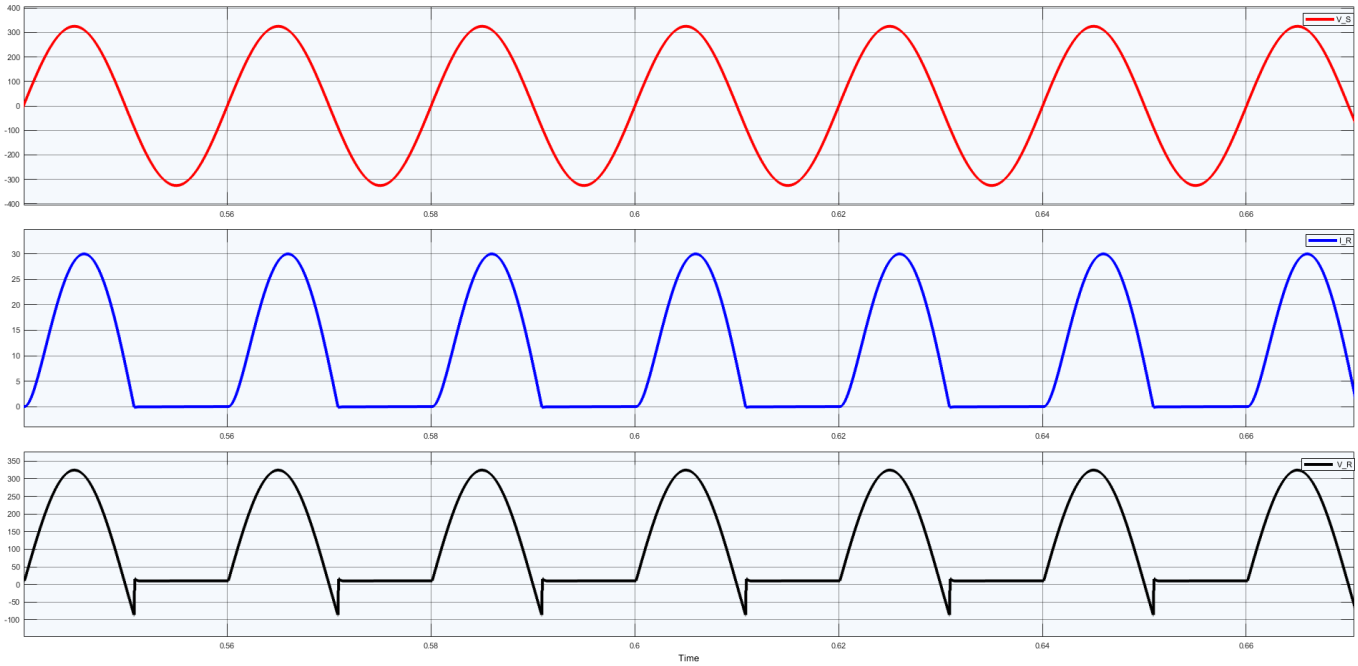

Figure 1.8: Scope Waveforms for Single Phase Half Wave Uncontrolled Rectifier with RLE load waveforms

1.9 Single Phase Half Wave Controlled Rectifier with R load

1.9.1 Circuit used for simulation

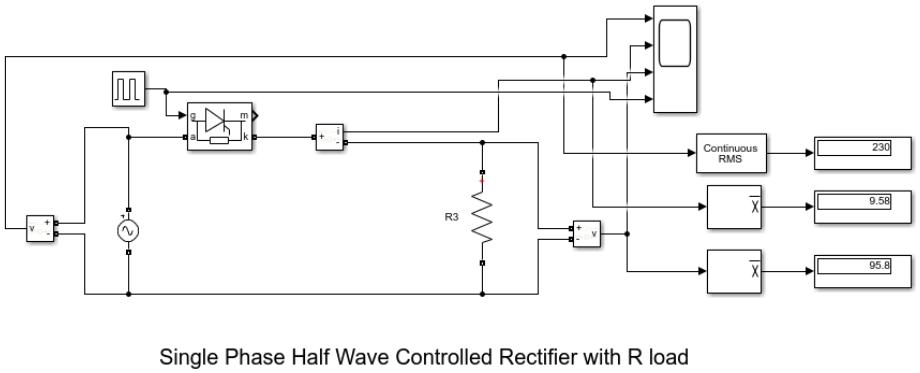

Figure 1.9: Circuit used for simulation

1.9.2 Components Required

Table 1.9: Components for Single Phase Half Wave Controlled Rectifier with R load load

Sr. No	Parameters	Ratings	Quantity
1	AC Single Phase Voltage Source	230V (V_{rms})	1
2	Resistor	10Ω	1
3	Inductor	10mH	1
4	Diode	-	1
5	Voltmeter	-	2
6	Ammeter	-	1

1.9.3 Observations

Table 1.10: Observations for Single Phase Half Wave Controlled Rectifier with R load

Parameters	Theoretical Values	Simulation Values
AC Input Voltage ($V_{in,rms}$)	230V	230V
Output Average Voltage ($V_{o,avg}$)	103.53V	101.1V
Output Average Current ($I_{o,avg}$)	10.35A	10.11A

It is observed that the simulated values accurately match the the- oretical values. As the load is resistive in nature, the output current is in phase with output voltage. From the output voltage and cur- rent waveforms, it can be deduced that the diode gets forward biased during the positive half cycle of the AC source.

1.9.4 Resultant Waveforms

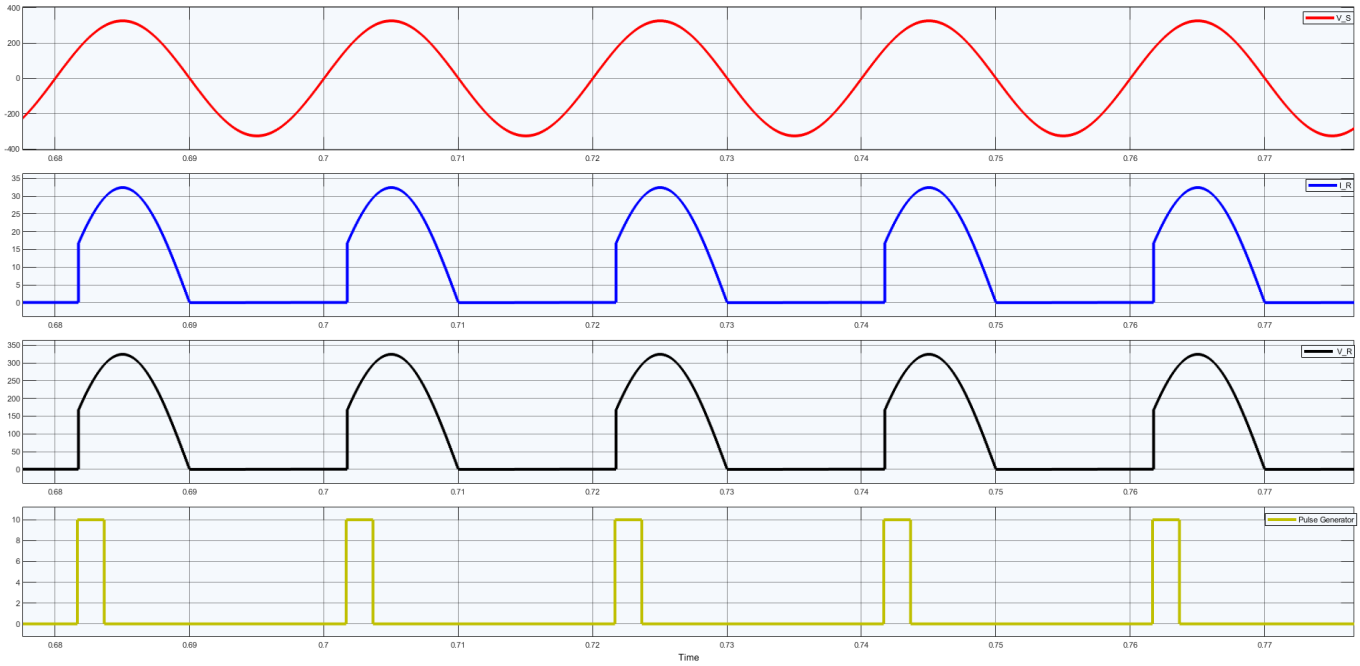

Figure 1.10: Scope Waveforms for Single Phase Half Wave Controlled Rectifier with R load

1.10 Single Phase Half Wave Controlled Rectifier with RL load

1.10.1 Circuit used for simulation

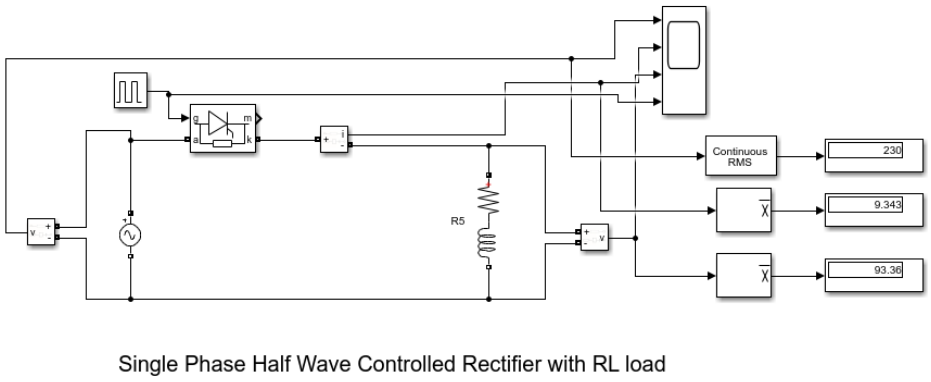

Figure 1.11: Circuit used for simulation

1.10.2 Components Required

Table 1.11: Components for Single Phase Half Wave Controlled Rectifier with RL load load

Sr. No	Parameters	Ratings	Quantity
1	AC Single Phase Voltage Source	230V (V_{rms})	1
2	Resistor	10Ω	1
3	Inductor	10mH	1
4	Diode	-	1
5	Voltmeter	-	2
6	Ammeter	-	1

1.10.3 Observations

Table 1.12: Observations for Single Phase Half Wave Controlled Rectifier with RL load

Parameters	Theoretical Values	Simulation Values
AC Input Voltage ($V_{in,rms}$)	230V	230V
Output Average Voltage ($V_{o,avg}$)	103.53V	101.1V
Output Average Current ($I_{o,avg}$)	10.35A	10.11A

It is observed that the simulated values accurately match the the- oretical values. As the load is resistive in nature, the output current is in phase with output voltage. From the output voltage and cur- rent waveforms, it can be deduced that the diode gets forward biased during the positive half cycle of the AC source.

1.10.4 Resultant Waveforms

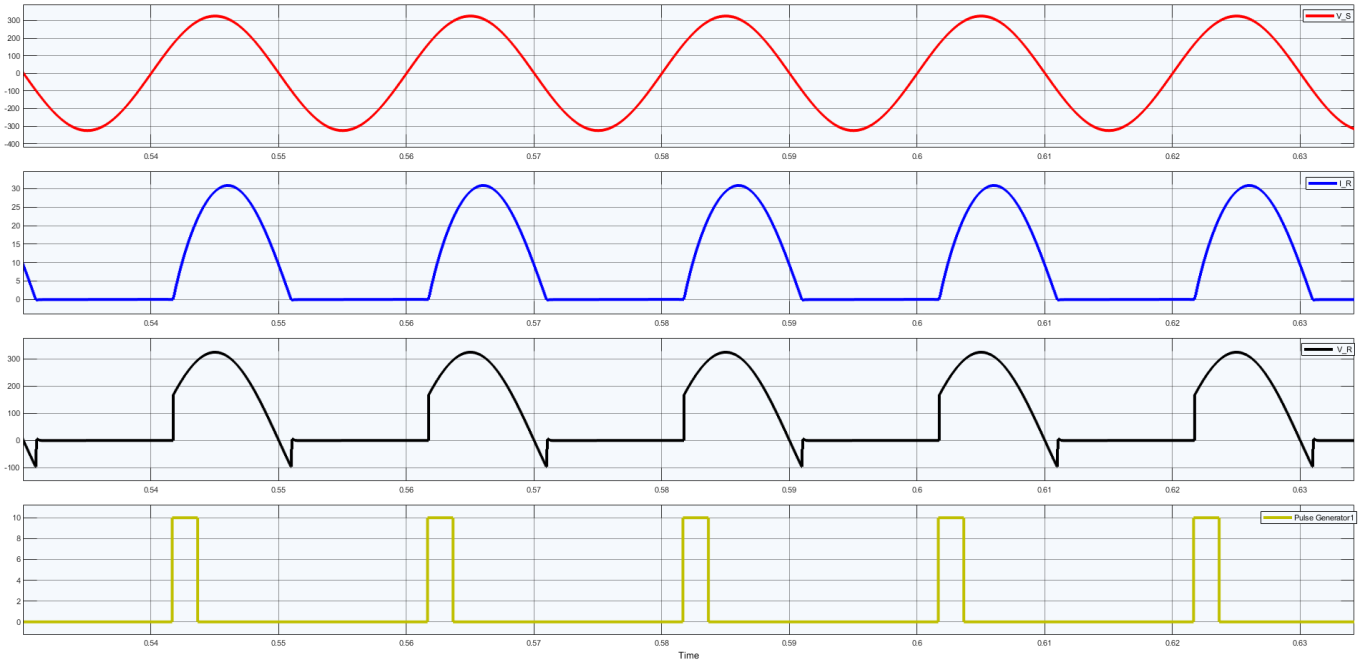

Figure 1.12: Scope Waveforms for Single Phase Half Wave Controlled Rectifier with RL load

1.11 Single Phase Half Wave Controlled Rectifier with RLE load

1.11.1 Circuit used for simulation

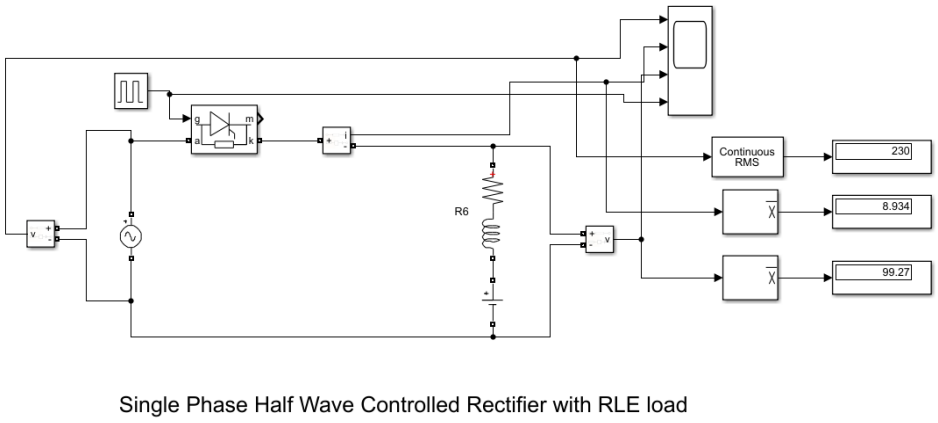

Figure 1.13: Circuit used for simulation

1.11.2 Components Required

Table 1.13: Components for Single Phase Half Wave Controlled Rectifier with RLE load load

Sr. No	Parameters	Ratings	Quantity
1	AC Single Phase Voltage Source	230V (V_{rms})	1
2	Resistor	10Ω	1
3	Inductor	10mH	1
4	Diode	-	1
5	Voltmeter	-	2
6	Ammeter	-	1

1.11.3 Observations

Table 1.14: Observations for Single Phase Half Wave Controlled Rectifier with RLE load

Parameters	Theoretical Values	Simulation Values
AC Input Voltage ($V_{in,rms}$)	230V	230V
Output Average Voltage ($V_{o,avg}$)	103.53V	101.1V
Output Average Current ($I_{o,avg}$)	10.35A	10.11A

It is observed that the simulated values accurately match the the- oretical values. As the load is resistive in nature, the output current is in phase with output voltage. From the output voltage and cur- rent waveforms, it can be deduced that the diode gets forward biased during the positive half cycle of the AC source.

1.11.4 Resultant Waveforms

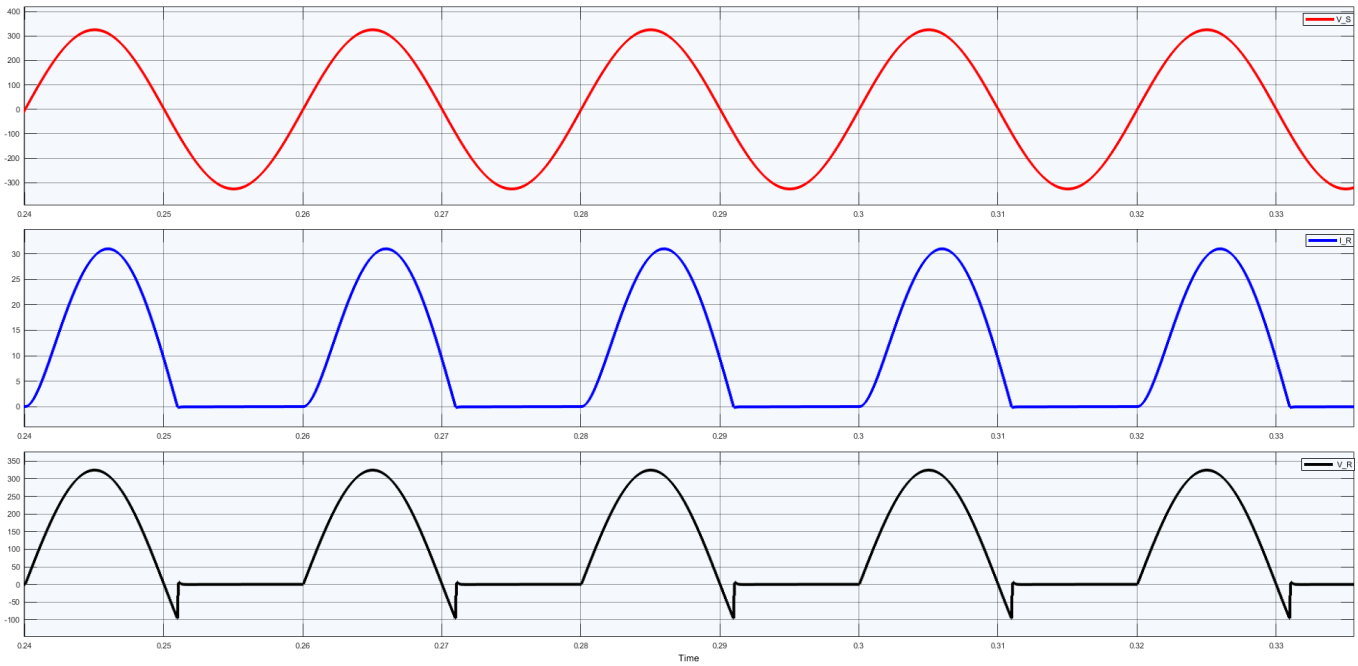

Figure 1.14: Scope Waveforms for Single Phase Half Wave Controlled Rectifier with RLE load

1.12 Results

1.12.1 Theoretical Calculation

The resistance **R** in the circuit shown in Fig. 2.2 is considered as 20 Ω, and the voltage (which is effectively the voltage across **R**) is considered as 50 V, 100 V, 150 V and 200 V in four steps as mentioned in the second column of Table-**??**. As per **Ohm's Law**, the current corresponding to all the four voltages are,

$$I = \frac{V}{R} = \frac{50}{20} = 2.5\ A\ (for\ V = 50V); \quad = 5\ A\ (for\ V = 100V); \quad = 7.5\ A\ (for\ V = 150V); \quad = 10\ A\ (for\ V = 200V)$$

1.12.2 Simulation Results

The simulink file is run for 10 sec considering V=50 V, and and corresponding current seen in the display is noted in the fourth column of second row of Table-**??**. Similarly, all other three rows are filled. Further, constantly varying ramp voltage is applied and the corresponding v-i graph is plotted in Fig. **??**.

Table 1.15: Observations for Single Phase Half Wave Controlled Rectifier with RLE load

Sl No	Applied Voltage (V) in Volts	Current (I) through R in Amps	
		Theoretical	Simulated
1	50	5	2.5
2	100	10	5
3	150	15	7.5
4	200	20	10

1.13 Conclusion

The design of single phase half wave rectifiers, both controlled and uncontrolled, with R, RL, RL with freewheeling diode, and RLE loads were implemented successfully in MATLAB using Simulink. The output waveforms for voltage and current were obtained in each case, and a comparison between theoretically calculated and simu- lated output parameter values was also performed.