Contents

List of Figures

List of Tables

Experiment 1

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 an electronic device that converts AC (alternating current) to DC (direct current). This is typically achieved using diodes, which allow current to flow in only one direction. In the case of a half-wave rectifier, only one half-cycle of an AC voltage waveform is permitted to pass, while the other half-cycle is blocked. By using a single diode, half-wave rectifiers are able to convert AC voltage to DC voltage.

There are two main types of single-phase half-wave rectifiers: uncontrolled and controlled. A single-phase half-wave uncontrolled rectifier is made up of an AC source, a diode, and a load. During the positive half-cycle of the AC source, the diode becomes forward biased and the circuit conducts, while during the negative half-cycle, the diode becomes reverse biased and blocks current. This type of rectifier is simple and inexpensive to construct, but it has limited applications due to its inability to control the DC output.

A single-phase half-wave controlled rectifier, on the other hand, includes a thyristor or SCR (Silicon Controlled Rectifier) in addition to an AC source and a load. The key difference between a controlled rectifier and an uncontrolled rectifier is the presence of the thyristor/SCR, which conducts only when gate pulses at a firing angle α are applied to it. Once the thyristor/SCR conducts, it continues to conduct even if the voltage across it becomes negative until the load current falls below the holding current level. The SCR automatically turns off when its voltage is reverse biased for a period longer than the SCR turn off time. This type of rectifier allows for better control of the DC output and is used in many applications, including power supplies, battery chargers, and DC motor drives.

In summary, rectifiers are important electronic devices that convert AC to DC voltage, and half-wave rectifiers are a type of rectifier that allows only one half-cycle of an AC voltage waveform to pass. While single-phase half-wave uncontrolled rectifiers are simple and inexpensive, they have limited applications due to their inability to control the DC output. Single-phase half-wave controlled rectifiers, which include a thyristor/SCR, allow for better control of the DC output and are used in many applications.

1.4 Theoretical Calculations

The theoretical calculations for a half-wave rectifier with an R load are given by the formulas:

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

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

In uncontrolled rectifiers, $\alpha = 0$, and the thyristor is replaced with a diode. For a single-phase half-wave uncontrolled rectifier with an RMS voltage of 230V and a resistive load of 10Ω, the output voltage is 103.53V, and the output current is 10.53A.

For a single-phase half-wave controlled rectifier with an RMS voltage of 230V and a resistive load of 10Ω and a firing angle of $\alpha = 30\circ$, the output voltage is 96.6V, and the output current is 9.66A.

1.5 Single Phase Half Wave Uncontrolled Rectifier with R load

1.5.1 Circuit used for simulation

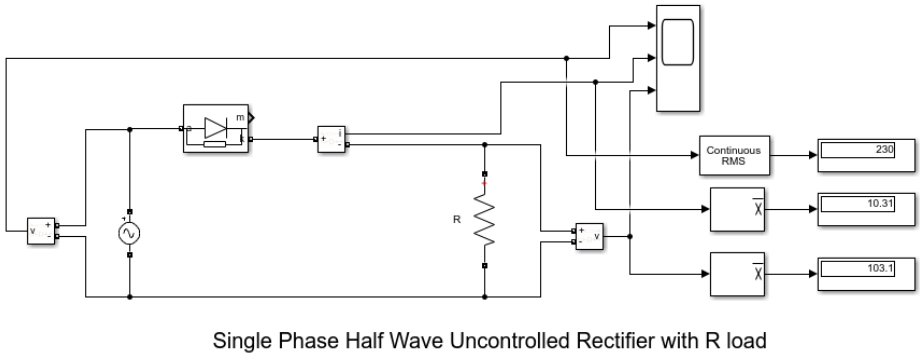

Figure 1.1: Circuit used for simulation

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

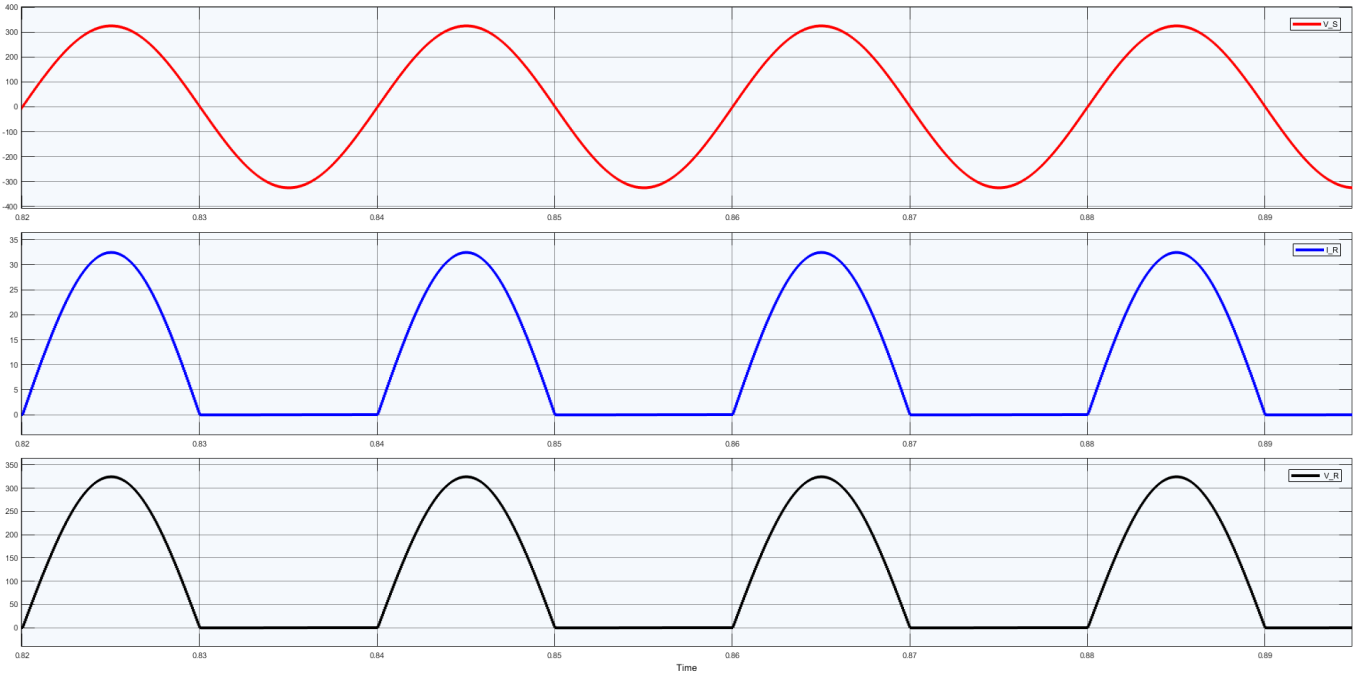

Figure 1.2: Scope Waveforms for Single Phase Half Wave Uncontrolled Rectifier with R load waveforms

1.6 Single Phase Half Wave Uncontrolled Rectifier with RL load

1.6.1 Circuit used for simulation

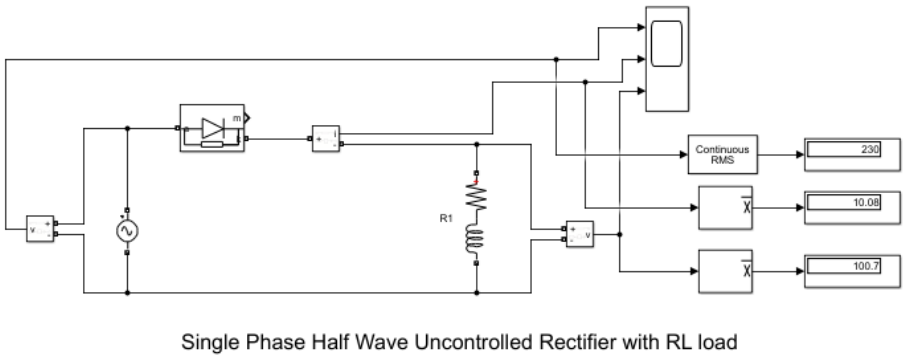

Figure 1.3: Circuit used for simulation

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

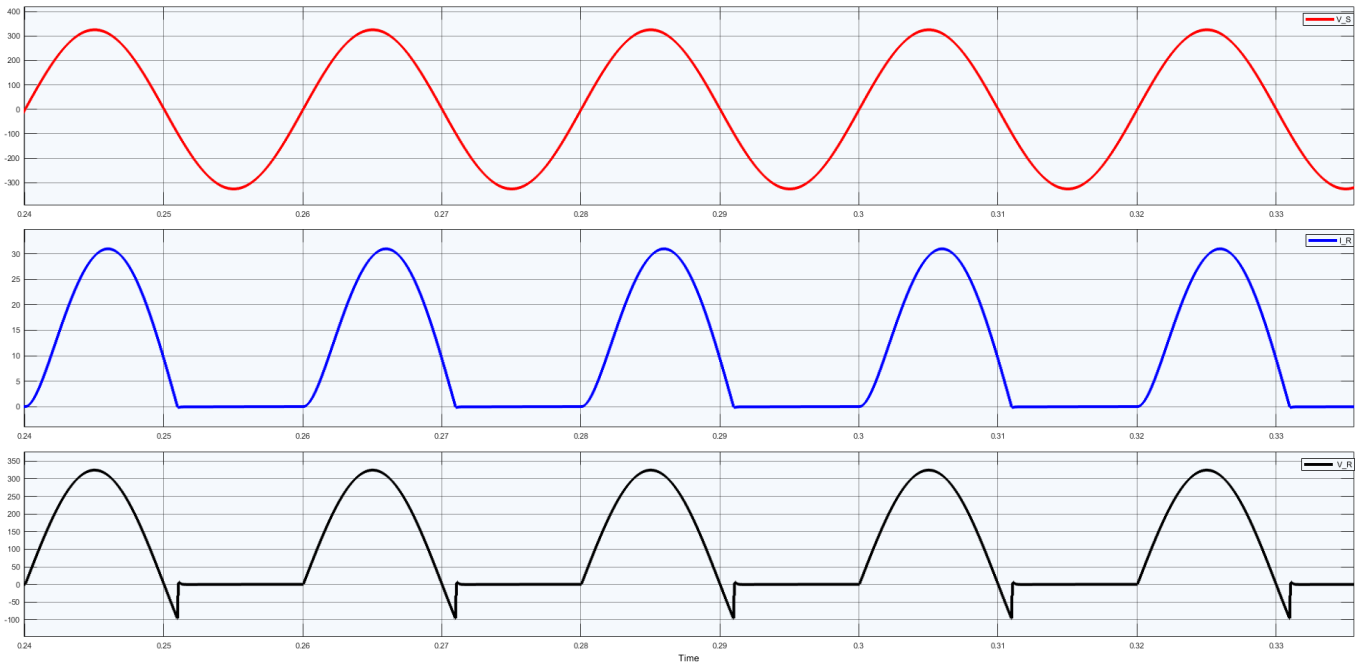

Figure 1.4: Scope Waveforms for Single Phase Half Wave Uncontrolled Rectifier with RL load

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

1.7.1 Circuit used for simulation

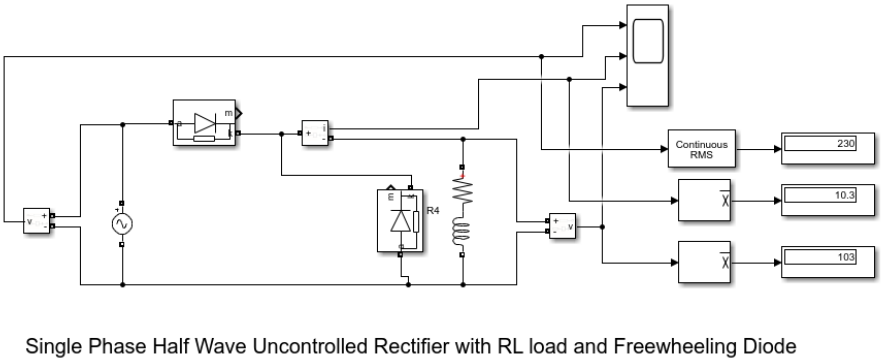

Figure 1.5: Circuit used for simulation

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

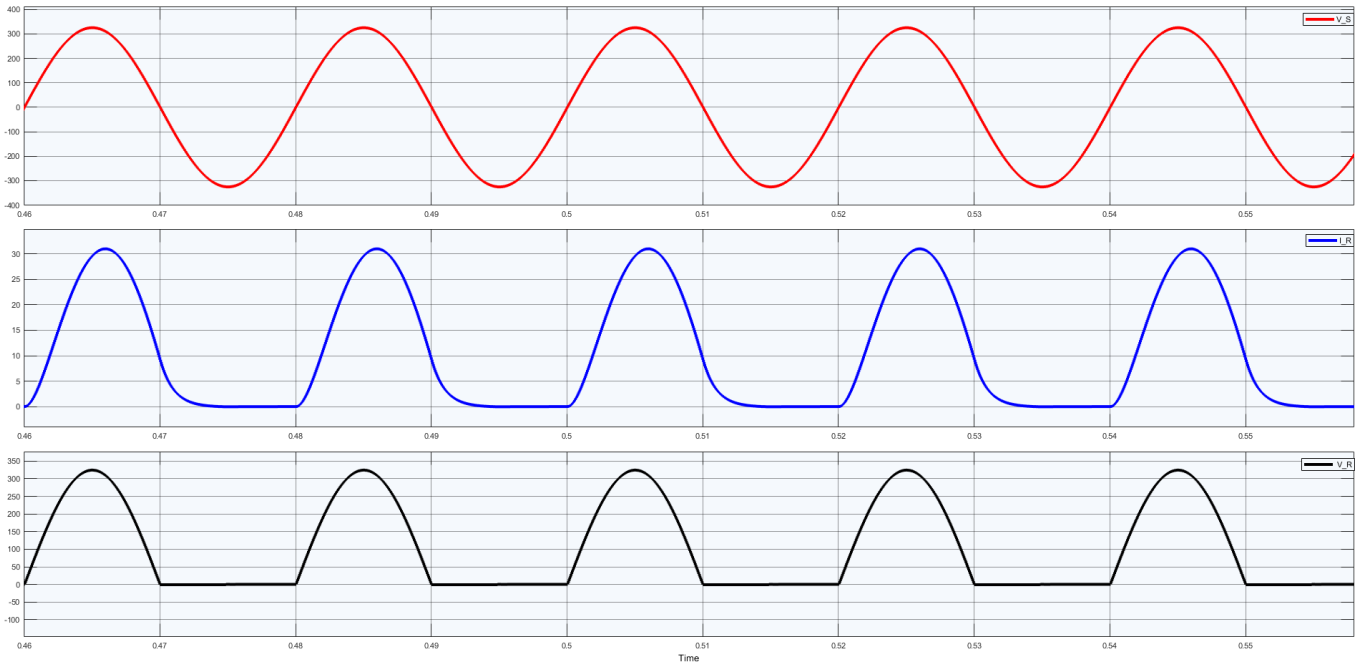

Figure 1.6: Scope Waveforms for Single Phase Half Wave Uncontrolled Rectifier with RL load and Freewheeling Diode

1.8 Single Phase Half Wave Uncontrolled Rectifier with RLE load

1.8.1 Circuit used for simulation

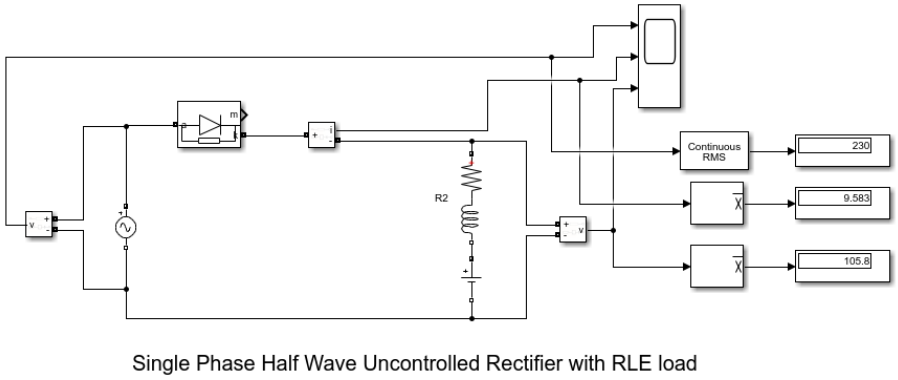

Figure 1.7: Circuit used for simulation

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

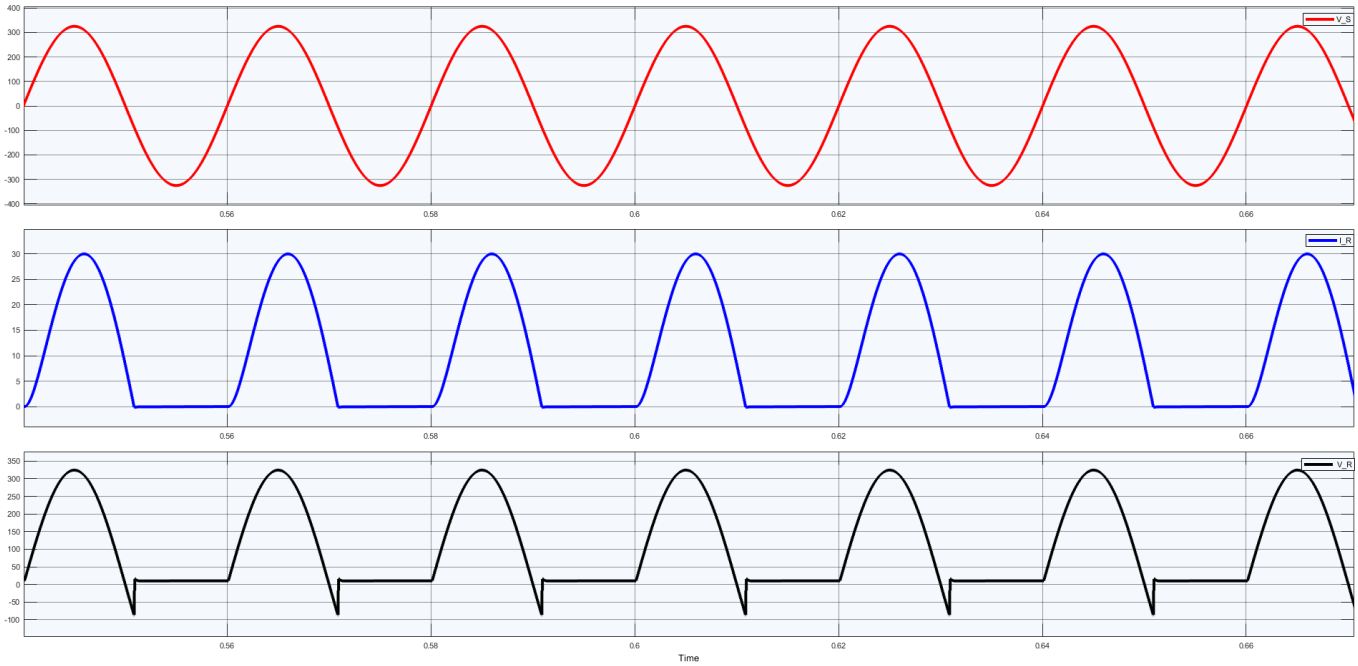

Figure 1.8: Scope Waveforms for Single Phase Half Wave Uncontrolled Rectifier with RLE load waveforms

1.9 Single Phase Half Wave Controlled Rectifier with R load

1.9.1 Circuit used for simulation

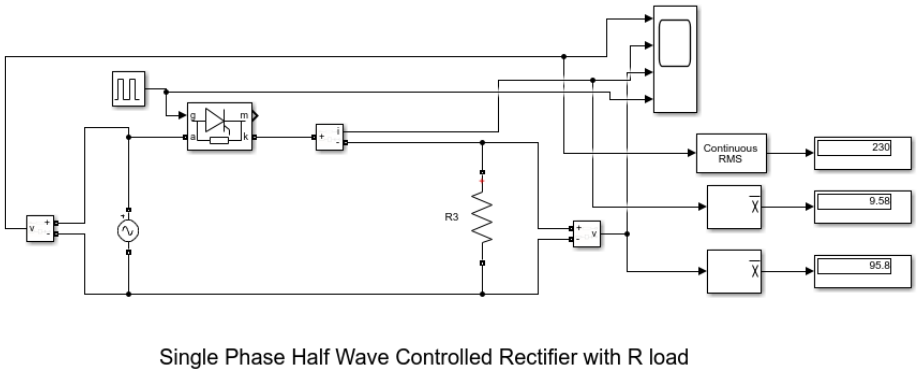

Figure 1.9: Circuit used for simulation

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

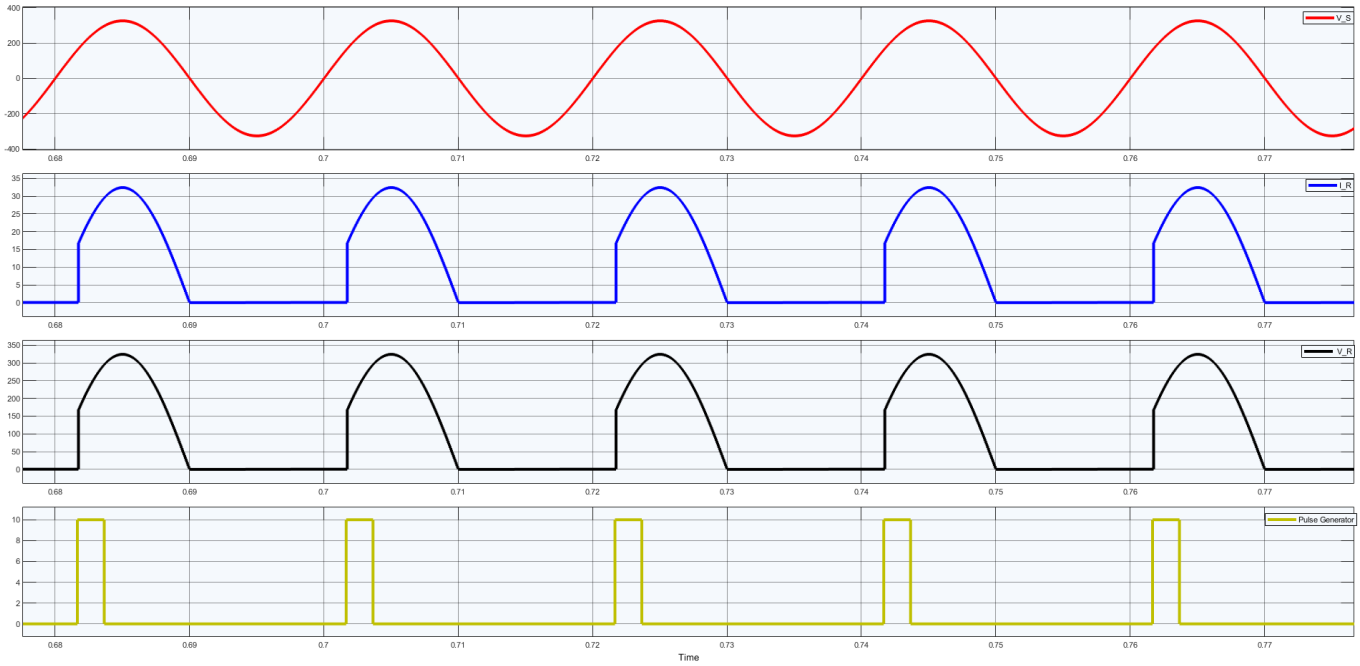

Figure 1.10: Scope Waveforms for Single Phase Half Wave Controlled Rectifier with R load

1.10 Single Phase Half Wave Controlled Rectifier with RL load

1.10.1 Circuit used for simulation

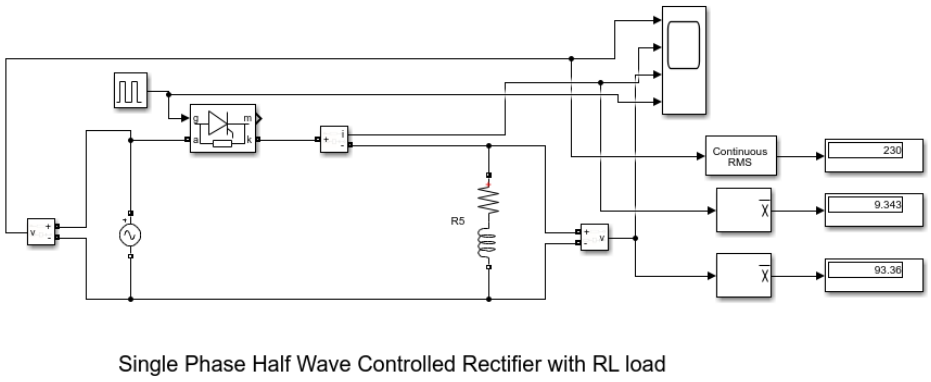

Figure 1.11: Circuit used for simulation

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

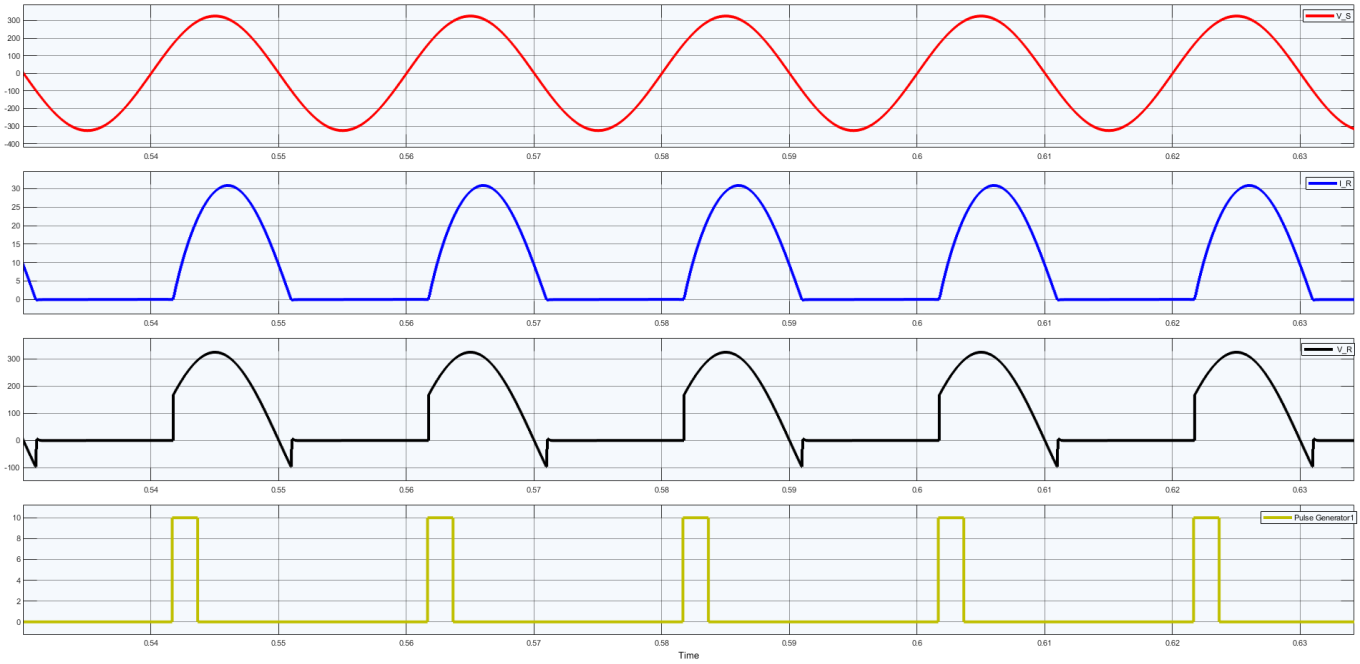

Figure 1.12: Scope Waveforms for Single Phase Half Wave Controlled Rectifier with RL load

1.11 Single Phase Half Wave Controlled Rectifier with RLE load

1.11.1 Circuit used for simulation

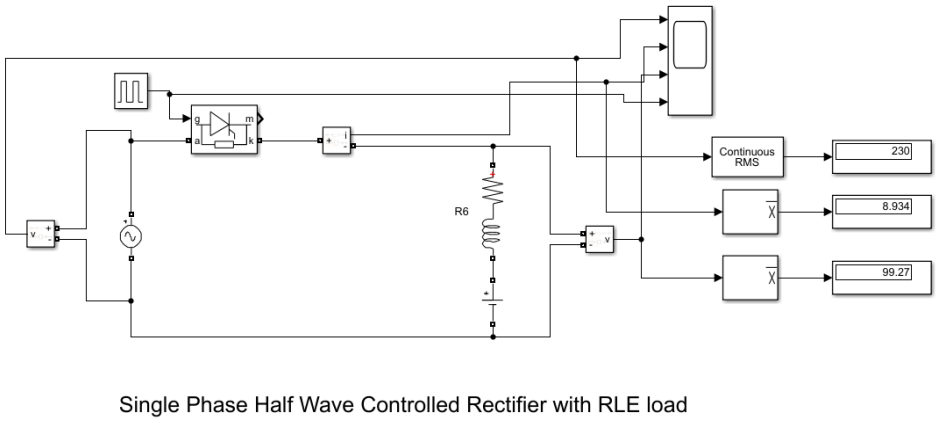

Figure 1.13: Circuit used for simulation

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

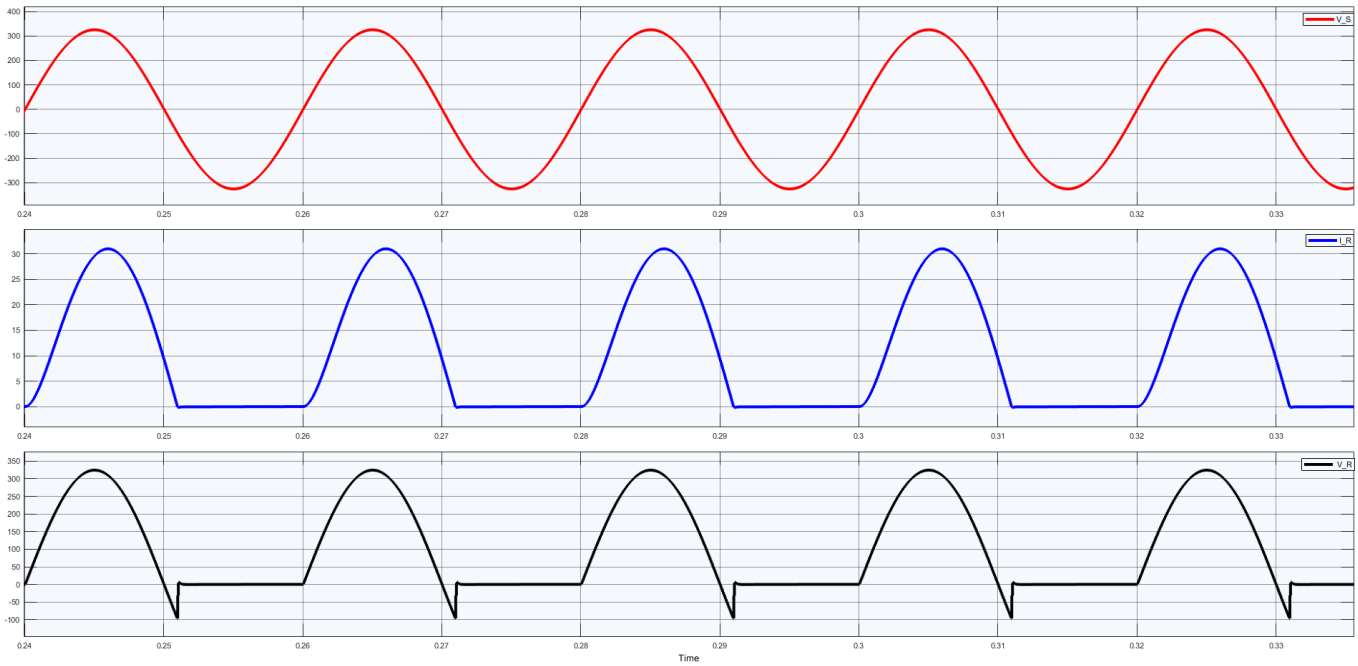

Figure 1.14: Scope Waveforms for Single Phase Half Wave Controlled Rectifier with RLE load

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.