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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 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

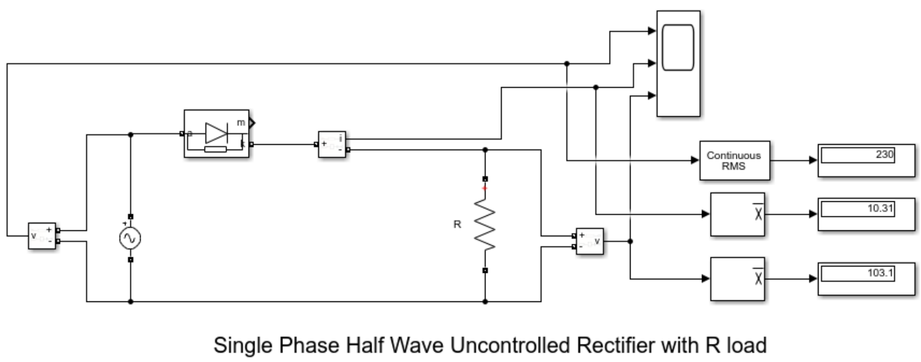

Figure 1.1: Circuit used for simulation

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 Resultant Waveforms

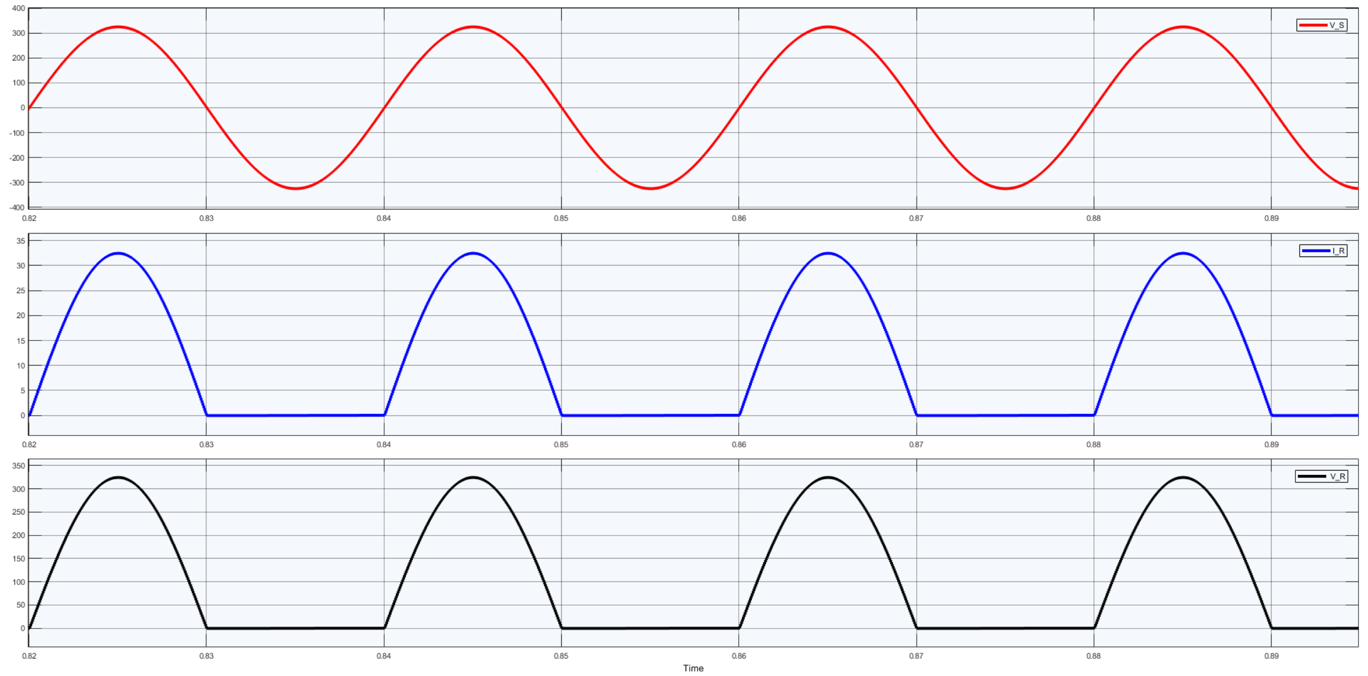

Figure 1.2: Circuit used for simulation

1.5.4 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.

1.6 Single Phase Half Wave Uncontrolled Rectifier with RL load

1.6.1 Circuit used for simulation

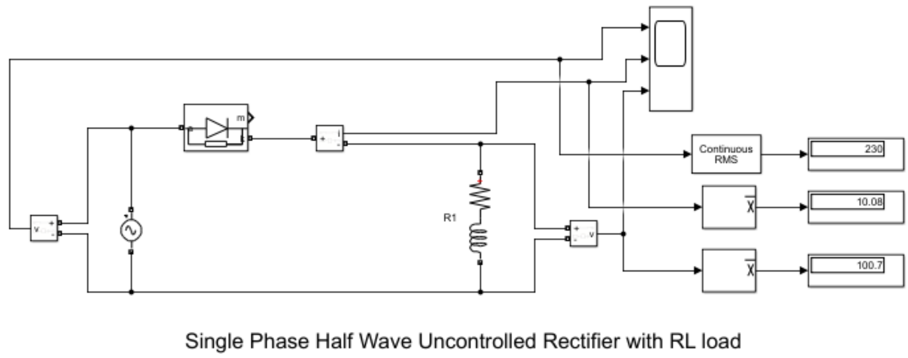

Figure 1.3: Circuit used for simulation

1.6.2 Components Required

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

1.6.4 Observations

Table 1.4: 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.

1.7 Results

1.7.1 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

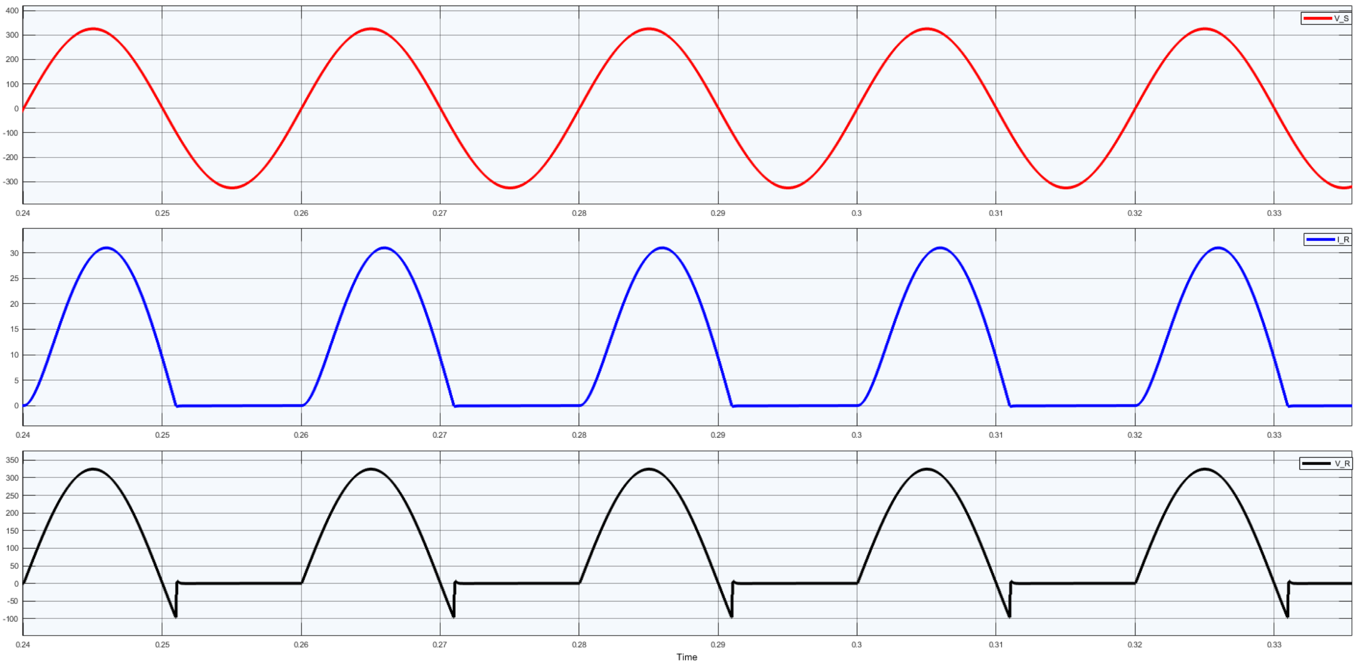

Figure 1.4: Circuit used for simulation

of Table-1.5. As per **Ohm's Law**, the current corresponding to all the four voltages are,

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

1.7.2 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-1.5. Similarly, all other three rows are filled. Further, constantly varying ramp voltage is applied and the corresponding v-i graph is plotted in Fig. 1.5.

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

Table 1.5: Simulation Results

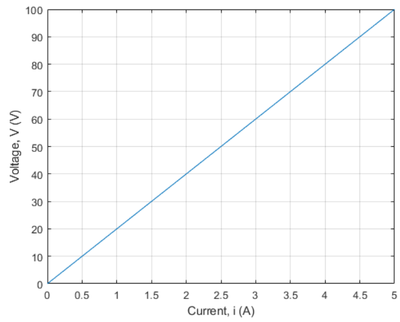

Figure 1.5: v-i characteristics of R

1.8 Discussion

From the data of third and fourth column of Table-1.5, it is seen that the simulated values exactly matches with the corresponding theoretical numbers. Further, the simulated v-i plot also matches with the theoretical$v$-i plot (see Fig. 1.5) of a resistance. The slope of the plot represents the resistance what is consider in the simulation. For example, consider the point at (100,5), and the slope of the line is $\frac{100-0}{5-0} = 20$ and that is the value of resistance. It is also seen that the v-i characteristics is same for sinusoidal applied voltage.

1.9 Observation

1.9.1 For Simulation

1. Proper simulation step size has to be chosen fro the simulation. In case of sinusoidal forcing function, the step size is chosen to be 10^{-4} s.

1.9.2 For Real Experiment

1. There might be error in resistance value which results in slightly mismatch in the results.

2. There might be a chance of error in readings due to analog instruments.

3. There might be a chance of change in temperature of the resistance if the experiment is run for long time, which effects the experimental results.

1.10 Conclusion

Verification of Ohm's Law is done through simulation in Matlab/Simulink platform. The simulation is done considering constant DC voltage, variable ramp voltage and sinusoidal voltage. In each case, the theoretical and simulated results matches well.

References

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[2] N. Paivinen and T. Gronfors, "Minimum spanning tree clustering of EEG signals", 6^{th} *Nordic Signal Processing Symposium (NORSIG-2004)*, Finland, pp. 149-152, June 9-11, 2004.