Experiment#3- Part#1

Diode Applications 1

Rectifier Circuit

Object

The purpose of this experiment is to demonstrate the operation of three different diode rectifier circuits which are the half-wave rectifier, center-tapped full-wave rectifier, and the bridge full-wave rectifier. In addition to that, the operation of a capacitor filter connected to the output of the rectifier will also be demonstrated.

Required Parts and Equipment's

1. Digital Multimeters
2. Electronic Test Board (M50)
3. Step-down center-tapped transformer (220V/12Vr.m. s)
4. Dual-Channel Oscilloscope
5. General purpose Silicon Diodes [D_1,D_2,D_7,D_8]=1N4001, [D_3,D_4,D_5,D_6]=WL04
6. Resistors, $R_1 = 1K\Omega, R_2 = 2K\Omega$
7. Capacitors $C_1 = 470\mu F, 25V$, $C_2 = 2200\mu F, 25V$, $C_3 = C_4 = 470\mu F, 63V$
8. Leads and BNC Adaptors

Theory

The rectifier is circuit that converts the AC input voltage into a pulsed waveform having an average (or DC) value. This waveform can then be filtered to remove the unwanted variations. Rectifiers are widely used in power supplies which provide the DC voltage necessary for electronic circuits. The three basic rectifier circuits are the half-wave, the center-tapped full wave, and the full-wave bridge rectifier circuits. The most important parameters for choosing diodes for these circuits are the maximum forward current, and the peak inverse voltage rating (PIV) of the diode. The peak inverse voltage is the maximum voltage the diode can withstand when it is reverse-biased. The amount of reverse voltage that appears across a diode depends on the type of circuit in which it is connected.

Some characteristics of the three rectifiers circuits will be investigated in this experiment.

- **Half-Wave Rectifier**

Figure 1 shows a schematic diagram of a transformer coupled half-wave rectifier circuit. The transformer is useful in electrically isolating the diode rectifier circuit from the 220V AC source, and also is used to step-down the input line voltage into a suitable value according to the turn's ratio.

The transformer's turns ratio is defined by:

$$n = \frac{V_{pr(r.m.s)}}{V_{s(r.m.s)}}$$

Where $V_{pr(r.m.s)}$ is the r.m.s value of the transformer primary winding voltage, and $V_{s(r.m.s)}$ is the r.m.s value of the transformer secondary winding voltage. In the circuit of Fig.1, $V_{pr(r.m.s)}$= 220V.

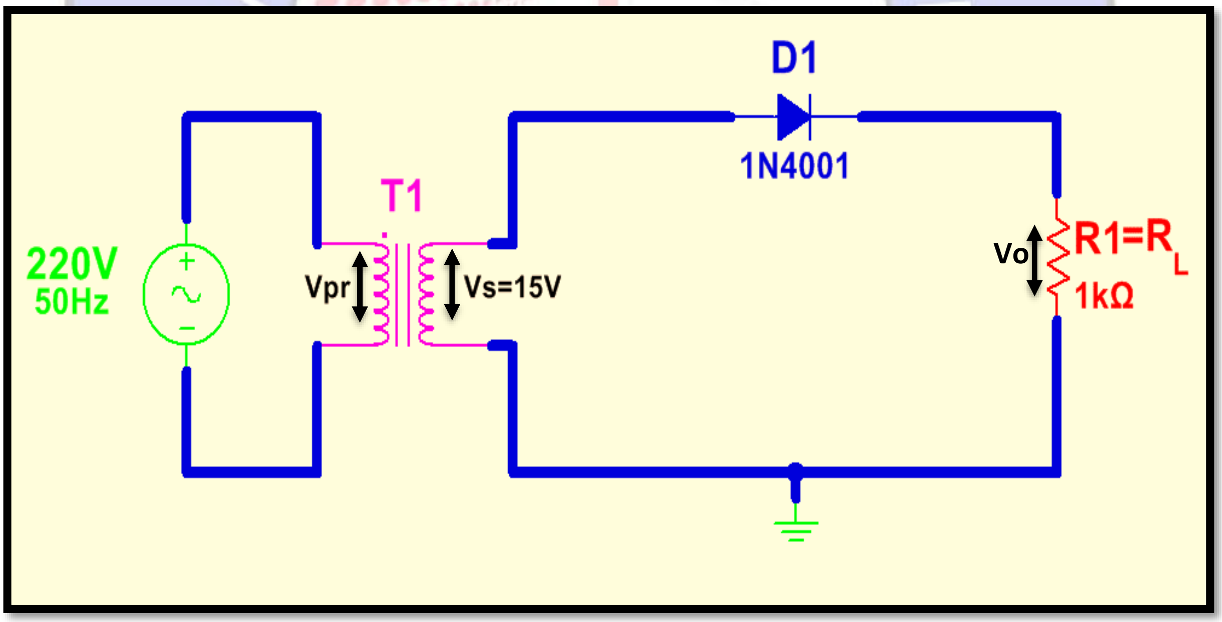

Figure 1: Half-Wave Rectifier with Transformer-Coupled Input Voltage

The peak value of the secondary winding voltage V_{sp} is related to the r.m.s value by the relation:

$$V_{sp} = \sqrt{2}\, V_{s(r.m.s)}$$

When the sinusoidal voltage across the secondary winding of the transformer goes positive, the diode is forward-biased and conducts current through the load resistor R_L. Thus, the output voltage across R_L has the same shape as the positive half-cycle of the input voltage.

When the secondary winding voltage goes negative during the second half of its cycle, the diode is reverse-biased. There is no current in this case, so the voltage across the load resistor is 0V. The net result is that only the positive half-cycles of the AC input voltage on the secondary winding appear across the load as shown in Fig.2. Since the output does not change polarity, it is a pulsating DC voltage with frequency equals to that of the input AC voltage.

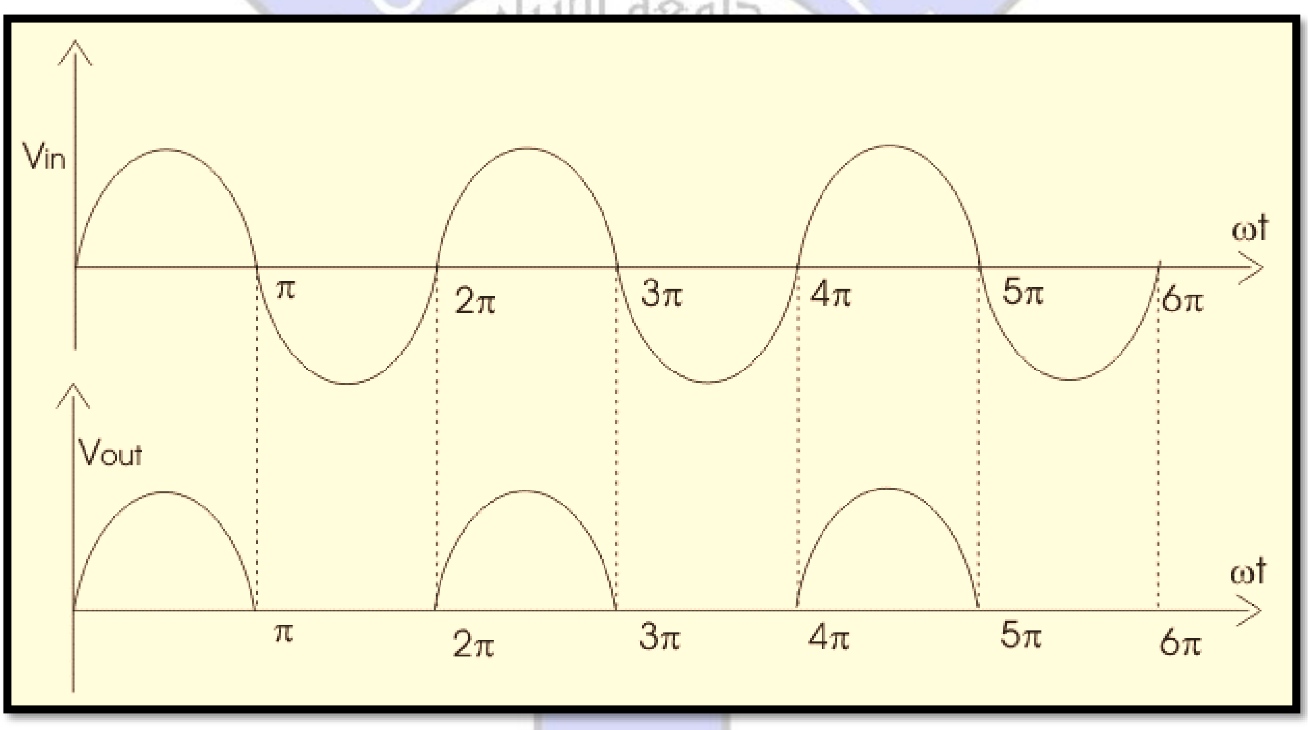

Figure 2: Waveforms of the Half-Wave Rectifier Circuit

When taking the voltage drop across the diode into account, the peak value of the output voltage is given by:

$$V_{op} = V_{sp} - 0.7$$

In equation (3), it was assumed that the voltage drop across the silicon diode is 0.7V when it conducts.

It can be verified that the average (or DC) value of the output voltage is given by:

$$V_{dc} = \frac{V_{op}}{\pi} = \frac{V_{sp} - 0.7}{\pi}$$

The peak inverse voltage (PIV) of the diode for this circuit equals the peak value of the secondary winding voltage:

$$PIV = V_{sp} = V_{op} + 0.7$$

- **Center-Tapped Full-Wave Rectifier**

The full-wave center-tapped rectifier uses two diodes connected to the secondary of a center tapped transformer as shown in Fig.3.

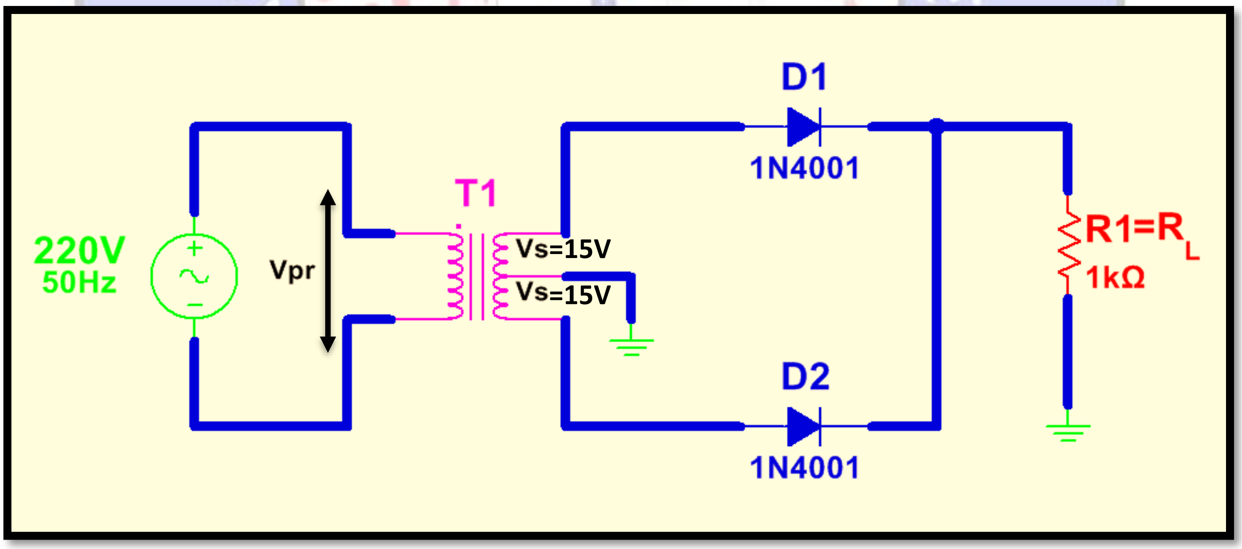

Figure 3: The Center-Tapped Full-Wave Rectifier Circuit

The Input voltage is coupled through the transformer to the center-tapped secondary. For the positive half cycle of the input signal, the polarities of the secondary winding voltages are shown in Fig.3. This makes the upper diode

D_1conducting and the lower diode $D_2$to be reverse-biased. The current path is through $D_1$and the load resistor RL. For the negative half cycle of the input voltage, the voltage polarities on the secondary winding of the transformer will be reversed causing $D_2$to conduct, while reverse-biasing D_1. The current path is through $D_2$and R_L. Because the output current during both the positive and negative portions of the input cycle is in the same direction through the load, the output voltage developed across the load resistor is a full-wave rectified DC voltage as shown in Fig.4.

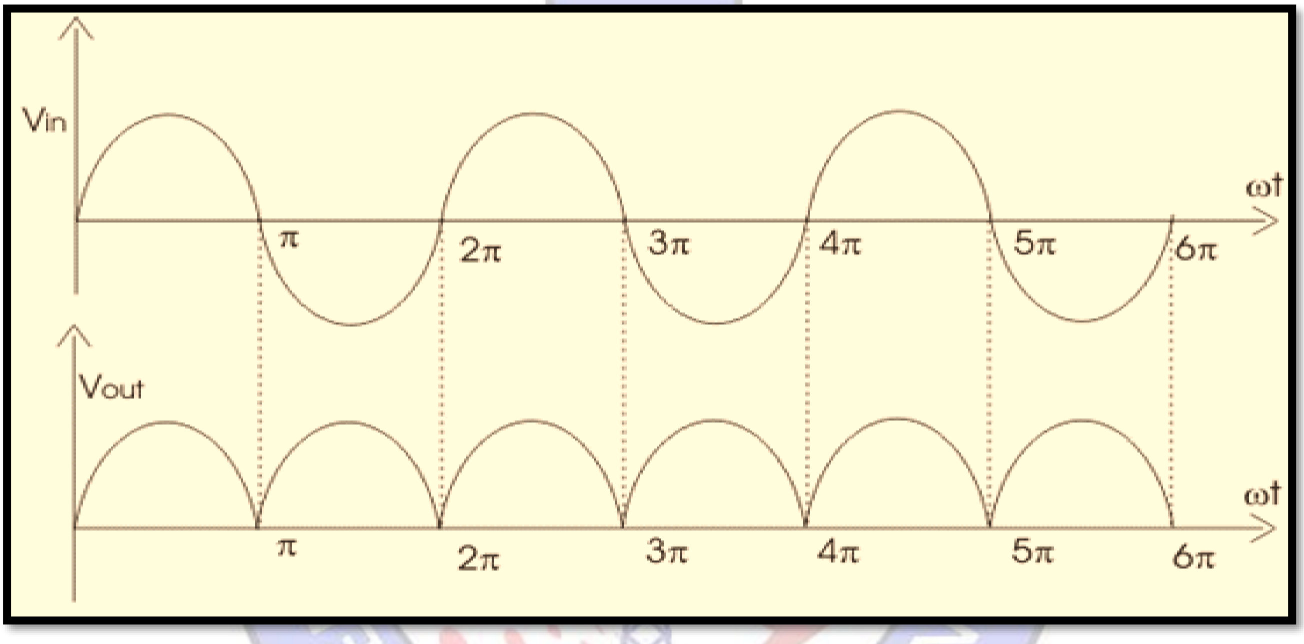

Figure 4: Waveforms of the Full-Wave Rectifier

The DC output voltage of the full-wave rectifier is given by:

$$V_{dc} = \frac{2V_{op}}{\pi} = \frac{2(V_{sp} - 0.7)}{\pi}$$

The peak inverse voltage (PIV) of each diode in this circuit is obtained as:

$$PIV = V_{sp} = V_{op} + 0.7$$

The frequency of the output voltage equals twice the line frequency as shown from the waveform of the output voltage.