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Experiment - 3

Half Wave and Full Wave Rectification

Objectives

At the end of the module the student would be able to

- Explain Rectification
- Explain Half Wave Rectification
- Explain Half Wave Rectification:For Positive Half Cycle
- Explain Half Wave Rectification:For Negative Half Cycle

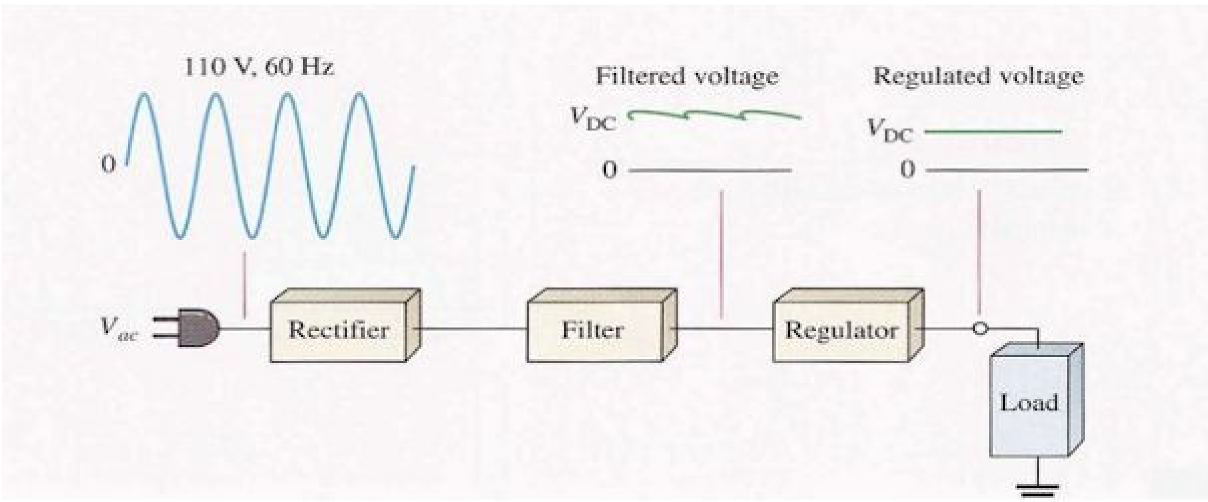
Apparatus RequiredWE

Serial No.	Apparatus	Range	Type	Quantity
1	Resistor	100 - 1kΩ		1
2	Diode			4
3	Voltmeter	0 - 10V	Moving Coil	1
4	Voltage Source	0 - 10V	AC	1
5	Oscilloscope			1

Theory

A rectifier is an electrical device that converts alternating current (AC) to direct current (DC). In half wave rectification, either the positive or negative half of the AC wave is passed, while the other half is blocked. A full-wave rectifier converts the whole of the input waveform to one of constant polarity (positive or negative) at its output.

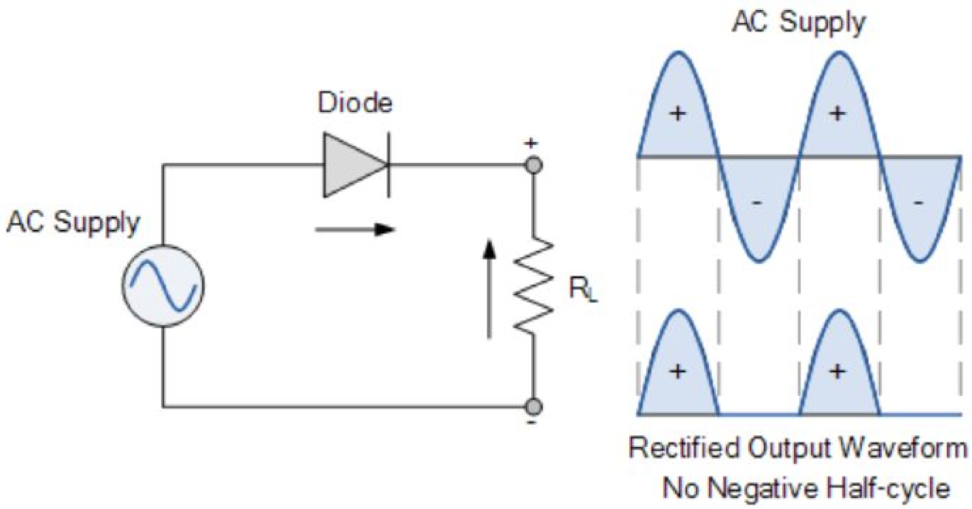
One of the very important applications of diode is in DC power supply as a rectifier to convert AC into DC. DC Power supply is the important element of any electronic equipment. This is because it provides power to energize all electronic circuits like oscillators, amplifiers and so on. In electronic equipments, D.C. Power supply is must. For example, we can’t think of television, computer, radio, telephone, mobile as well as measuring instruments like multi-meter etc. Without DC power supply. The reliability and performance of the electronic system proper design of power supply is necessary. The first block of DC power supply is rectifier. Rectifier may be defined as an electronic device used to convert ac voltage or current into unidirectional voltage or current. Essentially rectifier needs unidirectional device. Diode has unidirectional property hence suitable for rectifiers. Rectifier broadly divided into two categories: Half wave rectifier and full wave rectifier.



Half wave rectifier:

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.

In a half wave rectifier only half cycle of applied AC voltage is used. Another half cycle of AC voltage (negative cycle) is not used. Only one diode is used which conducts during a positive cycle. The circuit diagram of half wave rectifier without a capacitor is shown in the following figure. During positive half cycle of the input voltage anode of the diode is positive compared with the cathode. Diode is in forward bias and current passes through the diode and positive cycle develops across the load resistance RL. During negative half cycle of input voltage, Anode is negative with respect to cathode and diode is in reverse bias. No current passes through the diode hence output voltage is zero

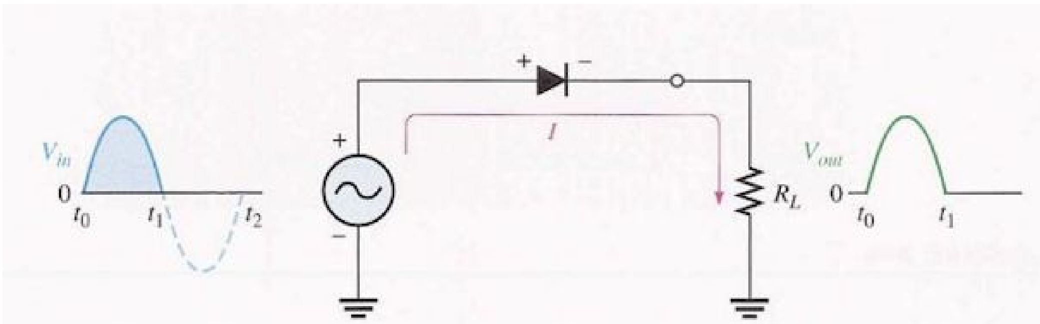


The output DC voltage of a half wave rectifier can be calculated with

$$V_{peak} = V_{rms} \times \sqrt{2}$$

$$V_{dc} = \frac{V_{peak}}{\pi}$$

Half Wave Rectifier : Positive Half Cycle



For positive half cycle,

$$V_I - V_b - I \times r_d - I \times R = 0$$

$$\Rightarrow \quad I = \frac{V_I - V_b}{r_d + R}$$

$$V_o = I \times R$$

$$\therefore \quad V_o = \frac{V_1 - V_b}{r_d + R} \times R$$

For $r_d << R$, $\quad V_o = V_1 - V_b$

For $V_1 < V_b$,

The diode will remain OFF. The output voltage is,

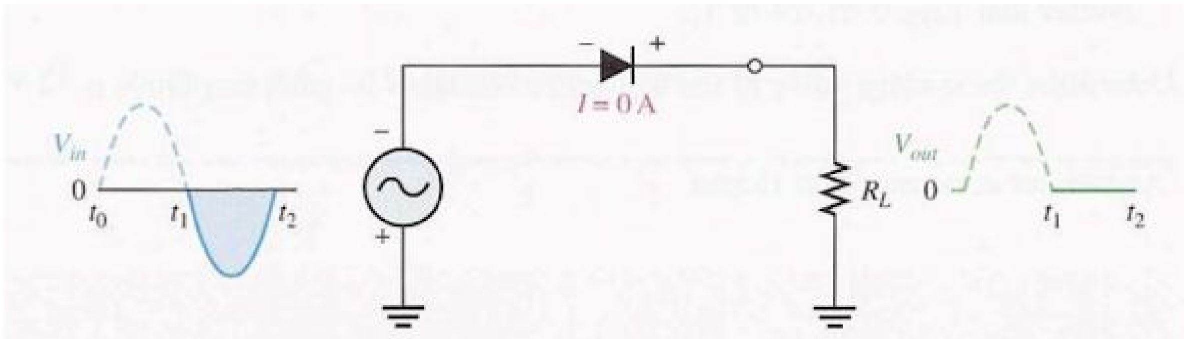
$$V_o = 0$$

For $V_1 > V_b$,

The diode will remain ON. The output voltage is,

$$V_o = V_1 - V_b$$

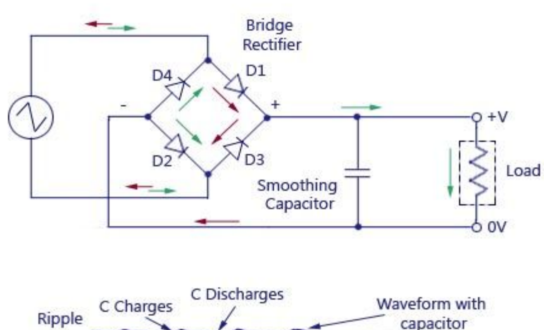
Half Wave Rectifier : Negative Half Cycle

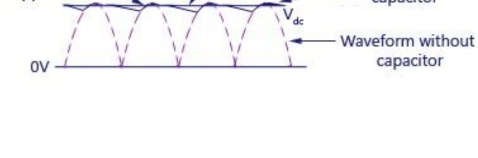


For negative half cycle,
Diode is reverse biased, acts as a open circuit, doesn't pass the waveform through.

For negative half cycle, $V_o = 0$, since $I = 0$

Full Wave Rectifier
The conversion of AC into DC is called Rectification. Electronic devices can convert AC power into DC power with high efficiency. A drawing of a full-wave bridge rectifier is given below. The bridge is composed of four diodes in a diamond shape. During the positive half-cycle of input voltage vin the terminal ‘A’ is at positive potential with respect to the terminal ‘B’ and because of this diodes D1 and D2 are forward biased whereas diodes D3 and D4 are reverse biased. The current therefore flows through diodes D1, D2 and load resistor RL. During the negative half-cycle of input voltage waveform, on the other hand, the diodes D3 and D4 are forward biased whereas the diodes D1 and D2 are reverse biased. As a consequence, current flows through diodes D3 and D4.





Peak Inverse Voltage

For rectifier applications, peak inverse voltage (PIV) or peak reverse voltage (PRV) is the maximum value of reverse voltage which occurs at the peak of the input cycle when the diode is reverse-biased.The portion of the sinusoidal waveform which repeats or duplicates itself is known as the cycle. The part of the cycle above the horizontal axis is called the positive half-cycle, the part of the cycle below the horizontal axis is called the negative half cycle. With reference to the amplitude of the cycle, the peak inverse voltage is specified as the maximum negative value of the sine-wave within a cycle's negative half cycle.

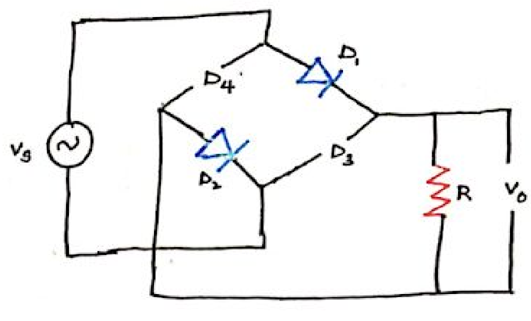
For Bridge Rectifier,
D1 and D2 is Forward Biased
D3 and D4 is Reverse Biased
PIV≥Vm

For Center Tapped Rectifier,
D2 is Forward Biased,
PIV at D1,
PIV≥2Vm

For the positive half cycle, diodes D1 and D2 conduct in series while diodes are reverse biased (ideally they can be replaced with open circuits) and the current flows through the load as shown.

D_1 and D_2 are forward biased
D_3 and D_4 are reverse biased

$$V_1 - V_0 = 0$$
$$\Rightarrow V_0 = V_1$$
$$V_0 = V_1 - 2 \times V_b$$
$$V_0 = V_1 - 2 \times V_b - 2 \times Ird.$$

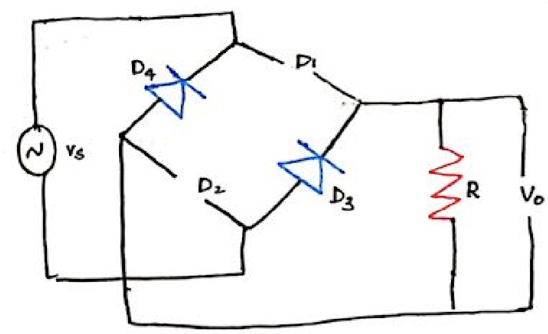


Postive Half Cycle

For the negative half cycle, diodes D3 and D4 conduct in series, but diodes D1 and D2 switch of as they are now reverse biased. The current flowing through the load is the same direction as before.

D_1 and D_2 are reverse biased
D_3 and D_4 are forward biased.

$$V_1 - V_0 = 0$$
$$\Rightarrow V_1 = V_0$$



Negative Half Cycle

Average DC Load Voltage

$$V_0 = V_m \sin \omega t \quad \forall \quad 0 \leq \omega t \leq \pi$$

$$V_{a} = V_{dc} = \frac{2 \times V_m}{\pi}$$

Average Load current

$$I_{av} = \frac{V_{av}}{R} = \frac{2 \times V_m}{\pi \times R}$$

$$I_{av} = \frac{2 \times I_m}{R}$$

RMS Load current

$$I = I_m \sin \omega t \quad \text{for} \quad 0 \leq \omega t \leq \pi$$

$$I_{rms} = \frac{I_m}{\sqrt{2}}$$

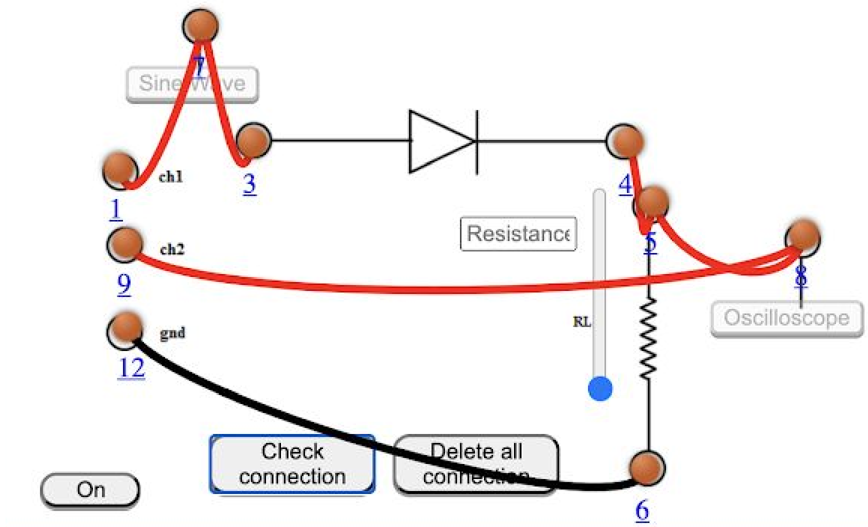
RMS Load Voltage

$$V_{rms} = I_{rms} \times R = \frac{I_m}{\sqrt{2}} \times R$$

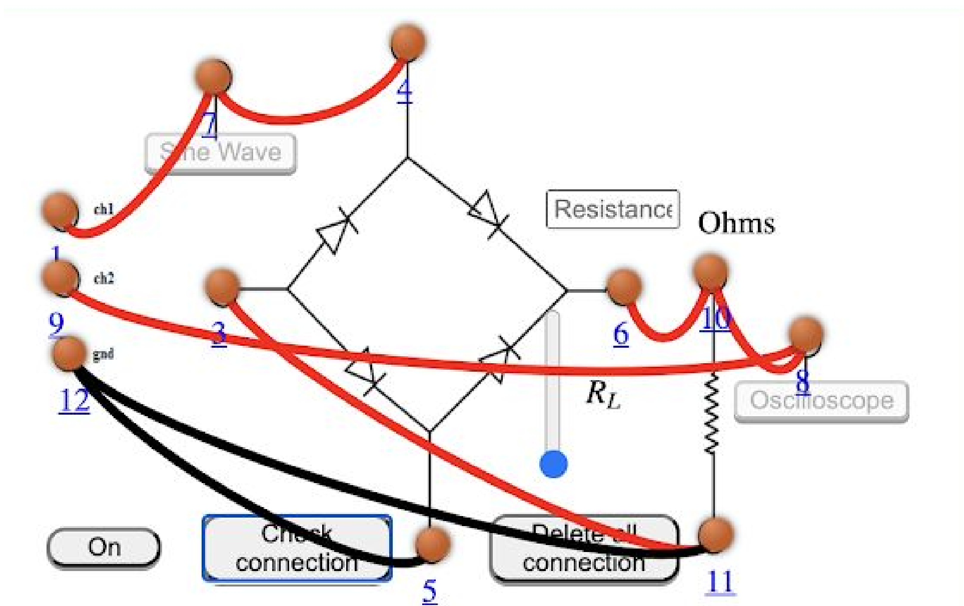
$$V_{rms} = \frac{V_m}{\sqrt{2}}$$

Circuit Diagram

Half Wave Rectifier

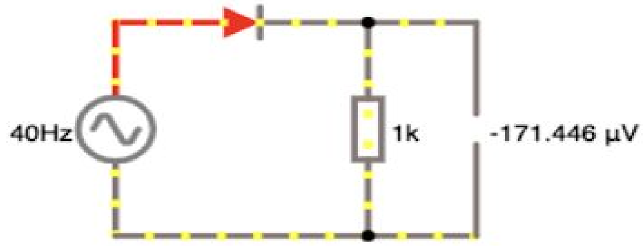


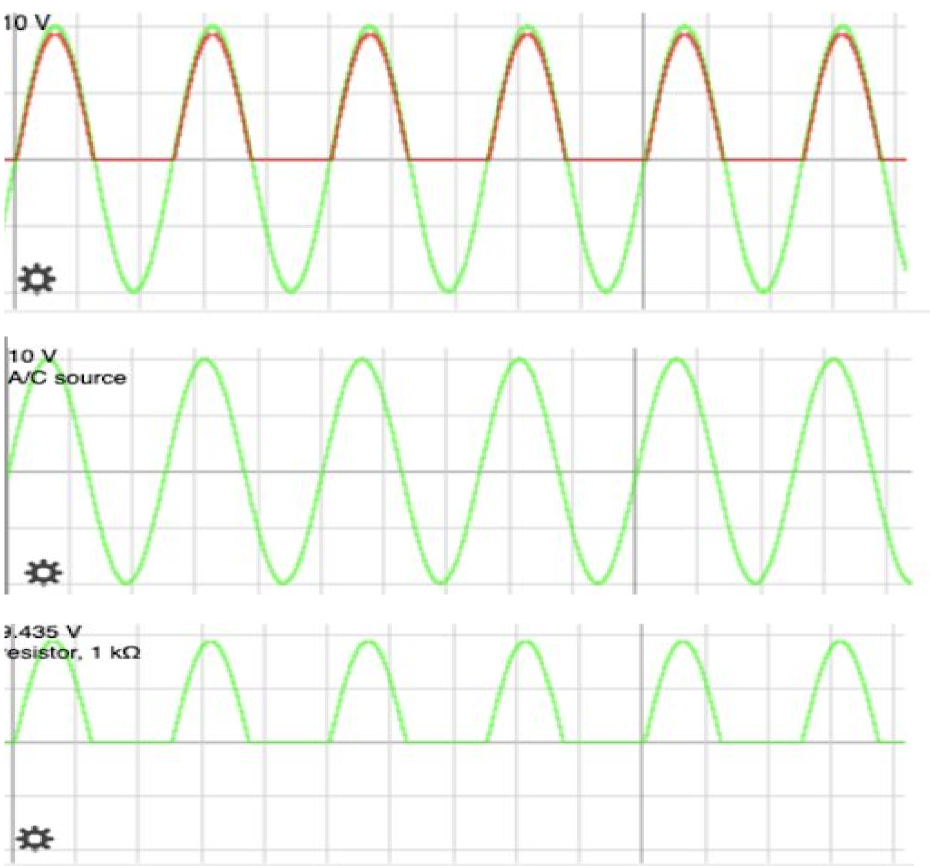
Full Wave Rectifier



Graphs

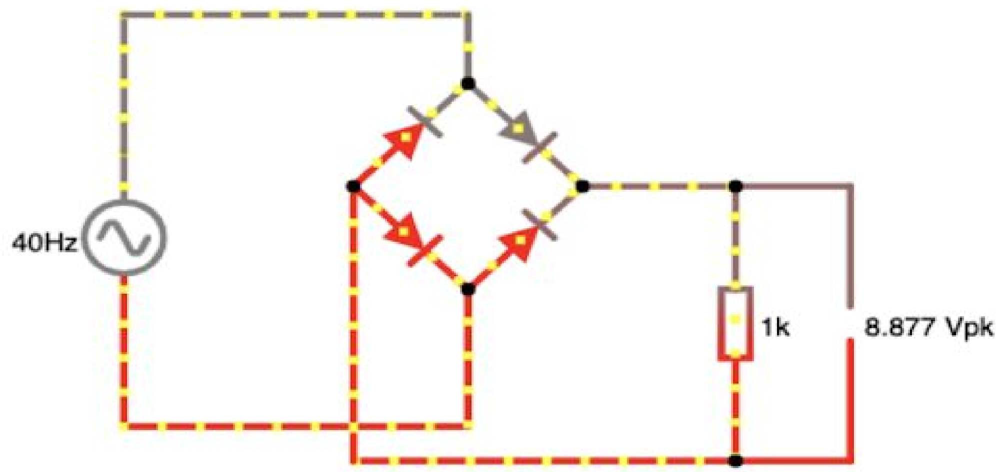
Half Wave Rectifier

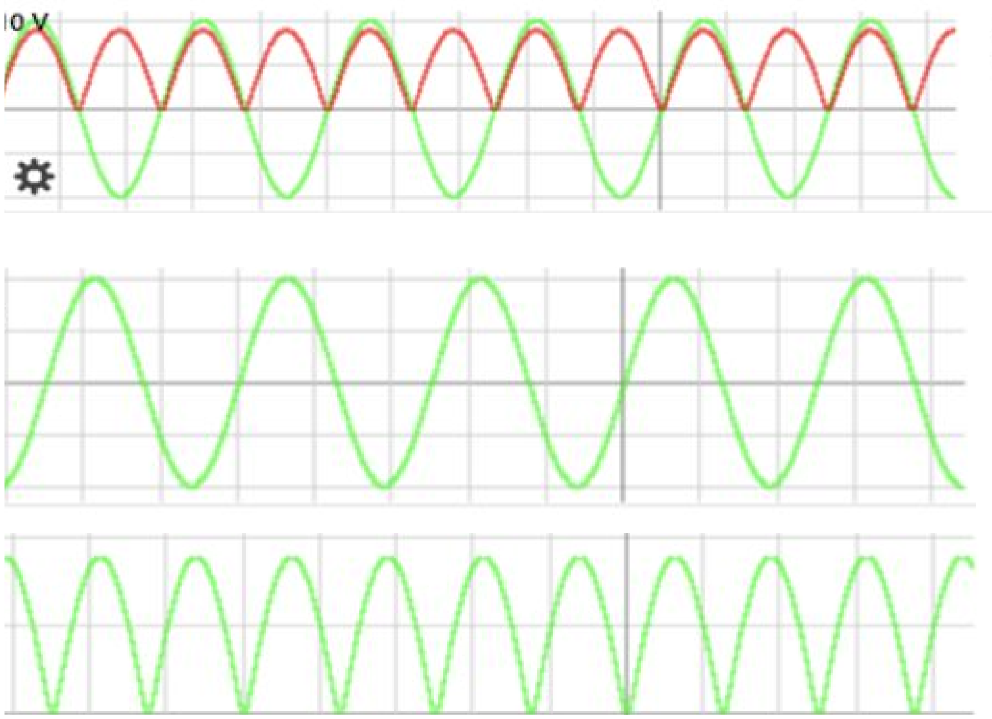




Source : http://www.falstad.com/circuit/

Full Wave Rectifier





Source : http://www.falstad.com/circuit/

Calculations :

Half Wave Rectifier :

Form Factor : It is defined as ratio of rms load voltage and average load voltage

$$F.F = \frac{V_{rms}}{V_{av}}$$

$$\Rightarrow F.F = \left(\frac{V_m}{2}\right) / \left(\frac{V_{av}}{2}\right) = \frac{\pi}{2} = 1.57$$

Ripple Factor

$$\gamma = \sqrt{(F.F^2 - 1)} \times 100\%$$

$$= \sqrt{1.57^2 - 1} \times 100\%$$

$$\gamma = 1.21\%$$

Efficiency : It is defined as ratio of dc power available at the load to the input ac power.

$$\eta\% = \frac{P_{load}}{P_{in}} \times 100\%$$

$$= \frac{I_{dc}^2 \times R}{I_{rms}^2 \times R} \times 100\%$$

$$\therefore \eta\% = \frac{(I_m^2/\pi^2)}{(I_m^2/4)} \times 100\% = \frac{4}{\pi^2} \times 100\% = 40.56\%$$

$$\therefore \eta\% = 40.56\%$$

$$V_m = 10V$$

$$V_{rms} = \frac{V_m}{\sqrt{2}} = \frac{10}{\sqrt{2}} = 7.07V$$

$$V_{dc} = \frac{V_m}{\pi} = \frac{10}{\pi} = 3.183V$$

$$V_{ac} = \sqrt{V_{rms}^2 - V_{dc}^2}$$

$$= \sqrt{7.07^2 - 3.183^2}$$

$$= 6.3129 V$$

$$\therefore \text{Ripple Factor} = \frac{V_{ac}}{V_{dc}}$$

$$= \frac{6.3129}{3.183}$$

$$\therefore \text{Ripple Factor} = 1.983$$

Full Wave Rectifier :

Form Factor : It is defined as the ratio of rms load voltage and average load voltage.

$$F.F = \frac{V_{rms}}{V_{av}}$$

$$= \frac{(V_m/\sqrt{2})}{(2V_m/\pi)} , \frac{\pi}{2\sqrt{2}}$$

$$\therefore F.F = 1.11$$

Ripple Factor

$$\gamma = \sqrt{(F.F^2 - 1)} \times 100\%$$

$$= \sqrt{(1.11^2 - 1)} \times 100\%$$

$$\therefore \gamma = 48.1\%$$

Efficiency : It is denfined as ratio of dc power available at the load to input ac power.

$$\eta\% = \frac{P_{load}}{P_{in}} \times 100\%$$

$$= \frac{I_{dc}^2 \times R}{I_{rms}^2 \times R} \times 100\%$$

$$\eta\% = \frac{(4 \times I_m^2/\pi^2)}{(I_m^2/2)} \times 100\%$$

$$= \frac{8}{\pi^2} \times 100\%$$

$$\therefore \eta\% = 81.13\%$$

$V_m = 10\,V$

$$V_{rms} = \frac{V_m}{\sqrt{2}} = \frac{10}{\sqrt{2}} = 7.07\,V$$

$$V_{dc} = \frac{V_m}{\pi} = \frac{10}{\pi} = 3.183\,V$$

$$V_{ac} = \sqrt{V_{rms}^2 - V_{dc}^2}$$

$$= \sqrt{7.07^2 - 3.183^2}$$

$$= 6.3129\,V$$

$$\therefore \text{Ripple Factor} = \frac{V_{ac}}{V_{dc}}$$

$$= \frac{5.3129}{3.183}$$

$$\therefore \text{Ripple Factor} = 1.983$$

Discussion

Half Wave Rectifier :
In a half wave rectifier only half cycle of applied AC voltage is used. Another half cycle of AC voltage (negative cycle) is not used. Only one diode is used which conducts during a positive cycle. The circuit diagram of half wave rectifier without a capacitor is shown in the following figure. During positive half cycle of the input voltage anode of the diode is positive compared with the cathode. Diode is in forward bias and current passes through the diode and positive cycle develops across the load resistance RL. During negative half cycle of input voltage, Anode is negative with respect to cathode and diode is in reverse bias. No current passes through the diode hence output voltage is zero

Full-Wave Rectifier :
The bridge is composed of four diodes in a diamond shape. During the positive half-cycle of input voltage vin the terminal ‘A’ is at positive potential with respect to the terminal ‘B’ and because of this diodes D1 and D2 are forward biased whereas diodes D3 and D4 are reverse biased. The current therefore flows through diodes D1, D2 and load resistor RL. During the negative half-cycle of input voltage waveform, on the other hand, the diodes D3 and D4 are forward biased whereas the diodes D1 and D2 are reverse biased. As a consequence, current flows through diodes D3 and D4.

Conclusion
The purpose of the rectifier is to convert the incoming ac from a transformer or other ac power source to some form of pulsating dc. That is, it takes current that flows alternately in both directions as shown in the first figure to the right, and modifies it so that the output current flows only in one direction
All rectifier outputs contain a considerable amount of ripple in addition to the DC component. In order to avoid AC components, a filter is connected at the output of the rectifier.

Capacitive Rectification

Objectives

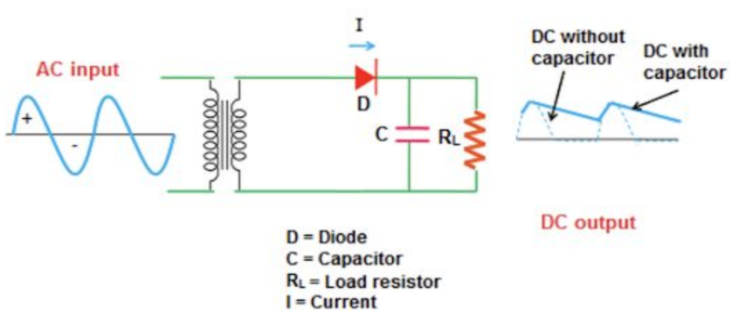
- Learn Filtering of Rectified signal
- Ripple Voltage and Ripple Factor
- Learn Capacitive filtering

Apparatus

Serial No.	Apparatus	Range	Type	Quantity
1	Voltage Source	0-10V	Moving Coil	1
2	Voltmeter	0-10V	AC	1
3	Capacitor	1μF - 100μF		1
4	Resistor	100 - 1kΩ		1
5	Diode			4

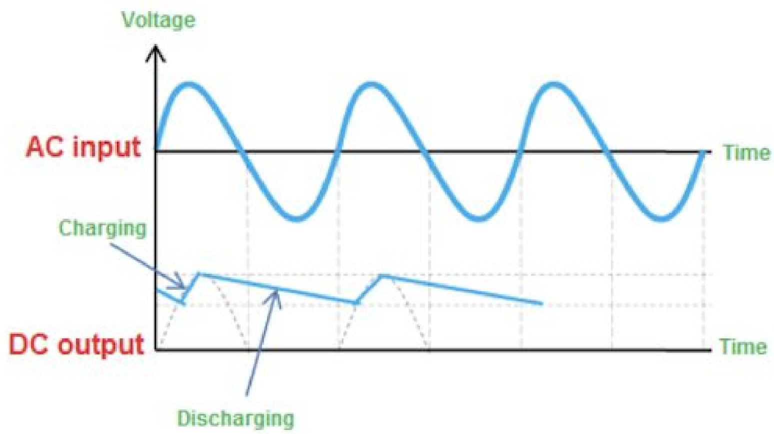
Theory

Half Wave Rectifier



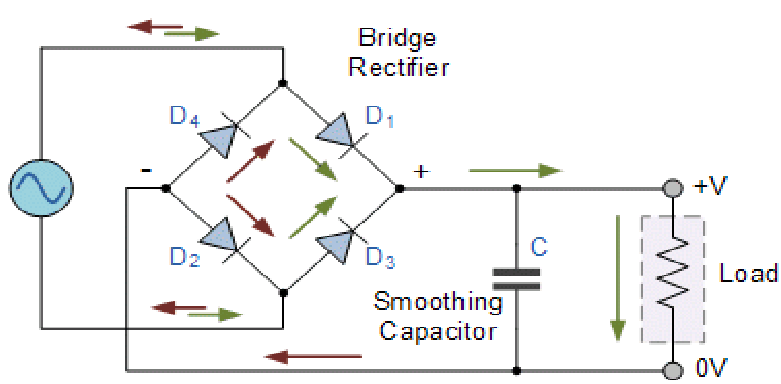
Half wave rectifier with capacitor filter

The half wave rectifier converts the Alternating Current (AC) into Direct Current (DC). But the obtained Direct Current (DC) at the output is not a pure Direct Current (DC). It is a pulsating Direct Current (DC).
The pulsating Direct Current (DC) is not constant. It fluctuates with respect to time. When this fluctuating Direct Current (DC) is applied to any electronic device, the device may not work properly. Sometimes the device may also be damaged. So the fluctuating Direct Current (DC) is not useful in most of the applications.
Therefore, we need a Direct Current (DC) that does not fluctuate with respect to time. The only solution for this is smoothing the fluctuating Direct Current (DC). This can be achieved by using a device called filter.
The pulsating Direct Current (DC) contains both AC and DC components. DC components are useful but AC components are not useful. So we need to reduce or completely remove the AC components. By using the filter, we can reduce the AC components at the output.
The filter is an electronic device that allows dc components and blocks the ac components of the rectifier output.
The filter is made up of a combination of components such as capacitors, resistors, and inductors. The capacitor allows the ac component and blocks the dc component.



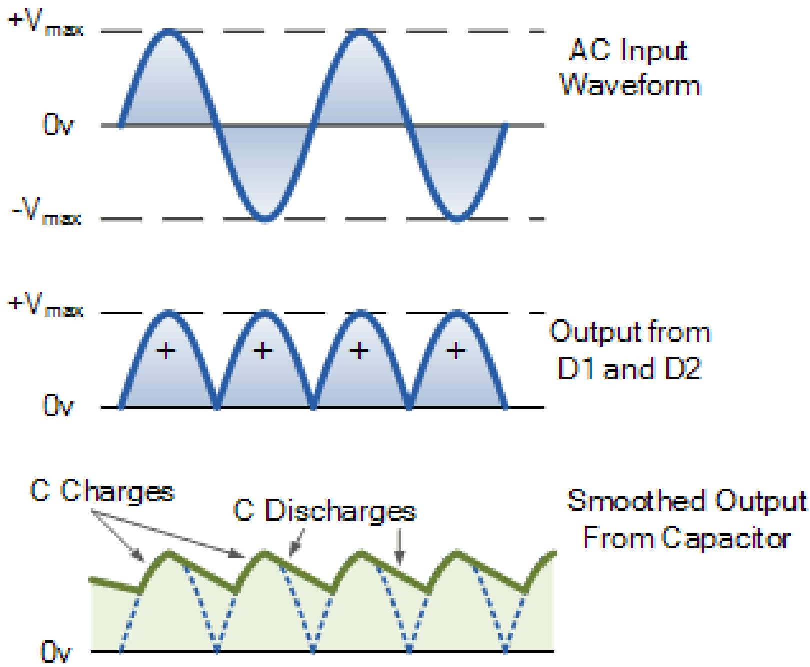
Half wave rectifier with filter o/p waveforms

Full Wave Rectifiers



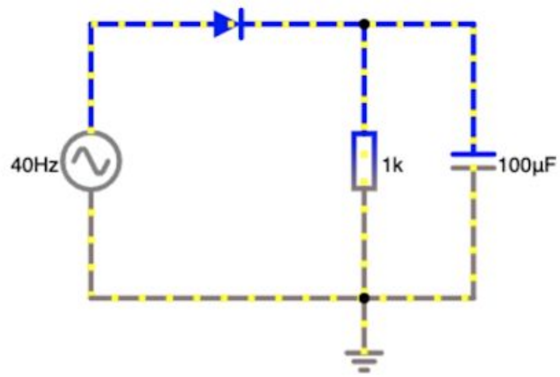
The working of the full wave rectifier with filter is almost similar to that of the half wave rectifier with filter. The only difference is that in the half wave rectifier only one half cycle (either positive or negative) of the input AC current will charge the capacitor but the remaining half cycle will not charge the capacitor. But in a full wave rectifier, both positive and negative half cycles of the input AC current will charge the capacitor.

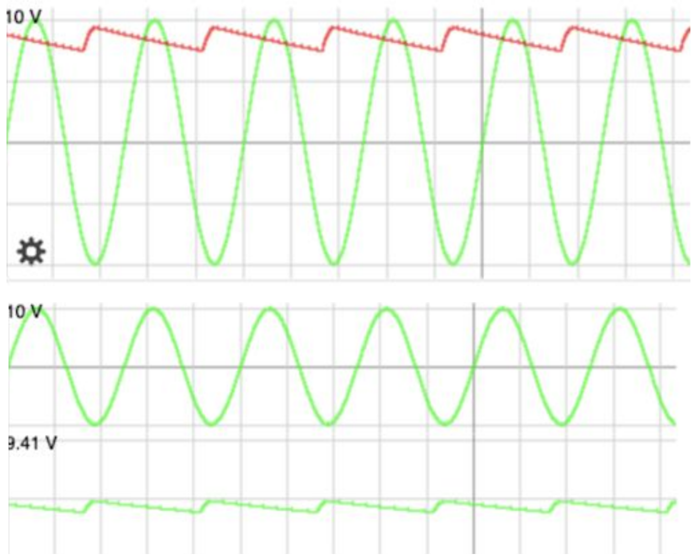
The main duty of the capacitor filter is to short the ripples to the ground and blocks the pure DC (DC components), so that it flows through the alternate path and reaches output load resistor RL.
When input AC voltage is applied, during the positive half cycle, the diode D1,D4 is forward biased and allows electric current whereas the diode D2,D3 is reverse biased and blocks electric current. On the other hand, during the negative half cycle the diode D2,D3 is forward biased (allows electric current) and the diode D1 is reverse biased (blocks electric current).
During the positive half cycle, the diode (D1,D4) current reaches the filter and charges the capacitor. However, the charging of the capacitor happens only when the applied AC voltage is greater than the capacitor voltage.
During the negative half cycle, the diode (D2,D3) current reaches the filter and charges the capacitor. However, the charging of the capacitor happens only when the applied AC voltage is greater than the capacitor voltage.
The capacitor is not completely uncharged, so the charging of the capacitor does not happen immediately. When the supply voltage becomes greater than the capacitor voltage, the capacitor again starts charging.
In both positive and negative half cycles, the current flows in the same direction across the load resistor RL. So we get either complete positive half cycles or negative half cycles. In our case, they are complete positive half cycles.



Graphs

<u>Capacitive Half Wave Rectification</u>

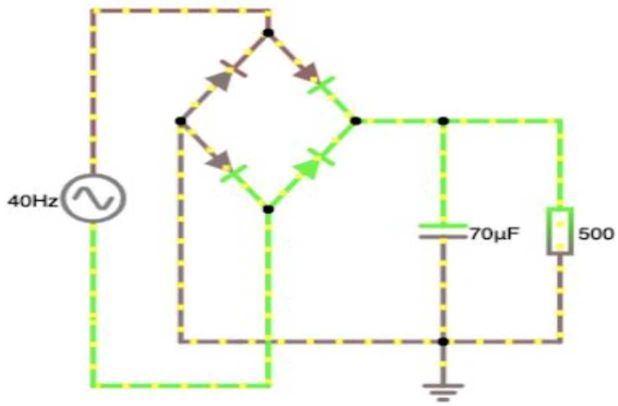


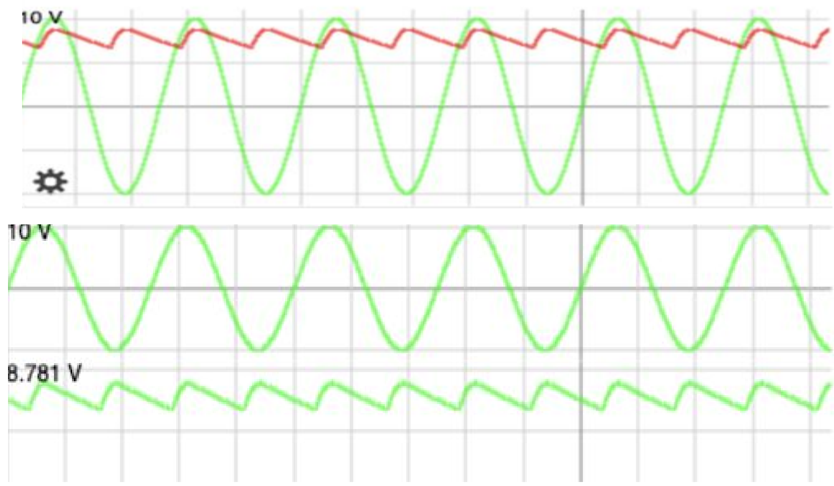


Discussion

The output of a half wave rectifier is not a constant DC voltage. You can observe from the output diagram that it's a pulsating dc voltage with ac ripples. In real life applications, we need a power supply with smooth waveforms. In other words, we desire a DC power supply with the constant output voltage. A constant output voltage from the DC power supply is very important as it directly impacts the reliability of the electronic device we connect to the power supply.
We can make the output of a half wave rectifier smooth by using a filter (a capacitor filter or an inductor filter) across the diode. In some cases, a resistor-capacitor coupled filter (RC) is also used. The circuit diagram below shows a half wave rectifier with capacitor filter.
A half wave rectifier is rarely used in practice. It is never preferred as the power supply of an audio circuit because of the very high ripple factor. High ripple factor will result in noises in the input audio signal, which in turn will affect audio quality.

Capacitive Full Wave Rectification





Discussion

For full wave rectification,
During the positive half cycle, the diode (D1,D4) current reaches the filter and charges the capacitor. However, the charging of the capacitor happens only when the applied AC voltage is greater than the capacitor voltage.
During the negative half cycle, the diode (D2,D3) current reaches the filter and charges the capacitor. However, the charging of the capacitor happens only when the applied AC voltage is greater than the capacitor voltage.
The capacitor is not completely uncharged, so the charging of the capacitor does not happen immediately. When the supply voltage becomes greater than the capacitor voltage, the capacitor again starts charging.
In both positive and negative half cycles, the current flows in the same direction across the load resistor RL. So we get either complete positive half cycles or negative half cycles. In our case, they are complete positive half cycles

Calculations :

For Capacitive Half Wave Rectifier

$V_m = 10\,V$

$V_{rms} = \frac{V_m}{\sqrt{2}} = \frac{10}{\sqrt{2}} = 7.07\,V$

$V_{dc} = \frac{V_m}{\pi} = \frac{10}{\pi} = 3.183\,V$

$V_{ac} = \sqrt{V_{rms}^2 - V_{dc}^2}$

$= \sqrt{7.07^2 - 3.183^2}$

$= 6.3129\,V$

$\therefore$ Ripple Factor $= \frac{V_{ac}}{V_{dc}}$

$= \frac{5.3129}{3.183}$

$\therefore$ Ripple Factor $= 1.983$

For Capacitive Full Wave Rectifier

$V_m = 5\,V$

$V_{rms} = \frac{V_m}{\sqrt{2}} = \frac{5}{\sqrt{2}} = 3.536\,V$

$V_{dc} = \frac{V_m}{\pi} = \frac{5}{\pi} = 1.591\,V$

$V_{ac} = \sqrt{V_{rms}^2 - V_{dc}^2}$

$= \sqrt{3.53^2 - 1.591^2}$

$= 3.151\,V$

$\therefore$ Ripple Factor $= \frac{V_{ac}}{V_{dc}}$

$= \frac{3.151}{1.591}$

$\therefore$ Ripple Factor $= 1.98$

Conclusion

Half- and full-wave rectifiers are used to convert AC into DC voltage. This is the primary function of the rectifier in industrial applications. For example, AC is used across the power grid, but to use electricity for welding, electroplating and as a DC source for motors with special speed controls, the AC must be changed to DC.

Zener Diode-Voltage Regulator

Objective

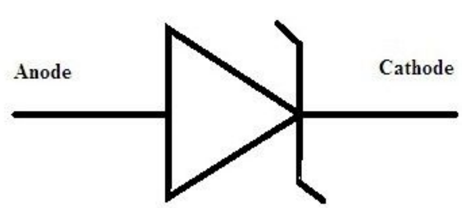
- At the end of the experiment, the student will be able to
- Explain the function of a Zener diode
- Explain Zener Diode as Voltage Regulator

Apparatus

Serial No.	Apparatus	Range	Type	Quantity
1	Voltage Source	0 - 30V	AC	1
2	Voltmeter	0 - 30V	Moving Coil	1
3	Ammeter	0 - 40mA	Moving Coil	3
4	Resistance	100Ω - 100kΩ		2
5	Zener Diode	3.3V - 10V		1

Theory

Zener diode is basically like an ordinary P-N junction diode but normally operated in reverse biased condition. But ordinary P-N junction diodes connected in reverse biased condition are not used as Zener diodes practically. A Zener diode is a specially designed, highly doped P-N junction diode.
Zener diodes are widely used as voltage references and as shunt regulators to regulate the voltage across small circuits. When connected in parallel with a variable voltage source so that it is reverse biased, a Zener diode conducts when the voltage reaches the diode's reverse breakdown voltage.



Applications of Zener Diode

The Zener diode is mostly used in commercial and industrial applications. The following are the main applications of the Zener diode.

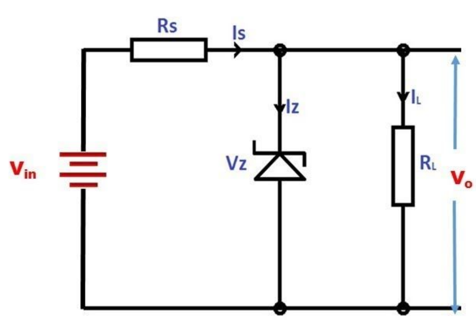
As Voltage Stabilizer – The Zener diode is used for regulating the voltage. It provides the constant voltage from the fluctuating voltage source to the load. The Zener diode is connected in parallel across the load and maintains the constant voltage VZ and hence stabilises the voltage.

For Wave Shaping – The Zener diode is used for converting the sine wave into the square wave.This can be done by placing the two Zener Diodes in series with the resistance. The diode is connected back to back and in the opposite direction.

Zener Diode as Voltage Regulator

The function of a regulator is to provide a constant output voltage to a load connected in parallel with it in spite of the ripples in the supply voltage or the variation in the load current and the zener diode will continue to regulate the voltage until the diodes current falls below the minimum I_Z(min) value in the reverse breakdown region. It permits current to flow in the forward direction as normal, but will also allow it to flow in the reverse direction when the voltage is above a certain value - the breakdown voltage known as the Zener voltage. The Zener diode is specially made to have a reverse voltage breakdown at a specific voltage. Its characteristics are otherwise very similar to common diodes. In breakdown the voltage across the Zener diode is close to constant over a wide range of currents thus making it useful as a shunt voltage regulator.

The purpose of a voltage regulator is to maintain a constant voltage across a load regardless of variations in the applied input voltage and variations in the load current. A typical Zener diode shunt regulator is shown in Figure 3. The resistor is selected so that when the input voltage is at V_{in}(min) and the load current is at I_L(max) that the current through the Zener diode is at least I_Z(min). Then for all other combinations of input voltage and load current the Zener diode conducts the excess current thus maintaining a constant voltage across the load. The Zener conducts the least current when the load current is the highest and it conducts the most current when the load current is the lowest.



Line Regulation

In this type of regulation, series resistance and load resistance are fixed, only input voltage is changing. Output voltage remains the same as long as the input voltage is maintained above a minimum value.

Percentage of line regulation can be calculated by =

$$\frac{\Delta V_0}{\Delta V_{IN}} * 100$$

where V0 is the output voltage and VIN is the input voltage and ΔV0 is the change in output voltage for a particular change in input voltage ΔVIN.

Load Regulation

In this type of regulation, input voltage is fixed and the load resistance is varying. Output voltage remains the same, as long as the load resistance is maintained above a minimum value.

Percentage of load regulation =

$$\left[\frac{V_{NL} - V_{FL}}{V_{NL}}\right] * 100$$

where VNL is the null load resistor voltage (ie. remove the load resistance and measure the voltage across the Zener Diode) and VF is the full load resistor voltage

When selecting the zener diode, it shouldn't exceed max power rating

$$I_{max} = \frac{Power}{Zener\ Voltage}$$

The total current drawn from the source is the same as that through the series resistor

$$I_S = \frac{V_S}{R_S}$$

The current through the load resistor is

$$I_L = \frac{V_L}{R_L}$$

and the zener diode current is

$$I_Z = I_S - I_L$$

If the voltage source is greater than V_Z

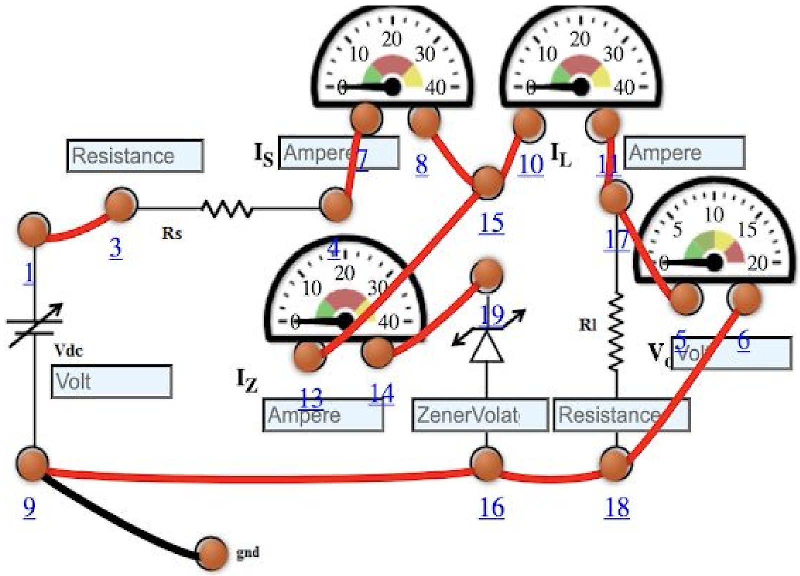
$$V_S = V_{in} - V_L \quad \text{and} \quad V_L = V_Z$$

If the voltage source is less than V_Z

$$V_S = \frac{R_S * V_{in}}{R_S + R_L} \quad \text{and} \quad V_L = \frac{R_L * V_{in}}{R_S + R_L}$$

Zener Diode - LINE Regulator

Circuit Diagram



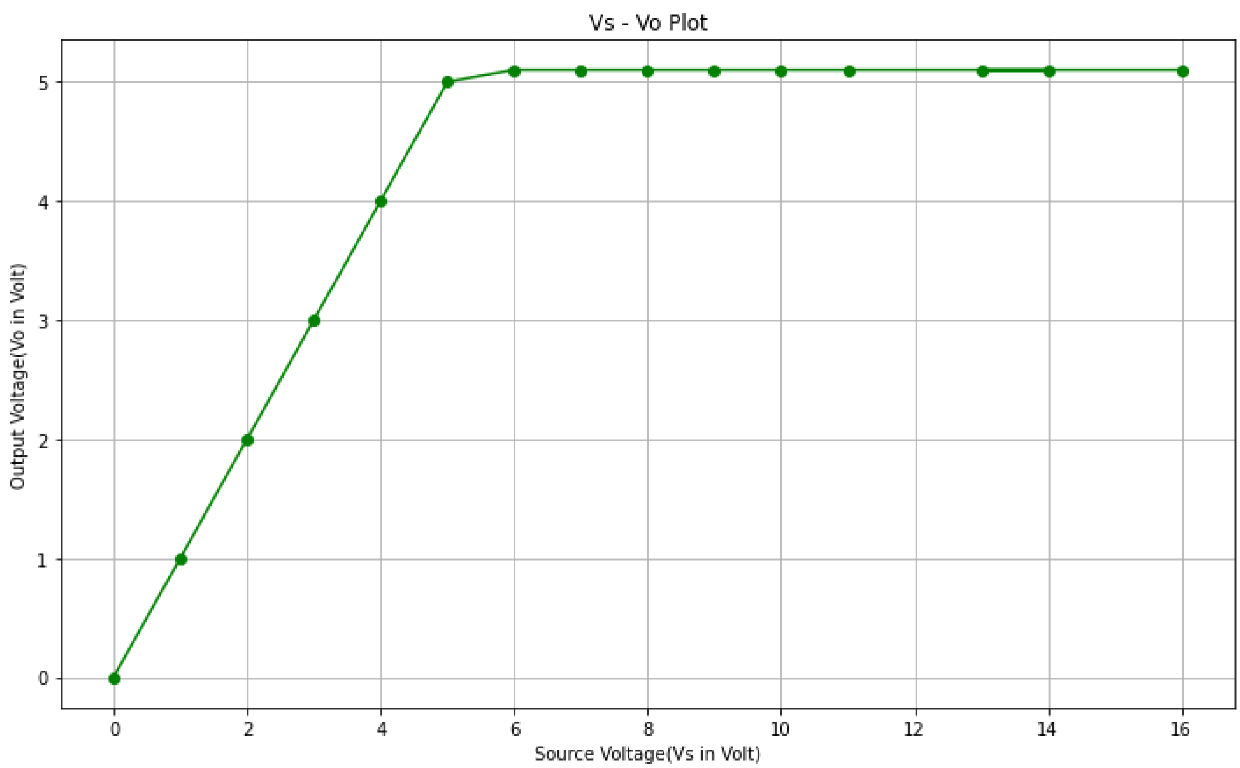
Table

S.No.	Unregulated supply voltage(V_S) V	Load Current(I_L) mAmp	Zener Current(I_Z) mAmp	Regulated Output Voltage(V_O) V	% Voltage Regulation
1	0	2.55	0	0	NaN
2	1	2.55	0	1	100
3	2	2.55	0	2	100
4	3	2.55	0	3	100
5	4	2.55	0	4	100
6	5	2.55	0	5	100
7	6	2.55	-1.650	5.10	83.3
8	7	2.55	-0.650	5.10	71.4
9	8	2.55	0.350	5.10	62.5
10	9	2.55	1.350	5.10	55.6
11	10	2.55	2.350	5.10	50.0

12	11	2.55	3.350	5.10	45.5
13	14	2.55	6.350	5.10	35.7
14	13	2.55	5.350	5.10	38.5
15	16	2.55	8.350	5.10	31.3

Resistance(R_S) = 1kohm
Zener Diode(V_Z) = 5.1 V
Resistance(R_L) = 2kohm

Graph



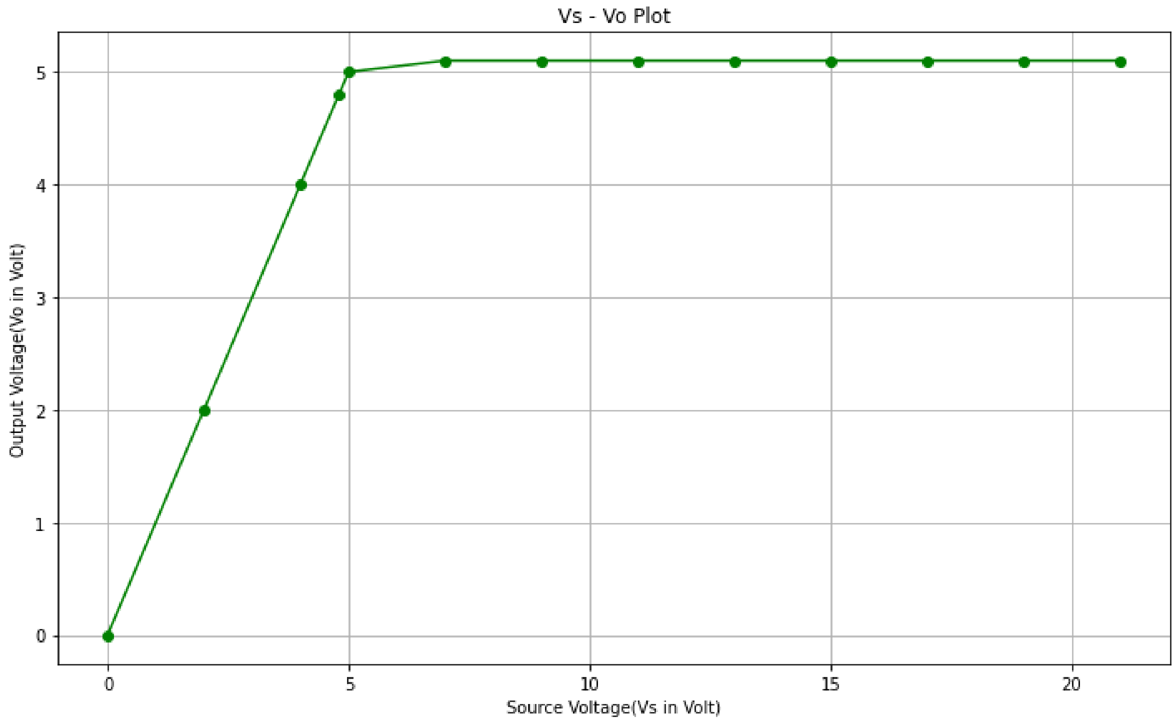
Table

Serial No.	Unregulated supply voltage(V_S) V	Load Current(I_L) mAmp	Zener Current(I_Z) mAmp	Regulated Output Voltage(V_O) V	% Voltage Regulation
1	0	1.02	0	0	NaN

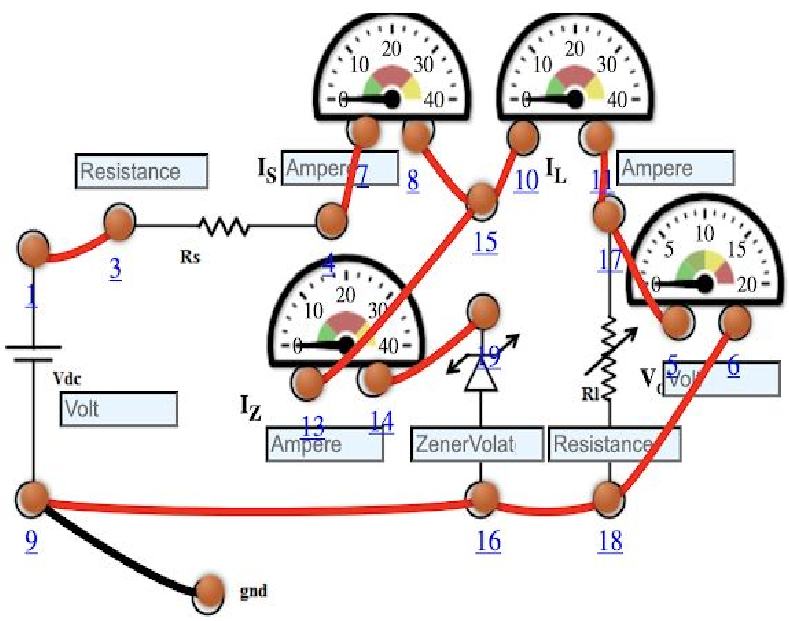
2	2	1.02	0	2	100
3	4	1.02	0	4	100
4	4.8	1.02	0	4.8	100
5	5	1.02	0	5	100
6	7	1.02	0.880	5.10	71.4
7	9	1.02	2.880	5.10	55.6
8	11	1.02	4.880	5.10	45.5
9	13	1.02	6.880	5.10	38.5
10	15	1.02	8.880	5.10	33.3
11	17	1.02	10.880	5.10	29.4
12	19	1.02	12.880	5.10	26.3
13	21	1.02	14.880	5.10	23.8

Resistance(R_S) = 1kohm
Zener Diode(V_Z) = 5.1 V
Resistance(R_L) = 5 kohm

Graph



Circuit Diagram



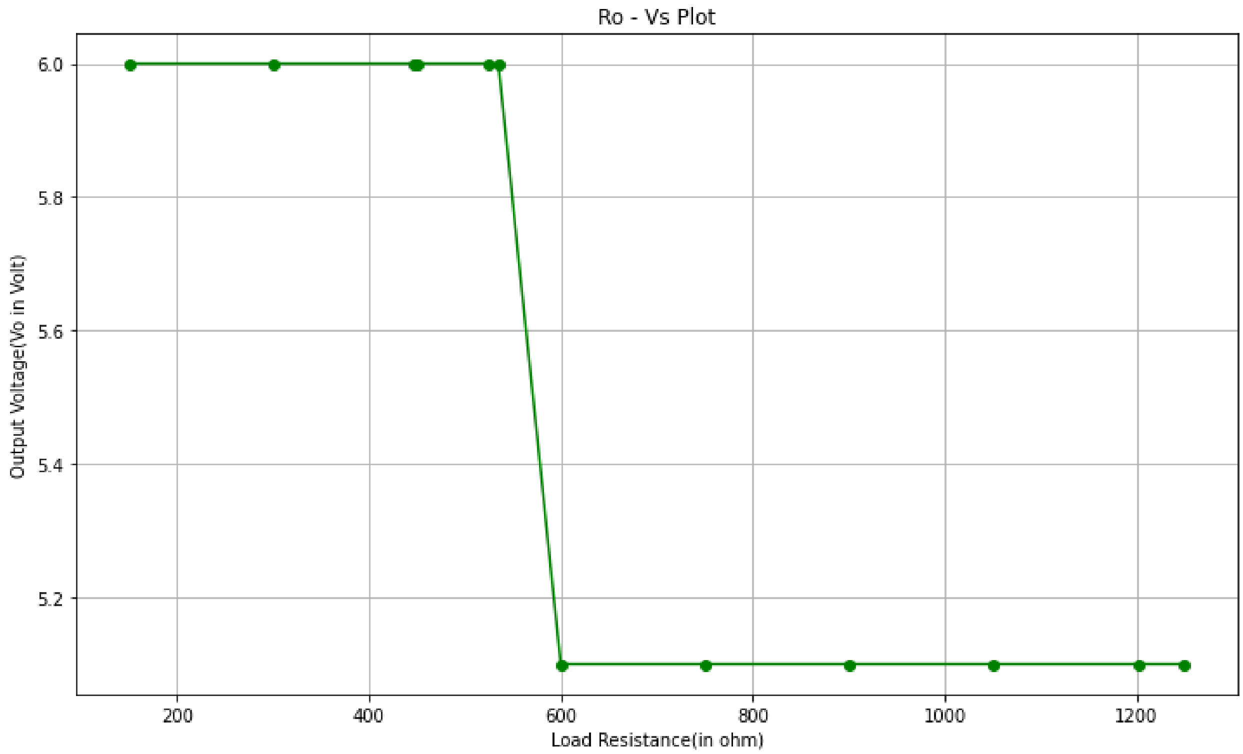
Table

Serial No.	Load Resistance(R_L) Ohm	Load Current(I_L) mAmp	Zener Current(I_Z) mAmp	Regulated Output Voltage(V_O) V	% Voltage Regulation

1	150	34.0	0	6	40.0
2	301	16.9	0	6	24.9
3	447	11.4	0	6	18.3
4	450	11.3	0	6	18.2
5	525	9.71	0	6	16.0
6	535	9.53	0	6	15.7
7	600	8.50	0.500	5.10	14.3
8	750	6.80	2.20	5.10	11.8
9	900	5.67	3.33	5.10	10.0
10	1051	4.85	4.15	5.10	8.69
11	1202	4.24	4.76	5.10	7.68
12	1250	4.08	4.92	5.10	7.41

Resistance(R_S) = 100 ohm
Zener Diode(V_Z) = 5.1 V
DC Voltage = 6 V

Graph



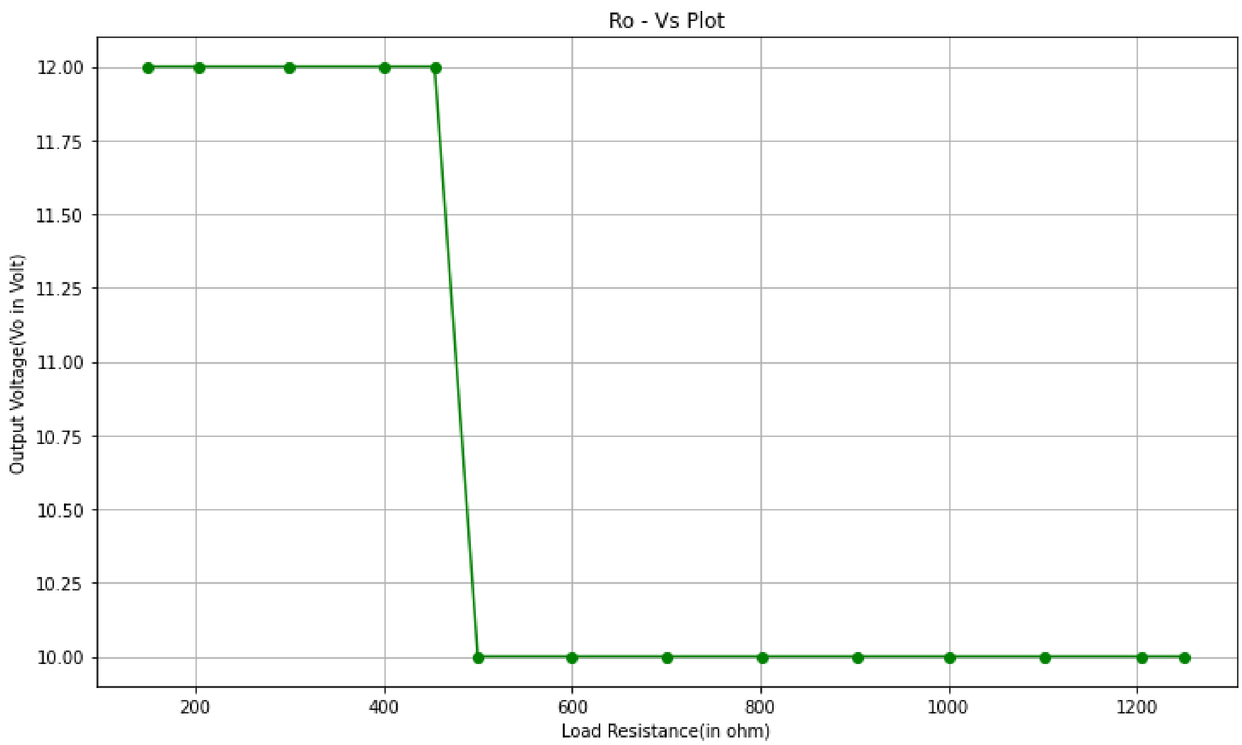
Table

Serial No.	Load Resistance(R_L) Ohm	Load Current(I_L) mAmp	Zener Current(I_Z) mAmp	Regulated Output Voltage(V_O) V	% Voltage Regulation
1	150	66.7	0	12	40.0
2	203	49.3	0	12	33.0
3	300	33.3	0	12	25.0
4	400	25.0	0	12	20.0
5	454	22.0	0	12	18.1
6	500	20.0	0.00	10.0	16.7
7	600	16.7	3.33	10.0	14.3
8	700	14.3	5.71	10.0	12.5
9	801	12.5	7.52	10.0	11.1
10	903	11.1	8.93	10.0	9.97
11	1000	10.0	10.0	10.0	9.09

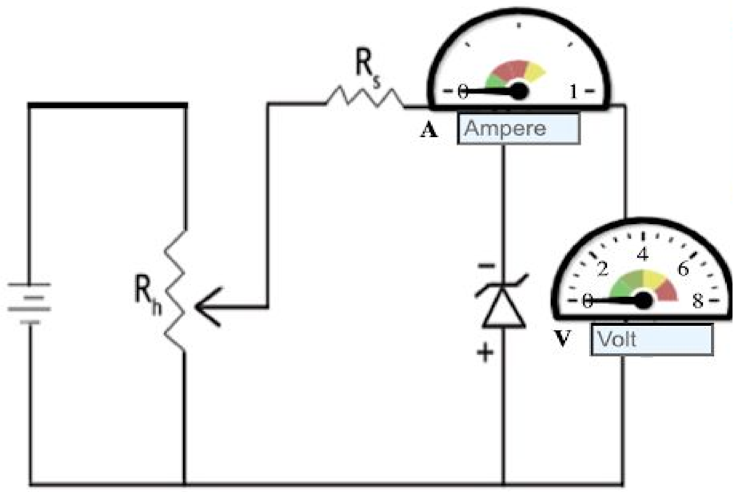
12	1102	9.07	10.9	10.0	8.32
13	1205	8.30	11.7	10.0	7.66
14	1250	8.00	12.0	10.0	7.41

Resistance(R_S) = 100 ohm
Zener Diode(V_Z) = 10 V
DC Voltage = 12 V

Graph



Circuit Diagram



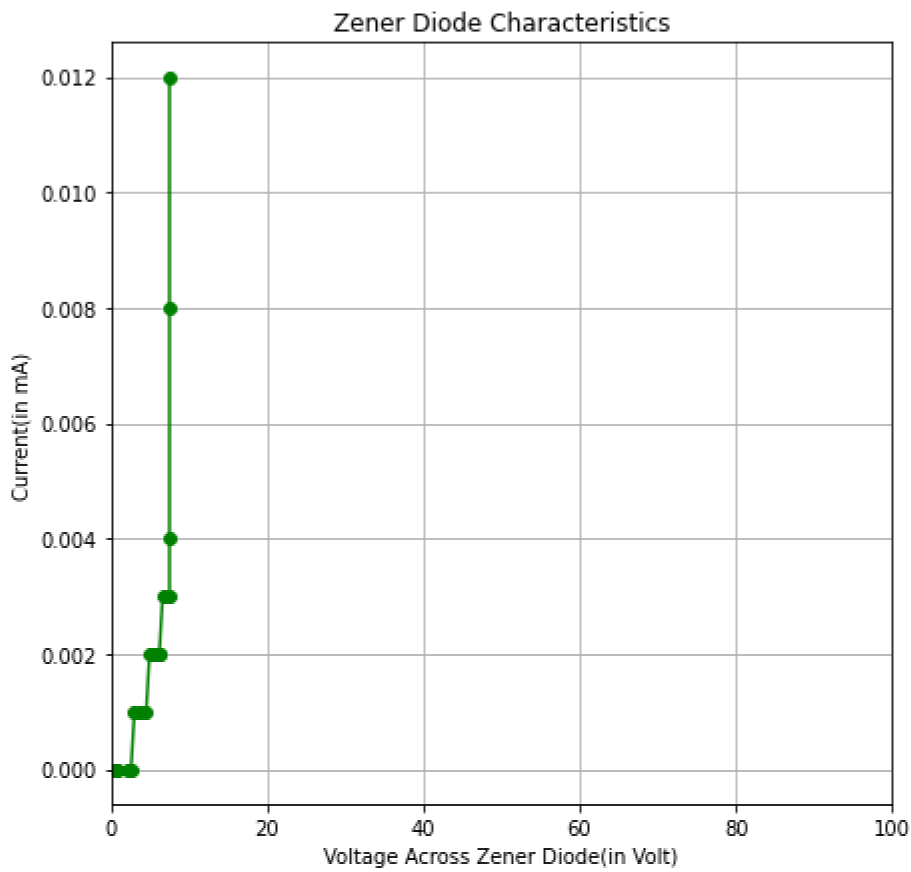
Table

Serial No.	Voltage Across Zener Diode	Current(in mA)
1	0.12	0
2	0.48	0
3	0.96	0
4	2.013	0
5	2.575	0
6	3.015	0.001
7	3.558	0.001
8	4.521	0.001
9	4.945	0.002
10	5.577	0.002
11	6.102	0.002
12	6.2017	0.002
13	6.626	0.003
14	7.5	0.003
15	7.5	0.004
16	7.5	0.008

17	7.5	0.012
18	7.5	0.02

Source ~ http://amrita.olabs.edu.in/?sub=1&brch=6&sim=24&cnt=4
Diode Used - BZX5C7V5

Graph



Discussion

The Zener diode is a unique device which exploits a property of diodes that is generally avoided in standard diode applications. Typical diodes have a very high reverse breakdown voltage, the voltage at which the diode begins to conduct in the reverse direction. This voltage is generally avoided in standard diodes, but Zener diodes are designed and manufactured to have a very specific reverse breakdown voltage.
Zener diodes are manufactured with a specific breakdown (zener) voltage.
Zener diodes are used to stabilize or regulate voltage.
Zener diode regulators provide a constant output voltage despite changes in the input voltage or output current.
As with most voltage regulators, the source voltage must be slightly higher than the Zener voltage in order to keep the Zener diode in reverse breakdown. Otherwise, the output voltage will simply follow the input voltage.
The equivalent circuit for a zener diode can be thought of as a battery of Vz volts, in series with a resistor of Rz ohms. It is because of this internal resistance that a voltage drop occurs across the zener diode, which is added or subtracted from the device rating to give an increased or decreased output. The value of Rz can be obtained from the manufactures data sheet for the device and is specified at a given current (Izt). Increasing the current through the zener higher than Izt, increases the voltage dropped across the internal impedance ($\Delta Vz = \Delta IzRz$) and the voltage across the zener diode increases. Likewise if the current through the zener drops lower than Izt, the voltage dropped across the internal impedance ($\Delta Vz = \Delta IzRz$) decreases and the voltage across the zener diode decreases.

Conclusion

The Zener diode, with its accurate and specific reverse breakdown voltage, allows for a simple, inexpensive voltage regulator. Combined with the right resistor, fine control over both the voltage and the supply current can be attained.
The breakdown voltage is lesser than a normal p-n junction diode
Thus, Zener Diode can act as a voltage regulator and is efficient at doing so.