INDEX

Cycle I

EXP.NO	DATE	NAME OF THE EXPERIMENT	PAGE NO	MARKS	SIGNATURE
1		PN Junction Diode Characteristics			
2		Zener Diode Characteristics			
3		Half Wave Rectifier			
4		Full Wave Rectifier			
5		Clipper and Clamper			

1. P-N JUNCTION DIODE CHARACTERISTICS

Aim

To study the Volt-Ampere Characteristics of Silicon P-N Junction Diode and to find cut-in voltage, static and dynamic resistances.

Apparatus / Components required:

S. No	Apparatus	Type	Range	Quantity
01	PN Junction Diode	1N4001		1
02	Resistance		1k ohm, 10% tolerance, 1/2 watt rating	1
03	Regulated power supply		(0 – 30V), 2A Rating	1
04	Ammeter	MC	(0-30)mA, (0-500)μA	Each 1
05	Voltmeter	MC	(0 – 1)V, (0 – 30)V	Each 1
06	Bread board			1
	Connecting wires			Few

Introduction:

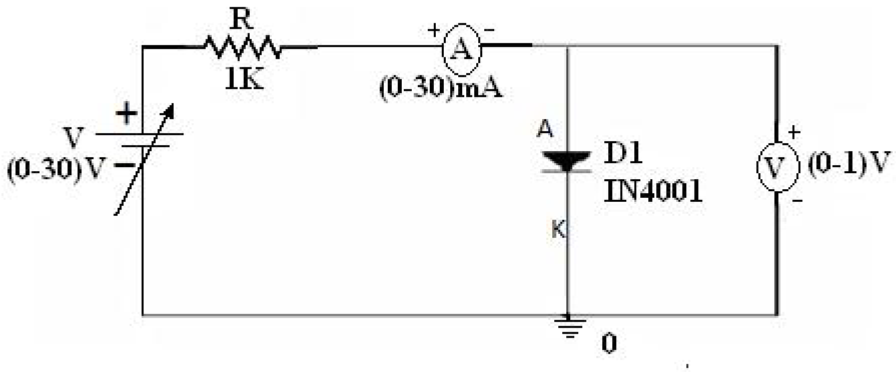
Donor impurities (pentavalent) are introduced into one-side and acceptor impurities into the other side of a single crystal of an intrinsic semiconductor to form a p-n diode with a junction called depletion region (this region is depleted off the charge carriers). This region gives rise to a potential barrier V_γ called **Cut- in Voltage**. This is the voltage across the diode at which it starts conducting. The P-N junction can conduct beyond this Potential.

The P-N junction supports uni-directional current flow. If $(+)^{ve}$ terminal of the input supply is connected to anode (P-side) and $(-)^{ve}$ terminal of the input supply is connected to cathode (N-side), then diode is said to be forward biased. In this condition the height of the potential barrier at the junction is lowered by an amount equal to given forward biasing voltage.

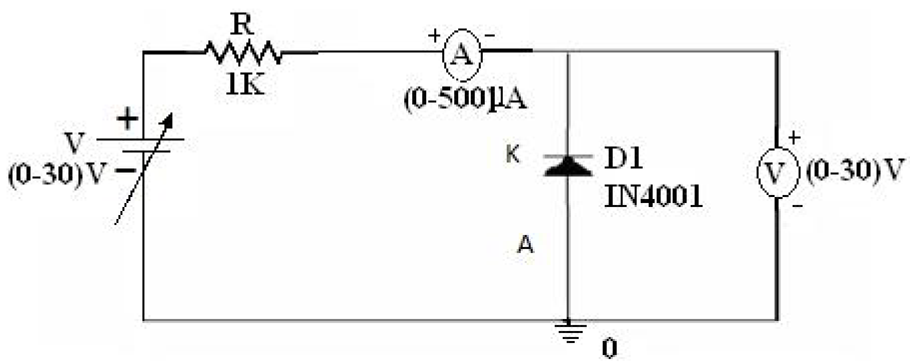
Both the holes from p-side and electrons from n-side cross the junction simultaneously and constitute a forward current (**injected minority current** – due to holes crossing the junction and entering N-side of the diode, due to electrons crossing the junction and entering P-side of the diode). Assuming current flowing through the diode to be very large, the diode can be approximated as short-circuited switch. If $(-)^{ve}$ terminal of the input supply is connected to anode (p-side) and $(+)^{ve}$ terminal of the input supply is connected to cathode (n-side) then the diode is said to be reverse biased. In this condition an amount equal to reverse biasing voltage increases the height of the potential barrier at the junction.

Circuit diagram:

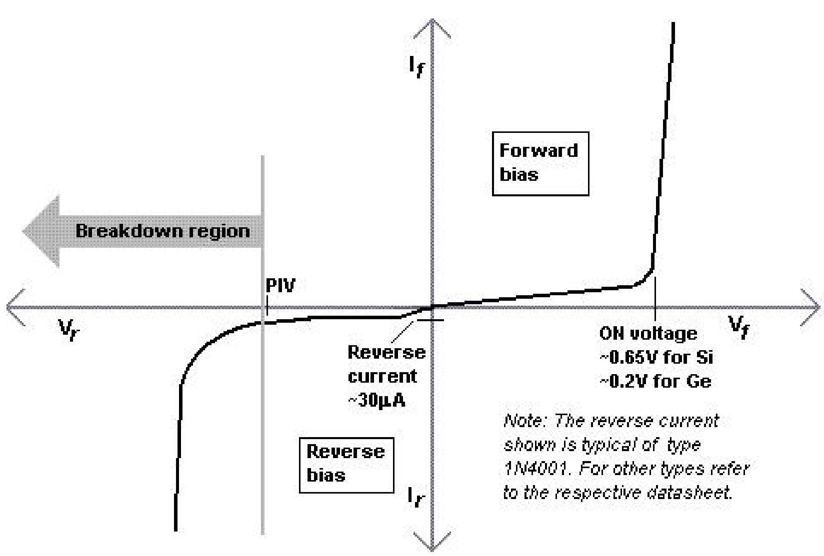
Forward Bias



Reverse Bias



Model Graph:



Both the holes on p-side and electrons on n-side tend to move away from the junction thereby increasing the depleted region. However the process cannot continue indefinitely, thus a small current called **reverse saturation current** continues to flow in the diode. This small current is due to thermally generated carriers. Assuming current flowing through the diode to be negligible, the diode can be approximated as an open circuited switch.

The volt-ampere characteristics of a diode explained by following equation:

$I = I_o(\exp(V/ \eta V_T)-1)$ I=current flowing in the diode I_o=reverse saturation current V=voltage applied to the diode

V_T=volt-equivalent of temperature=kT/q=T/11,600=26mV(@ room temp). η=1 (for Ge) and 2 (for Si)

Germanium diode has smaller cut-in-voltage than Silicon diode. The reverse saturation current in Ge diode is larger in magnitude when compared to silicon diode.

Procedure:

Forward Biased Condition:

1. Connect the PN Junction diode in forward bias i.e Anode is connected to positive of the power supply and cathode is connected to negative of the power supply.
2. Use a Regulated power supply of range (0-30) V and a series resistance of 1kΏ.
3. For various values of forward voltage (Vf) note down the corresponding values of forward current (If).

Reverse Biased condition:

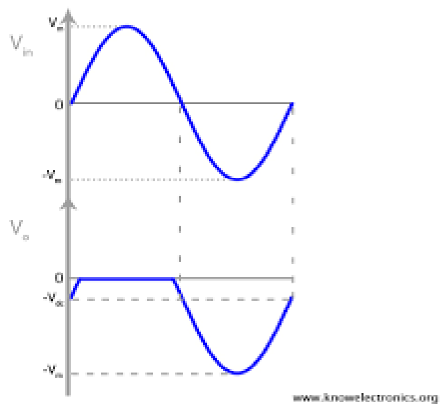
1. Connect the PN Junction diode in Reverse bias i.e; anode is connected to negative of the power supply and cathode is connected to positive of the power supply.
2. For various values of (Vr) note down the corresponding values of reverse current (Ir).

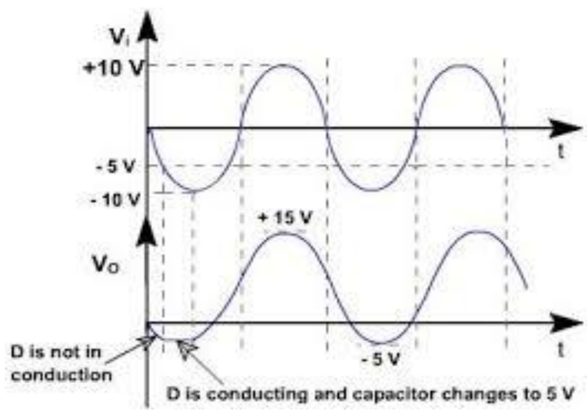
Precautions:

1. While doing the experiment do not exceed the ratings of the diode. This may lead to damage of the diode.
2. Connect voltmeter and Ammeter in correct polarities as shown in the circuit diagram.
3. Do not switch **ON** the power supply unless you have checked the circuit connections as per the circuit diagram.

Characteristics of PN junction diode:

1. Breakdown voltage can be traded with switching speed. A reduction in recombination lifetime through addition of suitable impurities will increase leakage current. This can be countered by decreasing diode area which however will lead to reduced forward current rating unless doping is increased. This will lead to a reduced breakdown voltage.
2. The breakdown voltage and reverse recovery are also related together in more direct manner. Regions which have higher doping also have a lower recombination lifetime so that a lower breakdown voltage diode is likely to have lower lifetime and better switching speeds. So a **single diode** cannot meet the diverse applications.





Tabular column:

Forward Bias

S. No	V_f (volts)	I_f (mA)

Reverse Bias

S. No	V_r (volts)	I_r (µA)

Result:

Thus the VI characteristic of PN junction diode was verified.

i. Cut in voltage = V

ii. Static forward Resistance R_{dc} = $(V_f/I_f)\ \Omega$

iii. Dynamic forward Resistance r_{ac} = $(\Delta V_f/\Delta I_f)\ \Omega$

iv. Static Reverse Resistance R_{dc} = $(V_r/I_r)\ \Omega$

v. Dynamic Reverse Resistance r_{ac} = $(\Delta V_r/\Delta I_r)\ \Omega$

Pre lab Questions:

1. What is the need for doping?
2. How depletion region is formed in the PN junction?
3. What is break down voltage?
4. What is cut-in or knee voltage? Specify its value in case of Ge or Si?
5. What are the differences between Ge and Si diode?
6. What is the relationship between depletion width and the concentration of impurities?

Post lab Questions:

1. Generate input and output characteristics in PN Junction diode using PSPICE and compare with the obtained output.
2. How does PN-junction diode acts as a switch?
3. Comment on diode operation under zero biasing condition.
4. For a uniformly doped silicon PN junction diode with an N-type doping of 10^{16} cm^{-3} and a P-type doping of 2 x 10^{16} cm^{-3}, Sketch the potential within the space charge region at equilibrium. What fraction of the built-in voltage is dropped in the N-region? Where will most of the built-in voltage be dropped if the P type doping is much larger than the N-type doping?
5. The depletion capacitance/Area measured for a symmetrical Silicon PN junction at different bias voltages is given below:

   (a) Determine the doping of N and P-regions

   (b) Determine the built-in voltage

   (c) Determine the depletion width at zero bias

2. ZENER DIODE CHARACTERISTICS

Aim:

To study the Volt-Ampere characteristics of Zener diode and to measure the Zener break down voltage.

Apparatus / Components required:

S. No	Apparatus	Type	Range	Quantity
01	Zener Diode	IZ 6.2		1
02	Resistance		1k ohm, 10% tolerance, 1/2 watt rating	1
03	Regulated power supply		(0 – 30V), 2A rating	1
04	Ammeter	mC	(0-30)mA	1
05	Voltmeter	mC	(0 – 1)V, (0 – 10)V	1
06	Bread board			1
	Connecting wires			Few

Introduction:

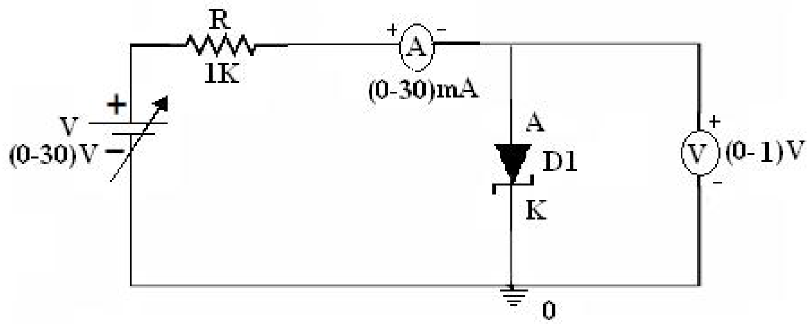
An ideal P-N Junction diode does not conduct in reverse biased condition. A **Zener diode** conducts excellently even in reverse biased condition. These diodes operate at a precise value of voltage called break down voltage. A **Zener diode** when forward biased behaves like an ordinary P-N junction diode. A **Zener diode** when reverse biased can either undergo **avalanche breakdown** or **Zener breakdown**.

Avalanche breakdown:-If both p-side and n-side of the diode are lightly doped, depletion region at the junction widens. Application of a very large electric field at the junction may rupture covalent bonding between electrons. Such rupture leads to the generation of a large number of charge carriers resulting in **avalanche multiplication**.

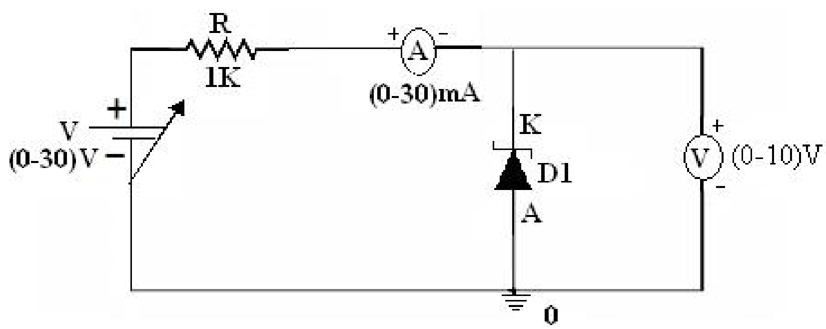
Zener breakdown:-If both p-side and n-side of the diode are heavily doped, depletion region at thejunction reduces. Application of even a small voltage at the junction ruptures covalent bonding and generates large number of charge carriers. Such sudden increase in the number of charge carriers results in **Zener mechanism**.

Circuit diagram:

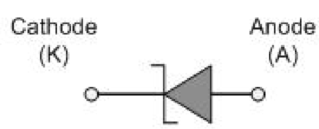
Forward Bias



Reverse Bias



Zener Diode Symbol:



Tabular column:

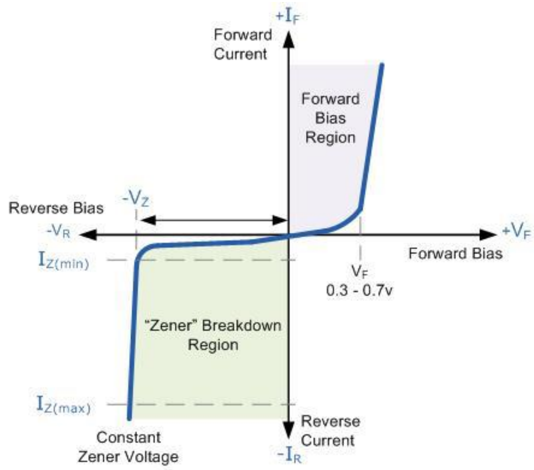
Forward Bias

S. No	V_f (volts)	I_f (mA)

Reverse Bias

S. No	V_f (volts)	I_f (mA)

Model Graph:



Precautions

1. While doing the experiment do not exceed the ratings of the diode. This may lead to damage of the diode.
2. Connect voltmeter and Ammeter in correct polarities as shown in the circuit diagram.
3. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

Procedure:

Forward Biased Condition:

1. Connect the Zener diode in forward bias i.e; anode is connected to positive of the power supply and cathode is connected to negative of the power supply as in circuit
2. Use a Regulated power supply of range (0-30) V and a series resistance of 1kΩ.
3. For various values of forward voltage (Vf) note down the corresponding values of forward Current (If).

Reverse biased condition:

1. Connect the Zener diode in Reverse bias i.e; anode is connected to negative of the power supply and cathode is connected to positive of the power supply as in circuit.
2. For various values of reverse voltage (Vr) note down the corresponding values of reverse current (Ir).

Result:

The Zener diode characteristics have been verified and the following parameters were calculated

i) Cut in voltage = ……… V

ii) Break down voltage =………. V

Characteristics of Zener Diode:

For IZ6.2 Zener diode,

Forward Bias:

At a given (constant) diode current, V exhibits an approximately linear shift in the VI -characteristic due to the combined effect of the temperature dependences of both I_S and V_T

Typically, the VI -characteristic shifts approximately -2 mV/°C.

Reverse Bias:

The temperature dependence of the reverse current is that of IS alone, which changes exponentially as a function of temperature. Typically, I_S approx. doubles for every 10 °C increase in Temperature. These variations may lead to significant changes in the operation of a circuit over a large temperature range and, in many applications, requires compensation strategies to be implemented in the design of some circuits.

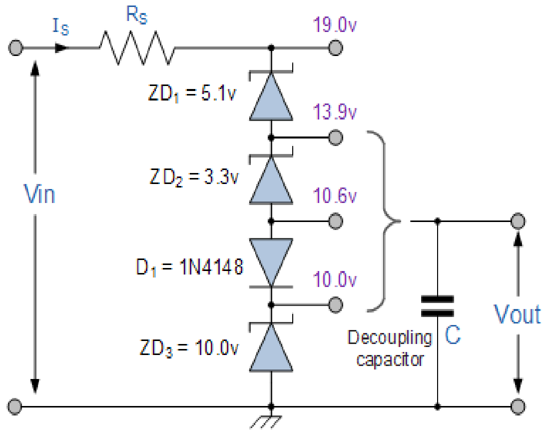
Pre lab Questions:

1. Explain the concept of Zener breakdown?
2. How depletion region gets thin by increasing doping level in Zener diode?
3. State the reason why an ordinary diode suffers avalanche breakdown rather than Zener breakdown?
4. Give the reasons why Zener diode acts as a reference element in the voltage regulator circuits.
5. What type of biasing must be used when a Zener diode is used as a regulator?

Post lab Questions:

1. Generate input and output characteristics in Zener diode using PSPICE and compare with the obtained output .
2. Design a DC power supply network using Zener diode.

3. What happens when the Zener diodes are connected in series?



4. Justify the use of Zener diode in a stabilization circuit?
5. How will you differentiate the diodes whether it is Zener or avalanche when you are given two diodes of rating 6.2 v and 24V?
6. How does a Zener diode protect meters from excess voltage that is applied accidentally

3. DIODE RECTIFIER CIRCUITS – Half Wave Rectifier (HWR)

Aim:

To design and construct the diode rectifier circuit and analyze the following parameters

a. To plot output waveform of the HWR

b. To find ripple factor using formulae

c. To find the efficiency

Apparatus / Components required:

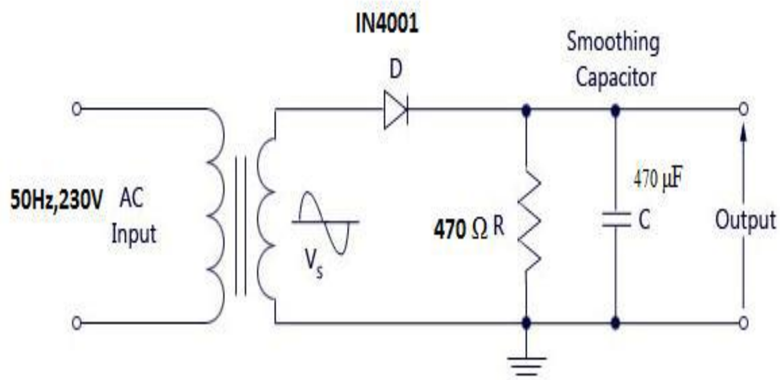
S. No	Apparatus	Type	Range	Quantity
01	Step down Transformer		(6-0-6)V, 500mA, 1A Rating	1
02	Resistance		470 ohm, 10% tolerance, 1/2 watt rating	1
03	Capacitor		470µF	1
04	Diode	IN4001		1
05	Bread board			1
	Connecting wires			Few

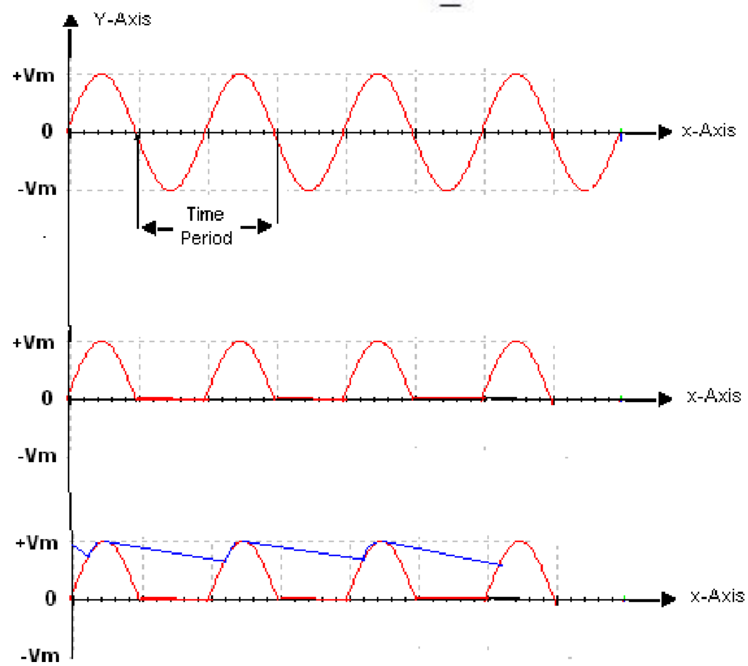
Half wave rectifier

A device is capable of converting a sinusoidal input waveform into a unidirectional waveform with non-zero average component is called a rectifier. A practical half wave rectifier with a resistive load is shown in the circuit diagram. In positive half cycle, Diode D is forward biased and conducts. Thus, the output voltage is same as the input voltage. In the negative half cycle, Diode D is reverse biased, and therefore output voltage is zero. A smoothing filter is induced between the rectifier and load in order to attenuate the ripple component. The filter is simply a capacitor connected from the rectifier output to ground. The capacitor quickly charges at the beginning of a cycle and slowly discharges through R_L after the positive peak of the input voltage. The variation in the capacitor voltage due to charging and discharging is called ripple voltage. Generally, ripple is undesirable, thus the smaller the ripple, the better the filtering action.

Ripple factor is a measure of effectiveness of a rectifier circuit and defined as a ratio of RMS value of ac component to the dc component in the rectifier output.

Circuit Diagram of Half Wave Rectifier





Observations:

	Input Waveform	**Output Waveform** (without filter)	**Ripple Voltage** (with filter)
Amplitude			
Time Period			
Frequency			

Theoretical calculations for Ripple Factor:

Without Filter:

$V_{rms} = V_m / 2$

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

Ripple factor (Theoretical) $= \sqrt{(\frac{V_{rms}}{V_{dc}})^2 - 1} = 1.21$

Ripple Factor(practical) $\gamma = \frac{V_{ac}}{V_{dc}}$ where $V_{ac} = \sqrt{(V_{rms}^2 - V_{dc}^2)}$

With Filter:

Ripple Factor (Theoretical) $r = \frac{1}{2\sqrt{3}fCR}$

Where f = 50Hz, R = 1KΩ, C = 1000μF

$$V_{ac} = \frac{V_{r(p-p)}}{2\sqrt{3}}$$

$$V_{dc} = V_m - \frac{V_{r(p-p)}}{2}$$

Ripple Factor(practical) $\gamma = \frac{V_{ac}}{V_{dc}}$

Percentage Regulation $= \frac{V_{NL} - V_{FL}}{V_{FL}} * 100$ %

V_{NL} = DC voltage at the load without connecting the load (Minimum current).

V_{FL} = DC voltage at the load with load connected.

Efficiency $\eta = \frac{P_{DC}}{P_{AC}}$

$P_{AC} = V_{2rms} / R_L$

$P_{DC} = V_{dc} / R_L$

The ripple factor can be lowered by increasing the value of the filter capacitor or increasing the load capacitance.

Result:

Thus the Half Wave Rectifier circuit is constructed and ripple factor, efficiency, Vp(rect), and Vdc values for circuits has been analyzed

4. DIODE RECTIFIER CIRCUITS – Full Wave Rectifier (FWR)

Aim:

To design and construct the diode rectifier circuit and analyze the following parameters

a. To plot output waveform of the FWR

b. To find ripple factor using formulae

c. To find the efficiency

Apparatus / Components required:

S. No	Apparatus	Type	Range	Quantity
01	Step down Transformer		(6-0-6)V, 500mA, 1A Rating	1
02	Resistance		470 ohm, 10% tolerance, 1/2 watt rating	1
03	Capacitor		470µF	1
04	Diode	IN4001		2
05	Bread board			1
	Connecting wires			Few

Full wave rectifier

A device is capable of converting a sinusoidal input waveform into a unidirectional waveform with non-zero average component is called a rectifier.

A practical half wave rectifier with a resistive load is shown in the circuit diagram. It consists of two half wave rectifiers connected to a common load. One rectifies during positive half cycle of the input and the other rectifying the negative half cycle. The transformer supplies the two diodes (D1 and D2) with sinusoidal input voltages that are equal in magnitude but opposite in phase. During input positive half cycle, diode D1 is ON and diode D2 is OFF. During negative half cycle D1 is OFF and diode D2 is ON. Peak Inverse Voltage (PIV) is the maximum voltage that has to be withstand by a diode when it is reverse biased. Peak inverse voltage for Full Wave Rectifier is $2V_m$ because the entire secondary voltage appears across the non-conducting diode **.**

The output of the Full Wave Rectifier contains both ac and dc components. A majority of the applications, which cannot tolerate a high value ripple, necessitates further processing of the rectified output. The undesirable ac components i.e. the ripple, can be minimized using filters.

Ripple Factor:

Ripple factor is defined as the ratio of the effective value of AC components to the average DC value. It is denoted by the symbol 'γ'.

$$\gamma = \frac{V_{ac}}{V_{dc}}, (\gamma = 0.48)$$

Efficiency:

The ratio of output DC power to input AC power is defined as efficiency.

$$\eta = \frac{(V_{dc})^2}{(V_{ac})^2}$$

η= 81% (if R >> R_f, then R_f can be neglected).

The maximum efficiency of a Full Wave Rectifier is 81.2%.

Percentage of Regulation:

It is a measure of the variation of DC output voltage as a function of DC output current (i.e., variation in load).

Percentage of regulation = $(\frac{V_{NL} - V_{FL}}{V_{FL}}) * 100$ %

V_{NL} = Voltage across load resistance, when minimum current flows through it.

V_{FL} = Voltage across load resistance, when maximum current flows through.

For an ideal Full-wave rectifier, the percentage regulation is 0 percent. The percentage of regulation is very small for a practical full wave rectifier.

Peak- Inverse - Voltage (PIV):

It is the maximum voltage that the diode has to withstand when it is reverse biased.

PIV = $2V_m$

Transformer Utilization Factor

Transformer utilization factor (TUF), which is defined as the ratio of power delivered to the load and ac rating of the transformer secondary, So, TUF = dc power delivered to the load/ac rating of transformer secondary Transformer Utilization Factor, TUF can be used to determine the rating of a transformer secondary. It is determined by considering the primary and the secondary winding separately and it gives a value of 0.693.

Theoretical Calculations:

Without filter:

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

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

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

Ripple factor (Theoretical) = $\sqrt{(\frac{V_{rms}}{V_{dc}})^2 - 1} = 0.48$

Ripple Factor (Practical) $\gamma = \frac{V_{ac}}{V_{dc}}$

With filter:

Ripple factor (Theoretical)

$$\gamma = \frac{1}{4\sqrt{3}fCR}$$

Where f = 50Hz, R =1KΩ, C = 1000μF.

$$V_{ac} = \frac{V_{r(p-p)}}{2\sqrt{3}}$$

$$V_{dc} = V_m - \frac{V_{r(p-p)}}{2}$$

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

Percentage Regulation = $(\frac{V_{NL} - V_{FL}}{V_{FL}}) * 100$ %

V_{NL} = DC voltage at the load without connecting the load (Minimum current).

V_{FL} = DC voltage at the load with load connected.

Efficiency % $\eta = \frac{P_{DC}}{P_{AC}}$

$P_{AC} = V_{2rms} / R_L$

$P_{DC} = V_{dc} / R_L$

The maximum efficiency of a Full Wave Rectifier is 81.2%

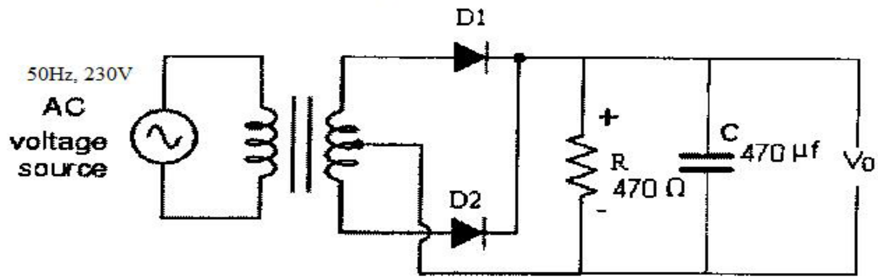
Transformer Utilization Factor

Transformer utilization factor (TUF), which is defined as the ratio of power delivered to the load and ac rating of the transformer secondary. So,

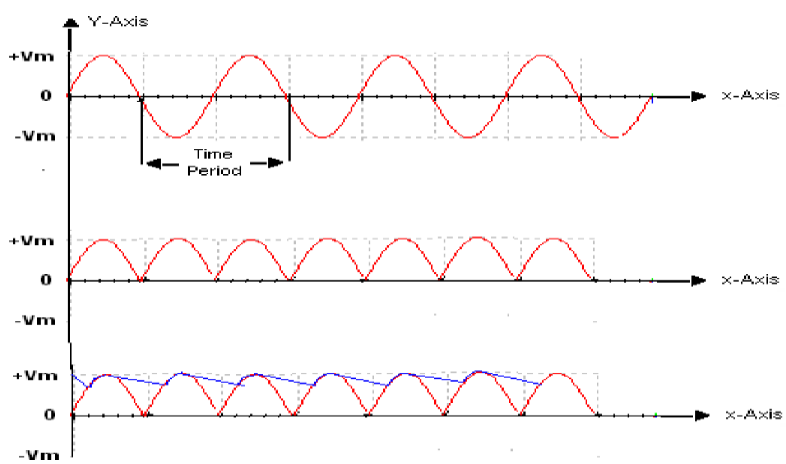
TUF = dc power delivered to the load/ac rating of transformer secondary

Transformer Utilization Factor, TUF can be used to determine the rating of a transformer secondary. It is determined by considering the primary and the secondary winding separately and it gives a value of 0.812.

Circuit Diagram



MODEL GRAPH:



Observations:

	Input Waveform	Output Waveform (without filter)	Ripple Voltage (with filter)
Amplitude			
Time Period			
Frequency			

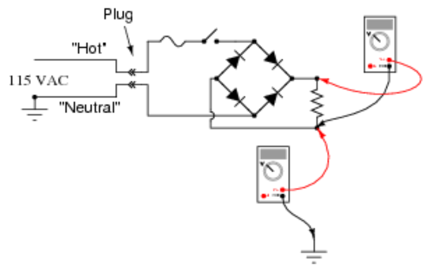
Pre lab Questions:

1. What is the PIV of rectifier circuits?
2. A bridge rectifier is preferable to a full-wave rectifier using center-tap transformer as
    a. It uses four diodes
    b. Its transformer does not require center-tap
    c. It requires much smaller transformer for the same output
    d. All of these
3. In a full-wave bridge rectifier, the current in each diode flows for
    a. Complete cycle of the input signal
    b. Half-cycle of the input signal
    c. Less than half-cycle of the input signal
    d. More than half-cycle of the input signal
4. What is the purpose of a filter in dc power supply?
5. What is TUF? Give the TUF of half wave, full wave-center tapped and bridge rectifier.

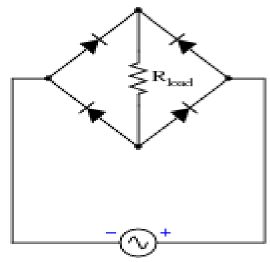
Post lab Questions:

1.When a 50Hz ac signal is fed to a rectifier, the ripple frequency of the output voltage waveform for full bridge rectifier is

(a) 25 Hz (b) 50 Hz (c) 100 Hz (c)150 Hz

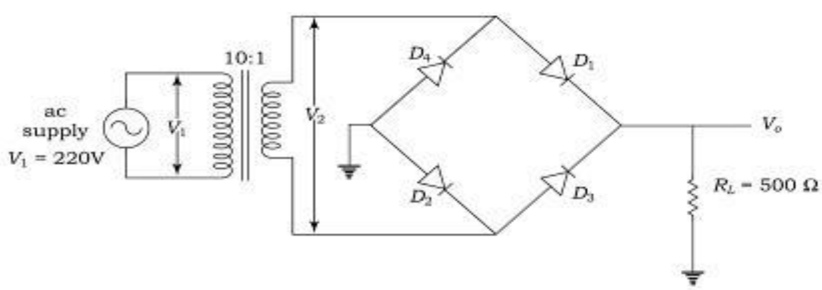


2. Trace the current through this rectifier circuit at a moment in time when the AC source's polarity is positive on right and negative on left as shown. Be sure to designate the convention you use for current direction (conventional or electron flow):



Also, mark the polarity of the voltage drop across R_{load}.

1. For the figure shown below. Determine (a) the DC output voltage, (b) DC load current, (c) the RMS value of the load current, (d) the DC power, (e)the AC power, (f) efficiency of rectifier, (g) peak inverse voltage of each diode, and (h) output frequency. Assume all diodes are ideal.



Result:

Thus the Full Wave rectifier circuits is constructed and ripple factor, efficiency, Vp(rect), and Vdc values for circuits has been analyzed

5. DIODE CLIPPER & CLAMPER

Aim

To construct and test the clipper and clamper circuits

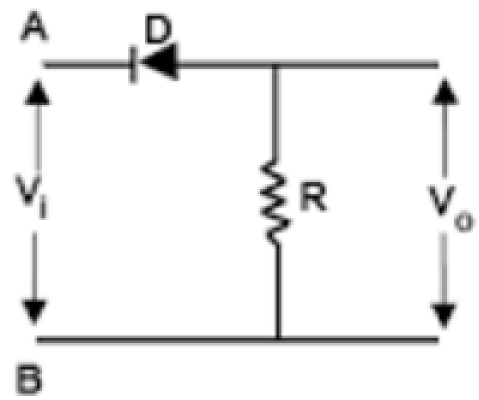
Apparatus / Components Required

Sl. No.	COMPONENT	SPECIFICATION	QTY
1.	CRO	(0-20M)HZ	1
2.	Function generator		1
3.	Resistor	10KΩ	1
4.	Capacitor	0.1μF	1
5.	Diode	IN4007	1
6.	Bread board	-	1
7.	Connecting wires	-	-

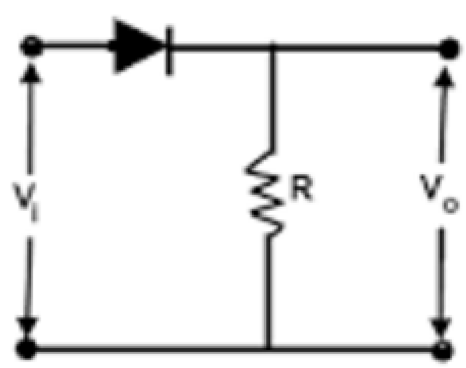
Theory – Clipper

A clipper is a device designed to prevent the output of a circuit from exceeding a predetermined voltage level without distorting the remaining part of the applied waveform. A clipping circuit consists of linear elements like resistors and non-linear elements like junction diodes or transistors, but it does not contain energy-storage elements like capacitors. Clipping circuits are used to select for purposes of transmission, that part of a signal wave form which lies above or below a certain reference voltage level. Thus, a clipper circuit can remove certain portions of an arbitrary waveform near the positive or negative peaks. Clipping may be achieved either at one level or two levels. Usually under the section of clipping, there is a change brought about in the wave shape of the signal.

Circuit Diagram of Diode Positive Clipper



Circuit Diagram of Diode Negative Clipper

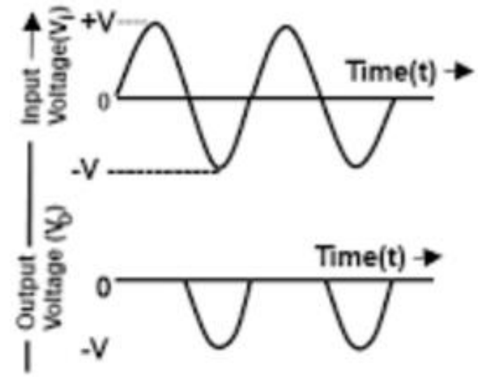


Tabulation

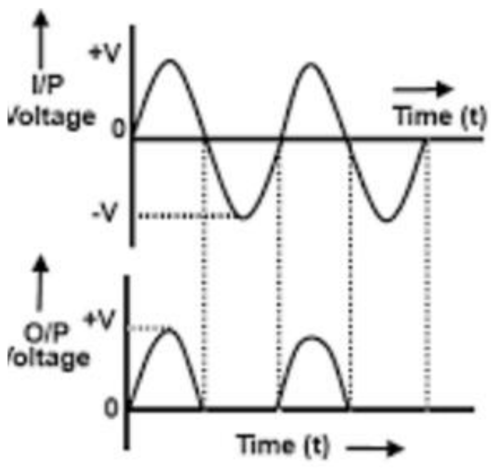
	Input voltage	Output voltage	Input frequency	Output frequency
Positive clipper				
Negative clipper				

Model Graph

Positive Clipper



Negative Clipper

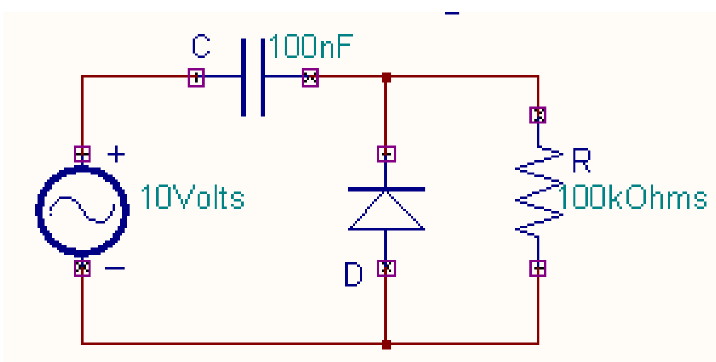


CLAMPER

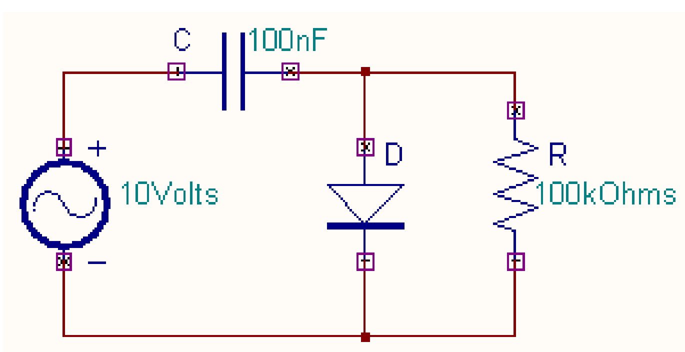
THEORY

A clamper is an electronic circuit that fixes either the positive or the negative peak excursions of a signal to a defined value by shifting its DC value. The clamper does not restrict the peak-to-peak excursion of the signal, it moves the whole signal up or down so as to place the peaks at the reference level. A diode clamp (a simple, common type) consists of a diode, which conducts electric current in only one direction and prevents the signal exceeding the reference value; and a capacitor which provides a DC offset from the stored charge. The capacitor forms a time constant with the resistor load which determines the range of frequencies over which the clamper will be effective

CIRCUIT DIAGRAM OF DIODE POSITIVE CLAMPER



CIRCUIT DIAGRAM OF DIODE NEGATIVE CLAMPER

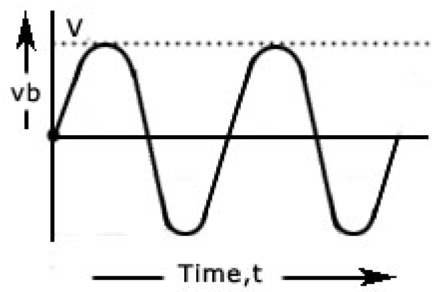


TABULATION

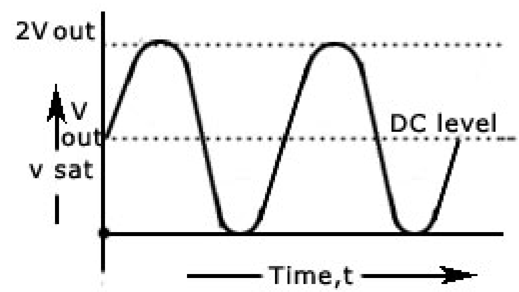
	Input voltage	Output voltage	Input frequency	Output frequency
Positive clamper				
Negative clamper				

MODEL GRAPH

POSITIVE CLAMPER

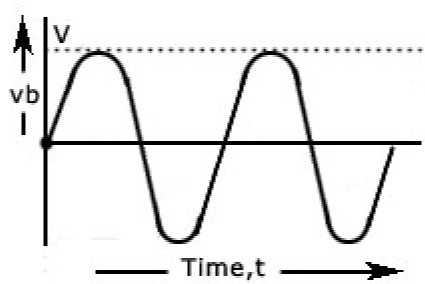


Input signal

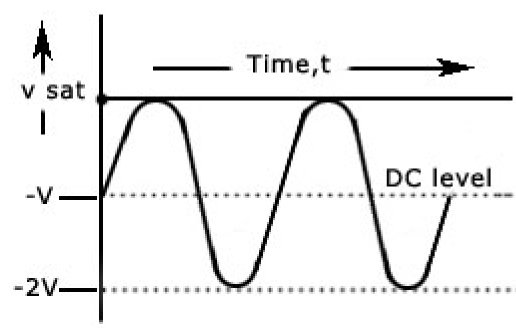


Output Waveform

NEGATIVE CLAMPER



Input signal



Output Waveform

RESULT:

Thus, the clamper circuit was constructed and the output waveforms were obtained