Laboratory Report Cover Sheet

SRM Institute of Science and Technology College of Engineering and Technology Department of Electronics and Communication Engineering
18ECC102J- ELECTRON DEVICES LABORATORY **Third Semester, 2021-22 (Odd Semester)**

Name :

Register Number :

Semester / Year :

Batch :

Venue :

Title of the Experiment :

Date of Performance :

Date of Submission :

Particulars	**Max. Marks**	**Marks Obtained**
Pre Lab	10	
In-Lab Performance	20	
Post Lab	10	
Total	**40**	

REPORT VERIFICATION

Staff Name :

Staff Signature :

1. VI CHARACTERISTICS OF PN JUNCTION DIODE

1.1 Objective

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

1.2 Hardware 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)*M*a	1
05	Voltmeter	MC	(0 – 1)V, (0 – 30)V	1
06	Bread board			1
	Connecting wires			Few

1.3 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.

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 Io=reverse saturation current V=voltage applied to the diode

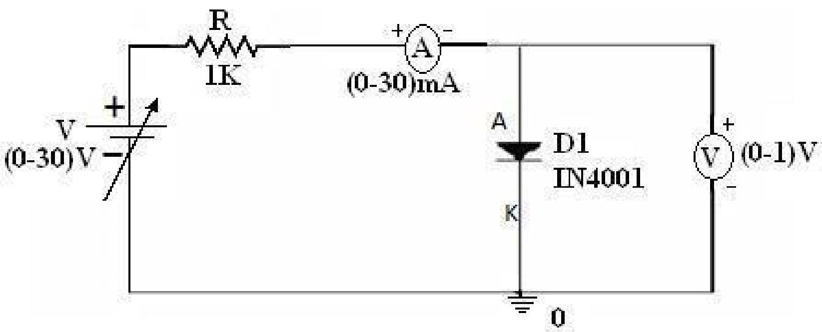
V_T=volt-equivalent of temperature=kT/q=T/11,600=26mV(@ room temp). η=1 (for Ge) and 2 (for Si)

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.

1.4 Circuit diagram:

1.4.1 Forward Bias



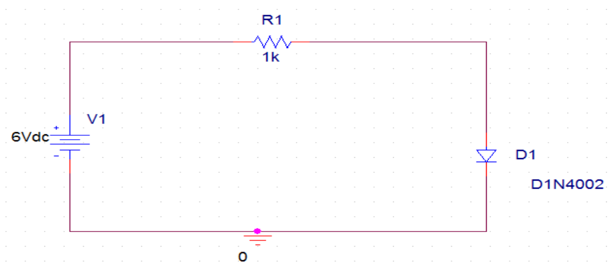
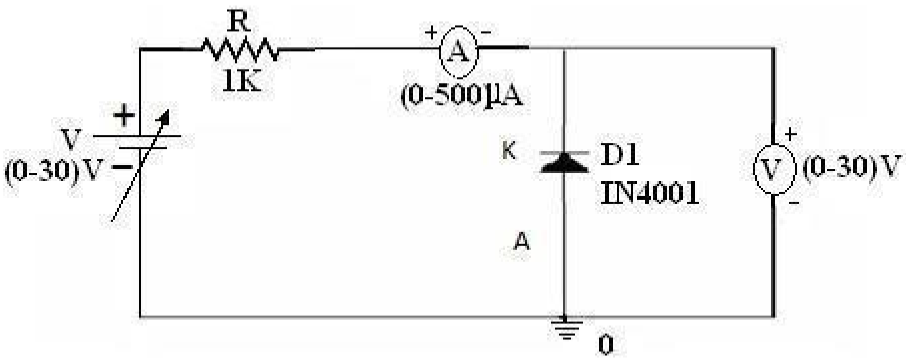


Fig 1.1 Circuit diagram for Forward bias

1.4.2 Reverse Bias



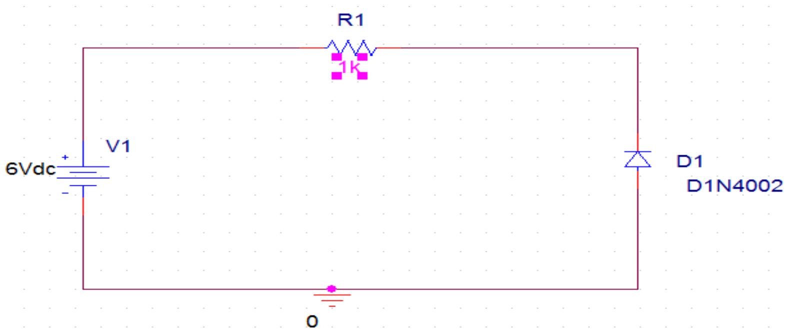


Fig 1.2 Circuit diagram for Reverse bias

1.5 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.

1.6 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.

1.7 Procedure

1.7.1 Forward Biased Condition

1. Connect the PN Junction diode in forward bias i.eAnode 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 1kΩ.
3. For various values of forward voltage (V_f) note down the corresponding values of forward current (I_f).

1.7.2 Reverse Biased condition

4. 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.
5. For various values of (Vr) note down the corresponding values of reverse current (Ir).

1.8 Tabular column

1.8.1 Forward Bias

S. No	V_f (volts)	I_f (mA)

1.8.2 Reverse Bias

S. No	Vr (volts)	Ir (μA)

1.9 Simulation Results

Cut In Voltage =   V

Break Down Voltage =   V

1.10 Model Graph

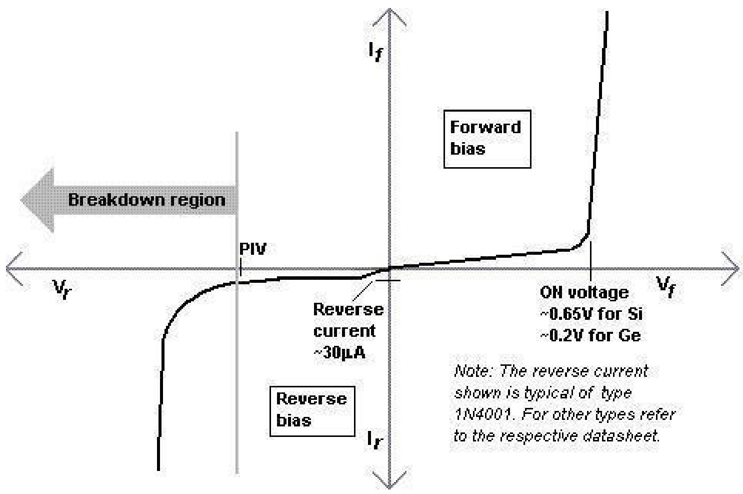


Fig 1.3 Model graph

Forward Bias

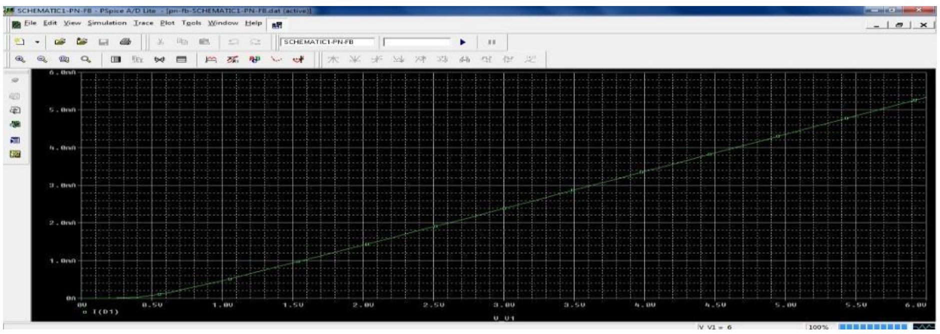


Fig 1.4 PSPICE Simulation output for Forward Bias

Reverse Bias

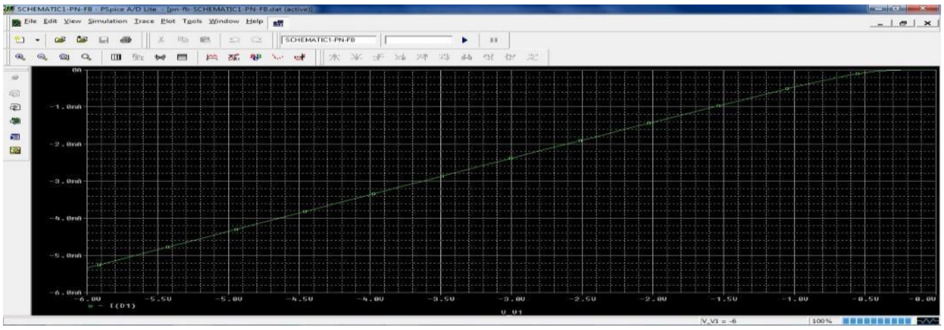


Fig 1.5 PSPICE Simulation output for Reverse Bias

1.11 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} = $(\Delta V_r/\Delta I_r)\ \Omega$

1.12 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. How many types of breakdown come in a diode ?

1.13 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)

Bias	Capacitance (F/cm^2)
0.25	3×10^{-8}
0.0	2.44×10^{-8}
-0.5	1.86×10^{-8}
-0.7	1.72×10^{-8}

Determine the doping of N and P-regions, (b) Determine the built-in voltage

(c) Determine the depletion width at zero bias

6. Design circuits to get the following outputs for the given waveform below.