Experiment # 2(a) Date:

V-I characteristics of PN junction Diode

Aim:
To study the VI characteristics of the PN junction diode using simulation and breadboard setup.

Apparatus required (simulation):
LTSpice software

Apparatus required (hardware setup):

Sl. No.	Item	Range	Quantity
1.	PN junction diode	1N4002	1
2.	Resistor	470Ω	1
3.	Ammeter	0-25 mA 0-500 μA	1 1
4.	Voltmeter	0-1 V 0-10 V	1 1
5.	Breadboard	-	1
6.	Wires	-	As required
7.	Regulated power supply	0-30 V	1

Theory:

A p-n junction is a piece of semiconductor material in which part of the material is p-type and part is n-type. When a junction is formed between p-type and n-type semiconductor materials, the resulting device is called a semiconductor diode. This component offers an extremely low resistance to current flowing in one direction and an extremely high resistance to current flowing in the other. Various types of diodes are available for different applications. These include rectifier diodes for use in power supplies, Zener diodes for use as voltage reference sources, light emitting diodes etc. The connection to the p-type material is referred to as the anode while that to the n-type material is called the cathode.

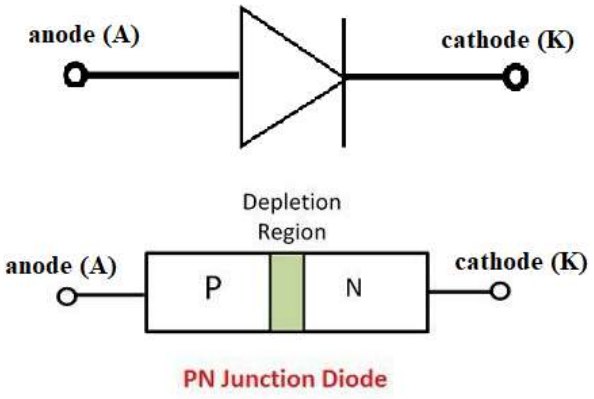

Fig.1

PN junction diode in forward bias

When an external voltage is applied to a p-n junction making the p-type material positive with respect to the n-type material, the p-n junction is forward-biased. The applied voltage opposes the contact potential, and, in effect, closes the depletion layer. Holes and electrons can now cross the junction and current flows. An increase in the applied voltage

above that is required to narrow the depletion layer (about 0.3 V for germanium and 0.7 V for silicon) and will result in a rapid rise in the current flow. The voltage at which the diode starts conducting is called knee voltage or threshold voltage or barrier cut-in voltage. The applied voltage should not be increased beyond a certain safe limit; otherwise, the diode is likely to burn out.

PN junction diode in reverse bias

When an external voltage is applied to a p-n junction making the p-type material negative with respect to n-type material, the p-n junction is reverse biased. The applied voltage is now in the same sense as the contact potential and opposes the movement of holes and electrons due to the opening up of the depletion layer. Thus, in theory, no current flows. However, at normal room temperature, certain electrons in the covalent bond lattice acquire sufficient energy from the heat available to leave the lattice, generating mobile electrons and holes. This process is called electron-hole generation by thermal excitation. The electrons in the p-type material and holes in the n-type material caused by thermal excitation are called minority carriers and these will be attracted by the applied voltage. Thus, in practice, a small current of a few microamperes for germanium and less than one microampere for silicon, at normal room temperature, flows under reverse bias conditions.

A. <u>Software Experiment</u>

Circuit for PN junction diode:

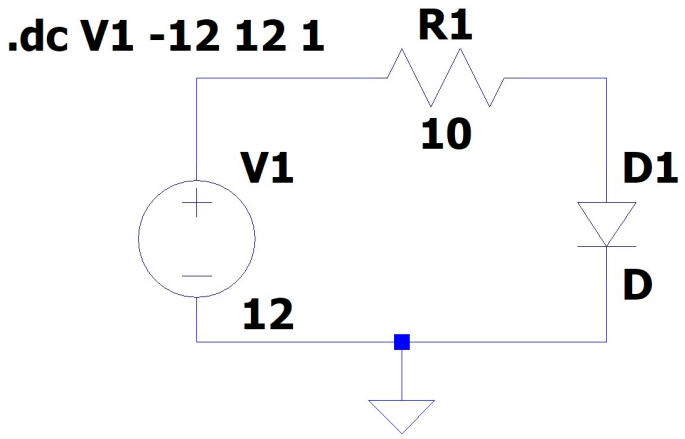

Fig.2

Procedure:

1. Launch LTSpice window.
2. Go to File and then New Schematic
3. Go to Edit and then components and choose the required components and draw the circuit diagram for obtaining the VI characteristics.
4. Set the values of the components as per the circuit diagram.
5. Then go to simulate, edit simulation command and choose DC sweep.
6. Then run the simulation.
7. Record the obtained VI characteristics

VI characteristics of PN junction diode obtained after simulation :

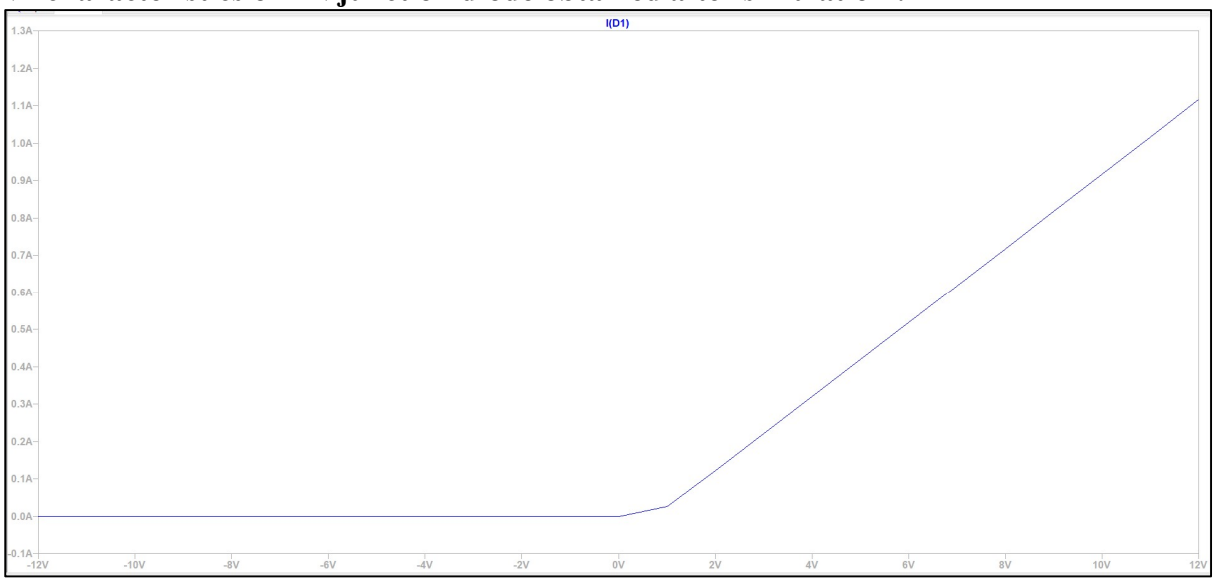

Fig.3

B. Hardware Experiment

Circuit diagram:

1) Forward bias of PN junction diode

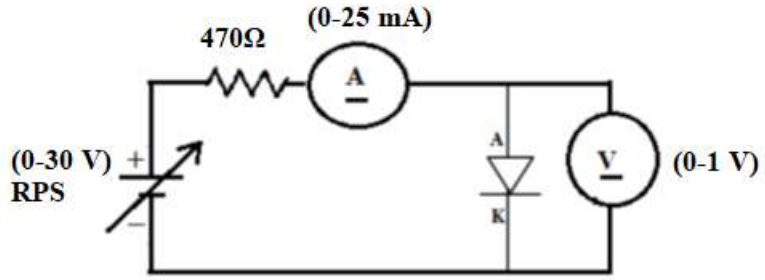

Fig.4

2) Reverse bias of PN junction diode

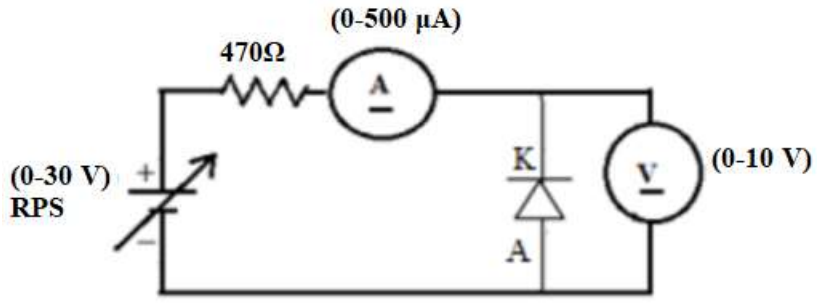

Fig.5

Experimental Procedure:

Forward characteristics:

1. Construct the circuit as per the circuit diagram.
2. Vary the voltage in steps by using the regulated power supply and note down the current in each step correspondingly.

3. Plot the characteristics between forward voltage and forward current, showing the turn-on voltage (cut in voltage / knee voltage) explicitly.

Reverse characteristics:

1. Construct the circuit as shown in the circuit diagram.
2. Vary the voltage in steps by using the regulated power supply and note down the current in each step correspondingly.
3. Plot the characteristics between reverse voltage and reverse current, showing breakdown voltage explicitly.

Tabular column:

1) Forward bias

Sl. No.	Voltage, VF (V)	Current, IF (mA)

2) Reverse bias

Sl. No.	Voltage, VR (V)	Current, IR (μA)

Model Graph:

VI characteristics of PN junction diode

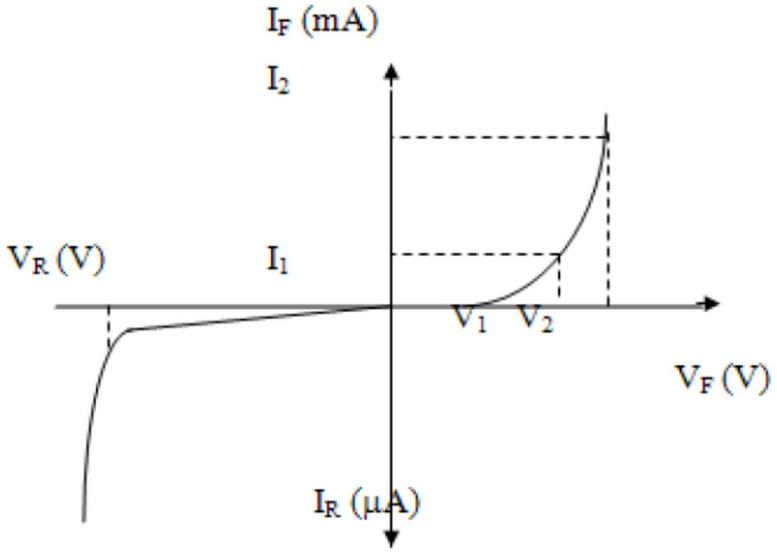

Fig.6

Result:

Thus, the VI characteristics of the PN junction diode were studied using software and hardware setups.