# Four Layer P-N-P-N Switching Devices
# (Shockley Diode)
# Lecture – 3

## TDC PART – II

## Paper - III (Group - A)

## Chapter - 4

**by:**

**Dr. Niraj Kumar,**

**Assistant Professor (Guest Faculty)**

**Department of Electronics**

**L. S. College, BRA Bihar University, Muzaffarpur.**

# Four Layer P-N-P-N Switching Devices (Shockley Diode)

# Lecture – 3

## TDC PART – II

### Paper - III (Group - A)

### Chapter - 4

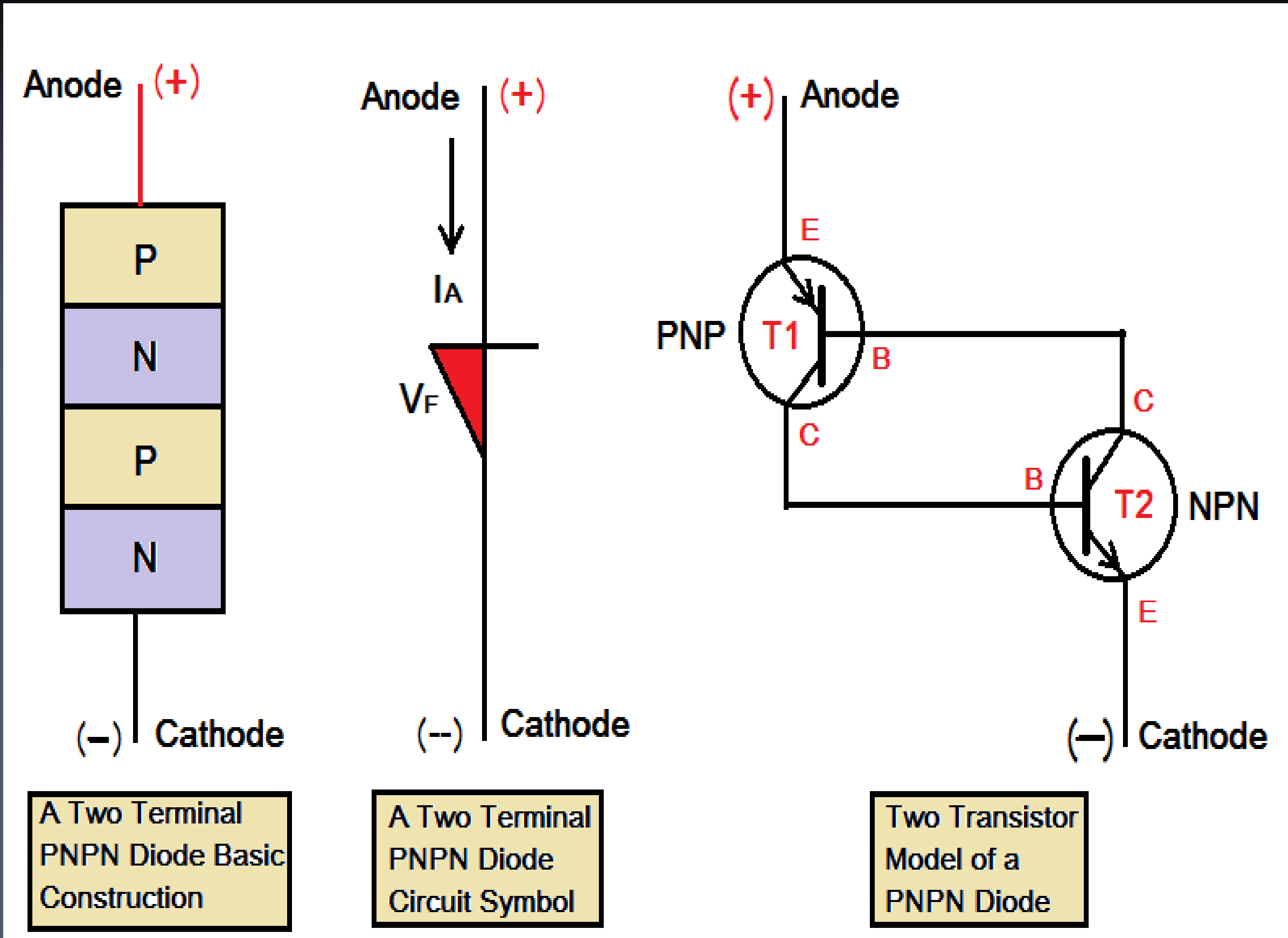
- **P-N-P-N Diode or Shockley Diode**
- **Lecture Content :-**

➢ **(3) Two Terminal P-N-P-N Diode Basic Structure**

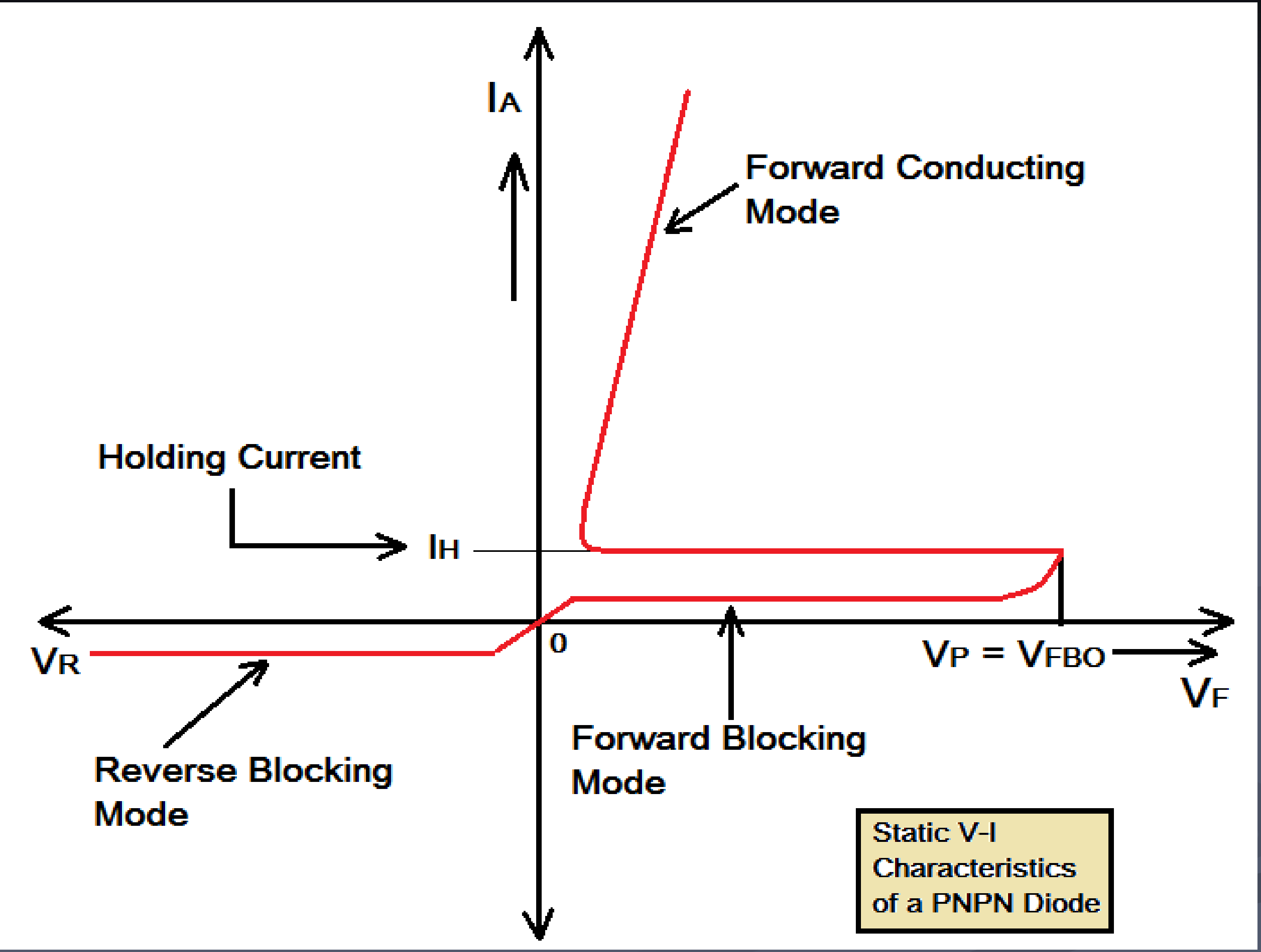
# P-N-P-N Diode or Shockley Diode

- **(3) Two Terminal P-N-P-N Diode Basic Structure**

- The **Shockley Diode** is a **Four Layer P-N-P-N Diode** with only **Two External Terminals** as shown in **Figure (3)** below with its graphical symbol. It is essentially a **Low-Current SCR without a gate.** The **V-I Characteristics,** shown in **Figure (4),** of the device are exactly the same as those encountered for the **SCR** with **$I_G = 0$.**




- **Fig (3)** Shown a Two Terminal P-N-P-N Diode Basic Construction, Circuit Symbol and Two Transistor Model.

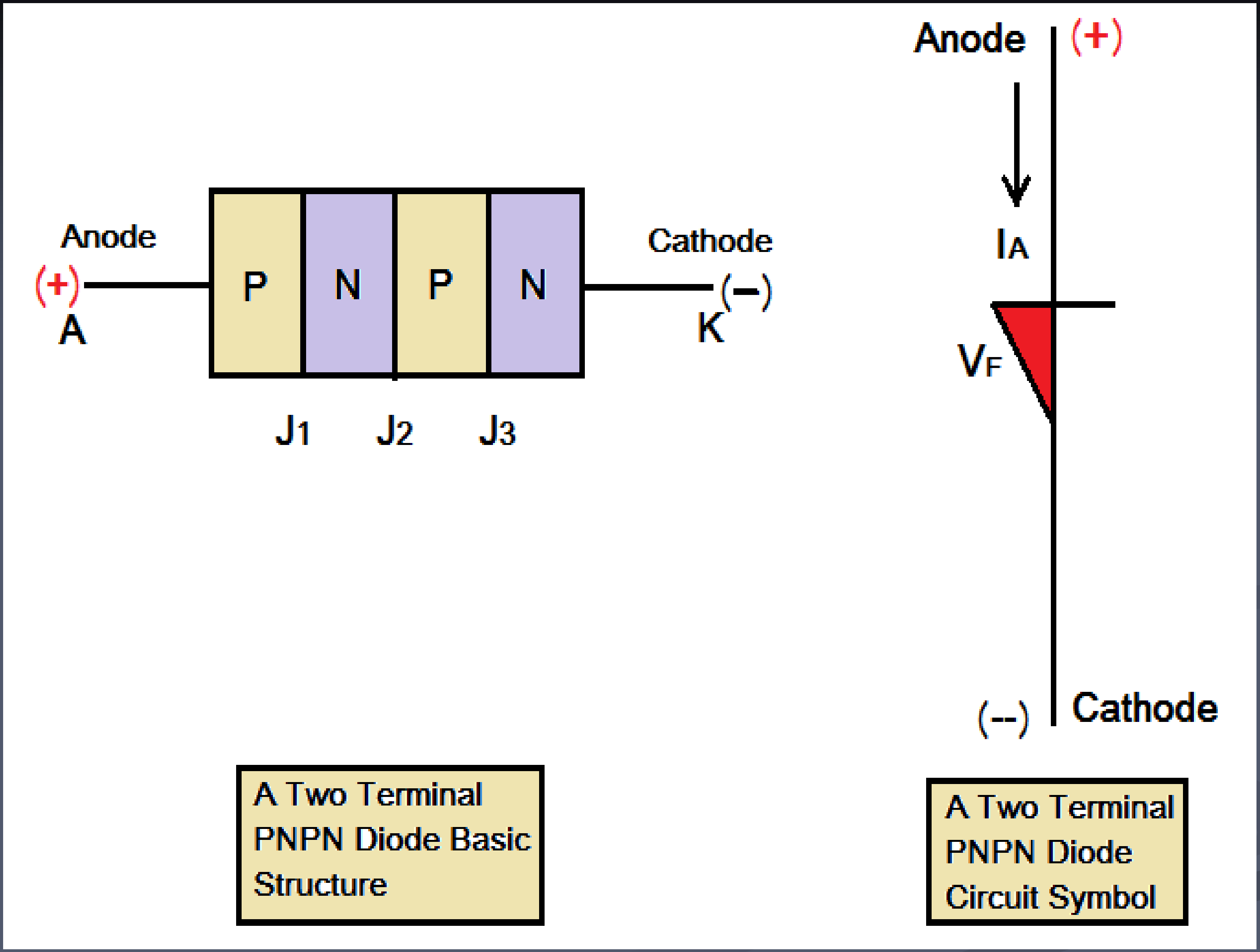



- **Fig (4)** Shown V-I Characteristics of a Four Layer P-N-P-N Diode.

- As indicated by the **V-I Characteristics**, the devices is in the **OFF State (Open-Circuit representation)** until the **Break Over-Voltage** is reached, at which time **Avalanche Conditions** develop and the device **Turned ON (Short-Circuit representation).**

- For switching the **Diode ON,** its **Anode-to-Cathode Voltage ($V_{AK}$)** must be increased to **Forward-Switching Voltage ($V_s$)** which is the equivalent of **SCR Forward Break over Voltage.** Like an **SCR,** it also has a **Holding Current.**

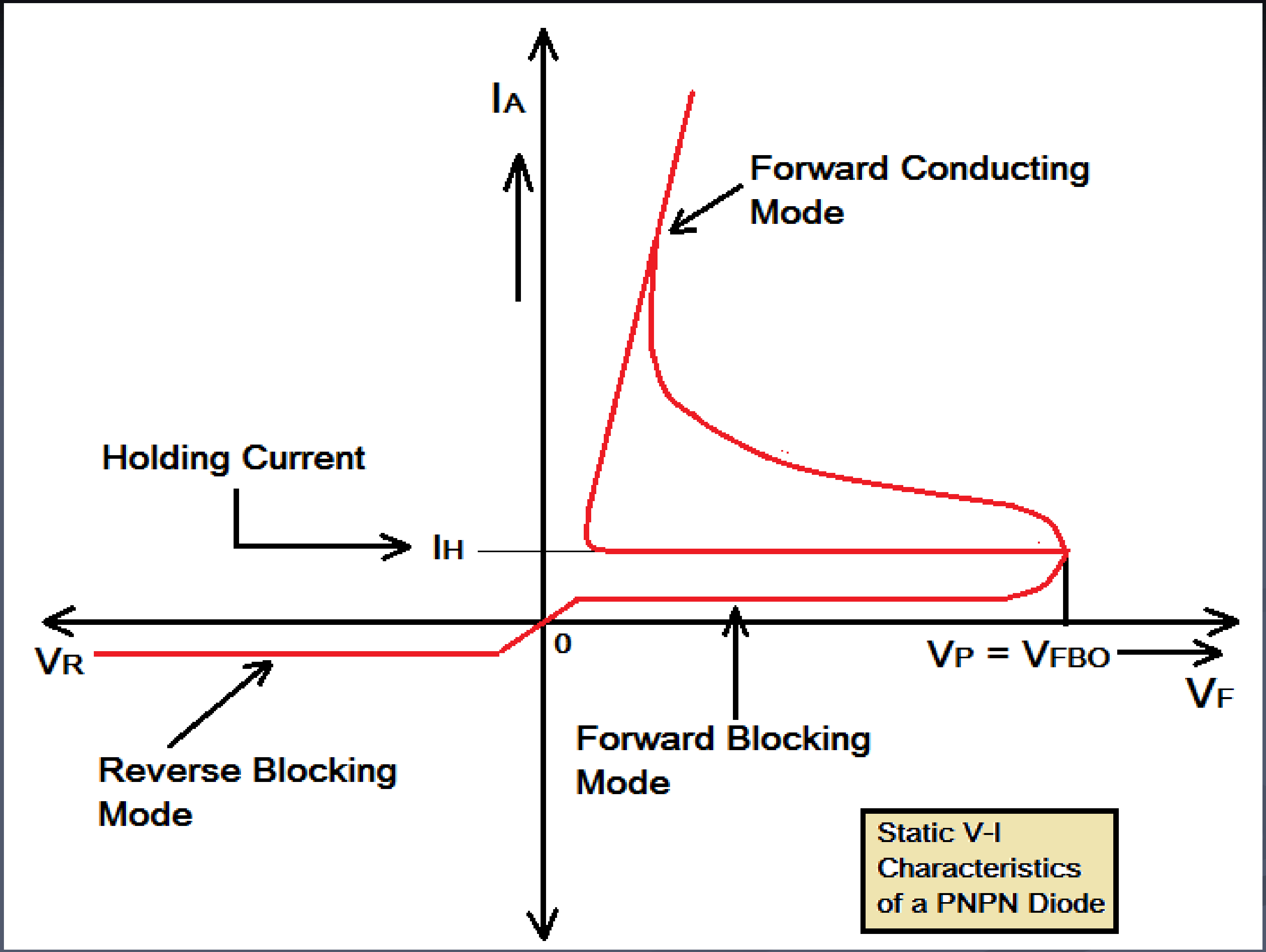
- Now first we consider a **Four-Layer Diode** structure with an **Anode (A) Terminal** at the outside **P-region** with a **Cathode (K) terminal** at the outside **N-region,** Shown in **Figure (5)** below.




- **Fig (5)** Shown a Two Terminal P-N-P-N Diode Basic Structure and Circuit Symbol

- We shall refer to the Junction nearest the **Anode (A) Terminal** as **Junction J1**, the **Centre Junction as J2**, and the junction nearest the **Cathode Terminal as Junction J3.** When the **Anode (A)** is biased **Positively** with respect to the **Cathode (K) (V positive),** the device is said to **Forward Biased.**

- However, as the **V-I characteristic of P-N-P-N Diode** shown in **Figure (6)** below, indicates the **Forward Biased Condition** of this **Diode** can be considered in two separate states, the **High-Impedence** or **Forward-Blocking State** and the L**ow-Impedence** or **Forward-Conducting State**. In the device illustrated here the **Forward V-I Characteristic** switches from the **Blocking State** to the **Conducting States** at a **Critical Peak Forward Voltage $V_P$.**




- **Fig (6)** Shown Static V-I Characteristic of a Two Terminal P-N-P-N Diode.

- We can anticipate the discussion of **Conduction Mechanisms** to follow by noting that an initial **Positive Voltage V places Junction J1 and J3** under **Forward Bias** and the **Centre Junction J2** under **Reverse Bias.** As Voltage **V** is **increased,** most of the **Forward Voltage** in the **Blocking State** must appear across the **Reverse Biased Junction J2.**

- After **switching** to the **Conducting State,** the voltage from **Anode (A)** to **Cathode (K)** is **very small (less than 1V),** and **we conclude that** in this condition **all three junctions must be Forward Bias.**

- The **Mechanism** by which **Junction J2** switches from **Reverse-Bias to Forward Biased** is the subject of much of the discussion to follow.

- In the **Reverse Blocking State (V negative), Junction J1 and J3** are **Reverse Biased** and **Junction J2 is Forward Biased.** Since the supply of **Electrons and Holes** to **Junction J2** is restricted by the **Reverse Biased junctions** on either side, the device current is limited to a **small saturation current arising from Thermal Generation of EHPs near Junction J1 and J3.**

- The current remains small in the **Reverse Blocking Condition** until **Avalanche Breakdown** occurs at a **Large Reverse Bias.** In a properly designed device, with **guard** against **Surface Breakdown**, the **Reverse-Breakdown Voltage** can be **several thousand volts.**

- We shall now consider the **Mechanism** by which the device, often called a **Shockley Diode,** switches from the **Forward-Blocking State to the Forward Conducting State.**

**to be continued ..............**