Four Layer P-N-P-N Switching Devices (Shockley Diode) Lecture – 6

TDC PART – II

Paper - III (Group - A)

Chapter - 4

by:

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Four Layer P-N-P-N Switching Devices (Shockley Diode)
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- **P-N-P-N Diode or Shockley Diode**
- **Lecture Content :-**

➢ **(6) Various States in V-I Characteristics of Two Terminals P-N-P-N Diode or Shockley Diode**

➢ **(I) Forward Blocking State (OFF-State),**

P-N-P-N Diode or Shockley Diode

- **(6) Various States in V-I Characteristics of Two Terminals P-N-P-N Diode or Shockley Diode**

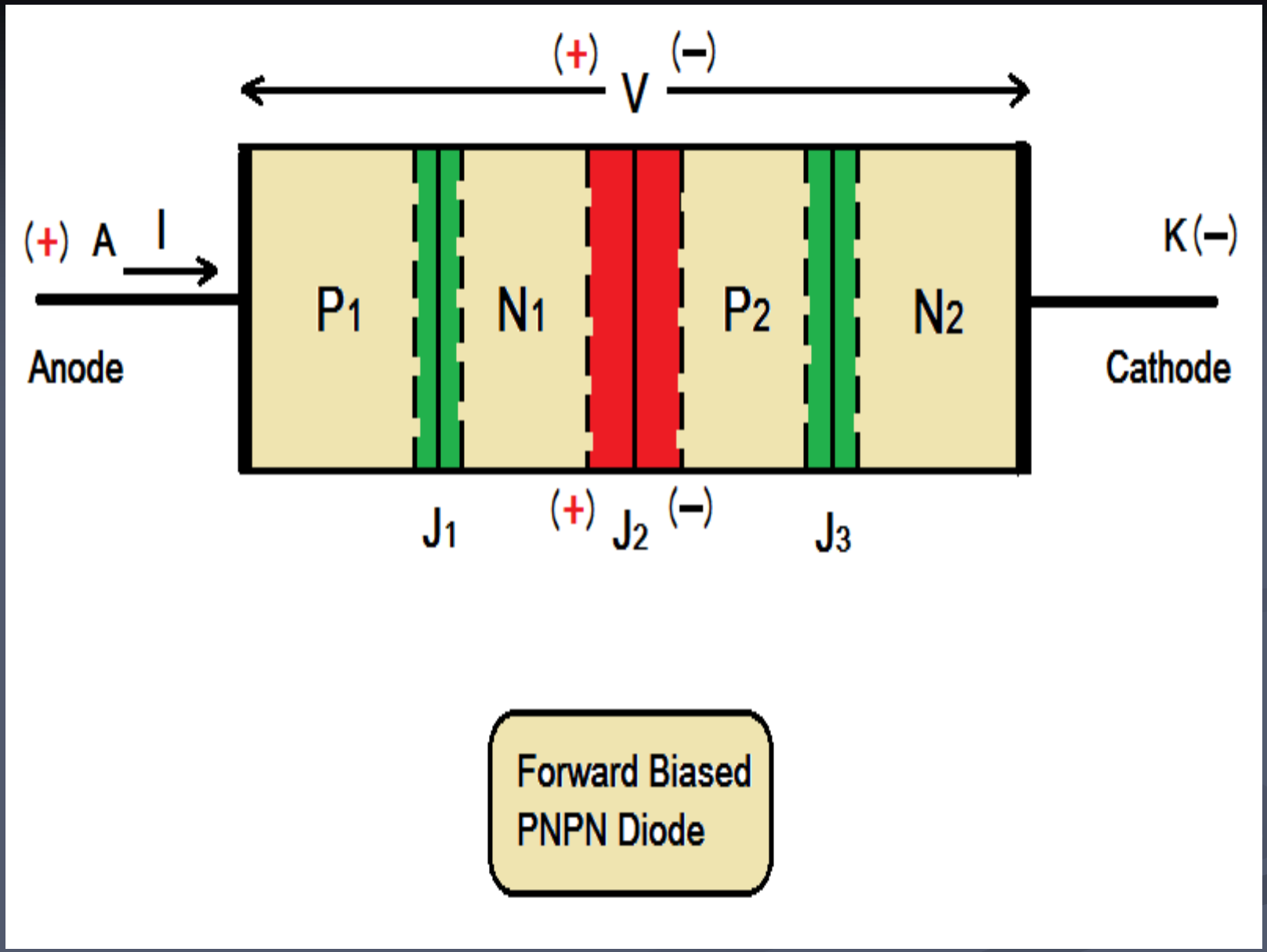
- A careful observation and detailed study of the **V-I characteristics** reveal that the **Two Terminal P-N-P-N Diode or Shockley Diode** has **three basic State of operation** namely the,

- **(I) Forward Blocking State (OFF-State),**
- **(II) Forward Conduction State (ON-State), and**
- **(III) Reverse Blocking State (OFF-State)**

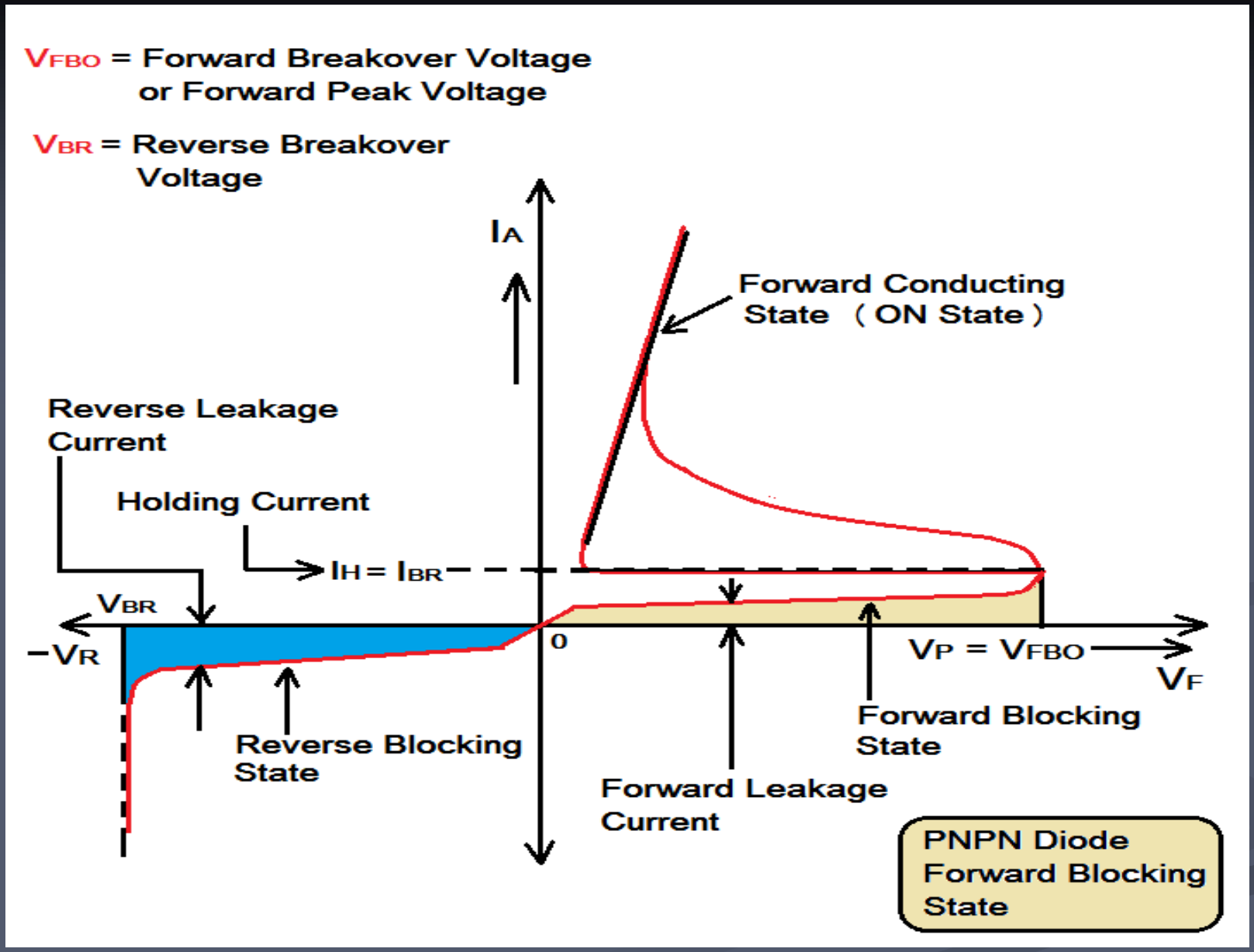
- The above basic State of Operations is discussed in great details below, to **understand the overall characteristics of a Two Terminal P-N-P-N Diode or Shockley Diode**. Let us now discuss each of the **Three State** one by one,

(I) Forward-Blocking State (OFF-State)

- When the device is **Biased in the Forward-Blocking State,** Shown in **Figure (12)** below, the **applied Voltage V** appears primarily across the **Reverse-Biased Junction J2.** Although **Junction J1 and J3 are Forward Biased,** the **Current is small.** The reason for this becomes clear if we consider the **Supply of Electrons available to N1 region and Holes to P2 region.**



- **Fig. (12)** Shown Forward Biased P-N-P-N Diode



- **Fig. (13)** Shown Forward Blocking State of a P-N-P-N Diode V-I Characteristics.

- Focusing attention first upon **Junction J1,** let us assume a **Hole is Injected from P1 region into N1 region.** If the **Hole recombines** with an **Electron in N1** (or in the **Junction J1** transition region), the **Electron must be resupplied to the N1 region** to **maintain Space Charge Neutrality.** The **supply of Electrons** in this case is severely restricted, however, by the fact that **N1 region** is terminated in **Junction J2, a Reverse Biased Junction.**

- In a normal **P-N Diode** the **N region is terminated in an Ohmic Contact,** so that the **supply of Electrons** required to **match recombination (and injection into P region) is unlimited.** In this case, however, the **Electron Supply** is **restricted essentially** to those **Electrons Generated Thermally** within a **Diffusion Length of Junction J2.** As result, the **Current passing through the J1 Junction is approximately the same as the Reverse Saturation Current of Junction J2.**

- A similar argument holds for the **Current through Junction J3; Holes** required for **injection into N2 region** and to **feed recombination in P2 region** must originate in the **Saturation Current of the Centre Junction J2.** The applied **Voltage V divides appropriately among the Three Junctions J1, J2, and J3** to accommodate this **Small Current throughout the device.**

- In this discussion we have tacitly assumed that the **Current crossing Junction J2 is strictly the Thermally Generated Saturation Current.** This implies that **Electrons injected by the Forward-Biased Junction J3** do not **Diffuse across P2 region** in any substantial numbers, to be **swept across the Reverse-Biased Junction into N1 region** by **transistor action.**

- This is another way of saying that **α_2** (for the **"N-P-N Transistor"**) are small. Similarly, the **supply of Holes of P2 region is primarily Thermally Generated,** since **few Holes Injected at Junction J1 reach Junction J2 without recombination** (i.e., **α_1** is small for the **"P-N-P Transistor"**).

- Now we can see physically why **Equation (6)** **implies** a **Small Current while** $\alpha 1 + \alpha 2$ **is small;**
- $I_a = I_{CBO1} + I_{CBO2} / 1 - (\alpha 1 + \alpha 2)$

..... (6)

- without the **Transport of Charge** provided by **Transistor Action,** the **Thermal Generation of Carries is the only significant source of Electrons to N1 region and Holes to P2 region.**

to be continued .....