Four Layer P-N-P-N Switching Devices (Shockley Diode) Lecture – 1

TDC PART – II

Paper - III (Group - A)

Chapter - 4

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Introduction of Four Layer P-N-P-N Switching Devices

- One of the most common applications of an **Electronic Devices is in Switching,** which requires the device to change from an **"OFF" or Blocking State** to an **"ON" or Conducting State.** We have discussed in this chapter, the use of **Transistor** in this application, in which **Base Current** derives the device from **Cut-OFF** to **Saturation.** Similarly, **Diodes** and other type of **Semiconductor Devices** can be used to serve as certain types of **Switches.**

- There are a number of important switching applications that require a devices remain in the **Blocking State** under **Forward Bias** until switched to the **Conducting State** by an **External Signal.** Several devices with fulfil this requirement have been developed, and we shell discuss a family of **Four Layers Semiconductor Switching Devices** in this Chapter, the **Semiconductor or Silicon Controlled Rectifier (SCR)** and related **Devices.**

- These devices are typified by **High Impedance (OFF Condition)** under **Forward Bias** until a **Switching Signal** is applied; after switching they exhibit **Low Impedance (ON Condition).** The signal required for switching can be varied externally; therefore, these devices can be used to **Block or Pass Currents at predetermined levels.**

- Actually these are **Breakdown Devices.** Basically these are **Four Layer Solid State P-N-P-N Devices** whose working depends on the phenomenon of **Avalanche Breakdown.** They are some times referred to by the **Generic Name** of "**Thyristor"** which is a **Semiconductor Switch** whose **Bi-Stable Action** depends on **P-N-P-N Regenerative Feedback.** We will discuss the following devices :-

- 1). P-N-P-N Diode or Shockley Diode
- 2). Silicon Controlled Rectifier (SCR)
- 3). Diac
- 4). Triac
- 5). Uni-Junction Transistor (UJT)
- 6). Programmable Uni-Junction Transistor (PUT)
- 7). Silicon Controlled Switch (SCS)
- 8). Light Activated SCR (LASCR) etc.

- These above listed devices have **Two or more Junctions** and can be **Switched ON or OFF** at an **Extremely Fast Rate.** They are also referred to as **Latching Devices. A Latch is kind of switch which initially once closed, remains closed until someone opens it.**

- The idea for the **Thyristor** is not new. The idea for the device was first put forward in **1950 by William Shockley,** one of the **inventors of the transistor.** Although some later the mechanism for the operation of **Thyristor also called SCR** was analysed further in **1952 by Ebers. Then in 1956 Bell Labotories** were the **first to fabricate a silicon based semiconductor device called "THYRISTOR"**.

- Its **first prototype** was **introduced by GEC Company (USA) in 1957.** Commercially, the **first silicon controlled rectifiers** became **available in the early 1960s** where it started to gain a significant level of popularity for power switching. With a small device **"Thyristor"** can control large amounts of **Voltage and Power.** This company did a great deal of **Pioneering Work** about the utility of **"Thyristors"** in the **Industrial Applications.**

- Later on, many other devices having characteristics similar to that of a **"Thyristor"** were developed. These **Semiconductor Devices,** with their characteristics identical with that of a **Thyristor,** are,

- 1). **Bidirectional Triode Thyristors** or **Triac,**
- **2). Bidirectional Diode Thyristors or Diac,**
- **3). Silicon Controlled Switch (SCS),**
- **4). Programmable Uni-Junction Transistor (PUT),**
- **5). Gate Turn-OFF Thyristor (GTO),**
- **6). Reverse Conducting thyristors (RCT)** etc.

- This whole family of **Semiconductor Devices** is given the name **"Thyristor".** Thus the team **"Thyristor"** denotes a family of **Semiconductor Devices** used for **Power Control in AC and DC systems.**

- The **P-N-P-N Devices** with **zero, one or two gates** constitute the basic thyristor. But today the thyristor family includes other similar multilayer devices also. The complete list of thyristor family members include,

- **1). Diac (Bidirectional Diode Thyristor),**
- **2). Triac (Bidirectional Triode Thyristor),**
- **3). SCR (Silicon Controlled Rectifier),**
- **4). Shockley Diode, SCS (Silicon Controlled Switch),**

- 5). SBS (Silicon Bilateral Switch),
- 6). SUS (Silicon Unilateral Switch) also known as Com-plementary SCRor CSCR, 7). LASCR (Light Activated SCR),
- 8). LAS (Light Activated Switch) and
- 9). LASCS (Light Activated SCS).

- One oldest member of this **Thyristor Family, called Silicon Controlled Rectifier (SCR),** is the most widely used device. **The most important member of the Thyristor family is the Silicon Controlled Rectifier (SCR).** SCR is a **Four Layer (P-N-P-N), Three Junction Semiconductor Devices** with **Three Terminals, namely,** the **Anode (A)**, the **Cathode (K) and** the **Gate (G).** It is a **Unilateral Device** and conduction takes place from **Anode (A) to Cathode (K)** under proper **Bias Conditions (forward bias).**

- At present, the use of **Silicon Controlled Rectifier (SCR)** is so vast that over the years, the word "**Thyristor"** has become **Synonymous with SCR.** It appears that the team **"Thyristor"** is now becoming more common than the actual team **SCR.** In this **Chapter,** the term "**SCR" and "Thyristor"** will be used at random for the same device **Silicon Controlled Rectifier (SCR).** Other members of **"Thyristor"** family are also discussed in this chapter.

- **Diacs and Triacs** are **Bidirectional Devices.** The **Diac** is a **Two-Terminal, Three Layer Device** and is commonly used for **Triggering Triacs.** The **Triac** is a **3-Terminal Semiconductor Device** and may be considered equivalent to **two SCRs** connected in **Anti Parallel. Shockley Diode** is a **Two Terminal Reverse Blocking Diode Thyristor having no Gate. SCS (Silicon Controlled Switch)** is similar to **SCR** except that it has **Two Gates** and can be **Turned-ON or OFF by either Gate (G).**

- **SUS (Silicon Unilateral Switch)** has **Gate (G) on the Anode (A) side** and can be employed as a **Programmable Uni-Junction Transistor (PUJT). SBS (Silicon Bilateral Switch)** is a device consisting of **two identical SUS Structures** arranged in **Anti Parallel** but having only **One Gate** that is used only for **External Synchronization or for proper biasing. LASCR** is the **Light-Activated SCR** which is **Turned ON by Photon Bombardment.**

- **UJT (unijunction transistor),** unlike a **bipolar transistor** has only **one junction,** and **like other conventional transistors,** it **processes the transistor action** and **operates like a switch.** The **characteristics of UJT** are similar to those of a **SUS.** Its **construction is**, however, different and it does not belong to **thyristor family.**

- A **“Thyristor”** has characteristics similar to a **“Thyratron Tube”.** But from the construction view point, a **Thyristor (a P-N-P-N device)** belongs to **Transistor (PNP or NPN device)** family. The name **“Thyristor”** is derived by combination of the **Capital Letters** from **“THYRatron”** and **“transISTOR”.**

- This means that **"Thyristor"** is a **Solid State Device** like a "**Transistor"** and has characteristics similar to that of a **"Thyratron Tube".** The present day we are not be familiar with **"Thyratron Tube"** as this is not being taught these days.

- The objective of this **Chapter** is to discuss the **"Thyristor" Construction, Operation, its Characteristics, Rating and Application** and other related topics useful for their applications

to be continued .....