Electronic Basics #20: Thyristor, Triac || Phase Angle Control

Introduction to Thyristors

A **thyristor** is a **semiconductor switching device** used in high-power applications, acting as a controlled rectifier. It allows current to flow only when a **gate pulse** is applied and remains conducting until the main circuit current drops below a certain level. Thyristors are widely used in **power control, motor drives, and AC voltage regulation**.

Structure of a Thyristor

A thyristor consists of **four alternating layers of P-type and N-type semiconductor material (PNPN structure)**, forming **three junctions (J1, J2, and J3)**. It has three terminals:

- **Anode (A)** – Connected to the positive voltage supply.
- **Cathode (K)** – Connected to the load or ground.
- **Gate (G)** – Controls the switching of the thyristor.

When a **small current** is applied to the **gate terminal**, the thyristor turns **ON**, allowing a large current to flow from **anode to cathode**. Once turned ON, the thyristor remains conducting even if the gate signal is removed, provided the current remains above the **holding current**.

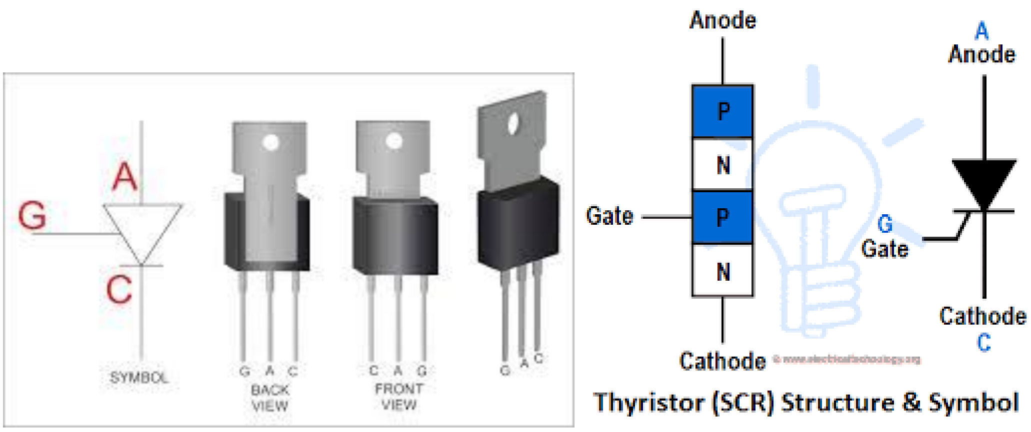

Fig20.1: Thyristor Diagram

Controlling Phase Angle Using MOSFET

In **AC power control**, a **thyristor** can be turned ON at a specific phase angle of the **AC cycle** to regulate power delivery. The key to controlling the phase angle is **delaying the thyristor triggering** using an external circuit.

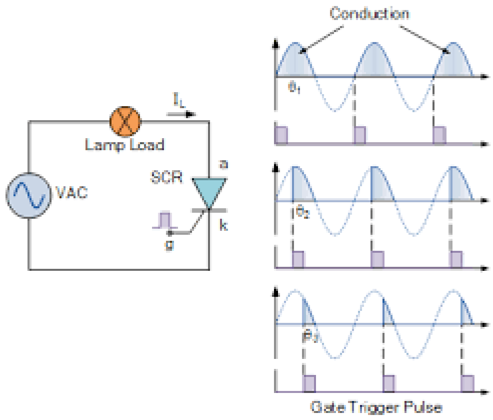

Fig20.2: Waveshape at different firing angle

Using a MOSFET to Interrupt Gate Current

A **MOSFET** can be used to interrupt the **gate current**, allowing precise control of the thyristor's operation:

1. **Initial Condition**: The **MOSFET is OFF**, and no gate current flows, preventing the thyristor from turning ON.
2. **Triggering the Gate**: The MOSFET is turned ON at a specific phase angle, allowing a pulse to reach the thyristor's gate. This triggers conduction.
3. **Interrupting the Current**: The MOSFET can be used to **block or limit the gate current**, controlling when the thyristor turns ON in each cycle.
4. **Phase Angle Control**: By adjusting the timing of the MOSFET switching, the **thyristor's conduction phase** can be controlled, effectively regulating power.

This technique is widely used in **AC dimmers, motor speed control, and heating applications**.

Effects of AC Voltage on Thyristor Operation

1. **Forward Blocking Mode**: When **positive AC voltage** is applied to the anode but the gate signal is absent, the thyristor remains OFF, blocking the current.
2. **Forward Conduction Mode**: Once the gate signal is applied, the thyristor **latches ON**, allowing current to flow for the remaining AC half-cycle.
3. **Commutation (Turn OFF)**: In an AC circuit, when the voltage **reverses polarity**, the current naturally drops to zero, turning the thyristor OFF.
4. **Harmonics and Power Factor Effects**: Controlling phase angle introduces **harmonics**, affecting power quality and power factor, requiring filtering techniques.

Applications of Thyristors with Phase Angle Control

- **Light Dimmers** – Adjusting brightness by controlling the **conduction angle**.
- **Motor Speed Control** – Regulating AC power to control speed.

- **Heaters and Industrial Power Control** – Using phase control to manage heating elements.
- **AC Voltage Regulation** – Thyristors in **power electronics** regulate voltage in AC applications.

Thyristors are essential components in **power electronics**, capable of efficiently switching and controlling AC power. By using **MOSFETs to control gate current**, precise **phase angle control** is achieved, optimizing **power delivery and efficiency**. However, phase control introduces **harmonics and power quality issues**, which must be managed using appropriate filtering techniques.