SNS COLLEGE OF TECHNOLOGY

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DEPARTMENT OF AUTOMOBILE ENGINEERING

COURSE NAME : 23AUB201 – AUTOMOTIVE ELECTRICAL DRIVES AND CONTROLS

II YEAR / III SEMESTER

Unit 4 – Power Electronic Devices

Topic : Steady state and switching characteristics of Power diodes

INTRODUCTION

- The steady-state and switching characteristics of power diodes are critical parameters that define their performance in power electronics applications.
- Power diodes are designed to handle high currents and voltages, making them ideal for rectification in power supplies, inverters, and other high-power applications.
- Understanding these characteristics is essential for designing reliable and efficient power electronics circuits.

STEADY STATE CHARACTERISTICS

- **Forward Voltage Drop (V_F)**: When forward-biased (anode voltage > cathode voltage), the power diode conducts current with a small voltage drop across it. For power diodes, this forward voltage drop typically ranges from 0.7V to 1.2V (for silicon diodes) and is a key factor in power loss, as power dissipation ($P = v_F \times I$) increases with higher currents.
- **Forward Current (I_F)**: This is the maximum current the diode can conduct in the forward direction. It is specified as a maximum continuous current (average current rating) and a peak forward current, which the diode can handle for short periods.

STEADY STATE CHARACTERISTICS

- **Reverse Blocking Voltage (V_R)**: When reverse-biased (cathode voltage > anode voltage), the diode ideally blocks current flow. The maximum reverse voltage the diode can withstand without breaking down is called the **peak reverse voltage** (PRV) or **reverse repetitive peak voltage** (V_{RRM}).
- **Reverse Leakage Current (I_R)**: In practice, a small leakage current flows when the diode is reverse-biased. This current is usually very small (in microamps) and increases with temperature. While leakage current does not significantly impact circuit operation, it contributes to minimal power loss

SWITCHING CHARACTERISTICS

- **Forward Recovery Time (t_{fr})**:
  - When the diode is switched from reverse bias to forward bias, there is a brief delay before it reaches its steady-state forward voltage.
  - During this time, the voltage across the diode gradually drops to the forward voltage.
  - Forward recovery time is usually short but can impact the efficiency in high-speed circuits.

SWITCHING CHARACTERISTICS

- **Reverse Recovery Time (t_{rr})**:
  - When the diode switches from forward bias to reverse bias, it does not immediately block current.
  - There is a brief period where the diode allows reverse current to flow as it clears excess charge carriers from its junction.
  - This time interval is called **reverse recovery time**, and it consists of:
    - ✓ **Storage Phase**: Initial phase where stored charge carriers are being removed.
    - ✓ **Decay Phase**: Remaining phase where reverse current decays to zero.

SWITCHING CHARACTERISTICS

- **Reverse Recovery Charge (Q_{rr}):**
  - The total charge that flows during the reverse recovery time.
  - This charge is proportional to the time and magnitude of reverse recovery current and contributes to switching losses.
  - Reducing Q_{rr} is essential for high-frequency applications, as it helps to minimize energy loss and improve efficiency.

SWITCHING CHARACTERISTICS

- **Reverse Recovery Current (I_{rr}):**
  - The peak reverse current that flows during reverse recovery.
  - This current can cause power losses and generate electromagnetic interference (EMI) in high-speed circuits.
  - Lower I_{rr} values are preferable for efficient performance.

TYPES OF POWER DIODE AND ITS SWITCHING CHARACTERISTICS

Standard (or General-Purpose) Diodes:

- . Moderate reverse recovery time and high power handling.
- Commonly used in low- to medium-frequency applications, such as rectifiers in power supplies

Fast Recovery Diodes:

- Designed with shorter reverse recovery times and lower Q_{rr} than standard diodes.
- Ideal for high-frequency applications, such as switching power supplies and motor drives.

TYPES OF POWER DIODE AND ITS SWITCHING CHARACTERISTICS

Schottky Diodes:

- Have very low forward voltage drop and negligible reverse recovery time (no stored charge in the junction).
- Suitable for high-frequency and low-voltage applications but limited by relatively low voltage ratings.

Ultra-Fast Recovery Diodes:

- Have extremely short reverse recovery times and low reverse recovery current.
- Used in high-speed circuits that require minimal switching losses and high efficiency.

IMPLICATION IN POWER ELECTRONICS APPLICATION

- **Power Losses**: Both forward voltage drop (in steady state) and reverse recovery characteristics (in switching) contribute to power losses in diodes. Devices with lower V_F and minimal t_{rr} are preferable for energy-efficient applications.
- **Thermal Management**: High switching frequencies increase switching losses, requiring effective thermal management to dissipate heat and ensure reliability.
- **Efficiency in High-Frequency Circuits**: Fast recovery and Schottky diodes are ideal for high-frequency applications where minimal reverse recovery losses are essential for maintaining efficiency and reducing EMI

THANK YOU !!!