

Contents – *High-Speed Semiconductor Devices*

1. Fundamentals of High-Speed Semiconductor Devices

- Physical limits of device speed
- Carrier transport mechanisms
- Carrier mobility
- Transit time
- RC delay and parasitic effects

Key Idea

Device speed is primarily limited by carrier transit time, parasitic capacitances, and resistive losses.

2. High-Speed PN Junction Diodes

- PN junction theory
- Junction capacitance
- Diffusion capacitance
- Switching characteristics
- Fast recovery diodes

Applications

- High-speed switching circuits
 - Power electronics
 - Microwave systems
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3. Schottky Barrier Diodes

- Metal-semiconductor contacts
- Schottky barrier formation
- Thermionic emission
- Switching performance

Advantages

- Very low switching time
- Low forward voltage drop
- High-frequency operation

4. High-Frequency Bipolar Junction Transistors (BJTs)

- BJT operation principles
- Current gain
- Base transit time
- Frequency response
- Cutoff frequency (f_{Tf_TfT})

Important Parameters

- Current gain (β)
- Transition frequency (f_{Tf_TfT})
- Maximum oscillation frequency ($f_{max_max}f_{max}$)

5. MESFET Devices

- Metal-Semiconductor Field-Effect Transistors
- Gallium Arsenide (GaAs) technology
- Microwave performance

Features

- High electron mobility
- Excellent RF characteristics

6. Junction Field-Effect Transistors (JFETs)

- Channel control
- Current-voltage characteristics
- Frequency limitations

7. High-Speed MOSFETs

- MOS structure
- Channel-length scaling
- Short-channel effects
- Velocity saturation

Key Concepts

- Device scaling
 - CMOS technology
 - VLSI applications
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8. High Electron Mobility Transistors (HEMTs)

- Heterostructures
- Two-dimensional electron gas (2DEG)
- Ultra-high-speed operation

Applications

- Satellite communications
 - Radar systems
 - Millimeter-wave circuits
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9. Heterojunction Devices

- Band-gap engineering
- Carrier confinement
- Heterostructure physics

Examples

- HEMTs
 - HBTs
 - Semiconductor lasers
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10. Heterojunction Bipolar Transistors (HBTs)

- Wide-bandgap emitter design
- Enhanced carrier injection
- High-frequency performance

Advantages

- High gain
- High-speed switching
- Low noise

11. Microwave and RF Device Performance

- Small-signal models
- S-parameters
- Noise characteristics
- Power gain

12. Device Reliability and Performance Limits

- Thermal effects
- Breakdown mechanisms
- Hot-electron effects
- Reliability concerns