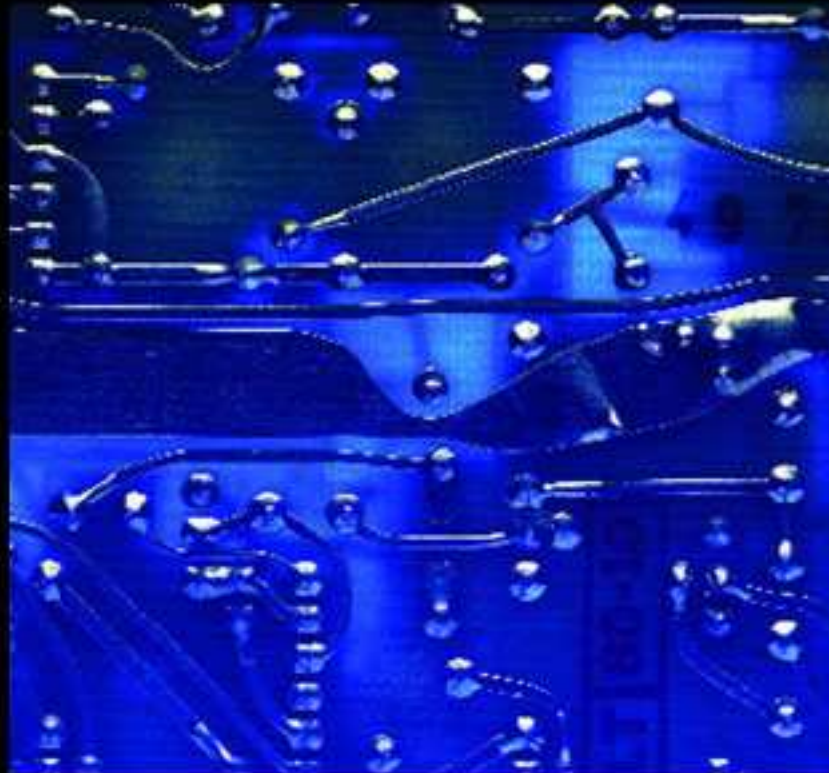


# ELECTRONIC DEVICES AND CIRCUIT THEORY

TENTH EDITION

BOYLESTAD



PEARSON

## Chapter 16 Other Two-Terminal Devices

# Other Two-Terminal Devices

**Schottky diode**  
**Varactor diode**  
**Power diodes**  
**Tunnel diode**  
**Photodiode**  
**Photoconductive cells**  
**IR emitters**  
**Liquid crystal displays**  
**Solar cells**  
**Thermistors**

# Schottky Diode

Also called **Schottky-barrier**, **surface-barrier**, or **hot-carrier diode**.

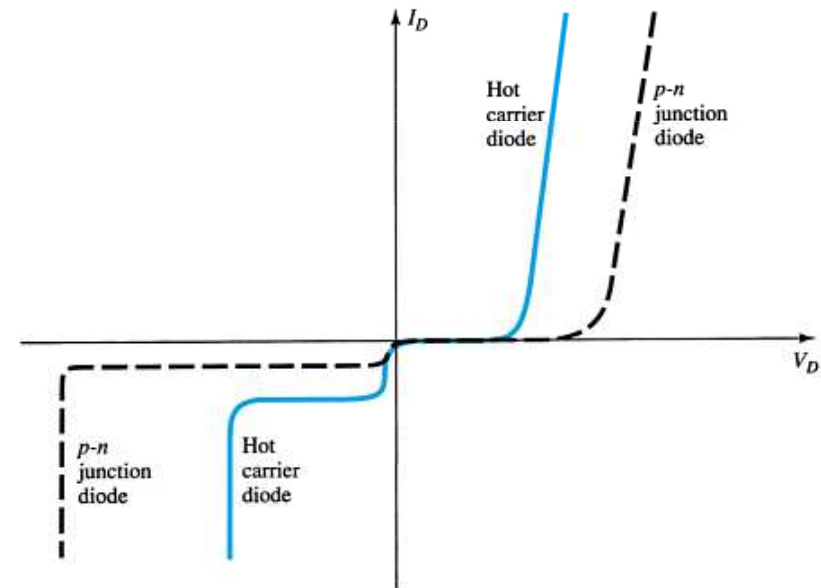
## Characteristics

(Compared with general-purpose diodes)

- **Lower forward voltage drop (0.2-.63V)**
- **Higher forward current (up to 75A)**
- **Significantly lower PIV**
- **Higher reverse current**
- **Faster switching rate**

## Applications

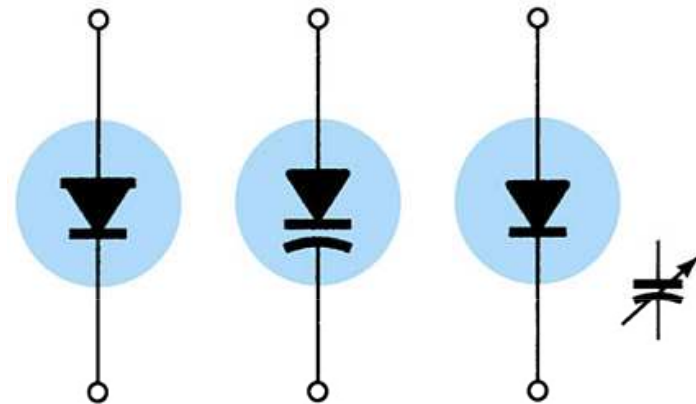
- High frequency switching applications
- Low-voltage high-current applications
- AC-to-DC converters
- Communication equipment
- Instrumentation circuits



# Varactor Diode

Also called a **varicap**, **VVC** (voltage-variable capacitance), or **tuning diode**.

It basically acts like a variable capacitor.



# Varactor Diode Operation

A reverse-biased varactor acts like a capacitor. Furthermore, the amount of reverse bias voltage determines the capacitance. As  $V_R$  increases the capacitance decreases.

$$C_{T(VR)} = \frac{C(0)}{(1 + |V_R/V_T|)^n}$$

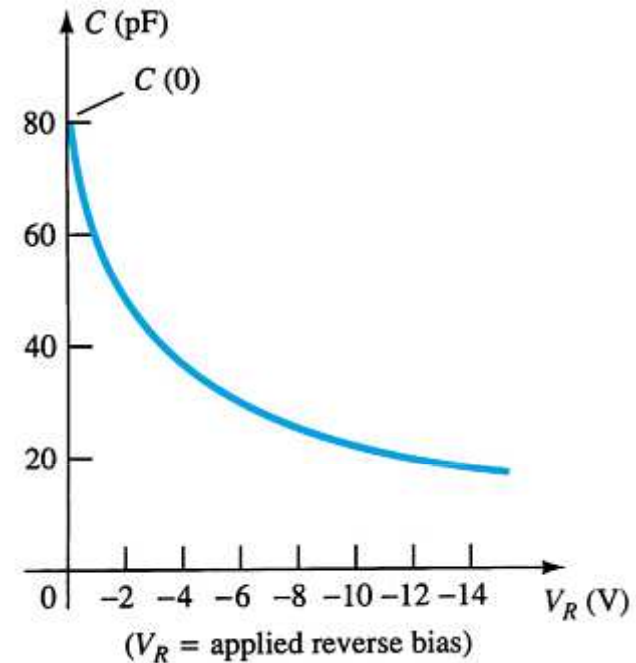
where

$C(0)$  = the capacitance with no reverse bias applied

$n = 1/2$  for alloy and  $1/3$  for diffused junctions

$V_T$  = maximum reverse bias voltage

$V_R$  = applied reverse bias voltage



# Varactor Diode Applications

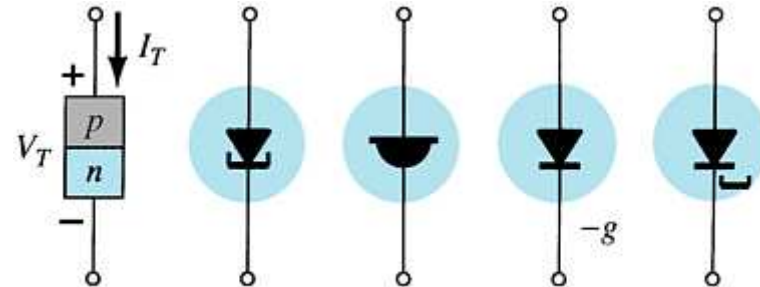
**FM modulator**  
**Automatic-frequency-control devices**  
**Adjustable bandpass filters**  
**Parametric amplifiers**

# Power Diodes

- **Power diodes used in high-power and high-temperature applications, such as power rectifier circuits, must be rated for power**
- **Power diodes are sometimes referred to as rectifiers**
- **They have the same symbol and operation as a general-purpose diode**
- **Power diodes are physically larger than general-purpose diodes, and they require heat sinking.**

# Tunnel Diodes

A tunnel diode has a **negative resistance** region, which means its current decreases as the forward-bias voltage increases.





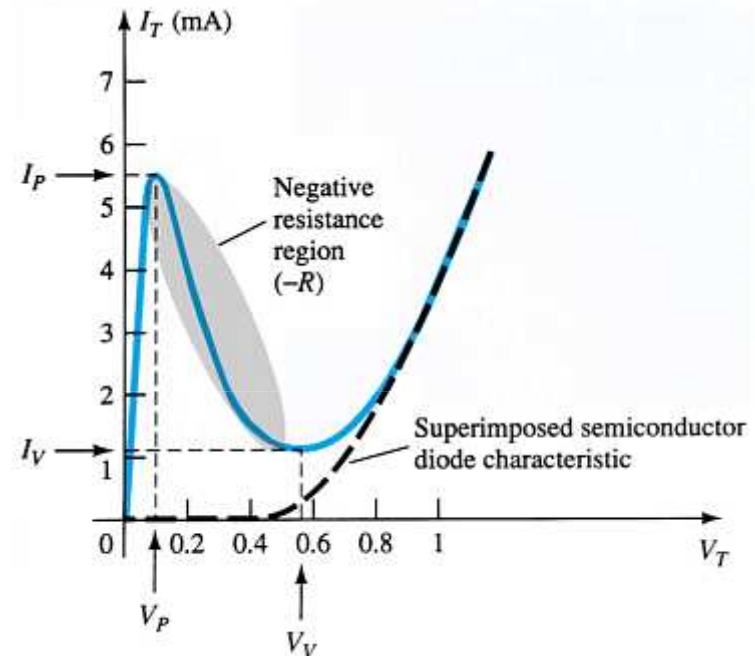
# Tunnel Diodes

## Operation

The characteristics of the tunnel diode indicate the negative resistance region. Note that this is only a small region of the characteristic curve.

If the forward bias voltage is beyond the negative resistance region, the tunnel diode acts like a general-purpose diode.

If the forward bias voltage is in the negative resistance region then the diode can be used as an oscillator.



# Tunnel Diode Applications

**High frequency circuits**

**Oscillators**

**Switching networks**

**Pulse generators**

**Amplifiers**

# Photodiodes

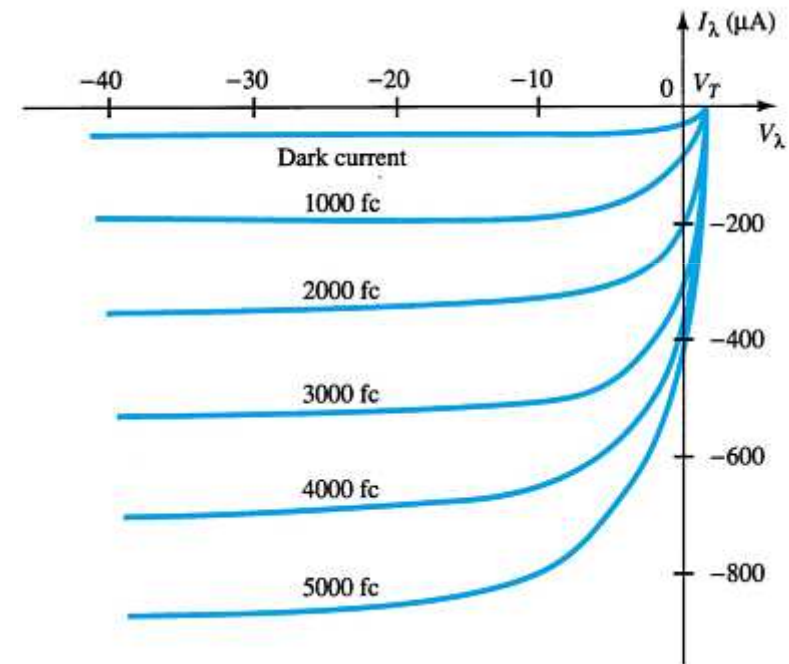
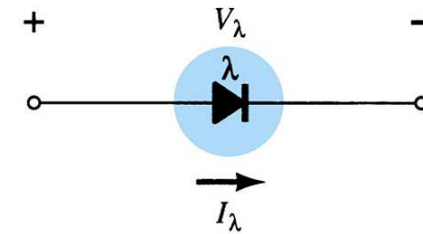
A photodiode conducts when light is applied to the junction.

## Operation

The photodiode is operated in reverse bias. When light of a particular wavelength strikes the junction it conducts. The higher the intensity of light (measured in foot-candles), the higher the conduction through the photodiode.

## Applications

- Instrumentation circuits as a sensor
- Alarm system sensor
- Detection of objects on a conveyor belt



Note that the diode conducts somewhat with no light applied, this is called the *dark current*.

# Photoconductive Cells

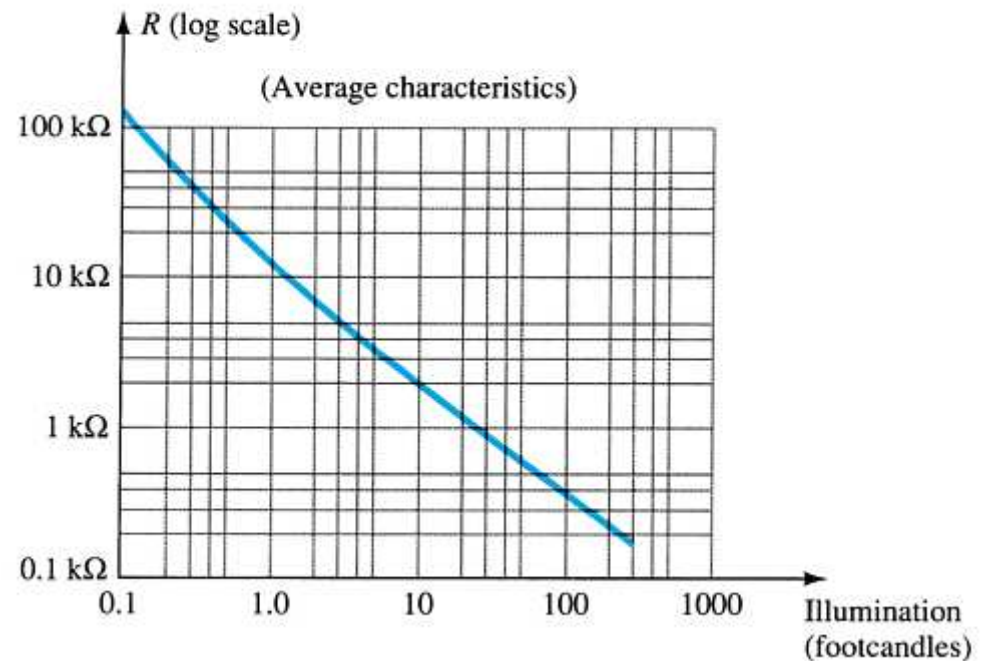
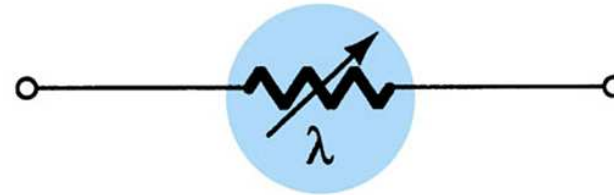
## Operation

A photoconductive cell varies resistance with intensity of light.

Like a common resistor, a photoconductive cell has no polarity and can be placed into the circuit in either direction.

## Applications

- Light/darkness detection
- Controlling intensity of lighting systems



# IR Emitters

These are diodes that emit IR (infrared radiation)

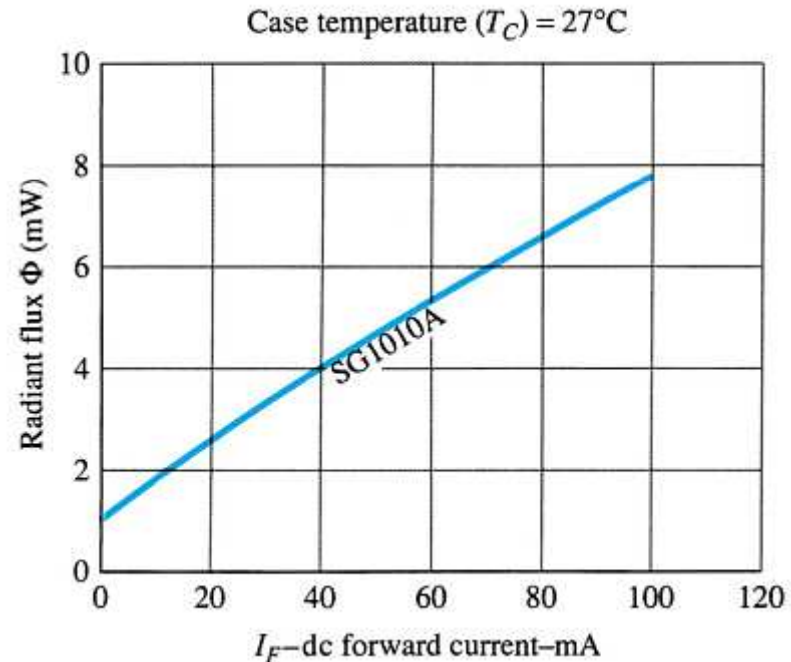
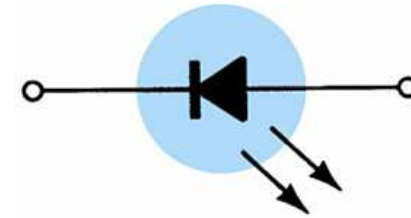
## Operation

IR emitter produce infrared radiation when forward biased. The higher the forward bias current, the greater the intensity of infrared radiation.

The radiation pattern can vary from widely dispersed to a very narrow, focused beam.

## Applications

- Card readers
- Shaft encoders
- Intrusion alarms
- IR Transmitters



# Liquid Crystal Displays (LCDs)

**There are two varieties—those with a light background and dark display or those with a dark background and light display.**

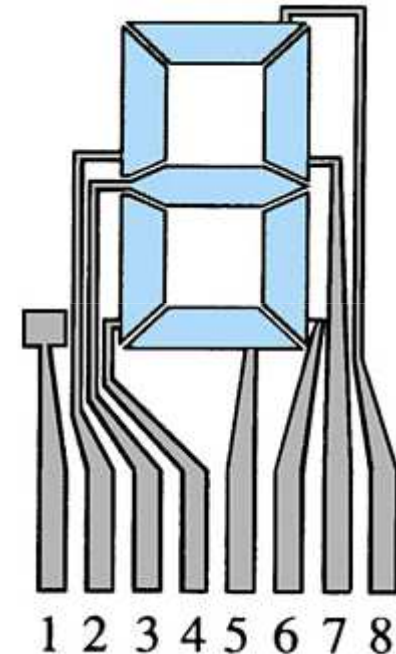
## Operation

**The background is either light or dark, when a voltage is applied to a segment then the alphanumeric display is visible. The amount of voltage necessary for display varies depending on the type of display, from 2 to 20V.**

**Low power LCDs require less power than LEDs. But LEDs have faster response times and longer life.**

## Applications

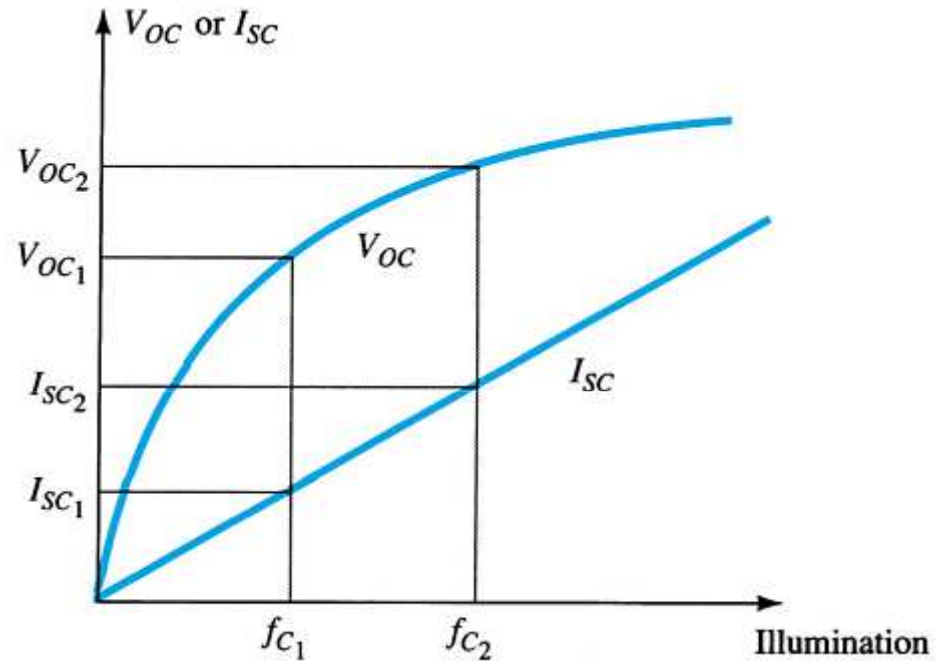
- **Digital clocks**
- **Digital thermometers**
- **Odometers**



# Solar Cells

**Solar cells produce a voltage when subjected to light energy.**

**The greater the light intensity, the greater amount of voltage produced.**



# Thermistors

Thermistors are resistors whose value changes with temperature.

## Operation

Thermistors are negative-coefficient devices—their resistance decreases as the temperature increases.

## Applications

- Sensors in instrumentation circuits
- Temperature correction circuitry



Specific resistance – (ohm-cm, the resistance between faces of 1 cm<sup>3</sup> of the material)  
(log scale)

