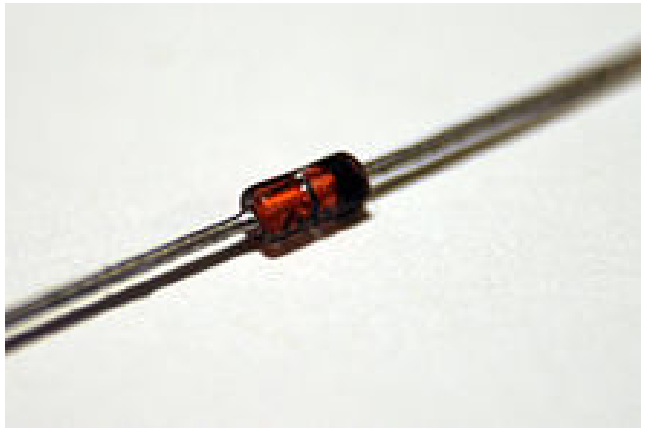
Special Purpose Diodes

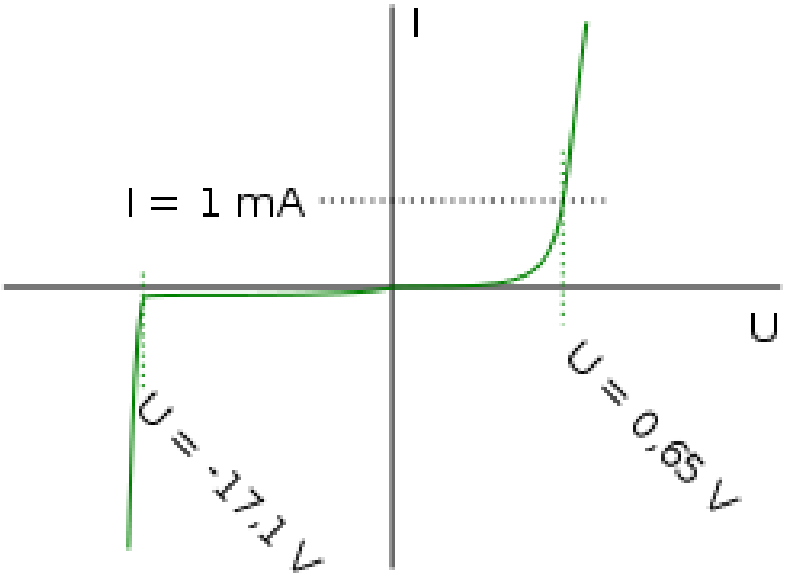
Contents

- Zener Diode
- Schottky Diode
- Light Emitting Diode(LED)
- Photodiode

Zener Diode

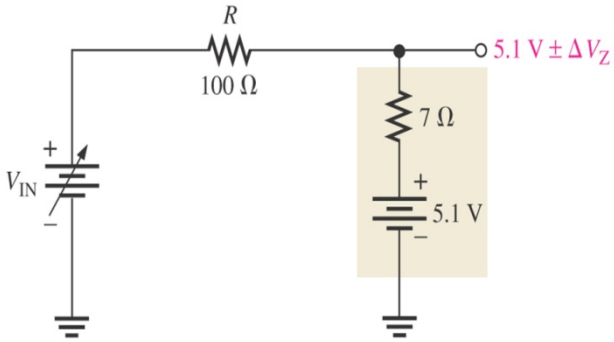
A Zener diode is a type of diode that permits current not only in the forward direction like a normal diode, but also in the reverse direction if the voltage is larger than the breakdown voltage known as "Zener knee voltage" or "Zener voltage."

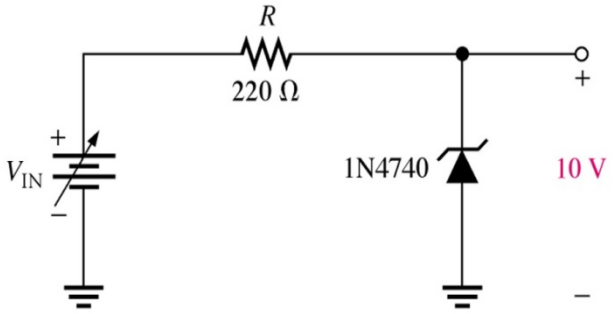




Basic Function

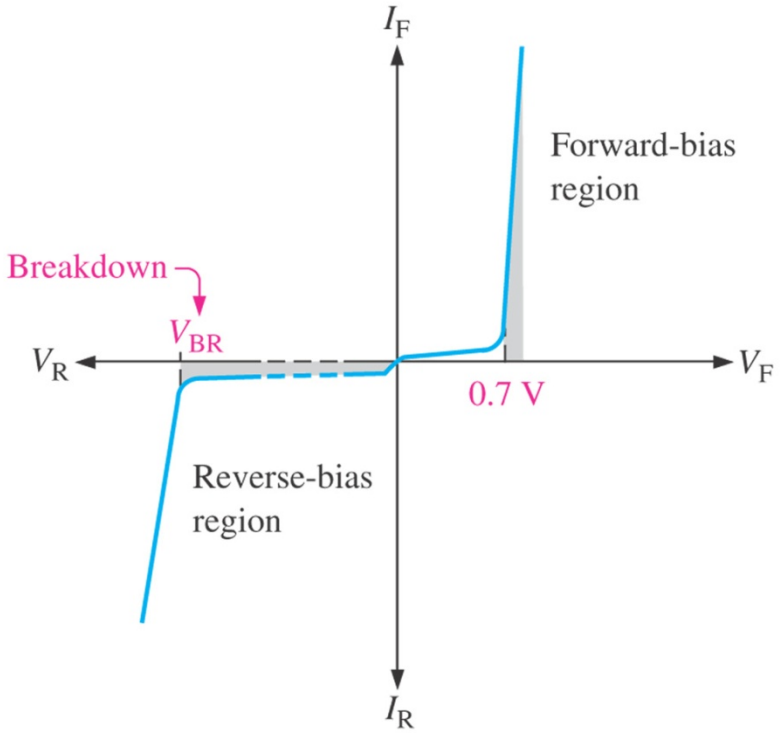
The basic function of **zener diode** is to maintain a specific voltage across its terminals within given limits of line or load change. Typically it is used for providing a stable reference voltage for use in power supplies and other equipment.



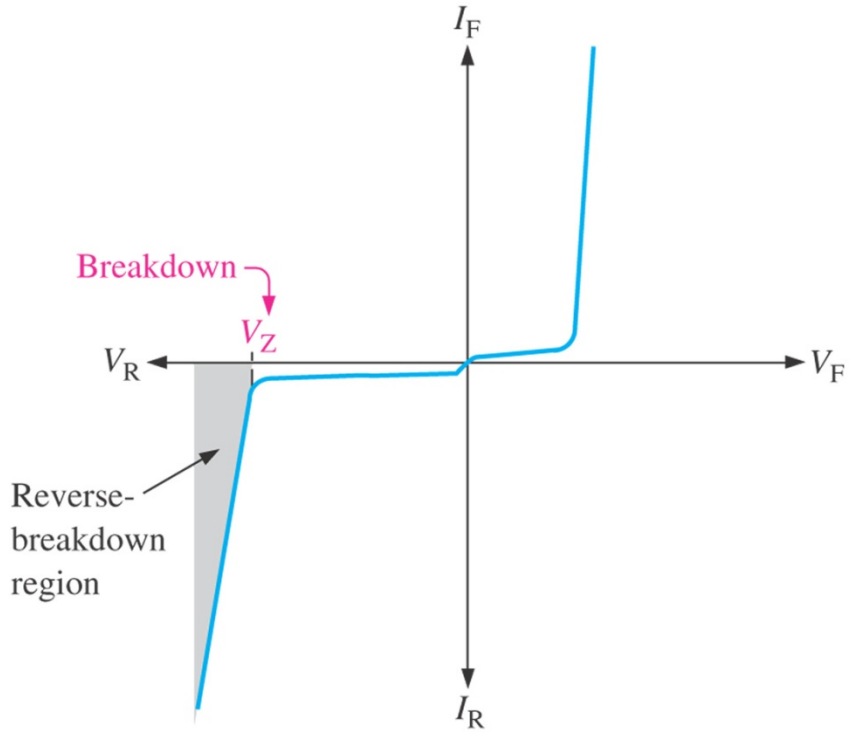


This particular zener circuit will work to maintain 10 V across the load.

Normal Diode vs Zener Diode

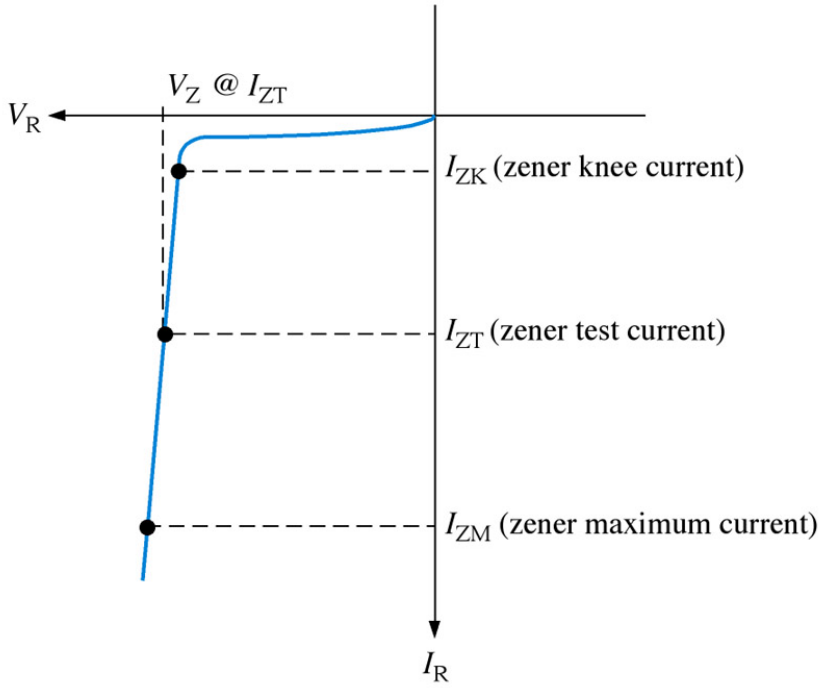


(a) The normal operating regions for a rectifier diode are shown as shaded areas.

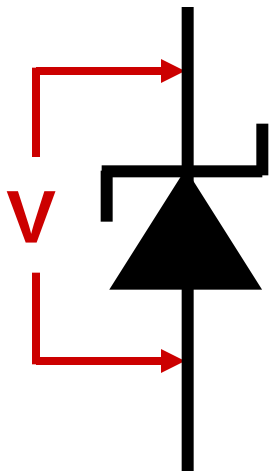


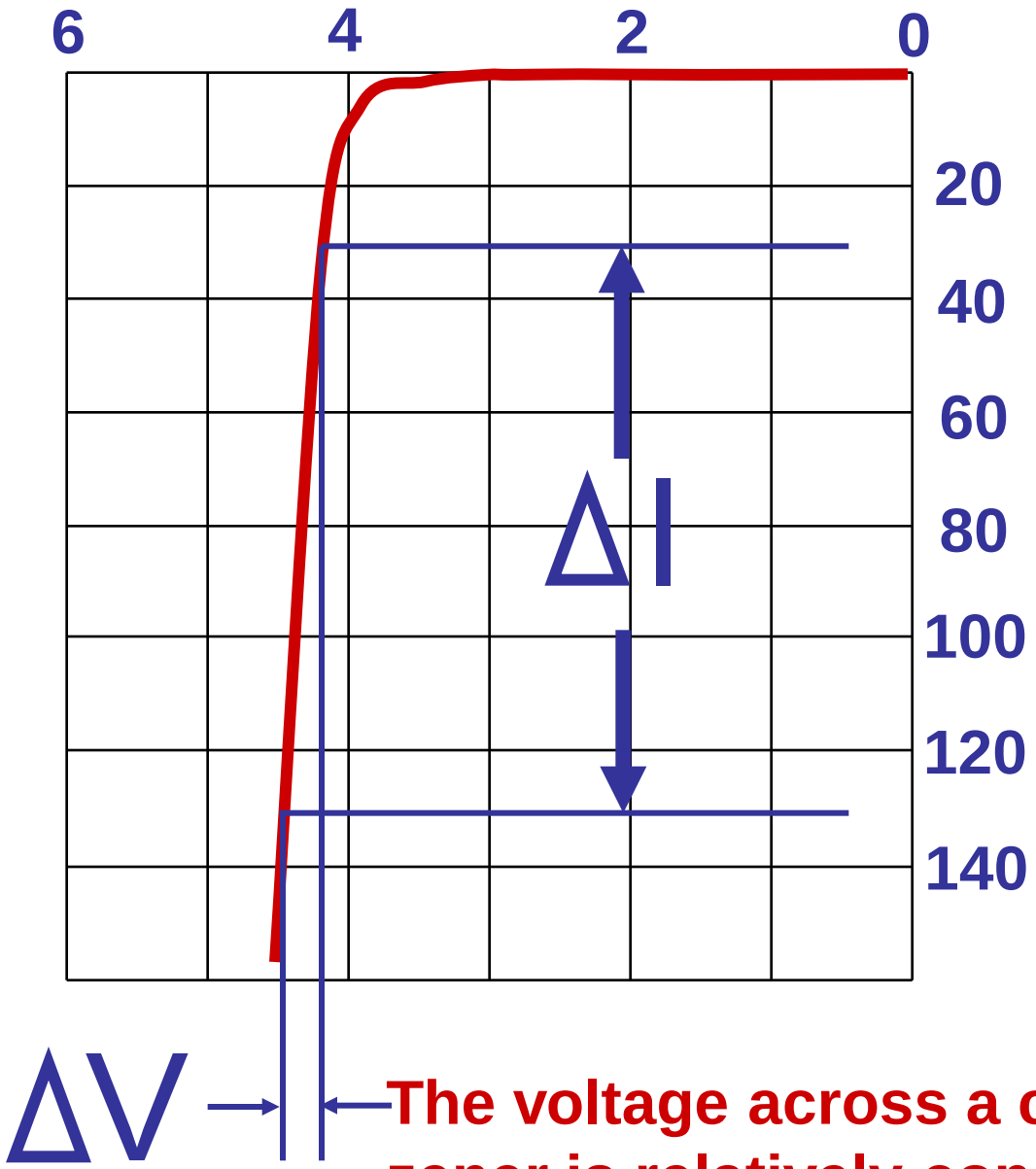
(b) The normal operating region for a zener diode is shaded.

The zener diode's breakdown characteristics are determined by the doping process. Low voltage zeners less than 5V operate in the zener breakdown range. Those designed to operate more than 5 V operate mostly in avalanche breakdown range. Zeners are available with voltage breakdowns of 1.8 V to 200 V.



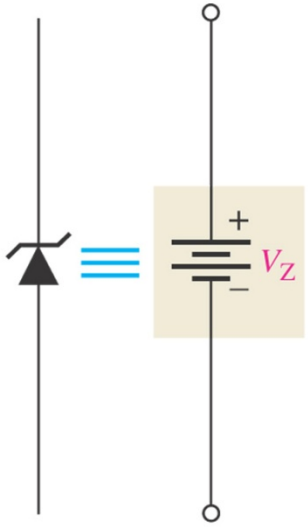
This curve illustrates the minimum and maximum ranges of current operation that the zener can effectively maintain its voltage.



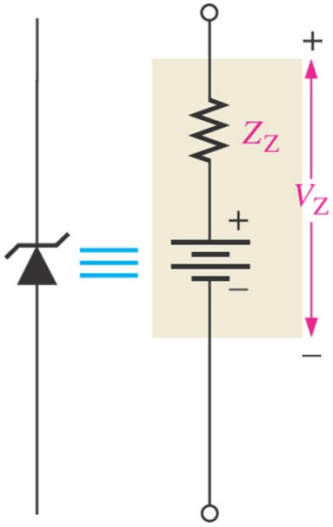


The voltage across a conducting zener is relatively constant.

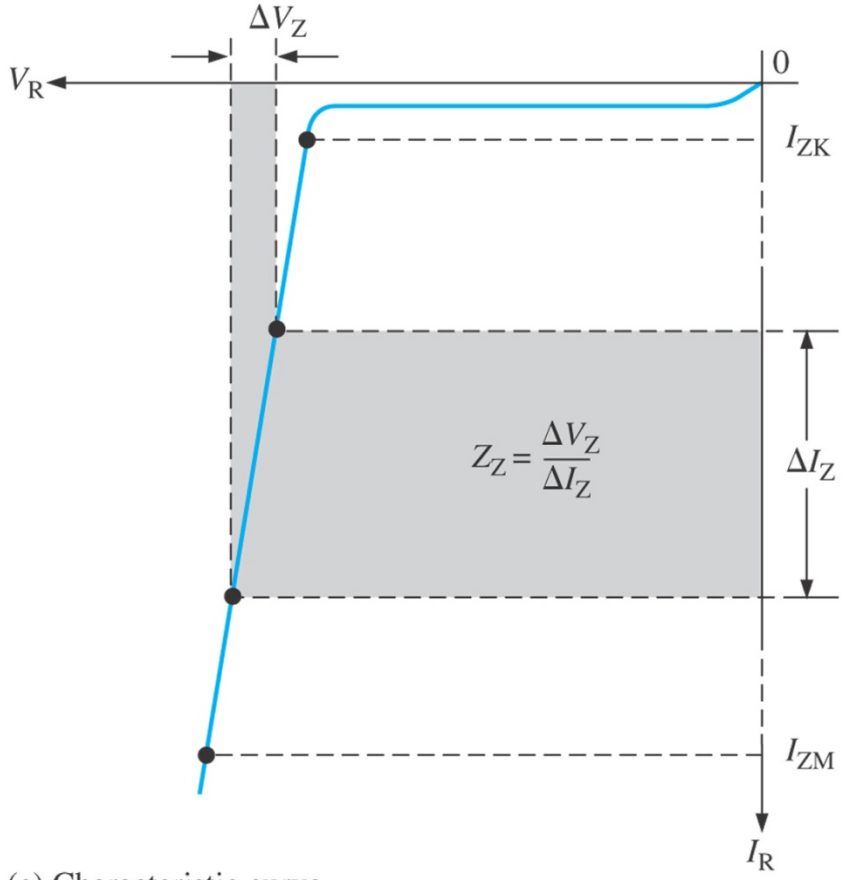
Equivalent Circuit



(a) Ideal



(b) Practical

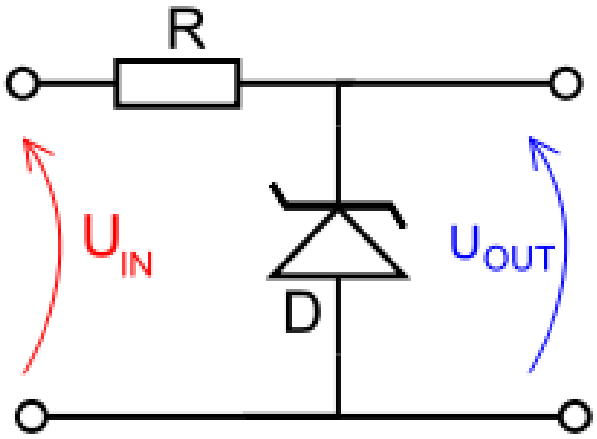


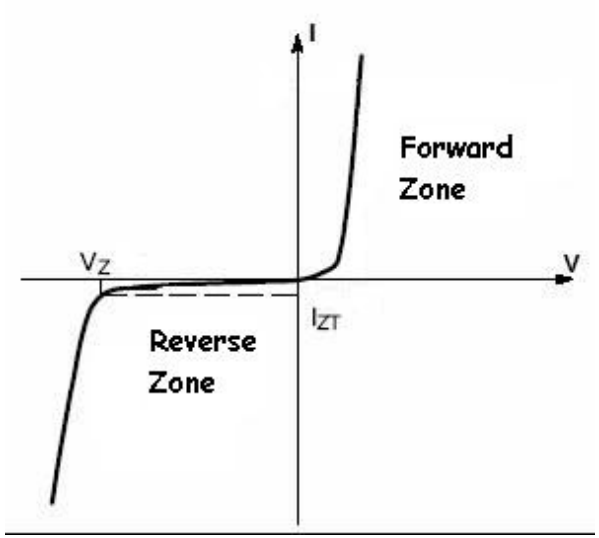
(c) Characteristic curve

Zener Diode applications

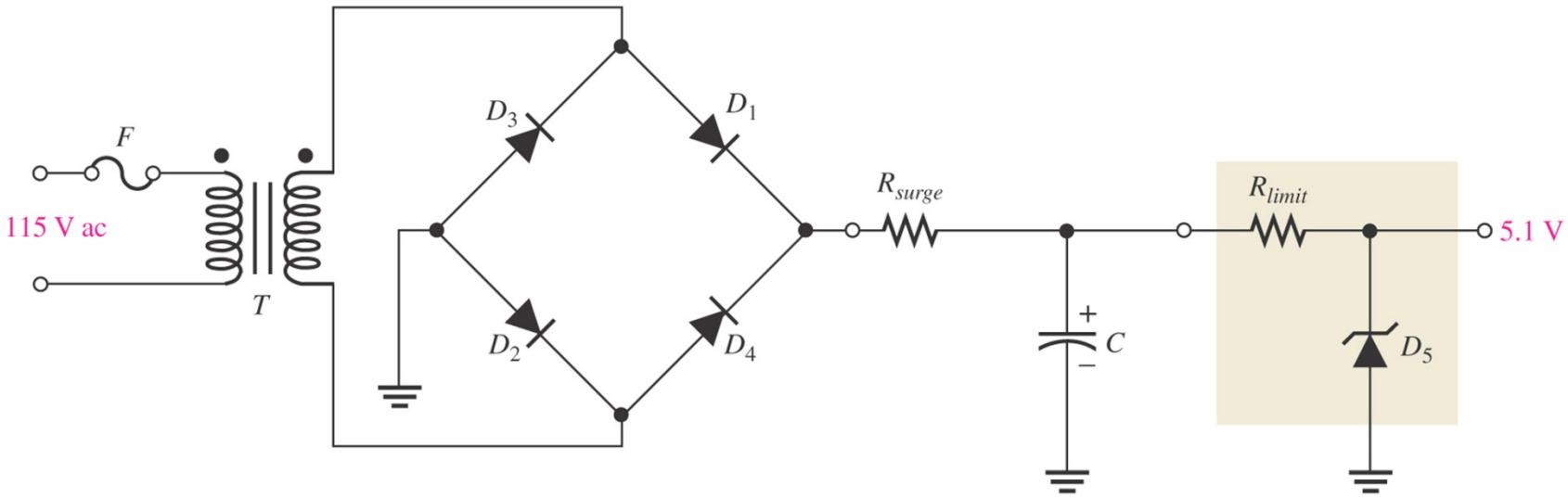
A zener diode is used on reverse polarization, as a

1. voltage limiter
2. basic (shunt) regulator
3. For protection against voltage peaks.





Zener regulated power supply preliminary schematic.

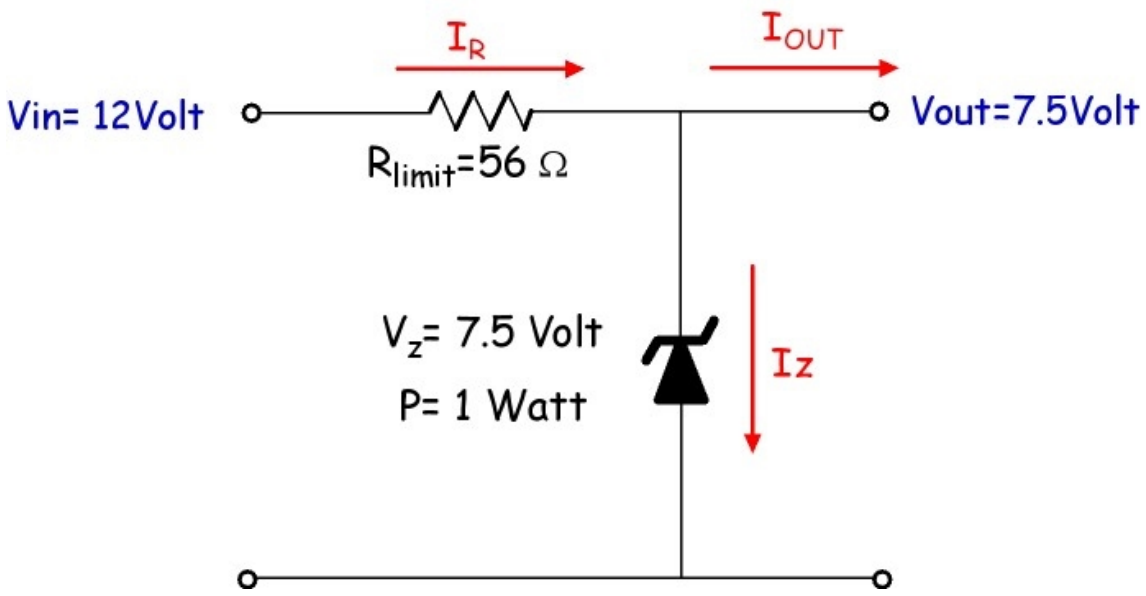


1N 4728 ... 1N 4764
SILICON PLANAR POWER ZENER DIODES

Type	Zener Voltage range [3]		Maximum Zener Impedance [1]			Reverse leakage current		Surge current	Maximum regulator current [2]
	Vznom	I_{ZT}	r_{zjT}	r_{zjk} at I_{zk}		I_R at V_R		at T_A = 25 °C	
	V	mA	Ω	Ω	mA	µA	V	I_R mA	I_{ZM} mA
1N4728	3.3	76	10	400	1.0	150	1	1375	275
1N4729	3.6	69	10	400	1.0	100	1	1260	252
1N4730	3.9	64	9	400	1.0	100	1	1190	234
1N4731	4.3	58	9	400	1.0	50	1	1070	217
1N4732	4.7	53	8	500	1.0	10	1	970	193
1N4733	5.1	49	7	550	1.0	10	1	890	178
1N4734	5.6	45	5	600	1.0	10	2	810	162
1N4735	6.2	41	2	700	1.0	10	3	730	146
1N4736	6.8	37	3.5	700	1.0	10	4	660	133
1N4737	7.5	34	4.0	700	0.5	10	5	605	121
1N4738	8.2	31	4.5	700	0.5	10	6	550	110
1N4739	9.1	28	5.0	700	0.5	10	7	500	100
1N4740	10	25	7	700	0.25	10	7.6	454	91

Example (Basic Regulator)

- Let's suppose that we have an input voltage of 12 Volt, and we want to limit the output voltage to 7.5 Volt. Then we choose a **1N4737** 7.5V zener diode. On the datasheet given, we can see that I_{ZT}= 34mA, which is the minimum current needed for reaching V_z, and I_{ZM}=121 mA is the maximum admisible current.



- A good working point is I_Z=80 mA, near the middle of the range.

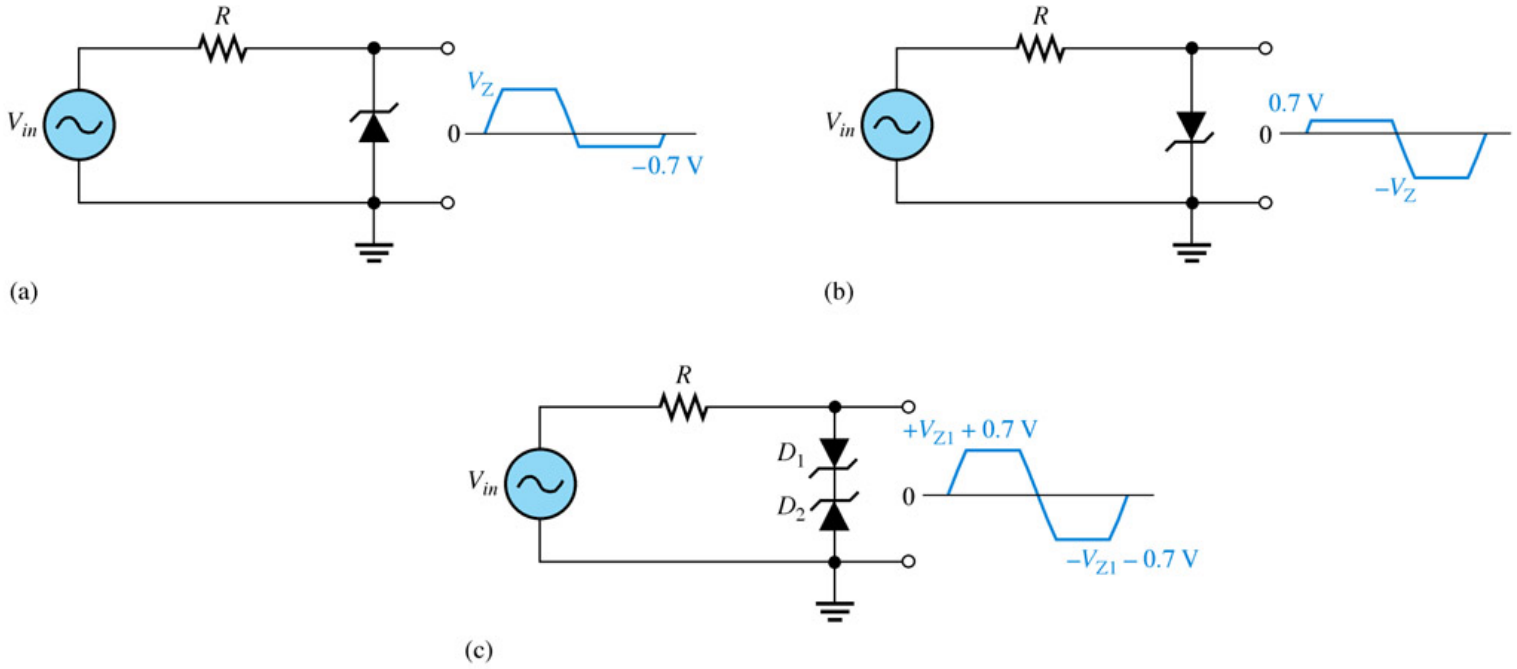
$$V_R = V_{in} - V_{out} = 12 - 7.5 = 4.5V$$

$$R_{limit} = \frac{V_R}{I_Z} = \frac{4.5V}{80mA} = 56\Omega$$

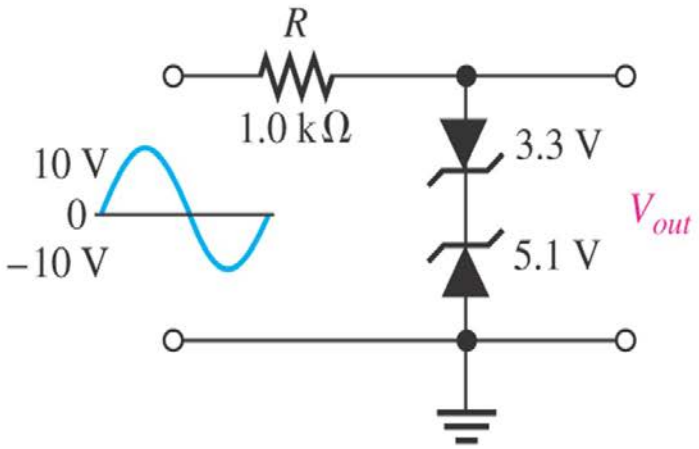
Note. A zener diode is used as a reference or regulator only on low current simple applications.

Zener Limiting

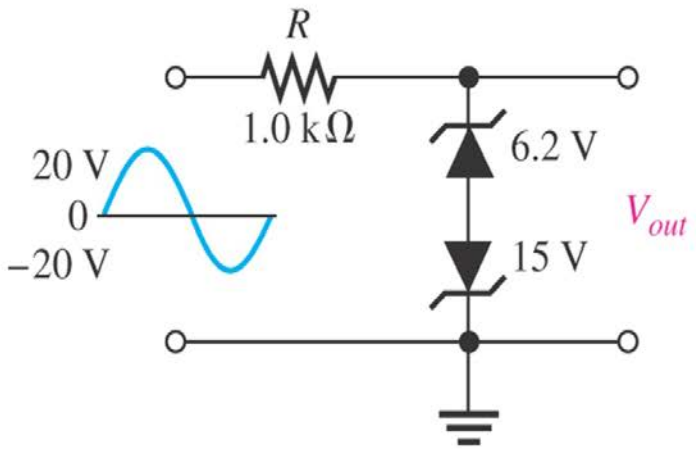
Zener diodes can used for limiting just as normal diodes. Recall in previous chapter studies about limiters. The difference to consider for a zener limiter is its zener breakdown characteristics.



Example(Zener Limiting)

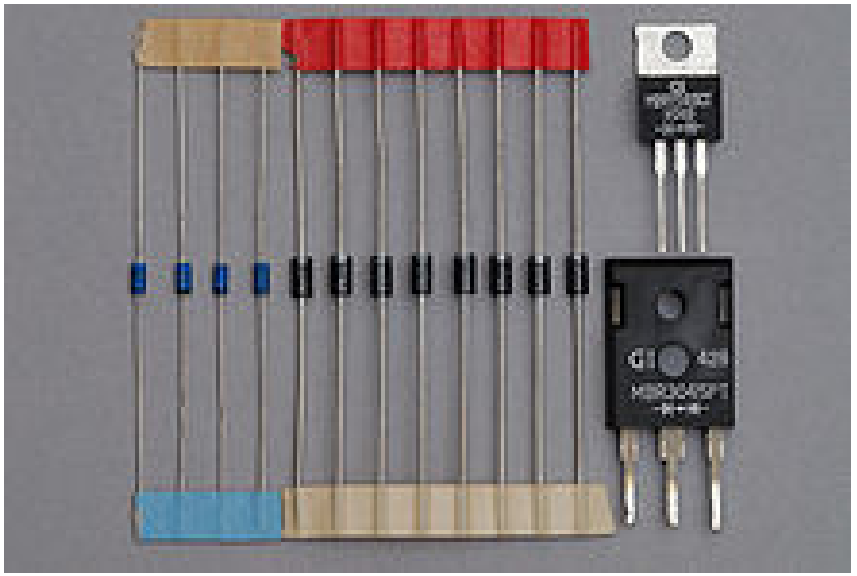


(a)



(b)

Schottky Diodes



Special Features

- Low forward voltage drop
- Fast switching action

Applications

- Switching Power Supply
- Voltage clamping
- Discharge protection

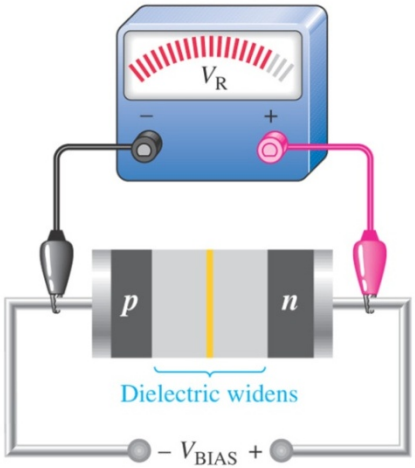
Comparing Diodes

Type	Maximum Breakdown Voltage	Maximum Current Rating	Forward Voltage Drop	Switching Speed	Applications
High Voltage Rectifier Diodes	30kV	~500mA	~10V	~100nS	HV circuits
General Purpose diodes	~5kV	~10kA	0.7 - 2.5 V	~25µS	50 Hz Rectifiers
Fast Recovery	~3kV	~2kA	0.7 - 1.5 V	<5uS	SMPS. Inverters, Resonant ckts.
Schottky Diodes	~100V	~300A	0.2 - 0.9 V	~30nS	LV HF Rectification
Power Zener Diodes	Operates in break down ~300 V	~75 W	-	-	References, Voltage Clamps

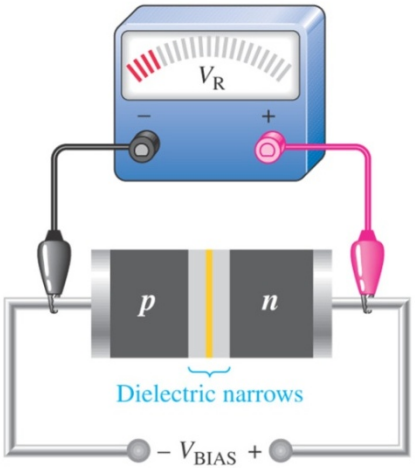
Reference: http://www.powerdesigners.com

Varicap

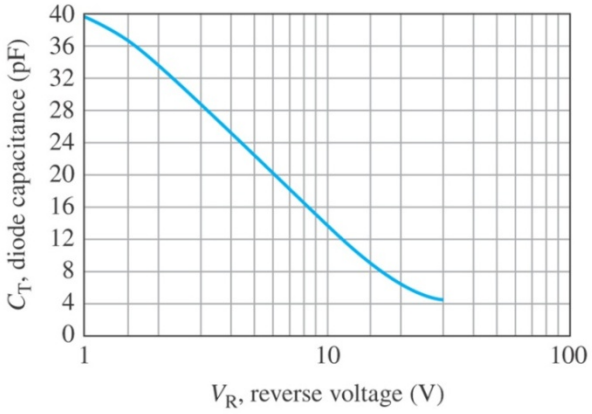
- a **varicap diode**, **varactor diode**, **variable capacitance diode**, **variable reactance diode** or **tuning diode** is a type of diode which has a variable capacitance that is a function of the voltage impressed on its terminals.



(a) Greater reverse bias, less capacitance



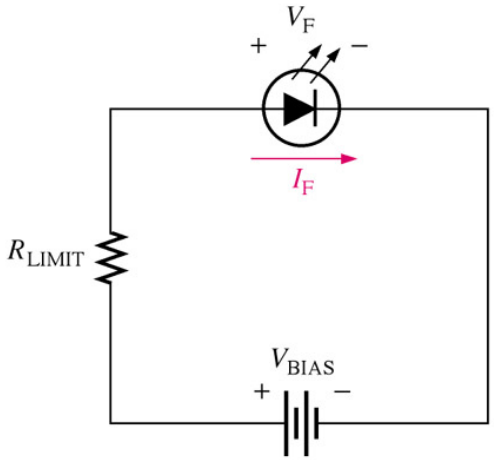
(b) Less reverse bias, greater capacitance



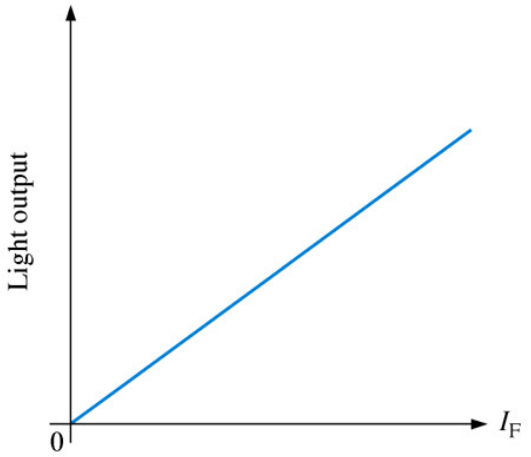
(c) Graph of diode capacitance versus reverse voltage

Light Emitting Diode

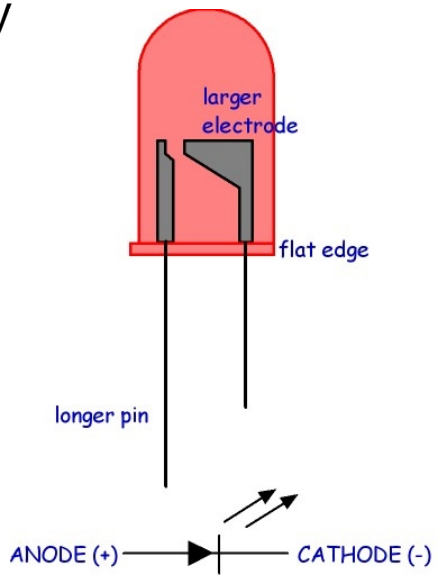
The **light-emitting diode** (LED) emits photons as visible light. Its purpose is for indication and other intelligible displays. Various impurities are added during the doping process to vary the color output.



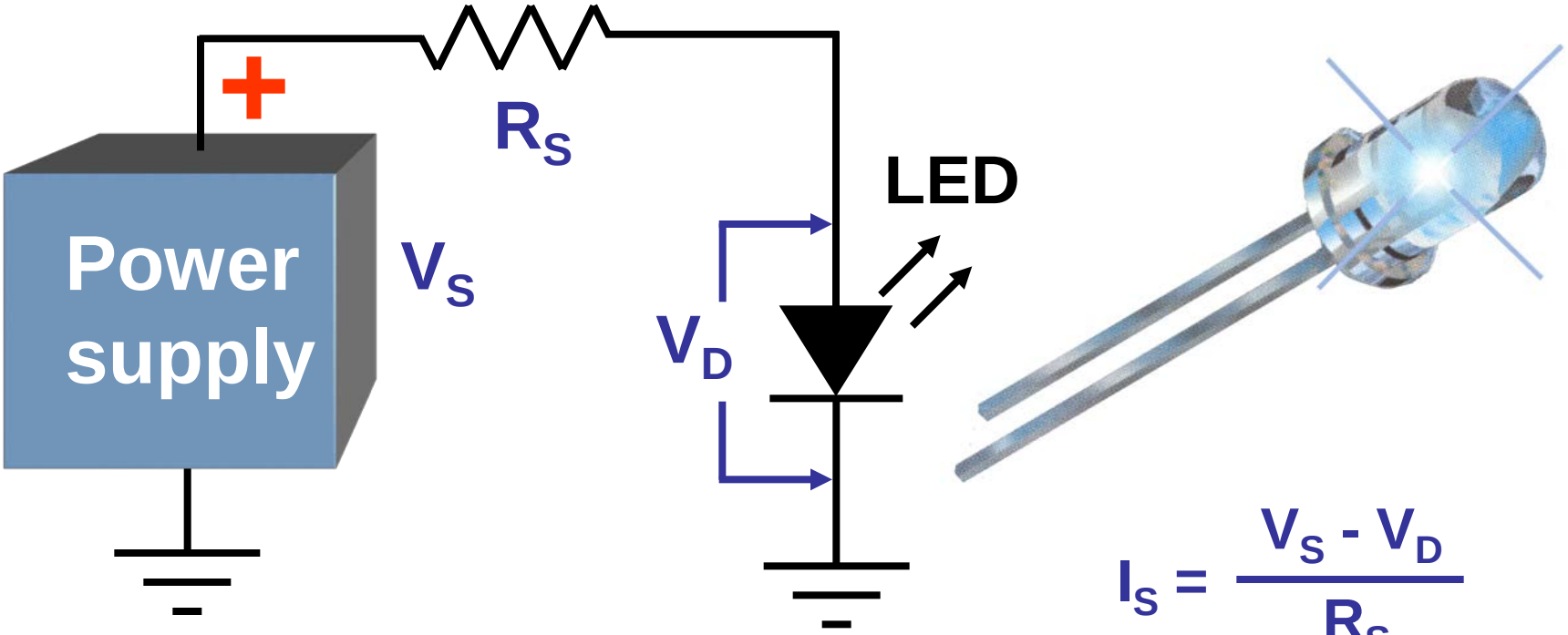
(a) Forward-biased operation



(b) General light output versus forward current



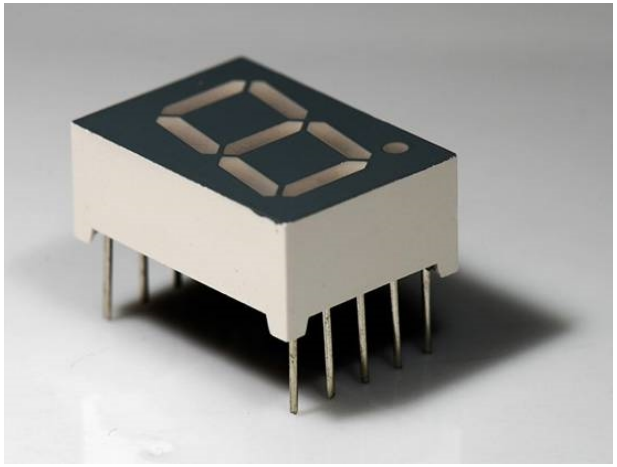
LED circuit

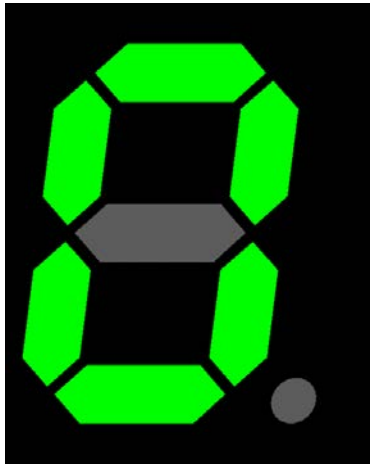


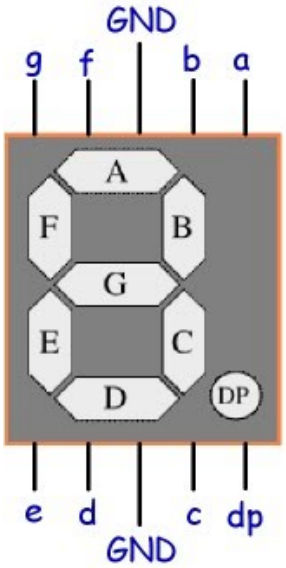
$$I_S = \frac{V_S - V_D}{R_S}$$

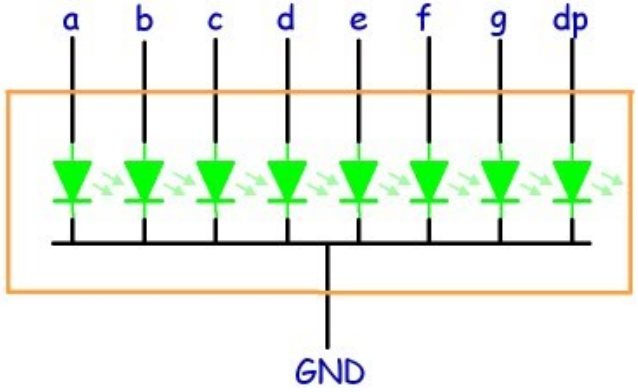
The typical voltage drop for most LEDs is from 1.5 to 2.5 V.

7 Segment LED

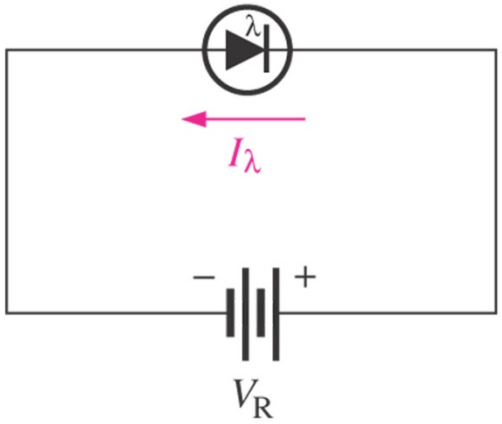




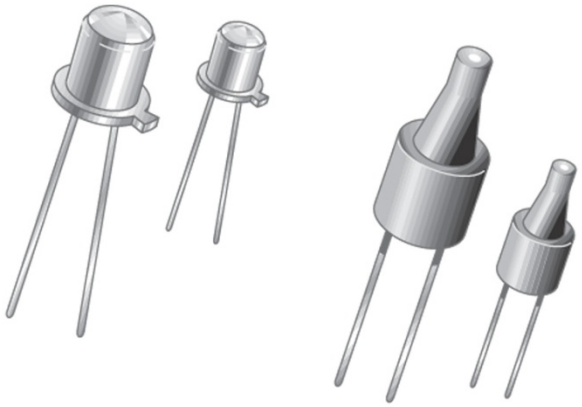




Photodiodes

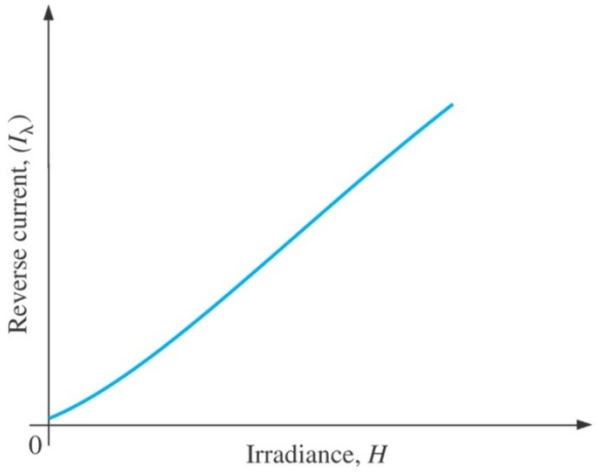


(a) Reverse-bias operation

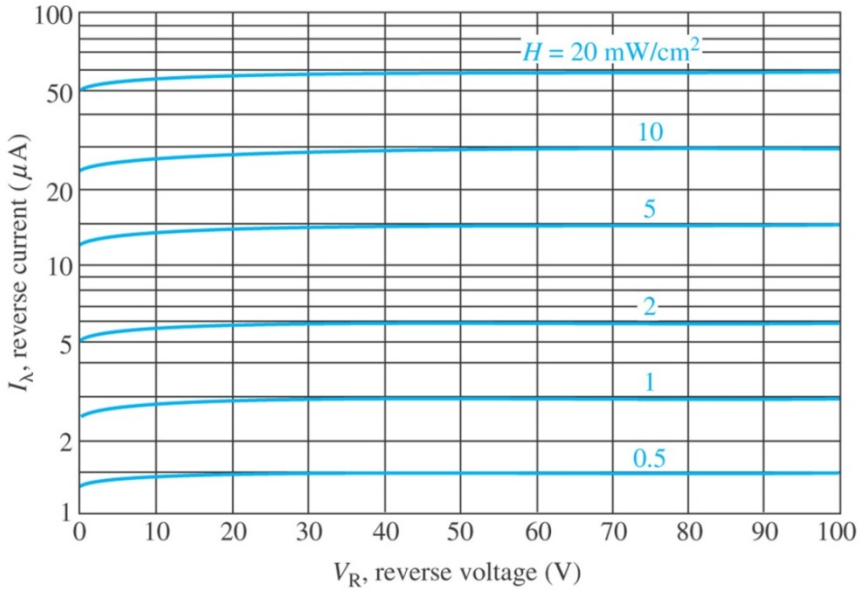


(b) Typical devices

(c) Alternate symbol



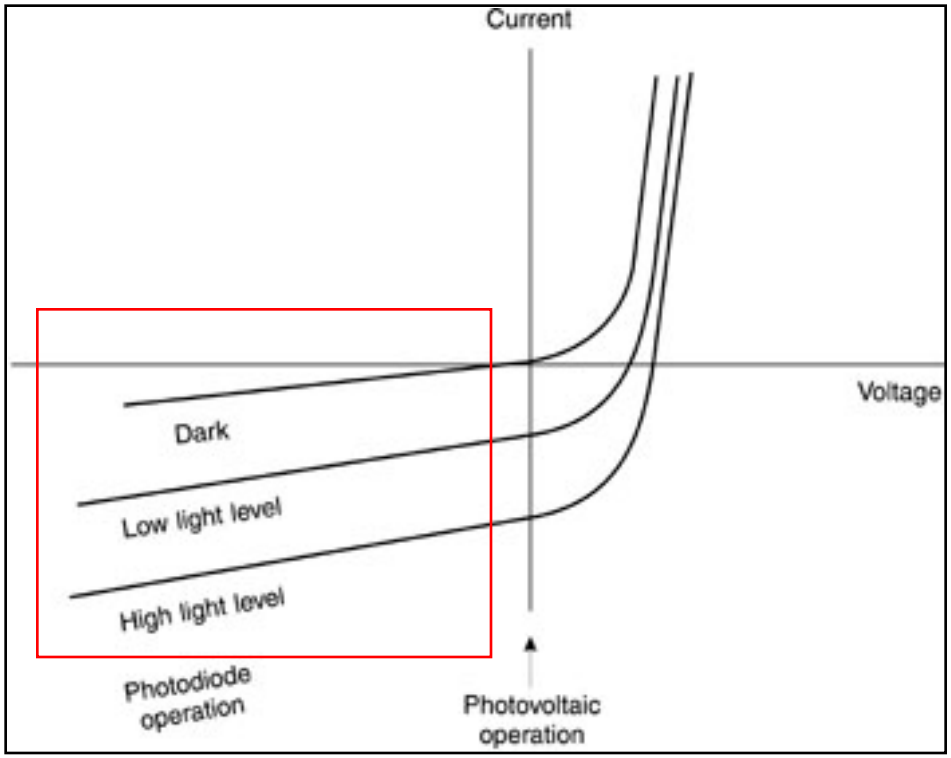
(a) General graph of reverse current versus irradiance



(b) Example of a graph of reverse current versus reverse voltage for several values of irradiance

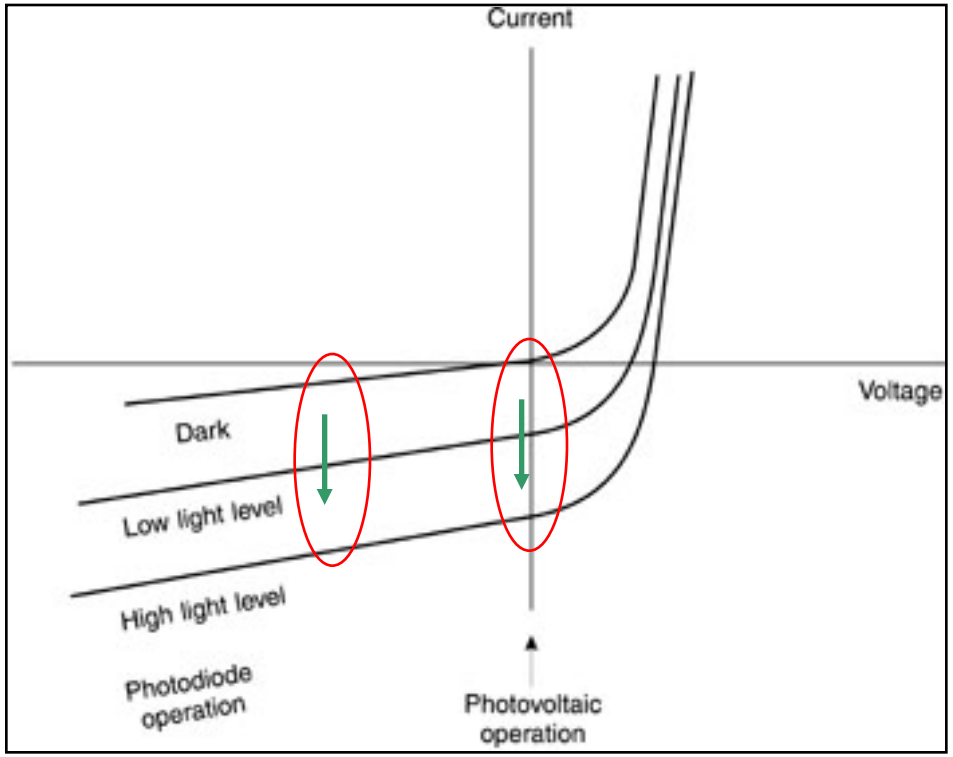
The **photodiode** is used to vary current by the amount of light that strikes it. It is placed in the circuit in reverse bias. As with most diodes when in reverse bias, no current flows, but when light strikes the exposed junction through a tiny window, reverse current increases proportional to light intensity.

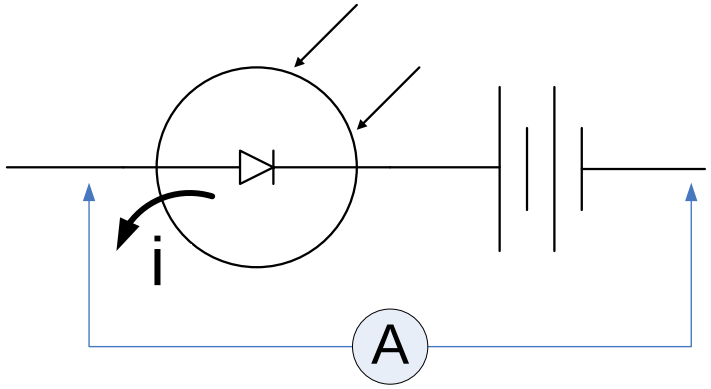
I-V characteristic



In the 1st quadrant, the device acts as a photovoltaic detector. It produces a voltage proportional to the incident light intensity. In the 3rd quadrant, **when a reverse voltage is applied**, it acts as a photoconductive detector. In the dark, the reverse current(Dark current, I_{DARK}) is very small. When light strikes the diode, there is little increase in the forward current, **but the reverse current can increase significantly**. The current is proportional to the intensity of the incident light.

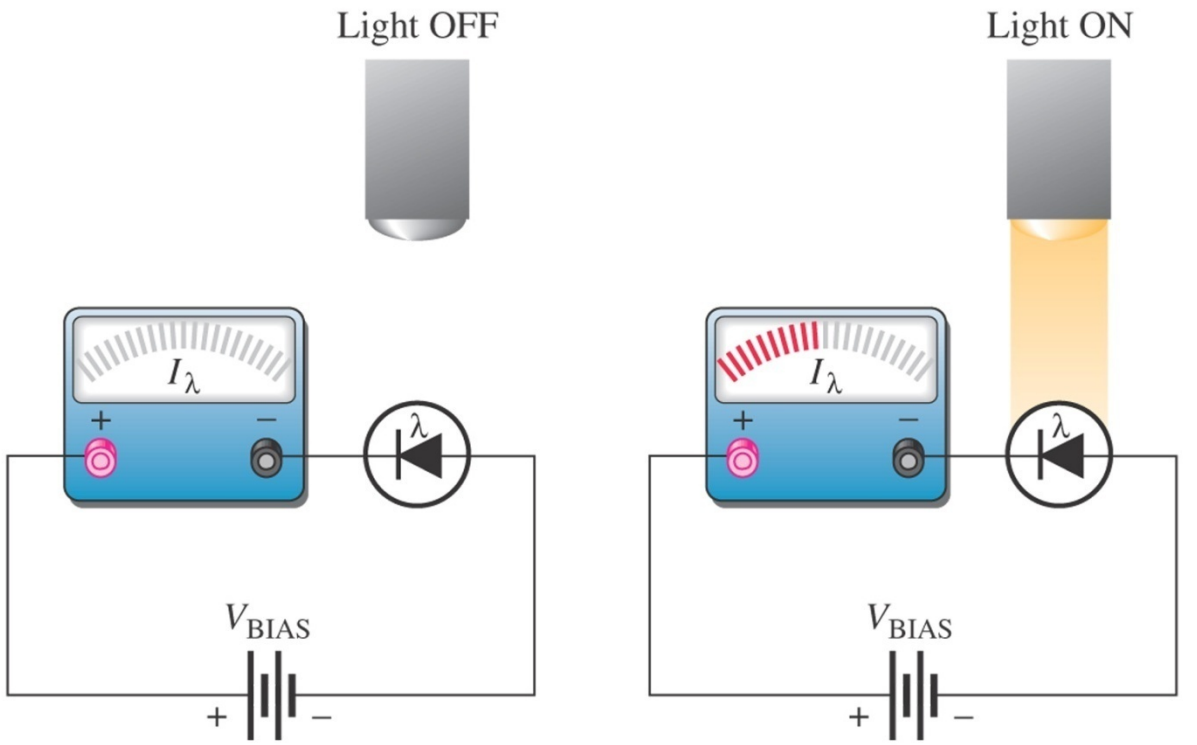
Using a photodiode in photoconductive mode





Reverse Current

Operation

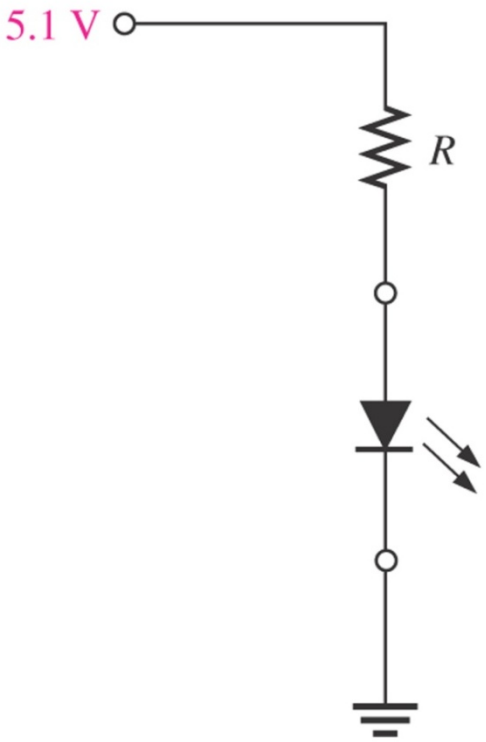


(a) No light, no current except negligible dark current

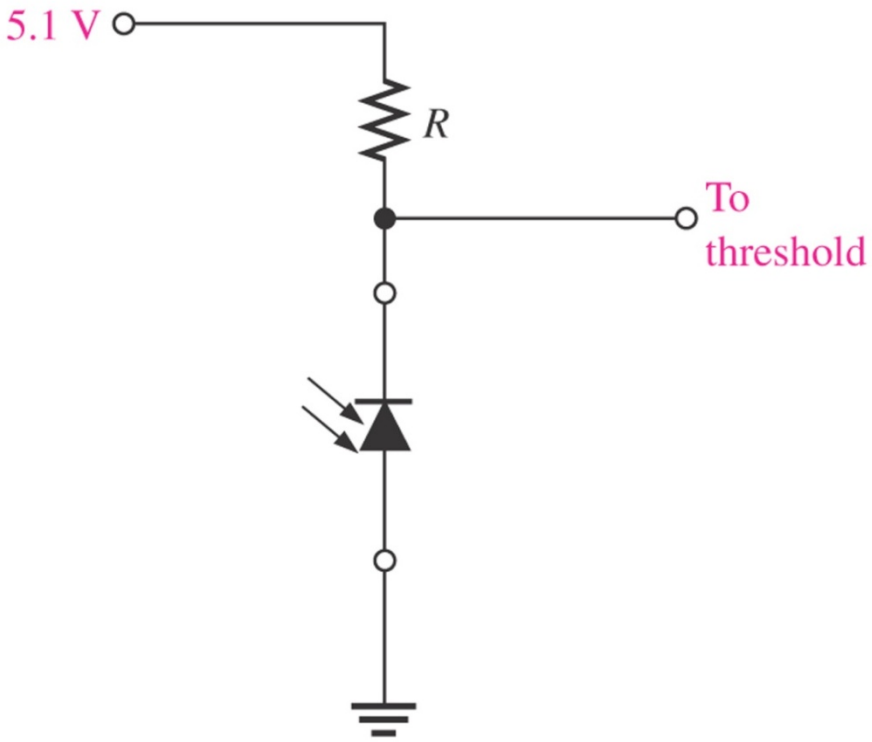
(b) Where there is incident light, resistance decreases and there is reverse current.

IR LED and receiver

Basic schematics of the IR emitter and IR detector circuits.

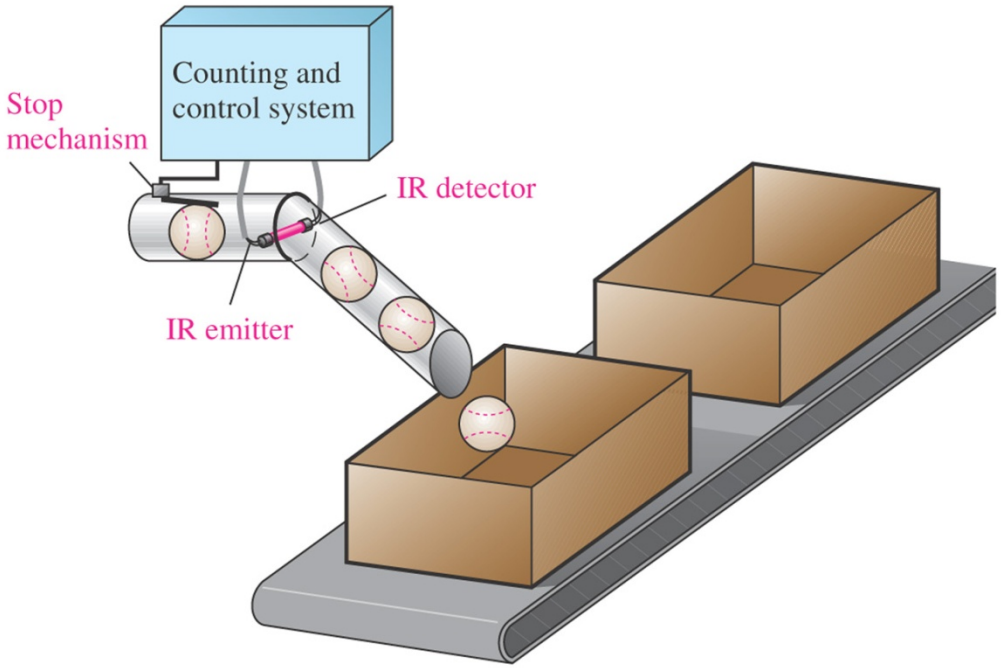


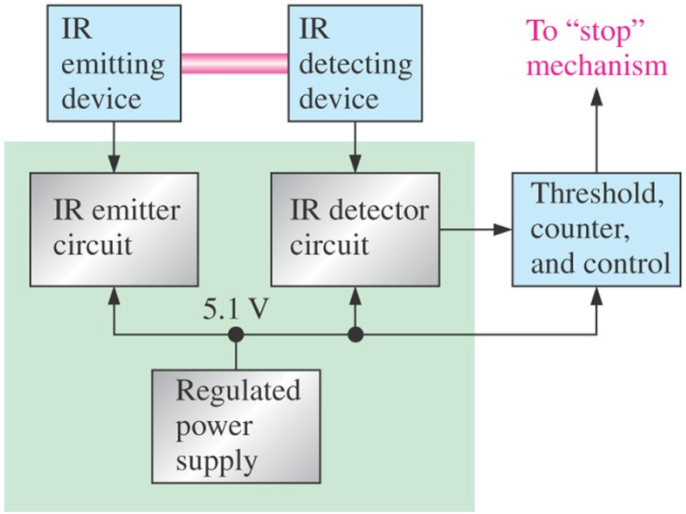
(a) IR emitter



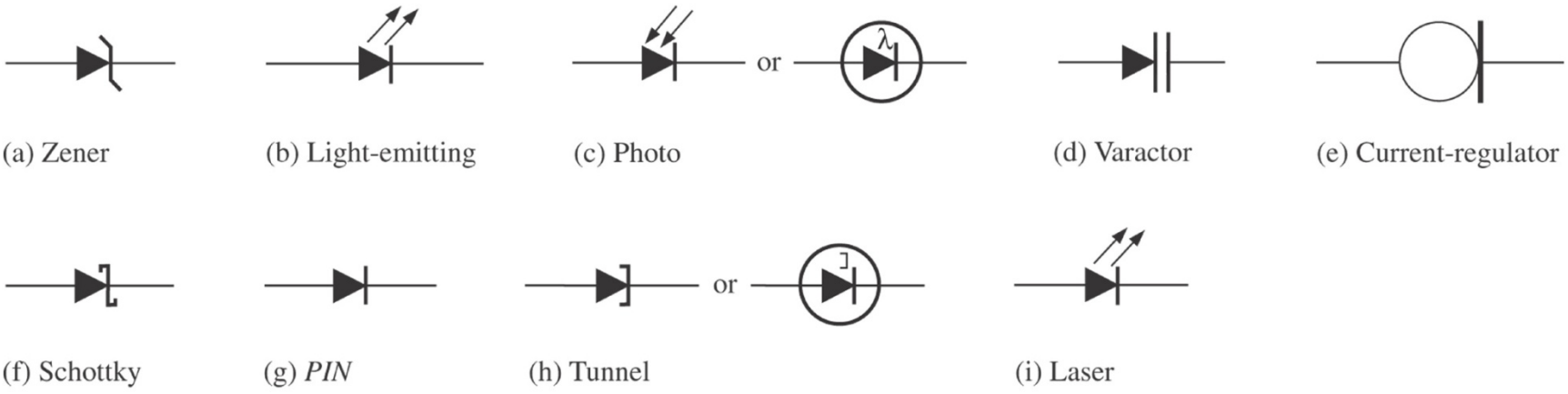
(b) IR detector

Counting System





Symbols



(a) Zener (b) Light-emitting (c) Photo (d) Varactor (e) Current-regulator

(f) Schottky (g) *PIN* (h) Tunnel (i) Laser