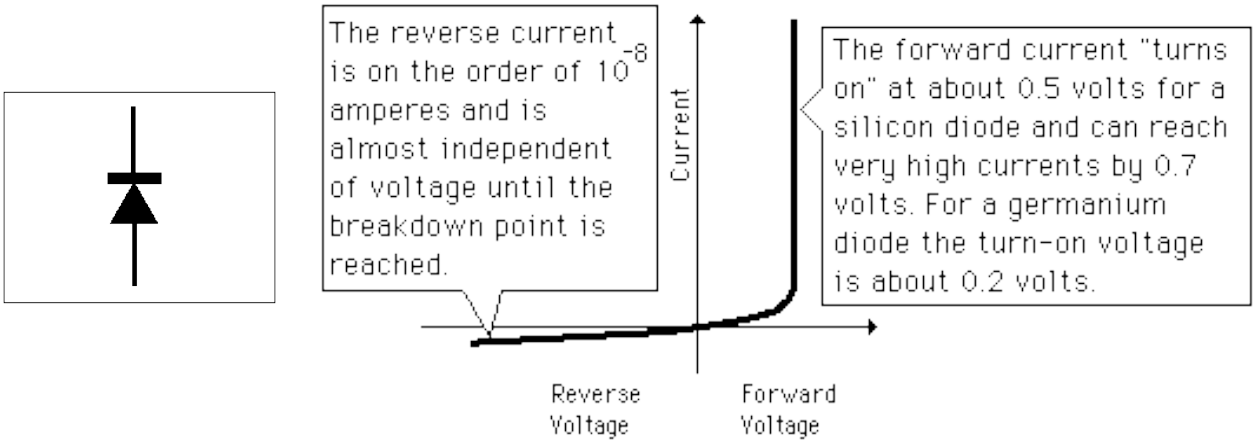
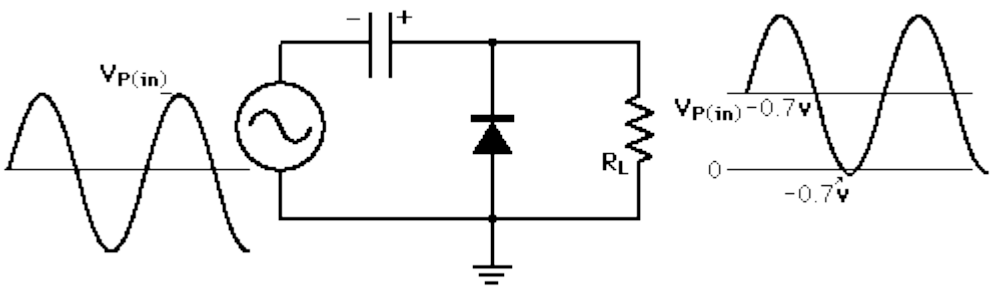
Diodes



The nature of the p-n junction is that it will conduct current in the forward direction but not in the reverse direction. It is therefore a basic tool for rectification in the building of DC power supplies.

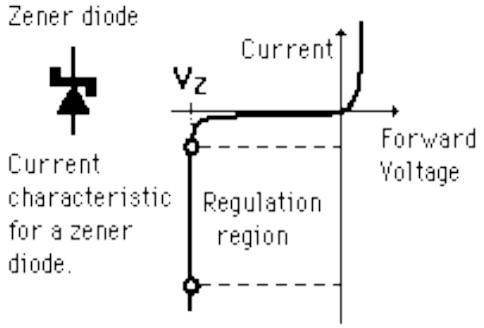
Types of Diodes

- **Normal (p-n) diodes:** Usually made of doped silicon or, more rarely, germanium.
- **Zener Diodes:** Diodes that can be made to conduct backwards. This effect, called Zener breakdown, occurs at a precisely defined voltage, allowing the diode to be used as a precision voltage reference.
- **Photo-diodes:** Semiconductors are subject to optical charge carrier generation and therefore most are packaged in light blocking material. If they are packaged in materials that allow light to pass, their photosensitivity can be utilized. Photodiodes can be used as solar cells, and in photometry.
- **Light Emitting Diodes:** In a diode formed from a direct band-gap semiconductor, such as gallium arsenide, carriers that cross the junction emit photons when they recombine with the majority carrier on the other side. Depending on the material, wavelengths (or colors) from the infrared to the near ultraviolet may be produced. The forward potential of these diodes depends on the wavelength of the emitted photons: 1.2 V corresponds to red, 2.4 to violet.

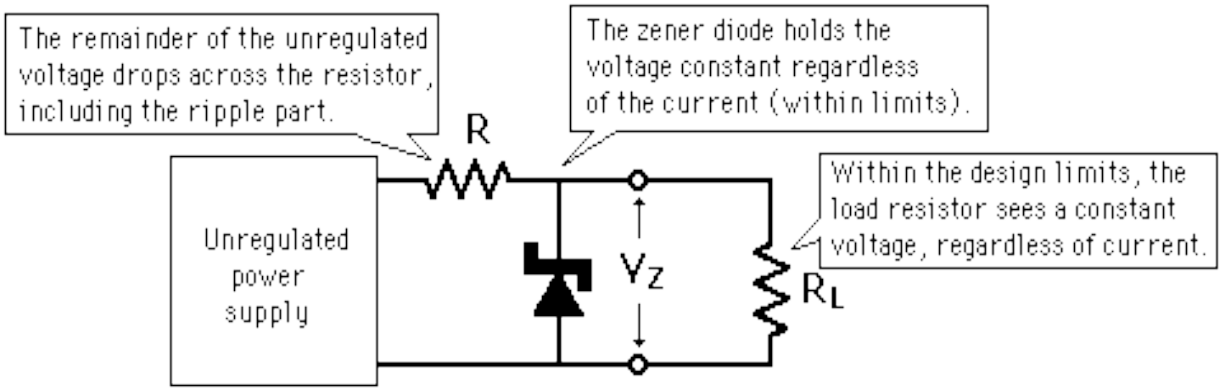


A diode can be used to clamp one side of a sinusoidal signal to near zero.

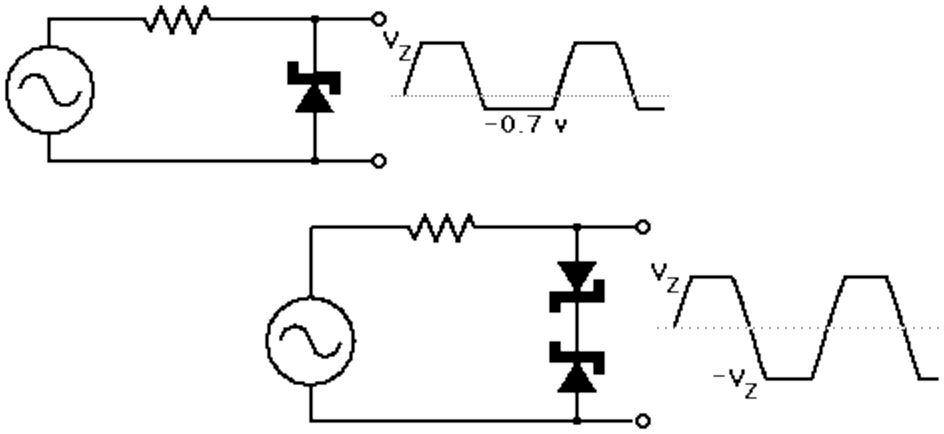
Zener Diodes:



The zener diode uses a p-n junction in reverse bias to make use of the zener effect, which is a breakdown phenomenon which holds the voltage close to a constant value called the zener voltage. It is useful in zener regulators to provide a more constant voltage, for improvement of regulated power supplies, and for limiter applications.

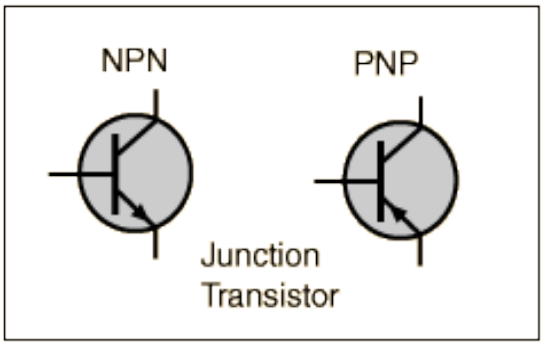


The constant reverse voltage V_z of the zener diode makes it a valuable component for the regulation of the output voltage against both variations in the input voltage from an unregulated power supply or variations in the load resistance. The current through the zener will change to keep the voltage at within the limits of the threshold of zener action and the maximum power it can dissipate.



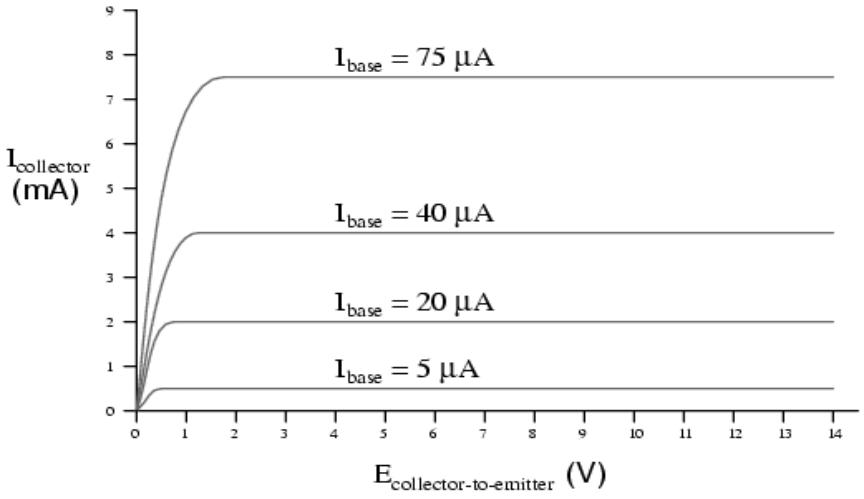
A single Zener diode can limit one side of a sinusoidal waveform to the zener voltage while clamping the other side to near zero. With two opposing zeners, the waveform can be limited to the zener voltage on both polarities.

Bipolar Junction Transistors (BJTs)



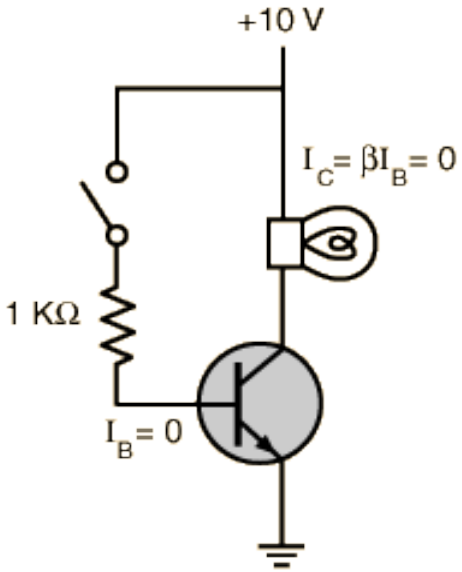
The generic transistor is called a bipolar junction transistor and is formed by two p-n junctions formed with the same substrate material, indicated by the middle letter in pnp or npn transistors. The transistor acts as a current amplifier, having many applications for amplification and switching.

- Bipolar transistors are so named because the controlled current must go through *two* types of semiconductor material: P and N. The current consists of both electron and hole flow, in different parts of the transistor.
- Bipolar transistors consist of either a P-N-P or an N-P-N semiconductor "sandwich" structure.
- The three leads of a bipolar transistor are called the *Emitter*, *Base*, and *Collector*.
- Transistors function as current regulators by allowing a small current to *control* a larger current. The amount of current allowed between collector and emitter is primarily determined by the amount of current moving between base and emitter.
- In order for a transistor to properly function as a current regulator, the controlling (base) current and the controlled (collector) currents must be going in the proper directions: adding at the emitter and going in the direction of the emitter arrow symbol. To achieve this we need to apply correct “biasing” voltages to the base-emitter and collector-base junctions.

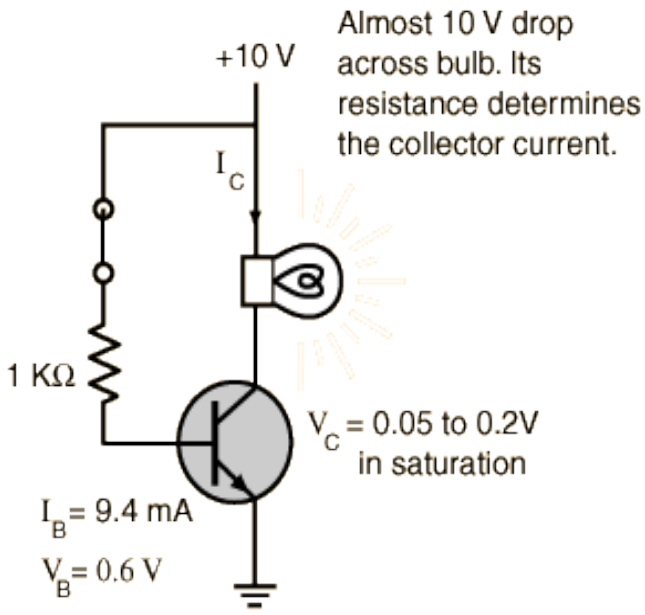


The adjoining curve represents the typical collector current variation with the collector-emitter junction voltage for different values of the base current. The flat region of the curve represents the saturated phase of the transistor.

Transistor used as a switch



There is no current to the base, so the transistor is in the cut off condition with no collector current. All the voltage drop is accoss the transistor.



The base resistor is chosen small enough so that the base current drives the transistor into saturation.

In this example the mechanical switch is used to produce the base current to close the transistor switch to show the principles. In practice, any voltage on the base sufficient to drive the transistor to saturation will close the switch and light the bulb.