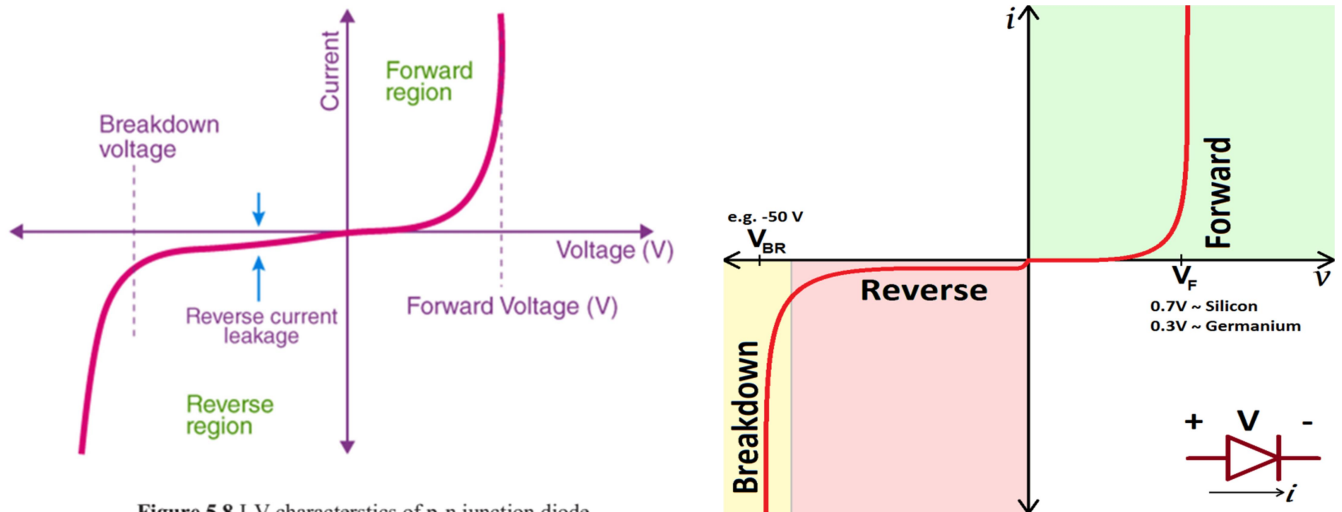


Current-voltage (I-V) characteristics of the semiconductor diode

- From the I-V curve (Figure below)
 - We can see that the current is very low if the forward voltage is lower than the cut-in voltage.
- The cut-in voltage
 - Is the voltage at which the forward diode current starts increasing rapidly.
- Once the forward bias exceed the cut-in voltage (0.3 V for germanium diode, 0.7 V for silicon diode),
 - The current will be dramatically increased, in the manner that the diode will function as a short-circuit.
- Since the diode can conduct very high current above the cut-in voltage, resistors are used in series with the diode to limit its current flow.
- In the reverse bias, a very small current called a reverse bias current or leakage current flows through the junction due to the minority charge carriers.
- If the reverse bias voltage is too high, a sharp change in the reverse bias characteristics occurs.
- At a certain voltage, called the breakdown voltage,
 - The current in the reverse direction increases rapidly.



Review Exercise 5.2. page 156/150

1. Define diode.
2. Under forward bias, the resistance is low and the current is high. True or False.
3. What are the current carriers in P-N junction diode?
4. What is forward bias? What is reverse bias?
5. The characteristic curve of the diode shows the relation between: (A) Current and voltage. (B) Voltage and resistance. (C) Voltage and power. (D) Resistance and temperature.
6. Depletion layer is caused by (A) doping (B) recombination (C) barrier potential (D) ions

5.3 Rectification

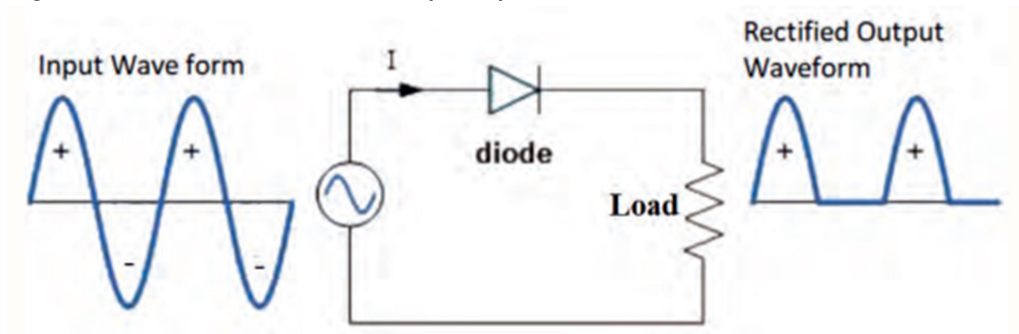
- A P-N junction diode conducts electricity when it is forward biased and it does not conduct electricity when it is reverse biased.
- Hence, it is used to rectify an alternating current (AC) voltage supply.

Rectification

- The process in which an AC voltage supply is converted into a unidirectional (DC) voltage
 - is the main function of diodes.
- and
 - The electric circuit used for the conversion is called a rectifier.
- When the AC input is applied to a junction diode, it becomes forward biased during the positive half cycle and reverse biased during negative half-cycle.
- There are two basic types of rectifier circuit used with power supplies:
 - half-wave rectifiers and full-wave rectifiers.

Half wave rectification

- Only allows one half-cycle of an AC voltage waveform to pass by blocking the other half-cycle.
- Therefore, the current in the circuit flows in only one direction.
- It consists of a diode and a load resistor connected in series to the cathode end of the diode.
 - Figure below illustrates the basic principle of a half-wave rectifier.

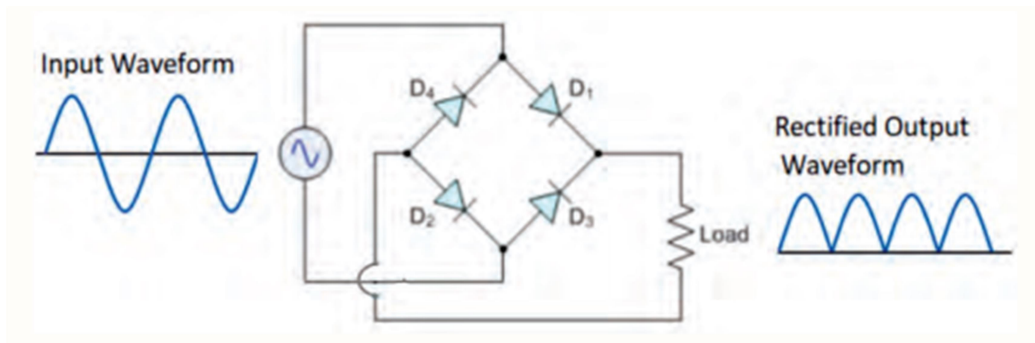


Working principle of Half Wave Rectifier:

- In a half-wave rectifier circuit during the positive half-cycle of the input, the diode is forward biased.
 - Current flows through the load resistor and a voltage is developed across it.
 - During the negative half-cycle, the diode is reverse biased and does not conduct.
 - Therefore, in the negative half-cycle of the supply,
 - no current flows in the load resistor as no voltage appears across it.
 - Thus the DC voltage across the load is sinusoidal for the first half-cycle only
 - and a pure AC input signal is converted into a DC pulsating output signal.

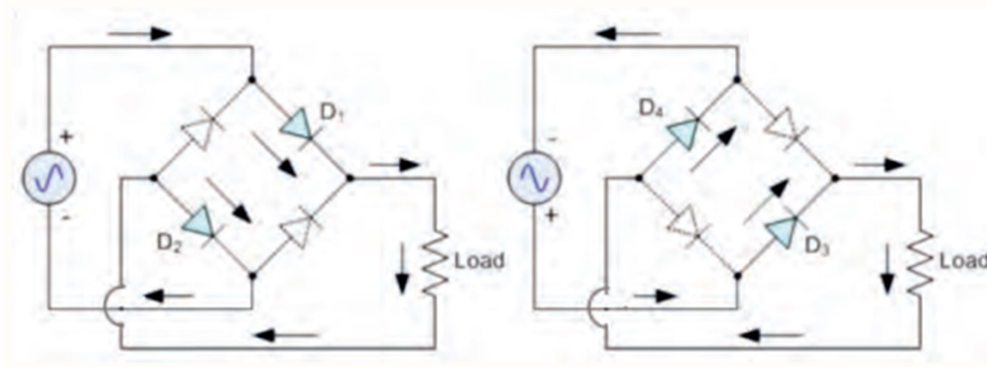
Full-wave Rectification

- The fact that the current flows only during half of each cycle in a half-wave rectifier is a disadvantage.
- To overcome this disadvantage, a full-wave rectifier can be used. Figure below shows a basic full-wave rectifier circuit, which uses four diodes arranged in a particular way.



Working principle of full wave bridge rectifier

- The four diodes, labeled D1 to D4, are arranged in such a way that only two diodes conduct current during each half-cycle.
- During the positive half-cycle of the supply,
 - Diodes D1 and D2 conduct in series.
 - However, diodes D3 and D4 are reverse biased and so the current flows through the load resistor, as shown in Figure below.
- During the negative half-cycle of the supply ,
 - Diodes D3 and D4 conduct in series,
 - but diodes D1 and D2 switch off as they are now reverse biased.
 - The current flowing through the load is the same direction as before as shown in Figure 5.11.



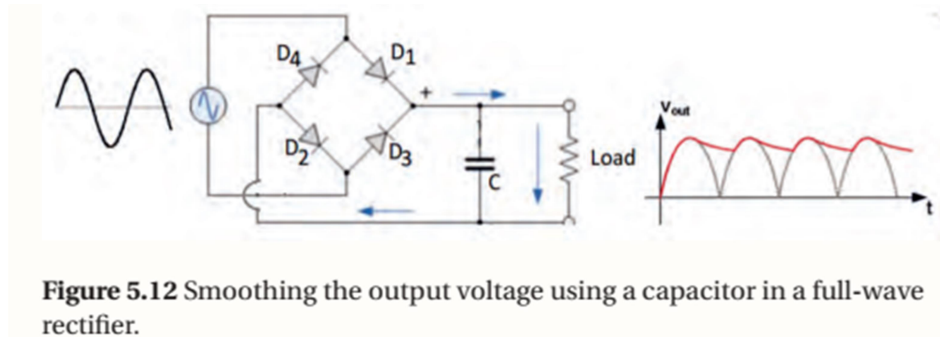
Class Work

1. The process of converting multidirectional I in to unidirectional I in multiple times is known as _____, and the device is also called _____.
2. Full-wave rectifier has an advantage than half-wave rectifier in the flow of current.
3. Write explicitly the working principle of Half wave rectification and full wave rectification.

Diodes and capacitor

- Capacitor is used in rectifier circuits to smooth the fluctuations of the output voltage.
- A capacitor stores charge and releases it later.
- The capacitor is connected across the terminals as shown in Figure 5.12.
- During the positive quarter-cycle of the output voltage, the capacitor is charged to the peak voltage.
- Then, as the rectifier voltage falls, the capacitor discharges and provides the required current to the load resistor from its stored charge..

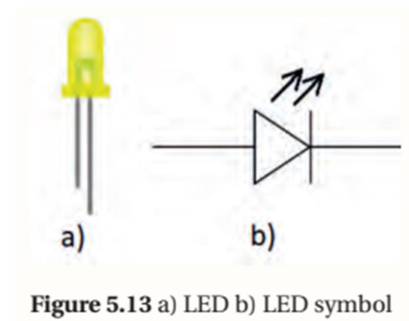
- This charging and discharging process of the capacitor smooths out the waveform.



Practical uses of diodes

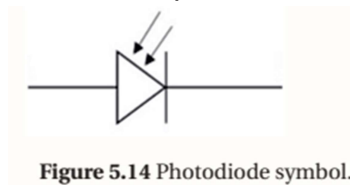
Light emitting diodes (LED)

- Is a P-N junction diode which can emit light when an electrical current flows through it Figure 5.13.
- It uses a special kind of doping
 - So that when an electron crosses the P-N junction, a photon is emitted, which creates light.
- Its frequency (color) is determined by the type of semiconductor material used in construction of the diode.
- It allows the current to flow in the forward direction and blocks the current in the reverse direction.
- They are very efficient producers of light.



Photodiode

- is a semiconductor device with a P-N junction that converts photons (or light) into electrical current.
 - Photons absorbed in the depletion region (or close to it) will create electron-hole pairs which will move to opposite ends of the diode due to the electric field.
 - Electrons will move toward the positive potential on the cathode, and the holes will move toward the negative potential on the anode.
- These moving charge carriers form the current (photocurrent) in the photodiode.



Logic gates

- Diodes and resistors can be combined with other components to construct AND and OR logic gates.
- This is referred to as diode resistor logic.

Over-voltage protection

- Excess voltage can damage our electronic devices.

- Sensitive electronic devices need to be protected from fluctuations in voltage; the diode is perfect for this.
 - Diodes achieve this by shutting down the switch after sensing an over-voltage condition.

Exercise 5.3

1. What is rectification?
2. Describe the function of resistor and capacitor in electronic circuit
3. The dc current through each forward-biased diode in a full-wave rectifier equals: (A) the load current (B) half the dc load current (C) twice the dc load current (D) one-fourth the dc load current.
4. The basic reason why a full-wave rectifier has a twice the efficiency of a half-wave rectifier is that: (A) it makes use of transformer (B) the heating loss is much less (C) it utilizes both half-cycles of the input (D) its output frequency is double the line frequency

Transistors and their application

- A Transistor is a semiconductor device
 - Used to amplify or switch electronic signals.
 - It is an essential component in an electronic circuit.
 - are classified into two types:
 - Bipolar junction transistors (BJT) and field effect transistors (FET).

BJTs.

- Are produced when a third layer is added to a semiconductor diode,
- The term, transistor, will now be used for a BJT.
- A transistor is a three terminal, two-junction device used to control electron flow.
- By varying the amount of voltage applied to the three terminals, the amount of current can be controlled.
 - This is how transistors can be used for amplification or switching.
- A transistor consists of three alternately doped regions.
- The three regions are arranged in one of two ways.
 - In the first method,
 - The P-type material is sandwiched between two N-type materials, forming an NPN transistor (Figure 5.15a).
 - In the second method,
 - a layer of N-type material is sandwiched between two layers of P-type material, forming a PNP transistor (Figure 5.15b).
- In both types of transistor,
 - The middle region is called the base and the outer regions are called the emitter and collector.
 - The emitter, base, and collector are identified by the letters E, B, and C, respectively.

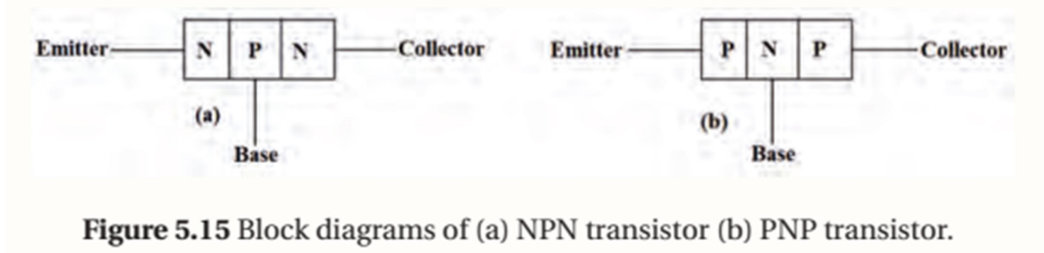


Figure 5.15 Block diagrams of (a) NPN transistor (b) PNP transistor.

Emitter:

- The section on one side that supplies charge carriers (electrons or holes).

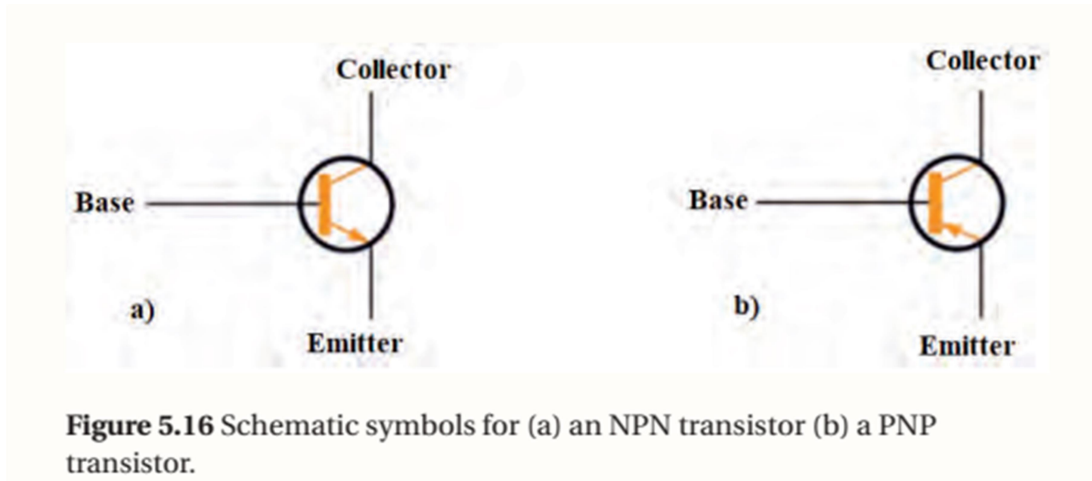
- is the heavily doped region as compared to the base and collector.

Collector:

- The section on the other side that collects the charges carriers.
- is moderately doped region and slightly larger in size as compared to the base and the emitter.

Base:

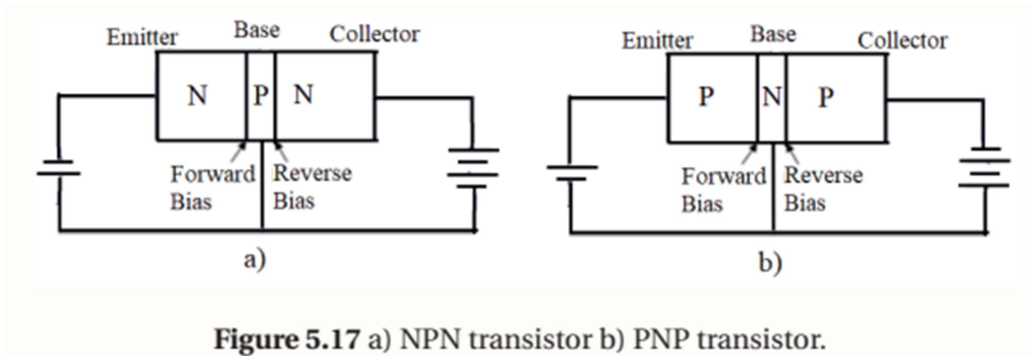
- The middle section between the emitter and the collector.
- is lightly doped and very thin.
- In the symbolic representation for a transistor (Figure 5.16), the arrow mark is placed on the emitter in the direction of conventional current flow.



Basic transistor operation

NPN transistor

- A transistor must be biased by external voltages so that the emitter, base, and collector regions interact in the desired manner. In a properly biased transistor, the emitter junction is forward biased and the collector junction is reverse biased.
- The emitter in NPN transistor is connected to the negative terminal of the battery while the base is connected to the positive terminal. Since the second P-N junction is required to be reverse biased for proper transistor operation, the collector must be connected to an opposite polarity voltage (positive), as shown in Figure 5.17a.



In the forward biased circuit:

- Electrons leave the negative terminal of the battery and enter the N material (emitter) as shown in Figure 5.18. This constitutes the emitter current I_E .

- Since electrons are majority current carriers in the N material, they pass easily through the emitter, cross over the junction, and combine with holes in the P material (base).
- As the base is lightly doped and very thin, only a few electrons combine with holes and they constitute the base current I_B .
- The electron majorities will diffuse to the collector region and constitutes collector current I_C .
- These electrons are influenced by the positive potential applied voltage to the collector and are attracted to the positive side of the voltage source of the collector.
- It can then be seen that the emitter current is the sum of the base current and collector current.

$$I_E = I_B + I_C \quad (5.1)$$

- The arrows in Figure 5.18 show the direction of the electron current which is opposite to the direction of the hole current (conventional current).

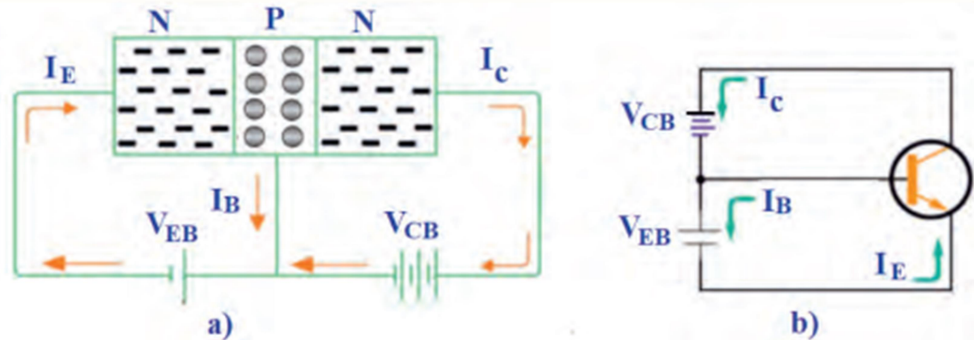


Figure 5.18 Electron current flow in NPN transistor (a) Block diagram NPN transistor (b) Schematic diagram of NPN transistor.

Class Work

1. Which of the following

PNP Transistor (page 163)