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APPLICATIONS OF SEMICONDUCTOR DEVICES

APPLICATIONS OF p-n JUNCTION DIODES

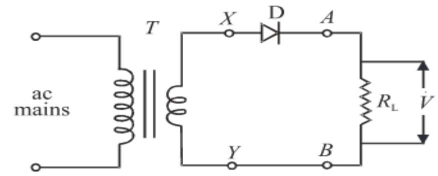
a p–n junction exhibits asymmetric electrical conduction ,i.e., its resistance in forward bias is different from that in reverse bias. This property of a diode is used in rectification, i.e., conversion of an ac signal into a dc signal(of constant magnitude).

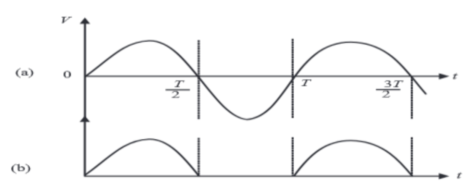
Half-Wave Rectification

The signal from ac mains is fed into a step down transformer T which makes it available at the terminals X and Y. The load resistance RL is connected to these terminals through a p-n junction diode D.

In the positive half cycle, during the time interval 0 to T/2, diode D will be forward biased and conduct, i.e., current flows through RL from A to B. However, during the negative half cycle, i.e., in the interval T/2 to T, D is reverse biased and the junction will not conduct, i.e. no current flows through R

The maximum reverse voltage that a diode can oppose without breakdown is called its Peak Inverse Voltage(PIV) $v_{dc} = \frac{v_m}{\pi}$



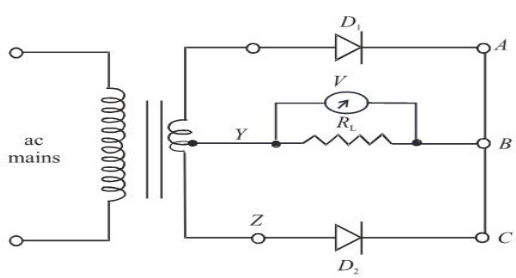


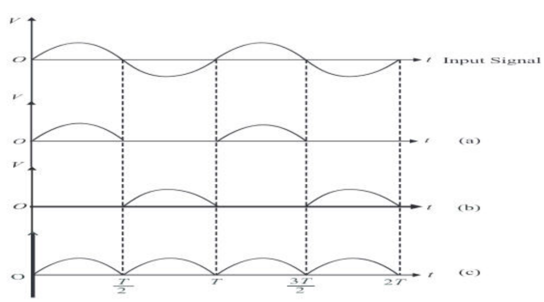
where Vm is the peak ac voltage. The dc current Idc through the load resistance RL is given by

$$I_{dc} = \frac{V_{dc}}{R_L} = \frac{V_m}{\pi R_L}$$

Full-Wave Rectification

The input signal in a centre tapped step down transformer. (It has two identical secondary windings connected in series.) D1and D2 are two p-n junction diodes, One end of the load resistance RL is connected to the central point Y of the secondary windings and the other end is connected to the cathode terminals of the diodes D1 and D2. The anodes of these diodes are connected respectively to the ends X and Z of the secondary windings. The potentials at the ends X and Z are in opposite phase with respect to Y, i.e., when potential of X is positive, Z will be negative and vice versa

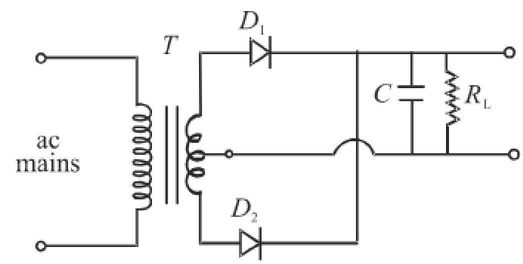




$$V_{dc} = 2 \times V_m/\pi$$

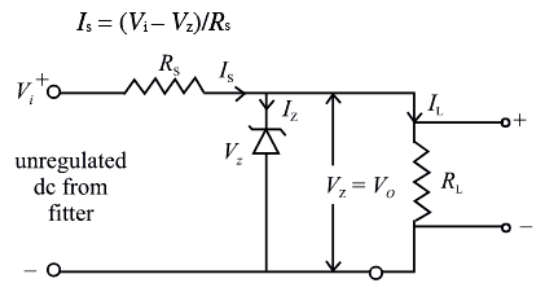
$$I_{dc} = \frac{V_{dc}}{R_L} = \frac{2V_m}{\pi R_L}$$

Filtering



The capacitor C connected across the load to reduce fluctuations is called a filter capacitor.

Zener Diode as a Voltage Regulator



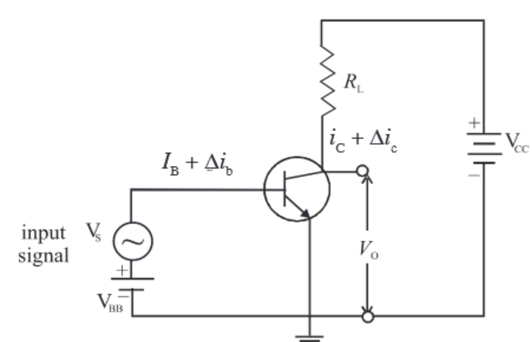
$$I_z = I_s - I_L$$

The power dissipation in Zener diode is given by the relation

$$P_d = V_z \times I_Z$$

TRANSISTOR APPLICATIONS

Transistor as an Amplifier



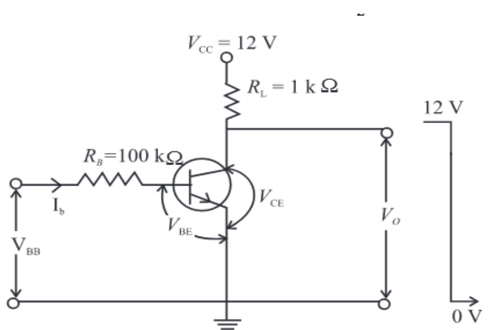
Voltage gain, $A_v = \frac{V_o}{V_i}$

Current gain, $A_i = \frac{i_o}{I_i}$

Power gain, $A_p = \frac{P_o}{P_i}$

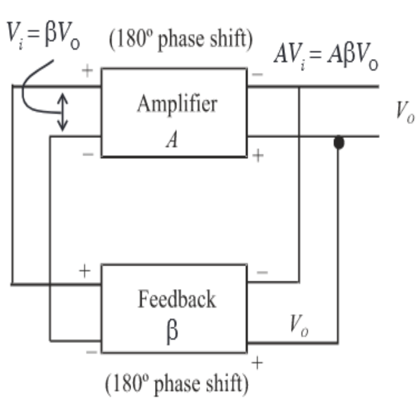
Transistor as a switch

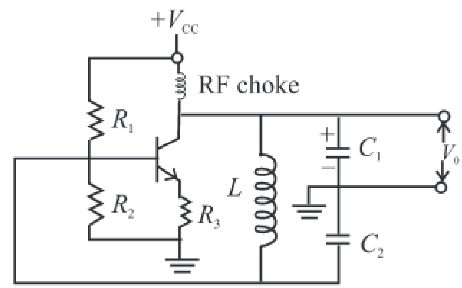
a transistor conducts current across the collector-emitter path only when a voltage is applied to the base. When no base voltage is present, the switch is off. When base voltage is present, the switch is on.



Transistor as an Oscillator

An electronic oscillator is a device which generates continuous electrical oscillations. In a simple oscillator circuit, a parallel LC circuit is used as resonant circuit and an amplifier is used to feed energy to the resonant circuit. It can generate frequencies from audio to radio range depending on the choice of L and C.

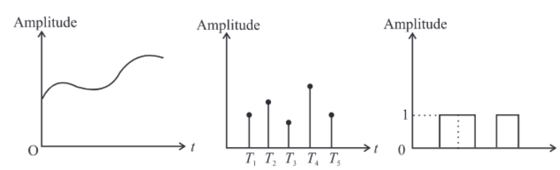




LOGIC GATES

The information carried by these waveforms is called signal.

- When the signal takes any value within a range of amplitude at any instant of time, it is called a continuous signal.
- When the signal takes the value only at certain times, it is called a discrete signal.
- When the signal takes only particular finite number of amplitude values, it is called a digital signal



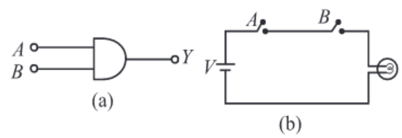
Basic Logic Gates

Logic gates are devices which have one or more inputs and one output. They give different output when the input bits differ in their arrangement. The output produced by these gates follows the laws of Boolean logic

AND Gate

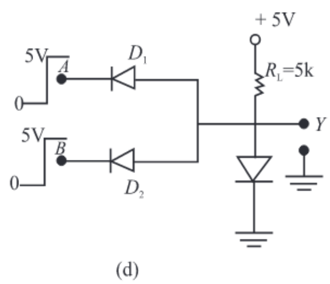
The Boolean expression for the AND operation is represented as

Y = A.B = AB = A × B and read as A AND B



A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

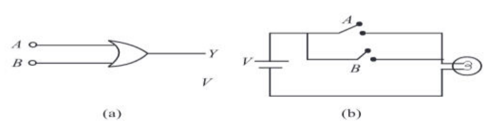
(c)



OR Gate

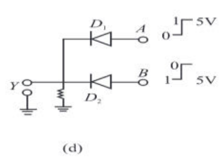
The Boolean expression for an OR operation is represented as

Y = A + B and read as A or B



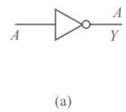
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

(c)



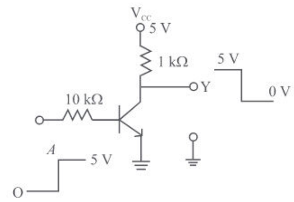
NOT Gate

Which inverts the signal, i.e., if input is '1' then output of NOT gate is '0' and for '0'input, the output is '1'.



A	Y = A
0	1
1	0

(b)



Combination Logic Gates

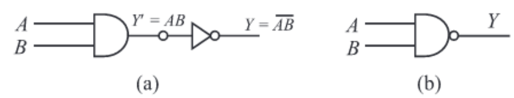
Two most important gates formed by combination of logic gates are (1) NAND[NOT+AND] and

(2) NOR [NOT+OR] gates.

NAND Gate

The NAND Gate is obtained by combining AND gate and NOT gate,

The Boolean expression of a NAND operation is represented as Y = A.B = A×B = AB



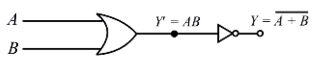
A	B	Y' = AB	$Y = \overline{AB}$
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

(c)

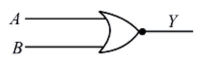
NOR Gate

The NOR gate, obtained by combining an OR gate and NOT gate

The Boolean expression for a NOR operation is represented as Y = A+B



(a)



(b)

A	B	Y′ = A+B	Y = $\overline{A+B}$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

Check Yourself

1. Which of the following are known as universal gates?
   a) NAND & NOR b) AND & OR
   c) XOR & OR d) EX-NOR & XOR
2. In Zener diode, the Zener breakdown voltage takes place at
   A) Above 6 v B) Below 6 V
   C)At 6 v D) All of the above
3. Voltage feedback in feedback amplifier is proportional to
   a) Grid voltage
   b) Square of output voltage
   c) Output voltage
   d) Square of gridvoltage
4. A transistor is essentially
   a) Power driven device
   b) A current operated device
   c) A voltage operated device
   d) A resistance operated device
5. Push pull amplifier employ
   a) 4 transistor
   b) 2 transistor
   c) 1 transistor
   d) None of the above

Stretch Yourself

1. Explain how a Zener diode helps to stabilize dc against load variation.
2. Draw a circuit using diodes and transistors to implement a NAND gate.
3. Draw a circuit using diodes and transistors to implement a NOR gate.
4. Why the Peak Inverse Voltage (PIV) of a p-n junction diode in half-wave rectifier with filter capacitor is double of that without the capacitor?
5. For a CE amplifier, RL = 2000 Ω , ri = 500 Ω and β = 50. Calculate voltage gain and power gain.

Hint to Check Yourself

1 a 2b 3c 4b 5b