19 Electronic Devices and Communication Systems

Semiconductor Electronics :

- The electrons in inner orbit of atom are bounded with nucleus so there is no change in their energy levels but the electrons in outer orbit are shared with other atoms so there is the change in their energy levels.
- For the electron in crystal different energy levels are available then the energy of electron in independent atom. These energy levels are called Energy Band.
- Electron can transit in any level of upper band as per energy gained by it and it behave as free electron and take part in conduction process. So this upper band is called conduction band.
- The energy difference between minimum energy of conduction band and maximum energy of valence band is called band gap. Band gap is represented by E_g.
- In the band gap region of energy any energy lavel does not exist. It implies electron cannot possess energy in this rigion. This region is called forbidden gap.
- In semiconductors the valence band is completly filled and conduction band is completely empty at 0K.

Explanation of conductor, insulator and semiconductor based on band theory :

Conductor : In conductor the conduction-band and valence-band superpose to each other. There is no farbidden gap in conductors.

Insulators : Forbidden gap is large in insulators ($E_g > 7eV$). The insulator like diamond the forbidden gap is of 6 eV.

Semiconductor : Forbidden gap is small in semiconductor ($E_g < 3eV$). In silicon it is of 1.1 eV.

Extrinsic Semiconductor : The semiconductor in which proper impurities are added in proper proportion are called extrinsic semiconductor.

N-Type Semiconductors :

- The conductivity of pure semiconductors can be drastically changed by adding impurities in the right proportion. This process of adding impurities in the semiconductor is known as doping.
- In Germenium or Silicon mainly the conduction process is due to the electrons obtained by addition of pentavalent donor impurities. In these crystals majority charge carriers are electrons. These pentavalent inpurities are called donor impurities. For N type semiconductor $n_e > n_h$

P - Type Semiconductors :

- In these type of semiconductors mainly the conduction process takes place by holes.
- For P-type semiconductors holes are mojority charge carriers and $n_h > n_e$.
- P-type semiconductor is formed by doping of trivalent impurities in pure semiconductor. These impurities are called accepter impurities.
- In stable condition the rate of production of electrons and holes as well as the recombination rate are same.
- Recombination rate = $R\, n_e n_h$

- For intrinsic semiconductor $n_e = n_h = n_i$, So recombination rate $= \mathrm{R}\, n_e n_h = \mathrm{R}\, n_i^2$

  $n_i^2 = n_e n_h$

  R = Recombination co-efficient, n_h = number density of hols, n_e = number density of electrons n_i = number density of electron in pure semiconductor.

P-N Junction Diode :

- When P-type and N-type semiconductors are joined permenently the P-N functiondiode is formed. In this device, anode and cathod two electrodes are there so it is called P-N junction diode.
- At small region at P-N junction in N type, electron and in P type, holes are not there. These micro regions are depleted from their respective majority charge carriers. So is called depletion region.

  In N part of this region positive ions and P part of this rigion nagetive ions are there, so electric field is formed in the direction from N to P.
- Width of depletion region is of the order of 0.5 μm.
- The distribution of electric potential in deplection region is called depletion barrier.
- For Si depletion barier is of 0.7 V and that for Ge is 0.3 V.

Forward bias

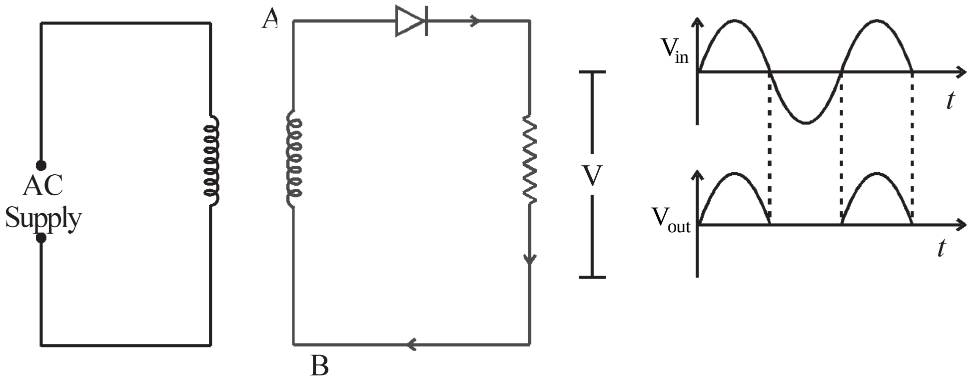
- When the positive terminal of battery is connected to P side of P-N junction and negative terminal is connected to N side of junction then such a connection is known as forward bias. In which external electric field and electric field of depletion region are in opposite direction.

Reverse bias :

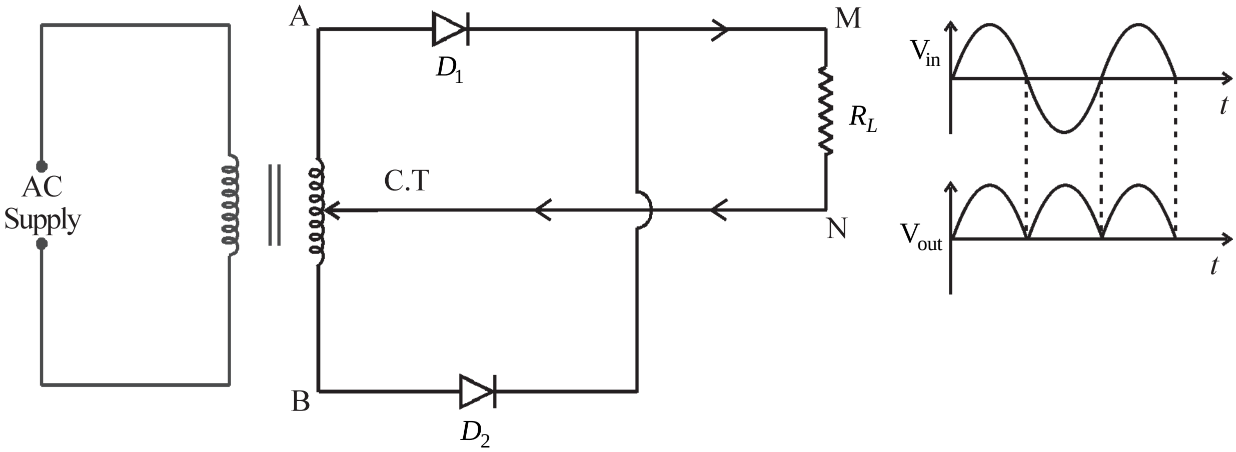
- When the positive terminal of battery is connected to N side of P-N junction and negative terminal is connected to P side of junction then such a connection is known as reverse bias. In which external electric field and electric field of depletion region are in same direction (helping mode.)
- In the forward bias connection of P-N junction the minimum voltage of external battery for which the current increases rapidly is called 'thresold voltage' or 'cut in voltage'
- In the reverse bias connection of P-N junction the voltage for which currrent increase rapidly is called 'Break down' voltage. It is denoted by V_R. If increase in current is, due to Zener effect then it is called Zener break down voltage V_Z and due to avalanche effect then it is called avalanche break down voltage V.

Rectification and Rectifier :

- The process of converting AC energy in to DC energy is called rectification.
- The circuit which convert AC energy in to DC energy is called rectifier
- **Half wave Rectifier :** The rectifier which gives DC current/voltage during half cycle out of full cycle of AC input voltage is called half wave retifier.

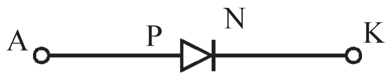


- **Full wave rectifier :** During both the half cycle of AC, the AC energy is converted in to DC energy is called full wave rectifier.



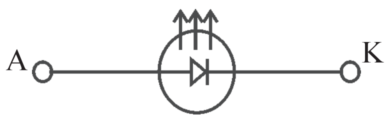
Types of diodes and their symbols :

(1) P-N Junction diode :

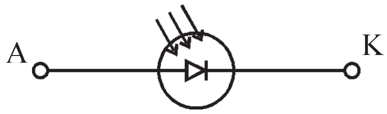


(2) Zener diode :

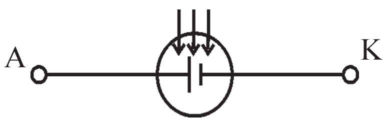
(3) Light emitting diode (LED) :



(4) Photo diode :



(5) Solar cell :



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(1) A pure silicon block is connected with battery of 2V emf at temperature 300 K. The length of cross section is 10 cm and cross sectional area is 1.0×10^{-4} m^2. How much electric current will flow through this block ? Mobility of electron is 0.14 $m^2 V^{-1} s^{-1}$ and number density is 1.5×10^{16} m^{-3}.

(A) 6.72×10^{-4} A (B) 6.72×10^{-5} A (C) 6.72×10^{-6} A (D) 6.72×10^{-7} A

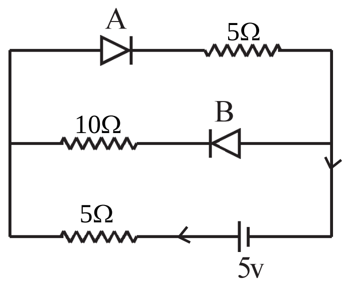
(2) Find the number density of impurity atom added to convert pure Silicon semiconductor having conductivity 6400 Ω^{-1} m^{-1}, in to n type semiconductor. Mobility of electron is 0.133 $m^2\ V^{-1}\ s^{-1}$. Neglect proporation of holes in conductor.

(A) 3×10^{22} m^{-3} (B) 3×10^{23} m^{-3} (C) 3×10^{24} m^{-3} (D) 3×10^{21} m^{-3}

(3) When in the given semiconductor Indium impurity is added the number density of holes is obtained 4.5×10^{23} m^{-3}, then find number density of electrons. For given semiconductor $n_i = 1.5 \times 10^{16}$ m^{-3}.

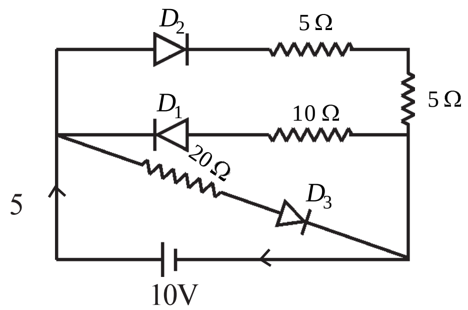
(A) 3×10^{9} m^{-3} (B) 4×10^{9} m^{-3} (C) 5×10^{8} m^{-3} (D) 6×10^{-9} m^{-3}

(4) Find current flowing through 5Ω resistance, (Consider both the diodes as an ideal diodes)



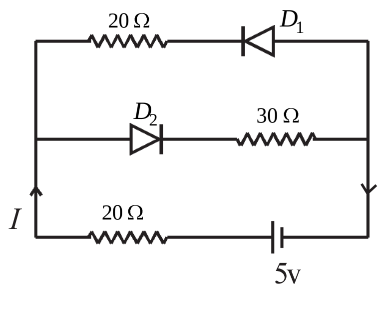
(A) 2.0 A (B) 1.0 A
(C) 0.5 A (D) 0

(5) Current flowing through the given circuit, I = ____________ A. (consider all the diodes as an ideal diodes)



(A) 0.5 A (B) 1 A
(C) 1.5 A (D) 2 A

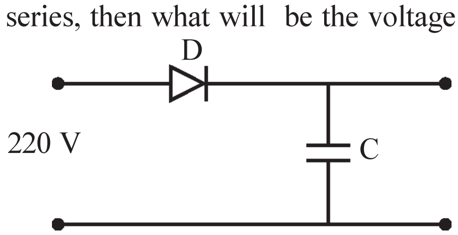
(6) Current drown from the battery in given circuit is, I = ________ (Diode D_1 and D_2 are ideal diode)



(A) $\frac{5}{40}$A (B) $\frac{5}{50}$A

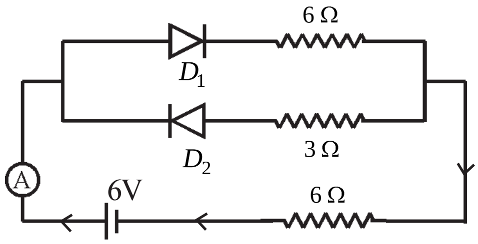
(C) $\frac{5}{10}$A (D) $\frac{5}{20}$A

(7) In the given circuit with 220 V (rms) AC voltage source a diode and a capacitor are connected in series, then what will be the voltage across two plate of capacitor ?



(A) 720 V (B) 110 V
(C) 311.1 V (D) $110\sqrt{2}\ V$

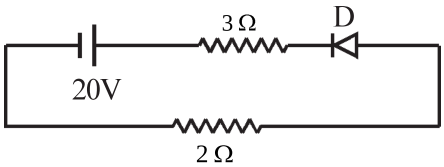
(8) Current flowing in the given circuit, $I =$ __________ (D_1 and D_2 are ideal diode)



(A) $\frac{5}{6}$A (B) $\frac{5}{7}$A

(C) $\frac{1}{2}$A (D) $\frac{5}{4}$A

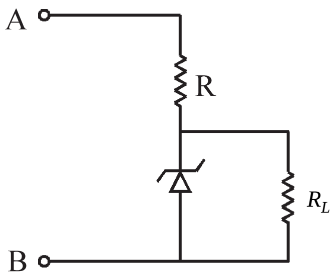
(9) What will be the potential difference between two terminal of $2\,\Omega$ resistance in the given circuit ? consider diode as an ideal diode.



(A) 10 V (B) 0 V

(C) 20 V (D) 12 V

(10) If in the given circuit when the voltage across two ends A and B is 15 V and Zener breakdown voltage is 6 V then the potential difference across two ends of resistor R will be __________ .



(A) 6 V (B) 11 V

(C) 9 V (D) 17 V

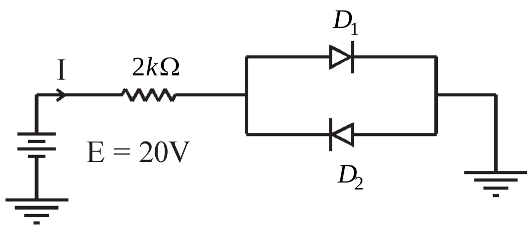
(11) The LED is working with 6 V battery and resistance R. When 10 mA current is passes through it the voltage drop obtained is 2 V, then value of R will be __________ .

(A) 40 $k\Omega$ (B) 4 $k\Omega$ (C) 200 Ω (D) 400 Ω

(12) The wavelength of light incident on photo diode is 1700 nm, then it's energy gap (E_g) will be how much ?

(A) 0.073 eV (B) 1.20 eV (C) 0.73 eV (D) 1.16 eV

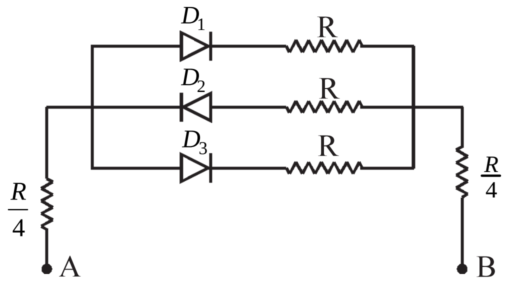
(13) Find the current flowing in the following circuit. Consider diode as an ideal diode.



(A) 0 (B) 9.65 mA

(C) 10.0 mA (D) 10.36 mA

(14) In the following circuit P–N junction diodes D_1, D_2 and D_3 are connected between A and B. Consider diodes as an ideal diodes. Arrange resistance obtained in the circuit when supply voltage is connected across A and B of following values (i) –10 V, –5 V (ii) –5 V, –10 V (iii) –4 V, –12 V



(A) (i) < (ii) < (iii) (B) (iii) < (ii) < (i)

(C) (ii) = (iii) < (i) (D) (i) ≡ (iii) < (ii)

(15) In the following question choose proper pairs from Column-1 and Column 2.

	Column - 1		**Column - 2**
(a)	Zener Diode	(p)	In photography
(b)	Photo Diode	(q)	In control of traffic light
(c)	LED	(r)	In cd player
(d)	Solar cell	(s)	In Voltage Regulated power supply

(A) a $\rightarrow$ p b $\rightarrow$ q c $\rightarrow$ r d $\rightarrow$ s

(B) a $\rightarrow$ q b $\rightarrow$ r c $\rightarrow$ s d $\rightarrow$ p

(C) a $\rightarrow$ r b $\rightarrow$ q c $\rightarrow$ p d $\rightarrow$ s

(D) a $\rightarrow$ s b $\rightarrow$ r c $\rightarrow$ q d $\rightarrow$ p

(16) The pieces of Aluminium and Silicon are placed in closed room at 280 K temperature, then which of the following statement is corrent ? (Initial temperature is 300 K)

(A) Resistance of both decreases.

(B) Resistance of both increases.

(C) Resistance of Aluminium decreases, but resistance of silicon increases

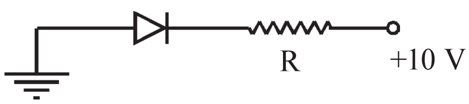
(D) Resistance of Aluminium increases, but resistance of silicon decreases

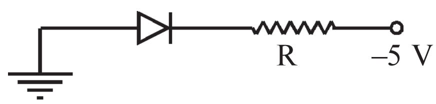
(17) The rms value of AC signal in half wave rectifier is ______________.

(A) Equal to value of DC (B) Less then value of DC

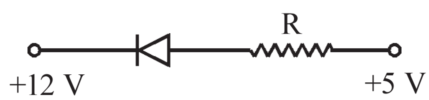
(C) Greater then value of DC (D) Zero

(18) Which diode is in forward bias from the following ?

(A) 

(B) 

(C) 

(D) 

Ans. : 1 (D), 2 (B), 3 (C), 4 (C), 5 (C), 6 (B), 7 (C), 8 (C), 9 (B), 10 (C), 11 (D), 12 (C), 13 (C), 14 (C), 15 (D), 16 (C), 17 (B), 18 (B)

Junction Transistor, Working of Transistor, Characteristic of Transistor Amplifier (common-emitter configuration) and Oscillator.

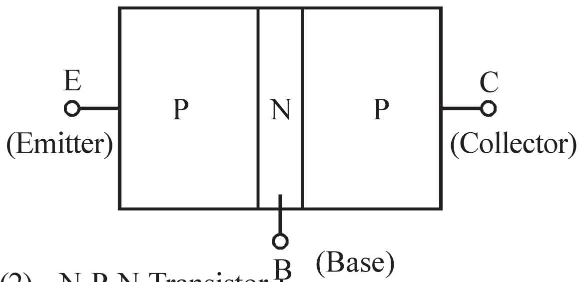
- Transister was invented by John Bardeen, walter Barten and Willium Schotky.

Transistor : Transistor is a device made up of two PN Junction diodes. Transistor is prepared by placing a thin chip of semiconductor of opposite type between two same type of semiconductors. It have three regions : Base Region (B), Emitter region (E) and collector region (C). Base (B) and collector (C) are in reversed bias mode and emitter (E) and Base (B) are in forward biased condition.

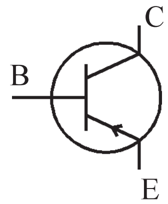
Transistor are of two types :

(1) P-N-P Transistor :

Schemetic diagram

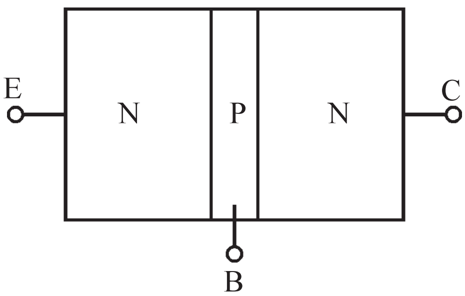


Symbolic diagram

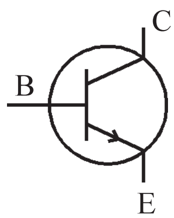


(2) N-P-N Transistor :

Schemetic diagram



Symbolic diagram



- Three different types of circuit in case of a transistor :

(1) Common Base (CB) (2) Common Collector (CC) (3) Common Emitter (CE)

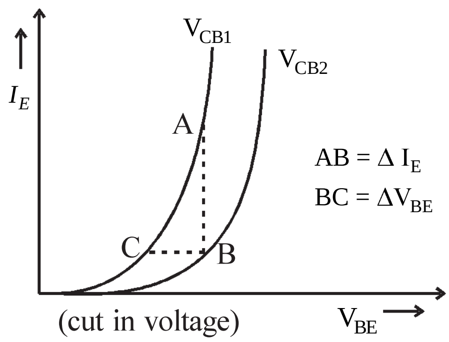
(1) Common Base Circuit :

(i) Input charecteristic

Equation of Current :

$I_E = I_B + I_C$ ($I_E =$ Emitter current, $I_B =$ Base current, $I_C =$ Collector curret)

$I_E \to V_{BE}$ (V_{CB} = constant)

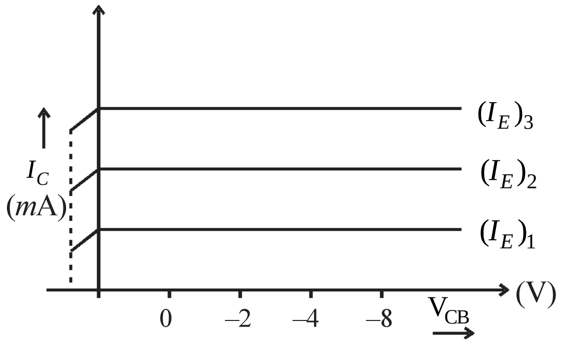


Characteristic input resistance, $r_i = \frac{BC}{AB}$

$r_i = \frac{\Delta V_{BE}}{\Delta I_E}$ $(V_{CB} = \text{Constant})$

(ii) Output Characteristic :

$I_C \rightarrow V_{CB}$ $(I_E = \text{Constant})$

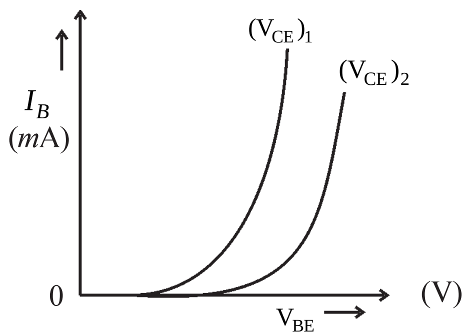


Characteristic Output Resistance

$r_0 = \left(\frac{\Delta V_{CB}}{\Delta I_C}\right)$ $(I_E = \text{Constant})$

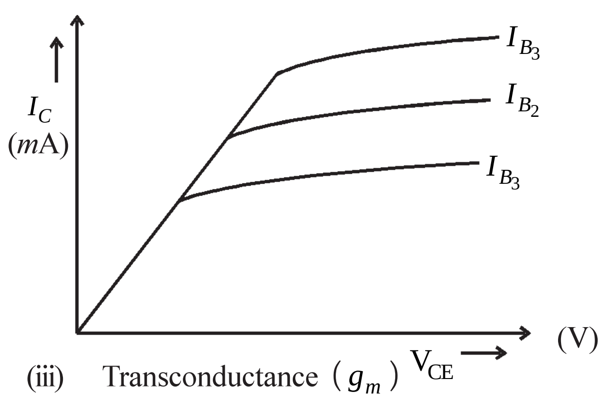
(2) Common Emitter Circuit (CE) :

(i) Input Characteristic :



Input resistance $r_i = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right)$ $(V_{CE} = \text{Constant})$

(ii) Output Characteristic :



(i) Output resistance $r_0 = \left(\frac{\Delta V_{CE}}{\Delta I_C}\right)$ $(I_B = \text{Constant})$

(ii) Current gain (β)

$\beta = \left(\frac{\Delta I_C}{\Delta I_B}\right)$ $(V_{CE} = \text{Constant})$

(iii) Transconductance (g_m)

$g_m = \frac{\Delta I_C}{\Delta V_{BE}} = \frac{\beta}{r_i}$

- Unit of g_m is mho (℧)

Equations for Common Base Amplifire :

(1) Current gain $(\alpha_{dc}) = \frac{I_C}{I_E}$

$\alpha = \alpha_{ac} = \frac{\Delta I_C}{\Delta I_E} \ (\alpha < 1)$

(2) Voltage gain (A_V)

$A_V = \frac{\Delta V_0}{\Delta V_i} = (\alpha \times \text{resistance gain})$

(3) Power gain (A_P)

$A_P = \frac{\Delta P_0}{\Delta P_i} = \alpha^2 \times$ resistance gain

Equations for Common Emitter Amplifire :

(1) Current Gain (β_{dc})

$\beta_{dc} = \frac{I_C}{I_B}$

$\beta_{ac} = \frac{\Delta I_C}{\Delta I_B} \ (V_{CE} = \text{Constant})$

Reletion between α and β

$\frac{1}{\beta} = 1 + \frac{1}{\alpha}$

(2) Voltage gain (A_V)

$A_V = \frac{V_0}{V_S} = -\frac{R_L \Delta I_E}{r_i \Delta I_B} = -\beta \cdot \frac{R_L}{r_i} = -g_m R_L$

(3) Power gain

$|A_P| = -\frac{\Delta V_{CE} \cdot \Delta I_C}{\Delta V_{BE} \cdot \Delta I_B} = A_V \cdot A_i = -\beta \frac{R_L}{r_i} \cdot \beta$

$\therefore A_p = \beta^2 \frac{R_L}{r_i} = g_m \beta R_L$

Applications of Transistor

(i) As a switch (ii) As an amplifier (iii) As an oscillator

- Equations of oscillating Frequency

$f = \frac{1}{2\pi\sqrt{LC}}$, L = Inductance C = Capacitance

(19) In an N – P – N common emitter amplifier when load resistance is $18\ \text{k}\Omega$ the voltage gain obtained is 270. If input resistance of circuit is $3\ \text{k}\Omega$ then what will be transconductance and current gain for that ?

(A) $0.015\ \mho$, 45 (B) $0.03\ \mho$, 25 (C) $0.02\ \mho$, 20 (D) $0.04\ \mho$, 20

(20) In an N – P – N common base transistor circuit 4 % electrons from emitter combines with holes in base. If collector current is 24 mA then find emitter current and current gain.

(A) 40 mA, 0.85 (B) 20 mA, 0.93 (C) 25 mA, 0.96 (D) 30 mA, 0.96

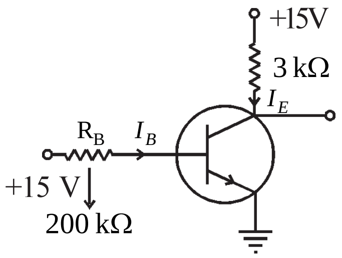
(21) The base current changes by $250\ \mu\text{A}$ when 175 mV input signal is applied to CE amplifire. If output voltage is 5V then find output resistance (R_L) and voltage gain for that.

(A) $1\ \text{k}\Omega$, 10 (B) $3\ \text{k}\Omega$, 12.5 (C) $70\ \text{k}\Omega$, 28.8 (D) $0.7\ \text{k}\Omega$, 28.8

(22) In N-P-N common emitter amplifier input voltage is changed by 200 mV, the collector current changes by 5 mA. Current gain in this circuit is 100. What should be the value of load resistance to obtain power gain equal to 5000 ?

(A) $3000\ \Omega$ (B) $2\ \text{k}\Omega$ (C) $1000\ \Omega$ (D) $4000\ \Omega$

(23) In the circuit, given in figure keeping voltage at base resistance R_B, equal to +15V, voltage V_{BE} and V_{CE} both becomes zero, then find I_c, I_β and β for that circuit.



(A) 7 mA, 250 mA, 38.7

(B) 5 mA, $50\ \mu\text{A}$, 100

(C) 5 mA, $75\ \mu\text{A}$, 66.6

(D) 10 mA, $200\ \mu\text{A}$, 50

(24) AC Current gain for N-P-N common emitter circuit is 150. Input resistance of transisstar is $500\ \Omega$. To obtain power gain equal to 1000 for this circuit, find the value of load resistance.

(A) $93.75\ \Omega$ (B) $22.22\ \Omega$ (C) $200\ \Omega$ (D) $300\ \Omega$

(25) For common emitter transistor the current gain is 0.98. If input and output load resistance are $70\ \Omega$ and $5\ \text{k}\Omega$ respectively then find voltage gain and power gain.

(A) 2200, 15700 (B) 400, 217150 (C) 2500, 121500 (D) 3500, 171500

(26) The current gain for a transistor is 50. When it is used as common emitter it's input resistance is $1\ \text{k}\Omega$ and maximum value of input voltage is 0.01V, then find value of collector current at that time.

(A) $500\ \mu\text{A}$ (B) 50 mA (C) $0.5\ \mu\text{A}$ (D) 0.5 mA

(27) In common base amplifire input resistance and load resistance are 3Ω and 24Ω respectively. If current gain is 0.6, then find voltage gain.

(A) 0.48 (B) 48 (C) 4.8 (D) 480

(28) In common base transistor amplifier current gain is 0.5. Emitter current is 7mA then find base current.

(A) 5.5 mA (B) 4.5 mA (C) 2.5 mA (D) 3.5 mA

(29) In transistor oscillator circuit, $L = \frac{20}{\pi^2} mH$ and $C = 0.02\ \mu F$, then find resonance frequency of oscillator

(A) 25 mHz (B) 25 kHz (C) 2.5 kHz (D) 250 kHz

Ans. : **19 (A), 20 (C), 21 (D), 22 (B), 23 (C), 24 (B), 25 (D), 26 (A), 27 (C), 28 (D), 29 (B)**

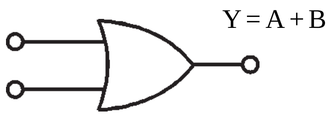
Logic Gates

Number of probability in logic gates is 2^n, Where $n =$ number of Inputs

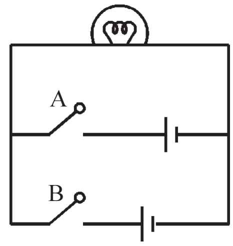
OR Gate : Boolean equation : $Y = A + B$

A	B	Y = A + B
0	0	0
0	1	1
1	0	1
1	1	1

Truth Table



Circuit symbol



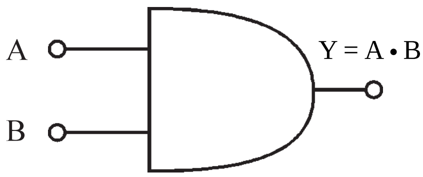
Circuit explaining working

When all input are zero then output is zero

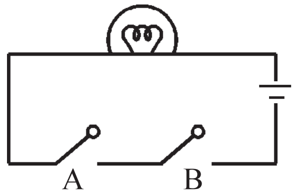
AND Gate : Boolean equation : $Y = A \cdot B$

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

Truth Table



Circuit symbol



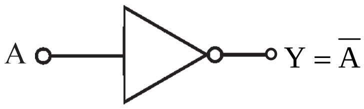
Circuit explaining working

When all input are 1 output is 1.

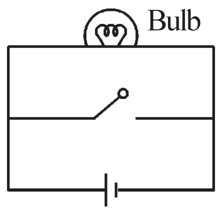
NOT Gate : Boolean equation : $Y=\overline{A}$ (Gate with only one input)

A	Y
0	1
1	0

Truth Table



Circuit symbol



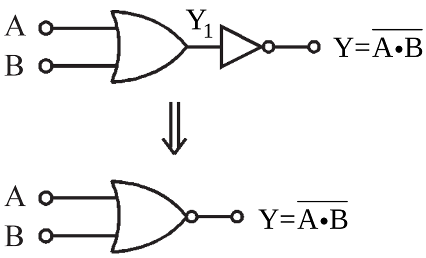
Circuit explaining working

output is opposite to input

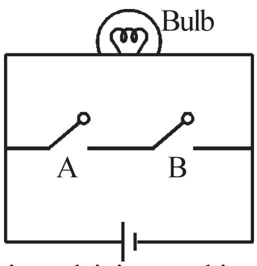
NAND Gate : Boolean equation : $Y=\overline{A \bullet B} = \overline{A}+\overline{B}$ (Output of AND gate is given to input of NOT gate to prepare NAND gate.)

A	B	Y_1=A•B	Y=$\overline{A \bullet B}$
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

Truth Table



Circuit symbol



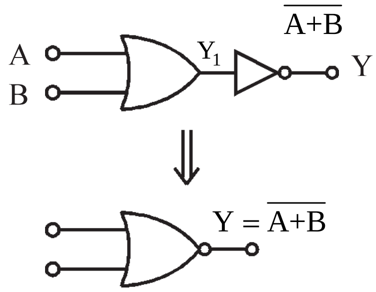
Circuit explaining working

When main input A and B are (0,1) and (1,0) output is always 1.

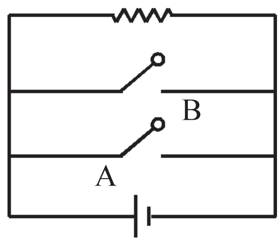
NOR Gate : Boolean equation : $Y = \overline{A+B} = \overline{A} \bullet \overline{B}$ (Output of OR gate is given to input of NOT gate to prepare NOR gate)

A	B	A+B	$\overline{A+B}$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

Trooth Table



Circuit symbol



Circuit explaining working

When either of input or both is present out put is always zero

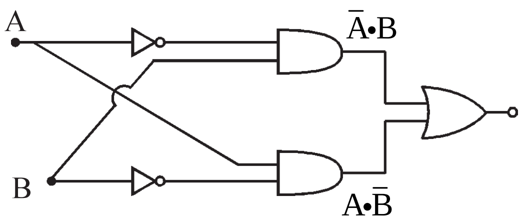
Note : OR, AND and NOT gates are called fundamantal logic gates NAND and NOR gates are called universal gate.

XOR Gate : Boolean equation : $Y = \overline{A} \bullet B + A \bullet \overline{B}$

Truth Table

A	B	$\overline{A}$	$\overline{B}$	$\overline{A} \bullet B$	$A \bullet \overline{B}$	$Y = \left(\overline{A} \bullet B + A \bullet \overline{B}\right)$
0	0	1	1	0	0	0
0	1	1	0	1	0	1
1	0	0	1	0	1	1
1	1	0	0	0	0	0

Main input A and B are same (0, 0) and (1, 1) the final output is zero.



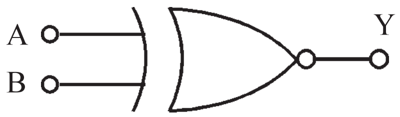
$Y = \left(\overline{A} \bullet B + A \bullet \overline{B}\right) \Longrightarrow$

XNOR Gate : Boolean equation : $Y = \overline{\overline{A} \bullet B + A \bullet \overline{B}} = (\overline{A} + B) \bullet (A + \overline{B})$

XNOR = NOT + XOR

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

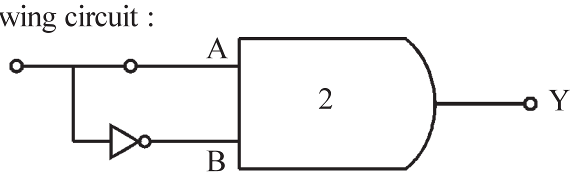
Truth Table



Circuit symbol

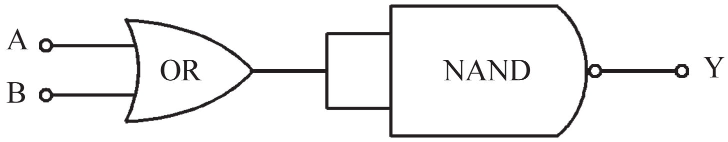
Main input A and B are same (0, 0) and (1, 1) the final output is 1.

(30) Find output Y for following circuit :



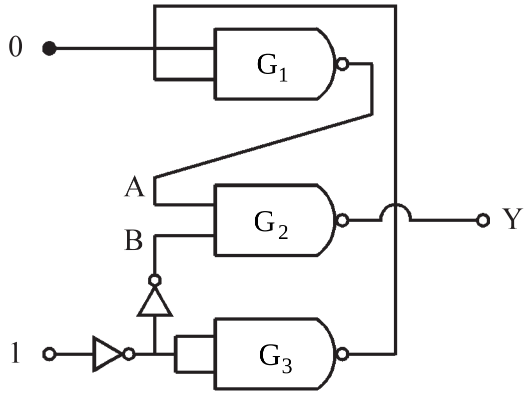
(A) 0 (B) 1 (C) 0, 1 (D) 1, 0

(31) As shown in the figure the combination of OR gate and short circuited NAND will behave as which gate ?



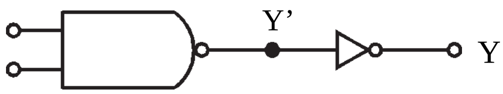
(A) NOT gate (B) OR gate (C) NAND gate (D) NOR gate

(32) Find output Y for following circuit.



(A) 0 (B) 1 (C) Between 0 and 1 (D) can't say any thing

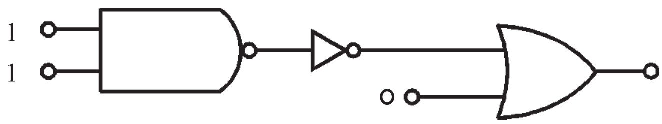
(33) Following combination will behave as which gate ?



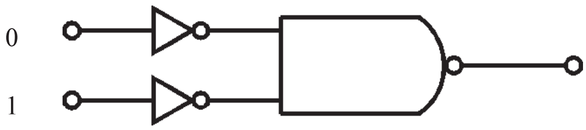
(A) AND gate (B) NAND gate (C) OR gate (D) XOR gate

(34) In the following circuit combinations output at A, B and C are respectively........

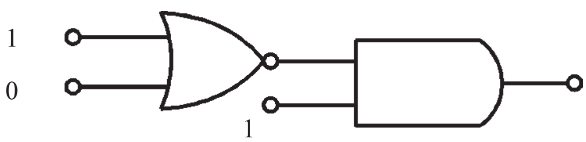
(A)



(B)

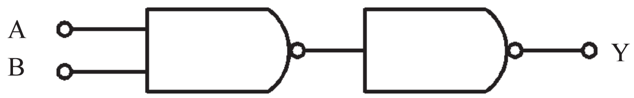


(C)



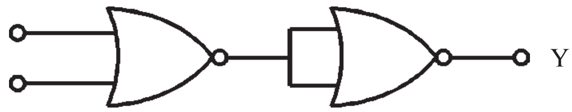
(A) 0, 1, 1 (B) 0, 1, 0 (C) 1, 1, 0 (D) 1, 0, 1

(35) Which gate will be obtained by combination of following gates ?



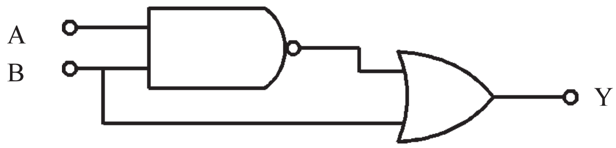
(A) XOR (B) AND (C) NAND (D) OR

(36) Which gate will be obtained by combination of following gates ?



(A) NOT (B) NAND (C) XOR (D) OR

(37) Which of following is correct option for given combination of gates ?

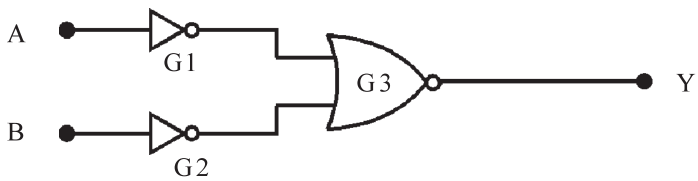


(A) $Y = \overline{A} \bullet B + \overline{B}$ (B) $Y = \overline{A} \bullet B + \overline{B} \bullet \overline{A}$ (C) $Y = \overline{A \bullet B} + B$ (D) $Y = (\overline{A} + \overline{B}).\overline{B}$

(38) For the given combination of gate which option from the following is correct ?

(A) $\overline{A \bullet B} = X$ (B) A+B = X (C) $A \bullet B = X$ (D) $\overline{A + B} = X$

(39) Following combination of gates will behave as which gate ?



(A) AND gate (B) XOR gate (C) NOR gate (D) NAND gate

Ans. : **30 (A), 31 (D), 32 (A), 33 (A), 34 (C), 35 (B), 36 (D), 37 (C), 38 (A), 39 (D)**

Experimental Techniques

(1) Draw forward bias charecteristic of P-N Junction diode and find static resistance and dynamic resistance.

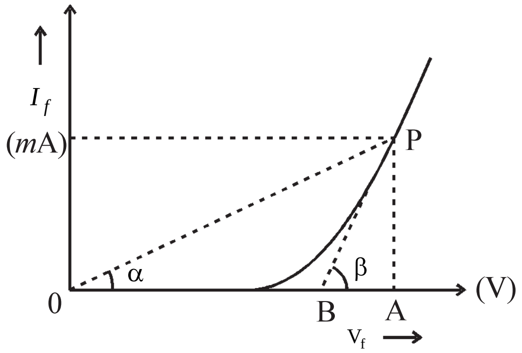
(2) Draw reverse characteristic curve of Zener diode and find breakdown voltage.

(3) Obtaine input and output characteristic curves of common emitter N-P-N transistor and final current gain.

(4) Differentiate diode, LED, Transistor, IC, resistance and capacitor from the given componants of circuit.

(1) **P-N Junction Diode :**

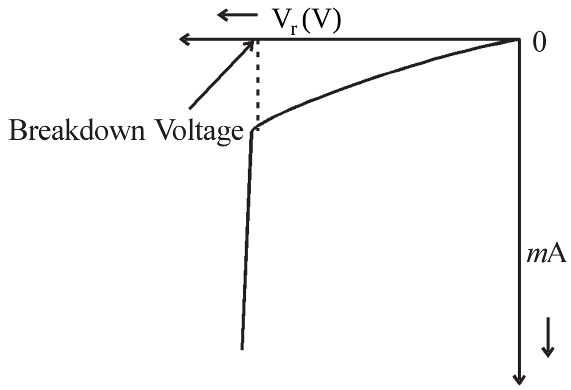
$I_f \rightarrow V_f$ (**Forward Bias**)



(i) Static resistance at point P $= \dfrac{OA}{AP} = \dfrac{1}{\tan\alpha}$

(ii) Dynamic Resistance $= \dfrac{AB}{AP} = \dfrac{1}{\tan\beta}$

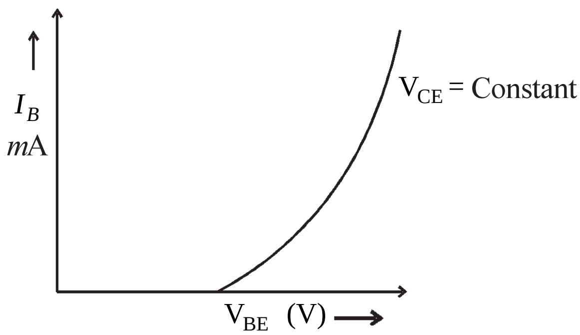
(2) **Zener Diode :**



(3) **Common Emitter :**

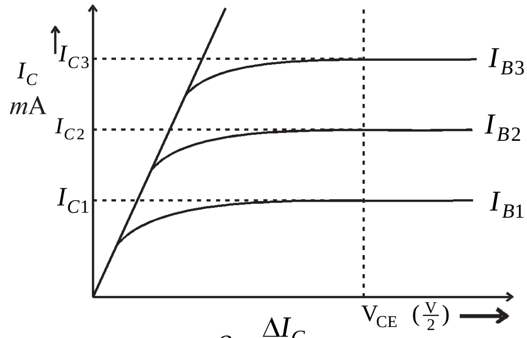
(i) Input characteristic

$I_B \rightarrow V_{BE}$ (V_{CE} = Constant)



(ii) Output charateristic

$I_C \rightarrow V_{CE}$ (I_B = Constant)



$\beta = \dfrac{\Delta I_C}{\Delta I_B}$

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(40) The resistance of P-N junction in forward and reverse bias are respectively ______, and ______

(A) $100\ \Omega, 10^6\ \Omega$ (B) $10^6\ \Omega, 100\ \Omega$ (C) $10^{-2}\ \Omega, 10^{-6}\ \Omega$ (D) $10^{-6}\ \Omega, 10^{-2}\ \Omega$

(41) The value of thresold voltage for Ge and Si are respectively ______ and ______

(A) 0.7 V, 0.3 V (B) 0.4 V, 0.5 V (C) 0.3 V, 0.8 V (D) 0.3 V, 0.7 V

(42) P-Side is earthed for a P–N junction diode and –3V electric potential is givnen to N-side then diode ______________.

(A) Will not conduct electric current (B) Will pass electric current partially

(C) Will conduct electric current (D) will breakdown

(43) In P–N junction diode the depletion region is formed due to ______________

(A) Driffing of holes (B) Diffution of constituent ions

(C) Driffing of electrons (D) Displacement of impurity ions

(44) For a transistar $\alpha = 0.95$. If change in emitter current is 10 mA then change in base current will be ______________.

(A) 10.5 mA (B) 0.5 mA (C) 9.5 mA (D) $\frac{20}{19} m$A

(45) In common base amplifire the input resistance is $4\,\Omega$ and load resistance is $32\,\Omega$. $\alpha = 0.5$, then what will be voltage gain ?

(A) 2 (B) 8 (C) 4 (D) 8

(46) For a transistor $\alpha = 0.95$. If change in emitter current is 100 mA then calculate change in collector current.

(A) 90 mA (B) 100 mA (C) 80 mA (D) 95 mA

(47) For common base amplifier and common-emitter amplifire the phase difference between input and output voltage are respectively ______________ and ______________.

(A) $0, 180°$ (B) 180°, 0 (C) 0°, 0° (D) $180°, 180°$

(48) What is the relation between current gain α and β for transistor ?

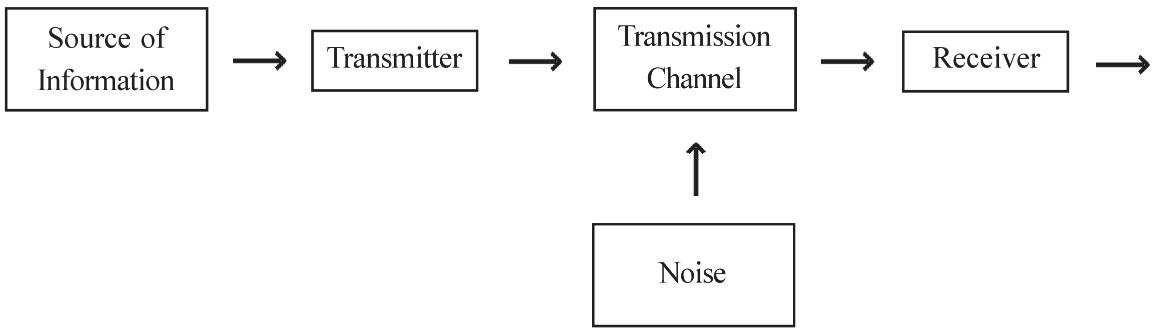
(A) $\beta = \frac{1+\alpha}{\alpha}$ (B) $\beta = \frac{\alpha}{1-\alpha}$ (C) $\beta = \frac{1-\alpha}{\alpha}$ (D) $\beta = \frac{\alpha}{1+\alpha}$

Ans. : 40 (A), 41 (D), 42 (C), 43 (B), 44 (B), 45 (C), 46 (D), 47 (A), 48 (B)

Communication Syatem

Basic Communication System :

Basic communication system consist of source of information, transmitter, link and receiver.



(i) **Information :** Any massage or thought can be represented by information. Information can be individual or in group. Information can be in the form of symbol, code, pair of words, picture.

(ii) **Transmitter :** In radio transmission the transmitter consist of transducer, modulator, amplifire and transmitting antena.

Transducer : Used to cenvert sound waves in electrical signals.

Modulator : It admixed audio electric signals with radio waves of high frequency.

Amplifire : Increases the efficiency of modulated waves.

Antenna : Waves are transmitted through antenna placed in space.

(iii) **Communication channel :**

- Communication channel is a medium connecting transmitter and receiver. The information is transmitted through this channel and reaches to receiver. Transmission link is other name of transmission channel.
- In radio and T.V. transmission the free space is used as transmission channel.

  Wireless communication : The communication system in which there is no connection of conducting wire between transmitter and receiver is called 'wireless communication'.
- In telephone system, two wire line is used as a transmission channel.

(iv) **Receiver :**

- Receiver section amplify the received signals which are transmitted through transmission channal. The signals passes through the demodulation process in the receiver and are converted into the original information using proper electronic device.
- Electrical signal given to loudspeaker converts it in to sound signal.
- Picture tube converts electrical signals into a picture.

Communication is of two type :

(i) Point to Point Communication mode

In Point to Point communication mode, communication takes over a link between single transmitter and single receiver.

For example, communication through telephone system.

(ii) Broadcast mode : In the broadcast mode there are large number of receivers corresponding to single transmiter for example, the transmission through radio and TV system.

Analog Signal and Digital Signal

- For transmission the information waves are converted in to electrical waves, which are called signal.

  Signal are of two types :

(i) Analog signal :

- An analog signal is a continuously varifing signal with respect to time.
- It's value can be any one between maximum and minimum value.
- It is represented by sine wave

  e.g. output signal of microphone or video camera.

(ii) Digital signal :

- The signal which have only two values which does not change with time is called Digital signal.
- It's minimum value is 0 and maximum value is 1.
- 0 and 1 is called bit. The group of bit is called byte.

  e.g. Digital signal are used in the digital communication.

Modulation :

- The process of superposing low frequency audio signals on waves with high frequency is called modulation.
- The low frequency signal is called modulating signal or modulating wave.
- The high frequency wave carry the information so is called carrier wave and the resultant mixed wave is called modulated wave.
- Carrier wave is of sine wave form, which is mathematically represented as follows :

  $e_c = E_c \sin(\omega_c t + \phi)$

  Where, $E_c =$ amplitude of carrier wave

  $\omega_c =$ angular frequency

  $\phi =$ Initial phase of wave

Types of Modulation :

There are three types of modulation :

(1) Amplitude modulation (AM)

(2) Frequency modulation (FM)

(3) Phase modulation (PM)

(1) Amplitude Modulation :

- A modulation in which the amplitude of the carrier wave E_c is varied in accordance with the instantaneous value of the modulating wave is called amplitude modulation.
- Carrier wave : $e_c = E_c \sin(\omega t + \phi)$
- Modulating wave : $e_m = E_m \sin \omega_m t$

$\therefore e = (E_c + e_m) \sin \omega_c t$

(The amplitude of carrier wave is varying according to instantaneous value of modulating signal)

$$\therefore e = (E_c + E_m \sin \omega_m t) \sin \omega_c t$$

$$= E_c (1 + \frac{E_m}{E_c} \sin \omega_m t) \sin \omega_c t$$

$e = E_c (1 + ma \sin \omega_m t) \sin \omega_c t$ is called mathematical form of amplitude modulated wave.

- $m_a = \frac{E_m}{E_c}$ is called modulation index
- Generally it's value is between 0 and 1. If m_a is greater then 1 then AM wave gets distorted.

Modulation index in percentage :

$$m_a = \frac{E_m}{E_c} = \frac{E_{max} - E_{min}}{E_{max} + E_{min}}$$

$$m_a (\%) = \frac{E_{max} - E_{min}}{E_{max} + E_{min}} \times 100\%$$

(2) Frequency Modulation :

- The process of changing the frequency of Audio signal in carrier wave is called frequency modulation.
- Frequency co-efficient $\delta = (f_{max} - f_c)$

$$= f_c - f_{min}$$

- $m_f = \dfrac{\delta}{m}$ is called modulation index (For Frequency)

  Where, $f_m =$ maximum frequency

  $$\therefore m_f = \frac{\delta}{f_m} = \frac{f_{\max} - f_c}{f_m} = \frac{f_c - f_{\min}}{f_m}$$

Demodulation :

- The process of separating sound-waves from modulated wave is called 'demodulation' or 'detection'
- This process is reverse process of modulation.
- A circuit separating these waves is called 'demodulation circuit' or 'detector circuit'

Propagation of Electromagnetic Waves :

- Propagation of waves is done in three ways :

  (1) Ground wave propagation or surface-wave propagation (2) Sky wave propagation (3) Space wave or Tropospheric propagation

(1) Ground Wave Propagation or Surface propagation :

- In the ground wave propagation electromagnetic waves propagate along the surface of Earth, so it is called ground wave propagation.
- The waves with frequency greater than 2 MHz can not propagate to long distance via surface wave propagation.
- The waves in MW band (Frequency 550 kHz – 1600 kHz) of AM radio propagate through ground wave.

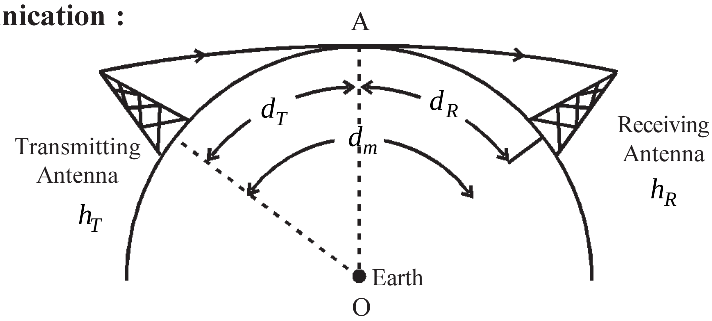
(2) Sky Wave Propagation :

- The electromagnetic waves emitted by transmitter reflected from ionosphere situated at height 60 km to 300 km and received at large distance by a receiver, this propagation is called sky wave propagation.
- The propagation of radio waves with frequence 2 MHz to 30 MHz is done by sky waves.
- The gas molecules in Earth's atmosphere are ionized and seperated in electrons and positive ions. This atmosphere is called ionosphere.
- The waves with frequencies corresponding to SW (Short Wave) band of radio broad casting can be propagated to long distance by ionosphere.

(3) Space Wave or Tropospheric Wave Propagation :

- The waves propagating to receiver directly from the transmitting antenna in a straight-line path or by reflecting from Earth are called space waves.
- Radio waves having frequency 30 MHz to 300 MHz are propagates by space wave propagation.

Line of Sight Communication :



- If the distance between transmitting antenna and receiver antenna is large, then the curvature of Earth comes in the ways of space wave propagation, because radio-waves can be received only up to the distance determined by line of sight.
- If receiving antenna is placed at height h_R and height of transmitting antenna is h_T, then maximum communication range is given by,

  $d_M = \sqrt{2h_T R} + \sqrt{2h_R R}$
- Area covered, $A = \pi d^2 = 2\pi Rh$
- Population covered = Population density $\times$ Area covered

  Important Equation :

(1) Wave length, $\lambda = \dfrac{c}{f}$

Where c = Velocity of light, f = frequency of wave, λ = wave length

(2) Carrier wave, $e_c = E_c \sin(\omega_c t + \phi)$

E_c = Amplitude of carrier wave

ω_c = angular frequency, ϕ = initial phase

(3) Permittivity of medium in the presence of free electrons : $\varepsilon = \varepsilon_0 - \dfrac{Ne^2}{m\omega^2}$

(4) Dielectric constant of medium with respect to vaccum : $K' = \dfrac{\varepsilon}{\varepsilon_0} = 1 - \dfrac{Ne^2}{m\omega^2 \varepsilon_0}$

(5) Refractive index of ionized medium : $n = \sqrt{k'} = \sqrt{1 - \dfrac{Ne^2}{m\omega^2\varepsilon_0}}$

Where, N = electron density of medium, e = charge of electron = 1.6×10^{-19} C, m = mass of electron = 9.1×10^{-31} kg, ε_0 = Permittivity of free space (Vaccum) = 8.854×10^{-12} F m^{-1}, ω = Angular frequency of Radio-waves = $2\pi f$

$n = \sqrt{1 - \dfrac{81N}{f^2}}$

(6) Critical frequency, $f_c = 9\sqrt{N_{max}}$

(7) Line of sight (Communication Range)

$d = \sqrt{2hr}$, Where h = height of antenna, r = radius of Earth

(8) Covered Area, $A = \pi d^2 = 2\pi rh$

(9) Covered Population = Population density $\times$ covered Area (A)

(10) Inductive reactance $= \omega L$

Capacitive reactance $= \dfrac{1}{\omega C}$

---

(49) The height of TV transmitter tower is 150 m at one place. To double the coverage area what should be the height of tower ?

(A) 150 m (B) 300 m (C) 75 m (D) 450 m

(50) Height of TV antenna is 200 m. If average population density is $4000\ \text{km}^{-2}$, then how many people can view TV programme ? Radius of Earth, $R_e = 6400\ \text{km}$.

(A) 3.2×10^8 (B) 3.2×10^7 (C) 3.2×10^6 (D) 3.2×10^5

(51) Find the height h_T of transmitting antenna if receiving antenna is at height 32 m. For satisfactorily line of sight communication between two antenna the maximum distance is 45.5 km. Radius of Earth $R_e = 6400\ \text{km}$.

(A) 50 m (B) 75 m (C) 25 m (D) 100 m

(52) For an amplitude modulated wave, find the maximum and minimum amplitude. Modulation Index is 25% and amplitude of carrier wave 8 V and frequency of carrier wave is 1 MHz.

(A) 12 V, 5 V (B) 10 V, 6 V (C) 10 V, 2 V (D) 15 V, 3 V

(53) In morning the maximum electron density of ionosphere is $10^{10}\ \text{m}^{-3}$. At Noon maximum electron density increases to $3\times10^{10}\ \text{m}^{-3}$, then find the ratio of critical frequency at morning and at noon.

(A) 1.732 (B) 1.414 (C) 2.000 (D) 2.236

(54) The electron density of ionosphere layers E, F_1, F_2 are $2\times10^{11}\ \text{m}^{-3}, 5\times10^{11}\ \text{m}^{-3}, 8\times10^{11}\ \text{m}^{-3}$ respectively, then find the ratio of critical frequency for reflected radio waves.

(A) 2 : 3 : 4 (B) 2 : 4 : 3 (C) 3 : 2 : 4 (D) 4 : 3 : 2

(55) For a co-axial cable inductance is $0.80\ \mu\text{H}$ and capacitance is 20 pF, then find impedence of this cable.

(A) $100\ \Omega$ (B) $4\times10^3\ \Omega$ (C) $4\times10^{-2}\ \Omega$ (D) $200\ \Omega$

(56) In a radio wave receiver to tune short wave and medium wave station the L–C circuit is used. In it capacitance are same but inductunce of coil L_s and L_m are different then.

(A) $L_s > L_m$ (B) $L_s < L_m$ (C) $L_s = L_m$ (D) Not any one

Ans. : 49 (B), 50 (B), 51 (A), 52 (B), 53 (A), 54 (A), 55 (D), 56 (B)

Passage based Question :

Passage : In a common base transistor amplifier the input resistance is $200\,\Omega$ and output resistance is $2000\,\Omega$. If $\alpha = 0.95$ then,

(57) (i) Voltage gain is ______________.

(A) 50 (B) 75 (C) 95 (D) 9.5

(58) (ii) Power gain is ______________.

(A) 50 (B) 75 (C) 9.025 (D) 90.25

Passage : In a common emitter amplifier input resistance is $1\,k\Omega$ and output resistance is $5\,k\Omega$. Input signal is of 10 mV and $\beta = 100$.

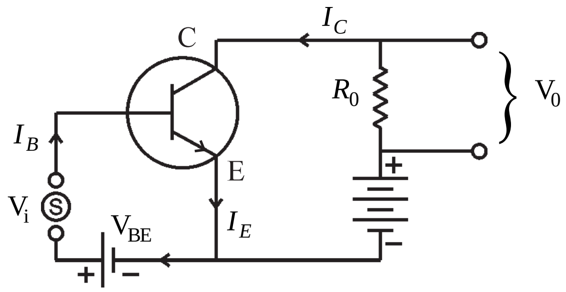
(59) (i) So output voltage = ______________

(A) 1.25 V (B) 2.25 V (C) 2.5 V (D) 5 V

(60) (ii) Power gain ______________

(A) 50,000 (B) 5500 V (C) 6 KV (D) 7500 V

Passage : An N–P–N transistor is connected in common emitter configuration as follow. Collector supply is 8V. Voltage drop is 0.8V at the load resistance of $800\,\Omega$ connected in collector circuit. If $\alpha = \frac{25}{26}$ then,



(61) (i) Collector emitter voltage V_{CE} = ______________.

(A) 8.2 V (B) 6.2 V (C) 7.2 V (D) 5.2 V

(62) (ii) If input resistance of transistor is $100\,\Omega$ then power gain will be ______________ .

(A) 1000 (B) 5000 (C) 2500 (D) 3000

Passage : A carrier wave of frequency 70 MHz and amplitude 40 V is modulated by an audio signal of frequency 2 kHz and amplitude 20 V.

(63) (i) Modulation index will be ______________.

(A) 20 % (B) 30 % (C) 40 % (D) 50 %

(64) (ii) Frequency spectrum of AM waves is ______________.

(A) 70,000 kHz – 69998 kHz (B) 65250 – 62050 kHz

(C) 52100 kHz – 45020 kHz (D) 72150 – 18750 kHz

Ans. : 57 (D), 58 (C), 59 (D), 60 (A), 61 (C), 62 (B), 63 (D), 64 (A)

Assertion - Reason type Question :

Instruction : Read assertion and reason carefully, select proper option from given below.

(a) Both assertion and reason are true and reason explains the assertion.

(b) Both assertion and reason are true but reason does not explain the assertion.

(c) Assertion is true but reason is false.

(d) Assertion is false and reason is true.

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(65) **Assertion** : Charge carriers in pure semicanductor are thermionic.

Reason : Control on number of charge carrier is easy.

(A) a (B) b (C) c (D) d

(66) **Assertion** : When two P–N junction diodes are placed back to back it behave as N–P–N transistor

Reason : Transistor is a device working by electric current, a triode valve is a device working by voltage.

(A) a (B) b (C) c (D) d

(67) **Assertion** : Resistivity of semiconductor increases with temperature.

Reason : At high temprature more co-valent bonds breaks.

(A) a (B) b (C) c (D) d

(68) **Assertion** : Common base amplifire gives voltage gain with phase difference.

Reason : The width of depletion region in P-N junction diode increases with increase in reverse bias.

(A) a (B) b (C) c (D) d

(69) **Assertion** : Common emitter amplifire gives voltage gain with phase difference.

Reason : The width of depletion region increases in P-N junction diode with increase in reverse bias.

(A) a (B) b (C) c (D) d

(70) **Assertion** : Electrons in conduction band possess more energy than electrons in valence bond.

Reason : Mobility of electrons and holes are equal.

(A) a (B) b (C) c (D) d

(71) **Assertion** : The signal which possess the level either 0 or 1 is called digital signal.

Reason : The signal which changes continuously with time is called analog signal.

(A) a (B) b (C) c (D) d

(72) **Assertion** : Photo diode is used in reverse bias mode.

Reason : In reverse bias decrease in minority charge is considereble.

(A) a (B) b (C) c (D) d

(73) **Assertion** : Mainly transistor is used in common emitter configuration.

Reason : In common emitter circuit large current gain and voltage gain is obtained.

(A) a (B) b (C) c (D) d

(74) **Assertion** : At definite temperature with less doped situation the conductivity of silicon is more.

Reason : Conductivity of pure semiconductor is less than the doped P-type semiconductor.

(A) a (B) b (C) c (D) d

(75) **Assertion** : Normally AM broadcasting is used, because it keep away the receiver complexity.

Reason : Required band width in FM is less than required band width of AM.

(A) a (B) b (C) c (D) d

(76) **Assertion** : Modulated waves are not received directly by headphone.

Reason : High frequency waves.

(A) a (B) b (C) c (D) d

(77) **Assertion** : Sky waves are not used for transmission of TV signals.

Reason : Frequency range of TV signal is of 60 MHz to 100 MHz

(A) a (B) b (C) c (D) d

Ans. : 65 (A), 66 (B), 67 (B), 68 (A), 69 (A), 70 (D), 71 (A), 72 (A), 73 (B), 74 (A), 75 (D), 76 (A), 77 (A)

Match the columns :

(78) **Gate** — **Truth Table**

(a) AND

(b) OR

(c) NOT

(d) NAND

(p)

A	Y
0	1
1	0

(q)

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

(r)

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

(s)

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

(A) $a \rightarrow s$ $b \rightarrow p$ $c \rightarrow q$ $d \rightarrow r$

(B) $a \rightarrow s$ $b \rightarrow r$ $c \rightarrow p$ $d \rightarrow q$

(C) $a \rightarrow r$ $b \rightarrow s$ $c \rightarrow p$ $d \rightarrow q$

(D) $a \rightarrow s$ $b \rightarrow q$ $c \rightarrow r$ $d \rightarrow p$

(79)

Column-1		Column-2	
(a)	Convenient frequency for satellite communication	(p)	15.625 kHz
(b)	Line frequency of TV system in India	(q)	15790 Hz
(c)	Lower frequency used in satellite communication	(r)	3000 MHz
(d)	At which frequency radio Silon 19.0 m broadcast	(s)	0.84 Hz

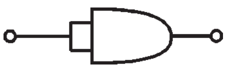
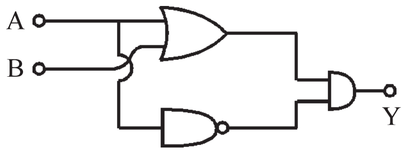
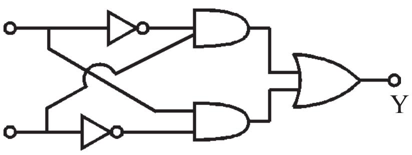
(A) a $\rightarrow$ r b $\rightarrow$ p c $\rightarrow$ s d $\rightarrow$ q

(B) a $\rightarrow$ q b $\rightarrow$ r c $\rightarrow$ s d $\rightarrow$ p

(C) a $\rightarrow$ p b $\rightarrow$ r c $\rightarrow$ q d $\rightarrow$ s

(D) a $\rightarrow$ s b $\rightarrow$ p c $\rightarrow$ r d $\rightarrow$ q

(80)

Symbol		Gate	
(a)		(p)	NOR
(b)		(q)	XOR (Special OR gate)
(c)	 *or* 	(r)	Equivalent to XOR gate
(d)		(s)	NOT

(A) a $\rightarrow$ r b $\rightarrow$ s c $\rightarrow$ p d $\rightarrow$ q

(B) a $\rightarrow$ s b $\rightarrow$ r c $\rightarrow$ q d $\rightarrow$ p

(C) a $\rightarrow$ s b $\rightarrow$ p c $\rightarrow$ q d $\rightarrow$ r

(D) a $\rightarrow$ p b $\rightarrow$ q c $\rightarrow$ r d $\rightarrow$ s

Ans. : 78 (C), 79 (A), 80 (B)

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