



POSTAL BOOK PACKAGE 2027

ELECTRICAL ENGINEERING

CONVENTIONAL PRACTICE SETS VOLUME - IV

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ELECTRICAL MATERIALS

CONVENTIONAL PRACTICE SETS

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Introduction to Engineering Materials

Q1 Discuss the difference in covalent bonding in carbon as:

- (i) diamond (ii) graphite

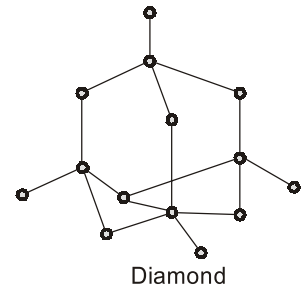
Solution:

(i) **Covalent bonding of Carbon in diamond:**

In diamond, every carbon atom bonds with four other adjoining atoms in a continuous network. No electrons are left unbonded. This results in very strong bonds between carbon atoms and is responsible for the great hardness of diamonds and their clear colourless appearance. Their great density bends light more than other crystals do making their appearance so spectacular.

Valence electrons of carbon atoms in diamonds are bonded to 4 electrons in **Tetrahedral arrangement**. The covalent bond is very strong, this makes diamonds have high melting points, the covalent bond in three dimensional structure causes diamond to become the hardest material.

The bonding of electrons, diamonds have tetrahedral shaped structures. Tetrahedral is one of the strongest structures. Diamond forces more carbon atoms into a smaller denser package. Since there are no free electrons to wander through the structure, diamonds are excellent insulators. The brilliance and fire of cut diamonds is due to a very high index of refraction (2.42) and the strong dispersion of light, properties which are related to the structure of diamonds.



(ii) **Covalent bonding of Carbon in Graphite:**

In graphite, each carbon atom shares electrons with only three neighbouring carbon atoms, leaving the fourth electron relatively free to roam around from one carbon atom to another, in much the same way as metals do. The carbon atoms form a network consisting of layers of interconnected carbons able to slide against each other making in a pencil. Unlike diamond, graphite is soft, pitch black in colour, and conducts electricity due to the free roaming valence electrons.

Valence electrons of graphite are only bonded to 3 valence electrons, so the covalent bond in hexagonal ring. Graphite is softer than diamond because they are held by weak intermolecular force. Graphite sheet like array of carbon atoms joined with minimal pressure.

Q2 (a) What is the value of directional bond angle in diamond and also write the coordination number of diamond cubic structure?

- (b) An electric field in a medium having relative permittivity '7' is passed into medium of relative permittivity of '2'. If \vec{E} makes an angle of 60° with the boundary normal then what angle does the field make with normal in the second medium?

Solution:

- (a) As we know that diamond structure has sp^3 hybrid covalent bond and each of its atom has four bonds. The directional bond angle in diamond structure is 109.5° . There are tetrahedral coordination of carbon atoms, hence the coordination number of diamond cubic structure is **Four (4)**.

give rise to metallic bond. The presence of such free electrons in a metal account nicely. For the high electrical and thermal conductivities, heat capacity surface lustre and other unique properties. Also these electrons never move inside a metal or in any solid with total freedom. All of them are influenced, to some extent by the other particles present inside and when their presence is taken into consideration.

Secondary Bonds: As compared to primary bonds, secondary bonds are weak. The driving force arises due to the attraction of electric dipoles contained in atoms or molecules.

(i) Van der Waals Bonds:

Atoms, molecules or ions of all substances exert attractive force on each other when they are brought closer bond so developed is known as Van der Waals bond. The forces that act are proportional to r^{-7} where r is separation between the atoms or molecules.

(ii) Hydrogen Bond:

Certain compounds, notably water, have much higher boiling and melting points than would be expected.

Example : Non-metallic hydrides H_2Te , H_2Se and H_2S .

Have the respective boiling points of -2° , -42° and -60° while H_2O with a still smaller molecular weight has a boiling point of $100^\circ C$.

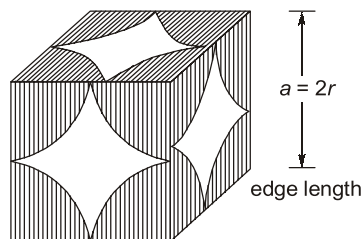
Q4 What are the main types of cubic crystal structure? Define atomic packing factor of all the cubic crystal structure materials.

Solution:

There are three types of cubic crystal structures:

- **Simple Cubic Crystal structure (SCC):**

In this structure, there is one Lattice point at each of the eight corners of the unit cell. It has a coordination number of six.



Atomic Packing Factor (APF) of the crystal structure is defined as the ratio of total volume of the atoms per unit cell to the volume of the unit cell. It is also known as packing efficiency (η).

Here,

$$APF = \frac{1 \times (\pi/6) a^3}{a^3} = \frac{\pi}{6} = 0.524$$

\therefore % APF = 52.4% filled

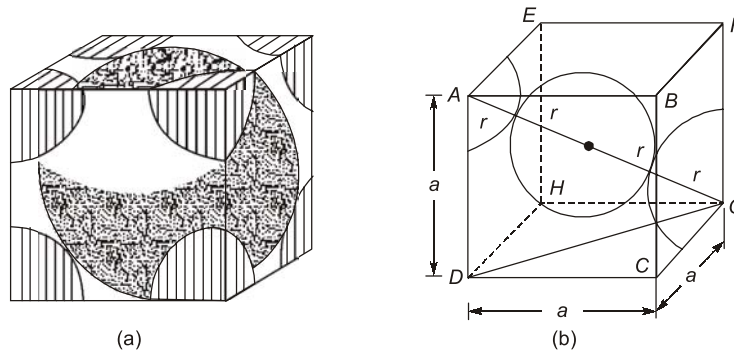
- **Body Centred Cubic structure (BCC):**

In this structure, in a unit cell there are eight corners and another atom is at the body centred. It has a co-ordination number of eight.

Note: (i) Simple cubic crystal
APF = 0.524 = 52.4%

(ii) BCC, APF = 0.68 = 68%

(iii) FCC, APF = 0.74 = 74%



Body centered cubic structure

From the figure,

$$r = \frac{a\sqrt{3}}{4}$$

Number of atom per unit cell
and for BCC,

$$N = 2$$

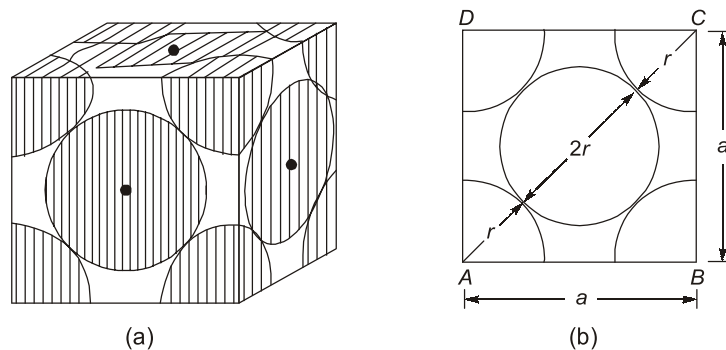
Now,

$$(\text{APF})_{\text{BCC}} = \frac{N \times \text{Volume of each sphere}}{\text{Total volume of each cell}}$$

$$= \frac{2 \times \frac{4}{3} \pi \left(\frac{a\sqrt{3}}{4} \right)^3}{a^3} = \frac{2 \times \pi \sqrt{3}}{16} a^3 = \frac{\pi \sqrt{3}}{8} = 0.68$$

\therefore % APF = 68% filled

- **Face Centred Cubic structure (FCC):** In this structure, one atom lies at each corner of the cube in addition to one atom at the centre of each face. The co-ordination number of FCC structure is $(4 + 4 + 4 = 12)$.



(Face centered cubic structure)

From the figure, Radius of FCC = $r = \frac{a\sqrt{2}}{4}$

Number of atom per unit cell
and for FCC,

$$N = 4$$

Now,

$$(\text{APF})_{\text{FCC}} = \frac{N \times \text{Volume of each sphere}}{\text{Total volume of each cell}}$$

$$= \frac{4 \times \frac{4}{3} \pi \left(\frac{a\sqrt{2}}{4} \right)^3}{a^3} = \frac{4}{3} \times \frac{\sqrt{2} \pi a^3}{2^3} = \frac{\sqrt{2} \pi}{6} = \frac{\pi}{3\sqrt{2}} = 0.74$$

\therefore % APF = 74 % filled



COMPUTER FUNDAMENTALS

CONVENTIONAL PRACTICE SETS

Page No. 66 - 130

Q1 Find the minimum product of sums of the following expression:

$$f = ABC + \bar{A}\bar{B}\bar{C}$$

Solution:

In order to find the minimum product of sums we must calculate what are the max terms.

We have SOP function as:

$$f = ABC + \bar{A}\bar{B}\bar{C}$$

⇒ Minimum terms are (0, 7)

Thus, maximum terms = (1, 2, 3, 4, 5, 6)

By using K-map

Hence, minimum product of sum will be $(\bar{A} + B)(A + \bar{C})(\bar{B} + C)$

BC	00	01	11	10
A				
0	0	0	0	1
1	1	1	1	1

Q2 Show with the help of a block diagram represent Boolean function:

$$f = AB + BC + CA$$

can be realised using only 4 : 1 multiplexer.

Solution:

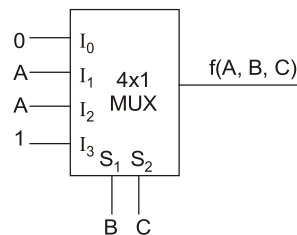
$$f = AB + BC + CA$$

A \ BC	00	01	11	10
0	0 ₀	0 ₁	1 ₃	0 ₂
1	0 ₄	1 ₅	1 ₇	1 ₆

Using MSB method:

	I ₀	I ₁	I ₂	I ₃
\bar{A}	0	1	2	③
A	4	⑤	⑥	⑦
	0	A	A	1

Implementing $f(A, B, C)$ using 4×1 MUX



- Q3** A logic network has two data inputs A and B , and two control inputs C_0 and C_1 . It implements the function F according to the following table.

C_1	C_0	F
0	0	$\overline{A+B}$
0	1	$A+B$
1	0	$A \oplus B$
1	1	AB

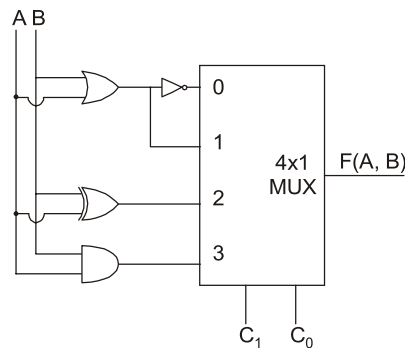
Implement the circuit using one 4 to 1 Multiplexer, one 2-input Exclusive OR gate, one 2-input AND gate, one 2-input OR gate and one Inverter.

Solution:

I_0 will get activated when both the select lines are zero thus I_0 will intake $\overline{A+B}$.

I_1 will get activated when C_1 is 0 and C_0 is 1 thus I_1 will intake $A+B$.

Similarly, I_2 will intake $A \oplus B$ and I_3 will intake AB .



- Q4** Find the minimum sum of products form of the logic function.

$$f(A, B, C, D) = \sum m(0, 2, 8, 10, 15) + \sum d(3, 11, 12, 14)$$

Where m and d denote the min-terms and don't cares respectively.

Solution:

$$f(A, B, C, D) = \sum m(0, 2, 8, 10, 15) + \sum d(3, 11, 12, 14)$$

CD \ AB	00	01	11	10
00	1 ₀	1	x ₃	1 ₂
01	4	5	7	6
11	x ₁₂	13	1 ₁₅	x ₁₄
10	1 ₈	9	x ₁₁	1 ₁₀

The minimum SOP form of the logic function is given as: $f(A, B, C, D) = B'D' + AC$.

- Q5** Express the function $f(x, y, z) = xy' + yz'$ with only one complement operation and one or more AND/OR operations. Draw the logic circuit implementing the expression obtained, using a single NOT gate and one or more AND/OR gates.

Solution:

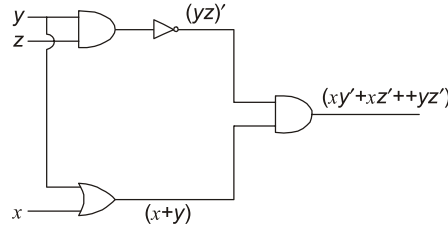
To use only single NOT gate, express it with only one complementation and one or more AND/OR operations.

$$f(x, y, z) = xy' + yz'$$

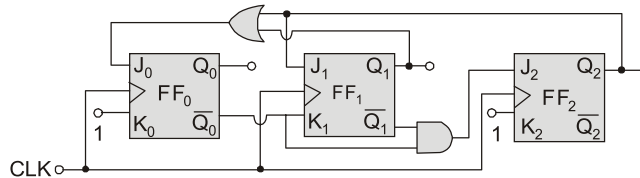
Add reduced term to f

$$\begin{aligned}
 f(x, y, z) &= xy' + yz' + xz' \\
 &= yz' + x(y' + z') = y(y' + z') + x(y' + z') \\
 &= (x + y)(y' + z') = (x + y)(yz)'
 \end{aligned}$$

Thus the given function has been represented using one complement operation with complement on yz. Logic circuit implementing the expression obtained is given as below:



Q6 For the synchronous counter shown in figure write the truth table of Q_0 , Q_1 and Q_2 after each pulse starting from $Q_0 = Q_1 = Q_2 = 0$ and determine the counting sequence and also the modulus of the counter.



What is the modulus of the counter with initial state $Q_2 Q_1 Q_0 = 000$?

- (a) 3
- (b) 4
- (c) 5
- (d) 6

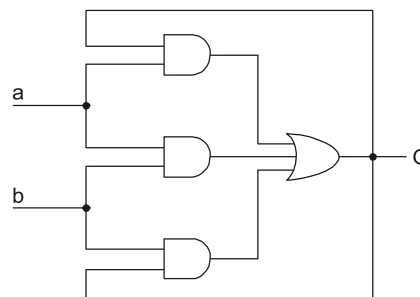
Solution: (c)

J_2 ($\bar{Q}_0 \bar{Q}_1$)	K_2 (1)	J_1 (Q_2)	K_1 (\bar{Q}_0)	J_0 ($Q_1 + Q_2$)	K_0 (1)	Q_2	Q_1	Q_0
Initially						0	0	0
1	1	0	1	0	1	1	0	0
1	1	1	1	1	1	0	1	1
0	1	0	0	1	1	0	1	0
0	1	0	1	1	1	0	0	1
0	1	0	0	0	1	0	0	0

There are 5 different states in the synchronous counter. Therefore, the modulus of the counter is 5.

Q7 Analyse the circuit in figure and complete the following table:

a	b	Q_n
0	0	
0	1	
1	0	
1	1	



Solution:

The output of the circuit is given as

$$Q_n = aQ_{n-1} + ab + bQ_{n-1}$$

$$Q_n = Q_{n-1}(a + b) + ab$$

a	b	Q_n
0	0	0
0	1	Q_{n-1}
1	0	Q_{n-1}
1	1	1

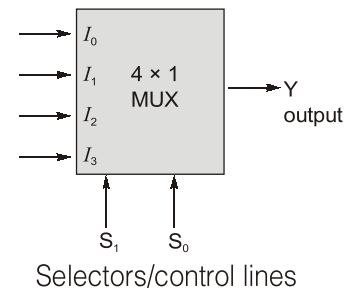
Q8 Difference between Mealy and Moore state Machine.**Solution:**

- (a) Mealy and Moore Models are the basic Models of state Machines. A state machine which uses only entry actions, so that its output depends on the state, is called a Moore model. A state machine which uses only input actions, so that the output depends on the state and also on inputs, is called a Mealy models. The Models selected will influence a design but there are no general indications as to which model is better choice of a Model depends on the applications, executions means (for instance, hardware systems are usually best realized as Moore Models) and personal preferences of a designer or programmer.
- (b) Mealy machine has outputs that depend on the state and input (thus, the FSM has the output written on edges) Moore machine has outputs that depend on state only. Thus, the FSM has the output written in the state itself.

Q9 Explain in brief about multiplexers, with circuit diagram.**Solution:**

It is combinational circuit which have many data inputs and single output depending on control or select lines. For N input lines, $\log_2 n$ (base 2) selections lines, or we can say that for 2^n input lines, n selection lines are required. Multiplexers are also known as "Data n selector or parallel to serial convertor or Many to one circuit or universal logic circuit". Multiplexers are mainly used to increase amount of the data that can be sent over the network within certain amount of time and bandwidth.

Now, the implementations of 4 : 1 Multiplexer using truth table and gates is shown below:



Truth table

S_1	S_0	Y
0	0	I_0
0	1	I_1
1	0	I_2
1	1	I_3

So final equation,

$$Y = S_1'S_0'I_0 + S_1'S_0I_1 + S_1S_0'I_2 + S_1S_0I_3$$

Q10 What are the different kinds of hazards found in digital circuits. Explain static hazard.**Solution:**

There are three different kinds of hazards found in digital circuits-

- (i) Static hazard (ii) Dynamic hazard (iii) Functional hazard

COMMUNICATION SYSTEMS

CONVENTIONAL PRACTICE SETS

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Amplitude Modulation

Q1 A two-tone modulating signal $e_m(t) = 5 \cos 2\pi \times 10^3 t + 4 \cos 4\pi \times 10^3 t$ modulates a carrier voltage $e_c(t) = 10 \cos 2\pi \times 10^6 t$. Find various frequency components present and corresponding modulation indices. Also obtain the amplitude of the signals present in each sidebands and the bandwidths.

Solution:

The expression of AM is given by,

$$\begin{aligned}\phi_{AM}(t) &= 10 \left[1 + \frac{5}{10} \cos(2\pi \times 10^3 t) + \frac{4}{10} \cos(4\pi \times 10^3 t) \right] \cos(2\pi \times 10^6 t) \\ &= 10 \left[1 + 0.5 \cos(2\pi \times 10^3 t) + 0.4 \cos(4\pi \times 10^3 t) \right] \cos(2\pi \cdot 10^6 t)\end{aligned}$$

$$m_1 = 0.5 \text{ and } m_2 = 0.4$$

$$\begin{aligned}\phi_{AM}(t) &= 10 \cos 2\pi \cdot 10^6 + 5 \cos(2\pi \times 10^3 t) \cos(2\pi \times 10^6 t) + 4 \cos(4\pi \times 10^3 t) \cos(2\pi \times 10^6 t) \\ &= 10 \cos(2\pi \times 10^6) + \frac{5}{2} \cos \left[2\pi \times (10^6 + 10^3)t \right] + \frac{5}{2} \cos \left[2\pi \times (10^6 - 10^3)t \right] \\ &\quad + 2 \cos \left[2\pi \times (10^6 + 2 \times 10^3)t \right] + 2 \cos \left[2\pi \times (10^6 - 2 \times 10^3)t \right]\end{aligned}$$

Upper sidebands,

$$F_C + F_1 = 10^6 + 10^3 = 1.001 \text{ MHz}$$

⇒

$$F_C + F_2 = 10^6 + 2 \times 10^3 = 1.002 \text{ MHz}$$

Now, Lower sidebands,

$$F_C - F_1 = 10^6 - 10^3 = 0.999 \text{ MHz}$$

⇒

$$F_C - F_2 = 10^6 - 2 \times 10^3 = 0.998 \text{ MHz}$$

Each sidedband W_1 ,

$$\frac{m_1 E_c}{2} = \frac{0.5 \times 10}{2} = 2.5 \text{ V}$$

Each sideband W_2 ,

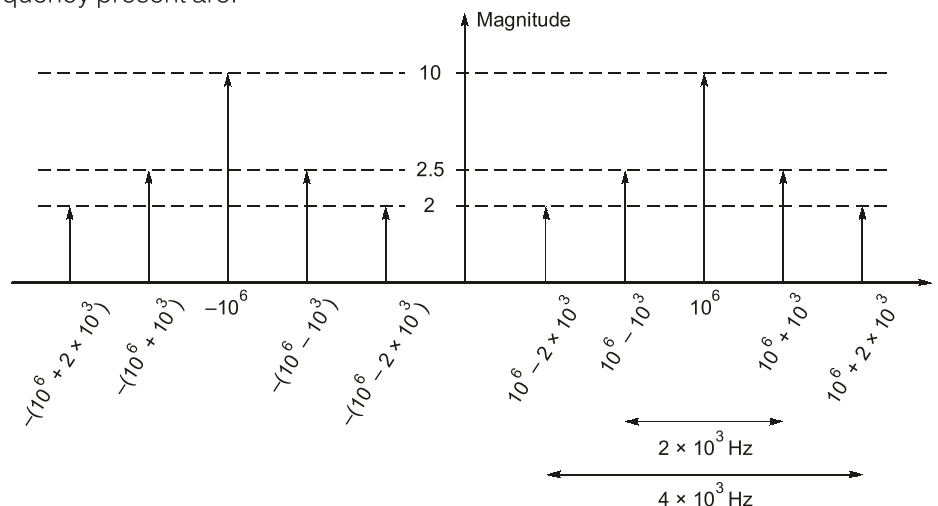
$$\frac{m_2 E_c}{2} = \frac{0.4 \times 10}{2} = 2 \text{ V}$$

Total bandwidth = 2 × Bandwidth of message signal m_2

$$W_m = 2 \text{ kHz}$$

Total bandwidth = 2 × 2 = 4 kHz

So, the frequency present are:



Q2 Show that power contained in one sideband is 1/6 to the total power of amplitude modulated signal at 100% modulation index.

Solution:

$$\begin{aligned} S_{AM}(t) &= A_c (1 + \mu \cos 2\pi f_m t) \cos 2\pi f_c t \\ &= A_c [1 + \cos 2\pi f_m t] \cos 2\pi f_c t \quad [\mu = 1] \\ &= A_c \cos 2\pi f_c t + A_c \cos 2\pi f_m t \cos 2\pi f_c t \\ &= A_c \cos 2\pi f_c t + \frac{A_c}{2} [\cos 2\pi(f_c + f_m)t + \cos 2\pi(f_c - f_m)t] \\ &= A_c \cos 2\pi f_c t + \frac{A_c}{2} \cos 2\pi(f_c + f_m)t + \frac{A_c}{2} \cos 2\pi(f_c - f_m)t \end{aligned}$$

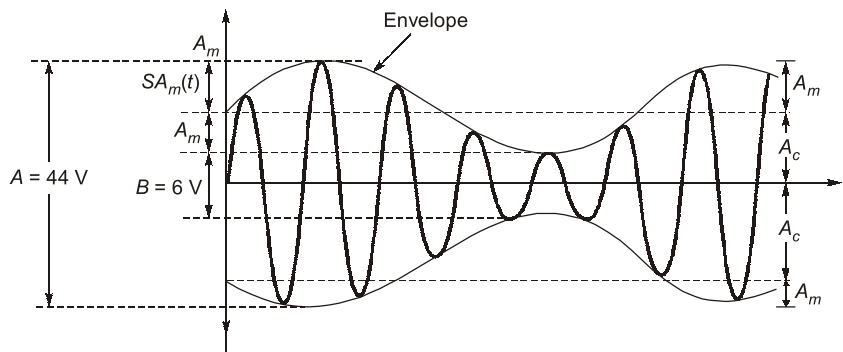
$$\text{Power in one sideband} = \frac{A_c^2}{4 \times 2} = \frac{A_c^2}{8}$$

$$\begin{aligned} \text{Total power} &= \frac{A_c^2}{2} + \left(\frac{A_c}{2}\right)^2 \times \frac{1}{2} + \left(\frac{A_c}{2}\right)^2 \times \frac{1}{2} \\ &= \frac{A_c^2}{2} + \frac{A_c^2}{8} + \frac{A_c^2}{8} = \frac{3A_c^2}{4} \end{aligned}$$

So,
$$\text{Ratio} = \frac{\frac{A_c^2}{8}}{\frac{3A_c^2}{4}} = \frac{1}{6}$$

Q3 An amplitude modulated signal, viewed on an oscilloscope, has a crest voltage of 44 V peak-to-peak. The bottom (or trough) point of the wave measures 6 V peak-to-peak. Find the modulation factor, percentage modulation and peak-to-peak unmodulated carrier voltage.

Solution:



Modulation factor,

$$m = \frac{A_m}{A_c}$$

From figure,

$$A = 2(A_c + A_m) \quad \dots(i)$$

$$B = 2(A_c - A_m) \quad \dots(ii)$$

Solving equation (i) and (ii),

$$A_c = \frac{A + B}{4}$$

$$A_m = \frac{A - B}{4}$$

Hence,

$$\mu = \frac{A - B}{A + B} = \frac{44 - 6}{44 + 6} = \frac{38}{50} = 0.76$$

$$\text{Percentage modulation} = \mu \times 100 = 76\%$$

Peak to peak unmodulated carrier voltage

$$= 2A_c = \frac{A+B}{2} = \frac{44+6}{2} = 25 \text{ V}$$

Q4 The antenna current of a transmitter is 11.5 amperes, when it is modulated to a depth of 45% by an audio wave. The current enhances to 12.5 amperes on account of simultaneous modulation by another audio sine wave. Find the modulation index of the second audio wave.

Solution:

Given, antenna current (I_t) of a transmitter is 11.5 amperes when modulation index (μ_1) is 0.45.

Total power in amplitude modulated signal is given as,

$$P_t = P_c \left(1 + \frac{\mu^2}{2} \right)$$

where, $P_t = I_t^2 R$ and $P_c = I_c^2 R$

R = Resistance and I_c = Carrier current

So,

$$I_t^2 R = I_c^2 R \left(1 + \frac{\mu^2}{2} \right)$$

$$I_t^2 = I_c^2 \left(1 + \frac{\mu^2}{2} \right) \Rightarrow I_t = I_c \sqrt{\left(1 + \frac{\mu^2}{2} \right)} \text{ Ampere}$$

As per question,

$$11.5 = I_c \sqrt{\left(1 + \frac{(0.45)^2}{2} \right)} \Rightarrow I_c = 10.96 \text{ Amperes}$$

On account of simultaneous modulation by another audio wave (modulation index, μ_2); the total modulation index is given by μ .

So, I_t become 12.5 Amperes.

$$I_t = I_c \sqrt{\left(1 + \frac{\mu^2}{2} \right)}$$

$$12.5 = 10.96 \sqrt{\left(1 + \frac{\mu^2}{2} \right)}$$

$$\Rightarrow 1 + \frac{\mu^2}{2} = 1.3$$

$$\frac{\mu^2}{2} = 1.3 - 1 = 0.3$$

$$\Rightarrow \mu = 0.775$$

The total modulation is due to simultaneous modulation of two audio waves. So,

$$\mu = \sqrt{\mu_1^2 + \mu_2^2}$$

$$(0.775)^2 = (0.45)^2 + \mu_2^2$$

$$0.6 - 0.2025 = \mu_2^2$$

$$\Rightarrow \mu_2 = 0.63$$

Hence, the modulation index of the second audio wave is 0.63 or 63%.

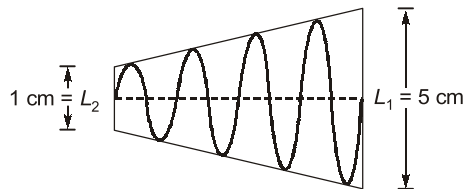
Q5 A collector modulated amplifier is tuned up, a sinusoidal modulating signal of 1 kHz is applied and the following measurements are made:

dc supply voltage = 12 V; dc supply current = 10 A; unmodulated rms current to a 50 Ω load = 1.5 A
trapezoidal pattern monitor offsets = 1 cm and 5 cm. Determine

- (a) modulation index
- (b) output carrier power
- (c) output power with modulation
- (d) dissipation in the transistor with modulation (assuming the transistor is the only source of losses) and
- (e) the collector conversion efficiency with modulation

Solution:

Trapezoidal pattern on display is as:



- (a) Modulation index $(m_a) = \frac{L_1 - L_2}{L_1 + L_2} = \frac{5 - 1}{5 + 1}$
 $\therefore m_a = 0.666 \approx 66.6\%$
- (b) Output carrier power $P_{OC} = I^2 R = (1.5)^2 \times 50 = 112.5 \text{ W}$
- (c) Output power (P_o) with modulation = $I_o^2 \times R$

where $I_o = I_C \sqrt{1 + \frac{m_a^2}{2}} = 1.5 \sqrt{1 + \frac{(0.66)^2}{2}}$

$\therefore I_o = 1.655 \text{ A}$
 Now, $P_o = (1.655)^2 \times 50 = 137 \text{ W}$

- (d) Dissipation in the transistor means $(P_{dc} - P_{oc}) = (12 \times 10) - 112.5 = 7.5 \text{ W}$

(e) Collector output power $= P_{Col.} = P_{dc} \left[1 + \frac{m_a^2}{2} \right]$... (i)

and $P_o = P_{oc} \left[1 + \frac{m_a^2}{2} \right]$... (ii)

Now collector conversion efficiency with modulation

$$= \frac{P_o}{P_{Col.}} = \frac{P_{oc}}{P_{dc}} = \frac{112.5}{120} = 0.9375 \times 100\% = 93.75\%$$

Q6 Consider a single-tone AM signal as follows:

$$s(t) = [1 + \mu \cos \omega_m t] \cos \omega_c t$$

If $\mu = 1/2$ and the upper sideband component is attenuated by a factor of 2, then determine the expression for the envelope of the resulting modulated signal.

Solution:

$$s(t) = [1 + \mu \cos \omega_m t] \cos \omega_c t$$

When $\mu = \frac{1}{2}$, $s(t) = \cos \omega_c t + \frac{1}{2} \cos(\omega_c t) \cos(\omega_m t)$

$$= \cos \omega_c t + \frac{1}{4} \cos(\omega_c + \omega_m)t + \frac{1}{4} \cos(\omega_c - \omega_m)t$$

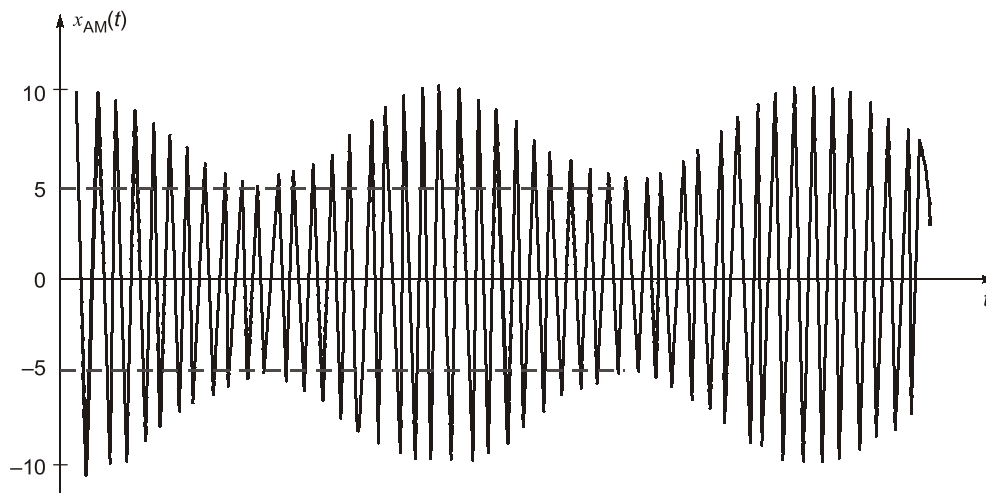
When the upper sideband is attenuated by a factor of 2, the resulting modulated signal will be,

$$\begin{aligned} y(t) &= \cos \omega_c t + \frac{1}{8} \cos(\omega_c + \omega_m)t + \frac{1}{4} \cos(\omega_c - \omega_m)t \\ &= \cos \omega_c t + \frac{1}{8} (\cos \omega_c t \cos \omega_m t - \sin \omega_c t \sin \omega_m t) + \frac{1}{4} (\cos \omega_c t \cos \omega_m t + \sin \omega_c t \sin \omega_m t) \\ &= \left(1 + \frac{3}{8} \cos \omega_m t\right) \cos \omega_c t + \left(\frac{1}{8} \sin \omega_m t\right) \sin \omega_c t \end{aligned}$$

Expression for envelope will be, $A(t) = \sqrt{\left(1 + \frac{3}{8} \cos \omega_m t\right)^2 + \left(\frac{1}{8} \sin \omega_m t\right)^2}$

Q7 A sinusoidally modulated ordinary AM waveform is shown in figure below.

- Determine modulation index.
- Compute the efficiency.
- Also, find the amplitude of the carrier which must be added to attain a modulation index of 0.1.



Solution:

- (a) Modulation index is given by

$$m_a = \frac{A_{\max} - A_{\min}}{A_{\max} + A_{\min}}$$

From figure, on substituting values, we get

$$m_a = \frac{10 - 5}{10 + 5} = \frac{1}{3}$$

- (b) Modulated AM signal is expressed as,

$$x_{AM(t)} = A \cos \omega_c t + m_a A \cos \omega_m t \cos \omega_c t \quad \dots(i)$$

or

$$x_{AM(t)} = A \cos \omega_c t + \frac{1}{2} m_a A [\cos(\omega_c - \omega_m)t + \cos(\omega_c + \omega_m)t]$$

Now,

$$P_c = \text{Carrier power} = \frac{1}{2} A^2$$

and

$$P_s = \frac{1}{2} \left[\left(\frac{1}{2} m_a A\right)^2 + \left(\frac{1}{2} m_a A\right)^2 \right] = \frac{1}{4} m_a^2 A^2$$

MICROPROCESSORS

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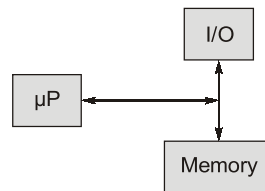
Introduction to 8085 and its Functional Organisation

Q1 Explain what do you understand by microprocessor. List a few of its uses.

Solution:

Microprocessor is a programmable, clocked register based electronic device that reads binary instruction from its memory and does the processing over it.

Microprocessor is an electronic chip that has a computing and decision making capability. When this microprocessor is used as a CPU in a system, then it is called as a microcomputer.



Uses of microprocessor:

- (i) Industrial PID controllers
- (ii) Calculators
- (iii) Data acquisition systems
- (iv) Laptop and personal computers

Q2 List the registers used in 8085.

Solution:

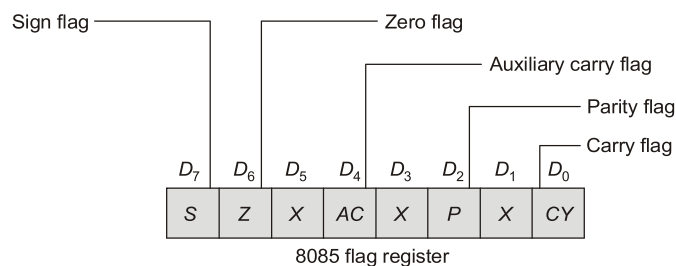
Registers are used in the microprocessor to store data temporarily during execution of program and may or may not be accessible to the users.

Important registers used in 8085 are:

- (i) Accumulator (8-bit)
- (ii) Register B (8-bit)
- (iii) Register C (8-bit)
- (iv) Register D (8-bit)
- (v) Register E (8-bit)
- (vi) Register H (8-bit)
- (vii) Register L (8-bit)
- (viii) Stack pointer (16-bit)
- (ix) Program counter (16-bit)
- (x) Flag register (8-bit)

Q3 Describe the flags of 8085 microprocessor.

Solution:



The 8085 microprocessor has 5 flags:

1. **Zero:** It is set to 1 when result is zero. Otherwise it is reset to zero.
2. **Carry:** If an arithmetic operations results in carry, it is set otherwise it is reset.
3. **Auxiliary carry:** In an arithmetic operation, when carry is generated by digit D_3 and passed to digit D_4 , the AC flag is set.
4. **Parity:** If the result has an even number of 1's the flag is set, for an odd number of 1's the flag is reset.
5. **Sign:** It is set if MSB of the result is 1, otherwise it is reset.

Q4 In 8085 microprocessor, what is the advantage of multiplexing the address bus with a data bus?

Solution:

Advantages of multiplexing the address bus with data bus are as follows:

1. Reduction in the number of pins required in the microprocessor. We save 8 pins at the cost of 1 ALE pin by using multiplexing.
2. Reduction in cost of microprocessor.
3. Reduction in space required by the microprocessor.
4. More efficient use of address bus since if it was used only for addressing, it would have remained idle for most of the T states.
5. Multiplexing address and data buses in the microprocessor allows for multiplexing in other peripheral devices as well without additional hardware. This results in a lot of cost + space saving for the whole circuit.

Q5 Describe the various addressing modes in the microprocessor 8085. Give suitable examples for each addressing mode.

Solution:

1. **Immediate addressing mode:** In this mode, the 8/16 bit data is specified in the instruction itself as one of its operand. E.g. MVI B, 20 H
2. **Register addressing mode:** In this mode, the data is copied from one register to another i.e. the operands are specified as contents of a register. E.g. MOV A, B
3. **Direct addressing mode:** The address of the operand is specified in the instruction.
E.g. LDA 3000 H
4. **Indirect addressing mode:** The data is transferred from the address pointed by the data in a register to another register. The address of the operand is in a register. E.g. MOV A, M
5. **Implied addressing mode:** The operand is implicit in the instruction and is not given explicitly.
E.g. RAL, CMP etc.

Q6 Explain different types of interrupts available in an 8085 microprocessor in details.

Solution:

An interrupts is a signal to the processor generated by hardware or software indicating an event that needs immediate action.

Types of Interrupts:

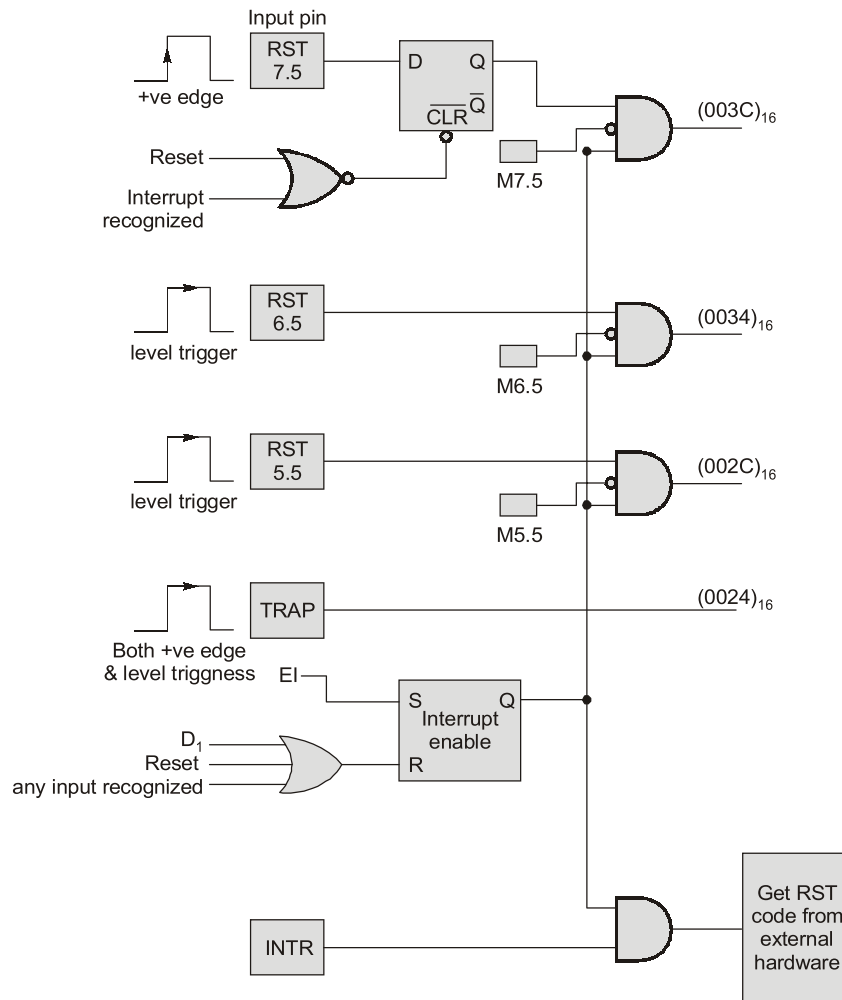
The 8085 has multilevel interrupt system. It supports two types of interrupts:

(a) Hardware (b) Software

Hardware: An external device initiates the hardware interrupts and placing an appropriate signal at the interrupt pin of the processor. If the interrupt is accepted then the processor executes an interrupt service routine.

Software: The cause of the interrupt is an execution of the instruction. These are special instructions supported by the microprocessor. After execution of these instructions microprocessor completes the execution of the instruction it is currently executing and transfers the program control to sub-routine.

There are five hardware interrupts:



TRAP:

- is a non-maskable interrupt.
- TRAP has the highest priority and vectored interrupt
- +ve edge and level triggered
- in case of sudden power failure, it executes a ISR and send the data from main memory to back up memory.

RST 7.5:

- is a maskable interrupt
- has the second highest priority
- is edge sensitive
- enabled by EI instruction

RST 6.5 & 5.5:

- both are level triggered i.e. input goes to high and stay high until it recognized
- maskable interrupt
- RST 6.5 has 3rd priority and RST 5.5 has 4th priority

INTR:

- is a maskable interrupt
- enabled by EI instruction
- it is a level sensitive interrupts

Software Interrupts in 8085:

The 8085 has eight software interrupts from RST0 to RST7. The vector address for these interrupts can be calculated as:

$$\text{Interrupt number} \times 8 = \text{vector address}$$

Instruction	Vector add
RST 0	0000H
RST 1	0008H
RST 2	0010H
RST 3	0018H
RST 4	0020H
RST 5	0028H
RST 6	0030H
RST 7	0038H

Q.7 What are the functions of the following pins of 8085 microprocessor?

- (i) READY
- (ii) ALE
- (iii) HOLD
- (iv) TRAP

Solution:

- (i) **READY (Input):** It is used by the microprocessor to sense or detect whether a peripheral is ready to transfer the data or not. A slow peripheral may be connected to the microprocessor through READY Line. If READY is HIGH the peripheral devices are ready, if it is LOW then the microprocessor waits till it goes HIGH.
- (ii) **ALE : (Address Latch Enable):** This is a positive going pulse or signal that is generated every time the 8085 Microprocessor begins an operation. It goes HIGH during first clock cycle of a M/C and enables the lower 8-bits of the address to be Latched either into the memory or external Latch.
- (iii) **HOLD (Input):** It indicates that another device is requesting for use of the address and data bus. After receiving a HOLD request, the microprocessor relinquishes the use of the buses as soon as the current machine cycle is completed. The processor regains the bus after the removal of the HOLD signal.
- (iv) **TRAP (Input):** It is a non-maskable interrupt having the highest priority among all interrupts. It is unaffected by any mask or interrupt enable.

Q.8 Draw the Pin diagram of 8085 microprocessor and briefly explain it.

Solution:

The 8085 A (Commonly known as the 8085) is an 8 bit general purpose microprocessor, capable of addressing 64 K of memory. The device has forty (40) pins, requires a +5 V single power supply, and can operate with 3 MHz single phase clock.

- Figure below shows the pin diagram of 8085 microprocessor. All the pins can be classified into six groups:
 - ⇒ Address bus
 - ⇒ Data bus