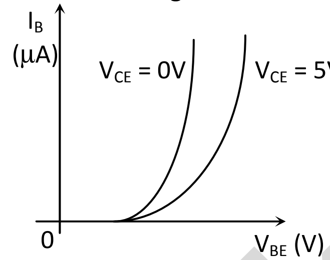
Q.1(a) Draw input & output characteristics of BJT. State significance of DC load line. [5]

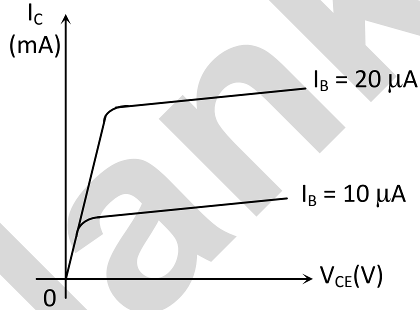
Ans.: (a) Input characteristics

$V_{BE} = f(I_B, V_{CE})$



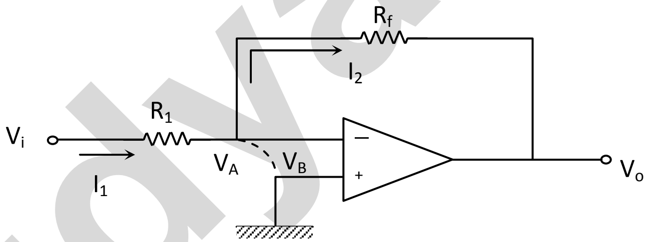
(b) Output characteristics

$I_C = f(I_B, V_{CE})$



Q.1(b) Explain the concept of virtual ground in operational amplifiers. [5]

Ans.:



Consider an inverting buffer amplifier as shown. Let V_a the potential at the inverting terminal of OP–AMP, assume that the iinput current of OP–AMP = 0, applying KCL at the inverting terminal node.

$I_1 = I_2$

$$\frac{V_i - V_a}{R_i} = \frac{V_a - V_o}{R_f}$$

$V_i - V_A = V_A - V_0$

The circuit is inverting buffer A = –1

So $V_0 = AV_i = -V_i$

$V_i - V_a = V_a - (-V_i)$

$2V_a = V_i - V_i = 0 \qquad V_a = 0$

Very few OP–AMPS for eg. 301, 748 & 777 have the OFFSET. Voltage null capability. Hence for most of the OP–AMPS we have to design an OFF–SET voltage corpersation network in order to reduce the ouptu offset voltage to zero.

Q.1(c) Compare class A and class C amplifier. **[5]**

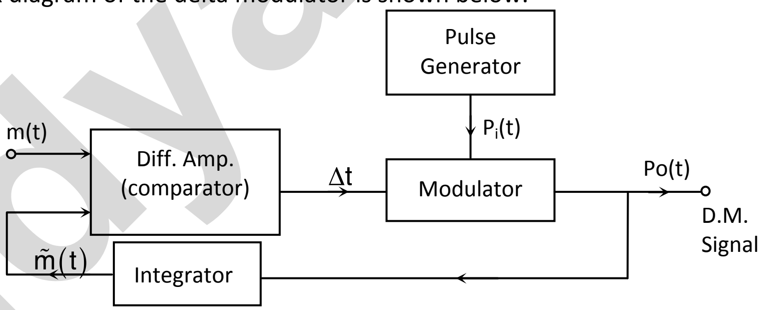
Ans.: In this **class-A**, amplifier operates in active region at all the times(2*π).

- Stage efficiency = $P_{oAC)}/ P_{DC} \times 100$ %
  Conduction angle 2π
  Conversion efficiency = 50%
- Load Power, $P_L = (V_L)^2/R_L = (V_{PP})^2/8*R_L$
- In this **class-C**, amplifier operates for less than half of the input cycle(less than π).
- It is basically a tuned amplifier.
- AC load power for class-C amplifier is, $P_L = (V_{PP})^2/8*R_L$
  Where, V_{PP} is peak to peak load voltage and R_L is load resistance
  Conduction angle less than π
  Conversion efficiency ≈ 90%

Q.1(d) Explain adaptive delta modulation. **[5]**

Ans.: Delta modulation is also a digital modulation system. In delta modulation just one bit is sent per sample, to indicate whether the present sample is larger or smaller than the previous sample. Thus in delta modulation, the modulated signal carries information not about the signal samples but about the difference between successive samples. If the difference is +ve or –ve a +ve or –ve pulse respectively is generated in the modulated signal. Thus D.M. carries the information about the derivative of m(t) and hence the name is delta modulation. Thus integration of delta modulated signal m (t) will be an approximation of m (t).

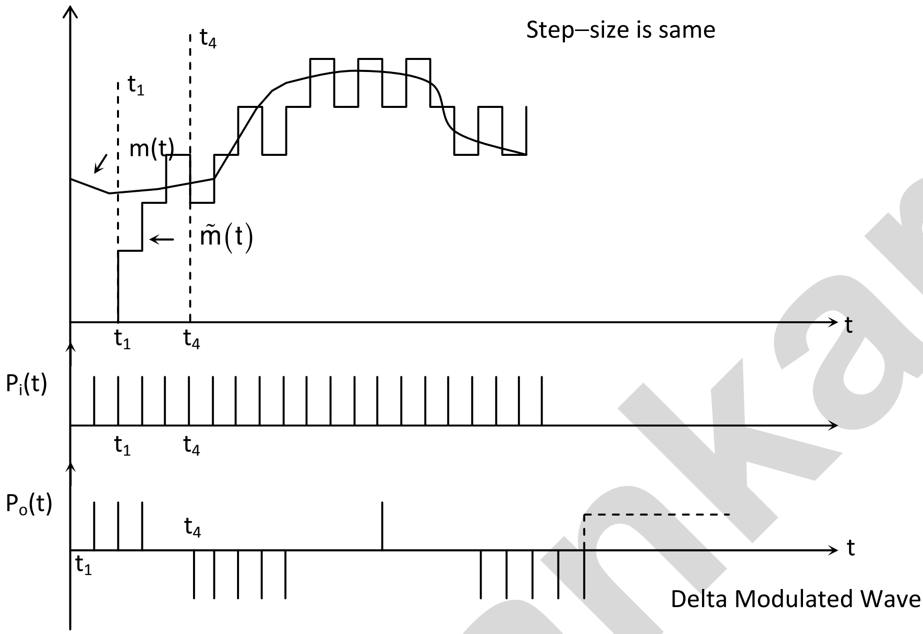
The block diagram of the delta modulator is shown below.



The pulse generator produce a pulse train $P_i(t)$ of positive pulses. The modulator receives $P_i(t)$ and $\Delta(t)$, the output of differential amp. The modulator output $P_o(t)$ is the product of input pulse train $P_i(t)$ and +1 or –1 depending upon the polarity of Δt. $P_o(t)$ is positive pulse if Δt is +ve and it is –ve pulse if Δt is –ve. The magnitude of Δt has no role in deciding $p_o(t)$. The output of modulator is applied to an integrator whose output is $\tilde{m}(t)$.

The input signal m (t) and the integrator output $\tilde{m}(t)$ is compared in difference amp. Whose output is $\Delta(t) = m(t) - \tilde{m}(t)$.

Following figure explains the operation of delta modulator.



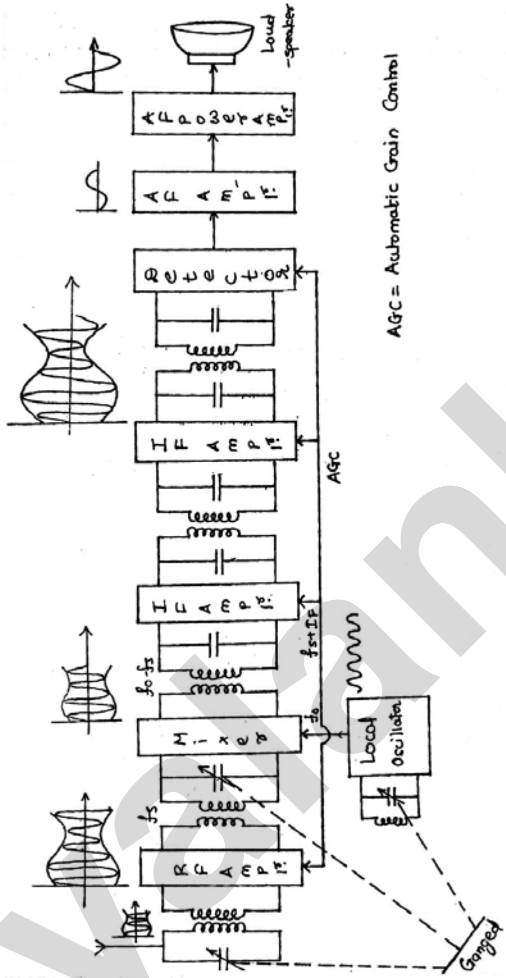
Q.2(a) Explain Superheterodyne receiver with suitable diagram. **[10]**

Ans.: The features of heterodyne receiver is that all incoming radio frequency signals called intermediate frequency by using heterodyne process.

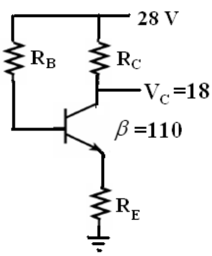
In this receiver, the received signal frequency is mixed with the local oscillator frequency f_0. The local oscillator is an LC oscillator which produce sinusoidal oscillations of frequency f_0. The frequency of local oscillator depends on the values of L & C of associated tuned circuit. The signal frequency f_s and signal f_0 gives to the mixer circuit.

Mixer is a non-linear circuit. It will produce the output which contain different frequency component such as f_s, f_0, $f_0 \pm f_s$, harmonics of input frequencies and the IC components. The inputs tank circuit of IF amplifier is tuned to $f_0 - f_s$ which is always 455 KHz and is known as Intermediate frequency I_f. To get I_f always = 455 KHz, the local oscillator should be tuned such that whatever may be input signal frequency f_s, local oscillator frequency f_0 should be always 455 KHz, more than f_s. AM wave with 455 KHz is amplified to the desired level by 2 or 3 I_f amplifier and then it is fed to the detector which detects a taken out the AF information from the AM wave. This audio frequency signal is then amplified by voltage and power amplifier so that it can drive the loudspeaker.

Block diagram of Superheterodyne Receiver



Q.2(b) **The emitter bias configuration as shown in following figure has the specifications:** **[10]**



$I_{CQ} = \frac{1}{2} I_{Csat}$, I_{Csat} = 8 mA V_C = 18V and β = 110

Determine R_C, R_E and R_B.

Ans.: Given : I_{CQ} = 4 mA, β = 110, V_C = 18V

Apply KVL to collector,

$$28 - I_C R_C - 18 = 0$$

$$R_C = \frac{28-18}{I_C} = \frac{10}{4\text{mA}} = 2.5\ \text{K}\Omega$$

$$I_{C\,sat} = \frac{V_{CC}}{R_C + R_E}$$

$\Rightarrow 8\text{ mA} = \dfrac{28}{2.5\text{K}\Omega + R_E}$

$R_E = 1\text{ k}\Omega$

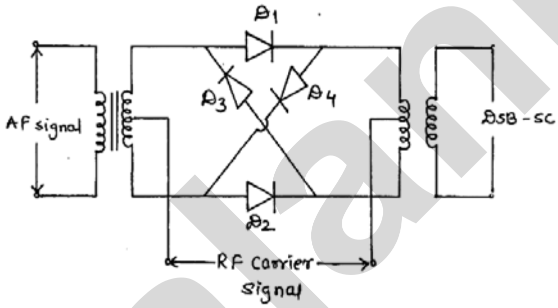
$I_B = \dfrac{I_C}{\beta} = 36.3\ \mu\text{A}$

$I_B = \dfrac{V_{CC} - V_{BE}}{R_B + (1+\beta)R_E} = \dfrac{28 - 0.7}{R_B + (1+110)}$

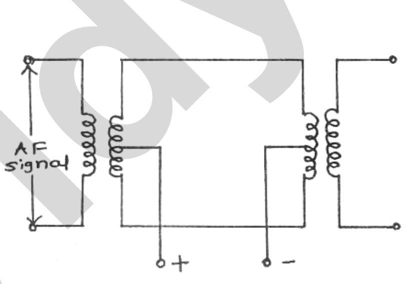
$\therefore\ R_B = 639.82\text{ k}\Omega$

Q.3(a) Explain generation of DSBSC using Ring Modulator. [10]

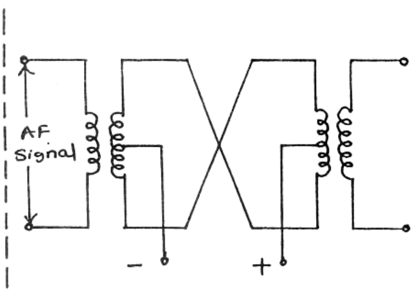
Ans.: The ring modulator is also known as Lattice or double balanced modulator. In this circuit, four diodes are connected in same direction and they will form a ring. Hence the name Ring Modulator.



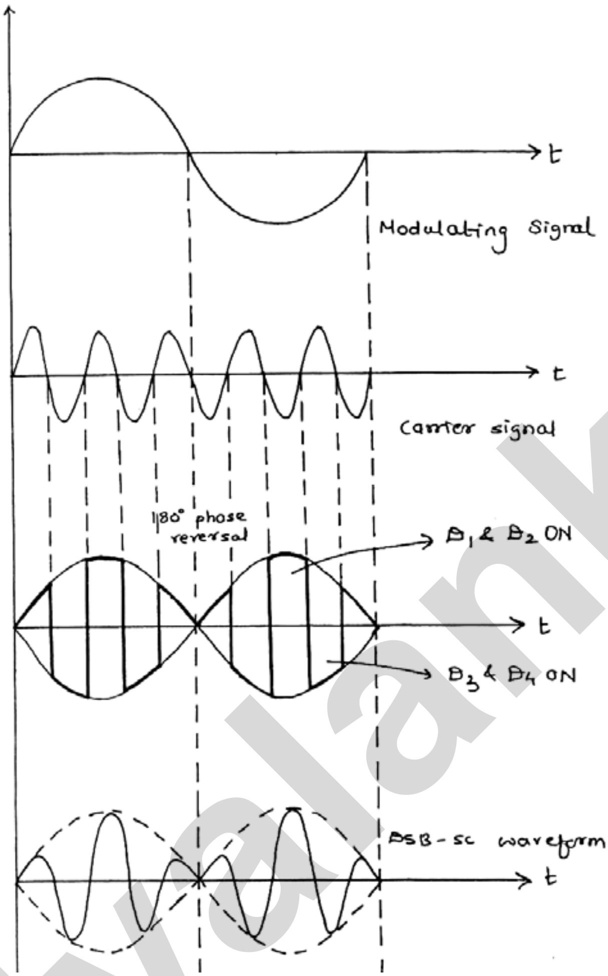
During +ve half cycle of carrier signal diode D_1 and D_2 are forward biased and acts as short circuit and diode D_3 and D_4 are reverse biased and act as open circuit as shown in figure A. Therefore, the modulating signal multiplies with the carrier signal, in the primary of output transformer.



During +ve half cycle of carrier.
Fig. (a)



During –ve half cycle of carrier.
Fig. (b)



During –ve half cycle of carrier signal. Diode D_3 and D_4 are F.B. and act as short circuit and diode D_1 and D_2 are R.B. and act as open circuit as shown in figure B. Therefore, the modulating signal m(t) is reversed i.e. –m(t) is multiplied by the carrier in the primary of output transformer. Thus the resultant current in primary is the subtraction of current through primary during +ve half cycle and –ve half cycle of RF signal. Therefore, at secondary of output transformer. the carrier is suppressed and we get only DSB–SC.

Q.3(b) With suitable waveforms explain how Op-amp can be used as integrator. [10]

Ans.: A circuit in which the output voltage waveform is the integral of the input voltage waveform is the integrator or the integration amplifier. Such a circuit is obtained by using a basic inverting amplifier configuration if the feedback resistor R_F is replaced by a capacitor C_F.

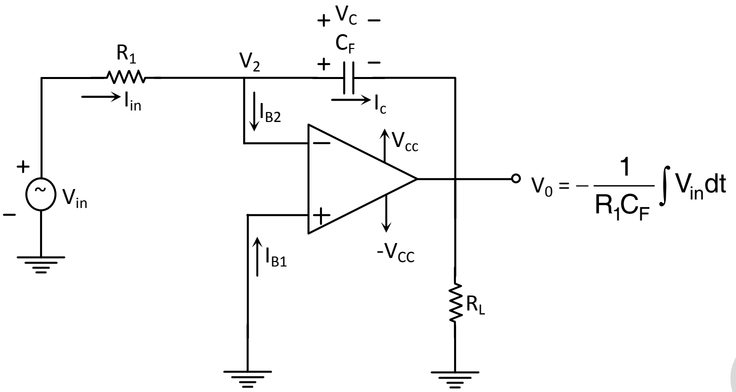


Fig. (a) : Basic Integrator

Expression for output of basic integrator Fig.(a)

The expression for output V_0 can be obtained by writing KCL equation at node V_2.

$$I_{in} = I_{B2} + I_c$$

Since $I_{B2} = 0$

$$I_{in} = I_c$$

$$\frac{V_{in} - V_2}{R_1} = C_F \frac{dV_C}{dt} \qquad (\because\ V_C = V_2 - V_0)$$

$$\frac{V_{in} - V_2}{R_1} = C_F \frac{d(V_2 - V_0)}{dt}$$

However, $V_1 = V_2 = 0$, because A is very large.

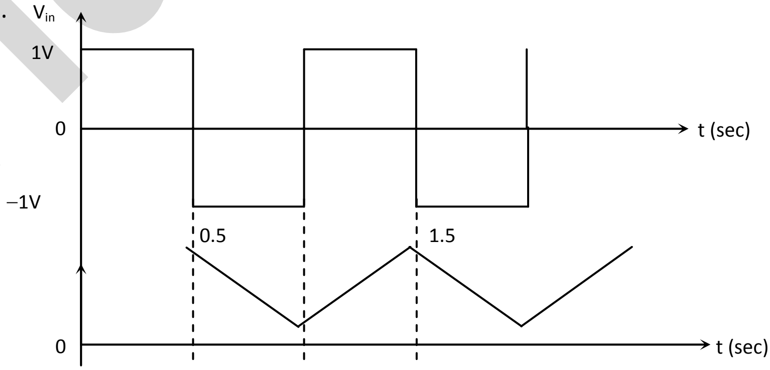
$$\frac{V_{in}}{R_1} = C_F \frac{dV_0(-)}{dt}.$$

Integrate both sides with respect to time t.

$$\int \frac{V_{in}}{R_1} dt = C_F \int \frac{d}{dt}(-V_0)$$

$$V_0 = -\frac{1}{R_1 C_F} \int V_{in} dt \qquad \dots (A)$$

The equation (A) shows that output voltage is directly proportional to time constant $R_F C_F$.



Q.4(a) For an AM DSBFC envelope with V_{max} = 20V and V_{min} = 4V; determine : [10]

(i) Peak amplitude of USF and LSF
(ii) Peak amplitude of carrier
(iii) Peak change in the amplitude of envelope
(iv) Modulation coefficient
(v) Draw the AM Envelope

Ans.: Given : V_{max} = 20V and V_{min} = 4V

(ii) Peak amplitude of carrier

$$V_C = \frac{V_{max} + V_{min}}{2} = \frac{20+4}{2} = \frac{24}{2} = 12\text{ V}$$

$$V_m = \frac{V_{max} - V_{min}}{2} = \frac{20-4}{2} = \frac{16}{2} = 8\text{ V}$$

(iii) Peak change in the amplitude of envelope $\pm$ 4V

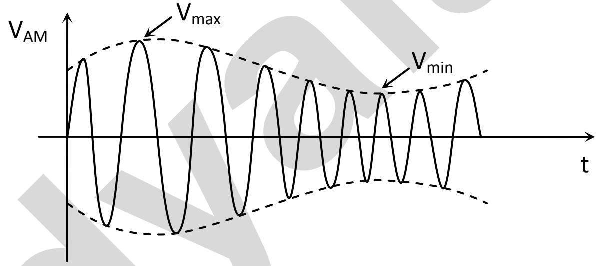
(iv) Modulation coefficient

$$m = \frac{V_m}{V_c} = \frac{8}{12} = 0.666$$

(i) Peak amplitude of USF and LSF

$$A_{USB} = A_{LSB} = \frac{mV_C}{2} = 3.96\text{ V}$$

(v) Draw the AM Envelope



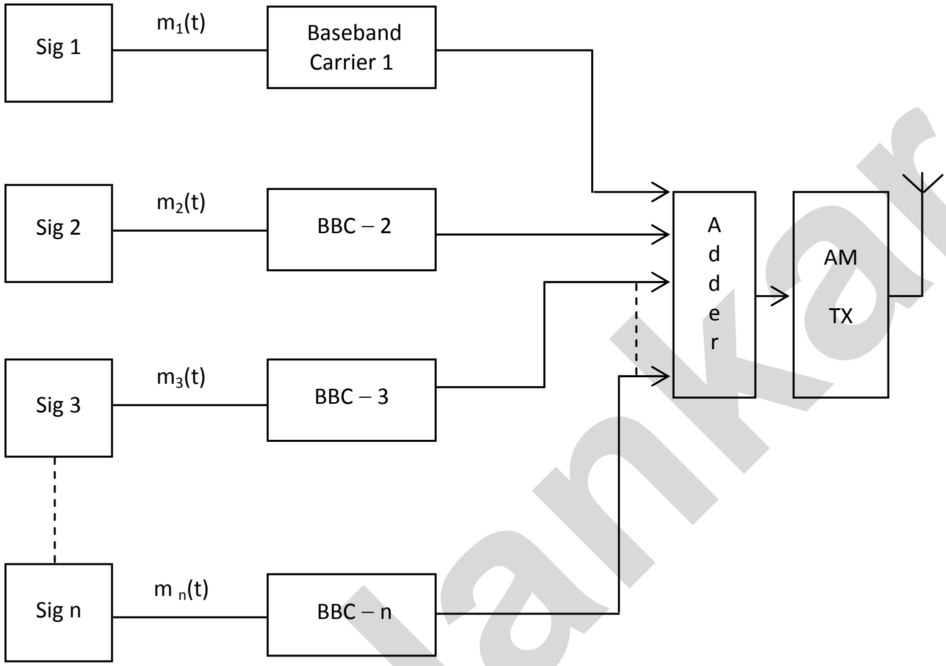
Q.4(b) Draw the PAM, PPM and PWM waveforms and compare them. [5]

Ans.:

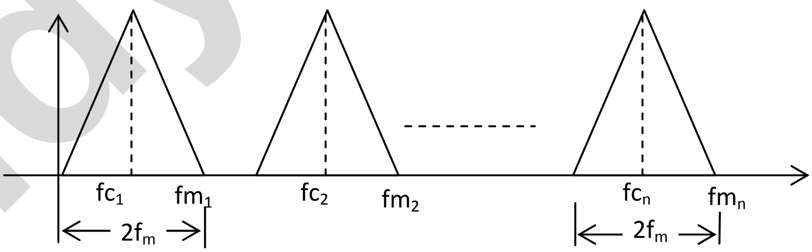
	Parameter	PAM	PWM	PPM
(i)	Information contained in	Amplitude Variation	Width Variation	Position Variation
(ii)	Bandwidth Requirement	low	high	high
(iii)	Noise immunity	low	high	high
(iv)	Transmitted Power	Varies with amplitude & pulses	Varies with variation in width	Remains constant
(v)	Need to transmit synchronization pulses	not needed	not needed	necessary
(vi)	Complexity of generation & detection	Complex	Easy	Complex

Q.4(c) Explain principle of FDM. [5]

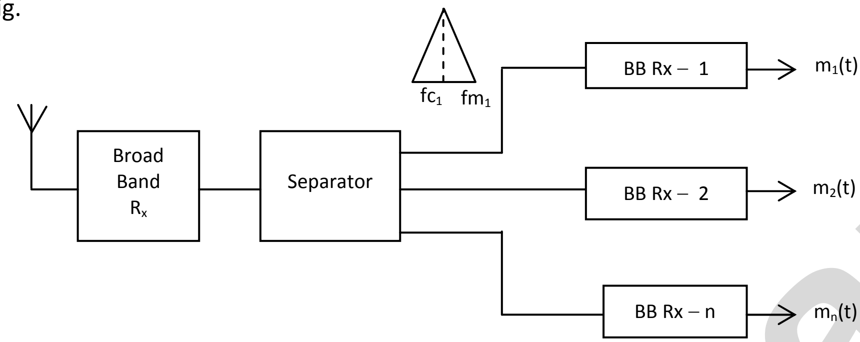
Ans.: FDM consists of simultaneous transmission of message of different channels by shifting them in frequency domain. The bock diagram of FDM T_x & R_x is as shown below.



In above diagram, all the base band carrier blocks are the amplitude modulators. Here, all the signals have the same frequency spectrum. Therefore, all these signals are upshifted in different frequency slot using amplitude modulator. For every BBC Block, the carrier frequency is different. Hence the output of BBC – 1 will be $f_{C1} \pm f_{m1}$. The output of BBC – 2 will be $f_{C2} \pm f_{m2}$. If all the modulating signals have the same B.W. then output of Adder will have the following spectrum.



This FDM signal is transmitted by the Tx. The block diagram of FDM Rx is as shown in fig.



At the receiving station, the FDM signal is received by the broad band Rx. The separator circuit uses approximate mixers & filters, tuned at proper frequencies. The separator has n outputs & each o/p is the modulated signal centered around fc_1, fc_2 –––– fc_n respectively. These outputs are given to BBR_X. These are nothing but AM Rx_s. Hence the output of each block is corresponding modulating signal.

Q.5(a) Explain and give ideal values of following parameters of an Op-Amp : (i) CMRR, (ii) Slew rate, (iii) Offset voltage, (iv) Input Resistance, (v) Output Impedance **[10]**

Ans.: **(i) CMMR :**

It can be defined as the ratio of the diferential voltage gain A_d to the common mode voltage gain A_{cm} is,

$$CMRR = \frac{A_d}{A_{cm}}$$

A_d is same as large signal voltage gain A. the common mode voltage gain is determined from the circuit of figure (a) using the equation,

$$A_{cm} = \frac{V_{ocm}}{V_{cm}}$$

where V_{ocm} = common mode output voltage
V_{cm} = common mode input voltage

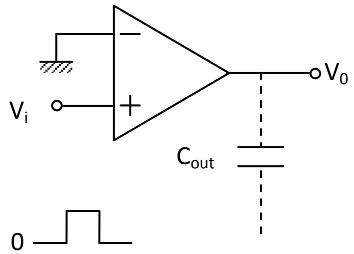
Generally, the A_{cm} is very small and A_d = A is very large, hence CMRR is very large and being a large value it is expressed in dB.

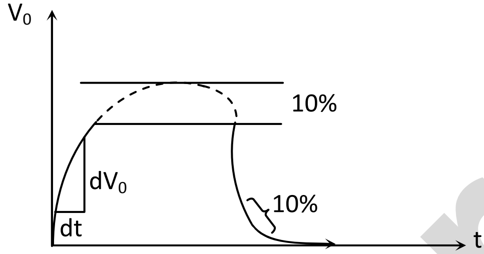
For 741C CMRR with (source resistance) $R_s \leq 10k\Omega$ = 90dB

The higher the value of CMRR, better is the matching between two input terminals and smaller is the output common mode voltage.

The 714C precision op–amp has CMRR = 120dB hence, it has better ability to reject common mode voltages such as electrical noise and preferred in noisy enviroment.

(ii) Slew rate:





When the OP–AMP is operated at high frequencies and when it is excited by a large signal voltage, due to saturation of the internal stages of OP–AMP, there is an effective capacitance C_{out} appearing across output terminals of OP–AMP (C_{out} is due to lead, wiring, stray and internal capacitance of OP–AMP).

Since voltage across capacitor cannot change instantaneously, it takes same time for output voltage to respond to input. Slow rate is defined as the maximum rate of change of output voltage w.r.t. to time.

$$S = \left.\frac{dV_0}{dt}\right|_{max} \text{ ; Unit is V/}\mu\text{ sec}$$

For ideal OP–AMP, slow rate = ∞. For μA741 slow rate = 0.5 V/μ sec.

Let $V_0 = V_m \sin(\omega_m t)$

$$\frac{dV_0}{dt} = V_m\, \omega_m \cos(\omega_m t)$$

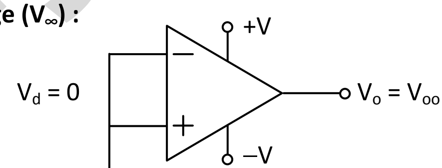
$$= 2\pi\, f_m\, V_m \cos(\omega_m t) \qquad = 2\pi\, f_m\, V_m \cos\theta$$

$$S = \left.\frac{dV_0}{dt}\right|_{max} = 2\pi\, f_{max}\, V_{max}\, 1$$

$$= 2\pi\, f_{max}\, V_{max}\, 1 \quad \text{V/}\mu\text{ sec}$$

where, V_{max} = maximum output voltage OP–AMP can provide without distortion
f_{max} = The maximum frequency OP–AMP can amplify without distortion

(iii) O/P Offset Voltage (V_∞) :



V_{00} is defined as the output voltage measured when the differential input voltage V_d is set zero. For ideal OP–AMP, V_{00} = 0. Practically, it can be as high as supply voltage $\pm$ V.

Due to the mismatch but the transistors used at the i/p stage of OP–AMP, there is a small differential o/p obtained from the first stage which is further amplified by the succeeding stages generating an output offset voltage V_{00}.
If V_{00} = 0, the OP–AMP is said to be balanced or nulled.

(iv) Input resistance (R_i) :

It is defined as resistance which can be measured at either the inverting or non-inverting terminal with the other terminal connected to ground.

It is few mega Ω for transistor input stage and extremely high (thousand of GΩ) for op-amp having FET based input stages. $-R_i = 2M\Omega$.

(v) Output Resistance (R_o) :

Output resistance R_o is the equivalent resistance that can be measured between the output terminal of the op–amp and the ground. It is 75Ω for 741C op–amp.

Q.5(b) Define and explain in brief Amount of information, average information, information rate and Channel capacity of a communication system. [10]

Ans.: The more the probability of an event the less is the amount of information associated with it and vice versa.

Thus we can define "Information as reciprocal of probability"

i.e. $I_K = \log_2\left(\frac{1}{P_K}\right)$ … (1)

$I_K \Rightarrow$ is the information of event 'k' with probability P_K

The unit of information is 'bit' when the base of log is '2' for base 'e' the unit is 'hat' for base 10. Unit is decit or Harley.

"Actually information is dimensionless quantity"

Average Information : The "Entropy" is defined as average information per message. It is denoted by 'H' and its unit is bits/message.

It is given by

$$H = -\sum_{K=1}^{M} P_k \log_2 P_K \quad \text{… (1)}$$

This expression indicates that the entropy of a source is depends only on the probabilities.

Information Rate :

If a message source generates message is at rate of 'r' messages per second. Then the rate of information " 'R' is defined as average number of bits of information per second". [Average information per second]

We know 'H' is the average number of bits of information per message

Hence R = r.H bits/sec.

If the source of message generates 'r' number of messages per second then. Information rate is given by

$R = r \times H$ r $\Rightarrow$ No. of messages / sec

H $\Rightarrow$ Message information / message

$$R = \left[r = \frac{\text{Message}}{\text{Sec}}\right] \times \left[H = \frac{\text{Average Information}}{\text{message}}\right]$$

R = Av. Information / Sec $\Rightarrow$ bits / sec.

Channel Capacity

The channel capacity is defined as the maximum possible bit rate a channel can support without introducing any error. i.e. channel capacity is the maximum of mutual information.

$\therefore$ C = max I (x ; y) bits/sec

The channel capacity is a function of only transition probabilities $P(y_j/x_i)$ which define the channel.

Channel capacity is defined as maximum average mutual information in any single use of the channel (i.e. signaling interval)

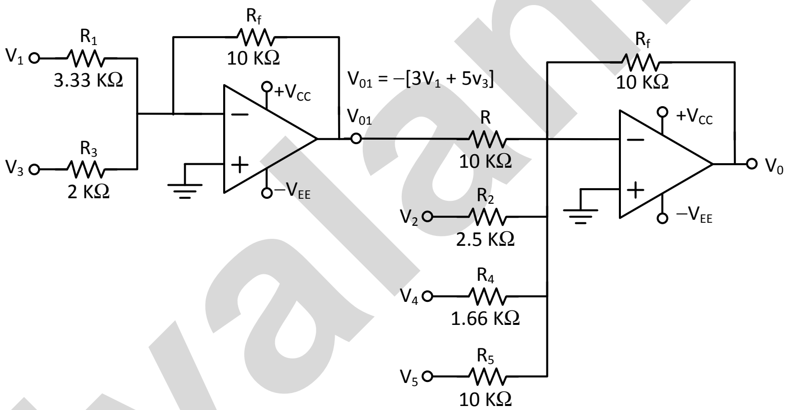
The transmission efficiency or channel efficiency is defined as

$$\eta = \frac{\text{Actual transinformation}}{\text{Maximum transinformation}}$$

Q.6(a) Implement using IC 741, $V_o = 3V_1 - 4V_2 + 5V_3 - 6V_4 - V_5$ **[5]**

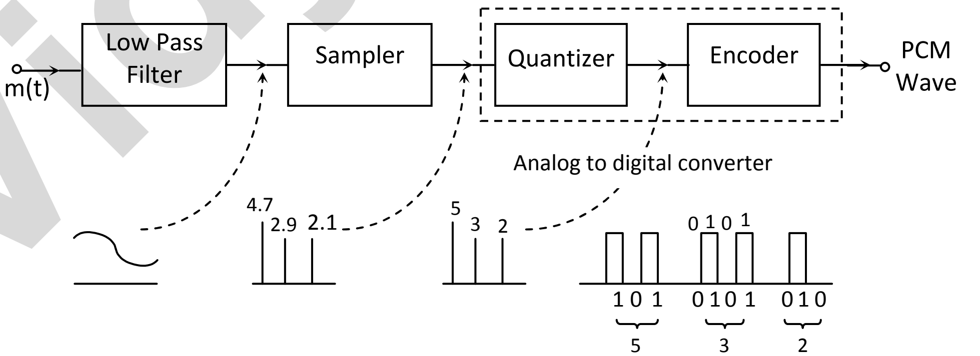
Ans.: $V_o = 3V_1 - 4V_2 + 5V_3 - 6V_4 - V_5$

$= (3V_1 + 5V_3) - (4V_2 + 6V_4 + V_5)$



Q.6(b) Write a note on Pulse Code Modulation with waveforms. **[5]**

Ans.: Following fig. shows the block diagram of the P.C.M. system.



Sampler : The incoming modulating signal is sampled with a train of narrow rectangular pulses. The sampling rate must be greater than twice the highest modulating frequency $> 2\ f_{m(max)}$.

The low pass filter is used to avoid frequencies greater than $f_{m(max)}$.
The sampled pulses are then quantized in the quantizer [Explain quantization].
The encoder encodes these quantized pulses into bits [Binary Code] as shown in fig.

P.C.M. B. W.

B.W. = [n (N + 1) +1] $2f_m$

where f_m = modulating frequency
n = no. of channels or signals to be transmitted
N = no. of bits per samples

Q.6(c) Obtain Expression for an FM Wave. [10]

Ans.: The instantaneous frequency of FM wave is given by

$$\omega t = \omega_c + \delta \quad \dots(1)$$

where δ is variation above or below ω_c depending on the modulating signal

i.e. $\delta \propto V_m \cos \omega_m t$

$$\delta = K V_m \cos \omega_m t \quad \dots(2)$$

where K is frequency deviation sensitivity and is defined as ratio of maximum frequency deviation to the amplitude of modulating signal and is measure din Hertz per volt i.e. Hz/Volts

$$\delta_{max} = K V_m \quad \dots(3)$$

The instantaneous frequency of FM wave is given by

$$\omega_i = \omega_C + \delta \quad \dots(4)$$

Let FM wave be defined by

$$v_{fm}(t) = V_C \sin \theta \quad \dots(5)$$

where θ is instantaneous phase and is obtained using instantaneous frequency

$$\omega_i = \frac{d\theta}{dt}$$

$$d\theta = \omega_i \, dt$$

$$\theta = \int_0^t \omega_i \, dt = \int_0^t [\omega_C + K V_m \cos \omega_m t] dt$$

$$= \omega_C \int_0^t dt + K V_m \int_0^t \cos \omega_m t \, dt = \omega_C t + \frac{K V_m}{\omega_m} \sin \omega_m t = \omega_C t + \frac{\delta_{max}}{\omega_m} \sin \omega_m t$$

$$= \omega_C t + M_F \sin \omega_m t \quad \dots(6)$$

put (6) in (5)

$$v_{fm}(t) = V_C \sin [\omega_C t + M_F \sin \omega_m t] \quad \dots(7)$$

where, $M_F = \dfrac{\delta_{max}}{\omega_m}$ – Modulation Index

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