ECCF

(CBCGS DEC 2018)

Q1] a) Explain the concept and significance of CMRR and Slew Rate in case of op-amps.

(05)

Solution :-

Common Mode Rejection Ratio (CMRR)
It is the figure merit of op-amp which decides how far op-amp is capable of rejecting common mode input signal V_C (noise) and amplify desired signal V_D i.e. (differential input voltage)
It is given as CMRR = $\frac{Ad}{Ac}$

Where A_d=differential gain
A_c=common mode gain

SLEW RATE
The maximum rate at which an amplifier can respond to an abrupt change of input level.
Slew rate = maximum rate at which amplifier output can change in volts per microsecond (v/µs)

The slew rate provides a parameter specifying the maximum rate of change of the output voltage when driven by a large step input signal.

$SR = \frac{dV0}{dt}$ v/ µs

If one tried to drive the output at a rate of voltage change greater than the slew rate, the output would not be able to change fast enough and would not vary over the full range expected, resulting in signal clipping or distortion. In any case, the output would not be amplified duplicate of the input signal if the op-amp slew rate were to be exceeded.

Q1] b) Given β = 120 and I_E 3.2 mA for a common-emitter configuration with r_0=∞ Ω, determine:

(a) Z_i

(b) A_v if a load of 2 KΩ is applied.

(c) A_i with the 2 KΩ load.

(05)

Solution :-

a) Zi = ?
It is given that input resistance $r_0 = \infty$
Therefore $Z_i = 0$

Q1] c) Discuss the factors that influence modulation index of an FM wave.

(05)

Solution :-

Modulation index specifies the amount of energy of carrier wave used in the modulation and frequency modulation transmits information over a carrier wave by varying the frequency. Modulation index is defined as the ratio of the maximum frequency deviation to the modulating frequency. It is given as:

$m_f = \delta f / f_m$
Where,
δf is the frequency deviation and
f_m is the modulating frequency.
Modulation index for FM is dimensionless quantity and it is used to find the depth of modulating signal with a given amplitude and frequency.
When modulating frequency decreases and the modulating voltage amplitude remains constant, the modulation index increases. This helps in differentiating frequency modulation from phase modulation.
The more the amount by which carrier frequency is varied from its unmodulated value, the more is the index of modulation.
The increase in the modulation index for FM implies increased depth of modulation which requires more bandwidth for transmission.
In FM signals, the efficiency and bandwidth both depend on the maximum modulating frequency and the modulation index.

Q1] d) Justify that adaptive delta modulation superior to delta modulation.

(05)

Solution :-

In adaptive **delta** modulation, the step size is not kept constant. Rather, when slope overload occurs the step size progressively becomes larger.

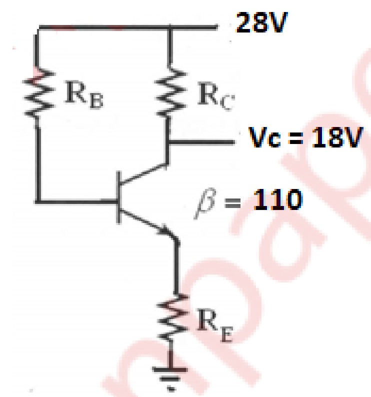
Output of the transmitter is string of continuous 1's or 0's, this indicates that overload has occurred that means DAC has lost the track of analog signal, with adaptive delta modulator, after a pre-determined number 1s and 0s, step size is automatically increased.
In case of slope overload, delta modulation output is train of positive or negative pulses. The integrator output increases which increases gain of amplifier.

When an alternative sequence of 1s and 0s is occurring this indicates that possibility of granular noise is high consequently DFC will revert to its minimum step size thus reducing possibility of granular noise.
As adaptive delta modulation overcomes the problem of slope overload and granular noise it is proved that it is superior to delta modulation.

Q2] a) The emitter bias configuration as shown in following figure has the specifications:

.ICQ = $\frac{1}{2}$ ICsat .ICsat = 8mA VC = 18V and ß = 110

Determine Rc, RE and RB.



(10)

Solution :-

Given: I_{CSAT}= 8mA

$I_{CQ}= \frac{1}{2} I_{CSAT}$

$I_{CQ}= \frac{1}{2} I_{CSAT}$

$I_{CQ}= \frac{1}{2} (8)$

I_{CQ}= 4mA

$I_{CSAT}= \frac{Vcc}{Rc+Re}$

$8= \frac{28}{Rc+Re}$

$R_C + R_E = \frac{28}{8}$ ……………………(1)

$V_C = V_{cc} - I_C R_C$

$18 = 28 - 4R_C$

$4R_C$ = 28-18

R_C = 2.5 Ω

Substitue R_C in equation 1,

$R_E = \frac{28}{8} - 2.5$

R_E = 1 Ω

$I_c = \beta I_B$

4 = 110 I_B

$I_B = \frac{4}{110}$

$I_B = \frac{v_{CC} - v_{BE}}{R_B + (\beta+1)R_E}$

$\frac{4}{110} = \frac{28-0.7}{R_B + (110+1)1}$

$R_B + (110+1)1 = \frac{28-0.7}{4} \times 110$

R_B + 111 =750.75

R_B = 639.75 Ω

Q2] b) Explain how op-amp can be used comparator and zero crossing detector.

(10)

Solution :-

Op-amp as comparator
Zero crossing detector is also op-amp that can be used as comparator.
A comparator, in electronics is a circuit configuration that compares two voltages (or currents) and indicates which one is larger. Thus, the input to the comparator should be different in nature.
Comparators can be easily configured using op-amps, since the op-amps have high gain and balanced different inputs.
Theoretically, an op-amp in open loop configuration (no feedback) can be used as a comparator when the input voltage at the non-inverting terminal (+) is greater than the voltage at the inverting terminal (-), the output of the op-amp saturates at its positive extreme. When the non-inverting input voltage drops below the inverting input voltage, the op-amp output switches to its negative saturation level.
Comparator circuits are most widely used in analog-to-digital converters (ADC's) and in oscillators.
A comparator circuit accepts input of linear voltage and provides a digital output.
When input < Vref, o/p is at +ve saturation means output changes whenever Vref level is crossed by Vin, hence comparator is also known as voltage level detector.

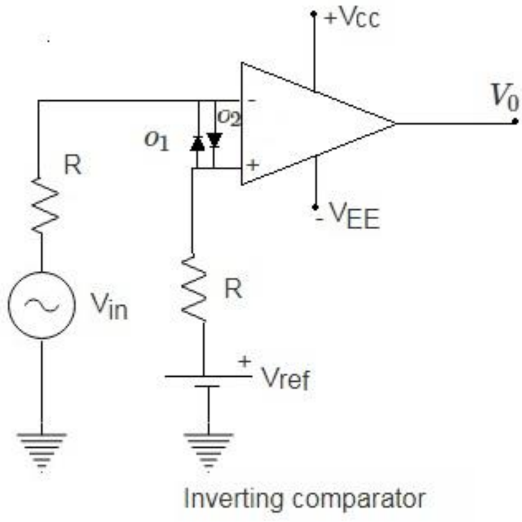


Fig.2.1 Comparator.

Diode D1 and D2 protects op-amp from excessive input voltage.
Output voltages, Vo = gain (V1dV1d)
∵∵ op-amp is operated in open loop
Ideally gain = ∞∞
v2=∞(Vcef−Vin)
When Vref>Vin,V2=+∞
Vref<Vin,V0=−∞
Practically, Gain = 2×1052×105 (High)
When Vref>Vin
Vo=+Vsat (Highest possible positive voltage)
When Vref<Vin
Vo=−Vsat (Highest possible negative voltage)

Q3] a) What is the source of the leakage current in a transistor? If the emitter current of a transistor is 8 mA and 1B is 1/100 of Ic, determine the levels of Ic and 1B.

(05)

Solution :-

Leakage current is generated by the minority carriers that move under the effect of applied reverse bias field can also be generated by thermal agitation, which again is enhanced by the reverse field the regenerative process finally leads to the permanent damage of the junction.

Given:

IE = 8 MA

IB=1/100 Ic

IC = ?

IB = ?

∵ IE = IB + IC

8 MA = IB + IC

8 MA = $\frac{1}{100}$ IC + IC

8 MA = ($\frac{1}{100}$+1) IC

8 MA = $\frac{101}{100}$ IC

IC =100×8MA101

I_C = 7.92 MA

∵ IB=$\frac{1}{100}$ IC= $\frac{1}{100}$ × 7.92MA

I_B =0.0792 MA

Q3] b) Draw and explain Colpitts oscillator.

(05)

Solution:-

The diagram of Colpitts oscillator is given below.
It contains RFC which is a radio frequency coil or choke. It permits an early flow of DC current. At the same time, it offers very high impedance to high frequency currents. In other words, RFC looks like a DC short and AC open.

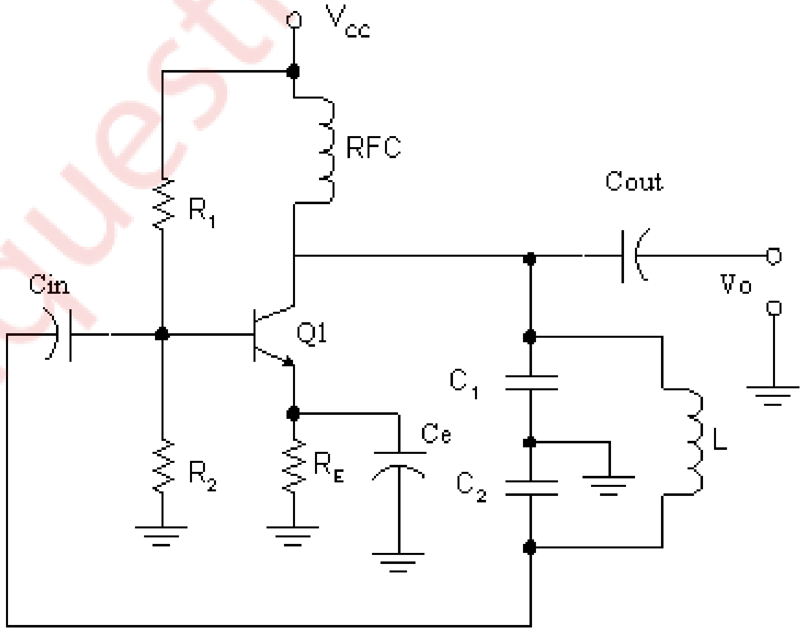


Fig.3.1 Colpitts oscillator.

Operation :

When supply is given, collector current starts using charges C_1 and C_2. C_1 and C_2 discharges through L setting up oscillation of frequency determined by circuit constant. The oscillation across C_2 are feedback to the base and appear in amplified form in the outfit supplying losses to tank circuit. Phase shift of 360^0 is obtained as follows:

1. Amplifer provides 180^0

2. Additional 180^0 is provided by capacitor tapping because points A and B are 180^0 out of phase.

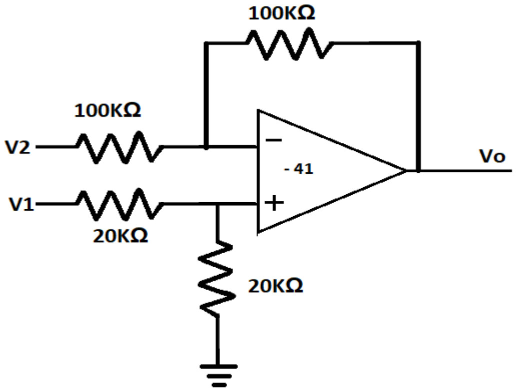
Q3] c) Explain principle of FDM

(05)

Solution :-

FREQYENCY DIVISION MULTIPLEXING (FDM)
Transmission of one signal at a time on a channel is a highly wasteful situation. This difficulty can be overcome if we can shift the frequency spectrum (range) of various signals so that they occupy different frequency ranges without overlapping. This is possible with modulation.
Therefore, it is possible to transmit a large number of signals at the same time on one channel by using modulation technique. This process of shifting signals to different frequency range is known as FDM.
At receiving end, the various signals can be separated by using appropriate filter.
FDM operates in a similar way to radio broadcasting where a number of different stations will broadcast simultaneously but on different frequencies. Listeners can then "tune" their radio so that it captures the frequency or station they want.
FDM gives a total bandwidth greater than the combined bandwidth of the signals to be transmitted. In order to prevent signal overlap there are strips of frequency that separate the signals. These are called guard bands.

Q3] d) Determine the output voltage for the circuit if V1=5 V and V2=3V



(05)

Solution :-

The circuit in which the output is equal to the difference between the 2 inputs is known as subtractor circuit.

By voltage divider rule $V_A = \frac{R}{R+R} \times v2$

By virtual ground concept $V_A = V_B = V_2/2$

Since input impedance of OPAMP is ∞ therefore $I_I = I_F$

$\frac{Vi - Vb}{R} = \frac{Vb - V0}{R}$

$V_1 - V_2 = -V_0$

$V_0 = V_2 - V_1$

$V_0 = 5V - 3V$

$\mathbf{V_0 = 2V}$

Q4] a) What is DSBSC wave and explain its generation using balanced modulator.

(10)

Solution :-

Operation :

Double Sideband Suppressed Carrier (DSBSC) is an amplitude modulation technique in which the modulated wave contains both the sidebands along with the suppressed carrier.
Conventional AM consists of the two sidebands and a carrier where the major transmitted power is concentrated in the carrier which contains no information. Thus to increase the efficiency and to save power, the carrier is suppressed in DSBSC system.
The DSBSC generation using balanced modulator based on nonlinear resistance characteristics of diode is given below in Fig 4.1.
The diode in the balanced modulator use the nonlinear resistance property for producing modulated signals.
Carrier voltage is applied in phase at both the diodes, while modulating voltage appears 180° out of phase at the diode inputs as they are at opposite ends of a center tapped transformer.
The modulated output currents of the two diodes are combined in the center tapped primary of the output transformer, which then gets subtracted.
The output of the balanced modulator contains two sidebands and sum of the harmonic components.
As indicated in the Fig 4.1, the input voltage at diode D1 is (v_c+v_m) and input voltage at diode D2D2 is (v_c-v_m).

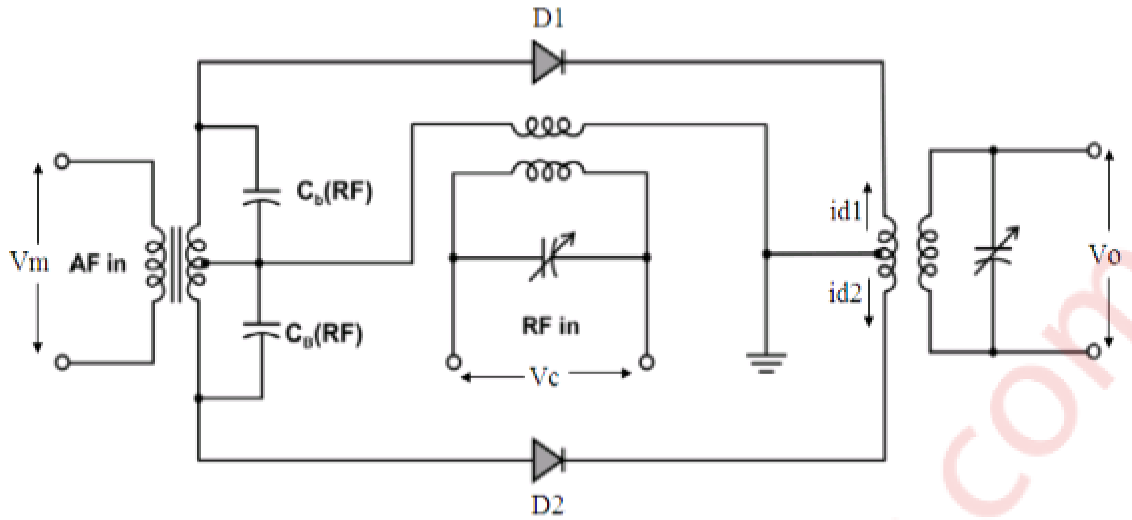


Fig4.1. Generation of DSBSC signal using balanced modulator

The primary current of the output transformer is i1=id1−id2
Where,
$id1 = a + b(v_c + v_m) + c(v_c + v_m)^2$
and $id2 = a + b(v_c - v_m) + c(v_c - v_m)^2$
Thus, we get,
$i1 = id1 - id2 = 2bv_m + 4cv_m v_c$
The modulating and carrier voltage are represented as,
$V_m = V_m \sin\omega_m t$ and
$v_c = V_c \text{ in}\omega_c t$
Substituting for v_m and v_c and simplifying, we get,
$i1 = 2bV_m \sin\omega_m t + 4c\frac{MVc}{2}\cos(\omega_c - \omega_m)t - 4c\frac{MVc}{2}\cos(\omega_c + \omega_m)t$

The output voltage v0v0 is proportional to primary current i1i1 and assume constant of proportionality as α, which can be expressed as,
$v0 = \alpha i1 = 2\alpha bV_m \sin\omega_m t + 4\alpha c\frac{MVc}{2}\cos(\omega_c - \omega_m)t - 4\alpha c\frac{MVc}{2}\cos(\omega_c + \omega_m)t$
Let $P = 2\alpha bV_{m+}$ and $Q = 2\alpha c\frac{MVc}{2}$
Thus we have,
$V_0 = P\sin\omega_m t + 2Q\cos(\omega_c - \omega_m)t - 2Q\cos(\omega_c + \omega_m)t$
The above equation shows that carrier has been cancelled out , leaving only two sidebands and the modulating frequencies.
The modulating frequencies from the output is eliminated by the tuning of the output transformer, which results in the below equation of the generated DSBSC wave.
$v0 = 2Q\cos(\omega_c - \omega_m)t - 2Q\cos(\omega_c + \omega_m)t$

Q4] b) What is multiplexing in communication system? Draw block diagram of TDM-PCM system and explain.

(10)

Solution :-

Multiplexing is the sending of a number of separate signals together, over the same cable or bearer, simultaneously and without interference.
There are generally two classifications. Time-division multiplexing, or TDM, is a method of separating, in the time domain, pulses belonging to different transmissions.
Use is made of the fact that pulses are generally narrow, and the separation between successive pulses is rather wide.
It is possible, provided that both ends of a link are synchronized, to use the wide spaces for pulses belonging to other transmissions.
On the other hand, frequency-division multiplexing, or FDM, concerns itself with combining continuous signals.
It may be thought of as an outgrowth of independent-sideband transmission, on a much-enlarged scale; i.e., 12 or 16 channels are combined into a group,5 groups into super group, and so on, using frequencies and arrangements that are standard on a worldwide scale.
Each group, super group or larger aggregate is then sent as a whole unit on one microwave link, cable or other broadband system.

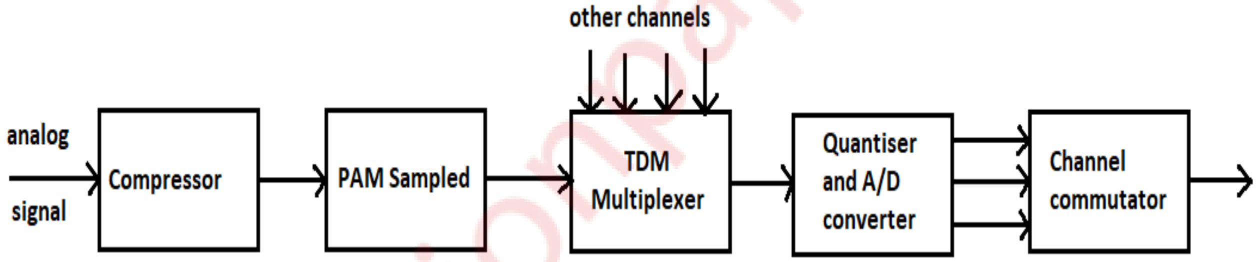


Fig 4.2 PCM Transmission.

Explanation of block diagram
When a large number of PCM signals are to be transmitted over a common channel, multiplexing of these PCM signals is required.
In PCM the signal to be transmitted (i.e. an analog signal which is band limited with frequency fm) is divided into different levels. These levels are known as quantization levels.
Sampler samples the analog signal with sampling frequency fs=2fm. At the output of sampler we get voltage of analog signal present at sampling instant. These sampling voltages are given to quantizer. The function of quantizer is to round off sampled voltages to nearest integer value belonging to quantization levels (some time the sampled voltage is round off to nearest level in between two quantization levels). The quantization reduces no of bits per word per sample. The quantized signals are then encoded into binary format using a digital encoder. The encoder is binary signal corresponding to quantization levels. Therefore, quantized levels are converted to digital (binary). This makes PCM as digital modulation.

Q5] a) State Shannon's theorem on channel capacity. What is the maximum capacity of a perfectly noiseless channel whose bandwidth is 120 Hz, in which the values of the data transmitted may be indicated by any one of the 10 different amplitudes?

(10)

Solution :-

Shannon's Theorem

A given communication system has a maximum rate of information C known as the channel capacity. If the information rate R is less than C, then one can approach arbitrarily small error probabilities by using intelligent coding techniques.
To get lower error probabilities, the encoder has to work on longer block of signal data, this entails longer delays and higher computation requirements.
Thus, if R ≤≤ C then transmission may be accomplished without error in the presence of noise.
The band width and the noise power place a restriction upon the rate of information that can be transmitted by a channel, it may be shown that in a channel which is disturbed by a white Gaussian noise, one can transmit information at a rate of C bits per second, where C is the channel capacity and is expressed as
C = B log2(1+S/N) bits/seconds.
Where
B → channel bandwidth in Hz
S →Signal power
N → Noise power.
Sum:
Given: B=120
N=10
C=?
According to Hartley law.
C=2 B log2N
C=2×120×1og2(10)
C = 797.26 bits/seconds.
maximum capacity of a perfectly noiseless channel whose bandwidth is 120 Hz, in which the values of the data transmitted may be indicated by any one of the 10 different amplitudes is 797.26 bits/seconds.

Q5 b) With respect to neat diagram explain the elements of analog communication system.

(10)

Solution:-

A continuous time varying signal, which represents a time varying quantity can be termed as analog signal. Fig (a) shows the generic block diagram of a analog communication system. Any communication system will have five blocks, including the information source and the destination blocks. However, from the practical design point of view, we are interested in three blocks, namely, transmitter, channel and receiver. This is because, we have little control over the other two blocks. Also, the communication in electrical form takes place mainly in these three blocks.

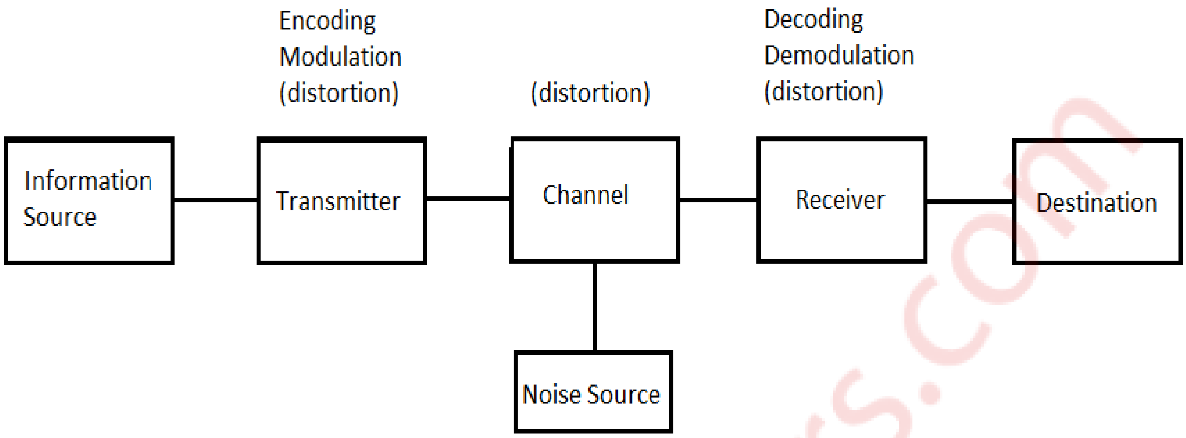


Fig (a) Block Diagram of analog communication system

The functions of each elements (block) are described below:

(A) Information Source: The objective of any communication system is to convey information from one point to the other. The information comes from the information source, which originates it. Information is a very generic word signifying at the abstract level anything intended for communication, which may include some thought, news, feeling, visual scene, and so on. The information source converts this information into a physical quantity. This physical expression of the information is termed as message signal.

(B) Transmitter: The objective of the transmitter block is to collect the incoming messages signal and modify it in a suitable fashion (if needed), such that, it can be transmitted via the chosen channel to the receiving point. The functionality of the transmitter block is mainly decided by the type or nature of the channel chosen for communication. The transmitter block involves several operations like

i) Amplification – It involves amplifying the signal amplitude and also adding required power levels.

ii) High frequency carrier signal – It is termed as carrier and is generated by stable oscillator.

iii) Modulation – It varies one of these 3 parameters amplitude, frequency and phase in accordance with variation of message signal.

iv) Radiation of modulated signal – The modulated signal is radiated into the atmosphere using an antenna as the transducer.

(C) Channel: Channel is the physical medium which connects the transmitter with that of the receiver. The physical medium includes copper wire, co-axial cable, fibre-optic cable, wave guide and free space or atmosphere. The choice of a particular channel depends on the feasibility and also the purpose of communication system.

(D) Receiver: The receiver block receives the incoming signal from the channel and process it to recreate the original form of the message signal. There are a great variety of receivers in communication system, depending on the processing required to recreate the original message signal and also final presentation of the message to the destination.

(E) Destination: The destination is the final block in the communication system which receives the message signal and process it to comprehend the information present in it. Usually, humans will be the destination block.

Q6] a) What is meant by Nyquist rate in sampling and explain its significance.

(05)

Solution :-

Sampling theorem (also known as Nyquist rate)
According to this theorem, it is possible to reconstruct a band limited analog signal from periodic samples, as long as the sampling rate is at least twice the frequency of highest frequency component of analog signal.
Mathematically it is given as:

$$F_s=2f_m$$

In telephony, a sample rate of 8 kHz is use for more AF of 3.4 kHz.
This theorem was the key to digitizing the analog signal. Using this, it was possible to turn the human voice into a series of ones and zeroes.

Q6] b) Give the proper definition for entropy and information rate.

(05)

Solution :-

Entropy
The average information per message of a source m is called its entropy denoted by H(m) Hence,
H(m)=∑ni=1pi7iH(m)=∑in=1pi7i bits
The term entropy refers to the relative degree of randomness. The higher the entropy, the more frequent are signaling errors. Entropy is directly proportional to the maximum attainable data speed in bps (bits per second). Entropy is also directly proportional to noise and bandwidth .
Information Rate
Information rate is represented in average number of bits of information per second.
Information rate denoted by R is given as
R = r H
Where, H = entropy or average information
r = rate at which message are generated.

Q6] c) Write short note on op-amp as differentiator.

(05)

Solution:-

Differentiator is a circuit which produces an output waveform whose value at any instant of time is equal to the rate of input at that point of time. Differentiator is a circuit which produces output voltage which is derivative of input voltage.

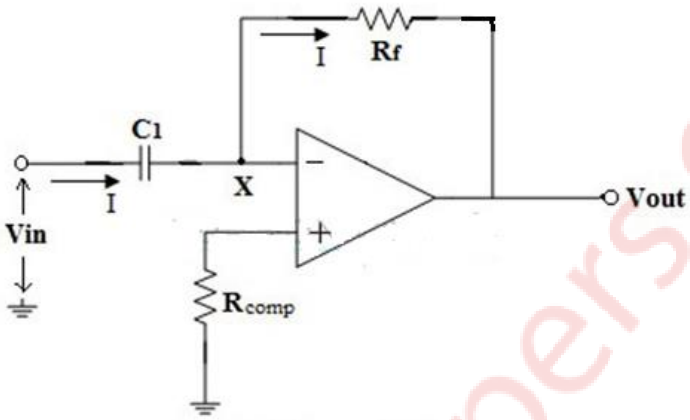


Fig.6.1 Op-amp as differentiator

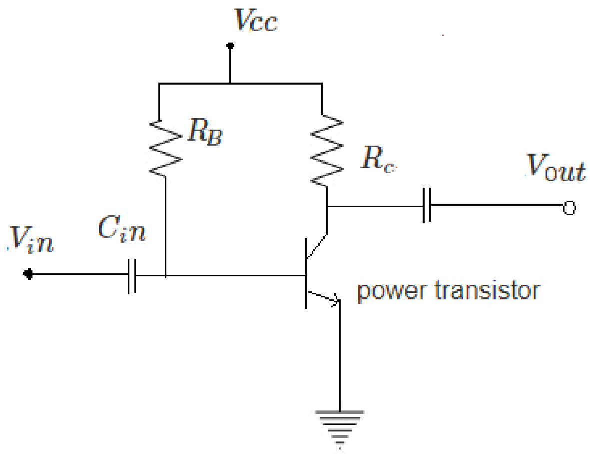
An op-amp differentiating amplifier uses a capacitor in series with the input voltage source, as shown in the figure below. For DC input, the input capacitor C1 remains uncharged and behaves like an open-circuit. The non-inverting input terminal of the op-amp is connected to ground through a resistor R_{comp}, which provides input bias compensation, and the inverting input terminal is connected to the output through the feedback resistor Rf.
An op-amp differentiating amplifier is an inverting amplifier circuit configuration, which uses reactive components (usually a capacitor than inductor).
The differentiator performs mathematical differentiation operation on the input signal with respect to time, i.e. the output voltage is proportional to the rate of change of the input signal.
Differentiating circuits are commonly used to operate on triangular and rectangular signals. While operating on sine wave inputs, differentiating circuits have frequency limitations.

Q6] d) Differentiate between Class A and Class C power amplifiers with respect to circuit diagram operating cycle and power efficiency.

(05)

Solution :-

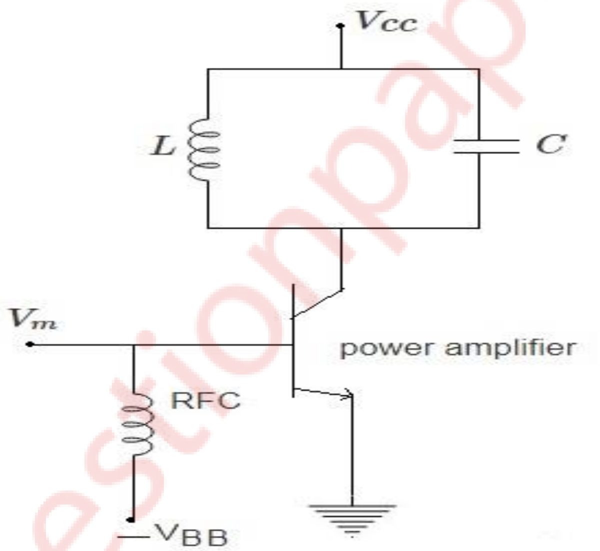
Class A Power amplifier.
1. Circuit diagram.



(series fed class A power amplifier)

2. Operating cycle: Circuit operates for entire 360˚ of input signal.
3. Power efficiency: Maximum efficiency (for series fed) = 25%
Maximum efficiency for transformer coupled = 50%

Class C Power Amplifier.
1. Circuit diagram.



2. Operating cycle: Circuit operates for less than 180˚ of input signal.
3. Power efficiency: Around 95% for class C power amplifier.