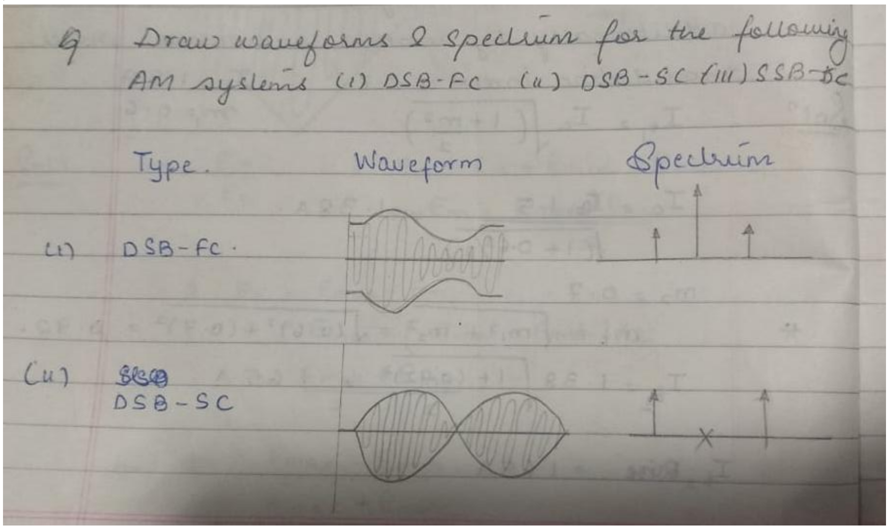
Question Bank Answers (PCOM – IAE1)

CONTENT WARNING: READING THIS DOCUMENT MAY CAUSE SUDDEN BURSTS OF INTELLIGENCE. PROCEED WITH CAUTION.

1. Draw spectrum and Wave form of DSB-FC, DSB-SC,



2. What are drawback of TRF receiver. How you overcome these drawbacks.

Disadvantages:

- Instability (RF amp^r provide g oscillations ⇒ unstable)
  2 stages of RF amp^r provide a very high gain and we require a very small voltage to achieve a feedback. This can be achieved thru stray capacitance, hence, ckt becomes unstable.
- Variation in Bandwidth:
  The range of AM receiver is 540 kHz to 1640 kHz. Consider a tuned ckt reqd to have a BW of 10 kHz at a freq. 540 kHz.
  Then $Q = \frac{f_r}{BW} = \frac{540k}{10k} = 54$.

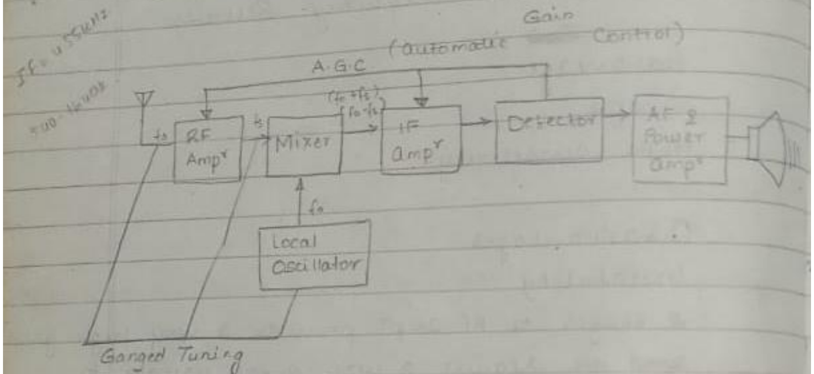
At the other end of the broadcast band i.e. at 1640 kHz, Q is increased by

$Q = \frac{1640k}{10k} = 164$. Thus, the value of Q is very large & practically unobtainable. The max. value of Q is 120.

$\therefore BW = \frac{1640k}{120} = 13.7\ kHz$.

Bcoz of this, receiver will pick up adjacent stages as well.

SUPERHETERODYNE RECEIVER.



This operates on the principle of heterodyning i.e. mixing

In this receiver, we down convert every received signal to a constant intermediate frequency (455kHz). This contains same modulation as that of received signal.

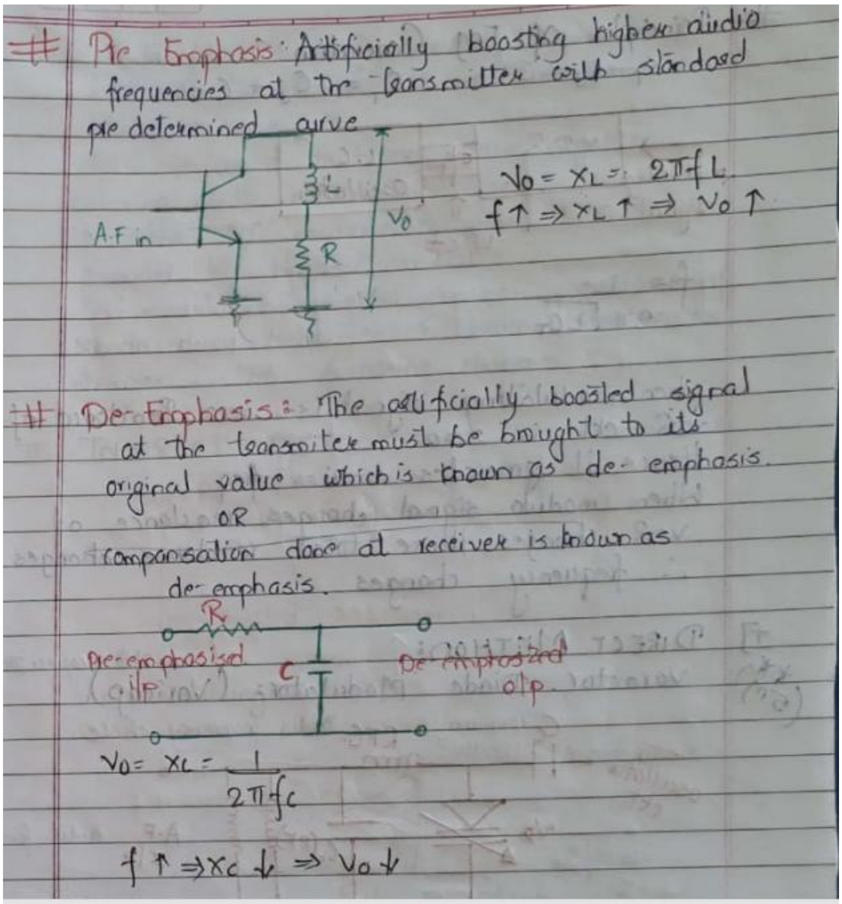
The local oscillator frequency is automatically changed when it mixes with signal freq. to produce constant I.F.

The i/p ckt of I.F ampʳ is a tank ckt which is used to select the I.F.

A.G.C: The o/p of the receiver maintained constant irrespective of fluctuations at the i/p.

A dc voltage from the detector is fed back to base of IF & RF ampʳ, transistor to change q-point & hence gain of the receiver.

3. Show how Pre-emphasis and De-emphasis circuit reduces noise



Pre Emphasis: Artificially boosting higher audio frequencies at the transmitter with standard pre determined curve

$V_0 = X_L = 2\pi f L$

$f\uparrow \Rightarrow X_L \uparrow \Rightarrow V_0 \uparrow$

De-Emphasis: The artificially boosted signal at the transmitter must be brought to its original value which is known as de-emphasis.

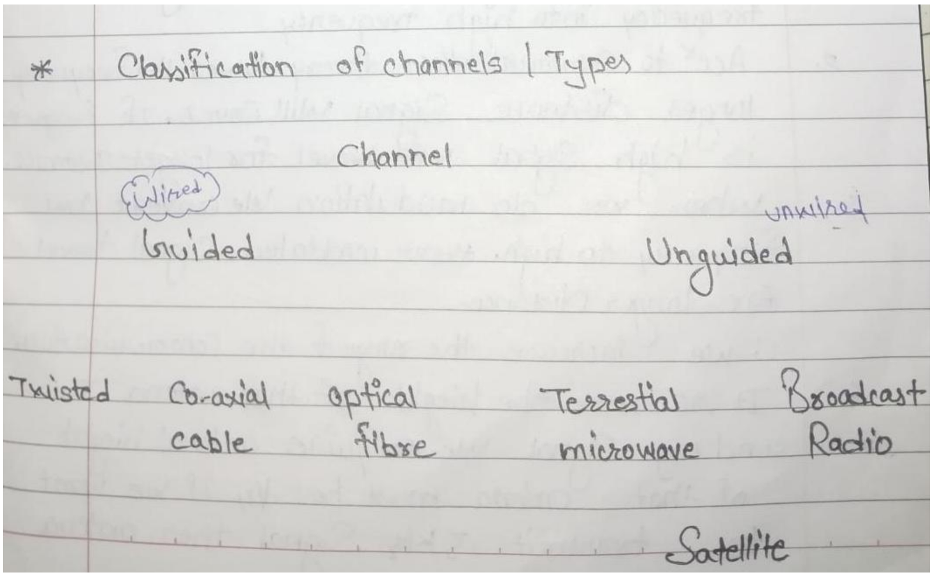
OR

compensation done at receiver is known as de-emphasis.

$V_0 = X_C = \frac{1}{2\pi f c}$

$f\uparrow \Rightarrow X_C \downarrow \Rightarrow V_0 \downarrow$

4. Compare different communication channels



* Classification of channels | Types

Channel

(Wired) Guided — Twisted, Co-axial cable, optical fibre

unwired Unguided — Terrestial microwave, Broadcast Radio, Satellite

Aspect	Guided (Wired) Channels	Unguided (Wireless) Channels
Physical Medium	Physical medium required (cables such as twisted pair, coaxial, optical fiber)	No physical medium; uses electromagnetic waves (e.g., radio waves, microwaves, satellites)
Types	Twisted Pair Cable, Coaxial Cable, Optical Fiber	Terrestrial Microwave, Broadcast Radio, Satellite Communication
Bandwidth	High, especially with optical fiber	Moderate to high (5G, satellite can be high but variable)
Mobility	Stationary, limited to where cables are installed	High mobility; supports on-the-go communication (e.g., mobile phones, Wi-Fi)
Installation Cost	High, especially for optical fiber due to physical infrastructure	Lower initial cost; no physical installation required for medium
Interference Susceptibility	Low (optical fiber is immune to electromagnetic interference)	High, can be affected by physical obstructions and weather conditions
Distance	Long-distance possible with optical fiber; limited for twisted pair	Long distances covered easily, especially with satellites
Flexibility	Less flexible; hard to relocate once installed	Highly flexible, adaptable to different environments
Signal Delay	Low (especially with optical fiber)	Potential for signal delay, especially with satellite communication
Use Cases	LANs, cable TV, high-speed internet (fiber-optic)	Mobile communications, satellite TV, remote area coverage

4. Define and classify External Noise

3.1.2 External Noise (Uncorrelated Noise) :

MU : May 11

University Questions

Q. 1 Classify and explain the various noises that affect communications. **(May 11, 5 Marks)**

- It is defined as the noise that is generated outside the device or circuit. As shown in Fig. 3.1.2 the external noise can be of three types :

  1. Atmospheric noise 2. Extraterrestrial and 3. Man made noise

1. **Atmospheric noise :**
   - This type of noise gets produced within the Earth's atmosphere
   - The common source of this type of noise is lightning.
   - This type of noise is in the form of impulses or spikes which covers a wide frequency band typically upto 30 MHz.
   - The sputtering, cracking etc heard from the loud speakers of radio is due to atmospheric noise.
   - This type of noise becomes insignificant above 30 MHz.

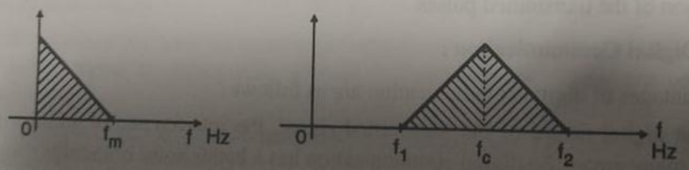
2. **Extraterrestrial noise :**
   - This type of noise originates from the sources which exist outside the Earth's atmosphere. Hence this noise is also called as deep space noise.
   - The noise originating from the sun and the outer space is known as **Extraterrestrial Noise.** The extraterrestrial noise can be sub-divided into two groups : (a) Solar noise (b) Cosmic noise. Our sun being a large body at very high temperatures radiates a lot of noise. The noise radiation from sun varies with the temperature changes on its surface.
   - The temperature changes follow a cycle of 11 years hence the cycle of great electrical disturbances (noise) also repeats after every 11 years.
   - The cosmic noise comes from the stars. This is identical to the noise radiated by sun because stars also are large hot bodies.
   - This noise is called as black body noise or thermal noise and it is distributed uniformly over the entire sky. The noise also gets originated from the center of our galaxy, other galaxies and special type of stars such as "Quasars" and "Pulsars".

3. **Man made noise (Industrial noise) :**
   - The man made noise is generated due to the make and break process in a current carrying circuit. The examples are the electrical motors, welding machines, ignition system of the automobiles, thyristorised high current circuits, fluorescent lights, switching gears etc.
   - This type of noise is also called as industrial noise.

6. Differentiate between Base band and Band pass signals?

1.4.3 Baseband and Bandpass Signals :

- The information signal or the input signal to a communication system can be analog i.e. sound, picture or it can be digital e.g. the computer data. **The electrical equivalent of this original information signal is known as the baseband signal.**
- In some systems, called the **baseband transmission systems,** the baseband signals (original information signals) are directly transmitted.
- In other words we can define a baseband signal as the one which is not modulated. All the voice, data and picture signals are called as the baseband signals.
- The frequency spectrum of a baseband signal is shown in Fig. 1.4.1(e). It generally occupies the frequency spectrum right from 0 Hz.



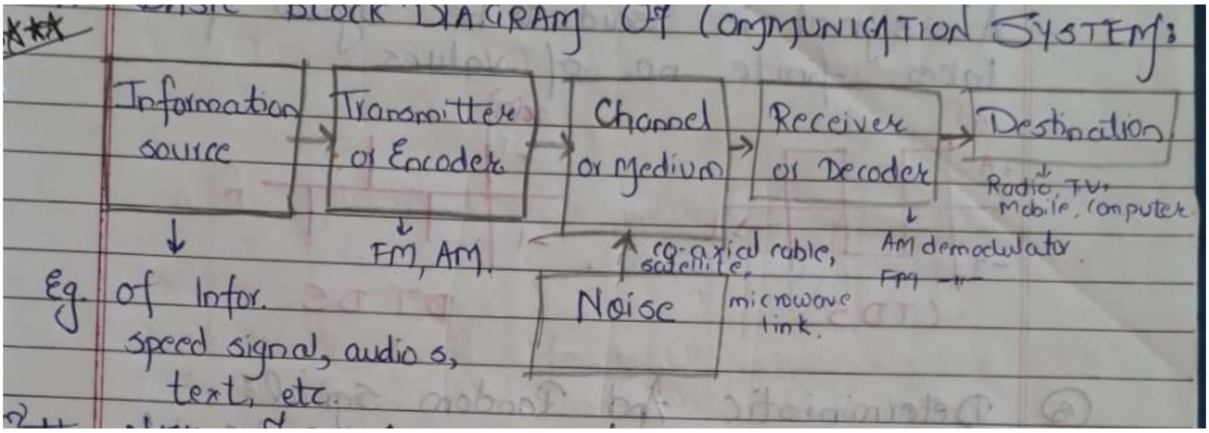
(e) Spectrum of a baseband signal **(f) Spectrum of a bandpass signal**

(D-7) **Fig. 1.4.1**

Bandpass signal :

- It can be defined as a signal which has a non zero lowest frequency in its spectrum. That means the frequency spectrum of a bandpass signal extends from f_1 to f_2 Hz.
- The modulated signal is called as the bandpass signal. It is obtained by shifting the baseband signal in frequency domain.
- The spectrum of bandpass signal is shown in Fig. 1.4.1(f). Note that the lowest frequency in its spectrum is f_1 Hz whereas the highest frequency is f_2 Hz.
- All the bandpass signals are not necessarily modulated signals. They can be available naturally as well.
- Examples of bandpass signals are the ultrasound waves, visible light, radio waves etc.

7. Describe basic block diagram of communication system



Description of Each Block

1. **Source**:
   - This is where the information originates. It could be voice, video, data, etc.
2. **Transmitter**:
   - This component encodes the information into a suitable format for transmission. It may involve modulation, amplification, and filtering.
3. **Communication Channel**:

- This is the medium through which the signal travels. It can be a wired (e.g., fiber optic, coaxial) or wireless (e.g., radio waves) channel.

4. **Receiver**:
   - The receiver captures the transmitted signal from the communication channel. It typically involves demodulation and may include amplification and filtering.
5. **Demodulator**:
   - This component processes the received signal to extract the original information from the modulated signal.
6. **Destination**:
   - This is where the processed information is delivered, such as a display, speaker, or data storage.

8. Fourier Transform Properties

(May 10, 5 Marks)

The time shifting property states that if x (t) and X (f) form a Fourier transform pair then,

$$x(t-t_d) \stackrel{F}{\longleftrightarrow} e^{-j2\pi f t_d} X(f) \quad \text{...(2.8.7)}$$

Here the signal $x(t-t_d)$ is a time shifted signal. It is the same signal x (t) only shifted in time.

Proof :

$$F[x(t-t_d)] = \int_{-\infty}^{\infty} x(t-t_d) \cdot e^{-j2\pi f t}\, dt \quad \text{...(2.8.8)}$$

$$\text{Let } (t-t_d) = \tau,$$

$$\therefore \quad t = t_d + \tau$$

$$\therefore \quad dt = d\tau.$$

Substituting these values in Equation (2.8.8) we get,

$$F[x(t-t_d)] = \int_{-\infty}^{\infty} x(\tau) \cdot e^{-j2\pi f (t_d+\tau)}\, d\tau = e^{-j2\pi f t_d} \int_{-\infty}^{\infty} x(\tau)\, e^{-j2\pi f \tau}\, d\tau$$

$$\therefore \quad F[x(t-t_d)] = e^{-j2\pi f t_d} X(f)$$

This shows that the time shifting does not have any effect on the amplitude spectrum, but there is an additional phase shift of $-2\pi f t_d$, which is denoted by the term $e^{-j2\pi f t_d}$.

...time shifting in communication systems...

2.8.7 Property 7 : Frequency Shifting :

The frequency shifting characteristics states that if x(t) and X(f) form a Fourier transform pair then,

$$e^{j2\pi f_c t}\, x(t) \stackrel{F}{\longleftrightarrow} X(f-f_c) \quad \text{...(2.8.11)}$$

Here f_c is a real constant.

Proof :

$$F\left[e^{j2\pi f_c t}\, x(t)\right] = \int_{-\infty}^{\infty} e^{j2\pi f_c t}\, x(t)\, e^{-j2\pi f t}\, dt = \int_{-\infty}^{\infty} x(t)\, e^{-j2\pi (f-f_c) t}\, dt$$

$$= X(f-f_c) \quad \text{...Proved.}$$

The term $X(f-f_c)$ represents a shifted frequency spectrum. The whole spectrum is thus shifted right by "f_c" in the frequency domain, when the signal x (t) is multiplied by $e^{j2\pi f_c t}$ in the time domain.

2.8.8 Property 8 : Differentiation in Time Domain

9. Friss Formula and its derivation.

6.32. Noise Figure Determination for Cascaded Stages of Amplifiers

In this article we shall determine the noise figure (F) of a cascaded amplifier in terms of noise figure of individual stages of amplifiers. It is evident that the noise generated in the first stage is amplified by the subsequent stages. Therefore, the noise figure (F_1) of first stage is much more important compared to the later stages in a multistage amplifier to determine the overall noise figure of the amplifier. Let the two stages of the amplifiers have available power gains A_1 and A_2 respectively. Now, the overall noise figure F of the cascaded amplifier can be determined as under.

The total available noise power density S_{no} consists of the total noise power density S_{n1} available at the output due to the first stage. It also consists of the total noise power density S_{n2} at the output due to second stage of the amplifier.

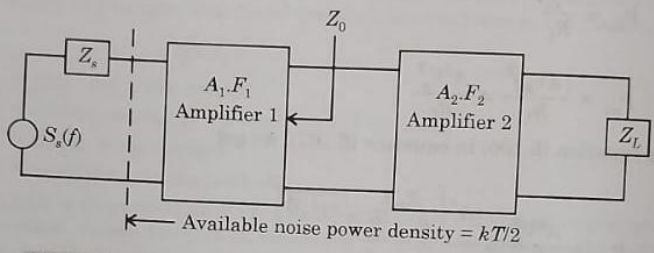


Fig. 6.23. *Determination of noise figure of cascaded amplifier or a multistage cascaded amplifier.*

Let F_1 and F_2 be the noise figures of the first stage and second stage of the amplifier, respectively. Total noise power density S_{n1} available at the output due to the first stage is given as

$$S_{n1} = \frac{kTF_1}{2} A_1A_2 \quad ...(6.113)$$

Let S_{n2} is the noise power density available at the output due to the second stage only. The source impedance for the second stage is the impedance seen at the output terminals of the first stage. Impedance seen at the output terminals of the first stage is denoted by Z_0. The noise component S_{n2} is due to noise sources inside the second stage amplifier only and it is immaterial whether Z_o is thermal or not. For convenience, we are assuming here that Z_o is a thermal.

Hence, the available power density is $kT/2$.

Let the noise figure of amplifier stage 2 be F_2. The available noise power density at the output due to amplifier in second stage will be given by

$$S_{n2} = \frac{kT}{2}(F_2 - 1)A_2 \quad ...(6.114)$$

Hence, the total noise power density delivered to the load by the cascaded amplifier is given as

$$S_n = S_{n1} + S_{n2} \quad ...(6.115)$$

Substituting equations (6.113) and (6.114) in equation (6.115), we get

$$S_n = S_{n1} + S_{n2} = \frac{kT}{2}F_1A_1A_2 + \frac{kT}{2}(F_2 - 1)A_2$$

or

$$S_n = \frac{kT}{2}[F_1A_1A_2 + (F_2 - 1)A_2] \quad ...(6.116)$$

Now, we are considering the overall amplifier for which noise power density S_n is expressed as

$$S_n = \frac{kT}{2}FA \quad ...(6.117)$$

where A = available gain of the cascaded amplifier

F = overall spectral noise figure

Because the overall available gain of a cascaded amplifier is the multiplication of the available gain of each stage, therefore,

we have

$$A = A_1 A_2 \quad \text{...(6.118)}$$

Substituting equation (6.118) in equation (6.117), we obtain

$$S_n = \frac{kT}{2} F A_1 A_2 \quad \text{...(6.119)}$$

On comparing equations (6.116) and (6.119), we get

$$S_n = \frac{kT}{2} [F_1 A_1 A_2 + (F_1 - 1) A_2] \quad \text{...(6.120)}$$

$$S_n = \frac{kT}{2} F A_1 A_2 \quad \text{...(6.121)}$$

$$F = F_1 + \frac{(F_2 - 1)}{A_1} \quad \text{...(6.122)}$$

It must be remembered that Noise Figure F_2 is the noise figure of the amplifier in second stage under the condition that the source is a positive impedance Z_0 equal to the output impedance of the amplifier in first stage.

In general, for a multistage amplifier, the overall spectral noise figure is given by

$$F = F_1 + \frac{F_2 - 1}{A_1} + \frac{F_3 - 1}{A_1 A_2} + \frac{F_4 - 1}{A_1 A_2 A_3} + \ldots \quad \text{...(6.123)}$$

From equation (6.123), we conclude that the first stage is most significant in determining the overall noise figure of the amplifier. Hence, in low noise amplifiers, the primary consideration is the design of the first stage which must have a low noise figure. This is sometimes obtained even at the cost of gain of the first stage of the multistage amplifier.

10. Define modulation Index of AM and FM

$m = \frac{E_m}{E_c}$

$m < 1$

$1/2$

$m_f = \frac{\delta}{f_m} = \frac{\text{deviation}}{\text{modulating } f_m}$

$m > 1$

12. Explain Noise Figure and Noise Factor with respect to Noise

3] NOISE FACTOR AND NOISE FIGURE:

It is defined in terms of signal to noise ratio at the input & the output of the system.

$$F = \frac{S/N \text{ ratio at input}}{S/N \text{ ratio at o/p}} = \frac{\frac{P_{si}}{P_{ni}}}{\frac{P_{so}}{P_{no}}}$$

$$F = \frac{P_{si}}{P_{ni}} \times \frac{P_{no}}{P_{so}}$$

where P_{si} & P_{ni} are signal & noise power at I/p, P_{so} & P_{no} are signal & noise power at o/p.

SNR at input is > than output. This is due to the noise added by the Amplifier.

Noise factor is the means to measure the amount of noise added.

The ideal value of Noise factor is unity.

NOISE FIGURE: Noise factor expressed in decibels dB is noise figure.

$$10 \log F$$

$$= 10 \log \left[\frac{S/N \text{ at i/p}}{S/N \text{ at o/p}}\right]$$

$$N.F. = 10 \log (S/N)_i - 10 \log (S/N)_o.$$

N.F can be improved by using amplifier & mixture stages that produce low noise.

13. Explain IEEE Radio Frequency bands with application

Sr No.	Freq Band & Name	Wavelength	Application
1	30Hz – 300Hz. Extremely Low freq (ELF)	10^4km – 10^3km.	Power transmission
2.	300Hz – 3kHz (voice freq)	10^3km – 100km	Audio Application.
3.	3kHz – 30kHz (VLF) very low freq	100km – 10km	Navy, Military Communication
4.	30kHz – 300kHz Low freq (L.f).	10km – 1km.	Aeronautical / Marine
5	300kHz – 3MHz Medium freq (m f)	1km – 100m	Amp Modulation (AM) Broadcast
6	3MHz – 30MHz High freq (H.F)	100m – 10m	Shortwave Transmission
7.	30MHz – 300MHz very high freq	10m – 1m	T.V. Broadcasting, FM Radio
8	300MHz – 3 GHz (10^6) (10^9) ultra high f (UHF)	1m – 10cm	Cellular Phones
9.	3GHz – 30GHz Super High freq.	10^{-1}m to 10^{-2}m.	Satellite Communication / RADAR
10	30GHz – 300GHz Extremely High freq	10^{-2}m – 10^{-3}m	Satellite Communication.

14. Explain Classification of Noise in detail

- Noise is defined as the unwanted form of energy which tends to interface with the proper reception and the reproduction of transmitted signals.
- Classification of noise
  There are several way to classify Noise, but conveniently Noise is classified as
  1) External Noise
  2) Internal Noise

3.1.2 External Noise (Uncorrelated Noise) :

MU : May 11

University Questions

Q. 1 Classify and explain the various noises that affect communications. **(May 11, 5 Marks)**

- It is defined as the noise that is generated outside the device or circuit. As shown in Fig. 3.1.2 the external noise can be of three types :

  1. Atmospheric noise 2. Extraterrestrial and 3. Man made noise

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- This type of noise originates from the sources which exist outside the Earth's atmosphere. Hence this noise is also called as deep space noise.
- The noise originating from the sun and the outer space is known as **Extraterrestrial Noise.** The extraterrestrial noise can be sub-divided into two groups : (a) Solar noise (b) Cosmic noise. Our sun being a large body at very high temperatures radiates a lot of noise. The noise radiation from sun varies with the temperature changes on its surface.
- The temperature changes follow a cycle of 11 years hence the cycle of great electrical disturbances (noise) also repeats after every 11 years.
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- The man made noise is generated due to the make and break process in a current carrying circuit. The examples are the electrical motors, welding machines, ignition system of the automobiles, thyristorised high current circuits, fluorescent lights, switching gears etc.
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NOISE

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Date

NOISE unwanted electrical disturbance.

- Co-related Noise (when signal is present noise present)
  - Intermodulation Distortion
  - Harmonic Distortion (produced by harmonics of fundamental fq)
- Un co-related Noise (even signal not present noise present)
  - Internal Noise
    - Short Noise
    - Transitive Time Noise
    - * Thermal Noise (Johnson, White)
    - Flicker Noise
  - External Noise
    - Atmospheric Noise
    - Man made Noise
    - Extra Terestrial Noise
      - Solar
      - Cosmic

⇒ Can reduce the effect of Noise → Statistical

If noise produced
Internal :- noise generated inside the receiver
External : — " — outside — " —

TYPES OF INTERNAL NOISE :

* Shot Noise : It is caused by random arrival of carriers (electrons / holes) at the o/p element of an electronic device such as diode, FET, BJT.
When amplified shot noise sounds similar to metal palates falling on a tin roof.

Shot Noise for diode is given by

$I_n = \sqrt{2qI_0B}$

I_n = r.m.s noise current

I_0 = DC current in device

B = Bandwidth

q = Charge 1.6×10^{-19} Columbs.

* Transit Time Noise:

Any modulation to a stream of carriers as they pass from i/p to o/p of device produces an irregular random variation. This is called Transit Time Noise. This are excessive at high frequency.

* Thermal Noise / White / Johnson / Thermal Agitation Noise:

Rapid and random movement of electrons within conductor due to heat is thermal Noise

* Flicker Noise: In Semiconductor device flicker noise is generated due to fluctuations in the carrier density

flicker

These exist for very low frequency

15. Justify how height of antenna reduces with modulation

2. Reduces the height of Antenna:

To transmit or to receive any signal we require an antenna. The height of that antenna must be $\lambda/4$ where $\lambda = \frac{c}{f}$ where

c = velocity of light = 3×10^8 m/sec

f ⇒ freq which we are transmitting

If we want to transmit 3kHz signal the ht. of antenna must be $\lambda = \frac{3 \times 10^8}{3 \times 10^3} = 10^5$ mts.

$\therefore \frac{\lambda}{4} = \frac{10^5}{4} = 2.5$ km which is very large

Practically it is impossible to build such a large antenna. Instant we use modulation & increase in freq to 3×10^6 Hz & calculate the antenna height

$\lambda = \frac{3 \times 10^8}{3 \times 10^6} = 100$ mts

$\therefore \lambda/4 = 25$ mts.

Hence height of antenna reduces

16. State and Prove a. Time shifting b.Frequency Shifting. C. Properties of Fourier Transform

The time shifting property states that if x (t) and X (f) form a Fourier transform pair then,

$$x(t-t_d) \overset{F}{\longleftrightarrow} e^{-j2\pi f t_d} X(f) \qquad ...(2.8.7)$$

Here the signal $x(t-t_d)$ is a time shifted signal. It is the same signal x (t) only shifted in time.

Proof :

$$F[x(t-t_d)] = \int_{-\infty}^{\infty} x(t-t_d) \cdot e^{-j2\pi ft}\, dt \qquad ...(2.8.8)$$

$$\text{Let } (t-t_d) = \tau,$$

$$\therefore \quad t = t_d + \tau$$

$$\therefore \quad dt = d\tau.$$

Substituting these values in Equation (2.8.8) we get,

$$F[x(t-t_d)] = \int_{-\infty}^{\infty} x(\tau) \cdot e^{-j2\pi f (t_d+\tau)}\, d\tau = e^{-j2\pi f t_d} \int_{-\infty}^{\infty} x(\tau)\, e^{-j2\pi f\tau}\, d\tau$$

$$\therefore \quad F[x(t-t_d)] = e^{-j2\pi f t_d} X(f)$$

...Proved.

This shows that the time shifting does not have any effect on the amplitude spectrum, but the an additional phase shift of $-2\pi f t_d$, which is denoted by the term $e^{-j2\pi f t_d}$.

2.8.7 Property 7 : Frequency Shifting :

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$$e^{j2\pi f_c t}\, x(t) \overset{F}{\longleftrightarrow} X(f-f_c) \qquad ...(2.8.11)$$

Here f_c is a real constant.

Proof :

$$F\left[e^{j2\pi f_c t}\, x(t)\right] = \int_{-\infty}^{\infty} e^{j2\pi f_c t}\, x(t)\, e^{-j2\pi f t}\, dt = \int_{-\infty}^{\infty} x(t)\, e^{-j2\pi (f-f_c) t}\, dt$$

$$= X(f-f_c)$$

...Proved.

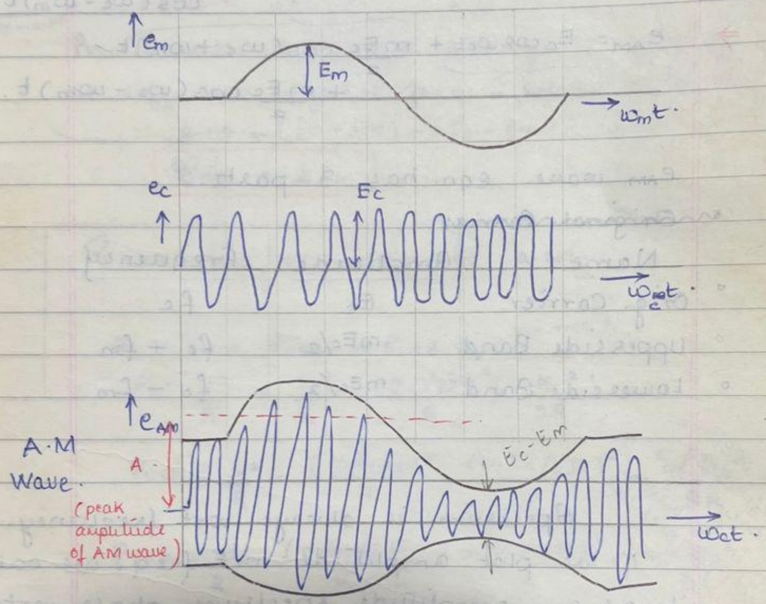
The term $X(f-f_c)$ represents a shifted frequency spectrum. The whole spectrum is thus shifted right by "f_c" in the frequency domain, when the signal x (t) is multiplied by $e^{j2\pi f_c t}$ in the time domain.

17. Derive the equation for Amplitude Modulation Wave

(10 marks description of A.M. & derivation)

Amplitude Modulation (AM):

The process of changing amplitude of the high frequency carrier wave w.r.t the instantaneous value of the modulating signal keeping frequency & phase constant



m Consider $e_m = E_m \cos \omega_m t$

C $e_c = E_c \cos \omega_c t$

A $A = E_c + e_m$

m

e Modulating Index, $m = \dfrac{E_m}{E_c}$

b/w 0 & 1

always expressed in %age.

$$e_{AM} = A\cos\omega_c t$$
$$= (E_c + e_m)\cos\omega_c t.$$
$$= (E_c + E_m\cos\omega_m t)\cos\omega_c t.$$
$$= E_c\left(1 + \frac{E_m}{E_c}\cos\omega_m t\right)\cos\omega_c t.$$
$$= E_c(1 + m\cos\omega_m t)\cos\omega_c t.$$
$$= E_c\cos\omega_c t + mE_c\cos\omega_m t\cos\omega_c t.$$
$$= E_c\cos\omega_c t + \frac{mE_c}{2}\left[\cos(\omega_c+\omega_m)t + \cos(\omega_c-\omega_m)t\right]$$

$$\Rightarrow e_{AM} = \underbrace{E_c\cos\omega_c t}_{O.C.} + \frac{mE_c}{2}\cos(\omega_c+\omega_m)t + \frac{mE_c}{2}\cos(\omega_c-\omega_m)t.$$

e_{AM} wave eqn. has 3 parts:
~~Original Carrier~~.

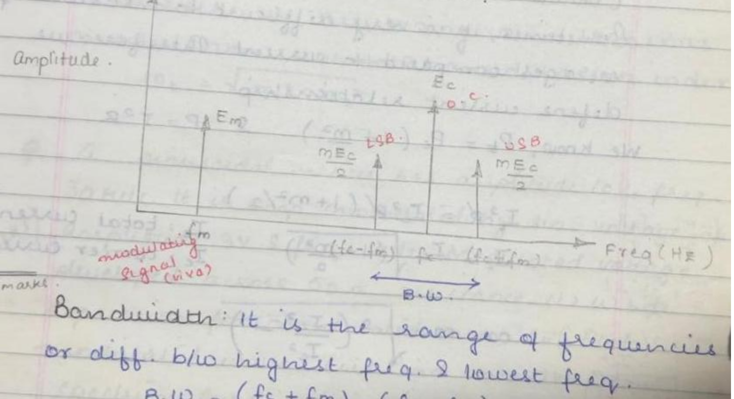
Name	Amplitude	Frequency
Orig. Carrier	E_c	f_c
Upperside Band	$mE_c/2$	$f_c + f_m$
Lowerside Band	$mE_c/2$	$f_c - f_m$

viva
USB & LSB are defined by frequency. can't denote in AM wave. can denote in spectrum

Spectrum is always wrt frequency. If we plot amplitude wrt freq, we call it as an amplitude spectrum, phase wrt freq ⇒ phase spectrum & power wrt freq ⇒ power spectrum.

From spectrum, we get additional info like freq. bandwidth, etc.

SPECTRUM: OF AM WAVE.



10 marks.

Bandwidth: It is the range of frequencies or diff. b/w highest freq. & lowest freq.

$$B.W = (f_c + f_m) - (f_c - f_m)$$
$$\boxed{B.W = 2f_m.}$$