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PART - A

2 Marks Questions

1.
Sol. • Among all noise, the most harmful noise is internal noise. It arises due to spontaneous fluctuations of the voltage or current in an electrical circuits.
This noise is of following types:
⇒ Shot noise
⇒ Flicker noise
⇒ Partition noise
⇒ Transit time noise
⇒ Thermal/White/Johnson Noise/Resistor Noise
⇒ The most important internal noise are (i) & (v).
2.
Sol. **SHOT NOISE (SN)**
• It arises in electronic devices (such as diodes and transistors) because of the discrete nature of current flow in the device.
• In electron tubes, SN is generated due to random emission of electrons from cathode.
• In semi-conductor devices, it is caused due to the random diffusion of minority carriers or simply random generation and recombination of electron hole pairs.
• It is always measured at the output.
3.
Sol. **Need of Modulation**
• To avoid the mixing of the signals.
• To increase the range of communication.
• To decrease the length of transmitting and receiving antenna.
• To improve the quality of reception i.e. increasing the value of S/N ratio.
• To allow the multiplexing of the signals.
• To remove the interference.

PART - B

5 Marks Questions

4.
Sol. **AMPLITUDE MODULATION**
• In amplitude modulation, the amplitude of a carrier signal is varied in accordance with the instantaneous value of modulating signal, whose frequency is invariably lower than that of the carrier.
• In practice, the carrier may be high-frequency (HF) while the modulating signal is audio frequency (AF).
Equation For AM
• Let, $c(t) = A_c \cos \omega_c t$ is a carrier wave having
 A_c = carrier amplitude
 ω_c = carrier frequency

and $m(t)$ = Base-band modulating signal band limited to maximum frequency " ω_m "

Here, $\omega_c = 2\pi f_c \gg \omega_m$

also,

$$\begin{aligned} f_m &: 50\text{Hz} - 15\text{kHz} \\ f_c &: 540 - 1650\text{kHz (For AM)} \\ &88 - 108\text{MHz (For FM Broadcast)} \end{aligned}$$

Now the AM MHz is described as,

$$X_{AM}(t) = A \cos \omega_c t$$

where, $A = A_c + m(t)$

$$\Rightarrow X_{AM}(t) = [A_c + m(t)] \cos \omega_c t$$

$$= A_c [1 + K_a m(t)] \cos \omega_c t$$

where, K_a = constant called amplitude sensitivity of modulator

- For our sake of convenience let us take,

$$X_{AM}(t) = A_c \cos \omega_c t + m(t) \cos \omega_c t$$

$$\begin{aligned} X_{AM}(\omega) &= A_c \pi [\delta(\omega - \omega_c) + \delta(\omega + \omega_c)] \\ &+ \frac{1}{2} [M(\omega - \omega_c) + M(\omega + \omega_c)] \end{aligned}$$

5.

Sol. Comparison between Low-level and High Level Modulation

S.No.	Parameter	Low-Level Modulation	High-Level Modulation
1.	Point at which modulation takes place	Modulation takes place in the initial stage of amplification	Modulation takes place in the final stage of amplification
2.	Power handling	Modulation circuitry has to handle low power	Modulation circuitry has to handle high power
3.	Complexity	Modulation circuitry is simple as it has to handle low power	Modulation circuitry is quite complex
4.	Range of transmission	In low level modulation range of transmission is small	Signal can be transmitted over longer distances
5.	Application	Low-level modulation is used only for laboratory purposes	This type of modulation is used in practical AM systems

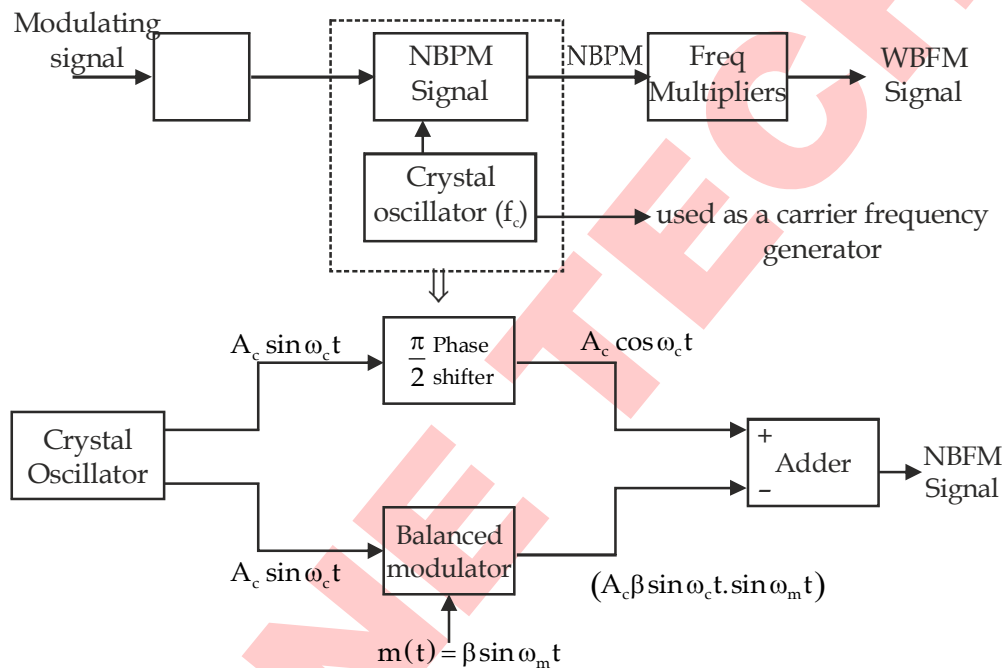
PART - C

20 Marks Questions

6.

Sol. INDIRECT METHOD OF FM GENERATION

- It is also known as "Armstrong Method of FM Generation".
- The basic principle of this method is to generate a NBFM signal indirectly by using a "Phase modulation technique" and then converting this NBFM into a WBFM by using frequency multiplier circuit.



- From figure-

$$X_{\text{NBFM}}(t) = A_c \cos \omega_c t - \frac{A_c \beta}{2} \cos(\omega_c - \omega_m)t + \frac{A_c \beta}{2} \cos(\omega_c + \omega_m)t$$

- In Armstrong method stability is high because crystal oscillator can be used to generate the highly stable small carrier frequency. It suffers from inherent noise caused by excessive multiplication and distortion at lower modulating frequencies.
- Crystal oscillator produces very small deviation in frequency.

Frequency Multipliers

- It is a non-linear device.

$$x(t) \xrightarrow[\text{i/p}]{\text{Frequency multiplier}} y(t) = x^2(t)$$

Now, from figure

$$X_{\text{FM}}(t) = \{A_c \cos[\omega_c t + \beta \sin \omega_m t]\}^2$$

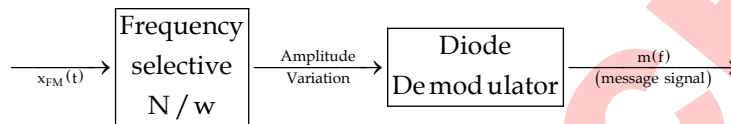
$$\Rightarrow X_{FM}(t) = \frac{A_c^2}{2} \left[1 + \cos \{ 2\omega_c t + 2\beta \sin \omega_m \} \right]$$

$\Downarrow$ $\Downarrow$
 double double

also, $\Delta f = \beta f_m \rightarrow$ it should be also doubled.

- The multiplier circuit changes the carrier frequency (f_c), modulation index (β) and so frequency deviation (Δf) by "n" times, where "n" is the multiplication factor.
- But modulating frequency " ω_m " remains constant.

DEMODULATION OF FM WAVE



Direct method

- By using slope discriminator.
 - Simple slope
 - Balance modulator
- Using phase discriminator:
 - Foster-seeley
 - Ratio detector

Indirect method

- Phase Locked Loop (PLL).

SIMPLE-SLOPE DETECTOR METHOD

- Here, the RLC resonant circuit is used as frequency selective network.

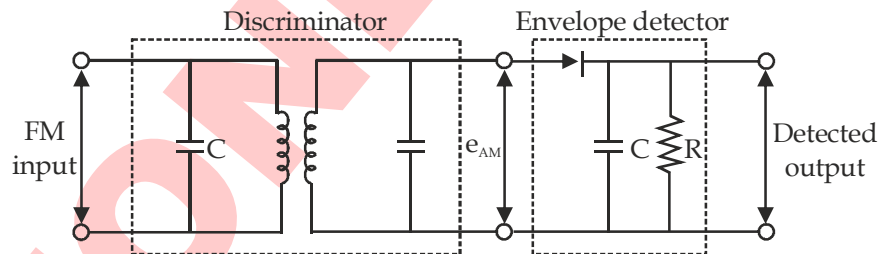
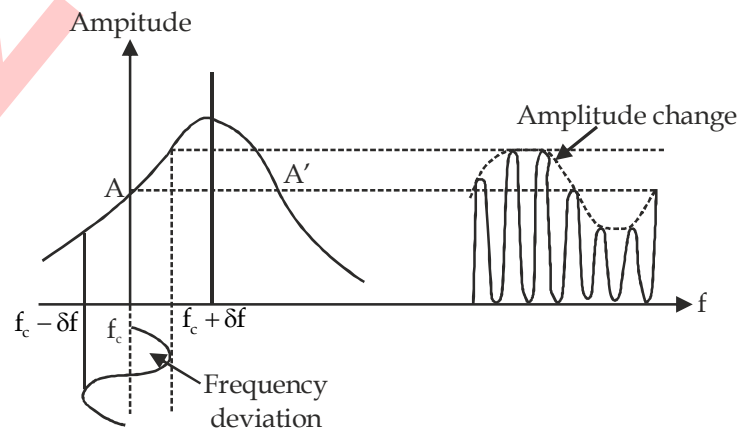


Fig.:- Circuit diagram of a slope detector)



(Slope detector characteristic curve)

- This circuit converts the FM signal into an AM signal as shown in the slope detector characteristic curve in figure.
- The AM signal from the output of the discriminator is applied at the input of envelope detector. At the output of the envelope detector, the original modulating or base band signal is obtained.

Disadvantages

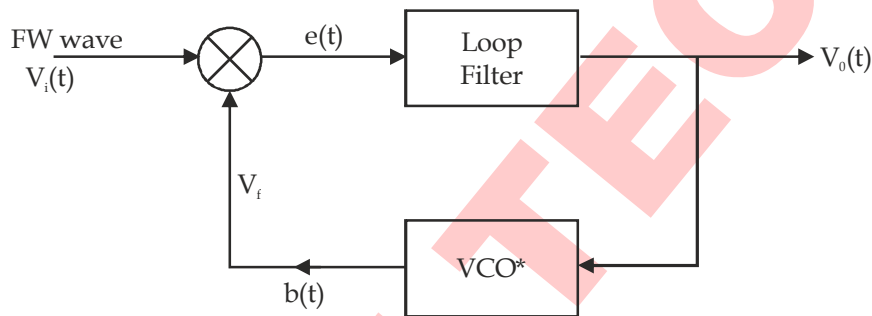
- Linear range is very poor.
- Circuit is sensitive to input amplitude variation.

7.

Sol. PHASE LOCKED LOOP (PLL)

- PLL is basically negative feedback system which may be used to extract a baseband signal from a frequency modulated carrier. It consists of 3 major components:

- Multiplier
- Loop Filter
- Voltage Controlled Oscillator (VCO)



Voltage controlled oscillator

- It is an electronic sine wave oscillator and frequency is governed by an externally applied voltage.
- VCO is a type of frequency modulator.

$$V_o(t) \rightarrow \boxed{\text{VCO}} \rightarrow$$

Case-1

When, $\boxed{V_{\text{VCO}} = A_c \cos \omega_c t}$

Case-2

When, $V_o(t) \neq 0$ then output,

$$\boxed{V_{\text{VCO}} = B \cos \left[\omega_c t + G_0 \int V_o(t) dt \right]} = V_f(t)$$

where, $G_0 = \text{sensitivity of VCO} = \frac{d\omega}{dV}$,
in rad/volt/sec

and $\omega_i = \text{instantaneous frequency}$
 $= \omega_c + G_0 V_o(t)$

PLL operation

- Consider an FM signal at the PLL input is given by,

$$V_i(t) = A_c \cos \left[\omega_c t + k_f \int_0^t m(t) dt \right]$$

$$V_i(t) = A_c \cos[\omega_c t + V_1(t)]$$

$$\left[\because k_f \int_0^t m(t) dt = V_1(t) \right] \quad \dots(i)$$

also, we have

$$V_f(t) = B \cos \left[\omega_c t + G_0 \int_0^t V_0(t) dt \right]$$

$$\left[\because G_0 \int_0^t V_0(t) dt = V_2(t) \right] \quad \dots(2)$$

$$V_f(t) = B \cos[\omega_c t + V_2(t)]$$

$$e(t) = V_f(t) * V_i(t)$$

$$= B \cos[\omega_c t + V_2(t)] A_c \cos(\omega_c t + V_1(t))$$

$$= \frac{BA_c}{2} \left[\sin(2\omega_c t + V_1(t) + V_2(t)) + \sin\{V_1(t) - V_2(t)\} \right]$$

$$\text{so, } V_0(t) \propto \sin[V_1(t) - V_2(t)]$$

from equation (1) and (2), we have,

$$V_0(t) \propto \sin[V_1(t) - V_2(t)]$$

In the absence of base band signal $m(t)$,

$$V_1(t) = V_2(t)$$

$$\text{because, } V_0(t) = 0$$

$$\text{also, } \frac{dV_1(t)}{dt} = k_f m(t) = \Delta\omega$$

$$\text{and } \frac{dV_2(t)}{dt} = G_0 V_0(t)$$

So,

$$V_0(t) = \frac{k_f m(t)}{G_0} = \frac{\Delta\omega}{G_0}$$

- From the above equation it is clear that the output voltage is proportional to modulating frequency therefore PLL circuit can convert FM signal into an AM signal.

Advantages

- Non-linearity is absent so harmonic distortion is zero.
- It will not respond to amplitude variation.
- It improves the threshold.

Note:

- ⇒ PLL demodulates the FM signal and improves the threshold.
- ⇒ PLL are used as FM demodulators when SNR is low.
- ⇒ PLL does not contain band pass limiter and discriminator.

Modes of PLL

- Free-running
- Capture
- Locking or tracking of input signal

Lock in Range (tracking range)

- Input signal V of frequency f , is applied to PLL and is locked with the frequency of VCO. Once the PLL is locked it can track the frequency changes in the incoming frequencies of the signal.
- The range of frequencies over which the PLL can maintain a lock with the incoming signal is called lock-in Range.

Capture Range

- The range of frequency over which the PLL can acquire a lock with the input signal is called capture range.
- In this range the difference between f_0 and f_s is minimum. The value of which depends upon the design of a system.

Pull in Time

- The total time taken by PLL to establish a lock is called pull in time. It depends upon:
 - ⇒ initial phase of the signal
 - ⇒ frequency difference between the incoming signal and VCO-frequency.
 - ⇒ Loop Gain
 - ⇒ Filter characteristics.