FM TRANSMITTERS

Depending upon the modulation there are two types of FM Transmitters.

1. Direct FM Transmitter:

Such transmitters produce the FM signal whose frequency deviation is directly proportional to the modulating signal.

Crystal oscillators cannot be used since their frequency cannot be varied significantly. ∴ other oscillators are used.

2. Indirect FM Transmitter:

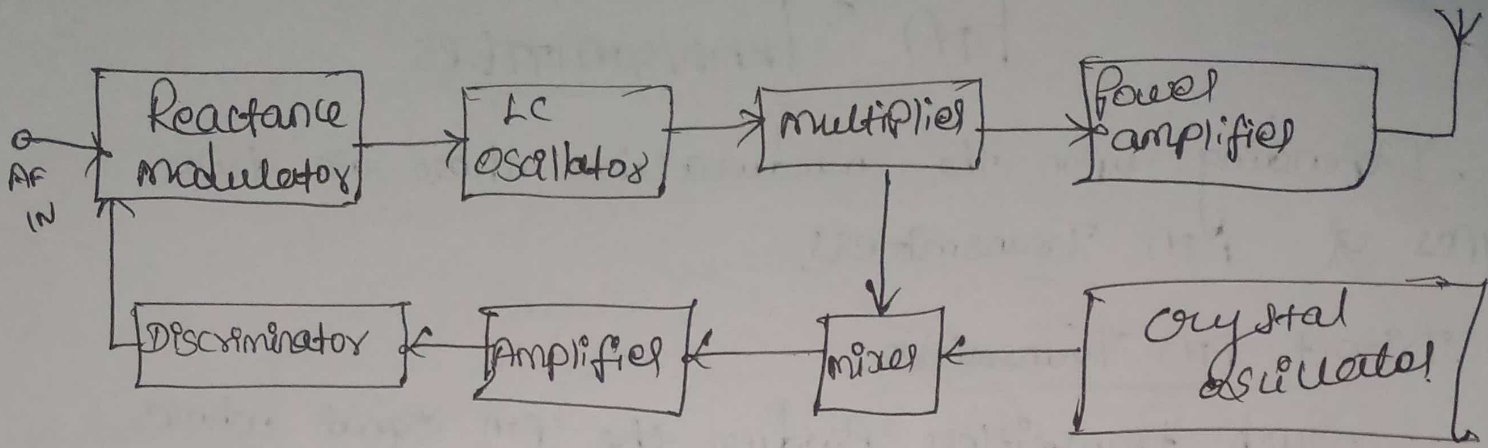
Such transmitters produce the FM signal whose phase deviation is directly proportional to amplitude of modulating signal.

Crystal oscillators are used here bcoz the frequency is not varied

AUTOMATIC FREQUENCY CORRECTION (AFC)

NEED:

The freq of the osc is directly varied in direct FM Transmitters. Hence such oscillators do not produce stable frequency. This problem can be overcome with the help of Automatic Frequency Correction (AFC).



Typical AFC circuit

→ The discrimanator reacts only to small changes in the carrier frequency but not to the frequency deviations in the carrier. (since it is too fast).

→ Higher freq. is fed to the mixer & to the discriminator.

→ Discriminator is tuned to the correct frequency difference which should exist between the LC oscillator and crystal oscillator & its o/p frequency is now somewhat higher. the discriminator will develop a Positive dc voltage.

→ Reactance modulator :- Voltage is applied to it whose transconductance is ↑ed by the positive voltage developed by the discriminator.

↳ It ↑es the equivalent capacitance of the reactance modulator by ↓ing the oscillator frequency.

The frequeny increase in the carrier frequency is thus lowered & brought to the correct value.

Direct FM Transmitters :-

1. CROSBY DIRECT FM TRANSMITTER (BROADCAST BAND FM TRANSMITTER)

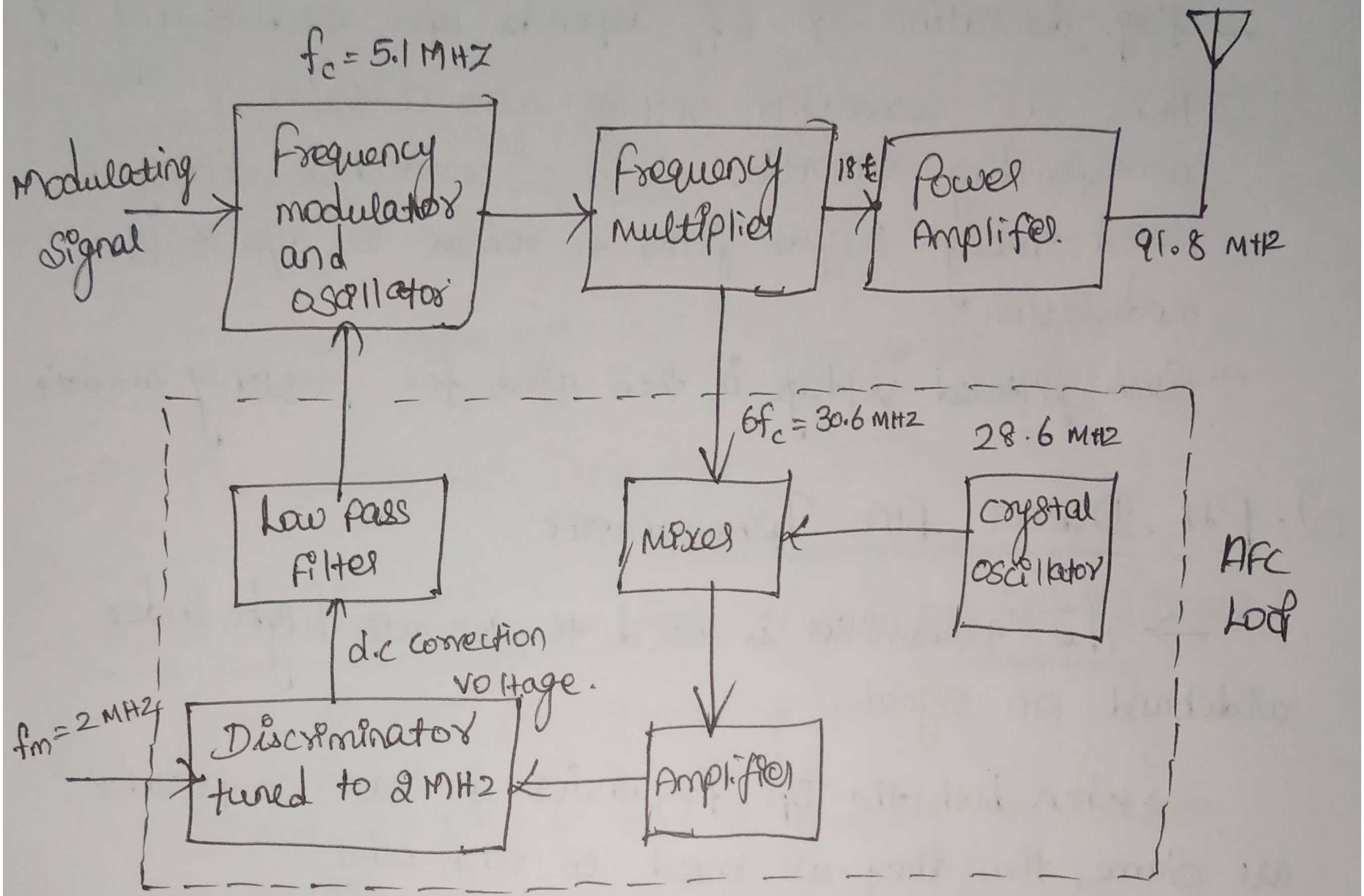


Fig: crosby direct FM Transmitter.

→ Frequency modulator can be Reactance Modulator or VCO.

→ Frequency of unmodulated carrier is $f_c = 5.1$ MHZ.

→ This freq. is multiplied by 18 to generate the transmitted freq of 91.8 MHZ. It is the center frequency of the FM signal.

→ AFC Loop is used to maintain the center frequency of the unmodulated carrier stable.

→ If the multiplier frequency is exactly $6f_c = 30.6$ MHZ

→ then no freq. correction is required & hence d.c. correction voltage must be zero.

→ However the freq of $6f_c$ contains FM.

→ freq. deviation of $6f_c$ depends upon modulating s/g.

→ Hence d.c correction voltage also contains corresponding variation. ∴ d.c correction voltage is passed through lowpass filter to remove the effect of modulation.

→ Such filtered voltage is then used for frequency correctio

2. PLL DIRECT FM TRANSMITTER:

→ This transmitter is used to generate high index wideband FM signal.

→ When both the i/p frequencies of phase comparator are same, then they are locked to each other.

→ under this situation, phase comparator o/p is zero.

→ If there is any shift in center frequency (f_o) of VCO, then phase comparator generates the correction voltage, which is given to summer through LPF.

→ This correction voltage adds to modulating signal voltage + corrects the VCO output.

→ LPF is used to remove the rapid changes in correction voltage due to frequency variations in FM signal.

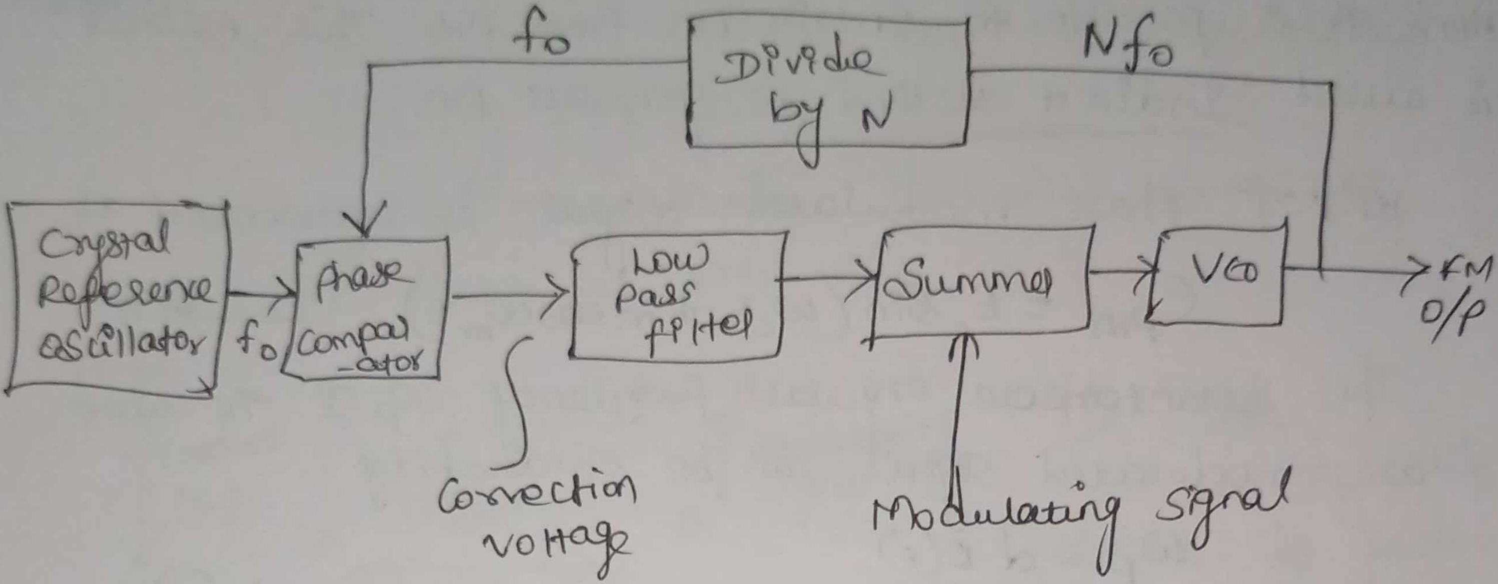


Fig: PLL Direct FM Transmitter.

INDIRECT FM TRANSMITTER: (ARMSTRONG METHOD)

(use of PM for generating FM).

→ Direct Method is used to directly modulate the carrier.

→ This is achieved by varying reactance of the components in the tank circuit.

→ Crystals can be used for better stability.

→ But since the reactance of the components is varied directly, the stability is not ensured.

→ Even if crystal oscillators are used stability problem still exists

→ Hence direct methods of FM generation are not suitable practically for broadcasting purposes.

W.K.T FM is one form of phase modulation. Hence it is possible to obtain FM from PM. This method is called <u>Indirect method to generate FM.</u>

W.K.T phase modulated signal is represented as,

$$e_{PM} = E_c \sin(\omega_c t + m \cos \omega_m t) \longrightarrow (1)$$

The instantaneous angular frequency ω_p of the above phase modulated signal can be obtained by

$$\omega_p = \frac{d\,\theta(t)}{dt} \longrightarrow (2)$$

Here $\theta(t) = \omega_c t + m \cos \omega_m t$, hence above equation will be

$$\omega_p = \frac{d}{dt}\left[\omega_c t + m \cos \omega_m t\right]$$

$$\omega_p = \omega_c - m \sin \omega_m t \times \omega_m \longrightarrow (3)$$

In terms of linear frequencies above equation can be written as,

$$f_p = f_c - m f_m \sin(2\pi f_m t) \longrightarrow (4)$$

The second term in the above equation represents the frequency shift with respect to center frequency. i.e.,

$$f_p = f_c + \Delta f \longrightarrow (5)$$

The above equation shows that frequency of the phase modulated signal varies around the carrier frequency f_c with the deviation of Δf. this deviation is

$$\Delta f = m f_m \sin(2\pi f_m t)$$

Hence max. deviation will be

$$\Delta f = m f_m \longrightarrow (6)$$

The above equation observes that if modulating frequency f_m remains constant, then frequency deviation will be directly proportional to m.

As long as modulating frequency does not change, PM produces FM o/p.

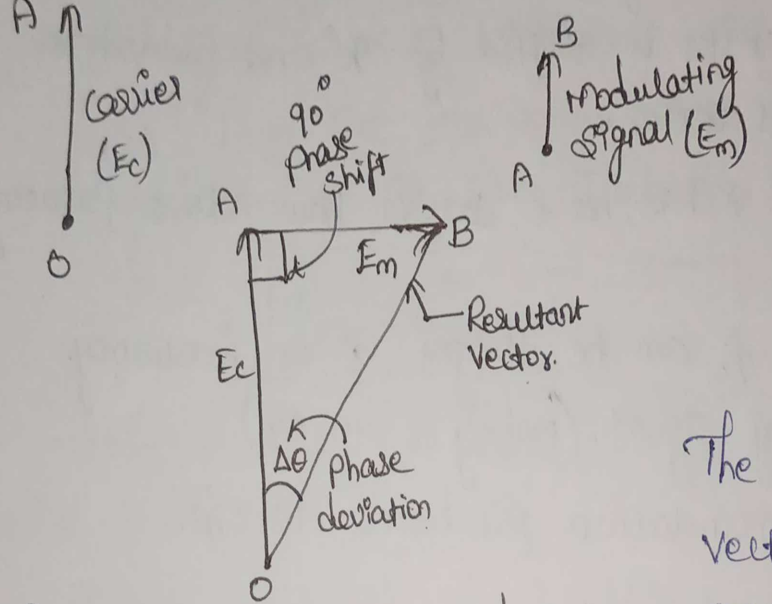


Fig: Illustration of phase modulation.

The phase modulated signal is obtained by vector addition of carrier & modulating signal.

The Modulating signal vector AB adds to the carrier signal vector OA with 90° phase shift.

The resultant phase modulated vector is OB with phase shift of $\Delta\theta$.

The peak phase shift or modulation index can be calculated as

$$\Delta\theta = m = \tan^{-1}\frac{E_m}{E_c} \longrightarrow (7)$$

For small angles,

$$\Delta\theta = m = \frac{E_m}{E_c} \longrightarrow (8)$$

OA & AB have same freq. This means carrier & modulating signal should have same frequency. under this condition phase modulation produces FM o/p.

Block Diagram:

→ To obtain the modulating signal of same frequency as that of carrier, amplitude modulation is used.

→ AM signal is first produced which amplitude modulates the carrier of frequency f_c.

→ This AM signal vector is shifted by 90° and added to carrier (f_c) signal vector.

→ Since both the vectors, AM & carrier have same frequency f_c the o/p is FM.

→ The frequency f_c can be thought of as frequency of the modulating signal. (Mod s/g is AM s/g)

→ Hence phase modulation produces FM o/p.

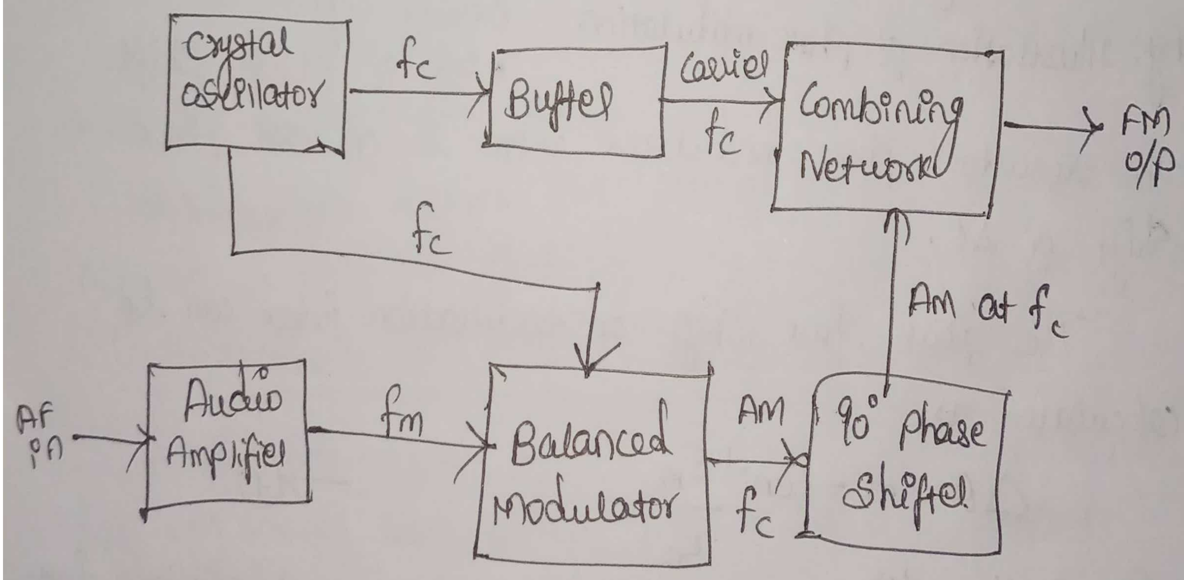


Fig: Block diagram of Armstrong method to generate FM.

→ Crystal oscillator generates the f_c. Highly stable frequency source.

→ Modulating signal is amplified & given to balanced modulator.

→ The balanced Modulator generates DSB AM signal at carrier freq. f_c. This signal is phase shifted by 90° in the phase shifter.

→ This phase shifted AM signal is added (vector addition) with the carrier signal in the combining network.

→ This N/W produces the FM signal at its o/p.

→ AM signal has two sidebands with voltages E_{LSB} & E_{USB}. Then the peak modulating signal voltage becomes vector addition of the two sideband voltages.

Thus

$$\bar{E}_m = \bar{E}_{LSB} + \bar{E}_{USB} \quad \rightarrow (9)$$

→ observe that AM signal is having frequency f_c with amplitude variations.

→ Hence resultant vector addition is phase modulated which is basically FM signal.

→ The buffer isolates the crystal source from combining network so that its stability is not disturbed.

ARMSTRONG MULTIPLIER WITH WIDEBAND FM OUTPUT :-

→ The FM signal at the o/p of combining network has very small modulation index & hence it cannot produce wideband FM output.

→ If the S/g at the o/p of combining n/w is multiplied in frequency, then wideband FM is obtained with very high transmit carrier frequency. Such carrier frequency is beyond the commercial FM broadcast band.