Generation and Detection of Frequency Modulated Waves:—

Generation:— Two methods of generating FM signal

1. Indirect method
2. Direct method

In the indirect method, a narrowband FM is first produced by modulating the carrier by the baseband signal. The resulting narrow band signal is then frequency multiplied to have the desired freq^n ~~method~~ deviation. In the direct method, on the other hand, the carrier freq^n is directly varied in accordance with the input baseband signal by means of a voltage controlled oscillator (VCO).

Indirect method of generating FM (Armstrong method):—

The Indirect method of generating WBFM was first proposed by E.H. Armstrong and the method is thus known as Armstrong method. A simple block diagram of generating FM signal by this method is shown in figure in the next page. NBFM is generated by using integrating the baseband signal $em(t)$ and using it to phase modulate the carrier generated by a crystal oscillator

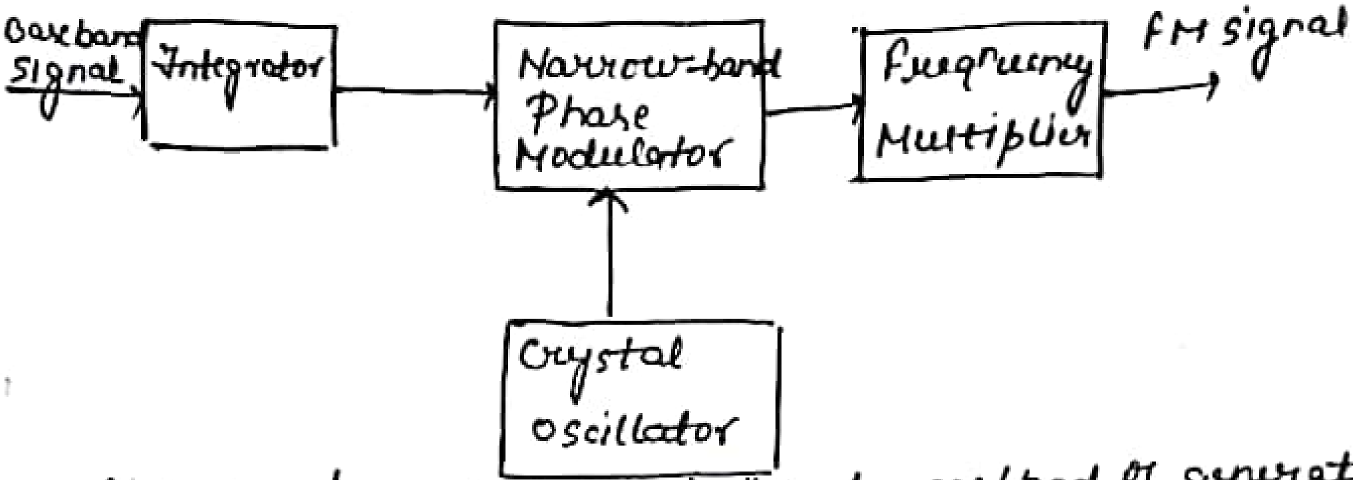

Fig: Block method of indirect method of generating FM wave

In order to minimize distortion in the phase modn, the maxm deviation or the index of modulation β is kept low. This results in NBFM. The NBFM is then converted into WBFM by using frequency multiplier. The carrier freqn of the resulting WBFM changes to a higher value during freqn multipli-cation.

Let $s_1(t)$ denote the o/p of the phase modulator which is the NBFM. Thus

$$s_1(t) = A_1 \left(\cos\left(2\pi f_1 t\right) + 2\pi k_1 \int_0^t e_m(t)\, dt \right) \quad \cdots (30)$$

$f_1 \rightarrow$ freqn of the crystal oscillator and k_1 is a constt. For sinusoidal modulating signal

$$s_1(t) = A_1 \left(\cos\left(2\pi f_1 t\right) + \beta_1 \sin\left(2\pi f_m t\right) \right) \quad \cdots (31)$$

where β_1 is the index of modn of NBFM, which is kept less than 0.3 radian to keep the distortion minimum.

The phase modulator o/p is next multiplied n-times in freqn by using the capacitor is ...

frequency multiplier, producing the desired WBFM, given by

$$s(t) = A_c\left(\cos\ 2\pi n f_1 t + 2\pi n k_1 \int_0^t e_m(t)\,dt\right) \quad \ldots (32)$$

writing $nf_1 = f_c$ and $nk_1 = k_f$ for sinusoidal desired signal modulating signal, we get the desired signal as

$$s(t) = A_c\left(\cos\left(2\pi f_c t + 2\pi k_f \int_0^t e_m(t)\,dt\right)\right)$$

that is, $s(t) = A_c\left(\cos\left(2\pi f_c t + \beta \sin(2\pi f_m t)\right)\right)$ $\ldots (33)$

where $\beta = n\beta_1$

Indirect generation of WBFM for practical use:—

The block diagram shown below describe a practical method of generating FM using indirect method. This figure shows a simplified diagram of a commercial FM generating system using Armstrong method.

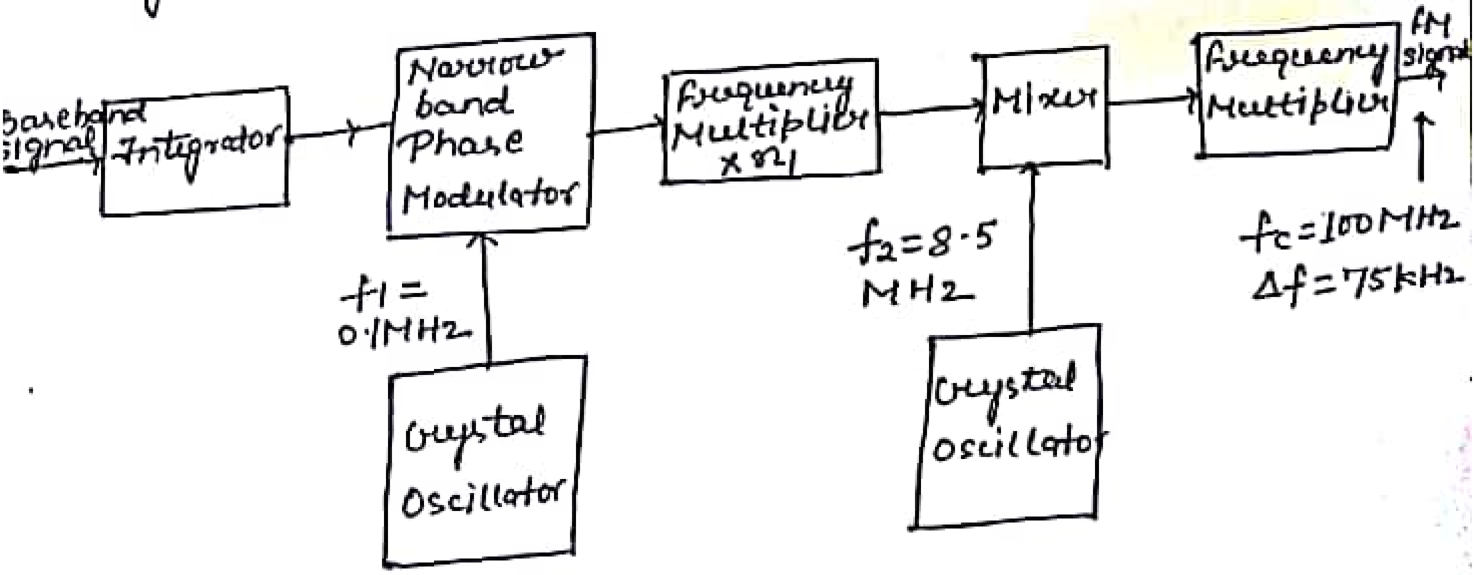

Fig: Block diagram of WBFM modn for practical use (Armstrong method)

For commercial use audio signal freqns are from 50 Hz to 15 kHz and $\Delta f = 75$ kHz. Let the final carrier frequencies of the FM required is $f_c = 100$ MHz.

Let $f_{c_1} = 100$ kHz be the carrier freqn of NBFM generated by crystal oscillator.

Keep β, to a maximum of 0.3 radians to limit the harmonic distortion produced by narrow-band phase modulator.

Let us assume $\beta_1 = 0.2$ radian. The lowest modulation freqn 100 Hz produces a deviation $\Delta f_1 = 0.2 \times 50 Hz = 10 Hz$ at the narrow-band phase modulator output while the largest modulation freqn 15 kHz produces a freqn deviation of

$$\Delta f_2 = 0.2 \times 15 kHz = 3 kHz.$$

The lowest modulation freqn is therefore of immediate concern, we select the value of $\Delta f_1 = 10$ Hz so, that at the highest modulating freqn β becomes even less.

In order to produce a freqn deviation of $\Delta f = 75$ kHz at the o/p, a freqn multiplication is required. For example, $\Delta f_1 = 10$ Hz and the required deviation is $\Delta f = 75$ kHz. For example, $\Delta f_1 = 10$ Hz and the required deviation is $\Delta f = 75$ kHz.

We therefore, require a total freqn multiplication by a factor

$$n = \frac{75000}{10} = 7500$$

... capacitance of the variable capacitor such ... varied by ..

A straightforward freqn multiplication equal to this value will lead to a very high value of carrier freqn than the desired 100 MHz. In order to achieve the desired deviation and carrier freqn we take help of a low-stage freqn multiplier.. This arrangement. uses two multipliers and a mixer. The mixer enables one to translate the carrier freqn suitably without altering Δf. The final stage multiplier gives the desired carrier freqn and deviation. Let n_1 & n_2 are the freqn multiplication factors for the two multipliers, so that

$$n = n_1 n_2 = \frac{\Delta f}{\Delta f_1} = \frac{75000}{10} = 7500 \quad \cdots (34)$$

The carrier freqn at the first multiplier output is translated downwards to freqn $(f_2 - nf_1)$ by mixing it with a carrier wave of freqn f_2, which is supplied by another oscillator. The carrier freqn at the input of the second multiplier is $\frac{f_c}{n_2}$, Thus,

$$f_2 - n_1 f_1 = \frac{f_c}{n_2} \quad \cdots\cdots (35)$$

Hence, with $f_1 = 0.1 MHz$ and $f_2 = 8.5 MHz$.

we get,

$$8.5 - 0.1 n_1 = \frac{100}{n_2} \quad \cdots\cdots (36)$$

using eqns (35) & (36) we get,

$$n_1 = 100 \quad \text{and} \quad n_2 = 75$$

Direct method of generation of frequency modulated wave –

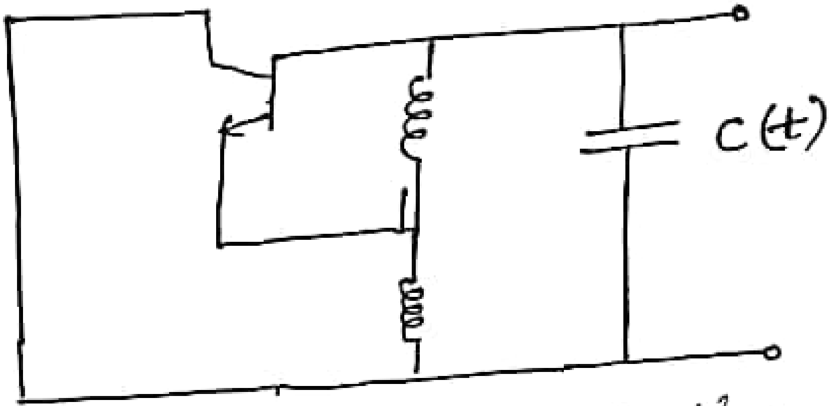

fig: Direct method of generation of FM using Hartley oscillator

In this method FM is generated by using a VCO (Voltage controlled oscillator), whose frequency varies linearly with the input control voltage. Thus in the direct FM system, the instantaneous freqn of the carrier wave is made to vary in accordance with the baseband signal by using a VCO.

A simple method for implementing this is to use a sinusoidal oscillator having a relatively high value of quality factor Q of the frequency determining network, and to control the oscillation freqn by symmetrical incremental variation of reactive components.

The freqn determining n/w consists of two inductors L_1 and L_2 and a capacitor

The capacitor is assumed to consist of a fixed capacitor shunted by a variable capacitor such as a varactor. The capacitance of the varactor diode can be varied by the applied voltage. Applying the modulating signal across this capacitor, it is possible to vary the freqn determining network and thereby vary the freqn of the oscillation of the oscillator in accordance with the modulating signal.

Assuming the instantaneous value of the capacitance to be $c(t)$, the freqn of oscillation of the Hartley oscillator can be written as

$$f_i(t) = \frac{1}{2\pi\sqrt{(L_1+L_2)\,c(t)}} \quad \text{---- (37)}$$

For a sinusoidal modulating signal, $e_m(t)$ of frequency f_m, the capacitance $c(t)$ can be expressed as

$$c(t) = C_0 + \Delta C \cos(2\pi f_m t) \quad \text{... (38)}$$

where, C_0 is the total capacitance in the absence of modulation and ΔC is the maximum change in the capacitance value.

Now from above two equations, we get,

$$f_i(t) = \frac{1}{2\pi\sqrt{(L_1+L_2)C_0}} \frac{1}{\sqrt{1+\frac{\Delta C}{C_0}\cos(2\pi f_m t)}}$$

$$\Rightarrow f_i(t) = f_0\left[1+\frac{\Delta C}{C_0}\cos(2\pi f_m t)\right]^{-1/2} \quad \text{.. (39)}$$

where f_0 is the unmodulated freqn of

The capacitor is assumed to consist of a fixed capacitor shunted by a variable capacitor such as a varactor. The capacitance of a the varactor diode can be varied by the applied voltage. Applying the modulating signal across this capacitor, it is possible to vary the freqn determining network and thereby vary the freqn of the oscillation of the oscillator in accordance withe the modulating signal.

Assuming the instantaneous value of the capacitance to be $C(t)$, the freqn of oscillation of the Hartley oscillator can be written as

$$f_i(t) = \frac{1}{2\pi\sqrt{(L_1+L_2)C(t)}} \quad \text{---- (37)}$$

For a sinusoidal modulating signal, $e_m(t)$ of frequency f_m, the capacitance $C(t)$ can be expressed as.

$$C(t) = C_0 + \Delta C \cos(2\pi f_m t) \quad \text{... (38)}$$

where, C_0 is the total capacitance in the absence of modulation and ΔC is the maximum change in the capacitance value.

Now from above two equations, we get,

$$f_i(t) = \frac{1}{2\pi\sqrt{(L_1+L_2)C_0}} \frac{1}{\sqrt{1+\frac{\Delta C}{C_0}\cos(2\pi f_m t)}}$$

$$\Rightarrow f_i(t) = f_0\left[1+\frac{\Delta C}{C_0}\cos(2\pi f_m t)\right]^{-1/2} \quad \text{.. (39)}$$

where f_0 is the unmodulated freqn of oscillation.

$$\Rightarrow \quad f_0 = \frac{1}{2\pi\sqrt{(L_1+L_2)C_0}} \quad \cdots\cdots (40)$$

If the maximum capacitance ΔC is small compared with the unmodulated capacitance C_0, we may approximate eqn (39) as

$$f_i(t) = f_0\left[1 - \frac{\Delta C}{2C_0}\cos(2\pi f_m t)\right] \quad \cdots\cdots (41)$$

Assuming $\frac{\Delta C}{2C_0} = \frac{-\Delta f}{f_0}$ (since an increase in capacitance reduces the frequency of oscillation), we get,

$$f_i(t) = f_0 + \Delta f \cos(2\pi f_m t) \quad \cdots\cdots (42)$$

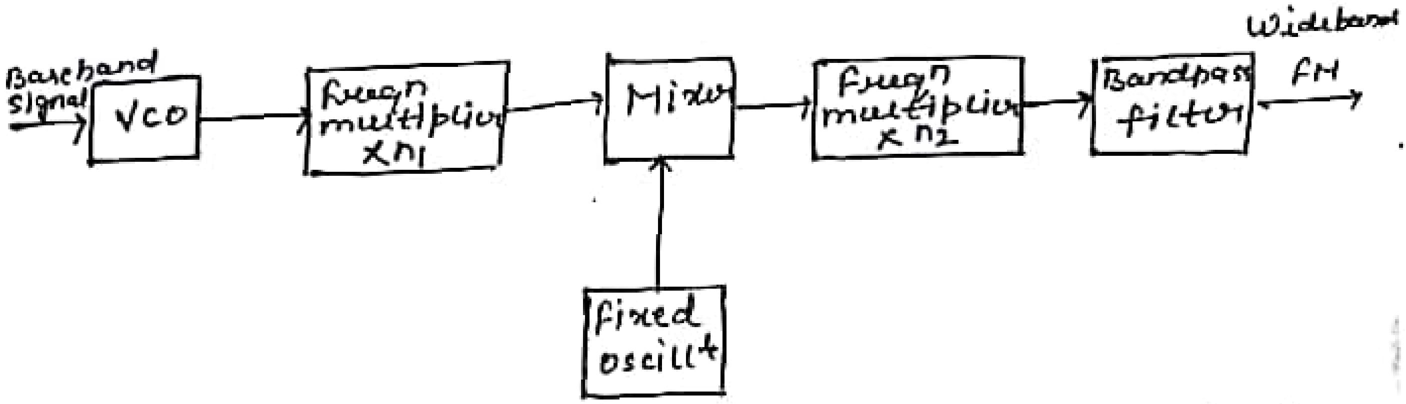

Fig: Block diagram for generation of WBFM using direct method.

Superheterodyne Receivers -

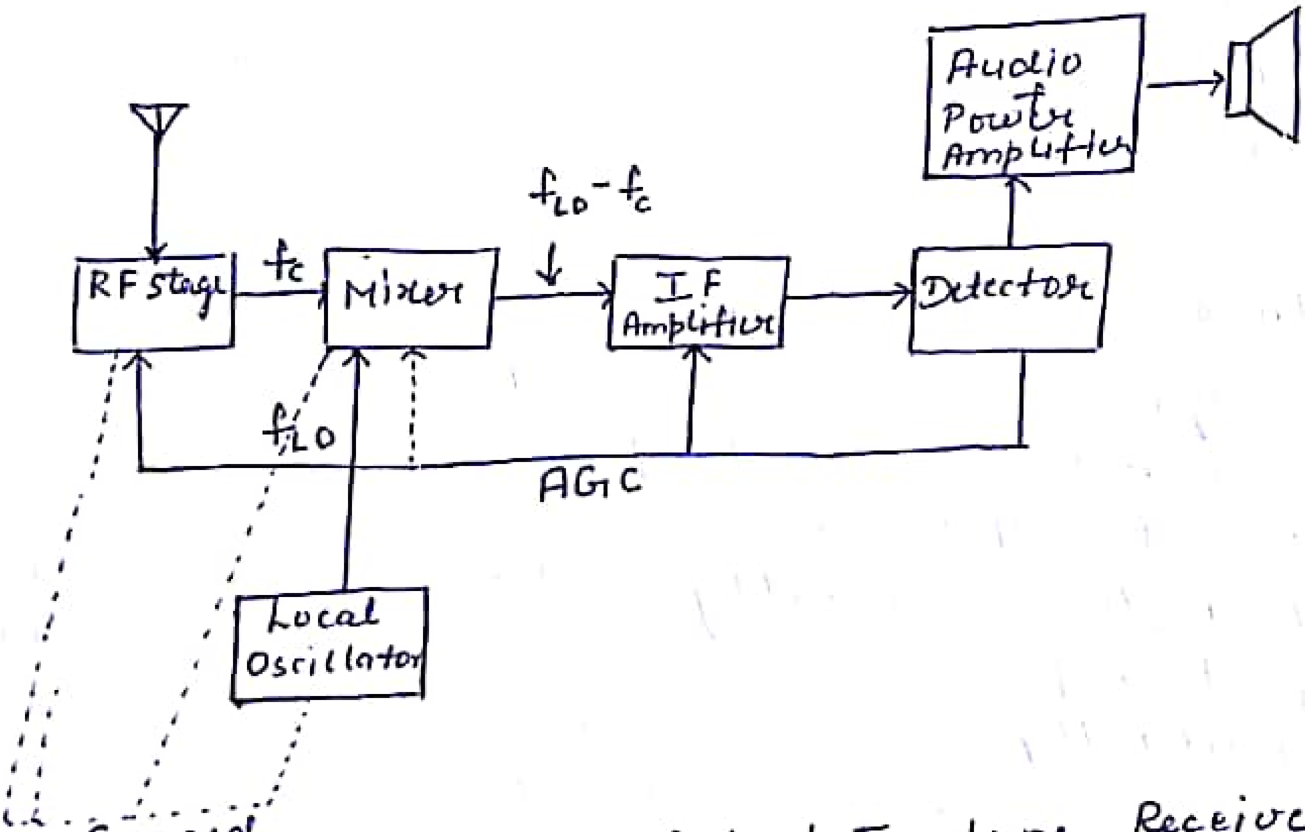

Fig1: Superheterodyne Receiver

Superheterodyne receiver was proposed as an alternative to Tuned Radio frequency (TRF) receiver which suffers from selectivity problem. The block diagram of superheterodyne or superhet receiver is shown in fig 1. In the superheterodyne Rx, the received RF signal voltage is combined with the local oscillator voltage and is converted into a signal of lower fixed freqn. This frequency is called the intermediate frequency (IF). The intermediate frequency signal however, contains the same modulation as the original carrier and can be (1)

Direct Method. of generation –

subsequently amplified and demodulated
to reproduce the original information. The
other units needed in SHRx are local
oscillator, mixer and intermediate freqn
(IF) amplifier.

A constt. freqn difference is maintained
between the local oscillator and RF stage,
through capacitance tuning in which the
capacitances are ganged together and
operated by a common control knob. The
IF amplifier usually contains a number
of transformers each consisting of a pair
of mutually coupled tuned circuits. with
this large number of double-tuned circuit
operating at a specially chosen freqn. the IF
provides most of the gain and BW require-
ments of the Rx. Thus the IF amplifiers
determines the selectivity and sensitivity
of SHRxs. Since the characteristics of
the IF amplifier are independent of the freq.
to which the Rx is tuned, the selectivity
and sensitivity of SHRx are strong
throughout the tuning range. Since
the R IF amplifier works at a fixed
~~constt.~~ IF freqn, the design of this
system is not difficult to provide
high gain and constant BW. The RF
stage of SH Rx may or may not contain
any RF amplifier. The main purpose
of this stage is to select the desired (4)

freqn and reject other interfering frequencies such as image freqn. The name superheterodyne stems from the fact that the Rx uses heterodyning (mixing) to generate the IF freqn which is above audio freqn (supersonic). The intermediate freqn is so called because it has a intermediate value b/w the Rxed carrier freqn and the final audio freqn. The output of the IF amplifier is demodulated by using an AM detector. The intelligence signal from the detector o/p is finally given sufficient ~~radio~~ audio amplification to drive the speaker. A d.c. level proportional to the Rxed signal strength is extracted from the detector stage by some special circuit management and fed back through AGC bus to control the gain of IF amplifier, mixer and/or RF amplifier. The automatic gain control allows the Rx to maintain a constant level o/p irrespective of the variation of the input signal strength. SH Rx is a standard form of radio receivers.

For common broadcast AM system IF is 455 KHz.

<u>Tuning of Superheterodyne Rxs.</u> :- The key to superheterodyne operation is to make the LO freqn track with the circuits that are

(3)

tuned to the incoming radio signal such as that a constant difference frequency (IF) is maintained. For common AM broadcast system the IF is 455 KHz. This means that the L.O. must always be at a freqn 455 KHz above the carrier signal to which the Rx is tuned. The front end of the Rx tuned ckts are usually made to track together by mechanically linked (ganged) capacitors in these circuits on a common variable rotor. The ganged capacitor has three capacitor sections, one each for RF amplifier, mixer and L.O. tank circuit. Small variable capacitances called 'trimmers' are connected in parallel with each section. These capacitances are adjusted for proper operation at highest freqn. For lowest frequency adjustment small variable capacitors called 'padders' are connected in series with the inductor in the tank circuit. The adjustment at the mid freqn is usually done by slight adjustment of the inductance in the tank circuit.

Scanned by CamScanner