WIDE BAND FM MODULATION:

For large values of modulation index m_f, greater than 10 the FM wave ideally contains the carrier and an infinite number of sidebands located symmetrically around the carrier. Such a FM wave has infinite bandwidth and hence called as wideband FM. The modulation index of wideband FM is higher than 1. The maximum permissible deviation is 75 kHz and it is used in the entertainment broadcasting applications such as FM radio, TV etc.

$$s(t) = A_C \, Cos(2\pi f_c t + \varphi(t)) \quad (1)$$

Finding its FT is not easy: $\phi(t)$ is inside the cosine. To analyze the spectrum, we use complex envelope. Consider single tone FM s(t) can be written as,

$$s(t) = ACcos(2\pi fct + \beta sin2\pi fm(t)) \quad (2)$$

Wideband FM is defined as the situation where the modulation index is above 0.5. Under these circumstances the sidebands beyond the first two terms are not insignificant. Broadcast FM stations use wideband FM, and using this mode they are able to take advantage of the wide bandwidth available to transmit high quality audio as well as other services like a stereo channel, and possibly other services as well on a single carrier.

The bandwidth of the FM transmission is a means of categorizing the basic attributes for the signal, and as a result these terms are often seen in the technical literature associated with frequency modulation, and products using FM. This is one area where the figure for modulation index is used.

GENERATION OF WIDEBAND FM SIGNALS:

The following two methods generate WBFM wave.

(1) Direct method

(ii) Indirect method

Direct Method

This method is called as the Direct Method because we are generating a wide band FM wave directly. In this method, Voltage Controlled Oscillator (VCO) is used to generate WBFM. VCO produces an output signal, whose frequency is proportional to the input signal voltage. This is similar to the definition of FM wave. The block diagram of the generation of WBFM wave is shown in the following figure 2.3.1.

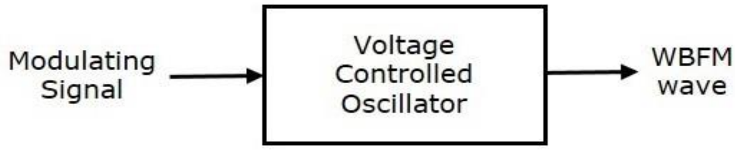

Figure 2.3.1 Block diagram of the generation of WBFM wave

Diagram Source Electronics Post

Here, the modulating signal m(t)m(t) is applied as an input of Voltage Controlled Oscillator (VCO). Voltage Controlled Oscillator produces an output, which is nothing but the WBFM.

$$Fi \ \alpha \ m(t)$$

$$fi = fc + kfm(t) \qquad (3)$$

Where, fi is the instantaneous frequency of WBFM wave.

Indirect Method

This method is called as Indirect Method because we are generating a wide band FM wave indirectly. This means, first we will generate NBFM wave and then with the help of frequency multipliers we will get WBFM wave. The block diagram of generation of WBFM wave is shown in the following figure 2.3.2.

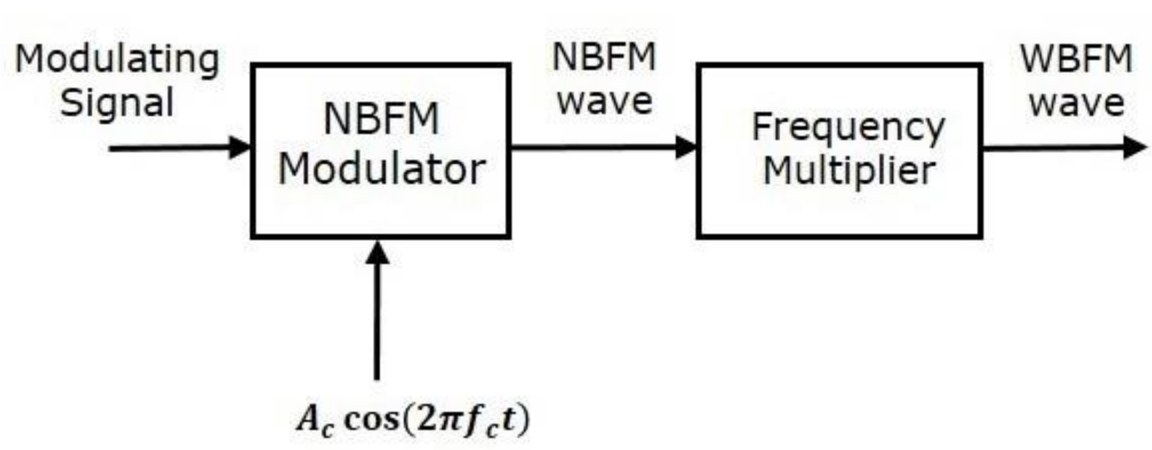

Figure 2.3.2 Block diagram of indirect method of generation of WBFM wave

Diagram Source Electronics Post

This block diagram in figure 2.3.2 contains mainly two stages. In the first stage, the NBFM wave will be generated using NBFM modulator. We have seen the block diagram of NBFM modulator at the beginning of this chapter. We know that the modulation index of NBFM wave is less than one. Hence, in order to get the required modulation index (greater than one) of FM wave, choose the frequency multiplier value properly. The generated narrowband FM signal can be converted to a wideband FM signal by simply passing it through a non–linear device with power P. Both the carrier frequency and the frequency deviation Df of the narrowband signal are increased by a factor P. Sometimes, the desired increase in the carrier frequency and the desired increase in Df are different. In this case, we increase Df to the desired value and use a frequency shifter (multiplication by a sinusoid followed by a BPF) to change the carrier frequency to the desired value.

Frequency multiplier is a non-linear device, which produces an output signal whose frequency is ‘n’ times the input signal frequency. Where, ‘n’ is the multiplication factor. If NBFM wave whose modulation index ββ is less than 1 is applied as the input of frequency multiplier, then the frequency multiplier produces an output signal, whose modulation index is ‘n’ times β and the frequency also ‘n’ times the frequency of WBFM wave. Sometimes, we may require multiple stages of frequency multiplier and mixers in order to increase the frequency deviation and modulation index of FM wave. For large values of modulation index mf , the FM wave ideally contains the carrier and an infinite number of sidebands located symmetrically around the carrier. Such a FM wave has infinite bandwidth and hence called as wideband FM.

The modulation index of wideband FM is higher than 1. The maximum permissible deviation is 75 kHz and it is used in the entertainment broadcasting applications such as FM radio, TV etc.

Frequency Spectrum of a Wideband FM wave

The expression for the wideband FM is complex since it is sine of sine function. The only way to solve this equation is by using the Bessel functions. By using the Bessel functions the equation for wideband FM wave can be expanded as follows :

$$eFM = s(t) = E_c\{J_0(m_f)sin\omega_c t + J_1(m_f)[sin(\omega_c + \omega_m)t - \sin((\omega_c - \omega_m)t] + J_2(m_f)[sin(\omega_c + 2\omega_m)t - \sin((\omega_c - 2\omega_m)t + J_3(m_f)[sin(\omega_c + 3\omega_m)t - \sin((\omega_c - 3\omega_m)t + J_4(m_f)[sin(\omega_c + 4\omega_m)t - \sin((\omega_c - 4\omega_m)t \quad (4)$$

Looking at equation (4), we can conclude the following points: The FM wave consists of carrier. The first term in equation(1) represents the carrier. The FM wave ideally consists of infinite number of sidebands. All the terms except the first one are sidebands. The amplitudes of the carrier and sidebands is dependent on the J coefficients. As the values of J coefficients are dependent on the modulation index mf , the modulation index determines how many sideband components have significant amplitudes as shown in fig.2 below.

The reason for this is that the amplitude of the FM signal i.e. Ec is always constant. AND the power transmitted is given by,

$$P_t = \frac{\left(\frac{E_c}{\sqrt{2}}\right)^2}{R} = \frac{{E_c}^2}{2R} \quad (5)$$

Where Ec = peak amplitude of FM wave. Therefore,

$$P_t = \frac{{E_c}^2}{2R} \quad If\, R = 1\Omega \quad (6)$$

Some of the J coefficients can be negative. Therefore, there is a 180o phase shift for that particular pair of sidebands. The carrier component does not remain constant. As J0(mf) is varying the amplitude of the carrier will also vary. However, the amplitude of FM wave will remain constant. For certain values of modulation index, the carrier component will disappear completely. These values are called Eigen values. In FM, the total transmitted power always remains constant. It is not dependent on the modulation index.