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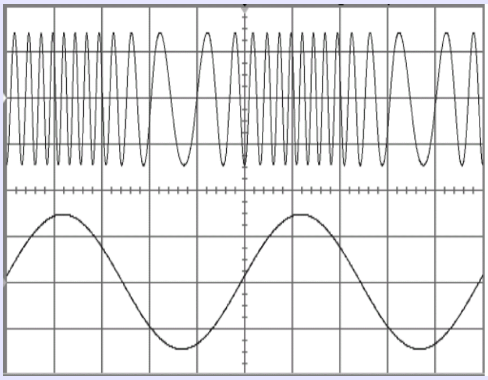
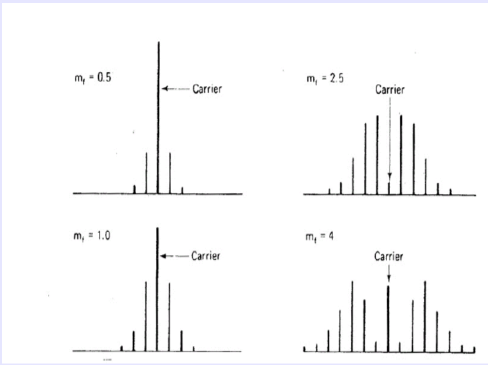
Application Note

FM : Modulation Index





The FM Modulation Index

The **index of modulation**, m_f, is given by the following relationship:

$$m_f = \delta / f_m$$

As can be seen from the equation, m_f is equal to the peak deviation caused when the signal is modulated by the frequency of the modulating signal; therefore, m_f is a function of both the modulating signal amplitude and frequency. Furthermore, m_f can take on any value from 0 to infinity. Its range is not limited as it is for AM.

To have example of FM Modulation Index , take SM5074 or SM5075 , and apply external modulating signal say 1 kHz with certain amplitude , the FM modulated signal when viewed in Analog Digital Oscilloscope e.g. HM1508-2 (alternatively use DSO from DS1000 series) . From FFT we can find minimum and maximum frequency component and thus δ , substitute the values and we have the value of modulation index.
Another method to have feel of wide variation in modulation index with FM modulation , to measure low and high frequency component from display of SM5074 or SM5075 at very low frequency. e. g. set carrier frequency to about 3 kHz sine, feed external FM input , say 0.3 Hz , 1 V sine signal from another source to the rear BNC of SM5074 and note the values of min and max frequencies from display .

Say carrier frequency set is 3 kHz
modulating frequency to 0.3 Hz
min frequency noted 2.479kHz
max frequency noted 3.915 kHz

$$\text{thus } m_f = (3.915 - 2.479)\,10^3 \;/\; 0.3$$
$$= 4786.66$$

Another live example is from FM radio stations, Let us take a FM broadcasting radio station, 98.3MHz with a power of 10 KW. The bandwidth of the modulation signal is from 30 Hz to 15 kHz which is excellent for high-fidelity broadcast. The maximum deviation set by the FCC, (δ), is 75 kHz. The range of the modulation index is ;

$$m_f(min) = \delta/f_m(max)$$
$$= 75\ kHz/15\ kHz$$
$$= 5 \qquad (\text{for } f_m = 15\ kHz)$$

and for

$$m_f(max) = \delta/f_m(min)$$
$$= 75\ kHz/30\ Hz$$
$$= 2500! \qquad (\text{for } f_m = 30\ Hz)$$

Note that the modulation index changes a lot with the modulation frequency (from 2,500 to 5).

There is another term " **Percentage of Modulation**" similar to AM modulation depth in percentage. However, unlike AM, it has nothing to do with the index of modulation. The practical implementation of FM communication systems in a limited bandwidth-channel environment, such as cellular radio, requires a limitation upon the maximum frequency deviation to prevent adjacent channel interference. For example, the FCC's Rules and Regulations limit FM broadcast-band transmitters to a maximum frequency deviation of ±75kHz.The maximum allowable deviation will be assigned the value of 100% modulation. Therefore, in equation form, the percentage of modulation is given by:

$$\%\ Modulation = (\delta / \delta_{max}) \times 100$$

This parameter is normally displayed at FM radio transmission station, when the signal is aired.

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