The FM Modulation Index

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

$$ m_f = \frac{\delta}{f_m} $$

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 $\delta$, 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 2.479 kHz
max frequency noted 3.915 kHz

thus

$$ m_f = \frac{(3.915 - 2.479) \times 10^3}{0.3} $$

= 4786.66

Another live example is from FM radio stations,
Let us take a FM broadcasting radio station, 98.3 MHz 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, \( \delta \), is 75 kHz. The range of the modulation index is:

\[
m_f{(\text{min})} = \frac{\delta}{f_m} \\
= 75 \text{ kHz}/15 \text{ kHz} \\
= 5 \quad \text{(for } f_m = 15 \text{ kHz)}
\]

and for

\[
m_f{(\text{max})} = \frac{\delta}{f_m{(\text{min})}} \\
= 75 \text{ kHz}/30 \text{ Hz} \\
= 2500! \quad \text{(for } f_m = 30 \text{ Hz)}
\]

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 \( \pm 75 \text{ kHz} \). The maximum allowable deviation will be assigned the value of 100% modulation. Therefore, in equation form, the percentage of modulation is given by:

\[
\% \text{ Modulation} = \left( \frac{\delta}{\delta_{\text{max}}} \right) \times 100
\]

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