ECC-201: Principles of Communication Systems

Autumn Semester 2025-26 **Tutorial Sheet:3**

1. An angle-modulated signal has the form

$$s(t) = 100\ cos[2\pi f_c t + 4sin(2\pi f_m t)]$$

where $f_c = 10\ MHz$ and $f_m = 1\ KHz$.

   (a) Assuming that this is an FM signal, determine the modulation index and the transmitted-signal bandwidth.

   (b) Repeat Part (a) if f_m is doubled.

   (c) Assuming that this is a PM signal, determine the modulation index and the transmitted-signal bandwidth.

   (d) Repeat Part (c) if f_m is doubled.

2. Signal $m(t)$ is shown in the figure. This signal is used once to frequency modulate a carrier and once to phase modulate a carrier.

   (a) Find a relation between k_p and k_f such that the maximum phase deviation of the modulated signals in both the cases are equal.

   (b) if $k_p = k_f = 1$, what is the maximum instantaneous frequency in both the cases.

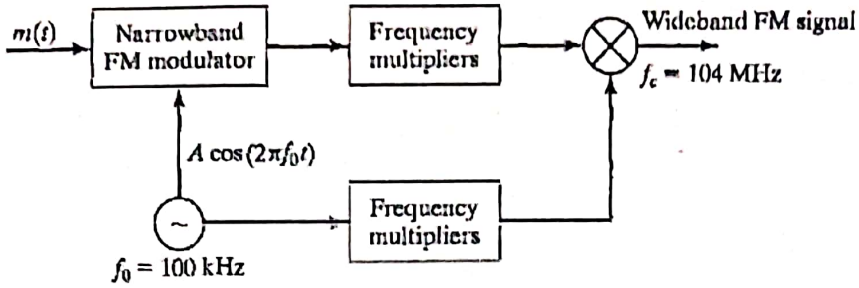
3. Consider a wide-band PM signal produced by a sinusoidal modulating wave $A_m cos(2\pi f_m t)$, using a modulator with a phase sensitivity equal to K_p radians per volt.

   (a) Show that if the maximum phase deviation of the PM signal is large compared with one radian, the bandwidth of the PM signal varies linearly with the modulation frequency f_m.

   (b) Compare this characteristic of a wide-band PM signal with that of a wideband FM signal.

4. An FM signal with a frequency deviation of 10 kHz at a modulation frequency of 5 kHz is applied to two frequency multipliers connected in cascade. The first multiplier doubles the frequency and the second multiplier triples the frequency. Determine the frequency deviation and the modulation index of the FM signal obtained at the second multiplier output.

5. To generate wideband FM, we can first generate a narrowband FM signal, and then use frequency multiplication to spread the signal bandwidth. Figure 1 illustrates such a scheme, which is called an Armstrong-type FM modulator. The narrowband FM signal has a maximum modulation index of 0.1 to keep distortion under control.



Armstrong FM modulator.

(a) If the message signal has a bandwidth of 15 kHz and the output frequency from the oscillator is 100 kHz, determine the frequency multiplication that is necessary to generate an FM signal at a carrier frequency of $f_c = 104$ MHz and a frequency deviation of $\Delta f = 75$ kHz.

(b) If the carrier frequency for the WBFM signal is to be with ± 2 Hz, determine the maximum allowable drift of the 100 kHz oscillator.