Cairo University
Faculty of Engineering
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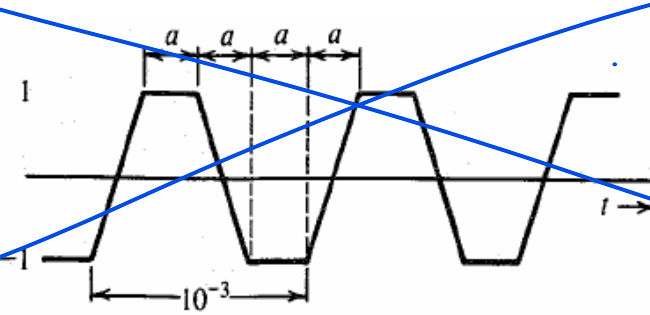
Communication
3rd year 2008 – 2009

Sheet 3

9. Determine the instantaneous frequency, in hertz, of each of the following waveforms
   a) $10 \cos (100\,\pi t + \pi/3)$
   b) $10 \cos (200\,\pi t + \sin \pi t)$
   c) $2 \exp [j200\pi t\,(1 + \sqrt{t})]$
   d) $\cos (200\,\pi t) \cos (\,5 \sin (2\pi t)) + \sin (200\,\pi t) \sin (\,5 \sin (2\pi t))$

2. Sketch $\varphi_{FM}(t)$ and $\varphi_{PM}(t)$ for the modulating signal m(t) shown in the figure, given $\omega_c=10^8$, $k_f=10^5$, and $k_p=25$.



3. Over an interval $|t|\le 1$, an angle modulated signal is given by

$$\varphi_{EM} = 10 \cos 13000t$$

It is known that the carrier frequency $\omega_c=10000$
a) If this was a PM signal with $k_p=1000$, determine m(t) over the interval $|t|\le 1$.
b) If this was a FM signal with $k_f=1000$, determine m(t) over the interval $|t|\le 1$.

4. An angle modulated signal with carrier frequency $\omega_c=2\pi \times 10^6$ is described by the equation

$$\varphi_{EM} = 10 \cos(\omega_c t + 0.1 \sin 2000\pi t)$$

a) Find the power of the modulated signal.
b) Find the frequency deviation Δf.
c) Find the phase deviation $\Delta\varphi$.
d) Estimate the bandwidth of $\varphi_{EM}(t)$.

5. Given $m(t)=\sin 2000\pi t$, $k_f=200000\pi$, and $k_p=10$.
a) Estimate the bandwidths of $\varphi_{FM}(t)$ and $\varphi_{PM}(t)$.
b) Repeat part (a) if the message amplitude is doubled.
c) Repeat part (a) if the ~~message~~ amplitude is doubled.
d) Comment on the sensitivity of FM and PM bandwidths to the spectrum of m(t).

6. A certain sinusoid at a frequency f_m is used as the modulating signal in both an AM (DSB-LC) and a FM system. When modulated, the peak frequency deviation of the FM system is set to three times the bandwidth of the AM system. The magnitudes of those sidebands spaced $\pm f_m$ Hz from the carrier I both systems are equal and the total average powers are equals in both systems. Determine:

a) The modulation index of the FM system.
b) The modulation index of the AM system.

7. The bandwidths of three angle modulated transmitting systems are compared, using the sinusoidal test signal $f(t) = a \cos(2f_m t)$. The resulting approximate bandwidths are tabulated in Table (1) below:

System	**a = 1 V** **f_m = 1 KHz**	**a = 2 V** **fm = 1 KHz**	**a = 1 V** **fm = 2 KHz**
A	2 KHz	2 KHz	4 KHz
B	40 KHz	80 KHz	80 KHz
C	50 KHz	100 KHz	50 KHz

Table (1) Test Results of Bandwidth.

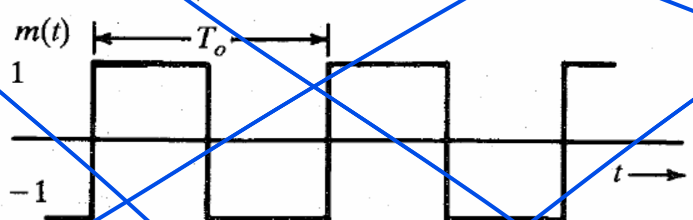
Identify the type of angle modulation used (FM or PM / Narrowband or Wideband) for each of these three systems.

8. The sinusoidal signal $f(t) = a \cos(2\pi f_m t)$ is applied to the input of a FM system. The corresponding modulated signal output (in volt) for $a = 1$ V, $f_m = 1$ KHz, is: $\Phi(t) = 100 \cos[2\pi * 10^7 t + 4 \sin(2000\pi t)]$ across a 50-ohm resistive load.

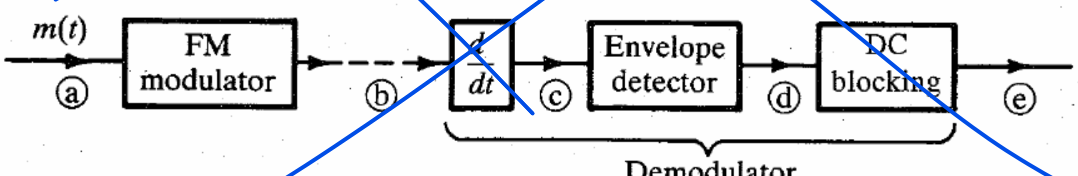
a) What is the peak frequency deviation from carrier?
b) What is the total average power developed by $\Phi(t)$?
c) What percentage of the average power is at 10.000 MHz?
d) What is the approximate bandwidth using Carson's rule?
e) Repeat parts (a) to (d) for the input parameters $a = 75$ V, $f_m = 2$ KHz; assume all other factors remain unchanged.

9. Design (only the block diagram) an Armstrong indirect FM modulator to generate an FM carrier with a carrier frequency of 98.1 MHz and Δf=75 kHz. A narrow band FM generator is available at a carrier frequency of 100 kHz and a frequency deviation Δf=10 Hz. The stock room also has an oscillator with an adjustable frequency in the range of 10 to 100 MHz. There are also plenty of frequency doublers, triplers and quintaplers.

10. A periodic square wave m(t) shown in figure (a) frequency modulates a carrier of frequency f_c=10 kHz with Δf=1 kHz. The carrier amplitude is A. The resulting FM signal is demodulated, as shown in figure (b). Sketch the waveforms at points b, c, d, and e.



(a)



(b)