Serial # 0

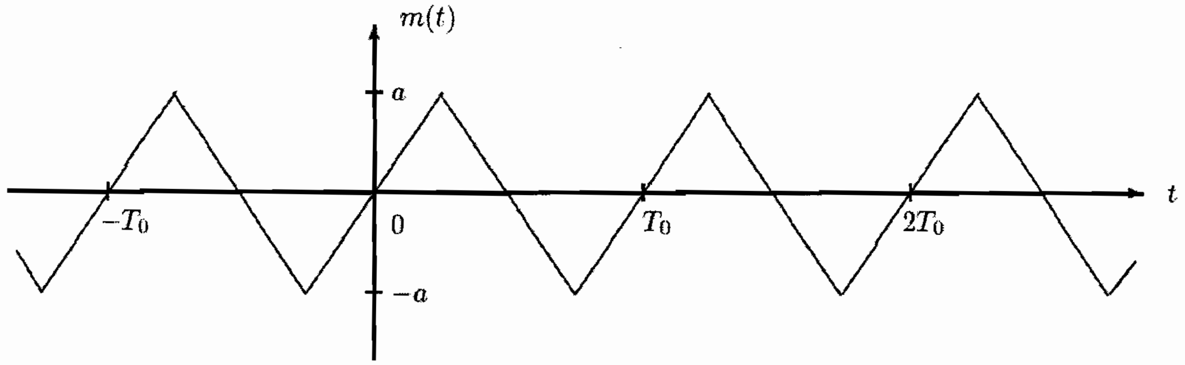
-2 points for not writing your serial #

King Fahd University of Petroleum & Minerals
Electrical Engineering Department
EE370: Communications Engineering I (071)
Quiz 4 (Take Home: submit by Monday 5, Nov 12, 2007, 5:00PM)

"I have neither given nor received unauthorized aid on this examination"

Name: KEY Section. Signature:____________

Angle Modulation:



Consider the *periodic* message signal $m(t)$ shown in the picture, and assume initially that $a = 1$ and $T_0 = 10^{-3}$.

Consider the (essential) bandwidth of the signal W to be the frequency corresponding to the fifth harmonic, i.e. $W = \frac{5}{T_0}$ Hz. Now, suppose $m(t)$ is angle modulated on a 1 MHz carrier.

2 (a) Find the bandwidth of an FM signal with $k_f = 100$.

3 (b) Find the bandwidth of a PM signal with $k_p = 2\pi \times 10^2$.

4 (c) How much is the percentage of message power lost by dropping the contribution of components above the fifth harmonics.

1 (d) For the FM case is this narrowband FM or Wideband FM, justify your answer.

a)

$$BW = 2(\Delta f + B) = 2(\Delta f + \frac{5}{T_0})$$

① $\Delta f_{FM} = \frac{k_f m_p}{2\pi} = \frac{100\, a}{2\pi} = \frac{100}{2\pi}$

① $BW_{FM} = 2\left(\frac{100}{2\pi} + \frac{5}{10^{-3}}\right) = 2(5015.92)\ Hz$

$\simeq 10.032\ KHz$

b) $BW = 2(\Delta f + \frac{5}{T_0}) = 2(\Delta f + 5000)$

① $\Delta f_{PM} = \frac{k_p \dot{m}_p}{2\pi} = \frac{\cancel{2\pi}\, 10^2\ \dot{m}_p}{\cancel{2\pi}}$

$= 100\ \dot{m}_p$

① $\dot{m}_p = \frac{2a}{T_0/2} = \frac{4(1)}{10^{-3}} = 4000 \Rightarrow \Delta f_{PM} = 4 \times 10^5$

① $BW_{PM} = 2(4 \times 10^5 + 5000) = 810\ KHz$

d) It is a narrow band FM (0.5) because $BW_{FM} \simeq 10.032\ KHz$ which is approximatly $= 2B \simeq 10\ KHz$ the bandwidth for narrow band FM (0.5) Δf is small.

c) Total power in the signal.

$\frac{1}{T_0}\int_{T_0} (m(t))^2\, dt = \frac{a^2}{3} = \frac{1}{3}$ See the next page for details (2)

From the book p 223

$m(t) = \sum_n C_n \cos n\omega_0 t \quad \omega_0 = \frac{2\pi}{1 \times 10^{-3}} = 2\pi \times 10^3$

$$C_n = \begin{cases} \frac{8}{\pi^2 n^2} & n \text{ odd} \\ 0 & n \text{ even} \end{cases}$$ (2)

$\tilde{m}(t) \simeq \frac{8}{\pi^2}\cos \omega_0 t + \frac{8}{\pi^2 9}\cos 3\omega_0 t + \frac{8}{\pi^2 25}\cos 5\omega_0 t$

$\text{power} = \frac{(8/\pi^2)^2}{2} + \frac{(8/\pi^2 9)^2}{2} + \frac{(8/25\pi^2)^2}{2} = 0.3330927$

$\% = \frac{1/3 - 0.3330927}{1/3} \times 100 = 0.0722\ \%$

negligable !

You can use your book & your notes. No discussion! Good luck, **Dr. Ali Muqaibel**

Total power $\propto$ area under square of the curve.

$$\frac{1}{T_0}\int_{T_0} m^2(t)\,dt = \underbrace{2}_{\text{symmetric}}\frac{}{T_0}\int_{-T_0/4}^{T_0/4} m^2(t)\,dt$$

$$= \frac{2}{T_0}\int_{-T_0/4}^{T_0/4}\left(\frac{2a}{T_0/2}\,t\right)^2 dt = \frac{2}{T_0}\int_{-T_0/4}^{T_0/4}\frac{16a^2}{T_0^2}\,dt$$

$$= \frac{32\,a^2}{T_0^3\;3}\,t^3\Big|_{-T_0/4}^{T_0/4} = \frac{32\,a^2}{3\;\cancel{T_0^3}}\left[\frac{\cancel{T_0^3}}{4^3} - \left(-\frac{\cancel{T_0^3}}{4^3}\right)\right]$$

$$= \frac{32}{3}\,\frac{2}{4^3}\,a^2 = \boxed{\frac{a^2}{3}}$$

for $a=1$ power $= \frac{1}{3}$