

Major Exam II

Tues. Dec. 19 (class-time)

Duration: 90 mins

Student Name:

ID#

1. [30 points] A carrier sinusoidal wave of frequency 100 kHz and amplitude 5V is frequency-modulated by a cosine signal of amplitude 2V and frequency 100 Hz. The frequency sensitivity of the modulator, $k_f = 25$ Hz/Volt.

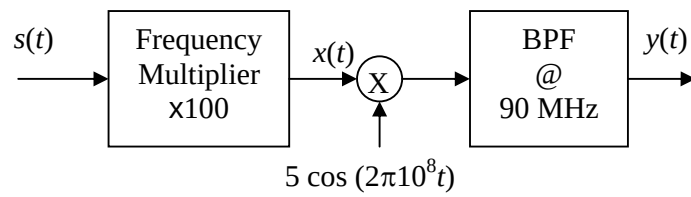
(a) Write down the time-domain expression of the FM signal $s(t)$.

(b) Find the average power of the FM signal $s(t)$.

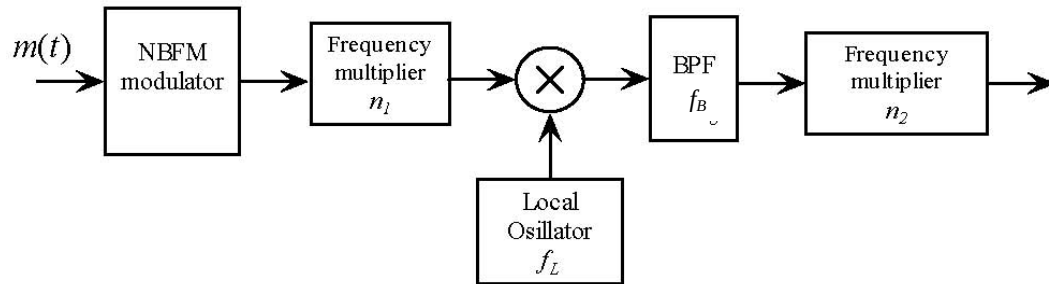
(c) Is $s(t)$ a NBFM signal? Why?

(d) Determine the approximate BW of $s(t)$ using Carson's rule.

(e) The signal $s(t)$ is applied to the system shown below. Find the frequency deviation and approximate BW of the signals $x(t)$ and $y(t)$.



2. [20 points] It is desired to design an Armstrong FM modulator to generate an FM signal with a carrier frequency of 100MHz and a frequency deviation of 75kHz using a narrow-band FM signal with a carrier frequency of 100kHz and a frequency deviation of 20Hz. Assume the local oscillator frequency is 9.5MHz, design the system by finding the values of n_1 , n_2 , f_B .



3. [20 points] A signal $m(t)$ with a spectrum $M(f) = \text{rect}(f / 20 \times 10^3)$ is sampled at 25% above the Nyquist rate using a pulse train $w(t)$, whose Fourier series is given by:

$$w(t) = \frac{1}{2} + \frac{1}{2} \left(\cos \omega_s t - \frac{1}{3} \cos 3\omega_s t + \frac{1}{5} \cos 5\omega_s t + \dots \right), \text{ where } \omega_s \text{ is the sampling radial frequency.}$$

(a) Sketch the spectrum of the message signal $m(t)$.

(b) Find the magnitude spectrum of the sampled signal $m_s(t)$.

(c) Sketch the spectrum of the sampled signal in the range of $-60 \text{ kHz} < f < 60 \text{ kHz}$.

4. [30 points] A 4-kHz signal is sampled at a rate 25% above the Nyquist rate.
- (a) If the sampled signal is to be converted into PCM using uniform quantization with a quantization noise not to exceed 1% of the peak value of the message, find the transmission rate R_T .
 - (b) Find the storage space (in bits) required on the computer to store a 10-second voice file generated using (a).
 - (c) Find the download time (in seconds) needed to download the file in (b) using a DSL link that supports a transmission rate of 100 kbps.
 - (d) If TDM is used to multiplex 24 signals generated using (a), find the transmission rate at the output of the multiplexer.
 - (e) If Delta modulation is used in stead of PCM with a sampling rate that is 4 times the Nyquist rate, find the transmission rate. Compare to PCM.