King Fahd University of Petroleum & Minerals
Electrical Engineering Department
EE370: Communications Engineering I (071)

Major Exam II

December 09, 2007
7:00 PM-8:30PM
Building 14-108

Please write your Serial #

Name: KEY

ID# :

Section (3) Dr. Kousa, SMW 9:00-9:50am

Please circle your section

(2) Dr. Kousa, SMW 10:00-10:50am

(1) Dr. Muqaibel, UT 8:30-9:45am

(4) Dr. Muqaibel, UT 10:00-11:15am

Question	**Mark**
1	/20
2	/20
3	/25
4	/35
Total	/100

Instructions:

1. This is a closed-book/notes exam.
2. The duration of this exam is one and half hours.
3. Read the questions carefully. Plan which question to start with.
4. CLEARLY LABEL ALL SIGNIFICANT VALUES ON BOTH AXIES OF ANY SKETCH
5. Work on your own.
6. Mobile phones are not allowed in the exam room.

Problem 1

Write True & False in the last column.
Correct Answer = 2. WRONG ANSWER = -1

1	Comparing VSB to SSB, VSB allows for relaxed filter design at the cost of more bandwidth.	T
2	The image station for the AM Holy Quran Channel (center frequency 850 kHz) is the channel, which is centered at 1305 kHz.	F
3	In AM superhetrodyne receiver, the IF filter is not tunable while the RF filter is.	T
4	In a superhytrodyne receiver to receive the channel at 900kHz, the local oscillator should be set to 1355 kHz.	T
5	An FM modulator is equivalent to a PM modulator followed by an integrator.	F
6	Comparing FM to AM, FM signals are immune to nonlinearity.	T
7	PLL is used to generate FM signals.	F
8	When differentiating an FM signal the resultant signal is both FM and AM modulated.	T
9	In PPM, the pulse amplitude is proportional to the sample value.	F
10	Time Division Multiplexing can be used for both analog and digital signals.	F

Problem 2:

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

$$\varphi_{EM}(t) = 2\cos\left(\omega_c t - 20\cos 1000\pi t - 10\cos 2000\pi t\right)$$

3 (a) Find the power of the modulated signal.

6 (b) If this is an FM signal with k_f=**20000π**, determine $m(t)$.

4 (c) Find the frequency deviation, Δf .

Hint : The maximum of $\sin x + \sin 2x$ is 1.76 and **NOT** 2.

4 (d) Estimate the bandwidths of $\varphi_{EM}(t)$ in Hz.

3 (e) Would you classify the modulated signal as narrow-band or wideband signal. Why?

a) $P = \frac{(2)^2}{2} = \boxed{2}$

b) $\varphi_{FM}(t) = A\cos(\omega_c t + k_f\, a(t))$

$\Rightarrow \quad K_f\, a(t) = -20\cos 1000\pi t - 10\cos 2000\pi t$

$\Rightarrow \quad m(t) = \frac{1}{K_f}\frac{d}{dt}(-20\cos 1000\pi t - 10\cos 2000\pi t)$

$= \frac{1}{20000\pi}(+20000\pi \sin 1000\pi t + 20000\pi \sin 2000\pi t)$

$\boxed{m(t) = \sin(1000\pi t) + \sin(2000\pi t)}$

c) $\omega_i = \frac{d}{dt}\theta_i = \omega_c + 20000\pi(\sin 1000\pi t + \sin 2000\pi t)$

$\Delta f = \frac{20000\pi}{2\pi}(\sin 1000\pi t + \sin 2000\pi t)$

$= 10000\,(1.76) = 17600 = \boxed{17.6\ KHz}$

d) By Carson's Rule $BW = 2(B + \Delta f)$ ①

$B = 2000\pi\ \text{rad/sec} = 1000\ Hz$ ②

$BW = 2(1000 + 17.6K) = 2(18.6k) = \boxed{37.2\ KHz}$ ①

e) $\beta = \frac{\Delta f}{f_m} = \frac{17.6k}{1k} = 17.6 \gg 1$ or

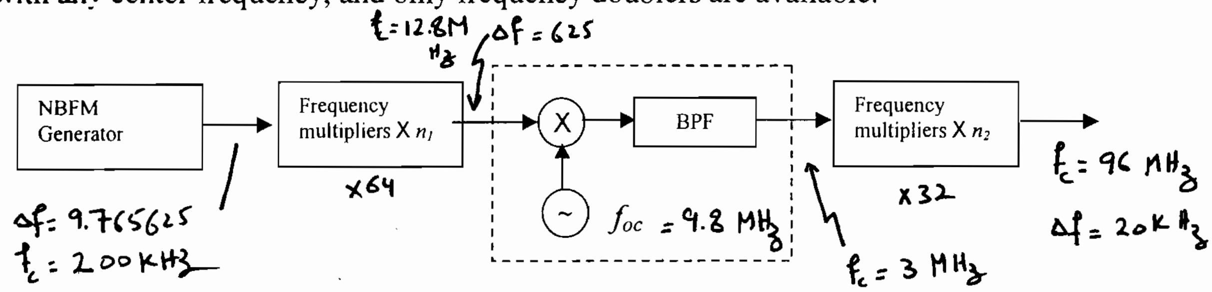
BW for NB is $2B = 2K$ but $37.2K \gg 2K$

$\Rightarrow$ **Wide band.**

b) 8 points of fc

Problem 3:

It is required to design an Armstrong indirect FM modulator to generate an FM signal with a carrier frequency of 96 MHz and Δf = 20 kHz. A narrow-band FM generator with f_c = 200kHz and adjustable Δf in the range of 9 to 10 Hz is available. The stock room also has an oscillator with adjustable frequency in the range of 9 to 10 MHz. There is a bandpass filter with any center frequency, and only frequency doublers are available.



Δf = 625 Hz

(a) Specify the design parameter for every block.

(b) Specify the carrier frequency and the frequency deviation after each block.

(a) from the diagram

$$n_1 n_2 = \frac{20K}{\Delta f} \quad \text{—(1)}$$

let $\Delta f = 9 \Rightarrow n_1 n_2 = \frac{20k}{9} = 2222.22$

$\Delta f = 10 \Rightarrow n_1 n_2 = \frac{20k}{10} = 2000$

But $n_1 n_2$ should by multiples of 2 "doublers" $\Rightarrow$ $\boxed{n_1 n_2 = 2048}$

$\Rightarrow \boxed{\Delta f = \frac{20K}{2048} = 9.765625}$

Also $n_2(n_1(200k) \pm f_{oc}) = 96M$ —(2)

$$n_2 n_1 (200k \pm n_2 f_{oc}) = 96M$$

$$\pm n_2 f_{oc} = (2048)(200K) - 96M = 313.6M$$

we have to choose the "+" sign to get possible f_{oc}

$$n_2 = \frac{313.6M}{f_{oc}}$$

let $f_{oc} = 9M \Rightarrow n_2 = 34.84$

$f_{oc} = 10M \Rightarrow n_2 = 31.36$

then $\boxed{n_2 = 32}$ only possible value using doublers.

$\Rightarrow f_{oc} = \frac{313.6M}{32} = \boxed{9.8 MHz = f_{oc}}$

in Eq (1) $\Rightarrow n_1 = \frac{2048}{32} = \boxed{64 = n_1}$

(b) see the diagram.

Problem 4:

The signal $g(t) = \text{sinc}^2(5\times10^3\pi t)$ is to be transmitted using PCM. The signal is sampled at 50% above Nyquist rate, uniformly quantized, and coded using 2 bits per sample.

(a) Fill in the following table:

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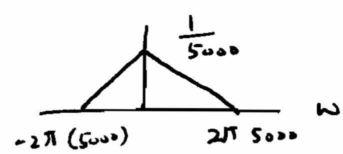
3	Signal Bandwidth in kHz	5 kHz
2	Nyquist rate of sampling	10,000 Samples/Sec
2	Used sampling rate	15,000 Samples/Sec
1	Minimum value of the signal $g(t)$	Zero
1	Maximum value of the signal $g(t)$	One
3	Maximum quantization error	$\Delta v/2 = 1/8 = 0.125$
3	Average quantization power	$P_q = (\Delta v)^2/12 = \frac{1}{12\times16} = 0.0052$
2	Transmission rate (bits/sec)	$15{,}000 \times 2 = 30{,}000$ bps

Hint: $\text{sinc}^2\left(\frac{Wt}{2}\right) \Leftrightarrow \left(\frac{2\pi}{W}\right)\Delta\left(\frac{\omega}{2W}\right)$ where W is the rad/sec, and $\Delta(x)$ is a triangle function of base $2W$ and height 1, symmetrical about the vertical axis.

$$\text{sinc}^2(5\times10^3\pi t) \Leftrightarrow \left(\frac{2\pi}{10^4\pi}\right)\Delta\left(\frac{\omega}{2\times10^4\pi}\right)$$

$$\left(\frac{1}{5000}\right)\Delta\left(\frac{\omega}{2\pi\times10^4}\right)$$



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(b) If we are willing to double the transmission rate (bits/sec), how much improvement (in dB) in SNR can be achieved? (sampling rate is not changed).

Number of bits will change from 2 to 4.

Improvement in SNR = 12 dB.

(c) If DPCM is used instead, where we are processing the difference in sample values rather than the sample values themselves.

(i) Find the maximum and minimum difference values.
(Note that the maximum and minimum differences are occurring between the sample at t = 0 and its adjacent samples before and after).

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Hint: sinc(x) = sin(x)/x

$g(0) = \text{Sinc}^2(0) = 1$

$g(T_s) = \text{Sinc}^2\left(5\times10^3\pi \times \frac{1}{15\times10^3}\right) = \text{Sinc}^2\left(\frac{\pi}{3}\right) = \left(\frac{\sin \pi/3}{\pi/3}\right)^2 = (0.827)^2 = 0.685$

$\therefore |d_p| = |g(T_s) - g(0)| = 0.315$

$-0.315 < d < 0.315$

(ii) If we keep using 2 bits for encoding, find the average quantization noise for DPCM.

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$\Delta V' = \frac{0.63}{4} = 0.$

$P_q = \frac{(\Delta V)^2}{12} = 0.00207$

(iii) How much improvement in SNR (in dB) is achieved by DPCM.

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$10 \log \frac{0.0052}{0.00207} \approx 4\ dB$

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(d) If DM is to be used. What should be the maximum sampling rate of a DM system if it is not to exceed the transmission rate of the PCM (of part a).

In DM we are using one bit/sample

$\therefore f_s = 30,000$ samples/sec.

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