

3614: Introduction to Communication Systems

Final Exam
December 13, 2006

I pledge that I have neither given nor received any assistance on this exam.

(signed)

Name (print)

Student Number

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1. (20 points) Multiple Choice – Choose the answer which best completes the sentence

1.1 [5 points] The Fourier Transform of a periodic time-domain signal is

- (a) periodic in the frequency domain
- (b) discrete in the frequency domain
- (c) continuous in the frequency domain
- (d) None of the above

1.2 [5 points] The transfer function of an ideal low pass filter with bandwidth 20kHz can be written as

- (a) $H(f) = \text{rect}\left(\frac{f - f_o}{40000}\right) e^{-j2\pi f T_o}$
- (b) $H(f) = \text{rect}\left(\frac{f}{40000}\right) e^{-j2\pi f T_o}$
- (c) $H(f) = \text{rect}\left(\frac{f}{20000}\right) e^{-j2\pi f T_o}$
- (d) None of the above

1.3 [5 points] If a message bandwidth has a B Hz, the bandwidth of the corresponding vestigial sideband AM signal B_T relates to B as

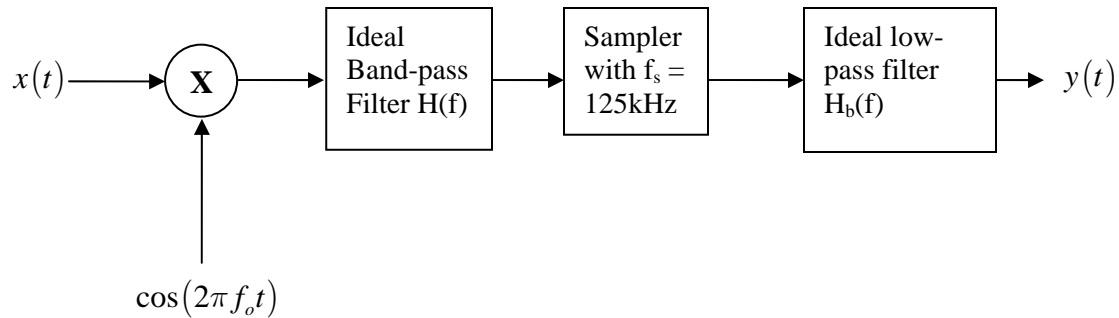
- (a) $B_T < B$ Hz
- (b) $B_T = 2B$ Hz
- (c) $B_T > 2B$ Hz
- (d) $B < B_T < 2B$
- (e) None of the above

1.4 [5 points] The output SNR of an FM system is

- (a) always better than the SNR of a DSBSC system with the same transmit power and message signal
- (b) never better than the SNR of DSBSC system with the same transmit power and message signal
- (c) never better than the SNR of a large carrier AM system with the same transmit power and message signal
- (d) None of the above

2. (25 points) Sampling and Frequency Translation

Consider the following system



where the input signal is

$$x(t) = \cos(2\pi f_c t)$$

with center frequency $f_c = 2\text{MHz}$. The input signal is mixed (multiplied) by a coherent carrier with frequency $f_o = 1.95\text{MHz}$. The resulting signal is passed through an ideal band-pass filter with frequency response

$$H(f) = \text{rect}\left(\frac{f - 40000}{30000}\right) + \text{rect}\left(\frac{f + 40000}{30000}\right)$$

The output of the ideal BPF is input to an ideal sampling device with sampling frequency $f_s = 125\text{kHz}$. The sampled signal is then passed through an ideal low-pass filter with frequency response

$$H_b(f) = \frac{1}{f_s} \text{rect}\left(\frac{f}{160000}\right)$$

(a) [15 points] Plot the magnitude spectrum $Y(f)$ at the output. Carefully label all curves and axes.

(b) [10 points] Write an equation of the time-domain output $y(t)$.

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3. (30 points) SNR of AM Systems

If the total received signal power of an amplitude modulated signal is -80dBm , the message bandwidth is 2.5MHz , the message power is 0.1W and the noise power spectral density is $N_o = -170\text{dBm/Hz}$

(a) [10 points] Determine the input (pre-detection) SNR of a DSBSC signal.

(b) [10 points] Determine the output (post-detection) SNR of a DSBSC signal.

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(c) [10 points] Determine the output (post-detection) SNR if the signal is a large carrier AM signal with amplitude sensitivity $k_a = 0.75$.

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4. (20 points) Consider a message signal

$$m(t) = \text{rect}\left(\frac{t - 1/1000}{0.0005}\right)$$

(a) [10 points] Plot the magnitude spectrum of a large carrier AM signal if the carrier frequency is $f_c = 150\text{kHz}$ and $k_a = 0.25$. Carefully label all points, curves and axes.

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(b) [10 points] Plot the time-domain function of a DSBSC signal for time $0 < t < 0.0015$. Label all axes and curves.

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5. (25 points) SNR of FM signals

Consider a received signal with total received power $P_r = -90\text{dBm}$, noise power spectral density $N_o = -165\text{dBm/Hz}$, a message bandwidth of 10kHz and a normalized message power of 0.2W .

(a) [10 points] If the threshold input SNR is 20dB , determine the maximum SNR attainable for an FM system.

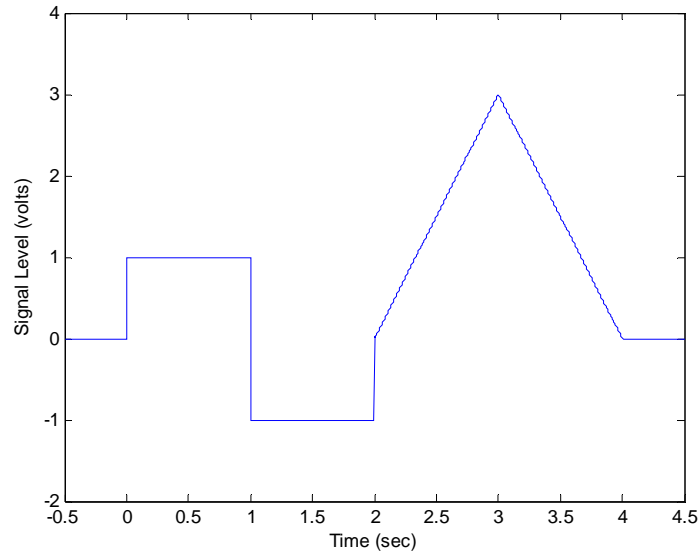
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(b) [5 points] How does the resulting transmit bandwidth compare to a DSBSC AM system?

(c) [10 points] How does the output SNR compare to an AM system? (Justify your answer)

6. (20 points) PM/FM

Consider the message signal



Message Signal for Problem 6

- (a) [10 points] Draw the time domain PM signal over the time -0.5 to 4.5 seconds for a carrier frequency of 5Hz and $D_p = \pi/2$ rad/V.

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(b) [10 points] Draw the time domain FM signal over the time -0.5 to 4.5 for a carrier frequency of 5Hz and $k_f = 4\text{Hz/V}$.