BITS, PILANI - DUBAI CAMPUS

Knowledge Village

III-Year – 2nd SEMESTER 2003-2004

Communication Systems (EEE UC383)
Comprehensive Exam (Closed Book)
Max Mark: 90

Date: 10/06/04
Time: 3 Hours
Weightage: 30%

Q1}

A transmitted angle carrier modulated carrier has carrier frequency $\omega_c = 2\pi 10^8$ and has the form:

$$x(t) = 7 \sin [\omega_c t + (1/3) \cos(300t + \pi/4) - (2/3)]$$

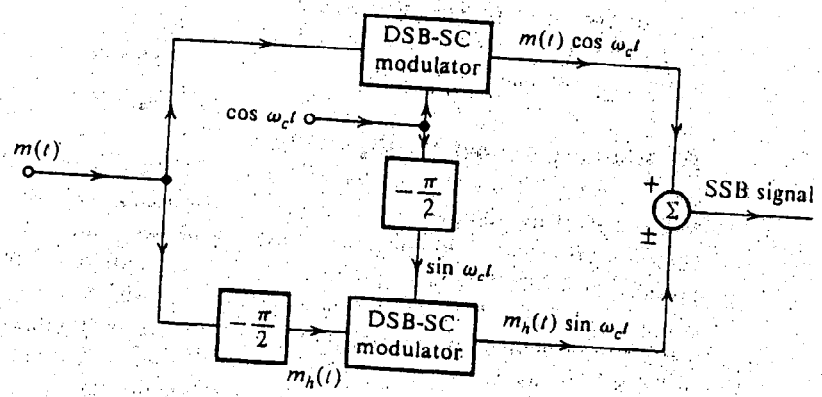
1. What is the maximum phase deviation $\Delta\varphi$ of this signal?
2. What is the maximum frequency deviation Δf of this signal?
3. What is the frequency deviation ratio (modulation index) β of this signal?
4. Estimate the bandwidth of this signal.

Q2} [8]

An USB signal is generated by using the phase-shift method (Fig. 1). If the input to this system is $m_h(t)$ instead of m(t), what will be the output? Is this signal still an SSB signal with bandwidth equal to that of m(t)? Can this signal be demodulated [to get back m(t)]? If so, how?

[8]

Fig. 1



Q3}

For an FM communication system with $\beta=2$ and white channel noise with PSD $S_n(w)=10^{-10}$, the output SNR is found to be 28 dB. The baseband signal m(t) is Gaussian and band-limited to 15kHz, and $m_p=3\sigma$ loading is used. The demodulator constant $\alpha=10^{-4}$. This means that the FM demodulator output is $\alpha\Psi(t)$ when the input is $A\cos[\omega_c t+\Psi(t)]$. In the present case, the signal at the demodulator output is $\alpha k_f m(t)$. The output noise is also multiplied by α.

a) Determine the received signal power S_i.
b) Determine the output signal power S_o.
c) Determine the output noise power N_o.

[8]

Q4}

A signal band-limited to 1MHz is sampled at a rate 50% higher than the Nyquist rate and quantized into 256 levels using a μ-law quantizer with μ=255.

a) Determine the signal to quantization-noise ratio.

b) The SNR found in part (a) was unsatisfactory. It must be increased at least by 10 dB. Would you be able to obtain the desired SNR without increasing the transmission bandwidth if it was found that a sampling rate 20% above the Nyquist rate is adequate? If so, explain how. What is the maximum SNR that can be realized in this way?

[8]

Q5}

A television signal has a bandwidth of 4.5MHz. This signal is sampled, quantized and binary coded to obtain PCM signal.

a) Determine the sampling rate if the signal is sampled at a rate 20% above the Nyquist rate.

b) If the samples are quantized into 1024 levels, determine the number of binary pulses required to encode each sample.

c) Determine the binary pulse rate (bits per second) of the binary-coded signal, and the minimum bandwidth required to transmit this signal. [6]

Q6} A signal $g(t)=\text{sinc}^2(5\pi t)$ is sampled (using uniformly spaced impulses) at a rate of: (i) 5 Hz; (ii) 10 Hz; (iii) 20 Hz. For each of the three cases:

a) Sketch the sampled signal

b) Sketch the spectrum of the sampled signal

c) Explain whether you can recover the signal g(t) from the sampled signal.

d) If the signal is passed through an ideal low-pass filter of bandwidth 5 Hz, sketch the spectrum of the signal. [10]

Q7}

Apply the Huffman coding method for the following message ensemble and their corresponding probabilities:

$$[X] = [\, x_1 \quad x_2 \quad x_3 \quad x_4 \quad x_5 \quad x_6 \quad x_7 \,]$$

$$[P] = [0.4 \quad 0.2 \quad 0.12 \quad 0.08 \quad 0.08 \quad 0.08 \quad 0.04]$$

Determine the code coefficients, word length and code efficiency.

[10]

Q8}

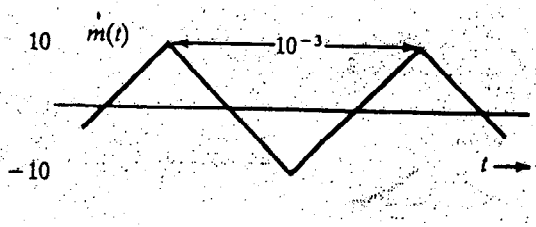
For the AM signal $[A+m(t)]\cos\omega_c t$ modulated by the signal shown in Fig. 2 with μ=0.8:

a) Find the amplitude and power of the carrier.

b) Find the sideband power and power efficiency η.

[6]

Fig. 2



Q9} The generator matrix of (6,3) linear block code is given as

$$G = \begin{matrix} 1 & 0 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 0 & 1 \end{matrix}$$

a) Construct the code generated by the matrix.
b) What will be the error correcting capabilities of this matrix?
c) If the received word is (101100), what will be the transmitted signal?

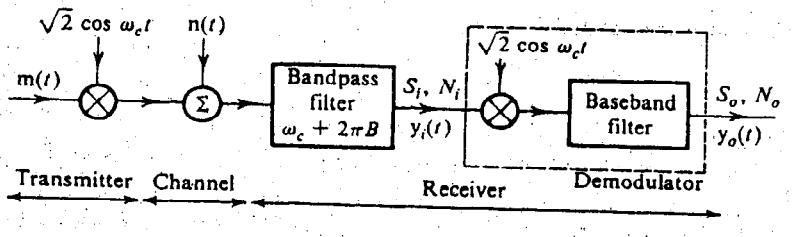
[10]

Q10} For a DSB-Sc system with a channel PSD of $S_n(\omega)$ 10^{-10} and a baseband signal of bandwidth 4 kHz, the receiver output SNR is required to be at least 30dB. The receiver is as shown in Fig. 3.

a) What must be the signal power S_i received at the receiver input?
b) What is the receiver output power N_0?
c) What is the minimum transmitted power S_T if the channel transfer function is $H_c(\omega) = 1^{-4}$ over the transmission band?

[8]

Fig-3



Q11} Write the answer that bets applies.

1. Wideband angle modulation can achieve higher output SNR than linear modulation methods, such as AM, DSB-SC and SSB, because:
   a) Wideband angle modulated carries have constant envelope.
   b) Wideband angle modulation sacrifices low bandwidth for high SNR.
   c) Synchronous demodulation is not required for angle modulated carries.
   d) Angle modulated carriers are not affected by noise at all.
2. A carrier is simultaneously modulated by two sine waves with modulation indices of 0.2 and 0.6; the total modulation
   a) is 1.
   b) is 0.8
   c) is 0.4
   d) Cannot be calculated unless the phase relations are known.
3. One of the main functions of the RF amplifier in a superheterodyne receiver is to
   a) provide improved tracking.
   b) increase the tuning range of the receiver.
   c) permit better adjacent channel rejection.
   d) improve the rejection of the image frequency.

4. The SNR of FM signal is increase by 6dB if the bandwidth
   a) halved.
   b) doubled.
   c) quadrupled.
   d) non of the above.
5. PSK signals can be demodulated without synchronous, or coherent, local carrier by using ----------
   a) envelope detector followed by threshold device.
   b) double integration.
   c) DPCM.
   d) DPSK
6. Source coding is used to
   a) eliminate redundancy in the data.
   b) detect/correct errors in signaling.
   c) decrease the bandwidth of the transmitted signal.
   d) improve probability of error.
7. Which is <u>not</u> one of the reasons that we use modulation?
   a) Channels often have a passband in which distortion and/or attenuation are low.
   b) Baseband signals must have relatively narrow bandwidth, due to fractional bandwidth considerations.
   c) Practical radiating antennas require bandpass signals centered at high frequency.
   d) Modulation can allow us to exchange bandwidth for transmit power.
8. The baseband audio bandwidth in broadcast AM radio is:
   a) in the 535kHz to 1605 kHz range.
   b) dependent on the signal being broadcast, i.e. voice or music.
   c) 5 kHz.
   d) 10 kHz.

[8]

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III-Year – 2nd SEMESTER 2003-2004

Communication Systems (EEE UC383) **Test-II (OB)** **Date: 9/5/04**

Max Mark:40 **Weightage: 10%.** **Time: 50 Min.**

Q1}

Design a uniform quantizer with the condition that the maximum error does not exceed 7% of the peak value of a symmetric message.

a) Find the minimum number N of quantization levels (power of 2).
b) What is the maximum signal-to-quantization ratio in dB we can get for this quantizer?

Q2}

A certain telephone channel has $H_c(\omega) = 10^{-3}$ over the signal band. The message signal PSD is $S_m(\omega) = \beta\ \text{rect}(\omega/2\alpha)$, with $\alpha = 8000\pi$. The channel noise PSD is $S_n = 10^{-8}$. If the output SNR at the receiver is required to be at least 30dB, what is the minimum transmitted power required? Calculate the value of β corresponding to this power.

Q3}

The input signal to a matched filter is a rectangular pulse defined by:

$x(t) = A\ \text{rect}(t-T/2)\quad 0<t<T$

Find the output of the matched filter and determine the maximum value of SNR.

Q4}

A compact disk (CD) recording system samples each stereo signals with a 16-bit analog-to-digital converter (ADC) at 44.1kb/s.

a) Determine the output signal-to-quantizing-ratio for a full-scale sinusoid.
b) The bit stream is augmented by the addition of error-correcting bits, clock extraction bits, and display and control fields. These additional bits represent 100 percent overhead. Determine the output bit-rate of the CD recording system.
c) The CD can record an hour's worth worth music. Determine the number of bits recorded on a CD.
d) For a comparison, a high-grade collegiate dictionary may contain 1500 pages, 2 columns per page, 100 lines per column, 8 words per line, 6 letters per word, and 7 bits per letter on average. Determine the number of bits required to describe the dictionary, and estimate the number of comparable books that can be stored on a CD.

Q5}

a) What are advantages of CDMA communication system over TDMA and FDMA systems?
b) Explain briefly the problems of SS/DS CDMA systems and how it can be overcome?

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Communication Systems (EEE UC383) **Test-I (CB)** **Date: 28.3.2004**

Max Mark:40 **Weightage: 10%** **Time: 50 Min.**

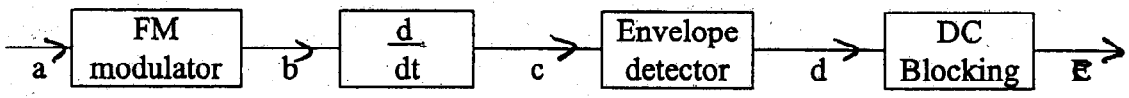
Q1} The baseband signal input to an AM transmitter is $m(t)= -20+60\cos(w_m t)$ where $f_m=w_m/2\pi = 1$ MHz. The transmitted carrier frequency is $f_c=20$MHz and the carrier amplitude is A=100.

a. What is the modulation index for this AM signal? Is it over-modulated?

b. Plot the transmitted power spectral density PSD.

c. Find the power efficiency. [8 pt]

Q2} A periodic square wave m(t) {of duration T_o and peak value of 1} frequency-modulate a carrier of frequency $f_c=10$ kHz with $\Delta f=1$kHz. The carrier amplitude is A. The resulting FM signal is demodulated as shown in the figure below. Sketch the waveforms at points a, b, c, d, and e. [8 pt]



Q3} Given a random process x(t)=k, where k is an RV uniformly distributed in (0,2).

a. Find the ensemble average $E_x[x(t)]$ and time average $E_t[x(t)=k]$.

b. Determine whether this process is ergodic.

c. Derive $R_x(t_1, t_2)$. Is this process wide-sense stationary? [7 pt]

Q4} a. Consider the signal $m(t)= 1000\,\text{sinc}(1000\pi t)$. State whether the signal is a power or energy signal, and why. Calculate the appropriate quantity (power or signal).

b. The signal from part a. is passed through an ideal low-pass filter (LPF) with cutoff frequency at 400 Hz. What percentage of the signal energy or power passes through the LPF? [7 pt]

Q5} Consider a superhetrodyne receiver designed to receive the frequency band of 1 to 30MHz with IF frequency 8MHz. What is the range of frequencies generated by the local oscillator for this receiver? An incoming signal with carrier frequency 10MHZ is received at the 10MHz setting. At this setting of the receiver we also get interference from a signal with some other carrier frequency if the receiver RF stage bandpass filter has poor selectivity. What is the carrier frequency of the interfering signal?

[5pt]