KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
COLLEGE OF COMPUTER SCIENCES & ENGINEERING
COMPUTER ENGINEERING DEPARTMENT

COE-341 – Data and Computer Communication
May 5th, 2010 – Major Exam #2

Student Name:
Student Number: **ModelA**
Exam Time: 90 mins

- Do not open the exam book until instructed
- The use of programmable calculators and cell phone calculators is not allowed – only basic calculators are permitted
- Answer all questions
- All steps must be shown
- Any assumptions made must be clearly stated

Question No.	Max Points	
1	40	
2	80	
3	40	
4	40	
5	40	
Total:	240	

Q.1) (40 points) Mark the following statements with either TRUE (T) or FALSE (F)

1	Maximum channel capacity given by Nyquist is two bits per second per Hertz.	
2	The music signal has a greater dynamic range in power compared to a voice signal.	
3	For MFSK and for a given energy per bit to noise density (E_b/N_0) figure, the bit error rate (*BER*) increases with the increase of *M* (i.e. the number of symbols).	
4	Nonlinear quantization is one method for improving a signal to quantization ratio for a PCM system.	
5	The total thermal noise on channel whose bandwidth is equal to *B* Hz is equal to N_0 times *B*, where N_0 is the noise power density.	
6	For twisted pair wires, wires with shorter the twist length, are less expensive and less immune to cross talk noise.	
7	Fiber optical communication is not affected by electromagnetic interference.	
8	To perform digital encoding for digital data, it is only required to know the set of allowed symbols and the rules of substitution.	
9	Satellites used for military purposes typically are launched into geostationary orbits.	
10	For optical communication, ILD devices are more efficient but more expensive than LED devices.	
11	The signal constellation of transmitted signal represents the transmitted energy per symbol.	
12	Multiplying the signal $m(t)$ by a carrier whose frequency is f_c in the time domain, results in translating the spectrum of $m(t)$ to be centered around f_c and $-f_c$.	
13	If a signal is sampled at a rate lower than the sampling rate, then it can be reconstructed without loss using a bandpass filter equal to its original bandwidth if large number of bits are used per sample.	
14	Step-index multimode fiber transmission produces the least distorted output compared to the other types of fiber transmission modes.	
15	The power of the FM or PM signal depends on the information signal.	
16	The typical bandwidth for an AM signal is larger than that for the FM signal for the same information $m(t)$.	
17	Frequency division multiplexing utilizes the idea of multiplying signals with carrier frequencies to produce spectra with overlapping areas.	
18	A band-limited signal has a spectrum bandwidth which extends from negative infinity to positive infinity.	
19	DSBSC AM signal consumes less power compared to a DSBTC AM signal.	
20	For sigma-delta modulation scheme discussed in class, the slope of the staircase function is fixed and is equal to T_s/δ.	

Q.2) (80 points) Choose the most appropriate answer for each of the following:

1. Digital transmission provides "data integrity" which means
    a. A uniform vehicle to transport both analog and digital information in the same transmission.
    b. To multiplex several digital signals (using TDM) on one high capacity link.
    c. With the use of repeaters, the effects of noise and other signal impairments are not cumulative.
    d. To be able to use encryption to support security and privacy for data
    e. None of the above.

2. A geostationary satellite has
    a. The same speed in kilometers per hours as any point on Earth's surface.
    b. The same angular speed in radians per second as any point on Earth's surface.
    c. Higher angular speed compared to a point on Earth's surface.
    d. Lower angular speed compared to a point on Earth's surface.
    e. Can have any arbitrary speed and elevation.

3. Given a channel whose bandwidth is equal to B Hz, the theoretical maximum channel capacity as given by Nyquist capacity formula is equal to
    a. Infinity.
    b. 2B bits per second.
    c. B bits per second.
    d. 1 bit per second per Hz.
    e. None of the above.

4. The following applications ordered from low frequency to high frequency should be:
    a. Satellite communication, laser-based communication, AM radio, and TV broadcast.
    b. AM radio, TV broadcast, satellite communication, and laser-based communication .
    c. Laser-based communication, satellite communication, TV broadcast, and AM radio.
    d. None of the above.

5. For M-ary (i.e. M > 2) ASK and PSK modulation, grey coding is used to
    a. Reduce the symbol error rate.
    b. Reduce the noise effect on the signal.
    c. Reduce the number of bit error per symbol error.
    d. Reduce the bit error while increasing the symbol error.
    e. None of the above.

6. For the free-space path loss model, the pass loss increases by 6 dB for every:
    a. If the carrier frequency is reduced to half.
    b. If the carrier frequency is reduced to one fourth.
    c. If the distance is doubled.
    d. If the distance is increased to four times.

7. The gain of an antenna element generally
    a. Increases with the increase of its surface area and the reduction of wavelength.
    b. Decreases with the increase of its surface area and the reduction of wavelength.
    c. Increases with the decrease of its surface area and the reduction of wavelength.
    d. Decreases with the increase of its surface area and the increase of wavelength.
    e. None of the above.

8. Infrared communications use part of the spectrum which is
    a. Lower in frequency than visible light, but higher then microwave.
    b. Lower in frequency than microwave but higher than AM/FM radio.
    c. Higher in frequency than visible light but lower than x-ray.
    d. Lower in frequency than AM/FM radio.
    e. Higher in frequency than visible light and x-ray.

9. One of the following is NOT a satellite communications application:
    a. Public Broadcasting services.
    b. Terrestrial Microwave links.
    c. Very Small Aperture Terminal.
    d. International Phone Links.
    e. Mobile and Cellular Telephony.

10. If a signal has bandwidth of 1000 Hz, in order to reconstruct it completely (i.e. no loss of information) from its samples, the duration between samples should at least be:
    a. 0.5 msec.
    b. 1 msec.
    c. 2 msec.
    d. 5 msec.
    e. 1000 Hz.

11. An AM signal that does not include the carrier information and with only one side of the bandwidth of the original signal is referred to as
    a. DSBTC.
    b. SSBTC.
    c. DSBSC.
    d. SSBSC.
    e. None of the above.

12. Comparing a multilevel FSK (MFSK) signal to a multilevel PSK (MPSK) signal:
    a. The MFSK signal uses approximately M times the bandwidth of the MPSK signal but both has the same power.
    b. The MPSK signal has less power but same bandwidth compared to the MFSK signal.
    c. The error performance of the MPSK signal is always better than MFSK signal.
    d. The MFSK signal uses more power but less bandwidth compared to the MPSK.
    e. These two signals can not be compared.

13. Comparing the efficiency of the encoding schemes: the NRZ (biphase) and the pseudoternary
    a. The pseudoternary encoding is more efficient compared to NRZ for the same power level.
    b. The NRZ is more efficient compared to the pseudoternary encoding for the same power level.
    c. The NRZ attempts to eliminate the DC component of the encoded signal.
    d. The pseudoternary has a DC component that makes it more vulnerable to channel errors.
    e. NRZ and pseudoternary encoding techniques are equally power efficient for the same sequence of bits.

14. Considering the sigma-delta modulation, the slope-overload noise refers to
    a. The signal $s(t)$ is too fast compared to be approximated by the staircase function.
    b. The signal $s(t)$ has regions where the slope is almost zero and thus large relative quantization error is produced.
    c. The number of quantization levels used is not sufficient.
    d. The signal $s(t)$ requires “companding” prior to encoding to improve SNR.
    e. The signal $s(t)$ has very low frequency components.

15. To increase the optical fiber utilization, the following widely applied technique is used
    a. Time division multiplexing.
    b. Space division multiplexing.
    c. Wavelength division multiplexing.
    d. Code division multiplexing.
    e. None of the above.

16. Consider a music signal with spectral components in the range of 200 to 20000 Hz. Assuming a sampling rate of 40000 samples per second will be used to generate the PCM signal. Then for an SNR level of 30 dB, the number of uniform quantization levels is equal to
    a. 2^30 levels.
    b. 16 levels.
    c. 32 levels.
    d. 2^n levels.
    e. Can not be determined from problem statement.

17. The minimum required data bit rate to transmit the PCM signal in the previous question is equal to
    a. 40 kb/s.
    b. 200 kb/s.
    c. 20 kb/s.
    d. 30 kb/s.
    e. Can not be determined from problem statement.

18. The typical bandwidth for a QPSK system that supports 20 kb/s, with $r = 1$, is equal to
    a. 10 kHz.
    b. 20 kHz.
    c. 30 kHz.
    d. 40 kHz.
    e. 80 kHz.

19. Comparing the sampling rate parameter for PCM and sigma-delta modulation (SDM):
    a. The sample rate for PCM is typically higher than that for SDM.
    b. The sampling rate for the PCM is typically lower than that for SDM.
    c. The sampling rates for two schemes can not be related to one another..
    d. The sampling rate for PCM is at least twice the sampling rate for SDM.
    e. None of the above.

20. Ranking these unguided media applications from low to high frequency
    a. Infrared, terrestrial microwave, and broadcast radio
    b. Broadcast radio, terrestrial microwave, and infrared
    c. Terrestrial microwave, broadcast radio, and infrared
    d. Infrared, broadcast radio, and terrestrial microwave

Q.3) (40 points) A sine wave is to be used for two different signaling schemes: (1) BPSK; (2) QPSK. The duration of a signal element is 10^{-5} second. If the received signal is of the following form:

$$s(t) = 0.005\sin(2\pi 10^6 t + \theta) \text{ volts}$$

Assume the measured noise power at the receiver is $2.5\text{x}10^{-8}$ watts and that $r = 0$.

a) **(5 points)** Compute the power of the signal s(t) in Watts.

b) **(5 points)** Compute the energy of the transmitted signal element.

c) **(10 points)** Compute the bandwidth of the signal s(t) in Hz.

d) **(10 points)** Compute the SNR value for the communication system in linear and dB scales.

e) **(10 points)** Determine the Eb/No (in dB) for each case (i.e. BPSK and QPSK cases).

Q.4) (40 points) Consider the Delta modulation scheme:

a) **(20 points)** The analog waveform shown below is to be delta modulated. The sampling period and the step size are indicated by the grid on the figure. The first DM output and the staircase function for this period are also shown. Assume the sampling period, Ts, is 1 msec.

a.1) Complete the rest of the staircase function (on the figure)?

a.2) Complete the rest of the DM output signal (on the figure)?

a.3) Define quantization noise distortion and slope overload distortion.

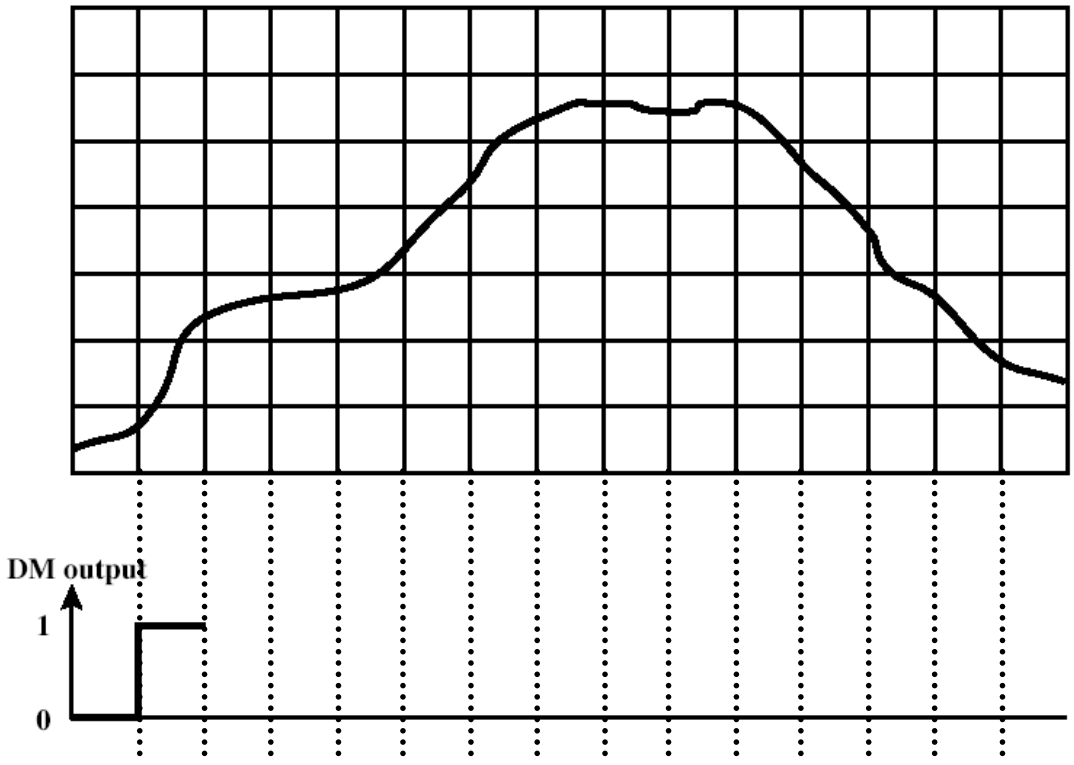
a.4) Indicate on the figure the regions where slope overload distortion exists and where quantization noise distortion exists?

b) **(5 points)** What is the minimum bit rate needed to communicate the modulated signal. Specify the bits needed to be transmitted to the receiver.

c) **(5 points)** Draw the signal reconstructed at the receiver.

d) **(5 points)** Draw a schematic diagram of the delta modulator

e) **(5 points)** What condition must be imposed on the DM parameters (i.e. Ts and δ) in order to guarantee that slope overload distortion does not occur?



Q5) (40 points) Assume an earth station is transmitting 250 Watts directed to an asynchronous satellite at the height of 35,863 km. If the carrier frequency is 4 GHz, calculate:

a) **(10 points)** The path loss assuming isotropic antennas.

b) **(10 points)** The path loss assuming the antenna gain for satellite and ground station to be 44 dB and 48 dB, respectively.

c) **(10 points)** The power level received at the satellite in dBm (decibel milliWatts) for part (b) and in Watts?

d) **(10 points)** What is effective radiated transmitted power in dBm (decibel milliWatts) for part (b) and in Watts?

Hint: free space loss in dBs is given by $L_{\text{dB}} = 20\log_{10}(d) - Gt_{\text{dB}} - Gr_{\text{dB}} + 20\log_{10}(f_c) - 147.6$, *where d is the distance in meters,* Gt_{dB} *is the transmitter antenna gain in dB,* Gr_{dB} *is the receiver antenna gain in dB,* f_c *is the carrier frequency in Hz.*