HW2

1. (10 points) Television channels are 14 MHz wide. How many bits/sec can be sent if 256-level digital signals are used? Assume a noiseless channel.

By Nyquist's Theorem:

Maximum data rate = 2B log\_2(V) = 2 \* 14MHz \* log\_2(256) = 2.24 \* 10^8 bps

2. (10 points) If a binary signal is sent over a 12-kHz channel whose signal-to-noise ratio is 30 dB, what is the maximum achievable data rate?

S/N = 10^(30dB/10) = 1000

By Shannon-Hartley Theorem:

Maximum data rate = B log\_2(1 + S/N) = 12 kHz \* log\_2(1 + 1000) ≈ 119607 bps

3. (10 points) 10 signals, each requiring 4000 Hz, are multiplexed on to a single channel using FDM. How much minimum bandwidth is required for the multiplexed channel? Assume that the guard bands are 100 Hz wide.

Minimum bandwidth = 10 \* 4000Hz + 9 \* 100Hz = 40900 Hz

4. (10 points) Suppose that A, B, and C are simultaneously transmitting 0 bits, using a CDMA system with the chip sequence of figure following:



What is the resulting chip sequence? give your answer as (+x,-x,-x, ...)

To transmit 0 bits, CDMA sends the negation of each chip sequence:

neg A = (+1 +1 +1 -1 -1 +1 -1 -1)

neg B = (+1 +1 -1 +1 -1 -1 -1 +1)

neg C = (+1 -1 +1 -1 -1 -1 +1 +1)

sum = neg A + neg B + neg C = (+3 +1 +1 -1 -3 -1 -1 +1)

5. (20 points) A CDMA receiver gets the following chips: (-1 +1 -3 +1 -1 -3 +1 +1). Assuming the chip sequences defined in figure following,



1. Which bits did station A send? (bit 1, bit 0, or silence)

(S · A) / 8 = (-1 +1 -3 +1 -1 -3 +1 +1) · (-1 -1 -1 +1 +1 -1 +1 +1) = 1  
So, station A sent bit 1.

1. Which bits did station B send? (bit 1, bit 0, or silence)

(S · B)/8 = (-1 +1 -3 +1 -1 -3 +1 +1) · (-1 -1 +1 -1 +1 +1 +1 -1) = -1

So, station B sent bit 0.

1. Which bits did station C send? (bit 1, bit 0, or silence)

(S · C)/8 = (-1 +1 -3 +1 -1 -3 +1 +1) · (-1 +1 -1 +1 +1 +1 -1 -1) = 0

So, station C was silent.

1. Which bits did station D send? (bit 1, bit 0, or silence)

(S · D)/8 = (-1 +1 -3 +1 -1 -3 +1 +1) · (-1 +1 -1 -1 -1 -1 +1 -1) = 1

So, station D sent bit 1.

1. (10 points) What is the percent overhead on a T1 carrier; that is, what percent of the 1.544 Mbps are not delivered to the end user?

Overhead percent = 1 / (8 \* 24 + 1) \* 100% = 0.518%

7. (10 points) A What is the percent overhead on a E1 carrier; that is, what percent of the 2.048 Mbps are not delivered to the end user? (round to one decimal place)

E1 carrier has 32 8-bit data samples packed into a frame. Thirty of the channels are used for information and up to two are used for signaling.

Overhead bits = 2 / 32 \* 100% = 6.25%

8. (10 points) Why has the PCM sampling time been set at 125 µsec?

Human voice frequency range used in voice calls is approximately 4000 Hz wide (300Hz to 3400Hz). By Nyquist Theorem, the sampling frequency is twice the bandwidth, at least 8000Hz. So the sampling cycle is 1/8kHz = 125μsec

9. (10 points) A simple telephone system consists of two end offices and a single toll office to which each end office is connected by a 1-MHz full-duplex trunk. The average telephone is used to make four calls per 8-hour workday. The mean call duration is 6 min. Ten percent of the calls are long-distance (i.e., pass through the toll office). What is the maximum number of telephones an end office can support? (Assume 4 kHz per circuit.)

Step 1: Calculate max circuits in the trunk:

Max circuits = 1MHz / 4kHz = 250

Step 2: Calculate long-distance traffic volume per phone :

4 calls in 8 hours per phone, each call lasts 6 min on average

Traffic per phone = 4 \* 6min / 8h \* 10% = 0.005

Step 3: Calculate phone capacity:

250 / 0.005 = 50000 phones