ECE 6390: Satellite Communications and Navigation Systems
Solutions to TEST 3 (Fall 2005)

1. **Short Answer Section (15 points)**

   (a) turbo

   (b) MEO

   (c) ephemeris

   (d) processing

   (e) constellation

   (f) gain

   (g) matched

2. **One Big Communications Link Design:**

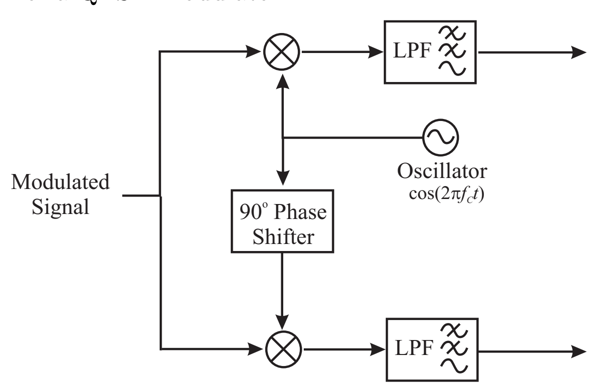
   (a) 8-bit quantization (6 dB of SNR for every bit used)

   (b) Samples/second = 64,000 bits/second ÷ 8 bits/sample = 8000 samples/sec. If we sample 8000 times per second, the Nyquist theorem states that we can capture frequency content in a baseband signal up to 4 kHz without aliasing.

   (c) The C/N (or SNR after down-conversion) of the receiver is given as 7 dB (5.0 linear scale).

$$\text{BER} = Q(\sqrt{2\text{SNR}}) = 7 \times 10^{-4}$$

   (d) Block diagram of a QPSK modulator:



(e) For every real 128 bits transmitted, there will be 256 total bits sent out of the BCH block coder. The symbol rate must double to accommodate the redundancy and, therefore, the bandwidth must double.

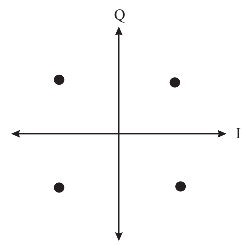
(f) From the diagram, the *transmitted RF* bandwidth of the raised cosine pulse is $B = 2(1+\kappa)f_0$ where f_0 is the symbol rate. There are 20 kbps transmitted, which means that 10,000 symbols per second are sent (remember that QPSK modulation sends 2 bits per symbol). Thus, the bandwidth for $\kappa = 0.3$ is 26 kHz.

(g) Shannon channel capacity states that for $B = 26$ kHz and $SNR = 5.0$ (7 dB):

$$\text{Capacity} = B \log_2 (1 + \text{SNR}) = 67 \text{ kbps}$$

If we are sending 20 kbps perfectly, then only 30% of the channel capacity is used. Note: bogus answers from the previous question were not double-penalized in this calculation.

(h) Signal constellation for $\pi/4$-QPSK:

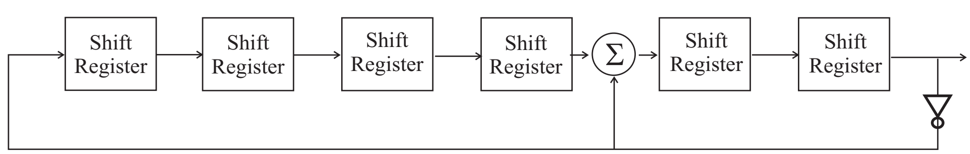


(i) We are after a total de-spread C/N of 3.2 (5 dB) with the interference.

$$\left(\frac{C}{N}\right)_{\text{despread}} = M\left(\frac{C}{N}\right)_{\text{spread}} = \frac{MC}{P_N + (Q-1)C} = \frac{MC}{C(\text{SNR})^{-1} + 19C} = \frac{M}{0.2 + 19} = 3.2$$

A value of $M = 60$ should do the trick.

(j) An m-sequence generator with 6 shift registers should produce a sequence with $M = 2^6 - 1 = 63$, which is enough to spread the signal according to the previous criterion:



(k) In addition to multiplexing capability, spread spectrum has a number of other advantages:

i. Stealthy, undetectable transmission (if the processing gain is high enough)

ii. The ability to filter/remove multipath components

iii. A level of encryption and privacy

iv. Uncoordinated sharing of spectral resources

Any 2 reasons remotely resembling these was accepted.

(l) The first filter is for attenuating out-of-band *interferers* that could drive subsequent amplifiers non-linear. Although it does filter out some noise, the serious noise-filtering is (must be) performed later in the RF chain.

(m) 2×4 kHz $= 8$ kHz.