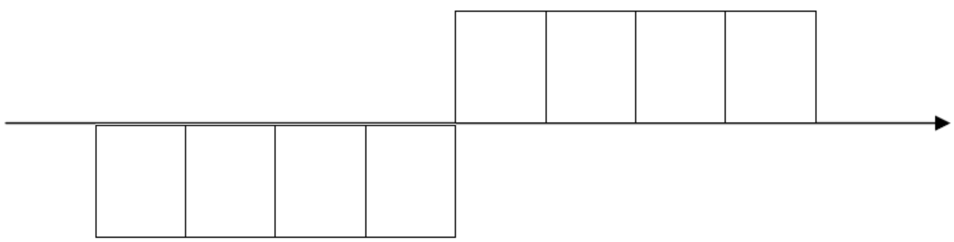
[Winter 2010 CSE3213 Communication Networks](#)
**Assignment # 3**
Instructor: Foroohar Foroozan

Review chapter 3 (Sections 3.6- 3.7) Garcia before attempting the assignment.

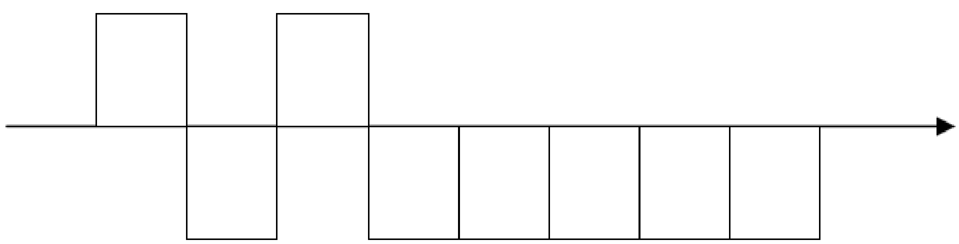
1. Most digital transmission systems are “self-clocking” in that they derive the bit synchronization from the signal itself. To do this the systems use the transitions between positive and negative voltage levels. These transitions help define the boundaries of the bit intervals.

a. The nonreturn-to-zero (NRZ) signaling method transmits a 0 with a +1 voltage of duration T, and a 1 with a −1 voltage of duration T. Plot the signal for the sequence n consecutive 1s followed by n consecutive 0s. Explain why this code has a synchronization problem.



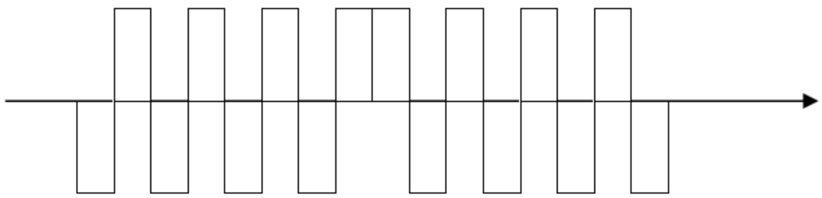
The above figure shows a sequence of 4 1s followed by 4 0s. A long sequence of 1s or a long sequence of 0s produces a long period during which there is no change in the signal level. Consequently, there are no transitions (“zero crossings”) that help a synchronization circuit determine where the boundary of each signaling interval is located.

b. In differential coding the sequence of 0s and 1s induces changes in the polarity of the signal; a binary 0 results in no change in polarity, and a binary 1 results in a change in polarity. Repeat part (a). Does this scheme have a synchronization problem?



The occurrence of a “1” induces a transition and helps synchronization. However sequences of “0s” still result in periods with no transitions.

c. The Manchester signaling method transmits a 0 as a +1 voltage for T/2 seconds followed by a −1 for T/2 seconds; a 1 is transmitted as a −1 voltage for T/2 seconds followed by a +1 for T/2 seconds. Repeat part (a) and explain how the synchronization problem has been addressed. What is the cost in bandwidth in going from NRZ to Manchester coding?



Every T-second interval now has a transition in the middle, so synchronization is much simpler. However, the bandwidth of the signal is doubled, as pulses now are essentially half as wide, that is, T/2 seconds.

2. Consider a baseband transmission channel with a bandwidth of 10 MHz. What bit rates can be supported by the bipolar line code and by the Manchester line code?

We saw that a bipolar code with pulses T-seconds wide occupies a bandwidth of W = 1/T Hz. Therefore a 10 MHz bandwidth allows a signaling rate of 10 megabits/second.
From the figure it can also be seen that a Manchester code occupies twice the bandwidth. Hence a 10 MHz bandwidth allows a signaling rate of 5 megabits/second.

3. Suppose a CATV system uses coaxial cable to carry 100 channels, each of 6 MHz bandwidth. Suppose that QAM modulation is used.

QAM modulation with $2^m$ point ⇒ m bits/pulse

T = pulse duration = 1/W ⇒ pulse rate = baud rate = W = $6 \times 10^6$

a. What is the bit rate/channel if a four-point constellation is used? eight-point?
   R = mW, if m = 4 ⇒ R = 24 Mbps. If m = 8, then R = 48 Mbps

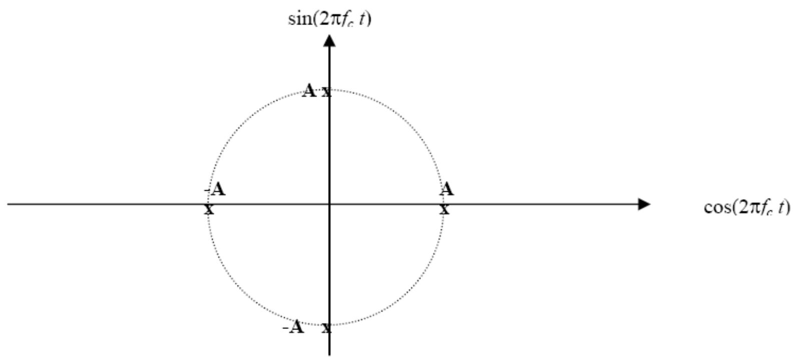
b. b. Suppose a digital TV signal requires 4 Mbps. How many digital TV signals can each channel handle for the two cases in part (a)?
   $R_{DTV}$ = 4 Mbps ⇒ $N_{DTV} = R/R_{DTV}$, where N is the number of digital TV signals per channel
   If m = 4 ⇒ $N_{DTV}$ = 6; if m = 8 ⇒ $N_{DTV}$ = 12.

4. A phase modulation system transmits the modulated signal $A\cos(2\pi f_c t + \varphi)$ where the phase φ is determined by the 2 information bits that are accepted every T-second interval:

for 00, φ = 0 ; for 01, φ = π/2 ; for 10, φ = π; for 11, φ = 3π/2.

a. Plot the signal constellation for this modulation scheme.

The signal constellation is shown below:




b. Plot approximately the output of the phase modulation system for a sequence 110110001001

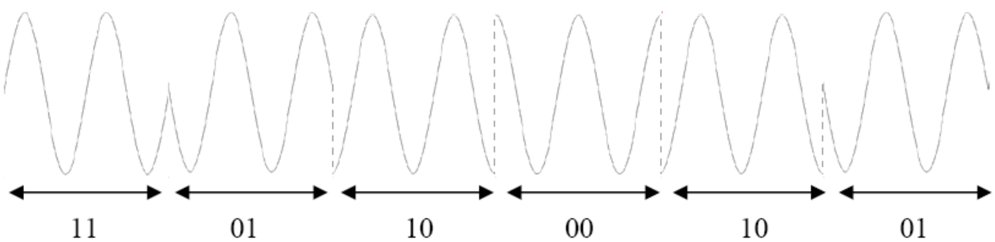
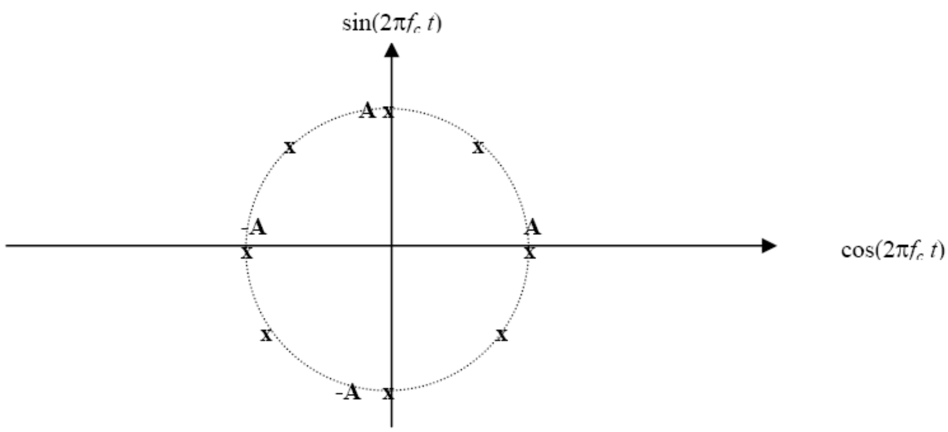



Figure 3: PSK waveform for the datastream 11 01 10 00 10 01

c. Explain how an eight-point phase modulation scheme would operate.




The generalization to an eight-point constellation is straightforward. In the above figure we can see that the four constellation points are placed at equidistant points in a circle about the origin. The figure below shows how eight points can be placed in a circle with angle $\pi/4$ between them.

5. Suppose that the receiver in a QAM system is not perfectly synchronized to the carrier of the received signal; that is, it multiplies the received signal by $2\cos(2\pi f_c t + \varphi)$ and by $2\sin(2\pi f_c t + \varphi)$ where $\varphi$ is a small phase error. What is the output of the demodulator?

The transmitted signal in QAM is $y(t) = A_k \cos(2\pi f_c t) + B_k \sin(2\pi f_c t)$

The upper multiplier in QAM demodulator computes the following:

$y(t)\, 2\cos(2\pi f_c t + \varphi) = 2\cos(2\pi f_c t + \varphi)\, A_k \cos(2\pi f_c t) + 2\cos(2\pi f_c t + \varphi)\, B_k \sin(2\pi f_c t)$
$= A_k \{\cos(\varphi) + \cos(4\pi f_c t + \varphi)\} + B_k \{-\sin(\varphi) + \sin(4\pi f_c t + \varphi)\}$

The lowpass filter removes the double-frequency component, so the output of the upper demodulator circuit is: $A_k \cos(\varphi) - B_k \sin(\varphi)$ . When the phase error $\varphi$ is small, then $\cos \varphi$ is approximately 1, and $\sin \varphi$ is approximately 0, so the phase error causes a small error in the demodulator output. As the phase error increases however, the desired signal $A_k$ becomes harder to discern because the cosine term decreases and the sine term increases.
It can be similarly shown that the output of the lower demodulator is: $B_k \cos(\varphi) + A_k \sin(\varphi)$ .