ECE 409 - WIRELESS COMMUNICATION - INVESTIGATION 18
INTRODUCTION TO CDMA - PART I

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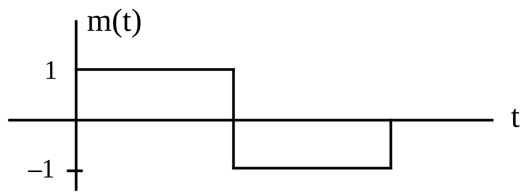
To do "well" on this investigation you must not only get the right answers but must also do neat, complete and concise writeups that make obvious what each problem is, how you're solving the problem and what your answer is. You also need to include drawings of all circuits as well as appropriate graphs and tables.

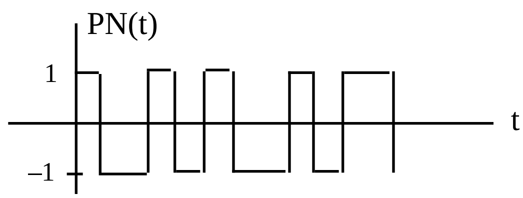
Up to now we've discussed two ways for multiple users to share a communication channel. One way is with frequency domain multiplexing in which each user has their own part of the spectrum. And the other way is with time division multiplexing in which each user is allocated a time slot every T seconds.

The objective of this and the next two Investigations is to look at ways in which multiple users can share space in a wireless environment. The objective of this Investigation is to introduce Code Division Multiple Access (CDMA) - also referred to as spread spectrum - in which users all share a "large" section of frequency spectrum but in such a way that each can retrieve their own signal. We will be introducing in particular Direct Sequence Spread Spectrum (DSSS) CDMA.

1. The objective of this first problem is to show how **Direct Sequence Spread Spectrum (DSSS)** signals are generated. DSSS signals are generated by multiplying polar NRZ_L message signals m(t) like the following

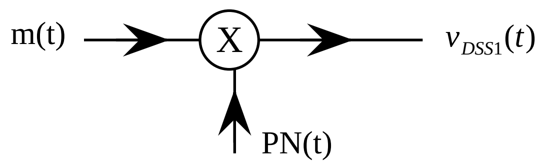


by a much higher frequency "pseudo random" pulse train PN(t) like the following

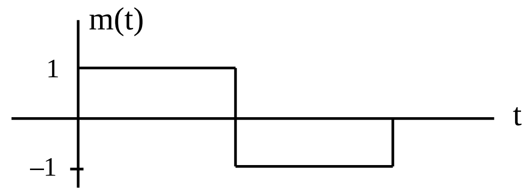


We call such signals pseudo random even though we generate them deterministically with linear feedback shift registers because the sequences of 1's and –1's look for all practical purposes like random sequences - like they were obtained by the flipping of a coin.

   a. Generate a "real" pseudo noise signal PN(t) by flipping a coin 20 times with 1 for heads and –1 for tails. Put your results in a table and then plot the signal
   b. Make use of your pseudo noise signal PN(t) in part (a) to sketch the DSSS signal $v_{DSS1}(t)$ at the output of the following circuit



for the message signal m(t) as follows

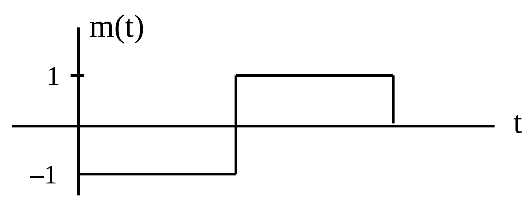


if the pulse width of the individual pulses making up PN(t) is 0.1 the size of m(t)'s pulses

c. How is the bandwidth of $v_{DSS1}(t)$ related to that of m(t). Explain

2. The objective of this problem is see how $v_{DSS1}(t)$ can be recovered
   a. Find and sketch $PN^2(t)$ for a given PN sequence. Describe your result
   b. Make use of your result in part (a) to draw a circuit for recovering m(t) from $v_{DSS1}(t)$.
   c. Test out your circuit in part (b) with the signals in Problem (1)

3. Now suppose a second user wants to transmit a DSSS signal with its PN code at the same time as the user in Problem (1)
   a. Generate a second "real" PN sequence by flipping a coin 20 times
   b. Generate a second DSSS signal $v_{DSS2}(t)$ for the following message signal m(t)



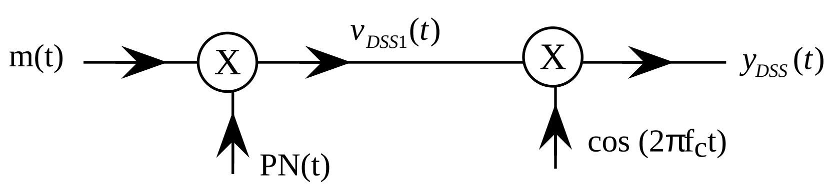
   c. To see how User One can recover his message signal from the received signal $v_{DSS1}(t) + v_{DSS2}(t)$ first graph $PN_1(t)$ equal to user one's PN code times $v_{DSS2}(t)$
   d. Describe your graph in part (c)
   e. Now make use of your results in part (d) and the previous problems to explain how User One can recover his message signal from $v_{DSS1}(t) + v_{DSS2}(t)$ by passing

$$\left(v_{DSS1}(t) + v_{DSS2}(t)\right)PN_1(t)$$

   through a lowpass filter

4. Generalizing on the result of Problem (3) we see that a given user can recover his message signal as long as his PN code is uncorrelated with the PN codes of the other users. Given all this what limits the number of users that can use a given region of the spectrum at the same time. Hint - what do all the other signals look like to a given user

5. Given a more complete DSSS system with its modulator as follows



   draw the corresponding receiver if the bandwidth of the DSSS spread spectrum signal is W

6. In order to minimize the power required of individual cell phone transmitters communities are divided into what are called **cells** with antennas for the transmission and receiving of signals.

a. Why do we want the power levels from all users to be the same at the cell's receiver
b. How would you get all the user powers to be equal at the cell antenna

7. What are advantages of CDMA