Objective

The objective of this experiment is to understand synchronization to digital signals at the receiver. The students will be familiar with the following items:

a) Time synchronization, reasons for timing mismatch
   1. Coarse synchronization via setting a threshold to determine where the signal energy starts
   2. Fine synchronization via correlating the received signal with a preamble known beforehand

b) Frequency synchronization, reasons for frequency mismatch; (Local oscillator differences, Doppler Spread)

c) Symbol synchronization/Coarse synchronization/ sample timing estimation

d) Effect of synchronization in the system; observing the effects of time/frequency offsets in the constellation diagram

e) Understanding how to do burst and symbol synchronization, and symbol timing synchronization. Learning how to sample the data and convert these samples to symbols, then, convert symbols to bits.

Pre-lab

- Understand the reason for synchronization
- Understand different types of synchronization. Coarse, fine, time, symbol, frequency, etc.
**Procedure**

In this experiment, the signals will be generated by the TAs using a signal generator. All of the benches will be required to capture the transmitted signal and synchronize to the transmitted signal, then, perform modulation analysis. Note all the following steps have to be done first in VSA and then in Matlab.

**I. TIME AND FREQUENCY SYNCHRONIZATION**

a) Tune your VSA to 915 MHz.
   - Data rate: 10ksps
   - Modulation: BPSK
   - Tx filter: RRC with alpha=0.3
   - The transmitted waveform is a burst transmission. 3 different burst is transmitted (in a frame). One burst for each bench. Think of this a TDMA scheme and each bench need to capture it own burst. At the beginning of each burst, a preamble is transmitted to help you perform time and frequency synchronization. Different preambles are transmitted for each burst. First burst (for the first bench) have a two concatenated m-sequence of $2^7$ (length is 127). Second burst has 2 concatenated m-sequence of $2^8$, and third burst has 2 concatenated m-sequence of $2^9$. The m-sequence generation is uploaded to Blackboard for you. Each burst includes also data symbols followed by the preambles. Between bursts there is a guard time. Also at the beginning and at the end of each frame there is guard time. Guard units should be determined by the students, it will not be provided.

b) Use modulation analysis in VSA
   - Use 2 by 3 screen mode and observe all the important modulation analysis plots.

c) Now, download the data to Matlab. You need to arrange the span according to the signal information given above.
   - Capture minimum of 0.5 sec of data
   - Capture signal with oversampling rate of 16
   - Note that VSA oversamples the data with 1.28
II. MATLAB PART:

a) Look at the power versus time and power spectrum of the signal that you captures. Comment.

b) Apply receiver filter (matched filter)

c) Plot eye diagram and constellation diagram

d) Estimate frequency offset

e) Correct (compensate frequency offset)

f) Plot eye and constellation diagram

g) Estimate optimal symbol and sample timing positions.

h) Synchronize to the data and downsample the received signal based on the above information.

i) Estimate phase offset

j) Correct the phase offset

k) Plot constellation diagram. Comment

l) Estimated transmitted data symbols and bits (note that each bench should detect the symbols in its own bench).

m) Convert the bits to characters and see what is your data (you should have an e-mail that is sent to you, you should be able to decode this data).

n) Calculate EVM & SNR

References

- Lecture notes