Lab - 3

Instructions:

1. Please plot so that we are able to understand, i.e., with legends, axis labels, titles etc.
2. Observations pertaining to each plot is expected below the same.
3. Kindly number your answers correctly.
4. **NO PLAGIARISM.**
5. **Put all the code in the Appendix at the end of the report.**
6. Ask any questions in class or via LMS so that it will be beneficial to all (us and you).

Questions:

Software Lab 2.1: Modeling Carrier Phase Uncertainty

Lab Objectives: The goal of this lab is to explore modeling and receiver operations in complex baseband, In particular, we model and undo the effect of carrier phase mismatch between the receiver LO and the incoming carrier.

Reading: Section 2.8 (complex baseband basics).

Laboratory Assignment

Consider a pair of independently modulated signals, $u_c(t) = \Sigma_{n=1}^{N} b_c[n]p(t-n)$ and $u_s(t) = \Sigma_{n=1}^{N} b_s[n]p(t-n)$, where the symbols $b_c[n]$, $b_s[n]$ are chosen with equal probability to be +1 and -1, and $p(t) = I_{[0,1]}(t)$ is a rectangular pulse. Let N = 100.

(1.1) Use Matlab to plot a typical realization of $u_c(t)$ and $u_s(t)$ over 10 symbols. Make sure you sample fast enough for the plot to look reasonably "nice."

(1.2) Upconvert the baseband waveform $u_c(t)$ to get

$$u_{p,1}(t) = u_c(t) \cos 40\pi t$$

This is a so-called binary phase shift keyed (BPSK) signal, since the changes in phase due to the changes in the signs of the transmitted symbols. Plot the passband signal $u_{p,1}(t)$ over four symbols (you will need to sample at a multiple of the carrier frequency for the plot to look nice, which means you might have to go back and increase the sampling rate beyond what was required
for the baseband plots to look nice).

(1.3) Now, add in the Q component to obtain the passband signal

$$u_p(t) = u_c(t) \cos 40\pi t - u_s(t) \sin 40\pi t$$

Plot the resulting Quaternary Phase Shift Keyed (QPSK) signal $u_p(t)$ over four symbols.

(1.4) Downconvert $u_p(t)$ by passing $2u_p(t) \cos(40\pi t + \theta)$ and $2u_p(t) \sin(40\pi t + \theta)$ through crude lowpass filters with impulse response $h(t) = I_{[0,0.25]}(t)$. Denote the resulting I and Q components by $v_c(t)$ and $v_s(t)$, respectively. Plot v_c and v_s for $\theta = 0$ over 10 symbols. How do they compare to u_c and u_s ? Can you read off the corresponding bits $b_c[n]$ and $b_s[n]$ from eyeballing the plots for v_c and v_s ?

(1.5) Plot v_c and v_s for $\theta = \pi/4$. How do they compare to u_c and u_s ? Can you read off the corresponding bits $b_c[n]$ and $b_s[n]$ from eyeballing the plots for v_c and v_s ?

(1.6) Figure out how to recover u_c and u_s from v_c and v_s if a genie tells you the value of θ (we are looking for an approximate reconstruction–the LPFs used in downconversion are non-ideal, and the original waveforms are not exactly bandlimited). Check whether your method for undoing the phase offset works for $\theta = \pi/4$, the scenario in (1.5). Plot the resulting reconstructions $\tilde{u}_c$ and $\tilde{u}_s$, and compare them with the original I and Q components. Can you read off the corresponding bits $b_c[n]$ and $b_s[n]$ from eyeballing the plots for $\tilde{u}_c$ and $\tilde{u}_s$?