ECE 460: Communication and Information Theory
Prof. B.-P. Paris
Homework 5
Due: October 10, 2018

Reading Madhow:

1. Chapter 3: sections 3.4 and 3.5. Note, the textbook in section 3.5 covers synchronization in continuous time while we treat it in discrete time in class. The latter is a little easier and allows MATLAB experiments. Nevertheless, you need to read section 3.5.

Problems

1. Madhow: Problem 3.21
2. Use MATLAB (or Octave) to conduct the following experiments with the adaptQuadratic.m (URL: `http://www.spec.gmu.edu/~pparis/classes/resources_460/adaptQuadratic.m`) MATLAB script that we used in class.
   (a) Vary the step size parameter μ to take the values 0.01, 0.05, 0.1, 0.25, 0.5, 0.75, 0.9, 0.95, 0.99. For each of these values, measure the number of iterations n until $|x[n] - 2| < 10^{-5}$ for the first time. Present your findings in a plot or table. Discuss any observations that you deem interesting.
   (b) What did you observe for $\mu = 0.5$? Can you explain your observation based on the iterative update rule $x[n+1] = x[n] \cdot (1 - 2\mu) + 4\mu$?
   (c) What do you observe when $\mu = 1$? Can you explain your observation based on the update rule?
   (d) What happens if $\mu < 0$ or $\mu > 1$? Can you explain your observations from the update rule?
3. Use MATLAB (or Octave) to conduct the following experiments with the adaptivePhaseTracking.m (URL: `http://www.spec.gmu.edu/~pparis/classes/resources_460/adaptivePhaseTracking.m`) MATLAB script that we used in class.

   For this problem, disable frequency offset (set `do_freq_offset = false`) and disable the I part of the controller by setting `eta = 0`.

(a) Set the standard deviation of the additive noise to `sigma=0.2;`.
Vary the step size parameter μ to take on the values $0.01, 0.03, 0.1, 0.3, 1$.
For each of these values of μ measure

- the iteration number N_0 such that the phase error for the corrected signal `r[n]` is less than 0.01, i.e., $|\text{phase}(r)| < 10^{-2}$, for the first time.
- the variance of the phase error $\text{Var}(\text{phase}(r)) = \frac{1}{M} \sum_{n=N_0+1}^{N_0+M} |\text{phase}(r)|^2$, with $M = 100$.

(b) Plot N_0 versus the step size μ and plot var_θ versus the step size μ. Discuss your findings and make a well justified recommendation for how the step size μ should be selected.

(c) Repeat the experiment for two other noise levels (e.g., `sigma=0.05;` and `sigma=0.8;`. Would you change your choice of μ in either of these cases?

4. Repeat the preceding problem with frequency offset and integral control: set `do_freq_offset = true` and `eta = mu/100`.