Project #3: Frequency Domain Analysis

ELEC 7560/7566 – Summer 2017

Due: Wednesday, August 2

Consider the Luré problem, with

$$G(s) = \frac{K_p}{(s+2)[(s+1)^2 + 4^2]}$$

$$\phi(y) = my + g\sin y$$

and $K_p > 0$, $m = 1.5$ and $g = -1$.

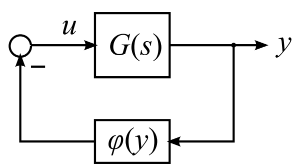

Figure 1: The Luré problem

1. **Linear System Analysis** (20pts) – Find the linear approximate model for the function $u = \phi(y)$ near the origin. In other words, find k for an approximate model

   $$u = -ky.$$

   Apply Nyquist's Criterion to assess stability of the linearized system. Remember to account for the gain k in the Nyquist diagram. Find the upper bound of K_p that yields a stable linear approximation.

2. **Circle Criterion** (20 pts) – Find slopes $0 \leq k_1 \leq k_2$ for the sector that bounds the nonlinear function $\phi(y)$. Sketch or plot the disk $D(-1/k_1, -1/k_2)$ and the Nyquist plot of $G(\omega)$ with $K_p = 1$. Apply the Circle Criterion to assess stability of the nonlinear system.

3. **Circle Criterion Analysis** (20 pts) – Using results from the Circle Criterion, find the largest K_p that results in an asymptotically stable closed-loop system.

4. **Simulation Study** (20 pts) – Simulate the Luré problem, and explore the upper limit for K_p. Remember to use the function $\phi(y)$ in the simulation model! Does the upper limit depend on the initial state? Discuss how the upper limit for K_p found by simulation compares to the upper limits found in Prob. 1 and Prob. 3.