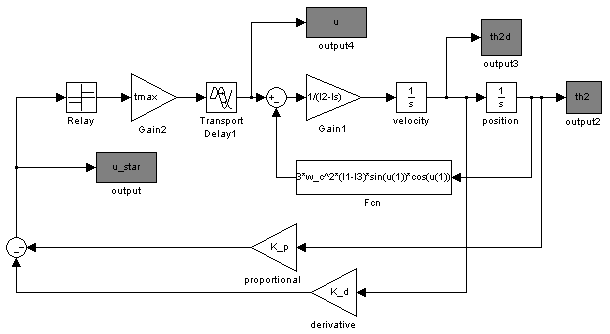
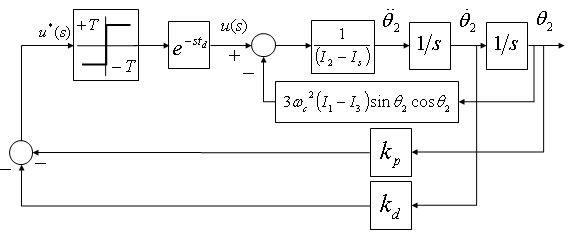
**Final Project Hints:**

Block diagram to implement in Simulink:



% define the Laplace variable

s = tf('s');

% thruster time delay

td = .1; % time delay

delay = exp(-td\*s);

% define PD controller

K = K\_p + K\_d\*s;

% combine G and K

GK = minreal(G\*K);

% predict the limit cycle response

[gm,ph,wgm,wpm]=margin(GK\*delay);

% for relay nonlinearity, N(A) = 4T/piA

% set N(A) = gain margin and solve for amplitude of limit cycle

A = 4\*tmax/(pi\*gm);

% plot predicted vs. actual limit cycle

plot(t/60,u\_star\*(180/pi),t/60,A\*sin(wgm.\*t)\*(180/pi));

Phase Plane Plots for Increasing 



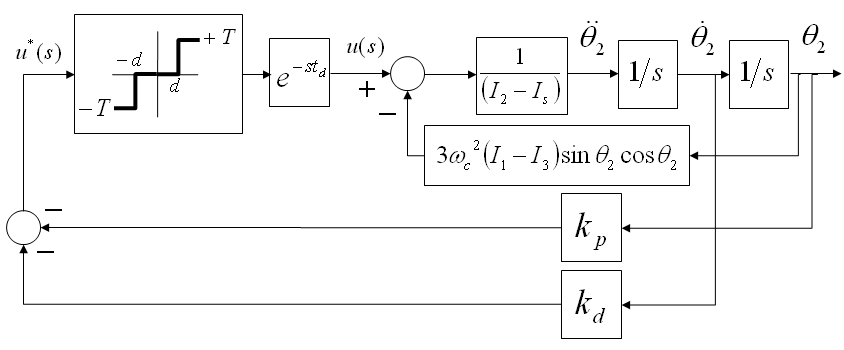




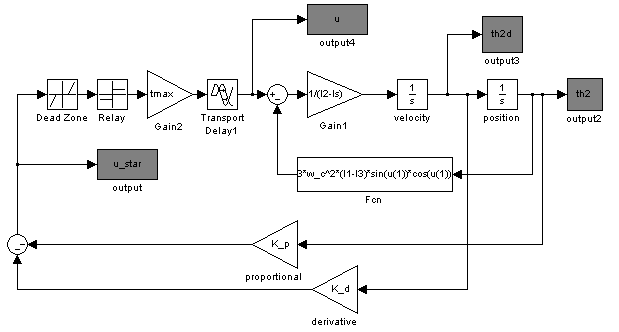


**Final Project Hints:**

**Analysis diagram:**



**Block diagram to implement in Simulink:**



**Switching response near origin with small deadband**



**Exaggerated deadband to show effect in phase plane**

