**EE/AA 448: Sensors and Actuators**

**Laboratory Module #8**

# Full State Feedback and Observers for the Pendulum Rig

**Assigned: Mar. 2, 2009**

**Due: 12:30 PM, Monday Mar. 9, 2009 (In Class)**

**WARNING**: THE PENDULUM RIGS HAVE POWERFUL MOTORS AND CONTROL BIG PIECES OF FAST MOVING ALUMINUM. THEY RUN ON HIGH VOLTAGES AND STRONG CURRENTS. DO NOT DO ANYTHING UNLESS YOU KNOW APPROXIMATELY WHAT WILL HAPPEN WHEN YOU DO IT. WORK IN TEAMS. BE CAREFUL!!!!

## Objectives

The objectives of this lab are to (a) design a state space regulator that keeps the pendulum pointing straight up and (b) design an observer for the full state.

## You Will Need...

To complete this module, you will need

1. A pendulum rig
2. A power supply
3. An I/O card and workstation

## Obtain the Full State

Make sure that the I/O card has a second analog input measuring the voltage across the small-valued resistor in series with the motor. Plot $\theta$, $\omega$ and $i$ as a function of time as the pendulum is moving but without any applied voltage. Note the current due to the back emf.

## Design a Full-State Feedback Controller

Choose poles for a full state feedback controller. Explain why you chose the poles you did. Implement the controller in your simulation and then on the pendulum rig. Adjust your choice of poles obtain better performance.

You may wish to filter the velocity and current values in your code.

You should also implement a deadzone compensator. First, determine a way to measure the deadzone of the motor, then add the appropriate compesnation to your code.

## Implement an Observer

Implement an observer. Explain how you obtained the gains for the observer. Still using the measured state in your controller, compare the observered state with the measured state. Do this in simulation first to tune your choice of observer poles. Then implement the observer with the pendulum rig.

Finally, try to get your full state feedback controller to work using the observer state instead of the measured state. Compare the performance.

NOTE: To demonstrate your observer working, especially the its transient response, you need to track an interesting reference input, such as a square wave.