Title: **Automatic Control III: Analysis of Mag. Lev. Dynamics**

Course: **Laboratory Experiments 4 (CSE411)**

Lab No.: **13** ***Category:*** **Automatic Control**

Date: **14/3/2023** ***Due:*** **20/3/2023** ***Time:*** **4 Hours**

Objectives:

1. To get familiar with MATLAB Control System Toolbox.
2. To understand the dynamics of the magnetic levitation system.
3. To know how to formulate a control problem.

Hardware Requirements:

- ✓ Feedback 33-006 Magnetic Levitation System.
- ✓ PC.

Software Requirement:

- ✓ MATLAB R2018a or higher.
- ✓ Simulink.

Pre-lab:

1. What is open-loop stability?
2. Define: Gain crossover frequency, phase crossover frequency, gain margin, phase margin, bandwidth, settling time, rise time, steady-state error.
3. What is Bode stability criterion?

Part 1: Analysis of the Open Loop Dynamics of the Magnetic Levitation System:

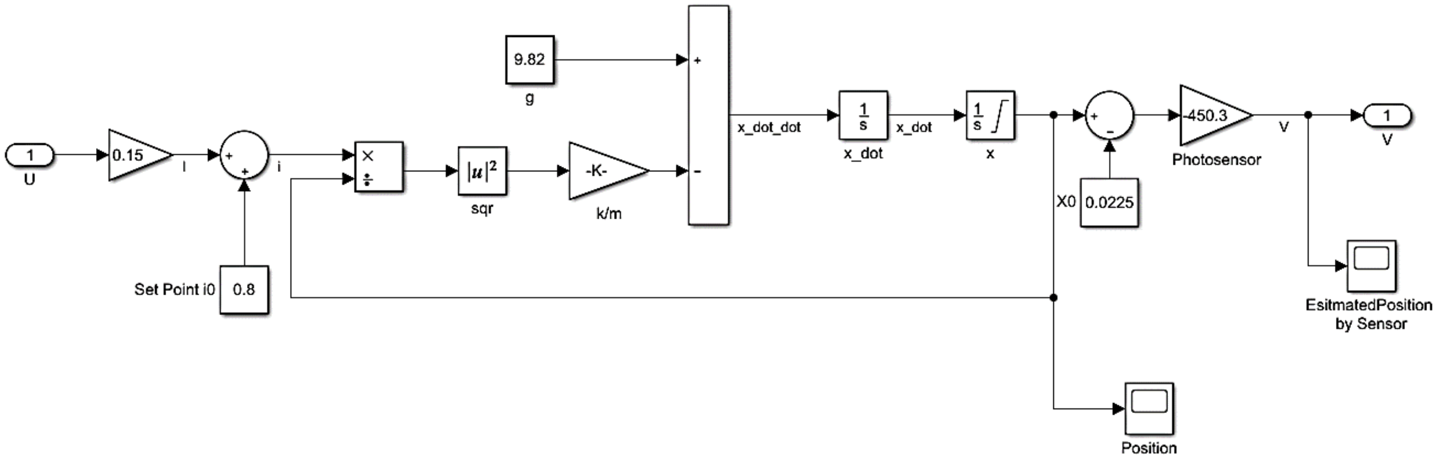

Figure 1 Simulink Model of the Magnetic Levitation System

1. Open the Simulink model of the magnetic levitation system (Figure 1).
2. Use the "Linear Analysis" tool to calculate an operating point for the equilibrium at the given set point.
3. Linearize the system at the calculated operating point and export the transfer function to workspace under name `sys_ss`.
4. Convert the system transfer function to the zero-pole-gain format and the transfer function format:

```
>> sys_zpk = zpk(sys_ss)
>> sys = tf(sys)
```

5. Plot the step response of the open loop system. What is remarkable from the step response?

```
>> step(sys)
```

6. Calculate the step response characteristics:

```
>> S = stepinfo(sys)
```

7. Draw the bode diagram of the open loop system. Determine (from diagram) stability margins and stability conditions for the system.

```
>> bode(sys)
```

8. Calculate the margins, crossover frequencies and determine stability for the system.

```
>> allmargin(sys)
```

Part 2: Analysis of the Analog Controller Provided by the Manufacturer:

1. The transfer function of the analog controller can be approximated as:

$$C(s) = \frac{\frac{s}{15\pi} + 1}{\frac{s}{900\pi} + 1}$$

```
>> s = tf('s')
>> C = (s/15/pi+1)/(s/900/pi+1)
```

2. Draw the bode diagram of the controller. What is the type of the controller?

```
>> bode(C)
```

3. Calculate the transfer function for the closed loop system.

```
>> CL = feedback(C*sys, 1)
```

4. Plot the step response for the closed loop system and study the characteristics of the step response curve.
5. Plot the bode diagram for the open loop system and determine stability margins and crossover frequencies.

Part 3: Controller Objectives:

From Parts 1 & 2, what are the objectives that need to be considered for the designed controller?

Technical References:

1. *Magnetic Levitation System; Getting Started: 33-006.* Feedback Instruments.
2. *Magnetic Levitation Control Experiments 33-942S.* Feedback Instruments.
3. *Modeling and Control of a Magnetic Levitation System.* Marwan K. Abbadi and Winfred Anakwa.