University of California
College of Engineering
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Lab 6 Magnetic Levitation Controller II

In the previous lab we obtained a linearized model for the magnetic levitation system. The model clearly indicated that the system is open-loop unstable and cannot be stabilized by a simple feedback gain (K). In this lab, we will design a feedback controller to stabilize this system. The following figure shows the block diagram of the controller.

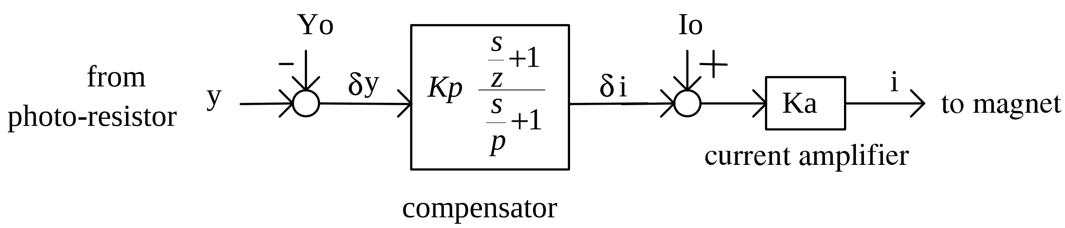
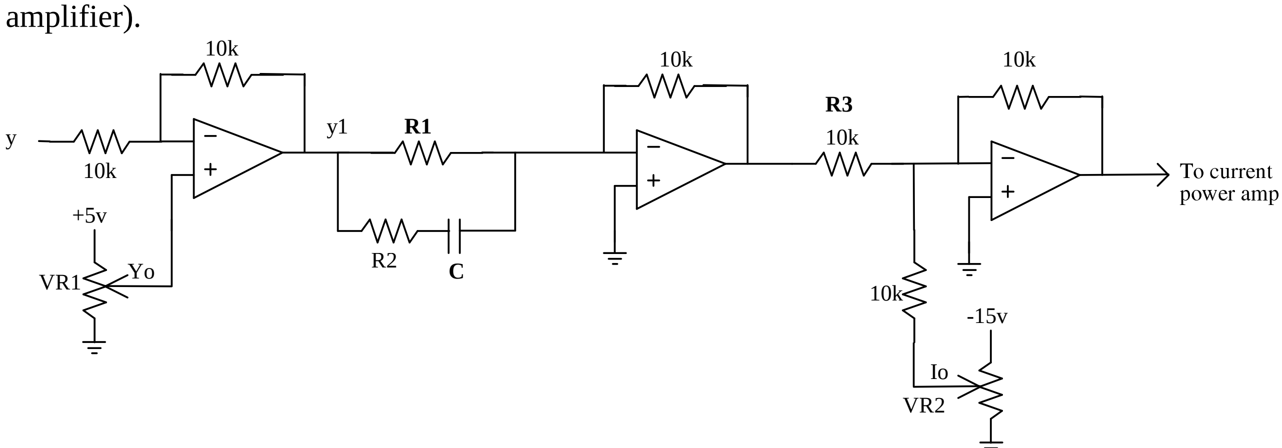


Figure 1 Controller block diagram

In Figure 1, the term Yo is the term that cancels the offset in the position signal y. In other words, the signal δy is zero if the ball is at the zero position (about 6mm from the base of the magnet). The term Io is the gravitational force cancellation term. This term is added to the compensator output (δi) so that the net force acting on the ball (at the zero position) is due to δi only. Both Yo and Io terms are the "offset" term and should not be included in the model. The term Ka represents the gain of the current power amplifier.

Figure 2 is an operational amplifier circuit realization of the block diagram (except the current amplifier).



Pre-Lab (Note: This is to be turned in with the lab writeup. If you do not complete it before the lab period, you will have a much harder time completing the lab):

(1) Plot the Nyquist plot of the linearized model transfer function (G(s)). Base on the plot, explain why a lead compensator should be used to stabilize the system rather than a lag compensator.

(2) From Figure 1 it is easy to see that the DC gain of the transfer function of the compensator (including current amplifier) is Kp*Ka where Ka is 1 (Amp/V). For the data obtained from Lab 4, determine the value of Kp so that the controller generates 1 Amp output for 1mm position error (i.e., ball displacement).

(3) Plot the Bode plot of the transfer function Kp*Ka*G(s) using the value of Kp determined in (2).

(4) Determine the cross over frequency and then find the transfer functions for two lead compensators so that the phase margins are 45 and 60 degrees.

(5) Determine two sets of values of R1, R2, and C in Figure 2 so that the transfer function of the circuit is Kp*C(s) where C(s) represents the lead compensator transfer functions obtained in (4).

In-Lab Procedure:

(1) Verify that the gain of the current power amplifier Ka is 1 (Amp/V).

(2) Construct the circuit using the component values determined in (5) above for 45 degree phase margin.

(3) To set the value of Yo, place the ball at the zero position and set VR1 until the output of the first amplifier (y1) reads zero volts.

(4) To set Io, remove R3 (10k resistor). Place the ball at the zero position and set VR2 until the force reading reaches zero.

(5) Install R3 in the circuit and place the ball at the zero position. Slowly remove the support. The ball should be levitated by the magnet at this point.

(6) Use a scope to monitor the voltage y1. Record the system's response to an impulse disturbance. The impulse disturbance input can be simulated by lightly taping the ball.

(7) Replace R1, R2, and C with the values that give 60 degree phase margin. Repeat step 6.