ELECTRICAL ENGINEERING TECHNOLOGY PROGRAM
EET 433 – CONTROL SYSTEMS ANALYSIS AND DESIGN

MAGNETIC LEVITATION EXPERIENCES

Magnetic levitation systems are good examples of control systems. The load is levitated balancing the force of gravity on the load with the magnetic attraction from the control system. If the magnetic attraction is too small, then the force of gravity dominates and the load will fall onto the ground. If the magnetic attraction is too strong, then it will dominate and the load will be attached to the control system. In the state of equilibrium, the magnetic force is equal in magnitude and with opposite sign to the force of gravity and therefore the load will be suspended levitating as the resulting force is equal to zero.

The design of a magnetic levitation system is not obvious and requires careful consideration of several parameters. During the next three laboratory experiences we will explore the characterization and design of a small magnetic levitation system. This work has been divided into two different parts:

Part 1.- System evaluation. In this part students will evaluate the global performance of the magnetic levitation system, understanding its range of operation and its limitations.

Part 2.- System Characterization. In this part students will characterize the different electronic components that make up the magnetic levitation system and how they interact with each other.

MAGNETIC LEVIATION SYSTEM - Part 1: SYSTEM EVALUATION

Goals: The goals of this laboratory experiment is to evaluate the overall performance of a magnetic levitation system. This system will be further studied and characterized in detail in the next two experiments.

Description of the magnetic levitation system: Figure 1 shows a photograph of the magnetic levitation system. Its main components are:

- Control board
- Electromagnet
- Position sensor
- Levitated object (load)

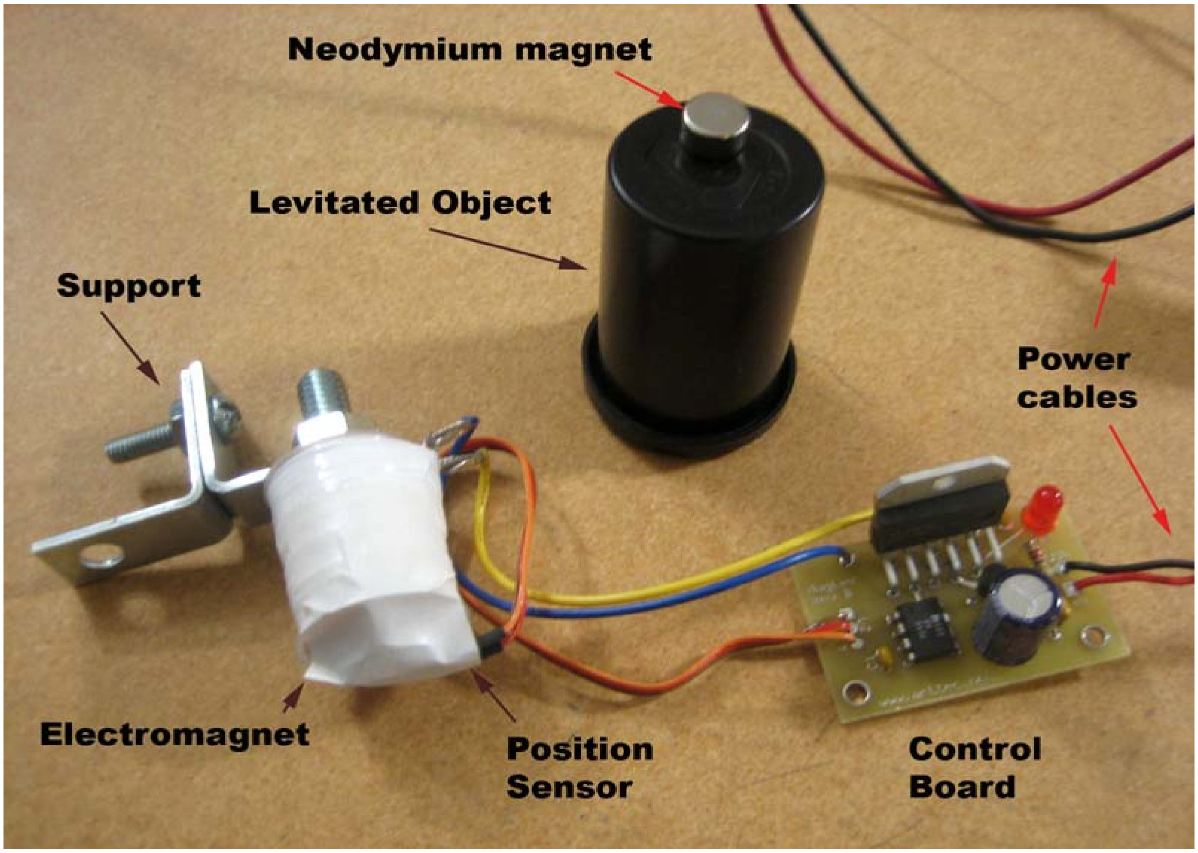

Figure 1: Picture of the magnetic levitation control system

- The control board receives the signal from the position sensor and generates the appropriate signal to drive the electromagnet in order to keep the levitated object stable. The red LED is an overheat alarm. If the red LED illuminated, **disconnect the power immediately.**

- The electromagnet generates a magnetic field with the appropriate direction and intensity as directed by the control board.

- The position sensor generates an electrical signal related to the relative position of the levitated object.

- The levitated object or load.

For the system under study, the levitated object will be one or two permanent Neodymium magnets taped to a plastic film canister. This allows experimentation with reversing the polarity of the magnet and changing the total weight of the levitated object.

STEP 1.- Draw a block diagram that shows the previous components and their interconnections in the levitation system.

- Set the initial weight of the levitated object to anything between 10 g and 14 g.

- Ensure that the electromagnet is securely attached to the workbench and in vertical position.

- Power the control board with +15V and GROUND.

- Hold the levitated object with your hand beneath the electromagnet at a distance of 2 cm to 3 cm. At this point you should feel a slight push or pull that is the result of the interaction between magnetic fields.

- Try to let the levitated object go very gently so you don't bump it up, down or sideways. If it pulls and sticks to the coil, you should add more weight to the canister; if it falls down, try to remove some weight or the second magnet. You may see the levitated object to oscillate over the set point before it stabilizes or falls down.

- If the control system continuously pulls the levitated object away, try reversing the polarity of the magnet in the levitated object of the position of the sensor or both. Eventually, one of these combinations will be correct.

STEP 2.- Measure the current drawn by the system in these three conditions:

- With no levitated object
- With levitated object suspended in a stable way
- With levitated object attached to the electromagnet

Are they similar? Different? Why?

STEP 3.- What is the range weight in the levitated object for the system to work correctly?

STEP 4.- What is the range of air gap between the electromagnet and the levitated object?

The next laboratory experience will study in detail the integrated circuits and signals used in this control system. For now, answer the following questions by observing the signals on the oscilloscope and trying to understand the overall process.

STEP 5.- Sketch the waveform observed in Pin 1 of the DIP chip. This pin is connected to the output of the position sensor. How does this signal change when varying the position of the levitated object. Measure the critical amplitudes and frequencies. Try to explain what is happening.

STEP 6.- Observe the waveform observed in Pin 7 of the DIP chip. This signal becomes the input to the chip that drives the current through the electromagnet. Sketch the waveform for the following three positions of the levitated object: no object, suspended stable and attached to the electromagnet. Measure the critical amplitudes and frequencies

STEP 7- Based on the observations on the last two questions, try to explain how the control system works.

STEP 8.- What are the main problems in observing these signals? Why do you think this is happening? How could this be avoided?

STEP 9.- What happens when we introduce a disturbance on the levitated object? What does this say about the stability of this system?

STEP 10.- The position sensor used in this control system is a Hall Effect sensor. What are Hall Effect sensors? What other types of sensors could be used in this system?

STEP 11.- Write a lab report using the appropriate format. The lab report should contain, at least, the answers to all the previous questions. The conclusions section of the report is especially important as you will be giving your opinion on the work you have done as well as the laboratory experience by itself.