Magnetic Suspension System Control Using Position and Current Feedback

Functional Requirements and Performance Specifications

Team: Gary Boline and Andrew Michalets

Advisors: Dr. Anakwa and Dr. Schertz

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Summary
Magnetic suspension systems are increasingly used in industrial rotating machinery applications. They offer a number of practical advantages such as low energy consumption, capacity for linear displacement, high rotational speeds and can operate at extreme temperatures with a longer lifespan. The absence of mechanical contacts that are present in traditional systems eliminates the problem of lubrication. The Magnetic Suspension System uses an electro-magnetic force to suspend a hollow metal ball. There are two initial inputs to the system: set point and reference input. The set point is the operating point of the system, around which a reference signal is tracked.

Goals
Unlike previous controller designs using this magnetic suspension platform, a controller will be developed to implement current feedback along with conventional position and velocity feedback to improve performance of the system. The magnetic suspension system diagram can be seen in Figure 1, and a photo in Figure 2.

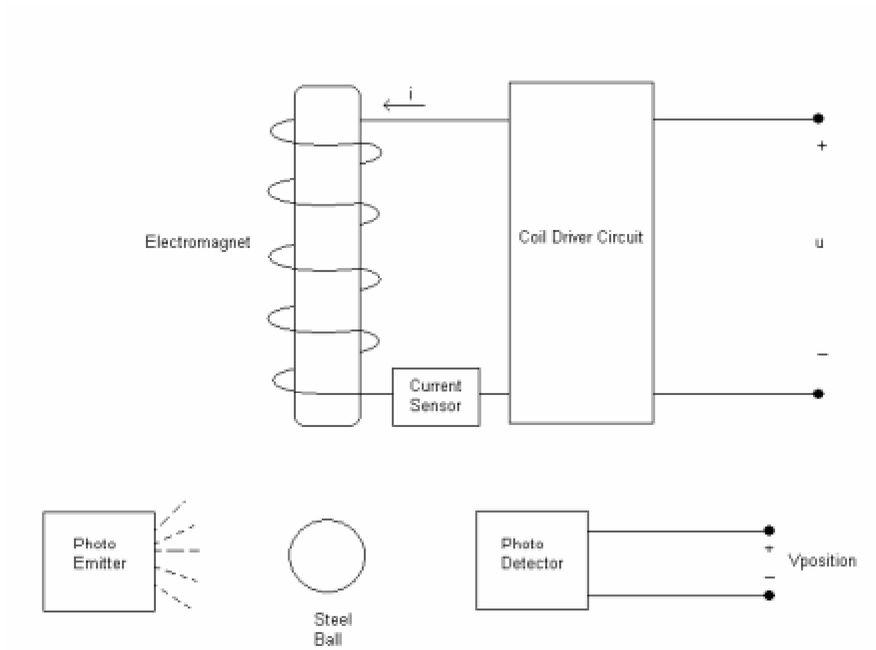

Figure 1: Magnetic Suspension Plant

Figure 2: Photo of Magnetic Suspension Plant

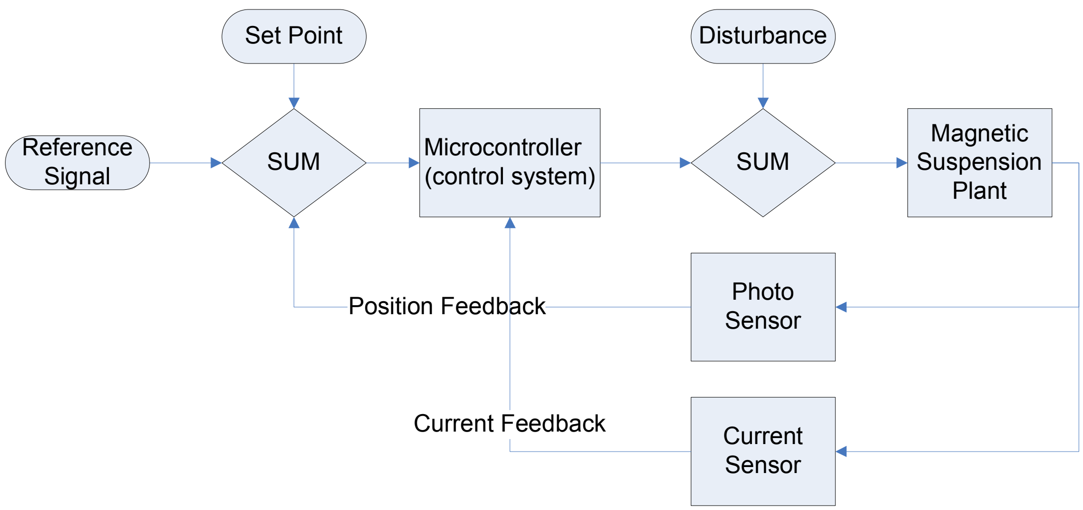

Figure 3: High Level Block Diagram

Subsystems

The magnetic suspension plant has been extensively modeled in previous projects and that will be the starting point to model the system using current, position and velocity feedback. Previous projects started with a nonlinear mathematical model of the magnetic suspension system plant and linearized it about a desired equilibrium position. The linearized plant transfer function obtained from previous projects is:

$$H(s) = \frac{7.67*0.18}{(1/961)*s^2 - 1} \qquad (1)$$

The photo sensor converts the position of the ball, suspended below the electro-magnetic coil, to a voltage. The current sensor is a 1 Ohm resistor which produces a voltage equivalent to current. The microcontroller chosen for this project is the Motorola Coldfire 32 bit microcontroller which features a floating point processor, Digital to Analog (D/A) and Analog to Digital (A/D) converters.

Specifications

The metal ball shall reach zero steady-state error with less than 0.6 seconds settling time and 20% overshoot. Sampling from the Coldfire microprocessor shall be interrupt driven with a sampling rate of 1ms. All calculations on the Coldfire microprocessor must be computed within the sampling time of 1ms using a floating point processor. The resolution of our D/A and A/D converters are unknown at this time.

I/O

The controller will primarily use the D/A and A/D converters of the Coldfire platform to create the controller. Set point and gain parameters will be user selectable along with a possible disturbance input.

Software Functionality

The software on the Coldfire platform will perform all the necessary conversions and calculations to implement the controller design. This includes discrete sampling via timers, user input, and signal output to the magnetic suspension plant.

References

[1] Dr. W. Anakwa. Control of a Magnetic Suspension System Using Position Error and Electromagnet Current. Project Proposal 2006-2007

[2] Namik K. Akyil. Control of a Magnetic Suspension System Using TMS320C31-Based dSPACE DS1102 and Simulink. IEEE 2005 International Conference on Mechatronics. July 10-12, 2005. Taipei, Taiwan.