Fuzzy Logic Control of a Magnetic Suspension System using xPC Target

Functional Description

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Introduction

Fuzzy logic is an alternative method of approaching control systems. Current closed-loop controllers employ feedback and detailed mathematical models of their system plant to create a control transfer function which will be implemented using electronic circuitry, or perhaps embedded processors. The control transfer functions use strict mathematical relationships to minimize steady state error, rise time, and increase stability.

Fuzzy logic presents a different approach to controller design. Fuzzy logic seeks to recreate the behavior of an expert human controller to replace the strict mathematical relationships. By using membership functions to convert the system inputs into 'fuzzy' terms, and using a rule-base approach to producing outputs, fuzzy logic offers an adaptable system for control applications. Whereas the conventional controller is only as effective as its plant model is accurate, fuzzy logic controllers often have no plant model, but only know the state of the inputs and outputs of the system. Fuzzy logic controllers have been shown to be effective control systems for especially difficult control problems,

such as systems with high degrees of non-linearity. The goal of this project is to implement a fuzzy logic controller for a magnetic suspension system using the Simulink-based xPC Target software and hardware.

Figure 1 shows the high-level block diagram for the entire system. A more detailed description of each sub-system follows.

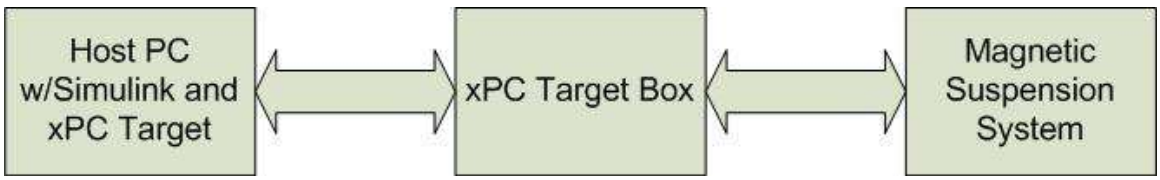

Fig. 1 – High Level Block Diagram

Host PC w/Simulink and xPC Target

The PC contains the Simulink and xPC Target application. All of the control models are created using Simulink on the PC. Once complete, the models are compiled into C code, and then transferred to the xPC Target Box using an ethernet connection.

xPC Target Box

The xPC target box acts as the real-time controller for the magnetic suspension system. The models from the PC are stored on the xPC target box as C code. Program execution and data retrieval are controlled by the host PC via ethernet. The xPC target box contains analog to digital and digital to analog converters which allow it to take data from the magnetic suspension system, and apply control signals to it.

Magnetic Suspension System

The magnetic suspension system suspends a metal ball in a magnetic field. Its inputs include a set point, and a reference input. The set point describes the origin of the coordinate plane for the suspension system, which is where the ball will hang at equilibrium. The reference input allows a waveform to be entered for the ball to follow. The outputs of the system include an error signal, and a ball position signal. These are both sent to the xPC Target Box through the A/D converter to control the system.

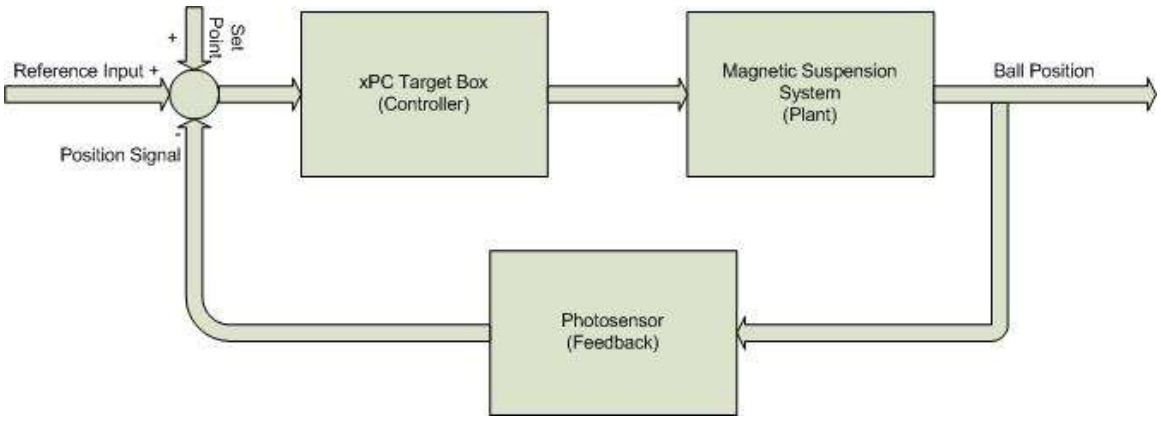

Fig. 2 – Control Block Diagram

Figure 2 shows the detailed control block diagram for the system. The reference input, set point, and ball position signals combine to form the error signal. The error signal is entered into the xPC Target box, which acts as the controller. The correction signal from the controller is applied to the magnetic suspension system, which acts as the plant. The photosensor measures the ball position and feeds that information to the

controller. A detailed diagram of the magnetic suspension plant is shown in figure 3.

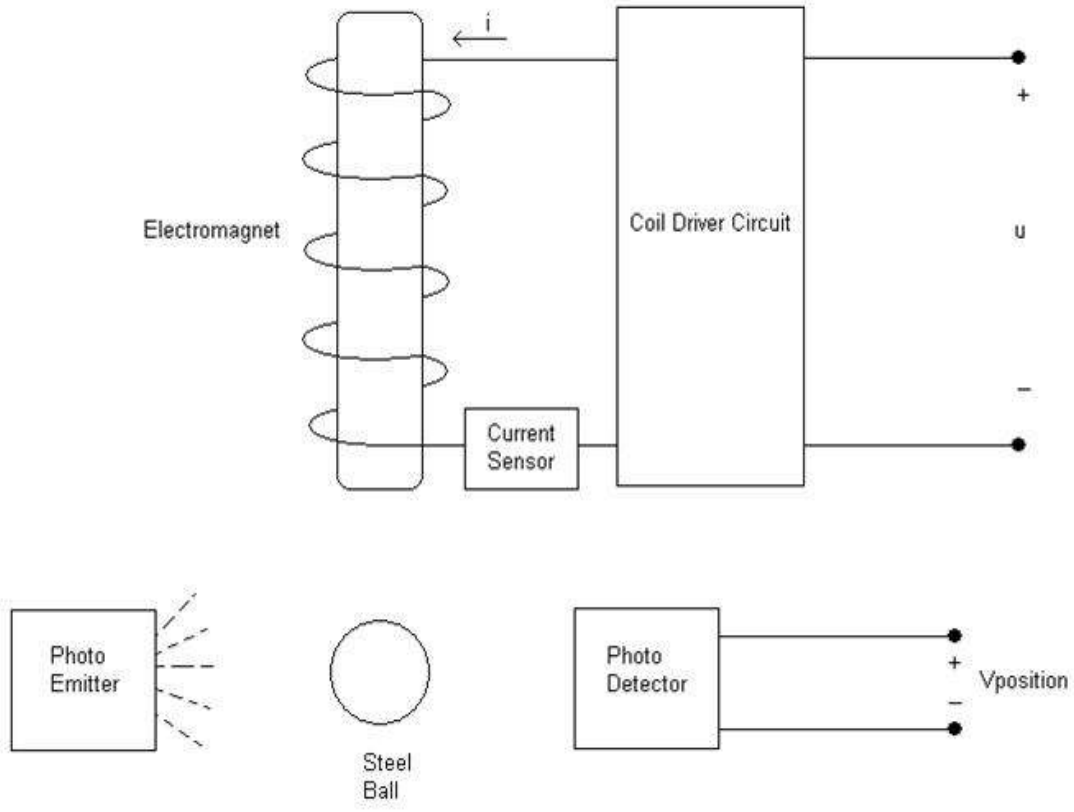

Fig. 3 – Plant Diagram

The ball is suspended using the electromagnet. The coil is driven using the coil driver circuit, the input of which is the voltage *u*. This voltage is applied directly by the xPC through the digital to analog converter. The current sensor is a one ohm resistor in series which allows measurements of current to be taken. The ball position is determined by the ball breaking a beam of light which is detected with the photo detector. This information is fed back to the xPC through the analog to digital converter.