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Magnetic Levitation using Real-Time PID

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***Abstract*—Magnetic levitation refers to floating of an object under the influence of electromagnetic force. The objective of this project is to build a system for achieving a stable magnetic levitation. It is controlled by a Proportional Integral Derivative (PID) control system. It is a closed loop control that monitors the position of the object. The controller attempts to minimize the error by adjusting the Pulse Width Modulation (PWM) input given to the coil. A hall sensor is used to monitor the position of the object and feedback any variations. A PIC microcontroller is used to implement the PID algorithm and drive the electromagnet**

Keywords—Magnetic levitation, PID control, PIC microcontroller

I. INTRODUCTION

Magnetic levitation systems suspends a ferromagnetic material. This eliminates frictional losses due to mechanical contacts. Due to this the object can be moved, oscillated or spun rapidly without any physical resistance. However, to obtain a stable magnetic levitation the electromagnet that creates the magnetic force needs to be controlled, Magnetic Levitation has a wide range of applications [3]. Transportation systems (high speed maglev trains), Aerospace Engineering (spacecraft launch system), Civil Engineering (elevators, cranes), Bio-medical Engineering (heart pump).

PID controllers typically use control loop feedback in industrial and control systems applications. The controller first computes a value of error as the difference between a measured process variable and preferred set-point. It then tries to minimize the error by increasing or decreasing the control inputs to the process, so that process variable moves closer to the set point. This method is most useful when a mathematical model of the process or control is too complicated or unknown. To increase performance, for example to increase the responsiveness of the system, PID parameters must be adjusted according to the specific application.

$$\text{Control Variable} = P_{out} + I_{out} + D_{out} \qquad (1)$$

This paper is focused on the building a system for achieving a stable magnetic levitation on a PIC microcontroller.

II. LEVITATOR MODEL

A. System Setup

The Levitation System is composed of an electromagnet, a hall-effect sensor, amplifier module, the micro-controller (PID mechanism) and a steel ball, etc. Its structure is simple, yet the control effect is very intuitionist and interesting [1]. The system works via the force of attraction between an electromagnet and the object. If the object gets too close to the electromagnet, the current in the electromagnet must be reduced. If the object gets too far, the current in the electromagnet must be increased to pull back the object to the equilibrium point.

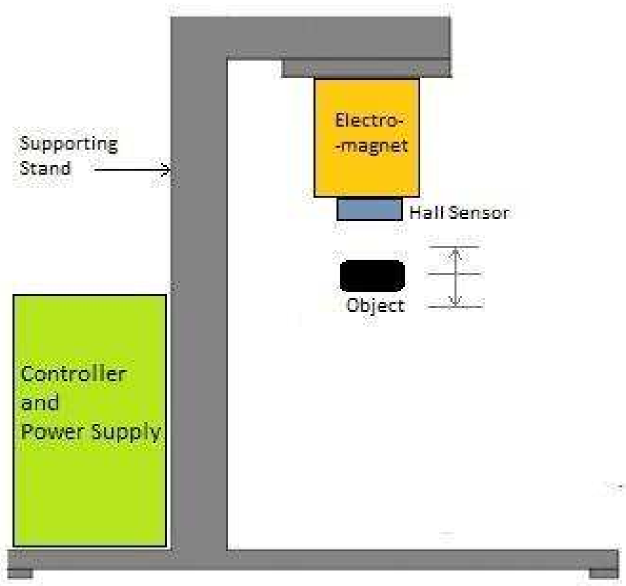

Fig. 1. System setup [1]

The main challenge in controlling the position of the suspended object is to maintain the balance of the weight of the suspended object and the electromagnetic force acting on it. We are interested only in controlling the vertical position of the suspended object. Thus all the dynamics will be concerned to vertical motion of the suspended object.

B. Calculations

Distance of object from electromagnet = 2.5cm

Margin of oscillation for the object = 1cm

Processing time for Single Iteration of PID = 1.1ms

Signal conditioning,

Hall sensor output range = 2.4V to 3.4V [7]

Amplifier design:
Senor output*2.47 - 4.07
Amplifier gain = 2.47
Subtractor = 4.07V

Using amplifier and resistive network,

Extended range = 1.8V to 4V

Electromagnet design [4],

I = 0.5629 A
F = 1.5691 N

C. Working of the circuit

The Hall sensor which is placed below the coil is used to sense the distance of the object from the coil. The sensor produces a voltage which is proportional to the magnetic flux incident on its flat surface. In case of weaker magnets, the Hall sensor output range will be less. To improve its response, we have provided a signal conditioning circuit. This circuit uses CMOS Op-Amp and a resistive network. This output is fed to the ADC input of the micro-controller. This will set up the feedback path.

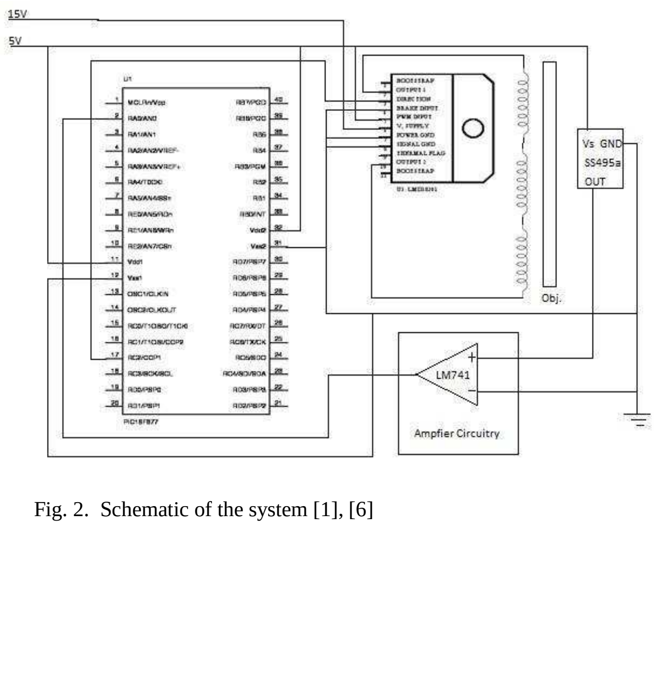

Fig. 2. Schematic of the system [1], [6]

The choice of the set point to be used in the control algorithm is based on the position of the object where it just balances its weight. We obtained this value after several attempts of identifying the optimum balance point. This set point may need to be changed depending on the desired distance of levitation. It should be noted that the power supplied to the coil should be sufficient to balance the object's weight. This requirement places a constraint on the weight of the object selected and the desired levitating distance.

Both attraction and repulsion is employed in a cycle. Positive width implies attraction and negative width implies repulsion. Low duty cycle (below 50%) will be repulsive whereas high duty cycle (above 50%) will be attractive.

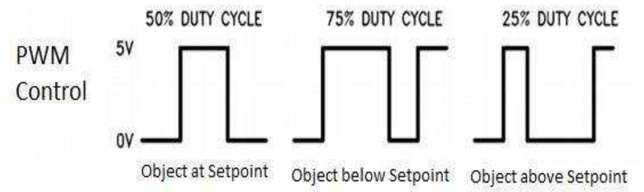

Fig. 3. Control of duty cycle for PWM [6]

III. Simulation Results

The simulation is made for the testing of PID and the implementation of PWM, this is done by using the Hall sensor output values according to datasheet.

A. PWM control results

At 50% duty cycle, the sensor output is 2.8V

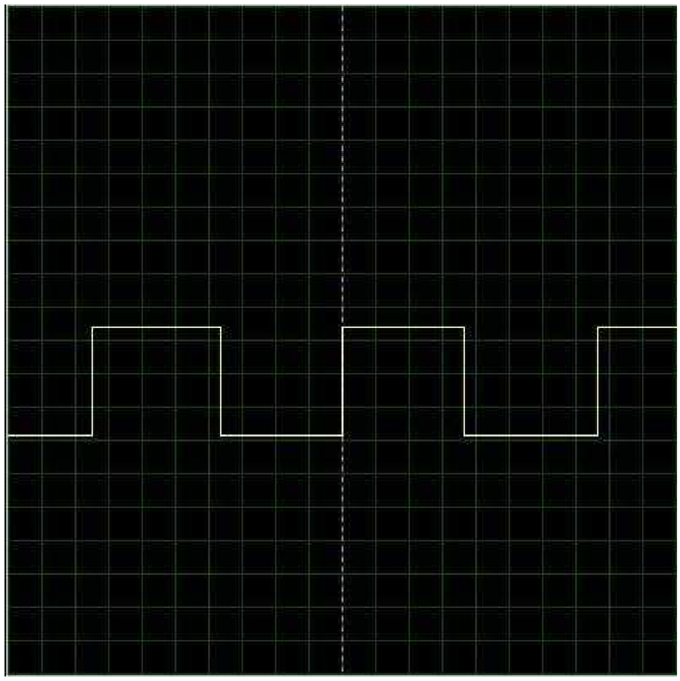

Fig. 4. 50% duty cycle PWM output.

At duty cycle less than 50%, the sensor output is 2.8V to 3.4V

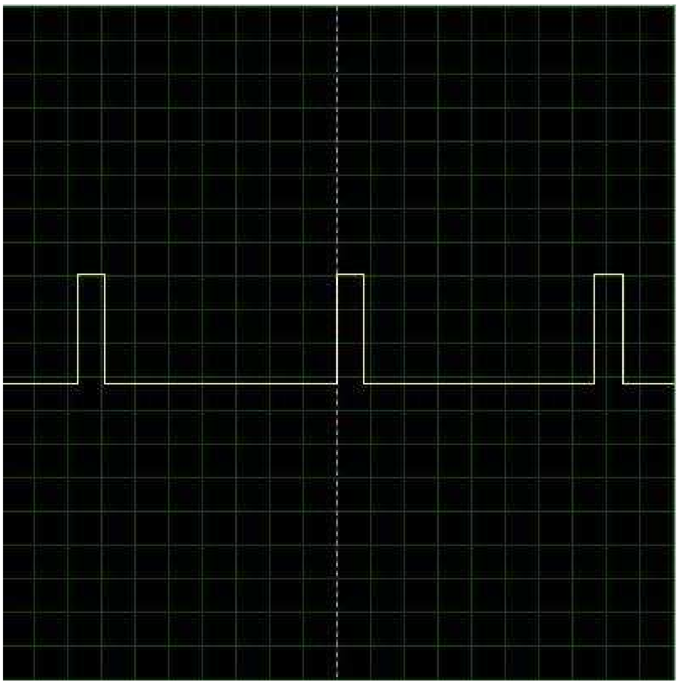

Fig. 5. Less than 50% duty cycle PWM output

At duty cycle greater than 50% the sensor output is 2.4V to 2.8V

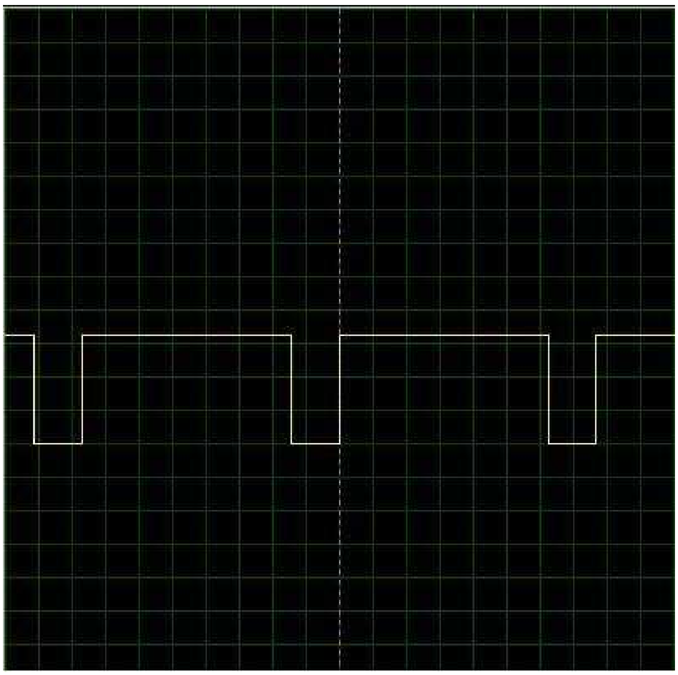

Fig. 6. Greater than 50% duty cycle PWM output

IV. CONCLUSION

The simulation results confirm that the PID control algorithm is working and the PWM is controlled as required according to the changes in the output of the sensor. However the tuning for the PID control is a difficult task that can only be done based on trial and error method, using the real-time values after the system is implemented.

The output range of sensor is increased to improve the control of the PWM on a larger scale. The PID control can be improved by selecting better PID coefficients.

REFERENCES

[1] Katie A. Lilienkamp and Kent Lundberg, "Low-cost magnetic levitation project kits for teaching feedback system design," *American Control Conference*, vol. 2, June 2004.

[2] Ashwani Soni, Abhishek Garg, Nikhil Kumar, Nitin Kumar, Akanksha Tayal, Shobhit University, Gangoh & Anurag Sighal, "Position Control for Electromagnetic Suspension System using FLC," *International Journal of Emerging Technology and Advanced Engineering*, vol. 4, issue 6, June 2014.

[3] Hamid Yaghoubi, "The Most Important Maglev Applications," *Journal of Engineering*, vol. 2013(2013), Article ID 537986, Acc. 19 Feb. 2013.

[4] Dahiru Sani Shuaibu and Sanusi Sani Adamu, "Design, Development and Testing of an Electromagnet for Magnetic Levitation System," *Technical report*, Department of Electrical Engineering, Bayero University, Kano Nigeria.

[5] Data Sheet, "PIC16X87XA Family," DS39582B, 2003.

[6] Data Sheet, "LMD 18200," National Semiconductor, September 1996.

[7] Data Sheet, "SS490 Series," Honeywell Inc.