Dynamic Ferrofluid Lamp

ECE445 Spring 2017

Mock Design Review

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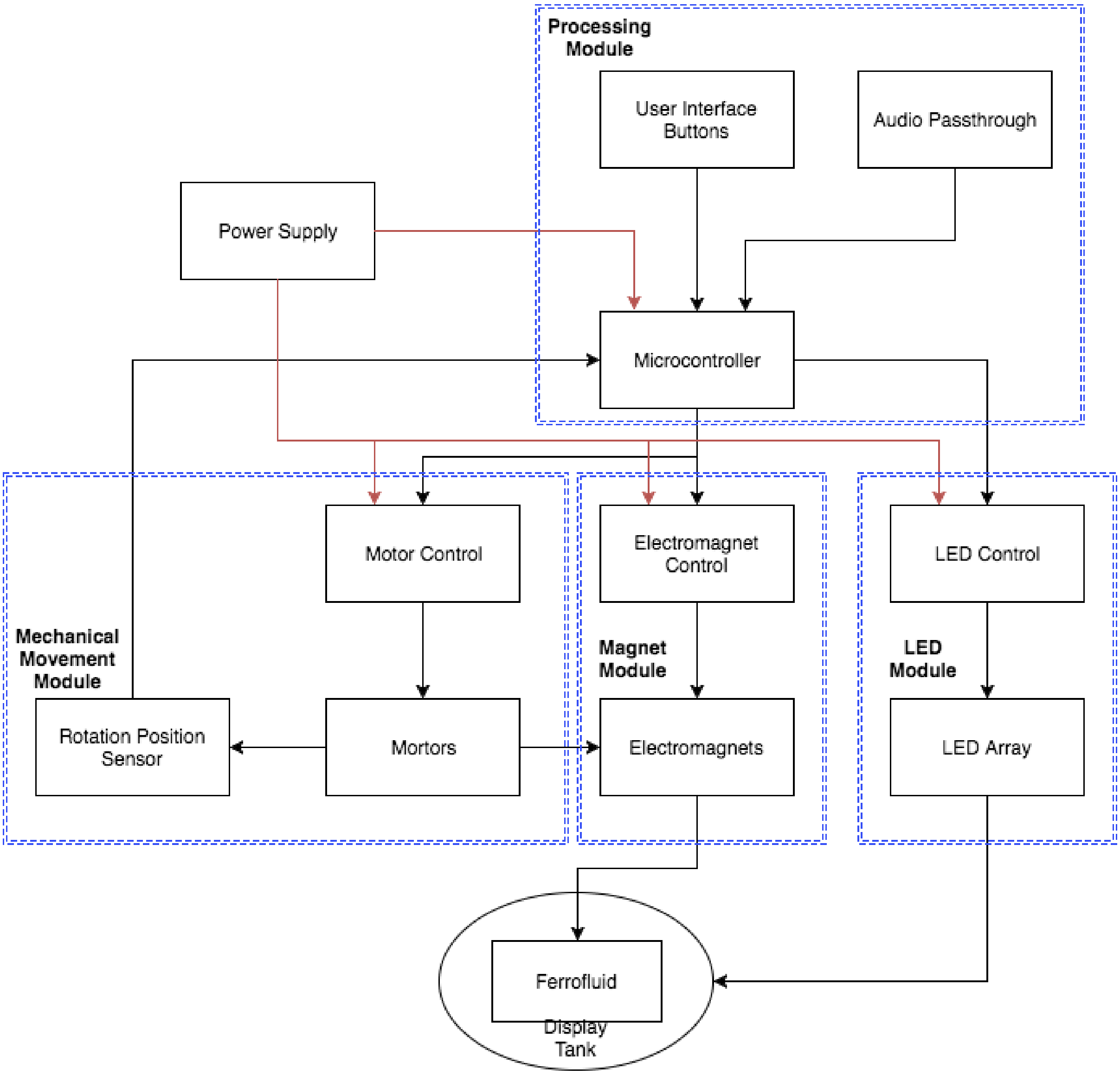
Introduction

Our dynamic ferrofluid lamp combines the lava lamp and the ferrofluid display such that users can not only use it as a lighting source, but also enjoy the amazing visual effects simultaneously. User-level interactions are also included such that users may modify the lighting intensity along with the ferrofluid with respect to some outside music. Users can set up the parameters to decide which frequencies of certain music will pass through, which will modify the magnetic field of the electromagnet array which in turn will change the shape of the ferrofluid. How the LED reacts to the sound depends on some pre-defined behaviors, such as the intensity of the LED will change according to different music(filtered by frequencies).

Block diagram



Block description

Mechanical Movement Module

The motor control unit receives a PWM signal, a clockwise signal, and a counterclockwise signal from the microcontroller that specify the speed and direction of the motors. We have three motors in total. Two of them are located at the bottom platform, one of which controls the vertical motion of the electromagnet located in inner cylinder, and the other controls the rotation movement of the bottom platform.

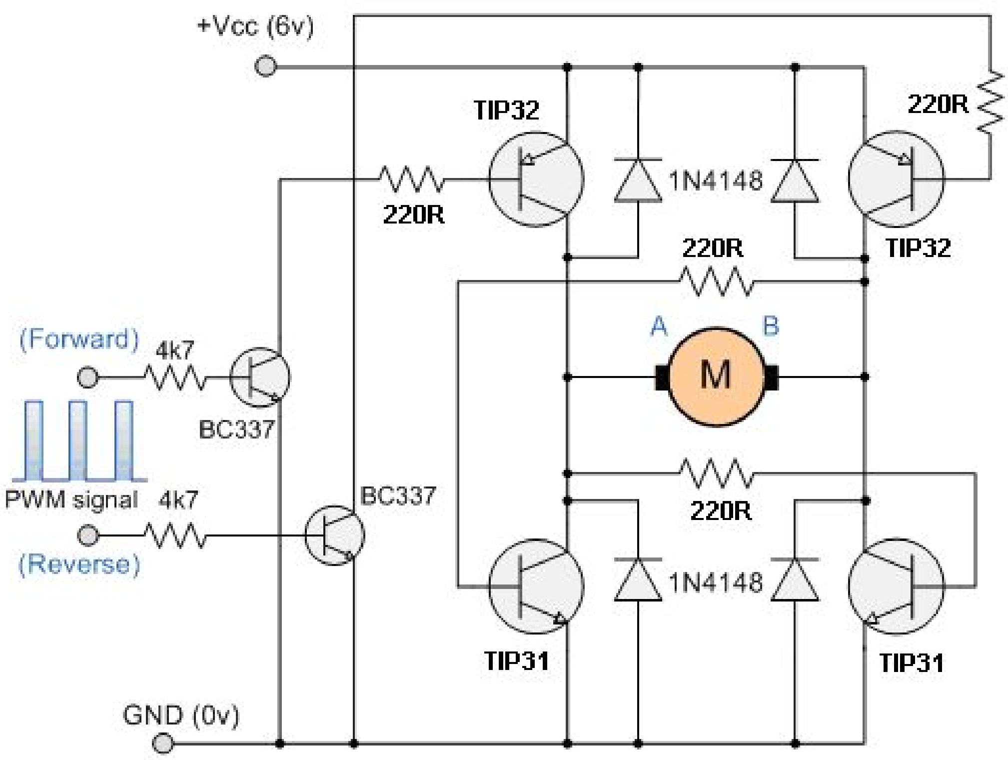
The third motor is located at the top platform and controls the rotation movement of that platform.

The rotation position sensor unit consists of pairs of infrared emitters and sensors. Aligned with holes in the rotation disks, these sensor pairs allow us to detect full rotations of the various platforms and notify the microprocessor. This will eliminate the accumulated offset between expected position and true position as time goes by.

The Motor unit consists of three motors. One will drive a threaded rod in the middle of the platform to move the electromagnet in the center cylinder vertically. The second motor will rotate the whole platform to provide rotational motion to the center electromagnet. The last motor will provide rotation to the electromagnet in the top compartment.

Circuit schematic

Motor Control: H bridge



Calculation

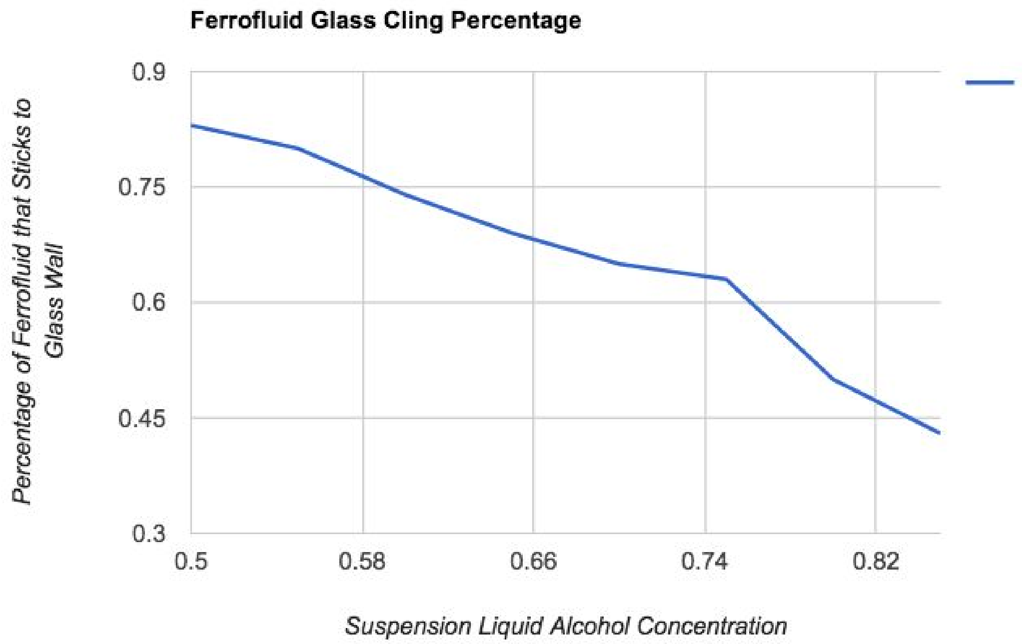
As what the previous group did in their last semester project[1], we are planning to use 22 AWG copper wire to wrap our electromagnet. The wire has a diameter of 0.0253 inches and an expected resistance of 52.939 Ohms/kilometer.

As for the number of wire loops around each electromagnet, we plan to have 250 loops on the electromagnet. Thus the length of the wires in total should be less than 5 centimeters. The magnetic field intensity can be calculated by following the equation: $B = \mu * n * I$, where B is the strength of the magnetic field, μ is the magnetic permeability of space, and n is the number of turns of wire per meter, and I is the current through the wire.

Because iron has a relatively large permeability, we would use iron as the core rod to drive the electromagnet. Therefore, μ here should be replaced with the permeability of the iron, which is 6.3 * 10e-3 H/m. Since we have 250 loops for 5 cm, the loop density is 250/5 = 50 turns/cm, which is 5000 turns/m. Together with the maximum current of 1A, we should have an estimated magnetic field strength of:

$B = (6.3 * 10e\text{-}3)(50)(1) = 31.5$ Tesla

Plot (experiment)



Requirements and Verifications

Requirement	Verification
The electric current passing through the slip ring[2] is 1A +/- 0.25A	1. Use a multimeter to measure the current passing through the slip ring at the beginning of the experiment 2. Use the same multimeter to measure the current passing through the slip ring 5 minutes later 3. Use the same multimeter to measure the current passing through the slip ring 10 minutes later 4. Make sure that each measurement of the current falls within our intended bound and if not, abort the experiment immediately and re-try.

Safety statement

When working with ferrofluid, it is important to correctly manipulate the ferrofluid. We will only select safe ferrofluids to play and test with. We will gather information about various potential ferrofluids first, then narrow down to the ones that are relatively safe. Also, the close distance between the ferrofluid and the electrical coils driving the magnetic fields is another significant risk. It would be extremely dangerous if the coils are broken and the ferrofluid leaks through the wires. During experiments, we will be testing in a watertight non-conducting box[3], and potentially wear non-conducting gloves to eliminate the risk as much as possible.

References

[1] Ferrofluid Clock Design Review, *Hanyao Zhang, TingWei Hsu, Zhiyuan Yao*, supervised under Luke Wendt, [online] https://courses.engr.illinois.edu/ece445/getfile.asp?id=8418

[2] Miniature Slip Ring, *Adafruit*, [online] https://www.adafruit.com/products/1195

[3] Comment added by Luke Wendt on Dynamic Ferrofluid Lamp, Team 59 Project Proposal, *Chen Huang, Chong Lu*,

[online] https://courses.engr.illinois.edu/ece445/getfile.asp?id=8826

[4] Electrical and Computer Engineering Machine Shop, *Scott A. McDonald*, Research Lab Shop Supervisor, 1049 ECE Building