Ferrofluid Clock

Project Proposal

ECE 445

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September 14th, 2016

Table of Contents

1. Introduction

1.1 Motivation/Statement of Purpose:

This project is important because it has the potential to provide viewing and entertainment value beyond what is offered by a standard digital clock (which doesn't really offer viewing pleasure). Admittedly, this project is not revolutionary in the sense that it holds humanitarian or significant research value -- nonetheless, it is still an interesting exploration of the future of dynamic and interactive displays. We selected this project because we wanted to create a product that each group member would consider personally using (stressing entertainment over strict practicality) and that could be described by the average onlooker as "fun."

1.2 Objectives:

The goal of the project is to create a ferrofluid clock that functions similarly to a typical digital clock. The end customer should be able to use the clock to tell time with suitable precision.

Expected Benefits:

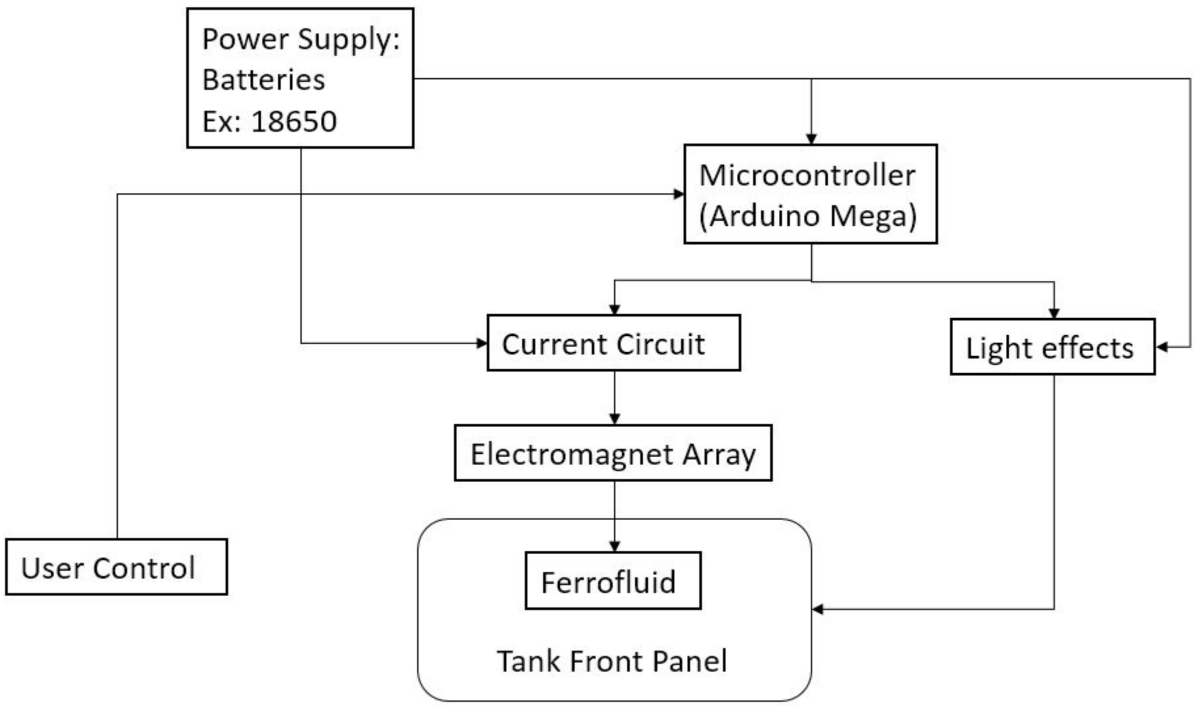
- Enhanced viewing pleasure over conventional digital clocks
- Everything offered by a typical timepiece (i.e. ability to tell time)
- General decorative value

Proposed Features:

- Moving ferrofluid display (numbers will be formed using ferrofluid) affected using a large array of electromagnets (at this time, we expect to require 64 separate electromagnets)
- Programming that allows the display to act as a digital clock
- Toggle-able blacklight to add spice to the display, as well as allow it to be viewable in the dark (fluid will have white or neon coloring added in)
- Toggle-able LEDs that can add color to the display under both light and dark conditions
- UI that allows the ability to change time manually

2. Design

2.1 Block Diagram:



2.2 Block Descriptions:

1. Ferrofluid tank(s) and front viewing panel - 5 self contained see-through chambers that each contains a certain amount of ferrofluid. The first and last two will contain 13x amounts of ferrofluid, while the center will contain 2x. “X” represents the amount required by each “pixel” in the display, which we plan to obtain experimentally. This is obviously the core of the display, acting as the “output” of our system.
2. Electromagnet array - array of 64 (expected) electromagnets that will be responsible for moving ferrofluid into its required spots. In essence, the electromagnets, in conjunction with the ferrofluid it attracts, act as the “pixels”
3. Microcontroller - Microprocessor unit using Arduino Mega. This controller has the record of current time and controls the electromagnet arrays. In detail, the microprocessor receives the current time and sends signals to the electromagnets in the arrays that need to be switched on. The sequence of switching on the electromagnets will be programmed into this unit based on the shape of the digits (importantly, ferrofluid will need to be moved up gradually, to counteract gravity). The microcontroller will also be responsible for controlling module 7.
4. User control - the interface and controls necessary to (through the microcontroller) allow the user to change the time displayed, as well as toggle the lights.

5. Power supply - consisting of rechargeable batteries, Ex: 18650 rechargeable li-ion battery. As the name suggests, this is responsible for providing power to the entire display.
6. Current circuit - a current control unit to assign required current to each electromagnets in the arrays. This will be affected by the microcontroller, and will, in turn, affect the electromagnet array.
7. Light effects - the black light and LED strips; the LEDs can be used to add color the display, while both can be used in conjunction to allow the display to viewable in a dim environment.

3. Requirements and Verification

Requirement	**Verification**
Display can be powered using a pack of batteries.	Use the battery pack to power all the electromagnets in all arrays and check to make sure all electromagnets act as expected.
Ferrofluid can be moved to any required “pixel” on the display.	Display all possible shapes of digits on each display and check if the desired shape is achieved.
Each pixel in the display will not hold more ferrofluid than 1.5 times 1/13th of the total ferrofluid in compartments 1,2,4, and 5, or ½ of the total ferrofluid in compartment 3.	Display all potential shapes on each display (i.e. 0-9, :) as well as all possible transitions. We will measure the sizes of all ferrofluid “pixels” in every case, checking that it is within tolerable levels. Size will be calculated from volume.
Temperature of the display casing does not reach unsafe levels (must stay under 107 degrees F, which is the threshold for a surface to become “too hot to touch”).	Continuously operate the device for an extended period of time (tentatively 24 hours, as stated in the next section) and measure the temperature over all external sections of the display.
All compartments of the display are leak-proof and can withstand a reasonable amount (tentatively 20 pounds) of trauma.	Drop and pressure test can be done on the compartments. We will test in high/low temperatures to stress the sealing material.
Blacklight and LEDs work when switched on and provides a visible effect.	Testing that the lights turn on and off is trivial. For visibility, we can test the strength of the effect under different lighting levels (e.g. brightly lit room, completely dark room)
The display must be portable.	All parts of the display, including the battery, must be contained within a single package. This package must not exceed 1 cubic meter (likely a generous limit) in size and 50 pounds in weight.

4. Tolerance Analysis

One of the most important aspects of our design is the current limitation of the power supply. We need to find out the minimal current that an electromagnet requires to attract the ferrofluid. We can't afford to use too much current, as doing so could lead to many disadvantages including power inefficiency, high temperature of the electromagnets, and quick depletion of the batteries..

We plan to test the operation temperature requirement by continuously operating the device for a period of 24 hours in room temperature and measure the temperature increase(s). We can then check the final temperature (and any intermittent temperatures, if they are higher than the final one) to check if it is either too high for comfort or high enough that it poses significant risk of damage to the system and/or surroundings.

The arrangement of the electromagnets will also be crucial. Since the electromagnets control the motion of the ferrofluid, they need to be able attract the ferrofluid correctly. The response between the magnet and the ferrofluid must be as expected. Otherwise, the tricks we would attempt later (i.e. displaying the time) would ultimately fail. We will test this by testing every possible case and adjusting the current through the magnets accordingly.

Lastly, the size of the whole design needs to fall within limits, as described in section 3. We need to make the display (particularly the electromagnets array and the tank) suitable for placement on a table while making the distance from which the digits can be discerned reasonable.

5. Cost and Schedule

5.1 Cost Analysis: LABOR

At this time, we will provide an estimate of each group member working on the project as 20 hours per week. With there being roughly ten weeks between now and expected project completion, our estimate for man hours required is 600.

Assuming a somewhat conservative $35 an hour, this amounts to $21,000. With overhead (2.5 times) factored in, we arrive at a total of $52,500 for the cost of labor.

5.2 Cost Analysis: PARTS

Parts	Estimated Cost (US Dollars)
Glass (or other clear material) rectangular prisms; flat to minimize ferrofluid required	30
Other sections of the chassis (wooden frame, base, support, etc.)	20
64 small electromagnets	20
Microcontroller	5
Wiring and gates	5
Input mechanism (likely buttons and knobs)	10
Battery	20
LED strips	5
Blacklight	5
Ferrofluid, coloring for blacklight	25
Total	145

Grand total = Cost of Labor + Cost of Parts = 52500 + 145 = 52645 USD.

5.3 Schedule

Week	Task	Responsibility
9/12	1. Finish project proposal; 2. Finish mandatory laboratory safety training; 3. Prepare and sign up mock design review. 4. Research the properties and making process of ferrofluid	Hanyao Zhang Ting-Wei Hsu Zhiyuan Yao
9/19	1. Mock design review 2. Start discussing the design specifications 3. Start designing the front panel, and begin drafting the Arduino design.	Hanyao Zhang Ting-Wei Hsu Zhiyuan Yao
9/26	1. Design review on style of the front panel. Make revision if necessary 2. Continue on Arduino design. 3. Start making sample electromagnets.	Hanyao Zhang Ting-Wei Hsu Zhiyuan Yao
10/3	1. Finalize the design of the front panel 2. Continue on control unit design. 3. Start on power supply design	Hanyao Zhang Ting-Wei Hsu Zhiyuan Yao

	4. Start the design of electromagnet arrays	
10/10	1. Continue all the on-going design processes. 2. Start design of the user interface. 3. Start testing with ferrofluid and mixing.	Hanyao Zhang Ting-Wei Hsu Zhiyuan Yao
10/17	1. Continue all the on-going design processes. 2. Start making prototypes of the front panel and the electromagnet arrays. 3. Finish the power supply design	Hanyao Zhang Ting-Wei Hsu Zhiyuan Yao
10/24	1. Finish the first draft of the Arduino control program 2. Finish first draft of user interface design	Hanyao Zhang Ting-Wei Hsu Zhiyuan Yao
10/31	1. Finish the drafts of all design-work 2. Finish the assembling of the arrays and test the basic function.	Hanyao Zhang Ting-Wei Hsu Zhiyuan Yao
11/7	1.Debugging and revision 2.Assemble the first prototype product and test	Hanyao Zhang Ting-Wei Hsu

		Zhiyuan Yao
11/14	1.Debugging and revision	Hanyao Zhang Ting-Wei Hsu Zhiyuan Yao
11/21 (Thanksgiving)	Enjoy Thanksgiving Break	Hanyao Zhang Ting-Wei Hsu Zhiyuan Yao
11/28	1.Test and verify 2. Demonstrations	Hanyao Zhang Ting-Wei Hsu Zhiyuan Yao
12/5	Final Presentation	Hanyao Zhang Ting-Wei Hsu Zhiyuan Yao