Ferrofluid Clock

Mock Design Review

ECE 445

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Introduction:
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 what may be 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.”

Design:
1. Block Diagram
2. Block Description

a) Ferrofluid tank(s) and front viewing panel
Five 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.

b) Electromagnet array array
of 65 (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”

c) 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.

d) 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.

e) 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.

f) 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.

h) 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. Circuit Schematic

4. Calculation
## 6. Requirement and Verifications:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification</th>
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<tbody>
<tr>
<td>Display can be powered using a standard 120V outlet. Maximum current should be 10A with +/- 10%.</td>
<td>Use the wall outlet to power all the electromagnets in all arrays, as well as all lights, and check to make sure all components act as expected.</td>
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<tr>
<td>Ferrofluid can be moved to any required “pixel” on the display.</td>
<td>Display all possible shapes of digits on each display and check if the desired shape is achieved.</td>
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<tr>
<td>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.</td>
<td>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.</td>
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<tr>
<td>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”).</td>
<td>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.</td>
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<tr>
<td>All compartments of the display are leak-proof and can withstand a reasonable amount (tentatively 20 pounds) of trauma.</td>
<td>Drop and pressure test can be done on the compartments. We will test in high/low temperatures to stress the sealing material.</td>
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<tr>
<td>Blacklight and LEDs work when switched on and provides a visible effect.</td>
<td>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)</td>
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<tr>
<td>Current through an electromagnet should be around 0.1 A.</td>
<td>Measure the current going through the heads of each solenoid using a multimeter (?).</td>
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<td>Each electromagnet produces the same field strength when provided with the same current within a 20% margin of error.</td>
<td></td>
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<tr>
<td>The maximum time required to change numbers on the display does not exceed 15 seconds.</td>
<td>Test every possible transition (e.g. 1 to 2, 5 to 6) 10 times each. Measure how long each transition takes and ensure that no trials fail the requirement.</td>
</tr>
<tr>
<td>Number of electromagnets: 65</td>
<td>Verifying this requirement is trivial.</td>
</tr>
</tbody>
</table>
Tolerance Analysis:

Cost and Analysis:

Schedule:

Ethics and Safety:
Safety is one of the most important concerns in creating our project; while what we hope to achieve with this project is more or less aesthetics, it goes without saying that we must also consider possible safety hazards in the design process.

First, the material we use needs to fulfill safety standards. We will use only a safe ferrofluid (that is, we will avoid using highly toxic, industrial grade products). Meanwhile, the fluid filled into the container along with the ferrofluid will not contain any hazardous materials. The seal of each container will be rigorously tested to ensure user safety and product usability. This last bit is particularly important due to the inherent volatility present when a fluid and electronics are in close proximity to each other.

Second, we considered the operation conditions and environment of the clock. Since the size of the clock will allow for desk use, we will use something like plexiglass for the outer shell to shatterproof the product to some degree. In addition, when the electromagnet arrays are in operation, current goes through the body of the clock and causes heat to be produced. In order to not burn the user, we considered either adding buffer material to the outer shell of the frame or to try to limit the maximum temperature the clock can reasonably reach.

Citations and References: