ECE 445 Spring 2017

Lava Lamp 2.0
The Inductioning
TEAM 44

Final Presentation
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INTRODUCTION
INTRODUCTION TO A LAVA LAMP

- Water
- Wax
- Heating source
- Density difference
## COMPARING LAVA LAMPS

<table>
<thead>
<tr>
<th></th>
<th>CLASSIC</th>
<th>LAVA 1.0</th>
<th>LAVA 2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow time:</td>
<td>2 hours</td>
<td>25 minutes</td>
<td>10 minutes</td>
</tr>
<tr>
<td>Brightness:</td>
<td>25W incandescent</td>
<td>2 color LED’s</td>
<td>3 ultra-bright white LED’s &amp; 3 color LED</td>
</tr>
<tr>
<td>Interactivity:</td>
<td>None</td>
<td>1 button, 1 lever: 5 colors &amp; variable brightness</td>
<td>2 buttons: 7 colors &amp; 5 brightness levels</td>
</tr>
<tr>
<td>Safety:</td>
<td>None</td>
<td>Temperature control</td>
<td>Temperature control + cool globe</td>
</tr>
</tbody>
</table>
OBJECTIVES

- OPERATION ➔ 50°C within 10 minutes
- BRIGHTNESS ➔ 3000 lux at 1 ft.
- INTERACTIVITY ➔ 7 Colors, 5 Brightnesses
- SAFETY ➔ 45°C outside the globe
PHYSICAL DESIGN

- Liquid Container (Glass)
- Temperature Sensor
- Passive Coil
- Active Coil
- LED lights
- PCB
LED PCB
LED PCB
MCU PCB
BLOCK DIAGRAM
BLOCK DIAGRAM

Control System
- Temperature Data
- DC Power
- On-Unit Input
- Light Control
- Temperature Control
- MCU

Measurement System
- Heat
- Temperature Data
- Temperature Sensor

Power System
- Data
- DC Power
- AC
- AC/DC

Energy System
- DC Power
- Light
- LED lights
- DC power
- EM Field
- Active Coil & Inverter

Glass
- Liquid
- Light
- EM Field
- Heat
- Passive Coil
MICROCONTROLLER UNIT (MCU)
# MCU Inputs & Outputs

<table>
<thead>
<tr>
<th>PIN</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Button 1</td>
<td>Input</td>
</tr>
<tr>
<td>Button 2</td>
<td>Input</td>
</tr>
<tr>
<td>Lava Temperature Sensor</td>
<td>Input</td>
</tr>
<tr>
<td>Heat Temperature Sensor</td>
<td>Input</td>
</tr>
<tr>
<td>Red LED PWM</td>
<td>Output</td>
</tr>
<tr>
<td>Green LED PWM</td>
<td>Output</td>
</tr>
<tr>
<td>Blue LED PWM</td>
<td>Output</td>
</tr>
<tr>
<td>White LED PWM</td>
<td>Output</td>
</tr>
<tr>
<td>Heat Output</td>
<td>Output</td>
</tr>
</tbody>
</table>

**Inputs:** 2

**Outputs:**
- 4 ×
- 1 ×

**Inputs:**
- 2 ×
- 2 ×

**Outputs:**
- 4 ×
- 1 ×
void loop()
{
    //Light
    userInput();  //Read User Input (button1, button2)
    calcLEDs();  //Calculate LED PWM Signals
    setLEDs();   //set LED PWM Signals;
    //Heat
    tempInput(); //Read Temperature Sensors
    calcHeat();  //Calculate Heat PWM Signals
    setHeat();   //Set Heat PWM Signals
}
MCU REQUIREMENTS

☑ LED light control
## MCU UNIT REQUIREMENTS

- Heat control

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Temp. Sensor Voltage (V)</th>
<th>MCU heat output to MOSFET (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;50°C</td>
<td>&gt;1.0</td>
<td>0</td>
</tr>
<tr>
<td>&lt;=50°C</td>
<td>&lt;=1.0</td>
<td>5</td>
</tr>
</tbody>
</table>
MCU REQUIREMENTS

Heat control

OUTPUT:
HIGH (5V)

INPUT:
1V (50°C)
TEMPERATURE SENSORS
TEMPERATURE SENSORS VERIFICATIONS

\[ Voltage[V] = 0.75 + (Temperature[^{°C}] - 25) \times 0.01 \]

- Measurement once every 15 sec.
- Output readable by MCU
- Precision of ±2 °C

- TESTED
- 0.1 to 1.75V
- (-40 to 125 °C)
- Equivalent to ±0.02V
LED CIRCUIT

Input

2
User

AC Wall Outlet

1

Control System

Data
DC Power
AC
AC/DC

Power System

Data
DC power
AC
AC/DC

Energy System

DC Power
LED lights

Active Coil & Inverter

DC power
EM Field

Passive Coil

EM Field
Heat

Liquid

Light

CREE

XR-M Color
LIGHTING REQUIREMENTS

Produce 3000 lux
1 foot away from light source

3566 lx
LIGHTING REQUIREMENTS

1124 lx

1149 lx

1844 lx

1119 lx

1574 lx

2489 lx
LIGHTING REQUIREMENTS

Control illuminance at 5 increments
LIGHTING REQUIREMENTS

Switch between

- Red
- Orange
- Yellow
- Green
- Blue
- Violet
- White
LIGHTING REQUIREMENTS
LED AND MCU POWER REQUIREMENTS

Supply 8.6V DC to LED circuit
LED AND MCU POWER REQUIREMENTS

Supply 3.3V DC to MCU
## ADDITIONAL POWER REQUIREMENTS

- LED circuit operates within 10A and 60W

<table>
<thead>
<tr>
<th>Mode</th>
<th>Current (A)</th>
<th>Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All on</td>
<td>5.11A</td>
<td>12.734W</td>
</tr>
<tr>
<td>White</td>
<td>1.8A</td>
<td>5.7W</td>
</tr>
<tr>
<td>R/G/B</td>
<td>1.03A</td>
<td>2.55W</td>
</tr>
<tr>
<td>O/Y/V</td>
<td>2.1A</td>
<td>5W</td>
</tr>
</tbody>
</table>
INDUCTION POWER SUPPLY

- 115:24 turn transformer
- Full-bridge rectifier
- Filter capacitor
- Equation for filter cap value:

\[ C = \frac{it}{\Delta V} \]
INDUCTION POWER REQUIREMENTS

120V AC to 34V DC
INDUCTION

Control System
- Temperature Data
- DC Power
- Light Control

Measurement System
- Heat
- Temperature

User
- AC Wall Outlet
- AC/DC
- DC power
- Data

Active Coil & Inverter
- DC power
- EM Field

Passive Coil
- EM Field
- Heat

Diagram showing the flow of power and control in an induction system.
HAND-BUILT INDUCTION DRIVER

- Built as a ZVS driver
- Frequency determined by: 
  \[ f = \frac{1}{2\pi\sqrt{LC}} \]
- Damaged MOSFETS prevented further testing
PRE-BUILT INDUCTION DRIVER

- Same basic design as hand built driver
- Built more robustly (capable of producing 1000W)
- Used to conduct induction tests
INDUCTION CIRCUIT
INDUCTION REQUIREMENTS

Heat water to 50°C within 10 minutes
INDUCTION REQUIREMENTS

Make sure active coil does not exceed 44°C
INDUCTION REQUIREMENTS

Surface temperature of glass does not exceed 44°C
CONCLUSIONS

- **OPERATION**: 50°C within 10 minutes
- **BRIGHTNESS**: 3000 lux at 1ft
- **CONTROL**: 7 Colours, 5 Brightnesses
- **SAFETY**: 45°C outside the globe
FUTURE WORK

- Integration of components into one working unit:
  - Power supplies
  - PCBs
- Better active coil to prevent overheating
  - Research in coils
- Updated physical design
Thanks Everybody!

Questions