Rebirth of Iconic 60's Technology: Dynamically Lighted, Closed-Loop Temperature Controlled Lava Globe

ECE445 Project Proposal

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1.0 Introduction

1.1 Motivation and Purpose

The traditional lava lamp is an iconic piece of technology. However, it has not changed much in the almost six decades that it has been around. The current models can take upwards of an hour to sufficiently heat the lava material enough for it to start moving. Not only that but they also lack heat safety features. Instead, their temperatures continue to rise to unsafe levels. The high temperatures also take away from the lava lamps visual appeal by causing the lava globules to become small and stay near the top of the container. Furthermore, current lava lamps offer no interaction to the user. Our project will address these concerns and bring the lava lamp into the modern era.

1.2 Objectives

User Requirements

- Reaches operational temperature within 40 minutes
- Thermal regulation prevents the product from reaching unsafe temperatures
- Provides more ambient light than traditional lava lamps
- Dimmer switch and mode button cycles distinct pre-programmed color modes

Product Features

- Easily plugs into any standard U.S. outlet
- Consumes less energy than other models
- Starts working 50% faster than other models
- Dynamic multicolored lighting
- Interesting and attractive conversation piece
- User can adjust light settings: brightness and color

2.0 Design

2.1 Block Diagram

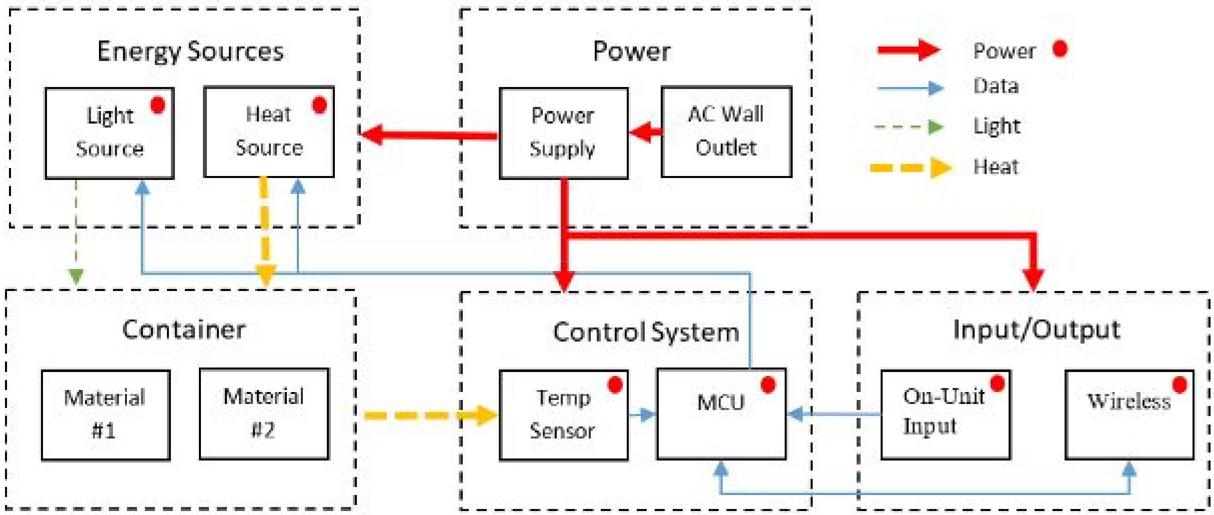

Figure 1: Lava globe block diagram

2.2 Block Descriptions

The elements within Figure 1 will be explained.

Power

AC Wall Outlet

The main power source for the project. This source provides 120V at 60Hz to the power supply.

Power Supply

The power supply receives input power from either an AC wall outlet or a lab bench power supply. This power is then transformed to appropriate levels for the various components throughout the lava globe that require power: the light source, heat source, temperature sensor, microcontroller (MCU), on-unit input, and wireless. Once transformed the power is directed to its destination module.

Energy Sources

Heat Source

The heat source receives data from the MCU and power from the power supply. The data is used to tell the heat source how much heat to produce. The provided power allows the heat source to produce heat. The heat is focused on the lava globe sphere in order to give enough kinetic energy to the globules to start moving.

Light Source

The light source receives data from the MCU and power from the power supply. The data are used to control the brightness and color of the lights. This light is used to illuminate the globules moving within the lava globe sphere and output light to the room.

Control System

Microcontroller

This module receives power from the power supply and either analog or digital data from the temperature sensor. The power allows the microcontroller to operate. The temperature sensor data is used to determine how much heat the heating source should produce. The MCU also sends data to the light source.

Temperature Sensor

The temperature sensor receives radiated heat from the lava globe sphere. This heat is converted into a voltage and sent to the MCU.

Lava globe sphere (container)

The lava globe sphere receives light from the light source and heat from the heating source. The light is used for the illumination of the globules within the sphere. The heat is used to give motion to these globules, but is also dispersed throughout the rest of the sphere. The sphere will radiate this heat and it will be measured by the temperature sensor.

User Controls

On-Unit Input

The on-unit input receives power from the power supply and input from the user. The user provides the input via either a button press or sliding a dimmer switch. This input is then sent to the MCU for processing.

Wireless

This block receives power from the power supply and also receives a wireless signal from the user. The user signal is relayed to the MCU where it is processed. Any feedback is transmitted back to the user via a wireless signal.

3.0 Requirements and Verifications

Requirements	**Verification**
AC Wall Outlet 1. Able to plug in a standard US 2-prong plug and receive at least 5 A AC between 115-125 V (rms) AC. The frequency should remain between 58-62 Hz.	AC Power Cord 1. Verification for item 1 a. Obtain a 2-prong working appliance (laptop charger, toaster, etc.) b. Plug in said appliance into the outlet c. Verify the appliance works properly, if so it passes
Power Supply 1. Accept 120V AC input and supply at least 5A at 19 - 20V 2. Provide at least 5A at 4.7 - 5V	Power Supply 1. Verification for item 1 a. Assemble a 4Ω resistor network that can dissipate 100W b. Connect the 20V output across the resistor network c. Use a multimeter to measure the voltage across the 20V output d. It should remain between 19V - 20V 2. Verification for item 2 a. Assemble a 1Ω resistor network that can dissipate 25W b. Connect the 5V output across the resistor network c. Use a multimeter to measure the voltage across the 5V output d. It should remain between 4.7V - 5V
Light Source 1. Must produce at least 300 lumens of light.	Light Source 1. Verification for item 1 a. Use a light meter 1m away from the lava lamp, in three directions 60° apart and horizontal to the lamp b. Measure at least 300 lux

2. Must be able to control power in increments of 30 lumens or less	2. Verification for item 2 a. From minimum power, step power up by small increments until the light meter registers a change in output. b. Record the flux as above and repeat c. At least 10 flux levels should have been recorded, each differing by less than 30 lux
3. Provide red, green, blue, purple, and pink lighting.	3. Verification for item 3 a. Use a cell phone camera to capture the light b. Use a color picker tool to confirm that the average hue and saturation of the lamp differs from the target hue by no more than 20° and target saturation by no more than 0.1 in either direction
Heat Source 1. Must provide at least 60W with a supply power of 20V. 2. Must be able adjust power in increments of 10W with a supply power of 20V.	Heat Source 1. Verification for item 1 a. Connect an ammeter inline with the heat source to a lab power supply at 20V b. Supply a control signal to produce maximum power c. Confirm that the heat source sinks at least 3A 2. Verification for item 2 a. Connect ammeter as above b. Use control to step power up by smallest increments. c. Record the current as above and repeat d. At least 6 levels should have been recorded, each differing by less than 0.5 A

Temperature Sensor 1. Able to take a temperature measurement at least once every minute. Need to work out controls problem before we know more. 2. Able to track temperature to at least one degree. Need to work out controls problem before we know more.	Temperature Sensor 1. Verification for item 1 a. Attach the temperature sensor to an object b. Heat the object c. Use the temperature sensor and an independent heat measurement device to track the heat change d. If the temperature matches the independent thermometer every minute then the requirement is met 2. Verification for item 2 a. Look at the data sheets
Microcontroller 1. Needs at least four input channels 2. Needs at least five output channels 3. Needs at least 20kB of memory 4. Needs a clock of at least 20 MHz 5. Needs to be able to run on 5V±1V	Microcontroller 1. Verification for item 1 a. Verify with the datasheet 2. Verification for item 2 a. Verify with the datasheet 3. Verification for item 3 a. Verify with the datasheet 4. Verification for item 4 a. Hook up the clock pin to the oscilloscope positive terminal and ground to the ground terminal b. Measure the clock frequency 5. Verification for item 5 a. Verify with the datasheet
Lava globe sphere 1. Needs to be watertight	Lava globe sphere 1. Verification for item 1 a. Seal the container with air inside b. Place container in a tub of water c. If there are no air bubbles then there is a good seal.

2. Able to handle temperatures up to 200 degrees Fahrenheit without damage. 3. Able to handle pressures up to 5 psi.	2. Verification for item 2 a. Check the associated documentation 3. Verification for item 3 a. Check the associated documentation
On-Unit Input 1. Able to accept user input and transmit the correct state to the MCU	On-Unit Input 1. Verification for item 1 a. From the output of the On-Unit Input, hook up the signal and GND to a multimeter positive and negative terminals respectively b. Vary the user input and verify the signal changes accordingly
Wireless 1. Be able to transmit and receive at a rate of at least 9600 baud.	Wireless 1. Verification for item 1 a. Check the datasheet

4.0 Tolerance Analysis

The most important module within this project is the heating source. Correct regulation of heat is critical to both the function and safety of the lava globe. Our operational temperature is 150ºF±2ºF. With the exception of startup (room temperature-150ºF), keeping the temperature of the heating source within this operational range will ensure both optimal lava globule conditions and thermal safety requirements are met.

We will confirm this tolerance is met by turning on the lava globe from room temperature, allow the lava globe to reach its optimal temperature of 150ºF, and then continue to monitor the temperature for six consecutive hours. If the temperature does not leave the 148ºF-152ºF range then the tolerance will be confirmed. This test will compensate for the tolerances of any components along power chain. This final temperature range is the most critical.

5.0 Cost and Schedule

5.1 Cost Analysis

Personnel	
Average Starting Salary	$67,000 [1]
Per Hour Rate	$32
Total Hours (20 / Week)	280
Personnel Cost (3 members)	$27,056
Total Cost (with overhead)	**$67,641**

Parts	
Power Supply (AC -> 5V, 5 A) with Power Plug	$13.95 [2]
Tactile Button	$0.89 [3]
Sliding Potentiometer	$2.85 [4]
30W Heating Resistors x3	$15 [5]
Analog RGB Strip	$19.95 [6]
Temperature Sensor	$2.27 [7]
ATmega328P	$2.00 [8]
Lava Container	$29.99 [9]
Bluetooth Module	$31.00 [10]
Total Parts Cost	**$117.90**

5.2 Schedule Summary

Week	Matt	Devin	Daniel
09/11 - 09/17	Proposal	Proposal	Proposal
09/18 - 09/24	Research Control Problem	Research Lighting MCU Control	Begin conversations with ID (Industrial Design) contact
09/25 - 10/01	Research Cntrl Prob. (cont) PCB Design	Research Wireless PCB Design Update ID contact	Research Heating Element Temperature Sensor
10/02 - 10/08	Design Review Update ID contact	Design Review	Design Review
10/09 - 10/15	Design PWM Circuit Design power supply	Conduct heating tests Update ID contact	Begin coding heating element logic
10/16 - 10/22	Test PWM Test power supply	Begin coding light logic	Test heating element logic Update ID contact
10/23 - 10/29	Revise PCB	Test light logic Finalize machine shop design Update ID contact	Finalize machine shop design
10/30 - 11/05	Finalize PCB Design Assemble and test prototype Update ID contact	Configure wireless Assemble and test prototype	Assemble and test prototype
11/06 - 11/12	Revise R&V Continue testing prototype	Revise R&V Continue testing prototype Update ID contact	Revise R&V Continue testing prototype
11/13 - 11/19	Final Testing	Final Testing	Final Testing Update ID contact
11/20 - 11/26	Break	Break	Break
11/27 - 12/03	Create Videos / Demo	Create Videos / Demo	Create Videos / Demo
12/04 - 12/10	Final Paper	Final Paper	Final Paper

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