SOLAR TRACKING AND LIGHTING DESIGN FOR A MULTIMEDIA SCULPTURE

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CODY MIDDLETON
CHELSEA RUSSELL
OVERVIEW

- Acknowledgments
- Project Description
- Specifications
- Mechanical
- Electrical System
- Programming
- Validation
- Recommendations
- Summary
ACKNOWLEDGEMENTS

• Financial Support
  • Coloma High School

• Advising
  • R. Gejji
  • D.A. Miller

• Mechanical Expertise
  • Jonathan Rhodes

• Mount Build Support
  • General Motors
Need Statement:

Coloma High School needs a control system design utilizing solar panels to power their sculpture, “A Coloma student is...”.
I. Electrical
   i. Output power of solar panels will charge the battery.
   ii. Output power of battery will be used to power the system.

II. Environmental
   i. All exterior components must be weatherproof.
   ii. All electrical components must withstand extreme temperatures (-20 °F/100 °F).

III. Control
   i. The system will control motor to position solar panels for optimal energy collection.
   ii. Power usage must be optimized to run for 7 days of low solar panel input without interruption.

IV. Lighting System
   i. The lights will have multiple color options including school colors.
   ii. Lighting must be connected to allow easy replacements or additions of lights.
MECHANICAL OVERVIEW

- Design
- Modeling
- Build
- Problems Encountered
**Goals:**

- ✓ 90° of daily rotation
- ✓ 3 adjustable seasonal angles
- ✓ Durable
- ✓ Inexpensive
MECHANICAL MODELING
Results:

- Up to 74° of daily rotation
- 3 adjustable seasonal angles
- Durable
PROBLEMS ENCOUNTERED

Set screw rounding
- Tension pin added
- Set screw flattened

Motor movement
- Motor modification
- Struts added
ELECTRICAL SYSTEM OVERVIEW

• Motor Control Circuit
• Positional Feedback
• LED Controls
• LED Connections
• Switches
### MOTOR CONTROL CIRCUIT

- **Logic controls:**
  - **Direction:** High = Clockwise  
    Low = Counterclockwise
  - **Brake:** High = stop motor
  - **PWM:** Controls speed of motor
  - **Photovoltaic Isolator** to isolate motor noise
• Problem: Analog values fluctuate rapidly
• Solution: Moving average function to smooth results
  • Trade off between accuracy and speed of response
LED CONTROLS

Red, White, and Blue
Red: R: 255 G: 0 B: 0
White: R: 255 G: 255 B: 255
Blue: R: 0 G: 0 B: 255

Coloma Green and Gold:
Green: R: 195 G: 235 B: 5
Gold: R: 14 G: 170 B: 8
**LED CONNECTIONS**

Problem: Intermittent connections when soldering to solder pads

Many solutions attempted:
• solder
• electrical tape
• hot glue
• heat shrink

Recommendation:
• purchase LED strips at needed lengths and DO NOT cut.
SWITCHES

- Lighting control switches

<table>
<thead>
<tr>
<th>SW1</th>
<th>SW2</th>
<th>SW3</th>
<th>Color</th>
<th>Function</th>
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<td>Solid</td>
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- Limit Switches
  - Stops motor if position of solar panel is too close to hitting the post
  - Backup for accelerometer

- System Control Switch
  - Position 1: Remote Mode
  - Position 2: Normal Mode
  - Position 3: Off
PROTOTYPING BOARD
SYSTEM BUILD
PROGRAMMING OVERVIEW

• Tracking
• NIGHTMODE
• Lighting
• Remote
• Recovery
SOLAR TRACKING ALGORITHM

1. Wait 1 hour
2. Timer Interrupt Triggered
3. Rotate Solar Panel 15°
4. Store Solar Panel Voltage
5. Solar Panel Voltage Increases
6. Move Panel 5°
7. Solar Panel Voltage Decreases
8. Solar Panel Voltage Decreases
SUNRISE AND SUNSET DETECTION

Tracker Function

Solar Panel Voltage < 13V AND
Accelerometer Position > 74°

Wait 3 hours

Solar Panel Voltage > 17V

Monitor Solar Panel Voltage

Return Panel to Start Position

Solar Panel Voltage < 17V
LIGHTING

• External Interrupts
• 3 modes
• 3 Color Combinations
  • Coloma Green and Gold
  • Red, White, and Blue
  • Rainbow

SOLID

FADE

BLINK
• Serial Communication
• Read from laptop keyboard
• Motor Control
  • Speed
  • Position
• RGB LED Control
  • Color
  • Mode
• Diagnostics
  • Solar Panel Voltage
  • Angle
  • Timer Value

**********MIDDLETON MOTOR CONTROLLER**********
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** For Motor Control Press s 
** For Color Press c 
** For Diagnostics Press d 
**********
RECOVERY

Limit Switch Triggered → Break From Move Motor Loop → Move Motor in Opposite direction → Record Error in Diagnostics
PROGRAM VALIDATION

- Programs Tested
  - Tracking
  - NIGHT
  - External Interrupts
  - Light Control
- Sensors simulated
- System Test Code
  - Data Logger
  - Motor Script
VALIDATION

Parkview Sunset Tracking

Voltage vs. Time of Day graph showing a drop in voltage as the day progresses.
# Power Budget

<table>
<thead>
<tr>
<th>Part</th>
<th>Number</th>
<th>Power (W)</th>
<th>Hours/day</th>
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SPECIFICATIONS MET

I. Electrical
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- Output power of battery will be used to power the system.

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- The lights will have multiple color options including school colors.
- Lighting must be connected to allow easy replacements or additions of lights.
RECOMMENDATIONS

✓ Purchase a more robust motor

✓ Design the circuit on a PCB

✓ Optimize the solar tracking algorithm
SUMMARY

✓ Three seasonal angles
✓ Up to 74° of daily rotation
✓ Hourly Tracking
✓ Three color combinations
✓ Three lighting modes
### ELECTRONIC BUILD: ACCELEROMETER

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Parkview Midday Testing