Autonomous Solar Pool Heater

Group 5 – Damian Shchur, Siddharth Patel, Daniele Sbaglia
Solar Pool Heater

- A gas or electric pool heater can be quite expensive
- Solar heaters can be a great low cost way of heating up a pool but they come with their own set of challenges
Project scheme

- The system will consist of two thermistors, two valves, a water pump and a solar heater all interfaced with our BS2 Controller.
- Thermistor T₁ will be placed in the pool. Thermistor T₂ will be placed in the solar fixture.
How it works

• The pump will send water through the filter, and into a three way valve. Normally, water will flow through the NO port of the valve directly back into the pool.

• As T2 becomes greater than T1 +10°C, the valve will actuate, sending water through the solar fixture and heating the pool. If T2 falls below the lower threshold of T1 + 8°C, the valve will revert back to its original state and send water back into the pool.
**Project Core: Thermistors**

- For temperature measurement, two separate RC circuits are used, with thermistors as variable resistors.
- AD592 thermistors
- In order to protect BS2, we use 220Ω resistors.
- \( C = 0.1 \text{ F} \)
- For calibration of the AD592 thermistors:

\[
\text{RC time} = \frac{\text{Constant}}{T(K)}
\]

- Because they can be assumed to be linear within a smaller operating range, we calibrated at 20°C which is within our operating range.
Project Core:
Thermistors

• We used a digital temperature sensor which was already calibrated as the basis for our calibration.
• Each Thermistor RC Circuit was calibrated separately due to tolerances in resistance and capacitance values.
• \( RC_{time1} = 833 \)
  \( RC_{time2} = 858 \)
• \( C_1 = 833 \cdot 293(K) = 244049 \)
  \( C_2 = 858 \cdot 293(K) = 251394 \)
• The constant values exceed the word size variable for BS2 (0-65536), therefore we divided \( C_1 \) and \( C_2 \) by 4.

\[
T_1 = \frac{C_1}{RC_{time1}} - 273 \\
T_2 = \frac{C_2}{RC_{time2}} - 273
\]
# Bill of Material and Prototype Cost

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Material</th>
<th>Estimated cost</th>
<th>Mass production per unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3 way Solenoid Valve ½” NPT</td>
<td>$140</td>
<td>$60</td>
</tr>
<tr>
<td>1</td>
<td>Solar Heater (optional)</td>
<td>$150</td>
<td>$80</td>
</tr>
<tr>
<td>50 ft</td>
<td>Tubing</td>
<td>$10</td>
<td>$3</td>
</tr>
<tr>
<td>1</td>
<td>Basic Stamp 2</td>
<td>$50</td>
<td>$25</td>
</tr>
<tr>
<td>2</td>
<td>Relay 120V (15A)</td>
<td>$200</td>
<td>$75</td>
</tr>
<tr>
<td>2</td>
<td>Thermistor AD592</td>
<td>$30</td>
<td>$3</td>
</tr>
<tr>
<td>2</td>
<td>Transistor</td>
<td>$1</td>
<td>$0.25</td>
</tr>
<tr>
<td>11</td>
<td>Resistors</td>
<td>$2</td>
<td>$0.5</td>
</tr>
<tr>
<td>5</td>
<td>Capacitors</td>
<td>$10</td>
<td>$4</td>
</tr>
<tr>
<td>1</td>
<td>Voltage Regulator IC</td>
<td>$2</td>
<td>$1</td>
</tr>
<tr>
<td>4</td>
<td>Diode</td>
<td>$5</td>
<td>$2</td>
</tr>
<tr>
<td>1</td>
<td>110/24-0 Transformer</td>
<td>$6</td>
<td>$3</td>
</tr>
<tr>
<td></td>
<td>PCB Production</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Labor cost</td>
<td>$30</td>
<td></td>
</tr>
<tr>
<td><strong>Total (with Solar Heater)</strong></td>
<td></td>
<td><strong>$606</strong></td>
<td><strong>$290</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$456</strong></td>
<td><strong>$210</strong></td>
</tr>
</tbody>
</table>
Electronic Circuit Diagram
Analysis advantages

- Solar heaters have a clear cut advantage over Gas and Electric heaters for long term Cost
  - For example, the amount of energy needed to heat a 7,500 gallon pool by one °F would be 60,000 BTU’s
  - A cubic foot of gas cost $2.34 on average and has 1,000 BTU’s of energy.
  - At that rate it would cost $140 per °F or $252 per °C
- Solar heaters are also better for the environment. While natural gas is a clean burning fuel in comparison to coal and gasoline, it still emits greenhouses gases
  - A typically pool heater with control circuits and valves costs approximately $4000. The estimated cost of our model is under $1000

<table>
<thead>
<tr>
<th></th>
<th>Heat Pump Pool Heater</th>
<th>Gas Pool Heaters</th>
</tr>
</thead>
<tbody>
<tr>
<td>How Does It Work?</td>
<td>A Heat Pump uses electricity to operate. They are actually a form of solar heater, as the sun-warmed air contributes to the efficiency of these units. This heat is extracted from the air, upgraded with a compressor, and then transferred to the water.</td>
<td>How Does It Work? Gas Heaters use natural or propane fuel. The gas is burned in a combustion chamber where the heat is transferred to the pool water. Operation requires a storage tank for propane gas, or hookup to natural gas, where available.</td>
</tr>
</tbody>
</table>
| System and Installation Cost | System unit cost range: $2400 - $4600  
Installation cost: $350 - $950  
Typical 15x30 pool: $3200 Unit $4200 Installed | System and Installation Cost  
System unit cost range: $2400 - $4600  
Installation cost: $350 - $950  
Typical 15x30 pool: $3200 Unit $4200 Installed |
Analysis disadvantages

- One disadvantage to using solar power is that the amount of heat energy generated in a given day is beyond your control.
- For example, a gas heater could be turned on at will, while with solar energy, it will only work on a sunny day.
- A solar heater will provide less power than an electric heater. This means it will take more time to heat up a pool compared to gas heaters.
- A disadvantage of our design is that the temperature threshold is hardcoded and therefore doesn’t allow the user to modify it without a computer; a future design may include a potentiometer or button to allow the user to modify this value without the need for a computer.
Thank you

For your attention