Temperature Control Unit
Members of Group 8

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Overview

• What is the Temperature Control Unit used for?

• What does the user have to do to run the unit?

• When will the water be ready?
OSHA Regulations

The OSHA web site was consulted for all the regulations on our board – [www.osha.gov](http://www.osha.gov)

(1) Conductors entering boxes, cabinets, or fittings shall also be protected from abrasion, and openings through which conductors enter shall be effectively closed. Unused openings in cabinets, boxes, and fittings shall be effectively closed.
(2) **Conductors for general wiring.**

All conductors used for general wiring shall be insulated unless otherwise permitted in this Subpart. The conductor insulation shall be of a type that is approved for the voltage, operating temperature, and location of use. Insulated conductors shall be distinguishable by appropriate color or other suitable means as being grounded conductors, ungrounded conductors, or equipment grounding conductors.

FCC Regulations
1) **Heater control device**

Patent Number: 6,157,010

Date: December 5, 2000

The aspects of this patent that concern our project are that it consists of a heater control device comprising of a heater for heating a load, a sensor for detecting the temperature of the load heated by the heater, a temperature adjusting circuit for generating a control signal that controls the driving of the heater so that the output of the sensor falls within a target temperature range.
2) Temperature attenuator to control heating

Patent Number: 4,994,649
Date: February 19, 1991

The aspects of this patent that concern our project is that it is concerned with a temperature attenuator for controlling the heating of a container, such as a temperature attenuator used to space a container, like a beverage container, from a hot plate on which the container is heated. The invention is particularly concerned with a temperature attenuator for a coffee container which is heated on a hot plate to be kept hot for serving at a later time. This invention also maintains the hot plate at an elevated temperature to heat the beverage contents of the container.
Design Alternatives

**Temperature Sensor**

We had to develop a way of packaging the sensor so that it will be waterproof, and still will be able to take an accurate measurement of the liquid in the cup.

- Epoxy
- Plastic bag
Hardware Design

Water Temperature Control Unit
Design Objectives

- Safety-Designing A Product That Meets All Safety Regulations And Standards By Law

- Hardware- Understanding The Operation Of The Design And Retrieving The Proper Components Needed To Complete The Design Stage

- Budget-Setting A Specific Limit On The Money That Is Invested In The Design Process Of The Product

- Testing- Hardware And Software Implementation. Making Sure Connections And Output Readings Are Accurate And Meet The Design Specifications
Design Specifications

Temperature Sensor

- Selecting a Temperature Sensor that provides an output reading that is in accordance with the input voltage on the A/D converter (5 V)
- Making sure the sensor operation input voltage meets the M68HC11 output voltage criteria
- Sensor calibrated reading (Celsius)
- Temperature range from 0 degrees Celsius to 100 degrees Celsius.
Design Specifications

- **Brookstone Heating Pad & Relay**
  - Selecting A Relay That Switches On An Input Voltage That Matches The Equivalent Output Voltage Of The M68HC11 Board
  - Relay That Operates a Voltage of 120 V and Consists Of a Single Switch
  - Selecting A Heating Pad That Meets The Temperature Output Requirements Of About 50 Degrees Celsius
Hardware Components

- LM35 DZ Temperature Sensor
- BrookStone Beverage Warmer
- Soundteck Buzzer
- Crydom Solid State Relay
- Twist On Connectors
- Heat Shrink
- Plastic Cover
- LCD Display
- Switches
LM35 DZ Temperature Sensor

- Supply Voltage Ranges From 35V To -0.2V
- Output Voltage Ranges From 6V To -1 V
- Output Current 10mA
- Temperature Displayed In Celsius
- Maximum Temperature The Sensor Can Withstand Is 260 Degrees Celsius With A Soldering Time Of 10 Seconds Per Terminal
Brookstone Heat Pad

- Heat Pad Has A Required Input Of 120 V For Proper Operation
- Power Rating Of 21 Watts
- Settings Of High & Low For Heating
- Maximum Heating Temperature Of 50 Degrees Celsius (Tested In Lab)
- Dimensions Of 3.5’ X 3.5’
Crydom Solid State Relay

- Requires Input From 3 to 32 V In Order For The Relay To Properly Operate
- Provides An Output Of 120 V With A Current Reading Of 2.5 A
- Consists Of Four Terminals (Two Terminals For the Input Voltage Consisting Of Voltage Input And Ground And Two Terminals For Voltage Output With Ground)
- Relay Acts As A Single Switch, When A Voltage From 3 to 32 Is Applied To The Input Terminal, The Switch Closes And Provides An Output Of 120 V With A Connection To The Wall Outlet
Testing Procedures

- **Temperature Sensor**
  - Calibrating The Voltage Output At Room Temperature With A Thermometer Reading In Celsius. Vreflow Calibrated At 0 Volts And Vrefhi Calibrated At 1V. Packaging The Temperature Sensor Terminals With Heat Shrink And Plastic Wrap. Testing For Water Presence Once Immersed In Water.

- **Brookstone Heat Pad**
  - Maximum Temperature Reading Of Water Substance And Time Required For Temperature Of Water Substance To Reach The Desired Temperature Input By The User. Applying Output Voltage From The M68HC11 Board To The Input Voltage Of The Relay To Switch On Heating Pad, Making Sure 120V is Used As The Input Voltage To The Heat Pad.
Problems Encountered


- Finding A Relay With An Input Voltage Less Than 5 Volts And An Output Voltage Of 120 Volts
Problem Solutions

- Temperature Sensor - Subtraction Of The Value Of 5 To The Current Temperature Reading In The Software Portion.
- Sensor Packaging - Selection Of Plastic Wrap For Sealant Of Temperature Sensor When Immersed In Water Substance.
How It Works?

Set Desired Temperature You Want Your Water Substance To Be On The LCD.

M68HC11 Sends Signal Through PA4 To The Relay Input.

Once Voltage Is Applied To The Relay The Switch Closes.

The Heating Pad Starts Heating The Water Substance To The Desired Temperature

The Current Temperature Of The Water Is Displayed On The LCD Through Use Of The Sensor

Once The Water Is Heated Over The Desired Temperature The Buzzer Will Go Off And 0V Is Applied To The Relay Closing Off Power Supply To The Heat Pad
Hardware Schematic

- All Vcc = 5 V
- Reset Second
- Increment Minute
- Increment Hours
- Heater switch
- To Buzzer
- Increment Temperature
- Reset Temperature
- Sensor
- Sensor Output
- +Vcc
- Ground
- +Vcc
- Heating Element
- To wall outlet
- 200 Hz
- Buzzer
- To wall outlet
Project Purpose

- Become Familiar With Design Stage Processes
- Understand How To Implement Hardware With Software In Design Cases
- The Importance Of Teamwork And Communication In The Design Process
- Familiarizing Ourselves With The Use Of The M68HC11 Board
Code

- Clock
- Acquiring Temperature from A/D Converter
- Turning Heater ON/OFF
- Turning Buzzer ON/OFF
- Setting Clock/Desired Temperature
- Displaying Everything on LCD screen
Clock

- Timer Routines
- Tasks
- Hours, Minutes, Seconds and AM/PM
- Counters
Timer Routines

Half Second Routine

Second Routine

Minute Routine
Tasks

Half Second Task
Second Task
Minute Task
Twelve Hour Task
Thirteen Hour Task
Thirteen Hour Task

THIRTEEN_HR
LDAA #1
STAA HOUR
JMP OC2DONE
Twelve Hour Task

TWELVE_HR  LDAA  AMPM
EORA  #1
STAA  AMPM
INC  HOUR_CNT
JMP  OC2DONE
**Acquiring Temperature from A/D Converter**

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>LDAB #30</td>
<td>* Delay for 105 microsec</td>
</tr>
<tr>
<td>WAITCP</td>
<td></td>
</tr>
<tr>
<td>DECB</td>
<td>* To charge pump</td>
</tr>
<tr>
<td>BNE</td>
<td>WAITCP</td>
</tr>
<tr>
<td>LDAA #00</td>
<td></td>
</tr>
<tr>
<td>STAA ADCTL,X</td>
<td>* Select pin PE0</td>
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<tr>
<td>WAITADC</td>
<td></td>
</tr>
<tr>
<td>BRCLR ADCTL,X $80</td>
<td>* Wait for flag bit</td>
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<tr>
<td>LDAA ADR2,X</td>
<td>* Get value from ADR2</td>
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<tr>
<td>LSLA</td>
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<tr>
<td>SUBA #5</td>
<td>* Adjust the temperature to</td>
</tr>
<tr>
<td>STAA TEMP</td>
<td>* Actual value</td>
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<tr>
<td>LDAA TEMP</td>
<td></td>
</tr>
<tr>
<td>STAA CUTEMP</td>
<td></td>
</tr>
<tr>
<td>LDAB DETEMP</td>
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## Setting Heater/Buzzer On/Off

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Description</th>
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<tr>
<td>ADDB #1</td>
<td>* ADD 1 FOR THE ERROR MARGIN</td>
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<tr>
<td>STAB TEMP2</td>
<td>* COMPARE CURRENT AND DESIRED</td>
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<tr>
<td>CMPA TEMP2</td>
<td>* COMPARE CURRENT AND DESIRED</td>
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<tr>
<td>BHI OFF</td>
<td>* TEMPERATURE+1</td>
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<tr>
<td>BSET PORTA,X $10</td>
<td>* TURN HEATER ON</td>
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<tr>
<td>BCLR PORTA,X $20</td>
<td>* TURN BUZZER OFF</td>
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<tr>
<td>BRA ON</td>
<td></td>
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<tr>
<td>OFF</td>
<td></td>
</tr>
<tr>
<td>BCLR PORTA,X $10</td>
<td>* TURN HEATER OFF</td>
</tr>
<tr>
<td>BSET PORTA,X $20</td>
<td>* TURN BUZZER ON</td>
</tr>
<tr>
<td>ON</td>
<td></td>
</tr>
<tr>
<td>PULB</td>
<td></td>
</tr>
<tr>
<td>PULA</td>
<td></td>
</tr>
<tr>
<td>PULX</td>
<td></td>
</tr>
<tr>
<td>RTS</td>
<td>* RETURN TO SUBROUTINE</td>
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Setting Clock

HALF_RTN
PSHA
PSHX
PSHB

BRSET PORTA,X 04 SETHOUR
BRSET PORTA,X 02 SETMIN
BRSET PORTA,X 01 SETSEC
# Setting Temperature

## Range of 30-100 °C

<table>
<thead>
<tr>
<th>SETTEMP</th>
<th>PSHX</th>
<th>PSHA</th>
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<tr>
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<td>BRSET</td>
<td>PORTD,X $10 CLRTEMP</td>
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<td>BRSET</td>
<td>PORTD,X 8 INCTEMP</td>
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<td>FINISH</td>
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<td>PULX</td>
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<td>STAA</td>
<td>DETEMP</td>
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<td>JMP</td>
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</tr>
<tr>
<td></td>
<td>JMP</td>
<td>FINISH</td>
</tr>
</tbody>
</table>
Displaying On LCD

LDAA SEC
STAA SEC_CNT
JSR ROW1
LDX #ECE
JSR PRINT
JSR ROW2
LDX #MESS
JSR PRINT
JSR DSPTIME
JSR ROW3
LDX #CTEMP
JSR PRINT
JSR DSTEMP
LDX #CELCIUS
JSR PRINT
JSR ROW4
LDX #DTEMP
JSR PRINT
JSR DSDETEMP
LDX #CELCIUS
JSR PRINT
Problems Encountered

Adjusting Data from A/D Converter

Problems With Row 1

Cursor
Questions?