CPU Temperature Regulation

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Sinan Yaldo
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Overview

- Problem Statement
- Prior Work
- Safety Concerns
- Project Features
- Objective Tree/Flowchart
- Software
- Assembly
- Hardware
- Labview
- Cost Analysis
- Packaging
- Design Alternatives
- Problems
- Conclusion
Problem Statement

1. Improve the existing method of cooling the CPU, while providing the user with real-time temperature status updates and warnings using I/O devices.

2. Develop safeguards to prevent CPU damage from overheating.
Prior Work/ Patents

• Grolen Communications uses audible alarm and adjustable airflow guides to optimize fan airflow
• KHealthCare provides a program enabling user to monitor 3 different fan speeds
• ECE 4600 project incorporates both ideas
Safety Concerns – OSHA Regulations

• **1926.300(b)(2)** – *Rotating parts must be guarded*

  Belts, gears, shafts, pulleys, sprockets, spindles, drums, fly wheels, chains, or other reciprocating, rotating or moving parts of equipment shall be guarded if such parts are exposed to contact by employees or otherwise create a hazard. Guarding shall meet the requirements as set forth in American National Standards Institute, B15.1-1953 (R1958), Safety Code for Mechanical Power-Transmission Apparatus.
Safety Concerns – OSHA Regulations

- **1926.300(b)(5) – Fan blades MUST be guarded**
  "Exposure of blades." When the periphery of the blades of a fan is less than 7 feet (2.128 m) above the floor or working level, the blades shall be guarded. The guard shall have openings no larger than 1/2 inch (1.27 cm).
Safety Concerns – OSHA Regulations

- **1926.300(b)(3) – Types of guarding for rotating parts**
  "Types of guarding." One or more methods of machine guarding shall be provided to protect the operator and other employees in the machine area from hazards such as those created by point of operation, ingoing nip points, rotating parts, flying chips and sparks. Examples of guarding methods are - barrier guards, two-hand tripping devices, electronic safety devices, etc.
Project Features

• 3-speed fan – Varies according to temperature levels
• 3 LED’s indicate to the user the fan’s operational speed
• Buzzer indicates when CPU temperature reaches 90 deg., despite high fan setting
Project Features

- LCD display provides the user with a real-time temperature value for the CPU, and the time.
- Computer monitors the temperature via Labview Graph, Alert display, and speaking out the temperature.
- 3 switches enable the user to set the hour, minutes and seconds for the clock on the LCD display.
Objective Tree

- Improved method of CPU cooling
  - Reduce chance for CPU overheat
    - Thermocouple the CPU unit
    - 3 different fan speeds
      - Higher speeds for higher temps.
    - Fan in close proximity with directed airflow
  - Display board provides feedback to user
    - LCD displays temperature values
    - LED’s indicate fan speed to user
    - Buzzer warns user of possible overheat
  - Prevention of overheat or damage to CPU
    - Added options with Labview Software
      - Error message warns user to shutdown

- Prevention of overheat or damage to CPU

- Added options with Labview Software
  - Error message warns user to shutdown

- Improved method of CPU cooling
CPU ON
Monitor Temp.

Temp. >= 76 deg. F
Fan in low speed setting

76 < Temp. < 86 deg. F
Fan in med. speed setting

86 deg. F <= Temp.
Fan in high speed setting
Buzzer warns user of high CPU temp.
(w/ Labview) Error message appears to shutdown
Software

- Assembly
- Labview
Assemble

```assembly
TEMPSR  PSHX
       PSHA
LDX    #REGBAS
BSET   ADCOPT,X ADPU
       *power up the A/D converter
LDAA   #40
       *ADPU = #%10000000
GLOOP  DECA
       *ADC = #%00000010
BNE    GLOOP
       *program the A/D Converter
LDAA   #ADC
STAA   ADCTL,X
```

**ADCTL — A/D Control/Status Register**

<table>
<thead>
<tr>
<th>BIT 7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>BIT 0</th>
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<tr>
<td>CCF</td>
<td>—</td>
<td>SCAN</td>
<td>MULT</td>
<td>CD</td>
<td>CC</td>
<td>CB</td>
<td>CA</td>
</tr>
<tr>
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<td>0</td>
<td>U</td>
<td>U</td>
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**OPTION — System Configuration Options**

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<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
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<th>BIT 0</th>
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<tr>
<td>ADPU</td>
<td>CSEL</td>
<td>IRQE</td>
<td>DLY</td>
<td>CME</td>
<td>CR1</td>
<td>CR0</td>
<td></td>
</tr>
<tr>
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<td>0</td>
<td>1</td>
<td>0</td>
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Table 12-1 A/D Channel Assignments

<table>
<thead>
<tr>
<th>CD</th>
<th>CC</th>
<th>CB</th>
<th>CA</th>
<th>Channel Signal</th>
<th>Result in ADRx if MULT = 1</th>
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<tr>
<td>0</td>
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<td>0</td>
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<td>0</td>
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</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>PE1</td>
<td>ADR2</td>
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<td>1</td>
<td>0</td>
<td>PE2</td>
<td>ADR3</td>
</tr>
<tr>
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<td>0</td>
<td>1</td>
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<td>PE3</td>
<td>ADR4</td>
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<td>0</td>
<td>0</td>
<td>PE4*</td>
<td>ADR1</td>
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<tr>
<td>ONESEC_TASK</td>
<td>JSR</td>
<td>TEMPSR</td>
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<tr>
<td>-----------------</td>
<td>--------</td>
<td>---------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>* to convert the analog to digital form</td>
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<tr>
<td>LDAA</td>
<td>$1031</td>
<td>*read the temp</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LDAB</td>
<td>#$2B</td>
<td>*86F</td>
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</tr>
<tr>
<td>SBA</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>BHI</td>
<td>tled3on</td>
<td>* &gt;86?</td>
<td></td>
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</tr>
<tr>
<td>CLR</td>
<td>PORTA,X</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>LDAA</td>
<td>$1031</td>
<td>* &gt;76?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LDAB</td>
<td>#$26</td>
<td></td>
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<tr>
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<td>PORTA,X</td>
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</tr>
<tr>
<td>LDAA</td>
<td>#00001000</td>
<td>*PA3</td>
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</tr>
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<td>PORTA,X</td>
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<tr>
<td>JMP</td>
<td>continue</td>
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<tr>
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<td>#00010000</td>
<td>*PA4</td>
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<td>#00100000</td>
<td>*PA5</td>
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## Hardware Components

<table>
<thead>
<tr>
<th>Component</th>
<th>Item Count</th>
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<tbody>
<tr>
<td>LCD</td>
<td>3 LED’s</td>
</tr>
<tr>
<td>Buzzer</td>
<td>3 Relays</td>
</tr>
<tr>
<td>Temperature Sensor</td>
<td>3 resistors</td>
</tr>
<tr>
<td>DAQ</td>
<td>3 push buttons</td>
</tr>
<tr>
<td>9V Fan</td>
<td>Wires</td>
</tr>
</tbody>
</table>
Hardware

- Temp Sensor
  - VRL
  - VRH
  - PE2

- Buzzer
  - PA5

- LED1
  - PA3
- LED2
  - PA4
- LED3
  - PA5
LABVIEW

Personal Computer

DAQ

Dedicated Cable for Signal Conditioning

Connector Box

Channel 0
Channel 1
LABVIEW
LABVIEW
LABVIEW
START

READ CHANNEL 0

MULT BY 100 & STORE

IS VALUE GREATER THAN 90F

YES

PLAY AUDIBLE AND VISUAL WARNING

DISPLAY "SYSTEM OK"

NO

AUDIBLE OUTPUT REQUESTED

PARSE THROUGH TEMP VALUES ARRAY

RETURN INDEX

LOCATE WAVE FILE

PLAY CURRENT TEMP

DISPLAY CURRENT TEMP
Cost Analysis

Components Cost

- M68HC11 Board = $100
- ISD 2590 Voice Chip = $30
- LCD Display = $23
- Fan = $12
- Project Enclosure w/ screws = $9
- Speaker = $5
- Microphone = $4
- Buzzer = $4
- Solder Wire = $3
- Thermocouples = $3
- Capacitors = $3
- Relays = $2.50 ea. x 3 = $7.50
- IC/PC Board = $2
- Wires = $2
- Switches = $1 ea. X 5 = $5
- LED’s = $0.60 ea. X 3 = $1.80
- Resistors = $1
- TOTAL = $215.30
Packaging

• Microcontroller board placed inside a box (to reduce ESD and wiring Problems). Holes were drilled out for I/O ports, mounting screws and power supply.
• Special PC board was cut to place 3 LED’s, 3 push buttons, buzzer and temperature sensor, which will be accessible to the user.
• Another PC board was cut to place four relays to control the fan speed and buzzer. This board is designed to hide inside the box. The relays were chosen to be SPDT, with clamping diode to eliminate fast discharge through microcontroller.
• Each wire was labeled as input or output with brief description. Most of the wires are soldered to the PC board for proper connection.
• LCD dimensions were taken to drill the hole on the box top.
• Voice Chip and other related parts were mounted on other board, but test is still in progress.
Picture of package
Design Alternatives

- At the beginning, secondary voltage supply was needed to run the fan and buzzer via relays, but later we found that we can bring 9V 200 mA power supply from the EVB transformer. As a result, we eliminated a second cost of transformer.
- We eliminated many resistors by connecting the LED’s and buzzer to one resistor to a common ground.
- Voice chip was bought to speak out the temperature and time. Test is still in progress.
- Instead of using 3 relays, we could have driven the fan using PWM (Pulse Width Modulation). PWM could be used to generate a controlled voltage source. But PWM requires us to bring a 5 volts fan with very low power consumption. Although PWM is less hardware, cost and more program controlled, but we prefer not to implement it because we might ruin our EVB board.
Problems Encountered

- In the timer code, there was 60 second delay due to extra code in the program. The problem was solved by placing the code in the main program. Also, there is no tool to debug the program.

- PE2 was connected to the temperature sensor. Another wire was connected to the DAQ card. As a result, temperature was not stabilizing and some error occurred due to noise. To eliminate the problem, data was sent to PA0 and then to the DAQ cards.

- The next problem was related to the fan speed. The fan was not working because PA3, PA4 and PA5 were going to the relays and not common ground was connected.

- Another problem issue was related to understanding the voice recording chip, because the spec is written for more advanced users and things were not making sense. We collected much information as possible and finally understood how it works.
Conclusion

• By combining different technologies, we developed a more effective method of CPU cooling

• Keeps user better informed of temperature status by graphs, LED’s and LCD display

• Prevents CPU damage by alerting user when to shutdown
Questions???