Queensland Academy
for Science, Mathematics and Technology

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Solar-Powered Bushfire Detection System Prototype
The History of Bushfire Prevention

• Fire towers and physical patrols by fire fighters at the scene
• Utilisation of satellite infra-red scanners is prevalent
• The advantages of deploying UAVs as a swarm include massive scalability, low communication overheads, reduced need for human supervision, and resilience against individual failure.
Prototyping a Solar-Powered Bushfire Detection System

Research Question
How can a rise in temperature be used as an indicator to initiate preventative measures for bushfires in rural areas?

Context
Bushfires are becoming a regular occurrence in regional Queensland, New South Wales and other international destinations. With the aid of this technology, an increase in temperature will alert the fire brigade of the increased likelihood of bushfires in rural localities.
Basic Functionalities

- When the sensor records a temperature above 39 degrees Celsius (Australia-wide agreed temperature that is deemed dangerous), a siren will sound and a red LED will illuminate.

- Subsequently, a Bluetooth notification will be sent to the paired mobile from the Bluetooth-enabled module. The block diagram below shows the elements of the circuitry.
### Variables

<table>
<thead>
<tr>
<th>Independent</th>
<th>Dependent</th>
<th>Controlled</th>
</tr>
</thead>
</table>
| • -Nil-     | • Whether each component delivered the desired output | • Same parts were used  
• The amount of voltage and current flowing through the circuitry. |
Materials

- **Power Supply:** Solar Panels
- **Controller:** 8051 – V2
- **Bluetooth Transmitter:** HC-05
- **ADC (Analogue to Digital Converters):** ADC0809
- **Temperature Sensor:** LM35
- **Buzzer:** 3V – 20V
- **Wires x 20**
- **LCD Display:** LCD-016M002D
- **Rechargeable Battery:** FG20121
- **800mA Low-Dropout Linear Regulator:** LM1117
- **ATMEL 8-bit Microcontroller with 8K Bytes:** AT 89S52
- **General Purpose Rectifiers (Glass Passivated):** 1N4001
- **Printed Circuit Board (PCB) x 3**
- **Resistors x 5**
- **Green LED x 1**
- **Red LED x 1**
- **Orange LED x 1**
Methodology Phase 1: Designing the System

- Prior to purchasing the required parts, drawing a schematic diagram was key. Using the online Proteus Schematic software, the following electrical diagram was developed.
Methodology Phase 2: Constructing the Prototype

- Understanding the electrical requirements of the system allowed the commencement of the construction phase after the appropriate parts were acquired.
  - (Parts sourced from S.P. Laboratories Bengaluru, India)
- Using the previously developed schematic diagram, the physical construction involved the programming of the ATMELE 8-bit Microcontroller through Embedded-C (computer programming language)
- The following code was programmed into the microcontroller:

```c
#include <lcd.h>
#include <uart.h>
#include <adc.h>

char text[]="SOLAR POWERED THERMAL HEAT SENSOR"; // unsigned int i;
void main()
{
    // int j=0;
    lcd_init();
    uart_init();
    adc_init();
    buz=0;
    lcd_cmd(0x80);
    uart_init();
    adc_init();
    buz=0;
    lcd_cmd(0x80);
    uart_init();
    adc_init();
    buz=0;
    lcd_cmd(0x80);
    lcd_string("SOLAR HEAT DET.");
    //lcd_cmd(0xc0);
    // lcd_string("DETECT."");
    /*i=0;
    while(text[j] !='\0') // searching the null condition in the sentence
    {
        lcd_data(text[j]);
        j++;
        for(i=0;i<=40;i++);
    }*/
    while (1)
    {
        //for(i=0x80;i<=0x8f;i++);
        //for(i=0;i<34;i++)
    }
```
Methodology Phase 3: Assembling the Hardware

• While providing an understanding of the design of the circuitry, the schematic diagram clarified how it was to be wired. From the diagram, the following instructions were derived:

I. The 8051 is powered up by connecting the solar panels to it.

II. The ADC0809 is powered up by connecting 5V and ground.

III. ADC Clock Pin is connected to P0.0 pin of 8051

IV. ADC OE pin connected to P0.1 pin of 8051

V. ADC ALE pin connected to P3.7 pin of 8051

VI. ADC ST pin connected to P3.5 pin of 8051

VII. ADC A2 pin connected to P3.4 pin of 8051

VIII. ADC A1 pin connected to P3.4 pin of 8051

IX. ADC A0 pin connected to P3.2 pin of 8051

X. Data pins of ADC D0-D7 is connected to P1.0-P1.7 respectively. (example: ADC D0 connects to P1.0)

XI. Temperature Sensor (LM 35) is powered up by connecting 5V and ground.

XII. Temperature Sensor (LM 35) output is connected to S1 pin of ADC

XIII. Bluetooth Module () is powered up by connecting 5V and ground

XIV. Bluetooth module TX pin is connected to P3.0 pin of 8051

XV. Bluetooth module RX pin is connected to P3.1 pin of 8051

XVI. Buzzer is connected to P0.3 8051 and another pin is connected to ground
Methodology Phase 4: The Untested Model
Bluetooth Pairing

1) Open the Bluetooth Terminal HC-05 app and press the scan button.

2) Select the device HC-05 and enter the code ‘1234’ and then enter.

3) You will return to the homepage. After returning, press the HC-05 button and you will be directed to a black dialogue box.
Temperature Emulation Testing

*(steam testing)*

1. Place the sensor under direct sunlight or a sunlight emulating device.
2. Boil 500mL of distilled water.
3. Hold the temperature sensor into the steam of the boiled water and watch the LCD display show an increased temperature value.
4. Once the temperature value is greater than 39˚C, watch the red LED illuminate and listen for a sounding siren.
5. Once the siren sounds, maintain the temperature sensor in the steam and watch the paired device relay the pre-programmed notification.
6. Once the siren has finished sounding, remove the temperature sensor out of the steam and wait until the LCD Display shows a temperature less than 39˚C and the LED to stop flashing.
7. If any of the above reactions do not take place or are delayed, note the delay or absence of the reaction for troubleshooting purposes.
8. Repeat steps 3 – 7 thrice to ensure that each component remains entirely functional.
Testing Data Phase I:

(a) Component Testing in Relation to Temperature Changes

<table>
<thead>
<tr>
<th>Trial</th>
<th>Temperature Sensor (T &gt; 39)</th>
<th>Temperature Sensor (Temperature &lt; 39)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1</td>
<td>Y/N</td>
<td>Y/N</td>
</tr>
<tr>
<td>Trial 2</td>
<td>Y/N</td>
<td>Y/N</td>
</tr>
<tr>
<td>Trial 3</td>
<td>Y/N</td>
<td>Y/N</td>
</tr>
</tbody>
</table>

Qualitative Observation: Each component returned the desired output and therefore, the circuit worked completely with negligible delays (< 1 second).
## Testing Data Phase II:

### (b) Boundary Case Testing – Boiled Water Method

#### Trial 1:

<table>
<thead>
<tr>
<th>Testing (Sound)</th>
<th>T&lt;38</th>
<th>T&lt;38</th>
<th>38</th>
<th>39</th>
<th>40</th>
<th>&gt;40</th>
<th>&gt;40</th>
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<td></td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
<td>No (Pass)</td>
<td>No (Pass)</td>
<td>Yes (Pass)</td>
<td>Yes (Pass)</td>
<td>Yes (Pass)</td>
<td>Yes (Pass)</td>
<td></td>
</tr>
</tbody>
</table>

#### Trial 2:

<table>
<thead>
<tr>
<th>Testing (Sound)</th>
<th>T&lt;38</th>
<th>T&lt;38</th>
<th>38</th>
<th>39</th>
<th>40</th>
<th>&gt;40</th>
<th>&gt;40</th>
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<td>Yes (Pass)</td>
<td>Yes (Pass)</td>
<td>Yes (Pass)</td>
<td>Yes (Pass)</td>
<td></td>
</tr>
</tbody>
</table>

#### Trial 3:

<table>
<thead>
<tr>
<th>Testing (Sound)</th>
<th>T&lt;38</th>
<th>T&lt;38</th>
<th>38</th>
<th>39</th>
<th>40</th>
<th>&gt;40</th>
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<td>No</td>
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<td>Yes (Pass)</td>
<td>Yes (Pass)</td>
<td>Yes (Pass)</td>
<td></td>
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</table>
Data Analysis & Areas for Improvement

- The overarching aim of the model is to notify the residents and emergency services.
- As stated in the preamble, the model induces many limitations that hinder its viability in today’s society.
- Additional sensors of other bushfire indicators should be added. An example of this is a humidity or smoke sensor.
- Using this inexpensive technology, we can reduce the reliance of residents on weather bureaus in areas prone to bushfires like regional Queensland and New South Wales in Australia.
- As the harsh terrain of bushfire-prone areas is often a victim of torrential rain, it is essential that a water-proofed body requires to be developed to ensure smoother industrial utilisation.
Evaluation of the Prototype & Scope for Future Research:

- The range of the Bluetooth module is a mere 30m. To ensure that assets (homes, farms and gardens) are not reduced to ashes, GSM technology, radio and televised broadcasts of messages can aid in doing so.
- When testing the device we used boiling water. This increased the temperature rapidly and reduced accuracy in testing.
- To ensure better testing of the device for industrial usage, it will be better tested under the natural heat of the sun to test the gradual increase in temperature as oppose to an unrealistic increase in temperature.
- Develop a water-proof (rain-proof) body for the device.
- Look for alternative ways to avoid false-alarms (i.e. from campfires or cigarettes)
The Economic Viability

• There lies a benefit of the model since its components are rather inexpensive.

• This would result in an increased demand as a result of the inexpensive nature of the prototype.

• If the aforementioned additions are implemented, successful utilization of the prototype is bound to occur.
Conclusion

- The system can successfully detect analogue signals and convert them to digital signals to attain actionable information.

- It completes the **3-step DCC principle** of *detect, comprehend and communicate*.

- Families can be saved from losing their lives to the heat-induced phenomena while not fuelling the ever-evolving fire of climate change.
Acknowledgements

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- **Dr. Kirsten Hogg** – for her continued guidance throughout the development of the system and the quality creation of the poster.

- **Deanna ________** - for the creative design of the poster.
Bibliography

