Protocamp Group 8: Safera

Prototyping and Developing a Thermocouple Solution

Members of the group:

Assistant: Juha Biström

Group members:

- Jyri Korhonen
- Antti Matikainen
- Anton Dyomin
- Vladimir Kurazhev

Basic information about: SAFERA

We sense what humans don't

- Safera is a Finnish company focusing on stove safety solutions.
- They develop and sell sensor packages which can be used to avoid unsafe situations.
- These sensor packages can be used to shut power to a stove in case the sensor determines a situation is potentially unsafe.
- The sensors utilize a variety of information sources such as temperature readings
- In order to determine determine if a situation i or is not safe, a variety of information about cooking situations is required.

Purpose of the Project

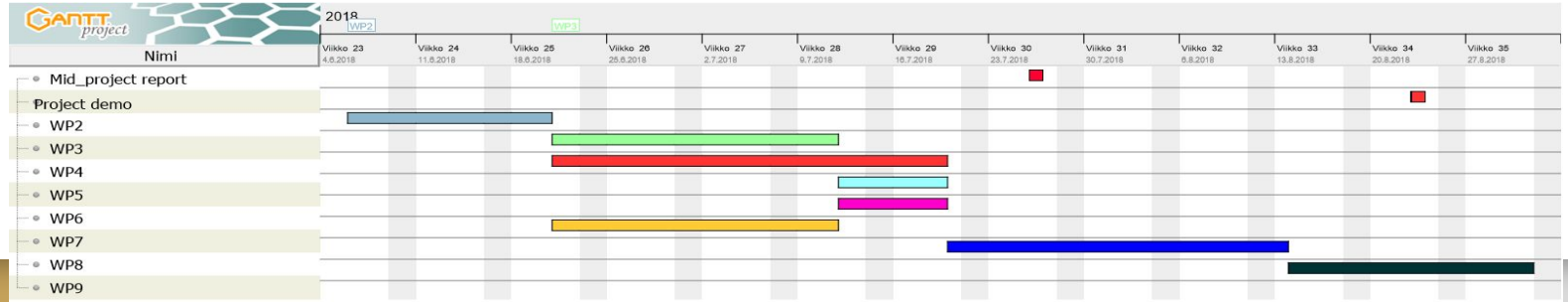
- In order to construct the data sets required Safera has a lab in which they can simulate a variety of cooking situations.
- They use a variety of sensors such as air particle sensors, cameras and most importantly thermocouples.
- Commercial thermocouple solutions can be quite expensive as well as being closed source and poorly documented. This means they are also difficult to repair.
- For these reasons, Safera sponsored this Protocamp group in order to develop an open-source well documented Thermocouple solution.

How Thermocouples work

- A thermocouple consists of two wires made of different metals which form an electrical junction, meaning voltage is generated based on the temperature difference between the ends.
- The voltage generated by the thermocouple can be used to calculate the temperature difference between the measuring end and the end connected to the sensor.
- The process of taking the temperature of the sensor side connection into account in order to form a more accurate measurement is known as Cold Side Compensation.
- The type used in this project is a so called K type Thermocouple, consisting of Chromel and Alumel. K type thermocouples are one of the most commonly used.

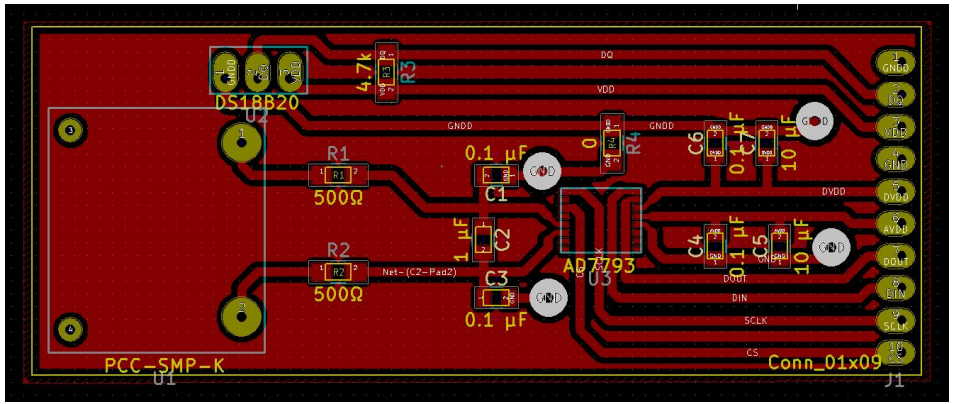
Project work packages

- During the initial planning stages of the project the work involved was divided thusly:
  - Hardware: The circuit board for the thermocouple sensor and ADC.
  - Software: A Windows / Linux program for recording sensor readings.
  - Work related to assorted other sensors such as an air particle counter.
- In addition to these work packages, the course itself included some administrative work related to, for example, project planning and reporting.



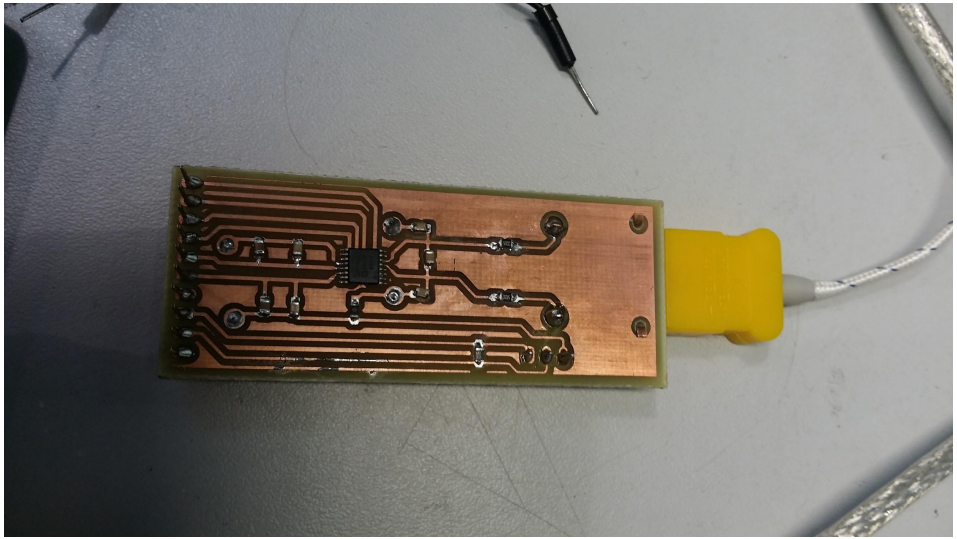
Hardware

- The circuit board for the Thermocouple sensor contains, in simplified terms, a plug to pug the thermocouple into, a filter for the readings and an AD7793 Analog to Digital Converter. Image is of the plan for the pcb.



Thermocouple sensor circuit board

- The completed version of the board.
- Prototype version, intended to be connected to a microcontroller.
- Circuit board manufactured at the workshop.
- Well documented, built using off-the-shelf components as well as a standardized connector.

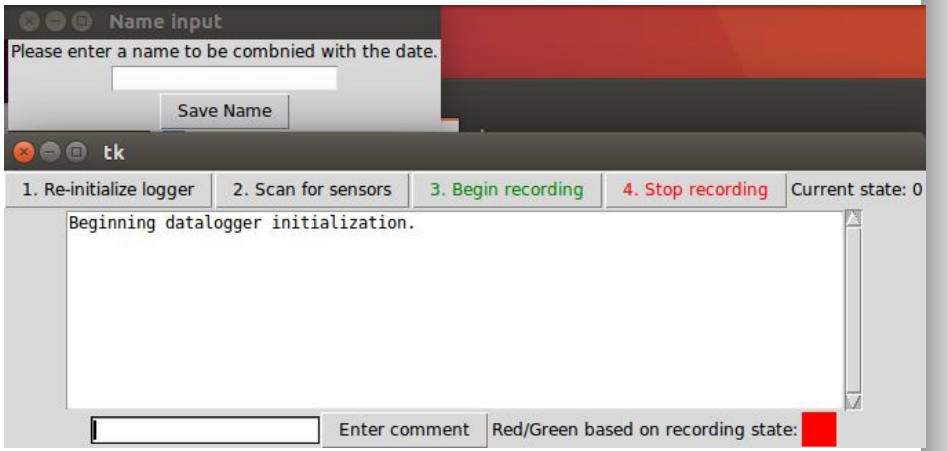


Software

- During the initial meetings with Safera and the group it was determined that the user interface and data logging software was to be written using Python.
- When researching how to read data from a serial port using Python the PySerial library quickly became the obvious choice.
- Conversions from voltage reading to temperature were done using another open source library.
- The user interface was created utilizing TKInter.
- As with other aspects of the course, coding was an exercise in learning as you do.

User Interface

- The need for a graphical user interface was one of the things outlined in Safera's original request.
- TK is the default user interface module bundled with Python.
- TK is an event based user interface where functions are called when the corresponding button is pressed.
- While TK allows for easy to learn UI creation, it lacks advanced functionality.



Additional sensors

- In addition to the data logging software and thermocouple solution the project included testing other assorted sensors.
- Other sensors considered for use in taking measurements related to cooking included a camera for recording the experiments as well as a air particle counter.
- Research was done into what would make for a good camera for this purpose.
- Additional research was done to determine suitable air particle count sensors.
- The sensor chosen was the Plantower PMS-5003, a relatively inexpensive air particle count sensor with a standard serial interface.

Project results

- Early on during the planning stage of the project it was planned that a Raspberry Pi would be used as a sensor hub. However, it became obvious it was not achievable and the choice to restrict the scope of the project was made.
- During the course of the project, the group developed the software and hardware for a thermocouple solution. This included designing and manufacturing the circuit board as well as assembly of the board.
- In addition to manufacturing the first iteration prototype of the board, the group discussed how the solution could be improved.

Room for improvement

- A part of development is reflection and review in order to determine how the product could be improved. The following are some thoughts the group had in no particular order:
- Software:
  - The software code, while it is currently documented, is not distributed into multiple files as would be good practice. This leads to the main file being downright monolithic.
  - In addition, the software could be improved significantly by utilizing the Python AsyncIO functionality. However, there was not enough time during the project to refactor the code in order to implement these changes.
- Hardware:
  - The use of a digital temperature sensor is redundant. Because the ADC can handle multiple inputs, the temperature sensor readings could be converted alongside the Thermocouple readings before being passed on.
  - The use of the AD7793 ADC proved quite challenging.
  - Minor design flaws in the board.
  - An Arduino was used for prototyping purposes. In later versions it could be replaced with a microcontroller on the board itself.

Thank You!

If we have time, this is your chance to ask questions.