Laboratory # 1
ECE:4880, Principles of ECE Design
Spring 2019

Due Dates:

Two-week Report: Wed. Feb 6

Final report and Demo: Fri. Feb. 22

Purpose: You are to design a thermometer with a web interface. The "design" is a set of documents that describe how to make this device. Accompanying this design is a prototype that demonstrates that the design works.

This design must satisfy a set of rigorous requirements, derived from this document. Some of these requirements will specify the expected functionality of the system. These are called *functional requirements*. Others will specify required properties of the system, such as response time, and mechanical specifications such as maximum size, ruggedness, etc. These are typically referred to *as design constraints*. **The initial challenge of this project is to analyze this document carefully and extract from it a list of functional requirements and a list of design constraints. The second challenge is to create and implement a design that satisfies all of the identified requirements and constraints.** As you read through this document, you may experience some uncertainty about the meaning or interpretation of certain requirements and/or aspects of system behavior which are not explicitly specified. It is important that you get all such uncertainties clarified before you finalize your design.

This assignment should be completed in "rapid prototyping" fashion, with tangible results expected early on. With this design technique, the first prototype may not work quite right, or fully implement all functionality, but will work in some fashion. After the first prototype is working, then features are added or designs are reworked to meet all the requirements by the end of the project schedule.

1. General Description:

This device consists of four separate assemblies:

a. A computer (PC or MAC or UNIX box) used for user interface, display, and control.

b. A thermometer sensor, at the end of a 2.0 +-0.1 meter cable. This should be a nice mechanical construction, capable of bouncing around without breaking. The sensor should not be damaged when placed in ice water.

c. A third box containing, at minimum, a display consisting of seven LEDs, a button, a battery, and a power switch. It is intended that the box, together with the sensor, can act as a battery-operated thermometer. The temperature data is then available on the internet.

d. A phone connected to the cellular network that can receive text messages.

2. Mechanical Requirements of the "third box"

a. This" third box" should be enclosed in some way, and physically robust (can stand being dropped from the workbench to the floor), and can be turned upside down, with the circuit, connectors, and switches still working.

b. All cable connections to the third box should have terminating connectors, securely mounted to the third box. These connectors should be the kind meant to be easily connected/disconnected by a casual user.

c. When dropped to the floor with cables connected, the connectors or cables should not break (although it is OK if they become disconnected).

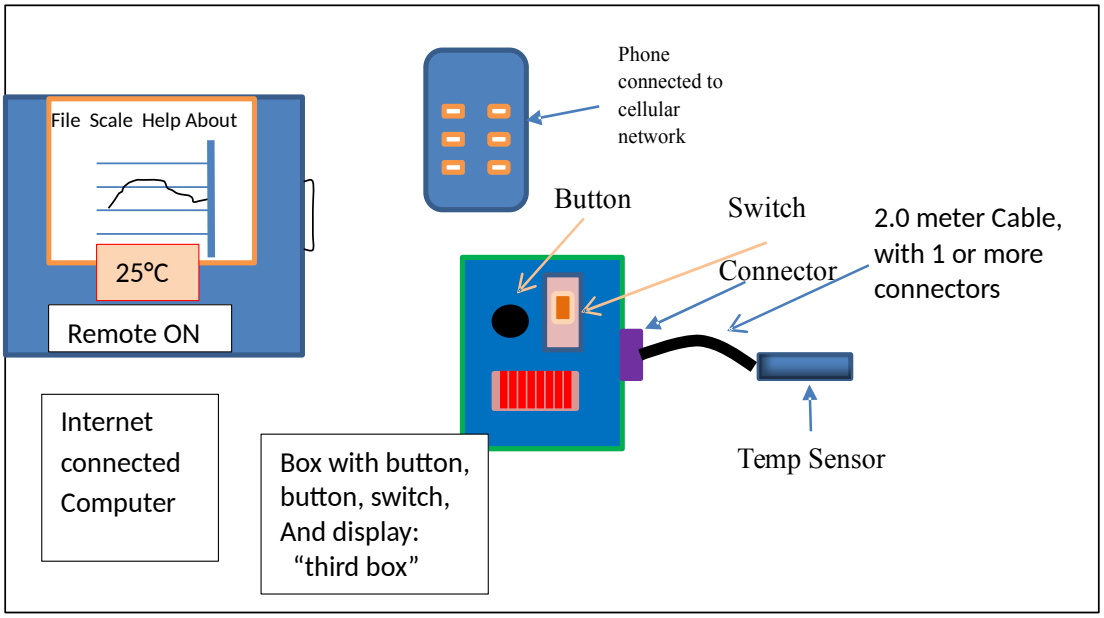

Figure 1: General Physical description of the temperature measurement system.

3. The switch on the third box functions as an on/off switch.

a. When the switch is "off", the thermometer system cannot display temperatures and temperature data is not available from the internet.

b. When the switch on the third box is "on", the following features are available locally at the third box.

4. When the button is pressed on the third box, the temperature of the thermometer sensor in degrees C is displayed as a binary integer on the LED display. (For example, if the temperature is 11 degrees C, the LED display should be [OFF OFF OFF ON OFF ON ON]).

5. Temperature Display details:

   a. The correct temperature should appear on the LED display when the button is pressed, with no noticeable delay. Delays are noticeable if they are longer than about 20 milliseconds.
   b. Negative temperatures should appear as a binary number in two's complement form on the seven-bit display.
   c. The button is to be "momentary contact": When pressed, the display is on, when not pressed, the display is off. The display should go dark when the button is released with no noticeable delay

6. Error Conditions:
   a. If the temperature sensor is not plugged into the third box, or is not working in some way, the display on the third box should notify the user that there is an error condition.
   b. if the sensor has been unplugged and is then plugged in, the third box should begin normal operation without user intervention.

7. When the power switch on the third box is "on" The following features are available from an internet connected computer when appropriate software is run on the computer:

   a. The real-time temperature, in degrees C or degrees F, (controlled by the computer user), is displayed prominently (in a large font) on the computer screen, and updated once a second.
   b. If the temperature sensor is unplugged from the third box, an "unplugged sensor" message should appear instead of the real time temperature.
   c. if the third box switch is off, a message "no data available" should appear instead of the real-time temperature.
   d. By user action on the computer, the LED temperature display on the third box can be turned on or turned off . (so, the computer can virtually "press the button" on the third box.) The button response me in this situation shall be less than 1 second.
   e. When the computer is connected to the internet, and the switch on the third box is on, a graph of the past temperature readings from the third box can be displayed on the computer screen. The graph of the past 300 seconds of data should be available within 10 seconds of the start of the software on the computer.
      i. The graph is the temperature in degrees C. The top of the graph corresponds to 50 degrees C, and the bottom, 10 degrees C. The graph should always have these limits, and is always in degrees C, irrespective of the real-time temperature display format.
      ii. This graph scrolls horizontally, with the latest temperature at the right side of the screen, and past temperature values on the left side of the screen. Once a second, a new temperature value is added to the graph on the right side, and the graph scrolls from right to left . (The look is similar to a "chart recorder"). Older

temperature values scroll off the graph on the left. The chart should have x-axis labels as described in (iv), below.

iii. The physical size of the graph should be scalable with the mouse.

iv. The total time record displayed on the graph is 300 seconds. The horizontal graph should correspond to, and be labeled in, "seconds ago from the current time". (this means the c marks should be in the range 300->0)

v. If there is data missing (perhaps the switch on the third box was off, or perhaps the temperature sensor is not plugged in), this should be obvious on the graph display. Missing data should be clearly discernable from data that is off-scale (too large or too small).

vi. This also applies to the present time display of data. If the third box is off or the temperature sensor is not plugged in, the graph should continue to scroll and the graph data should be shown as missing. When the error is corrected, the graphing and real time display of data should resume.

8. If the computer is on and the third box is off, the graph and real time display of data should appear on the computer screen within 10 seconds of the third box being turned on.

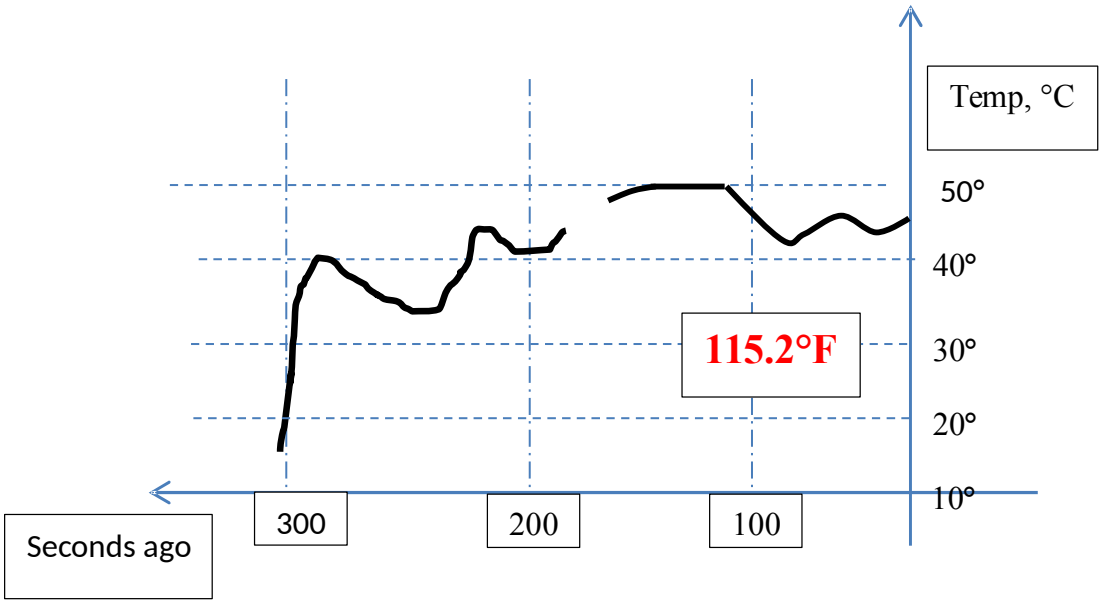

Figure 2: Possible look for the computer graph display. New data appears at the right and the graph scrolls to the left. Here, something went wrong 180 seconds ago, for 20 seconds or so.

9. When the computer is on and the third box is on, a text message will be sent to a specified phone number whenever the real-time temperature exceeds a certain value or is lower than a certain value.

a. The two text messages, the max temperature, the min temperature, and the phone number

can all be altered with the computer user interface.

10. Total Range of Operation

    a. The design range of the possible temperature displayed should be at least from minus 10 to +63 degrees Celsius. This does not have to be verified by testing, (simply because it is not feasible to verify this in this class) but should be addressed by the design.

9. When someone holds the temperature sensor in their hand, the heat from their fingers should make the temperature go up after a few seconds. Holding a soldering iron close to or briefly touching the sensor should do the same, even more quickly.

10. In the lab, at room temperature, the output of the thermometer should be approximately 22 degrees C, +-4 degrees C.

11. When placed in a water-ice mixture, the output of the thermometer should be 0 degrees C, +- 2 degrees C.