Laboratory # 1 ECE:4880,
Principles of ECE/CSE Design Fall 2025

Purpose:

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

This design must satisfy a set of exacting requirements, as laid out in this document. Some of these requirements specify the expected functionality and performance of the design, and some are mechanical specifications**. The primary challenge of this project is to analyze the requirements carefully and create and implement a design that satisfies all of them.** As you read through this document, you may experience some uncertainty about the meaning or interpretation of certain requirements. It is important that you clarify all such uncertainties before finalizing your design.

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

Requirements:

1. General Description: This device consists of four separate assemblies:

    a. A computer (PC or other desktop or laptop) device used for the user interface, display, and control.

    b. Two thermometer sensors, each 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 sensors should not be damaged when placed in ice water.

    c. A third box containing, at minimum, a display (e.g., a set of 7-segment LEDs or equivalent), buttons, a battery, and a power switch. It is intended that the box, together with the sensors, can act as a battery-operated thermometer. The temperature data is then available on the internet.

    d. A cellphone that can receive text messages or emails.

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).

   d. If a sensor has been unplugged and/or is then plugged in, the third box should maintain normal operation without user intervention.

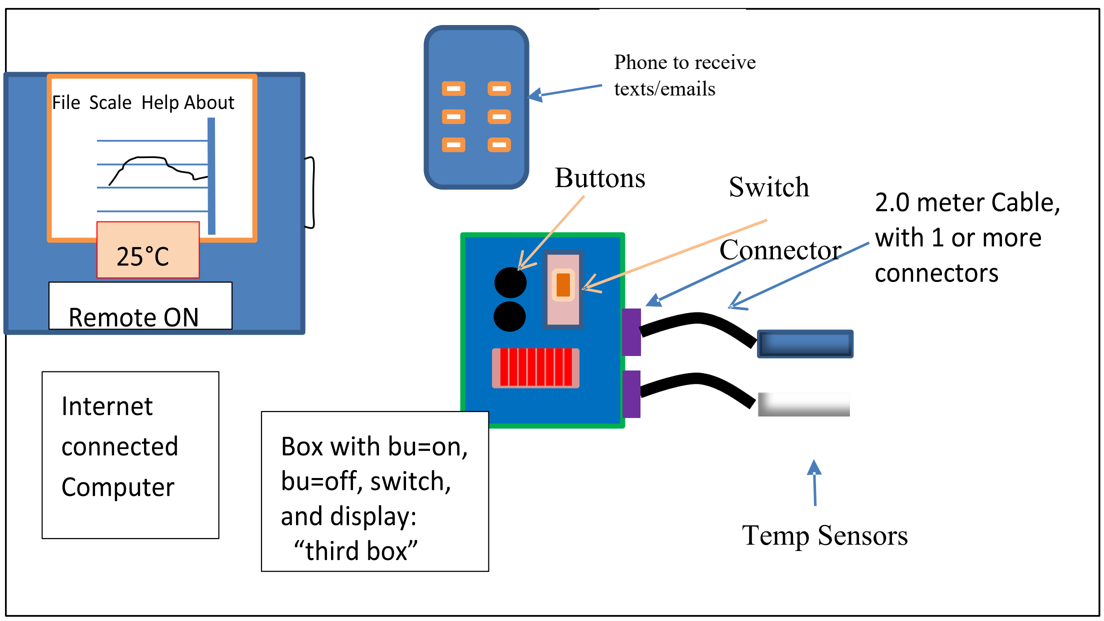

Figure 1: General Physical description of the temperature measurement system.

3. The switch on the third box functions as an on/off switch. When the switch is “off”, the thermometer system cannot display temperatures, and temperature data is not available from the internet.

4. When the switch on the third box is “on”, the following features are available locally at the third box. When the button for sensor 1/sensor 2 is pressed on the third box, a display on the box shows the temperature of the thermometer sensor with the button “on” in degrees C. The screen should also show “Sensor 1/ Sensor 2 off” for sensor(s) with button “off”. There are no requirements on the resolution or size of the display. However, it must have the following features:

a. The correct temperature should appear on the display when the button is pressed for a sensor, with no noticeable delay. Delays are noticeable if they are longer than about 20 milliseconds.

b. The display should be clearly readable under normal indoor lighting conditions, and all temperatures within the normal range of operation of this device (as specified below) should be displayed correctly.

c. The two buttons for the two sensors could be both on or both off, or one on and one off. The screen on the third box should show the correct information accordingly.

d. If any temperature sensor is not plugged into the third box, or is not working in some way, the display should notify the user that there is an error.

5. When the power switch on the third box is "on", the following features are available from an internet (wired/wireless) connected computer when appropriate software is running on the computer:

   a. The real-time temperature for the two sensors, 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.

      i. If a temperature sensor is unplugged from the third box, an "unplugged sensor" message should appear instead of the real-time temperature.

      ii. If the third box switch is off, a message "no data available" should appear instead of the real-time temperature.

   b. By user action on the computer, the temperature display for a sensor on the third box can be turned on or turned off (in other words, the computer can virtually "press the button" in the third box). The button response in this situation should be less than 1 second.

   c. When the computer is connected to the internet, and the om-switch in the third box is on, a graph(s) 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 starting the software on the computer.

      i. The graph is the temperature in degrees C/F. You should have a mechanism for users to switch between degrees C and degrees F. The top of the graph corresponds to 50 degrees C (122 degrees F), and the bottom, 10 degrees C (50 degrees F). The graph should always have these limits.

      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 (point iv), below.

iii. 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).

iv. If data is missing (perhaps the on-switch in 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 discernible from data that is off scale (too large or too small).

v. This also applies to the present time display of data. If the third box is off or a 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.

6. 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.

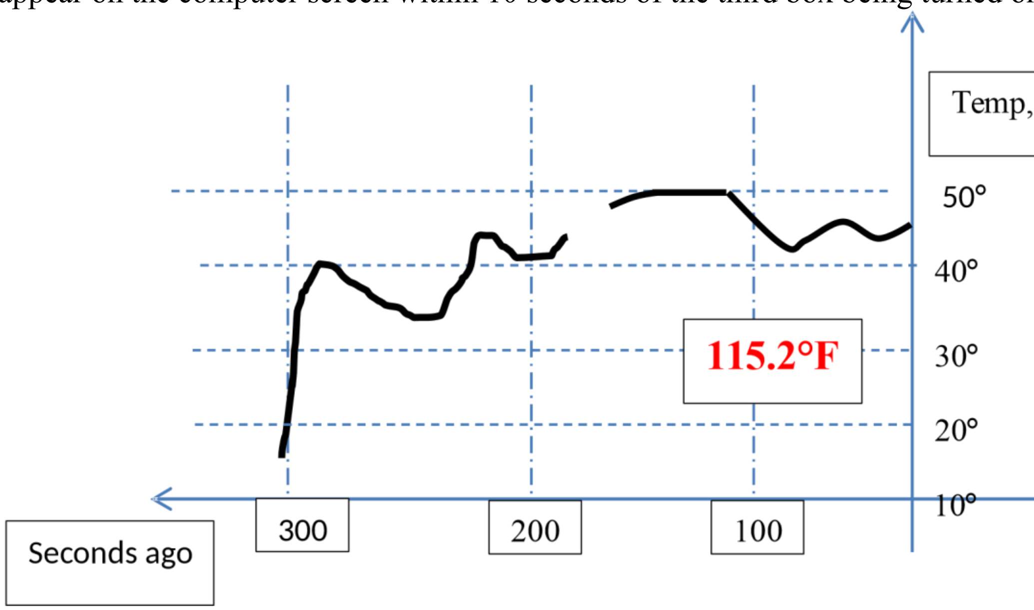

Figure 2: Possible look for the computer graph display. New data appears at the right, and the graph scrolls to the left. Something went wrong 180 seconds ago, for 20 seconds or so.

7. When the computer is on and the third box is on, a text/email will be sent to a specified phone number/email address whenever the real-time temperature exceeds a certain value or is lower than a certain value. The two messages, the max temperature, the min temperature, and the phone number/email address can all be altered with the computer user interface.

8. Total Range of Operation

   a. The design range of the possible temperature displayed should be at least from -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.

b. When someone holds a 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.

c. In the lab, at room temperature, the output of the thermometer should be approximately 22 degrees C, ± 4 degrees C.

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