VTMS

Vacuum and Temperature Monitoring System

Seascan Inc.

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Project Motivation

Seascan Inc. is a small company that manufactures oceanographic instrumentation and equipment to be used primarily in scientific research and development. They create a number of pressure tolerant enclosures to protect electronic equipment and battery packs when submerged in water. The housings are tested by using a vacuum pump, ball valve, and vacuum gauge and then monitored for 12 to 24 hours to ensure proper functionality. This project is driven by the need to guarantee the enclosure is sealed every time it goes into the water once it is in the hands of the customer. The usage of vacuum, temperature, and humidity sensors will assure the user that the state inside of the enclosure is within the desired parameters. Additionally, a set of LEDs installed inside and/or outside of the housing would allow the user to easily check the status of the enclosure.

Key Accomplishments

Hardware Selection: After thorough research, the hardware components were selected based on the functionalities needed for the project. The ESP32-DEVKITC-32UE by Espressif was selected for the microprocessor because of the integrated WiFi and Bluetooth capabilities. The BME280 sensor by Bosch was selected since it measures humidity, temperature, and barometric pressure.

Initial Prototype Development: An initial prototype was assembled with the ESP32, reed switch, and breakout boards of the BME280, RTC, MicroSD (**Fig. 1**). The ESP32 is flashed with Arduino code which initializes the RTC with the current date and time, collects sensor data, and then stores it on a MicroSD card. This prototype was developed to evaluate the components selected and ensure they are suited for the desired main circuit (**Fig. 2**).

BLE and Bluetooth Firmware: Using the Arduino IDE, the firmware was developed to test the BLE functionalities of the ESP32. The code initializes the ESP32 as a BLE server to advertise its existence to a client. A BLE service is created with characteristics containing values to store the pressure, temperature, and humidity readings. Once the advertising has started, the sensor readings can be read from a client device.

Graphical User Interface: Through some initial research Tkinter along with some other python modules were chosen to design the graphical user interface. Thus far, the GUI is able to accept user input, including device settings and data logging settings, and store them into a database (**Fig. 3**). A plot, that will eventually display vacuum, temperature, and humidity data, was added as well.

Reed Switch Assembly: The reed switch will wake the main circuit from low power mode. Due to being unable to physically interact with anything inside the pressure housing, a swipe of a magnet on the outside will trigger the reed switch. The reed switch selected is the MDSM-4 by Littlefuse which is cheap and effective.
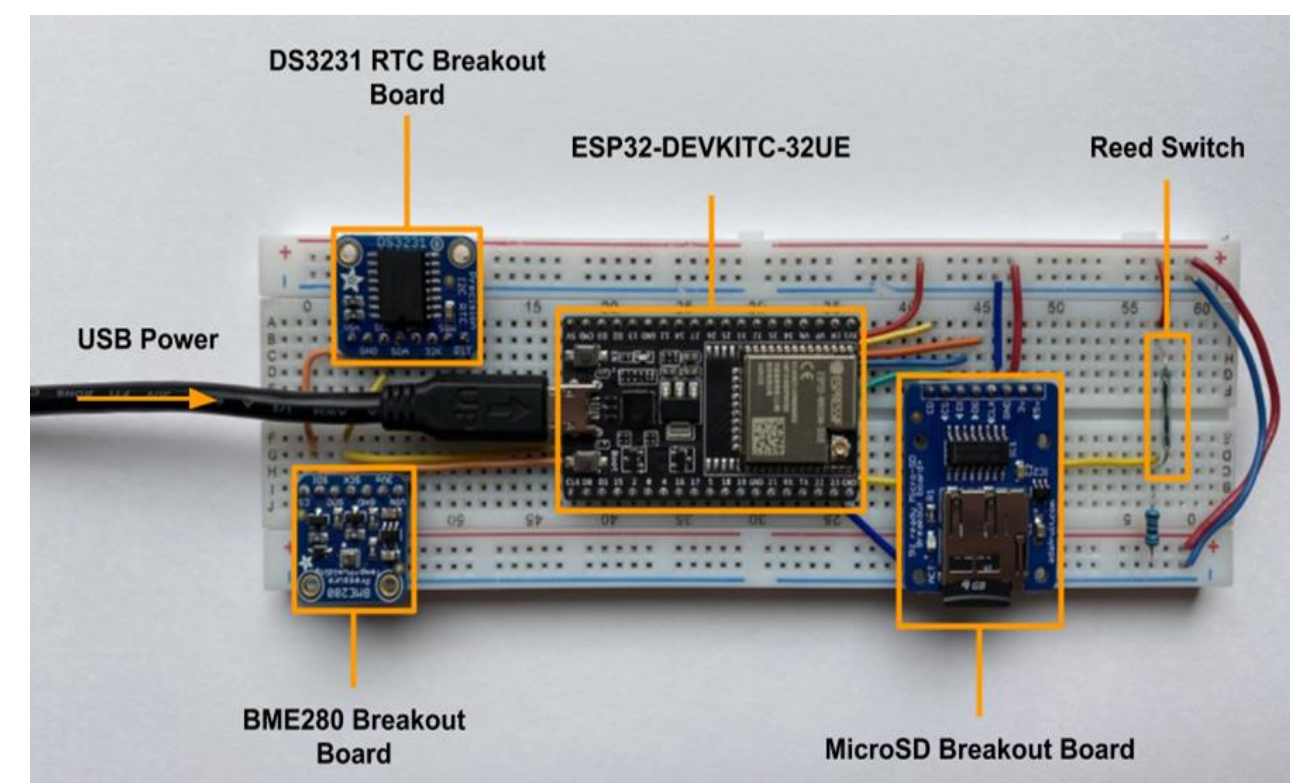

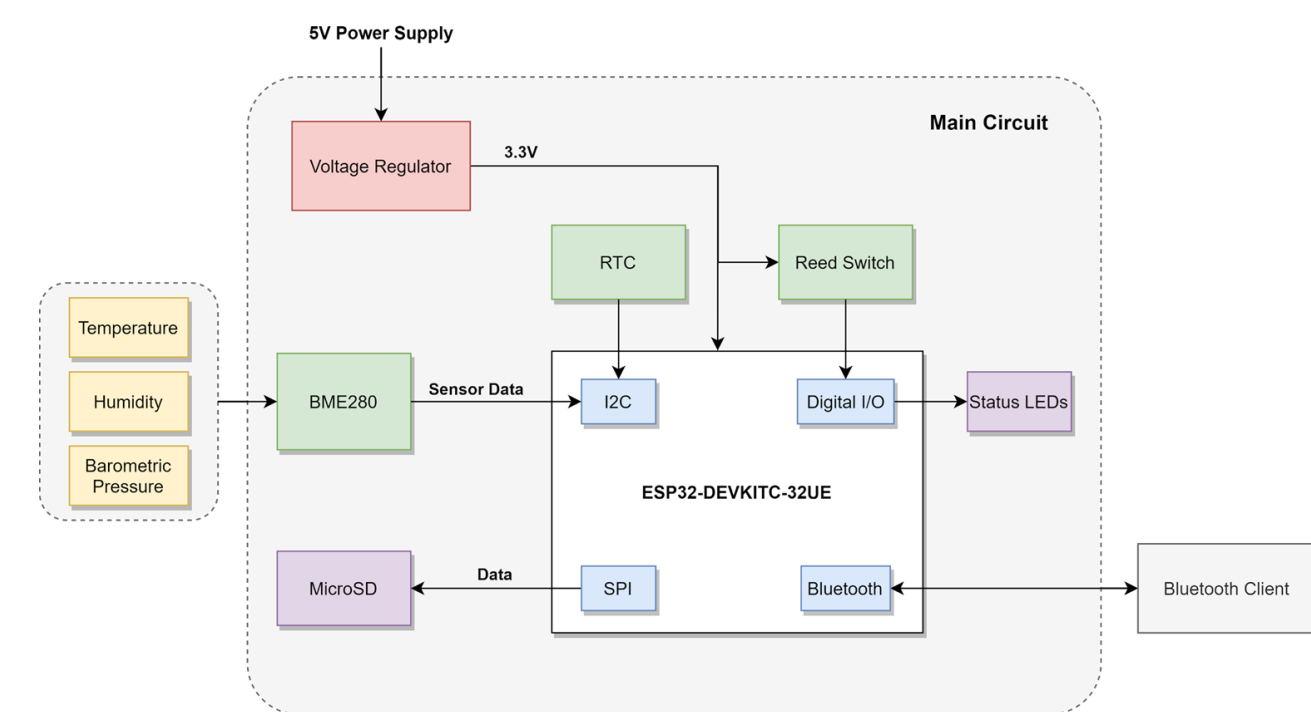**Fig. 1:** The initial prototype for evaluating hardware
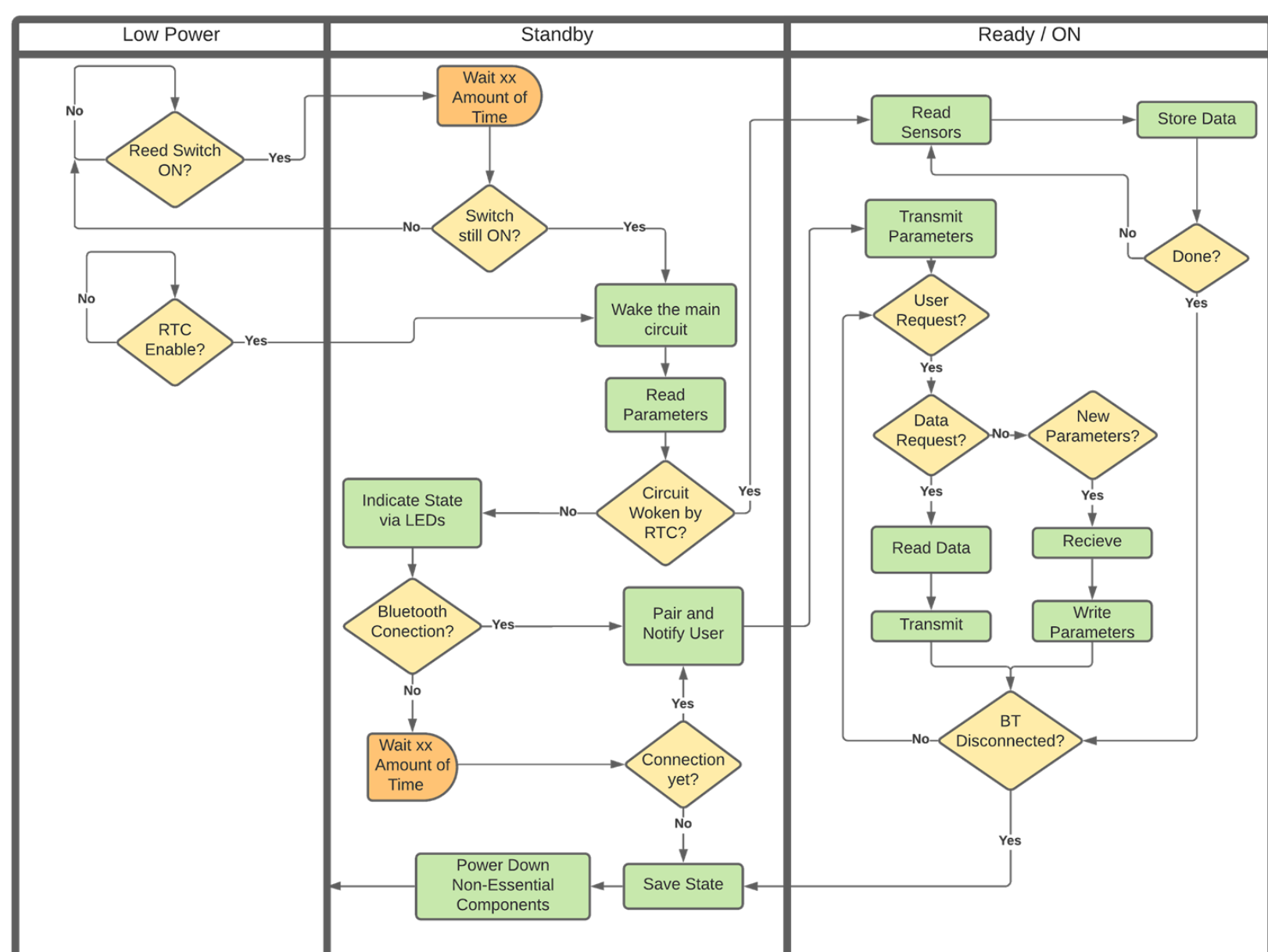

Fig. 2: The functional block diagram

Fig. 3: GUI application window

Fig.4: Flowchart of embedded firmware

Anticipated Best Outcome

The ABO is a functional prototype that can monitor vacuum, temperature, and humidity levels and report the status to the user. A GUI application will be created to display sensor data, remaining battery life, and accept user inputs. The system needs to be able to send and receive data between the main circuit and GUI application via Bluetooth or WiFi connection. A schematic and PCB will also be fabricated for the hardware prototype. A system user manual describing the hardware and software components will accompany the prototype, along with test results and a demonstration of the working system.
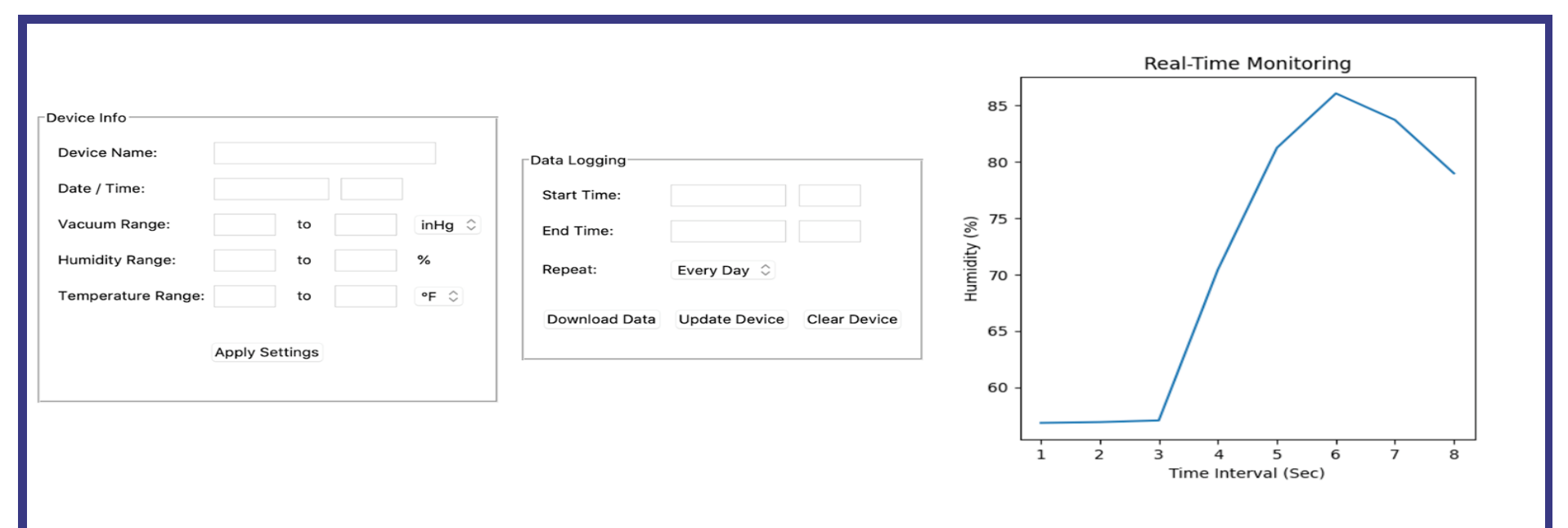
Remaining Technical Challenges

Data Processing and Transmission: Moving forward, managing data will likely be the most difficult task. A Bluetooth Low Energy script must be developed so that a PC can communicate with the ESP32. This code must be able to connect to a BLE server then interpret and process any incoming or outgoing data appropriately. Incoming packets to the PC will contain battery percentage, humidity, temperature, pressure, and time stamp data while outgoing packets will contain any parameters set by the user. The firmware will also need to be modified to interpret and process data in an inverse manner.

Firmware Development: The firmware will be further developed to include all the features of the final system (**Fig. 4**). Low power mode functions will be added with an external wakeup for the reed switch and a timer wakeup for the user-defined sensor reading frequency. The battery life will also be monitored and recorded and be sent to the GUI to display. A series of LEDs will be added to the main circuit to indicate whether the vacuum, humidity, and temperature levels are within the user-defined range.

Schematic and PCB Fabrication: Using a program called Circuitmaker, the components from the evaluated prototype will be placed and wired on a schematic. Then a custom PCB will be designed by placing and routing the components using the PCB design tool on Circuitmaker. An additional external circuit board with LEDs will also be fabricated for use with non-transparent pressure housings.

System User Manual: A system user manual will be created to accompany the functional prototype. This manual will walk the user through how to operate the hardware and GUI. There will also be documentation of the firmware and software written for the system.

Implications for Company & Economic Impact

Seascan's pressure tolerant enclosures are essential for oceanographic research and the ability to ensure their performance is even more crucial. As the company seeks to expand the market of their products, they will need to meet the demand for monitoring and collecting data from these enclosures. The first and most substantial step towards doing so will be developing the Vacuum and Temperature Monitoring Sensor (VTMS) and a complementary application. From this, Seascan will be able to offer their customers the option to retrofit each enclosure with a VTMS system. This would ultimately improve the product's reliability, longevity, and increase its value.