Valsalva Device

Non-Invasive Heart Failure Prediction

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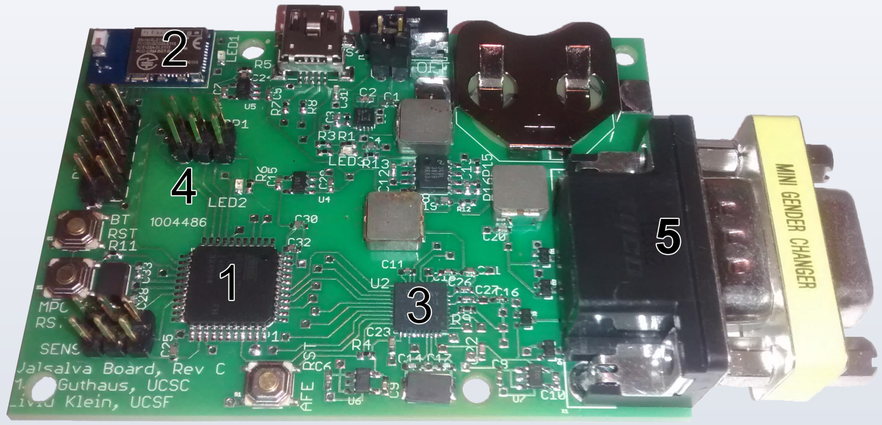
Abstract

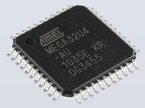
Heart failure has become more common due to the increasing population of the elderly. However, heart failure can be predicted via the Valsalva maneuver which bases the prediction on the patient's breath pressure and blood pressure. Generally, devices that can measure this information are either bulky and expensive or require some type of invasive procedure, e.g. a sensor implanted with a pacemaker. The device that we created is small, non-invasive, and interacts with common, modern technologies such as smartphones. Our device, named the Valsalva board, is a printed circuit board that contains several sensors and micro controllers to predict heart failure using the Valsalva maneuver. While collecting this data, it is transferred over to a nearby phone using Bluetooth Low Energy to be displayed, analyzed in a meaningful way, and shared with a patient's physician remotely.

Overview

- Gather data from the barometric pressure sensor and pulse oximeter while guaranteeing each sample is error free
- Have the Atmega 32u4 microcontroller gather these samples, confirm their correctness, and transfer the data to the Bluetooth module to be transferred to a remote phone
- Create an smart phone application that connects to the Bluetooth device on the board and receives the data coming from the board
- This application must also present the data in a well presented manner way such that it can be easily viewed by the patient or doctor

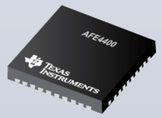
The Valsalva Board: Material and Methods





1. This is Atmega 32u4 microcontroller. It is the central processor responsible for coordinating all the input sensor data and transferring it too the Bluetooth module to be transferred over to a nearby phone.

2. This is the BLE113 Bluetooth Low Energy module. Its job is to take the data sent from the Atmega using SPI and transfer it a nearby phone. The benefits of using this low power device is that it is easily programmable and can run off a simple 3 Volt battery for a significant amount of time.



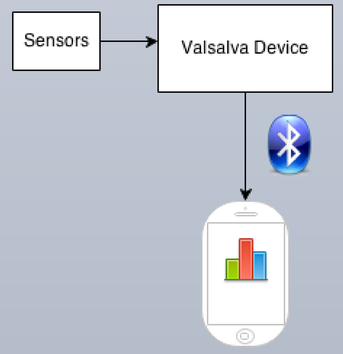
3. This is the AFE4400. This device interacts with a pulse oximeter finger probe by converting the probes analog output into a more readable digital result. It signals the Atmega when this conversion has finished in which the value can be read off using SPI and stored in the Atmega.

4. This is a barometric pressure sensor sold by Adafruit which will be connected to the board on the pictured 6-pin connector. The Valsalva maneuver requires the patient release the air in their lungs and pressurize a tube. This sensor will take air pressure sample and transfer it to the Atmega using I2C.

5. This is the pulse oximeter finger probe and it is connected to the board with a DE-9 connector shown in the above picture. This uses several LEDs that let light pass through the finger which can determine the oxygen saturation of the patient. This data is caught by the AFE4400.

Data Analysis

Currently, an Android smart phone is being used to connect to the BLE113 on the board. The data set is being represented using AndroidPlot which is an open source graphing tool for Android devices. After a few seconds of collecting the patients breath pressure and oxygen saturation, the phone analyzes the data and presents a prediction or their current risk of heart failure.



Results

- Due to a voltage problem with the board, the pulse oximeter does not work correctly.
- This means that the data collected cannot be used because the sensor data is not accurate.
- Therefore, there also still requires some work completing a way to present this data.
- However, everything else appears to work as described in the previous section.
- Data from the pressure sensor is obtained and transferred using Bluetooth to the phone to be displayed as a graph.
- The phone application is still very plain and requires some refinement.

Conclusion

Due to the defect in the board, the research stopped a bit short, so the current board does not have the capability to collect accurate data. However, the tools to collect and present this data have been built, so the next variation of this board can use these tools to complete the research.

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Online References

- Atmega32u4 - sparkfun.com
- BLE113 – bluegiga.com
- AFE4400 – ti.com
- Pressure Sensor - adafruit.com
- Pulse Oximeter - medicalsupplies.com