EEar

High Level Design Proposal

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# **1 Introduction**

Human deafness can make everyday interactions within the home harder to interpret and impossible to notice; since so many alarms or sensors alert us by making a noise, there has to be a way to detect when something interacts with the objects outside or inside the home, whether it may be a neighbor ringing a doorbell or fire that is growing by the second. The only way that a deaf person can be aware of each input is through a wristband that vibrates at different levels when such an input (that ranges in importance) interacts with the person.

# **2 Problem Statement and Proposed Solution**

**Problem Statement**

Deaf people need a way to be informed when various alarms go off in their homes- without a sensor that depends on sound, they would have no idea if something is wrong within their household. While technologies exist that flash when their phone rings or when someone is at the door, the flashing would be of no help to a deaf person who is sleeping. In addition, there is no product that alerts a person in a different way for the many types of interactions that occur within the modern day household. There is similarly not a device that tells a person the severity of a situation that needs a response; for example, someone ringing the doorbell would elicit a small response whereas a fire or carbon monoxide would trigger a much greater response to the person.

**Proposed Solution**

We intend to make a wristband that communicates with all of the alarm systems in a home, such as smoke alarm, carbon monoxide detector, and intruder alarm for front and back doors. By attaching a small microcontroller to the speaker output of these various alarms, the wristband will receive a signal through WiFi and Bluetooth capabilities that will cause it to vibrate. In addition to vibrating, the wristband will display text indicating which alarm has been tripped. Because the device always needs to be active, it will have a rechargeable battery to ensure that it remains on. Batteries could be swapped out so that one battery will be completely charged at all time.

# **3 System Requirements**

The embedded intelligence will require the user to disable the alarm by pressing a push button on the bracelet when they have dealt with the issue. Additionally, the bracelet will alert the user when the battery power has dropped below 20% by using a battery sensing chip that will be on the bracelet.

We will be building two hubs that will be able to communicate with each other via WiFi. WiFi will be used between the hubs because they will be placed on different floors of the house and need a range that will reach that far. The hubs will also be communicating with different sensors that will be placed near sources of loud noise. The hubs and sensors will communicate via WiFi, so the sensors will need to be able to communicate at least the distance of the length of a house, since there will be a hub on every floor. All of these sensors will be plugged into a wall outlet, so the power consumption from WiFi is not of concern. The wristband will communicate with the hubs via Bluetooth. Since there will be multiple hubs in a home the range of the communication would need to be the length of a house. The wristband is powered using a rechargeable Lithium-Ion coin cell battery, rated at 50 mAh, sized at 23mm in diameter, 3 mm in height. The battery will be recharged by placing a micro-USB port on the device. The system would ideally be able to run for a day without needing to be charged. Because the user is not always at home, they will not always need to be wearing the device. It is at this time that it could be charged. Because the hubs and sensors will be plugged in, we do not have to worry about charging them.

On the microphone interface, there will be a switch that has a number of different symbols that reflect different situations (i.e. a doorbell symbol, an intruder symbol, a smoke symbol for carbon monoxide, and a fire symbol) and the user selects one of these based on where the microphone interface is placed. On the wristband, there is a button that is used to clear the warnings once the user has been made aware of these warnings.

The microphones will be installed next to any fire or smoke alarms and doorbells (anything that makes a loud noise that can interact with the user). These will be classified what type of alarm they are when they are being installed so that the user knows what kind of alarm is being triggered instead of getting a generalized warning system. The wristband is worn by the user and can be charged by a micro-USB cord when the battery is low.

We do not expect this project to involve dangerous voltage or current levels. However, while using electronic devices there is always a risk of electric shock, such as when the device is being plugged into a power source for charging. We will be very careful in our design of the wristband to ensure a safe connection between the battery and the charger so that there is not a risk for the user.

The wristband will include a strap for the user’s arm and should be comfortable for the user in terms of weight and size. The sensor should be as small as possible and have an attachment feature to allow its secure placement on the device it will be sensing. In our research, we discovered that watches that are considered heavy watches can be upwards of 250 grams. We will set 250 grams as our maximum weight and aim for making it lighter. Typical watch faces are about 1.5-1.75 inches in diameter, we are planning to have our watch be no wider than 1.75 inches at its widest point.

# **4 System Block Diagram**

## **4.1 Overall System**



The system will consist of a sensor network, hub network, and the wristband. The sensor network will only communicate with the hub network, sending a signal via WiFi to the hub network when an alarm is going off. The hub network will communicate with the sensor network via WiFi and the wristband via Bluetooth. There will be no direct communication between the wristband and the sensor network.

## **4.2 Subsystem and Interface Requirements**

**Sensor Network**

The sensor network is a sensor that will be placed near any alarms in the house and will use microphones to detect if the alarm is sounding. When an alarm is going off, the sensors will relay an alert message to the hub network depending on which state it is in. A user can have as many sensors as they need in their house, but each sensor would communicate directly with the hub network, without communicating with any other sensors.

* Microphone - A microphone will be placed so that it is facing the alarm. If the alarm goes off, the sensor will know that it needs to check what state it is in and communicate with the hub network.
* State Switch - The user will be able to set the type of alarm the sensor is listening for using a switch. If the alarm is sounding, the sensor network will check which state the switch is in so that it can alert the hub network of which type of alarm is sounding.

**Hub Network**

The hub network receives alerts from the sensor network via WiFi. It will be able to receive alerts from however many sensors the user buys for his or her house. The hubs will be located on every floor of the house so that they can together broadcast across the whole house via Bluetooth, since that will be the way the hubs communicate with the wristband.

**Wristband**:

The wristband would first receive signals from the hub network based on which alarm is going off at the moment; then, depending on the classification of that alarm, the LCD displays a message specific to that alarm. This warning level of this message is displayed using LEDs and the buzzer is activated and pulsed to inform the user an alarm is on. In the background, a battery check is running.

* LCD - the LCD display is dependent upon the type of signal that it receives; if the alert is a fire alarm, then a string would be displayed on the LCD saying “FIRE”. An alert for low battery would also show up at a different location of the screen when the battery is low (so the screen could both display a threat alert and a low battery alert).
* LED - The LEDs are dependent upon the input signal warning classification; if the signal is a non-threat, the LEDs glow green, and if the signal is a threat, the LEDs glow red.
* Buzzer - This component is also dependent on the input signal warning classification; if it is a non-threat, the buzzer setting will be low, whereas if it is a threat, the buzzer setting will be high.
* Battery Check - The battery will be monitored by a Texas Instruments LM8364 chip that is designed to continuously check the battery charge and send a signal when the battery is determined to have a low state of charge. The chip is designed to check for undervoltage conditions and has a very low power consumption. If the battery is determined to be getting too low (20%), warnings will be displayed on the wristband at set intervals (perhaps every 30 minutes) until the band is recharging.

## **4.3 Future Enhancement Requirements**

Some future endeavors in furthering the design of the wristband include what part of the house the more pressing alerts are coming from. This includes saying what floor or room a fire is located so the user can avoid it as they leave the house, or even more important the location of carbon monoxide gas when the alarms are going off; with this feature included, the user will be able to avoid any potential danger that they can’t see.

Another feature that will be allocated to a future version of the wristband is customizable alerts, where the user could plug the wristband into a computer and create custom alerts (e.g. “Basement Fire”, “Front Doorbell”, “Food Ready in Kitchen”, etc.) which would then be uploaded onto the wristband for future use when those specific alarms are triggered.

An important feature that could also be of some use in the future would be if any of the pressing alerts are activated and not cleared for more than 2 minutes, then emergency services would be automatically contacted, thus eliminating the need for further action within the house, allowing the user to leave as quickly as possible.

**5 High Level Design Decisions**

**Wristband:**

The wristband interface is the most complicated of the subsystems. The incoming alert will be interfaced by a wireless signal that wakes up the low energy Bluetooth chip. The Bluetooth chip will then wirelessly receive the alert from the nearest hub in the network. This alert will be interfaced and transferred to the main microcontroller. The microcontroller will process the alert and send the corresponding alert to the LCD screen while simultaneously providing power to the buzzer and to LED. The user will be alerted by this combination of aspects and can use the reset button to clear the alert from the LCD and turn off the LED. In terms of powering the wristband, the power source will be a rechargeable lithium coin cell battery. This battery will be monitored by a Texas Instruments battery monitor chip. When the Texas Instruments chip determines a low charge state, it will interface a signal to the microcontroller which will then alert the user that the battery is low via the buzzer, LCD and LED components. The microcontroller will be connected to the LCD, LED, battery sensor chip, alert clear button and buzzer components via I/O pins. The Bluetooth chip via an available SPI, I2C or UART interface that is clocked by the microcontroller.

**Hub Network:**

Each hub will need to communicate with the sensors, other hubs, and the wristband itself. When the sensor is triggered, it will send a signal via WiFi to the nearest hub. The WiFi chip has the capability to send the signal either via an SPI or UART interface. The sensor will only send an output to the hub if it picks up a volume level greater than a comparison value measured in dB. This way, the hub will only be activated if a sensor is going off, rather than have it constantly be comparing unnecessary values. If the user is on a different floor than that hub, then that hub will send another WiFi signal to the closest hub in a beacon-like system until the hub closest to the user is pinged. At this point, the closest hub will send a signal to the wristband via Bluetooth to conserve power. This Bluetooth signal could be sent via an SPI, I2C, or UART interface. Each hub will be powered via a wall adapter plug and so power is not a concern. Therefore, the hub will, in total, consist of a WiFi chip, a Bluetooth chip, a wall adaptor, and a surface mount power jack.

**Sensor Network:**

The sensor network will have a set of inputs and outputs for when alarms are triggered: the input is the sound level and if the input is higher than the warning threshold value (ex. 105 dB) then a certain string is sent to the hub network through WiFi which is specific for each sensor. The microphone will connect to the audio jack which will connect to an available I/O pin on the WiFi chip, which will be programmed to read the signal. Within the circuit connected to the audio jack, the microphone signal is inputted and the a binary option is computed. This operation checks if the microphone signal is louder than the determined value; if it is, then a 1 is outputted and sent to the Hub. If not, then a 0 is outputted. Therefore, the sensor network will consist of a microphone, an audio jack, a wall adaptor, a surface mount power jack, and a WiFi chip.

# **6 Open Questions**

* We have never worked with programming a device that is expected to communicate with other devices over both WiFi and Bluetooth at the same time.
* At this point in our planning, we are not sure what type of design our wristband will actually have. We believe that the design will be something we solidify once we have more of our electronics portion physically built.
* Another issue would be if one alarm goes off (and multiple sensors are near it) this could trigger multiple alarms at once. However, one solution could be to look at the frequency response of the alarms individually. If the frequency response of the alarm going off at the moment doesn’t match other alarms, then those alarms won’t go off- but at this point, we do not know how to implement this system of checking the frequency response.
* We are also not sure how to change the settings for the buzzer or how to create different buzzer outputs for different scenarios.

# **7 Major Component Costs**

Major components and costs are summarized in the table below. (Note that this is the amount of parts required for 1 wristband, 1 hub, 1 sensor). This total cost estimate is for the major components and doesn’t include minor components like resistors, capacitors, etc… The actual cost will be higher based on the addition of these other necessary components to make the components listed below functional.

|  |  |  |  |
| --- | --- | --- | --- |
| Parts: | Subsystem Component: | Quantity | Cost: |
| LCD Screen - [Adafruit SHARP Memory Display Breakout](https://www.adafruit.com/products/1393) | Wristband | 1 | $39.95 |
| Battery Sensing Chip- [TI LM8364](http://www.digikey.com/product-detail/en/texas-instruments/LM8364BALMF20-NOPB/LM8364BALMF20-NOPBTR-ND/568486) | Wristband | 1 | $0.31 |
| Bluetooth Low Energy Chip Dev Board- [nRF52832](https://www.sparkfun.com/products/13990) | Wristband | 1 | $19.95 |
| Clear Alert Button- [Push Button](http://www.digikey.com/product-detail/en/copal-electronics-inc/CFPB-1CC-1W6W/563-1232-ND/2357718) | Wristband | 1 | $2.07 |
| Buzzer - [Buzzer](http://www.digikey.com/product-search/en/audio-products/alarms-buzzers-and-sirens/720967?k=buzzer&k=&pkeyword=buzzer&pv397=565&FV=fff4000b%2Cfff80047%2C38009e%2C1f140000&mnonly=0&newproducts=0&ColumnSort=0&page=1&quantity=0&ptm=0&fid=0&pageSize=25) | Wristband | 1 | $4.70 |
| LED - [LED](https://www.sparkfun.com/products/9590) | Wristband | 1 | $0.35 |
| MCU- [Ultra-Low Power Microcontroller](http://www.ti.com/product/MSP432P401R) | Wristband | 1 | $3.68 |
| Battery - [Lithium Rechargeable Battery](http://www.digikey.com/product-detail/en/panasonic-bsg/VL-2330-F3N/P002-ND/965119) | Wristband | 1 | $7.82 |
| WiFi Chip - [ESP8266](https://www.sparkfun.com/products/13678) | Hub Network and Sensor | 2 | $6.95 |
| Bluetooth Chip - [nRF52832](http://www.digikey.com/product-detail/en/nordic-semiconductor-asa/NRF52832-QFAA-R/1490-1052-1-ND/5428660) | Hub Network and Wristband | 2 | $5.73 |
| Audio Signal Jack- [Audio Signal Jack](http://www.alliedelec.com/switchcraft-35rapc2av/70214257/) | Sensor | 1 | $0.63 |
| Microphone - [Microphone](https://www.walmart.com/ip/47552388?wmlspartner=wmtlabs&adid=22222222222034807108&wmlspartner=wmtlabs&wl0=e&wl1=o&wl2=c&wl3=10360016643&wl4=kwd-1105704134494&wl12=47552388_10000000599&wl14=3%205mm%20microphone&veh=sem) | Sensor | 1 | $7.88 |
| Wall Adapters - [Power Supply](http://www.digikey.com/product-detail/en/volgen-america-kaga-electronics-usa/KTPS05-03315U-VI-P1/62-1234-ND/5820199) | Hub Network and Sensor | 2 | $8.76 |
| Surface Mount Power Jack - [Power Jack](http://www.digikey.com/product-detail/en/cui-inc/PJ-040-SMT-TR/CP-040PJTR-ND/1530980) | Hub Network and Sensor | 2 | $0.55 |
| **Total Cost:** |  |  | $171.58 |

# **8 Conclusions**

By the end of Spring Semester, we intend to have a working device that can be worn on a deaf person's wrist to alert them of alarms sounding in their house. This system will use sensors that listen to the alarms people already have in their houses and signal to the hubs that will be located on each floor of the house. This communication will be done via WiFi. The hubs will then assess the signal they received and send the message to the wristband, which will interpret the message and convey the warning to the person wearing the device. Through the use of the LCD display, the LED light, and the vibration of the buzzer, the person will be alerted of the type of alarm that is sounding. This will be most important when the user is sleeping, when they are less likely to be aware of any visual signals that a problem is occurring. The vibration will wake the user and help them remain safe.

**References**

* Links for Parts
* <https://www.adafruit.com/products/1393>
* <http://www.digikey.com/product-detail/en/texas-instruments/LM8364BALMF20-NOPB/LM8364BALMF20-NOPBTR-ND/568486>
* <https://www.sparkfun.com/products/13990>
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* <http://www.digikey.com/product-search/en/audio-products/alarms-buzzers-and-sirens/720967?k=buzzer&k=&pkeyword=buzzer&pv397=565&FV=fff4000b%2Cfff80047%2C38009e%2C1f140000&mnonly=0&newproducts=0&ColumnSort=0&page=1&quantity=0&ptm=0&fid=0&pageSize=25>
* <https://www.sparkfun.com/products/9590>
* <http://www.ti.com/product/MSP432P401R>
* <http://www.digikey.com/product-detail/en/panasonic-bsg/VL-2330-F3N/P002-ND/965119>
* <https://www.sparkfun.com/products/13678>
* <http://www.digikey.com/product-detail/en/nordic-semiconductor-asa/NRF52832-QFAA-R/1490-1052-1-ND/5428660>
* <http://www.alliedelec.com/switchcraft-35rapc2av/70214257/>
* <https://www.walmart.com/ip/47552388?wmlspartner=wmtlabs&adid=22222222222034807108&wmlspartner=wmtlabs&wl0=e&wl1=o&wl2=c&wl3=10360016643&wl4=kwd-1105704134494&wl12=47552388_10000000599&wl14=3%205mm%20microphone&veh=sem>
* <http://www.digikey.com/product-detail/en/volgen-america-kaga-electronics-usa/KTPS05-03315U-VI-P1/62-1234-ND/5820199>
* <http://www.digikey.com/product-detail/en/cui-inc/PJ-040-SMT-TR/CP-040PJTR-ND/1530980>
* Other References

- <http://www.fratellowatches.com/watches-pencils-13-weight-of-watches/>