

# Protect-U

## ECE 445 Design Document

Santan Katragadda, Bhavish Bhattar, Ali-Berk Eroglu

Team 35

TA: Stephanie Jaster

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# 1 Introduction

## 1.1 Objective

Sexual assault and harrassment has been a common problem in society for many years. It is known to be the most underreported violent crime. Cases are often times dismissed or not even brought to court as the evidence presented becomes a "he said vs she said" case in which the victim's pleas struggle to gain validity without concrete proof. During sexual assaults or assaults of any nature, offenders seek to neutralize the victim's phone and take advantage of settings where there are no cameras or recording equipment. This causes an extremely low percentage of offenders being held accountable for their crimes.

Our solution seeks to help victims through the use of a wearable device that can record audio and emit a loud siren to attract attention to the situation. The user should be able to wear this device discreetly attached to a keychain, inside of a pocket, or hidden by attaching it to an undergarment. The audio that is recorded from the device will be saved to the user's phone via bluetooth, which then could ultimately be sent to the cloud, or authorities to provide the victim with evidence needed to bring justice to the perpetrator in the unfortunate circumstance that a sexual crime or assault is committed against them.

## 1.2 Background

According to statistics by the Rape, Abuse & Incest National Network (RAINN), 11.2% of college students experience rape or sexual assault through force, violence, or incapacitation [2]. More specifically, 23.1% of undergraduate females are victims of these crimes. Shockingly, only 20% of female student victims aged 18-24 report these crimes to law enforcement [2]. A major reason for this is the lack of evidence as the victim feels that he/she may lose the case. Overall, 995 out of 1000 perpetrators of sexual assault walk free [3].

As technology has evolved, there are no wearable products with prevalent market share that are made specifically for preventing or collecting evidence during these situations. Perpetrators will oftentimes seek to remove the victim's phone from them making it an unreliable defense. A simple phone app, thus would not suffice as it would be difficult for the user to unlock their phone, navigate to the app, and activate the alarm or recording without the perpetrator taking notice. A discreet wearable would minimize the amount of actions the victim would have to do in a critical situation. Sexual assault is still a prevelant part of society and it is time that technology is utilized to help protect victims and aid them in providing evidence to law enforcement.

## 1.3 High-level requirements list

- The device will only be activated when the user taps it 3 times within 2 seconds to turn on its recording capabilities or 5 times within 3 seconds to turn on the in-built alarm.
- The device can record up to 10 minutes of audio and save it in internal memory.
- The audio saved on the device is transmitted to the user's phone through a bluetooth connection and it will be saved to the phone through a software application.

## 2 Design

### 2.1 Overview

The successful functionality of the device hinges on the proper execution of 4 main systems, the user interface, the control unit, the functional unit and the power system. The user interface is the system that facilitates the interaction between the user and the device. This includes the trigger mechanism necessary to deploy the functionality of the device, the phone application to put in necessary information and access the data stored by the device and the LED Indicators that display device status information. In addition the functional unit carries out the main functionalities of the device, primarily the alarm system and the audio recording capabilities. Both these systems are driven by the control unit, which contains the device memory to store any recorded audio, the bluetooth module which will transfer the data to the phone and the microcontroller which will drive all the interactions between the components. Finally all of this is only possible with the power system, which will be driven by a rechargeable battery.

### 2.2 Block Diagram

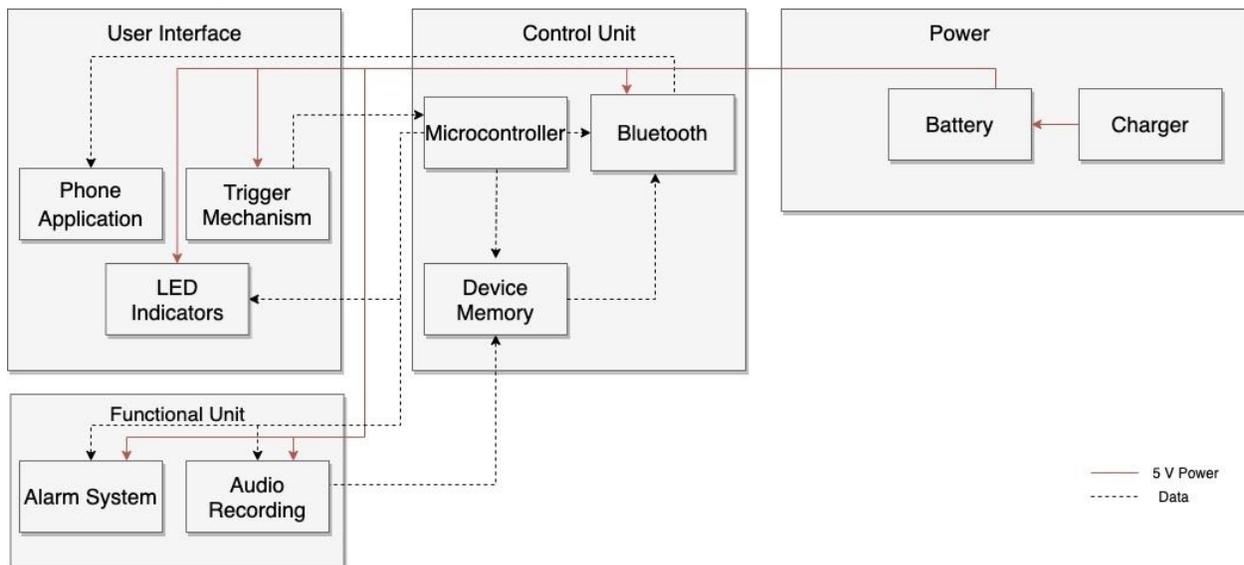


Fig 2.2 Block Diagram

## 2.3 Physical Design

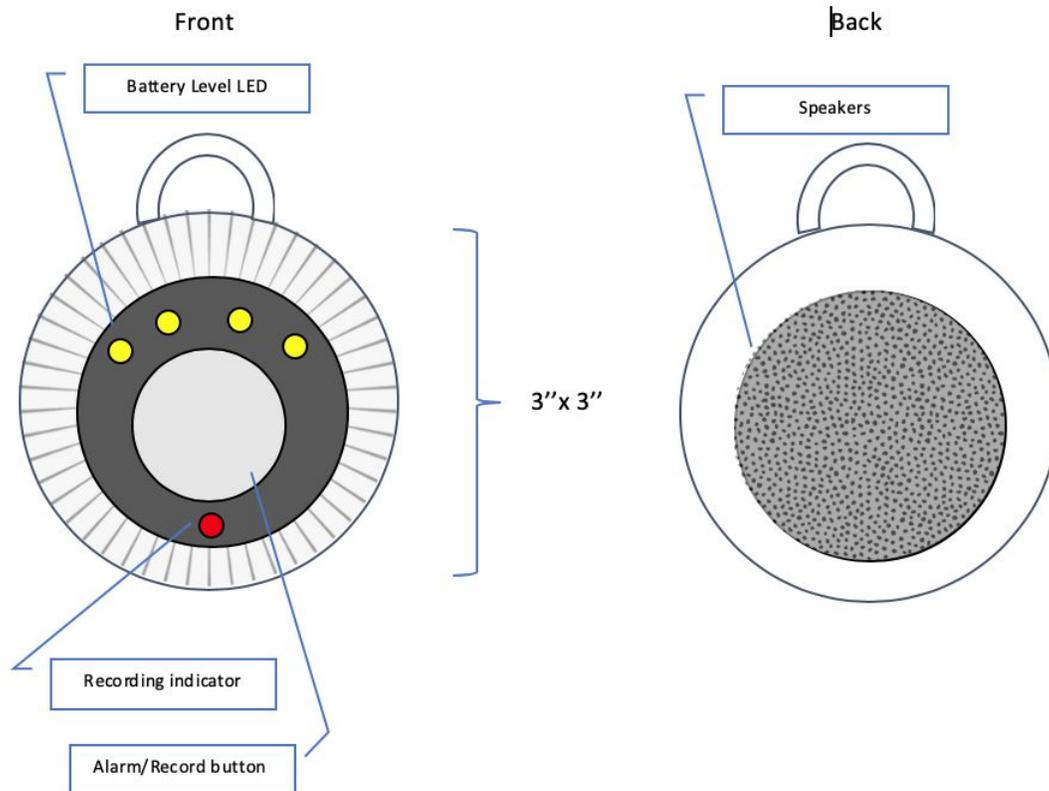


Fig 2.3 Physical Design

## 2.4 Functional Overview

### 2.4.1 User Interface

#### Trigger mechanism:

A button on the wearable device that upon a three taps will begin recording audio and upon five taps will deploy an alarm and reach out to parties for help. This button must have a clear capacity to detect individual taps in quick succession in order to identify if the user is trying to activate a functionality or if it was just accidentally pressed.

Requirements	Verification
<ol style="list-style-type: none"> <li>1. Easily pressable and distinguishable from the rest of the device</li> <li>2. Must be able to identify when 3 or 5 presses have occurred in the time frames</li> </ol>	<ol style="list-style-type: none"> <li>1. Confirm that with 100% accuracy that when blindfolded users can find the button within 10 seconds</li> <li>2. If 3 presses occur over a span greater than 2 seconds or 5 presses occur over a span greater than 3 seconds nothing happens and that the operation occurs if they are successfully pressed in the timeframe</li> </ol>

**Phone Application:**

A mobile application that will interface with the bluetooth from the device. The application needs to be able to receive bluetooth data files even when being run in the background. Once the appropriate permissions are given to the application, it must be able to store data directly on the phone or even send out the data to parties that could provide assistance to the user.

Requirements	Verification
<ol style="list-style-type: none"> <li>1. If permissions are granted to the phone application, even if the application is running in the background, it will be able to receive and save audio files via bluetooth</li> <li>2. Must be able to save the audio files to the file system of the phone</li> </ol>	<ol style="list-style-type: none"> <li>1. Audio will sent via bluetooth to the phone, within 2 minutes of sending the recording, the phone should have the audio saved in it's file system while the application is running in the background</li> </ol>

**LED Indicators:**

LED lights which are placed on the top of the device that will indicate to the user when the recording is activated, and the current charge level of the device. To indicate the current charging level, a charge detection circuit will be used on the battery to illuminate zero to four of the LEDs, four indicating 100% charge and each LED representing 25%.

Requirements	Verification
<ol style="list-style-type: none"> <li>1. LED lights are able to accurately display how much battery life the device has to the nearest 25%</li> <li>2. A red LED will shine when recording is taking place.</li> </ol>	<ol style="list-style-type: none"> <li>1. Use a voltage meter to detect both the fully charged and discharged voltages of the battery then validate that at the appropriate intervals of voltage the appropriate LEDs are glowing to indicate remaining charge</li> <li>2. Test that whenever audio recording is enable the red LED will be shining</li> </ol>

**2.4.2 Functional Unit**

**Alarm system:**

Once the alarm is triggered, the device must be capable of outputting a loud enough siren to attract attention from people in the vicinity. A speaker with an amplification circuit would be used here.

Requirements	Verification
<ol style="list-style-type: none"> <li>1. The alarm must be noticable and attention grabbing at 100 feet away</li> </ol>	<ol style="list-style-type: none"> <li>1. Using a db recording application, check that the alarm is able to produce a 50db sound at 100 feet</li> </ol>

**Audio recording:**

Device must be able to record audio in the nearby vicinity. We will use a microphone with an amplification circuit to accomplish this. The device needs to be able to detect voices through clothing and has to be clear.

Requirements	Verification
1. The microphone is able to pick up conversations between individuals at a distance of 2 meters even under clothing	1. Have the device placed under an individual's shirt and let them have a conversation with another individual that is standing 2 meters away. Have another individual that is not aware of what was said in the conversation discern the contents of the conversation

### 2.4.3 Control Unit

**Bluetooth:**

Device can send the audio recording via bluetooth to the victim's mobile device

*Requirement: The bluetooth must be powerful enough to allow for audio files to be transferred between the device and the phone at a reasonable rate*

**Microprocessor:**

Contains logic for managing memory, bluetooth, audio recording, and alarm system.

*Requirement: Must be programmable and able to coordinate bluetooth and memory managing capabilities.*

**Device Memory:**

Micro SD card to store audio recordings on wearable device

*Requirement: Must be at least 100 MB so that it has the capacity to store a 10 min interaction directly on the device.*

### 2.4.4 Power System

**Battery:**

Battery with a charging circuit and USB-to-serial converter

*Requirement: Battery that produces output voltage between 3-5 volts.*

Requirements	Verification
1. Battery should supply 3.7V and current at a rate of 500 mA.	1. Use a voltmeter and ammeter to verify the supplied voltage and current values.

**Charger:**

Micro-USB charging port will be used to charge the battery. By charging at a rate of 100mA the charger will be able to recharge the battery at a quick rate while also not posing a risk of the battery over heating.

Requirements	Verification
1. Charger should charge the battery at a rate of 100 mA.	1. Discharge the battery 2. Use an ammeter to verify the charging current while charging the discharged battery.

**2.5 Risk Analysis**

The control unit poses the greatest risk for successful completion of the project. The bluetooth functionality may not function as intended as the group is inexperienced with the protocols. Coding the microcontroller may also pose a challenge as there are many conditions involving the button, LED's, alarm, and inputs from the phone that need to be taken into account. Also, writing to and reading from device memory may be challenging as the write speed may not be fast enough to record the audio. Also, transferring the memory from the device to the phone may be difficult using the control unit as specific permissions must be bypassed to write to the phone without user interaction.

**2.6 Tolerance Analysis**

The tolerance that we must maintain is that the rate of transfer from the audio device to the phone must be maintained. We must uphold that even in the event that the user is separated from their phone or recording device, that any audio that is collected will be transmitted to the phone so that it has the capacity of providing assistance to the user. This poses a challenge as the large audio files represent a hurdle when transmitting it to the phone so it is imperative that any audio that is being recorded can be transmitted quickly in chunks so that whatever is recorded can be stored safely.

### 3 Cost and Schedule

#### 3.1 Cost Analysis

Our fixed cost analysis is separated into labor and parts. Labor will be calculated assuming an hourly rate of 35\$ an hour for each of the team members. We will also assume a 10 hour work week for a total of 14 weeks. Our final calculation comes out to  $3 * 35 * 10 * 14 * 2.5 = \$36750$

Part	Cost per Unit (\$)	Quantity	Total Price (\$)
Lithium Ion Polymer Battery - 3.7v 500mAh	7.95	1	7.95
Adafruit Micro Lipo - USB LiIon/LiPoly charger - v1	5.95	1	5.95
HiLetgo HC-05 Wireless Bluetooth RF Transceiver	7.99	1	7.99
Arduino Pro Mini 328 - 3.3V/8MHz	9.95	1	9.95
FT232RL FTDI USB To TTL Serial Converter Adapter Module	5.68	1	5.68
Speaker Digi-Key CPI-2207-95-SMT-T R	3.43	2	6.86

Total			
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## 4 Discussion of Ethics and Safety

Given that this product aims to help victims in providing evidence to the victim, it is important that the audio data recorded is not modified in any way by the device. This is in compliance with number 3 in the IEEE code of ethics in which we will be honest about the data used in the device [4]. We will keep this in mind during the development stage of the product. One-party consent recording is legal in 38 states, however 12 states still require all-party consent for audio recordings. If this device were to make it to market, this would need to be clearly stated so the user doesn't accidentally record audio illegally in certain states. This is in accordance with number 5 in the IEEE code of ethics in which we are urged to improve the understanding of individuals on the societal implications of our technology [4]. Additionally, in compliance with number 1 in the IEEE code of ethics, we will ensure that all safety precautions are taken in the construction of the device to ensure that there is very minimal risk of harm to the user, and if any such risk does exist, information would be provided to the user to inform them of the proper usage to avoid said risk.

Since this device is a wearable and can potentially have close contact with the human body, extra precautions are necessary to protect the user. The outside of the wearable device will be an insulating casing that will make sure that no wires are exposed. This will minimize the risk the user faces when using the device while it is raining outside or when the user is sweating. Although lithium ion batteries have become the standard in rechargeable consumer products, there is still a level of risk that must be mitigated when using them. The battery will be purchased from a reputable company with a protection circuit built into the battery. The protection circuit will prevent the battery voltage from getting too high or too low and will cause the battery to cut out at 3.0 volts. This also prevents the other circuitry in the device from shorting or being damaged by improper power input. The manufacturer recommended charger for the battery will also be used to prevent malfunctions in the battery. The charging will have three stages: a preconditioned charge, constant-current fast charge, and a constant-voltage trickle to top the battery off. These stages prevent overcharging of the battery. There will also be a voltage detection circuit that can visibly notify the user when the battery has charged.

When working on developing this device, our group will take many precautions to ensure our safety and the safety of those around us. All members of the group have completed and passed the required lab safety training. We will make sure to not modify circuits while the power is connected, as well as be vigilant of any burning parts to make sure we do not start a fire. The lab will also be equipped with a fire extinguisher in case of emergency. Additionally, our group will have at least two members present when working in the lab to help prevent accidents. In the

situation the group needs to work with equipment that the members of the group are unfamiliar with, we will ensure that there will be the necessary supervision to validate the proper usage of the equipment. Finally, the group will not use other individual's work without the proper citations, and certify that the idea and design of the project is original and unique [1].

#### Parts List:

- Battery - Lithium Ion Polymer Battery - 3.7v 500mAh (Protection included)
  - <https://www.adafruit.com/product/1578>
- Battery- Charging Circuit <https://www.adafruit.com/product/1304>
- Bluetooth Module - HC-05
  - <https://www.amazon.com/HiLetgo-Wireless-Bluetooth-Transceiver-Arduino/dp/B071YJG8DR?th=1>
- Micro Controller- Arduino Pro Mini 328 - 3.3V/8MHz
  - <https://www.sparkfun.com/products/11114>
- Micro Controller Programmer:  
[https://www.banggood.com/FT232RL-FTDI-USB-To-TTL-Serial-Converter-Adapter-Module-p-917226.html?akmClientCountry=America&p=DQ30066511122014069J&utm\\_campaign=educ8stv&utm\\_content=3216](https://www.banggood.com/FT232RL-FTDI-USB-To-TTL-Serial-Converter-Adapter-Module-p-917226.html?akmClientCountry=America&p=DQ30066511122014069J&utm_campaign=educ8stv&utm_content=3216)
  - Youtube video for how to program  
<https://www.youtube.com/watch?v=78HCgaYsA70>
- Speaker
  - <https://www.digikey.com/product-detail/en/cui-devices/CPI-2207-95-SMT-TR/2223-CPI-2207-95-SMT-DKR-ND/11591341>
  - <https://www.eleccircuit.com/super-small-amp-12w-by-ic-tda7052/>
- Mic  
<http://www.learningaboutelectronics.com/Articles/Microphone-amplifier-circuit.php>
- SD-Card:  
[https://www.amazon.com/dp/B004ZIENBA/ref=psdc\\_3015433011\\_t3\\_B001CQT0X4](https://www.amazon.com/dp/B004ZIENBA/ref=psdc_3015433011_t3_B001CQT0X4)
  - Cover: <https://www.sparkfun.com/products/544>
- Voltage detection circuit

[http://wiki.seeedstudio.com/Battery\\_Detector\\_with\\_Polymer\\_Lithium\\_Ion\\_1050mAh\\_3.7V/](http://wiki.seeedstudio.com/Battery_Detector_with_Polymer_Lithium_Ion_1050mAh_3.7V/)