Final Report

Tactile Feedback Glove to Detect Induced Electromagnetic Fields

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May 1st, 2019

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Abstract

In this paper, we document the design, implementation, and verification of a tactile feedback glove in order to detect the potentially hazardous induced electromagnetic fields (EMFs) commonly encountered by electrical workers and first responders. Our device makes use of a magnetometer, a static electric field meter, and an alternating electric field meter in order to determine the magnitude of induced EMFs; if a potential electrical hazard is detected, the vibrating disks in the glove will power on and the field magnitude will be displayed on a wrist-mounted LCD screen. Although our components are mounted on an arc flash rated glove, we encourage that it be used to supplement appropriate personal protective equipment (PPE), rather than replace it.

Table of Contents

1 Introduction

1.1 Purpose

The job titles “Electrical Worker” and “First Responder” consistently rank in the top ten most dangerous jobs in the United States. There are around two deaths by electrocution per day for electrical workers in the US, and even more in underdeveloped countries with less rigorous safety standards. These deaths frequently come from unnoticed electrical hazards, such as voltage leaks, arc flashes, or accidental contact with live wires. By developing a device to intuitively alert the user of such electrical hazards, we hope to decrease this staggering number of avoidable tragedies [1].

1.2 Functionality

The proposed device is an insulated glove that can detect the induced EMFs generated by AC power lines and wires from a distance. The gloves would then vibrate with increased intensity as field strength increases. This tactile response would alert the user of a potentially harmful electrical hazard before tragedy can strike. The vibrations would allow one to increase their reaction time to avoid the hazard, similar to how one recoils when touching a hot stove.

1.3 Subsystem Overview

As seen in the block diagram below, the successful operation of our system relies on three modules: a power module, a sensing module and a periphery module. The power module sends 5V regulated voltage to all components that need it. The sensing module is composed of a magnetometer to detect magnetic fields, as well as a non-contact electric field meter so that we may detect static voltage build up as well. The magnetic field sensor will send readings straight to the microcontroller, and the electric field data needs to be calculated by measuring voltage across the transistor and dividing by the gain of the circuit. These signals then feed into our microcontroller, which then displays these two readings on the LCD, as well sending voltage to the vibration disks in response to varying threshold values.

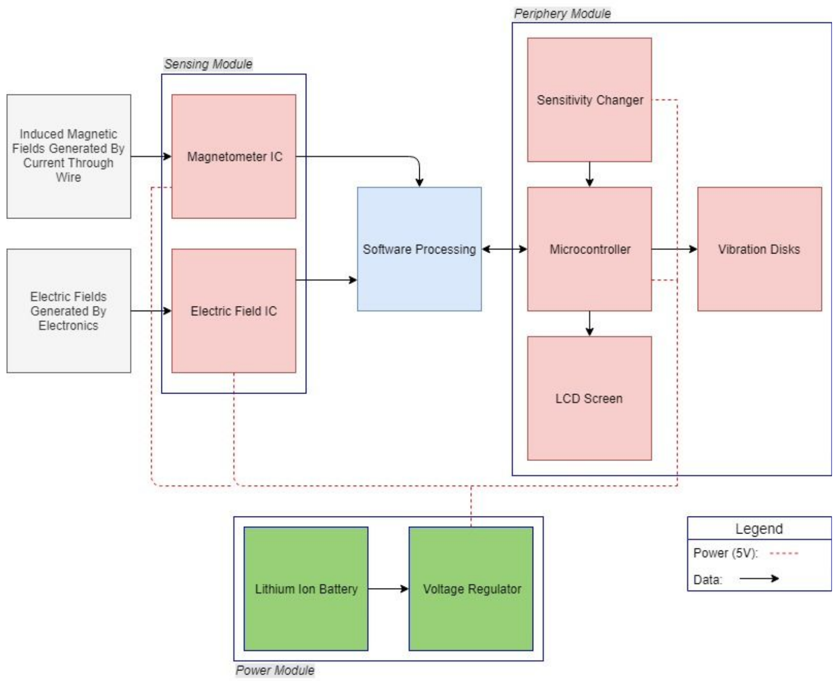


Figure 1: Block Diagram

2 Design

2.1 Physical Diagram

To provide better insight as to the ideal appearance of our device, we have included the physical design below. By mounting the magnetometer and both electric field sensing modules on the back of the hand, the sensors can obtain the closest EMF magnitudes to those at the user's fingertips, without hampering movement, and by placing a vibration disk on each fingertip, we ensure that the user takes note of any electrical hazard, even if not paying attention to the device. Finally, the microcontroller, voltage regulator, and LCD would be mounted on the backside of the wrist. This not only prevents the back of the hand from becoming overcrowded, but it also mimics the wristwatch, making it more intuitive for the user to check the magnetic field magnitude on the LCD.

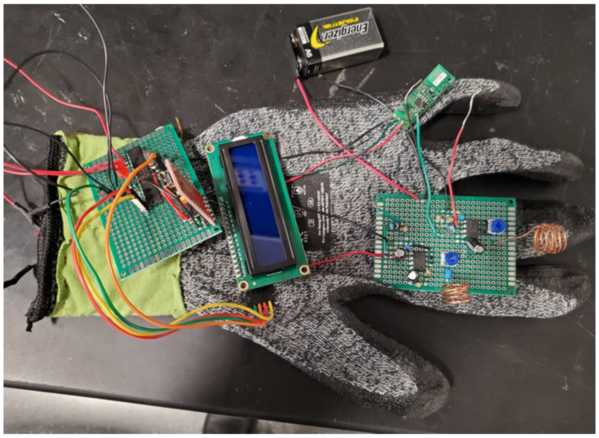


Figure 2: Initial Physical Design

Figure 3: Final Layout of Glove

2.2 Software Flowchart

In our software, we specify how the microcontroller will interface with both the sensing module and the periphery module. If the magnitude of an electric field or an alternating magnetic field is higher than a given threshold value, the strength of that field will be displayed on the LCD, and the vibration disks will power on. This provides our system with an effective interface between all modules, so that none of the sensitive components are exposed to currents or voltages outside of their tolerance ranges.

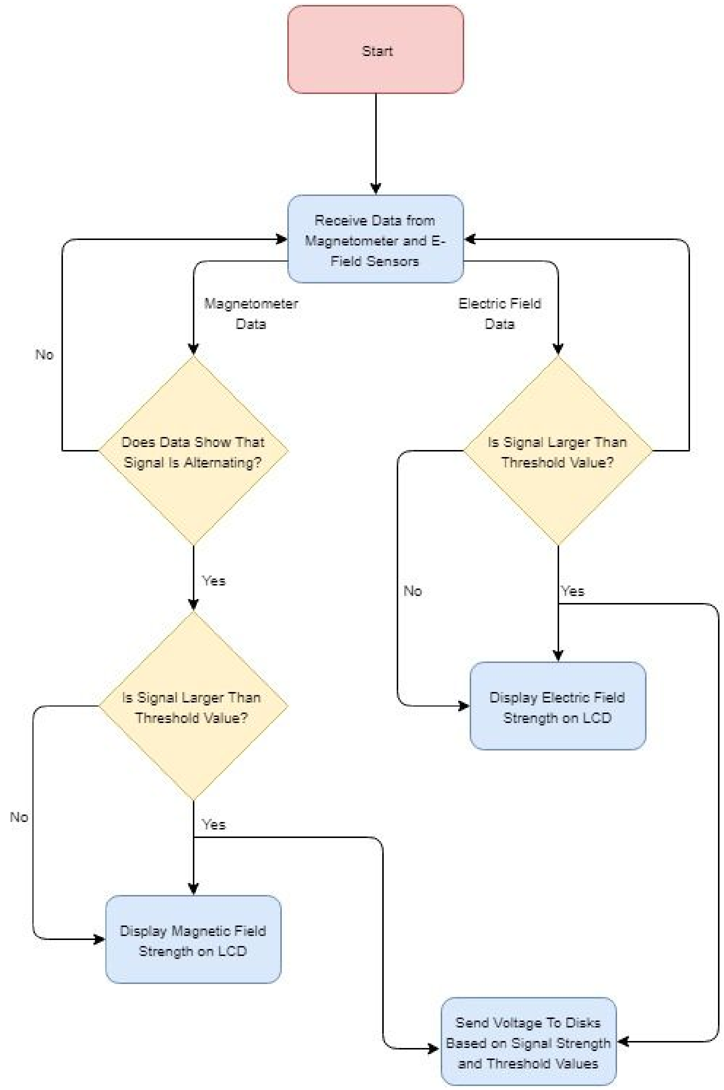
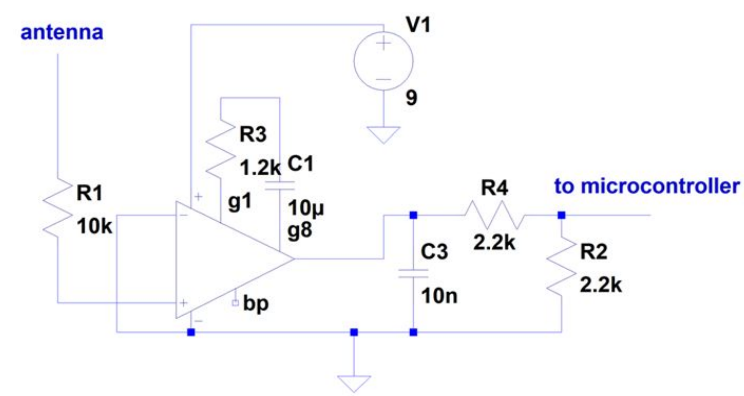
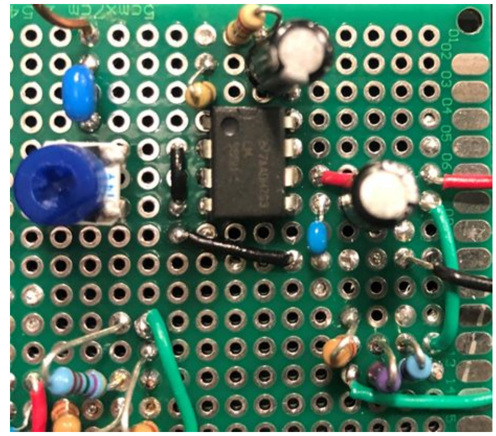


Figure 4: Software Flowchart

2.3 Electric Field Sensor

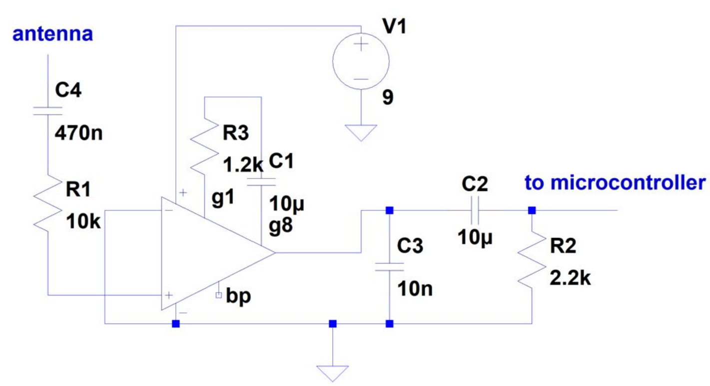
Our Electric Field Sensor is actually comprised of two different Electric Field Sensing Circuits. Our main purpose for this sensor is to detect static electric fields produced by a live wire. That is what our first sensor does. As pictured in Figures 5.1 and 5.2 this circuit is comprised of an LM386 Low Power Amplifier which allows us to easily control the gain. The gain is proportional to R1 and R3 so a 10k Potentiometer at R1 gives us further control when it comes to tuning our circuit to the environment.

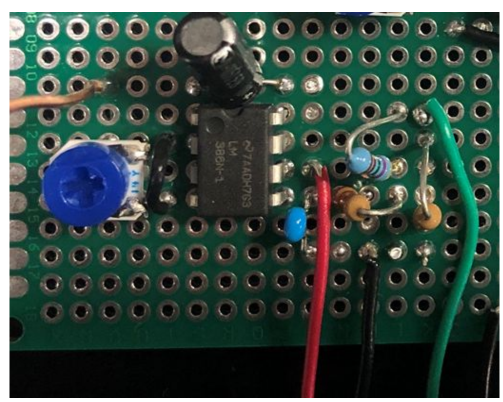




Figures 5.1 and 5.2: Circuit schematic and physical layout of static electric field meter

Our second circuit in this sensor, pictured in Figures 6.1 and 6.2, is an alternating electric field sensing circuit. This sensor is meant to detect an electric field produced by a large alternating current flowing through a wire. This circuit is a redundancy for the Magnetometer, but we found it important to include given that the Magnetometer came with very little information and the possibility of it not working was fairly high. This circuit is identical to the static electric field circuit with the addition of two capacitors, one before the amplifier's input and one after the amplifiers output, to ensure that only alternating current is being detected.





Figures 6.1 and 6.2: Circuit schematic and physical layout of alternating electric field meter

While we saw the values we were what we expected them to be, we also saw spikes in voltage output upwards of 30V. This was most likely due to the charge dissipation from the live wire. These spikes meant we could not safely send our circuits signal straight to the microcontroller. This problem could have been solved with the addition of a surge protection circuit in between the sensor and the microcontroller. Had we had more time we would have been able to implement this additional circuit and safely integrate the sensor into the system.

2.4 Magnetometer

The magnetometer we chose to use is admittedly not the best one for the job. The selection was made when the scope of our project included detecting household magnetic fields as low as 3 microtesla. In order to pick up these minuscule fields that at times can barely be distinguishable from noise, we purchased the MI-CB-1DH-S-A magnetometer from Aichi Steel Corporation. This sensor has nanotesla resolution which would allow us to detect these small magnetic field changes. However, later in the design and construction process we realized that there was no point in having an electrical glove that could detect magnetic fields detected by household wires, because with any reasonably rated electrical glove you could touch a 120V AC wire with no issue. Therefore, we changed the scope of our project to more high voltage applications such as transformers, solenoids and overhead power lines. These electrical hazards generate much larger magnetic fields and as a result, there is no need for a sensor this sensitive.

To delve further into the electrical characteristics of the magnetometer, it has an output range from 0.1 to 5V which is mapped to it's ∓50 microtesla detecting range. This turned out to be useful as our microcontroller's analog input pins could only take a max of 5V anyway, so there was no additional voltage regulation needed. In standard, low noise conditions the sensor outputs a steady sine wave with a peak to peak value of around 2.0-2.3V. The most useful feature of this sensor was our ability to lower it's detection cutoff frequency to 0.1Hz. This meant that we could filter out any static ferromagnetic fields which was a key requirement of our project.

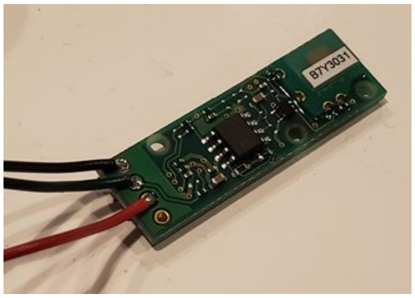


Figure 7: Magnetometer, with all appropriate soldered connections

2.5 Microcontroller

The microcontroller circuitry that we designed used an ATMega328-PU chip. This chip was selected because of the vast amount of documentation and resources surrounding it. It was also ideal due to it having 28 pins of which we used 19. Having this many pinouts allowed us to avoid doubling up on any signals and causing interference/problems. The microcontroller was connected to a USB to TTL serial bus which served to communicate with the device and upload software. Furthermore, when used in conjunction with a voltage regulator, the serial bus was able to power the chip with a consistent 5V. Other components included a 16 MHz crystal oscillator and

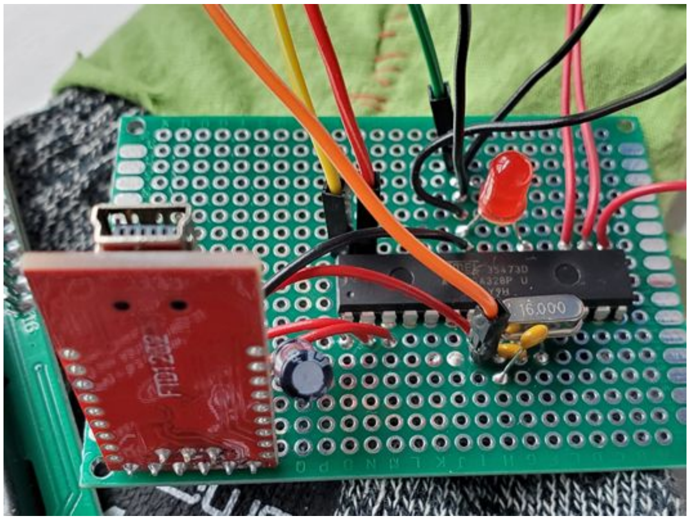


Figure 8: Microcontroller with surrounding circuitry

2.6 Feedback Subsystem

Our feedback subsystem consists of two main components: the LCD, and the five vibration disks. As this is the part of the system that interfaces directly with the user, it is vital that we make it possible for the wearer to be capable of noticing and reacting quickly to device output; therefore, we elected to place a vibration disk on the wrist. We originally intended to mount the vibration disks on each finger tip but decided against it for several reasons. If the glove were to be worn by an electrical worker, adding vibrations disks to the fingertips would hinder dexterity. It is also not practical, as cutting through or sewing kevlar is very difficult, and if the user's fingers do not reach the end of the glove they will not be able to feel the vibrations.. We ultimately decided on the Adafruit Vibrating Mini Motor Disc, not only for their low price but also for their ease of use; each disk only requires an input ranging between 0V and 5V, with vibrational intensity increasing linearly with voltage magnitude.

3 Cost and Schedule

3.1 Parts

Part	Quantity	Cost
ATMega328-PU	1	$8.99
Nanotesla Sensor MI-CB-1DH-S-A	1	$185.00
Adafruit Vibrating Motor Disc	5	$9.75
5V Voltage Regulator	1	$0.95
Lithium Ion Battery	1	$54.95
OLED Display	1	$10.99
Arc Flash Gloves	1	$42.10
LM386 Low Voltage Amplifier	2	$1.01
Piezoelectric Sensor	1	$2.95
10 kΩ Trimpot Resistor	2	$2.41
2.2 kΩ Resistor	1	$0.10
220 Ω Resistors	5	$0.50
4.7 µF Polar Capacitor	1	$0.71
10 µF Polar Capacitor	1	$0.22
10 nF Capacitor	1	$0.10
470 nF Capacitor	1	$0.10
1 MΩ resistor	1	$0.10
2N2222 Transistors	5	$12.90
Total		

3.2 Labor

According to the Engineering Illini Success report for 2016-17, as released by Engineering Career Services, the average starting salary for a Computer Engineering graduate was $88,369, and $71,166 for Electrical Engineering graduates [2]. As our project contains two electrical engineering majors and one computer engineering major, we calculate the hourly pay below:

Average Salary: ($88,369 x 2($71,166))/3 = $76,900.33

Per Per Hourly Wage: $76,900.33/yr x 1yr/2080 work hours = $36.97/hr

Therefore, we calculate the total labor cost below, assuming an average of 20 hours of work per week:

3 people x $36.97/hr x 20 hrs/person/week x 13 weeks = $28.837.63

3.3 Schedule

Week	Baleigh	Bryn	Prabhakar
Feb 18-24	Design circuit for electric field meter	Design circuit for magnetometer	Finalize device list and order parts
Feb 25-Mar 3	Design circuit for voltage regulators	Design microcontroller	Overview of design
Mar 4-10	Characterize electric field meter	Characterize vibrating motor disk	Characterize nT sensor
Mar 11-17	Assemble and test electric field meter circuit	Assemble and test magnetometer circuit	Assemble power module and microcontroller
Mar 25-31	Integrate all modules	Integrate all modules	Test microcontroller
April 1-7	Test electric field response of glove	Test magnitude response of glove	Test magnetic field response of glove
April 8-14	Test electric field response of glove	Test magnetic field response of glove	Test magnitude response of glove
April 15-28	Rehearse presentation and draft waiver	Rehearse presentation and draft waiver	Rehearse presentation and draft waiver

4 Requirements and Verification

4.1 Magnetometer

The first requirement of our magnetometer was that it was able to filter out static geomagnetic/ferromagnetic fields. This is important as it eliminates false positives coming from something as trivial as a fridge magnet or hard drive. To verify this requirement we placed a permanent magnetic in front of the sensor while we were probing its output voltage on the oscilloscope. With the cutoff frequency being set to 0.1Hz, the datasheet informed us that the desired output should be flat and outputting a voltage close to 0V which is the sensor's low saturation output voltage. The data below shows that this requirement was satisfied.

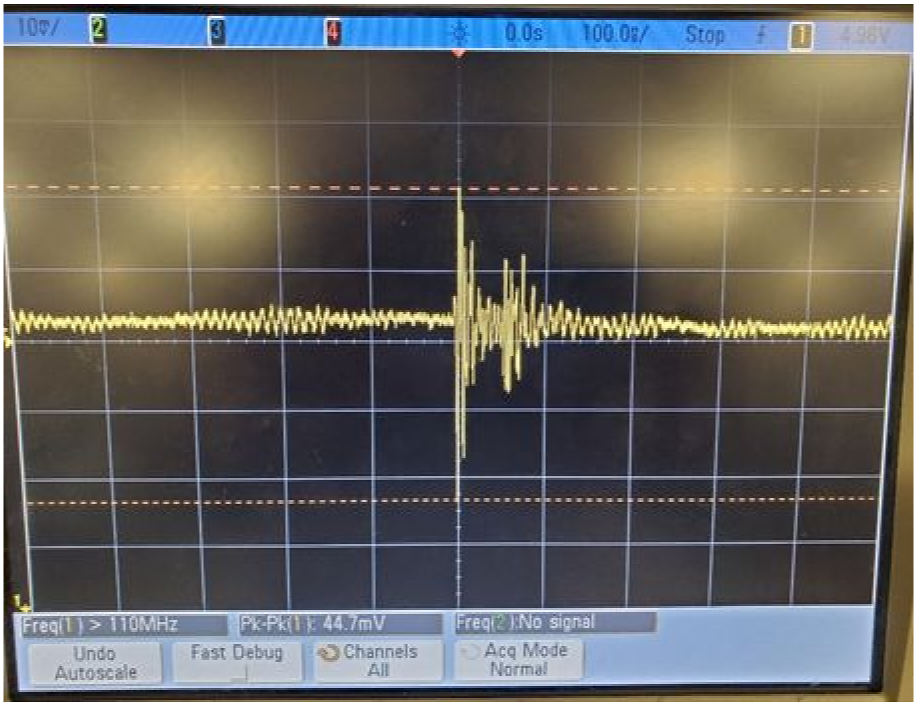


Figure 9: Magnetometer output when encountering a ferromagnetic field.

The output is relatively flat, with some magnetic noise in the middle, and in the millivolt range which is exactly what we had hoped to see.

The second requirement of our magnetometer is that it needed to be able to detect AC fields in the range of ∓50 microtesla which is the range of the magnetometer. Furthermore, the magnetometer needed to output no more than 5V. To test this we placed the magnetometer 6 inches away from the Electromagnetic Pulse Device (see Appendix _), while probing the sensor. The ideal output would be a waveform that spikes during the duration of the pulse, meaning it is distinguishable from noise, and has a max peak to peak value of no more than 5V. As expected, the data shows a value of around 3.97V with spikes in the waveform during the short duration of the pulse.

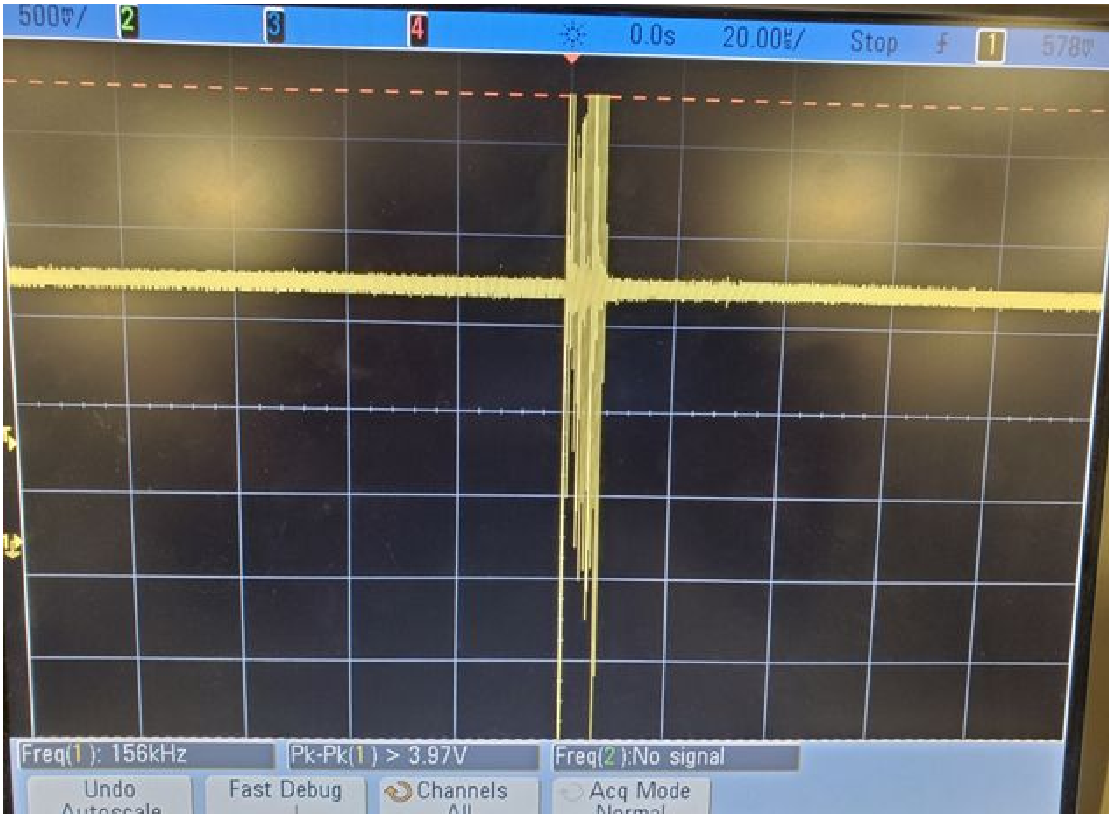


Figure 10: Magnetometer output when encountering an AC Magnetic Field.

4.2 Static Electric Field Sensor

The key requirement for the static electric field meter circuit was to be able to detect a static electricity buildup from a minimum of 6 inches and a maximum of 48 inches, as generated by our electrostatic generator. To verify this requirement we used a 12kV live wire to generate a static electric field, and then recorded the sensor's voltage output at 6 inch increments, 6-48 inches away from the live wire. In Figure 11 the orange curve represents what we would expect to see from our circuit and the blue line represents our experimental data when ignoring the voltage spikes. We can see that the voltage output does not decrease below around 0.95V. This makes sense considering the amount of noise present in the Senior Design Lab. Our signals would logically not dip below that level.

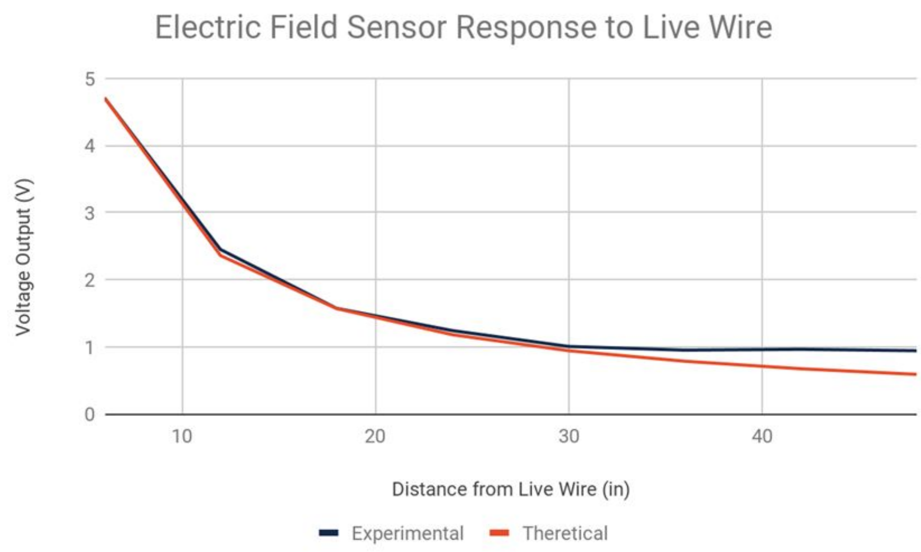


Figure 11: Static Electric Field Sensor Response to Live Wire

In Figure 12 we can see the spikes in voltage output from our circuit. They are very short bursts, but they would have damaging effects on our microcontroller.

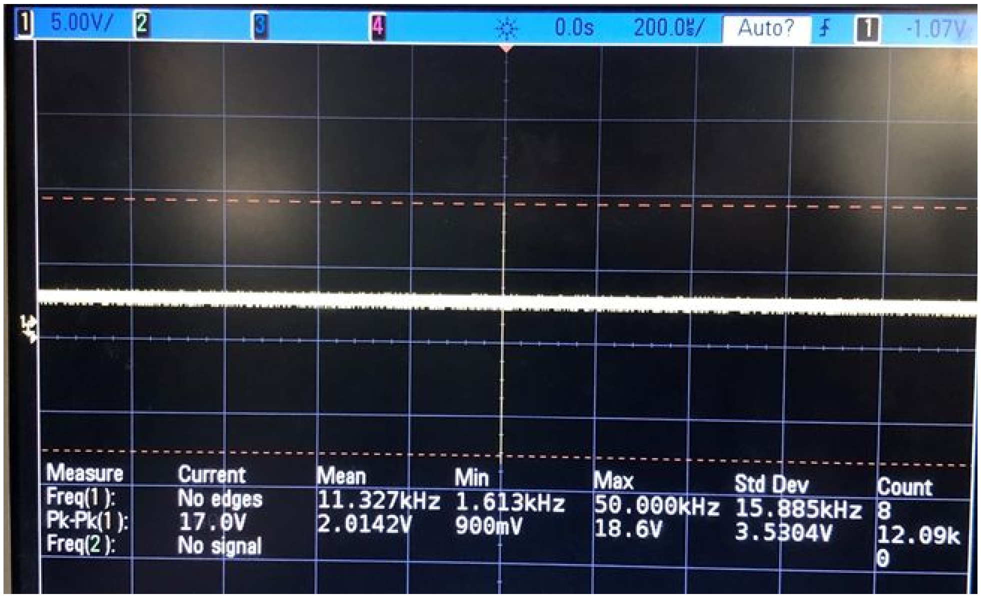


Figure 12: Oscilloscope measurement of Static Electric Field Sensor showing voltage spike

4.3 Alternating Electric Field Sensor

With our alternating electric field sensor we needed to be able to detect an alternating electric field. To test this we ran a 20V peak to peak sine wave at 60Hz through a 1MΩ resistor. Then, like our static electric field sensor, we measured the sensor's output at 6 inch intervals from 6-48 inches from the resistor. Unfortunately there is a lot of noise present in the senior design lab and in electric fields in general, so our sensor output does not dip below around 3.5V as seen in Figure 13.

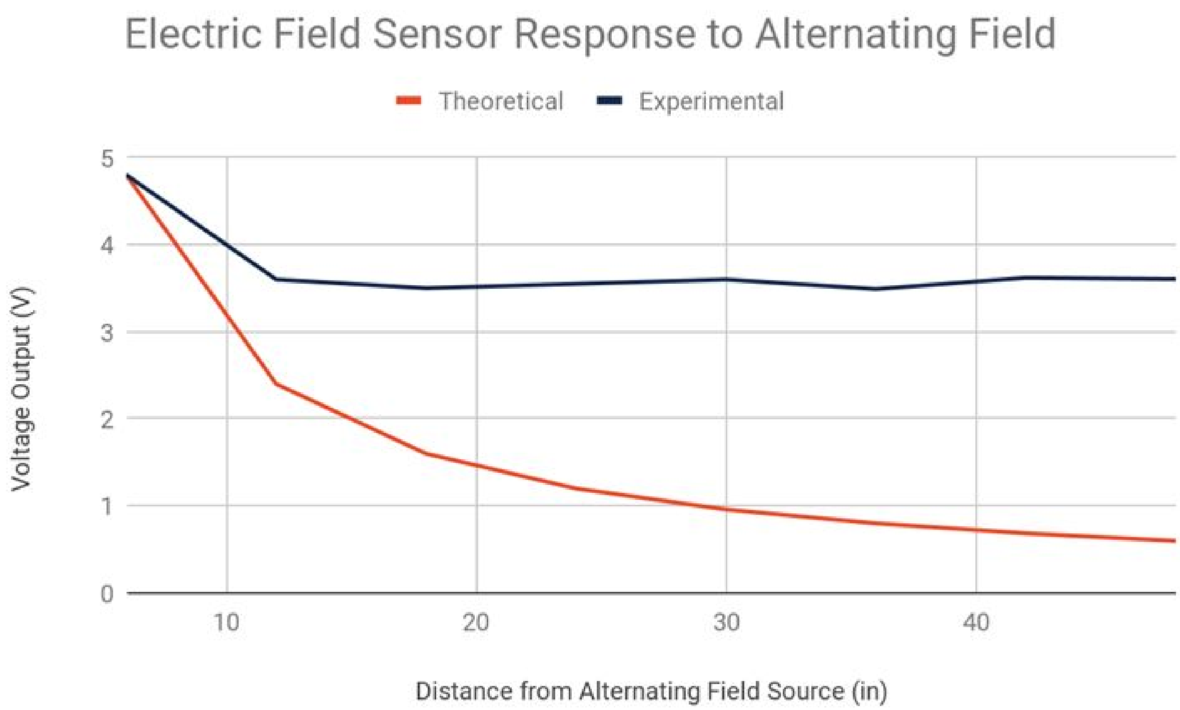


Figure 13: Alternating Electric Field Sensor Response to Alternating Field

4.4 Vibration Disks

For our set of vibration disks, it was necessary to demonstrate that the vibration intensity increased linearly with the input voltage. This is related to our need to keep the interface between the device and the user as intuitive as possible; if the vibrational intensity didn't increase linearly, a user might be mislead as to the hazard present. Unfortunately, Adafruit provided us with neither a datasheet nor a circuit schematic, so to prove that our disks performed as needed we needed to perform empirical testing. This was quite simple- like most vibration disks, ours were simply shaftless motors whose frequency controlled the intensity of vibrations. We thus tested our components by attaching a vibration disk to a piezoelectric sensor, in order to obtain a quantitative value for the vibrational intensity. Although the manufacturer website stated that the turn on voltage was 2V [3], we decided instead to supply the vibration disks starting at 0V. Surprisingly, we read nonzero outputs for input voltages below 2V, which simply suggests that the motors within the disks had already started to move, but were simply less easily perceptible.

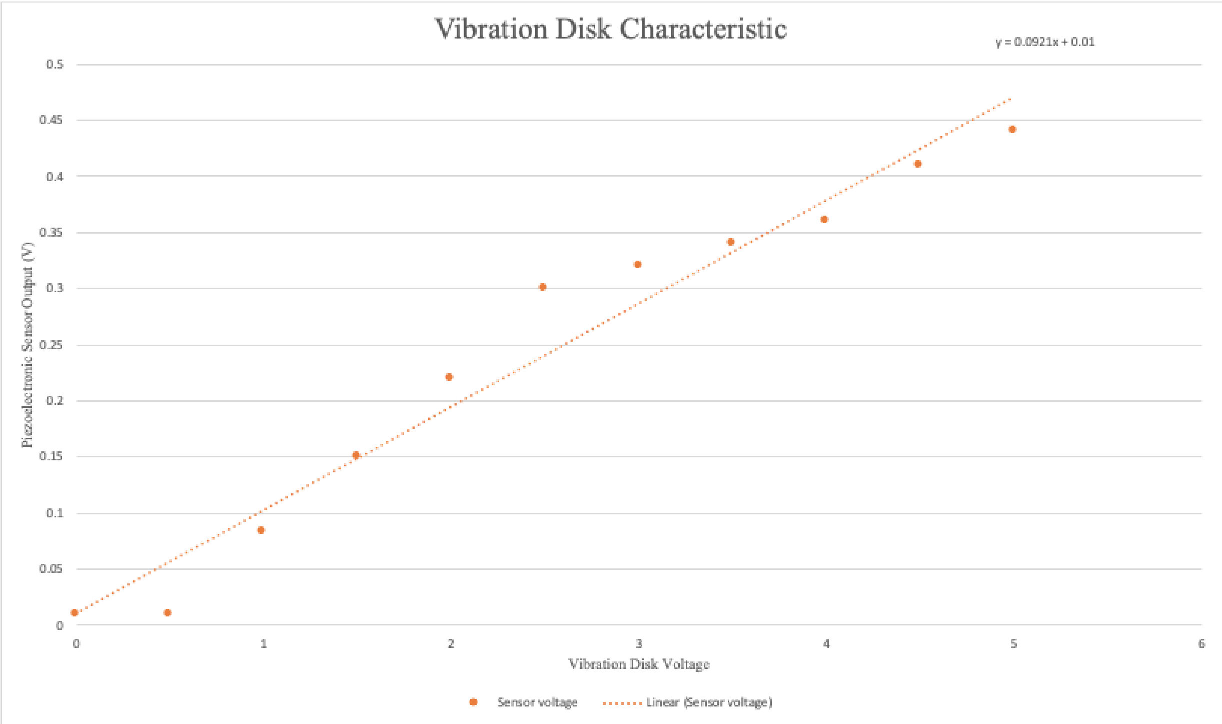


Figure 14: Piezoelectric sensor output plotted as a function of vibration disk supply voltage

As can be seen from the line of best fit applied to the previous graph, the vibration magnitude did increase linearly with input voltage- to an extent. However, because the variations from linear behavior were not large enough to be perceptible by a human holding one of the disks, we decided that no additional change to our device software was necessary.

5 Conclusion

5.1 Accomplishments

Throughout the course of this semester, there were many things to be proud of. An important aspect of this class is teamwork. At the beginning of the semester there were major teamwork and communication issues within our group. These pose a huge problem in the real world so it was important that they were resolved as quickly as possible. As the weeks went by, our teamwork and communication improved significantly and we were able to get many of our goals accomplished.

Another accomplishment we are proud of is the device itself. Although it was not fully integrated, each of the sensors on their own functioned very well and inline with our requirements and verification and the microcontroller/periphery module was fully integrated and functioned perfectly. With a few more weeks, we are confident that we could have fixed the remaining issues and gotten a fully functional glove.

5.2 Future Work

There is quite a bit of future work left to be done before we as a group would consider this project to be an ideal first prototype. The first thing we wish to do is properly integrate both sensors with the microcontroller and periphery systems. Even though both sensors functioned well on their own, they each had issues preventing us from integrating them with the rest of the system.

The Electric Field Sensor generated a mean max value of around 5 VDC, but occasionally due to noise would yield voltage spikes of upwards of 30V. After continued exposure to these voltage spikes the ATMega328-PU microcontroller would most certainly burnout, which is why we made the executive decision not to integrate it for our demonstration. This problem is an easy fix however, as we would just need to add a voltage regulator circuit to attune any voltages in excess of 5V.

The magnetometer also yielded stellar results during testing via the Electromagnetic Pulse Device and an oscilloscope. We saw no visible reaction to static ferromagnetic fields, which was one our most important requirements. We also saw background noise level readings of 2-2.3V which is consistent with the sensors datasheet. The sensor responded appropriately to the AC magnetic fields generated by the Electromagnetic Pulse Device, with voltage levels never exceeding the saturation level of 5V.

The issues with the magnetometer arose when integrating with the microcontroller. Instead of those accurate voltage readings we observed while probing the device, we were reading either 0V or 5V on the serial monitor connected to the microcontrollers analog pins, instead of the range of values in between. This issue is what prevented the integration with the rest of the glove, and our best guess to what is causing this problem is that the input impedance of the magnetometer is too large for the microcontrollers analog pins. Some solutions to this problem that we may try to implement in the future are using a buffer between the microcontroller and the magnetometer, using a microcontroller with a larger acceptable input impedance, or use a different magnetometer. The best solution in our mind is to use a different magnetometer as we don't need it to be as sensitive as it is, and we could reduce the costs of the device significantly.

Finally, the last bit of future work we will discuss is the need to size down our components. An electrical glove has very limited real estate to mount components, so large components create unnecessary clutter. We ideally would like to shrink the entire design to one or two PCBs, instead of the numerous perfboards we utilized. This would not only improve the usability of the glove, but would also result in a much more polished final product.

5.3 Ethical Considerations

As future electrical and computer engineers, we hold a responsibility to our society and to our profession to make a positive impact on the world. This can be best stated by the IEEE Code of Ethics- in particular, our promise to "hold paramount the safety, health, and welfare of the public," as well as to "avoid injuring others [or] their property … by false or malicious action" [4]. Just like in all our future endeavors as engineers, we must take these considerations into account when designing and building our project. We approached this by building our glove off of an arc flash rated glove; even if an electrical incident were to occur and possibly damage our product, we would ensure the user's safety. By ensuring that the end user understands how to safely operate our device, we can avoid injuring our end users.

A key risk associated with our project came from our use of lithium ion batteries. If the lithium ion battery in our device is overcharged or introduced to extreme temperatures, there is the possibility of explosion [5]. Fortunately, Kevlar is a thermal insulator, which should prevent the device from seeing any spikes in temperature [6].

Furthermore, we need to prepare for the possibility of the battery or other electronics in our project being introduced to water. While we can strongly discourage users from using our project in damp or moist environments, we still have the obligation to protect our users from the consequences of accidental exposure of components to water. We will address this by building our glove out of Kevlar, which is very water resistant. When exposed to water, the filament tenacity of Kevlar remains virtually unchanged even after 200 days, and hydrolysis only results in a 5% loss of strength after 20 hours [6]. We can thus rest assured that a Kevlar glove will keep our electronic components safe from brief exposure to water; however, to minimize the risk to the user, we will not recommend extended exposure.

In addition, considering the environment our project may be used in, there is also the concern of arcing from electrical equipment to our glove. Fortunately, Kevlar is also commonly used as protection from arc flashes and will thus offer protection from electrical hazards [6]. We'll also make sure to note how many cals the Kevlar gloves are rated for- although our gloves are not a replacement for personal protective equipment in the lab or production environment, we don't want to risk being liable to user injury by failing to specify the acceptable conditions for use of our project.

Furthermore, it is also our ethical responsibility to "be honest and realistic in stating claims or estimates based on available data," again, as per the IEEE code of ethics [4]. By rigorously testing all portions of our project, we are confident that our claims are both honest and realistic. Although we were not able to fully synthesize all portions of our project, we made it our goal to never misrepresent our data or our device's functionality, and thus fulfilled our role as ethical members of the engineering community.

Works Cited

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Appendix A- Requirements and Verification Tables

Magnetometer

The magnetometer is responsible for communicating the magnitude of alternating magnetic fields, in order to determine if the user is near an electrical hazard.

Requirements	Verification
1. Filter out most static magnetic fields such as geomagnetism and permanent magnets, and detect alternating fields instead.	1. Hold a permanent magnet in place. Connect the MI-CB-1DH-S-A magnetometer's V+ pin to the bench's 5V power supply, the GND pin to the bench's ground, and the OUT pin to the bench oscilloscope. 2. Restrict the cut-off frequency to 0.1 Hz to ensure that most static fields are ignored. 3. Use an electromagnetic pulse device (EMP) to induce an alternating magnetic field, and use the oscilloscope to verify that the sensor output magnitude increases.
2. Detect fields from ∓ 50 microtesla generated from AC wires from a minimum of 6 inches and a maximum of 48 inches. Also can not output more than 5V.	1. Provide power to the electromagnetic pulse device. 2. Connect the MI-CB-1DH-S-A magnetometer's V+ pin to the bench's 5V power supply, the GND pin to the bench's ground, and the OUT pin to the bench oscilloscope. 3. Place the magnetometer 6 inches from the electromagnetic pulse device, which will output an alternating magnetic field. 4. Verify that the field is distinguishable from noise and that the peak to peak output does not exceed 5V.

Static Electric Field Meter

The static electric field meter is responsible for communicating the magnitude of static electric fields, in order to determine if the user is near an electrical hazard.

Requirements	Verification
1. Must detect static electricity build up from a distance of 6-48 inches.	1. Connect the electric field meter circuit to power. 2. Generate a static electricity charge with an output of approximately 12 kV/m using an electrostatic generator. 3. Place the sensor 6 inches from the static electricity charge. If the electric field meter does not send a signal indicating an electric field, increase the electric field meter gain.

Alternating Electric Field Meter

The alternating electric field meter is responsible for communicating the magnitude of alternating electric fields, in order to determine if the user is near an electrical hazard. This is intended as a redundancy for the magnetometer; as our device may be used in high risk areas, we included both subsystems to maximize the safety of the end user.

Requirements	Verification
1. Must detect commonly encountered AC voltages (3-30 V/m) from a distance of 6 inches to 48 inches.	1. Connect the electric field meter circuit to power. 2. Connect a 1 MΩ resistor to the bench digital multimeter, and generate a sinusoidal wave at 60 Hz with a magnitude of 20 V. Make one of the wires longer, as it will be used for electric field measurement. 3. Place the sensor 6 inches away from the longer wire. If the electric field meter does not send a signal indicating an electric field, increase the electric field meter gain.

Vibration Disks

The vibration disks are an essential part of communicating any detected electrical hazards to the end user; by providing haptic feedback, we can make sure that the end user is aware of electrical hazards, whether they are paying attention to the device or not.

Requirements	Verifications
1. Vibration intensity must increase as supply voltage increases.	1. Connect the vibration disk to the bench DC power supply 2. Connect the piezoelectric sensor in parallel with a 1 MΩ resistor to the bench oscilloscope, with the other terminal connected to ground. 3. Tape one end of the piezoelectric sensor to the vibration disk, and the other to the bench (in order to neglect vibration of the bench). 4. Starting at 5V and ending, increase the DC power supply by 0.5 V. Record the peak voltage values from the piezoelectric sensor. 5. Plot the data and generate a line of best fit; this will determine the degree to which the vibration intensity increases with voltage.

Appendix B- Electromagnetic Pulse Testing Device

It is not an easy task to generate an alternating AC magnetic field that is noticeable at a distance. It was a very time consuming and difficult task to even develop this piece of testing equipment. The method we chose to generate these sorts of fields for testing was an Electromagnetic Pulse Device. The device consists of two main modules: a power supply module and a spark-gap/coil module.

Power Supply Module:

The power supply circuit consists of mains power flowing into a transistor, connected as a simple oscillator where its collector drives the primary winding of a small step-up transformer. The small capacitors speed up the "turn-off" time of the transistor. Then a current limiting inductor limits the short circuit current to a miniscule value, with two more capacitors serving to ground any other signal. This is then connected to the spark gap portion of the circuit.

Spark Gap Circuit:

The power supply sends a charge to the 5kV reservoir capacitor. After an appropriate amount of charge is gathered in the capacitor it discharges across two tungsten spark gaps. The amount of current in the inductor rises rapidly and resonates along with the circuit. The excess resonate power is then emitted through the coil in the form of an AC Magnetic Pulse.

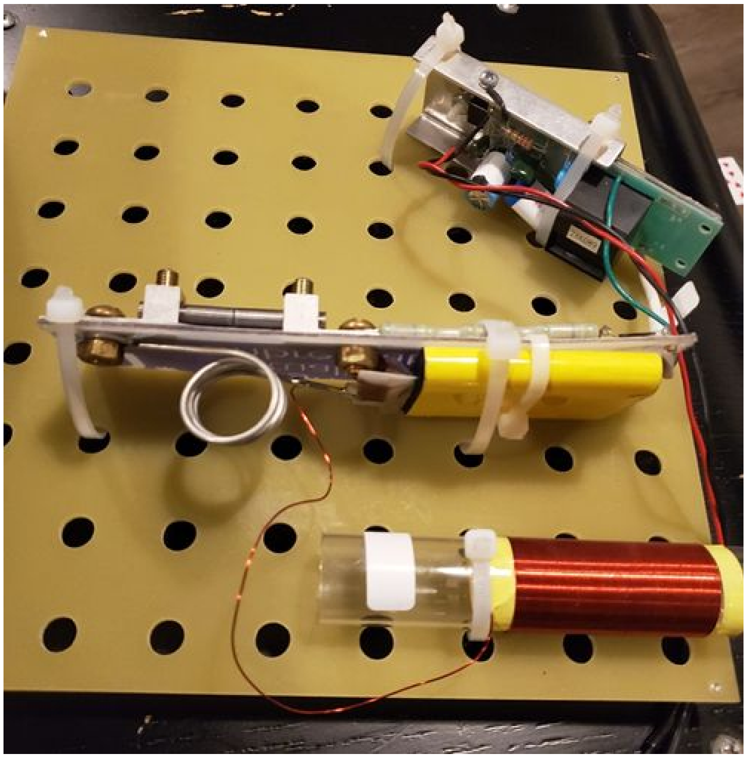

Figure 15: Electromagnetic Pulse Device

Appendix C- General Liability Release Form

General Liability Release of Claims

Effective immediately upon execution, I, [*Individual Releasing Liability*], for and in consideration of the payment to me of [*Price of Device*], the receipt and sufficiency of which is hereby acknowledged, do hereby release and forever discharge [*Prabhakar Zutshi, Baleigh Clark, Bryn Carroll*], their agents, employees, successors and assigns, and their respective heirs, personal representatives, affiliates, successors and assigns, and any and all persons, firms or corporations liable or who might be claimed to be liable, whether or not herein named, none of whom admit any liability to the undersigned, but all expressly denying liability, from any and all claims, demands, damages, actions, causes of action or suits of any kind or nature whatsoever, which I now have or may hereafter have, arising out of or in any way relating to any and all injuries and damages of any and every kind, to both person and property, and also any and all injuries and damages that may develop in the future, as a result of or in any way relating to the following:

[Electrical Injury]

[General Injury]

It is understood and agreed that this payment is made and received in full and complete settlement and satisfaction the causes of action, claims and demands mentioned herein; that this Release contains the entire agreement between the parties; and that the terms of this agreement are contractual and not merely a recital. This Release may not be altered, amended or modified, except by a written document signed by both parties.

Furthermore, this Release shall be binding upon the undersigned, and his respective heirs, executors, administrators, personal representatives, successors and assigns. This Release shall be subject to and governed by the laws of the State of Illinois.

This Release has been carefully read and fully understood by the undersigned. The terms have been explained to me and I am freely, knowingly and voluntarily entering into this Release.

EXECUTED this ____ day of _________________, 20____.

Signed: __________________________________*Sign Here*

Print Name:

Signed: __________________________________*Sign Here*

Print Name: