60 Hertz Electromagnetic Field Detector/Interface System

UIUC ECE 445, Spring 2012 – Team #13

3 Segments of this Presentation

1. Introduction
2. Engineering Process
3. Final Project Analysis

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1 Introduction

Background, Objectives & Initial Design Thoughts

Background

Mr. Jamie Norton came up to us with a unique project requiring us to build a user friendly device which would have applications in neuroscience .

Working with a different department and the **potential for further research** is what attracted us most to this project.

Project Objectives

What was required?

- A 60-Hertz electromagnetic radiation detection device
- Greater Sensitivity, Portability, and user-friendliness than previous designs
- Integrated Haptic Feedback

Why do we need it?

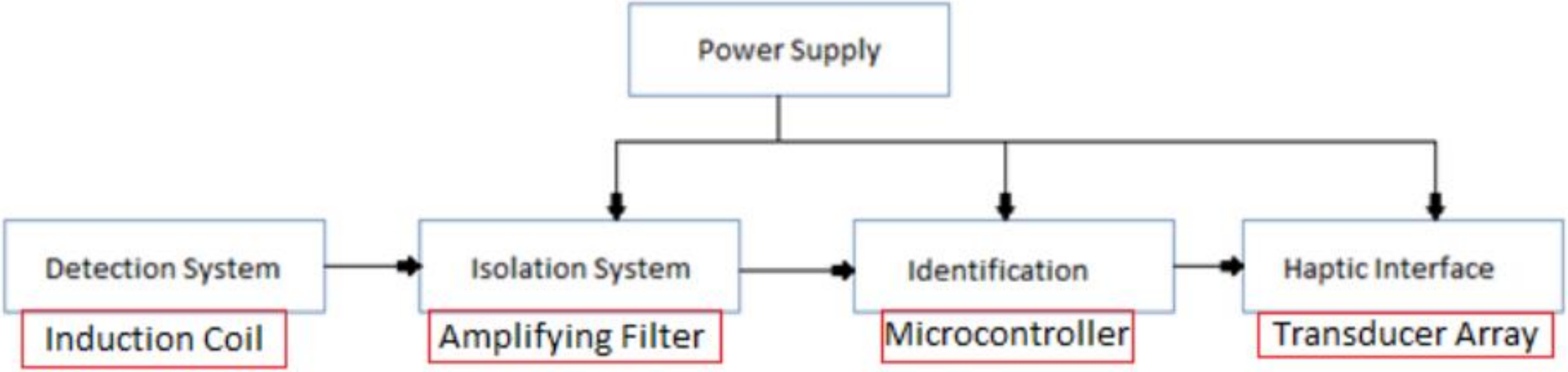
- To detect ambient noise that decreases SNR of EEG Machines
- It has potential research applications in Brain-Machine interfacing and the development of new senses

Features

- Static 3-axis coil configuration for detection of all polarizations
- Detection of electromagnetic radiation between 55 and 65 Hertz
- Haptic feedback user interface
- Compact, portable design
- Filter with in built amplifier and rectifier to reduce number of parts used.

Plan & Block Diagram

After a few brainstorming sessions amongst ourselves, meetings with Jamie and consulting with professors, we came up with the following block diagram which we stuck with to the end.



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Engineering Process

Final Design Choices, Justification, Hardware development

Step 2 : Making it all

Moving ahead

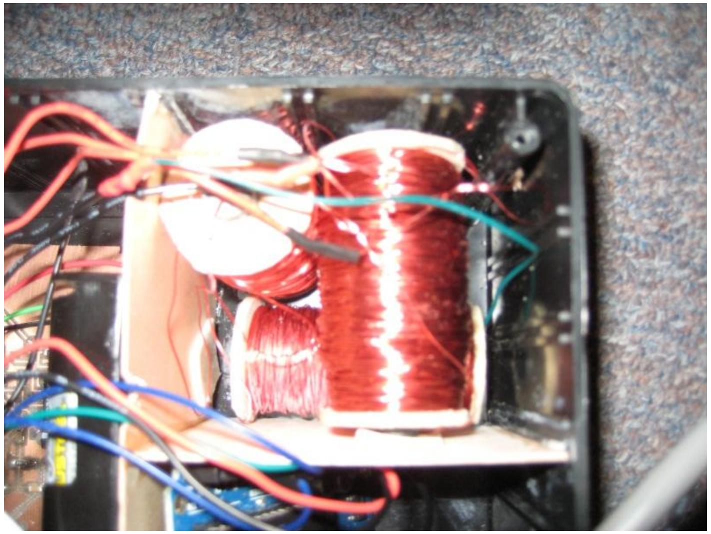
After finalizing the block diagram we went on to **design each module** and develop the necessary hardware for it.

The next few slides will discuss each individual design choice.

Antenna’s

- Coils hand-wrapped around ferrite cores
- Wooden stoppers to preserve shape
- Counting Error → More turns than expected

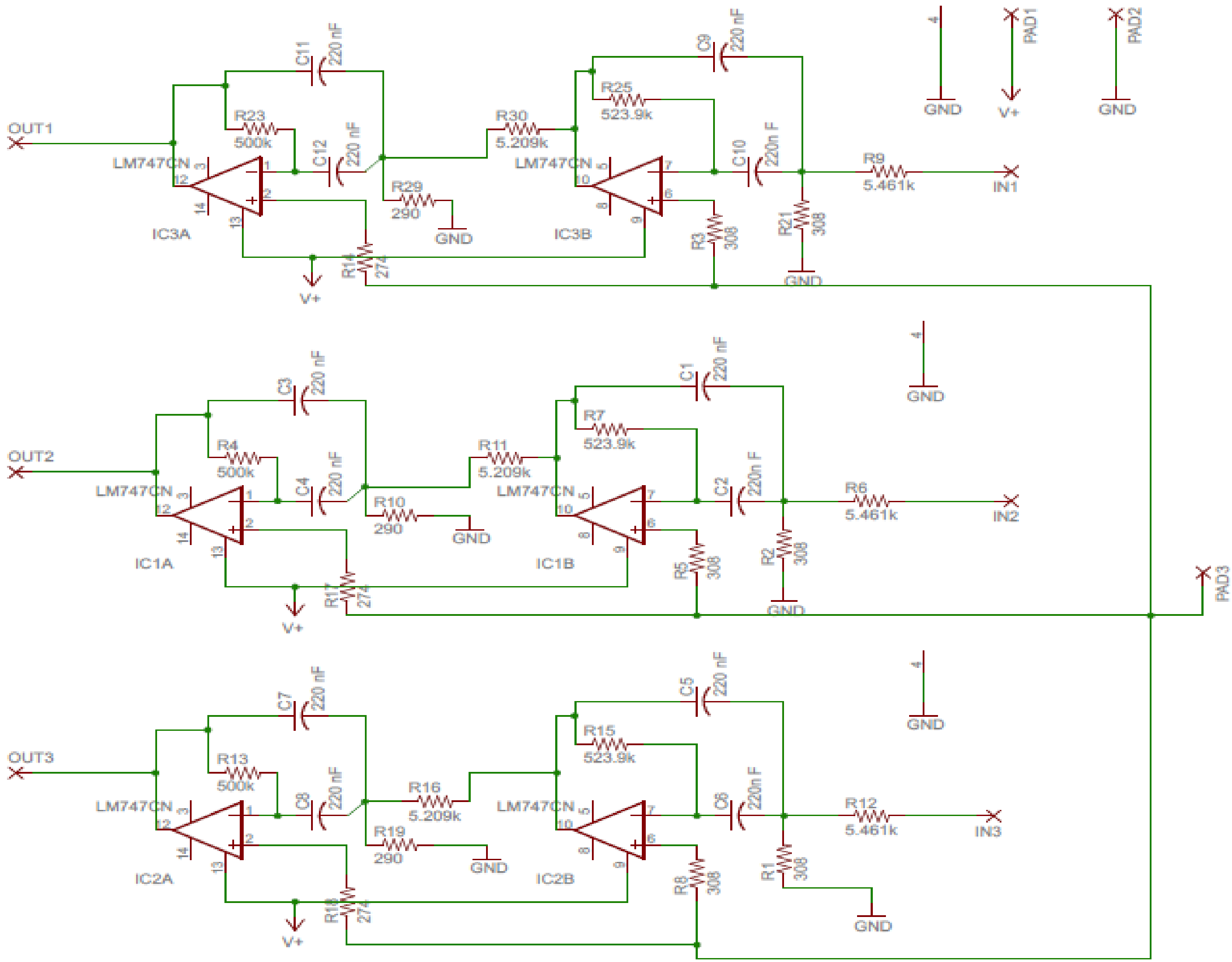
  - Adjustment in filter gain



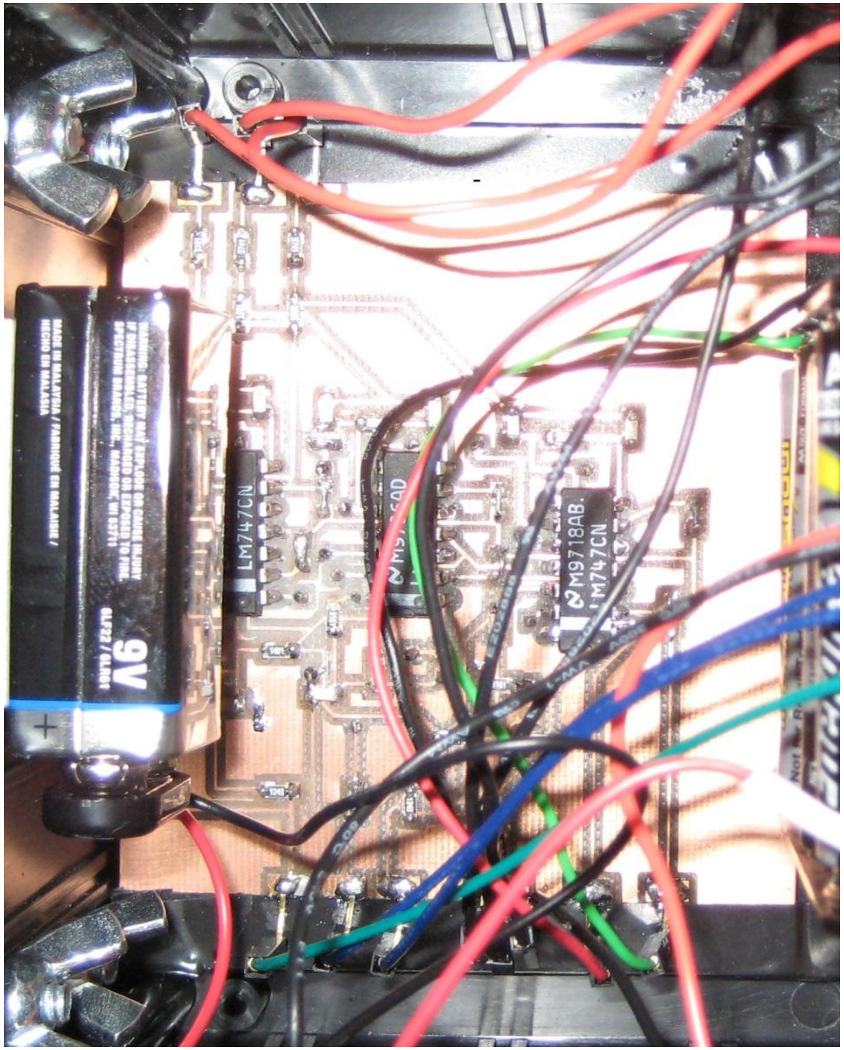
Filter Design

- Two-pole active band-pass filter
- Center Frequency:60Hz
- A single Supply Design
- 3 dB Bandwidth: 10Hz
- Power Supply: 6V
- Desired Gain: 200 V/V

Filter Schematic

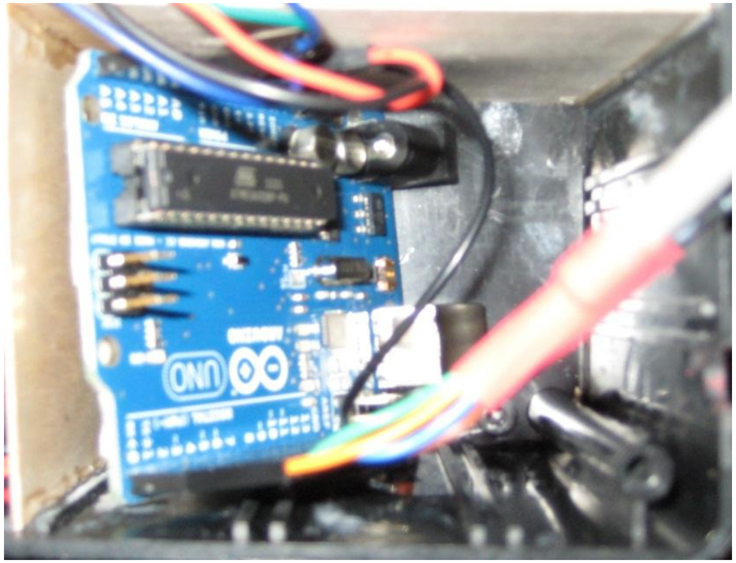


Actual Filter Circuit



Software (Input)

- Intensity detection routine
  - Sampling over ~2 periods (34ms)
  - Vector sum of maximum intensities from each channel



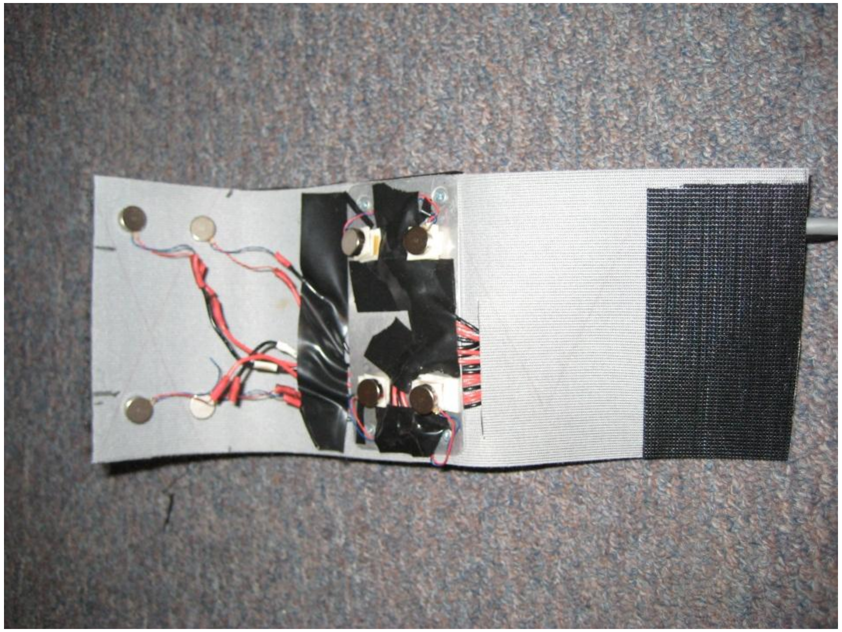
Software (Output)

- Driving micro-transducer array
  - Number of high digital outputs corresponds to intensity of field
- Saturation Handling
  - Single coil saturates → Feedback unit pulses

Micro-transducer Array

- Driven by BJT array
  - Controlled by Arduino outputs
- Mounted on self-made wristband
  - Vinyl band with mounted project box
- Four above wrist, four below
- Low Resolution, High Intuitiveness
  - Sense of touch
  - Mapping

User Interface Picture

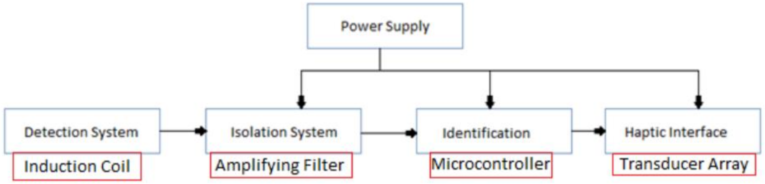


- Interweaved rubber and tape for vibration damping
- Velcro for adjustable size

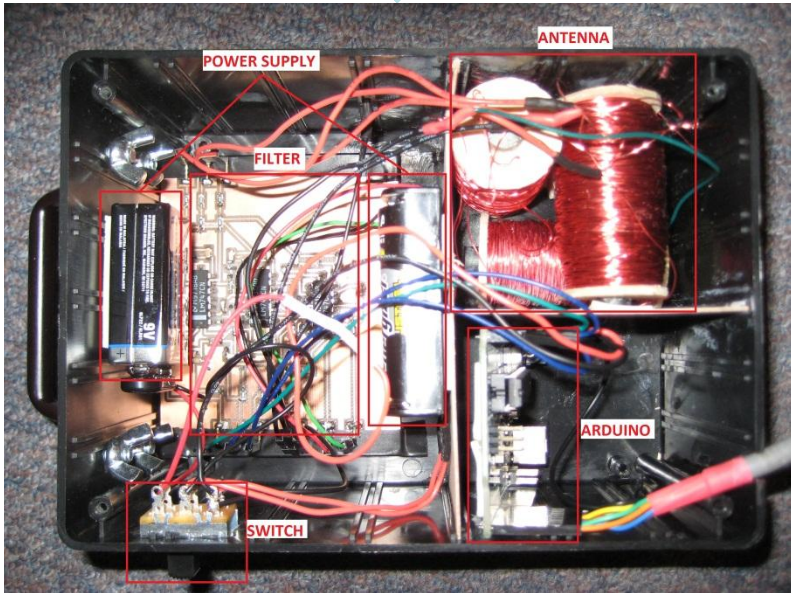
- Disconnecting, 8 conductor cable for ease of use

3 Final Project Analysis

Tests, Successes, Challenges, Ethical considerations and Recommendations



Putting it all together



Test Procedures

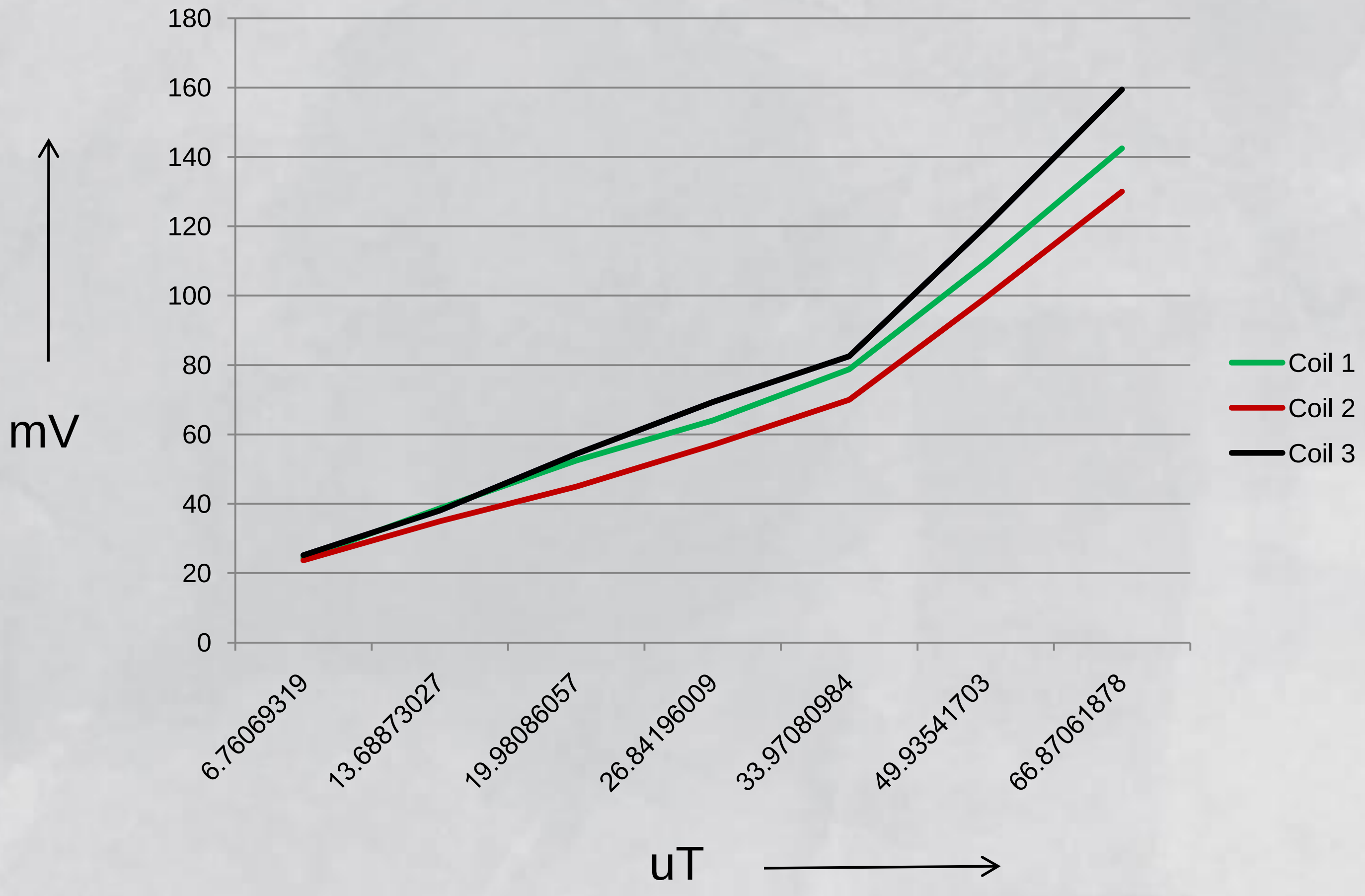
Antenna

- The detection coils were placed in a Helmholtz coil generating a constant 60 Hertz magnetic field. The induced response was measured using an oscilloscope.

Filter

- Each channel was swept with 60 Hertz waveforms to characterize the gain. The frequency was also varied around 60 Hertz to characterize the bandwidth

Antenna tests and results



A graph Showing Voltage Induced vs Magnetic Field for each coil separately

Filter tests and results

- Adjustment in filter gain
- Testing using proto-board before PCB
- Lack of exact required resistances → pass-band offset to one side
  - Increased bandwidth in design
- Diode nonlinearities
  - Converted to single-supply

Filter tests and results

Channel#1			Channel#2			Channel#3		
Vin (mV)	Vin_actual (Vm)	Vout (Vm)	Vin (mV)	Vin_actual (Vm)	Vout (Vm)	Vin (mV)	Vin_actual (Vm)	Vout (Vm)
0	1.313	120	0	1.72	135.9	0	3.28	135
1	2.813	171.9	1	2.81	253	1	5.16	287
2	3.75	453	2	3.91	315.6	2	6.56	306
3	4.188	581	3	6.56	472	3	5.94	481
4	5	793.8	4	7.97	675	4	8.31	668
5	6.375	850	5	9.69	1019	5	9.22	1063
10	11.72	1766	10	14.69	1950	10	14.38	1953
15	16.09	2250	15	20.31	2310	15	18.63	2340
20	23.75	2480	20	24.7	2470	20	23.13	2530
30	32.19	2770	30	36.25	2730	30	35.94	2810
40	43.75	2970	40	44.69	2940	40	45.94	3110
50	54	3130	50	55	3080	50	55.63	3220
60	62.5	3270	60	64	3230	60	66.25	3340
70	75.62	3420	70	75	3350	70	75.62	3440
75	78.75	3450	75	79.37	3500	75	81.88	3500
80	80	3470	80	85.63	3500	80	85.63	3500

- Gain 1: 163.7
- Gain 2: 175.3
- Gain 3: 140.2

Table showing filer test results at 60 Hz. See where it saturates.
We noticed that no significant gain was observed outside a 10 Hz window

Test Procedures

Microcontroller

- The robustness of the code was tested by outputting serial data regarding the detected amplitudes to a computer, and comparing with the input waveform.

Haptic Feedback

- The feedback array contained in the wristband was tested by driving each individual BJT on at a time using the Arduino.

Power Supply

- The batteries worked properly, only concern is as the 6V source for the op-amps slowly falls in voltage value, the output offset falls with it, and the Arduino code constant for the offset must be adjusted.

Full System test

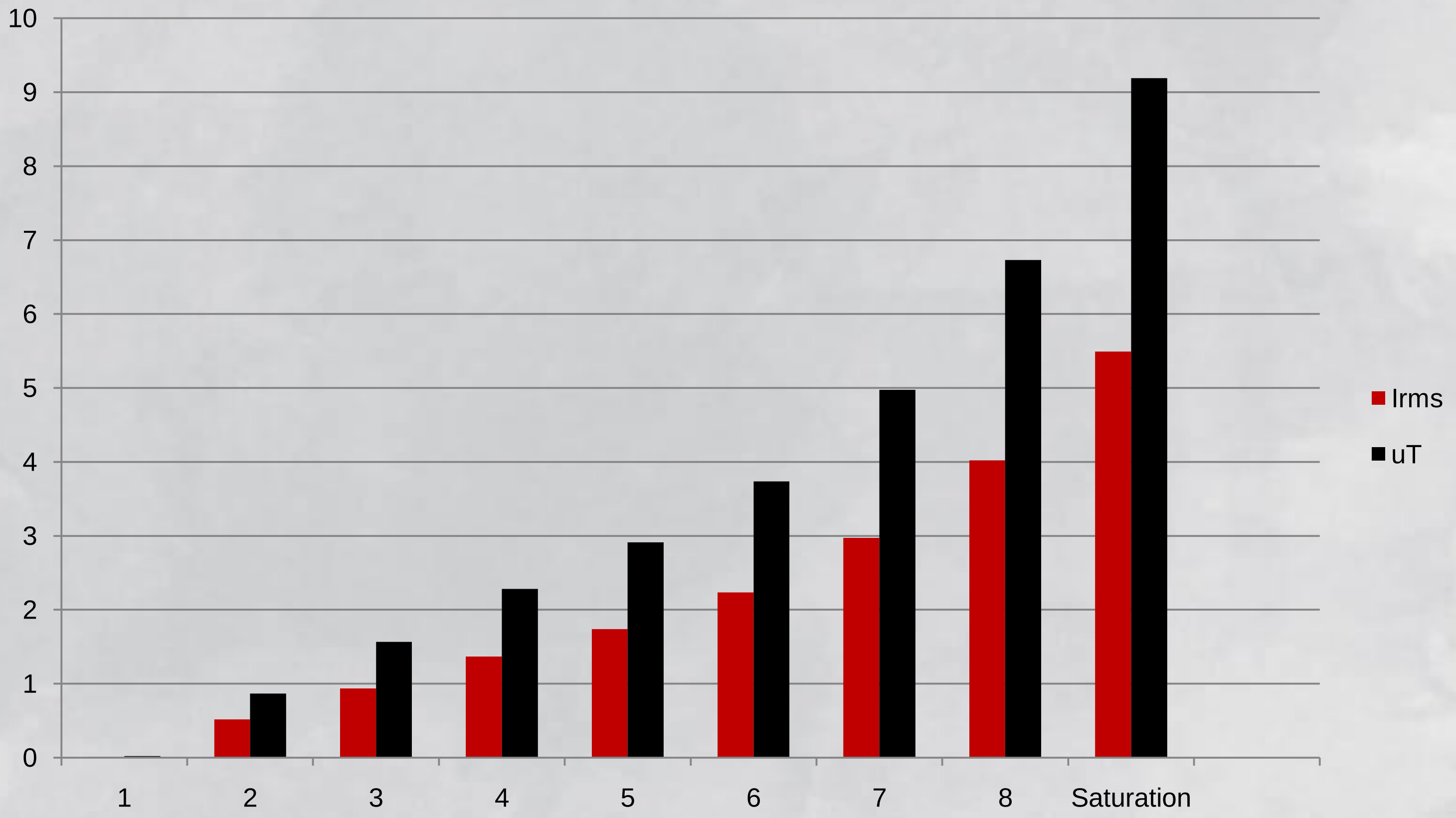


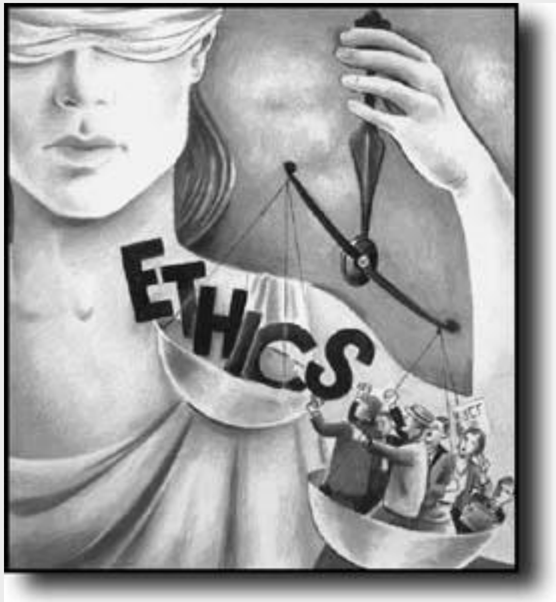
Chart shows input current and corresponding magnetic field levels, and the number of micro-transducers turned on

As the table shows, the system can detect magnetic field strengths from around 0.01 uT to around 10 uT.

Ethical Considerations

We commit ourselves to abide by the ethical code laid down by the **IEEE**. A few considerations specific to our project are :

- Safety concern - if this device is used in areas of high radiation density. We ensured that currents do not exceed normal levels.
- No Ghost Hunting!
- Being honest to our clients – No false promises, and keeping the cost in mind.



Recommendations for future work

Tunable Filter
More compact case
Different user-interface
Larger size array using better transducers
Wireless communication sensor & feedback

From All of us

Thank You!

All peer reviewers
Everyone at the parts shop
Prof. Doug Jones
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Dr. Serge Minin
Jack Boparai
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Mr. Jamie Norton
Prof. Paul Scott Carney