Power Chest Strap

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Abstract

The Power Chest Strap is an unobtrusive device, like a heart rate monitor, worn around the chest that harvests energy from the expansion of the chest during breathing. The chest strap stores electrical energy that can charge electronic devices such as cell phones. Since small portable devices grow in number, the power strap allows a convenient way to charge your device without having to find a wall outlet for a charger. Research on systems that scavenge energy from arm or leg movement already exist [6] [7], but these systems require the ability of the user to move their arms and legs. The power chest strap can remove the limitation that the user must have limbs to scavenge energy, and extend prosthesis battery life for quadriplegic and paraplegics. The device must not interfere with medical devices such as pacemakers, as the Power Chest Strap may power them.

Chapter 1: Introduction and Background

The increasing use of portable electronic devices has created a corresponding need to power these devices. There are power packs that allow charging your portable device through a USB cable. However, these devices raise a sustainability concern, as well as greatly inconveniencing the user due to our limited carrying capacity. In recent years, an interest has developed in generating electricity from human movement, especially movement associated with the user's everyday actions. Wearable technology doesn't require extra pockets or bags in order to carry the extra baggage. The challenge with this approach is to find a method of generating significant amounts of power without placing onerous constraints on the wearer.

Devices that harvest energy from body movements already exist [9] [11]. Generally, the user needs to have limbs in order to achieve such harvesting. The devices uses piezoelectric The idea of the Power Chest Strap came from the idea to power prosthetic limbs through body movement. Since some people do not have limbs, the idea to build a device to harvest energy through the movement of the chest during breathing emerged, since every living human breathes. Current portable devices, like pacemakers, require an external battery source to power the device and would require frequent trips to the hospital to replace the battery, or have wires protruding from the body attached to an external battery pack. The Power Chest Strap can help reduce hospital fees as it reduces the need to frequently exchange batteries. Keeping in mind the Power Chest Strap's primary uses, water resistance, portability, unobtrusiveness, and affordability are necessary.

The Power Chest strap uses magnets to induce current in a wire as the chest expands. Ampere's law's Law is used to calculate the current [25]:

$$I = \frac{B}{\mu_o n}, \text{ where } \mu_o = 4\pi \times 10^{-7} \text{N/A}^2, \text{ and } n = \frac{N}{l}$$

the number of rings per unit length. The magnetic field was measured with a Gauss meter. The current then goes into an energy scavenging circuitry, which contains a half wave rectifier. The energy harvested gets stored into a rechargeable battery and can then charge a low powered electronic device by plugging it in to the batteries encasement with a USB cable. The Power Chest Strap allows the user to create/store your own energy that you create and use it to power a device.

Chapter 2: Requirements and Specifications

Customer Needs Assessment

The Power Chest Strap customer needs power generation, comfort, portability, reasonable pricing, water resistance, and otherwise does not interfere with other devices. People do not like wearing uncomfortable products, and the average person cares about their budget. People who wear medical monitoring devices would not want this device if it affected their life support. All humans perspire so the Power Strap must resist water. The device must store the power generated in a battery to allow for charging of devices at a later time. The device must produce about 0.8W of power.

Requirements and Specifications

Encased inside non-conducting material, the Power Chest strap provides comfort. It has an adjustable width, weighs one pound or less, has height less than six inches, and allows portability. For maximum production, the power strap costs $35 or less. Self-sustaining device eliminates the need for wall outlets. The device should not affect other devices. A layout of all of the marketing requirements and engineering specifications are listed in TABLE I. The expected dates of deliverables are listed in TABLE II.

Currently, not many devices try to harness the potential energy that our body possesses and converts it to electrical energy. Thus, there are not many articles that can assist the process of creating the device. Other challenges include inducing enough current with magnets, encasement's flexibility, and material conductivity.

TABLE I: POWER CHEST STRAP REQUIREMENTS AND SPECIFICATIONS

Marketing Requirements	Engineering Specifications	Justification
1, 4	Encased inside 'Lectrolite® Premium material (electrically conductive fabric)	People like comfort. The fabric must control electrostatic discharge and the accumulation of static charge, which may interfere with sensitive electronic equipment.
2	Cost < $35	More production if cheaper
4	EM radiation cannot penetrate encasing	Current medical devices continue working
1,5,9	Adjustable 30" – 46" buckle strap around the chest	Customers have different chest sizes
1,6,7	Weights <1lb	A heavy device may cause back pain
1,3,6	Does not exceed 6"x2"x1"	Any larger would vest like
3	Charges to USB	Charging a phone needs a USB port
1,8	Water resistant 3 ATM or 30m underwater	Can get the device wet and not harm it
10	Generates at least 1mAh	Most hearing aids drain 1.1mA [23]

Marketing Requirements

1. Comfortable
2. Reasonably priced
3. Portable
4. Other devices not affected

5. Adjustable Sizes 6. Light Weight 7. Allow physical activity 8. Durable 9. Easy installation 10. Generate power

TABLE II: POWER CHEST STRAP DELIVERABLES

Delivery Date	Deliverable Description
02/28/2014	EE460 Report V1
03/17/2014	EE460 Report V2
04/24/14	EE 461 Design Review
05/19/14	EE 461 demo device
06/13/14	EE 461 report
11/10/14	EE 462 demo device
11/24/14	ABET Sr. Project Analysis
12/05/14	Sr. Project Expo Poster
12/12/14	EE 462 Report

Chapter 3: Functional Decomposition

Error! Reference source not found.FIGURE I and TABLE III depicts the chest strap's basic layout showing the chest expansion input and creating kinetic energy, and the useable energy stored output, charging a device.

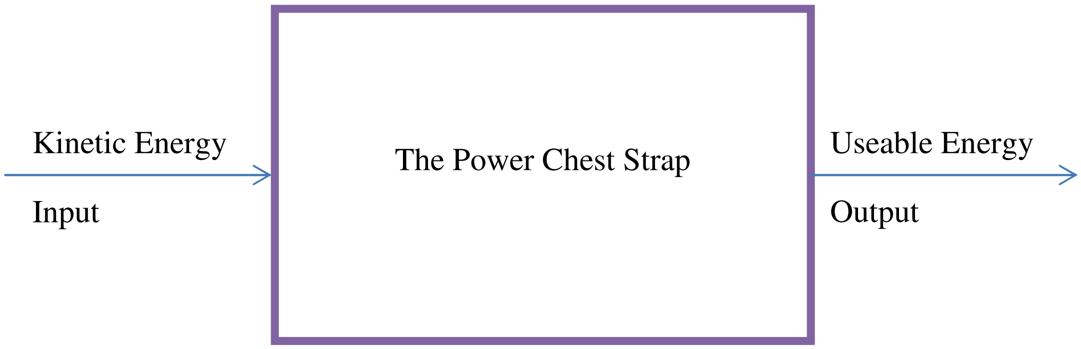

FIGURE I: POWER CHEST STRAP LEVEL 0 BLOCK DIAGRAM.

TABLE III: LEVEL ZERO BLOCK DIAGRAM DESCRIPTION.

Module	Power Chest Strap
Input	Kinetic Energy
Outputs	Stored electrical Energy
Functionality	Convert movement of the human chest to useable energy to charge low power devices.

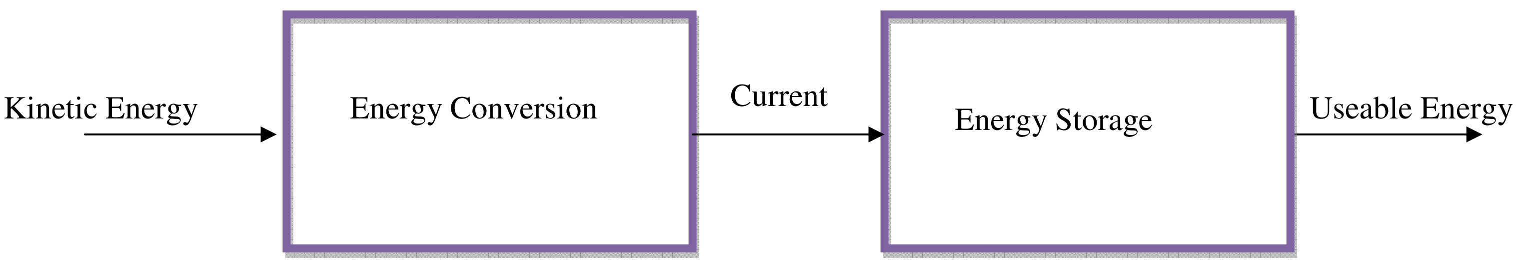

FIGURE II: POWER CHEST STRAP LEVEL 1 BLOCK DIAGRAM.

TABLE IV: LEVEL ONE BLOCK DIAGRAM DESCRIPTION

Module	Energy Conversion
Input	Kinetic Energy
Outputs	Current
Functionality	Convert movement of the human chest to current.
Module	Energy Storage
Input	Current
Outputs	Stored electrical Energy
Functionality	Store the current into a battery.

Error! Reference source not found.FIGURE II and TABLE IV show the Power Chest Strap's major sub components and their functions. The energy conversion component transforms the kinetic energy harnessed from the chest's expansion and compression into current, which then charges a battery.

Chapter 4: Development

Parts Selection:

For induction to occur, we must first take into consideration Faraday's law of induction and Fleming's right hand rule. Faraday's law states that "the induced emf in a circuit is proportional to the rate of change of magnetic flux through any surface bounded by that circuit." [14]. This indicates that the amount of current we wish to induce would depend entirely on how fast we change the magnetic field that is affecting the wire. However, it is not enough to only need a changing magnetic field to induce a current, we also need to take into account the direction in which the current will be induced. If we change the magnetic field in a direction that will not induce a current in the direction that we want the current to flow, we would not be able to acquire anything out of it. Thus, we require to also take into account Fleming's right hand rule to know which direction the current will be induced. Keeping that in mind, as long as the current being induced by the entire magnet all goes the same direction we can produce enough current to charge a battery.

Before we can apply Faraday's law and Fleming's rule we must first consider what form the coil should take, and determine the type and strength of the magnets, as well as the orientation of the magnets. Electromagnets require power and are very large, but we're trying to create power only through the movement of chest expansion and contractions, so our only option is to use permanent magnets. There are several types of permanent magnets that could fit our purpose: Neodymium Iron Boron (NeFeB), Samarium Cobalt (SmCo), Aliminum Nickel Cobalt (AlNiCo), Ceramic or Ferrite [10]. To build that is comfortable to wear, as well as it being unobtrusive, we need powerful by small magnets. Since the Neodymium type magnets are the strongest, we can get it in smaller sizes. The rating of Neodymium magnets range from N27.to N50 according to Chinese standards. Acquiring stronger magnets would allow us to lessen the amount of inductance required to induce current. We acquired N48 magnets that are 1/2in x 1/8in Disc. The 'N' stands for Neo, whereas the '48' stands for the maximum energy product in Mega-Guass Oersteds (MGOe), and 1 MGOe = 7958 kJ/m^3 [8].

After acquiring the magnets we need, we need to decide on what and how to induce the current in the coil we are building. Since we want the device to be as compact as possible, using 26 or smaller gauge wires would be too big, and since we don't expect to be producing more than 200mA with this device, 36 AWG wires are small enough while not losing too much power

to heat [11]. The more important aspect to consider is the topology in which the coils would take shape. There have been reports before describing the inductance of coils in certain shapes, whether it is flat, or wrapped like a solenoid. This will be explained in a later section.

We found many energy harvesting circuits, however, due to the small amount of voltage that we will be producing, we used the one that consumed the least power to help us convert the induction current to power [13]. The MOSFETs used in [13] are custom build with widths of "1800µm and 1200µm in combination with a transistor length of 0.35µm for the PMOS and NMOS transistor" [13]. Since we did not have the resources to build our own we decided to find MOSFETS that are low in voltage. The FDS6574a and FDS6575 MOSFETS have threshold voltages of 0.6V typ. The MOSFETS also have a low R_{on} of 4mΩ [2][3]. The low turn on voltage and R_{on} of these MOSFETS mean that we would have less power loss.

The diode in [13] is an active diode that they custom built. The diode consists of a MPS PMS switch driven by a comparator. Since neither of us had the ability to build our own transistors, we decided to find a diode with low forward voltage to suffice. Regular diodes usually have a 0.7V forward voltage which is definitely too large for us to use. Schottky diodes typically only have a lower forward voltage than a regular diode, and can go as low as 150mV. We found the PMEG2020 shottky diode due to its low forward voltage of 265mV when forward current is 100mA. Although Peters, Handwerker, Maurath, and Manoli built their own active diode [13], the PMEG2020 should serve our purpose well enough due to its low forward voltage.

For an object that is going to be wrapping around the body tightly, we need the power chest strap to be comfortable enough for the user to wear for long periods of time without an irritations arising. We decided to use cotton as it is a natural insulator while also being very sturdy. The cotton will be wrapping around the electronics, preventing the user from getting shocked from any kind of electrostatic discharge, as well as providing a more aesthetically pleasing exterior. Due to perspiration, however, we would need to use a layer of polyvinyl between the cotton and the electronics so when the cotton gets wet, it would not short the circuitry, or cause an electrical discharge. .

Coil Topology

Wire can be coiled in many different way to induce a current. The best way to wrap wire would entirely depend on how we want to orient the magnets, or how we want to induce a current. Choosing an orientation of the poles of our magnets is the most important deciding factor. If we have our poles adjacent to the chest, it would be better to use a solenoid as the magnetic fields formed by the magnet would also be adjacent to the body as shown in Figure 3.

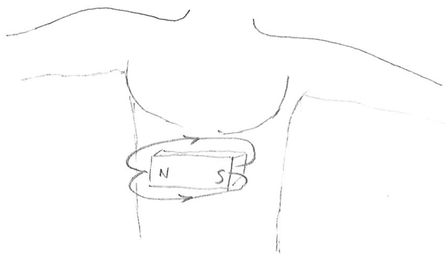

Figure 3: Adjacent orientation of magnet across chest creates magnetic fields that are adjacent to the chest.

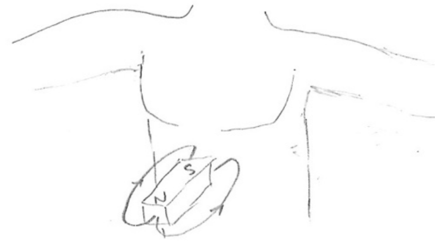

Figure 4: Perpendicular orientation of magnet across chest creates magnetic fields perpendicular to the chest.

Current can only be induced perpendicular to the magnetic field according to Faraday's law of induction, so moving the magnets along the body would induce currents perpendicular to the body. Similarly, if we orient the magnetic poles perpendicular to the chest it is better to use flat coils to induce a current. This is because the direction of the current induced would be adjacent to the chest and perpendicular to the magnetic fields of the magnets. To calculate the inductance of the flat coils we would need to refer to Roadstrums paper on Flat coils. He proposes that we need to "think of the total inductance as the inductance in each turn plus the mutual inductance each turn with every other" [5]:

$$L_{flat\ coil} = nL_{one\ turn} + 2\left((n-1)M_{1,2} + (n-2)M_{1,3} + \cdots + M_{1,n}\right) \quad [Eq. 1]$$

Calculating the inductance of a solenoid is a lot simpler. Using the equation from Wolfson [14]:

$$L_{solenoid} = \frac{\mu_0 A N^2}{l} \quad [Eq\ 2.]$$

Where A is the area of the solenoid, N is the number of turns, l is the length of the solenoid, and μ_0 is the permeability of air. Calculating the inductance, and subsequently the current induced would allow us to know which topology would induce more current. However, in order to do that, we would need to assume that both topologies have the same amount of turns over the same length of space. This would not be possible in reality, so we would need to build each and test it experimentally.

Energy Harvesting Circuit:

A dilemma was encountered when the harvesting circuitry was designed. The requirement of the circuit is that it should rectify the AC signal produced by the solenoid. A single solenoid acting at a normal breathing rate of 0.27Hz produces a very low voltage of about 0.14mV. The circuit will need to have a very low turn on voltage. The ultra-low-voltage active rectifier [1] was studied and simulated based on our needs. The problem is that the

dimensions needed for the MOSFETS in order to have low power losses do not exist. The required size should have a width of 1800 µm and 1200 µm in combination with a transistor length of 0.35 µm. The circuit in FIGURE III was built. The minimum turn on voltage for the PMOS is -0.4V with an $R_{DS(on)}$ of 0.01Ω [2]. The minimum turn on voltage for the NMOS is 0.4V with an $R_{DS(on)}$ of 0.0075Ω [3]. The typical forward voltage V_F of the Schottky Diode is 200mV[4].

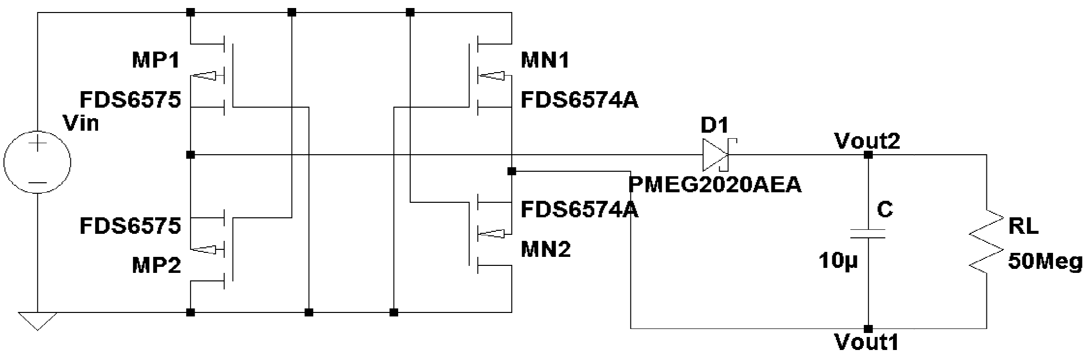

FIGURE V: ENERGY HARVESTING CIRCUIT

Analysis the circuit in FIGURE III, it can be see that MP1 and MN2 are always on. In order for each device to turn on, more voltage is required.

Concept of Final Product

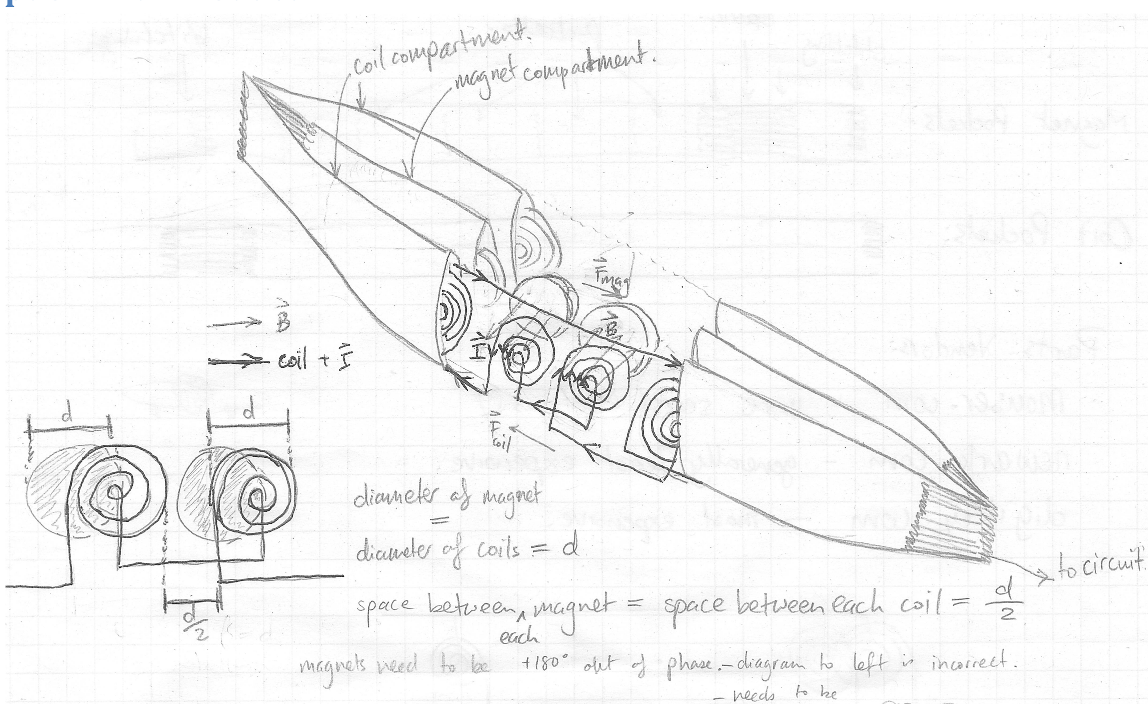

Figure 6: Concept drawing of implementation of the flats coils.

The concept shown in Figure 6 features the implementation of the flat coils. 3 compartments separate the coils from the magnets. The two outer compartments carry the flat coils while the middle compartment carries the magnets. The elastic fabric in combination with the non-stretch fabric ensures that the outer compartments move in the opposite direction of the middle compartment. The complication in implementing this design would be the need to make sure that the flat coils are correctly aligned with the magnets, since they are optimally out of phase by the length of the radius of the coils.

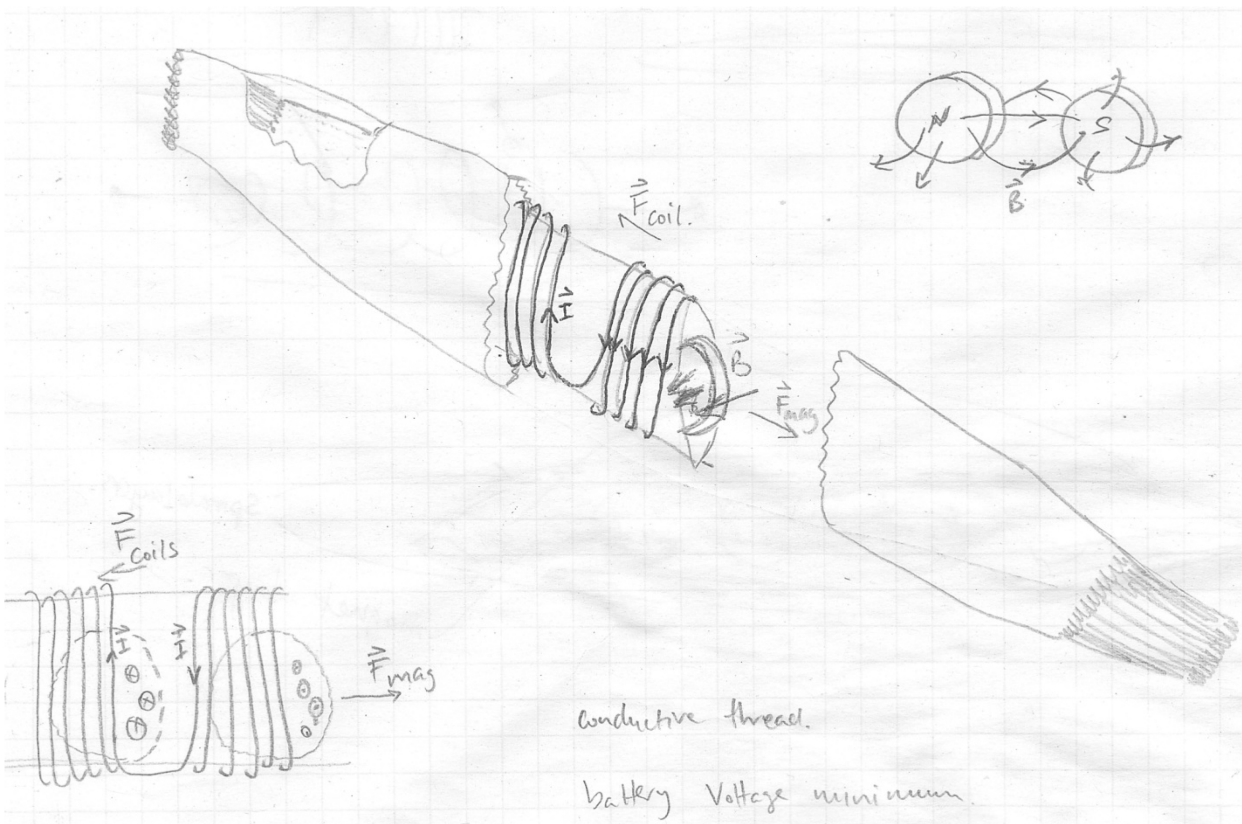

Figure 7: Concept drawing of solenoid implementation.

The concept shown in Figure 7 contains two compartments; one built inside the other. This implementation for the solenoid coils requires that the magnets are encased in a sturdy but flexible tube, while solenoid would be wrapped on the outside of the tubing. At the time of drawing, the solenoid concept was expected to work with the magnetic field normal to the direction of current. However, this is not true upon further investigation. The magnetic poles would need to face the ends of the product in order for a current to be induced, even if it’s a changing field either way. The complication to building this design would be the bulkiness of the product , and finding neodymium bar magnets small enough.

Chapter 5: Data and Analysis

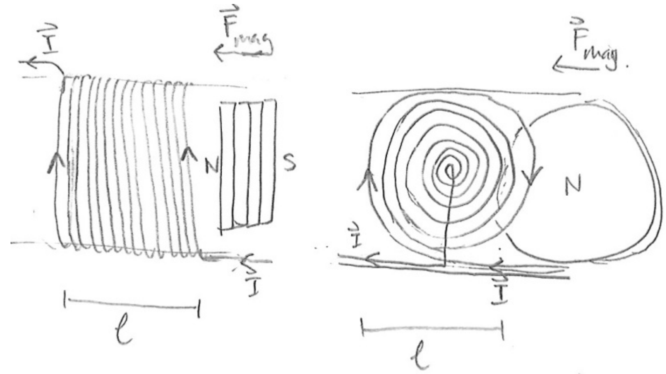

Figure 8: Direction of current induced in the solenoid (left) and flat coils (right).

Tests to determine which coil topology generated more current were conducted. By passing magnets, as shown in Figure 8, over a set length l we can determine which topology would induce the greater amount of current. Copper wire was wrapped around a flattened PVC tube to create the solenoid using about 30 turns to cover 1in, and the flat coils were adhered to a piece of cardboard using about 14 turns covering 1in in diameter. By using a Multimeter and connecting it as an ammeter, it was determine that the solenoid induced a greater amount of current as the flat coil only generated a max of about 14mA, while the solenoid generated about 30mA. This shows that the solenoid was able to produce more current over the same length. However, this result may be skewed by human error as it is impossible to move the magnet at the exact same speed for both topologies, though it still shows that the solenoid can produce more current over the same length of space.

Testing the energy harvesting circuit was more simple and straight forward. After determining that the circuit works in simulation, we bought the parts and mounted them onto a PCB. Since the circuit only consisted of several transistors and a diode, there was nothing we could tweak; we only needed to get the results. However, after we mounted the parts onto the PCB, and tried to operate the circuit with more realistic numbers than that in the simulation, we determined that the circuit does not work for the amount of energy that we are trying to produce.

Chapter 6: Conclusion

In testing, the strap works to the expected extent predicted from calculations. Bodily energy transfer into the strap's circuitry follows mechanical motion. Despite accomplishment of this goal, the belt remains less than operational in practical usage. Primarily, the lesser current derived from respiration cannot accomplish the required magnitude to activate charging transistors in the battery adapter. Optimistically, future improvements in low power transistor circuits and inductive mechanisms would provide a remedy for the current limitations. As such, this design remains viable for exploration in the presence of more advanced technology.

Adaptations that may apply to the belt and a new approach to the design seem likely to warrant an alternative look that may prove to circumvent our design limitations.

Chapter 7: Recommendations

For future endeavors, designers may implement several different strategies in improving upon current mechanisms. Custom building your own transistors would allow you to more closely follow the circuit described in [12] as this would allow you to build extremely low voltage transistors that aren't readily available from vendors. Another strategy to compensate for the transistors high turn-on voltage, a boost convertor would boost the voltage produced and could possibly alleviate the circuit's small currents. As a favorable option, the inductance of the coils in current strap design would ideally incorporate into the boost converter in order to save materials and power while realizing similar or better technical specifications for current conversion. According to Faraday's law, a further improvement means regarding small current exists in the incorporation of greater numbers of turns and stronger magnets. Increasing the number of turns provides a linear increase in current, but comes with a size drawback. The greater the number of turns, the bulkier the strap may become if technological improvements in inductive material do not become available. Of course, manufacturing techniques hold the capacity to produce flatly wound coils that take up less space which allows for the viability of this half of the approach. The simpler approach, stronger magnets, provides the better half of the equation to increase current as they may be placed in an isolation environment and do not take up hefty device area. However, a better route to harnessing more current may exist in redesign into a partially mechanical strap using gears. Gears supplement inductive materials in providing current to the transistors and operate off of the same inhalation / exhalation mechanism. Therefore, greater percentages of the body's natural energy may be converted into usable electricity.

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Appendix D: Senior Project Analysis

ABET Analysis

Power Chest Strap

Student Engineers:

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Advisor: Tina Smilkstein**: X**____________ **Date:** _____________

1. Summary of Functional Requirements

The Power Chest Strap customer needs power generation, comfort, portability, reasonable pricing, water resistance, and otherwise does not interfere with other devices. People do not like wearing uncomfortable products, and the average person cares about their budget. People who wear medical monitoring devices would not want this device if it affected their life support. All humans perspire so the Power Strap must resist water. The device must store the power generated in a battery to allow for charging of devices at a later time. The device must produce about 0.8W of power [12].

2. Primary Constraints

Currently, not many devices effectively harness the potential energy that our body's possess and convert that energy into electrical energy. Thus, there aren't many articles that can assist the process of creating the device. Other challenges include inducing enough current with magnets, encasement's flexibility, and material conductivity.

3. Economic

Human capital includes soldering, sewing, designing, testing. These require financial capital such as money, and time. Soldering guns, sewing machines, oscilloscopes, digital multi-meters, and power supplies are all required real capital in producing this project. Other capital to consider includes natural capital: magnets, copper, silicon, lead, iron.

Benefits accrue with product use, as we are able to generate energy and cut the amount of batteries we use, and thus, the amount of batteries we throw out. The project requires labor as an input, as well as material cost to build it. The cost at this moment comes mostly from our own pockets as well as the EE Dept. Sr. Project Fund. TABLE VI below describes the components required for this project, however, notice that more resistive, capacitive, and diode components are included as the actual amount of these components are currently unknown (TABLE VII).

TABLE V: LABOR AND PARTS COST ESTIMATES

Labor Costs @ $30/Hour:	$11,000		Parts Costs:	$200	
Optimistic Hours	Pessimistic Hours	Realistic Hours	Optimistic Cost	Pessimistic Cost	Realistic Cost
200	600	350	$100	$300	$200

PERT used to estimate the cost:

$$\text{Time Estimate} = \text{te} = \frac{\text{ta}+4\text{tm}+\text{tb}}{6}$$

Where the optimistic, ta, pessimistic, tb, and most realistic, tm, values were used.

TABLE VI:COMPONENT COST ESTIMATE

Parts	Quantity (unit)	Total Cost ($)
1/4W Resistor Box (w/ 860 units)	1	24.99
Capacitor Box (w/ 645 units)	1	29.15
Diode Box (100 units)	1	5.80
Li-Ion Battery	1	17.99
Electrical wires	50ft	8.99
Neodymium Magnets (¼ x 1/16 in)	30	6.99
Breadboard	2	15.00
Integrated Circuits	8	12.00
Shipping	1	12.00

TABLE VII: ACTUAL COMPONENT COSTS

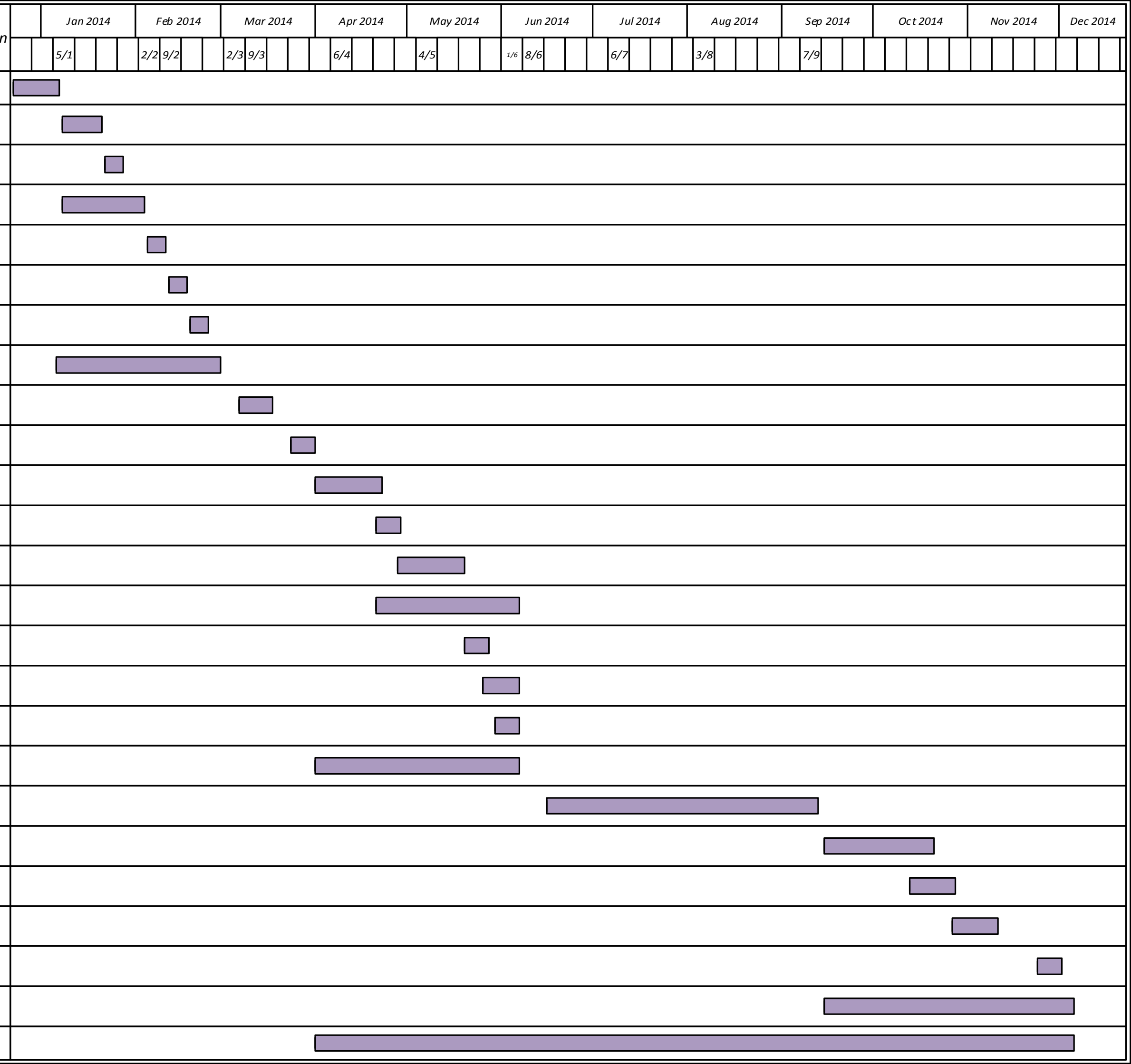
Parts	Quantity (unit)	Total Cost ($)
Fabric	1ftx1ft	13.10
Diodes	5	2.10
Electrical wires	50ft	8.99
Neodymium Magnets (¼ x 1/16 in)	10	29.99
Hollow tubing	10ft	4.58
Integrated Circuits	20	23.30
Li-Ion Polymer battery	1	29.99
Shipping		4.99

After designing the circuit of the device, no resistors or capacitors were needed. The No additional equipment required since the school has provided enough of the required equipment for use. TABLE VIII describes an estimate of development time.

Gantt Chart

TABLE VIII: GANTT CHART OF SCHEDULED DELIVERABLES

ID	Task Name	Start	Finish	Duration
1	Abstract	12/23/2013	1/6/2014	11d
2	Requirements and Specifications V1	1/8/2014	1/20/2014	9d
3	Block Diagram	1/22/2014	1/27/2014	4d
4	Literature Search	1/8/2014	2/3/2014	19d
5	Gant Chart and Cost Estimates	2/5/2014	2/10/2014	4d
6	ABET Senior Project Analysis	2/12/2014	2/17/2014	4d
7	Requirements and Specifications V2	2/19/2014	2/24/2014	4d
8	Report V1	1/6/2014	2/28/2014	40d
9	Report V2 (Callaborate)	3/7/2014	3/17/2014	7d
10	Spring Break	3/24/2014	3/31/2014	6d
11	Design simple scavenger circuit	4/1/2014	4/22/2014	16d
12	Simulate scavenger circuit (Adrianne)	4/21/2014	4/28/2014	6d
13	Incorporate battery charging circuit and simulate (Dennis)	4/28/2014	5/19/2014	16d
14	Gather Parts (Adrianne)	4/21/2014	6/6/2014	35d
15	Build Prototype circuitry(Dennis)	5/20/2014	5/27/2014	6d
16	Testing and Troubleshooting circuitry (Collaborate)	5/26/2014	6/6/2014	10d
17	EE461 demo	5/30/2014	6/6/2014	6d
18	EE461 Report	4/1/2014	6/6/2014	49d
19	Summer Vacation	6/16/2014	9/12/2014	65d
20	Improve energy scavenging circuitry	9/15/2014	10/20/2014	26d
21	Build Improved system prototype (Dennis)	10/13/2014	10/27/2014	11d
22	Test Improved system (Adrianne)	10/27/2014	11/10/2014	11d
23	EE462 Demo	11/24/2014	12/1/2014	6d
24	EE462 Report	9/15/2014	12/5/2014	60d
25	Data Collection	4/1/2014	12/5/2014	179d



After project completion, the project can take two paths: continue with the research and improve the design of the product, or leave the project as open development, allowing anyone interested to take up and improve the project.

4. If manufactured on a commercial basis:

The product can prove useful to the mass market; thus, estimated to sell 100,000 units each year. Taking into account labor costs about $20,000 and parts costs at most $20 per unit, each device would cost $25 to produce. Devices can sell at $35 per unit accruing $1mil profit per year.

5. Environmental

Manufacturing the device produces pollution as gasoline combustion from delivery of components and from soldering the components. Deforestation may occur to produce required instruction manuals or factories. The disposal of the batteries used may infect other species habitats. The mining of the silicon and other materials also affect the environment because these come from the earth.

6. Manufacturability

The manufacturing process has challenges. Bad soldering for the smaller pieces may cause lifted traces and no continuity. In addition, the circuitry inside of the holdings needs to remain stable while also being comfortable when wearing it.

7. Sustainability

The fabric on the device would need cleaning, and the battery would need changing after a few years. The project introduces another method of sustainable energy thus giving us another alternative to harness potential energy within the environment around us. Increasing the energy efficiency as well as reducing energy loss can greatly improve device's environmental sustainability. In order to improve the device further would require more research, thus resulting in higher costs, which we may not have.

8. Ethical

The device should not harm anyone with use; however, if the device requires maintenance and harms the user, we must take full responsibility in ensuring that harming a user will not happen again. Better fail-safe design needs enforcement. Since the device produces electrical current, it can turn into a lethal weapon through misuse and alterations.

As with all companies, manufacturing may elicit possible rumors of child labor if outsourced to other countries, causing social and ethical issues. Child labor violates the second point in the IEEE code of ethics [20]. Patent infringement may occur as the mass market may not have such a product at the moment, but that doesn’t mean someone hasn’t thought of the idea yet and has filed a patent. The patent applications database will then be searched if it does not appear in the issued patent database. Some unfiled patents may also conflict with our research, and depending

on who keeps a better log, problems may arise. Some political parties may also have issues with this product; infringing on patents violates point seven of the IEEE code of ethics [20] as we do not properly credit contributions of others to society.

The ethical stance called Consequentialism attempts to examine all of the possible consequences or ramifications attendant upon actions, and typically determines “wrong” and “right” behavior in relation to the “good” such behavior promoters. Ultimately, we should strive to produce the greatest good for the greatest number. [22] With this philosophy, the Power Chest Strap is thought of as ethical because it does more good than bad.

9. Health and Safety

Improperly trained factory workers handling equipment in manufacturing the device can acquire serious injuries, or even death. The device produces electrical currents that may harm the user, thus any exposed wires needs treatment immediately or it may cause injury. The buckle strap, when used improperly, can restrict breathing.

10. Social and Political

Some political issues associated come with the design, manufacture, and use of the Power Chest Strap. The Green Party [21] encourages alternative energy use, therefore encouraging the use of the product.

The product affects several stakeholders, both direct and indirect. The direct stakeholders include: group members, Adrianne and Dennis, senior project advisor Tina, the customers, patent developers, energy companies, the FCC, suppliers, and people providing feedback. The indirect stakeholders include: mailmen, the parts producers, battery companies, fitness companies, hospitals, the military, utility companies, banks, department chair, 24hr food services, and the NSA. Essentially everyone on the planet has an effect due to the ripple effect of events.

The project may harm some stakeholders. Less money goes to the electric companies. The delivery truck cause more pollution in the air affecting the customers. The businesses not purchased from may shut down due to lack of business.

On the other hand, stakeholders benefit greatly. The stores where we sell the product and buy our parts get business. The customers, in general, benefit from the convenience of charging their phones or portable devices less.

11. Development

Scavenger circuits are widely used to harvest energy. These circuits harvest energy from many sources such as impact energy, but vibration energy proves most efficient thus far [3]. Google scholar is a great website to check authenticity of sources as well as to find new articles, and patents.

We learned about how scavenging circuitry harvests energy out of human kinetic energy. The magnets move across a wire induces current. The current goes to the harvesting circuitry. Lastly the energy scavenged travels to a rechargeable battery to which the user can extract the energy into his/her device. For safety reasons, the material that encases the circuitry should not conduct electricity.