

## Induction unit for supplemental energy in Wireless Sensor Networks

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### ABSTRACT

*Wireless sensor networks (WSNs) are an important emerging area of wireless computing and networking. Throughout our society we use these WSNs in many areas; environment monitoring, smart spaces, medical systems, robotic exploration, disaster recovery systems, and military systems. WSNs present many uses and challenges such as developing a system architecture or model for WSNs [6,8], designing of appropriate low-energy networks [3,11], routing strategies for the networks [2] and deploying application specific approaches [12]. In this research paper we shall introduce the supplemental energy source for a sensor node to help create a stable energy source to be used to cope with the limited battery life.*

**KEYWORDS:** Induction, Power aware device, Collaboration, Wireless Sensor Network, Supplemental Energy

### 1. INTRODUCTION

Wireless Sensor Networks (WSNs) are constantly growing and technology is constantly advancing. In the past before sensor networks wireless sensors were mainly passed by word of mouth [1] Sensor data started being communicated by pneumatic means [1]. With the development of electrical signals sensors were able to be

passed by analogue. Upon the transformation to digital signals we began to see the use of sensors by digital signals [1]. With all these advances in the way sensors could be communicated more and more information was being able to be passed and stored as well. One downside is the limited battery life associated with these wireless sensors. This research project is a twofold project. First, we will research WSNs and get a historical background to help us further our project. Second we will build a prototype that will use magnetic kinetic energy to produce a never ending power source which will be attached to the nodes and serve as a battery to the sensors.

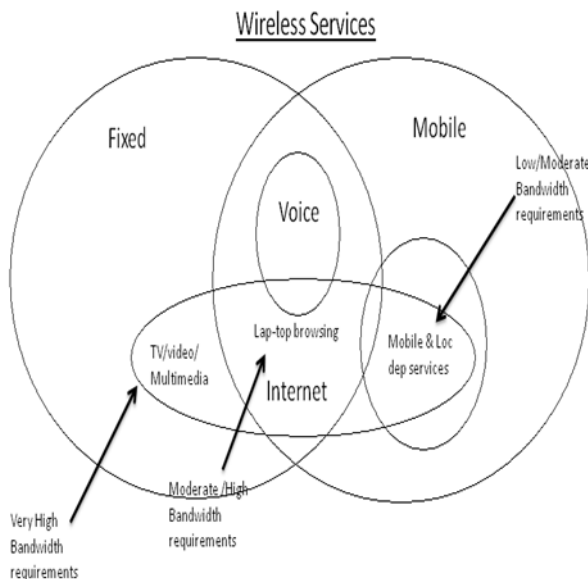
### 2. BACKGROUND

There have been many articles that have focused around my research topic leading to the design of my induction unit. Through my readings I have found many interesting topics that have helped me to become more acquainted with sensor technology. In the 1980's, instrumentation communication such as the IEEE-488 standard [18] was developed. Later came the Fieldbus standard targeting sensors, actuators and instrumentation in industrial environments with tight real-time requirements [16, 17]. Other approaches were the ASi standard [14] targeting sensor communication and the IEEE

1451 standard [15, 19] targeting the conversion of low level communications such as RS-23 and current loops to a bus structure. However, all these approaches make data available only to a few predetermined users [13].

With initially finding this dilemma in past technology it was only a matter of time before sensor technology would be able to reach a larger array of locations. Based on these types of standards we now see the evolution of virtual measuring environments. By adopting Internet technology, sensors and actuators thus become available to users worldwide [13].

Throughout the background investigation another area I have come across that has seen major improvement is that of wireless services and the breakdown of cost for allowing devices to communicate over a wide area network.



**Figure 1. Wireless Services**

From figure one we are able to see that all types of services share the same bandwidth requirements and are what we need to improve on in order for this induction unit for supplemental energy (ISUE) to be more efficient in our society. With the improvement's and rapid advances in IT we have come a long way in making this mobile network more affordable for one thing and more efficient for another. The future only holds more advances, making this ISUE the most logical piece of equipment to utilize in sensory networks.

We must also consider Joseph Henry who was the man who discovered inductance. Even though he was not the first to publish his work he was the first to discover it.[20] One equation the he introduced in order to help us better understand induction useful for me in calculating which design will be the best to use based on testing of the battery's.

Induction unit starting equation for Inductance

$$L = \frac{(N^2)\mu A}{\mathcal{L}}$$

- A = number of turns
- L = length
- A = cross sectional core
- $\mu$  = permeability of the core

**Figure 2. Equation**

This equation helps in being able to see the relationship between both the amount of cable actually wound around the tube and also the amount of energy produced. In all means the more cable that we use the better the energy output for units smaller that 1/2 inch in diameter of coil wrapped. With the more test that I am able to complete I believe that I will be able to develop a strong algorithm to help predict and also demonstrate the ISUE peak usage. I believe that with more examination of test results we

will soon be able to find the best suitable arrangement for this battery in order to create the best IUSE possible.

### 3. IMPLEMENTATION

Upon completion of my historical overview to gain more background and insight on WSNs I have found that there are used in many different aspects including environment monitoring, smart spaces, medical systems, robotic exploration, disaster recovery systems, and military systems [6, 8].

This is a structural diagram of the induction unit for supplemental energy (IUSE). It would allow for the maximum amount of output of potential DC current to be used to supply power. It would use a three layer casing unit that will house the entirety of the project.

The first layer will be a bottom casing that will allow for sturdy support under the framing of the second level and will also contain a small battery in order to store the obtained energy. This frame will be a rectangular base which will be approximately 2.0 mm thick and approximately 3.0 cm by 4.0 cm and will contain five plastic tubes that will wrapped with a copper coil and be holding a metal ball bearing.

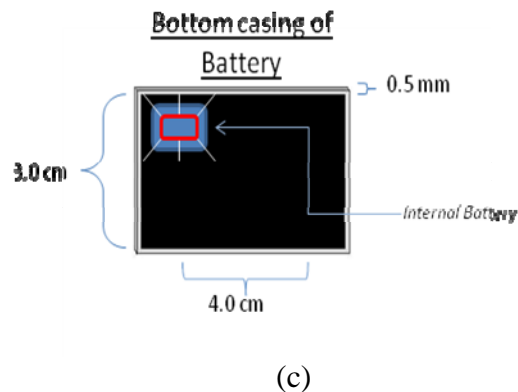
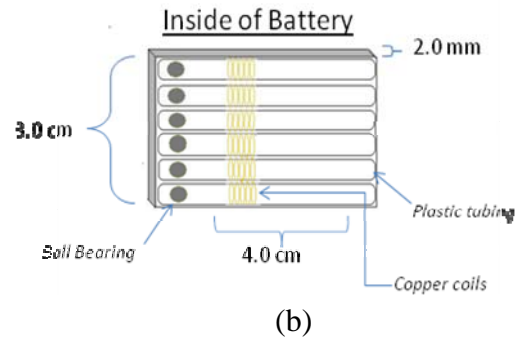
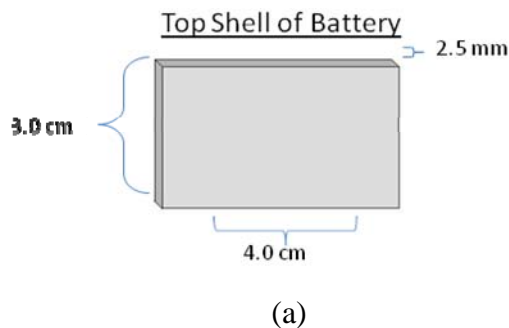


Figure 3. Structural Illustration

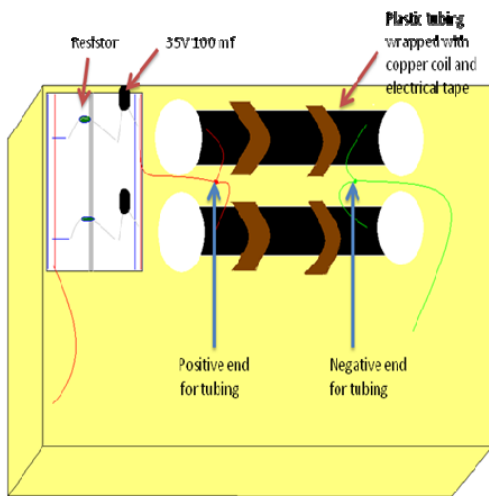
The top layer will be approximately 2.5 mm thick and 3.0 cm by 4.0 cm and will be hollowed in order to cover the middle layer and attach to the base.

The prototype of my design will be slightly bigger for research purposes. I have decided to use clear plastic tubing that has an opening of 5/8" and is approximately 1.5 mm thick. I capped the end of the plastic tubing off with hard white plastic caps that measure 3/4". I have wrapped the plastic tubing with 1/4" of copper wire creating a coil like shape around the tubing. I have also placed that magnetic bearing that is cylinder in shape and has a diameter of approximately 1/2".

For experimental purposes my first prototype will consist of all materials listed above except for the metal base. For ease of creation I will be using a treated wood base

approximately 6”/11”/1” to allow for easier changes and modifications to my prototypes. I first cut my clear plastic tubes in to 6” strips and began wrapping them with copper coils. After wrapping in approximately .25 inches of copper I attached the tubes to my piece of treated wood with tubing attachment pieces that will not react with the copper coil. I used metal screws to put the reinforcements in place to hold the tubes flat against the surface of the base. I am using rechargeable AAA batteries as my interior battery in order to be able to store the kinetic energy created by the induction unit.

**Illustration of Design**

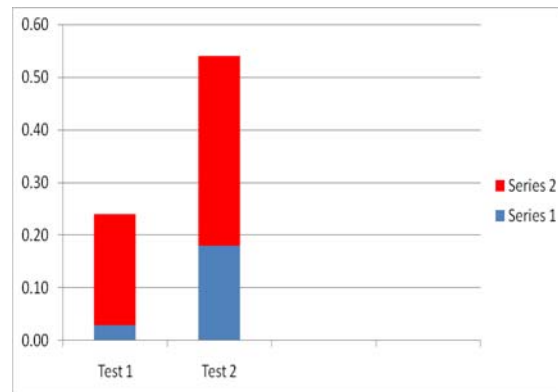


**Figure 2. Illustration of Design**

Through examination of other similar designs I decided to use an aluminum 2200 uF 35V Capacitor in order to obtain the energy and pass it to the internal rechargeable battery’s which will then be transferred to the output for the external induction unit for supplemental energy.

**4. SIMULATIONS**

**Induction Unit for Supplemental Energy**



**Figure 4. Results**

This table shows the outputs for two different optimal arrangements for the Induction. This data represents two successful different tests on the prototype design for the induction unit. I am attempting to produce as much energy as possible in order to obtain information that will later help to decide which prototype design will be most beneficial in the creation of the induction unit for supplemental energy. Test one is the first arrangement for the prototype. The first arrangement of the prototype consisted of two clear plastic tubes that were approximately 2 mm thick and 5/8” in diameter. They were each wrapped in approximately 1/4” of copper coil and then placed securely on to the wooden base. From the positive end of the tube I ran the wire into a bread board passing the current in a parallel series through two diodes and then out of the positive hub on the bread board. I connected positive end to the positive end of the volt meter and connected the negative end to the negative end of the volt meter. I then used a constant shaking motion to create kinetic energy and was only able to obtain from .03 to .21 millivolts. I was able to obtain some more voltage with a more uniformed motion of going up and down with the prototype. In

the chart above the blue bottom half of the test one bar is for the lowest output obtained and the red bar is displaying the output for the highest output. After only being able to produce this little amount of potential output for the IUSE I decided to try and redesign the prototype to be able to utilize more of what it was creating rather than losing it to various factors. The first step I took was to insulate the copper coils and tubing with black electrical tape. I believe that doing this will help to keep the magnetic field stronger and more secure to help the design retain more of the energy it is creating. I tried the same method of testing again using the volt meter and was able to obtain more sufficient results obtaining from .18 to .36 millivolts. As In the first test I used the blue bottom bar in test two to represent the lowest output of energy for the test and used the red bar to represent the highest output for the IUSE. I have begun altering the prototype yet again in a few different areas.

Induction Unit for Supplemental Energy

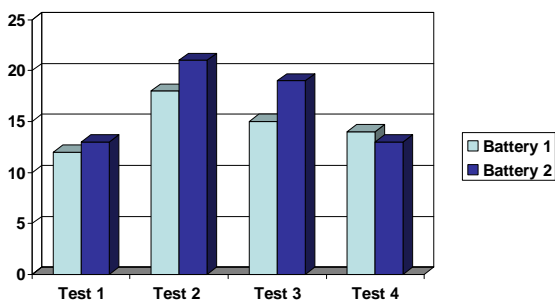


Figure 5. Results

In figure four we are able to see another set of test I ran for a different prototype. I have found that with changing the length of the copper that is wrapped around the tubing I am able to create more energy with more cable. As you can see from the test battery one did better in 75% of the test I performed.

The battery one was wrapped with more coils approximately 10 for inch lengths for each test. For the second battery I used the same amount of coil and added the electrical wrapping to it once again in order to help maintain the amount of energy output I will first be rewrapping the copper coil to be approximately 1/2” thick around the plastic tubing. I believe that with this thicker coiling I will be able to produce a stronger magnetic field from the magnet passing through the inside. It will allow the magnet go create a larger magnetic field and produce more energy output. I will then again, knowing that it helped to increase the output, be wrapping the tubes and coil with a thin layer of black electrical tape. I also will now be including the internal battery to help store more energy and allow for a larger output. I will be using a battery holder to contain four AAA rechargeable batteries. In order to pass the energy in the most beneficial way I will be using the 2200uF 35V capacitor to store the energy produced by the actual unit and pass it to the rechargeable battery pack which will then allow the energy to pass through a hub and then to the output. I believe that this design will be the prototype we are looking for and will allow for the most optimal output of energy.

## 5. CONCLUSIONS

This project allowed us to create energy by allowing the ball bearings to pass back in forth inside of the copper coiling which is located around the plastic tubing that will house the ball bearings. In the first few designs of the ISUE I was not able to obtain enough energy to allow for the output desired. After a few alternative designs I was able to begin producing a larger output that has the potential to allow for a substantial output to power the wireless nodes in the sensory networks. The energy produced was

then passed onto the interior battery found on the first layer of the unit in order to store it before usage. The use of battery to store the energy and pass it on will allow for a greater increase in the amount of energy created allowing for a more efficient output. Throughout all of my research I have had many advances with understand the background and present dealing with induction units and electrical current. The main purpose of the research project is to help me to become more away of induction units and also to create this prototype for and Induction Unit for Supplemental energy. After creating this I will continue my research and testing and hopefully within the next six to twelve months I will be able to have a fully functional miniature version of my design in order to help me make this disgn more optimal for ; environment monitoring, smart spaces, medical systems, robotic exploration, disaster recovery systems, and military systems This smaller version will allow for more mobility and hopefully a better quality in time for users.

## 6. ACKNOWLEDGEMENTS

We would like to thank the URC committee members for all of there support. We would also like to thank the department chair Dr. Reza Mirdamadi as well as Dr. Seung-yun Kim for all of there hard work and dedication to our research. We would also like to thank Seth cook and the SURoC robotics team for there effort in this research. Finally we would like to thank the HuCS research group for there guidance through our bi-weekly meetings.

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