DEVELOPMENT OF A WIRELESS MOBILE CHARGER

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in partial fulfillment for the requirements of a B.E Degree in Telecom Engineering

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<u>CERTIFICATE</u>

It is certified that the work contained in this thesis entitled **"Development of a Wireless Mobile Charger"** carried out by Sunnia Malik, Amna Hanif and Haris under the supervision of Dr Ashraf Masood for the partial fulfillment of degree of Bachelors of Telecom (Electrical) Engineering is correct and approved.

X

Brig (R) Dr Ashraf Masood
Dean, MCS

ABSTRACT

With smart phones becoming increasingly common, more and more people are complaining about battery drainage and having to recharge their phones frequently. A viable solution is presented in this report which involves a transmitter that will be used to transmit radio waves and a receiver which will be used to receive those waves and harvest power from those waves. A Wi-Fi router is used as the transmitter in our project and the receiver module is designed to reap its power. In this manner power that would be otherwise wasted is utilized efficiently in charging the phone's battery. Current wireless chargers implemented on QI standard work for only 2-4cm and use the principle of electromagnetic induction. Our project aims to increase this range to provide greater convenience to users. It will work as a universal wireless charger for all devices having the receiver module. This report focuses on the complete design along with specifications and details of tasks completed and objectives achieved in the course of our project.

DECLARATION

No portion of work presented in this dissertation has been submitted in support of another award or qualification either at this institution or elsewhere.

DEDICATION

In the name of Allah, the Most Merciful, the Most Beneficent

To our parents and teachers, without whose help, this project would not have been possible.

ACKNOWLEDGEMENT

There is no success without the will of ALLAH. We are grateful to ALLAH for giving the strength which enabled us to complete this project. We are also grateful to our parents, family, teachers and everyone who supported us through this project. Without their guidance and help we would not have been able to achieve our goals.

Contents

Figures and Tables:

List of Abbreviations:

EIRP: Effective Isotropic Radiated Power

FSL: Free Space Loss

IRL: Isotropic Received Level

ISM: Industrial, Scientific and Medical bands

RSL: Receiver Signal Level

VCO: Voltage Controlled Oscillator

HBT: Hetero Junction Bipolar Transistor

MMIC: Monolithic Microwave Integrated Circuits

RF: Radio Frequency

PA: Power Amplifier

VSWR: Voltage Standing Wave Ratio

EMDS: Momentum Design Software

CHAPTER 1

INTRODUCTION

1. Introduction:

1.1. Background:

Smart phones have become very common nowadays and due to their high end functionalities, their battery drains too quickly. The existing electric power storing technology has no revolutionary improvement, and common wire charging method has hitches in aspects of space and distance, location of electrical source and the interconnection of power transfer. This calls for coming up with a wireless power supply system that will allow the user freedom of movement while phone is being charged.

In past resonance coupling and LASER techniques were used for wireless power transfer but the problem with resonance coupling is that it works for very short range (2-4cm) and LASER requires line of sight availability which creates problems.

The aim of this project is to overcome these problems and provide a greater range to the user and a greater degree of mobility whilst charging phone's battery.

1.2. Project Description and Salient Features:

1.2.1. Project Description:

This project involves the charging of mobile devices using wireless power transfer. This is accomplished by employing a Wi-Fi router, which serves as a microwave generation source that produces radio waves in the S-band region (2-4GHz) specifically the ISM band (2.4-2.5 GHz). The signal is then amplified using bidirectional pole mounted amplifier and then it is transmitted using a Yagi antenna. A single antenna is used for receiving the microwave signals. The antenna is followed by an impedance matching & filter circuit which transfers the signal efficiently to the rectifier circuit for conversion of signal into DC. A series of charge pumps are then used for DC to DC amplification of voltage and current to get the required amount of power at the output. At last this output is fed to the battery of the mobile device to enable charging.

1.2.2. Prospective Application Area:

This project is designed to serve as a prototype for wireless charging using electromagnetic power transfer. It seeks to harvest energy from Wi-Fi routers that are installed in homes as well as business and educational organizations. Therefore power that would be otherwise wasted is resourcefully utilized through this project. Upon further development and enhancement, it can be used for wide scale production and its provision can be allowed in future cell phones to enable charging via Wi-Fi.

1.2.3. Salient Features:

The basic aim of this project is to come up with a system that will work similarly as a wireless charging hotspot (however certain circuitry must be incorporated in the mobile device). This system can be used in cafes, homes, offices and cars to enable the mobile phones and other devices like I pads, Galaxy Note etc to charge automatically if they come in the range.

The block diagram of the system is shown below:

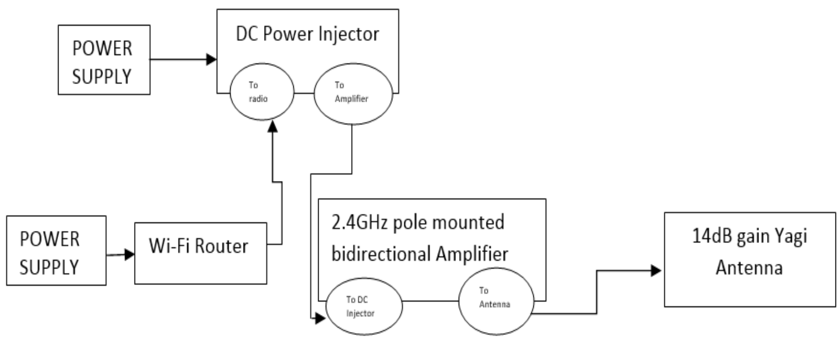


Figure 1: Block diagram of transmitter

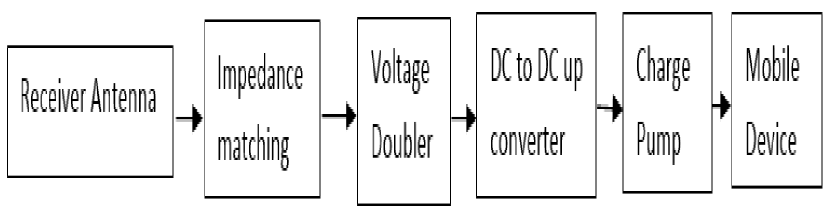


Figure 2: Block Diagram of receiver

1.3. Scope, Objectives, Specifications and Deliverables of the project:

1.3.1. Scope:

The already implemented technique for wireless charging is the 'Qi' (pronounced as Chee) technology which is an immature technology and its distance of wireless power transfer is very small. Although the technology charges the devices wirelessly but the device still has to be kept in contact with a wireless charging pad which is attached to the switch. So it still has limitations like the old wired charger. The objective of our project is to improve upon this range by means of power harvesting techniques to capture power available in the environment. The most common of these sources is the Wi-Fi router, therefore we have implemented the receiver system on its frequency band.

1.3.2. Objectives:

The basic aim of the project is to:

- Understand antenna design and theory
- Understand software related to antenna and circuit designing for example HFSS and Proteus
- Design and Implement Wireless Charging System which would enable wireless charging of cell phones
- Practical objective is to achieve a range of 2-3m. For this a transmitter and receiver module will be designed at a frequency of 2.4GHz to accomplish increased range
- Another objective is to present this project as a part of our B.E degree

1.3.3. Technical Specifications:

The receiver system will be inside the cell placed at the back of the cell phone cover case in the case where size of cell phone is not small e.g. tablets, notebooks etc. its output terminals will be connected to the battery's terminals and for the case where dimensions of the receiver system are not comparable to the dimensions of the handset we can insert receiver in USB port.

The transmitter will be fixed and could be placed behind the picture on the wall or on the roof of the car. The physical range of wireless charging will be in few meters that will depend on the power levels reception of the receiver.

The electrical parameters required for power supply to drive the transmitter system are 9V and 2400 mA maximum. The different stages of the transmitter will have different voltage and current thresholds to achieve the desired level of power and transmit it, since the operating frequency, biasing voltage and tuning voltages for transmitter are factors which will decide the operation of the transmitter.

Furthermore the receiver system is designed such that it is efficient to deliver the desired power level to the battery. The received power level is amplified to the extent such that after rectification and amplification the desired values of 3.2 V voltage and 250mA current could be achieved to charge the mobile device.

1.3.4. Deliverables:

The deliverables will include a transmitter which can be mounted on the wall of the room, just like a Wi-Fi router. It will transmit the electromagnetic waves. The receiver will be placed in between the battery and the back cover of the mobile device. It will receive the electromagnetic waves to charge the mobile device. The distance between the transmitter and the receiver will be within few meters giving the person freedom to place the mobile anywhere or use it while it is getting charged.

CHAPTER 2

LITERATURE REVIEW

2. Literature Review:

Nikola Tesla[1] is the person who first perceived the notion of Wireless Power Transmission and demonstrated “the transmission of electrical energy without wires" in 1981.

Figure 3: Wireless Transmission Tower

Hatem Zeine[2] introduced the Cota wireless power transmission system. The technology employs a phased array antennas for microwaves, which are used to steer waves in a specific direction, and the time-reversal properties of electromagnetic waves to concentrate power on a wireless receiver while avoiding any of the radiation to hit stumbling blocks, resulting in an inherently safe charging system. Cota uses a single microwave transmitter, operating in the 2.4 or 5.8GHz. Unlike most wireless charging systems that require the close proximity between the transmitter and the device being charged, the yet to be launched Ossis transmitter will provide effective charging to distances of about 30 feet (9 m). This means that a single unit would suffice for most households and offices. The microwave power from the transmitter is directed onto charging receivers that convert the received power into a form that can be used to charge device batteries, or even to directly run portable devices.

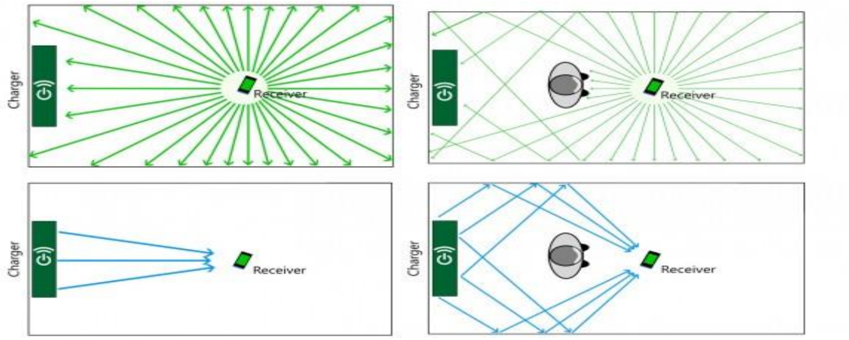


Figure 4: COTA Wireless Charging System

The earliest of the wireless chargers utilized the principle of electromagnetic induction where both the transmitter and the receiver had inductors in their circuitry. The primary inductor in the transmitter, connected to a current source, stores the energy in form of magnetic field. When the secondary inductor in the receiver comes in the influence of this field, current flows through it which charges the battery of the phone. These chargers are implemented on the QI standard which has been developed by Wireless Power Consortium (WPC).

The above technology is currently being used by many companies including Asus, HTC, Huawei, LG Electronics, Motorola Mobility, Nokia, Samsung, BlackBerry, and Sony. The range for QI standard is up to 4cm therefore chargers based on this are manufactured as power mats upon which the QI standard compliant phones with appropriate back cover are placed for charging. The first of these mats and covers was developed in 2009 by Duracell. Right now many companies are involved in manufacturing of such mats like Google recently launched its wireless charger for nexus.

Research work has been done on resonance coupling which allows midrange operation (up to 1m) and electromagnetic radiations which are suitable for long range. However these technologies are immature and hence further research is being done before companies start utilizing these technologies.

Figure 5: Wireless Charging Pad based on Qi technology

2.1. Techniques of Wireless Charging:

Several techniques are available for wireless charging, each having its own limitations and plus points. These include:

2.1.1. Electromagnetic Induction:

This technology facilitates the transmission of electrical energy from a power source (inductive charger) to an electrical load (inductive receiver) without connecting wires. Based on the principles of electromagnetic coupling, inductive chargers use an induction coil to create an alternating electromagnetic field from within a charging base station, while a second coil embedded in a portable device receives power from the electromagnetic field and converts it back into electrical current that is used to power the device and charge its battery. The technology is especially useful in cases where wires are hazardous, impossible to connect, or simply inconvenient.

2.1.2. Resonance Coupling:

Resonant power transmission is a special, but widely used method of inductive power transmission which involves tuning of the coils at the transmitter and receiver at a particular frequency to allow maximum energy to be coupled. It is used for midrange up to 1m.

2.1.3. Electromagnetic Power Transfer:

This method is used for long range of power transfer. In this technology, electrical power is first converted into electromagnetic waves which are then transmitted through an antenna to the receiving device. At the receiver the electromagnetic waves are converted back to current to charge the battery.

It is due to the long range of EM power transfer that we chose to use this method in our project.

2.2. Microtrip Antennas:

A patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit board, with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. Common microstrip antenna shapes are square, rectangular, circular and elliptical, but any continuous shape is possible. Some patch antennas do not use a dielectric substrate and instead are made of a metal patch mounted above a ground plane using dielectric spacers; the resulting structure is less rugged but has a wider bandwidth.

Advantages of microstrip antenna include:

- Low cost to fabricate
- Light weight
- Easy to form large array
- Conformal structures are possible

However there are certain disadvantages of microstrip antenna. These include:

- Limited bandwidth
- Low power handling

2.3. Impedance Matching:

In electronics, impedance matching is the practice of designing the input impedance of an electrical load or the output impedance of its corresponding signal source to maximize the power transfer or minimize signal reflection from the load.

The term "impedance matching" is rather straightforward. It's simply defined as the process of making one impedance look like another. Frequently, it becomes necessary to match a load impedance to the source or internal impedance of a driving source. A wide variety of components and circuits can be used for impedance matching.

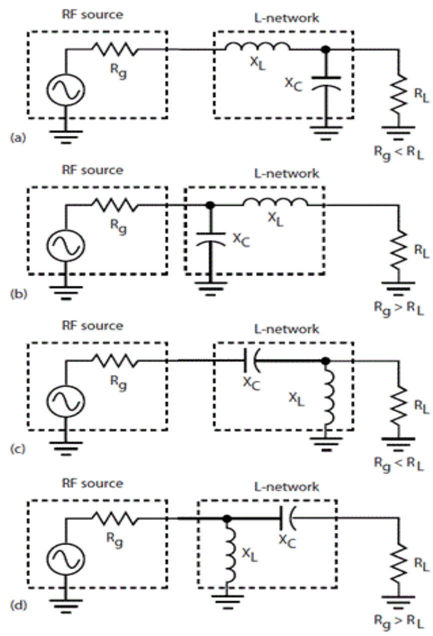


Figure 6: Types of L impedance matching

During impedance matching, a specific electronic load (RL) is made to match generator output impedance (Rg) for maximum power transfer. The need arises in virtually all electronic circuits, especially in RF circuit design. The primary applications of L-networks involve impedance matching in RF circuits, transmitters, and receivers. L-networks are useful in matching one amplifier output to the input of a following stage. Another use is matching antenna impedance to a transmitter output or a receiver input. Any RF circuit application covering a narrow frequency range is a candidate for an L-network. While the L-network is very versatile, it may not fit every need. There are limits to the range of impedances that it can match. In some instances, the calculated values of inductance or capacitance may be too large or small to be practical for a given frequency range. This problem can sometimes be overcome by switching from a low-pass version to a high-pass version or vice versa.

CHAPTER 3

DESIGN

AND

DEVELOPMENT

3. Design and Development:

3.1. Design Description:

The approach that has been adopted for designing the wireless charging system is that it uses a microwave source (Wi-Fi router), amplifier and transmitting antenna on the transmitter system. On the receiving system, there is a receiving antenna, impedance matching and rectifier circuit and charge pump circuitry which is used as an energy storing device for mobile station’s battery.

The project is divided into six phases for completion on the basis of time and effort required for each task:

- Receiving patch antenna design
- Fabrication of the antenna
- Testing of the transmitter to determine power received by patch antenna at required distances
- Simulation and designing of the hardware of the receiver system based on testing results
- Implementation and integration of the hardware
- Testing and optimization to enhance range

Keeping in view the size constraints of the receiver, a rectangular microstrip patch antenna was selected for design upon thorough literature review. The patch antenna with a good gain and low reflection coefficient was designed in HFSS software. The patch antenna was then fabricated and an SMA connector was attached to it. The transmitter equipment was then set up in the microwave lab consisting of TP-link Wi-Fi router followed by pole mounted amplifier and Yagi antenna. The receiver patch was attached to the antenna testing bench connected to the CPU at a distance of 1m from the transmitter. The program was run on the computer to observe received signal level.

The results of this testing were used to develop the receiver system which takes the same amount of received power and converts it to the threshold voltage and current required by Li-ion batteries present in mobile phones. Simulations were done for rectifier system design and charge pump circuit that were supposed to give required output to the battery.

3.2. Detailed Project Implementation:

3.2.1. Transmitter System:

The transmitter system consists of a TP-Link wireless Wi-Fi router which normally has a full transmission power of 250mW. The output of this router which is normally connected to the dipole antenna is fed to the 2.4GHz bidirectional pole mounted amplifier's 'to radio' terminal using cable and connector. The amplifier's 'to antenna' terminal is connected to the Yagi antenna which has a 14dB gain. The DC bias voltage required to operate the amplifier is provided through a DC injector. The amplifier's ground pin is attached to a metallic surface for proper grounding. This system transmits an output power of 1W which can then be harvested at a distance of few meters.

Figure 7: 1 Watt bidirectional amplifier

3.2.2. Receiver Patch antenna:

Antennas are used to collect and transmit electromagnetic energy. For our receiver, we designed an inset fed rectangular microstrip patch antenna. Patch antennas were emplyed because of their ease of incorporation into the Printed Circuit Boards (PCB). A general representation of a rectangular patch antenna is shown in the figure given below:

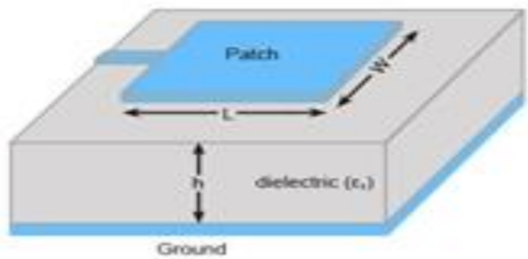


Figure 8:2D model of a microstrip antenna

The features of the antennas are defined mainly by their geometries and the physical properties from which they are made. Basically, a microstrip "patch" antenna is a metal radiator, usually copper, that is placed on top of a dielectric (substrate). The substrate is also grounded. The design of patch antennas requires precise physical dimensions, and power feeding method/location for the antenna. We used the Rodgers RT duroid 5880 substrate (its datasheet is attached in Appendix A). This substrate has a height d = 1.57mm and a dielectric constant of εr = 2.2 F/m. The frequency of resonance was fo= 2.45 GHz. The antenna was designed based on the aforementioned parameters. The width of the patch was found as:

$$W \cong \frac{c}{2f}\left(\sqrt{\frac{2}{\varepsilon r + 1}}\right) = \text{ 48.4mm}$$

Where εr is the dielectric constant, f is the operating frequency and c is the speed of light. With the width of the patch known, the effective permittivity can be found using:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W_p}\right]^{-1/2} \quad \text{for } W_p / h > 1 \quad = 1.99\text{F/m}$$

Effective permittivity needs to be accounted for due to fringing fields. Fringing fields consist of those parts of the electric field lines that are partially in the substrate dielectric and partially in the air.

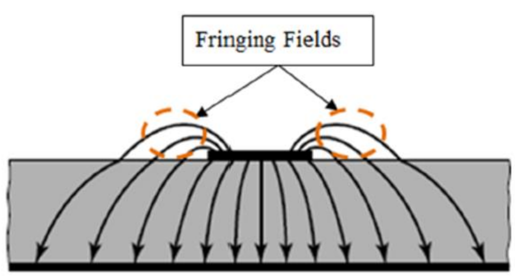


Figure 9: Fringing fields

If this inhomogeneous medium (air and the dielectric) is replaced with a homogeneous one, then all properties of the line or patch remain unchanged.

Because of the fringing effects, electrically the patch of the microstrip antenna apparently seems er than its physical dimensions. This phenomenon will be represented by ΔL, which is a function of the effective dielectric constant εeff and the width-to-height ratio (w/d) found as:

$$\Delta L = h(0.412)\frac{(\varepsilon_{eff}+0.3)(w/d+0.264)}{(\varepsilon_{eff}-0.258)(d+0.8)}$$ =0.728mm

Since the length of the patch has been extended by ΔL, the effective length of the patch is found as:

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}} - 2\Delta L$$ =32mm

The values of w and Leff were then verified by means of an online microstrip patch antenna Calculator.

The antenna was then matched to Zo = 50 Ω transmission lines using inset feed. Matching reduces the loss of the signal and reflected power towards the transmission line that supplies a smooth transition of energy from the antenna input impedance to the feed line. The inset distance was found using the formula below:

$$y_o = \frac{L}{\pi}\cos^{-1}\sqrt{\frac{Z_o}{Z_1}}$$ =12.37mm

Using these parameters, the design was made in HFSS and the gain and return loss was observed, the model is shown below:

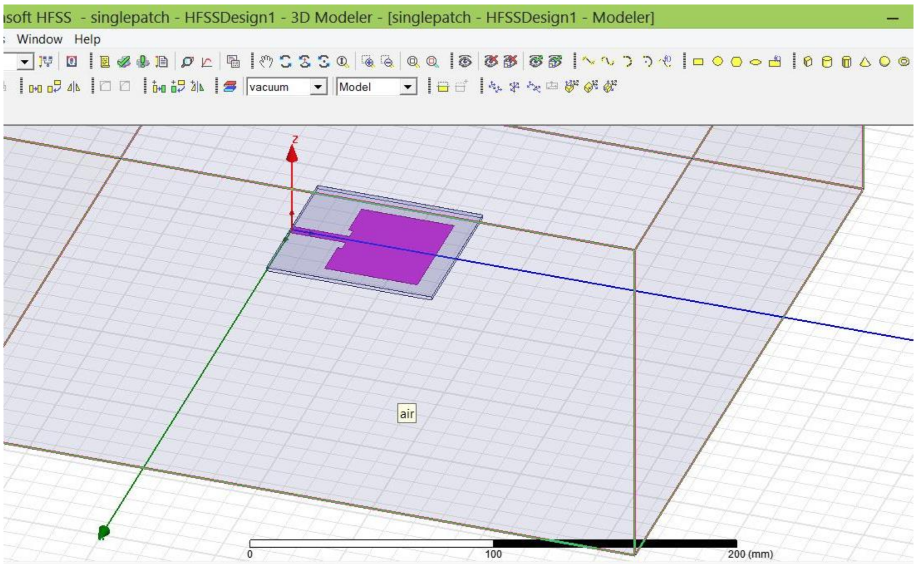


Figure 10: HFSS patch antenna design

3.2.3. Voltage Doubler Rectifier circuit:

As its name suggests, a **Voltage Doubler** is a voltage multiplier circuit which has a voltage multiplication factor of two. The circuit consists of only two diodes, two capacitors and an oscillating AC input voltage (a PWM waveform could also be used). This simple diode-capacitor pump circuit gives a DC output voltage equal to the peak-to-peak value of the sinusoidal input. In other words, almost double the peak voltage value because the diodes and the capacitors work together to effectively double the voltage.

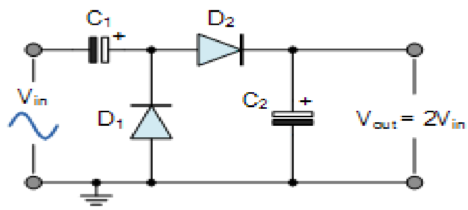


Figure 11: Voltage Doubler Circuit

This circuit is used because of the received power and voltage constraints. The diodes used are HSMS 2860 Schottky diodes which are low Barrier diode manufactured by Agilent for frequency range of 915MHz to 5.8GHz. Schottky barrier diode chip consist of a metal-semiconductor barrier formed by deposition of a metal layer on a semiconductor. Their purpose is to convert the AC input into DC output which can then be supplied to the battery after passing through regulation phase.

The voltage doubler circuit was simulated in ADS using two schottky diodes (HSMS 2860) to determine the values of the capacitors required for our specific case. Upon hit and error method, the values of capacitors were changed and the output was observed. The maximum output voltage was observed for capacitance values of 200pF for C1 and 150pF for C2.

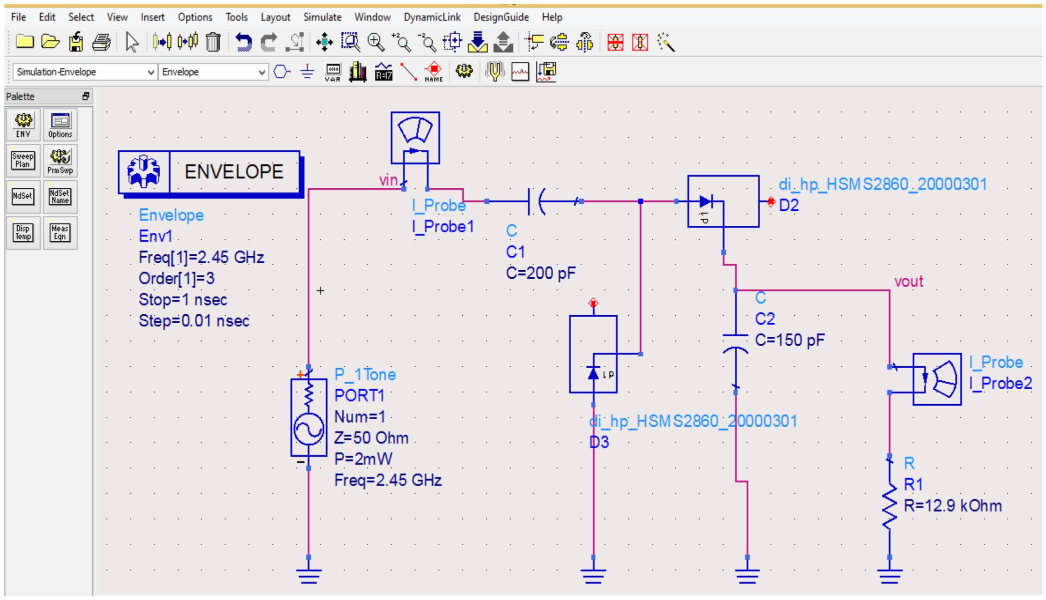


Figure 12: Design of voltage doubler in ADS

3.2.4. Impedance Matching Network:

The objective of the impedance matching network is to match the input impedance of the rectifier to the antenna impedance so that maximum power may be transferred. In this condition, the antenna sees at its output the complex conjugate of the antenna impedance. The L network consisting of a capacitor parallel to an inductor is used in our design. The 50 ohms resonant impedance of the antenna was matched to the voltage doubler's impedance using a capacitor C1 (= 0.27 pF) and an inductor L1 (= 5.35 nH) between the antenna and the rectifier.

3.2.5. DC to DC Voltage Upconverter:

MAX1724 IC is used to accomplish the task of dc voltage up conversion. It is a compact, high-efficiency, step-up DC-DC converter available in tiny, 5-pin TSOT packages. They feature an extremely low 1.5μA quiescent supply current to ensure the highest possible light-load efficiency. So minimum required voltage for MAX1724 to operate is 0.91V and current sensitivity of 1.5uA as we can see from data sheet:

ELECTRICAL CHARACTERISTICS

(V_{BATT} = 1.2V, V_{OUT} = 3.3V (MAX1722/MAX1723), V_{OUT} = $V_{OUT(NOM)}$ (MAX1724), $\overline{SHDN}$ = OUT, R_L = ∞, **T_A = 0°C to +85°C**, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Minimum Input Voltage		MAX1722/MAX1724			0.8		V
Operating Input Voltage	V_{IN}	T_A = +25°C	MAX1722/MAX1724	0.91		5.5	V
			MAX1723 (Note 2)	1.2		5.5	
Minimum Startup Input Voltage		T_A = +25°C, R_L = 3kΩ	MAX1722/MAX1724		0.83	0.91	V
			MAX1723 (Note 2)		0.87	1.2	
Output Voltage	V_{OUT}	MAX1724EZK27	T_A = +25°C	2.673	2.7	2.727	V
			T_A = 0°C to +85°C	2.633		2.767	
		MAX1724EZK30	T_A = +25°C	2.970	3.0	3.030	
			T_A = 0°C to +85°C	2.925		3.075	
		MAX1724EZK33	T_A = +25°C	3.267	3.3	3.333	
			T_A = 0°C to +85°C	3.218		3.383	
		MAX1724EZK50	T_A = +25°C	4.950	5.0	5.050	
			T_A = 0°C to +85°C	4.875		5.125	
Output Voltage Range	V_{OUT}	MAX1722/MAX1723		2		5.5	V

Figure 13: Electrical characteristics of voltage regulator

This IC is used to generate a regulated 5V output from a lower voltage input to supply appropriate voltage to the charge pump.

Since the IC was available in Proteus Simulation software, therefore we simulated it to see the working. The typical operating circuit as given in the datasheet was used to model the circuit:

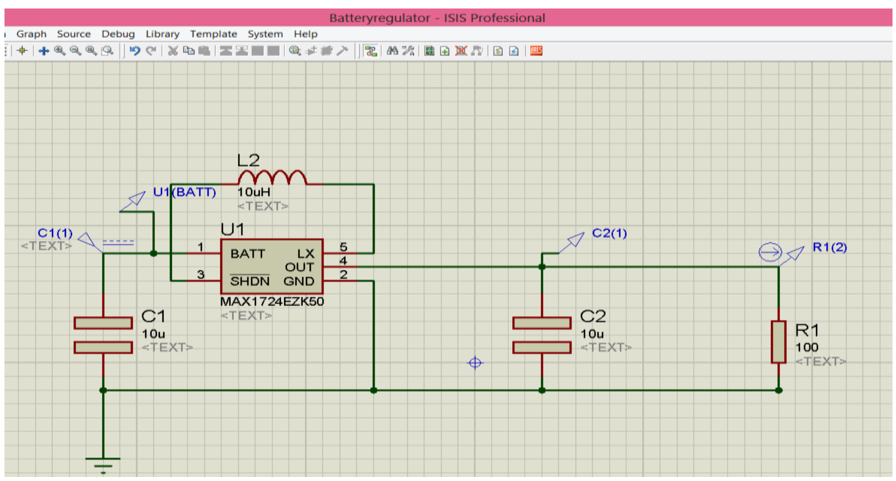


Figure 14: Simulation of MAX1724 IC in Proteus

3.2.6. Charge Pump Circuit:

The purpose of charge pump is to store the small voltage supplied to it so that a regulated optimum voltage and current can be supplied to the battery for charging. The charge pump that we used is MAX682. They are specifically designed to serve as high-efficiency auxiliary supplies in applications that demand a compact design.

ELECTRICAL CHARACTERISTICS

(V_{IN} = 3V, $V_{\overline{SKIP}}$ = 0V, C_{IN} = 1µF, C_X = 0.47µF, C_{OUT} = 2µF, $I_{\overline{SHDN}}$ = 22µA; I_{MAX} = 250mA for MAX682, I_{MAX} = 100mA for MAX683, I_{MAX} = 50mA for MAX684; T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}	Regulation with V_{IN} > 3.6V requires $\overline{SKIP}$ = high	2.7		5.5	V
Input Undervoltage Lockout Threshold			2.0	2.35	2.6	V
Input Undervoltage Lockout Hysteresis				100		mV
Output Voltage	V_{OUT}	0 < I_{LOAD} ≤ I_{MAX}; 3.0V ≤ IN ≤ 3.6V for $\overline{SKIP}$ = 0, 3.0V ≤ IN ≤ 5.5V for $\overline{SKIP}$ = IN	4.80	5.05	5.20	V
Maximum Output Current	I_{MAX}	MAX682	250			mA
		MAX683	100			
		MAX684	50			

Figure 15: Electrical characteristics of charge pump

According to datasheet a single MAX682 charge-pump regulator generates 5V from a 2.7V to 5.5V input. However by making a parallel arrangement of 2 ICs, the current can be increased to 0.5A and hence a higher charging rate can be achieved. We used a similar configuration with 3 MAX682 ICs in parallel to increase the current to 0.75A.

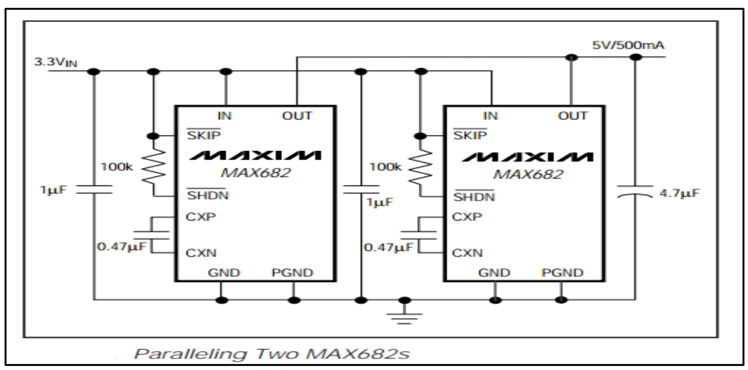
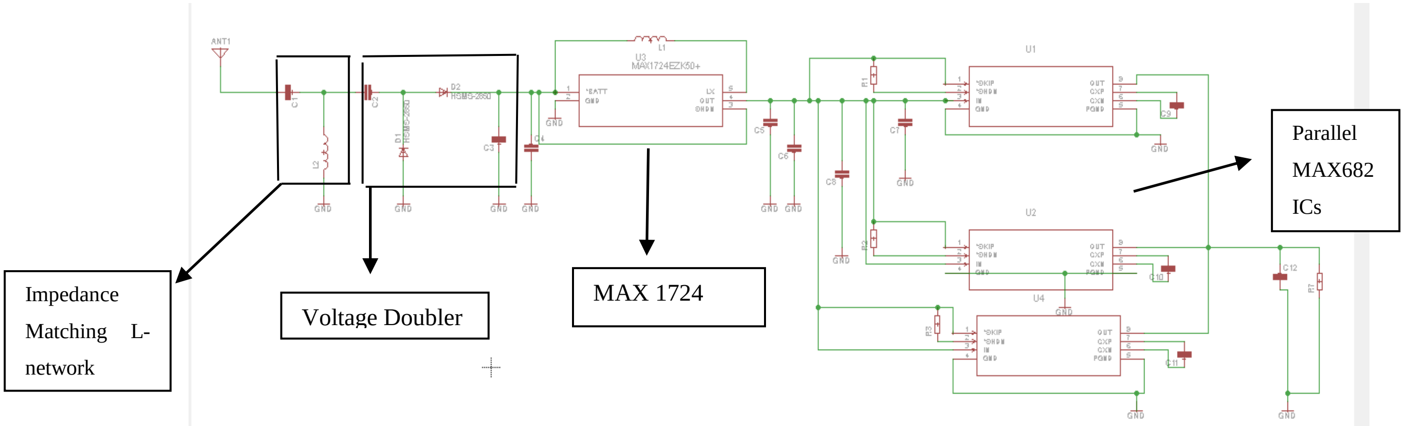


Figure 16: Parallel arrangement of MAX682 ICs to yield 0.5A current

3.3. Software Design and Hardware Implementation:

The complete schematic of the design was made in Eagle CAD software based on the data available in the datasheets. The design is shown in the captured shot shown below:



The PCB board was made from the schematic as shown below:

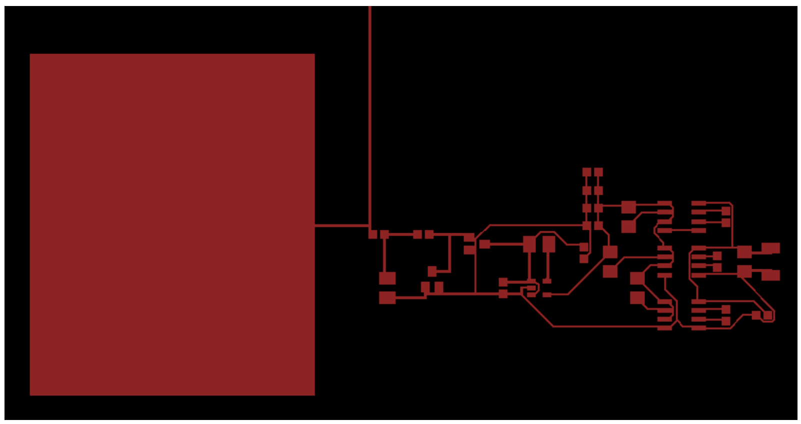


Figure 17: PCB board layout

The design was then printed on a glazy paper and then toner was transferred to the RT Duroid 5880 substrate using heat. After this etching was done and the components were mounted on their respective places. The implemented PCB board is shown below:

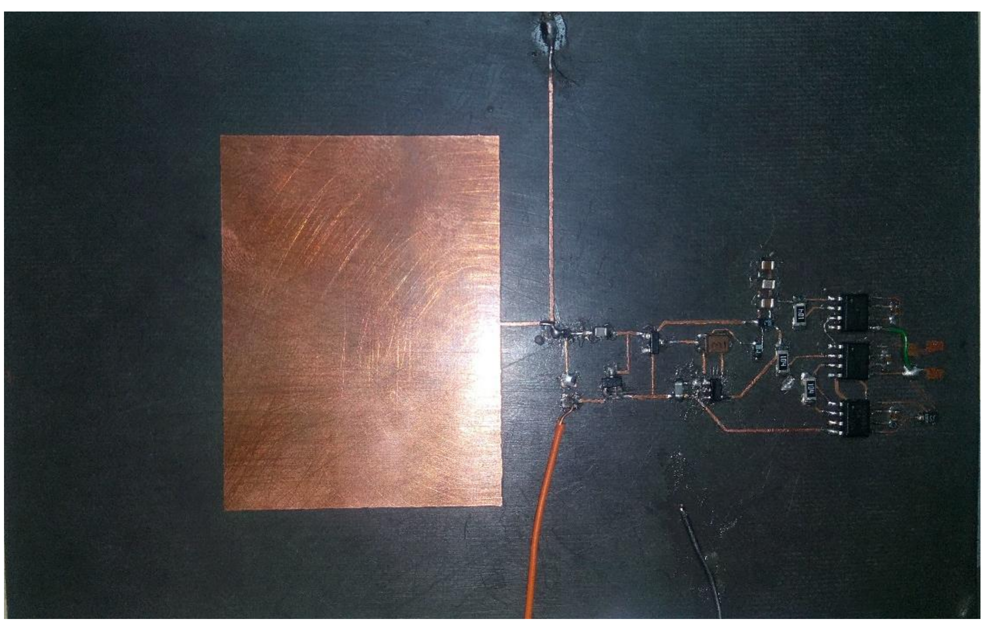


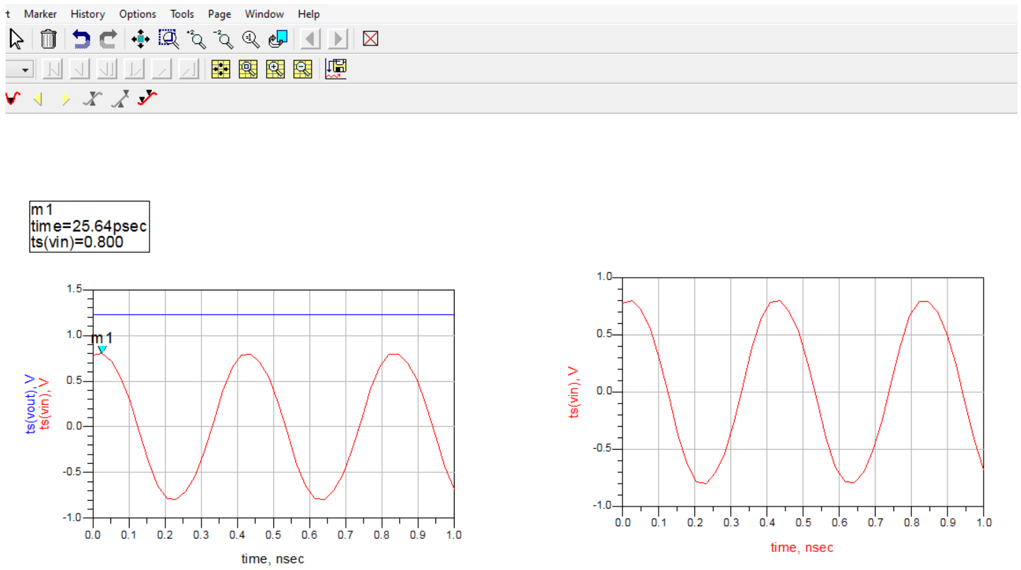
Figure 18: Final PCB board

CHAPTER 4

PROJECT ANALYSIS AND EVALUATION

4. Project Analysis and Evaluation:

The results of voltage doubler simulation is given in the diagram below:



In the top graph, the input current versus time is sketched with red colour and the output current versus time is shown with the blue line. In the second one, the input voltage versus time is sketched with red colour and the output voltage versus time is shown with the blue line. Both of these graphs clearly depict that the input AC voltage has been converted to double DC voltage.

The results of the antenna simulation are shown below:

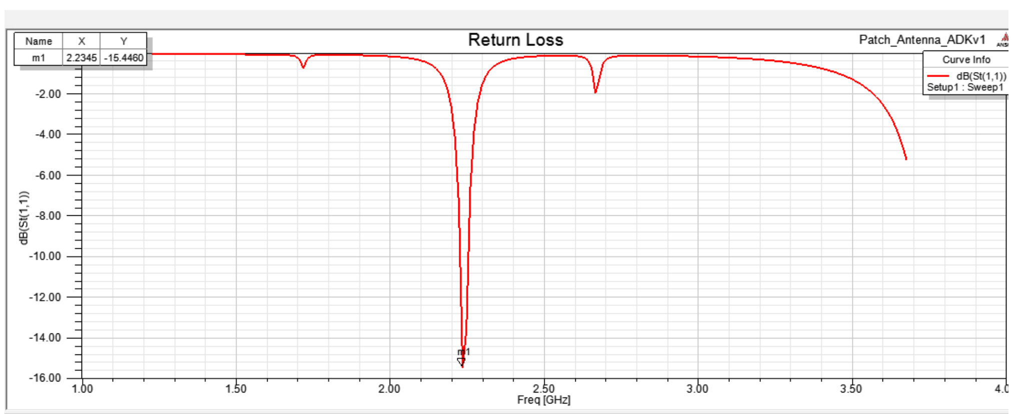


Figure 19:Return loss of patch antenna

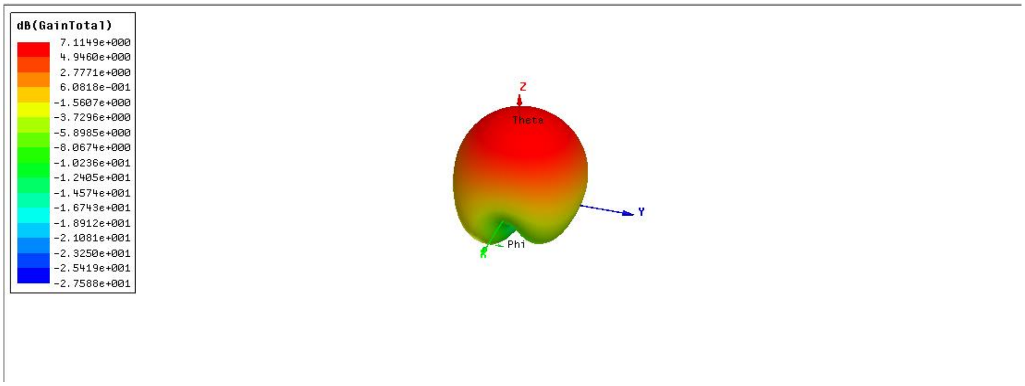


Figure 20:Gain of Patch

The simulation of voltage regulator for the receiver was done in Proteus and it was seen, as shown below that for inputs of 1V and 2V, the IC gives an output voltage of 4.76V which approximately equals 5V.

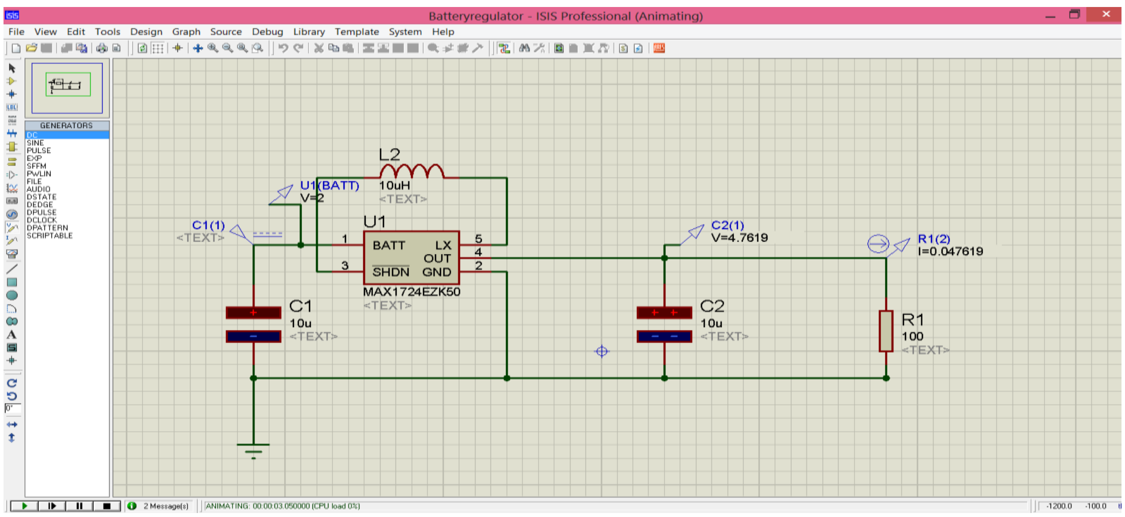


Figure 21: MAX1724 simulation at 2V input

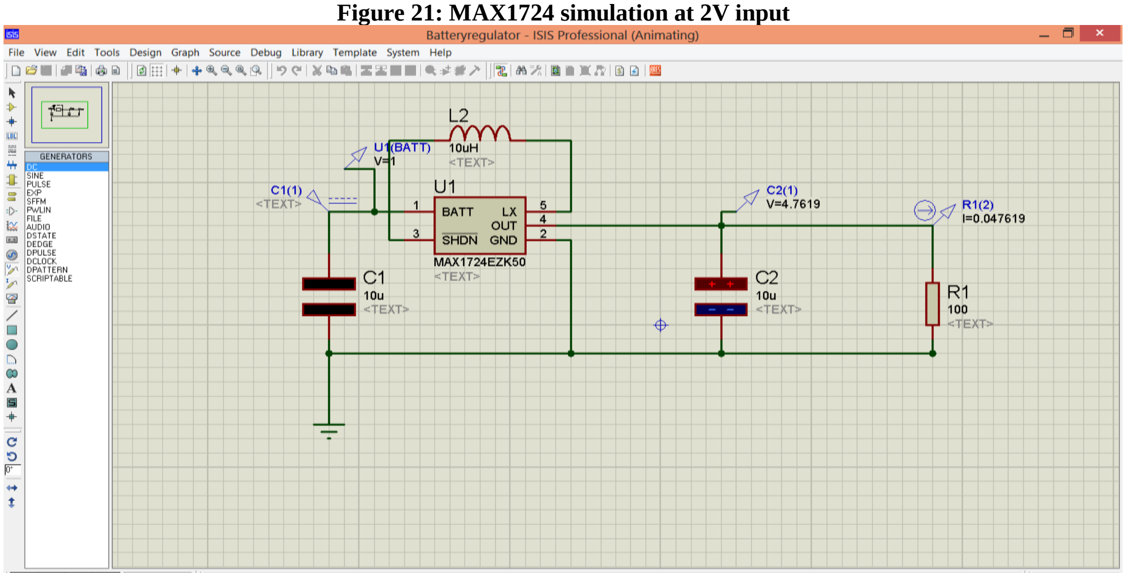


Figure 22: MAX1724 simulation at 1V input

This project successfully proves the concept of charging a mobile device battery using wireless RF energy harvesting. The transceiver system is able to get enough power to start charging the phone up to 1.2m. But due to the less power received at far distance, the charging process is slow i.e. if a mobile device normally get charged in one hour and thirty minutes, this system is able to charge the device but it will take more time up to four hour and thirty minutes which further depends on the threshold define such as 3.7 volts and 250mA current. If the amount of current is less due to less power received, automatically that effect the charging time of the device.

Distance (m)	Power Received (mW)	Voltage(V)
0.15	73.6	1.61
0.5	56.3	1.52
0.75	38.1	1.3
1	6	0.92

Figure 23: Power versus distance between transmitter and receiver

This is an important result because it shows the circuit that is designed, simulated, and tested throughout this project is being used to accomplish project objective. The following data was taken by measuring Power and current values versus the distance between the two antennas.

CHAPTER 5

FUTURE WORK

5. Recommendations for Future Work:

- The receiver can be made compact enough to be placed inside the back cover of the mobile device
- Rectennas at receiver system can be designed to increase the power harvested
- Transmitter antenna diversity can be used to provide a wide area of charging space
- Smart antennas can be designed for electronic bam steering for detecting receivers present in the range and transmitting power only to those receivers, in this manner, power losses would be minimized
- The frequency can be increased further to minimize the dimensions of receiver antenna, however this would also increase path losses
- The range of wireless charging can be increased by increasing the transmission power and by improving the RF-DC rectification process at the receiver end

CHAPTER 6

CONCLUSION

6. Conclusion:

6.1. Overview:

Wireless power or energy transmission is the transmission of electrical energy from a power source to an electrical load without using wires. Wireless transmission is useful in cases where interconnecting wires are inconvenient, hazardous or impossible. WPT is also very useful in minimizing the transmission and distribution losses.

6.2. Achievements:

After doing this project we are able to understand wireless communication based power transfer through antennas using electromagnetics, antenna design and theory, software related to antenna and circuit designing for example HFSS and Proteus and Integrated circuits.

6.3. Limitations:

The substrates like Roger RT Duroid are not available in the local market and are pretty expensive and testing cannot be done on such laminates as a lot of money is wasted and we can run out of budget. More over surface mount diodes are also not available in the market with zero bias and testing equipment would cost heavy on pocket.

Also a single millimeter change in any of the dimension will cause the system to run on any other frequency and the system will not work properly and whole system will be a waste. Hence systems are required to be fabricated with great precision and care.

6.4. Applications:

This project finds many applications for business as well as private purposes. It can be placed in homes where everyone with different mobile phones and specifications can utilize a single charger to charge their phones. In this way the mess created by lots of chargers and their wires will be eliminated. Time would also be saved as the users would not need to waste their precious time trying to untangle the charger wire and placing the switch in the socket. An added benefit would be the increased range so that the user is not confined near the switch and can move anywhere up to the achieved range.

It can be placed inside restaurants and cafes to serve as wireless charging hotspots. However this will work once the mobile devices are fitted with the receiving antenna circuitry. This shortcoming can be overcome by providing the facility of fitting the customers' phones with receiving antenna circuitry. Doing this will not only give a boost to the reputation of the restaurant but also increase their sales and hence profits

It can also be used in offices and organizations. The productivity of workers will improve as they will not be worried about petty matters like low battery of their phones/ devices.

Furthermore, it can be used in a car to charge devices while using them at the same time and without any limitation of range. This will be particularly advantageous to people sitting at the back as they are usually unable to use their phones while charging due to the short charger wire.

7. References:

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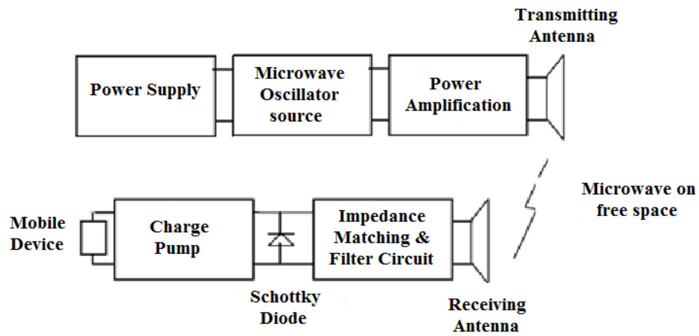
APPENDIX A-Synopsis

Wireless Mobile Charger

Extended Title: Wireless System for charging mobile devices over a short range by transfer of electrical power through electromagnetic waves

Brief Description of The Project / Thesis with Salient Specs: In this project, we will be working on the design of a transmitter that provides wireless charging to devices by transfer of power via an antenna. For this purpose, the mobile devices will also be fitted with an antenna to receive the electromagnetic radiations from the charger.



Scope of Work:

This project will involve

- Wireless charging up to a range of 1-1.5m
- Charging of several devices irrespective of their varying requirements
- Radio frequency communication in the microwave S-band region

Academic Objectives :

To strengthen our programming skills and learn about the complexities involved in Radio frequency communication. The project will encompass practical implementation of the subjects Embedded systems, Electronics, Wireless radio frequency communication, Control Systems and Programming, hence reinforcing our knowledge of these subjects.

Application / End Goal Objectives:

The main aim of this project is to develop a system that will work similarly as a wireless charging hotspot (however certain circuitry must be incorporated in the mobile device). This system can be used in cafes, homes, offices and cars to enable the mobile phones and other devices like Ipads, Galaxy Note etc to charge automatically until fully charged.

Previous Work Done on The Subject :

- Wireless charging mats based on QI standard and electromagnetic induction are available in the market.
- Research work has been done on the methods of resonance coupling and microwave power transfer.

<u>REFERENCES:</u>

1-http://batteryuniversity.com/learn/article/charging_without_wires

2-Wireless Charger for Low Power Devices using Inductive Coupling

3-Nikola Tesla, "The Transmission of Electrical Energy Without Wires as a Means for Furthering Peace," Electrical World and Engineer. Jan. 7, p. 21, 1905

4-http://en.wikipedia.org/wiki/Qi_%28inductive_power_standard%29

Material Resources Required : • Oscillator • Microcontrollers • Schottky diodes • Antennas • Capacitors and inductors
No of Students Required : 3
Special Skills Required : Programming microcontrollers, design and simulation of antenna in HFSS, electronic circuit designing and printed circuit board implementation

Approval Status:

Supervisor Name: Dr Ashraf Masood

Assigned to: NC Amna Hanif
NC Sunnia Malik
NC Muhammad Haris

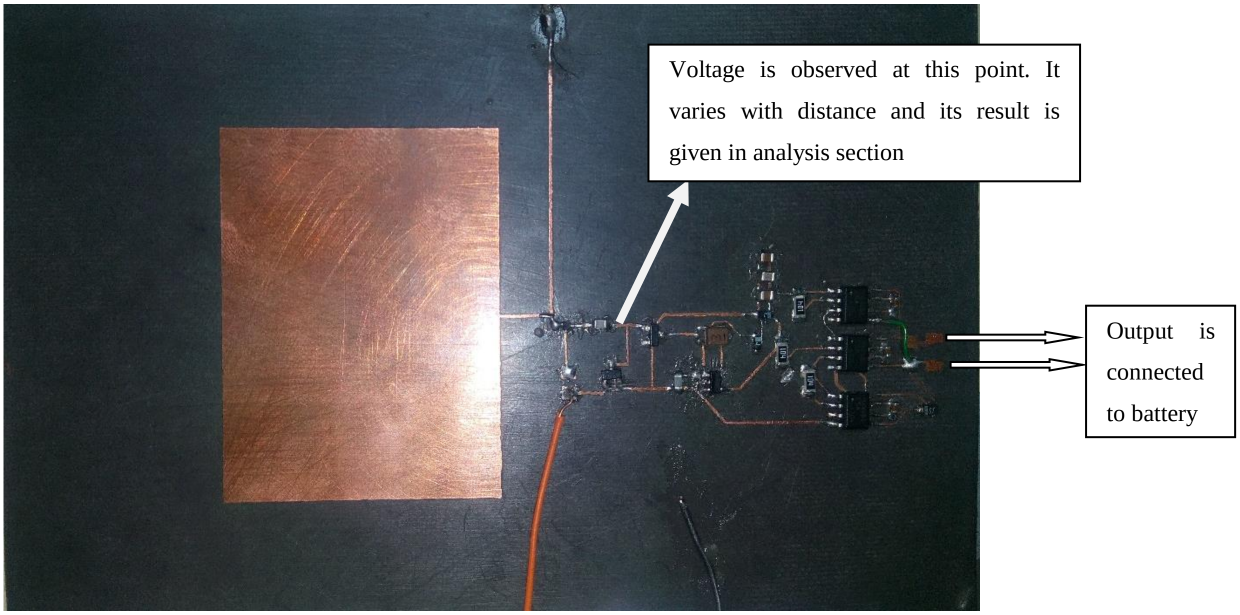
APPENDIX B-Cost breakdown

Task	Cost Incurred
Charge Pump, schottky diodes and voltage up converter	Rs.11500 (including delivery charges)
Capacitors, Inductors and Resistors	Rs.750
Substrate import duty tax	Rs.2023
Components import duty tax	Rs.1755
Fabrication of antenna	Rs.3000
Printing of circuit boards	Rs.5000

APPENDIX C-Timeline

Work Modules	Expected/Actual Completion Time
Literature Review	March 2014 - May 2014
Analyzing the selected techniques	June 2014
Familiarizing with Impedance Matching and antenna design techniques and software	July 2014 - August 2014
Design of antenna and testing of equipment	September 2014 – 14th February 2015
Implementation of hardware	15th February 2015- 30th April 2015
Thesis Writing	May 2015

APPENDIX D-Demonstration Outline



Result of MAX1724 IC Simulation in Proteus: