Design and Development of Frequency Conversion Circuit to Charge the Cell Phone

SUBMITTED BY

Md. Abu Saleh
ID: 072-19-707

Salauddin Mahmud
ID: 072-19-681

Redwan Haider Chowdhury
ID: 072-19-729

A project report Submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in
Electronics and Telecommunication Engineering

SUPERVISED BY

A.K.M Fazlul Haque

Assistant Professor

Department of Electronics and Telecommunication Engineering

Daffodil International University

DAFFODIL INTERNATIONAL UNIVERSITY
DHAKA, BANGLADESH
MARCH 2011

APPROVAL

This project entitled "**Design and Development of Frequency Conversion Circuit to Charge the Cell Phone** submitted by Md. Abu Saleh, Salauddin Mahmud and Redwan Haider Chowdhury to the Department of Electronics and Telecommunication Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of Bachelor of Science in Electronics and Telecommunication Engineering and approved as to its style and contents. The presentation has been held on 3rd March, 2011

BOARD OF EXAMINERS

____

Prof. Dr. Md. Golam Mowla Chowdhury **Chairman**
Professor and Head
Department of Electronics and Telecommunication Engineering
Daffodil International University

____

Dr. Subrata Kumar Aditya **External Examiner**
Professor and Chairman
Department of Applied Physics
Dhaka University

____

A.K.M Fazlul Haque **Internal Examiner**
Assistant Professor
Department of Electronics and Telecommunication Engineering
Daffodil International University

____

Md. Mirza Golam Rashed **Internal Examiner**
Assistant Professor
Department of Electronics and Telecommunication Engineering
Daffodil International University

DECLARATION BY THE CANDIDATE

We do hereby declare that the work presented in this project entitled ***"Design and Development of Frequency Conversion Circuit to Charge the Cell Phone"*** submitted towards completion of Bachelor of Science in Electronics and Telecommunication Engineering at the Daffodil International University, Dhaka. It is an authentic record of our original work under the guidance of **A.K.M Fazlul Haque, Assistant Professor**, **Department of Electronics and Telecommunication Engineering**, Daffodil International University. We have not submitted the matter embodied in this project for the award of any other degree.

Supervised by:

____

A.K.M Fazlul Hoque
Assistant Professor
Department of Electronics and Telecommunication Engineering
Daffodil International University

Submitted by:

____

Md. Abu Saleh
ID: 072-19-707
Department of Electronics and Telecommunication Engineering
Daffodil International University

____

Salauddin Mahmud
ID: 072-19-681
Department of Electronics and Telecommunication Engineering
Daffodil International University

____

Redwan Haider Chowdhury
ID: 072-19-729
Department of Electronics and Telecommunication Engineering
Daffodil International University

ACKNOWLEDGEMENTS

First and foremost, we would like to express our cordial gratefulness to Almighty ALLAH for HIS kindness, for which we successfully completed our Project within time and we also apologize to Him for our any kind of mistakes.

We would like to express our sincere gratitude to our supervisor, **A.K.M Fazlul Haque, Assistant Professor**, Department of Electronics and Telecommunication Engineering, Daffodil International University. His dedicated efforts, wise advices and keen knowledge showed the path of achievement.

We would like to thank the graduate committee of Dr. M. Lutfar Rahman, Professor and Dean, Faculty of Science and Information Technology, Daffodil International University, Dr. Md. Golam Mowla Choudhury, Professor and Head, Department of Electronics and Telecommunication Engineering, Daffodil International University and Dr. Subrata Kumar Aditya, Professor, Department of Applied Physics, Electronics and Communication Engineering , University of Dhaka.

We would also like to thank our seniors who were ready with a positive comment all the time.

We would like to thank our entire course mate in Daffodil International University, who took part in this discuss while completing the course work.

We also like to thank to other faculty members, the staffs of the Department of Electronics and Telecommunication Engineering and Faculty of Science and Information Technology, Daffodil International University.

And last but not the least we must acknowledgement with due respect the constant support and patience of our family member for completing this project report.

ABSTRACT

In this project, a mobile battery charging system is used by signal Strength (frequency) where those frequencies are available in the air to connect the BTS (base transceiver Station) and with the other mobile phone. So a new design and development of a circuit is introduced to charge the battery. In order to use this technique, a clamping circuit with respect to filtration to get our desired output to charge the battery has been used. Battery shape factors are smaller and charging science continues to develop. When we think portable and our mind want to determine to see a portable device with various characteristics such as hand-held, good visibility, good flexibility, good functionality, lightweight, and easy to use. So the battery power is a portable power to run also from a portable power source i.e., from frequency, this technique is converted to the voltage w.r.t current. In this project, the frequency to the required voltage to charge the mobile phone automatically has been designed and converted.

TABLE OF CONTENTS

CONTENTS	Page

List of Figure

List of Table

Chapter 1 Introduction

1.1 General Introduction

Cellular mobile communication network is the most interesting developments area. When the cellular phone was first implemented, it was large from today's network. In the cellular phone, the usually every parts of the circuit had its electronics device those was very large. These large device required large amount of power. So voltage and current are very large. This large device was very difficult to carry from one place to another. In this case, the device is improved by changing the large circuit using a small chip which combined thousands of IC (integrated Circuit), Transistor, diode and various electronics devices. These electronics devices are related with the information and computer age. These huge strides that we have made the communications and computers are possible only because of the great successes that we have achieve the fields of electronics. It is sometimes unbelievable that how many electronics devices that we carry in everyday of our life.

From today's network, portable source like as batteries are more effective source to run the mobile phone as far as he can. Using the batteries, the mobile phone can communicate with the other. So batteries are very important source for communication.

1.2 Aims and objectives

The goal of this thesis is to determine to use the electromagnetic (EM) radiation to capture the reliable power in order to charge the battery with respect to run the cell phone circuit parallel. So the signal is needed from the environment and converted it to the electrical energy that the required power. This system will be used by using our existing Base station Antenna.

1.3 Organization of the project

Now-a-days mobile communication is the current and very informative issue in the communication field. So the use of the mobile is vastly increased. To run the mobile without external source, the circuit diagram has designed. The frequency range of 5KHz to5MHz are used, those are seen in Chapter 5. Using the frequency as a source to our designed circuit the signal are clamped in first step, discussed in chapter 3.
In chapter 3, the apparatus description i.e., types of instrument, specification etc are discussed. Difference between various types of instrument must be needed to complete any kind of project. So the difference between diodes, descriptions about circuits, various type of working principle are discussed in chapter 3, where the calculation of the circuit diagram is also present. For the simulation circuits by using Orcad (Pspice) are discussed with the output wave shape is in chapter 4.
In chapter 5, the experimental setups with the measurement of data are discussed and capture the real-time output. In Chapter 6, the overall benefits and future plan of our proposed methods and techniques have been discussed.

Finally in chapter 7 concludes the outcome of the project.

Chapter 2 Historical Overview

2.1 Literature Survey:

The history of mobile phone or cell phone started in 1920s [1]. That time the radio was the most effective device for making communication. The radio phones were used in taxis, cars where two way radio communications was used. First official mobile or cell phone was used in 1946 by the Swedish police. This phone was connected hand held phone to telephone network. This phone was very similar to the two-way radio phone which was used in taxis, cars for portable communication.

In 1947 D. H. Ring created the architecture of Hexagonal Cells for cellular network in Bell Labs. Another engineers from Bell Labs created the cell tower which had the ability to transmit and receive the signal in different three directions. Before this creation the cell phone only worked in two directions by an antenna. In 1960s the electronics equipment was used in cell phone [2]. In this time the technology of cell phone was available. But the problem of the user was restricted to a certain block of areas called cell areas. In cell areas the base stations were covering small areas. If the cell user moved the outside of the cell areas then the user couldn't get the signal for transmitting or receiving. This problem was solved by an engineer named Amos Edward Joel at Bell Labs. He was discovered and developed the term of hand off [1]. This hand off technology eliminated the problem. This technology enabled to continue the cell from one area to another area. The recent years, the wireless charging protocol was introduced by IEEE journal but the protocol was used by RFID. These device received signal form the environment which is called electromagnetic radiation (included base station, radio wave, satellite, TV, user generated).

The thinking is developed about wireless charging for cell phone. From the surveying result with a flood of electronic products with wireless charging capability arriving on the market in the coming years 234.9 million units in 2014, up by a factor of 65 from 3.6 million in 2010, according to iSuppli Corp.[2]

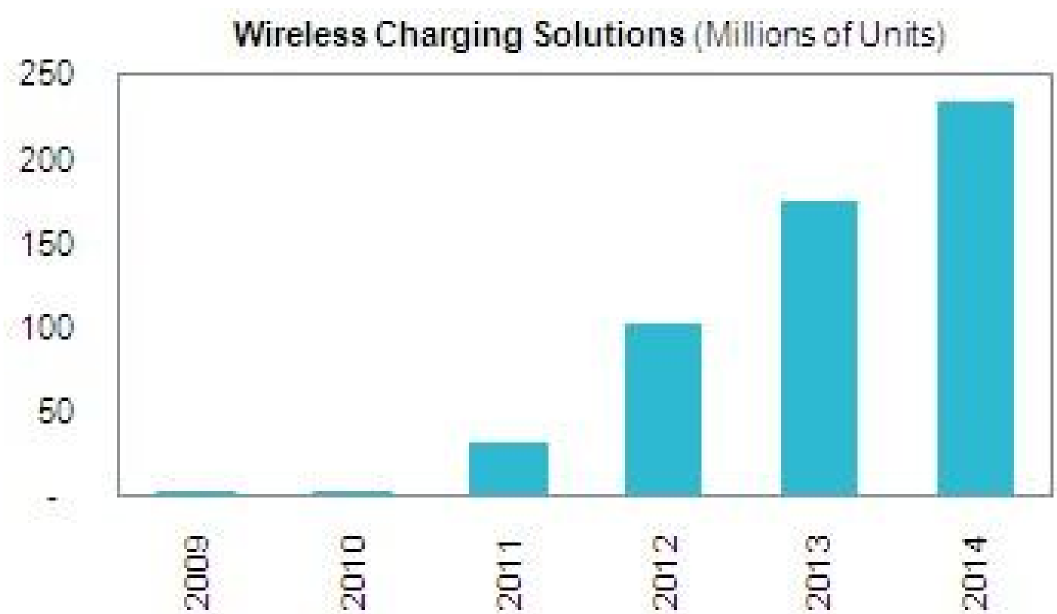


Fig 1. Surveying result

Chapter 3 Circuit Description

3.1 Apparatus

Table 1: Instrument specification

Name	Specification	Pieces
Zener Diode	1N4735A, ±6.2V	3
Capacitor	0.047uF / 47nF /47000pF	3

3.2 Circuit Block

Fig. 2 shows, the proposed circuit block diagram for the wireless charging protocol.

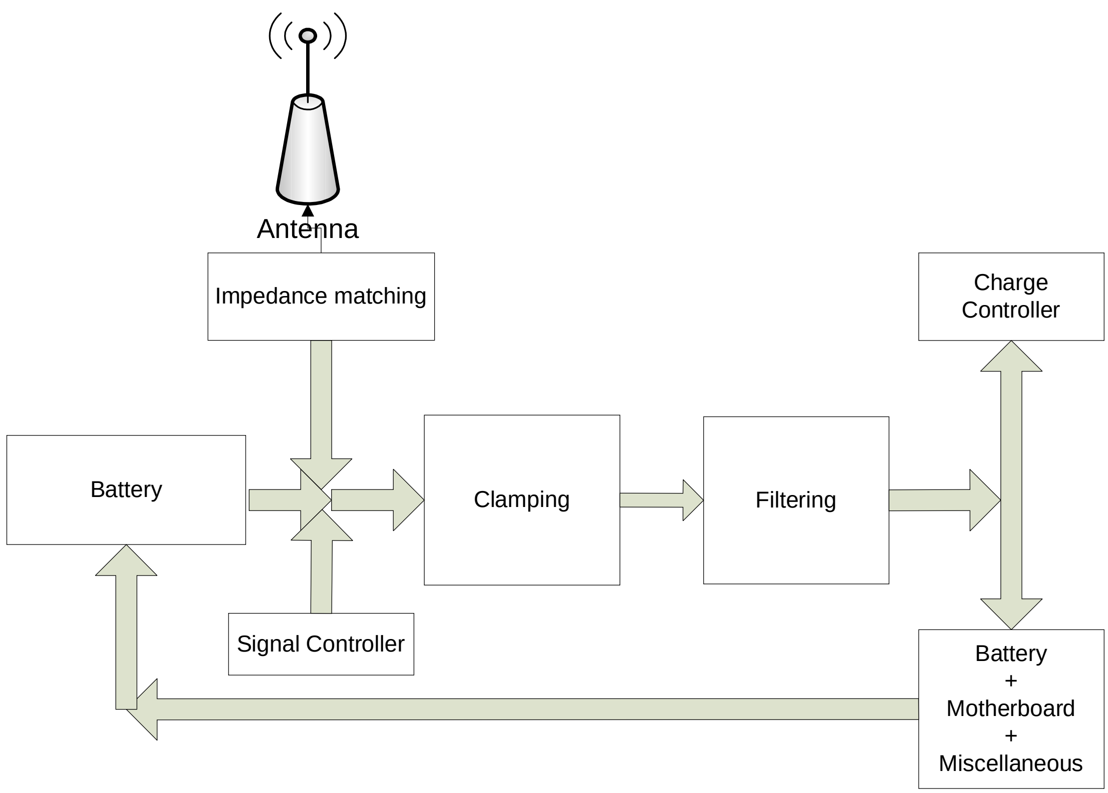


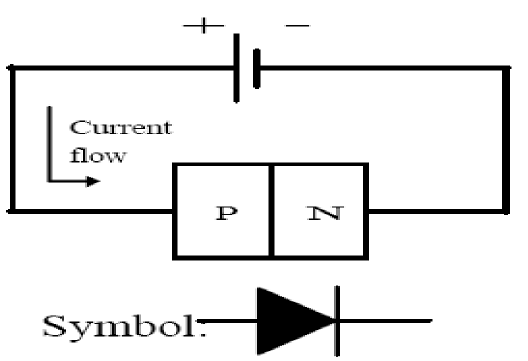
Fig 2. Block Diagram of Proposed Circuit

3.3 Working Principle:

3.3.1 About Apparatus:

3.3.1.1 Normal diodes:

A diode consists of a p-type semiconductor joined to an n-type semiconductor. A diode only passes current in one direction. If it is connected up as shown opposite, current will flow. However, if the power source is connected up the opposite way around, current will not flow.



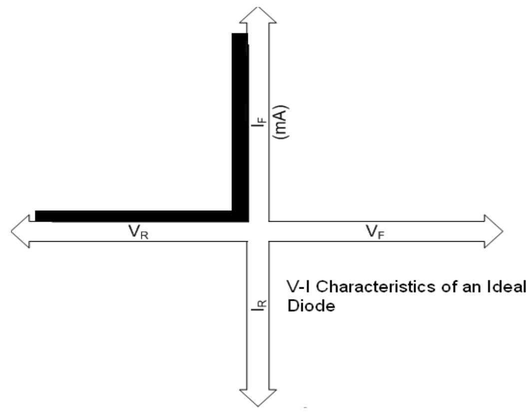


Fig 3. Normal diode with V-I characteristics

3.3.1.2 Zener diodes:

A Zener diode is connected the opposite way around from a normal diode. Normal diodes cannot pass any current if connected up in this way, and may be destroyed. However, Zener diodes connected in reverse will pass current, if the voltage across the diode exceeds a certain value, known as the breakdown voltage. After the breakdown voltage has been reached, the voltage across the diode will not change much, even if the current is greatly increased.

3.3.1.2.1 Features of Zener Diode (1N4735A) [7]:

- Zener Breakdown Voltage : 6.2 V
- Low Profile Maximum Height of :1.0 mm
- Maximum surge Current : 760mA
- Temperature : +0.01 to +0.055 (%/ ^{0}C)
- Max leakage current(I_R) w.r.t Voltage(V_R=3.0) : 10µA
- Low Leakage
- ESD(Electrostatic Discharge) Rating of Class 3 (> 16 kV) per Human Body Model

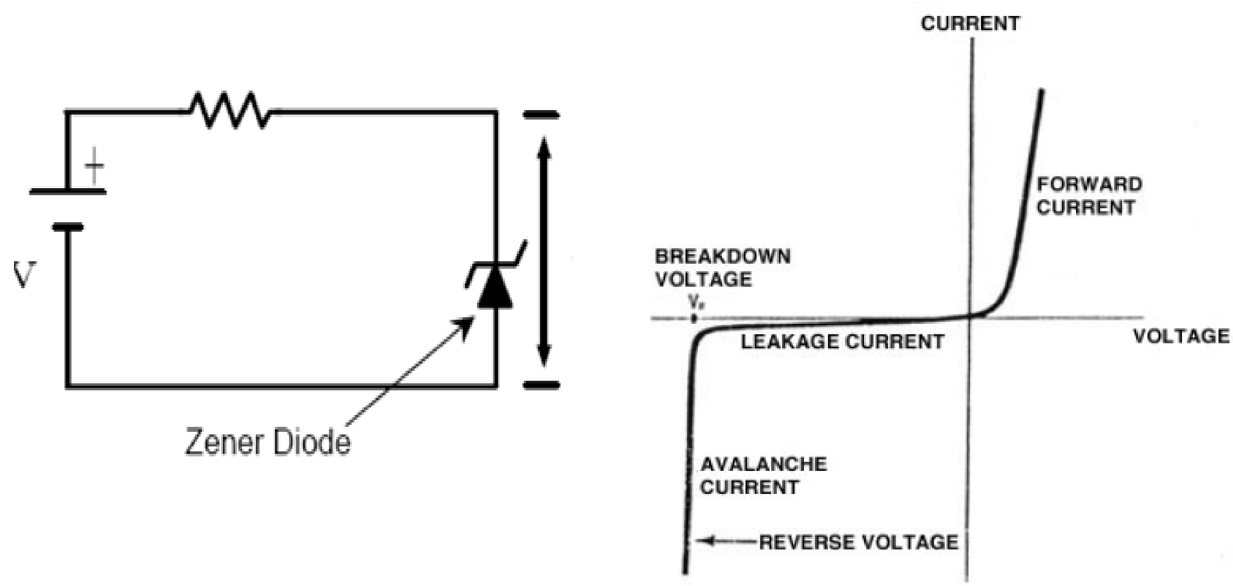


Fig 4. Zener diode and V-I Characteristics

3.3.1.3 Difference between normal Diode and Zener diode:

1. A regular diode will let current go in only one direction (forward bias) which is the direction of the arrow that we would see on fig3. If current is applied in the opposite direction (reverse bias) then we would not have current on the other end unless the voltage that we apply to it surpasses its Breakdown Voltage then we would have a reading since the REGULAR diode would be burn out.
2. Zener diodes would act the same way as a regular diode except that in reverse bias it would allowed current to pass when the voltage surpasses its Breakdown Voltage (Zener Voltage).Fig 4.

A conventional solid-state diode will not allow significant current if it is reverse-biased below its reverse breakdown voltage. When the reverse bias breakdown voltage is exceeded, a conventional diode is subject to high current due to avalanche breakdown. Unless this current is limited by circuitry, the diode will be permanently damaged due to overheating. In case of large forward bias (current in the direction of the arrow), the diode exhibits a voltage drop due to its junction built-in voltage and internal resistance. The amount of the voltage drop depends on the semiconductor objects and the doping concentrations. [5]

3.3.1.4 Capacitor:

Capacitor is an electrical component which is made by two metallic plates separated by a insulating material which is known as dielectric. There are different results produced by DC & AC supply to a capacitor. The working of a capacitor in both the conditions is as follows: When any capacitor is connected between an AC sources, one plate is at a negative potential and the other plate is at a positive potential (due to the voltage source). Hence opposite

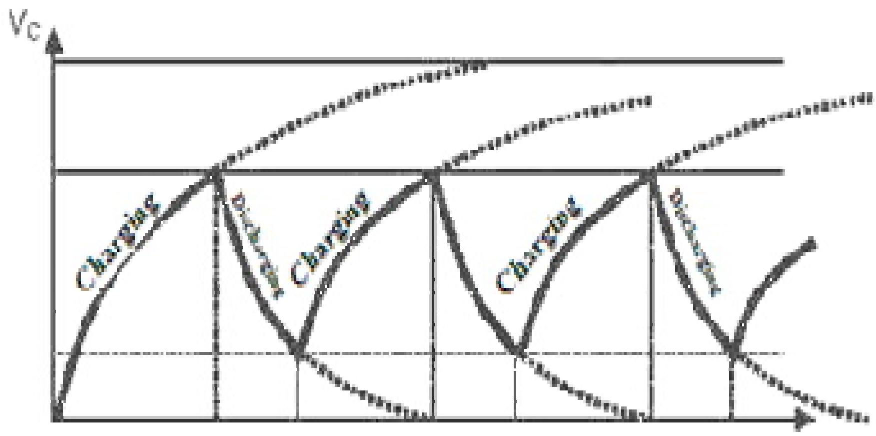


Fig 5. Charging and Discharging Principle

charges develop on the both the plates.[4] The time when the plates of capacitor are charging there is flow of current from the supply source into the capacitor, and when the value of voltage across the two plates of the capacitor becomes equal to maximum input voltage to the capacitor, this flow of current stops. In this way, we can say that at the time of charging of capacitor the flow of current stores charges in the both of the plates. It is known as charging state of capacitor [4]. In our project, we are using the ceramic capacitor to change the wave shape as per his possibility. Because the ceramic capacitor can use for faster change the wave shape and can change the ripple from various rectification in this circuit. At the beginning side, we have to use the variable capacitor to match the antenna impedance with the circuit impedance. Those capacitors are called Trimmer.

3.3.1.4.1 Applications of a Capacitor:

The basic function of a capacitor is charging and discharging. It stores electrical energy and provide that energy when the circuit needed. The function of a capacitor is given below:

- It allows the flow of AC but blocks the flow of DC.
- It is used to matching impedance of a circuit.[5]
- It feeds the desired signal to any section.
- It is used for phase changing.
- It is used for creating a delay in time.[4]
- It is used for filtration and also removing ripples from rectified waveforms.

For an example capacitor stored energy as a water tank. Water is stored in a tank; similarly charge is stored in a capacitor. This protocol is called capacitor charging. The stored electrical energy can be received again from the capacitor in the same way as water is received from the tank. This protocol is called capacitor discharging.

3.3.2. About Circuit

Fig 6 . the total circuit has been designed and developed in this project

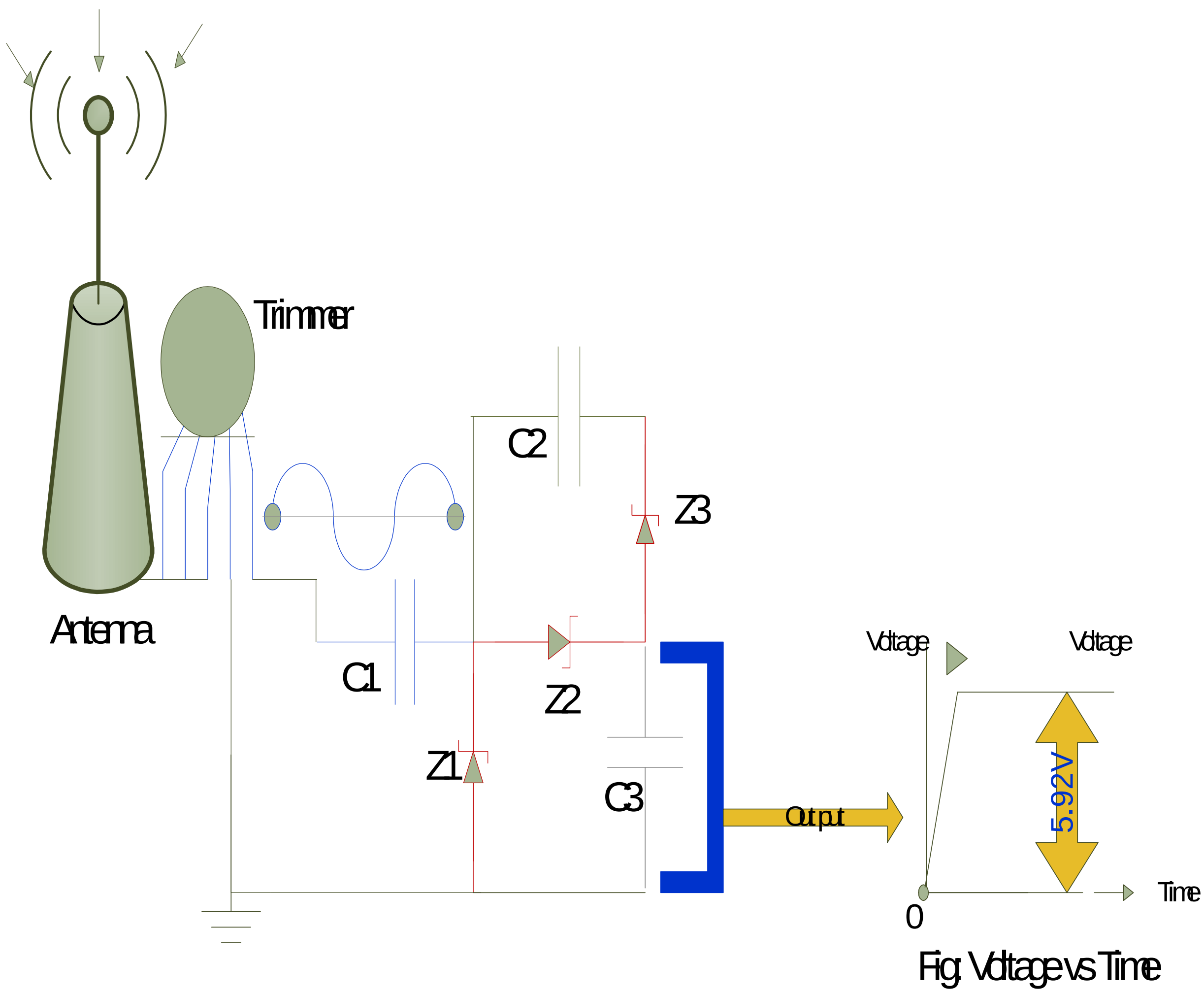


Fig 6. Proposed Circuit diagram.

3.3.2.1 Working principle of circuit diagram:

The input signal is almost 2mV AC where frequency is 5MHz which is collected from function generator.

This signal is fed to capacitor of the given circuit with respect to Zener Diode (Z1). This circuit is called clamping and the clamping input signal means the circuit shifts the voltage above its reference points. (Brief in 3.3.2.2). Then there is no negative portion, only positive portion is present. It looks like a pulsating position.

Using capacitor (C2) filter this pulsating position is removed and it produces a dc voltage where the Zener diodes (Z2,Z3) produces the reverse current. So at the output capacitor (C3), the measured output voltage is DC and approx. 6V i.e., 5.92V and its corresponding current is over 400mA. i.e., the power of our designed circuit is 5.92V*400mA=2.368watt. which is over 1.85 watt for mobile charged.

3.3.2.2 Clampers:

A clamper is an electronic circuit that prevents a signal from exceeding a certain defined magnitude by shifting its DC value. The clamper does not restrict the peak-to-peak excursion of the signal, but moves it up or down by a fixed value. A diode clamp (a simple, common type) relies on a diode, which conducts electric current in only one direction; resistors and capacitors in the circuit are used to maintain an altered dc level at the clamper output.(Fig 7.)

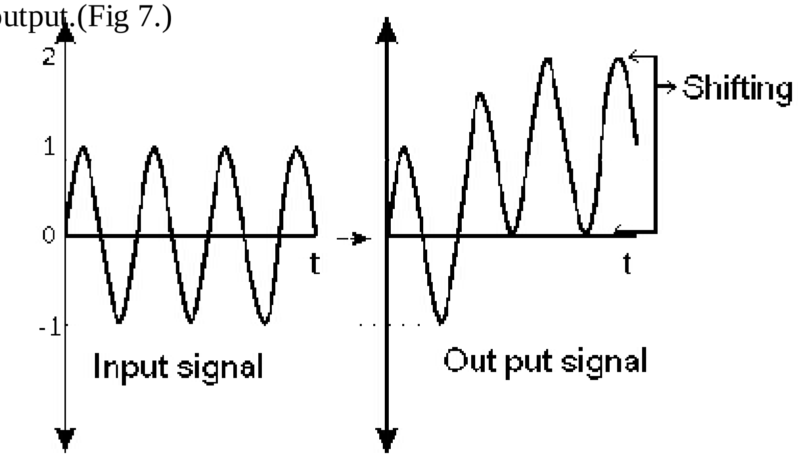


Fig 7. Clamping (Shift) principle

A clamping circuit (also known as a clamper) will bind the upper or lower extreme of a waveform to a fixed DC voltage level. These circuits are also known as DC voltage restorers.[8] Clampers can be constructed in both positive and negative polarities. When unbiased, clamping circuits will fix the voltage lower limit (or upper limit, in the case of negative clampers) to 0 Volts.[5] These circuits clamp a peak of a waveform to a specific DC level compared with a capacitive coupled signal which swings about its average DC level (usually 0 V).

3.3.3 Calculation:

The equation of clamping is

$V_{out}= 2V_{in}+V_{bias}$

Where ,

V_{in} = input voltage

V_{bias} = biasing voltage

(A bias voltage between the diode and ground offsets the output voltage by that amount.)[8]

The equation for the Circuit goes to,

$V_{out(Clamping)}=2V_{in}+V_{bias}$

$V_{out} = V_{out(Clamping)}+4\ V_{out(Clamping)}+V_{bias}$

$= 2V_{in}+V_{bias}+4(2V_{in}+V_{bias})+ V_{bias}$

$=2V_{in}+0+8V_{in}+0+0$

$=10V_{in}$

So, $V_{out} =10V_{in}$

From the designed circuit, the theoretical equation has been build up. By using this equation, the output result will be the 10 times of the input voltage. But In the experimental result, this project shows that the total output is not matched with the theoretical equation. i.e., the applied input voltage 2mV (AC) with respect to 5MHz frequency and the output result has been found 5.91V (DC).

Chapter 4 Simulation

For the simulation, we are using Voltage=1V and the Frequency= 100Mhz. but in experimental chapter, we were used 5MHz with respect to 0.002V.

4.1 Clamping position:

Fig 8. Shows, the 1st clamping position in the designed circuit.

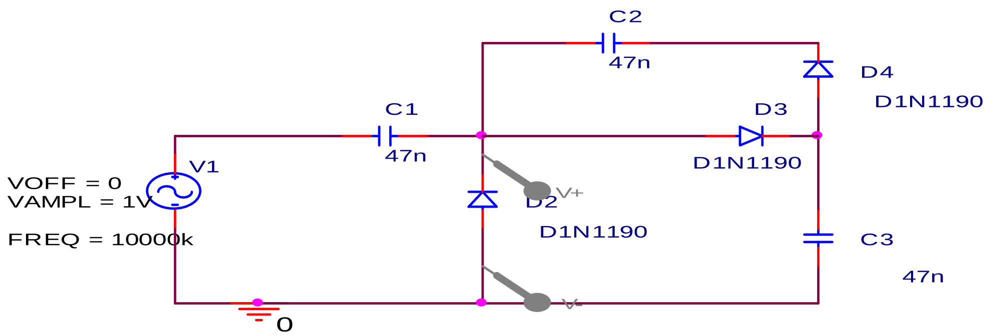


Fig 8. 1st Clamping position

At the Input Frequency of from the signal generator, the 1st step is converted by the clamping the frequency i.e., try to change the signal shape from negative to positive portion. So the output simulation wave shape is just like to try the clamping position below in fig 9.

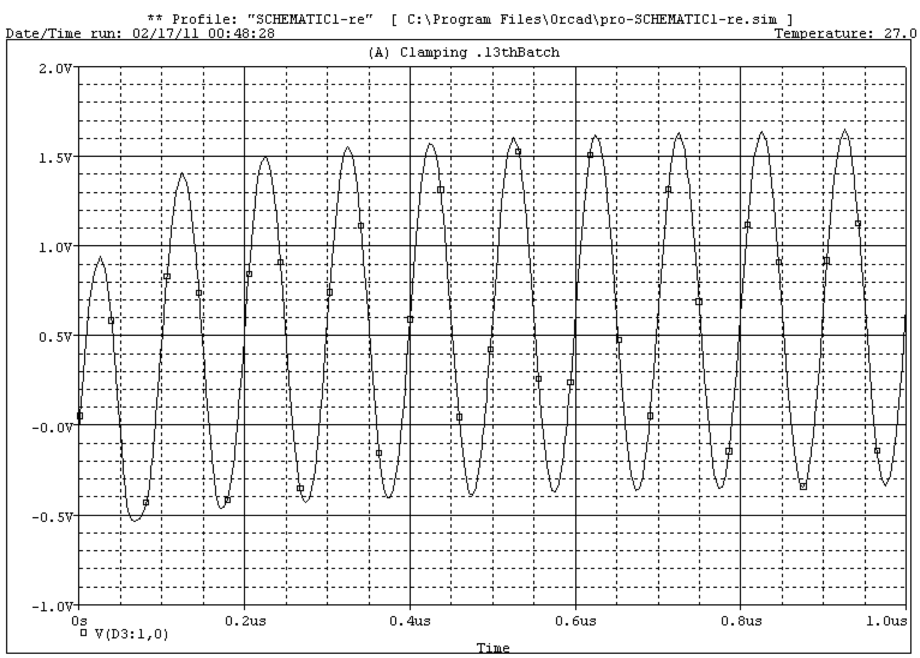


Fig 9. Clamping position at 10MHz

4.2 At output level

The output simulation result comparative with respect to 1V has been shown in Fig 10

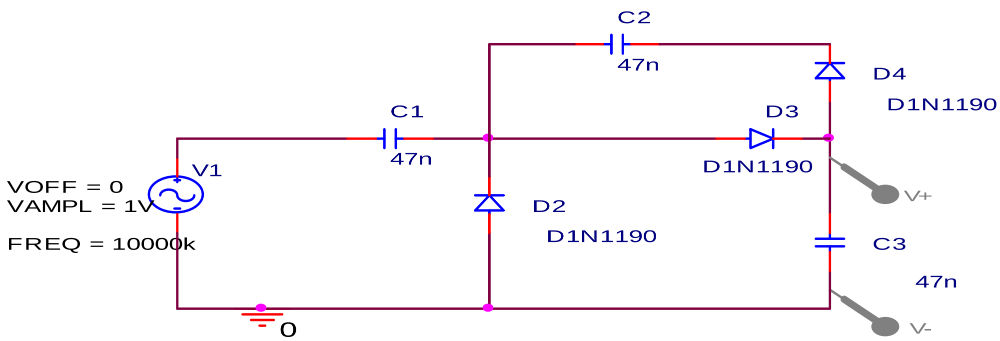


Fig 10. Output Position

After clamping the frequency, the wave shape has increased at the positive side and thus the output goes to fix the pulsating position (fig .11). At some millisecond of time, the wave shape at the capacitor end fixed and we could use the voltage to charge the battery.

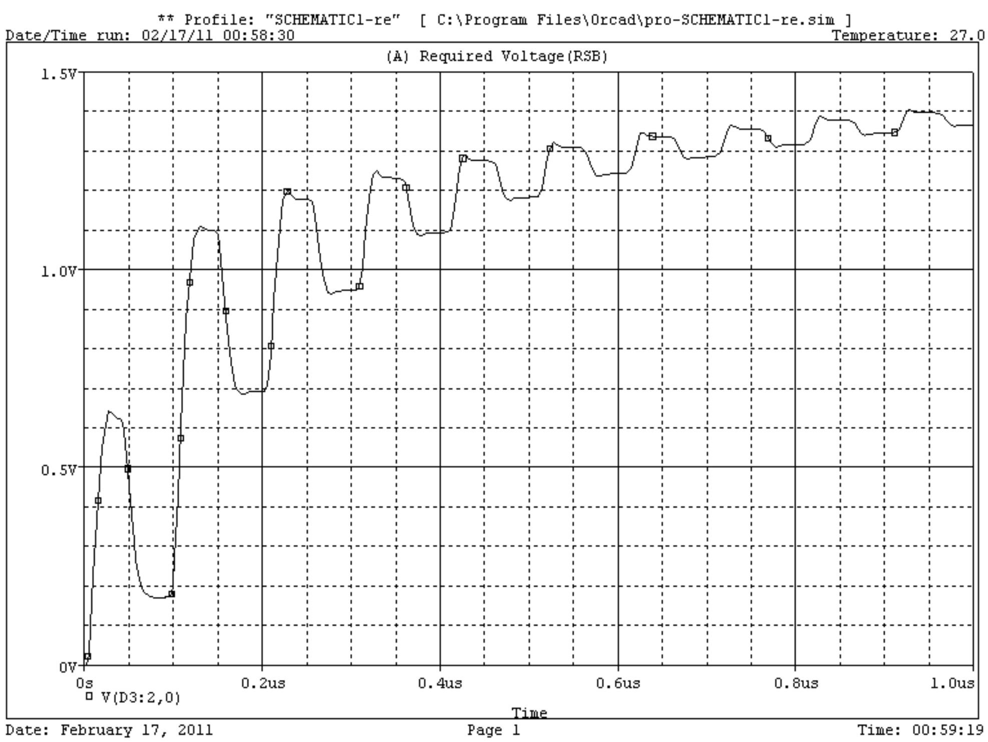


Fig 11. Simulation output level at 10MHz

4.3 Comparison:

4.3.1 Part 1

Fig 12. Shows, The output voltage with respect to input signal at 10MHz, where the measured output is DC across the capacitor

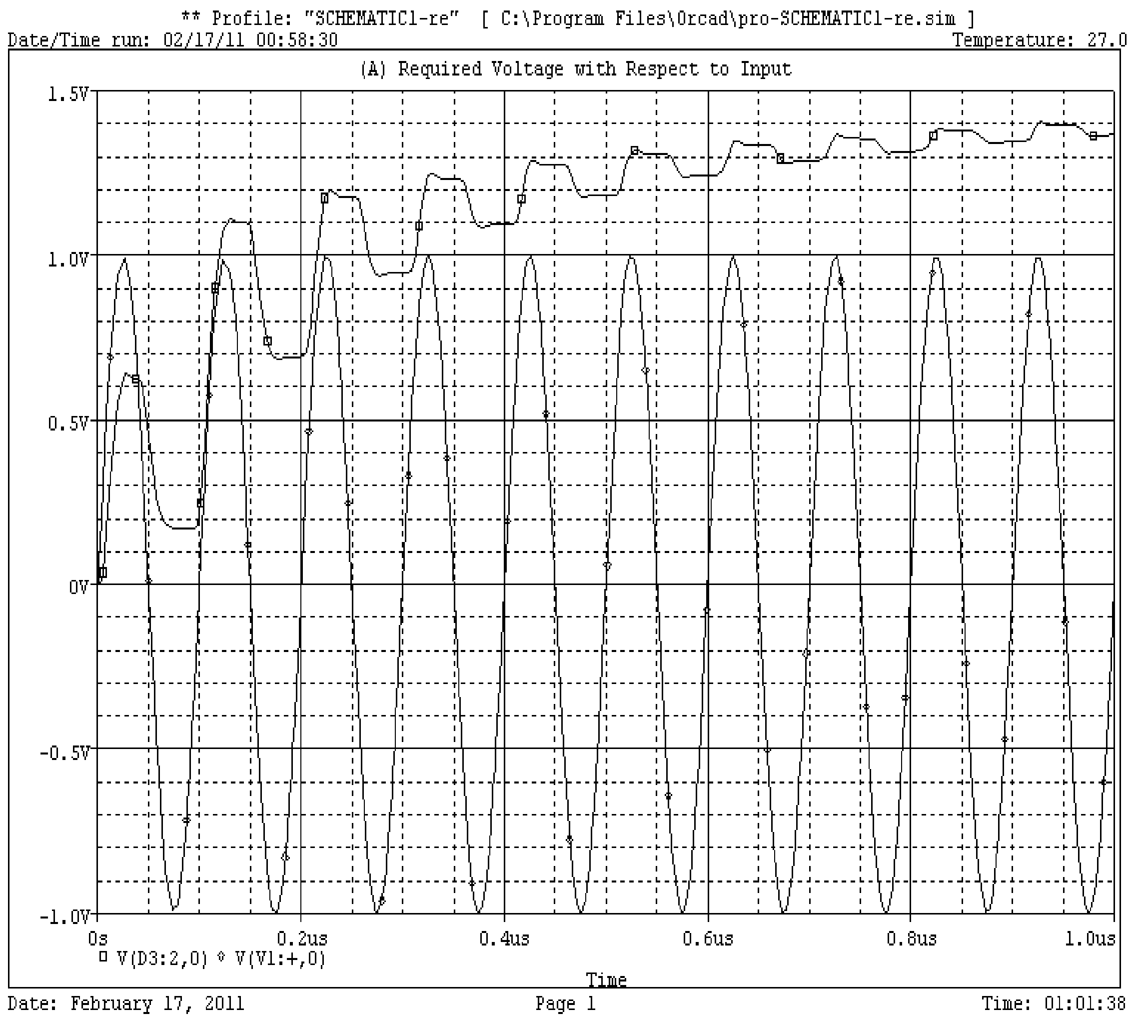


Fig 12. Output in comparison with the input signal (where the freq is 10MHz)

4.3.2 Part 2

For comparing with the Base Transceiver station to Mobile frequency i.e., 935MHz, the output voltage will be 140% from the input voltage i.e., 1.4V (fig 13 shows).

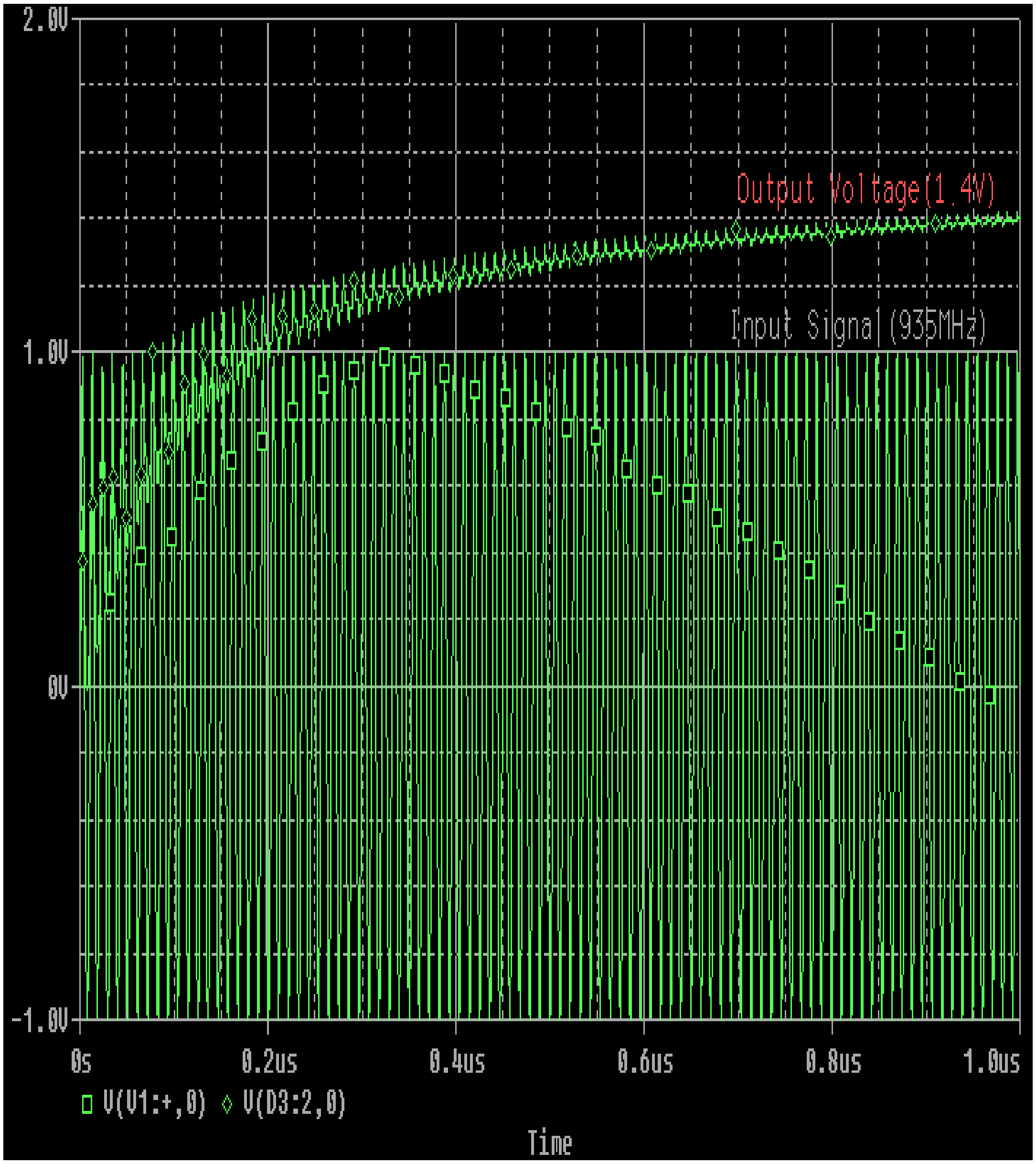


Fig 13. Simulation output for 935MHz

Chapter 5 Experimental Setup

5.1 At Soldering Board

The designed and developed circuit has been soldered in the soldering board to avoid the wire connection problem, which is shown below in fig14.

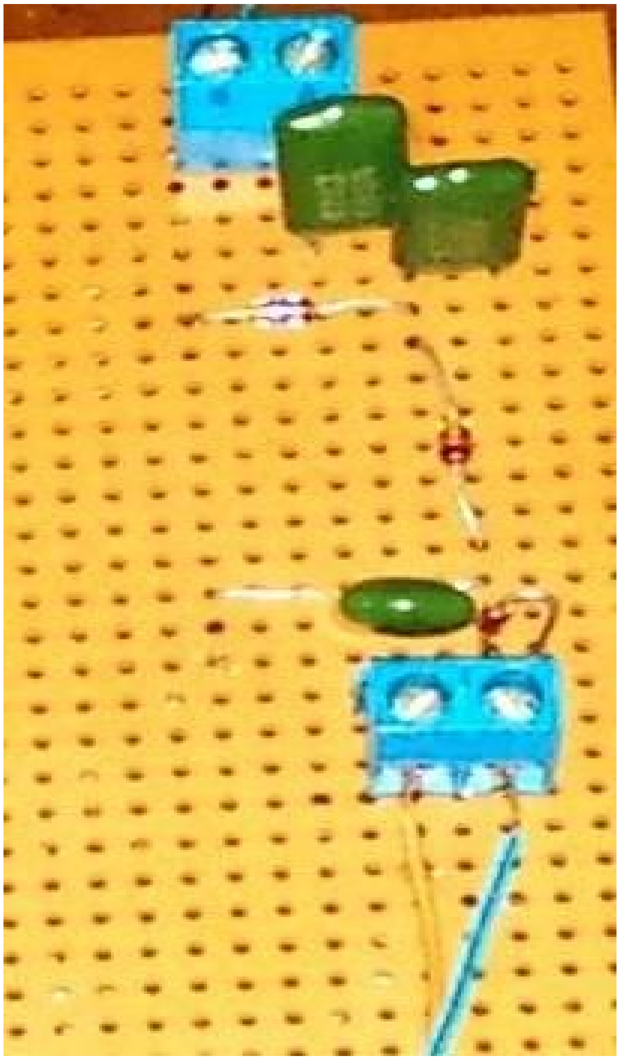


Fig 14. Connection state

5.2 Input Frequency

For input frequency, we are using 5MHz from the Function Generator (Fig 15). If we vary with any kind of frequency, the output voltage is same i.e., 5.91(In average) and current more than 400mA.

Fig 15. Source frequency from Function generator.

Table 2: Calibration at different frequencies

	Input		**Output**	
No.	**Frequency**	**Voltage(AC)**	**Voltage (DC)**	**Current**
1.	5MHz	~0.002	−5.92	≥400mA
2.	4.5MHz	~0.002	−5.91	≥400mA
3.	4MHz	~0.002	−5.93	≥400mA
4.	3.5MHz	~0.002	−5.85	≥400mA
5.	3MHz	~0.002	−5.91	≥400mA
6.	2.5MHz	~0.002	−5.89	≥400mA
7.	2MHz	~0.002	−5.91	≥400mA
8.	1MHz	~0.002	−5.91	≥400mA
9.	100K	~0.002	−5.92	≥400mA
10.	5K	~0.002	−5.91	≥400mA

® '~' means AC

® '−' means DC

So, in average, we have found 5.91V across the frequency range in 5KHz-5MHz.

5.3 In Charging State

The output has been got i.e., 5.91V and current more than 400mA, then used a mobile phone to charge the battery shown in fig 16.

Fig 16. Connection for charging

5.4 Charge Complete State

Fig 17. shows the completed state of charging of mobile phone within 2 hour in the laboratory.

Fig 17. Charged filled from required source

Chapter 6 Benefits

6.1 Advantage

I. No need external source to charge the battery.

II. Remove the extra electric bill to charge by external source.

Let us consider, the cost of electric bill is 0.02tk/hour and to charge the mobile phone, we have to use the external source 2 hour/day

For one person total cost in a year will be =365*0.04=14.60tk. So in our country almost 3 billion people are using mobile phone. So the total cost of the electric bill by using mobile phone in our country in an year will be= 30000000*14.6= 438000000tk

So a large amount of money will save using our project.

III. It is flexible to charge the mobile phone because no need to carry the external charger when we are in travel.

IV. This circuit design is in low cost to add with the mobile phone.

Chapter 7 Conclusions

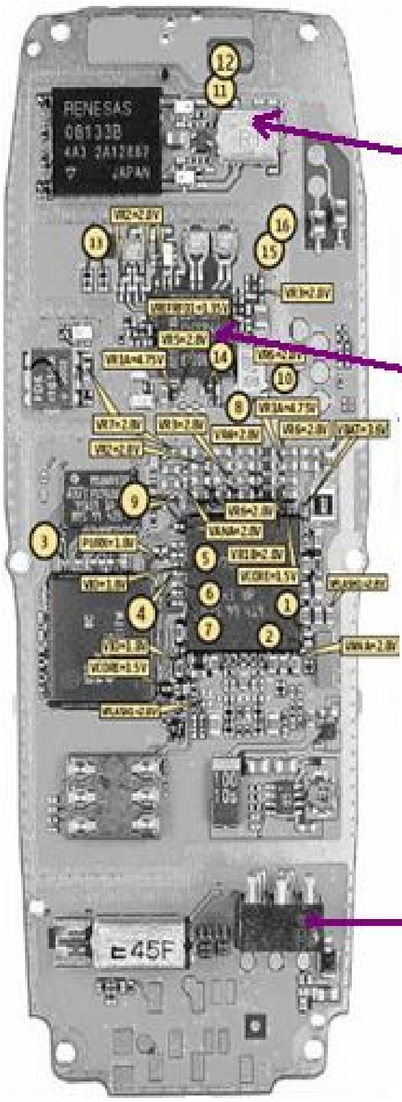
7.1 Conclusion

In this project, the wireless charging protocol has been developed for mobile unit .Here, 5MHz input signal from signal generator (where voltage is 2mV) is used & got 5.92 V dc as output. Using this input signal with respect to this designed circuit is capable to charge the mobile phone, because mobile phone needs more than 3.7V and 400mA to charge the battery. So the power needed for a mobile phone is 1.85watt (For Nokia). This power is varied by the change of current level. So this project’s output current also varies to charge the mobile phone. So the proposed circuit designed can be used to charge any mobile phone.

7.2 Further Work

In the current future, we will receive the signal from the BTS (Base Transceiver Station) and convert it into the required the needed voltage where the frequency range is 890-960MHz for GSM. And also we will able to get enough power to turn on the phone. This is an important result because it shows that the circuit that is designed, simulated, and tested throughout this research, which can be used to complete our ultimate goal. Because of this result, it is probable that with more focus placed on the antenna, and using antenna, we could stored energy, those becomes more advanced, this work will be successful at achieving a commercial product. The ultimate goal is to get everything in the phone and use RF energy to charge the battery [fig 17]. To achieving these goals would be the modeling of the circuit in a program suitable for simulating high frequency circuits, the design of a testing board and procedure for verifying the simulation results, and finally creation of a board and antenna combination that would be small enough. Those signals will come from the BTS will received by the mobile antenna switch [Fig 17] where our impedance matching [Fig 17] circuit will be added with the antenna. This signal strength will converted by our designed circuit [Fig 17]. And the output will feed to the mobile charging port. By this way mobile will charge automatically and the others software will running with a moment ally. In near future we will use the signal from BTS (where frequency is (895-960) MHz) for GSM 900. The voltage level as downlink is ~2.69V for GSM 900 and the uplink is ~2.01V. So using this range of voltage, we will convert it into over 5 voltage dc to charge the mobile phone.

Fig 18. shows the mother board of a Nokia standard cell phone and fig 19. Shows the comparison board with motherboard and the placement of the designed circuit that has been developed in this project.



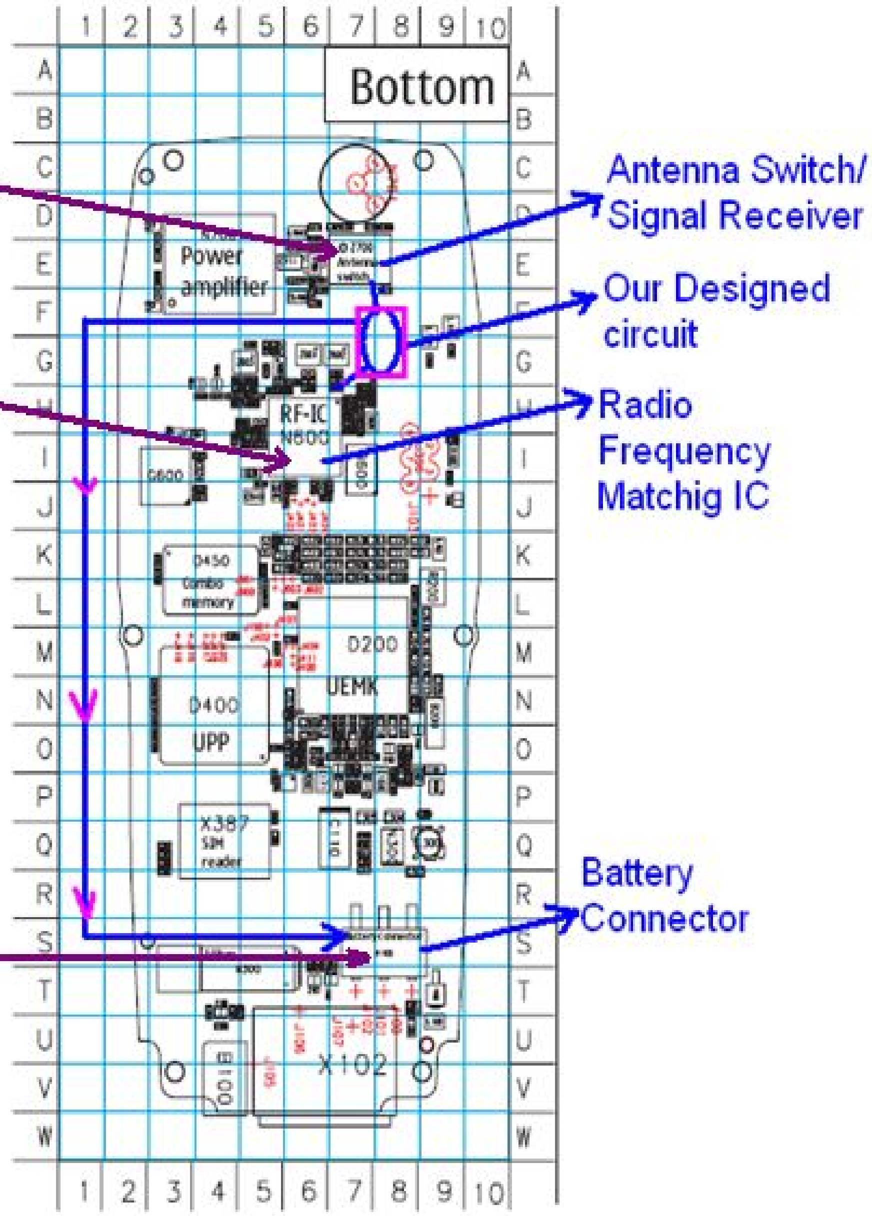


Fig 18. Motherboard of Nokia [6]   Fig 19. Proposed circuit placement at Nokia [6]

Reference:

[1] William Stallings (2nd second), Wireless Communication and Networks, 2005, ISBN-81-203-3019-6.

[2] www.isuppli.com/Mobile-and-Wireless-Communications/News/Pages/Wireless-Charging-Market-Set-to-Expand-by-Factor-of-Nearly-70-by-2014.aspx

[3] A B Richard C. Dorf (ed.) *The Electrical Engineering Handbook*, CRC Press, Boca Raton, 1993, ISBN 0-8493-0185-8 pg.457

[4] Robert F. Coughlin, Frederick F. Driscoll (Sixth Edition) Operational Amplifier AND Linear Integrated Circuit, 2007-2008, ISBN-81-302-2096-4 pg.372

[5] Robert L. Boylestead, Louis Nashelsky (Ninth Edition) Electronic Devices And Circuit Theory, 2007, ISBN-81-203-2967-8 pg.89, 766.

[6] Customer care support, RH-59/60 Schematic sDiagrams. Nokia.

[7] Md. Rafiquzzaman khan(1st edition) Basic Electronics-1, ENT-133,pg.121-128

[8] S. P. Bali, *Linear Integrated Circuits*, Tata McGraw-Hill, 2008 ISBN 0070648077, pg.279.

Fig. Team member of this project with Supervisor