WIRELESS POWER TRANSMISSION

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CERTIFICATE

This is to certify that project report entitled "**WIRELESS POWER TRANSMISSION**", submitted by ABHINEET DHILLON, ANKIT CHAUDHARY, SHIVALI SONI in partial fulfillment for the award of degree of Bachelor of Technology in Electronics and Communication Engineering to Jaypee University of Information Technology, Waknaghat, Solan has been carried out under my supervision.

This work has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

Date: 01.06.2012

N Sharma.

Ms. Neeru Sharma

Sr. Lecturer

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List of Abbreviations & Symbols

AC: Alternating current

DC: Direct current

LASER: Light Amplification (by) Stimulated Emission (of) Radiation

NASA: National aeronautics and space administration

Nm: Nano metre

LED: Light emitting diode

RF: Radio frequency

PCB: Printed circuit board

BJT: Bipolar junction transistor

MOSFET: metal-oxide semiconductor field-effect transistor

LCD: Liquid crystal display

VLED: Visible light emitting diode

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ABSTRACT

Wireless power transmission is the process that takes place in any system where electrical energy is transmitted from a power source to an electrical load, without interconnecting wires. Wireless transmission is useful in cases where instantaneous or continuous energy transfer is needed, but interconnecting wires are inconvenient, hazardous, or impossible. While the physics are identical, wireless energy transfer is slightly different from wireless transmission for the purpose of telecommunications (the transferring of information), such as radio, where the signal-to-noise ratio, or the percentage of power received, becomes critical if it is too low to recover the signal successfully. With wireless energy transfer efficiency is the more important parameter. . In our initial research we discovered many have looked into the feasibility of wireless power transmission and there are many solutions that all offer promise. Other technologies for wireless power include those based upon microwaves and lasers. Our team chose to research the feasibility of wireless power transmission through inductive coupling. This consists of using a transmission and receiving coils as the coupling antennas. Although the coils do not have to be solenoid they must be in the form of closed loops to both transmit and receive power. Wireless power transmission is the means to power devices without a built in power source such as a generator or battery. Furthermore, on a larger scale as consumable energy sources on the planet are dwindling in number it remains an important task to look to the future. If it was possible to transmit power wirelessly it would be economical to retrieve power from outer space and simply transmit it back to the planet's surface as an endless power source To transmit power an alternating current must be passed through a closed loop coil. The alternating current will create a time varying magnetic field. The flux generated by the time varying magnetic field will then induce a voltage on a receiving coil closed loop system. This seemingly simple system outlines the major principle that our research investigated. The primary benefits to using inductive coupling are the simplicity of the transmission and receiving antennas, additionally for small power transmission this is a much safer means of conveyance. To demonstrate the success of our the teams research we created a receiving circuit to maximize the amount of received power and light an LED at a distance up to two feet.

CHAPTER 1

INTRODUCTION TO

WIRELESS POWER TRANSMISSION

1.1 Introduction to Wireless Power Transmission

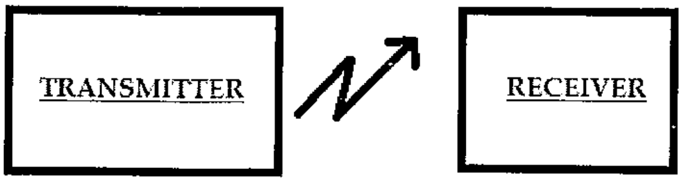


Fig.1

Wireless power transmission is the process that takes place in any system where electrical energy is transmitted from a power source to an electrical load, without interconnecting wires. Wireless transmission is useful in cases where instantaneous or continuous energy transfer is needed, but interconnecting wires are inconvenient, hazardous, or impossible. While the physics are identical, wireless energy transfer is slightly different from wireless transmission for the purpose of telecommunications (the transferring of information), such as radio, where the signal-to-noise ratio, or the percentage of power received, becomes critical if it is too low to recover the signal successfully. With wireless energy transfer efficiency is the more important parameter.The most common form of wireless power is carried out using induction, followed by electrodynamic induction. Other technologies for wireless power include those based upon microwaves and lasers. Wireless energy transfer or wireless power transfer is the process which takes place in any system where electrical energy is transmitted from a power source to an electrical load, without interconnecting wires in an electrical grid. Wireless transmission is ideal in cases where instantaneous or continuous energy transfer is needed, but interconnecting wires are inconvenient, hazardous, or impossible.

1.2 Possible Solutions

They are of two types:-

- Near field
- Far field

1.2.1 Near Fields :-

Near field are wireless transmission techniques over distances comparable to, or a few times the diameter of the device(s), and up to around one quarter of the wavelengths used. Near field energy itself is non-radiative, but some radioactive losses will occur. In addition there are usually resistive losses. Near field transfer is usually magnetic (inductive), but electric (capacitive) energy transfer can also occur.

1.2.1.1 Induction method

The action of an electrical transformer is the simplest instance of wireless power transmission. The primary and secondary circuits of a transformer are not directly connected. The transfer of energy takes place by electromagnetic coupling through a process known as mutual induction. A principle function is the capability to step the primary voltage either up or down example battery charger of mobile phone.

The main drawback to induction is short range. The receiver must be directly adjacent to the transmitter or induction unit in order to efficiently couple with it.

1.2.1.2 Resonant induction method

Electromagnetic induction works on the principle of a primary coil generating a predominantly magnetic field and a secondary coil being within that field so a current is induced in the secondary. Coupling must be tight in order to achieve high efficiency. As the distance from the primary is increased, more and more of the magnetic field misses the secondary. Even over a relatively small range the simple induction method is grossly inefficient, wasting much of the transmitted energy.

When resonant coupling is used the transmitter and receiver inductors are tuned to a mutual frequency and the drive current is modified from a sinusoidal to a non sinusoidal transient waveform. Pulse power transfer occurs over multiple cycles. In this way significant power may be transmitted over a distance of up to a few times the

size of the transmitter.

Common uses of the technology are charging the batteries of portable devices such as laptop computers and cell phones, medical implants and electric vehicles, and powering contactless smartcards.

1.2.1.3 Electrostatic induction method

Tesla illuminating two exhausted tubes by means of a powerful, rapidly alternating electrostatic field created between two vertical metal sheets suspended from the ceiling on insulating cords.

The "electrostatic induction effect" or "capacitive coupling" uses two electrodes for wireless energy transmission. High-frequency alternating current can produce an electric field between two plates, which can be intercepted by a receiving device within the field, the capacitance between fixed plates and the powered device form a voltage divider, making high potentials a requirement of this method. For example, Tesla demonstrated wireless lamps illuminated by energy that was coupled through an alternating electric field. This mechanism is sometimes called "the Tesla effect".

1.2.2 __Far Fields__ :-

Far field methods achieve longer ranges, often multiple kilometer ranges, where the distance is much greater than the diameter of the device. The main reason for longer ranges with radio wave and optical devices is the fact that electromagnetic radiation in the far-field can be made to match the shape of the receiving area (using high directivity antennas or well-collimated Laser Beam) thereby delivering almost all emitted power at long ranges.

1.2.2.1 Radio and microwave

Power transmission via radio waves can be made more directional, allowing longer distance power beaming, with shorter wavelengths of electromagnetic radiation, typically in thermic range. A rectenna may be used to convertthe microwave energy back into electricity. Retina conversion efficiencies exceeding 95% have been realized.

Power beaming using microwaves has been proposed for the transmission of energy from orbiting solar power satellites to Earth and the beaming of power to spacecraft leaving orbit has been considered.

Power beaming by microwaves has the difficulty that for most space applications the required aperture sizes are very large due to diffraction limiting antenna directionality. For example, the 1978 NASA Study of solar power satellites required a 1-km diameter transmitting antenna, and a 10 km diameter receiving rectenna, for a microwave beam at 2.45 GHz[1]. These sizes can be somewhat decreased by using shorter wavelengths, although short wavelengths may have difficulties with atmospheric absorption and beam blockage by rain or water droplets. Because of the "thinned array curse," it is not possible to make a narrower beam by combining the beams of several smaller satellites.

1.2.2.2 Laser

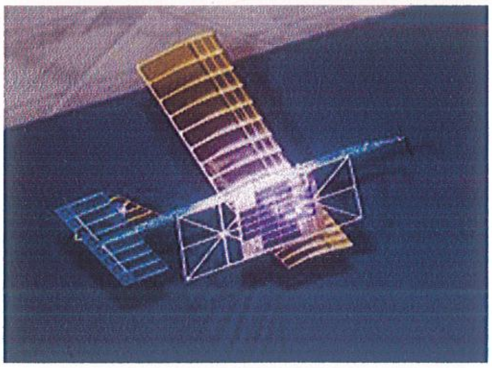


Fig. 2

With a laser beam centered on its panel of photovoltaic cells, a lightweight model plane makes the first flight of an aircraft powered by a laser beam inside a building at NASA Marshall Space Flight Centre.With a laser beam centered on its panel of photovoltaic cells, a lightweight model plane makes the first flight of an aircraft powered by a laser beam inside a building at NASA Marshall Space Flight Center.

In the case of electromagnetic radiation closer to visible region of spectrum (10s of microns (μm) to 10s of nm), power can be transmitted by converting electricity into a laser beam that is then pointed at a solar cell receiver. This mechanism is generally known as "power beaming" because the power is beamed at a receiver that can convert it to usable electrical energy.

1.3 DESIGN CHOICE

After reviewing the possible solutions, inductive coupling was chosen as the best alternative. Our team believes that inductive coupling based system will meet most of the design criteria in the designated time given to us. We also felt that our background and knowledge of electromagnetic fields and transformer theory would help us resolve any problems encountered during the design process. Inductive coupling also offers several advantages over other options that are as follows:

- **Simple Design** – The design is very simple in theory as well as the physical implementation. The circuits built are not complex and the component count is very low too.
- **Low Cost** - The entire system is designed with discrete components that are readily available. No special parts or custom order parts were necessary for the design. Thus we were able to keep the cost of the entire system very low.
- **Practical for Short Distance** – The designed system is very practical for short distance as long as the coupling coefficient is optimized. The design also offers the flexibility of making the receiver much smaller for practical applications.

<u>Inductive coupling also has some shortcomings that need to be addressed.</u>

- **High Power Loss** – Due its air core design the flux leakage is very high. This results in a high power loss and low efficiency.
- **Non-directionality** – The current design creates uniform flux density and isn't very directional. Apart from the power loss, it also could be dangerous where higher power transfers are necessary.

1.4 THEORETICAL BACKGROUND

Our power transmission system utilizes the concepts of transformer theory. In a basic single phase transformer as shown in figure 1, when the primary coil is connected to an AC source, a time varying flux is produced in the core. This flux is confined within the magnetic core. If another coil is added on the same core, the flux links the second coil inducing voltage at its terminals given by the equation 1.1. where N is the number of turns of the secondary coil and φ is the flux generated [6]. Furthermore if a load is connected across the terminals of the coil, current flows across the load.

$$V = -N\,(\partial\varphi/\partial t)$$

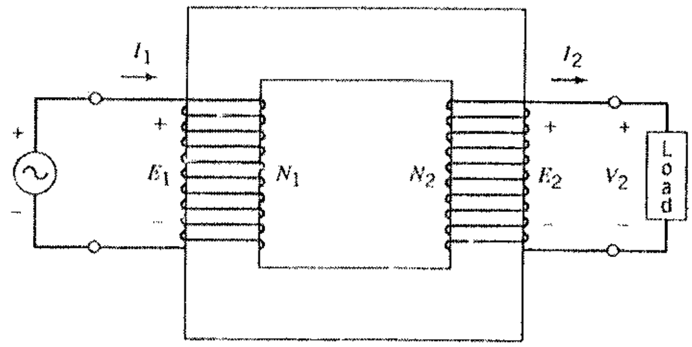


Figure 3: An Ideal Transformer

Our system follows the same concepts of Faraday's law of electromagnetic induction, but with two major differences. Our system is an air core transformer i.e. there is no solid magnetic core that confines the flux produced at the primary. This means that there is high flux leakage and only a portion of the flux generated induces an emf across the secondary coil. Moreover in our system the primary and secondary coils are two feet apart, which results in low flux linkage, low coupling, and even lower power transfer. Therefore the biggest challenge in this project is to maximize the flux linkage between the primary and secondary coils to be able to transfer enough power to light an LED at the given distance.

1.4.1 Transformer

A **transformer** is an electrical device that transfers energy from one circuit to another purely by magnetic coupling. Relative motion of the parts of the transformer is not required for transfer of energy. Transformers are often used to convert between high and low voltages, to change impedance, and to provide electrical isolation between circuits

Transformers are adapted to numerous engineering applications and may be classified in many ways:

- By application (power supply, impedance matching, circuit isolation),
- By frequency range (power, audio, RF)
- By cooling type (air cooled, oil filled, fan cooled, water cooled, etc.)
- By ratio of the number of turns in the coils

Step-up

- The secondary has more turns than the primary.(We are using this type in our project)

Step-down

- The secondary has fewer turns than the primary.
- If the flux in the core is sinusoidal, the relationship for either winding between its number of turns, voltage, magnetic flux density and core cross-sectional area is given by the universal emf equation:

$$E=4.44\ f\ N\ a\ B$$

Where E is the sinusoidal root mean square voltage of the winding, 'F' is the frequency in hertz, N is the number of turns of wire, 'a' is the cross-sectional area of the core and B is the peak magnetic flux density in tesla. The value 4.44 collects a number of constants required by the system of units.

1.4.2 High frequency operation

- The universal transformer emf equation indicates that at higher frequency, the core flux density will be lower for a given voltage. This implies that a core can have a smaller cross-sectional area and thus be physically more compact without reaching saturation. It is for this reason that the aircraft manufacturers and the military use 400 hertz supplies. They are less concerned with efficiency, which is lower at higher frequencies (mostly due to increased hysteresis losses), but are more concerned with saving weight.

1.4.3 Air cores

- High-frequency transformers may also use air cores. These eliminate the loss due to hysteresis in the core material. Such transformers maintain high coupling efficiency (low stray field loss) by overlapping the primary and secondary windings.

1.5 PREVIOUS WORK

1.5.1 Nikolai Tesla

Nikolai Tesla was the first to develop the designs for wireless power transmission. Tesla was famed for his work in the research and work with alternating current. His wireless research began with his original transformer design and though a series of experiments that separated the primary and the secondary coils of a transformer. Tesla performed many wireless power transmission experiments near Colorado Springs. In Tesla's experimentation, Tesla was able to light a filament with only a single connection to earth [1]. Tesla's findings lead him to design the Wardenclyffe plant as a giant mushroom shaped wireless power transmitter. Tesla was never able to complete construction of this project.

1.5.2 Space Satellite System

The concept of wireless power transmission has been an area of research that the U.S. Department of Energy (D.O.E.) and the National Aeronautical Space Administration (NASA) have been working to develop. NASA has been looking into research to develop a collection of satellites with the capability to collect solar energy and transmit the power to earth. The current design for project by NASA and DOE is to use microwaves to transfer power to rectifying antennas on earths [2].
Similar to this system, NASA and DOE have put research into using laser technology to beam power to earth. Japan's National Space Development Agency (NASDA) has also been performing this variety

of research to use satellite and laser technology to beam power to earth. Japan is expected to have the laser technology developed by 2025 [2]. The use of laser technology would theoretically eliminate many of the problems that could occur with the use of microwaves.

1.5.3 Microsystem and Microsensor Power Supply

Currently, the use of inductive coupling is in development and research phases. There several different projects that use inductive coupling to create alternatives for batteries. One developed at the Tokyo Institute of Technology is to develop a power supply for a medical sensor while it is left inside the human body. In this system, [3], power was transmitted by both electromagnetic waves when at close distance to the transmitter an also by magnetic flux when at farther distances. The receiver portion utilizes a cascade voltage booster to charge capacitors within the device to provide the necessary power to the system. Another similar project, [4], done at Louisiana State University in Baton Rouge, uses inductive coupling in a similar method recharge an internal small battery in a small bio-implanted microsystem.

CHAPTER 2

REQUIREMENTS AND SPECIFICATIONS

2.1 Basic Requirements of Transmitter Circuit

We need to make a transmitter circuit that actually takes up DC voltage from the power source and changes into AC voltage (working like an oscillator).For making such a circuit we need to create a flip flop kind of a circuit that alternatively switches on the transistor and thus changing the polarity of voltage everytime an alternate transistor is switched on .Thus giving us an AC sine wave.The Flip Flop is a symmetrical arrangement using two transistors with cross-coupling. Each transistor has a base bias resistor (10k in our case) and a LED with 470R resistor in the collector lead to form the collector load. The circuit consists of two identical halves and is called a **Flip Flop** because one half is **ON** while the other half is **OFF**. The ON half is keeping the OFF half OFF but it cannot keep it off indefinitely and gradually the OFF half turns ON via the 10k base-bias resistor. This drives the ON side OFF and the circuit changes state. In other words it flips over. The same events occur in the other half of the cycle and the circuit eventually flops back again. This sounds very complicated but in reality the circuit is quite simple in operation as one half is exactly the same as the other and there's only 5 components in each half.

2.2 Hardware Requirements

The transmitter circuit consists of following basic components:

- A power supply
- A set of power Mosfets to drive the cross coupling
- An Air core inductor that acts like the primary coil of the step up transformer

The receiver circuit consists of following basic components:

- An inductor (preferably etched on a PCB) to act as a secondary coil
- An LED or any other load that has to be wirelessly charged or run.

2.3 Software Requirements

The various software requirements of the system are:

- A simulation program that helps us simulate the transmitter side to check if the circuit is giving a sine wave of the required frequency.

- A PCB interfacing software that will help us design the receiver and also etch the PCB at the same time through the machine compatible to the software.

2.4 Circuit Specifications

The specifications of the hardware components and the software used are given below.

2.4.1 Hardware Specifications

1. Power Mosfet

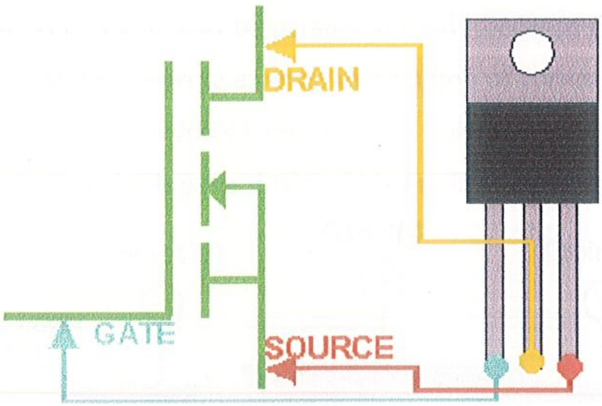


Figure. 4

Power MOSFETs (Metal Oxide Semiconductor Field Effect Transistor) are the most commonly used power devices due to their low gate drive power, fast switching speed and superior paralleling capability. Most power MOSFETs feature a vertical structure with Source and Drain on opposite sides of the wafer in order to support higher current and voltage. Figure 1a and 1b show the basic device structures of Trench and Planar MOSFETs respectively. Trench MOSFETs are mainly used for <200V voltage rating due to their higher channel density and thus lower on-resistance. Planar MOSFETs are good for higher voltage ratings since on-resistance is dominated by epi-layer resistance and high cell density is not beneficial. The basic MOSFET operation is the same for both structures.

The bipolar power transistor is a current controlled device. A large base drive current as high as one-fifth of the collector current is required to keep the device in the ON state. Also, higher reverse base drive currents are required to obtain fast turn-off. Despite the very advanced state of manufacturability and lower costs of BJTs, these limitations have made the base drive circuit design more complicated and hence more expensive than the power MOSFET.

Another BJT limitation is that both electrons and holes contribute to conduction. Presence of holes with their higher carrier lifetime causes the switching speed to be several orders of magnitude slower than for a power MOSFET of similar size and voltage rating. Also, BJTs suffer from thermal runaway.

Their forward voltage drop decreases with increasing temperature causing diversion of current to a single device when several devices are paralleled. Power MOSFETs, on the other hand, are majority carrier devices with no minority carrier injection. They are superior to the BJTs in high frequency applications where switching power losses are important. Plus, they can withstand simultaneous application of high current and voltage without undergoing destructive failure due to second breakdown. Power MOSFETs can also be paralleled easily because the forward voltage drop increases with increasing temperature, ensuring an even distribution of current among all components. However, at high breakdown voltages (>200V) the on-state voltage drop of the power MOSFET becomes higher than that of a similar size bipolar device with similar voltage rating.

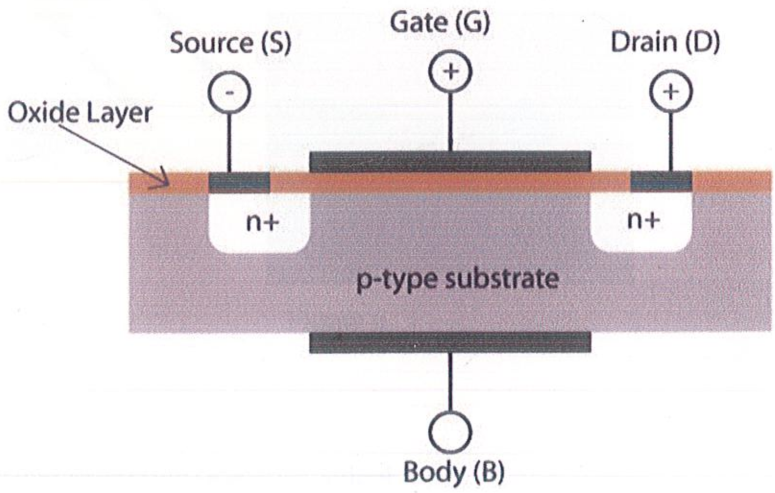


Figure 5

<u>Following is the Power Mosfet used in our project</u>:

➢ **IRFP250**

<u>This transistor features the well established advantages of Mosfets such as</u>

- Voltage control
- Very fast switching
- Ease of paralleling
- Temperature stability of the electrical parameters

Well suited for applications such as :

- Switching power supplies
- Motor controls
- Inverters
- Choppers
- Audio amplifiers
- High energy pulse circuits

2. Capacitors

<u>Following capacitors have been used in the project</u> :

➢ **Polypropylene capacitors** (transmitter side)

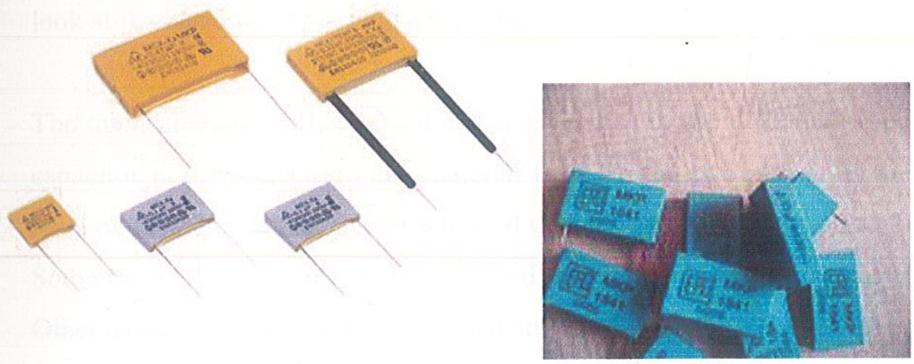


Figure 6

➢ **Cylinderical capacitor** (Receiver side-4.7 μF)

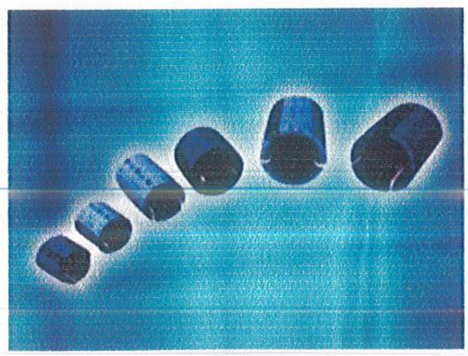


Figure 7

Electronic capacitors are one of the most widely used forms of electronics components. However there are many different types of capacitor including electrolytic, ceramic, tantalum, plastic, sliver mica, and many more. Each capacitor type has its own advantages and disadvantages can be used in different applications.

The choice of the correct capacitor type is of great importance because it can have a major impact on any circuit. The differences between the different types of capacitor can mean that the circuit may not work correctly if the correct type of capacitor is not used.

Capacitor basics

there are many different types of capacitor, but they all conform to the same basic physical laws. These determine the basic way the capacitor operates, its value, i.e. the amount of charge it will hold and hence its capacitance.

In order to understand some of the reasons why various forms of capacitor are used, it is necessary to look at the basic theory behind capacitance

The main element of the capacitor that gives rise to the different properties of the different types of capacitor is the dielectric - the material between the two plates. Its dielectric constant will alter the level of capacitance that can be achieved within a certain volume.

Some types of capacitor may be polarised, i.e. they only tolerate voltages across them in one direction. Other capacitor types are non-polarised and can have voltages of either polarity across them.

Typically the different types of capacitor are named after the type of dielectric they contain. This gives a good indication of the general properties they will exhibit and for what circuit functions they can be used.

Overview of different capacitor types

There are many different types of capacitor that can be used - most of the major types are outlined below:

Ceramic capacitor: The ceramic capacitor is a type of capacitor that is used in many applications from audio to RF. Values range from a few picofarads to around 0.1 microfarads. Ceramic capacitors are by far the most commonly used type of capacitor being cheap and reliable and their loss factor is particularly low although this is dependent on the exact dielectric in use. In view of their constructional properties, these capacitors are widely used both in leaded and surface mount formats Read more about the ceramic capacitor

Electrolytic capacitor: Electrolytic capacitors are a type of capacitor that is polarised. They are able to offer high capacitance values - typically above 1μF, and are most widely used for low frequency applications - power supplies, decoupling and audio coupling applications as they have a frequency limit if around 100 kHz. Read more about the electrolytic capacitor.

Tantalum capacitor: Like electrolytic capacitors, tantalum capacitors are also polarised and offer a very high capacitance level for their volume. However this type of capacitor is very intolerant of being reverse biased, often exploding when placed under stress. They must also not be subject to high ripple currents or voltages above their working voltage. They are available in both leaded and surface mount formats. Read more about the tantalum capacitor.

Silver Mica Capacitor: Silver mica capacitors are not as widely used these days, but they still offer very high levels of stability, low loss and accuracy where space is not an issue. They are primarily used for RF applications and and they are limited to maximum values of 1000 pF or so. Read more about the silver mica capacitor.

Polystyrene Film Capacitor: Polystyrenc capacitors are a relatively cheap form of capacitor but offer a close tolerance capacitor where needed. They are tubular in shape resulting from the fact that the plate / dielectric sandwich is rolled together, but this adds inductance limiting their frequency response to a few hundred kHz. They are generally only available as leaded electronics components.

Metallised Polyester Film Capacitor: This type of capacitor is a essentially a form of polyester film capacitor where the polyester films themselves are metallised. The advantage of using this process is that because their electrodes are thin, the overall capacitor can be contained within a relatively small package. The metallised polyester film capacitors are generally only available as leaded electronics components.

Polycarbonate capacitor: The polycarbonate capacitors has been used in applications where reliability and performance are critical. The polycarbonate film is very stable and enables high tolerance capacitors to be made which will hold their capacitance value over time. In addition they have a low dissipation factor, and they remain stable over a wide temperature range, many being specified from -55°C to +125°C. However the manufacture of polycarbonate dielectric has ceased and their production is now very limited. Read more about the polycarbonate capacitor

Polypropylene Capacitor: The polypropylene is sometimes used when a higher tolerance is necessary than polyester capacitors offer. As the name implies, this capacitor uses a polypropylene film for the dielectric. One of the advantages of the capacitor is that there is very little change of capacitance with time and voltage applied. They are also used for low frequencies, with 100 kHz or so being the upper limit. They are generally only available as leaded electronics components.

3. Resistors

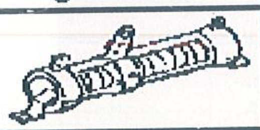
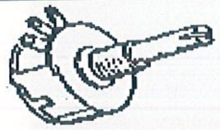
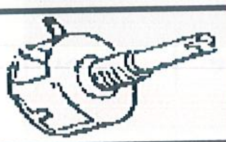
TYPICAL RESISTOR	TYPE	SYMBOL
A 	FIXED CARBON	
B 	FIXED WIREWOUND (TAPPED)	
C 	ADJUSTABLE WIREWOUND	
D 	POTENTIOMETER	
E 	RHEOSTAT	

Table 1

Resistance is the opposition of a material to the current.It is measured in ohms.All conductors represent a certain amount of resistance,since no conductor is 100 % efficient.To control the electron flow(current) in a predictable manner,we use resistors.Electronic circuits use calibrated limped resistance to control the flow of current.Broadly speaking,resistor can be divided into two groups viz.

fixed & adjustable (variable) resistors.In fixed resistors,the value is fixed and cannot be varied.In variable resistors,the resistance value be varied by an adjuster knob.It can be divided into

a) Carbon composition
b) Wire wound
c) Special type

The most common type of resistors used in projects is carbon type.The resistance value is normally indicated by colour bands.Each resistance has four colours,one of the band on either side will be gold or silver,this is called fourth band and indicates the tolerance,other three bands will give the value of resistance (see table).

Resistor comes in various sizes(power rating).The bigger,the size,the more power rating of ¼ watts.

Following are the few resistors that we have used in our project.

- R1,R5 – 100 ohm
- R2,R3 – 10 Kilo ohm
- R4 – 1 Kilo ohm

Color	Value	Multiplier	Tolerance
Black	0	$\times10^0$	± 20%
Brown	1	$\times10^1$	± 1%
Red	2	$\times10^2$	± 2%
Orange	3	$\times10^3$	± 3%
Yellow	4	$\times10^4$	- 0, + 100%
Green	5	$\times10^5$	± 0.5%
Blue	6	$\times10^6$	± 0.25%
Violet	7	$\times10^7$	± 0.10%
Gray	8	$\times10^8$	± 0.05%
White	9	$\times10^9$	± 10%
Gold	–	$\times10^{-1}$	± 5%
Silver	–	$\times10^{-2}$	± 10%
None	–	–	± 20%

Table 2

4. LEDs

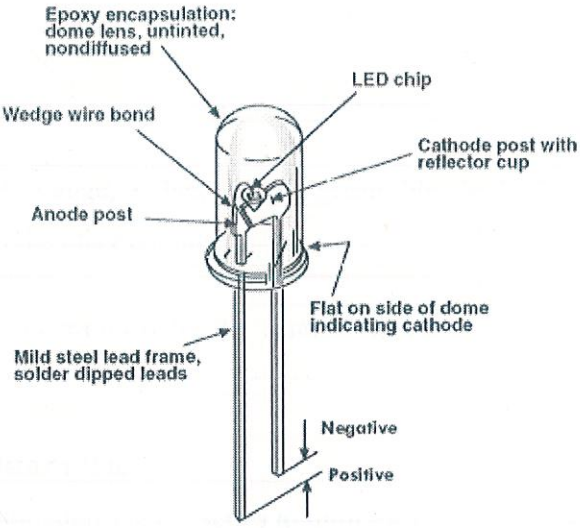
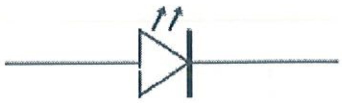


Figure 8

Circuit symbol :



Light emitting diodes, commonly called LEDs, are real unsung heroes in the electronics world. They do dozens of different jobs and are found in all kinds of devices. Among other things, they form numbers on digital clocks, transmit information from remote controls, light up watches and tell you when your appliances are turned on. Collected together, they can form images on a jumbo television screen or illuminate a traffic light.

Basically, LEDs are just tiny light bulbs that fit easily into an electrical circuit. But unlike ordinary incandescent bulbs, they don't have a filament that will burn out, and they don't get especially hot. They are illuminated solely by the movement of electrons in a semiconductor material, and they last just as long as a standard transistor. The lifespan of an LED surpasses the short life of an incandescent bulb by thousands of hours. Tiny LEDs are already replacing the tubes that light up LCD HDTVs to make dramatically thinner televisions.

Never connect an LED directly to a battery or power supply!

It will be destroyed almost instantly because too much current will pass through and burn it out.

LEDs must have a resistor in series to limit the current to a safe value, for quick testing purposes a 1k Ω resistor is suitable for most LEDs if your supply voltage is 12V or less. **Remember to connect the LED the correct way round!**

LEDs are available in red, orange, amber, yellow, green, blue and white. Blue and white LEDs are much more expensive than the other colours.

The colour of an LED is determined by the semiconductor material, not by the colouring of the 'package' (the plastic body).

Calculating an LED resistor value

An LED must have a resistor connected in series to limit the current through the LED, otherwise it will burn out almost instantly.

The resistor value, R is given by:

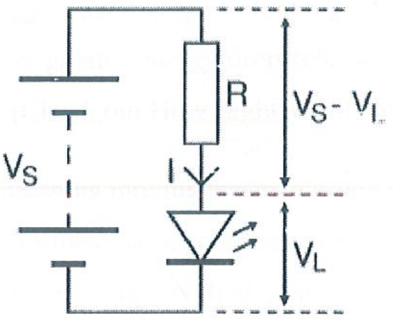


Figure 9

$$R = (V_s - V_L) / I$$

V_S = supply voltage

V_L = LED voltage (usually 2V, but 4V for blue and white LEDs)

I = LED current (e.g. 10mA = 0.01A, or 20mA = 0.02A)

Connecting several LEDs in parallel with just one resistor shared between them is generally not a good idea.

If the LEDs require slightly different voltages only the lowest voltage LED will light and it may be destroyed by the larger current flowing through it. Although identical LEDs can be successfully connected in parallel with one resistor this rarely offers any useful benefit because resistors are very cheap and the current used is the same as connecting the LEDs individually.

If LEDs are in parallel each one should have its own resistor.

Light is a form of energy that can be released by an atom. It is made up of many small particle-like packets that have energy and momentum but no mass. These particles, called photons, are the most basic units of light.

Photons are released as a result of moving electrons. In an atom, electrons move in orbitals around the nucleus. Electrons in different orbitals have different amounts of energy. Generally speaking, electrons with greater energy move in orbitals farther away from the nucleus.

For an electron to jump from a lower orbital to a higher orbital, something has to boost its energy level. Conversely, an electron releases energy when it drops from a higher orbital to a lower one. This energy is released in the form of a photon. A greater energy drop releases a higher-energy photon, which is characterized by a higher frequency. (Check out How Light Works for a full explanation.)

As we saw in the last section, free electrons moving across a diode can fall into empty holes from the P-type layer. This involves a drop from the conduction band to a lower orbital, so the electrons release energy in the form of photons. This happens in any diode, but you can only see the photons when the diode is composed of certain material. The atoms in a standard silicon diode, for example, are arranged in such a way that the electron drops a relatively short distance. As a result, the photon's frequency is so low that it is invisible to the human eye -- it is in the infrared portion of the light spectrum. This isn't necessarily a bad thing, of course: Infrared LEDs are ideal for remote controls, among other things.

Visible light-emitting diodes (VLEDs), such as the ones that light up numbers in a digital clock, are made of materials characterized by a wider gap between the conduction band and the lower orbitals. The size of the gap determines the frequency of the photon -- in other words, it determines the color of the light. While LEDs are used in everything from remote controls to the digital displays on electronics, visible LEDs are growing in popularity and use thanks to their long lifetimes and miniature size. Depending on the materials used in LEDs, they can be built to shine in infrared, ultraviolet, and all the colors of the visible spectrum in between

5. Air core Inductors

The term air core coil describes an inductor that does not use a magnetic core made of a ferromagnetic material. The term refers to coils wound on plastic, ceramic, or other nonmagnetic forms, as well as those that actually have air inside the windings. Air core coils have lower inductance than ferromagnetic core coils, but are often used at high frequencies because they are free from energy losses called core losses that occur in ferromagnetic cores, which increase with frequency. A side effect that can occur in air core coils in which the winding is not rigidly supported on a form is 'microphony': mechanical vibration of the windings can cause variations in the inductance.

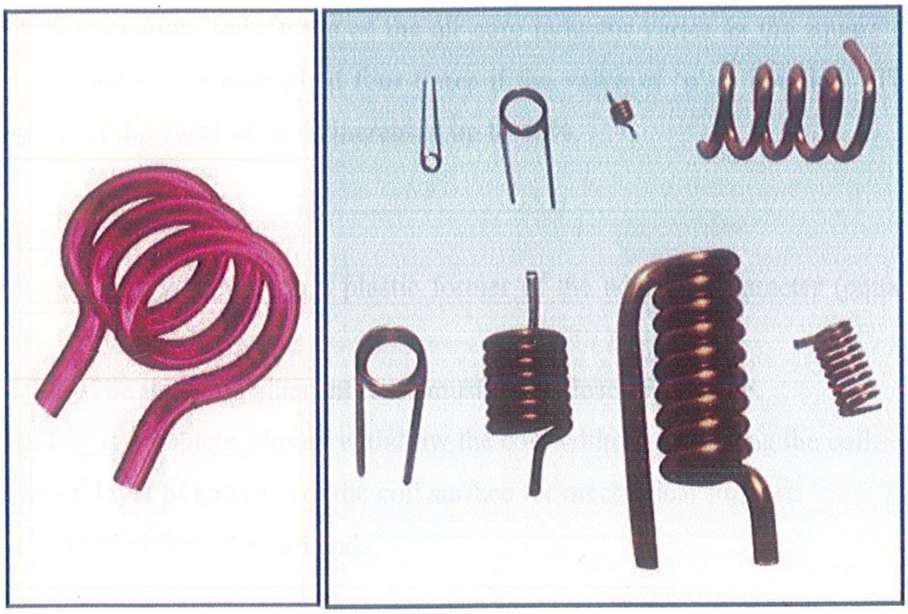


Figure 10

How to make an Air-Core Inductor

The inductance of an air cored inductor can be represented using the simplified formula shown below and to calculate the inductance of an air-core inductor, the same equation may be used.

$L= (d^2 * n^2)/ (18d+40l)$

Where' L ' is the inductance in Micro Henries [μH]

•'d' is the diameter of the coil from one wire centre to another wire centre. It should be specifies in inches.

•'l' is the length of the coil specified in inches.

•'n' is the number of turns.

Notes :

•The length of the coil used in the inductor should be equal to or 0.4 times the diameter of the coil.

•As shown in the equation, inductance of the air-core inductor varies as the square of the number of turns. Thus the value 'l' is multiplied four times if the value of 'n' is doubled. The value of 'l' is multiplied by two if the value of 'n' is increased up to 40%.

Winding the coil

•The coil must be first wounded on a plastic former of the adequate diameter (equal to the required core diameter).

•The winding must be tight and adjacent turns must be as close as possible.

•After the winding is complete, slowly withdraw the core without disturbing the coil.

•Now apply a thin layer of epoxy over the coil surface for mechanical support.

•Remove the insulation from the coil ends.

Suppose you want to make an inductor which of diameter of the coil is 1 inch and the coil length is given by 23 inches and number of turns is 300. We have to find the inductance of the inductor.

$L= (1^2 * 300^2)/(18+40* 23)$

$L=95\ \mu H$

d (coil diameter in inches)	1	(inches)
l (coil length in inches)	23	(inches)
n (number of turns)	300	
Calculate Inductance		
L (Inductance)	95.94883	(uH)

Table 3

6. Diodes

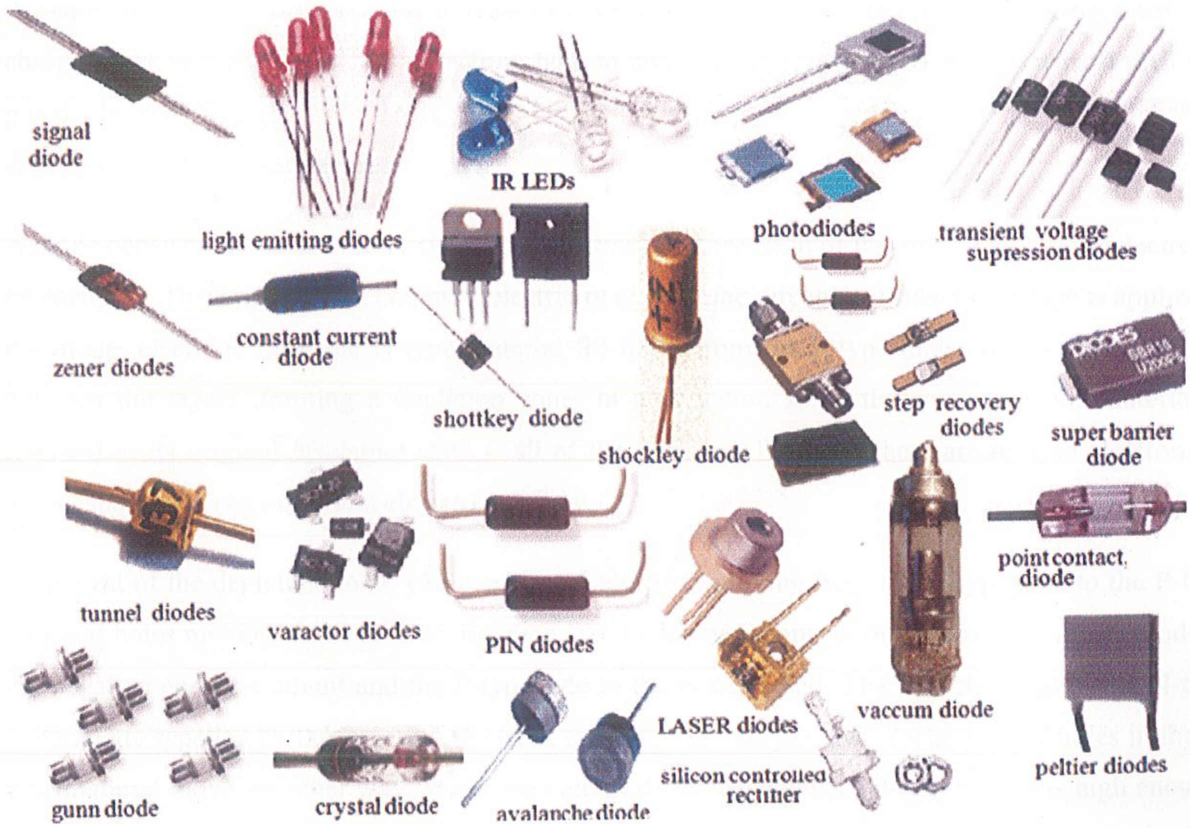


Figure 11

A diode is the simplest sort of semiconductor device. Broadly speaking, a semiconductor is a material with a varying ability to conduct electrical current. Most semiconductors are made of a poor conductor that has had impurities (atoms of another material) added to it. The process of adding impurities is called doping.

In the case of LEDs, the conductor material is typically aluminum-gallium-arsenide (AlGaAs). In pure aluminum-gallium-arsenide, all of the atoms bond perfectly to their neighbors, leaving no free electrons (negatively charged particles) to conduct electric current. In doped material, additional atoms change the balance, either adding free electrons or creating holes where electrons can go. Either of these alterations make the material more conductive.

A semiconductor with extra electrons is called N-type material, since it has extra negatively charged particles. In N-type material, free electrons move from a negatively charged area to a positively charged area.

A semiconductor with extra holes is called P-type material, since it effectively has extra positively charged particles. Electrons can jump from hole to hole, moving from a negatively charged area to a positively charged area. As a result, the holes themselves appear to move from a positively charged area to a negatively charged area.

A diode consists of a section of N-type material bonded to a section of P-type material, with electrodes on each end. This arrangement conducts electricity in only one direction. When no voltage is applied to the diode, electrons from the N-type material fill holes from the P-type material along the junction between the layers, forming a depletion zone. In a depletion zone, the semiconductor material is returned to its original insulating state -- all of the holes are filled, so there are no free electrons or empty spaces for electrons, and charge can't flow.

To get rid of the depletion zone, you have to get electrons moving from the N-type area to the P-type area and holes moving in the reverse direction. To do this, you connect the N-type side of the diode to the negative end of a circuit and the P-type side to the positive end. The free electrons in the N-type material are repelled by the negative electrode and drawn to the positive electrode. The holes in the P-type material move the other way. When the voltage difference between the electrodes is high enough, the electrons in the depletion zone are boosted out of their holes and begin moving freely again. The depletion zone disappears, and charge moves across the diode.

If you try to run current the other way, with the P-type side connected to the negative end of the circuit and the N-type side connected to the positive end, current will not flow. The negative electrons in the N-type material are attracted to the positive electrode. The positive holes in the P-type material are attracted to the negative electrode. No current flows across the junction because the holes and the electrons are each moving in the wrong direction. The depletion zone increases.

In our project following diodes have been used :

- **Standard Silicon Switching Diode: 1N4148**
  - High speed diode
  - Used for high speed(extreme) switching
  - Cathode band colour-Black

- **Schottky Barrier diode: 1N5818**
  - Low power loss
  - High Efficiency
  - High current capability
  - Low forward voltage drop
  - For use in high frequency inverter
  - For use in polarity protection application

2.4.2 Other Specifications

Receiver coils and circuitry

The secondary receiver coils are similar designs to the primary sending coils. Running the secondary at the same resonant frequency as the primary ensures that the secondary has a low impedance at the transmitter's frequency and that the energy is optimally absorbed.

To remove energy from the secondary coil, different methods can be used, the AC can be used directly or rectified and a regulator circuit can be used to generate DC voltage.

The secondary coil has a capacitor. This will allow the two circuits to be coupled therefore, transferring power efficiently. The capacitor is used only for this frequency, and the value of this capacitor will change depending on the frequency. The primary coil creates a magnetic field, when another coil is placed near it, energy will be induced into it.

CHAPTER 3

DESIGN OF THE SYSTEM

3.1 Hardware Designing

3.1.1 Block Diagram

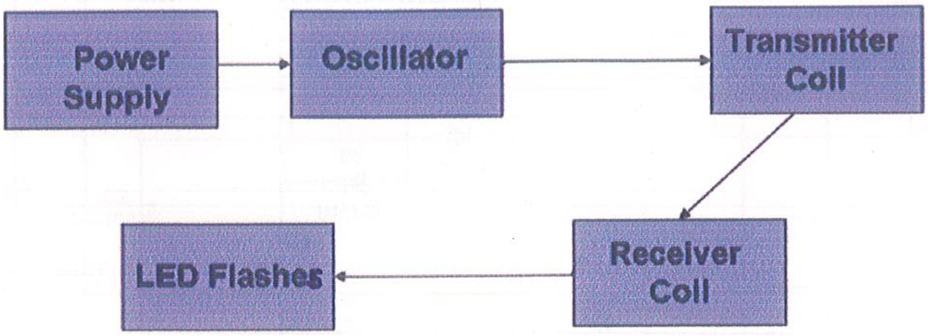


Figure 12

With all the necessary background research completed it became clear what basic design components the entire system would require. First we needed a method to power the transmission side of the system. The power supply would then power an oscillator which would provide the carrier signal with which to transmit the power. Oscillators are not generally designed to deliver power, thus it was necessary to create a power amplifier to amplify the oscillating signal. The power amplifier would then transfer the output power to the transmission coil. Next, a receiver coil would be constructed to receive the transmitted power. However, the received power would have an alternating current which is undesirable for lighting a LED. Thus, a voltage booster and rectifier would be needed to increase the received voltage while outputting a clean DC voltage. Finally, a LED flasher circuit would be constructed to flash the LED when enough power had been received to light the LED. The entire system can be seen in the figure.

3.1.2 Circuit Diagram

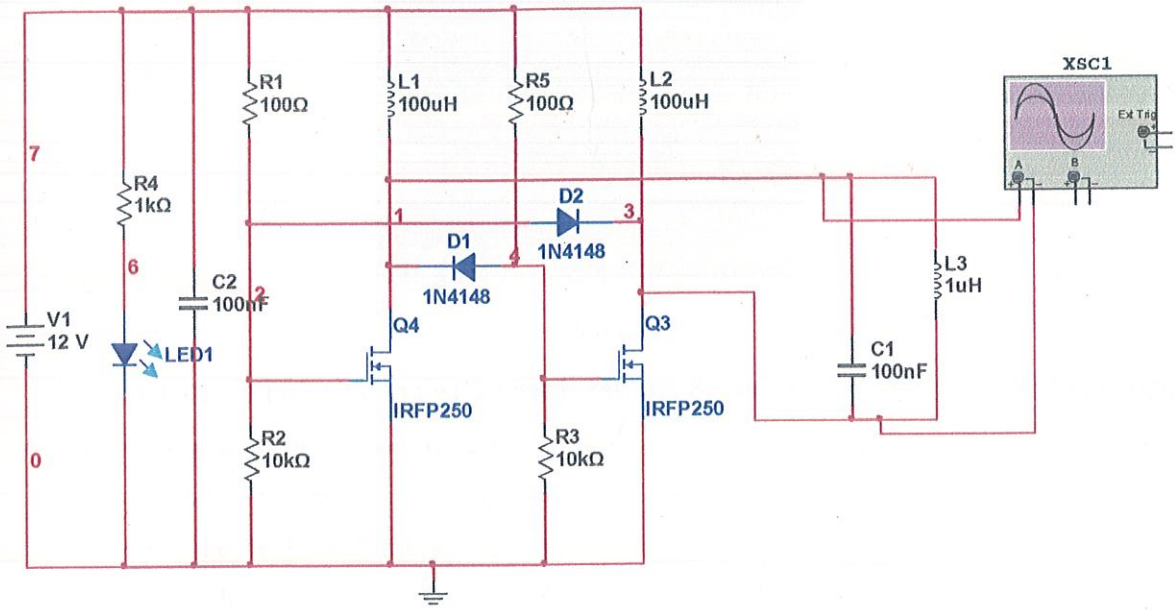


Figure 13

3.2 Basic description of power transfer using inductive coupling

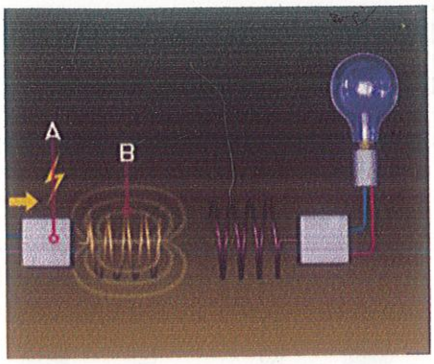


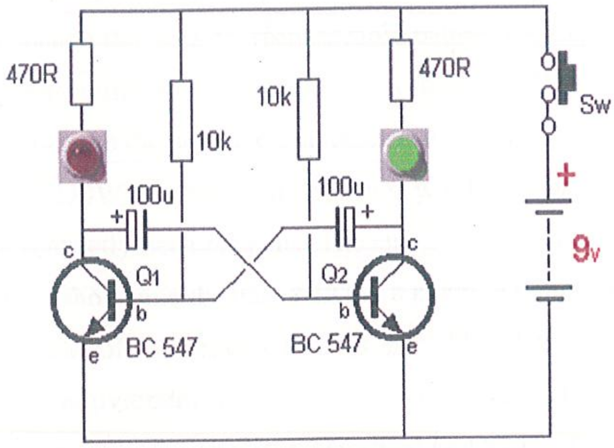
Figure 14

- A circuit [A]attached to the wall socket converts the standard 60-hertz current to 10 megahertz and feeds it to the transmitting coil [B]. The oscillating current inside the transmitting coil causes the coil to emit a 10-megahertz magnetic field. At the receiving side the inductor coil receives the field and the frequency is changed to 60-hertz like the power transmission is done wireless. The basic idea is to transfer power to a known circuit via magnetic coupling. The power transferred can be used in various applications such as lighting up of LED or automatic mobile charging wirelessly, etc.
- A parallel LC tank circuit is fed via ac voltage source(here we have used a modified version of royer oscillator).
- The ac voltage source works at the resonant frequency of LC tank circuit.
- The condition of resonance is used to provide stable resonating frequency provided by the parallel LC tank circuit.

When this transmitter circuit is powered up, another LC tank circuit is brought with a load(here an LED) attached in parallel. The large magnetic field generated by the transmitter circuit induces current in the receiver side and powers up the load(in our case the led glows).

3.3 Working Of The Circuit

We have explain the condition when a transistor is **conducting** and when it is **non-conducting** (turned off). We can also talk about the electrolytics, as they are experiencing a voltage change on their leads that is not obvious at first glance. A prototype or analogy of the circuit we have used is shown and explained here.



THE FLIP FLOP CIRCUIT IN ACTION

We can also mention that a conducting transistor is equivalent to a very low value resistor (we are talking about the resistance between the collector-emitter leads). In fact we can think of it more accurately as a very low voltage drop, in the order of about 0.35v. A transistor that is OFF is called CUT-OFF and one that is fully turned ON is called BOTTOMED or SATURATED. These are the two states for the transistors in the Flip Flop circuit. One transistor is CUT OFF while the other is SATURATED.With these facts in mind we can again go through how the circuit works. When the power is applied, the slight difference in characteristics between the two transistors and electrolytics causes one transistor to turn on faster than the other. Suppose Q1 turns on faster via the uncharged 100u electrolytic C1, LED2 and the 470R resistor. The voltage on the collector of Q1 will drop to about 0.35v and LED1 will light up. The positive lead of capacitor C2 will have 0.35v on it and this voltage will also be on the baseof Q2. Transistor Q2 will be turned off by this action but LED2 will come on for a short time while C1 charges.C2 begins to charge in the reverse direction (electrolytics can do this provided the voltage is not too high) and as the voltage rises above .6v, Q2 begins to turn on.

This lowers the voltage on its collector and begins to turn on LED2. The positive end of C1 is also connected to the collector and as the voltage drops, this effect is transferred to the base of Q1 via C1. This action begins to turn off Q1 and its collector voltage rises.Since C2 is connected to this point, the base of Q2 will see a rising voltage and it will turn on harder. In a very short time the two transistors have changed state. There's a little more concerning C1. An electrolytic can be considered to be a rechargeable battery and when C1 is charged at the beginning of the cycle, it will have about 5v across it (for a 9v supply).If we change this to a 5v rechargeable battery the explanation will be easier. The positive terminal of the battery will be connected to the collector of Q2 and when the transistor turns ON, the collector will be .35 above the negative rail. (the zero rail).This means the negative terminal of the battery will be 4.85v BELOW the zero rail. In other words the base of Q1 will see a negative voltage of 4.85v. And this is exactly what happens. The energy in the electrolytic will now be removed by the 10k resistor and after a short time the base will see a positive voltage of .6v and Q1 will begin to turn on and change the state of the circuit.This is how the delay is created for each of the cycles. Before we leave the multivibrator there's an important concept that should be explained.Since each transistor is either ON or OFF, the circuit is classified as DIGITAL, since it has only two states and the time to change from one state to the other is so fast that we do not take it into account.If we take the collector of one of the transistors, say Q1, it will be either HIGH or LOW and never part- way between. These digital states will be very important later in our course, when we connect transistors to integrated circuits. Integrated circuits are digital devices with inputs that only accept either HIGHs or LOWs. The transition time between these two states must be very quick to prevent noise getting in. If noise were to get in, the circuit would not work. Many IC's are counting devices and noise will cause them to count at maximum speed. Others will create excessive noise if the input line is at about mid-rail voltage. It takes a small period of time for the chip to start to produce countinous noise and if the transition is fast enough, it does not get the opportunity to start-up. The astablemultivibrator is also called an oscillator and when it is connected to an IC it will provide pulses called clock pulses. These clock pulses enable the IC to count or perform other functions such as division etc. The flip flop is also called a square wave oscillator and either the same circuit or a similar circuit is now available in an IC to produce clock pulses.

- When supply given at t=0, we get v=high at the bases of both MOSFETS (All this occur in microsecond).
- Instantly the MOSFETS get off due to the reverse bias operation of both diodes.

- When voltage (high) goes to R1, L1, R5, L2.the base(gate) of q4 is high.
- Also Through L1, high voltage goes to drain of Q4.(drain source get short).
- Since Q4 is shorted, L1 gets grounded.
- So input to D1 is negative. The negative input passes negative voltage to the gate of Q3(the 2nd MOSFET). This prevents the MOSFET to be on even though D2 sends a high voltage signal to collector.
- Since Q3 is open switch, point 3 is at high voltage and point 1 is at low(or grounded). Therefore, **L3 coil attains a voltage drop.**
- In such a situation L2 and L3 become connected in series with the resistance across L3 as negligible.
- As L2 and L3 are followed by a grounded voltage, hence point 3 also attains a low voltage.
- This low voltage sends negative voltage through D2 and the gate of Q4 become V_{low}, therefore turning it off.
- While the Q3 is switched on due to high voltage at its base or gate through R5.
- In this way point 3 becomes V_{low} and point 1 becomes V_{high}, therefore again bringing a **voltage drop in L3 but in the opposite direction,in such a way a changing flux is generated in the transmitting coil.**

3.4 Softwares used

3.4.1 Simulation software-MULTISIM

1.SIMULATION

National Instruments Circuit Design Suite is a suite of EDA (Electronics Design Automation) tools that assists you in carrying out the major steps in the circuit design flow. *Multisim* is the schematic capture and simulation program designed for schematic entry, simulation, and feeding to downstage steps, such as PCB layout. It also includes mixed analog/digital simulation capability, and microcontroller co-simulation.

- **SCHEMATIC CAPTURE** is the first stage in developing your circuit.

This is where you choose the components you want to use, place them on the circuit window in the desired position and orientation, wire them together, and otherwise prepare your design. You can modify component properties, orient your circuit on a grid, add text and a title block, add subcircuits and buses, and control the color of the circuit window background, components and wires.

- **PLACING COMPONENTS**

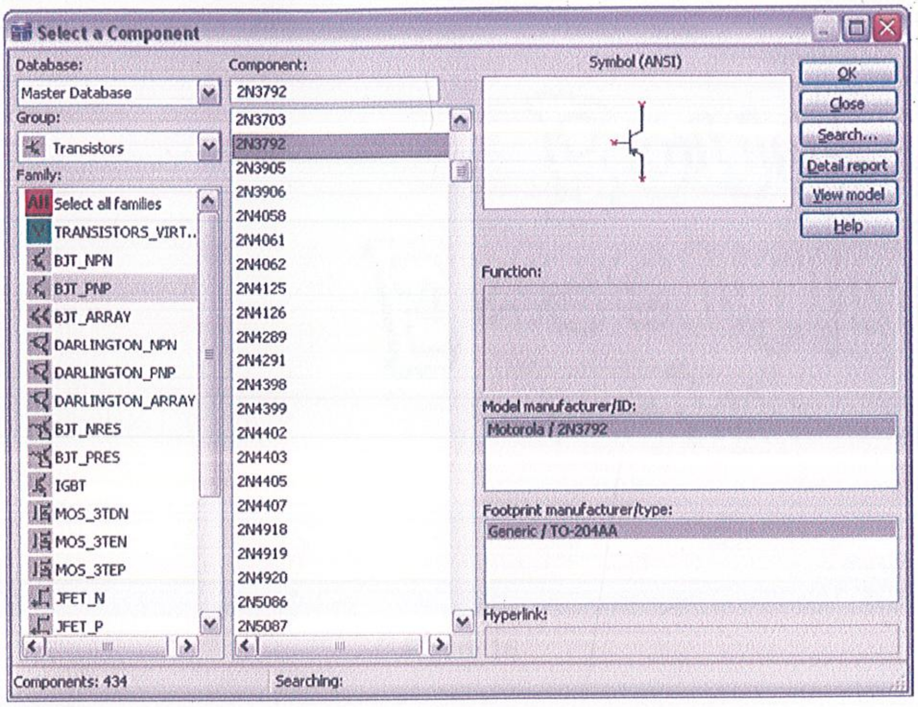


Figure 15

- **WIRING COMPONENTS**

- **LABELLING**

CIRCUIT SIMULATION

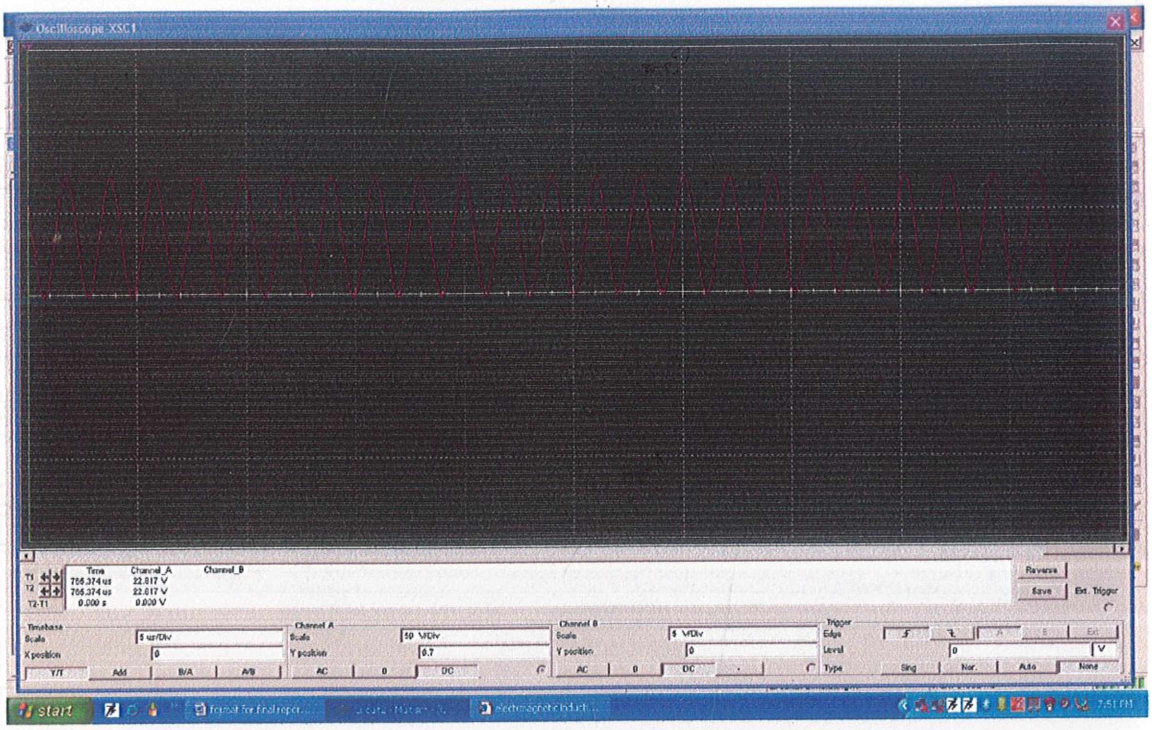


Figure 16

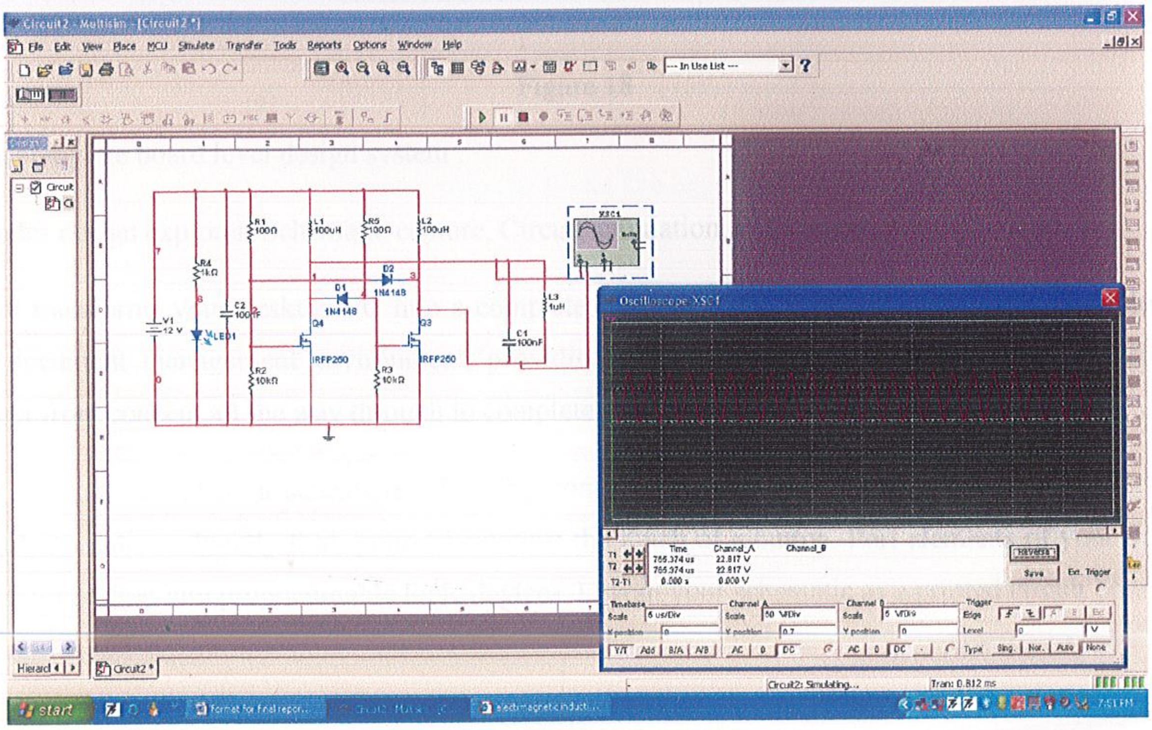


Figure 17

3.4.2 *For PCB design- PROTEL DESIGN SYSTEM*

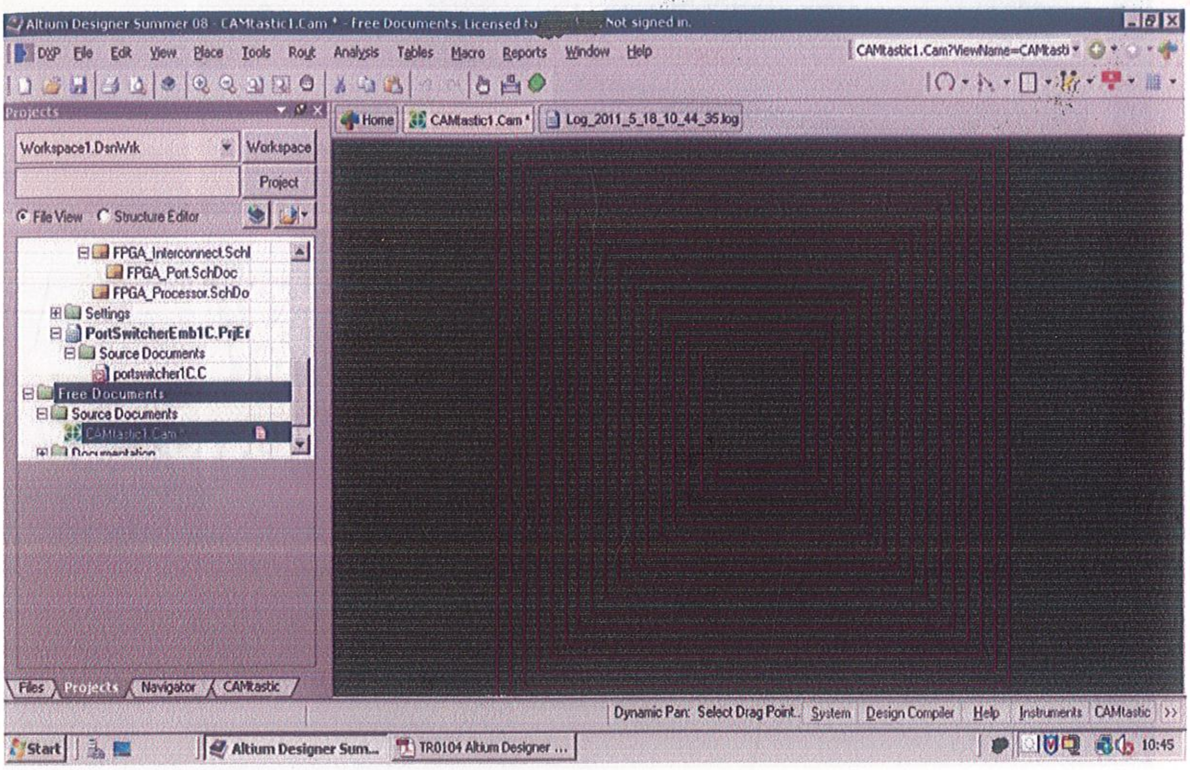


Figure 18

It's a complete board level design system .

Includes design explorer, Schematic capture, Circuit simulation, PCB layout.

Protel transforms your desktop PC into a complete,integrated,full 32-bit printed circuit board design and document management environment, providing everything you need to take your electronics project from concept,all the way through to completed boards.

Capture your circuit as a schematic, choosing components from a vast array of libraries. Perform circuit simulations directly from your schematicat the touch of a button. Port elements of your design for incorporation into programmable logic devices. Layout your schematic as a printed circuit boards.

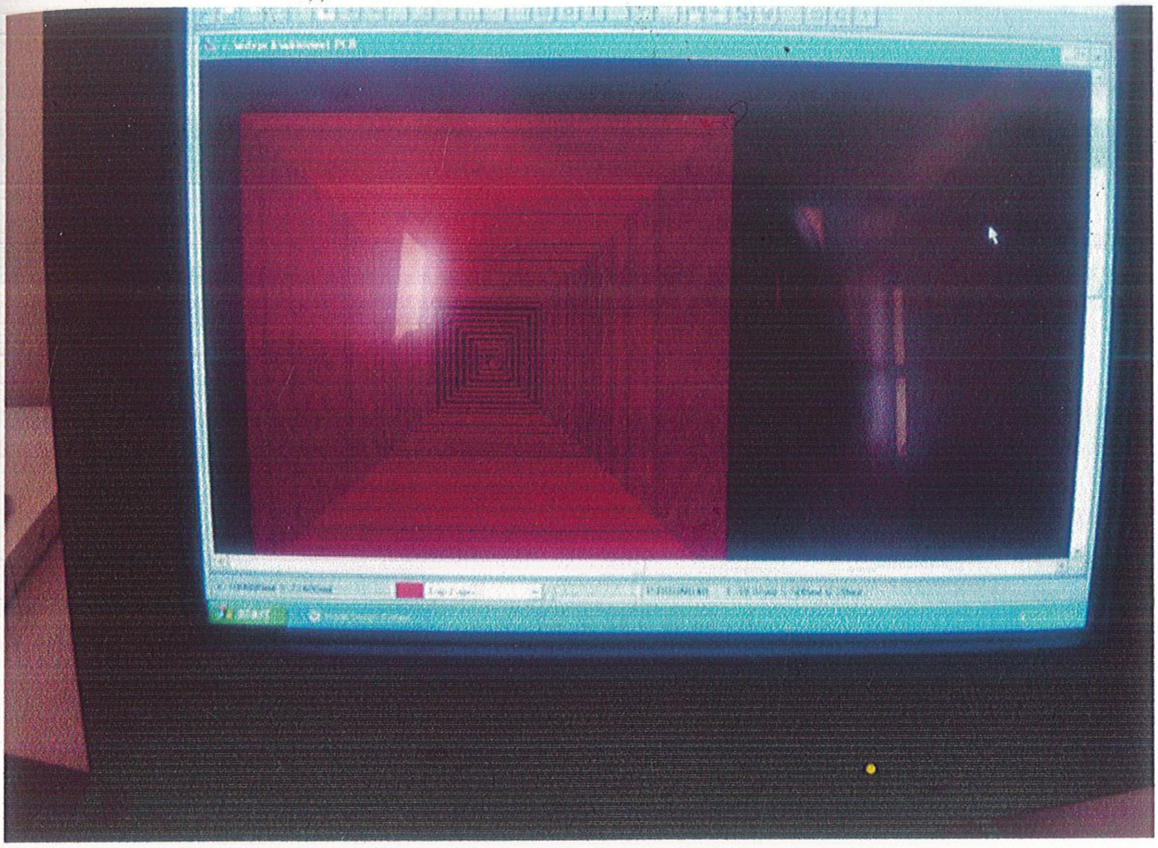


Figure 19

Figure shows how an inductor is made using the Protel Design System software.

<u>This software is used as follows:</u>

- Start working on the blank worksheet
- Make the rectangular spiral inductor using pencil tool
- Save the worksheet for further processing and PCB designing using the machine compatible with the software.

CHAPTER 4

IMPLEMENTATION, TESTING

AND

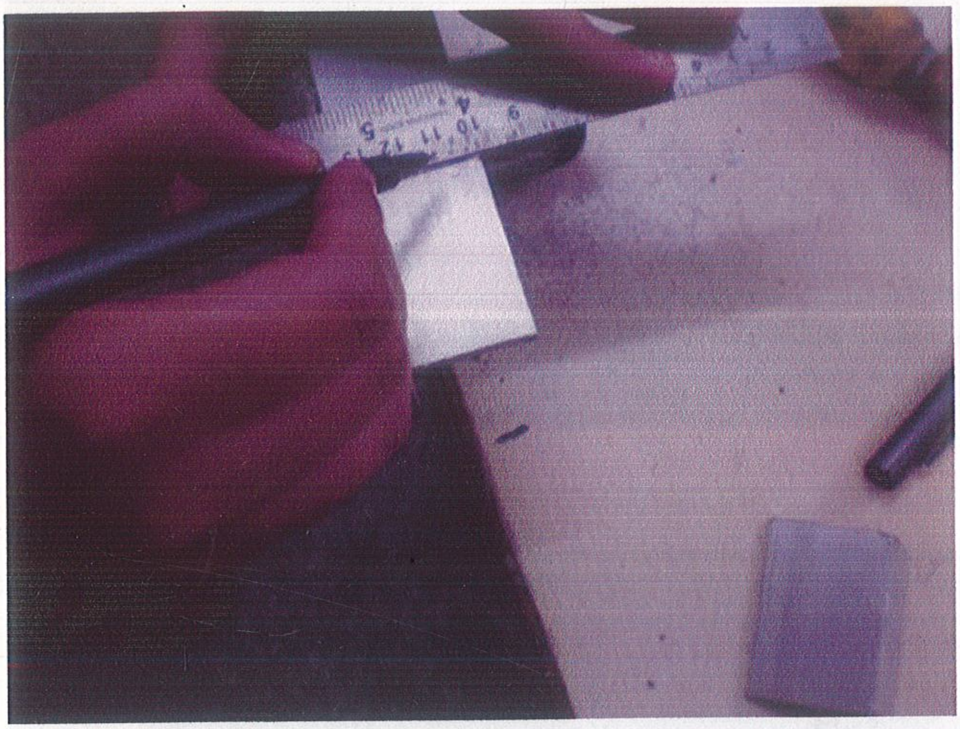
RESULTS

4.1 TRANSMITTER SIDE IMPLEMENTATION

4.1.1 Step by Step hardware Implementation

We illustrate the process of the making of the transmitter side step by step with the help of pictures that we clicked through the process.(Figure 20-Figure 31)

STEP 1:



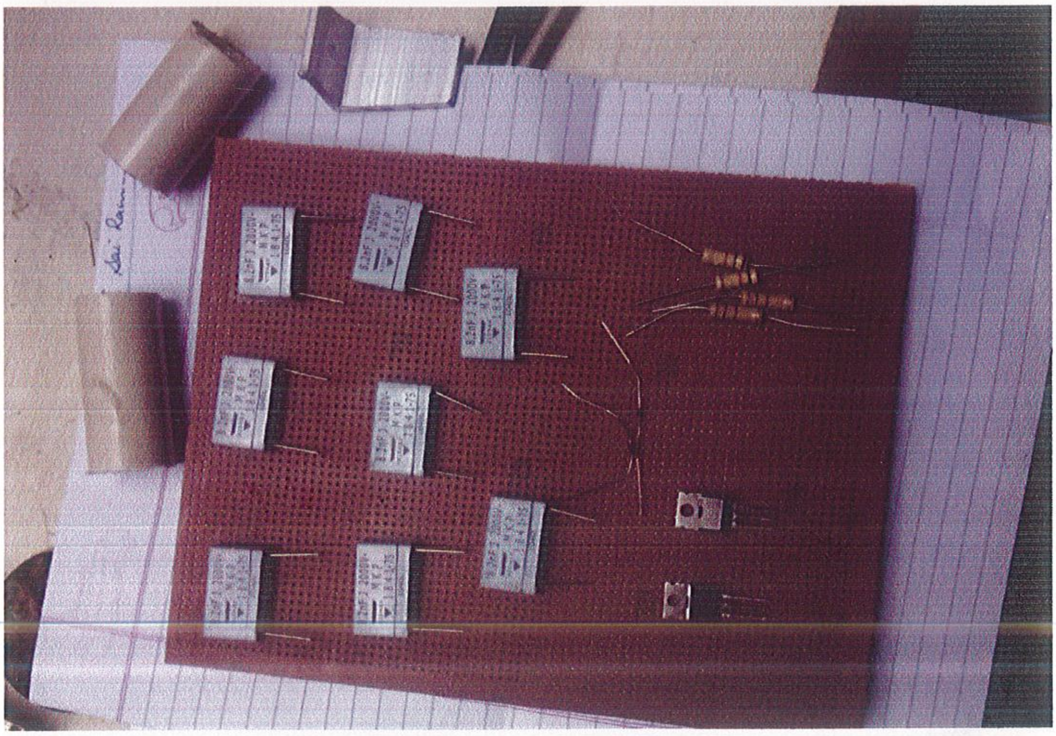
Measurements being taken to form 2 aluminium heat sinks for the two power Mosfets.

1 inch each of aluminium piece would do.

STEP 2:

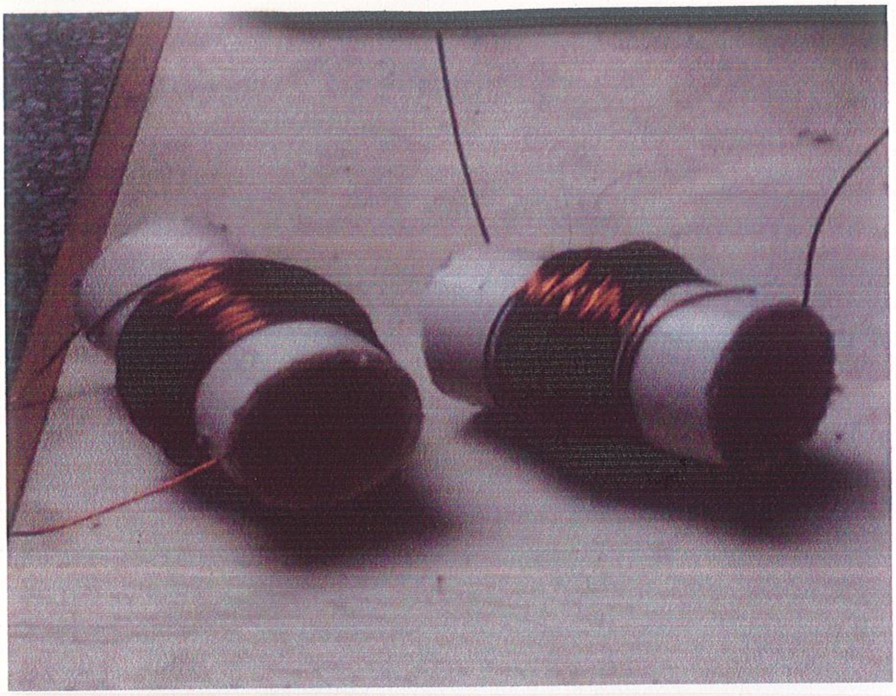
The two aluminium pieces are ready.

STEP 3:



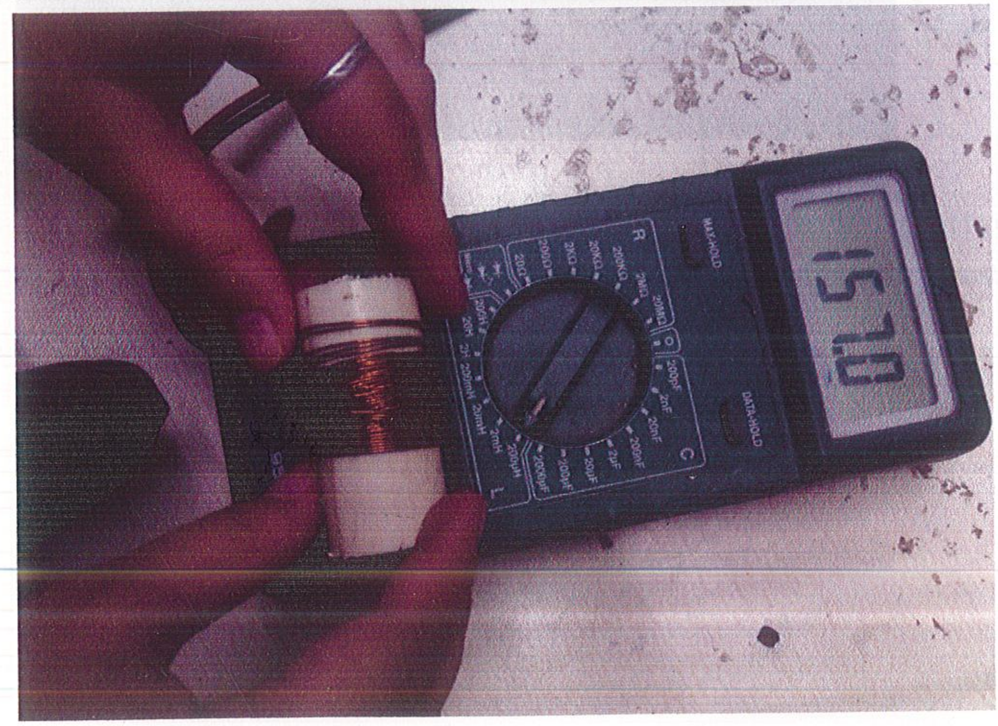
All the components going to be used in the transmitter side are shown before being soldered to the PCB.

STEP 4:



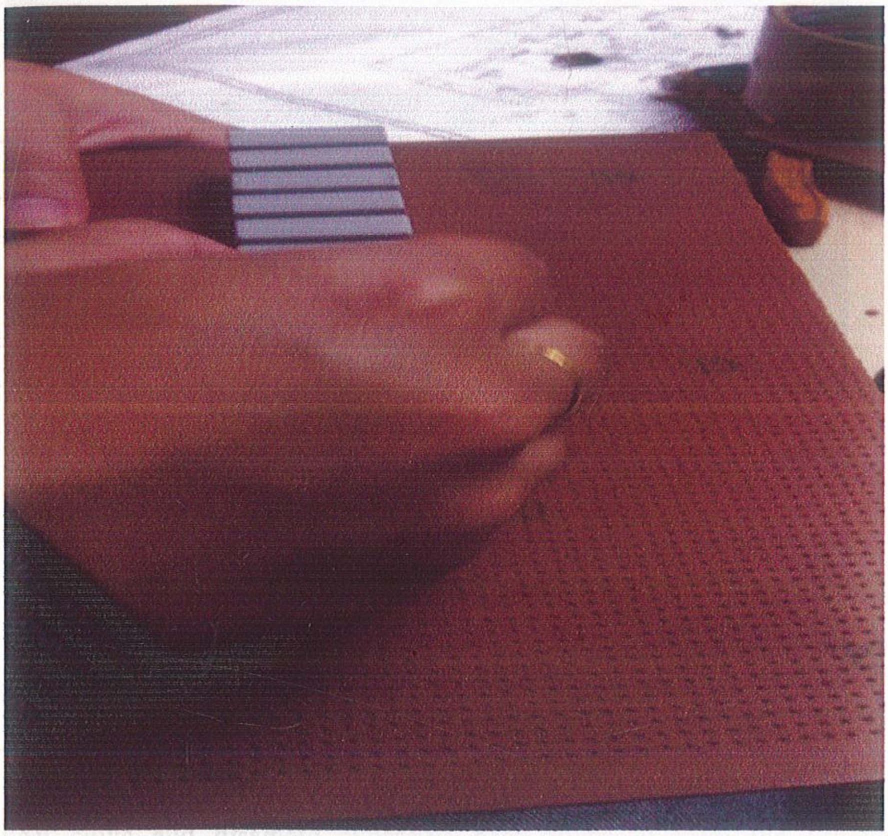
Copper wire is used to wound around two plastic tubes .Their open ends are clearly shown in order to properly bind it to the bread board.

STEP 5:



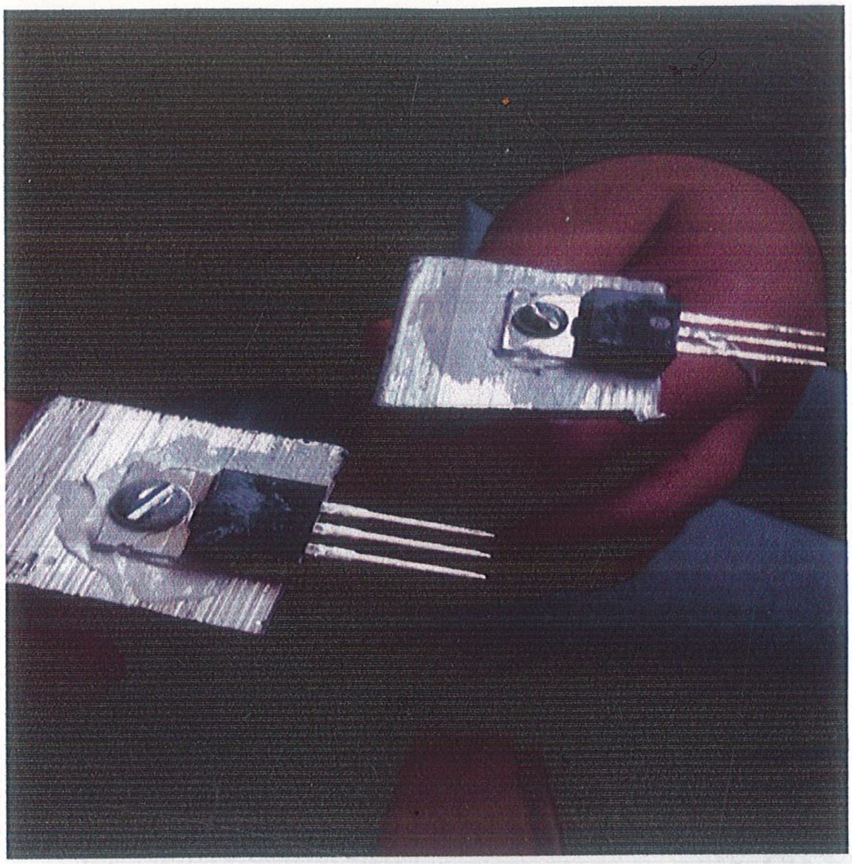
The total value of inductance should be around 100uH. Being measured by Inductance calculator meter.

STEP 6:



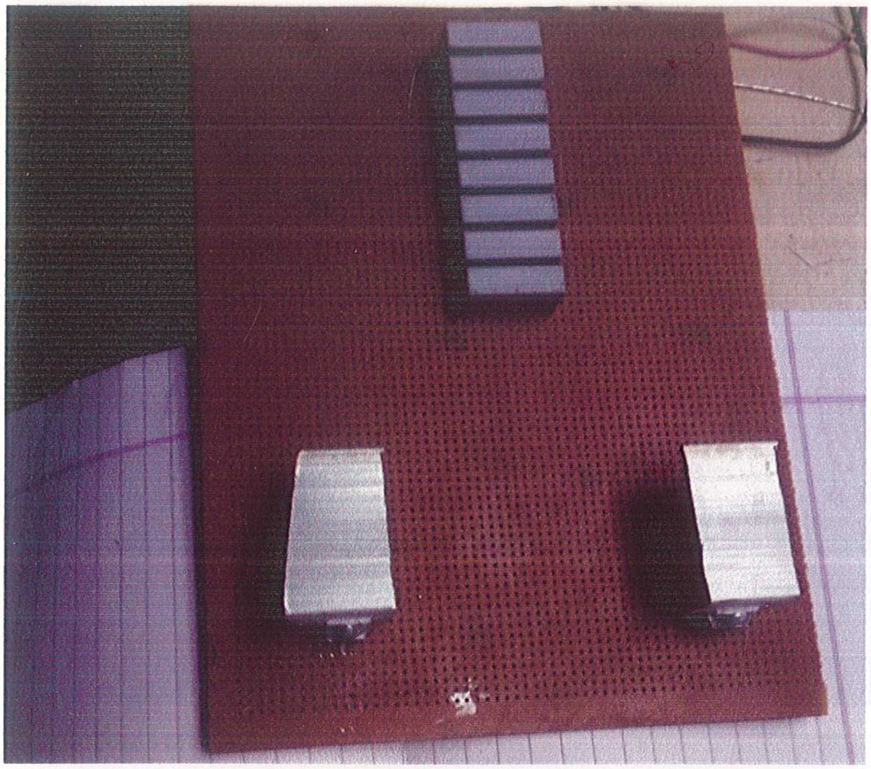
Polypropylene capacitors are being fitted into the PCB to be finally soldered. Other type of capacitors cannot be used. Other types of capacitors, if they work at all are most likely going to be very lossy and overheat and melt in minutes. Hence we use these.

STEP 7:



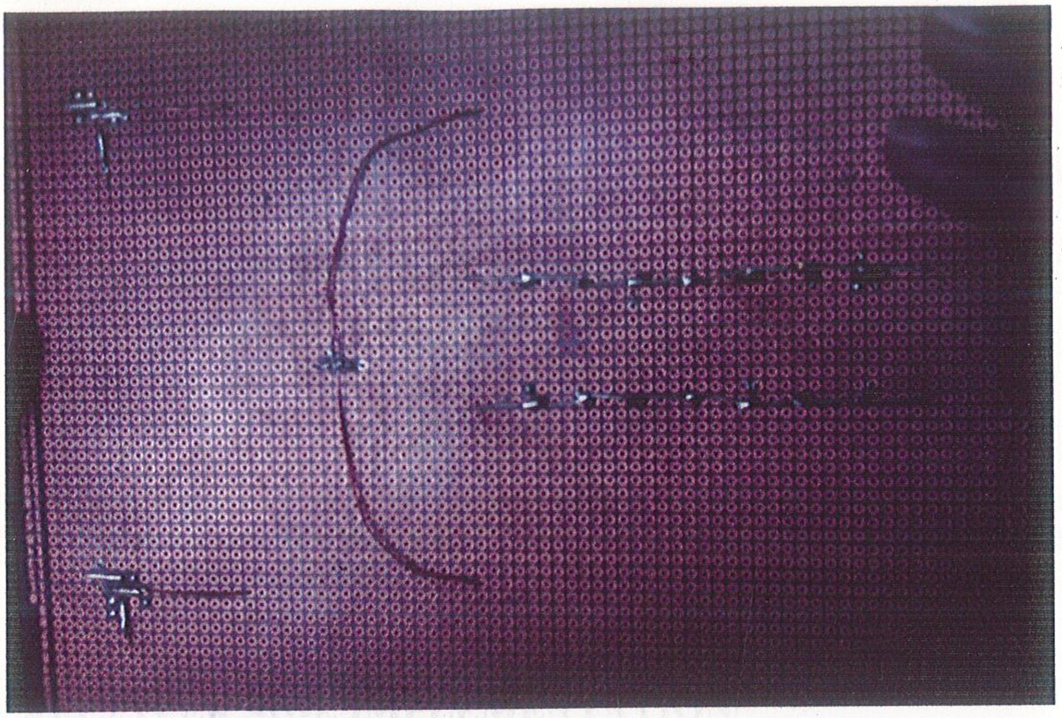
The power Mosfets are stuck with the aluminium pieces we had already cut. These will work as heat sinks and dissipate excessive heat produced from the Mosfets. A thermally adhesive compound is used to stick them. Achieves exceptional conductivity while **permanently** bonding components.

STEP 8:



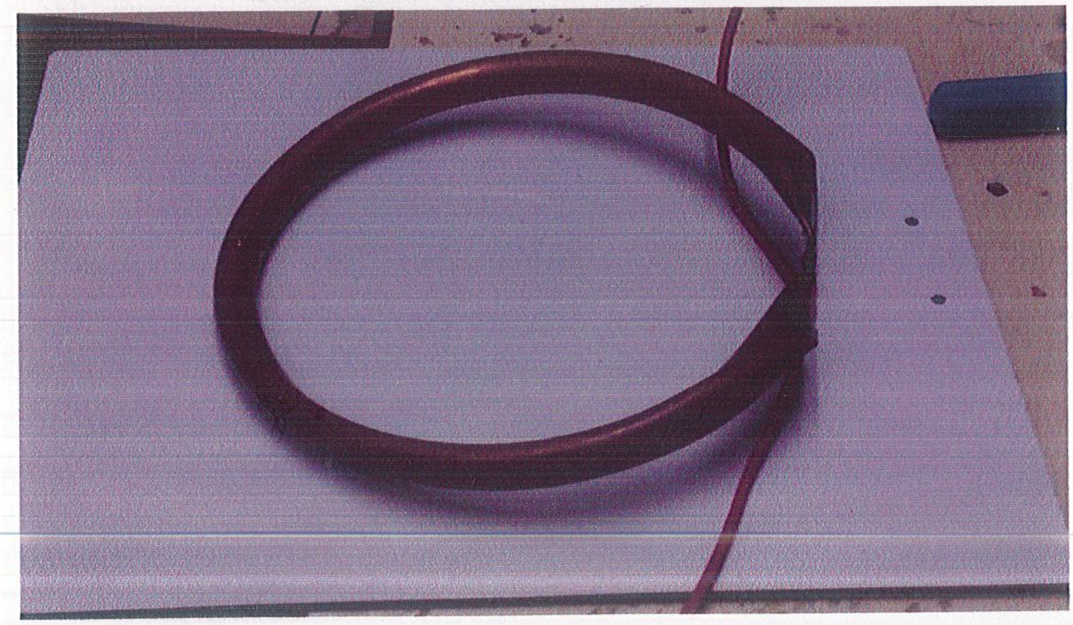
STEP 9:

STEP 10:



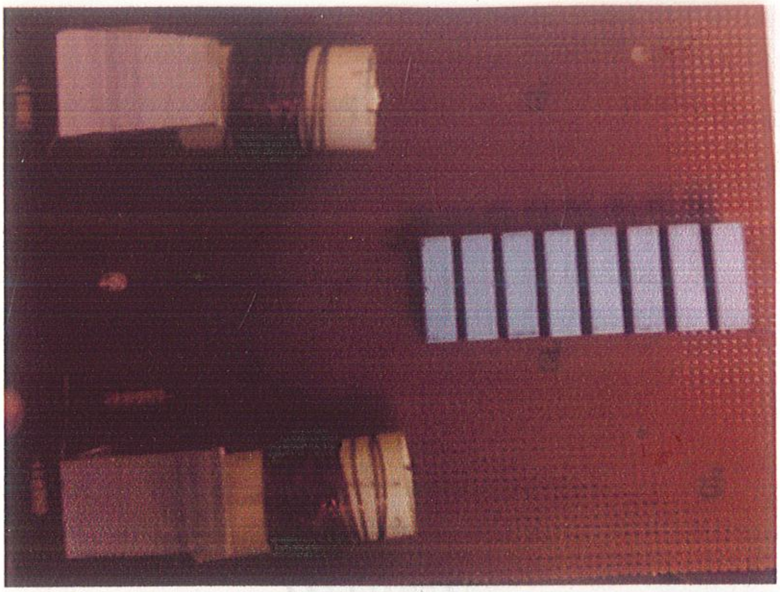
Components are soldered on the PCB.

STEP 11:



A 1μH copper loop inductor is used as the primary coil of the transmitter side. It is an air core inductor as earlier described.

STEP 12:



4.2 RECEIVER SIDE IMPLEMENTATION

4.2.1 PCB Designing on software

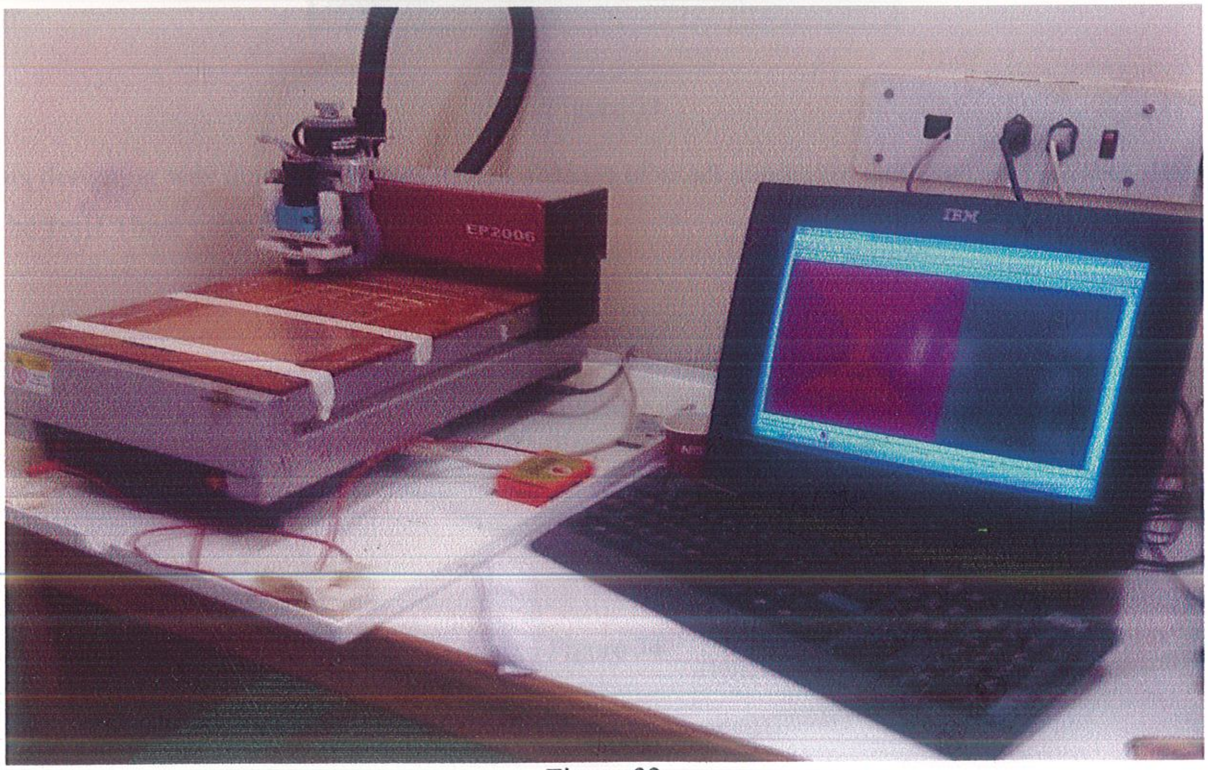


Figure 32

Protel Design System was used to design the receiver circuitry .i.e: The rectangular inductor that will act as a secondary coil in this step up transformer kind circuit.

The design of receiver circuitry was decided as planar square spiral inductor after lots of discussions of the most efficient design for an inductor on PCB which was space efficient as well.

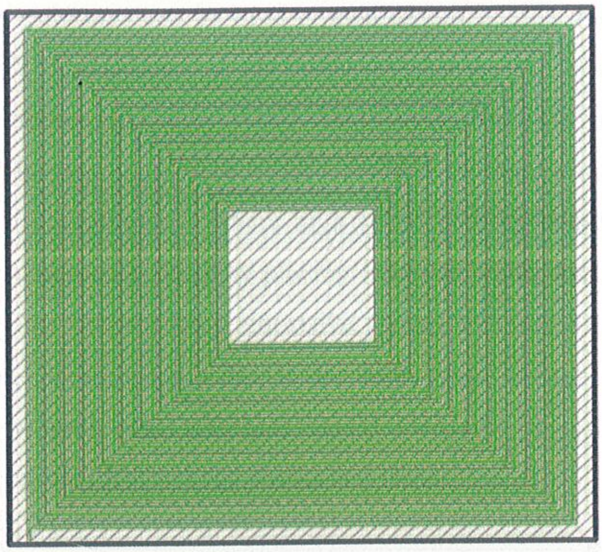


Figure 33

This designing was done after series of calculations of exact conductor inductance which was desired to be 1mH.These calculations will be shown below :

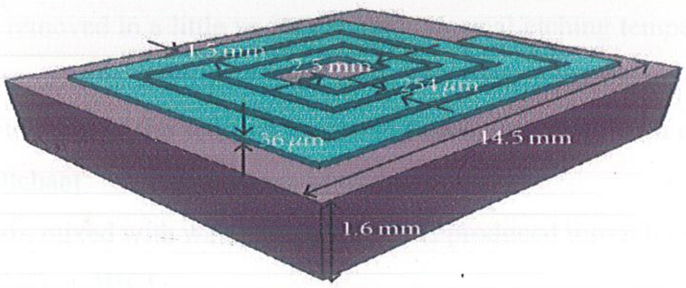


Figure 34

4.2.2 General Process of etching

Etching is where the excess copper is removed to leave the individual tracks or traces as they are sometimes called. Buckets, bubble tanks, and spray machines lots of different ways to etch, but most firms currently use high pressure conveyerised spray equipment. Spray etching is fast, ammoniacal etching solutions when sprayed can etch 55 microns of copper a minute. Less than 40 seconds to etch a standard 1 oz, 35 micron circuit board.

Many different chemical solutions can be used to etch circuit boards. Ranging from slow controlled speed etches used for surface preparation to the faster etches used for etching the tracks. Some are best used in horizontal spray process equipment while others are best used in tanks. Etchents for PTH work have to be selective and be non aggressive to tin / tin lead plating, which is used as the etch resist. Copper etching is normally exothermic, where high speed etching is carried out solution cooling is normally required. This is normally done by placing titanium water cooling coils into the 49t chant. Almost all etching solutions liberate toxic corrosive fumes, extraction is highly recommended. All etchents are corrosive and toxic, mainly due to the high metal content. P.P.E. Personal Protection Equipment must always be used, spent solutions should always be disposed of properly and not down local drains, where they pollute local sewage works and rivers.

Ferric Chloride

An old favorite, also very good at staining fingers, clothing, etc brown. Etch rate can be very high but is dependant on solution movement over the surface of the board and temperature. At 70C using Spray etching 1oz copper is removed in a little under a minute, normal etching temperature is more likely to be 45C. When etching circuits if up to 5% of HCL is added it, increases etch rate, helps to stop staining, and reduces the risk of the solution sludging. Ferric especially with extra HCL makes a very good stainless steel 49tchant.

When Ferric crystals are mixed with water some free HCL produced through hydrolysis.

$FeCl_3 + 3H_2O > Fe(OH)_3 + 3HCL$

The basic etching reaction takes place in 3 stages. First the ferric ion oxidizes copper to cuprous chloride, which is then further oxidized to cupric chloride.

$FeCl_3 + Cu > FeCl2 + CuCl$

$FeCl_3$ + CuCl > $FeCl2$ + $CuCl_2$

As the cupric chloride builds up at further reaction takes place,

$CuCl_2$ + Cu > 2CuCl

The etch rate quickly falls off after about 17oz/gallon (100g/l of copper has been etched. For a typical solution containing 5.3lb/gallon (530g/l) of ferric chloride.

4.2.3 ***Final Receiver after PCB Etching***

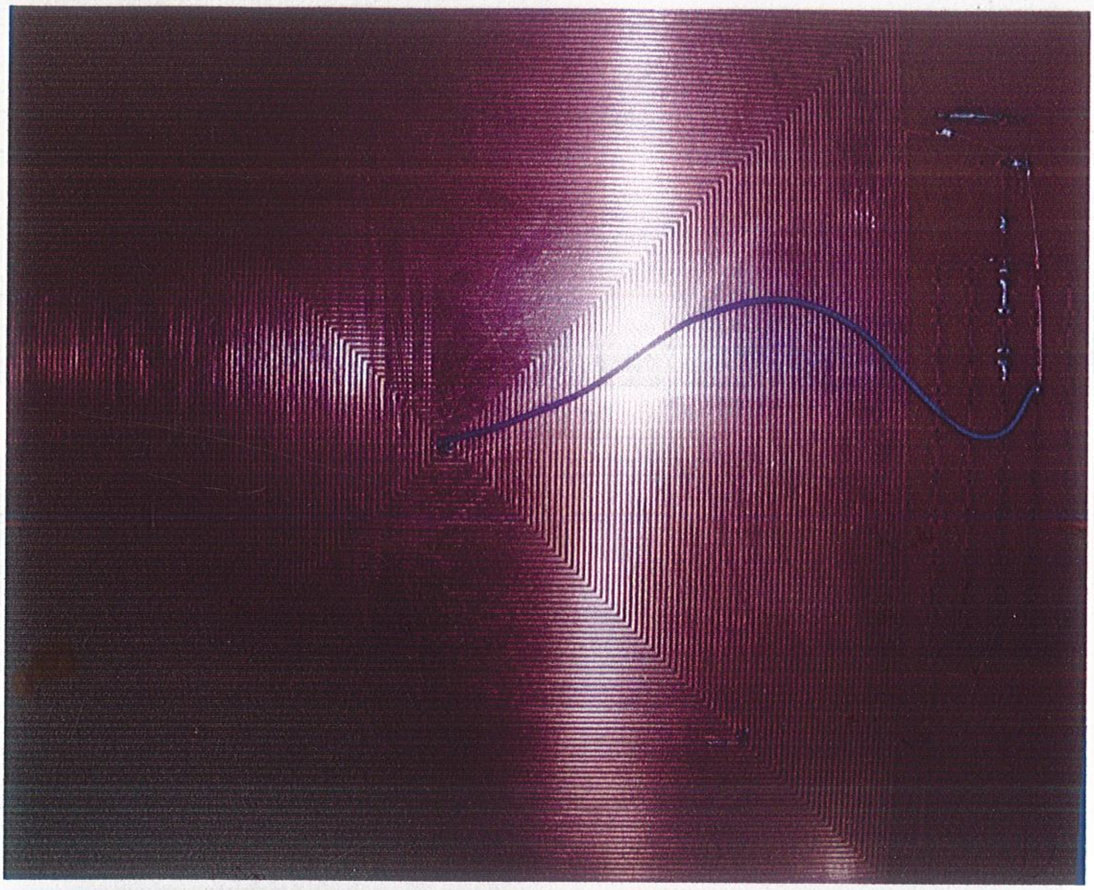


Figure 35

- After designing the PCB on the software we finally get it etched on a CCB (a cooper coated bord) of size specifications- 25 X 20 cm .
- We then solder one end of inductor with one end of LED and the other end to the left over led(end) of LED.

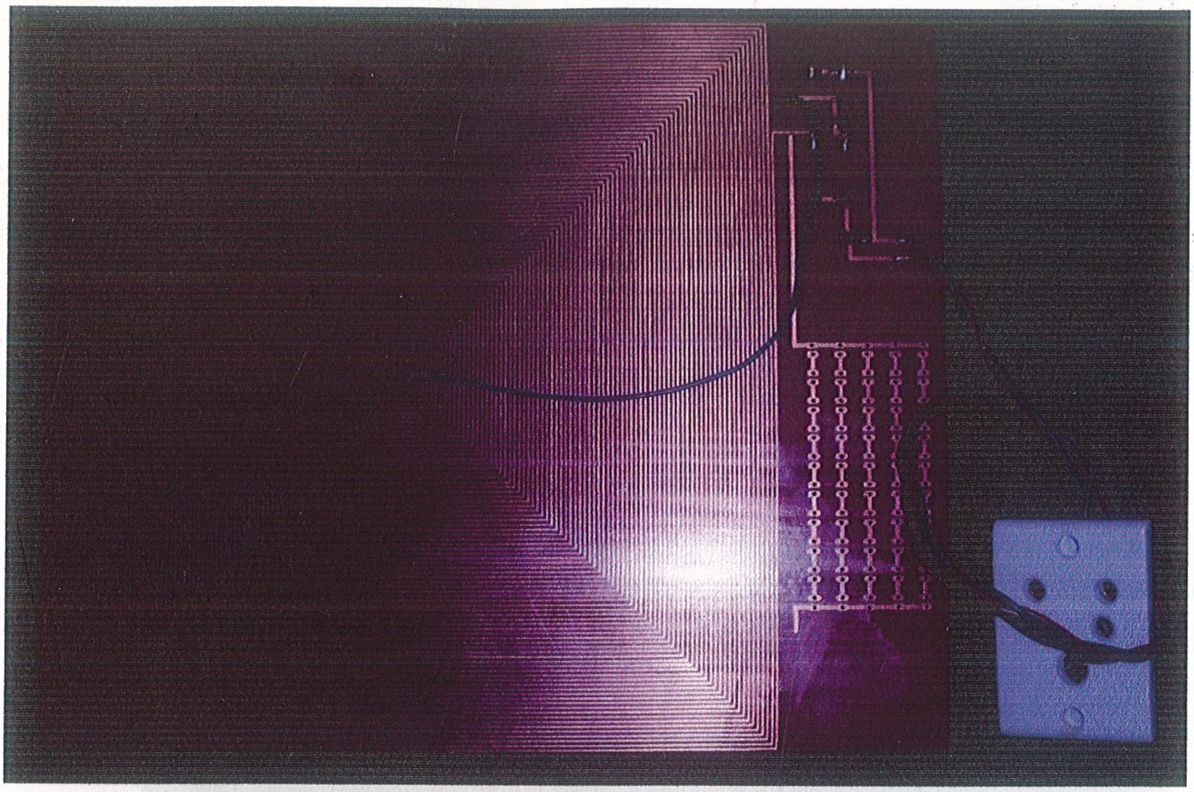


Figure 36

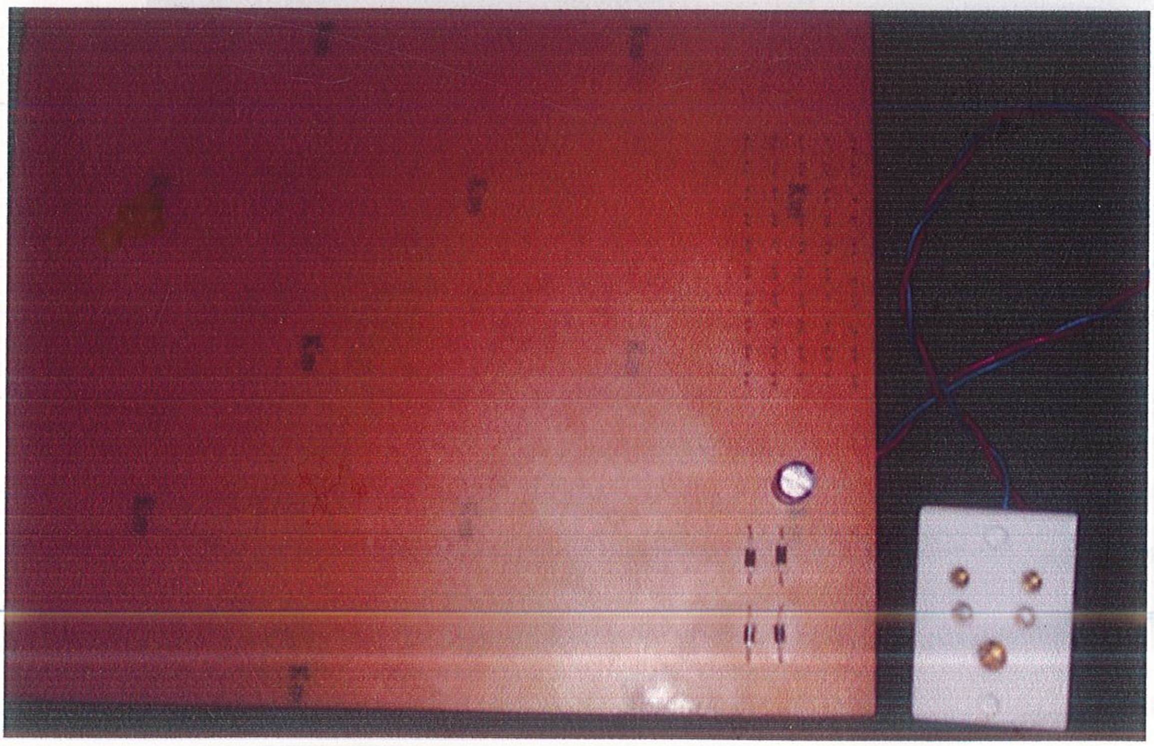


Figure 37

- The same holds true for the above two figures.These are the receiver coils for the second part of the project i.e: wireless mobile charging
- The designing has been done in a similar way except that a switch has been connected at one end .
- A cylindrical capacitor has been connected in parallel to the switch
- And a bridge rectifier circuit has been connected to the ends of the inductor coil.This has been done just to ease mobile chargind because bridge rectifier circuit gives an AC output.

4.3 Testing

4.3.1 Transmitter Side testing

- Using an oscilloscope
- A wire

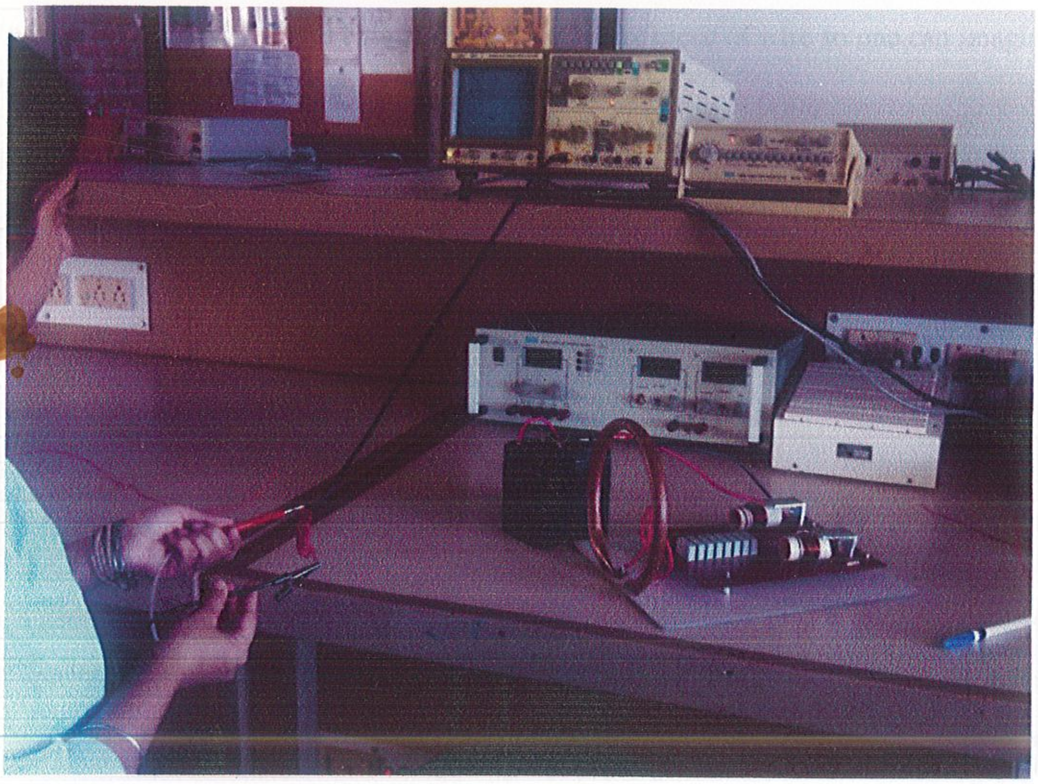


Figure 38

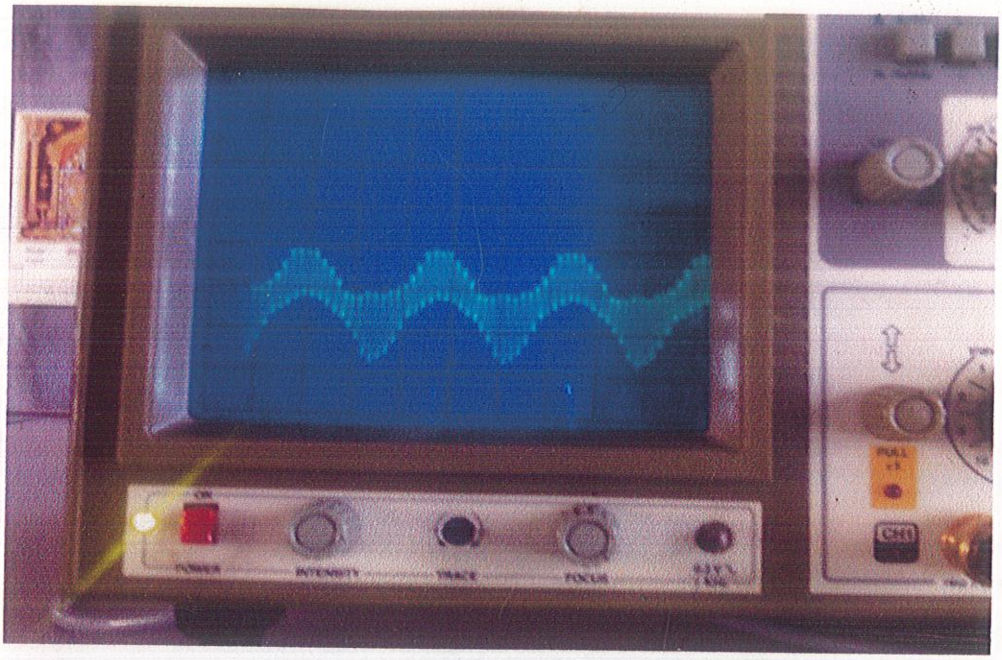


Figure 39

Result : We can see sinusoidal waves being generated in a tiny piece of wire so one can imagine what would be the result of a well tuned circuit !!

4.3.2 Receiver Side testing

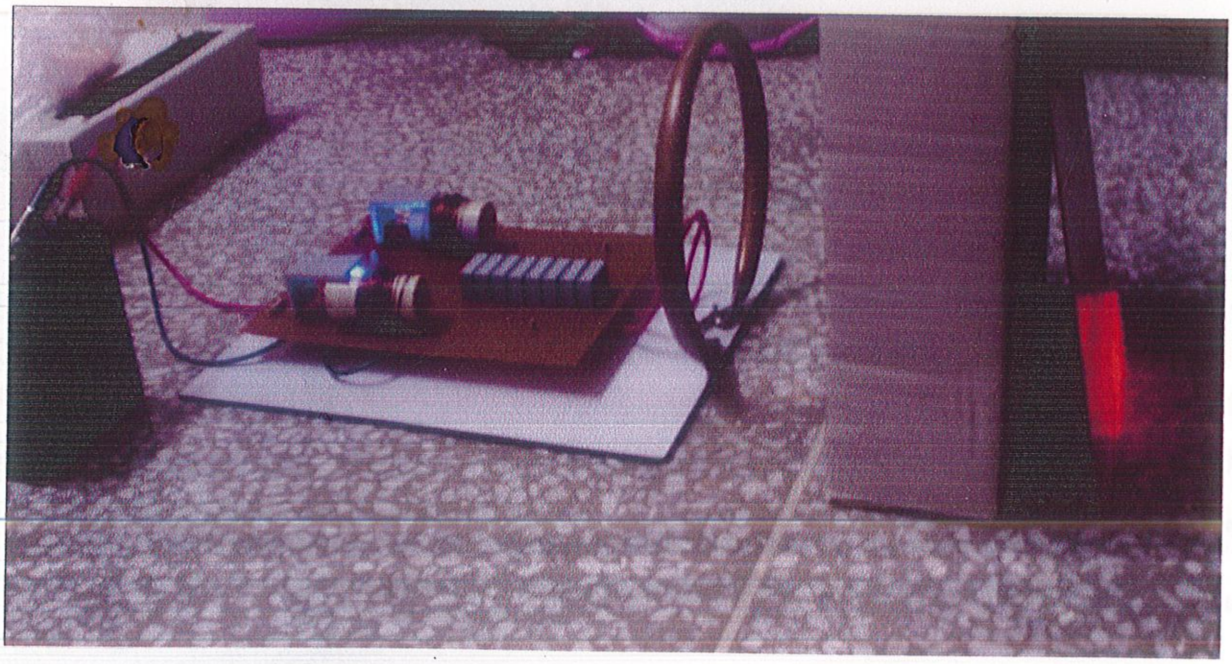


Figure 40

Result: One can see how a bunch red LEDs are lit wirelesslessly even when there is a thick barrier between the transmitter and receiver !!!

4.4 Results

The following section will illustrate the various results we achieved during the project : Physical results as well as mathematical results.

4.4.1 Transmitter side simulation results

With reference to the figures/snapshots from the simulation using MULTISIM software we list down a few figures that are an output of the transmitter circuit.

- The output wave is a sinusoidal wave of high frequency :0.6 GHz
- The voltage of output wave is stepped up on the receiver side.
- The "kind of flip flop circuit" or a switching between two Mosfets is done on transmitter side.
- This oscillator circuit that helps convert DC into AC by changing the polarity across transmitter inductor (1 μH) produces the wave at such a high frequency due to use of high speed switching diodes and Mosfets.
- A very high frequency is much needed in successful wireless transmission of power.
    - Energy ∞ 1/ λ (Energy inversely proportional to wavelength)
    - Energy or power transmitted hence directly proportional to frequency.
    - Hence for efficient transmission of power even after losses is much required in our project hence we work at such high frequencies (for minimum power attenuation) so that transfer over 1 or 2 feet is possible.

4.4.2 Receiver coil results

- The receiver coil acts as a step up transformer .The receiver inductor being~1mH
- Hence steps up the voltage from 12 V to 220 V for successful mobile charging.

- Difference being that normally in our homes we charge our mobiles at 220 V but at 50 Hz because everything is wired and there are least losses,no transmission over long distances wirelessly is required.

CHAPTER 5

CONCLUSION, FUTURE WORK

&

APPLICATIONS

5.1 CONCLUSION

The feasibility of wireless power transfer is a definite reality as our project has demonstrated. The major point of the research was to evaluate whether or not inductive coupling was a feasible solution. While it is possible to transmit and receive power using inductive coupling it has some definite drawbacks. For our team's project the goal distance was One feet, at such a large distance inductive coupling is far too inefficient in its current state.

WIRELESS POWER TRANSFER is an innovative creation that enables the users to experience the convenience and ease of use; it is also a piece of safety guaranteed and controllable device. Last but not least, this technology unveils a new design for battery charging; the design should be welcomed by users in many aspects such as safety, ease of use, environmental friendly and water-proof capability. The invention offers a new common platform for standardizing charging equipment for various portable electronic devices with a minimum risk level.

5.2 SYSTEM DESIGNED

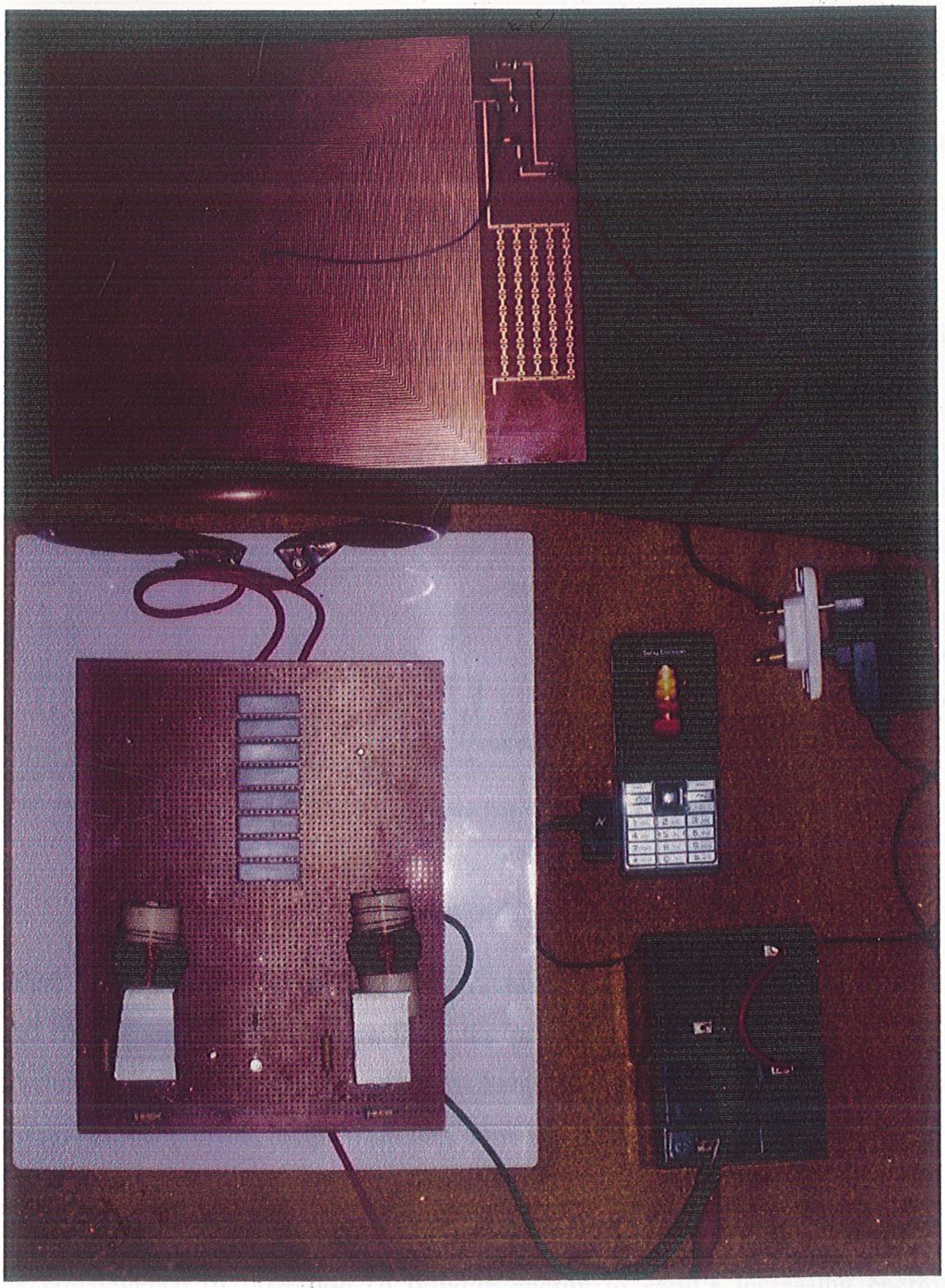


Figure 40

MOBILE BEING CHARGED THROUGH WIRELESS POWER TRANSMISSION

5.3 FUTURE WORKS & APPLICATIONS

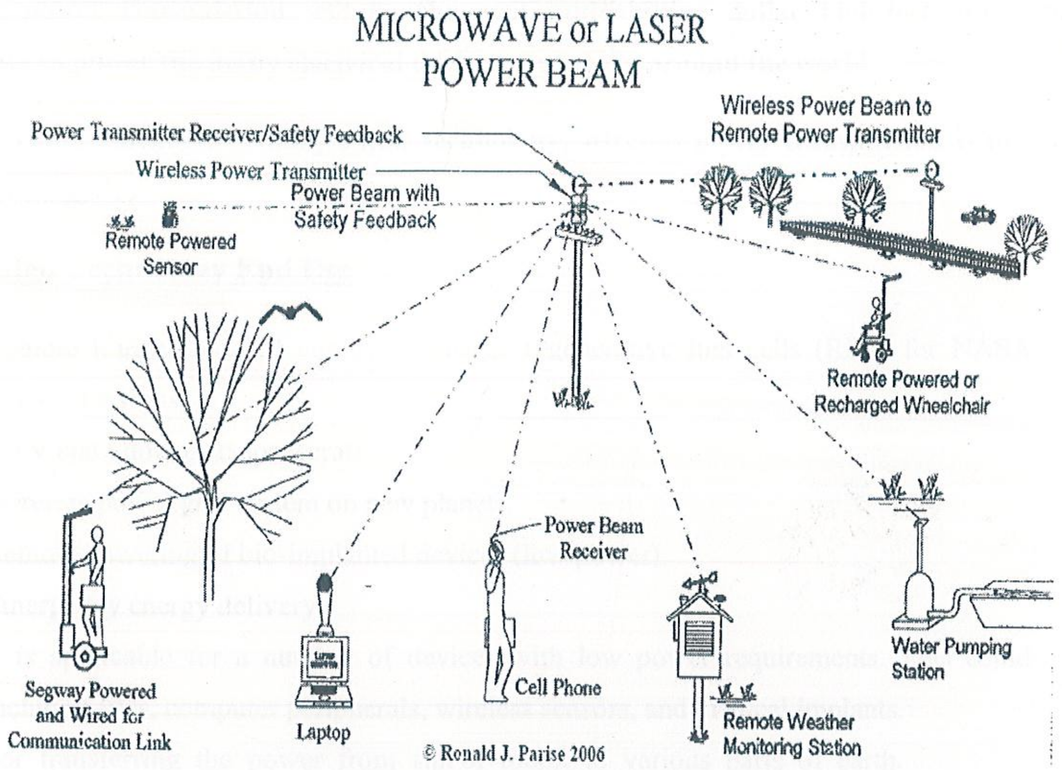


Figure 41

The wireless power beam can be microwave, laser, or any other power beam that can be transmitted over a substantial distance from the power transmitter to the device with minimal power attenuation in the atmosphere. This recharging/power system can be used on electrical power equipment: hand drills, hedge trimmers, snowblowers, etc., increasing operational reliability and longevity between recharges. The recharging system can be used for recreational vehicles such as golf carts, jet skis, snowmobiles, etc., reducing pollution and noise levels during operation, and improving convenience of operation.To provide energy to earth's increasing energy need the concept of wireless power transmission is a novel idea.To efficiently make use of renewable energy i.e.,solar energy. Solar panels can be employed outside in space so that abundant solar energy is available. Solar panels can placed in geostationary orbits.

On-board energy storage can be reduced significantly for any electrically powered portable device, reducing weight and allowing for component up-grades that require higher power levels.

Wireless power transmission will be the next multi-billion dollar high-tech innovation in electronics to power the many electrical devices used daily around the world.

Wireless communication is today's new technology; wireless power transmission is tomorrow's new technology!!!

Anticipated Technology End Use

- Remote transmission of energy to charge regenerative fuel cells (RFC) for NASA space missions.
- UAV and unmanned spacecraft.
- Wireless power grid system on new planets.
- Remote powering of bio-implanted devices (low power).
- Emergency energy delivery.
- It is applicable for a number of devices with low power requirements. This could include LEDs, computer peripherals, wireless sensors, and medical implants.
- For transferring the power from sun or moon to various parts of earth.
- The power transferred can be used to charge any appliance in the room wirelessly by increasing the strength of magnetic field and keeping in mind the safe exposures values of the corresponding field.
- RFID applications
- Mobile phone wireless charging
- Wireless Battery Charging For Electric Vehicles
- **Inductive coupling still has a definite future in the short range transmission distance. This particularly has medical implementations to transmit a few inches to power a remote sensor implanted in the human body.**

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