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Wireless Mobile Charger using Inductive Coupling

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Abstract: ***This system demonstrates the concept of wireless mobile charging system using the principle of inductive coupling. The system allows users to wirelessly charge their mobile phones without plugging in the mobile adapter. The system is demonstrated using a charging pad where users just need to place their adapter circuit to charge the mobile phone. For this purpose the advanced power transfer concept is utilized. A high frequency transformer is used to convert mains input 230V AC to 12 V DC. This output is supplied to the charging pad coil. When the adapter coil comes in range of the charging pad coil, the power is thus transferred wirelessly to the receiving coil and this 12 V DC is provided to the adapter circuit which is used to convert this 12 V DC to 5V DC which is then supplied to the mobile phone. So this allows us to charge the mobile phone wirelessly without plugging it in. The system can be further enhanced by integrating the charging adapter within the mobile itself so that users will just need to place their mobile phones on the charging pad to charge it.***

Index Terms**:** ***Advanced power transfer, inductive coupling, mobile charger, wireless.***

I. INTRODUCTION

This system demonstrates the concept of wireless mobile charging system. The system allows users to wirelessly charge their mobile phones without plugging in the mobile adapter. The system is demonstrated using a charging pad where users just need to place their adapter circuit to charge the mobile phone. For this purpose the advanced power transfer concept is utilized [1].

Most of today's wireless chargers use inductive charging that is using a transmitter and receiver coil in close proximity. Electric toothbrushes were one of the first devices to use this charging method and mobile phones are the largest growing sector to charge without wires. To retrofit an existing mobile phone for mobile charging, simply attach a "skin" that contains the receiver and provides interconnection to the charger socket. Many new devices will have this feature built in. Wireless charging with inductive coupling uses an electromagnetic field that transfers energy from the transmitter to the receiver [2].

It is well known that Nikola Tesla is a genius who lit the w orld. He is the person who defied the efficiency of direct current invented by Thomas Edison. After that, he invented the Alternating current in order to over come the problem of direct current [3].

When Nikola Tesla discovered alternating current (AC) electricity, he had great difficulty convincing men of his time to believe in it. Thomas Edison was in favor of direct current (DC) electricity and opposed AC electricity strenuously. Tesla eventually sold his rights of his alternating current patents to George Westinghouse for $1,000,000. After paying off his investors, Tesla spent his remaining funds on his other inventions and culminated his efforts in a major breakthrough in 1899 at Colorado Springs by transmitting 100 million volts of high-frequency electric power wirelessly over a distance of 26 miles at which he lit up a bank of 200 light bulbs and ran one electric motor! With this souped up version of his Tesla coil, Tesla claimed that only 5% of the transmitted energy was lost in the process. But broke of funds again, he looked for investors to back his project of broadcasting electric power in almost unlimited amounts to any point on the globe. The method he would use to produce this wireless power was to employ the earth's own resonance with its specific vibrational frequency to conduct AC electricity via a large electric oscillator [3].

II. PROBLEM STATEMENT

Nowadays, electricity is very important in daily life. Without any electrical appliance, the world will stop working. Some electrical and electronic appliances require charging, some examples been mobile phones, cameras, Bluetooth headsets and also car phone charging systems. A copper wire is used to transfer the current from the supplier to the load.

With so many appliances in one place there will be so many wires at that place to supply each appliance. The crowdedness of the cables produce mess which will produce other problems such as trip and fall and unplugging perplexity caused by intertwined of gadget cords.

The need to constantly plug and unplug the device also poses problems as there is significant wear and tear on the socket of the device and the attaching cable.

There is also cost associated with maintaining mechanical connectors and the usage of separate chargers will be eliminated too as it does not require wire for charging.

The study is therefore aimed at eliminating the above problems as well as the sparks and debris associated with so many wires or cables in contact and also promoting greater convenience and ubiquity for charging everyday devices.

By designing and constructing a method by circuit to transmit wireless electrical power (to transmit voltage) wirelessly from source to device (through space and charge a designated low power device) will eliminate the use of cables in the charging process thus making it simpler and easier to charge a low power device. It would also ensure the safety of the device since it would eliminate the risk of short circuit.

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III. OVERVIEW

By transferring voltage via cable, the efficiency of the power transferring is about 95%. The losses that appear in the transferring via cable are because of the insulator or cable heating. The losses of the power transfer via cable can be affected by the distance of the cable. The longer the cable, more losses occurred in the system.

Same thing happen to the wireless power transfer, losses happen in the circuit system. Moreover, losses that occur are gradually high. Just for a few inches of distance, the efficiency is dropping to only 10%.

In the way of transmitting the power wirelessly there are many methods that can be used which has been researched by others. As an example, the inductive coupling done by Marin Soljacic from MIT. Years ago, Tesla had performed so many researches on wireless power and he succeeded in his researches and managed to light a bulb grounded on earth [3].

Even so, he could not proceed with the mushroom cap wireless power transmitter due to some problem [3]. Many researches to continue his project are widely done nowadays.

A. Review of Existing Relevant Work

There are a number of methods for transmitting power wirelessly. The most popular and effective of which are inductive coupling, resonant inductive coupling, capacitive coupling, radio frequency and microwave power transmission, and laser power beaming. This section will discuss the different approaches of wireless charging devices.

Inductive Coupling

One of the oldest techniques of transferring energy wirelessly is inductive coupling. An inductor is a wire formed in a coil where an induced current produces a magnetic field which is based on the principle of electromagnetic induction [4]. Electromagnetic induction was first discovered by English scientist, Michael Faraday in 1831. He found that by moving a magnet through a coil of wire, a voltage was induced across the coil. When a complete path was created, the induced voltage caused an induced current. Faraday's Law states:

- The amount of voltage induced in a coil is directly proportional to the rate of change of the magnetic flux with respect to the coil, $\frac{d\varphi}{dt}$.
- The amount of voltage induced in a coil is directly proportional to the number of turnsof wire in the coil (N).

The formula that represents Faraday's Law is the following:

$$V_{ind} = N\frac{d\varphi}{dt}$$

Where Vind = the induced voltage

N = number of turns of wire in the coil

$\frac{d\varphi}{dt}$= the rate of change of the magnetic flux

The induced voltage is proportional to the number of turns of wire in the coil, and to the rate of change of the magnetic field.

Another method of inducing voltage across a coil is to cause the current to fluctuate.

When the current changes, the magnetic field also changes. This causes an induced voltage across the coil. The formula below is example of the effects of fluctuating current:

$$V_{ind} = L\frac{d\varphi}{dt}$$

Where Vind = the induced voltage

L = inductance

$\frac{d\varphi}{dt}$= the rate of change of the current

The induced voltage is directly proportional to the inductance, and to the rate of change of the current. It can be seen from this formula that the faster the current through an inductor changes, the greater the induced voltage will be. In an AC circuit, the induced voltage is directly dependent on frequency. As frequency increases so does the rate of change of the current.

The formula of inductance is as follows:

$$L = \frac{N^2 \mu A}{l}$$

$$\mu = \mu_r \mu_0$$

Where L = inductance of coil in Henrys

N = Number of turns in wire of coil (straight wire=1)

μ= Permeability of core material ($\mu = \mu_r \mu_0$)

μ_r = Relative permeability (1 for air)

μ_o = Permeability of free space ($4\pi \times 10^{-7} H/m$)

A = Area of coil in square meters (πr^2)

l = Average length of coil in meters

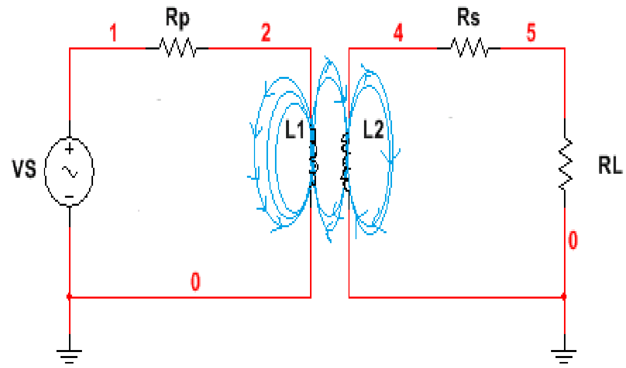

Fig 3.1: Simplified Circuit Illustrating Inductive Coupling [4]

When a second coil is introduced to a changing magnetic field of the primary coil, it will cause an induced voltage in the second coil, thereby magnetically coupling the coils.

The voltage induced in the second coil is a function of mutual inductance, calculated by the following formula:

$$L_M = k\sqrt{L_1 L_2}$$

Where L_M = Mutual inductance

k = coefficient coupling between the two coils

$$k = \frac{\varphi_1}{\varphi_2}$$

L_1 = Inductance of coil 1

L_2 = Inductance of coil 2

The formulas above describe the principles of induction and how voltage is induced in a second coil.

In the circuit in Fig 3.1, the transmitter has an AC source which is connected to a resistor (Rp) and an inductor (L1), where the resistor represents power loss due to heat. As inductor 1 (L1) receives the fluctuating current from the AC source it creates a magnetic field and induces voltage in L2.

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The receiver circuit which has L2, Rs, and RL is powered by the changing magnetic field of the transmitter. Again Rs represents the power loss of the inductor and RL is the load.

In order to strengthen the magnetic field of an inductor, a ferromagnetic core is inserted between the coils. A ferromagnetic core provides a better path for the magnetic lines of force and increases the amount of coupling between the coils [4].

Devices such as electric toothbrushes, charging mats for cell phones, and medical implants use this method to recharge batteries. Some of the disadvantages of inductive charging are the inefficiency of power transmission at a further distance, inability to control the electromagnetic interference, and the electric heat lost.

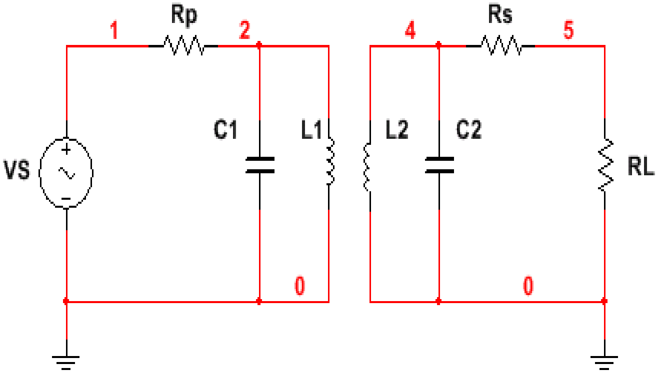

Fig 3.2: Simplified circuit of Resonant Induction Coupling [5]

There have been some attempts to reduce transfer loss in inductive coupling [5][6].

Methods such as implementing ultra-thin coils, higher frequencies, and enhancing drive electronics are possible solutions. When implementing higher frequency induction to deliver high power the efficiency reaches 86%, the other two methods are still being investigated for any improvements.

Resonant Induction

A variation of inductive coupling is resonant inductive coupling (RIC). A RIC circuit adds capacitors to the circuit to tune the circuit to the operating frequency. Resonance is the tendency of a system to oscillate with larger amplitude at some frequencies than at others. Resonance of a circuit involving capacitors and inductors, in parallel, occurs because the collapsing magnetic field of the inductor generates an electric current in its windings that charges the capacitor, and then the discharging capacitor provides an electric current that builds the magnetic field in the inductor. The circuit in Fig 3.2 is a simplified representation of resonant inductive coupling.

In this system, the capacitors in parallel with the inductor set the resonant frequency.

The two circuits need to resonate at the same frequency in order for this system to function properly. It is important to note that resonance increases the range of inductive coupling.

In 2007, MIT researchers experimented with self-resonant inductive coils, concluding that resonance enhances power transmission range and strength. The researchers demonstrated this by powering a 60W light bulb at a distance of two meters with an efficiency of 45%.

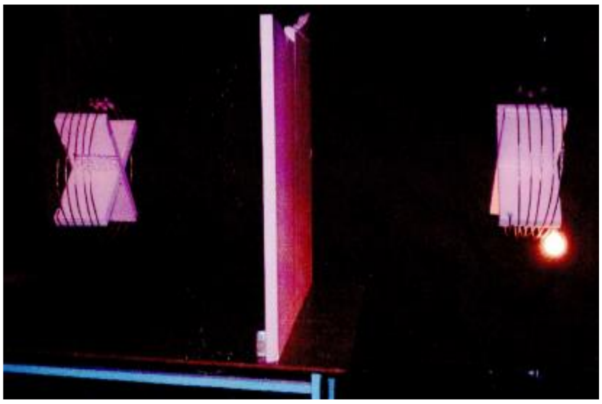

Fig 3.3: MIT lighting 60W bulb 2 meters away [7]

Capacitive Coupling

A third method for wireless power transfer involves separating the power source and the load with two parallel plates. These plates act as the anode and cathode of a typical parallel plate capacitor. Since the electric field is contained between the plates, there is very little energy leakage. However, this design's effectiveness is heavily dependent upon the available area on the receiving system, and the distance between the TX and RX plates.

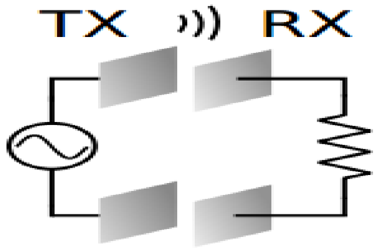

Fig 3.4: Basic Capacitive Coupled System [8]

Power is transferred to load based on the relationship:

$$I(t) = C\frac{dV}{dt}$$

Where C is the capacitance given by the equation for parallel plate capacitors:

$$C = \frac{\epsilon_r \epsilon_0 A}{d}$$

Where ϵ_r is the relative permittivity of air (1 in this case)

A is overlapping area,

d is the separation distance, and

ϵ_0 is the permittivity of a vacuum, 8.854×10^{-12} F/m

Since ϵ_r is approximately 1, the capacitance between the TX and RX plates will be much less than that of equivalently sized parallel plate capacitors. This results in a lower current and slower energy transfer. This makes it imperative that A be as large as possible and d be as small as possible. However, for mobile systems, particularly small ones, this bears the risk of limiting mobility and consuming valuable space on the platform. On the other hand, however, this method of charging is highly efficient. Most losses come from the source series resistance, R_S. Minimal losses result from the transfer itself. Thus, while the capacitive coupling method may be slower or larger than some alternatives, it is likely the most efficient means of energy transfer [8].

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Microwave Power Transmission

Microwaves are widely used for point-to-point communications because their small wavelength allows conveniently-sized antennas to direct them in narrow beams, which can be pointed directly at the receiving antenna. This allows nearby microwave equipment to use the same frequencies without interfering with each other, as lower frequency radio waves do.

Microwave power transfer (MPT) uses the far-field effects of electromagnetic radiation to transfer power wirelessly over long distances. Applications considered include energy transfer from space-based solar stations [8]. The basic premise for this type of power transmission is to use beam-forming or other directional antenna techniques to direct power to a combined rectifier/antenna unit (known as a “rectenna”). Current research on MPT has achieved relatively low efficiency rates, often less than 1% [9]. Additionally, microwave power transmission is limited by safety regulations set in the United States by the Federal Communications Commission (FCC). The FCC defines maximum permissible exposure rates for both the general public and for the workplace [10]. Guidelines based on these recommendations (intended for the communications industry, but applicable to all microwave applications) recommend power levels on the order 1 watt or less for a 3 foot dish antenna to keep exposure to acceptable levels more than one wavelength from the transmitting antenna [11]. While this limit could be exceeded by using the higher occupational exposure limits and by setting a minimum approach distance that is greater than one wavelength from the charging device(likely 1 meter or more, depending on the frequency and power levels used), it is unlikely that MPT will be able to match the power transfer levels of near-field techniques, especially considering efficiency.

Laser Power Beaming

Laser power beaming utilizes laser light to transfer electrical energy from one place to another [13].

It works on the same principles as solar power, using photovoltaic cells to generate electricity. The only difference is that, rather than collecting energy from the sun, energy from a source is used to generate a laser. The laser stimulates the photovoltaic cells, which generate electricity. Laser power beaming has a number of benefits. The narrow beam of the laser allows for energy transfer at long distances. The receiver consists only of a small photovoltaic array, allowing for easy integration even in compact devices. Unlike other methods of energy transfer, laser power beaming does not interfere with nearby radio signals [13]. However, there are several severe limitations on transferring energy via laser.

First, the amount of power transferred is directly proportional to the power of the laser.

This makes this method impractical for anything more that charging relatively small, lightly loaded devices. The more power the system requires the larger and stronger the laser must be to sustain it. As the laser becomes more powerful, the overall system becomes prohibitively expensive. Additionally, having a large number of high power lasers would make the environment dangerous for human workers as those lasers could pose a serious threat of bodily harm.

Another limitation is the efficiency of modern photovoltaics. Current technology only allows for less than 20% efficiency on average, meaning that only 1/5 of the energy directed at a photovoltaic cell is converted into useable electrical energy. Certain types of photovoltaics known as concentrator solar cells can have efficiencies as high as 40%, but this still represents a prohibitive amount of energy loss. This also only represents losses on the receiving side of the transfer and does not take into account the efficiency of the laser emitter. This can vary greatly depending upon the laser design and output power. However, the higher the power of the laser, the less efficient the energy conversion process becomes [13].

B. Market

In recent years, markets of wireless charging have gradually grown as consumers are purchasing more electronic devices. According to the company IHS Technology, the wireless power market is expected to grow from $216 million in 2013 to $8.5 billion in 2018 [14]. This is due to an anticipated switch from wired to wireless technologies within many industries. For example, Thoratec, a healthcare company, is working with WiTricity on a wireless way to charge heart pumps and other medical equipment. Another example is, Lockheed Martin, the aerospace and defense giant. Lockheed is working on a laser-based system to recharge drones in mid-light[14]. This technology has helped industry to explore into a new dimension which they use to contribute to the study of wireless power transfer.

C. Health and Safety Concerns

One of the biggest concerns of wireless power transmission is safety for the environment and for humans. Exposure to electromagnetic fields (EMF) is not a new phenomenon, but exposure to man-made electromagnetic fields has been steadily increasing as technologies and communication behavior have created more and more artificial sources. Currently there are multiple organizations studying the effects of EMF. Organizations such as the World Health Organization (WHO) [15], the International Commission on Non-Ionizing Radiation Protection (ICNIRP),

National Institute for Occupational Safety and Health (NIOSH), and the Institute of Electrical and Electronic Engineering (IEEE) studied and formulated guidelines establishing limits of EMF exposure [6].

At the relatively low utilization frequencies of operation of this project, RF safety is not a significant issue.

With RF and lower frequencies, the primary health concern comes from heating due to EM wave absorption by the body. The amount of absorption is related to the wavelength of the EM wave relative to the body. At low frequencies, these wavelengths are on the order of hundreds of meters to kilometers. At these wavelengths, absorption levels are much lower than at frequencies where the waves are of similar wavelength to the human body.

Frequencies below 100kHz are often below the threshold where specific exposure limits are defined, due to their low risk for adverse health effects.

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D. Detailed Review of the Best Work

From the medium of transmission presented above, many things have to be considered before choosing the medium of transmission for this project. The efficiency of the medium, the cost of the project, the health and safety concern and the simplest project as it can be.

From the consideration above, the simplest project that can be done is the transmission by using the inductive coupling. The design of the project will be displayed in the methodology.

E. Brief Introduction of Proposed Work

Inductive Coupling

Inductive or Magnetic coupling works on the principle of electromagnetism. When a wire is in proximity to a magnetic field, it generates a magnetic field in that wire. Transferring energy between wires through magnetic fields is inductive coupling. If a portion of the magnetic flux established by one circuit interlinks with the second circuit, then two circuits are coupled magnetically and the energy may be transferred from one circuit to the other circuit.

This energy transfer is performed by the transfer of the magnetic field which is common to both circuits.

In electrical engineering, two conductors are referred to as mutual-inductively coupled or magnetically coupled when they are con Figd such that change in current flow through one wire induces a voltage across the end of the other wire through electromagnetic induction. The amount of inductive coupling between two conductors is measured by their mutual inductance [4].

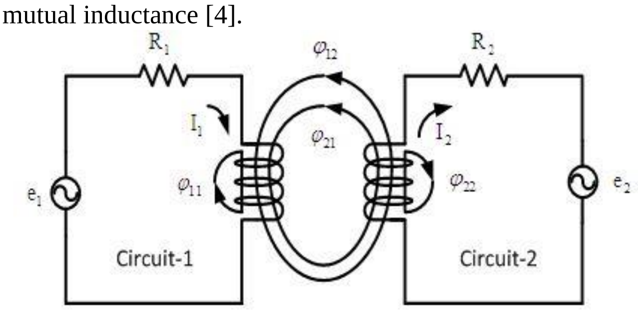

Fig 3.5: Inductive coupling with four component fluxes [4]

Magnetic coupling between two individual circuits are shown in Fig 3.5. For the purpose of analysis we assume the total flux which is established by *i*1 (circuit-1 current) is divided into two components. One component of it is that part which links with circuit-1 but not with circuit-2, φ_{11}. The second component of it is which links with both circuit-2 and circuit-1, φ_{12}. In this similar way the flux established by *i*2 (circuit-2 current) also has two components. One component of it is φ_{22} which links with only circuit-2 but not with circuit-1 and the other component is φ_{21} which link with both circuit-2 and circuit-1.

$\varphi_1=\varphi_{11}+\varphi_{12}$ and,

$\varphi_2=\varphi_{22}+\varphi_{21}$

In equation one, φ_{12} is a fractional part of φ_1, which links with the turns of circuit-2. So φ_{12} is called the mutual flux produced by circuit-1.

In the same way, in equation two, φ_{21} is the fractional part of φ_2 which links with the turns of circuit-1. So φ_{21} is called the mutual flux produced by circuit-2.

This is the phenomenon of how the inductive coupling takes place between two individual circuits. This effect can be magnified or amplified through coiling the wire.

Power transfer efficiency of inductive coupling can be increased by increasing the number of turns in the coil, the strength of the current, the area of cross-section of the coil and the strength of the radial magnetic field. Magnetic fields decay quickly, making inductive coupling effective at a very short range.

Inductive Charging

Inductive charging uses the electromagnetic field to transfer energy between two objects. A charging station sends energy through inductive coupling to an electrical device, which stores the energy in the batteries. Because there is a small gap between the two coils, inductive charging is one kind of short-distance wireless energy transfer.

Induction chargers typically use an induction coil to create an alternating electromagnetic field from within a charging base station, and a second induction coil in the portable device takes power from the electromagnetic field and converts it back into electrical current to charge the battery. The two induction coils in proximity combine to form an electrical transformer.

Greater distances can be achieved when the inductive charging system uses resonant inductive coupling [16].

Advantages of Inductive Charging

Inductive charging carries a far lower risk of electrical shock, when compared with conductive charging, because there are no exposed conductors. The ability to fully enclose the charging connection also makes the approach attractive where water impermeability is required; for instance, inductive charging is used for implanted medical devices that require periodic or even constant external power, and for electric hygiene devices, such as toothbrushes and shavers, that are frequently used near or even in water.

Inductive charging makes charging mobile devices and electric vehicles more convenient; rather than having to connect a power cable, the unit can be placed on or close to a charge plate [16].

Drawbacks of Inductive Charging

The main disadvantages of inductive charging are its lower efficiency and increased resistive heating in comparison to direct contact. Implementations using lower frequencies or older drive technologies charge more slowly and generate heat for most portable electronics. Inductive charging also requires drive electronics and coils that increase manufacturing complexity and cost [16].

Newer approaches diminish the transfer losses with ultra-thin coils, higher frequencies and optimized drive electronics, thus providing chargers and receivers that are compact, more efficient and can be integrated into mobile devices or batteries with minimal change. These technologies provide charging time that is the same as wired approaches and are rapidly finding their way into mobile devices. The Magnetic charge system employed high-frequency induction to deliver high power at an efficiency of 86% (6.6 kW power delivery from a 7.68 kW power draw) [16].

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Uses of Inductive Charging and Inductive Coupling

- Inductive charging is used in transcutaneous energy transfer (TET) systems in artificial hearts and other surgically implanted devices.
- It is used in Oral-B rechargeable toothbrushes by the Braun (company) since the early 1990s.
- Hughes Electronics developed the magnetic charge interface for general motors. The general motors' EV1 electric car was charged by inserting an inductive charging paddle into a receptacle on the vehicle. General motors and Toyota agreed on this interface and it was also used in the Chevrolet S-10 EV and Toyota RAV4 EV vehicles.
- Nintendo Wii uses an energizer inductive charging station for inductively charging the Wii remote.

IV. METHODOLOGY

Since this project is aimed at charging mobile phone wirelessly, Descriptive, Analytical, Applied, and Fundamental based researches are carried out.

The entire circuit of the wireless mobile charger was redrawn from a preliminary drawing using livewire simulation software. This is software used to design or build circuits as well as simulate them to check for accuracy and efficiency of the circuit design before finally constructing the physical work.

This section explains the methods used in the designing and constructing of the device; the components used and a list of various tools and equipment used. Several tests are done on both the software and hardware parts. Troubleshooting of the designed wireless mobile charger is carried out.

A. Tools and Equipment Used

Several tools and equipment were used during the design and construction of this project. Some of these tools and equipment and how they proved useful are explained below.

- *Set of screw drivers:*

The screwdrivers were used to tighten and loosen screws.

- *Magnifying glass:*

The magnifying glass was used in identifying the colour coding of resistors and also aided in soldering.

- *Soldering iron and soldering iron stand:*

The soldering iron was used to melt lead to enable soldering of components. The soldering iron heats to a high temperature which posed danger so the soldering stand was used to contain it while it was hot to prevent danger.

- *Soldering iron sucker:*

The soldering iron sucker was used to dis-solder the lead from the PCB.

- *Multimeter:*

This is an electronic measuring instrument which combines several electrical measurement functions into one unit. It is used to measure voltages (volts), currents (amperes), resistances (ohms), and also to check continuity of the circuit. It was also used to test components such as the fuses and continuity in the cables used.

- *Oscilloscope*

The oscilloscope is an instrument used to display and analyze the waveform of electronic signal.

B. Block Diagram of Wireless Mobile Charger

The block diagram of wireless mobile charger consist of two sections namely the transmitter circuit and the receiver circuit, the transmitter circuit consist of a 230V AC supply, AC to DC rectifier, DC to AC inverter, a high frequency transformer and a transmitter coil whiles the receiver circuit consist of a receiver coil, AC to DC rectifier, voltage regulator and finally a mobile phone which is used as a load.

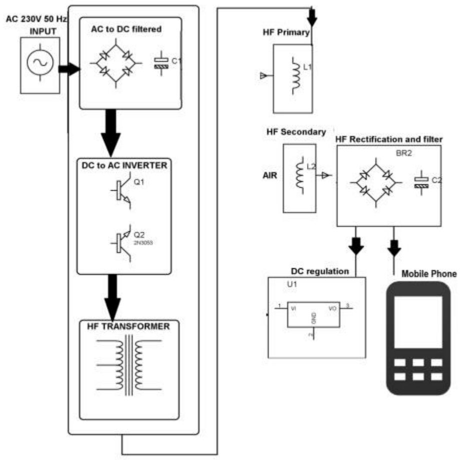

Fig 4.1: Block diagram of wireless mobile phone charger [17]

C. Component Specification

Table I: Component Specification [17]

Number	Name	Specification	Quantity
1	Fuse	630Ma (5A)	1
2	Printed circuit board	Small	1
3	LED	Red	1
4	Fixed capacitor	0.22µF/100V	4
5	Electrolytic capacitor	470µF/35Vand 10µF/63V	2
6	Resistor	330+/- 5%Ω and 7.8+/-5%Ω	5
7	Diode (1N4007)	BA157	10
8	Zener diode	1N4734A	1
9	Coil	26guage, 9cm diameter	1
10	Bipolar transistors (NPN)	2N3053	2
11	Voltage regulator IC	7805	1
12	High frequency transformer	230V to 12V (AC)	1
13	USB connector	4 pin	1
14	PBT connector	2-pin	1

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D. Component Analysis

Hardware Components:

1. High frequency transformer
2. Voltage regulator
3. Transistor
4. Coil
5. LED
6. Diode
7. Resistor
8. Capacitor
9. Fuse
10. USB connector
11. PBT connector

High Frequency Transformer

The high-frequency transformers are calculated with the help of the effective core volume V_e and the minimum core-cross-section A_{min}. For a required power output $P_{out} = V_{out} \cdot I_{out}$ and a chosen switching frequency a suitable core volume V_e must be determined. Then an optimal ΔB is selected depending on the chosen switching frequency and also regarding the temperature rise of the transformer. Frequencies are usually between 20 and 100kHz [18].

In this our project high frequency transformer was used to convert 230V AC to 12V AC and to gain a frequency between 25kHz to 40kHz.

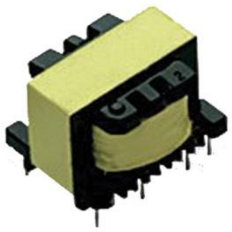

Fig 4.2: Image of HF-Transformer [18]

Voltage Regulator IC

Features

- Output Current up to 1A
- Output Voltages of 5, 6, 8, 9, 10, 12, 15, 18, 24V
- Thermal Overload Protection
- Short Circuit Protection
- Output Transistor Safe Operating Area Protection

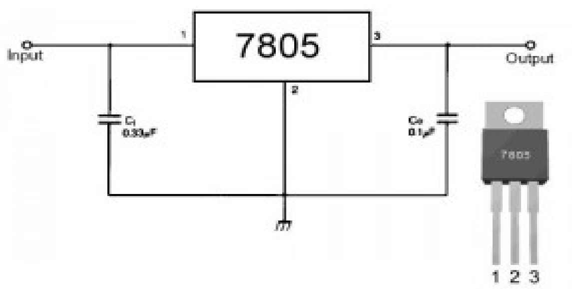

Fig 4.3: Diagram of Voltage Regulator [19]

A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level. A voltage regulator may be a simple "feed-forward" design or may include feedback control. In this project a 7805 voltage regulator was used in order to maintain a constant output voltage of 5V DC.

The output voltage can only be held *roughly* constant; the regulation is specified by two measurements:

Load regulation is the change in output voltage for a given change in load current (for example: "typically 15mV, maximum 100mV for load currents between 5mA and 1.4A, at some specified temperature and input voltage").

Line regulation or input regulation is the degree to which output voltage changes with input (supply) voltage changes - as a ratio of output to input change (for example "typically 13mV/V"), or the output voltage change over the entire specified input voltage range (for example "plus or minus 2% for input voltages between 90V and 260V, 50-60Hz") [19].

Transistor

A transistor is a semiconductor device used to amplify and switch electronic signals. NPN, a two-junction (bipolar) semiconductor transistor with an N-type collector and emitter, and a P-type base. In such a device, the current amplification arises from the injection of holes from the emitter into the base, and their subsequent collection in the collector [20]. In this project two 2N3053 bipolar transistors (NPN) were used as a switch and to aid the transformer attain a frequency between 25kHz to 40kHz.

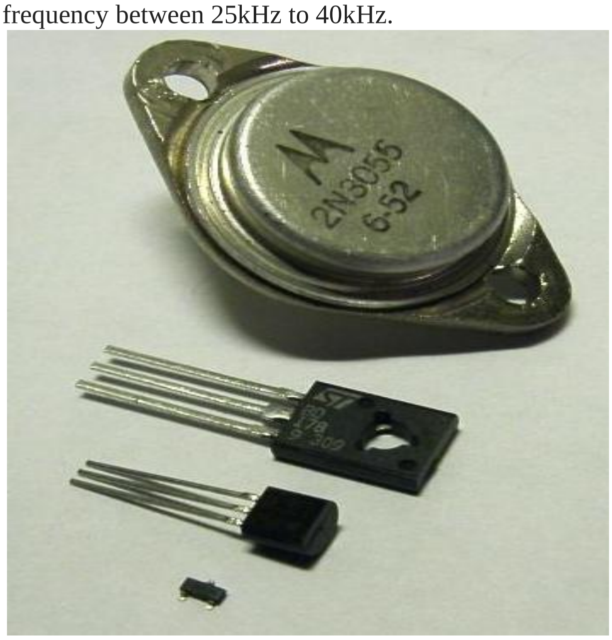

Fig 4.4 Image of Bipolar Transistors (NPN) [20]

Coil

A coil is a series of loops. A coiled coil is a structure where the coil itself is in turn also looping, one loop of wire is usually referred to as a turn, and a coil consists of one or more turns. Coils are often coated with varnish and/or wrapped with insulating tape to provide additional insulation and secure them in place.

In this project a 26 gauge copper wire was used to form a coil of 9 turns at the transmitter side and 36 turns at the receiver side.

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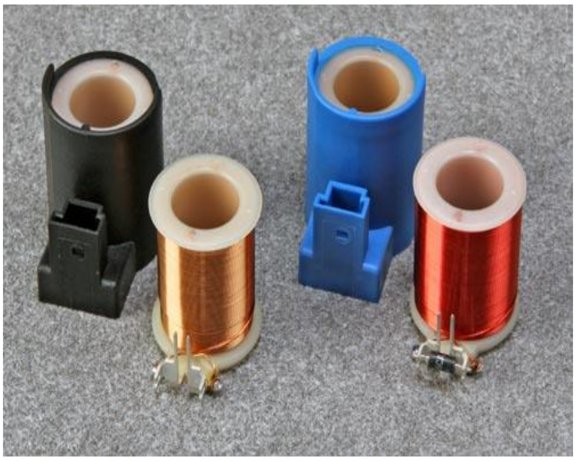

Fig 4.5: Image of a coil [21]

LED

LED(s) are semiconductor devices. Like transistors, and other diodes, LED(s) are made out of silicon. What makes an LED give off light are the small amounts of chemical impurities that are added to the silicon, such as gallium, arsenide, indium, and nitride. When current passes through the LED, it emits photons as a by-product [22].

In this our project a red LED was used as a power indicator and moreover LED(s) produce photons directly and not via heat.

Fig 4.6: Image of LED [22]

Diode

Diodes are used to convert AC into DC these are used as half wave rectifier or full wave rectifier. Three points must be kept in mind while using any type of diode.

- Maximum forward current capacity
- Maximum reverse voltage capacity
- Maximum forward voltage capacity

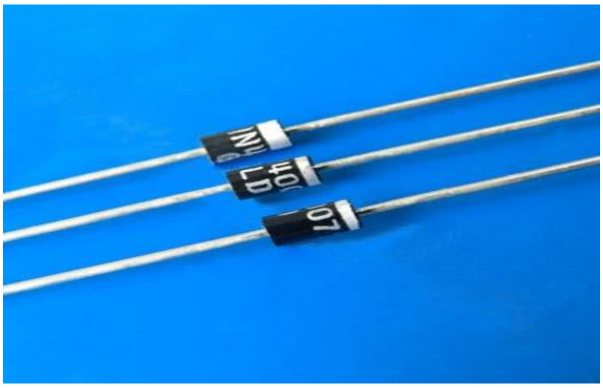

Fig 4.7a: Image of PN junction diodes [23]

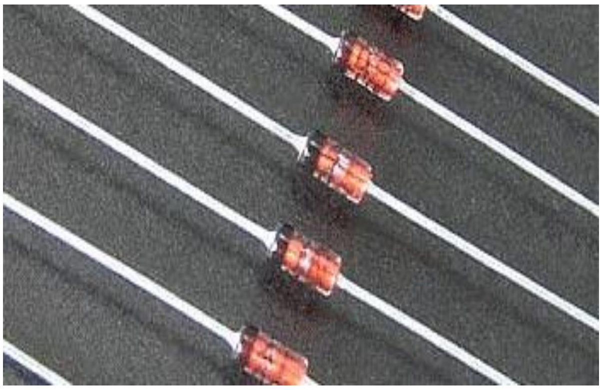

Fig 4.7b: Image of zener diodes [23]

In this project four PN junction, 1N4007 type diodes were used as a bridge rectifier and zener diode also to serve a purpose of blocking the charges feeding when the load is fully charged and more importantly because of the following reason:

Diodes of number IN4001, IN4002, IN4003, IN4004, IN4005, IN4006 and IN4007 have maximum reverse bias voltage capacity of 50V and maximum forward current capacity of 1 Amp.

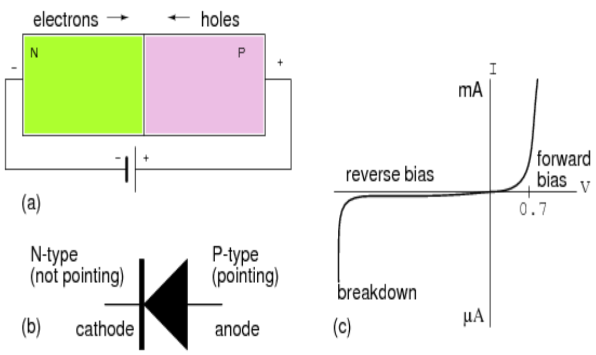

Fig 4.8: Characteratic curve of PN Junction diode [23]

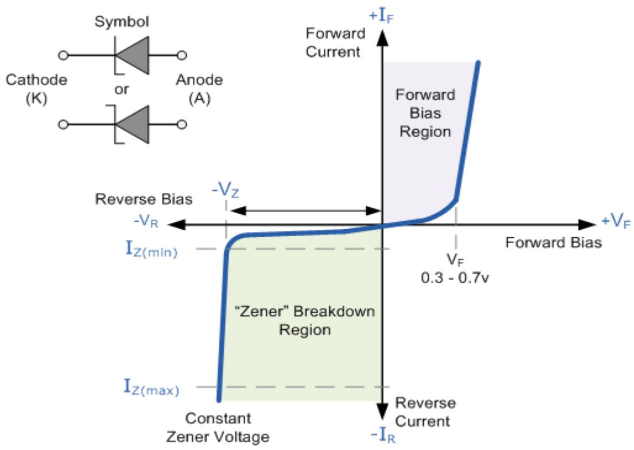

Fig 4.9: Characteristic curve of zener diode [23]

Resistor

A resistor is a two-terminal electronic component designed to oppose an electric current by producing a voltage drop between its terminals in proportion to the current, that is, in accordance with Ohm's law: V = IR

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Fig 4.10: Image of Film Resistors [24]

The primary characteristics of resistors are their resistance and the power they can dissipate. Other characteristics include temperature coefficient, noise, and inductance. Less well-known is critical resistance, the value below which power dissipation limits the maximum permitted current flow, and above which the limit is applied voltage [24].

In this project film resistors were used to limit the flow of current with regards to the component they are installed to.

Capacitor

A capacitor is a passive electronic component consisting of a pair of conductors separated by a dielectric. When a voltage potential difference exists between the conductors, an electric field is present in the dielectric. This field stores energy and produces a mechanical force between the plates. The effect is greatest between wide, flat, parallel, narrowly separated conductors.

Fixed Capacitor

The fixed capacitor is constructed in such a manner that it possesses a fixed value of capacitance which cannot be adjusted; it was used in the project to maintain a constant and unchanging value of capacitance and also has the ability to hold an electrical charge.

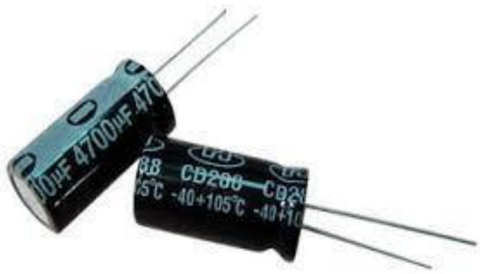

Fig 4.11: Image of Fixed Capacitors [25]

Electrolytic Capacitor

The electrolytic capacitor is used in the project because they are polarized capacitors whose anode electrode (+) are made of a special metal on which an insulating oxide layer originates by anodiazation (forming), which acts as the dielectric of the electrolytic capacitor.

Electrolytic capacitor is used where a large amount of capacitance is required. It was used for the project because of its following features;

- It containment of a high concentration of ions
- They are polarized, which means that the voltage on the positive terminal must always be greater than the voltage on the negative terminal

Fig 4.12: Image of Electrolytic Capacitor [26]

Fuse

A fuse is a type of low resistance resistor that acts as a sacrificial device to provide over current protection of either the load or source circuit. Its essential component is a metal wire or strip that melts when too much current flows through it, interrupting the circuit that it connects [27].

In the project a 5A cartridge fuse was connected at the point of the 230V AC input to protect the circuit from a current above 5A.

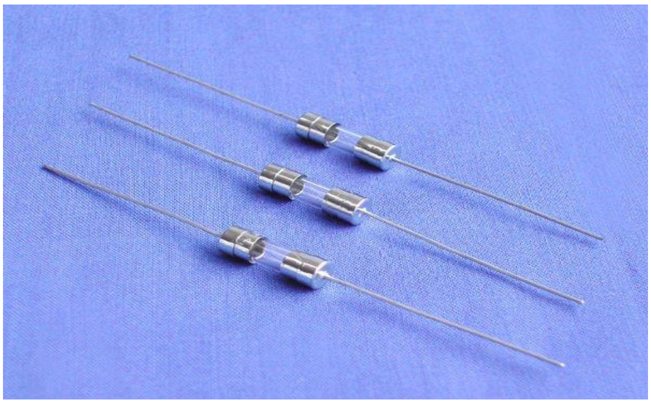

Fig 4.13: Image of cartridge fuses [27]

USB Connector

Universal Serial Bus (USB) is a hardware interface for connecting peripherals such as keyboards, mouse, joystick, storage device etc [28].

USB connector was used in the project as a port in which the USB cable is connected to in order to induce power to the phone through the USB cable.

Fig 4.14: Image of USB connecter [28]

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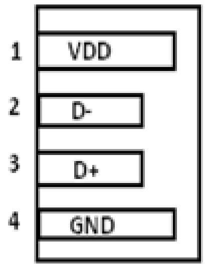
USB Power



VDD	Red
D-	White
D+	Green
GND	Black

Fig 4.15: Block Diagram and Table of a Typical USB Connector [28]

Before using USB as a power source you must be aware of the colour coding. The Fig C and table D shows the colour coding of a typical USB A type connector. If you cut open a USB cable you will see 5 different wires. There is a shielding wire which shields the USB data from interference. There are Red and Black wires which form the VDD and Ground respectively. Then there are White and Green wires which form D- and D+ which are used for data communication [28].

In this project USB bus forms part of the USB connecter to supply 5V DC regulated power (maximum 500mA) to each port on pins 1 and 4 (Refer Fig C). The pins 1 and 4 are longer than the data pins to ensure that the power pins mate first and next the Data pins. Low power devices can then therefore be powered from USB there by eliminating the need of separate power supply such as Adaptors.

PBT Connector

Two Pin, Screw type PCB Terminal Block, generally used for power connections on a circuit board. Owing to high mechanical strength, heat resistance up to 150degC and non-combustible nature of the PBT (Polybutylene terephthalate) material.

In our project PBT connecter type was used to link the receiver coil to the receiver circuit board and also is strongly recommended for connections that require high degree of electrical insulation [29].

Fig 4.16: Image of PBT connector screw terminal - 2 Pin [29]

E. Circuit Design of Wireless Mobile Charger

The device was first designed and the circuit proposed was simulated using a computer simulation software (livewire software). A prototype was then constructed and tested before it was transferred to the perforated board.

Design of the Device

The design of the project is divided into sections. Each section was separately designed according to the desired specificaions.

Design of the AC Power Supply and Rectification Circuit

A 5A fuse was used for protection from over currents and short circuits.

This section is intended to receive an incoming 230V AC power input and then rectified by four diodes with the full wave rectification system which convert the 230V AC into pulsating 230V DC. The rectified output is then smoothed by a filter consisting of capacitors because of the pulsating DC output.

Design of the Inverter Circuit

The filted 230V DC is then converted back to 230V AC by running it through two NPN- transistors whose output transformer is very small with few windings at a frequency of tens or hundreds of kilohertz. The frequency is usually chosen to be above 20kHz to make it inaudible to humans.

Design of Transformer Circuit

This section is intended to receive an incoming 230V AC power input and then step it down to approximately 12V AC and at the same time, protect the circuit from over currents and short circuits.

A step down transformer rated 230V/12V capable of handling the maximum current (1.5A) to be drawn by the circuit was used to achieve the conversion from 230V to 12V.

Design of the Transmitter Coil and Receivcer Coil

This stage consist of two coils namely the transmitter coil which is of 9 turns, 26 gauge copper size and a diameter of 9cm, and the receiver coil which is of 36 turns, 26 gauge copper size and a diameter of 9cm. The transmitter coil induces the 12V AC which from the transformer wireless to the reciever coil by the help of inductive coupling.

Design of the Rectification Circuit

The rectification circuit consists of four 1n4007 diodes (D1, D2, D3 and D4) and an electrolytic capacitor (C5). The four 1N4007 diodes will be connected in bridge with the electrolytic capacitor connected in shunt with the diodes and it negative terminal connected to the ground.

The rectification circuit will be used to rectify the 12V AC to 12V DC. During the first half alternating cycle, diode (D1) offers a higher resistance and hence prevent high current to flow through it to the circuit, while diode (D2) offers a lower resistance and hence allows current to flow through to the circuit. In the second half alternating cycle, the same thing happens to diode (D3) and (D4) and hence full cycle is obtained.

The rectified DC voltage is then filtered by an electrolytic capacitor of about 1000microf.

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Design of Voltage Regulator Circuit

- The filtered DC voltage being unregulated IC LM7805 is used to get 5v constant at its pin no 3 irrespective of input dc varying from 9v to 14v.
- The regulated 5volts dc is further filtered by a small electrolytic capacitor of 10 micro F for any noise generated by the circuit which can be used for battery charging. One LED is connected to this 5v point in series with a resistor of 330ohms to the ground i.e. negative voltage to indicate 5v power supply availability.

E. Design Calculation (Wireless Power Transfer Model Calculation)

Details of Transmitting Coil:
Radius of the transmitting coil (r) = 4.5cm
Radius of the cross-section (a) = 0.09cm
Number of transmitting coil Turns (N) = 9 turns
Coil wire size= 26 gauge
Diameter= 9cm
Width of the winding=11.139

Details of Receiving Coil:
Radius of the receiving coil (r) = 4.5cm
Radius of the cross-section (a) = 0.225cm
Number of receiving coil Turns (N) = 36 turns
Coil wire size= 26 gauge
Diameter= 9cm
Width of the winding=11.139

F. Theoretical Calculation

- Inductance of the Winding:

Inductance of transmitter coil = $N^2 \mu_0 r$ (ln (8r/a) – 1.75)
= 9^2 x 4π x 10^{-7} x 8 x (ln ((8x4.5)/0.225) -1.75)
= 2.708mH
Inductance of receiver coil = $N^2 \mu_0 r$ (ln (8r/a) – 1.75)
= 36^2 x 4π x 10^{-7} x 8 x (ln((8x0.45)/0.225) - 1.75)
= 43.3mH

- Resistance of the winding:

Resistance of the Winding (R) = ρl/A
Length of transmitter coil (l)=Circumference of coil x N
= 2π x D x N
=2π x 9 x 9
= 508.938cm
Length of receiver coil (l) = Circumference of coil x N
= 2π x D x N
=2π x 9 x 36
= 2035.752cm
A = 2πr(r+h), where, h = width of the winding
= 2π x 4.5 (4.5+11.139)
= 442.24cm
P = Resistivity of Copper
= 1.796×10^{-8}
Resistance of transmitter coil = 2.066×10^{-8} Ω
Resistance of receiver coil = 8.267×10^{-8} Ω

- Resistance of Leakage path:

R = ρl/A
P = Resistivity of Air = 10^6 (assumed)
l = length of air gap = 6.5cm (Distance to be transmitted)
A = Area of air gap (Rectangular Area between two coils)
R = 1.54 MΩ

- Resonant Frequency:

f = 1/2π sq.rt of LC
L = = 2.708mH
C = 0.0047nF (Capacitor Used)
f = 1.4 MHz

- Resonance Condition:

For Resonance to occur, $X_L = X_C$
X_L = Inductive reactance (Reactance of Coil)
X_C = Capacitive Reactance
X_L = 2π x f x L
= 23820.812 Ω
= 23.8 KΩ
X_C = 1/2π x f x C
= 24188 Ω
= 24.188 KΩ

Thus, $X_L = X_C$ and so Resonance occurs resulting in transfer of power wirelessly.

G. Simulation of Circuit Diagram

The simulation of the circuit diagram of wireless mobile phone charger was done by the help of livewire-professional edition software.

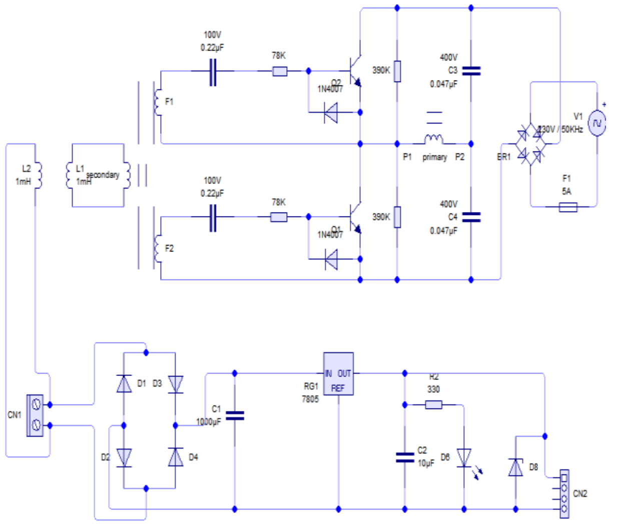

Fig 4.17: Simulation of wireless mobile charger circuit diagram [17]

H. Procedures for Constructing Wireless Mobile Charger

The device was first designed and the circuit proposed was simulated using a computer simulation program. A prototype was then constructed and tested before it was transferred to the printed circuit board (PCB). Considering this project we had to mount the component related to power supply sections as per the circuit diagram and the layout. While mounting we checked for the proper polarity of components like diodes, electrolytic capacitors, etc. as one reversed polarity mounting could result in none functioning of the project or even sometimes damaging to the extent of irrepairability. The components we soldered with the help of soldering iron and soldering wire (lead). For soldering, the soldering iron was powered up and made to heat for about few seconds, once heated up, it was ready to solder components to the board.

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The components were soldered by touching the hot tip of the iron between the component leads and the copper surface of the printed circuit board (PCB) along with the solder wire tip touched at the same spot.

Solder wire melt on the copper surface also touching the component lead resulting in canonical formation with the component lead at its center and PCB at its base after removal of the iron from the tip of the component and the surface. This whole process of soldering a point did not take more than 5 seconds else a component might burn out from heat of iron and could be rendered useless.

The soldering process started with the component from the lowest level of mounting and then soldered the component of greater height of mounting, and once the power supply section was mounted, IC sockets were mounted. Power was applied to the board without inserting the IC's in the socket.

Continuity between directly connected components was checked with the multimeter in buzzer mode without giving power to the board. The output for 12V DC/5V DC was also checked for by taking power from the transformer, the power indicator of the LED glows, and situations where the LED did not turn on meant there had to be checks for the polarity of the components if properly assembled and also checked the continuity of the tracks on the PCB.

A check was made for the 5V DC across the VCC and GND terminals of the IC bases. Starting with mounting of output side components, checks was made for input power at the input point of components/socket like transistors, inverters, filters, etc.

As continuity test was carried out without applying power, there were some discontinuities found. A jumper wire was thus soldered between the discontinuous points. Power on test was then carried out from the output side to check if the output devices were functioning properly.

I. Packaging of Wireless Mobile Charger

- The measurement of the printed circuit board was taken and coral draw software was used to draw the design of the Perspex sheet. The computer output is connected to a machine called epilock which was used to cut the size of the printed circuit board.
- The constructed circuit was enclosed in a spacious Perspex box.
- The printed circuit board with the device circuit was glued down to the Perspex box.
- The transmitter and the receiver coils were held in position with a perspex sheet.
- Epoxy glue was used to seal the edges of the Perspex box with that completing the packaging.

J. Testing of the Device

Continuity Test:

- In electronics, a continuity test is the checking of an electric circuit to see if current flows (that it is in fact a complete circuit). A continuity test is performed by placing a small voltage (wired in series with an LED or noise-producing component such as a piezoelectric speaker) across the chosen path. If electron flow is inhibited by broken conductors, damaged components, or excessive resistance, the circuit is "open".
- This test is performed just after the hardware soldering and configuration has been completed. This test aims at finding any electrical open paths in the circuit after the soldering. Many a times, the electrical continuity in the circuit is lost due to improper soldering, wrong and rough handling of the PCB, improper usage of the soldering iron, component failures and presence of bugs in the circuit diagram. We use a multi meter to perform this test. We keep the multi meter in buzzer mode and connect the ground terminal of the multi meter to the ground. We connect both the terminals across the path that needs to be checked. If there is continuation then you will hear the beep sound.

Power on Test:

- This test is performed to check whether the voltage at different terminals is according to the requirement or not. We take a multi meter and put it in voltage mode. Remember that this test is performed without ICs. Firstly, we check the output of the High frequency transformer; whether we get the required 12V AC voltage.
- We then apply this voltage to the power supply circuit. Note that we do this test without ICs because if there is any excessive voltage, this may lead to damaging the ICs.
- We check for the input to the voltage regulator (7805) i.e., are we getting an input of 12V and a required output. EX: if we are using 7805 we get output of 5V at output pin.
- This output from the voltage regulator is given to the power supply pin of specific ICs. Hence we check for the voltage level at those pins whether we are getting required voltage. Similarly, we check for the other terminals for the required voltage. In this way we can be assured that the voltage at all the terminals is as per the requirement.

K. Precautionary Measures Taken in the Design and Construction

A lot of precautions were taken during the design and construction of the device. The following are some of the precautions taken:

- With the power supply cut off from the PCB, the IC's were carefully inserted thus special attention was taken while inserting the IC's because if the pins bent while inserting, they may break off rendering it unusable for further use in the project.
- The assembled PCB was kept in far off vicinity of moisture areas as water may short circuit the PCB (when powered on).
- The data sheets of the various components were consulted to ensure proper pin connection and correct functioning.
- All components in the circuit were connected in their right polarities to prevent explosion.
- Calmness and relaxation was ensured to prevent misconnection of components.
- The use of isolated power source to enable the system reduces risk and also reduces the possibility of destroying the test equipment.
- The casing for the device was constructed with a Perspex material for it to have a lighter weight.

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- The soldering iron was used to melt lead to enable soldering of components. The soldering iron heats to a high temperature which posed danger so the soldering stand was used to contain it while it was hot to prevent danger.

V. DISCUSSIONS AND RESULTS

A. Discussions

Block Diagram of Wireless Mobile Charger Using Inductive Coupling

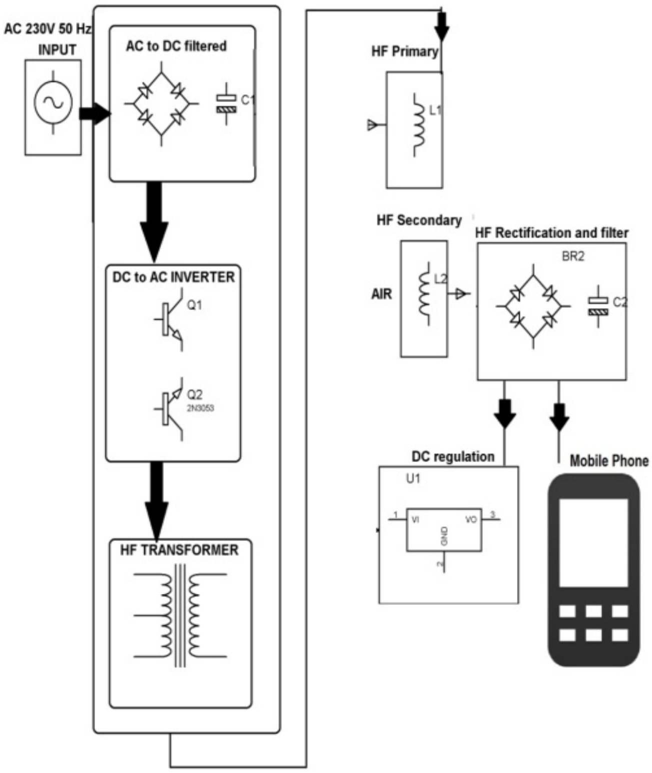

Fig 5.1: Block diagram of wireless mobile charger [17]

Detailed Explanation of the Block Diagram of Wireless Mobile Charger

Rectifier and Filter Stage:

AC input of 230V is rectified by four diodes with the full wave rectification system which converts the 230V AC into pulsating 230V DC. The rectified output is then smoothed by a filter consisting of capacitors because of the pulsating DC output.

Inverter Stage:

The filtered 230V DC is then converted back to 230V AC by running it through two NPN- transistors whose output transformer is very small with few windings at a frequency of tens or hundreds of kilohertz. The frequency is usually chosen to be above 20kHz to make it inaudible to humans.

HF Transformer Stage:

The inverted 230V AC is used to drive the primary winding of the high-frequency transformer. This converts the voltage to 12V AC on its secondary winding at a frequency of 25kHz to 40Khz.

HF Primary and Secondary Coil Stage:

This stage consist of two coils namely the transmitter coil which is of 9 turns, 26 gauge copper size and a diameter of 9cm, and the receiver coil which is of 36 turns, 26 gauge copper size and a diameter of 9cm. The transmitter coil induces the 12V AC which is from the transformer wirelessly to the receiver coil by the help of inductive coupling.

HF Rectification and Filter Stage:

The 12V AC output from the transformer is rectified by four diodes with the full wave rectification system which convert the 12V AC into pulsating 12V DC.

The rectified output is then smoothed by a filter consisting of capacitors because of the pulsating DC output.

DC Regulation Stage:

At this stage the filtered 12V DC is been automatically regulated to get an output voltage of 5V DC which is constantly maintained and being fed to the output load.

Circuit Design by Simulation

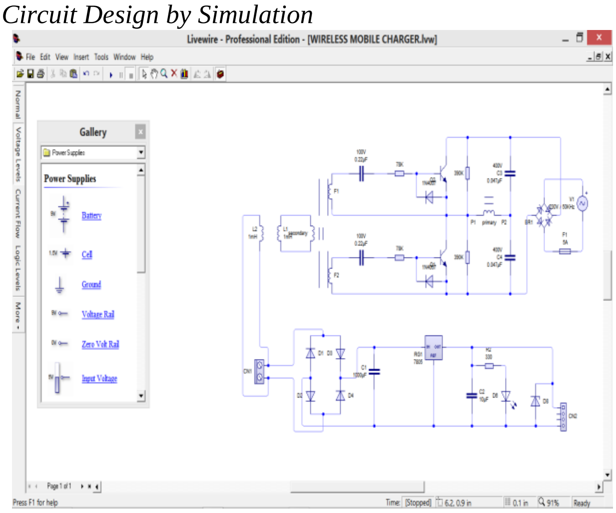

Fig 5.2: Circuit diagram of wireless mobile charger [30]

Operation of Circuit Design by Simulation

Electronic transformer works on half bridge and double line frequency. The AC power is given as an input to the bridge rectifier where it is converted into DC. Through a resistor and capacitor it gets charged, in one half cycle Q1 (collector to emitter) starts conducting, F1 provides biasing for this Q1 transistor. Current flows from P1 to P2 of primary coil. Then current passes through capacitor C4 and reaches ground. In another half cycle Q2 (collector to emitter) starts conducting and F2 provides bias for this transistor. Then current flows through C3 and then P2 to P1 reaches Q2 and then negative. So in one half cycle flow of current it is from P1 to P2, in another half cycle flow of current it is from P2 to P1. Biasing for F1, F2 is done automatically i.e. we can't say that when which coil gets bias, so current flowing in the primary coil in both half cycles generates AC in secondary coil. As the transistors are fast switching devices frequency of AC becomes 25KHz.This is fed to copper windings L1 which are connected to secondary of transformer.L1 transfers the 25 KHz AC to L2 by means of EMF (Principle of transformer). Voltage induced L2 coil is fed to 4 diodes forming a Bridge Rectifier that delivers dc which is then filtered by an electrolytic capacitor of about 1000microf. The filtered dc being regulated IC LM7805 is used to get 5v constant at its pin no 3 irrespective of input dc varying from 9v to 14v. The regulated 5volts dc is further filtered by a small electrolytic capacitor of 10 micro F for any noise generated by the circuit which can be used for battery charging.

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One LED is connected to this 5v point in series with a resistor of 330ohms to the ground i.e. negative voltage to indicate 5v power supply availability. The 5v dc is used for other applications as at when required. The output of bridge rectifier i.e., +12V is taken to drive the 12V DC Fan.

Advantages and Disadvantages of the Wireless Mobile Charger

Advantages

Wireless Power Transmission Using 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.

Lower Frequency Operation – The operating frequency range is in the kilohertz range. Furthermore there is low risk of radiation in the LF band.

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 was 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.

Disadvantages

Wireless Power Transmission using Inductive coupling also has some disadvantage's that need to be addressed.

High Power Loss – Due its air core design the flux leakage is very high. This results in a high power loss and low efficiency. But when combined with the resonant principle, Power loss can be reduced with an increase in 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.

B. Results

Performance Graph

The voltage being transmitted to the receiver drops as the distance between the transmitter circuit and the receiver circuit increases.

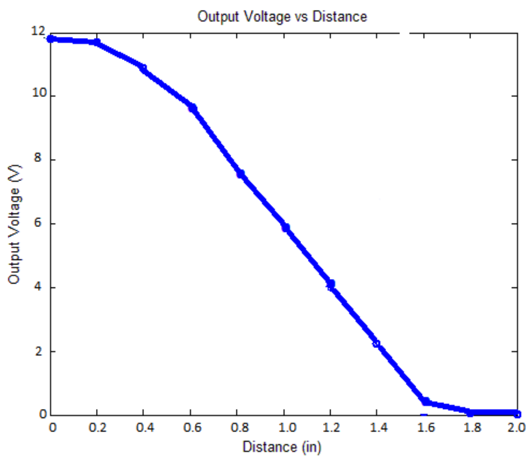

Fig 5.3: Graph between Voltage and Distance [17]

The efficiency of the power being transmitted drops as the distance between the transmitter circuit and the receiver circuit increases.

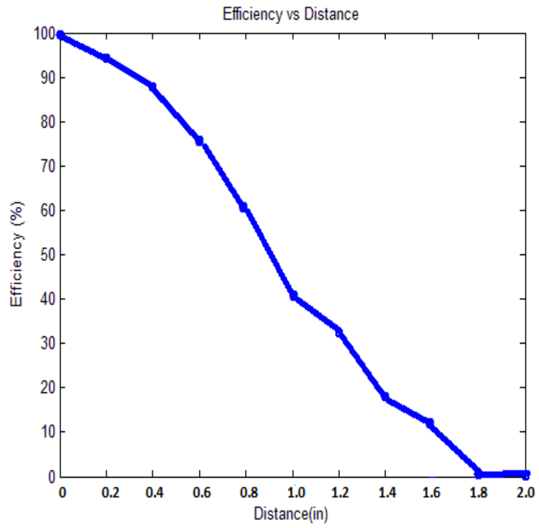

Fig 5.4: Graph between Efficiency and Distance [17]

Performance and Analysis

230V AC was provided to the input of the high frequency transformer.

12V AC was calculated across the transmitter coil.

When the distance between transmitter coil and receiver coil was 0 inch, the voltage measured across the receiver coil was 11.8v. So the energy transfer efficiency was 95.5%.

When the distance between transmitter coil and receiver coil was 0.2 inches, the voltage measured across the receiver coil was 11.7V AC. So the energy transfer efficiency was 94.35%.

When the distance between transmitter coil and receiver coil was 0.4 inches, the voltage measured across the receiver coil was 10.9V AC. So the energy transfer efficiency was 87.94%.

When the distance between transmitter coil and receiver coil was 0.6 inches, the voltage measured across the receiver coil was 9.3V AC. So the energy transfer efficiency was 76.93%.

When the distance between transmitter coil and receiver coil was 0.8 inches, the voltage measured across the receiver coil was 7.4V AC. So the energy transfer efficiency was 61.61%.

When the distance between transmitter coil and receiver coil was 1 inch, the voltage measured across the receiver coil was 5.9V AC. So the energy transfer efficiency was 41.07%.

When the distance between transmitter coil and receiver coil was 1.2 inches, the voltage measured across the receiver coil was 4.1V AC. So the energy transfer efficiency was 36.96%.

When the distance between transmitter coil and receiver coil was 1.4 inches, the voltage measured across the receiver coil was 2.3V AC. So the energy transfer efficiency was 16.42%.

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When the distance between transmitter coil and receiver coil was 1.6 inches, the voltage measured across the receiver coil was 0.5V AC. So the energy transfer efficiency was 12.3%

The above mentioned measurements suggest that the system is suitable for use only when the distance between transmitter coil and receiver coil ranges from 0 to about 1.4inches.

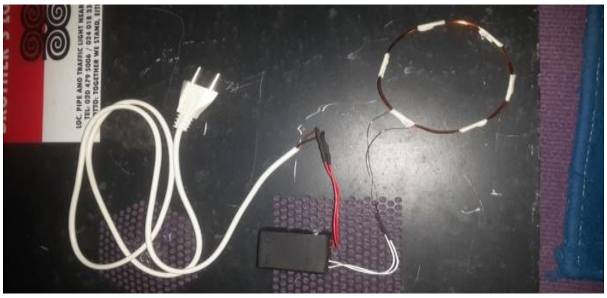

Fig 5.5: Photograph of transmitter circuit after construction [17]

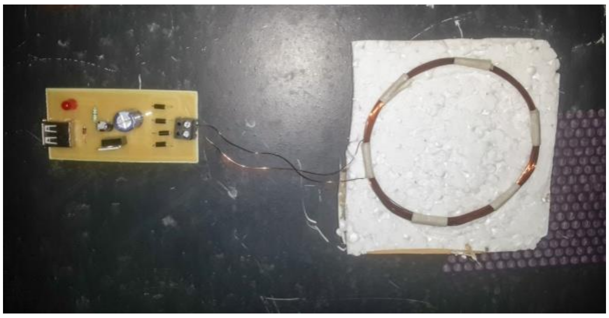

Fig 5.6: Photograph of Receiver circuit after construction [17]

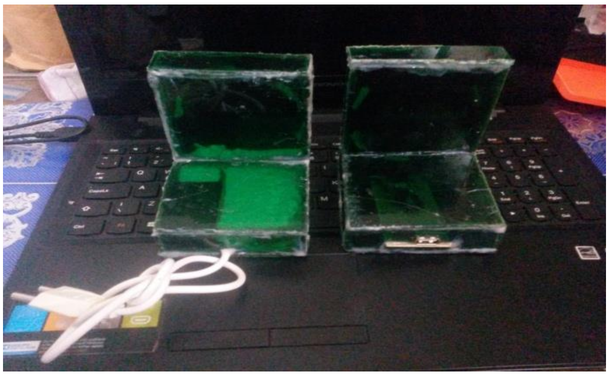

Fig 5.7: Photograph of wireless mobile charger using inductive coupling final work [17]

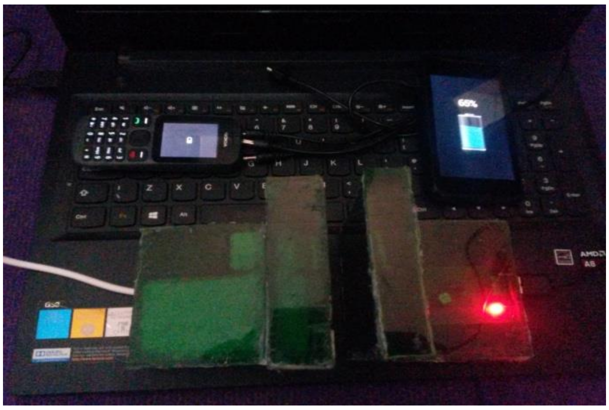

Fig 5.8: Photograph of final work during testing [17]

VI. CONCLUSION

This system demonstrates the concept of wireless mobile charging system. For this purpose a high frequency transformer was used to convert mains input 230V AC to 12 V DC. This output was supplied to the charging pad coil when the adapter coil comes in range of the charging pad coil, the power is transferred wirelessly to the receiving coil and this 12 V DC is provided to the adapter circuit which is used to convert this 12 V DC to 5V DC which is then supplied to the mobile phone. The goal of this project was to design and implement a wireless mobile phone charger via inductive coupling. After analysing the whole system step by step for optimization, a system was designed and implemented. Experimental results showed that significant improvements in terms of power-transfer efficiency have been achieved and measured results were in good agreement with the theoretical models. It was described and demonstrated that inductive coupling could be used to deliver power wirelessly from a source coil to a load coil and charge a mobile phone. This mechanism is a potentially robust means for charging mobile phone wirelessly.

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