WIRELESS CHARGER

Micro Project Report

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CERTIFICATE

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ABSTRACT

The main objective of this project is to demonstrate 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. It is demonstrated using a charging pad where users just need to place their adapter circuit to charge their mobile phone. The system is based on a coupling magnetic field, thus designed and constructed as two parts: the transmitter part and receiver part. An oscillation circuit converts DC energy to AC energy to transmit magnetic field by passing frequency and then induce the receiver coil. The Ampere’s law, Biot Savart’s law and Faraday law are used to calculate the inductive coupling between the transmitter coil and the receiver coil. We have constructed a wireless mobile charger using magnetic induction and the efficiency of the system is calculated by varying the distance between the coils.

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INTRODUCTION

In recent years, wireless charging technology has gained significant attention and popularity due to its convenience and potential to revolutionize the way we power electronic devices. Wireless charging eliminates the need for cumbersome cables and adapters, allowing for a more streamlined and efficient charging experience. This technology has found applications in various sectors, including consumer electronics, automotive, healthcare, and more.

Wireless charging, also known as inductive charging, utilizes the principles of electromagnetic induction to transfer power wirelessly between a charger (transmitter) and a compatible device (receiver). It relies on the concept of creating a magnetic field to induce an electric current in a nearby receiver, enabling the charging process.

Wireless charging technology represents a significant step forward in the realm of power delivery for electronic devices. Its convenience, flexibility, and potential for integration across multiple industries make it an appealing solution for a wire-free future. As research and development continue, wireless charging is expected to evolve further, offering faster charging speeds, longer ranges, and broader compatibility.

PRINCIPLE OF WORKING

2.1 Near Field Vs Far Field-

Near Field in Wireless Transmission:

The near field in wireless transmission refers to the region immediately surrounding the transmitter, where the electromagnetic fields are dominant. This region is also known as the reactive near field or induction field. In near-field communication (NFC) or wireless charging applications, the near field is the primary focus.

In the near field, the wireless signals are characterized by complex interactions between the transmitter and the receiving device. The behavior of the signals in this region is influenced by the proximity and geometry of the transmitter and receiver. The near field is typically characterized by a distance that is much smaller than the wavelength of the transmitted signals.

Far Field in Wireless Transmission:

The far field in wireless transmission refers to the region farther away from the transmitter, where the electromagnetic fields propagate as electromagnetic waves. This region is also known as the radiation field or the free-space propagation region.

In the far field, the wireless signals exhibit well-defined characteristics and follow the principles of electromagnetic wave propagation. The signal strength decreases with distance according to the inverse square law, and the wavefronts become more planar and uniform. The far field is typically characterized by a distance that is several wavelengths or more.

The transition between the near field and the far field occurs at a distance known as the far-field distance or the Fraunhofer distance. This distance depends on the wavelength of the transmitted signals and the size of the transmitter. The distinction between the near field and the far field is relevant in wireless communication systems for different reasons. In near-field communication (NFC) technologies, such as contactless payments or data transfer between devices, the near field is utilized for short-range communication within a few centimeters. In contrast, the far field is important for long-range wireless communication, where the transmitted signals propagate over greater distances and cover larger areas.

2.2 Inductive Coupling-

Inductive coupling is a fundamental principle of wireless charging technology. It involves the transfer of power wirelessly between a charger (transmitter) and a compatible device (receiver) through the use of electromagnetic induction.

In inductive coupling, an alternating current is passed through a coil in the charging pad, creating a time-varying magnetic field around it. When the receiver, equipped with its own coil, comes into proximity with this magnetic field, it induces a current in the receiver's coil through electromagnetic induction. This induced current is then converted back into electrical energy, allowing the device to be charged without the need for physical connections or cables.

Overall, inductive coupling enables the transfer of power from the charging pad to the receiver by utilizing the magnetic field created by the alternating current, providing a wireless and convenient charging experience.

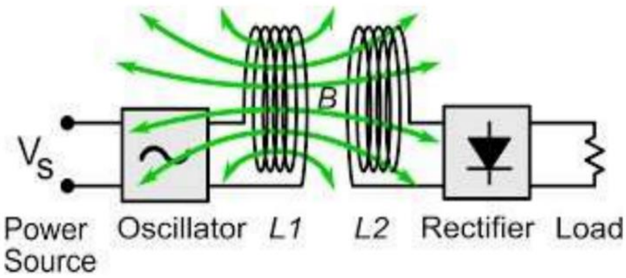

Fig 1. Simplified Circuit Illustrating Inductive Coupling

Inductive coupling in wireless charging can be described using the following formulas:

2.2.1 Mutual Inductance (M):

Mutual inductance represents the extent to which two coils are coupled magnetically. It is denoted by the symbol M and is measured in Henry (H). The mutual inductance between two coils can be calculated using the formula:

$$M = k * \sqrt{L1 * L2}$$

Where:

M is the mutual inductance

k is the coefficient of coupling (ranges from 0 to 1, representing poor to perfect coupling)

L1 and L2 are the self-inductances of the two coils

2.2.2Induced Voltage (V):

The induced voltage in the receiver coil can be calculated using Faraday's law of electromagnetic induction. The formula is:

$$V = -M * dI/dt$$

Where:

V is the induced voltage

M is the mutual inductance between the transmitter and receiver coils

dI/dt is the rate of change of current in the transmitter coil

OVERVIEW OF COMPONENTS

Hardware Requirements:

- Copper Wire (25 gauge)
- IRFZ44N MOSFET
- LM7805 and LM7809
- Transformer
- Resistors
- Capacitors
- IN4007 Diode
- Type-C Connector
- Breadboard

HARDWARE SPECIFICATIONS:

3.1 Copper Wire:

A copper wire is a single electrical conductor made of copper. Copper has the lowest resistance to the flow of electricity of all non-precious metals. It has high tensile strength thus resists stretching, neck-down, creep, nicks and breaks, and thereby also prevents failures and service interruptions. Copper has a higher ductility than alternate metal conductors with the exception of gold and silver hence it is easy to draw down 16 to diameters with very close tolerances. Copper has excellent creep characteristics that minimizes loosening at connections. It resists corrosion from moisture, humidity, industrial pollution, and other atmospheric influences.

3.2 IRFZ44N MOSFET:

MOSFET is an abbreviation for metal-oxide semiconductor field-effect transistors. It has a source, gate, and drain. The gate of a MOSFET is insulated from the channel. Because of this MOSFET is known as an IGFET which stands for insulated-gate field effect transistor. Unlike transistors, MOSFETs are voltage controlled devices i.e. they can be turned on or turned off by supplying the required Gate threshold voltage (VGS). There are two basic types of MOSFETs :-

i)Depletion type MOSFET (D-type MOSFET)
ii)Enhancement type MOSFET (E-type MOSFET)

The primary difference between the two types of MOSFETs is the difference between the constructions. The IRFZ44N is a N-channel enhancement type MOSFET with a high drain current of 49A and low Rds value of 17.5 mΩ which help in increasing the efficiency of switching circuits. It also has a low threshold voltage of 4V at which the MOSFET will start conducting. Hence it is commonly used with microcontrollers to drive with 5V. The pulsed drain current (ID-peak) is 160A, minimum gate threshold voltage (VGS-th) is 2V, maximum gate threshold voltage (VGS-th) is 4V, gate-source voltage is (VGS) is ±20V (max), maximum drain-source voltage (VDS) is 55V.

Fig.2 IRFZ44N MOSFET

IRFZ44N PINOUT CONFIGURATION:

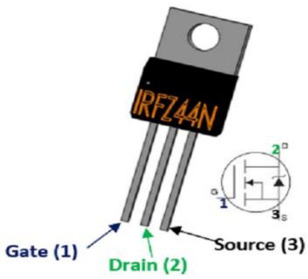

Fig.3 Pinout Configuration of IRFZ44N MOSFET

PIN NAME AND CORRESPONDING FUNCTIONS:

Pin Number	Pin Name	Description
1	Gate	Controls the biasing of MOSFET
2	Drain	Current flows in through Drain

3	Source	Current flows out through source

Table 1

3.3 IN40007 Diode:

IN4007 diode is a device which allows current flow through only one direction. That is the current should always flow from the anode to cathode. The IN4007 diode can be used to prevent reverse polarity problems. They are used in half wave and full wave rectifiers. And also used as protection devices and current flow regulator.

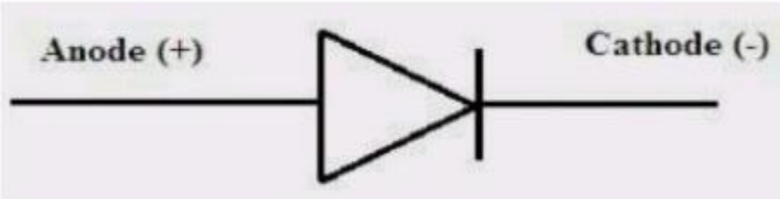

Fig.4 Symbol of Diode

3.4 Capacitor:

Capacitors an electrical or electronic component that stores electric charges. Basically, a capacitor consists of 2 parallel plates made up of conducting materials, and a dielectric material (air, mica, paper, plastic, etc.) placed between them. Electrolytic capacitors are polarized capacitors so these are used where energy with required polarity is necessary. Here oxide film obtained by a chemical reaction acts as a dielectric material. Capacitors are used as filters in rectifier circuits, as bypass capacitors in amplifier circuits. They are also used in T.V. and radio receivers for tuning purposes.

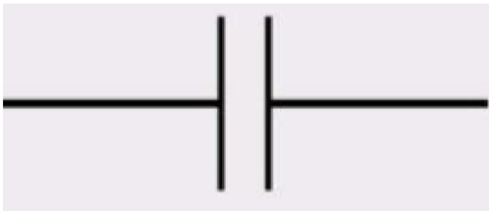

Fig.5 Symbol of Capacitor

3.5 LM7805 and LM7809:

The 7805 and 7809 Voltage Regulator IC is a commonly used voltage regulator that finds its application in most of the electronics projects. It provides a constant +5V output voltage for a variable input voltage supply. 7805 IC is an iconic regulator IC that finds its application in most of the projects. The name 7805 signifies two meanings, “78” means that it is a positive voltage regulator and “05” means that it provides 5V as output. Hence 7805 will provide a +5V output voltage.

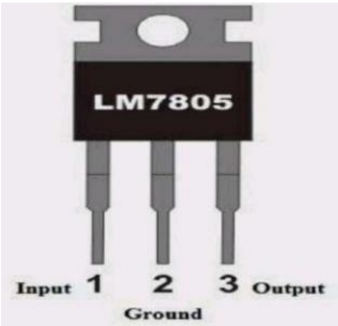

Fig.6 LM7805

3.6 Resistors:

A resistor is a passive electronic component and senses to prevent or limit the flow of electrons. It is a two terminal device that works on the principle of ohm’s law which prevents overflow of voltage. Resistance can be derived from ohm’s law i.e. V=IR, which indicates that voltage is directly proportional to the current flowing through the conductor. Each resistor comes with two wires called leads. Between these two leads there lies a ceramic part which actually resists the flow of current. Resistor consists of 3 coloured strips that indicate the value of resistance.

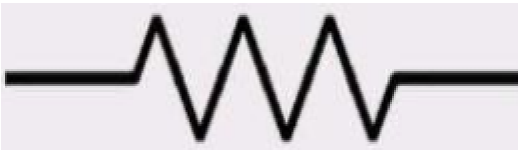

Fig.7 Symbol of Resistor

3.7 Transformer:

A transformer is an electrical device that transfers electrical energy between two or more circuits through electromagnetic induction. It consists of two or more coils of wire, known as windings, which are magnetically coupled but electrically isolated from each other. Transformers are widely used in various applications, including power transmission, voltage regulation, and impedance matching.

Voltage Transformation:

The voltage transformation ratio of a transformer is determined by the turns ratio. For an ideal transformer with negligible losses, the voltage transformation can be calculated using the following formula:

$$V2 = V1 * a$$

Where:

V1 is the voltage across the primary winding

V2 is the voltage across the secondary winding

a is the turns ratio (N1 / N2)

Fig.8 Transformer

3.8 Breadboard:

A Breadboard, also known as a protoboard, is a construction base for prototyping of electrons. The word referred to a literal breadboard, a polished piece of wood used for slicing bread. Later, solderless breadboards became available as it does not require soldering, and is used for creating temporary prototypes and experimenting with circuit design which means it is reusable and because of this reason it is popular among students for many projects. The bread board consists of clips which are called tie or contact points, the clips will be maintaining a gap of 2.54mm between each one of them. They are connected from pin to other pins using metal strips.

METHODOLOGY

Wireless charging technology enables wireless power transfer from a power source such as charger to a load such as a mobile device conveniently across an air gap by eliminating the bunch of wire. Wireless power transmission involves the exchange of power without the need for physical connections.

Circuit Diagram:

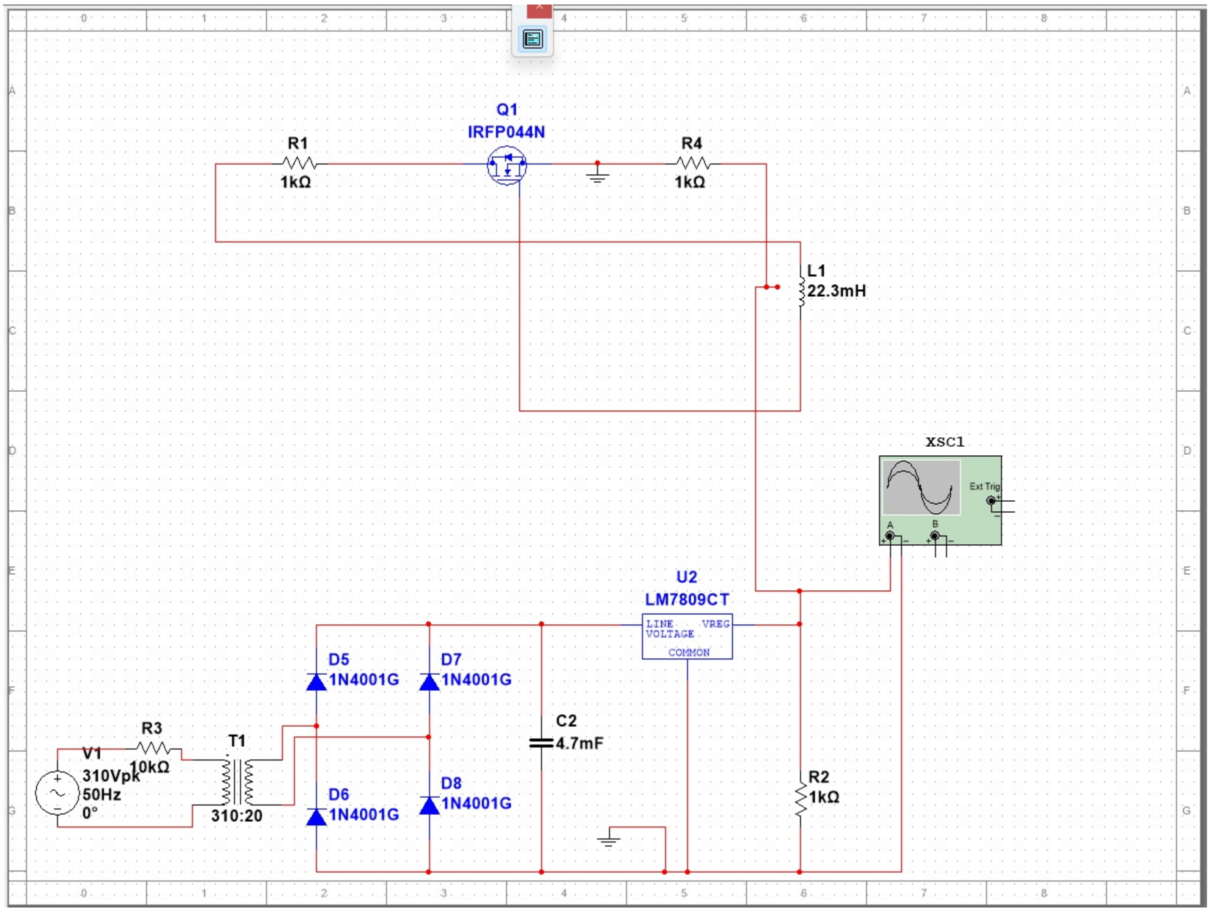

Fig.9 Transmitter Circuit

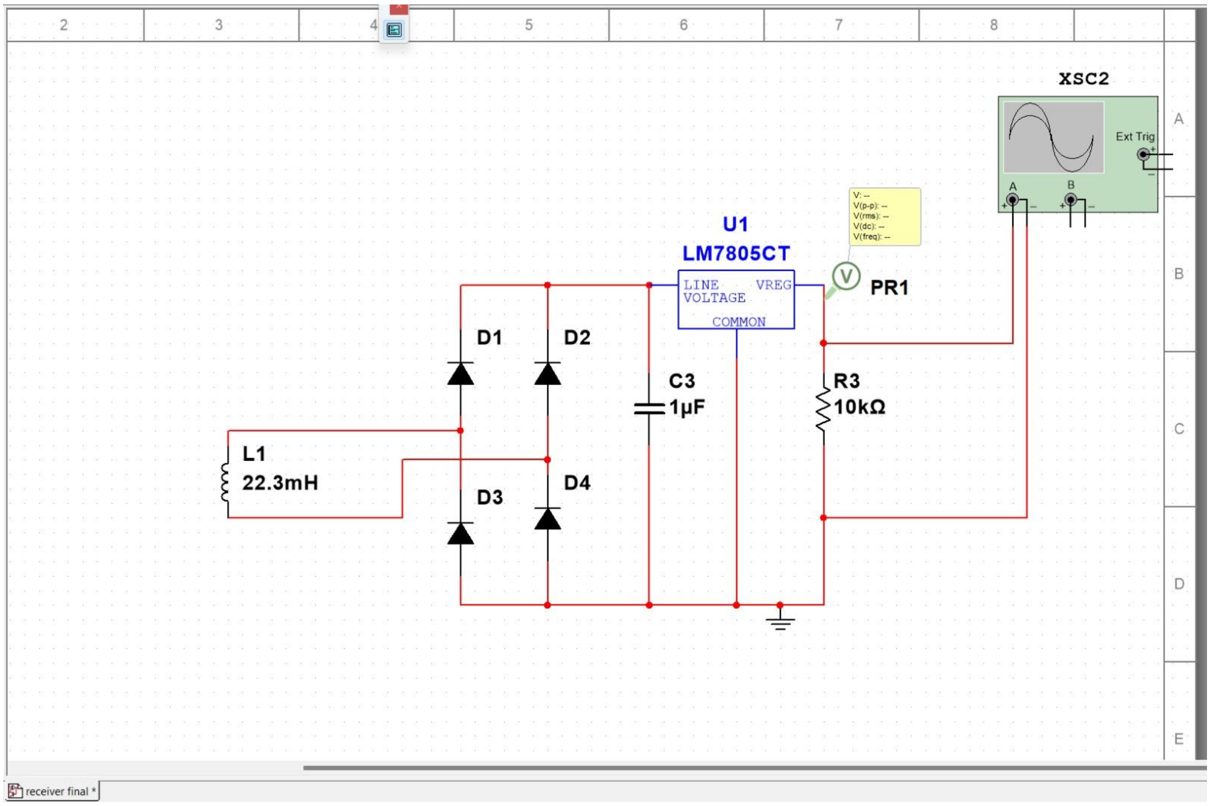

Fig.10 Receiver Circuit

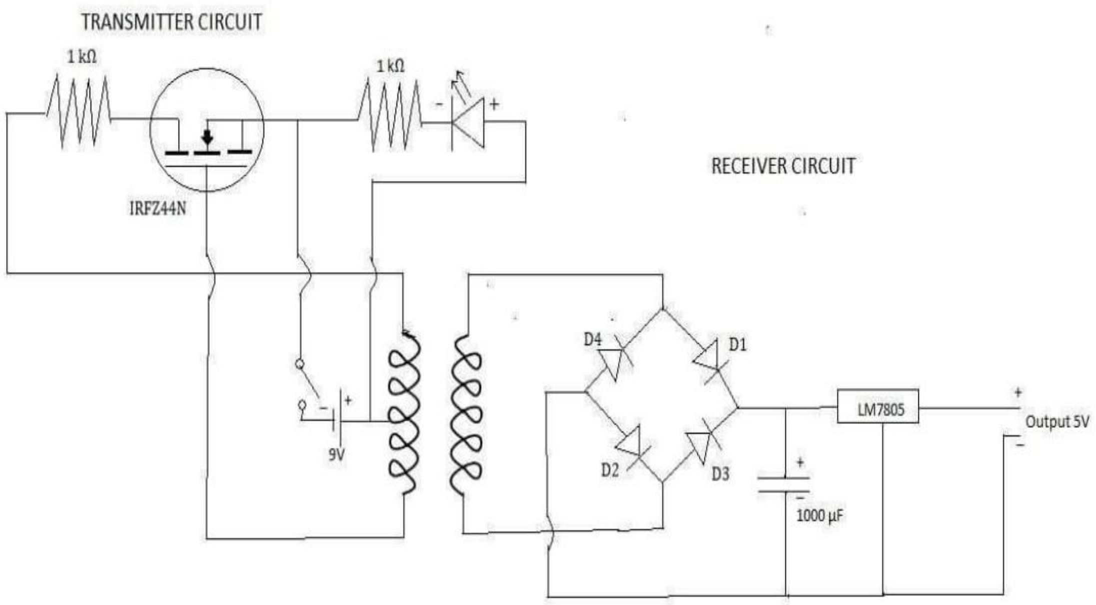

Fig.11 Circuit Diagram

Working of the System:

The circuit for wireless power transform consists of transformer, rectifier, voltage regulator, transmitter, receiver, current amplifier and connectors.

Current amplifier: Here we use MOSFET Z44 to invert the DC current to AC. It also works as a current amplifier, so that it increases the efficiency of the coil.

Transmitter coil: Power supply is given to the transmitter. Copper coil is wound into several turns. When power supply is given to the coil, a magnetic field is produced. Hence the power gets transferred.

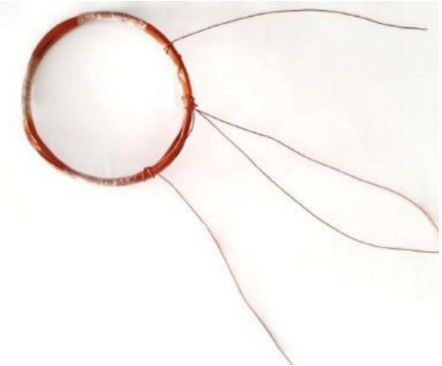

Fig.12 Transmitter Coil

Receiver coil: The receiver coil is the secondary coil and has the same design as the primary coil. Running the secondary at the same resonant frequency as the primary ensures that the secondary has 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 directly rectified and a regulator circuit can be used to generate DC voltage.

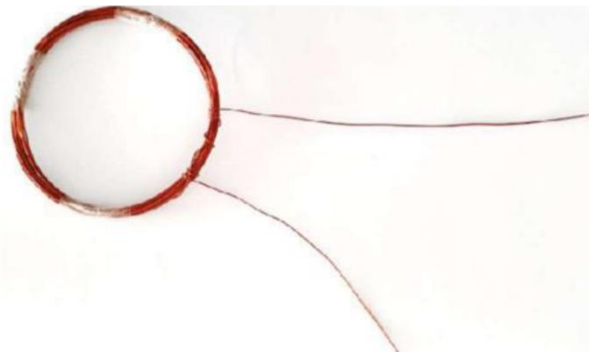

Fig.13 Receiver Coil

Rectifier: The output from the secondary coil is rectified by the use of a rectifier using four diodes connected with each other. The rectifier is used to convert AC to DC. We use a full wave rectifier in this case. The full wave rectifier produces a smooth DC with less ripples. In the positive half of the AC cycle, D1 and D2 conduct because they’re forward biased. Positive voltage is on the anode of D1 and negative voltage is on the cathode of D2. Thus, these two diodes work together to pass the first half of the signal through. In the negative half of the AC cycle, D3 and D4 conduct because they’re forward biased: Positive voltage is on the anode of D3 and negative voltage is on the cathode of D4. The net effect of the bridge rectifier is that both halves of the AC sine wave are allowed to pass through, but the negative half of the wave is inverted so that it becomes positive to produce pure DC.

Voltage regulator: Voltage regulator is used to obtain a constant DC source. We use IC 7805 for this purpose. The number 78 signifies that it is a positive voltage regulator and 05 signifies that it gives 5V output.

CALCULATIONS

Details of Transmitting Coil:

Radius of transmitting coil(r)=2.15 cm

Radius of cross-section(a)=0.02483 cm

Number of transmitting coil turns(N)=30 turns

Coil wire size=25 gauge

Diameter=4.30 cm

Width of the winding= 0.343 cm

Details of Receiving Coil:

Radius of receiving coil(r)=2.15 cm

Radius of cross-section(a)=0.02483 cm

Number of receiving coil turns(N)=30 turns

Coil wire size=25 gauge

Diameter=4.30 cm

Width of the winding= 0.343 cm

Theoretical Calculations:

Inductance of the Winding:

Inductance of transmitter coil= $N^2 \mu_0 r (\ln(8r/a)-1.75)$

$=30^2 \times 4\pi \times 10^{-7} \times 2.15 (\ln((8 \times 2.15)/0.0248)-1.75)$

$=11.6$ mH

Inductance of receiver coil= $N^2 \mu_0 r (\ln(8r/a)-1.75)$

$=30^2 \times 4\pi \times 10^{-7} \times 2.15 (\ln((8 \times 2.15)/0.0248)-1.75)$

$=11.6$ mH

Resistance of the Winding:

Resistance of the Winding=ρl/a

Length of the transmitting coil= Circumference of coil x N

=2π x D x N

=2 x 3.14 x 4.30 x 30 cm

=810.12 cm

Length of the receiving coil= Circumference of coil x N

=2π x D x N

=2 x 3.14 x 4.30 x 30 cm

=810.12 cm

A=2πr(r+h)

Where, h= width of the winding

=2 x 3.14 x 2.15(2.15+0.343)

=33.66 cm^2

ρ = resistivity of copper = 1.796 x 10^{-8}

Resistance of transmitter coil = 4.322 x 10^{-5} Ω

Resistance of receiving coil = 4.322 x 10^{-5} Ω

Resonant frequency of the receiver coil:

$f= \frac{1}{2\pi\sqrt{LC}}=\frac{1}{2\pi\sqrt{11.6*10^{-3}*1000*10^{-6}}}$ =46.73

L=11.6 x 10^{-3} mH

C=1000 μF

f= 46.73 Hz

CRITICAL ISSUES

1.Why IRFZ44N MOSFET is used in wireless charger?

The IRFZ44N MOSFET is used in wireless charger for it’s ability to switch high currents and handle high power efficiency.

Here are few reasons why it is used-

1.Switching Capability

2.Power Handling

3.Thermal Performance

4.Cost-effectiveness

2. Why center tapping in case of coil of transmitter?

The center tapping is done in case of transmitter’s output stage due to-

1.Efficient Power Transfer

2.Cancellation of even harmonics

3.Output Power Doubling

4.Reduced Output Impedance

CONCLUSION

Wireless charging is a much convenient and easier system to use for charging various devices. We constructed a wireless mobile charging system using transmitter and receiver coils. The distance between the coils were varied to study the change in output voltage and hence the efficiency. We observed that the efficiency,

(i) decreases with increase in the distance between the coils

(ii) increases with the increase in no of turns.

Thus the predicted theoretical condition matches with the experimental results. Even though wireless charging is still pretty much in its early stages, the technology is anticipated to evolve dramatically over the next few years.

FUTURE SCOPE OF WIRELESS CHARGING

Wireless charging is a dependable, convenient, and a secure method of powering and charging electrical equipment. It is gaining momentum in healthcare, automotive, aerospace and consumer goods production industries. Some of them are:

•Solar power satellite

•Wirelessly powered home appliances

•Wirelessly charging of electric vehicles on the way

•Wireless power used in medical devices.

•Wirelessly powered train.

REFERENCES

1. Muhammad Ahsan Javaid, Dr. Kamran Liaqat Bhatti, Engr. Zeeshan Raza, Engr. Umer Ilyas, Shan ul Haq. “Wireless Power Transmission “A Potential Idea for Future”“ International Journal of Scientific & Engineering Research ISSN: 2229-5518, Volume 6, Issue 3, Page: 933-937, March-2015.

2. Murugeshan R. “Electricity & Magnetism”, Ninth revised edition, reprint 2013, Publications - S Chand & Company PVT-LTD, Ram Nagar, New Delhi – 110055, Chapter13, Sections 13, 14, 30 and18.

3. Omkar Singh. “Wireless mobile charger” International Journal of Electronics, Electrical and Computational System (IJEECS) ISSN: 2348-117X, Volume 5, Issue 6, Page: 97-105, June 2016.

4. Otchere Peter Kweku. “Wireless mobile charger using inductive coupling” International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-7, Issue-1, Page:84-99, October 2017.