ISSN 2349-7815

International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 10, Issue 3, pp: (10-21), Month: July - September 2023, Available at: www.paperpublications.org

ELECTROMAGNETIC INDUCTION TECHNIQUE OF WIRELESS POWER TRANSFER FOR UNIVERSAL WIRELESS CHARGING DEVICE

Ogbodo Emmanuel Utochukwu[1], Ifeyinwa Faith Ogbodo[2],
Onyenanu Chukwunonso Nnanyelum[3], Nwanonobi Benjamin Chibuzo[4]

Department of Industrial & Production Engineering[2,4]
Department of Chemical Engineering,[3]
Department of Electronics & Computer Engineering[1]
Nnamdi Azikiwe University, Awka.

DOI: https://doi.org/10.5281/zenodo.8355586

Published Date: 18-September-2023

Abstract: **With the constant and increase growth in technological advancements, technical know-how and innovations, keeping up with the trends becomes the order of the day, most technological advancement aim at further improving our way of life and/or providing new and easier ways to solve a general problem, with so many examples to site, like the invention of smart home security systems, smart baby monitors, self-driven cars, digital voting systems etc, wireless power transfer seems to be at the very top of this list. The main objective of wireless power transfer is to eliminate damage of mobile phone USB port and make the transfer of power from sources to devices more convenient and seamless. Wireless charging of gadgets is one of the new emerging technologies in the world at the moment. The most common method used at the moment is wireless power transfer by inductive coupling. Wireless power transfer is one of the simplest and cheapest ways of charging as it eliminates the use of conventional copper cables and current carrying wires. The research methodology and principle of operation are devised for wireless power transfer through inductive coupling, and a feasible design is modeled accordingly. The inductive coupling technique is used since currently it's the easiest method of wireless power transfer because of high efficiency and large amount of the energy transferred. In this project report, results of experiments done to check wireless power transfer will be discussed. Also, to further show its versatility and range of applications the power transferred will be used to charge small and medium devices with emphasis on mobile phones with the aid of additional circuitry; and also study the effect of placing hurdles between the transmitter and receiver so as to establish if it is an alternative in the medical industry for charging pace makers.**

Keywords: **Electromagnetic Induction, Electromagnetic Hypothesis, Inductive Coupling, Wireless Power Transfer (WPT), Wireless Charger, Resonant Transformer, Contactless Feed System.**

1. INTRODUCTION

Electricity is a necessity of today's present-day life. Without it, people live in troubles as days pass by. The traditional utilization of electricity is made conceivable using wires. Propelled innovation has empowered the purchase of an assortment of compact electronic devices. However, users are still required to physically connect these devices when the

ISSN 2349-7815

International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 10, Issue 3, pp: (10-21), Month: July - September 2023, Available at: www.paperpublications.org

battery has been used up. Subsequently, wireless power transfer (WPT) is recommended to understand the likelihood of the connector battery-free electronic devices, which could enhance both the size and quality. Therefore, there is a longing dream to utilize WPT technology and remove the remaining wired power connection. There is an increase interest for wireless power transfer system. Wireless data transfer by means of the Ethernet protocol or generally known as WIFI was produced around 1988 by NCR Corporation, and broadly marketed in 1999.

Analysts anticipate that 100 million individuals will reutilizing Wi-Fi by 2006. Homes, workplaces, universities and schools far and wide have introduced Wi-Fi hardware to cover their premises with remote access to the web. Wi-Fi access is accessible in an increasing number of cafés, airplane terminals and lodgings [1]. Accordingly, it is not difficult to feel that a created wireless power transfer technology would offer the same potentials at home and in business applications. There are numerous applications, for example, mobile phones, portable PCs, and home theater hardware, in which remote vitality exchange would be attractive. Many of the contactless feed systems are based on the electromagnetic induction's principle. Little Separation wireless power transfer as shown through the utilization of affectation. Information of electric circuit rationale and electromagnetic hypothesis is vital to understand the functional configuration. The idea of Wireless electricity started with the analyses of Heinrich Hertz and Nikola Tesla at around the 1890s, and it still under the exploration until today. It has been strived ordinarily all through the most recent century [2]. The main benefit of inductive wireless power transfer is the minimal effort and exceedingly productive strategy for transferring power.

1.1 Problem Statement

The project seeks to eliminate the use of wires in the transmission of power from the source to the device (Electrical load). Although WPT is based on electromagnetic induction, there are various methods that are used. Some are less efficient than others and costly while others don't allow for a long range of transmission

1.2 Aim and Objectives

The aim of the project is to successfully design and demonstrate the charging of mobile phones wirelessly on a universal charger using inductive coupling technique of wireless power transfer; while the objectives was to apply WPT to eliminate conductors and wires, eliminating clusters in workspaces and devices can be charged wirelessly.

2. RELATED WORKS

The early history of wireless power transfer involves two main figures that are Nikola Tesla and a group of researchers from Massachusetts Institute of Technology (MIT).

2.1. Nikola Tesla

Nikola Tesla was born on July 9, 1856 in Yugoslavia. Tesla had an uncommon ability, in which he can envision things so well that they appear to be genuine. This permitted him to assemble mental as opposed to physical models that prompted successful design. His weakness was he took extremely poor notes. He just recorded those things that he thought to be completely fundamental or vital. Tesla had passed his time in his experimentation. In 1899, he went to Colorado Springs to construct a research center and attempted to discover so many thoughts. One of the thoughts was the wireless transmission of energy. He had manufactured a resonant transformer called as Tesla loop, accomplished a noteworthy achievement in his work by transmitting 100 million volts of electric vitality remotely. In his trial, he could light 200 lights, 26 miles far from his lab to illuminate a bank and run one electric motor. Tesla asserted that can transfer electrical power at 95% proficiency, yet the innovation must be racked in light of the fact that the impacts of transmitting such high voltages in electric circular segments would have been awful to human and electrical region [2]. Tesla theories of the wireless transmission of energy were somewhat not quite the same as today's vision. His theories were focused on his thought of the earth as a mammoth conductor. Tesla transferred energy directly through the earth's surface [3].directly through the earth's surface [3]. So far, wireless power transmission has come a long way. From Nicola Tesla's demonstrations to actually charging devices wirelessly. Currently, transferring electrical energy through the air is no longer a problem. Engineers are constantly working towards improving the efficiency of the power transmitted wirelessly without putting humans nor the environment at risk, while sticking to methods that will be cost-effective and easily commercialized. Though still in the early stages, a 3940 good number of electronic design and manufacturing firms have rolled out devices that can charge phones, cars, and some other house hold appliances wirelessly. Clearly, wireless power transmission is heading to a point where the efficiency of the power transferred will be similar to that of wire, but obviously more reliable.

ISSN 2349-7815

International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 10, Issue 3, pp: (10-21), Month: July - September 2023, Available at: www.paperpublications.org

WPT will generally make it safe in certain situations, as in the case of imbedded sensors such as cardiac pace makers, visual prostheses, cochlear implants, and other implantable medical devices.

Table 2.1: Characteristic Comparison of Reviewed Literature

Technology	Range	Efficiency	Cost	Safety	Antenna Device	Frequency
Inductive coupling	Short	Low	Economical because the used equipment are cheap and available	It is safe from biological point of view	Coils of Wire	KHz-MHz
Micro wave	Long	High	Relatively expensive compared to other methods	Dangerous on health due to high frequency range	Parabolic Dish	GHZ
Magnetic resonance coupling	Short	medium	Economical because the used equipment are cheap and available	It is safe from biological point of view	Tuned coils lumped element resonator	KHZ

Wireless power transmission is largely based on the radiation of electromagnetic fields. However, there are safety limits that determine the levels of human exposure to electromagnetic fields. Currently two world bodies give directives on the human exposure guidelines. These are the Institute of Electrical and Electronic Engineers (IEEE) and the International Commission on Non-Ionizing Radiation Protection (ICNIRP). [19]. The main standards are: “IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz” (IEEE C95.1-2005) and “ICNIRP Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields (up to 300 GHz). The purposes of the IEEE and ICNIRP guidelines are similar: “The purpose of this standard is to provide exposure limits to protect against established adverse health effects to human health induced by exposure to RF (radio frequency) electric, magnetic, and electromagnetic fields over the frequency range of 3 kHz to 300 GHz.” [IEEE].“The main objective of this publication is to establish guidelines for limiting EMF (electromagnetic field) exposure that will provide protection against known adverse health effects. An adverse health effect causes a detectable impairment of the health of the exposed individual or of his or her offspring; a biological effect on the other hand, may or may not result in an adverse health effect”. [ICNIRP]Both the IEEE and ICNIRP groups in their recent publications claim that there is no justified evidence to show that human exposure to radio frequency (RF) electromagnetic fields cause cancer, however evidence shows that RF electromagnetic fields could actually raise the temperature of a human, cause heating up of body tissues and may stimulate nerve and muscle. [20]

Also, the concept of WPT has come a long way, especially in the aspect of applying it to the present tech on ground. While there is so much focus on improving the efficiency, little light has been shaded on aspects of powering the system via more sustainable means such as via solar energy, back-up batteries and the likes. In this project, besides developing a device that can charge mobile phones wirelessly, we have attempted to introduce solar power as a way of making the system more efficient especially for users in developing countries where electricity supply is still stable.

3. METHODOLOGY AND SYSTEM DESIGN

This paper incorporates two methodologies, those for its software design and those for the hardware design. The best methodologies suitable were chosen and fully utilized to produce an optimal, working, cost efficient product. Below are the different methods used;

3.1 Waterfall Model

In order to develop good quality, efficient and maintainable product, we have studied different software lifecycles and chosen the most suitable. A product's life cycle is the period of time that starts when a product is conceived and ends when the product is no longer available for use [22]. In a Software Development Life Cycle (SDLC), a variety of models to be used have been proposed, some of which include:

1. Build and fix model

2. The waterfall model

3. Increment Process model

a. Iterative enhancement model

b. The Rapid Application Development (RAD) model

4. Evolutionary Process model

a. Prototyping model

b. Spiral model

5. The unified process

A .Build and Fix Model: This is basically a two-phase model. The first phase is to write the code and the second is to fix the code. Fixing in this context is either error correction or addition of further functionality.

B Increment Process Models: Here we have:

I. **Iterative Enhancement Model:** This model has the same phase as the waterfall model, but with fewer restrictions being that the phases occur in cycles. A useable product is released at the end of each cycle, with each release providing additional functionality.

II. **The Rapid Application Development Model:** This model incorporates user involvement in the development process. The continuous user involvement is essential from the requirement phase to the delivery of the product. This ensures the involvement of user's expectation and perspective in requirement elicitation, analysis and design of the system.

C Evolutionary Process Models: This resembles iterative enhancement mode but the difference is that this does not require a useable product after each cycle.

Under this model we have:

I. **Prototyping Model:** This solves the major limitations of the waterfall model because a working prototype is first developed instead of the actual system. Basically, it has limited functional capabilities, low reliability, and untested performance. After the finalization of the system requirement and specification (SRS) document, the prototype 45 is discarded and actual system is then developed using the waterfall approach.

II. **Spiral Model:** This model incorporates techniques that deals sufficiently with the uncertainties associated with building systems.

However, this model has some difficulties to be solved before it can be generally applied life cycle model. These difficulties are lack of explicit process guidance in determining objectives, constraints and alternatives; relying on risk assessment expertise; and providing more flexibility than required for projects.

D The Unified Process Model: This model supports iterative development where projects are developed through series of short, fixed length mini-projects. Every iteration ends with a tested, integrated and executable system and requires its own requirement analysis, design, implementation and testing activities.

Waterfall Model: This model is the most familiar mode adopted software developers. It consists of five phases, which are: Requirement Analysis and Specification, Design, Implementation and Testing, Integration and System Testing, Operation and Maintenance. These models were compared according to the given table and the best chosen for the project requirement.

ISSN 2349-7815

International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 10, Issue 3, pp: (10-21), Month: July - September 2023, Available at: www.paperpublications.org

Table 3.1: Selection based on project requirement and type of project with associated risk [23]

	Waterfall	Prototype	Iterative enhancement	Evolutionary Development	Spiral	RAD
Requirements						
Are requirementseasily Understandable	Yes	No	No	No	No	Yes
Dowe change requirements quite often?	No	Yes	No	No	Yes	No
Can we define requirements early in the cycle	Yes	No	Yes	Yes	No	Yes
Requirements are indicating a complex system to be built	No	Yes	Yes	Yes	Yes	No
Project type and risk						
Project isthe enhancement of the existing system	No	No	Yes	Yes	No	Yes
Funding isstable for the project	Yes	Yes	No	No	No	Yes
High reliability Requirements	No	No	Yes	Yes	Yes	No
Tight project Schedule	No	Yes	Yes	Yes	Yes	Yes
Use of reusable Components	No	Yes	No	No	Yes	Yes
Are resources (time, money, people, etc.) scarce?	No	Yes	No	No	Yes	No

From table 3 above, we note that the waterfall model satisfies majority of the project requirement and is thus chosen. The waterfall model has five phases requirements analysis and specification, design, implementation and unit testing, integration and system testing and operation and maintenance. These phases do not overlap and each phase must be completed before the next begins.

3.2. Requirements Analysis and Specifications

A summary of the fundamental requirements/specifications for this wireless charging with emphasis on charging of mobile phones, Power Banks and MP3, etc. using inductive coupling method of wireless power transfer include;The system should include three sources of power (mains, Power Bank, and Any other 5 D.C supply, transmitter units, receiver units, wireless power transfer capabilities and an LED indicator.

3.2.1. Specifications

- **Voltage Regulator**

Input: 100-240v. 50/60Hz 600mA

Output: 5v-7v, 1A

The output mode of the product can be adjusted automatically by the load.

- **Transmitter**

Input: 5w-10w adjustable automatically by load.

Input Voltage: 5-7v

Output: same as Input

ISSN 2349-7815

International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 10, Issue 3, pp: (10-21), Month: July - September 2023, Available at: www.paperpublications.org

- **Receiver**

Input: 5w-10w adjustable automatically by load.

Input Voltage: 5-7v

Output: same as Input

3.3 Design

3.3.1 Figure 3.1: Circuit diagram of simple Wireless Transmitter and Receiver circuit

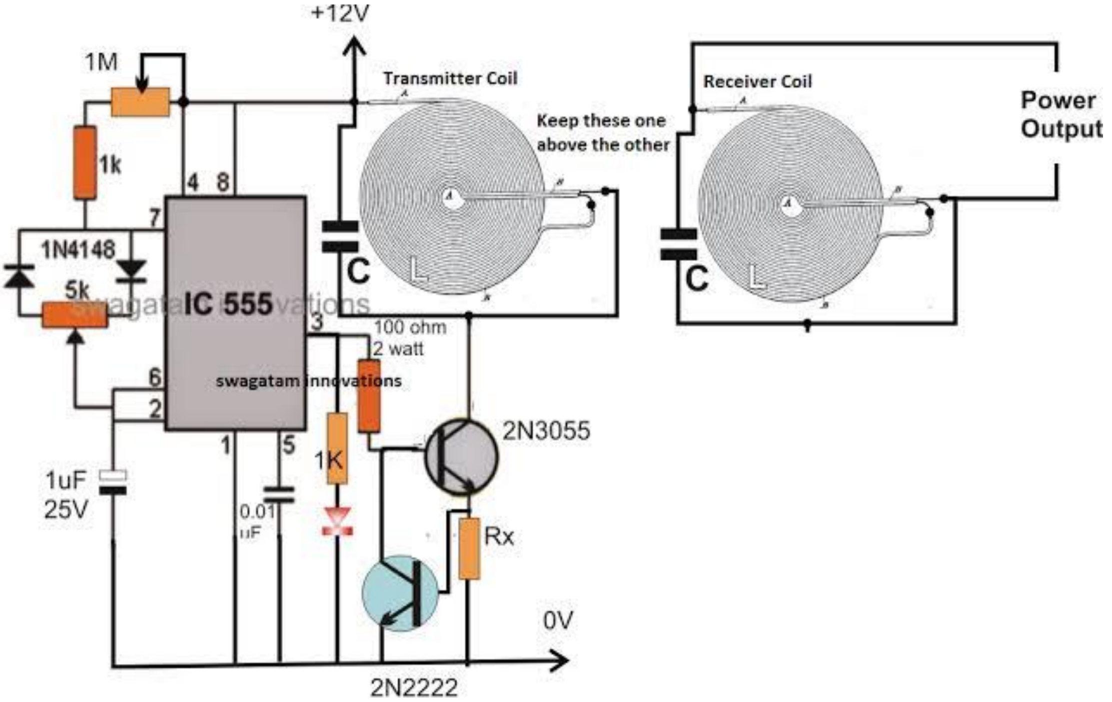


Figure 3.1: Circuit diagram of simple Wireless Transmitter and Receiver circuit

3.3.2 System Subsystems

For better design and construction, the system has been divided into four major subsystems. These subsystems perform major tasks relevant to the project. These are:

1. Power Supply Subsystem.

2. Indicator Subsystem.

3. Transmitter Subsystem.

4. Receiver Subsystem.

3.3.3 Power Supply Subsystem.

This subsystem's function encompasses the supply and distribution of power in the whole system, in other to maintain a level of reliability we developed the system to have three different power supplies and a switching unit in other to tackle the issue of irregular power supply we have in our country Nigeria, these different power supply units include:

1. Mains.

2. 5 volt DC supplying devices.

3. Laptop

ISSN 2349-7815

International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 10, Issue 3, pp: (10-21), Month: July - September 2023, Available at: www.paperpublications.org

Mains: This refers to the electrical power supply gotten directly from the Power holding company of Nigeria (PHCN). This power is of the AC current type of 230v/50hzand must be rectified to DC and stepped down to 5v to enable it charge a mobile phone directly. It comprises of four main sub-systems which are:

1. The Transformer

2. The Rectifier Circuit

3. The Filter

4. The Regulator Each block is explained in general and then follows the design.

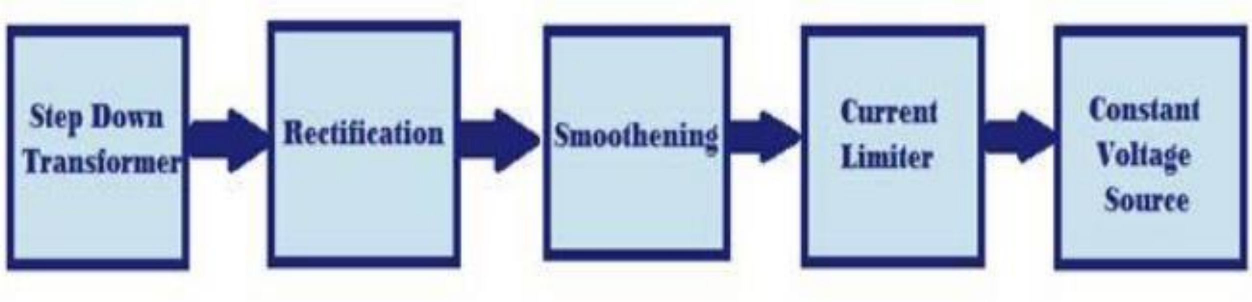
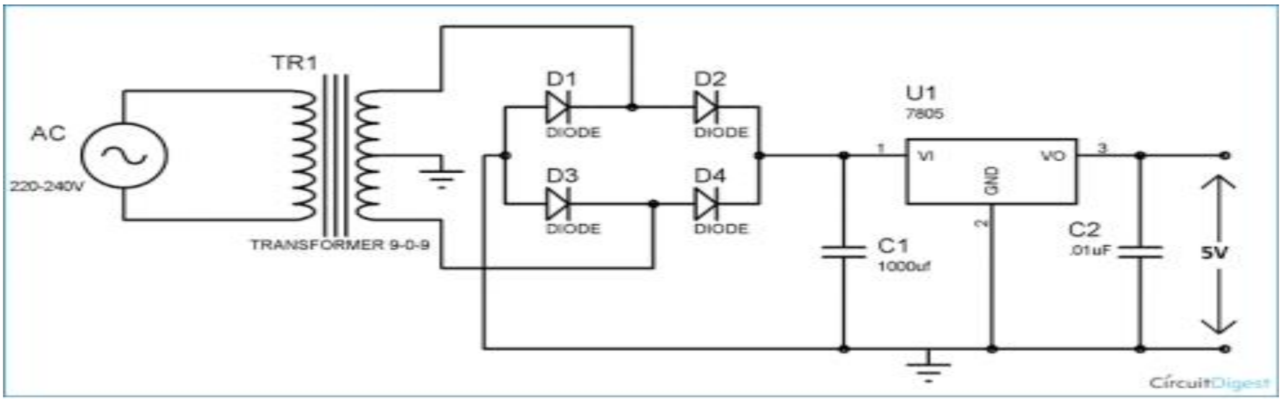


Figure 3.2: Block diagram of the power circuit. [21]



The Figure 3.3: Circuit diagram of the power supply unit. [24]

The input transformer: A transformer is a device which can step up or step down voltage levels, following the law of conversation of energy. The AC entering into the project has the voltage level of 220/120V. It needs the input transformer to step down the incoming AC to the required lower-level voltage i.e. close to 9V (AC). This lower level is further used by other blocks to get the required 5V DC. [19] [13] [25]

The rectifier circuit

A rectifier circuit is the combination of diodes arranged in such a manner that converts AC into DC voltage. The stepped-down voltage from the transformer is still AC. To convert it into DC, a good rectifier circuit is needed. Without the rectifier circuit, it is not possible to have the required output 5V DC voltage. This circuit comes in nice integrated packages or can be made using four diodes as well.

Basically, there are two types of the rectifier circuit; half-wave and full-wave. However, the one which was chosen is a full-wave rectifier, as it is more power efficient than the first one. [19]

The filter: A capacitor filter is used when there is need to convert a pulsating DC into pure or to remove distortion from signal. The rectifier circuit converts the incoming AC to DC but unluckily it does not make it a pure DC. The output of the rectifier is pulsating and is called pulsating DC. This pulsating DC is not considered good to power up sensitive devices.

ISSN 2349-7815

International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 10, Issue 3, pp: (10-21), Month: July - September 2023, Available at: www.paperpublications.org

So, the rectified DC is not very clean and has ripples. It is the job of the filter to filter out these ripples and to make the voltage compatible for regulation. A rule of thumb is DC voltage must have less than 10 percent ripples to be regulated perfectly. The best filter in this case is the capacitor. A capacitor is charge storing device. But actually, it can be best used as a filter. It is the most inexpensive filter for basic 5V power supply design.

The regulator: A regulator is the integrated circuit used to give a constant output voltage regardless of input voltage changes. Voltage regulation is very important because a change in output voltage when the load changes is not needed. An output voltage independent of the load is always required. The Regulator IC not just makes the output voltage independent of varying loads, but also from line voltage changes.

Step 1: Selection of regulator IC

The selection of a regulator IC depends on your output voltage. As 5V is required, LM7805 Voltage Regulator IC is needed. [11] In the design process, the next thing is that the voltage, current and power ratings of the selected regulator IC needs to be known. This is done by using the datasheet of the regulator IC.

7805 IC Rating:

• Input voltage range 7V − 35V

• Current rating I.V = 1A

• Output voltage range Vmax. = 5.2V, Vmin. = 4.8VThe datasheet of LM7805 prescribes to use a 0.01μF capacitor at the output side to avoid transient changes in the voltages due to changes in load and a 0.1μF at the input side of regulator to avoid ripples if the filtering is far away from regulator.

Step 2: Selection of transformer the right transformer selection means saving a lot of money. The minimum input to the selected regulator IC has to be known which is 7V (See above datasheet values). So, a transformer is needed to step down the main AC to at least this value. But, between the regulator and secondary side of the transformer, there is a diode bridge rectifier too.

The rectifier has its own voltage drop across it i.e. 1.4V. There is need to compensate for this value as well. [10] [11]So mathematically:

Vsecondary= 7V + 1.4V

Vsecondary = 8.4V (peak value).

This means the transformer with a secondary voltage value equal to 9V or at least 10% more than 9V should be selected.

From these points, for 5V DC power supply design, a transformer of current rating 1A and secondary voltage of 9V is selected. Why 1A current? Because the regulator IC has a current rating of 1A, meaning that more current than this value cannot be passed to the regulator IC. Selecting a transformer with the current rating more than this will cost extra money.

Step 3: Selection of diodes for bridge

The best is using a full wave rectifier

1. Its advantage is DC saturation is less as in both cycle diodes conduct.

2. Higher Transformer Utilization Factor (TUF).

3. 1N4007 diodes are used as it is capable of withstanding a higher reverse voltage of 1000v whereas 1N4001 is 50V. [10]

Step 4: Selection of smoothing capacitorKnowledge of Ripple factor is essential while designing the values of capacitorsIt is given by [23] [24]• $y = 1/(4\sqrt{3}fRC)$ (as the capacitor filter is used)

1. f = frequency of AC (50 Hz)

2. R=resistance calculated

R = V/I.c

ISSN 2349-7815
International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 10, Issue 3, pp: (10-21), Month: July - September 2023, Available at: www.paperpublications.org

V= secondary voltage of transformer

•V = 9√2 = 12.7

•R = 12.72/500mA = 25.4Ω standard 18Ω chosen

3. C= filtering capacitanceWe have to determine this capacitance for filtering• y= Va.c − rms/Vdc• Va.c − rms = Vr/2√3• Vd.c = Vmax. − (Vr/2)•Vr = Vmax. − Vmin.Vr = 5.2 − 4.8 = 0. 4vVa.c − rms = .3464v

Vdc = 5vY = 0 . 06928Hence the capacitor value is found out by substituting the ripple factor in Y = 1/(4√3fRC)

Thus, C= 2314µF and standard 2200µF is chosen Datasheet of LM7805 prescribes to use a 0.01µF capacitor at the output side to avoid transient changes in the voltages due to changes in load and a 0.1µF at the input side of regulator to avoid ripples if the filtering is far away from regulator.

3.3.4 Transmitter Subsystem.

This subsystem encompasses the transmitter section of the system which operates on the principles of electromagnetic induction. Inductive charging also Known as (wireless charging or cordless charging) is a type of wireless charging that uses an electromagnetic field to transfer energy between two objects using electromagnetic induction which is the production of electricity across a magnetic field. Inductive charging is usually done with a charging station or inductive pad (transmitter). [26] [28] [29] Energy is sent through this transmitter which in turn delivers this energy to a receiver wirelessly which then utilize this energy to charge batteries or run electronic devices. Induction chargers use an induction coil to create an alternating electromagnetic field from within a charging base, and a second induction coil (receiver) in the portable device takes the power from the EM field and converts it back into electric current to charge batteries. The two coils in proximity combine to form an electrical transformer. It should be noted that the greater the distance between the two coils the lower the power received. Although greater distances between transmitter and receiver can be achieved using resonant inductive coupling, our project adapts the inductive coupling method of wireless power transfer.

3.3.5 Receiver Subsystem.

This subsystem consists of the receiver coil component of the charging system, this subsystem takes the transmitted power induced wirelessly from the transmitter and converts the alternating current back to direct current. The receiver subsystem has a rectifier interfaced to it which does this conversion of currents.

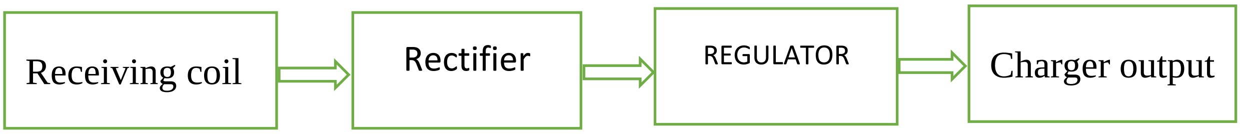


Figure 3.4: Block Diagram of the Transceiver Unit. [30]

4. SYSTEM IMPLEMENTATION AND RESULT

4.1. Working Principle:

Having used the "Near-Field (non-radiative)" Technique for construction of the device in which the device works in a close range of not more than 5cm, we have from the requirements specification and analysis and design, a working principle of the system has been deduced as follows: This wireless charger is a device which leverages on the working principles of electromagnetic induction to implement a system of wireless power transfer with emphasis on inductive coupling. The system also comprises a Double display output unit (LED), also interfaced with the voltage regulator. The display shows either Blue or Red based on the output of the Transmitter Tx. When power is sent to the transmitter, they radiate the power outwards to a particular intensity and diameter based on our calculations, determined by the number of turns and the coil diameter. Consequently, the receive circuits when placed in close proximity to the outward electromagnetic radiations of the transmitter, couples/completes the circuit and thus power will be transferred from the transmitter and subsequently received by the receiver wirelessly. This received power which is a Direct current (DC) will then be rectified to a 5v DC which will be used to charge mobile devices.

ISSN 2349-7815

International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 10, Issue 3, pp: (10-21), Month: July - September 2023, Available at: www.paperpublications.org

4.2. Tests and measurements

A number of tests were done to check the operations of the system since efficiency is an important part of the system's operation, corresponding measurements were carried out. The measurement data is presented in Table 7 and the efficiency curve is shown in Figure20.

Table 4.1: Custom 15 WWPT Table System Efficiency Measurement Data.

TX volt-age, V	TX cur-rent, A	TX power, W	RX power, W	Efficiency	Load, Ohm
12,08	0,8	9,664	5	51,7384106	29,47592
12,08	1,245	15,0396	10	66,49113008	14,73796
12,08	1,71	20,6568	15	72,61531312	9,825306667
12,08	2,165	26,1532	20	76,47247756	7,36898
12,08	2,645	31,9516	25	78,24334306	5,895184
12,08	3,125	37,75	30	79,47019868	4,912653333
12,08	3,625	43,79	35	79,92692396	4,210845714
12,08	3,77	45,5416	36,4	79,92692396	4,04889011

The test was carried out using Array 3711 a programmable DC electronic load. TX volt-age is the voltage supplied to the transmitter module and RX power is the total power that sinks in the load on a constant current mode. This test was carried out keeping in mind that the efficiency of an electrical system depends on System Performance, Time, Cost and losses.

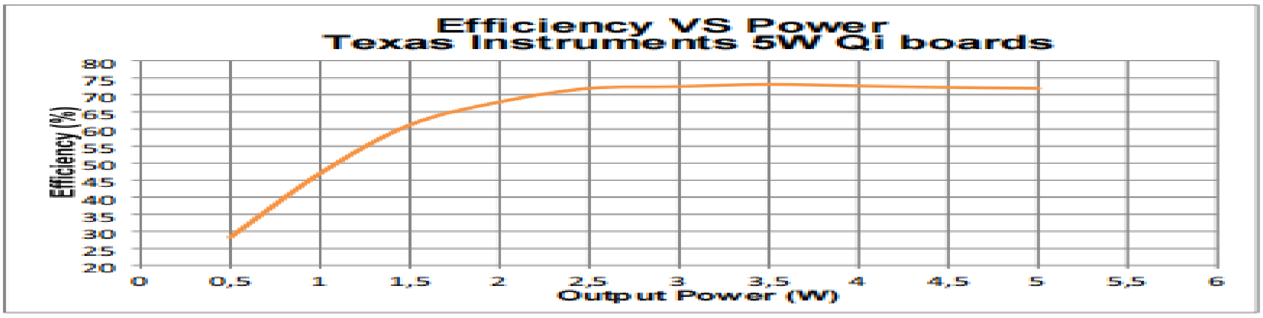


Figure 4.1:TI5wQikitsmeasuredtransferefficiencycurve.[43]

4.3 Hardware Testing

In electronics, a continuity test is the process of checking an electric circuit to see if currents flow i.e.if in fact the circuit is accurately connected. We performed a continuity test on our project by placinga small voltage (wired in series with an LED) across each path of the circuit board. If the electron flow is inhabited by broken conductors, damaged components, or excessive resistance, the circuit is said to be "open" and necessary adjustments would be required. We performed this test immediately after the hardware soldering and all configuration has been completed. This test aims atfinding any electrical open paths in the circuit after the soldering. Many times, the electrical continuity in the circuit is lost due to improper soldering, wrong and rough handling of the PCB, Improper usageof the soldering iron, component failures and presence of bugs in the circuit diagrams. We used a multi meter to perform this test. We kept the multi meter in buzzer mode and connected the ground terminal of the multi meter to the ground. We connected both the terminals across the path that neededto be checked. If there is no inhibition to the flow of current hence continuity is achieved, and we willhear the beep sound.

Table 4.2: Unit testing

TEST	STEPS	EXPECTEDRESULT	ACTUAL RESULT
ON/OFF	Plug the power cord	Red LED Lights on	Blue LED Lights on

ISSN 2349-7815

International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 10, Issue 3, pp: (10-21), Month: July - September 2023, Available at: www.paperpublications.org

Power ON Test.

This test is performed to check whether the voltage at different terminals is according to the requirement. To perform this test, we took a multi meter and put it in voltage mode. This test was performed without IC's because if there is any excessive voltage, this may lead to the damage of theIC's. There are two ways to perform this test which are: [36]

1. Measuring a transformer's output result to check if we obtain the required 9VAC voltage.

2. Checking the output of the fully charged battery using a multi meter. Then we applied a givenamount of voltage to the power supply circuit. Since our circuit consists of a voltage regulator,we simply measured the input to the voltage regulator to confirm if we were transmitting the required 5V since we were using a 7805 voltage regulator IC we got an output of 5V. We alsotested the output terminal of the other components of our circuit and we determined that we obtained the required voltage from our circuit.

EMF TEST

In order to check if our system is safe, electromagnetic field (EMF) measurements with SPECTRANNF5035 pre-Compliance EMC/EMI spectrum analyzer were conducted. According to the testresults, our system's exposure at 125kHz was below both IEEE and ICNRP limits. No criticalexcesses were observed. Different EMF strength values were measured in different distances to thedevice. The average values of EMF strength were 5.6μT without load and 6μT with the test LED.Obviously, the system complies even with the strict IEEE uncontrolled environment limit.[3]. Apparently, the project is still on-going and there are still many goals that can be accomplished. Thenext steps could include the developing of more powerful systems which could be used with laptops,then in testing and debugging and integration to platforms via novel prototypes. Furthermore, anessential goal for future would be R&D of the magnetic resonance WPT systems, which are slowlystarting to emerge and offer numerous advantages over inductive coupling transfer.

4.3.1 Continuity Test.

In electronics, a continuity test is the process of checking an electric circuit to see if currents flowing if in fact the circuit is accurately connected. We performed a continuity test on our project by placing a small voltage (wired in series with an LED) across each path of the circuit board.

Table 4.3: Unittesting

TEST	STEPS	EXPECTED RESULT	ACTUAL RESULT
ON/OFF	Plug the power cord	Red LED Lights on	Blue LED Lights on

5. CONCLUSION

An electronic device/platform that wirelessly transmits power to charge mobile phones was developed. We were able to design discrete components such as the transmitter, receiver coils and a full bridge voltage rectifier for the system design process.

Conclusions are as follows:

1. Based on the theory of wireless power transfer using inductive coupling, which was the method used in this project, it was seen that various aspects i.e. distance, resonant frequency, quality factor, coil turns ratio determine the efficiency of WPT. In addition, there is an exponential decay for power versus the distance of separation.

2. From the analysis it was seen that at 0cm separation distance, the power transfer was most efficient.

3. From the project WPT for short range or near field occurred up to a distance of 5cm after which the power transferred began to significantly drop.

4. We also concluded that WPT can be used in other applications. In this project we were able to charge a 5V battery from power that was transmitted wirelessly.

5. Lastly, we can conclude that WPT is not affected by non-magnetic materials shielding the two coils. This therefore means that it can be effectively used in the medical field to charge pacemakers and other devices.

6. RECOMMENDATIONS

This paper studied preliminary analysis of the design of a wireless transfer system. The following areas are recommended for further study;

- Research on the variation of the Q factor and damping factor, this can be done by designing a receiver circuit which is in synchrony with the transmitter circuit.
- The receiver circuit could have a feedback system which will change the load accordingly and which can be detected by the oscillator so that it also adjusts accordingly to achieve optimum power output.
- Studying on the effect of using multiple receivers on the power output, a major challenge in the design was obtaining a reasonable amount of power. This study can investigate if the power obtained in the receiver will be higher.
- Study on increasing the charging range of the device with increase in the diameter coils as that's the only way to increase the charging range, but also have the coils to not be too heavy in the process thus maintaining the portability aspect of the device.

REFERENCES

[1] Leopold Summerer, and Oisin Purcell ESA. Concepts for wireless energy transmission via laser- Advanced Concepts Team Keplerlaan 1. NL-2201AZ Noordwijk, the Netherlands. Leopold.Summerer@esa.int.

[2] Eric Dollard. 2010. Theory of Wireless Power.

[3] Prof Burali Y. N.,and Prof. Patil C.B. Wireless Electricity Transmission Based On Electromagnetic and Resonance Magnetic Coupling. NanasahebMahadik Polytechnic Institute, PethSangli, India.

[4] Cincinnati Technical Center. Electromagnetic radiation and how it affects your instruments [online]. Occupational Safety & Health Administration. Cincinnati, Ohio; May 20, 2014. URL:https://www.osha.gov/SLTC/radiofrequency radiation/electromagnetic_fieldmemo/electromagnetic.html#sectio n_6 Accessed 13 November 2019.

[5] Sun, Tianjia, Xie, Xiang, Wang, Zhihua. Wireless Power Transfer for Medical Microsystems [eBook]. New York: Springer; 2013. URL: http://www.springer.com/engineering/circuits+%26+systems/book/978-1-4614-7701-3 Accessed 15 November 2019.

[6] Schneider, D., "Wireless power at a distance is still far away [Electrons Unplugged]," *Spectrum*, *IEEE*, vol.47, no.5, pp.34,39, May 2015.