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DESIGN AND CONSTRUCTION OF A SIMPLE INDUCTIVE MOBILE CHARGING SYSTEM

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(BU/UP/2023/1613)

A RESEARCH REPORT SUBMITTED TO THE DEPARTMENT OF PHYSICS IN PARTIAL FULFILLMENT OF REQUIREMENT FOR THE A WARD OF DEGREE OF BACHELORS IN SCIENCE AND EDUCATION IN BUSITEMA UNIVERSITY

MAY, 2026

Declaration

I, **Arapmwanga Elijah** (Reg. No. **BU/UP/2023/1613**), hereby declare that this research report is my original work and has not been submitted to any institution of higher learning for the award of any academic qualification.

Name: Arapmwanga Elijah

Signature:  **Date:** 24/08/2026

Approval

This research report by **Arapmwanga Elijah** (Reg. No. **BU/UP/2023/1613**) was conducted under my supervision and has been submitted with my approval as a partial fulfillment of the requirements for the award of a Bachelor of Science with Education (Physics) of Busitema University.

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Dedication

I dedicate this work to my lovely mother Ms. Chesha sliphia and my dad Mr. Mwanga Fred for the great contribution they have offered me towards the successful completion of this project

Acknowledgement

I would like to express my sincere gratitude to the Almighty God for granting me good health, strength, and guidance throughout the course of this study. I am deeply grateful to my supervisor, Dr. Richard Cliffe Ssenyunzi, for his invaluable guidance, support, and patience throughout the development of this project. His mentorship has greatly contributed to the successful completion of this work. I also extend my appreciation to the lecturers and laboratory technicians of the Department of Physics, Busitema University, for their academic support and technical assistance. I particularly acknowledge Dr. Andima Geoffrey, Dr. Akoba Rashidah, Ms. Namakula Layila, and Dr. Atim for their guidance during my study. I am sincerely thankful to my parents and family for their continuous support, encouragement, and financial assistance throughout my academic journey. I also appreciate my siblings, Chelangat Lucius and Chelangat Gesiya, for their support and motivation. Finally, I extend my appreciation to my classmates (2023–2026 cohort) of Busitema University for their cooperation, support, and shared academic experiences, which contributed to the successful completion of this project.

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LIST OF ACRONYMS

MOSFET – Metal Oxide Semiconductor Field Effect Transistor

AC – Alternating Current

DC – Direct Current

EV – Electric Vehicles

EMF – Electromotive Force

LED – Light Emitting Diode

Abstract

This study presents the design and construction of an inductive mobile charging system based on the principle of electromagnetic induction. The system was developed to demonstrate wireless power transfer without direct electrical contact, providing an alternative to conventional wired charging methods. The system consists of a transmitter coil connected to a power source and a receiver coil integrated with a rectification and voltage regulation circuit. Performance evaluation was conducted by measuring output power and efficiency at varying separation distances between the transmitter and receiver coils. The results indicate that the output power decreases from approximately 0.12 W at a separation distance **of** 0.1 cm to 0.007 W at 0.8 cm, while the efficiency reduces from 5.0% to 0.29% over the same range. This demonstrates that power transfer efficiency is highly dependent on coil separation distance due to reduced magnetic coupling. Despite the observed efficiency limitations at larger distances, the system successfully demonstrates the feasibility of inductive power transfer for low-power applications. The findings suggest that system performance can be improved through optimization of coil design, alignment, and operating frequency.

CHAPTER ONE: INTRODUCTION

1.0 Introduction

Inductive coupling is a technology that enables the transmission of electrical energy from a power source to an electrical load without the use of physical conductors. In recent years, inductive charging systems have gained significant attention due to the rapid growth of portable electronic devices such as smartphones, wearable electronics, medical implants, and electric vehicles. Unlike conventional wired charging systems, inductive charging eliminates the need for direct electrical connectors, thereby reducing mechanical wear, improving safety, and enhancing user convenience. Among the different inductive power transfer techniques, electromagnetic induction has become the most widely used method for short-distance wireless charging applications. Inductive wireless charging systems operate by generating a time-varying magnetic field in a transmitter coil, which induces an electromotive force in a nearby receiver coil. This principle forms the basis of many modern inductive charging systems used in consumer electronics.

This chapter presents the background of inductive power transfer technology, the problem addressed by the study, the aim and objectives of the research, as well as the significance and scope of the study.

1.1 Background of the Study

The foundations of inductive power transfer can be traced back to the nineteenth-century discoveries of scientists such as André-Marie Ampère and Michael Faraday, whose work on electromagnetism and electromagnetic induction established the fundamental principles used in modern electrical engineering (Ipinnimo et al., 2025). These discoveries showed that electric currents generate magnetic fields and that changing magnetic fields can induce electric currents in nearby conductors. Later, Nikola Tesla expanded these ideas by demonstrating the possibility of transmitting electrical energy without physical conductors. In 1899, Tesla conducted experiments showing that electrical energy could be transferred over distances of several meters using electromagnetic fields (Singh, 2016).

Although Tesla's experiments demonstrated the feasibility of inductive energy transmission, practical implementation remained limited due to technological constraints at the time.

Interest in inductive power transfer declined for several decades but was revived in 2007 when researchers at the Massachusetts Institute of Technology successfully demonstrated efficient energy transfer using resonant inductive coupling. In their experiment, a light bulb was powered using two resonant coils, which significantly increased the efficiency of energy transfer over moderate distance (Kumar et al., 2018).

This breakthrough stimulated renewed research and industrial interest in inductive power technologies.

Modern charging systems primarily utilize near-field power transfer techniques, particularly inductive power transfer and resonant inductive coupling (Mung et al., 2015).Unlike far-field methods such as microwave or laser power transmission, which can transmit energy over long distances but often suffer from low efficiency and safety challenges, near-field inductive systems operate efficiently over short distances and are well suited for applications such as smartphone charging and medical implants (Systems, 2020)

The theoretical foundation of inductive charging system is based on Maxwell's equations, which describe how electric and magnetic fields interact. In inductive charging systems, alternating current flowing through a transmitter coil produces a time-varying magnetic field. This changing magnetic field induces an electromotive force in a nearby receiver coil according to Faraday's law of electromagnetic induction. To improve efficiency and increase operating distance, many modern systems employ resonant inductive coupling, where both transmitter and receiver circuits are tuned to the same resonant frequency. This resonance significantly enhances energy transfer efficiency while allowing greater separation between the coils (Shanmugam et al., 2022).

1.2 Problem Statement

The rapid growth of portable electronic devices such as smartphones, smartwatches, and other rechargeable gadgets has increased the demand for efficient and convenient charging technologies. Conventional wired charging systems require physical connectors between the power source and the device. These connectors are prone to wear and tear, mechanical damage, and reduced durability due to repeated plugging and unplugging. In addition, damaged charging ports and exposed connectors may increase maintenance costs and, in some cases, lead to potential electrical safety risks. Inductive power transfer has emerged as a promising alternative to conventional wired charging systems because it eliminates the need for physical electrical connections. However, the performance of inductive charging systems strongly depends on factors such as coil design, alignment between transmitter and receiver coils, operating frequency, and the distance between the coils. These factors significantly influence the efficiency of power transfer. Therefore, this project aims to design and construct an inductive power transfer system based on the principle of electromagnetic induction and investigate how coil configuration and operating parameters affect the efficiency of power transfer to identify an optimal design for improved charging performance.

1.3 Aim of the Study

The aim of this study is to design and construct an inductive mobile charger based on the principle of electromagnetic induction and to investigate how coil separation distance and circuit parameters affect system performance.

1.4 Objectives of the study

1. To design the transmitter and receiver circuits required for inductive power transfer using electromagnetic induction.
2. To construct and assemble an inductive charging system based on the designed transmitter and receiver circuits.
3. To evaluate the performance of the system at different separation distances between the transmitter and receiver coils.

1.5 Significance of the study

This study is significant both academically and practically. From a technological perspective, it demonstrates a practical approach to wireless power transfer using inductive coupling, thereby contributing to the development of alternative charging technologies that eliminate the need for physical electrical connections. This has the potential to reduce mechanical wear and tear associated with conventional charging cables and improve user convenience.

From a safety perspective, inductive charging systems minimize direct contact with exposed electrical connectors, thereby reducing the risk of electrical hazards. In addition, reduced dependence on charging cables can contribute to minimizing electronic waste resulting from damaged or discarded charging accessories.

Academically, this study provides a practical application of electromagnetic induction principles, bridging the gap between theoretical concepts and real-world implementation. It also offers experimental insights into the effect of coil separation distance on power transfer efficiency, which can be useful for further research and development in wireless power systems.

1.6 Scope of the Study

This study focuses on the design, construction, and evaluation of an inductive power transfer system based on the principle of electromagnetic induction. The project involves the development of transmitter and receiver coils, the assembly of the required electronic components, and the experimental assessment of power transfer between the coils. The study is limited to short-distance inductive power transfer for low-power electronic devices such as smartphones. Large-scale applications, including inductive charging systems for electric vehicles and industrial power transfer, are beyond the scope of this work. All materials used in the construction of the system are sourced from locally available electronic component suppliers in Uganda. The design, construction, and experimental testing of the system are conducted in the Physics Laboratory at Busitema University, Nagongera Campus.

CHAPTER TWO: LITERATURE AND THEORETICAL REVIEW

2.0 Introduction

Inductive power transfer is a method of transmitting electrical energy between two or more circuits through a shared magnetic field allowing electricity to pass through without physical electrical connections between the power source and the load. Inductive charging technology has advanced rapidly in recent years due to the increasing demand for portable electronic devices and smart systems. Modern research shows that inductive charging provides improved convenience, safety, and flexibility compared to wired charging systems (Loureiro & Pereira, 2026). Inductive power transfer techniques include inductive coupling, magnetic resonance coupling, and microwave transmission. Among these techniques, electromagnetic induction remains the most widely used method for short-distance inductive charging because of its simplicity and reliability of inductive chargers, existing technologies, previous studies and efficiency factors (Ganesa et al., 2024). This chapter reviews the principles of electromagnetic induction, overview inductive power transfer methods, theoretical foundations of electromagnetic induction and the research gaps.

2.1 Inductive Power Transfer Technology

Inductive power transfer involves transmitting electrical energy through magnetic or electromagnetic fields from a transmitter to a receiver. In inductive power transfer technology, energy is transferred between two coils via a varying magnetic field generated by alternating current in the transmitting coil. This principle underpins most consumer wireless charging systems. The transmitting coil produces a magnetic field when alternating current flows through it, The receiving coil captures this magnetic field and converts it into electrical energy, which is then rectified and regulated for safe device operation (Shinde et al., 2022).inductive charging technology has become widely adopted in smartphones, medical implants, and industrial equipment due to its reliability, safety, and ability to reduce mechanical wear from connectors.

The key parameters affecting inductive power transfer technologies include the operating frequency, coil geometry, coupling coefficient distance between the coils and the medium between

the coils. Recent innovations include multiphase inductive couplers that improve power density and efficiency, making power transfer more viable for high-power applications such as electric vehicles (Xue et al., 2025).

2.2 Comparison of inductive coupling with other technologies

Inductive Power Transfer systems are classified according to their physical operating principles, transmission distance, operating frequency range, and power levels. According to (Zhang et al., 2022), inductive technologies can broadly be divided into near-field (non-radiative) and far-field (radiative**)** techniques. The main categories of power transfer technologies include Inductive coupling, Resonant inductive coupling, and Microwave power transmission. Each method differs in terms of efficiency, transmission range, complexity, safety, and application domain.

2.2.1 Inductive Coupling

Inductive coupling is the simplest and most mature power transfer technology. It uses magnetic field coupling between two coils placed in a close distance. When alternating current flows through the primary coil, a time-varying magnetic field is generated. According to Faraday's Law, this changing magnetic flux induces voltage in the secondary coil. Inductive systems operate efficiently when the separation distance is small (typically less than the coil diameter), the coils are properly aligned, and the operating frequency is optimized.

Most smartphone inductive chargers operate at frequencies between 100 kHz and 205 kHz under standards developed by the Power Consortium (Zhang et al., 2022). However, inductive coupling suffers from rapid efficiency drop when coil misalignment or distance increases. Despite this limitation, it remains the most widely adopted technique for portable device charging.

2.2.2 Resonant Inductive Coupling

Resonant inductive coupling improves power transfer by tuning both transmitter and receiver circuits to the same resonant frequency using capacitive compensation networks. At resonance, energy oscillates efficiently between magnetic and electric fields, reducing reactive losses. Resonant systems offer Improved tolerance to misalignment, extended transmission distance and higher power capability. This method is particularly useful in electric vehicle charging systems and medium-power industrial applications. However, resonance control increases system complexity and requires precise frequency tuning (Liu et al., 2020).

2.2.3 Microwave Power Transmission

Microwave power transmission operates at higher frequencies between 300MHz to 300GHz as compared to other systems and can transfer energy over longer distances using directive antennas. Research has explored its application in space-based solar power systems. Although microwave systems can transmit significant power, challenges include alignment, atmospheric attenuation and Safety considerations. Therefore, microwave power transfer is mainly limited to research and specialized applications (Eteng et al., 2021).

The above studies can be summarized in the table below

Table 2: 1 *Table showing power transfer*

Technology	**Range**	**Efficiency**	**Cost**	**Operating frequency**
Inductive coupling	Short	Low	Economical	KHz-MHz
Microwave	Long	High	Relatively expensive compared to other methods	GHZ
Magnetic resonance coupling	Short	Medium	Its economical	KHZ

A comparison of these power transfer technologies shows that inductive coupling offers the best balance between efficiency, Safety, Cost and provide Simplicity for short-range consumer electronics charging, inductive coupling remains the most practical solution however far-field methods are more suitable for remote sensing and specialized industrial applications.

2.3 Review of Related Work

Inductive charging through electromagnetic induction has advanced considerably, particularly in improving efficiency and expanding its applications from portable electronics to electric vehicles. Studies by Mung et al. (2015) demonstrated the feasibility of resonant inductive coupling for EV charging over small air gaps, but their system suffered significant efficiency losses under coil misalignment, leaving a gap in achieving reliable performance in practical conditions. Similarly Shanmugam et al. (2022) introduced dynamic wireless charging for moving vehicles using embedded road coils, yet their approach is limited by high infrastructure costs, complexity, and unresolved concerns regarding consistent power delivery and safety. In the domain of portable electronics, Farghly et al. (2025) developed a compact charger with adaptive resonance tuning that improved performance under moderate misalignment, but challenges remain in handling larger misalignments, reducing system complexity, and ensuring long-term efficiency.

2.4 Research gap

Although inductive charging systems are widely used for portable electronic devices, their performance is highly sensitive to coil separation distance and alignment. Many existing studies focus on large-scale or resonant systems for electric vehicles, while fewer studies examine simple low-power inductive systems suitable for laboratory-scale design and experimental analysis. Building on the above studies the current study contributes by designing a practical and cost effective inductive and reduced complexity mobile charger using electromagnetic induction, with particular emphasis on analyzing the effect of coil separation distance on power system performance.

2.5 Factors Affecting inductive power transfer efficiency

Inductive power transmission is mainly affected by several important factors that determine how efficiently energy is transferred from the source to the receiver. One major factor is the distance between the transmitter and receiver. As the distance increases, the amount of power received decreases significantly because energy spreads out and weakens over space. This is especially noticeable in short-range systems like inductive phone charging, where even a small increase in distance can greatly reduce efficiency.

alignment and orientation of the transmitting and receiving components. For maximum power transfer, the coils or antennas must be properly aligned, if they are not directly facing each other, the coupling between them becomes weaker, resulting in less energy being transferred. Proper positioning is therefore essential for maintaining high efficiency.

The strength of the coupling between the transmitter and receiver also plays a crucial role, Strong coupling occurs when the components are close and well-aligned, allowing more energy to be transferred. Weak coupling, on the other hand, leads to significant power losses and reduced performance of the system.

Finally, environmental factors and obstacles can affect inductive power transmission. Objects such as metal, walls, or even human bodies can absorb, block, or reflect electromagnetic waves, reducing the amount of power that reaches the receiver and additionally, interference from other electronic devices and surrounding conditions can further decrease efficiency.

2.6 Theoretical Foundations of inductive power transmission

2.6.0 Electromagnetic induction

Since this project is based on inductive coupling, it is grounded in classical electromagnetic theory.

Electromagnetic induction is the fundamental principle behind inductive power transfer. It refers to the production of an electromotive force (EMF) across a conductor when exposed to a changing magnetic field.

2.6.1 Faraday's Law of Electromagnetic Induction

Faraday's Law states that the induced EMF in a coil is proportional to the rate of change of magnetic flux through the coil:

$$EMF = -Nd\Phi/dt \ldots\ldots\ldots\ldots\ldots\ldots \quad (2.1)$$

Where Φ= magnetic flux

$\mathbf{N}$= number of turns

And the negative sign indicates **Lenz's Law**

Lenz's Law states that the direction of the induced current opposes the change that produced it This principle governs the operation of the receiver coil. When alternating current flows through the transmitter coil, it produces a changing magnetic field, which induces voltage in the secondary coil

2.6.2 Ampere's Law

Ampere's Law explains that electric current produces a magnetic field around a conductor. In a circular coil, the magnetic field strength depends on, Current magnitude, Number of turns and Coil radius. The generated magnetic field is essential for energy transfer between coils. Higher current results in stronger magnetic flux, thereby improving coupling (Zhang et al., 2022)

2.6.3 Biot–Savart Law

The Biot–Savart Law provides a mathematical expression for calculating the magnetic field produced by a current element. It is useful in determining the magnetic field distribution within the transmitter coil, which directly influences induced voltage in the receiver coil.

Accurate modelling of magnetic field distribution improves design optimization and efficiency (Liu et al., 2020)

Mathematically the expression can be written as

$$B = \frac{\mu_0 NI}{2R} \quad \text{........................... (2.2)}$$

Where:

- B = magnetic field strength
- N = number of turns
- I = current
- R = coil radius

The above expression is important since it can be used to calculate the magnetic field in the transmitter and the receiver circuit

2.6.4 Mutual Inductance and Coupling Coefficient

Mutual inductance (M) describes the relationship between two coils whereby a change in current in one coil induces voltage in the other. The coupling coefficient (k) indicates how effectively magnetic flux links the two coils. Its value ranges from 0 to 1, where k=1 represents perfect coupling and k<1 represents leakage flux, improving coupling coefficient significantly enhances power transfer efficiency(Transfer, 2021).

The mutual inductance between two coils is given by

$$M = k\sqrt{\{L_1 L_2\}} \ldots\ldots\ldots\ldots\ldots (2.3)$$

Where:

M = mutual inductance

k = coupling coefficient

L_1 = inductance of transmitter coil

L_2 = inductance of receiver coil

The above equation is critical because power transfer depends strongly on the coupling coefficient k

2.6.5 Power Transfer Efficiency

The efficiency of the system is calculated from the expression

$$\eta = \frac{P_{out}}{P_{in}} x\ 100 \ldots\ldots\ldots\ldots\ldots\ldots (2.4)$$

Where:

$$P = VI$$

Thus,

$$\eta = \frac{V_{out} I_{out}}{V_{in} I_{in}} x100 \ldots\ldots\ldots\ldots\ldots\ldots (2.5)$$

The efficiency of inductive power transfer systems decreases rapidly as the distance between coils increases because the magnetic coupling coefficient decreases.

CHAPTER THREE: METHODS AND MATERIALS

3.0 Introduction

This chapter describes the materials used in the design and construction of an inductive mobile charging system and the experimental procedures used to evaluate its performance. The chapter explains the design of the transmitter and receiver circuits used for inductive power transfer based on electromagnetic induction, the construction and assembly of the system, and the experimental methods used to measure the system performance. In addition, the methods describe how the performance of the inductive power transfer was evaluated by varying the separation distance between the transmitter and receiver coils. This experimental investigation was conducted to analyze the relationship between magnetic coupling and power transfer efficiency.

3.1 Materials Used and Description in the Study

The inductive charging system was constructed using electronic components obtained from local electronic suppliers in Uganda. The main components used in the system include copper wire, an IRFZ44N MOSFET transistor, heat sink, resistors, rectifier diodes, a voltage regulator, a capacitor, a power supply, a digital multimeter, and other materials used for circuit assembly. Copper wire of 25-gauge thickness was used to construct both the transmitter and receiver coils. Copper is commonly used in electrical circuits because of its high electrical conductivity and low resistance to current flow. When current flows through the transmitter coil, a magnetic field is produced around the coil. This time-varying magnetic field induces an electromotive force in the receiver coil through electromagnetic induction.

An IRFZ44N metal-oxide semiconductor field-effect transistor (MOSFET) was used as a switching device in the transmitter oscillator circuit. The heat sink was used to absorb and spread the heat over a large surface area allowing it to dissipate safely into the surrounding air, keeping the circuit elements at a stable operating frequency. The MOSFET controls the current flowing through the transmitter coil and enables the generation of an alternating magnetic field required for inductive power transfer. Resistors of 1 kΩ were used in the circuit to regulate current flow and protect electronic components from excessive current, a direct current power supply was

used to provide electrical energy to the transmitter circuit. A switch was incorporated into the circuit to control the supply of power during system operation.

The receiver section of the system consisted of a receiver coil, a rectifier circuit using 1N4007 diodes, a filtering capacitor, and an LM7805 voltage regulator. The receiver coil captures the magnetic field generated by the transmitter coil and converts it into an induced alternating voltage. The rectifier circuit converts the alternating voltage into direct current. The electrolytic capacitor smoothens the rectified voltage to reduce fluctuations, and the voltage regulator stabilizes the output voltage to approximately 5 V, which is suitable for charging low-power electronic devices.

A light emitting diode (LED) was used as an indicator to confirm the presence of electrical power in the receiver circuit. Soldering wire was used to create strong electrical connections between circuit components during assembly. A digital multimeter and milliammeter were used to measure voltage and current values respectively during the experiment. Sandpaper was used to remove insulation from the copper wire before soldering, and a meter rule was used to measure the separation distance between the transmitter and receiver coils during experimental testing.

The Circuit diagram is as shown below

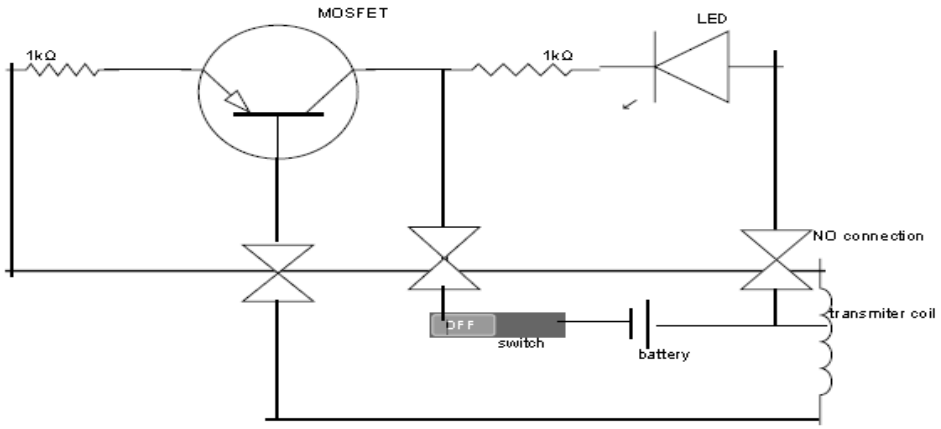


Figure 3.1 *transmiter circuit diagram*

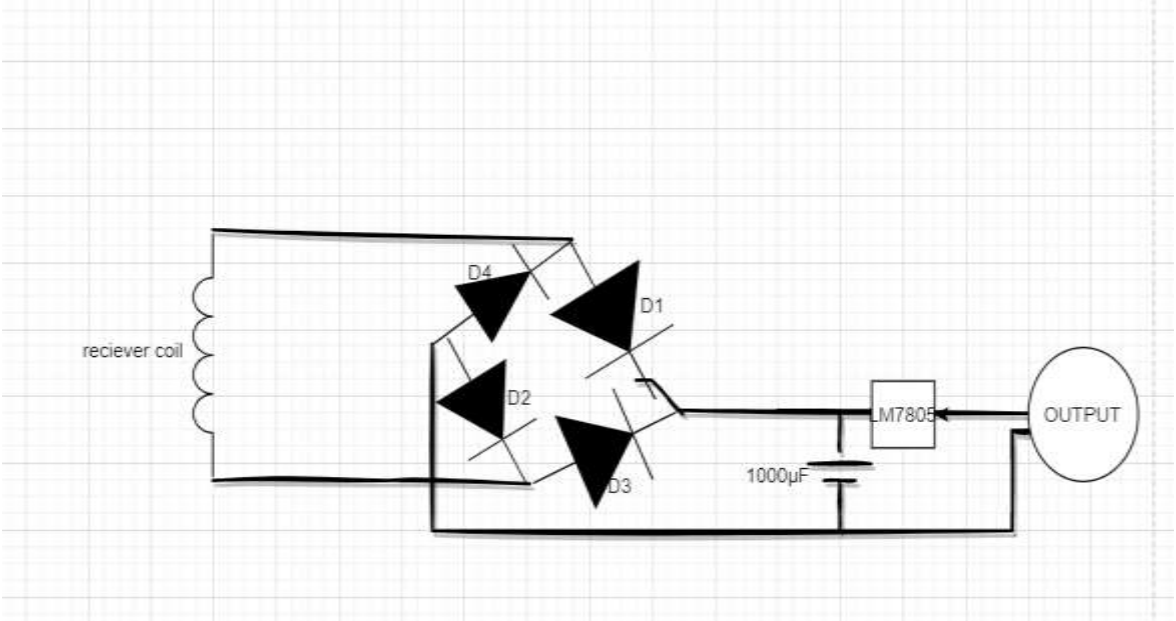


Figure 3.2: *Receiver circuit diagram*

3.2 Design of the inductive Charging System

The inductive mobile charging system was designed based on the principle of electromagnetic induction. The system consists of two main units: the transmitter circuit and the receiver circuit. The transmitter circuit generates a time-varying magnetic field using a switching oscillator circuit connected to the transmitter coil. When electrical power is supplied to the circuit, current flows through the transmitter coil and produces a magnetic field around the coil. The MOSFET transistor operates as a switching device that periodically interrupts the current, creating a varying magnetic field required for inductive power transfer

The receiver circuit is positioned near the transmitter coil so that the changing magnetic field produced by the transmitter coil links with the receiver coil. According to Faraday's law of electromagnetic induction, the changing magnetic flux induces an electromotive force in the receiver coil. The induced voltage is alternating in nature and must therefore be converted into direct current before it can be used to power electronic devices.

This conversion is achieved using a diode rectifier circuit that converts the alternating voltage into pulsating direct current. The electrolytic capacitor smooths the rectified output voltage by

reducing ripple, and the LM7805 voltage regulator stabilizes the output voltage to a constant level suitable for powering low-power devices such as smartphones or LEDs as shown below,

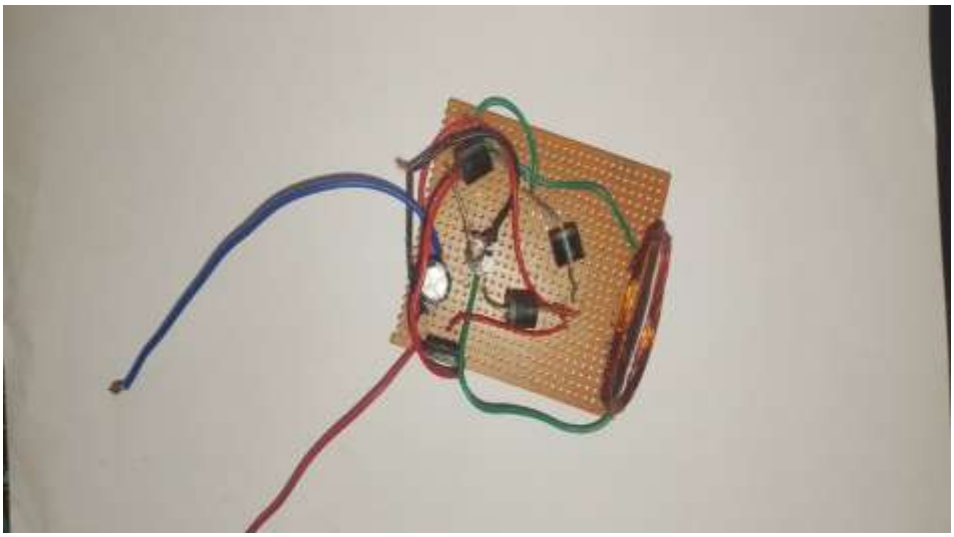


***Figure 3.3**: Receiver circuit*

3.3 Experimental Design

The experiment was designed to investigate the effect of coil separation distance on wireless power transfer efficiency. In this investigation, the independent variable was the distance between the transmitter and receiver coils. The dependent variables were the output voltage, output current, and power transfer efficiency of the inductive charging system. Several factors were kept fixed during the experiment, including the number of coils turns, coil diameter, alignment between the coils, and the input power supplied to the transmitter circuit.
The working hypothesis of the experiment was that the efficiency of wireless power transfer would decrease as the separation distance between the transmitter and receiver coils increased. This behavior is expected because increasing the distance between the coils reduces the magnetic coupling coefficient between the coils.

3.4 Experimental Procedure

The transmitter circuit was first connected to the power supply and activated using the switch. When the circuit was switched on, current flowed through the transmitter coil and generated a changing magnetic field. The receiver coil was positioned close to the transmitter coil so that the magnetic field could induce an alternating voltage in the receiver coil. The induced alternating voltage from the receiver coil was passed through the rectifier circuit where it was converted into direct current. The filtering capacitor reduced voltage ripple and the voltage regulator stabilized the output voltage.

The separation distance between the transmitter and receiver coils was measured using a meter rule. The receiver coil was gradually moved away from the transmitter coil while maintaining alignment between the coils. For each separation distance, the output voltage and current produced by the receiver circuit were measured using a digital multimeter and milliammeter respectively. The input voltage and current supplied to the transmitter circuit were also measured to determine the input power of the system. The measurements were repeated for several distances to observe how the inductive power transfer efficiency changed with increasing coil separation.

The full assembly of the system is as shown below

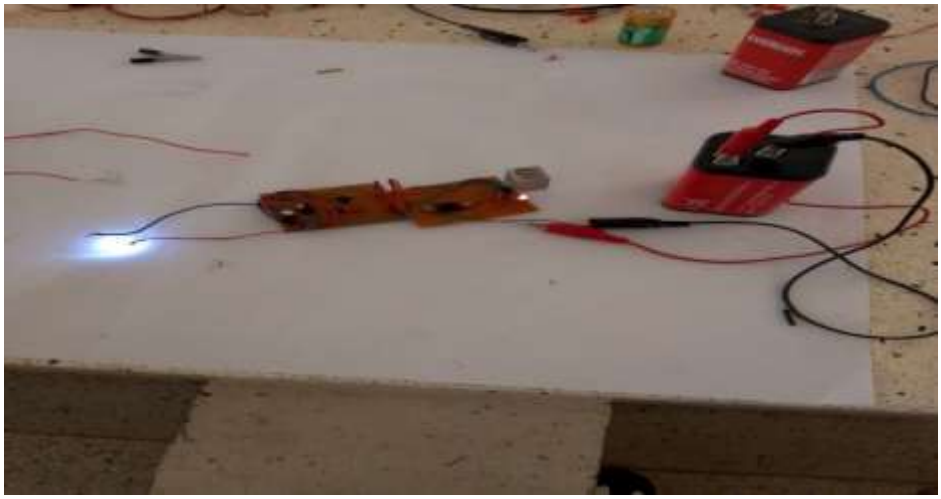


Figure 3.4 *Overall inductive charging system*

3.5 Efficiency Calculation and Data Analysis

The power transfer efficiency of the inductive charging system was determined by comparing the output power delivered by the receiver circuit to the input power supplied to the transmitter circuit. The electrical power in the circuits was calculated using the relationship

$$P = VI \quad \text{..... (3.1)}$$

where P represents electrical power, V represents voltage, and I represent current.

The efficiency of the inductive power transfer system was calculated using the equation

$$\eta = \frac{P_{out}}{P_{in}} x\ 100 \quad \text{..... (3.2)}$$

where P_{out} is the output power measured at the receiver circuit and P_{in} is the input power supplied to the transmitter circuit and η represents the efficiency of the charging system, the calculated efficiency values were recorded for different separation distances between the transmitter and receiver coils. The results were tabulated and a graph of power transfer efficiency versus coil separation distance and another graph of power output versus separation were plotted to analyze the relationship between magnetic coupling and inductive power transfer performance.



Figure 3.5: Constructing the Transmitter Circuit



Figure 3.6: Testing the Overall Circuit



Figure 3.7: Data Collection

CHAPTER FOUR: RESULTS AND DISCUSSION

4.0 Introduction

This chapter looks at the results which are presented in tables and in graphs, it also consists of the discussion of the findings of the research

4.1 Results

Table 4. 1: shows how distance affects the power input

Distance D(cm)	$\boldsymbol{I_{in}(A)}$	$\boldsymbol{V_{in}(v)}$	$\boldsymbol{P_{in}(w)}$
0.1	0.6	4.0	2.4
0.2	0.6	4.0	2.4
0.3	0.6	4.0	2.4
0.4	0.6	4.0	2.4
0.5	0.6	4.0	2.4
0.6	0.6	4.0	2.4
0.7	0.6	4.0	2.4
0.8	0.6	4.0	2.4

Table 4. 2: *variation of distance with power output*

Distance(cm)	I_{out} **(A)**	$V_{out}(V)$	$P_{out}(w)$
0.1	0.040	3.00	0.12
0.2	0.036	2.86	0.10
0.3	0.030	2.78	0.083
0.4	0.025	2.70	0.068
0.5	0.020	2.65	0.053
0.6	0.014	2.40	0.034
0.7	0.008	2.20	0.018
0.8	0.004	1.80	0.007

Table 4. 3: *variation of distance with efficiency*

Distance (cm)	**Power input (w)**	**Power output (w)**	**Efficiency=** $\frac{P_{out}}{P_{in}} x\ 100$ (%)
0.1	2.4	0.12	5.0
0.2	2.4	0.10	4.2
0.3	2.4	0.083	3.5
0.4	2.4	0.068	2.8
0.5	2.4	0.053	2.2
0.6	2.4	0.034	1.4
0.7	2.4	0.018	0.75
0.8	2.4	0.007	0.29

Graphical illustration of results

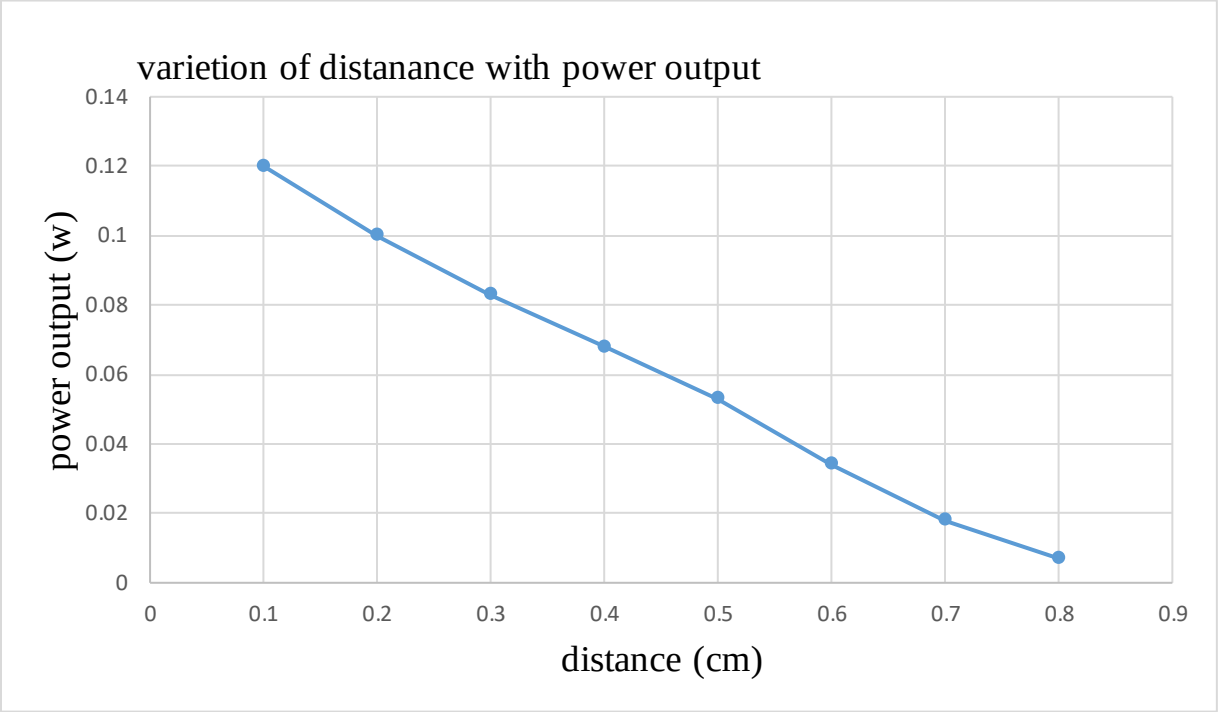


Figure 4.1*: graph of variation of distance and output power*

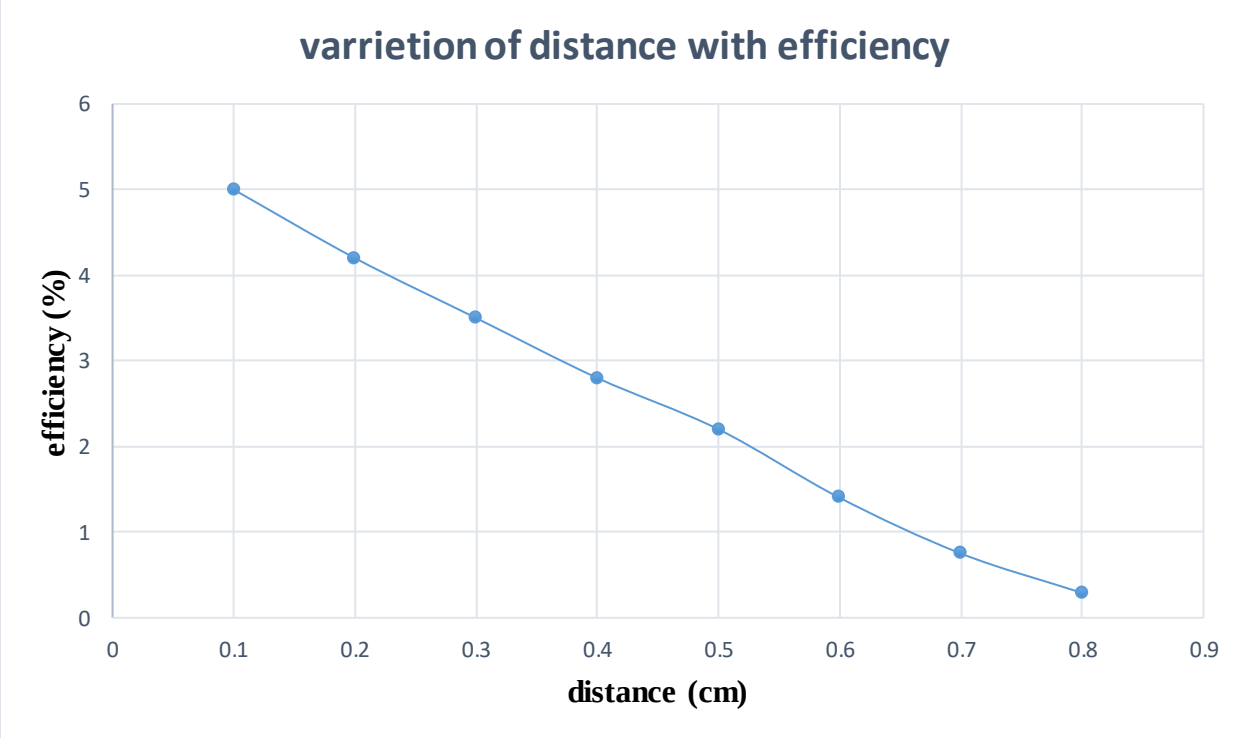


Figure 4.2: graph of variation of distance and efficiency

4.2: Discussion of results

The results on table **4:2** that were plotted on figure **4.1** shows decreasing trend, indicating that power transfer reduces significantly as the separation between the transmitting and receiving coils increases. At a very small distance of 0.1 cm, the system achieves its highest output power of 0.12 **W**, which demonstrates strong magnetic coupling between the coils. However, as the distance increases gradually to 0.8 cm, the output power drops sharply to 0.007 W, showing that only a very small amount of energy is received at larger separations.

This behavior is due to the weakening of the magnetic field with increasing distance. Since in inductive power transfer systems, energy is transmitted through a magnetic field generated by the transmitter coil. As the coils move farther apart, the magnetic flux linking them reduces, resulting in lower induced voltage and hence reduced power output. Furthermore, the graph suggests that the reduction is not linear but rapid, especially beyond 0.5 cm, where the output power becomes almost negligible. This indicates that the effective operating range of the system is limited to very short distances.

The results on table:4.3 that were plotted on the figure:4.2 also show a consistent decreasing trend, like that of power output. The efficiency is highest at 5.0% when the coils are separated by 0.1 cm, but it drops steadily to 0.29% at 0.8 cm. This indicates that as the distance increases, a larger proportion of the input power is lost rather than being transferred to the output. The decrease in efficiency can be because of several power losses within the system. As the distance increases, the magnetic coupling between the coils weakens, leading to reduced energy transfer. At the same time, resistive losses in the coils and other circuit components remain present, meaning that more energy is dissipated as heat instead of being delivered to the load. This explains why efficiency declines even though the input power remains constant at 2.4 W.

CHAPTER FIVE: CONCLUSSION AND RECOMMENDATIONS

5.0 Introduction

This chapter is about the conclusion and recommendations based on the findings of the research that has been conducted.

5.1 Conclusions

The study successfully designed and tested an inductive mobile charging system capable of transferring power based on the principle of electromagnetic induction. The results showed that the system performs best at very short distances, achieving a maximum output power of 0.12 W and efficiency of 5.0% at 0.1 cm, which indicates strong magnetic coupling between the coils when they are closely aligned. However, the performance of the system declines sharply as the distance between the coils increases. At 0.8 cm, the output power and efficiency dropped significantly to 0.007 W and 0.29%, respectively, demonstrating that the system is highly inefficient at larger separations. Overall, the findings show that while the system works, it is limited to short-range applications and suffers from considerable energy losses, making it less practical without further improvements.

5.2 Recommendations

a) For the mobile charger to operate efficiently, the coil design must be improved by increasing the number of turns, especially in the transmitter coil, to increase the strength of the magnetic field created.
b) exploring methods of minimizing the effects of coil misalignment, reduced charging distance so as to improve the overall efficiency and practical usability of the inductive charging system.
c) Other alternative measures besides the heat sink should be used so us to control the overheating of the transmitter coil which results in increased power losses weakening the strength of the magnetic field.
d) Increasing the strength of the magnetic field in the transmitter circuit by using two MOSFETS to increase the strength of the induced electromotive force.

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