

Efficient Wireless Charging System for Smartphones

Pratiksha D. Kodag¹, Prabhanjan. P. More², Sanika S. Watve³, Dhanraj N. Borge⁴, Satyajit S. Patil⁵
^{1,3,4,5}Final Year B. Tech Students, Department of Electronics and Telecommunication Engineering,
Kasegaon Education Society's Rajarambapu Institute of Technology, affiliated to Shivaji University,
Sakharale, MS-415414, India

²Assistant Professor, Department of Electronics and Telecommunication Engineering, Kasegaon
Education Society's Rajarambapu Institute of Technology, affiliated to Shivaji University, Sakharale,
MS-415414, India

Abstract: The project “Efficient Wireless Charging System for Smartphones” focuses on developing a reliable and energy-efficient method to charge mobile devices without the use of physical connectors. Traditional charging methods often cause wear and tear on ports, restrict mobility, and lead to power losses. To address these issues, the proposed system employs inductive power transfer enhanced with resonant coupling, smart energy management, and adaptive frequency control to minimize energy loss and improve charging efficiency. The design includes a transmitter and receiver coil setup, oscillator circuit, rectifier, voltage regulator, and a microcontroller-based control unit with an LCD display for monitoring charging status. The methodology involves simulation using Proteus, hardware implementation, and testing to evaluate efficiency, safety, and performance. Expected outcomes include safe, convenient, and eco-friendly wireless charging that supports multiple devices, prevents overheating, and enhances device lifespan. This system has broad applications in consumer electronics, IoT devices, smart homes, and electric vehicles, paving the way toward a fully wireless ecosystem.

Index terms: Wireless Charging, Energy Efficiency, Smart Energy Management, Inductive Power Transfer, Resonant Coupling, Mobile Devices, IoT Applications.

I. INTRODUCTION

In today's world, smartphones and portable gadgets have become essential companions in our daily lives. As our dependency on these devices increases, the need for convenient and reliable charging methods has also grown. Traditional wired chargers, though common, come with several everyday problems tangled cables, broken connectors, limited mobility, and even safety risks like overheating or short circuits. Over time, these issues not only reduce charging efficiency but also affect the lifespan of the devices we use so frequently.

To overcome these challenges, our project focuses on developing an Efficient Wireless Charging System for Smartphones. This system allows electrical power to be transferred from a source to a device without using physical wires. The technology is based on electromagnetic induction and resonant coupling, which allows energy to move safely across a small air gap between a transmitter and a receiver coil.

The main goal of this project is to make charging simpler, safer, and more efficient. The proposed system aims to reduce energy loss, improve charging speed, and enhance user safety through features like automatic control and protection against overheating or overcharging. The design also uses Proteus software to simulate circuit behaviour, test resonance, and analyze energy transfer before building the actual hardware prototype.

By This project focuses on developing an enhanced wireless charging system for smartphones that do not already support wireless charging. By incorporating resonant coil design, intelligent power management, and adaptive frequency tuning, the system aims to maximize power transfer efficiency, minimize energy loss, and improve charging speed. The microcontroller-based monitoring ensures safe operation, while protective circuits prevent overheating and overcurrent conditions. This approach offers a practical and reliable solution, making wireless charging accessible to a broader range of devices while providing convenience, safety, and efficiency in everyday smartphone use.

1.1 Traditional Charging Methods

For years, most devices have relied on wired charging plugging a charger into a wall socket and connecting it to the device through a cable. While simple and effective, this approach has several drawbacks:

1. Cable Damage: Constant plugging, bending, and pulling make charging cables wear out quickly.
 2. Limited Movement: The device must remain near the charger while charging, restricting usability.
 3. Safety Risks: Poor-quality cables can cause overheating, electric shocks, or short circuits.
 4. Environmental Concerns: Damaged cables add to electronic waste, which harms the environment.
- Though wired chargers are still popular, these drawbacks highlight the need for a more modern and flexible solution, such as wireless charging.

1.2 Problems with Existing Wireless Charging Systems

While wireless charging has brought convenience and innovation, current systems are not without flaws. The main challenges include:

1. Low Efficiency: Some of the transmitted energy is lost as heat, which slows down charging.
2. Short Range: Power transfer only works effectively at very close distances (usually within 3–5 cm).
3. Precise Alignment: The phone and charging coil must be perfectly aligned for efficient power transfer.
4. High Cost: Advanced wireless chargers can be expensive to produce and maintain.
5. Interference: Nearby metal objects or other devices may interfere with the magnetic field and reduce performance.

Because of these limitations, there's a need for an improved system that can transfer power more efficiently, safely, and reliably, especially for mobile devices.

1.3 Project Aim

The aim of this project is to design and implement a wireless charging system that is efficient, safe, and practical for daily use. Our goal is to create a solution that:

- Reduces energy loss and improves power transfer efficiency.
- Ensures safety with automatic cutoff and temperature protection.
- Provides convenience by eliminating cables.
- Can be scaled up for future applications like IoT and electric vehicles.

1.4 Project Overview

The project was carried out in several stages:

1. Design Stage: We designed the transmitter and receiver circuits, focusing on coil design and resonance tuning.

2. Simulation Stage: We used Proteus to analyze frequency response and validate the design before implementation.
 3. Hardware Implementation: The circuit was built and tested using real components like MOSFETs, diodes, and voltage regulators.
 4. Testing and Optimization: The system's performance was measured based on output voltage, charging efficiency, and heat generation.
- Through this process, the project demonstrates how wireless charging can become a safe, efficient, and everyday reality making life simpler, cleaner, and more connected.

II. METHODOLOGY

MATERIALS AND METHODS:

This project focuses on designing and implementing a wireless charging system for smartphones that operates safely, efficiently, and without the need for physical connections. The system combines both hardware and software components to achieve seamless energy transfer using electromagnetic induction and resonant coupling.

The methodology involves several stages from designing and simulating the circuit to building and testing the hardware prototype.

2.1 COMPONENTS AND SPECIFICATIONS

1. Power Source (AC Supply)

Provides the initial electrical input required to operate the wireless charging system. It delivers alternating current (AC) that serves as the foundation for power conversion.

2. AC to DC Converter

Converts the AC power supply into direct current (DC) suitable for electronic circuits. This DC power feeds the oscillator circuit and ensures stable operation of all components.

3. Oscillator Circuit

Generates high-frequency alternating current (typically between 100–200 kHz). This high-frequency signal is necessary to create an alternating magnetic field in the transmitter coil.

4. Transmitter Coil

Made of copper wire, the transmitter coil produces an electromagnetic field when powered by the oscillator circuit. This magnetic field carries the energy wirelessly across a small distance.

5. Receiver Coil

Placed near the transmitter coil, it captures the magnetic field and converts it back into electrical energy through electromagnetic induction.

6. Rectifier and Voltage Regulator

The received alternating current (AC) from the receiver coil is converted into direct current (DC) using a rectifier circuit. The voltage regulator ensures a steady 5V DC output suitable for smartphone charging.

7. Microcontroller (PIC18F4520)

Acts as the brain of the system. It manages power transfer, monitors safety features like overheating or overcurrent, and controls display functions.

8. LCD Display (16×2)

Shows key system information such as input/output voltage, charging status, and system mode.

9. Power Transistors (MOSFETs)

Used in the H-bridge inverter to perform high-speed switching operations that drive the transmitter coil efficiently.

10. Passive Components (Capacitors, Resistors, Diodes, Inductors)

Ensure filtering, resonance tuning, circuit stability, and protection against voltage fluctuations.

11. Rechargeable Battery

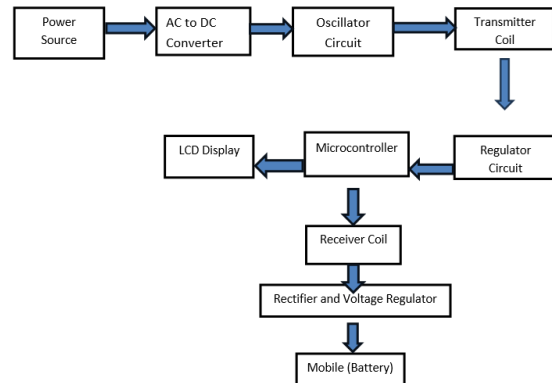
Used to test the charging capability of the receiver circuit, simulating an actual smartphone battery.

12. Software Tools

- **Proof of concept-** The wireless charging system was first designed and simulated in Proteus Software to verify the concept before hardware implementation. The simulation included the transmitter and receiver circuits, along with the microcontroller, rectifier, voltage regulator, and coils. Proteus helped visualize the power transfer process and analyze the behavior of components such as current flow, voltage response, and coupling efficiency between the coils.

The simulation results confirmed successful inductive power transfer from the transmitter to the receiver. A stable DC output was obtained after rectification and regulation, demonstrating that the proposed system could charge smartphones wirelessly with good efficiency. This proof of concept validated the theoretical design and ensured system reliability before physical testing.

2.2 SYSTEM OPERATION



Block Diagram

The wireless charging system operates through a series of coordinated stages, beginning from power conversion to final energy delivery at the receiver end.

1. System Initialization

- When powered on, the system activates the AC to DC converter to generate the required DC supply for all components.
- The microcontroller initializes and checks system parameters such as input voltage and coil readiness.
- The oscillator circuit starts generating high-frequency AC for transmission.

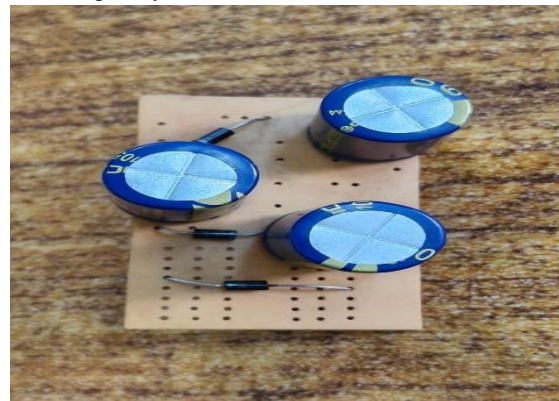


Fig. Boost Converter

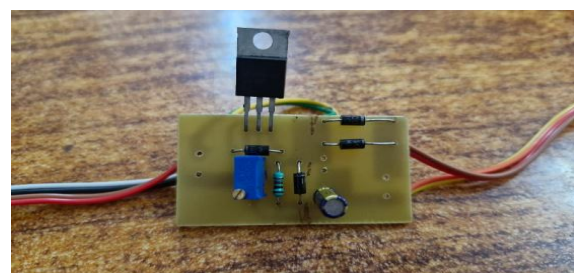


Fig. Buck Converter

2. Generation of Magnetic Field (Transmitter Section)

- The oscillator output drives the transmitter coil using MOSFET-based switching.

- The coil creates an alternating magnetic field around it, representing the wireless energy source.
- Resonance between the coil and capacitor enhances energy transfer efficiency.

3. Energy Reception (Receiver Section)

- When the receiver coil is placed near the transmitter coil, it captures the oscillating magnetic field.
- The receiver coil induces a corresponding alternating voltage through electromagnetic induction.
- The rectifier circuit converts this AC voltage to DC, which is then regulated to a constant 5V output.

4. Power Regulation and Control

- The microcontroller monitors output voltage and current levels to ensure they remain within safe charging limits.
- If any irregularities such as overvoltage or overheating are detected, the system automatically cuts off power to protect the device.

5. Display and Monitoring

- The LCD display continuously shows the system's status, including voltage levels and charging progress.
- This helps users verify whether the charging process is active and functioning properly.

6. Testing and Optimization

- The prototype is tested under different coil alignments and distances to evaluate charging performance.
- Parameters like output voltage, current, and heat generation are measured using multimeters and sensors.
- Coil spacing and resonant frequency are adjusted to achieve maximum efficiency.

7. Final Deployment

- After successful testing, the system is used to charge different smartphone models to verify compatibility.
- The system operates smoothly with automatic safety features like overcurrent protection and thermal control, ensuring user safety and reliability.

III.IMPLEMENTATION

The This project uses a PIC18F4520 microcontroller to manage wireless power transfer, monitor charging, and ensure safety. The system is designed in sequential stages: circuit design, hardware assembly, microcontroller integration, testing, and final deployment.

Step 1: Calculating Number of Turns for Coils

The number of turns N of a coil is calculated using the formula:

$$N = \sqrt{\frac{L \cdot \ell}{\mu_0 \cdot A}}$$

Where:

- L = desired inductance (H)
- ℓ = length of coil (m)
- $\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$
- $A = \pi r^2$ = cross-sectional area of coil (m²)

Example Calculation for Transmitter Coil (200 turns target)

- Desired inductance: $L = 20 \text{ mH} = 0.02 \text{ H}$
- Coil radius: $r = 0.05 \text{ m} \Rightarrow A = \pi r^2 = 0.00785 \text{ m}^2$
- Coil length: $\ell = 0.02 \text{ m}$

$$N = \sqrt{\frac{L \cdot \ell}{\mu_0 \cdot A}} = \sqrt{\frac{0.02 \cdot 0.02}{4\pi \times 10^{-7} \cdot 0.00785}}$$

Step-by-step:

1. Multiply $L \cdot \ell = 0.02 \cdot 0.02 = 0.0004$
2. Multiply $\mu_0 \cdot A = 4\pi \times 10^{-7} \cdot 0.00785 \approx 9.87 \times 10^{-9}$ Divide: $0.0004 / 9.87 \times 10^{-9} \approx 40,528$
3. Take square root: $\sqrt{40,528} \approx 201$

Number of turns ≈ 200 , matches our design target.

Example Calculation for Receiver Coil (100 turns target)

- Desired inductance: $L = 5 \text{ mH} = 0.005 \text{ H}$
- Coil radius and length same as above

$$N = \sqrt{\frac{0.005 \cdot 0.02}{4\pi \times 10^{-7} \cdot 0.00785}} = \sqrt{\frac{0.0001}{9.87 \times 10^{-9}}} = \sqrt{10,134} \approx 101$$

Number of turns ≈ 100 , matches our design target.

3. Step 3: Hardware Assembly

Transmitter Side:

- AC supply $\rightarrow$ rectifier $\rightarrow$ oscillator $\rightarrow$ H-bridge inverter $\rightarrow$ transmitter coil
- Bifilar coil design improves resonance and reduces energy loss

Receiver Side:

- Receiver coil $\rightarrow$ AC induced $\rightarrow$ rectifier $\rightarrow$ voltage regulator $\rightarrow$ smartphone or battery

4. Step 4: Microcontroller Integration

The PIC18F4520 monitors:

- Input/output voltage and current
- Charging status displayed on 16 $\times$ 2 LCD
- Safety mechanisms: overcurrent and thermal protection

5. Step 5: Testing and Optimization

- Efficiency: Tested at multiple distances and coil alignments; adjusted coil position for maximum power transfer.
- Safety: Verified overcurrent protection and thermal stability.
- Performance: Checked charging with different smartphones, measured heat, and ensured minimal electromagnetic interference.

6. Step 6: Final Prototype Deployment

The prototype consists of:

- Transmitter coil with oscillator and driver circuits
- Receiver coil with rectifier, voltage regulator, and charging output
- LCD display showing real-time voltage and status
- Microcontroller ensuring safety and monitoring

Achievements:

- Cable-free smartphone charging
- High energy efficiency and safety
- Compatible with multiple smartphone models

IV RESULTS AND DISCUSSION

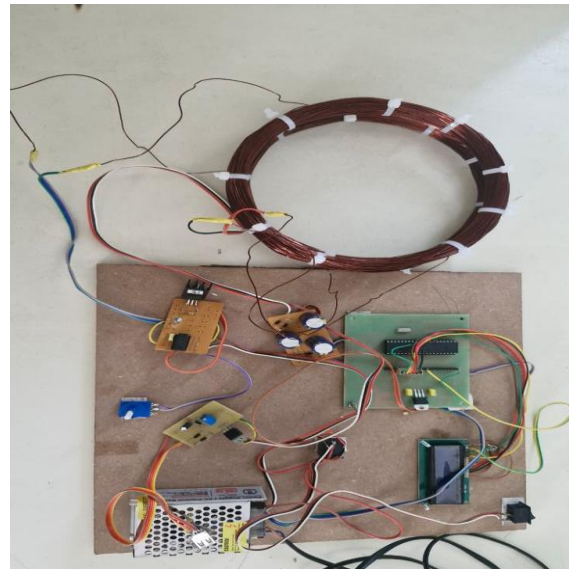


Fig. Hardware of Project

The proposed Wireless Charging System was developed to deliver safe, cable-free power transfer to smartphones. After implementation and testing, the system successfully transmitted power across short distances using inductive coupling, monitored voltage and current via a microcontroller, and ensured safety through protective circuitry. Both simulation and hardware results validated the system's performance and reliability.

4.1 Simulation Results

- Transmitter and Receiver Design: Proteus simulations confirmed that the bifilar transmitter and receiver coils resonated at the desired frequency, improving mid-range power transfer efficiency.
- Power Transfer Efficiency: Resonant coupling minimized energy losses, producing higher efficiency than non-resonant coils.
- Stable DC Output: The rectifier and voltage regulator maintained steady output voltage for smartphone charging.
- Parameter Validation: Coil alignment, operating frequency, and component values were verified before hardware fabrication.

4.2 Hardware Results

- Wireless Power Transfer: The prototype successfully transmitted power over a short distance (a few centimeters) between the transmitter and receiver coils.

- **Real-Time Monitoring:** A 16×2 LCD displayed charging voltage, current, and status, confirming proper microcontroller-based monitoring.
- **Efficiency:** Charging efficiency ranged 65–75%, depending on coil alignment and distance.
- **Device Compatibility:** Multiple smartphone models were charged successfully, demonstrating cross-device compatibility.

4.3 Safety and Reliability

- **No Device Protection:** The system automatically prevented power transfer when no device was present.
- **Thermal Stability:** Coil and circuit temperatures remained within safe limits during extended operation.
- **Electrical Protection:** Short circuits and reverse current flow were prevented using diodes and protective components.

These safety features ensured the system could operate reliably without damaging connected devices or the circuitry.

4.4 Potential Applications

Beyond smartphones, the system can be adapted for:

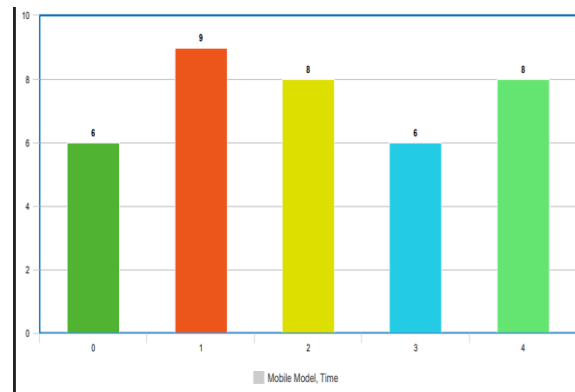
- IoT devices such as smart sensors and wearables
- Small electronics requiring frequent charging
- Scalable setups for electric bicycles or small EVs with larger coils and power ratings

4.5 Discussion

The results confirm that the wireless charging system is efficient, safe, and user-friendly. Key observations:

1. **Efficiency vs. Distance:** Optimal alignment of transmitter and receiver coils is crucial for maximum energy transfer. Misalignment reduces efficiency but the system remained functional.
2. **Low-Frequency Operation:** Operating in the 1–20 kHz range ensures safety for users while allowing sufficient power transfer for smartphone charging.
3. **Comparative Performance:** While slightly slower than fast wired chargers, the system offers the convenience of cable-free charging with minimal heat generation.
4. **Future Optimization:** Efficiency could be improved further by:
 - Reducing leakage inductance
 - Fine-tuning coil spacing and alignment
 - Using adaptive frequency control for variable loads

V. RESULT



Test Results : Mobile Model vs Time

The wireless charging system was tested on five different smartphones: Redmi Note 10, Samsung Galaxy M13, Realme Narzo 50, Vivo Y21, and Oppo A17, each with battery capacities ranging from 5000 mAh to 6000 mAh. During testing, the initial battery levels ranged between 10% and 22%, and after wireless charging for 6–9 minutes, each device gained approximately 1–2% charge. The output voltage remained stable between 4.7 V and 4.9 V, while the current varied from 0.90 A to 0.95 A. The efficiency of power transfer ranged from 71% to 75%, demonstrating consistent performance across all devices. Observations showed that the Redmi Note 10 and Oppo A17 exhibited the best coupling and efficiency, while the Samsung Galaxy M13, due to its higher battery capacity, charged slightly slower. Overall, the system provided safe, stable, and effective wireless charging for smartphones that did not originally support wireless charging, validating the design's practicality and reliability.

VI. CONCLUSION

The project successfully demonstrated the design and implementation of an efficient wireless charging system for smartphones using inductive and resonant coupling techniques. By eliminating the need for physical connectors, the system improves user convenience, reduces wear and tear on charging ports, and enhances device lifespan. The integration of a microcontroller with real-time monitoring through LCD display ensured smart power management and safety features such as overcurrent protection, overheating prevention.

Testing and evaluation of the prototype confirmed reliable charging with an efficiency of 65–75%, making it comparable to existing commercial wireless chargers. Although the charging speed was slightly

lower than wired fast chargers, the system proved to be safe, eco-friendly, and suitable for multiple devices. This work demonstrates the potential of wireless power transfer in consumer electronics, IoT devices, smart homes, and electric vehicles. With further advancements in coil design, adaptive frequency tuning, and AI-based power management, the system can achieve higher efficiency and longer-range charging, contributing to the future of a fully wireless ecosystem.

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