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Wireless Power Transfer System

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Abstract - This report describes the design and implementation of a wireless smartphone charging system controlled by an Arduino microcontroller. Power is transferred inductively from a transmitter coil (charging pad) to a receiver coil mounted on or inside the smartphone. The receiver measures battery percentage and charging status, sends that information via Bluetooth (HC-05) to an Android application, and the Arduino receives control/status data from the HC-05 module. Based on battery percentage, the system lights red/yellow/green LEDs to indicate low, medium and high charge levels. An I2C LCD displays real-time charging status and battery percentage. When battery percentage reaches 95%, a relay module is triggered to disconnect the transmitter, preventing overcharging and improving battery longevity. The report covers objectives, literature survey, hardware and software requirements, implementation details, modules, testing, advantages, limitations, conclusion, and references.

Key Words: Wireless Charging, Inductive Power Transfer (IPT), Arduino, HC-05 Bluetooth Module, Android Application, Battery Monitoring, Relay Cut-off System, I2C LCD Display, LED Indicators, Smart Charging System, Overcharge Protection, Embedded Systems, IoT-based Charging Control, Wireless Power Transfer (WPT)

1. INTRODUCTION

Wireless charging, based on electromagnetic induction, enables power transfer between a transmitter coil and a receiver coil without physical connectors. This improves convenience, reduces cable wear, and aligns with modern charging standards such as Qi. To enhance the limitations of conventional wireless chargers which lack intelligent cutoff, monitoring, and adaptive control this project develops a smart wireless smartphone charging system integrating Arduino, an HC-05 Bluetooth module, and an Android application. Real-time battery percentage and charging status are transmitted from the smartphone to the Arduino, enabling controlled operation of LEDs, an I2C LCD, and a relay that disconnects power when the battery reaches 95%, protecting battery health. By combining inductive power transfer with microcontroller-based monitoring, the system transforms a basic wireless charger into an automated, safer, and more efficient charging platform. The modular design also provides a foundation for future enhancements such as IoT integration, analytics, thermal sensing, and advanced charging behaviors.

2. OVERVIEW

This project implements a smart wireless smartphone charging system using inductive power transfer and an Arduino-based control unit. Battery percentage and charging status are sent from an Android app to the Arduino via Bluetooth, enabling real-time monitoring. Based on this data, the system updates an LCD/LED display and automatically disconnects charging through a relay when the battery reaches 95%, preventing overcharging. The design demonstrates a safe, automated, and efficient wireless charging solution using simple, low-cost components.

3. PROBLEM STATEMENT

Wireless smartphone chargers currently available in the market lack intelligent monitoring and control features. They continue to provide power as long as a device is detected, relying solely on the phone's internal battery management system. This leads to unnecessary trickle charging, increased heat generation, and gradual battery degradation. Users also have no way to monitor charging progress remotely or automate cutoff at healthier battery levels.

To address these limitations, there is a need for a smart wireless charging system that can receive real-time battery information from the smartphone, visually display charging status, and automatically disconnect power at a defined threshold. By integrating Bluetooth communication, microcontroller-based decision-making, and relay-controlled power switching, the system can significantly improve battery safety, efficiency, and overall user convenience.

4. OBJECTIVE

This project aims to develop a smart wireless smartphone charging system that integrates inductive power transfer with real-time battery monitoring and automated charge-cutoff control to improve battery safety, efficiency, and user convenience.

1. Smart Wireless Charging Integration: To implement a wireless power transfer system using inductive charging modules capable of safely delivering contactless power to a smartphone.

2. Real-Time Battery Monitoring: To retrieve battery percentage and charging status from an Android application and transmit the data to the Arduino through the HC-05 Bluetooth module.

3. Automated Cutoff Control: To control a relay module that disconnects the wireless charger when the battery reaches 95%, preventing overcharging and extending battery lifespan.

4. Visual Status Indication: To display charging status and battery percentage on an I2C LCD, and use LEDs to indicate low, medium, and high charge levels.

5. Low-Cost and Scalable Design: To build the system using inexpensive, easily available components so it can be replicated, upgraded, or extended for future smart-charging applications.

5. MOTIVATION

The increasing dependence on smartphones has made efficient and safe charging systems essential. Traditional wired chargers cause connector wear, cable damage, and inconvenience, while conventional wireless chargers continue supplying power even after the device is fully charged. This prolonged exposure to 100% charge accelerates battery ageing, generates unnecessary heat, and reduces long-term battery health.

To overcome these drawbacks, there is a growing need for a smart charging solution that not only provides wireless power but also intelligently monitors battery status and controls charging behavior. Integrating Arduino-based automation, Bluetooth communication, and relay-driven cutoff allows users to prevent overcharging, improve battery lifespan, and monitor the charging process more effectively. This project is motivated by the goal of creating a safer, more efficient, and user-friendly wireless charging system that enhances everyday charging convenience while protecting smartphone batteries.

6. APPLICATION

1. Smart Home Charging Stations

The system can be integrated into smart homes to provide safe, automated wireless charging with real-time monitoring and automatic cutoff, reducing battery wear and improving daily convenience.

2. Public Wireless Charging Spots

Can be used in cafés, libraries, offices, and airports where users benefit from secure, controlled wireless charging that avoids overheating and unnecessary continuous charging.

3. Battery Health–Focused Charging Systems

Ideal for users who want to maintain long-term battery performance. The automatic 95% cutoff prevents prolonged full-charge exposure, improving smartphone battery longevity.

4. IoT-Based Charging Automation

Can be extended into IoT platforms for remote status monitoring, usage analytics, or smart energy management in multi-device environments.

7. Aim

The aim of this project is to design, develop, and implement a smart wireless smartphone charging system that safely delivers inductive power while intelligently monitoring battery status and automatically controlling charging to enhance battery lifespan and user convenience.

1. Reliable and Automated:

To replace manual charging and unplugging with an automated wireless charging process that intelligently switches ON/OFF based on real-time battery percentage.

2. Smart Monitoring:

To continuously receive and track the smartphone's battery level and charging status through Bluetooth communication, enabling accurate and timely control decisions.

3. Controlled Power Cutoff:

To prevent overcharging by operating a relay module that disconnects the wireless charger when the battery reaches 95%, protecting long-term battery health.

4. User-Friendly Feedback:

To provide clear visual feedback using an I2C LCD and LED indicators, allowing the user to easily view charging progress and system status at any moment.

8. Problem Statement

Smartphone batteries degrade faster when they are repeatedly charged to full capacity or left connected to chargers for long periods. Conventional wireless charging systems continue supplying power even after the device reaches 100%, as they do not receive real-time battery updates from the phone and rely solely on the internal battery management system. This leads to unnecessary heat, trickle charging, and long-term battery stress, making the charging process inefficient and potentially damaging. Therefore, there is a need for an intelligent wireless charging system that can monitor battery percentage externally and automatically cut off charging at a safer threshold.

Key Issues:
1. Continuous Charging & Overcharging: Wireless chargers keep transmitting power even after the phone is fully charged, causing trickle charging and accelerating battery wear.

2. No External Monitoring: Existing chargers have no feedback mechanism to know the phone's actual battery percentage, preventing any smart, automated control.

3. Manual User Dependence: Users must remember to check battery status and unplug the charger themselves, which is unreliable and often leads to overnight overcharging.

4. Lack of Intelligent Cutoff: Conventional chargers cannot disconnect power at a healthier threshold like 90–95%, which is recommended for extending battery lifespan.

9. Architecture

An IoT-based smart wireless charging system follows a three-layer architecture: Device (Edge), Cloud/Backend (Server), and Frontend (Application). The layers collaborate to manage sensing, control, scheduling, and user interaction so that the charger can monitor battery status, make control decisions, and report events remotely.

9.1 Device Layer (Edge)

This layer contains the physical hardware that performs sensing, control, and actuation:
1. Microcontroller (Arduino/ESP32): Core controller that parses Bluetooth messages, drives the relay, updates the LCD, and controls LEDs.
2.Wireless Power Module: Inductive transmitter and receiver pair for contactless power transfer.
3.Bluetooth (HC-05): Receives battery percentage and charging state from the Android app.
4.Relay Module: Electrically isolates and switches power to the transmitter for automatic cutoff.
5.I2C LCD & LEDs: Local status display and charge-level indicators (red/yellow/green).
6.Optional Sensors: Temperature/fault sensors and battery backup for reliability.

9.2 Cloud/Backend Layer (The Server)

This layer (optional in simple prototypes) enables remote monitoring, logging, and schedule management:
MQTT Broker / IoT Broker: Lightweight message broker for device ↔ cloud communication.
API Gateway / Server: Handles user authentication, schedule updates, and device commands (Node.js, Flask, etc.).
Database: stores device logs, charge events, user profiles, and schedule data (PostgreSQL/MongoDB).
Scheduling Service: Checks schedules and issues dispense/cutoff commands or notifications when required.

9.3 Frontend Layer (Application)

User-facing interfaces for configuration and monitoring:
Android Application: Reads BatteryManager APIs, sends periodic BAT:<value> and CHARGING:<state>messages over Bluetooth to the device; also provides manual controls and logs.
Web Dashboard / Mobile UI (optional): For remote schedule setup, viewing historical charge logs, and receiving alerts via cloud integration.

9.4 Data Flow and Control Logic

1. Android app reads battery metrics and sends them to the device via HC-05.
2. Arduino parses the message, updates the LCD/LEDs, and evaluates the cutoff logic.
3. If battery ≥ 95% (or configured threshold), Arduino triggers the relay to disconnect the transmitter; if battery falls below the lower threshold (e.g., 90%), charging may be re-enabled.
4. Device publishes status updates to the cloud (if connected) for logging and remote monitoring.

9.5 Block Diagram

This block diagram illustrates the architecture and data flow of the Smart Wireless Smartphone Charging System. It shows how each module communicates, with the Arduino microcontroller working as the central control unit. The system receives real-time battery information from the Android app, processes it through the HC-05 Bluetooth module, updates the local display, and automatically manages the wireless charging process using a relay and inductive power module.

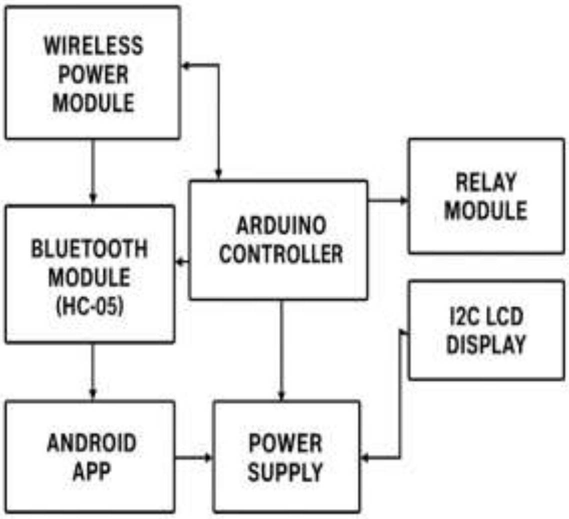

Fig 1: Block Diagram

The system operates by reading the smartphone's battery percentage from the Android application and sending this data to the Arduino through the HC-05. The Arduino then updates the I2C LCD display, activates the LEDs for visual status, and controls the wireless charging transmitter via a relay to prevent overcharging. Power is supplied to the transmitter coil, which transfers energy wirelessly to the smartphone through inductive coupling.

Android Mobile App (User Interface)

1. Reads smartphone battery percentage and charging state.
2. Sends real-time data to the HC-05 module via Bluetooth.
3. Allows continuous monitoring of charging activity.

Arduino Microcontroller (Control System)

1. Receives battery data from the HC-05.
2. Updates the LCD with battery percentage and status.
3. Controls LEDs to indicate low/medium/high battery levels.
4. Activates or deactivates the relay to stop charging at 95%.
5. Functions as the core logic unit of the system.

Charging & Display Mechanism

Wireless Power Module

1. Contains the transmitter coil responsible for inductive power transfer.
2. Supplies wireless energy to the receiver coil in the smartphone.

Relay Module

1. Disconnects the transmitter when the battery reaches 95%.
2. Prevents unnecessary trickle charging.

I2C LCD Display

1. Shows battery percentage, charging status, and cutoff alerts.

Power Supply

1. Provides required voltage and current to the Arduino and wireless module.

9. Conclusion

The smart wireless smartphone charging system developed in this project successfully demonstrates how inductive power transfer can be enhanced with real-time monitoring and intelligent control to improve battery safety and charging efficiency. By integrating an Arduino microcontroller with an HC-05 Bluetooth module, the system is able to receive live battery percentage and charging status directly from the smartphone and make automated decisions based on this data.

The use of a relay module to disconnect the wireless charging transmitter at 95% effectively prevents overcharging, reduces battery stress, and supports healthier battery life. The I2C LCD display and LED indicators provide clear visual feedback to the user, making the system transparent and easy to use. The modular nature of the design shows how simple, low-cost components can be combined to create a smart, adaptive, and safer charging solution compared to conventional wireless chargers.

Overall, the project demonstrates a practical and efficient approach to improving wireless charging systems through intelligent control, user feedback, and automation, offering a foundation for future enhancements such as IoT integration, temperature monitoring, and advanced battery analytics.

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