International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 03 Issue: 03 March 2025
Page No: 297-302
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2025.0041

Enerlink: Empowering EVs with Dynamic Vehicle-To-Vehicle Charging

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Abstract
This paper proposes a smart charging system aimed at optimizing the utilization of energy resources in vehicles. An Arduino Uno microcontroller, acting as the central processing unit, interfaces with various sensors, primarily a DC voltage sensor linked to a 12V battery. Continuously monitoring the battery's voltage level, the system detects when the battery is nearing depletion. At this juncture, the driver can trigger a request for charging assistance by pressing a designated push button. Upon activation, the system employs a ZigBee module to transmit the request to nearby vehicles equipped with compatible receivers. The recipients are then prompted to respond to the request through a real-time IoT webpage. Once a nearby vehicle accepts the request, acknowledgment status is relayed back to the initiator, informing them of the successful arrangement. This innovative system leverages IoT technology to foster efficient communication and collaboration among vehicles, enabling timely assistance in critical situations. By facilitating seamless interactions between drivers and their surrounding environment, the proposed solution aims to enhance overall energy management and ensure uninterrupted mobility, thereby promoting sustainability and convenience in the realm of vehicular operations.
Keywords: *Internet of Things(IoT), Serial Peripheral Interface (SPI)*

1. Introduction
This project introduces a smart charging system utilizing an Arduino Uno microcontroller and a DC voltage sensor to monitor a 12V battery's status. When the battery nears depletion, the driver can request charging assistance via a push button. The system uses a ZigBee module to communicate this request to nearby vehicles equipped with compatible receivers. Accepted requests are acknowledged through an IoT webpage, facilitating efficient energy management and collaboration among vehicles. This approach aims to enhance mobility and sustainability by ensuring timely assistance and optimal energy utilization in vehicular operations. The project aims to optimize vehicular energy management by enabling real-time charging assistance requests and responses through IoT communication, fostering collaboration among vehicles for enhanced mobility and sustainability. This paper consists of a system made using zigbee protocol to request nearby electric vehicles to help us when we are less on fuel (i.e., charge of batter is low)

2. System Design
2.1 Architecture Diagram
The architecture diagram for the ENERLINK: Empowering EVs with Dynamic vehicle-to-vehicle charging. The diagram consists of a transmitter and a receiver in it. Figure1 shows Architecture Diagram of Transmitter

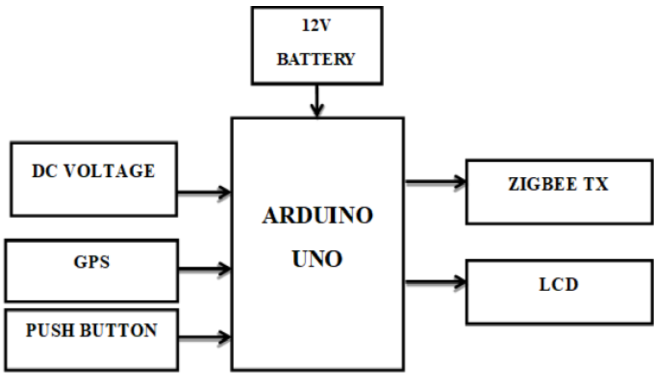

Figure1 Architecture Diagram of Transmitter

In this project, an Arduino uno microcontroller acts as the central processing unit, interfacing it with

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multiple sensors to ensure efficient energy management. A DC voltage sensor is connected to a 12V battery, continuously monitoring its voltage level. The Arduino Uno tracks the battery's charge status and identifies when the battery's voltage drops below a critical threshold. At this point, it triggers the system to request charging assistance. This setup enables proactive monitoring and management of the battery's energy, ensuring timely intervention when the battery approaches depletion. Figure 2 shows Architecture Diagram of Receiver [1-5]

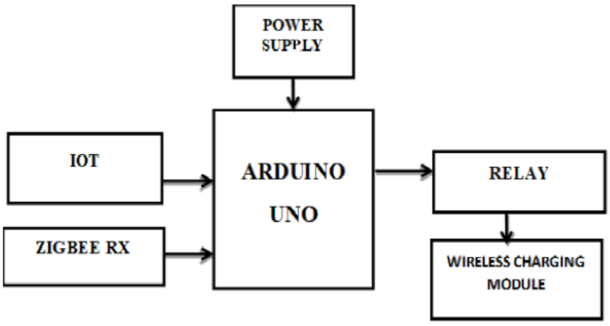

Figure 2 Architecture Diagram of Receiver

When the charge of the battery drops below the critical level, the driver presses a designated push button, which sends a charging request through a ZigBee module to nearby vehicles. This request is broadcasted and displayed on an IoT webpage accessible by the nearby vehicles. These vehicles can view the request and respond in real-time through the webpage interface, facilitating an efficient and coordinated approach to addressing the charging needs. This system enables timely communication and collaboration among vehicles, ensuring that assistance can be promptly arranged when battery levels are critically low. Figure 3 shows Request Transmission. [6-10]

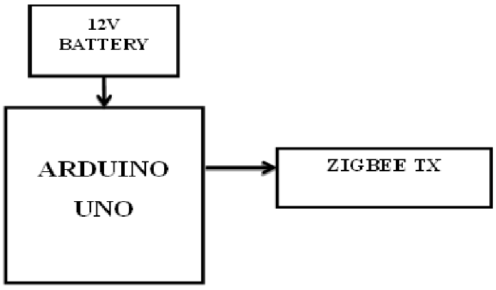

Figure 3 Request Transmission

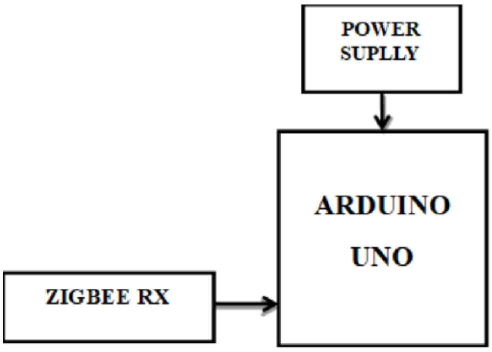

Figure 4 Request Receiver

In this project, an Arduino Uno microcontroller acts as the central controller, interfacing with various sensors. A DC voltage sensor is linked to a 12V battery, continually monitoring its voltage level. When the battery approaches a low charge, the driver presses a push button. This triggers a transmission of a charging request via a ZigBee module to nearby vehicles. Upon transmission, the system awaits acceptance from nearby vehicles. The request status is displayed on an IoT webpage on the receiver's end. Once the request is accepted by a nearby vehicle, the acceptance status is relayed back to the requester. This setup enables efficient communication and coordination for charging needs between vehicles in proximity.

2.2 ZIGBEE Protocol

The nRF24L01+ is a 2.4 GHz transceiver featuring an integrated baseband protocol engine, making it ideal for low-power wireless applications. It operates within the global ISM frequency range of 2.400 – 2.4835 GHz. To build a functional radio system, an MCU and a few external passive components are required. Communication and configuration of the nRF24L01+ are handled through a Serial Peripheral Interface (SPI), which provides access to all configuration registers. The embedded Enhanced Shock Burst™ protocol engine supports multiple operational modes, including manual and advanced autonomous protocols. It facilitates efficient data transfer between the radio front end and MCU, reducing overall system costs by managing high-speed link layer operations. Utilizing Gaussian Frequency Shift Keying (GFSK) modulation, the transceiver allows users to configure parameters such as frequency channel, transmission power, and air

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data rate. Due to its high data transmission rate and two power-saving modes, the nRF24L01+ is well-suited for ultra-low power applications. Figure 5 shows ZIGBEE. [11-13]

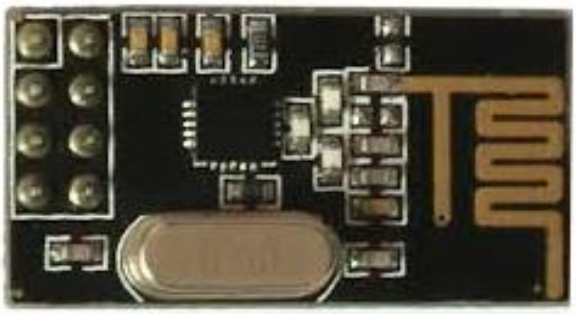

Figure 5 **ZIGBEE**

This transceiver is pin-compatible with the nRF24L01 and maintains on-air compatibility with models such as nRF2401A, nRF2402, nRF24E1, and nRF24E2. It features improved intermodulation and wideband blocking performance, ensuring compliance with RF regulatory standards through internal filtering. Additionally, built-in voltage regulators provide high power supply rejection ratio (PSRR) and support a broad input voltage range.

2.3 EMBEDDED C

Embedded C is a widely used programming language in the field of embedded systems. It is essential for developing software that enables microcontrollers and processors to execute specific tasks in electronic devices. This language plays a key role in the functionality of various modern gadgets, including mobile phones, washing machines, and digital cameras. The block diagram illustrates how Embedded C is utilized to control an LED connected to Port 0 of a microcontroller. Since C programming is widely used in embedded systems, it is the preferred choice for such applications. C is favored in embedded system development due to several key advantages:

- Simple and easy to learn
- Highly reliable for system stability
- Portable across different hardware platforms
- Scalable for future modifications and enhancements
- widely used in embedded systems

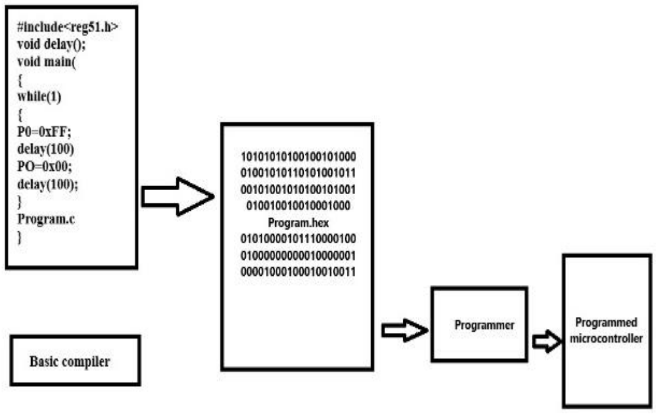

Figure 4 **Block Diagram**

3. Embedded System Programming

3.1 Basic Declaration

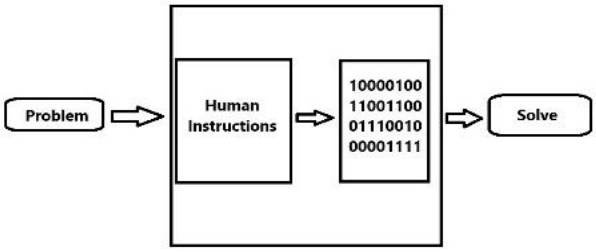

Figure 6 **Embedded System Block Diagram**

programming language is a set of functions designed to perform specific tasks, following defined syntax rules and fundamental components. C programming is structured around functions and includes elements such as variables, character sets, data types, keywords, and expressions. Embedded C extends the standard C language by incorporating additional features like specialized data types, keywords, and header files, typically included using the #include directive. Each programming language follows its own syntax rules and fundamental building blocks to execute operations efficiently. Figure 6 shows Embedded System Block Diagram.

4. System Design

A system is a structured approach to organizing, working, or executing tasks based on predefined rules, programs, or plans. It ensures that all components function together in real-time computation while following a specific set of guidelines. A system can also be described as a the method of organization or task execution that adheres

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to a predetermined framework. An embedded system is a control system that integrates software and hardware, enabling a device to operate independently or as part of a larger system. These systems vary in size, from small-scale to complex designs, and are often microcontroller-based to perform specialized tasks. An embedded system consists of three primary components:

- **Hardware:** The physical structure that includes essential components such as a microcontroller-based integrated circuit, power supply, and LCD display.
- **Application Software:** This software allows users to modify and customize the embedded system's code to execute specific tasks.
- **Real-Time Operating System (RTOS):** An interface that manages system operations, ensuring efficient processor latency control while serving as the system's execution manager.

5. Simulation and Result

This simulation represents a wireless communication system designed using Arduino microcontrollers, ZigBee modules, and a GPS module. The circuit consists of two Arduino boards, each connected to a ZigBee module, allowing wireless data transmission between them. A GPS module is integrated into one of the Arduino setups, likely to provide location data, which is then transmitted via the ZigBee module. The second Arduino, receiving the transmitted data, processes it and displays relevant information on an LCD screen. Additional circuit components, including resistors, capacitors, buttons, and other sensors, support the functionality of the system. The primary objective of this simulation is to establish a real-time remote data communication setup, which can be useful in applications such as location tracking, IoT-based monitoring, and sensor data transmission. The use of ZigBee modules ensures a reliable and efficient wireless connection, while the LCD screens provide a user-friendly interface for data visualization. washing machines, and digital cameras. The block diagram illustrates how Embedded C is utilized to control an LED connected to Port 0 of a microcontroller. Since C Programming Figure 7 shows Simulation Diagram.

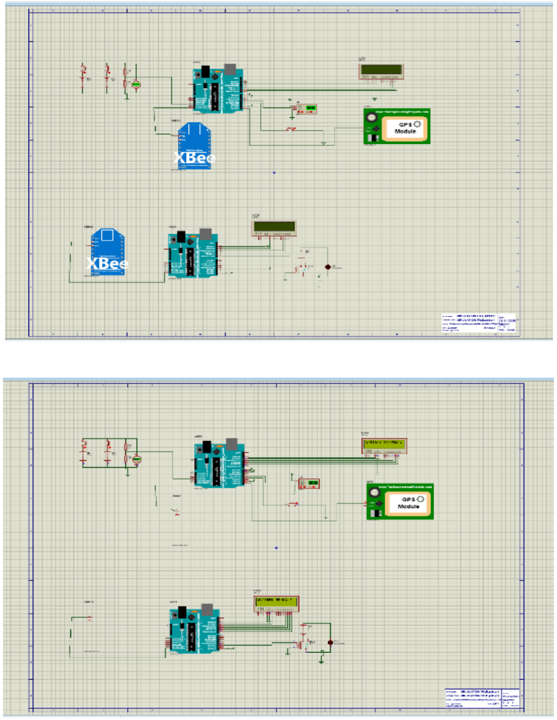

Figure 7 Simulation Diagram

6. Applications

- Emergency Charging Assistance: Provides timely help to vehicles with low battery levels by connecting them with nearby vehicles that can offer charging support.
- Fleet Management: Enhances the efficiency of vehicle fleets by enabling real-time energy management and coordination among fleet vehicles, reducing downtime and optimizing energy resources.
- Smart Transportation Systems: Integrates with smart city infrastructure to facilitate efficient energy use and improve the overall management of vehicular operations in urban environments.
- Sustainable Mobility Solutions: Supports sustainability by promoting the efficient use of energy and reducing the need for traditional charging infrastructure through vehicle-to-vehicle cooperation.
- Remote Areas Support: Offers a practical solution for providing charging assistance in remote or underserved areas where conventional charging stations might be scarce.

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7. Advantages

This project offers several advantages, including enhanced vehicle energy management through real-time monitoring and assistance requests, improved efficiency in critical situations by enabling timely charging support, and fostering collaboration among vehicles to optimize energy utilization. By leveraging IoT and ZigBee technology, the system reduces dependence on traditional charging infrastructure, promotes sustainable mobility, and provides practical solutions for energy management in both urban and remote areas. This method enhances vehicle performance while promoting a more sustainable and efficient transportation system.

8. Future Enhancement

Future enhancements for this smart charging system could include integrating advanced machine learning algorithms to predict battery depletion more accurately and optimize the timing of assistance requests. Incorporating GPS and mapping technologies could facilitate automated routing of assistance requests to the nearest available vehicles. Additionally, expanding the system to include communication with public charging stations and vehicle-to-grid (V2G) technology could further enhance energy management and sustainability. Integration with vehicle-to-everything (V2X) communication could also enable broader network coordination, improving overall efficiency and responsiveness in diverse driving environments.

Conclusion

In conclusion, this smart charging system effectively enhances vehicle energy management by enabling real-time communication and coordination among vehicles. Utilizing an Arduino Uno microcontroller, DC voltage sensors, and ZigBee modules, the system allows vehicles to request and receive charging assistance efficiently. By integrating IoT technology for status updates and acknowledgments, the project ensures timely support, reduces the reliance on conventional charging infrastructure, and contributes to more sustainable and efficient vehicular operations. This innovative approach improves overall mobility and promotes better energy utilization, addressing critical charging needs in various scenarios.

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