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IoT-Based Smart Village System for E-Vehicle Charging and Smart Lighting

S.BRINDHA[1] , K.ABINAYA[2] , P.DHIVYA[2], K.GNANAKIRUTHIKA[2] , B.MADHUMITHA[2].
[1] Assistant Professor,[2] Student, Department Of Information Technology Vivekanandha College Of Engineering For Women, Tiruchengode, Namakkal, Tamilnadu

Abstract - The paper overviews a novel technique for the wireless charging system of electric vehicles which verifies the developed theory using battery charger application of electric vehicles. The implemented wireless charging system of batteries for Electric vehicles by inductive coupling method has been presented in this paper. The driving circuit is used between the transmitter coil & receiver coil. the research underscores the social economic, environmental, and technical implications of such innovations. Smart lighting systems can control the street light efficiently by using RCWL0516 sensors. The lighting is designed to enhance rural areas by implementing smart lighting solutions. The core component of this system is the RCWL0516 Doppler Radar Motion Sensor. By seamlessly integrating this sensor into the system architecture, we demonstrate a novel approach to energy-efficient and adaptive lighting control. which plays a pivotal role in detecting human presence and controlling the lighting. These systems provide reliability, low maintenance, and long product life.

Keywords— electric vehicles; Wireless power transfer; inductive power transfer; battery charging; RCWL0516 sensor;

I. INTRODUCTION:

In 1891, Nikola Tesla proposed the idea of wireless power transmission and demonstrated the first wireless power transfer system for illumination. Sometimes connecting too many wires in small power sockets becomes inconvenient and hazardous. Electric vehicles are the same as normal vehicles, but an electric motor is used in an electric vehicle for propulsion purposes, and for power supply that motor battery is used [1]. New types of rechargeable batteries are available which are used because of small in size, as compared to conventional lead acid batteries the energy storage capacity is higher, and their weight is also less. The charging process is bulky for users in plug-in electric vehicles because for charging the battery, a charger is required which is directly connected to a vehicle or sometimes the battery is removed for charging purposes. By utilizing inductive power transfer technology this difficult charging process is simplified [1].

The inductive power transfer (IPT) method is designed to deliver power wirelessly via magnetic coupling from a static transmitter to one or more movable secondary receivers [1]-[7]. In between the
primary source and secondary load, there is a large air gap. The power supply is either single phase or three eet Lighting System",Phases depending on the power requirement. WPT system generally consists of a power supply, transmitter (primary coil), receiver (secondary coil), microcontroller, battery, sensors, and matching circuit [11]. Depending on the magnetic structure of the coil IPT system is a strong and controllable magnetic field for WPT.

The advantages of the IPT system are listed below [1]-[7], [10] –

- The system is Safe.
- Reliable.
- The system has low maintenance

A street lighting system is the most fundamental electrical system that is implemented on the roads. Due to environmental concerns, lighting control system plays an important role inflation of energy utilization without compromising comfort goals. The street lights are to be lit constantly for more than 12 hours per day which requires plenty of electric power The expenditure on energy is very high this system not only optimizes energy consumption but also offers enhanced control, customization, and adaptability, catering to the diverse needs and dynamics of rural communities.

Traditional lighting systems in rural areas often suffer from inefficiencies, leading to waste of energy and increased maintenance costs. Moreover, these systems may not provide adequate illumination, compromising the safety and security of the residents. With the integration of IoT technologies, it is possible to develop intelligent lighting systems that are responsive, energy efficient, and tailored to the specific needs of rural communities.

The RCWL-0516 is a widely recognized detecting motion sensor module that offers high sensitivity and reliability in detecting motion within its range. By leveraging the capabilities of the RCWL-0516 sensor, it becomes feasible to either distributed or lumped topologies.

The AC is generated in the transmitter coil by the power supply at a very low frequency. Via magnetic fields, single primary coil and multiple secondary coils are coupled. The constant frequency current in the primary coil creates a design of a smart lighting system that can detect human presence and adjust the illumination levels accordingly. This not only conserves energy but also enhances the overall user experience by providing seamless and adaptive lighting solutions. The evaluation of rural areas in the age of technology and the importance of integrating modern solutions. Unlike the traditional PIR (Passive Infrared) sensors that detect changes in infrared radiation, the RCWL0516 uses microwave radar technology. It emits microwave signals and detects any reflected signals due to motion. A long detection range is capable of detecting motion from a distance of several meters.360° detection angle offers a wide detection coverage

LITERATURE SURVEY

The concept of wireless power transfer by transmitter coil method has been discovered for many years and is now gaining more. A literature survey is a prime component of this dissertation; an exhaustive review of the subject area has been done as given below.

Hui Zhi (Zak) Beh [1] proposed a DCS (double-coupled system) which is used for charging the battery of an electric vehicle. In between the primary coil and secondary pickup, the intermediary coupler is placed where it operates as a switch. The system efficiency is increased by sharing all losses between the branches.

Jesus Sallan [4] explains a new design process in which a design factor is considered to choose the parameter of a coreless IPT such as an optimum number of coils, compensation capacitors, and frequency. If an appropriate design is selected then there is the possibility to deliver high power with high efficiency.

Akshaya K. Swain [5] explains a bidirectional IPT system in which wireless power transfer is possible easily between the two sides which are separated by an air gap, through weak magnetic coupling. Without an accurate mathematical model system is difficult to design and control. A dynamic model has been developed by state variables. This model is a standard tool for steady state and transient analysis of IPT systems as well as for the design of controllers.Dukju Ahn and Songcheol Hong

[12] says that for the IPT system, the concept of repeaters can be applied, which enhances the power transfer distance between the transmitter and receiver coil by placing intermediate repeaters. The position of the repeater between the transmitter and receiver is carefully obtained. The efficiency is significantly different from each other for two different configurations while delivering the same amount of power. Better efficiency is obtained if the repeater is inserted nearer to the transmitter than the receiver. The 10-15 cm gap is between the road surface and the bottom of an electric vehicle, this gap is large for vehicles like trucks or buses therefore to extend the charging distance depending on the gaps certain methods are needed. By inserting repeaters this goal is achieved.

Need for Wireless Power Transfer System

In future the fuels like coal, petrol, and diesel will vanish because these are non-renewable sources of energy. The transportation system will have limitations in the future. Therefore we go for the electric vehicle for transportation purposes. The usage of PEV is currently increasing but there are some battery-related problems such as a slower charging rate, low energy storage capacity, size, and weight [1]. New technology is required to reduce battery-related problems and for the development of EVs. Due to charging-related issues, many consumers do not accept PEVs on a priority basis [11]. To reduce battery-related problems, and greenhouse gases and to resolve the magnetic field radiation problem the concept of a Wireless Power Transfer (WPT) system is developed [10]. Many charging stations are built on the side of the road since the users travel further distances by recharging their electric vehicles. Therefore high high-capacity battery is not required and it is replaced by a small battery, since reduces the weight of the battery [1].

WPT eliminates the need for physical connections, allowing for greater mobility and flexibility in device placement. Users can simply place their devices within the proximity of the charging source without dealing with cords and plugs. Eliminating physical connectors reduces the wear and tear associated with plug-in connections, increasing the lifespan of devices. WPT systems can be designed with safety features such as overvoltage and overcurrent protection, minimizing the risk of electrical hazards. WPT systems can be combined with IoT technologies to enable smart charging features, such as adaptive charging rates and remote monitoring. WPT systems can incorporate user-friendly interfaces and controls, enhancing the overall user experience and convenience. the need for wireless power transfer systems is driven by the demand for convenient, safe, and sustainable charging solutions that cater to the evolving needs of modern environments and lifestyles.

The RCWL0516 sensor's integration into smart street lighting systems provides a method to enhance efficiency, safety, and sustainability. Its ability to detect motion accurately makes it a valuable component in modernizing urban and rural lighting infrastructures. The primary function of the RCWL0516 sensor is to detect motion within its range. By placing this sensor in streetlights, the system can detect the presence of pedestrians, vehicles, or any other moving objects. This enables the streetlights to illuminate only when necessary, conserving energy when no motion is detected. Traditional streetlights often remain on throughout the night, regardless of whether there's any activity on the streets. With the RCWL0516 sensor, streetlights can be programmed to activate only when motion is detected, leading to significant energy savings.

By illuminating streetlights only when motion is detected, the RCWL0516 sensor ensures that pedestrians and drivers have adequate visibility when they are on the road or walking paths. This can enhance safety by reducing dark areas and potential blind spots. Over-illumination can contribute to light pollution, affecting the environment and disrupting nocturnal wildlife. The use of sensors like RCWL0516 ensures that lights are activated only when necessary, minimizing unnecessary light emission and its adverse effects. Implementing smart street lighting with motion sensors can lead to cost savings in terms of energy bills and maintenance. By reducing the operational hours of streetlights based on actual needs, municipalities can achieve a more cost-effective lighting solution.

PROPOSED METHOD

1. WIRELESS CHARGER

Represents the block diagram of the proposed wireless power supply system for charging the battery of electric vehicles. It consists of two parts a transmitter to generate an AC signal that is to be transferred, a transmitting and receiving coil to transfer power wirelessly, and a receiver to convert the received AC signal into DC voltage for charging the battery of an electric vehicle [10]. The implementer system aims to design a prototype of a wireless power supply system to recharge the battery of an electric vehicle and avoid wastage of power.

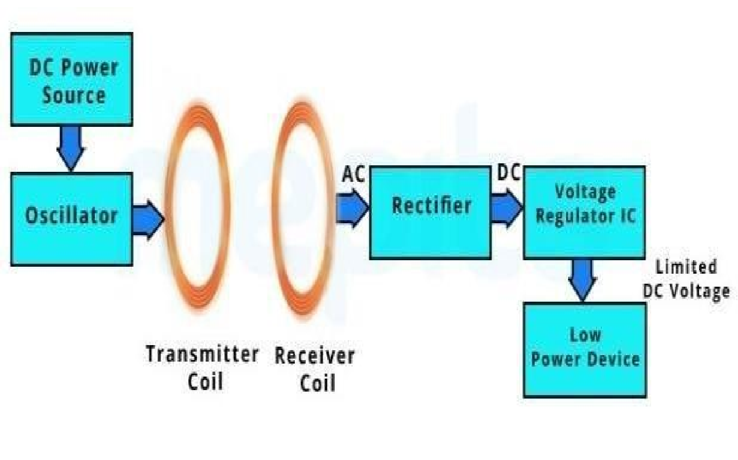


Fig .1 A basic block diagram

A basic block diagram of a wireless power transfer system consists of two sections. One is a transmitter section or primary coil and another is a receiver or secondary coil section.

A. DC POWER SUPPLY

The required voltage and current output range to accommodate a variety of Electronic devices. safety mechanism such as overvoltage protection to safeguard connected devices. the power supply for high efficiency to minimize energy waste and heat generation.

A. OSCILLATOR

The required frequency range of this application and the design of an oscillator can provide the desired frequencies. specify the required output amplitude and design the oscillator to maintain it within the desired range.

B. TRANSMITTER COIL AND RECEIVER COIL.

The transmitter coil has an appropriate shape and size for efficient power transfer. Specify the power handling capacity of the transmitter coil for use convenience. Consider incorporating features to tolerate misalignment between the transmitter coil and receiver coil for user convenience. Implement a cooling mechanism, such as heat sinks or fans, to manage heat generated during power. Design an enclosure for physical protection and meets safety standards. adaptive power control mechanisms to dynamically adjust the transmitted power based on the proximity and power requirements of the receiving device. power factor correction in the transmitter

circuit to improve power factor and overall energy efficiency during wireless power transfer.
the receiver coil to efficiently capture energy from the transmitter coil. the receiver coil design allows for easy integration with various devices that need wireless power. voltage and current ratings of the receiver coil based on the requirements of the receiving device. provisions for integrating energy storage elements, such as capacitors or batteries, to store excess energy during peak transfer periods and provide a stable power output.

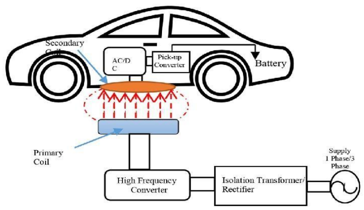


Fig.2 Block diagram of wireless charge

C. RECTIFIER CIRCUIT

Diodes with appropriate voltage and current ratings to handle the expected values in our circuit. a filtering capacitor to smooth the rectified DC output and reduce ripple. load regulation mechanisms to ensure a stable output voltage under varying loads.

D. VOLTAGE REGULATOR IC

the required output voltage and ensure the selected voltage regulator IC can provide the desired level. the dropout voltage of the regulator to ensure stable output even when the input voltage is close to the desired output voltage. easy integration with other components in your system, ensuring compatibility with the overall design.

E. TWO CHANNEL RELAY MODULE

A relay is an electromagnetic switch that is controlled by a small electrical signal. It consists of an electromagnet and a set of contacts. The term "two-channel" refers to the presence of two independent relay circuits on the module. Each channel typically has its own set of relay contacts. Relay modules often provide electrical isolation between the low-voltage control circuit and the high-voltage switched circuit. This is crucial for safety and to protect sensitive components.

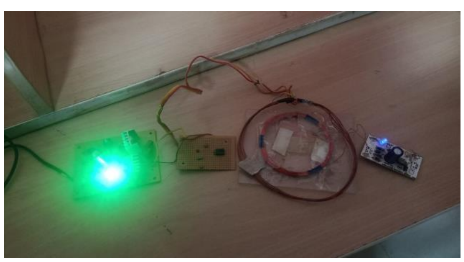


Fig.3 Photograph of the wireless charging system.

2. SMART LIGHTING

A. LDR SENSOR MODULE

LDR (Light Dependent Resistor), The core element of the module is the LDR. This is a semiconductor device whose resistance changes in response to the amount of light falling on it. In darkness, the resistance is high, while the resistance decreases in the presence of light. LDR sensor modules typically provide analog output signals proportional to the light intensity. The analog output can be interfaced with microcontrollers.

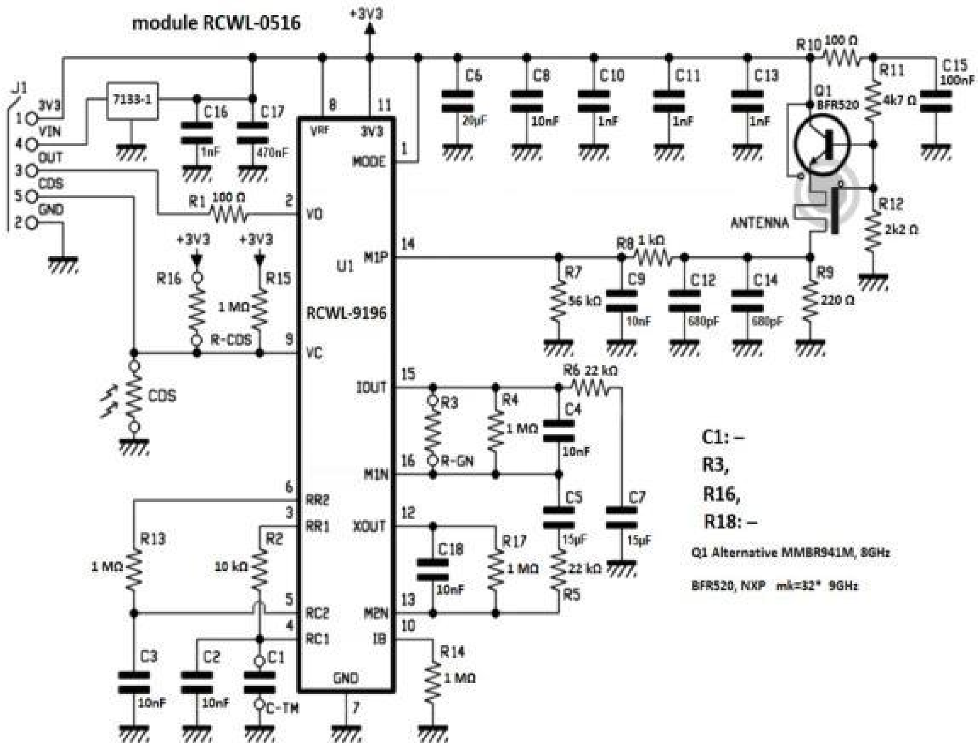


Fig.4 A basic block diagram

B. TRIM POTENTIOMETER

A trim potentiometer, short for potentiometer, is a variable resistor used in electronic circuits for calibration or adjustment. It consists of a resistive track and a wiper that can be moved along the track, changing the resistance. Trim pots are typically small and mounted on a circuit board.

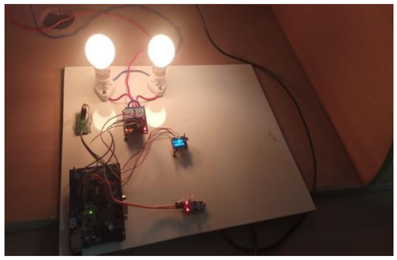
C. LM393- DUAL IN PACKAGE COMPARATOR IC

LM393 contains two independent voltage comparators in a single package. A voltage comparator is a device that compares two input voltages and outputs a digital signal indicating which one is larger. The LM393 typically operates with a dual power supply in the range of 2 to 36 volts, but it can also function with a single supply.

D. RCWL0516 MICROWAVE RADAR SENSOR

RCWL0516 Sensor, providing insights into its working principles and effectiveness in motion detection. Utilized for motion detection with high sensitivity and low false positives. Enables the system to respond dynamically to the presence of individuals or vehicles in the vicinity. RCWL0516 uses microwave radar technology. It emits microwave signals and detects any reflected signals due to motion. A long detection range is capable of detecting motion from a distance of several meters.360° detection angle offers a wide detection coverage. adjustable sensitivity and delay some modules come with potentiometers to adjust sensitivity and delay time. Low Power Consumption is designed for energy efficiency, making it suitable for battery-operated applications.

Fig.5 Photograph of smart lighting



CONCLUSION

Implemented for wireless charging system which is used to recharge an electric vehicle battery. The driving circuit is used between the transmitter coil &receiver coil where MOSFET and micro-controller operate as a switch. Power transfer is allowed by turning ON the transmitter circuit when the vehicle is present, and turning OFF power transfer when the vehicle is absent to overcome the energy waste and to avoid the magnetic field radiation problem. The proposed driving circuit utilizes an AC switch which controls the system power transferred. The implementation of an inductive power transfer system is verified by using the battery charger application of electric vehicles. A prototype practical system is developed with an efficiency level of 67 % and results are verified. The system provides reliability, long life, and safety. Smart lighting experiment demonstrates a successful implementation of a smart street lighting solution that offers reliability, low maintenance, and adaptability, contributing to improved lighting conditions in rural areas while ensuring energy efficiency and long product life. Further optimizations and scalability considerations can be explored for broader applications in diverse environments.

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