International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 8 Issue 5, Sep-Oct 2024 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

On Road Wireless Electrical Vehicle Charging System using Solar Panel

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ABSTRACT

Electric vehicles are seen as an alternative option in response to the depletion of resources. In order to increase the use of EVs in daily life, practical and reliable methods to charge batteries of EVs are quite important, accordingly wireless power transfer (WPT) is considered as a solution to charge batteries [5]. The system makes use of a Solar panel, IR Sensor, battery, regulator circuitry, copper coils, AC to DC converter module, ATmega microcontroller (Arduino) and LCD display to develop the system. The solar panel is used to power the battery through a charge controller. The battery is charged and stores DC power. The DC power now needs to be converted to AC for transmission[6]. For this purpose, here we use a wireless charging module.

How to cite this paper: Shubhradeep Saha | Raja Das | Subhranil Ghosh "On Road Wireless Electrical Vehicle Charging System using Solar Panel" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-8 | Issue-5, October 2024, pp.438-445, URL: www.ijtsrd.com/papers/ijtsrd69381.pdf

IJTSRD69381

I. INTRODUCTION

The idea is based on the technology proposed by ElectReon Wireless, an Israeli start-up [1]. Eliminating the need for bulky batteries with limited driving range and lifespan offers several significant advantages. Vehicles equipped roads, receiving a continuous supply of energy without stopping to recharge. This eliminates the range anxiety associated with electric vehicles and allows for longer journeys without interruption.

Additionally, smaller capacity batteries can be used in vehicles, resulting in reduced weight and cost. This opens up possibilities for more spacious interiors, increased passenger capacity, and improved overall vehicle efficiency. Reducing the reliance on batteries also addresses concerns about the environmental impact of battery production and disposal.

The wireless solution is increasingly spreading as a method of battery charging for Electric Vehicles (EVs). The standard technology of wireless EV battery charging is based on the Inductive Power Transfer (IPT) between two coupled coils, one connected to the electronic circuit and the other one connected to the rechargeable battery. The IPT provides benefits in terms of safety and comfort, due to the absence of a plug-in operation through IPT, the electrocution risk typically arising from power cords is avoided and the battery charging operation can automatically start [7].

According to the state of the EV, there are mainly two types of IPT for the wireless charging static IPT, when the vehicle is stationary and nobody is inside it (e.g. in a parking area); dynamic or quasi-dynamic IPT, when the vehicle is being used (e.g. while in motion or during the traffic red light). The wireless power transfer obviously represents the only solution for the dynamic charging, since the wired connection would be impossible during the motion [9]. In spite of the undeniable advantages brought by Inductive Power Transfer, the researchers have to deal with several issues in order to make this technology even more attractive for the EV market.

II. DESIGN AND ANALYSIS

Proposed System

In an effort to address battery problems, the concept of roadway this system, the electric vehicle is charged on the road by wireless power charging, and the battery can hence be downsized and no waiting time for charging is needed. The main objective of our project is to design and develop wireless power transfer systems coupling principle, the wireless power transfer technology receiver's frequency is tuned in exact with the resonance frequency of the transmitter unit below the road, the electrical power will flow from the transmitter coil inside the platform to the vehicle [8]. This project describes the design and implementation of a wireless power transfer system for moving electric vehicles involving the model EV system.

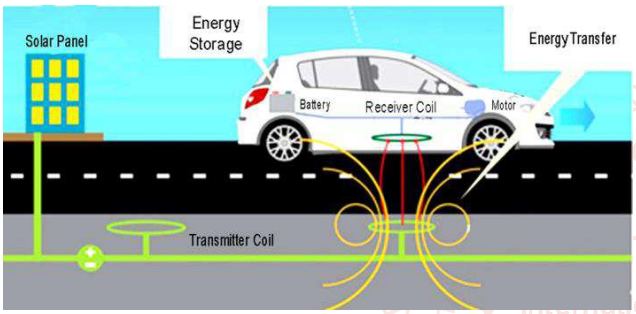

Fig.1

Inductive Power Transfer for Electric Car

Implemented through Inductive Power Transfer, the wireless charging for car drivers is convenient as far as safety and comfort are concerned the user should not be worried about handling power cords, thus avoiding the electrocution risk, and could park the car in proper spaces so that the charging operation can automatically start. The coils are generally placed in the following way the one connected to the grid is placed on the ground and the other one, connected to the battery, is placed in the bottom of the vehicle chassis. Different examples of commercial wireless charging stations for electric cars can be provided, since the EV companies are increasingly interested to this innovative charging technology [10]. Among manufacturers, Toyota, Nissan, General Motors and Ford are some of the companies showing interest in the inductive charging method.

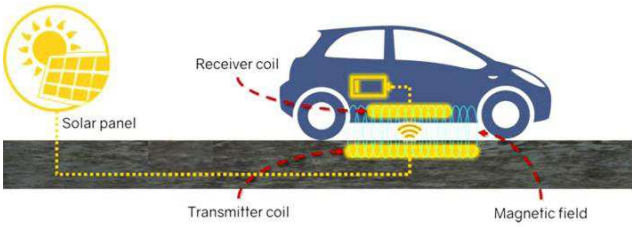

Fig. 2

III. COMPONENTS & METHODOLOGY

According to our project requirements, the following components are required

Component List:

1. Arduino UNO
2. IR Sensor Module
3. 16x2 LCD Module
4. Wireless Charging Module
5. Solar Panel
6. Vero Board
7. IC7805
8. Battery 18650
9. BMS 1A TP4056
10. On Off Switch
11. WPC Sheet
12. Toy Car

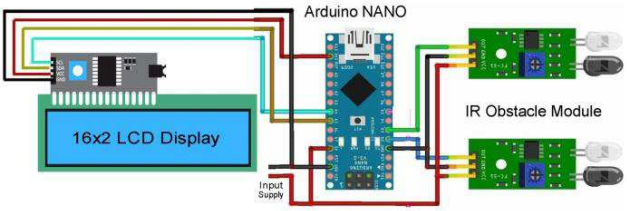

Fig. 3 Circuit Diagram of Charging Indicator Section

Component Details:

Introduction to Arduino Nano:

Arduino is an Integrated Development Environment based upon Processing. It has made very easy several things namely these are embedded system, physical computing, robotics, automation and other electronics-based things [11].

Every Arduino has the same functionality (more or less) and the same features except the number of pins and size. Arduino Nano is a small chip board based on ATmega 328p.

No.	Pin Number	Pin Description
1	D0 – D13	Digital Input / Output Pins.
2	A0 – A7	Analog Input / Output Pins.
3	Pin # 3, 5, 6, 9, 11	Pulse Width Modulation (PWM) Pins.
4	Pin # 0 (RX) , Pin # 1 (TX)	Serial Communication Pins.
5	Pin # 10, 11, 12, 13	SPI Communication Pins.
6	Pin # A4, A5	I2C Communication Pins.
7	Pin # 13	Built-In LED for Testing.
8	D2 & D3	External Interrupt Pins.

Fig. 4 Pin Description

- Arduino Nano is a small, compatible, flexible and breadboard friendly Microcontroller board, developed by Arduino.cc in Italy, based on ATmega328p (Arduino Nano V3.x) / Atmega168 (Arduino Nano V3.x).

- It comes with exactly the same functionality as in Arduino UNO but quite in small size.
- It comes with an operating voltage of 5V; however, the input voltage can vary from 7 to 12V.
- Arduino Nano Pinout contains 14 digital pins, 8 analog Pins, 2 Reset Pins & 6 Power Pins.
- Each of these Digital & Analog Pins is assigned with multiple functions but their main function is to be configured as input or output.
- They are acted as input pins when they are interfaced with sensors, but if you are driving some load then use them as output.
- Functions like pinMode() and digitalWrite() are used to control the operations of digital pins while analogRead() is used to control analog pins.
- The analog pins come with a total resolution of 10bits which measure the value from zero to 5V.
- Arduino Nano comes with a crystal oscillator of frequency 16 MHz. It is used to produce a clock of precise frequency using constant voltage.
- There is one limitation using Arduino Nano i.e. it doesn't come with DC power jack, means you cannot supply external power source through a battery.
- This board doesn't use standard USB for connection with a computer; instead, it comes with Mini USB support.
- Tiny size and breadboard friendly nature make this device an ideal choice for most of the applications where sizes of the electronic components are of great concern.
- Flash memory is 16KB or 32KB that all depends on the Atmega board i.e Atmega168 comes with 16KB of flash memory while Atmega328 comes with a flash memory of 32KB. Flash memory is used for storing code. The 2KB of memory out of total flash memory is used for a bootloader.

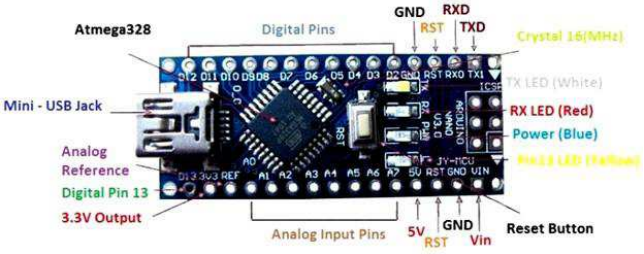

Fig. 5 Arduino Nano

- The SRAM can vary from 1KB or 2KB and EEPROM is 512 bytes or 1KB for Atmega168 and Atmega328 respectively.
- This board is quite similar to other Arduino boards available in the market, but the small size makes this board stand out from others. It is programmed using Arduino IDE which is an Integrated Development Environment that runs both offline and online.

Microcontroller	Atmega328p/Atmega 168
Operating Voltage	5V
Input Voltage	7 – 12 V
Digital I/O Pins	14
PWM	6 out of 14 digital pins
Max. Current Rating	40mA
USB	Mini
Analog Pins	8
Flash Memory	16KB or 32KB
SRAM	1KB or 2KB
Crystal Oscillator	16 MHz
EEPROM	512bytes or 1KB
USART	Yes

Fig. 6 Specifications of Arduino Nano Board

- No prior arrangements are required to run the board. All you need is board, mini-USB cable and Arduino IDE software installed on the computer. USB cable is used to transfer the program from computer to the board.
- No separate burner is required to compile and burn the program as this board comes with a built-in boot-loader.

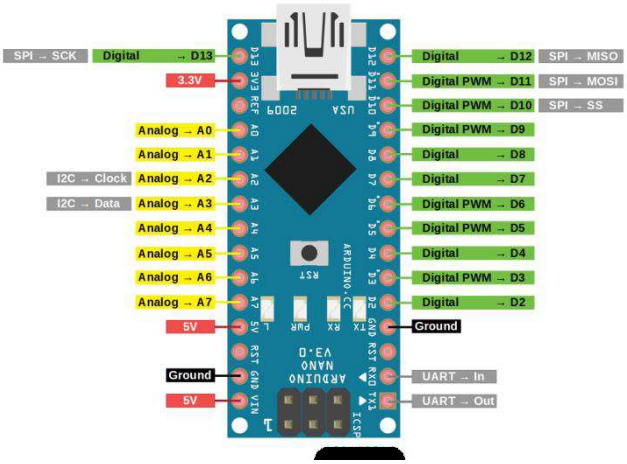

Fig. 7 Pinout of Arduino Nano Board

- Each pin on the Nano board comes with a specific function associated with it.
- We can see the analog pins that can be used as an analog to digital converter where A4 and A5 pins can also be used for I2C communication. Similarly, there are 14 digital pins, out of which 6 pins are used for generating PWM.

Pin Description

Vin. It is input power supply voltage to the board when using an external power source of 7 to 12 V.

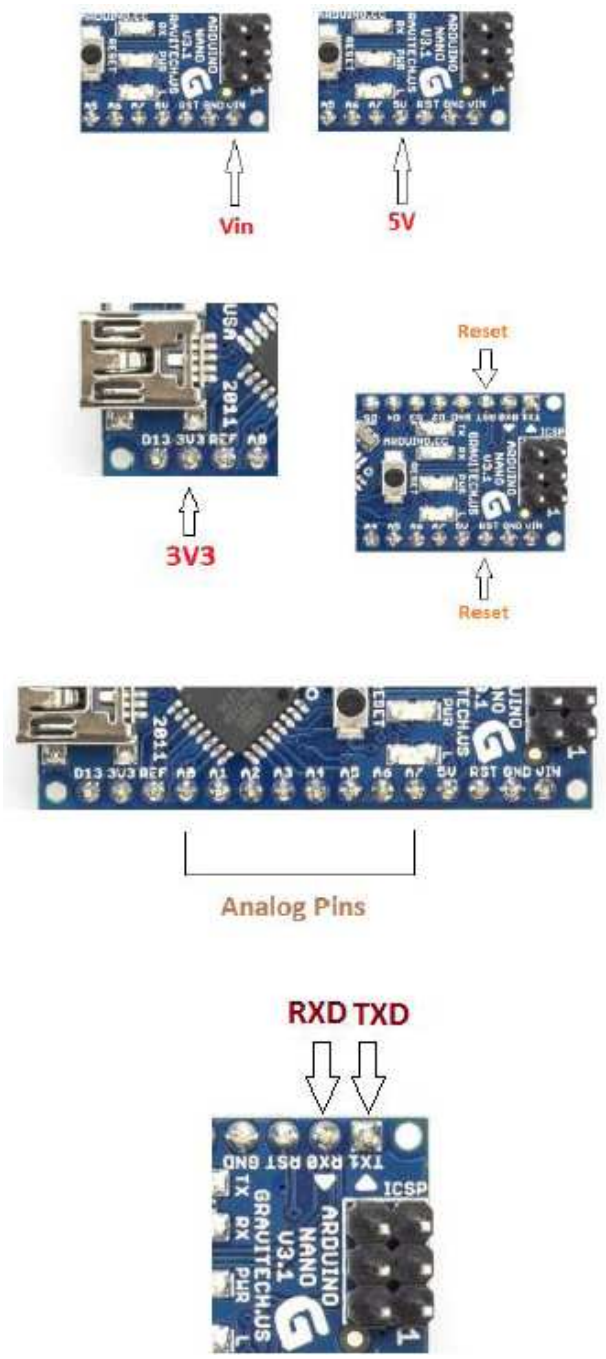

Fig. 8 Pin Description of Arduino Nano

5V. it is a regulated power supply voltage of the board that is used to power the controller and other components placed on the board.

3.3V. this is a minimum voltage generated by the voltage regulator on the board.

GND. These are the ground pins on the board. There are multiple ground pins on the board that can be interfaced accordingly when more than one ground pin is required.

Reset. Reset pin is added on the board that resets the board. It is very helpful when running program goes too complex and hangs up the board. LOW value to the reset pin will reset the controller.

Analog Pins. There are 8 analog pins on the board marked as A0 – A7. These pins are used to measure the analog voltage ranging between 0 to 5V.

Rx, Tx. These pins are used for serial communication where Tx represents the transmission of data while Rx represents the data receiver.

13. This pin is used to turn on the built-in LED.

AREF. This pin is used as a reference voltage for the input voltage.

PWM. Six pins 3,5,6,9,10, 11 can be used for providing 8-pit PWM (Pulse Width Modulation) output. It is a method used for getting analog results with digital sources.

SPI. Four pins 10(SS),11(MOSI),12(MISO),13(SCK) are used for SPI (Serial Peripheral Interface). SPI is an interface bus and mainly used to transfer data between microcontrollers and other peripherals like sensors, registers, and SD card [13].

External Interrupts. Pin 2 and 3 are used as external interrupts which are used in case of emergency when we need to stop the main program and call important instructions at that point. The main program resumes once interrupt instruction is called and executed.

I2C. I2C communication is developed using A4 and A5 pins where A4 represents the serial data line (SDA) which carries the data and A5 represents the serial clock line (SCL) which is a clock signal, generated by the master device, used for data synchronization between the devices on an I2C bus.

Communication and Programming

- The Nano device comes with an ability to set up a communication with other controllers and computers. The serial communication is carried out by the digital pins like pin 0 (Rx) and pin 1 (Tx) where Rx is used for receiving data and Tx is used for the transmission of data. The serial monitor is added on the Arduino Software which is used to transmit textual data to or from the board. FTDI drivers are also included in the software which behaves as a virtual com port to the software.
- The Tx and Rx pins come with an LED which blinks as the data is transmitted between FTDI and USB connection to the computer.
- Arduino Software Serial Library is used for carrying out a serial communication between the board and the computer.
- Apart from serial communication the Nano boards also support I2C and SPI communication. The

Wire Library inside the Arduino Software is accessed to use the I2C bus.

- The Arduino Nano is programmed by Arduino Software called IDE which is a common software used for almost all types of board available. Simply download the software and select the board you are using. There are two options to program the controller i.e either by the bootloader that is added in the software which sets you free from the use of external burner to compile and burn the program into the controller and another option is by using ICSP (In-circuit serial programming header).
- Arduino board software is equally compatible with Windows, Linux or MAC, however, Windows are preferred to use.

Liquid crystal displays (LCDs) have materials which combine the properties of both liquids and crystals. An LCD consists of two glass panels, with the liquid crystal material sand witched in between them. The inner surface of the glass plates are coated with transparent electrodes which define the character, symbols or patterns to be displayed polymeric layers are present in between the electrodes and the liquid crystal, which makes the liquid crystal molecules to maintain a defined orientation angle.

Fig 9 LCD Display

The LCD is a dot matrix liquid crystal display that displays alphanumeric characters and symbols. Liquid Crystal Display screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	VEE
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight Vcc (5V)	Led+
16	Backlight Ground (0V)	Led-

Fig.10 LCD Pin Description

TP4056 3.7V Lithium Battery Charging/Discharging Module with Solar Power – Solar power is one of the extensive renewable energy available in our earth; using solar power efficiently could help us to meet 30% of our energy demands. And that's the reason we are seeing many solar based products in the market. And today we are about to see the design of a simple solar powered LED light using high power LED which can be used for household purpose instead of primitive lights. In this project, we are going to build a simple and cheap solar light. The solar panel will charge a lithium battery during day time. Unlike other circuits, we will not be using a microcontroller or sensor, because the idea of the project is to reduce the component count to reduce the price and complexity of the circuit. The charger has voltage and current regulation and full charge indicator facilities.

TP4056 is a complete constant current-voltage linear charging module for single-cell 3.7 V lithium batteries. It will continuously monitor the voltage level of the battery during charging and discharging. The module operates with 5V 1A DC voltage, can be provided by the USB mini cable, and commonly used in Smartphone chargers. Due to the low number of the external component count, make the TP4056 module ideally suited for our portable electronics application.

Features of TP4056 module:

- Include Current Monitor
- Under Voltage Lockout
- Automatic Recharge
- Charger and Protection Circuit in One Module
- Two Status Pin to Indicate Charge Termination

- Indicate the Presence of an Input Voltage
- Preset 4.2V Charge Voltage with 1.5% Accuracy

Type	Charger, Protection Board
Module	TP4056
Battery Type	Li-Ion
Battery Voltage	3.7V to 4.2V
Input Current Max.	1A
Input Voltage	4-8V
Output Voltage	4.2V
Connector Type	USB Mini
Charging Method	Linear Charging
Charging Precision	1.5%
Package	SMD

Fig. 10 TP4056 specifications

Working Principle of TP4056 module: Lithium-Ion and Lithium-Polymer cells may explode if a shorted, overcharged, charged, or discharged with too high currents. TP4056 module is a combination of charger and protection for single cell 3.7V lithium batteries. Hence this module will monitor the voltage level of the lithium battery during charging and discharging.

Inside the module IC TP4056A, DW01A, and P-type MOSFET FS8205A are used. The charging process is controlled by the TP4056A Liner voltage IC, charge current is set by connecting a 1.2KΩ resistor from RPROG (Pin: 2) to GND. The DW01A battery protection IC is designed to protect lithium-ion/polymer battery from damage or degrading the lifetime due to overcharge, over discharge. No blocking diode is required due to the FS8205A internal PMOSFET architecture and has prevented to negative charge current circuit.

The recommended operating voltage for the TIP4056 module circuit is 4-8V, 1A DC supply. You can use any type of mobile charger and its cable to power this module. When the charger is turned ON, the RED led will go high indicating that the battery is being charged. Once the module charges the battery completely, it will automatically stop charging and the Red LED will turn OFF and the Blue LED will turn ON to indicate the completion.

Wireless Charging Module Working Principle:

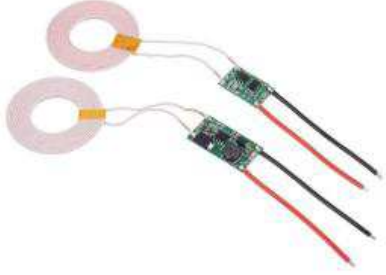

Fig. 11 Wireless Charging Module

Model	XKT-412.
Input Voltage	3.7 V to 12VDC
Output	5V / 1A current
Normal Use Distance	2 ~ 10mm
Operating Current	1.2-2 A.
Tx/Rx Coil Dimensions	Diameter 43mm, Inner diameter 20mm,
Coil Wire Thickness	2.3mm
The transmitting module size	18mm*8.5mm*15mm
The receiving module size	10mm*25mm*3mm
Shipment Weight	0.035 kg
Shipment Dimensions	15 × 10 × 8 cm

Fig. 12 Charging Module Specifications

Two conductors are said to be inductively coupled or magnetically coupled when they are configured in a way such that change in current through one wire induces a voltage across the ends of the other wire through electromagnetic induction. A changing current through the first wire creates a changing magnetic field around it by Ampere's circuital law. The changing magnetic field induces an electromotive force (EMF or voltage) in the second wire by Faraday's law of induction. The amount of inductive coupling between two conductors is measured by their mutual inductance. The coupling between two wires can be increased by winding them into coils and placing them close together on a common axis, so the magnetic field of one coil passes through the other coil.

XKT-412 is a high-frequency and high-power integrated circuit with a small size and strong output power. It can work in a higher frequency range and can greatly reduce the volume and size of the transmitting coil. It can enhance the transmission power and reduce the cost of the coil. Due to the small requirement for coil inductance, PCB can be used directly as the transmitter to make production and application easier. The chip adopts the most advanced wide-voltage adaptive technology chip design process. The same transmitting circuit can be used in any working range without changing any components. It is extremely convenient to use, the circuit is extremely simple, and it has the characteristics of high precision and good stability. It is specially used in wireless induction intelligent charging and power supply management system, with high reliability and performance. XKT412 is responsible for processing the wireless power transmission function in the system, adopting the principle of electromagnetic energy conversion and cooperating with the receiving part for energy conversion and real-time monitoring of the circuit. It responsible for the intelligent control of fast charging of various batteries, XKT412 only needs to cooperate with very few external components can be made into

a highly reliable wireless fast charger and wireless power supply. Automatically adapt to the power supply voltage adjustment function, so that it can work under a wide range of voltages.

Figure 13 represents the two coils models for a wireless transmitter[4]. In this case, the transmitter and receiver are centralized, and we note by V1 and V2 the input and output voltages of this IPT(Inductive Power Transfer).

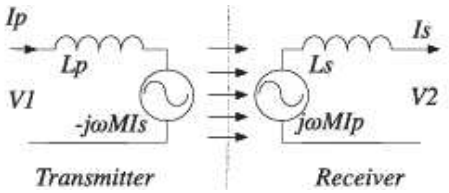

Fig. 13 Transmitter and Receiver Coil Models

Within this model, the input and output voltages are defined in terms of the "M" mutual inductance, the "ω" operating frequency, and the primary and secondary currents. The mutual inductance is related to coefficient of magnetic coupling by:

$$M = k.\sqrt{L_S.L_P} \quad (1)$$

The impedance reflected from the secondary to the primary may be expressed through equation (2).

$$Z_r = \frac{\omega^2 M^2}{Z_S} \quad (2)$$

Where Zs is the impedance of the secondary network, and this is depending on the selected compensation topology. The current flowing through the secondary winding is expressed as it is in equation (3)[2].

$$I_S = \frac{j\omega M I_P}{Z_S} \quad (3)$$

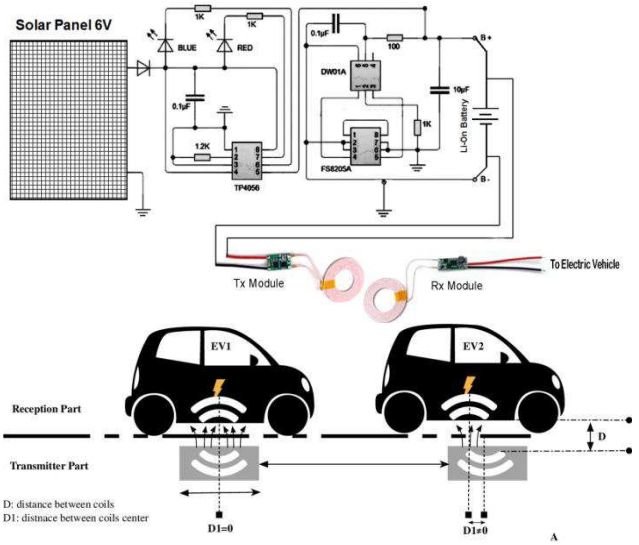

Fig. 14 Complete Circuit Diagram of Wireless EV Charging System Full working of the Project is as shown in [3].

IV. CONCLUSION

This project has presented a unique vision of the concepts which are used in this particular field. It aims to promote technology innovation to achieve a reliable and efficient outcome from the various instruments. Experimental work has been carried out carefully. The result shows that higher efficiency is indeed achieved using the surrounded system. With a common digitalized platform, these latest instruments will enable increased flexibility in control, operation, and expansion; allow for entrenched intelligence, essentially foster the resilience of the instruments; and eventually benefit the customers with improved services, reliability and increased convenience. This project presents the major features and functions of the various concepts that could be used in this field in detail through various categories. Since this initial work cannot address everything within the proposed framework and vision, more research and development efforts are needed to fully implement the proposed framework through a joint effort of various entities.

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