SCHOOL OF ELECTRICAL ENGINEERING

Wireless Charging System of Electric Vehicle

A project submitted
in partial fulfillment of the requirements for the degree of
B.Tech in Electrical and Electronics Engineering

By

Aravindhan R (20BEE1019)

Rishikumar NA (20BEE1010)

Udhaya Shankar P (20BEE1028)

Sabareesh M (20BEE1034)

Jasper Joshua A (20BEE1136)

Course Instructor

Dr. Kuruseelan S

April 2023

UNDERTAKING

This is to declare that the project entitled "Wireless Charging System of Electric Vehicle" is an original work done by undersigned, in partial fulfillment of the requirements for the degree "B. Tech in Electrical and Electronics Engineering" at School of Electrical Engineering, VIT Chennai.

All the analysis, design and system development have been accomplished by the undersigned. Moreover, this project has not been submitted to any other college or university.

Aravindhan R (20BEE1019)

Rishikumar NA (20BEE1010)

Udhaya Shankar P (20BEE1028)

Sabareesh M (20BEE1034)

Jasper Joshua A (20BEE1136)

—

ABSTRACT

The world has started moving towards Electric Vehicle to reduce pollution caused by IC engine vehicles. This transformation is not easier as we think there are many problems should be considered like motor designing, battery charging and design of vehicle that must be spacial for battery accommodation and also for seating and luggage. Other major disadvantage is charging time and charging station in the appropriate places. In view of charging time is the major drawback when compared to IC engine vehicle and also the world moves towards luxury and sophistication plugging the cable is also becoming one of the disadvantage. To overcome these problem we have come with an idea of wireless charging system as we use in mobile. Which also help to overcome the plugin problems. Here we will use the principle of magnetic resonance for voltage transmission from primary coil placed in road and parking lot to secondary side placed in Electric Vehicle. In the road side a ac voltage supply is rectified, inverted for efficient transmission and by the use of mutual inductance coil we can transfer the voltage and rectified for battery charging. By considering the installation costs we may not new road where there already exists a good quality road we can place the coil by undergoing some patch works which is less costly and the coils can be packed under ferrite tile of weight lesser than 4 kilogram and also it is transmission efficient. to withstand heavy load and vibration caused by high speed vehicles. It also have some advantage like plug points, including convenience, safety, reduces the battery size, reduces the weight of the vehicle and improved aesthetics with some disadvantages like installation cost and compatibility of different of EV model.

Table of Contents

1. Introduction

In recent years Electric Vehicle market has a exponential growth with advantages like less emission of green house gasses and also Electric Vehicle is the only choice as the fossil fuel availability is very low. Increased cost of fuels compared to the price of electricity also one of the major reason for transmission to Electric Vehicle. To overcome the disadvantage of charging time and plugging in Electric Vehicle Wireless charging system can be used where mutual inductance coils are used to transfer voltage from the primary coil in the road or parking lot to secondary coil in the Electric Vehicle. the dc power is converted to a high-frequency ac to drive the transmitting coil through a compensation network which will be placed under the ground. The high-frequency current in the transmitting coil generates an alternating magnetic field, which induces an ac voltage on the receiving coil. By resonating with the secondary compensation network, the transferred power and efficiency are significantly improved. At last, the ac power is rectified to charge the battery. The most expected outcome is to run the Electric Vehicle without charging and using the distribute generation resources in a efficient way. To design and simulate a wireless charging system for Electric Vehicle. To charge the battery using wireless charging system using magnetic resonance between roads and the inductor in the vehicle. To ensure the availability of battery pack for the EVas it is charged continuously while in motion as well as in stationary position. It also eliminates the plugging in of charging cables. The most important objective is to charge the battery in a efficient way without wasting resources and zero charging time and to ensure charging of batteries both while running and in stationary. In conclusion, Installation of coil in road side and compatible secondary coil in Electric Vehicle plays a major. Here both the government who plans for construction of road and the automobile industry should work in a coordination to achieve this system available to use successfully for consumers. Even if there is a small diversion from one another it may become a drawback for this system to be successful. The need of coordination is that the coil and frequency of supply voltage should not be varied as like a change in charging pins of ios and android it should have a universal system. Which enables the customer to buy Electric Vehicle and establish the system in all the ends of the world.

SOURCE RECTIFIER (ROAD-SIDE):

This wireless EV charging system requires an AC power source to power the system first. Input power passes through the source rectifier. This is because we know the battery can only be powered by his DC power supply, but the source is AC power. Therefore, source rectifiers are used to convert AC-DC power, which introduces additional distortion on the input side of the power supply current during conversion, lowering the power factor. Therefore, in addition to AC-DC conversion power factor correction, the input current is converted to a nearly sinusoidal waveform in phase with the line voltage to increase efficiency and improve power factor.

LOAD RECTIFIER (VEHICLE-SIDE):

An electric vehicle (EV) wireless charging load rectifier is responsible for converting an alternating current (AC) signal from the mutual induction coil into a direct current (DC) signal that can be used to charge the EV battery. In wireless charging, the charging pad produces an alternating magnetic field that induces a voltage in the vehicle's receiving coil. This induced AC voltage must be rectified and regulated to match the EV battery voltage. This is where the load rectifier comes in. A rectifier circuit usually consists of diodes or semiconductor switches arranged in a specific configuration to ensure that an AC signal is converted to a DC signal. The rectifier circuit also includes a smoothing capacitor to filter the DC signal, ensuring that the output voltage is stable and free of high frequency noise and ripple.

SOURCE:

AC power for wireless EV charging systems may vary depending on specific implementation and system requirements. However, the AC power source for wireless charging systems is usually the AC power grid, the same source used to power homes and businesses. The AC power grid provides high voltage, high frequency AC signals that are transmitted over power lines and distributed to homes and businesses. This AC signal can be stepped down to a lower voltage and frequency for use in wireless charging systems. Alternatively, AC power for the wireless charging system can be generated from a local power source by generators or renewable energy systems such as solar panels and wind turbines. These local power sources can generate AC power that can be used to wirelessly charge EVs either directly or via battery storage systems. Regardless of the power source, the AC signal must be converted to a specific frequency and voltage range suitable for wireless EV charging, typically by a power electronics converter, before being sent to a wireless charging pad and the peak amplitude in our case given by the source is 325V and the frequency is 50Hz.

INVERTER:

An inverter is a device which converts DC voltage into AC voltage. Inverters are used in most of the applications to convert DC to AC. The conversion of dc to alternating voltage is achieved by converting energy stored in the dc source such as the battery or capacitor, or from a rectifier output, into an alternating voltage. This is done using switching devices like thyristors which are continuously turned on and off, and then stepping up using the transformer. But some configurations of the inverter don't require an inverter.

GROUND SIDE INVERTER:

The ground side inverter inverts the DC voltage coming from the AC source rectifier to AC voltage . In this inverter the output AC voltage the inverter also changes the frequency. This change in frequency will be high, because this high frequency is responsible for the more power transmission through the coil. Higher the frequency higher will the power delivered at the transmission coil. This transmission coil will be placed under the road.

TRANSMISSION COIL:

Transmission coil is a device which transmits the power from the primary coil to the secondary coil. This primary coil consists of high frequency AC voltage in which it is linked with the secondary coil and due to the high frequency the ideal transformers will transmit the power completely. This transmission coil will work with the principle of mutual inductance. Then the power is sent to the car side rectifier.

BATTERY:

Battery is a device which will store energy and deliver it for future use. A battery is a device that converts chemical energy contained within its active materials directly into electric energy by means of an electrochemical oxidation-reduction (redox) reaction. This type of reaction involves the transfer of electrons from one material to another via an electric circuit. In electric vehicles, Lithium-ion batteries are generally used nowadays. This lithium-ion battery has a lot of advantages and disadvantages.

2. Scope

FUTURE SCOPE:

While in-drive wireless charging technology for electric vehicles (EVs) is still in the early stages of development, it holds great potential for future electric vehicles. The concept of wireless charging while driving is called dynamic wireless charging or charging on the move. This includes installing wireless charging infrastructure on roads and highways so that electric vehicles can be charged while driving. The technology works by using magnetic fields to wirelessly transfer energy from the road to the vehicle's battery. The main advantage of dynamic wireless charging is that it eliminates the large and heavy batteries currently required for good range. This could lead to lighter and more efficient electric vehicles, as well as lower battery costs. Another advantage of dynamic wireless charging is that it provides a more seamless and convenient charging experience for EV owners, as the vehicle does not need to be stopped and plugged in for charging. Instead, I was able to drive and load at the same time. However, there are some challenges that must be addressed before dynamic wireless charging becomes widespread. These challenges include infrastructure costs, standardization of technology and ensuring the safety of the charging process. Despite these challenges, the future scope of wireless EV charging while driving is promising, and continued advances in technology and infrastructure could lead to increased adoption in the coming years.

The advantages are

- Longest life of all batteries
- Constant power
- Temperature tolerant
- Charging fast and safe
- Lightweight, etc.

The disadvantages are

- It is quite expensive
- When it is exposed to the environment it has a possibility of exploding nature.

WORKING PRINCIPLE:

In this wireless EV charging system, we first need to feed the power to the system using an AC source, the input power is then pushed through the diode bridge rectifier as we know the battery can only be powered through a DC supply but the source is AC. So, to convert AC to DC supply DBR is used and while converting more distortion occurs at the input side of the supply current and the power factor is reduced So along with the AC to DC conversion power factor correction also happens to increase the efficiency by transforming the input current close to a sinusoidal waveform that is in phase with the grid voltage, therefore improving the power factor. Now in the second stage, a DC to AC inverter creates a high-frequency AC voltage of 80 to 120 kHz from there the compensation networks are then used to improve system efficiency using a capacitor to reduce additional losses. Then the sender and receiver coils, supported by ferrite plates are used to enhance and direct magnetic coupling for wireless transfer

MUTUAL INDUCTANCE:

When changing current in one coil induces an EMF in the other, the phenomenon is called mutual induction. The strength of the EMF induced depends on the mutual inductance of the pair of coils. The S.I. unit of mutual inductance is Henry, the same as that of self-inductance.

2.1 Abbreviations and Acronyms

ICE- Internal Combustion Engine

HEV- hybrid electric vehicle

PWM- Pulse Width Modulation

SCR - Silicon Controlled Rectifier

fs- Switching frequency

3. Methodology

3.1 Diagram Explanation

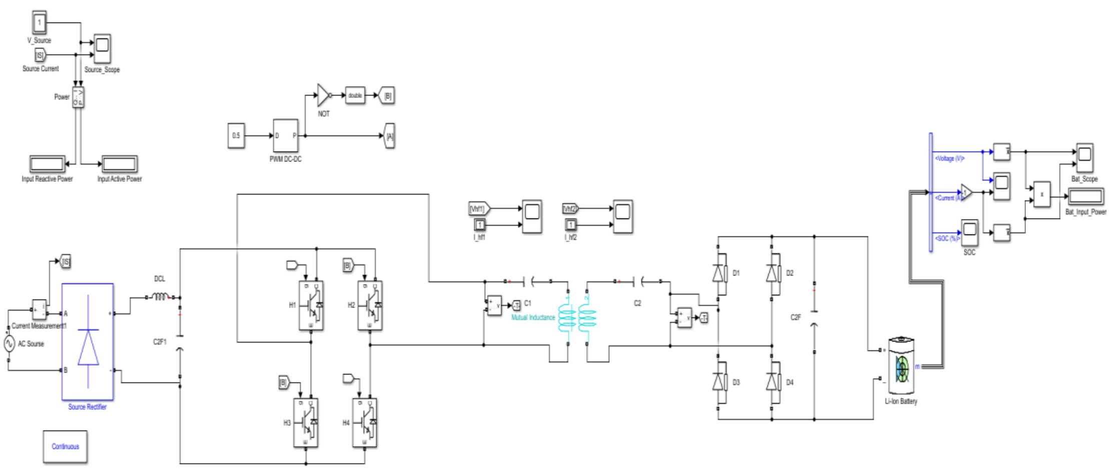


Fig. 1

- The voltage source of 325V, 50Hz AC is used for the system.

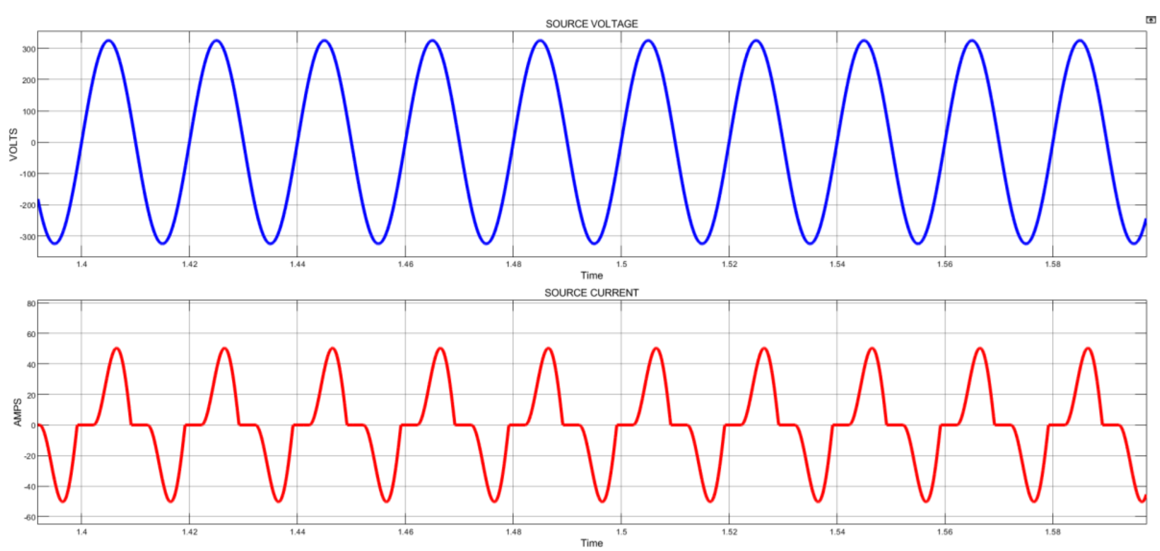


Fig.2

- The voltage supply is connected to the rectifier to get the DC voltage.
- Then the DC voltage is inverted to AC voltage with a switching frequency of 30,000Hz to increase the transmission efficiency.

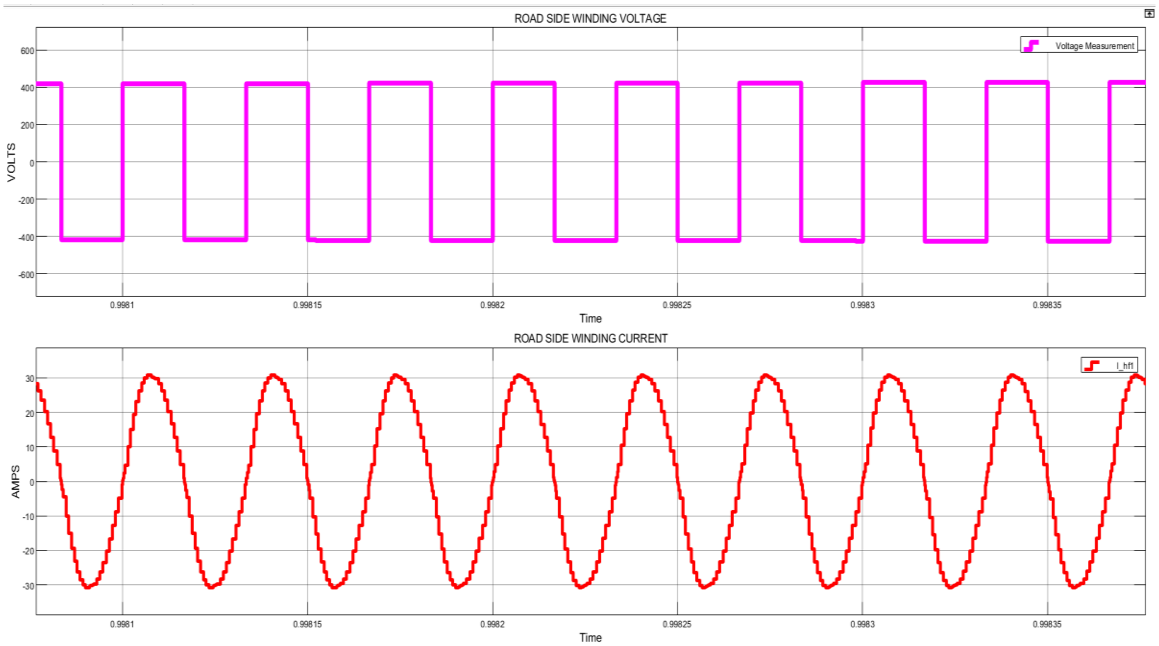


Fig.3

- We get an AC supply around 410V and 30,000Hz which is transmitted to the vehicle through the mutual inductance.
- The primary winding has the value of resistance and inductance of around 1*10^-3Ω and 266.16*10^-6H respectively.
- The secondary winding has the value of resistance and inductance value of around 1*10^-3Ω and 266.16*10^-6H respectively.
- The mutual inductance value is around 85.46*10^-6 H.
- The received secondary voltage is around 385V and 30,000Hz.

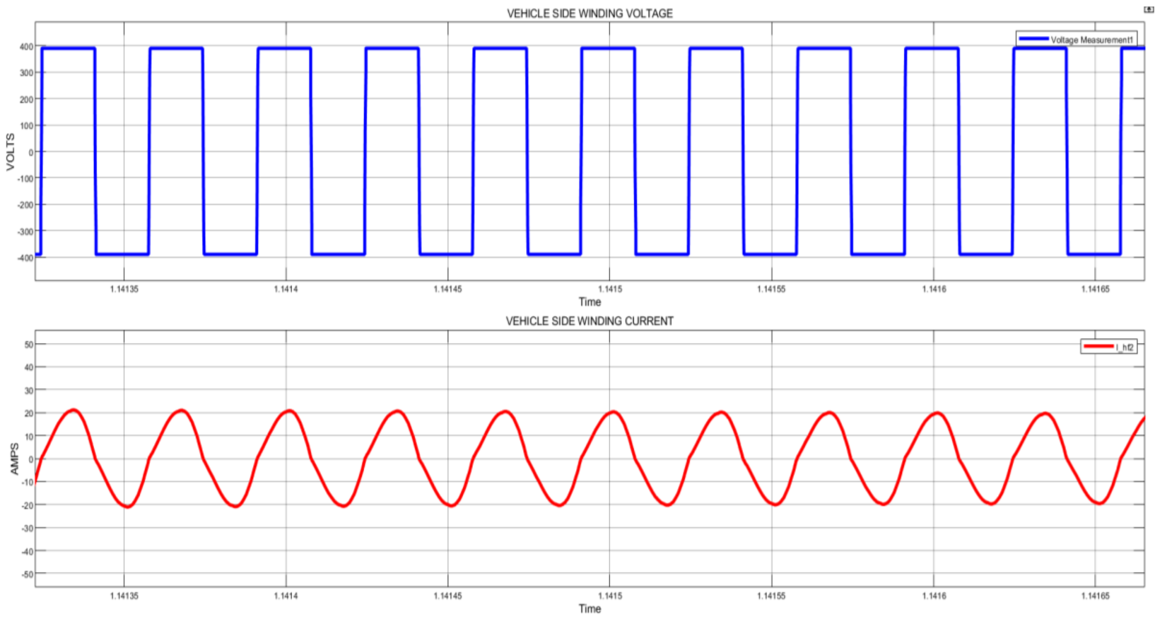
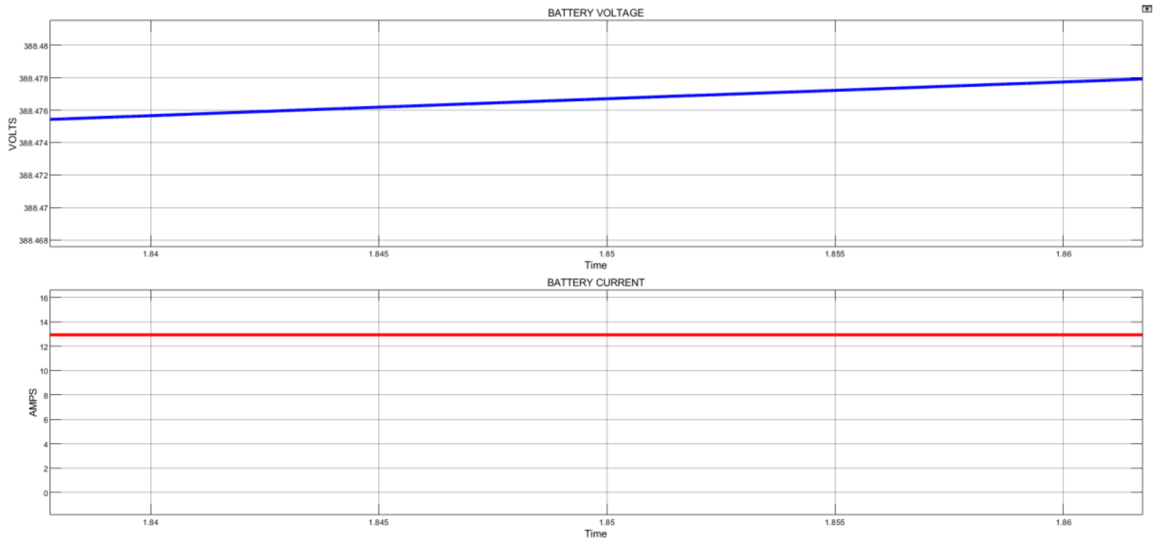


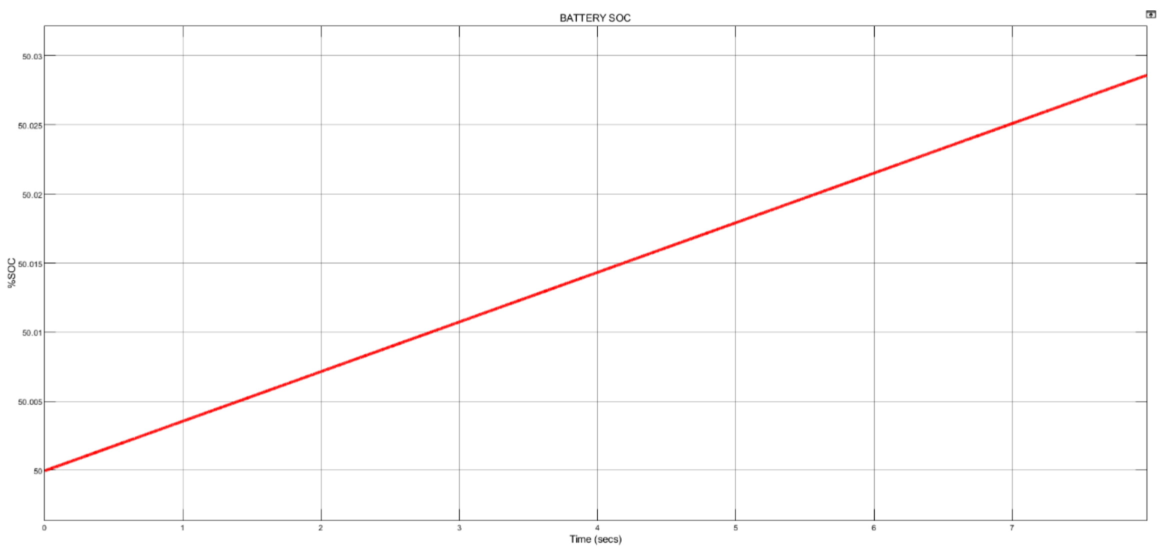
Fig.4

- The received voltage is converted to DC with voltage around 380V.
- The DC voltage is used to charge the lithium-ion battery with nominal voltage of 360V with a capacity of 100Ah and assumed that the battery has a initial voltage of 50%.

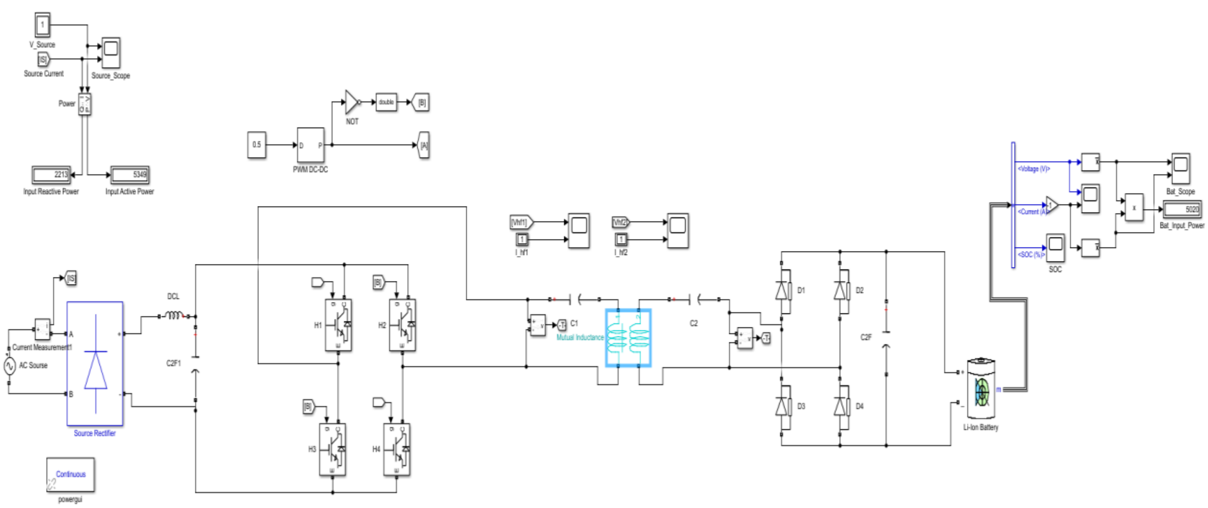
4. Conclusion

- The received DC voltage is used to charge the battery with the assumption of 50% of initial charge.





- The following figure represents the input and output power in the display at real time.



Input power=5349W

Output power= 5020W

Efficiency = (Output power/Input power) *100

= (5020/5349) *100

Efficiency = 93.849%

5. Team Members Contribution

Register Number	Name	Contribution / Role in this Project
20BEE1010	Rishikumar NA	Finding Real World Problem, Rectifier
20BEE1019	Aravindhan R	Inverter, Literature Survey
20BEE1028	Udhaya Shankar P	Civil Study, Road part Simulation
20BEE1034	Sabareesh M	SOC Estimation, Vehicle Side Rectifier
20BEE1136	Jasper Joshua A	Scope analysis, EV part Simulation

References

Wireless charging systems for electric vehicles,October 2022,Renewable and Sustainable Energy Reviews 167(5834):112730,DOI: 10.1016/j.rser.2022.112730.

A new wireless charging system for electric vehicles using two receiver coils,Naoui Mohamed a, Flah Aymen a, Mohammed Alqarni ,Ain Shams Engineering JournalVolume 13, Issue 2, March 2022, 10156

Efficient Wireless Charging for Electric Vehicle ,International Journal of Engineering Research & Technology (IJERT) http://www.ijert.org ISSN: 2278-0181 IJERTV9IS100230 (This work is licensed under a Creative Commons Attribution 4.0 International License.) *Published by : www.ijert.org Vol. 9 Issue 10, October-2020*

Wireless Charging of Electric Vehicle While Driving,November 2021,IEEE Access PP(99):1-1 DOI:10.1109/ACCESS.2021.3130099,License,CC BY 4.0

Dynamic wireless charging of electric vehicles on the move with Mobile Energy Disseminators, Leandros A . Maglaras School of Computer Science and Informatics De Montfort University, Leicester, UK Jianmin Jiang Department of Computing University of Surrey, Guilford, UK Athanasios Maglaras Electrical Engineering Department T.E.I. of Thessaly, Larissa, Greece,(IJACSA) *International Journal of Advanced Computer Science and Applications, Vol. 6, No. 6, 2015*