BIRLA INSTITUTE OF TECHNOLOGY, MESRA

DYNAMIC WIRELESS CHARGING OF ELECTRIC VEHICLES

Final Report

SUBMITTED TO:

DR. P.S RATHORE
DR. DEEPAK VERMA
DR. APRAJITA PANDEY

SUBMITTED BY:

ROHAN VERMA- BTECH/25171/19
PALAK GUPTA-BTECH/25127/19
KUSHAGRA GUPTA- BTECH/25164/19
SOHAIB AHMEDD-BTECH/25176/19
ANANYA SHARMA-BTECH/25179/19

ACKNOWLEDGEMENT

I would like to express my profound gratitude to Dr. P.S Rathore sir, Dr. Deepak Verma sir and Dr.Aprajita Ma'am of EEE department for their contributions to the completion of my project titled DYNAMIC WIRELESS CHARGING OF ELECTRIC VEHICLE.

I would like to express my special thanks to our mentor Dr.Deepak Verma Sir for his time and efforts he provided throughout the year. Your useful advice and suggestions were really helpful to me during the project's completion. In this aspect, I am eternally grateful to you.

I would like to acknowledge that this project was completed entirely by me and not by someone else.

Signature

Rohan Verma

Palak Gupta

Kushagra Gupta

Sohaib Ahmed

Ananya Sharma

DECLARATION

I hereby declare that this project work entitled "Dynamic Wireless Charging of Electric Vehicle" has been prepared by me during the year 2023 under the guidance of DR. DEEPAK VERMA, Department of Electrical and Electronics, BIT MESRA, Jaipur in the partial fulfilment of B. Tech degree prescribed by the college.

I also declare that this project is the outcome of my own effort, that it has not been submitted to any other university for the award of any degree.

Date: 20.04.2023

Abstract

Dynamic wireless charging of electric vehicles is a technology that enables the charging of EVs while they are in motion. Unlike traditional plug-in charging infrastructure, this technology utilizes wireless power transfer to provide a continuous charging experience for EVs on the move. This means that electric vehicles can recharge their batteries while driving, without needing to stop and plug into a charging station. Dynamic wireless charging technology is based on the principle of electromagnetic induction. It involves the use of a charging pad embedded in the road surface that generates a magnetic field. The EV is fitted with a receiver coil that is placed close to the charging pad, and this coil picks up the magnetic field and converts it into electrical energy that charges the battery.

One of the main benefits of dynamic wireless charging is that it eliminates the need for EVs to stop and recharge, which can be time-consuming and inconvenient. This technology allows for EVs to travel longer distances without worrying about running out of charge, and it can also reduce the size and weight of batteries, making EVs lighter and more efficient. Dynamic wireless charging also has the potential to reduce the need for traditional charging infrastructure, such as charging stations. This can be especially useful in areas where it may not be practical or cost-effective to install charging infrastructure, such as highways or remote areas.

However, there are several challenges associated with dynamic wireless charging. One of the biggest challenges is the technical complexity of the system. The technology requires a high level of precision and accuracy in the design and installation of the charging pads, and it may be difficult to ensure that the charging coils in the EV are properly aligned with the charging pads. Another challenge is the cost of implementing dynamic wireless charging infrastructure. The technology is currently more expensive than traditional charging infrastructure, and there may be significant costs associated with retrofitting existing roadways with the necessary charging pads .In addition, there are regulatory issues that need to be addressed. There may be safety concerns associated with the use of dynamic wireless charging technology, and it may be necessary to establish standards and regulations to ensure that the technology is safe and effective.

Despite these challenges, dynamic wireless charging has the potential to revolutionize the way we charge EVs, making it more convenient and efficient. As research and development in this area continue, it is likely that we will see further advancements in technology, making it more practical .

Contents

1. Introduction

Electric vehicles (EVs) are becoming increasingly popular as an eco-friendly alternative to traditional gasoline-powered cars. However, one of the main challenges facing EVs is the need for charging infrastructure. EVs require regular charging, and this can be inconvenient for drivers who need to stop and plug in their cars at charging stations. Wireless charging technology for EVs has the potential to overcome this challenge by enabling charging while the EV is in motion. This technology uses electromagnetic induction to transfer power wirelessly from a charging pad embedded in the road surface to a receiver coil in the EV, providing a continuous charging experience without the need for traditional plug-in charging infrastructure. The trade market of electric vehicles (EVs) has gradually begun to grow. To revive the vehicle within a short span, high power charging devices or charging stations are required by the existing conductive charging method as shown in fig1.1

Additional inconvenience is caused by incompatible plugs receptacles between different EV models. Charging infrastructure can be shared by different EV models as for the wireless charging technologies [1].

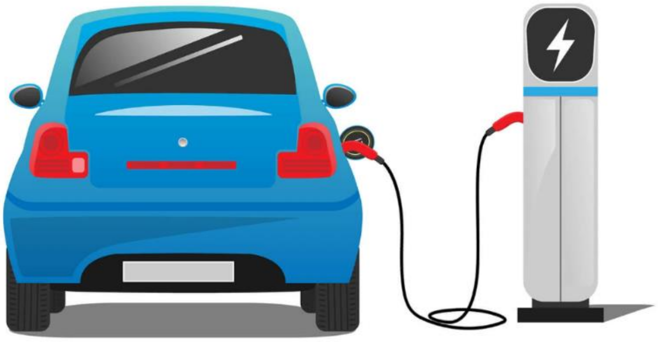

Fig 1.1: Wired Charging system for EV

The deployment of 85 million autonomous vehicles, is expected by 2035, hence establishment of wireless charging is needed, to incorporate in such vehicles [2]. WPT makes the system simplify, automatic, secure, economical and more efficient, whereas using of cables makes system so expensive. For instance, at the time of placing EV's for little while in parking lot, Wireless charger systems enable automated charging.

Fig 1.2: Proposed Wireless Charging system for EV

It eradicates the need for pilot interruption in course of charging. Main hindrance for acquiring wireless charging, coil misalignment and large airgap. To improve misalignment tolerance, various coil structures are used. The radial coil is pre-owned based on its unsophisticated erection [3]-[6]. Using Miscellaneous coils like Double D type [8], [7] and [9] solenoid type, [10] leads to increased air gap between transmitter and receiver coils. Airgap between both coils shown in Fig 1.3.

The reduction of coil misalignment before WPT's commencement, improves transfer efficiency. In [12], the wireless charger was demonstrated by using conveyors and servo motors which helps in positioning the receiver to the transmitter.

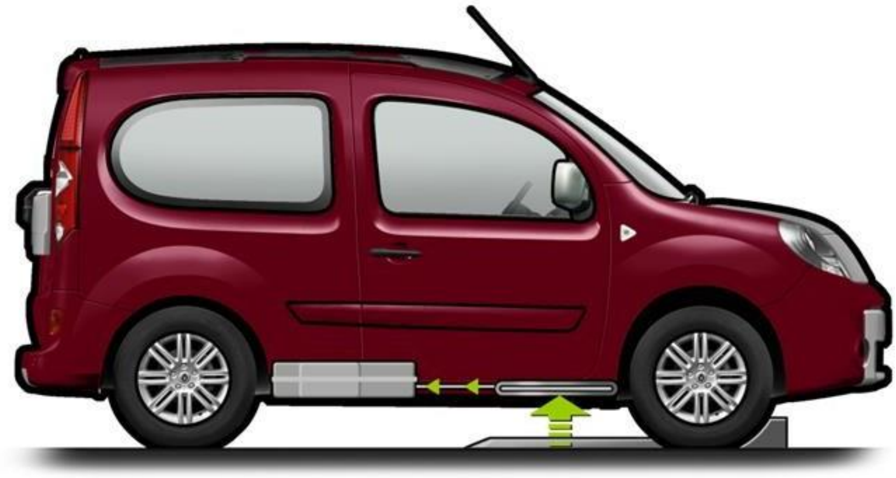

Fig 1.3: Airgap between the coil

As a result of numerous stances of vehicles and ground clearance magnetic coupling is varied. This succumbs the power efficiency. To specify this significance, using of high reactive power and resonant elements is strongly recommended in both transmitter and receiver side. By using Power conversion technique, the contactless coupler, and the power electronics system the battery is charged. The proposed system location in EV is Showed in Fig 1.4

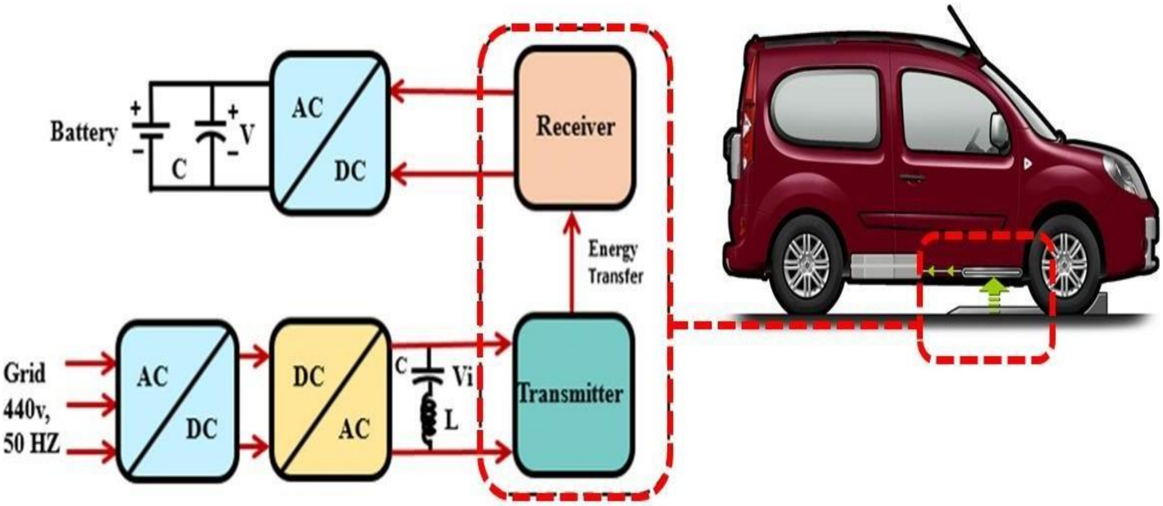

Fig 1.4: The proposed system location in EV

This system was designed with a Super-Capacitor and a Lithium-Ion Battery. This cordless charger comprises of rectifier, LC filter. This algorithm is used here is constant voltage and constant current, which compensates the transient state, and to achieve more stability.

2. BLOCK DIAGRAM

In recent trend, wireless power transfer is initializing to seek more and more attention. The block diagram comprises of Grid, rectifier, inverter, LC filter, linear transformer, super capacitor and battery. The low frequency AC supply is supplied by grid, is rectified and inverted to high frequency AC supply. In order to evict the harmonics, LC filter is brought into use. The high frequency AC supply is provided to transmitter coil and an emf is induced in the Receiver coil and the emf is recast from AC to DC. DC supply is used to charge to EV battery through of super capacitor. In this system we are used a control system to self-regulate the transmitter coil for different types of EV's. the control system has a MOSFET, inductive filters and Sawtooth reference signals to get desired output. A general block diagram for the wireless power transfer for EV is shown in Fig. 2.1.

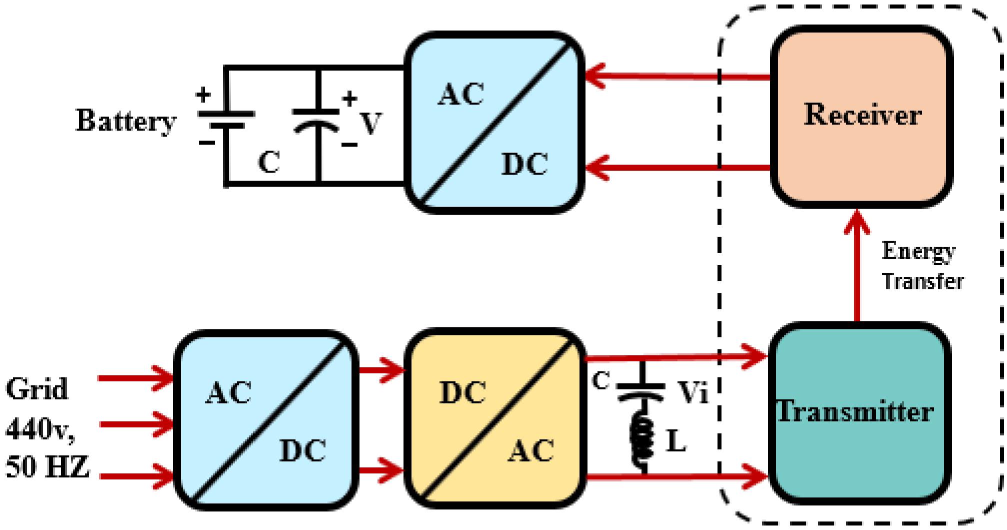

Fig. 2.1: General block diagram for a wireless power transfer for EV

3. PRINCIPLE USED

The principle used in this project is Faraday's Law of Electromagnetic induction. Due to the Principle of Faraday's Law of Electromagnetic induction, the induced emf energizes the receiver coil. On account of magnetic field, the variations in the coupling factor k which is calculated by

$$k=M/L1L2$$

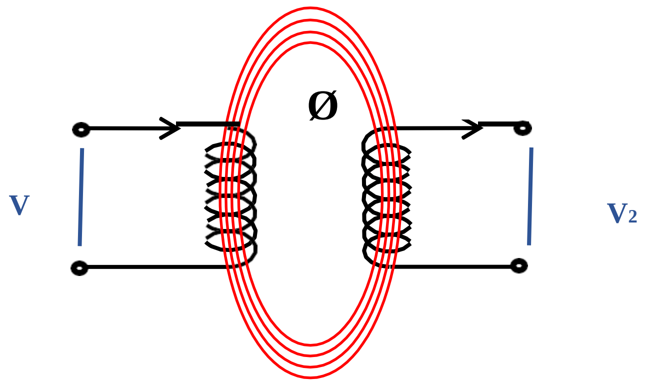

Fig. 3.1: Over view diagram of mutual inductance

Here Coil 1and Coil 2 are brought in proximity in magnetic field, the two-coil use to attract each other, which leads to voltage generation. This in turn changes or affect the I current & V (voltage)in coil2. This so called as mutual inductance.

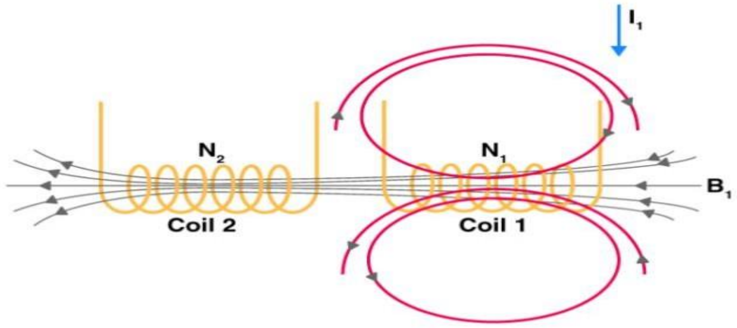

Fig. 3.2: Overview diagram of mutual inductance

Let us assume the Transmitter, with number of turns as L1, and the current I1, in a magnetic field of Ø. when transmitter and Receiver are brought into proximity, some magnetic flus may pass in Receiver.

MUTUAL INDUCTION

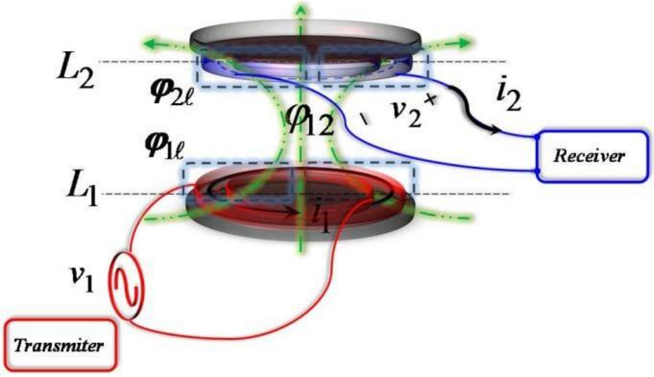

Fig. 3.3: Overview diagram of mutual inductance

Ø_{21}→magnetic flux in one turn of coil 2 due to current I1

If we vary the current with respect to time, then there will be an induced emf in coil 2.

$\mathcal{E}_{ind} = -\frac{d\text{Ø}}{dt}$ [According to Faraday's law] $\mathcal{E}_{21} = -N_2 \frac{d\text{Ø}_{21}}{dt}$ $\mathcal{E}_{21} = -\frac{d}{dt}(\bar{B}A)$

The induced emf is coil 2 directly proportional to the current passes through the coil 1.

$N_2 \text{Ø}_{21} \propto I_1$ $N_2 \text{Ø}_{21} = M_{21} I_1$ …..(1)

The constant of proportionality is called as mutual inductance. It can be written as

$\mathcal{E}_M = \frac{N2\ \text{Ø}21}{I_1}$ …..(2)

The SI unit of inductance is henry (H)

$1H = \frac{1(\text{Tesla}).1(m^2)}{1A}$

In a similar manner, the current in coil 2, I2 can produce an induced emf in coil 1 when I2 is varying with respect to time. Then,

$\mathcal{E}_{12} = = -N_1 \frac{d\text{Ø}_{12}}{dt}$ $N_1 \text{Ø}_{12} \propto I_2$ $N_1 \text{Ø}_{12} = M_{21} I_2$ …..(3)

$M_{21} = \frac{N_1 \text{Ø}_{12}}{I_2}$ …..(4)

This constant of proportionality is another mutual inductance.

4.CIRCUIT DIAGRAM

This the circuit diagram for wireless power transfer for different clearance. This circuit is consisting of two main blocks. They are

- Primary side
- Secondary side

Table no. 1: Components and their scope table

Stage	Component	Symbol	Value	Unit	Scope
PRIMARY SIDE	MOSFET	Fet1-Fet4	1	mΩ	INVERTER
	CAPACITOR	Cr	160	nF	LC FILTER
	INDUCTOR	Lr	37.5	μH	
	REGULATOR				
	TRANSMITTER WINDING	1	52	V	TRANSMITTER
			0.01	Ω	
			75	μH	
SECONDARY SIDE	RECEIVER WINDING	2	6	V	RECEIVER
			0.01	Ω	
			1.36	μH	
	DIODE	D1-D4	1	mΩ	RECTIFER
	CAPACITOR	C0	100	μH	SUPER CAPACITOR
	RESISTOR	R0	3	Ω	LOAD
SUB SYSTEM	DIODE	D5-D8	1	mΩ	RECTIFER
	INDUCTOR	L1-L4	152	μH	FILTER
	DIODE	D9-D12	1	mΩ	RECTIFER
	CAPACITOR	Cf	47	μH	RC FILTER
	RESISTOR	Rf	150	Ω	

Primary side is static because it is in underground of parking lot or a road, whereas the secondary side is dynamic because it is located in underbody of the vehicle. Once the primary side is energized, the due to the mutual inductance secondary coil is energized.

The induced voltage is fed to the load (Battery). The circuit diagram is shown below.

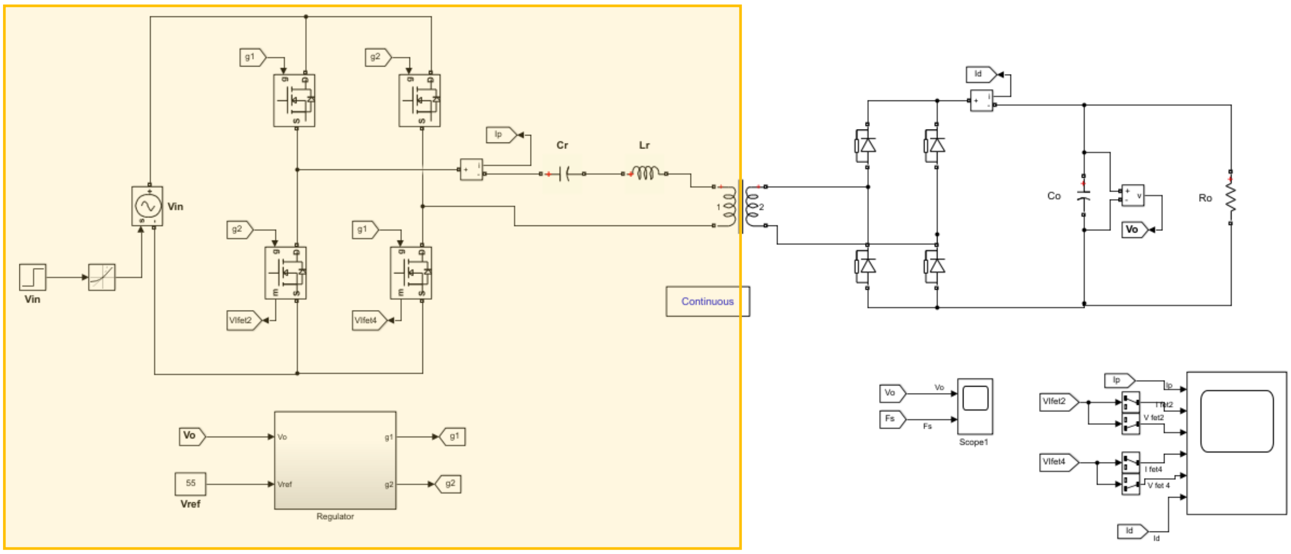

Fig. 4.1: Circuit Diagram (Primary side)

4.1 PRIMARY SIDE

The primary side is fixed inside the ground of parking lot. It is comprising of rectifier, inverter, LC filter and resonant element. The input (AC supply) from the grid is supplied to the primary side.

4.1.1 RECTIFIER

Rectifier is semiconductor device that acts as diode which allows current to pass through unidirectional. It is very simplest structure in electrical engineering component It is an important component in electronic equipment, where they are widely used. main application of rectifiers is to convert DC supply from AC supply. It is also called as AC to DC converter. In all electronic modules, the rectifiers are used as converters.

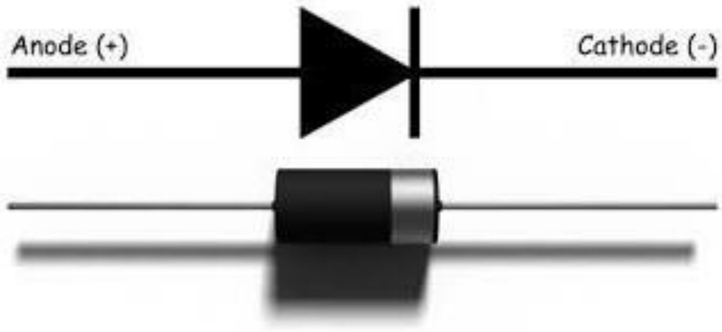

Fig. 4.2: Diode with Anode and Cathode

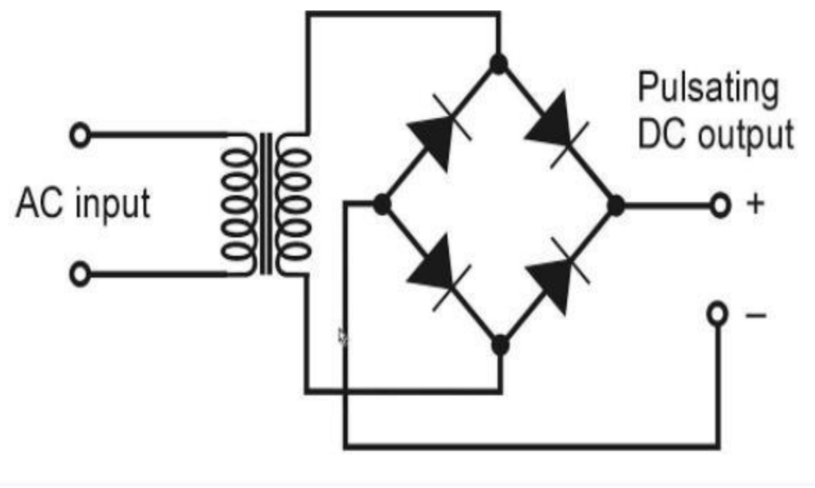

Fig. 4.3: Bridge rectifier

Rectifier diode is made of chemically fusing the N and P type material by using some fabrication. Different types of rectifier are available in market such as full-wave, half - wave and full-wave bridge. In full wave rectifier, both the positive and negative cycles of AC supply are utilised.

It uses the positive wave of AC supply and reciprocates the negative wave as a positive wave and supplied to the load as continuous positive wave. Sometimes, the filters are mostly used to remove the distortion which is presented in the AC supply. Due to the low power loss, this rectifier is widely used all over the industries.

4.1.2 INVERTER

Inverter is one of the static power electronics devices which converts the DC supply from the energy sources such as fuel cells, batteries or to AC supply. It is one of the Even though some electronic equipment uses the dc voltage, majority of the household appliances uses AC voltage. So, there is a need to convert the DC power to AC power so that, it might be used for household appliances The Input DC can be any required voltage, to operate the AC modules.

A MOSFET is a four-lead component and its name is source(S), gate (G), drain (D) and body (B) leads. In general, the body of the MOSFET is in connection with the source terminal thus forming a three-terminal device such as a field-effect transistor. MOSFET is generally considered as a transistor and employed in both the analog and digital circuits. It is mostly utilized where high current and high voltages are involved. It changes the one electric form of energy to another form, but it does not generate the power. So, it is often referred as convertor, not a generator.

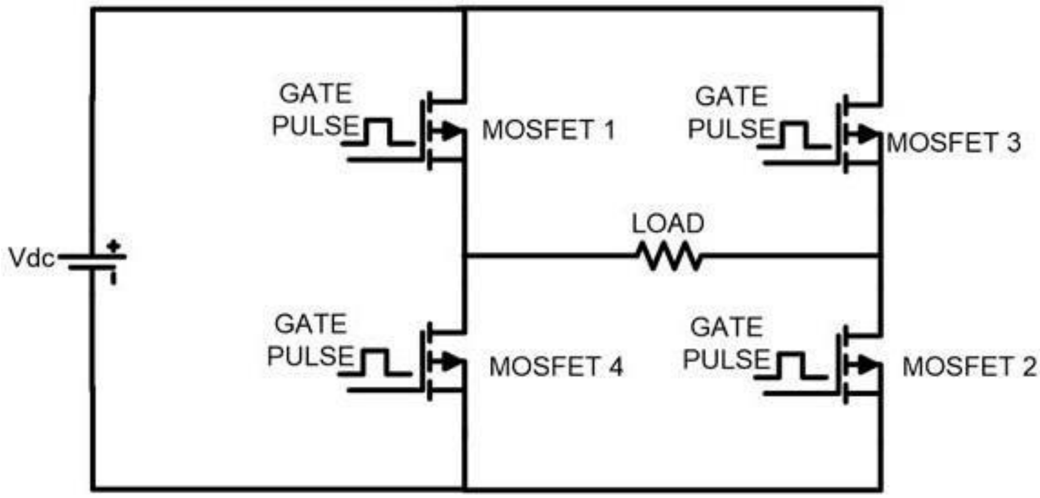

Fig. 4.5: Inverter

It is mostly used power system, as it converts the DC to Ac which is mainly utilized in transmission lines. Here the MOSFET is used as inverter, has 3 terminals, which brings evolution in power electronics. Without MOSFET, the integrated modules will not be possible.

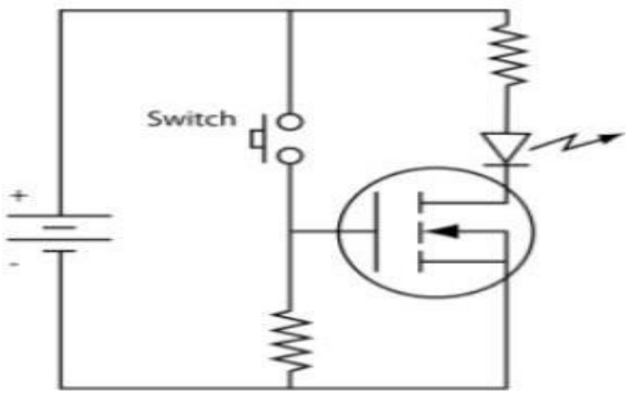

Fig. 4.6: MOSFET as switch

MOSFET inverts the direction of voltage, in turns acts as a inverter by using gate pulse. It is the vital block in designing the circuit, which can be fed to logic gates such as OR, NOT, AND, NAND, NOR.

According to the waveform obtained the inverts are classified into Square, Modified, sine wave. The square wave inverter is most economical inverter and simplest inverter.

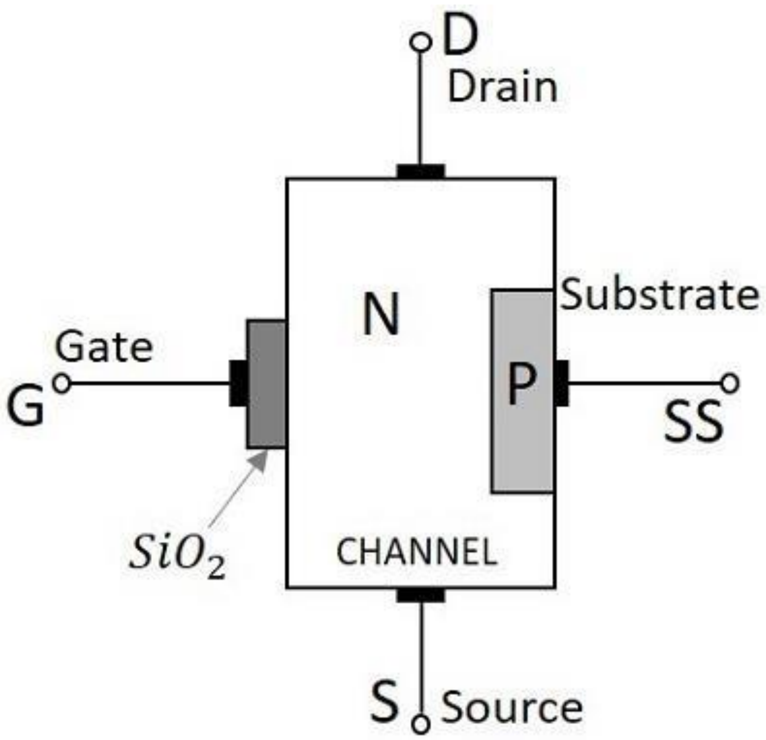

Fig. 4.7: MOSFET symbol

The obtained output will be the square wave. As it converts AC to DC supply, it not used quite often because obtained output in not standard sine wave. While connecting load, it may cause more power loss.

In modified square wave inverter, it reciprocates the signal which is approximate to sine wave. It is also called quasi wave inverter. Sine wave is more complex and efficient.

4.1.3 LC FILTER

Filter is the circuit which is plays vital role in filtering the AC components in output from rectifier. It allows DC supply to pass through it and it is fed to the load. It is passive element, which consists combination of resistor, inductor and capacitor. LC filter is the tuned circuit by fusing of Capacitors and inductor, to pass the electric signal of specified frequency. Capacitor will not allow DC supply to pass through it, but allows AC current to pass through, whereas the Inductor allows the AC supply but blocks the DC supply. Since these two components are passive in nature with extremely opposite characteristics. By collaborating these two components, the noises can be reduced drastically. So this electric circuit is widely used in the industries.

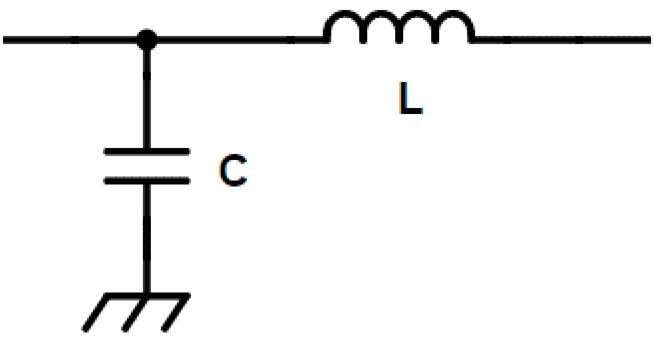

Fig. 4.8: LC filter symbol

LC filter can be used as low-pass, multiplexer, high-pass, band-pass for filtering distortions. This reduces the clattering sound which presents in circuits. This filter will pass the regulated signal with less distortion and completely. The applications of high-pass filter and low pass filters are mostly used in filtering circuit.

Fig. 4.9: LC filter in prototype

4.1.4 LINEAR TRANSFORMER

In this transformer, the winding current will be almost proportional to the flux. In the below diagram, the primary winding is always connected to voltage source. The secondary winding is always connected to load. Transformer is 4 terminal, which has 2 coupled coils

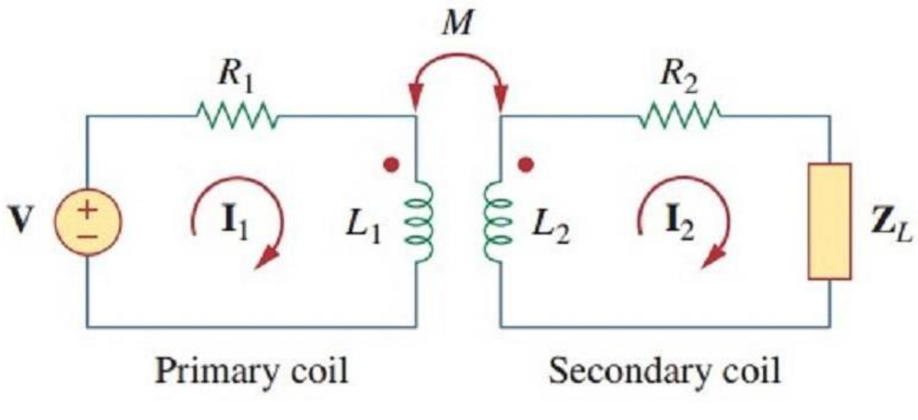

Fig. 4.10: LC filter in prototype

The resistance R1 is connected in primary winding to measure the input loss, and to measure the loss in secondary side R2 is connected in series with L2. Linear transformer is so called as air core transformers which always as constant magnetic permeability for all two coils. The AC voltage can be maximized or minimised by means of static device, so called as transformer. It works on mutual induction principle.

It transmits the electric signal from primary winding to secondary winding without changing in current and voltage values. The mutual induction implies that two coil are coupled, if there is change of current in one coil, the emf is induced in another coil. Transformer also works in such principle.

Fig. 4.11: Linear transformer

4.2 SECONDARY SIDE

The secondary side is fixed inside the underbody of Electric vehicles. It is comprising of rectifier, supercapacitor and battery. The input (AC supply) from the grid is supplied to the primary side.

The primary side is fixed inside the ground of parking lot. It is comprising of rectifier, inverter, LC filter and resonant element. The input (AC supply) from the grid is supplied to the primary side.

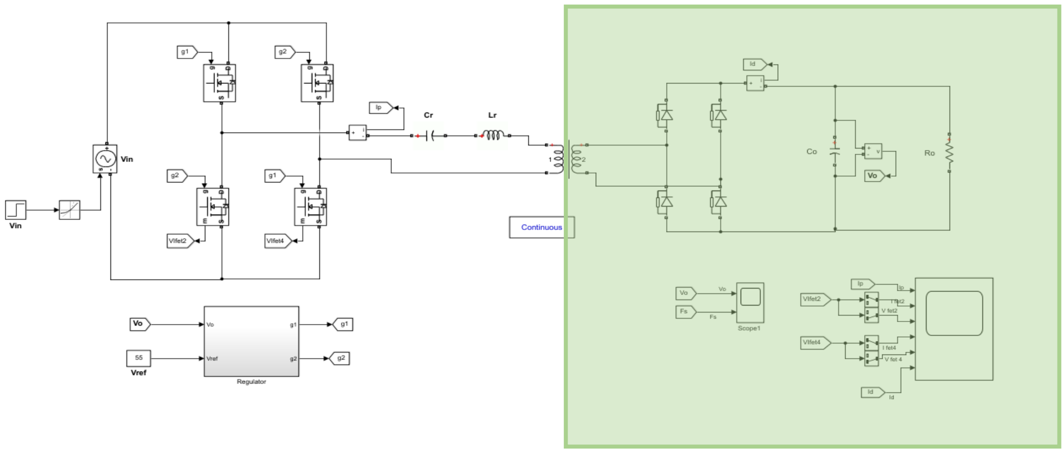

Fig. 4.12: Circuit of Secondary side

4.2.1 RECTIFIER

Rectifier is semiconductor device that acts as diode which allows current to pass through unidirectional. It is very simplest structure in electrical engineering component

It is an important component in electronic equipment, where they are widely used. main application of rectifiers is to convert DC supply from AC supply. It is also called as AC to DC converter. In all electronic modules, the rectifiers are used as converters. Rectifier diode is made of chemically fusing the N and P type material by using some fabrication.

Different types of rectifier are available in market such as full-wave, half -wave and full-wave bridge. In full wave rectifier, both the positive and negative cycles of AC supply are utilised. It uses the positive wave of AC supply and reciprocates the negative wave as a positive wave and supplied to the load as continuous positive wave.

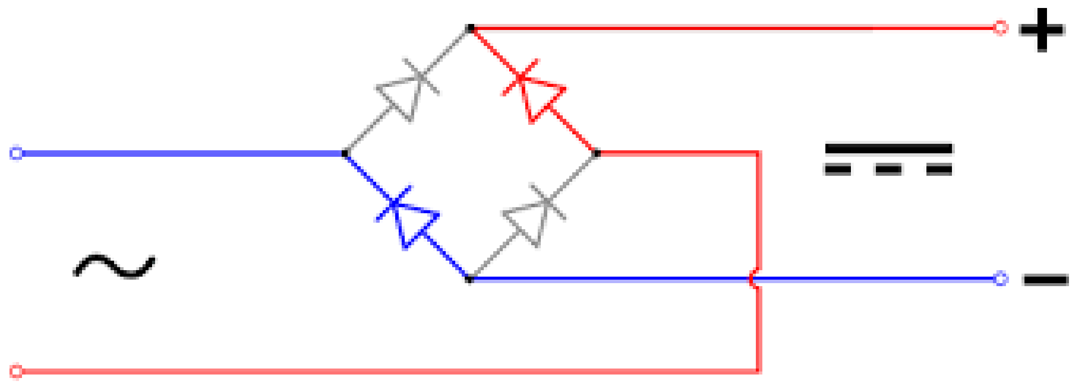

Fig. 4.13: Circuit of Rectifier

Sometimes, the filters are mostly used to remove the distortion which is presented in the AC supply. Due to the low power loss, this rectifier is widely used all over the industries.

Fig. 4.14: Diode rectifier

The main application of rectifiers is to convert DC supply from AC supply. It is also called as AC to DC converter. In all electronic modules, the rectifiers are used as converters.

4.2.2 SUPER CAPACITOR

Super capacitor acts as source to the battery. When electric vehicle starts moving abruptly while charging, there is a chance for damaging the battery life and also the wastage of power, so the super capacitor is used utmost.

Fig. 4.14 Super capacitor

It is otherwise known as ultra-capacitor. It is comparatively having more capacity when it is compared to the other capacitors. With the current trend of Research and development, it is divided into 3 types

- Pseudo capacitor
- Double layer capacitor
- Hybrid capacitor

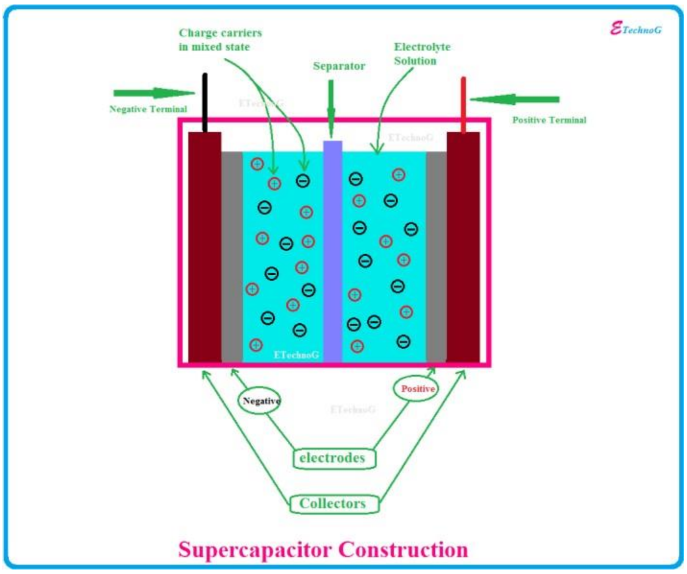

Fig. 4.15: Construction of super capacitor

Double layer capacitor stores the charge electrostatically, pseudo capacitor stores electro chemically and hybrid stores the in both the combination. In current trend, technology of super capacitor was evolved, improved its battery sustainability, this modern era uses the super capacitor as backup of source and frequently used as booster in other equipment.

The super capacitors will act as bridge between the batteries and capacitor. It acts as a main role in storing energy in automotive field. The serious issues in automotive industry is storing electric energy rapidly. In course of time, super capacitor is used, generator converts kinetic energy to electric energy. this energy is stored in super capacitor, later it is used to accelerate the motor. This component can be used in all the all the appliances which run or using batteries. It can be applied to laptop, cell phones and electric cars. The advantage is it help in charging the appliance quicker.

4.2.3 BATTERY

Always battery converts the chemical energy into electric energy in which it stores. Here the electron flows from one material to another via external circuit. this flow generates the current.

In order to balance the electron flows, ion which are charged, will flow through the electrolyte in turn makes the contact electrodes. There will a dissimilar chemical reaction, for different electrodes and electrolyte. Most hybrid and electric vehicle use lithium-ion battery.

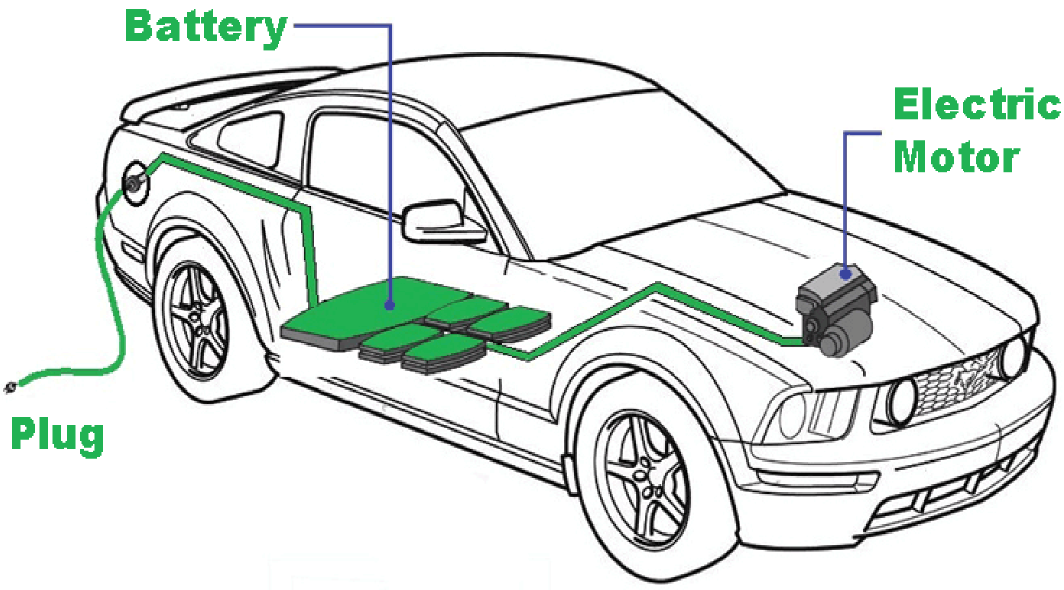

Fig. 4.16 Battery in car

In lithium-ion battery efficiency will be high and maintenance cost is economical when compared to other batteries. It is very compact in nature too.

Fig. 4.17: Battery arrangement for EV

This battery is used since 1990. Which is rechargeable, mostly used in electronic modules and hybrid vehicles which seems to be more popular in army. Research says that this battery has extended lifespan, more secure, economical, high charging speed, and energy density. Battery having lithium material, when reacts with water, exhibits the hydrogen. It has low discharge rate around 1.5%- 2.5 % for a month. The material used for anode is graphite and for cathode is lithium cobalt oxide.

5.CONTROL SYSTEM

SIMULATION DIAGRAM

The input AC signal is so called as step input is fed to the rate limiter, in which it maintains the desired value. the output from rate limiter is again fed to rectifier which

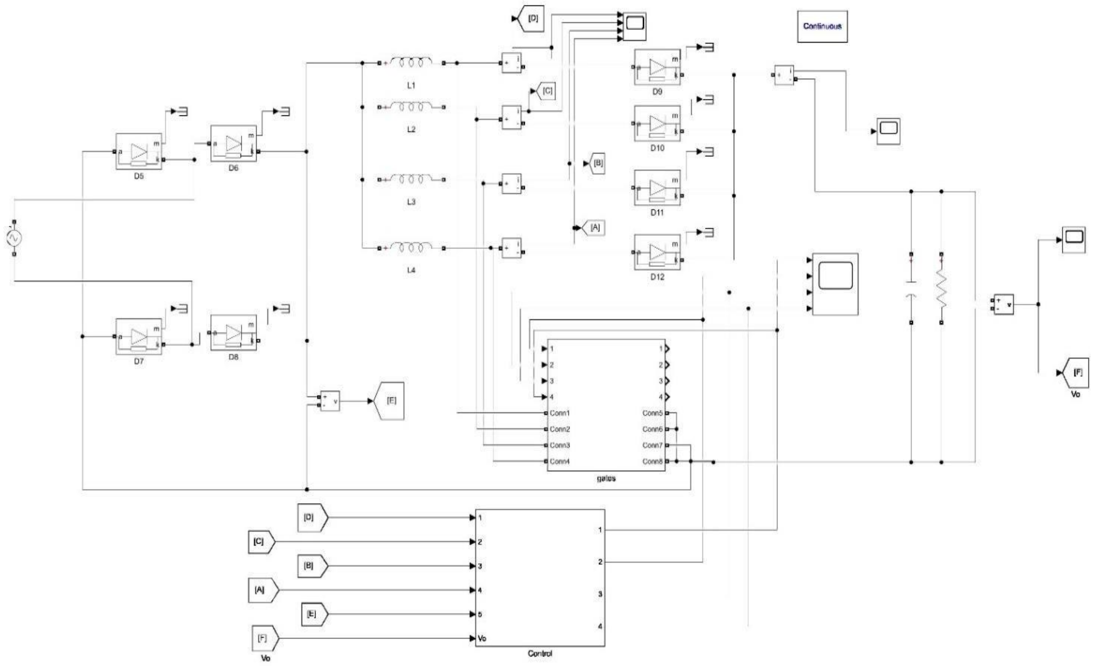

Fig. 5.1: control system simulation circuit

alters the input low frequency AC to DC supply. Then the sets of MOSFETs are used to convert again to high frequency AC supply. Here the MOSFET is sourced by signal generator by providing the reference signal. The tapped AC is suckled to LC filter to eradicate the distortion while performing power conversion. Then by using the principle of mutual induction, the ac supply is transferred from primary winding of linear transformer to the secondary winding.

The received AC supply is fed to the rectifier, to convert into DC supply for suppling the batteries. The converted DC supply is provided to the battery by means of super capacitor. Here the super capacitor plays the role as source for the battery, in order to reduce the battery damages. There is separate control system is enrolled for auto tapping the number of turns based on different ground clearance.

The MOSFET in main diagram is the control system which seems to be the body of the cordless charger. The MOSFET gates automatically taps the number of turns by determining the desired voltage by referring the sampling input.

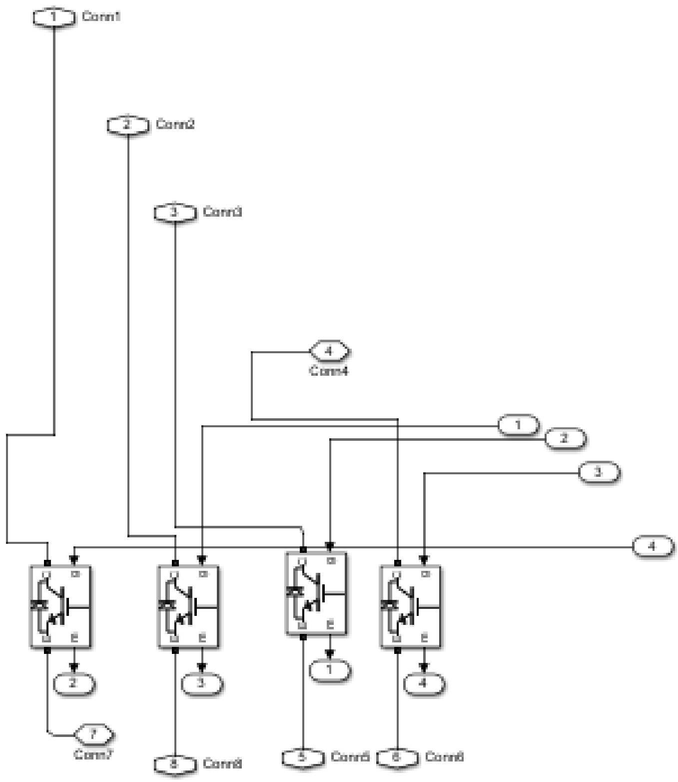

Fig. 5.2: Inverter in subsystem

The MOSFET in main diagram is the control system which seems to be the body

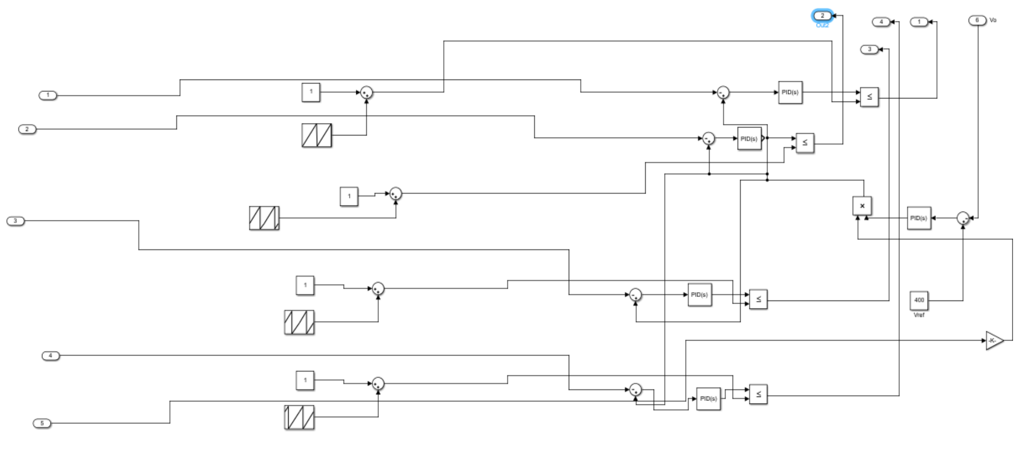

Fig. 5.3: Control system

of the cordless charger. The MOSFET gates automatically taps the number of turns by determining the desired voltage by referring the sampling input. The MOSFET output is supplied to control block. This control block determines the number of turns to be added based on ground clearance.

5.1 REGULATOR

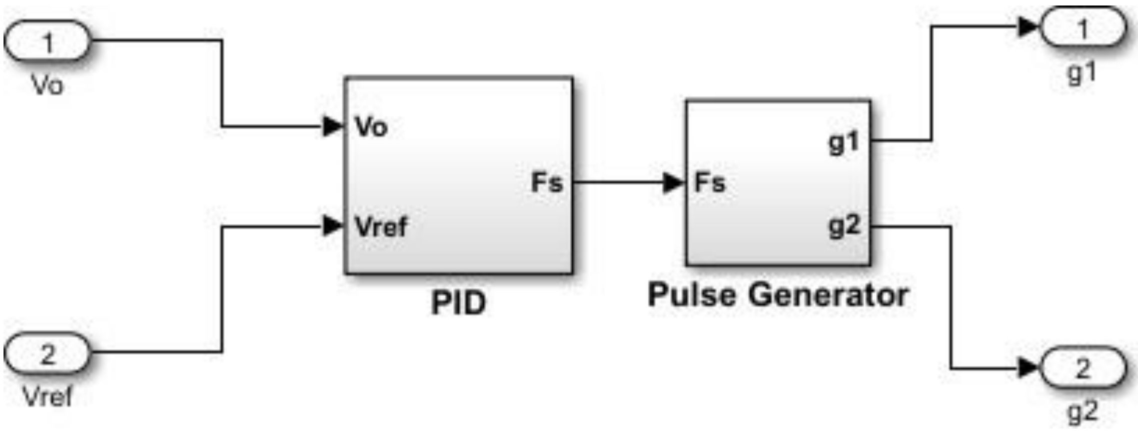

Fig. 5.4: Regulator

Regulator is device which maintains the constant output with pre-set value of voltage or current, in respective of changing in any input parameters. Here its vital role is gives the input signal to MOSFET for providing the AC signal with specified time period.

5.2 PID CONTROLLER

PID Controller is proportional-integral-derivative controller, in which it is broadly used in all over the industries for need of providing the continuous constant control. This is mainly used to calculating the errors in control system. It is used to control the speed, pressure, flow, and also the temperature. This controller at first will notice the sensor, compute output by summing the proportional response, integral response, and derivative response

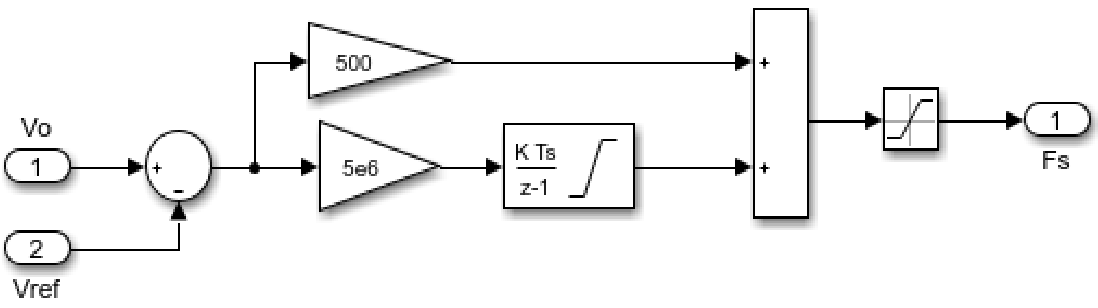

Fig. 5.5: PID Controller

5.3 PULSE GENERATOR

Pulse generator is the circuit which generate the pulses. These pulses are used to operate the digital circuits. It has a capacity to create pulses in 100 ps. The main application is it is fed to the device to find the fault.

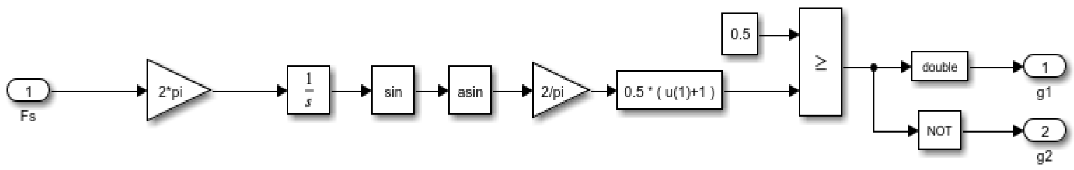

Fig. 5.6: Pulse generator

Pulse generator is the circuit which generate the pulses. These pulses are used to operate the digital circuits. In pulse width modulation, the load power is controlled by chopping effectively by discrete, and it eliminates the power wastage.

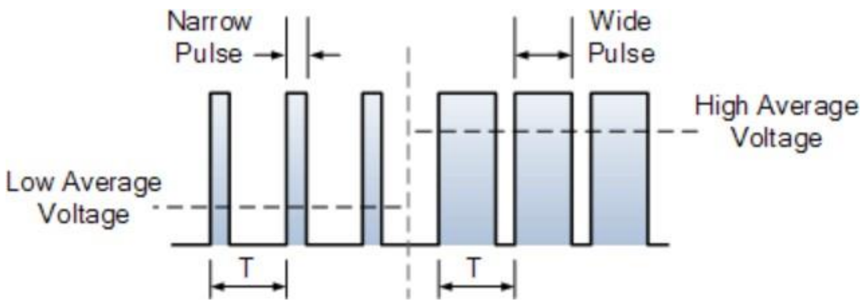

Fig. 5.7: Pulse width Modulation

6. SIMULATION AND EXPERIMENTAL RESULTS

Input voltage 440 v given from grid to Vin and its range is drawn in Fig no. 6.1

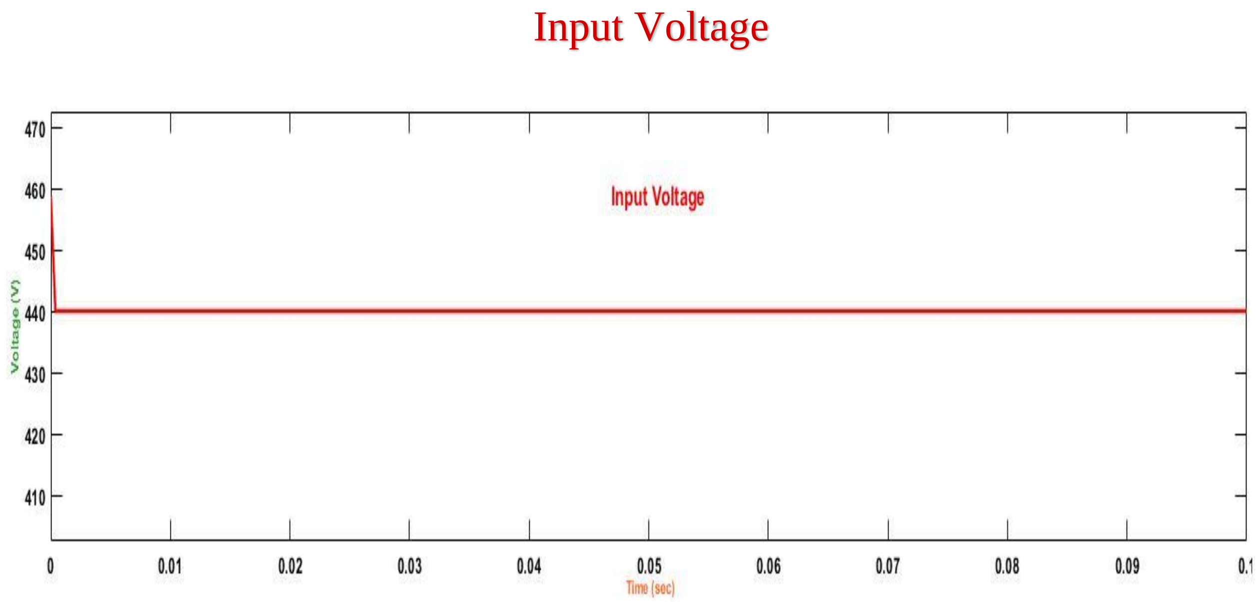

Fig 6.1 Input Voltage (Voltage vs time)

Input current 4 amps is given to the circuit and its range is drawn in Fig no.6.2

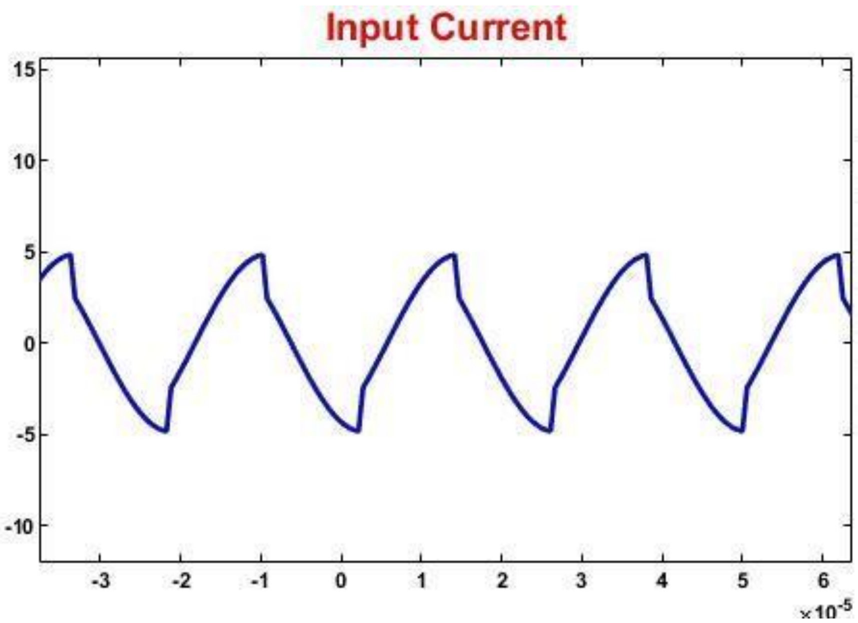

Fig no. 6.2 Input Current (Current vs time)

Fetched step 1 Voltage output from MOSFET 2 is shown in Fig no. 6.3

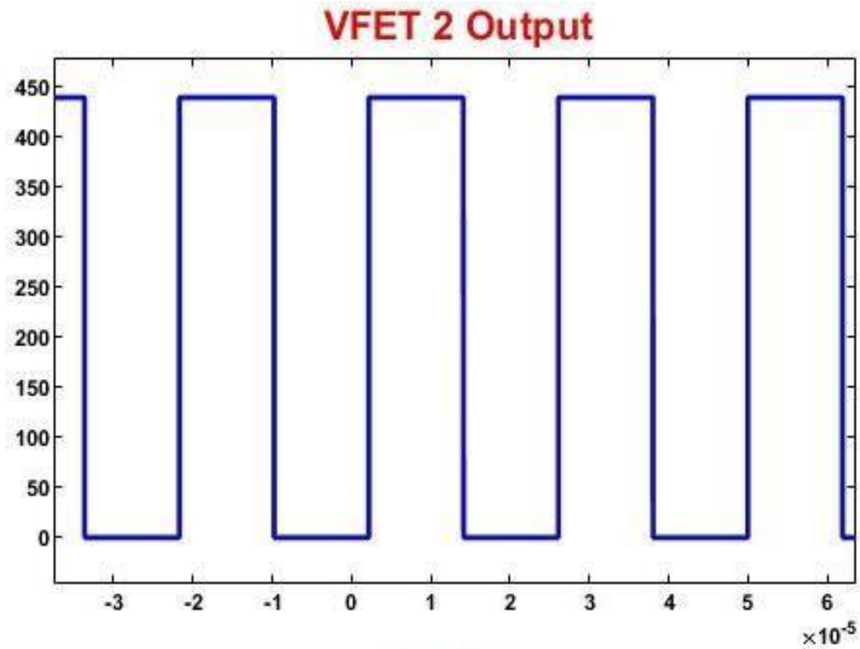

Fig no. 6.3 VFET 2 Output (Voltage vs time from MOSFET 2)

Fetched step 2 Voltage output from MOSFET 4 is shown in Fig no. 6.4

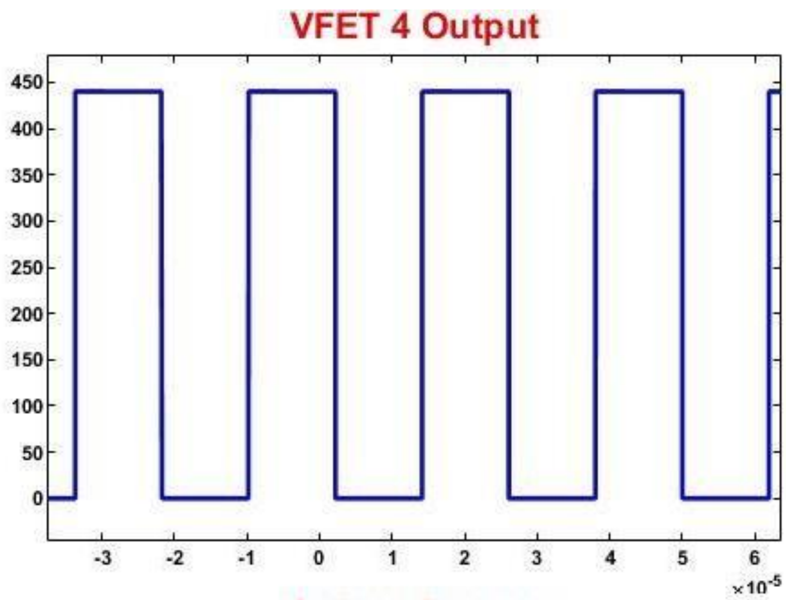

Fig no. 6.4 VFET 4 Output (Voltage vs time from MOSFET 4)

Fetched step 2 Current output from MOSFET 2 is shown in Fig no. 6.5

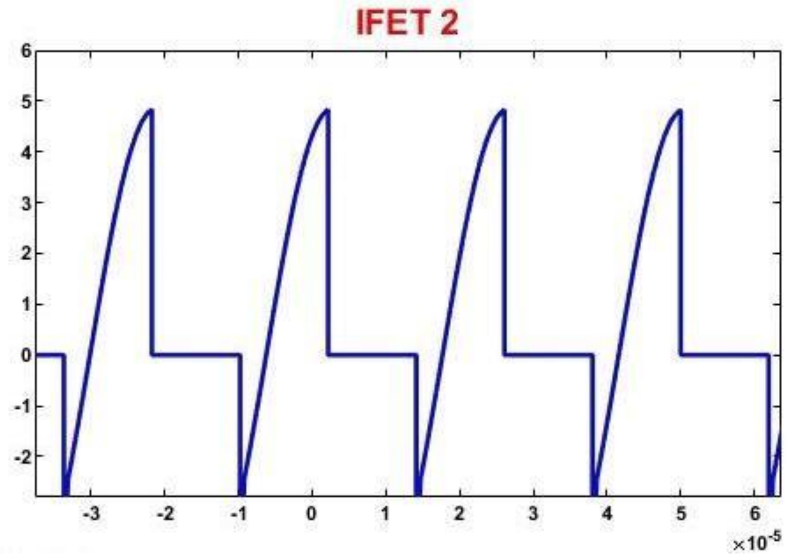

Fig no. 6.5 IFET 2 (Current vs time from MOSFET 2)

Fetched step 2 Current output from MOSFET 2 is shown in Fig no. 6.6

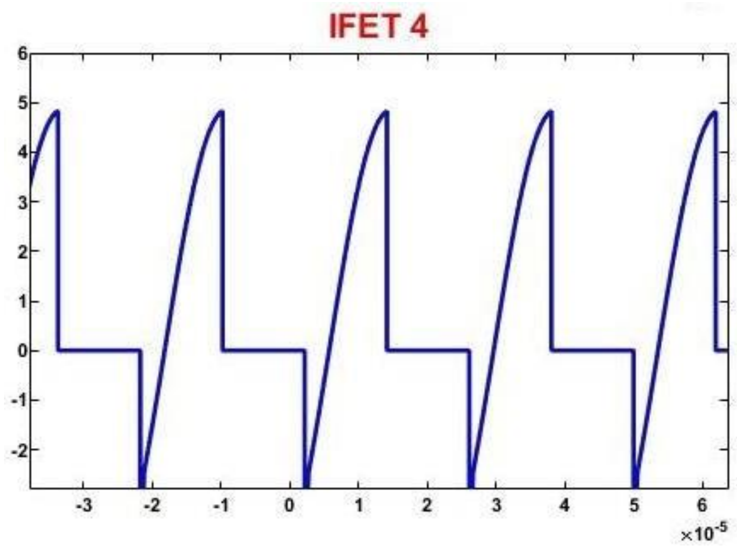

Fig no. 6.6 IFET 4 (Current vs time from MOSFET 4)

Fetched Final output Current to Load is shown in Fig no. 6.7

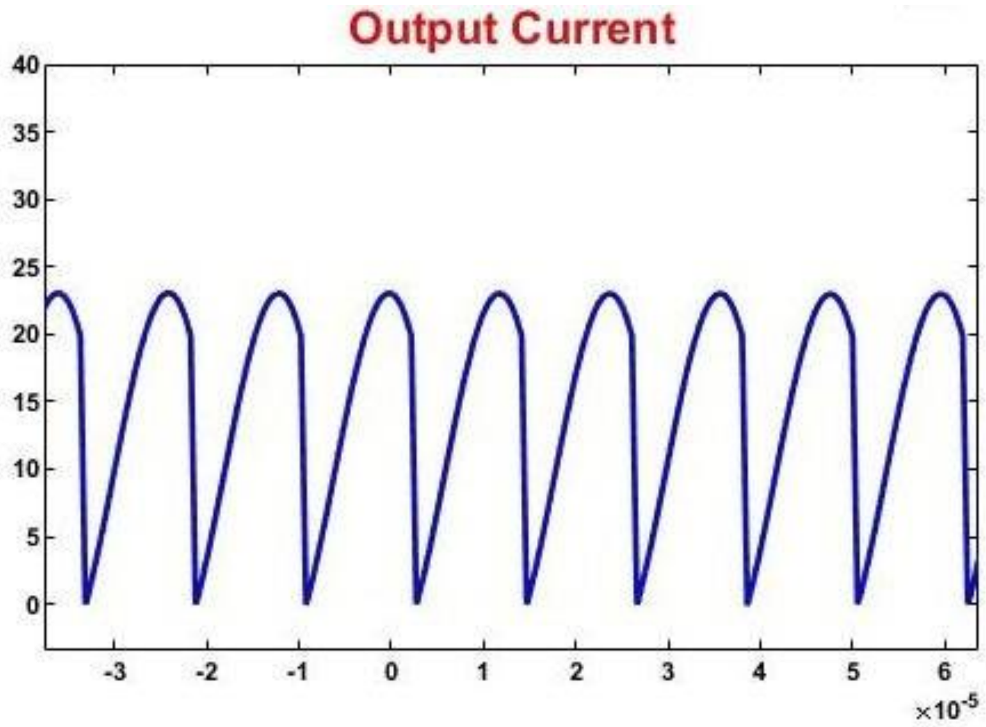

Fig no. 6.7 Output current (Current vs time)

Input voltage 45 v given to Load is drawn in Fig no. 6.8

Output Voltage

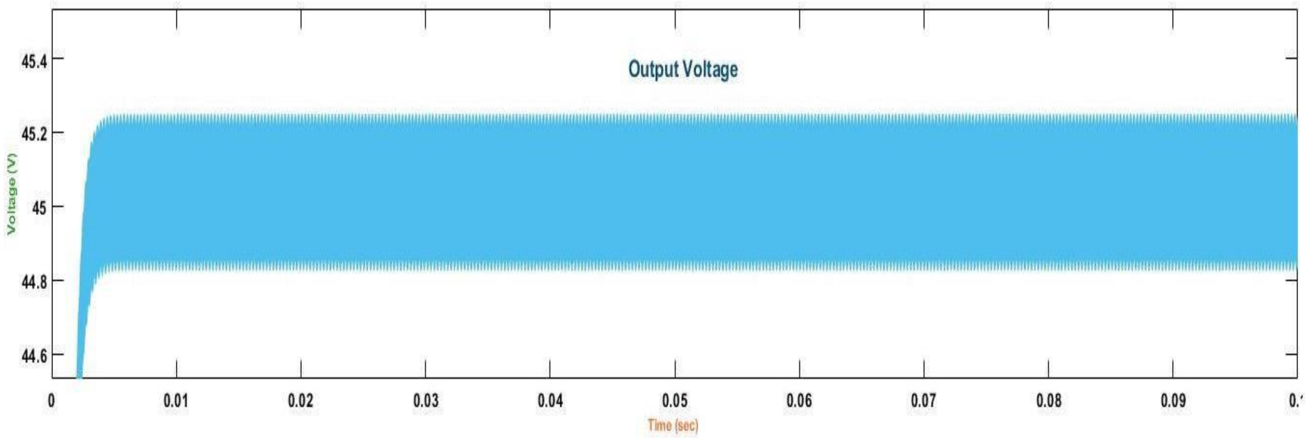

Fig no. 6.8 Output Voltage (Voltage vs Time)

7. CONCLUSION

In this material, an authentic method is portrayed to handle different ground clearance in wireless power transfer systems. The measurements used for the above parameters show reliable results for proposed theme. In the prototype zero visible heating of the used relays was notified.Several simulations were Performed. Regardless of previous studies, we inspected with some real-world charger placement limitations in the surveillance area such as walls, ground clearance. The above delivered system is economical and highly beneficial because it uses inverters, rectifiers and filters to handle a different coupling factor.Separate control system is enrolled, where, the transmitter coil is automatically tapped for transferring the power to the battery based on the ground clearance within 200mm. Eventually, this paper contributes to the typical hindrance of varying ground clearance. The wireless charger was procedurally verified for the battery at 4.5 kWh, super capacitor at 3.8KWh with a peak efficiency of 86%.

REFERNCES

1. Dr. A. Geetha, Ph.D, Asst.prof, C. Subramani, Prof, T. M. Thamizh Thentral, “Jour of Adv Research in Dynamical & Control Systems”, Vol. 10, 07-Special Issue, 2018 “An Efficient Wireless Power Transfer using Class E2 Converter for Electric Vehicle”.

2. Chun Qiu , K. T. Chau , Tze Wood Ching , and Chunhua Liu “Journal of Asian Electric Vehicles”, Volume 12, Number 1, pp. 1679 - 1680 June 2014 “Overview of Wireless Charging Technologies for Electric Vehicles”.

3. S. Chon and G. Reig, “EV market and wireless charging,” page no. – 4, January 2018,

4. A. P. Sample, D. T. Meyer, and J. R. Smith, “Analysis, experimental results, and range adaptation of magnetically coupled resonators for wireless power transfer,” IEEE Transactions on Industrial Electronics, vol. 58, no. 2, pp. 544–554, Feb 2011

5. Z. N. Low, R. A. Chinga, R. Tseng, and J. Lin, “Design and test of a high-power high-efficiency loosely coupled planar wireless power transfer system,” IEEE Transactions on Industrial Electronics, vol. 56, no. 5, pp. 1801–1812, May 2009

6. J. Kim, J. Kim, S. Kong, H. Kim, I. S. Suh, N. P. Suh, D. H. Cho, J. Kim, and S. Ahn, “Coil design and shielding methods for a magnetic resonant wireless power transfer system,” Proceedings of the IEEE, vol. 101, no. 6, pp. 1332–1342, June 2013.

7. J. M. Miller, O. C. Onar, and M. Chinthavali, “Primary-side power flow control of wireless power transfer for electric vehicle charging,” IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 3, no. 1, pp. 147–162, March 2015.

8. M. Budhia, J. T. Boys, G. A. Covic, and C. Y. Huang, “Development of a single-sided flux magnetic coupler for electric vehicle ipt charging systems,” IEEE Transactions on Industrial Electronics, vol. 60, no. 1, pp. 318–328, Jan 2013

9. G. A. Covic and J. T. Boys, “Modern trends in inductive power transfer for transportation applications,” IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 1, no. 1, pp. 28–41, March 2013

10. M. Budhia, G. Covic, and J. Boys, “A new ipt magnetic coupler for electric vehicle charging systems,” in IECON 2010 - 36th Annual Conference on IEEE Industrial Electronics Society, Nov 2010, pp. 2487– 2492
11. G. A. J. Elliott, J. T. Boys, and G. A. Covic, “A design methodology for flat pick-up icpt systems,” in 2006 1ST IEEE Conference on Industrial Electronics and Applications, May 2006, pp. 1–7.

12. H. Omori, M. Inoue, N. Kimura, T. Morizane, and M. Nakaoka, “A new large-gap wireless ev charger with a power superimposition communication,” in 2017 19th International Conference on Electrical Drives and Power Electronics (EDPE), Oct 2017, pp. 65–69.

13. J. Schneider and J. O’Hare, “Alignment, verification, and optimization of high-power wireless power charging systems,” May 2017, US Patent 9637014B2.

14. Y. Matsuda, H. Sakamoto, H. Shibuya, and S. Murata Sojo, “A non-contact energy transferring system for an electric vehicle-charging system based on recycled products,’’ Journal of Applied Physics 99, 08R902 2006.

15. M. Budhia, G.A. Covic, J.T. Boys, and C.Y. Huang, “Development and evaluation of single sided flux couplers for contactless electric vehicle charging”, in Proc. IEEE Energy Conv. Cong, pp. 614- 621, 2011.

16. K. W. Klontzl A. Esse, P. J. Wolfs, and D. M. Divan, “Converter Selection for Electric Vehicle Charger Systems with a High-Frequency High-Power Link,” in Rec. IEEE Power Electron. Spec Conf. (PESC), pp. 855-861, 1993.

17. A. J. Moradewicz and M. P. Kazmierkowski, “Contactless energy transfer system with FPGA-controlled resonant converter,” IEEE Trans. Ind. Electron., vol. 57, no. 9, pp. 3181–3190, Sep. 2010.

18. N. Chawla and S. Tosunoglo, “State of the Art in Inductive Charging for Electronic,” in 2012 Florida Conference on Recent Advances in Robotics, 2012.

19. Joshua Le-Wei Li, “Wireless Power Transmission: State-of-the-Arts in Technologies,” in Proceedings of the Asia-Pacific Microwave Conference 2011.

20. C. S. Wang, O. H. Stielau, and G. A. Covic, “Design consideration for a contactless electric vehicle battery charger,” IEEE Trans. Ind. Electron., vol. 52, No. 5, pp. 1308–1313, Oct. 2005.

21. A. Neves, D. M. Sousa, A. Roque and J. M. Terras, “Analysis of an inductive charging system for a commercial electric vehicle,’’ Power Electronics and Applications (EPE 2011), pp.1-10, Sep. 2011.

22. P. Si, A. P. Hu, J. W. Hsu, M. Chiang, Y. Wang, S. Malpas and D. Budgett, “Wireless power supply for implantable biomedical device based on primary input voltage regulation,” in Proc. 2nd IEEE Conf. Industrial Electron., pp. 235-239, May 2007.

23. S.Y.R. Hui and W.W.C Ho, “A new generation of universal contactless battery charging platform for portable Consumer Electronic equipment,” IEEE Trans. Power Electronics, vol. 20, pp. 620-627, May. 2005.

24. S. Brehaut and F. Costa, “Gate driving of high power IGBT by wireless transmission,” International Power Electronics Motion Control, 2006, 5th IEEE IPEMC 2006. conference record of the 2006 IEEE, pp. 1-5, vol.1, Shanghai, china, Aug. 2006.

25. O. Lucia, L. A. Barragan, J. M. Burdio, O. Jiménez, and D. Navarro, “A versatile power electronics test-bench architecture applied to domestic induction heating,” IEEE Trans. On Industrial Electronics, vol. 58, no. 3, pp. 998-1007, 2011.

26. 1M. Budhia, G.A. Covic and J.T. Boys, “Design and optimization of circular magnetic structures for lumped inductive power transfer systems,” IEEE Trans. Power Electronics, vol. 26, No. 11, pp 1115-1123, Nov. 2011.

27. S. Valtchev, B. Borges, K. Brandisky, and J. Ben Klaassens, “Resonant Contactless Energy Transfer With Improved Efficiency,” IEEE Trans. on Power Electronics, vol. 24, No. 3, pp. 685-699, Mar. 2009.

28. Y. P. Su, L. Xun, and S. Y. R. Hui, “Mutual inductance calculation of movable planar coils on parallel surfaces”, in Power Electronics Specialists Conference, vol. 24, pp. 3475-3481, June 2008.

29. J. Acero, C. Carretero, I. Lope, R. Alonso, O. Lucia, and J.M. Burdio, “Analysis of the Mutual Inductance of Planar-Lumped Inductive Power Transfer Systems,’’ IEEE Trans. Industrial Electronics, vol. 60, pp. 1-11, Jul. 2011.

30. O. C. Onar, J. M. Miller, S. L. Campbell, C. Coomer, C. P. White and L. E. Seiber, “A Novel Wireless Power Transfer for In-Motion EV/PHEV Charging,” IEEE 28th Power Electronics Conf. and Expos. APEC’2013, pp. 3073 - 3080, Long Beach, CA, Mar. 2013.

31. C. Yu, R. Lu, Y. Mao, L. Ren, and C. Zhu, “Research on the Model of Magnetic-Resonance Based Wireless Energy Transfer System,” in Proc. IEEE2009 Vehicle Power and Propulsion Conference, Dearborn, MI, 7-10 Sep. 2009.

32. Bernard Multon, “Modèles électriques du transformateur électromagnétique,” Antenne de Bretagne de l’École Normale Supérieure de Cachan, 1997.

33. Dragan Maksimovic, Robert W. Erickson, and Carl Griesbach, “Modeling of Cross Regulation in Converters Containing Coupled Inductors,” IEEE Trans. Power Electronics, vol. 15, No. 4, pp. 605-617, Jul. 2000.

34. R.W. Erickson and D. Maksimovic, Fundamentals of Power Electronics, 2nd ED., Kluwer Academic Publisher, 2004.

35. R. Laouamer, M. Brunello, J. P. Ferrieux, O. Normand, and N. Buchheit, ‘‘A multiresonant converter for non-contact charging with electromagnetic coupling,’’ in Proc. 23rd Int. Conf. Ind. Electron. Control Instrum., 1997, vol. 2, pp. 792–797.

36. A.P. Sample, D.A. Meyer and J.R. Smith, “Analysis, experimental results, and range adaptation of magnetically coupled resonators for wireless power transfer,” IEEE Trans. Industrial Electronics, vol. 58, No. 2, pp. 544-554, Feb. 2011.

37. S. Cheon, Y.-H. Kim, S.-Y. Kang, M.L. Lee, J.-M. Lee, and T. Zyung, “Circuit-model based analysis of a wireless energy-transfer system via coupled magnetic resonances,” IEEE Trans. Industrial Electronics, vol. 58, No. 7, pp. 2906-2914, July 2011.

38. R. Bosshard, J. Muehlethaler, J. W. Kolar, and I. Stevanovic, “Optimized magnetic design for inductive power transfer coils,” in Applied Power Electronics Conference, 2013.

39. J.T. Boys, A.P. Hu and G.A. Covic, “Critical Q analysis of a current-fed resonant converter for ICPT applications,” Electronics Letters, vol. 36, No. 17, pp. 1140-1142, Aug. 2000.

40. R. Laouamer, Thèse.de l’Institut National Polytechnique de Grenoble – INPG 1998, “Chargeur de Batteries à Couplage Inductif pour Véhicule Electrique,” G2ELAB, Grenoble, France.

41. T.C.Y. Ho, B. Gomersall and R. Li, “Contactless Charging for Electric Vehicles with a Large Air Gap,” IEEE Power Electronics and Applications Conference EPE’11, Birmingham, UK Aug. 2011.

42. A. Ecklebe, and A. Lindemann, “Analysis and Design of a Contactless Energy Transmission System with Flexible Inductor Positioning for Automated Guided Vehicles,” IEEE 32nd Conf. Industrial Electron. IECON’2006, pp. 1721–1726, Paris, France, Nov. 2006.

43. H. H. Wu, A. Gilchrist, K. D. Sealy, and D. Bronson, “A high efficiency 5 kW inductive charger for EVs using dual side control,” IEEE Trans. Ind. Inf., vol. 8, no. 3, pp. 585–595, Aug. 2012.

44. R. Bosshard, U. Badstübner, J. W. Kolar, and I. Stevanovic, “Comparative evaluation of control methods for inductive power transfer,” in Proc. of the 1st International Conference on Renewable Energy Research and Applications (ICRERA), 2012.

45. R. Bosshard, J. Mühlethaler, J. W. Kolar, and I. Stevanovic, “The η Pareto front of inductive power transfer coils,” in Proc. of the 38th IEEE Industrial Electronics Conference (IECON), 2012.

46. Brevet : Inventeurs: Patric Camaruti et Henri Bondar. Numéro de demande internationale : PCT/FR2006/000614 Numéro de publication internationale: WO 2007/107642 A1. Date de dépôt international : 21 mars 2006 (21.03.2006). Title: Dispositif de transport de l’énergie par influence partielle à travers un milieu diélectrique.