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Design and Analysis of On-Road Charging Electric Vehicle (OLEV)

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Abstract:- This paper deals with On Road Charging Electric Vehicle (OLEV) which is an innovative technology in electricity-powered transportation system. It picks up electricity from pick up coil which buried under the ground. The electric vehicle used so far need a battery for energy storage and charging stations are needed for filling the battery. We have fill the battery after a certain interval of time since the capacity of battery is limited. But On Charging Electric Vehicle (OLEV) is a solution for the limitation of existing plug-in electric vehicle. The principle behind OLEV is electromagnetic induction. The electric vehicle is charged, when it is moved along the path consisting pick up coil buried under the road. The power is stored in the battery and when the electric vehicle moves along the path where the pick-up coil is not installed, the power stored in the battery is used up. The OLEV replaces the huge batteries and charging stations. It also reduces losses and limit the atmospheric pollution.

***Keywords**:- OLEV, Recharging road, Power pickup unit, plug in electric vehicle, SMFIR.*

I. INTRODUCTION

One of the major concerns around the world in recent years is regarding the environmental problems. The environmental pollution and the depletion of ozone layer due to the burning of fossil fuels are greatly hot issues around the world. Nearly 95% of the total transportation energy is derived from petroleum based fuel and the amount of carbon-di-oxide produced from this sector is enormous. Globally the carbon-di-oxide CO_2 emission from fossil fuel were 9.765 gigatonnes (Gt) in the year 2014. According to United State environment protection agency (EPA) around 14% of 2010 global greenhouse gas emissions are from transportation sector. In this scenario effective measures should taken to reduce carbon-di-oxide CO_2emission . But we can't reduce the number of vehicles in the present developing society to minimize the carbon-di-oxide CO_2emission . Therefore, as an alternative energy source, the electric power has a greater importance. So, the recent developments have been focused on the advancement of electric vehicles which are expected to reduce the pollution and fuel costs. Many studies on electric vehicles have been performed in recent decades. But the problem with the existing electric vehicle technology is its long charging time. It takes a lot of time for recharge. Also the bulky batteries make it costly. Other problems associated with existing electric vehicles includes bulky size and weight, low power capacity, limited range, short life expectancy and high cost.

On-Road Charging Electric Vehicle is a new electricity powered transportation system to overcome the limitation of the existing electric vehicle technology. It can charge its battery while stationary or driving and eliminates the need of stopping at charging stations for a long time to charge the bulky battery. The OLEV operates with an electric motor and a battery installed in the vehicle. The input supply frequency is converted to a very high frequency using inverter and these high frequency current flows through the power line which is buried under the road. A pickup device installed under the vehicle collect the magnetic field from under-ground power cables and this is then rectified, regulated and stored in a battery [1].

The key technology behind on road charging electric vehicle is Shaped Magnetic Field in Resonance(SMFIR) [2]. It is technology which is intended for the wireless power transfer under dynamic operation. As a principle we are using shaped magnetic field in resonance (SMFIR) method for transfer our power. Under SMFIR we are using L-C cancellation method for resonance. It provides us a great efficiency for transferring power up to an admirable distance. In this project Energy transfer mechanism consists of high frequency inverter, power line and pick-up module. The wireless power transfer can be classified as vertical magnetic flux type and horizontal magnetic flux type based on the direction of the magnetic flux at the pick-up module [3].

In vertical there are two power lines with opposite current directions underneath the road surface forming a current loop. Due to the current in the power lines, magnetic flux is induced around each power line. Between the power lines, the magnetic fluxes from the two power lines are added. The pickup module catches the vertical magnetic flux through copper coils around the ferrite core. The direction of the magnetic flux from the power lines is the same as the direction of the flux to the pickup module.

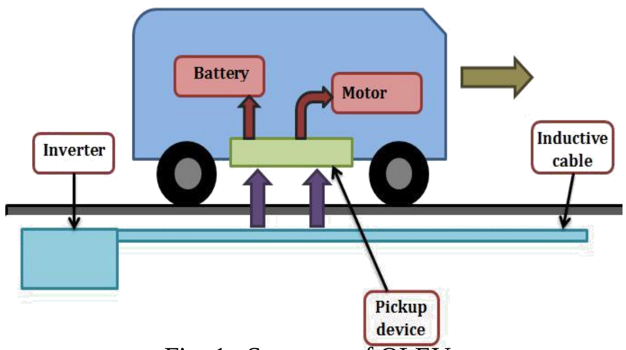

Fig. 1. Structure of OLEV

Energy transfer mechanism consists of high frequency inverter, power line and pick-up module. The design of power lines and the pickup module are the key technologies for effective power transfer [4]. According to the direction of the magnetic flux at the pick-up module noncontact power transfer can be classified as vertical magnetic flux type and horizontal magnetic flux type. In vertical, there are two power lines with opposite current directions underneath the road surface forming a current loop. Due to the current in the power lines, magnetic flux is induced around each power line. Between the power lines, the magnetic fluxes from the two power lines are added. The pickup module catches the vertical magnetic flux through copper coils around the ferrite core. This type has the advantage of efficient power transfer because the direction of the magnetic flux from the power lines is the same as the direction of the flux to the pickup module. Horizontal magnetic flux types are of less efficient as there is no adding of flux in the center portion.

SMFIR technology enables the electric vehicle to be charged while the vehicle is in motion. The power cable installed under the road surface can generate a high frequency electromagnetic field as depicted in the Figure 1.

The power converter gets the supply of single phase 230V. The pick-up coil sets attached under the vehicle's bottom-floor are tuned to a 10 kHz resonant frequency and are designed to have maximized exposure to the generated magnetic field, which has an optimized field shape for the same purpose. In this way, the transmission efficiency can be maximized while reducing the magnetic field leakage outside of designed intended space.

The design objective is to obtain the maximum power transmission efficiency with the pre-determined level of required power capacity by optimizing the paired power supply

II. METHODOLOGY

A. Frequency Converter

These devices usually consist of a rectifier stage (producing direct current) which is then inverted to produce ac of the desired frequency. The single phase frequency converters uses a single phase input and produce corresponding dc output. The first component of all frequency converters is a device known as a rectifier or converter. A rectifier converts alternating current (ac) to direct current (dc). The output of the rectifier is given to inverter. The inverter may use thyristors or IGBT. Here we are used IGBT inverter. The PWM (pulse width modulation) is widely applied in the frequency converter industry. The inverter is the power electronic circuit, which converts the dc voltage into ac voltage. The dc source is normally a battery or output of the controlled rectifier.

The single phase 230 V, 50 Hz from the grid has to be converted into high frequency (say 10 kHz) AC electricity before it is given to the primary in cables. although the block diagram shows a single inverter block for frequency conversion, it actually consist of a rectifier, dc link and a single phase inverter.

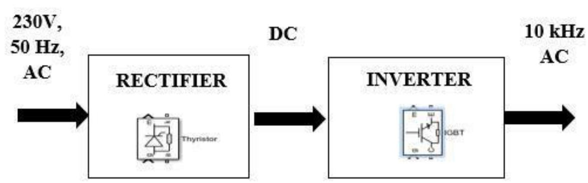

Fig. 2:- Frequency Converter

B. Rectifier

Most of the power electronic based converters uses Single phase uncontrolled rectifiers. but it is unable to control the output dc voltage / current magnitude when the input ac voltage and load parameters remain fixed. This problem can be overcome if the diodes are replaced by thyristors . So we are using fully controlled rectifier for ac to dc conversion.

C. Dc Link

Once the rectification is accomplished, the power is then routed to an inverter to obtain the final output. The DC Once the rectification is accomplished, the power is then routed to an inverter to obtain the final output. The DC that is fed into the inverter is called the DC link. As the name implies, the two sources are linked together with a filter capacitor. The DC link capacitor is placed between the rectifier and the voltage inverter. The voltage across the inverter is made constant by a capacitor that is placed parallel to the DC source. The device helps protect the inverter

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network from momentary voltage spikes, surges and EMI. The selection of the suitable DC link capacitor s important for the proper functioning of the system .

D. Inverter

Single-phase square wave type voltage source inverter is used here. It produces square wave output voltage. The main advantage of these type of inverter is its simple control logic and also the power switches will operate at a lower frequencies when compared to other types of inverter. Old generation inverters were used thyristor switches. It becomes less likely because of its low switching frequency. But the new generation inverter uses IGBT switches whose switching frequency is in the range of several kilohertz.

E. Road Embedded Power line And The Pick Up Module

Electric power line have been submerged 30 cm deep under the road. The high frequency AC supply is connected to the power line. Power lines are designed in such that it meet the safety standards.

Electronic ignition pickups are a component found on traditional electronic distributor ignition systems. The fifth generation OLEV has an ultra slim S-type core when viewed from the front as shown in Figure 4. The width of the S-type power supply module is significantly reduced compared to the I-type width of 10 cm. Ideally I-type structure of power supply rail with maximum output power of 27KW for a double pickup coil having 20cm air gap and 24 cm lateral displacement.

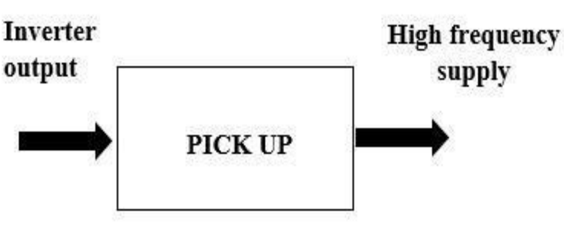

Fig. 3:- Pick Up System

The power line module consists of a power line cables, ferrite core blocks and mechanical components. The cables carry current and generate magnetic flux which links to pick up modules. The pickup modules which are attached to the bottom face of the vehicles capture the active magnetic flux from the power lines. Induced voltage and current generate AC power in the pick up module. Primary coils are cables which are wrapped around the core. A circular or rectangular type coil is used as the primary coil with various secondary coils such as circular types or double sided types and single-sided polarized coils.

F. Rectifier And Regulator

Thy ristor controlled single phase full wave rectifier is used. 10 kHz, 200 V peak square wave is given as the input to

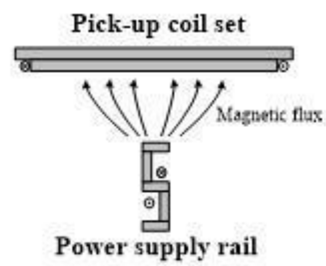

Fig. 4:- S-Type Core System

the rectifier. The rectification is the function of rectifier. Here square wave is converted to dc supply. A voltage regulator is used to regulate voltage level. The output of a voltage regulator will be fixed irrespective of any change in load conditions. It acts as a buffer for protecting components from damages. Here we use a high value capacitor as regulator at the output of rectifier. If we use high value capacitor, the capacity of charging is high and discharging time is low. Thus we can also reduce the ripples in the output waveform. The voltage regulator gives the value close to the desired output. At output we get a constant dc.

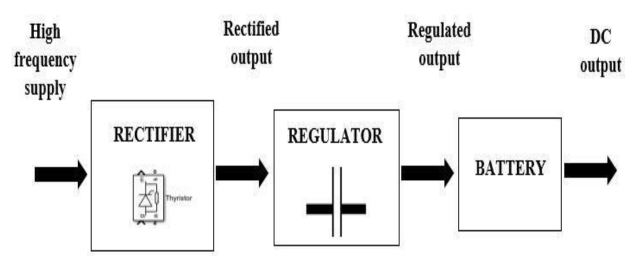

Fig. 5:- Regulated Rectifier Output

G. Lithium-Ion Battery

A lithium-ion battery rechargeable battery. Lithium ions move from the negative electrode to the positive electrode during discharge and reverse while charging. Li-ion batteries use an inter collated lithium compound as one electrode material, compared to the metallic lithium used in a non-rechargeable lithium battery. Most electric vehicles use lithium ion batteries. Lithium ion batteries have higher energy density, longer life span and higher power density than most other practical batteries. Li-ion batteries should be used within safe temperature and voltage ranges in order to operate safely and efficiently. The principle of operation is based on reversible process of Li ion transfer between cathode and anode. The widely used compounds for transport applications are

LiF eP O_4 (LFP), $Li_4T\ i_5O_{12}$ (LTO), $LiNiMnCoO_2$ (NMC), and $LiNiCoAIO_2$ (NCA).

Fig. 6:- Lithium-Ion Battery

E. Motor

In PMDC motor there is no need of having field coils. The field is produced by permanent magnet. The supply voltage to the armature will have armature resistance drop and rest of the supply voltage is countered by back emf of the motor.

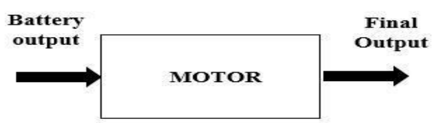

Fig. 7:- Motor

The advantages of PMDC motor over other types of DC

No need of field excitation arrangement. No need of input power for excitation.
No field coil hence space for field coil is saved which reduces the overall size of the motor.
Cheaper and economical for fractional kW rated applications.

PMDC motor and Dc motor have same characteristics. But for PMDC motor the speed torque characteristics are more linear and also predictable

III. SIMULATION AND RESULTS

The figure 8 shows the overall simulation of On Road Charging Electric Vehicle.

The applied input to the frequency converter is 230V, 50 Hz (Figure 9) single phase ac sine wave. It can be seen that, we have obtained a square wave with 10 kHz frequency and 215 V peak (Figure 10) as expected.

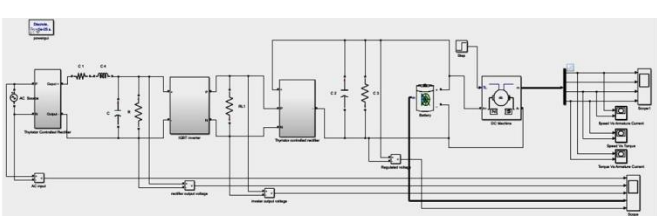

Fig. 8:- Simulation of On Road Charging Electric Vehicle

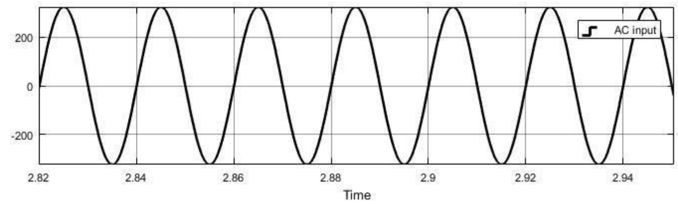

Fig. 9:- AC Input Waveform

The high frequency square wave which is transmitted by the power line and collected by the pickup, is then rectified and regulated to obtain 200 V dc as in Figure 11.

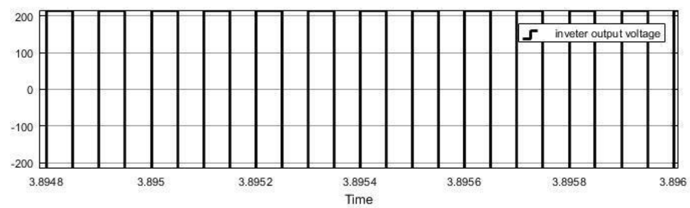

Fig. 10:- High Frequency Inverter Output

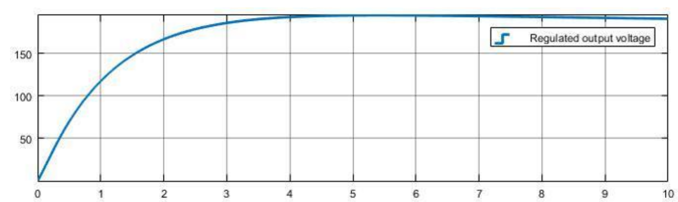

Fig. 11:- Regulator Output

The Li-ion battery' s charging and discharging characteristics is obtained as in Figure 12 and it matches with the ideal characteristics of the Li-ion battery.

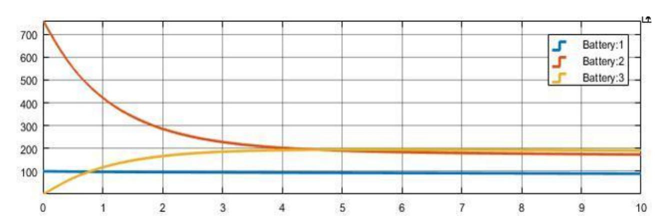

Fig 12:- Battery Output

As we know, for a permanent magnet DC motor the speed and torque is inversely proportional. So at the starting of the motor the speed will be minimum and the torque will be maximum. As the vehicle moves gradually the speed increases and the torque decreases proportionally.

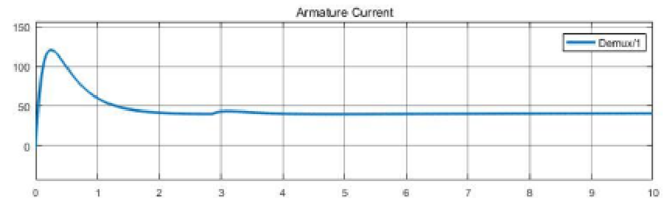

Fig. 13:- Armature Current vs Time Characteristics Motor

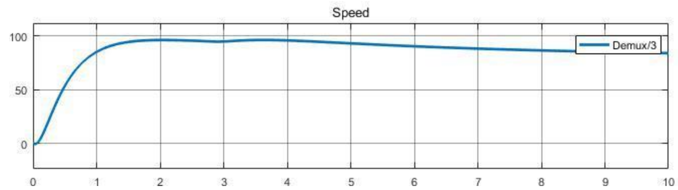

Fig. 14:- Speed vs Time Characteristics of Motor

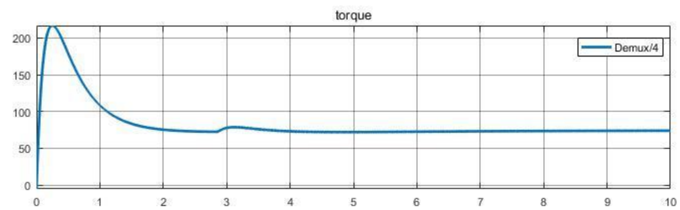

Fig. 15:- Torque vs Time Characteristics of Motor

Since the permanent magnet dc motor is used the flux will be a constant and hence the torque is directly proportional to the armature current. The simulation result (Figure 15) also substantiates this.

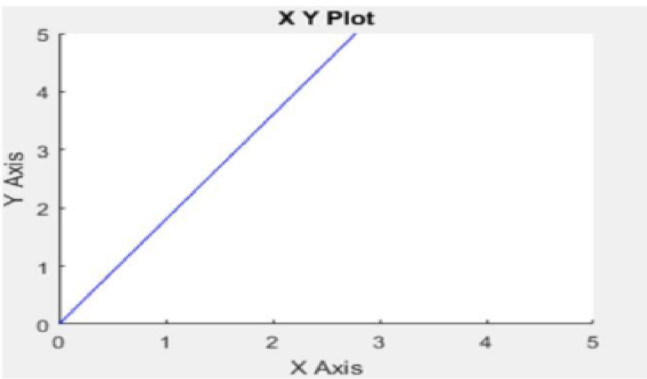

Fig. 16:- Torque Vs Armature Current of motor

IV. CONCLUSION

This paper deals with an electric vehicle which charges on road. On-Road Charging Electric Vehicle is a ground breaking technology that accelerates the development of purely electric vehicles as a viable option for future transportation systems, be they personal vehicles or public transport. The main issues of existing electric vehicles are its price, weight, volume, driving distance, and lack of charging infrastructure . This vehicle is capable of solving these issues that hinders the commercialization of electric vehicle. This is not only the most promising alternative of the gasoline vehicle but also the most practical approach to the Conventional electric vehicle. As it charges while running it saves the time of charging which make On-Road Charging Electric Vehicle a most efficient one. This project will be a solution to today's world where inefficient transportation system is a major problem and it will also help to develop an eco-friendly transportation system.

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