A Modular Charging Unit for Hybrid Electrical Vehicle Using Photovoltaic System

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Abstract*: The power transfers from the source to different loads in industrial and commercial systems have become a hectic design for power system Designer. Different methods have been proposed to reduce the losses in power transfer in various systems. We are using a modular charging unit for HEV using PV. Wireless power transfer technology has taken a new trend towards power transfer. In this paper a Wireless power transfer technology is proposed for hybrid electric vehicle charging unit. The wireless charging is adopted with the technology of replacing the loosely coupled coils with a transformer. The WPT is initiated with input source of energy from Photovoltaic system and its controller is governed by soft computing techniques to get optimized output for optimal charging. Thus determining how much charge is required to charge a electric vehicle according to the load demand. The proposed WPT is monitored for various robust conditions simulating industrial and commercial standard scenarios and the proposed algorithms is checked for optimal values and then initialed to get a better stability and dynamic analysis of the WPT. By seeing the availability of the conventional resources and demand we are using photovoltaic (PV) as the alternative resources. The P&O algorithm is used with the PV.*

Key words*: Hybrid Electrical Vehicle, Wireless Power Transfer, Photo Voltaic Supply, P&O Algorithm.*

I. Introduction

As per the rising rate of the oil prices and the environmental issues have contributed of development and commercialization of EV and HEV. They are emerging the market with pace and very soon the supporting market will necessary. The demand for vehicle is rising day by day the world population is increasing. This has led to high fuel demand which ultimately results in high population levels and global warming. The price of fuel has grown up as well. So, it is highly desirous to adopt a technology that can minimize the fuel consumption to lower pollution and fuel expenses. Hybrid electric vehicle (HEV) can well suit this requirement. HEV is driven by the combination of an engine and a battery powered motor. This help in reducing fuel consumption thus pollution and fuel expenses as well.

The main objective of this project is to drive the hybrid electric vehicle apart from load demand with fully charged battery and photovoltaic system. Wireless power transfer is a technology which could set human free from the annoying wires. The difference between a wireless charger and a conventional conductive or wired charger is that a transformer is replaced by a set of loosely couple coils. The advances make the wireless power transfer very attractive to the hybrid electric vehicle charging applications in both stationary and dynamic charging scenarios. This presentation reviewed to technologies in WPT area applicable to a modular charging unit for hybrid electric vehicle using photovoltaic system. Battery technology is no longer relevant so in this presentation we are penetrating of electric vehicles and the photovoltaic system which will determine when and how much charge is required to charge an electric vehicle according to the load demand require achieved by the controller. In this paper we are going to represent the cost effective and the alternative method for charging the electric vehicle. In this the battery will be charged by both the PV and the external charging unit alternatively. Both the sources will be separated by the relay switches. In the following block diagram we are presenting the “Modular charging unit or electric vehicle using PV.

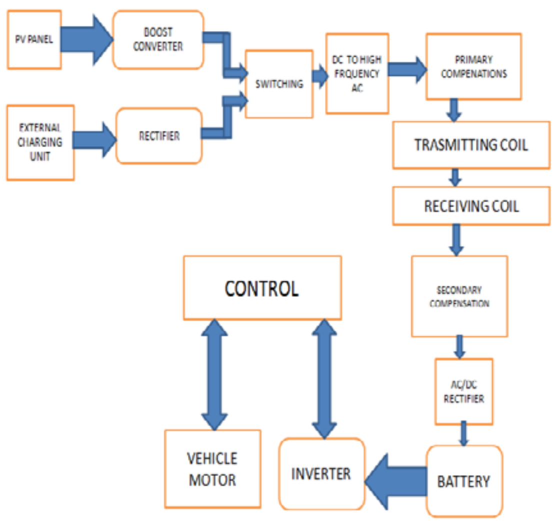

Fig1: A block diagram for modular charging unit

The block diagram of proposed modular unit charging system is given in a Fig 1.An alternative PV supply with External charging unit is given here. Two charging schemes are providing here.1) If we are taking the supply as an external charge unit to charge the battery. In this case the power will rectify using rectifier. Switching or relay will use to allow power from one source. The rectified power or the dc power is converted to high frequency ac o drive the transmitting coil through a compensation network. Consider the insulation failure in primary side coil, a high-frequency isolated transformer may be inserted between the dc-ac converter and the primary side coil for extra safety and protection. The high frequency coil 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. Then the ac power is rectified to charge the battery. The power from the battery will be inverted using the inverter .The motor of the vehicle will be run by the Ac power. A control strategy has given for controlling the speed of the motor.

If we are using the alternate supply PV .The ac supply will be off using relay, at the same time the PV supply will be flow through the circuit and the relay will be on .And the same method will repeat to charge the battery and to move the vehicle.

II . PV Cell

A visible light is converted into the direct current by the photovoltaic cell(PV cell). Some infrared (IR) or ultraviolet (UV) radiation is converted into DC electricity through PV cell. Solar cells, also known as photovoltaic (PV) cells, convert sunlight directly into electricity. PV gets its name from the process of converting light energy (photons) to electrical energy or electricity (voltage), which is known as the pv effect. By the physical and chemical phenomenon a electrical device known as solar cell used to convert the light energy into the electrical energy(electricity).The electrical characteristics like voltage, current and resistance will be varied when the light will be direct to it. Rarely solar cell can be used individually, similar characteristics cells are connected or encapsulated to form modules, which are the basic building blocks of solar array. The two basic limiting parameters of the solar cell to characterize it are: short circuit current and the open circuit voltage.

Semiconductor material that is, the materials that act as insulators at low temperatures, but as conductors at heat or high temperature are used to manufacturing of the solar cell. Generally the solar cell are made by silicon because of its special chemical characteristics. The silicon and the other semiconductor material used in solar cells are crystalline, multicrystalline, microcrystalline and amorphous.crystalline silicon arranged in a ordered structure. Multicrystalline or polycrystalline (poly Si) regions of crystalline Si separated by ‘grain boundaries’, where bonding is irregular and not arranged in ordered manner. Amorphous (a-Si:H) less regular and no order in the structural arrangement of atoms, leading to ‘dangling bonds’, which can be passivated by hydrogen.

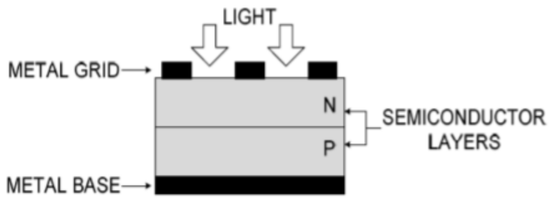

Fig2:Solar pv cell

The conversion of the energy in term of the photon into electricity has by the solar cell by means of the photoelectric phenomenon found in certain types of semiconductor materials such as silicon and selenium. The basic device of a photovoltaic system is the photovoltaic cell. A group of cell is known as panel. A group of panel may formed the large term of array. The term array is usually employed to describe a photovoltaic panel or a group of panels.

A. MATHEMATICAL MODEL OF PV CELL

A photovoltaic module is mathematically modeled using single diode equivalent circuit. The various parameters which have power to affect and control the characteristic of a cell are environmental parameters like irradiance and temperature, module effecting or the internal parameters like ideality constant, Boltzmann constant energy band- gap and charge of electron, limiting parameters like open circuit voltage, short circuit current, series resistance, and shunt resistance. A mathematical model of single diode PV cell is developed based on current-voltage characteristics of a solar cell. An ideal PV cell is represented by a current source which is connected to a antiparallel diode in an addition of equivalent series and a shunt resistance parameter to an ideal PV cell.

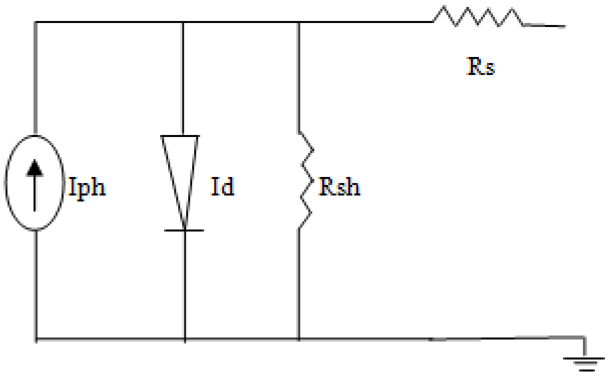

Fig3 :solar diode model of pv

The main equation for the output current of a module is as follow:

$$I_o = n_p i_{ph} - n_p i_{rs}\left[\exp\left(k_o \frac{v}{n_s} - 1\right)\right] \quad (1)$$

Where *Io* is the PV array output current, V is the PV output voltage, *Iph* is the photocurrent of the cell that is proportional to irradiation of solar, *Irs* is the reverse saturation current of the cell that depends on temperature, *Ko* is a constant, *ns* represents the number of PV cells connected in series, and *np* represents the number of such strings connected in parallel.

In (2) Cell photocurrent is calculated from

$$I_{ph}=[I_{scr}+k_i(T-T_r)*\frac{S}{100}] \quad (2)$$

$$I = I + K\ T - T\ S \quad (3)$$

Iscr - Cell short-circuits current at reference temperature and radiation;

Ki - short-circuit current temperature coefficient;

Tr -cell reference temperature;

The cell reverse saturation current is computed from:

$$\mathrm{I_{rs}}=\mathrm{I_{rr}}\left[\frac{\mathrm{T}}{\mathrm{T_r}}\right]^3 \exp[\frac{\mathrm{qE_g}}{\mathrm{kA}}[\frac{1}{\mathrm{T_r}}-\frac{1}{\mathrm{T}}] \quad (4)$$

I_{rr} -reverse saturation at T_r

A-Identity factor

K-Boltzmann's constant = 1.38065 * 10e-23

q- Charge of an electron = 1.6022 * 10e-19

EG- band gap energy of the semiconductor used in the cell.

The PV array has been designed taken into consideration its dependence upon the irradiance, temperature. The PV array has been modeled using the equations (4.1)–(4.5). The various values of the voltage and current obtained have been plotted in the open circuit I-V curves of the PV array . The model of the PV module is implemented using a MATLAB Simulink model.

III. Wireless Power Transfer

A wireless power transfer system is very suitable or worthy for the recharging of electric vehicles. As per the demand for electric vehicles like high efficiency, a large air gap, and a good tolerance to make the device compact, cheaper, reliable and the light-weight . The WPT (wireless power transfer) technology, which can eliminate all the problems related to wired or conventional charging is very important for the EV and HEV .Transferring energy to the EV without wire or wirelessly makes the charging system very easier. For a stationary WPT system, the drivers just need to park their car and leave. For a dynamic WPT system, which means while driving itself EV could be powered; the EV is possible to run continuous without a stop. A typical wireless EV charging system is shown in Fig.4.It includes following steps to charge an EV wirelessly. First, the ac power is converted to a dc power source using ac to dc converter with power factor correction.

Then, the dc power is converted to a high-frequency ac power so that it can able to drive the transmitting coil through a compensation network. when the insulation of the primary side coil will be failure, a high-frequency isolated transformer and the primary side coil may be inserted between the dc-ac inverter for extra safety and protection. In the transmitting coil the high- frequency current generates an alternating magnetic field, so that an ac voltage can induces on the receiving coil. The power and efficiency of the device are improved with the help of the secondary compensation network. At last, the ac power is rectified by the rectifier to charge the battery.

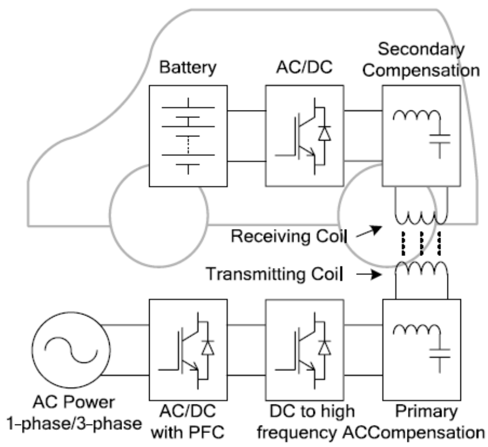

Fig4:wireless EV charger

Fig shows that a wireless EV charger consists of the following main parts:

1) The transmitting and receiving coils.

2) The compensation network in the primary and

the secondary side.
3) The ac-dc nd dc-ac converter
4)An ac power supply.

IV. Hybrid Electric Vehicle

A hybrid vehicle is a vehicle that uses two or more appropriate power sources to run the vehicle; for example, a conventional internal combustion engine and also a higher level electric motor. The hybrid electric vehicles (HEVs), most commonly referred as combination of an internal combustion engine and one or more electric motors. However, other techniques to capture and use energy also included, like diesel-electric trains which are run by both diesel engine and electric motor and submarines that works with diesel engines to power the rotors and also to charge batteries that gives power to the craft when submerged.

Modern HEVs make use of effective-improving methods like regenerative brakes converts the vehicle's kinetic energy into electric energy which will charge the battery, not wasting it as heat energy as conventional brakes do. Some kind of HEVs uses the internal combustion engine to produce electricity by running an electrical generator, to recharge the batteries or to directly power the electric drive motors. Many HEVs reduce idle emissions because of shutting. down the ICE during idle and restarting it when it is needed; this phenomenon is called start-stop system. A hybrid-electric gives less emissions in its ICE more than a sized gasoline car, a HEV's gasoline engine is always smaller than a sized pure gasoline-burning vehicle and will not directly drive the car, will be geared to move at maximum speed and also fuel economy is also improved.

HEV Types

The types of HEV are defined by power train makes the vehicle to the road and may be divided into series, parallel, or series-parallel.

Series HEV

In series hybrids, only the electric motor will drives he drive train, and a small ICE acts as a generator to on the electric motor or to recharge the batteries. They also have a bigger size of battery pack over parallel hybrids, making it more expensive. If the batteries are less, the small combustion engine can produce power in its optimum settings all the times, will make it more effective in extensive city driving.

A series hybrid is similar to the battery electric vehicle (BEV) as per the design. Here, the combustion engine runs an electric generator instead of directly driving the wheels. For moving the vehicle the generator used to charge the battery and powers the electric motor. When more power are required, the motor collect electricity from both the battery and the generator. Series hybrids may also be known as an extended-range electric vehicles (EREVs) or range-extended electric vehicles (REEVs), because the gas engine only produces electricity which may be used by the electric motor and will not directly run the wheels.

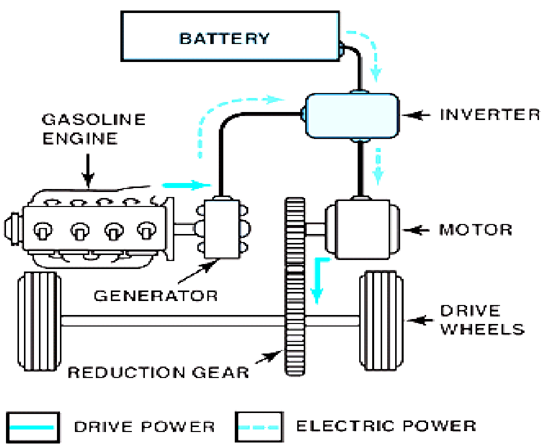

Fig5:Power flow through a series hybrid.

Parallel HEV

In a parallel hybrid bicycle human and motor power are mechanically paired at the pedal drive train or at the rear or the front wheel, e.g. using a hub motor, a roller pressing onto a tire, or a wheel connection with the help of transmission element. Human and motor torques I connected to each other. Almost all Motorized bicycles, Mopeds are of this type .

A parallel hybrid is made by an internal combustion engine (ICE) and an electric motor combined with a mechanical transmission both. Distribution of power in the engine and the motor is varied so both run in its optimum operating region as much as possible. There is no need for extra or separate generator in a parallel hybrid. Whenever the operation of generator's is demanded, the motor operates as generator. In the case of parallel mild hybrid, the vehicle will not drive in pure electric mode.

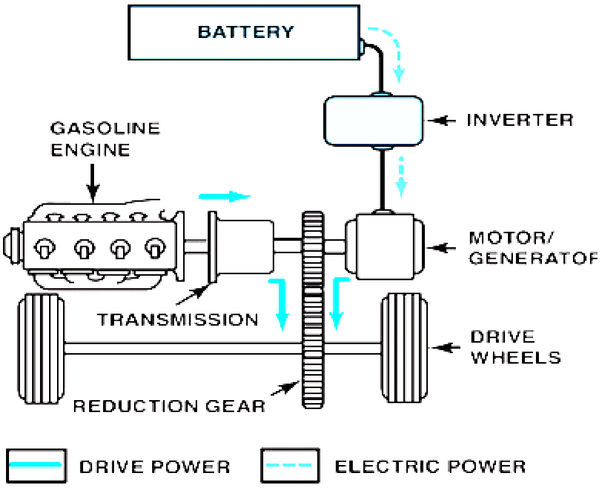

Fig6: Power Flow through A Parallel Hybrid

Series-Parallel HEV

The vehicle can be on by the gasoline engine working itself, the electric motor alone, or by both energy working together. Power distribution between the engine and motor is designed so that the engine can operates in its optimum operating point can possible.

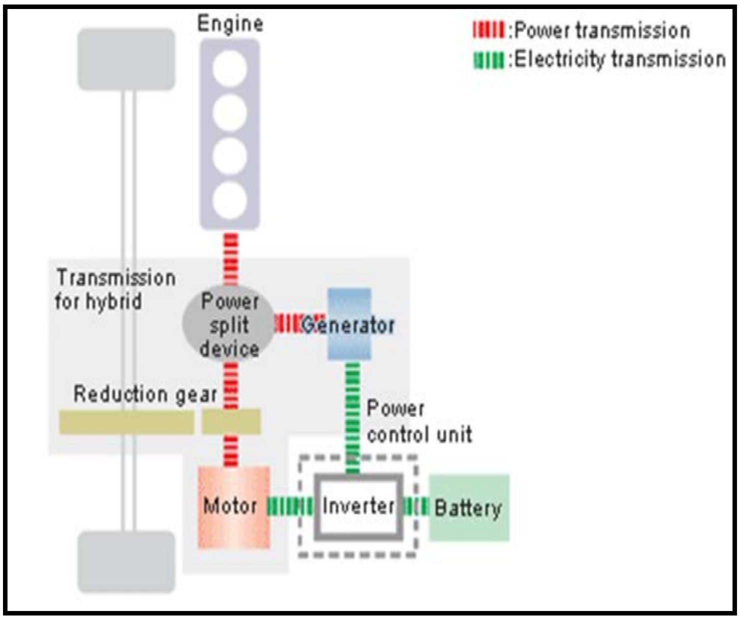

Fig 7:Power flow through a Series-parallel hybrid

V. SIMULATION RESULTS

The operation of a modular or a alternative charging unit for HEV using WPT and PV has shown in Fig 7.

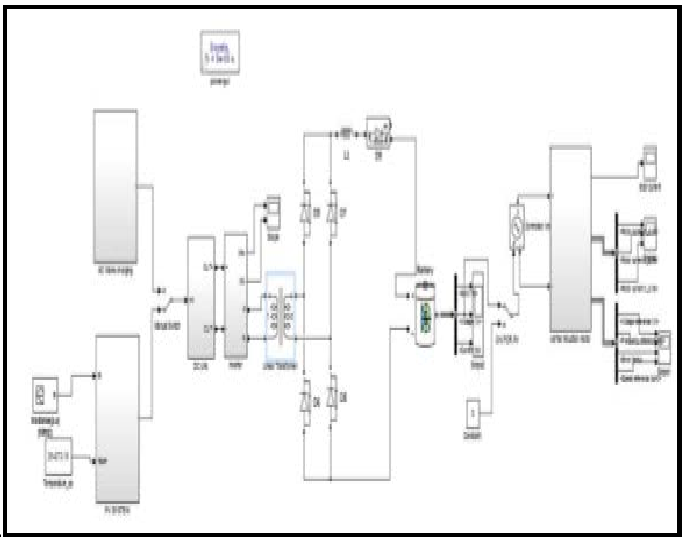

Fig 7: Simulation modelling of high frequency WPT for alternating charging unit.

Rotor speed waveform has shown in the following figure.

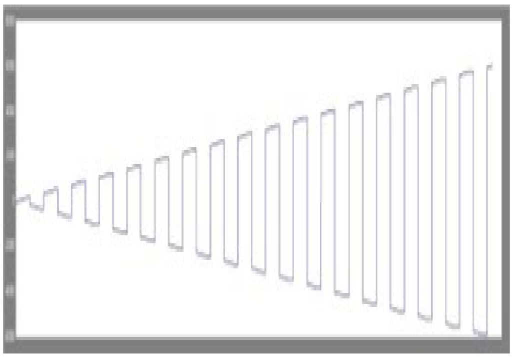

Fig 8:Rotor speed voltage waveform

In the following figure the voltage and the current waveform has shown.We used the the vsi fed induction motor .

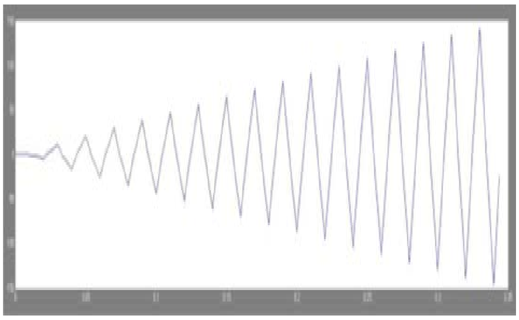

Fig 9:rotor speed current wavwform

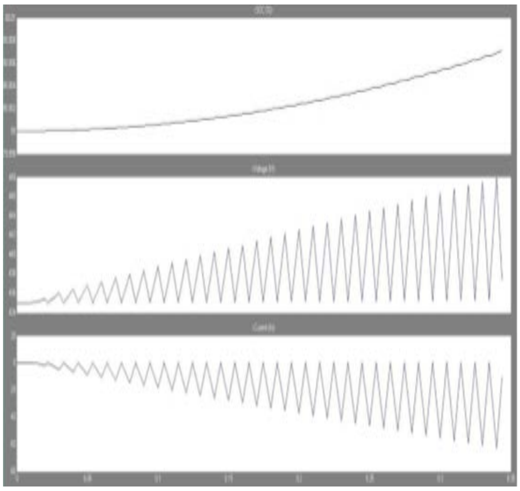

Fig 10R:Battery parameters

In the above fig the battery parameters has dicussed.The state of charge(SOH),the voltage and the current output has shown.

VI. Conclusion

In this paper an optimal wireless power transfer technology has proposed by which the total losses in the power transfer are reduced. The proposed method was implemented by replacing the conventional transformer with loosely coupled coils. Due to this the voltage profile has been improved at the charging unit, thereby maintaining voltage stability in the charging system. The modified version of wireless transfer,

constitutes increasing exploitation ability, and exhibits robust behavior and reduces the chagrining topology cost by removing the transformer thereby making it the most promising scheme. From this it can be concluded that the differential scheme can produce more efficient charging schemes for hybrid vehicles. With the view on experimental simulations and solutions, it is proved well that the proposed scheme reduces the losses and finds a better application towards hybrid vehicle charging schemes, usefulness of the differential scheme is justified with the
computed results.

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