Power Output Capability of PHEV for V2G

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Abstract- *The main motive for the invention of PHEV is to reduce pollution related hazards, but afterwards it can be recognized that it can be used to feed the increasing energy demand. PHEV mainly runs on battery and when battery exhausts, IC engine comes into picture. IC engine can be used as a secondary source for it. Hence the pollution causes due to PHEV is less than compared to conventional vehicles. The battery as well as IC engine can take part in energy exchange between the grid and the vehicle. PHEV is capable of providing electrical energy when there is high demand of electricity at peak load. When it is parked at parking lot it will be source of energy generation. The parking lot in which so many such cars are parked will able to provide large amount of power. The paper analyses the power output capability of vehicle in vehicle to grid (V2G) scenario. The amount of power provided by each vehicle may be less but when such hundreds of vehicles are considered the amount of power will be significant. The efficiency of the parking lot can be increased when interfaced with the PV modules.*

Keywords- Plug-in Hybrid Electric Vehicle (PHEV), Parking lot, V2G power

I. INTRODUCTION

The increasing price of oil leads to the invention of vehicles operated on electricity called as electric vehicles [EV]. The electrics vehicles can be classified as purely battery operated vehicles, hybrid electric vehicles and plug-in hybrid electric vehicles. The classification is done depending upon the sources of energy available. It is capable of providing electrical energy to grid. The battery present in the vehicle can be act as load as well as source. When it is parked at parking lot it will be source of energy when there is high demand of electricity at peak load. The parking lot has so many such cars are parked will able to provide large amount of power. Clean and efficient transportation is essential for the sustainable development of the whole world which can be accomplished using electrification.

The electric vehicles have some drawbacks due to its heavy weight and battery parameters such as it used to take long time for battery charging. The battery was not suitable for long trips. The batteries in EV handle high amount of power (up to a hundred kW) and high energy capacity (up to tens of kWh) compared to other electronic devices within a prescribed space and weight. The drawback can be overcome by providing another source of energy i.e. either petrol or diesel. The consumption of fuel should be as low as possible. The battery of the vehicle can be charged by taking electricity from the grid. This creates an extra load on the grid hence the vehicle should be charge when the grid has low demand. When the battery gets charged, it acts as a load. The battery acts as source when it is sufficiently charged and is able to provide power to the grid. The exchange of power between the vehicle and the grid is termed as V2G. This power is very helpful in peak load hours. When the battery of the vehicle is exhausted, IC engine comes into picture. It will perform both the functions i.e. to drive the vehicle and to charge the battery. The IC engine can be shut down when the state of charge (SOC) of battery reaches to its maximum position. Hence battery as well as IC engine can used to feed the power to the grid. The tariff rate for V2G during peak load time will be more than the normal tariff rate. This will be a way of income for car owner.The output of one vehicle is negligible when compared with the centralized generation. But when output of hundreds of vehicles is taken into consideration at the places where hundreds of vehicles are parked such as parking lots, then the there will be a significant amount of power which is even more than the centralized generation.

II. PHEV AS A SOURCE OF ENERGY GENERATION

The charging of the vehicle can be done with the help of battery charger. It may be installed at home or at public charging station. The vehicle can be charged using AC as well as DC. In case of AC, there are 2 charging levels available depending magnitudes of charging voltage and current. Generally, level 1 on board charger is given with the vehicles by the manufacturers. Level 2 and DC charger is employed at the public charging station or parking lots. The duration of charging can be varied according to the voltage and current rating of charger. DC chargers are generally used at higher voltages to reduce the duration of charging. This creates an extra load on a system. Hence the vehicle should be charged at low load condition. The other advantage of this will be the tariff rate of charging will be low in such condition. The battery of the vehicle can be charged using renewable sources such as solar energy. The solar panels can be installed at the roof of the parking lot. In such case, the battery can be charged during daytime only. Here solar energy can be efficiently used to charge the batteries of the vehicle as well as to feed power to the grid. This will increase the installation cost of parking lot. If the fuel is replaced by biodiesel then the pollution will reduced to zero. The vehicle will fully run by renewable sources.

The battery capacity of the PHEV lies in the range 3-10.5kWh. The amount of power obtained from parking lots is available in small increments. These can also be used to provide ancillary services. V2G takes place with the help of an aggregator. During peak load demand, grid operator gives signal to the aggregator. Aggregator locates nearby parking lot and communicates with the fleet owner and the power can be supplied to the grid. This information exchange takes place within few seconds.

III. SYSTEM MODEL

The system model which consisted of the vehicle battery is given below:

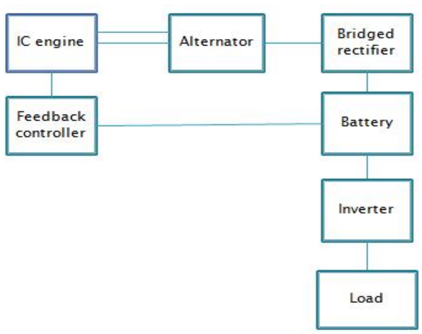

Fig: V2G system model

The system consists of an IC engine which is coupled with an alternator. The vehicle has inbuilt dynamo. The speed of the dynamo is controlled with the help accelerator. AC output of the alternator is given to the bridge rectifier which converts it into DC. The DC voltage is given to the battery of the vehicle. The output of battery is boosted with the help of step up transformer and converted to AC with the help of inverter to which a load is connected. The acceleration of the engine is controlled with the help of feedback controller which is nothing but a comparator which compare the reference voltage with battery voltage and controls the acceleration.

The PHEV vehicle is costly and difficult to get hence a prototype model is constructed using an IC engine of a 2 wheeler. The lead acid battery which is generally used in conventional vehicle is preferred here. The power output of PHEV is much higher compared to the conventional vehicle. The battery size of PHEV is up to 10.5kWh whereas in conventional vehicle small battery having rating up to 8Ah is used. In PHEV, generally 2 batteries are used, one lithium ion battery to drive the vehicle and another small lead acid battery for other small purposes. In this system, only one battery is used which performs both the functions. The battery performance is based on its state of charge (SOC). There are many factors which influence SOC of battery such as its usable capacity, charge-discharge rates, hysteresis, ageing, temperature and self discharge. By considering these factors, overall efficiency of battery is calculated which comes out to be 85-90%. The SOC of the battery can determined either by measuring the specific gravity of the battery or by directly measuring the voltage. The relation between SOC and voltage can be calculated from the datasheet provided by the manufacturer.

Here only battery of 7Ah is used. The charging current required for battery is 0.7A. The SOC of the battery should be monitored all the time. The feedback controller is used for controlling purpose. It consists of a comparator IC which compares the reference voltage with the output voltage of the battery. The reference voltage is provided externally using a step down transformer. The comparator output is connected to a dc series motor through a variable resistive port. The accelerator wire is connected to the dc series motor through a gear box. When the reference voltage is equal to the battery voltage, the output voltage will be zero and the motor is at standstill. When the battery voltage is less than the reference voltage, the output voltage will be will be positive and the motor moves in forward direction. In similar way, the motor moves in opposite direction.

When the SOC of battery decreases, the acceleration of the engine should be increased and when the battery gets fully charged the acceleration should be as low as possible. The value of port resistance is adjusted such that the acceleration can be categorized into 4 parts i.e. 25%, 50%, 75% and 100%. The output of battery is given to the inverter which converts the DC into AC 230V. The load can be applied at the output of the inverter.

Fig: Hardware model

For calculating the power output capability of the PHEV, the lead acid battery should be replaced by the lithium ion battery.

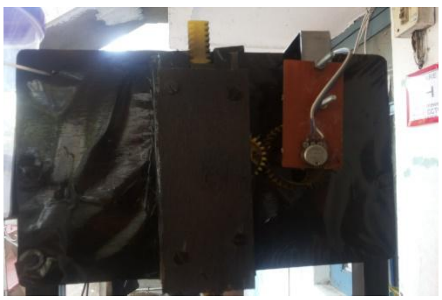

Fig: Feedback control through gear mechanism

IV. RESULT AND CONCLUSION

The No load dynamo output= 16.6 V and when a battery with 12 V, 7 Ah is applied in fully charged condition, the output of dynamo= 12.2 V

Dynamo output	Battery voltage level	Engine Speed	Engine Speed in km/hr
12.8 V	12.8 V	100%	80
11.1 V	12.6V	75%	60
7.9 V	12.4 V	50%	40
5.3 V	12.3V	25%	20
0 V	12.2V	0%	0

Fig: performance of engine at no load condition

After one hour trial at fixed speed found, consumption of fuel is 0.95L petrol and the battery got charged from 40% to 90% SOC approximately without load. When load of 20 W is applied, the battery charges from 40% to 64% SOC approximately. For calculating the power output capability of PHEV, the lead acid battery is replaced with the lithium ion battery in matlab simulink model and results are taken. The energy provided is nearly 2.20kWh per liter.

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