Design of Intelligent Converter for Vehicle to Grid Power Flow

Rahul A. Jagtap[1] Dr. P.M. Daigavane[2] Dr.S.G. Tarnekar[3]
[1]Student [2]Head of Dept. [3]Professor
[1,2,3]Department of Electrical Engineering
[1,2,3]GHRCE, Nagpur (India)

Abstract— Electric vehicle are widely used in various fields. Now a days, vehicles are using battery for getting energy for its utilization. So a battery is used to give supply to the motor of electric vehicle. As battery is passing tremendous amount of energy it which sometimes cause losses of energy. So overcome this concept of intelligent converter is proposed. This paper presents a design scheme of intelligent converter and for that, a new method bi-directional mechanism was discussed.

Key words: Battery Charger, Solar Panel, Electric Vehicle, Vehicle to Grid, Energy Storage System, Bi-Directional Meter, Inverter V2G Operation

I. INTRODUCTION

Electric vehicles have become popular due to high-efficiency electric motor, controller and power by alternative energy source. This alternative energy source for a clean, efficient and environmentally friendly urban transmission system. Electric vehicle is pollution free and high efficient.

Battery bank, bi-directional DC/DC converter, bi-directional DC/AC Inverter, solar panel in this component is used for Design of Intelligent charger for Electric Vehicle to Grid power flow.

Electric Vehicles battery is used as energy source. Solar panel are mounted on roof of the car(Electric Vehicle) which charge the battery with the help of the solar power/energy. Battery and solar panel's DC supply is passing through the DC to AC inverter. Inverter gives the supply to the Grid. When state of charge (SOC) of the battery gets 20% then grid power is used to charge the battery to via Bi-directional meter. Bi-directional meter is a two way meter it measures the power flowing in two directions. Vehicle to Grid and Grid to Vehicle.

II. BLOCK DIAGRAM OF ELECTRIC VEHICLE TO GRID POWER FLOW

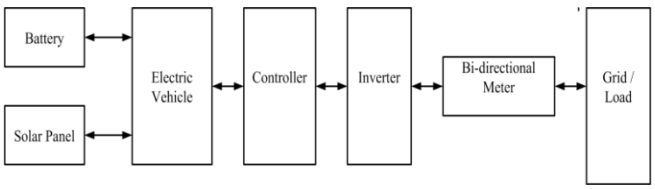

Fig. 1: Block diagram of Electric Vehicle to Grid power flow.

A. Battery:

Fig. 1: Battery

- Lead-acid battery- 12 V, 10 Amp
- Nominal capacity 65 Ah
- Weight 20 kg
- Dimension (L*W*H)mm -350*168*175.

Lead-acid battery has,

- Relatively low cost
- Easy availability of raw materials (Lead, sulfur).
- Easy of manufacture.
- Favorable electromechanical characteristics.

Nominal battery parameter for lead-acid battery has,

- Commercially available - Readily available from several manufacture
- Operating temperature - ambient poor performance in extreme cold
- Self-discharge - ~2% per day, but see text below
- Number of life cycle - Up to 800 to 80% capacity
- Recharge time – 8 h (but 90% recharge in 1 h possible)

Basic terms of battery,

1) State of Charge (SOC):

SOC is defined as the remaining capacity of a battery and it is affected by its operating condition such as load current and temperature.

If Ah capacity is used.

$$\text{SOC} = \frac{Remaining\ capacity}{Rated\ capacity}$$

2) Depth of Discharge (DOD):

DOD is used to indicate the percentage of the total battery capacity that has been discharged.

3) State of Health (SOH):

SOH is defined as the ratio of the maximum charge capacity of an aged battery to the maximum charge capacity when the battery was new.

SOH is an important parameter for indicating the degree of performance degradation of a battery and for estimating the battery remaining lifetime.

B. Solar Panel:

Trinosolar smart energy together.
Module number – 290-PC/PA14

Fig. 2: Solar Panel

Specification of Solar panel has,

1) Maximum power (Pmax) – 300 W
2) Maximum power voltage (Vmax) – 36.9 V
3) Maximum power current (Imax) – 8.13 A
4) Open circuit voltage – 45.3 V
5) Short circuit current – 8.60 A

C. Inverter:

600 VA
12 V DC to 230 V AC
Pure sine wave inverter

Fig. 3: Inverter

Inverter is a device convert DC to AC power, by using the basic principal of converting low voltage DC to high voltage AC.

In put terminal of inverter directly connect to relay circuit and controller, for the purposed of 'ON' or 'OFF' the inverter. Block diagram of Inverter connection as show in following,

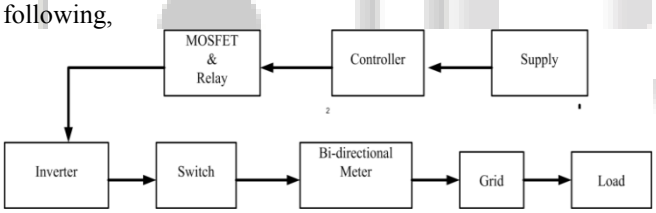

Fig. 4 Block diagram of Inverter connection

In the case of inverter is 'ON' then the output AC power of the inverter passes through bi-directional meter which checks the voltage, current and frequency of the output. Then the power from bi-directional meter flow towards the grid. Grid gives that power to the load (domestic, commercial and small appliances).

D. Bi-Directional Meter:

Fig. 5: Bi-Directional Meter

Bi-directional meter is a two way energy meter. It measure the power flowing in two direction vehicle to Grid and Grid to vehicle

Connection of Bi-directional meter:
1-phase, 2-wire, 1-current transformer (CT)

Inverter output is connected to the bi-directional meter via current transformer (CT), for the protection of bi-directional meter 3 ampere fuse is used. Connection diagram of bi-directional meter has following,

E. Inverter:

600 VA, 12 V DC to 230 V AC,
Pure sine wave inverter.

Inverter is a device convert DC to AC power. The basic principal of converting low voltage DC to high voltage AC.

Input terminal of inverter directly connected to relay circuit and controller, for the purposed of 'ON" or 'OFF' the inverter. Block diagram of Bi-directional meter connection as show in following,

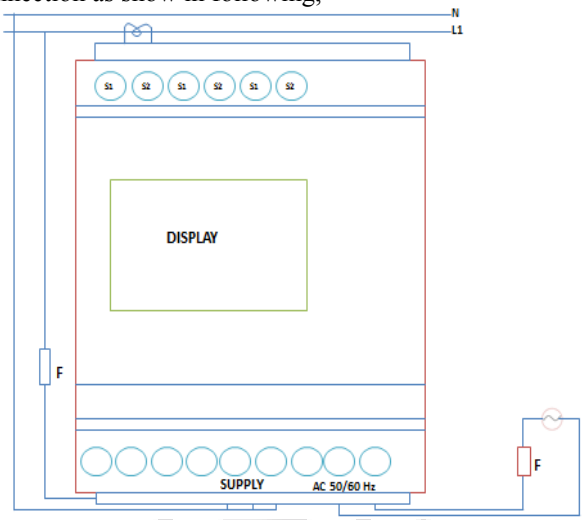

Fig. 5 Bi-directional meter connection

In the case of inverter is 'ON' then the output AC power of the inverter passes through bi-directional meter which checks the voltage, current and frequency of the output. Then the power from bi-directional meter flow towards the grid. Grid gives that power to the load (domestic, commercial and small appliances)

Why is the converter Intelligent:

- It checks whether supply is reachable to grid or not
- It also check the capacity of battery
- It provides sufficient charge (power) to start the vehicle.

F. View of Design of Intelligent Converter for Electric Vehicle To Grid Power Flow:

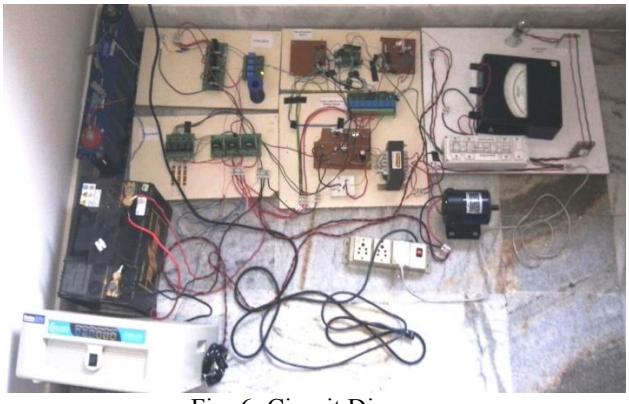

Fig. 6: Circuit Diagram

From above figure it is shown that a DC supply is given through a battery as well as from solar panel to the converter. Ti is then passes through the MOSFET circuit which is used for controlling it's voltage. From their it's flow through the relay circuit for protection purposed a micro-controller is placed between the relay and switching circuit to identify the voltage coming from either battery or solar panel. The voltage which is developed in switching circuit is transfer to the grid through inverter.

A bi-directional meter is directly connected to the inverter output via current transformer. In bi-directional meter switch is connected to the input of inverter which convert DC voltage to AC voltage for supplying to the grid. Bi-directional meter displayed the value of voltage given to the vehicle to grid and grid to vehicle.

G. Future View

For Proposed topology, role of single car becomes insignificant. Presumption required for 2020

- Total Electric Vehicles= 1 Lakh
- solar Powered Electric vehicles=30,000
- Single Electric Vehicle =408 watts
- Total : 30,000 x 408 = 12.24 Mw

III. CONCLUSION

In this paper, for electric vehicle considering vehicle to grid is presented. Under the peak-load condition, the sequence and the control method of battery charging and discharging for the rapid-charger is proposed. Now days, Vehicle to Grid energy Transactions are picking up. The scheme proposed is supposed to support the Grid.

REFERENCES

[1] Ga-Gang Choi, Doo-Yong Jung, Sung-Chon Choi, Chung-Yuen Won, Yong-Chae Jung,"10kW Rapid-Charger for Electric Vehicle Considering Vehicle to Grid(V2G)" , 2012 IEEE 7th International Power Electronics and Motion Control Conference - ECCE Asia June 2-5, 2012, Harbin, China
[2] Doo-young Jung, Young-hyokJi, Su-won Lee, Chung-yuen Won, YongchaeJung, Kwang-DukSeo, "Grid-Connected Peak-Load Compensation System Based on Lithum-Polymer Battery", Telecommunications Energy Conference, INTELEC 2009, 18-22. Oct. 2009
[3] Yogesh Sunil Wamborikar, AbhaySinha, "Solar Powered Vehicle" Proceedings of the World Congress on Engineering and Computer Science 2010 Vol II WCECS 2010, October 20-22, 2010, San Francisco, USA
[4] Henry Oman "Solar Energy for Electric Vehicle" IEEE TRANSACTIONS ON SOLAR POWER, 1998
[5] Julio Mayen, BobSteinmetz, CraigSteinhauser "Advanced Electric Vehicle Battery Charger" ECE 445 Senior Design Project, September 21st, 2007.
[6] SiddarthaMal,ArunabhChattopadhyay, Albert Yang, RajitGadh "Elecric Vehicle Smart charging and vehicle to grid operation" United states Department of Energy,one Million Electric vehicles by 2015, February 2011
[7] Young-Joo Lee, AlirezaKhaligh, Ali Emadi Advanced Integrated Bidirectional AC/DC and DC/DC Converter for Plug-In Hybrid Electric Vehicles, IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 58, NO. 8, OCTOBER 2009.
[8] www.intelligent-charging.com/cell_monitoring.htm
[9] Siqi Li, Junjun Deng, and Chunting Chris MiSingle-Stage ,Resonant Battery Charger With Inherent Power Factor Correction for Electric Vehicles, IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 62, NO. 9, NOVEMBER 2013
[10] Ann Holms ,RonyArgueta , "The Electric Vehicle " A Technical Research Report March 11, 2010
[11] M.EIChehaly. Omar Saadeh, C.Martinez"Advantages& Applications of Vehicle to Grid Mode of Operation in Plug-in Hybrid Electric Vehicles" IEEE Electrical Power & energy Conference, 2009

