Optimal Implementation Of Portable Charger For EVs

Prof. Ganesh.B.Murade[1], Mr.Harshal.R.Tamboli[2], Mr.Krushnakant.S.Shardul[3], Mr.Mithil.R.Kanade[4], Mr.Kunal.R.Lite[5]
[1]Assistant Professor, Dept of Electrical Engineering
[2, 3, 4, 5]Dept of Electrical Engineering
[1, 2, 3, 4, 5] Dr.VithalraoVikhePatil College Of Engineering, Ahmednagar, Maharashtra, India

Abstract- *In recent decades, the research and development activities related to transportation come to the conclusion of high efficiency, clean, battery based electric vehicles (EVs) which are proposed to replace conventional vehicles in the near future. Battery charging has given more importance in the sector of EVs. Even though growth of EV is still lagging due to lack of charging infrastructure. This paper explains on-board electric vehicle charger which comprises two stage operation which is interleaved PF correction and DC-DC conversion.*

Keywords- Electric vehicles (EVs), Battery, On-board charger, Boost converter, dc-dc power converters

I. INTRODUCTION

Automobiles have made great contributions to the growth of society by satisfying many of the needs for mobility in day to day life. Development of internal combustion (IC) engine is one of the greatest achievements of modern technology. But due to usage large number of automobiles , it affects environment and human life also. Air pollution, global warming, and rapid depletion of crude oil reserves become a serious problem now. As an alternative to replace conventional vehicles, development of electric vehicles (EVs) is done in recent times. Electric vehicle is an electric motor driven transportation medium that runs with the help of electric battery. Battery supplies necessary electrical energy to run all the electrical as well as electronic applications in EV. So in electric vehicles prime source is battery . Main function of battery is to store the energy (charge) and to deliver that energy (discharge). Major three battery types are preferred for an EV are lead –acid ,nickel based batteries such as nickel-metal, nickel-cadmium and lithium based batteries such as lithium-ion, lithium-polymer .Battery selection depends on specific energy which is co-related with the EV range (in km) for higher range EV , battery capacity should be more to meet the demand which increases the battery capacity. Charging of battery is most important parameter in the energy storage systems. Hence electric vehicle chargers have been introduced to charge the EV battery. Charger provides power from utility to charge the

II. ELECTRIC VEHICLE CHARGING

Charger merely deliver the energy to the vehicle, usually in the form of a high voltage AC or DC supply which transform the electrical energy into a form which can be applied directly to the battery. It can be seen that the EV community needs several power supply options. Three different power levels have been defined but within these levels a very wide range of options are available to accommodate the different existing power grid standards of the national electricity generating utilities. Table illustrates different EV charging levels.

Charging Level	Power Supply	Input Power	Output Power	Charging Time
Level 1	120 V AC 12A-15A	1.44 kW to 1.92 KW	1.22KW to 1.63 KW	High
Level 2	208-240 V 15-80A	3.12KW To 19.2 KW	2.65KW To 16.32KW	Moderate
Level 3	200V-920V 500A	100KW To 460KW	85KW To 391KW	Less

Level 1 charging can be used at residential locations where level 2 and level 3 are used at public places. Level 3 charging provides fast charging for the suitable EVs. There are number of connectors available based upon voltage as well as current rating. SAE 1772, CHAdeMO, CCS , commando are the EV connectors available for charging .

III. CHARGING METHODS

The charging of battery will affect the performance and life of the battery. When the charging current is too large, the internal resistance of the battery increases. This cause increase in temperature . It may damage the battery also. On the other hand, if the charging current is too small, a long charging time is required, which is not acceptable. Therefore, in order to achieve better performance of the battery and does not require too long time to charge it, different charging method of the battery is very important. Different charging methods are explained below.

A. Constant Voltage

In this method, Constant voltage is maintained across battery. Constant voltage allows full current to flow through the battery until the power supply reaches its preset value. Charging current decreases when the battery is fully charged. Such simple concept is applied in cheap car battery chargers . The advantage of charging at constant voltage is that it allows the cells with different capacities and at different rate of discharge . This method is suited for lead-acid batteries. Constant voltage charging is shown in Fig.1

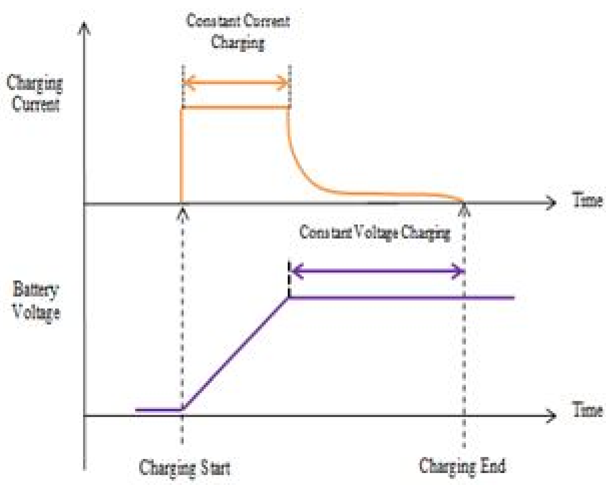

Fig.1

B. Constant current

As the name suggests, constant current is maintained across the battery and voltage is allowed to increase gradually .Constant current method is exactly reverse process compared to constant voltage method .Battery charges in a short interval of time by maintaining proper charging degree of battery. If a battery is assumed to be fully charged and even charged further then it will damage the battery plates and life also. This method is suitable for Nickel-metal batteries. Battery should be disconnected once charged. Constant current method is shown in Fig.2

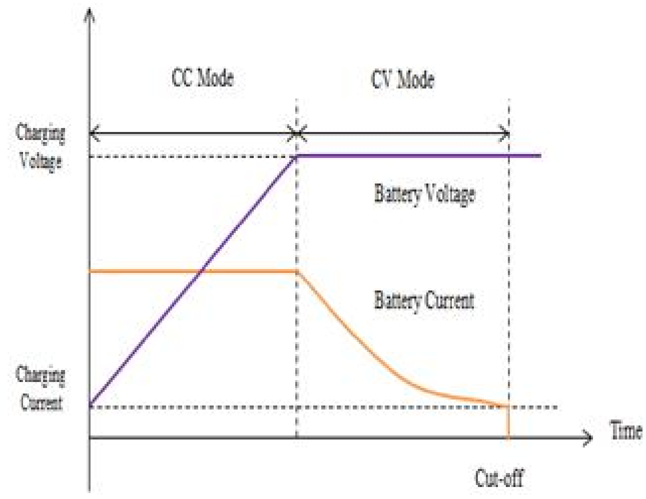

Fig.2

C. Pulse Charging

Pulse charging method charges battery with the periodic pulse current. Charging rate can be easily controlled by controlling width of pulses. This method remove unwanted chemical reactions at the electrode such as gas formation. Due to this, method is more efficient than the other one. This method is shown in Fig.3

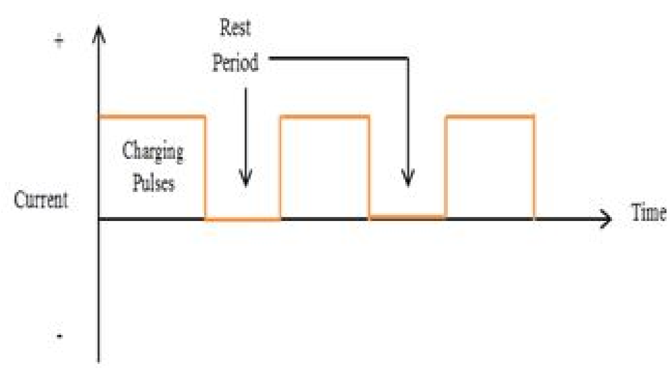

FIG 3

D. Constant Voltage- Constant Current

Both the methods have certain advantages and dis-advantages . In order to improve charging, constant voltage – constant current method is proposed. Constant current is initiated in the beginning of charging. This continues till battery voltage level reaches to preset value. When the voltage sets, charger will switch to constant voltage mode and continue charging process . Once battery get fully charged battery gets disconnected.

E. Negative Pulse Charging

Negative pulse charging method is an complementary method used along with the pulse charging method. In this ,very short discharge pulse is applied in the rest period .The short discharge pulse helps in avoiding gas bubbles on electrodes . This method is preferred to improve overall charging process and ultimately the life of battery. Fig.4 shows negative pulse charging process.

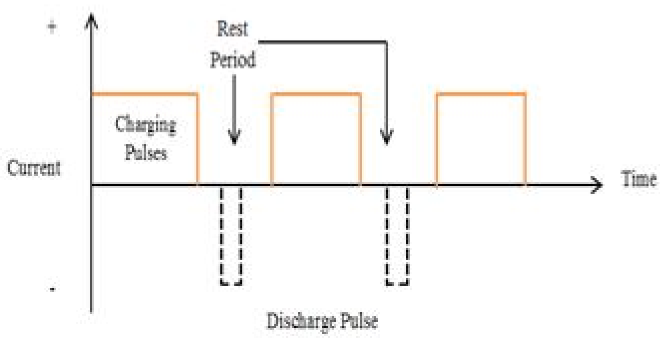

Fig.4

IV. CIRCUIT DESCRIPTION

On board EV charger is the solution for the battery charging which can be installed at residential as well as commercial locations. Charger consists of different conversion units that handles large amount of power . Block diagram of charging unit is shown in Fig.5

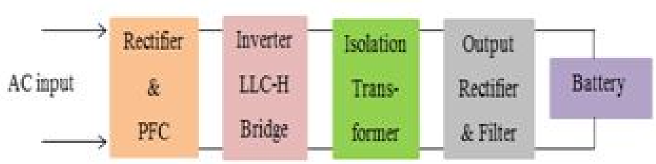

Fig.5

EV charger comprises of AC to DC converter, power factor correction unit, DC to AC converter and LLC-H bridge unit, isolation transformer and filters . Typically , a two-phase interleaved PFC is coupled with an LLC DC-DC converter. Each component has importance regarding efficiency ,output power ,harmonics elimination .

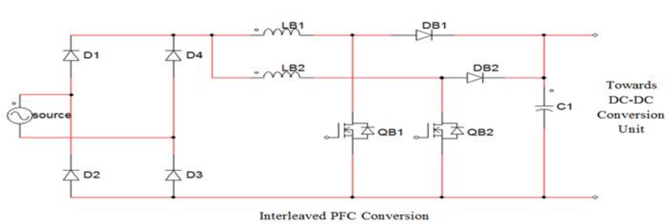

Fig.6

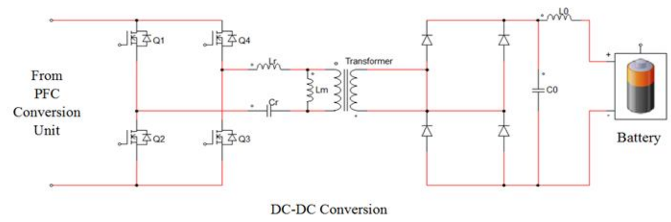

Fig.7

Fig.6 shows first stage of charger unit composed of interleaved PFC block which includes Vacinput ,input filter, bridge rectifier and boost converter .The input Vac maybe single phase or three phase depending upon power handling capacity of charger . The applied AC input get converted into DC with the help of bridge rectifier (D1,D2,D3,D4) . Ideally , it is presumed that converted DC output has pure characteristics . But practically , it contains some ripples cause due to harmonic distortion. Hence PFC block helps in maximizing power factor and minimizing grid harmonic distortion by drawing AC input current in phase with AC input voltage. Two boost converter units are connected in circuit to reduce conduction loss. It consists of two inductors (LB1,LB2)connected out of phase with each other. Boost converter increase the switching frequency which reduces input current ripple. Also minimizes rating of filter (C1).

The second stage of charger unit consist of the DC-DC converter block which includes two-phase H bridge , LLC tank ,isolation transformer , output bridge rectifier and output filter which is shown in Fig. 7. The PFC output voltage is fed into the DC-DC converter as a input. High switching frequency DC output is converted into AC by the N-channel MOSFET (Q1,Q2,Q3,Q4) connected in bridge configuration .This modulates the waveform to generate square pulse waveform . LLC resonant topology reduces switching losses by zero voltage switching. The LLC tank circuit follows the DC switching block. The resonant tank circuit is named LLC because it composed of resonant inductor (Lr) , resonant capacitor (Cr) and magnetizing inductor.(Lm) of isolation transformer After LLC circuit, output becomes almost sinusoidal waveform. Isolation transformer isolates primary switching block from secondary load side to avoid the electromagnetic interference noise .Also protection against short circuit on load side. Isolation transformer is one to one transformer which has same windings at primary as well as secondary side. Secondary side transformer output signal is again rectified by output bridge rectifier and finally output DC power is delivered to the battery.

V. CONCLUSION

Electric vehicles are expected to enter the world market such that by 2030, 10% of the vehicles will be of EV type. To achieve this percentile, there must be more advancement in the facility provided by the electric vehicle chargers. To have a better understanding on EV technology, this study outlines the various types of EV, battery chargers and charging stations. EV charging is considered as a big load to the utility.Chargers are currently based on full-wave rectification using diodes and progressively thyristor are used.

Later designs use microprocessor-controlled charging technologies with several algorithms being implemented for parameter monitoring and control.

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