ISSN 2395-1621

Design of on-Board Integrated Charger for Electric Vehicles Based on Split Three Phase Induction Motor

[#1]Mr. Ganesh Punjaram Thombre, [#2]Mrs. S. V. Tade

[1]Student, Sinhgad Institute of Technology, Lonavala
[2]Assistant Professor, Sinhgad Institute of Technology, Lonavala

ABSTRACT

Today as storage of crude oil going to vanish from the world due to the excessive use therefore use of alternative source of energy in various applications becoming must. Use of electrical vehicle instead of conventional vehicle running on petrol, diesel etc. is the most prominent option as most of the crude oil used for purpose of running vehicle. The most important factor in electric vehicle is design of battery charging system. The battery charging system is the most important part of electric vehicle therefore the design of charger by utilizing traction motor winding as inductor filter helps to reduce disturbance in input as well as helps to keep vehicle as lighter as possible and cost effective. The input filter in high power rectifier keeps line current distortion within the allowable limit. Simulation results for the proposed concept are provided for comparison of AC to DC converter with and without filter inductor and charging of battery from AC grid with the effect of input inductive filter across battery.

Index Terms— Conventional electric vehicle charging system, proposed electric vehicle charging, use of traction motor winding as inductor filter.

ARTICLE INFO

Article History

Received: 14th August 2020

Received in revised form : 14th August 2020

Accepted: 16th August 2020

Published online : 16th August 2020

I. INTRODUCTION

The Today's trend in market is to run vehicle by using electrical energy. As the crude oil deploying day by day and it also pollute environment, a new source of energy for transport application must be find.

Therefore electric vehicles are the best option to replace conventional vehicles running on crude oil application. But there are some difficulties in use of electric vehicles like charging of electric vehicles battery time and charging station.

As the use of electric vehicles instead of conventional vehicle is very effective to reduce pollution as well as dependency on crude oil. Therefore most of the countries and their scientist and engineers working on these issues. As we know that most of the companies in automobile industries introducing day by day new vehicles in market which are getting charged very rapidly and giving better response.

Therefore motivation of this project is to design a fast charger of electric vehicle to make electric vehicle comparable with conventional vehicle in terms of refuelling or recharging of electric vehicle batteries.

ELECTRIC VEHICLE BACKGROUND

An electric vehicle uses one or more electric motors or traction motors for propulsion.

Types of electric vehicle: - Hybrid electric vehicle, Plug in electric vehicle.

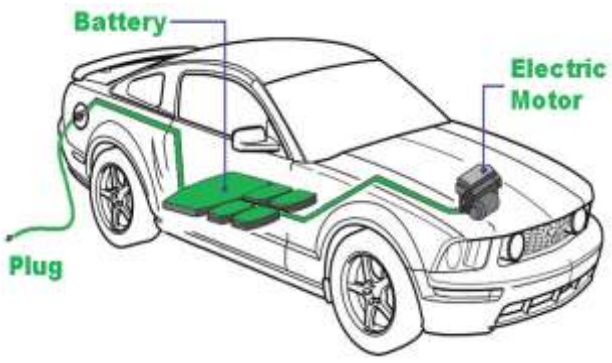

Fig.1 Layout of electric vehicle

Working principle of electric vehicle: - Electric vehicle uses electric motor to run vehicle and electric supply to motor is given through the batteries. Batteries charged by using on board charging system or off charging system from the charging point provided at different location.

Types of charging system:-

1. On board charging system
2. Off board charging system

II. METHODOLOGY

For increase the efficiency of the electric vehicle by reducing weight, volume and cost, traction motor used in such a way that it performs another independent operation when the vehicle will park. Traction and charging are not simultaneous process, induction motor as well as driving circuitry of the motor can be used in charging circuit to form on board integrated charger. While charging, when vehicle at immobile state, we can use the inductance of stator winding as an inductive filter at in front of AC to DC converter.

2.1 Conventional electric vehicle charging system:-

In conventional three phase induction motor as we feed power to stator winding rotating magnetic field produce which rotates in the stator air gap at asynchronous speed. The conventional three phase induction motor with inverter and battery shown in above fig.

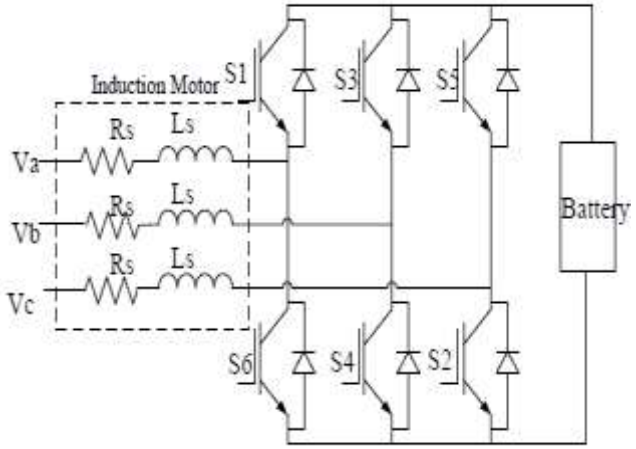

Fig.2.1 Conventional Three Phase charging system

At the time of charging, vehicle should stationary, so motor can be stopped by applying mechanical brakes but application of mechanical brakes, increase the stress on the motor shaft. Another option is to use an extra clutch to rotate motor freely. There are number of disadvantages of above techniques such as it increase the magnetizing current and it would lead to the heating of motor as well as lower efficiency and also add the mechanical hardware, this are not feasible options.

Above drawback can be eliminated by split three phase induction motor. In split three phase induction motor, winding of induction motor divided in two equal half portions with zero degree displacement, so it shares the same magnetic circuit. Here in split three-phase induction motor each phase winding carries same current, as well as each phase winding produced same magnetic field of the same magnitude but opposite in direction, so resultant is zero. Thus no RMF, no torque and motor simply work as an inductive filter during charging.

2.2 Matlab Simulation of converter without filter:-

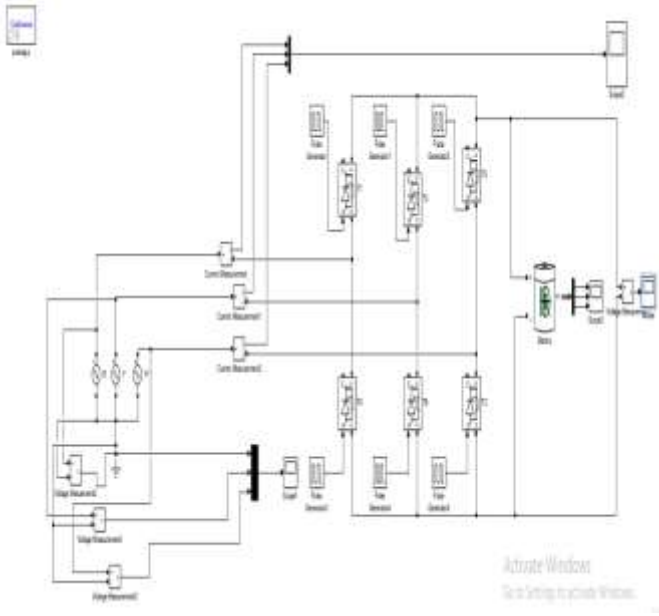

Fig.2.2 Convention charging system with battery matlab simulation model

2.3 Results:-

1) Converter input Current waveform:-

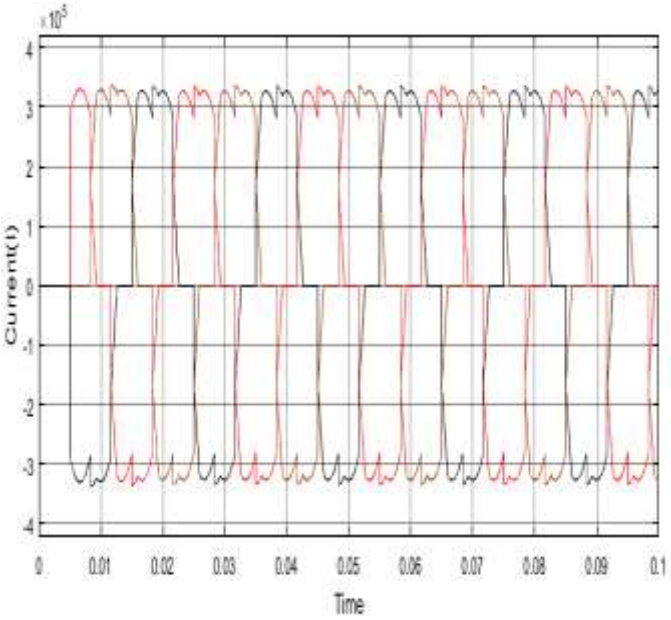

Fig.2.3a Converter input Current waveform

From the input current waveform of filter it is observed that whenever we are using supply any source point directly to the load there is harmonics present in the supply current because of which power factor of the system becomes low and absorbs more power.

2) THD graph

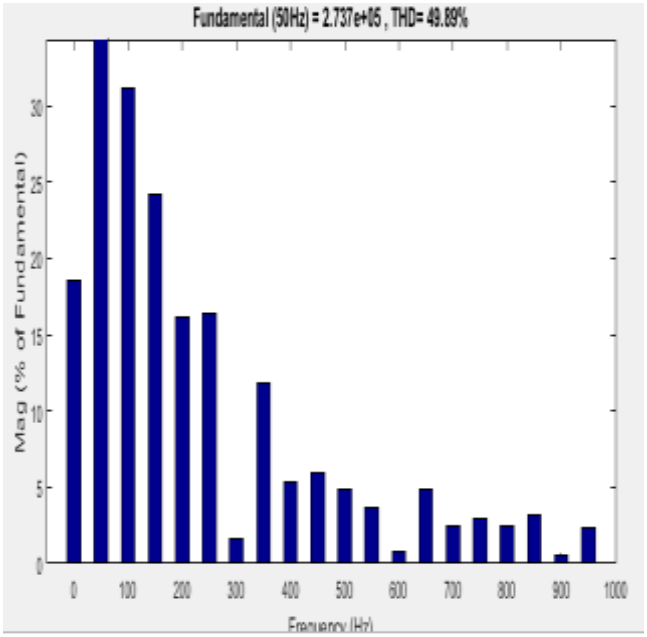

Fig.2.3b FFT analysis without inductor filter

From the FFT analysis it is clear that their 49% THD in input current waveform which ultimately affects in the form low power and unnecessary absorption more power.

3) **Converter voltage across the battery:-**

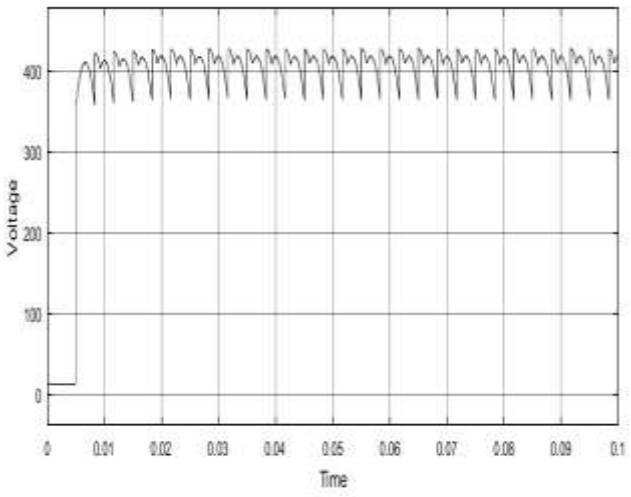

Fig.2.3c Converter voltage across the battery

The DC voltage available at the output of the converter is less than the expected voltage because of the harmonics in the input supply which also affects the battery voltage and charging time.

3. Proposed design of electric vehicle charger:-

In integrated split phase induction motor charger, same circuitry for charging and traction can be implemented. In charging mode, charging of battery is done by closing switch G1, G2 and G3 for greed connection and move the switch a, b and c toward 1,2 and 3 for cancelation of the rotating magnetic field. Second mode is traction mode in which battery supply the power to the traction motor and this can be achieved by moving switch a, b and c to 1' 2' and 3'. By making such type of arrangement winding of an induction motor goes in star connection and motor capable to produce rotating magnetic field. This arrangement of proposed system shows in following fig.

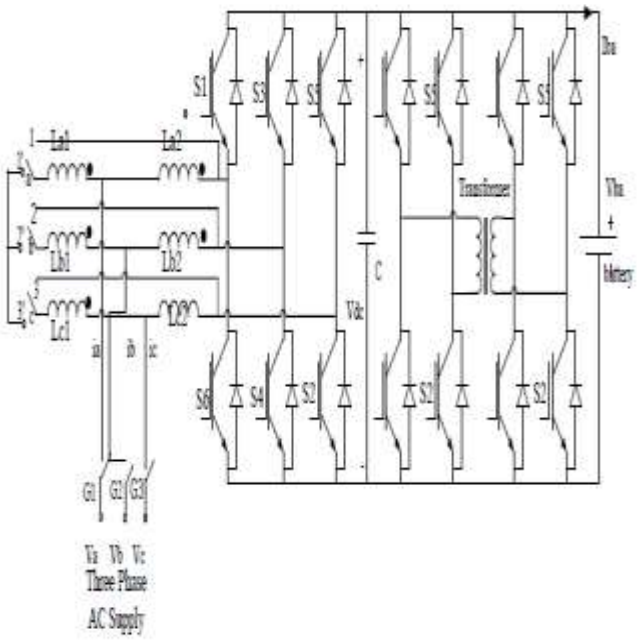

Fig.3 Proposed designed charging system

Input side 3-ϕ bridge ac to dc converter basically used for greed side power control and the dual active bridge dc to dc converter used for controlling charging and discharging of the battery. Here Va, Vb and Vc are the greed side voltage and Ia, Ib and Ic are the grid side current Vdc is the dc side voltage and Vba represent the battery side voltage and Iba represent the battery side current, R and L represent the resistance and inductance of the induction motor respectively and it can also be used for making buck/boost characteristics of the converter as well as to obtain the unity power factor of the converter and also use to control the bidirectional power of the converter.

Above designed system operated as follows. At the time of charging power flow from greed to the battery, in that ac to dc converter work as the rectifier and dual active bridge dc to dc converter the dc output voltage of the ac to dc converter at desired voltage level which required for battery, and also provide constant current and constant voltage charging of the battery.

When power flow reversed that means from battery side to the ac side during traction process bidirectional dual active bridge dc to dc converter converts the battery voltage level which required for dc to ac converter, and ac to dc converter acct as an inverter and supply power to the traction motor. Instead of that the dual active bridge dc to dc converter provides galvanic isolation and protects the system from switching surges and abnormal conditions. **For simplicity we have checked the effects of inductive filter on the performance of the converter in matlab without DC to DC converter and inverter circuitry.**

3.1 Matlab Simulation of converter with filter:-

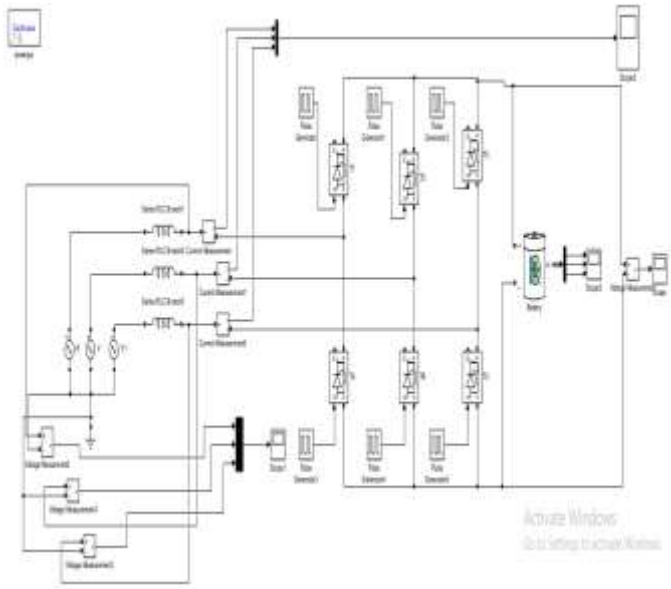

Fig.3.1 Converter circuitry with inductive filter matlab simulation model

3.2 Results:-

1) Filter output Current waveform:-

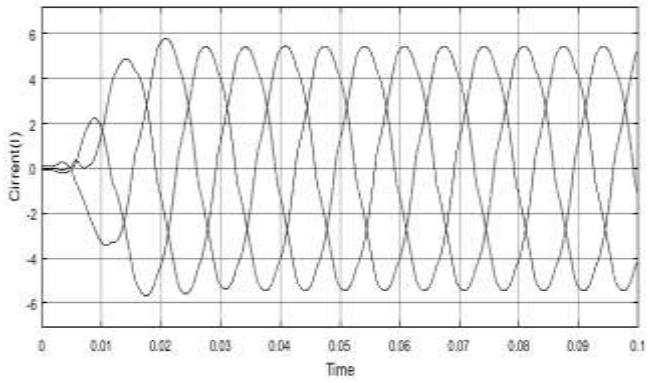

Fig.3.2a Filter output current waveform

The output current waveform of the inductor filter showing that current waveform becoming more sinusoidal therefore harmonics component getting reduced which helps to improve the input power factor as well as low consumption of power.

2) FFT analysis:-

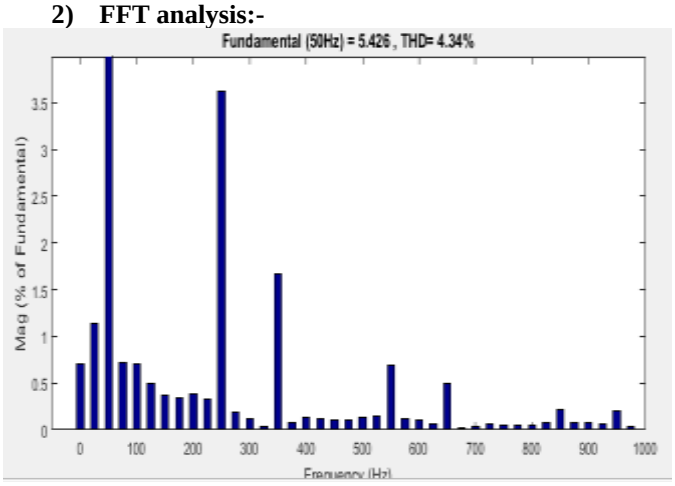

Fig.3.2b FFT analysis of input current with inductor filter

Above graph shows that the use of the inductor filter in the input circuit redices THD upto 4.34% therefore distortion in current becomes low which increases power factor of the system.

3) Converter output DC voltage:-

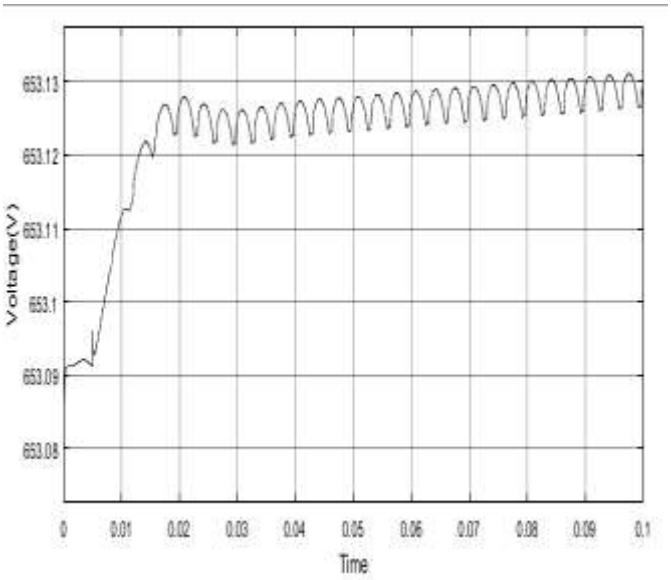

Fig.3.2c Converter output DC voltage

From above fig. it is clear that converter with inductive filter draws sinusoidal current and provides regulated constant output DC voltage across the battery.

III. FUTURE SCOPE

Design of charging system with split phase three phase induction motor winding to reduce the harmonics in the charging system as well more effective use of induction motor winding for the purpose of reducing harmonics in the input supply for charging system as well as output of the battery.

IV. CONCLUSIONS

From simulation result and mathematical calculation it is concluded that, traction motor used in electric vehicle can be used to improve power quality of input supply given to the converter by using traction motor stator winding as inductor filter. Which also helps to reduce the on board weight of battery charging system.

REFERENCES

[1] Amol S. Kamble, "On-Board Integrated Charger for Electric Vehicle Based on Split Three Phase Induction Motor", Department of Electrical Engineering Government Engineering College Aurangabad 431005, India.

[2] Murat Yilmaz, Member, IEEE, and Philip T. Krein, Fellow, IEEE "Review of Battery Charger Topologies, Charging Power Levels, and Infrastructure for Plug-In Electric and Hybrid Vehicles" IEEE Transactions on Power Electronics, Vol. 28, No. 5, May 2012.

[3] M. Yilmaz and P.T. Krein, "Review of battery charger topologies, charging power levels and infrastructure for plug-in electric and hybrid vehicles," IEEE Trans. on Power Elec., vol. 28, no. 5, pp. 2151– 2169, 2013.

[4] Murat Yilmaz, Member, IEEE, and Philip T. Krein, Fellow, IEEE "Review of Battery Charger Topologies, Charging Power Levels, and Infrastructure for Plug-In Electric and Hybrid Vehicles" IEEE Transactions On Power Electronics, Vol. 28, No. 5, May 2012.

[5] SAE Electric Vehicle Inductive Coupling Recommended Practice, SAE 5-1773, Feb. 1, 1995.

[6] Arnaldo Arancibia, "A Unified Single- and Three-Phase Control for Grid Connected Electric Vehicles" IEEE Transactions On Smart Grid, Vol. 4, No. 4, December 2013.

[7] Saeid Haghbin, Sonja Lundmark, Mats Alaküla, and Ola Carlson "Grid-Connected Integrated Battery Chargers in Vehicle Applications: Review and New Solution" IEEE Transactions On Industrial Electronics, Vol. 60, No. 2, February2013.

[8] Lacressonniere F., Cassoret B.: 'Converter used as a battery chargerand a motor speed controller in an industrial truck'. 2005 European Conf. Power Electronics and Applications, 2005.

[9] Haghbin S., Khan K., Zhao S., Alakula M., Lundmark S., Carlson O.: 'An integrated 20-kw motor drive and isolated battery charger for plug-in vehicles', IEEE Trans. Power Electron., 2013, 28, (8), pp.4013–4029.

[10] Shiney.S.Varghese1 , Sincy George 2 Department of Electrical Engineering "Analysis of AC-DC Converter Based on Power Factor and THD" International Journal of Emerging Technology and Advanced Engineering Website: www.ijetae.com (ISSN 2250-2459,ISO 9001:2008 Certified Journal, Volume 3, Issue 2, February 2013.

Internet:

1) https://afdc.energy.gov/files/pdfs/51227.pdf
2)https://www.researchgate.net/publication/224244866_Smart_electric_vehicle_charging_system
3) https://ieeexplore.ieee.org/document/7914515
4) https://en.wikipedia.org/wiki/Electric_vehicle
5)https://new.siemens.com/global/en/products/energy/medium-voltage/solutions/emobility.html
6) https://www.driveelectricvt.com/charging-stations/types-of-charging
7)https://www.energy.gov/eere/electricvehicles/vehicle-charging

