ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

Modified SEPIC Converter Based Electric Vehicle Battery Charger

R.Deebiga[1], M.Thamil alagan[2], T.Suresh Padmanabhan[3]

PG Student [EEE], Dept. of EEE, Bharathiyar College of Engineering and Technology, karaikal, Tamilnadu, India[1]

Associate Professor, Dept. of EEE, Bharathiyar College of Engineering and Technology, karaikal,Tamilnadu, India[2]

Assistant Professor, Dept. of EEE, Bharathiyar College of Engineering and Technology, karaikal, Tamilnadu,India[3]

ABSTRACT: In this paper, a plug-in electric vehicle battery charger is proposed based on MODIFIED SEPIC PFC and LLC scheme. additionally, a new approach in introduced to actively control the dc link voltage and track the maximum efficiency point of a LLC converter over the wide voltage range of the high voltage battery pack up in electrical vehicle application. Comprehensive circuit modeling and loss analysis at maximum efficiency point of LLC converter are carried out. The Performance analysis of modified SEPIC dc-dc converter with inverter has keep wide output voltage in low input voltage conditions. The operational analysis and the design are done for the 400W power output of the modified converter. The SEPIC and MODIFIED SEPIC performances are verified in Matlab/ simulink environment.

KEYWORDS: Sepic, Modified Sepic, LLC, Battery, Electrical Vehicle, Converters

I.INTRODUCTION

In recent years the plug-in electric vehicles (PEVs) are operated under Li-ion battery pack up.Since it has more attractive features such as high energy density, no memoryeffect, and slow loss of charge. The charging profile of a typical Li-ion battery cell is plotted in Fig. 1. According to the waveform, the voltage of a deeply depleted Li-ion cell can go down to 1 V. The wide voltage range of Li-ion cell is plotted to a wide voltage range (100 V – 420 V) of the on-board battery pack. Consequently, the on-board charger must be compatible with this wide voltage range [1].

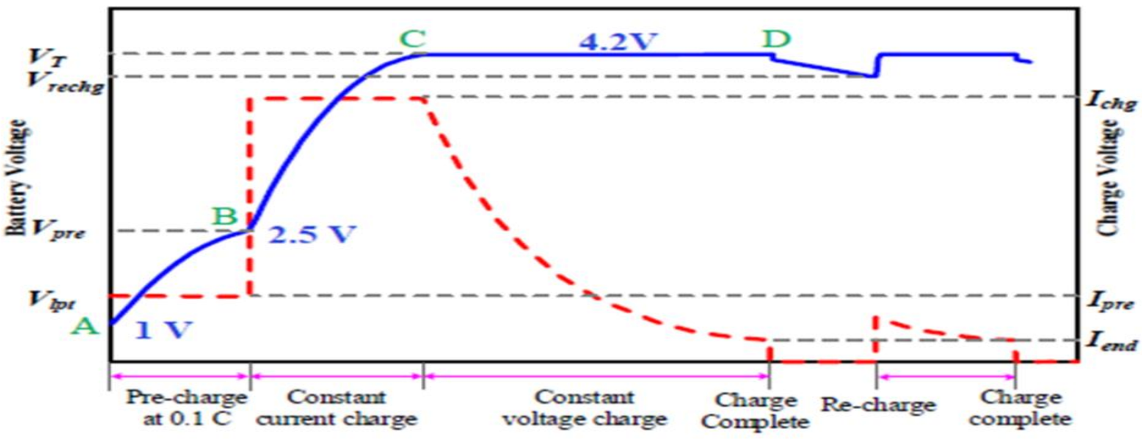

Fig:1Li-ion battery cell

The battery isolation charging network have consists with two power converters, front-end stage for rectification of ac input power and power factor correction (PFC), and second-stage dc/dc converter for voltage regulation and galvanic isolation [2]–[3]. Boost and its derivative topologies are commonly utilized in the PFC stage.Power supplies with active power factor correction (PFC) techniques are becoming necessary for many types

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

of electronic equipment to meet harmonic regulations and standards, such as the IEC 61000-3-2 [4]. PFC rectifiers have wide array of industrial applications such as telecommunication and industrial application.Boost and its derivative topologies are commonly utilized in the PFC stage. This is because of their simple circuit configurations, continuous input current, and low total harmonic distortion (THD).In dc/dc conversion, zero-voltage switching (ZVS) topologies are preferable to enhance efficiency of chargers [9]–[11]. In particular, LLC topology has several advantages over other ZVS topologies, such as short circuit protection, good voltage regulation in light load condition, the ability to operate with ZVS over wide load ranges, diode reverse recovery losses through soft commutation.

The conversional two stage conversion in PEV battery charging applications, optimization of the LLC converter over the wide output voltage ranges becomes a challenging problem. Therefore in this paper, new approach to optimize the efficiency of the LLC stage over the full battery voltage ranges (100 V – 420 V) and load conditions without adding any additional circuit or implementing on/off control. Becoming the resultant of the modified converter is to analysed the well suited to implement high-static gain step-up converters. The use of high static gain and low-switch voltage topologies can improve the efficiency operating with low input voltage.

II.CONVENTIONAL CIRCUIT

The schematic diagram of a conventional two stage isolated PEV battery charger based on boost PFC and full bridge LLC topologies is plotted in Fig.2. In PEV battery charging applications, optimization of the LLC converter over the wide output voltage ranges becomes a challenging issue.

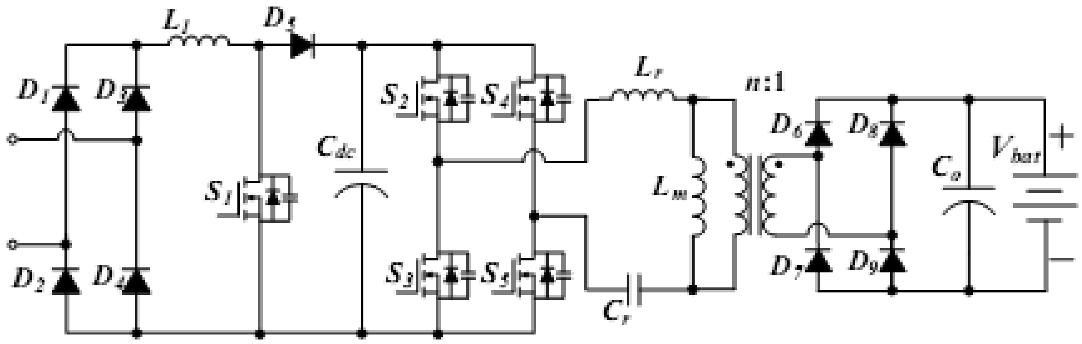

Fig.2. Conventional two stage isolated charger based on boost PFC and full bridge LLC converters.

Battery chargers have their output voltage ranges to be 310 V – 420 V and 260 V – 440 V, respectively. However, neither work is able to charge the deeply depleted battery pack (100 V – 250 V).

III.PROPOSED TOPOLOGY

The modified SEPIC converter is accomplished by including of the diode DM and the capacitor CM in basic SEPIC converter. The voltage multiplier technique is used to increase the static gain of single-phase boost dc–dc converters. An adaptation of the voltage multiplier technique with the modified SEPIC converter is presented in fig.3. Many operational characteristics of the basic SEPIC converter are changed with the proposed modification. The capacitor CM is charged with the output voltage of the basic boost converter. Therefore, the voltage applied to the inductor L2 during the conduction of the power switch S is higher than that in the basic sepic converter, thereby increasing the static gain.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

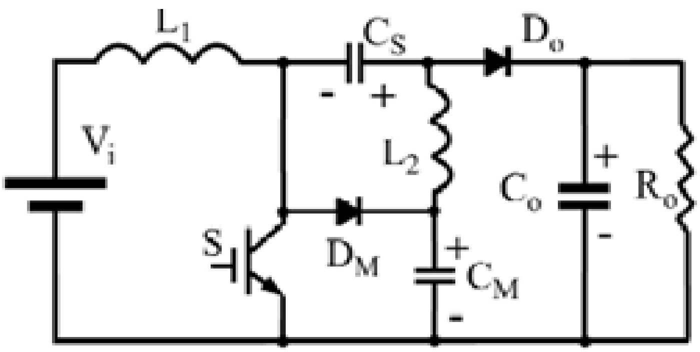

Fig: 3(a). Modified SEPIC converter

Fig.3(b) shows the proposed bridgeless SEPIC PFC rectifier with voltage multiplier cell. The bridgeless configuration will reduce the conduction losses and the multiplier cell (and C_M and D_m) will increase the gain and reduce the switch voltage stress. Hence the proposed topology enhances the overall efficiency. The proposed circuit consists of two symmetrical configurations. A single-ended primary-inductor converter (SEPIC) PFC stage is utilized. Thus, the dc link voltage can vary in a wide range without satisfying the compatibility with universal grid input.

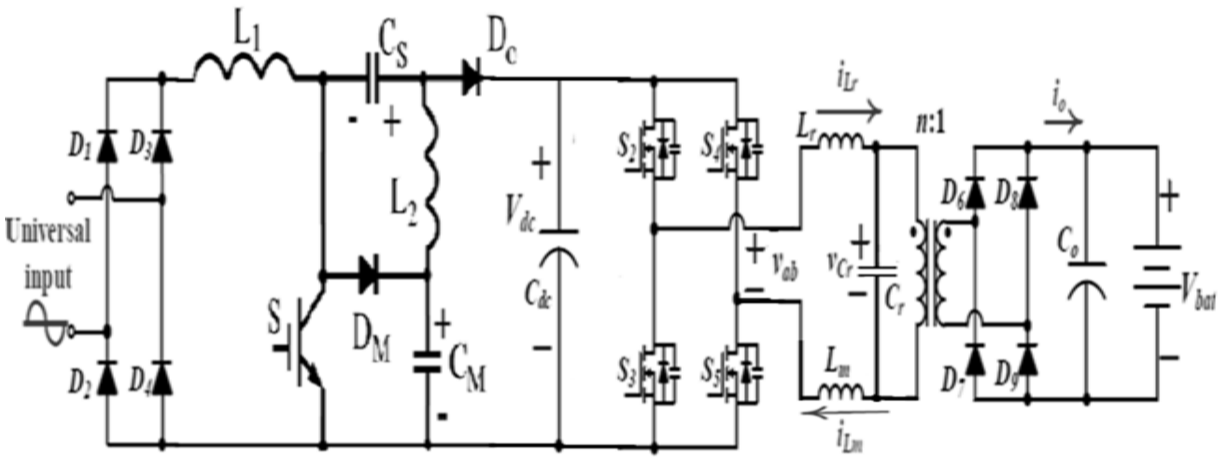

Fig.3 (b). Proposed two stage isolated charger based on SPEIC and full bridge

By actively controlling the dc link voltage with respect to the variation of battery voltage, the conversion efficiency of the dc/dc converter is always regulated to be the optimal value through keeping the switching frequency close to its primary resonant frequency and thereby minimizing the circulating current in the resonant tank. With the proposed maximum efficiency point tracking technique, the efficiency performance of dc/dc converter is improved across the wide battery voltage range.

PRINCIPLE OF OPERATION

The proposed circuit consists of two symmetrical configurations as illustrated in Fig.3, the modified SEPIC circuit is analyzed for the positive half line cycle configuration (on state) shown in Fig.4(a)&(b). Assuming that the three inductors are operating in DCM, then the circuit operation during one switching period Ts in a positive half-line period can be divided into three distinct operating modes,

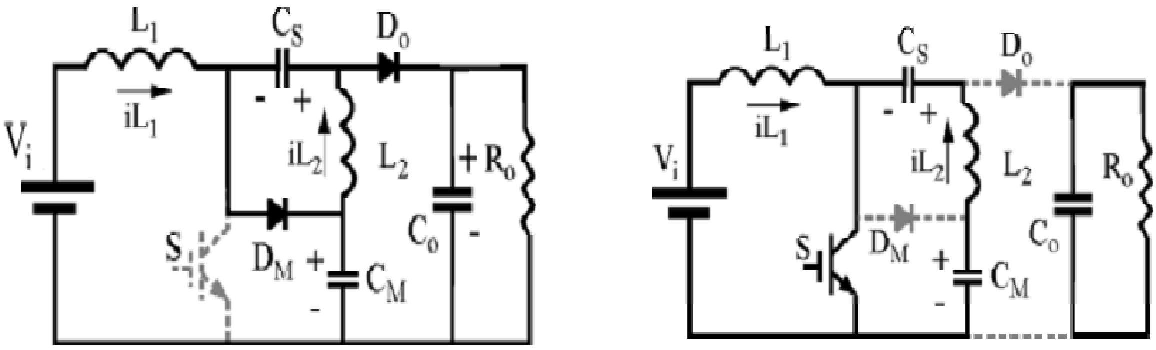

Fig: 4(a) First Stage (Switch off)   (b) Second Stage (Switch on)

The first stage of operation varies from time t_0 to t_1. At the instant t0, the switch S is turned-off and the energy stored in the input inductor L_1 is transferred to the output through the capacitor CS and output diode DO, and also to the capacitor through the diode DM. Therefore, the switch voltage is equal to the capacitor CM voltage. The energy stored in the inductor L_2 is transferred to the output through the diode DO. The second stage operation varies from time t_1 to t_2. At the instant t_1, the switch S is turned-on and the diodes DM and Do are blocked, and the inductors L_1 and L_2 store energy. The input voltage is applied to the input inductor L_1 and the voltage VCS−VCM is applied to the inductor L_2. The voltage VCM is higher than the voltage VCS.

IV.SIMULATION RESULT

Modified SEPIC converter based battery charging converter is simulated by using MATLAB software. It composed of SEPIC converter whose one of the inductor is made as coupled inductor. The power factor corrected output is achieved by using PI and PID controller. The sepic converter based battery charging scheme is shown in figure: 5. Output voltage and gate pulses are shown in figure: 6 to 8. The simulation parameters are given in table :1.

PARAMETERS	VALUES
Inductor,(L1, L2)	1mH , 500µH
Capacitor (Cs, C_m)	660nF
Output Capacitor	500µF
Switching frequency	50Hz
Input voltage	110V
Output voltage	300V
Output Current	0.46A

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

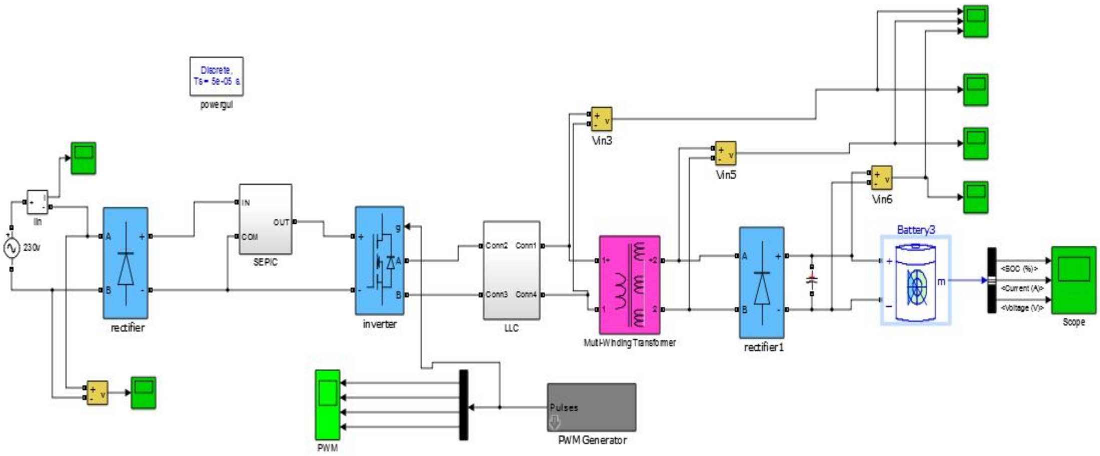

Fig:5 Conventional system

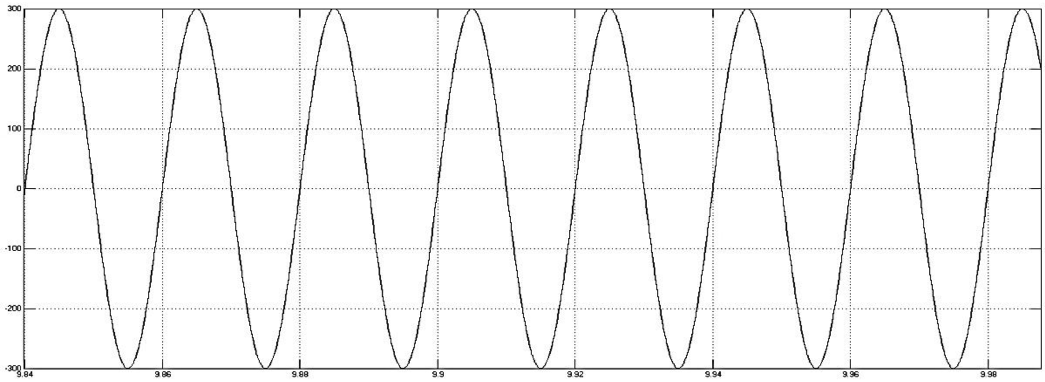

Fig: 6(a) conventional output voltage

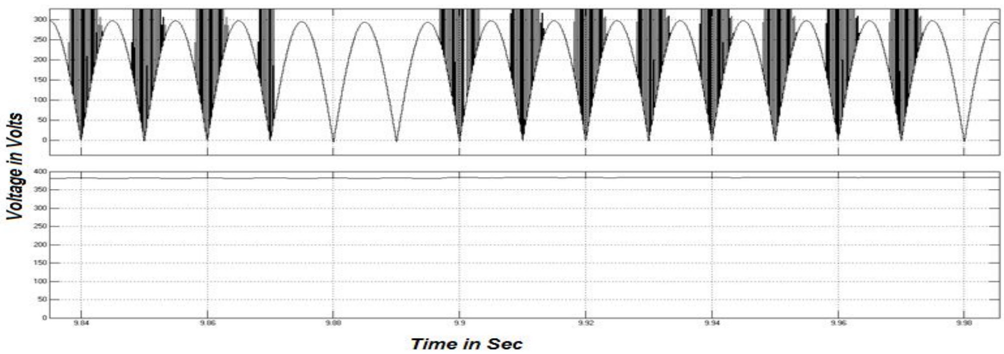

Fig: 6(b) sepic converter output

The output voltage, ripple voltage, and output current waveforms are depicted and it is clear that the output voltage is tightly regulated due to the lag compensator. The waveforms are shown in figures (fig: 8 to 11).

IJAREEIE

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

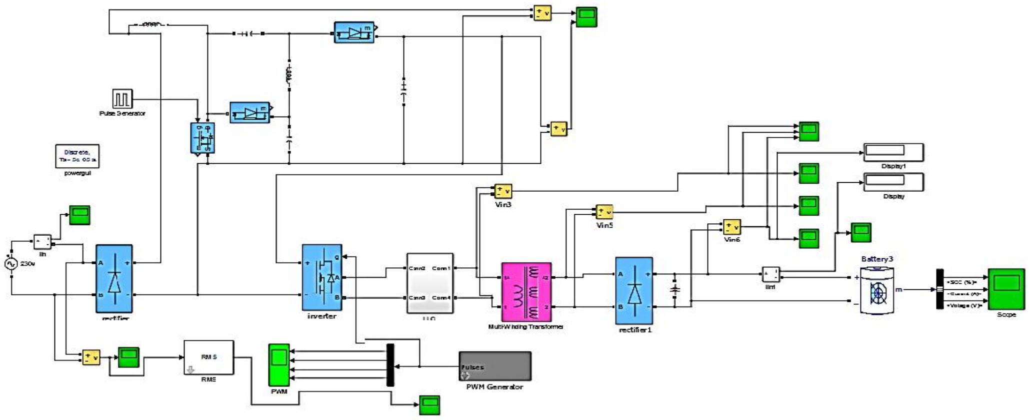

Fig:7 Proposed Circuit Diagram

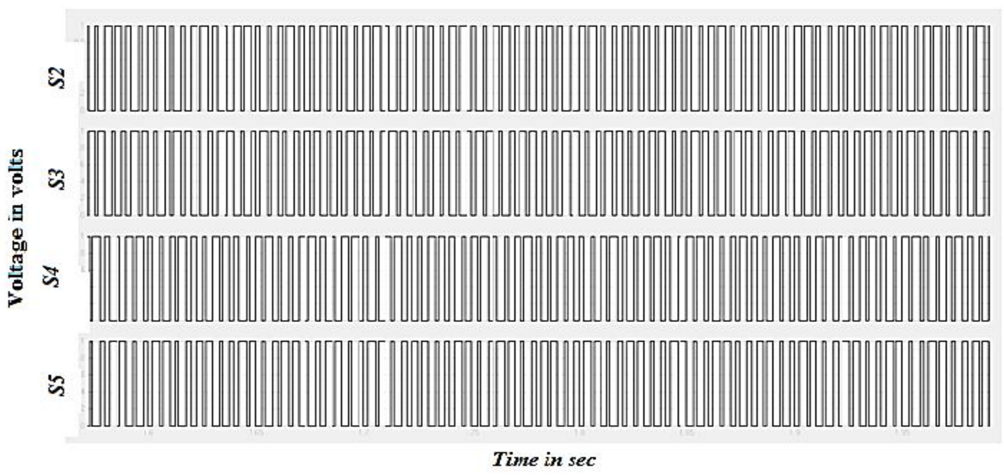

Fig: 8 Gate Pulses

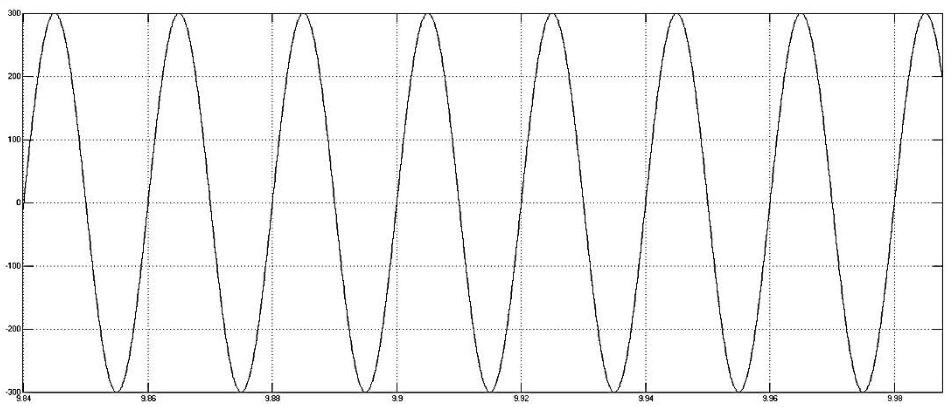

Fig: 9 output voltage waveform for proposed circuit

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

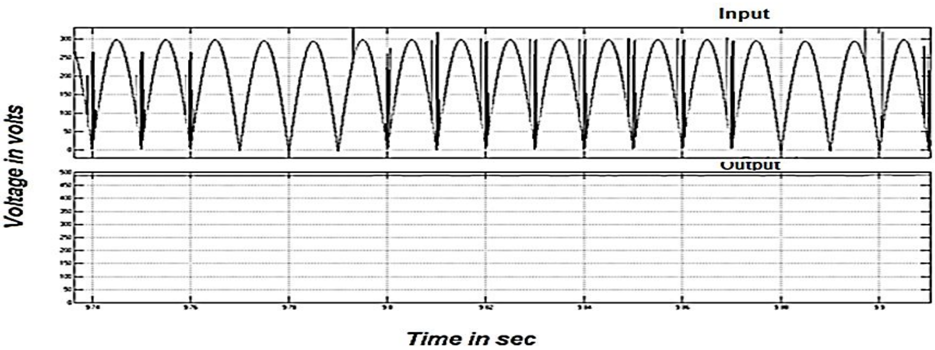

Fig: 9(b) modified SEPIC CONVERTER VOLTAGE

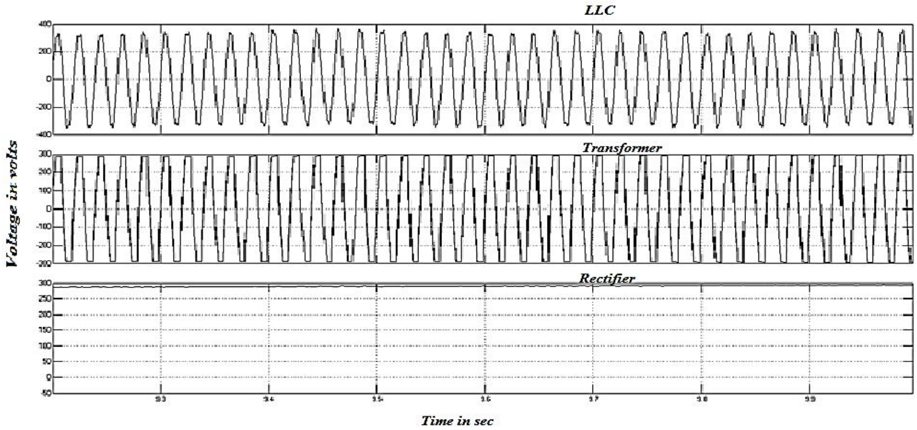

Fig: 10 waveforms for LLC & transformer & rectifier

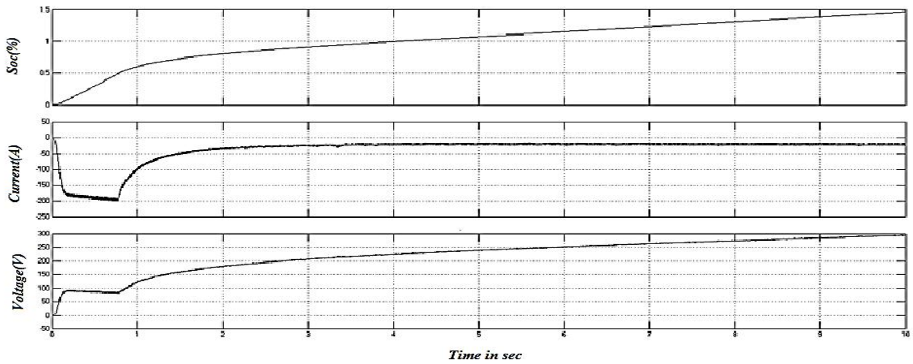

Fig: 11 battery output

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

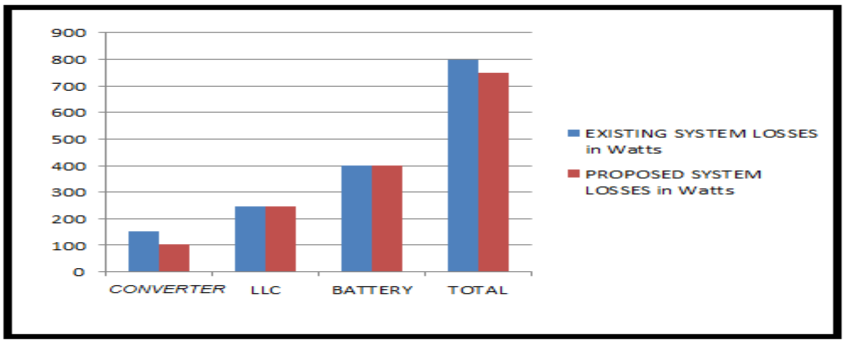

Fig.12: Graph for losses calculation

According to the simulation data and the loss analyses described for existing and proposed system, the efficiency graph is drawn for switching losses and shown in graph.12. The losses are described for converter, LLC filter, and battery.

V. CONCLUSION

A modified sepic converter is proposed for electrical vehicle batter charging application. The PFC can achieve by using LLC scheme and these new approach is actively control the dc link voltage and track the maximum efficiency point of a LLC converter over the wide voltage range of the high voltage battery pack up in electrical vehicle application. Comprehensive circuit modeling and loss analysis at maximum efficiency point of LLC converter are carried out. The Performance analysis of modified SEPIC dc-dc converter with inverter has keep wide output voltage in low input voltage conditions. The operational analsised and the design are done for the 400W power output of the modified converter. The output voltage, THD, losses and PFC of the SEPIC and MODIFIED SEPIC performances are verified in Matlab/ simulink environment.

REFERENCES

[1] H. Wang and A. Khaligh, "Comprehensive topological analyses of isolated resonant converters in PEV battery charging applications," in IEEE Transportation Electrification Conference and Expo., 2013, pp. 1–7.
[2] M. Yilmaz and P. Krein, "Review of Battery Charger Topologies, Charging Power Levels and Infrastructure for Plug-in Electric and Hybrid Vehicles," IEEE Trans. Power Electron., vol. 28, pp. 1–1, 2012.
[3] G. Pellegrino, E. Armando, and P. Guglielmi, "An Integral Battery Charger With Power Factor Correction for Electric Scooter," IEEE Trans. Power Electron., vol. 25, no. 3, pp. 751–759, Mar. 2010.
[4] H.-S. Kim, M.-H. Ryu,J.-W. Baek, and J.-H. Jung, "High-Efficiency Isolated Bidirectional AC–DC Converter for a DC Distribution System," IEEE Trans. Power Electron., vol. 28, no. 4, pp. 1642–1654, Apr. 2013.
[5] F. Musavi, W. Eberle, and W. G. Dunford, "A High-Performance Single-Phase Bridgeless Interleaved PFC Converter for Plug-in Hybrid Electric Vehicle Battery Chargers," IEEE Trans. Ind. Appl., vol. 47, no. 4, pp. 1833–1843, Jul. 2011.
[6] F. Musavi, M. Craciun, D. S. Gautam, W. Eberle, and W. G. Dunford,"An LLC Resonant DC–DC Converter for Wide Output Voltage Range Battery Charging Applications," IEEE Trans. Power Electron., vol. 28, no. 12, pp. 5437–5445, Dec. 2013.
[7] C. Qiao, K. M. Smedley, "A topology survey of single-stage power factor corrector with a boost type input current-shaper", IEEE Trans. Power Electron., Vol. 16, No. 3, pp. 360–368, 2001.
[8] M. H. L. Chow, Y. S. Lee, C. K. Tse,"Single-stage single-switch isolated PFC regulator with unity power factor, fast transient response, and low-voltage stress," IEEE Trans. Power Electron., Vol. 15, No. 1, pp. 156–163, 2000.
[9] M. Prudente, L. L. Pftscher, G. Emmendoerfer, E. F. R. Romaneli, R. Gules, "Voltage multiplier cells applied to non-isolated DC–DC converters", IEEE Trans. Power Electron., Vol. 23, No. 2, pp. 871–887, 2008.
[10] Q. Zhao, F. C. Lee, "High-effiency, high step-up DC–DC converters", IEEE Trans. Power Electron., Vol. 18, No. 1, pp. 65–73, 2003.