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

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

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 5, May 2018

Enhancement of Speed of the Electrical Vehicle using Power Electronic Transformer

Ashish Shukla[1], Durga Sharma[2], Vishwanath Prasad Kurmi[3]

M.Tech Student, Dept. of EEE, Dr. C V Raman Institute of Science and Technology, Bilaspur, Chhattisgarh, India[1]

HOD, Dept. of EE, Dr. C V Raman Institute of Science and Technology, Bilaspur, Chhattisgarh, India [2]

Asst Prof, Dept. of EEE, Dr. C V Raman Institute of Science and Technology, Bilaspur, Chhattisgarh, India[3]

ABSTRACT: Power electronic transformers have emerged as an alternative to conventional 50/60 Hz transformers. The main advantage of a power electronic transformer over a conventional transformer is its compact size. Due to their compact size power electronic transformers can be used to power electric vehicles, Power electronic transformer can make electrical vehicle generate more power than before. This paper presents a new idea to power the electrical vehicle using a power electronic transformer, which aims to improve various performance parameters of the electrical vehicle and make it more cost-effective. MATLAB- simulink software is used for simulation purpose.

KEYWORDS: Power electronic transformer, electrical vehicle, performance parameters, MATLAB-simulink.

I. INTRODUCTION

Transformers are universally used for voltage conversion, but there are some issues with a conventional transformer, they are bulky, massive and expensive. Another way, which can be used for voltage conversion is power electronic transformers. In power electronic transformers, the frequency is increased so significantly that size is reduced by a considerable margin. There are many topologies available within power electronic transformers. One topology has three stages, namely input, output and isolation. This topology uses DC link capacitors with several power electronic converters [1]. Another topology makes use of matrix converters for AC-AC conversion and it basically avoids the need of the DC link capacitors [2]. There are various combinations of these two topologies is also possible. This paper focuses on topology given in [1].

Electrical vehicles are expected to take over one-third of the transportation market by 2025. They offer some advantages over gasoline vehicles, but they still some issues. First of all, they are heavily dependent on Lithium-ion batteries, Lithium being a very costly mineral its cost is expected to go even higher. There are very few countries where Lithium is found. The second problem is their applicability in remote areas, these are the places where vehicle's mileage decreases, which would make the battery last even shorter and lack of charging facilities in the remote areas would not help either. The third problem is lack of charging facilities, many more charging stations will be needed if the industry keeps on growing as its growing now.

Power electronic transformers can be one stop solution to all above-mentioned problems, power electronic transformers can help electric vehicles generate more power than before. Power electronic transformers are much more compact than conventional transformers so lack of space inside the vehicle would not be a much of a problem. Because of power electronic transformer, even a smaller battery will be sufficient to power an electrical vehicle. This reduces its dependency on Lithium-ion batteries.

II. CIRCUIT CONFIGURATION OF THE PROPOSED SYSTEM

Some modification has been made in the configuration given in [1] as per requirements of electrical vehicles. A battery is used as an input, which is connected to two step-up choppers in cascade, power MOSFET is used as a switch in the chopper. Presence of multiple choppers reduces source current, it also reduces the primary current in the transformer which means a reduction in the copper loss as well. Next comes the isolation stage, where the output of the second chopper is used as an input to a single phase full bridge inverter. This inverter converts a DC voltage into a high-

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

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

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 5, May 2018

frequency square wave AC voltage of 1000 Hz. Which is given as input to a step up transformer, the output of the transformer is connected to a full bridge rectifier, which converts square wave AC voltage into a DC voltage with help of a DC link capacitor. Next is the output stage where this DC voltage works as input to a three-phase inverter which is connected to an induction motor load.

The circuit given in figure 1 is a circuit of the input stage of a power electronic transformer as given in [1], the circuit in figure 2 is modified version of this circuit as per the requirements because it is very difficult to get a three phase AC supply inside an electrical vehicle. While isolation and output stage remains same and only difference is that in electrical vehicle induction motor is used as a load.

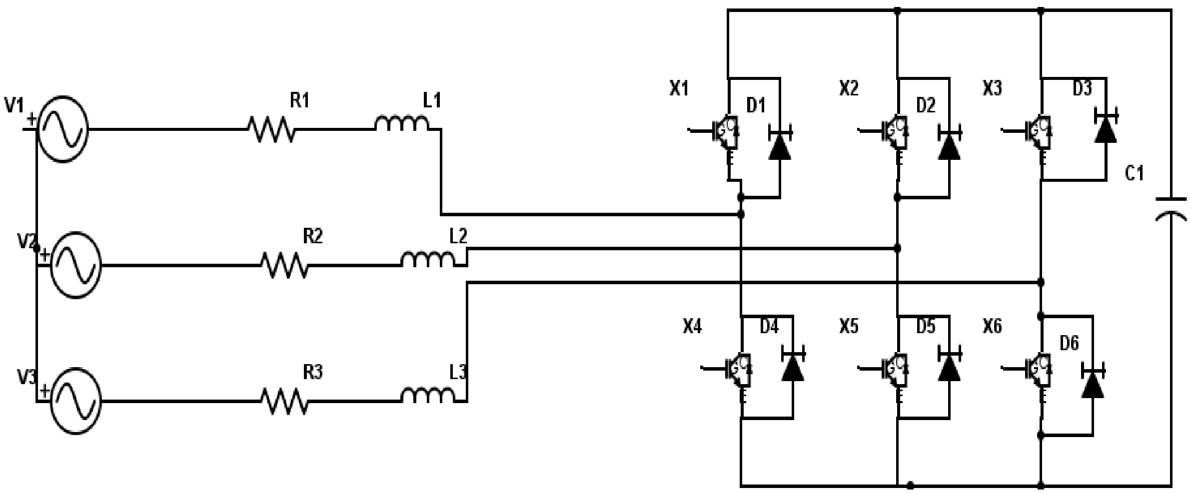

Fig 1 Input stage of a power electronic transformer

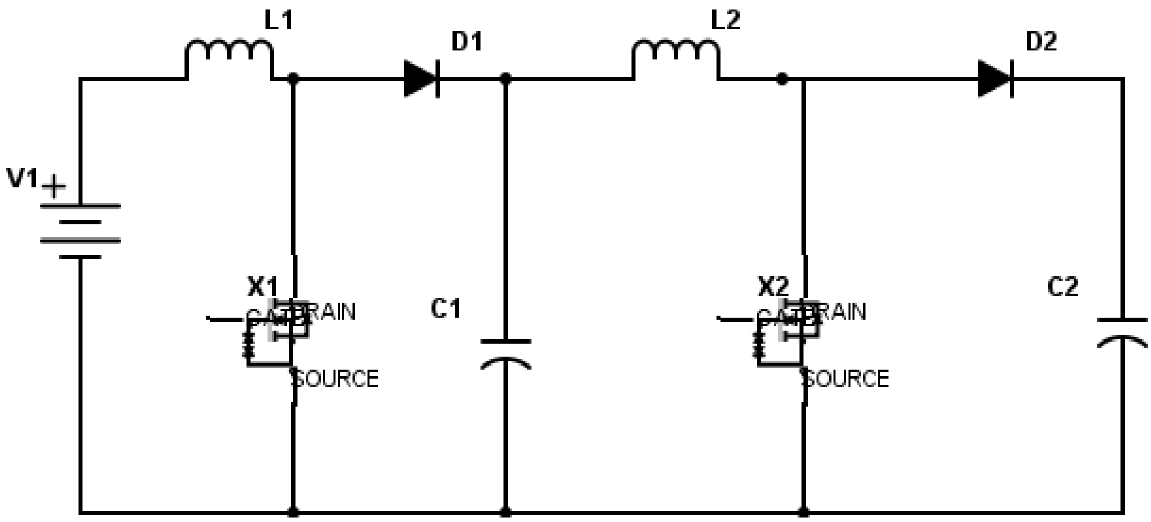

Fig 2 Input stage of the proposed system

Copyright to IJAREEIE DOI:10.15662/IJAREEIE.2018.0705003

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

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

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 5, May 2018

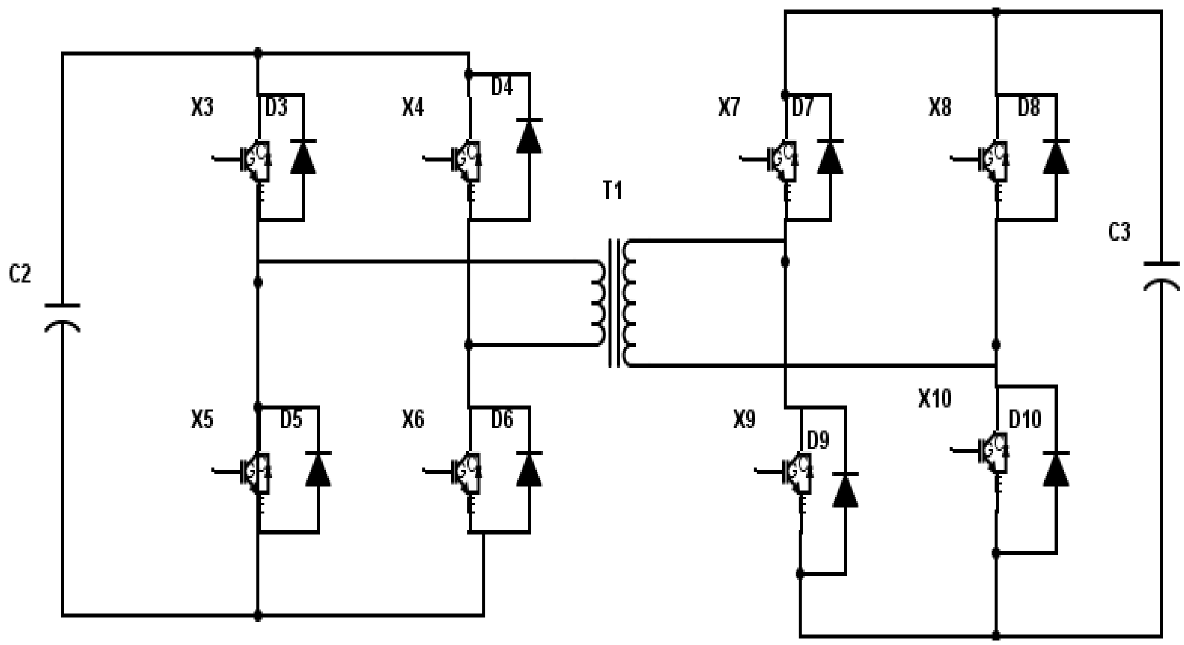

Fig 3 The isolation stage

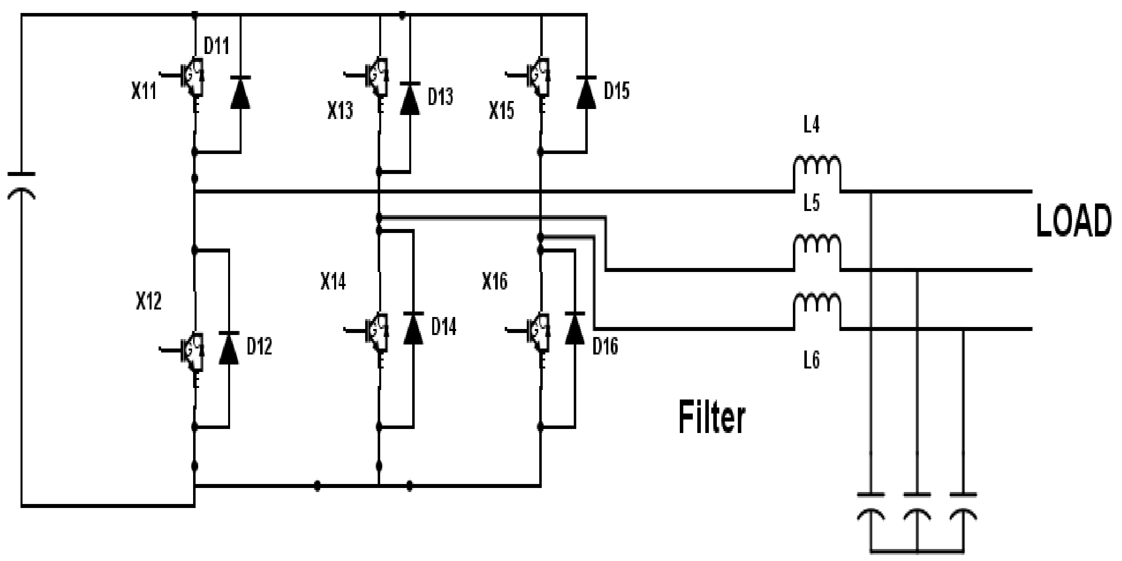

Fig 4 The output stage

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

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

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 5, May 2018

III. SIMULATIONS

First power electronic transformer model is simulated with an R-L load. In the second and third simulation, modified power electronic transformer model powering an electrical vehicle is simulated in MATLAB-simulink software

First Simulation – Exact replica of the above circuits was simulated in MATLAB-simulink software. Figure one is used as input stage in this simulation. The first simulation was testing the performance of power electronic transformer with a three-phase star connected R-L load.

Table1Various parameters and their values

Parameters	Values
Supply voltage	66 Kv (line to line)
Input resistance(R_1)	0.8929 ohms
Input inductance(L_1)	16.58 mH
DC link capacitor(C_1)	100 micro Farads
DC link capacitor(c_2)	100 micro Farads
Output filter inductance	1 mH
Output filter capacitance	470 micro Farads
Transformer operating frequency	1000 Hz
Transformer power rating	2 MVA

Second and third simulation – In these simulations, a modified model of the Power electronic transformer which is used to power electrical vehicle is simulated with two different power ratings of the transformer. Figure 2 is used as input stage here while induction motor is used as a load.

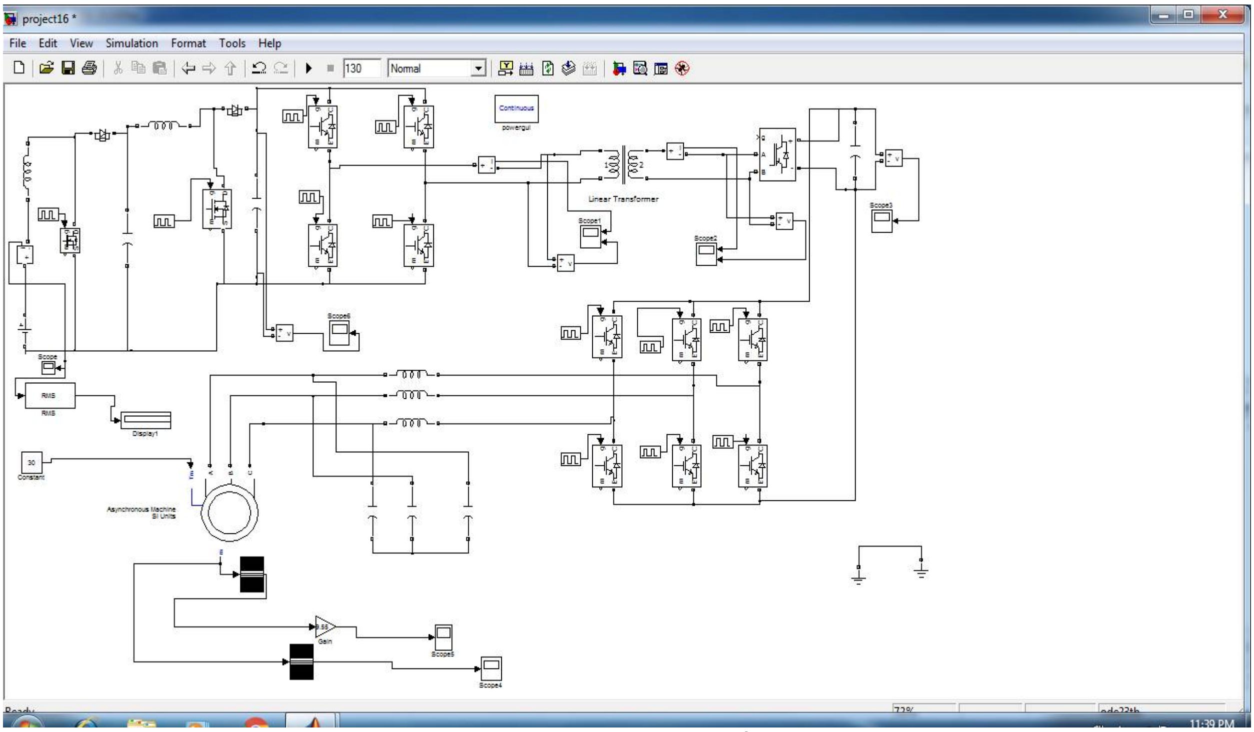

Fig 5 MATLAB-simulink model of the proposed system

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

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

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 5, May 2018

Table2 various parameters and their values

Parameters	Values
V_1	100 volts
Duty cycle of the first chopper X_1	0.7
Duty cycle of the second chopper X_2	0.6
Inductor L_1	0.136 H
Inductor L_2	0.136 H
Capacitor C_1 = Capacitor C_2	10 micro Farad
Turn ratio of the transformer	1:370
Power rating of transformer	2 MVA (first simulation), 5 MVA (second simulation)
Capacitor C_3	1 mF
Filter inductors	0.056 H
Filter Capacitors	47 micro Farad
Induction motor power rating	250 HP
Induction motor Number of poles	2

IV. RESULT AND DISCUSSION

First simulation – Operation of power electronic transformer supplying a three-phase R-L load was satisfactory, our aim was to ensure a 66 kv (line to line) to 33 Kv (line to line) voltage conversion.

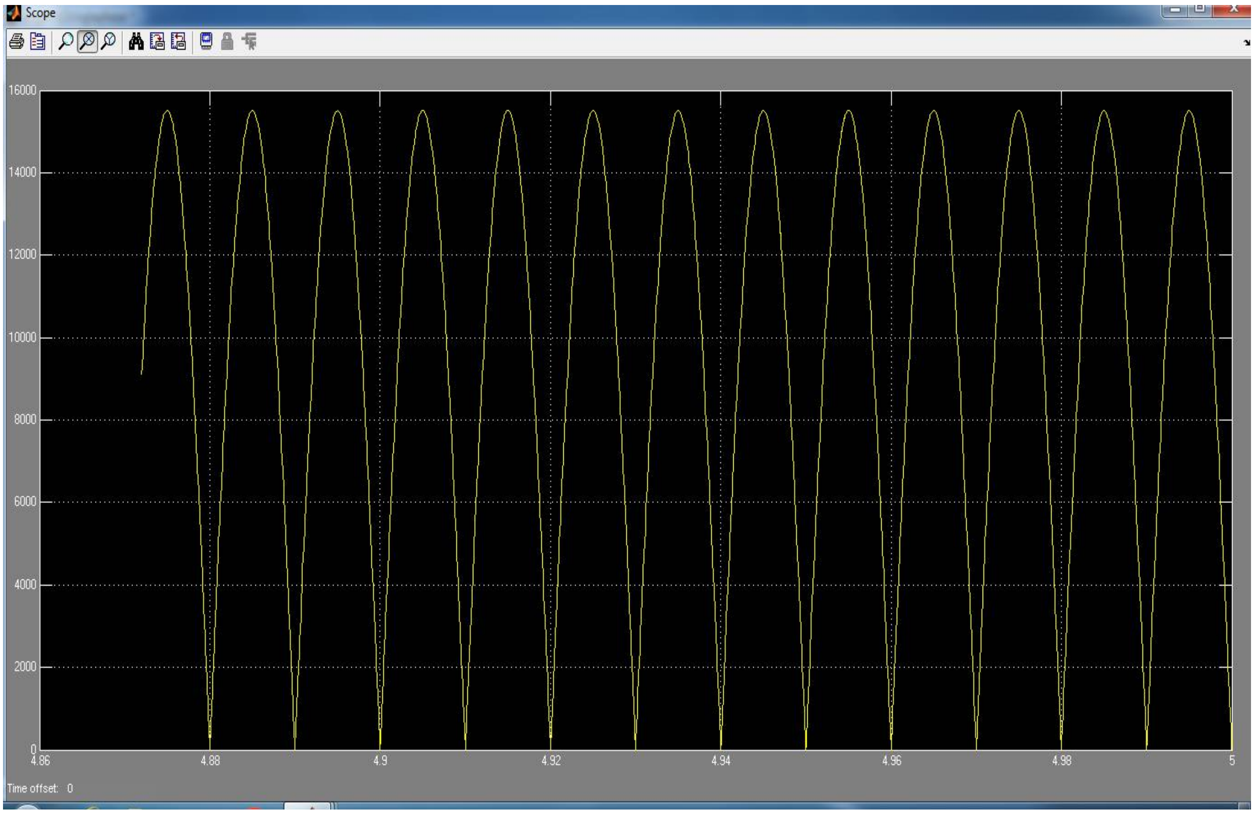

Fig 6 Voltage at capacitor C_1 v/s time in seconds

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

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

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 5, May 2018

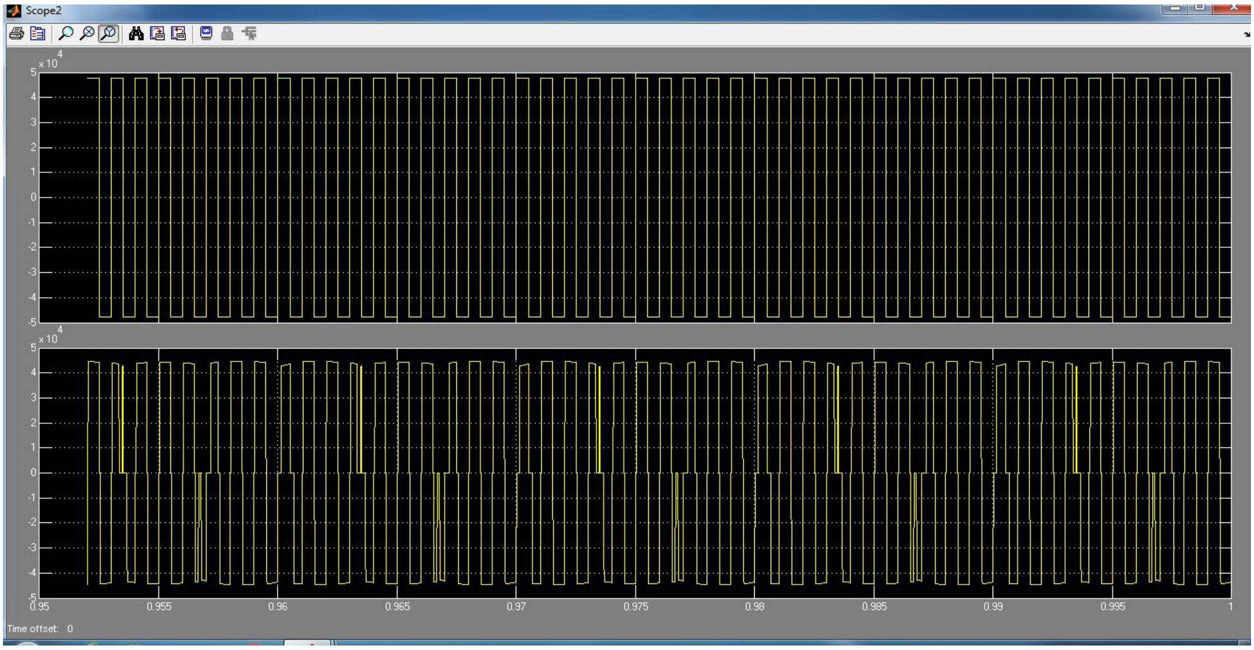

Fig 7 Primary and secondary voltages of transformer v/s time in seconds

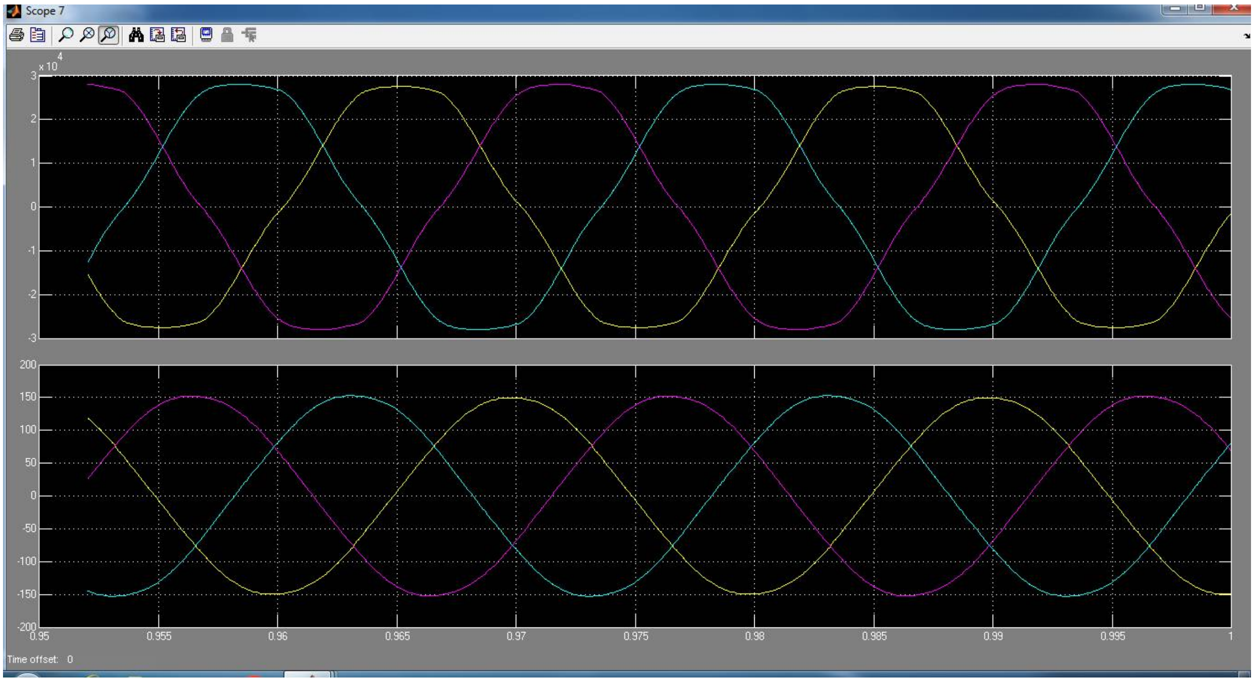

Fig 8 Output voltage and current v/s time in seconds

Second and third simulation - Torque and speed in rotation per minute is measured for two different power ratings of the transformer. Maximum torque is higher for the higher power rating of the transformer, maximum speed remains the same. Acceleration increases with a power rating of the transformer. Performance of the induction motor load is shown in Table2.

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

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

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 5, May 2018

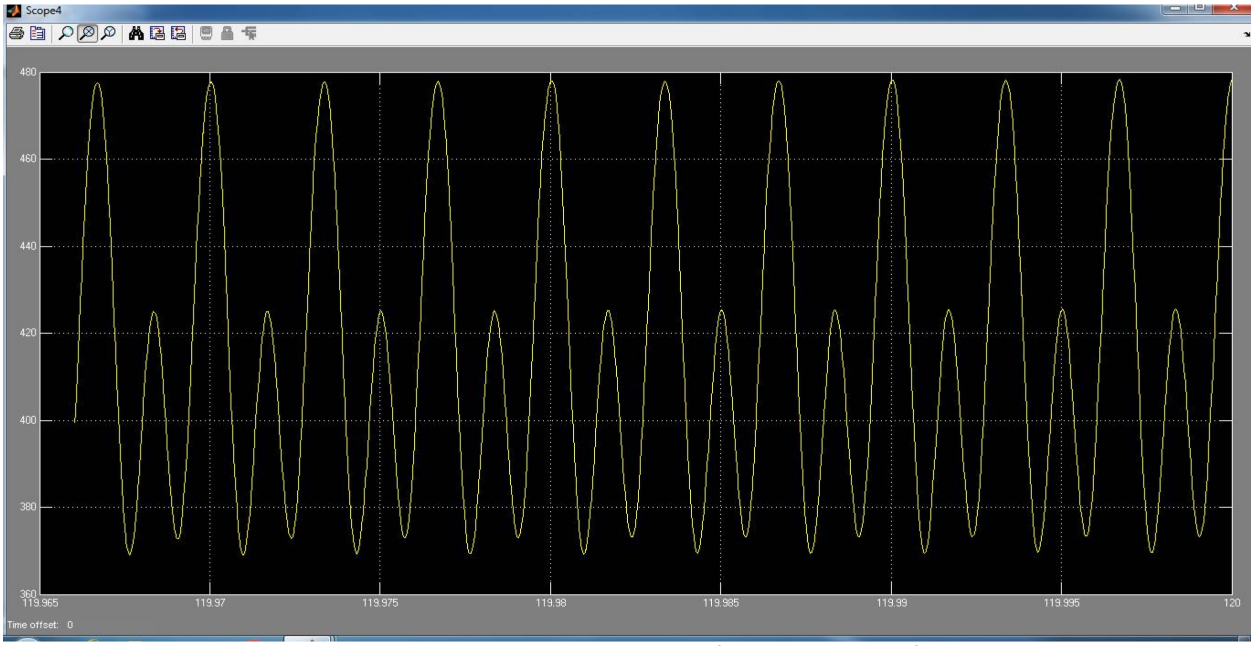

Fig 9 Torque in N-m v/s time in seconds for a 2 MVA transformer

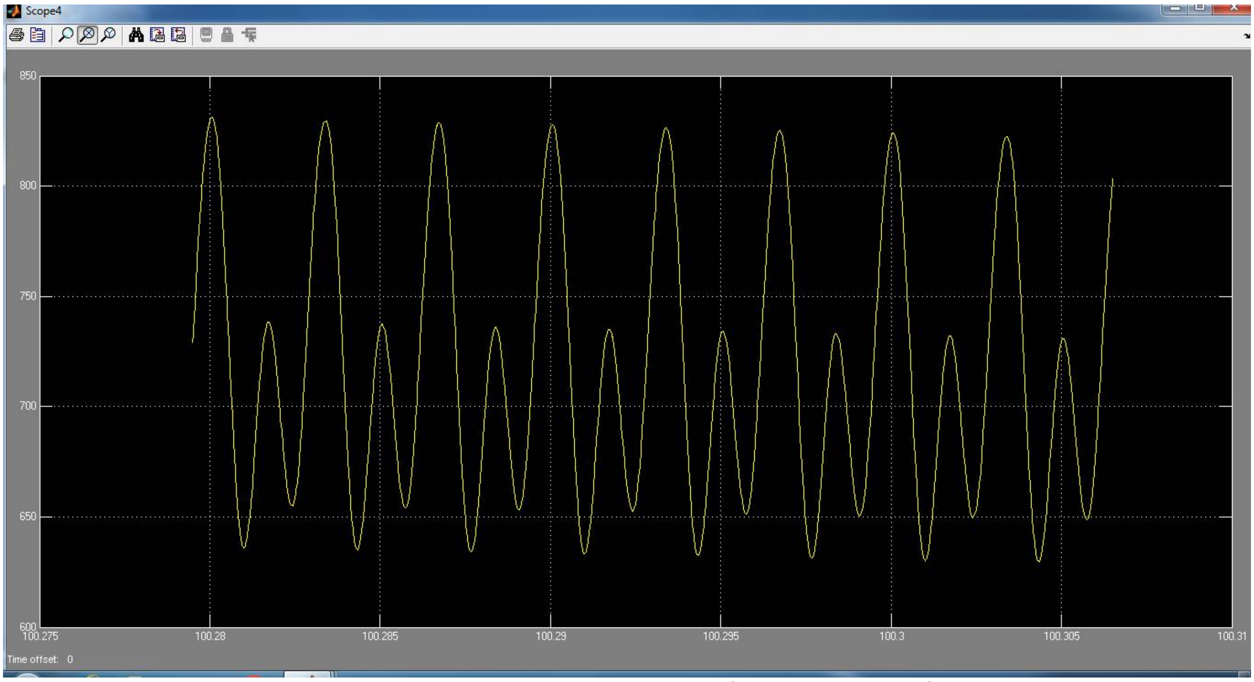

Fig 10 Torque in N-m v/s time in seconds for a 5 MVA transformer

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

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

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 5, May 2018

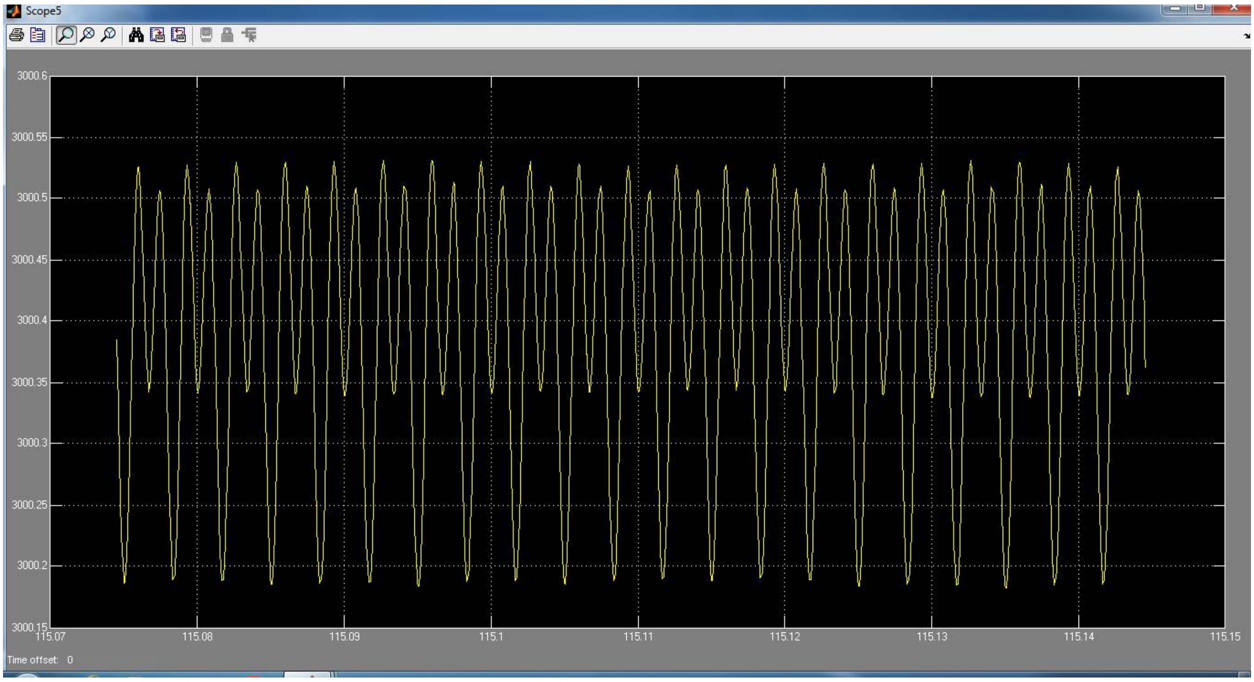

Fig 11 Speed in rotations per minute v/s time in seconds for a 2 MVA transformer

Table 3 Electrical vehicle performance parameters

Power rating of Transformer	Maximum speed	Maximum torque
2 MVA	2995 rpm	470 N-m
5 MVA	3004 rpm	840 N-m

V. CONCLUSION

Simulation results were a satisfactory only concern being the high value of source current, which can be reduced by adding a few more step-up choppers. Electrical vehicles with this new configuration will definitely generate more power than the ones in the market currently and it is expected to be more useful for heavier vehicles, but reduction in cost is still a dubious claim, which can only be assured after a sufficient amount of practical experimentation.

REFERENCES

[1] S.Alepuz,F. Gonzalez Molina, J Martin Arnedo,J A Martinez Velasco "Time domain model of a bidirectional distribution electronic power transformer" International conference on power systems transients Vancouver Canada 2013.

[2] J. Fallah Ardeshir,A. Ajami,A Jalilvand,A. Mohammadpour "Flexible power electronic transformer for power flow control applications" Journal of operation and automation in power engineering 2013.

[3] Hakan Acikgoz O, Fatih Kececioglu, Ahmet Gani, Ceyhun Yildiz, Mustafa Sekkeli "Optimal control and analysis of three phase electronic power transformer" World Conference on Technology, Innovation and Entrepreneurship Kilis Turkey 2015.

[4] Saurabh Chauhan "Motor torque calculations for electrical vehicles" INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH VOLUME 4, ISSUE 08, AUGUST 2015.