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Closed Loop Controlled Bridgeless PFC Boost Converter Fed Reverse Voltage MLI for High Power Applications

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Abstract

The objective of this paper is to design a closed loop controlled Bridgeless PFC Boost Converter followed by single phase seven-level Multi-level Inverter (MLI). High efficiency and unity power factor can be obtained by using this closed loop control Bridgeless PFC Boost Converter. Inverter used here is Reverse Voltage MLI (RV MLI). Since it has less number of switches and cost is less. In this, performance of the MLI has greatly increased and the THD reduced to 1%. This topology gives more output power. This system is also called as Double Conversion UPS. Since this gives more power. So it is used in High Voltage applications like Marine and industries. This project also proposes an Electric Vehicle (Electric Train) power conditioning system by using this closed loop controlled Bridgeless PFC Boost converter and three-phase seven-level Reverse Voltage Multi-level Inverter.

Keywords: Unity Power Factor, Power Factor Correction, Feed-forward control technique, Bridgeless Boost converter, Reverse Voltage Multi-level Inverter

1. Introduction

Multilevel inverters are used in high-voltage as well as high power applications. A new topology requires less numbers of switches and carrier signals when compared to other existing topologies [1]. This paper, deals with a reversing-voltage component to increase the multilevel inverter performance and multilevel inverter output by compensating the disadvantages mentioned. This topology requires less number of

components compared to existing inverters (particularly in higher levels) and it requires less carrier signals. Therefore, the overall cost and complexity of the multilevel inverter is greatly decreased particularly for higher output voltage levels. This paper [6], deals with PFC. A systematic review of bridgeless power factor correction (PFC) boost rectifiers is presented. Performance comparison between conventional bridge PFC boost rectifier and bridgeless PFC boost rectifier is performed. Loss analysis and efficiency evaluation for DCM/CCM boundary operations are provided. The electric vehicle power conditioning system and UPS usually consists of converter section and inverter section. Converter is used to convert ac input voltage to dc output voltage and the inverter is used to convert dc to ac output voltage. In general PFC Boost Converters are used to increase the output voltage and power factor. Multi-level Inverters are used to give dc output voltage. The proposed system consists of a double conversion UPS, where the first conversion stage is active Power Factor Correction (PFC) rectifier and the second conversion stage is Reverse Voltage Multi-level Inverter (RV MLI). PFC is performed by using closed loop controlled Bridgeless PFC converter which gives unity power factor. So the losses in the supply voltage get reduced and the output voltage of the system gets increased. In general, Multi-level Inverter (MLI) has many switches. To overcome this situation, single phase seven level Reverse Voltage MLI is used. This double conversion UPS is used in High power applications like Marine applications. This project also proposes an Electric vehicle (EV) power conditioning systems usually utilize a high-energy battery pack to store energy for the electric traction system. The high-energy battery pack is usually charged from a utility ac outlet. Energy conversion during the battery charging is performed by an ac to dc converter, which are used to charge the high-energy battery pack. It has front-end boost converter, which performs input power factor correction and alternate current to direct current conversion. PFC is used to improve the quality of the input current. AC/DC converter is usually fed with three phase seven level Reverse Voltage Multi-level Inverter (RV MLI) which is connected to an induction motor. This system gives more power. So this can be used in electric train power conditioning system.

2. Closed loop controlled Bridgeless PFC Boost converter and RV MLI fed single phase load

Closed loop controlled Bridgeless PFC boost converter and Reverse Voltage MLI has of ac to dc converter and dc to ac inverter. It gives high output power. So it is also called Double conversion UPS. So it can be used in marine application.

Fig 1 shows block diagram of closed loop Bridgeless PFC Boost converter and Reverse Voltage Multi-level Inverter fed single phase load. In this ac supply is given to Bridgeless PFC Boost Converter. Conventional PFC Boost Converter suffers from high conduction losses in the input rectifier bridge and it has poor power factor and less output voltage.

High efficiency and unity power factor can be achieved by using this Bridgeless PFC Boost Converter. Unity Power Factor (UPF) can be obtained by using this closed loop. So here feed forward and feed- back unit is used to achieve UPF. Here, inverter

used is Reverse Voltage Multi-level Inverter (RV MLI). It has two units. Level generation unit and Polarity generation unit. Level generation unit is used to produce required output voltage levels with out polarity. Polarity generation unit is used to generate output voltage with positive or negative polarity. This MLI has less number of switches and cost is less. By using this closed loop, performance of the Multi-level Inverter has greatly increased and THD will reduced to 1%. This topology gives more power. RV MLI is fed to single phase load. It can be R load or RL load.

Fig 2 shows Circuit diagram of closed loop controlled Bridgeless PFC Boost converter and RV MLI fed single phase load which is used in High power Marine applications.

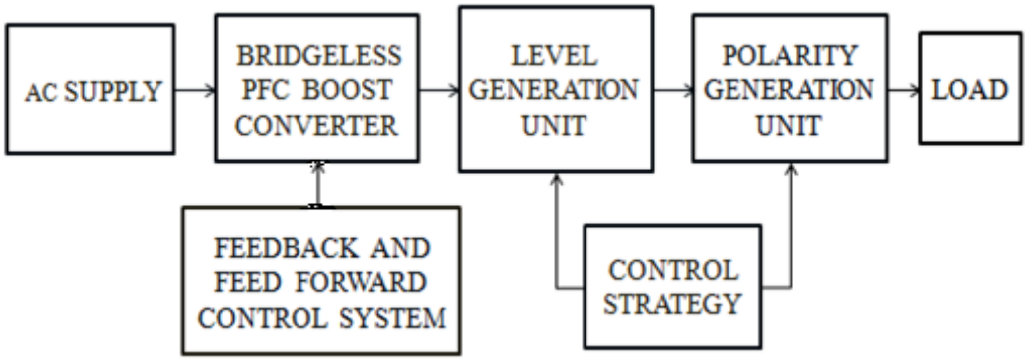

Fig. 1: Block diagram of closed loop Bridgeless PFC Boost converter and Reverse Voltage Multi-level Inverter fed single phase load

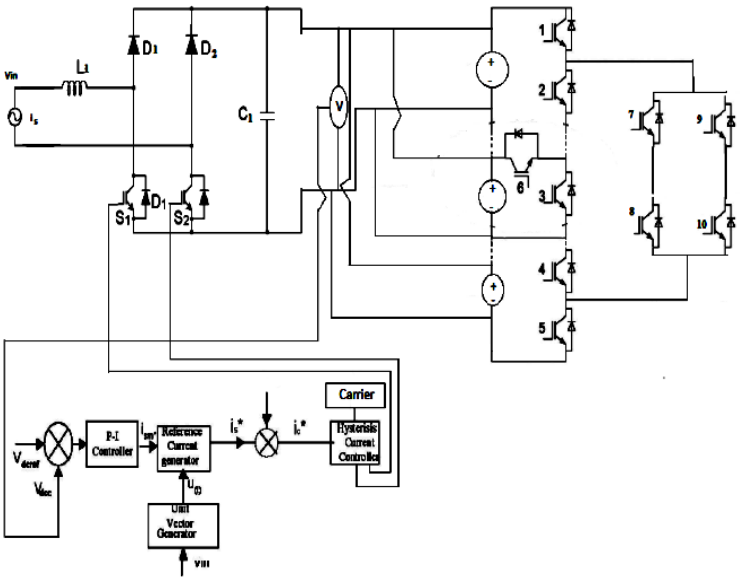

Fig. 2: Circuit diagram of closed loop controlled Bridgeless PFC Boost converter and RV MLI fed single phase load

I. Block diagram of an Electric train power conditioning system

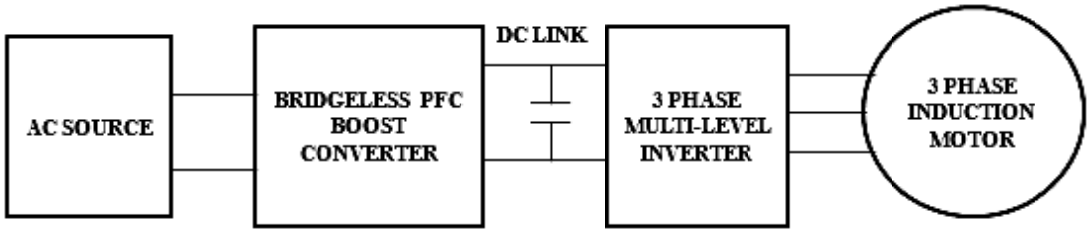

Fig. 3: Block diagram of an Electric Train Power Conditioning system

Fig 3 shows block diagram of an Electric Vehicle like Electric Train Power conditioning system. In this, single phase closed loop controlled Bridgeless PFC Boost converter is connected to three phase Reverse Voltage MLI which is fed to three phase induction motor. Capacitor is used to storge energy. By using closed loop controlled Bridgeless PFC Boost converter, performance of the RV MLI has greatly increased. THD get reduced and output voltage get increased.

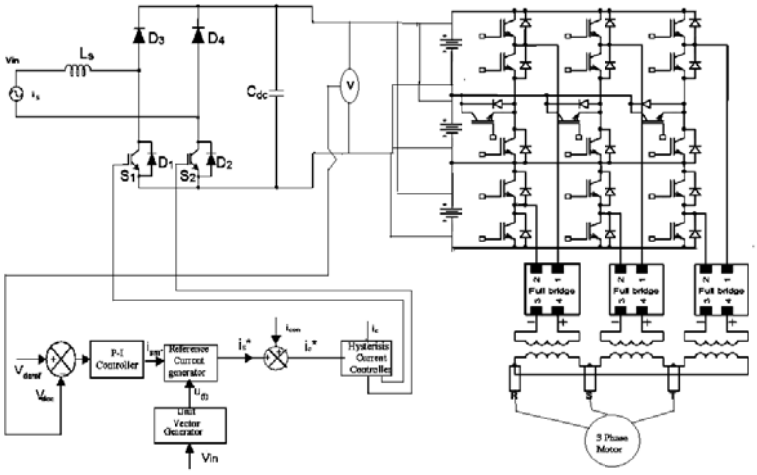

Fig. 4: Circuit diagram of an Electric Train Power conditioning system

Fig 4 shows circuit diagram of an Electric Vehicle like Electric Train Power conditioning system which is used in Electric Train. In this, three phase Reverse Voltage Multi-level Invver is connected with closed loop controlled Bridgeless PFC Boost converter. Output of the three phase RV MLI is connected to the three phase load. Here, three phase induction motor is used.

3. Simulation Results

Closed loop controlled Bridgeless PFC Boost Converter fed Reverse Voltage MLI input voltage is 250V ac. Converter gives 520V dc output then it is symmetrically

divided into MLI. This gives 1500V ac output which is used for High Power Applications. This circuit gives Unity Power Factor at the input and the output Power Factor is 0.9949.

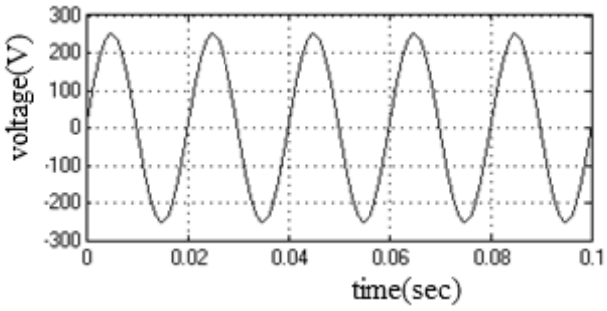

Fig. 5: Input voltage waveform

Fig.5 shows input voltage waveform of Conventional Bridge PFC Boost Converter. Here, input voltage is 250Vrms.

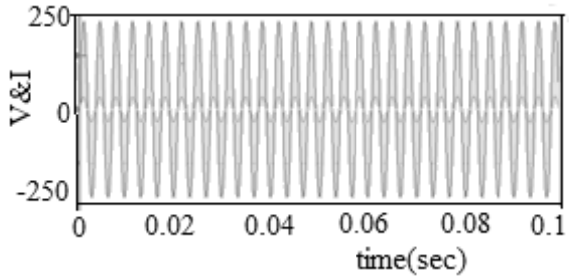

Fig. 6: Unity power factor at the supply

Fig. 6 Shows that input voltage and current are inphase. So power factor is unity at the supply side.

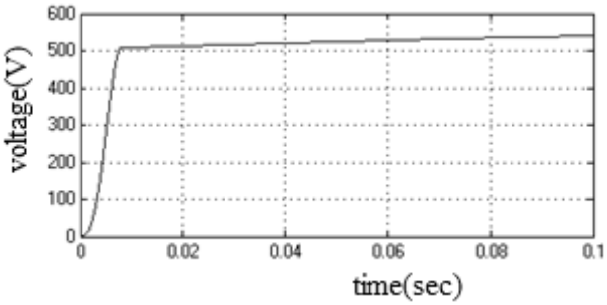

Fig. 7: Output Voltage waveform

Fig. 7 shows output voltage waveform of Closed loop controlled Bridgeless PFC Boost Converter. DC output voltage obtained is 520V.

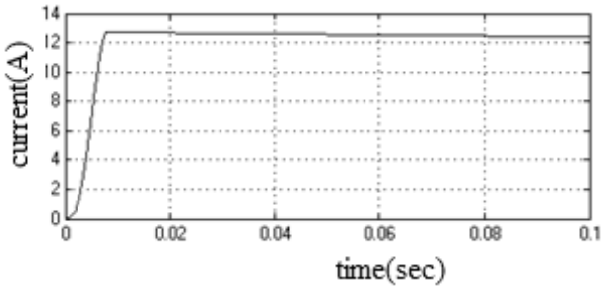

Fig. 8: Output Current waveform

Fig. 8 shows output current waveform of Closed loop controlled Bridgeless PFC Boost Converter. DC output current is 13A.

Tab.1: Specifications adopted for the simulated single phase circuit

Parameters	**Values**
Converter ac input voltage	250V
DC output voltage	520V
Inverter output voltage	1500V
Inverter output current	15A
V_{rms}	1060.8V
I_{rms}	10.6V
Power	11.24KW

Various parameters used in controlled Bridgeless PFC Boost converter and RV MLI fed single phase load is shown in table 1 Single phase closed loop controlled bridgeless PFC Boost converter fed RV MLI gives more power. Its output power rating is 11.24KW.

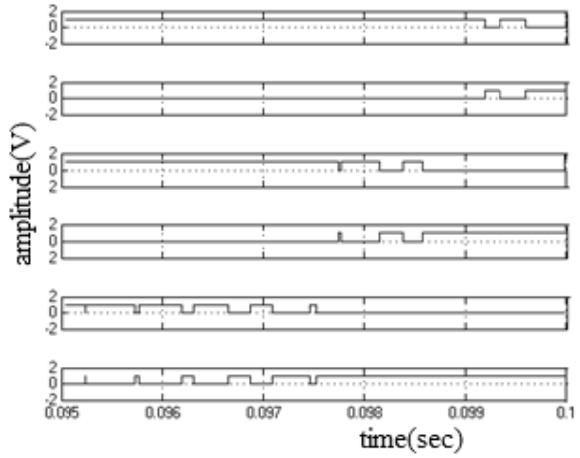

Fig. 9: Gate signals for high frequency switches

The resulting PWM waveforms for driving the high frequency switches in the level generation part are illustrated for one complete cycle in Fig. 9. These switching signals are given to six high frequency switches which are used to generate output voltage with required levels.

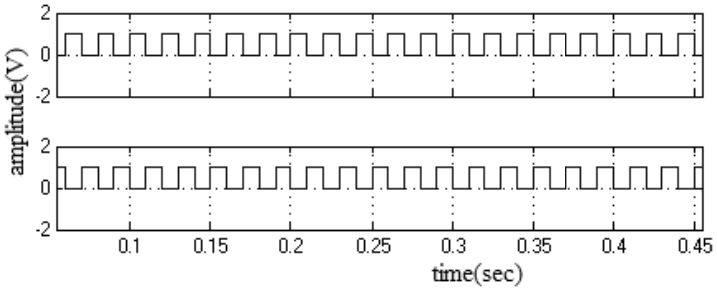

Fig. 10: Gate signals for low frequency switches

Gate signals for low frequency switches are shown in fig 10. These switching signals are given to four low frequency switches which are used to generate output voltage with required polarity.

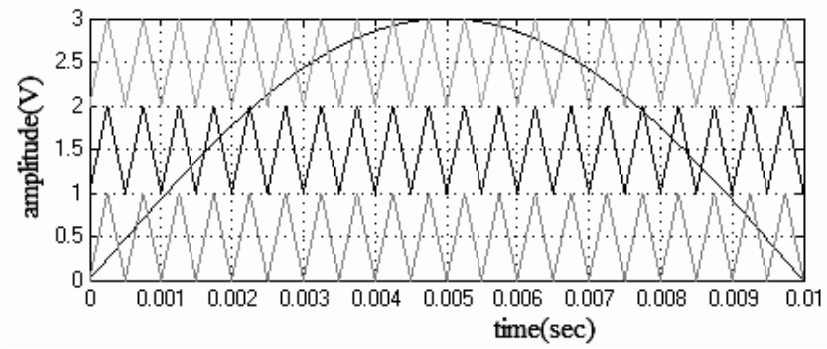

Fig. 11: PDPWM waveform

Fig. 11 shows PDPWM waveform of RV MLI. Modulating signal is sine wave form and the triangular waveform is carrier signal.

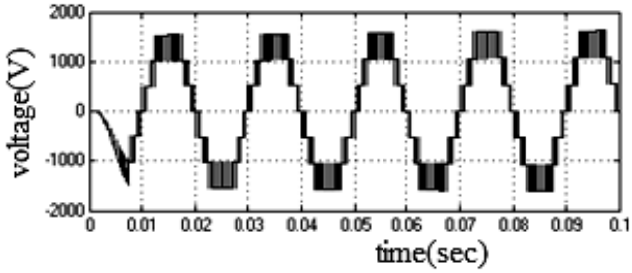

Fig. 12: Seven level output waveform

Fig. 12 shows seven level output voltage waveform of Reverse Voltage Multi-level Inverter. In this, output voltage is 1500V.

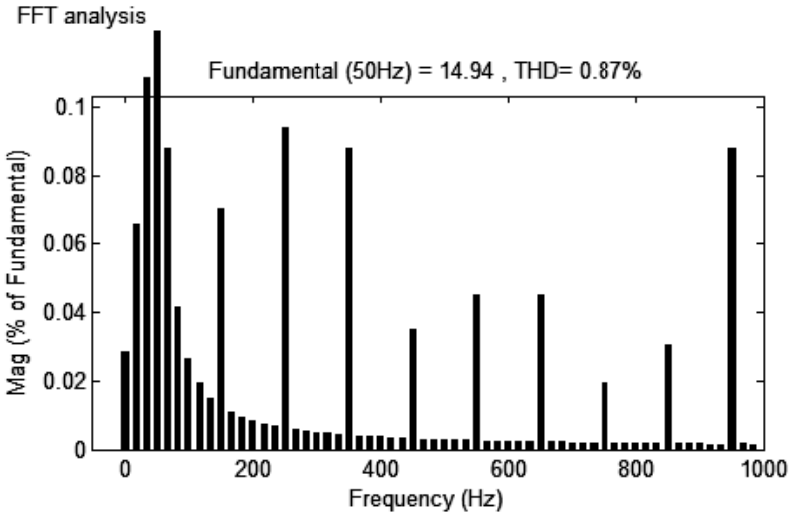

Fig. 13: output Current Distortion in MATLAB

Output Current Distortion through matlab is 0.87%.

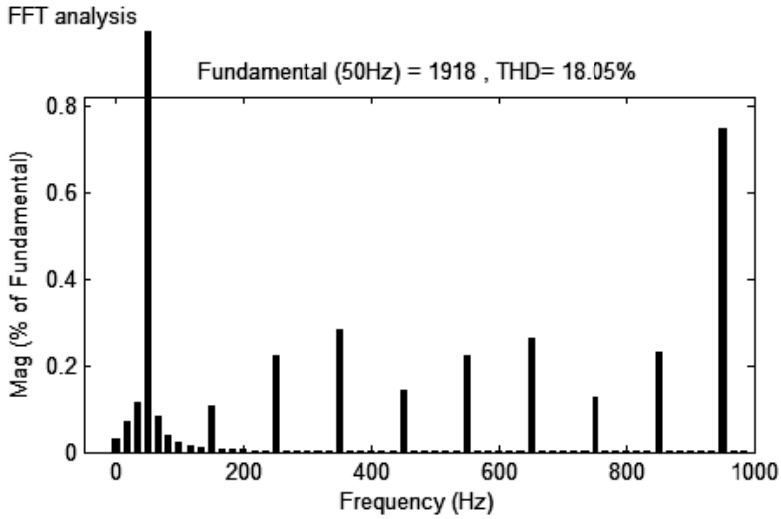

Fig. 14: Output Voltage Distortion in MATLAB

Total Harmonic Distortion at the output voltage through matlab is 18.05%

2144 HP, 50 Hz 1500 rpm induction motor is used in closed loop controlled Bridgeless PFC Boost converter and three phase seven level Reverse Voltage MLI fed three phase induction motor for Electric Vehicle like Electric train power conditioning system.Various parameters like motor speed, electro magnetic torque and stator current is measured.

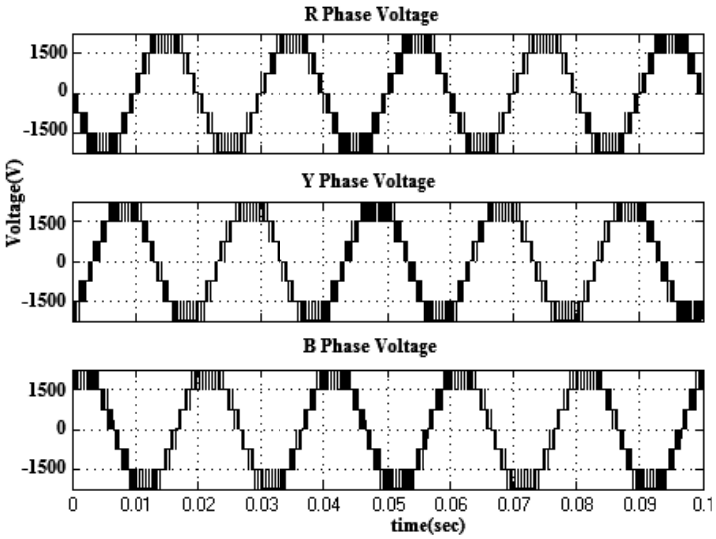

Fig. 15: Three phase seven level RV MLI output

Fig 15 shows three phase seven level Reverse Voltage MLI output.

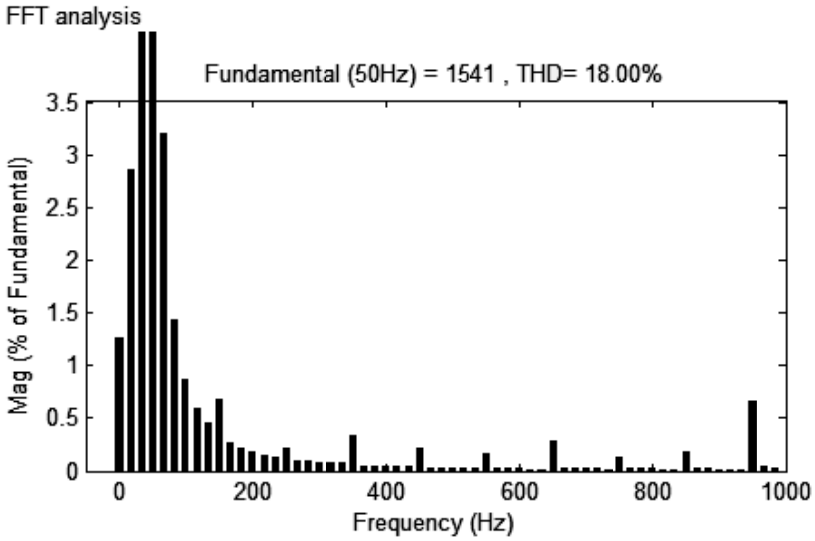

Fig. 16: Output Voltage Harmonic Distortion

Fig 16 shows output Voltage Harmonic Distortion through matlab which is 18.00%.

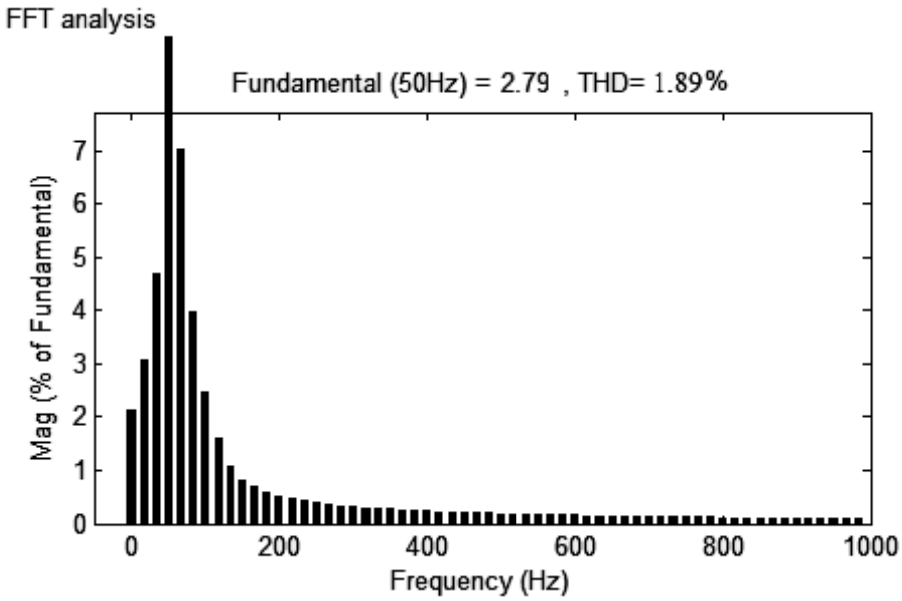

Fig. 17: Output Current Harmonic Distortion

Fig 17 shows output Current Harmonic Distortion. Output Current Harmonic Distortion through matlab is 1.89%.

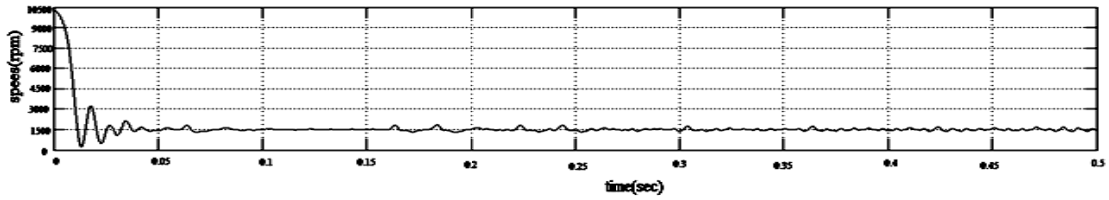

Fig. 18: Waveform of speed

Fig 18 shows speed of the motor by using matlab. Here, speed is 1500rpm.

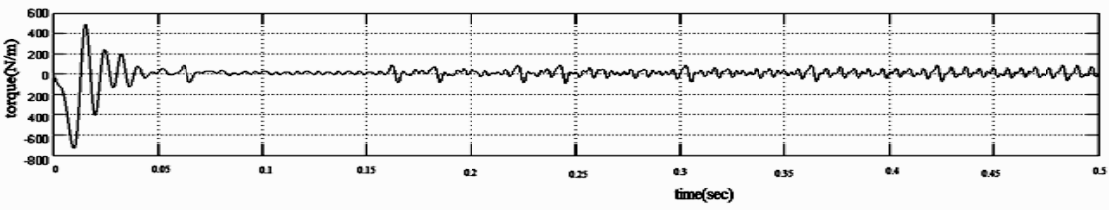

Fig. 19: Electro magnetic torque Waveform

Fig 19 shows waveform of electro magnetic torque.

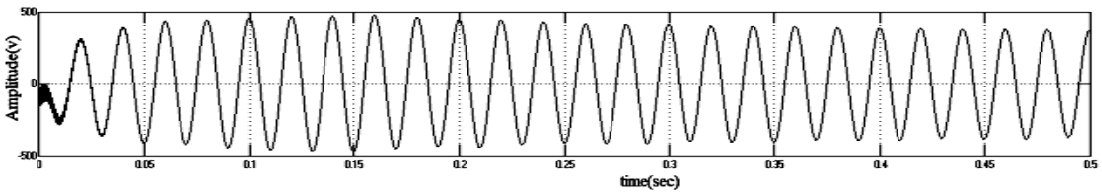

Fig. 20: stator current waveform

Stator current waveform by using matlab is shown in fig 20.

Tab.2: Specifications adopted for the simulated three phase circuit

Parameters	**Values**
Voltage	3000V
Current	309A
Power	1600KW
Horse Power	2144HP
Frequency	50Hz
Stator resistance	0.02155ohm
Rotor resistance	0.01231ohm
Mutual Inductance	0.01038H
Speed	15000rpm

Induction motor characteristics is shown in table 2. Power rating of the RV MLI is 1600KW. So 2144 HP induction motor is used. Induction motor frequency range is 50 Hz and the speed of the motor is 1500 rpm.

4. Conclusion

Thus the double conversion UPS and Electric Vehicle like Electric train power conditioning system is designed by using closed loop controlled Bridgeless PFC Boost converter and Reverse Voltage Multi-level Inverter. Double conversion UPS gives 18KVA power which can be used in marine applications. Electric train power conditioning system gives 3000KVA power. Unity Power Factor at the supply side is obtained by closed loop Bridgeless PFC Boost converter. So the Multi-level Inverter output has greatly increased. Voltage drop has greatly reduced. This system gives less THD and it is low cost and simple to implement.

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