ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

MULTI-PULSE AC-DC CONVERTERS FOR POWER QUALITY IMPROVEMENT IN DC DRIVES

Dr. V.S. Vakula*[1], Ms. R. Sandhya Rani[2] & Mrs V.V. VijethaInti[3]
[*1]Assistant Professor & HOD, Department of EEE, UCEV, JNTUK, Vizianagaram, Andhra Pradesh, India
[2]PG Student, Department of EEE, UCEV, JNTUK, Vizianagaram, Andhra Pradesh, India
[3]Research Scholar, Department of EEE, JNTU Kakinada, Andhra Pradesh, India

DOI: 10.5281/zenodo.1345617

ABSTRACT

This article presents the design, modeling and simulation of three-phase multi-pulseAC–DC converters (MPC)for the improvement of power quality by the elimination of harmonics in ac mains and ripples in dc output.Multi pulse converters are operated with DC motors and run at different conditions to obtain output with less harmonic distortion.Total harmonic distortion is calculated by FFT analysis.With the help of MATLAB/Simulink modelling, simulation and digital implementation has been done for power quality improvement in DC drives using multi pulse converters.

Keywords: AC–DC converters, DC motor, Multi pulse converter, Harmonic reduction, power quality, rectifiers.

I. INRTODUCTION

In converter circuits generally semiconductor switching devises are used which generates harmonics voltages and currents. Three phase ac-dc conversion of electric power are employed in the applications such as Adjustable speed drives (ASDs), Highvoltage dc (HVDC) transmission, Electro-chemical processes such as electroplating, Telecommunicationpower supplies, batterycharging, uninterruptible power supplies (UPS), High-capacitymagnet power supplies, high-power induction heatingequipment'sand converters for renewable energy conversion systems The major contributor to power system harmonics and consequences are diode bridge rectifiers. Generally converters are fed from three phase ac supply and have power quality problems like harmonics injection causes ac voltage distortion, rippled dc voltages and poor power factor. Various methods are used to minimize the problems in ac-dc converters. The DC motor drives are used in industries for converting electrical energy to mechanical energy. The advantage of choosing DC motors over AC components is because of their speed control.The main objective of the paper is to provide the power to consumer/industry load with proper sinusoidal wave of the voltage and current with fixed frequency and magnitude with minimized Total harmonic distortion,according to IEEE standards THD must be less than 5%. Power quality improvement can be achieved in 3-phase ac-dc converters by using multi-pulse converters. The converters are strong, simple, rough and efficient. The auto transformer based arrangement are more economical due to reduced magnetic losses. Different configurations from 12 pulse, controlled 24 pulse and controlled 48 pulse based ac-dc converters have been reported in literature.In literature several publications are reviewed and found on reduction on total harmonic distortion of power systems which are discussed in below section 2. This paper is divided into five sections. Starting with Section 1 gives introduction. Section gives detailed view of literature on reducing THD. Section 3 discussed about modeling of uncontrolled 12 pulseand controlled 12 pulse converter, controlled 24 pulse converter, controlled 48 pulse converter. Section 4 presents digital implementation, THD results and discussion. Section 5 concludes this paper.

II. LITERATURE REVIEW

The main objective of the research is to lessen harmonics in converters. Many methods are implemented and developed by the researches based on the needs and suitability. Selective harmonic elimination with pulse width modulation(SHEPWM) or programmed-PWM. This method calculates the switching instants of the devices in order to satisfy certain criteria. SHE method gives best outputs among PWM methods with low switching frequency to fundamental frequency ratios, direct control over output waveform harmonics.

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

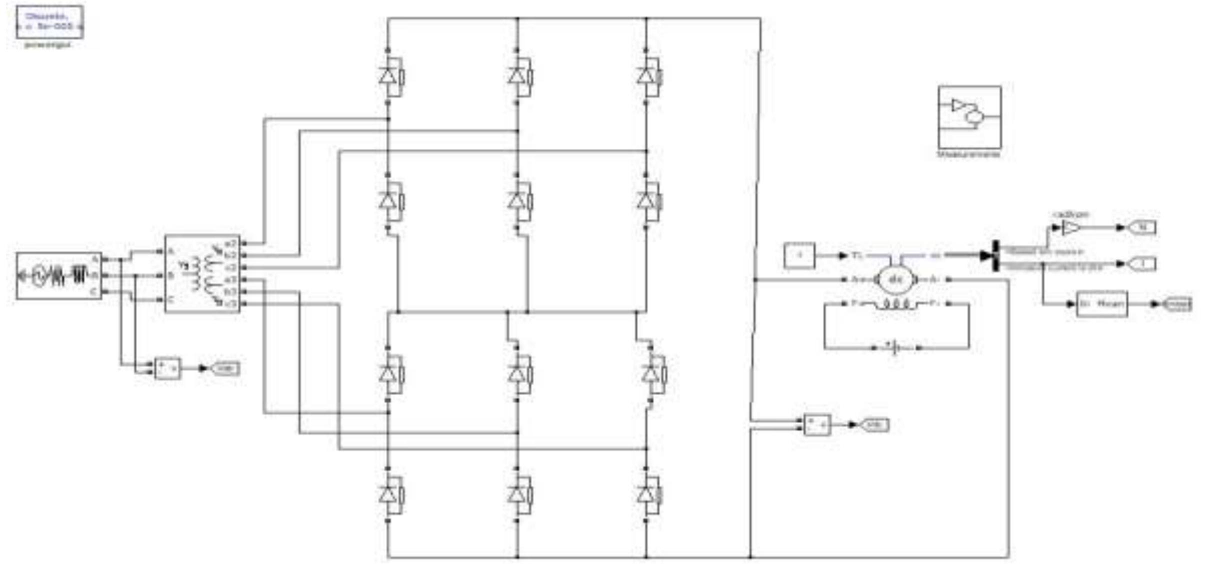


Fig.1. Uncontrolled 12 Pulse Model MATLAB/Simulink

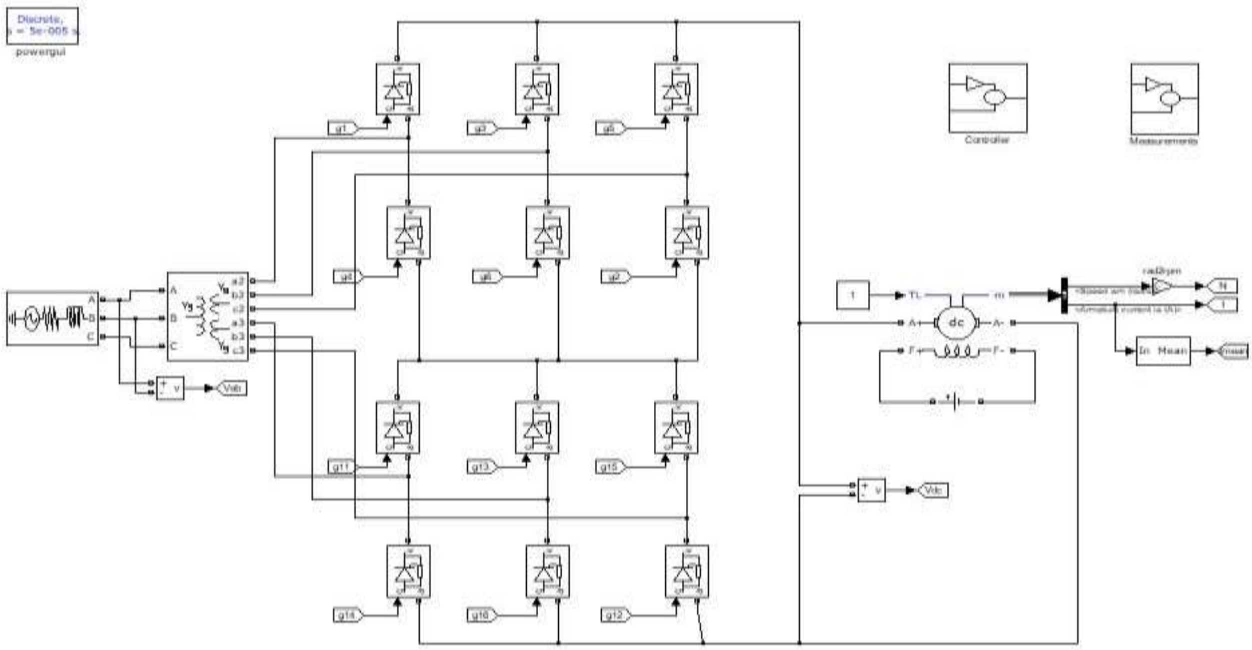


Fig. 2. Controlled 12 Pulse Model In MATLAB/Simulink

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

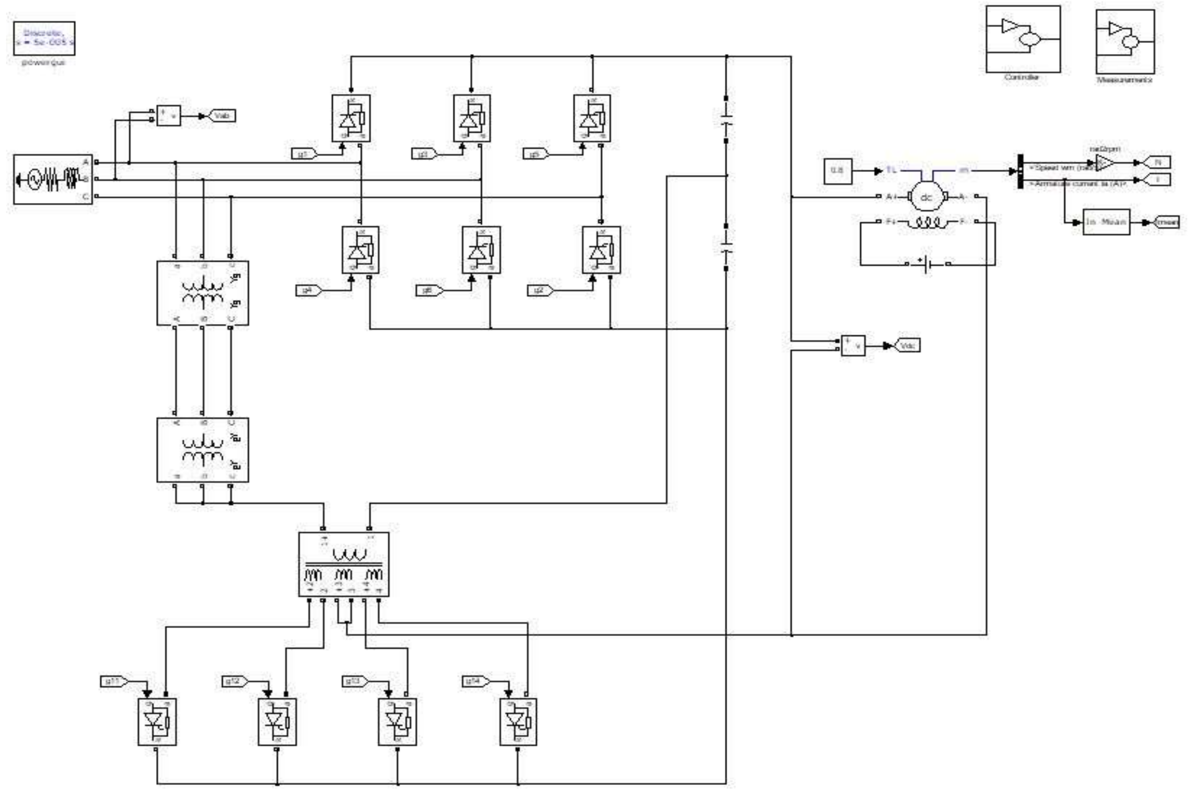


Fig. 3.Controlled 24 Pulse Model InMATLAB/Simulink

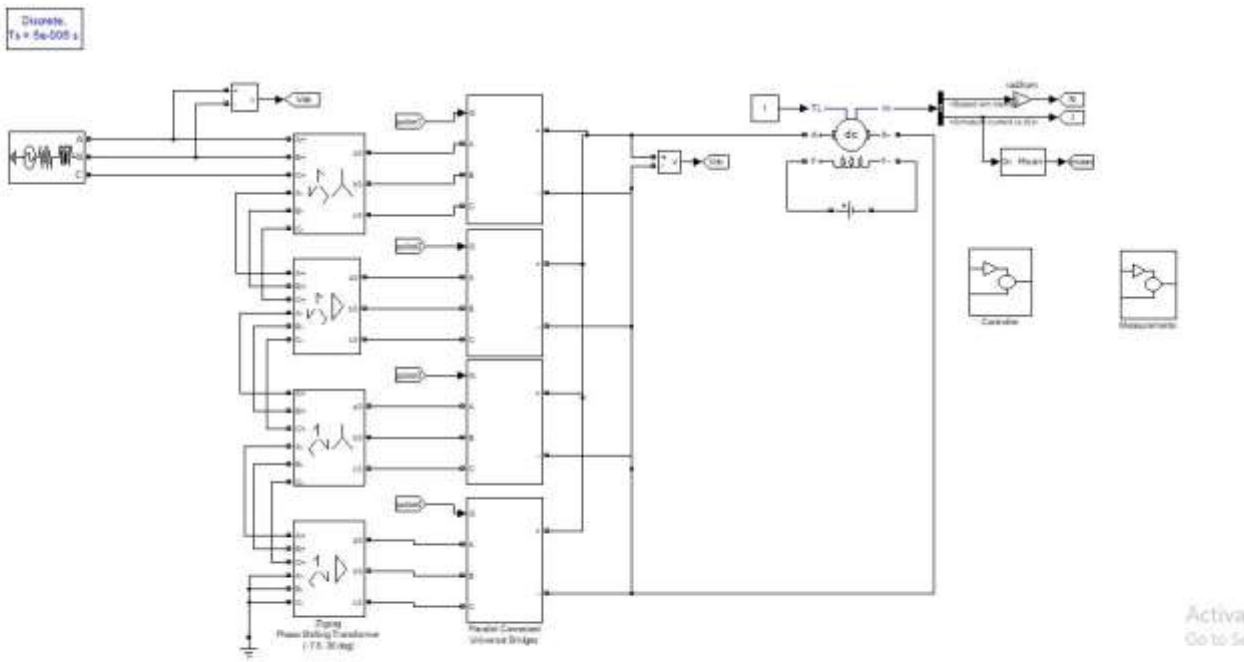


Fig. 4.Controlled 48 Pulse Model In MATLAB/Simulink

Multi pulse converters are designed to matured level for ac-dc with reduced harmonic currents and reactive power burden, fluctuations at input ac mains and reduced rippled dc output with unidirectional and bidirectional flow for feeding loads for few kilowatts to several megawatts. In some applications power system is fed from source to ac loads, so these multi pulse converters are developed using diode rectifiers and transformers circuit configurations starting with 12 pulse uncontrolled and controlled, 24 pulse controlled, 48 pulse controlled and higher number of pulses to maintain low total harmonic distortion of ac mains current and low ripple dc output. Modeling of multi pulse converterspresents that in adjustable speed DC drives consists f a rectifier section in which AC source voltage is converted into DC voltage by rectifier circuit. The output of DC voltage is fed to adjustable speed DC motor.The diode rectifier has non liner load characteristics causing harmonics in output voltages and currents.

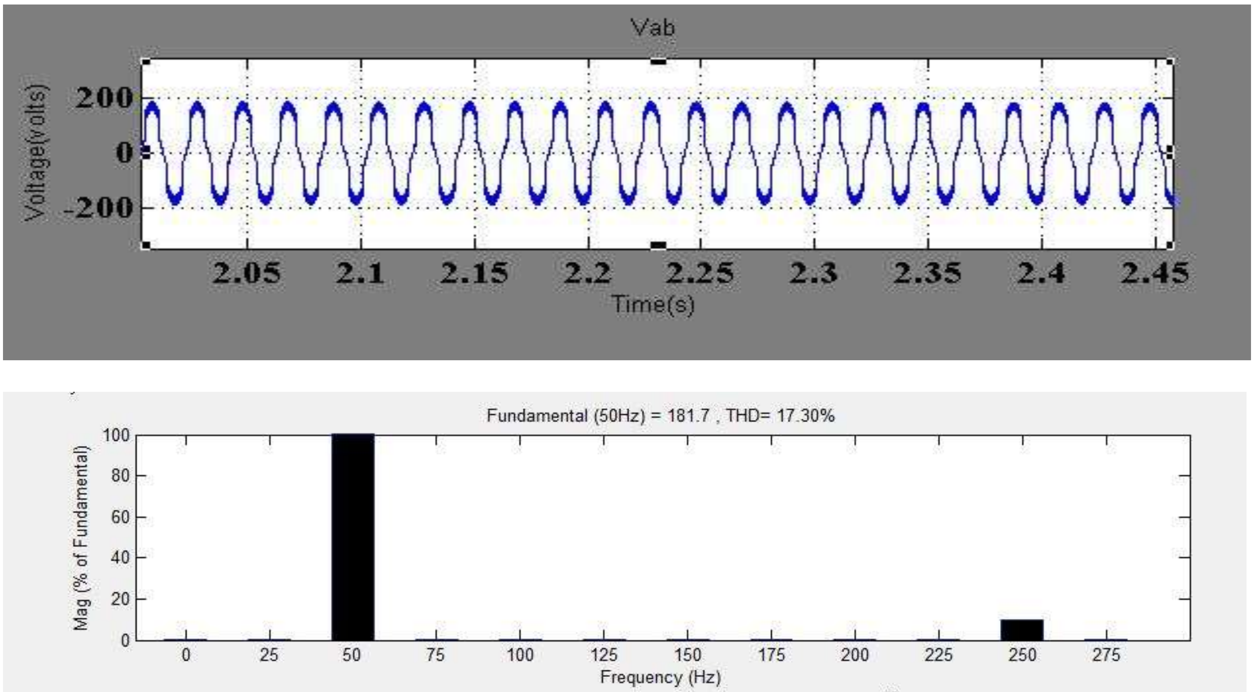


Fig.5. Vab line voltage and its THD = 17.30%, for 12 pulse uncontrolled rectifier

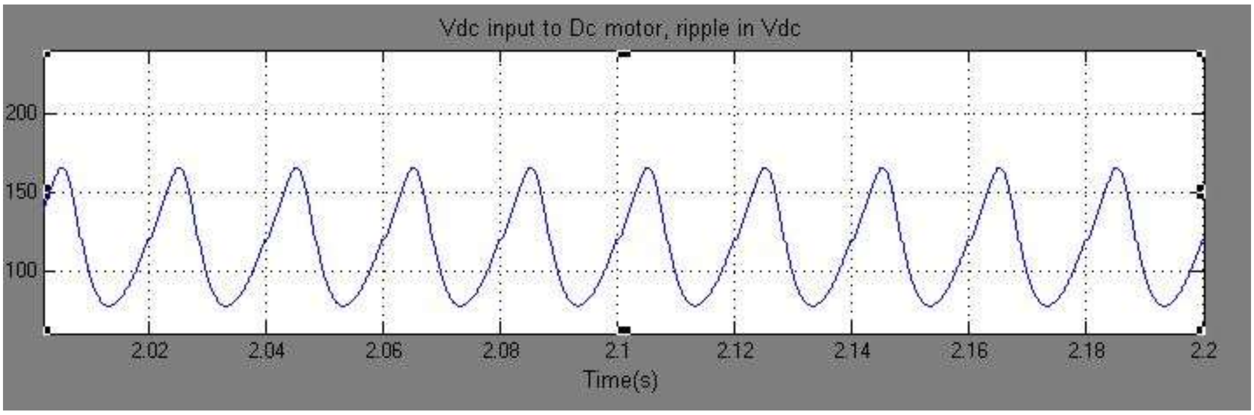


Fig. 6. Voltage across DC input, ripple = 165-75=90V

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

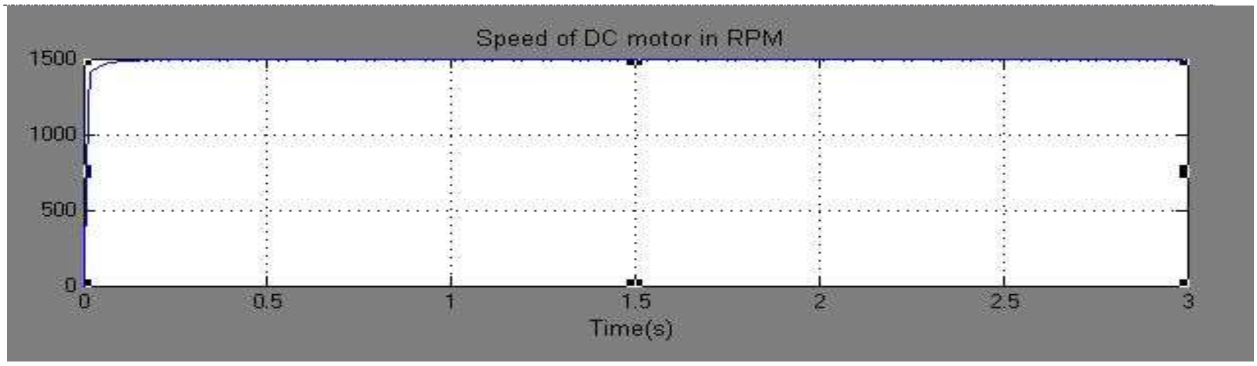


Fig. 7. Speed response of DC motor, at 88% rated speed.

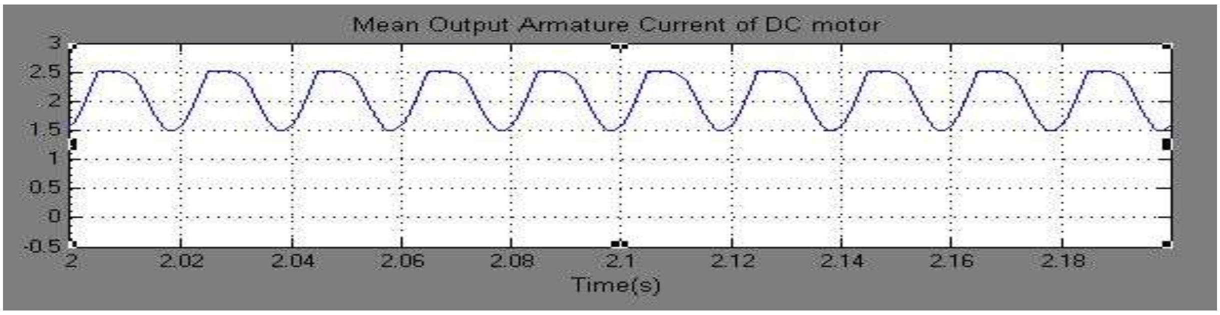
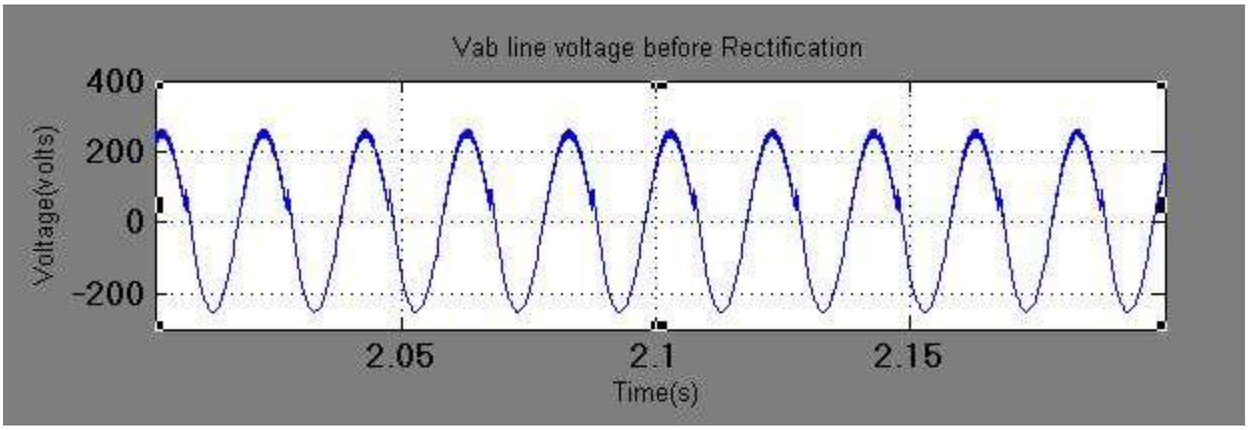


Fig. 8. Output DC Current ripple 2.6-1.2=1.4A

After using the PI controller the output voltage, current, speed and total harmonic distortion values are better compared with uncontrolled 12 pulse model. The controller reduced the harmonic content and errors in DC motor output. To mitigate the small fluctuations in controlled 12 pulse converter, a controlled 24 pulse converter is further implemented. The out puts obtained are pure sinusoidal with THD 2%, low currentand voltage values.



ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

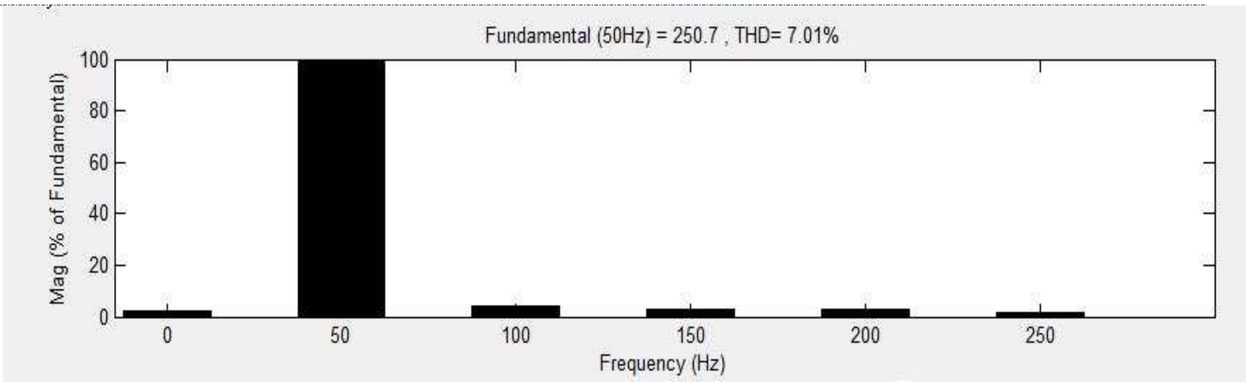


Fig. 9.Vab line voltage and its THD = 7.01%, for 12 pulse controlled rectifier.

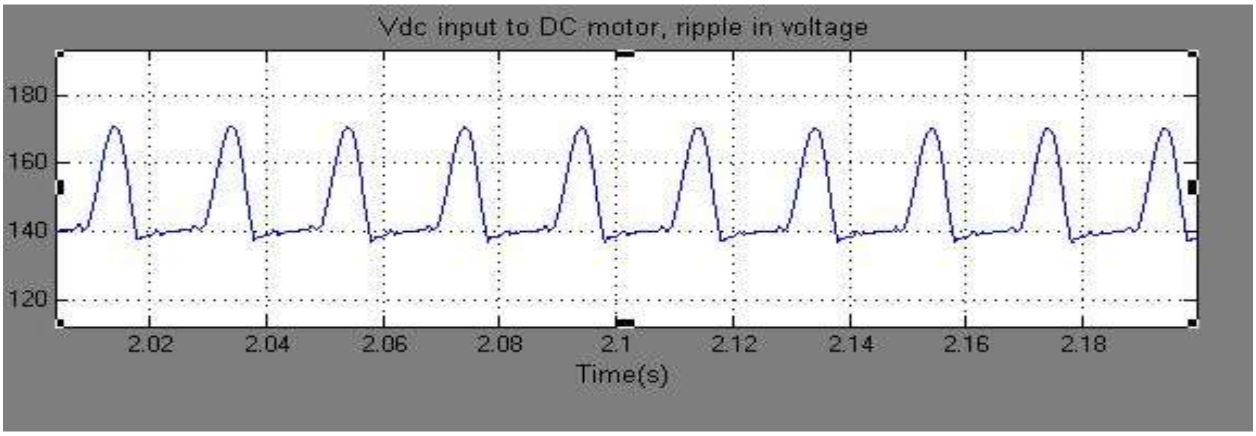


Fig. 10. Voltage across DC input, Ripple = 175-137=38V.

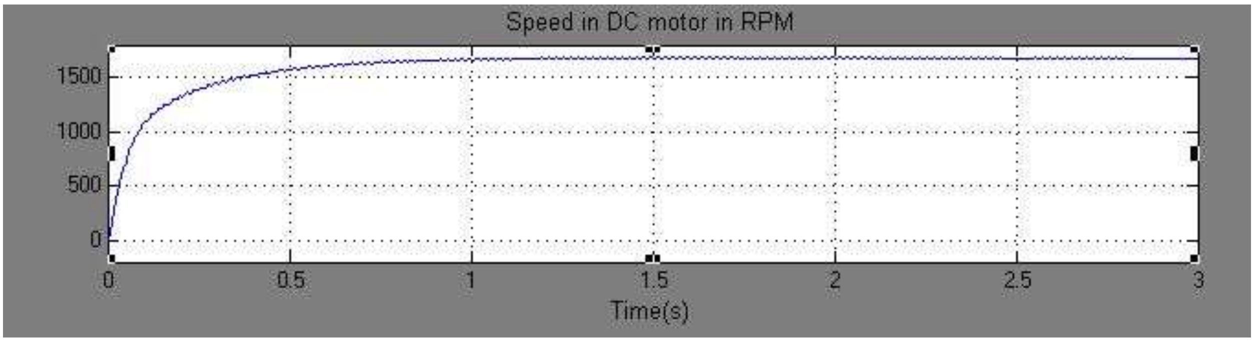


Fig.11. Speed response of DC motor, at 100% of rated speed.

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

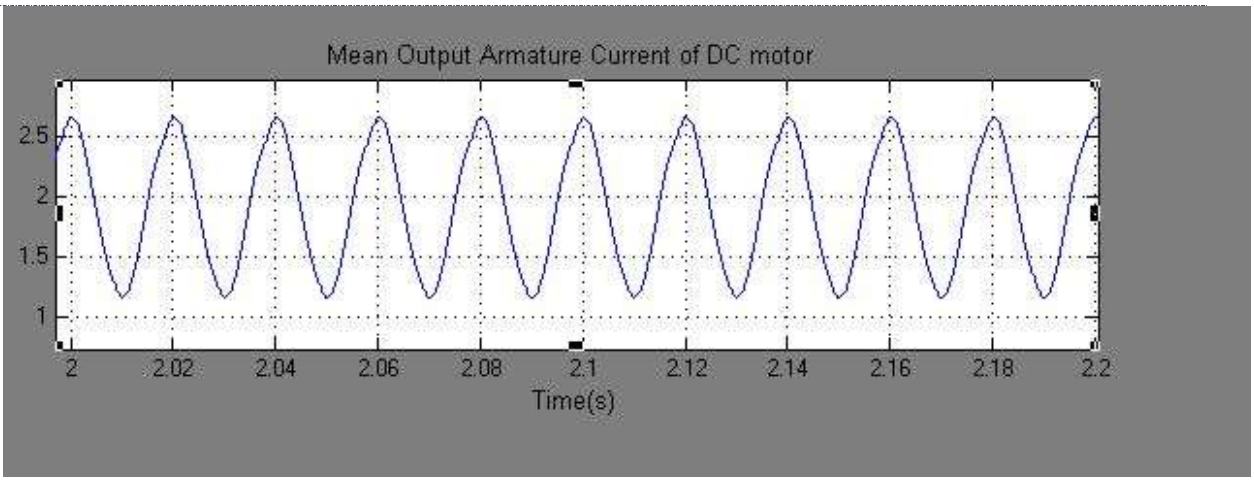


Fig. 12. Output DC Current ripple(2.6-1.3=1.3A).

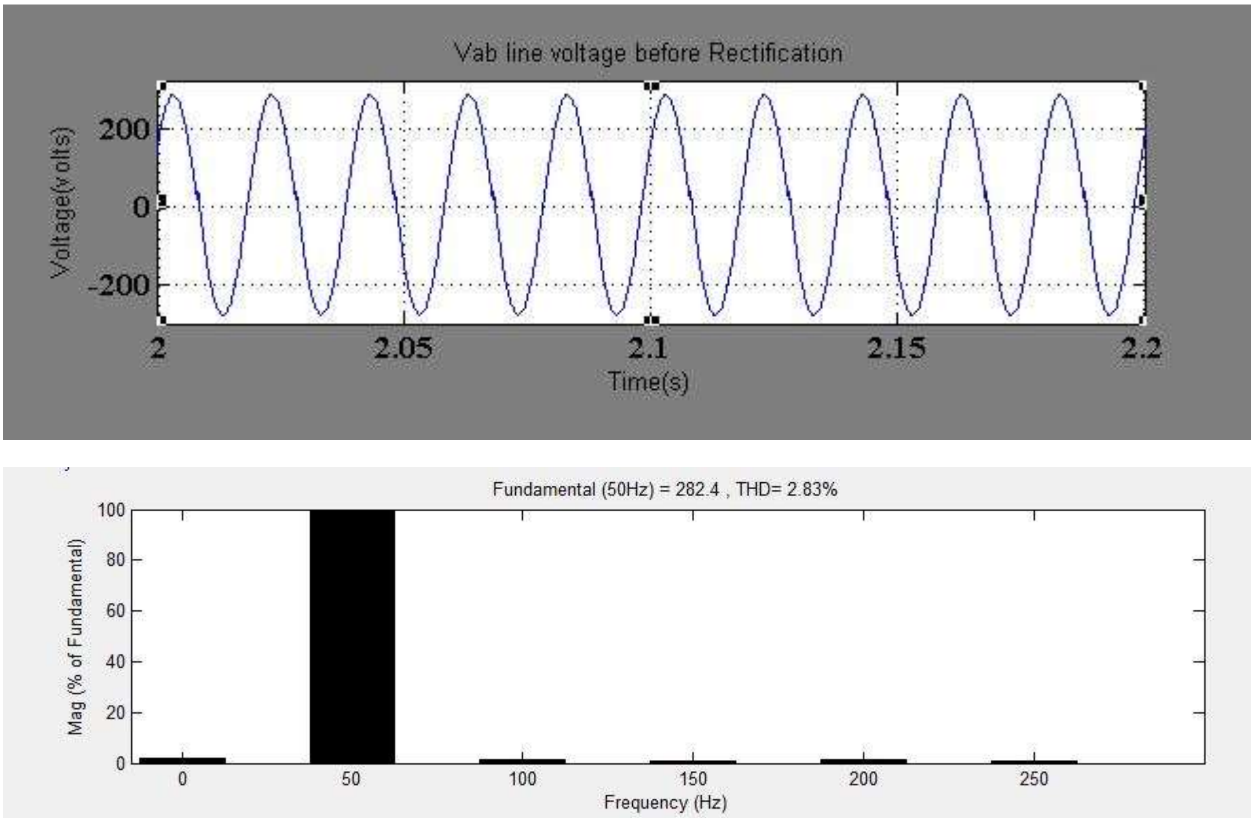


***Fig. 13.Vab line voltage and its THD =2.83%, for 24 pulse controlled rectifier*.**

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

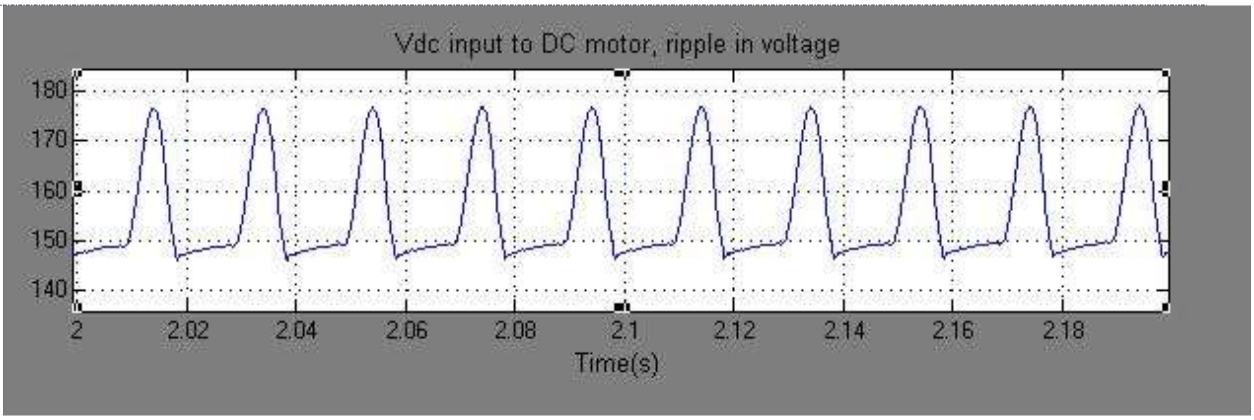


Fig. 14 Voltage across DC input, Ripple = 177-147=30V.

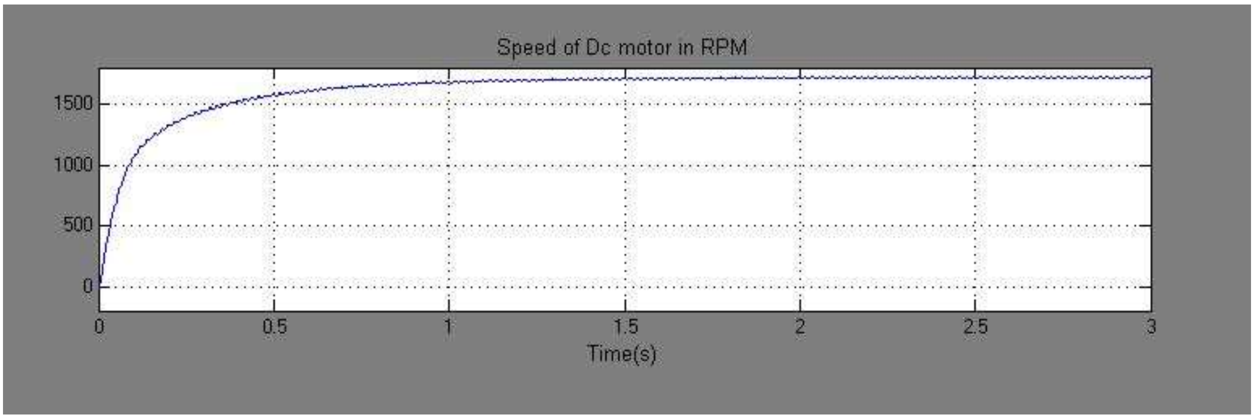


Fig. 15. Speed response of DC motor, at 100% rated speed.

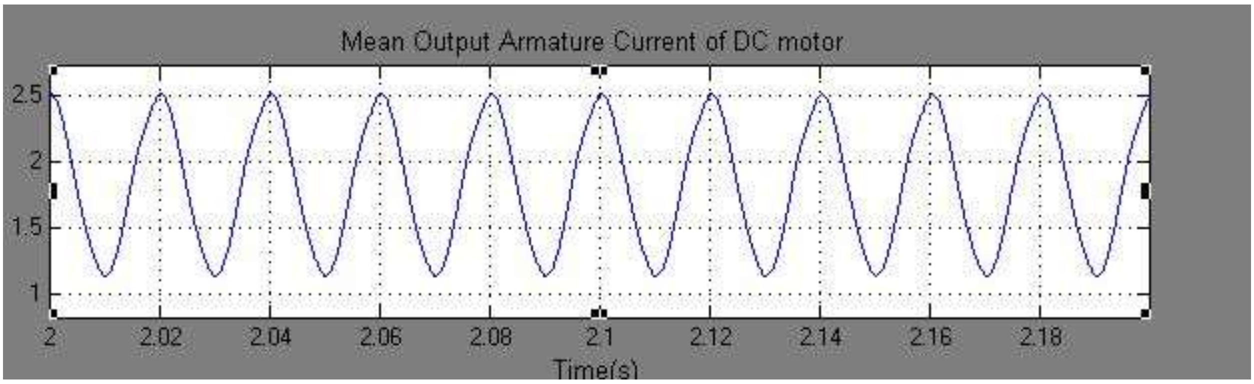


Fig. 16. Output DC ripple Current ripple(2.5-1.4=1.2A).

III. MODELLING OF MULTI-PULSE CONVERTER

The modeling of different configurations of converters has been done in MATLAB/Simulink without and with controller method for 12 pulse converter. To minimize the harmonics in 12 pulse model 24 pulse converter and 48 pulse converter are designed for obtaining quality results.

In uncontrolled method a three phase source is used to fed power to three winding transformer. The three winding transformer is used in which input is given on primary side and other two windings for rectifiers on secondary side. The rectified output is fed into DC motor having the following ratings.

Power = 5HP=3.73kW
Voltage = 240V
Speed = 1750rpm

Field voltage =300V
Armature Resistance = 2.581Ω
Armature Inductance = 0.028 Ω
Filed Resistance = 281.3 Ω
Filed Inductance = 156 Ω
Field Armature Mutual Inductance =0.9483 Ω
Total Inertia = 0.02215 kg m^2
Viscous Friction Coefficient (B_m) = 0.002953 N m s
Friction Torque Coefficient (T_f) = 0.5161 N m

The 48 pulse converter is modeled by using eight 6-pulse converters phase shifted each other by 7.5 degrees. All the eight transformer primaries are to be connected in series. Fig. 4 shows the arrangement of 48 pulse controlled converter in which there are two groups of positive and negative. Positive group consists of four six pulse converters and similarly negative group consists another four six pulse converter.

IV. RESULTS AND DISCUSSION

The results obtained are discussed below. The Simulink model is designed.In multi pulse controlled converter method, the controller consists of two loops. First one is outer speed loop in which a set reference speed is compared with a real speed of the DC motor. This generates an error signal by comparing set speed=1700 and real speed=1750 and then error is passed through PI controller to generate a reference current. This reference current will be the input for inner current loop, which helps in keeping the current limit of electrical machines. This error signal is again passed through a PI controller to generate switching signals.

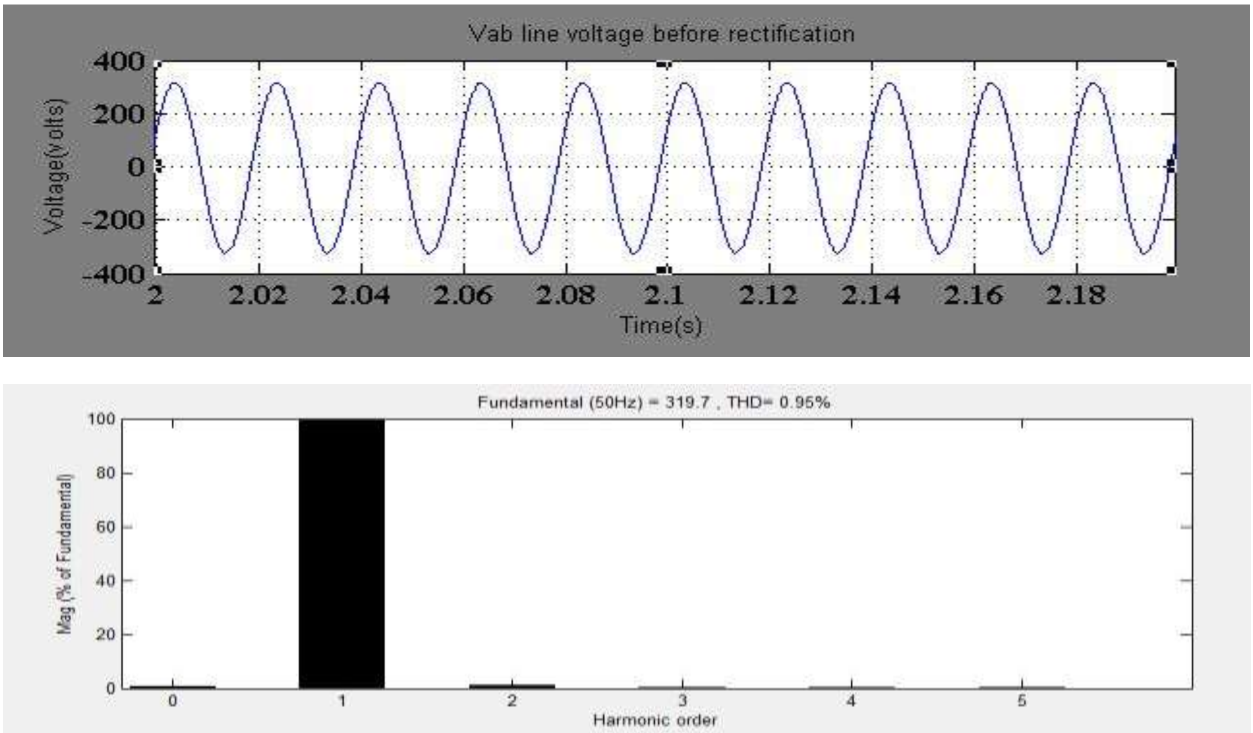


Fig. 17.Vab line voltage and its THD = 0.95%, for 48 pulse controlled rectifier.

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

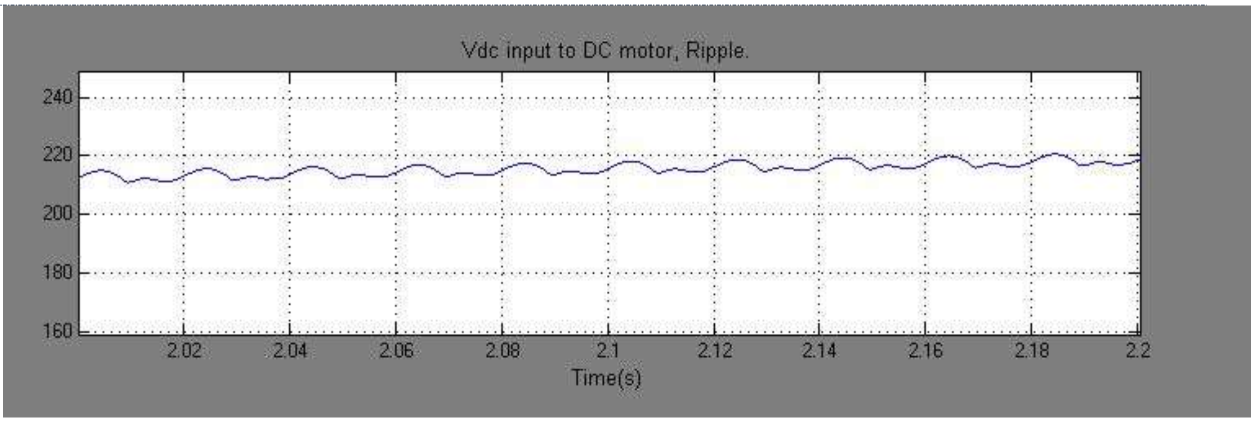


Fig. 18. Voltage across DC input, Ripple = 179-159= 20V

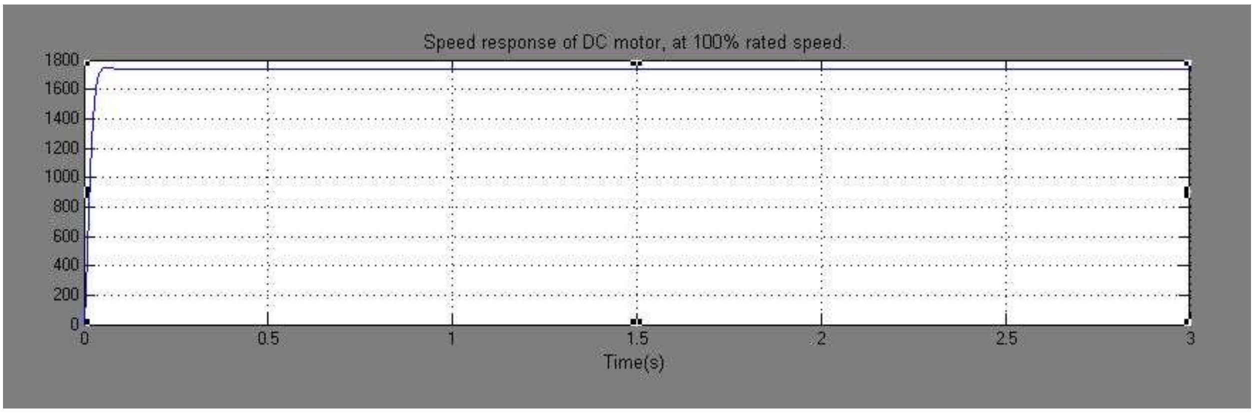


Fig.19. Speed response of DC motor, at 100% rated speed.

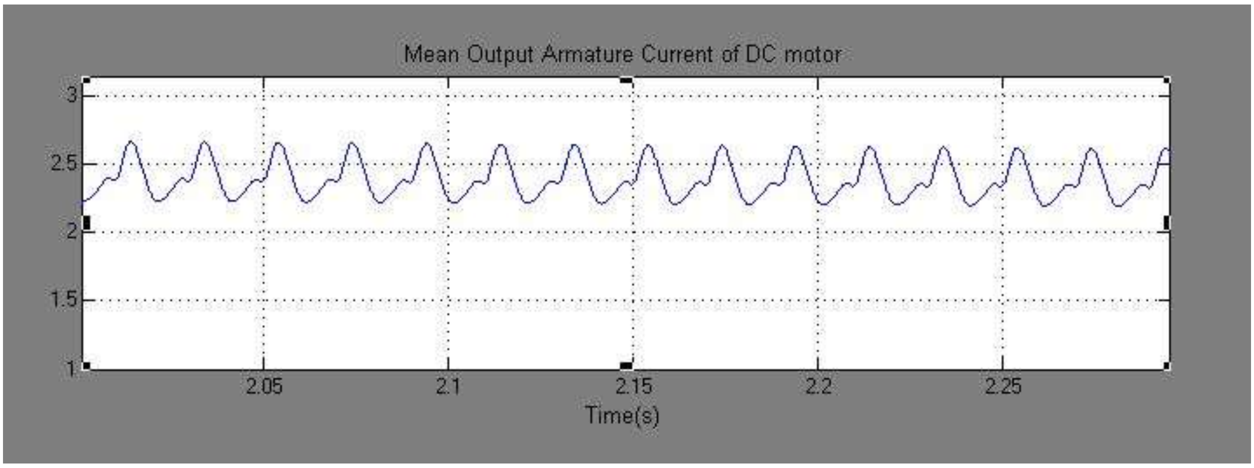


Fig. 20. Output DC Current ripple (2.65-2.25=0.40A)

The results of uncontrolled 12 pulse rectifier was shown in Figs. 5-8. fig5 shows the V_{ab} line voltage before rectification with total harmonic distortion (THD) = 17.30%. Total Harmonic Distortion is calculated by FFT(fast fourier transform) analysis. Fig.7 shows speed response of a DC motor which is fed with rectified DC output of AC power. Here the motor is operated at 88% of rated speed. As this model is run without controller in which no speed reference and current reference is taken. In this process the settling time is nearly 4.3s. Fig6,8 shows dc side voltage and current outputs. The Armature current is 1.4A and voltage ripple is 90V which seems to be very high. So to improve the speed response, THD , output ripple in voltage and current the 12 pulse converter is modeled with PI controller which consists of two loops. In controlled 12 pulse configuration the set reference speed is compared real speed and error is generated. The error signal is passed through the PI controller to minimize the error, before feeding the output to thyristors.

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

Figs. 9-12shows results of controlled 12 pulse rectifier. From fig.9 shows the Vab line voltage before rectification with total harmonic distortion (THD) =7.01%.Total Harmonic Distortion is calculated by FFT analysis. Fig.11 shows the speed response of DC motor fed with DC power obtained after rectification with the help of 12 pulse controlled rectifier. The reference speed is taken as 1700rpm which is compared with real speed 1750rpm of the DC motor. It's a controlled method so operated at 100% rated speed. Hence for a controlled system, settling time is reduced to 3.5s as well as the steady state error also. Fig's 10,12 shows the dc side voltage and current outputs. The armature current is 1.3A and voltage ripple is 38V which seems to be better than uncontrolled 12 pulse outputs.

Figs. 13-16 shows results of controlled 24 pulse rectifier. From fig.13 shows the Vab line voltage before rectification with total harmonic distortion (THD) =2.83%.Total Harmonic Distortion is calculated by FFT analysis. Fig.15 shows the speed response of DC motor fed with DC power obtained after rectification with the help of 24 pulse controlled rectifier. The reference speed is taken as 1700rpm which is compared with real speed 1750rpm of the DC motor. It's a controlled method so operated at 100% rated speed. Hence for a controlled system, settling time is reduced to 2s as well as the steady state error also. Fig's 14,16 shows the dc side voltage and current outputs. The armature current is 1.2A and voltage ripple is 30V which is less in comparison with 12 pulse controlled operation output.

Figs. 17-20 shows results of controlled 48 pulse rectifier. From fig.17shows the Vab line voltage before rectification with total harmonic distortion (THD) =0.950%.Total Harmonic Distortion is calculated by FFT analysis. Fig.19 shows the speed response of DC motor fed with DC power obtained after rectification with the help of 48 pulse controlled rectifier. In this method the transfomer is phase shifted each other by 7.5 degrees in which the all the transformer primaries are to be connected in series. It's a controlled method so operated at 100% rated speed. Hence for a controlled system, settling time is reduced to 1.5s as well as the steady state error also. Fig's 18,20 shows the dc side voltage and current outputs. The armature current is 0.4A and voltage ripple is 20V which is less in comparison with 12 pulse controlled operation output.

V. CONCLUSION

This paper presents different configurations and comparison of multi pulse ac-dc converters. The uncontrolled 12 pulse, controlled 12 pulse, controlled 24 pulse and controlled 48 pulse models are implemented and simulated in MATLAB/Simulink.The results are compared and it is clearly shown that as we increase number of pulses the THD decreases, low ripple current and voltage outputs are obtained with less steady state error.

REFERENCES

[1] Bose, B.K., January 1992. Recent advances in power electronics. Power Electronics, IEEE Transactions on, 2–16.Chivite-Zabalza, F.J., Forsyth, A.J., May 2007. A Passive 36-Pulse AC–DC converter with inherent load balancing using combined harmonic voltageand current injection. Power Electronics, IEEE Transactions on 22 (3), 1027–1035.

[2] Dubey, G.K., May 2002. Fundamentals of Electrical Drives.CRC Press.IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems, April 9 1993, IEEE Std 519–1992, pp. 1–112.

[3] Qiang Song, Wenhua Liu, Zhichang Yuan, Wenhui Wei, Yuanhua Chen, 2004. DC voltage balancing technique using multi-pulse optimal PWM forcascade H-bridge inverters based STATCOM. Power Electronics Specialists Conference, PESC 04. IEEE 35th Annual, vol. 6, pp. 4768–4772.

[4] Sahali, Y., Fellah, M.K., June 2003. Selective harmonic eliminated pluse-width modulation technique (SHE PWM) applied to three-levelinverter/converter, Industrial Electronics. ISIE'03. IEEE International Symposium on Industrial Electronics 2, 1112–1117.

[5] Singh, B., Gairola, S., Chandra, A., Kamal Al-Haddad, June 2007. Zigzag connected autotransformer based controlled AC-DC converter for pulsemultiplication. IEEE International Symposium on Industrial Electronics (ISIE), 889–894, 4–7.

[6] Singh, B., Gairola, S., Singh, B.N., Chandra, A., Al-Haddad, K., January 2008. Multipulse AC–DC converters for improving power quality: a review.Power Electronics, IEEE Transactions on 23 (1), 260–281.

[7] Wakileh, G.J., 2001. Power Systems Harmonics, Fundamentals, Analysis and Filter Design.Springer.Wang, J., Huang, Y., Peng, F.Z., 2005.A practical harmonics elimination method for multilevel inverters.

[8] D. D. Shipp and W. S. Vilcheck, "Power quality and line Considerations for variable speed ac drives," IEEE Trans. Ind. Appl., vol. 32, no. 2, pp. 403–409, Mar./Apr. 1996.
[9] G. Seguier, "Power Electronic Converters: AC-DC Conversion", McGraw Hill Book Company, New York, 1987.
[10] Y. Liu, N. Watson, and J. Arrillaga, "A new concept for the control of the harmonic content of voltage source converters," in Proc. IEEE Conf. Power Electron. Drive Syst., 2003.
[11] C. M. Young, M. H. Chen, C. H. Lai and D. C. Shih, "A novel active interphase transformer scheme to achieve three-phase line current balance for 24-pulse converter," IEEE Trans. on Power Electron., vol.27, no. 4, pp. 1719-1731, April 2012.
[12] S. wang, J. Wang and W. Yang, "A novel 24-pulse diode rectifier with an auxiliary single-phase full-wave rectifier at dc side," IEEE Trans OnPower Electron, March 2017

CITE AN ARTICLE

Vakula, V. S., Dr, Rani, R. S., Ms, & VijethaInti, V. V., Mr. (2018). MULTI-PULSE AC-DC CONVERTERS FOR POWER QUALITY IMPROVEMENT IN DC DRIVES. *INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY*, *7*(8), 284-295.