

Analysis of 3-Phase AC-DC Thyristor Controlled Converter Fed to DC Motor

Jyotsana Singh¹, Hitesh Lade²P.G. Student, Department of Electrical Engineering, Satyam Education & Social Welfare Society Group of Institutions,
Bhopal, India¹Assistant Professor, Department of Electrical Engineering, Satyam Education & Social Welfare Society Group of
Institutions, Bhopal, India²

ABSTRACT: This paper presents the discussion of multi-pulse improved power quality ac-dc converter configuration, comparative factors and selection of specific. Reliable low distortion DC supply is a prime concern for medium and high voltage applications. Multipulse converters is one of the popular device that furnishes low ripple DC output with the benefit of direct conversion from AC supply. The three-phase multi-pulse AC to DC conversion system have a phase-shifting transformer and a three-phase source. Every such type of converter provides a 6-pulse AC to DC conversion system, that's why in order to produce more sets of 6-pulse systems, a uniform phase-shift is required and hence with proper phase-shifting angle, 12, 18, 24, 30, 36 and higher pulse systems have been produced. This paper describes the comparative analysis and design of even group combinations namely 6, 12 and 24 pulse converters with MATLAB simulations. The performance improvement of multi-pulse converter is achieved for total harmonics distortion (THD) in supply current, DC voltage ripples and form factor. The Input A.C current waveform and the DC output waveform and harmonic analysis has been observed.

KEYWORDS: Total Harmonic Distortion (THD), Three phase AC-DC Converter, Ripple Factor, Power Factor, Thyristor Bridge.

I. INTRODUCTION

A power electronic device creates harmonic distortion and cause voltage dip if not protected. Three-phase ac-dc conversion of electric power is widely employed in HVDC system, adjustable-speed drives, uninterruptible power supply and utility interfaces with non conventional energy sources such as solar photovoltaic systems (PVs), etc[1,5]. AC-DC converters, which are also known as rectifiers, are basically contained diodes and rectifiers and are very popular due to the absence of any control system for power diodes [3]. These methods use two or more converters where the harmonic generated by one converter is cancelled out by another by proper phase shift. Auto transformer based converters usually reduces the total harmonic distortion (THD) along with weight and size of transformer [4]. Many methods based on the multi pulse switching have been proposed which are based on autotransformer or multi winding isolation transformer although both of them provides small size of transformer but need a complex structure also the autotransformer lacks the isolation between input and output & other also can be completely damaged by accidental overloading of one of the any phase because all primary windings are common.

II. OBJECTIVE OF PRESENT STUDY

The Present Study Is An Effort Towards Analyzing The Different Multi-Pulse AC To DC Converters In Solving The Harmonic Problem In A Three-Phase Converter System. The Effect Of Increasing The Number Of Pulses On The Performance Of AC To DC Converters Has Been Analyzed. For Performance Comparison The Major Factors Considered Are The Ripple Percentage, Form Factor And The Total Harmonic Distortion (THD)

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

III. MULTI-PULSE METHODS

Different rectifiers are used for conversion of AC supply into DC supply. For uncontrolled conversion, diodes have been preferred, while for the controlled conversion, thyristors have been implemented. The performance improvement of multi-pulse converter is achieved for total harmonics distortion (THD) in supply current, DC voltage ripples and form factor. All the simulations have been done for similar ratings of RL Load, for all the multi-pulse converters configurations, so as to represent a fair comparison among controlled and uncontrolled continuations of multi-pulse converters. The effect of increase in number of pulses in converter circuits for uncontrolled and controlled multipulse converter on input supply current and DC side voltage and current has been presented in this paper. There are two type of pulse converter according to controlling techniques first one uncontrolled and second

one is controlled multi-pulse converter. Uncontrolled multi-pulse has fixed output and controlled multi-pulse converter has controlled output which can control by the firing angle 'α'.

There are various multi-pulse converters which classified according to number of pulse.

Let us suppose that the number of pulse is 'm' Fois output frequency and Fs is supply frequency

$$F_o = mF_s \text{-----(1)}$$

And length of pulse also depend on number of pulse pulse length = $2 * \pi / m (\text{inrad})$ ----- (2)

IV. SIMULATION MODEL OF MULTI PULSE CONVERTER

A. Six Pulse Converter

The simulation block of three phase six pulse thyristor is shown in Fig 1. It consists of three phase ac source to supply .The line voltage are V_{ab} , V_{bc} & V_{ca} . A six pulse thyristor bridge is connected to the three phase supply. This is universal thyristor bridge. It consists six thyristor in a bridge manner, which converts the constant ac into the dc supply.

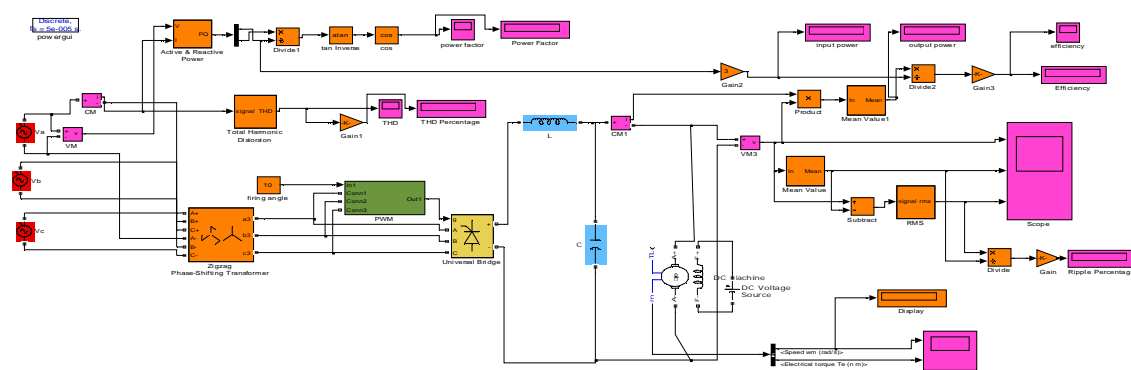


Fig. 1. Six pulse thyristor converter

B. Twelve Pulse Converter

The simulation block of three phase twelve pulse thyristor is shown in Fig 2. It consists of three phase ac source to supply .The line voltage are V_{ab} , V_{bc} & V_{ca} . Two six pulse thyristor bridge is connected to the three phase supply. This is universal thyristor bridge. It consists six thyristor in a bridge manner, which converts the constant ac into the dc

supply. The input of these converters is taken from the phase shifted secondary Zigzag transformer. These are two three phase transformers whose secondaries are connected in star. This configuration provides the phase shift of 30 degrees between the two converters. A synchronous six pulse generator is used to generate the pulses to the bridge circuit these pulses are used to fire the thyristors.

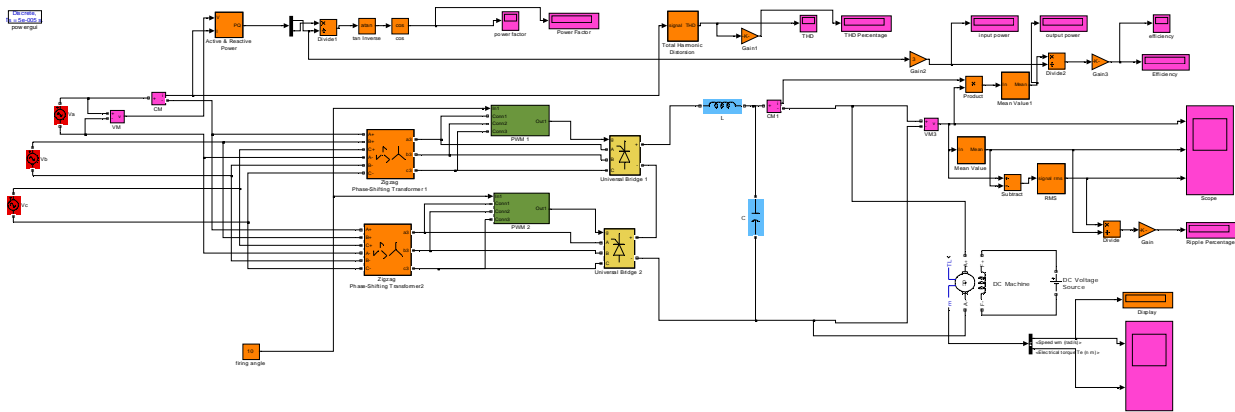


Fig. 2. Twelve pulse thyristor converter

C. Eighteen Pulse Converter

The simulation blocks of three phase six pulse thyristor are shown in Fig 5.3. It consists of three ac voltage sources, V_a , V_b & V_c . The line voltages are V_{ab} , V_{bc} & V_{ca} . Three six pulse thyristor bridge is connected to the phase supply. The inputs of these converters are taken from the output of three phase shifting transformers. These are three phase transformers. These three phase transformers provide the phase shift of 20 degrees between the three converters. A synchronized pulse generator is used to generate the pulses to the bridge circuit of the converters. These pulses are used to fire the thyristors.

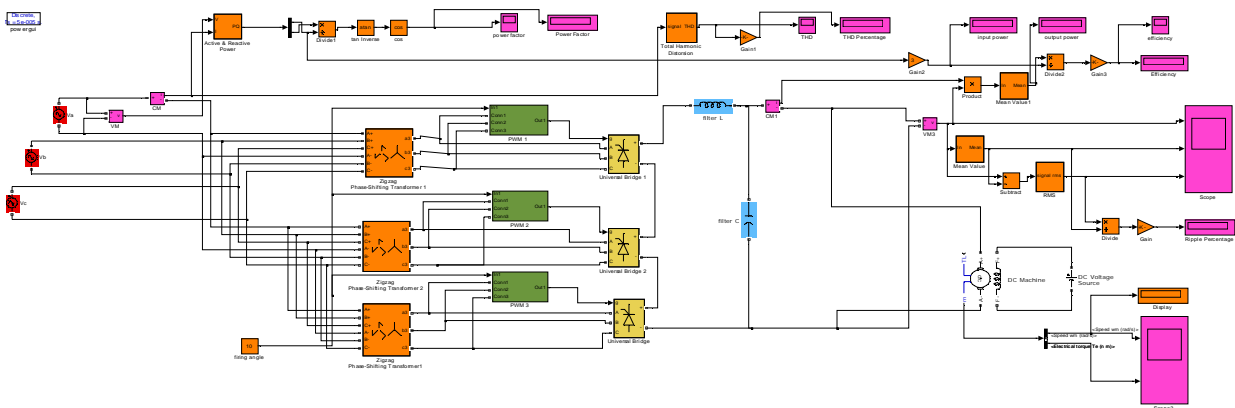


Fig. 3. Eighteen pulse thyristor converter

D. Twenty Four Pulse Converter

The simulation blocks of three phase six pulse thyristor are shown in Fig 4. It consists of three ac voltage sources, V_a , V_b & V_c . The line voltages are V_{ab} , V_{bc} & V_{ca} . In the proposed design four six pulse thyristor bridge is connected to the

phase supply. The inputs of these converters are taken from the output of four phase shifting transformers. These are three phase transformers. These three phase transformers provide the phase shift of 20 degrees between the three converters.

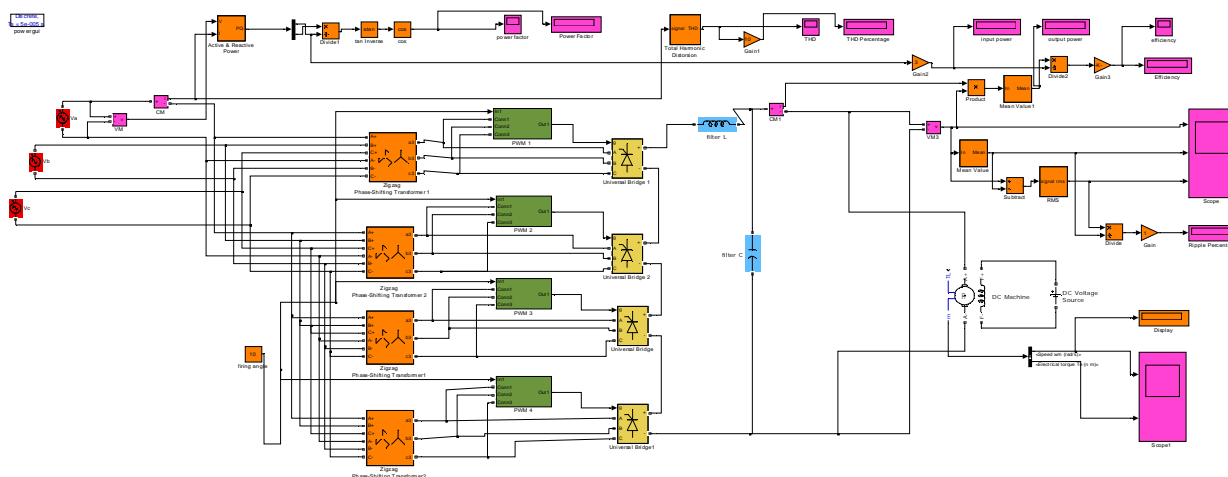


Fig. 4. Twenty-Four pulse thyristor converter

V. EXPERIMENTAL RESULTS

The results of six pulse, twelve pulse and eighteen pulse thyristor converters are compared. This can be done by comparing the waveform of input current and output voltage with different values of firing angles on the basis of ripple content and THD. It is observed by seeing the waveform of input current that the waveform of higher pulse converter is more nearer to sinusoidal. The voltage waveforms are also compared the ripple in the output voltage decreases as the number of pulses is increased.

As seen from the result of 6, 12, 18 and 24 pulse controlled converter with 10 degree firing angles that the ripple in six pulse converter is greater than twelve pulse, eighteen and twenty-four pulse converter. That means with the increase in pulse number, output voltage and input current THD is improved. When we increased the firing angles output voltage ripple and THD of input current is also increased.

Comparison of result for 6, 12, 18, 24- pulse controlled converters is given in Table.1. Results of 6, 12, 18 and 24 pulse controlled converter with 10 degree firing angles

Table-1

S no.	Converter / Firing Angle	10 degree		
		Is THD%	VoRipple%	P.F.
1.	6 Pulse	25.81	0.34	0.95
2.	12 Pulse	8.59	0.89	0.91
3.	18 Pulse	9.02	0.94	0.87
4.	24 Pulse	0.88	0.03	0.95

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

VI. CONCLUSION

The various isolated multi-pulse configurations were simulated using MATLAB/SIMULINK and the results have been presented in this paper in Table 1. The effect of pulse variation on different multi-pulse converters reveals that with DC Motor load because of inductance there is smoothing effect on current, therefore current THD decreases. The discussed technique can be considered to be the better alternatives for power quality improvement because of the reduced size of the converter, lower cost and higher efficiency as compared to other methods of power quality improvement.

REFERENCES

- [1] B. Singh, B.N. Singh, A. Chandra, K. Al-Haddad, A. Pandey, and D.P. Kothari, "A review of three-phase improved power quality ac-dc converters," *IEEE Trans. Ind. Electron.*, vol. 51, no. 3, pp. 641–660, Jun. 2004.
- [2] IEEE Guide for Harmonic Control and Reactive Compensation of Static Power Converters, IEEE Std. 519-1992.
- [3] B. Singh, S. Gairola, B.N. Singh, A. Chandra, and K.A. Haddad, "Multi-pulse AC-DC Converter for Improving Power Quality: A Review", *IEEE Transactions, On Power Delivery*, Vol. 23 No. 1 January 2008
- [4] M.H.J. Bollen, *Understanding Power Quality Problems: Voltage Sags and Interruptions*. Piscataway, NJ: IEEE Press, 2000.
- [5] F.J.M. de Seixas and I. Barbi, "A 12kW three-phase low THD rectifier with high frequency isolation and regulated dc output," *IEEE Trans. Power Electron.*, vol. 19, no. 2, pp. 371–377, ar. 2004.
- [6] A. Arvinda, A. Guha, Novel topology for 24 pulse rectifier with conventional transformer for phase shifting, *Electrical Energy System (2011)*, IEEE Conference, pp. 108-114, 2011.
- [7] D.A. Paice, *Power Electronic Converter Harmonics- Multi-pulse Methods for Clean Power*. New York, IEEE Press, 1996.
- [8] R. Mayura, P. Agarwal, Performance investigation of Multi-pulse Converter for Low Voltage High Current applications, *IEEE Conference on Computer Science and Automation Engineering (CSAE)*, vol. 1, pp. 211-216, 2011.
- [9] R. Redl, P. Tents, and J.D. Van Wyk, "Power electronics polluting effects," *IEEE Spectr.*, vol. 34, no. 5, pp. 32–39, May 1997.
- [10] A. Chaturvedi, D. Masand - Comparative analysis of three phase AC-DC controlled multi-pulse converter: *Electrical, Electronics and Computer Science (SCEECS)*, 2012 IEEE Students' Conference, pp. 1-4, March 2012
- [11] B.K. Bose, "Recent advances in power electronics," *IEEE Trans. Power Electron.*, vol. 7, no. 1, pp. 2–16, Jan. 1992. *Times New Roman*
- [12] 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.
- [13] D.A. Jarc and R.G. Schieman, "Power line considerations for variable frequency drives," *IEEE Trans. Ind. Appl.*, vol. IA-21, no. 5, pp. 1099–1105, Sep. 1985.
- [14] N. Mohan, T.M. Undeland, W.P. Robbins, *Power Electronics: Converters, Applications, and Design*, 3rd Edition, 2002