Scientific Journal of Impact Factor(SJIF): 3.134
e-ISSN(O): 2348-4470
p-ISSN(P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 2,Issue 5, May -2015

18 Pulse Uncontrolled Rectifier

Jay Patel

Dept. Electrical Engineering, K.J.Institute of engineering and technology, Savli- Vadodara

ABSTRACT : *In this project, a 18 pulse rectifier has been designed for high voltage application. Three 3-phase are obtained from a single three phase source using zig-zag inter connection of conventional single phase transformer. Thus from the three 3-phase system displaced by 20˚, (obtained using zig - zag connection) 3 six pulse rectifier are obtained that are cascaded to realize a eighteen pulse rectifier. Phase shift of 0˚ and 20˚ are made using star and zig-zag connection and thus finally the addition of relevant line voltage. We can also bring down THD of it up to 5.47%*

Keywords: *Controlled Rectifier, phase shiftingtransformer, Microcontroller based control, Harmonic reduction technique*

1. INTRODUCTION

Conventional ac-dc converters are developed using diodes and thyristors to provide controlled and uncontrolled unidirectional and bidirectional dc power, however, these converters have problems of:

- poor power quality in terms of injected current harmonics,
- resultant voltage distortion,
- slowly varying rippled dc output at load end
- low efficiency, and
- large size of ac and dc filters

To overcome these drawbacks and meet contemporary power quality standards, it has become imperative that research in power converters has to address power quality aspects like reducing harmonic currents, higher power factor, lower EMI/RFI at input ac mains and well-regulated dc output. Increased awareness of power quality has led to the development of a new breed of ac-dc converters referred to as improved power quality ac-dc converters one of which has been classified as, multi-pulse rectifiers. Multi-pulse rectifiers are unidirectional multi-pulse converters that are used for high power applications which involve high voltage and low current. This paper is about the design of transformer for the realization of a 18-pulse rectifier involving the transformation of a single 3-phase system to three 3-phase systems using zig-zag interconnection of conventional three-phase and single phase transformers. A 6-pulse rectifier is implemented by cascading three 6-pulse rectifiers fed from three 3-phase systems displaced by 20º. The 18-pulse rectifier topology is obtained by cascading three 6-pulse rectifier systems which translate to cascading of three 6-pulse rectifiers fed from four 3-phase systems displaced by 20º.

2. PROPOSED 18-PULSE RECTIFIER TOPOLOGY

The realization of the 18-pulse rectifier involves obtaining three 3-phase systems with a defined phase shift between them from a single 3-phase system using interconnection of three-phase and single-phase transformers. For harmonic elimination, the required minimum defined phase shift is given by :

Phase shift = 60◦/Number of six-pulse converters. Thus, in order to get 18 pulses we require 20°phase shift which can be obtained by cascading three 6-pulse rectifier systems which translates to cascading of three 6-pulse rectifiers fed from three 3-phase systems displaced by 20º. Special transformers delta zig-zag (-20º, 0º, 20º) or star extended - delta ± (20º) should be used to obtain 20º displacement. This special transformer is phase-shifting transformer which is an indispensable device in multi-pulse diode rectifier. It performs three main functions:

- To obtain phase displacement between primary and secondary line to line voltages

- Proper secondary voltage
- Electric isolation between utility supply and rectifier.

Depending on the winding arrangement there are two types:

1. Y/Z
2. Y/Y

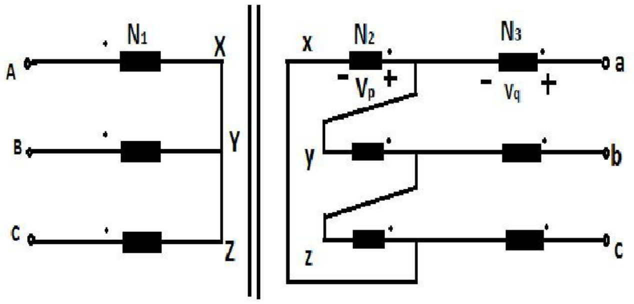
Here we are using Y/Z connection i.e. primary in star and secondary in zig-zag. Again Y/Z are of two types i.e. Y/Z-1 and Y/Z-2 , one giving the leading and other giving lagging displacement of δ.

Thus, from this, we will have one 3 phase star connected primary and 4 secondary windings.

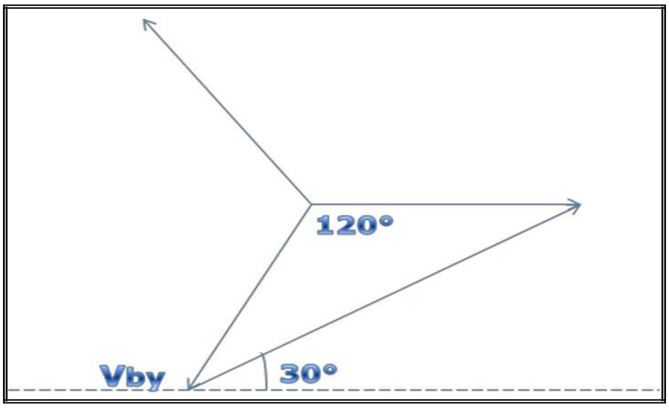
These 4 outputs are connected to the four 6 pulse bridges which can be connected in series for high voltage applications and in parallel, for high current applications. The block diagram for the proposed work is as follows:

3. THE RESPECTIVE VECTOR DIAGRAMS:

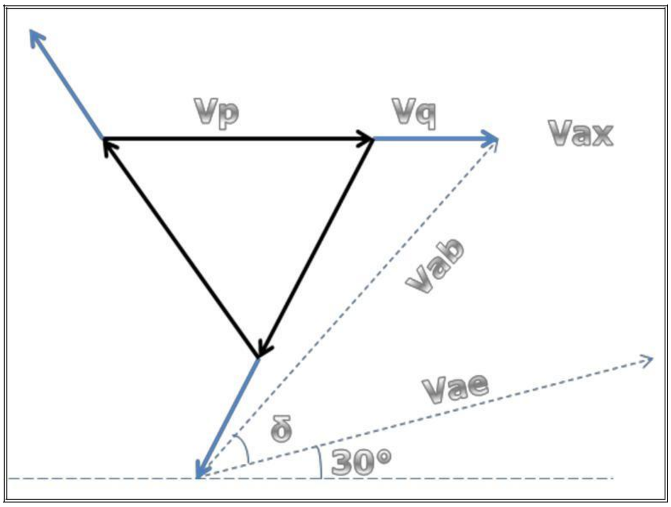
-Y/Z-1 (leading)



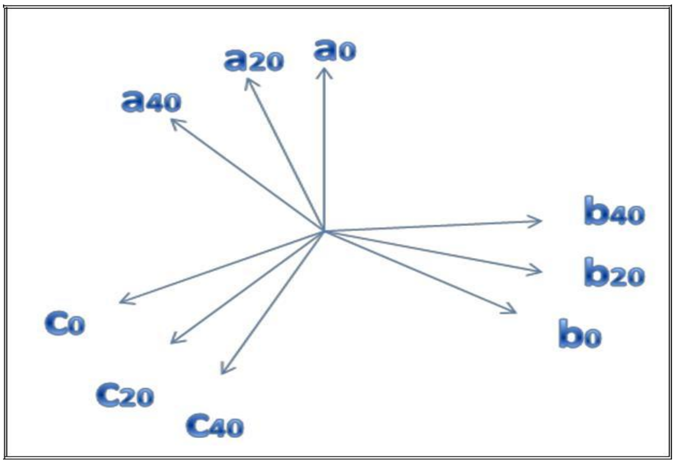
The phasor diagram for the primary is as follows:



The phasor diagram for the secondary is as follows:



Hence, we get a +15 degree phase shift. Similarly, we can get -15 degree phase shift by another method which includes different connections of delta and is called Y/Z-2. This way we will get required phase displacement in output and all four different outputs are as follows



4. DESIGN ASPECTS OF THE RECTIFIER TOPOLOGY:

The design parameters of the rectifier topology including those of the ratings of the devices pertaining to the individual bridges and the transformers are dependent on the output of the rectifier. The rectifier topology is designed for a dc output voltage of 100V.

$$Vo = 3\frac{Vm}{\pi}$$

- The four series-cascaded diode bridges produce an output voltage of 100V, therefore, the dc voltage provided by each bridge = 105/3 = 35V. The dc output voltage of a 3-phase diode bridge is given by,

Vm = The peak value of the voltage feeding the bridge and therefore the corresponding rms voltage is given as follows

$$Vo = 3\frac{\sqrt{2}Vrms}{\pi}$$

The DC voltage of a 3- phase diode bridge is given by, Vo = Vm

Vm = the peak value of the voltage feeding the bridge and therefore the corresponding rms voltage is given as follows

35 = [Vrms]

So, Vrms = 25.916V

Thus, the line voltage of all three secondary winding should be 25.916V

5.Turns ratio of various transformers

1.star-star connection:

- Y- primary Vline(rms) = 415V
- Y- secondary desiered line voltage = 25.916V i.e. N2/N1 = 25.916/415 = 0.0624

2. star-zig-zag connection:

$$\frac{N1}{N2+N3} = \frac{\text{VAB}}{2\sin{(30° + \delta)}\,Vab}$$

$$\therefore N1 = 10.45(N2+N3) \qquad (3)$$

Also,

$$\therefore \frac{N3}{N2+N3} = \frac{\sin{(30° - \delta)}}{\sin{(30° + \delta)}} \qquad \text{(from Y/Z-2)}$$

$$\therefore \frac{N3}{N2+N3} = 0.2266$$

$$\therefore N3 = 0.2266(N2+N3) \qquad (4)$$

$$\therefore 0.7734N3 = 0.0066N2$$

$$\therefore N2 = 3.41306N3 \qquad (5)$$

From (3) & (4)

$$\therefore \frac{N1}{10.45} = \frac{N3}{0.2266}$$

$$\therefore N1 = 46.1165N3$$

Also,

$\therefore N2 = 3.41306N3$

$$= 3.14306(\frac{N1}{46.116})$$

$\therefore N2 = 0.0681N1$

Now if we say 1 turn = 1 volt

Primary turns N1= 239.6

$\therefore N2 = 16.31$

$$\therefore N3 = \frac{N1}{46.1165} = 5.19$$

As

So, N1= 239.6; N2 = 16.31; N3 = 5.19

For Y/Z-1 we want phase of 20º so, $\delta = 20^{\circ}$

$$\frac{N1}{N2+N3} = \frac{1}{2\sin\,(30^{\circ}+\delta)}\frac{415}{25.916}$$

$$\therefore \frac{N1}{N2+N3} = 10.45$$

Thus, we can say that in zig-zag connection the voltage across star should be 5.19 and across delta 16.31 to get exact 20º phase displacement.

SIMULATION AND EXPERIMENTAL RESULTS:

Now we have shown the input current at the time of simulation in following two figures.

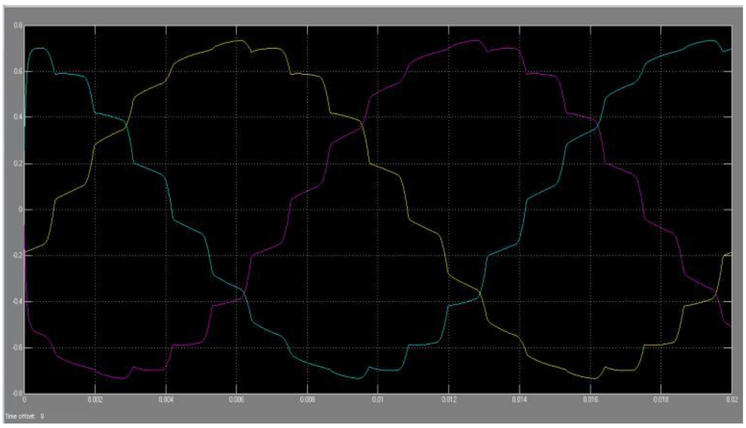


Fig. “exact 18 steps in input current”

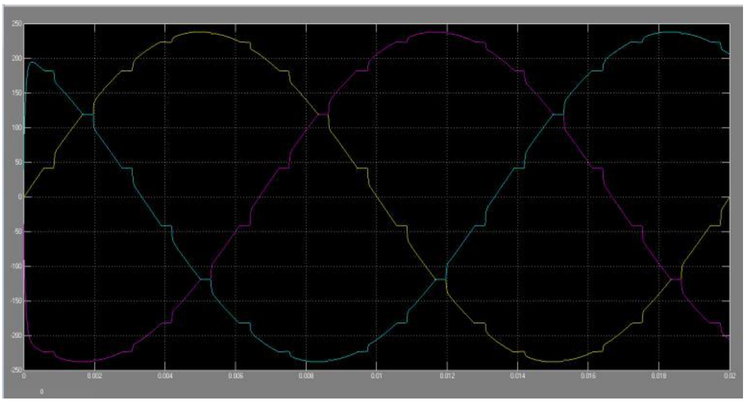


Fig. “exact 18 steps in input voltage”

Lets see the total harmonic distortion in MATLAB simulation .It is shown in figure A. We got 5.47% THD without using any reactor in output line.

Now we will see the output wave forms in which we can see 18 pulses.

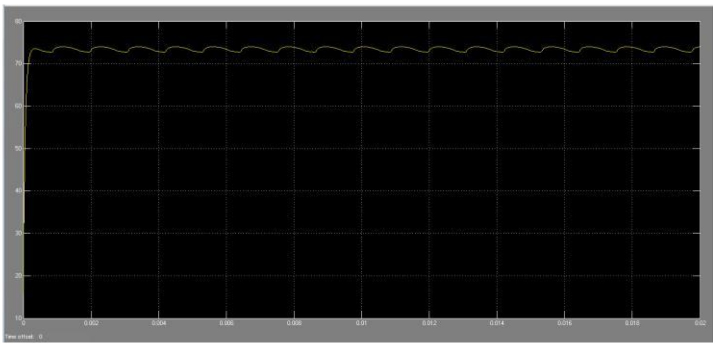


Fig. “18 pulses in output”

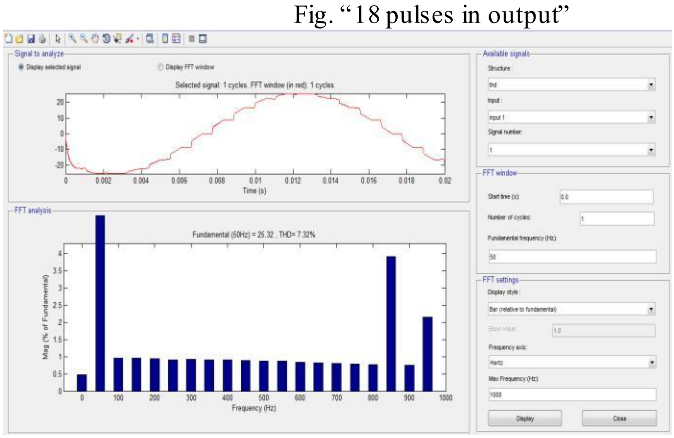


Fig A “ THD of input sine wave, 5.42%”

B. Experimental Results

Typical waveforms of the output 18-pulse dc voltage observed on the oscilloscope are shown in Fig B. and Theexperimental set up is shown in Fig. A

7. CONCLUSION

In this paper a 18-pulse rectifier is realized by conventional transformers that meets the theoretical harmonic estimates. These results which are practically obtained (by experimental set up)have already been verified by MATLAB simu lation results.

It is the authors' opinion that this concept will find many commercial and industrial applications mainly in the medium and high power range.

REFERENCES

1) BhimSingh,G. Bhuvaneswari and VipinGarg, "Pulse

Multiplication in AC–DC Converters for Harmonic Mitigation in Vector-Controlled Induction Motor Drives"

IEEE Transactions on Energy Conversion, Vol. 21, No.2, June 2006, pp. 132-142.

2) Bhim Singh, G. Bhuvaneswari and VipinGarg, "A

Novel Polygen Based 18-Pulse AC– DC Converter for Vector-Controlled Induction Motor Drives", IEEE

Transactions on Power Delivery, Vol.22, No.2, March 2007, pp.488- 497

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) B. S. Lee, P. N. Enjeti, and I. J. Pitel, "An optimized active interphase transformer for auto-connected 12-pulse rectifiers results in clean input power," in Proc.

IEEE Conf. APEC, Atlanta, GA, Feb. 1997, vol. 2, pp. 666–671.

5) H. A. Pacheco, G. Jimenez, and J. Arau, "Optimization method to design filters for harmonic current reduction in a three phase rectifier," in Proc. IEEE

Conf. CIEP, Puebla, Mexico, Aug. 1994, pp. 138–144.

6) 24-PULSE RECTIFIER REALIZATION BY 3-PHASE TO FOUR 3-PHASE TRANSFORMATION USING CONVENTIONAL TRANSFORMERS N. Arvindan and P. Pushpakarthick , S.S.N. College of Engineering, Anna University (Chennai), Tamilnadu

******