

# Designing and Harmonic analysis of a new 24-Pulse Rectifier using diodes with Phase Shifting Transformer

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**Abstract—** In this paper, a simplified type of twenty four pulse rectifier has been proposed for dc applications, the twenty four pulse converter has been obtained from combining four six pulse rectifier in parallel, since these rectifier are connected to two 3 phase transformers, so that the desired phase shift is obtained by utilizing star and delta connections. So every individual six pulse rectifier output is supplementary to induce the relevant voltages. The look of twenty four pulse converter primarily focuses on harmonics reduction, commonly diode rectifiers is wide used for AC/DC conversion. a serious disadvantage is, the rectifiers can inject giant harmonic distortion within the input currents. Clearly a 12-pulse device is employed for reducing the harmonics injected; however it additionally includes the  $(12n\pm 1)$  harmonics within the input currents. So as to scale back the harmonics within the input current, the twenty four pulse rectifier is projected. Wherever it'll reduce the lower order harmonics like 5th, 7th, 11th and 13th. though Its reduces the low order harmonics, however the AC output voltage from transformer would have  $24n\pm 1$  order harmonics due to the phase shift concerned in transformer. However this twenty four pulse device is relatively a lot of economical than alternative rectifiers was concisely explained, verified and stimulated by using MATLAB & SIMULINK package.

**Index Terms—** 24-pulse, AC-DC Converter, Power Quality, harmonics.

## I. INTRODUCTION

The Conventional rectifiers are created using diodes and thyristors, which is controlled and uncontrolled has the following issue such as reduction in power quality due to current harmonic injection, low efficiency and in need of large size of AC and DC filters.

To reduce the disadvantages of these converters and to obtain the enhanced power quality, the examination has been done to find out the solution to this disadvantages and it has ended with multi pulse diode converters for the conversion of AC/DC. Multi-pulse rectifiers are unidirectional and were utilized for high power applications. But considering the economic condition the 24 pulse converter selected for its advantage. This paper is deals with the study of 24 pulse

converter operation, working of phase shifting transformers formed by delta to star and delta to delta conversion. And also the harmonics comparison of 24 pulse converter over the low pulse converter.

A 12-pulse rectifier is formed by combing two 6-pulse rectifiers fed from two 3-phase systems dislodged by  $30^\circ$ . The 24-pulse rectifier topology is gotten by combining two 12-pulse rectifier systems which mean combining of four 6-pulse rectifiers fed from four 3-phase systems relocated by both  $30^\circ$  and  $60^\circ$ .

For instance, the routine 12-pulse diode rectifier consolidates two six-pulse diode connects through phase shifting transformers, in arrangement for low-voltage applications. This results in the end of 5th and 7th harmonics in the output. To acknowledge higher pulse number, extra phase shifting transformers have been utilized with expanding the VA rating and the expense of the parts. The methodology parallel connection scheme does not oblige extra phase shifting transformer.

## II. PROPOSED 24-PULSE RECTIFIER TOPOLOGY:

The acknowledgment of the 24-pulse rectifier includes acquiring four 3-phase system with a characterized phase shift between them from a solitary 3-phase system utilizing interconnection of three-phase and single-phase transformers. For harmonic disposal, the obliged least characterized phase shift is given by:

phase shift =  $60^\circ / \text{Number of six-pulse converters}$ .

In this manner, to get 24 pulses we require  $30^\circ$  and  $60^\circ$  phase shift which can be acquired by combining two transformers delta-delta ( $-60^\circ$ ) delta - star ( $+30^\circ$ ) ought to be utilized to get  $90^\circ$  displacement. This extraordinary transformer is phase shifting transformer which is an imperative gadget in 24-pulse diode rectifier. It performs three fundamental capacities such as to get proper output voltage.

## III. WORKING OF PHASE SHIFTING TRANSFORMERS:

- 1)  $\Delta/Y$
- 2)  $\Delta/\Delta$

1)Delta-Star Connection of Transformer:

In this type of connection, the primary connected in delta fashion while the secondary current is connected in star is shown in Fig.1 and Fig.2.

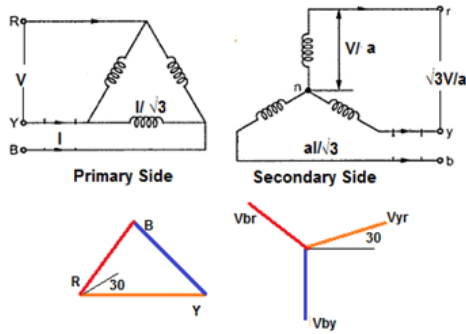


Fig.1

The main use of this connection is to step down the voltage i.e. It can be noted that there is a phase shift of 30° between primary line voltage and secondary line voltage as leading.

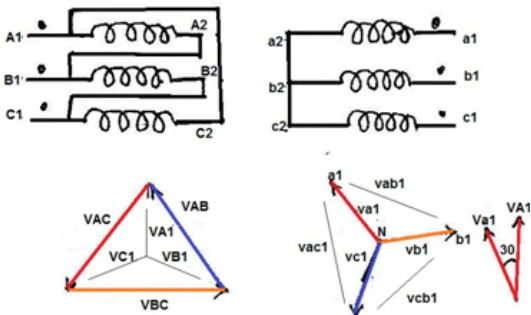


Fig.2

Key point:

- 1) As primary in delta connected:
- 2) Line voltage on primary side = Phase voltage on Primary side.
- 3) Now Transformation Ration (K) = Secondary Phase Voltage / Primary Phase Voltage
- 4) Secondary Phase Voltage = K X Primary Phase Voltage.
- 5) As Secondary in Star connected
- 6) Line voltage on Secondary side =  $\sqrt{3}$  X Phase voltage on Secondary side. So,
  - 1) Line voltage on Secondary side =  $\sqrt{3}$  X K X Primary Phase Voltage.
  - 2) Line voltage on Secondary side =  $\sqrt{3}$  X K X Primary Line Voltage.
  - 3) There is +30 Degree or -30 Degree Phase Shift between Secondary Phase Voltage to Primary Phase Voltage

Advantages of Delta-Star Connection:

- 1) No distortion due to third harmonic components.
- 2) Elimination of 3rd order harmonics.

2)Delta-Delta Connection of Transformer:

In this type of connection, both the three phase primary and secondary windings are connected in delta as shown in the

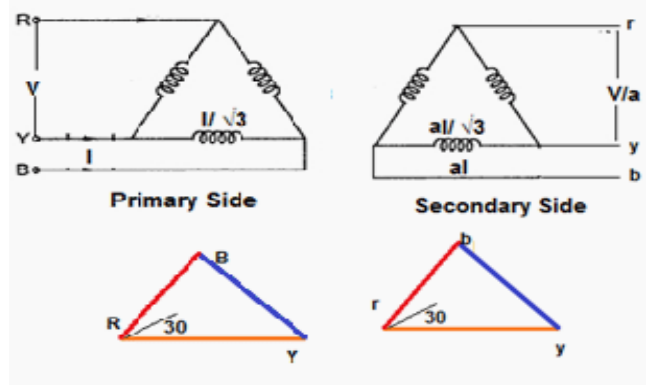


Fig.4

The voltages on primary and secondary sides can be shown on the phasor diagram (Fig.4):

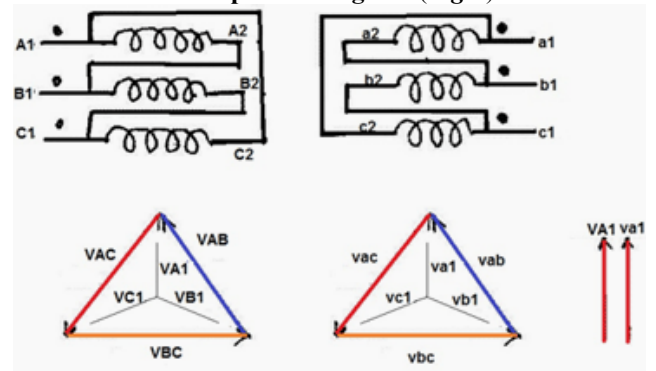


Fig.5

This connection proves to be economical for large low voltage transformers as it increases number of turns per phase.

Key points

- 1) Primary Line Voltage = Sec. Line Voltage.
- 2) Primary Phase Voltage= Sec. Phase Voltage.
- 3) 60 Degree between primary and secondary voltages.

Advantages of Delta-Delta Transformer Connection:

- 1) Due to closed delta, third harmonic voltages are absent.

IV.DESIGNING OF THE RECTIFIER TOPOLOGY:

The outline parameters of the rectifier topology including those of the evaluations of the gadgets relating to the individual extensions and the transformers are subject to the output of the rectifier. The rectifier topology is intended for a DC yield voltage of 300v.

The four combined arrangement diode extensions deliver a yield voltage of 300v, thus, the DC voltage gave by each one extension =  $300/4 = 75v$ . The DC yield voltage of a 3-phase diode extension is given by,

$V_m$  = Peak voltage input voltage and the respective is  $V_{rms}$  voltage is provided as follows

$$V_0 = (3/\pi) * V_m$$

$$V_{rms} = V_m$$

$$\text{So, } V_{rms} = 222.14 \text{ v}$$

In this way, the line voltages of every one of the four secondary windings ought to be 222.14 V.

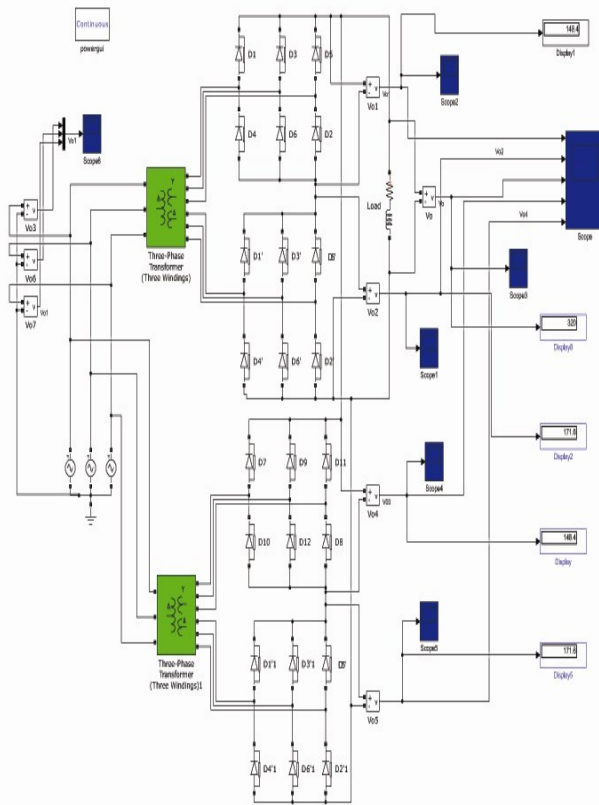


Fig.5

V.MATLAB BASED SIMULATION RESULTS:

24–pulse AC-DC converters are reproduced and stimulated in a MATLAB environment alongside Simulink and Power System Blockset (PSB) toolboxes. The AC- DC converter supplies the consistent RL Load ( $R= 50 \text{ ohm}$  ,  $L=0.65 \text{ H}$ )with an input of 300v, 50Hz AC supply. The MATLAB model of a 24-pulse AC- DC converter is demonstrated in Fig.5 presents a MATLAB model of the 24-pulse AC- DC converter. resultant waveforms for the 24-pulse AC- DC converter are indicated in Fig.3(vo1,vo2,vo4,vo5). The waveform of individual 6 pulse converter are demonstrated in figure separately . The required output of the rectifier is demonstrated in figure Fig.6(vo3) . Table .1 looks at the power quality parameters of 24-pulse over the 12-pulse AC- DC converter.

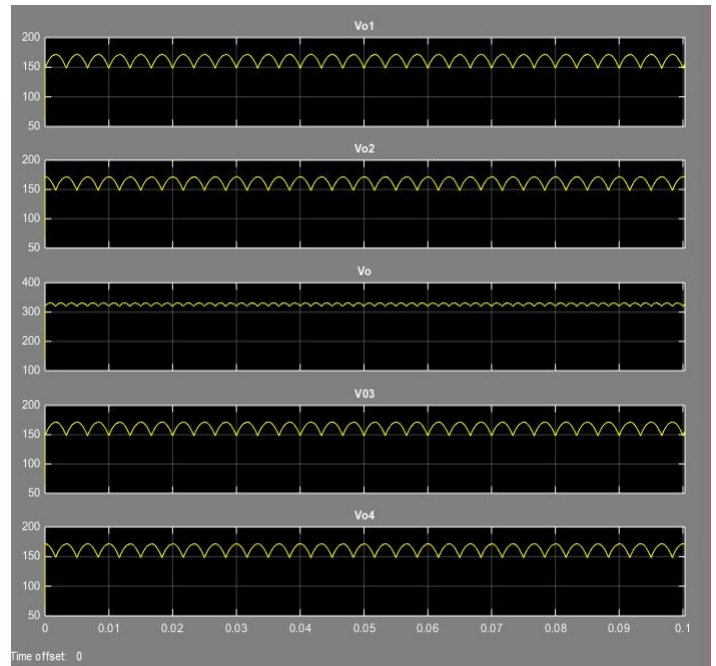


Fig.6

Sr. No.	Topology	Load, (kW)	THD of $V_s$ (%)	AC Mains Current $I_1$ (A)	THD of $I_1$ (%)	Crest Factor, CF	Displacement Factor, DPF	Power Factor, PF	DC Voltage (V)	Load Current $I_{dc}$ (A)
1	12-pulse	0.92	1.1	1.32	15.6	1.4	1.00	0.9985	573.9	1.67
		1.51	1.0	2.12	13.3	1.4	1.00	0.9996	573.0	2.60
		2.17	1.1	3.04	12.1	1.4	1.00	0.9997	570.9	3.77
		3.10	1.1	4.36	11.8	1.4	1.00	0.9997	570.0	5.34
		4.05	1.1	5.68	11.5	1.4	1.00	0.9997	567.4	6.93
		5.18	1.1	7.27	11.2	1.4	1.00	0.9997	566.2	8.84
		5.98	1.1	8.41	11.1	1.4	1.00	0.9997	564.3	10.01
		6.88	1.1	9.63	11.0	1.4	1.00	0.9988	562.4	11.46
2	24-pulse	7.64	1.1	10.83	10.7	1.4	1.00	0.9988	561.2	12.24
		1.10	0.9	1.536	5.0	1.4	1.00	0.9952	584.4	1.801
		2.07	0.8	2.905	4.9	1.4	1.00	0.9962	578.8	3.464
		3.10	0.8	4.352	5.0	1.4	1.00	0.9963	574.8	5.228
		4.20	0.8	5.89	5.0	1.4	1.00	0.9963	572.7	7.07
		5.22	0.8	7.27	5.0	1.4	1.00	0.9963	569.1	8.75
		5.97	0.8	8.36	5.0	1.4	1.00	0.9963	565.8	10.09
		6.53	1.0	9.12	5.0	1.4	1.00	0.9963	564.5	11.02
6.92	1.0	9.68	5.0	1.4	1.00	0.9963	562.4	11.72		
7.53	1.0	10.49	4.9	1.4	1.00	0.9963	562.0	12.70		

Table.1

VI.CONCLUSION:

In light of the proposed outline, reproduction, and test outcomes, it has been watched that power quality has been enhanced altogether by utilizing the proposed phase shifting transformer based 24-pulse AC-DC converter .since the harmonic distortion is reduced in the proposed 24 pulse converter. And this outlines that the proposed plan is suitable for minimal effort, high voltage applications. The ensuing 24-pulse converter has displayed a high level of execution with clean power qualities.

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