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Multipulse Converter for Analysing Total Harmonics Distortion and Its Mitigation

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***Abstract*— Reliable low distortion DC supply is a prime concern for medium and high voltage applications. Multilpulse converters is one of the popular device that furnishes low ripple DC output with the benefit of direct conversion from AC supply. It consists of identical six pulse converter units and may involve phase shifting transformers, autotransformers or even transformer less systems. This paper describes the comparative analysis and design of even group combinations namely 6, 12 and 24 pulse converters with MATLAB simulations. The simulated models have been formulated for medium line voltage and power applications to validate the utility and cost effectiveness. The Input A.C current waveform and the DC output waveform and harmonic analysis has been observed.**

***Index Terms*— Multipulse converter,Total harmonics distortion, Form factor, Ripple content.**

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].

II. OBJECTIVE OF PRESENT STUDY

The present work is for analyzing various multi-pulse AC-DC converting for solving harmonics trouble in a three-phase converter system.For performance comparison the major factors considered are the total harmonic distortion (THD) ripple percentage, form factor.

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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 [7, 9]. 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 [11]. 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 types of conversion techniques , one is uncontrolled in which diodes are implemented and other is controlled in which thyristors are implemented respectively [12].The performance improvement is achieved for total harmonics distortion (THD) in input current, DC voltage ripples and form factor. All the simulation is done for RL load and the results shows THD, which is agree with the IEEE St 519-1992. The result also shows the work done by increasing the pulses in circuits for controlled multipulse converter in supply current, dc side voltage and current.[14]

IV. SIMULATION OF UNCONTROLLED MULTI-PULSE CONVERTERS

A. Six-Pulse Converter

As the basic converter unit of HVDC transmission is used for rectification, where electrical power flows from the AC side to the DC side and inversion where the power flow is from the DC side to the AC side. Thyristor valves operate as switches which turn on and conduct current when fired on receiving a gate pulse and are forward biased. The six pulse Converter Bridge shown in Fig 1.

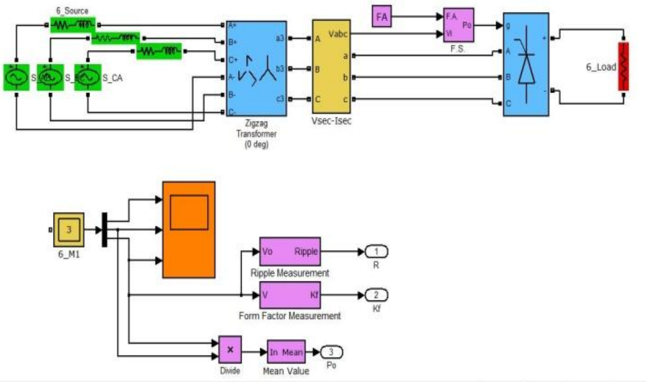

Fig.1 Controlled six pulse converter bridges**.**

The characteristic AC side current harmonics generated by 6-pulse converters are 6n±1, Characteristic DC side voltage harmonics generated by a 6-pulse converter are of the order 6n±1.

B. Twelve Pulse Converter

When two six pulse converter bridge is connected in series with two 3 phase system having phase difference of 30 electrical degree from each other. The phase difference effected to cancel out the 6-pulse harmonics on the AC and DC side. With the use of 12 pulse converter 5^{th} and 7^{th} harmonic are eliminated but still 11^{th} and 13^{th} harmonic are present. Figure 2 shows a 12 pulse controlled converter

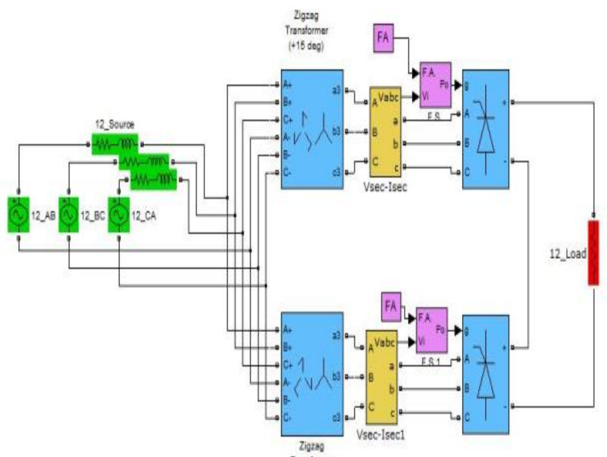

Fig 2. Controlled twelve pulse converter bridge.

C. Twenty-Four Pulse Converter

The 24-pulse converter and the corresponding connections are shown in fig. 3.

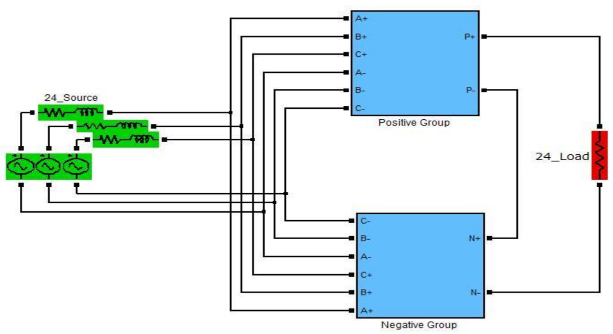

Fig 3. Controlled 24 pulse converter

This connection contains four six pulse converters having phase difference of 15 degrees from each other, thus it provide twenty four pulse rectification with much lower harmonics on AC and DC side. Its AC output voltage would have 24n±1 order harmonics i.e., 23rd, 25th, 47th, 49th harmonics.

V. SIMULATION RESULTS OBTAINED FOR MULTI-PULSE CONVERTERS

The simulation setups for respective multilevel converters were initiated for estimation of DC output voltage, current and its impact on source current is determined by monitoring the form factor and ripple factor of the test circuits.

A. Output of source current, load current, d.c. output current

In the subsequent results displayed source current (SC), Load current or output current (LC) and D.C output voltage (OV) respectively. For all the converter bridge these output is shown in figure 4 to 6 for 6, 12 and 24 pulse respectively.

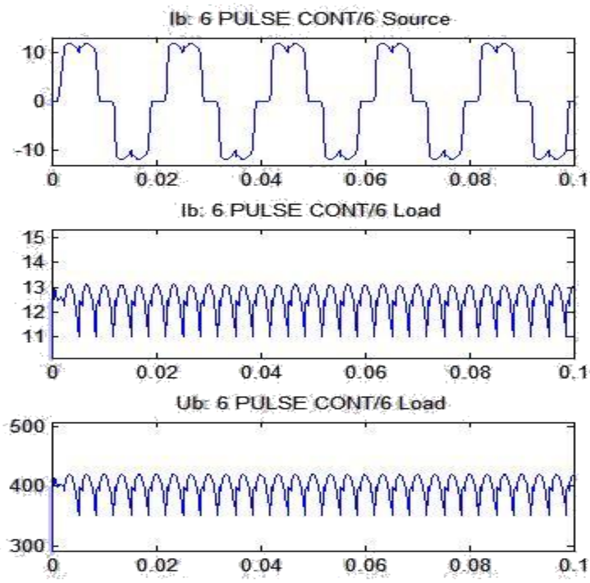

Fig 4. Output for SC, LC, OV for 6 pulse

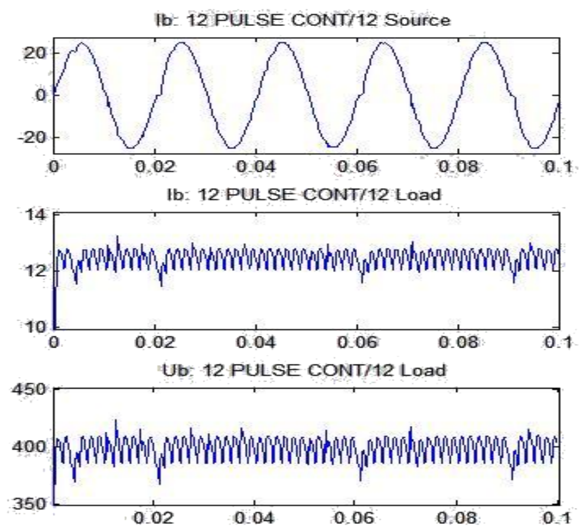

Fig 5. Output for SC, LC, OV for 12 pulse

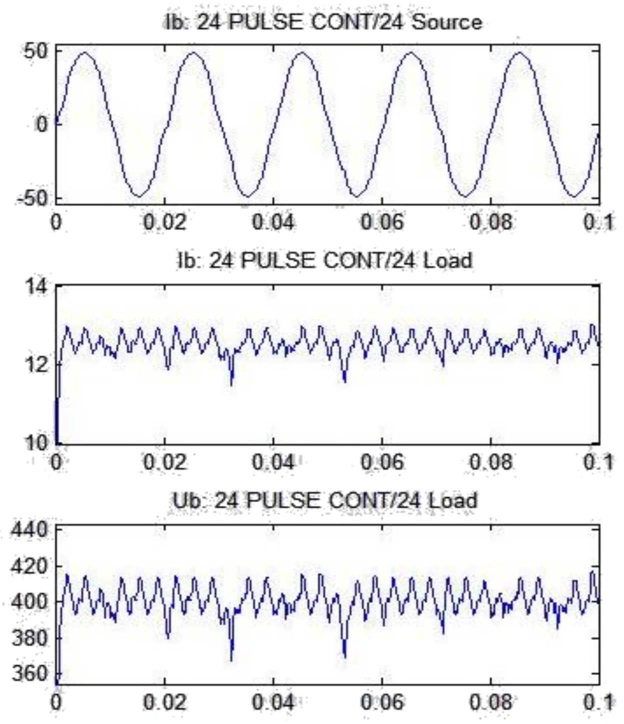

Fig 6. Output for SC, LC, OV for 24 pulse

B. Voltage & Ripple Factor v/s firing angle output

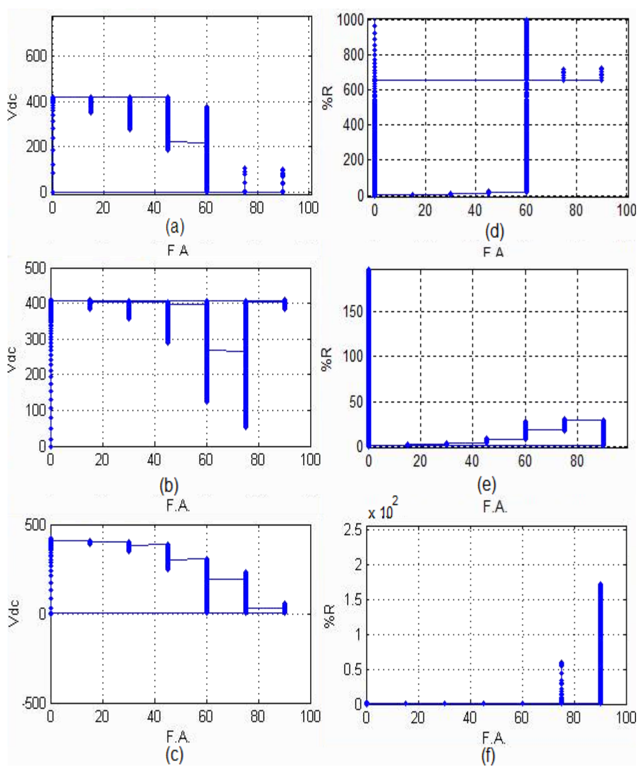

Fig 7. Output for voltage v/s. firing angle for (a) 6 pulse (b) 12 pulse (c) 24 pulse ; Output for Ripple v/s. firing angle for (d) 6 pulse (e)12 pulse (f)24 pulse

VI. Comparison of the Output Observed

Table 1: Total Harmonic Distortion results

No. of pulses	THD
6	0.45
12	0.15
24	0.11

Table 2: % Ripple Content Observed results

No. of pulses	Ripple
6	4.447
12	2.049
24	1.515

Table 3: Form Factor Observed results

No. of pulses	Form factor
6	1.001
12	1
24	1

VII. Performance Analysis and Comparison

All the data obtained after simulation of afore said models using MATLAB/SIMULINK has been collected here so as to ease the comparison of factors accounted for i.e. THD, Ripple Content and Form Factor between controlled Multi-pulse converters. All the results obtained from Tables 1 to 3 and categorized on the basis of pulse provided so as to ease the comparison.

VIII. Result of Simulation

The objective of the present work is to investigate the performance of controlled multi-pulse converters by increasing the number of pulses. These converters are studied in terms of harmonic spectrum of AC supply current, total harmonic distortion, Ripple Content & form factor in the AC supply. Therefore in general with increase in number of pulses in multi-pulse case the performance parameters of these converters have remarkably improved. The THD for controlled converters has reduced than for the consecutive uncontrolled.

IX. Conclusion

The various isolated multi-pulse configurations were simulated using MATLAB/ SIMULINK and the results have been presented in this paper in Table 1 to Table 3. The effect of pulse variation on different multi-pulse converters reveals that with RL load because of inductance there is smoothing effect on current, therefore current THD decreases. The effect is similar for different multi-pulse converters, i.e. it increases current discontinuity and hence affecting the harmonic spectrum adversely.

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