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18 PULSE CONVERTERS WITH DELTA - DIFFERENTIAL CONNECTIONS FOR HARMONIC MITIGATION

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Abstract— *This paper centers to 3/9 stage auto-transformer with different windings per stage is controlled a 9-stage AC to DC converter this kind of transformer has 40o stage move between the yield voltages, it is provided from a three stage AC source with star or delta association, to utilize this sort of transformer in aviation the activity recurrence ought to be at 400Hz notwithstanding lessen the current symphonious mutilation through a three stage line reactor are associated after three stage AC source for this situation the current consonant twisting abatements to esteem under 5% and it can be under 3% level by utilizing an extra concealment gadgets (Stifles) at the yield of the converter, this autotransformer incorporates three segments each dispersed 120o electrically separated. Each segment includes a fundamental winding and a couple of stage move windings, it is a primary component in 18 beat converters, the multiphase amendment can be investigated by utilizing orca recreation programming, and demonstrated the examinations between the odd stages so the 9 stages has a lower estimation of the swell factor which is 0.763 %.*

Keywords *–Power quality autotransformer, line reactor, chokes,multiphase rectification.*

1. INTRODUCTION

An autotransformer has only a single winding with two end terminals, and one or more terminals at intermediate tap points. The primary voltage is applied across two of the terminals, and the secondary voltage taken from two terminals, almost always having one terminal in common with the primary voltage. The primary and secondary circuits therefore have a number of windings turns in common. Since the volts-per-turn is the same in both windings, each develops a voltage in proportion to its number of turns. In an autotransformer part of the current flows directly from the input to the output, and only part is transferred inductively, allowing a smaller, lighter, cheaper core to be used as well as requiring only a single winding. One end of the winding is usually connected in common to both the voltage source and the electrical load. The other end of the source and are connected to taps along the winding. Different taps on the winding correspond to different voltages, measured from the common end. In a step –down transformer the source is usually connected across the entire winding while the load is connected by a tap across only a portion of the winding. In a step –up transformer, conversely, the load is attached across the full winding while the source is connected to a tap across a portion of the winding. As in a two-winding transformer, the ratio of secondary to primary voltages is equal to the ratio of the number of turns of the winding the connect to. An autotransformer does not provide electrical isolation between its windings as an ordinary transformer does, if the neutral side of the input is not at ground voltage, the neutral side of the output will not be either. A failure of the insulation of the windings of an autotransformer can result in full input voltage applied to the output. Also, a break in the part of the winding that is used as both primary and secondary will result in the transformer acting as an inductor in series with the load. These are important safety considerations when deciding to use an autotransformer in a given application. Because it requires both fewer windings and a smaller core, an autotransformer for power applications is typically lighter and less costly than a two-winding transformer, up to a voltage ratio of about 3:1 beyond that, a two-winding transformer is usually more economical. In three phase power transmission applications, auto transformers have the limitations of not suppressing harmonic currents and as acting as another source of ground fault currents. A large three-phase autotransformer may have a "buried" delta winding, not connected to the outside of the tank, to absorb some harmonic currents. For a variable autotransformer intended to conveniently vary the output voltage for a steady AC input voltage. The term is often used to describe similar variable autotransformers made by other makers. To provide very small increments of adjustment, the secondary connection is made through a brush that slides across the winding coils. Variable autotransformers are still used when an undistorted Variable voltage sine wave is required. The autotransformer in this paper acts good role to build the 18 pulse rectification so that includes the three phase AC voltage source V_{ph1}, V_{ph2} and V_{ph3} is connected to the center tap point in each respective leg of the transformer and it has a 9 phases at the output with multiple windings per phase, and there is a 40_o phase shift between them, the boost ratio of this type of autotransformer defined by the ratio of the desired output voltage to the AC source voltage. For example, if the AC source voltage is 110 Volts and the desired output voltage of the transformer is 220 Volts then the boost ratio is 2. But the boost ratio for the applied autotransformer in this paper is 2.5. The system of 18 pulse converter is illustrated in the fig. 1-a and fig. 1- b.

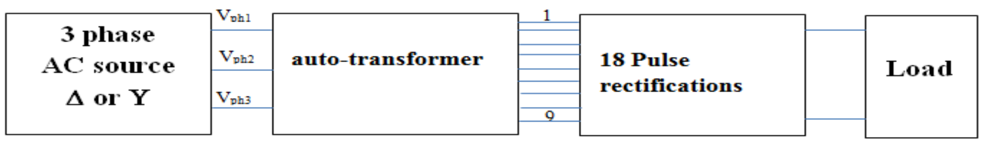

Fig. 1-a: Illustrates of system of 18 pulse converter using autotransformer without three phase line reactors.

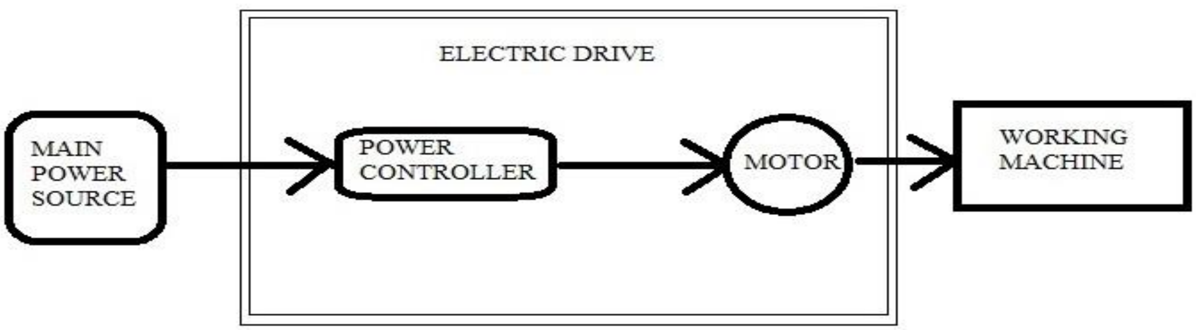

Fig. 1-b: Illustrates of system of 18 pulse converter using autotransformer with three phase line reactors, they are used to suppress the current harmonic distortion.

2. DESCRIPTION

The fig. 2 shows the implementation of the multiphase autotransformer so that includes three sections each spaced by 120_oeach section contains a main winding, the first main winding should be divided through the center tap into a first turns n_1 and the second turns n_2, thus the center tap determines the boost ratio through the ratio of the first turns n_1 to the total turns of the main winding which is $n_1 + n_2$,to realize the boost ratio 2.5 the total turns of the first main winding is 1 and the first turns n_1 is 0.4 ,and the second turns is 0.6 .For the boost ratio 2 the first turns n_1 is equals to the second turns n_2 of 0.5, the pair of phase shift windings each have one end connected to the center tap of the main windings. The other end of each phase shift windings 9, 4 is a phase of the autotransformer that is shifted $+/-40_o$ electrically from the output end 1 and they have the turns number of n_3.The second and third main windings have the same turns number of n_1, n_2 and n_3 as determined in the first main winding, the ratio between the first, second and third number of turns of about 0.4: 0.6: 0.74, respectively .The three phase AC voltage source V_{ph1}, V_{ph2} and V_{ph3} are applied to the center tap of each main windings respectively, the fig. 3 shows the winding configuration of the used autotransformer for boost ratio 2.5 . To reduce the current harmonic distortion produced by this transformer will be through a three phase line reactor are connected after three phase AC source in this case the current harmonic distortion decreases to value less than 5% and it can be less than 3% level by using an additional suppression devices (Chokes) at the output of the converter.

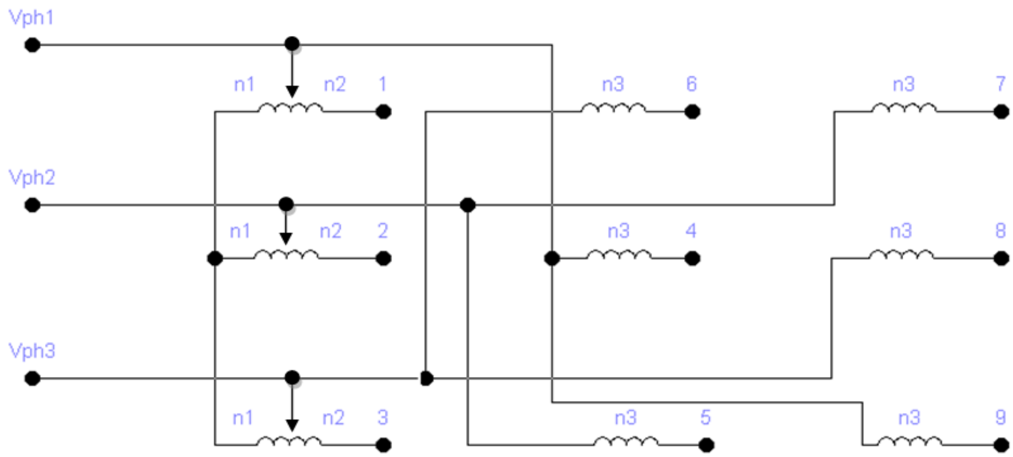

Fig. 2: Illustrates the implementation of the 3/9 auto-transformer.

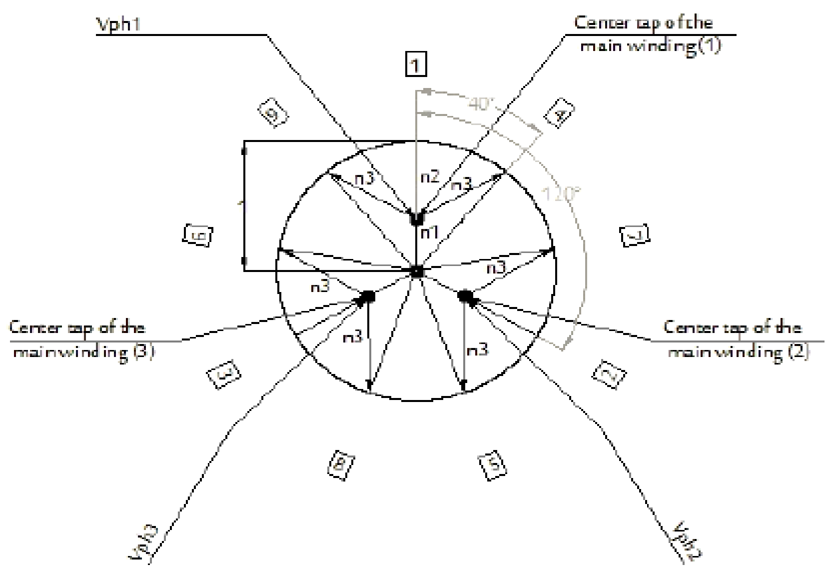

Fig. 3: Illustrates the winding configuration of the auto-transformer so that the boosting ratio of 2.5, then n1:n2:n3 = 0.4; 0.6; 0.74.

3. ANALYSIS OF 18 PULSE CONVERTER

3.1 Study of the voltages

a- The average output voltage

For the bridge rectifier with m phases, the average output voltage is given as the following:

$$V_{o/p\ average} = 2.(m/\pi).V_{max}.\ \mathrm{Sin}(\pi/m)$$

b- The effective output voltage

Let $V_{o/p\ effective}$ is the effective voltage at the output of bridge rectifier with m phases then the expression of this voltage is given as the following:

$$V_{o/p\ eff} = \frac{2.(\ V\max)}{\sqrt{2}} * \frac{\sqrt{1+(\sin 2\pi/m)}}{(m/2\pi)}$$

4. 18-PULSE CONVERTERS

Figure 8 demonstrates the 18-beat Δ-differential converter, with three indistinguishable burdens. Figure 9 demonstrates the relationship between kVA rating and the swing proportions to the 18-beat Δ- differential converter. The evident energy of the essential side is the same of (9), the optional power is communicated by (12), and the successful kVA and the heap control are figured by (7) and (8), separately.

The best point occurs when the autotransformer process near 17% of the load power, as shown in figure 9

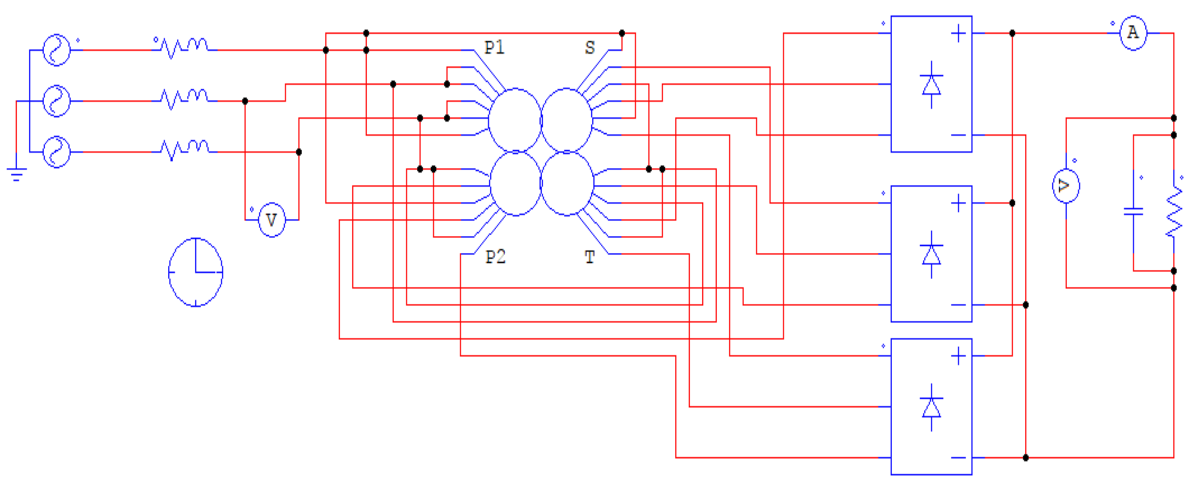

Fig. 8. 18-pulse Δ-differential converter.

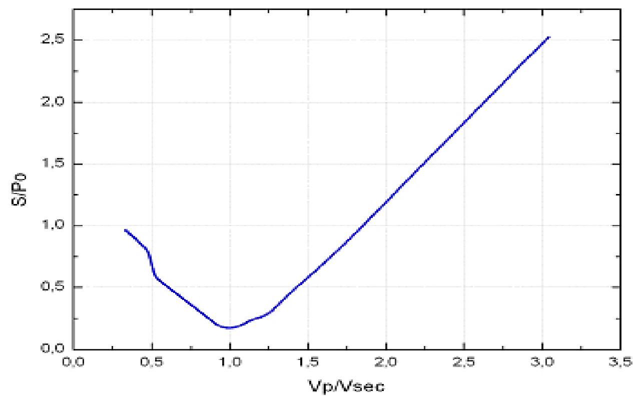

Fig. 9. Turn ratios versus kVA rating of the autotransformer with 18-pulse Δ-differential connection.[1]

The simulations are performed for the optimum point. The average voltage at this point is 300 V. Figure 10 shows the rectified and secondary voltages.

Figure 11 illustrates the voltage and current in one phase of the AC mains. The harmonic pectrum of the line urrent is shown in figure 24. The harmonic components are $k \cdot 18 \pm 1$ ($k = 1, 2, 3 \ldots$).

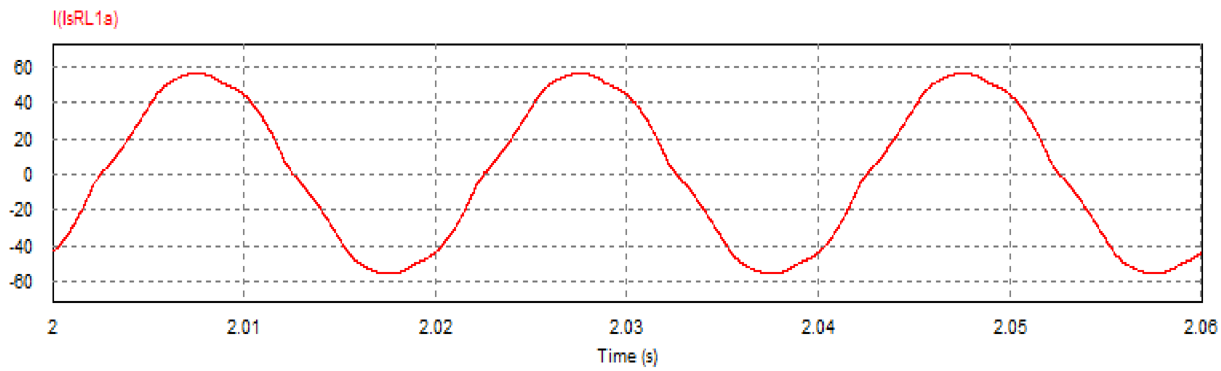

Fig. 11. Voltage and current in one phase of the AC mains.

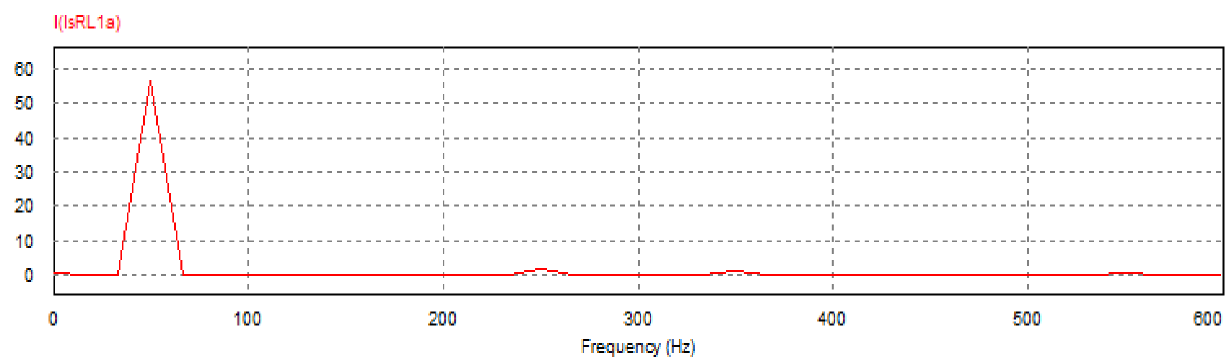

Fig. 12. Harmonic spectrum of the line current.

5. APPLICATIONS FOR 9 PHASES

- Study of voltages for the rectifier with 9 phases Using the general equations as shown above, where that m = 9 and the $V_{i/peff}$ = 220V, V_{max} = 220 = 311.12V. The /results are: $V_{o/p\ average}$ = 609.68V, $V_{o/p\ eff}$ = 609.79V, V_{RWM}=612.78V.
- Study of the currents for the rectifier with 9 phases For the load resistance R_l = 1KΩ. The results are: $I_{o/p\ average}$ = 0.60968A, $I_{o/p\ eff}$ = 0. 60979A, $I_{Daverage}$ = 0.0676A.
- The ripple factor for the rectifier with 9 phases For m = 9 (odd) and n = 2m, n = 18, then the result is K_o = 0.00764 or K_o = 0.763%.
- Verification by simulation The figure (10) represents the rectifier with 9 phases, it is verified by simulation program (Orcad), the results of the input and output voltages are shown by figure (11) and the results of voltage and current in each diode are shown by figure (12), in addition to that the figure (13) shows the ripple factor in terms of the odd and even phases number, the figure (14) shows the ripple factor in terms of the odd phases number , the figure (15) shows the ripple factor in terms of the even phases number .

6. Conclusions

In this paper, the 3/9 phase autotransformer with multiple windings per phase is used to supply DC systems so that the current harmonic distortion is reduced to less than 0. 3%. The output voltage is gradually increased, when the number of phases is increased, The output voltage tends to be a perfect DC voltage, the diode should be capable of supporting greater inverse voltages V_{RWM} , when the number of phases is increased (if m is odd), but diodes with V_{RWM} $2V_{max}$ can generally be used, regardless of the number of phases and the parity, at the contrary of the voltage currents in the diodes decrease when the number of phases is increased, finally, the more important is the ripple factor K_o which decreases from=7% to if m=3 to K_0 = 0.763% if m = 9, the following figures represent the ripple in function of the number of phases. We conclude that the rectifiers of odd number of phases have smaller ripples.

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