REVIEW OF ANALYSIS AND ASPECTS OF FIVE PHASE TRANSFORMER BY USING MATLAB SIMULATION

Duggelwar Vikrant S.[1], Ahire Mayuri R.[2], Lonare Sagar N.[3] Ghugarkar Madhuri A.[4] Mr.Nadeem B. Shaikh [5]

[12,3,4,6]*BE Student, Department of Electrical Engineering SVIT College Of Engineering Chincholi Nashik, Maharashtra India .*

[5]*HoD & Assistant Professor Department of Electrical Engineering Chincholi SVIT Nashik Maharashtra India.*

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Abstract - *The considerable research effort has been in place to develop commercially feasible multiphase drive systems. Since the three-phase supply is available from the grid there is a need to develop a static phase transformation system to obtain a multiphase supply from the available three-phase supply, direct application in electrical machines laboratory for different motor drives supply strategies. Thus, this paper proposes a novel transformer connection scheme to convert the three phase grid supply to a five-phase fixed voltage and fixed frequency supply. The proposed transformer connection outputs five phases and thus can be used in applications requiring a five-phase supply. Currently, the five-phase motor drive is a commercially viable solution. The five-phase transmission system can be investigated further as an efficient solution for bulk power-transfer. The connection scheme is elaborated by using the simulation and experimental approach to prove the viability of the implementation. Multiphase machines have become serious contenders for safety-critical applications that require wide fault tolerant capabilities and higher system reliability.*

***Key Words*:** *Five phase, multiphase, three phase, transformer, turn ratio.*

1. INTRODUCTION

Three-phase electric machines are today used on a large scale in various industrial applications due to their multiple advantages, such as: low production costs, high reliability and robustness, and maintenance free operation. Additionally to all these, one should not ignore the three-phase supply system accessibility and the development of power electronics used in motor control strategies which give more reasons to choose an AC machine over a DC one. But AC electric machines used in industrial applications are not limited to only three-phase system. Other multiphase electric generators and motors are lately studied in order to increase even more AC machines performances. For example, two-phase induction motors are widely used in fractional power applications; five-phase and six-phase generators are recommended by their

enhanced fault capability, high power six-phase ore even twelve-phase motors are used in order to reduce the phase current and the torque ripple Multi-Phase (more than three phase) systems are the focus of research recently due to their inherent advantages compared to their three-phase counterparts. The applicability of multiphase systems is explored in electric power generation, transmission, and utilization. The five-phase transmission system can be investigated further as an efficient solution for bulk power-transfer. Multiphase machines have become serious contenders for safety-critical applications that require wide fault tolerant capabilities and higher system reliability. The geometry of the fabricated transformer is elaborated in this paper. The five phase power is 0.5179 times more than the three phase power and 2.25 times more than the single phase power.

1.1 Motivation

Whenever a Three Phase Induction Motor is run, a problem with ripple torque & harmonics. This hampers the smooth operation of the machine and is found also aggravates the amount of heat that is generated. The ripple content can be smoothened by supplying the motor with a multi-phase supply which is greater than the three phase supply. Five phase helps to reduse heat and which is interesting to study.

1.2 Objectives

Whenever a Three Phase Induction Motor is run, a problem with ripple torque & harmonics. This hampers the smooth operation of the machine and is found also aggravates the amount of heat that is generated. The ripple content can be smoothened by supplying the motor with a multi-phase supply which is greater than the three phase supply. Selection of an even number of phases should be avoided because it degrades the performance of the motor as the poles coincide with each other. Care must be taken so that the number of phases is not multiples of three. Therefore, a Five Phase Supply may be preferred.

AC-DC converters may cause distortions in the supply voltage due to their nonlinear characteristics which might lead to poor power quality in terms of harmonics injected, causing poor power factor. The five phase power is o.5179 times more than the three phase power and 2.25 times more than the single phase power.

Multiphase machines have become serious contenders for safety-critical applications that require wide fault tolerant capabilities and higher system reliability. However, this adds more complexity to the adopted power converters. Multiphase, especially a 6-phase and 12-phase system is found to produce less ripple with a higher frequency of ripple in an ac–dc rectifier system. Thus, 6- and 12-phase transformers are designed to feed a multi pulse rectifier system

2. THREE PHASE TO FIVE PHASE TRANSFORMER SIMULATION

2.1 Winding Arrangement for Five-Phase Star Output

Three separate cores are designed with each carrying one primary and three secondary coils, except in one core where only two secondary coils are used. Six terminals of primaries are connected in an appropriate manner resulting in star and/or delta connections and the 16 terminals of secondaries are connected in a different fashion resulting in star or polygon output. The connection scheme of secondary windings to obtain a star output is illustrated and the corresponding phasor diagram is illustrated in Fig.The construction of output phases with requisite phase angles of 72 between each phase is obtained using appropriate turn ratios, and the governing phasor equations are illustrated in (1)–(10).The turn ratios are different in each phase. The choice of turn ratio is the key in creating the requisite phase displacement in the output phases. The input phases are designated with letters “X” “Y”, and “Z” and the output are designated with letters “a”, “b”, “c”, “d”, and “e”. As illustrated in Fig. 4.2, the output phase “a” is along the input phase “X”. The output phase “b” results from the phasor sum of winding voltage “ c6c5” and “b1b2 ”, the output phase “c” is obtained by the phasor sum of winding voltages “ a4a3” and “ b3b4”. The output phase “d” is obtained by the phasor addition of winding voltages “a4a3 ” and “c1c2 ” and similarly output phase “e” results from the phasor sum of the winding voltages “c3c4” and “b6b5 ”. In this way, five phases are obtained. The transformation from three to five and vice-versa is further obtained by using the relation given in (1)–(10)

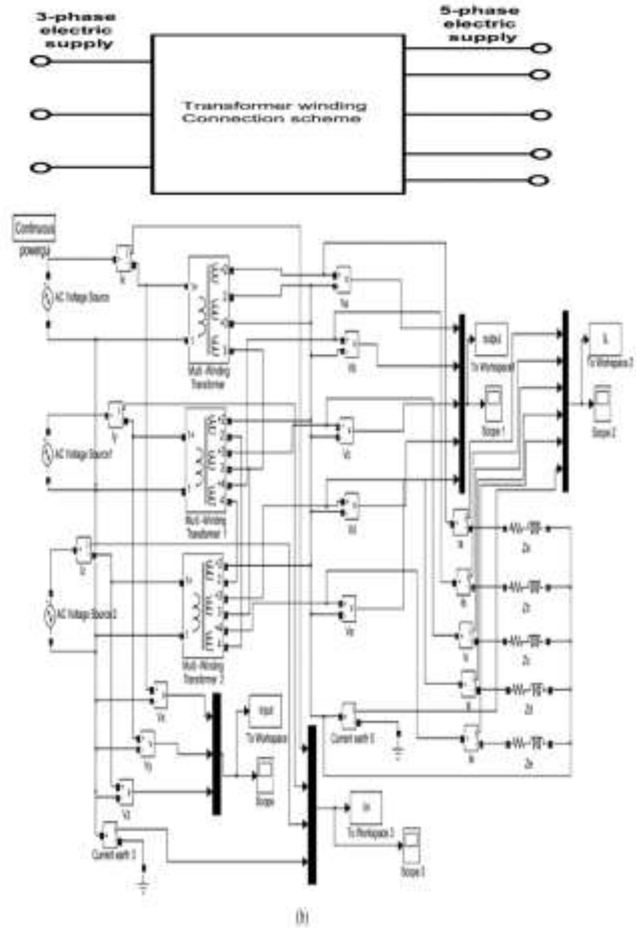


Fig -1-Simulation of three phase to five phase transformer

$$\begin{bmatrix} V_a \\ V_b \\ V_c \\ V_d \\ V_e \end{bmatrix} = \frac{1}{sin\frac{\pi}{3}} \times \begin{bmatrix} sin\frac{\pi}{3} & 0 & 0 \\ 0 & sin\frac{\pi}{15} & -sin\frac{4\pi}{15} \\ -sin\frac{2\pi}{15} & sin\frac{\pi}{5} & 0 \\ -sin\frac{2\pi}{15} & 0 & sin\frac{\pi}{5} \\ 0 & -sin\frac{4\pi}{15} & sin\frac{\pi}{15} \end{bmatrix} \begin{bmatrix} V_x \\ V_y \\ V_z \end{bmatrix} \quad \text{.............................. (1)}$$

$$V_a = V_{max} Sin(\omega t) \quad \text{............... (2)}$$

$$V_b = V_{max}Sin(\omega t + \frac{2\pi}{5}) \ldots\ldots\ldots\ldots (3)$$

$$V_c = V_{max}Sin(\omega t + \frac{4\pi}{5}) \ldots\ldots\ldots\ldots (4)$$

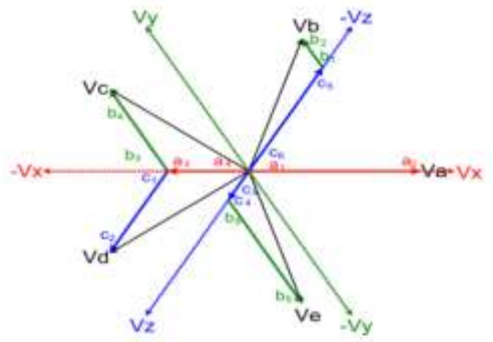
$$V_d = V_{max}Sin(\omega t - \frac{4\pi}{5}) \ldots\ldots\ldots\ldots (5)$$

$$V_e = V_{max}Sin(\omega t - \frac{2\pi}{5}) \ldots\ldots\ldots\ldots (6)$$

$$V_x = V_{max}Sin(\omega t) \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

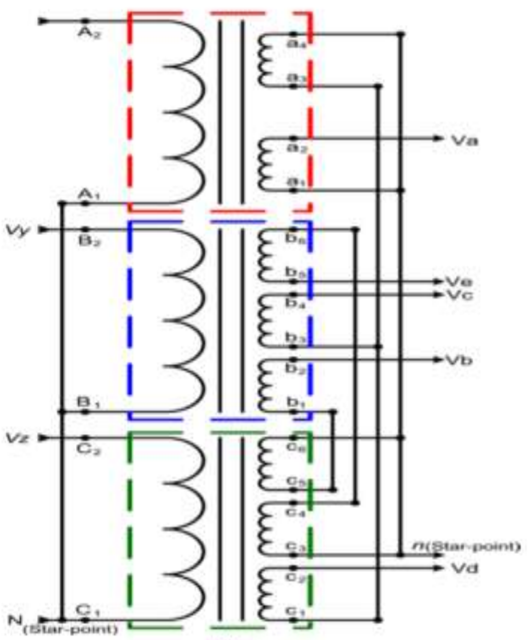
$$V_y = V_{max}Sin(\omega t + \frac{2\pi}{3}) \ldots\ldots\ldots\ldots (8)$$

$$V_z = V_{max}Sin(\omega t - \frac{2\pi}{3}) \ldots\ldots\ldots\ldots\ldots\ldots (9)$$



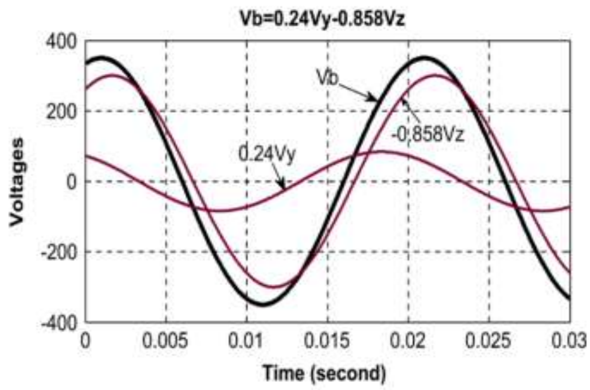
Phasor diagram of the proposed transformer connection (star-star).

2.2 Simulation Results

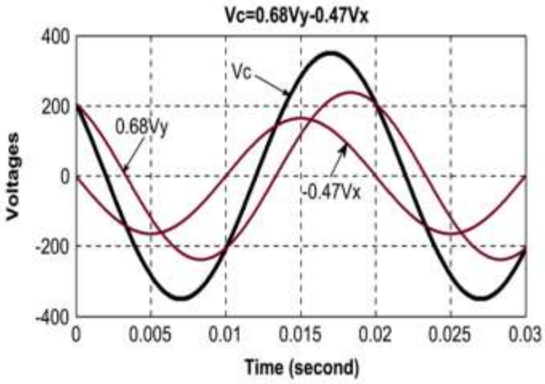


(a)

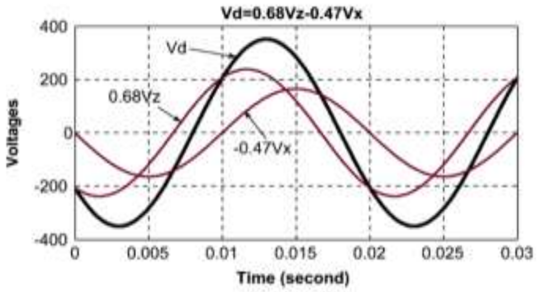
The designed transformer is at first simulated by using "simpowersystem" block sets of the Matlab/Simulink software. The inbuilt transformer blocks are used to simulate the conceptual design. The appropriate turn ratios are set in the dialog box and the simulation is run. . Standard wire gauge SWG) . A brief design description for the turn ratio, wire gauge, and the geometry of the transformers [Fig. (a)] are shown in the Appendix. The simulation model is depicted in Fig. (b) and the resulting input and output voltage waveforms are illustrated in Fig.. It is clearly seen that the output is a balanced five-phase supply for a balanced three-phase input. Individual output phases are, also, shown along with their respective input voltages. The phase Va is not shown because (i.e., the input and the output phases are the same). There was no earth current flowing when both sides neutrals were earthed. The input and output currents with earth current waveforms are also shown in fig. From this, we can say that the transformer, connected to the X input line, carries 16.77% (19.5/16.7) more current than that of the other two transformers (or two phases). Due to this efficiency, the overall transformer set is slightly lower than the conventional three-phase transformer.



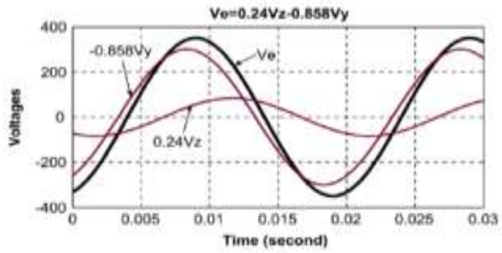
(a)



(b)



(c)



(d)

Fig. (d)–(g). (d) Input Vz and Vy phases and output Ve phase voltage waveforms. (e) Input three-phase and output five-phase voltage waveforms. (f) Input three-phase and output five-phase load current waveforms at PF 0.4. (g) Input three-phase and output five-phase load current waveforms at PF 0.8.

2.3 Application's

In industries high speed drives applications is used. Five phase transmission lines can provide the same power capacity with a lower phase-to phase voltage and smaller, more compact towers compared to a standard double-circuit three-phase line.

 Direct application in electrical machines laboratory for different motor drives supply strategies. The differences between phase voltages amplitudes and waveforms do not exceed an acceptable value of 2%. Such an electric transformer represents a cheap, convenient and easy to build solution to the PWM converters.

The increasing use of nonlinear loads in electrical systems causes many problems in the supply. Multipulse rectifiers emerge as a solution, improving power quality.

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3. CONCLUSIONS

This project proposes a new transformer connection scheme to transform the three-phase grid power to a five-phase output supply. The connection scheme and the phasor diagram along with the turn ratios are illustrated. The successful implementation of the proposed connection scheme is elaborated by using simulation. A five-phase induction motor under a loaded condition is used to prove the viability of the transformation system. It is expected that the proposed connection scheme can be used in drives applications and may also be further explored to be utilized in multiphase power transmission systems. The increasing use of non-linear loads in electrical systems causes many problems in the supply. Multipulse rectifiers emergeas a solution, improving power quality. In this project,a three-to-five phase transformer was successfully designed, simulated and May be implement to make a multi-pulse AC-DC converter. For balanced output, he input must have balanced voltages. Any unbalancing in the input is directly reflflected in the output phases.

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BIOGRAPHIES

Duggelwar Vikrant S.
U.G. Student, Electrical Enginering
SVIT, nshik, Maharashtra, India.

Ahire Mayuri R.
U.G. Student, Electrical Enginering
SVIT, nshik, Maharashtra, India.

Lonare Sagar N.
U.G. Student, Electrical Enginering
SVIT, nshik, Maharashtra, India.

Ghugarkar Madhuri A.
U.G. Student, Electrical Enginering
SVIT, nshik, Maharashtra, India.

Proff. Mr. Nadeem B. Shaikh,,
HoD & Assistant Professor of Electrical Engineering Dept, SVIT, Nashik,Maharashtra, India.