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Modelling of Three To Seven Phases Transformer Connection by Using MATLAB Software

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ABSTRACT: The whole modelling has been simulated by using MATLAB Software. Multi-winding transformer block was taken from the sim-power system block library and turn ratios set in the dialog box then simulated. The complete design and simulation of the proposed work is presented in this paper. Now we have mentioned the simulation results only for RL load. Seven phase transmission system can be developed for the generation of bulk power transfer. As per need of the induction motor under a loaded condition is used to proof the viability of transformation system. In seven phase's, each phases shifted from the order by 51.42° (360°/7) and got the sin wave voltage/current. The connection scheme was expanded by using the modelling and simulation approach to prove the viability of the implementation.

KEYWORDS: Multi-winding transformer, Multiphase system, Multiphase transmission, Three-to-Seven phases.

I.INTRODUCTION

The transformer is an important element in the development of high-voltage electric power transmission. Transformers can be classified into various types (step up, step down and matching transformers) according to ratio of the numbers of turns in the coils (turns ratio), as well as whether or not the primary and secondary are isolated [1-2].

Multiphase i.e. More than three phase systems are the focus on research recently due to their inherent advantage compared to the three phase counterparts. It has applicability of explored to electric power generation in multiphase systems [3-5] transmission [4-6] and utilization [7-8]. The research on eleven-phase transmission system was initiated due to the increasing a rising cost of right way for a transmission corridors, environmental program, and various stringent licensing laws [9].Six-phase transmission lines can provide the same power capacity with a lower line voltage and smaller towers as compared to a standard double circuit three-phase line [4]. The dimension of the six-phase smaller towers may also lead to the reduction of magnetic fields and electromagnetic interference [9-10]. Normally no-load test, blocked rotor and load tests are performed on a motor to determine its parameters. Although the supply is used for multiphase motor drives obtained from multiphase inverters could have more current ripples, these are the controlling methods available to lower the current distortion below 1%, based on application and requirement [11-13].

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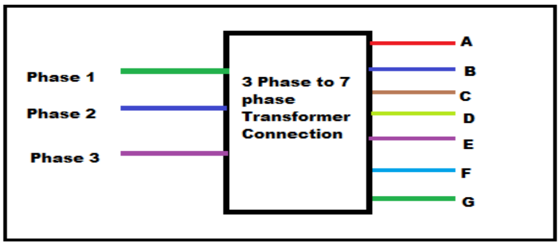

Figure 1: Block representation of the proposed system

We know that from the theory multi-phase motors are invariably supplied by ac/dc/ac converters. Thus, the multiphase electric drive is limited for the modelling and control of the supply systems [13]. Our main work is to develop static transformation system to change the phase number from three to eleven-phase (where n>3 and odd). Now we, are generating a novel phase transformation system which convert three phase to an eleven-phase supply [14].
In Multiphase, system six phase and twelve phase is found to produce less ripple with a high frequency in an AC-DC rectifier system. Thus six and twelve phase transformers are designed to feed a number of pulses rectifier system and technology has matured [15]. Recently, twenty four phase and thirty six phase transformer systems have proposed for supplying a number of pulse rectifier systems [12-16]. These designs are also available for an odd number of phases, such as five, nine and eleven etc.
In this paper we have proposed a special transformer connection scheme to get a balance eleven-phase output supply from the balance three-phase input supply. The expected application areas of the power transformer are the electric power transmission system and power electronic converters (AC-DC and AC-AC), and the multiphase electric drive system. The block represented of the proposed system is shown in figure 1.The fixed voltage and fixed frequency available grid supply can be transformed to the fixed frequency Seven-phase output supply. The output however, may be made variable by inserting the autotransformer at the primary side. The input and output supply can be arranged in the following manner [20] as below.
I) Input Star, Output Star.
II) Input Star, Output heptagon.
III) Input Delta, Output Star.
IV) Input Delta, Output heptagon.
The input has being three-phase system the windings are connected in a usually fashion. The hendecagon output connection may be derived following a similar approach. The output/secondary side connection is discussed in the following subsections.

II.WINDING ARRANGEMENT OF SEVEN PHASE STAR OUTPUT

Here separates iron core are designated with one primary and three secondary coils, six terminal of primary side are connected in an adoptable manner resulting in star and or delta connection and the 18 terminals of secondary's are connected in a different fashion in a star/hendecagon output. The new connection scheme of secondary winding to obtain an input star and output star is illustrated in figure 2 and the corresponding phasor diagram is shown in figure 4 similarly for input delta and output star connection is also shown in the figure 3. The construction of the output (star) phase with requisite phase angles of 360/7=51.42° between each phase is obtained using appropriate turn ratio and the governing phasor equation is given in (3). Selecting the turn ratio is the key in creating the phase displacement in the output phases.
The turn ratio between different phases is given in the table 1. The input phases are made and is given with letter is "x", "y" and "z" and output are designed with letter is "a", "b", "c", "d", "e", "f" and "g". The mathematically derivation for this connection is the basic addition of real and imaginary part of vectors. Given example, to the solution (1) gives the turn ratio of the phase "b", (Vb taken as unity).

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$$Vx\,[\cos(2\pi/7) + j\sin(2\pi/7)] - Vz\,[\cos(1.66\pi/7) - j\sin(1.66\pi/7)] = 1 \quad (1)$$

Equating real and imaginary parts and solving Vx and Vz We get,

$$\left|Vx\right| = \sin(1.66\pi/7)/\sin(\pi/3) = 0.5271$$
$$\left|Vz\right| = -\sin(2\pi/7)/\sin(\pi/3) = 0.6243 \quad (2)$$

Thus equation (3) is the result voltage of the two different coils; one output phase is generated from only one coil namely "a3a4" in contrast to another phase utilizes by two coils.

$$\begin{vmatrix} Va \\ Vb \\ Vc \\ Vd \\ Ve \\ Vf \\ Vg \end{vmatrix} = 1/\mathrm{Sin}(\pi/3) \begin{vmatrix} \mathrm{Sin}(\pi/3) & 0 & 0 \\ \mathrm{Sin}(8.571) & 0 & -\mathrm{Sin}(51.42) \\ 0 & \mathrm{Sin}(42.85) & -\mathrm{Sin}(54.54) \\ -\mathrm{Sin}(34.2) & \mathrm{Sin}(25.71) & 0 \\ -\mathrm{Sin}(34.2) & 0 & \mathrm{Sin}(25.71) \\ 0 & -\mathrm{Sin}(54.54) & \mathrm{Sin}(42.85) \\ \mathrm{Sin}(8.571) & -\mathrm{Sin}(51.42) & 0 \end{vmatrix} \quad (3)$$

$Va = V_{max}\mathrm{Sin}(\omega t)$ $\quad Vx = V_{max}\mathrm{Sin}(\omega t)$

$Vb = V_{max}\mathrm{Sin}(\omega t+2\pi/7)$ $\quad Vy = V_{man}\mathrm{Sin}(\omega t+2\pi/3)$

$Vc = V_{max}\mathrm{Sin}(\omega t+4\pi/7)$ $\quad Vz = V_{max}\mathrm{Sin}(\omega t-2\pi/3)$

$Vd = V_{max}\mathrm{Sin}(\omega t+6\pi/7)$

$Ve = V_{max}\mathrm{Sin}(\omega t-6\pi/7)$

$Vf = V_{max}\mathrm{Sin}(\omega t-4\pi/7)$

$Vg = V_{max}\mathrm{Sin}(\omega t-2\pi/7)$

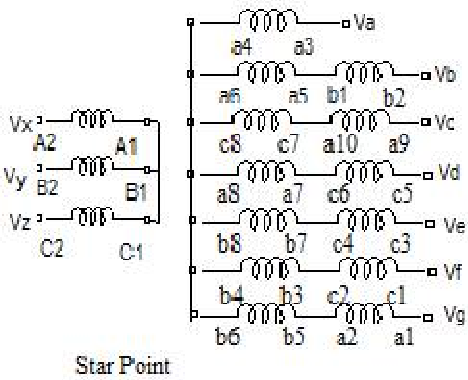

Fig 2: Proposed transformer winding star-star connection

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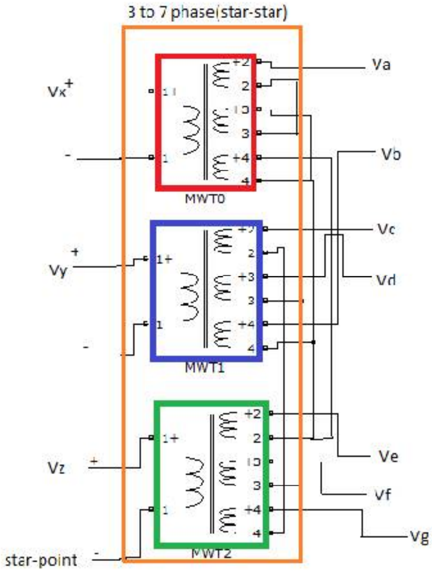

(*MWT=Multi-winding transformer)

Figure 3:A schematic drawing of a three phase power system utilizing a three phase to seven phase “star-star” power transformer with secondary windings.

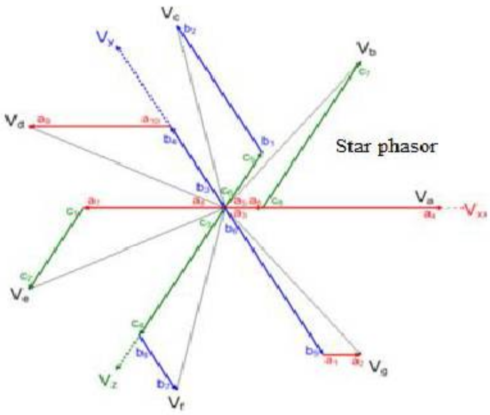

Figure 4: Phasor diagram of the proposed transformer conection (star-star)

III. WINDING ARRANGEMENT OF SEVEN PHASE DELTA OUTPUT

In this case winding arrangement three separate cores designed with individual carrying primary and two secondary coils. In this designed the phase difference will be 51.42. Six terminals of primaries are connected in an appropriate manner resulting in delta-HEPTAGON. Simulation, Eighteen terminals of secondaries are connected in star-hendecagon output. The turn ratios are different in an individual phase. The input phases are designed given with letters “x”, “y”, and “z” and the output are designated with letters are “A”, “B”, “C”, “D”, “E”, “F”AND “G”,”. The three phases to seven phase connection designed model is shown in figure. 6 in this value of Va = Vx.

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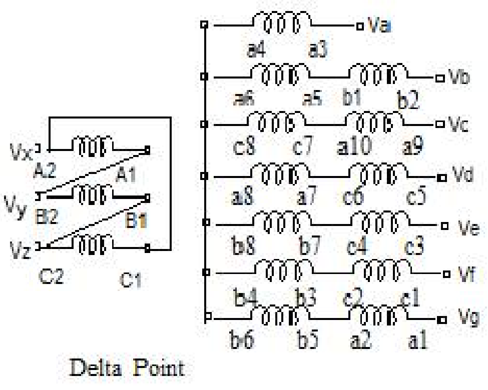
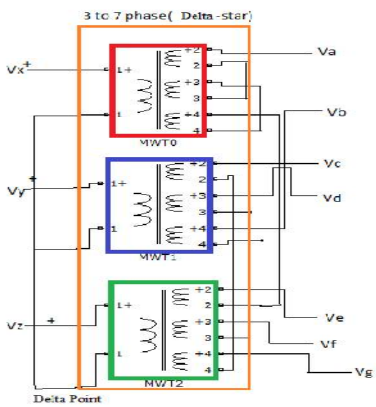


Figure 5: Proposed transformer winding delta-star connection



(*MWT = Multi-winding transformer)

Figure 6: A schematic drawingof a three phase power system utilizing a three phase to seven phase “delta-star” power transformer with secondary windings.

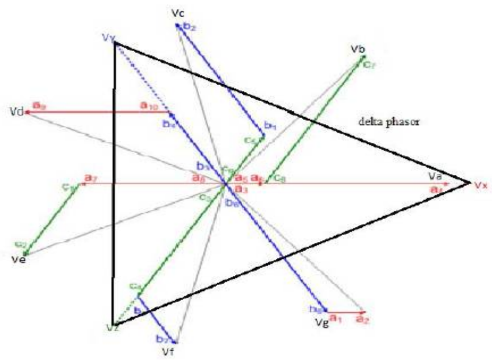


Figure 7: Phasor diagram of the proposed transformer connection (delta-star)

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IV.SIMULATION

The new designed/structure is at the first using “Sim power system” block set of the MATLAB/Simulink sofware. Multiwinding transformer block is chosen from the sim-power system block library and the turn ratios are set in the dialog box and the simulation is run. The resulting input and output current and votage waveform. The output will be unbalance if input is unbalanced and also if the input is balance then output is also balance. The three phase output from a seven phase input supply can also be obtain in similar fasion.

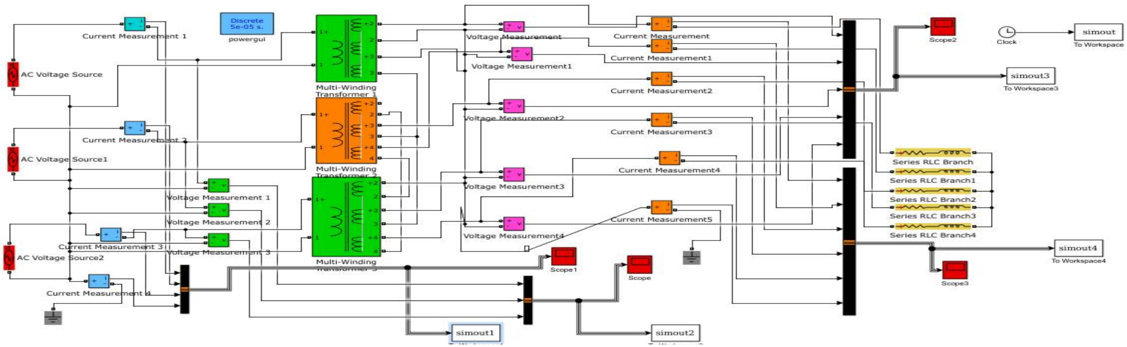

Figure 9: MATLAB/SIMULINK model of Three-to-Seven phase Star Transformation

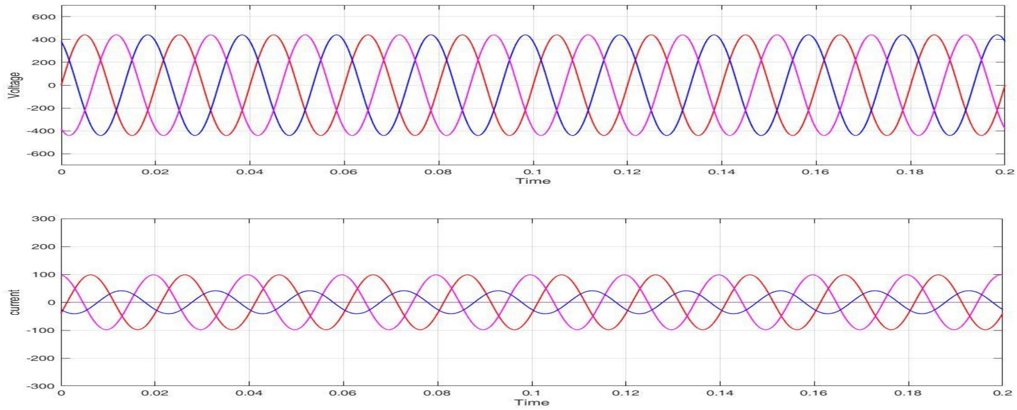

Fig 10: Input current and voltage waveforms of Star-Star

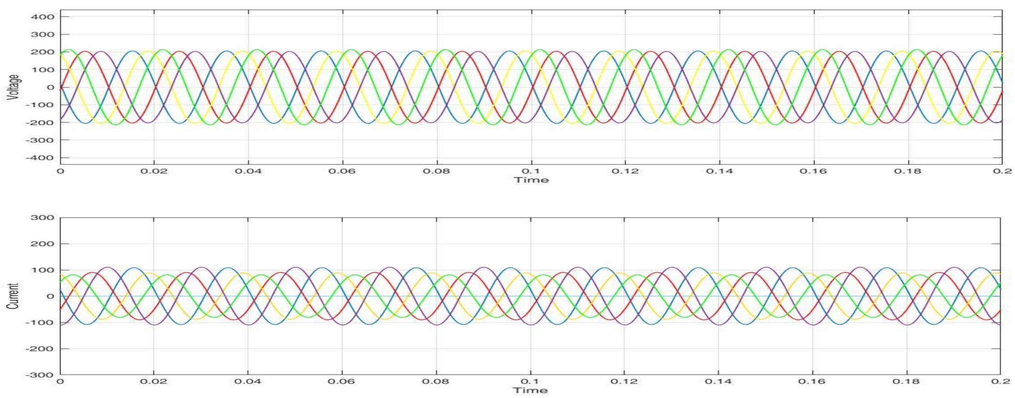

Fig 11: Output current and voltage waveforms of Star-Star

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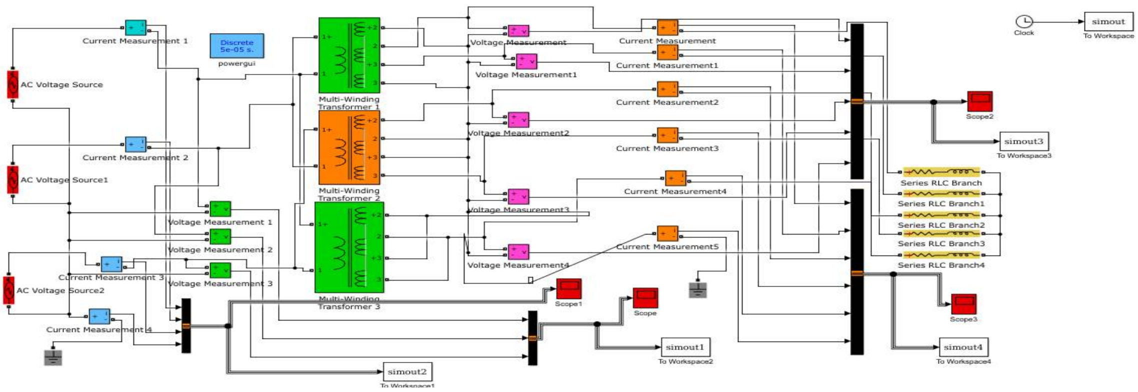

Figure 12: MATLAB/SIMULINK model of Three-to-Seven phases Delta Transformation.

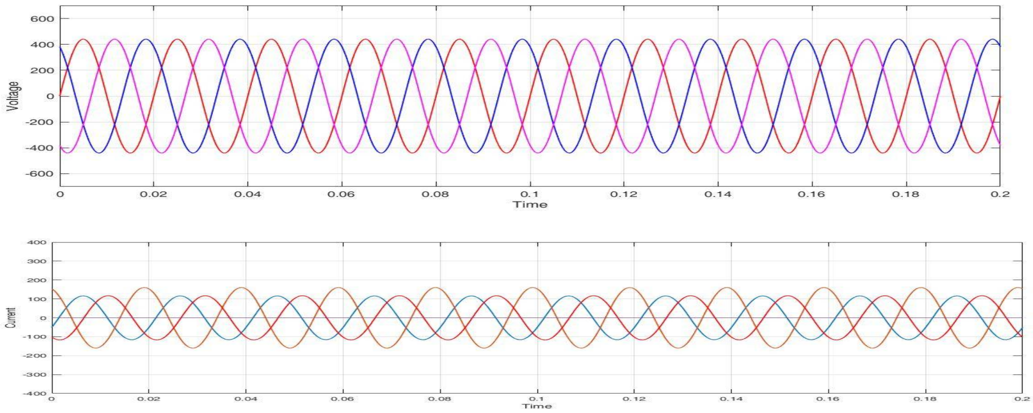

Fig 13: Input current and voltage waveforms of delta-star

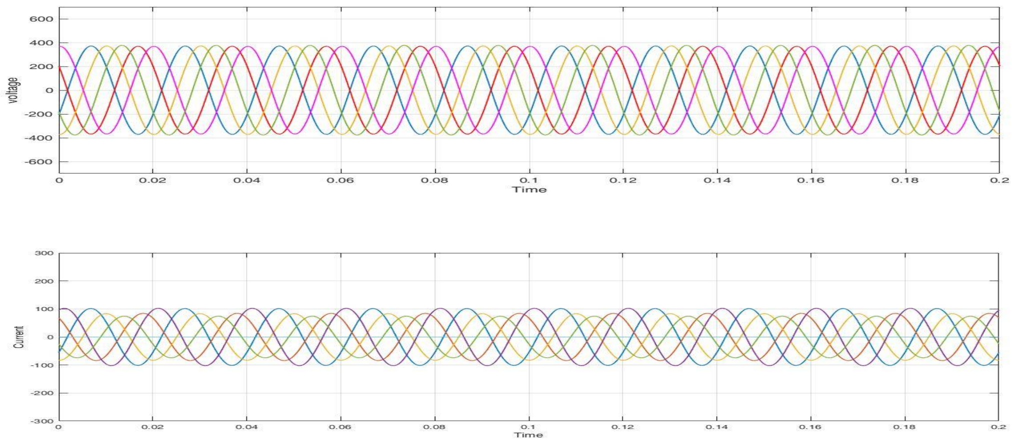

Fig 14: Output current and voltage waveforms of delta-star.

V. RESULT AND DISCUSSION

In this simulation we have No-load and load tests are performed on the three to Seven phase transformers and their load test are performed by connecting seven phase RL load. The value of load is given by R=50Ω and L=5mH. Thus the (star-star) connection resulting wave forms of a three phase primary side and a seven phase secondary side. The output voltage can also be adjusted by simply varying the taps of the autotransformer. The output voltage is balance then input

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voltage is also balance. Any unbalancing in the input is directly reflected in the output phases. Under no-load conditions, 440 V is applied at the primary side. The input side voltage and current wave forms, under no-load and loaded steady-state conditions, the input voltage and currents under loaded conditions are 440 V and 24 A are recorded and shown in Figure 10. Corresponding no-load and loaded condition voltage and current wave forms for the secondary side (seven phase) and the loaded current in the secondary side is nearly 14 A and the voltage is 400 V are presented in the Figure 14.

VI.CONCLUSION

The new connection scheme and the phasor diagram along with the turn ratios are illustrated. This method required the main data of transformer, the phase shifting and as well as the winding connections of the transformer. The seven-phase induction motor under a loaded condition is used to prove the viability of the transformation system. The 3/7 AC multiphase transformer has been simulated by using MATLAB simulation software, which has been proved to be powerful tools to simulates such a typical connection transformers.

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