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A Possibilities of Simulation of Three Phases to Thirteen Phase's Transformer Connection

Satish Karekar
Department of Electrical Engineering, Parthivi College of Engineering and Management, Sirsakala Bhilai-3, Chhattisgarh Swami Vivekanand Technical University, India

Abstract- Possibilities of simulation three to thirteen AC multiphase transformer to convert into DC power through modelling. For this modelling we have need multiphase transformer. The whole modelling has been simulated by using MATLAB Software. Multiwinding 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. Here we have mentioned the simulation results only for RL load. Thirteen phase transmission system can be developed for the generation of bulk power transfer. As per need of the induction motor under their viability of the implementation.
Keywords- Multi-winding transformer, Multiphase system, Thirteen phases, MATLAB Software.

I. INTRODUCTION

It is a static device which transfers the electric power from one circuit to another circuit without a change of frequency and mutual induction between two circuits linked by a common magnetic flux is called Transformer [1]. It can change the voltage level and impedance transformation. The transformer is an important element in the development of high-voltage electric power transmission [2]. Transformers are classified into various types such as (step up, matching transformers and step down) according to ratio of the numbers of turns in the coils (turns ratio), when the primary and secondary winding are isolated or not [3]. 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 [4-6] transmission [5-7] and utilization [8-9]. 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 [10]. 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 [5]. The dimension of the six-phase smaller towers may also lead to the reduction of magnetic fields and electromagnetic interference [10-11]. 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 [12-14].

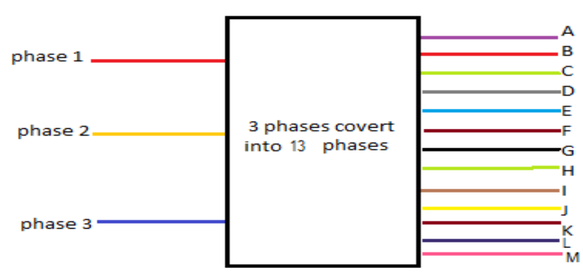

Figure 1: Block representation of the proposed system

Multiphase, especially a Six phase and twelve phase system is found to produce less ripple with a high frequency of ripple 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 [14]. Recently, twenty four phase and thirty six phase transformer systems have proposed for supplying a number of pulse rectifier systems [13-17]. The reason of choice for six, twelve, and twenty four-phase system is that these numbers are multiples arrangement of three and designing in this type of system is simple and straight modified/designed.

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Whenever the complexity of the system is increases with increasing the number of phase. These designs are also available for an odd number of phases, such as five, nine and eleven etc. The usually practice for analysis is to test the designed motor for a number of operating conditions with pure sinusoidal supply [10], [16]. The research on multiphase generators has recently started and few references are available [4-6]. The research on multiphase drive systems has been significantly developed since the beginning of this century due to advancement in semiconductor devices and digital signal processors technologies. Detailed reviews on state-of-the-art multiphase drive research are available [20].

In this paper we have proposed a special transformer connection scheme to get a balance thirteen-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 thirteen-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 as below.

Input Star, Output Star.

Input Star, Output Tridecagon.

Input Delta, Output Star.

Input Delta, Output Tridecagon.

The input has being three-phase system the windings are connected in a usually fashion. The tridecagon output connection may be derived following a similar approach. The output/secondary side connection is discussed in the following subsections [2].

II. WINDING ARRANGEMENT OF THIRTEEN PHASES 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 thirty terminals of secondary's are connected in a different fashion in a star/ Tridecagon 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 360/13=27.69° 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", "g", "h", "i", "j", "k" ,"l" and "m". The mathematically derivation for this connection is the basic addition of real and imaginary part of vectors.

$$Vx\,[\cos(2\pi/13) + j\sin(2\pi/13)] - Vz\,[\cos(1.66\pi/13) - j\sin(1.66\pi/13)] = 1 \qquad (1)$$

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

$$|Vx| = \sin(1.66\pi/13)/\sin(\pi/3) = 0.4508$$
$$|Vz| = -\sin(2\pi/13)/\sin(\pi/3) = 0.6243 \qquad (2)$$

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.

$$\begin{vmatrix} Va \\ Vb \\ Vc \\ Vd \\ Ve \\ Vf \\ Vg \\ Vh \\ Vi \\ Vj \\ Vk \\ Vl \\ Vm \end{vmatrix} = 1/\sin(\pi/3) \begin{vmatrix} \sin(\pi/3) & 0 & 0 \\ \sin(1.66\pi/13) & 0 & -\sin(2\pi/13) \\ 0 & \sin(\pi/13) & -\sin(2\pi/13) \\ 0 & \sin(\pi/3) & 0 \\ -\sin(2\pi/13) & \sin(\pi/13) & 0 \\ -\sin(2\pi/13) & 0 & \sin(\pi/13) \\ 0 & 0 & \sin(\pi/3) \\ 0 & -\sin(2\pi/13) & \sin(\pi/13) \\ \sin(\pi/13) & -\sin(2\pi/13) & 0 \\ \sin(\pi/3) & 0 & 0 \\ \sin(\pi/13) & 0 & -\sin(2\pi/13) \\ 0 & \sin(\pi/13) & -\sin(2\pi/13) \\ 0 & \sin(\pi/3) & 0 \end{vmatrix} \qquad (3)$$

Va= V max (sinωt) Vx=V max (sinωt)

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$Vb= V\ max\ (\sin\omega t+2\pi /13)$

$Vc= V\ max\ (\sin\omega t+4\pi /13)$

$Vd= V\ max\ (\sin\omega t+6\pi /13)$

$Ve= V\ max\ (\sin\omega t+8\pi /13)$

$Vf= V\ max\ (\sin\omega t+10\pi /13)$

$Vg=V\ max\ (\sin\omega t+12\pi /13)$

$Vh=V\ max\ (\sin\omega t-12\pi /13)$

$Vi= V\ max\ (\sin\omega t-10\pi /13)$

$Vj= V\ max\ (\sin\omega t-8\pi /13)$

$Vk=V\ max\ (\sin\omega t-6\pi /13)$

$Vl= V\ max\ (\sin\omega t-4\pi /13)$

$Vm= V\ max\ (\sin\omega t-2\pi /13)$

$Vy=V\ max\ (\sin\omega t+2\pi /3)$

$Vz= V\ max\ (\sin\omega\ t+4\pi /3)$

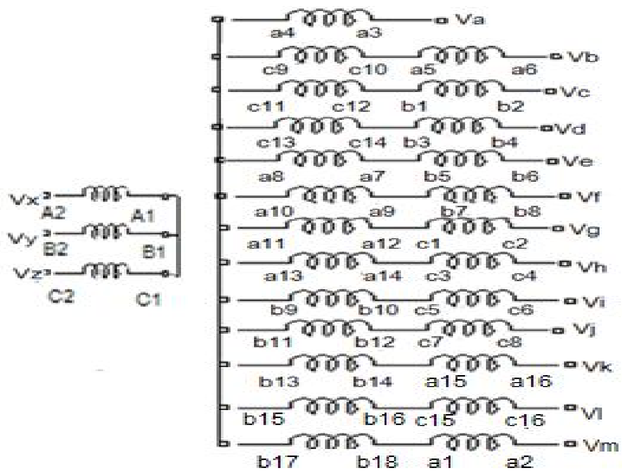
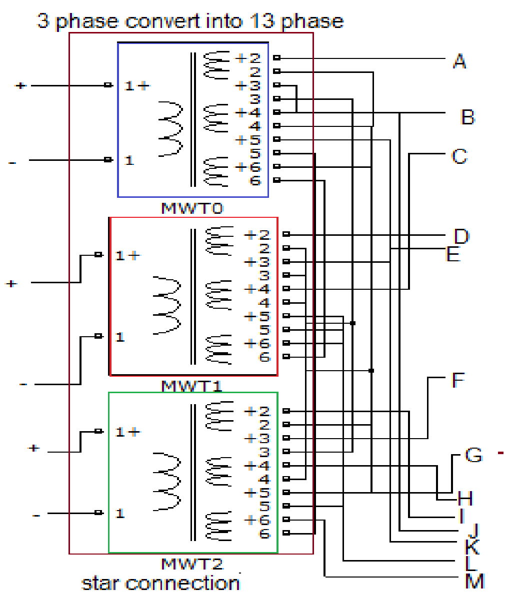


Figure 2: Proposed transformer winding star-star connection



(*MWT=Multi-winding transformer)

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

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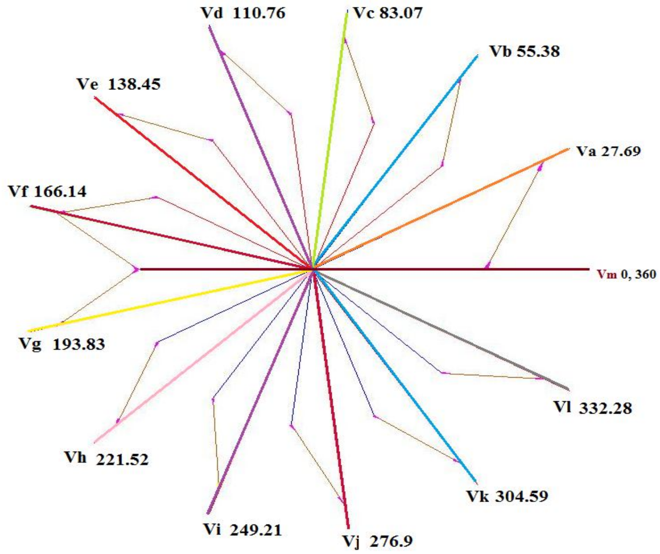

Fig 4: Phasor diagram of the transformer conection (star-star)

III. WINDING ARRANGEMENT OF THIRTEEN PHASES DELTA OUTPUT

In this case winding arrangement three separate cores designed with their individual carrying primary and two secondary coils. In this modelling and designed the phase difference will be 27.69 degree. Six terminals of primaries are connected in an adoptable manner resulting in delta-tridecagon. Simulation, thirty terminals of secondary are connected in star- tridecagon output. The turn ratios are different in an individual phase. The input phases are designed given with alphabets “x”, “y”, and “z” and their output is designated with letters are “A”, “B”, “C”, “D”, “E”, “F”, “G”, “H”, “I”, “J”, “K”, “L” and “M”. The thirteen phase connection designed model is shown in figure 6 in this value of Va=Vx.

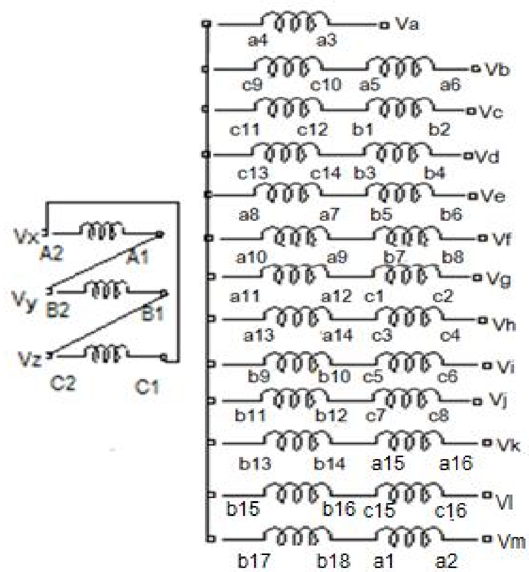

Figure 5: Proposed transformer winding delta-star connection

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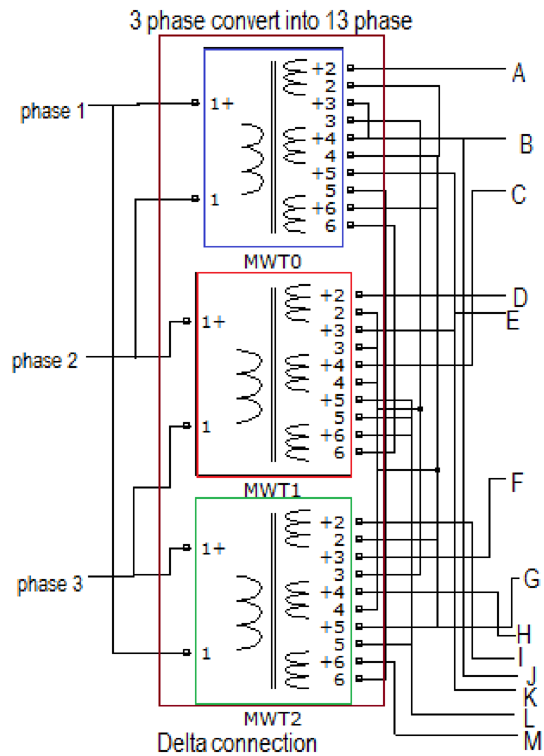

(*MWT = Multi-winding transformer)

Figure 6: A drawing of a three phase power system utilizing a three phase to thirteen phases "delta-star" power transformer with secondary windings.

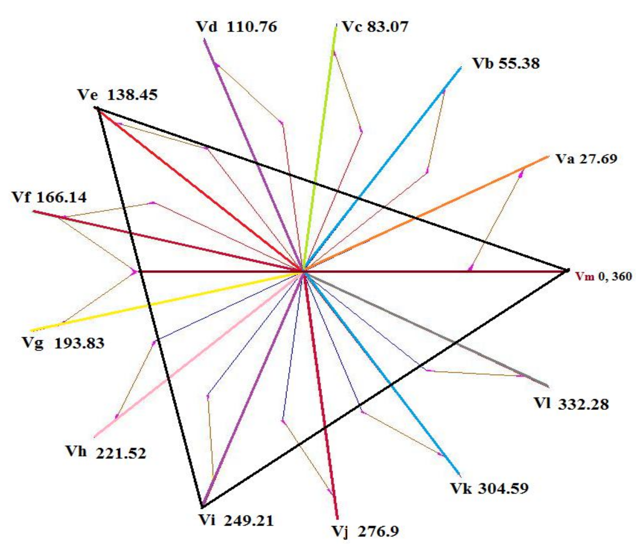

Figure 7: Phasor diagram of the proposed transformer connection (delta-star)

When there is a three-phase voltages (line-to-neutral) are defined as.

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$$V_j = V_{max} \sin (\omega t + n\pi/3)$$

J = x, y, z, and n=0, 2, 4, respectively, (4)

$$V_k = V_{max} \sin (\omega t + n\pi/13),$$

k=1,2,3,4,5,6,7,8,9,10,11 and n=0,2,4,6,8,10,12,14,16,18,20 respectively (5)

Using (3), A thirteen-phases output can be created from a three phase input supply.

A transformer is a two port network the opposite connection is also possible that is if thirteen-phase supply is given at the input the output are three phases. If the power generated is thirteen phases it has to be converted to three phase which has to be connected to the grid.

A general expression for "n" phase system derived as.

$$V_r = [(-1)\ a\ V_x \sin (\theta) + (-1)\ b\ V_y \sin (f) + (-1)\ c\ V_z \sin(\gamma)] \quad \text{Where r=phase no 1,2,3……………n,} \qquad (6)$$

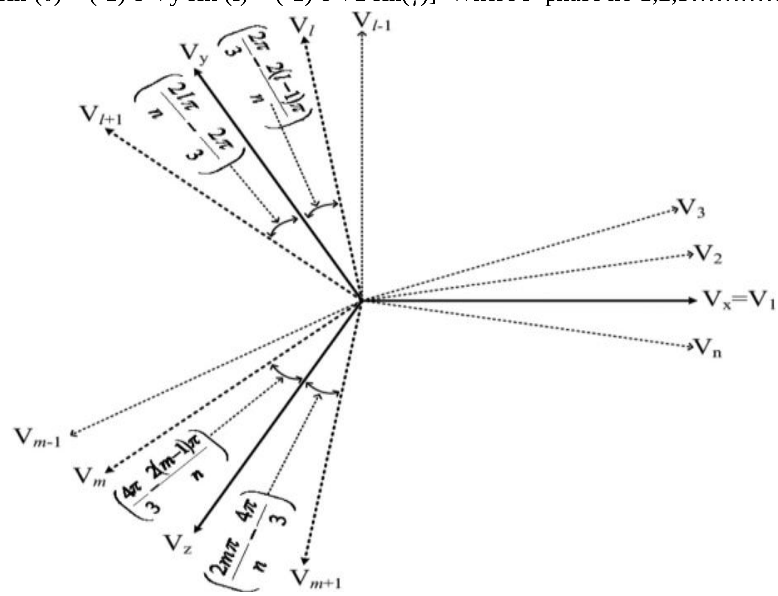

Figure: 8. General phasor diagram of three phase system from "n" phase system.

From the above figure 8 we can derive an expression for a general case,

Let us assume $V_x = V_1$; and n=number of phases in the system.

Vx, Vy, V1, V2, V3,….Vm….are the phases. Then

Vy=1/sin (2 π/n) [sin (21π/n-2 π/3) V1+sin (2π/3-2 (l-1) π/n) V l+1]

Where 1 = 4 and (21π/n) > (2π/3) > (2(1-1) π/n) and n=13

Vy=1/sin (2 π/13) [sin (2x4 π/13-2π/3) V4 + sin (2π/3-2(1) π/13) V 4+1]

Vy=1/sin (27.69) (sin (-9.230) + sin (92.30) V5, and it lies between 130>120>98.18

Vz=1/sin (2 π/n) [sin (2mπ/n-2 π/3) Vm + sin (2π/3-2(m-1) π/n) V m+1]

Where (2mπ/n)> (2π/3)> (2(m-1) π/n) and m>1

N=13

M=8

Vz =1/sin (27.69) [sin (2x8π/13-2π/3) V8+sin (2π/3-2(7) π/13) V9]

Vz=1/sin (27.69) [sin (101.53) V8+sin (-73.84) V9], and it lies between 261.81>120>229.09

IV. SIMULATION RESULTS

The novel modeling and simulation designed is 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 are given in Figure 10 and Figure 11 for star-star and Figure 13 and Figure 14 for delta-star. 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 thirteen phase input supply can also be obtain in similar fasion.

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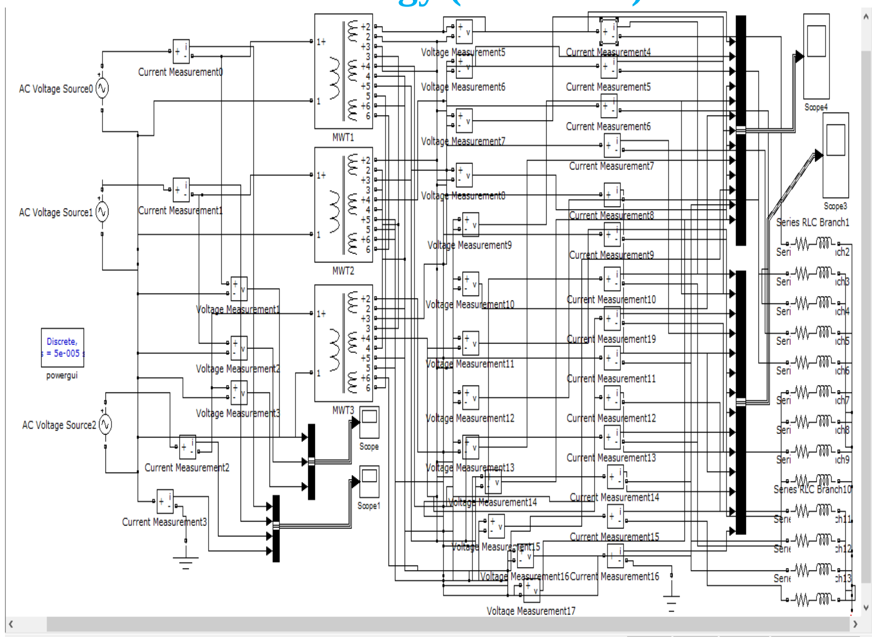


Figure 9: MATLAB/SIMULINK model of Three-to-Thirteen phases Star Transformation

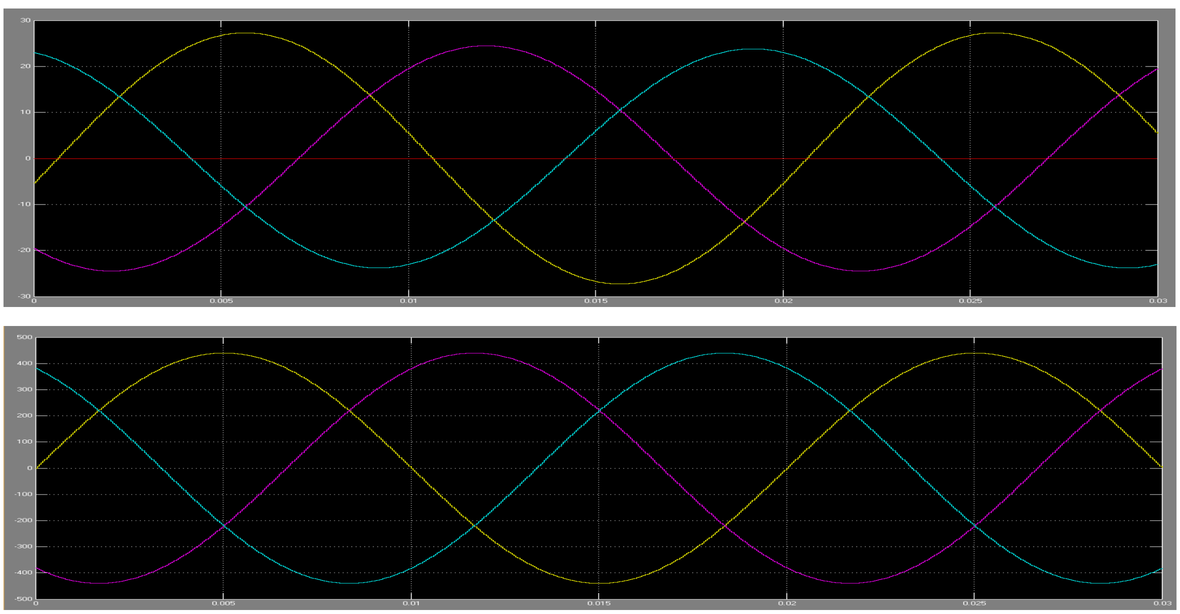
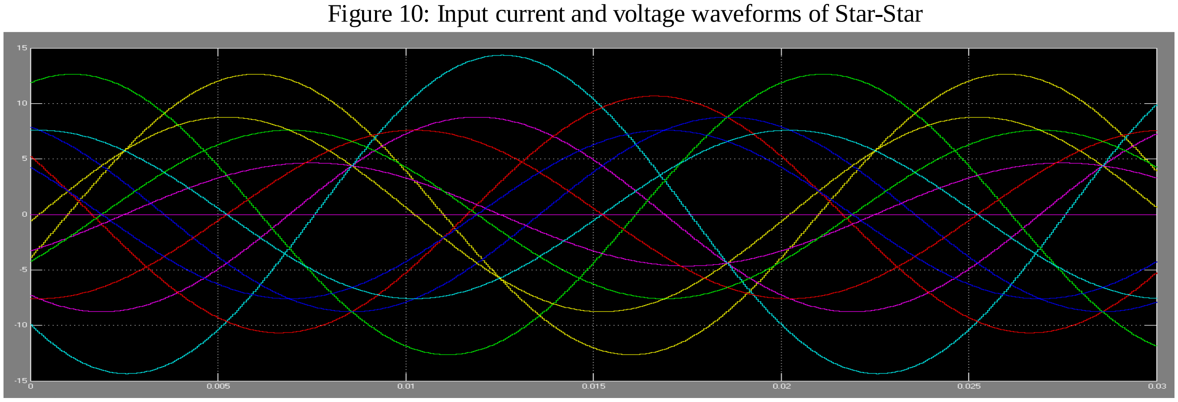


Figure 10: Input current and voltage waveforms of Star-Star



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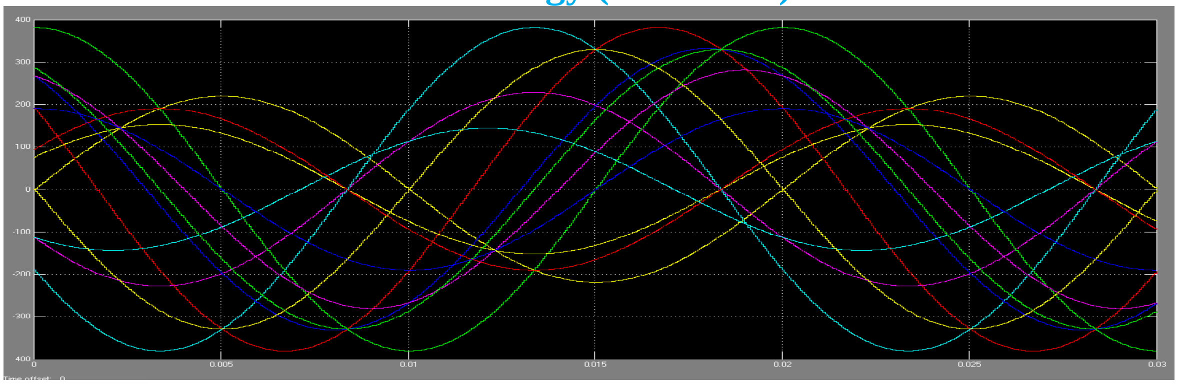

Figure 11: Output current and voltage waveforms of Star-Star

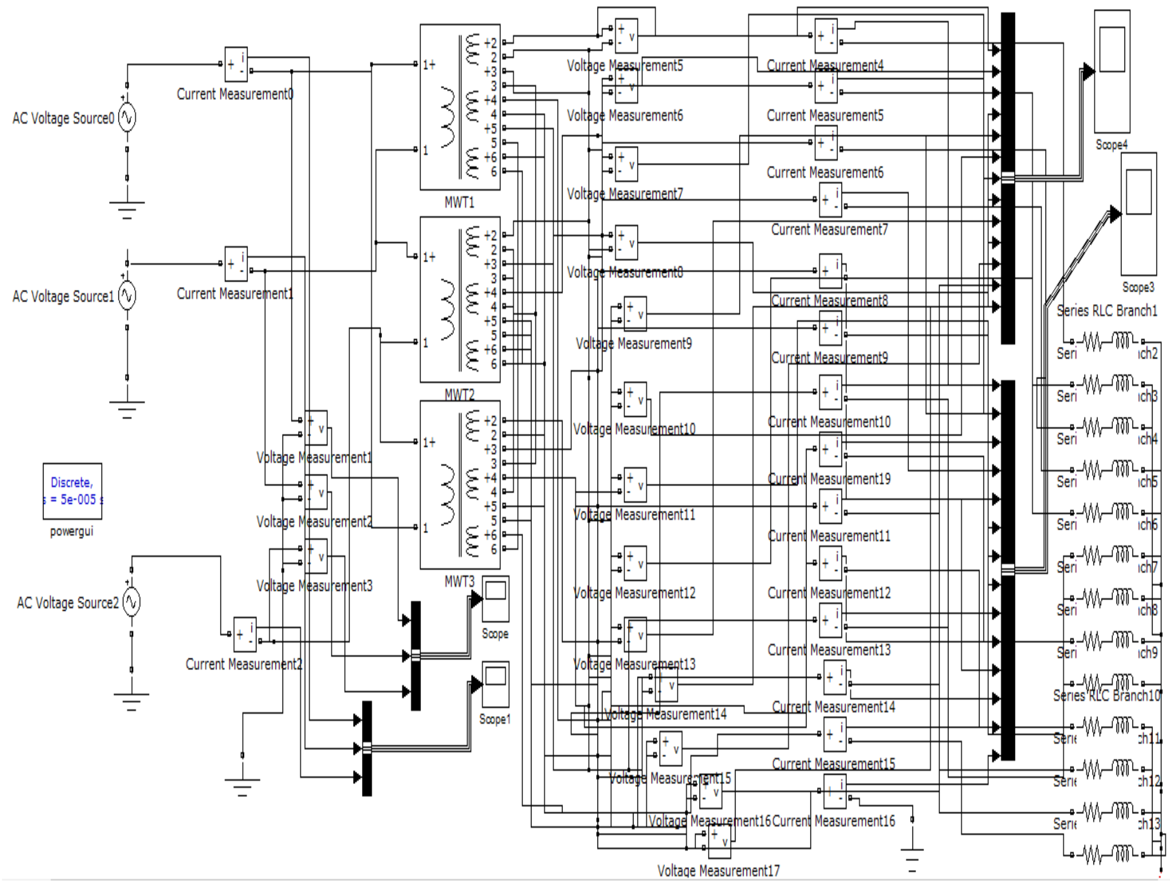

Figure 12: MATLAB/SIMULINK model of Three-to-Thirteen phases Delta Transformation.

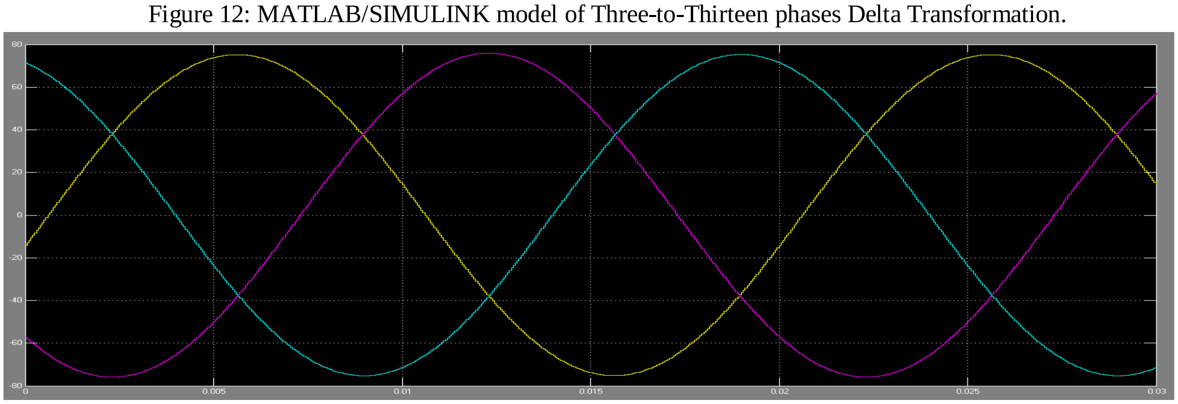

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Figure 13: Input current and voltage waveforms of delta-star

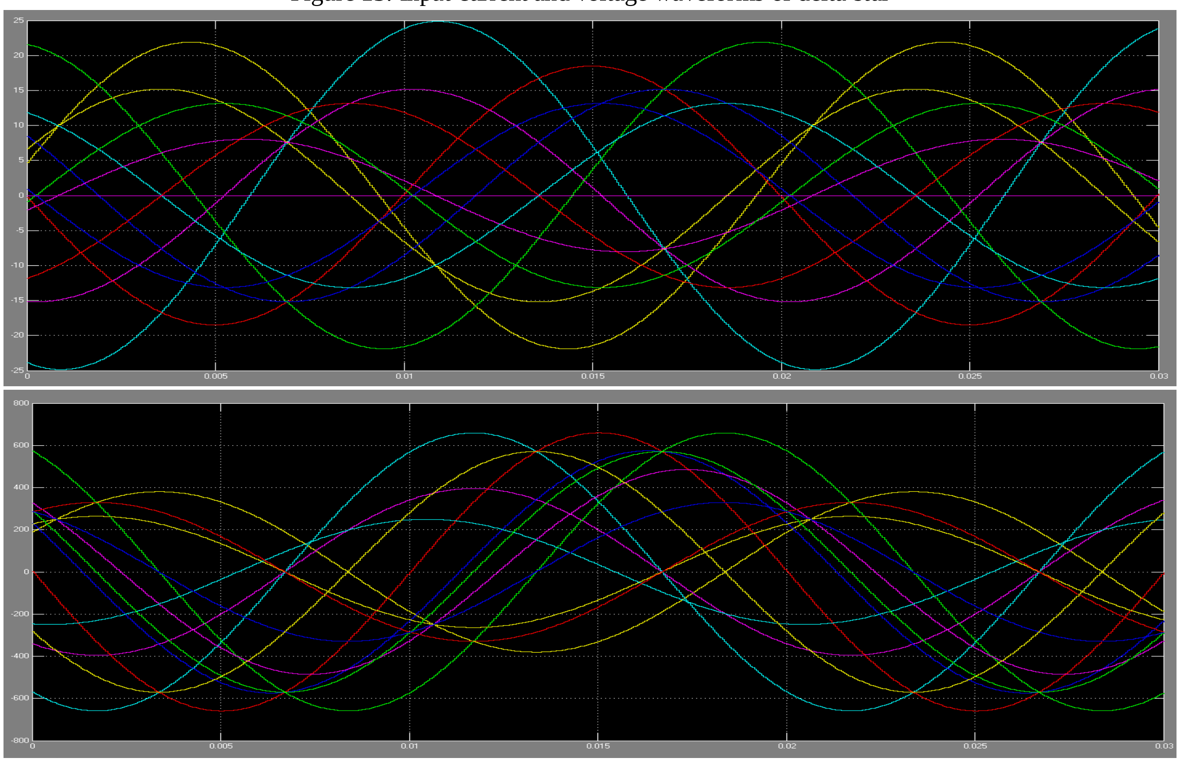

Figure 14: Output current and voltage waveforms of delta-star.

V. RESULTS AND DISCUSSION

In this modelling and experimental work is setup and their simulation results obtained by using the designed three to thirteen phase's transformation system. The novel designed transformation system ratio are 1:1 (input: output), then the output voltage is similar to the input voltage. Now transformation ratio can be altered to suit the step up or step down requirements. In this simulation we have No-load and load tests are performed on the three to thirteen phase transformers and their load test are performed by connecting eleven phase RL load. The value of load is given by R=25Ω and L=5mH. Thus the (star-star) connection resulting wave forms of a three phase primary side and a thirteen phase secondary side are shown in figure 10 and figure 12 respectively. When three single phase auto-transformer is used to supply input phase of the novel transformer connections. These output voltage can also be adjusted by simply varying the taps of the autotransformer. When the output voltage is balance then input voltage is also balance. Any unbalancing in the input is directly reflected in the output phases. There is 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 of voltage and current wave forms to their secondary side (thirteen phase) and the loaded current in the secondary side is nearly 14 A and the voltage is 400 V are presented in the Figure 13.

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VI. CONCLUSION

This paper proposes a new complex transformer connection scheme to transform three phase grid power to a Thirteen-phase output supply. 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 Thirteen-phase induction motor under a loaded condition is used to prove the viability of the transformation system. The 3/13 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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