Simulation of Three-Phase to Five-Phase Transformation Using a Special Transformer Connection

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Abstract – The main aim in this paper to build a three phase to six phase AC multiphase transformers simulation. We complete modelling has been simulated by using MATLAB software. A new technique of six-phase sin wave of fixed voltage, current & frequency is obtained now we have also used for R-L load resolves. This is a special transformer connection scheme to obtain the balanced five-phase supply with the input as the balanced three-phase. The fixed voltage and the fixed frequency available grid supply can be transformed to the fixed voltage & the fixed frequency five-phase output supply. Three separate cores are designed with each carrying on primary and three secondary coils, except in one core where only two secondary coils are used. The connection scheme of secondary windings to obtained a star output. The turn ratios are different in each phase.

Keywords: Multi-winding Transformer, Five phase, Multi phase, Three phase, Turn ratio.

I. INTRODUCTION

Multiphase (more than three phase) systems are the focus of the research recently due to their intrinsic advantages compared to their three-phase counterparts. The applicability, transmission, and utilization. The research on six-phase transmission system was initiated due to the rising cost of right of way for transmission passageways, conservational issues, and various stringent licensing laws. Six-phase transmission lines can provide the same power capacity with a lower phase to phase voltage and smaller, more compact towers matched to a standard double circuit three-phase line. The geometry of the six-phase compact towers may also aid in the reduction of magnetic fields as well [1-2]. The research on multiphase generators has started recently and only a few references are available. The present work on multiphase generation has reconnoitered asymmetrical six-phase (two sets of stator windings with 30º phase displacement) induction generator configuration as the solution for use in renewable energy generation. As for as multiphase motor drives are concerned, the first proposal was given by Ward and Harrer way back in 1969 and since then, the research was slow and steady until the end of the last century. The research on multiphase drive systems has gained momentum by the start of this century due to availability of cheap reliable semiconductor devices and digital signal processors [1-4].

II. FIVE PHASE DRIVE MODEL

The input and output supply can be arranged in the following manner-

a) input star, output star

b) input delta, output star

c) input star, output polygon

d) input delta, output polygon

Since input is a three-phase system, the windings are connected in a usual fashion. The output side or secondary side connection is discussed in the following subsections [4-9].

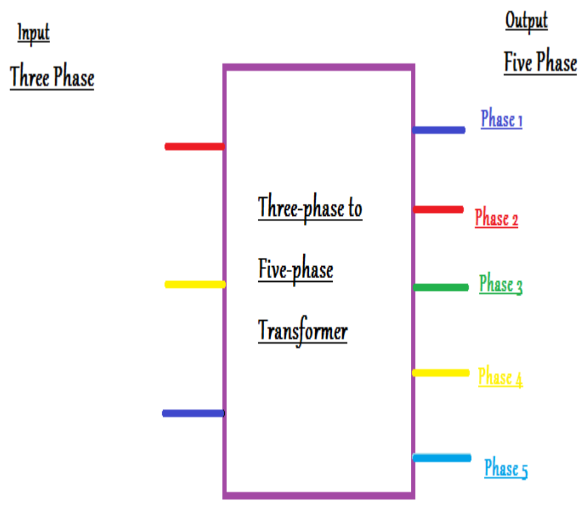
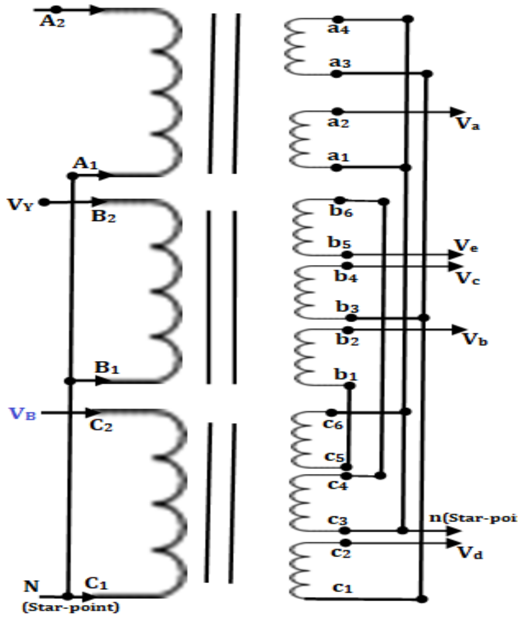


Fig.1 Block diagram representation of the proposed system.

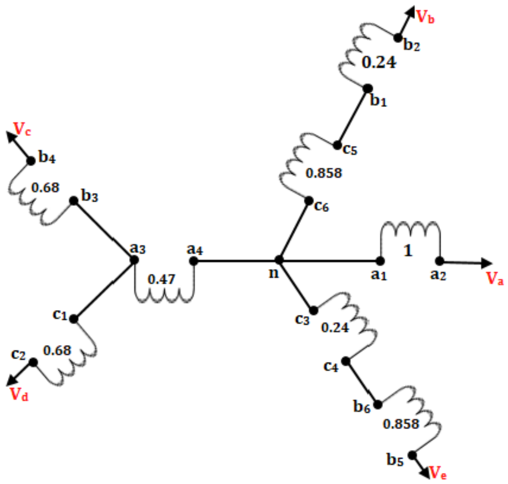
III. WINDING ARRANGEMENT FOR FIVE-PHASE STAR OUTPUT

The separate sores are design with each carrying one primary and three secondary coils, except in one core where only two secondary coils are used. Six terminals primaries are connected in an applicable manner resulting in star or delta connections and the sixteen terminals of secondary are connected in different fashion resulting in star or polygon output [5-11]. The connection scheme of secondary windings to obtain a star output with its derived equation and phasor is shown below [1-3, 8-9].



(a)

Fig.2. (a) Proposed transformer winding arrangements (star-star).



(b)

Fig.2. (b) Proposed transformer winding connection (star).

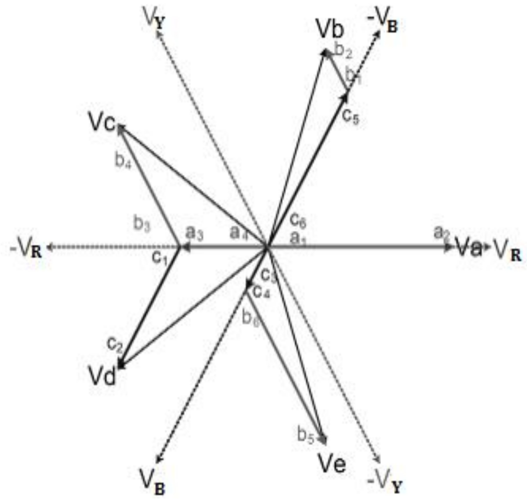


Fig.3 Phasor diagram of the proposed transformer connection (star-star).

$$\begin{bmatrix} V_a \\ V_b \\ V_c \\ V_d \\ V_e \end{bmatrix} = \frac{1}{\sin\frac{\pi}{3}} \times \begin{bmatrix} Sin(\frac{\pi}{3}) & 0 & 0 \\ 0 & Sin(\frac{\pi}{15}) & -Sin\left(\frac{4\pi}{15}\right) \\ -Sin\left(\frac{2\pi}{15}\right) & Sin(\frac{\pi}{5}) & 0 \\ -Sin\left(\frac{2\pi}{15}\right) & 0 & Sin(\frac{\pi}{5}) \\ 0 & -Sin\left(\frac{4\pi}{15}\right) & Sin(\frac{\pi}{15}) \end{bmatrix} \begin{bmatrix} V_R \\ V_Y \\ V_B \end{bmatrix} \quad \text{........(1)}$$

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

$$V_b = V_{max}\ Sin\left(\omega t + \frac{2\pi}{5}\right) \quad \text{..........} \quad (3)$$

$$V_c = V_{max}\ Sin\left(\omega t + \frac{4\pi}{5}\right) \quad \text{..........} \quad (4)$$

$$V_d = V_{max}\ Sin\left(\omega t - \frac{4\pi}{5}\right) \quad \text{..........} \quad (5)$$

$$V_e = V_{max}\ Sin\left(\omega t - \frac{2\pi}{5}\right) \quad \text{..........} \quad (6)$$

$$V_R = V_{max}\ Sin(\omega t) \quad \text{..........} \quad (7)$$

$$V_Y = V_{max}\ Sin\left(\omega t + \frac{2\pi}{3}\right) \quad \text{..........} \quad (8)$$

$$V_B = V_{max}\ Sin\left(\omega t - \frac{2\pi}{3}\right) \quad \text{..........} \quad (9)$$

$$\begin{bmatrix} V_R \\ V_Y \\ V_B \end{bmatrix} = \frac{1}{\sin\left(\frac{2\pi}{3}\right)} \times \begin{bmatrix} Sin\left(\frac{2\pi}{5}\right) & 0 & 0 & 0 & 0 \\ 0 & Sin\left(\frac{2\pi}{15}\right) & Sin\left(\frac{4\pi}{15}\right) & 0 & 0 \\ 0 & 0 & 0 & Sin\left(\frac{4\pi}{15}\right) & Sin\left(\frac{2\pi}{15}\right) \end{bmatrix} \begin{bmatrix} V_a \\ V_b \\ V_c \\ V_d \\ V_e \end{bmatrix}$$

…. (10)

IV. PROPOSED METHODOLOGY

The designed transformer is at first simulated by using, “sim-power-system” block sets of the MATLAB/Simulink software. In this section author need to mention his simulation/experimental research model with neat block diagrams and flow charts.

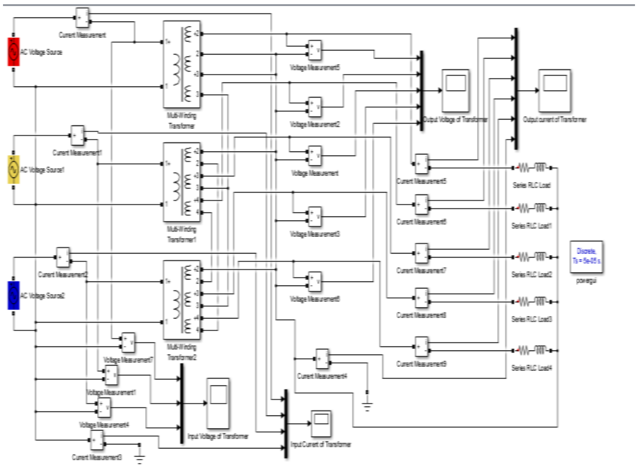


Fig.4 MATLAB simulation model of the three-phase to five-phase transformer.

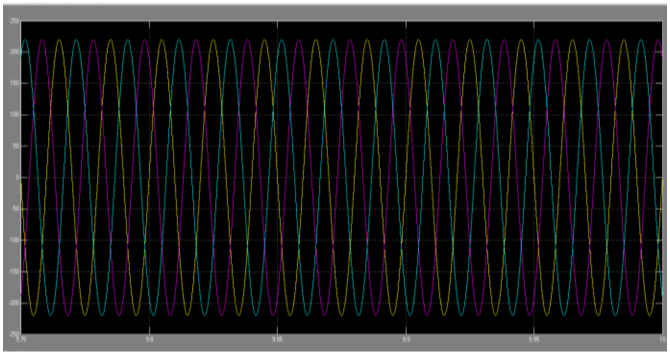


Fig.5 Output current of three-phase transformer with discrete.

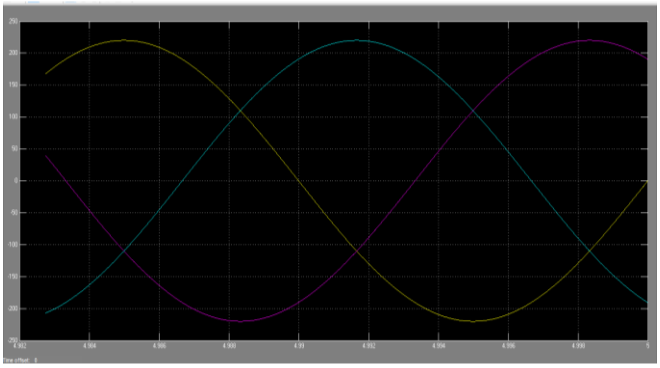


Fig.6 Output voltage of three-phase transformer with continuous.

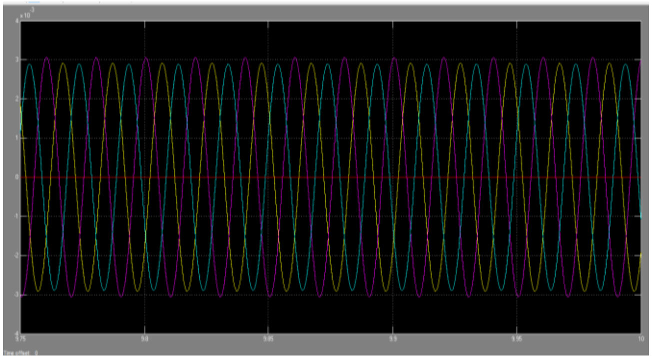


Fig.7 Output current of three-phase transformer with discrete.

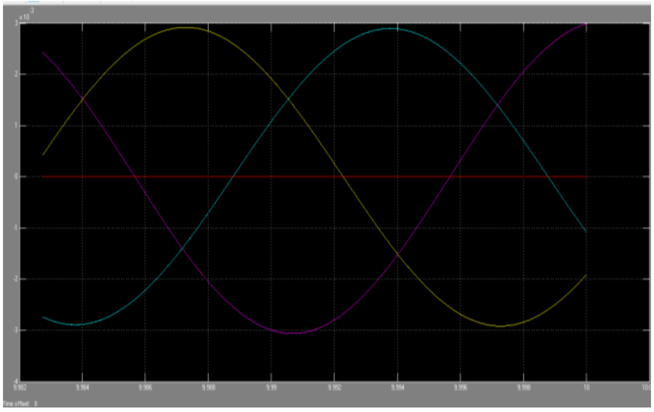


Fig.8 Output current of three-phase transformer with continuous.

V. SIMULATION/EXPERIMENTAL RESULTS

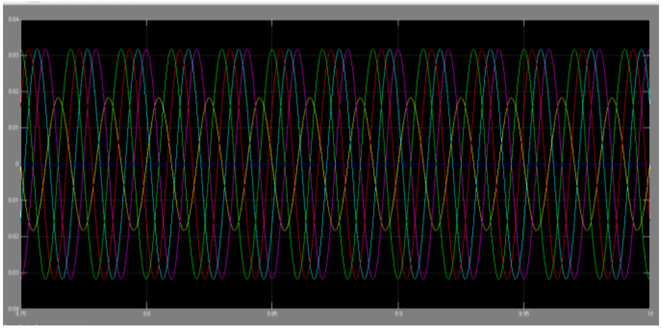


Fig.9 Output current of five-phase transformer with discrete.

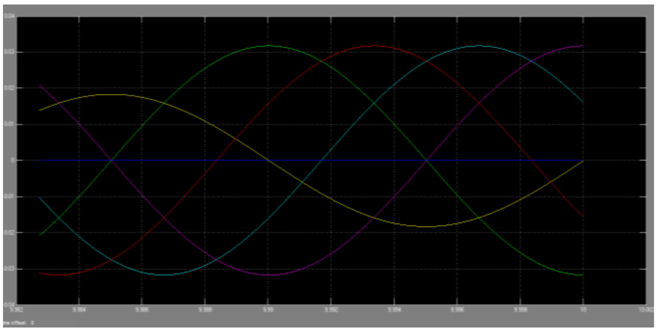


Fig.10 Output current of five-phase transformer with continuous.

TABLE 1. DESIGN OF THE TRANSFORMER PROPOSED

Primary N_P	Secondary N_S	Turn Ratio N_P/N_S	SWG
Phase-R	a_1a_2	1	17
	a_3a_4	0.47	15
Phase-Y	b_1b_2	0.68	17
	b_3b_4	0.858	17
	b_5b_6	0.24	17
Phase-B	c_1c_2	0.68	17
	c_3c_4	0.858	17
	c_5c_6	0.24	17

VI. CONCLUSION

This paper proposes a 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 & experimentation. A five-phase induction under a loaded condition is used to prove viability of the transformation system. It is expected that the proposed connection scheme can be used in drives applications and also be further explored to be utilized in multiphase power transmission system.

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