A Multi Phase Transformation System Using a Special Transformer Connection

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Abstract- 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 output transformer connection outputs five phases can be used in applications requiring a five-phase supply. Multi-phase motor drives have been studied from more than thirty years. The interest has grown so that some international power electronic conferences have hosted sessions on the multi-phase motor drives. Generally, multi-phase machines drive has many advantages over conventional three-phase drive such as high power handling capability by dividing the required power between multiple phases, reduced torque pulsations and higher reliability. Three phase drive, the loss of stator phase does not prevent the machine from starting and running. The main advantages of multi-phase systems are reduced rotor harmonic currents, increased torque per ampere for the same volume machine, reduced stator copper losses. The main application areas of multiphase induction motor drives are ship propulsion, traction (including electric and hybrid electric vehicles) and the concept of more-electric aircraft. A difference between Three-Phase supply and Five-Phase supply. Other suitable applications are locomotive traction aerospace and high power applications. Presently the grid power available is only limited to three-phase so the supply to multi-phase motors is invariably given from power electronic converters.

Keywords: *Five phase, multiphase, three phase, transformer, turn ratio ,voltage, frequency.*

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I. INTRODUCTION

MULTIPHASE (more than three phase) systems are the focus of research recently due to their intrinsic advantages compared to their three-phase systems. The application of multiphase systems is investigate in electric power generation [1]–[5], transmission, and utilization [10]–[15]. The research on six-phase transmission system was initiated due to the rising cost of right of way for transmission environmental issues and various stringent licensing laws. multi phase transmission lines can provide the same power capacity with a lower phase-to-phase voltage and smaller, more compact compared to a standard double-circuit three-phase line. The geometry of the multi-phase compact towers may also aid in the reduction of magnetic fields as well [9].

The research on multiphase generators has started recently and only a few references are available [2]–[8]. The present work on multiphase generation has investigated asymmetrical six-phase (two sets of stator windings with 30 phase displacement) induction generator configuration as the solution for use in renewable energy generation.

Three-phase electric power is a common method of alternating current electric power transmission. It is a type of multi-phase system and is the most common method used by electric power distribution grids worldwide to distribute power. It is also used to large motors and other large loads. A three-phase system is generally economical more than others because it uses less conductor material to transmit power than equivalent single-phase or two-phase systems at the same voltage In a three-phase system, the circuit conductors carry three alternating currents (of the same frequency) which reach their instantaneous peak values at different times. One conductor act as a reference, the other two currents delayed in time by one-third and two-thirds of one cycle of the electric current. This delay between phases effect of giving constant power transfer over each cycle of the current and also makes it possible to produce a rotating magnetic field in an electric motor.

As far as multiphase motor drives are consider , the first proposal was given by Ward and Harrer way back in 1969 [1] and since then, the research on multiphase drive systems has gained movement of by the start of this century due to availability of cheap reliable semiconductor devices. It is to here that the multiphase motors are invariably supplied by ac/dc/ac converters. The focus on the multiphase electric drive is limited to the modeling and control of the supply systems. Little effort to develop any static transformation system to change the phase number from three to n-phase.

The scenario has now changed with this paper, proposing a multi phase transformation system which converts an available three-phase supply to an output five-phase supply. Multi phase a 6-phase and 12-phase system is found to produce less ripple factor with a higher frequency of ripple in an ac–dc rectifier system. Multi phase 6- and 12-phase transformers are designed to feed a multi pulse rectifier system and the technology has matured. Multi phase 24-phase and 36-phase transformer system has been proposed for supplying a multi pulse rectifier system [16]–[17]. The choice for multi phase a 6-, 12-, or 24-phase system is that these numbers are multiples of three and designing this type of system is simple and straightforward. Increasing the number of phases certainly enhances the complexity of the system. Up to the even number of phases are available but there is no odd number of phases like 5, 7, 11 etc so we a contribution to do these odd number of phases.

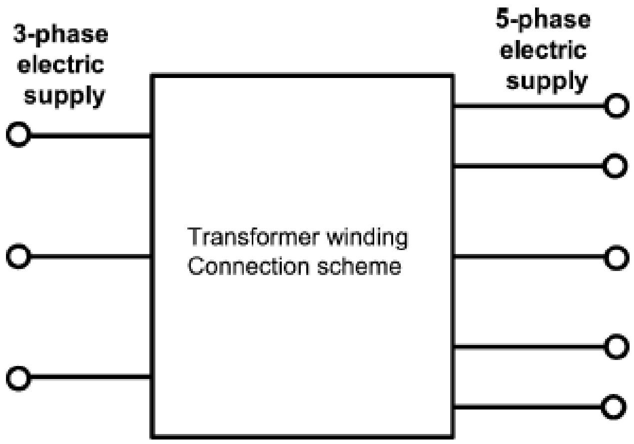
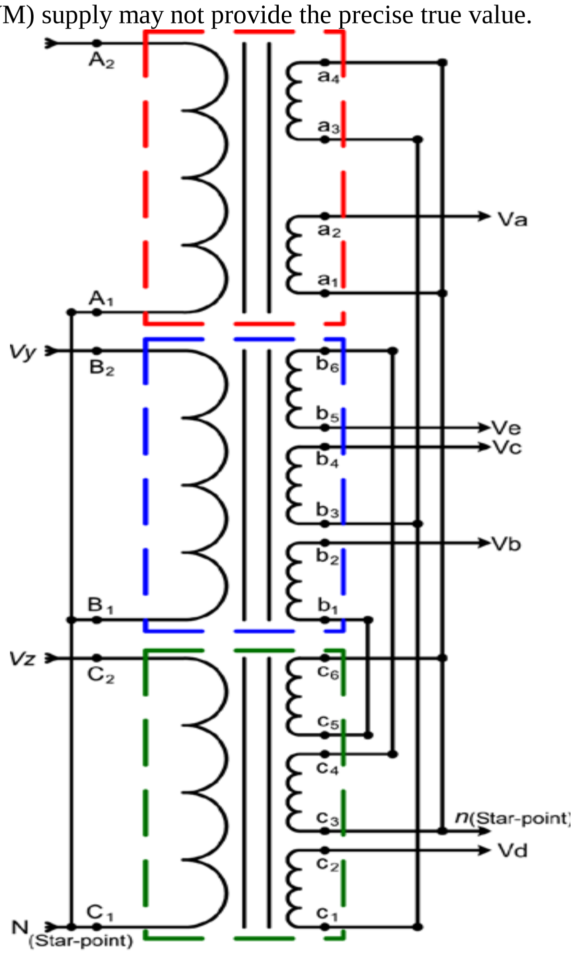


Fig1. Block representation of the proposed system

The usual practice is to test the designed motor for a number of operating conditions with a pure sinusoidal supply to ascertain the desired performance of the motor . Normally, a no-load test, closed rotor, and load tests are performed on a motor to determine its parameters. The supply used for a multiphase motor drive obtained from a multiphase inverter could have more current ripple, there are adjustable control methods available to lower the current distortion even below 1%, based on application and requirement. Hence, the circuit parameters obtained by using the pulse width-modulated (PWM) supply may not provide the precise true value.



(a)

Fig2.Proposed transformer winding arrangement.

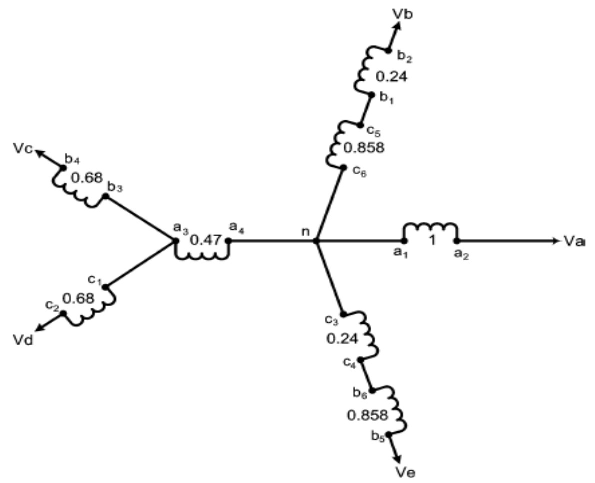


Fig 3 Proposed transformer winding connection.

Thus, a pure sinusoidal supply system available from the utility grid is required to the motor. This paper proposes a special transformer connection scheme to obtain a balanced five-phase supply with the input as balanced three phase circut. The block diagram of proposed system as shows in Fig.1 The fixed voltage and frequency grid supply can be transformed to the fixed voltage and fixed frequency five-phase output supply. The output may be made variable by inserting the autotransformer at the input side.

The input and output supply are arranged in the following manner:
a) Input star, output star;
b) Input star, output polygon;
c) Input delta, output star;
d) Input delta, output polygon.
Since input is a three-phase system is windings are connected in a usual fashion. The output side connection is discussed in the following subsections[17,19].

II. WINDING ARRANGEMENT FOR FIVE-PHASE STAR OUTPUT

Three are separate cores are designed with each carrying one primary and three secondary coils, except the one core where only two secondary coils are used. Six terminals primaries are connected in an appropriate manner resulting in star or delta connections and the 16 terminals are connected in a different fashion resulting in star output. The connection of secondary windings to obtain a star output is shows in Fig. 2 and the corresponding phasor diagram is shows in Fig. 3. The construction of output phases with phase angles of 72 between each phase is obtained using appropriate turn ratios, and the output phasor equations are illustrated in (1)–(10). The turn ratios are different in each phase. The 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". 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 "a3a4 " and " b3b4". The output phase "D" gathering by the phasor addition of winding voltages " a3a4" 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[19]. The transformation from three to five and vice-versa is further obtained by using the relation given below

$$\begin{vmatrix} v_a \\ v_b \\ v_c \\ v_d \\ v_e \end{vmatrix} = \frac{1}{\sin\left(\frac{\pi}{3}\right)} X$$

$$\begin{bmatrix} \sin\left(\frac{\pi}{3}\right) & 0 & 0 \\ 0 & \sin\left(\frac{\pi}{15}\right) & -\sin\left(\frac{4\pi}{15}\right) \\ -\sin\left(\frac{2\pi}{15}\right) & \sin\left(\frac{\pi}{5}\right) & 0 \\ 0 & -\sin\left(\frac{4\pi}{15}\right) & \sin\left(\frac{\pi}{15}\right) \end{bmatrix} ..1$$

$$v_a = v_{\max} \sin(\omega t)..........2$$

$$v_b = v_{\max} \sin\left(\omega t + \frac{2\pi}{5}\right)....3$$

$$v_c = v_{\max} \sin\left(\omega t + \frac{4\pi}{5}\right)....4$$

$$v_d = v_{\max} \sin\left(\omega t - \frac{4\pi}{5}\right)....5$$

$$v_e = v_{\max} \sin\left(\omega t - \frac{2\pi}{5}\right)....6$$

$$v_x = v_{\max} \sin(\omega t)............7$$

$$v_y = v_{\max} \sin\left(\omega t + \frac{2\pi}{3}\right)....8$$

$$v_z = v_{\max} \sin\left(\omega t - \frac{2\pi}{3}\right)....9$$

$$\begin{bmatrix} v_x \\ v_y \\ v_z \end{bmatrix} = \frac{1}{\sin\left(2\pi/3\right)} *$$

$$\begin{bmatrix} \sin\left(\frac{2\pi}{5}\right) & 0 & 0 & 0 & 0 \\ 0 & \sin\left(\frac{2\pi}{15}\right) & \sin\left(\frac{4\pi}{15}\right) & 0 & 0 \\ 0 & 0 & 0 & \sin\left(\frac{4\pi}{15}\right) & \sin\left(\frac{2\pi}{15}\right) \end{bmatrix} ..10$$

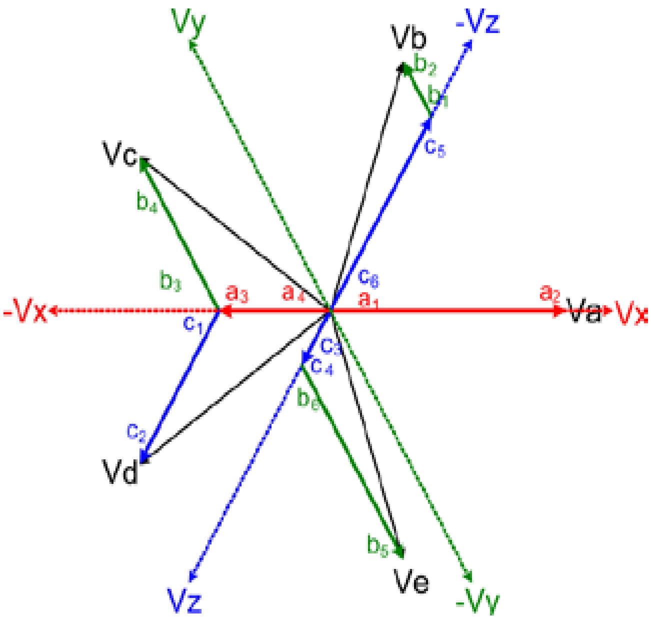


Fig.4 phasor representation of the proposed transformer connection

III III. SIMULATION RESULTS

The designed transformer is at first simulated by using the Matlab/Simulink software. The transformer blocks are used to simulate the design. The appropriate turn ratios are set in the dialog box and the simulation is run. The simulation model in Fig. 4 and resulting input and output voltage waveforms are in Fig. 5. It is clearly seen that the output is a balanced five-phase supply for a balanced three-phase input. Individual output phases are, shown along with their respective input voltages.The simulation graphs of the proposed model the output of the three phase transformer is 300V after converting the three phase to five phase the output is also coming as 300V. The output voltages can be adjusted by simply varying the taps in autotransformer. For balanced the output, the must have balanced input voltages. Any unbalancing in the input is directly reflected by the output phases. In the input and output voltage waveforms under noload steady-state conditions are recorded and shown in Fig.5 and Fig.6. Modeling these set of transformers it is very useful for multiphase.Fig.7,Fig.8,Fig.9,Fig.10,Fig.11

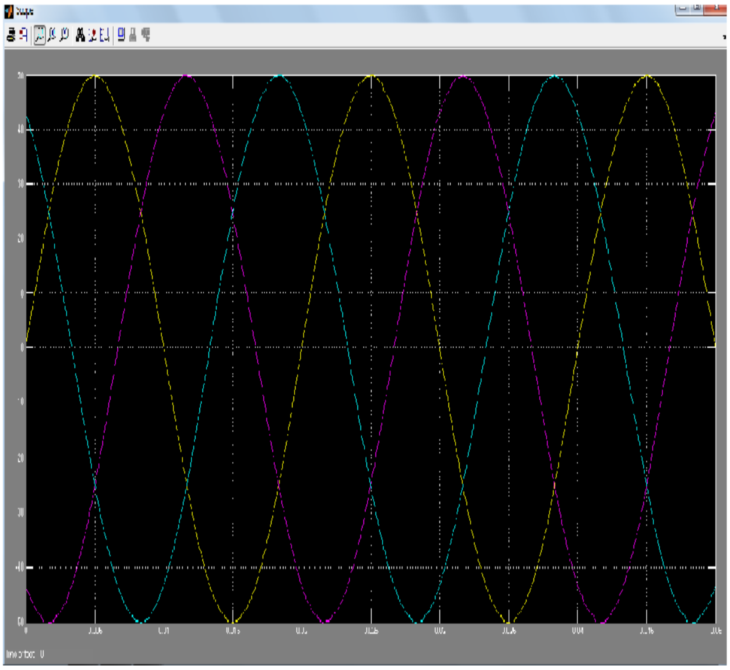


Fig.05 Output Voltage of the three phase transformer

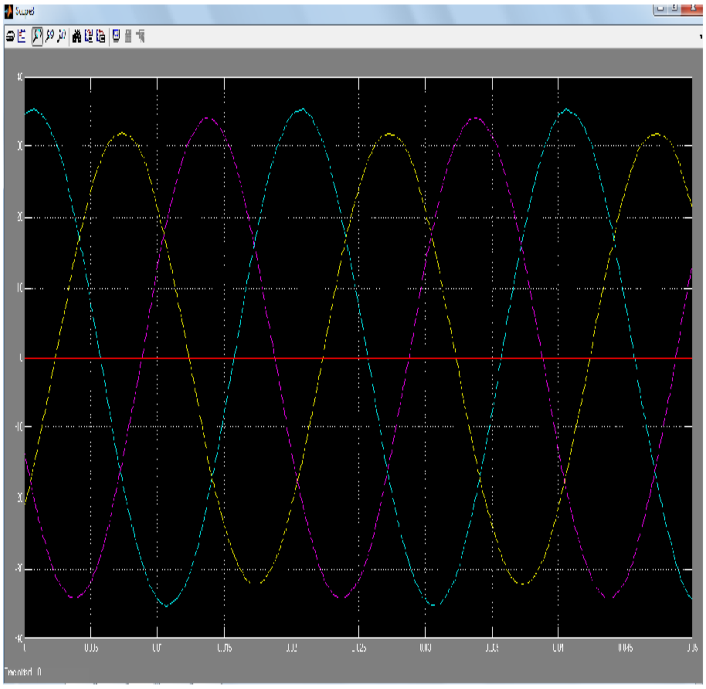


Fig.7 Output Current of Three phase transformer

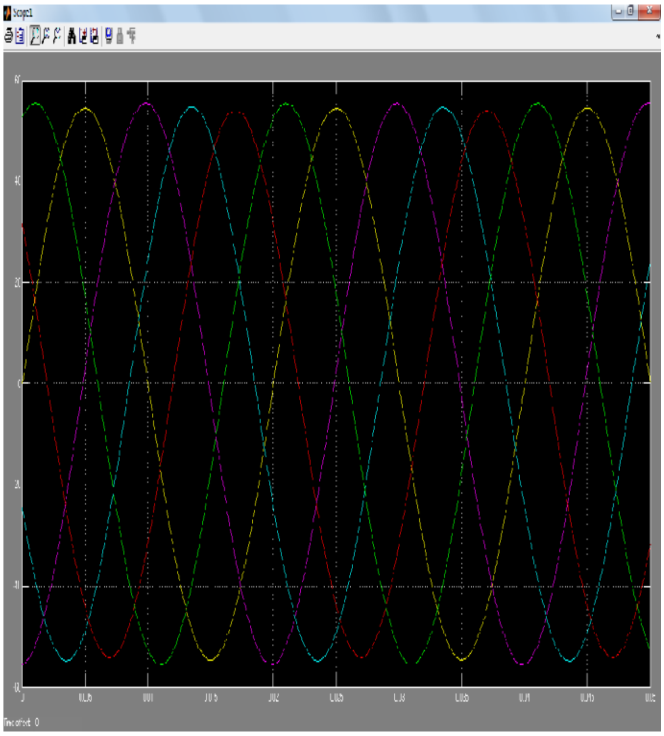


Fig.06 Output Voltage of Five phase transformer

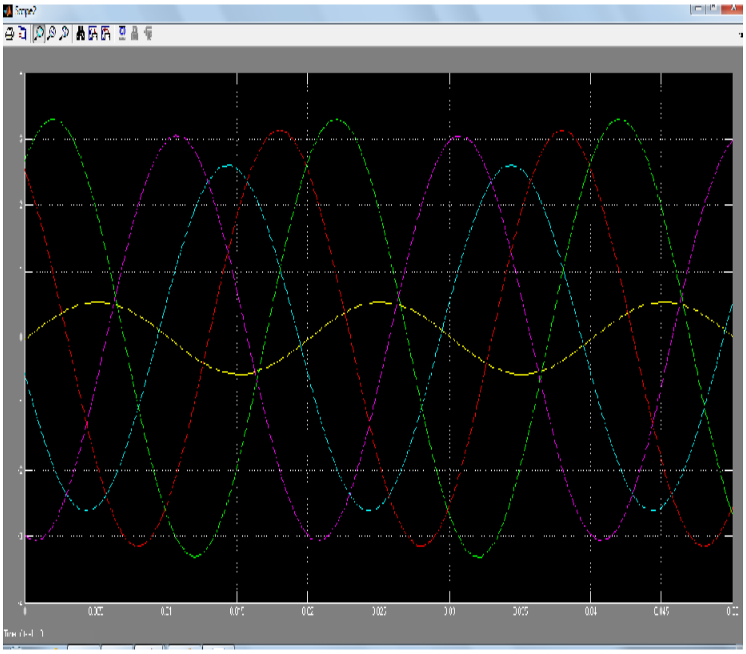


Fig.8 Output Current of Five phase transformer

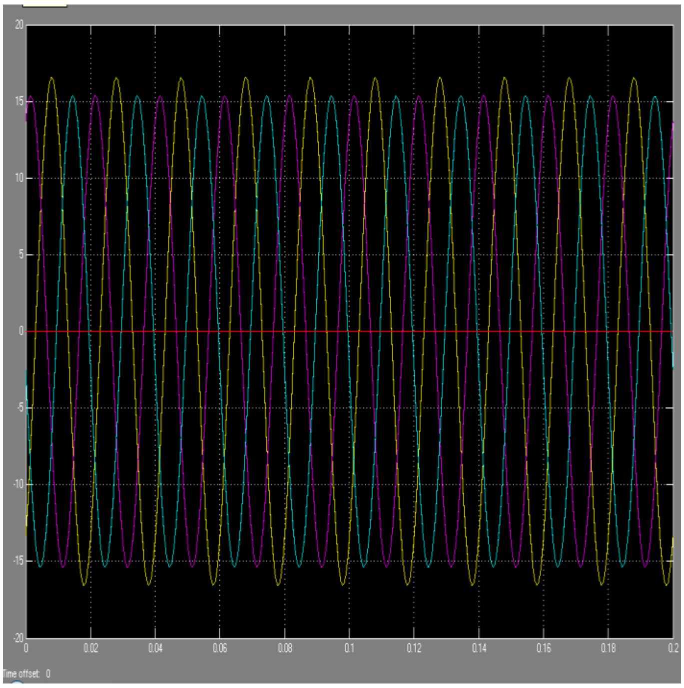


Fig.9 output Five phase voltage waveform

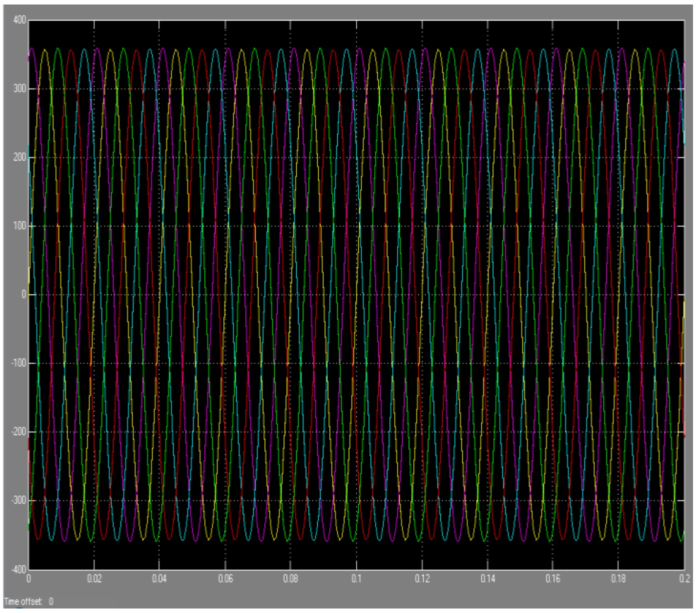


Fig.10 output Five phase voltage waveform

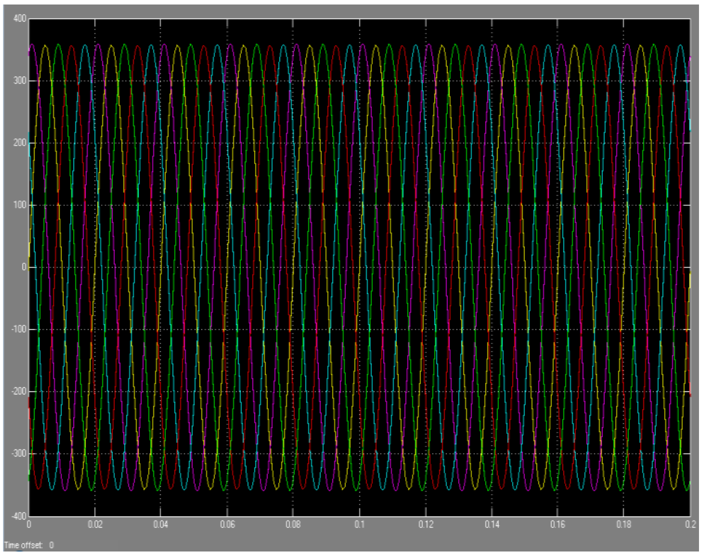


Fig.11output current five phase voltage waveform

IV. CONCLUSION

This paper proposes a new transformer connection scheme to transform the three-phase grid power to a five-phase supply. The connection and the phasor diagram. 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 the viability of the transformation system. The 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.

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