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

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Abstract - Multiphase (more than three phase) systems are the interesting area of research recently because of their inherent advantages contrasted with their three-phase counterparts. The multiphase motors are constantly provided by ac/dc/ac converters. This is an extraordinary transformer connection technique to acquire a balanced five-stage supply with the contribution as balanced three phases. The fixed voltage and fixed frequency available grid supply can be changed to the fixed voltage and fixed frequency five-stage output supply. Since input is a three-stage system, the windings are associated in a typical manner. Three separate cores are designed with each conveying one primary and three secondary loops, aside from in one core where just two secondary windings are utilized. Six terminals of primaries are associated in a appropriate way bringing about star and additionally delta associations and the 16 terminals of secondaries are associated in an alternate form bringing about star or polygon output. The configuration plan of secondry windings to get a star outcome. The turn proportions are distinctive in each stage. The decision of turn proportion is the key in making the imperative phase displacement in the output phase. The development of yield stages with imperative phase angles of 72 between each phase is obtained utilizing suitable turn proportions. The designed transformation turns proportion can be accomplished by just multiplying the gain factor in the turn proportions. This work presents a three-phase to five-phase transformation using a special transformer connection. The applicability of multiphase systems is explored in electric power generation, transmission, and utilization.

Keywords - Power Converters, AC to DC conversion, DC to AC conversion, AC to AC conversion, Inverter, Transfer less converter, transfer based converter.

I. INTRODUCTION

Variable speed motor drive system is required in numerous industrial applications as they offer significant advantages compared to a fixed speed drive system. The major advantages include higher efficiency, better power factor, reduced thermal loading and thus reduced overall operational costs. Three-phase motor drives are traditionally used in industrial drives due to readily available three-phase supply and off-the-shelf motor availability. Power electronic converters are used as interface between three-phase grid supply and the driving motor. The power converter has no limitation in number of legs being used and thus there is no restriction in the number of phases of the converters. With the advancement in power semiconductor technology this additional degree of freedom in power electronic converter is now exploited by developing multi-phase supply options. Hence multi-phase (more than three-phase) electric drives have attracted much attention in recent years due to some inherent advantages that they offer compared to their three-phase counterpart such as lower motor torque pulsation, less DC link current harmonics, higher redundancy and hence better fault tolerant characteristics and lower per phase converter ratings etc. The major applications of multi-phase drives are assumed in safety critical applications such as ship propulsion, 'more electric aircraft' applications, electric and hybrid-electric vehicles, traction, mining, oil & gas and in general purpose applications.

When referring to multi-motor drive system, means more than one machine are controlled simultaneously either independently or under identical operational conditions. In three-phase multi-motor drive system, two topologies are possible:

i) X number of three-phase motors with independent vector control, which is fed using X number of three-phase inverters with 3X legs. Motor/inverter sets connected in parallel, with common DC link.

ii) X number of three-phase motors which is fed using one three-phase inverter. In this structure motors have to be identical and to operate under the same load torque with the same angular speed.

This is a generalized concept where multi-phase machine's stator can be either connected in series or in parallel while supply is given from only one power source and all the machines can be controlled independently both in transient and steady state conditions.

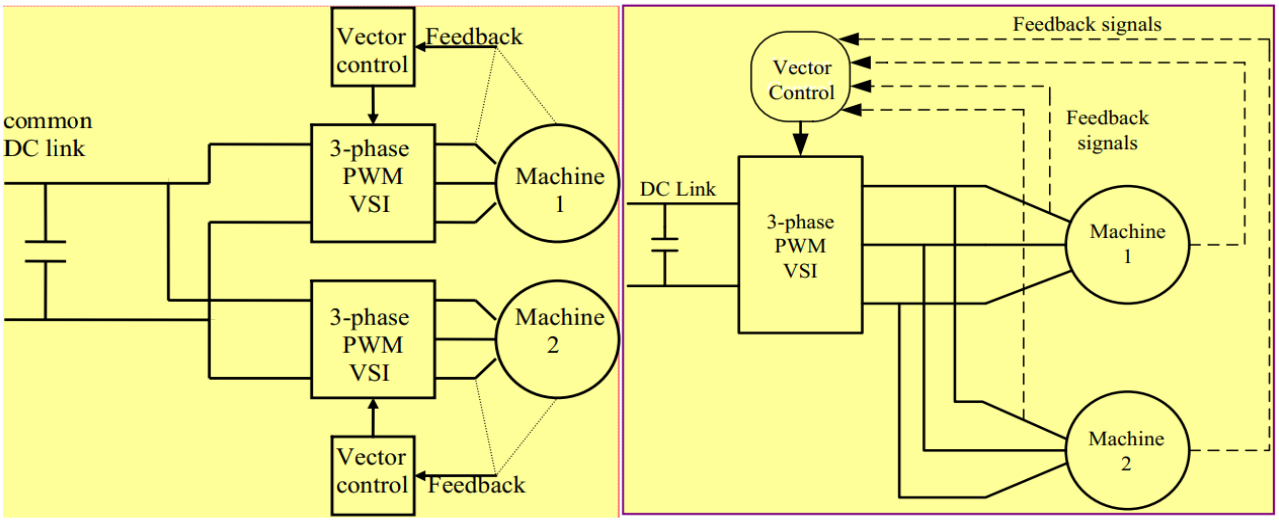


Figure 1.1 Basic representation three-phase multi-motor drive systems.

II. PROPOSED APPROACH

The appropriateness of multiphase systems is investigated in electric power generation, transmission, and usage. The exploration on six-phase transmission system was started because of the increasing expense of right of path for transmission passages, environmental pollution issues, and different stringent licensing laws. Six phase transmission lines can furnish a similar power limit with a lower phase-to-phase voltage and smaller, more minimal towers contrasted with a standard double-circuit circuit three-phase line.

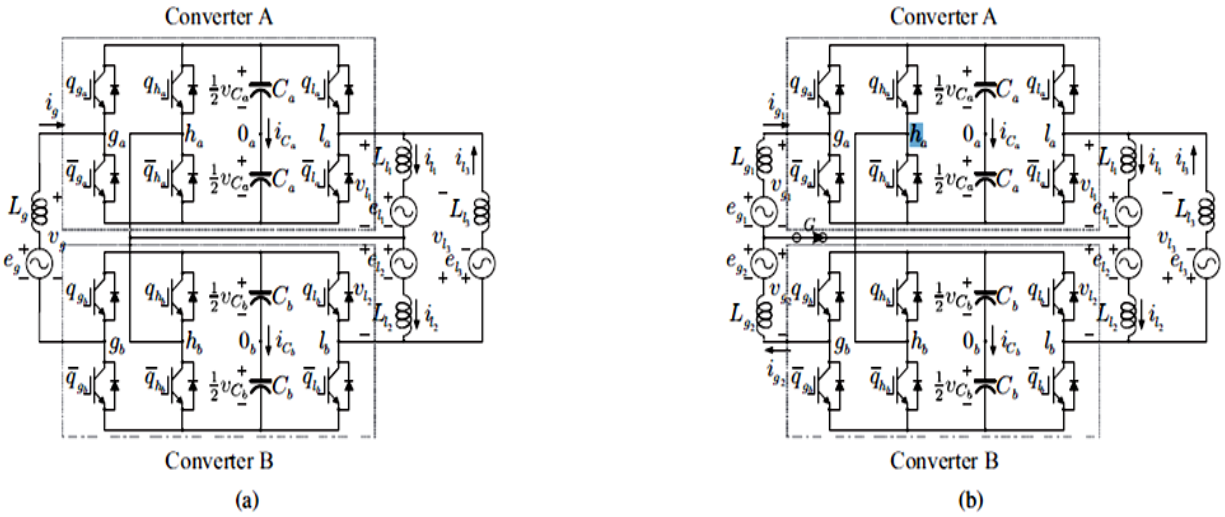


Figure 2.1 Different Single Phase to Three Phase Converter Topology.

The geometry of the six-phase minimized towers may likewise help in the lessening of magnetic fields too. The examination on multiphase generators has begun as of late and just a couple of references are accessible. The present work on multiphase generation has explored topsy-turvy six-phase (two arrangements of Stator windings with 30 phase dislodging) acceptance generator setup as the answer for use in sustainable power source generation. To the extent multiphase engine drives are concerned, the primary proposition was given by Ward and Harrer path in 1969 and from that point forward, the examination was gradual until the finish of the most recent century. The exploration on multiphase drive systems has picked up energy by the beginning of this century because of accessibility of modest dependable semiconductor devices and advanced signal processors. Point by point audits on the cutting edge in multiphase drive research is available.

It is to be accentuated here that the multiphase motors are perpetually provided by ac/dc/ac converters. Accordingly, the focal point of the exploration on the multiphase electric drive is constrained to the demonstrating and control of the supply systems (i.e., the inverters). Little exertion is made to build up any static change system to change the phase number from three to - phase (where 3 and odd).

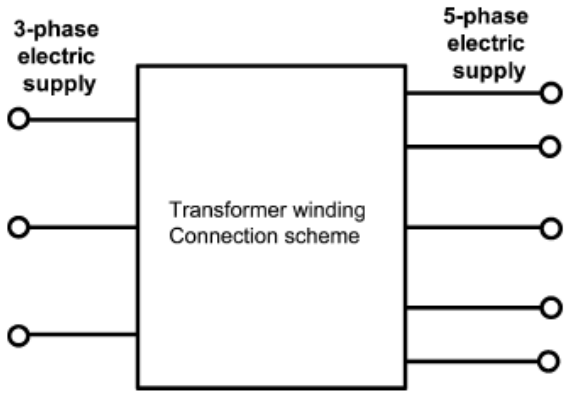
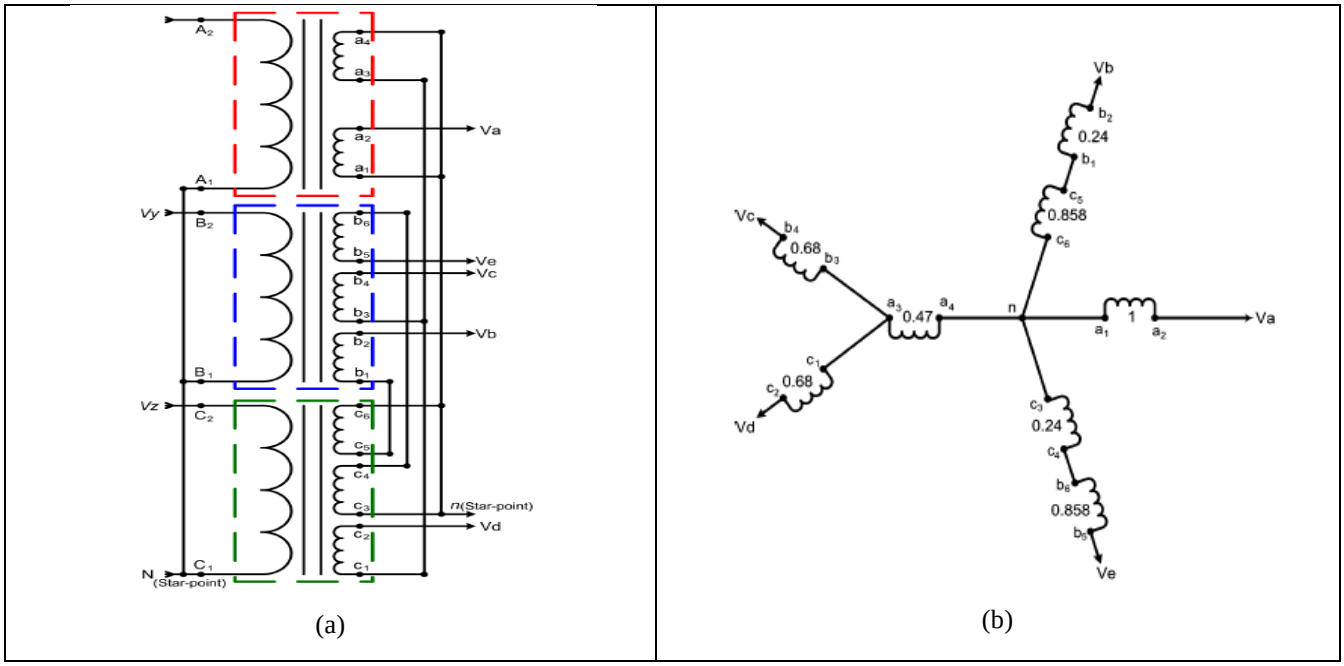


Figure 2.2 Block Representation of Proposed System.

The situation has now changed with this invertigation, proposing a novel phase change system which changes over an accessible three-phase supply to a yield five-phase supply. Multiphase, particularly a 6-phase and 12-phase system is found to deliver less swell with a higher frequency of swell in an ac– dc rectifier system.

Thus, 6-and 12-phase transformers are designed to feed a multipulse rectifier system and the innovation has developed. As of late, 24-phase and 36-phase transformer systems have been proposed for providing a multipulse rectifier system. The reason of choice for a 6-, 12-, or 24-phase system is that these numbers are products of three and designing this sort of system is basic and clear. However, expanding the quantity of phases absolutely improves the multifaceted nature of the system. None of these designs are accessible for an odd number of phases, for example, 5, 7, 11, and so forth.



(a) (b)

Figure 2.3 (a) Proposed Transformer winding arrangements (Star-Star). (b) Proposed Transformer winding connection (Star).

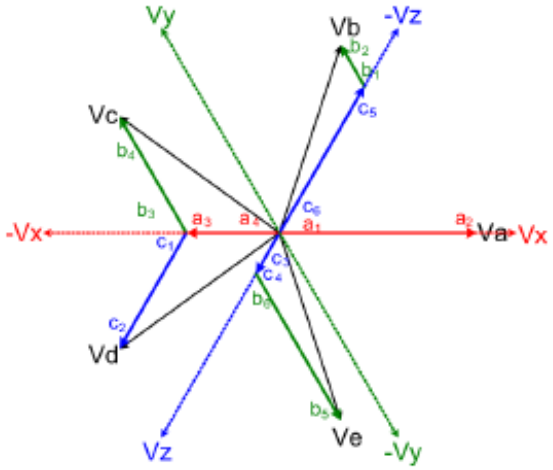


Figure 2.4 Phasor diagram of the proposed transformer connection (Star - Star)

The common practice is to test the designed motor for various working conditions with an unadulterated sinusoidal supply to find out the coveted execution of the motor. Typically, a no-load test, blocked rotor, and load tests are performed on an engine to decide its parameters. In spite of the fact that the supply utilized for a multiphase engine drive obtained from a multiphase inverter could have more current ripple, there are control techniques accessible to bring down the present distortion even beneath 1%, in light of use and necessity.

Hence, the machine parameters acquired by utilizing the pulse width-modulation (PWM) supply may not give the exact true value. In this way, an unadulterated sinusoidal supply system accessible from the utility framework is required to encourage the engine. This invertigation proposes an uncommon transformer association plan to acquire an adjusted five-phase supply with the contribution

as adjusted three phases. The square outline of the proposed system is appeared in Fig. 2.2. The settled voltage and settled frequency accessible network supply can be changed to the settled voltage and settled frequency five-phase yield supply. The yield, however, might be made variable by embeddings the autotransformer at the info side. The info and yield supply can be masterminded in the accompanying way:

1) input star, output star;

2) input star, output polygon;

3) input delta, output star;

4) Input delta, output polygon.

Since input is a three-phase system, the windings are connected in an usual fashion.

III. SIMULATION RESULTS

Simulation of Proposed work has performed on Mataln simulator Matlab Simulink. The outcome of proposed work waveform has been shown in figure. Figure 3.1 shows the three phase output voltage waveform of proposed work.

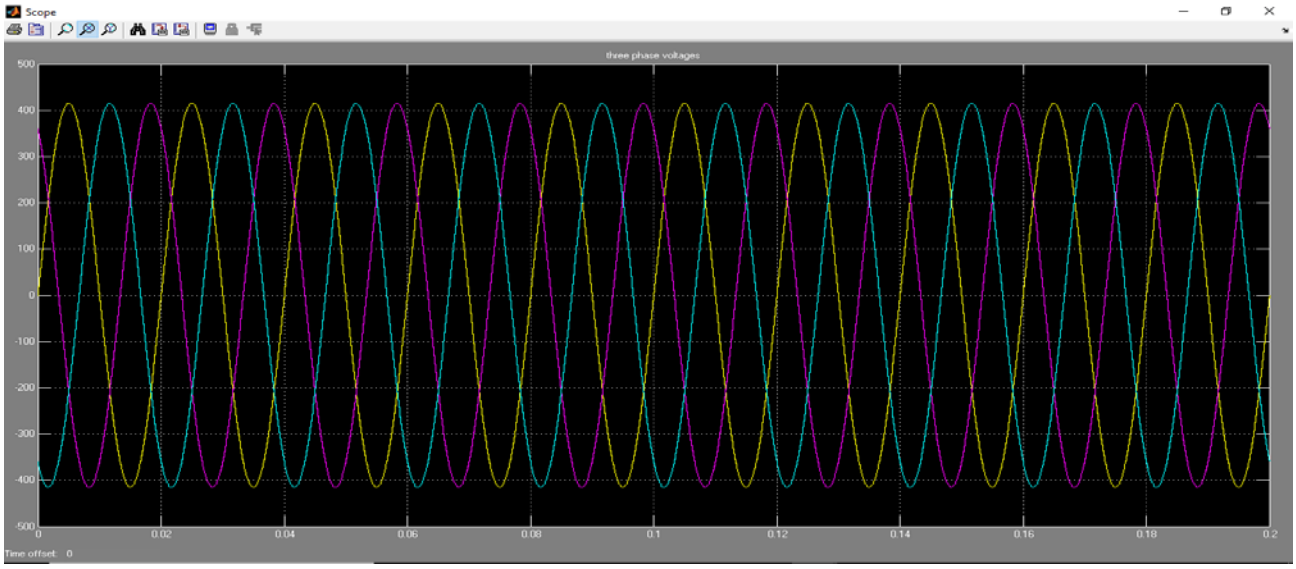


Fig.3.1 Three Phase Source Voltage.

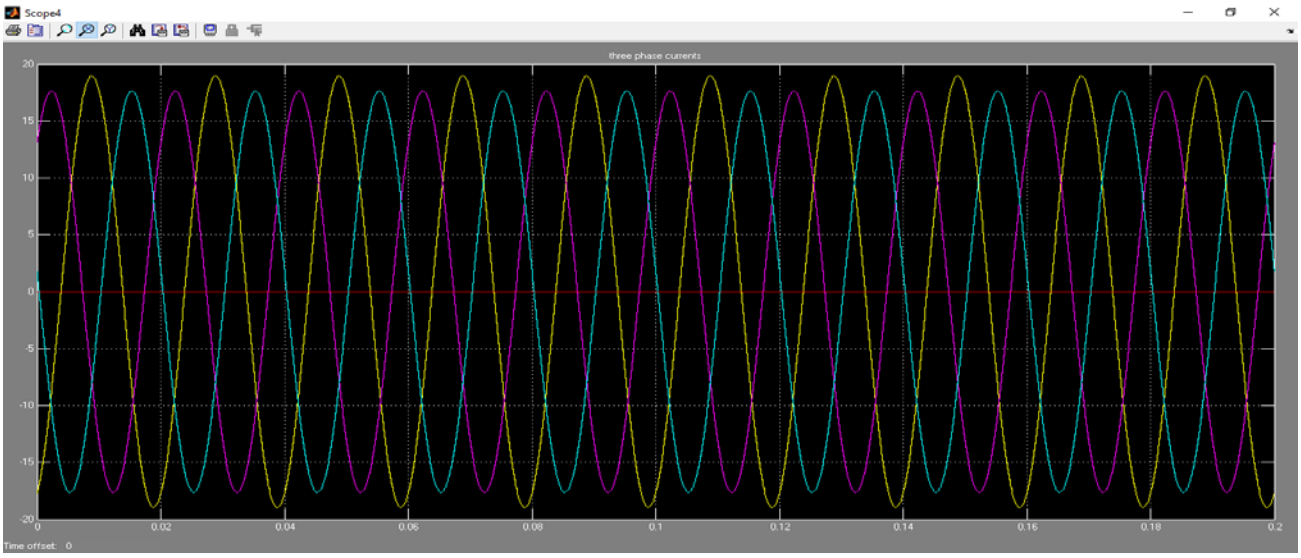


Fig. 3.2 Three Phase Source Current.

Second output waveform of proposed three phase current has been shown in figure 3.2. Waveform has been taken form Matlab model simulation. Figure 3.3 shows the five phase current waveform on simulation of proposed model.

In figure different color represents different phases of power currents and voltages.

A five phase voltage simulation waveform has been shown in figure 3.4 based on simulation of model on Matlab simulink.

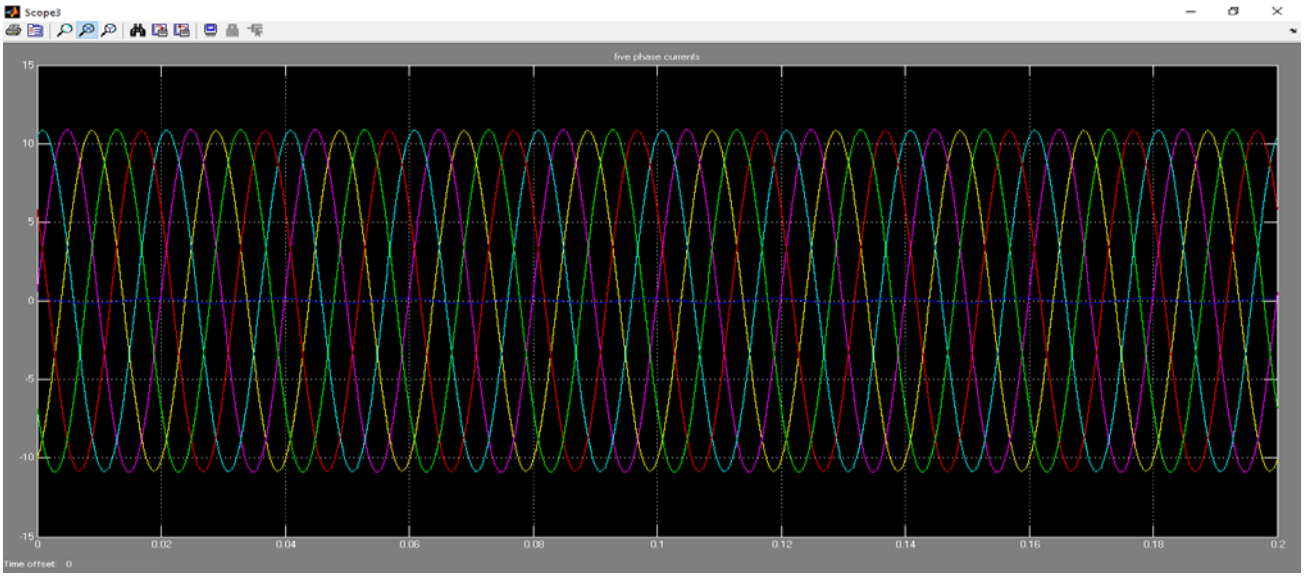


Fig. 3.3 Transformed Five Phase Current.

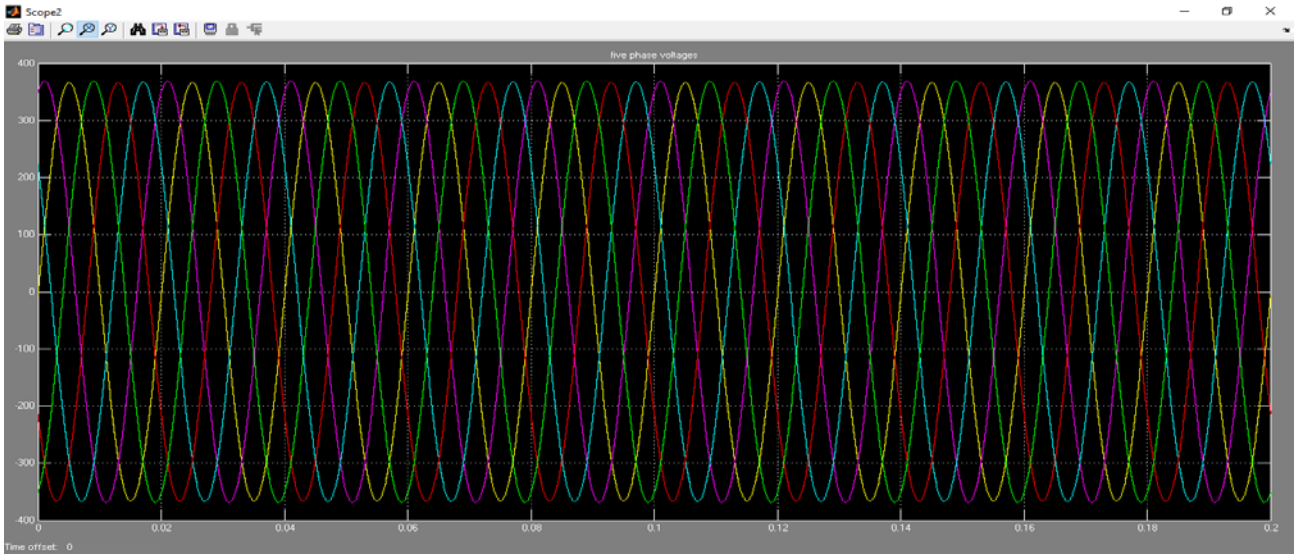


Fig. 3.4 Transformed Five Phase Voltage.

IV. CONCLUSION

The first five-phase induction engine drive system was proposed in the late 1970s for adjustable speed drive applications. From that point forward, an impressive research exertion has been set up to grow monetarily attainable multiphase drive Systems. This work presents usage and reenactment of a three-phase to five-phase change utilizing a unique transformer association on Mtalb IDE and Simulated on Matlab Simulink. The examination on six-phase transmission system was started because of the increasing expense of right of path for transmission corridors, environmental challenges, and different stringent permitting laws. Six phase transmission lines can furnish a similar power limit with a lower phase-to-phase voltage and smaller, more minimized towers contrasted with a standard double-circuit three-phase line. The Simulation and experimental outcomes are comparable and support the hypothetical contemplations. The control methods can direct the dc-interface voltages and guarantee reduces grid power factor. A five-phase acceptance engine under a loaded condition is utilized to demonstrate the feasibility of the change system. It is normal that the proposed association plan can be utilized as a part of drives applications and may likewise be additionally investigated to be used in multiphase power transmission systems.

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