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ANALYSIS OF A SPECIAL TRANSFORMER CONNECTION USING A NOVEL TECHNIQUE

Abdul Rana Ibrahim

ABSTRACT

There is rapid development in the power system applications in early from the 19th century in many areas like transmission, distribution and power system appliances. In the year 1970 there is rapid development in the sector of machines. In late 1970 the first five phase induction motor drive system was proposed the world. Since there is huge research attempts has been placed to develop the multiphase drive systems. The three-phase supply is available from the grid; there is a need to develop a static phase transformation system to obtain a multiphase supply from the available three phase supply. So this paper suggests a novel transformer connection idea to convert the three phase grid supply to a five phase fixed voltage by maintaining the constant frequency supply. Now days the use of five phase motor dive is ever-increasing in commercial purpose and in future also. To satisfy these there are having solutions first, implementation of six phase transmission. To implement this we have to change the three phase to six phase. This paper proposes the implementation of three phase to five phase transformer has been proposed. The five-phase transmission system can be investigated further as an efficient solution for bulk power transfer. The modeling of the five phase transformer is proposed and it is simulated in the Matlab environment.

1. INTRODUCTION

MULTIPHASE (more than three phase) systems are the focus of research recently due to their inherent advantages compared to their three-phase counterparts. The applicability of multiphase systems is explored in electric power generation transmission and utilization. The research on six-phase transmission system was initiated due to the rising cost of right of way for transmission corridors, environmental 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 compared 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. The research on multiphase generators has started recently and only a few references are available. 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. As far 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. It is to be emphasized here that the multiphase motors are invariably supplied by ac/dc/ac converters. Thus, the focus of the research on the multiphase electric drive is limited to the modeling and control of the supply systems (i.e., the inverters). Little effort is made to develop any static transformation system to change the phase number from three to -phase (where n> 3 and odd). The scenario has now changed with this paper, proposing a novel phase transformation system which converts an available three-phase supply to an output five-phase supply. Multiphase, especially a 6-phase and 12-phase system is found to produce less ripple with a higher frequency of ripple in an ac–dc rectifier system. Thus, 6- and 12-phase transformers are designed to feed a

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multi-pulse rectifier system and the technology has matured. Recently, a 24-phase and 36-phase transformer system have been proposed for supplying a multipulse rectifier system .The reason of choice for 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. However, increasing the number of phases certainly enhances the complexity of the system. None of these designs are available for an odd number of phases, such as 5, 7, 11, etc., as far as the authors know.

MULTIPHASE (more than three phase) systems are the focus of research recently due to their intrinsic advantages compared to their three-phase systems. The applicability of multiphase systems is investigate in electric power generation [1]–[5], transmission [6]–[9], and utilization. The research on six-phase transmission system was initiated due to the rising cost of right of way for transmission corridors, environmental 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 compared 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 [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.

As far as multiphase motor drives are concerned, the first proposal was given by Ward and Harrer way back in 1969 [1] 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. It is to be emphasized here that the multiphase motors are invariably supplied by ac/dc/ac converters. Thus, the focus of the research on the multiphase electric drive is limited to the modeling and control of the supply systems. Little effort is made 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 novel phase transformation system which converts an available three-phase supply to an output five-phase supply.

2. WINDING ARRANGEMENT FOR FIVE-PHASE STAR OUTPUT

Three separate cores are designed with each carrying one primary and three secondary coils, except in one core where only two secondary coils are used. Six terminals of primaries are connected in an appropriate manner resulting in star and/or delta connections and the 16 terminals of secondaries are connected in a different fashion resulting in star or polygon output. The connection scheme of secondary windings to obtain a star output is illustrated in Fig. 1 and the corresponding phasor diagram is illustrated in Fig. 2. The construction of output phases with requisite phase angles of 72 between each phase is obtained using appropriate turn ratios, and the governing phasor equations are illustrated. In The turn ratios are different in each phase. The choice of 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”. As illustrated in Fig. 2, 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 “a4a3 ” and “b3b4 ”. The output phase “D” is obtained by the phasor addition of winding voltages “a4a3 ” and “c1c2 ” and similarly output phase “E” results from the phasor sum of the winding voltages “c3c4 ” and

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" b6b5". In this way, five phases are obtained. The transformation from three to five and vice-versa is further obtained by using the relation given in the below equations 1-10.

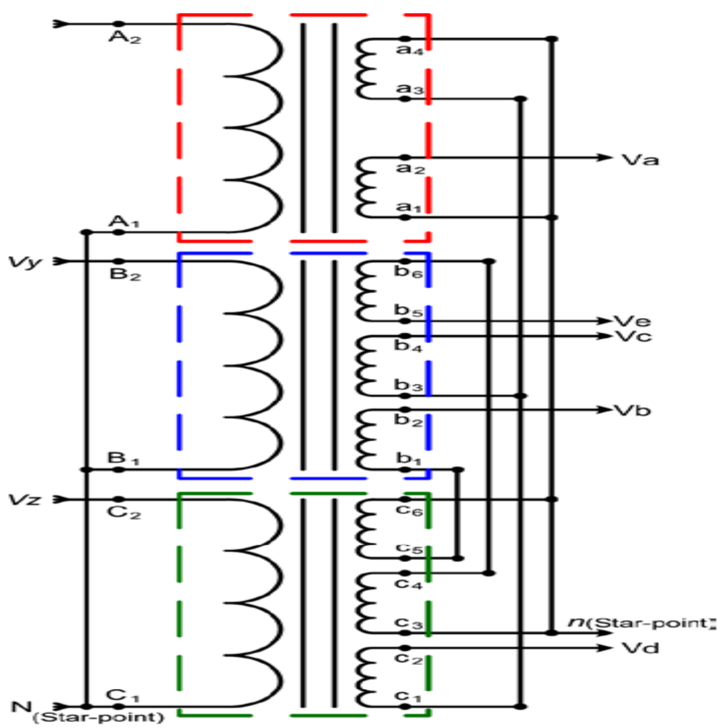

Fig.1: Proposed transformer winding arrangement.

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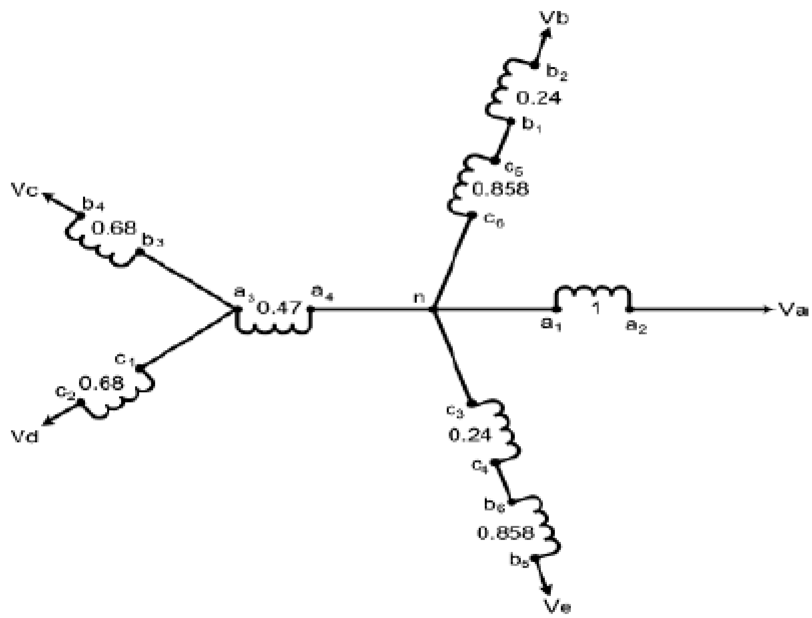

Fig.2 Proposed transformer winding connection

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, blocked rotor, and load tests are performed on a motor to determine its parameters. Although the supply used for a multiphase motor drive obtained from a multiphase inverter could have more current ripple, there are control methods available to lower the current distortion even below 1%, based on application and requirement. Hence, the machine parameters obtained by using the pulse width-modulated (PWM) supply may not provide the precise true value. Thus, a pure sinusoidal supply system available from the utility grid is required to feed the motor. This paper proposes a special transformer connection scheme to obtain a balanced five-phase supply with the input as balanced three phase.

3. WINDING ARRANGEMENT FOR FIVE-PHASE STAR OUTPUT

Three separate cores are designed with each carrying one primary and three secondary coils, except in one core where only two secondary coils are used. Six terminals of primaries are connected in an appropriate manner resulting in star and/or delta connections and the 16 terminals of secondaries are connected in a different fashion resulting in star or polygon output. The connection scheme of secondary windings to obtain a star output is illustrated in Fig. 1 and the corresponding phasor diagram is illustrated in Fig. 2. The construction of output phases with requisite phase angles of 72 between each phase is obtained using appropriate turn ratios, and the governing phasor equations are illustrated. The turn ratios are different in each phase. The choice of turn ratio is the key in creating the requisite phase displacement in the output phases.

CONCLUSIONS

This paper proposes a new 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 of the proposed connection scheme is elaborated by using

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simulation and experimentation. A five-phase induction motor under a loaded condition is used to prove the viability of the transformation system. It is 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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