Modified Control Method for Industrial Split Phase Induction Motor

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ABSTRACT

This paper deals with an ac motor controlling with a power electronic circuit the mainaimisto control the torque and speed of the ac motor. The total circuit is modeled and simulated using MATLAB 2012 A software and the circuit is simulated using SimPower System and Simulink tool box and the total circuit is simulated under power graphical user interface environment and circuit is modeled and simulated to obtain required characteristics. Keywords: 1-phase Cycloconverter, Splitphase Induction Motor, PWM pulse generator, IGBT MATLAB (2009a).

I. INTRODUCTION

Analysis of induction motors controlled with Cycloconverter has been investigated extensively. The single-phase induction motor init its simplest form is structurally the same as an apoly phase induction motor having a squirrel cage rotor, the only difference is that the split phase induction motor has single winding on the stator. The split-phase induction motor is the most commonly used motor in the utility network which produces mmf stationary in space but alternating in time, a polyphase stator winding carrying balanced currents produces mmf rotating in space around the air gap and constant intime with respect to the observer moving with the mmf. Splitphase induction motors are usually built with small power, they are widely used in domestic and commercial applications. This paper shown a speed control scheme for a split phase induction motor fed with Cycloconverter. Cycloconverter are used in very large variable frequency drives with ratings from few megawatts to many tens of megawatts. A single-phase input Cycloconverter is shown in Figure 1, single-phase input to single-phase output Cycloconverter is shown in Fig. 4, the simplest Cycloconverter circuit. Thesingle phase induction motor init its simplest form is structurally the same as a poly phase induction motor having a squirrel cage rotor, the only difference is that the split phase induction motor has single winding on the stator. The split phase induction motor is the most commonly used motor in the utility network which produces mmf stationary in space but alternating in time, a polyphase stator winding carrying balanced currents produces mmf rotating in space around the air gap and constant intime with respect to the observer moving with the mmf. Splitphase induction motors are usually built with small power, they are widely used in domestic and commercial applications. IGBTs have the advantage for high speed, high power switching for building PWM controlled Cycloconverter.

II. LITERATURE SURVEY

Mantooth, H.A.; Analogy Inc., Beaverton, OR, USA; Hefner, Allen R. An electrothermal network simulation methodology is used to analyze the behavior of a full-bridge, pulse-width-modulated (PWM), voltage-source inverter, which uses insulated gate bipolar transistors (IGBTs) as the switching devices. The electrothermal simulations are performed using the Saber circuit simulator and include control logic circuitry, IGBT gate drivers, the physics-based IGBT electrothermal model,
and thermal network component models for the power-device silicon chips, packages, and heat sinks. It is shown that the thermal response of the silicon chip determines the IGBT temperature rise during the deviceswitching cycle. The thermal response of the device TO247 package and silicon chip determines the device temperature rise during a single phase of the 60-Hz sinusoidal output. Also, the thermal response of the heat sink determines the device temperature rise during the system startup and after load-impedance changes. It is also shown that the full electrothermal analysis is required to accurately describe the power losses and circuit efficiency.

Don-Ha Hwang The winding insulation of low-voltage induction motors in an adjustable-speed drive system with IGBTpulselength modulated (PWM) inverters is substantiably stressed due to the uneven voltagedistribution and excessive voltage stress \( \frac{dv}{dt} \), which resultinthe prematureinsulation breakdown. In this paper, the detailed insulation test results of 48 low-voltage induction motors are presented. Different types of insulation techniques are applied to 48 motors. The insulation characteristics are analyzed with partial discharge, discharge inception voltage, and dissipation factor tests. Also, breakdown tests by high voltage pulses are performed.

Don-Ha Hwang IGBT PWM inverter has been concerned that insulation breakdown and irregular voltage distribution on statorwinding due to high rate of voltage rise \( \frac{dv}{dt} \) caused by high-frequency switching and impedance mismatch between inverter and motor. In this paper, voltagedistribution and statorwinding of induction motor driven by IGBT PWM inverter is studied. To analyze the irregular voltage of statorwinding, high frequency parameter is computed by using finite element method (FEM). An equivalent circuit composed by distributed capacitances, inductance, and resistance is derived from these parameters. This equivalent circuit is then used for simulation in order to predict the voltage distribution among the turns and coils. The variable effect on rising time of the inverter and cable length on the voltagedistribution is also presented. In order to experiment, an induction motor, 50 HP, with taps from one phase and a switching surge generator were built to consider the voltage distribution.

Takahashi, TAsPWM variable frequency technology advances in the use of IGBT power transistors, concerns have arisen over the amount of conductor located between the controller and the low-voltage induction motor. Several technical papers have been presented on the subject of \( \frac{dv}{dt} \) from these controllers and the effect on motor insulation. This paper builds on these previous papers while detailing the application of transmission theory, drive current feedback design impact, proper modeling techniques of conductors, distributed impedance, and motor design considerations, theoretical and experimental test data are included to support the findings. Although the focus of this paper is on applications below 5 HP, some theories and tests presented should be considered in larger systems. Chipping, de-barking, washing, and coating applications in the industry sometimes do not lend themselves well to close proximity location of motors and controllers. IGBT PWM design, motor design, and installation guidelines are discussed as solutions with several options presented to the engineer.
partial discharge, dissipation factor, and discharge inception voltage test results. Also, breakdown tests by high voltage pulse are performed.

Kawabata, Takao; Mitsubishi Electr. Corp., Hyogo, Japan; Honjo, K.; Sashida, N.; Sanada, A. A high-frequency link DC/AC converter developed for flexible, compact, and high-efficiency uninterruptible power supply (UPS) systems is discussed. The DC/AC converter consists of a 50% duty ratio rectangular voltage output inverter, a high-frequency transformer, a pulse-width modulation (PWM) cycloconverter, and an LC filter. For this converter, a three-phase output DC/AC converter can be easily realized with only one inverter and one three-phase cycloconverter. Conversion efficiency is inherently high because the inverter can utilize zero-current switching to minimize the switching loss. Output waveform control is improved because the dead time in the cycloconverter PWM can be eliminated. The main circuit configuration, the PWM method of the cycloconverter used to obtain a sinusoidal output voltage and the switching method of the inverter are described. The experimental results of a 1 kVA DC/AC converter using a high-frequency link of 20 kHz in both single-phase and three-phase output are discussed.

Gopakumar, K.; Indian Inst. of Sci., Bangalore, India; Ranganathan, V.T.; Bhat, S.R. A PWM (pulse width modulation) strategy is proposed for a split phase induction motor drive, where at low speeds each of the inverters is operated with conventional three-phase space phasor modulation, thereby avoiding fifth and seventh harmonics in the motor voltage. At the higher end of the speed range a voltage space phasor modulation based on the twelve-sided polygonal vertices is used, so that the benefit of a higher speed in the modulation range is retained. A technique for achieving the transition to that range without current transients is proposed. The scheme is verified through computer simulation, using a space-phasor-based model of the split phase motor. Details of a practical control circuit for voltage space-phasor-based PWM pulse generation are presented, and the results from an experimental drive are highlighted.

An examination is made of the operation of split-phase induction motors from pulse width modulated (PWM) voltage source inverters. Splitting the phase windings leads to reduced voltage ratings for the inverter switches. The inverters are operated with space phasor-based PWM. It is well known that with this technique, a three-phase inverter can give a maximum peak fundamental of 0.577 V/sub DC/ for the motor phase voltage (with a circular trajectory for the voltage space phasor), as against 0.5 V/sub DC/ with sine triangle modulation.

Holik, P.J.; Dept. of Electron. & Electr. Eng., Glasgow Univ.; Dorrell, D.G.; Popescu, M. The performance of an external-rotor split-phase induction motor for use in such applications as ceiling fans (although the pole number would be much higher than the 2-pole machine studied here). This machine has short axial length with respect to its diameter. The auxiliary winding is only used to start the machine and it is wound orthogonal to the main winding and connected in parallel to it using a centrifugal switch. The paper highlights how an external can, which connects the two end-rings, can be used to improve the motor performance. The paper describes a 2-D finite element analysis (FEA) of the machine to show the performance and also to describe the pulsating torque of the machine.

Khajeh, A.; Amirkabir Univ. of Technol., Tehran; Moghani, J.S.; Shahbazi, M a predictive direct torque control (DTC) scheme for split-phase induction machine (SPIM) is established. The induction motor has two sets of stator three-phase windings spatially shifted by 30 electrical
degrees. The major drawback of SPIMs is occurrence of extra harmonic currents. Thus in the DTC of SPIMs in addition to control of torque and flux we should consider simultaneously minimizing harmonic components of stator current. Predictive DTC along with optimized SVPWM is used in this paper. Simulation results show that in addition to a good dynamic response, current harmonics in this scheme is significantly reduced.

Dorrell, D.G.; Dept. of Electron. & Electr. Eng., Glasgow Univ., UK; a simple but effective impedance matrix analysis technique that allows the analysis of a split-phase induction motor. Using this technique, the asynchronous torques as well as the main performance of a split-phase machine can be predicted to aid design of the machine. The model is tested against the SPEED software from the University of Glasgow, which uses the cross-field and rotating field techniques, which theoretic machines with windings containing MMF harmonics.

Andersen, P.S.; Danfoss Compressors GmbH, Flensburg; Dorrell, D.G.; Weihrauch, N.C.; Hansen, P.E.; a method for calculating the synchronous torque dips in a split-phase induction machine. First it derives the equivalent circuits so that the torque speed/curve can be obtained over a full speed range (including asynchronous torque oscillations). When the currents are resolved these are used to calculate the synchronous torques from a set of interactions between the machine MMFs and the slot permeances. This gives the synchronous torques (speed and magnitude) which can be superimposed onto the torque/speed curve. The method is tested experimentally and found to give reasonable results. This type of motor has singlephase stator winding called main winding. In addition to this, stator carries one more winding called auxiliary winding or starting winding. The auxiliary winding carries a series resistance such that its impedance is highly resistive in nature. The main winding is inductive in nature. As main winding is inductive, current \( I_m \) lags voltage by \( 90^\circ \) while \( \Phi_m \), the phase angle of auxiliary winding changes with speed. Hence between two currents, there exists a phase difference. The resultant flux is that of the auxiliary winding rotating in the magnetic field. Due to this, the starting torque, which acts only in a direction is produced.

The auxiliary winding has a centrifugal switch in series with it. When motor gathers speed up 75% of the synchronous speed, centrifugal switch gets opened mechanically and in running condition auxiliary winding remains out of the circuit. So motor runs only stator winding. So auxiliary winding is designed for short time use while the main winding is designed for continuous use. As the current \( I_m \) and \( I_n \) are split from each other by angle \( \alpha \) at start, the motor is commonly called split phase motor.

The torque–speed characteristics of split-phase motors is such that the starting torque \( T_s \) is proportional to the split angle \( \alpha \) but split phase motors give poor starting torque which is 125 to 150% of full load torque.

The direction of rotation of this motor can be reversed by reversing the terminal of either the main winding or auxiliary winding. This changes the direction of rotation of the motor. The split-phase (SP) motor is more accurately the resistance–start, split-phase, induction run motor, is recommended for medium-duty applications. It can run at constant speed even under varying load conditions where moderate torque is acceptable. Split-phase motor has a squirrel-cage rotor.
cage rotors and both a main or running winding and a starting or auxiliary winding. The schematic diagram for an SP motor, Figure 1, shows the starting winding in series with a centrifugal switch and the main winding in parallel across the AC line. The starting winding is wound with fewer turns of smaller-diameter, higher-resistance wire than the main winding.

When energized, current flowing in the starting winding is essentially in phase with the line voltage, but current flowing in the parallel main winding lags behind line voltage because it has lower resistance and higher reactance.

![Figure 2. Single-phase motor - Resistance start split-phasemotor](image)

**III. SIMULATION CIRCUITS AND RESULTS**

![Figure 3. (a) Source Voltage (b) Output Voltage (c) Output current waveform of Single Phaseto Single Phase Cycloconverter When Input Frequency is Two Times Output Frequency](image)
Phase Induction Motor, When Input Frequency to the Cycloconverter is Two Times Output Frequency

**Figure 4.** Main Winding Current (b) Auxiliary Winding Current Waveform of Single Phase Induction Motor, When Input Frequency to the Cycloconverter is Two Times Output Frequency

**Figure 5.** (a) Rotor Speed (b) Load and Electromagnetic Torque Waveform of Single Phase Induction Motor, When Input Frequency to the Cycloconverter is Two Times Output Frequency
Figure 6. (a) Source Voltage (b) Output Voltage (c) Output current Waveform of Single Phase to Single Phase Cycloconverter When Input Frequency is Three Times Output Frequency

Figure 7. (a) Main Winding Current (b) Auxiliary Winding Current Waveform of Single Phase Induction Motor, When Input Frequency to the Cycloconverter is Three Times Output Frequency
Figure 8. (a) Rotor Speed (b) Load and Electromagnetic Torque Waveform of Single Phase Induction Motor, When Input Frequency to the Cycloconverter is Three Times Output Frequency

Figure 9. (a) Source Voltage (b) Output Voltage (c) Output Current Waveform of Single Phase to Single Phase Cycloconverter When Input Frequency is Four Times Output Frequency
Figure 10. (a) Main Winding Current (b) Auxiliary Winding Current Waveform of Single Phase Induction Motor, When Input Frequency to the Cycloconverter is Four Times Output Frequency.

Figure 11. (a) Rotor Speed (b) Load and Electromagnetic Torque Waveform of Single Phase Induction Motor, When Input Frequency to the Cycloconverter is Four Times Output Frequency.
Figure 12. (a) Source Voltage (b) Output Voltage (c) Output Current Waveform of Single Phase to Single Phase Cycloconverter When Input Frequency is Five Times Output Frequency.

Figure 13. (a) Main Winding Current (b) Auxiliary Winding Current Waveform of Single Phase Induction Motor, When Input Frequency to the Cycloconverter is Five Times Output Frequency.
IV. CONCLUSION

The PWMcontrolledCycloconvertercircuits isdesignedandsimulated anddesiredresults are obtained. Single phase Cycloconverter used forSinglephasemotoritgeneratesupply torque characteristics that matches with demandtorque characteristics ofparticular machine by the use of designing Cycloconverterdifferentdesired frequency are obtained toequalizethe torquedemandofmachine. Thisdifferentfrequency of Cycloconverterisalso usefulatreplace flywheelfrom theoperatingmachine which reducesthecause oftorsional vibrationand fatigue damage of machine. The paper proposedfeedback controlschemeof Cycloconverterfed split phase induction motor. Furthermore, itprovidesmeansfor limiting the slip and consequently the motor current. Thismeansa reductionin the Cycloconverterrating andbetterefficiency. This contribution willreporton the results obtainedusing matlabforsinglephase Cycloconvertercoupled toan induction motor.

V. REFERENCES


