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Study of Performace of Dual Stator Induction Motor

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Abstract— This paper explains a new speed control for an induction motor with two stators. In-depth saturation is avoided. The combined impact of the stator caused the magnetic load to peak in this case, and it was comparable to the load on an analogous single stator winding. It is unaffected by voltage inverters and varied frequencies. In IM, an analogous sinusoidal distributed winding replaces the squirrel cage. As a result, high order space harmonics are not taken into account here, and the rotor current generates two field distributions that rotate at various speeds due to the varying numbers of poles and sinusoidal properties of the stator winding. The IM drive with two stators offers the advantages of speed sensor-less operation, improved dependability, and greater flexibility to adjust the machine's resulting torque-speed curve, and two terms of stator currents can independently control zero-speed operation. It is specifically made to lessen the negative effects of stator resistance influence at low speed operation and to make speed sensor-free control schemes easier to implement.

Keywords— Dual stator, field oriented machine, low speed, sensor-less, and volts per Herz

I. INTRODUCTION

The use of induction drive systems in numerous industrial applications is growing in the present. The introduction of power electronic frequency converters, which can produce multi-phase voltage and current systems, is what caused it. The principal applications for induction motors with multiphase squirrel cages are high power electrical drives or drives with particular control needs [1-2]. The key benefits of these motors are their increased torque density, increased efficiency, decreased torque pulsations, and increased fault tolerance. It is feasible to reduce the currents of motor circuits and power converter circuits thanks to the potential of power distribution among a higher number of phases.

The dual 3- stator winding in induction motor is the most intriguing and frequently used multiphase driving method [3]. Two separate 3- stator windings are present in the induction machine with two stators, which also has a shared squirrel cage rotor winding and the same machine core. The layout of the motor core in the stator windings can generally be classified into two major categories.

The first one consists of a design in which two distinct 3-stator windings are spaced apart along the stator core consecutively [4]. Since each stator winding is magnetically related to the rotor cage winding, there is no magnetic coupling between the stator windings in this instance.

The same frequency AC voltage source is fed into each of the two stator windings either simultaneously or separately. The motor with the first type of dual stator construction has two stator windings that are placed in the same stator core but are spatially displaced [5]. The studies support the claim that this construction is promising. This essay analyses the overall strategy and management of twin stator induction motors. Mathematical models of IM with dual stators have been described, and direct torque control and rotor field-oriented control are used to observe the principles and practises of vector control.

II MULTIPLY-WOUND STATOR IM

A. Introduction

Commercially, induction machines can be obtained in two main methods. Three electrically isolated circuits are coiled tri-filarly around each pole of the motor's two stators, which is why each phase is located in the same stator slot. The machine is wound to sustain less than the flux density in saturation when all three stator windings are powered in parallel at the rated voltage in order to prevent magnetic saturation in the stator steel [6].

There are two aspects of this machine structure that are intriguing. Triple-n harmonics are initially permitted access to the star-points of the stator's winding in order to be driven into the machine on the properly linked winding circuits. For instance, when the source star-point, Vn, is connected to the star-points of the stator windings, Vn1, Vn2, and Vn3, zero-sequence current enters the machine. Note that the rotor winding's physical design prevents this zero-sequence current from being induced.

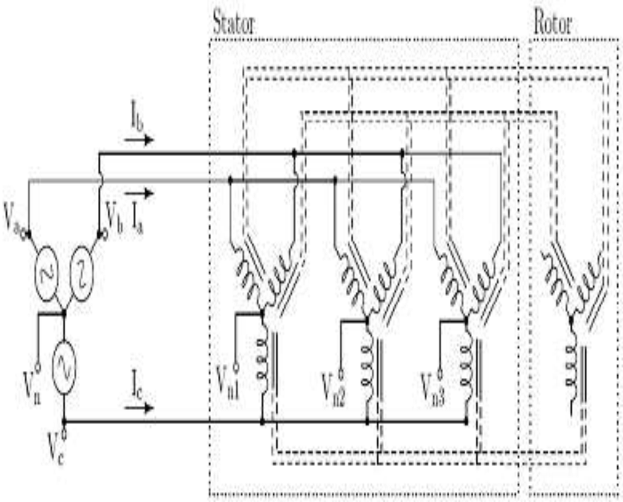

Fig 1: Multiple-stator IM Model.

B. Equivalent Circuit Model

In induction machines, the steady-state functioning is frequently represented using equivalent circuits for each phase. Fig. 2 depicts such an equivalent circuit. where phase current is denoted by Ia, equivalent stator winding resistance by Ra, and stator winding leakage resistance by X1 Reactance X2 is the corresponding rotor leakage. The stator to rotor magnetising inductance is represented by the reactance Xm. Leaks and inductance with magnetising are important aspects of machine architecture.

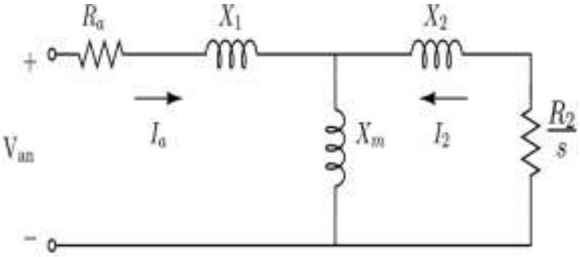

Fig 2: Induction Machine Phase-to-Neutral Equivalent Circuit

To model a machine in steady-state and determine machine parameters empirically in this equivalent circuit. The total impedance of the terminal phase to the neutral is

$Zeq = jX1 + Ra + Zg$

For the impedance of the air gap and from the stator, the rotor is observed

$Zg = jXmk \parallel (jX2 + Rs/s)$

Given that the terminal current, Ia is simply observed

$Ia = Van/Zeq$

And the current of rotor is

$I_2 = (Ia \cdot jXm)/ (jX2 + R2/s + jXm)$

from divider of the current between the rotor impedance and the magnetising reactance

C. IM WINDING DRIVE WITH DUAL STATOR

The IM has a typical diecast squirrel-cage rotor, and the stator's two independent windings are wound with different numbers of poles (for example, 2/6 or 4/12). Any combination of different pole numbers could be employed, but it has been discovered that the pole ratio 1:3 offers the best magnetic material utilisation, avoids localised saturation, and reduces additional stator losses. Each stator winding contains a separate variable-frequency, variable-voltage inverter that is connected to a single DC bus. Important DSIM drive parts can be seen in Fig. 3.

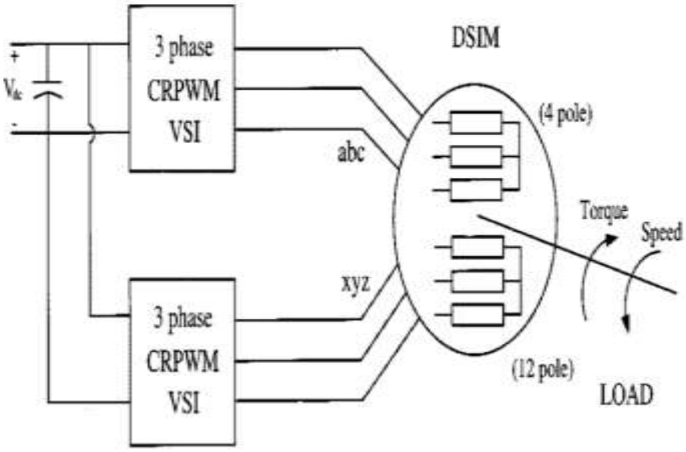

Fig 3: Induction machine drive with Dual stator winding

The peak magnetic loading consumed by the combined effect of the two stator MMFs must be comparable to that of an equivalent winding with a single stator design in order to prevent deep saturation [7].

In order to restore the values by limiting the minimum electrical frequency in the low-pole number winding, the low pole number winding in the stator is stepped up by applying a controlled amount of torque to a winding with a high pole. It lessens the effect on the stator's resistance, stator voltage drop, voltage measurement, and rotor flux vector estimation.

This is crucial since the typical induction machine is invisible at zero speed. Zero-speed functioning at any excited frequency and making the system visible at all speeds in the IM with two stators. In the operation of synchronous machines, two frequencies are in an equal ratio identical to the pole number, however in the operation of asynchronous machines, the frequency is maintained constant in the low-pole number winding maintained at minimal value.

There is no mutual coupling between stator windings that are sinusoidally dispersed in space but have different numbers of wounded poles. Distributed windings result in the production of space harmonics. Triple harmonics are removed in the absence of a neutral connection, even if the pole ratio between two windings should be 1:3. Common harmonics arise in triple order between two windings. Real windings should take into account the fact that there is no reciprocal coupling caused by space harmonics.

Since they share a winding and have nearby slots in common, there is a common leakage flux that connects them. Mutual leaking coupling is the result.

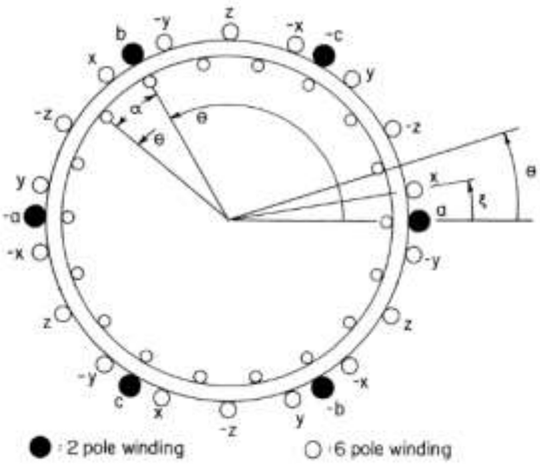

Fig 4: windings distribution of DSIM

CONTROLLING METHODS

Two separate induction machines are used by the IM with two stators, and the shaft is mechanically connected. As a result, the controlling methods used in IM and DSIM are comparable. To determine the precise flux level, extra factors must be taken into account due to the shared magnetic structure.

Synchronous operation, where the stator frequencies contain an equal ratio to the number of poles, and asynchronous operation, where the frequency is maintained at a minimum value (2.5 Hz) in the low-pole winding numbers, regardless of mechanical speed, are the two distinct working modes. This mode allows for zero-speed operation [8]. In this mode, saturation is produced by asynchrously moving two stator MMF, and the resulting flux distortion is distributed. Less frequency is contained, therefore the added losses are minimal.

D. Constant Voltage/frequency control

There are two distinct modes of operation. The two stators have the same voltage and frequency when travelling at high speeds (i.e., synchronous mode). The algebraic sum of the torques T1 and T2 corresponds to the resulting torque at a particular rotor speed. By varying the stator voltages' magnitude in each winding, the torque can be produced.

The abc winding frequency is fixed when the mechanical speed requires a frequency below the minimum value, and the resulting torque is modified by adjusting the frequency (and voltage) provided to the xyz winding.

It has two stators that function in asynchronous mode; the first, abc, operates in the driving region and the second, xyz, operates in the generating region. The torque can be regulated from zero to the rated value while operating at zero speed in this working mode. Figure 5 shows a block diagram of the control system.

E. Vector Control

The proposed control scheme has two operating modes: synchronous mode, which is defined as frequencies above a minimum frequency fmin, and asynchronous mode. remaining frequencies are low speed range for frequencies (asynchronous mode).

A typical indirect field orientation in the synchronous mode depends on the slip relation that is employed. To create the torque command for the xyz winding, T*e2, the necessary torque, Te1, generated by the abc currents, is subtracted from the external torque command, T*e. The torque producing (ieqs2) and flux command producing (ieds2) current components are used to determine the slip frequency swe2.

The torque equation, which depends on the inverse of the slip relation, is produced by current ieqs1 and is used to maintain the proper flux orientation for low-pole winding. The frequency equation for low-speed operating in asynchronous mode is determined at

$$w_{min} = 2*pi*f_{min}.$$

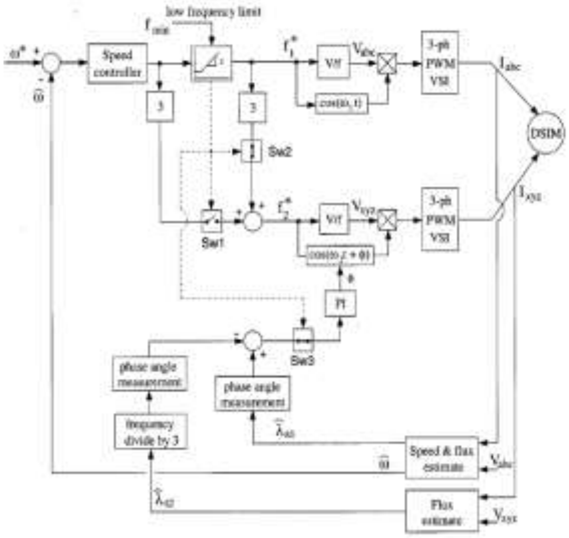

Fig 5: Proposed control scheme using constant volts per hertz (V/Hz) mode

This frequency explains the frequency of slip needed to obtain torque-producing current ieqs1 along with the rotor speed. The integral of the input frequency we1 is used to calculate the vector rotation angle in order to maintain the rotor flux's sequence. Due to this operating mode, the low-pole winding must provide a torque that is more than that of the load. The additional torque is offset by a torque that is equal to and opposite to that produced by inserting windings in the high-pole number.

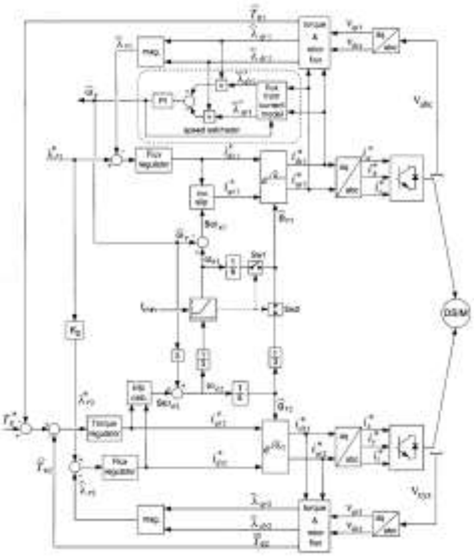

Fig 6: Proposed control scheme using indirect field orientation

III SIMULATION RESULTS

The simulation results for the suggested strategies are displayed below. The results are achieved as needed, and it is evident that it may be used at zero speed and without a load while keeping the stator's frequency at or above the minimum frequency level.

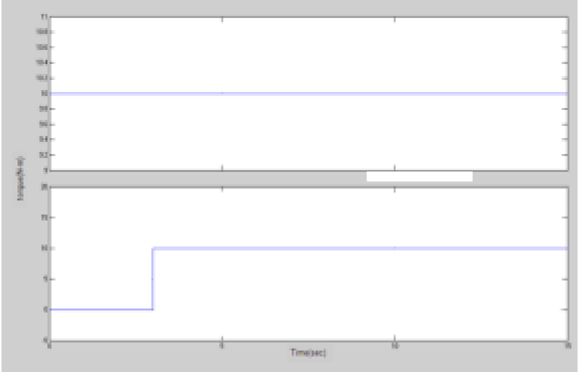

Fig7: Load Torque T1 and T2

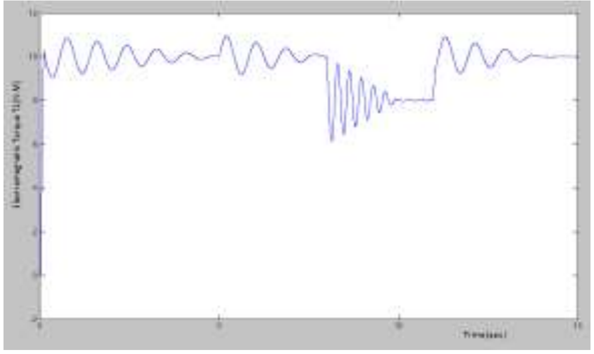

Fig 8: Electromagnetic Torque produced by abc stator

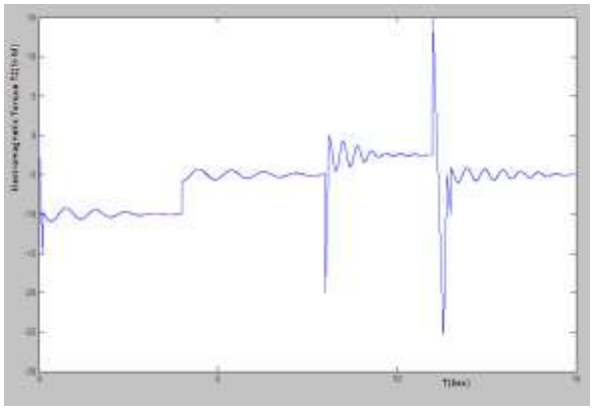

Fig 9: Electromagnetic Torque produced by xyz stator

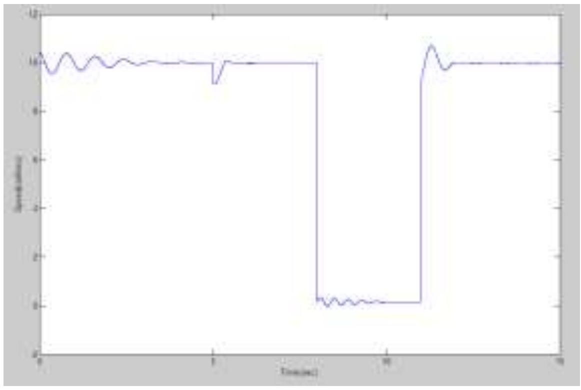

Fig 10: Speed control obtained by V/F controlling Technique

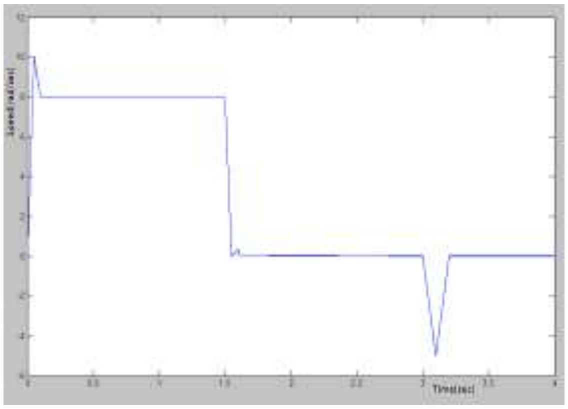

Fig 11: Estimated speed

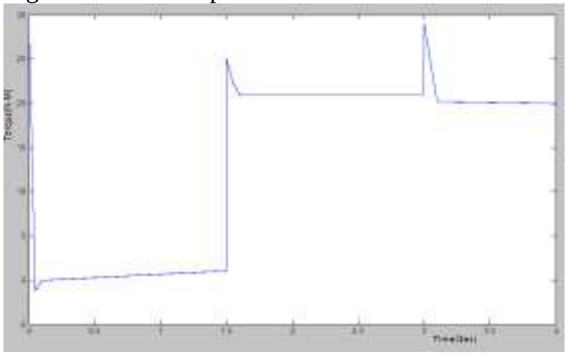

Fig 12: Torque obtained by the stator 1

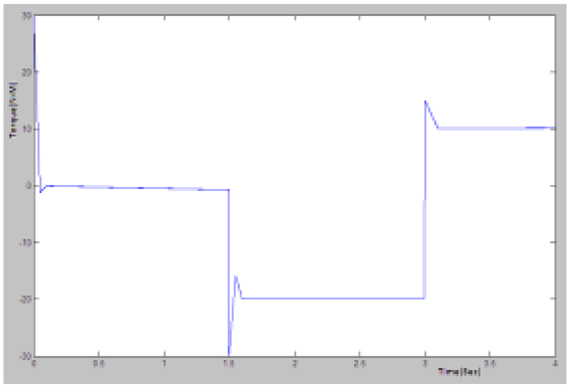

Fig 13: Torque obtained by the stator 2

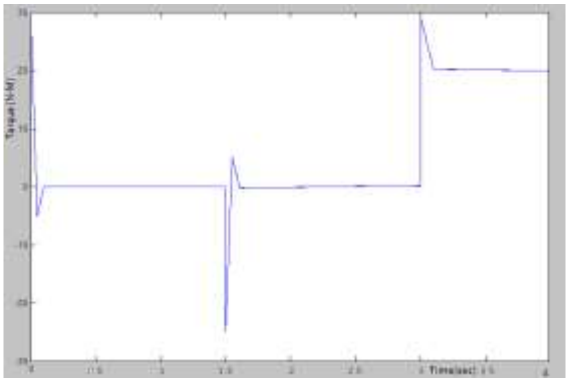

Fig 14: Output Torque

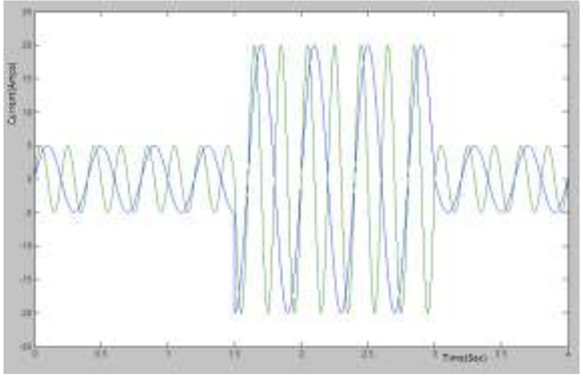

Fig 15: Phase currents of stator 1 and stator 2

IV CONCLUSION

Dual Stator Induction Motor (DSIM) performance has been examined here. The ability of DSIM to function at low speeds at higher stator frequencies has been found to be improved. This characteristic aids in sensorless functioning. Scalar constant V/Hz and vector control work nicely with DSIM.

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