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Speed Control of Induction Machine Drive with Two Stators

B.Sravani
M.Tech (PE&ED),
K.O.R.M College of Engineering,
Kadapa, A.P, India.

G.Venkata Sagar
Assistant Professor,
Dept of Electrical Engineering,
K.O.R.M College of Engineering,
Kadapa, A.P, India.

B.Mouli Chandra
Associate Professor,
Dept of Electrical Engineering,
K.O.R.M College of Engineering,
Kadapa, A.P, India.

Abstract:

The paper presents IM drive with 2 stators is explained. It avoids deep saturation, the peak magnetic load occurred in combined effect of stator and be similar to that of an equivalent single stator winding. It is independent of variable frequency and voltage inverter. In induction motor replacing the squirrel cage by an equivalent sinusoidal distributed winding. Therefore high order space harmonics can be neglected and rotor current produces two field distributions that rotate at different speeds, because it contain different number of poles and sinusoidal characteristics of stator winding. In induction machine drive with two stators has advantages of speed sensor less operation, better reliability, and more flexibility to manipulate the resultant curve of the motortorque-speed and operation of zero-speed is achieved independently by controlling the 2 terms of currents in stator. It is specially designed to reduce the negative impact of stator resistance influence at low speed operation and it makes easier for implementing of speed sensor less control schemes.

Index Terms:

Dual stator, field oriented machine, low speed, sensorless, and volts per Herz.

I.INTRODUCTION:

In present days, the electrical drive systems are helpful in IM with multiphase squirrel cage in different industrial applications is becoming high. It is caused by the development of power electronic frequency converters that can generate multi-phase systems of voltages and currents. In high electrical power drives Multiphase squirrel cage induction motors are specified or at particular requirements these drives are used for controlling [1-2].

The different types of motor are very important for the increment of torque density, at high efficiency, at decreasing pulse of torque; it is tolerant at high fault and a decrease in the wanted rating per inverter leg. The power distribution is possible between a greater number of phases makes it get a great reduction of motor current in circuits and converter in power circuits.Among the different multiphase drive solutions, one of the most interesting and widely applied is the dual 3-φ stator winding squirrel cage induction motor [3]. The induction machine of two stators contains two separate 3-φ stator windings;the same machine core is sharing and the common squirrel cage rotor winding.

Basically the layout of the windings of statorin the motor core, are classified in to 2 groups in the IM with 2 stators. The first one comprises the construction in which two separate 3-φ stator windings are located sequentially along the stator core [4]. In this type magnetic coupling is not occurred between the windings of stator, but two stator windings are magnetically coupled with the rotor cage windingseparately. The two stator windings can be supplied from the same or separate AC voltage sources of the same frequency. This type of motor construction was considered and described in many papers written by the author and others. In the previous type of dual stator structure or design consist the motor with 2 stator windings they are placed at distance in the stator core [5].

The studies permit the statement that this is promising construction. The performance of this type of motors is observed in few papers and it is the subject of this article. In this paper it consists of some common analysis and control of induction motors with 2 stators. In this model of IM with two statorsit is described in mathematical modelsand the principles and vector control methods, by using rotor field-oriented control (FOC) and direct torque control (DTC) are discussed.

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II.Multiply-wound Stator IM:

These commercially-available induction machines are differing in two ways. The two stators of the motors are wound "three-in-hand," it describes that there are three electrically-isolated circuits wound tri-filarly in the same stator slots for every pole of every phase. To avoid magnetic saturation in the stator steel, the machine is wound to support less than the saturation flux density when all three stator windings are driven in parallel at the rated voltage [6].

This machine structure is interesting in two different ways. In the First way triple-n harmonics are allowed to access the star-points of the stator windings to be driven into the machine on the appropriately connected winding circuits. For example, if the source star-point, Vn, are connected to the Vn1, Vn2, and Vn3,stator winding star-points, then zero-sequence current is passed into the machine. Note that this zero-sequence current cannot be induced in therotor winding due to its physical construction.

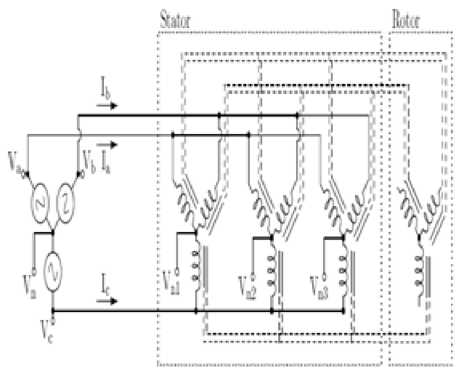

Figure 1: Multiple-stator Induction Machine Model.

Equivalent Circuit Model In Steady-state operation of induction machines is often modeled on a per-phase basis in terms of equivalent circuits. One such equivalent circuit is shown in Fig2. Where, Ra is the equivalent stator winding resistance, Ia is phase current, and X1 is the leakage2 of the stator winding.

The equivalent rotor leakageis the reactance X2. The reactance Xm represents the stator to rotor magnetizing inductance. The leakages and the magnetizing inductance are involved functions of the machine construction.

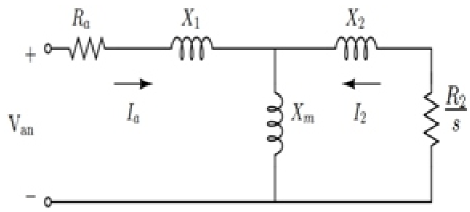

Figure 2: Induction Machine Phase-to-Neutral Equivalent Circuit

In This equivalent circuit to model a machine in steady-state, as well as empirically determine machine parameters. The total terminal phase to neutral impedance is

Zeq = jX1 + Ra + Zg

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

Zg = jXmk || (jX2 + Rs/s)

Given that the terminal current, Ia is simply observed

Ia = Van/Zeq

And the rotor current is

I2 = (Ia • jXm)/ (jX2 + R2/s)

From divider ofthe current between the magnetizing reactance and the rotor impedance

III.IM WINDING DRIVE WITH DUAL STATOR:

Theinduction machine consists of a standarddiecast squirrel-cage rotor and each stator consists of two separate windings, it is not wounded for same number of poles, it is varied at particular ratio (e.g., 2/6 or 4/12).Any combination of dissimilar pole numbers could be used,however to better utilize the magnetic material; avoid localized-saturation, and additional stator losses, in this method it is observed that it is the mostadvantageous configuration having a pole ratio of 1: 3.

Two stators consist of independent variable-frequency-and it also consists of variable-voltage inverter,these are shared in a common dc-bus. In the below fig 3 the main components of the DSIM drive is observed.

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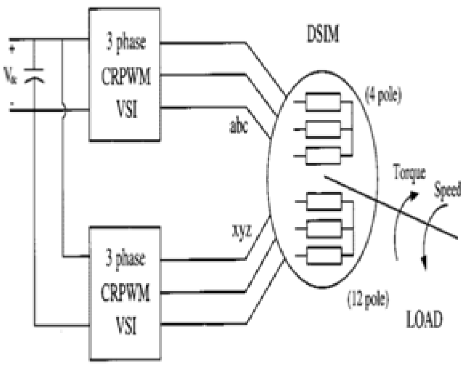

Fig 3: Induction machine drive with 2 stator winding

By using of IM with 2 stators, by placing the stators in the similar manner it avoid deep saturation;the combined effect of the 2 stator MMFs it causes the peak magnetic load is producedand that is similarto that of an equivalent single stator winding design [7].In the low-pole numbers, the frequency of statorareexcited moreby applying controlled amount of torque with thehigh-pole number winding, therefore it limits the minimum electricalfrequency in the low-pole number winding to determineits values again. It decreases the impact on stator resistance,in the stator voltage measurement drop of voltage is occurred and it is easy to get the required rotor flux vector. This is especially importantat zero speed, where the normal induction machine becomesunobservable.

In the IM with 2 stators, zero-speed operation at any excited frequency and making the systemobservable at all speeds. Here 2 separate operating modes are assumed:initiallyin synchronous operation, it consists of two frequencies in the machine which consist the same ratio as the pole number, and another one isasynchronous operation, in this method frequency is maintained constant at minimum value by placing low-polenumber winding.If the stator windings are distributed sinusoidal in space by having dissimilar number of poles, it does not have any mutual couplingamong them.

Real distributed windings, onthe other hand, will produce space harmonics. If the pole ratiobetween the windings is 1:3, the only common harmonics arethose of triple order, but, in the absence of a neutral connection,triple harmonics are eliminated. Thus, even if real windings areconsidered, there will be no mutual coupling due to space harmonics.In this project 2 windings share common slots andare placed nearer, here leakage flux linked each other in the 2 windings. By applying all the conditions the obtained is called mutual leakage coupling.

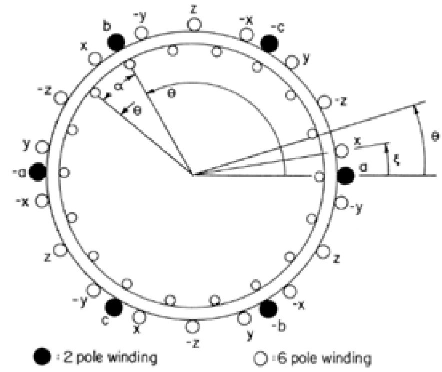

Fig 4: windings distribution of DSIM

IV.CONTROLLING METHODS:

The induction motor with two statorsacts as two independent induction machines and the shaft is mechanically coupled. Here well observed and experimental controlled techniques are used in IM drives these kind of used applicableterms are used in the DSIM. However, because of the common magneticstructure some additional consideration must be given toobtain the exact flux level.In asynchronous operation low pole frequencies are remains same up to minimum value (2.5 HZ) without any consideration of mechanical speed. This mode is used to achieve zero-speed operation [8]. In this mode,saturation is caused by moving 2 stators MMF in asynchronous manner and distortion is occurred by distribution in resultant flux. By having minimum frequency and by neglecting the additional losses occurred in the asynchronous mode.

Constant Voltage/frequency control

In constant V/F control it consists of two different working modes. 2 stators consists same voltage and frequency at high speeds (i.e.,synchronous mode). The outputtorque for a given rotor speed corresponds the torques T1 and T2 by algebraic sum. By adjusting the magnitude of the stator voltagesto get required torque by each winding. When the mechanical speed demands a frequency below theminimum value, the frequency of the abcwinding is fixed andthe output torque is adjusted by controlling the frequency (andvoltage) supplied to the xyz winding.In asynchronous mode, first stator abc works in the motoring regionand secondstator xyzworks as a generator. The important thing in the workingmode is that if stator trends to work at zerospeed and that the torque can be controlled from zero to ratedvalue. In the below figure represents the control scheme is shown in Fig 5 is observed.

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Vector Control:

In the vector control method it consists oftwo operating modes: in the initial method minimum frequency fmin is indicated in a high speed range (synchronous mode) and in next mode less frequency are indicated by low speed (asynchronous mode).In the synchronous mode, a standard indirect field orientationdepending upon the relation of slip is used. The required torque producedby the abc-currents, Te1, is removed off the externaltorque command T*e to produce the torque command for the xyz winding T*e2. The slip frequency swe2is computed using thecommanded flux producing, ieds2, and torque producing, ieqs2,current components. To stabilize the correct fluxorientationof the low-pole number winding, the commanded torque extractscurrent ieqs1and it is based upon theinverse of the slip relation.For low-speed operation (i.e., asynchronous mode) the equation offrequency we1is clamped at

wmin = 2*pi*fmin.

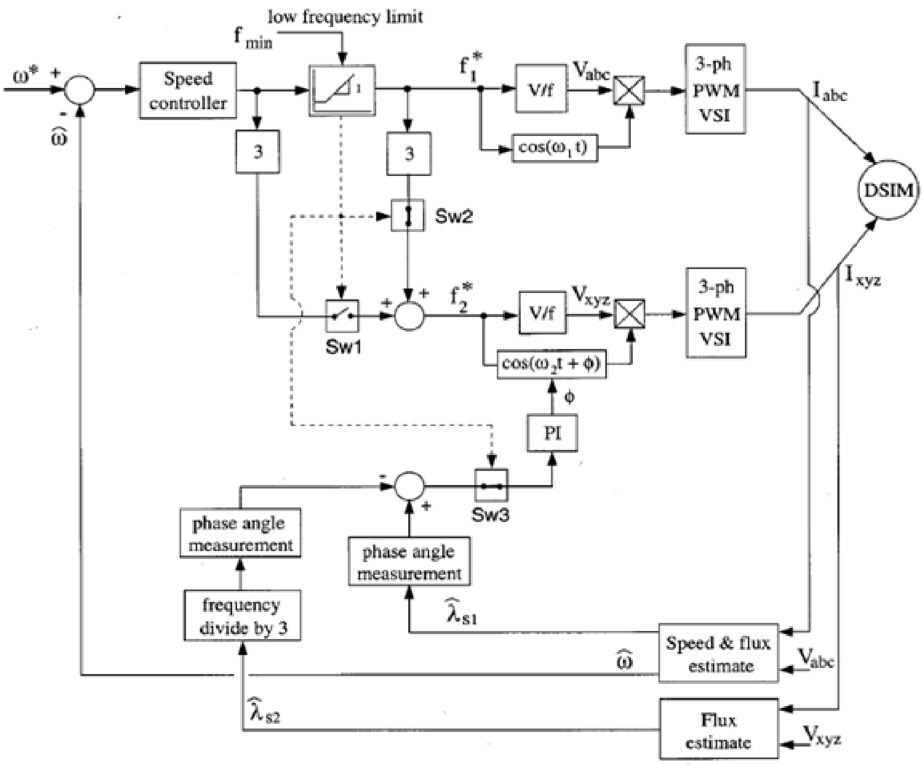

Fig 5: Proposed control scheme using constant volts per hertz (V/Hz) mode

This frequency,together having the rotor speed, explains the slip frequencyused to define the current ieqs1is produced by the torque. The orientation of the rotor flux is maintained by the angle in vector rotation iscomputed as the integral by havingfrequency we1as input. Hence thisoperating mode forces the low-pole winding to extracts a torquein presents of that of the load, the extra torque is compensated byan equal and opposite torque obtained by the winding in high-pole number.

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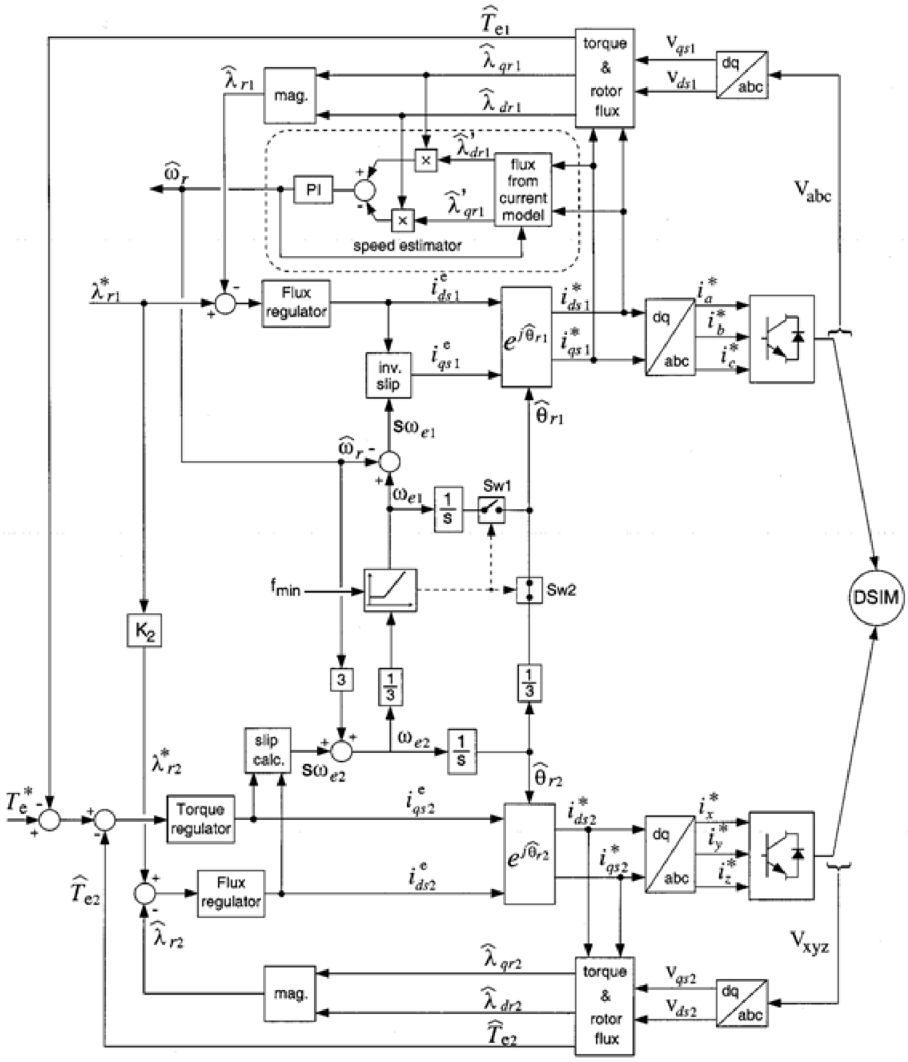

Fig 6: Proposed control scheme using indirect field orientation

V.SIMULATION RESULTS:

Simulation results are used to controltechniques proposed by this section is shown in below fig.The results are obtained as required and it is clearly shown that it can be operated in zero speed and it is also operated in no load while keeping the stator frequency at constant or increasing the frequency level from minimum.

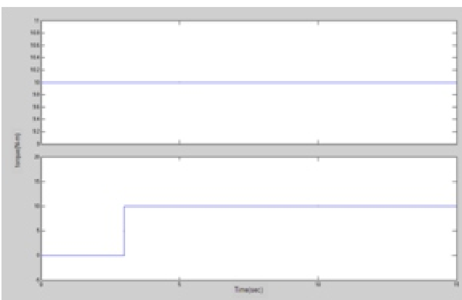

Fig7: Load Torque T1 and T2

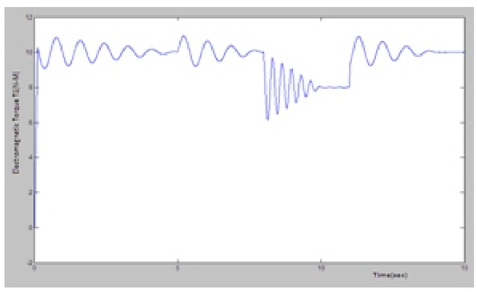

Fig 9: Electromagnetic Torque produced by xyz stator

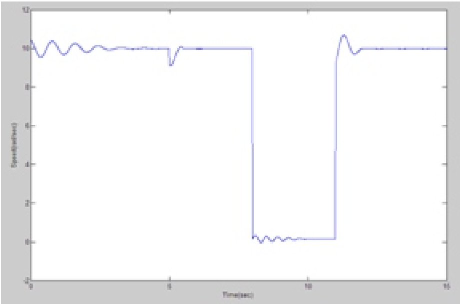

Fig 10: Speed control obtained by V/F controlling Technique

By observing the above figure 7 is the load torque produced by the stator 1 and stator 2. Fig 8,9 is Electromagnetic torques produced by the abc stator and xyz stator. Fig 10 represents the speed that was controlled in V/F controlling technique it also shows the direct increase of speed and sudden decrease of speed is observed it shows the accurate resultant speed is obtained in this process.

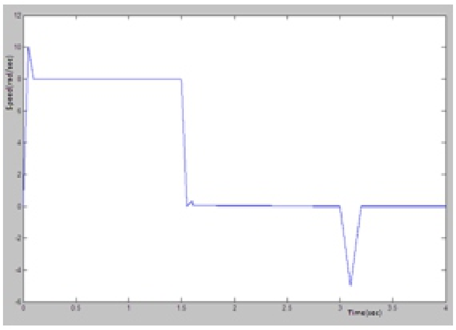

Fig 11: Estimated speed

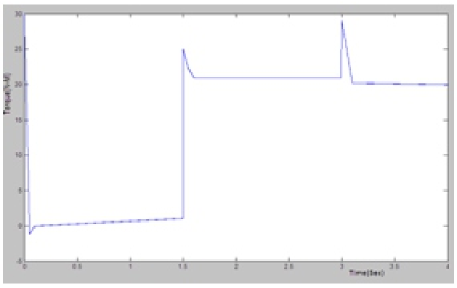

Fig 12: Torque obtained by the stator 1

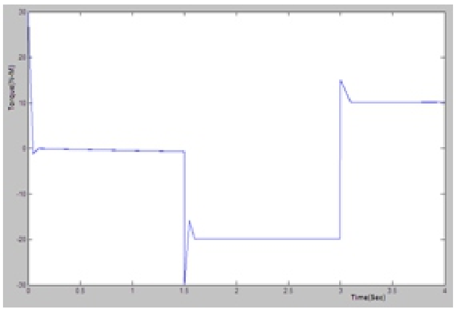

Fig 13: Torque obtained by the stator 2

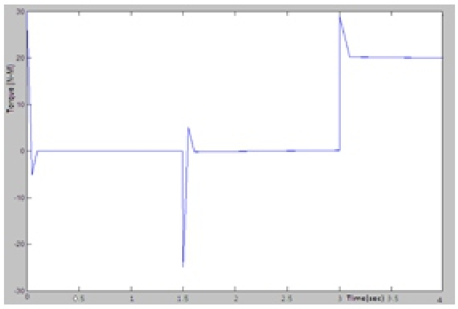

Fig 14: Output Torque

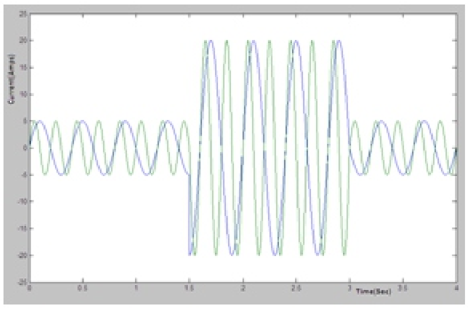

Fig 15: Phase currents of stator 1 and stator 2

By using the Flux controlling method the Torque produced by the stator 1 and stator 2 are observed in figure 12 and 13. The required output torque is obtained is observed in fig 14 it is the average of two torques i.e 1 &2. In the figure 15 shows one of the phase currents of stator 1 and 2.

VI.CONCLUSION:

To the Induction motor consisting of standard squirrel cage rotor and stator by adding a stator to the induction motor, it improves its capability to operate in low and zero speed, maintaining relatively high stator frequencies.

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Author’s Details:

B.SRAVANI, M.Tech (PE&ED) K.O.R.M College of Engineering, Kadapa, Andhra Pradesh, India

G.VENKATA SAGAR, M.Tech, Assistant Professor, Depatment Of Electrical And Electronics Engineering, K.O.R.M College Of Engineering, Kadapa, Andhra Pradesh, India.

Dr. B.MOULI CHANDRA, M.Tech., Ph.D, Associate Professor, HEAD Of theDepatment Of Electrical And Electronic Engineering, K.O.R.M College Of Engineering, Kadapa, Andhra Pradesh, India.