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# Induction Machine Drive with Dual Stator Winding

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**ABSTRACT:**

***A new dual stator winding induction machine drive is described in this paper. The proposed induction machine consists of a standard squirrel-cage rotor and a stator with two separate windings wound for a dissimilar number of poles. Each stator winding is fed from an independent variable-frequency variable-voltage inverter. The proposed drive offers such advantages as speed sensor less operation, better reliability, and more flexibility to manipulate the resultant torque–speed curve of the motor. In the proposed drive, zero-speed operation is achieved by independently controlling the two sets of stator currents, hence, maintaining a minimum electrical frequency independent of the mechanical speed. This feature is especially important to minimize the negative impact of the stator resistance influence at low-speed operation and it greatly simplifies the implementation of speed sensor less control schemes. The drive is well suited for either constant volts per hertz or field-oriented (FO) operation. Circulating harmonic currents, common to most dual stator machines, are eliminated by the dissimilar pole number in each stator winding.***

***Index Terms—Dual stator, field orientation, induction machine, Torque And Speed Control, low speed, sensor less, Saturation, variable-frequency, volts per hertz.***

## INTRODUCTION:

BROADLY speaking, from the point of view of the stator winding, dual stator machines can be categorized as "*split wound*" and "*self-cascaded*." The *split-wound* machine was introduced in the 1920s as a means of increasing the total power capability of large synchronous generators . Since then, they have been used in many other applications ranging from synchronous machines with ac and dc outputs as part of uninterrupted power supplies (UPSs) and as current-source inverters to large pumps, compressors, and rolling mills. *Split-wound* machines made it possible to extend the power range of solid-state-based drives beyond the power capability of a single inverter and, more recently, new multilevel topologies have been introduced as well . Additionally, due to the inherent redundancy, it is claimed that the system exhibits a better reliability In a *split-wound* machine, the stator winding consists of two similar but separate three-phase windings wound for the same number of poles.

Both stators are fed with the same frequency and the rotor is a standard squirrel cage. The two stator windings are mutually coupled and small unbalances in the supplied voltages generate circulating currents Furthermore, because of the low impedance to harmonic currents there is a high level of circulating currents when a non sinusoidal voltage source supply is used [9], adding losses and demanding larger semiconductor device ratings.

## Existing System:

The proposed induction machine consists of a standard die cast squirrel-cage rotor and a stator with two separate windings wound for a dissimilar number of poles (For eg: 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, it is found that the most advantageous configuration should have a pole ratio 1: 3. Each stator winding is fed from an independent variable-frequency variable-voltage inverter, sharing a common dc-bus. Fig. 1 shows the main components of the proposed DSIM drive. To avoid deep saturation, the peak magnetic loading produced by the combined effect of the two stator MMFs must be similar to that of an equivalent single stator winding design. To maintain the saturation level in the stator teeth the peak air-gap flux density must be maintained. At the same time, to maintain the, loading of the stator yoke, the peak flux density per pole must be identical in both the dual stator and single stator designs.

## Proposed System:

Analyses of induction motors are routinely carried out by replacing the squirrel cage by an equivalent sinusoidally distributed winding. This is done under the assumption that high-order space harmonics can be neglected. Given the particular characteristics of the machine considered in this study, having two simultaneous MMFs distributions that move in space with respect to each other and to the rotor bars, it is critical to clarify the interaction between the instantaneous rotor bar currents and the stator MMFs, as well as the possible interaction between the two stator windings.

For this purpose, a detailed, yet simple, dynamic model of the machine was developed. Coupled magnetic circuit theory and complex space-vector notation is used throughout the derivation. This technique was chosen because of its generality and the great deal of simplification that is achieved. The following general assumptions are made:

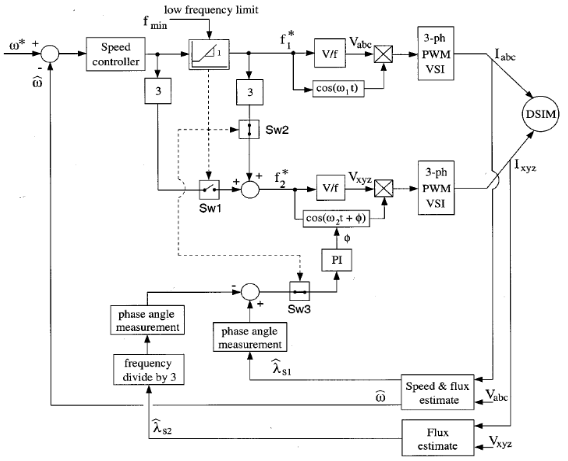
• negligible saturation;

• uniform air gap;

•stator windings sinusoidally distributed;

•no electrical interconnection between stators;

• negligible inter-bar current




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

## TORQUE AND SPEED CONTROL

The DSIM behaves as two independent induction machines, mechanically coupled through the shaft. Therefore, all known control techniques used in induction motor drives are also applicable to the DSIM. However, because of the common magnetic structure some additional consideration must be given to maintain the correct flux level Two distinct operating modes are defined: *synchronous* operation where the stator frequencies are in the same ratio as the pole number and *asynchronous* operation where the frequency in the low-pole number winding is kept constant at a minimum value ( 2.5 Hz), regardless of the mechanical speed. This mode is used to achieve zero-speed operation. In this case, the two stator MMFs move asynchronously and the resultant flux distribution is distorted, causing localized saturation. However, because of the low frequency, the additional losses are negligible. During *synchronous* operation, both MMFs move synchronously and the resultant air gap flux distribution corresponds to that shown in Fig. 3. The goal of the control technique is to always maintain the stator frequency at or above a minimum value, regardless of the mechanical speed.

### *Constant V/Hz*

The operation and control will be explained using Fig. 4. As shown, there are two operating modes. For high speed, both stators are fed with voltages of the same

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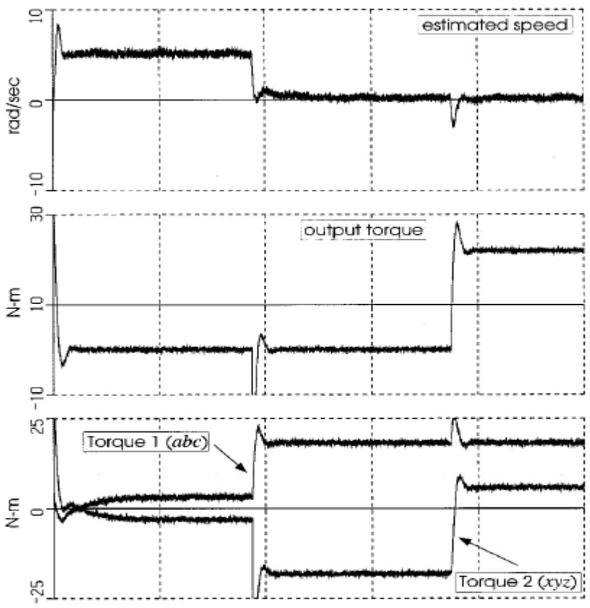
frequency (i.e., *synchronous* mode). This produces the torque–speed curves of Fig. 4(a), which have been exaggerated for clarity. The output torque for a given rotor speed corresponds to the algebraic sum of the torques and . The torque produced by each winding is controlled by adjusting the magnitude of the stator voltages.

## SIMULATION RESULTS

Simulation results using the control techniques proposed in the previous section are shown in Figs. 12 and 13. The results prove the feasibility of the concept and clearly show the operation at zero speed and no-load while keeping the stator frequency at or above the minimum frequency.

## EXPERIMENTAL RESULTS

The experimental work was carried out using a 3-kW prototype wound for a 4/12-pole combination. A six-leg inverter with a 300-V dc bus was used. The control software was implemented in a Motorola 56000 DSP and the rotor position was estimated by integrating the terminal voltages. Zero-speed operation using constant V/Hz and indirect field orientation are shown in Figs. 14 and 15. The response in both cases is excellent, showing a very stable and accurate operation.



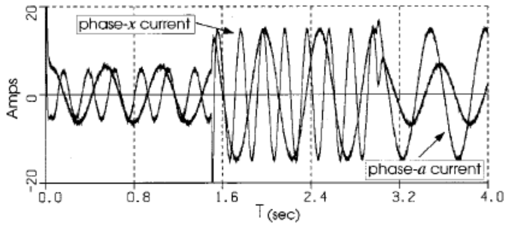




Fig. 13. Direct field orientation during *asynchronous* operation.

## CONCLUSIONS

A new type of dual stator winding induction machine has been presented. The proposed DSIM has a standard squirrel-cage rotor and two stator windings wound for a dissimilar number of poles. The main advantage of the drive is its improved capability to operate at low and zero speeds, maintaining relatively high stator frequencies. This feature is particularly useful for implementation of speed sensor less schemes and it adds a new degree of flexibility to standard control methods currently used in ac drives. Two control schemes have been proposed, simulated, and tested using a prototype, showing very good performance. The DSIM is especially well suited for both scalar constant V/Hz and vector control. A detailed design of the DSIM and performance comparison with a standard induction machine is reported in a separate paper, which is to be published.

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