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A Review of Speed Control Methods of Induction Motor

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Abstract: *Induction motors do not run at synchronous speed, they are generally fixed speed motors. In Industries mechanical loads should not only be driven but should also be driven at desired speed. Therefore, the need of speed control methods for induction motor arises.There are various methods of speed control for an induction Motor. In this paper literature reviews on different speed controlmethods and their performance based on SPWM Inverter, harmonics reduction and speed-torque characteristics so as to analyze the most effective techniques among them considering the presence of harmonics as well as minimization of odd harmonics through Inverter.*
Keywords: *Induction Motor, VSI, PWM, MLI.*

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I. Introduction

Various methods for speed control of induction motor include pole changing, stator voltage control, supply frequency control, rotor resistance control, scalar control and vector control. The relationship for rotor speed is given by Eq.1

$$N_r = \frac{120f}{P}(1-s) \qquad (1)$$

As seen from expression above rotor speed can be controlled by changing pole. Poles can be changed using multiple stator windings, pole amplitude modulation etc. This method of speed control is not recommended since poles are generally fixed for induction machine.

Apart from this, stator voltage control and supply frequency control are methods for speed control in these methods stator voltage is controlled with the help of ac voltage regulator and supply frequency is controlled using cycloconverters respectively. Their major drawback is that the yoke of machine gets saturated since the E.M.F. equation for Induction Motor is given by

$$E = \sqrt[2]{2}\,\pi\phi_m fN \qquad (2)$$

Scalar control and Vector control method is far better than above described methods. In this method the ratio of stator voltage to that of frequency is varied accordingly to get the desired speed and torque. The only drawback of the method is that it is unsuitable for industries where precise control is of prime importance.

Other than this illustration of vector control strategy for an Induction Motor (IM) drive using sinusoidal pulse width modulation technique has been efficient.

II. Literature Review

M. H. Nehrir proposed a technique for speed control of three-phase induction motor by stator voltage control[19]. A. Munoz-Garcia proposed and analyzed control scheme based on the popular constant volts per hertz (V/f) method using low-cost open-loop current sensors [20].S.Doki et al. proposed a technique which classified into two groups, slip frequency controlled, indirect vector control and direct vector control [25].B.N. Singh et al. proposed a comprehensive analysis of a vector-controlled induction motor drive using a fuzzy logic-based sliding mode speed controller [32].Bor-Ren Lin proposed a technique for three phase ac/dc/ac converter with a power factor pre-regulator to improve the power quality in the input side and a pseudo random noise generator to reduce the emitted acoustic noise and the mechanical vibration for an induction motor drive [35].Jae-Ho Choi et al. has been proposed an indirect current control scheme for a PWM voltage source converter [36].Ivensky G. et al. proposed ZCS series resonant converters [37].J.S.Lai et al. proposed an induction motor drive that uses an improved high-frequency resonant DC link inverter [39]. P.N. Enjeti et al. proposed the control strategy to improve the performance of a PWM AC to DC converter under anunbalancedoperating conditions [40]. José R. Rodríguez, et al. proposed regenerative rectifiers with reduced input harmonics and improved power factor [43].R.Ghoshet al. proposed a control of a four-wire rectifier system using split-capacitor topology. [44].H. Fujita et al. proposed and analyzed unified power quality conditioners (UPQC's), which aim at the integration of series-active and shunt-active filters which compensate for voltage flicker/imbalance, reactive power, negative sequence current, and harmonics [48].

2.1 Literature Review Summary

Sr. No.	Author's Name	Converter	Method/Techniques	Performance
1	M. H. Nehrir [19]	3 Phase SPWM Inverter	Stator voltage control &Sine wave Variac voltage control	Speed of IM torque of IM
2	A. Munoz-garcia [20]	PWM Inverter	V/F method using Open loop current sensor with stator resistance drop and slip frequency	Stator current
3	S.Doki et al [25]	SPWM Inverter	Indirect and direct vector control technology	All Performance Parameter of IM
4	B.N. Singh et al [32]	SPWM using CSI	Vector controlled Technology with fuzzy logic	Speed of IM
5	Bor-renlin [35]	PWM Three phase ac/dc/ac converter	Space vector modulation with hysteresis current control	Power quality Acoustic noise Resonant vibration Reduction of torque
6	Jae-Ho Choi et [36]	PWM using VSI	Indirect & direct current control	Sinusoidal line current unity power factor ripple-free DC output voltage
7	Ivensky G. Et [37]	3 phase inverter	ZCS series resonant	Series resonant power converters RMS current
8	J.S.Lai et al. [39]	3 phase DC link inverter.	High-frequency resonant	Voltage overshoot Zero crossing failure problems
9	P.N. Enjeti et al. [40]	PWM AC-to-DC power converter	Under unbalancing and balancing condition	Reduce lower-order abnormal harmonics
10	José R. Rodríguez, et al. [43]	PWM AC-DC-AC power converter	Current harmonics injection method	Reduced input harmonics and improved power factor
11	R.Ghosh et al. [44]	Single-carrier-based & CSPWM Star connected rectifier system	Split-capacitor topology.	Peak-to-peak neutral current ripple
12	H. Fujita et al. [48]	UPQC	Different type filter Two closed loop PI controllers	Voltage imbalance, Reactive power, Negative sequence current & harmonics.
13	Y.Pal et al. [50]	UPQC	Series-active filter and shunt-active filter	Power factor correction, Voltage regulation, Voltage and current harmonics mitigation, Mitigation of voltage sag, swell and voltage dip
14	This Paper	SPWM Two and Five Level Inverter	Vector Control	Constant Speed with Constant Torque, Variable speed with Constant Torque, Comparison in THD

III. Problem Identification

The problem is in terminal voltage has a limit which is crossed will lead to a negative effect on insulation and operation of motor.The main drawback of rotor resistance method is its poor efficiency due to additional losses because of added resistance.

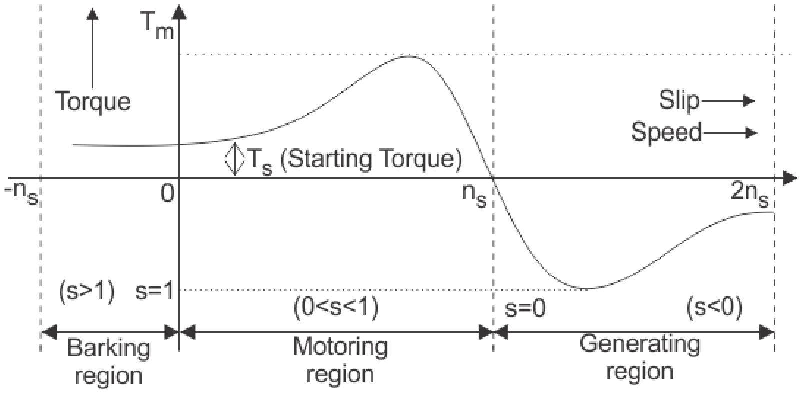

Fig.1 Speed Torque Characteristic for Induction Motor

The above figure shows the speed torque characteristic of IM. In this, there are three regions shown, via, braking region, motoring region & generating region.

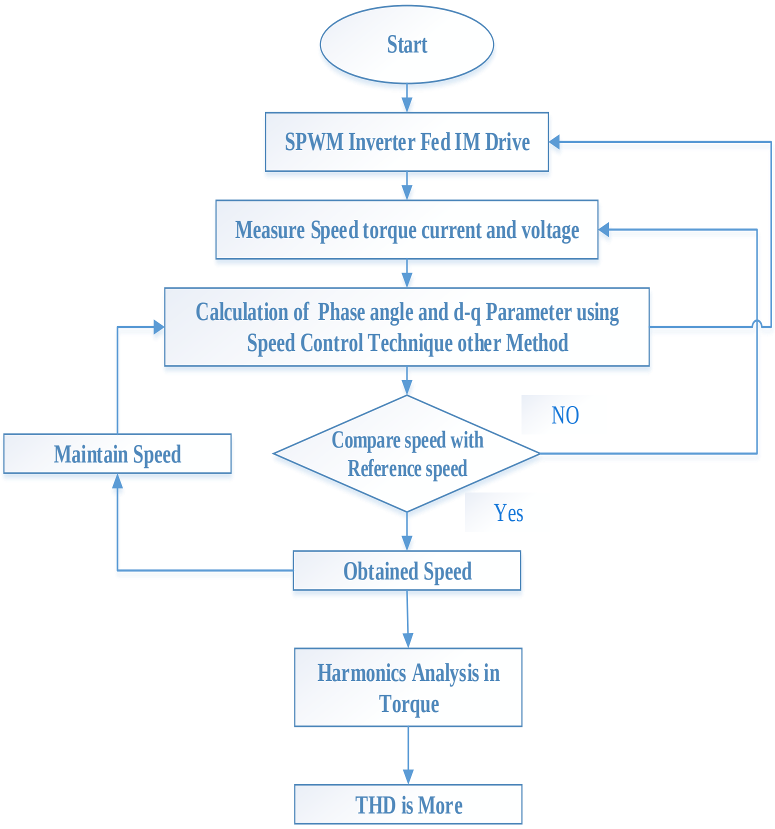

Fig.2 Flow Chart of Problem Identification

This flow chart represents how to control the speed of Induction motor Drive and some method having different type of Problems which are dynamic parameter as well aslowerorder harmonics component are present in torque. Motor are not reliable for more time due to lower order Harmonics Components.

IV. Proposed Methodology

Different Controlling Schemes for Speed Control of Three Phase Induction Motor:

Scalar control as the name indicates, is due to magnitude variation of the control variable only and disregards the coupling effect in machine. This temporary dipping of flux reduces the torque sensitivity with slip and lengthens the response time. However, their importance has diminished recently because of the superior performance of vector or Field orientated control (FOC) drives.

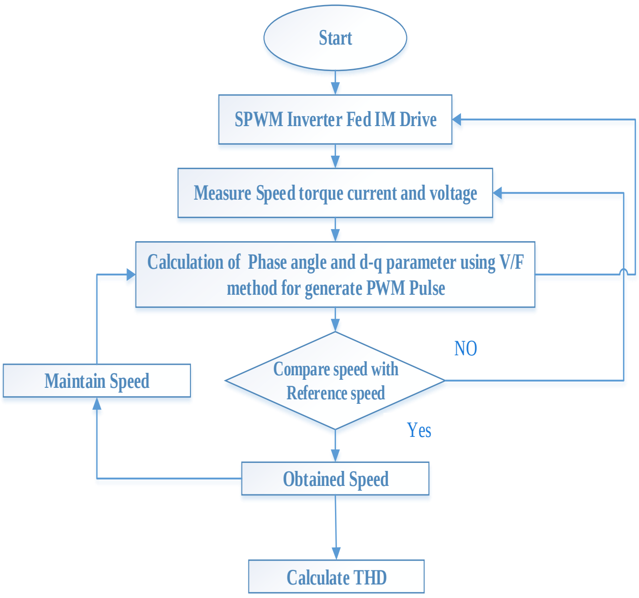

Fig. 3 Flow Chart of V/F of an SCIM

Scalar control is expensive and destroys the mechanical robustness of the induction motor. So, these are the limitation of scalar control which is overcome by Field orientated control (FOC) for induction motor drive.

Vector Control or Field Orientated Control (FOC)

The block diagram of the proposed control scheme has been shown in Fig. 4. The inverter controls the speed of the SCIM under step change in speed and load. The control scheme employed for the two levels SPWM inverter is as follows.

The squirrel cage induction motor drive with vector or field-oriented control offers a high level of dynamics performance and the closed-loop control associated with this derive provides the long-term stability of the system. Induction Motor drives are used in a multitude of industrial and process control applications requiring high performances. In high performance drive systems, the motor speed should closely follow a specified reference trajectory regardless of any load disturbances, parameter variations, and model uncertainties. In order to achieve high performance, field-oriented control of induction motor (IM) drive is employed. However, the controller design of such a system plays a crucial role in system performance.

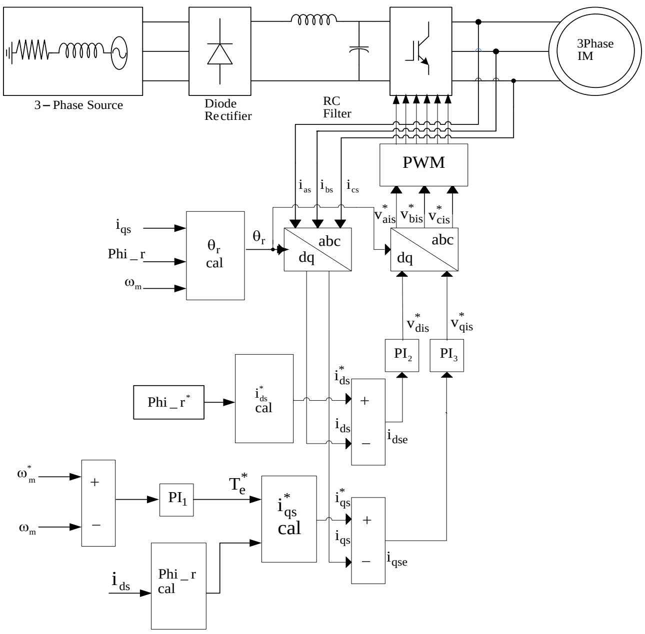

Fig.4. Block Diagram of Vector Control of SCIM

The decoupling characteristics of vector-controlled IM are adversely affected by the parameter changes in the motor. So, the vector control is also known as an independent or decoupled control.

V. Conclusion

This paper presents the literature review of various authors whose works on various methods used for speed control of IM drive, through literature survey and review about speed control of induction motor various problems in their methodology such as speed variations, current and voltage ripple or harmonics through scalar control methods. This paper explain about various problems faced for controlling of IM because of complex controlling circuitry and also discussed the proposed methodology) and compare different speed control techniques.

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