Vector Controlled in Induction Motor Drive

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Abstract— Vector control is the most popular control technique of AC Induction Motor. Induction motors are the most widely used electrical motors due to their reliability, low cost and robustness. However, induction motors do not inherently have the capability of variable speed operation. Due to this reason, earlier dc motors were applied in most of the electrical drives. But the recent developments in speed control methods of the induction motor have to their large scale use in almost all electrical drives. Also Direct Torque Control method have been used because of its simplicity and very fast torque and flux control response for high performance IM drive application.

Key words: dc motors, IM, AC motors, FOC, IMD.

I. INTRODUCTION

A. BASIC BLOCK DIAGRAM:

Be it domestic application or industry, motion control is required everywhere. The systems that are employed for this purpose are called drives. Such a system, if makes use of electric motors is known as an electrical drive. In electrical drives, use of various sensors and control algorithms is done to control the speed of the motor using suitable speed control methods. The basic block diagram of an electrical drive is shown below:

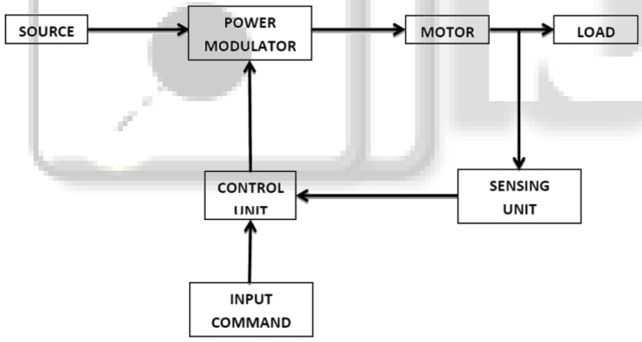

Fig. 1: an electrical drive

II. DYNAMIC MODELING OF 3 PHASE INDUCTION MOTOR

A. INTRODUCTION:

Nikola Tesla first developed the principles of multi-phase AC motors in 1888. Because an IM is less expensive electrically and mechanically performance is good, and it is most commonly used in industry.

In general, IM consists two parts 1.Stator and 2. Rotor. Stator carries the field winding which is connected single or multi phase voltage source. It is creates the magnetic field between stator and rotor. There are two tapes of rotor winding wounded and squirrel cage rotor. This is less expensive and more robust.

B. CONSTRUCTION AND PRINCIPLE OF IM:

The Induction machine can be operated as a motor or a generator. In 3 phase AC machine have similar construction. The stator is usually made of laminated sheet steel (to reduce eddy current losses) which is attached to an iron frame. Stator conductors are connected in three phase delta or wye. The rotor contains bars of aluminum or copper in the rotor.

Under normal operation, an IM runs at a speed which is lower than the synchronous so that a time charging magnetic field is created to couple stator and rotor winding.

The synchronous motor speed is directly proportional to the i/p AC line frequency driving the stator fields and inversely proportional with the number of magnetic poles created in the stator by the choice of stator winding coil positions.

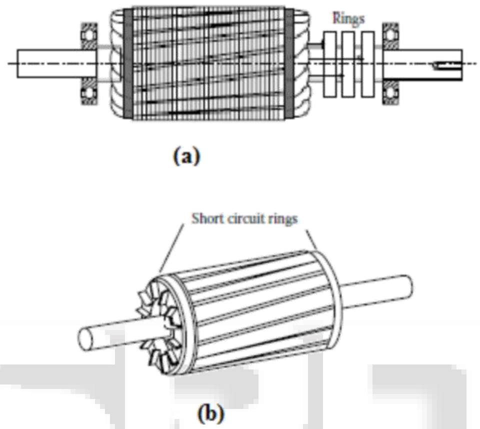

Fig. 2: Construction of IM

$N_{S}=\frac{120F}{P}$ $W_{S}=\frac{2\pi N_S}{60}$

C. mathematical representation:

The proper modeling each induction machine is a key to apply the most efficient drive methods to the stator winding.

1) Stator Equation:

$Vas = ias\,rs + \frac{d\lambda as}{dt}$v ………………….(2.1)

$Vbs = ibs\,rs + \frac{d\lambda bs}{dt}$v ………………….(2.2)

$Vcs = ics\,rs + \frac{d\lambda cs}{dt}$v ………………….(2.3)

2) Rotor Equation:

$Var = iar\,rr + \frac{d\lambda ar}{dt}$v ………………..(2.4)

$Vbr = ibr\,rr + \frac{d\lambda br}{dt}$v ……………….(2.5)

$Vcr = icr\,rr + \frac{d\lambda cr}{dt}$v …………………(2.6)

D. Machine Model arbitrary Ref. frame:

There are three main reference frames of motion which could be used to model. The three phase induction machine in its three main region of operation. These are the stationary reference frame for startup the synchronous reference frame for equilibrium motion and the rotor reference frame for changing speed by acceleration or deceleration.

Park transformations which are known easily understand between the stator and rotor. When W=0 this means the reference frame does not move (stationary) and this transformations is commonly used in adjustable speed drives. Similarly when the reference frame is revolving in synchronous speed the reference frame can be represented in synchronous reference frame.

By applying rotating coordinate transformation to the stator and rotor voltages, current and flux linkages eq.

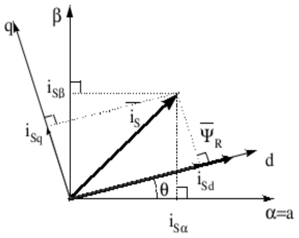

Fig. 4: Relation Between ABC and dq0 arbitrary co-ordinate reference frames

The torque matrix:

$$T_{qd0}(\theta) = \frac{2}{3}\begin{bmatrix} \cos\theta & \cos\left(\theta - \frac{2\pi}{3}\right) & \cos\left(\theta + \frac{2\pi}{3}\right) \\ \sin\theta & \sin\left(\theta - \frac{2\pi}{3}\right) & \sin\left(\theta + \frac{2\pi}{3}\right) \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix} \quad \ldots\ldots\ldots\ldots(2.8)$$

The inverse matrix:

$$[T_{qd0}(\theta)]^{-1} = \begin{bmatrix} \cos\theta & \sin\theta & 1 \\ \cos\left(\theta - \frac{2\pi}{3}\right) & \sin\left(\theta - \frac{2\pi}{3}\right) & 1 \\ \cos\left(\theta + \frac{2\pi}{3}\right) & \cos\left(\theta + \frac{2\pi}{3}\right) & 1 \end{bmatrix} \quad \ldots\ldots\ldots\ldots..(2.9)$$

III.

A. FIELD ORIENTATED CONTROL OF AN INDUCTION MOTOR:

Rotor field orientated control (FOC) of an induction motor drive (IMD) can achieve such performance levels similar to that of a dc motor drive. The coupling between the flux and torque producing components of stator current is a major deterring factor in achieving high dynamic performance in an IMD. This is overcome successfully in FOC making it the standard control adopted by industries. Indirect rotor FOC estimates the rotor flux position in an indirect manner by adding the instantaneous slip speed with the rotor speed and integrating the result.

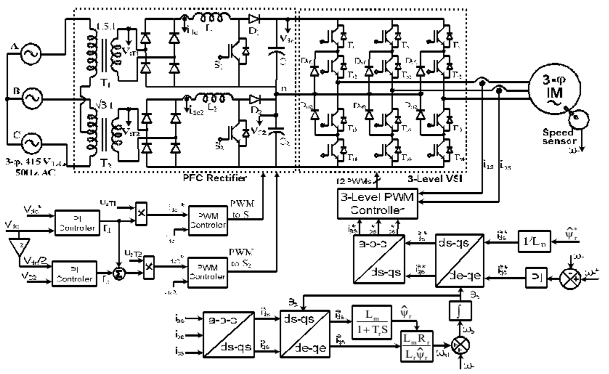

Fig. 5: control scheme

B. *Wave form of Sinusodial –pluse-with-modulation:*

In sinusoidal pulse width modulation there are multiple pulses per half-cycle and the width of the each pulse is varied with respect to the sine wave magnitude corresponding to that duration. Fig shows the gating signals and output voltage of SPWM with unipolar switching. In this scheme, the switches in the two legs of the full-bridge inverter are not switched simultaneously, as in the bi-polar scheme. In this unipolar scheme the legs R, Y and B of the full-bridge inverter are controlled separately by comparing carrier triangular wave v_{car} with the three control sinusoidal signals v_{c_R}, v_{c_Y} and v_{c_B} respectively which are displaced by 120^o. This SPWM is generally used in industrial applications. The number of pulses per half-cycle depends upon the ratio of the frequency of carrier signal (f_c) to the modulating sinusoidal signal. The frequency of control signal or the modulating signal sets the inverter output frequency f_o and the peak magnitude of control signal controls the modulation index m_a which in turn controls the rms output voltage.

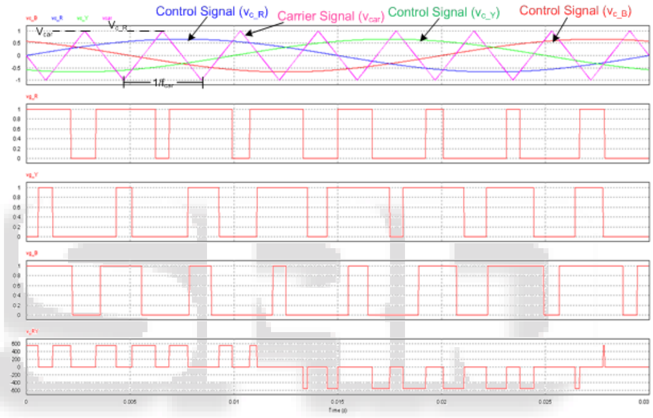

Fig. 6:Wave form of Sinusodial –pluse-with modulation

C. *SIMULATION RESULT:*

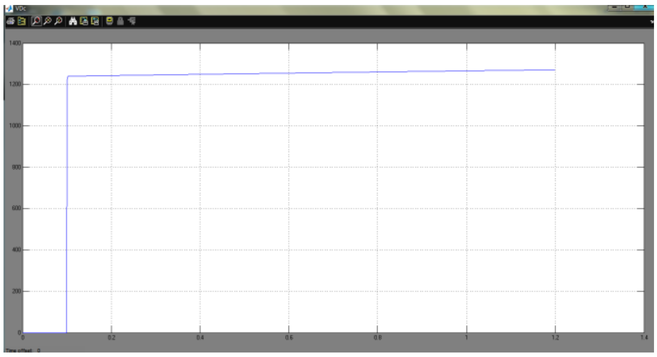

Fig. 7: Va&Ia

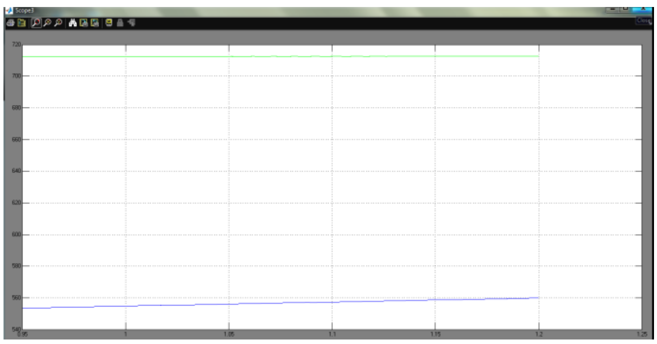

Fig. 8: Vc1&vc2

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