# Design and development of a low cost field oriented control speed control of an induction motor.

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***Abstract-*** **The Induction motor has been widely used in industry and is considered as the best candidate for Electrical Vehicle (EV) applications due to its advantages such as: simple design, ruggedness, and easy maintenance. However, the precise control of induction motor is not easy to achieve, because it is a complicated nonlinear system, the electric rotor variables are not measurable directly, and the physical parameters could change in different operating conditions. So the control of an induction motor becomes a critical issue, especially for the EV applications in which both fast transient responses and excellent steady state speed performance are required. In recent years, the control of induction motor has become an important research topic and a variety of control methods have been born. This paper proposes a new motor speed control approach based on methods of field oriented control theory. The new method gets rid of PI regulators compared to the traditional control methods and the algorithm is very simple. The result of simulation shows that this control system has good dynamic and static performance.**

## I. INTRODUCTION

An induction motor or asynchronous motor is an AC electric motor in which the electric current in the rotor needed to produce torque is obtained by electromagnetic induction from the magnetic field of the stator winding. An induction motor can therefore be made without electrical connections to the rotor. An induction motor's rotor can be either wound type or squirrel-cage type.

Three-phase squirrel-cage induction motors are widely used as industrial drives because they are self-starting, reliable and economical. Single-phase induction motors are used extensively for smaller loads, such as household appliances like fans. Although traditionally used in fixed-speed service, induction motors are increasingly being used with variable-frequency drives (VFD) in variable-speed service. VFDs offer especially important energy savings opportunities for existing and prospective induction motors in variable-torque centrifugal fan, pump and compressor load applications. Squirrel-cage induction motors are very widely used in both fixed-speed and variable-frequency drive applications.

Field-oriented control (also referred to as vector control) is often used in high- performance drive applications. The technique, conceived in the early 1970s, achieves DC machine-like performance from induction machines; and while computationally intensive, the availability of cheap, powerful microprocessors has made field-oriented control a viable choice for modern high performance drive systems.

## II. FIELD ORIENTED CONTROL(FOC) OF AN INDUCTION MOTOR

The interest in field-oriented control stems from the ability to obtain a nearly instantaneous torque response (i.e. Dc machine-like performance) in induction machines. This performance is achieved by exploiting the natural de-coupling which results when the characteristic equations for an induction machine are written in the rotor-flux reference frame.

FOC have made possible the application of IM for high performance applications where traditionally only DC drives were applied. Separate excitation DC motor has similar way as field oriented scheme that allows the control of IM. Speed control of three-phase AC electric motors is achieved by controlling the current where it is one of the methods used in variable-frequency drives or variable speed drives to control its torque. FOC torque is obtained by controlling the torque and flux current independently. By using FOC, at low and high speeds, there is not any torque ripples, thus smoother and accurate control can be achieved. Field oriented control methods are two types-

1. **Direct FOC**
2. **Indirect FOC**

The direct VC method relies on the stator or air-gap flux with generation of unit vector signals. From stator voltage and current, the air-gap signals can be measured directly and estimated. Stator quantities can be directly computed through the stator flux. Rotor field angle does not need rotor speed in these systems. Rotor field angle and unit vectors are indirectly acquired by summation of the rotor speed and slip frequency which happens in Indirect Vector Control (IVC).

**Direct Field Orientation Control (DFOC)**

In order to capture the flux information of the motor, flux sensors, such as hall flux sensors, can be used to measure the mutual magnetic fields $□_m$ . Mount the flux sensors inside of the motor; and thus, two components $□_m$□□And $□_m$□ of the mutual magnetic fields can be detected based on the motor flux equations

$□_r$□ $L_r I_r$ □ $L_m I_s$

□□□□$_m$□ $L_m I_r$ □ $L_m I_s$

The rotor flux can be expressed by eliminating rotor current Ir:

$$\Psi_r = \frac{L_r}{L_m}\Psi_m - (L_r - L_m)I_s$$

Use the measured mutual flux component $□_m$□ and $□_m$□ the rotor components in two axes can be obtained as :

$$\Psi_r = \sqrt{\Psi_{\alpha r}^2 + \Psi_{\beta r}^2}$$

$$\cos\theta_e = \frac{\Psi_{\alpha r}}{\sqrt{\Psi_{\alpha r}^2 + \Psi_{\beta r}^2}}$$

The rotor flux magnitude and angle can be further expressed as:

$$\Psi_{\alpha r} = \frac{L_r}{L_m}\Psi_{\alpha m} - (L_r - L_m)i_{\alpha s}$$

$$\Psi_{\beta r} = \frac{L_r}{L_m}\Psi_{\beta m} - (L_r - L_m)i_{\beta s}$$

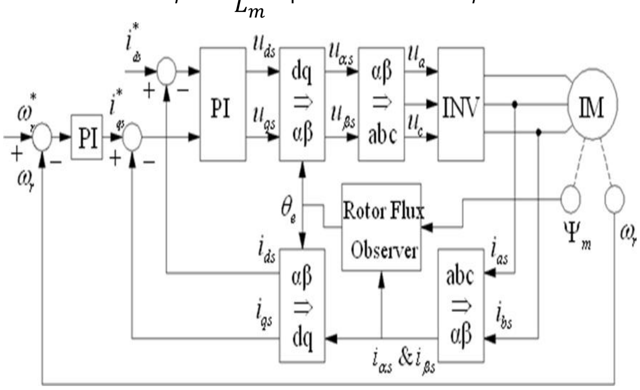


Figure 2.1: DFOC system diagram

In field orientation control, there are two kinds of coordinate transformations: three phase to two phase (Clarke transformation),and stationary to rotation (Park transformation). To accomplish the rotating transformation, the flux angle $□_e$ Must be known precisely.

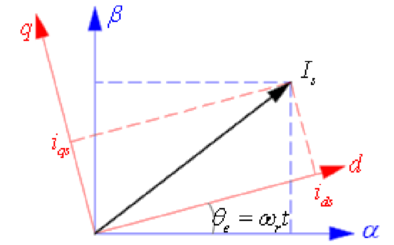

Figure 2.2: The rotating angle between the stationary and rotational frames

## III.CLARKE TRANSFORMATION

The Clarke transformation transfers a three-phase system into a two-phase system. Take the currents, for example:

$$\begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} = \begin{bmatrix} \frac{2}{3} & -\frac{1}{3} & -\frac{1}{3} \\ 0 & \frac{\sqrt{3}}{3} & -\frac{\sqrt{3}}{3} \end{bmatrix} \cdot \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix}$$

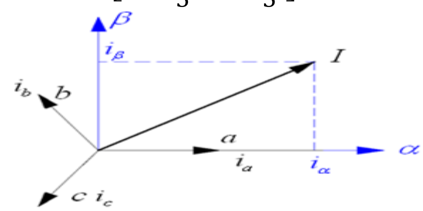

Figure 3.1: Clarke transformation of three-phase currents

In this thesis, (a,b,c) □ (□,□) is used to represent the Clarke transformation.

## IV.PARK TRANSFORMATION

The Park transformation transfers a stationary system into a rotational system:

$$\begin{bmatrix} i_d \\ i_{\beta q} \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \cdot \begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix}$$

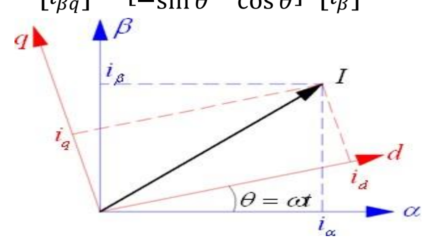

Figure 4.1: Park transformation of two-phase currents

Here (□, □ ) □ $(d, q)$ is used to represent the Park transformation.

## V. SIMULINK OF FOC INDUCTION MOTOR

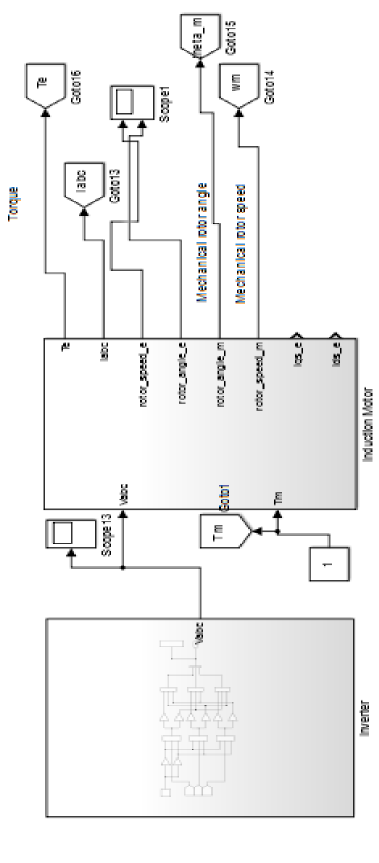


Figure 5.1: Equation model of induction motor

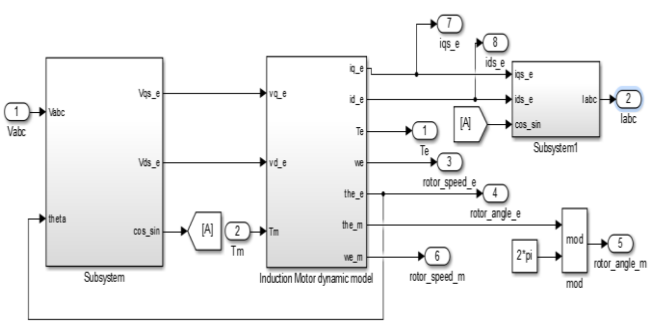


Figure 5.2: subsystem of induction motor

## VI.SIMULATION RESULT:

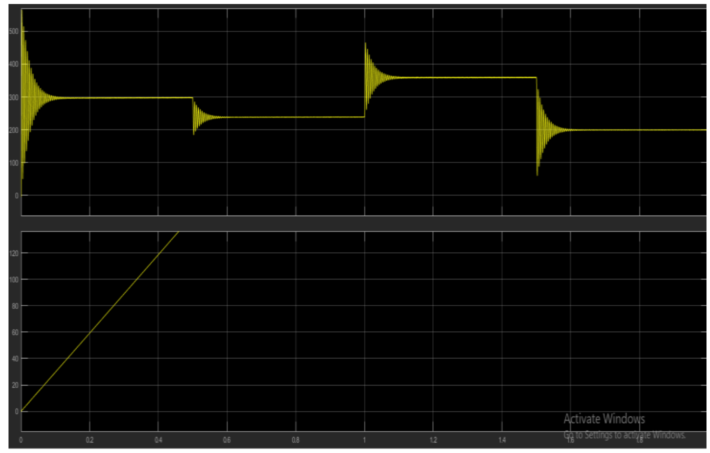

Figure 6.1:speed and torque simulation for reference torque

## VII.CONCLUSION

Fast response of vector control make it better than other method of speed control of induction motor , by using this method we attain maximum response in minimum time. This response is fast, accurate and gives a good result for variable speed of induction motor speed control is discussed using PI controller in the field oriented coordinates. The method uses a proportional integral controller to adjust the motor speed based on speed errors, and draws the motor speed quickly to reference speed. The simulation results show good performance of the designed controller that has very low overshoot.

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