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Ifoc Without Using Current Sensors

Nimi G Vijayan
PG Scholar, Power Electronics &Drives
EEE Department MEA
Engineering College
Perinthalmanna,Kerala,India

Ajmal K T
Assistant Professor,
EEE Department
MEA Engineering College
Perinthalmanna,Kerala,India

***Abstract:* - This paper introduces a new vector control strategy which does not use current and voltage sensors. Two orthogonal current components are derived from rotor speed. The torque and flux in the determination of three phase voltage reference of SPWM inverter, stator and rotor currents in stationary and rotating frames can be derived from corresponding motor dynamic equations. Simulation results are presented to demonstrate the feasibility and performance of the proposed methodology.**

Keywords—Vector control without current and voltage sensors; induction motor control; drives

I. INTRODUCTION

In existing indirect field oriented vector control method (IFOC) is mostly used for installing high performance induction motor drive system. It has current and voltage sensors. Current sensors measure the stator current of motor, from these current values direct axis currents, quadrature axis currents and voltage reference command will be derived.[1]

In IFOC, the stator current will be measured instead of rotor currents. If any fault occurred in current sensors the faulty signal will feedback and increase the system speed dangerously and will collapse the system. This is a major issue in industries;[2] also if we use current and voltage feedback system, additional current controllers are required. Hence overall system cost and design complexity will increase. Applying the proposed control strategy these problems can be eliminated.

This paper introduce an indirect vector control strategy without using current and voltage sensors, so this strategy does not have current loop and current controllers. This strategy will give good dynamic and steady state performance. Considering this reasons overall design become simple and cost efficient.[3]

In this method due to influence of parameters, the motor will deteriorate and also the DC link disturbances will effect in low speed. In actual cases the disturbances in DC link can be neglected.[3]

Synchronous rotating rotor flux oriented reference (d-q) frame. The torque component Iq will generate electromagnetic torque and Id will excite the motor flux. These two current components are orthogonally decoupled each other.[4] The value of their current can be calculated from electromagnetic torque (Te) and rotor flux (λr).

This block diagram represents the proposed control strategy. Here the rotor speed (Wr) is measured by using speed sensors. This rotor speed will feedback to flux and torque producer. The values of flux and torque are derived from rotor speed. From these values we find Ids, Iqs, Idr, Iqr from this Iαs, Iαr, Iβs, Iβr will be calculated. According to motor dynamic equation Uα, Uβ will be calculated and by using two phase to three phase transformation method three phase voltage reference signal can be determined. These three phase reference sinusoidal signal will compare with a carrier wave and produce pulses. which are given to inverter. The inverter will produce required balanced three phase voltage. supply and will drive the motor.

But due to influence of parameters of the motor will detoriate. Also the DC link disturbances will effect. In low speed. Introduced control strategy will give good dynamic and steady state performance. In actual cases the disturbances in DC link will be neglected.

II. PROPOSED CONTROL METHODOLOGY

Based on rotor field orientation vector control theory, the stator current of squirrel cage induction motor can be decomposed into two orthogonal components in the synchronous rotating rotor flux oriented reference(d-q) frame. The torque current Iq generate electromagnetic torque. Id will excite the motor flux. These two current components are orthogonally decoupled each other .the value of their current can be calculated from electromagnetic torque (Te) and rotor flux (λr).

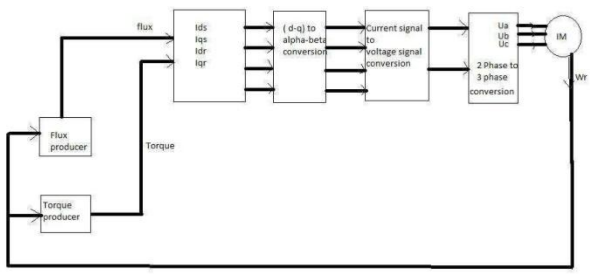

Fig.1Block diagram of proposed control strategy(IFOC without sensors)

This is the block diagram representation of proposed control strategy. Here the rotor speed (Wr) is measured by using sped sensors. This rotor speed will feed back to flux and torque producer. Then we get the values of flux and torque. From these valus we find Ids, Iqs, Idr, Iqr. After that Iαs ,Iαr, Iβs, Iβrwill calculated. According to motor dynamic equation ,we find Uα, Uβ. By using two phase to three phase transformation method, the three phase voltage reference value can be determined. These three phase reference sinusoidal signal will compare with a carrier wave and produce pulses. These pulses are given to inverter. And inverter produce required balanced three phase voltage supply. It will drive the motor.[5]

The decoupling character of flux and torque component of will shows in phasor diagram.

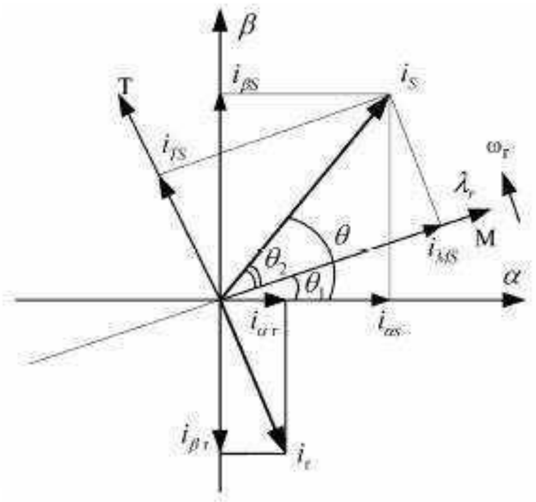

Fig.2 phasor diagram of stator and rotor current.

First we calculate d – q frame current quantities by using following formulas.

Iqs = (Te*4*Lr) / (3*p*Lm*λr) (1)

Ids = λr / Lm (2)

Wsl = (Iqs*Rr) / (Ids*Lr) (3)

The s,r represent the stator and rotor variables. q, d indicate

(19)

reference frame variables.

Rr	Rotor resistance
Lm	Mutual inductance
Ls	Inductance of stator
Lr	Inductance of rotor
λr	Flux in rotor side
Te	Torque
P	Pole paires
d/dt	Differential operator.

In practical cases the magnitude of flux maintained at constant value, particularly the motor runs below its base speed.

The angle between Iqs and Ids axis is

θ = arctg (Iqs / Ids) (4)

The angle of rotor flux in stationary frame can be written as

θe = ∫ (Wsl + Wr)dt (5)

Wr = Rotor speed

The expression for stator current in stationary frame

Iα = cosθe*Ids – sin θe*Iqs (6)

Iβ = sinθe*Ids + cosθe*Iqs (7)

The voltage current equation in rotor side

Lm*p*Ids + (Rr+Lr*P)*Idr = 0 (8)

Lm*Ws*Ids + (Rr + Lr*p)Idr + Rr*Iqr=0 (9)

This can be written as

Rr*Idr + P (Lm*Ids + Lr*Idr)=0 (10)

Rr*Idr+P*λr=0

In this control strategy (rotor field orientation vector control)

λr = λdr (11)

λqr = 0 (12)

Most probabley,flux value must be kept at a constant value;

Or d/dt (λr) =0 (13)

According to these requirements ,the values of Ids and Iqs can be obtained as

Idr = (λr / Lr) – (Lm / Lr)*Ids (14)

Iqr = (-Lm/Lr*Iqs) (15)

The Iαr,Iβr currents can be represented in stationary frame as

Iαr = cosθe*Idr - sinθe*Iqr (16)

Iβ = sinθe*Idr + cosθ*Iqr (17)

Based on the motor voltage current equation in stationary frame

Uαs = (Rs + Ls*p)*Iαs + Lm*p*Iαr (18)

Uβs = (Rs + Ls*p)*Iβs + Lm*p*Iβr

Rs	stator resistance
Ls	inductance of stator

Applying two phase to three phase transformation, reference voltage command can be determined.

Ua = Uα (20)

Ub = -1/2Uα + √3/2*Uβ (21)

Uc = -1/2*Uα - √3/2*Uβ (22)

Then the applied stator voltage magnitude, frequency, phace can be determined from the motor dynamic equations. these values are calculated from speed value. We do not use any voltage and current sensors, feedback loops, current and voltage controllers. It has no complicated algorithm. due to these things the proposed control strategy can greatly reduce the overall cost and simplify the design.[6]

III. ANALYSIS OF SIMULATION RESULTS

The simulation research used to evaluate this proposed control strategy. The fig(1) shows the block diagram of control topology. An induction motor driven by using SPWM inverter. And the reference command will produced from flux and torque references. this investigation concentrated on the performance of motor with decoupled torque and flux. the motor parameters are Rs = 8; Rr = 4; Lss = 0.47; Lr = 0.47; Lm = 0.44; P = 4.

Simulation tests are used to evaluate proposed control method. Here we take the base speed of motor is 1000 rpm.fig (3) shows working motor at 1000 rpm.At this time load applied to the motor is zero.In this situation motor has good dynamic and steady state performance.

shows the speed responds of motor running at a speed of 1000 rpm at no load conditions. when we analyze the speed responds, first the speed starting from zero value. gradually increase that value and at 0.15 sec the speed become overshooting to a peak value of 1100 rpm.From that moment the gradually decreasing and settled at 0.75 sec.We can see that the transients in are very less.The performance is very smooth. Steady state error is very less about 5%.Te fig(4) shows current responds .Here we can sea that, current overshooting to to a value of 50 ampere. But at .25 sec it will coming to down and settling to a value of 3 ampere.fig(5) shows torque responds. here the torque responds is not much better than the IFOC .

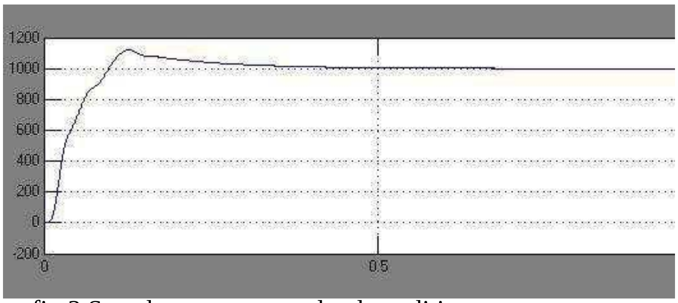

fig.3 Speed response at no load condition

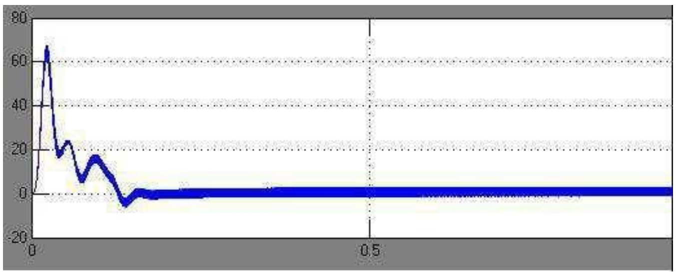

Fig.4 Torque response at no load condition

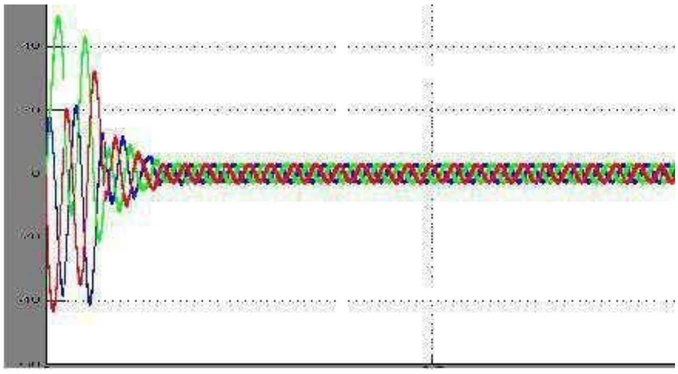

Fig.5 stator currents at no load condition

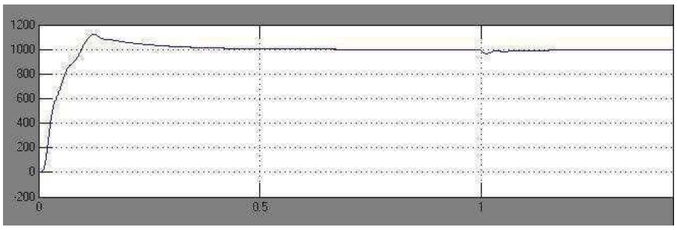

Fig.6 speed response for 10Nm load at 1 sec

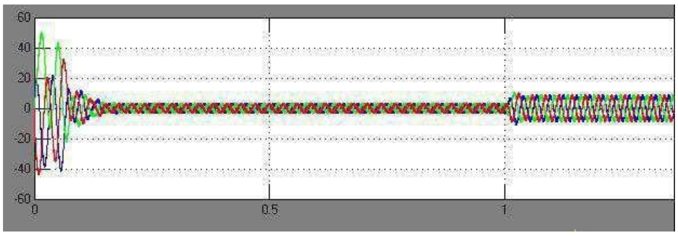

Fig.7 Stator current for 10 Nm load at 1 sec

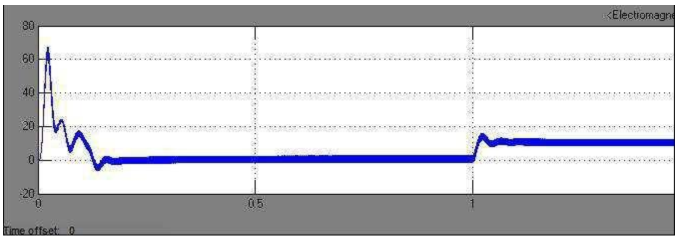

Fig.8 Torque responds for 10 Nm load at 1 sec

When a load of 10 Nm applied to the motor at 1 sec,the motor become settled to 1000 rpm at 0.7sec.After that it maintained at a constant speed. But at 1 sec,the motor speed wil suddenly decreases to a value of about 975 rpm and after 0.25 sec,the system regained to a value of 1000 rpm.

The speed range of motor is 750-1100 rpm.We can apply a loadbetween0–10Nm.

IV.CONCLUSION

This paper introduces a new vector control strategy which does not use current and voltage sensors. Two orthogonal current components are derived from rotor speed. The torque and flux in the determination of three phase voltage reference of SPWM inverter, stator and rotor currents in stationary and rotating frames can be derived from corresponding motor dynamic equations. Simulation results are presented to demonstrate the feasibility and performance of the proposed methodology. It has good dynamic and static characterestics.But torque ripples cannot be eliminate completely.

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