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Study of Indirect Field Oriented Control of Induction Motor for Inverter and Multilevel Inverter

Neha Choudhary
DIT, University
Dehradun, India

S.Bhanu Prakash
DIT, University
Dehradun, India

Sandeep Kumar
International College of Engineering
Ghaziabad, India

ABSTRACT:
With the help of Field Oriented Control method operation, Induction motor can be analyzed similar as a DC motor. This can be done by changing the a-b-c frame to D-Q variable in synchronously rotating frame. In this paper Vector Control technique has been employed to Induction Motor through Inverter as well as Diode Clamped Multilevel Inverter. MLI change the output in staircase case form which is near about sinusoidal waveform thus reducing the harmonic distortion. Hysteresis band current controller technique has been applied. The system is stimulated in Sim Power Sim/Simulink (MATLAB).

Keywords: Inverter, Power Electronic Converter, Vector Control, H-B current controller, d-q transformation.

INTRODUCTION:

Speed control of DC motor is easier compared to Induction motor but now a day in industries use of DC motor is Reducing and Induction Motor are gaining popularities in spite of their tougher speed control. So by changing the a-b-c variable to d-q variable their speed control can be improved as it will function as DC motor. Field Oriented Control explains Induction Motor in relative simple term by using d- q variable. Three-phase induction motor can be modeled in an arbitrary two axis (d & q-axis) rotating reference frame. It will be shown that when we choose a synchronous reference frame in which rotor flux lies on the d-axis; this model can estimate the stator current along the direction of two- reference axis as D & Q axis. Induction Motor when driven by Field Oriented Controller, behaves as separately excited DC Motor to control torque and flux. In this paper first inverter is used and then operation on diode clamped multilevel inverter is performed. Multilevel is advantageous then conventional inverter because they generate the pulses near about sinusoidal waveform and in staircase form thus reduce the harmonic content, ripple content and improve the efficiency. Hysteresis band current control technique is used. This paper emphasizes on the fact that when induction motor are fed through Field Oriented Control or Vector Control, it torque pulsation are reduced and motor run smoothly. In this manner efficiency of induction motor are also increase and losses are reduced. The dynamic model of the induction motor is necessary for understanding and analyzing the three-phase inductor motor for the purpose of speed control.

POWER ELECTRONIC CONVERTER:

Power electronic converters are those devise which change on form of energy to another form of energy either from DC to AC or AC to DC. In past days Inverter was being used but inverter have some disadvantage being associated to its working so Multilevel inverter are being used now a day in place of inverter. As levels of multilevel inverter are improved their performances also increase. Here level of

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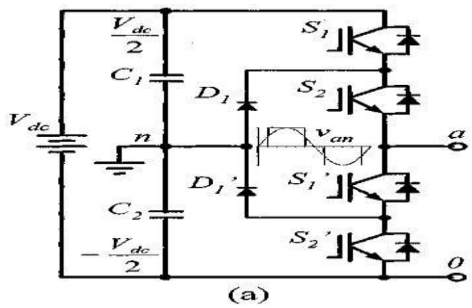
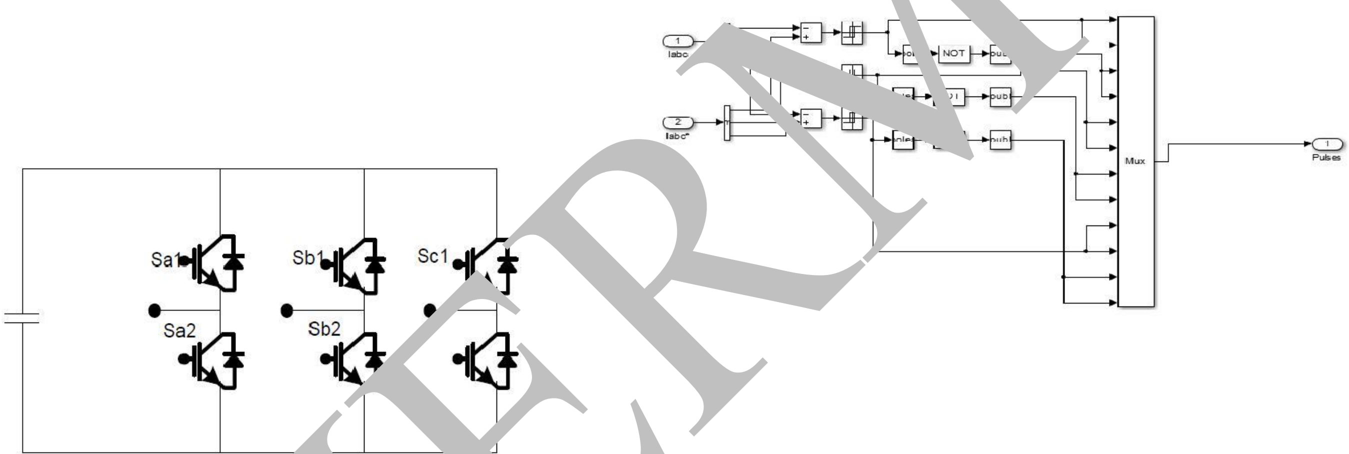
inverter terms is associated to the output voltage of MLI.

HYSTERESIS BAND CURRENT CONTROL:

Hysteresis band PWM is an instantaneous feedback current control technique where the actual current continuously tracks the command current within the hysteresis band. Voltage level will be at its highest or lowest value when the measured current crosses the lowermost or uppermost hysteresis band respectively. This type of controller has excellent dynamic response low cost and easy implementation although it has large ripple current in steady state and generates sub harmonic content also.





(b)

Fig 2.(a) DCMLI (b) IGBT Inverter.

Some other technique for generation of pulses for power electronic converter is SHE, PWM, SVPWM, DTC etc,

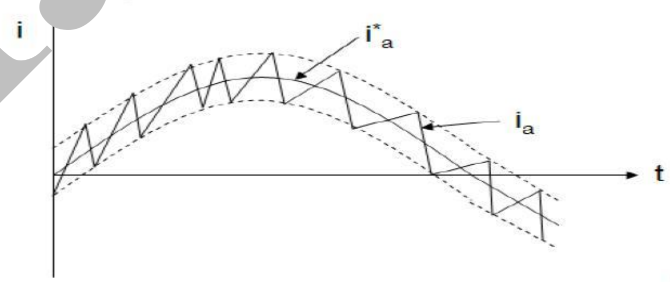


Fig 3 Hysteresis band current controller

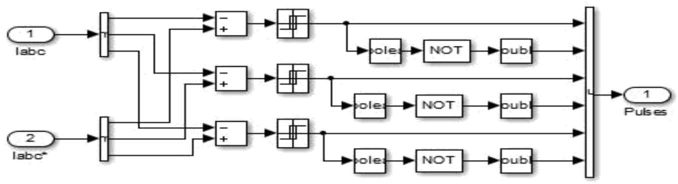


Fig 4. H-B current controller for Inverter

VECTOR CONTROL:

In scalar control there is coupling effect means if one quantity is changed other will also be affected thus if flux is changed torque is affected and vice versa although scalar control are simple to implement. Vector control is free from coupling affect thus if flux is changed it does not have any effect on torque and vice versa. Vector control allows speed and torque to be nearly controlled. Field oriented control has two modal that is voltage modal and current modal. Voltage modal flux estimation is better at higher speed whereas current modal is made at any speed. Field Oriented Control of Induction Motor is based on dynamic modeling of Induction Motor.

It is also possible to have hybrid modal where voltage modal is effective at higher speed and current modal at lower speed range. In Field Oriented Control, Induction motor will operate as separately excited DC motor as it allows Induction Motor in comparatively simple term using d-q variable as number of equation are reduced. The goal is to Some Unseen factors in Software Sustainability transform the three phase stationary reference frame variable into two phase stationary reference frame variable and then transform these to synchronously rotating reference frame. Transformation of three phase axes to two phase stationary Axes

$$\begin{bmatrix} Vqs^s \\ Vds^s \end{bmatrix} = \frac{2}{3}\begin{bmatrix} \cos\theta & \cos(\theta-120) & \cos(\theta-120) \\ \sin\theta & \sin(\theta-120) & \sin(\theta+120) \\ 0.5 & 0.5 & 0.5 \end{bmatrix}\begin{bmatrix} Vas \\ Vbs \\ Vcs \end{bmatrix}$$

Transformation of stationary axes to synchronously rotating axes

$V_{qs} = V_{qs}^{s}\cos\theta - V_{ds}^{s}\sin\theta$ $V_{ds} = V_{qs}^{s}\sin\theta + V_{ds}^{s}\cos\theta$

Flux linkage expression in terms of current can be written as

$$\psi_{qs} = L_{ls} i_{qs} + L_m (i_{qs} + i_{qr})$$

$$\psi_{qr} = L_{lr} i_{qr} + L_m (i_{qs} + i_{qr})$$

$$\psi_{qm} = L_m (i_{qs} + i_{qr})$$

$$\psi_{ds} = L_{ls} i_{ds} + L_m (i_{ds} + i_{dr})$$

$$\psi_{dr} = L_{lr} i_{dr} + L_m (i_{ds} + i_{dr})$$

$$\psi_{dm} = L_m (i_{ds} + i_{dr})$$

Torque expression in stationary frame is given bellow

$$T_e = \frac{3}{2}\left(\frac{P}{2}\right)(\psi_{dm} i_{qr} - \psi_{qm} i_{dr})$$

Torque expression in dynamic rotating frame is given as below

$$T_e = \frac{3}{2}\left(\frac{P}{2}\right)(\psi^s{}_{dm}\, i^s{}_{qr} - \psi^s{}_{qm}\, i^s{}_{dr})$$

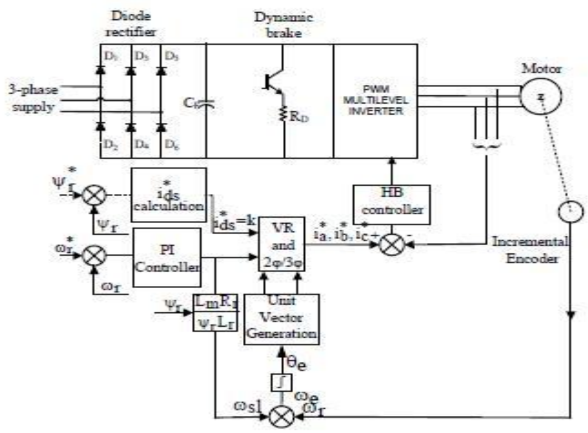


Fig 6. Block diagram of Indirect Field Oriented Control

RESULTS:

For validation of previously discussed approached stimulation is performed and result are shown below for Inverter as well as Multilevel Inverter for Indirect Field Oriented Control of Induction Motor.

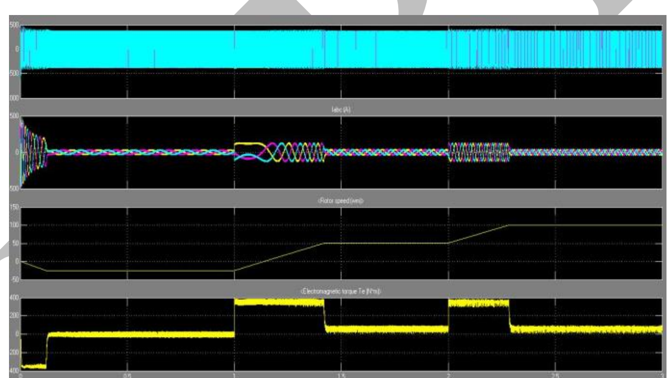


Fig. 7. Layout and simulation results

MOTOR PARAMETER:

Motor Type- Squirrel Cage, nominal power- 50*746, voltage-460, frequency-60, stator resistance-0.087,stator inductance- 0.8, rotar resistance- 0.228, rotar inductance-0.8, mutual inductance- 34.7

PI CONTROLLER PARAMETER:

Kp-550, Ki- 150, Torque Limit- 350

CONCLUSION AND FUTURE SCOPE:

From the above result it is clear that motor run smother using field oriented control. As level of MLI is increased performance also get better. Also different modulation technique can be used for better performance.

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