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SMALL FILM CAPACITOR INVERTER OBSERVATIONAL INDUCTION MOTOR CONTROL APPROACH TO IMPROVE WITH RELIABILITY AND POWER DENSITY OF THREE PHASE VARIABLE SPPED DRIVE APPLICATIONS

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ABSTRACT:

The main aim of this project is a small film capacitor inverter based induction motor control approach to improve with reliability and power density of three phase variable sped drive applications. In this project a new and simple phase induction motor drive for near unity power factor operation with low supply current harmonics. the indirect vector controlled induction motor drive is used as load, but any load which is capable of regenerating can be employed. In this project A position sensor less vector-controlled induction motor (IM) drive system integrated into HVAC applications. The motor power is supplied by a small dc-link film capacitor inverter fed by a three-phase diode front-end rectifier. A PI motor current- regulator-free control strategy is proposed to meet the aforementioned challenges by combining a model-based controller (MBC) and a hexagon voltage manipulating controller (HVC). The MBC finds the command output voltage with the intersection of the torque and rotor flux linkage command. In the HVC mode, the command voltage vector can be determined simply by the torque command and the hexagon voltage boundary. The proposed system is implemented in a MATLAB/SIMULINK environment.

I.INTRODUCTION

There is increasing interest in the monitoring lifetime of electrolytic capacitors for reliable and safe operation. On the other hand, offline monitoring techniques require additional measurements as well as a priori data for the reference model, which makes monitoring process complicated and difficult. In this regard, a range of regenerative converters and control methods have been proposed in order to minimize or reduce these passive components on a dc bus. The focus of most studies has been on how to reduce the dc-bus capacitor of three-phase pulse width modulation (PWM) rectifier's and single-phase diode rectifiers .All previous studies were equipped with a conventional closed-loop current controller to regulate the air-gap torque and flux linkage of ac motors. How-ever, instantaneous current control in a small dc-bus capacitor inverter with the diode rectifier front-end is not straightforward because the dc-link voltage and output power to the motor decrease periodically due to the absence of energy storage. This rapid dc voltage reduction drives the motor to be operated frequently in the field-weakening region below a based speed. Therefore, the current control strategy becomes more complicated under voltage-limited conditions because multiple-objective sub controllers, such as field-weakening, ant windup control, and over modulation scheme, should be designed care-fully based on the complex tradeoff between the sub control actions and current control dynamics. This paper presents a position sensorless vector-controlled induction motor (IM) drive system integrated into HVAC applications. The motor power is supplied by a small dc-link film capacitor inverter fed by a three-phase diode front-end rectifier. A motor-current PI regulator-free control strategy is proposed to meet the aforementioned challenges by combining a model-based voltage controller (MVC) and a hexagon voltage manipulating controller (HVMC). The MVC finds the command output voltage with the intersection of the torque and rotor flux linkage command.

In HVMC mode, the command voltage vector can be determined simply by the torque command and the hexagon voltage boundary. The MVC is performed under non-limited conditions and motor control is handed automatically over to the proposed HVMC in the voltage shortage region. These voltage selection rules allow for the choice of an objective voltage vector in the absence of PI control gains, sub-controllers, and observers for closed-loop control.

III. PROPOSED SYSTEM AND CONTROLLIG

Fig.1presents an overall block diagram of the control system augmented to include the proposed algorithm to compensate for the parameter variation effects in real time. A simple back-EMF tracking-based position sensor less method was employed for motor position estimation.

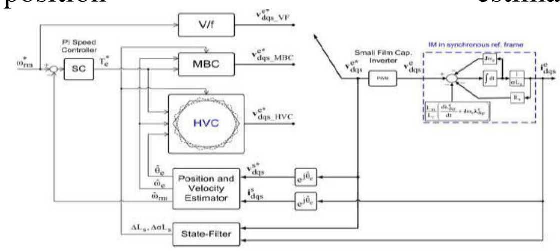

Fig.1. Overall control block diagram

IV.MOTOR CONTROLLER DESIGN WITH SMALL DC-LINK CAPACITOR INVERTER

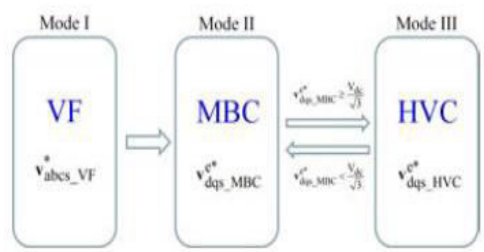

Figure.2 Proposed IM control strategy for small capacitor inverters.

Fig.1 shows a block diagram of the proposed control strategy for an IM using a complex vector representation. Here, $V^{*}abcs$ and $V^{e*}dqs$ are the stator voltage commands in the abc - reference frame and the synchronous reference frame, respectively, and Vd c de-notes the measured dc-link voltage. When starting (Mode I), the scalar Volts/Hz or *V/f* open-loop control is introduced to avoid the lack of observability of the motor back-EMF voltage at low speeds. This feature permits the drive system to satisfy the starting speed requirement of the back-EMF tracking-based

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position sensor less operation, of which the threshold begins in the vicinity of 10% of the rated speed. The control authority is then handed over to model-based control (MBC,Mode II)or hexagon voltage manipulating control (HVC, Mode III), depending on the amount of available dc-link voltage.

Ratings and parameters	Value	Unit
Rated power output	1.5	kW
Rated voltage	220	V
Rated speed	1500	r/min
R_s / R_r at 25 °C	2.47 / 0.7	Ω
L_m / σL_s	134 / 12.6	mH

The motor stator voltage and flux linkage equation can be expressed using a complex vector representation:

$$V_{dqs}^{e} = R_s\, i_{dqs}^{e} + \sigma L_s \frac{di_{dqs}^{e}}{dt} + J\, w_e \sigma L_s\, i_{dqs}^{e} + \frac{L_m}{L_r}\frac{d\lambda_{dqr}^{e}}{dt} + J\frac{L_m}{L_r} w_e \lambda_{dqr}^{e}$$

Where I^edqs is the d–q axis stator current vector in the synchronous reference frame, Rs is the stator resistance, we is the synchronous angular velocity, σ Ls is the stator transient leakage inductance, and λ^edqr represents the d–q axis stator and rotor flux linkage vector. Lm and Lr represent the magnetizing and rotor inductance, respectively. At the steady state, the motor air-gap torque and the rotor flux linkage of the rotor fluxoriented- controlled (RFO) IM can be expressed as

$$T_e = \frac{3}{2}\,\frac{P}{2}\,\frac{L_m}{L_r}\,\lambda_{dr}^{e}\, i_{qs}^{e}$$

$$\lambda_{dr}^{e} \cong L_m i_{ds}^{e}$$

Where P is the number of poles.

The stator voltage equation can be also simplified as

$$V_{ds}^{e} = R_s\, i_{ds}^{e} - w_e \sigma L_s\, i_{qs}^{e}$$

$$V_{qs}^{e} = R_s\, i_{qs}^{e} + w_e L_s\, i_{ds}^{e}$$

By combining all above equn's, the torque and rotor flux linkage command can be obtained as a function of the rotor speed:

$$T_e^{*} = \frac{3}{2}\,\frac{P}{2}\,\frac{L_m}{L_r}\,\lambda_{dr}^{e*}\left(\frac{V_{ds}^{e*} - R_s\, i_{ds}^{e*}}{-\, w_e \sigma L_s}\right)$$

$$\lambda_{dr}^{e*} = L_m\left(\frac{V_{qs}^{e*} - R_s\, i_{qs}^{e*}}{w_e L_s}\right)$$

Fig. 3 presents a zoomed view of the stator voltage
solutions between (4) and (5) in the synchronously rotating dq volt plane. The desired torque of (4) forms a line in the complex d-q plane and is shown in blue.

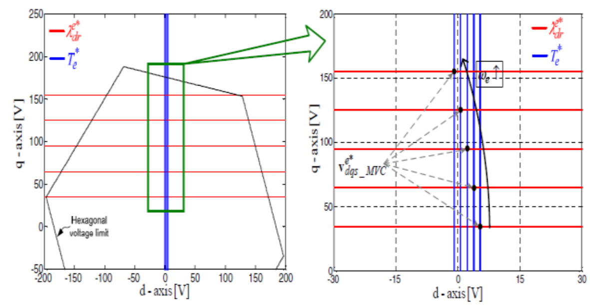

Fig. 3. Voltage command selection in the MVC mode.

The rotor flux linkage line, which is shown in red, shifts downward along the q-axis direction as the flux decreases at a certain rotor speed or the rotor speed decreases for a given flux.

V. COMPENSATION OF EFFECTS OF PARAMETER DRIFTS

In practice, the rotor flux level is not maintained properly in the MVC and HVMC mode because the machine parameters of (6) and (10) drift due to magnetic saturation and initial errors. The voltage errors of (6) and (10) also results in an incorrect actual stator current, which might result in high copper or iron losses for a given torque condition. In HVAC applications, the main operation is performed in the speed range from 50% up to 90% of the rated motor speed. Fig.4 shows the stator

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current deviation trajectories of a tested IM, as shown in Table I, at 60% of the rated speed and 67% of the rated torque. The stator resistance error has little impact on the current deviation at this speed. In practical applications, an online compensation for model errors is believed to be more effective in achieving accurate motor control. This paper proposes a voltage disturbance state-filter [14] to decouple the parameter dependency of MVC and HVMC mode. Fig. 4presents a block diagram of the disturbance voltage estimation strategy using a complex vector representation in the synchronous reference frame. A familiar PI-type Luenberger-style model-current observer controller was adopted to estimate the voltage disturbance resulting from parameter variations, where the estimated output current I^e dqs follows the stator current $\mathbf{I}^e$ dqs . Because the command voltage vector $\mathbf{v}^e$ dqs is fed-forward to the observer, the voltage disturbance error $\mathbf{v}^e$ dqs _D can be estimated at the output of the observer controller. Here, the stator current has a certain amount of harmonics with six times the synchronous and grid frequency due to the manipulated voltage on the hexagon boundary and fluctuating dc-bus voltage. A resonant-type filter is introduced to reject these ripple components of $\mathbf{I}^e$dqs , which achieves enormously high gains at resonant frequencies of concern. This structure can estimate and compensate for voltage deviation resulting from disturbances and uncertainties . The estimated disturbance voltage and stator current in the s-domain are given by

$$\Delta\hat{v}^e_{dqs\_D} = \begin{pmatrix} \hat{R}_s \hat{\mathbf{i}}^e_{dqs} + s\sigma\hat{L}_s \hat{\mathbf{i}}^e_{dqs} + \mathbf{J}\omega_e \sigma \hat{L}_s \hat{\mathbf{i}}^e_{dqs} \\ + s\dfrac{\hat{L}_m}{\hat{L}_r}\hat{\boldsymbol{\lambda}}^e_{dqr} + \mathbf{J}\dfrac{\hat{L}_m}{\hat{L}_r}\omega_e \hat{\boldsymbol{\lambda}}^e_{dqr} \end{pmatrix} - \mathbf{v}^{e*}_{dqs} \cdot$$

$$\hat{\mathbf{i}}^e_{dqs} = \mathbf{i}^e_{dqs} - \frac{1}{G(s)}\Delta\hat{\mathbf{v}}^e_{dqs\_D}$$

where

$$G(s) = \frac{K_p s + K_i}{s} + \frac{K_r \omega_{cut} s}{s^2 + \omega_{cut} s + \omega^2_{h\_6fg}} + \frac{K_r \omega_{cut} s}{s^2 + \omega_{cut} s + \omega^2_{h\_6fe}}$$

where Kp and Ki represent the PI gains. w_{h_6fg} , $w_{f_{6fe}}$, w_{cut}, and Kr represent the grid frequency, concerned synchronous frequency, 3dB cut-off frequency, and resonant filter gain, respectively. In this paper, superscript "^" represents the corresponding variables are estimated.

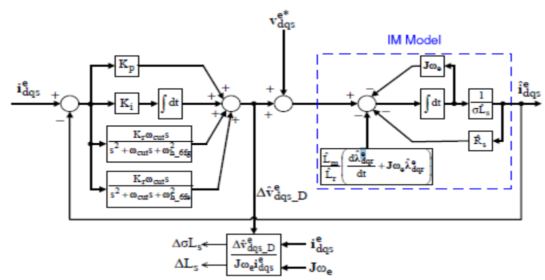

Fig.4. State-filter design for decoupling the parameter dependency.

CONCLUSION

This project addresses the controller design of a position sensorless vector-controlled IM drive system supplied from a small dc-link film capacitor inverter fed by a three-phase diode front-end rectifier. The proposed approach focuses on the controller performance when entering or leaving the infeasible voltage domain. The motor current PI regulator free control structure presents a smooth transition from the MBC under the unconstrained voltage region to the HVMC when the voltage limit is encountered. The algorithm can provide adequate results over a number of potential secondary upsets found in the current regulator-based control structure. The operation

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sensitivity under motor parameter drifts is also examined to decouple its influence using a voltage disturbance state filter. The test results clearly show that the proposed method can improve the inverter reliability without sacrificing the motor control performance.

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