MRAS BASED SENSORLESS VECTOR CONTROL OF INDUCTION MOTOR

DISSERTATION

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CERTIFICATE

I, Ashish Chourasia, Roll No. 2k12/C&I/04 student of M. Tech. Control & Instrumentation (C&I), hereby declare that the dissertation titled "**Model Reference Adaptive System (MRAS) based Sensorless Vector Control of Induction Motor**" under the supervision of Dr. Madhusudan Singh of Electrical Engineering Department Delhi Technological University in partial fulfillment of the requirement for the award of the degree of Master of Technology has not been submitted elsewhere for the award of any Degree.

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ABSTRACT

Induction motors are widely used in many industrial applications, represent the starting point and often termed as the workhorse machinery for any electrical drive system, whenever planned to be designed. In correspondence to the modern control theory of electrical machines, the induction motor can be described by more than one mathematical model, in accordance to the employed control method. In the symmetrical three-phase version or in the unsymmetrical two-phase version, this electrical motor type can be associated with vector control strategy. Through this control method, the induction motor operation can be analyzed in a similar way to a separately excited DC motor. The goal of this dissertation is to summarize the existing speed control techniques available through vector control. Starting from vector control principles, the work suggests the *d*-*q* axes unified approach for understanding the important concepts of contrast among different techniques of speed control through vector control. However, the vector control or field oriented control is one of the basic modern tools of speed control; the dependence of the technique on mechanical measuring sensors is one of the major areas of concern. The estimation techniques are available to counter this, from which Model Reference Adaptive Control scheme is also discussed and simulated. The MRAC based scheme will not only improve the system efficiency, cost, and maintenance requirement of the mechanical sensing components.

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LIST OF ABBREVIATION

MRAS	Model Reference Adaptive System
MRAC	Model Reference Adaptive Controller
SVCIM	Sensorless Vector Control of Induction Motor Drive
EKF	Extended Kalman Filter
FLC	Fuzzy Logic Controller
VSI	Voltage Source Inverter
PI	Proportional Integral
CEMF	Counter Electromotive Force
VR	Vector Rotation

LIST OF SYMBOLS

Symbols	***Description***
$\boldsymbol{d^s - q^s}$	Stationary rotating reference frame direct or quadrature axis
$\boldsymbol{d^e - q^e}$	Synchronously rotating reference frame direct or quadrature axis
$\boldsymbol{\psi_a}$	Armature reaction flux linkage (Webber – turns)
$\boldsymbol{\psi_r}$	Rotor flux linkage
$\boldsymbol{\psi_s}$	Stator flux linkage
$\boldsymbol{\psi_m}$	Air gap flux
$\boldsymbol{\psi_{qs}}$	$q^e -$ axis stator flux linkage
$\boldsymbol{\psi_{qr}}$	$q^e -$ axis rotor flux linkage
$\boldsymbol{\psi_{ds}}$	$d^e -$ axis stator flux linkage
$\boldsymbol{\psi_{dr}}$	$d^e -$ axis rotor flux linkage
$\boldsymbol{\psi_{dm}}$	$d^e -$ axis air gap flux linkage
$\boldsymbol{\psi_{qm}}$	$q^e -$ axis air gap flux linkage
$\boldsymbol{\psi_{qs}^s}$	$q -$ axis stator flux linkage
$\boldsymbol{\psi_{ds}^s}$	$d -$ axis stator flux linkage
$\boldsymbol{i_{qs}}$	$q^e -$ axis stator current
$\boldsymbol{i_{qr}}$	$q^e -$ axis rotor current
$\boldsymbol{i_{dr}}$	$d^e -$ axis rotor current
$\boldsymbol{i_{ds}}$	$d^e -$ axis stator current
$\boldsymbol{L_m}$	Magnetizing Inductance
$\boldsymbol{L_{ls}}$	Stator Leakage inductance
$\boldsymbol{L_{lr}}$	Rotor Leakage inductance
$\boldsymbol{v_{qs}}$	$q^e -$ axis stator voltage
$\boldsymbol{v_{ds}}$	$d^e -$ axis stator voltage
$\boldsymbol{v_{qr}}$	$q^e -$ axis rotor voltage

$\boldsymbol{v_{dr}}$	$d^e -$ axis rotor voltage
$\boldsymbol{R_s}$	Stator resistance
$\boldsymbol{R_r}$	Rotor resistance
$\boldsymbol{L_s}$	Stator inductance
$\boldsymbol{L_r}$	Rotor inductance
$\boldsymbol{\omega_e}$	Stator or Line frequency
$\boldsymbol{\omega_r}$ **or** $\boldsymbol{W_m}$	Rotor electrical speed
$\mathbf{W_{es}}$	Estimated speed
$\mathbf{W_{ref}}$	Reference Speed
$\boldsymbol{\omega_{sl}}$	Slip frequency
S	Laplace operator
P	Poles
$\boldsymbol{\theta_e}$	Angle of synchronously rotating frame
$\boldsymbol{\theta_r}$	Rotor angle
$\boldsymbol{\theta_{sl}}$	Slip angle
$\boldsymbol{v_{qs}^s}$	$q^s -$ axis stator voltage
$\boldsymbol{v_{ds}^s}$	$d^s -$ axis stator voltage
$\boldsymbol{i_{qs}^s}$	$q^s -$ axis stator current
$\boldsymbol{i_{ds}^s}$	$d^s -$ axis stator current
$\boldsymbol{K_s}$	Slip gain
Q	Reactive power
$\boldsymbol{Q^*}$	Reactive power reference
$\boldsymbol{\widehat{K_s}}$	Estimated Slip Gain
$\boldsymbol{K_f}$	Weighting factor
$\boldsymbol{\Delta K_s}$	Incremental slip gain
$\boldsymbol{i_a^*, i_b^*}$ & $\boldsymbol{i_c^*}$	Stator current reference
$\boldsymbol{i_{qs}^*}$	Stator quadrature-axis reference current
$\boldsymbol{i_{ds}^*}$	Stator direct-axis reference current
$\boldsymbol{\lvert\psi_r^*\rvert}$	Stator flux reference input
$\boldsymbol{T_e}$	Developed Torque (Nm)

T_L	Load Torque
t_{off}	Turn-Off time (sec)
T_e^*	Torque reference
V_d	DC voltage
V_m	Peak phase voltage
V_f	Induced Emf
V_I	Inverter DC voltage
V_g	Rms air gap voltage
V_R	Rectifier DC voltage
v_d	Inst. DC voltage
v_s	Inst. Supply voltage
v_f	Inst. Field voltage
$\|\psi\|_{r\,est}$	Estimated rotor flux linkage
N_s	Synchronous Speed (rpm)
N_r	Rotor Speed