أية

بسم الله الرحمن الرحيم

﴿٣٤﴾ ۞ ٱللَّهُ نُورُ ٱلسَّمَٰوَٰتِ وَٱلْأَرْضِۚ مَثَلُ
نُورِهِۦ كَمِشْكَوٰةٍ فِيهَا مِصْبَاحٌۖ ٱلْمِصْبَاحُ فِى زُجَاجَةٍۖ ٱلزُّجَاجَةُ
كَأَنَّهَا كَوْكَبٌ دُرِّىٌّ يُوقَدُ مِن شَجَرَةٍ مُّبَٰرَكَةٍ زَيْتُونَةٍ لَّا شَرْقِيَّةٍ وَلَا
غَرْبِيَّةٍ يَكَادُ زَيْتُهَا يُضِىٓءُ وَلَوْ لَمْ تَمْسَسْهُ نَارٌۚ نُّورٌ عَلَىٰ نُورٍۗ
يَهْدِى ٱللَّهُ لِنُورِهِۦ مَن يَشَآءُۚ وَيَضْرِبُ ٱللَّهُ ٱلْأَمْثَٰلَ لِلنَّاسِۗ وَٱللَّهُ
بِكُلِّ شَىْءٍ عَلِيمٌ ﴿٣٥﴾

سورة النور

Dedication

To my family

ACKNOWLEDGMENT

In the name of Allah, Most Gracious, and Most Merciful

My deep appreciation and heartfelt gratitude goes to my supervisor, assoc. prof. Dr. Mergani Fatih E/Rahman Taha and Co-Supervisor assoc. Prof. : Dr. Awadalla Taifour Ali for their constant guidance and the appreciable time they devoted to promote this work.

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Abstract

This research presents the theory, design and simulation of a fuzzy logic based controller used for an indirect field oriented controlled three phase induction motor (IM). Field Oriented Control (FOC) theory is the base of special control method for induction motor drives. With this theory induction motors can be controlled like a separately excited dc motor. This method enables the control of field and torque of induction machine independently by manipulating the corresponding oriented quantities. Induction motor is modeled in stationary reference frame in term of *dq* form. Three speed control techniques, Direct, Scalar and conventional PD are used to compare the performance of the control system with fuzzy logic controller. The models are carried out using MATLAB/SIMULINK. The simulation results demonstrate that the performance of the Indirect Field Oriented Control (IFOC) technique with fuzzy logic controller is better, especially with dynamic disturbances than that for the other three types of control. Besides that the research focuses on studying the effect of some fuzzy controller parameters on indirect field oriented control of an induction motor. Those parameters include the shape and number of linguistic variables of membership functions (MFs). Only Triangular, Gaussian and Bell membership functions are considered for the shape. The fuzzy controller uses both the speed error and its rate of change as input, and electromagnetic torque as an output in a relationship mapped by a fuzzy rules table.

مستخلص

هذا البحث يقدم النظري , التصميم والمحاكاة لحاكمة المنطق الغامض التي تستخدم تحكم توجيه المجال غير المباشر, للتحكم في المحرك الحثي ثلاثي الاطوار. نظرية تحكم توجيه المجال المباشر, تمثل الأساس لطرق التحكم الخاصة في المحركات الحثية. بهذه النظرية يمكن التحكم في المحرك الحثي مثل محركات التيار المستمر منفصل الاثارة. هذا الاسلوب يمكن من التحكم في المجال والعزم للمحرك الحثي كلاً على حدا , وذلك بمعالجة الكميات المقابلة لكلٍّ. تمت نمذجة المحرك الحثي في الاطار المرجعي الثابت في صيغة المباشر والمتعامد dq . ثلاث تقنيات للتحكم في السرعة , و هي المباشر , القياسي والمتحكم التقليدي التناسبي التفاضلي استخدمت لمقارنة الآداء مع نظام التحكم ذو حاكمة المنطق الغامض. النماذج تمّ ايجادها باستخدام الحزمة البرمجية للمحاكاة ماتلاب. نتائج المحاكاة توضح أنّ تقنية تحكم توجيه المجال غير المباشر باستخدام حاكمة المنطق الغامض , خصوصاً عند الخلل الدناميكي أفضل من أنواع التحكم الثلاث الأخرى. بجانب ذلك يركز البحث على دراسة تأثير بعض معاملات الحاكمة الغامضة على تحكم توجيه المجال غير المباشر للمحرك الحثي , هذه المعاملات تشمل شكل وعدد المتغيرات اللغوية لدالة العضوية . بالنسبة للشكل تمّ الأخذ في الاعتبار دالة العضوية المثلثية ، القاسيان ودالة الجرس. تستعمل الحاكمة الغامضة كلاً من خطأ السرعة ومعدل تغيره كدخل والعزم الكهرومغناطيسي كخرج في علاقة كتبت في جدول القواعد الغامضة .

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

a, b, c		switching variables
d		duty ratio
E		energy, J
$\mathbf{e}$		space vector of EMF, V
e		instantaneous EMF, V
$\mathcal{F}$		space vector of magnetomotive force, A
f		frequency, Hz
Í		phasor of current, A
I		constant value of current (e.g., rms or peak), A
$\mathbf{i}$		space vector of current, A
i		instantaneous current, A
J		mass moment of inertia, kgm^2
L		inductance, H
m		modulation index, or mass, kg
n		rotational speed, r/min
P		real power, W
P		differentiation operator *(d/dt), s^{-1}*
P_p		number of pole pairs
R		resistance, Ω
S		apparent power, VA
s		slip
T		torque, Nm, or period, s
t		time, s
u		linear speed, m/s
$\acute{V}$		phasor of voltage, V
V		constant value of voltage (e.g., rms or peak), V
$\mathbf{v}$		space vector of voltage, V
v		instantaneous voltage, V
X		reactance, Ω
$\boldsymbol{\alpha},\boldsymbol{\beta}$		angle, rad
η		Efficiency

$\boldsymbol{\theta}$		angular position, rad
$\acute{\Lambda}$		phasor of flux, Wb
Λ		rms value of flux, Wb
λ		space vector of flux, Wb
$\boldsymbol{\sigma}$		leakage factor
$\boldsymbol{\tau}$		time constant, s
$\boldsymbol{\omega}$		angular velocity or radian frequency, rad/s
$\boldsymbol{\phi}$		magnetic flux
e		revolving reference frame
s		stator reference frame
T		transposed
*		conjugate or reference
'		Estimated
μ		degree of membership
U, V		Union, maximum operator
$\cap$, Λ		Intersection, minimum operator
$\hat{A}$		Complement
e		Error
ce		Change in error

LIST OF ABBREVIATIONS

AI		Artificial Intelligent
ANFIS		Adaptive NeuroFuzzy Inference System
ASDs		Adjustable-Speed Drives
COA		Center of Area
CSI		Current Source Inverter
CVH		Constant Volts/Hertz
DFO		Direct Field Orientation
DOF		Degree Of Fulfillment
DSP		Digital Signal Processor
DTC		Direct Torque Control
EMF		Electromotive Force
EMI		Electromagnetic Interference
FLC		Fuzzy Logic Controller
GTO		Gate Tum-Off Thyristor
GUO		Graphical User Interface
IFO		Indirect Field Orientation
IGBT		Insulated Gate Bipolar Transistor
ITR		Ideal Transformer
IM		Induction Motor
MF		Membership Function
MMF		Magnetomotive Force
MOM		Mean of Maxima
NL		Negative Large
NM		Negative Medium
PF		Power Factor
PD		Proportional-Differentiation
PI		Proportional-Integral
PL		Positive Large

PM		Positive Medium
PWM		Pulse Width Modulation
SCR		Silicon Controlled Rectifier
SVPWM		Space Vector Pulse Width Modulation
VSI		Voltage Source Inverter
Z		Zero
SUBSCRIPTS		
A, B, C		phase A, phase B, phase C
a, b, c		phase A, phase B, phase C
act		actual
c		capacitive
cm		common mode
cr		critical
D		D-axis of revolving reference frame
d		d-axis of stator reference frame
dc		direct current
elec		electrical
eq		equivalent
f		field or flux
i, in		input
L		line or load
l ,$\boldsymbol{\sigma}$		leakage
M		Motor
m		magnetizing or peak
max		maximum
mech		mechanical
N		neutral
out		output
Q		Q-axis of revolving reference frame
q		q-axis of stator reference frame

R,r		rotor
S, s		stator
rat		rated
sh		slot harmonic
si		slip
St		starting
sw		switching
syn		synchronous