

قال تعالى:

﴿بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ﴾ (1) رَبِّ اِنْعَمْ اَلَمْ يَلِنْ دَ (2) نِ الرَّحِيمِ (3) يَوْمَ
اِيَّاكَ نَذَعُنْ (4) اِيَّاكَ نَسْتَعِينُ (5) اَطْمِ اُسْتَقِرِّمِ اَطْمِ (6) ذِينَ اَنْعَمْتَ
عَلَيْهِمْ غَيْرِ اَلْمَغْضُوبِ عَلَيْهِمْ وَلَا الضَّالِّينَ (7) ﴿

صدق الله العظيم

سورة الفاتحة الآيات {1-7}

DEDICATION

To my Mother,

To the soul of my father,

To my husband,

To my sisters and brother, without their help, support, and patience, I could not have done this effort.

ACKNOWLEDGEMENTS

First, I would like to thank Uncle ALI to his support and encouragement .

I would like to thank and appreciate the effort which was done by my advisor Dr. Nagm Eldean Abdo Mustafa Hassanian.

I would also like to thank my loving family for their support, motivation and help, and special thanks to my husband to his patience and support.

Without the support and encouragement of my family, and friends I would never have finished my degree.

Last, I would like to thank my dead father to his believe on me.

ABSTRACT

This research presents a performance based comparative study fuzzy PI controller to control the speed of squirrel-cage induction motor (SCIM) by replacing the conventional proportional–integral (PI) controller.

Performances of fuzzy PI controller also compared with the conventional PI speed controller in terms of several performance measures such as peak overshoot (Mp%), settling time (Ts).

The indirect vector control is simulated both with PI and Fuzzy pi controller and results are analyzed and compared. Fuzzy pi controller is found to perform better than the conventional PI controller.

المستخلص

هذا البحث يقيم اداء المحرك الحثي عند استخدام المتحكم التناسبي التكاملي الغامض

بدلا عن المتحكم التناسبي التكاملي.

المتحكم التناسبي التكاملي الغامض تمت مقارنته بالمتحكم التناسبي

التكاملي وقياس الاداء بواسطة اقصى قيمة لتجاوز الحد وزمن الاستقرار.

نظام التحكم بتوجيه المجال تم تمثيله بواسطة المتحكم التناسبي التكاملي

الغامض والمتحكم التناسبي التكاملي والنتائج تم تحليلها ومقارنتها.

وجد ان المتحكم التناسبي التكاملي الغامض افضل من اداء المتحكم التناسبي التكاملي

TABLE OF CONTENTS

HOLLY QURAN	I
DETECTION	II
ACKNOWLEDGEMENTS	III
المستخلص	V
TABLE OF CONTENTS	VI
LIST OF FIGURES	IX
LIST OF TABLES	XI
LIST OF SYMBOLS	XII
LIST OF ABBREVIATION	XIV
CHAPTER ONE	
INTRODUCTION	
1. 1 Introduction	1
1 .2 Problem	3
1.3 Objectives	3
1.4 Methodology	4
1.5 Thesis outline	4
CHAPTER TWO	
LITERATURE OVERVIEW	
2.1Introduction	5
2.2 Construction and Operation	5
2.2.1 Principle of rotating magnetic field	7
2.3 Speed Control of Induction Motors	7
2.3.1Speed Control Techniques	8
2.3.2 Variable rotor resistance control	9

2.3.3 Variable Stator Voltage	9
2.3.4 Scalar control	10
2.3.5 Vector Control or Field Orientated Control (FOC)	11
2.3.6 Proportional – Integral (PI) control	14
2.3.7 Fuzzy Logic Control	16
2.3.8 Components of FLC	17
2.3.9 Direct torque control	20
CHAPTER THREE MATHEMATICAL MODEL	
3.1 Introduction	22
3.2 Mathematical model of induction motor in dq coordinate	23
3.2.1 The Voltage Equation in dq Coordinate	23
3.2.2 The Flux Equation in dq Coordinate	23
3.2.3 The Torque Equation in dq Coordinate	24
3.2.4 Motion Equation	24
3.3 Vector Control of Induction Motor	25
3.3.1 Torque and flux equations for Vector Control	26
3.4 Indirect Field Orientation Method (IFO)	28
3.5 Matlab model of fuzzy controller	29
CHAPTER FOUR RESULTS AND DISCUSSION	
4.1 Introduction	33
4.2 Fuzzy pi results	35
4.3 PI results	39

4.4 Comparison between Fuzzy pi and Pi Controller Results	43
<p style="text-align: center;">CHAPTER FIVE</p> <p style="text-align: center;">CONCLUSION AND RECOMONDATION</p>	
5.1 Conclusion	49
5.2 RECOMMENDATION	50
REFFERENCES	51
APPENDIXES	55

LIST OF FIGURES

Figure No.	Title	Page No.
2.1	Induction motor rotor types	5
2.2	complete diagram of indirect vector control induction motor	14
2.3	Fuzzy Logic Controller Structure	17
3.1	Membership Functions for both the inputs	29
3.2	Membership Functions for the output	29
3.3	Rule Viewer with $e = 0.5$ and $\Delta e = 0.5$	31
3.4	3-dimensional view of control surface	31
4.1	block diagram of indirect vector control of induction motor	34
4.2	motor speed when using fuzzy pi controller at no load	36
4.3	torque when using fuzzy pi controller at no load	36
4.4	Stator current when using Fuzzy pi controller at no load	37
4.5	motor speed when using Fuzzy pi control at load torque =30N-m, at time t=1 sec.	37
4.6	torque when using Fuzzy pi control at load torque =30N-m, at time t=1 sec.	38
4.7	stator current of IVCIM when using Fuzzy pi control at load torque =30N-m, at time t=1 sec.	38
4.8	motor speed when using pi controller at no load	40
4.9	torque when using pi controller at no load	40
4.10	Stator current when using pi controller at no load	41
4.11	speed when using pi controller at load torque =30N-m, at time t=1.5 sec.	41

4.12	torque when using pi controller at load =30N-m, at time 1.5 sec.	42
4.13	stator current when using pi controller at load =30N-m, at time t=1.5 sec.	42
4.14	motor speed when applying load (30N-m) at t=2.5 sec and removing at 5sec.	44
4.15	Motor speed when applying load (30Nm) at t=1 sec and removing at 1.9sec.	45
4.16	torque when applying load (30N-M) at 2.5sec and removing at 5sec	45
4.17	Torque when applying load(30N-M) at 1sec and removing at 1.9sec.	46
4.18	stator current when applying load(30N-M) at 2.5 and removing at 5sec.	46
4.19	Stator current when applying load (30N-M) at 1sec and removing at 1.9sec.	47
4.20	Comparison between speed of fuzzy pi controller & pi controller when applying load at 1.5sec.	48

LIST OF TABLES

Table No.	Title	Page No.
1	the corresponding rule table for the speed controller	30
2	Induction motor parameters	34
3	Performance analysis of Fuzzy PI controller at load 0NM and 30 NM	35
4	Performance analysis of PI controller at load 0NM and 30 NM	39
5	Performance analysis of IM at applying and removing load	44

LIST OF SYMBOLS

Symbol	Description
N_s	Synchronous speed
R_r	Rotor resistance
R_s	Stator resistance
J	inertia
ΔT	Change of Torque
i_q, i_d	Direct & Quadrature axis current
L_s	Stator inductance
L_r	Rotor inductance
ψ	The multiplication of the flux linkage λ by the rated angular Speed
p	The d/dt operator
λ	The flux linkage
ω_e	Stator frequency
ω_r	Rotor electrical speed
$v_{qs}, v_{ds}, v_{qr}, v_{dr}$	The voltages of stator and rotor in dq reference frame
$i_{qs}, i_{ds}, i_{qr}, i_{dr}$	The currents of stator and rotor in dq reference frame
$\psi_{qs}, \psi_{ds}, \psi_{qr}, \psi_{dr}$	The flux linkages of stator and rotor in dq reference
p	Number of poles
T_e	The electromagnetic torque
Δi_{qs}^*	The components of stator current producing by torque
i_{qs}^*	The actual control signal U or current
L_d	Direct axes inductance

L_q	Quadrature axes inductance
k_p, k_i	The proportional and integral gain factors respectively
ω_2^*	The slip speed
ω_r^*	The reference command speed
E, e	the error
$CE, \Delta E, \Delta e$	derivative of error
T^*	The output torque
T_s	The sampling time
n_p	The motor's pole-pair
T_L	The load torque
I_a I_b I_c	Three phase currents
i_{qs}^s, i_{ds}^s	The currents of stator and rotor in stationary dq reference frame
i_{qs}^e, i_{ds}^e	The currents of stator and rotor in synchronous dq reference frame
ρ	Angular position
θ_2	The slip speed angle
θ_r	The rotor angle

LIST OF ABBREVIATIONS

DTC	Direct torque control
MOSFET	Metal Oxide Silicon Field Effect Transistor
IGBT	Insulated Gate Bipolar Transistor
PWM	pulse width modulation
PWM-VSI	pulse width modulation-voltage Source inverter
SVPWM	space vector pulse width modulation
VFD	variable frequency drive
FOC	field oriented control
IFO	indirect field oriented control
DFO	direct field oriented control
DTC	direct torque control
IM	induction machine
FLC	fuzzy logic controller
MF	membership function
COA	centre of area
MP%	over shoot
T _s	settling time

