

Abstract

Due to the increasing demand for compact and reliable motors and the evolution of low cost power semiconductor switches and permanent magnet (PM) materials, brushless motors became popular in every application from appliance and automotive to medical, military products and aerospace industry. Unlike brushed DC motors, every brushless motor requires a drive to supply commutated current to the motor windings synchronized to the rotor position. In other words, some kind of feedback position sensors is necessary to commutate brushless motors. PM brushless motor drives have sine wave and trapezoidal wave versions. The sin wave PM brushless motor drive, also called the PM synchronous motor drive, is fed by sine wave voltage and uses continuous rotor position feedback signals to control the commutation. On the other hand, the trapezoidal wave PM brushless motor drive, also called the PM brushless dc (BLDC) motor drive, is fed by trapezoidal wave voltage and uses discrete rotor position feedback signals to control the commutation.

In this work, some details about PM brushless motors are introduced from point of view of classifications, advantages, construction, operation, comparing it with brushed motor and induction motors. This kind of motor not only has the advantages of DC motor such as better velocity capability and no mechanical commutator but also has the advantage of AC motor such as simple structure, higher reliability and free maintenance. In addition, brushless DC motor has the following advantages: smaller volume, high force, and simple system structure. So it is widely applied in areas which need high performance drive.

From the control point of view, recently, many modern control methodologies such as nonlinear control, optimal control, variable structure control and adaptive control have been widely proposed for permanent magnet brushless DC motor. However, these approaches are either complex in theoretical bases or difficult to implement. Proportional-Integral-Derivative (PID) control with its three term functionality covering treatment to both transient and steady-states response, offers the simplest and yet most efficient solution to many real world control problems. In spite of the simple structure

and robustness of this method, optimally tuning gains of PID controllers have been quite difficult.

In this thesis the PID controller is used for speed control of a PM brushless DC motor which drives a load. The Particle Swarm Optimization (PSO) and Bacterial Foraging (BF) are used to tune the parameters of the PID speed controller to attain a specified response. These techniques are based on the minimization of a so called fitness function. Fitness function is the function which measures the performance of the system in the presence of PID controller with their parameters chosen by the proposed optimization techniques. Optimization techniques used in choosing the optimum PID parameters are usually based on knowing the model of the system to be controlled where the (BLDC) motor is modeled in simulink at Matlab. The proposed technique was more efficient in improving the step response characteristics as well as reducing the steady-state error, rise time, settling time and maximum overshoot.

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Contents

	Page
Abstract	I
Acknowledgement	III
Contents	IV
List of Figures	VII
List of Tables	X
List of Main Symbols	XI
List of Main Abbreviations (Nomenclature)	XIII
Chapter (1): Introduction	1
1.1 General	1
1.2 Literature review	1
1.2.1 PM Brushless Motors (PMBL)	1
1.2.2 PID Controller	2
1.2.3 PID Controller Parameter Tuning	3
1.2.3.1 Traditional Methods	4
1.2.3.1.1 Ziegler-Nichols (ZN) Tuning Rule	4
1.2.3.1.2 Relay Feedback Tuning Method	8
1.2.3.1.3 Kappa-Tau Tuning Rule	10
1.2.3.1.4 Pole Placement Tuning Rule	10
1.2.3.1.5 Dominant Pole Design	11
1.2.3.1.6 Design Based on Gain and Phase Margin Specifications	12
1.2.3.2 Intelligent Methods	13
1.2.3.2.1 Incremental Fuzzy Expert PID Control (IFE)	13
1.2.3.2.2 Fuzzy PID speed Controller	14
1.2.3.3 Biological Optimization Algorithms	16
1.2.3.3.1 Genetic Algorithm (GA-PID)	16
1.2.3.3.2 Particle Swarm Optimization (PSO-PID)	17
1.2.3.3.3 Bacterial Foraging Optimization (BFO-PID)	19
1.3 Thesis Objective	20
1.4 Thesis Outlines	20

Chapter (2): Fundamentals of Control System	22
2.1 Motion Controller	22
2.2 Transducers and Sensors	22
2.2.1 Position Transducers	23
2.2.2 Velocity Transducers	31
2.2.3 Presence Sensors	32
2.3 Actuators	35
2.4 DC Motors	36
2.4.1 Wound Field DC Motor	36
2.4.2 Brushless DC (BLDC) Motor	38
2.4.2.1 Construction and Operating Principle	39
2.4.2.2 Electronic Commutation	41
2.4.2.3 Comparing BLDC Motor to Other Motors Types	44
2.5 Motor Drive Configuration	47
2.5.1 Drive Controller	47
2.5.2 Power Converter	48
2.5.2.1 Single Phase Converter	48
2.6 PID Speed Control of BLDC Motor	53
2.6.1 Adjusting the PID Gains	56
Chapter (3): Mathematical Model of Brushless DC Motor	58
3.1 Build Up The Complete System Simulink Model	63
3.1.1 BLDC Motor Model	63
3.1.2 Three-Phase Inverter	65
3.1.3 PID Controller Simulink Model	69
Chapter (4): Optimization Techniques	71
4.1 Introduction	71
4.2 Optimization Problem Classification	71
4.3 Selection Factors	73
4.4 General Formulation of Optimization Problem	73
4.5 Compromise Solution Methods for Multi-Objective Problems	75
4.5.1 Weighted Sum Method	75
4.5.2 Global Criterion Method	76
4.5.3 Constraint (Trade-Off) Method	77
4.5.4 Sequential (Lexico Graphic) Method	79

4.5.5 Min.-Max. (Goal Attainment) Method	80
4.5.6 Integrated Absolute Error (IAE)	81
4.5.7 Integrated Square Error (ISE)	82
4.5.8 Integrated of Time-Weighted-Absolute-Error(ITAE)	82
4.6 Stochastic Optimization Techniques	83
4.6.1 Particle Swarm Optimization (PSO)	83
4.6.1.1 Background of Particle Swarm Optimization	84
4.6.1.2 Parameter Selection	87
4.6.1.3 PSO Advantages	88
4.6.1.4 Tuning of PID Controller with PSO (PSO-PID)	88
4.6.2 Bacterial Foraging (BF) Technique	89
4.6.3 Application of (BF) Technique	92
Chapter (5): Simulation Results	93
5.1 Measurements of BLDC Motor Voltage and Current	93
5.2 Step Response with (PSO-PID)	95
5.3 Step Response with (BF-PID)	97
5.4 Speed Tracking Control	100
Chapter (6): Conclusion and Future Work	103
6.1 Conclusion	103
6.2 Future Work	104
References	105
Appendix A: Implementation Algorithms (PSO,BFO)	109
Appendix B: (BLDC) Parameters	114
ملخص الرسالة	116

List of Figures

Figure No.	Caption	Page
Figure (1.1):	Determination of model parameters from a step response	5
Figure (1.2):	Nyquist curve of the process $G(i\omega)$	6
Figure (1.3):	Nyquist curve the process and the identified point A	7
Figure (1.4):	Scheme of the relay feedback test	8
Figure (1.5):	System output signal and output for relay feedback	8
Figure (1.6):	The limit cycle parameters with, (a) Ideal relay. (b)Relay with hysteresis	9
Figure (1.7):	Dominant poles of closed loop system	12
Figure (1.8):	Block diagram of fuzzy self-adjusting PID controller	15
Figure (1.9):	Control scheme of fuzzy set-point weighting (FSW)	16
Figure (1.10):	Optimal PID control	17
Figure (2.1):	A typical motion control system	22
Figure (2.2):	Resolver and corresponding signals	24
Figure (2.3):	Optical encoder	25
Figure (2.4):	Components and operating principle of a rotary absolute encoder	26
Figure (2.5):	Disk of absolute encoder and its output signal	27
Figure (2.6):	Components and operating principle of a rotary incremental encoder	27
Figure (2.7):	Quadrature encoder output channels A and B	28
Figure (2.8):	Usage of complementary channel \bar{A} with channel A to cancel noise	29
Figure (2.9):	Connection of encoder to counter of DAQ card	29
Figure (2.10):	Limit switch	32
Figure (2.11):	Inductive proximity sensor	33
Figure (2.12):	Capacitive proximity sensor	34
Figure (2.13):	Speed/Torque characteristics for wound field DC motor	37
Figure (2.14):	Trapezoidal back EMF	40
Figure (2.15):	Sinusoidal back EMF	40
Figure (2.16):	Stator of BLDC motor	40
Figure (2.17):	Rotor magnet cross section	41
Figure (2.18):	Three-phase Bridge and coil current direction	42
Figure (2.19):	Trapezoidal control with Hall sensor feedback	43
Figure (2.20):	Three-phase full-bridge power circuit for BLDC motor drive	43
Figure (2.21):	BLDC motor transverse section	43
Figure (2.22):	DC drive built-in controllers	47

Figure (2.23): One quadrant converter (a) Circuit diagram (b) Voltage-current diagram	49
Figure (2.24): Two quadrant converter (a) Circuit diagram (b) Voltage-current diagram	50
Figure (2.25): Two quadrant converter (a) Normal operation (b) braking with field reversal (c) Regenerative braking with armature reversal	50
Figure (2.26): Voltage-current diagram	51
Figure (2.27): Single-phase dual converter	52
Figure (2.28): Typical brushless drive system	53
Figure (2.29): PID diagram	54
Figure (3.1): BLDC motor model	64
Figure (3.2): Three-phase inverter	65
Figure (3.3): Gating signals with phase shift 60°	66
Figure (3.4): Simulink inverter model	67
Figure (3.5): Simulink gate signal generation model	68
Figure (3.6): Trapezoidal back emf function	68
Figure (3.7): Simulink PID controller model	69
Figure (3.8): Complete simulink block diagram of the system with PID controller	70
Figure (4.1): Graphical representation of constaraint method	78
Figure (4.2): Concept of modification of a searching point by PSO	86
Figure (4.3): flow chart of PSO	87
Figure (5.1): Line – Line voltage V_{ab}	93
Figure (5.2): Effect of torque variation (50% from full load torque)on three-phase currents of the stator	94
Figure (5.3): Effect of torque variation (75% from full load torque)on three-phase currents of the stator	94
Figure (5.4): Phase voltage V_a	95
Figure (5.5): Torque / Speed characteristics	95
Figure (5.6): Step response of the closed loop system with PSO-PID controller using ITSE based fitness function and without PSO-PID controller	96
Figure (5.7): Effect of torque variation (75% from full load torque) on the speed response using PSO	97
Figure (5.8): Variation of external load torque (75% from full load torque)	97
Figure (5.9) : Step response of the closed loop system with BF-PID controller using ITSE based fitness function and without BF-PID controller	98
Figure (5.10): Effect of torque variation (50% from full load torque) on the speed response using BF technique	99

Figure (5.11): Variation of external load torque (50% from full load torque)	99
Figure (5.12): Step response of the closed loop system with (PSO, BF) PID controller ITSE based fitness function and without (PSO, BF) PID controller	100
Figure (5.13): Variable reference speed (Rad. / Sec.)	100
Figure (5.14): Variation of electrical rotor angular speed (Rad. / Sec.) without using controller	101
Figure (5.15): Variation of electrical rotor angular speed (Rad. / Sec.) according to variable reference by using (PSO-PID) controller	101
Figure (5.16): Variation of electrical rotor angular speed (Rad. / Sec.) according to variable reference by using (BF-PID) controller	102

List of Tables

Table No.	Title	Page
Table (1.1):	ZN PID step response tuning parameters	5
Table (1.2):	ZN PID frequency response tuning parameters	6
Table (2.1):	Switching sequence of BLDC motor	42
Table (2.2):	Comparing BLDC motor to a brushed DC motor	44
Table (2.3):	Difference between PMSM and BLDC	46
Table (2.4):	Summary of control operation of DC motor	52
Table (5.1):	PSO-PID controller parameters	96
Table (5.2):	BF-PID controller parameters	98

List of Main Symbols

β	Weighting factor
v	Velocity
e_{ss}	Steady-state error
F	Fitness function value
I	Current
K_d	Derivative gain
K_i	Integral gain
K_p	Proportional gain
M_p	Maximum overshoot
N_c	Number of chemotactic steps
N_{ed}	Number of elimination-dispersal events
N_{re}	Number of reproduction steps
N_s	Swimming length
p	Dimension of search space
P_{ed}	Elimination dispersal probability
q	Time shift operator
s	Total number of bacteria
t_r	Rise time

t_s Settling time

V Voltage

List of Main Abbreviations (Nomenclature)

AC	Alternating Current
ADC	Analog to Digital Converter
AVR	Automatic Voltage Regulator
BF	Bacterial Foraging
BFOA	Bacterial Foraging Optimization Algorithm
BLAC	Brushless AC
BLDC	Brushless DC
DAC	Digital to Analog Converter
DC	Direct Current
EC	Evolutionary Computing
E-coli	Escherichia coli
EMF	Electromotive Force
FOC	Field Oriented Control
GA	Genetic Algorithm
I	Integral
IAE	Integrated Absolute Error
IFE	Incremental Fuzzy Expert
ISE	Integrated of squared error
ITAE	Integrated of Time weight Absolute Error

ITSE	Integrated of Time weight Squared Error
MOP	Multi-objective Optimization
Nd	Neodymium
OE	Output Error
P	Proportional
PID	Proportional-Integral-Derivative
PM	Permanent Magnet
PMBL	Permanent Magnet Brushless
PMSM	Permanent Magnet Synchronous Motor
PSO	Particle Swarm Optimization
PWM	Pulse Width Modulation
SmCo	Samarium Cobalt
SOP	Single Objective Optimization
WGAM	Weighted Goal Attainment Method
ZN	Ziegler Nichols