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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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
Nc	Number of chemotactic steps
Ned	Number of elimination-dispersal events
Nre	Number of reproduction steps
Ns	Swimming length
p	Dimension of search space
Ped	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