

Contents

1 Introduction	1
1.1 DC Motors	1
1.1.1 Advantages Of DC Motors	1
1.1.2 Disadvantages Of DC Motors	2
1.2 AC Motors	2
1.2.1 Advantages Of AC Motors	2
1.2.2 Disadvantages Or Limitations Of AC Motors	3
1.2.3 Permanent Magnet Synchronous Motors	3
1.3 Brush Less DC Motors (BLDCM)	6
1.3.1 Rotor	9
1.3.2 Hall Sensors	10
1.3.3 Construction Of BLDC Motor	10
1.3.4 Applications Of BLDC Motors	14
1.3.5 Advantages of BLDC Motors	15
1.3.6 Disadvantages Of BLDC motors	15
1.4 Control strategies for speed control of a general motor	18
1.5 PID Controller	18
1.5.1 Fuzzy Logic Controller	22
1.5.2 Fuzzification	25
1.5.3 Membership Functions	25
1.5.4 Fuzzification Methods	27
1.5.5 Knowledge Base	30
1.5.6 Inference Engine	31
1.5.7 Fuzzy Rule Base	32
1.5.8 Defuzzification	38
1.5.9 Assumptions in a Fuzzy control System Design	42
1.6 Outline of the Ph.D. Thesis:	44

2 Formulation Of The Problem	45
2.1 Block diagram of Speed Control of BLDC Motor and its working	45
2.1.1 Hardware Components Used in Speed Control System	46
2.1.1.1 Analog input card (SCXI-1122)	48
2.1.1.2 Analog output card (SCXI-1124)	49
2.1.1.3 DAQ (Data Acquisition) Board	49
2.1.1.4 Pulse width modulation (PWM) controller	52
2.1.1.5 Driver Circuit	54
2.1.2 Software	
2.1.2.1 LabVIEW	54
2.1.2.2 Front panel	55
2.1.2.3 Block diagram	55
2.1.2.4 Tools palette	57
2.1.2.5 Controls palette	57
2.1.2.6 Functions palette	57
2.1.2.7 PID Toolkit	58
2.1.2.8 Fuzzy logic tool kit	59
2.2 Literature survey and motivation for the present work	60
2.2.1 General Literature Survey	60
2.2.2 Literature Survey on Fuzzification, Rule Base and Defuzzication	64
2.2.3 Literature Survey on the Application of PID, FLC and IFLC for the Speed Control of BLDC Motor Drives	70
2.2.4 Literature Survey on the FLC and IFLC for the Effect of Noise/ Disturbance	79
2.3 Motivation for the Present Work	84
3 Design and Development of PID and Auto Tuned PID Controllers	86
3.1 VI block diagram for PID control using Lab VIEW	86

3.2 Auto tuned PID controller	87
3.3 Experimental Results and Discussion	88
4 Design and Development of FLC/AIFLC controllers	91
4.1 Design and Development of C2ISO FLC	91
4.1.1 Selection of number of Traingular membership functions	91
4.1.2 Selection of defuzzification method	93
4.1.3 Sampling rate	93
4.1.4 Experimental results and discussions	93
4.1.5 Conclusions	96
4.2 Design and development of C3ISO FLC	97
4.2.1 VI block diagram for 3ISO FLC	97
4.3 Design and development of 2 input AIFLC	97
4.3.1 VI Block diagram for 2ISO AIFLC	99
4.4 Design and development of C3ISO AIFLC	99
4.5 Desired speed	100
4.6 Load variations	100
4.7 Brake applications	100
4.8 Effect of noise on FLC/ AIFLC/(C2ISO and C3ISO)	104
4.8.1 Design and development of FLC and AIFLC (C2ISO andC3ISO) for studying the effect of noise on speed control of BLDC motor	104
4.8.2 Separation of Gaussian white noise using IIR filter	106
4.9 Design and development of controllers for suppressing Gaussian white noise introduced in FLC and AIFLC (C2ISO and C3ISO) using IIR filter	107
5. Results and Discussion	
5.1 PID and auto tuned PID controllers	111
5.2 Fuzzy Logic Controller (FLC) and Auto Integrated Fuzzy Logic Controller (AIFLC)	112

5.3 Gaussian white Noise	118
5.3.1 2 ISO FLC	118
5.3.2 3 ISO FLC	118
5.3.3 2ISO AIFLC	119
5.3.4 3 ISO AIFLC	119
5.4 IIR filter	119
6 Conclusions	
6.1 PID and auto tuned PID controllers	121
6.2 Fuzzification and defuzzification methods	121
6.3 MISO FLC/AIFLC	122
6.4 Brake application	123
6.5 Load variations	123
6.6 Effect of Gaussian white noise	123
6.7 IIR (chebyshev) filter	124
6.8 Scope of the future work	125
Appendix	
Results of speed control of BLDC motor	
List of Abbreviations	
Photographs of BLDC motor	