

CONTENTS

Chapter 1 PREFACE	1
1.1 Introduction	1
1.2 Basic concepts of linear servo unit	3
1.3 Research background and significance	4
1.3.1 Elliptical piston parts and their CNC turning.....	4
1.3.2 Active vibration control with CNC turning and other applications.....	6
1.3.3 Research base and the current problem.....	6
1.3.4 Significance of the research	7
1.4 Research background in China and other country on linear servo unit	8
1.5 The main purpose of the dissertation.....	10
1.6 Chapter summary	13
Chapter 2 Research on structure of the linear servo unit	14
2.1 Introduction	14
2.2 Basic VCM magnetic circuit and its problem	14
2.2.1 The effect by the gap parameters	15
2.2.2 The effect by the requirement of velocity and acceleration	16
2.3 Combinatorial driving structure	20
2.3.1 Rectangle magnetic structure	21
2.3.2 Basic magnetic combinatorial method and structure	22
2.3.3 The design for combinatorial structure	23
2.4 Structure design for bearing and assembling	24
2.4.1 Bearing structure	24
2.4.2 Assembling method and structure design.....	27
2.5 System model and its analysis	28
2.5.1 System model	28
2.5.2 Identification and analysis of the open loop system	30
2.5.3 The effect on the system characteristics by the motor structure parameters	36
2.6 Chapter summary	37
Chapter 3 Magnetic circuit design and realization of the linear motor	38
3.1 Introduction	38

Contents

3.2 Magnet selection and basic design method	39
3.2.1 Magnet selection.....	39
3.2.2 Basic design method	40
3.3 Structure coefficient method for NdFeB magnetic circuit	42
3.3.1 Structure coefficient	42
3.3.2 Structure coefficient design method	43
3.3.3 Design analysis for axis direction magnetic circuit	45
3.3.4 Structure coefficient and magnet cost.....	47
3.4 Steps using structure coefficient design method	48
3.5 Design example and features comparison	48
3.5.1 Design example for axis magnetic circuit.....	48
3.5.2 Magnetic leak coefficient and distributing of the magnetic field.....	50
3.6 Chapter summary	52
Chapter 4 Repetitive learning controller for linear servo unit.....	53
4.1 Introduction	53
4.2 Repetitive learning controller.....	54
4.2.1 Principle and structure	54
4.2.2 Design and analysis of repetitive learning controller	57
4.2.3 Design steps and method for repetitive controller.....	61
4.3 The application of digital repetitive controller for linear servo unit	62
4.3.1 Digital transfer function model of the linear servo motor	62
4.3.2 Linear servo unit repetitive controller	63
4.4 Computer simulation.....	64
4.4.1 Computer simulation for repetitive controller.....	64
4.4.2 Linear servo unit repetitive controller with variable gain.....	65
4.5 Chapter summary	67
Chapter 5 Linear servo unit nonlinear PID controller	68
5.1 Introduction	68
5.2 Nonlinear feedback tracking controller.....	68
5.2.1 Nonlinear tracking differentiator	68
5.2.2 Linear servo unit nonlinear extension state observer	71
5.2.3 Linear servo unit nonlinear controller	75
5.2.4 Simulation on nonlinear tracking controller for linear servo unit	77
5.3 Nonlinear feedback repetitive learning controller	79

Contents

5.3.1 Principle and structure	79
5.3.2 Simulation on nonlinear learning controller	81
5.4 Chapter summary	84
Chapter 6 The realization of the linear servo unit.....	85
6.1 Introduction	85
6.2 Non hardware dependent structure (NHD).....	85
6.2.1 The basic idea of NHD.....	85
6.2.2 Software and hardware requirements for NHD structure.....	86
6.3 NHD controller based on DSP (NHD-DSP).....	86
6.3.1 General requirements	86
6.3.2 Controller and structure based on DSP.....	88
6.3.3 Communication of the system	90
6.3.4 The management and reconstruction of the system control algorithm	90
6.3.5 Software function and structure.....	91
6.4 The application of NHD-DSP controller for PC- based CNC elliptical piston turning system.....	92
6.4.1 Special CNC system and open structured CNC system	92
6.4.2 Noncircular parts CNC turning system using NHD-DSP controller... <td>92</td>	92
6.5 Chapter summary	94
Chapter 7 Application research of linear servo unit	95
7.1 Introduction	95
7.2 Extracted CNC system (ECNC).....	95
7.2.1 System structure for ECNC system	96
7.2.2 The construction of the ECNC system.....	98
7.3 Using linear servo unit in ECNC system	102
7.3.1 Circular and noncircular CNC turning.....	102
7.3.2 The realization of ECNC noncircular turning system.....	103
7.3.3 The structure of the ECNC noncircular turning system.....	103
7.4 Linear servo unit and experiments on ECNC system	105
7.5 Chapter summary	108
Chapter 8 Conclusions.....	109
References	111
Publications.....	120
Acknowledgements	122