

Contents

Acknowledgments — V

Preface — VII

1 Introduction — 1

- 1.1 Overview of fuel cell — 1
- 1.2 Classification of fuel cell — 2
- 1.3 Characteristics of fuel cell — 2
- 1.4 PEM fuel cell working principle — 4
- 1.5 Characteristics of the PEM fuel cell — 6
- 1.6 Research progress for the control method of the PEM fuel cell — 6
- 1.7 Problems in the fuel cell control — 8
- References — 9

2 Setup of the PEM fuel cell experiment platform — 13

- 2.1 Overall architecture — 13
- 2.2 Gas supply subsystem — 13
- 2.3 Humidification subsystem — 18
- 2.4 Power conditioning subsystem — 20
- 2.5 Control subsystem — 20
- References — 23

3 Modeling of the PEM fuel cell system — 25

- 3.1 Stack voltage model — 25
- 3.2 Cathode flow model — 26
- 3.3 Anode flow model — 28
- 3.4 DC/DC converter model — 29
- 3.5 Simulink model — 30
- References — 33

4 Control of PEM fuel cell without load current feedback — 35

- 4.1 SPM-based ASFPC — 35
 - 4.1.1 Joint estimation of states and parameters based on SPM — 35
 - 4.1.2 SPM-based controller design without considering noise estimation information — 40
 - 4.1.3 SPM-based controller design considering noise estimation information — 43
- 4.2 Real-time simplified VDFLC — 46
 - 4.2.1 Control structure — 46

4.2.2	Real-time fuzzy inference strategy —	46
4.3	Simulations and experiments —	51
4.3.1	SPM-based ASFPC —	51
4.3.2	Real-time simplified variable-domain fuzzy control —	59
4.3.3	Comparison of two control methods —	68
4.4	Source codes —	71
4.4.1	Joint estimation of parameters and states without considering noise information (M file) —	71
4.4.2	Joint estimation of parameters and states considering noise information (M file & C-Sfunction) —	72
4.4.3	ASFPC algorithm based on SPM —	83
4.4.4	Real-time simplified VDFLC algorithm —	95
	References —	108
5	Control of PEM fuel cell with load current feedback —	111
5.1	Control approach for underactuated systems based on fuzzy reasoning and random search optimization —	111
5.1.1	Dynamically connected fuzzy inference model based on the single-input rule modules —	111
5.1.2	Random search optimization —	113
5.2	Controller design for PEM fuel cell flow underactuated system —	118
5.2.1	Control strategy —	118
5.2.2	Fuzzy controller design —	118
5.3	Output tracking control —	122
5.3.1	Fuzzy cluster modeling of fuel cell —	122
5.3.2	Sliding mode output tracking control —	125
5.3.3	Steady-state compensation —	126
5.4	Simulations and experiments —	127
5.4.1	Fuzzy control based on SIRMs dynamically connected fuzzy inference model and the random search —	127
5.4.2	Output tracking control —	131
5.5	Source codes —	138
5.5.1	SIRMs-based dynamically connected fuzzy inference control (Fixed ID) —	138
5.5.2	SIRMs-based dynamically connected fuzzy inference control (DID, Version 1) —	151
5.5.3	SIRMs-based dynamically connected fuzzy inference control (DID, Version 2) —	173
5.5.4	Output tracking control —	194
	References —	208

6 Conclusion and future work — 209

6.1 Conclusion — 209

6.2 Future work — 210

Index — 213