

# Contents

<b>1</b>	<b>Introduction</b>	1
1.1	Background and Motivation	1
1.2	Review of Prior Work	4
1.3	Overview of the Bidirectional Closed-Loop Brain–Machine Interface System	10
1.4	Outline of This Book	13
<b>2</b>	<b>Neural Recording Front-End Design</b>	17
2.1	Introduction	17
2.1.1	Signal Characteristics	18
2.1.2	Design Specifications	19
2.2	Design of a Low-Noise Neural Amplifier	21
2.2.1	Review of Prior Work	21
2.2.2	Circuit Implementation	24
2.2.3	Measurement Results	29
2.3	A Pre-whitening Neural Amplifier	32
2.3.1	Introduction	32
2.3.2	Analysis of Pre-whitening Neural Amplifier Design	33
2.3.3	Circuit Implementation	40
2.3.4	Measurement Results	41
2.4	Design of a Low-Power Analog-to-Digital Converter	45
2.4.1	Introduction	45
2.4.2	Circuit Implementation	46
2.4.3	Measurement Results	48
2.5	A Compressed Sensing Neural Signal Acquisition System	51
2.5.1	Introduction	51
2.5.2	A Brief Background of Compressed Sensing	53
2.5.3	System Overview	54
2.5.4	Circuit Implementation	56
2.5.5	Measurement Results	63

<b>3</b>	<b>Neural Feature Extraction</b>	69
3.1	Introduction	69
3.2	Natural Logarithmic Domain Field Potential Energy Extraction	71
3.2.1	Introduction	71
3.2.2	System and Circuits Implementation	72
3.2.3	Measurement Results	79
3.3	Action Potential Discrimination	82
3.3.1	Introduction	82
3.3.2	Circuit Implementation	86
3.3.3	Experimental Results	89
3.4	Matched Filter for Neural Feature Extraction	92
3.4.1	Introduction	92
3.4.2	Matched Filter and Pre-whitening for Optimum Correlation Detection	93
3.4.3	Methodologies	95
3.4.4	Experimental Results	98
<b>4</b>	<b>Neural Stimulator Design</b>	103
4.1	Introduction	103
4.1.1	Background of Neurostimulation	104
4.1.2	Electrode and Electrolyte Interface	104
4.2	Overview of Electrical Stimulator Design	105
4.2.1	Methods of Stimuli Generation	107
4.2.2	Stimulation Waveform and Electrode Configuration	108
4.2.3	Methods for Charge Balancing	110
4.3	Design of a General-Purpose Stimulator	112
4.3.1	Architecture of the Stimulator	112
4.3.2	Circuit Implementation	113
4.3.3	Measurement Results	115
4.4	An Energy Efficient Net-Zero Charge Neural Stimulator	118
4.4.1	Introduction	118
4.4.2	Motivation and Innovation	119
4.4.3	Circuit Implementation	123
4.4.4	Experimental Results	130
4.4.5	Conclusion	134
<b>5</b>	<b>Bidirectional Neural Interface and Closed-Loop Control</b>	137
5.1	Introduction	137
5.2	Stimulation Artifacts in the Bidirectional Neural Interface	138
5.2.1	Introduction	138
5.2.2	Review of Prior Work	139
5.2.3	Analysis of Stimulation Artifacts	140
5.2.4	Methods	145
5.2.5	Experimental Results	147
5.2.6	Conclusion	152

5.3	Closed-Loop Neural Interface System .....	155
5.3.1	Introduction .....	155
5.3.2	Mechanism of Closed-Loop Neural Interface System .....	156
5.3.3	Design of a Closed-Loop Neural Interface with a PID Controller .....	158
<b>6</b>	<b>System Integration and Experiments .....</b>	<b>165</b>
6.1	Introduction .....	165
6.2	The PennBMBI: A General-Purpose Experimental Platform .....	166
6.2.1	Introduction .....	166
6.2.2	System Overview .....	167
6.2.3	Hardware Implementation .....	169
6.2.4	Experimental Results .....	175
6.3	The Watermaze .....	179
6.3.1	Introduction and Background .....	179
6.3.2	System Overview .....	181
6.3.3	Hardware Implementation .....	182
6.3.4	Software Implementation .....	190
6.3.5	Experimental Results .....	196
6.4	Bidirectional Neural Interface for Freely Behaving Macaque .....	199
6.4.1	Introduction and Background .....	199
6.4.2	Circuit and System Design .....	200
6.4.3	Experimental Results .....	206
<b>7</b>	<b>Conclusion and Future Direction .....</b>	<b>217</b>
7.1	Summary of the Work .....	217
7.2	Future Direction .....	219
	<b>Bibliography .....</b>	<b>221</b>
	<b>Index .....</b>	<b>237</b>

Brain-Machine Interface

Closed-loop Bidirectional System Design

Liu, X.; Van der Spiegel, J.

2018, XXXIII, 242 p. 213 illus., 158 illus. in color.,

Hardcover

ISBN: 978-3-319-67939-6