

# Contents

Nomenclature . . . . .	XI
<b>1 Introduction</b>	<b>1</b>
1.1 Definition of block pulse functions . . . . .	1
1.2 Elementary properties of block pulse functions . . . . .	2
1.3 Block pulse series expansions . . . . .	4
1.4 Convergence of block pulse series . . . . .	6
1.5 Two dimensional block pulse functions . . . . .	9
<b>2 Operations of block pulse series</b>	<b>11</b>
2.1 Vector forms of block pulse series . . . . .	11
2.2 Elementary operation rules . . . . .	13
2.3 Other operation rules . . . . .	25
2.4 Recursive formulas of integrals . . . . .	36
2.5 Notes on operational matrices . . . . .	39
<b>3 Block pulse operators</b>	<b>42</b>
3.1 Definition of block pulse operators . . . . .	42
3.2 Properties of block pulse operators . . . . .	44
3.3 Operation rules of block pulse operators . . . . .	45
3.4 Extensions of block pulse operators . . . . .	50
3.5 Notes on block pulse operators . . . . .	53

<b>4</b>	<b>Block pulse transforms</b>	<b>56</b>
4.1	Definition of block pulse transforms . . . . .	56
4.2	Operation rules of block pulse transforms . . . . .	60
4.3	Extensions of block pulse transforms . . . . .	62
<b>5</b>	<b>Block pulse operational matrices for integrations</b>	<b>67</b>
5.1	Improved integration operational matrix . . . . .	67
5.2	Generalized integration operational matrices . . . . .	71
5.3	Properties of generalized integration operational matrices . . . . .	75
5.4	Discrete integrators and integration operational matrices . . . . .	85
5.5	Extended integration operational matrices . . . . .	87
5.6	Properties of extended integration operational matrices . . . . .	92
<b>6</b>	<b>Nonparametric representations of dynamic systems</b>	<b>104</b>
6.1	Block pulse transfer matrices of linear systems . . . . .	104
6.2	Block pulse transfer matrices and differential equations . . . . .	111
6.3	Block pulse transfer matrices and system block diagrams . . . . .	116
6.4	Identification of block pulse transfer matrices . . . . .	122
<b>7</b>	<b>Input-output representations of dynamic systems</b>	<b>126</b>
7.1	Single-input single-output time-invariant linear systems . . . . .	126
7.1.1	System analysis . . . . .	127
7.1.2	System identification . . . . .	128
7.1.3	Block pulse regression equations . . . . .	131
7.1.4	Sensitivity analysis . . . . .	137
7.2	Single-input single-output time-varying linear systems . . . . .	139
7.2.1	System analysis . . . . .	140
7.2.2	System identification . . . . .	141
7.2.3	Block pulse regression equations . . . . .	142

7.3	Multi-input multi-output linear systems . . . . .	148
7.3.1	System analysis . . . . .	148
7.3.2	System identification . . . . .	149
7.4	Linear systems containing time delays . . . . .	150
7.4.1	System analysis . . . . .	151
7.4.2	System identification . . . . .	151
7.5	Hammerstein model nonlinear systems . . . . .	153
7.5.1	System analysis . . . . .	154
7.5.2	System identification . . . . .	154
7.6	Inversions of Laplace transforms . . . . .	156
7.6.1	Functions in general forms . . . . .	156
7.6.2	Functions in special forms . . . . .	159
7.7	Integral equations . . . . .	162
7.7.1	Deconvolutions . . . . .	162
7.7.2	Fredholm integral equations . . . . .	165
7.7.3	Volterra integral equations . . . . .	166
<b>8</b>	<b>State space representations of dynamic systems</b>	<b>169</b>
8.1	Time-invariant linear systems . . . . .	169
8.1.1	System analysis . . . . .	169
8.1.2	System identification . . . . .	173
8.1.3	Optimal control . . . . .	174
8.2	Time-varying linear systems . . . . .	179
8.2.1	System analysis . . . . .	179
8.2.2	System identification . . . . .	181
8.2.3	Optimal control . . . . .	183
8.3	Linear systems containing time delays . . . . .	186
8.3.1	System analysis . . . . .	186
8.3.2	System identification . . . . .	189
8.4	Bilinear systems . . . . .	191

8.4.1	System analysis . . . . .	191
8.4.2	System identification . . . . .	195
8.5	Hammerstein model nonlinear systems . . . . .	197
8.5.1	System analysis . . . . .	197
8.5.2	System identification . . . . .	198
8.6	General nonlinear systems . . . . .	200
8.6.1	System analysis . . . . .	200
8.6.2	System identification . . . . .	202
<b>9</b>	<b>Practical aspects in using block pulse functions</b>	<b>203</b>
9.1	Use of sampled data in block pulse function methods . . . . .	203
9.2	Influence of noise in block pulse function methods . . . . .	207
9.3	Practical applications of block pulse function methods . . . . .	211
<b>A</b>	<b>Some block pulse integration operational matrices</b>	<b>215</b>
<b>B</b>	<b>Some formulas about upper triangular matrices</b>	<b>219</b>
<b>C</b>	<b>Some relations in block pulse difference equations</b>	<b>223</b>
	<b>References</b>	<b>227</b>
	<b>Index</b>	<b>236</b>