



W. Bolton

Instrumentation and Control Systems



Contents

	<i>Preface</i>	ix
1	Measurement systems	
	1.1 Introduction	1
	1.2 Instrumentation systems	2
	1.3 Performance terms	5
	1.4 Reliability	10
	1.5 Requirements	11
	Problems	14
2	Instrumentation system elements	
	2.1 Introduction	17
	2.2 Displacement sensors	17
	2.3 Speed sensors	24
	2.4 Fluid pressure sensors	25
	2.5 Fluid flow	27
	2.6 Liquid level	31
	2.7 Temperature sensors	33
	2.8 Sensor selection	38
	2.9 Signal processing	39
	2.10 Signal transmission	54
	2.11 Smart systems	57
	2.12 Data presentation elements	58
	Problems	62
3	Instrumentation case studies	
	3.1 Introduction	68
	3.2 Case studies	68
	3.3 Data acquisition systems	74
	3.4 Testing	77
	Problems	79
4	Control systems	
	4.1 Introduction	82
	4.2 Control systems	83
	4.3 Basic elements	86
	4.4 Case studies	89
	4.5 Discrete-time control systems	98
	Problems	98

5	Process controllers	5.1	Introduction	101
		5.2	On-off control	102
		5.3	Proportional control	104
		5.4	Derivative control	108
		5.5	Integral control	110
		5.6	PID control	112
		5.7	Tuning	115
		5.8	Digital systems	119
			Problems	121
6	Correction elements	6.1	Introduction	125
		6.2	Pneumatic and hydraulic systems	125
		6.3	Directional control valves	129
		6.4	Flow control valves	135
		6.5	Motors	142
		6.6	Case studies	149
			Problems	151
7	PLC systems	7.1	Introduction	156
		7.2	Logic gates	157
		7.3	PLC system	160
		7.4	PLC programming	162
		7.5	Case studies	169
			Problems	173
8	System models	8.1	Introduction	179
		8.2	Gain	180
		8.3	Dynamic systems	183
		8.4	Differential equations	193
			Problems	197
9	Transfer function	9.1	Introduction	200
		9.2	Transfer function	200
		9.3	System transfer functions	206
		9.4	Block manipulation	208
		9.5	Multiple inputs	212
		9.6	Sensitivity	213
			Problems	216
10	System response	10.1	Introduction	219
		10.2	Inputs	219
		10.3	Determining outputs	220
		10.4	First-order systems	226
		10.5	Second-order systems	230

	10.6	Stability	240
	10.7	Software Problems	245
			247
11	Frequency response		
	11.1	Introduction	252
	11.2	Sinusoidal inputs	255
	11.3	Bode plots	261
	11.4	System identification	271
	11.5	Stability	272
	11.6	Compensation Problems	275
			278
12	Nyquist diagrams		
	12.1	Introduction	282
	12.2	The polar plot	282
	12.3	Stability	284
	12.4	Relative stability Problems	287
			288
13	Controllers		
	13.1	Introduction	290
	13.2	Controllers	290
	13.3	Frequency response	295
	13.4	Systems with dead time	296
	13.5	Cascade control	299
	13.6	Feedforward control Problems	300
			300
	Appendix A: Errors	Measurement errors	303
		Random errors	304
		Combination of errors	307
	Appendix B: Differential equations	Differential equations	311
		Solving differential equations	312
	Appendix C: Laplace transform	The Laplace transform	319
		Obtaining the transform	320
		The inverse transform	324
		Solving differential equations	324
		<i>Answers</i>	327
		<i>Index</i>	334