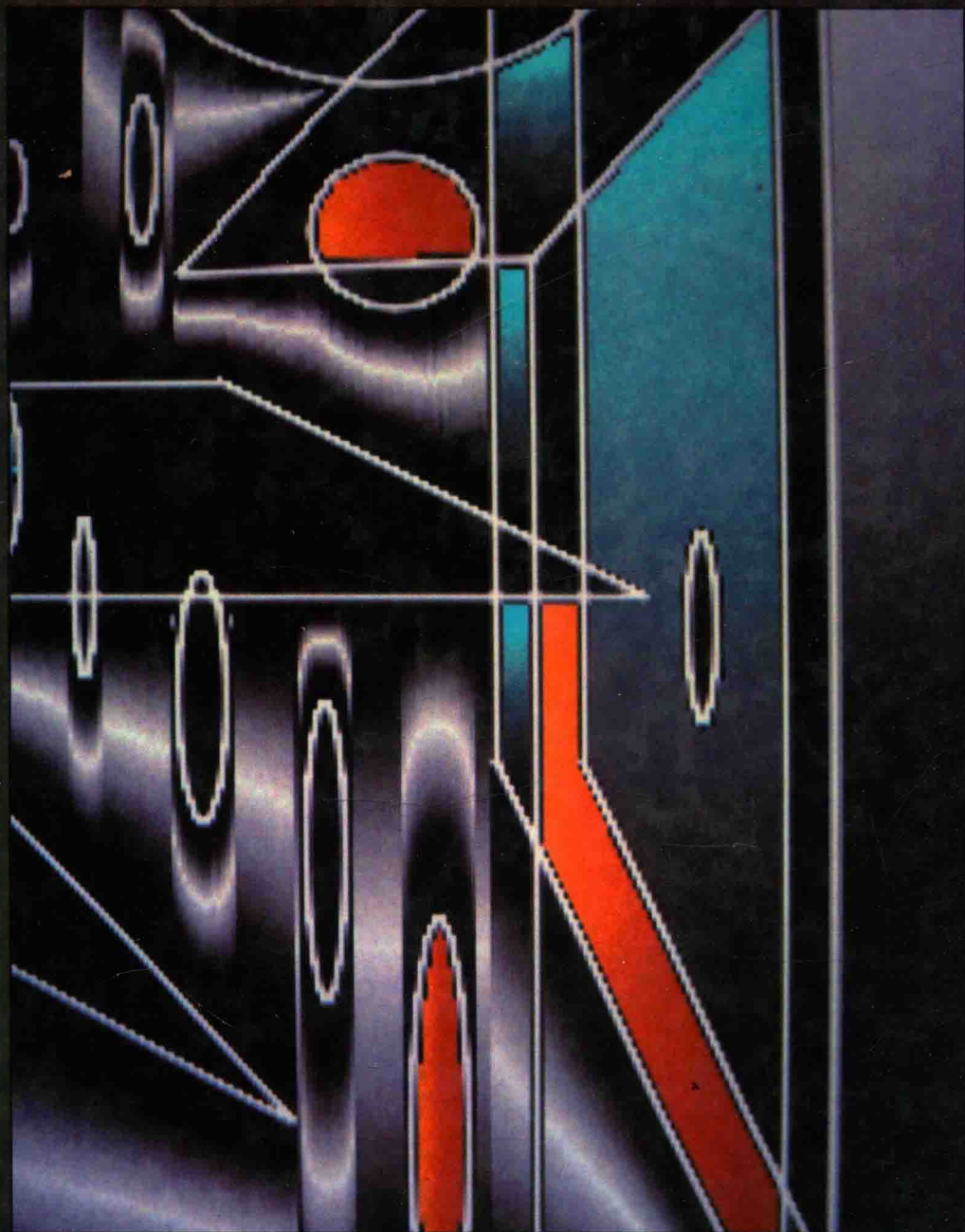


PROCESS CONTROL INSTRUMENTATION TECHNOLOGY

THIRD EDITION



CURTIS D. JOHNSON

PROCESS CONTROL INSTRUMENTATION TECHNOLOGY

THIRD EDITION

Curtis D. Johnson

University of Houston



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PREFACE

The advancement of both knowledge and technique has resulted in the development of specialists in process control. Today, it is possible to delineate process-control activities into three categories, each with specific requirements with regard to training. The process-control system engineer is concerned with the design of an overall process-control system that will provide the regulation specified by the manufacturing process experts. This activity requires a good theoretical understanding of stability, mode characteristics, and general process-control loop dynamic characteristics. The process-control technologist or applied engineer is responsible for the design of specific elements required to implement the overall design specified for the system. This involves a good, design-level understanding of the measurement, electronic, and pneumatic features inherent in process-control loops. The process-control technician or mechanic is responsible for the final assembly and testing of the elements of the process-control loop and the system as a whole. This requires a good working knowledge of the electronics, pneumatics, and mechanical features of process-control loop installations.

This book was developed primarily to fulfill the instructional needs of the last two categories, that is, the applied process engineer, technologist, and advanced technician. Many fine textbooks exist that cover the stability and design criteria of process-control systems, usually involving the use of Laplace transform methods. Often these books do not cover the system elements per se, such as measurement methods, signal conditioning, and final control elements. Indeed, there has been a serious lack of texts that cover process-control elements with less than the mathematical rigor of Laplace transforms and yet enough math to allow the design of loop elements to satisfy specifications. This volume has been prepared to fill this need. Its overall objective is to provide instructional material for a general understanding of process-control characteristics such as elements, modes, and stability along with detailed knowledge of measurement technique, control mode implementation, and final control element functions. In keeping with modern trends, the digital aspect of process-control technology is stressed.

The student background is assumed to consist of that acquired by an advanced sophomore in a two-year engineering/technology program or a junior in a four-year program. Consequently, a basic knowledge of physics and analog and digital electronics is assumed along with math through college algebra, although some knowledge of calculus would be beneficial.

It is quite remarkable how the technology of process control has evolved in a scant ten years since the first edition of this text. It will be of no surprise to anyone working in this field that most of the changes have to do with

computers. Consequently, most of the changes in this book have to do with computers and digital processing.

In recognition of the growing application, a new chapter on programmable controllers has been added. Actually it is a chapter on the control of discrete-state processing systems, but that is usually done by programmable controllers. Although I only touched on it in this book, the programmable controller is even taking over control of continuous processes, for example, using PID.

Chapters 3 and (now) 11 have to do with digital signal processing and computer-based control. Many changes have been made to these chapters in an attempt to make them more current with new practice.

I wish to thank the users of the book for the many excellent suggestions forwarded for consideration in this edition. I could not use them all, but I took them all into account. A special thanks to Helene J. Blake for being patient, understanding, helpful, and a great inspiration to me in all aspects of my life.

Curtis D. Johnson

CONTENTS

1. INTRODUCTION TO PROCESS CONTROL	1
INSTRUCTIONAL OBJECTIVES	1
1.1 Introduction	1
1.2 Definition of Process Control	2
1.3 Elements of Process Control	3
1.3.1 Identification of Elements	4
1.3.2 Block Diagram	5
1.4 Evaluation of Process Control	6
1.4.1 System Evaluation Criteria	7
1.4.2 Dynamic Response Evaluation Criteria	9
1.5 Analog Versus Digital Processing	12
1.5.1 Analog Processing	12
1.5.2 Digital Processing	13
1.6 Units, Standards, and Definitions	20
1.6.1 Units	20
1.6.2 Standard Signals	22
1.6.3 Definitions	24
1.6.4 Process-Control Drawings	30
1.7 Time Response	31
1.7.1 Nonoscillating Response	31
1.7.2 Oscillating Response	33
1.8 Significance and Statistics	34
1.8.1 Significant Figures	34
1.8.2 Statistics	36
Summary	39
Problems	40
 2. ANALOG SIGNAL CONDITIONING	 43
INSTRUCTIONAL OBJECTIVES	43
2.1 Introduction	43
2.2 Principles of Analog Signal Conditioning	44
2.2.1 Signal Level Changes	44
2.2.2 Linearization	44

2.2.3 Conversions	46
2.2.4 Filtering and Impedance Matching	47
2.3 Passive Circuits	47
2.3.1 Divider Circuit	48
2.3.2 Bridge Circuits	49
2.3.3 RC Filters	61
2.4 Operational Amplifiers	64
2.4.1 Op Amp Characteristics	65
2.4.2 Op Amp Specifications	68
2.5 Op Amp Circuits in Instrumentation	69
2.5.1 Voltage Follower	69
2.5.2 Inverting Amplifier	70
2.5.3 Noninverting Amplifier	71
2.5.4 Differential Amplifier	72
2.5.5 Voltage-to-Current Converter	74
2.5.6 Current-to-Voltage Converter	76
2.5.7 Integrator	76
2.5.8 Linearization	77
2.5.9 Special Integrated Circuits (ICs)	79
2.6 Industrial Electronics	79
2.6.1 Silicon Controlled Rectifier (SCR)	79
2.6.2 TRIAC	84
Summary	85
Problems	86
 3. DIGITAL SIGNAL CONDITIONING	 89
INSTRUCTIONAL OBJECTIVES	89
3.1 Introduction	89
3.2 Review of Digital Fundamentals	90
3.2.1 Digital Information	91
3.2.2 Fractional Binary Numbers	92
3.2.3 Boolean Algebra	94
3.2.4 Digital Electronics	96
3.2.5 Programmable Logic Controllers	97
3.2.6 Busses and Tri-State Buffers	97
3.3 Converters	99
3.3.1 Comparators	99
3.3.2 Digital-to-Analog Converters (DACs)	102
3.3.3 Analog-to-Digital Converters (ADCs)	107
3.4 Data Acquisition Systems	116
3.4.1 Data Acquisition System (DAS)	116
3.4.2 Application Notes	118

Summary	119
Problems	120
 4. THERMAL TRANSDUCERS	 122
INSTRUCTIONAL OBJECTIVES	122
4.1 Introduction	122
4.2 Definition of Temperature	123
4.2.1 Thermal Energy	123
4.2.2 Temperature	124
4.3 Metal-Resistance Versus Temperature Devices	128
4.3.1 Metal Resistance Versus Temperature	128
4.3.2 Resistance Versus Temperature Approximations	130
4.3.3 Resistance-Temperature Detectors	134
4.4 Thermistors	137
4.4.1 Semiconductor Resistance Versus Temperature	137
4.4.2 Thermistors	139
4.5 Thermocouples	142
4.5.1 Thermoelectric Effects	142
4.5.2 Thermocouples	144
4.5.3 Thermocouple Transducers	150
4.6 Other Thermal Transducers	151
4.6.1 Bimetal Strips	152
4.6.2 Gas Thermometers	154
4.6.3 Vapor Pressure Thermometers	155
4.6.4 Liquid-Expansion Thermometers	156
4.7 Design Considerations	157
Summary	163
Problems	164
 5. MECHANICAL TRANSDUCERS	 167
INSTRUCTIONAL OBJECTIVES	167
5.1 Introduction	167
5.2 Displacement, Location, or Position Transducers	168
5.2.1 Potentiometric	168
5.2.2 Capacitive and Inductive	169
5.2.3 Variable Reluctance	171
5.2.4 Level Transducers	172
5.3 Strain Transducers	175
5.3.1 Strain and Stress	175
5.3.2 Strain Gage Principles	179

5.3.3 Metal Strain Gages (SGs)	181
5.3.4 Semiconductor Strain Gages (SGs)	184
5.3.5 Load Cells	186
5.4 Motion Transducers	187
5.4.1 Types of Motion	187
5.4.2 Accelerometer Principles	191
5.4.3 Types of Accelerometers	195
5.4.4 Applications	197
5.5 Pressure Transducers	198
5.5.1 Pressure Principles	199
5.5.2 Pressure Transducers ($p > \text{one atmosphere}$)	201
5.5.3 Pressure Transducers ($p < \text{one atmosphere}$)	204
5.6 Flow Transducers	205
5.6.1 Solid Flow Measurement	206
5.6.2 Liquid Flow	207
Summary	213
Problems	214
 6. OPTICAL TRANSDUCERS	 217
INSTRUCTIONAL OBJECTIVES	217
6.1 Introduction	217
6.2 Fundamentals of EM Radiation	218
6.2.1 Nature of EM Radiation	218
6.2.2 Characteristics of Light	221
6.2.3 Luminous Energy Units and Principles	227
6.3 Photodetectors	232
6.3.1 Photodetector Characteristics	232
6.3.2 Photoconductive Detectors	233
6.3.3 Photovoltaic Detectors	237
6.3.4 Photodiode Detectors	240
6.3.5 Photoemissive Detectors	240
6.4 Pyrometry	243
6.4.1 Thermal Radiation	243
6.4.2 Broadband Pyrometers	244
6.4.3 Narrowband Pyrometers	247
6.5 Optical Sources	249
6.5.1 Conventional Light Sources	249
6.5.2 Laser Principles	251
6.6 Applications	254
6.6.1 Label Inspection	254
6.6.2 Turbidity	257
6.6.3 Ranging	258

Summary	258
Problems	259
 7. FINAL CONTROL	 262
INSTRUCTIONAL OBJECTIVES	262
7.1 Introduction	262
7.2 Final Control Operation	263
7.2.1 Signal Conversions	264
7.2.2 Actuators	264
7.2.3 Control Element	264
7.3 Signal Conversions	265
7.3.1 Analog Electrical Signals	265
7.3.2 Digital Electrical Signals	267
7.3.3 Pneumatic Signals	269
7.4 Actuators	272
7.4.1 Electrical Actuators	272
7.4.2 Pneumatic Actuators	280
7.4.3 Hydraulic Actuators	282
7.5 Control Elements	284
7.5.1 Mechanical	285
7.5.2 Electrical	287
7.5.3 Fluid Valves	289
Summary	295
Problems	296
 8. DISCRETE-STATE PROCESS CONTROL	 298
INSTRUCTIONAL OBJECTIVES	298
8.1 Introduction	298
8.2 Definition of Discrete-State Process Control	299
8.3 Characteristics of the System	300
8.3.1 Discrete-State Variables	302
8.3.2 Process Specifications	304
8.3.3 Event Sequence Description	307
8.4 Ladder Diagram	315
8.4.1 Background	315
8.4.2 Ladder Diagram Elements	317
8.4.3 Ladder Diagram Examples	319
8.5 Programmable Controllers	325
8.5.1 Relay Sequencers	326
8.5.2 Programmable Controller	327

8.5.3 Programmable Controller Operation	329
8.5.4 Programming	331
8.5.5 Advanced Features	336
Summary	336
Problems	337
9. CONTROLLER PRINCIPLES	340
INSTRUCTIONAL OBJECTIVES	340
9.1 Introduction	340
9.2 Process Characteristics	341
9.2.1 Process Equation	341
9.2.2 Process Load	342
9.2.3 Process Lag	343
9.2.4 Self-Regulation	343
9.3 Control System Parameters	344
9.3.1 Error	344
9.3.2 Variable Range	346
9.3.3 Control Parameter Range	346
9.3.4 Control Lag	347
9.3.5 Dead Time	347
9.3.6 Cycling	348
9.3.7 Controller Modes	348
9.4 Discontinuous Controller Modes	349
9.4.1 Two-Position Mode	350
9.4.2 Multiposition Mode	353
9.4.3 Floating Control Mode	355
9.5 Continuous Controller Modes	359
9.5.1 Proportional Control Mode	359
9.5.2 Integral Control Mode	363
9.5.3 Derivative Control Mode	366
9.6 Composite Control Modes	368
9.6.1 Proportional-Integral Control (PI)	368
9.6.2 Proportional-Derivative Control Mode (PD)	372
9.6.3 Three-Mode Controller (PID)	375
9.6.4 Special Terminology	377
Summary	378
Problems	379

10. ANALOG CONTROLLERS	382
INSTRUCTIONAL OBJECTIVES	382
10.1 Introduction	382
10.2 General Features	383
10.3 Electronic Controllers	384
10.3.1 Error Detector	384
10.3.2 Single Mode	386
10.3.3 Composite Controller Modes	397
10.4 Pneumatic Controllers	403
10.4.1 General Features	403
10.4.2 Mode Implementation	404
10.5 Design Considerations	408
Summary	412
Problems	413
11. DIGITAL CONTROLLERS	416
INSTRUCTIONAL OBJECTIVES	416
11.1 Introduction	416
11.2 Digital Electronics Methods	417
11.2.1 Simple Alarms	418
11.2.2 Two-Position Control	418
11.2.3 Multivariable Alarms	420
11.3 Computers in Process Control	422
11.3.1 Programmable Controllers	423
11.3.2 Data Logging	423
11.3.3 Supervisory Control	426
11.3.4 Computer-Based Controller	431
11.4 Characteristics of Digital Data	437
11.4.1 Digitized Value	437
11.4.2 Sampled Data Systems	439
11.5 Controller Software	441
11.5.1 Software Format	442
11.5.2 Input Data Operations	444
11.5.3 Controller Modes	448
11.6 Computer Controller Examples	459
Summary	464
Problems	464

12. CONTROL LOOP CHARACTERISTICS	467
INSTRUCTIONAL OBJECTIVES	467
12.1 Introduction	467
12.2 Control System Configurations	468
12.2.1 Single Variable	468
12.2.2 Cascade Control	471
12.3 Multivariable Control Systems	472
12.3.1 Analog Control	473
12.3.2 Supervisory and Direct Digital Control	474
12.4 Control System Quality	475
12.4.1 Definition of Quality	475
12.4.2 Measure of Quality	479
12.5 Stability	484
12.5.1 Why Instability?	484
12.5.2 Stability Criteria	486
12.6 Process Loop Tuning	490
12.6.1 Open Loop Transient Response Method	490
12.6.2 Ziegler–Nichols Method	494
12.6.3 Frequency Response Methods	496
Summary	500
Problems	502
 APPENDIX 1 UNITS	 509
A.1.1 SI Units	509
A.1.2 Other Units	509
A.1.3 Standard Prefixes	511
 APPENDIX 2 DIGITAL REVIEW	 512
A.2.1 Number Systems	512
A.2.2 Boolean Algebra	517
A.2.3 Digital Electronic Building Blocks	519
 APPENDIX 3 THERMOCOUPLE TABLES	 522
 APPENDIX 4 MECHANICAL REVIEW	 528
A.4.1 Motion	528
A.4.2 Force	529

APPENDIX 5 P & ID SYMBOLS	533
A.5.1 Introduction	533
A.5.2 Interconnections	533
A.5.3 Balloon Symbols	533
A.5.4 Instrument Symbols	535
REFERENCES	537
GLOSSARY	538
SOLUTIONS TO ODD PROBLEMS	543
INDEX	564

C H A P T E R 1

INTRODUCTION TO PROCESS CONTROL

INSTRUCTIONAL OBJECTIVES

This chapter will consider the overall process-control loop, its function, and its description. After you read it, you should be able to

1. **Draw a block diagram of a process control loop with a description of each element.**
2. **List three typical dynamic variables.**
3. **Describe three criteria used to evaluate the response of a process-control loop.**
4. **Define analog signal processing.**
5. **Describe the two types of digital process control.**
6. **Define accuracy, hysteresis, and sensitivity.**
7. **List the SI units of measure for length, time, mass, and electric current.**
8. **Convert a physical quantity from SI to English units and vice versa.**
9. **Define the types of measurement time response.**

1.1 INTRODUCTION

To study the elements of process control effectively, it is necessary to have an overall understanding of process-control principles. With such an understanding, how particular elements affect the overall control problem can be fully described. This chapter provides a general introduction to process control with an emphasis on industrial applications. An equally important facet of the chapter is the definition of common terms and units of measure that are a necessary part of any study of the subject.

The elements of a complex system are much easier to understand if the operation of the whole system is considered first. Obviously, it would be quite frustrating to study all the elements of an automobile without first noting that the result would be a transportation vehicle with certain characteristics. In keeping with this idea, this chapter discusses the overall process-control loop, its function, and its description.