

Basic and Advanced Regulatory Control: System Design and Application

2nd Edition

TABLE OF CONTENTS

PREFACE	xiii
CHAPTER 1—INTRODUCTION	1
Symbols	2
CHAPTER 2—MATHEMATICAL BACKGROUND, DIAGRAMS, AND TERMINOLOGY	5
Mathematical Foundation	6
Diagrams and Terminology	17
Direct- or Reverse-acting?	24
References	25
CHAPTER 3—PROCESS AND CONTROL LOOP CHARACTERISTICS ..	27
Steady-state Characteristics	28
Dynamic Characteristics	35
Control Loop Characteristics	48
Summary	54
References	55
CHAPTER 4—PID CONTROL	57
Feedback Control	57
Summary	76
References	77
CHAPTER 5—MODIFICATIONS TO STANDARD PID CONTROL	79
Set Point “Softening”	80
Integral-only Mode	85
Interactive or Noninteractive Controller	86
Independent Gains	89
Internal Filter	90
Nonlinearization	92
Set Point Tracking and Bumpless Transfer	94
“Bumpless” Tuning	96
Preventing Reset Windup	97

Discrete Control Algorithms	102
Incorporating Engineering Units in Controller Gain	107
Commercial Examples of Modifications	109
Process Control Using FOUNDATION™ Fieldbus	112
References	118
CHAPTER 6—TUNING FEEDBACK CONTROL LOOPS	119
Performance Criteria	120
Tuning for Self-regulating Processes	123
Tuning Liquid-level Control Loops	149
Other Tuning Situations: Runaway Processes	169
Typical Tuning Values for Particular Types of Loops	170
Practical Considerations for Loop Tuning	170
References	172
CHAPTER 7—SELF-TUNING	173
Scheduled Tuning	174
On-demand Tuning	174
Adaptive Tuning	177
Tuning Aids	179
References	181
CHAPTER 8—ADVANCED REGULATORY CONTROL	183
CHAPTER 9—CASCADE CONTROL	187
Cascade Control Technology	187
Identifying Candidate Applications	191
Implementation, Operation, and Tuning	194
Cascade Control Using FOUNDATION™ Fieldbus	198
References	198
CHAPTER 10—RATIO CONTROL	201
Ratio Control Technology	201
Automatic Ratio Adjustment	203
Scaling the Ratio Control Components	207
Ratio Control Using FOUNDATION™ Fieldbus Function Blocks	208
References	209
CHAPTER 11—FEEDFORWARD CONTROL	213
Designing Feedforward Control Systems	216
Dynamic Compensation	226
Further Considerations of the Feedback Controller	237
Feedforward: In Perspective	238
Feedforward Control Using FOUNDATION™ Fieldbus	241
References	242

CHAPTER 12— OVERRIDE (SELECTOR) CONTROL	245
Override Control	245
Other Methods of Implementation	256
Override Control Using FOUNDATION™ Fieldbus	263
References	265
CHAPTER 13— CONTROL FOR INTERACTING PROCESS LOOPS.....	267
Variable Pairing	268
Decoupling	276
Decoupling Application Examples	286
References	290
CHAPTER 14—DEAD-TIME COMPENSATION AND MODEL-BASED CONTROL.....	291
Smith Predictor Control	292
Dahlin’s Algorithm	299
An Overview of Z-Transform Theory	300
Internal Model Control	305
References	310
CHAPTER 15—MULTIVARIABLE MODEL PREDICTIVE CONTROL.....	311
Real-world Problems	311
History	313
Unconstrained MPC for SISO Processes	314
Prediction	315
Unconstrained MPC for MIMO Processes	324
Constrained MPC	329
Variations in MPC Vendor Offerings	330
MPC in Perspective	332
References	334
CHAPTER 16—OTHER CONTROL TECHNIQUES.....	335
Split-range Control	335
Cross-Limiting Control	338
Floating Control	339
Hot or Chilled Water Supply Systems	343
Cooling Tower Systems	344
Increasing Valve Rangeability	346
Time Proportioning Control	349
References	351

APPENDIX A—SIGNAL SCALING	353
APPENDIX B—DERIVATION OF EQUATIONS FOR INSTALLED VALVE CHARACTERISTICS.....	359
INDEX	365