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(英文版)

# 控制系统基础

Elements of Control Systems

(美) 苏希尔·古普塔 (Sudhir Gupta) 著

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# 出版说明

随着我国加入 WTO，国际间的竞争越来越激烈，而国际间的竞争实际上也就是人才的竞争、教育的竞争。为了加快培养具有国际竞争力的高水平技术人才，加快我国教育改革的步伐，国家教育部近来出台了一系列倡导高校开展双语教学、引进原版教材的政策。以此为契机，机械工业出版社陆续推出了一系列国外影印版教材，其内容涉及高等学校公共基础课，以及机、电、信息领域的专业基础课和专业课。

引进国外优秀原版教材，在有条件的学校推动开展英语授课或双语教学，自然也引进了先进的教学思想和教学方法，这对提高我国自编教材的水平，加强学生的英语实际应用能力，使我国的高等教育尽快与国际接轨，必将起到积极的推动作用。

为了做好教材的引进工作，机械工业出版社特别成立了由著名专家组成的国外高校优秀教材审定委员会。这些专家对实施双语教学做了深入细致的调查研究，对引进原版教材提出了许多建设性意见，并慎重地对每一本将要引进的原版教材一审再审，精选再精选，确认教材本身的质量水平，以及权威性和先进性，以期所引进的原版教材能适应我国学生的外语水平和学习特点。在引进工作中，审定委员会还结合我国高校教学课程体系的设置和要求，对原版教材的教学思想和方法的先进性、科学性严格把关。同时尽量考虑原版教材的系统性和经济性。

这套教材出版后，我们将根据各高校的双语教学计划，举办原版教材的教师培训，及时地将其推荐给各高校选用。希望高校师生在使用教材后及时反馈意见和建议，使我们更好地为教学改革服务。

机械工业出版社

# 序

*Elements of Control Systems* 由 Sudhir Gupta 编著, 2002 年出版。本书的内容是经典控制理论的基本方法和自动控制的常用技术, 主要包括线性连续控制系统的建模、瞬态响应分析、频率响应分析、稳定性分析、各种控制器的整定与系统设计等等。

从本书的体系结构和内容取舍可见, 作为自动控制理论课程的教材, 本书具有如下特点:

1. 书中对概念的定义严格, 讲述详细, 深入浅出, 较少从纯数学角度的推导, 侧重从物理意义直观地解释问题, 为说明概念的举例, 浅显易懂。

2. 全书的工程实践背景强, 例题量大, 且结合工程实际。如在开关控制(第 9 章)一章中, 给出了温度开关控制、步进电动机开关控制的实际电路图等, 并进行分析, 这对于未接触过实际控制系统的在校学生, 是很有启发和帮助的。

3. 全书的章节安排和内容与国内目前使用的大多数教材不同, 如不包括稳态误差分析、非线性系统分析等内容, 根轨迹的内容也缩减为稳定性分析(第 8 章)一章中的一节。在 MATLAB 控制系统工具箱普遍应用的今天, 对根轨迹内容的缩减, 可使学生把注意力集中在用根轨迹方法分析系统上, 而不是如何绘制根轨迹上。

4. 书中用大量篇幅(第 9~13 章)讲述各种实用的控制器, 包括开关控制器、模拟控制器、数字控制器、模糊控制器。对这部分内容的侧重, 有利于工程实践观念的培养。

5. 书中将自动控制理论和自动控制系统紧密结合起来, 通过控制系统的实例分析, 不仅帮助理解控制理论, 而且有助于掌握常见控制系统的工作原理。

6. 在语言方面, 全书文字流畅、易读。本科生在学完大学英语, 并掌握一定的专业词汇后, 较易阅读本书。

本书可作为高等院校本科电子信息类专业自动控制理论课程教材或教学参考书, 也可供相关专业研究生参考或从事自动化技术的工程技术人员作为自学读物。

北京工商大学

翁贻方

2004 年 1 月

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# PREFACE

There are a number of excellent textbooks covering the subject of control engineering at the engineering level. These books are typically written for a two-semester course in control engineering or for an intense one-semester course in the senior year. As is typical of engineering textbooks, these treat control theory from a mathematical point of view.

*Elements of Control Systems* does not do that. This book is suitable for

- Two- or four-year college programs requiring an in-depth understanding of control systems
- A one-semester university course at the freshman level
- Industry personnel interested in developing a greater understanding of control principles

It has been very difficult to decide on the precise content of such a textbook. It is not a handbook, so it cannot contain every single aspect of it, and it is not a “how-to” recipe book focusing on very specific topics. An attempt has been made to cover the major topics in control system technology. It should permit the reader to develop sufficient understanding to operate, maintain, and regulate control systems. At the same time, it should permit the reader to design and develop basic control systems.

No attempt has been made to cover PLCs or their operation or programming. This topic is a field in itself, and a chapter in this text could not have done justice to it.

Even though a number of PLCs have begun to offer continuous control modules, their primary application is in digital I/O and not in process control.

Sensors, transducers, and actuators form an important segment of control technology, but so do microcontrollers, data converters, and instrumentation interface circuits. These again have not been covered in lieu of more relevant subject matter.

Where possible, an attempt has been made to point out the issues with circuit components and their impact on system operations. A chapter has been dedicated to digital control, still treating it from the classical control point of view. A chapter on fuzzy logic control provides a solid introduction to the topic. An attempt has been made to avoid excessive use of some of the cryptic terms commonly used with fuzzy control.

### **How to Use the Book**

The book consists of two major sections: the first part covers control system theory and the second part covers controllers and their applications.

It is important that the first part be studied with some diligence. The reader should be fully comfortable with the notions of time and frequency response before tackling controllers and their applications. The first chapter introduces the concept of a control system. The second chapter covers block diagrams, followed by a chapter on Laplace transformation. Laplace transformation is covered with an application-oriented approach. It is not intended to provide a solid foundation in operational calculus but apply it to determine system transfer functions in the following chapter on mathematical modeling. Having an understanding of the origin of transfer functions, time and frequency response techniques are covered. The discussion on stability is the coverage on controllers. It is intended to develop awareness for the consequences of improper controller selection and adjustment.

The second part of the book deals with controllers, their operation, adjustment, and analog and digital implementation. Some of these topics can actually be studied independently of the first, but it is not recommended. The section on digital controllers requires some understanding of microcontrollers and their programming. Annotated software listings have been provided in each case.

I would like to thank a number of people who have provided valuable support for this book project: Charles Stewart, publisher at Prentice Hall for his acceptance of the initial manuscript and his encouraging words; my copyeditor, Linda Thompson and project editor, Lisa Garboski, for their skills and painstaking effort; Eric Sells and Al Lovrich of Microchip Technology; Mark Siegesmund of CCS, Inc.; and Naomi Fernandes of The MathWorks Inc.

Many thanks also should go to the reviewers: Jeff Slutsky, Rochester Institute of Technology; Richard L. Windley, ECPI College of Technology; C. Richard G. Helps, Brigham Young University; John Glozy, DeVry Institute of Technology; and Dr. Nebojsa Jaksic, DeVry Institute of Technology.

I would also like to thank my family: my wife Nita for putting up with my spending countless hours working on the manuscript, my son Sachin for very valuable help



with computer work, and my daughter Avina for help in transforming the handwritten notes into a printed document. Above all I would like to thank them for their constant encouragement.

### **Feedback**

This being the first edition, it is possible that mistakes may have been made, in spite of the best efforts of the author and the publisher. It would be greatly appreciated if you can point these out. Any kind of constructive criticism is welcome.

Sudhir K. Gupta  
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# CONTENTS

出版说明	iv
序	v
<b>PREFACE</b>	<b>vii</b>
<b>1 BASIC CONCEPTS</b>	<b>1</b>
Introduction	1
Control Terminology	1
Functioning of a Control System	8
Examples of Closed-Loop Control Systems	9
Problems	12
<b>2 BLOCK DIAGRAMS</b>	<b>13</b>
Introduction	13
Definition of a Block Diagram	14
Summing Point	15
Takeoff Point	16
Block Diagram Representation of an Equation	16
Block Diagram Representation of Control Systems	17
Transfer Functions	19
General Transfer Function	19
Transfer Function of a Closed-Loop System	20

Comparison of Positive-Feedback and Negative-Feedback Systems	22
Unity Feedback Systems	28
Conversion to a Unity Feedback System	28
Block Diagram Simplification	29
Op-Amp Simulation of a Block Diagram	34
Summing Point	35
Summing Point with Adjustable SP Input	36
Gain Block	38
Constant-Gain (Noninverting) Block	38
Constant-Gain (Inverting) Block	41
Takeoff Point	41
Summing Point with Multiple Inputs	42
Problems	50

**3 LAPLACE TRANSFORMS** **54**

Introduction	54
Transformations	54
Laplace Transform Integral	55
Transform Notation	56
Rules of Transformation	56
Forward Transformation Procedure	61
Inverse Transformation Procedure	67
Partial-Fraction Expansion	79
Distinct Roots	80
Repeated Roots	81
Applications of Laplace Transforms:	
Differential Equations	88
Problems	93

**4 MATHEMATICAL MODELING** **97**

Introduction	97
Mathematical Model	98
Nonlinear Behavior	98
Transfer Functions	99
Electrical Networks	100
Resistor	101
Capacitor	101

Inductor	102
Series <i>RC</i> Circuit	103
Series <i>RL</i> Circuit	105
Series <i>RLC</i> Circuit	107
Mechanical Systems	112
Mass	112
Spring	113
Damper	113
Spring Mass Damper System	114
Analogy Between Physical Systems	116
Fluid Systems	117
Single-Tank Fluid-Level System	117
Two-Tank Fluid-Level System	119
Thermal Systems	122
Heating Systems	123
Problems	124

## **5 TRANSIENT RESPONSE**

**127**

Introduction	127
Time Response	127
Input Functions	129
Step Function	129
Pulse Function	131
Impulse Function	132
Delayed Impulse Function	133
Ramp Function	134
Sinusoidal Function	134
Types of Transient Responses	135
Overdamped Response	135
Critically Damped Response	136
Underdamped Response	136
Constant Oscillations	137
Increasing Oscillations	137
Exponential Rise	138
Transient Response Through Laplace Transformation	138
Impulse Function Response	144
Characteristic Equation	148
Poles and Zeros of the Transfer Function	151

*s*-Plane and Pole-Zero Map 153  
Pole Location and Transient Response 155  
Problems 160

**6 FREQUENCY RESPONSE 162**

Introduction 162  
Methods Used for Frequency Response  
Representation 164  
Frequency Response Determination 166  
Problems 186

**7 COMMON TRANSFER FUNCTIONS 189**

Introduction 189  
Common Blocks (Transfer Functions) 191  
Constant Block 192  
Time Response of a Constant TF 195  
Frequency Response of a Constant Block 195  
Integral Block 198  
Time Response of an Integral Block 198  
Frequency Response of an Integral Block 200  
Derivative Block 203  
Time Response of a Derivative Block 204  
Frequency Response of a Derivative Block 204  
The Relationship Between Integral  
and Derivative Blocks 208  
First-Order Lag Block 208  
Time Response to a Unit Step Input 209  
Frequency Response of a First-Order  
Lag Block 213  
First-Order Lead Block 219  
Time Response to a Unit Step Input 220  
Frequency Response of a First-Order  
Lead Block 220  
Second-Order Lag Block 224  
Time Response to a Unit Step Input 225  
Characteristics of Underdamped Response 231  
Frequency Response of a Second-Order  
Lag Block 234  
Second-Order Lead Block 238

Time Response to a Unit Step Input	240
Frequency Response of a Second-Order Lead Block	240
Dead Time: Transportation Lag Block	241
Time Response to a Unit Step Input	243
Frequency Response of a Dead-Time Block	243
Problems	244

## **8 STABILITY** **248**

Introduction	248
Concept of Stability	248
Stability and the Open-Loop Transfer Function	252
Open-Loop Gain and Operating Frequency	255
Stability from a Bode Plot	259
Gain and Phase Margins	261
Gain and Phase Crossover Frequencies	261
Gain Margin (GM)	261
Phase Margin (PM)	263
Desired Gain and Phase Margins	264
Stability from the Characteristic Equation	269
Routh Criterion for Stability	271
Root Locus Analysis	278
Root Locus Through MATLAB	281
Problems	288

## **9 CONTROLLERS: THE ON-OFF CONTROLLER** **291**

Introduction	291
Role of a Controller	291
Types of Controllers	292
Use of a Percent as Input and Output	293
Measured Value as a Percentage Value	295
Set Point as a Percentage Value	296
Error as a Percentage Value	296
On-Off Control	298
Types of On-Off Control	298
Electronic Implementation (Analog)	299
Two-Position Control	303
Neutral Zone	304
Controller Action	306

**xvi** Contents

Applications	308
Electronic Implementation	309
Multiposition (Floating) Control	315
Problems	315

**10 ANALOG CONTROLLER I**

**318**

Introduction	318
Proportional Controller (P)	318
Transfer Characteristic	319
Proportional Band	321
Relationship Between Percent Output and Physical Controller Output	322
Electronic Implementation	326
Frequency Response of a Proportional Controller	332
Proportional Control of a Closed Loop	334
Steady-State Operation with Zero Error	339
Proportional Controller with Offset	346
Offset Voltage Adjustment	346
Integral Controller (I)	346
Electronic Implementation	353
Limiting DC Gain	354
Frequency Response of an Ideal Integral Controller	355
Frequency Response of a DC Gain-Limited Integral Controller	356
Derivative Controller (D)	359
Electronic Implementation	365
Frequency Response of a Derivative Controller	366
Limiting High-Frequency Gain	367
Problems	375

**11 ANALOG CONTROLLER II**

**378**

Introduction	378
Composite Controller Modes	378
Serial Implementation	379
Parallel Implementation	379
PI Controller	380
Electronic Implementation of a PI Controller	383
Frequency Response of a PI Controller	384

PD Controller 391  
 Electronic Implementation of a PD Controller 393  
 Frequency Response of a PD Controller 395  
 PID Controller 400  
 Electronic Implementation 410  
 Changing the Operating Mode 412  
 Frequency Response of a PID Controller 412  
 Problems 417

**12 DIGITAL CONTROLLER 420**

Introduction 420  
 Digital Controller 421  
 Controller Sequence of Operation 422  
 Considerations for Digital Control 424  
 Digital Two-Position Control 426  
 Sequence of Operation 426  
 Microcontroller Implementation  
 of a Two-Position Controller 427  
 Digital PID Controller 433  
 Analog PID Algorithm 433  
 Digital PID Algorithm 433  
 Zero-Order Hold (ZOH) 435  
 Ideal Digital PID Algorithm 440  
 Discrete PID Algorithm—BASIC Language 440  
 Manual Control Mode 442  
 Velocity Algorithm 443  
 Improved Derivative Term 444  
 Microcontroller Implementation of a PID Controller 445  
 DC Motor Control 445  
 Control Software Description 448  
 Problems 453

**13 FUZZY CONTROLLER 455**

Introduction 455  
 Continuum World 455  
 Conventional Logic 457  
 Fuzzy Logic and Fuzzy Logic Terminology 457  
 Fuzzy Control System 475  
 Problem Identification 476  
 Conceptual Design 476  
 Problems 487



**14 CONTROLLER TUNING AND SYSTEM DESIGN 491**

- Introduction 491
- Performance Criteria 492
  - Controller Tuning 492
  - Controller Tuning: Known Plant Model 493
- Plant Model from Experimental Response Testing 504
- Step Response Test 504
  - Graphical Analysis 505
  - Computational Method 508
- Frequency Response Test 511
- Experimental Determination of Controller Setting 518
  - Continuous Cycling Method 518
  - Reaction Curve Method 519
- Case Study: Machine Positional Control System 521
  - Drive Mechanism 522
  - Position Transducer 522
- Problems 530

**15 ADDITIONAL CONTROL TECHNIQUES 533**

- Introduction 533
- Feedforward Control 533
  - Disturbance Signal 534
- Ratio Control 537
- Cascade Control 537
- Autotuning Controller 539
- State-Space Techniques 540
  - State Variables 540
  - State Equations 540
  - Transfer Function to State-Space Representation 543
- Problems 545

**BIBLIOGRAPHY 547**

**APPENDIX A MATLAB 549**

**GLOSSARY 559**

**INDEX 565**

教辅材料申请表