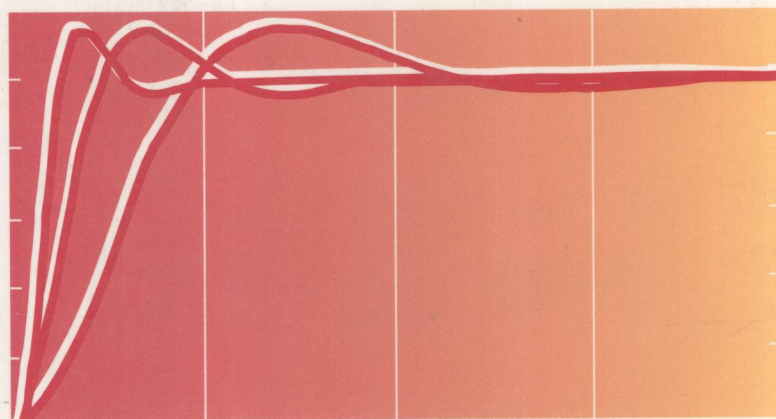




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FOR MS-DOS PERSONAL COMPUTERS

# MATLAB<sup>®</sup> TOOLS FOR CONTROL SYSTEM ANALYSIS AND DESIGN



BENJAMIN C. KUO  
QUANE C. HANSELMAN



MATLAB<sup>®</sup>  
CURRICULUM  
SERIES

# **MATLAB<sup>®</sup>**

## **Tools**

### **for Control System**

### **Analysis**

### **and Design**



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# Contents

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<b>Part 1</b>	<b>Getting Started</b>	<b>1</b>
<b>1</b>	<b><i>JUMP START—FOR THOSE WHO ARE IN A HURRY!</i></b>	<b>3</b>
<b>2</b>	<b><i>TO THE INSTRUCTOR AND STUDENT</i></b>	<b>4</b>
<b>3</b>	<b><i>ABOUT THIS TEXT</i></b>	<b>6</b>
3.1	Conventions Used in This Text	6
3.2	Organization	6
<b>4</b>	<b><i>HARDWARE AND SOFTWARE</i></b>	<b>7</b>
4.1	Hardware and Software Requirements	7
4.2	Software Installation	8
4.2.1	<i>MS-DOS Personal Computers (PCs),</i>	8
4.2.2	<i>Macintosh Computers,</i>	9
4.3	Hardcopy Output	9
4.3.1	<i>MS-DOS PCs,</i>	9
4.3.2	<i>Macintosh Computers,</i>	10

## 5 ABOUT THE CSAD TOOLBOX

11

- 5.1 Initializing the CSAD Toolbox 11
- 5.2 Assumptions 11
  - 5.2.1 *MATLAB Familiarity*, 11
  - 5.2.2 *Control Systems Familiarity*, 12
- 5.3 Restrictions 13
  - 5.3.1 *Single-Input, Single-Output Systems*, 13
  - 5.3.2 *Numerical Accuracy*, 13
- 5.4 User Input 14
  - 5.4.1 *Yes/No Input*, 14
  - 5.4.2 *Single-Number Input*, 14
  - 5.4.3 *Character String Input*, 15
  - 5.4.4 *Polynomial Input*, 15
  - 5.4.5 *Vector Input*, 16
  - 5.4.6 *Matrix Input*, 16
  - 5.4.7 *Graphical Input*, 16
- 5.5 Polynomial Manipulation 17

## Part 2 Theory and Tools

19

## 6 MATHEMATICAL FOUNDATION

21

- 6.1 Introduction 21
- 6.2 Complex Variables and Functions 22
  - 6.2.1 *Complex Variables*, 22
  - 6.2.2 *Functions of a Complex Variable*, 22
  - 6.2.3 *Poles and Zeros of a Complex Function*, 23
- 6.3 Differential Equations/State Equations 24
  - 6.3.1 *State Equations*, 24
- 6.4 Transfer Functions (SISO Systems) 26
  - 6.4.1 *Transfer Functions with Time Delays*, 27
  - 6.4.2 *The Characteristic Equation*, 28
- 6.5 Time Responses with CSAD Functions 28
  - 6.5.1 *Unit-Step Response with the tftplot Function*, 29
  - 6.5.2 *Impulse Response with the tftplot Function*, 30
  - 6.5.3 *Unit-Ramp Response with the tftplot Function*, 31
  - 6.5.4 *The iltpplot Function*, 32
- 6.6 Partial-Fraction Expansion 34
- 6.7 Block Diagrams and Signal Flow Graphs 35
  - 6.7.1 *Manipulating Block Diagrams with tfseries, tfparall, and tfcloop*, 37
  - 6.7.2 *Feedback Systems with Constant Feedback*, 38
  - 6.7.3 *Multiple-Loop Systems*, 38
  - 6.7.4 *The State Diagram*, 40
- Exercises 40

7.1	Introduction	43
7.2	The State-Variable Formulation	44
7.3	The <i>svstuff</i> Function	45
7.4	Characteristic Equation and Eigenvalues	46
7.5	State Transformations	46
	7.5.1 Controllable Canonical Form (CCF),	47
	7.5.2 Observable Canonical Form (OCF),	48
	7.5.3 Diagonal Transformation,	48
	7.5.4 CCF, OCF, and DF Transformations Using <i>svstuff</i> ,	49
7.6	Relationships between State Variables and Transfer Functions— Decomposition	52
	7.6.1 Direct Decomposition,	52
	7.6.2 Parallel Decomposition,	54
	7.6.3 Cascade Decomposition,	55
	7.6.4 Decomposition with <i>svstuff</i> ,	57
	7.6.5 Cascade Decomposition and Series Connection of Systems,	57
	7.6.6 Parallel Connection of Two Systems,	60
	7.6.7 Feedback Connections of Two Systems,	61
	7.6.8 Feedback System with Constant Feedback,	63
	7.6.9 Multiple-Loop Systems,	64
7.7	Controllability and Observability of Linear Time-Invariant Systems	64
7.8	Unit-Step Response	68
7.9	Impulse and Ramp Responses	73
	Exercises	75

**8 TIME-DOMAIN ANALYSIS**

8.1	Introduction	78
8.2	Stability of Linear SISO Systems	79
8.3	Steady-State Performance	81
	8.3.1 The Type of Control Systems,	82
	8.3.2 The Error Constants,	82
8.4	Transient Response	84
	8.4.1 The Unit-Step Response and Time-Domain Specifications,	84
8.5	First- and Second-Order Systems	86
	8.5.1 First-Order Systems,	86
	8.5.2 Second-Order Systems,	87
	8.5.3 Analytical Expressions for $t$ , and $t_s$ ,	91
	8.5.4 <i>t<sub>ford</sub></i> ,	92
	8.5.5 Closed-Loop Systems Simulation,	92
8.6	Root-Locus Diagram	93
	8.6.1 Properties of the Root Loci,	93
	Exercises	99



## **9 FREQUENCY-DOMAIN ANALYSIS**

**102**

- 9.1 Introduction 102
- 9.2 Frequency-Domain Specifications 103
- 9.3 Stability Analysis in the Frequency Domain 108
  - 9.3.1 *The Nyquist Criterion (Minimum-Phase Systems),* 108
  - 9.3.2 *The Nyquist Criterion (General Case),* 110
  - 9.3.3 *The Bode Plot,* 110
  - 9.3.4 *The Magnitude-versus-Phase Plot,* 113
- 9.4 CSAD Functions for Frequency-Domain Analysis 114
  - 9.4.1 *bplot,* 114
  - 9.4.2 *plrplot,* 118
  - 9.4.3 *mvpplot,* 119
  - 9.4.4 *Using the fddesign Function for Frequency-Domain Analysis,* 120
- Exercises 121

## **10 DESIGN OF CONTROL SYSTEMS**

**123**

- 10.1 Introduction 123
- 10.2 The PID Controller 124
- 10.3 Design with *tddesign* 126
  - 10.3.1 *The PD-Controller Design,* 127
  - 10.3.2 *The PI-Controller Design,* 129
  - 10.3.3 *Design of the PID Controller,* 131
- 10.4 Design of the PID Controller in the Frequency Domain 133
  - 10.4.1 *Design of the PI Controller,* 136
  - 10.4.2 *Design of the PD Controller,* 139
  - 10.4.3 *Design of the PID Controller,* 142
- 10.5 The Lead-Lag Controller 144
  - 10.5.1 *Design of the Phase-Lead Controller in the Time Domain,* 145
  - 10.5.2 *Design of the Phase-Lead Controller in the Frequency Domain,* 147
  - 10.5.3 *Design of the Phase-Lag Controller in the Time Domain,* 149
  - 10.5.4 *Design of the Phase-Lag Controller in the Frequency Domain,* 152
- 10.6 State-Feedback Control: Pole-Placement Design 154
  - 10.6.1 *State Feedback with Integral Control,* 160
- Exercises 162

## **Part 3 CSAD Toolbox Reference**

**165**

## **INDEX**

**223**

**Part**

# 1

## ***Getting Started***

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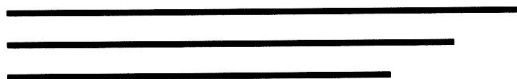
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# 1

## ***Jump Start—For Those Who Are in a Hurry!***

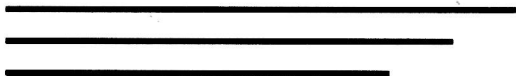


Briefly, here is what you need to do to get going.

1. Create a place for the *CSAD Toolbox* to reside on your hard disk. On an MS-DOS PC this means creating a subdirectory named CSAD in the MATLAB subdirectory. On a Macintosh this means creating a folder named CSAD\_Toolbox within the MATLAB folder.
2. Copy the files from the floppy disk into the subdirectory or folder you just made.
3. Make MATLAB aware of the new files so you can use them. On an MS-DOS PC this means adding the subdirectory CSAD to the MATLABPATH. On a Macintosh this means throwing out the MATLAB Settings file.
4. Initialize the software. To the MATLAB prompt type `>>csad <CR>`. (Note: you must do this once every time you start MATLAB and wish to use the *CSAD Toolbox*.) Then type `>>help csad <CR>` to see the names and a description of the most important functions in the *CSAD Toolbox*.

# 2

## ***To the Instructor and Student***



You're probably wondering why produce yet another software package for control system analysis and design? After all, many undergraduate texts in this area offer software packages to accompany the text material. Moreover, for those having *The Student Edition of MATLAB* or access to the professional version of MATLAB with the *Control System Toolbox*, this text and software may appear redundant.

So why another software package? The reason is to provide a set of tools that offers a consistent, convenient, and productive approach specifically focused at undergraduate control system analysis and design. By using MATLAB as the platform for the software, all the benefits of MATLAB can be utilized. For example, the underlying numerical algorithms in MATLAB are the best available, and MATLAB runs on all popular computers and on just about any monitor.

*The Student Edition of MATLAB* and the *Control System Toolbox* both offer many powerful tools (M-files) for the analysis of control systems. These tools were developed for users who are more familiar with control systems and with MATLAB than is the typical undergraduate student, who is learning the material for the first time. To address this issue, *MATLAB Tools for Control System Analysis and Design* offers a set of tools that minimizes the amount of MATLAB knowledge required. In doing so, the user can focus more clearly on thinking about and solving the control system problems at hand. Key to providing this focus is the

inclusion of many menu-driven, user-interactive tools (i.e., function M-files). These tools offer menu options that allow the user to explore all topics of academic interest. Menu items include: finding the rise time, settling time, and percent overshoot from a step response plot; finding asymptote angles, angles of departure and arrival, and marginal stability points on a root locus plot; finding the peak resonance, bandwidth, and stability margins from a frequency response plot. In addition, specific menu-driven tools are provided for the design of PID and lead/lag controllers.

Finally, this text and software don't try to be everything for everyone. All control system analysis and design programs, including this one, have their own advantages as well as disadvantages. There are many things that are not done here, and certainly there are things that are done that you would like to see done differently. As a result, we would like to encourage you to provide feedback about those features you would like to see changed or added in future editions of this text and software. To do so, contact us at the address given below or better yet send E-mail or a FAX. Without your input, this is an open loop system. So take the time to close the loop. Your feedback is guaranteed to maintain stability and improve performance!

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# 3

## About This Text

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### 3.1 CONVENTIONS USED IN THIS TEXT

The following conventions are used throughout this text:

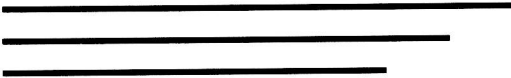
<b>Bold Initial Caps</b>	Key names, MATLAB menu names, MATLAB menu item names.
Constant Width	User input, function and file names, commands, and screen displays. Note: MATLAB commands are case sensitive, <CR> means pressing the return or enter key, and >> is the MATLAB prompt.
<i>Italics</i>	Book titles, names of sections of this text, important terms and concepts, MATLAB and toolbox names, and mathematical notation.

### 3.2 ORGANIZATION

This book is organized into three parts, each containing one or more chapters. The material you are reading now is Part 1: Getting Started. Part 2: Theory and Tools introduces important control system concepts and, more important, illustrates problem solving using *CSAD Toolbox* functions. In Part 3: *CSAD Toolbox* Reference, *CSAD Toolbox* functions are described in detail.

# 4

## ***Hardware and Software***



### **4.1 HARDWARE AND SOFTWARE REQUIREMENTS**

The software provided with this text consists of a set of MATLAB M-files called the *Control Systems Analysis and Design Toolbox*, or *CSAD Toolbox*. These M-files will run on any computer that runs MATLAB and on any version 3.0 or later of the MATLAB software. The software has not been tested on version 4, so some minor problems may exist. To run well, the MATLAB workspace should have at least 100K bytes of available workspace. For most users, this should not pose a problem.

The *CSAD Toolbox* requires approximately 100K bytes of disk space depending upon the disk sector size. In addition, on MS-DOS computers, the operating system environment parameter space must be large enough to add the *CSAD Toolbox* to the parameter MATLABPATH. This will be more thoroughly discussed in the following installation chapter.

It is assumed that MATLAB and the *CSAD Toolbox* will be installed on a hard disk. With much reduced capabilities, MATLAB and the *CSAD Toolbox* can be installed on floppy disks.

See *The Student Edition of MATLAB* or the *MATLAB User's Guide* for further information on MATLAB requirements.



## 4.2 SOFTWARE INSTALLATION

The *CSAD Toolbox* is copyrighted and licensed for use on a single computer only. You are not allowed to give the program to friends or to install the software on multiple computers. **You are violating the law if you violate the license or copyright restrictions. Doing so makes you liable for criminal prosecution.**

We, the authors of this text, know how prevalent software piracy is, especially on college campuses where the desire for software often exceeds the resources to purchase it legally. Despite this, we encourage you to act responsibly and to encourage responsible actions by others. We are not a big faceless corporation that makes billions or even millions of dollars. Quite the contrary, we are two entrepreneurs who have spent many hours in the hopes of providing quality software at a very reasonable price. So, before you engage in or promote the piracy of this software ask yourself the question: Would I do this if I were the author of this work?

### 4.2.1 MS-DOS Personal Computers (PCs)

The *CSAD Toolbox* is distributed on one 720K byte 3.5" diskette or one 360K byte 5.25" diskette. The procedure described subsequently creates a subdirectory for the *CSAD Toolbox*, copies the M-files to that subdirectory, and modifies the `MATLABPATH` so that `MATLAB` recognizes the M-files in the *CSAD Toolbox*.

The following instructions assume that drive A is a floppy disk drive and drive C is the hard disk where the software is to be installed. If this is not the case, substitute the appropriate drive designations, or seek assistance from a more experienced PC user. All commands given are MS-DOS commands.

#### Procedure:

1. Create a subdirectory on the hard disk within the subdirectory where `MATLAB` resides (assumed to be `c:\MATLAB`), and set it to be the current directory.

```
c> md \MATLAB\CSAD <CR>
c> cd \MATLAB\CSAD <CR>
```

2. Insert the *CSAD Toolbox* diskette in drive A and type

```
c> copy A:CSAD <CR>
```

3. Update the `MATLAB` search path. `MATLAB`'s search path is specified in the environment parameter `MATLABPATH`. Somewhere on your system in a batch file (`AUTOEXEC.BAT` or `MATLAB.BAT` are likely possibilities) is a statement defining `MATLABPATH`. For example it could be

```
set MATLABPATH=\MATLAB\MATLAB;\MATLAB\DEMO
```