

# Contents

<b>Preface</b>	<b>xiii</b>		
<b>Chapter 1 Signals</b>	<b>1</b>		
Overview	2		
1-1 Types of Signals	3		
1-2 Signal Transformations	6		
1-3 Waveform Properties	9		
1-4 Nonperiodic Waveforms	11		
1-5 Signal Power and Energy	21		
Chapter 1 Summary	24		
Problems	25		
<b>Chapter 2 Linear Time-Invariant Systems</b>	<b>30</b>		
Overview	31		
2-1 Linear Time-Invariant Systems	31		
2-2 Impulse Response	35		
2-3 Convolution	40		
2-4 Graphical Convolution	46		
2-5 Convolution Properties	49		
2-6 Causality and BIBO Stability	57		
2-7 LTI Sinusoidal Response	60		
2-8 Impulse Response of Second-Order LCCDEs	64		
2-9 Car Suspension System	71		
Chapter 2 Summary	77		
Problems	78		
		<b>Chapter 3 Laplace Transform</b>	<b>83</b>
		Overview	84
		3-1 Definition of the (Unilateral) Laplace Transform	84
		3-2 Poles and Zeros	87
		3-3 Properties of the Laplace Transform	88
		3-4 Circuit Analysis Example	96
		3-5 Partial Fraction Expansion	97
		3-6 Transfer Function $\mathbf{H}(s)$	104
		3-7 Poles and System Stability	106
		3-8 Invertible Systems	109
		3-9 Bilateral Transform for Continuous-Time Sinusoidal Signals	111
		3-10 Interrelating Different Descriptions of LTI Systems	112
		3-11 LTI System Response Partitions	115
		Chapter 3 Summary	121
		Problems	122
		<b>Chapter 4 Applications of the Laplace Transform</b>	<b>128</b>
		Overview	129
		4-1 s-Domain Circuit Element Models	129
		4-2 s-Domain Circuit Analysis	131
		4-3 Electromechanical Analogs	137
		4-4 Biomechanical Model of a Person Sitting in a Moving Chair	143

4-5	Op-Amp Circuits	146	6-5	Filter Design by Poles and Zeros	268
4-6	Configurations of Multiple Systems	151	6-6	Frequency Rejection Filters	272
4-7	System Synthesis	154	6-7	Spectra of Musical Notes	278
4-8	Basic Control Theory	157	6-8	Butterworth Filters	279
4-9	Temperature Control System	164	6-9	De-Noising a Trumpet Signal	287
4-10	Amplifier Gain-Bandwidth Product	168	6-10	Resonator Filter	290
4-11	Step Response of a Motor System	170	6-11	Amplitude Modulation	292
4-12	Control of a Simple Inverted Pendulum on a Cart	173	6-12	Sampling Theorem	306
	Chapter 4 Summary	178		Chapter 6 Summary	321
	Problems	179		Problems	323
<b>Chapter 5 Fourier Analysis Techniques</b>		<b>187</b>	<b>Chapter 7 Discrete-Time Signals and Systems</b>		<b>331</b>
	Overview	188		Overview	332
5-1	Phasor-Domain Technique	188	7-1	Discrete Signal Notation and Properties	333
5-2	Fourier Series Analysis Technique	190	7-2	Discrete-Time Signal Functions	336
5-3	Fourier Series Representations	192	7-3	Discrete-Time LTI Systems	341
5-4	Computation of Fourier Series Coefficients	193	7-4	Properties of Discrete-Time LTI Systems	344
5-5	Circuit Analysis with Fourier Series	207	7-5	Discrete-Time Convolution	348
5-6	Parseval's Theorem for Periodic Waveforms	210	7-6	The $z$ -Transform	350
5-7	Fourier Transform	212	7-7	Properties of the $z$ -Transform	354
5-8	Fourier Transform Properties	217	7-8	Inverse $z$ -Transform	359
5-9	Parseval's Theorem for Fourier Transforms	224	7-9	Solving Difference Equations with Initial Conditions	362
5-10	Additional Attributes of the Fourier Transform	225	7-10	System Transfer Function	364
5-11	Phasor vs. Laplace vs. Fourier	228	7-11	BIBO Stability of $\mathbf{H}(z)$	365
5-12	Circuit Analysis with Fourier Transform	229	7-12	System Frequency Response	367
5-13	The Importance of Phase Information	230	7-13	Discrete-Time Fourier Series (DTFS)	372
	Chapter 5 Summary	236	7-14	Discrete-Time Fourier Transform (DTFT)	377
	Problems	237	7-15	Discrete Fourier Transform (DFT)	383
			7-16	Fast Fourier Transform (FFT)	387
<b>Chapter 6 Applications of the Fourier Transform</b>		<b>245</b>		Chapter 7 Summary	390
	Overview	246		Problems	391
6-1	Signal Filtering	246	<b>Chapter 8 Applications of Discrete-Time Signals and Systems</b>		<b>396</b>
6-2	Passive Filters	254		Overview	397
6-3	Active Filters	262	8-1	Discrete-Time Filters	397
6-4	Ideal Brick-Wall Filters	266	8-2	Notch Filters	402
			8-3	Comb Filters	407

---

8-4	Deconvolution and Dereverberation	411	<b>Appendix C</b>	<b>Mathematical Formulas</b>	<b>443</b>
8-5	Deconvolution and Filtering Using the DFT	417	<b>Appendix D</b>	<b>MATLAB<sup>®</sup> and NI LabVIEW MathScript RT Module</b>	<b>446</b>
8-6	Computing Spectra of Periodic Signals	422	<b>Appendix E</b>	<b>Answers to Selected Problems</b>	<b>454</b>
8-7	Computing Spectra of Nonperiodic Signals	426			
	Chapter 8 Summary	432			
	Problems	433			
<b>Appendix A</b>	<b>Symbols, Quantities, and Units</b>	<b>437</b>	<b>Index</b>		<b>457</b>
<b>Appendix B</b>	<b>Review of Complex Numbers</b>	<b>439</b>			