

CONTENTS

Preface	xii
Chapter 1 Amplification	1
Objectives	1
Introduction	2
Basic Amplifiers	2
Basic Amplifier Concepts, 2	Basic Amplifier
Characteristics, 3	
Amplifier Calculations	5
Ideal Amplifiers, 5	Practical Amplifiers, 6
Ideal Amplifier	8
Feedback	9
Feedback Calculations, 10	Advantages of
Feedback, 11	
Operational Amplifiers	11
Practical Operational Amplifier	12
General Amplifier Characteristics, 13	Amplifier
Analysis, 14	
Operational Amplifier Types	15
Summary	16
Questions	17
Problems	17
Chapter 2 DC Specifications and Circuits	19
Objectives	19
Introduction	20
Gain Specifications	20
Open-Loop Gain, 20	Difference-Mode Gain, 22
Common-Mode Gain, 22	
Input and Output Resistance Characteristics	23

CONTENTS

Error Sources	24
Input Offset Voltage, 25	Input Bias and Offset Currents, 25
Other Specifications	26
Basic Operational Amplifier Circuits	27
Voltage Follower, 27	Noninverting Amplifier, 30
Inverting Amplifier, 33	
Summary	36
Questions	36
Problems	37

Chapter 3 DC Applications

39

Objectives	39
Introduction	40
Temperature Measurement	40
Thermistors, 40	Thermocouples, 40
Solid-State Temperature Transducers, 42	An Electronic Thermometer, 45
Modern Temperature Transducers, 48	
Meters	49
Increasing Meter Input Resistance, 49	Improving Meter Voltage Sensitivity, 51
Current-to-Voltage Converters, 52	
Voltage Regulation	54
Manual Control, 56	Simple Transistorized Regulator, 58
Op Amp Voltage Regulators, 59	Increasing Regulator Current Capability, 63
Error Sources, 64	
Shunt Regulation	66
Switched-Mode Regulators	68
Integrated Circuit Voltage Regulators	70
Summary	73
Questions	73
Problems	75

Chapter 4 AC Specifications and Circuits

76

Objectives	76
Introduction	77
Basic AC Characteristics	77
Frequency Response (Gain versus Frequency), 77	Phase Response (Phase versus Frequency), 79
Slew Rate, 81	
Feedback and Stability Considerations	86
Frequency Response, 86	Phase Response, 89
Composite Response, 90	Stability, 94
Frequency Compensation	97
Summary	102

Questions 102
Problems 103

Chapter 5 Audio Applications

105

Objectives 105
Introduction 106
Basic Audio Amplifier Concepts 106
 General Characteristics of Audio Amplifiers, 106
 Typical Circuit Configurations, 107 Single-Supply
 Operation, 107 Noise in Audio Amplifiers, 108
Audio Circuits in General 111
 Offset Problems, 112 Compensated Operational
 Amplifiers, 113 Uncompensated Operational
 Amplifiers, 116
Typical Audio Amplifiers 120
 Block Diagram, 120 Preamplifiers, 121 Equalizer
 Amplifiers, 122 Tone Control, 125 Audio Op
 Amps, 129 Power Op Amps, 132
Summary 136
Questions 136
Problems 137

Chapter 6 High-Frequency Amplifiers

139

Objectives 139
Introduction 140
Ultrasonics 140
 Applications, 140 Op Amps for Ultrasonics, 141
Narrow-Band Amplifiers 143
 Spectrum Diagrams, 144 Radio Frequency
 Amplification, 147
Wide-Band Amplifiers 149
Pulse Components 150
Video Amplifiers 152
 Requirements for Video Amplifiers, 152 Video Op
 Amps, 153
Noise 160
Automatic Gain Control (AGC) 160
 Typical IF Amplifier with AGC, 161 Other
 Applications, 163
Summary 164
Questions 165
Problems 166

Chapter 7 Filter Basics

167

- Objectives 167
- Introduction 168
- Filter Fundamentals 168
 - Filter Classifications, 168
 - Filter Graphs and Calculations, 168
- Passive Filters 170
 - Low-Pass Filters, 171
 - High-Pass Filters, 173
 - Band-Pass Filters, 175
 - Band-Reject Filters, 176
 - Miscellaneous Filter Facts, 176
- Simple Active Filters 178
 - First-Order Filter Fundamentals, 179
 - Active Filters without Feedback, 180
 - Active Filters with Feedback, 181
 - Active First-Order Band-Pass Filters, 182
- Summary 183
- Questions 184
- Problems 184

Chapter 8 Advanced Filter Circuits

186

- Objectives 186
- Introduction 187
- Second-Order Filters 187
 - Sallen-Key (VCVS) Filters, 188
 - Multiple-Feedback Second-Order Filters, 194
- Band-Pass Filters 196
 - Wide-Band Filters, 196
 - Multiple-Feedback Band-Pass Filters, 198
- State-Variable Filters 201
 - General Characteristics of State-Variable Filters, 201
 - Typical State-Variable Filter, 202
- Biquadratic Filters 203
 - General Characteristics of Biquadratic Filters, 204
 - Typical Biquadratic Filter, 205
- Band-Reject, or Notch, Filters 208
 - Multiple-Feedback Notch Filter, 208
 - Biquad Notch Filter, 210
 - State-Variable Notch Filter, 210
- Miscellaneous Filters 212
- High-Order Filters 213
 - General Characteristics of High-Order Filters, 213
 - Third-Order High-Pass Filter, 215
 - Fourth-Order Low-Pass Filter, 216
- Summary 217
- Questions 218
- Problems 218

Chapter 9 Oscillators	220
Objectives	220
Introduction	221
Sinusoidal (Sine Wave) Generators	222
Phase Shift Oscillator, 222	Wien Bridge Oscillator, 224
Twin-T Oscillator, 227	Quadrature Oscillators, 228
LC Oscillators, 230	
Nonsinusoidal Waveform Generators	233
Basic Fundamentals, 234	Square Wave Oscillators, 236
Pulse Generator, 241	
Summary	244
Questions	245
Problems	246
Chapter 10 Mathematical Operations	247
Objectives	247
Introduction	248
Summing Circuits	248
Addition, 248	Multiplication, 252
Subtracting, 253	Averaging, 252
Circuits, 253	Applications of Summing
Integration	255
Concepts of Integration, 255	Practical Integrator, 258
Integrator Frequency Response, 260	
Differentiation	261
Practical Differentiator, 263	Differentiator Frequency
Response, 263	
Logarithmic Amplifiers	264
Concepts of Logarithmic Amplifiers, 264	Logarithmic
Amplifier Applications, 266	
Other Mathematical Circuits	268
Summary	271
Questions	272
Problems	273
Chapter 11 Special-Purpose OP Amps	274
Objectives	274
Introduction	275
Comparators	275
Zero-Crossing Detector, 275	Level Detector, 276
Window Comparator, 278	Comparator
Applications, 279	
Instrumentation Amplifiers	281
Concepts of Instrumentation Amplifiers, 281	
Instrumentation Amplifier Applications, 284	

Current Difference Amplifiers	285
Transconductance Amplifiers	287
Programmable Amplifiers	290
Op-Amp-Related Integrated Circuits	291
Sample-and-Hold Circuits,	291
Analog Signal-Processing Subsystem,	293
Timer IC,	295
Summary	297
Questions	298

Chapter 12 Using OP Amps with Semiconductor Devices

300

Objectives	300
Introduction	301
Diodes and Op Amps	301
Precision Diode,	302
Absolute-Value Circuits,	303
Detectors,	306
Zener Diode Applications,	308
FET Applications	310
Voltage-Variable Resistors,	310
Gain Control,	311
Oscillators,	312
FET Switches,	313
Bipolar Transistor Applications	314
Power Switches,	314
Current Drivers,	316
Audio Applications,	316
Power Control Devices	319
Summary	321
Questions	321

Chapter 13 Applications

323

Introduction	323
Thermometer	324
Tone Detector	326
Tone Detector Circuit Operation,	327
Troubleshooting the Tone Detector,	327
Level Sensor	328
Level Sensor Circuit Operation,	329
Troubleshooting the Level Sensor,	331
Voltage-Controlled Oscillator (VCO)	331
VCO Circuit Operation,	332
Troubleshooting a VCO,	334
Current-Controlled Oscillator	335
Function Generators	336
Function Generator Block Diagram,	336
Integrator Operation,	337
Square and Triangular Wave Output,	339
Sawtooth Wave Output,	340
Pulse and Sine Wave Output,	340
Triangular-to-Sine Wave Conversion,	340
LSI Function Generator,	341

Absolute-Value Circuit	342
Summary	343
Questions	345
Problems	346

Appendix A: Data Sheet	347
-------------------------------	------------

Appendix B: Basic Formulas	356
-----------------------------------	------------

Glossary	360
-----------------	------------

Bibliography	376
---------------------	------------

Answers	378
----------------	------------

Index	381
--------------	------------