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Analog Electronics Analysis and Design

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Contents

<i>Preface</i>	<i>xi</i>
<i>Acknowledgements</i>	<i>xiv</i>
1 Introductory Topics	1
1.1 Basic concepts and terminology	1
1.2 Circuit analysis	2
1.2.1 Linear circuit analysis	2
1.2.2 Non-linear circuit analysis using graphical techniques	6
1.2.3 Non-linear circuit analysis using piecewise-linear modelling	9
1.2.4 Small-signal analysis of non-linear circuits	10
1.3 The basic electronic circuit	15
References and further reading	16
Tutorial questions	17
2 Electronic Devices and Components	20
2.1 Temperature limitation	20
2.2 Voltage limitation	22
2.3 Performance of semiconductor devices: diodes and transistors	23
2.3.1 Semiconductor material	23
2.3.2 Junction diode	23
2.3.3 Bipolar junction transistor (BJT)	26
2.3.4 Field-effect transistors (FETs)	30

2.4	Performance of passive components: resistors, capacitors and wound components	35
2.4.1	Resistors	35
2.4.2	Capacitors	38
2.4.3	Wound components: inductors and transformers	42
2.5	Manufacturing costs	47
	References and further reading	50
	Tutorial questions	50
3	Small-signal Amplifiers: Basics	53
3.1	BJT bias circuits	55
3.2	FET bias circuits	65
3.3	AC operation: coupling and bypass	70
3.4	AC performance	75
3.4.1	Gain, input impedance, output impedance	75
3.4.2	AC modelling	78
3.4.3	AC analysis	83
3.5	Single-stage configurations	90
	References and further reading	102
	Tutorial questions	103
4	Frequency Response	110
4.1	Sinusoidal response of CR networks	111
4.2	General small-signal amplifier model	115
4.3	Amplifier response at LF	117
4.4	Amplifier response at HF	121
4.5	Overall response of specific amplifiers	124
4.6	Distortion	128
4.7	Pulse response	129
	References and further reading	132
	Tutorial questions	133
5	Feedback	135
5.1	Fundamentals	135

5.2	Gain sensitivity	138
5.3	Effect of feedback on frequency response and bandwidth	139
5.4	Reduction of distortion using negative feedback	141
5.5	Noise reduction using negative feedback	142
5.6	Basic feedback arrangements	143
5.7	Effect of feedback on input and output resistances	145
5.8	Practical implementation of feedback	149
	References and further reading	152
	Tutorial questions	152
6	Small-signal Amplifiers: Advanced Topics	154
6.1	Bootstrapping	154
6.2	Biasing by current mirror	155
6.3	Active loads	156
6.4	Differential stage	157
6.5	Darlington stage	168
6.6	Complementary stage	171
6.7	Cascode amplifier	171
6.8	Cascaded amplifiers	174
6.9	Tuned amplifier	176
	References and further reading	181
	Tutorial questions	182
7	Operational Amplifiers	184
7.1	Basics	184
7.2	Amplifier circuit analysis	189
7.3	Op-amp applications	199
7.3.1	Linear applications	199
7.3.2	Switching applications	208
7.4	Non-ideal op-amp performance	211
7.4.1	Finite parameters	212
7.4.2	DC offsets	215
7.4.3	Output loading	218

7.4.4 Slew rate	219
7.4.5 Stability	221
7.5 Some practicalities	231
References and further reading	234
Tutorial questions	235
8 Power Amplifiers	241
8.1 Basics: efficiency, distortion, classification	241
8.2 Single-ended class A arrangements	244
8.3 Push–pull class A power stage	250
8.4 Class B power stage	252
8.5 Class AB operation	257
8.6 Class C power stage	259
8.7 Switched-mode power stages: classes D and E	260
References and further reading	263
Tutorial questions	263
9 Analog Signal Generation and Processing	265
9.1 Signal generation: linear oscillators	265
9.1.1 CR oscillators	267
9.1.2 LC oscillators	275
9.1.3 Crystal oscillator	282
9.2 Analog signal processing	283
9.2.1 Limiting, clamping and rectification	284
9.2.2 Filtering	286
9.2.3 Shaping	293
9.2.4 Modulation and demodulation	302
References and further reading	303
Tutorial questions	304
10 Pulse Circuits	310
10.1 Discrete-component pulse circuits	310
10.1.1 Transistors as switches	310

10.1.2	Discrete bistable circuits	315
10.1.3	Discrete monostable circuits	320
10.1.4	Discrete astable circuits	323
10.2	Op-amp pulse circuits	324
10.2.1	Op-amp astable circuits	324
10.2.2	Op-amp monostable circuits	328
	References and further reading	330
	Tutorial questions	330
11	Power Supplies	334
11.1	Types of supplies	337
11.2	AC–DC supplies	337
11.2.1	Transformation	338
11.2.2	Rectification	338
11.2.3	Smoothing	349
11.2.4	Linear regulators	367
11.2.5	Current limiting and protection	385
11.2.6	Switched-mode techniques	387
11.3	DC–AC supplies	389
11.4	DC–DC supplies	390
11.5	Voltage multiplication	390
11.6	Batteries	392
	References and further reading	397
	Tutorial questions	398
	<i>Appendix A: Fourier Representation</i>	404
	<i>Appendix B: Tuned Circuits</i>	407
	<i>Appendix C: Component Coding</i>	416
	<i>Appendix D: Preferred (E-series) Component Values</i>	420
	<i>Appendix E: Manufacturers' Data Sheets of Selected Devices and Integrated Circuits</i>	422
E.1	Philips signal diode type BAX13	423
E.2	Philips voltage-reference diode type BZX79	428
E.3	Philips voltage-reference diode type BZV85	437

<i>E.4 Philips bridge rectifier type BY224</i>	448
<i>E.5 Philips low-power npn BJT BC107-9</i>	456
<i>E.6 Texas high-power npn BJT type TIP31</i>	469
<i>E.7 Siliconix low-power n-channel JFET type J201-4</i>	473
<i>E.8 Siliconix medium-power n-channel VMOST type VN46AFD</i>	480
<i>E.9 Philips general-purpose bipolar operational amplifier type 741</i>	487
<i>UK/US Differences in Terminology, Spelling and Notation</i>	493
<i>Index</i>	494

Preface

Analog Electronics is an undergraduate main course text dealing with the analysis and design of continuous-signal electronic hardware. No previous experience in the subject is assumed. Treatment throughout is at device/component level with sufficient explanation to enable the reader develop both an understanding of the principles involved and a proficiency in basic design.

The material covers the analog electronics syllabuses of the first 2 years of MEng, BEng and BSc courses in Electronics and related subjects, providing a sound foundation for more specialised work in final-year options and post-graduate studies. The book will also be useful to students of Higher Diploma courses in Electronics.

Each chapter begins by listing the coverage so that the reader can see at a glance the direction of the work. Over 50 worked examples are included in the text and more than 120 further graduated tutorial questions, with answers, provide readers with the opportunity to test their developing understanding and design ability. Although devoted mainly to analog electronics, pulse circuits are also included since this material is not normally covered in complementary texts devoted to digital electronics.

The introductory chapter is concerned with basics including essential terminology, circuit analysis techniques applicable to electronic circuits and the operation of the basic transistor-load-power supply circuit in the linear and switching modes.

Chapter 2 is devoted to the various electronic devices and components: transistors, diodes, resistors, capacitors, inductors and transformers. The material included is limited to that required as foundation to the use of these circuit elements in subsequent work, the emphasis being on practical details. Brief explanation of device operation is included for completeness; the reader is referred to the author's text *Semiconductor Device Technology* for more detailed information where necessary. The chapter concludes with an outline of component and manufacturing costs.

For convenience, the major topic of amplification is subdivided into small-signal amplifiers, operational amplifiers and power amplifiers, with separate chapters devoted to frequency response and feedback. Chapter 3 covers the fundamentals of linear circuit performance and design: biasing, dc stability, load line analysis and ac performance at mid-frequencies, together with comparison of the performance of the various configurations of both BJT and FET single-stage circuits.

The topic of frequency response is considered in chapter 4 with the effects of series and shunt capacitance on the gain and phase response of linear circuits being examined initially,

leading to treatment of amplifier response at low and high frequencies, including the effect of stray capacitance. The significance of limited frequency response as far as distortion is concerned is included here, and the chapter concludes with consideration of the pulse response of analog circuits.

Chapter 5 introduces feedback and investigates its effect on gain, bandwidth, stability, input and output resistance, distortion and noise before considering the practical implementation of the various feedback arrangements.

More advanced aspects of small-signal amplifiers are described in chapter 6, notably bootstrapping, biasing by current mirror and the use of active loads. The chapter continues with consideration of differential, Darlington and complementary stages together with treatment of the cascode arrangement, the effect of cascading amplifier stages and the performance of tuned amplifiers.

Operational amplifiers are dealt with in chapter 7. After consideration of general aspects, a typical commercially-available op-amp is used as a vehicle for performance analysis, providing a useful example of the application of some of the techniques discussed previously. The concept of the hypothetical ideal op-amp is introduced and the circumstances discussed under which a practical op-amp may be considered as ideal, thereby greatly simplifying the analysis of circuits employing this type of amplifier; a range of linear and switching applications is then investigated using this simplification. The latter part of the chapter deals with the significance of the imperfections of the practical op-amp, such as finite parameters, offsets, output loading, slew rate limiting and stability; compensation for closed-loop stability is considered in detail.

Chapter 8 on power amplifiers considers the special aspects associated with higher power stages, notably power efficiency and distortion, and examines classes A, B and AB performance and implementation. Special-purpose class C operation and switched-mode power stages, classes D and E, are also discussed briefly.

Developing from previous work on feedback, linear oscillators are considered in chapter 9 in the context of analog signal generation; the work covers the theory and practical aspects of the various CR , LC and crystal types. The second half of this chapter is devoted to various aspects of analog signal processing. Signal limiting, clamping and precision rectification are covered initially followed by sections on filtering, based mainly on the popular Sallen and Key active filter, shaping using piecewise-linear techniques together with an introduction to modulation and demodulation.

Both discrete-component and op-amp based pulse circuits are considered in chapter 10. After an introductory section concerned with the various aspects of the use of transistors as switches, the operation and design of discrete-component bistable, monostable and astable circuits are examined. Then, extending the work on the use of op-amps in switching applications in chapter 7, sections are included on op-amp based astable and monostable circuits, illustrating the relatively simple design procedures involved.

The final chapter on power supplies considers the various stages of ac-dc, dc-ac and dc-dc supplies, and includes a section on batteries. The concept of power is introduced initially together with the significance and determination of the average and root-mean-square values of a time-varying quantity. Based on the linear ac-dc supply, transformation and rectification are then considered, followed by detailed coverage of the various types of smoothing filter, with performance and component selection being considered in each case. The operation and design of linear regulators is then included with further sections on current limiting and protection. Switched-mode techniques for ac-dc supplies, inverters and step-up converters are then introduced, but the reader is referred to texts devoted to power electronics for detailed

consideration of these specialist topics. The section on batteries is concerned mainly with the designation and performance of the popular disposable and rechargeable types. Battery performance parameters are listed and the factors affecting battery selection considered.

Each chapter includes a detailed list of reference material to assist the reader in further work. Additional material on the Fourier representation of non-sinusoidal waveshapes, the performance of tuned circuits, component coding, ranges of preferred component values and manufacturers' data sheets for a range of typical devices and ICs is included as appendixes.

Malcolm Goodge

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