CAMBRIDGE

Cambridge University Press
0521815363 - Hands-On Electronics: A One-Semester Course for Class Instruction or Self-Study
Daniel M. Kaplan and Christopher G. White
Table of Contents
More information

Contents

List of figures *page* xi
List of tables xv
About the authors xvi
To the Reader xvii
Acknowledgments xviii
Introduction xix

1 Equipment familiarization: multimeter, breadboard, and oscilloscope 1

1.1 Multimeter 1
1.2 Breadboard 2
1.2.1 Measuring voltage 4
1.2.2 Measuring current; resistance and Ohm's law 5
1.2.3 Measuring resistance 8
1.3 Oscilloscope 8
1.3.1 Probes and probe test 10
1.3.2 Display 11
1.3.3 Vertical controls 11
1.3.4 Horizontal sweep 12
1.3.5 Triggering 12
1.3.6 Additional features 13

2 *RC* circuits 15

2.1 Review of capacitors 15
2.1.1 Use of capacitors; review of AC circuits 17
2.1.2 Types and values of capacitors 19

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
0521815363 - Hands-On Electronics: A One-Semester Course for Class Instruction or Self-Study
Daniel M. Kaplan and Christopher G. White
Table of Contents
More information

2.2 Review of current, voltage, and power 20
2.2.1 Destructive demonstration of resistor power rating 21
2.3 Potentiometer as voltage divider 22
2.3.1 DC voltage divider 23
2.3.2 AC voltage divider 23
2.4 *RC* circuit 24
2.5 *RC* circuit as integrator 24
2.6 Low-pass filter 25
2.7 *RC* circuit as differentiator 27
2.8 High-pass filter 28
2.9 Summary of high- and low-pass filters 28

3 Diodes 31

3.1 Semiconductor basics 31
3.2 Types of diodes 35
3.3 Rectification 36
3.4 Diode action – a more sophisticated view 37
3.5 Measuring the diode characteristic 38
3.6 Exploring rectification 40
3.7 Input and output impedance 45

4 Bipolar transistors 47

4.1 Bipolar-junction-transistor basics 47
4.1.1 Basic definitions 50
4.1.2 Simplest way to analyze transistor circuits 51
4.1.3 Ebers–Moll transistor model 52
4.2 Experiments 54
4.2.1 Checking transistors with a meter 54
4.2.2 Emitter follower 55
4.2.3 Common-emitter amplifier 57
4.2.4 Collector as current source 59
4.2.5 Transistor switch 60
4.3 Additional exercises 61
4.3.1 Darlington connection 61

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
0521815363 - Hands-On Electronics: A One-Semester Course for Class Instruction or Self-Study
Daniel M. Kaplan and Christopher G. White
Table of Contents
More information

4.3.2 Push–pull driver 62
4.3.3 Common-base amplifier 63

5 Transistors II: FETs 65

5.1 Field-effect transistors 65
5.1.1 FET characteristics 66
5.1.2 Modeling FET action 68
5.2 Exercises 69
5.2.1 FET characteristics 69
5.2.2 FET current source 70
5.2.3 Source follower 71
5.2.4 JFET amplifier 73

6 Transistors III: differential amplifier 75

6.1 Differential amplifier 75
6.1.1 Operating principle 76
6.1.2 Expected differential gain 76
6.1.3 Measuring the differential gain 77
6.1.4 Input offset voltage 78
6.1.5 Common-mode gain 78
6.2 Op amps and their building blocks 79
6.2.1 Current mirror 79
6.2.2 Differential amplifier with current-source loads 80
6.2.3 Improved current mirror 82
6.2.4 Wilson current mirror 82

7 Introduction to operational amplifiers 85

7.1 The 741 operational amplifier 85
7.1.1 741 pinout and power connections 86
7.1.2 An ideal op amp 87
7.1.3 Gain of inverting and noninverting amplifiers 88
7.1.4 Op amp ‘golden rules’ 90
7.1.5 The nonideal op amp 90

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
0521815363 - Hands-On Electronics: A One-Semester Course for Class Instruction or Self-Study
Daniel M. Kaplan and Christopher G. White
Table of Contents
More information

7.2 Experiments 91
7.2.1 Testing open-loop gain 91
7.2.2 Inverting amplifier 92
7.2.3 Noninverting amplifier 93
7.2.4 Voltage follower 94
7.2.5 Difference amplifier 95
7.3 Additional experiments 97
7.3.1 Current source 97
7.3.2 Noninverting summing amp with difference amplifier 98

8 More op amp applications 101

8.1 Op amp signal processing 101
8.1.1 Differentiator 102
8.1.2 Integrator 103
8.1.3 Logarithmic and exponential amplifiers 105
8.2 Experiments 106
8.2.1 Differential and integral amplifiers 106
8.2.2 Logarithmic and exponential amplifiers 108
8.2.3 Op amp active rectifier 108
8.2.4 Op amp with push–pull power driver 109
8.3 Additional exercises 111

9 Comparators and oscillators 113

9.1 Experiments 113
9.1.1 Op amp as comparator 113
9.1.2 Unintentional feedback: oscillation 115
9.1.3 Intentional positive feedback: Schmitt trigger 116
9.1.4 *RC* relaxation oscillator 117
9.1.5 555 timer IC 118
9.2 Additional experiments 121
9.2.1 Alarm! 121
9.2.2 Sine/cosine oscillator 122
9.2.3 Active bandpass filter 123

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
0521815363 - Hands-On Electronics: A One-Semester Course for Class Instruction or Self-Study
Daniel M. Kaplan and Christopher G. White
Table of Contents
More information

10 Combinational logic 125

10.1 Digital logic basics 125
10.1.1 Logic levels 126
10.1.2 Logic families and history 127
10.1.3 Logic gates 129
10.1.4 Summary of Boolean algebra 130
10.2 CMOS and TTL compared 131
10.2.1 Diode logic 131
10.2.2 Transistor–transistor logic (TTL) 132
10.2.3 Complementary MOSFET logic (CMOS) 133
10.2.4 Powering TTL and TTL-compatible integrated circuits 136
10.3 Experiments 137
10.3.1 LED logic indicators and level switches 137
10.3.2 MOSFETs 138
10.3.3 CMOS NAND gate 140
10.3.4 Using NANDs to implement other logic functions 140
10.3.5 TTL quad XOR gate 141
10.4 Additional exercises 142
10.4.1 7485 4-bit magnitude comparator 142

11 Flip-flops: saving a logic state 143

11.1 General comments 144
11.1.1 Schematics 144
11.1.2 Breadboard layout 144
11.1.3 Synchronous logic 144
11.1.4 Timing diagrams 144
11.2 Flip-flop basics 145
11.2.1 Simple RS latch 145
11.2.2 D-type flip-flop 147
11.3 JK flip-flop 148
11.4 Tri-state outputs 149

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
0521815363 - Hands-On Electronics: A One-Semester Course for Class Instruction or Self-Study
Daniel M. Kaplan and Christopher G. White
Table of Contents
More information

11.5 Flip-flop applications 151
11.5.1 Divide-by-four from JK flip-flops 151
11.5.2 Contact bounce 152
11.5.3 Electronic coin toss 153

12 Monostables, counters, multiplexers, and RAM 155

12.1 Multivibrators 156
12.2 Counters 156
12.3 Experiments 157
12.3.1 Bi-quinary ripple counter 157
12.3.2 Monostable multivibrator 159
12.3.3 Multiplexer and finite-state machine 162
12.3.4 RAM 162

13 Digital↔analog conversion 167

13.1 A simple D/A converter fabricated from familiar chips 168
13.2 Tracking ADC 170
13.3 080x ADC and DAC chips 171
13.3.1 Successive-approximation ADC 171
13.4 Additional exercises 177
13.4.1 Digital recording 177
13.4.2 Successive-approximation ADC built from components 178

Further reading 183
Appendix A Equipment and supplies 185
Appendix B Common abbreviations and circuit symbols 188
Appendix C RC circuits: frequency-domain analysis 191
Appendix D Pinouts 194
Glossary of basic electrical and electronic terms 197
Index 199

© Cambridge University Press www.cambridge.org