
Red Pitaya for Test & Measurement



Prof Dr Dogan Ibrahim
Near East University



an Elektor Publication

LEARN DESIGN SHARE

Preface	13
Chapter 1 • Red Pitaya – Quick Startup Guide	15
1.1 What is Red Pitaya ?	15
1.2 What’s in the Box	18
1.3 The Diagnostic Kit	18
1.4 Impedance Analyzer Extension Board	18
1.5 Sensor Extension Module	19
1.6 Red Pitaya Casing	19
1.7 Red Pitaya Board Layout	20
1.8 Brief Specifications of the Red Pitaya Board	21
1.9 Getting Started	23
1.9.1 Connecting Red Pitaya Board Through an Ethernet Cable	25
1.9.2 IP Address of the Red Pitaya Board	26
1.9.3 Changing the IP Address	27
1.9.4 Accessing the Red Pitaya Operating System	28
1.9.5 Wireless Connection Without a Router	33
1.10 Summary	35
Chapter 2 • Resistors	36
2.1 What is a Resistor	36
2.2 Series and Parallel Resistors	40
2.2.1 Series Connection	40
2.2.2 Parallel Connection	41
2.2.3 Hybrid Connection	42
2.3 Ohm’s Law	43
2.3.1 Division of Current	45
2.3.2 Division of Voltage	47
2.4 Kirchoff’s Laws	49
2.4.1 Kirchoff’s Current Law	49
2.4.2 Kirchoff’s Voltage Law	50
2.5 Power in Resistor Circuits	53
2.6 Using Red Pitaya To Measure Voltage	55
2.7 Thermistors	62

2.8 Summary	63
2.9 Exercises	64
Chapter 3 • Capacitors	66
3.1 What is a Capacitor	66
3.1.1 Parallel Plate Capacitor	68
3.1.2 Capacitors in Parallel	69
3.1.3 Capacitors in Series	69
3.1.4 Marking of Capacitors	70
3.2 Current Through a Capacitor	72
3.3 Resistor - Capacitor Circuits	72
3.4 Energy Stored in a capacitor	77
3.5 Red Pitaya Experiment with Resistor – Capacitor Circuit	78
3.6 Summary	82
3.7 Exercises	83
Chapter 4 • Inductors	84
4.1 What is an Inductor	84
4.2 Resistor – Inductor Circuits	86
4.3 Energy Stored in an Inductor	90
4.4 Red Pitaya LCR Meter	90
4.5 Summary	91
4.6 Exercises	91
Chapter 5 • Alternating Current and Voltage	93
5.1 What is Alternating Current	93
5.1.1 Root Mean Square Value	94
5.1.2 Average Value	94
5.2 Phase and Phase Difference	95
5.3 Other Waveforms	97
5.3.1 Square Wave	97
5.3.2 Triangular Wave	98
5.4 Red Pitaya Experiments With Waveforms	98
5.4.1 Experiment 1	98
5.4.2 Experiment 2	101

5.4.3 Experiment 3	103
5.4.4 Experiment 4	104
5.4.5 Experiment 5	105
5.5 Transformers	109
5.6 Resistors, Capacitors, and Inductors in AC Circuits and Resonance	111
5.6.1 Inductive Reactance and Capacitive Reactance.	111
5.6.2 Resonance.	112
5.6.3 Experiment 6	114
5.7 Summary	116
5.8 Exercises	117
Chapter 6 • Semiconductor Diodes	118
6.1 The Semiconductor Diode	118
6.2 Types of Diodes.	120
6.2.1 Power Supply Circuits	120
6.2.2 Light Emitting Diodes (LED)	123
6.2.3 Zener Diodes	124
6.2.4 Varactor Diodes	125
6.3 Red Pitaya Experiment - Half Wave Rectifier Circuit	125
6.4 Summary	127
6.5 Exercises	127
Chapter 7 • Bipolar Transistors	129
7.1 How a Transistor Works	129
7.2 The NPN Transistor	130
7.2.1 DC Analysis	130
7.2.2 AC Analysis – Transistor Amplifiers	136
7.3 Red Pitaya Experiment	141
7.4 Summary	144
7.5 Exercises	144
Chapter 8 • Operational Amplifiers.	146
8.1 What is an Operational Amplifier	146
8.2 Operational Amplifier Circuits	147
8.2.1 Inverting Circuit	148

8.2.2 Non-Inverting Circuit.	149
8.2.3 The Voltage Follower	150
8.2.4 Summing Amplifier	150
8.2.5 The Difference Amplifier	152
8.2.6 The Differentiator Amplifier	152
8.2.7 The Integrator Amplifier	152
8.3 Operational Amplifiers With Single Power Supply.	153
8.4 Red Pitaya Experiments – Operational Amplifiers.	153
8.4.1 Experiment 1 – Inverting Amplifier	153
8.4.2 Experiment 2 – Integrating Amplifier.	155
8.5 Operational Amplifier Function Generator	156
8.5.1 Generating Square Wave	156
8.5.2 Generating Sine Wave	158
8.5.3 Triangle Wave Generator	160
8.6 Red Pitaya Experiment – Phase Shift Oscillator	160
8.7 FILTERS	162
8.7.1 Low-Pass Butterworth Filters	164
8.7.2 High-Pass Butterworth Filters	168
8.7.3 Band-Pass Butterworth Filters	172
8.8 Red Pitaya Experiments – Filters and Bode Plotter	174
8.9 Summary	178
8.10 Exercises	178
Chapter 9 • Modulation and Radio Communication Circuits	180
9.1 What is Modulation	180
9.1.1 Amplitude Modulation	180
9.1.2 Frequency Modulation	182
9.2 Wavebands.	183
9.3 Red Pitaya - Software Defined Radio (SDR)	184
9.4 Summary	186
9.5 Exercises	186
Chapter 10 • Visual Programming	187
10.1 What is Visual Programming	187

10.2 PROJECT 1 - Flashing an LED on Red Pitaya Board	188
10.3 PROJECT 2 - Flashing Two LEDs Alternately.	191
10.4 PROJECT 3 – Chasing LEDs	192
10.5 PROJECT 4 – FLASHING LEDs A NUMBER OF TIMES	193
10.6 PROJECT 5 – INTERRUPTING THE PROGRAM FROM THE KEYBOARD	194
10.7 Using the Extension Module	195
10.8 PROJECT 6 – The Buzzer.	197
10.9 PROJECT 7 – Buzzer with a Push-Button Switch.	199
10.10 PROJECT 8 – Generating the SOS Morse Code	201
10.11 PROJECT 9 – Relay and DC Motor.	203
10.12 PROJECT 10 – Generating Sound with a Known Frequency	205
10.13 PROJECT 11 – Sound Effect.	206
10.14 PROJECT 12 – Light Activated Switch	208
10.15 PROJECT 13 – Sound Activated Switch	211
10.16 PROJECT 14 – Sending e-Mail	213
10.17 PROJECT 15 – Temperature Sensor	213
10.18 PROJECT 16 – Temperature Activated Alarm	215
10.19 Summary	216
Chapter 11 • Controlling Red Pitaya from Matlab	218
11.1 Matlab Interface	218
11.2 Summary	223
Chapter 12 • Microcontrollers	224
12.1 Microcontroller Systems	224
12.1.1 RAM	228
12.1.2 ROM	228
12.1.3 PROM	228
12.1.4 EPROM.	228
12.1.5 EEPROM.	228
12.1.6 Flash EEPROM.	228
12.2 Microcontroller Features	229
12.2.1 Supply Voltage	229
12.2.2 The Clock.	229

12.2.3 Timers	229
12.2.4 Watchdog.	229
12.2.5 Reset Input	230
12.2.6 Interrupts	230
12.2.7 Brown-out Detector.	230
12.2.8 Analogue-to-digital Converter (ADC)	230
12.2.9 Serial Input-Output	231
12.2.10 EEPROM Data Memory	231
12.2.11 LCD Drivers	231
12.2.12 Analog Comparator	231
12.2.13 Real-time Clock.	231
12.2.14 Sleep Mode	231
12.2.15 Power-on Reset.	231
12.2.16 Low Power Operation	232
12.2.17 Current Sink/Source Capability	232
12.2.18 USB interface	232
12.2.19 CAN Bus interface	232
12.2.20 Ethernet interface	232
12.2.21 ZigBee interface	232
12.2.22 Multiply and divide hardware	232
12.2.23 Operating temperature	232
12.2.24 Pulse Width Modulated (PWM) Outputs	233
12.2.25 Package size.	233
12.2.26 DMA	233
12.3 Microcontroller Architectures	233
12.3.1 RISC and CISC	233
12.4. 8, 16, or 32 Bits ?.	234
APPENDIX	236
A.1 Starting Python on Red Pitaya.	236
A.2 Variable Names.	237
A.3 Comments	237
A.4 Indentation.	237

A.5 Line Continuation	238
A.7 Python Data Types.	238
A.8 Python Operators	241
A.9 Control of Flow	243
A.10 Trigonometric Functions	248
A.11 Mathematical Functions	249
A.12 Print Statement.	249
A.13 String Functions	250
A.14 Date & Time Functions	251
A.15 User Defined Functions.	252
A.16 Keyboard Input	253
A.17 Files.	254
A.18 Exceptions	254
A.19 Python Input-Output Control.	255
A.20 Example Programs.	256
Index	266