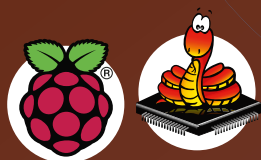


Raspberry Pi Pico for Radio Amateurs

Program and build RPi Pico-based ham station
utilities, tools, and instruments



Dogan Ibrahim, G7SCU

Raspberry Pi Pico for Radio Amateurs

Program and build RPi Pico-based hams station utilities, tools, and instruments



Dogan Ibrahim, G7SCU

● This is an Elektor Publication. Elektor is the media brand of
Elektor International Media B.V.

PO Box 11, NL-6114-ZG Susteren, The Netherlands

Phone: +31 46 4389444

● All rights reserved. No part of this book may be reproduced in any material form, including photocopying, or storing in any medium by electronic means and whether or not transiently or incidentally to some other use of this publication, without the written permission of the copyright holder except in accordance with the provisions of the Copyright Designs and Patents Act 1988 or under the terms of a licence issued by the Copyright Licensing Agency Ltd., 90 Tottenham Court Road, London, England W1P 9HE. Applications for the copyright holder's permission to reproduce any part of the publication should be addressed to the publishers.

● **Declaration**

The Author and Publisher have used their best efforts in ensuring the correctness of the information contained in this book. They do not assume, and hereby disclaim, any liability to any party for any loss or damage caused by errors or omissions in this book, whether such errors or omissions result from negligence, accident, or any other cause.

All the programs given in the book are Copyright of the Author and Elektor International Media. These programs may only be used for educational purposes. Written permission from the Author or Elektor must be obtained before any of these programs can be used for commercial purposes.

● **British Library Cataloguing in Publication Data**

A catalogue record for this book is available from the British Library

● **ISBN 978-3-89576-481-3** Print

ISBN 978-3-89576-482-0 eBook

● © Copyright 2021: Elektor International Media B.V.

Editor: Jan Buiting

Prepress Production: D-Vision, Julian van den Berg

Elektor is part of EIM, the world's leading source of essential technical information and electronics products for pro engineers, electronics designers, and the companies seeking to engage them. Each day, our international team develops and delivers high-quality content - via a variety of media channels (including magazines, video, digital media, and social media) in several languages - relating to electronics design and DIY electronics. www.elektormagazine.com

Preface	11
Chapter 1 • Raspberry Pi Pico Hardware	12
1.1 Overview	12
1.2 Pico hardware module	12
1.3 Comparison with the Arduino UNO	14
1.4 Operating conditions and powering the Pico	15
1.5 Pinout of the RP2040 microcontroller and Pico module	16
1.6 Other RP2040 microcontroller-based boards	18
1.6.1 Adafruit Feather RP2040	18
1.6.2 Adafruit ItsyBitsy RP2040	19
1.6.3 Pimoroni PicoSystem	19
1.6.4 Arduino Nano RP2040 Connect	20
1.6.5 SparkFun Thing Plus RP2040	21
1.6.6 Pimoroni Pico Explorer Base	21
1.6.7 SparkFun MicroMod RP2040 Processor	22
1.6.8 SparkFun Pro Micro RP2040	22
1.6.9 Pico RGB Keypad Base	23
1.6.10 Pico Omnibus	23
1.6.11 Pimoroni Pico VGA Demo Base	24
1.6.12 Tiny 2040	25
Chapter 2 • Raspberry Pi Pico Programming	27
2.1 Overview	27
2.2 Installing MicroPython on Pico	27
2.2.1 Using a Raspberry Pi 4 to help install MicroPython on the Pico	27
2.2.2 Using a PC (Windows 10) to help install MicroPython on Pico	34
Chapter 3 • Simple Programs – Software Only	38
3.1 Overview	38
3.2 Examples	38
3.2.1 Average of two numbers read from the keyboard	38
3.2.2 Average of 10 numbers read from the keyboard	38
3.2.3 Surface area of a cylinder	39
3.2.4 °C to °F conversion	40

3.2.5 Surface area and volume of a cylinder – user function.	41
3.2.6 Table of squares of numbers	41
3.2.7 Table of trigonometric sine.	42
3.2.8 Table of trigonometric sine, cosine and tangent	43
3.2.9 Trigonometric function of a required angle.	43
3.2.10 Words in reverse order	44
3.2.11 Calculator	45
3.2.12 Dice	46
3.2.13 Sorting lists	47
3.2.14 File processing — writing	47
3.2.15 File processing — reading	47
3.2.16 Squares and cubes of numbers.	48
3.2.17 Multiplication timetable	48
3.2.18 Odd or even?	49
3.2.19 Binary, octal, and hexadecimal.	49
3.2.20 Add two matrices	50
3.2.21 Shapes	50
Chapter 4 • Amateur Radio Programs — Software Only	53
4.1 Overview	53
4.2 Examples	53
4.2.1 4-band resistor color code identifier.	53
4.2.2 4-band resistor color code identifier including small resistors	55
4.2.3 Resistive potential divider	57
4.2.4 Resistive attenuator design — equal source & load resistances.	59
4.2.5 Resistive attenuator design — unequal source & load resistances	63
4.2.6 Zener diode based voltage regulator.	65
4.2.7 RC circuit frequency response	69
4.2.8 Resonance in series RLC circuits	71
4.2.9 Calculating the inductance of a single-layer coil	74
4.2.10 Constructing a single-layer coil for required inductance	76
4.2.11 Bipolar junction transistor (BJT) voltage divider biasing.	77
4.2.12 Designing a common-emitter BJT transistor amplifier circuit	80

4.2.13 Designing active low-pass filters	84
4.2.14 Quarter-wave vertical antenna length	89
4.2.15 The '555' Monostable / bistable / astable chip	90
4.2. Impedance matching	96
Chapter 5 • Simple Hardware-Based Projects	99
5.1 Overview	99
5.2 Project 1: Flashing the on-board LED	99
5.3 Project 2: External flashing LED	101
5.4 Project 3: Changing the LED flashing rate using pushbutton interrupts	104
5.5 Project 4: Binary counting LEDs	109
5.6 Using parallel LCDs	112
5.7 Project 5: LCD functions — displaying text	115
5.8 Project 6: Seconds counter – Parallel LCD.	120
5.9 Using I ² C LCDs	121
5.10 Project 7: Seconds counter with I ² C LCD	121
Chapter 6 • Amateur Radio Hardware-based Projects.	125
6.1 Overview	125
6.2 Project 1: Station mains On/Off power control	125
6.3 Project 2: Station clock	129
6.4 Project 3: Station temperature and humidity	134
6.5 Project 4: Station geographical coordinates	137
6.6 Waveform generation – using software.	144
6.6.1 Project 5: Generating a squarewave signal with amplitude under +3.3 V.	145
6.6.2 Project 6: Generating fixed voltages	150
6.6.3 Project 7: Generating a sawtooth signal	152
6.6.4 Project 8: Generating a triangular-wave signal	154
6.6.5 Project 9: Arbitrary periodic waveform	156
6.6.6 Project 10: Generating a sinewave signal	158
6.6.7 Project 11: Generating an accurate sinewave signal using timer interrupts	161
6.7 Waveform generation — using hardware	163
6.7.1 Project 12: Fixed-frequency waveform generator	164

6.7.2 Project 13: Generating waveforms with frequency-entry on keypad and LCD readout	171
6.8 Project 14: Frequency counter	181
6.9 Voltmeter – Ammeter – Ohmmeter – Capacitance meter	187
6.9.1 Project 15: Voltmeter	188
6.9.2 Project 16: Ammeter.	190
6.9.3 Project 17: Ohmmeter.	190
6.9.4 Project 18: Capacitance meter	192
6.10 Project 19: RF power meter	196
6.10.1 RF attenuators	203
6.10.2 dB, dBm, and W?	204
6.11 Project 20: Using the RadioStation Click board	206
6.12 Morse Code exercisers	217
6.12.1 Project 21: Characters entered by the user	217
6.12.2 Project 22: Sending randomly generated characters	222
6.12.3 Project 23: Setting Morse speed using an LCD and a rotary encoder	225
6.13 Project 24: Relay sequencer with time delays	232
6.14 Project 25: FM radio with the Raspberry Pi Pico	236
6.14.1 Project 26: Modified FM Radio - increasing the output signal level – connecting a loudspeaker.	244
6.14.2 Project 27: FM radio using an LCD and external buttons	246
6.14.3 Project 28: FM radio using an LCD and rotary encoder.	251
6.15 Project 29: Measure the frequency and duty cycle of a PWM waveform – screen display.	257
6.16 Project 30: Measure the frequency and duty cycle of a PWM waveform – LCD display	259
6.17 Raspberry Pi Pico Bluetooth interface	260
6.17.1 Project 31: Controlling an LED from a smartphone using Bluetooth.	260
6.18 Project 32: Station security.	265
6.19 Project 33: Generating accurate squarewave signals using the Raspberry Pi Pico State Machines	270
6.20 Project 34: Using Wi-Fi with the Raspberry Pi Pico – Controlling an LED from a smartphone	271

6.21 Project 35: Audio amplifier module with rotary encoder volume control	279
6.22 Project 36: Morse decoder	285
6.23 Raspberry Pi Pico RTL-SDR	296
6.24 Project 37: Using the FS1000A 433 MHz transmitter/receiver pair	298
Chapter 7 • Running a Program Automatically after the Raspberry Pi Pico Boots .	304
APPENDIX.	306
Parts Used in Projects	306
Index	307