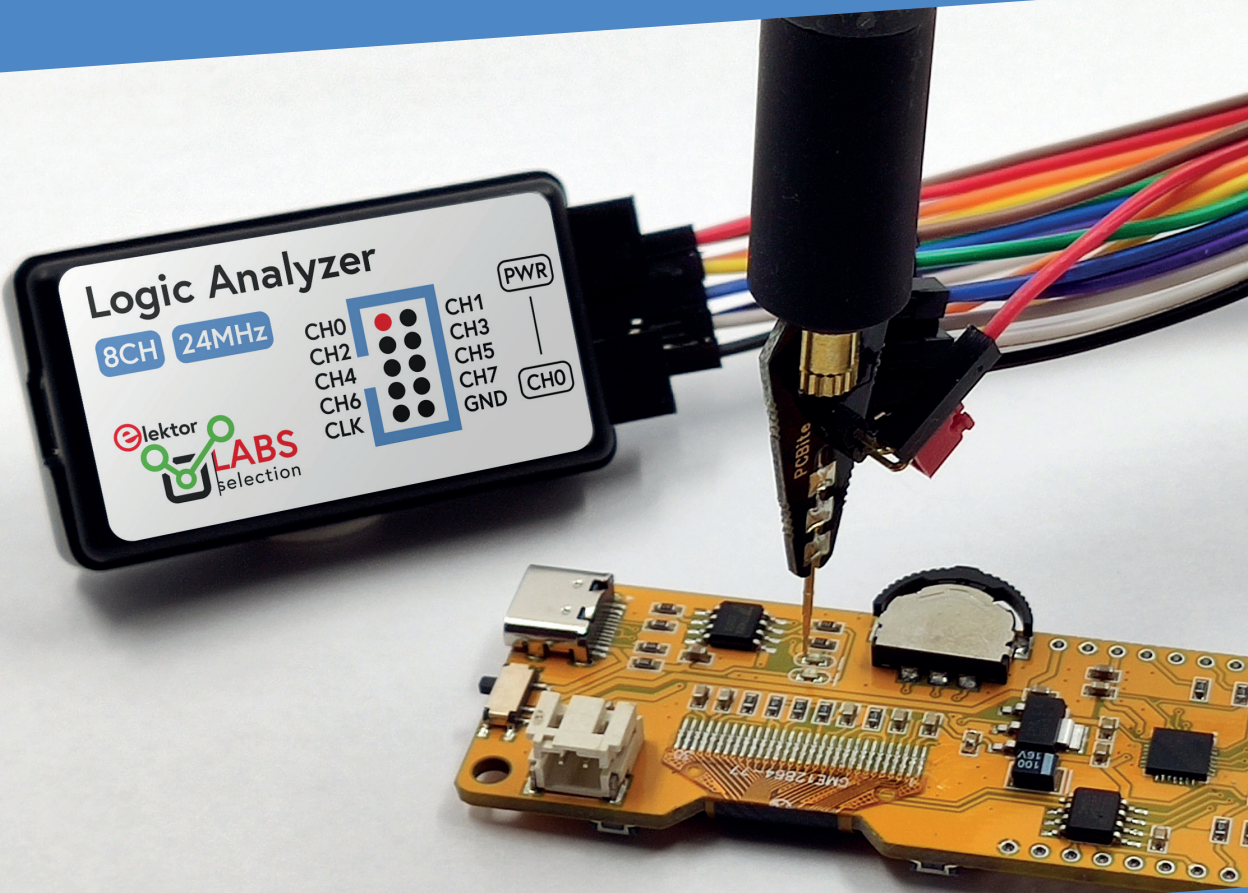


Logic Analyzers in Practice

PC USB Logic Analyzers with
Arduino, Raspberry Pi, and Co.



Jörg Rippel

Logic Analyzers in Practice

PC USB Logic Analyzers with Arduino,
Raspberry Pi and Co.



Jörg Rippel

● 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, editor, 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 978-3-89576-592-6** Print
ISBN 978-3-89576-593-3 eBook

● © Copyright Elektor International Media
www.elektor.com
Translator: Martin Cooke
Prepress Production: D-Vision, Julian van den Berg
Printed in the Netherlands

Elektor is 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

Contents

Preface	8
Chapter 1 • What You Need to Know About Logic Analyzers	9
1.1 What is a Logic Analyzer?	9
1.1.1 What software can you use with a logic analyzer?	14
1.1.2 Will a basic logic analyzer do the job?	16
1.2 Why do I need a logic analyzer?	16
1.3 What's so special about a logic analyzer?	18
1.4 What a logic analyzer is not	19
1.5 How do I connect a logic analyzer?	22
1.6 What should I pay for a logic analyzer?	25
1.6.1 The entry-level model	25
1.6.2 The mid-range model	26
1.6.3 High-end models	27
Chapter 2 • Choosing the Right Logic Analyzer	29
2.1 Important criteria and specification	29
2.2 Bandwidth and sampling rate	29
2.3 Logic levels and Threshold Voltage.	33
2.3.1 What is a logic level?	33
2.3.2 What is a threshold voltage?	33
2.3.3 How does the logic analyzer interpret signals?	33
2.3.4 Check the threshold voltage.	37
2.4 Positive and negative logic	39
2.5 Analogue and digital inputs.	40
2.6 Synchronous and asynchronous sampling.	41
2.6.1 Synchronous sampling	41
2.6.2 Asynchronous sampling	42
2.6.3 When to choose synchronous or asynchronous sampling?	43
2.7 Buffer and Stream modes.	43
2.7.1 Buffer mode.	44
2.7.2 Stream mode	45

2.7.3 The pros and cons	45
2.8 The USB port	46
2.9 Simple and complex triggering	47
2.10 Checklist for choosing a logic analyzer	48
2.10.1 A checklist of your own needs.	49
2.10.2 What's really important?	50
2.10.3 Logic analyzers.	51
2.10.4 Mixed signal devices	52
2.10.5 Horses for courses	53
Chapter 3 • Protocols and Hardware	55
3.1 Experimental circuits	55
3.1.1 What you will need	55
3.1.2 Additional tools.	59
3.2 The software user interface concept.	61
3.3 The I ² C bus	64
3.3.1 The I ² C weather station.	68
3.3.2 Analyzing the I ² C protocol	72
3.3.3 The weather station source code	79
3.4 The SPI bus	82
3.4.1 Raspberry Pi Pico with SPI graphics display	86
3.4.2 SPI Analysis.	90
3.4.3 SPI display source code	97
3.5 UART / RS-232	98
3.5.1 The Raspberry Pi Pico and serial data transfer	100
3.5.2 UART analysis.	103
3.5.3 Source code for the Pico UART	106
3.6 NeoPixel and the WS281x.	107
3.6.1 The RGB-LED adapter board.	109
3.6.2 WS28xx analysis	110
3.6.3 RGB-LED source code	115
3.7 The HD44780 LCD display controller	116

3.7.1 Bus Pirate and LCD adapter	117
3.7.2 HD44780 analysis	122
3.8 The 1-Wire protocol	125
3.8.1 Source code for the DS1820	130
3.9 Final thoughts on the protocol	130
Chapter 4 • Pitfalls	132
4.1 Errors and issues when measuring	132
4.2 The test probes	132
4.3 The ideal test setup	134
4.4 Ground loops	139
4.5 Earthing considerations at high frequency	140
4.6 Probe loading	140
4.7 Where to tap into the signal	141
4.8 Input voltage range	142
4.9 Using a logic analyzer as a scope	143
Post script	144
Appendix: Setting Up Your Work Environment	145
A1.1 Raspberry Pi Pico and Thonny with MicroPython	145
A1.2 Raspberry Pi Pico and Thonny with CircuitPython	151
A1.3 Arduino UNO and the Arduino IDE	157
A1.4 The Raspberry Pi and Python	163
Literature References	166
Index	167