

# Oscilloscopes

Understanding and  
Using Them Effectively



**ROHDE & SCHWARZ**  
Make ideas real



Academy Pro Title by  
**Rémy Mallard**

---

# Oscilloscopes

## Understanding and Using Them Effectively



Rémy Mallard

---

● 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 made every effort to ensure the accuracy of the information contained in this book. They do not assume, or 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. The author expresses his sincere gratitude to Arrow Electronics and Trenz Electronic for granting permission to include various tables, figures, and program codes in this book.

● **ISBN 978-3-89576-677-0** Print  
**ISBN 978-3-89576-676-3** eBook

● © Copyright 2025 Elektor International Media  
[www.elektor.com](http://www.elektor.com)  
Editor: Clemens Valens  
Prepress Production: D-Vision, Julian van den Berg  
The image of the oscilloscope on the cover was sponsored by Rohde & Schwarz.  
Printers: Ipskamp, Enschede, 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](http://www.elektormagazine.com)

## Contents

|                                                                                    |           |
|------------------------------------------------------------------------------------|-----------|
| <b>Acknowledgements</b> .....                                                      | <b>14</b> |
| <b>Chapter 1 • Introduction</b> .....                                              | <b>15</b> |
| 1.1 – What Is an Oscilloscope? .....                                               | 16        |
| 1.2 – Basic Operation of an Analogue Oscilloscope .....                            | 19        |
| 1.2.1 – General Block Diagram .....                                                | 19        |
| 1.2.2 – Amplifiers .....                                                           | 20        |
| 1.2.3 – Time Base and Sweep .....                                                  | 20        |
| 1.3 – Basic Characteristics of an Oscilloscope .....                               | 30        |
| 1.3.1 – Sensitivity and Vertical Scale .....                                       | 30        |
| 1.3.2 – Time Base, Sweep, and Horizontal Scale .....                               | 32        |
| 1.3.3 – Bandwidth .....                                                            | 32        |
| 1.3.4 – Specific Characteristics of Digital Oscilloscopes .....                    | 36        |
| 1.3.4.1 – Sampling Frequency .....                                                 | 36        |
| 1.3.4.2 – Number of Bits and Effective Number of Bits (Digital Oscilloscope) ..... | 40        |
| 1.3.4.3 – Memory Capacity/Depth (Digital Oscilloscope) .....                       | 41        |
| 1.3.4.4 – Refresh Rate (Digital Oscilloscope) .....                                | 44        |
| <b>Chapter 2 • Oscilloscope Probes</b> .....                                       | <b>46</b> |
| 2.1 – What is a Probe? .....                                                       | 46        |
| 2.2 – User Safety .....                                                            | 50        |
| 2.3 – Passive Voltage Probe .....                                                  | 51        |
| 2.3.1 – Impedance and Capacitance .....                                            | 57        |
| 2.3.2 – Frequency Limit .....                                                      | 59        |
| 2.3.3 – Voltage Limit .....                                                        | 62        |
| 2.3.4 – Influence of the Probe Ground Wire .....                                   | 63        |
| 2.3.5 – When Should You Use a 1:10 Passive Probe? .....                            | 63        |
| 2.4 – Active Voltage Probe .....                                                   | 64        |
| 2.5 – Differential Voltage Probe .....                                             | 65        |
| 2.5.1 – Voltage Limit .....                                                        | 68        |
| 2.5.1.1 – Gain and Attenuation .....                                               | 68        |
| 2.5.1.2 – Differential Voltage Range .....                                         | 69        |

|                                                                       |           |
|-----------------------------------------------------------------------|-----------|
| 2.5.1.3 – Common-Mode Voltage Range . . . . .                         | 70        |
| 2.5.1.4 – Maximum Admissible Voltage . . . . .                        | 71        |
| 2.5.1.5 – Common Mode Rejection Ratio (CMRR) . . . . .                | 71        |
| 2.5.2 – Frequency Limit . . . . .                                     | 72        |
| 2.5.3 – Complete Galvanic Isolation . . . . .                         | 72        |
| 2.6 – Other Types of Probes . . . . .                                 | 73        |
| 2.6.1 – HV (High Voltage) Probe . . . . .                             | 73        |
| 2.6.2 – Current Probe . . . . .                                       | 74        |
| 2.6.3 – Near-Field Probe and Contact Probe . . . . .                  | 75        |
| 2.7 – Connector Types . . . . .                                       | 75        |
| 2.8 – Choosing a Probe . . . . .                                      | 76        |
| <b>Chapter 3 • Choosing an Oscilloscope . . . . .</b>                 | <b>78</b> |
| 3.1 – Not Too Fast... . . . .                                         | 78        |
| 3.2 – Analogue or Digital? . . . . .                                  | 79        |
| 3.3 – Laboratory and Portable Oscilloscopes . . . . .                 | 81        |
| 3.3.1 – Laboratory Oscilloscope . . . . .                             | 81        |
| 3.3.2 – Portable or ‘Field’ Oscilloscopes (with Screen) . . . . .     | 82        |
| 3.3.3 – PC-Based Oscilloscopes . . . . .                              | 84        |
| 3.3.4 – Other Types of Oscilloscopes . . . . .                        | 86        |
| 3.3.4.1 – Tablet Oscilloscope . . . . .                               | 86        |
| 3.3.4.2 – Oscilloscope for Computer, Tablet, and Smartphone . . . . . | 86        |
| 3.3.4.3 – Pen Oscilloscope . . . . .                                  | 87        |
| 3.3.4.4 – Oscilloscope Kits . . . . .                                 | 87        |
| 3.3.4.5 – Software Oscilloscopes in Circuit Simulators . . . . .      | 88        |
| 3.3.4.6 – Building Your Own Oscilloscope? . . . . .                   | 88        |
| 3.3.5 – DSO, MSO, DPO, MDO, and Other Oscilloscope Types . . . . .    | 89        |
| 3.4 – Assessing User Needs . . . . .                                  | 94        |
| 3.4.1 – Place of Use? . . . . .                                       | 94        |
| 3.4.2 – Number of Signals to Display Simultaneously? . . . . .        | 95        |
| 3.4.3 – Maximum Voltage Applied to the Oscilloscope Input? . . . . .  | 95        |
| 3.4.4 – Maximum Frequency of Signals to Be Observed? . . . . .        | 96        |

|                                                                                                                             |            |
|-----------------------------------------------------------------------------------------------------------------------------|------------|
| 3.4.5 – Nature of Signals to Be Observed (Varying or Repetitive)? . . . . .                                                 | 97         |
| 3.4.6 – Displaying Signals in the Frequency Domain? . . . . .                                                               | 97         |
| 3.5 – Evaluating the Performance of an Oscilloscope . . . . .                                                               | 97         |
| 3.5.1 – General Performance . . . . .                                                                                       | 97         |
| 3.5.1.1 – Bandwidth . . . . .                                                                                               | 97         |
| 3.5.1.2 – Sampling Rate . . . . .                                                                                           | 98         |
| 3.5.1.3 – Resolution . . . . .                                                                                              | 98         |
| 3.5.1.4 – Memory Depth . . . . .                                                                                            | 99         |
| 3.5.1.5 – Segmented Memory . . . . .                                                                                        | 99         |
| 3.5.1.6 – Screen Refresh Rate . . . . .                                                                                     | 100        |
| 3.5.2 – Display Resolution and Screen Type . . . . .                                                                        | 100        |
| 3.5.3 – Ergonomics . . . . .                                                                                                | 100        |
| 3.5.4 – Other “Details” . . . . .                                                                                           | 101        |
| 3.6 – Hardware or Software Updates (Digital Oscilloscope) . . . . .                                                         | 101        |
| 3.6.1 – Software... and Bugs . . . . .                                                                                      | 101        |
| 3.6.2 – Official and Unofficial Updates . . . . .                                                                           | 102        |
| 3.6.3 – Maintenance and Metrological Verification (Recalibration) . . . . .                                                 | 102        |
| 3.7 – Second-Hand Oscilloscope: A Good Deal? . . . . .                                                                      | 102        |
| 3.8 – Conclusion . . . . .                                                                                                  | 103        |
| <b>Chapter 4 • Oscilloscope Configuration . . . . .</b>                                                                     | <b>105</b> |
| 4.1 – Installation and Operating Position . . . . .                                                                         | 105        |
| 4.2 – Getting Started and Viewing a Trace . . . . .                                                                         | 105        |
| 4.2.1 – Getting Started - No Visible Trace . . . . .                                                                        | 107        |
| 4.2.2 – Getting Started - Visible Trace, but Fixed Horizontal Line . . . . .                                                | 108        |
| 4.2.3 – Getting Started - Visible Trace, Square Wave (CAL Signal) or<br>Near-Sinusoidal (Finger Signal): Success! . . . . . | 110        |
| 4.2.4 – Initial Setup Adjustments . . . . .                                                                                 | 110        |
| 4.3 – Probe Calibration . . . . .                                                                                           | 111        |
| 4.3.1 – LF Adjustment (Low Frequency). . . . .                                                                              | 111        |
| 4.3.2 – HF Adjustment (High Frequency) . . . . .                                                                            | 113        |
| 4.4 – Coupling Modes . . . . .                                                                                              | 113        |
| 4.4.1 – DC Coupling (Direct Current). . . . .                                                                               | 114        |

|                                                                                 |     |
|---------------------------------------------------------------------------------|-----|
| 4.4.2 – AC Coupling (Alternating Current) . . . . .                             | 115 |
| 4.4.3 – Other Coupling Modes . . . . .                                          | 116 |
| 4.4.3.1 – Ground Coupling (GND, GD, or 0) . . . . .                             | 117 |
| 4.4.3.2 – High-Frequency Rejection (HF Reject) . . . . .                        | 117 |
| 4.4.3.3 – Low-Frequency Rejection (LF Reject) . . . . .                         | 117 |
| 4.4.3.5 – Invert (Polarity Inversion) . . . . .                                 | 117 |
| 4.5 – Triggering Modes . . . . .                                                | 118 |
| 4.5.1 – Manual Triggering (Norm, Normal) . . . . .                              | 119 |
| 4.5.2 – Automatic Triggering (AT, Auto, Auto Setup) . . . . .                   | 123 |
| 4.5.3 – Single Triggering (One-Shot) . . . . .                                  | 124 |
| 4.5.4 – Trigger Source and Slope . . . . .                                      | 126 |
| 4.5.5 – Other Types of Triggering . . . . .                                     | 130 |
| 4.5.5.1 – TV Video Triggering . . . . .                                         | 130 |
| 4.5.5.2 – External Signal Triggering (EXT) . . . . .                            | 131 |
| 4.5.5.3 – Mains (LINE) Triggering . . . . .                                     | 132 |
| 4.5.5.4 – Pulse Width Triggering . . . . .                                      | 132 |
| 4.5.5.5 – Interval Triggering. . . . .                                          | 132 |
| 4.5.5.6 – Event Counting Triggering . . . . .                                   | 132 |
| 4.5.5.7 – Digital Pattern Triggering . . . . .                                  | 133 |
| 4.5.5.8 – Runt Pulse Triggering. . . . .                                        | 133 |
| 4.5.6 – Hold-Off (Inhibition) . . . . .                                         | 133 |
| 4.5.7 – Roll Mode . . . . .                                                     | 133 |
| 4.6 – Essential Settings . . . . .                                              | 134 |
| 4.6.1 – Input Sensitivity Adjustment (Vertical Scale) . . . . .                 | 134 |
| 4.6.2 – Time Base Adjustment . . . . .                                          | 137 |
| 4.7 – Simultaneous Visualisation of Multiple Signals . . . . .                  | 140 |
| 4.7.1 – Displaying Separate Traces (Analogue Oscilloscope) . . . . .            | 140 |
| 4.7.1.1 – Displaying Two Signals in Chopped Mode (CHOP) . . . . .               | 140 |
| 4.7.1.2 – Displaying Two Signals in Alternate Mode (ALT or DUAL MODE) . . . . . | 141 |
| 4.7.2 – Displaying Combined Traces . . . . .                                    | 141 |
| 4.7.2.1 – Displaying Two Signals in Addition Mode . . . . .                     | 141 |
| 4.7.2.2 – Displaying Two Signals in Subtraction Mode . . . . .                  | 143 |

---

|                                                                             |            |
|-----------------------------------------------------------------------------|------------|
| 4.7.3 – Displaying Advanced Calculated Traces (Beyond A+B or A–B) . . . . . | 143        |
| 4.8 – Using Measurement Cursors (Markers) . . . . .                         | 144        |
| 4.9 – Special Functions . . . . .                                           | 146        |
| 4.9.1 – Selection of Input Impedance . . . . .                              | 146        |
| 4.9.2 – Adding an Offset Voltage via the Oscilloscope . . . . .             | 146        |
| 4.9.3 – Isolated Channels . . . . .                                         | 147        |
| <b>Chapter 5 • Basic Measurements . . . . .</b>                             | <b>148</b> |
| 5.1 – Measuring a Voltage . . . . .                                         | 148        |
| 5.1.1 – Measuring a Constant Voltage . . . . .                              | 151        |
| 5.1.2 – Measuring an Alternating Voltage. . . . .                           | 159        |
| 5.1.3 – Measuring a DC Offset Voltage . . . . .                             | 165        |
| 5.1.4 – Measuring Very Low-Value Voltages . . . . .                         | 170        |
| 5.2 – Time Measurements . . . . .                                           | 172        |
| 5.2.1 – Measuring a Time Interval. . . . .                                  | 173        |
| 5.2.2 – Measuring a Period. . . . .                                         | 176        |
| 5.2.3 – Measuring a Frequency . . . . .                                     | 178        |
| 5.2.4 – Measuring a Duty Cycle . . . . .                                    | 179        |
| 5.2.5 – Measuring a Phase Shift . . . . .                                   | 181        |
| 5.2.6 – Measuring a Rise or Fall Time . . . . .                             | 184        |
| <b>Chapter 6 • Advanced Measurements and Functions. . . . .</b>             | <b>189</b> |
| 6.1 – Warnings . . . . .                                                    | 189        |
| 6.2 – Measuring Mains Voltage . . . . .                                     | 189        |
| 6.2.1 – Measurement Using a Differential Probe . . . . .                    | 191        |
| 6.2.2 – Measurement Using an Isolation Transformer . . . . .                | 192        |
| 6.2.3 – Measurement Using an Optocoupler . . . . .                          | 193        |
| 6.3 – Measurements in a Mains Power Supply. . . . .                         | 194        |
| 6.3.1 – Measurement in a Linear Mains Power Supply . . . . .                | 194        |
| 6.3.2 – Measurement in a Switched-Mode Power Supply . . . . .               | 195        |
| 6.3.3 – Measurement in a Transformerless Mains Power Supply . . . . .       | 196        |
| 6.4 – Noise Measurement. . . . .                                            | 197        |
| 6.5 – XY Measurement and Lissajous Figures . . . . .                        | 201        |
| 6.5.1 – Measuring the Phase Shift Between Two Periodic Signals . . . . .    | 205        |



|                                                                                                  |     |
|--------------------------------------------------------------------------------------------------|-----|
| 6.5.2 – Displaying the Characteristics of a Dipole . . . . .                                     | 206 |
| 6.6 – Calculated Values and Computed Traces . . . . .                                            | 211 |
| 6.6.1 – Computed Values. . . . .                                                                 | 211 |
| 6.6.2 – Computed Traces . . . . .                                                                | 213 |
| 6.7 – Protocol Analysis and Serial Data Decoding (I <sup>2</sup> C, SPI, UART, etc.). . . . .    | 214 |
| 6.7.1 – Verifying the Electrical Validity of Signals . . . . .                                   | 215 |
| 6.7.2 – Serial Data Decoding (General Considerations) . . . . .                                  | 219 |
| 6.7.3 – I <sup>2</sup> C Serial Data Decoding . . . . .                                          | 220 |
| 6.7.3.1 – Manual Decoding of I <sup>2</sup> C Serial Data. . . . .                               | 221 |
| 6.7.3.2 – Automatic Decoding of I <sup>2</sup> C Serial Data with Picoscope 2204 . . . . .       | 222 |
| 6.7.3.3 – Automatic Decoding of I <sup>2</sup> C Serial Data with Rigol DS1054Z . . . . .        | 224 |
| 6.7.4 – Decoding SPI Serial Data . . . . .                                                       | 225 |
| 6.7.4.1 – Manual Decoding of SPI Serial Data. . . . .                                            | 226 |
| 6.7.4.2 – Automatic Decoding of SPI Serial Data with Picoscope 3204D-MSO . . . . .               | 228 |
| 6.7.4.3 – Automatic Decoding of SPI Serial Data with Rigol DS1054Z . . . . .                     | 229 |
| 6.7.5 – Decoding UART/RS-232 Serial Data . . . . .                                               | 230 |
| 6.7.5.1 – Manual Decoding of UART/RS-232 Serial Data . . . . .                                   | 231 |
| 6.7.5.2 – Automatic Decoding of UART/RS-232 Serial Data with Picoscope 2204<br>or 3204 . . . . . | 232 |
| 6.7.5.3 – Automatic Decoding of UART/RS-232 Serial Data with Rigol DS1054Z . . . . .             | 235 |
| 6.7.6 – Decoding Serial Data on a Differential Bus . . . . .                                     | 237 |
| 6.8 – Spectral Analysis . . . . .                                                                | 238 |
| 6.9 – Measurements and Specific Functions . . . . .                                              | 241 |
| 6.9.1 – Power Measurement. . . . .                                                               | 242 |
| 6.9.2 – Measuring the Impedance of a Dipole. . . . .                                             | 242 |
| 6.9.3 – Bandwidth Measurement (Amplitude-Frequency Response) . . . . .                           | 245 |
| 6.9.3.1 – Bandwidth Measurement Using the Point-by-Point Method . . . . .                        | 246 |
| 6.9.3.2 – Bandwidth Measurement Using the Wobulation Method . . . . .                            | 248 |
| 6.9.4 – Jitter Measurement . . . . .                                                             | 249 |
| 6.9.5 – Eye Diagram . . . . .                                                                    | 250 |
| 6.9.6 – Event Counter/Totaliser . . . . .                                                        | 254 |
| 6.9.7 – Integrated Function Generator. . . . .                                                   | 254 |

---

|                                                                     |            |
|---------------------------------------------------------------------|------------|
| 6.9.8 – Communication Interface . . . . .                           | 255        |
| 6.9.9 – Touchscreen Display . . . . .                               | 256        |
| 6.9.10 – Voice Control . . . . .                                    | 256        |
| 6.9.11 – Data Recording (Screen Traces and Configuration) . . . . . | 256        |
| 6.9.11.1 – Recording Displayed Waveforms . . . . .                  | 257        |
| 6.9.11.2 – Recording Oscilloscope Configurations . . . . .          | 258        |
| 6.9.12 – Checking an Infrared Remote Control . . . . .              | 258        |
| 6.9.13 – Exploring Unknown Signals... . . . .                       | 259        |
| <b>Chapter 7 • Exercises (and solutions) . . . . .</b>              | <b>260</b> |
| 7.1 – Exercise 1 . . . . .                                          | 260        |
| 7.2 – Exercise 2 . . . . .                                          | 260        |
| 7.3 – Exercise 3 . . . . .                                          | 261        |
| 7.4 – Exercise 4 . . . . .                                          | 261        |
| 7.5 – Exercise 5 . . . . .                                          | 262        |
| 7.6 – Exercise 6 . . . . .                                          | 262        |
| 7.7 – Exercise 7 . . . . .                                          | 263        |
| 7.8 – Exercise 8 . . . . .                                          | 263        |
| 7.9 – Exercise 9 . . . . .                                          | 263        |
| 7.10 – Exercise 10 . . . . .                                        | 263        |
| 7.11 – Solutions to the Exercises . . . . .                         | 264        |
| 7.11.1 – Solution to Exercise 1 . . . . .                           | 264        |
| 7.11.2 – Solution to Exercise 2 . . . . .                           | 264        |
| 7.11.3 – Solution to Exercise 3 . . . . .                           | 264        |
| 7.11.4 – Solution to Exercise 4 . . . . .                           | 264        |
| 7.11.5 – Solution to Exercise 5 . . . . .                           | 265        |
| 7.11.6 – Solution to Exercise 6 . . . . .                           | 265        |
| 7.11.7 – Solution to Exercise 7 . . . . .                           | 266        |
| 7.11.8 – Solution to Exercise 8 . . . . .                           | 267        |
| 7.11.9 – Solution to Exercise 9 . . . . .                           | 267        |
| 7.11.10 – Solution to Exercise 10 . . . . .                         | 268        |
| <b>Chapter 8 • Signal Generators . . . . .</b>                      | <b>269</b> |
| 8.1 – Main Characteristics . . . . .                                | 270        |

|                                                                                                    |            |
|----------------------------------------------------------------------------------------------------|------------|
| 8.1.1 – Technology Used . . . . .                                                                  | 270        |
| 8.1.2 – Signal Type . . . . .                                                                      | 270        |
| 8.1.3 – Signal Frequency . . . . .                                                                 | 272        |
| 8.1.4 – Signal Amplitude . . . . .                                                                 | 273        |
| 8.1.5 – Output Types and Protections . . . . .                                                     | 274        |
| 8.1.6 – Characteristics of Digital Generators. . . . .                                             | 277        |
| 8.1.7 – Modulation (AM, FM, sweep) . . . . .                                                       | 279        |
| 8.1.8 – Choosing a Signal Generator . . . . .                                                      | 280        |
| 8.2 – Usefulness (and Usage) of a Signal Generator . . . . .                                       | 281        |
| 8.2.1 – Bandwidth Measurement. . . . .                                                             | 282        |
| 8.2.2 – Distortion Measurement . . . . .                                                           | 282        |
| 8.2.3 – Stimulus with Intermittent Signals . . . . .                                               | 283        |
| 8.2.4 – Validation of a Logic or Analogue Stage . . . . .                                          | 285        |
| 8.2.5 – Verification of Circuit Protection . . . . .                                               | 285        |
| 8.2.6 – Simulation of Analogue Sensors. . . . .                                                    | 286        |
| <b>Appendix 1 – Electrical Safety . . . . .</b>                                                    | <b>287</b> |
| <b>Appendix 2 – Digitisation of a Signal . . . . .</b>                                             | <b>290</b> |
| A2.1 – Why Digitise an Analogue Signal? . . . . .                                                  | 290        |
| A2.2 – Analogue-to-Digital Conversion . . . . .                                                    | 290        |
| A2.3 – Sampling Frequency . . . . .                                                                | 292        |
| A2.4 – Quantization and Resolution . . . . .                                                       | 295        |
| A2.5 – Digital-to-Analog Conversion . . . . .                                                      | 298        |
| <b>Appendix 3 – Glossary . . . . .</b>                                                             | <b>302</b> |
| <b>Appendix 4 – Creative Repurposing . . . . .</b>                                                 | <b>307</b> |
| A4.1 – Turning a Television into an Oscilloscope . . . . .                                         | 307        |
| A4.2 – Turning an Oscilloscope into a Television... . . . .                                        | 307        |
| A4.3 – Turning an Oscilloscope into an Audio Phasemeter . . . . .                                  | 309        |
| A4.4 – Turning an Oscilloscope into a Spectrum Analyser. . . . .                                   | 310        |
| <b>Appendix 5 – Photographing Oscilloscope Waveforms on an<br/>Analogue Oscilloscope . . . . .</b> | <b>312</b> |
| <b>Appendix 6 – Make Your Own Probe? . . . . .</b>                                                 | <b>313</b> |
| A6.1 – Make Your Own Passive Probe? . . . . .                                                      | 313        |

---

|                                                                     |            |
|---------------------------------------------------------------------|------------|
| A6.2 – Make Your Own Active Probe? . . . . .                        | 314        |
| A6.3 – Make Your Own Differential Probe? . . . . .                  | 316        |
| <b>Appendix 7 – Important Details . . . . .</b>                     | <b>317</b> |
| A7.1 – Bandwidth . . . . .                                          | 317        |
| A7.1.1 – At the Upper End of the Bandwidth . . . . .                | 317        |
| A7.1.2 – At the Lower End of the Bandwidth . . . . .                | 317        |
| A7.1.3 – Outside the Specified Bandwidth . . . . .                  | 317        |
| A7.2 – Vertical Resolution . . . . .                                | 318        |
| A7.2.1 – Resolution Higher than 8 Bits with an 8-Bit ADC? . . . . . | 318        |
| A7.3 – Update Rate . . . . .                                        | 319        |
| A7.4 – Maximum Input Voltage . . . . .                              | 319        |
| A7.5 – Other Considerations . . . . .                               | 320        |
| A7.5.1 – Automatic Bandwidth Limitation . . . . .                   | 320        |
| A7.5.2 – Software-Based Bandwidth Limitation . . . . .              | 320        |
| <b>Appendix 8 – Useful Links . . . . .</b>                          | <b>321</b> |
| <b>Index . . . . .</b>                                              | <b>323</b> |