

Contents

Foreword7

Chapter 1 • Preparations8

1.1 Choice of the Controller8

1.2 The Arduino Nano9

1.3 Supply Voltage11

Chapter 2 • Preliminary Tests.13

2.1 Port Outputs13

2.2 Analog inputs and outputs16

2.3 The Serial Plotter.18

2.4 PWM Signal Generator21

2.5 A Sawtooth Generator23

2.6 Direct Digital Synthesis25

Chapter 3 • GCC Programming28

3.1 Fast port outputs.28

3.2 PWM Output28

3.3 Timer Interrupt32

3.4 Fast Sine Wave Generator33

3.5 AD Buffering39

Chapter 4 • The 'MSR' Laboratory46

4.1 Two-channel DDS Generator47

4.2 Binary Serial Transmission48

4.3 Frequency Setting51

4.4 Deflection Times and Dual-channel Operation54

4.5 Triggering.58

4.6 DC Voltage Output.60

Chapter 5 • Additional Inputs and Outputs63

5.1 DDS Phase Adjustment63

5.2 Signal Generator up to 8 MHz64

5.3 Frequency Measurement.68

5.4 Additional Analog Inputs.72

5.5 Capacitance Measurement from 1 pF	74
5.6 Resistance Measurement up to 1 M Ω	76
5.7 Resistance Measurement from 1 Ω	78
Chapter 6 • Measurements and Experiments	80
6.1 Subsampling	80
6.2 Examination at Higher Frequencies	82
6.3 Measurements on a Synchronous Signal.	84
6.4 Frequency Response of a Low-pass Filter	86
6.5 An LC Low Pass	89
6.6 LC Resonance	91
6.7 Transistor Test Circuit	93
Chapter 7 • Firmware Extensions.	97
7.1 Alternative DDS Functions	97
7.2 Reduced Amplitude	98
7.3 Triangle and Sawtooth	99
7.4 X-Y Representation	101
7.5 Frequency Sweep	104
7.6 Ramp Function	106
7.7 Measurement of Characteristic Curves	110
Chapter 8 • Application Examples	114
8.1 The Emitter Follower	114
8.2 Emitter Follower as Impedance Converter.	115
8.3 Sallen-Key Filter	116
8.4 Beat-Frequency Generator	117
8.5 Operational Amplifier	120
8.6 Voltage Doubling	121
8.7 All-pass Filter	123
8.8 Bandpass Filter	125
Appendix.	128
A.1 Bill of Materials	128
A.2 Breadboard Drawings.	128
A.3 Support Software	128