

Contents

Preface	5
1. Introduction	7
2. Digital multimeters	8
2.1 Types of digital multimeters	8
2.2 Properties of digital multimeters.....	9
2.2.1 Accuracy and errors of digital multimeters.....	10
2.2.2 Suppression of common and serial interfering voltages	11
2.3 DC voltage measurement.....	12
2.3.1 Electrometric amplifiers.....	12
2.3.2 Shielding in electrometric amplifiers	13
2.3.2.1 Floating shieding	13
2.3.2.2 Equipotential shieding	15
2.4 DC current measurement	16
2.4.1 Linear current measurement	16
2.4.2 Logarithmic current measurement.....	18
2.5 High voltage and current measurement.....	19
2.5.1 High voltage measurement	20
2.5.2 High current measurement.....	20
2.6 Resistance measurement.....	23
2.6.1 Medium resistance measurement	23
2.6.2 Small resistance measurement	23
2.6.3 High resistance measurement.....	24
2.7 Limiting factors in measuring voltages, currents and resistances.....	26
2.8 Measurement of AC voltages	28
2.8.1 Mean value measurement.....	29
2.8.2 RMS measurement	30
2.8.3 Peack value measurement.....	32
2.9 Temperature measurement	32
2.9.1 Temperature measurement wit thermocouples	32
2.9.2 Temperature measurement with resistance sensors	35
2.10 A/D converters in multimeters.....	37
2.10.1 Integration A/D converters.....	37
2.10.2 Suppression of interference voltage	40
2.11 Switches and multiplexers	41
2.11.1 Contact switches	41
2.11.2 CMOS switches	42
2.11.3 Multiplexers.....	42
3. Sources, calibrators and voltage standards.....	45
3.1 Types of sources, calibrators and voltage standards	45
3.2 Properties of sources, calibrators and voltage standards.....	47
3.3 Voltage references	47
3.3.1 Voltage references with Zener diode.....	47
3.3.2 Voltage references with bipolar transistors.....	49

3.3.3	Voltage references with unipolar transistors	50
3.3.4	Voltage references with Josephson cell	50
3.4	D/A converters used in calibrators	51
3.4.1	D/A converters with one modulator	51
3.4.2	D/A converters with two modulators	53
3.5	Output amplifiers for sources and calibrators	54
3.5.1	Output voltage amplifiers	54
3.5.2	Output current amplifiers	56
4.	Selective amplifiers and voltmeters	57
4.1	Types of selective amplifiers and voltmeters	57
4.2	Properties of selective amplifiers	57
4.3	Selective amplifiers with analogue signal processing	58
4.3.1	Amplifiers with continuous detector	58
4.3.2	Amplifiers with switch detector	61
4.4	Selective amplifiers with digital signal processing	62
5.	Time intervals, frequency and phase meters	65
5.1	Types of universal counters	65
5.2	Properties of universal counters	66
5.3	Digital time interval meters	66
5.3.1	Errors analysis of measuring time intervals	67
5.3.2	Methods of increasing the accuracy of time interval measurements	69
5.3.2.1	Interpolation method	69
5.3.2.2	Vernier methods	70
5.3.2.3	Measurement of the mean value from multiple intervals	72
5.4	Digital frequency meters and their ratio	73
5.4.1	Direct frequency measurement	73
5.4.2	Indirect frequency measurement	74
5.4.3	Frequency measurement with a higher frequency range	76
5.4.3.1	Mixing method for frequency measurement	76
5.4.3.2	Automatic frequency measurement	78
5.4.3.3	Frequency measurement with frequency synthesizer	79
5.4.4	Digital frequency ratio meters	80
5.4.5	Continuous digital frequency and phase meters	81
5.5	Digital phase shift meters	82
6.	Impedance meters and circuit analyzer	85
6.1	Types of impedance meters and circuit analyzer	85
6.2	Properties of measured dipoles and quadropoles	86
6.2.1	Properties of dipoles	86
6.2.2	Properties of quadropoles	89
6.3	Impedance meters	90
6.3.1	Impedance meters with digital output	90
6.3.2	Impedance meters with signal mixers	94
6.3.3	Digital impedance meters	94
6.4	Impedance analyzers	95
6.5	Circuit analyzers	96

7. Signal generators	99
7.1 Types of signal generators	99
7.2 Types of generated signals.....	99
7.2.1 Harmonic signals.....	100
7.2.1.1 Single-tone signal.....	100
7.2.1.2 Two-tone signal	101
7.2.1.3 Multi-tone signals.....	101
7.2.2 Modulated signals	102
7.2.2.1 Amplitude modulated signal.....	102
7.2.2.3 Phase modulated signal	104
7.2.3 Swept signals.....	104
7.2.4 Pulse signals.....	105
7.2.4.1 Rectangular and trapezoidal signals.....	105
7.2.4.2 Pulse modulated harmonic signals	105
7.2.4.3 Quadrature amplitude modulated signals	106
7.2.5 Random signals	108
7.3 Generation of deterministic signals.....	110
7.3.1 Amplitude synthesis	110
7.3.2 Frequency synthesis	113
7.3.3 Phase synthesis.....	114
7.4 Generation of pseudo random signals	117
8. Digital oscilloscopes and transients records	119
8.1 Types of digital oscilloscopes	119
8.2 Properties of digital oscilloscopes and data logs.....	123
8.3 Signal digitization in oscilloscopes.....	125
8.3.1 Sampling.....	125
8.3.2 Quantization.....	128
8.3.3 A/D conversion.....	130
8.4 Triggering, data storing and signal displaying.....	133
8.4.1 Trigger functions	133
8.4.2 Data storing.....	134
8.4.3 Signal displaying	134
8.5 Signal processing in digital oscilloscopes	137
8.6 Oscilloscope probes	140
8.6.1 Voltage passive probes.....	140
8.6.2 Active, differential and isolated voltage probes.....	143
8.6.3 Logic probes	145
8.6.4 Current probes	146
9. Spectral analyzers	148
9.1 Types of spectrum analyzers.....	148
9.2 Properties of spectrum analyzers	148
9.3 Spectral signal analysis	149
9.3.1 Spectral analysis of continuous signals	150
9.3.2 Spectral analysis of sampled signals.....	151
9.3.3 Influence of the final signal acquisition time on its frequency spectrum ...	153
9.4 Analogue spectrum analyzers with digital output	155
9.4.1 Spectrum analyzers without frequency conversion.....	155

9.4.2	Frequency conversion spectrum analyzers	156
9.4.3	Mixing spectrum analyzers	158
9.5	Digital spectrum analyzers	160
9.5.1	Analyzers with digital signal filtering	160
9.5.2	Discrete Fourier transform analyzers	161
9.5.3	Real-time spectrum analyzers	163
9.6	Spectrum analyzer accessories	164
9.6.1	Attenuators	164
9.6.2	Passive filters	167
9.6.3	Coaxial cables and impedance loads	168
10.	Electric power and energy meters	170
10.1	Types of electrical power and energy meters	170
10.2	Power and energy quantities	172
10.3	Measurement of power and energy	173
10.4	Instruments for measuring electrical power and energy	175
10.4.1	Analog electric power and energy meters	175
10.4.2	Digital power and energy meters	178
10.4.3	Voltage and current measuring transformers	180
11.	Inspection and diagnostic devices	181
11.1	Inspection instruments	181
11.2	Diagnostic instruments	182
11.2.1	Insulation current and dielectric absorption meters	182
11.2.2	Impedance and loss factor	184
11.2.3	Partial discharge meters	186
11.2.4	Frequency response analyzing meters	193
12.	Measuring systems	195
12.1	Measuring systems with separate instruments	195
12.1.1	Systems with IEEE 488 interface	195
12.1.2	Systems with RS 232 C interface	198
12.1.3	USB systems	201
12.2	Centralized measuring systems	203
12.2.1	Systems with PC plug-in cards	203
12.2.2	Modular measuring systems	206
12.3	Decentralized measuring systems	209
12.3.1	Structures of decentralized measuring systems	209
12.3.2	Systems based on RS-482 and RS-485	210
12.4	Programs for measuring, acquisition and data processing	211
12.4.1	Special programs	211
12.4.2	Universal programs	212
	Physical units applicate in the book	215
	Prefixes units in the book	215
	Expression of amplitude ratio in dB	216
	List of symbols	217
	References	219