

# CONTENTS

<b>PREFACE</b>	<b>xi</b>
<b>Chapter 1 MEASUREMENT AND ERROR</b>	<b>1</b>
1-1 <i>Definitions</i>	1
1-2 <i>Accuracy and Precision</i>	2
1-3 <i>Significant Figures</i>	3
1-4 <i>Types of Error</i>	6
1-5 <i>Statistical Analysis</i>	10
1-6 <i>Probability of Errors</i>	12
1-7 <i>Limiting Errors</i>	16
<i>Questions</i>	18
<i>Problems</i>	18
<b>Chapter 2 SYSTEMS OF UNITS OF MEASUREMENT</b>	<b>20</b>
2-1 <i>Fundamental and Derived Units</i>	20
2-2 <i>Systems of Units</i>	21
2-3 <i>Electric and Magnetic Units</i>	23
2-4 <i>International System of Units</i>	27
2-5 <i>Other Systems of Units</i>	27
2-6 <i>Conversion of Units</i>	30
<i>Problems</i>	30

<b>Chapter 3</b>	<b>STANDARDS OF MEASUREMENT</b>	<b>34</b>
3-1	Classification of Standards	34
3-2	Standards for Mass, Length, and Volume	36
3-3	Time and Frequency Standards	37
3-4	Electrical Standards	39
3-5	Standards of Temperature and Luminous Intensity	46
3-6	IEEE Standards	47
	Questions and Problems	48
<b>Chapter 4</b>	<b>DIRECT-CURRENT INDICATING INSTRUMENTS</b>	<b>50</b>
4-1	Suspension Galvanometer	50
4-2	Torque and Deflection of the Galvanometer	51
4-3	Permanent-Magnet Moving-Coil Mechanism	55
4-4	DC Ammeters	61
4-5	DC Voltmeters	65
4-6	Voltmeter Sensitivity	68
4-7	Voltmeter-Ammeter Method of Measuring Resistance	72
4-8	Series-Type Ohmmeter	74
4-9	Shunt-Type Ohmmeter	78
4-10	Multimeter or VOM	80
4-11	Calibration of DC Instruments	84
4-12	Alternating-Current Indicating Instruments	85
4-13	Thermoinstruments	94
4-14	Electrodynamometers in Power Measurements	97
4-15	Watt-hour Meter	99
4-16	Power-Factor Meter	101
4-17	Instrument Transformers	103
	Problems	108
<b>Chapter 5</b>	<b>BRIDGES AND THEIR APPLICATION</b>	<b>110</b>
5-1	Introduction	110
5-2	Wheatstone Bridge	110
5-3	Kelvin Bridge	117
5-4	Guarded Wheatstone Bridge	122
5-5	AC Bridges and Their Application	125
5-6	Comparison Bridges	129
5-7	Maxwell Bridge	132
5-8	Hay Bridge	134
5-9	Schering Bridge	136
5-10	Unbalance Conditions	138

5-11	Wien Bridge	141
5-12	Wagner Ground Connection	142
5-13	Potentiometer	144
	Problems	145
<b>Chapter 6</b>	<b>ELECTRONIC INSTRUMENTS FOR MEASURING BASIC PARAMETERS</b>	<b>147</b>
6-1	Amplified DC Meter	148
6-2	AC Voltmeter Using Rectifiers	151
6-3	True RMS-Responding Voltmeter	155
6-4	Electronic Multimeter	156
6-5	Considerations in Choosing an Analog Voltmeter	161
6-6	Differential Voltmeters	163
6-7	Digital Voltmeters	169
6-8	Component Measuring Instruments	178
6-9	Q Meter	186
6-10	Vector Impedance Meter	195
6-11	Vector Voltmeter	199
6-12	RF Power and Voltage Measurement	203
	Problems	206
<b>Chapter 7</b>	<b>OSCILLOSCOPES</b>	<b>207</b>
7-1	Introduction	207
7-2	Oscilloscope Block Diagram	208
7-3	Cathode Ray Tube	210
7-4	CRT Circuits	223
7-5	Vertical Deflection System	224
7-6	Delay Line	230
7-7	Multiple Trace	233
7-8	Horizontal Deflection System	235
7-9	Oscilloscope Probes and Transducers	239
7-10	Oscilloscope Techniques	242
7-11	Special Oscilloscopes	248
	Problems	258
<b>Chapter 8</b>	<b>SIGNAL GENERATION</b>	<b>259</b>
8-1	The Sine-Wave Generator	259
8-2	Frequency Synthesized Signal Generator	270
8-3	Frequency Divider Generator	274
8-4	Signal Generator Modulation	277
8-5	Sweep-Frequency Generator	277

8-6	<i>Pulse and Square-Wave Generators</i>	282
8-7	<i>Function Generator</i>	291
8-8	<i>Audiofrequency Signal Generation Problems</i>	293 295
<b>Chapter 9</b>	<b>SIGNAL ANALYSIS</b>	<b>296</b>
9-1	<i>Wave Analyzers</i>	296
9-2	<i>Harmonic Distortion Analyzers</i>	300
9-3	<i>Spectrum Analysis Problems</i>	306 324
<b>Chapter 10</b>	<b>FREQUENCY COUNTERS AND TIME-INTERVAL MEASUREMENTS</b>	<b>325</b>
10-1	<i>Simple Frequency Counter</i>	325
10-2	<i>Measurement Errors</i>	337
10-3	<i>Extending the Frequency Range of the Counter</i>	341
10-4	<i>Automatic and Computing Counters Problems</i>	345 347
<b>Chapter 11</b>	<b>TRANSDUCERS AS INPUT ELEMENTS TO INSTRUMENTATION SYSTEMS</b>	<b>348</b>
11-1	<i>Classification of Transducers</i>	348
11-2	<i>Selecting a Transducer</i>	349
11-3	<i>Strain Gages</i>	353
11-4	<i>Displacement Transducers</i>	359
11-5	<i>Temperature Measurements</i>	369
11-6	<i>Photosensitive Devices Problems</i>	384 384
<b>Chapter 12</b>	<b>ANALOG AND DIGITAL DATA ACQUISITION SYSTEMS</b>	<b>392</b>
12-1	<i>Instrumentation Systems</i>	392
12-2	<i>Magnetic Tape Recorders</i>	394
12-3	<i>Self-Balancing Potentiometer</i>	403
12-4	<i>Digital-to-Analog Conversion</i>	407
12-5	<i>Analog-to-Digital Conversion</i>	409
12-6	<i>Multiplexing</i>	421
12-7	<i>Spatial Encoders</i>	424

<b>Chapter 13</b>	<b>COMPUTER-CONTROLLED TEST SYSTEMS</b>	<b>429</b>
13-1	<i>Testing an Audio Amplifier</i>	429
13-2	<i>Testing a Radio Receiver</i>	431
13-3	<i>Instruments Used in Computer-Controlled Instrumentation</i>	435
13-4	<i>IEEE 488 Electrical Interface</i>	443
13-5	<i>Digital Control Description</i>	445
13-6	<i>Example of Signal Timing in a Microprocessor-Based Measurement Questions</i>	446 447
<b>APPENDIX</b>		<b>449</b>
	<i>Abbreviations, Symbols, and Prefixes</i>	450
	<i>Decibel Conversion Tables</i>	452
	<i>Table 1: Conversion of Decibels to Power and Voltage (or Current) Ratios</i>	455
	<i>Table 2: Conversion of Voltage (or Current) and Power Ratios to Decibels</i>	457
<b>SELECTED ANSWERS</b>		<b>459</b>
<b>INDEX</b>		<b>463</b>