

Contents

<i>Preface</i>	<i>xi</i>
<i>Preface to the Fifth Edition</i>	<i>xiv</i>
Part-I General Concepts	1
1. Types of Applications of Measurement Instrumentation	3
1.1 Why Study Measurement Systems?	3
1.2 Classification of Types of Measurement Applications	5
1.3 Computer-Aided Machines and Processes	7
1.4 Conclusion	8
<i>Problems</i>	8
<i>Bibliography</i>	9
2. Generalized Configurations and Functional Descriptions of Measuring Instruments	11
2.1 Functional Elements of an Instrument	11
2.2 Active and Passive Transducers	15
2.3 Analog and Digital Modes of Operation	17
2.4 Null and Deflection Methods	17
2.5 Input-Output Configuration of Instruments and Measurement Systems	18
2.6 Conclusion	30
<i>Problems</i>	31
3. Generalized Performance Characteristics of Instruments	32
3.1 Introduction	32
3.2 Static Characteristics and Static Calibration	33
3.3 Dynamic Characteristics	91
<i>Problems</i>	149
<i>Bibliography</i>	153

Part-II Measuring Devices	155
4. Motion Measurement	157
4.1 Introduction	157
4.2 Fundamental Standards	157
4.3 Relative Displacement: Translational and Rotational	158
4.4 Relative Velocity: Translational and Rotational	230
4.5 Relative-Acceleration Measurements	245
4.6 Seismic- (Absolute-) Displacement Pickups	245
4.7 Seismic- (Absolute-) Velocity Pickups	249
4.8 Seismic- (Absolute-) Acceleration Pickups (Accelerometers)	251
4.9 Calibration of Vibration Pickups	272
4.10 Jerk Pickups	275
<i>Problems</i>	294
<i>Bibliography</i>	300
5. Force, Torque, and Shaft Power Measurement	301
5.1 Standards and Calibration	301
5.2 Basic Methods of Force Measurement	303
5.3 Characteristics of Elastic Force Transducers	311
5.4 Torque Measurement on Rotating Shafts	328
5.5 Shaft Power Measurement (Dynamometers)	335
5.6 Vibrating-Wire Force Transducers	338
<i>Problems</i>	339
<i>Bibliography</i>	343
6. Pressure and Sound Measurement	345
6.1 Standards and Calibration	345
6.2 Basic Methods of Pressure Measurement	347
6.3 Deadweight Gages and Manometers	347
6.4 Elastic Transducers	357
6.5 Vibrating-Cylinder and Other Resonant Transducers	381
6.6 Dynamic Testing of Pressure-Measuring Systems	383
6.7 High-Pressure Measurement	388
6.8 Low-Pressure (Vacuum) Measurement	390
6.9 Sound Measurement	400
<i>Problems</i>	422
<i>Bibliography</i>	425
7. Flow Measurement	426
7.1 Local Flow Velocity, Magnitude and Direction	426
7.2 Gross Volume Flow Rate	462
<i>Problems</i>	513
<i>Bibliography</i>	517

8. Temperature Measurement 518

- 8.1 Standards and Calibration 518
- 8.2 Thermal-Expansion methods 524
- 8.3 Thermoelectric Sensors (Thermocouples) 531
- 8.4 Electrical-Resistance Sensors 553
- 8.5 Junction Semiconductor Sensors 565
- 8.6 Digital Thermometers 569
- 8.7 Radiation Methods 569
 - Problems* 596
 - Bibliography* 599

Part-III Manipulating, Transmission, and Recording of Data 601**9. Manipulating, Computing, and Compensating Devices 603**

- 9.1 Bridge Circuits 603
- 9.2 Amplifiers 612
- 9.3 Filters 628
- 9.4 Integration and Differentiation 643
 - Problems* 655
 - Bibliography* 658

10. Data Transmission and Instrument Connectivity 659

- 10.1 Cable Transmission of Analog Voltage and Current Signals 659
- 10.2 Cable Transmission of Digital Data 663
- 10.3 Fiber-Optic Data Transmission 663
- 10.4 Radio Telemetry 664
- 10.5 Pneumatic Transmission 669
- 10.6 Synchro Position Repeater Systems 670
- 10.7 Slip Rings and Rotary Transformers 671
- 10.8 Instrument Connectivity 673
- 10.9 Data Storage with Delayed Playback (An Alternative to Data Transmission) 676
 - Problems* 677
 - Bibliography* 677

11. Voltage-Indicating and -Recording Devices 678

- 11.1 Standards and Calibration 678
- 11.2 Analog Voltmeters and Potentiometers 678
- 11.3 Electrical Instruments 684
- 11.4 Digital Voltmeters and Multimeters 687
- 11.5 Signal Generation 691
- 11.6 Electromechanical Servotype *XT* and *XY* Recorders 694
- 11.7 Thermal-Array Recorders and Data Acquisition Systems 695
- 11.8 Analog and Digital Cathode-Ray Oscilloscopes/Displays and Liquid-Crystal Flat-Panel Displays 696

x Contents

11.9	Displays	703	
11.10	Virtual Instruments	703	
11.11	Magnetic Tape and Disk Recorders/Reproducers	703	
11.12	Fiber optic sensors	706	
	<i>Bibliography</i>	709	
12.	Data-Acquisition Systems for Personal Computers		710
12.1	Essential Features of Data-Acquisition Boards	711	
12.2	The DasyLab Data-Acquisition and -Processing Software	712	
12.3	DasyLab Simulation Example Number One	716	
12.4	DasyLab Simulation Example Number Two	720	
12.5	DasyLab Simulation Example Number Three	727	
12.6	A Simple Real-World Experiment Using DasyLab	731	
	Answers to Selected Problems		739
	Index		746