

Preface

Knowledge of instrumentation is for experimentalists a kind of fluency in the language of measurement. But it is a fluency not so commonly possessed, and without which much of the experimental process remains hidden and mysterious. The basic goal in writing this book is to provide a treatment of useful depth of the basic elements of the instrumentation “language,” namely electronics, sensors, and measurement.

The present epoch is arguably a golden age for instrumentation. The crucial ingredient has been the exceptional development of semiconductor fabrication technology, and this has led to the present richness in both analog and digital integrated circuits. The former provide relatively inexpensive but high-performance electronic modules (such as the operational amplifier) which can serve as building blocks for more complex circuits, whereas the latter have culminated in the desktop computer, which has permeated modern life generally and revolutionized the instrumentation world with its capacity to act as a measurement controller and data storage center. Finally, silicon micromachining is creating a host of new sensors for such quantities as acceleration and pressure.

The sources of this book are threefold. First, it arises from the process of teaching the subject for more than a decade. Second, it is driven by the repeated experience of acting as a consultant on instrumentation to colleagues in physics, biology, chemistry, psychology, and geography. Finally, instrumentation has played a fundamental role in my own research. These distinctly different threads are reflected in the particular objectives that I wished the book to fulfill: to serve as a reference and handbook for researchers and to serve as a possible textbook for senior undergraduate or graduate students preparing for careers in experimental science or engineering.

Personal experience has taught me that when a book is consulted as a handbook or reference, it is read in a very localized manner. Only a particular block of

material may be referenced at one time. For this reason, each chapter has been written in a reasonably self-contained style, with its own citations. The requisites of a textbook are somewhat different. Ideally, chapters should link logically from one to another in sequence. Teachers of course like to see problems, so a modest selection of worked examples and end-of-chapter questions is provided. These are intended to suggest typical lines of questioning. In a course setting, simulation assignments and individual projects can be the best way to develop familiarity and understanding of the concepts.

As a subject, instrumentation presents particular challenges and difficulties because of the diversity of an audience that might include physicists, biologists, chemists, experimental psychologists, geophysicists, engineers, and medical researchers. Each group possesses a very different background, so no simple common baseline exists from which a text can proceed. To address this reality, a certain amount of review material has been included, especially in the first four chapters. For some, this will be quite familiar, but hopefully still welcome as a summary. For others, these topics will be an essential component in a reference on instrumentation.

Following the preliminaries just noted, the next four chapters cover topics related to signal conditioning. These include amplification and filtering. Waveform generation is also discussed at this point. Hence, the first eight chapters provide a review and/or development of essential concepts in electronics. Many practical circuit examples based on tested PSpice simulations are included.

The logical flow of the remainder of the book is structured around the notion that physical quantities (such as heat and light) can be transformed by sensors into electrical quantities, which then can be measured. In choosing sensors for inclusion, the guiding principle was to focus on real-world scenarios. This meant selecting those sensors that are typically employed for the most common ranges of temperature, light intensity, magnetic field strength, pressure, and so forth. Transducers intended for use well outside these ranges (such as very high or low temperatures or exceptionally weak light levels) are considered here to be “special purpose” and thus are not covered.

The final chapter focuses on measurement systems. This represents, to an extent, the present state-of-the-art approach to complex instrumentation tasks. It is also an area of continuing rapid progress and change.

In writing a book such as this, an author is faced with basic choices in regard to what is to be included and what is to be excluded. Any manuscript could be expanded with additional material, or equally, compressed by trimming. On the one hand, an encyclopedic volume is usually impractical; yet the omission of key material must be avoided. In the end, however, only one book can be written. Experience, personal opinion, and taste play a role, which explains why no two

authors would ultimately produce the same text. This is the book *I* wanted but could never find.

Finally, it is with pleasure that I acknowledge debts of various sorts to the following individuals: Dr. Robert G. Rosehart, President of Wilfrid Laurier University, for providing release time from my usual academic obligations in order to complete the final phase of writing; Dr. Thomas von Foerster and Jeannette Mallozzi of Springer-Verlag New York, Inc.; Manfred Gartner, for technical help in computer-related matters; Dr. Reinhard Neul of Robert Bosch, GmbH; Liz Searcy of Analog Devices; Michael F. Grimaldi of Kistler Instrument Corporation; Joseph C. Nowlan of Walker Scientific, Inc.; Bob Christensen of GMW Associates; Peter D. Stolpe of F.W. Bell; Carl Nybro, Vanessa Trujillo, and Don Clinchy of National Instruments; Brian Withnell and Bill Porter of Agilent Technologies; and especially, Professor John Smith of the University of Waterloo, for his lasting contributions, first as teacher and mentor, then as colleague, collaborator, and friend.

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