
Preface

Numerous computerized appliances wash clothes, prepare coffee, play music, guard homes, and perform endless useful functions. However, no electronic device operates without receiving external information. Even if such information comes from another electronic device, somewhere in the chain, there is at least one component that perceives external input signals. This component is a sensor. Modern signal processors are the devices that manipulate binary codes generally represented by electric impulses. As we live in an analog world that mostly is not digital or electrical (apart from the atomic level), sensors are the interface devices between various physical values and the electronic circuits that “understand” only the language of moving electrical charges. In other words, sensors are eyes, ears, and noses of the silicon chips. This book is about the man-made sensors that are very much different from the sensing organs of living organisms.

Since the publication of the previous edition of this book, sensing technologies have made remarkable leaps. Sensitivities of sensors have become higher, their dimensions smaller, selectivity better, and prices lower. A new, major field of application for sensors—mobile communication devices—has been rapidly evolving. Even though such devices employ sensors that operate on the same fundamental principles as other sensors, their use in mobile devices demands specific requirements. Among these are miniature dimensions and complete integration with the signal processing and communication components. Hence, in this new edition, we address in greater detail the mobile trend in sensing technologies.

A sensor converts input signals of a physical nature into electrical output. Thus, we will examine in detail the principles of such conversions and other relevant laws of physics. Arguably one of the greatest geniuses who ever lived, Leonardo da Vinci, had his own peculiar way of praying (according to a book I read many years ago, by Akim Volinsky, published in Russian in 1900). Loosely, it may be translated into modern English as something like, “*Oh Lord, thank you for following Thy own laws.*” It is comforting indeed that the laws of Nature do not change—it is our appreciation of the laws that is continually refined. The sections of the book that cover these laws have not changed much since the previous editions. Yet, the sections that describe the practical designs have been revised substantially. Recent ideas and developments have been added, while obsolete and less interesting designs were dropped.

In the course of my engineering work, I often wished for a book which combined practical information on the many subjects relating to the most important physical principles, design, and use of various sensors. Of course, I could browse the Internet or library bookshelves in search of texts on physics, chemistry, electronics, technical, and scientific magazines, but the information is scattered over many publications and websites, and almost every question I was pondering required substantial research. Little by little, I gathered practical information on everything which is in any way related to various sensors and their applications to scientific and engineering measurements. I also spent endless hours at a lab bench, inventing and developing numerous devices with various sensors. Soon, I realized that the information I had collected would be quite useful to more than one person. This idea prompted me to write this book, and this fifth updated edition is the proof that I was not mistaken.

The topics included in the book reflect the author's own preferences and interpretations. Some may find a description of a particular sensor either too detailed or broad or perhaps too brief. In setting my criteria for selecting various sensors for this new edition, I attempted to keep the scope of this book as broad as possible, opting for many different designs described briefly (without being trivial, I hope), rather than fewer treated in greater depth. This volume attempts (immodestly perhaps) to cover a very broad range of sensors and detectors. Many of them are well known, but describing them is still useful for students and for those seeking a convenient reference.

By no means this book is a replacement for specialized texts. It gives a bird's-eye view at a multitude of designs and possibilities, but does not dive in depth into any particular topic. In most cases, I have tried to strike a balance between details and simplicity of coverage; however simplicity and clarity were the most important requirements I set for myself. My true goal was not to pile up a collection of information but rather to entice the reader into a creative mindset. As Plutarch said nearly two millennia ago, *"The mind is not a vessel to be filled but a fire to be kindled. . ."*

Even though this book is for scientists and engineers, as a rule, the technical descriptions and mathematic treatments generally do not require a background beyond a high school curriculum. This is a reference text which could be used by students, researchers interested in modern instrumentation (applied physicists and engineers), sensor designers, application engineers, and technicians whose job is to understand, select, or design sensors for practical systems.

The previous editions of this book have been used quite extensively as desktop references and textbooks for the related college courses. Comments and suggestions from sensor designers, application engineers, professors, and students have prompted me to implement several changes and to correct errors. I am deeply grateful to those who helped me to make further improvements in this new edition. I owe a debt of gratitude and many thanks to Drs. Ephraim Suhir and David Pintsov for assisting me in mathematical treatment of transfer functions and to Dr. Sanjay V. Patel for his further contributions to the chapter on chemical sensors.

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Jacob Fraden