

Handbook of Modern Sensors

Fourth Edition

Jacob Fraden

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Physics, Designs, and Applications

Fourth Edition

 Springer

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ISBN 978-1-4419-6465-6 e-ISBN 978-1-4419-6466-3
DOI 10.1007/978-1-4419-6466-3
Springer New York Heidelberg Dordrecht London

Library of Congress Control Number: 2010932807

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Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

Since publication of the previous, the 3rd edition of this book, the sensor technologies have made a remarkable leap ahead. The sensitivity of the sensors became higher, the dimensions – smaller, the selectivity – better, and the prices – lower. What have not changed, are the fundamental principles of the sensor design. They still are governed by the laws of Nature. Arguably one of the greatest geniuses ever lived, Leonardo Da Vinci had his own peculiar way of praying. It went like this, “*Oh Lord, thanks for Thou don’t violate Thy own laws.*” It is comforting indeed that the laws of Nature do not change with time, it is just that our appreciation of them becomes refined. Thus, this new edition examines the same good old laws of Nature that form the foundation for designs of various sensors. This has not changed much since the previous editions. Yet, the sections that describe practical designs are revised substantially. Recent ideas and developments have been added, while obsolete and less important designs were dropped.

This book is about devices commonly called *sensors*. The invention of a microprocessor has brought highly sophisticated instruments into our everyday life. Numerous computerized appliances, of which microprocessors are integral parts, wash clothes and prepare coffee, play music, guard homes, and control room temperature. Sensors are essential components in any device that uses a digital signal processor. The processor is a device that manipulates binary codes generally represented by electric signals. Yet, we live in an analog world, where such devices function among objects that are mostly not digital. Moreover, this world is generally not electrical (apart from the atomic level). Digital systems, however complex and intelligent they might be, must receive information from the outside world. Sensors are the interface devices between various physical values and electronic circuits that “understand” only a language of moving electrical charges. In other words, sensors are eyes, ears, and noses of silicon chips.

In the course of my engineering work, I often felt a strong need for a book which would combine practical information on diversified subjects related to the most important physical principles, design and use of various sensors. Surely, I could find almost all I had to know by surfing Internet or browsing library bookshelves in search for texts on physics, electronics, technical magazines, manufacturer’s

catalogues and websites. However, the information is scattered over many publications, and almost every question I was pondering required substantial research work. Little by little, I have been gathering practical information on everything, which in anyway was related to various sensors and their applications to scientific and engineering measurements. Soon, I realized that the information I collected might be quite useful to more than one person. This idea prompted me to write this book and this 4th edition is the proof that I was not mistaken.

In setting my criteria for selecting various sensors for the 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 those who look for a convenient reference. It is the author's intention to present a comprehensive and up-to-date account of the theory (physical principles), design, and practical implementations of various (especially, the newest) sensors for scientific, industrial, and consumer applications. 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 too broad or, on the contrary, too brief. In most cases, the author tried to strike a balance between a detailed description and simplicity of coverage.

It is clear that one book cannot embrace the whole variety of sensors and their applications, even if it would be called something like "*The Encyclopedia of Sensors*." This is a different book and the author's task was much less ambitious. Here, an attempt has been made to generate 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 and/or design sensors for practical systems.

The prior editions of this book have been used quite extensively as desktop references and textbooks for the related college courses. Comments and suggestions from the sensor designers, professors, and students prompted me to implement several changes and 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 Drs. Todd E. Mlsna and Sanjay V. Patel for their invaluable contribution to the chapter on chemical sensors.

Even though the book is intended for the scientific and engineering communities, as a rule, technical descriptions and mathematic treatments do not require a background beyond a high school curriculum. Simplicity of description and intuitive approach were the key requirements that I set for myself while working on the manuscript. My true goal was not to pile up a collection of information but rather to entice the reader into a creative process. As Plutarch said nearly two millennia ago, "*The mind is not a vessel to be filled but a fire to be kindled. . .*"

San Diego, California
April, 2010

Jacob Fraden

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