Preface

Throughout history, measurement has played a vital part in the development of society, and its significance is still growing with the ongoing advances in technology. The outcome of a measurement may have important implications for the resultant actions. The correct execution of a measurement is, therefore, highly important, making heavy demands not only on the executor's skills but also on the designer's competences to create measurement systems with the highest possible performance.

This book on measurement science is adapted from a course book on measurement and instrumentation, used by undergraduate students in electrical engineering at the University of Twente, The Netherlands. It deals with basic concepts of electronic measurement systems, the functionality of their subparts and the interactions between them. The most important issue of all is the quality of the measurement result. How to design a measurement system or instrument with the highest performance under the prevailing conditions. How to get the most of the system in view of its technical limitations. How to minimize interference from the environment. And finally: how to evaluate the measurement result and account for the remaining errors.

A course book cannot give the ultimate answer to such questions. Its intention is merely to offer basic knowledge about the physical and instrumentation aspects of measurement science, the availability and characteristics of the major measurement tools and how to use them properly. More importantly, the book tries to make students aware of the variety of difficulties they may encounter when setting up and using a measurement system and make them conscious of the fact that a measurement result is always error-ridden. Solving such problems is not only a matter of knowledge; experimental skills and experience are even important to arrive at the specified performance. To that end, the course in measurement and instrumentation of which this book is a consequence, is accompanied by a series of practical exercises, directed to the evaluation of sensor characteristics, signal processing and finally the total measurement system.

The organization of the book is as follows. Chapter 1 is an introductory chapter in which concepts of measurement science and the general architecture of a measurement system are described. In Chapter 2 some fundamental aspects of measurement science are reviewed: the international system of units, measurement standards and physical quantities and their relations. Measurement errors and uncertainty are discussed extensively in Chapter 3; it includes the basic elements of probability

theory, methods to analyse and evaluate uncertainty and general techniques to minimize measurement errors.

Chapters 4, 5 and 6 deal with signal conditioning and conversion: Chapter 4 is on analogue signal conditioning (amplification, filtering, modulation); Chapter 5 on digital signal conditioning (sampling, multiplexing and digital operations); and Chapter 6 on the conversion from analogue tot digital and vice versa.

For each (physical) quantity a multitude of sensing strategies is available. In the next three chapters the major sensing methods are reviewed: in Chapter 7 we discuss the measurement of electrical, magnetic, thermal and optical quantities; in Chapter 8 mechanical quantities and in Chapter 9 chemical quantities. Measurement of multi-dimensional geometry is performed by imaging: the result is some kind of image in some domain. How these images are acquired and can be interpreted are the topics of Chapter 10. Finally, Chapter 11 covers particular aspects of system design and virtual instrumentation.

The book is written by a team of authors, all from the Department of Electrical Engineering, University of Twente. Chapters 3 (uncertainty) and 10 (imaging) are authored by F van der Heijden, Chapters 5 (digital signal conditioning) by M Korsten, Chapter 9 (chemical quantities) by W Olthuis and the remainder by P Regtien. V Pop contributed to the section on virtual instruments in Chapter 11.

Reading this book requires some basic knowledge of calculus, complex functions, physics and electronics, about equivalent to the first term undergraduate level. As with any course book, this one covers just a selected number of issues from an otherwise wide area. Connection to other relevant literature has been made by adding a short list of books at the end of each chapter, with a short indication of the subject and level. The enthusiastic reader may consult the cited references to the scientific literature for more detailed information on the subjects concerned.

Paul P L Regtien
University of Twente, The Netherlands
April 2004