MODERN MEASUREMENTS
Fundamentals and Applications

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PREFACE

There are several books related to instrumentation and measurement that explain how measurement methods work and how instruments can be designed, selected, and used to implement the different measurement methods needed to obtain the desired measurement result with the desired accuracy. But no books are available, to our knowledge, that explain what "measuring" means and which essential activities must be performed to accomplish a measurement.

This is somehow surprising, because measurement has always been an important, and sometimes critical, activity that has developed with the humankind, becoming a significant part of its culture. Today everything is measured, and we are surrounded by instruments, often without being aware of their silent presence. Despite this pervasive presence of every kind of instruments and the many kinds of measurements we perform in our everyday life, measurement is probably the only relevant technical activity that is rarely grounded on a well-defined and widely known models. It is rather considered as a mere tool, not as an independent branch of science and technique, so that it is often confined to the role of appendix, sometimes not so relevant, of other subjects.

This book is aimed at filling this gap, and providing a unique framework, valid for any kind of measurement. So, do not expect too many technical details on how a specific instrument works, or a specific measurement method can be implemented. Many excellent books already cover these topics. Here you will find those fundamental bricks that are present in every modern instrument and are part of every modern measurement activity. You will also discover the importance of some "hidden" bricks, such as the primary standards, without which no universally recognized measurement would be possible.

You will discover the importance of digital signal processing in modern measurements, and how critical it may become if some specific mathematical issues are disregarded. Do not expect to find how modern oscilloscopes or multimeters are designed and developed, since this is the aim of many dedicated books and handbooks. On the contrary, you will find how the aforementioned fundamental bricks can be combined to implement two of the most popular and used instruments.

Most importantly, and maybe surprisingly for those readers who are not yet familiar with this field, you will discover that every measured value is "wrong" in the sense that, due to a number of different factors that influence any measuring activity, we are never able to know the so-called "true value" of the measurand. But you will also discover that we know how to quantify how "wrong" our measurement result is. This is achieved by providing the so-called measurement uncertainty, which tells us how good and reliable the obtained measurement result is. This information is essential when we use a measurement result as the input element of a decision-making process and we wish to quantify the risk of a wrong decision.

To accomplish our goal, we have organized this book into two parts. Part I (Fundamentals) presents a model of the modern measurement activity and the already recalled fundamental bricks. It starts (Chapter 1) with a general model that introduces these bricks and the uncertainty concept, provides an overview of these bricks in the following chapters, and finishes (Chapter 7) with a more general and complex model that encompasses both traditional (*hard*) measurements and *soft* measurements, aimed at quantifying nonphysical concepts, such as quality, satisfaction, and comfort.

Part II (Applications) is aimed at showing how the concepts presented in Part I can be usefully applied to design and implement measurements in some very important and broad fields. We cover system identification (Chapter 8), reliability (Chapter 9), and electromagnetic compatibility (EMC) (Chapter 10) not only for their importance in many application areas, from manufacturing to health and safety, but also because their intrinsic complexity is the perfect test bench to prove the usefulness of the concepts introduced in Part I.

We sincerely hope that this book may provide a new, systematic insight into such an important field as instrumentation and measurement, and can help both experts and beginners, with a useful analysis tool, to understand the essential meaning of the measuring activity, regardless of its specific application.

The Editors

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