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Book Reviews

Handbook of Measurement Science*

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THIS handbook came into being following a recommendation in 1976 by the Technical Committee for Higher Education of the International Measurement Confederation. Peter Sydenham was appointed project manager. As two volumes of the book are now in our hands, we must acknowledge that he has made a magnificent job of it. It is not easy to persuade prospective authors that their contribution should conform to a common line of thought, and downright difficult to have them accept a standard format. Moreover, the authors contributing to this book are not only selected for their expertise but come from three continents, often the texts being in a language foreign to their mother tongue. In my opinion Sydenham has succeeded in guiding them such that the handbook appears as a coordinated whole, be it that variations from chapter to chapter remain visible to the reader.

Records on the roots of measurement are more than 3000 years old. For instance, the Babylons gave an accurate account of the settling phenomena of the sun as the year went through its seasons. Yet, about two hundred years ago, the highly abstract notion of time measurement (as opposed to e.g. measurement of length and mass) still had to be explained to the average educated person: "De la mesure du tems" (Almanach, 1789). Until this century, measurement activities were universally regarded as the by-product of one of the principal sciences and even today one occasionally meets an exponent of this absolute attitude. It is one of the commendable features of this handbook that it presents measurement science as a discipline in its own right, possessing its own fundamentals and methodology while simultaneously showing how dependant the act of measurement is of the help of supporting disciplines. Measurands are restricted to natural phenomena, application areas such as psychology (Suppes and Zinnes, 1963) are not covered.

The selection and presentation of material for this handbook reflects the fact that much of the supporting disciplines, particularly most of the realization technologies, have matured over only the last fifty years, some of them in even a much shorter period. As one may not expect that the average practising reader is familiar with all of the newer developments, the editor could not escape the ambiguity of having handbook chapters with an introductory flavour. Thus one can observe that the chapters are of predominantly two kinds, one being the group of fundamental and/or relatively young aspects of measurement science, the other the group of all supporting disciplines.

In the second group there are a number of well-established subjects which could have been handled in the form of short notes as befits a handbook. However, apparently the editor has opted for uniformity of presentation. The result of this and of similar decisions (e.g. allowing for repetition in chapters for the sake of clarity) are 1413 pages of valuable handbook, mostly very pleasantly readable; a commendable feat!

While many other books concentrate on kaleidoscopic descriptions of various ways and means of measurement, this handbook places heavy emphasis on fundamentals of measurement. For instance, validity of scales in the physics domain and their mapping onto the domain of real, rational numbers: 'theory and philosophy of measurement'. Also fundamental, and written in a slightly introductory manner: 'signals and systems in the time and frequency domain'; discrete signals and frequency spectra'. These subjects have been limited strictly to the domain of measurement, digging deep enough to unearth e.g. the concept of 'biased' vs 'unbiased' estimator. Fundamental and relatively new are chapters 7 and 8: 'pattern recognition' and 'parameter estimation'. These texts are highly contrasting, Chapter 7 providing good insight almost without recourse to mathematics; Chapter 8 being a concise account of the theory of parameter estimation but complete with all the mathematical notations and relations. Also 'measurement systems dynamics' and 'fundamentals of transducers' are good examples of contributions which can function both as introductory text and as a reference. Especially the latter provides not only the basis for computer-assisted design of transducers but also gives the user a very concrete and structured insight into the innards and operation of transducers.

Apart from this group of fundamental chapters there is a broad group of chapters on subjects which, in relation to measurement science, are regarded as supporting disciplines: calculation of deterministic and stochastic errors, signal filtering and processing, both analogue and digital. The chapter on analogue filtering treats a selection of well-known instrumentation filters, e.g. Butterworth, Thomson, Chebyshev and inverse Chebyshev. The transfer of a simple network (Bessel) and of the also popular Gaussian pulse response filter is omitted. The chapter on digital filtering introduces the bare notions on analysis of digital filters, but must be qualified as insufficient. It should have treated the various configurations (direct, canonic, cascade, parallel form, etc.) and their implication on quantization noise generation/propagation, also the problems of instability associated with quantization (limit cycles). Other chapters deal with signal-to-noise improvement, signal-to-data conversion, transmission of data. The latter provides insight into the problem of matching the spectral properties of the acquired signal to the spectral transfer of the transmission medium, relation of signal-to-noise ratio to error rate, error correction and detection.

The chapter that follows is on closed-loop systems, this chapter finds itself a bit out of place in the first volume. The subject is treated from a classical view which, for the time being, should be sufficient for a handbook of measurement science. However, the subject matter of the book is not really enriched by the inclusion of a control subject. Further chapters in the broad supporting discipline category: human factors in display, system design considerations (including reliability) and system management.

Continuing with critical comments. Missing are texts pointing out the relation between problem modelling and the performance of alternative measurement strategies. Also on signal-conditioning methods. Rarely is a transducer selected purely on the basis of the required function alone: more often than not one is obliged to choose that transducer which is capable to withstand adverse environmental conditions, while simultaneously performing, or approximating within prescribed tolerance limits, the desired function. The format of the output signal of that transducer type is not necessarily optimal or even acceptable by the signal-processing component of the system. Then a conditioner must transform the available transducer output format into a signal which is acceptable: e.g. an attenuator, a transformer, a resolver to d.c. converter, a signal chopper. Further a text is wanting on the suppression at the source of noise pick-up (electromagnetic interference (EMI), radio-frequency

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interference (RFI), or simply ground-loop current-induced noise), e.g. the use of virtual-earthing (Wagner) techniques, differential measurements, servoed cable shields, floating amplifiers or even modulation methods to separate the measurement signal spectral density from the noise-signal spectrum.

In the chapter on system dynamics, the text would have benefited when bond-graph techniques were introduced, especially since the chapter on fundamentals of transducers is based on the graph concept. The added advantage would be that system dynamics analysis by computer simulation become better accessible to the reader.

The chapters on transducer practice represent a very limited selection on types of measurands: displacement, flow, temperature and a few chemical variables. If a third volume were contemplated, one would expect additional texts on the measurement of force, mass, velocity and acceleration, strain, magnetic field strength and, probably, optical signals.

One of the foundations of measurement science is metrology, the system of standards and traceability. Two chapters are devoted to this important subject. In these texts, the international scope of the handbook is done justice. The quality of measurement systems depends on reliable standards and traceability. The handbook provides important administrative information to all those engaged in the design, manufacture and use of measurement instruments.

On the whole, the handbook texts predominantly provide insight without much recourse to mathematics. This approach is partly responsible for the good readability and facilitates the early phases of modelling of a measurement problem. Of course, when the ultimate purpose of modelling is computer-assisted analysis and design, the reader must refer back to specialized textbooks which deal with the subjects in greater (mathematical) depth. My overall impression is that this *Handbook of Measurement Science* fills a long felt gap. Considering the international composition of contributing authors, the book is remarkably coherent in design and use of language. Recommended reading for both instrumentation engineers and students who can make regular use of it. The publishers, John Wiley are to be complimented with its presentation, the choice of fount and the quality of diagrams and graphs.

References

De la mesure du tems. Almanach de Gotha, chez C. G. Ettinger, Gotha, 1789.

Suppes, P. and Zinnes, J. L. (1963). Basic measurement theory, in (Luce, Bush and Galanter, Edited by) *Handbook of Mathematical Psychology*. John Wiley, London.

About the reviewer

D. Bosman graduated *cum laude* in 1954 from the Department of Electrical Engineering of Delft University of Technology. From 1954–1969 he was engaged in the design and development of automated measurement systems for airborne and windtunnel applications, at the Aerospace Laboratorium in Amsterdam. His last position there was head of the Avionics Laboratory. Since 1969 he has been a full professor at Twente University of Technology where he holds the chair of Measurement Science and Instrumentation. Currently the main topics of research are image processing for industrial applications and flat-panel-display technology.

Optimal Relay and Saturating Control Systems Synthesis*

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BOOKS on nonlinear control, in contrast to those dealing with linear theory, are quite rare and because of the diverse nature of the mathematical methods used in the various approaches they tend to concentrate on a specific aspect. Typical topics include absolute stability methods; analytical techniques often of a restricted nature or involving approximations, such as the describing function; and optimal relay control. The latter subject to which this book is devoted is the only rigorous nonlinear synthesis technique and first started to receive attention in the forties and early fifties although a few phase-plane studies of relay systems had taken place earlier. Interest centred on the time optimal control of position systems, such as antennae and guns, which could be represented by approximately second-order dynamics and also on-off controls for missiles. Solutions were obtained to several of these problems by engineering intuition and phase-plane techniques. Although these results hinted at the possibility of a general theory of optimal control it was almost a decade later before closely related theories based on the calculus of variations, dynamic programming, and the maximum principle appeared in the control literature. These theories enabled solutions to be found for the minimization of more general performance criteria and the growing aerospace industries requirements of control designs, such as fuel optimal controls for space vehicles, provided a strong motivation for development of the subject. Despite, however, its past and continuing success in aerospace applications optimal relay control theory has found relatively few uses in industrial applications. Typically these have been in the controls of positioning devices such as cranes and manipulators and current developments in automated factories may therefore involve an increasing use of this design approach. Optimal relay control theory has not been used more for the design of industrial control systems because of the unavailability in many cases of good state-space models for industrial processes, the difficulty of obtaining solutions from the theory for high-order systems and the inappropriateness for industrial purposes of the performance criteria for which analytical results can be obtained.

The book by Dr Ryan therefore addresses a relatively specialist topic which is of interest to control theorists and some practising control engineers. The author's stated aim is to produce a book which comprises a self-contained exposition of deterministic optimal relay and saturating control-system synthesis, presented at a level of rigour suited to a broad spectrum of engineers and applied mathematicians. The book is not therefore for the reader who wishes to obtain an introduction to optimal control and it will be more easily followed by a reader with some previous experience of the subject.

The first chapter includes a brief historical review with references to the development of the subject and some of the well-known earlier textbooks. The Harvard system of referencing is used with the complete list of references given at the end of the book. Throughout the text, reference to the original results, related material and additional reading have in general been well chosen and are a good feature of the book. Motivation for the class of optimal control problems to be studied is then provided by considering two examples, altitude control of a rigid body for a lunar soft-landing craft in its descent phase and an attitude-control problem, applicable to the same vehicle, or a satellite. The examples are solved by introducing the Hamiltonian function and stating the procedures which have to be used to obtain the

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