Electrical Measurements & Measuring Instruments

Golding & Widdis

Wheeler's Student Edition

ELECTRICAL MEASUREMENTS AND MEASURING INSTRUMENTS

THE LATE

E. W. GOLDING

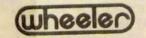
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FIFTH EDITION



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PREFACE TO FIFTH EDITION

It is now thirty years since the first edition of this book was published and I would like to express my deep and sincere appreciation of its acceptance by so many readers in all parts of the Englishspeaking world. During recent years I have visited many countries in which the book has been used and have been most gratified by the kind remarks made about its value to students and practising engineers. These comments have come from engineers met, sometimes in quite remote places, in East and Central Africa, India, Pakistan, Malaya, Hong Kong and Australia, and they have given me great pleasure.

With the passing of the years, and with the changes which have taken place in my own professional interests, it has become increasingly difficult to keep pace with the rapid advances made in the subject of Electrical Measurements. I have felt it imperative, therefore, to seek assistance in the task of revising the book in a way which, I hope, will prove satisfactory to the present-day reader. In this I have been extremely fortunate in receiving the co-operation of Dr. F. C. Widdis. He has had great experience in both the practical and academic sides of the subject, and he has been mainly responsible for the many changes made in preparing this fifth edition.

We hope that, so far as possible within the confines of a single volume, the latest practice has now been covered adequately and that the book will continue to be as useful as in the past.

Perhaps the most significant single change has been the adoption of the rationalized M.K.S. system of units, which is now increasingly used in teaching the subject. For the benefit of readers who find themselves in the transition stage of conversion from the C.G.S. to the M.K.S. system, a comprehensive comparison between the formulae in the two systems has been made, and we hope that this will be helpful to those who are not yet entirely conversant with the M.K.S. system.

E. W. GOLDING

LONDON, DECEMBER, 1962

PREFACE TO FIRST EDITION

WHEN this book was first contemplated, it was the author's intention to produce a short text-book covering the syllabuses of the B.Sc. (Eng.), City and Guilds (Final) and I.E.E. examinations. As the work progressed, however, it was realized that the groundwork for these examinations could not be adequately covered in a book of the size originally planned. Extension of the text being thus necessitated, the author felt that the scope and method of treatment could with advantage be modified to suit, also, the requirements of electrical engineers in general, for whom, owing to the rapid advances taking place in the electrical industry and in the interconnection of power systems, the subject of electrical measurements is assuming an ever-increasing importance. In particular, it was thought that engineers engaged in the standardizing and metering side of the industry could be catered for.

Some of the subjects dealt with—e.g. Transient Phenomena are essentially mathematical, and cannot well be treated otherwise, but the mathematics throughout the book has been kept as simple as possible and should be followed easily by most readers. The theory of most of the methods of measurement has been given in full, but in many cases smaller type has been used for such theoretical discussions, so that the reader may omit them, if desired, and consider only the resulting expressions.

References and bibliographies are given at the ends of the chapters, their inclusion being both an acknowledgment of the sources of the author's information—in certain cases—and an augmentation of the text, which can, at the best, give only a general outline of so large a subject in the space of a single volume.

A number of worked examples have been given as illustrations, and a selection of examination questions (with answers) is included at the end of the book. In this connection the author's thanks are due to the Senate of the University of London, the City and Guilds of London Institute, and the Institution of Electrical Engineers for permission to use questions from their examination papers.

Most of the illustrations have been specially made for this book, but the author is glad to acknowledge his indebtedness to the many firms and authorities who have very kindly supplied him with information, drawings, and photographs relating to their apparatus. Individual acknowledgments are made in the text. Messrs. Elliott Bros., Ltd., had drawings specially made from photographs of their instruments The author is indebted also to Messrs. A. T. Dover, B. Hague, and P. Dunsheath for permission to reproduce five illustrations from their books; to B. G. Churcher and C. Dannatt,

PREFACE

Prof. W. M. Thornton, and Prof. S. P. Smith for their co-operation, and to Mr. N. A. Allen for information regarding cable tests with high-voltage direct current.

The author gratefully acknowledges the help which he has received from advanced students in the Electrical Engineering Department of University College, Nottingham, in the shape of proof reading. He would like, also, to tender his sincere thanks to Dr. H. Cotton for his continued and lively interest in the book during its preparation; to Mr. T. M. E. Ward for kindly reading the proofs of Chapters XX and XXI; and to his wife for her unfailing help and consideration while the book was being prepared.

Acknowledgment should also be made to the British Standards. Institution for permission to make extracts from several of their instrument specifications. Copies of these specifications can be obtained from the Institution at British Standards House, 2 Park Street, London, W.1.

E. W. GOLDING

UNIVERSITY COLLEGE, NOTTINGHAM, 1933

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AUTHORS' NOTE ON THE RATIONALIZED M.K.S. SYSTEM OF UNITS

In previous editions of the book the C.G.S. system of units was used throughout, but the rationalized M.K.S. (metre-kilogrammesecond) system is now being used increasingly, especially in the teaching of electrical engineering, and it has been adopted throughout this edition. The derivation of the system is discussed in Chapter II. It has important advantages in that practical units ampere, volt, ohm etc.—are used throughout and the conversion factors necessary in the C.G.S. system are eliminated. The only complication in this system is the introduction of the primary magnetic constant $\mu_0 = 4\pi \times 10^{-7}$ and the primary electric constant $\varepsilon_0 = \frac{1}{36\pi \times 10^9}$, which must be memorized. Each of these constants has a value of unity in the C.G.S. system.

In the M.K.S. system, force is measured in "newtons" and lengths in metres. A newton is the force necessary to give a mass of 1 kilogramme an acceleration of 1 metre per sec per sec and it is equivalent to 10^5 dynes in the C.G.S. system.

With the introduction of the M.K.S. system, the view has been expressed, in some quarters, that the classical methods of deriving electromagnetic and electrostatic formulae should be revised. This is because the unit magnetic pole used in the classical derivations has no physical existence, and it is possible, instead of using this concept, to explain the origin and properties of the magnetic field in terms of the effects of electric currents. The classical methods, however, provide a simple means of studying the properties of fields and are therefore adhered to in Chapter I. A very full discussion of alternative methods of developing field theory will be found in Ref. (24) at the end of Chapter 1.