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Preface

The last ten years have seen a great flowering of the theory of digital data modulation. This book is a treatise on digital modulation theory, with an emphasis on these more recent innovations. It has its origins in a collaboration among the authors that began in 1977. At that time it seemed odd to us that the subjects of error-correcting codes and data modulation were so separated; it seemed also that not enough understanding underlay the mostly ad hoc approaches to data transmission. A great many others were intrigued, too, and the result was a large body of new work that makes up most of this book. Now the older disciplines of detection theory and coding theory have been generalized and applied to the point where it is hard to tell where these end and the theories of signal design and modulation begin.

Despite our emphasis on the events of the last ten years, we have included all the traditional topics of digital phase modulation. Signal space concepts are developed, as are simple phase-shift-keyed and pulse-shaped modulations; receiver structures are discussed, from the simple linear receiver to the Viterbi algorithm; the effects of channel filtering and of hardlimiting are described. The volume thus serves well as a pedagogical book for research engineers in industry and second-year graduate students in communications engineering.

The production of a manageable book required that many topics be left out. The major constraint in the book is that it is strictly limited to *phase* modulation. Schemes in which data symbols cause changes in signal amplitude are omitted. Much other exciting new work had to be left out: Channel equalization, new hardware, new error-correcting codes, and multiple-access problems are a few of these subjects. Some readers may seek a more thorough grounding in the mathematical basis of communications theory, since the book assumes a basic knowledge of vector spaces, probability, and random processes. In addition, the rapid treatment of detection theory, information theory, and phase-lock loops may not be enough for some readers.

The book is organized as follows. An introduction expounds the reasons, both technical and commercial, why digital transmission has become so important. Communications theory is the subject of Chapter 2; detection and signal space theory are introduced, along with the error probability and spectrum of a modulation and some simple receivers for it. The older, simpler modulation schemes like phase-shift keying and their real-world behavior provide illustrations of these theories. Chapters 3 and 4 then develop in detail the energy and bandwidth performance of a very general class of modulations called continuous-phase modulations or CPM. Chapter 5 looks at the simultaneous energy and bandwidth performance of these modulations, from the standpoint of both particular schemes and the Shannon theory of modulation. Chapter 6 deals with CPM transmitter structures, while Chapters 7 and 8 discuss more sophisticated receivers than those in Chapter 2. Synchronization and performance with partial phase knowledge form the subject matter of Chapters 9 and 10. Chapter 11 explores the effect of modulations on error-correcting codes. A half-year course in digital modulation could focus on Chapters 1-5 and 7, with other topics chosen to suit the instructor's taste. A shorter, more theoretical course could feature Chapters 2-4.

In writing this book, we have attempted to give some idea of the historical development of the subject, but we have not performed a rigorous literature search and we apologize to the many contributors to the field who have not been referenced by name. We are deeply indebted to our colleagues and co-workers at McMaster University in Canada, the University of Lund and Chalmers Technical University in Sweden, and Rensselaer Polytechnic Institute in the U.S.A., and to our industrial co-workers at INTELSAT, AT & T—Bell Laboratories (U.S.A.), the General Electric (U.S.A.) Corporate Research and Development Center, Codex Corporation (U.S.A.), Ericsson Radio Systems (Sweden), and the European Space Agency. Of this large body of co-workers we must give special mention to Rudi de Buda, Nils Rydbeck, Arne Svensson, and Göran Lindell. It is a special pleasure to acknowledge the typing services of Doris Glöck, Constance Brough, Inga-Britt Holmdahl, Annette Laiacona, and Sandi-jo Rumsey and the patience and guidance of our editor, L. S. Marchand. Certain government agencies were instrumental in the support of the new research in the book; these were the Swedish Board of Technical Development (STU) and the Natural Sciences and Engineering Research Council of Canada.

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