ANALOG & DIGITAL COMMUNICATION

W. David Gregg

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Concepts, Systems, Applications, and Services in Electrical Dissemination of Aural, Visual, and Data Information

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To Patricia, Randy, and Donna

Preface

This book is about concepts, systems, practical applications, and services in the electrical generation and dissemination of aural, visual, and data information. It is a freshly organized and balanced presentation of both analog and digital communication employing unifying notation, terminology, and illustration. It provides the user with an understanding of the methodology of concepts and systems and relates this methodology to practical applications and services.

The book is designed as a fundamental textbook in communications for junior and senior undergraduates. The practicing professional and beginning graduate student will also find it useful.

The prerequisites are introductory linear systems and probability. Students with upper division standing or above are usually adequately prepared or can pursue this prerequisite material concurrently. Mathematical preliminaries for this material are presented in introductory sections as they are needed. Many of the important concepts can be completely developed by using only ordinary algebra and differentiation or integration of sinusoids and exponentials. Some of the section discussions, examples, and problem statements require familiarity with introductory electrical and electronic circuits. Generally, the presentation assumes that the students have had no formal exposure to the techniques and principles of the electrical communication process.

The content follows the logical order of intellectual activity, progressing from factual introduction and illustration, through analysis and applications, to evaluation. The intent is to provide the user with a sound understanding of the fundamentals as well as insight into approaches and methodology involved in analyzing, planning, designing, and evaluating communication systems. It also provides a solid base for further study and research.

The topic of communication is addressed at the outset with a thorough discussion of signal waveforms, signal spectra, modulation features, bandwidth requirements, and quality measures such as signal-to-noise ratio characteristics and error probabilities. All major techniques of amplitude and frequency modulation, pulse modulation, and pulse-coded modulation, with and without error-control coding are considered in a unified manner. There is a detailed treatment of other practical topics such as interference, receiver noise figures, antenna gains, and transmission losses, as well as the more advanced concepts of information, channel capacity, and error control coding.

Of particular interest is the new approach I have taken in topic selection, organization, and presentation. The concepts of analog, pulsed, and pulse-coded systems are developed and illustrated with common notation for common parameters, in a step-by-step method, with continuity between system configurations and graphical illustrations. This promotes maximum understanding of the similarities and differences, and advantages and disadvantages, of the various concepts. The presentation emphasizes the functional operations involved in electrical structuring and dissemination of aural, visual, and data information. It stresses the principles and concepts underlying the systems and practical applications rather than the components and devices, which undergo continuous change. Important principles are illustrated by completely worked-out examples using practical-sized parameter values, with continuity between examples, and with follow-up problem statements tied to practical applications. The generous quantity of carefully developed problem statements enables the user to select the type of problem desired to emphasize a principle; these problems follow the sections chronologically in their respective chapters. Often key principles are developed from different viewpoints by using several problems.

The material in various chapters is supplemented by tables in the appendix that are tailored to the book's subject matter and problem statements. A balance is provided between theoretical concepts, systems and their applications and services, and service operating standards.

Various topics pertaining to communication services and practical application not usually found in books dealing with concepts and systems make the presentation different and stimulating. This includes a description of the historical technological development leading to the present communication sector. Discussed specifically are technological innovation, illustration of organization of the radio spectrum, the various bands, frequency allocations and characteristics, key organizational aspects of the FCC pertaining to domestic communication standards and regulation, and the structure and function of the International Telecommunications Union, and CCITT standards for international communication. Concepts and systems are related to regulated operating standards in practical applications such as AM and FM radio broadcast, commercial television, class D citizens band, telephony, space telemetry, wire communications, telegraphy, and satellite communication. System characteristics are illustrated with practical operating values for signal power, transmission bandwidths, time and frequency multiplexing hierarchies, data rates, signal-to-noise ratios, and operating frequencies. There are numerous photographs of spectrum-analyzer

and oscilloscope displays of laboratory instrumentation for various modulation, sampling, and filtering applications using the parameter values in the chapter discussions and examples; thus the reader can clearly visualize the effects of signal parameter changes. The concept of information measure is illustrated by using the information content of television picture frames, written text in English and Russian, and sampled waveform sources. It relates information measures and source coding features to practical teletype codes by employing modern pulse-code modulation with illustrations and explanation.

In keeping with the dramatic shift toward digital systems, evidenced by transitions to digital telephony, digitization of network television for global distribution, research with all-digital receivers, message switching, electronic funds transfer and the like, the discussion of the digital applications has been given extensive treatment.

This book is intended to prepare the user for participation in the various engineering, scientific, or technical tasks in the communications industry. It also imparts a working knowledge to peripheral users in areas such as management, statistics, industrial engineering, and the production side of communication. Also it hopefully will motivate further study in the more advanced and specialized technical areas of communication such as systems design, systems engineering, random processes, and the like. Finally, it acquaints the user with the many careers available in the communication sector, ranging from system design or engineering, to technical pursuits in the common carrier industry or the various bureaus and regulatory bodies of governmental agencies, as well as domestic and international organizations.

The topic material in this book can be used for one or more semesters or quarters depending on the preference of the instructor. There is adequate material for an effective in-depth course in either analog communication, digital communication, or selected topics from both, over one or two semesters. For a one-semester course in analog communication, I recommend Chapters 1 to 5 and Chapter 10 with Chapters 6 and 7 optional; for an in-depth one-semester treatment of digital communication, I recommend Chapters 8 and 11 to 14 with Chapter 9 optional. A one-semester course in both analog and digital systems can be pursued by using Chapters 1 to 5, 8, 11 to 12, with Chapter 14 optional. For a two-semester presentation, I recommend Chapters 1 to 7 followed by Chapters 8 to 14. Various sections throughout the text contain more advanced material which is intended to be supplementary and can be omitted at the users option without loss of continuity; such sections are designated by the asterisk symbol *.

I acknowledge with appreciation the feedback I received from my many students during the period of teaching from manuscript notes. I thank the staff of the Department of Electrical Engineering at the University of Texas for their typing and drafting assistance. I am grateful to my wife and children for their patience and understanding during the time I devoted to writing this book. Finally, I am pleased to have this work published by John Wiley, and thank the many staff members involved in bringing this book to market.

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