Solid State Radio Engineering

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Preface

This book is about the analysis and design of the radio-frequency electronic circuits that are the building blocks of radio transmitters and receivers. It reflects the developments of the past decade, which have initiated an unprecedented growth in the use of analog radio systems for personal and business voice communications. Continuing advances in solid state technology have resulted in transmitters that are smaller, cheaper, and more reliable than ever before. Parallel developments have occurred in the home entertainment radio and television fields. As a result, radio engineers versed in the solid state art are in demand.

Because of the rapid changes in radio technology, teachers of courses in radio circuits have often had to rely on material that is scattered through many different textbooks, technical journals, and application notes. This volume meets the need for a comprehensive book on radio electronics.

Solid State Radio Engineering is unique because of its broad coverage of both receiver and transmitter circuits and its illustration of theoretical concepts with numerical examples from real circuits. Design that uses practical circuit elements instead of idealized mathematical models is emphasized. The letter symbols used for semiconductor device currents and voltages conform for the most part with IEEE Standard notation.

The last five chapters present for the first time in textbook form considerable information on RF power amplifiers. Currently, power amplifier design is often accomplished by using cut-and-try techniques and rules of thumb. Often, theoretical explanations of power amplifier operation are too complicated or require too much time for a designer to use. This book brings these principles to the student or practicing design engineer in a way that not only makes them understandable but also makes them useful for design. The discussions in Chapters 12 to 16 include not only accepted state-of-the-art technology, based on bipolar junction transistors, but also VMOS RF power FETs, high-efficiency techniques, envelope elimination and restoration, and other newly emerging technologies that are expected to play significant roles in radio engineering during the next decade.

This book is intended to be both a reference for the working engineer and a textbook for senior-level students in electrical engineering and electrical technology. A knowledge of complex algebra, Fourier series, and Fourier transforms will enable its reader to handle the mathematics in the book. As an

aid to self-study, practical design examples are included throughout. These are reinforced by homework problems that are keyed to the corresponding sections of the text.

The material presented is appropriate for either a two-semester or three-quarter course sequence. For shorter course offerings, some chapters may be omitted. For example, if receiving systems are of primary interest, Chapters 1 to 11 can be used. For transmitters, Chapters 1 to 8 and 12 to 16 (with the possible omission of Sections 14-3 to 14-6) are recommended. If the students have an adequate background in noise and modulation theory, Chapters 2 and 8 can be omitted. Prior knowledge of resonant impedance matching might permit skipping all of Chapter 3, with the exception of Section 3-6, which is used frequently in the following chapters.

A brief introductory chapter considers the concept of modulation and the functions performed in a typical transmitter and receiver. It is followed by a discussion of electrical noise because of its importance in the design of RF amplifiers and mixers in receivers. Chapters 3 to 7 include the component parts of receiver systems, and Chapter 8 provides the modulation theory necessary for an understanding of the operation of AM, SSB, FM, and TV receivers.

A thorough treatment of the design of narrowband, tapped resonant circuits for impedance matching, as well as the use of tapped mutual inductance circuits for both wideband and narrowband matching, is given in Chapter 3. The design of small-signal, tuned amplifiers for maximum gain with a specified degree of stability is considered next. This is followed by an analysis of sinusoidal oscillations in *LC* and crystal oscillator circuits; and a unique, laboratory-tested procedure is given for the design of a common-base Colpitts oscillator for specified output.

A phase-locked loop will soon be included in nearly every radio receiver, transmitter, and piece of test equipment. Hence, the simpler aspects of loop operation are outlined in Chapter 6, along with the characteristics of the basic loop components and some applications to communication equipment. This is followed by analysis of diode, BJT, and FET mixer circuits.

Chapters 9 to 11 are devoted to receivers. Because design techniques are changing constantly with the introduction of new integrated-circuit packages, the fundamental signal processing in each type of receiver is stressed without a detailed description of all possible circuits. Analysis of various types of AM and FM detectors is found in the corresponding chapters, along with information on ceramic, crystal, and surface-acoustic-wave IF filters. The basic principles of color picture transmission are given in Chapter 11, along with a block-diagram explanation of the receiver circuitry. Although not directly related to the subject matter of the book, this is the one piece of radio

equipment that the student owns and uses every day. Furthermore, it incorporates most of the principles studied in preceding chapters.

Chapters 12 to 16 are organized by practice rather than theory. Thus Class A and B amplification along with the broadband transformer and filter networks normally used in SSB transmitters are discussed first. Similarly, Class C and Class C mixed-mode power amplifiers and the discrete-element or transmission-line matching networks normally used with them, are presented together. Chapter 14 treats several types of high-efficiency power amplifiers (Classes D, E, F, and S). Chapter 15 includes CW, FM, and AM transmitters, since they have similar configurations. The last chapter examines single-sideband and multimode transmitters, envelope elimination and restoration, and other related techniques.

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