BOOK REVIEW

Cyclostationarity in Communications and Signal Processing

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Stationary and wide-sense stationary stochastic processes are among the most prevalent models for random signals in electrical engineering. Stationarity assumptions are valuable in communications engineering because they allow formal definition of a random signal's power spectral density, thereby providing the foundation for frequency-domain analysis of such signals. Some potentially important properties of many, if not most, types of communication signals are not effectively captured by stationary process models, however. For example, the statistical behavior of a signal consisting of a deterministic sine wave with known phase in additive stationary noise is periodic rather than constant as a function of time. A random signal with this characteristic is a cyclostationary signal. Signals formed by superposition of two or more cyclostationary signals whose periods are not harmonically related are *polycyclostationary*. Recent interest in these types of signals has arisen within the communications and signal processing R&D communities because many communications signals are inherently cyclostationary and because it has been demonstrated that cyclostationarity of such signals can be exploited in useful ways.

Although fundamental work on the theory of cyclostationary processes dates back to the 1950's, the study of cyclostationary signals in the context of communication engineering has really emerged since the mid-1980's. A rapidly growing number of research articles and theses, including many authored by the contributors to this book, have examined the role of cyclostationary signals in a wide variety of communications and signal processing applications. Treatments in chapters of earlier books [1,2] and recent survey articles [3,4] have provided starting points for communications and signal processing engineers interested in learning about cyclostationary signals but have only scratched the surface when describing applications. This book is the first to provide an introduction to cyclostationary signals together with a survey of important applications that is both broad and satisfyingly deep.

The book is organized in two parts. Part I contains six chapters which, although written by various authors, provide a reasonably coherent introduction to cyclostationary signals and 11 several of the most important application areas. Chapter 1, written by Gardner, is an 80-page introduction to cyclostationary signals culminating with a survey of how cyclostationarity can be exploited in certain signal detection and characterization applications. Chapters 2-6 present theory and applications of higher-order cyclostationarity; array processing of cyclostationary signals; linear filtering for cyclostationary signals; state-space methods for representation, prediction, and identification of cyclostationary processes; and spectral theory and estimation for cyclostationary processes. Part II consists of seven shorter articles, also by various authors, covering such topics as blind channel identification and equalization, synchronization, multipath channel identification, and DSP implementation of cyclostationary algorithms.

This book is a timely contribution that should be a valuable reference for academic and industrial R&D engineers in signal processing and communication systems. Because it contains contributions from many authors, notation and terminology are not entirely consistent throughout the book (e.g., some authors use E(.) to denote expectation in the traditional probabilistic sense while others use it to mean fraction-of-time expectation). This should not present a substantial difficulty to the intended audience, however. Indeed, it is a small price to pay for a reference work that presents a body of recent theoretical developments and application methods, some of which were previously documented only in Ph.D. theses and conference proceedings papers.

References

[1] W.A. Gardner, Introduction to Random Processes with Applications to Signals and Systems, 2nd ed., McGraw-Hill, 1990.

[2] W.A. Gardner, Statistical Spectral Analysis: A Nonprobabilistic Theory, Prentice-Hall, 1987.

[3] W.A. Gardner, "Exploitation of spectral redundancy in cyclostationary signals," IEEE Signal Processing Magazine, vol. 8, pp. 14-36, April 1991.

[4] R.S. Roberts, W.A. Brown, and H.H. Loomis, Jr., "Computationally efficient algorithms for cyclic spectral analysis," IEEE Signal Processing Magazine, vol. 8, pp. 38-49, April 1991.