Book Review

An Introduction to Random Vibrations, Spectral and Wavelet Analysis, 3rd ed., by D. E. Newland. Wiley, New York, 1993, Paperbound, 477 pp.

The first edition of this book was written in 1974, the ice age of signal analysis. The author's purposes then were to discuss the field of random vibration because it was not dealt with much in undergraduate schools of engineering at that time, and to illuminate spectral estimation based on the fast Fourier transform (FFT). He noted at that time that most users of the FFT have "incomplete understanding of the nature of the approximations involved. . ." and hoped the book would help. Maybe that edition did not help. Now, 20 years later, it is my opinion that few users of the FFT analyzer have evolved past Newland's estimation of the skills of most users. The second edition (1984) added multidimensional random vibration and added some programs; the third (1993) adds the concept of wavelet transform. This edition further fulfills the hopes expressed in the original work.

The book discusses many important topics, some in more detail and some clearer than others. But taken together, this is a very good book. I list the contents of the book to show its comprehensiveness:

The contents shows that this book deals with many topics, most treated rather briefly, but with enough detail and with enough clarity to allow the reader to grasp many of the concepts quickly. The number of chapters in this book compared to the number of pages show the brevity of most of the subject's presentations. Fourier analysis (not even Fourier series) is covered in only eight pages.

Some treatments, like the explanation of correlation, begin simply enough but end with cryptic, and not especially useful, equations. The discussions of auto- and cross correlations could benefit by illustrative physical, rather than mathematical, examples. But considering that many

Shock and Vibration, Vol. 1, No. 6, pp. 585–587 (1994)

CCC 1070-9622/94/060585-03

steps are often omitted, probably due to editorial concerns, the mathematics is well explained and clear.

I particularly liked the chapter on excitation-response relations for linear systems. Both steady-state and impulse response methods are presented mathematically and illustrated graphically. It seemed to be a very intelligible treatment and stood out, either because I was most familiar with this topic, or more likely because the author's efforts were particularly strong. But there are other important sections worth mentioning.

I also liked the chapter on the accuracy of measurements, partially because measurements are what I do, and partially because the working group I chair has yet to develop a standard, after more than 9 years, to evaluate commercial FFT analyzers. Measurements involve the chain of accuracies in producing, from analog signals, a form that is understandable and quantified. And measurements inherently include the assumptions used in the implementation of software and the physical hardware manufacturing limits including the electronics. The hardware aspects of instrumentation are not discussed much and I do not really think the author addresses the basic problem: "What is the totality of errors we incur when measuring a finite random process?" He includes neither the various simplifying assumptions that are associated with accompanying errors (not that they are easily determined) nor the inherent inaccuracies of instrumentation. Nevertheless, he emphasizes that the combination of long averaging time and narrow bandwidth is important. We know of this as the "BT Product," that BANDWIDTH * TIME (of Analysis) must be as high as possible and always greater than 1.0.

The treatment of a finite length cosine signal, compared to an infinite one, is well done and illustrative. It points out the basic problems associated with even a simple deterministic signal.

Newland does an excellent job in his discussion of "confidence limits," that are often, for most people, just engraved in a switch of an instrument. The uninitiated may think the confidence limits hold but, after reading this book, he or she will recognize some of the sweeping assumptions used in coming up with that phrase. The end result is that, except for very well behaved signals, the errors associated with analysis are not easily determined. For those of us who have seen (or have done) analysis with signal analyzers, all the time trusting the data from the sophisticated instrument, this book will give a new respect for the term "whoops."

However, this is not a guide to use signal analysis instrumentation correctly. (There is nothing on "Hanning," "Rectangular," or "Zoom.") But it is not meant to be that type of book. It does help the basic understanding of certain concepts that can only help us all make a better measurement. Also, this book does not emphasize measurement problems. It is focused on the mathematics of signal analysis and random vibrations. The other sections, making up a major part of the text, include mostly theory, some examples, and worked-out problems.

The chapter on windows and smoothing is quite good and the sections on the practical considerations of these topics are very illuminating. Most people do not think of aliasing because most modern instruments do this automatically; but not all of them. The author's explanation of aliasing is clear and easily understood and worthwhile to know for all measurement situations. The treatment of the FFT is very good. It gives a flow chart to allow you to program your own computer (which may cost more than several dedicated analyzers after you have debugged the code).

In addition to a very good discussion and explanation of random noise generators found in most analyzers these days, the author explains the solution of structural vibration based on the response of continuous linear systems.

Wavelet analysis, a relatively new (1980s) concept is introduced in a very understandable way. Wavelets arose because it was impossible to determine from a Fourier analysis, if a frequency component arises from a local disturbance at the frequency in time or as a result of the near-infinite repetition of components throughout the life of the signal. The concept is complex and is not "bedtime" reading, unless you want a nonaddictive sleep inducer, but Newland's treatment is thorough (almost 100 pages) and lucid.

The book has many "homework" problems and answers and makes an ideal self study book for those sufficiently motivated. It may be also good as a textbook, especially if there is an accompanying solutions book for instructors. But it no doubt requires additional lecture notes by the instructor. It is also effective as a reference book for practicing engineers and scientists who still know their mathematics, or for those in industry who want an overview of the signal analysis and random vibration field.

This is not an easy book to read, but it is well written and clear. It is on a level meant for someone who remembers most of his/her mathematics, who needs a review or an introduction to the field, or who wants a fast refresher.

Reviewed by:
Richard J. Peppin
Scantek, Inc.
Silver Spring, MD