

Nonlinear Random Vibration: Analytical Techniques and Applications, Second Editions

Cho W.S. To, CRC Press, Boca Raton, (2012)
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This is Professor Cho W. S. To's newest book and this second edition reports primarily on a number of analytical treatments and approaches in the analysis of nonlinear dynamic engineering systems subjected to a variety of random excitations and disturbances.

The author began writing the first edition of this book of the same title during a 1991–1992 sabbatical at the University of California at Berkeley from his host university, the University of Western Ontario, Canada. This original edition was completed and published in 2000. The book's second edition, which is the subject of the present review, was published in 2012 and includes a number of minor alterations, improvements, and corrections from first edition which are highlighted below.

Before discussing details in this review, it should be noted that Prof. To recently also published a complementary book in 2010 for readers interested in focusing more on solving problems in nonlinear random vibration from a computational, rather than analytical, approach.

Comparing both editions of *Nonlinear Random Vibration* reveals that the overall organization of the second edition remains largely unchanged from the original book. The new edition still contains the same seven chapters as the original, the only major organizational change being the addition of an Appendix, which is described and assessed below.

Chapter 1 of the book is an "updated introduction to the reviews in the general areas of nonlinear random vibration" and is to include a list of "books exclusively dealing with and related to analytical techniques and applications cited". However, at only a page and a half in length and covering mostly the book's organization and layout, this chapter is written more as a preface than as a comprehensive introduction to the general motivation, history, and important examples of nonlinear random vibration. The latter high-level overview is especially missed in the present book since immediately from the start of Chapter 2 the author delves deeply into detailed mathematical approaches used in the remainder of the book. In addition, with the exception of a citation of the author's aforementioned 2010 computational book, this reviewer found only one reference of 39 in Chapter 1 that was new and published after To's first edition, in 2000.

Overall, this reviewer found the technical material covered in Chapters 2 through 7 to be very good. The

topics for the book's subject are well covered, no important major topics have been omitted, and the quality and presentation of the material are very satisfactory. Chapter 2 contains a short discussion on both, the Markovian or "memoryless," as well as the non-Markovian and non-stationary, process solutions to stochastic nonlinear differential equations.

The exact solutions to the general form of the Fokker–Planck–Kolmogorov (FPK) equations introduced in Chapter 2 are examined in a number of ways in Chapter 3. It is clear that Chapters 2 and 3 are intended to serve as the groundwork and basis for the material covered in all later chapters of the book.

Since most real-world nonlinear random vibratory systems are not amenable to the formal closed-form solutions presented in earlier chapters, Chapters 4 and 5 present approximate solutions based on the Statistical (or equivalent) Linearization (SL) and Statistical Non-Linearization (SNL) techniques, respectively. The material covered in the newly added Section 5.5 of the second edition covers an improved SNL technique, recently published in the literature by the book's author, for yielding approximate solutions to multi-degree-of-freedom nonlinear systems. Continuing in the area of approximate solutions methods, Chapter 6 delves into various approaches and examples of stochastic averaging methods (e.g., classical, energy envelope-based).

It should be noted that solutions to both, general one- and multiple-degree-of-freedom systems are presented for each of the topics examined in Chapters 3 to 5. In addition, a generous number of engineering example problems is also solved in detail to illustrate the methods. Finally, Chapters 4 to 6 each contain a helpful analysis and discussion on the expected accuracy of each of the proposed approaches.

Chapter 7, the book's final chapter, contains brief descriptions of a number of other approximate solution approaches useful primarily for solving to single degree-of-freedom random nonlinear systems (due to the high mathematical and computational cost when applying them to multiple-degree-of-freedom systems). The assortment of techniques presented in this chapter includes truncated hierarchy (including both Gaussian and non-Gaussian closure) schemes, perturbation techniques for problems with sufficiently small nonlinearity, and functional series techniques (including both Volterra and Wiener–Hermite series expansions). A helpful addition to the second edition is the inclusion of more detailed steps in the derivation of the Volterra series expansion techniques described in Section 7.4.1

As mentioned, the inclusion of a new Appendix in the second edition is one of the few significant organizational changes to the book. It is alternately described

by the author both as a “brief introduction” and an “outline” for “rapid review” of the basic concepts and theory of probability, random variables, and random processes. Though brief and likely too advanced for a true introduction to these subjects, the Appendix is adequate as a quick refresher and is a useful addition to the second edition for completeness of the overall treatment of the subject of random nonlinear vibrations.

From an overall book-wide perspective, there are several points that warrant comment. To begin with, the author’s self described primary goals of the second edition are to (a) include treatment of various theoretical developments in the field of nonlinear random vibrations made since the 2000 first edition and to (b) correct a number of errors and misprints. Related to the first goal, this reviewer expected to see significantly more recent work from the literature since 2000 included and cited throughout the second edition. With the exception of a very small handful of new references (i.e., only six new of 312 total), the vast majority of references in the text date back to the 2000 original edition (e.g., recall only a single new reference is added to the updated introductory Chapter 1). That is, while errata from the original edition have been corrected, the second edition does not contain a substantial amount of new, updated developments made in nonlinear random vibrations since 2000.

On the positive side, there are a number of attractive features of the book that have been held over from the first edition, and even expanded upon, that are quite helpful. For example, the second edition includes the addition of more explanatory details between first edition mathematical derivation steps, particularly within the example problems. Furthermore, this book

contains a very generous number of example problems throughout, giving very practical worked illustrations to an at times highly technical and theoretical subject. For example, a full 2/3 of the material presented in Chapter 3 covers the solution of example problems influenced by real-world engineering applications and systems. It was nice to see that most of these example problems reference a specific external reference from the literature such as a technical journal article or book.

Related to references overall, this book is well referenced for a standard textbook. Virtually every one has been specifically chosen and cited for a definite reason; there was virtually no mass grouping of references as has been increasingly the norm in the recent literature.

In summary, the technical material in Prof. To’s 2012 second edition of *Nonlinear Random Vibration: Analytical Techniques and Applications* is well presented, of sufficient depth, detail, and quality, and supported by a good number of solved example problems. If To ever considers a third edition, it would be further improved by the inclusion of (a) a more thorough examination of recent technical developments, (b) an increase in the number and quality of illustrative figures, (c) and perhaps, since this book is aimed at serving as an advanced graduate level textbook, a set of homework problems at the end of each chapter.

Robert M. Koch
Naval Undersea Warfare Center
1176 Howell Street,
Newport RI 02881 USA
robert.m.koch@navy.mil