

Xingjian Jing - Ziqiang Lang

Frequency Domain Analysis and Design of Nonlinear Systems based on Volterra Series Expansion

A Parametric Characteristic Approach

Frequency Domain Analysis And Design Of Nonlinear Systems Based On Volterra Series Expansion A Parametric Characteristic Approach Understanding Complex Systems

Lei Huang



Frequency Domain Analysis And Design Of Nonlinear Systems Based On Volterra Series Expansion A Parametric Characteristic Approach Understanding Complex Systems:

Frequency Domain Analysis and Design of Nonlinear Systems based on Volterra Series Expansion Xingjian Jing, Ziqiang Lang, 2015-02-17 This book is a systematic summary of some new advances in the area of nonlinear analysis and design in the frequency domain focusing on the application oriented theory and methods based on the GFRF concept which is mainly done by the author in the past 8 years The main results are formulated uniformly with a parametric characteristic approach which provides a convenient and novel insight into nonlinear influence on system output response in terms of characteristic parameters and thus facilitate nonlinear analysis and design in the frequency domain The book starts with a brief introduction to the background of nonlinear analysis in the frequency domain followed by recursive algorithms for computation of GFRFs for different parametric models and nonlinear output frequency properties Thereafter the parametric characteristic analysis method is introduced which leads to the new understanding and formulation of the GFRFs and nonlinear characteristic output spectrum nCOS and the nCOS based analysis and design method Based on the parametric characteristic approach nonlinear influence in the frequency domain can be investigated with a novel insight i e alternating series which is followed by some application results in vibration control Magnitude bounds of frequency response functions of nonlinear systems can also be studied with a parametric characteristic approach which result in novel parametric convergence criteria for any given parametric nonlinear model whose input output relationship allows a convergent Volterra series expansion This book targets those readers who are working in the areas related to nonlinear analysis and design nonlinear signal processing nonlinear system identification nonlinear vibration control and so on It particularly serves as a good reference for those who are studying frequency domain methods for nonlinear systems **The Bio-Inspired**

X-Structure/Mechanism Approach for Exploring Nonlinear Benefits in Engineering Xingjian Jing, 2025-07-04 This book presents a unique approach to the design and analysis of beneficial nonlinearity which can take an important and critical role in engineering systems and thus cannot be simply ignored in structural design dynamic response analysis and parameter selection A key issue in the area is thus systematically addressed about how to analyze and design potential nonlinearities introduced to or inherent in a system of under study which is a must do task in many practical applications involving vibration control energy harvesting sensor systems and robots etc This book together with several other books in this book series is to present an up to date summary on the most recent development of a cutting edge method for nonlinearity manipulation and employment developed in recent several years named as the X shaped structure or mechanism approach The X shaped structure or mechanism is a generic structure or mechanism representing a class of beneficial geometric nonlinearity with realizable and flexible linkage mechanism or structural design of different variants or forms quadrilateral diamond polygon K Z S V shape or others which all share similar geometric nonlinearity and thus similar

nonlinear stiffness damping properties flexible in design and easy to implement This book is particularly to present a systematic frequency domain analysis design and optimization method of critical structural or control parameters in nonlinear systems including the X structure mechanism dynamics aiming at better dynamic performance and special nonlinear response as expected in engineering practice Cases studies in vehicle suspension energy harvesting fault detection and fuzzy membership optimization are all showcased The new analysis and design method introduced in this book definitely present a totally new and powerful approach to optimization and understanding of a class of nonlinear systems from a special frequency domain point of view

Frequency Domain Nonlinear Vibration Features for Fault Diagnosis in Complex Structures Quankun Li,Xingjian Jing,2025-03-05 This book provides a comprehensive introduction to recent advances in frequency domain nonlinear vibration features utilized for fault diagnosis in complex structures in the field of mechanical civil aeronautical and aerospace engineering It illustrates their basic principles advantages drawbacks and applications in detail through theoretical analysis and simulation experimental study This book focuses on frequency domain nonlinear vibration features and its main contents can be classified into two parts according to the introduced features One is about features based on the SOOS second order output spectrum and the other is about features based on the OS DF output spectrum at the double frequency or the second harmonic frequency Complex structures in this book include satellites aeroengines bridges pipelines frames etc and corresponding multiple degree of freedom MDOF models include chain type beam type ring like grid like unit like and rotating models Detailed theoretical analysis and case demonstration help undergraduates graduates and researchers have a systematical learning process and understand basic dynamic characteristics of complex structures more thoroughly Then some models methods and results in this book can be a valid reference for the design optimization and iteration of next generation complex structures On the other hand this book provides a totally new inspiration for fault diagnosis methods combined with artificial intelligence and machine learning algorithms since frequency domain nonlinear vibration features introduced in this book are more sensitive and effective to faults

Analysis and Design of Nonlinear Systems in the Frequency Domain Yunpeng Zhu,2021-03-25 This book focuses on the development of three novel approaches to build up a framework for the frequency domain analysis and design of nonlinear systems The concepts are derived from Volterra series representation of nonlinear systems which are described by nonlinear difference or differential equations Occupying the middle ground between traditional linear approaches and more complex nonlinear system theories the book will help readers to have a good start to analyse and exploit the nonlinearities Analysis and Design of Nonlinear Systems in the Frequency Domain provides clear illustrations and examples at the beginning and the end of each chapter respectively making it of interest to both academics and practicing engineers

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the academic libraries in the UK and Ireland *Frequency Domain Theory of Nonlinear Volterra Systems Based on Parametric Characteristic Analysis* Xingjian Jing, 2008 **Describing Functions, Volterra Series, and the Analysis of Nonlinear Systems in the Frequency Domain** J. C. Peyton Jones, S. A. Billings, University of Sheffield. Department of Control Engineering, 1990 Applications of Nonlinear Dynamics Visarath In, Patrick Longhini, Antonio Palacios, 2009-02-11

The field of applied nonlinear dynamics has attracted scientists and engineers across many different disciplines to develop innovative ideas and methods to study complex behavior exhibited by relatively simple systems. Examples include population dynamics, fluidization processes, applied optics, stochastic resonance, locking and light formations, lasers, and mechanical and electrical oscillators. A common theme among these and many other examples is the underlying universal laws of nonlinear science that govern the behavior in space and time of a given system. These laws are universal in the sense that they transcend the model specific features of a system and so they can be readily applied to explain and predict the behavior of a wide ranging phenomena, natural and artificial ones. Thus the emphasis in the past decades has been in explaining nonlinear phenomena with significantly less attention paid to exploiting the rich behavior of nonlinear systems to design and fabricate new devices that can operate more efficiently. Recently there has been a series of meetings on topics such as Experimental Chaos, Neural Coding and Stochastic Resonance which have brought together many researchers in the field of nonlinear dynamics to discuss mainly theoretical ideas that may have the potential for further implementation. In contrast the goal of the 2007 ICAND International Conference on Applied Nonlinear Dynamics was focused more sharply on the implementation of theoretical ideas into actual devices and systems.

A Scattering Variable Approach to Nonlinear Systems Gerald Harvey Naditch, SYRACUSE UNIV N.Y., 1974. A new mathematical model is developed which extends Volterra series analysis of nonlinear systems with memory to high frequency systems including those containing linear passive distributed component devices. Scattering variables described by a linear transformation of voltage and current in lumped circuits and by incident and reflected waves in distributed circuits are used as fundamental quantities in Volterra functional series. A set of nonlinear Volterra scattering kernels results describing the output signal behavior of the system. The frequency domain Volterra kernels which can be interpreted as generalized response functions are analogous to linear scattering parameters. They can be used to describe power transfer and distortion measures of nonlinear multi ports. In particular when the input signal amplitudes are small the n th order harmonic component in the output signal can be closely approximated by evaluating a single kernel.

Modified author abstract **Analysis and Control of Nonlinear Systems with Stationary Sets** Jinzhi Wang, 2009. This book presents the analysis as well as methods based on the global properties of systems with stationary sets in a unified time domain and frequency domain framework. The focus is on multi input and multi output systems compared to previous publications which considered only single input and single output systems. The control methods presented in this book will be valuable for research on nonlinear systems with stationary sets. The Volterra

Series and Its Application Mark Dunn,2013-11 Modeling of weakly nonlinear systems by means of Volterra series analysis is presented Necessary conditions for representing nonlinearities by a Volterra series are developed analytically as well as heuristically A two condition convergence criterion for Volterra series and a method for determining Volterra transfer functions are established For systems with multiple nodes an extension of Volterra series analysis method of nonlinear currents is developed and applied to a MESFET amplifier Finally methods of quantifying nonlinear behavior are discussed

Frequency-domain volterra approach to nonlinear systems Sungbin Im,1994 **Nonlinear System Identification** Stephen A. Billings,2013-09-23 Nonlinear System Identification NARMAX Methods in the Time Frequency and Spatio Temporal Domains describes a comprehensive framework for the identification and analysis of nonlinear dynamic systems in the time frequency and spatio temporal domains This book is written with an emphasis on making the algorithms accessible so that they can be applied and used in practice Includes coverage of The NARMAX nonlinear autoregressive moving average with exogenous inputs model The orthogonal least squares algorithm that allows models to be built term by term where the error reduction ratio reveals the percentage contribution of each model term Statistical and qualitative model validation methods that can be applied to any model class Generalised frequency response functions which provide significant insight into nonlinear behaviours A completely new class of filters that can move split spread and focus energy The response spectrum map and the study of sub harmonic and severely nonlinear systems Algorithms that can track rapid time variation in both linear and nonlinear systems The important class of spatio temporal systems that evolve over both space and time Many case study examples from modelling space weather through identification of a model of the visual processing system of fruit flies to tracking causality in EEG data are all included to demonstrate how easily the methods can be applied in practice and to show the insight that the algorithms reveal even for complex systems NARMAX algorithms provide a fundamentally different approach to nonlinear system identification and signal processing for nonlinear systems NARMAX methods provide models that are transparent which can easily be analysed and which can be used to solve real problems This book is intended for graduates postgraduates and researchers in the sciences and engineering and also for users from other fields who have collected data and who wish to identify models to help to understand the dynamics of their systems **The Volterra and Wiener Theories of Nonlinear Systems** Martin Schetzen,1980 This text presents a complete and detailed development of the analysis design and characterization of non linear systems using the Volterra and Wiener theories as well as gate functions thus yielding new insights and a better comprehension of the subject The Volterra and Wiener theories are useful in the study of systems in biological mechanical and electrical fields **Volterra Series Truncation and Reduction in the Frequency Domain for Weakly Nonlinear System** L.M. Li,Billings S.A.,2006 **Analysis and Design of Nonlinear Systems in the Frequency Domain** Bin Zhang,2008 Weakly Nonlinear Systems Federico Beffa,2023-11-17 The open access book covers a large class of nonlinear systems with many practical engineering applications The approach is based on

the extension of linear systems theory using the Volterra series In contrast to the few existing treatments our approach highlights the algebraic structure underlying such systems and is based on Schwartz's distributions rather than functions The use of distributions leads naturally to the convolution algebras of linear time invariant systems and the ones suitable for weakly nonlinear systems emerge as simple extensions to higher order distributions without having to resort to ad hoc operators The result is a much simplified notation free of multiple integrals a conceptual simplification and the ability to solve the associated nonlinear differential equations in a purely algebraic way The representation based on distributions not only becomes manifestly power series alike but it includes power series as the description of the subclass of memory less time invariant weakly nonlinear systems With this connection many results from the theory of power series can be extended to the larger class of weakly nonlinear systems with memory As a specific application the theory is specialised to weakly nonlinear electric networks The authors show how they can be described by a set of linear equivalent circuits which can be manipulated in the usual way The authors include many real world examples that occur in the design of RF and mmW analogue integrated circuits for telecommunications The examples show how the theory can elucidate many nonlinear phenomena and suggest solutions that an approach entirely based on numerical simulations can hardly suggest The theory is extended to weakly nonlinear time varying systems and the authors show examples of how time varying electric networks allow implementing functions unfeasible with time invariant ones The book is primarily intended for engineering students in upper semesters and in particular for electrical engineers Practising engineers wanting to deepen their understanding of nonlinear systems should also find it useful The book also serves as an introduction to distributions for undergraduate students of mathematics

[The Volterra Series and Its Application - Hardcover](#) Mark Dunn, 2013-09 Modeling of weakly nonlinear systems by means of Volterra series analysis is presented Necessary conditions for representing nonlinearities by a Volterra series are developed analytically as well as heuristically A two condition convergence criterion for Volterra series and a method for determining Volterra transfer functions are established For systems with multiple nodes an extension of Volterra series analysis method of nonlinear currents is developed and applied to a MESFET amplifier Finally methods of quantifying nonlinear behavior are discussed

Frequency Domain Analysis and Design of Nonlinear Systems with Application in Chemical Engineering Nik Nor Liyana Nik Ibrahim, 2017

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