

Studies in Systems, Decision and Control

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Zdzislaw Trzaska

Mixed Mode Oscillations (MMOs)

Fundamentals and Applications

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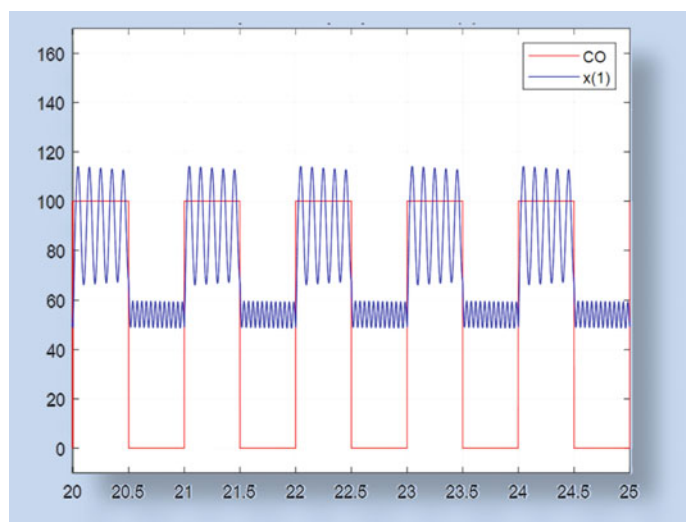
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Preface

This book focuses on plenty of problems relating to mixed mode oscillations (MMOs for short) that often occur in real nonlinear dynamical systems. The problem of dissection of MMOs into a sequence of small-amplitude oscillations (in brief SAOs) and of large-amplitude oscillations (in brief LAOs) is highlighted. A typical sequence of transitions is that even a relatively uncomplicated system, described in terms of deterministic evolution equations, may exhibit a sudden change to a completely new, qualitatively different behavior after smooth changes in the control parameter. Mastering this art guarantees the correctness of the procedures used to study nonlinear dynamical systems. In this book, we strive to meet such challenges.

The emphasis is on existing and systematically emerging new methods in the field for scientists, engineers and practitioners working in many, often interdisciplinary, fields where nonlinear dynamics plays a key role. These areas include analytical and environmental sciences, control engineering, electrical circuit analysis, mechanical systems and biochemical and medical research as well as in economics, among others. This is the first comprehensive approach to this topic emphasizing the nature of the phenomena studied and the effects of their analysis. Properties of MMOs are illustrated by several examples presented in each chapter.

Each chapter of the book is, to a large extent, self-contained with its own notation and method of presentation. Coverage includes:

- Dynamic behavior of nonlinear systems
- Fundamentals of processes exhibiting MMOs
- Mechanism and function of a structure of MMOs' patterns
- Analysis of MMOs in electric circuits and systems
- MMOs in chemistry, biology and medicine
- MMOs in mechanics and transport vehicles
- MMOs in fractional-order systems.

This is the first complete introduction to the mixed mode oscillations' identification and control that fully combines software tools—providing professionals and students to hands-on master critical techniques, thanks to computer simulations based on the straightforward MATLAB environment.

The center of concern is set on existing as well as emerging continuous methods for researchers, engineers and practitioners active in the many and often interdisciplinary fields, where electrochemistry, biology and medicine play a key role. These fields will range—among others—from analytical and environmental sciences to sensors, materials sciences and biochemical research. This is the first extensive description of this topic and very demanding physically in-depth insight in the interpretation of analytical results and those obtained from computer calculations. One should emphasize that the mechanisms and conditions for the formation of spatial and spatiotemporal patterns are of tremendous importance for understanding of such phenomena in chemical, cardiovascular and biological systems.

This book falls into a category intended to survey MMOs in practical systems occurring in many applications, such as electrical and electronic engineering (circuits and control systems), mechanical systems and transport vehicles as well as in electrochemistry and biological structures. These applicable areas proved to be filled with many interesting MMOs in various structures and forms. Reading the book can provide researchers with better and better knowledge not only to carry out a qualitative analysis and calculations of a given model, but also to independently identify the phenomena underlying the formal and mathematical description of the system under study.

The material is presented in seven chapters, and each of them is divided into sections. Usually, the first section of a chapter is of an introductory nature, explains phenomena and exhibits numerical results. Investigations of a more advanced nature are presented in the subsequent sections of each chapter. The bibliography contains only those papers that are referenced in the text and is no way meant to be complete.

It is hoped that the book will provide the readers with better understanding of the nature of MMOs, richness of their behaviors and interesting applications.

Warsaw, Poland
April 2021

Zdzisław Trzaska

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