531
MIT
1997

Applied Asymptotic Methods in Nonlinear Oscillations

by

YU. A. MITROPOLSKII
Institute of Mathematics,
Kiev, Ukraine

and

NGUYEN VAN DAO
Vietnam National University,
Hanoi, Vietnam

AV - D1/482

KLUWER ACADEMIC PUBLISHERS
DORDRECHT / BOSTON / LONDON

CONTENTS

Preface ix

Chapter 1. Free Oscillations of Quasi-linear Systems 1

1. Free oscillations of systems governed by a general second order differential equation 1
2. Conservative systems 10
3. Dissipative systems 17
4. Stationary amplitudes and their stability 20
5. Equivalent linearization of nonlinear oscillatory systems 22
6. Nonlinear oscillatory systems with slowly varying parameters. Adiabatic invariants. 25
7. Free oscillations of systems governed by a third order differential equation 41
8. Free oscillations of systems governed by N-order differential equation 49

Chapter 2. Self-excited Oscillations 58

1. Lienard and Routh-Hurwitz criteria. Stability of equilibrium states 58
2. Self-excited oscillations of a mechanical system 72
3. Dynamic absorber for quenching self-excited oscillations of the mechanical systems having one degree of freedom 75
4. Dynamic absorber for quenching self-excited oscillations of systems having two degrees of freedom 85
5. Self-excited oscillation of a system with N degrees of freedom 90
6. Dynamic absorber for a beam undergoing self-excited oscillation 94
7. Absorber for self-excited oscillations of a plate 100

Chapter 3. Forced Oscillations 107

1. Statement of the problem 107
2. Nonresonance case 109
3. Resonance case 118
4. External harmonic excitation of a nonlinear oscillator. Duffing's equation. Jump phenomenon 129
5. Subharmonic oscillations 137
6. Nonstationary oscillations 145
7. Multi- frequency oscillations in systems with one degree of freedom 156
8. Forced oscillation of systems governed by N-order differential equation 164
9. Single-frequency oscillations in nonlinear systems with multiple degrees of freedom 178
10. Multi-frequency oscillations in nonlinear systems with multiple degrees of freedom 180

Chapter 4. Parametrically-excited Oscillations 196

1. Some examples of parametrically-excited oscillators 196
2. Behaviour of oscillators governed by a Mathieu equation 199
3. Oscillators governed by a nonlinear Mathieu equation 206
4. Some generalized Mathieu equations 211
5. Parametric oscillations of mechanical systems with hysteresis 226

6. Indirectly-excited parametric oscillations 234
7. Parametrically - excited oscillations in an electromechanical system 239

Chapter 5. Interaction of Nonlinear Oscillations 245
1. Forced oscillations of systems with self excitation. Synchronization effect 245
2. Interaction between self-excited and parametric oscillations 254
3. Generalized Van Der Pol equation 257
4. Interaction of subharmonic oscillations 263
5. Interaction between parametric and forced oscillations in multidimensional systems 272

Chapter 6. Averaging Method 282
1. The idea of averaging by Bogoliubov 283
2. Averaging differential equations with slowly varying parameters 291
3. Averaging in systems excited by impulsive forces 293
4. Conditions for uniformity in the averaging method 297
5. Averaging in systems containing slow and rapid motions 300
6. Averaging in systems containing rotation. Motion of satellites 303
7. Modified averaging methods 319
8. Averaging method and stability of motion in the critical case 322

Appendix 1. Principal Coordinates 327

Appendix 2. Some Trigonometric Formulae Often Used in the Averaging Method 331

References 332

Index 336