

Table of Contents

Foreword	ix
Philippe ROESCH	
Preface	xiii
Chapter 1. Notions of Instability	1
1.1. Introduction	1
1.1.1. Lyapunov's Direct Method	3
1.1.2. Lyapunov's Indirect Method	5
1.2. Comparison of Notions of Resonance and Instability	8
1.2.1. Notion of Resonance	8
1.2.2. Notion of Instability	22
1.3. Instability Due to Self-Sustained Excitation	23
1.3.1. Multiple-Degree-of-Freedom Systems	24
1.3.2. Single-Degree-of-Freedom System	46
1.4. Parametric Instability	54
1.4.1. General Case	54
1.4.2. Mathieu's Equation	54
1.4.3. Typical Application	57
1.5. Summary of Methods Used to Ensure or Increase the Stability of a System	60
1.5.1. Notion of Degrees of Stability	60
1.5.2. Main Corrector Systems	67
Chapter 2. Rotor/Structure Coupling: Examples of Ground Resonance and Air Resonance	91
2.1. Introduction to Ground Resonance	91
2.2. Ground Resonance Modeling	99

2.2.1. Minimum Degree-of-Freedom Model	99
2.2.2. Stability Criteria	110
2.2.3. Energy Analysis	113
2.3. Active Control of Ground Resonance	115
2.3.1. Active Control Algorithm	115
2.3.2. Performance Indicators	135
2.3.3. Implementation of Active Control	137
2.4. Air Resonance	143
2.4.1. Phenomenon Description	143
2.4.2. Modeling and Setting Up Equations	144
2.4.3. Active Control of Air Resonance	149
Chapter 3. Torsional System: Instability of Closed-Loop Systems	153
3.1. Introduction	153
3.2. Governing Principle	153
3.2.1. History and Sizing of Flyball Governor	154
3.2.2. Simple Mathematical Sizing Criterion	155
3.2.3. Physical Analysis of Criterion and Effect of Parameters	164
3.3. Industrial Cases	168
3.3.1. Case of Airplane With Variable-Setting Angle Propeller Rotor	168
3.3.2. Case of Tiltrotor Aircraft	175
3.3.3. Case of Helicopter	176
Chapter 4. Self-Sustaining Instability for Rotating Shafts	201
4.1. Introduction to Self-Sustaining Instability	201
4.2. Modeling of Effect of Internal Damping on Rotating Systems	206
4.2.1. Instability Origins	206
4.2.2. Highlighting Instability	207
4.2.3. Stability Criterion for a Flexible Shaft	222
Chapter 5. Fluid-Structure Interaction	245
5.1. Introduction	245
5.1.1. Fluid-Structure Interaction Issues	245
5.1.2. Instability and Energy Analysis	246
5.1.3. Brief Description of Flutter	248
5.2. Flutter of an Airfoil in an Airstream	250
5.2.1. Setting Up Equations	252
5.2.2. Industrial Examples	259
5.3. Whirl Flutter	312
5.3.1. Introduction to Convertible Aircraft Case	313

Table of Contents vii

5.3.2. Enhanced Convertible Aircraft Rotor Reed's Modeling – Stability	315
5.3.3. Whirl Flutter Active Control: Case of Tilt Rotor	326
Bibliography	335
Index	339