Research Square

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Design and Characteristics of a Novel QZS Vibration Isolation System with Origami-inspired Corrector

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Research Article

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Abstract

A new class of quasi-zero-stiffness (QZS) vibration isolation systems, inspired by the origami metamaterial, is proposed to achieve high-performance vibration suppression in this paper. According to the mechanical characteristics of Tachi-Miura origami (TMO) with single degree-of-freedom, the nonlinear geometric relationship is developed with the folding angle as the master variable. By utilizing equivalent transformation and virtual work principle, the static model is established, the influence of structural parameters on stiffness is investigated, and the negative stiffness mechanism of origami mechanism is revealed. By adding a linear spring with positive stiffness to the origami in parallel, the Tachi-Miura origami vibration isolator (TMOriVi) is obtained. Subsequently, the governing equation is presented by means of the harmonic balance method. Two types of instability situations, jump phenomenon and unbounded response, are studied, and their analytic criteria and relationship are derived. Finally, through the parametric influence analysis and a series of comparative studies, the effectiveness and superiority of the proposed isolator are verified. The proposed vibration isolation system with great design flexibility exhibits a significant potential in the field of low-frequency vibration isolation.

Full Text

This preprint is available for download as a PDF.

Figures

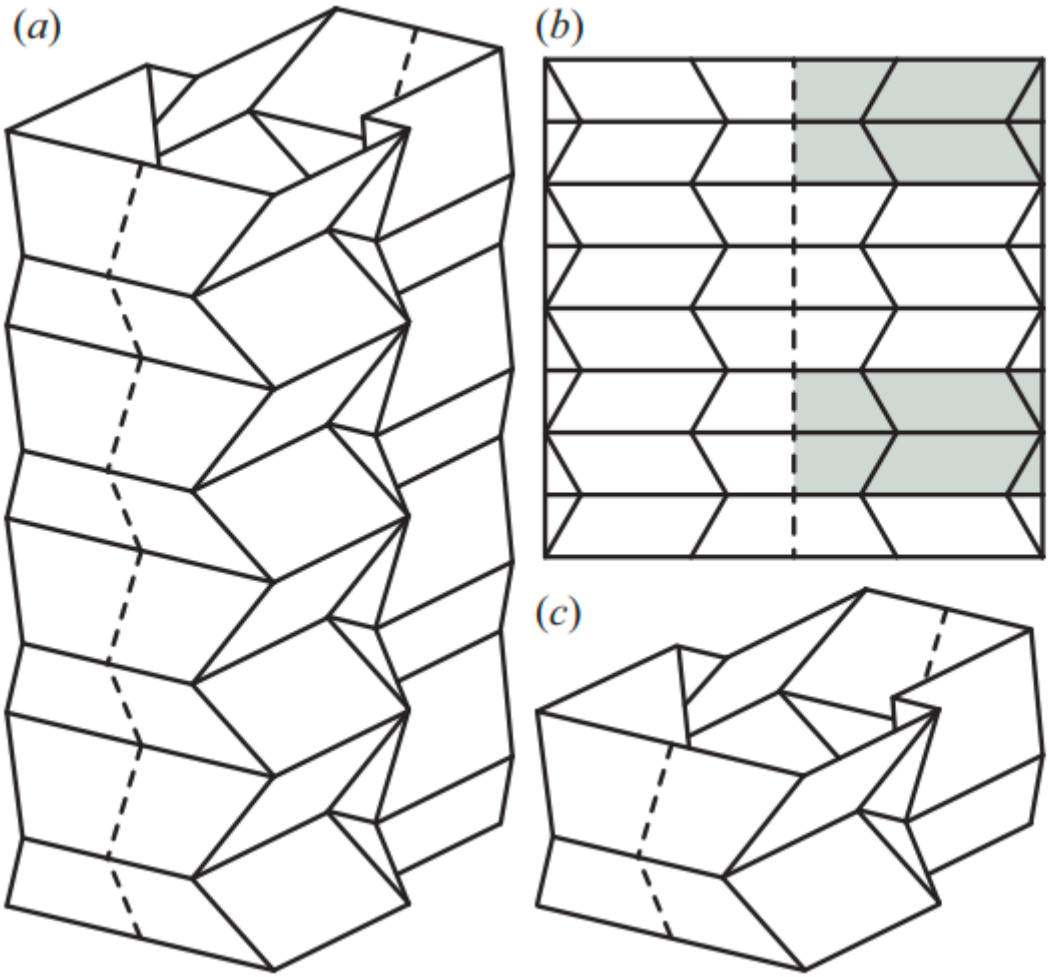


Figure 1

Tachi-Miura origami: a 3D model; b 2D structure; c two-layer origami structure

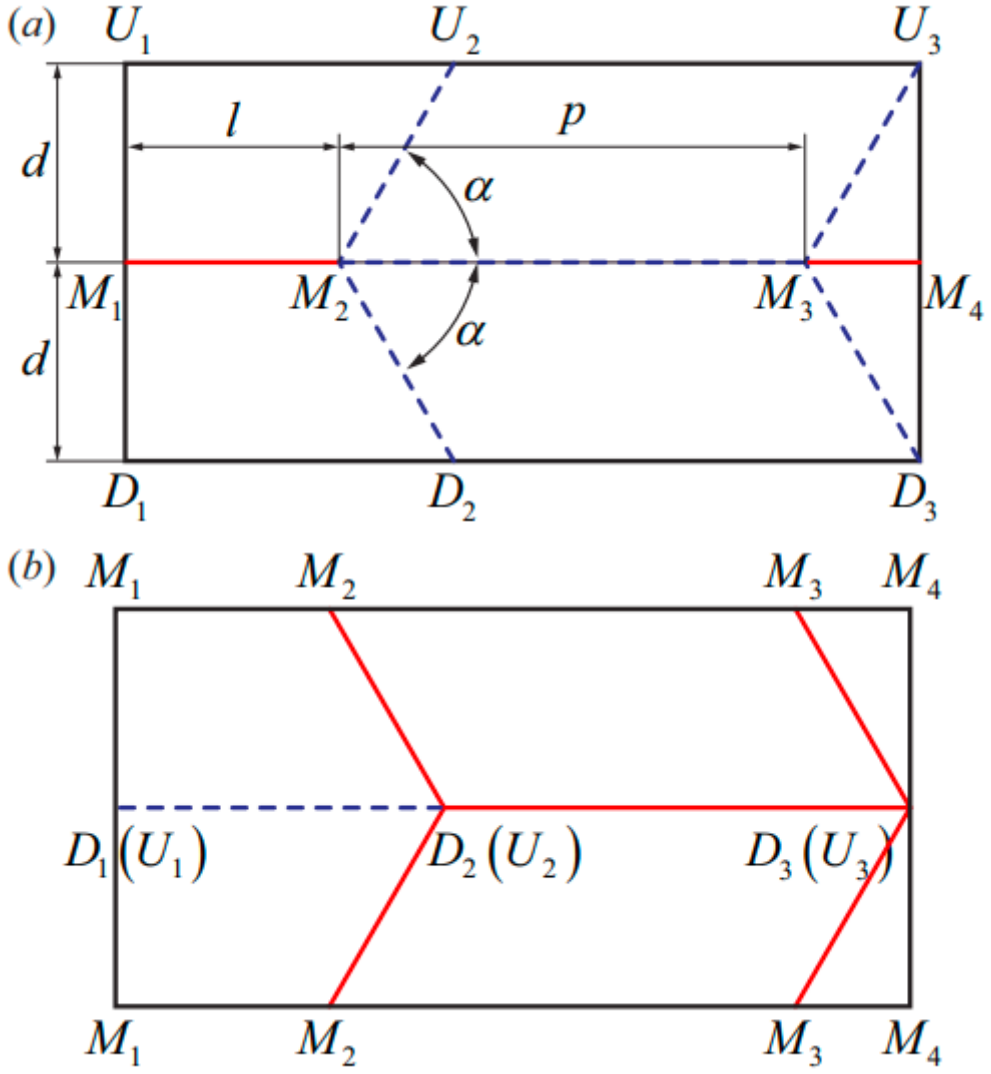


Figure 2

The two basic folded patterns: a pattern 1; b pattern 2

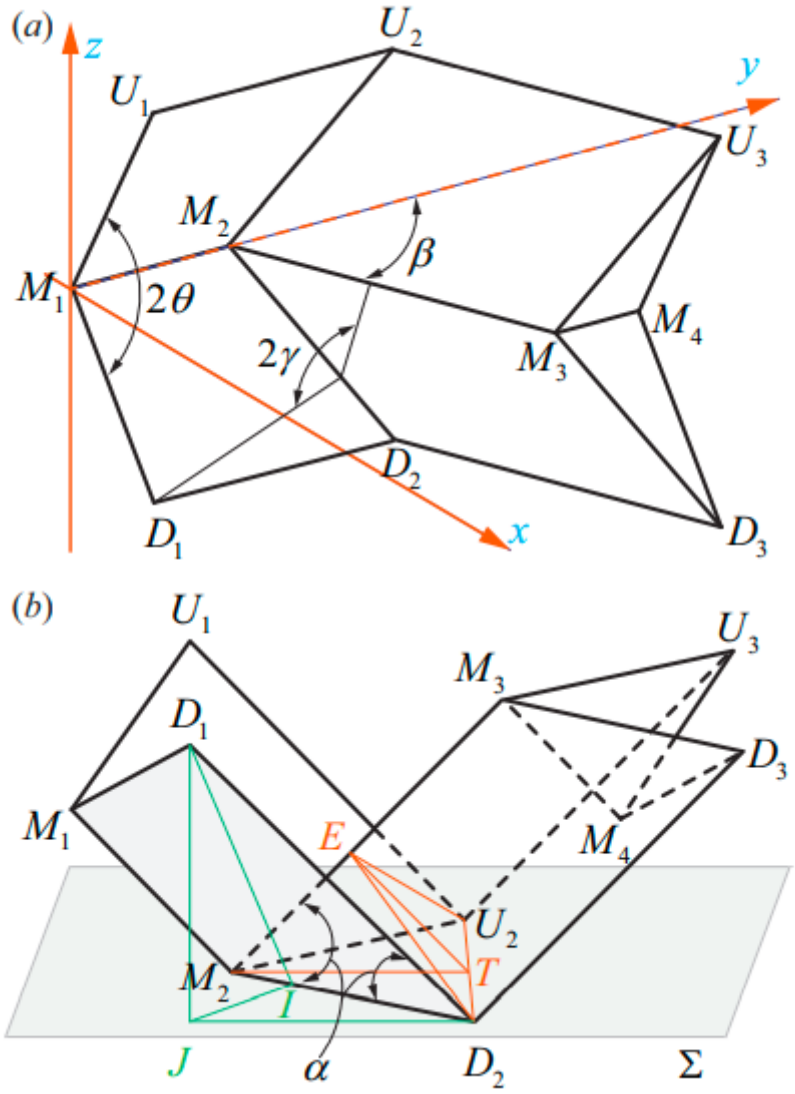


Figure 3

The 3D model of basic folded pattern: a with vertical view; b with slope view

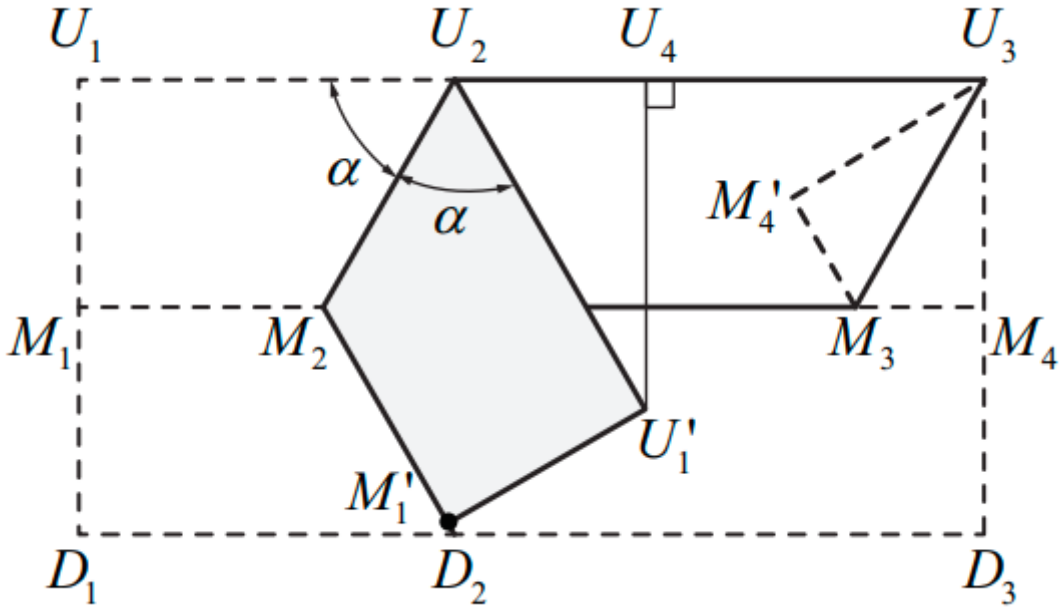


Figure 4

The fully folded state of basic folded pattern

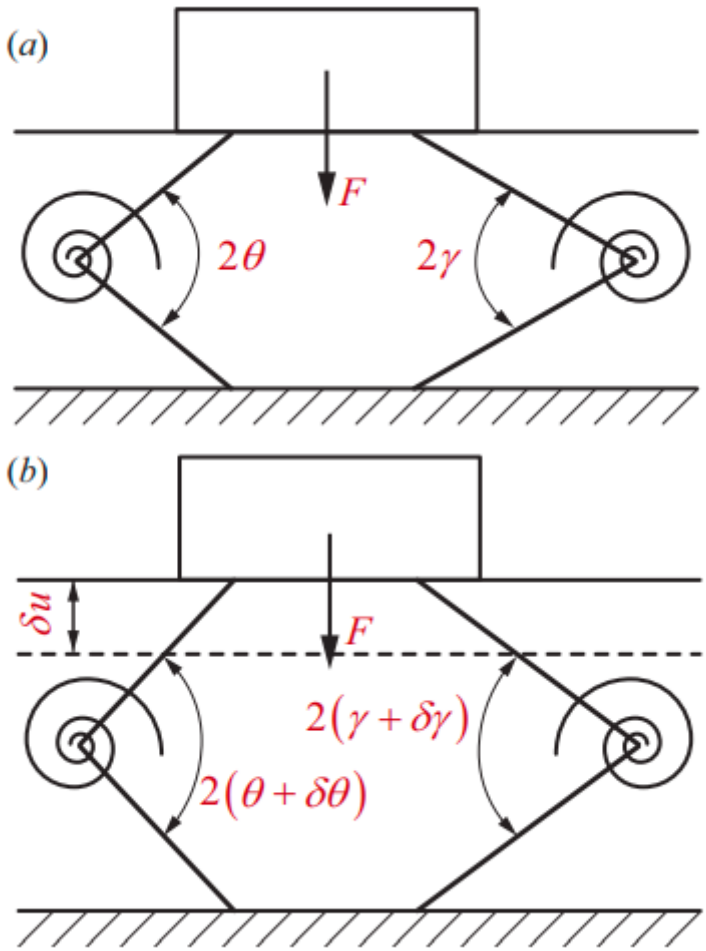


Figure 5

Mechanical model of TMO: a static equilibrium state; b virtual displacement state

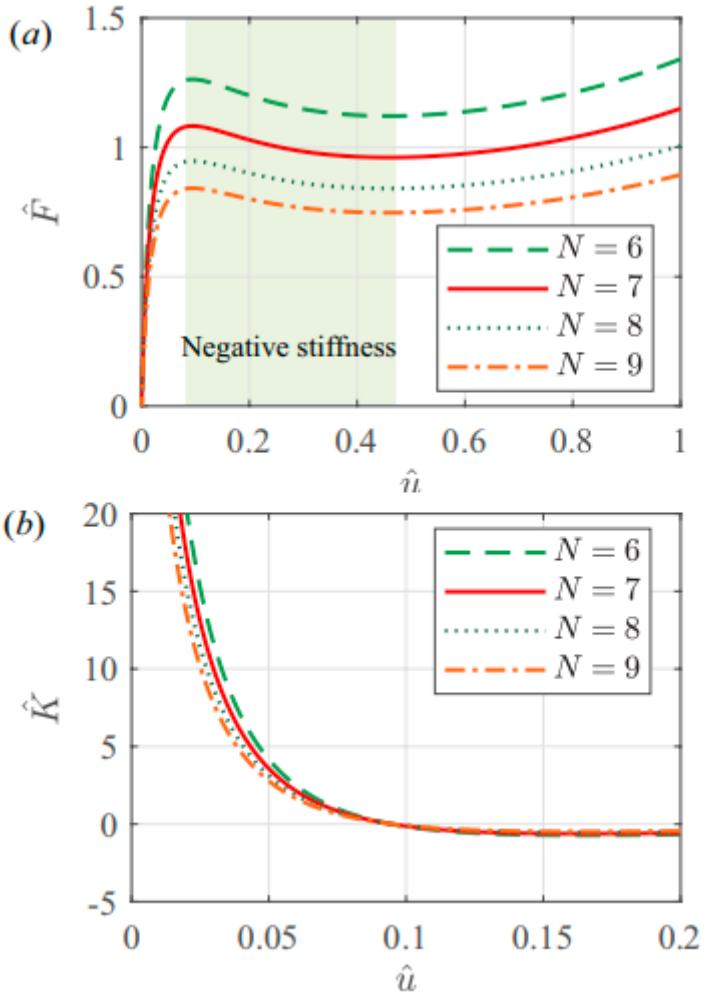


Figure 6

Effect of N on the static characteristics: a non-dimension force; b non-dimension stiffness

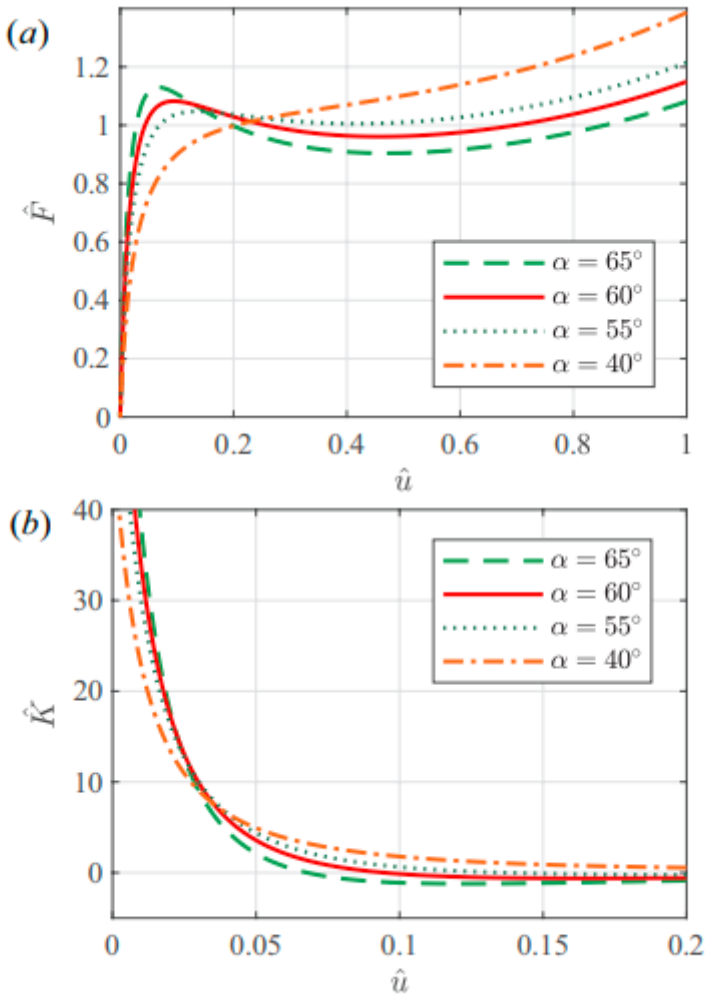


Figure 7

Effect of α on the static characteristics: a non-dimension force; b non-dimension stiffness

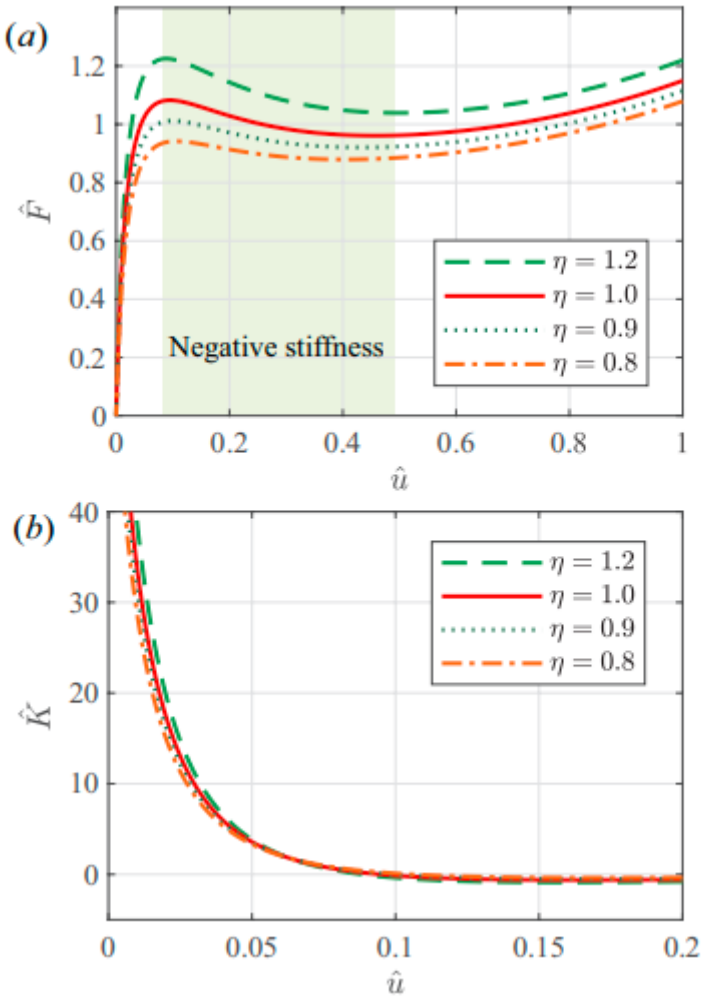


Figure 8

Effect of η on the static characteristics: a non-dimension force; b non-dimension stiffness

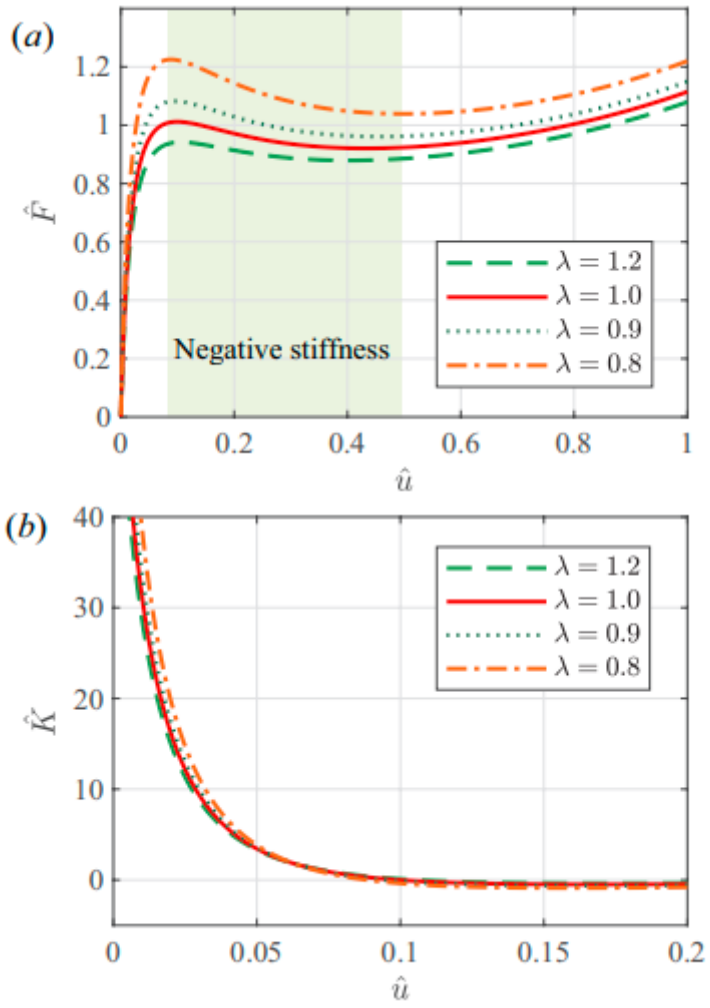


Figure 9

Effect of λ on the static characteristics: a non-dimension force; b non-dimension stiffness

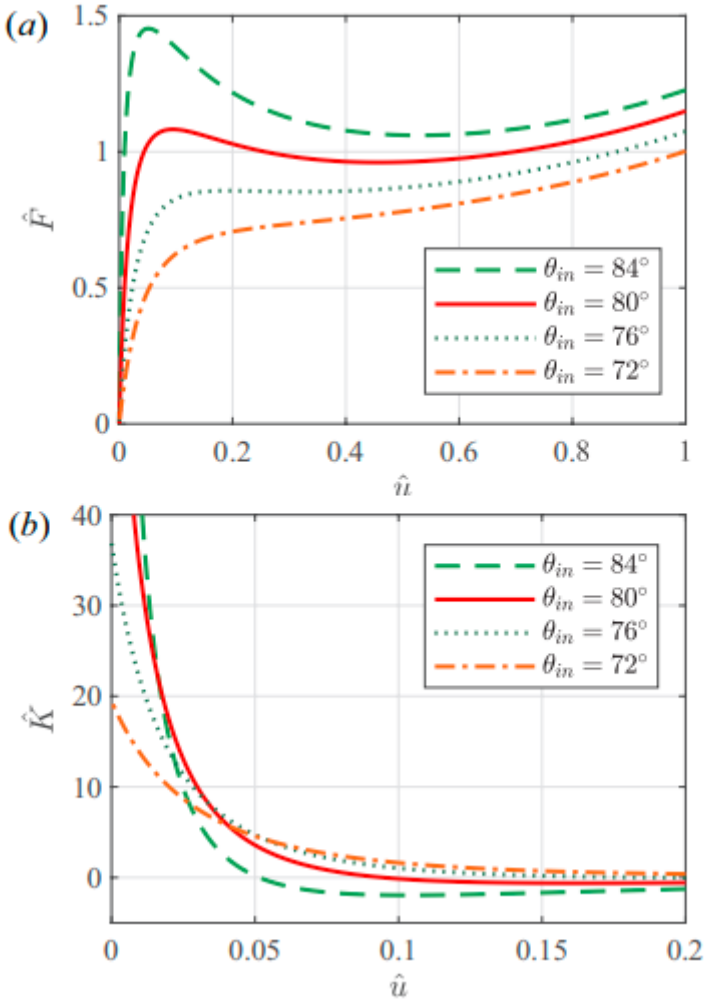


Figure 10

Effect of θin on the static characteristics: a non-dimension force; b non-dimension stiffness

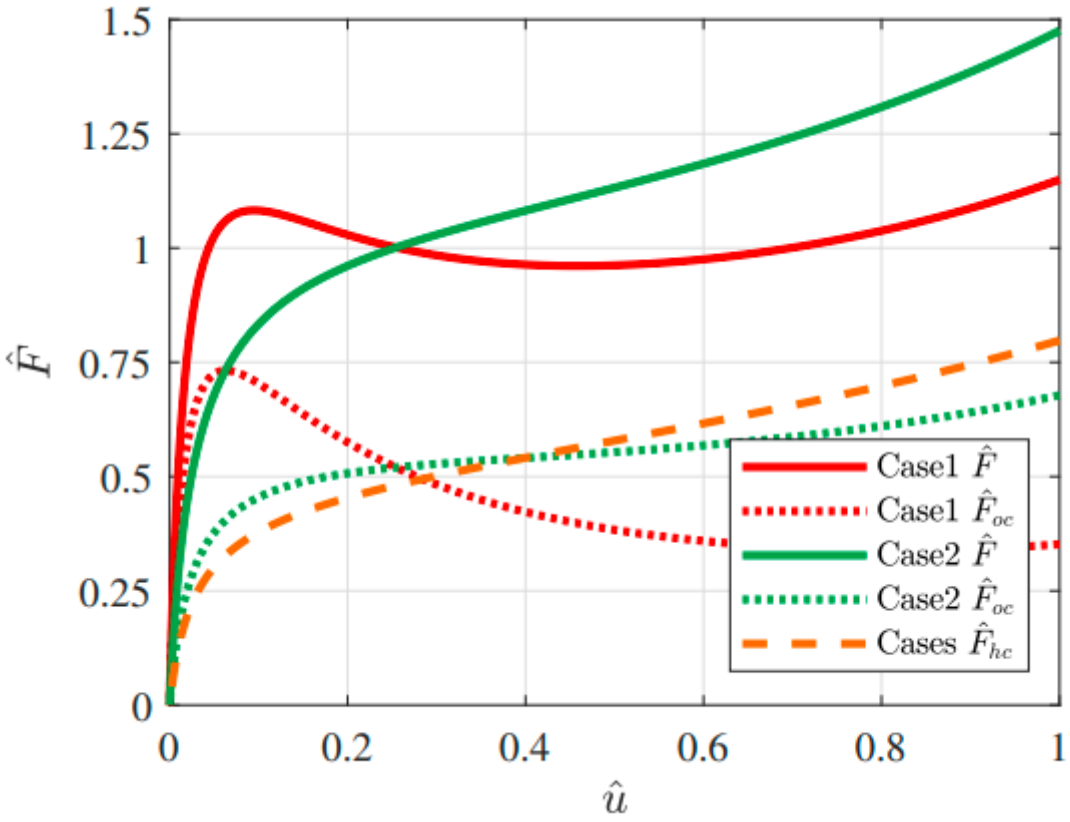


Figure 11

Restoring force decomposition of TMO under two cases

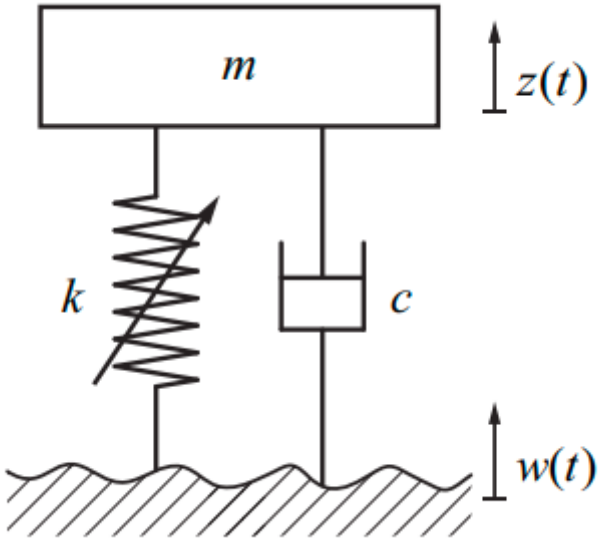


Figure 12

Dynamic model of TMOriVI under base excitation

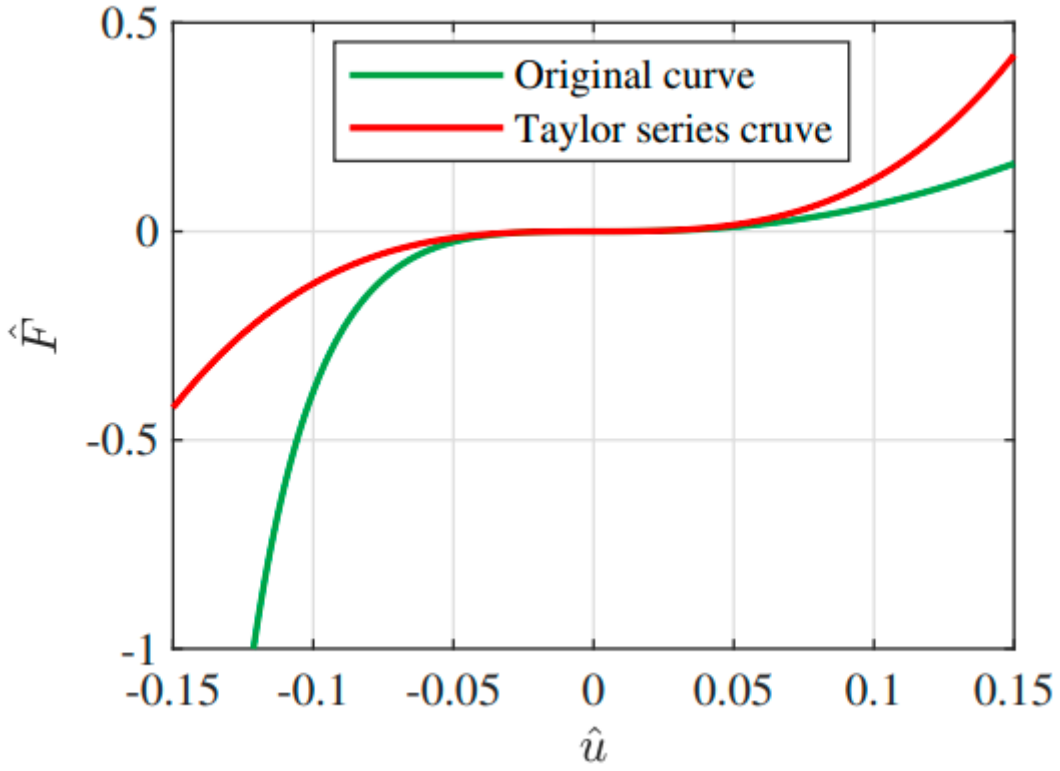


Figure 13

Comparison of restoring forces between original curve and Taylor series curve

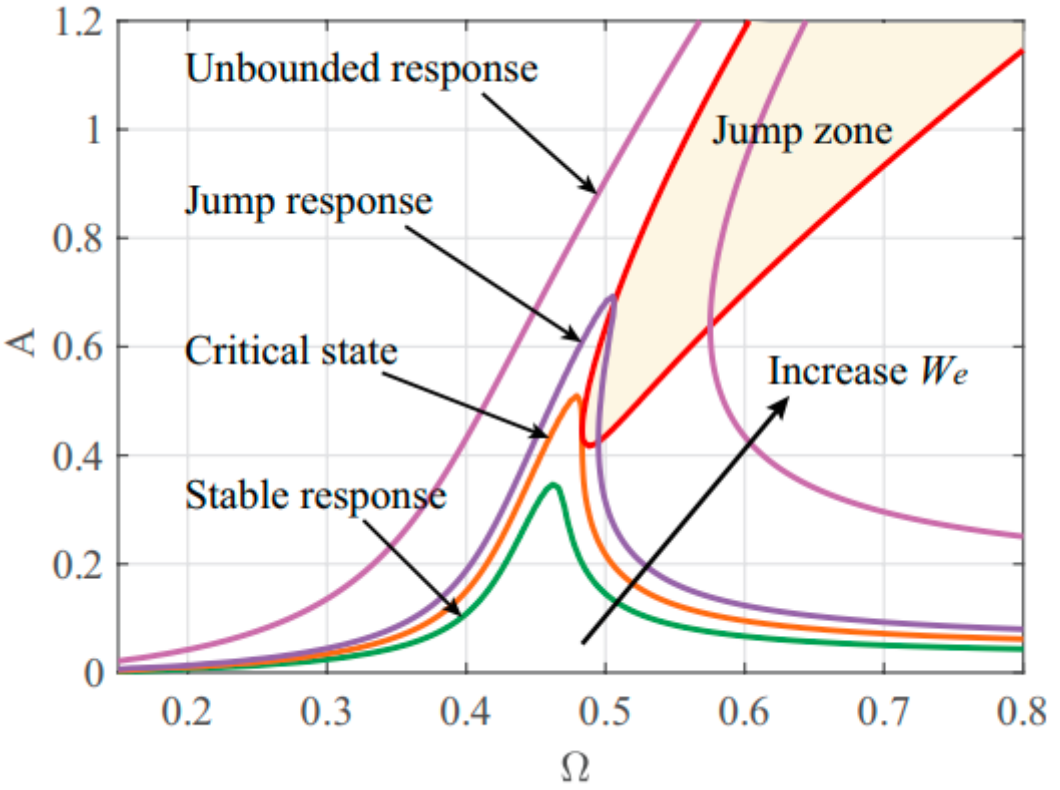


Figure 14

Amplitude-frequency responses with different excitation amplitude

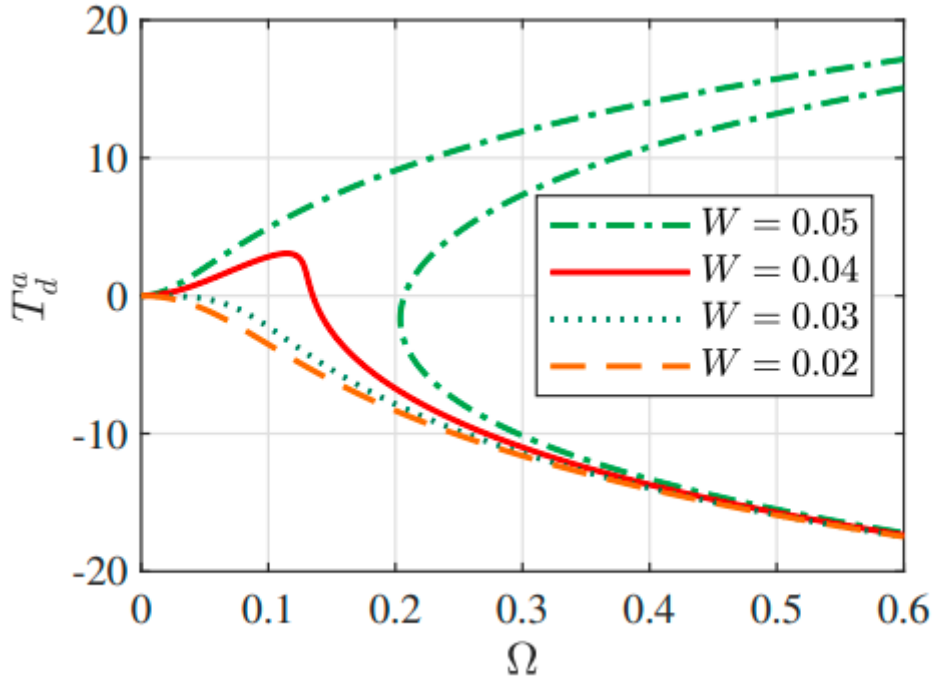


Figure 15

Transmissibility–frequency curves with different values of excitation amplitud

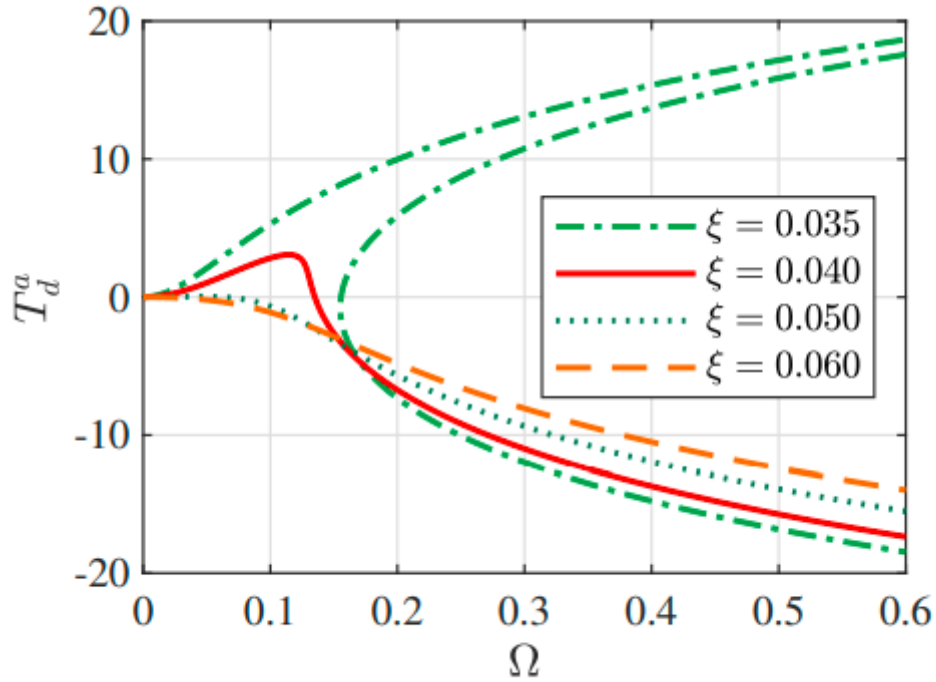


Figure 16

Transmissibility–frequency curves under different damping coefficients

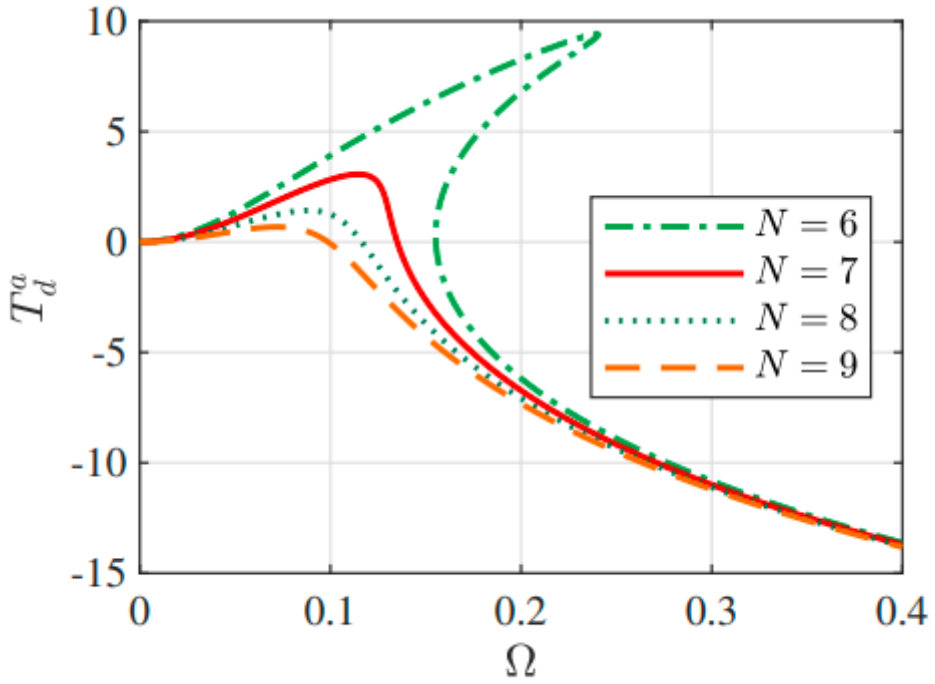


Figure 17

Transmissibility–frequency curves with different values of layers

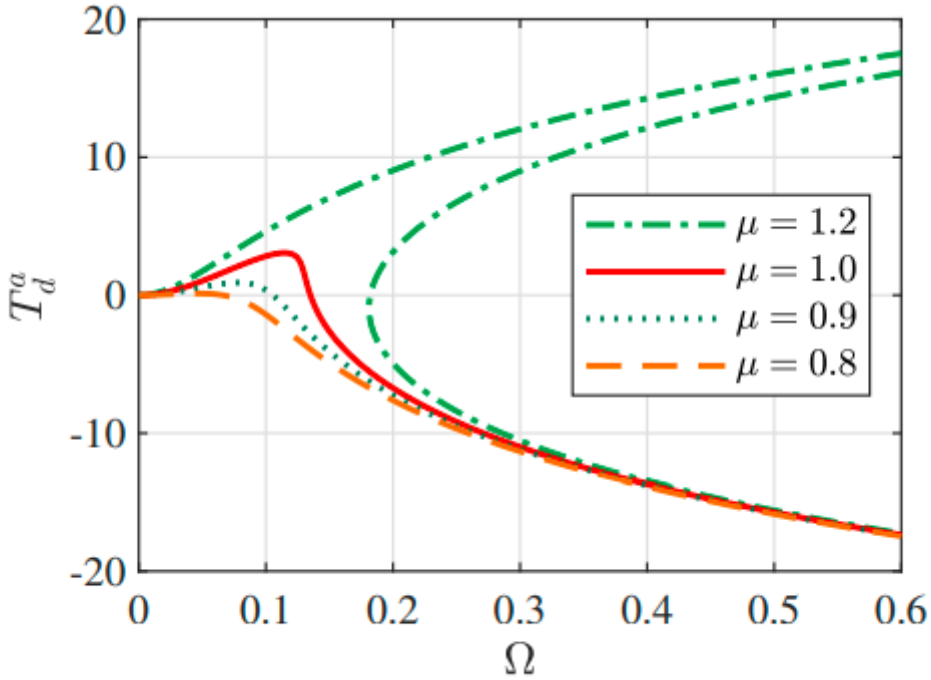


Figure 18

Transmissibility–frequency curves under different μ

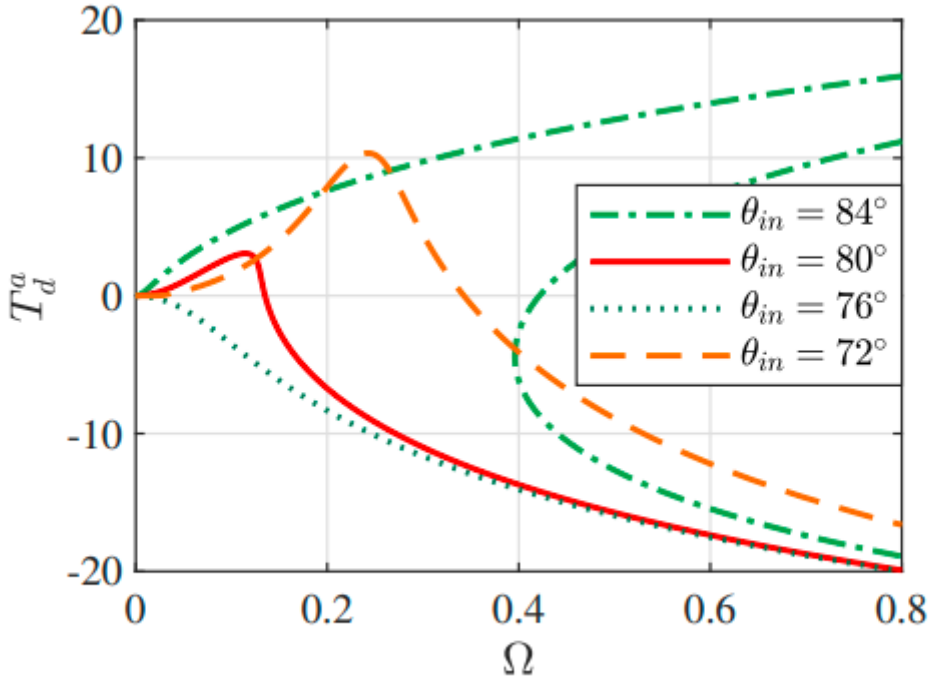


Figure 19

Transmissibility–frequency curves with different values of θin

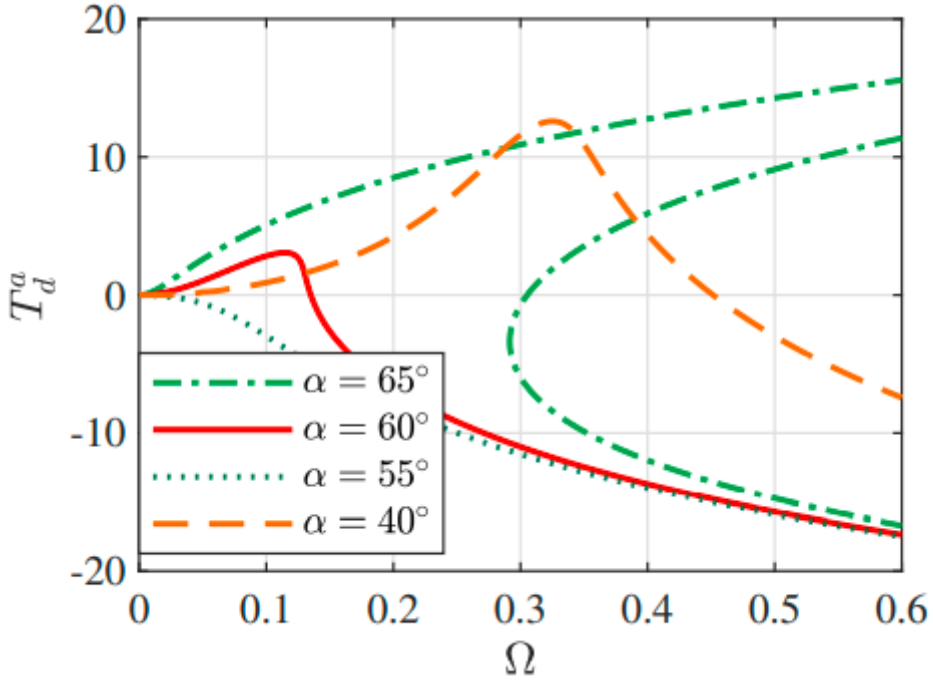


Figure 20

Transmissibility–frequency curves under different α

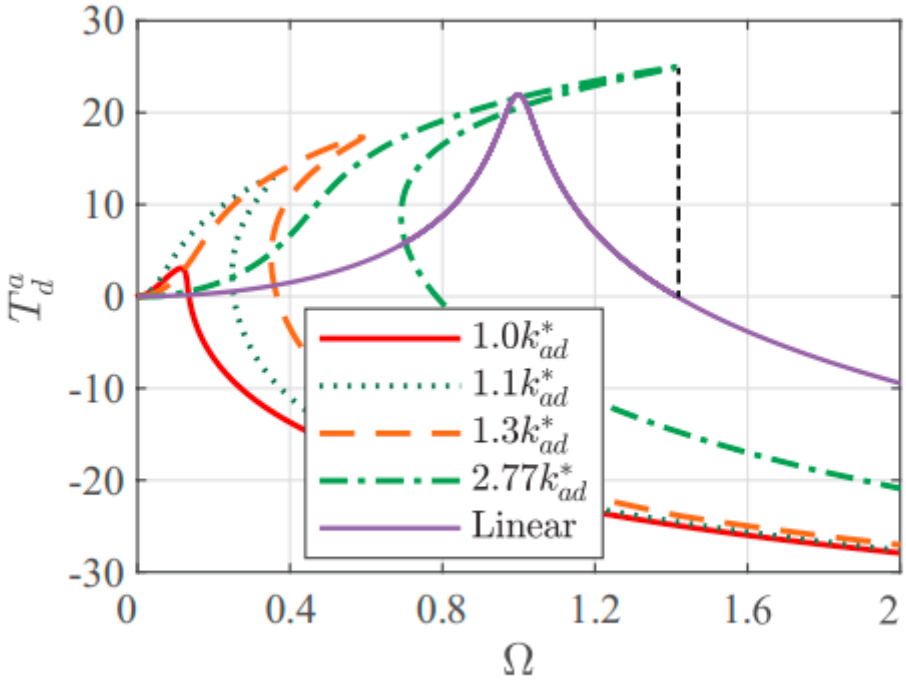


Figure 21

Transmissibility–frequency curves with different values of kad