Pneumatic Artificial Muscle Actuator Under Parametric and Hard Excitations

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Abstract

In this work, a single degree of freedom system consisting of a mass and a Pneumatic Artificial Muscle (PAM) subjected to time varying pressure inside the muscle is considered. The system is subjected to hard excitation and the governing equation of motion is found to be that of a nonlinear forced and parametrically excited system under super- and sub-harmonic resonance conditions. The solution of the nonlinear governing equation of motion is obtained using the method of multiple scales (MMS). The time and frequency response, phase portraits and basin of attraction have been plotted to study the system response along with the stability and bifurcations. Further, the different muscle parameters have been evaluated by performing experiments which are further used for numerically evaluating the system response using the theoretically obtained closed form equations. The responses obtained from the experiments are found to be in good agreement with those obtained from the method of multiple scales. With the help of examples, the procedure to obtain the safe operating range of different system parameters have been illustrated.

Full-text

Due to technical limitations, full-text HTML conversion of this manuscript could not be completed. However, the manuscript can be downloaded and accessed as a PDF.

Figures

Figure 1

(a) System with a mass and a PAM (b) equivalent spring-mass-damper system, (c) free-body diagram

Figure 2

Frequency response at superharmonic resonance condition taking system parameters as Table 1.

Figure 3

Time response and phase portraits corresponding to Fig. 2 at (a, b) point P (c, d) point R.

Figure 4

please see the manuscript file for the full caption

Figure 5

please see the manuscript file for the full caption

Figure 6

Frequency response at subharmonic resonance condition taking system parameters as Table 1.

Figure 7

Time response and phase portraits corresponding to Fig. 6 at (a, b) point C (c, d) point A.

Figure 8

please see the manuscript file for the full caption

Figure 9

please see the manuscript file for the full caption

Figure 10

Quasi-static PAM model identification (a) schematic diagram (b) actual experiment set-up.

Figure 11

Dynamic PAM model identification using forced excitation (a) schematic diagram (b) actual experiment set-up.

Figure 12

please see the manuscript file for the full caption

Figure 13

please see the manuscript file for the full caption

Figure 14

please see the manuscript file for the full caption