Numerical simulations of energy harvesting in a portal frame coupled with a nonlinear energy sink

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Abstract. The present work presents the investigation of energy harvesting in a portal frame coupled with a non-linear electromagnetic energy sink, excited by an unbalanced DC motor. The energy scavenging is performed by two sources: a piezoelectric material and the energy generated by the electromagnetic energy sink. The coupling of the structure with the piezoelectric material and the electromagnetic energy sink resulted in a non-linear electromechanical coupling model. For dynamics, the analysis of the system considers bifurcation diagrams, phase portraits, power spectral densities, and 0-1 test. Numerical simulations show the existence of chaotic behavior for some regions of the parameter space. Additionally, to control the vibration amplitudes of the structure and improve energy production, an adjustment of the parameters of the non-linear electromagnetic energy sink is proposed.

Introduction

The main advantage of nonlinear energy harvesters is the conversion of energy over a wider range of frequencies of vibrations [1-2]. The Fig. 1a illustrates the portal frame coupled with a non-linear electromagnetic energy sink, excited by an unbalanced DC motor, and Fig. 1b illustrates the displacements for Portal frame and NES for Eq. (1).

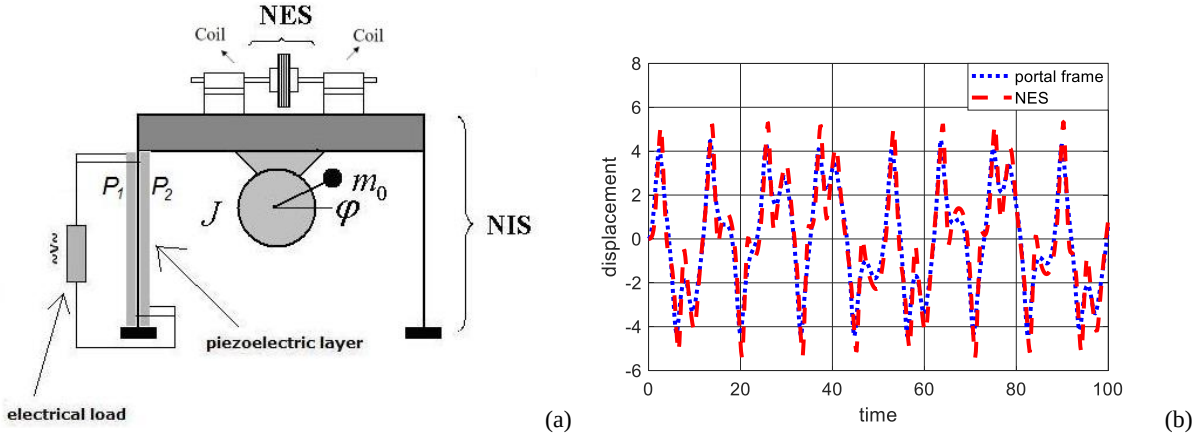

Figure 1: (a) Portal frame energy harvester scheme with nonlinear-energy sink. (b) Portal frame and NES displacements in non-dimensional form.

In Eq. (1) is presented the mathematical model for Fig. 1a in dimensionless form [1-2].

$$
\begin{aligned}
&x''-\beta_1 x+\alpha x'+\alpha_2(x'-z')+\beta_3 x^3+\alpha_3(x-z)^3-\theta(1+\Theta|x|)v=\delta_1\varphi''\sin\varphi+\delta_1\varphi'^2\cos\varphi\\
&z''-\varepsilon_1(x'-z')-\varepsilon_2(x-z)^3=0\\
&\varphi''=\rho_1\cos\varphi x''-\rho_3\varphi'+\rho_2\\
&\rho v'-\theta(1+\Theta|x|)x+v=0\\
&F_e=\psi(x'-z')
\end{aligned}
\qquad (1)
$$

Results and discussion

Numerical simulation results demonstrate a chaotic behavior (test 0-1, k=0.9), for parameters: $\alpha_1=0.1$, $\beta_1=1$, $\beta_3=0.2$ $\delta_1=8.373$, $\rho_1=0.05$, $\rho_2=100$, $\rho_3=200$, $\alpha_2=0.1$, $\alpha_3=0.5$, $\varepsilon_1=1$, $\varepsilon_2=5$, $\theta=0.20$, $\Theta=0.60$, $\rho=1.00$ and $\psi=1.00$. The numerical results showed a powered generation of the 1.0022 units for using PZT, and 0.1243 units, for using of the non-linear electromagnetic energy sink.

References

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