Generalized energy balanced method for a combined nonlinear vibration absorber energy harvester with nonlinear energy sink

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Abstract. Energy harvesting from vibrations for powering low power electronic devices gained attention in recent years. In this work, a combined vibration absorber energy harvester system is investigated. The harmonically excited primary system is attached with a nonlinear energy sink (NES) which consists of a mass, an essentially nonlinear element, and a damper. The energy transfer from the primary system to the NES takes place in an irreversible manner, confined to the NES, and dissipated through the damper which is harvested by using piezoelectric transduction mechanism. A generalized energy balance method is developed to analyse the system to generate the periodic solutions. The periodic solution is continued using a path tracing algorithm and bifurcation points are identified. This methodology will help to optimize the system parameters for efficient vibration absorption and energy harvesting.

Introduction

Multifunctional energy harvesting devices which can achieve one or more than objectives such as vibration absorption combined with energy harvesting or vibration isolation combined with energy harvesting has been investigated in the literature [1,2]. Nonlinear energy sink (NES) is a passive device to achieve irreversible energy transfer. This device with the essential stiffness nonlinearity is found to be effective in attenuating the vibration in practical applications. In this work, a combined vibration absorber energy harvester system with NES as the vibration absorber and an energy harvester with a piezoelectric transduction mechanism is investigated. The model of the system with nondimensional equations of motion is given below.

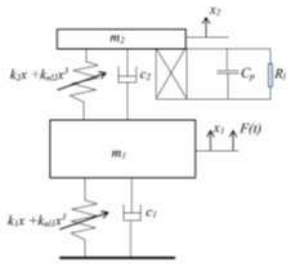

Figure 1: Model of a combined vibration absorber harvester system

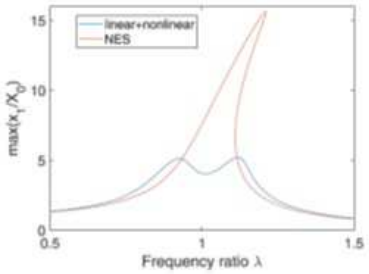

Figure 2: Frequency response

$$x_1'' + \zeta_1 x_1' + \alpha_1 x_1^3 + \zeta_2(x_1' - x_2') + \alpha_2(x_1 - x_2)^3 = X_0 \cos \lambda\tau \tag{1}$$

$$\mu x_2'' - \zeta_2(x_1' - x_2') - \alpha_2(x_1 - x_2)^3 - \chi v = 0 \tag{2}$$

$$v' + \epsilon v + \kappa x_2' = 0 \tag{3}$$

In this work, the dynamics of the system is investigated using a generalized energy balance method [3] which is an efficient method to generate the periodic solutions of strongly nonlinear systems. Preliminary study conducted on the same system with a harmonic balance method and the frequency response plots are generated with the help of a continuation algorithm which is shown in Fig.2. The study provide more insight into the combined vibration absorption energy harvesting and also provide a platform to develop optimized solutions for multi functional energy harvesting systems.

References

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