Harvesting energy from 2D-array of harvesters

Mohammad Reyaz Ahmad Vali[*] and Ali Shaikh Faruque [*]

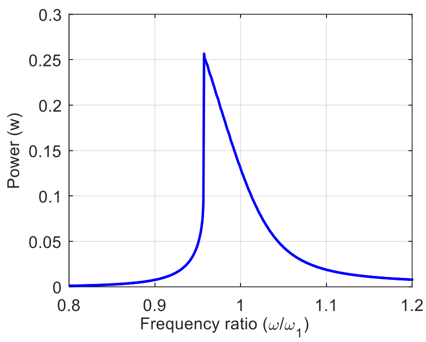
[*]*Department of Applied Mechanics, Indian Institute of Technology-Madras (IIT-M), Chennai, India*

Abstract. Energy harvesting from coupled 2D-array of pendulums subjected to harmonic base excitation is studied in this work. Numerical technique is developed to obtain the system response. Broadband energy harvesting is investigated for the system. Bandwidth of operating frequency of harvesters for various levels of mistuning and for different positioning of mistuning in the harvester set is studied. Optimal bandwidth and power from these sets are obtained.

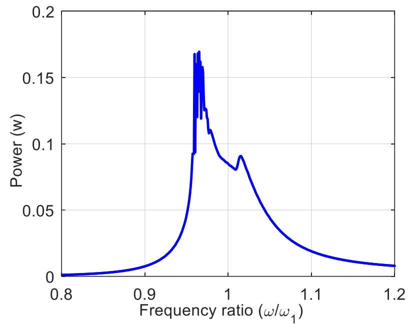
Introduction

The dream of smart facilities across the world with information at everyone hand requires sensing all around. This requires millions of sensors to be employed measuring different sets of data. Running of these sensors requires electrical power. Thousands of wireless sensors are used for structural health monitoring, environmental control, military applications, etc. Powering them using batteries poses challenges in replacement, maintenance and disposal. This can be overcome by directly powering them by ambient sources of energy. Vibrational energy from ambient sources is tapped to convert it into electrical energy by means of electromagnetic, electrostatic and piezoelectric transduction [1]. In this study electromagnetic principle is used to tap the ambient energy by means of 2D-array of interconnected pendulums [2]. Magnets are attached at end of pendulums and magnetic coil placed just below each of them serves the purpose of harvesting energy. The magnetic interaction among the neighbouring pendulums are assumed to be small and are therefore neglected. Equations of motion are obtained from Lagrange's method and voltage generated in each harvester is calculated by voltage equation for the coil. Numerical solution of this system is obtained which provides time histories of displacement and velocity of harvesters. Mistuning of pendulum lengths is introduced to study the broadband harvesting characteristics of system [3]. Operating bandwidth of frequency is analysed for different set of values of mistuned lengths for 10 x 10 array for relatively optimal harvesting characteristics.

Frequency response of total power obtained



(a)



(b)

Figure 1: (a) PowerFRF of tuned 10 x10 harvester array (b) PowerFRF for one set of mistuned 10 x 10 harvester array.

This 2D-array of pendulums are connected by springs in longitudinal direction and torsional springs in lateral direction. In the Fig.1(a), tuned harvester set is shown which gives the maximum peak power among all the harvester sets. In Fig.1(b), mistuned harvester set with 2% of mistuning done to 55,56, 65 and 66 positions of 10 x 10 array is considered. It can be seen that multiple peaks are obtained due to mistuning effect. Various values of mistuning and for different positions in the array is studied for obtaining the operating range of frequencies. For each set of harvesters, excitation frequency (ω) is swept and RMS amplitude of total power obtained for that particular frequency is plotted to obtain the frequency response function (FRF) for power. The peaks obtained for mistuned sets play crucial role in deciding bandwidth and so is the mistuning. The power FRFs for different sets of harvesters are explored to obtain relatively optimal bandwidth for the operating power.

References

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