DEPARTMENT OF CIVIL ENGINEERING
IIT DELHI

VIRTUAL SMART STRUCTURES AND DYNAMICS LAB

EXPERIMENT 2

IDENTIFICATION OF HIGH FREQUENCY MODES OF BEAM IN "FREE-FREE" CONDITIONS USING ELECTRO-MECHANICAL IMPEDANCE (EMI) TECHNIQUE

OBJECTIVES

This experiment aims to identify the high frequency modes of an aluminium beam in "free-free" conditions, which otherwise cannot be captured by the usual vibration techniques, using the electro-mechanical impedance (EMI) technique. To learn more about the EMI technique, click (http://strlab.iitd.ac.in/SSDL/piezo.pdf).

EXPERIMENTAL METHODOLOGY

This experimental setup is an shown in Fig. 1. It consists of an aluminium beam of dimensions 299x18.2x2.15mm with a pair PZT sensor bonded on the two edges at the mid point. "Free-free" conditions are ensured by hanging the beam vertically through cello tape, whose flexibility ensure "free-free" conditions. The two PZT patches are connected with each other such that the positive electrode of one patch joins the positive electrode of the other, so that they are excited in phase when an alternating voltage is applied across the combination. The wires from the combination are connected to Agilent E4980 LCR meter which is in turn connected to the LAN port and thus accessible to the user through the World Wide Web. Hence, only axial vibrations are induced and flexural vibrations are ruled out.

The user may acquire the plots of conductance (*G*) and susceptance (*B*) against frequency using the LCR meter. The VEE PRO based interactive dialog box available in the main page of the experiment (http://strlab.iitd.ac.in/SSDL/exp2.html) can be used for this purpose. A frequency range of 100 kHz to 110 kHz at an interval of 100 Hz is recommended. The dialog box stores frequency, G and B in the computer of the user. Plots are also available in the VEE PRO dialog box.

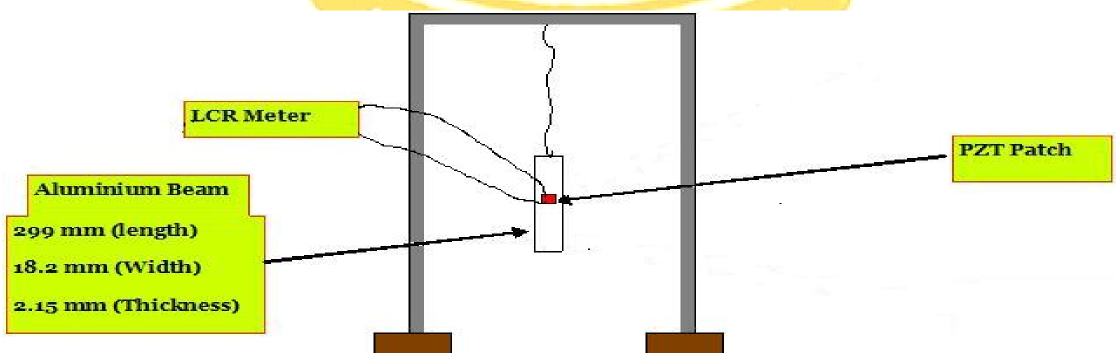

Fig. 1 Experimental set up.

The user may plot G vs frequency in excel. The peak in the plot is the resonance frequency of the beam. Following plot is expected if the experiment is correctly performed.

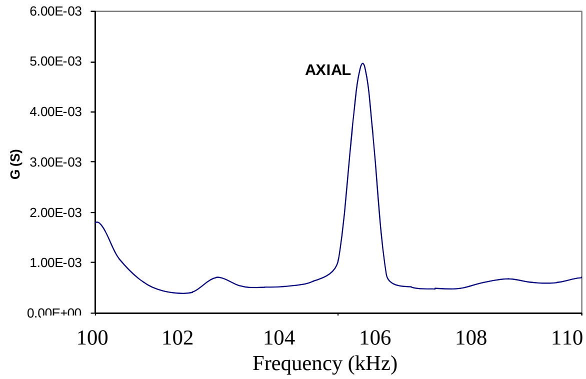

Fig. 2 Expected plot of G vs frequency.

From the frequency plot, the user can identify the natural frequency of the beam as the frequency corresponding to which peak voltage response is observed. The user may compare the frequency obtained through this experiment with the theoretical frequency given below (Paz, 2004).

$$f_n = \frac{2n-1}{4L_{half}}\sqrt{\frac{E}{\rho}} \qquad (1)$$

where E denotes the Young's modulus of elasticity of the beam, ρ the material density and L_{half} the half length of the beam. The user may compute the first ten frequencies by substituting n = 1, 2,..., 10 and conclude as to which frequency is identified.

REFERENCES

Chopra, A. (2001), Dynamics of Structures, Prentice Hall of India limited, New Delhi.

Paz, M. (2004), Structural Dynamics: Theory and Computations, 2nd ed., CBS Publishers and Distributors, New Delhi.

Bhalla, S. and Soh C. K. (2004), "High Frequency Piezoelectric Signatures for Diagnosis of Seismic/ Blast Induced Structural Damages", NDT &E International, Vol. 37, No. 1 (January), pp. 23-33.

Literature on piezoelectric sensors: http://strlab.iitd.ac.in/SSDL/piezo.pdf