DEPARTMENT OF CIVIL ENGINEERING

IIT DELHI

VIRTUAL SMART STRUCTURES AND DYNAMICS LAB

EXPERIMENT 3 (SIMULATION)

Damage Detection and Qualitative Quantification Using Electro-Mechanical Impedance (EMI) Technique

OBJECTIVES

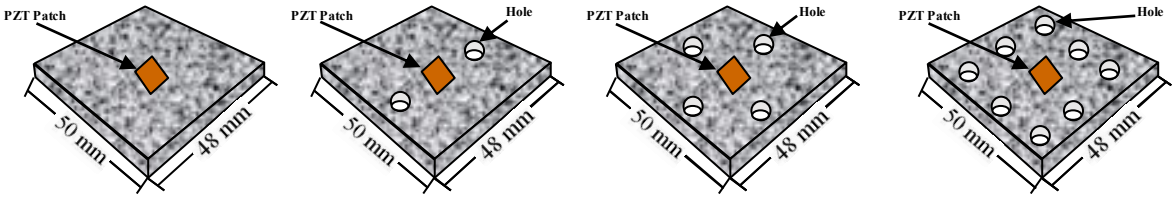
This experiment aims to teach the user, through a database of measured data, how occurrence of damage in a structure changes the conductance signature (EMI technique). The test structure is an aluminium block (50 x 48 x 10 mm), having a surface bonded PZT patch (see Fig. 1a). To learn more about the EMI technique, click (http://ssdl.iitd.ac.in/vssdl/piezo.pdf).

EXPERIMENTAL METHODOLOGY

In this experiment, user gets an option of drilling multiple holes of 5 mm diameter in the host structure (aluminium block) to induce damage of three different severities in virtual mode:

1. Incipient Damage : 2 Holes (see Fig. 1b)
2. Moderate Damage : 4 Holes (see Fig. 1c)
3. Severe Damage : 8 Holes (see Fig. 1d)

The three damages are illustrated in Fig. 1



Pristine damage (a) | Incipient damage 2 holes (b) | Moderate damage 4 holes (c) | Severe damage 8 holes (d)

Fig.1: Illustration of various stages of damage.

User has the facility to acquire signature of the structure in pristine as well as the three damaged conditions. The signature acquisition is simulated to occur in same fashion as in the case of real experiment performed through LCR meter. User can acquire the signatures in this fashion for any damaged state and can download the signature as delimited data file. The data file for any condition has three columns: frequency

(kHz), conductance (S) and susceptance (S). The user can compare the signature of any two stages for example: pristine and incipient damage, pristine and moderate damage and pristine and severe damage. Alternatively, the user can plot the signatures of all the four states in a single graph and make observation as to how the signatures change with increase of damage severity.

To statistically quantify damage, compute root mean square deviation (RMSD) in conductance by following equation directly in MS excel:

$$RMSD(\%) = \sqrt{\frac{\sum_{i=1}^{n}(G_i^1 - G_i^0)^2}{\sum_{i=1}^{n}(G_i^0)^2}} \times 100 \qquad (1)$$

Where

G_i^0 = Baseline conductance value at i^{th} frequency.

G_i^1 = Conductance value after damage at i^{th} frequency.

n = No. of frequency data points

As an exercise plot a histogram of RMSD for the various damaged states. Note your observations and draw conclusions.

REFERENCES

1. Bhalla, S. and Soh C. K. (2004),"Structural Health Monitoring by Piezo-Impedance Transducers. Part II Applications", Journal of Aerospace Engineering, ASCE Vol. 17, No.4 (October), pp. 166-175.

2. Literature on piezoelectric sensors: http://ssdl.iitd.ac.in/vssdl/piezo.pdf

3. Literature on Smart Materials: http://ssdl.iitd.ac.in/vssdl/smart.pdf

4. Bhalla, S. (2004),"A mechanical Impedance Approach for Structural Identification, Health Monitoring and Non-Destructive Evaluation Using Piezo-Impedance Transducers", Ph. D. Thesis, School of