Low frequency and boundary condition effects on impedance based damage identification

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Details of the investigations on the application of Electro Mechanical Impedance (EMI) technique using smart piezoelectric (PZT) sensors for damage detection of structures are presented in this paper. The behavior and the ability of this method to detect damages, in a homogenous material are studied for its effective utilization in structural health monitoring. Experimental investigations are conducted on a homogenous aluminium plate bonded with PZT patches to study the effects of external low frequency vibrations (mass loading) and boundary condition on EMI signatures and the observations are discussed using RMSD as damage index computed between pristine and damaged states. Effect of low frequency vibration on the resulting EMI signature and the corresponding RMSD is found to be less than 2%. This is the threshold upper control value (UCL) beyond which the change in RMSD shall truly reflect the damage.

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1. Introduction

Civil engineering infrastructure is one of the most expensive national investments and assets of any country as it facilitates country's economic development. Hence it is important to continuously maintain and monitor the strength and serviceability condition of a building for effective load transmission. Presence of damages like cracks has to be identified and quantified in order to assess the condition of a structure. In recent years, the structures are monitored using “smart” materials using specialized algorithms and techniques. The piezoelectric sensors (PZT) is one of such smart sensing technologies that can be used for condition monitoring of any structure. PZTs are capable of acting as both sensor and actuator. When a PZT patch attached to a structure is driven by a fixed, alternating electric field of high frequency, a small deformation is produced in the PZT patch and the attached structure. The response of this mechanical vibration is transferred back to the PZT patch in the form of an electrical response. When a crack or damage causes change of the mechanical dynamic response, it is manifested in the electrical impedance response of the PZT patch. This Electro Mechanical Impedance (EMI) technique is now very widely accepted as a cost effective and highly sensitive technique for SHM and non-destructive evaluation (NDE) of a variety of engineering systems \cite{1}. The structural element to be monitored is instrumented with a PZT patch on the surface, and is excited through an alternating voltage signal using an impedance analyzer/LCR meter, sweeping through a particular frequency range (of the order of tens to hundreds of kHz). At any particular frequency, the patch

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