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One-dimensional Parametric Study of Damage Detection in a Solid Material using a Nonlinear Wave Modulation Spectroscopy (NWMS) Technique.

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Abstract: Nonlinear Wave Modulation Spectroscopy (NWMS) is one of the most powerful techniques used to detect damage in materials. It consists in simultaneously applying two continuous waves with different frequencies, the one high, f2, and the other low, f1. When the material is damaged, the frequency spectrum exhibits harmonics and sidebands which are located at (f2 + f1) and (f2 - f1). This paper presents a parametric simulation study of the nonlinear propagation of elastic waves in solid media, which can be represented by a one dimensional mass-spring system. The system of motion equations is resolved by a fourth order Runge-Kutta iterative method. A quadratic nonlinearity can be introduced locally in the system at any spring. The objective of the paper is to highlight the ability of the nonlinear acoustic methods, especially the NWMS (Nonlinear Wave Modulation Spectroscopy), to detect damages in solid material. The study of the evolution of the sidebands amplitude, according to the low frequency of the wave (pump wave), f1, in cracked and intact material will be presented. It is shown that this amplitude reaches a maximum when the pump frequency corresponds to a resonance frequency of the system. In addition, the study shows the strong dependency of the resulting frequency spectrum of the received signal upon the nonlinearity magnitude as well as the rigidity of the simulating crack spring.

Keywords : Nonlinear Modulation Spectroscopy, Damage detection, nonlinear wave propagation simulation