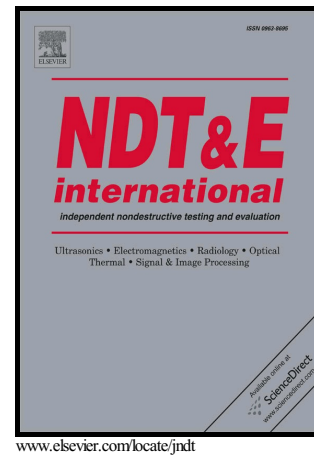


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# Ultrasonic imaging of nonlinear scatterers buried in a medium

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## Abstract

In this paper, an ultrasonic technique for imaging nonlinear scatterers, such as cracks, buried in a medium is proposed. The method called amplitude modulation consists of a sequence of three acquisitions for each line of the image. The first acquisition is obtained by transmitting with all elements of the phased array. Next the second and third acquisitions are obtained by transmitting with odd elements only and even elements only, respectively. An image revealing nonlinear scattering from the medium is reconstructed line by line by subtracting the responses measured with second and third acquisitions (odd elements and even elements) from the response obtained with all elements transmitting. The method was implemented on three different conventional multi-channel electronic platforms equipped with different ultrasonic probes (center frequency 3MHz to 5MHz, 64 or 128 elements). A crack (6mm-deep x 24mm-long) in a stainless steel block was investigated. With all probes and multi-channel electronic platforms, higher detection specificity of the crack was obtained with amplitude modulation compared with conventional ultrasound imaging. Image contrast (ratio between crack response amplitude over background amplitude) was increased by 5dB with amplitude modulation compared with conventional ultrasound imaging.

**Keywords:** ultrasonic imaging; amplitude modulation; phased array; nonlinear scatterers;

## 1. Introduction

Fast and reliable detection and sizing of cracks is of interest, in particular for hazard monitoring of civil engineering constructions (e.g. dam, bridge, oil pipelines), or for non-destructive testing (NDT) of metallic structures (e.g. railway tracks) and composite structures (e.g. wings of aircrafts). It is well established that cracks produces nonlinear (or wave-amplitude dependent) acoustic scattering. Numerous nonlinear ultrasonic techniques [1–3] have been proposed to detect nonlinear scattering the last couple of decades. Most of them give access to a single nonlinear parameter for the whole

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