Ultrasonic Colinear and Vibroacoustic Modulation Shear Wave Mixing for Structural Damage Detection

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The presented paper is an experimental study of Vibro-Acoustic Modulation (VAM), and colinear ultrasonic wave mixing using Shear-Horizontal waves (SH) as nonlinear ultrasonic techniques for detecting and localizing damage in metallic structures. The work uses a setup of copper beams containing various crack depths excited by paired piezoelectric actuators: a high-frequency (HF) ultrasonic carrier and a low-frequency (LF) excitation tone. Signals are generated digitally and amplified; in-plane wave motion perpendicular to the beam length to observe modulation effects.

The experiment compares modulation signatures at multiple HF/LF combinations along a sample's length: before, and after a crack at a specific location.

Signal processing focuses on modulation sidebands. For VAM, the expected sideband location is at HF ± n·LF, where n is a sideband modulation harmonic. In collinear mixing, the modulations at HF ± LF are examined. Metrics that are compared are defined by modulation and sidebands amplitude between samples, sideband orders obtained, and a comparison of the damage index.

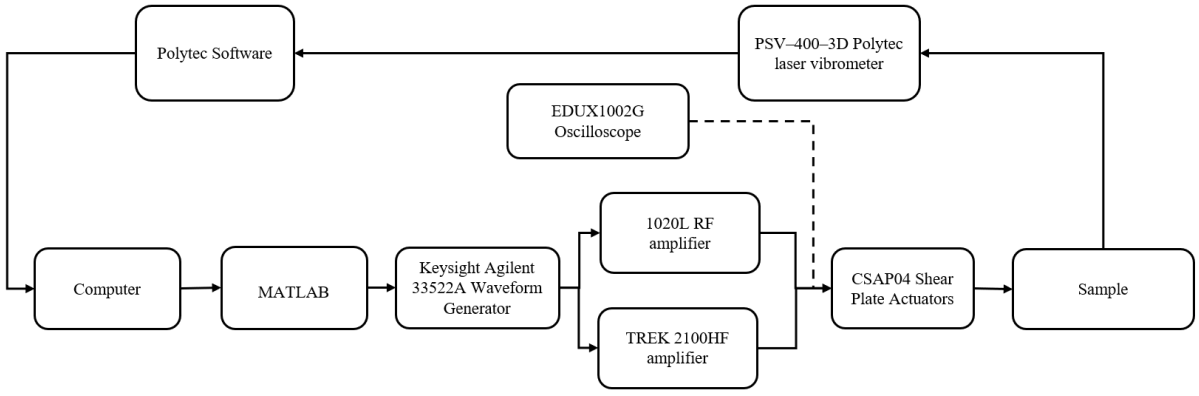

Figure 1. Scheme of experimental setup

From existing literature and theory, it is anticipated that both methods will generate modulation sidebands when nonlinear contact or stiffness changes are present, and that these sidebands will provide localization of damage (increased modulation amplitude near the crack). The paper aims to experimentally expand and verify the behaviour of SH waves in non-destructive structural health monitoring using nonlinear ultrasonic indicators.