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Time Series Analysis of Distorted Vibratory Signals

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Nonlinear processes persist not only in the changing Earth systems, which are the geoscientist's target for observation, but also in our measuring methods. To study the inner structure of the Earth by means of seismic acquisition techniques the most widely used artificial signal source is the vibrator. The vibrator mechanics and the near-surface material coupled together act as a complex system, which distorts the theoretical signal to be emitted. This system has nonlinear effects degrading the temporal and spatial resolution. To achieve improvement in the vibratory seismic techniques the true source signal has to be known and used in the signal processing. It is accepted currently, that the far field signal of a vibrator is proportional to the time derivative of the ground force signal. An approximation to it is the weighted sum of the baseplate and the reaction mass accelerations. Unfortunately this ground force signal cannot describe accurately the upper harmonics in the distorted source function.

The measured geophone signals are giving better information on the source function as presented in this paper. The time-frequency behavior of the geophone signals is analyzed by wavelet transformation to separate their harmonic components. The basic wavelet could be a chirp wavelet mimicking the theoretical sweep of the vibrator. As a result better resolution and noise sensitivity are achieved in the analysis technique. With the help of the vibratory source signal analysis, an estimation method is developed, which is based on the combination of different data. As a result the total distorted energy can be used as useful signal in data processing. The combined information is coming from the measured vibratory accelerations and the relative amplitude and phase data calculated from geophone signals. In case of vibratory source it makes a new ground force signal estimate, which can describe properly even the distorted nature of the signal output caused by nonlinear dynamic effects.

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