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A Technique for the Analysis of Transient Seismic Signals

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Abstract

An analytical method, called the "multiple filter technique," is shown to be a fast and efficient means of studying multi-mode dispersed signals. Amplitudes and phases, as functions of period and velocity, are determined from the output of a set of narrow-band digital filters. The group velocities and other dispersion parameters determined by this technique are concordant with theoretical values when the method is tested with synthetic seismograms. It can recover broader portions of the dispersion present in ordinary seismic recordings compared to the classical peak and trough method. A simple diagnostic diagram is introduced in order to study the time and frequency resolution permitted by this analytic technique.

I. Introduction

The "multiple filter technique" is shown to be a fast, efficient method of analyzing multiply dispersed signals. The amplitudes and phases of signals passed by an array of narrow-band filters can be used to measure group velocity, relative excitation and transmission as functions of period and velocity, lateral refraction, modal vibrations of the surface, and other dispersion parameters associated with a variety of modes recorded by a single station for one event.

This technique can recover broader portions of the dispersion present in ordinary recordings, compared to the classical peak and trough method. This latter method often fails when the signal-to-noise ratio decays or when the signal is contaminated by other arrivals. Similar difficulties have been noted when the phase delay calculated by ordinary Fourier analysis has been differentiated in order to obtain the group velocity.

Digital methods have been used previously in dispersion studies, such as the investigation by Alexander (1963), who used frequency and velocity windows to isolate portions of the observed modes. Archambeau, Flinn and Lambert (1966) also used digital filters in a search for dispersion in body wave arrivals.

Recently, Landisman, Dziewonski and Satô (1969, which will be referred to as "Paper I" hereafter) developed an automated process called "moving window analysis", which produces a display of amplitudes and/or phases as functions of period and group velocity. These results were calculated by Fourier analysis of suitably windowed portions of the seismogram. Results produced by the multiple filter technique often show greater frequency resolution, when compared with those calculated by the moving window process. The present technique does not have the intrinsic period shift noted for the earlier method, and the results are obtained with a much smaller expenditure of computer time (Section II).

The dispersion parameters inferred from multiple filter analysis can be tested, using specially prepared synthetic seismograms. The measured results compare favorably with the theoretical values (Section III). A simple diagnostic diagram is introduced which may be used to study the results produced by the multiple filter technique for dispersion curves of various types. An analysis of the time and frequency resolution

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