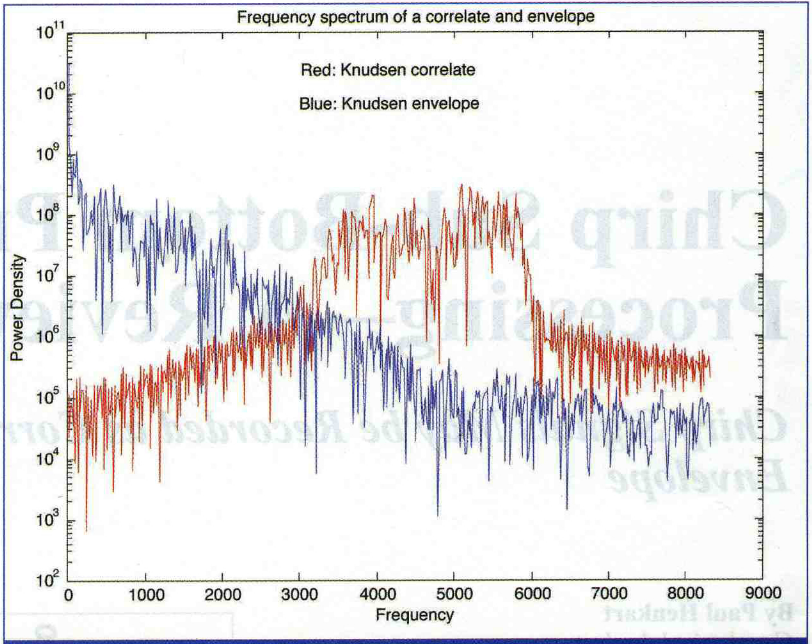

A comparison of the frequency domain of the correlate and envelope signals.

Generally, the chirp signal takes the following path or steps: it is generated by the transducer, it reflects back off of some object, it is received by the transducer, it is digitized and processed, and it is written to some storage medium and displayed.

The gain, or signal power, may be adjusted at the transducer during send and receive stages, as well as during the processing stage, usually just prior to display. The transmit/receive gain adjustments are independent of each other, but are a constant shift in power. All signal amplitudes are adjusted by the same amount. The gain adjustment during processing may vary with two-way travel time, and usually start from a selected water bottom time (i.e., they are "hung" from the seafloor). Time varying gain (TVG) is inadequate when the water bottom can not be picked, so automatic gain control may be an option.

In principle, the chirp signal is the same as the seismic industry's Vibroseis sweep signal. Most introductory courses in geophysics, *Seismic Data Analysis* by Oz Yilmaz and *Encyclopedic Dictionary* by Robert E. Sheriff cover the convolutional theory of acoustic signals traveling through the Earth and Vibroseis processing.

The first sweep signal processing step is to deconvolve, correlate or match filter the transmitted signal with the received signal. This way, the long outgoing sweep signal is compressed and the resulting signal is similar to the conventional seismic signal. The correlation step is best left to the manufacturer's recording device, since it requires knowledge of the exact outgoing signal.

The marine sub-bottom profiler is different from the land Vibroseis system in that Vibroseis sweeps are much lower in frequency (often less than 100 hertz), while the marine chirp systems are more than several kilohertz. The marine chirp systems use additional signal processing techniques to lower the frequency content so that the signals can be displayed the particular manner the seismic user is accustomed to seeing them.

The next processing step is to divide the correlated signal (the correlate) into two parts. The first part is untouched and the second one is phase shifted by 90º. The phase-shifted signal is called the Hilbert transform, or quadrature.

The untouched signal and the Hilbert transform are then merged into a new single signal to form the analytic, or complex signal. The analytic signal resembles a complex number in that each sample has two computer words, similar to a complex number. The real part of each sample is the original signal, and the imaginary part of each sample is the corresponding Hilbert transform. The analytic signal has twice the number of computer words, or bytes, as the correlate because each sample has two words: the real and the imaginary.

The complex modulus (square root of the sum of squares of the real and imaginary) of each sample is formed from the analytic signal and becomes the envelope, or instantaneous amplitude. The envelope contains only positive numbers, and no longer has any phase information, but it is much lower in frequency and can be displayed as the geologist/geophysicist is accustomed to. The envelope is the same length and has the same sample interval as the correlate.

What to Record

Sub-bottom profilers offer digital output in addition to a real-time display of the envelope data. The digital output is often formatted similar to the Society of Exploration Geophysicist (SEG)-Y standard. But, the output may be from any of the intermediary processing steps. The SEG-Y file may contain one of the following signals: the raw