anti-alias filter rolloff. The best available analog low-pass filters have a rolloff zone that extends about 30% beyond the frequency at which they begin to attenuate the signal. This is the reason digital signal analyzers that use anti-alias filters (as all should) sample at about 1.3X the Nyquist rate. They then "throw away" (i.e., don't display) the frequency band that was affected by filter rolloff.

Note that when using the "do-it-yourself" approach to digital signal processing of sticking an inexpensive analog-to-digital (A/D) board in a PC and hooking up a transducer or two, you typically will have no anti-alias protection unless you supply it externally. Some higher-end A/D boards are now available with on-board anti-alias filters. Without them, you are taking a risk that your data may be corrupted by aliasing.

Spectrum Analysis

While it is instructive to look at your measured data in the time domain, often more can be learned about the system's dynamic behavior by transforming the time data to the frequency domain. Fourier published the mathematics for the series and transform that bear his name in 1822.

The Fourier Series provides a means to break down any periodic function into an infinite series of sine and cosine terms

$$y(t) = \frac{a_0}{2} + \sum_{n=1}^{\infty}\left[a_n \cos(2\pi n f_0 t) + b_n \sin(2\pi n f_0 t)\right] \tag{16.1}$$

Each succeeding pair of sine and cosine terms has a frequency that is an integer multiple of the first, or fundamental, frequency. These terms are called the harmonics of the function. The original function can be approximated by summing a finite number of these terms as was shown in Figures 3-19 through 3-21 (pp. 54-55). For a periodic (i.e., repeating) function, continuous in the time domain, such as a cam-follower acceleration function, the Fourier series can be used to find its discrete set of harmonics in the frequency domain.

Figure 16-8 shows such a function, simplified to contain only two harmonics. Note that the time and frequency domains are nothing more than alternate ways to view the same data. Theoretically, converting a function from the time domain to the frequency domain or vice-versa does not alter the function. Of course, summing of a finite number of terms of an infinite series leaves out the effects of the excluded terms. Also, numeric roundoff errors will always take a small toll.

The Fourier Transform or Fourier integral, provides a means to transform continuous, nonperiodic functions from the time to the frequency domain.

$$H(f) = \int_{-\infty}^{\infty} h(t) e^{-j2\pi f t}\, dt \tag{16.2}$$

The inverse Fourier transform allows conversion in the opposite direction.