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CONSEQUENCES OF OVERSAMPLING

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Oversampling is generally perceived as an inefficient practice because of the redundancy it creates in the data, but rarely is it considered detrimental. The resulting increase in bandwidth seldom if ever, provides new information, as the signal is often badly attenuated and not very useful above a certain frequency. The decision to oversample is often based on the assumption that no undue harm will result from sampling more frequently.

The problem arises when oversampling is performed on the output of a digital-to-analog (D/A) converter, where the signal is maintained at a constant voltage level (equal to the last reading) between successive samples of the original signal. This is tantamount to repeating each reading *n* times in the interval between samples (see Figure 1), where *n* (an integer) is the factor by which the sampling rate is increased. Clearly, the variance of the time series is unaffected by this oversampling. In a spectral plot it means the area under the curve remains the same but is redistributed to cover the added bandwidth, a process that is almost the reverse of aliasing.

A case in point is the Applied Technologies' (ATI) sonic anemometer output, which is updated every 0.1 s. in addition to providing serial digital readings representing wind measurements every 0.1 s, the manufacturer offers D/A outputs of the same readings, designed primarily for monitoring purposes. Many investigators not only treat the latter as their primary signal source, but sample them at rates which are multiples of 10 Hz, sometimes even at rates arbitrarily chosen to suit the requirements of other sensors in the field. In some cases, the investigators have noted a sharper than expected drop in spectral response at the high-frequency end, without knowing what caused it.

To test the effect of oversampling on atmospheric spectra, we selected an 819.2-s time series of vertical velocity (w) from an ATI sonic anemometer, mounted at 22 m, and sampled at their standard 10-Hz rate. We then simulated 20-Hz and 40-Hz oversampling by repeating each data point two and four times, respectively. The spectra computed for the three time series are shown superimposed in Figure 2. No corrections were made for distortions introduced by the spatial and digital smoothing of the signals, nor for aliasing due to discrete sampling. It should be noted, however, that the departure from the -2/3 slope observed in the 10-Hz spectrum follows the form predicted for the cumulative effect of all the distortions encountered. (See the graphical analysis of those errors presented in Application Note No. 1.)

The only significant difference is in the spectral shape at frequencies above 1 Hz. The spectrum drops more and more sharply with increased oversampling. As a result, the spectrum takes on an f^{-1} slope in the 1-5 Hz range. Looking from an entirely different perspective, one can see that the normal and two-times-oversampled spectra are really aliased versions of the four-times-oversampled spectrum.

Our recommendation to ATI sonic anemometer users who sample the analog signals instead of the digital outputs is to keep the sampling rate strictly at 10 Hz or multiples of 10 Hz. In the latter case, it is possible to retrieve the 10-Hz time series by simply picking every n^{th} data point. This would preserve the integrity of measurements and provide spectra that can be properly corrected for the filtering and the aliasing inherent in measurements from this sonic anemometer.

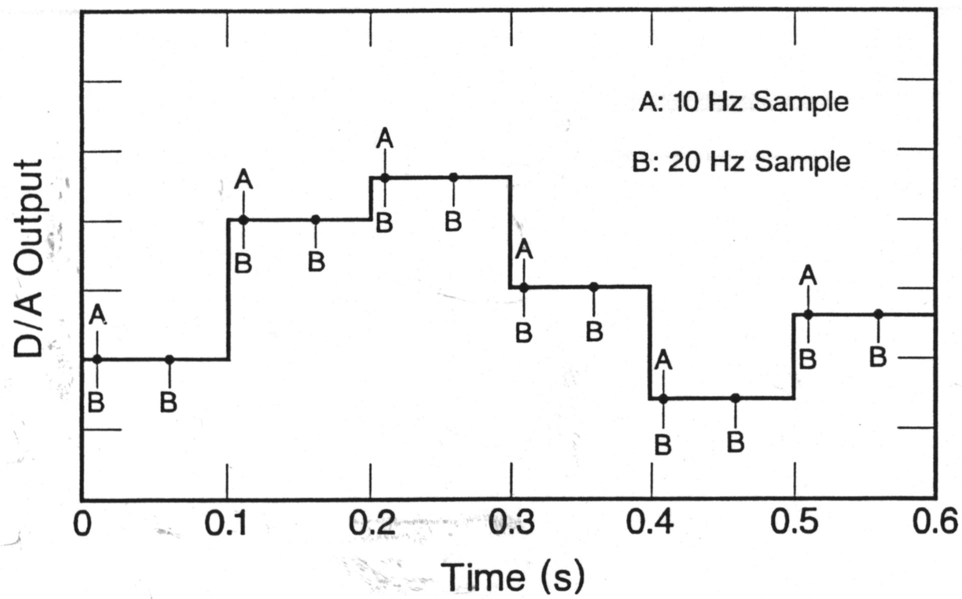

Figure 1. Effects of sampling ATI's digital-to-analog output more frequently than the prescribed 10 Hz rate.

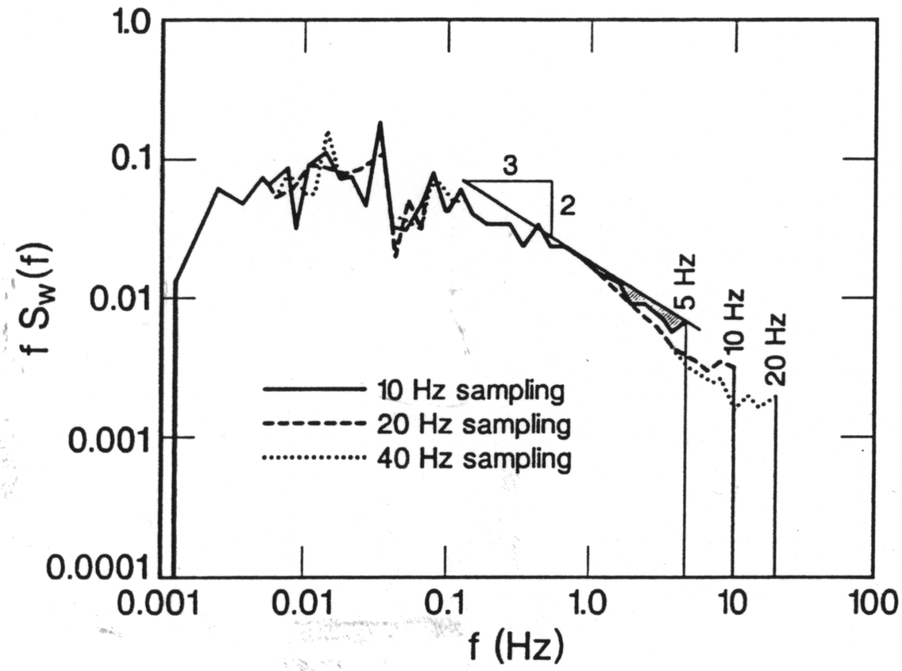

Figure 2. Consequences of two and four times oversampling of ATI's digital-to-analog output on the measured *w* spectrum.