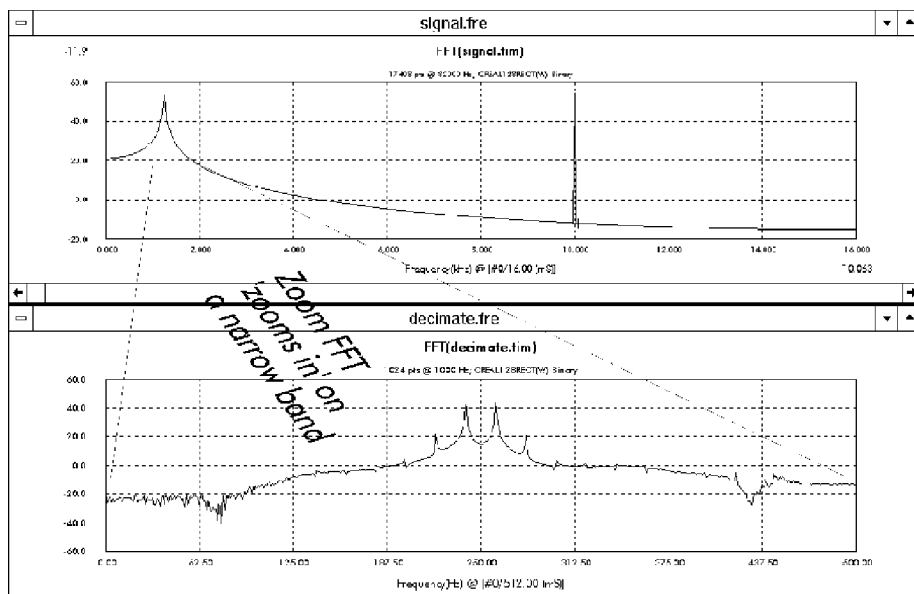
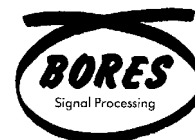


The 'zoom' FFT



The 'zoom' FFT is a useful technique for 'zooming in' on a narrow frequency band in spectral analysis.

The frequency resolution of an FFT is determined only by the total length of time spanned by the samples - regardless of the sample rate.

At high sample rates, a large number of samples have to be taken to span a given time and achieve a given resolution. So for high resolution with high sample rate, where only a narrow band is of interest, FFT sizes are inconveniently large and wasteful. Actually for practical implementation on real DSP hardware, very large FFT sizes may simply be impossible.

The 'zoom' FFT uses a reduction of sample rate to make a limited number of samples span a longer time: hence increasing the frequency resolution of the FFT. The technique is closely related to multirate filtering (and in fact is the same as Single Sideband Modulation).

You can experiment with zoom FFT techniques using **DSPworks** and **QEDesign**.

A simple example shows how the zoom FFT technique can be implemented. In the example spectrum, only two closely spaced signals are of interest: these are tones at 1.24 kHz and 1.26 kHz.

Unfortunately the 10 kHz tone defines the bandwidth of the signal and hence forces a minimum sample rate: in this example, 32 kHz. The FFT size is 1024 points.

With the 1024 point FFT of the full frequency range the frequency band of interest is squashed into a few points of the spectrum, and in fact the resolution is poor enough that the two signals are not resolved.

To implement the zoom FFT, I filter the signal to leave only a narrow band about the frequencies of interest: in this case a bandpass filter 400 Hz wide, centred on 1.25 kHz.

Then I reduce the sample rate by a factor of 32, to 1 kHz, giving me a 500 Hz FFT bandwidth. The tones are now nicely resolved, only the band of interest is shown, and I have not had to calculate a huge FFT.

This is undersampling, and at first sight violates sampling theory. But sampling theory only says we have to sample faster than twice the signal bandwidth: not the highest frequency.

The undersampling results in aliasing so that lots of signal frequency bands, each 500 Hz wide, get reflected back upon each other to form the resulting spectrum.

Because the filter cut out all except the frequencies we want, this does not matter: but aliasing will have an effect because some frequency bands will be back to front, and still occurs if the signal crosses the band edges.

Also, note that I was careful in this example to filter so that the frequencies that remain all lie within one of the 500 Hz bands. This conveniently avoids aliasing due to the signal crossing the 500 Hz band edges. This was possible in an example where I chose the parameters, and it helps to keep things simple: but in practical situations things will not usually work out so conveniently.

It should be easy to see that we could always modulate the signal: multiplying it by a complex exponential to bring the band we want down to baseband. Then we could still apply the zoom FFT technique, with this one additional step.

It should also be obvious that there are similarities of technique between the zoom FFT and multirate filtering.

Actually, there are a lot of things to bear in mind when using this technique: but this simple example does at least show that there is no magic to it, and perhaps indicates some of its potential.