Real-Time Bandwidth and Overlap Processing

Spectrum Analysis is a very broad topic. In this article we intend to address real-time bandwidth and overlap processing.

Since everyone knows what we mean with the expression "real-time", we are not going to spend too much time on this subject. However, we'd like to define what "real-time" means in connection with doing FFT spectrum analysis.

Real-Time Bandwidth

The correct term is "Real-Time Bandwidth" and it defines the highest frequency at which we can calculate a spectrum without missing any data. This frequency is determined by the processing speed of our DSP processor, i.e. the time it takes to calculate the FFT and whatever other functions are requested.

As shown in Figure 1, if frequencies higher than the real-time bandwidth are present and processed, there will be gaps in the data acquired while the DSP processor is doing its calculations. This is hardly a problem if the data is stationary, i.e. periodic: no vital information is lost, since the signal repeats itself in the subsequent cycle. On the other hand, if the signal is a short-duration, one-time transient, the possibility exists that it cannot be analyzed.

High processing speed is also important in other cases, such as when input signal parameters are changing rapidly; it's also important when we want to perform averaging, especially with a large number of averages. Conversely, when analyzing data whose bandwidth is less than the real-time bandwidth, we might consider doing something while the DSP processor is waiting for the data block to be collected. We can perform what is called Overlap Processing.

Overlap Processing

Assume we are collecting and analyzing 10 kHz data with 25.6 kHz sampling frequency, and we wish to calculate a 1k FFT. The data collection time (also known as Time Window) for collecting 1024 time samples is exactly 40 msec. If the FFT processor calculates and displays a spectrum in 10 msec, then it will sit and wait for 30 msec until the acquisition of the next block is completed.

Once the first block is collected, rather than waiting for the next block to be fully collected, we can proceed to calculate a new spectrum by using part of the data from the new block and part of the data from the old block. If the data is stationary, there is no reason why we cannot 'mix' data from the two blocks.

With the values given above, we could initiate a new FFT calculation by using 75% of the previous block and 25% of the latest one. We would then be performing what is called 75% overlap processing and our apparent processing time (after the first block) would be 10 msec per spectrum, rather than 40 msec.

Where this process becomes even more significant is when we are operating at very low frequencies, i.e. below 1 kHz, when we want to calculate large transforms, i.e. greater than 1k, or when we want to calculate many spectra in order to do averaging. For example, let's assume we are operating in a 100 Hz frequency range and wish to calculate 16 averages. The data collection time is 4 sec and, without overlap processing, we need 64 sec. With 75% overlap, we need 4 sec for the first block and 1 sec for each successive one, or 4x1 + 1x15 = 19 sec to perform the same task. ❑

Figure 1. Data collection and Real-Time bandwidth. The FFT processor waits for the completion of data collection in (A). In (B), data gaps are produced. Data acquisition at the real-time bandwidth is shown in (C).