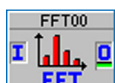


TECHTIP 41001

DASYLab® FFT analysis module basics

INTRODUCTION



DASYLab® provides the Fast Fourier Transform (FFT) module to allow a user to analyze time-based data in the frequency domain. The documentation that is provided in the DASYLab User's Manual provides information on the mechanics involved in setting up this module, but it does not provide details on how to set up an experiment that utilizes the FFT module effectively. This document should be considered a supplement to the User's Manual. Its scope is limited to the version of the module that provides a "Real FFT of a Real Signal." The reader can find additional information on this subject in the references provided at the end of this tech tip.

The FFT module is available in DASYLab/Standard, DASYLab/FULL and DASYLab/PRO versions and can be selected under the "Signal Analysis" module group.

DISCUSSION

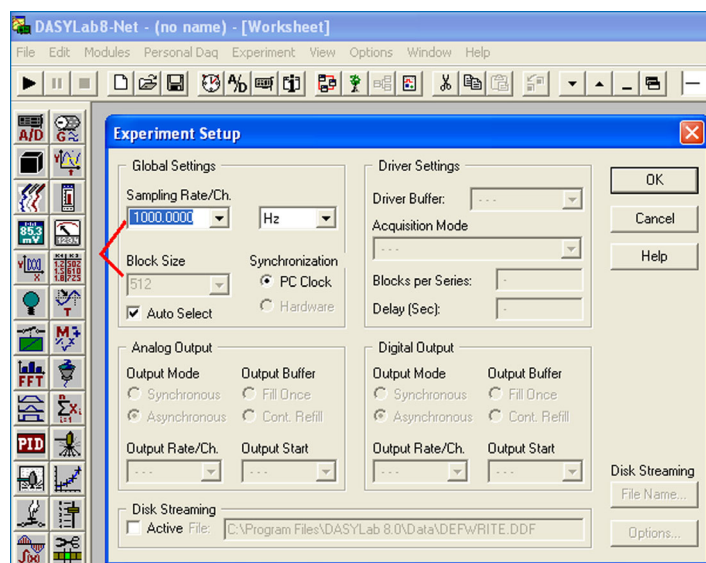
Selecting the Experiment Sample Rate

To use the FFT module effectively, the user must have some idea of the range of frequencies contained in the time domain signal being measured. This range is usually defined as 0 Hz to the highest frequency of interest (call this frequency FH). If the data acquisition system includes a good low-pass filter that limits the range of frequencies that can be measured, the cutoff frequency of this filter can be used as a good estimate of FH. Otherwise, the user should take advantage of his or her knowledge of the physical process being measured to estimate FH.

The experiment sample rate (let's call it FS) should be selected to be at least 4 to 10 times FH. High speed data acquisition systems such as IOtech's Wavebook or Daqbook systems allow for large channel systems to be configured with exceptionally high sample rates to provide sufficient over-sampling in most applications. The minimum theoretical sampling rate (called the Nyquist rate) needed to produce valid FFT data is $2 * FH$. However, since FH is usually an estimate rather than a hard and fast number, most experts recommend a much higher rate than

Nyquist to make sure that a phenomenon called *aliasing* does not occur.

Selecting the frequency of sampling, FS, determines the maximum frequency component that will be calculated by the DASYLab FFT algorithm. This maximum frequency component is equal to $FS/2$. So if the sampling rate is 100 kHz, the maximum frequency component calculated and shown on the Y/T chart by the FFT module is 50 kHz.

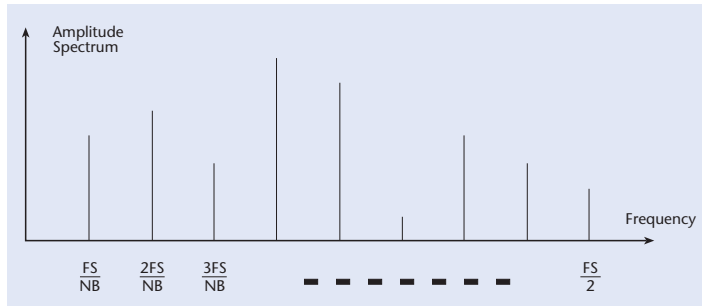


Experiment **Sample Rate** and **Block Size** are configured under the "Experiment Setup" pull down menu screen

Selecting the Block Size for the FFT

The FFT algorithm in DASYLab operates on a finite number of samples of the time signal being measured. This is the block size, which we will designate as NB. For the FFT algorithm used by DASYLab to function properly, NB must be equal to a power of 2. The block size determines the *resolution* of the frequency spectrum generated by the FFT algorithm. The higher the block size, the

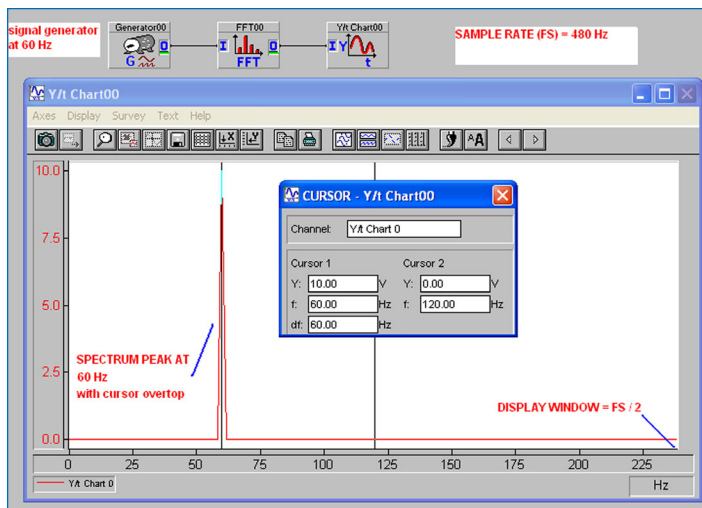
higher the resolution of the frequency spectrum. The lowest frequency in the spectrum is then equal to (FS/NB) , and all other frequencies in the spectrum are integer multiples of that frequency. The resulting frequency spectrum (actually the “Amplitude Spectrum” in DASyLab) produced by the FFT algorithm looks like the following graphic.



FS = Sample Rate
NB = Block Size

Note that in the case of the “Amplitude Spectrum,” there are a total of $NB/2$ lines or frequency components. The user sets the sampling rate and the block size in DASyLab using the Experiment Setup option in the Experiment pull-down menu.

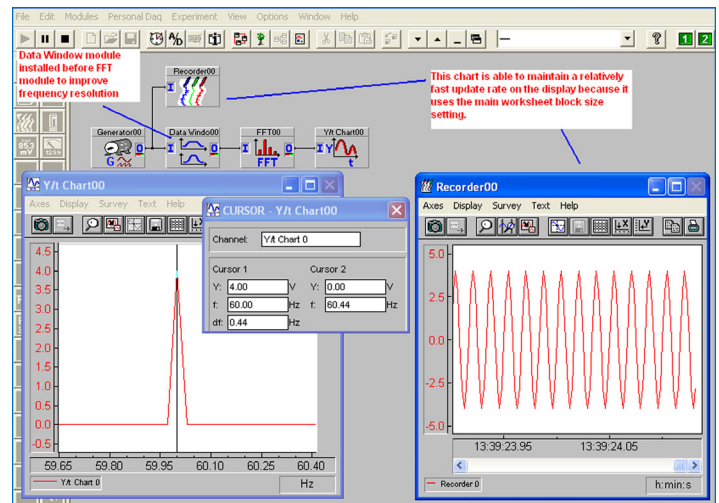
Note that the shape of the amplitude spectrum for a particular time function will depend to some extent on the sampling rate and block size selected. If there is a frequency component in the time function that is at or near one of the frequencies calculated by the FFT, the spectrum will display a sharp peak at that frequency. Otherwise, the peak may be “spread” over two or more frequencies surrounding the correct frequency.



A simple FFT demonstration using the built in DASyLab signal generator module. The Y/T chart is always used to display the output of the FFT module.

Using the Data Window module to improve frequency resolution

The Data Window module prepares data for further analysis, especially by an FFT module. It does so by changing the block size so that an FFT module following it can be provided with appropriate block sizes (in powers of two). The Data Window module also represents a buffer that can store blocks or parts of blocks. The output block size is independent of the input block size and equal to the defined vector size, which is configured in the setup screen of the Data Window module. This allows larger pieces of data to be sent through the FFT algorithm as a block, which improves spectral resolution. The “Vector Length” is effectively the block size that leaves the Data Window module and is received by the FFT module. You can then divide the Vector Length into the sample rate to determine the frequency resolution of the spectrum. The predefined Vector Lengths that are visible in the pull down window should be selected when using this module with an FFT because they have been pre-selected as powers of two. The maximum Vector Length that can be selected is 32768. This allows you to increase the resolution of the FFT analysis while keeping the overall worksheet block size lower. This provides a fast real-time response from other operations and displays in the worksheet.



The same FFT worksheet with a **DATA WINDOW** module installed before the FFT module. The Recorder module operates using the main worksheet block size while the FFT operates using a block size dictated by the **vector length** setting located in the Data Window module.

CONCLUSION

Useful References

1. *Signal Conditioning and PC-based Data Acquisition Handbook*, ISBN 0-9656789-3-8, IOtech, Inc., 2004.
2. *The Fundamentals of Signal Analysis*, Application Note 243, pub. no. 5952-8898E, Hewlett-Packard, Inc., January 1995.
3. Hoffman, Forrest, *An Introduction to Fourier Theory*, available on the Internet at the following URL:
<http://aurora.phys.utk.edu/~forrest/papers/fourier/index.html>