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#AS122 - Power Spectrum Analysis

AcqKnowledge can be used to obtain the power spectrum of any time domain waveform. The power spectrum indicates the power of each frequency component of the source time domain waveform. The power spectrum can be used to analyze a variety of physiological signals. The ECG (rate) and EEG signals are often categorized using spectral analysis.

This application note intends to show how to relate power in the time domain to power in the frequency domain using very simple signals in hopes of clarifying the explanation. The FFT in *AcqKnowledge* allows frequency representation using linear or logarithmic scaling. All discussions and analyses for this paper are done using linear scaling.

The power spectrum (PS) is defined as the square of the linear spectrum magnitude:

$$PS = (Mag)^2$$

To relate the power in the time domain to power in the frequency domain you will need to multiply the INTEGRAL number for frequency window measurements by the following formula:

$$\int |f(t)|^2 dt = [N_T \cdot N_F / (\Delta F)^2] \cdot \int |F(f)|^2 df$$

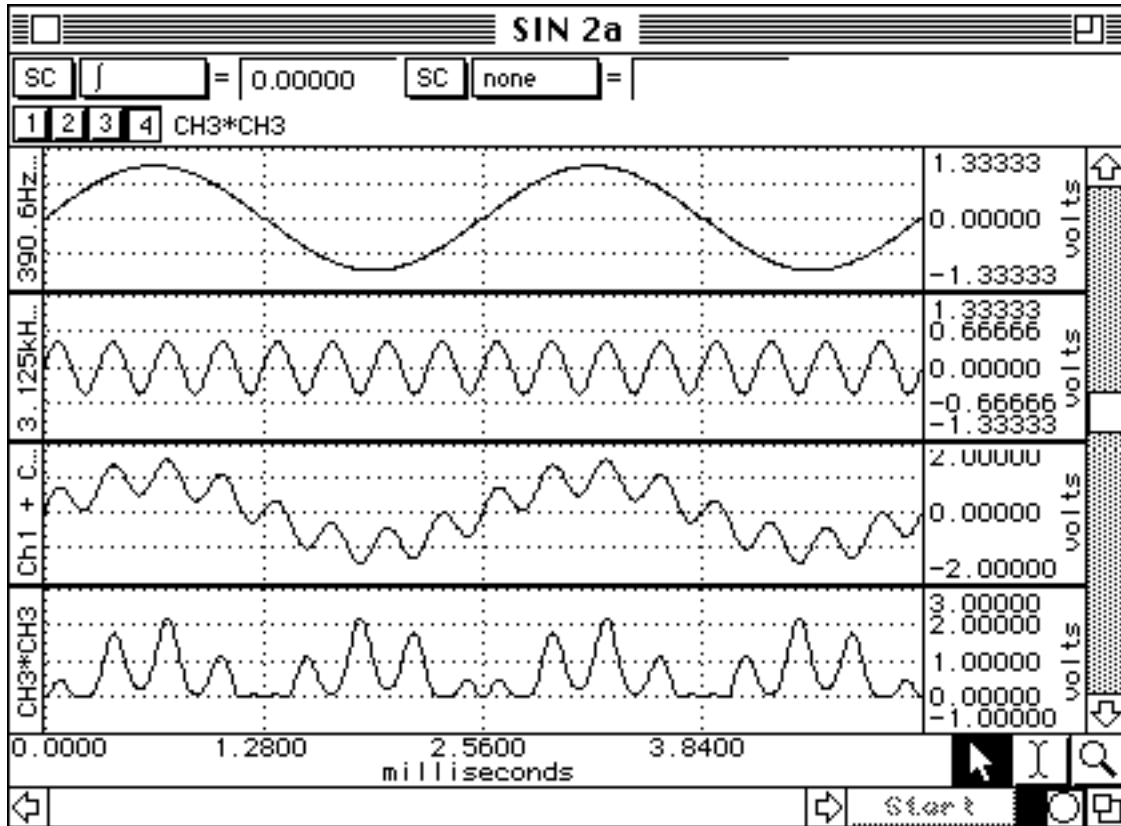
Where:

N_T = Number of Samples selected in Time Domain for FFT

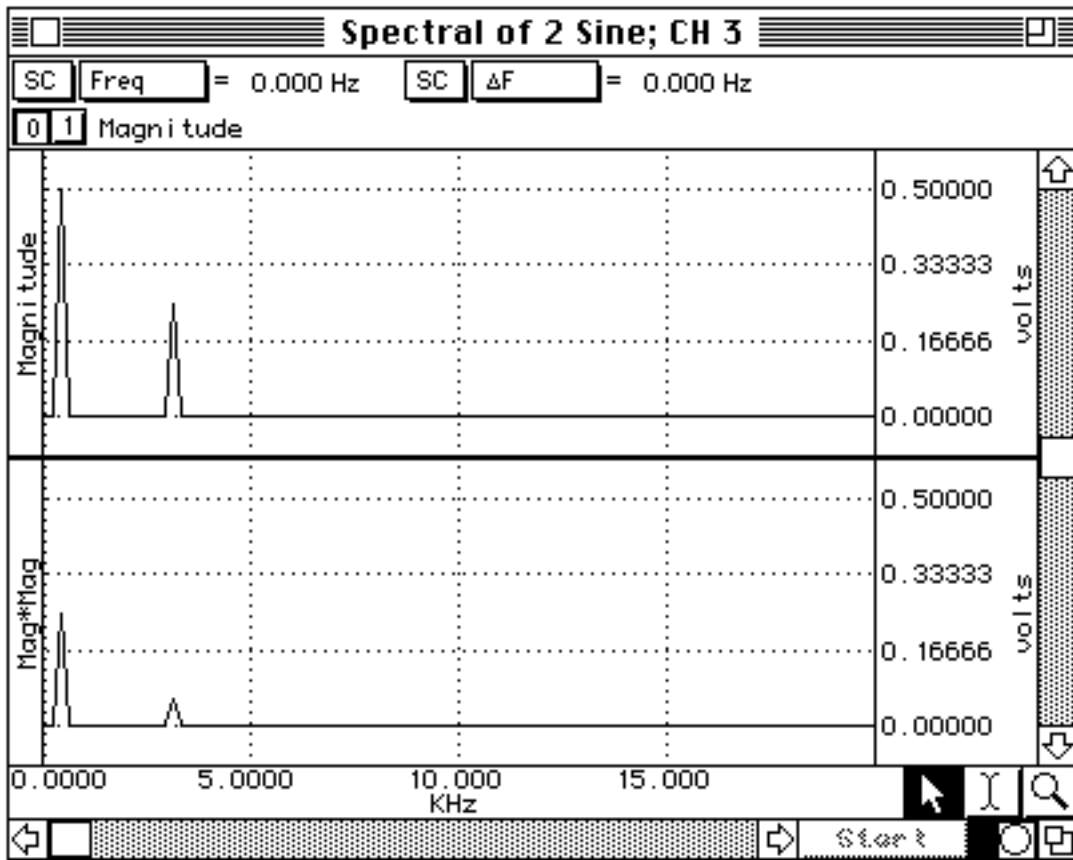
N_F = Total Number of Samples in Frequency Domain

ΔF = Total Frequency range in Frequency Domain

This formula is used to relate the power from the frequency to time domain, and is thus also useful to calculate Power Spectrums over varying frequency ranges. Let's look at an ideal example to simplify this discussion. Our example consists of two perfect sine waves (390.6Hz and 3.125kHz) with exactly 512 points that are added together.



Check to see if the above relation works out. Take the Linear Magnitude FFT of the composite waveform. As expected, we see 2 spectral peaks corresponding to the frequencies of the summed sine waves. Note that the magnitude of the 3.124kHz sinewave is half of the 390.6Hz sine wave as expected. Channel 1 is the magnitude squared.



Taking the integral of the Magnitude squared we get

$$\int |F(f)|^2 df = 61.035$$

Now check the time domain power.

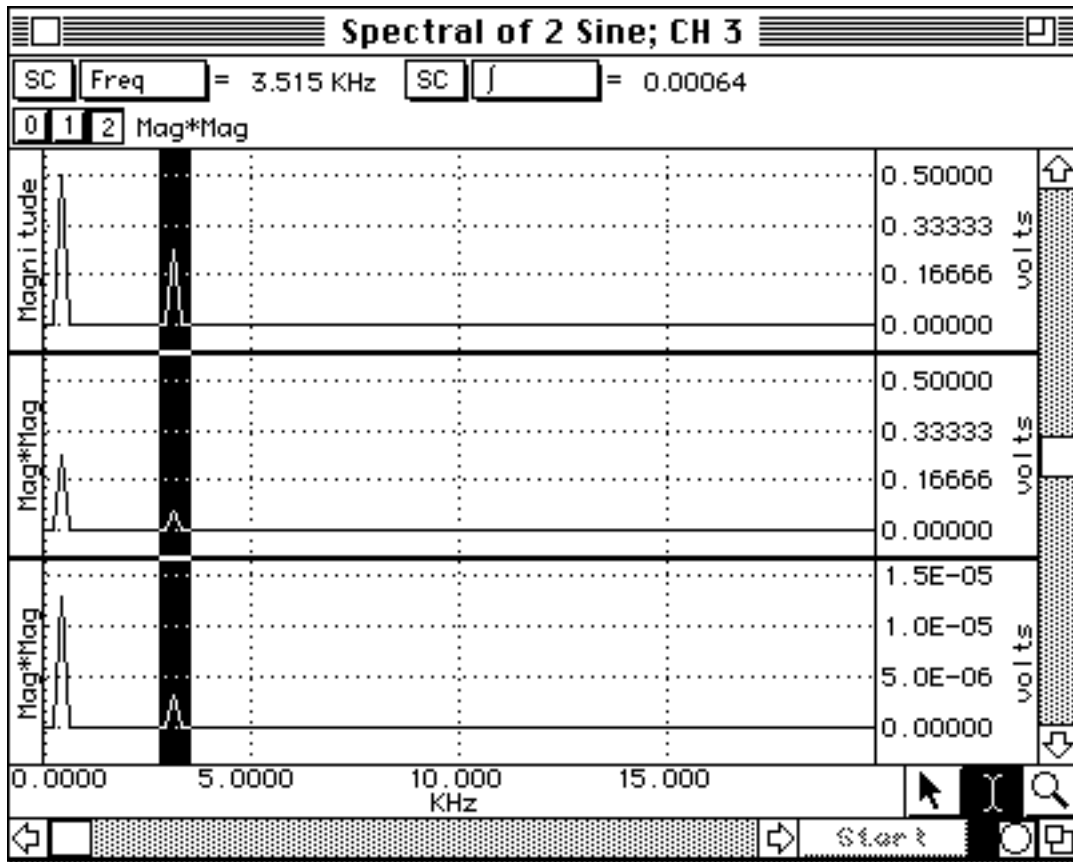
$$\int |f(t)|^2 dt = 0.00320$$

Check to see that the power is the same in the time domain as the frequency domain.

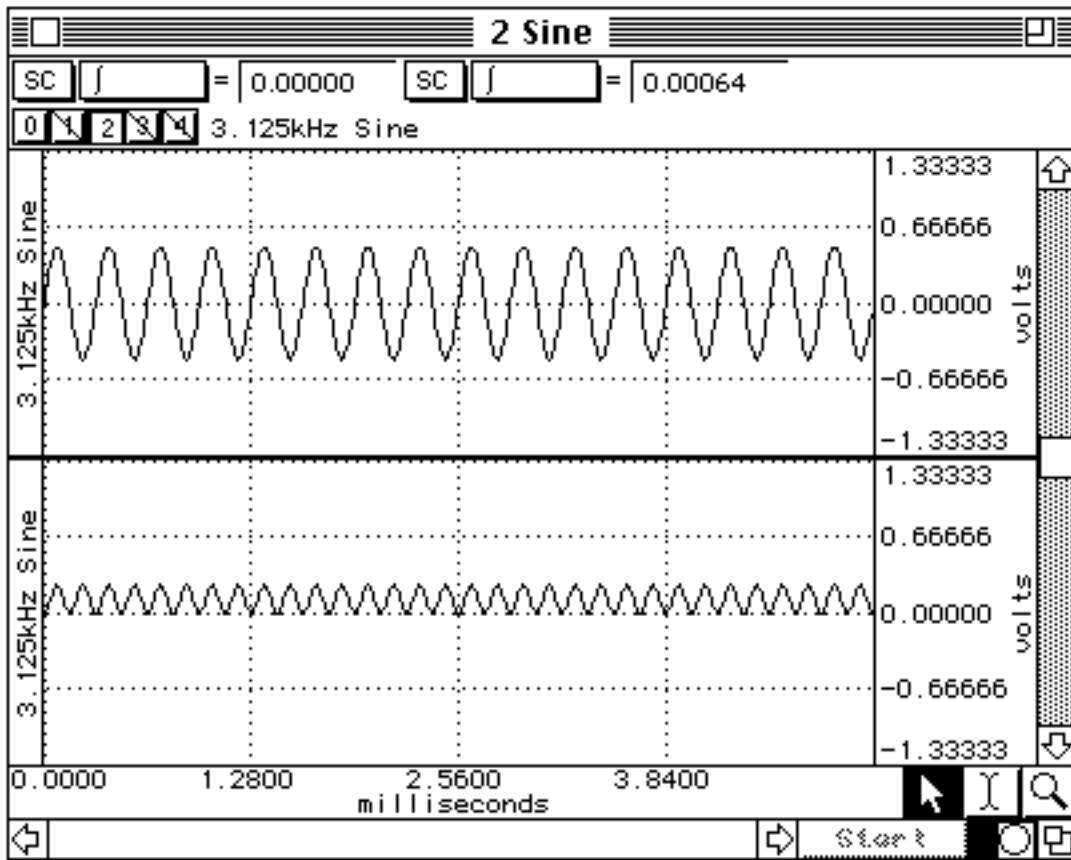
$$0.00320 = 512 * 256 / (50 \text{ KHz})^2 * 61.035$$

$$512 * 256 / (50 \text{ KHz})^2 = 5.24288e-5$$

Note that we can take the scaling constant calculated above and multiply the frequency response by it. This result is placed in channel 3. If we then select the second peak and integrate, we get the power in the 3.125kHz sine wave.



Now take the original 3.125kHz sine wave and square it. Select the entire wave and integrate it. We see that the power of 3.125kHz wave is 0.00064 as expected. I have taken the liberty of not showing the selected area so that this document will xerox better.



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