RMS CALCULATION FROM SPECTRUM

A spectrum has the followings characteristics:
- F_{MAX} - representing the maximum frequency calculated from the time-signal (Ex. 1600 Hz)
- Spectrum resolution, distance between two consecutive lines (Ex. Δf =1 Hz)
- Lines number L= $F_{MAX}/ \Delta f$ (Ex. 1600/1 = 1600 lines)
- Lines amplitude - A_i (in Volt, g, mm/sec, etc)

If you have a 1 Volt RMS sinusoid (as shows Figure 1) and you measure it with a FFT spectrum analyzer, the height of the line, or combination of lines that represent the signal will always add up to 1 Volt RMS.

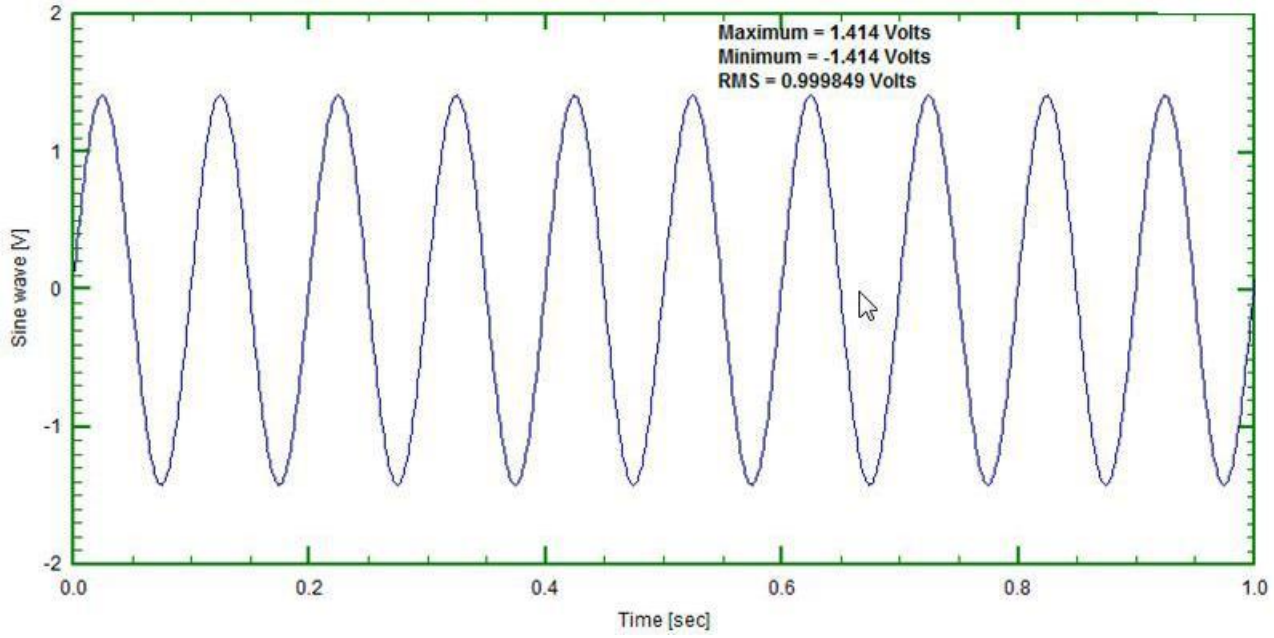

Figure 1

If there is no windowing applied to the time signal prior to calculating the FFT of the sinusoid and the sinusoid frequency is centered on the center of the FFT line of the spectrum (the sinusoid frequency is a multiple of spectrum resolution - Δf), then the height of the single line will be 1 Volt RMS (Figure 2). In this particular case, the *line* amplitude coincides with the *peak* value.

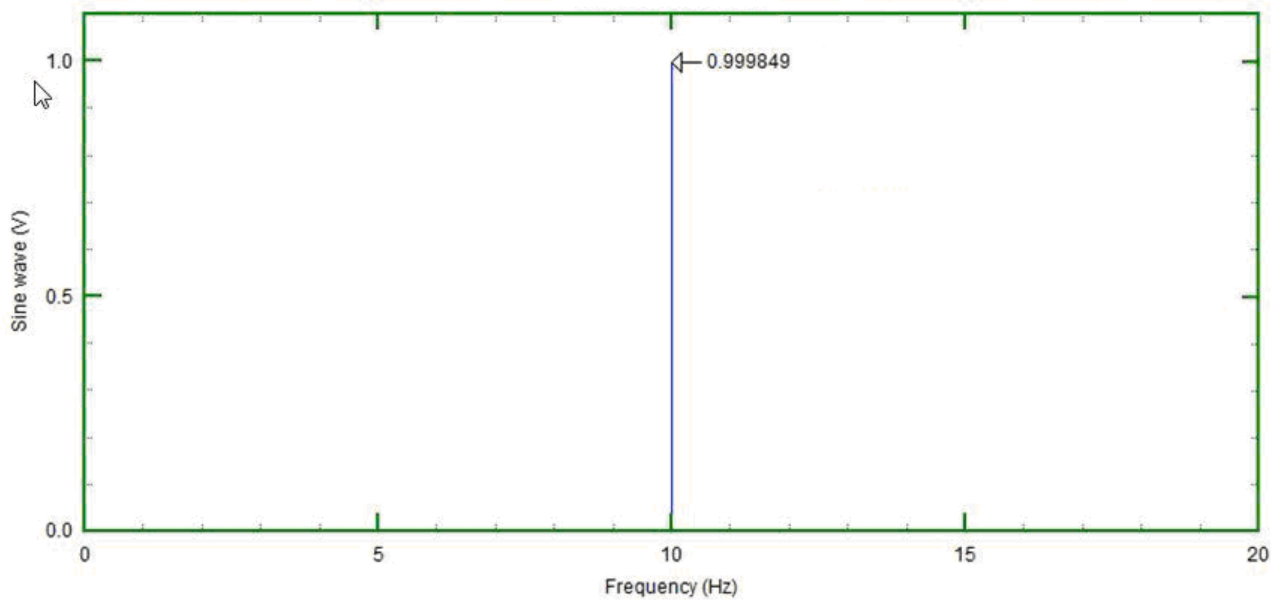

Figure 2

Confusion may appear when applying a time windowing function (typically a Hanning window) to the time signal prior to calculating the spectrum. Because the applied window narrows the time record (remember the time record is 1/Δf), the frequency lines are broadened and overlapped, consequently the single frequency sinusoid is now represented by 3 frequency lines (typically if the sinusoid is again centered on the center frequency of the specific frequency line of the calculated spectrum).

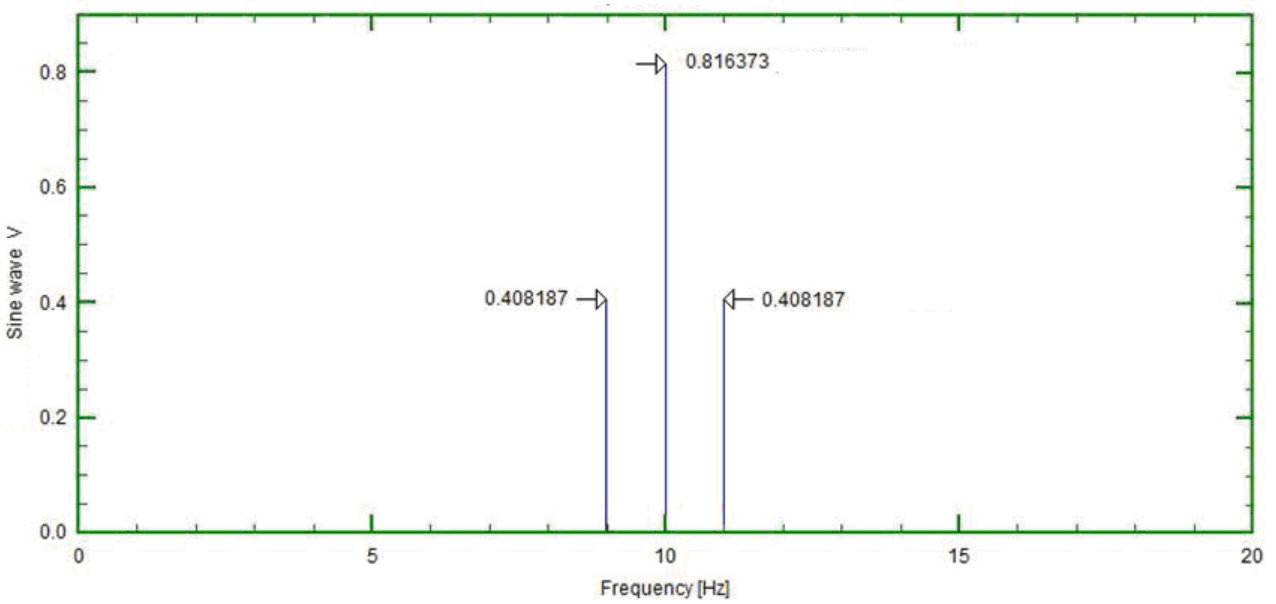

Figure 3

Total RMS value can be calculated with formula:

$Ampl = \sqrt{[Line(i-1)^2 + Line(i)^2 + Line(i+1)^2]}$ *[Formula 1]*

So, in our case:

$Ampl = \sqrt{[(0.408187)^2 + (0.816373)^2 + (0.408187)^2]} = 1V_{RMS}$

If the sinusoid frequency is not centered (the frequency is not a multiple of

spectrum resolution), the sidelines are uneven.
The lines belonging to the sinusoid create the „peak' or "spectrum peak".
As can be seen, the "spectrum line" is not equivalent with "spectrum peak".

To calculate the RMS value (peak value), the line amplitude must be used, as formula 1 shown above.
Calculation requires squaring the line amplitudes, adding them, and then applying the square root.

The *CXM* instruments (version 1.17 or newer) show at cursor level, the line value, but if a peak is found, they will show both line and peak values.

In the next Figure, the cursor is located on a line, but not peak. The shown value is the line value:

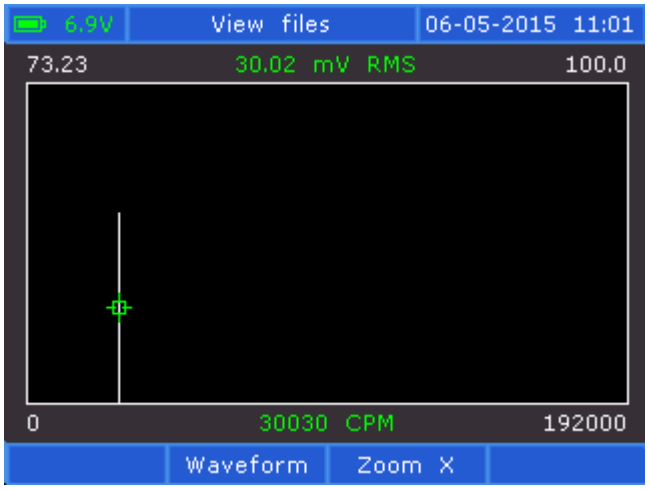

Figure 4

In the Figure 5, the cursor is placed onto a peak.
In this case, two values are show:

- Line value
- Peak value and its frequency (in squared brackets)

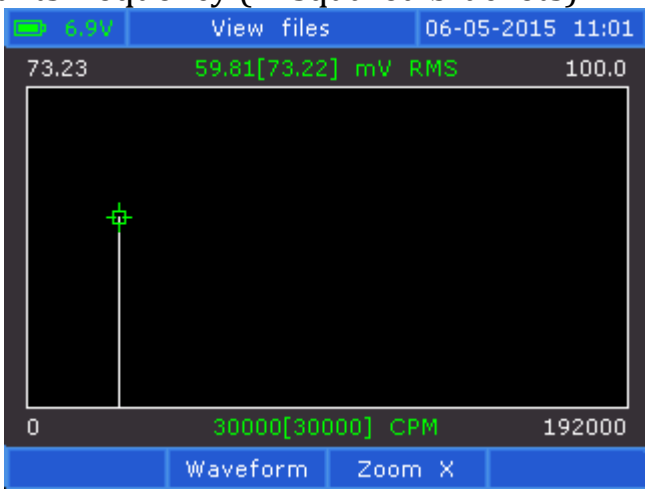

Figure 5

In *CXSpectra*, the user can select the value shown at cursor position, either the *line* value or *peak* value.

In Figure 6 is show a spectrum with the cursor set to "Peak", for a sinusoid

having the frequency of 49.245 Hz (not a multiple of spectrum resolution):

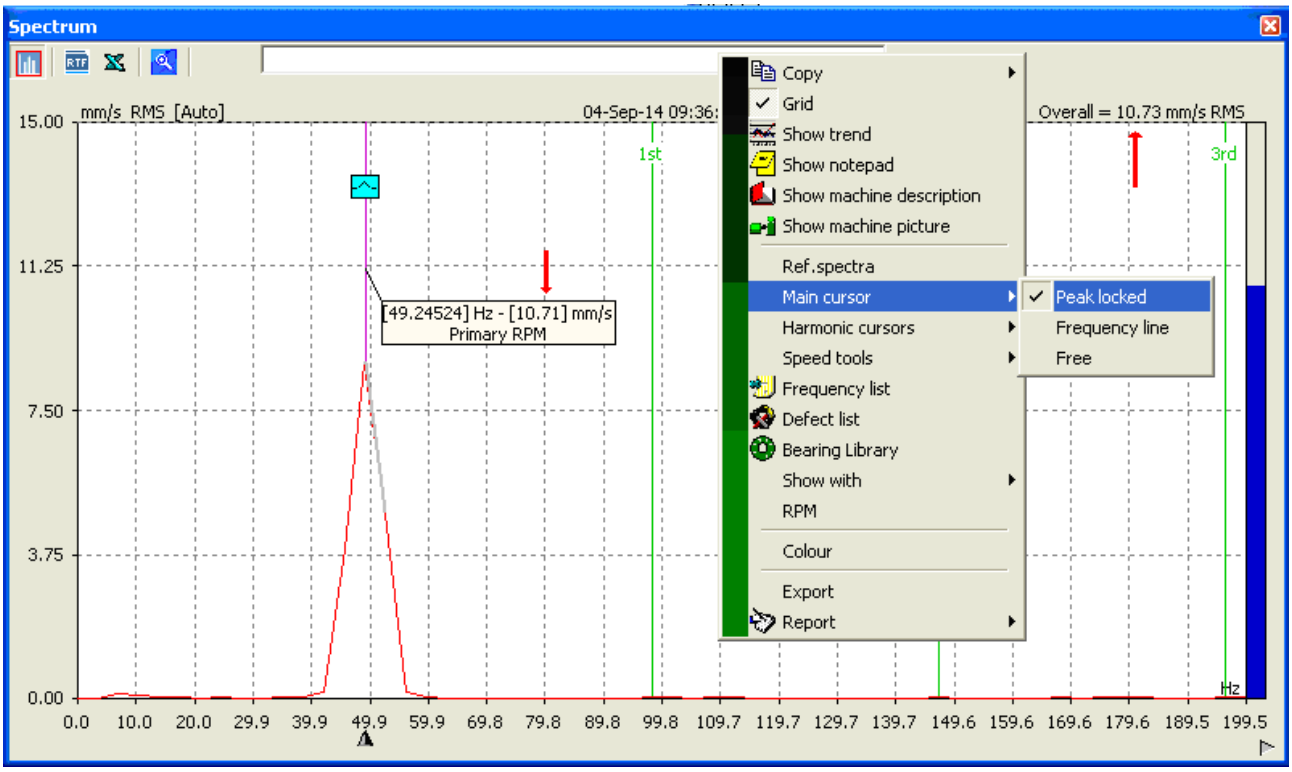

Figure 6

Observe that the labeled value of the *Peak* value (10.71 mm/sec RMS) is very close to the overall (*Total)* value, 10.73 mm/sec RMS. A small difference occur due to noise (observe a small flat peak near 8 Hz).

In Figure 7 appears the same spectrum, but with cursor set onto "Frequency line".

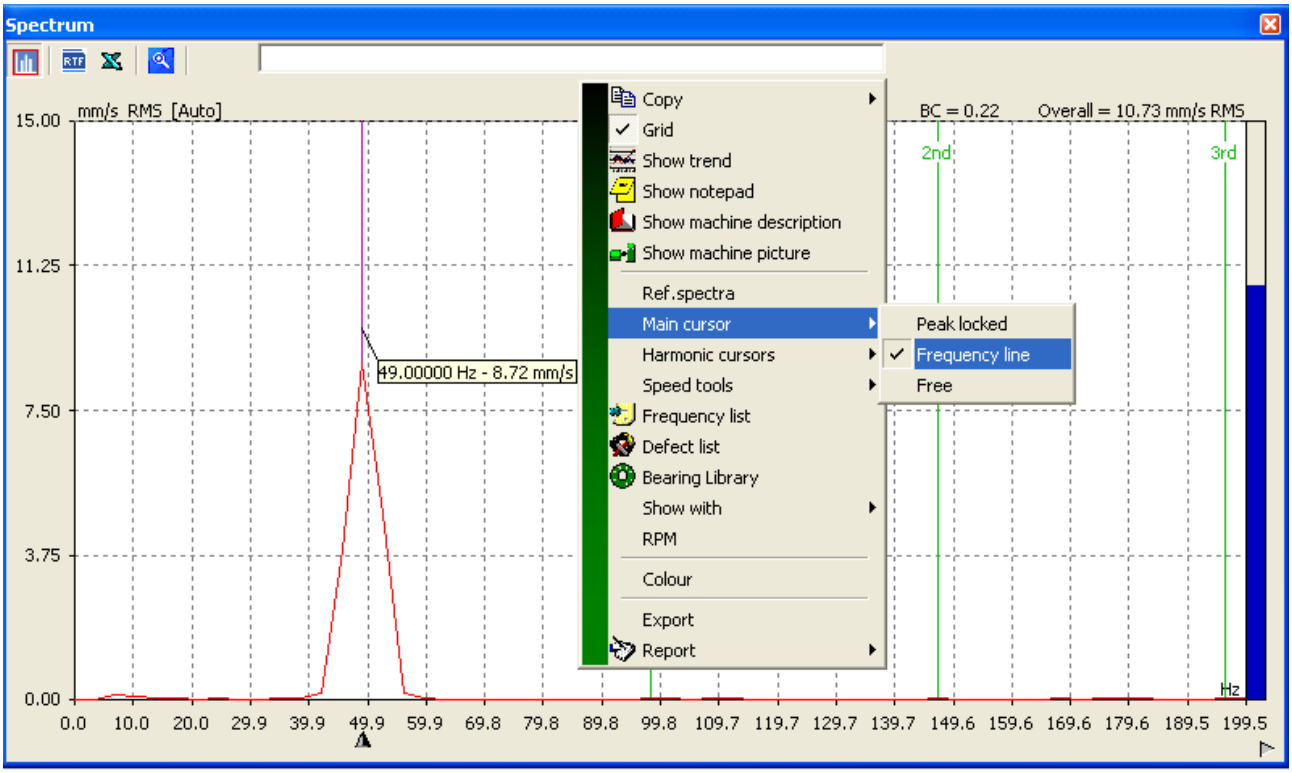

Figure 7

The line amplitude is only 8.72 mm/s RMS.
Peak (amplitude) value can be determined, including in the calculation the left and right lines (at 48 and 50 Hz), as well.
In our example, these lines have the amplitude of 3.93 and 4.85 mm/sec RMS.
Using [Formula 1], the result is 10.71 mm/sec RMS, as in Figure 6.

For more details, please see the *CXSpectra* Help, chapter: *"Spectra peak calculation".*

Documentation Feedback

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