CRYSTAL INSTRUMENTS

HIGH-RESOLUTION RANDOM CONTROL AT LOW FREQUENCIES

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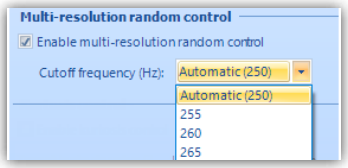
Random control is a fundamental vibration test for various industries and manufacturers of products. The FFT based control algorithm transforms time signals to the frequency domain where analysis, calculation, comparison…average, (etc.) are done. The performance of Random control is determined by how well the FFT describes the system characteristics. Proper spectrum resolution must be chosen in order to avoid missing any desirable observations and to meet the requirement of the control performance.

Characteristics of most mechanical systems usually have more details at low frequencies than high frequencies and are better described in a logarithmic frequency scale. Since FFT provides uniform frequency resolution, the selected resolution that is sufficient at high frequencies may be too sparse at low frequencies, thus resulting in poor control performance during Random control testing. To resolve this issue, a higher resolution must be selected to reveal details at low frequencies. However, a higher resolution requires more computation power and more storage to save data, which causes an increased loop time and a slower spectrum refresh rate.

The trade-off between control performance at low frequencies and the whole system response is always difficult, but Crystal Instruments has the solution: Multi-Resolution Random Control. This technique is recently introduced to the Random Control algorithm, dividing the whole frequency range into low and high frequency bands. Two different control loops with different sampling rates are used in each frequency band respectively. Eight times the selected resolution is applied to the low frequency band in calculation of the control loop. As a result, the control performance is greatly improved at low frequencies without increasing the loop time or decreasing the spectrum refresh rate. The vibration test can be recorded to the limited storage space.

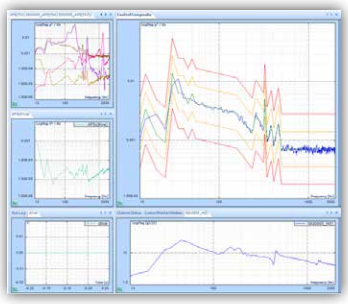
The cutoff frequency that divides the frequency range to two bands is automatically calculated by EDM. In addition, a few adjacent frequencies are offered as a choice to avoid resonance or anti-resonance.



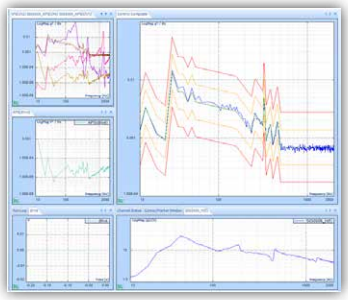
Test Results:
In the composite windows below, a test is running without multi-resolution control at 400 lines.

The blue line is the control spectrum. The green line is the profile spectrum. Yellow and red lines are alarm and abort limits.

In this case, a Spider is running a Random test with a profile where there are a few peaks and valleys below 100 Hz and between 200 to 500Hz. We can see that control spectrum matches the profile very well between 200 to 500Hz, but is not satisfactory below 100Hz. The reason is described in the first half of this article.



With multi-resolution control enabled, the resolution in the low-frequency range is much higher and the control performance is greatly improved. The control spectrum matches the profile below 100Hz as well as 200 to 500Hz.

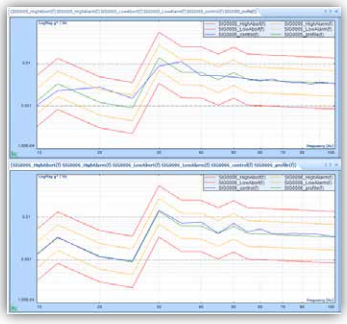


The control composite windows below are zoomed in to the 13~100Hz range.

The top chart shows how the control(f) matches profile(f) WITHOUT multi-resolution control.

The bottom chart shows how the control(f) matches profile(f) WITH multi-resolution control.

Control(f) matches profile(f) much better with the multi-resolution control.



The difference between control(f) and profile(f) is much more minimized in the low-frequency range with multi-resolution control.

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