CRYSTAL INSTRUMENTS

# Shaped Random & Burst Random Output Excitation in MIMO FRF Modal Analysis

**Application Note 069**

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# Contents

## Introduction

Modal testing and analysis are important processes that improve the design of a product. Therefore, it is crucial to ensure testing is carried out with optimal settings. The Shaped Random and Burst Shaped Random output excitation introduced by Crystal Instruments provides unique advantages such as a better estimation of the quality factor, damping and FRF amplitude. This indicates that the obtained modal parameters are more accurate. A modal test is carried out to examine the data to see the improvement in the results with these newly introduced techniques when compared to the conventional shaker excitation signals. The green curve shows the FRF obtained using the Shaped Random excitation and the blue curve shows the FRF obtained using the white noise excitation. As illustrated, the advantages of shaped peaks using the newly introduced approach leads to more accurate estimations of the quality factor, damping and FRF amplitude as discussed in the forthcoming sections. (Figure 1.1)

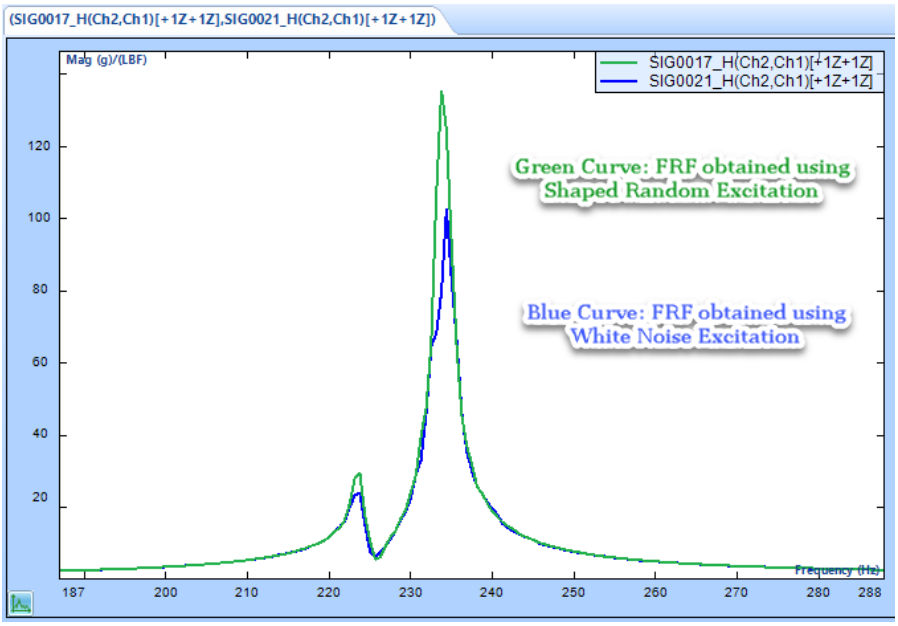


*Figure 1.1 Overlapped FRF for the Shaped Random and White Noise excitation signals*

Shaped Random and Burst Shaped Random excitation is added to the popular output types for MIMO FRF Modal testing. These include White noise (Random), Burst Random, Periodic Random, Pseudo Random, Chirp, Burst Chirp, and more. (Figure 1.2)

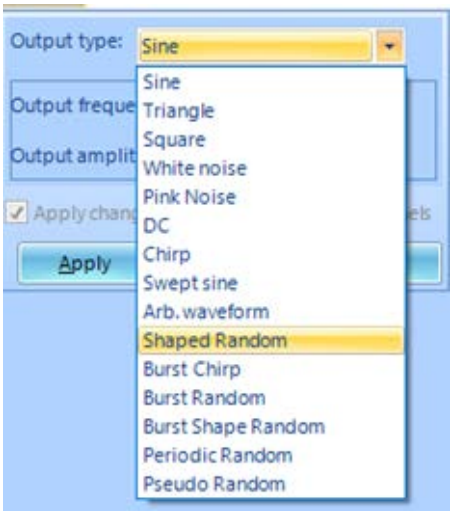


*Figure 1.2 Shaped Random and Burst Shaped Random output excitations added*

Shaped Random and Burst Shaped Random provides improved excitation to the structure under test since the level of excitation can be tuned over the frequency range. This will increase the signal to noise ratio in some regions where the response level is lower. The customizable profile entered by the user in the frequency domain helps increase the response level at certain desired frequencies. Adding a burst percentage also provides an opportunity to control the time duration of no output. These advantages make Shaped Random and Burst Shaped Random output excitation highly desirable.

### Settings

The following example illustrates the quick and easy setup required for Shaped Random and Burst Shaped Random output excitations for MIMO FRF testing offered in EDM Modal software.

1. Shaped Random setup involves the editing of a PSD (Power Spectral Density) profile. (Figure 2.1)

Click on the **Edit** button and the following window will pop up to allow users to specify the shape of the drive PSD file. (Figure 2.2)

Using the breakpoint table, any shape of the PSD file for the drive signal can be easily defined. Also available are the selections of **White Noise** and **Pink Noise**.

The shaped random output is still of the random nature. (Figure 2.3)

2. Burst Shaped Random setup involves the editing of a PSD (Power Spectral Density) profile and the burst percentage.

Click the Edit button in the output setting and the edit window pops up to allow users to specify the shape of the drive PSD file. In addition, the burst percentage is specified by the user in the edit window. (Figure 2.4)

Using the breakpoint table, any shape of the PSD file for the drive signal can be easily defined. Also available are the selections of **White Noise** and **Pink Noise**.

The burst shaped random output is still of the random nature. (Figure 2.5)

## Modal Test

A modal test is carried out to compare the effect of the shaped random excitation signal and white noise excitation signal. In this case, the shaker excitation test is executed on the test structure by performing a MIMO FRF test carried out in the latest 9.0 release of the EDM Modal software. The RMS voltage levels are the same for both excitation signals. However, with the shaped random excitation, a higher energy is concentrated in the frequency range of 200-250 Hz which has two closely spaced modes. All other test settings such as the frequency range, block size, windowing, and averaging are kept the same for both tests. (Figure 3.1 and Figure 3.2)

The block signals show the shaped random excitation and white noise excitation signals and the response of the unit under test to these shaker excitations. The FRF plot shows that the interested modes are well identified in the desirable frequency range. The coherence graph shows that the input and output are well correlated. (Figure 3.3)

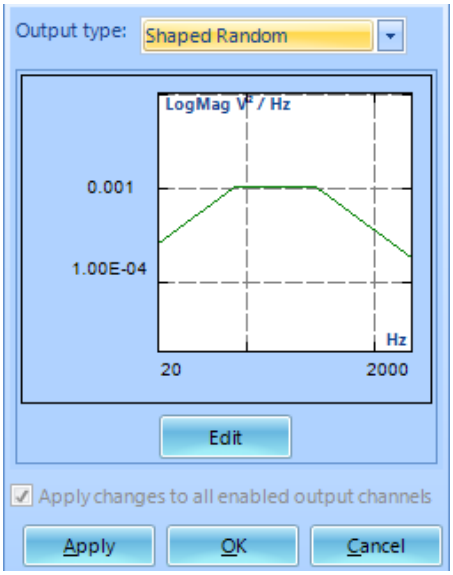


*Figure 2.1 Output Setting of Shaped Random*

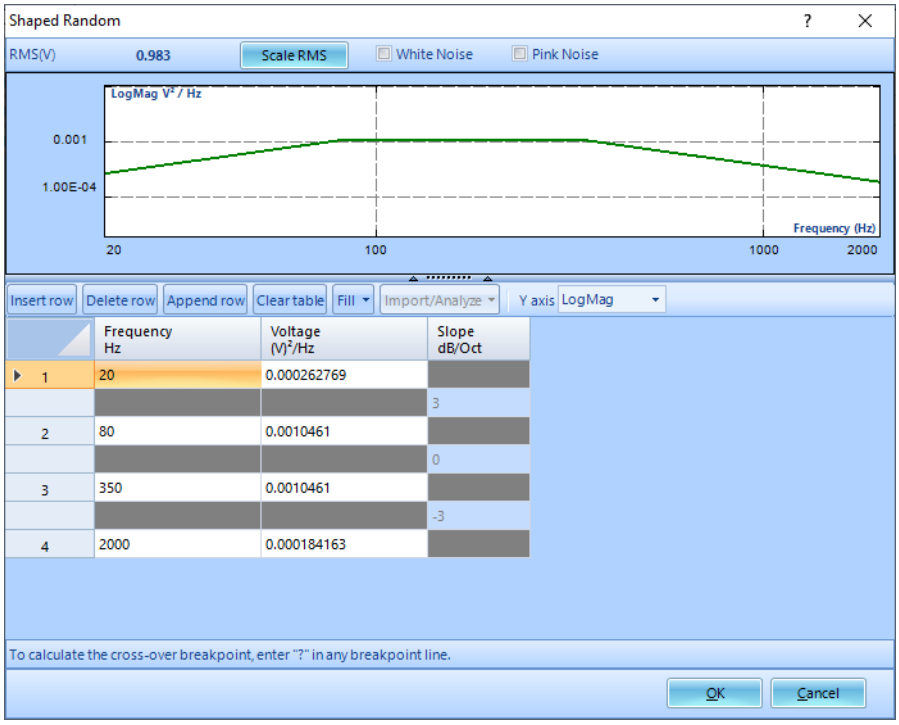


*Figure 2.2 Shaped Random Edit Window*

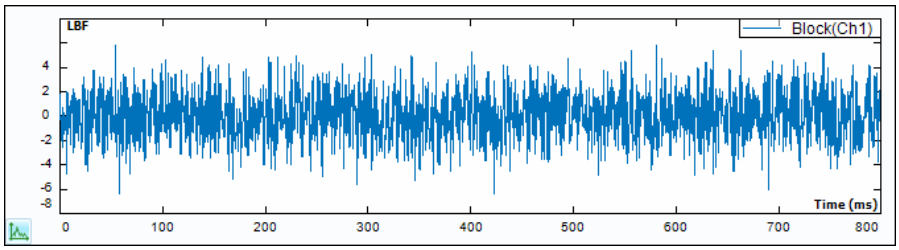


*Figure 2.3 Excitation Force for Shaped Random*

Comparing the results from the shaped random excitation to the white noise excitation, we obtain the following overlaid FRF plot. (Figure

3.4)

The overlapped FRF plot shows that the peaks are much sharper and better identified with the shaped random excitation signal due to the increased energy concentration in that frequency range. A better estimation of the peaks also leads to an accurate calculation of the Quality factor, damping and FRF amplitude as shown in the tables below.

The results emphasize the unique advantages of the Shaped Random output excitation in Modal Analysis. To learn more about the EDM 9.0 release and the EDM Modal software, please visit https://www.crystalinstruments.com/.

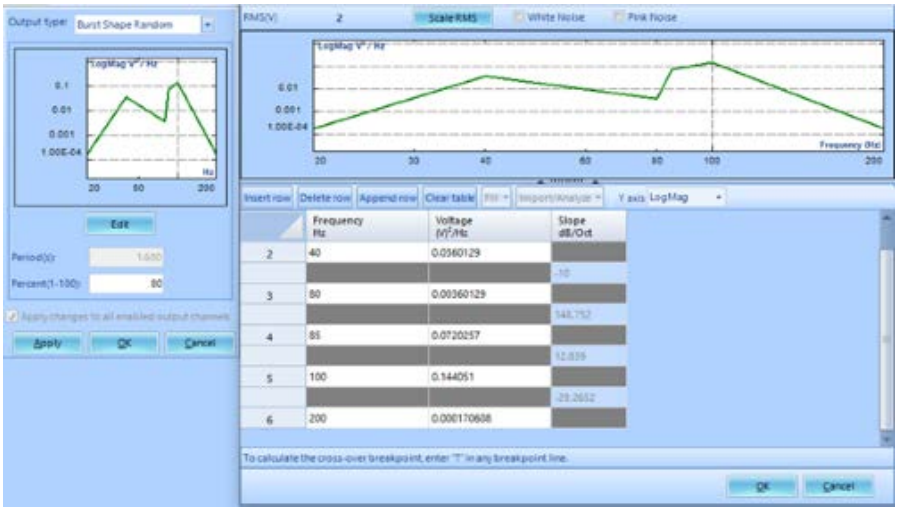


*Figure 2.4 Output Setting and Edit Window of Burst Shaped Random*

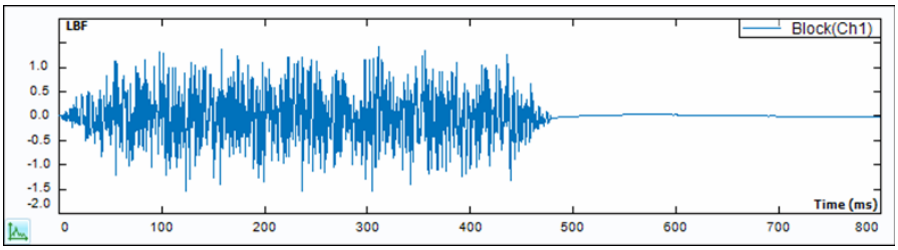


*Figure 2.5 Excitation Force for Burst Shaped Random*

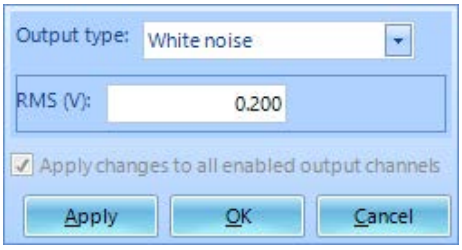


*Figure 3.1 White Noise Shaker Excitation Signal Setting*

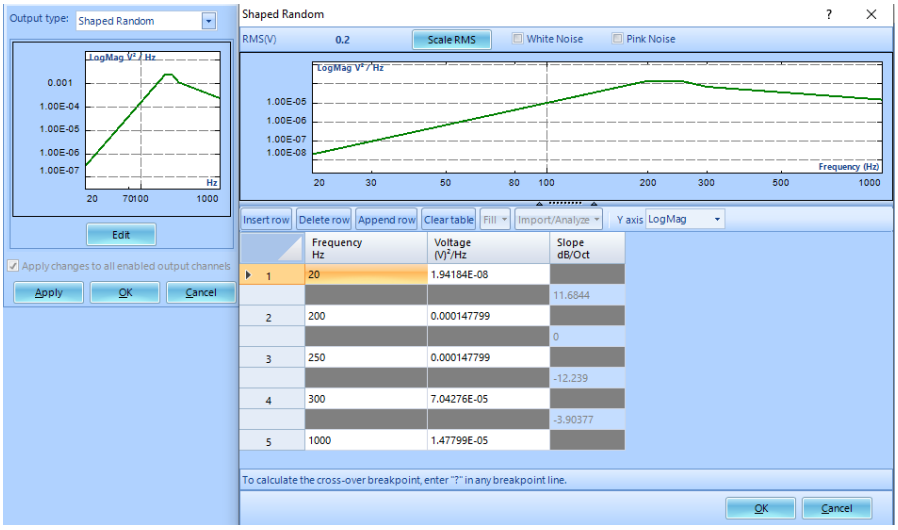


*Figure 3.2 Shaped Random Shaker Excitation Signal Setting*

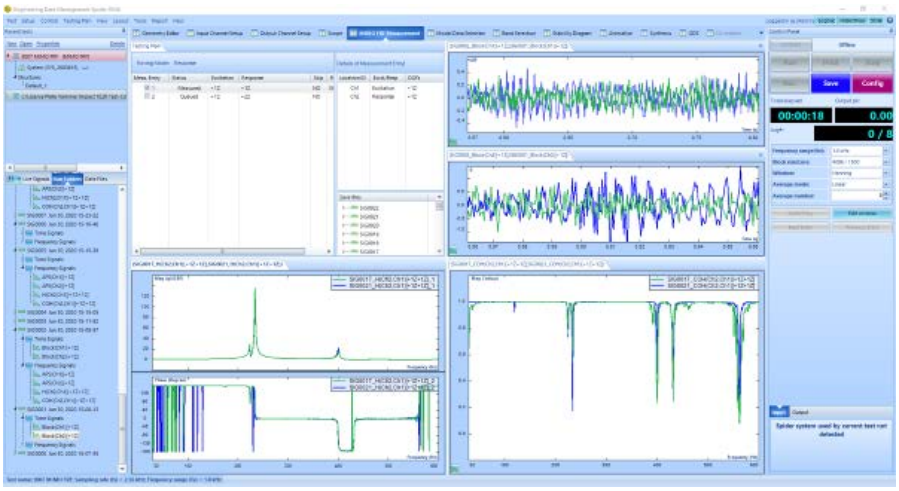

*Figure 3.3 MIMO FRF Modal test using the Shaped Random and White Noise excitations*

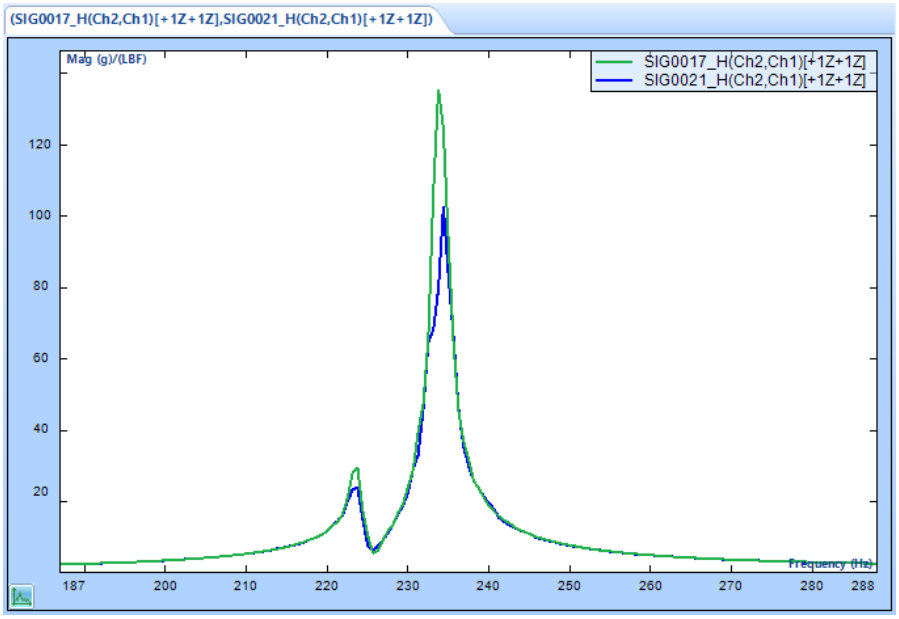


*Figure 3.4 Overlaid FRF for the Shaped Random and White Noise excitations*

| Resonant Frequency | Q values With Shaped Random | Q values With White Noise | Est. Error |
|---|---|---|---|
| 223 Hz | 1.515 | 1.16 | 1.3 times wrong |
| 233 Hz | 2.873 | 1.461 | 1.96 times wrong |

*Table 1 Quality Factor comparison for the Shaped Random and White Noise excitations*

| Resonant Frequency | Damping With Shaped Random | Damping With White Noise | Est. Error |
|---|---|---|---|
| 223 Hz | 0.33 | 0.431 | 1.3 times wrong |
| 233 Hz | 0.174 | 0.342 | 1.96 times wrong |

*Table 2 Damping comparison for the Shaped Random and White Noise excitations*

| Resonant Frequency | FRF Amplitude with MR (g/LBF) | FRF Amplitude no MR (g/LBF) | Est. Error |
|---|---|---|---|
| 223 Hz | 29.6884 | 24.0893 | 1.23 times wrong |
| 233 Hz | 135.6649 | 79.7911 | 1.7 times wrong |

*Table 3 FRF Amplitude comparison for the Shaped Random and White Noise excitations*

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