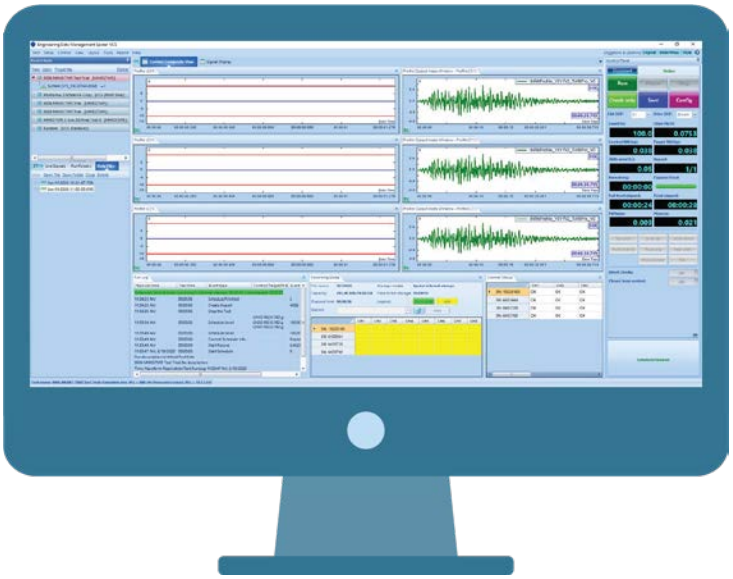
CRYSTAL INSTRUMENTS

Earthquake Testing on a Three-Axis Shaker System

Application Note 070



Aakash Umesh Mange - Senior Application Engineer

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Introduction

Earthquake testing is a crucial process that is used to determine the seismic performance of a structure. The utilization of a physical testing method helps users better understand the complexity involved in earthquake forces. A shaker table is typically used to execute a physical method of testing. The results from earthquake testing are used to optimize the design and material properties of the unit under test.

A vibration control test is one of the most reliable ways to carry out this type of dynamic testing. An earthquake profile is programmed into the controller and the shaker table then simulates this movement. It is challenging to accurately represent the earthquake motion. The controller must ensure good control of the low-frequency components which is a significant part of earthquake testing. The hardware configuration is another essential component and the utilization of a three-axis shaker table is an accurate implementation for this type of vibration control testing. (Figure 1.1)

A similar application is discussed here. A three-axis servo shaker by Nissoku Engineering Co., Ltd. (Japan) is used along with a Crystal Instruments' MIMO (Multiple-Input-Multiple-Output) vibration control system to perform an earthquake test. (Figure 1.2 and Table 1)

The long stroke length, high force rating, large payload capacity and wide frequency range of the 3-axis shaker system by Nissoku Engineering Co., Ltd. allows for accurate testing of earthquake waveforms. The AS-10 TB tri-axial sensor which has a sensitivity of 98.07 m/s^2 sensitivity and a frequency response of DC – 350 Hz is used for this test. Additional details about the sensor are provided in the following table. (Table 2)

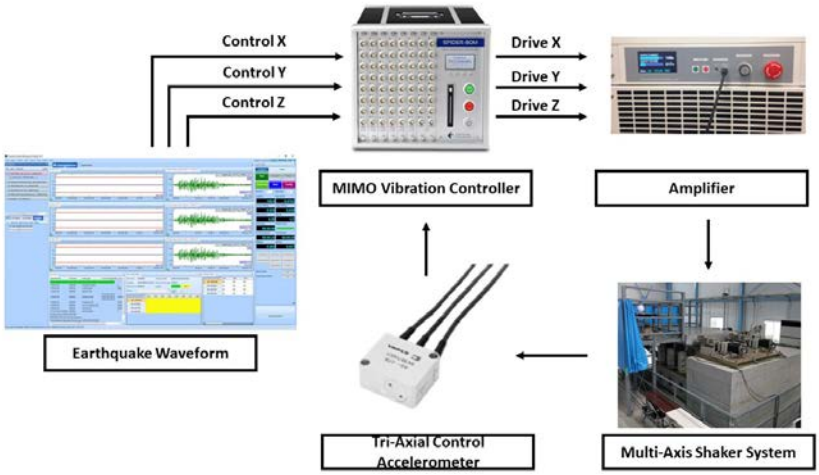

Figure 1.1 Multi-Axis Earthquake Waveform Vibration Control Test Block Diagram

Figure 1.2 Nissoku Engineering Co., Ltd Three-Axis Servo Shaker System

	X - Axis	Y - Axis	Z - Axis
Force (Sine)	88.25 kN	88.25 kN	117.6 kN
Frequency Range (Sine & Random)	0.1 - 150 Hz	0.1 - 150 Hz	0.1 - 150 Hz
Maximum Acceleration	27 m/s^2	27 m/s^2	30 m/s^2
Maximum Velocity	0.7 m/s	0.7 m/s	0.7 m/s
Maximum Displacement	400 mm (p-p)	400 mm (p-p)	200 mm (p-p)
Maximum Payload	2000 kg		
Table Size	2800 mm x 2800 mm		

Table 1 Specifications of the Nissoku Engineering Co., Ltd Three-Axis Shaker System

The efficient Spider-80M by Crystal Instruments' is a dedicated hardware for MIMO vibration control testing applications. This chassis features 8 outputs which is helpful in executing 6-degree of freedom MIMO testing.

The MIMO TWR test type available in the EDM MIMO VCS software by Crystal Instruments' provides precise, real-time, multi-channel control for mimicking earthquake waveforms. (Figure 1.3)

Test Details

1. An earthquake waveform with a duration of 31 seconds is run on the 3-axis servo shaker using the MIMO vibration control system. (Figure 2.1)

2. The profile is imported into the Crystal Instrument's EDM Waveform Editor software to fine tune the sampling rate and frame size which helps in better representation and optimized control of this waveform. (Figure 2.2)

Observing the spectrogram, the major components of this earthquake profile are in the lower frequency region.

3. The resampled waveform is then imported into the Crystal Instruments' MIMO TWR (Time Waveform Replication) test of the MIMO VCS software. (Figure 2.3)

4. The input channel is configured to ensure the setup of multiple control channels. DC Single-End input mode is enabled for controlling the profile down to 0.3 Hz. After the shaker settings are configured and the test parameters are setup, the pre-test is designed accordingly.

The shaped random signal allows the user to tune the level of excitation over the frequency range. This helps improve the signal to noise ratio in the areas where a higher response is desired. This option of customizing the PSD helps in measuring an accurate FRF during the pre-test stage which furthers facilitates better control of the profile during the full-level test. (Figure 2.4)

	Value
Sensitivity	98.07 m/s^2
Frequency Response	DC - 350 Hz
Safe Excitation	6 V AC or DC
Recommended Excitation	1 to 3V AC or DC
Input Resistance	120 Ω ± 5%
Output Resistance	120 Ω ± 5%
Cable	0.08 mm^2 vinyl shielded cable

Table 2 Specifications of the AS-10TB Sensor

Figure 1.3 Crystal Instruments Spider-80M MIMO Vibration Controller

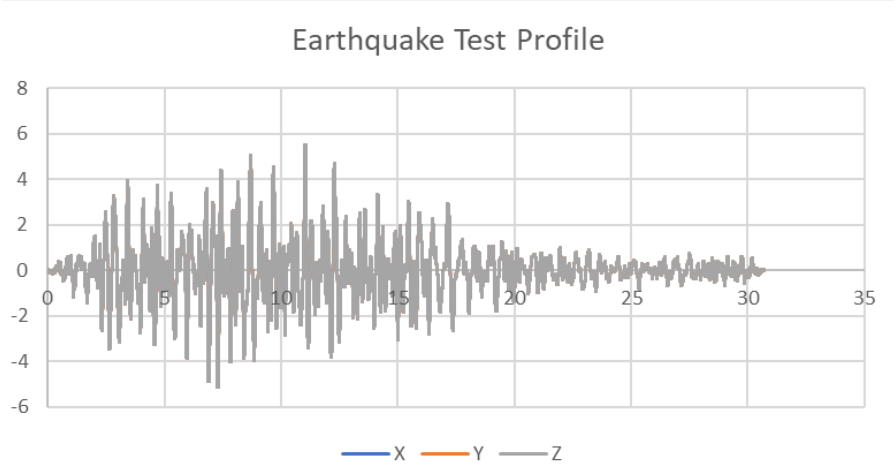

Figure 2.1 Earthquake Waveform for MIMO Vibration Control Testing

5. The profile exported from EDM Waveform Editor is imported into the EDM MIMO TWR test and the run schedule is set accordingly after checking the profile against the shaker parameters to ensure the safety of running this test.

As shown below, the vibration test runs smoothly, and the Crystal Instruments controller and software is successful in controlling the earthquake waveform on the 3-axis servo shaker system. (Figure 2.5)

The results emphasize the efficiency and reliability of the Crystal Instruments' MIMO Vibration Control System. To learn more, please visit https://www.crystalinstruments.com/.

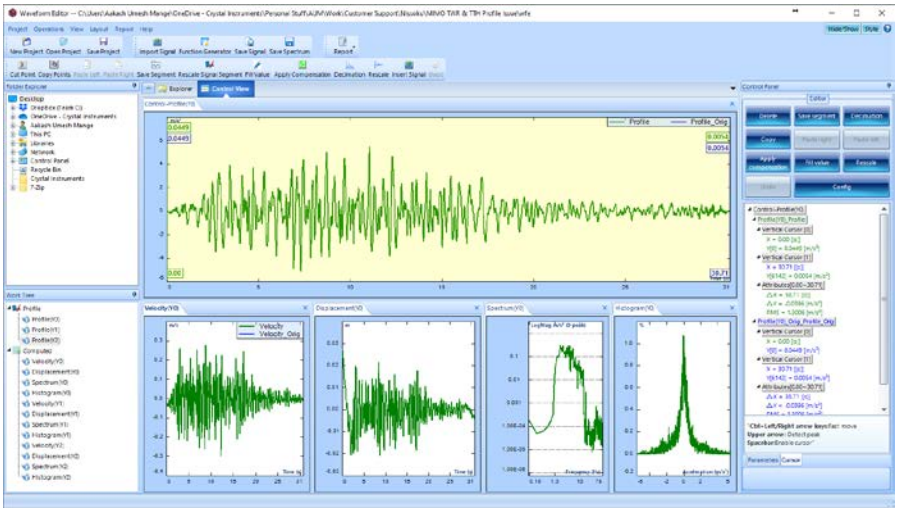

Figure 2.2 EDM Waveform Editor

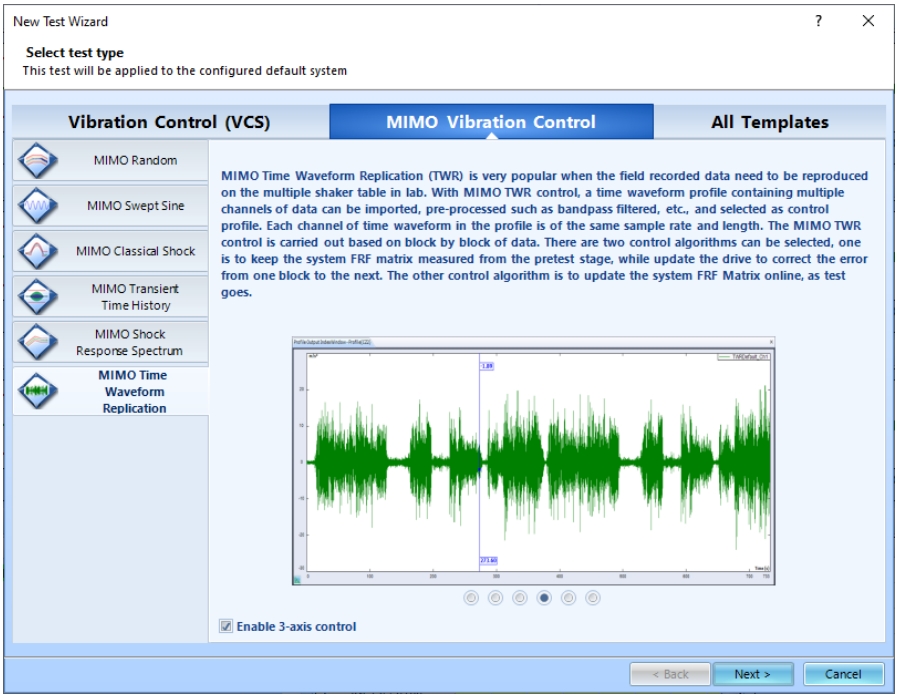

Figure 2.3 EDM MIMO VCS Software

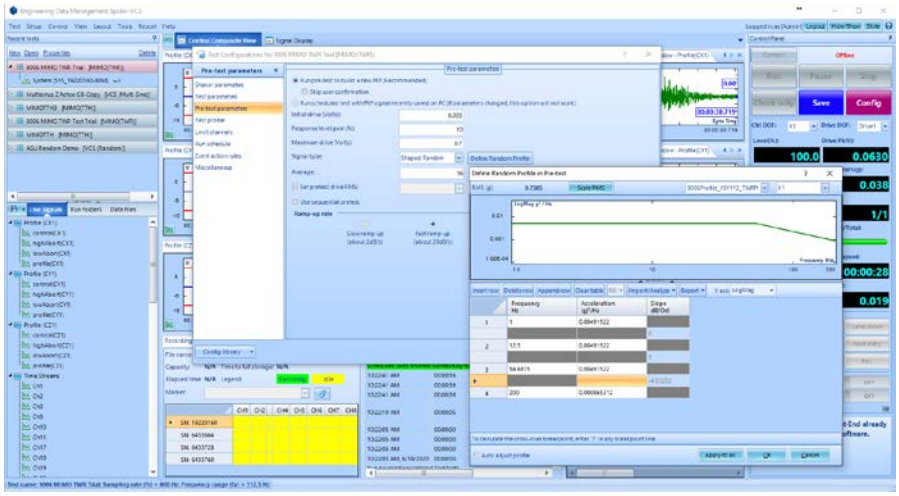

Figure 2.4 EDM MIMO TWR Pre-Test

Figure 2.5 EDM MIMO TWR Test

Crystal Instruments Corporation
2090 Duane Avenue
Santa Clara, CA 95054

Crystal Instruments Testing Lab
15661 Producer Lane, STE H
Huntington Beach, CA 92649

Crystal Instruments Testing Lab
1548A Roger Dale Carter Boulevard
Kannapolis, NC 28081

Phone: +1 (408) 986-8880
Fax: +1 (408) 834-7818
www.crystalinstruments.com