A White Paper from
Emerson Network Power™
Embedded Computing

Product Testing: Creating Meaningful Test Data for Our Customers: A White Paper

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Product Testing: Creating Meaningful Test Data for our Customers

Abstract

As Emerson creates more complex products, and as the rules and regulations governing the operation of those products become more diverse, challenges will arise as to how to test our products to ensure that the needs of our customers are met. To be ready for these challenges, Emerson's regulatory department must stay a step ahead and work with various groups to find innovative ways to effectively test our products and meet new and existing standards—maintaining a reliable end product of superior quality and performance.

This article discusses one recent situation where Emerson's regulatory group, together with a local engineering and testing firm, displayed ingenuity by developing and implementing a new testing strategy to provide dependable results for our customers. Accurate and reliable testing is a necessary part of product development and an integral component in the workflow at Emerson. This is another example of how we show our commitment to excellence while exceeding the expectations of our customers.

What Is NEBS?

All Emerson products undergo numerous testing requirements. One of those requirements is designed according to NEBS (Network Equipment-Building System), which specifies criteria regarding personnel safety, protection of property, and operational continuity for telecommunications equipment used in a Central Office. One of the standards within NEBS is GR-63-CORE (Physical Protection). This standard specifies tests for a variety of environmental conditions, including earthquake testing and office vibration testing. Earthquake testing simulates vibration from an earthquake. Office vibration testing simulates the typical vibration that occurs in an office as a result of nearby construction equipment or outside rail or truck traffic. These tests determine the affect of two different types of vibration on in-service telecommunications equipment. Emerson products are exposed to earthquake and office vibration testing to prove that they will operate properly under such conditions.

Earthquake and Office Vibration Testing

Earthquake and office vibration testing, per the NEBS GR-63-CORE standard, are tests that are designed to be performed at the system level since the results of the testing are greatly influenced by the physical and mechanical characteristics of the cabinet in which the equipment is mounted. Emerson's customers, who design their equipment to be used in the Central Office environment, need to have their equipment tested to meet the requirements of this standard. Our goal is to perform sufficient testing on our products to enable us to supply them with data indicating that our product, when incorporated into their equipment, will not cause that equipment to be vulnerable to failure during earthquake or office vibration activity. To meet this goal in regards to earthquake and office vibration testing, we had to accomplish two tasks. To assist with this, we enlisted the help of DATASYST Engineering and Testing Services, Inc. of Delafield, WI.

The first task was to create an adapter that would attach our test fixture to the shaker table without obstructing usable board space within the test fixture. To create meaningful test data, we wanted to use our compact and extremely durable test fixture that is rugged enough to survive repeated vibration tests and yet small enough to be easily transportable to the test site. This fixture is able to withstand repeated exposure to the various levels and types of vibration encountered during testing according to the NEBS GR-63-CORE standard. Originally, Emerson's test fixture directly attached to the shaker table with clamps. The clamp positioning inhibited use of some of the board slots within the test fixture. We needed to create a mounting adapter that would attach the test fixture to the shaker table and allow all of the board slots to be used for testing, increasing capacity and thus reducing overall testing time.

The second task was to create test profiles that would duplicate during shelf-level testing the vibration forces that are exerted on the upper part of a cabinet during system-level testing. Since our product is a circuit pack, it is not possible to conduct testing on our product and obtain meaningful data without being able to perform the testing in a typical telecommunications cabinet. However, it is not feasible to use Emerson's rigid test fixture in a cabinet, and a cabinet is too large and cumbersome to store or transport for frequent test-

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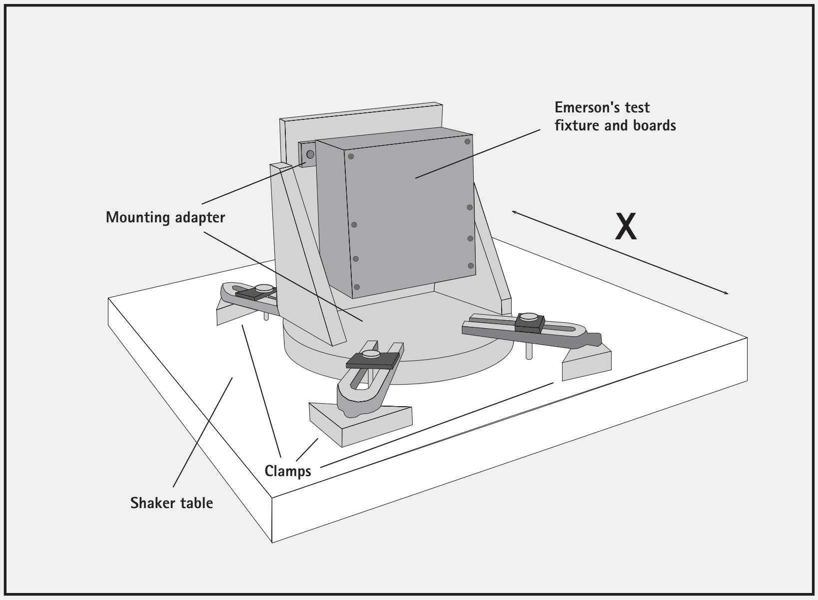

Figure 1: Shelf-level test configuration, X (side-to-side) axis

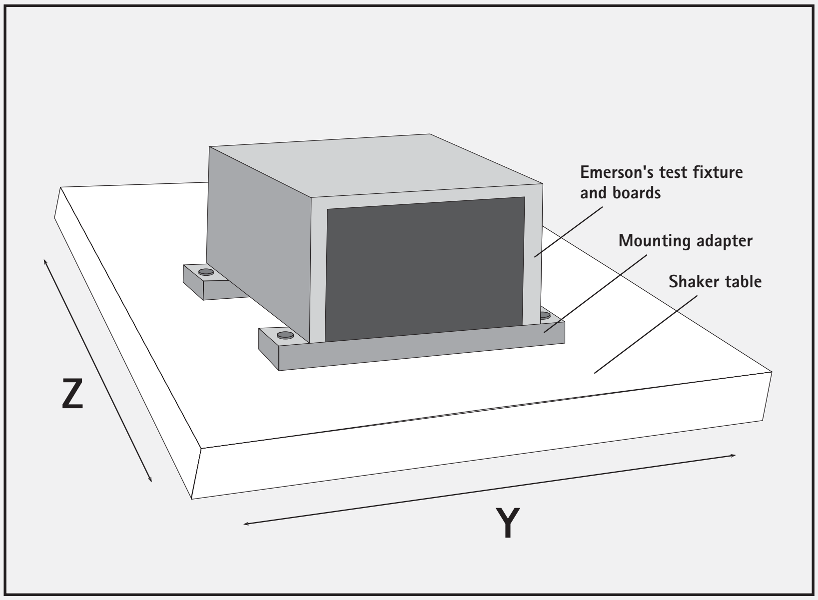

Figure 2: Shelf-level test configuration, Y (vertical) and Z (front-to-back) axes

ing. During shelf-level testing with the test fixture mounted to the shaker table, the forces exerted on the boards would clearly not be equivalent to those exerted when the boards are loaded in the top of a cabinet. We needed to develop corrected test profiles for shelf-level testing that would allow the test fixture to be mounted to the shaker table but exert the same forces on the boards as would be seen when the boards are mounted in the top of a telecommunications cabinet (as per the NEBS GR-63-CORE standard).

Designing a Mounting Adapter

Emerson's test fixture used for vibration testing is designed to be mounted directly to a shaker table and will hold a maximum of four boards for testing. Due to the variations of bolt hole patterns among different shaker tables, the fixture has to be mounted to the table using a clamping system which interferes with one or more of the board slots, limiting the number of boards that can be tested at one time. The engineers at DATASYST designed a mounting adapter so the test fixture could be mounted to the shaker table in all three axes required for testing without blocking access to the board slots. The adapter allows X-axis testing in its standard configuration with the clamps directly attached to the mounting adapter (see Figure 1). It can be easily disassembled and modified to mount the test fixture to the shaker table for testing in the Y- and Z-axes (see Figure 2). Each configuration allows all of the board slots in the test fixture to be used for testing, increasing capacity and saving time. This is a time-saving measure that doesn't sacrifice data accuracy or reliability.

Collecting Data for Corrected Test Profiles

Earthquake testing of telecommunications equipment uses a prescribed waveform called VERTEQII. This is an acceleration over time waveform which was synthesized from several typical earthquakes and known building and soil site conditions. Per the NEBS GR-63-CORE standard, there are three profiles for this waveform. Each has a severity level based upon the specific geographic location of the facility where the equipment will be installed. The risk and historical severity level of earthquakes in a particular location or zone determine which profile is used for testing. Since the installation location of Emerson products is typically not known beforehand, we perform earthquake testing at the worst-case severity level, which is zone 4. The zone 4 pattern is completely random and tests for the maximum vibration from the equipment in response to various frequencies.

A swept sine survey is performed on the equipment before the zone 4 earthquake profile to determine the natural mechanical frequency of the frame or cabinet and to verify that the response spectrum of the equipment falls within the NEBS standard's requirements. The swept sine survey pattern uses predetermined frequencies for a set period of time at each frequency to find resonance.

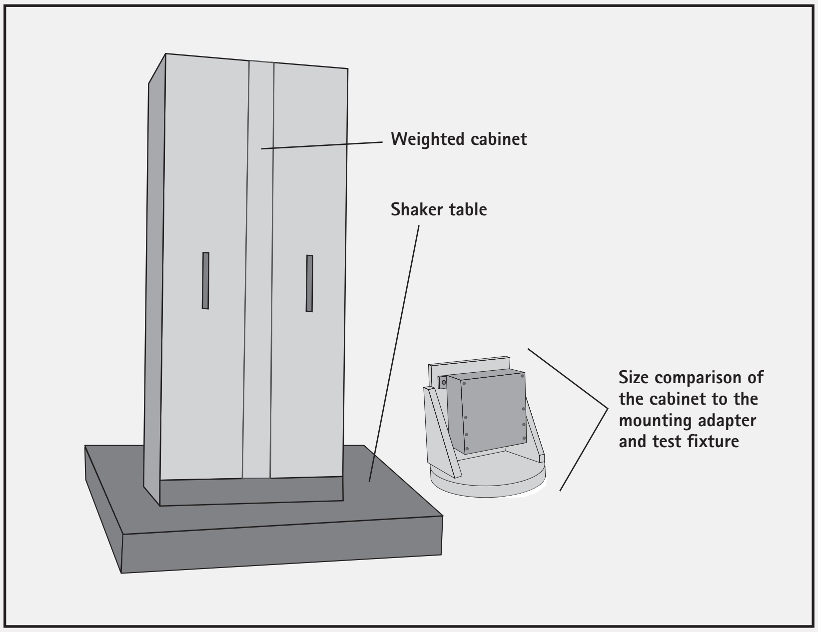

Figure 3: System-level test configuration

As stated earlier, office vibration testing simulates the typical vibration that occurs in an office as a result of nearby construction equipment or outside rail or truck traffic. This test can be performed at any time in the order of the three tests. It uses a pattern similar in nature to the swept sine survey pattern, but with a lower acceleration level and sweep rate, and wider frequency range.

After discussions with DATASYST about the test methodology that would provide Emerson and its customers with the most meaningful and accurate test data, it was decided that DATASYST would perform system-level testing in all three axes for each test to generate corrected test profiles to be used in all future shelf-level testing. Corrected test profiles would encapsulate the worst-case acceleration levels measured at the top of a weighted cabinet. These profiles would be integrated into the office vibration, swept sine survey and zone 4 earthquake profile tests when performed at the shelf level.

For testing, DATASYST used a standard telecommunications cabinet that is normally used for validation of the vibration test equipment. The cabinet was mounted to the shaker table using the mounting points provided at the cabinet base (see Figure 3). Due to the size of the cabinet, two different shaker tables had to be used. A vertical shaker was used for the Y (vertical) axis and a horizontal shaker was used for the X (side-to-side) and Z (front-to-back) axes. Then the cabinet was fully populated with shelves containing equipment to duplicate the mass and stiffness characteristics of a fully loaded cabinet. Accelerometers, instruments that measure acceleration and convert it into an electrical analog voltage, were attached to the shaker tabletop (control) and to the top of the cabinet (response). To simulate the forces at the top of a cabinet in future tests, the response accelerometer reported the acceleration at the top of the cabinet during testing. The cabinet top is where the boards would typically be loaded for testing. However, for this test no boards were

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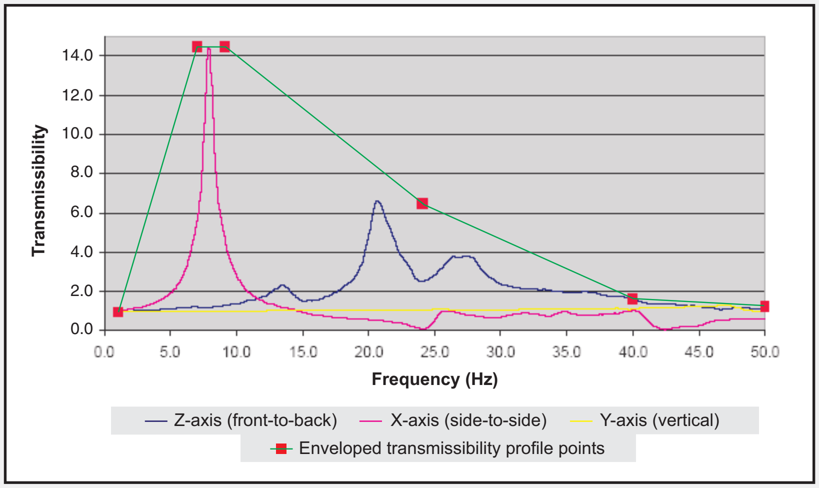

Figure 4: Transmissibility of all three axes for the swept sine survey during system-level testing and the resulting enveloped transmissibility profile

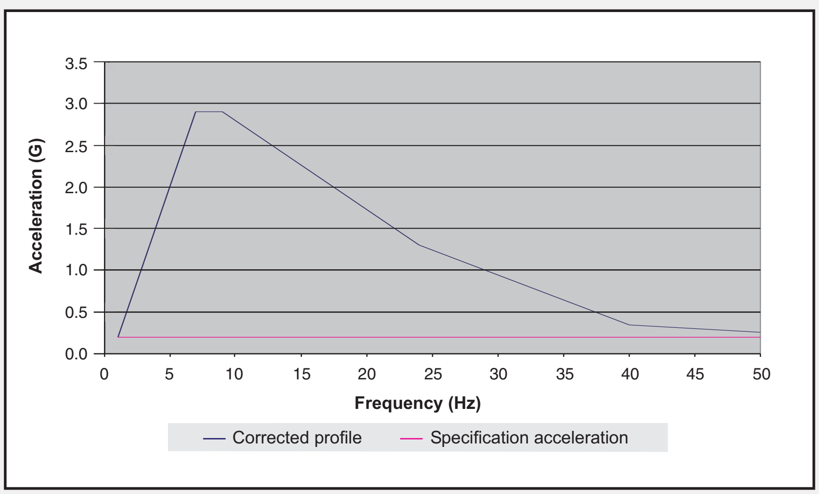

Figure 5: Corrected profile applied during the swept sine survey shelf-level test

loaded since the goal of testing was to collect acceleration data for corrected test profiles.

The loaded cabinet was then exposed to the office vibration, swept sine survey and zone 4 earthquake profile tests, each in the three different axes, one axis at a time. The only deviation from the normal test profile was during the office vibration test. For this test, the normal sweep rate was increased from 0.1 octaves per minute to 0.5 octaves per minute to expedite the test. The swept sine survey was performed to find the natural mechanical frequency of the cabinet for each axis of vibration. For the zone 4 earthquake profile, the vibration controller first had to “learn” the response of the system. This was accomplished by duplicating the desired profile at a low level and gradually increasing to the full level before placing the equipment on the shaker table. Once the profile was reproduced successfully at the full level, the equipment was placed on the shaker table as in Figure 3 and the full test was run.

Creating and Using Corrected Test Profiles for Shelf-Level Testing

The ratio of the data from the response accelerometer at the top of the cabinet to the control accelerometer on the shaker tabletop is called transmissibility. The transmissibility data from the office vibration and swept sine survey tests was used to define the response of the top of the cabinet. After the office vibration and swept sine survey tests were completed, the data from the control and response accelerometers and the transmissibility were saved. After the zone 4 earthquake profile test was completed, the time history and SRS data were saved for the control and response accelerometers. The SRS or “shock response spectrum” is the measured acceleration of the system in one axis at each frequency.

Swept Sine Survey Corrected Test Profile

To create the swept sine survey corrected profile, the transmissibility data taken from each axis during the profile generation (i.e., system-level testing) was imported into a spreadsheet. The data was plotted for each axis and then overlapped to provide a visual representation of transmissibility versus frequency (see Figure 4). A transmissibility profile that enveloped the worst case data points, or the points of maximum transmissibility, for all axes was defined using this data. This profile, which can be seen in Figure 4 as "Enveloped transmissibility profile points," was used to create a corrected test profile for shelf-level testing of all three axes. In Figure 4, "Z-axis (front-to-back)" is the transmissibility measured during Z-axis testing. "X-axis (side-to-side)" is the transmissibility measured during X-axis testing. "Y-axis (vertical)" is the transmissibility measured during Y-axis testing.

The shelf-level testing setup was assembled (see Figures 1 and 2) and the swept sine survey test was performed using the corrected profile in the three axes, one axis at a time. Cables were connected to the boards to verify that they were working properly at all times during testing. See Figure 5 for an example of the corrected profile and specification acceleration. "Corrected profile" is the corrected profile created from the data in Figure 4. "Specification acceleration" is the acceleration specified in the NEBS standard for this test.

Zone 4 Earthquake Profile Corrected Test Profiles

The time history data collected at the top of the rack during the system-level testing was used to make three corrected profiles for the zone 4 earthquake profile testing. See Figure 6 for an example of the zone 4 SRS analysis performed during system-level testing. Since this is a random pattern, the data from testing in each axis could not be combined to make one corrected profile like with the swept sine survey. In Figure 6, "Max

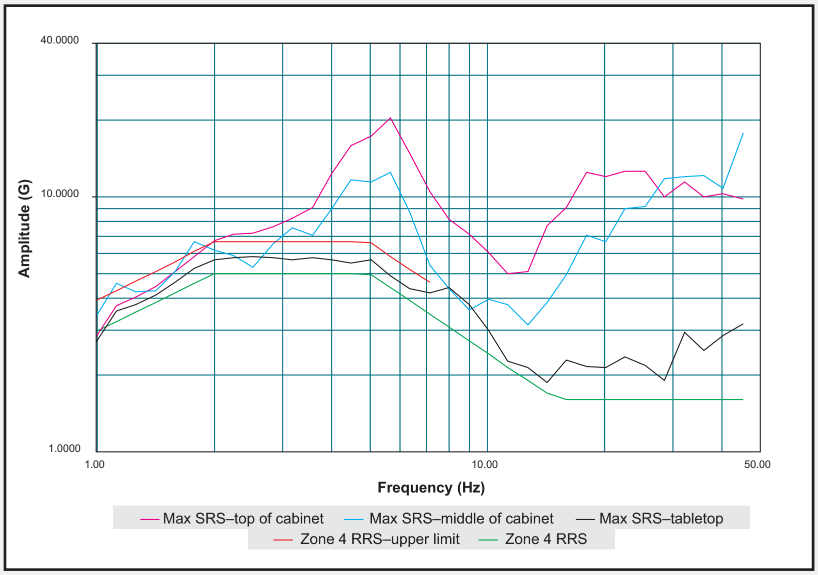

Figure 6: SRS of the X-axis (side-to-side) for the zone 4 earthquake profile during system-level testing

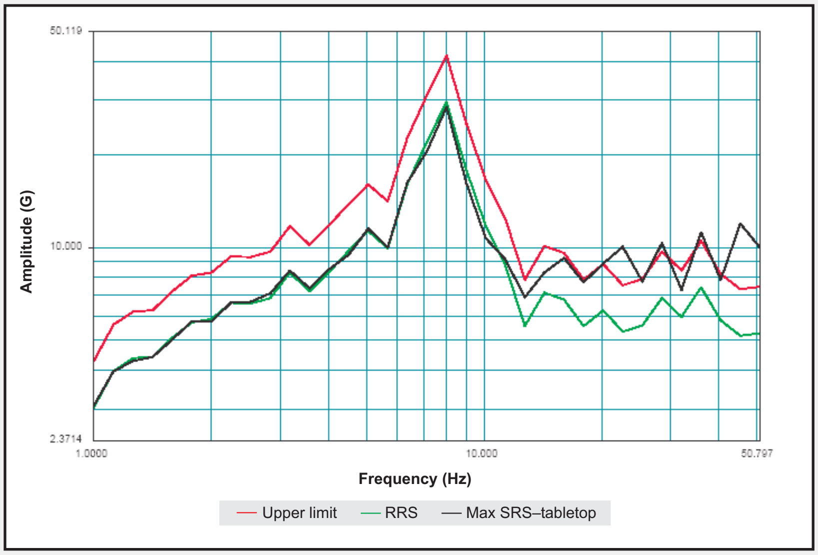

Figure 7: Corrected profile (RRS) applied during the zone 4 earthquake profile shelf-level test for the X-axis (side-to-side)

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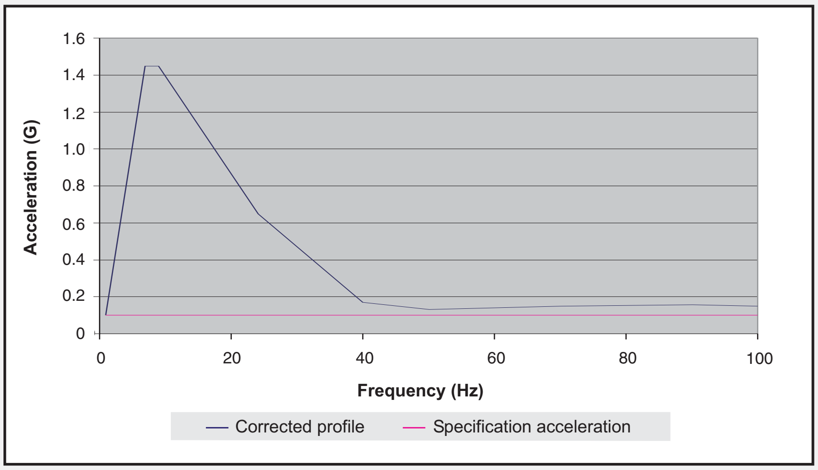

Figure 8: Corrected profile applied during the office vibration shelf-level test

SRS-top of cabinet" is the maximum amplitude of the system measured at the top of the cabinet. "Max SRS-middle of cabinet" is the maximum amplitude of the system measured at the middle of the cabinet. "Max SRS-tabletop" is the maximum amplitude of the system measured from the shaker tabletop. "Zone 4 RRS" is the set of values defining the "required response spectrum" or minimum amplitude that must be met at specific frequencies during the test. "Zone 4 RRS-upper limit" defines the upper limit, from 1 to 7 Hz, for the shaker table RRS.

Before shelf-level testing, the corrected profiles were run on the shaker table with dummy weights in place of the mounting adapter and test fixture. This verified that the table was capable of reproducing the corrected profiles and allowed the controller to learn the new profiles. This also assures that the profile tests will be performed only once at the full level during shelf-level testing and does not subject the equipment under test to unnecessary stresses from multiple runs.

The shelf-level testing setup was assembled (see Figures 1 and 2) and the zone 4 earthquake profile test was performed using the three corrected profiles for their respective axis, one axis at a time (see Figure 7 for an example of the X-axis profile). Cables were connected to the boards to verify that they were working properly at all times during testing. In Figure 7, "Upper Limit" is the RRS plus three decibels. "RRS" is the set of values defining the "required response spectrum" or minimum acceleration that must be met at specific frequencies during the test (this is the corrected profile created from the data in Figure 6). "Max SRS-tabletop" is the acceleration measured at the tabletop.

Office Vibration Corrected Test Profile

The office vibration corrected profile was created similarly to the swept sine survey corrected profile. The transmissibility data taken from each axis during the profile generation (i.e., system-level testing) was imported into a spreadsheet. The data was plotted for each axis and then overlapped to provide a visual representation of transmissibility versus frequency (similar to Figure 4). A transmissibility profile that enveloped the worst case data points, or the points of maximum transmissibility, for all axes was defined using this data. The profile was used to create a corrected test profile for shelf-level testing of all three axes.

The shelf-level testing setup was assembled (see Figures 1 and 2) and the office vibration test was performed using the corrected profile in the three axes, one axis at a time. Cables were connected to the boards to verify that they were working properly at all times during testing. See Figure 8 for an example of the corrected profile and specification acceleration. "Corrected profile" is the corrected profile from the swept sine survey (for 0-50 Hz) and the Max SRS-top of cabinet data from the office vibration system-level test (for 50-100 Hz). "Specification acceleration" is the acceleration specified in the NEBS standard for this test.

Summary

The results from using these corrected test profiles for shelf-level testing were successful. Emerson's boards withstood earthquake and office vibration testing with no operational failures or permanent structural or mechanical damage. The mounting adapter and corrected test profiles proved to be viable solutions. The adapter saved time by allowing use of all of the board slots in the test fixture and by modifying to permit all three axes to be tested quickly and easily. The corrected test profiles increased the applicability of test data by recreating the vibration at the top of a telecommunications cabinet for use during shelf-level testing, allowing use of our test fixture and eliminating the need for a full-size cabinet. Also, developing a business relationship with a local engineering and testing firm allowed for fast turnaround and cost effectiveness.

As testing regulations become more complex, telecommunications equipment manufacturers will need to develop innovative methods of product testing. This article provided an example of how Emerson developed one such method, maintaining a reliable end product while increasing the efficiency of the testing procedure. This test method provides customers with test data that is relevant to their system-level testing. Corrected test profiles are another way Emerson makes strides in continuous product improvement. With the flexibility to exercise creative solutions, Emerson will continue to develop cutting-edge processes, improve product quality and increase product performance.

About Emerson Network Power

Artesyn Communication Products has now become the Embedded Computing business of Emerson Network Power. Emerson Network Power, a business of Emerson (NYSE:EMR), is the global leader in enabling Business-Critical Continuity™. Preparing customers for high-stakes opportunities and threats, Emerson Network Power provides reliable power, precision cooling, connectivity and embedded computing solutions for IT, communications, healthcare and industrial systems. Backed by the largest global services organization in the industry, Emerson Network Power offers network reliability programs encompassing engineering, installation, project management and support services. For more information on the full spectrum of enterprise-wide solutions from Emerson Network Power, visit www.emersonnetworkpower.com.

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