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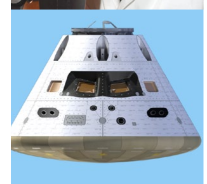


# Best Practices for Use of Sine Burst Testing

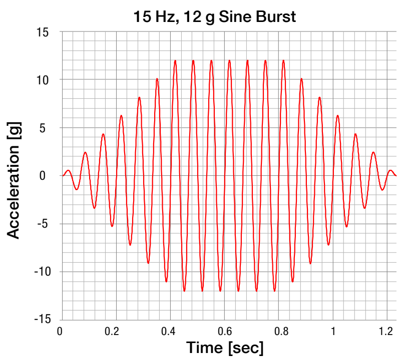
Sine Burst (SB) Testing is used for strength testing of aerospace hardware as an alternate to static pull and centrifuge tests. The main advantage is that testing can be implemented while hardware is on the shaker for other tests. It also imposes a lower number of cycles on the hardware compared with a sine dwell or sweep, and is particularly suitable for relatively stiff components or electronics boxes, instruments, or spacecraft. Identified risks can be mitigated by best practices.

## Background of SB Testing

In the late 1980's, the SB method was used as a means to impart a static load into a component, instrument, or relatively small/stiff spacecraft. The shaker controller is used to apply an enveloped sinusoidal base drive acceleration to the item at a fixed frequency with 5-10 cycles at peak level as shown in the Figure. The test frequency is such that the item response would be pre-resonant or as close as possible to the rigid body mode, usually being no more than 1/3 of the first mode frequency of the test article. Because the test article is being accelerated as a rigid body, a uniform inertial body load is generated in the test article.

## Limitations and Risk of SB Testing

To achieve the target stresses in some areas of the hardware, an over-test may need to be imparted in other areas. Therefore, pre-test analysis is required to verify the stress targets can be achieved within acceptable levels of over-test. Also, if the required load case is unidirectional (say compression), there will be a reversal load (tension) imparted on the article or vice-versa. This is a single axis test so different orientations of the test article may be required to achieve strength qualification. There is a need to monitor the test article for any unexpected dynamic amplification, especially if the applied frequency does not meet the 1/3 of natural frequency guideline.




## SB Testing Risks can include:

- Impacting the shaker stops by exceeding the shaker maximum displacement or stroke.
- Shaker stiction: The controller computes a linear transfer function of acceleration to update the drive for the next level. If the shaker has any stiction (non-linear behavior) at the targeted test levels, the updated drive may be higher than required and impart an unintended over-test.
- An unintended operator action or controller setting, which drives the amplifier to an over-test.
- Drive signal adjustments: If the test procedure is such that intermediate levels require engineering adjustments to the drive signal, the risk is a wrong calculation of this adjustment and would lead to an unintended over-test.
- Lack of independent test over-protection system.
- Incorrect software version in the drive controller.

*For information contact the NESC at www.nesc.nasa.gov*

## Best Practices for SB Testing

**Consider these best practices during the planning and execution phases:**

1) Given the impulsive nature of SB testing, do not count on the shaker displacement soft shut down (SSD) switch and set a proper SB frequency high enough not to exceed the displacement that triggers the SSD.

2) Drive adjustments made by engineering personnel should be independently checked and the test sequence should be restarted from the lower levels.

3) Avoid using SB testing at high levels of assembly or on a complete flight unit. The preference is to use the method with engineering test units, which usually comprise the structure under test with mass simulators.

4) Develop metrics for routinely assessing the mechanical "health" of the shaker and slip table systems.

5) Evaluate the drive signal magnitude and the coherence function estimate between the drive and control accelerometer prior to test continuation. Coherence in the frequency band close to the SB frequency should not be lower than 0.9.

6) Perform a checkout with a mass mockup and compare recorded drive signal voltages at each level during the actual test. Ensure adequate test planning between the analysts, the test engineers, and operators.

7) Review and understand the time history acceleration and or force data collected after each test run, including the controller drive voltage and amplifier output time histories.

8) Reconsider testing via SB any hardware that is inherently non-linear, unless the non-linear nature is understood and accounted for in the pre-test analysis.

9) If any of the risk mitigations fail or a new flaw is discovered, the final defense resides in the use of an independent over-test protection system along with hardware positive margin of safety for the abort setting.

## References


1) NASA Report on High Energy Solar Spectroscopic Imager (HESSI) Test Mishap, (Washington, D.C.: NASA Headquarters, Code S, May 2000)

2) LADEE Spacecraft, Type C Mishap, IRIS Case Number: S–2012–124–00008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