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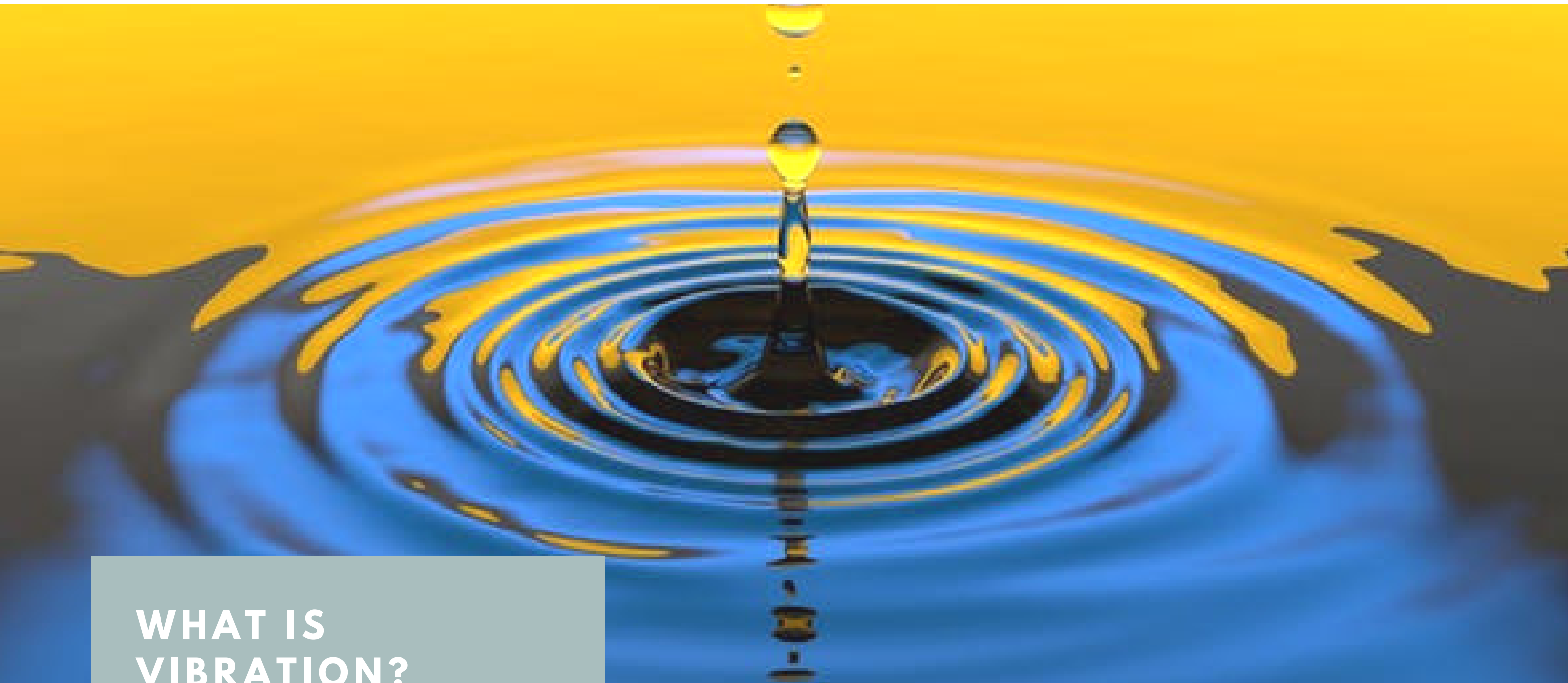
WHY DO WE NEED VIBRATION TESTING?

4 Reasons Why We Need Vibration Testing / Measurement



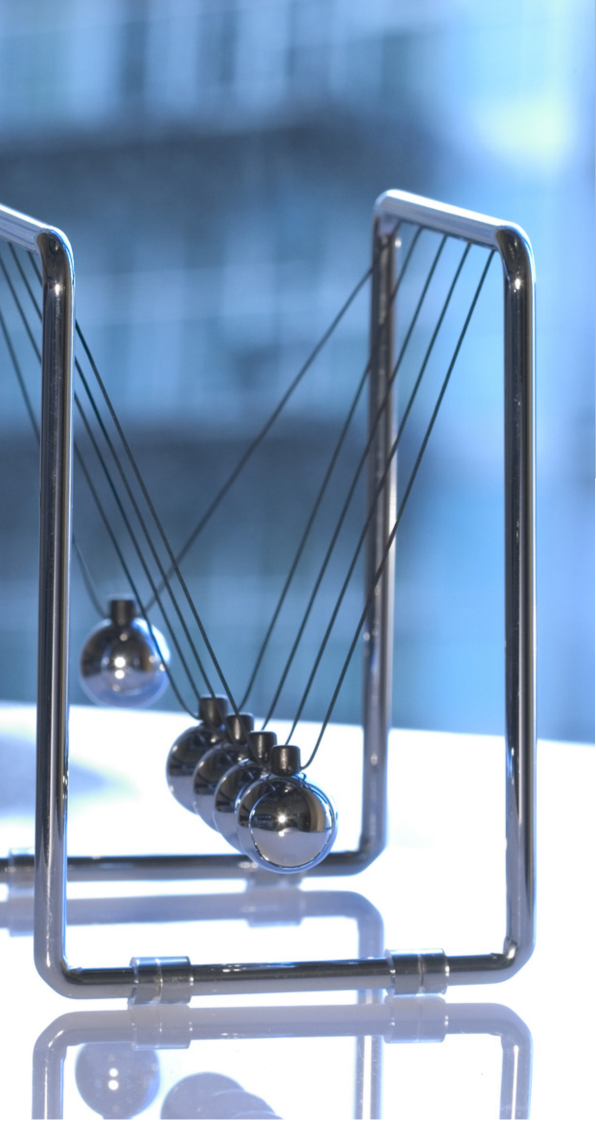
WHAT IS VIBRATION?

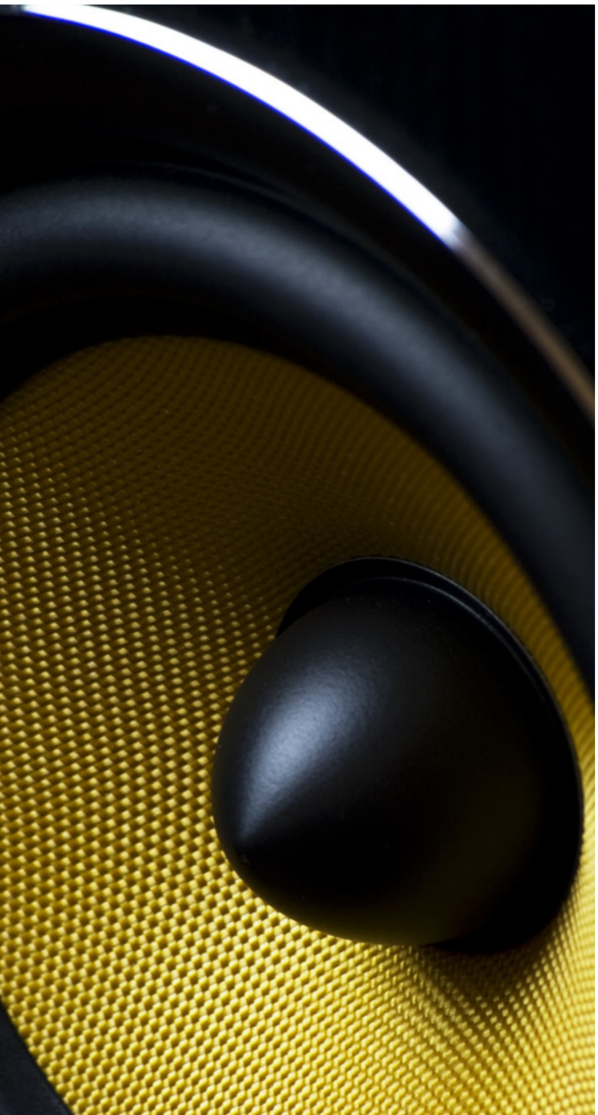
“Oscillation at a certain equilibrium point”

WHY WE NEED VIBRATION TESTING / MEASUREMENT

Vibration testing mimics the conditions that a product or structure might see during its lifetime while under a test environment.

A founding physics principle states that every object vibrates to some degree. That can be at the micro level, where atomic and sub-atomic particles vibrate at slow or fast rates. Vibrations also happen at the macro level, where huge objects experience environmental forces causing them to move. It’s fair to state that vibrations are inescapable facts of life, and they’re necessary factors in a fluid world.





WHY IS NEEDED? READ ON!

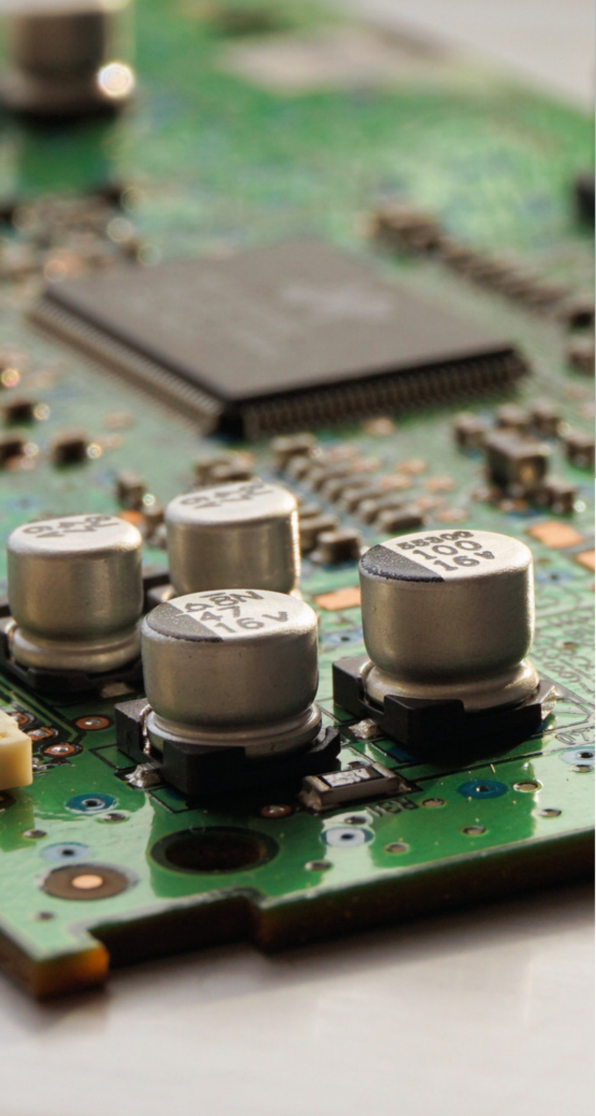
New to vibration testing?

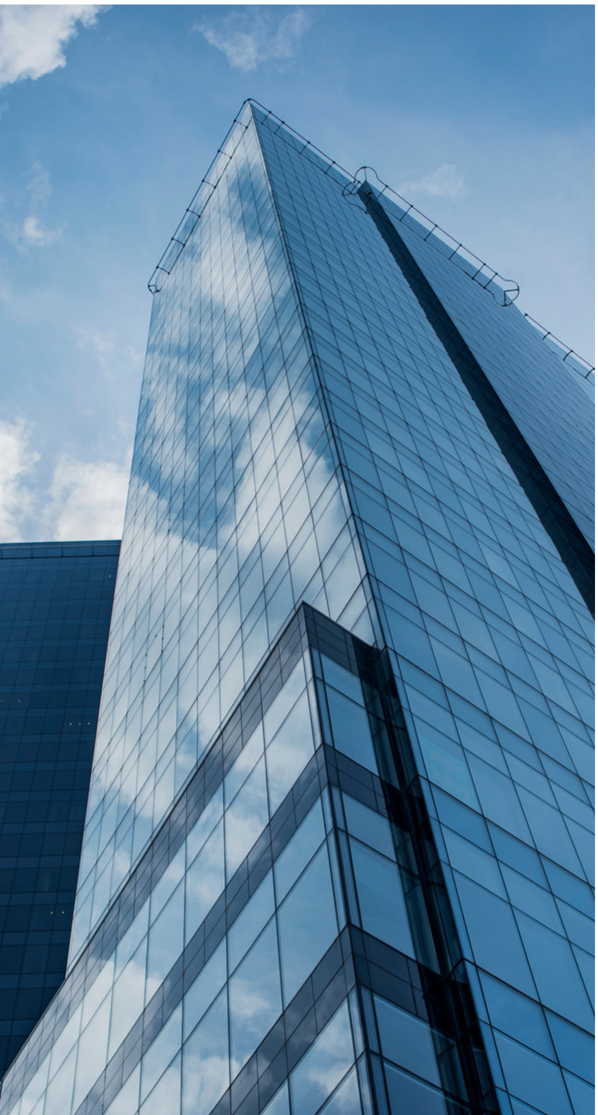
In technical terms, vibrations are mechanical oscillations that respond to forces pushing objects outside their equilibrium or resting point. These highs and lows, or back and forth swings, are measurable. They relate in terms like frequency, waveforms and spectrums. Vibrations respond directly to timed intervals that can be measured using suitable product vibration testing equipment.

Vibrations can be periodic with specific wave intervals, like pendulums in mechanical clocks. Or they can be random, such as vehicle suspensions responding to a rough gravel road. Vibrations can also happen to static devices like electronic equipment sitting on a shelf where external forces cause them to shake. They can also occur in mobile equipment such as engines and fans that produce internal forces, causing them to vibrate.

Many mechanical vibrations are desirable outcomes of planned design. Loudspeakers are good examples where vibrations are intentional to produce sound. However, some vibrations are undesirable and result from improper design or fair wear and tear on equipment out of balance or improperly tuned.

Whether vibrations are intentional or unintentional, there are precise vibration testing services and vibration testing standards available to verify parameters. These vibration testing facilities can determine whether oscillations are inside or out of tolerable range.





WHY IS NEEDED? READ ON!

Why Products Are Vibration Tested?

Products are vibration tested to determine limits and tolerances. Every product is vulnerable to vibration loads and potential breakage or failure. That includes tiny objects like microprocessors and circuit boards right up to giant structures like bridges and skyscrapers.

Vibration testing allows designers, engineers and manufacturers to know what stress limits their product can withstand. Testing through vibrations ensures the product is qualified for its intended purpose and meets safety and regulatory standards, as well as complies with any International Standards Organization (ISO) requirements. Part of due diligence in vibration testing determines fatigue testing, failure limits and structural integrity screening.

Many industries routinely use vibration testing as part of their quality control program. Finding out what vibrations a product withstands before release makes good business sense. Known limitations allow the end user to employ their product safely and put it into trouble-free service. Testing for vibration resistance prevents product recall, supports warranty conditions and provides excellent product purchase value.

VIBRATION TESTING *allows designers, engineers and manufacturers to know what stress limits their product can withstand.*

WHY IS NEEDED? READ ON!

New to vibration testing?

1. To fulfill the development objective

Vibration is everywhere and components are constantly subjected to vibration. Vibration testing can be used to ensure that products are robust and perform safely during operation or transit, avoiding unexpected performance or early life failure in field.
Simulated vibration environments in the laboratory are used to qualify products during design. Design is everything. By bringing testing up front in the design cycle, there are opportunities to gauge product performance and gather insight that will otherwise not be there. If you get it right you have shorten time to market. By doing testing in the design stage you optimize the development stage. Optimization means using data to look into the future and eliminate repeat failures.
The demand for shorter product lifecycle is directly affecting Research & Development (R&D) Department of any industry. R&D Department must shorten the total product development phase. The shorter product development phase will require more advance development, since it has less room for repetitive problems and failures during the prototype testing.
Product development cannot afford to have repetitive failures during prototype testing. Repetitive failures will lead to delay of mass production timing, which will end up with opportunity loss. Starting mass production with an unsolved prototype testing problem, will also provide greater risk of high numbers of product recalls which lead to even greater loss.
Electrodynamic Shaker (ED Shaker) has been utilized for many years to help industries to reduce the product development time. We can use ED Shaker for below task at different stage of product development:

- Lab Scale Component Testing
- Lab Scale Unit Testing
- FEM Validation

WHY IS NEEDED? READ ON!

Reduce the product development time

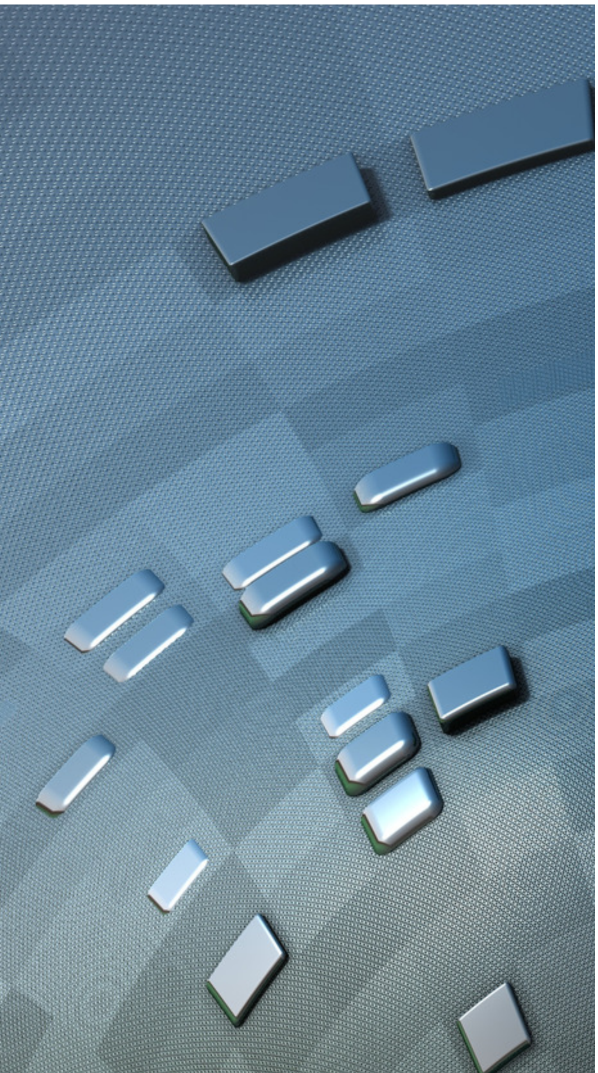
2. To comply with Standards

Simulated vibration environments in the laboratory are used to test products against different standards, e.g. Mil-std 810 etc.. One of the most common test requirements is for qualification of electronics, vehicle systems, and weapons for military applications.

The most common US military standard is MIL STD 810 with various revisions. MIL-STD-810 is a public military test standard that is designed to assist in the environmental engineering considerations for product design and testing. MIL-STD-810 vibration contains test methods and planning for engineering direction for considering the influences that environmental stresses have on material, products or equipment throughout all phases of their service life. Used by the United States Military to test product limits and capabilities that the product will experience throughout its life. MIL-STD-810 vibration testing is also used as a standard for commercial products.

Equally critical is the standardization and minimum performance of aviation equipment. The most common commercial aviation standard in the US is the DO-160 (Environmental Conditions and Test Procedures for Airborne Equipment) published by RTCA, the Radio Technical Commission for Aeronautics. DO-160 is coordinated with the EUROCAE/ED-14 specification from EUROCAE.

As automotive OEMs shifted costs to their suppliers, they also shifted the majority of testing requirements as well. There are many ISO standards geared toward automotive vibration testing, however most qualification acceptance standards are published or provided directly by the automotive OEMs. For instance, GM routinely publishes specifications such as the GMW3172.



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Design is everything

3. *To analyse vibration problem*

If a product has vibration problems, using Modal testing, FRF testing or Operating Deflection Shape, can help to identify and analyse them.

Modal Testing

Modal testing is the form of vibration testing of an object whereby the natural (modal) frequencies, modal masses, modal damping ratios and mode shapes of the object under test are determined. There are several ways to do modal testing but impact hammer testing and shaker (vibration tester) testing are commonplace. Several input signals are available for modal testing, but the sine sweep and random frequency vibration profiles are by far the most commonly used signals. Small objects or structures can be attached directly to the shaker table. With some types of shakers, an armature is often attached to the body to be tested by way of piano wire (pulling force) or stinger (Pushing force). When the signal is transmitted through the piano wire or the stinger, the object responds the same way as impact testing, by attenuating some and amplifying certain frequencies. These frequencies are measured as modal frequencies. Usually a load cell is placed between the shaker and the structure to obtain the excitation force.

FRF Testing

Frequency response measurements are used extensively in modal analysis of mechanical systems. Frequency response functions can have various units and meanings associated with them. For instance, when performing modal analysis, it is most common to measure and calculate accelerance frequency response functions.

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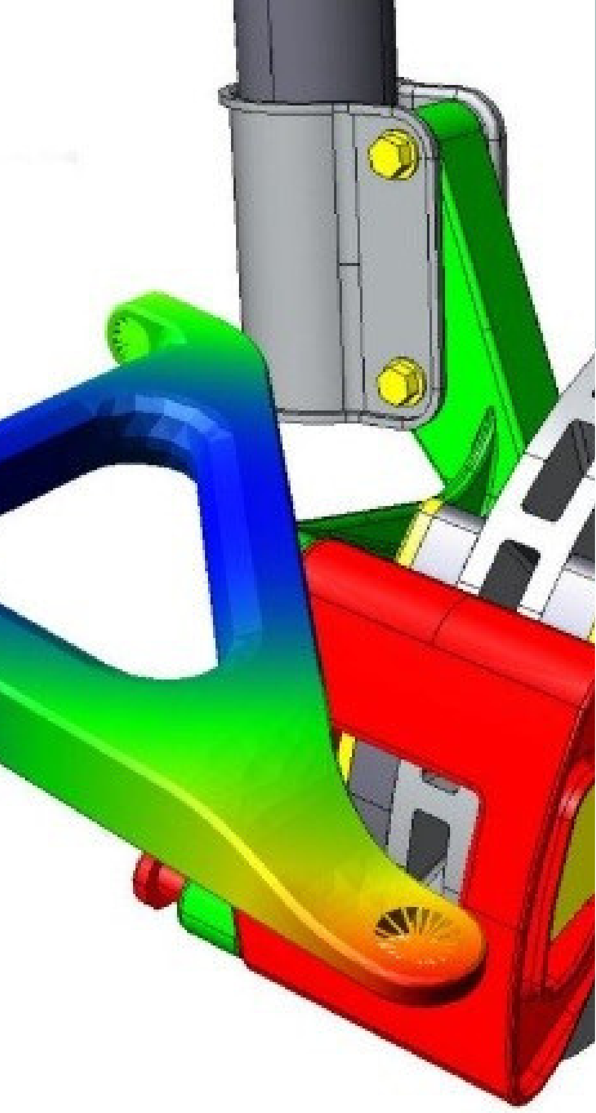
Optimize the development stage

Operating Deflection Shape

Operating deflection shape (ODS), is a term often used in the structural vibration analysis, known as ODS analysis. ODS analysis is a method used for visualisation of the vibration pattern of a machine or structure as influenced by its own operating forces. This is as opposed to the study of the vibration pattern of a machine under an (known) external force analysis, which is modal analysis. Operational Deflection Shapes (or ODS) analysis gives additional insight into noise or vibration problems that individual measurements alone do not.

By using Vibration Shaker, we will be able to perform FRF Testing or Modal Testing. After that, by using suitable DAq, Sensors and Analysis Software, we will be able to see Resonance Frequency and Mode Shape or ODS (Operating Deflection Shape). By knowing the Mode Shape or ODS, we will be able to see the behavior of our product at certain frequency or certain resonance. Finally, by knowing the behavior, we can determine which kind of improvement we need to perform to our product to reduce the vibration level of our product and perform less “trial and error” iteration during product development lifecycle.

Good product designers and manufacturers do preliminary evaluation throughout the production procedure.



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Eliminate repeat failures

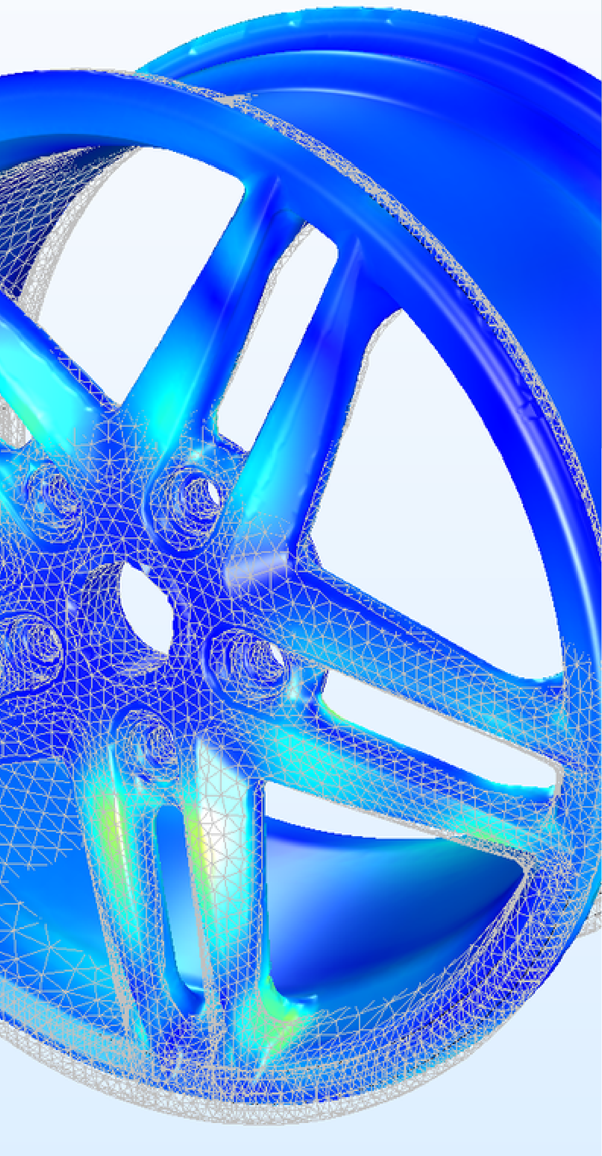
4. To validate Finite Element modelling

Resonance Frequency

In sound applications, a resonant frequency is a natural frequency of vibration determined by the physical parameters of the vibrating object. This same basic idea of physically determined natural frequencies applies throughout physics in mechanics, electricity and magnetism, and even throughout the realm of modern physics.
Bridges, aircraft wings, machine tools, and all other physical structures have natural frequencies. A natural frequency is the frequency at which the structure would oscillate if it were disturbed from its rest position and then allowed to vibrate freely. All structures have at least one natural frequency. Nearly every structure has multiple natural frequencies.
Resonance occurs when the applied force or base excitation frequency coincides with a structural natural frequency. During resonant vibration, the response displacement may increase until the structure experiences buckling, yielding, fatigue, or some other failure mechanism.

Frequency Response Function

There are many tools available for performing vibration analysis and testing. The frequency response function is a particular tool.
A frequency response function (FRF) is a transfer function, expressed in the frequency domain.
Frequency response functions are complex functions, with real and imaginary components. They may also be represented in terms of magnitude and phase.
A frequency response function can be formed from either measured data or analytical functions.
A frequency response function expresses the structural response to an applied force as a function of frequency.



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Shorten time to market

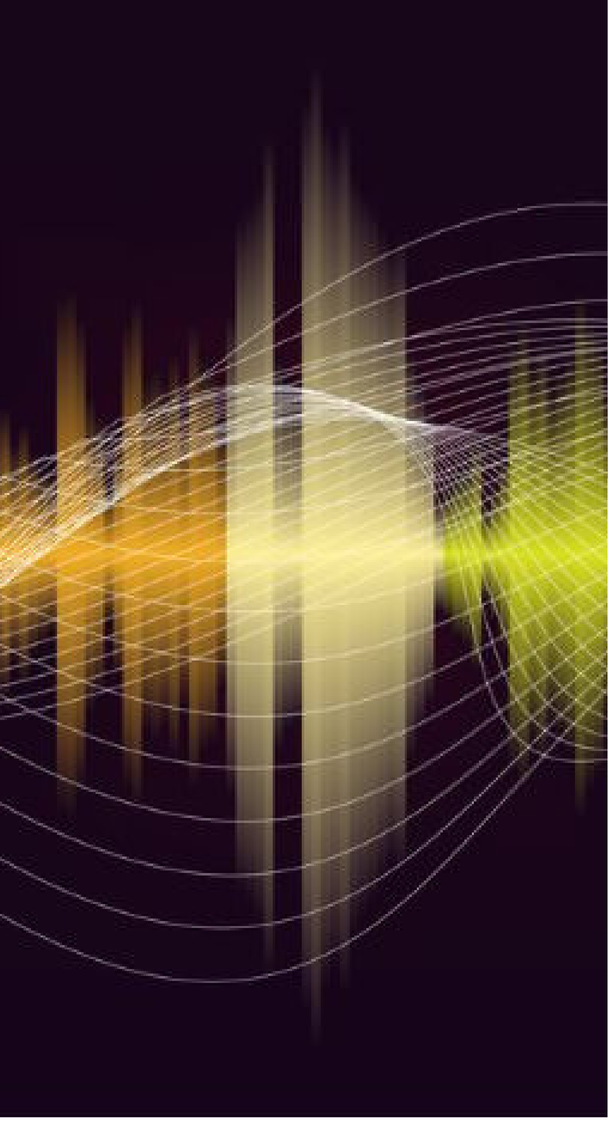
The response may be given in terms of displacement, velocity, or acceleration. Furthermore, the response parameter may appear in the numerator or denominator of the transfer function.

Mode Shape

A mode of vibration is characterized by a modal frequency and a mode shape. It is numbered according to the number of half waves in the vibration. A mode shape is a specific pattern of vibration executed by a mechanical system at a specific frequency. Different mode shapes will be associated with different frequencies. The experimental technique of modal analysis discovers these mode shapes and the frequencies. For example, if a vibrating beam with both ends pinned displayed a mode shape of half of a sine wave (one peak on the vibrating beam) it would be vibrating in mode 1. If it had a full sine wave (one peak and one trough) it would be vibrating in mode 2. Basically, the mode shapes of a system are obtained when you calculate its response due to initial conditions only.

By using Vibration Shaker, we will be able to perform FRF Testing or Modal Testing. After that, by using suitable DAq, Sensors and Analysis Software, we will be able to obtain below results:
- Resonance Frequency
- Mode Shape
- Damping Ratio

We will be able to use these data to validate our FEM (Finite Element Model) Simulation. By having FEM Simulation validated, we will be able to use it to predict the vibration response of our product and improve the design even before the prototyping stage. This will even shorten the “trial and error” iteration during product development lifecycle.



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Types of Vibration Testing

There are two distinct vibration testing types. One is **preliminary vibration testing** where devices undergo a rigorous and sophisticated examination to help improve product design. This normally happens in a clinical setting like a shock and vibration testing lab or research and development facility.

Vibration testing and analysis allows manufacturers to stretch stresses and strains to the breaking point. This sets product parameter limits and maximum tolerances. Knowing limitations is extremely important in critical evaluations like spacecraft vibration testing.

The other type of vibration testing type is **secondary evaluation**. This applies to products and equipment already in service. Vibration testing is invaluable for maintaining peak performance or predicting potential failure. Expensive, dangerous or catastrophic failures happen when huge machines suffer vibrations from internal or external forces causing them to wear, stop or explode.

Both vibration testing types are ounces of prevention paying off in pounds of cure. Good product designers and manufacturers do preliminary evaluation throughout the production procedure. Engineers plan for vibration loads and tolerances, but they can only do so much on a computerized model. At some point, products need vibration testing in the real world and under actual force loads.

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Controlled Vibration Testing

Vibration testing in a controlled facility is a precise and exacting procedure. Trained professionals use sophisticated machines to test all types of products for vibration tolerances. Generally, the larger the product is, the bigger the testing machinery needs to be. Testing weights can go from a few ounces to thousands of pounds.

Vibration testing equipment pieces are often called shakers. That's a simplistic term for a complicated instrument. In its essence, vibration testing comes down to shaking a product. However, the way it's done and the manner data extracts take a lot of experience to get meaningful information.

Products being vibration tested in a specialized testing facility are fixed to a table on top of the mechanized shaking instrument. Most vibration testing machines have some type of clamping device that holds the unit being tested to the vibration table. Some clamps are spring activated. Other units secure their unit through multiple bolts and restraining plates referred to as a test fixture. Test fixtures are often custom built for the specific part being tested.

Once secured, the vibration instrument, or shaker, activates through operator-controlled power amplifiers and exciter controls. These variable adjustments let the vibration analyst vary the rate and speed of vibrations introduced to the device under testing (DUT). Two varied measurements gather meaningful data from the vibration test, allowing the analyst to conclude the product failure point. Measurements include:

WHY IS NEEDED? READ ON!

Controlled Vibration Testing

Frequency: This is the number of vibrations or peaks of vibration passing a given point in a given time. Like light and electrical waves, vibration frequencies use the Hertz measurement. That standard is one peak every second. Many vibration tests record oscillations in the kilohertz range with a thousand or more cycles per second.

Amplitude: This measurement records the maximum extent of vibrations or oscillations taken from the point of equilibrium. Amplitude is a highly variable figure and depends on the amount of force applied to a DUT as well as the duration of its test cycle runs. Vibration analysts express amplitude in peak value terms, also using the Hertz scale.

Computerized recordings of vibration tests give the analyst two types of information. This lets the analyst know what's happening to the DUT when they change stress levels like resonance resistance, amplitude scales and frequency alternations. The two computer scales include:

- Waveform information that shows what happened from one moment to the next during vibration testing.
- Spectrum information that summarizes everything that happened while the vibration testing data was gathered.

WHY IS NEEDED? READ ON!

Sine and Random Vibration Testing

The two common vibration tests involve frequencies introduced in either sine or random vibration patterns. Sine is a linear vibration pattern that's also referred to as sinusoidal vibration testing. It involves vibrations administered at the same rate throughout the test.

SINE VIBRATION TESTING involves vibration administered at exactly the same rate throughout the test.

RANDOM VIBRATION TESTING involves shakers that let the operator introduce vibrations at a totally random and unpredictable rate.

Sine vibration testing is suitable for low-risk products intended for light- and medium-duty applications. That's fine for many products, but the real world is far from static. Heavy-duty products have all sorts of vibration challenges that range from low frequency and amplitude oscillations to extremely high conditions.

Advanced vibration testing usually uses random vibration patterns. Sophisticated shakers let the operator introduce vibrations at a random and unpredictable rate. This gives the DUT wide exposure to changing conditions they'd expect to find outside of the controlled facility and out in the real world.

WHY IS NEEDED? READ ON!

Industries Using Vibration Testing

Many different industries use vibration testing as part of their manufacturing process. Leading manufacturers want to ensure product reliability. Vibration testing is part of building credibility, and it also protects the manufacturer's integrity and reputation. These are some of the industries that typically use vibration testing during product development:

- **Aerospace manufacturers** ensure highly sensitive components can withstand enormous takeoff forces as well as extreme space conditions.
- **Automotive manufacturers** minimize flaws in ride and handling by vibration testing many parts prior to installation on the production line.
- **Aviation manufacturers** avoid parts and system failure like wing movements and engine pressures by vibration testing.
- **Consumer goods manufacturers** involve vibration testing to ensure products withstand everyday rigors in household use.
- **Defense departments** employ vibration testing in equipment and weapons systems to make sure they can be safely transported and used in the field of battle.
- **Electronic manufacturers** test complex parts for potential breaking by running prototypes through vibration testing.
- **Marine manufacturers** reduce driveline wear and hull fatigue by having vibration testing done in controlled facilities.
- **Medical equipment manufacturers** prevent failure in life-saving hospital equipment by having parts vibration tested.
- **Oil and gas manufacturers** rely on vibration testing to prevent production problems in a highly volatile industry.
- **Power generation stations** also use vibration testing to make sure high-voltage equipment operates safely and dependably.

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ETS Solutions Asia Pte Ltd
No. 1 Kaki Bukit Road 1, #03-20 Enterprise One,
Singapore 415934
Tel: +65 6340 1036
Email: sales@etssolution-asia.com
Website: www.etssolution-asia.com