HANDBOOK

Key Factors to Consider When Configuring a Vibration Measurement System

By Stephen Hanly
VP of Sales & Marketing
Midé Technology Corporation

Contents

Key Factors to Consider When Configuring a Vibration Measurement System

The ability to measure, monitor and analyze vibration is essential to many industries and areas of research & development. Unfortunately, the proper methods of creating an accurate and repeatable vibration measurement system are not always clear to engineers unfamiliar with the nuances of test equipment and vibration analysis. This handbook offers an overview of some of the challenges associated with vibration measurement, including proper component selection, signal conditioning, system configuration and setup, and waveform analysis.

Vibration Sensors

Let's start with the basics: vibration is defined as oscillating motion about a position of equilibrium. Some common examples of vibration measurement include monitoring an electric motor, turbine or bearing, health monitoring, and resonance detection.

Accelerometers are widely used to monitor vibration in aerospace, automotive and manufacturing applications. Mechanical engineers often use them to diagnose problems with rotating equipment or assess the stability of structures that are subject to periodic stresses (such as monitoring the vibrations caused by trains/trucks crossing bridges, etc.) They are also often used in monitoring for condition-based maintenance, allowing engineers to examine the vibrations produced by a piece of equipment to assess its health, and monitoring the stresses sensitive equipment undergoes during transportation.

The most common method of acquiring vibration data involves connecting accelerometers and configuring them into a data acquisition system that can deliver high-resolution (24-bit) vibration data at very high sample rates. Modern data acquisition systems can plot, log, filter, and analyze vibration data in real time, and allow using a variety of accelerometer types. They can even allow for wireless streaming of vibration data over Wi-Fi if properly configured.

A variety of other tools and techniques are also available for vibration measurement, depending on the application.

Selecting an Appropriate Accelerometer

As mentioned previously, accelerometers are the most commonly used sensor type for vibration measurement. When mounted directly on (or in) a vibrating structure, an accelerometer proportionally converts mechanical energy to electrical energy. Acceleration is generally represented with the gravitational constant *g*, which equals 9.81 m/s^2. Three main types of accelerometers are used for vibration test:

- ***Piezoelectric accelerometers*** are the most popular and widely used for industrial applications. Their lead zirconate titanate (PZT) sensing elements produce electric charge or output under acceleration. Piezoelectric accelerometers have very low noise and offer performance superior to capacitive MEMS or piezoresistive accelerometers in all vibration and most shock applications. Many variants are available: triaxial or single axis, from high sensitivity types for seismic applications down to low sensitivity for shock testing; some types are designed to handle the most extreme environments, even nuclear ones. Their most significant downside is that they are AC coupled, so they can't measure the gravity vector or sustained accelerations.

- ***Capacitive MEMS (micro-electro-mechanical systems) accelerometers*** are the smallest and least expensive accelerometer options and are often used in smart phones. They can be mounted directly to printed circuit boards, which has made them electrical engineers' preferred choice. Although their low cost and small size have made them popular, they offer significantly lower data quality, especially on the higher frequency and amplitude end. They are generally unsuitable for industrial applications; but they are a DC coupled and a great option for human-based applications. Their low cost and power consumption also make them a good choice for health monitoring.

- ***Piezoelectric accelerometers*** are the foremost type for shock testing, but they are preferred for vibration measurement. Because they are based on strain gauges, they require the use of amplifiers and temperature compensation, they offer very wide bandwidth (from 0 to several thousand hertz) and low noise characteristics. They can be gas or fluid damped, which protects the accelerometer and prevents it from reaching its internal resonant frequency. Because they are DC coupled, their output can be integrated to calculate velocity and displacement during shock events.

  - Charge mode piezoelectric accelerometers are extremely durable because of their ability to withstand hostile conditions, including extreme temperatures (-200°C to +400°C); some can even operate in nuclear environments. However, their high impedance requires the use of special cabling for noise shielding. A charge amplifier is also required, which adds to system cost and complexity.

  - Voltage mode Internal Electronic Piezoelectric (IEPE) accelerometers have become the most commonly used accelerometer type. They are very similar to charge mode piezoelectric accelerometers but include a built-in charge amplifier. That eliminates the need for special cabling and simplifies integrating them into a system. A constant DC power source is required, which many data acquisition systems now include. The microelectronic circuit built into these accelerometers means they can't match a charge mode accelerometer's ability to tolerate hostile environments, but their typical temperature range of -40° to +125°C is sufficient for the majority of applications.

As with any type of sensor, ensuring vibration measurement accuracy depends on choosing the right accelerometer for the specific application. In many cases, the accelerometer is the most critical link in the measurement chain. For example, for shock testing that requires integrating the acceleration data for velocity or displacement, choose either a capacitive MEMS or piezoresistive accelerometer. Piezoelectric accelerometers are ideal for vibration measurement, but special high sensitivity accelerometers are needed for lower frequency applications. Table 1 offers guidelines on which accelerometer type is best suited to various applications.

Want to learn more?

Read more about choosing accelerometers for vibration measurement:

- Shock & Vibration Overview eBook
- Accelerometers: Taking the Guesswork out of Accelerometer Selection
- Accelerometer Specifications: Deciphering an Accelerometer's Datasheet
- Cheat Sheet: Accelerometer Datasheet Specifications
- Piezoelectric Accelerometers: Mysteries On How They Work… Revealed!
- Piezoelectric Accelerometers: Theory and Application
- Piezoelectric Accelerometers and Vibration Preamplifiers
- 6 Ways to Measure Vibration

	Slam Stick C	Slam Stick X	Slam Stick S
Application	**Capacitive MEMS**	**Piezoelectric**	**Piezoresitive**
Static Acceleration (0 Hz, 1 g) Gravity, Sensor Orientation	✓		✓
G Force (0 Hz, <25 g) Rocket, Centrifugal, Aircraft	✓		✓
Seismic (<1 Hz, <1 g) Earthquake, Waves, Bridges		✓	
Low Frequency Vibration (<5 Hz, <25 g) Human Motion, Robotics	✓	✓	✓
General Vibration (5 Hz to 500 Hz, <25 g) Electric Motor, Car Suspension	✓	✓	
High Frequency Vibration (>500 Hz, <25 g) Gear Noise Analysis, Turbine Monitoring		✓	
General Shock (<100 Hz, <200 g) General Testing, Shock Absorber Testing	✓	✓	✓
High Impact Shock (<250 Hz, >200 g) Drop Testing		✓	✓

For more information on accelerometer types and what's best for your application refer to Midé's blog post on Accelerometer Selection.

Table 1. Applications of various accelerometer types.

Non-accelerometer Contact Vibration Sensors

Strain Gauges

An accelerometer is one type of contact vibration sensor, but there are several other types, including strain gauges. A strain gauge is essentially a foil with an electrically conductive grid. As the strain gauge is stretched or compressed, the electrical resistance of the grid increases or decreases proportionally. The main advantage strain gauges offer is that they are versatile and accurate; they can be installed on virtually any surface and shape, and they measure both static and dynamic loads. They also measure strain directly, so that calculating the stress in the material is fairly easy.

Strain gauges are also very small, and lightweight, so they don't really alter the overall stiffness of the test specimen. Relative to other types of vibration sensors, they are inexpensive, ranging from just a few dollars for a basic one to a few hundred for very high-quality ones.

Their downside? They are difficult to install properly; strain gauges must be perfectly bonded to the material across the entire face to strain with the test article. Also, the electronics necessary to amplify the signal and acquire the data are costly (upwards of $10,000) and cumbersome.

Electromagnetic velocity sensors

Electromagnetic velocity sensors, although increasingly difficult to source, offer the advantages of measuring velocity directly and a very high temperature range. They operate by using the current generated from a magnet traveling within a coil.

Gyroscopes or Angular Rate Sensors

In contrast with accelerometers, which measure linear acceleration, gyroscopes measure angular rate. Instead of an output expressed in g's, the gyroscope's output is a rate value, typically displayed as degrees per second (°/s).

Gyroscopes provide a frame of reference that is impossible to obtain with an accelerometer alone (or even a bunch of accelerometers). Accelerometers measure inertial forces, so they can help provide a frame of reference in relation to gravity, but that reference becomes difficult to maintain when the accelerometer is also vibrating. An accelerometer can also get "disoriented" during events with sustained static accelerations (like a banking aircraft) that can be misinterpreted as the gravity vector. The gyroscope, however, allows the system to know the true course of motion. When used in conjunction with accelerometers, gyroscopes help keep track of the orientation of the system. Gyroscopes aren't usually used alone for vibration measurement, but when paired with accelerometers, offer a much more complete picture of the vibrating environment.

Non-contact Vibration Sensors

Not all vibration sensors require direct contact with the source of the vibration:

» ***Microphone or acoustic pressure sensor***: Microphones offer a cost-effective way to measure high-frequency vibration and are especially useful to determine how a system's vibration changes with time. Health monitoring applications can greatly benefit from using a microphone on cost and simplicity. Microphones can also provide a very clear and accurate representation of the frequency content in a vibration.

» ***Laser displacement sensor***: Laser displacement sensors use triangulation with a transmitting and receiving lens. A laser beam is emitted toward the target through a transmitting lens. The light then reflects back towards the sensor and is directed by a receiver lens to a receiving element. As the target moves closer and farther away, the angle of the reflected light changes (it's focused on a different position on the receiving element). Displacement sensors are preferable in applications that prevent the use of accelerometers, such as rotating components, or when the accelerometer's mass would have too much influence on the motion of the system.

» ***Eddy current or capacitive displacement sensors***: These sensors have similar advantages and disadvantages as lasers for vibration measurement. Although they offer a way to "measure vibration through the air" without altering the vibrating system, they can only measure relative motion; they need to remain fixed and measure the difference in motion of a nearby structure. As a result, they are best used only in the lab, given the fragility of the test system (expensive sensors, wiring concerns, and power supplies).

Want to learn more?

Read more about alternative vibration measurement methods:

- Vibration Sensor Types and Where to Buy Them
- Shock & Vibration Overview eBook
- 6 Ways to Measure Vibration

Implementing Signal Conditioning

Inadequate signal conditioning can be a significant source of vibration measurement error. Signal conditioning is the manipulation of the analog signal output of a sensor to prepare it so the data acquisition system's digitizer can measure the signal effectively and accurately. In fact, signal conditioning is among the most important components of a data acquisition system because, unless real-world signals are optimized for the digitizer chosen, the accuracy of the measurement will be uncertain.

Signal conditioning for accelerometer-based vibration measurement can include:

» ***Filtering***: Filters reject unwanted noise within a certain frequency range. Low-pass filters are often used to block out noise in electrical measurements. Filtering can also prevent aliasing from high-frequency signals by using an anti-aliasing filter to attenuate signals above the Nyquist frequency (the minimum rate at which a signal can be sampled without introducing errors, which is twice the highest frequency present in the signal). Anti-aliasing filters are a form of low-pass filter characterized by a flat passband and fast roll-off. Because accelerometer measurements are commonly analyzed in the frequency domain, anti-aliasing filters are ideal for vibration applications.

» ***Amplification***: Amplifiers increase the signal's voltage level to match the analog-to-digital converter (ADC) range, thereby increasing the measurement resolution and sensitivity. In addition, locating external signal conditioners closer to the signal source improves the measurement signal-to-noise ratio by magnifying the voltage level before it is affected by environmental noise.

» ***Isolation***: Electrical isolation breaks the galvanic path between the input and output signal. In this way, unwanted signals on the input line are prevented from passing through to the output. Isolation is required when a measurement must be made on a surface with a voltage potential far above ground. Isolation is also used to prevent ground loops. Voltage signals that fall well outside the range of the digitizer can damage the measurement system and injure the operator. For that reason, isolation is usually required in conjunction with attenuation to protect the system and the user from dangerous voltages or voltage spikes.

» ***Excitation***: Many types of transducers, including accelerometers, require external voltage or current excitation. Accelerometers often have an integrated amplifier, which requires current excitation provided by the measurement device.

» ***Linearization***: Linearization involves converting a non-linear input signal to a linear output signal. It is necessary when sensors produce voltage signals that aren't linearly related to the physical measurement.

Want to learn more?

Read more about signal conditioning for accelerometers in vibration measurement:

- The Engineer's Guide to Signal Conditioning
- Introduction to Signal Conditioners

Choosing and Configuring the Data Acquisition System Hardware

Once the analog signal from an accelerometer (or whichever sensor type you've chosen) is properly conditioned, it must be converted to a digital signal and recorded. When evaluating data acquisition hardware for a specific application, consider these selection criteria:

» ***Sensor compatibility***: The sensor selection will often dictate what type of data acquisition system is appropriate based upon the sensor's output. Does the sensor have a digital output? What is the output range? Low sensitivity sensors may require amplification of their output. A data acquisition system that can provide the excitation voltage to power the sensor can eliminate the need for external power supplies, simplifying the measurement system setup significantly.

- ***Maximum sampling rate***: Best practices call for sampling the signal at a rate 10 times greater than the upper end of the frequency range of interest to capture the vibration profile accurately. For most shock and vibration measurement applications, a data acquisition system requires a sample rate of at least a few thousand hertz, but it all depends on the frequency range of interest. For example, consider the sample of vibration data recorded on a test aircraft shown in Figure 1. The data, which was sampled at 2,500 Hz, is made up of many different frequencies, ranging from 50 to 600 Hz. However, if this same dataset were sampled only at 500 Hz (as indicated by the dashed red line), the vibration environment would appear much different and would be inaccurately represented. General guidelines on the appropriate sample rate are >10,000 Hz for shock testing, >5,000 Hz for general vibration, and ~1,000 Hz for slower vibration or movement.

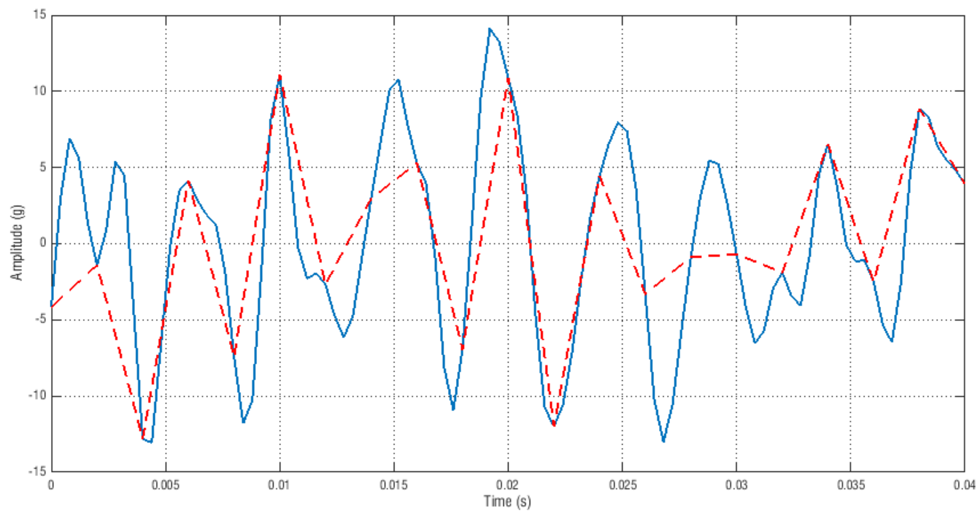


Figure 1. This vibration data was sampled at 2,500 Hz during a test flight. Sampling at only 500 Hz (the dotted red line) would have produced a misleading representation of the vibration.

- ***Measurement resolution***: Resolution is generally specified in bits, which can then be used to calculate the resolution in acceleration units. For example, consider an accelerometer system with 16-bit resolution; in other words, it has 216 (65,536) acceleration levels or bins it can measure. Figure 2 illustrates the importance of resolution on a simple 60 Hz sine wave with two lines of different resolutions. An instrument with 5-bit resolution provides 25 discrete acceleration levels that can be detected, while 3-bit resolution only provides 23 or 8 discrete levels. Data acquisition systems typically have resolution on the order of 16 or 24 bits. Lower quality shock and vibration data loggers, however, may only have 12-bit resolution or less, which may not be sufficient for some applications.

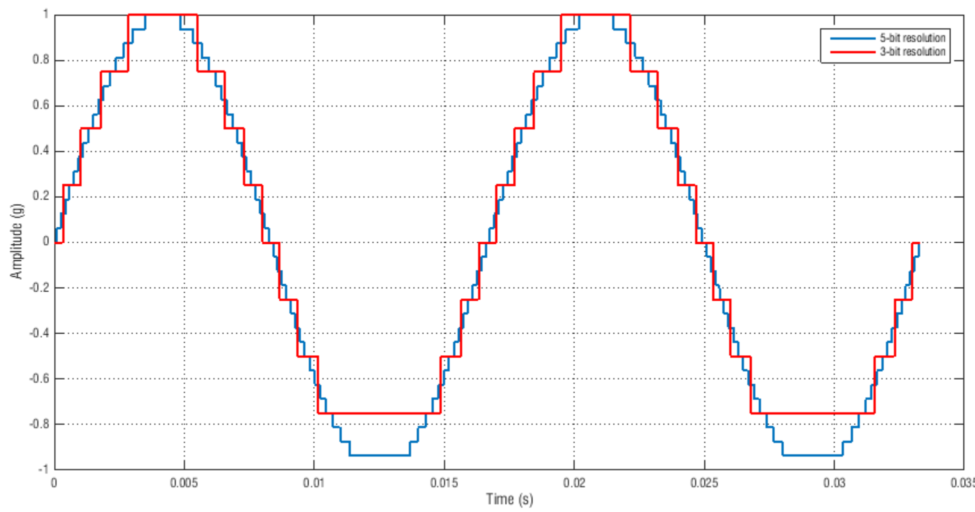


Figure 2. A 5-bit 1g sine wave (blue) compared with a 3-bit version of the same sine wave (red).

» ***Filtering capabilities***: As mentioned previously, filtering removes unwanted frequency content and should be an important part of any evaluation of different data acquisition systems. High-pass filters remove lower frequency vibration and are inherent in all piezoelectric accelerometers (resistor and capacitor in series), which gives these accelerometers the AC response. Analog low-pass filters are crucial to preventing aliasing; once a signal is aliased, it can't be filtered out digitally in software which can't be filtered out in software.

An ideal filter would uniformly pass all frequencies below a specified limit and eliminate all above that limit. This ideal filter would have a perfectly linear phase response to the same upper frequency limit. But given that ideal filters don't exist; some compromise is necessary on a filter's amplitude and phase response. Four main different types of filters are used:

1. ***A Butterworth filter*** is known for its maximally flat amplitude response and a reasonably linear phase response. The Butterworth filter is the most popular for vibration measurement.

2. ***The Bessel filter*** has nearly perfect phase linearity so it is best suited for transient events like shock testing. It has a fairly good amplitude response but its amplitude roll-off is slower than the Butterworth or Chebyshev filter.

3. ***The Chebyshev filter*** has a faster roll-off in the amplitude response, which is achieved by introducing a ripple before the roll-off. These filters have a relatively nonlinear phase response.

4. ***Elliptic filters*** have the steepest roll-off in the amplitude response, but they have a ripple in both the pass band and stop band. In addition, their phase response is highly nonlinear. This is only used for applications where phase shift or ringing are not a concern; they also have a tendency to distort complex time signals.

The best filter for a particular application will depend on the application, but in general, the Butterworth filter is best for vibration and the Bessel is best for shock testing.

Want to learn more?

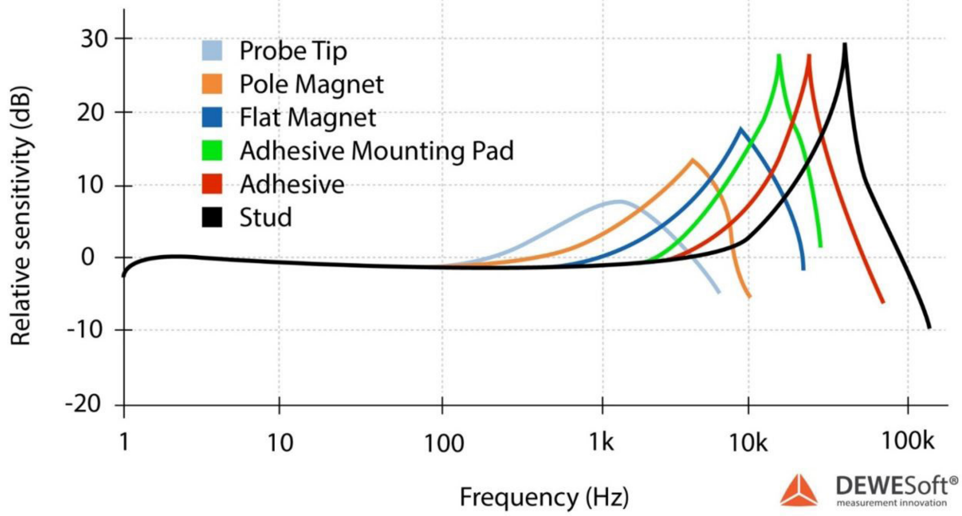
Read more about configuring a system for vibration measurement:

- How Fast Must We Sample?
- Sample Rate: How to Pick the Right One
- Which Anti-Alias Filter is Best?
- Filter Selection for Shock and Vibration Applications

Vibration Measurement System Setup

As powerful as modern data acquisition systems can be, they can be relatively expensive to purchase, can be very heavy and bulky (not very portable), require connection to an AC power supply, and an external controller to run the control and acquisition application software and to allow data storage. Many of the hardware components may not be rated for use in harsh environments where vibration measurements must be made. Finally, setting up the hardware and software required will generally require the assistance of an instrumentation expert.

Accelerometer Mounting



The method used to mount the accelerometer to the vibrating structure and the coupling between the sensor and the measurement point is critical to obtaining accurate results because they influence the resonant frequency of the accelerometer. Here are some commonly used mounting methods:

- ***Stud mounting*** is the best mounting method in terms of accelerometer performance and will maximize the frequency response of the accelerometer. It's important to torque the accelerometer down to the manufacturer's specifications; inadequate mounting torque can reduce the frequency response. Perhaps the most important factor when stud mounting is to use a coupling fluid such as grease, oil, petroleum jelly or beeswax. Using a coupling fluid solves a lot of mounting problems, including inadequate mounting torque, surface flatness, and surface roughness.

- ***Adhesive options*** vary, but the most important parameter for accelerometer performance is not the adhesive type, but the thickness of the adhesive used.

  - **Loctite® or a two-part epoxy** offers a permanent mounting option that improves repeatability and measurement time.

  - **Wax or duct seal putty** aren't as effective as Loctite or epoxy but still offer surprisingly good frequency response and removal of the accelerometer is much easier.

  - **Double-sided tape** offers the lowest frequency response of all the adhesives, but for many applications it is still effective. The thickness of the adhesive is the most important factor.

» ***Adhesive mounting pads*** offer the very high frequency response of adhesives and stud mounting; but allow swapping out accelerometers easily. For large structures, it is much easier to instrument the structure with adhesive mounting pads first, then attach the accelerometers for the test. At the end of testing, the accelerometers can easily be removed and moved to the next test project. If, after analyzing the data, the team determines more testing is needed, having the mounting pads remain on the structure ensures the tests can be repeatable. Adhesive mounting pads also prevent epoxy from damaging expensive accelerometers.

» ***Magnetic mounting bases*** allow easy, mess-free accelerometer mounting on ferrous structures for short-term measurement applications. Use caution with magnetic mounting bases to avoid structure damage or personal injury.

» ***Handheld or probe tip*** options are a possibility with applications that are difficult to reach for proper mounting and/or have sensitive coatings or materials that prevent using adhesives or bolting. A probe tip can be used to press the accelerometer to the structure manually, this drastically reduces the measurable frequency range to less than 100 Hz or so. They are not recommended for frequency ranges less than 10 Hz.

Wiring

Stringing the wiring needed to connect the accelerometers to the data acquisition system is both extremely time-consuming and can be difficult to accomplish in field settings. Wiring can sometimes require modifications to the test environment to accommodate the wiring from sensors to data acquisition systems to a power source. This can limit where measuring occurs and can sometimes require the use of special "test samples" designed for measurement, not field use. Test data must often be acquired on site, rather than in a lab or on a test bench.

Wiring also can introduce undesirable mechanical, electrical, and electromagnetic noise, which can compromise data quality if not taken into account. Minimizing cable lengths is generally the best way to minimize noise; a high-quality vibration data logger is also important.

Environmental Concerns

The environment in which they are performed can have a significant impact on the accuracy of vibration measurements.

» ***Temperature:*** Temperature is the most significant environmental concern. All sensors will have some temperature dependence, especially piezoelectric accelerometers, so temperature compensation will be needed to offset these effects. Although some sensors have the necessary compensation hardware integrated into the sensor package, in others, it may be necessary to add a temperature sensor and perform compensation.

» ***Base strains:*** Many piezoelectric accelerometers use a piezoelectric element with a tip mass mounted to the base and measuring shear. When the surface the accelerometer is mounted to experiences strain, this can often appear as "acceleration" in the data. Although accelerometer manufacturers design their sensors to minimize the effect; base strains can still result in erroneous data.

» ***Acoustic noise***: Noise is simply pressure waves that can excite the accelerometer and the structure under test. Although these induced vibrations are normally much less than the actual inherent structural vibrations, they remain something to consider.

» ***Transverse vibrations***: Accelerometers are sensitive to vibrations acting in directions perpendicular or orthogonal to the main axis of interest. This transverse sensitivity is typically less than 5% for single-axis accelerometers; triaxial accelerometers typically have a little higher transverse sensitivity.

» ***Magnetic fields***: The magnetic sensitivity of accelerometers is very low, but this effect should be considered, especially in extreme environments like naval vessels.

» ***Humidity***: Although most accelerometers are sealed to ensure reliable operation in humid environments, humidity can cause issues at cable connections. Particularly hu mid environments may require pre-wired special accelerometers to ensure accurate data. Data loggers and vibration meters may also need special housings or accessories for humid environments.

» ***Corrosive substances***: Accelerometers or data loggers with plastic housings may be susceptible to corrosive agents, so prevent these substances from coming in contact with data acquisition equipment.

» ***Shock and vibration***: Consider what the data acquisition electronics will be required to withstand during use. Electronics that are well-suited to use in a lab might not be able to survive use in the field. Field applications might require robust electronics and/or special accessories and cases to dampen shock and vibration levels to which the electronics will be exposed.

Want to learn more?

- Accelerometer Mounting Best Practices for Vibration Measurement
- Shock and Vibration Overview

Vibration Analysis Basics

Acquiring the vibration data is only part of the challenge of vibration measurement; the other part is the analysis of the data acquired. It's important to understand the types of waveforms associated with vibration analysis, the important differences between them and when it is appropriate to use each type of vibration analysis tool. However, in a handbook of this length, it's unrealistic to attempt an in-depth exploration of this topic. To gain a better understanding of how and when to use various forms of vibration analysis, check out the resources listed under "Want to Learn More?"

Time domain vibration analysis

Vibration analysis starts with a time-varying, real-world signal from a transducer or sensor. Analyzing vibration data in the time domain (amplitude plotted against time) is limited to a few parameters in quantifying the strength of a vibration profile: amplitude, peak-to-peak value, and RMS. Figure 3 is a simple sine wave with these parameters identified.

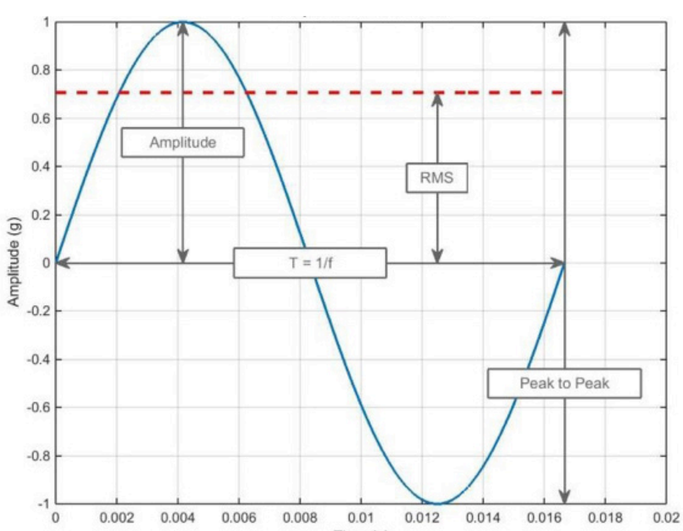


Figure 3. A simple 60 Hz sine wave with the amplitude, peak-to-peak, RMS, frequency, and period identified.

- The ***peak or amplitude*** is valuable for shock events, but it doesn't take into account the time duration and thus the energy in the event.
- The same is true for ***peak-to-peak*** value with the added benefit of providing the maximum excursion of the wave, which is useful when looking at displacement information, specifically clearances.
- The ***RMS*** (root mean square) value is generally the most useful because it is directly related to the energy content of the vibration profile and thus the destructive capability of the vibration. RMS also takes into account the time history of the wave form.

Vibration is an oscillating motion about equilibrium so most vibration analysis looks to determine the rate of that oscillation or the frequency, which is proportional to the system's stiffness. The number of times a complete motion cycle occurs during a period of one second is the vibration's frequency and is measured in hertz (Hz). For simple sine waves, the vibration frequency could be determined from looking at the waveform in the time domain; however, as different frequency components and noise are added, spectrum analysis is necessary to obtain a clearer picture of the vibration frequency.

Frequency domain vibration analysis

The ***fast Fourier transform (FFT)*** is an efficient algorithm used to compute a discrete Fourier transform (DFT). This Fourier transform outputs vibration amplitude as a function of frequency so that the analyzer can understand what is causing the vibration. The frequency resolution in an FFT is directly proportional to the signal length and sample rate. To improve the resolution, the time of the recording must be extended, but be careful of a changing vibration environment.

A ***spectrogram*** takes a series of FFTs and overlaps them to illustrate how the spectrum (frequency domain) changes with time. If vibration analysis is being done on a changing environment, a spectrogram can be a powerful tool to illustrate exactly how that spectrum of the vibration changes.

A ***power spectral density (PSD)*** takes the amplitude of the FFT, multiplies it by its complex conjugate and normalizes it to the frequency bin width. This allows for accurate comparison of random vibration signals that have different signal lengths. For this reason, PSDs are typically used to describe random vibration environments like those specified in military and commercial test standards.

Want to learn more?

Read more about vibration analysis tools and techniques:

- Vibration Analysis: FFT, PSD, and Spectrogram Basics
- Understanding the Basics of Fourier Transforms
- Frequency Leakage in Fourier Transforms
- Top 8 Vibration Analysis Software Packages

Conclusion

Obviously, this handbook has only touched on some of the high points of vibration measurement. To learn more about tools and techniques for making better vibration measurements, including those optimized for making measurements in the field like our Slam Stick™ technology, contact Midé Technology at (781) 306-0609 or via the web at https://www.mide.com.

Slam Stick™

Midé Technology Corporation, founded in 1989, develops, produces and markets high performance products for many industries, including aerospace, automotive and manufacturing. Our innovative people, systems approach, and customer focus provides us with the ability to conceptualize, design and deliver these high performance, intelligent systems and services tailored to our clients' specific needs.

Steve Hanly is Vice President of Sales and Marketing for Midé Technology Corporation. He joined the company as an engineer in 2010 and has since held a number of engineering, product management and marketing positions with the company. Hanly holds an undergraduate and master's degree in mechanical engineering and aerospace engineering, both from Worcester Polytechnic Institute, and is currently in an MBA program from University of Massachusetts, Amherst.