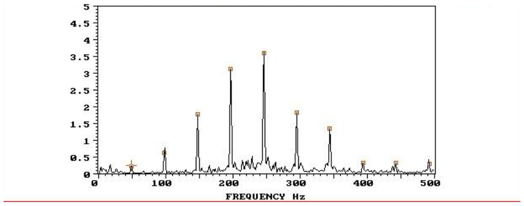
Reading accelerometer specifications

To obtain vibration data this is meaningful for your application, it is important to understand the performance characteristics of the accelerometer under consideration.

Sensitivity

Sensor sensitivity is often described as nominal, which means the voltage output per engineering unit. The amplitude of the AC signal will correspond to the amplitude of the vibration measured. All frequencies will be present simultaneously. This is what creates a vibrational signal spectrum.

Example: 100 mV/g yields an AC voltage output of 100 mV/g of acceleration.



High sensitivity results in a high signal-to-noise ratio. Interfering electrostatic and electromagnetic noise will be less bothersome than with a low-sensitivity device. This may bring two disadvantages: greater weight and a lower resonant frequency.

Sensitivity tolerance

The tolerance of the sensitivity is the maximum allowable deviation between the nominal sensitivity and the actual measured sensitivity of a sensor, as measured at room temperature at 100 Hz. The exact sensitivity may vary from the nominal sensitivity within the specified tolerance range. The sensitivity of the sensor is shown in the calibration data and units vary based on type.

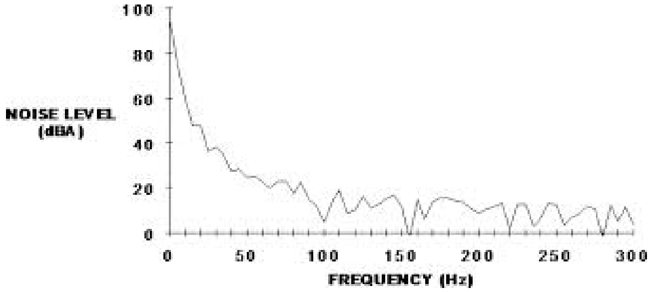
Sensor type	Sensitivity tolerance
Internally amplified	mV/g
Internally amplified velocity output	mV/ips
Non-internally amplified, charge mode	pC/g

Electronic noise

Noise generated by the amplifier circuit is specified as either broadband or spectral.

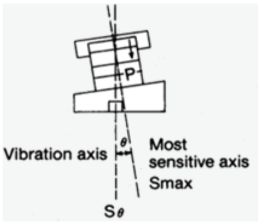
- Broadband electronic noise is a measurement of the total noise energy over a specified bandwidth (typically 2 - 25,000 Hz).
- Spectral noise levels are measured at a specific frequency, and may be specified in equivalent units of vibration (g).

Measured noise typically decreases as frequency increases. However, because lower acceleration readings are normally associated with lower frequencies, machinery noise at low frequencies is more often a problem than noise at high frequencies.



Transverse sensitivity

This percentage value is the sensitivity of the accelerometer at 90° compared to the sensitive axis of the sensor. Sensitivity to lateral motion can be held to <5% of the normal sensitivity on many Wilcoxon accelerometers. It is important that the measurement being taken only comes from acceleration from one direction; the sensor must not produce any significant response when motion is applied in the lateral axes.

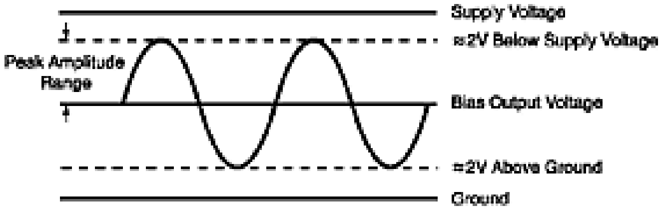


$$\text{Transverse sensitivity \%} = \frac{\text{Maximum or average output}}{\text{Transducer sensitivity}} \times 100$$

Peak amplitude

Peak values are the maximum amplitude vibration that can be measured by a sensor before distortion occurs in the amplifier due to overloading. If the maximum amplitude of a given sensor is not sufficient for the application, a sensor with lower sensitivity or a higher BOV and power supply voltage can be used.

Peak amplitude is determined by:
a. calculating the difference between the power supply voltage and the BOV
b. calculating the difference between the BOV and ground (0 V)
c. take the smaller value of (a) or (b) and subtract 2 V
d. divide the value (c) by the sensitivity (in V) of the sensor.
The resulting number is a good approximation of the maximum amplitude signal (expressed in g's) that may be measured before distortion occurs.



Frequency response

The frequency response describes the maximum deviation of sensitivity over a frequency range. The nominal and actual sensitivity of a sensor are measured at a specific frequency, typically 100 Hz. The frequency response is typically governed at the high frequency end primarily by the mechanical resonance of the sensor. The frequency response specification is described by a range at ±X% or ±3 dB.

- ±X% means that over the specified frequency range the sensitivity will be within the percentage stated.
- ±3 dB range is generally used in military or scientific specifications. 3 dB is approximately 30%.

Low-frequency response

The low-frequency cutoff for piezoelectric accelerometers is commonly set from 1 - 5 Hz to reject any pyroelectric output. Some models have extended ranges to near DC. Low-end frequency response limitations are the result of low frequency “high-pass” filtering used by all manufacturers to reduce the amplifier noise at low frequencies generally caused by thermal events.

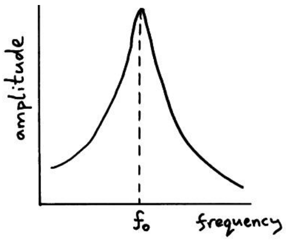
In some low frequency sensors, there may also be high frequency “low-pass” filters used to eliminate unwanted signals and interference from high frequency vibration signals.

High-frequency response

This is a function of the mechanical characteristics and the method used to attach the device. Most accelerometers exhibit an undamped single degree of freedom response when securely mounted. Response is relatively flat to about 20% of the mounted resonant frequency. Electronic filtering can increase the flat response to 50% of the mounted resonant frequency.

Resonance frequency

This the primary (largest) mechanical resonance of the sensor. However, there may be sub-resonances present at lower frequencies.

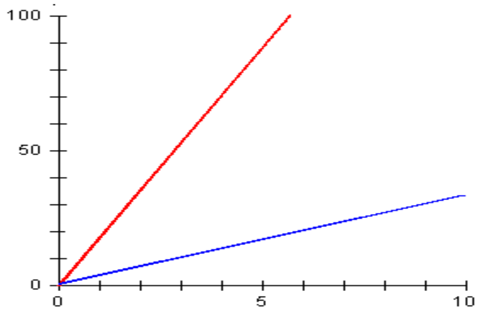


Amplitude linearity

Amplitude linearity is a measure of how linear the sensor’s output is over its specified amplitude range. It is sometimes called amplitude nonlinearity, as it specifies the deviation from perfect linearity. An accelerometer would ideally have exactly the same sensitivity at any amplitude point within its specified range. However, accelerometers do not typically operate within those guidelines. Amplitude linearity specifications offer a means of identifying the limitations on how far accelerometer output deviates from perfect linearity.

There are two industry-recognized means of properly specifying amplitude linearity. The most restrictive is to specify a percentage of reading over the entire full scale range. For example, 1% per 0 - 2,000 g. This is a close tolerance specification, as it means that accelerometer sensitivity cannot vary by more than ±1% at any point in the amplitude range of 0 to 2,000 g.

A much less restrictive way is to specify linearity in quantities. For example, 1% per 500 g, 0 - 2,000 g. At the top end of the amplitude range (2,000 g), sensitivity can vary as much as 4% from the low end of the amplitude range (0 g).



Temperature sensitivity

The temperature sensitivity of a sensor is the voltage output change per degree of measured temperature. The temperature circuit is separate from the accelerometer circuit and is powered by the same type of power supply as an internally amplified accelerometer. The temperature circuit biases this power supply voltage down to a voltage that corresponds to the sensor case temperature.

Although accelerometer sensitivity varies with temperature, many sensors are optimized for stable sensitivity over a wide temperature range. In general, the higher the temperature the higher the degree of error, unless compensated for in design and component selection.

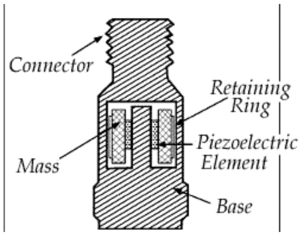
Transient temperature effects

Thermal transient errors can occur at very low frequencies in compression mode accelerometers and often go undetected. This problem has been eliminated with the development of shear mode accelerometers.

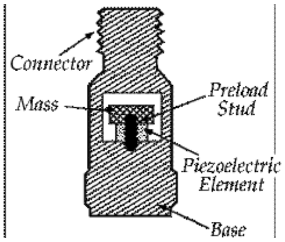
Strain effects

The machinery being monitored may flex, bend or stretch at the mounting point of the sensor, causing an erroneous output. Isolation can be improved by using insulated mounting studs or adhesive mounting adaptors. Strain effects differ by type of sensor; shear mode accelerometers are much less sensitive to such errors than conventional compression types.

Shear design: The sensing element and seismic mass are secured to an upright base. This preload produces a stiff structure with good frequency response and greater mechanical integrity. Since the sensitive axis is not in-line with the mounting surface, adverse environmental conditions such as base strain and thermal transients do not produce false signals as in other designs.
Compression design: The sensing element is in between the seismic mass and the base with an elastic pre-load bolt. Motion into the base compresses the crystal, creating an output. Compression designs are much more suited than flexural designs to industrial applications because of their high resonance and durability. Compression designs generally have thick bases and should be used on thick-walled structures.



Shear mode



Compression mode