18ECO133T

Sensors and Transducers

UNIT V

Session 8: SLO – 2

How do accelerometers work?

- Most accelerometers rely on the use of the piezoelectric effect, which occurs when a voltage is generated across certain types of crystals as they are stressed.
- The acceleration of the test structure is transmitted to a seismic mass inside the accelerometer that generates a proportional force on the piezoelectric crystal.
- This external stress on the crystal then generates a high-impedance, electrical charge proportional to the applied force and, thus, proportional to the acceleration.

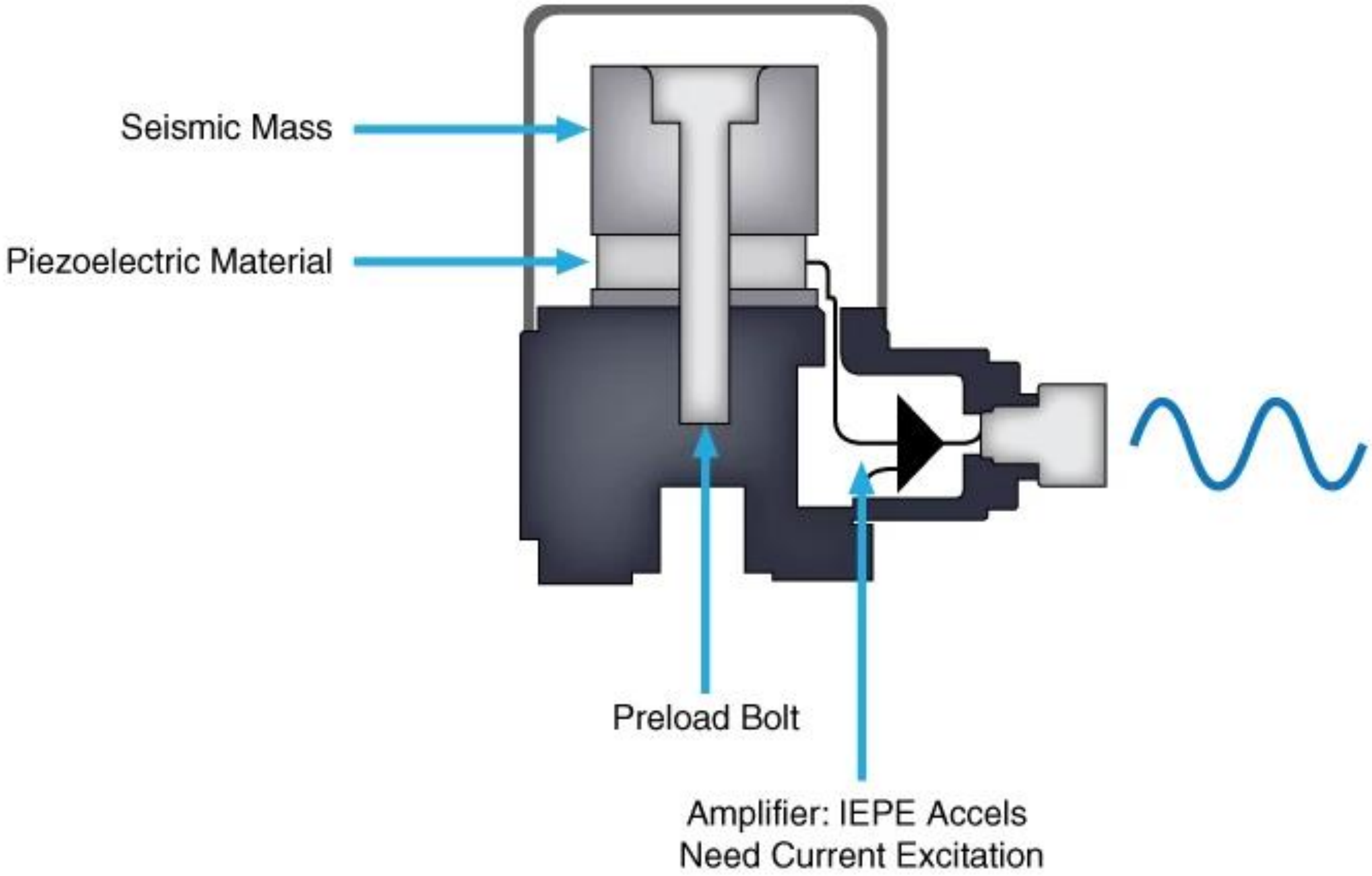


Figure 3. *IEPE accelerometers output voltage signals proportional to the force of the vibration on the piezoelectric crystal.*

- Piezoelectric or charge mode accelerometers require an external amplifier or inline charge converter to amplify the generated charge, lower the output impedance for compatibility with measurement devices, and minimize susceptibility to external noise sources and crosstalk.
- Other accelerometers have a charge-sensitive amplifier built inside them. This amplifier accepts a constant current source and varies its impedance with respect to a varying charge on the piezoelectric crystal.
- These sensors are referred to as Integrated Electronic Piezoelectric (IEPE) sensors. Measurement hardware made for these types of accelerometers provide built in current excitation for the amplifier. You can then measure this change in impedance as a change in voltage across the inputs of the accelerometer.

TO CHOOSE THE RIGHT ACCELEROMETER

Different electrical and physical specifications for accelerometers.

1.Vibration Amplitude

The maximum amplitude or range of the vibration you are measuring determines the sensor range that you can use. If you attempt to measure vibration outside a sensor’s range, it distorts or clips the response. Typically, accelerometers used to monitor high vibration levels have a lower sensitivity and lower mass.

2.Sensitivity

Sensitivity is one of the most important parameters for accelerometers.

It describes the conversion between vibration and voltage at a reference frequency, such as 160 Hz. Sensitivity is specified in mV per G. If typical accelerometer sensitivity is 100 mV/G and you measure a 10 G signal, you expect a 1000 mV or 1 V output.

The exact sensitivity is determined from calibration and usually listed in the calibration certificate shipped with the sensor. Sensitivity is also frequency dependent.

A full calibration across the usable frequency range is required to determine how sensitivity varies with frequency.

Figure 4 shows the typical frequency response characteristics of an accelerometer.

In general, use a low sensitivity accelerometer to measure high amplitude signals and a high sensitivity accelerometer to measure low amplitude signals

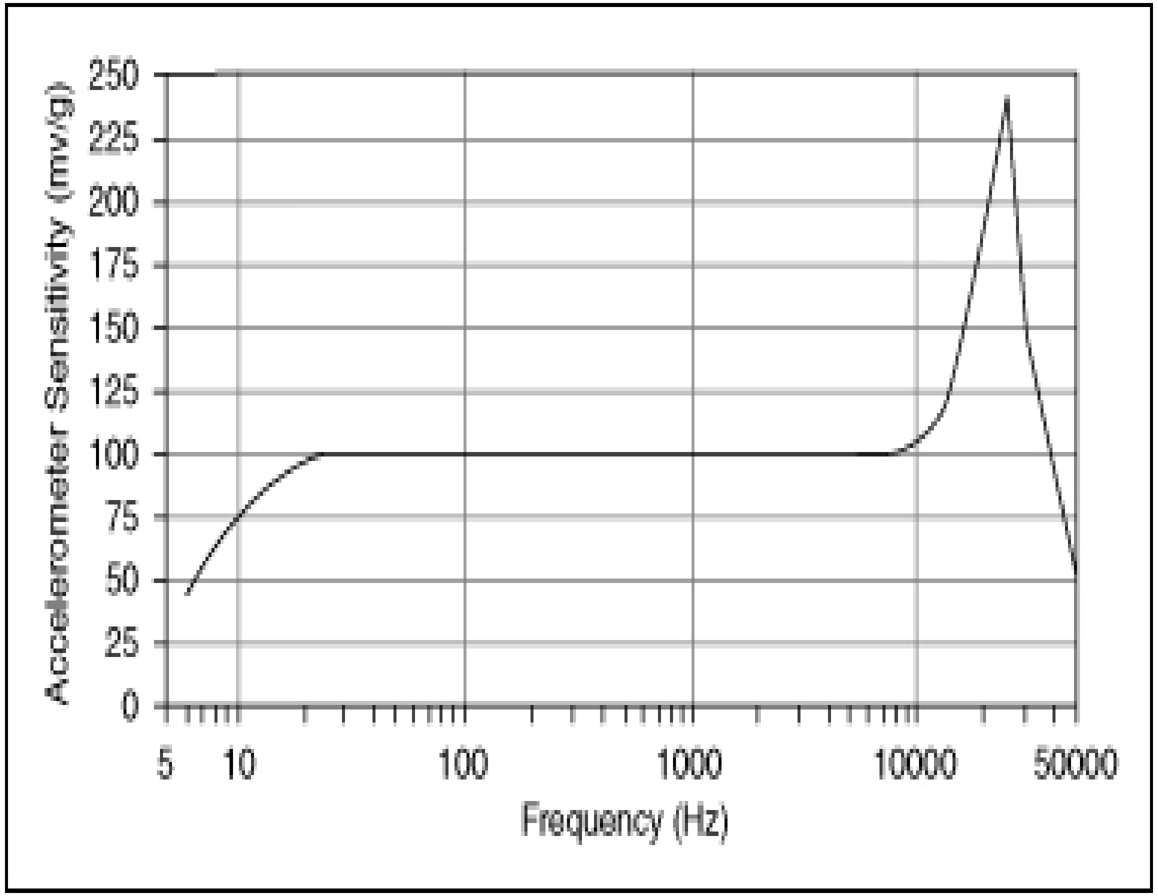


Figure 4. *Accelerometers have a wide usable frequency range where sensitivity is relatively flat.*

3.Number of Axes

You can choose from two axial types of accelerometers. The most common accelerometer measures acceleration along only a single axis.

This type is often used to measure mechanical vibration levels. The second type is a triaxial accelerometer.

This accelerometer can create a 3D vector of acceleration in the form of orthogonal components. Use this type when you need to determine the type of vibration, such as lateral, transverse, or rotational.

4. **Weight**

Accelerometers should weigh significantly less than the structure you are monitoring.

Adding mass to the structure can alter its vibrational characteristics and potentially lead to inaccurate data and analysis.

The weight of the accelerometer should generally be no greater than 10 percent of the weight of the test structure.

Another consideration for your vibration measurement system is how to mount the accelerometer to the target surface. You can choose from four typical mounting methods:

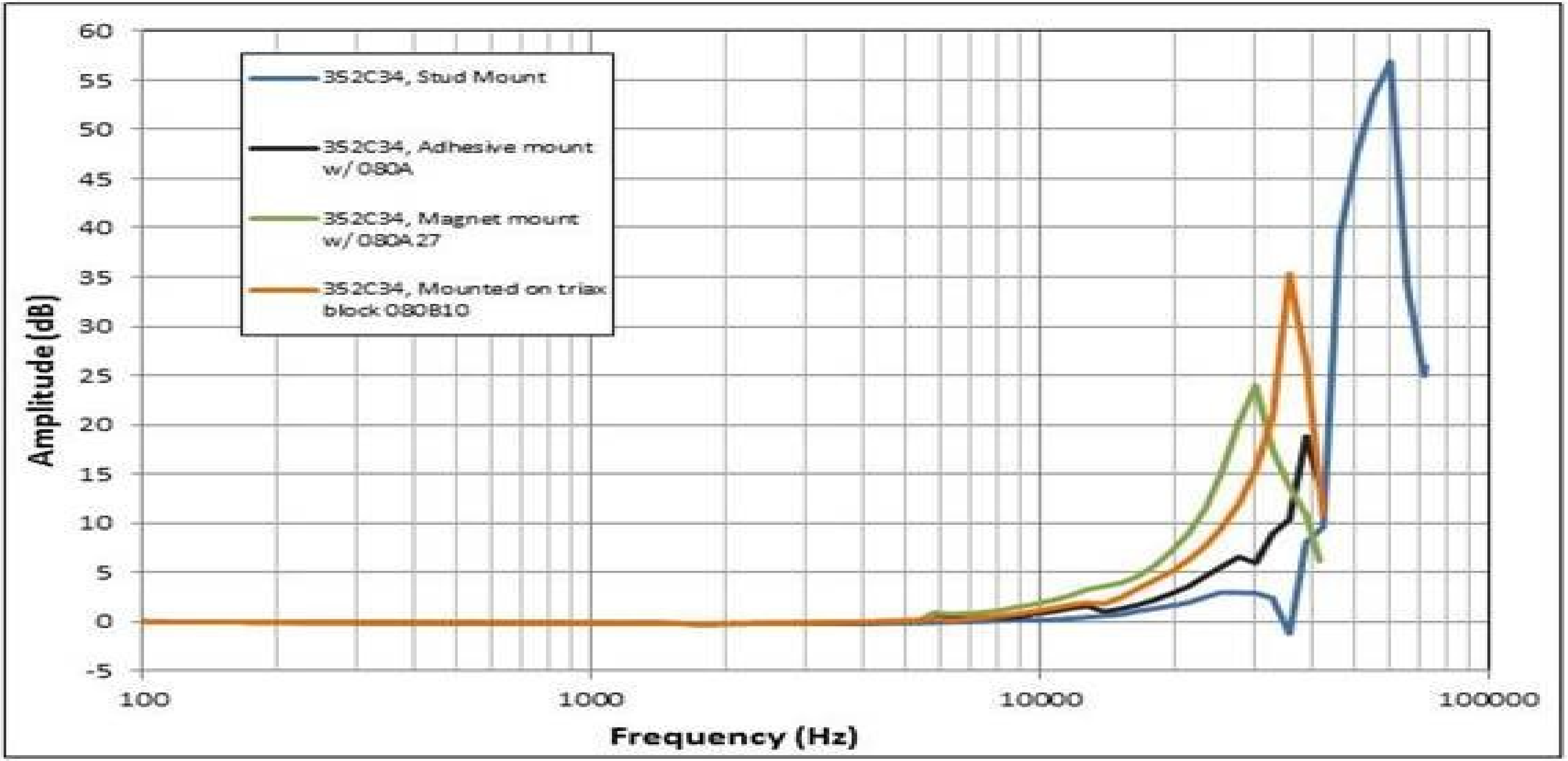
- Handheld or probe tips
- Magnetic
- Adhesive
- Stud mount

Stud mounting is by far the best mounting technique, but it requires you to drill into the target material and is generally reserved for permanent sensor installation. The other methods are meant for temporary attachment. The various attachment methods all affect the measurable frequency of the accelerometer. Generally speaking, the looser the connection, the lower the measurable frequency limit. The addition of any mass to the accelerometer, such as an adhesive or magnetic mounting base, lowers the resonant frequency, which may affect the accuracy and limits of the accelerometer’s usable frequency range. Consult accelerometer specifications to determine how different mounting methods affect the frequency measurement limits. Table 1 shows typical frequency limits for a 100 mV/G accelerometer.

Method	Frequency Limit
Handheld	500 Hz
Magnetic	2,000 Hz
Adhesive	2,500 to 5,000 Hz
Stud	> 6,000 Hz

Table 1. *Frequency Limits for Mounting a 100 mv/G Accelerometer.*

Figure 5 shows the approximate frequency ranges of different mounting techniques, including stud mounts, adhesive mounts, magnet mounts, and triax block mounts.



5.Environmental Constraints

- When choosing an accelerometer, pay attention to critical environmental parameters such as maximum operating temperature, exposure to harmful chemicals, and humidity. You can use most accelerometers in hazardous environments because of their rugged and reliable construction. For additional protection, industrial accelerometers built from stainless steel can protect the sensors from corrosion and chemicals.
- Use a charge mode accelerometer if the system must operate in extreme temperatures. Since these accelerometers do not contain built-in electronics, the operating temperature is limited only by the sensing element and materials used in the construction. However, since they do not have built-in conditioning and charge amplification, charge mode accelerometers are sensitive to environmental interference and require low-noise cabling. If the environment is noisy, you should use an inline charge converter or IEPE sensor with a built-in charge amplifier.
- Humidity specifications are defined by the type of seal an accelerometer has. Common seals include hermetic, epoxy, or environmental. Most of these seals can withstand high levels of moisture, but a hermetic seal is recommended for fluid immersion and long exposure to excessive humidity.

6.Cost

Although charge mode and IEPE accelerometers have similar costs, IEPE accelerometers have a significantly lower cost for larger, multichannel systems because they do not require special low-noise cables and charge amplifiers. In addition, IEPE accelerometers are easier to use because they require less care, attention, and effort to operate and maintain.

Single axis accelerometer

Triaxial accelerometer

Signal Conditioning for Accelerometers

- When preparing an accelerometer to be measured properly by a DAQ device, you need to consider the following to ensure you meet all of your signal conditioning requirements:
- Amplification to increase measurement resolution and improve signal-to-noise ratio
- Current excitation to power the charge amplifier in IEPE sensors
- AC coupling to remove DC offset, increase resolution, and take advantage of the full range of the input device
- Filtering to remove external, high-frequency noise
- Proper grounding to eliminate noise from current flow between different ground potentials
- Dynamic range to measure the full amplitude range of the accelerometer

Selection Guide to Vibration Transducers (Pickups)

Acceleration pickup applications — from everyday to aerospace —