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Practical guide to Accelerometers

Overview

This guide will explain: what an accelerometer is, what it measures, the differences between the types of accelerometers, applications for accelerometers, and contrast accelerometers to acceleration recorders.

Accelerometer

An accelerometer is a sensing element that measures acceleration; acceleration is the rate of change of velocity with respect to time. It is a vector that has magnitude and direction. Accelerometers measure in units of *g* – a *g* is the acceleration measurement for gravity which is equal to $9.81 m/s^2$. Accelerometers have developed from a simple water tube with an air bubble that showed the direction of the acceleration to an integrated circuit that can be placed on a circuit board. Accelerometers can measure: vibrations, shocks, tilt, impacts and motion of an object.

Types of Accelerometers

There are a number of types of accelerometers. What differentiates the types is the sensing element and the principles of their operation.

Capacitive accelerometers sense a change in electrical capacitance, with respect to acceleration. The accelerometer senses the capacitance change between a static condition and the dynamic state.

Piezoelectric accelerometers use materials such as crystals, which generate electric potential from an applied stress. This is known as the piezoelectric effect. As stress is applied, such as acceleration, an electrical charge is created.

Piezoresistive accelerometers (strain gauge accelerometers) work by measuring the electrical resistance of a material when mechanical stress is applied

Hall Effect accelerometers measure voltage variations stemming from a change in the magnetic field around the accelerometer.

Magnetoresistive accelerometers work by measuring changes in resistance due to a magnetic field. The structure and function is similar to a Hall Effect accelerometer except that instead of measuring voltage, the magnetoresistive accelerometer measures resistance.

Heat transfer accelerometers measure internal changes in heat transfer due to acceleration. A single heat source is centered in a substrate and suspended across a cavity. Thermoresistors are spaced equally on all four sides of the suspended heat source. Under zero acceleration the heat gradient will be symmetrical. Acceleration in any direction causes the heat gradient to become asymmetrical due to convection heat transfer.

MEMS-Based Accelerometers

MEMS (Micro-Electro Mechanical System) technology is based on a number of tools and methodologies, which are used to form small structures with dimensions in the micrometer scale (one millionth of a meter). This technology is now being utilized to manufacture state of the art MEMS-Based Accelerometers.

Future Accelerometer Advancements

In the next decade, NANO technology will create new applications and dramatically reshape this area of technology.

Applications for Accelerometer

From industry to education, accelerometers have numerous applications. These applications range from triggering airbag deployments to the monitoring of nuclear reactors. There are a number of practical applications for accelerometers; accelerometers are used to measure static acceleration (gravity), tilt of an object, dynamic acceleration, shock to an object, velocity, orientation and the vibration of an object. Accelerometers are becoming more and more ubiquitous: cell phones, computers and washing machines now contain accelerometers.

Other practical applications include:

- Measuring the performance of an automobile
- Measuring the vibration of a machine
- Measuring the motions of a bridge
- Measuring how a package has been handled

Selecting an Accelerometer

When selecting an accelerometer for an application the first factors to consider are:

1. Dynamic Range: Dynamic range is the +/- maximum amplitude that the accelerometer can measure before distorting or clipping the output signal. Dynamic range is typically specified in g's

2. Sensitivity: Sensitivity is the scale factor of a sensor or system, measured in terms of change in output signal per change in input measured. Sensitivity references the accelerometer's ability to detect motion. Accelerometer sensitivity is typically specified in millivolt per (mV/g).

3. Frequency response: Frequency response is the frequency range for which the sensor will detect motion and report a true output. Frequency response is typically specified as a range measured in Hertz (Hz).

4. Sensitive axis: Accelerometers are designed to detect inputs in reference to an axis; single-axis accelerometers can only detect inputs along one plane. Tri-axis accelerometers can detect inputs in any plane and are required for most applications.

5. Size and Mass: Size and mass of an accelerometer can change the characteristics of the object being tested. The mass of the accelerometers should be significantly smaller than the mass of the system to be monitored.

Acceleration Recorders

An accelerometer by itself is only a sensing element, in order for it to be useful the sensor needs to be combined with other elements such as, power, logic, memory and a means to translate the output. An acceleration recorder incorporates all of these elements into one package.

One example of an acceleration recorder is the GP series designed by Sensr. They are rugged, compact instruments for recording motion, shock, impact, orientation and temperature. The instruments have been specifically designed to be user-friendly. The GP series data loggers feature: real-time data streaming, a USB interface, easy-to-use software, LED alert indicators, event flagging and a tri-axial MEMS-based accelerometers.