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QUARTZ PEIZOELECTRIC FORCE SENSORS

PCB Piezotronics, Inc. is Uniquely positioned in the sensor industry to satisfy a wide range of research, test, measurement, monitoring and control applications.

PCB Piezotronics, Inc. Specializes in the development, application and support of piezoelectric & strain gauge force sensors, load cells and torque sensors. Strain gage technology is utilized for Load cells and Torque sensors, while Piezoelectric quartz sensing technology forms the sensing principle for Strain and Dynamic force sensors. PCB provides a wide range of sensors to address the needs of those involved with the measurement of Load, Torque, Strain and Dynamic Force.

Structural Solutions Private Limited exclusively represents PCB Piezotronics, Inc., U.S.A in India. **Structural Solutions Private Limited** is a professional engineering company engaged in offering high end technology intensive products and system solutions to Indian industry for Torque, Load, Strain & Dynamic Force Measurements

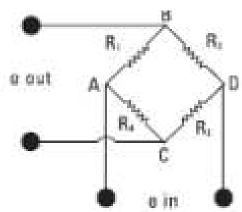
CHARACTERISTICS AND BENIFITS OF QUARTZ PEIZOELECTRIC FORCE SENSORS

Strain gage load cell technology has its place for DC (static) force measuring and measurements requiring accuracy better than 1.0% of full scale, Quartz Piezoelectric Force sensors offer many advantages. This paper is intended to acquaint with quartz piezoelectric force sensors characteristics and benefits of this technology.

Principle of operation of Strain gage load cells

Load cells produce an output voltage proportional to the applied force. The output voltage is produced by a change in resistance in strain gages which are bonded to the load cell's structure. The magnitude of the change in resistance corresponds to the deformation of the load cell and therefore the applied load.

The four-arm Wheatstone Bridge configuration shown below depicts the strain gages used in our load cells. This configuration allows for temperature compensation and cancellation of signals caused by forces not directly applied to the axis of the applied load.



A regulated 5 to 20 volt DC or AC rms excitation is required and is applied between A and D of the bridge. When a force is applied to the transducer structure the Wheatstone Bridge is unbalanced causing an output voltage between B and C which is proportional to the applied load.

Principle of operation of Quartz Force sensors

Most of the Quartz force sensors are designed with thin quartz crystal discs that are “sandwiched” between upper and lower base plates. An elastic, beryllium-copper stud holds the plates together and preloads the crystals. This “sensing element” configuration is then packaged into a rigid, stainless-steel housing and welded to assure the internal components are sealed against contamination.

When force is applied to this sensor, the quartz crystals generate an electrostatic charge that is proportional to the input force. This charge output is collected on electrodes that are sandwiched between the crystals. It is then either routed directly to an external charge amplifier or converted to a low impedance voltage signal within the sensor.

Characteristics of Quartz Piezoelectric force sensors

Stiffness: With a modulus of elasticity between 11 and 15 x 106 psi, quartz is nearly as stiff as solid steel. All quartz force sensors are assembled with stacked quartz plates and stainless steel housings. This stiff structure offers an extremely fast rise time enabling response to, and accurate capture of, rapid force transient events.

Dynamic response : Piezoelectric sensors can measure from near DC(quasi-static) to several kHz, while strain gage load cells are limited from “true DC “ to only several tens of Hz .The frequency response of quartz piezoelectric force sensor is tens times higher frequency response than a strain gage load cell. The high frequency response is determined by the mechanical characteristics of mass and stiffness.

Quartz piezoelectric force sensors are stiffer and don't require deflection to produce an output like a strain gage load cell. Thus, they achieve higher frequencies since frequency is proportional to square root of stiffness.

Mass factors into the frequency calculation because frequency is also proportional to the square root of the inverse of the mass. Quartz piezoelectric force sensors weigh less than the strain gage load cells and thus contribute to higher frequency response.

Low frequency response is determined by the electrical characteristics of the piezoelectric force sensor. A static limitation is set by the DTC for an ICP output sensor and by drift rate for charge output sensors. Low frequency response for the quartz piezoelectric force sensors is thus limited.

Size: Size is often an important consideration when selecting a force sensor. Quartz piezoelectric force sensors are smaller than strain gage load cells of equivalent range. This is a significant advantage since the quartz piezoelectric types take up a minimal space and do not add significant mass loading for dynamic tests.

Electrical Output: Another benefit of an ICP output quartz piezoelectric force sensor, is a high 5 or 10 volt output, whereas the full scale strain gage output may only be up to 20 mV when using a 2 mV/V strain gage and a 10 Volt DC power supply. The high voltage output of the piezoelectric sensors provides a significant benefit in terms of signal to noise ratio, especially when the test is remote and requires a long cable run.

Multiple Ranges: Quartz Piezoelectric force sensors may be used for multiple measuring ranges without removing the force sensor from the test fixture.

By the simple formula V=Q/C, where V is the voltage output, Q is the charge produced, and C is the system capacitance, multiple output ranges may be selected by adjusting the value of C. The value of C may be adjusted internally in ICP output sensors and externally in a charge amplifier for charge output sensors. This feature allows lower ranges to be measured while the sensor is experiencing much higher static loading.

By comparison, a strain gage load cell of a specific measuring range must be purchased for each desired measuring range required in a test.

Overload Protection: The most common failure mode of a strain gage is the application of force beyond the yield point of the strain gage flexure (overload range). Overloading the load cell may cause permanent damage to the flexure, which could lead to a zero shift, non-linearity and a general fatigue of the metal flexure, reducing the load cell's life.

Quartz piezoelectric force sensors react to stress, not strain, meaning there is virtually no deflection during measurement. Most have a compressive strength of 3.0 x 108 Pa (4.351 x 104 psi), which allows massive overloading without risk of crushing the sensor. Even when the sensor is overloaded beyond its stated measuring range, they suffer no ill effects, zero-shift, fatigue or linearity change.

Most ICP output force sensors are designed to provide a full-scale 5 volts output at rated measuring range. However, the circuit typically provides output of 30 volts and beyond without damage. Several ICPsensors have a built-in circuit that protects the electronics up to 100 volts impact induced shock overload. This electrical overload is typically six times or more of the rated capacity.

Stability: Quartz force sensors are very stable since they are made of solid-state construction and quartz, a natural piezoelectric sensing element, has no aging effects. Since they do not deflect under load like strain gage load cells, there is little chance for sensitivity change and frequent calibration is not required.

Temperature effects: Quartz piezoelectric force sensors may be operated from 100 °F to 400 °F (-73 °C to 204 °C). Strain gage load cells have a useful temperature range limited from 65 °F to 200 °F (-54 °C to 93 °C). This limited operating temperate range of strain gage load cells is due to the combination of solder melting point, the backing material of the strain gage and bonding agents used to attach the gages to the metal flexure]. Additionally, at elevated temperatures, the insulation resistance of strain gage load cell insulation materials can degrade significantly, leading to sensor non-linearity.

Because of the effect of temperature on the strain gage resistance, the mismatch between coefficient of expansion of the strain gage and the flexure, and bridge out-of-balance condition, these load cells require a temperature compensation circuit in order to provide a stable output. The various temperature-related measuring errors include thermal expansion, point response, thermal sensitivity change and electrical loading.

	Quartz Piezoelectric Force Sensor	Gage Load Cell Strain
Siffness	Stiff as a solid steel	Not as stiff as quartz force sensor
Dynamic Response	Has Ten times higher frequency response than load cells	Lower frequency response than Quartz force sensors
Size	Smaller than strain gage	Big in size
Mutliple Ranges	Lower ranges can also be measured even while the sensor is experiencing much higher static loading.	load cell of a specific range is required for each desired measuring range
Electrical Output	5 / 10 V output available	20mV output
Overload protection	Several ICP Sensors Have a built-in Circuit that protects the electronics up to 100 V	Overloading causes permanent damage to the flexure, zero shift, non-linearity and a general fatigue of the metal flexure.
Sensitivity Stability	Little chance for sensitivity change and frequent calibration is not required	Sensitivity changes when exceeds its rated lifetime limit
Temperature Range	-73 °C to 204 °C	-54 °C to 93 °C

Although strain gage technology is commonly taught and widely used, comparisons indicate that quartz force sensors can provide both technical and cost advantages in certain applications.

Quartz piezoelectric sensors measure from near DC (quasi-static) to several kHz, while strain gage load cells are limited from "true DC" (static) to only several tens of Hz. Quartz piezoelectric force sensors excel in dynamic applications requiring high frequency response, long-term stability and durability, while strain gage load cells are well suited for static and low frequency measurements.

Additional benefits of quartz piezoelectric technology include; small size, low mass, extended measuring range, overload protection, high voltage output, extended operating temperature range, low acquisition cost and low life-cycle cost.

Complete range of Dynamic Force Sensors, Strain gage Load cells, Torque Sensors, Signal conditioners and other Accessories will be offered in Rupees or in Foreign Exchange at competitive prices by **Structural Solutions Private Limited**

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