MEASUREMENT SPECIALTIES

Piezo Film Sensors

Technical Manual

Internet Version

Part 10 of 18

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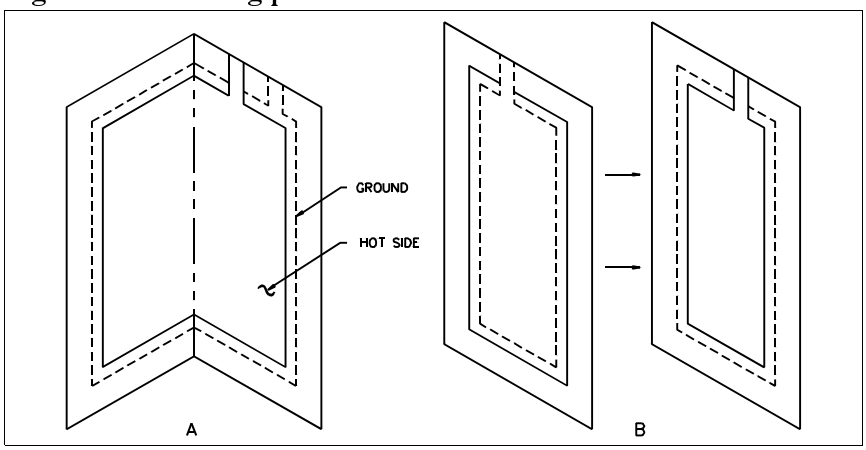
VIBRATION SENSING

One of the first applications for piezo film was as an acoustic pickup for a violin. Later, Gibson Guitar introduced a line of acoustic guitars with piezo film as a saddle-mounted bridge pickup, mounted in the bridge. The very high fidelity of the pickup led the way to a family of vibration sensing and accelerometer applications.

Music Pickups

Piezo film is used today in four guitar pickup designs; the first is a thick film, compressive (under the saddle) design; the second is a low cost accelerometer; the other two are contact microphones, one folds around the saddle which is inserted into the bridge, while the last is an after market pickup design that is taped to the instrument. Because of the low Q of the material, these transducers do not have the self-resonance of hard ceramic pickups.

Figure 57. Shielding piezo film



Shielding can be achieved by a foldover design as shown in Figure 57. The hot side is the slightly narrower electrode on the inside of the fold. The foldover technique provides a more sensitive pickup than alternative shielding methods because the shield is formed by piezoelectric material. Conventional shielding laminates can be easily fabricated by a multilayer laminate of piezo film, adhesive and shielding foil.

Machine Monitoring

The fidelity of a shielded piezo film sensor in musical instruments led to the development of vibration sensors for machines. In its simplest mode, piezo film vibration sensors behave essentially like dynamic strain gauges. The film does not require an external power source, yet typically generates signals greater than strain gauges **after** amplification. A typical piezo film sensor produces four orders of magnitude higher voltage signal than a foil-type strain gauge, and two orders higher than semiconductor types. The frequency response of the piezo film strain gauge is also superior.

The extreme sensitivity is due to the form of the piezo film material. The low thickness of the film results in a very small cross sectional area. Thus very small longitudinal forces create very large stresses within the material.

Piezo film sensors can be affixed to a vibrating surface and monitor the amplitude and frequency of the vibrating structure. The sensors can cover larger areas than normal strain gauges so any direct comparisons should be performed in **uniform** strain fields for meaningful results. Obviously, point-type transducers may be used where required, although the low capacitance of the small sensor area will require additional consideration. Operation down to fractions of Hz can be achieved by either conventional charge amplifiers or, since signal levels are relatively high, simple high impedance FET buffer circuits.

Bearing Wear Sensors

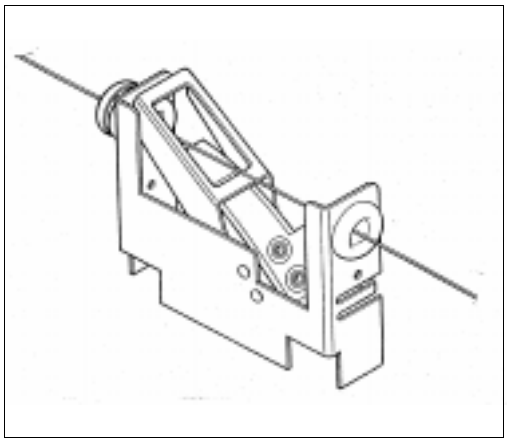
A shielded piezo film sensor has been used to monitor bearings for wear and evidence of spall. The sensors are permanently affixed to the outer surface of the bearing race with epoxy. The low mass and thin profile allow its use as a built-in nondestructive testing sensor, rather than the time consuming use of accelerometers for periodic fault-condition checks.

Fan Flow Sensor

A laminated beam type sensor is used in ducted airflow as a centrifugal fan failure sensor. The presence of air flow is detected by the vibrations in the sensor caused by the turbulence of air flow at about 100 Hz. The absence of this signal is used for trigger electronics. The sensor and switching electronics are based around a TL084 quad bi- FET op amp, with typical input signals of 80 mV. Sensor reliability is the key feature. Since the sensor is subjected to virtually no operating stresses, it has an indefinite working life.

Thread Break Sensor

Figure 58. Threadbreak sensor



Textile plants require the continuous monitoring of often thousands of lines of thread for breakage. An undetected break event can require that a large volume of material be discarded, as the labor costs to recover the material exceed the manufacturing cost. Drop switches, where switch contact closure occurs when the thread breaks, are very unreliable. Lint fouls the contact points, resulting in no output signal. A piezoelectric film vibration sensor, mounted to a thin steel beam, monitors the acoustic signal caused by the abrasion of the thread running across the beam, analogous to a violin string (Figure 58). The absence of the vibration instantly triggers the machinery to stop.

Vending Sensors

Shielded dynamic strain gauges of piezo film have been affixed to the underside of a vending product delivery tray to verify that product was properly vended. The absence of the impact induced vibration triggers an "Out of Order" warning. In a second application, slot machine coin counting is provided by a piezo film element. The sensors confirm delivery of coins won, discouraging gamblers from falsely claiming equipment defects. A ticket dispensing machine counts tickets delivered with a piezo beam design.