

# **A New Low Frequency Variable Capacitive Flight Test Accelerometer**

---

Technical Paper 331  
By Bruce Lent

## A new low frequency variable capacitive flight test accelerometer

---

Piezoresistive (PR) flight test accelerometers have traditionally been specified due to their high accuracy, low frequency and DC response capabilities within extreme environments. As PR sensor designs can also include an undesirable tendency toward excessive zero and sensitivity shifts over a wide temperature range, variable capacitance (VC) sensing technologies are also used. Unlike PR accelerometers, the high-level, low impedance output sensitivity of a typical VC sensor is not dependent upon applied excitation voltage. VC accelerometers are also inherently more rugged than PR devices and can withstand 10k g shock levels without sensor damage.

Specified VC accelerometers must be highly rugged for continuous use conditions and offer stable performance. Quantity requirements per test can vary according to aircraft, ranging anywhere from less than a dozen, to up to several hundred. Accelerometers may be subjected to high frequency vibrations of up to 50g rms at frequencies of up to 1200 Hz. Since frequencies below 50 Hz are relevant for this type of testing, accelerometer damping and natural frequency characteristics provide much of the low-pass filtering. Additional electronic filtering at the input amplifier is also desirable and anti-aliasing filters may be required.

For aircraft flutter measurements on control surface locations, such as wingtips, VC accelerometers experience low temperatures at most measurement points. The sensors are also used to measure vibrations originating from struts, axels, brakes, as well as gear shimmy. This is the most hazardous area for accelerometers, since they will be exposed to mud, splash, icing and moisture. To prevent water ingress during hose down, an RTV potting, like DC3145 is recommended, which is easily peeled off for accelerometer removal. When braking, temperatures can meet or exceed the maximum VC accelerometer operating temperature. In addition, engine load cycle measurements require flight test sensors to be mounted at locations encircling the engine inlet fan case, providing six degrees of freedom acceleration data for the engine's rigid body motion during flight cycles.

The Endevco® model 7290A VC accelerometer has been used within thousands of industry flight test applications because of its flat frequency response, inherent stability over wide temperatures and low frequency measurement capabilities down to 0 Hz. The sensors operate from 9.5 to 18.0V and offer a high-level, low impedance output. Sensor frequency response is controlled by near-critically gas damped sensors, resulting in very small thermally-induced changes. Incorporation of mechanical internal over-range stops allows the sensor to withstand very high shock and acceleration loads. Design of model 7290A requires use of several accelerometers with special modifications for hot and cold aircraft zones. These provide combined thermal zero and sensitivity shifts of 5% over a temperature range of -25°C to +75°C.

Its next generation, the newly released model 7290E, employs integral digital temperature compensation for improved stability over a wide operating temperature range with reduced thermal errors. Available in ranges from 2 to 150 g, model 7290E incorporates a patented, optimally gas damped VC sensing element (see figure 1) which controls sensor frequency response for negligible changes over temperature. These accelerometers provide accuracy in demanding extreme temperature environments, broadband high amplitude vibrations and severe weather conditions.

In addition, the extended range of model 7290E allows for use of the same accelerometer at all aircraft measurement points, with a combined thermal zero and sensitivity shift of 2% over a temperature range of -40°C to +100°C. One accelerometer model will operate within specification while exposed to cold temperatures at altitudes up to 13,000 meters, while tolerating heat from the engine fan case and landing gear brakes. The standard model 7290E also will operate from a wide range of supply voltages, from 9.5 to 36 volts DC. Available in a range of excitation voltages and choice of differential or single ended output and cable length, model 7290E offers +0.2% FSO typical non-linearity and hysteresis for most ranges, with superior frequency response, for the highest level of available measurement accuracy in the industry.



Figure 1: The Endevco® model 7290E VC accelerometer with Nomex cable