Benefits of IEPE accelerometer isolation design

By Renard Klubnik

Integrated electronics piezoelectric (IEPE) accelerometers are a mainstay of the industrial vibration monitoring market. These rugged devices are found in a variety of industries monitoring anything from small circulation pumps to large cooling tower gearboxes. The explosion of the wind turbine market has made them the sensor of choice for monitoring these massive, slow speed equipment. Effective wind turbine monitoring is performed in the nacelle with sensors located at five key locations. ISO 10816 standards for condition monitoring of onshore wind turbines (Part 21) identifies these locations as shown in Figure 1.

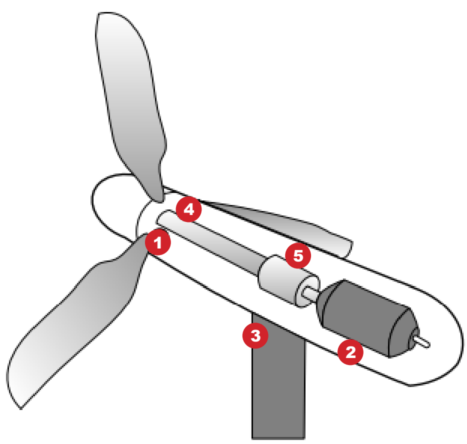

Figure 1: Schematic diagram of a wind turbine

1. mainframe (mounting of main bearing)
2. mainframe (back)
3. tower
4. main bearing
5. gearbox

While the purpose of accelerometers is to measure the condition of rotating components, by virtue their position inside high towers exposes them to side effects of lightning strikes of the tower. Even though the wind turbine industry has taken precautions to guard against such strikes by including lightning receptors in their design, accelerometers can still experience catastrophic failure as a result of fallout from such high voltage strikes.

History: Benefits of IEPE accelerometer isolation design

Integrated electronics piezoelectric (IEPE) accelerometers feature an internal amplifier which converts the high-output impedance charge signal from the sensing crystals into a low-impedance voltage output signal for analysis. This standardized design is compatible with most hand held data collectors and FFT analyzers.

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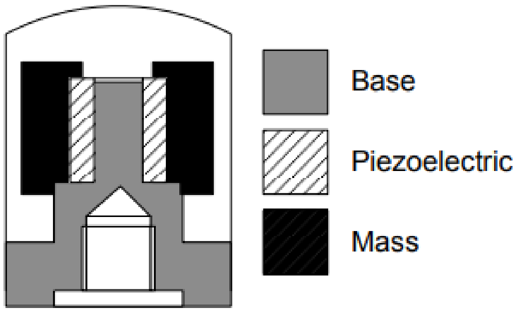


Figure 2: Shear design IEPE accelerometer

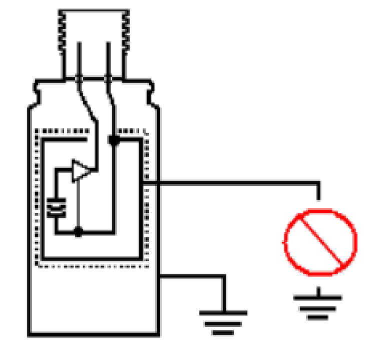


Figure 3: Electrical characteristics of IEPE sensors

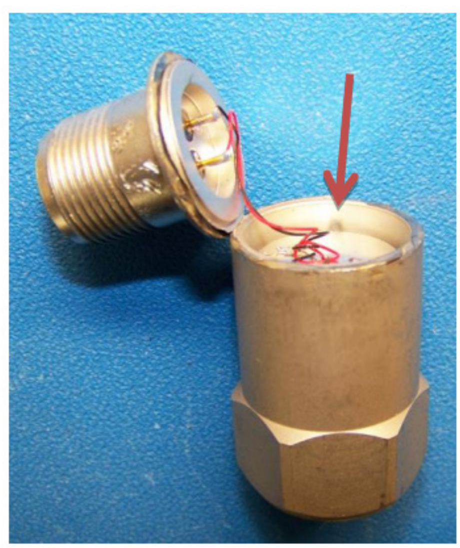
Figure 2 illustrates the basic configuration of a shear design IEPE accelerometer. The base, piezoelectric crystal and mass are the core of the sensing structure. The printed circuit board with the amplifier circuit sits on top of the mass completing the sensor pellet. A faraday shield is attached around the core to limit the influence of radio frequency (RF) signals. The pellet assembly is inserted into the accelerometer body with the only attachment point being the base.

An isolation material is used between the base of the accelerometer and the pellet assembly, providing between 100 and 500 volts of protection. For most applications, the isolation is sufficient enough to protect the sensor in industrial environments. Figure 3 (left) shows the electrical characteristics of sensor body and internal electronics.

Current status: Lightning strikes in wind turbines

When lightning strikes wind turbines, several thousand volts of electricity are injected into the tower for a short period. If not properly protected, catastrophic failures can result. Even when measures are in place, several thousand volts of short term transient energy can be present inside the nacelle constantly searching for a path to ground. If an accelerometer is within that path, it can be fatally destroyed.

The photo to the right is an accelerometer from a wind tower that sustained a lightning strike. Notice the small black mark indicative of the location where the energy jumped from the case of the accelerometer into the active IEPE circuit. Permanent damage to the IEPE circuit can be seen.

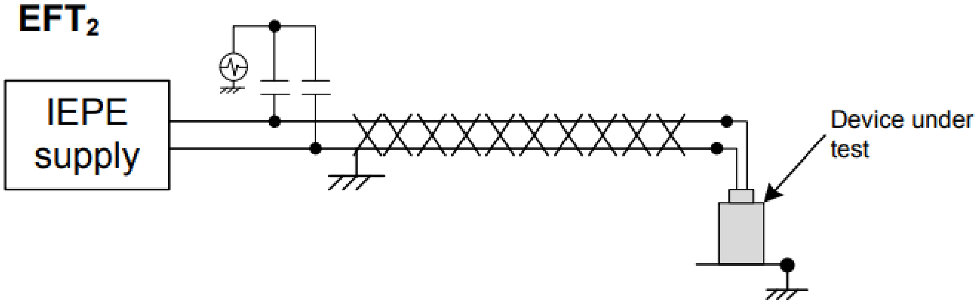


To better understand what happens in cases of lightning strikes, a study was conducted to investigate what types of electromagnetic interference (EMI) caused failures in typical IEPE sensors. Various tests were performed conforming to International Electrotechnical Commission (IEC) 61000 conditions of achieving electromagnetic compatability. The purpose of the tests was to identify typical sensor resistance to electrical fast transients up to 4 kV and surge immunity tests up to 6 kV.

EFT testing of IEPE sensors

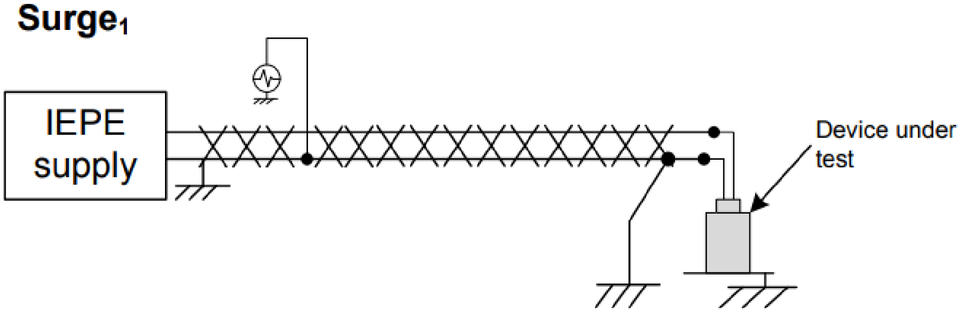
Several EFT burst immunity test were performed. For this test, energy was capacitively coupled directly to the shield and signal lines in separate test. When surge energy was applied to the shield, grounded or floating, no damage resulted. When surge energy was applied to both signal lines A and B simultaneously no damage occurred. When surge energy was applied to either the A or B signal line separely, the sensor sustained catostrophic failure.

EFT_2

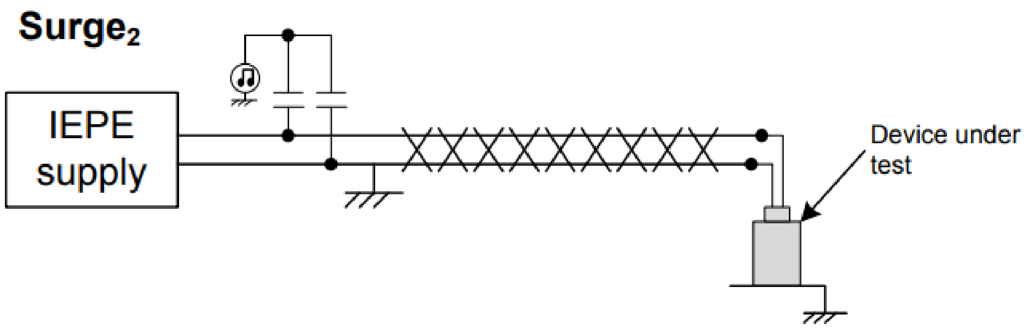


For the surge immunity test, energy was coupled to the sensor cable shield, both grounded and ungrounded. Under this configuration, no damage was sustained to the accelerometer.

$Surge_1$



Then surge energy was applied to the accelerometer signal lines A and B. For this test, visible damage occurred to the printed circuit board assembly. This failure mode was not consistent with the failures seen in wind turbine applications.



As a result of these tests, an engineering study commenced to design a new sensor body that would eliminate failures due to fast transients being presenst in wind turbine nacelles. Preliminary testing of a new prototype design has shown promising results in being able to withstand surge voltages as high as 6 kV. Some projections have placed the ability of this sensor to withstand transient voltages as high as 12 kV. Field tests are currently being performed to evulate this newly designed IEPE sensor in wind turbines worldwide. At present no failures have been reported. Testing is ongoing to ensure this new mechanical design can withstand the rigors of wind turbine installations worldwide.