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Isotron and charge mode piezoelectric accelerometers, pros and cons

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Should one use a high impedance PE type charge mode accelerometer, or one with internal electronics (IEPE)? This is one of the most commonly asked questions fielded by our application engineers. Aside from the key determining factor, namely their operating temperature ranges, there are four important factors that deserve careful consideration.

1. Dirty environments

With any type of measurement system, every component in the measurement chain (the sensor, cable, and amplifier) should be kept clean and dry in order to achieve the desired performance characteristics. If water gets into the cable connector, for example, a fault condition will develop in either PE or IEPE system. However, PE accelerometers are especially sensitive to external contamination due to their high impedance nature. This requires more care in daily maintenance. In test environments, where heavy moisture and contaminants exist, the low output impedance of IEPE sensors have an obvious advantage.

> **IEPE sensors have an advantage where heavy moisture and contaminants exist.**

2. Long cable run

Signal-to-noise ratio in the PE based system is a function of the amount of capacitance (length of cable) between the sensor and the charge amplifier. In applications where long cables (over 200 ft) are needed between the charge amplifier and the accelerometer, two points require consideration:

a) With a typical charge amplifier, the addition of 6000 pF of cable capacitance (200 ft) will increase the noise floor of the amplifier by about 4 times. Although the relationship between cable length and amplifier noise is not linear, the noise increase from less than 50 ft of cable is typically considered negligible.

b) With a very long cable run, the difference in cost between noise treated cables and ordinary coaxial cables may be significant.

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3. Range flexibility

One of long-standing advantages of PE based system is its ability to change its usable dynamic range. In a typical shock and vibration measurement application, the range of measurement is unknown. During the equipment selection/setup process, the test engineer usually estimates the required maximum range based on past experiences, and supplements that with a safety factor when choosing the range of the accelerometer. With an IEPE accelerometer, if the peak acceleration level exceeds the engineer's estimates, part of the accelerometer output signal would appear clipped, because the full scale range (rated maximum output swing) of the transducer is fixed at the factory. The engineer has no other option but to employ a different model with a higher range.

> **PE based systems can change their usable dynamic range.**

On the other hand, with a high impedance PE transducer and an external charge amplifier, the engineer can manipulate the full scale range adjustment on the amplifier, and the test may continue without requiring a substitution. This is due to the fact that most PE accelerometers are capable of greater than 120 dB of dynamic range. Using an external charge amplifier gives the user the flexibility to customize the operating range in any given test.

4. Durability

Consider the following scenario—two piezoelectric accelerometers with identical physical design. One is equipped with internal electronics (IEPE), the other without (PE). It is undeniable that the PE type scores much higher than the IEPE type in mean-time-between-failure (MTBF) due to its simplicity. This distinction is most relevant when applied to extreme environmental conditions. In many environmental stress screening (ESS) applications where the accelerometers are usually inside the test chamber, the transducers will experience the same thermal cycling and dynamic profile that the test article is exposed to. If an IEPE accelerometer is used in this case, the internal amplifier and the crystal element sees the chamber condition at all times. With a PE accelerometer, on the other hand, the charge amplifier would be sitting outside of the chamber at ambient condition, minimizing the unnecessary stress on the amplifier. It can therefore be argued that PE accelerometers are more durable than IEPE types under certain conditions.

> **PE accelerometers are more durable than IEPE types under certain conditions and can operate at higher temperatures.**

In addition, all electronic components, including the internal amplifier inside all IEPE type designs, are sensitive to ESD damage. It is not difficult to “fry” the circuit of an IEPE transducer on a very low humidity day when ESD precaution was not exercised. PE accelerometers, however, are inherently insensitive to ESD.

There are many situations that one type of accelerometer design is preferred over the other. It is necessary to consider all the advantages and limitations before selecting between PE and IEPE. When in doubt, our experienced Application Engineers will help you choose the right type for your specific applications.

Comparison of PE and IEPE Accelerometers

Advantages— PE (piezoelectric)	Limitations— PE (piezoelectric)
1. Adjustable full scale output through range changes in charge amplifier 2. High temperature operation to 700˚C available for special purpose devices 3. Interchangeable with existing charge systems with no system compatibility issues 4. Simpler design, fewer parts, more durable 5. Charge converter electronics is usually at ambient condition, away from test environment, minimizing necessary stress	1. More care/attention is required to install and maintain high impedance systems at peak operating condition 2. Special low noise cable required to minimize triboelectric noise (generated by cable motion) 3. Capacitive loading from long cable run results in noise floor increase 4. External charge amplifier is required for operation
Advantages—IEPE (Isotron, Piezotron, etc.)	**Limitations—IEPE** (Isotron, Piezotron, etc.)
1. Less operator attention, training and installation expertise required 2. Uses standard coaxial cable or ribbon wire 3. Drives long cables without noise increase or loss of resolution 4. Operates directly into many data collectors with built-in constant current input 5. Operates across slip rings 6. Lower total system cost per channel	1. Full scale output characteristics fixed within sensor—lack of range adjustability 2. Relatively limited temperature range (<125˚C for general purpose, <175˚C for special purpose) 3. Discharge time constant (affects low frequency response characteristics) is fixed within the sensor 4. Sensitive to ESD (Electrostatic Discharge) 5. The built-in amplifier is always exposed to the same test environment as the sensor