Radio Frequency Interference on Internally Amplified Accelerometer Signals

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Interference on accelerometer outputs from radiation at radio frequencies (RF) has been recognized for some time. Recent requirements by the European Community have forced the manufacturers of these sensors to pay closer attention to this problem. The following applies only to transmission by wire.

Since accelerometers operate at maximum frequencies of about 10 kHz, steady sinusoidal radio frequency signals operating at greater than 500 kHz could be rejected using low pass filters. However, in order to transmit information, these RF signals are often modulated at frequencies which are within the frequency band of the accelerometers. If these signals enter the cable or other parts of the wiring, they will encounter the termination of the accelerometer's circuit which is usually a unipolar (field effect) or bipolar transistor. The transistor's p-n junction is nonlinear and will therefore detect the modulation of the RF. When the RF is not modulated, which is equivalent to modulation at a frequency of zero, the DC output bias voltage of the two wire system will shift. Once the signal has been detected by the nonlinear element, it can no longer be filtered without making the accelerometer inoperative.

The accelerometer's circuit can be redesigned to reduce these effects, which would result in some other disadvantages such as increased noise, or the transmission system could be changed using constant voltage rather than constant current powering. A redesign of the circuit would only be a temporary solution and not cure the essence of the problem. It is essential that the wiring system be properly designed to prevent the RF from entering into the cabling. Effective shielding is the single and most important measure in curing any RF interference problem. In order to obtain maximum effectiveness of a particular shielding measure, no breaks or points of entry should be permitted in the shield and the ends of the shield must be terminated properly.

The following applies to an internally amplified accelerometer having a relatively low output impedance, with its outer case isolated from signal return to prevent ground loops at power frequencies, and with its connector attached to the outer housing or case. Figure 1 shows a typical case isolated industrial accelerometer. The signal is transmitted using a twisted pair shielded cable, which has about 10 dB less RF pickup than a braided coax cable, since the signal return lead twisted around the signal lead provides additional shielding. A triaxial cable provides even better shielding. The case or housing of the accelerometer is isolated from a grounded metal structure whenever the accelerometer is mounted using dielectric epoxies or electrically isolated mounting pads.

Table 1 shows the different grounding schemes for different connections of the outer shield and its effects at RF and power frequencies. Other schemes such as connecting the shield to the case through a capacitor or resistor are not shown, since they are impractical. This shield must be connected directly to both ends of the cable, or one end directly and the other end through a component having low impedance at RF using very short lead lengths. If not connected at either end, there will be substantial (of the order of 30 dB for the units tested) increases in RF pickup. If the housing is not connected to the shield, there exists a short exposed lead acting as an antenna inside the 2 pin connector and a short exposed lead between the connector and the inner housing. Grounding the housing to the structure provides no shielding from RF interference.

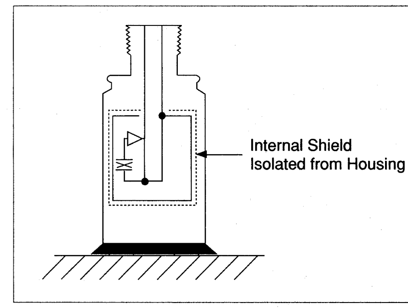
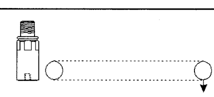
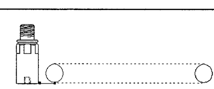
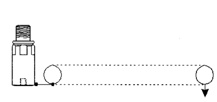
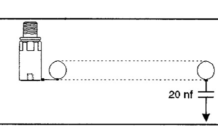
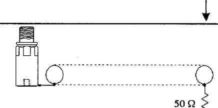


Figure 1. Typical case-isolated industrial accelerometer.

The best solution is to attach the accelerometer to an electrically isolated mounting pad and connect both ends of the shield directly. For battery powered data collectors the shield can also be tied to both ends directly without using the cemented mounting pad. Scheme 5, 4 and 3 of Table 1 are the other available options in descending order of preference. It should be noted that the shield, which is

Table 1. Accelerometer grounding schemes and their effects at RF and power frequencies.

Grounding Schemes	Diagram	Radio Frequencies Case Grounded or Case Isolated	Power Frequency Case Grounded	Power Frequency Case Isolated
1. Cable shield connected to instrumentation ground and not connected to sensor case		High pickup due to insufficient shielding at sensor even if sensor case is grounded	Low pickup	Low pickup
2. Cable shield connected to sensor case and not connected to instrumentation ground		High pickup	Low pickup	High pickup
3. Cable shield connected to instrumentation ground and to sensor case		Low pickup	Slight pickup due to unbalance of mutual inductance between each conductor to shield and the current in shield, if instrumentation ground and machine ground are at different potential	Low pickup
4. Cable shield connected to instrumentation ground through capacitor and to sensor case		Low pickup	Low pickup	High pickup due to lack of shielding at low frequencies
5. Cable shield connected to instrumentation ground through a 50 ohm resistor and to sensor case		Low pickup	Pickup due to unbalance of mutual inductance reduced by lowering the current in the shield using a resistor	Low pickup

Note: Diagrams show outer case (inner case, signal lead, and return not shown).

not part of the accelerometer's circuit, does not have to be terminated into the cable characteristic impedance at either end to prevent standing waves.

A better design, yet a more difficult mechanical design for case isolated accelerometers, would be to attach the connector to the inner housing or signal return, which is electrically isolated from the structure to which the accelerometer is attached. The shield can be connected to the instrumentation ground without creating large currents in the cable shield in case the machine and the instrumentation are at different power frequency potentials. For base isolated accelerometer designs where the shield is connected to the signal return, the connector is attached to the signal return and therefore has no RF hole at the connector.