Radio frequency interference on internally amplified accelerometer signals

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Interference on an accelerometer outputs from radiation at radio frequencies (RF) has been recognized for some time. 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 pas 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 would not correct the underlying 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 most important measure in curing any radio frequency interference (RFI) 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 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 crystal drives an amplifier and the entire assembly is electrically isolated from the case of the accelerometer. The circuit "common" connection ties to both the internal shield and the common of the circuit.

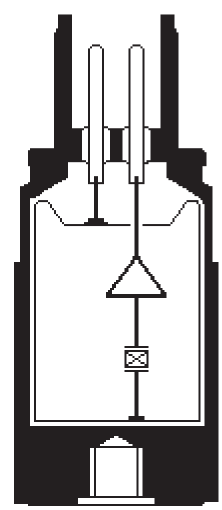
Figure 1

The signal is transmitted using a twisted pair shielded cable, which has about 10 dB less RF pickup than a braided coaxial cable, since the signal return lead twisted around the signal lead provides additional 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.

There are different grounding schemes for connections of the outer shield and its effects at RF and power frequencies. Schemes such as connecting the shield to the case through a capacitor or resistor are not used, since they are impractical. For the best RF protection this shield must be connected directly to both cable ends, 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 (on the order of 30 dB fro the units tested) increases in RF pickup. However, it must also be understood that connecting both ends of a cable shield to ground will result in a "ground loop" that will increase AC line frequency noise pickup, even though it will reduce the RF interference.

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 RFI shielding.

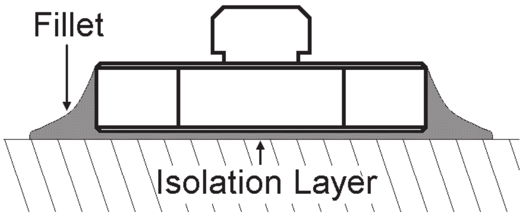

Figure 2

The best solution is to attach the accelerometer to an electrically isolated mounting pad, as illustrated in figure 2, 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. It should be noted that the shield, which is 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.

Wilcoxon has taken special precautions in the design and construction of premium-grade connectors to help users minimize the exposure of their accelerometer connections to RF. The 6SL and 6Q series of connectors incorporate a special shield (backshell) over the connections behind the connector barrel. Figure 3 illustrates the installation of the backshell.

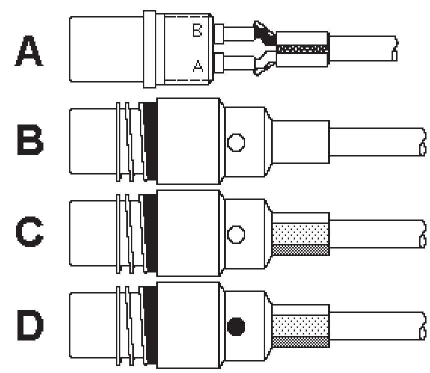

Figure 3

In "A" the shield ferrule is crimped to the shield. In "B" the backshell with a conductive spring is screwed onto the back of the connector barrel. In "C" the backshell is crimped to the shield ferrule, ensuring the connection backshell and spring. In "D" the connector body is filled with non-conducting epoxy to provide an environmental seal to the electrical connections.

Figure 4 is a photograph showing how the spring produces a shield covering over the gap between the backshell and sensor connector neck. This spring connection provides an effective shield against RF penetration to the accelerometer connection wiring.

When the connectors are ordered, 6Q or 6SL means the spring will be installed. For an "isolated" connection, the cables are ordered with 6QI or 6SLI part numbers. The addition of the "I" to the part number of a connector indicates the isolated connection. When these connectors are ordered for field installation, the spring is included in the connector kit and the user has the option of either keeping the spring attached, for connecting the shield, or removing the spring, for isolating the shield.

Figure 4

Table 1 on the following page lists the preferred connections for shielding and grounding to minimize RFI. It should be noted that some connection schemes that reduce RFI may cause increased power line interference because of ground loops being introduced on the shield circuit. These recommendations all assume that standard 2-pin MIL-C-5015 style connectors and shielded, twisted pair wires are being used. Where the table indicates the shield at the sensor is "connected," it means using the Wilcoxon 6Q or 6SL connector. Use of coaxial connectors on the accelerometer or coaxial cable for the wiring will cause increased susceptibility to RFI in measurement circuits.

Table 1: preferred connections for shielding and grounding to minimize RFI

Preference for RFI protection	Sensor mounting	Sensor style	Shield at sensor	Shield at measurement	AC signal interference
1	Isolated pad	Case isolated	Connected	Grounded	Minimal AC pick-up
2	Stud mount	Case isolated	Connected	Grounded	Severe ground loop problem, AC pick-up
3	Stud mount	Case isolated	Connected	RF ground through capacitor	Minor AC pick-up
4	Stud mount	Case isolated	Connected	Isolated	Minimal AC pick-up
5	Stud mount	Case isolated	Isolated	Grounded	Minor AC pick-up
6	Isolated pad	Case isolated	Isolated	Grounded	Minor AC pick-up
7	Isolated pad	Case grounded	Connected	Isolated	Moderate AC pick-up
Ineffective	Stud mount	Case isolated	Isolated	Isolated	Serious AC pick-up
Never	Isolated pad	Any kind	Isolated	Isolated	Serious AC pick-up