Platform Noise Measurements on Submarines and Surface Ships in High EMI Environments

Introduction

The continuing effort to minimize the radiated noise on submarines and surface ships necessitates the measurement of lower levels of structure-borne noise created by on-board mechanical systems. As passive listening techniques are becoming more sophisticated, the ability to monitor, diagnose and remediate even the slightest noise sources must be improved. Ironically, the electromechanical systems employed to lower mechanically generated noise levels also wreaks havoc on the sensitive electrical systems needed to measure these systems.

The Problem

Magnetic actuators require large amounts of electrical current to generate the forces needed for the desired mechanical movement. This current must be delivered via cabling systems from a distant power source to the actuator. As described by the Biot-Savart law, any current carrying conductor will create a magnetic field, and the magnitude of this field increases with increasing current. Thus, as shown in Figure 1, a cable segment carrying current to a magnetic actuator will create a magnetic field in the vicinity of the cable segment.

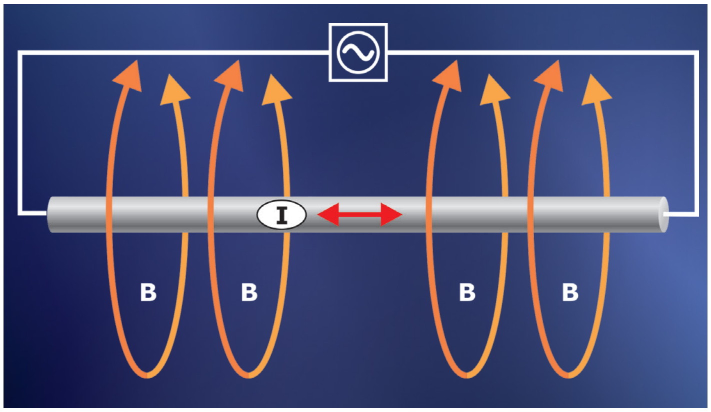


Figure 1: Magnetic field B created by current flow I in conductor segment

This phenomenon in-and-of itself is not troublesome, however, as described by Faraday's Law, any conductor loop exposed to a time varying magnetic field will have an AC voltage signal induced within the loop. To the measurements engineer trying to make low-level noise readings in the close quarters of a modern day submarine or surface ship utilizing high power magnetic actuators can be extremely difficult: ***Biot-Savart + Faraday = Trouble!***

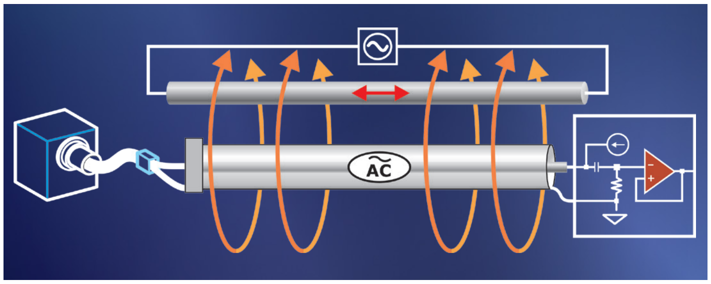


Figure 2: Voltage noise signal induced in sensor wire exposed to magnetic field

Minimizing loop area in extension wires is vital for sensor cables subject to high magnetic fields. Shielded/twisted wire is an effective connection scheme as the tight wrapping of the inner wires reduces electromagnetic susceptibility and the outer electrostatic shielding reduces pick-up from hostile noise voltage sources. In high magnetic fields however, even tightly wrapped wires are not enough to prevent magnetically induced noise signals from corrupting the measurement.

There are certain sensor connections that are particularly vulnerable to electromagnetic pickup. The Triaxial Integrated Electronics, Piezo-Electric (IEPE) Accelerometer utilizing a 4-wire connector is one such example. If single-ended signal conditioning is used for the X, Y and Z accelerometers, three large conductor ground loops are created in the wiring to the signal conditioner, as shown in Figure 3.

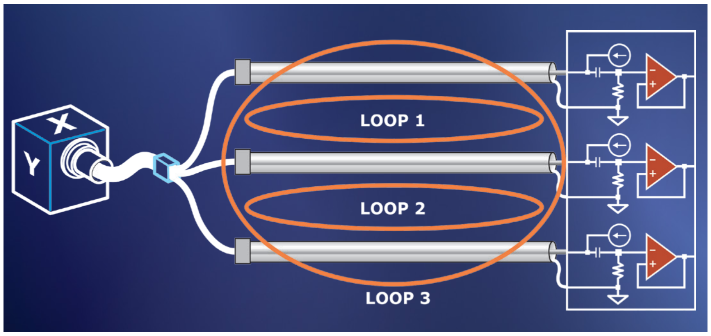


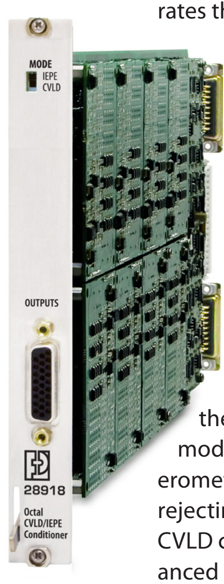
Figure 3: Ground loops created by improper connection of signal conditioner to triaxial accelerometer

If these conductor loops are exposed to time varying magnetic fields, there will be noise voltages inserted within the ground wires, and in some cases this noise may actually be larger than the signal of interest.

The Solution

While ground loops are a problem with all measurement systems, it is imperative to prevent even the smallest ground loops in sensor wiring exposed to high magnetic fields. The best way to break ground loops with triaxial, biaxial or grounded accelerometers or for any other complex sensor hookup configuration is to use isolated rather than grounded IEPE instrumentation. While isolated IEPE instrumentation has been available for many years, it has usually taken the form of large, single channel stand-alone instruments utilizing the isolation of the AC power supply transformer. Due to their large size, these instruments are not suitable to large channel-count measurement systems. Another technique employed to provide isolated inputs is the use of miniature DC/DC converters that provide independently isolated power to multi-channel systems. While this achieves higher density, amplifier noise performance suffers due to the switching transients inherent in DC/DC converter based systems.

The Precision Filters 28918 isolated IEPE conditioner uses proprietary input circuitry to provide high density, low noise IEPE excitation even to grounded loads without introducing ground loops. A fully populated 28016 chassis can provide 128 channels of isolated IEPE conditioning in only 10.5 inches (6U) of rack space. Each channel has independently programmable gain to 1,024 and 4-pole low-pass or band-pass filters with selectable cut-offs up to 30 kHz. The 28918 filter is software selectable to flat Butterworth type response for spectral analysis of rotating machinery noise, or linear phase Bessel type response for time domain analysis of wave shapes associated with shock or impulse phenomenon. Both filter types have stop-band zeroes for improved alias rejection, allowing lower sample rates than their Bessel and Butterworth counterparts.



In high magnetic field environments, when low-level signals are being measured, even the best magnetic wiring practices cannot prevent magnetic noise pickup from corrupting the measurements. The constant voltage line drive (CVLD) sensor can be used to reduce noise pick-up. The CVLD sensor presents the vibration signal as modulated current in the hook-up wire loop rather than a variable voltage. Since the CVLD signal conditioner measures this current flow and is not sensitive to magnetically induced voltage signals, it can be used to measure accurate low-level vibration signals even in the presence of large magnetic interference. In CVLD mode, the 28918 is fully compatible with CVLD accelerometers, accurately measuring vibration signals while rejecting noise signals by more than 80 dB. Unlike other CVLD conditioners on the market, the 28918 has fully balanced inputs providing improved rejection of electrostatic noise caused by large voltage signals in the vicinity of the sensor wires.

The 28918 is the optimal instrument for making low-level vibration measurements in the harsh magnetic environment of modern day submarines and surface ships. Whether the sensor type is IEPE or CVLD and whether the noise source is electrostatic, electromagnetic or ground loops, the 28918 will acquire accurate low-level signals and provide clean, amplified data-acquisition-ready output signals.

CVLD/IEPE Conditioning Turn-Key Systems Scalable to Your Needs

With three fully self-contained chassis systems to choose from, the Precision 28000 Signal Conditioning System is scalable to meet any size CVLD/IEPE measurement task.

128-Channel CVLD/IEPE Conditioning System

- Up to 128 channels with 8-channel 28918 Isolated CVLD/IEPE Conditioner plug-in cards
- Self-contained chassis system; cards, controller, power supply and cooling requires only 6U (10.5 inches) of cabinet space

64-Channel CVLD/IEPE Conditioning System

- Up to 64 channels with 8-channel 28918 Isolated CVLD/IEPE Conditioner plug-in cards
- Self-contained chassis system; cards, controller, power supply and cooling requires only 3U (5.25 inches) of cabinet space

32-Channel CVLD/IEPE Conditioning System

- Up to 32 channels with 8-channel 28918 Isolated CVLD/IEPE Conditioner plug-in cards
- Self-contained chassis system; cards, controller, power supply and cooling requires only 2U (3.5 inches) of cabinet space

For more information, please contact Alan Szary, Precision Filters, Inc. at 607-269-7694, or ars@pfinc.com.

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