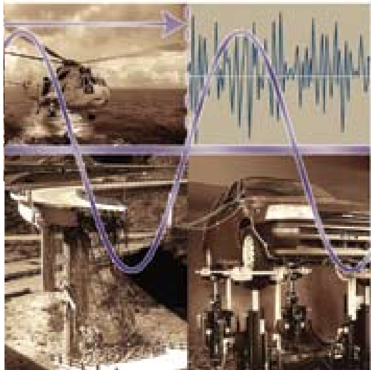


ERI News

your reliability newsletter

May 2007 | Equipment Reliability Institute | Volume 27

In this issue...

The Same Isolator – Is it Capable of Providing Both Shock and Vibration Protection?

by Herb Lekuch

The answer is - Yes - if the isolator is properly selected.

It depends on the application, the properties of the isolator and the sensitivity of the equipment. For instance, the performance of COTS electronics on Navy ships is often degraded by

- ◦ sustained vibration from propulsion machinery or over-stressed by
- ◦ shock from the ship's own guns or enemy action (particularly by nearby underwater explosions).

Low frequency isolation mounts* can effectively protect against vibration and shock (although space for isolators can be difficult to arrange). Aboard aircraft, sensitive optical surveillance and other delicate equipment can require precisely tuned isolators to reduce in-flight vibration. Supplementary 'lock out' mounts protect against shock in hard landings.

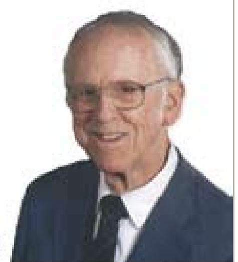
I'll cover the Navy COTS shipboard application in this section and precision isolation in another article.

Shipboard Applications

Navy machinery and electronics aboard ships are often mounted on anti-vibration isolators to protect the equipment from shock and vibration. The purpose of the isolators is to act as a control device – that is, as a mechanical filter in the load path between the ship and the equipment. The position and orientation of the isolators, and how they operate, can substantially reduce (or amplify) the vibration or shock above the mount (equipment side) versus the motion applied at the bottom of the isolator.

Equipment damage usually relates to peak acceleration in shock or stress fatigue from cumulative vibration. Designs are simplified if the isolators chosen for the equipment are capable of simultaneously reducing vibration and shock. Commercial isolators are readily available today that are capable of achieving these reductions over a broad range of loads and conditions. Elastomer isolators of this type from Shocktech are shown in Figure 1 (next page). Other manufactures of elastomer mounts are Newport News and Enidine. Cable mounts with similar characteristics are available from IDC and others.

(*) low frequency mounts generally refers to isolation systems below 10 Hz. To properly select isolation with dual characteristics, it is important to [A] know the vibration and



Voice of the President

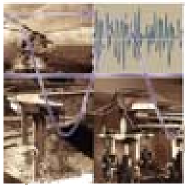
Shake 3 Axes At Once

Hooray! Military Standard 810, in its 2008 "G" revision, will finally recognize the need for vibration testing simultaneously in several directions. Recognize that the long-practiced three single-axis tests don't find all the problems.

"I was alarmed to discover that IMV and Shinken have sold more 3-axis shakers to Japanese OEM's and tier suppliers than they have sold to the entire United States defense and automotive sectors combined. I believe this technology has been a factor in the Japanese gaining automotive market share."

Those wise words came from Joseph P. Sullivan, Vibration & Simulation Technical Specialist, Visteon Corporation, Van Buren Township, Michigan. They were directed to the committee that is striving to release 810G in May, 2008.

Joe is concerned that USA manufacturers are still



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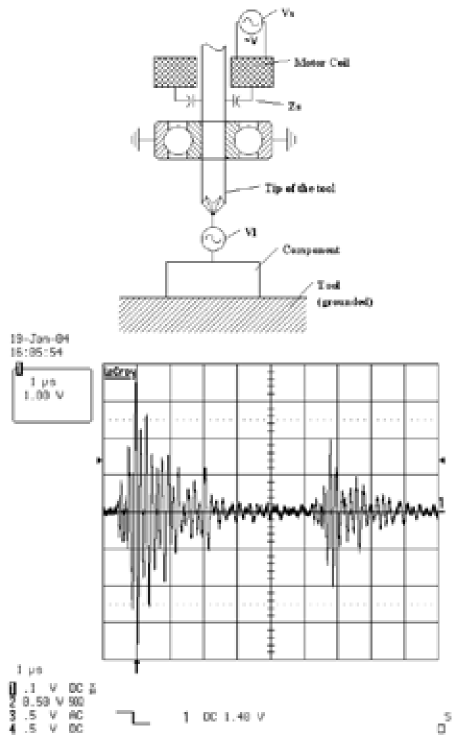
Grounding and Reliable Operation of Equipment

by Vladimir Kraz

Proper grounding of equipment is crucial for safe, proper and uninterrupted operation of equipment. According to Allen Bradley Journal, Sept. 2003, "Improper grounding accounts for up to 40 percent of costly power-related problems, including damage and downtime." While conventional means of grounding and its verification are well-known, let's consider other, less known aspects of grounding which contribute greatly to equipment downtime while remaining "below the horizon" for many in the industry.

As more and more tools in manufacturing process have electronics content and the complexity of this electronics increases, it is no longer enough to consider quality of grounding only for DC and for AC mains. Let's consider how high-frequency signals that are omnipresent in production environment can affect electronics equipment and, as such, almost any tool in today's manufacturing process.



High frequency signals that are often fall in category of EMI (Electromagnetic Interference) are often generated by normal operation of such equipment as stepper motors, relays, solenoids, as well as by switched power supplies and electronics circuits omnipresent in the tools. Such signals propagate through the entire tool and further throughout the facility via common connection to all the tools – ground. The specifics of the signals imposed on ground are more of transient nature than of continuous emission. Figure 1 illustrates a typical noise on ground in an industrial tool. This voltage was measured between an actuator (in this particular case it was a bit of an electric screwdriver) and the product which this actuator touched – all in the same tool. As seen, the peak voltage exceeded 3V. How that could happen if within the tool all conductive parts were grounded and this grounding was checked with the multimeter which showed that the ground connection between the tip of the screwdriver bit and the product that it worked on was 2 Ohms or better? In order for us to answer this question, we need to think outside of a proverbial "box" of DC and low-frequency AC practices and measurements.

First, we need to clear the air of an illusion that if ground connection was measured when the tool is at rest, this ground connection would remain intact during normal operation of the tool. Many ground connections are made via ball-bearings which when at rest, make reasonably good electric connection, but in motion are simply pieces of metal separated by insulative lubricant. Another erroneous assumption that needs to be cleared is that if ground connection looks good, it ought to be good indeed. Most tools are composite, meaning that they are made of several separate parts, such as frame, robotic arm, loader,

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conveyer, etc., etc. When all these parts are put together, ground connection is not always guaranteed. Anodized aluminum, as an example, is not a conductor. A painted metal part is not a conductor either; however enough of assumably good ground connections are made via such surfaces. Unless measurements prove good ground connection, it always should be considered a suspect.

The most significant reason for overvoltage on ground is the fact that at high frequencies a wire is no longer just a short circuit as it was at DC or at 50/60Hz. A simple straight wire at high frequencies is an inductor and as such, may present significant impedance to high frequency current. Similarly, coiled ground wire is an inductor as well, and it also may present significant impedance. On a top of it, at high frequencies only the outer layer, or skin, of wire conducts current – this is called a "skin effect." This skin effect adds to impedance of ground wires at high frequencies. Let's examine the effect of this impedance. A stepper motor consumes current that has significant high-frequency content (the detailed explanation of this phenomenon is outside the scope of this paper). This current must flow in its return path, which in many motors is combined with its ground. According to the Ohm's law, this current will produce voltage across the impedance of a ground wire. The higher the high frequency current, i.e. the noisier the tool, the higher the voltage. Similarly, the higher the impedance of ground wire, the higher the resulting voltage. This voltage across ground wire causes the tool or a part of the tool to electrically "bounce" vs. other parts of the tool and vs. good ground. This situation is very common in many production tools. It should be emphasized that the high-frequency noise is caused not only by stepper motors, but by a multitude of sources, including but not limited to such high-amplitude signals and voltage transient during commutation -- such short spikes have wide bandwidth.

This high-frequency voltage on supposedly-grounded surfaces produces several adverse effects that may affect equipment operation:

- ◦ The most sensitive parts in the process can be damaged by this voltage. Figure 2 shows the current observed during test shown in Figure 1. 180mA current may be quite sufficient for some electronics devices in process of assembly to be damaged, either immediately, or be weakened enough to fail in the field soon (latent damage)

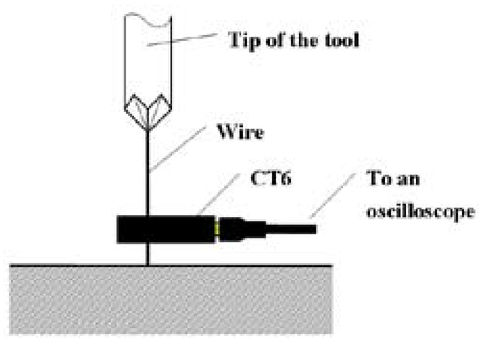

Figure 2. Current Measurement Setup in the Tool

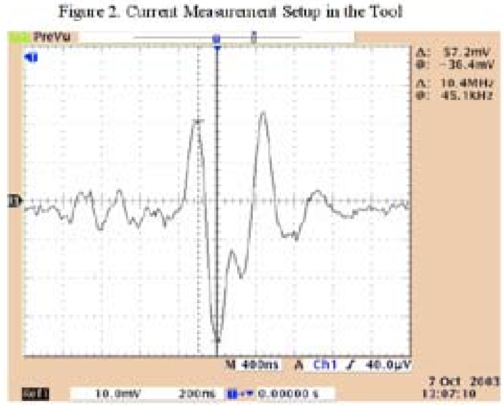

Figure 2a. Current in GBB (gold ball bonding) Tool (peak current is 182mA)

- ◦ High-frequency voltage may affect readings of sensors installed in the tools. "Extra" few millivolts induced on sensor wires may alter the temperature or humidity readings causing unpredictable adverse effects on the process

ERI News mentioned by Sensors web site

We're happy to observe that Sensors magazine's Melanie Martella listed ERI News in her recent "Mel's Picks" column. Read more...

Upcoming courses taught by ERG teachers

Steve Brenner, who has been working in the field of environmental simulation and reliability testing for over 30 years, will teach "Vibration and Shock Test Fixture Design":

- ► October 22-24, 2007, Easton, PA
- ► November 13-15, 2007, Roy (near Salt Lake City), Utah

Herb Lekuch, with extensive background in mechanical design, analysis and test, developed over 30 years of aerospace, military and industrial experience, will teach:

- ► "Enclosed and Shock Isolated Shipboard Electronics", October 16-17, 2007, at College Point, NY

Feedback on "What's a 'g'?" article

A "G" is the earth's gravitational acceleration at sea level, about 32.2 feet/sec/sec. When Newton dropped the apple, it accelerated at one "G."

For high impedance piezoelectric transducers for

◦ High-frequency voltage may influence test results in IC testers and board testers

◦ High-frequency voltage may induce false signals into electrical circuits causing equipment malfunction and lock-up

When equipment malfunctions or otherwise exhibits signs of mysterious behavior, one of telltale signs of it being influenced by high-frequency noise is apparent randomness of such malfunctions. It takes a coincidence of the step of operation of equipment that is most sensitive to such noise and an occurrence of noise. One has to be present at the right time at the right place with appropriate instrumentation to catch noise occurrence and to correlate it to the tool's malfunction. This, of course, is not realistic. What is realistic is continuous monitoring of high-frequency signals on ground in the tools and in the processes that are sensitive to the noise.

Recommended Practices
Noise issues are not likely to go away – if nothing else, their importance will only grow because more and more tools now contain both noise-generating electronics and, in turn, are more susceptible to noise themselves. More and more manual processes are being replaced by automated ones. To add to that, the components processed in the tools are getting more and more sensitive.

A two-step approach to understand and quantify noise problems is recommended:

Ground Noise (EMI) Audit
During this audit the noise, or EMI, map of the facilities is created. Measurements of EMI on the ground of each tool will give you a good baseline of the status of the ground at your facility. It also will provide you with information on EMI hot spots.

Continuous Ground and EMI Monitoring
In order to catch the occurrences of high noise incidents, warn personnel and correlate tool malfunction with their causes, nothing beats continuous monitoring of ground integrity and noise on ground. A correlation of time/date stamp of tool lockup and high noise incident happening at the same time will pay for itself many times over in understanding the root causes of the problem. A trend of noise on ground can be calculated and preventive measures can be taken before noise reaches levels where it can cause problems.

Instrumentation
Conventional tools, such as a multimeter, are unusable for high-frequency measurements – they do not have sufficient bandwidth nor can they record the peak values of the constantly varying signal. For ground EMI audits, tools such as Ground Pro (Figure 3) are recommended. Ground

Pro can measure peak and average noise on ground plus ground impedance in accordance with existing standards. For continuous monitoring of EMI on ground the most optimal tool is Ground Master that, in addition to monitoring ground impedance, provides independent monitoring of noise on up to 8 different ground points either within the tool or on several tools. Ground Master has its own indication and alarm, and in addition it provides comprehensive data to a facility monitoring or a data acquisition system.

References:

1. AB Journal, September 2003

acceleration, load, pressure torque, etc., sensitivity is stated in picocoulombs/G.

For IEPE transducers (Internal Electronics Piezoelectric), mV/G.

For bridge based transducers using either metal foil or piezoresistive gages, sensitivity should be specified as millivolts out/V in/G. (mV/V/G). Some transducer manufacturers, who came to piezoresistive transduction after using piezoelectric methods for years (Endevco, PCB, etc.), still specify these as mV/G - but this is technically improper.

Chuck Wright, ERI specialist

Connector Photos Needed

I need photo images of multi-pin electrical connectors showing bent and corroded pins and possibly looking into receptacles. Most useful: card-edge connectors for insertion into LRUs (line replaceable units) or "black boxes". If you have images that might help me convey the idea of "intermittency", please postal mail or attach them to an e-mail.

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2. “How Good is Your Ground” V. Kraz, P. Gagnon, Evaluation Engineering Magazine, May 2006

3. “EOS Exposure of Magnetic Heads and Assemblies in Automated Manufacturing,” Vladimir Kraz, Patsawat Tachamaneekorn, Dutharuthai Napombejara, EOS/ESD Symposium Proceeds, 2005

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Vladimir Kraz is a Director of Instrumentation in 3M Static Control Group. He was a founder and a president of Credence Technologies, a manufacturer of ESD and EMC instrumentation which 3M has acquired. Mr. Kraz is author of numerous papers in trade publications on the topics of ESD and electromagnetic compliance, as well as a number of U.S. and foreign patents. Mr. Kraz is a member of IEEE, ESDA and AES. He is a Chair of SEMI EMC Task Force, a member of SEMI ESD Task Force, a member of ESDA Ionization and Handlers Standards Committees.

Test Lab Musings (part 16)

by Robert L. Renz

As much as I try to keep my $1000 accelerometers in their original boxes for storage between tests, when I am getting set up or changing the shaker orientation I substitute a 4” x 8” plastic parts tray with soft foam on the bottom. It gives me a specific place to set an accelerometer when I need to briefly remove it from fixture or DUT and I have already put the manufacturer’s storage box away. The box is a small plastic parts tray with a layer of ESD foam. Not fancy, but a lot safer than setting the accelerometer on the shaker.

If you have multiple shakers in your facility, think about making one of your shaker controllers portable. Mounting the controller, the signal conditioners, and maybe a color printer in a portable roll-around rack will give you backup in case one of your other controllers is in the shop, plus you can roll it to a location (perhaps close to an active shaker) where you need additional monitoring.

Clean your accelerometer connectors regularly, particularly if you are using piezoelectric-type accelerometers. The low level of signal from these accelerometers makes them far more susceptible to noise than ICP accelerometers. How to clean them? Check the accelerometer manufacturer’s recommendations, but as a general rule, you need an oil-cutting solvent that doesn’t leave a residue, such as isopropanol.

Robert L. Renz of General Dynamics - Advanced Information Systems at Bloomington, Minnesota.

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