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Q: Why calibrate a vibration transducer?

A: The pervasiveness of vibration and shock sensors continues to grow at an exponential rate. You can find these sensors everywhere, from aerospace labs and automotive test bays, to smart structures providing condition monitoring systems and active control. While these sensors continue to improve the performance of people, products and processes, this growing nation of test and automation is also growing a calibration liability. Considering the work involved with calibrating all these sensors, the question typically follows, "Do we really *need* to calibrate all these sensors?"

In most cases, the answer is "yes." At sometime during a sensor's product life cycle, either at time of manufacture or in test, a sensor must be calibrated. Simply answered, without calibration to a known acceleration standard, an accelerometer's output cannot be absolutely verified and trusted. Another common response at this point is "Yes, I know it's a good idea, but it takes time to calibrate and they always pass anyway…"

True, calibration takes time and a sensor will usually pass. However, strictly speaking, when an accelerometer fails calibration (due to mechanical or electrical problems), all scaled data measured by that sensor are invalid since the time of last valid calibration. Often it is impossible to tell exactly when a sensor has failed; therefore, test data taken during the full calibration interval must be revalidated or scrapped – wasting time and money. This is why the most critical and costly measurement applications require sensor calibration both immediately before and immediately after each test, to validate the data.

Q. What is driving implementation of automated calibration systems today?

A. Evolving domestic and international standards, along with growing inventories of accelerometers, have driven the demand for companies to invest in automated calibration systems. The cost of outsourcing calibration begins to justify a calibration system purchase return on investment (ROI) once a user crosses a hundred calibrations per year threshold. Additionally, uniform quality standards like ISO 9001 and ISO 17025 evolve as measurement technology advances. What was considered sufficient or state-of-the-art a decade ago in terms of quality doesn't necessarily meet standards today. Not all calibration systems can pass these new standards. For example, total harmonic distortion measurement are now required in the ISO 16063-21 standard for vibration calibration.
As vibration and shock tests have become more ubiquitous and testing in general has become less expensive on a per channel basis, sensor inventories have grown to meet expanding channel count capabilities. All accelerometers need regular calibration, and automation speeds the process, lower cost and reduces uncertainty. Also significant is looming obsolescence. Many older calibration systems run only in DOS or early

Windows® versions, and computer hardware and software support is becoming non-existent.

Q. What does the typical engineer need to know about accelerometer calibration related to the standards?

A. Standards can often be technically and administratively intimidating. The first thing an engineer can do to reduce anxiety associated with learning a new calibration standard is to speak with a professional from either his calibration service provider, or appropriate calibration system manufacturer. In most cases, calibration is covered broadly in the standards section on the control of measuring and test equipment. The calibration professional can help distill the essence of the standard into its technical and procedural components. It is remarkable how quickly a complicated standard can be tamed with a little bit of helpful advice. Armed with representative data plots, example procedures and recommended calibration intervals, a typical engineer can quickly and knowledgably present and recommend a course of action for his team to move through compliance and/or certification to the various technical and quality standards. For example, our application engineers routinely help new calibration customers with performance characterizations of our precision air-bearing calibration shaker as compared to the ISO16063-21 vibration calibration standard.

Q. What is meant by calibration "traceability" and why is it important?

A. Traceability is achieved through an unbroken link of reference calibrations back to a physical constant or national standard. In many cases this may be to the US National Institute of Standards (NIST) or in Europe to the UK National Physical Laboratory (NPL) or Germany’s national calibration authority (PTB). Traceability is important to ensure the validity of the overall calibration system results. Typical calibration techniques utilize a back-to-back or reference sensor with which the test accelerometer signal is compared. In calibrating the system reference accelerometer, each step in the link of these reference calibrations adds more uncertainty into the end calibration performed. To provide the lowest possible uncertainty in our customers’ calibration data, PCB Group is one of the few organizations that operates our own in-house laser interferometer and is accredited for primary calibration of accelerometers for test and reference use.

Q. Walk us through the typical process for calibrating an accelerometer.

A. Mount the accelerometer, press start, and print cal certificate. It really is that simple. Of course, the calibration user or technician must ensure that mounting surfaces of the sensor under test and the shaker reference are flat; have no nicks/burrs; and are free of residue. Proper strain relief of sensor cabling is also important. Additionally, a small amount of silicone grease at the sensor mounting interface will ensure proper contact and cleanly transfer vibration at higher frequencies for a smooth calibration curve. Problems with any of these situations can cause anomalies, or local resonance “glitches” in the calibration results.

Q. What are some specific challenges in calibrating accelerometers?

A. Transverse motion introduced by the excitation system or calibration shaker is a common source of error. Shakers are structures and have modes of vibration, just like anything else. With traditional mechanical flexure-based exciters, the undesired transverse motion of the shaker can be more than 100% more than the desired primary axis motion. This large cross-axis excitation motion, coupled with a small transverse sensitivity in accelerometers, can cause an undesirable "glitch" at certain frequencies in the calibration curve. Also costly and troublesome with older calibration systems, is the sheer amount of time it takes to perform calibration. Some older systems can take more than 10 minutes per axis – providing for lots of "hurry up and wait!" Finally, ISO 17025 compliance of the calibration certificate can be a challenge. While the standard sets specific guidelines for calibration certificates, interpretation of this can be overwhelming. Unfortunately, not all calibration software is compliant, nor can it be customized to meet these requirements.

Q. How often should a user calibrate?

A. Depends. Most manufacturers recommend annual accelerometer calibration, but how a sensor is used and specific test requirements often dictate proper calibration interval. Exceeding the accelerometer's high or low temperature specifications, or if it is dropped, would be cause for recalibration. If the test object is safety critical or failure of the test object expensive, the calibration interval should be immediately before the test and immediately after the test. Such is the case with space flight hardware. On the other side, if the accelerometer is used only occasionally and there is a documented history of stability, the calibration interval might be extended to every 2 years.

Q. Is there any way I can make a quick accelerometer sensitivity check without doing a complete calibration?

A. Yes, TMS and PCB Group offers a portable 1 g shaker that can be used in non-critical applications to quickly check an accelerometer sensitivity at a single point fixed reference frequency. The 1g shaker is also useful for sending a 1g test signal end-to-end in multi channel systems to validate cable continuity and basic measurement channel scaling. It is important to remember, however, that the 1g shaker should not be considered a substitute for complete accelerometer calibration.

Q. Why are more modern calibration systems moving toward air-bearing shakers?

A. To use my kid's slang, because "they rock." Or conversely, they actually don't rock. Air-bearing shakers virtually eliminate transverse motion inherent in traditional flexure-based shakers. In fact, most flexure-based shakers fail to meet ISO 16063-21 recommended transverse motion specification. Earlier generation air-bearing shakers had a number of drawbacks, including difficulty in mounting the sensor under test, and adjustment of support rubber bands, depending on accelerometer mass. Our new generation design addresses these drawbacks. By using a unique locking support and a

Lorentz force lifting mechanism integral to the shaker, calibrating accelerometers of different sizes becomes fast and easy. This is in addition to other benefits, such as a self-centering bearing for easy operation, and electrical isolation for reduced noise floor.

Q: What is The Modal Shop's role in the calibration and test services market?

A: As part of the PCB Group, The Modal Shop continually probes the vibration calibration community for customer inputs and creative solutions to meet these needs. In addition to working directly with large channel count accelerometer users, technical personnel with The Modal Shop participate in the standards committees, network with leading calibration practitioners, correspond with national labs and participate in round robin calibration exercises. The end result of this focused effort is high quality products, rapid response service and sound technical advice for accelerometer calibration users.

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