



Vehicle Noise/Vibration/Harshness Testing Automotive

using the WaveBook

Application Note #54

Application Summary

Sometimes, a new vehicle coming off the production line is not perfect. Most problems are not serious, however, and fall into the category of noise, vibration, and harshness, NVH. When one or more of these crop up, the Quality Assurance team is alerted immediately to find the source of deviation from acceptable.

One major vehicle testing lab, for example, is charged with testing new vehicles, and occasionally, pre-production models. It's not unusual for them to conduct an on-line, two-hour inspection when something is not working to specifications, and especially when the problem is not immediately obvious. They must determine if a problem is related to suppliers' part quality, component design, or manufacturing. In addition to troubleshooting vehicles, the Quality Assurance team audits the production process and keeps the equipment calibrated, such as alignment and brake testing machines.

Potential Solution

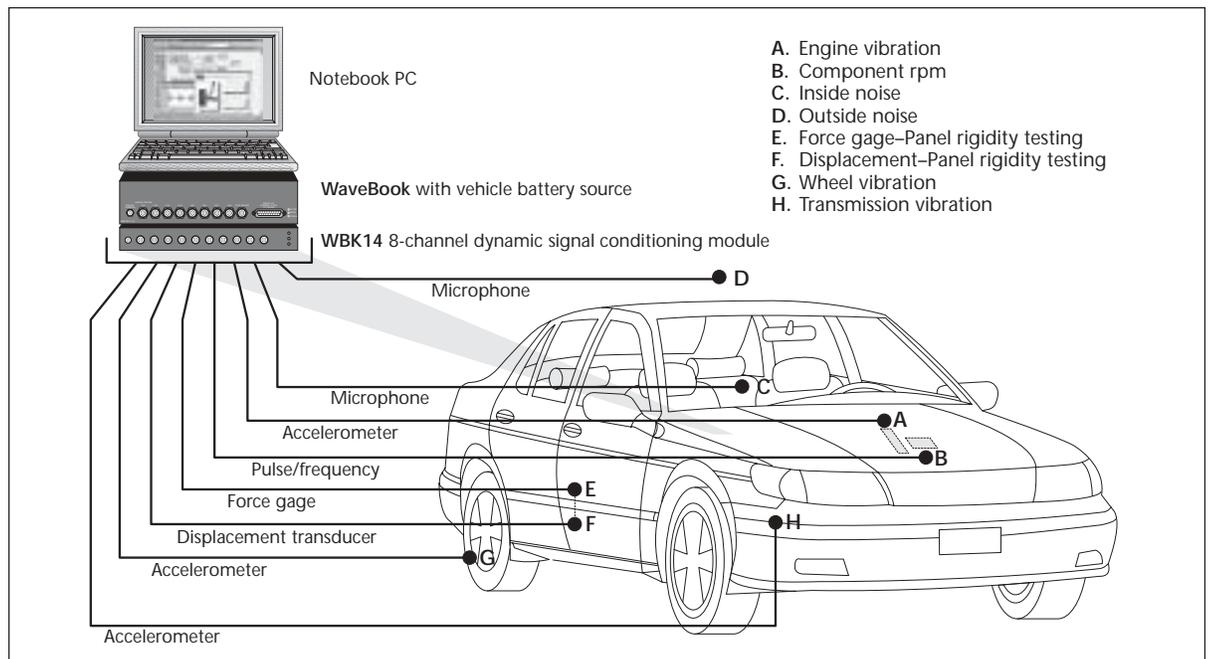
Because many issues manifest in NVH, QA does most of its work with microphones and accelerometers. The next most critical activity is panel-rigidity testing,

which is measuring force versus displacement of the body metal using a displacement transducer and a force gauge. The test engineers have traditionally used X-Y plotters to measure these variables. But plotters are slow and limited in their ability to accumulate massive data in an economical format. The engineers also used FFT equipment that came in large boxes and were particularly difficult to manage on the factory floor. With increasing vehicle production, QA needed to modernize and replace the X-Y plotters and FFT boxes to accelerate the process, save more data, and distribute the data faster

IOtech's Solution

The Product Quality Assurance section manager investigated a number of other solutions and selected the IOtech WaveBook™ vibration analyzer. It immediately replaced stacks of paper. The WaveBook lets them do the panel rigidity test and data acquisition much quicker and easier than the X-Y recorder. They can make measurements on all the different points on the vehicle body, then save each file and bring it up later, or plot the charts and e-mail the results. This has been a great time-saver.

The Quality Assurance Manager purchased the DASyLab® software and found it easy to use and more intuitive than previous software packages. In



The WaveBook and WBK14 signal conditioning module both conveniently operate from the 12V vehicle battery, so test engineers can gather much of the data on actual road trips. Panel rigidity tests, on the other hand, are typically conducted in the lab.



fact, his test engineers have been writing their own programs for vibration testing based on the **DASYLab**® software package. Other advantages of the equipment include; small and compact size which make it easy to carry around; and a 12 VDC power requirement, which makes it instantly available for vehicle testing.

Vibration testing is a search for the source of a noise, shake, or vibration. Engineers measure the frequency of the vibration and look for components that are rotating at the same frequency at that particular vehicle speed to determine the source of the sound or vibration, such as a tire, the transmission, or the engine. Vibrations typically run under 10 gs at 5,000 Hz or less, but the frequency range for sound is from nearly zero to 20 kHz. Sound is measured in both the inside and outside of the car, and the signals feed directly to the IOtech **WaveBook** so they can be analyzed with a laptop computer and **DASYLab**® software.

Test plans for the future include instrumenting a tire-force variation machine with IOtech equipment. It will be added as an upgrade to the electronics capability and replace an older FFT and chart recorder presently used. The tire is preloaded to 400 kgm and rotated to measure the variation in force. The tires can have hard and soft spots that show up on the force measurement. One hard spot is a first order condition, two hard spots are a second order condition, and measurements are made to 10 hard spots to define a 10th order condition. Specifications are put on the drawings for the tire manufacturers to indicate acceptable levels for first and second order anomalies, and sometimes third order. It's used as an audit of tire quality and a diagnostic tool for finding shakes or vibrations in vehicles. The force variation machine uses load cells so it provides a voltage output compatible with the **WaveBook**, but the engineers will also perform frequency analysis and order tracking on the signal.

Conclusion

The Quality Assurance team at a major vehicle manufacturer replaced outdated X-Y recorders and FFT analyzers with an IOtech **WaveBook** for faster and easier data acquisition and analysis of sound and vibration data. The **WaveBook** also stores the data in an electronic format that can be sent directly over the e-mail

to their technical center, which eliminates stacks of plotter paper and numerous hand-written reports. The transition from X-Y plotters was quick and easy for the test engineers. Although they went through a small learning curve because the IOtech equipment is very different, they experienced no problems.

WaveBook Series

The WaveBook™ series of portable and desktop digitizers offer multi-channel waveform acquisition and analysis for portable or laboratory applications. All WaveBook models include 8 built-in channels expandable up to 72 channels of voltage, accelerometer, microphone, strain gage, thermocouple, position encoder, frequency, high voltage, and other signal types. For applications beyond 72 channels, up to four WaveBooks can be combined within one measurement system, for a total capacity of 288 channels. WaveBooks are available with either an Ethernet or parallel connection to a PC.

Features

- PC connection via Ethernet, parallel, PC-Card, or PCI card
- 1 µs/channel scanning of any combination of channels
- Expandable up to 288 high-speed channels
- SYNC connection allows multiple units to measure synchronously
- Add up to 224 lower-speed thermocouple channels
- DSP-based design provides real-time digital calibration on all channels
- Single and multichannel analog triggering with programmable level and slope
- Digital TTL-level and pattern triggering
- Pulse trigger and external clock
- Programmable pre- and post-trigger sampling rates
- Sixteen 1-MHz digital inputs
- Operable from AC line, a 10 to 30 VDC source, such as a car battery, or optional compact rechargeable battery module



Included Software

- WaveView™ for *Out-of-the-Box*™ setup, acquisition, and real-time display:
 - Scope mode for real-time waveform display
 - Logger mode for continuous streaming to disk
- eZ-Analyst™ for real-time spectrum analysis
- Export data in third-party formats
- Includes drivers for Visual Basic®, Delphi™, C++ for Windows®, DASYLab®, and LabVIEW®
- ActiveX/COM development tools

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