EDITORIAL

April’s Fool

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They say that April 1st is the time to be fooled, whether by prank or by misfortune. In my case it was the latter that had me fooled during some vibration testing I had done several years ago. I thought I would share this cautionary tale with the readers of *Sound & Vibration*, and perhaps some of you will be able to relate. If nothing else, you may find it amusing, but there is also a lesson to be learned. Don’t put blind faith in your data – you might find yourself looking like a fool.

Several years ago (coincidentally, not far from April 1), I was getting back into testing after having been away from it for some time. I was excited and perhaps a little nervous to have joined a new organization and to perform my first test, the results of which had important implications for an impending decision. Having done many tests in the past, I cautiously but confidently set up the accelerometers on the test structure, configured the data acquisition software and ran my usual checks. Everything seemed fine. I went ahead and took several sets of data under various operating conditions and after further review, decided all looked well. So I set about post-processing the data.

Here’s where things took a turn for the worse. I was looking at rotating machinery vibration data, I had a good RPM signal and all my channels seemed to track with RPM as expected. The color maps looked reasonable and the vibration levels from the various accelerometer locations seemed to make sense at first glance. However, I noted that the harmonic content of all the signals was nearly “perfect,” with really sharp, clean lines in the color maps and without a lot of broadband energy between the harmonics. It was eerily reminiscent of what I had previously seen when looking at an FFT of a saw-tooth wave: strong fundamental and very nice, clean integer harmonics.

This image shown in Figure 1 is not the actual data in question, but is in fact a time/frequency color map of a saw-tooth wave as it sweeps up in frequency from 10 to 200 Hz. My data looked just like this. Though somewhat surprised by how clean and orderly the data looked, I had no reason to doubt it, since it tracked well with RPM and did not look like “bad data” to me. I chalked it up to the new software I was using and the lack of recent test practice.

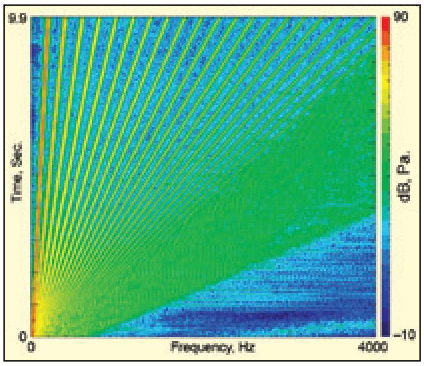

Figure 1. sawtooth wave sweep color map.

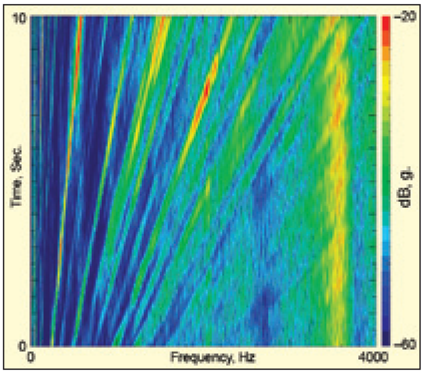

Figure 2. Actual RPM sweep color map.

I should explain that the main goal of this test was to show the level of vibration in the system as the measurement location moved away from the source. The result would argue for (or against) some expensive countermeasures, which were very unpopular at the time. Based on my analysis of this dataset, I saw a strong trend that, though somewhat surprising, was clear in the data.

What I saw was that as the measurement location moved away from the source, not only did the vibration levels *not* decrease as expected, but in several key locations, the vibration levels actually increased! Perplexed, I thought about this a great deal. I considered the physics of the system I was testing, the excitation source, the structures through which the vibrations were transmitted, potential resonances in the system, etc. that could explain this. I had been around a long time and had seen a lot, and with some imagination, I was able to put together in my mind a very particular set of conditions that just might explain this behavior.

Having convinced myself that there was a plausible, physics-based explanation, I assembled a detailed report, complete with color maps, order cuts and brilliantly written explanations and conclusions. I was proud of the work and eagerly shared it with the community, knowing however, that the result would be very unpopular because it supported the more difficult countermeasure path. As expected, my colleagues were unhappy with the result, but knowing that one cannot argue with data, they reluctantly agreed to implement the unwieldy solution required to mitigate this problem.

I went home that day with mixed feelings. I was happy that my first test in this new position had resulted in an important decision being made, but something really nagged me about the data. My plausible physics explanation notwithstanding, I just couldn’t shake the feeling that something wasn’t right.

The next day, I looked again at the data, and revisited the test stand where I had done the test. Why were the harmonics so clean? Why did the vibration levels not match my understanding of the physics of this piece of machinery? I opened the data acquisition software and went through every part of the setup and couldn’t find anything. I couldn’t put my finger on it, but I became increasingly suspicious that something wasn’t right. So I did the only thing that made sense to me at the time: I (secretly) decided to repeat the test. Luckily, the test stand was still available, but because I had de-instrumented the setup after the previous test, I had to basically start from scratch.

It’s a good thing I did, This time around, I set my pride aside and asked one of my colleagues to check over my setup once I had everything ready to go. I duplicated what I had done the first time around, and within a few seconds of looking at my test definition in the software, my colleague pointed out my fatal error: IEPE (integrated electronics piezoelectric). I had completely forgotten that the new-fangled sensors that are used these days have integrated signal conditioning within the transducer, and it is critical to tell the DAQ front-end which mode to use: “voltage” or IEPE. Well, being an old-school test guy, I had always used external signal conditioners with a standard voltage input to the DAQ, so I just plain overlooked that step. I realized that I had left all my vibration channel signal conditioning modes on the DAQ to voltage (the default setting) and not IEPE. Big mistake!

Shocked, horrified and embarrassed, I suddenly realized that my first round of data (and all the physics rationalization that I drew from it) were complete and utter nonsense. I redid the test with the appropriate IEPE mode selected for all the vibration channels, and suddenly the results made perfect sense. Now, the data looked “real,” and the behavior was exactly what I would have expected: The farther from the source, the lower the vibration level. The color map in Figure 2 demonstrates what the data should have looked like (not the actual data from that test).

What I learned was that strangely, when an IEPE transducer is plugged into a voltage channel (without any power supply to the chip in the transducer), there actually is a somewhat coherent signal generated by the transducer. Wwhile it doesn't represent anything real, to a "veteran rookie" like I was at the time, it *resembled* something that looked like reality. Boy, did I get fooled.

I quickly issued a new report and brought it to the attention of the engineers I had so brilliantly duped into going down the wrong path the day before. The resulting embarrassment and friendly (but serious) rebuking served to teach me a few good lessons. Thankfully, the dreaded countermeasure was no longer needed (it actually never was), and everybody went home happy with the final result.

You are probably already thinking about the numerous things I did wrong, but I'll summarize them for you here:

I lacked basic knowledge of the transducer types I was using and their function, simply relying on just plugging them in and letting the software do the rest.

I did not calibrate my vibration channels. A hand-calibrator check would have certainly failed without the appropriate IEPE setting, and I would have been forced to troubleshoot the problem before I ever took any data.

I believed my data too much and did not trust my intuition. I assumed my data were correct, even though they showed a behavior that didn't make physics sense to me. My "plausible" physics explanation was a stretch, but my non NVH-trained colleagues accepted it, since I was the "expert." I even had myself convinced.

Being new to the organization, I was too proud and too much in a hurry to impress my colleagues with excellent and timely results.

Besides reminding myself of the need to be more disciplined and thorough when setting up a test, the main lesson I learned was that one should not put blind faith in data, especially when it flies in the face of what experience and knowledge show to be true. I have read that pilots in training are taught to "trust their instruments," and this is a very good lesson to learn. However, if the instruments are not used properly, it is easy to imagine an errant pilot who is following the instruments, flying the plane to the ground even though a quick view out the window would show the ground fast approaching.

In my story, everything worked out for the better, but my ego sure took a beating. I continue to do testing to this day, and I can tell you that not a single test goes by without a thought about this little episode.

And as you might expect, I now follow some simple steps to ensure I have good data, and I *never* forget to match the transducer type to the DAQ channel configuration.

Thankfully, I have yet to repeat this rookie mistake. "Once burned, twice shy," as the saying goes.

So far, I am happy to report that I am an April's Fool no more.

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