S&V Questions and Answers

Transducer/Signal Conditioner Overload Effects

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One aspect of our testing activity is the ability to recognize a good vs. a bad measurement. Over time, we will all make our share of bad measurements. But, the question is, how many of us will realize that it's bad and be able to trouble-shoot the root cause of the problem and correct the situation? Bad measurements can be made for numerous reasons, such as bad analyzer setup, test setup, transducer selection, environmental factors, etc. Some of these areas will be the focus of future columns. In this month's Q & A column I picked a transducer selection problem that I have made myself and have seen others make.

This month's question is: **How can I tell that I am overloading my accelerometer and/or signal conditioning and what effect does this have on my measurements?**

Here's the testing scenario that leads to the above question: A test engineer is setting up to collect a set of Frequency Response Function (FRF) measurements using an impact testing technique. The test structure is lightly damped. The engineer selects an accelerometer with a sensitivity of 100 mV/g. Once the structure and analyzer were appropriately set up, a typical FRF was measured using four averages. The measured result is shown in Figure 1.

Without closer inspection, we might consider this FRF to be an acceptable measurement. It shows several distinct peaks, which may be associated with structural resonances. However, some of you have noticed that something is not quite right. The measurement should look like its been plotted from an equation. And this measurement has many peaks and valleys that appear to be periodic as a function of frequency. The phase and coherence functions would also show that something is wrong (this in itself will be a topic of discussion in a future column). When the root cause of the problem was identified and corrected, a second FRF measurement was made as shown in Figure 2. This is identical to the FRF measurement shown in Figure 1 as far as the analyzer setup and measurement location is concerned. So what's the difference?

To understand the difference between the FRF measurements in Figures 1 and 2, we need to start at the beginning. When setting up an instrumentation system, one of the first tests you should make is a time domain measurement. Why, because you already know what it should look like. The hammer force signal should be a short duration pulse and the accelerometer signal should be a transient comprised of a summation of exponentially decaying sinusoids. The best way to view these signals is to use the analyzer's largest analysis bandwidth, typically 20 kHz or higher. The large bandwidth will yield a time domain measurement with the highest sample rate, thereby providing a high resolution view of the digitized time waveforms. Figure 3 shows typical time domain signals observed while making the FRF measurement in Figure 1.

The excitation signal (top graph in Figure 3) appears as a short duration pulse like you would expect. However, the response signal does not look like a summation of decaying sinusoids. It is clipped between 0.0 and 0.05 sec. Your first thought might be that the analyzer's input range is set too low and the analyzer's front end is actually clipping the response signal. Most analyzers keep you from making this mistake by providing some sort of overload indication. In this case, the analyzer was not the source of the clipping. Exceeding the voltage limit of the accelerometer and signal conditioning caused the clipping. Since the accelerometer had a sensitivity of 100 mV/g, the response was being clipped at a little over 50 g as shown in Figure 3. This is very evident by viewing the accelerometer signal in the time domain and not so evident from the FRF measurement in Figure 1.

So how do we fix the problem? We need to select a different model of accelerometer that has an acceleration range greater than 50 g. The satisfactory measurement in Figure 2 was made using a different accelerometer, one that had a sensitivity of 10 mV/g and an acceleration range of ±500 g. Figure 4 shows the time domain view of the excitation and response signals when using the accelerometer with the greater range. Notice that typical response levels are in the range of ±200 g – much larger than what the original accelerometer was capable of measuring.

The lesson learned here is two-fold. First, view your signals in the time domain with high resolution to confirm that your signals look like what you expect. Second, know your transducers and signal conditioning.

Next Month's Q & A column addresses the question: If I must use an exponential (response) window when doing impact measurements, how can I compute the amount of damping I'm adding to an FRF measurement and can this be corrected for in the modal analysis system.

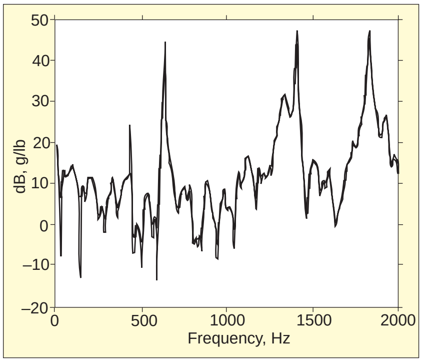

Figure 1. Typical frequency response function measurement

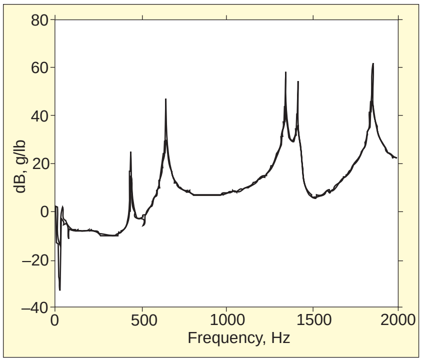

Figure 2. Good frequency response function measurement.

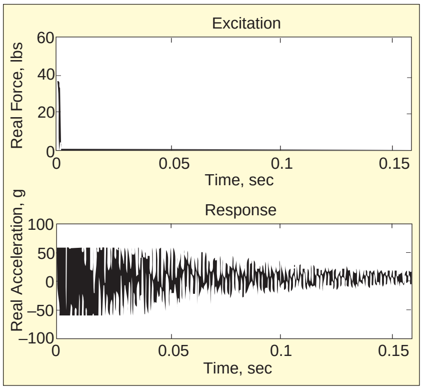

Figure 3: Time domain view of excitation and response signals.

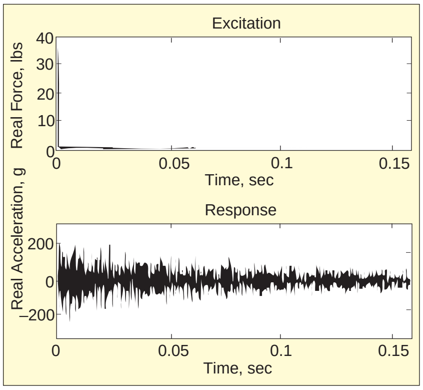

Figure 4. Time domain signals using a correct accelerometer.

Dear S & V Reader,

I'd like to welcome you to this new column which will be appearing every month. It will feature practical questions related to sound and vibration testing and analysis, along with explanations of the answers to the questions.

I have been fortunate, along with my colleagues at Sage Technologies, to meet and learn from technicians and engineers around the country while lecturing, training, consulting, and doing product development. The common ground we all share is the need to make and interpret measurements. Over the years we have been asked many questions related to sound and vibration testing and analysis. Many questions are thought provoking and subtle. And many are very difficult to answer because they often involve factors that would only be discovered through personal experiences. Unfortunately, we all cannot spend the time and make the mistakes that need to be made and recognized, in order to learn the principles involved in these fields of work. As a community we have a great opportunity to learn from each other, due to our collective experiences. I feel that the exchange of information provided through this question and answer format will help all of us do a better job in our testing and analysis work.

Every month we will pick one or more questions for discussion that will highlight some aspect of sound and vibration testing and analysis. Initially, my colleagues and I will pick the questions to get the column going. However, to really enhance the exchange of information we need you to participate by sending us your questions. From the questions and information received we will pick one or more for future Q & A columns. Your questions can be basic or advanced and on any topic related to sound and vibration. Please send your questions or comments to:

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A popular feature of Sound & Vibration, the S&V Questions and Answers Column has returned after a 15-year hiatus. The column will appear monthly in S&V. It features practical questions related to sound and vibration testing and analysis, along with explanations of the answers to the questions. Dave Formenti writes this column with the help of his peers at Sage Technologies. Sage Technologies, a national manufacturer's representative company with over 140 man-years of experience, provides expert advice and sales assistance for sound and vibration measurement instrumentation and analysis software.

Dave has over 26 years of experience in the sound and vibration field specializing in structural dynamics and dynamic signal measurements using multi-channel spectrum analyzers. Before joining Sage Technologies Dave worked for Data Physics, GenRad, Structural Measurement Systems (SMS), Hewlett Packard, and the General Motors Proving Ground.