MODAL SPACE - IN OUR OWN LITTLE WORLD by Pete Avitabile

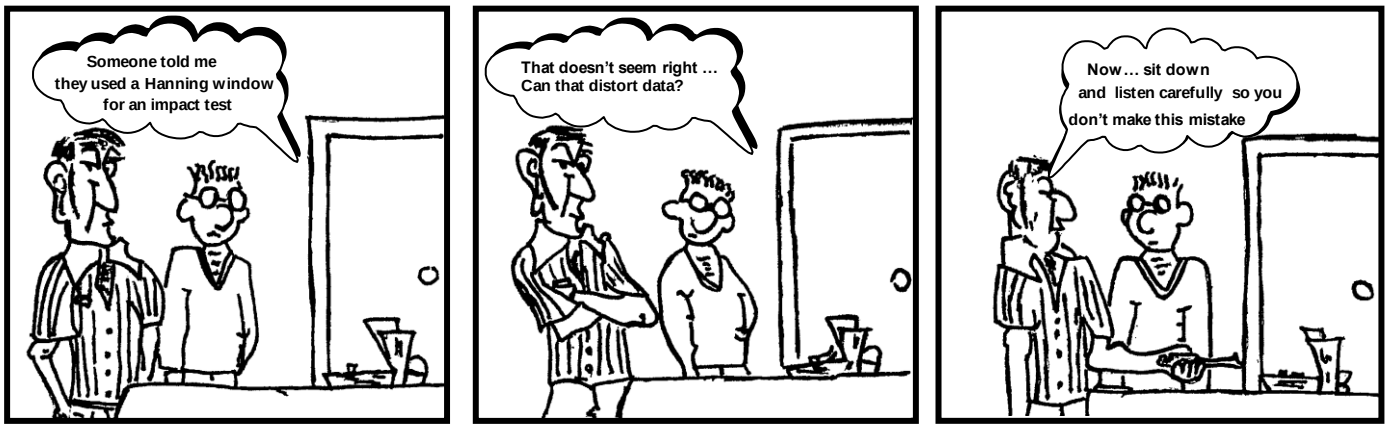

Illustration by Mike Avitabile

Someone told me they used a Hanning window for an impact test. That doesn't seem right…Can that distort data? Now… sit down and listen carefully so you don't make this mistake.

So…where do I start here??? First, let's just try to understand how things like this happen. Many times people take measurements in very difficult situations where the measurement conditions are not optimal to say the least. There are many instances where measurements are not the pretty textbook figures that we all wish we had for our measured frequency response functions.

There are plenty of situations where the system is in a very noisy environment, or the measurement transducers are not optimal, or the excitation is not sufficient to provide a measurable response, etc. And these are just some of the issues we face taking measurements. And please let's not forget that there may be nonlinearities (our arch-enemy) and complicated damping mechanisms (our arch-enemy's best friend) that all compound the measurement situation.

And because we have these types of difficulties and because we see them so often, we come to expect that all of our measurements are always going to have all of these difficulties. And then it becomes the rule, rather than the exception, that we come to expect this is just the way a measurement should be all the time.

But is that really so? Do all of our measurements really have such poor qualities all the time? Or is it just that we have become complacent and assume that's the way it should be?

So let's start by looking at the measurement that you provided in Figure 1. Oh my…..that is a really bad looking measurement. And at first glance I know that all of us could argue that this is from a nonlinear system, with a complicated damping mechanism, with a noisy environment with transducers that are the best that can be used to obtain this measurement and so on.

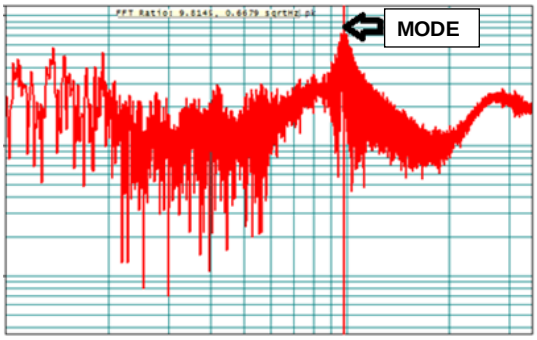

Figure 1: An example of a really bad measurement

But the real question is maybe why is this measurement so poor? Is it really from a nonlinear system? Is there really a complicated damping mechanism? Is there really a noisy environment? Are the transducers really that bad?

Or are all these just easy excuses that we can say because we really don't know or have just become accustomed to such poor measurements and assume "that's just the way it is".

I can't really comment on the measurement above other than you mentioned that it was from an impulsive excitation and that the measurement was made with a Hanning window applied – because that's the way it has traditionally been done. So the question is if this is really the right way to make this measurement.

So let's procede with a typical impact measurement on a general structure; actually this is a composite rib stiffened spar type structure that has been used before in other measurement situations. So the first thing we will do is to make a measurement with what would be the appropriate measurement

dignal processing parameters and then retake the measurement but use a Hanning window to show dramatic differences.

This first frequency response measurement (FRF) is shown in Figure 2 along with the coherence and the input excitation and output time responses. Now for this particular configuration, there really isn't any need to use a window on the input or output because the measurement is completely observable within the sample interval and satisfies the periodicity requirement of the fourier transform process. Notice that the coherence is very good and the FRF is also very good for this measurement. ***And just to be clear if any window was to be applied then it would be the exponential window for the response.***

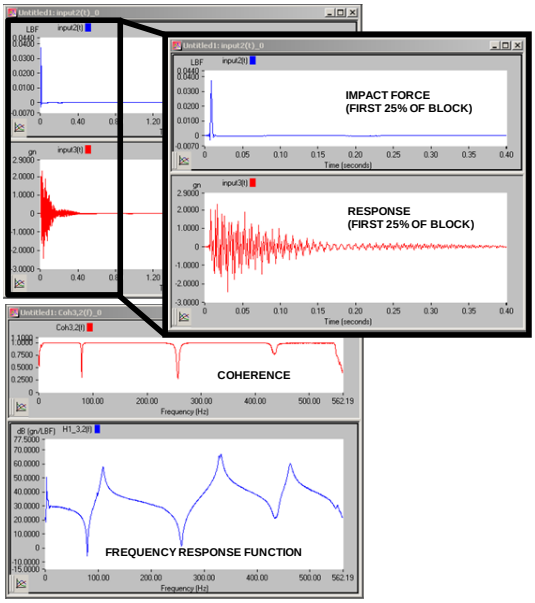

Figure 2: An example of an impact measurement with appropriate signal processing parameters applied

Now… let's make a measurement and apply a Hanning window on the measurement which is shown on the left column in Figure 3. ***Now please make sure you understand this is <u>not</u> the way to take this measurement but I am going to show exactly how bad this measurement can be.*** The input excitation and time response are the same but you can see that the FRF and coherence for this measurement are terrible – and terrible is an understatement of how bad this measurement actually is.

But what is confusing is that the time signals really don't look terrible by any means. Well what you have to realize is that the signals that are shown are the raw measured data and do not show the effects of the windows on the data. So it is not really showing how the data has been affected by the Hanning window applied in the time domain – but certainly the frequency domain shows a dramatic degradation of the measured FRF and coherence.

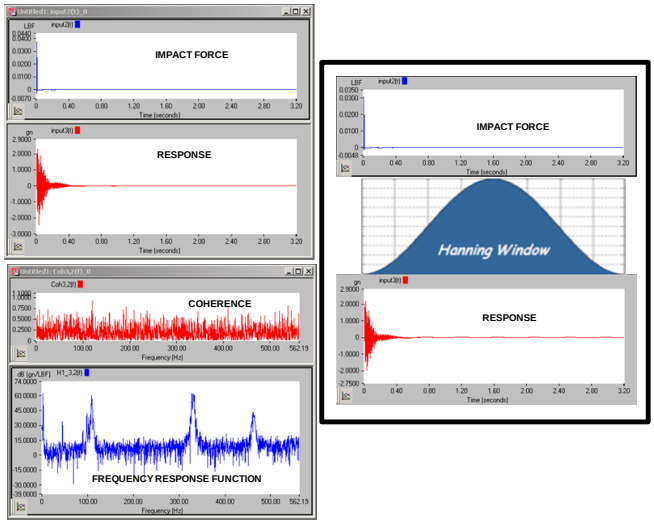

Figure 3: An example of an impact measurement with totally inappropriate signal processing parameters applied

In order to understand what happens when the Hanning window is applied, the right column in Figure 3 shows the two time signals with the Hanning window also displayed with the window appropriately scaled to visually compare with the measurements made. Now if you look closely at Figure 3 you will quickly see that the Hanning window is going to seriously attenuate the beginning of the time record of the input excitation and output response – and in fact will essentially weight all the important information regarding the transient response to zero thereby leaving a measurement which is essentially a measurement of the noise in the system. This now becomes very clear why the FRF and coherence in Figure 3 are so poor – the measurement has been essentially reduced to noise.

But if you weren't paying attention or have been misguided to think that this is just the way measurements typically look, then you might think that this was "the best measurement that can be obtained under the circumstances". But the reality of the situation here is that the signal processing parameters to process the data have been totally, incorrectly specified and the measurement has been completely distorted by this.

I understand that there are measurement situations where there are difficulties due to all the reasons mentioned **<u>but</u>** that does not give you the right to inappropriately process the data and cause additional errors "because you think it doesn't make a difference". In the case shown here, all the distortion was due to incorrectly processing the data and, in so doing, totally good data was converted into terrible, ugly measurements that are not acceptable under any circumstances.

I hope that this helps to explain the questions you had. If you have any other questions about modal analysis, just ask me.