MODAL SPACE - IN OUR OWN LITTLE WORLD *by Pete Avitabile*

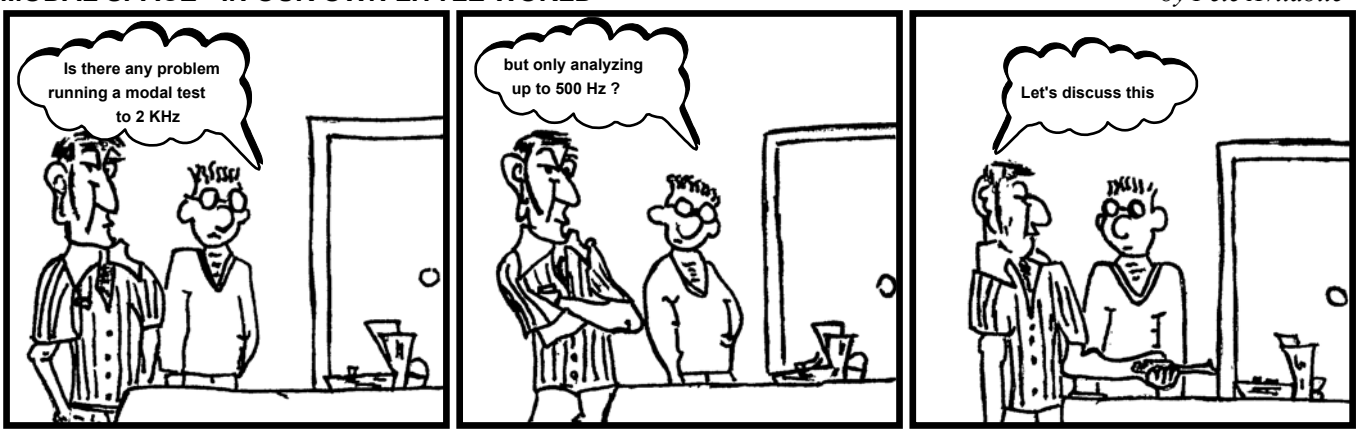

Illustration by Mike Avitabile

Is there any problem running a modal test with 2 KHz excitation but only analyzing up to 500 Hz ?
Let's discuss this.

Now this is an interesting question. There are several issues to be discussed relative to this. The more important question is maybe why one would want to run a test in this fashion in the first place and then discuss some of the issues that might have an effect on the overall measurement and then possibly some alternate things to consider.

So let's consider a measurement as shown in Figure 1. As the question was posed, the measurement would be acquired over a 2KHz range but the only range up to 500 Hz is to be analyzed.

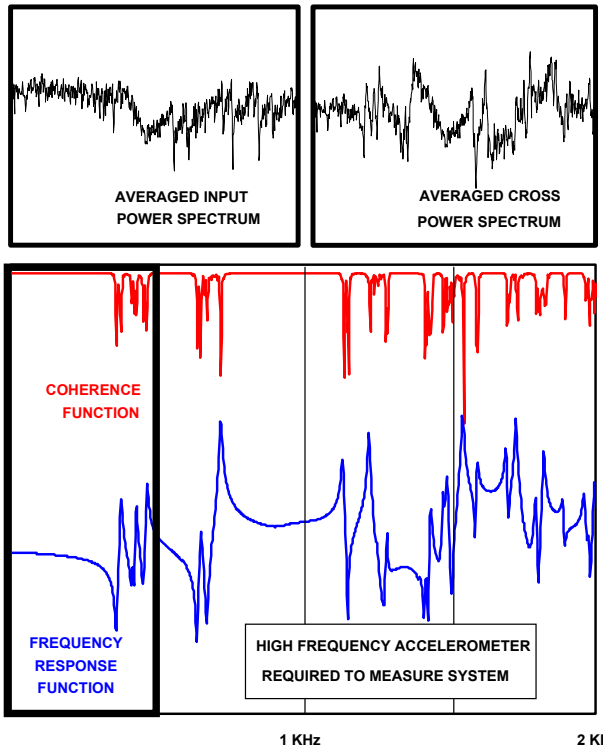

Figure 1 – Measurement over 2KHz with 500 Hz Concern

There is really no right or wrong answer here but I have some strong feelings regarding the adequacy of this measurement as shown. Without some very specific details, I really don't want to make this measurement as requested. Looking at the input power spectrum, cross power spectrum, frequency response function and coherence, there is definitely excitation and response to 2 KHz. There appears to be considerably higher response levels in the higher frequency range as well as many more modes of the system. This measurement looks acceptable overall but is it really the best possible measurement over the 500 Hz frequency range of interest?

The first thing to maybe consider is why is there only a need to extract model information up to 500 Hz when the excitations are a much higher frequency. Well, the analysis or design to be considered may only involve lower order frequencies. It may be that the model to be developed is only needed to address response up to 200 or 400 Hz and there is no need to consider the contribution of higher frequencies for the aspects of the design to be considered. That implies that the higher modes do not significantly participate in the overall response of the system and can be excluded from the analysis.

So if this is the case then the excitation need not extend to a high frequency to extract the measurements and model to describe the system dynamics appropriately. But possibly the excitation may have come from an operating condition where the input excitation is broadband and excites this wide frequency range. But because it is an operating condition, it may be considered a better excitation than an artificially generated excitation – but this is definitely debatable.

But there may also be a dual purpose need for the test. While you may only be concerned for frequencies up to 500 Hz for your analysis, there may be others that need to use and analyze the data for other applications up to 2 KHz. This is always a

problem when one test is to be used for multiple purposes and analyses. This is not the optimum way to conduct a test but may be used purely in consideration of time aspects when a test article is not available for long duration or is an expensive piece of hardware on a tight production schedule. In any event, there may be multiple reasons for this type of test scenario.

But what might be the issues that might affect the overall measurement. Well, there needs to be some consideration to the transducers used to acquire the measurement. If the excitation extends to well beyond 500 Hz (and up to 2KHz) then the transducers selected must be suitable for responses at this high frequency range. Of course, this implies that the accelerometers selected should be suitable for high frequency and, as such, may not be as sensitive at lower frequencies than an accelerometer that is selected specifically for a lower frequency range. So the issue that is of concern is the appropriate selection of transducer that is going to provide a suitable measurement below 500 Hz while not being overloaded or saturated by the higher frequency excitation. This can cause an inappropriate transducer selection

As another issue, the excitation up to 2KHz will cause high frequency response that may not be of interest or may excite other problems (such as nonlinearities) that might contaminate the overall measurement. My preference would be to measure only the frequency range of interest as shown in Figure 2.

It seems much wiser to limit the excitation used with a low pass filter and not ever excite the higher frequency modes of the system. This would then possibly allow the use of more

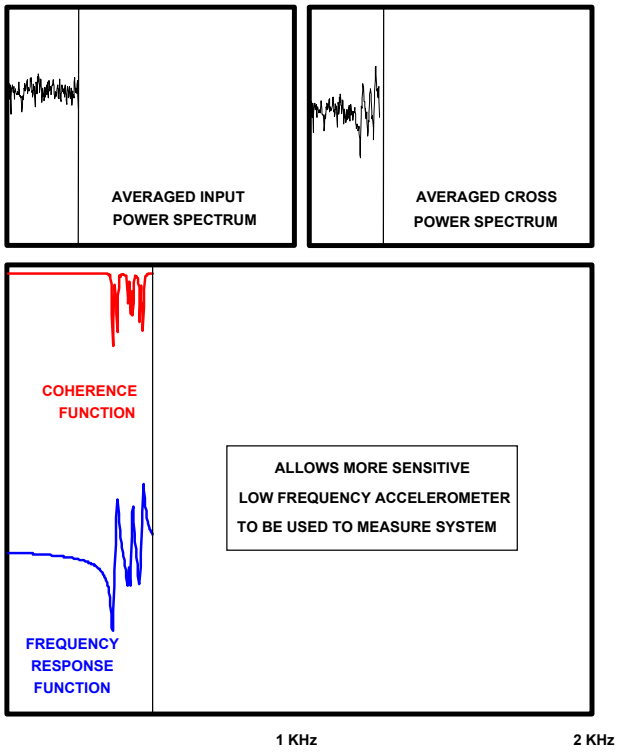

Figure 2 – Frequency Excitation to 500 Hz

sensitive lower frequency accelerometers that would provide a much better measurement overall. This also allows for a better utilization of the analog to digital converter in the acquisition system. But the bottom line is that the instrumentation and their associated signal conditioning must also be considered. Unnecessary loading of the transducer makes no sense at all. Why excite and measure something that isn't of concern?

But looking at the measurement, there may be some concern as to the contribution of the modes just beyond 500Hz and up to 1 KHz. If they are not measured then at some time in the future, there may be a reason or need to evaluate beyond what was required today. And looking at that next band in Figure 3, you can see that there is definitely some dominant modes that may be of interest (if not today, then maybe tomorrow). So you see that often there is not a clear cut answer as to what frequency range might be appropriate. But one thing is clear – the transducers selected for making the measurements are very sensitive to the actual frequency range to be tested and this needs to be well thought out before a test is conducted.

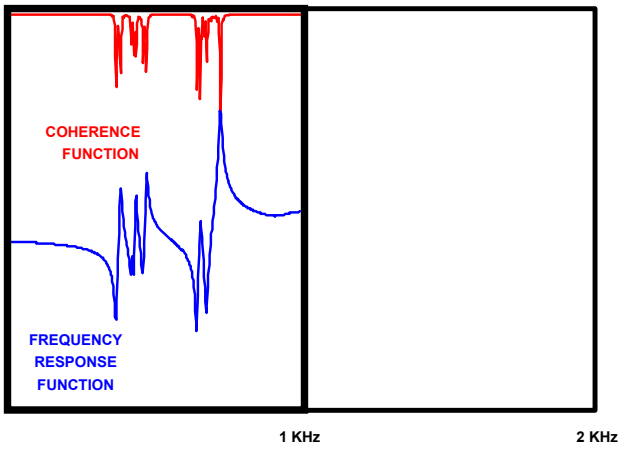

Figure 3 – Measured Response to 1 KHz

So what if I am forced to run a test with a 2 KHz excitation but only analyze to 500 Hz. It might be best to run a test with 2KHz excitation and a second test with 500 Hz excitation. Both measurements should provide equivalent information if all the issues identified above have been properly addressed. And if I am forced to excite the structure to 2 KHz, then I would run both tests and analyze both sets of data to see if there are any significant differences. Of course, this still would imply that the instrumentation would have to be suitable for both frequency ranges and therefore may not be optimum for the lower frequency range.

I hope that this little discussion has shed some light on the effects of acquiring data well beyond the actual frequency range of interest. It can be done, if required, but there may be some issues related to selecting transducers that appropriately measure the actual frequency band of interest accurately. You need to evaluate this carefully. If you have any more questions on modal analysis, just ask me.