MODAL SPACE - IN OUR OWN LITTLE WORLD by Pete Avitabile

Illustration by Mike Avitabile

Someone told me that you can't accept a FRF when the input spectrum has more than a 20 dB rolloff
Let's discuss this and consider difficulties.

Well this is a very touchy topic with many people. I remember back when some people claimed that there could be no more than 1 dB rolloff on the input spectrum. Well this was a very harsh criterion and in fact this actually excited many modes well outside the band of interest and could potentially saturate the accelerometers thereby making a poor measurement.

Now let's understand why we even try to make rules to live by in modal testing. Many times there may be some tests where we may want to provide some guidance as to typical ways to conduct the test. This is intended to protect us from making measurements that may not be particularly useful in some testing scenarios.

But the problem is that some of these "suggested rules" get interpreted as if they are cast in stone as if they were the Ten Commandments. And maybe at the time the "suggested rules" were made might have been back 20 or more years ago when instrumentation was not as good as it is today and back when 12 bit acquisition systems were very commonplace. But maybe those rules are not as critically needed today with much better instrumentation and 24 bit acquisition systems commonly used.

So while I think "suggested practices" are clearly needed, I also think that we need to realize that they are suggested and we need to understand how to interpret if the measurement is useful or not.

So to illustrate this, a simple plate structure was tested with an impact excitation technique. Two tests were performed. One test with a harder tip with an input spectrum with a 10 dB rolloff over the frequency range of interest. The second test was with a softer tip with 30 to 35 dB rolloff - approximately 10 dB rollover over the first third of the spectrum, approximately 25 dB rolloff over the next third of the spectrum with the remaining rolloff over the last third of the spectrum.

The hard tip and soft tip input force spectrum are shown in Figure 1.

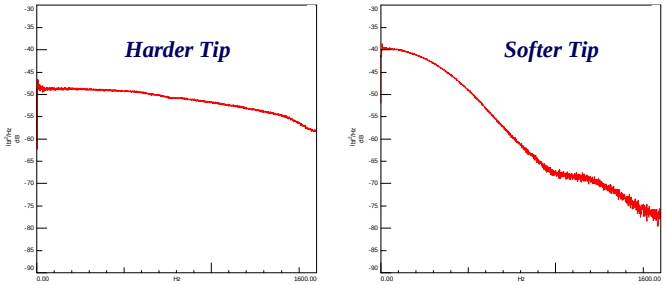

Figure 1 – Comparison of Hard Tip and Soft Tip Force Spectrum

The drive point FRF for the modal test with the harder hammer tip is shown in Figure 2 and the drive point FRF for the test with the softer tip is shown in Figure 3. Now clearly, the FRF with the harder tip is overall a much better measurement as evidenced by the coherence. One thing to notice in the FRF with the softer tip is that the measurement at the higher frequency shows some variance on the FRF overall and there is a slight degradation of the coherence at the higher frequencies.

Now we have to ask ourselves exactly why are we taking the measurements and performing the modal test. Sometimes tests are performed to obtain very high quality measurements for very specific applications. But sometimes measurements are made to get a general understanding of the generic characteristic shapes for the structure and maybe do not need to have the same high quality as some other tests that we may need to perform.

Think of it like buying lumber for a home building project. We don't always need knot free wood for the entire project. Sometimes wood of a lower quality is more than adequate for the project undertaken.

Now I would always like to take high quality measurements all the time but sometimes the cost involved in doing that makes the test prohibitively expensive. So let's see just how good or bad these measurements are. Modal parameters were estimated from both sets of measurements. The generic mode shapes are shown in Figure 4 for reference. A MAC was also computed for the two sets of mode shapes and is shown in Table 1.

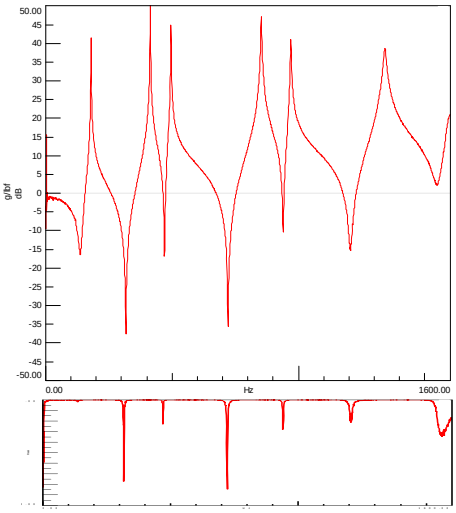

Figure 2 – FRF and Coherence for Hard Tip

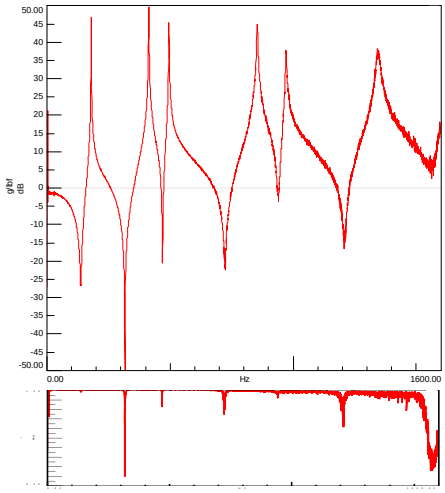

Figure 3 – FRF and Coherence for Soft Tip

Now the mode shapes are seen to be essentially the same from both tests. So the FRF measurements seem to be adequate for the simple assessment of mode shapes for the structure.

Now I am not advocating that this type of input force spectrum rolloff is acceptable but sometimes there is still useful information that can be obtained from data. So while we have "suggested rules" that doesn't necessarily mean that the data is not useful. But we do need to be careful as to how we collect the data and interpret the results.

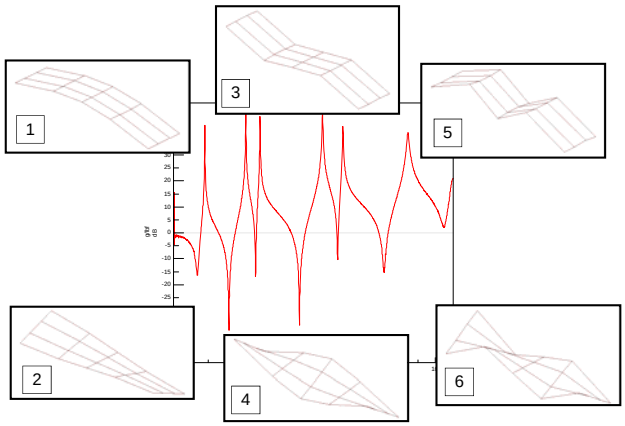

Figure 4 – Mode Shapes for Structure

Table 1 – MAC for Two Modal Tests Performed

Frequency	*179.3 Hz*	*413.5 Hz*	*495.1 Hz*	*853.7 Hz*	*970.6 Hz*	*1345.2 Hz*
179.3 Hz	*100*	*0.006*	*0.152*	*0.048*	*32.868*	*0.006*
413.5 Hz	*0.006*	*100*	*0.015*	*0.123*	*0.002*	*9.974*
495.1 Hz	*0.152*	*0.015*	*100*	*0.001*	*0.165*	*0.075*
853.6 Hz	*0.048*	*0.124*	*0.001*	*100*	*0*	*0.179*
970.6 Hz	*32.873*	*0.002*	*0.165*	*0*	*100*	*0*
1345.2 Hz	*0.006*	*9.975*	*0.075*	*0.179*	*0*	*100*

I hope this helps to explain that sometimes we have "suggested rules" but that sometimes we can still use information beyond the typical acceptable range of useful data. If you have any other questions about modal analysis, just ask me.