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

Illustration by Mike Avitabile

Is it really necessary to reject a double impact?
Are they really a problem?
Let's talk about this.

I know that many people will say that a double impact is totally unacceptable. It is not the optimum condition for collecting impact data for a modal test. However, under certain circumstances, it may be reasonable to accept a measurement that has resulted from a double impact. Let's discuss this problem that may arise when a double impact occurs and explain how to determine if the measurement is acceptable or not.

First, let me state that I would like to avoid double impact measurements at all costs. It is not a desirable situation but at times it is unavoidable. The real concern should be the adequacy of the frequency response measurement which is really the deciding factor. Just recently, I was involved in a modal test where double impact measurements were a concern. The engineer involved in the test was quite firm in his position that no double impact measurements would ever be acceptable. (In fact, the engineer quoted reputable sources as to his position on this subject). When asked why double impacts were unacceptable, the engineer responded with a comment that any good test engineer knows not to accept a double impact measurement! This is good advice but the engineer really didn't understand what were the limiting factors in this type of measurement situation; he only knew not to accept the measurement. Of course , if the measurement is not good as evidenced by the coherence and poor input forcing function spectrum, then the double impact measurement may well not be acceptable.

Unfortunately, since double impacts were a problem, the engineer picked a measurement location that avoided double impacts but resulted in an extremely poor measurement overall. The measured FRF was much worse than the measurement that resulted from the double impact. In order to illustrate some points, let's take a look at some of the acquired measurements and explain some of the problems, pitfalls and things to consider when faced with this problematic measurement situation.

While the actual structure under test is not shown, the system can be simply depicted by the schematic shown in Figure 1. The cantilevered plate-like structure is very responsive and prone to double impacts during testing. Two measurement locations were considered - the end of the cantilevered where double impacts are likely to occur and a location on the plate closer to the cantilevered end where double impacts are avoided. (Note that in all frequency plots, a dB scale was used with 100 dB of dynamic range for plotting the input spectrum and frequency response function; the coherence is plotted on top of the frequency measurements for ease of interpretation with a range of 0 to 1).

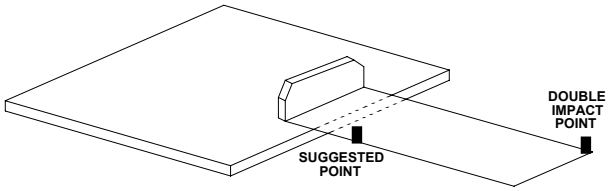

Figure 1 - Structure with Measurement Locations

The engineer wanted to avoid the "double impact location" and identified a "suggested point" where there was no double impact observed. The measurement for the "suggested point" (impact time history, input force spectrum, frequency response function and coherence) are shown in Figure 2.

The first thing to notice is that the impact and force spectrum appear to be very good. The force pulse contains one pulse and the resulting frequency spectrum is reasonably flat over the entire frequency range with less than 10 dB rolloff over the entire frequency range.

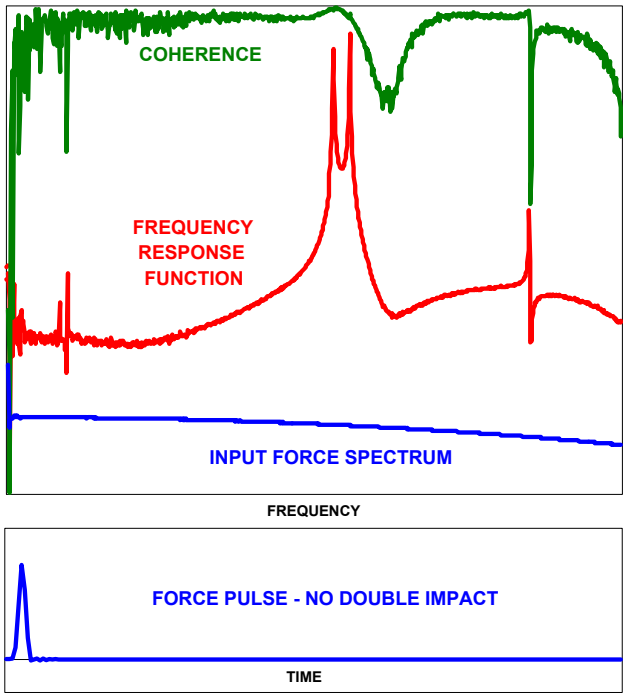

Figure 2 - Measurement with No Double Impact

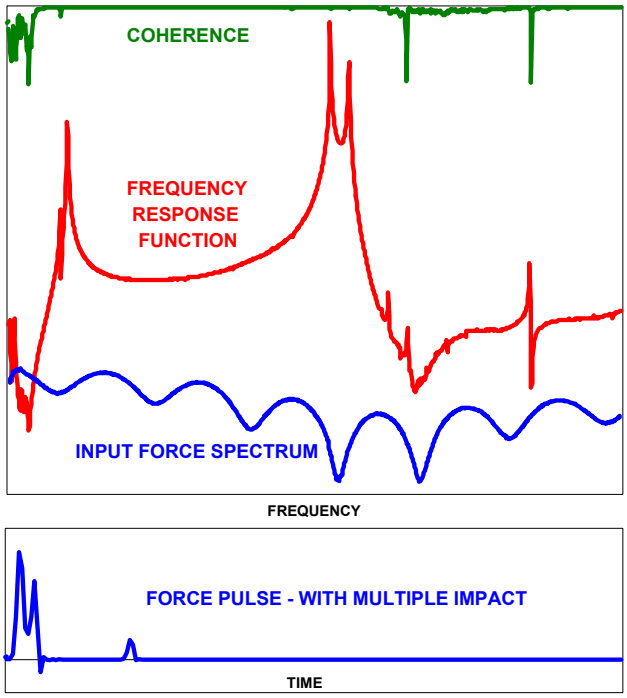

Figure 3 - Measurement with Multiple Impacts

The resulting frequency response function and coherence are also presented in the same plot. In general, the frequency response function is not particularly good as evidenced by the poor coherence at many frequencies over the spectrum. Notice that the coherence is very poor at low frequencies and there appears to be 2 peaks that are not excited very well and appear to be in the noise of the measurement.

Clearly, there is no double impact but the measurement adequacy in my mind is very poor - and most would agree that this is not a very good frequency response measurement. In fact, the engineer attempted to defend this poor measurement stating that the structure is very complicated, with many joints and possible nonlinear behavior. (I wish I had a dollar for every time I have heard that statement ! Nonlinearity and joints and damping - oh my!).

Now let's consider the measurement where the double impact, actually multiple impacts, are observed. Now this measurement clearly has multiple impacts on the input force excitation. The input spectrum is not flat and has some variance over the frequency spectrum. The actual variation is between 20 and 25 dB over the spectrum. Of course, I agree that I would avoid this particular measurement but the frequency response measurement and coherence are actually very good.

The frequency response function is relatively good and the peaks in the measurement are well defined especially at the lower frequency range (where previously the peaks were not measured well and were contaminated with noise). There are also two additional peaks in the higher frequency range that were not even observed in the previous measurement. Actually if I hadn't made all this fuss concerning the double impact and just showed the frequency response function and coherence, most people would have accepted the measurement without any questions. (It also can be stated that the previous measurement would not have been considered acceptable if only the frequency response function and coherence were shown).

So what do we need to be concerned about? If the input spectrum has significant drop out at any particular frequency, then the measurement may not be adequate. But before we can make any assessment, the input force spectrum, frequency response function and coherence need to be reviewed and evaluated. We cannot make a blanket statement that double impact measurements are unacceptable.

I agree that I will avoid double impacts at all costs to be safe - but we have to realize that the double impact itself is not necessarily a problem if the input force spectrum, frequency response spectrum and coherence are all acceptable. If you have any more questions on modal analysis, just ask me.