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

Illustration by Mike Avitabile

What are some of the most important things to consider when impact testing?
Let's discuss this.

This is a very good question. The most important considerations can be broken down into those that are impact related and those that are response related. The excitation concerns are numerous. Only issues pertaining to hammer tip, trigger delay and double impacts are discussed here. However, other issues related to overload/underload of the analog to digital converter, poor utilization of the digitizer, and difficulties with testing nonlinear structures, are some additional concerns (but are not addressed in this article). The response concerns lie with the signal decay and the need for windows to minimize leakage. Let's first discuss the excitation issues and then the response issues.

First of all, the hammer tip is largely responsible for the frequency spectrum that is excited. In general, the harder the tip, the wider the frequency range that is exicted. The hammer tips typically used range from rubber to metal on the extremes with various intermediate tips such as the soft plastic, hard plastic, eraser, etc. Each of these tips are designed to have a certain amount of elastic deformation during impact. The total time duration of the tip impact is directly related to the corresponding frequency range that is excited. Generally, the shorter the length of the time pulse, the wider the frequency range that is excited (Figure 1 shows some typical tips).

While this is generally the case, often the local flexibility of the structure can play an important part of the total time of the impact and therefore can have an effect on the force spectrum imparted to the structure. You may have noticed this when testing structures that have dramatically varying stiffnesses throughout the structure. When impacting a stiff region, one input frequency spectrum is observed and a much different, narrower frequency range is excited when impacting more flexible regions. (The published impact tip frequency spectrum provided by the hammer manufacturer does not include any of the local structure flexibility effects.) Be careful !!!

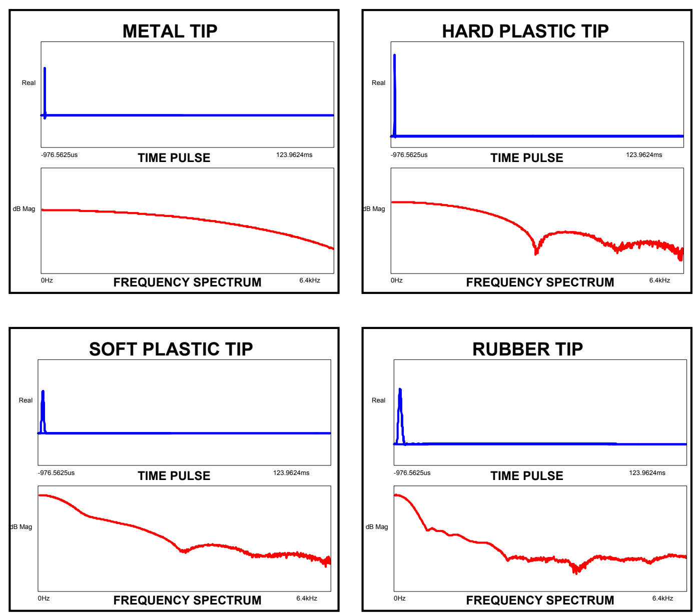

Figure 1

Another somewhat important test consideration for impact testing relates to the need for pretrigger delay. Since the measurement initiation is controlled by the leading slope of the pulse, part of the pulse is lost and the resulting spectrum is distorted unless some pretrigger delay is specified. The effects of spectrum distortion is shown in Figure 2. The red pulse and resulting frequency spectrum are clearly different than the correct blue pulse and resulting frequency spectrum with pretrigger delay. This can cause some input frequency spectrum distortion which will have an effect on the computed FRF.

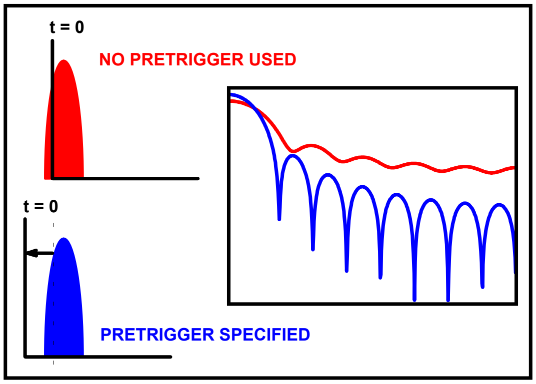

Figure 2

Typically, a pretrigger delay of 1% to 5% of the time window is sufficient to eliminate this effect. Care must be exercised when specifying this delay since some FFT analyzers use a plus (+) delay for pretrigger delay while others use a minus (-) delay for pretrigger delay. This causes a totally incorrect frequency spectrum if not applied correctly. Check your time pulse to assure that the entire pulse is captured in the time signal. In addition, some analyzers use a percentage of the block whereas others use an absolute time value in seconds. If absolute time is used then this can cause problems especially when changing bandwidths during test setup. Be careful !!!

Another annoying impact testing problem is the double impact. The double impact generally causes a non-uniform, non-flat input force spectrum. Two typical double impacts are shown in Figure 3. The "ripple" in the spectrum is not desirable especially if the force spectrum dips substantially. A drop of 30 dB or more is cause for concern especially if it occurs at a resonant peak - and it often does.

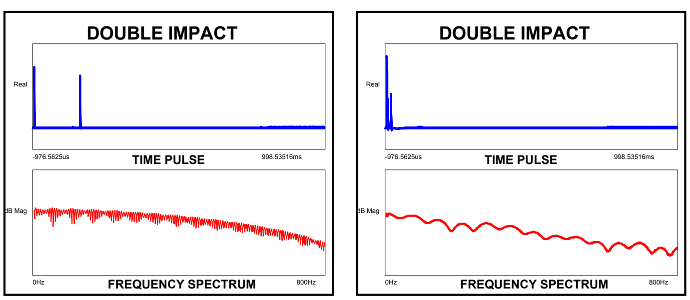

Figure 3

The reason for the double impact is generally from two possibilities. First, many double impacts occur due to new or inexperienced impact testers. It takes some time to get accustomed to swinging the hammer - it is a much different technique than driving nails! But even with experience, sometimes a double impact is unavoidable. Often, with lightly damped structures, the response of the structure is so fast that the hammer can not move away from the structure due to the response of the structure. In these cases, double impacts are unavoidable. The problem is that often the impact spectrum will have significant drop out at the major resonances of the structure. This can produce undesirable effects and must be avoided. One possible technique to overcome the double impact problem is to use the principle of reciprocity. The impact and response locations can be swapped thereby eliminating the double impact problem. This can often solve the problem but many times mass loading effects can become an separate issue.

The last major concern relates to the response and the need for the exponential window. The response of the system may not decay to zero within the sample interval of the FFT. When this is the case, then leakage can occur unless a window is used. The most appropriate window is the exponential window but should only be used when necessary. Many times the window is not necessary if the signal naturally decays within the sample interval.

Often, the data acquisition system can be setup to allow this to happen. Two signal processing parameters should always be explored before using the window. The bandwidth selection can be changed which has a direct effect on the total time required to capture data. If you halve the bandwidth, you double the time sample. Another approach to increase the total time of the sample interval is to change the total number of samples for the acquisition. Both of these two signal processing parameters allow more time data to be collected and should always be explored prior to the use of the window. However, a window may still be required to minimize the effects of leakage if the signal does not die out by the end of the sample interval. Figure 4 shows one time signal in blue that requires an exponential window whereas the red time signal and sample interval does not require a window (or at least substantially reduces the need for the window).

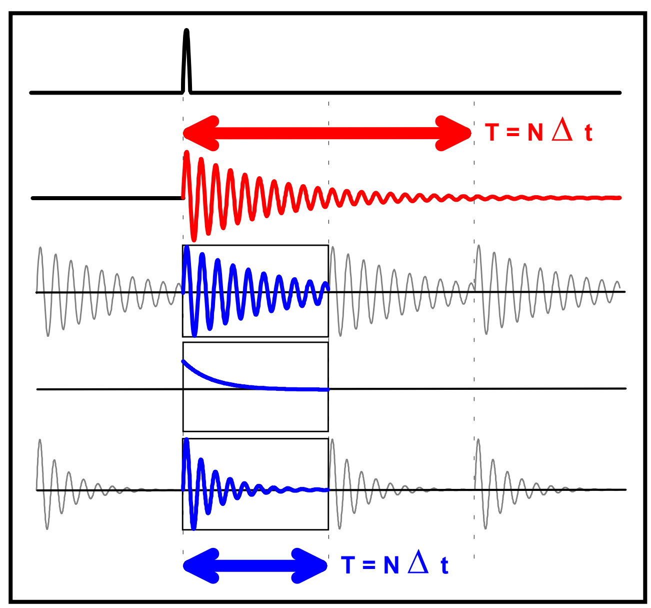

Figure 4

I hope this helps to explain some of the more important concerns when impact testing. If you have any other questions about modal analysis, just ask me.