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

Illustration by Mike Avitabile

Sometimes my impact force is very smooth just as expected but often it looks like it is oscillating – Why is that?
Let's look at some measurements and talk about this.

Many times when performing impact testing, the force pulse appears to very regular shaped with a pulse that resembles a half-sine wave. The event starts at zero, followed by the pulse and returns to zero for the duration of the measurement event.

However, many times the force pulse seems to oscillate about zero after the initial half-sine pulse. The real question is why does this happen, should it occur, is it possibly a double impact and should a window be used to minimize the effect of this.

Well … there is a lot to answer here and I may not be able to cover it all in this one article. This problem is referred to as "filter ring". Let's start out with some simple measurements to show this problem that is often seen. Just by taking a few sample measurements, the effect can be observed and hopefully better understood with some simple examples and illustrations.

This is a problem that can be seen on many FFT analyzers. For the measurements and discussion here, I am going to use a general BRAND XYZ FFT analyzer. A typical measurement will be made on a typical structure with a impact force hammer and response accelerometer. However, only the force input will be discussed here. Some of the force pulses will be very regular shaped just as we would expect to see in a textbook case. But other measurements will have a force pulse that has an oscillation to the end of the time pulse as if it is the response of a simple single degree of freedom system. This problem is often refered to as "filter ring". It is due to the fact that the analog anti-aliasing filters on the front end of the analog to digital converter (ADC) may show some response due to their own natural frequencies that are possibly excited due to the force pulse. This is actually what occurs. The force pulse will excite different frequency ranges depending on the tip that is used to excite the structure as is well understood by everyone.

But here is the problem. Depending on what frequency range (bandwidth) is selected, this filter ring may or may not be noticeable on your analyzer. Now on the surface this doesn't sem reasonable until the actual inside working of the FFT analyzer is considered. Usually, the FFT manufacturers have different sets of anti-aliasing filters – one for low frequency work and one for high frequency work. Typically, if you are measuring lower frequency ranges, the lower frequency filter is employed. If a soft impact tip is used then this will not significantly cause any filter ring. But if a slightly harder tip is used, then the upper frequency range of the hammer excitation may excite the low frequency analog anti-aliasing filter. The filter gets excited and has a dynamic response characteristic which manifests itself on the force pulse as this filter ring.

So let's take some measurements to illustrate this filter ring characteristic and see how setting different frequency bandwidths may have an effect on the filter ring observed. An impact hammer will be used with four different tips over two different frequency ranges. The hammer tips will consist of a very soft red air capsule, a medium blue plastic tip, a harder white plastic tip and a metal tip. In each case, the hammer is used to impact a structure to acquire a time trace. In one set of measurements, the frequency bandwidth is set at 400 Hz and in the second set of measurements the bandwidth is set to 1600 Hz. The two figures on the next page show the results of the different impacts over the two frequency bands. The tips range from softest to hardest from top to bottom.

Notice that the 400 Hz bandwidth has significantly more filter ring as the hammer tips go from softer to harder. This is because the harder tip excites a wider frequency range and has a great possibility of exciting the low frequency analog anti-aliasing filter.

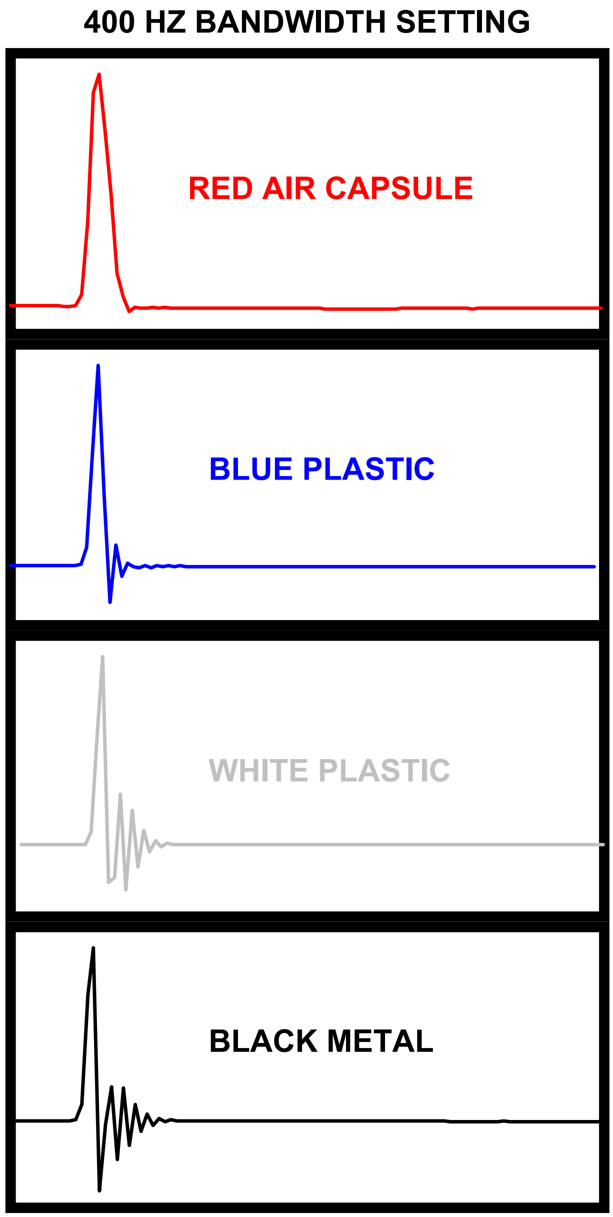

Figure 1 – Impact with 400 Hz Bandwidth

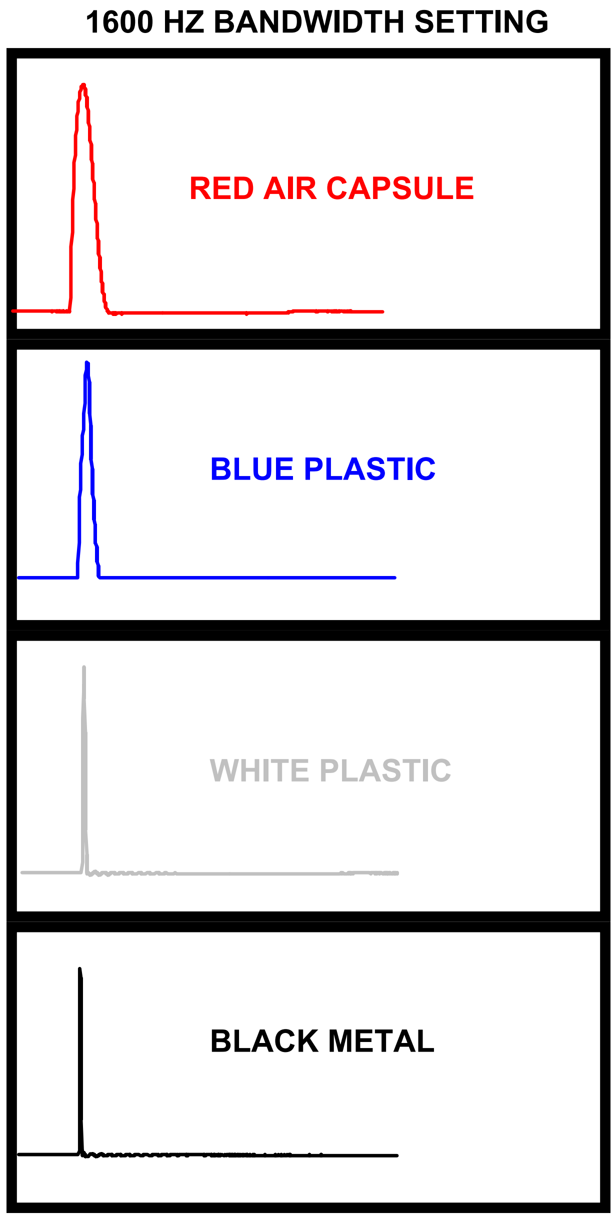

Figure 2 – Impact with 1600 Hz Bandwidth

Comparing the 400 Hz bandwidth to the 1600 Hz bandwidth, there is a noticeable change in the filter ring – there is hardly any ring at all for the 1600 Hz bandwidth. And the only difference was the selection of the bandwidth.

On this particular FFT analyzer, the two sets of anti-aliasing filters are used depending on which bandwidth is selected. Clearly, the filter ring is much more obvious when the harder tip is used over the lower frequency range. This is because the harder tip has significantly more energy at the higher frequencies which excites the filter dynamic characteristics. Notice how the softer tip doesn't excite this filter ring very much at all.

Generally, a softer tip is a better selection to assure that the filter ring does not occur. If there is filter ring then it makes sense to select a higher frequency range so that the filter ring is minimized. Then it is not a serious issue and the problem is resolved.

I hope that this little discussion has shed some light on this problem regarding filter ring observed on the force time history. If you have any more questions on modal analysis, just ask me.