MODAL SPACE - IN OUR OWN LITTLE WORLD by Pete Avitabile

Illustration by Mike Avitabile

Hey – I ran a test and got some extra modes I didn't expect. Does the overall test set up have any effect? This really needs some discussion

The test set up can have a significant effect on the overall test results in some circumstances. You must be very careful with this. From what you explained to me, it seems that in this case the test conditions related to the test set up changed during the course of the test and had an effect on the modes that were extracted.

I guess the first thing to do is to recreate some of the data that led you to believe that there may have been some problems with the test that was conducted. When you first showed me the original stability diagram, you indicated that you didn't expect that there would be several frequencies with very close and almost repeated roots. The stability diagram in Figure 1 had what appeared to be very close frequencies.

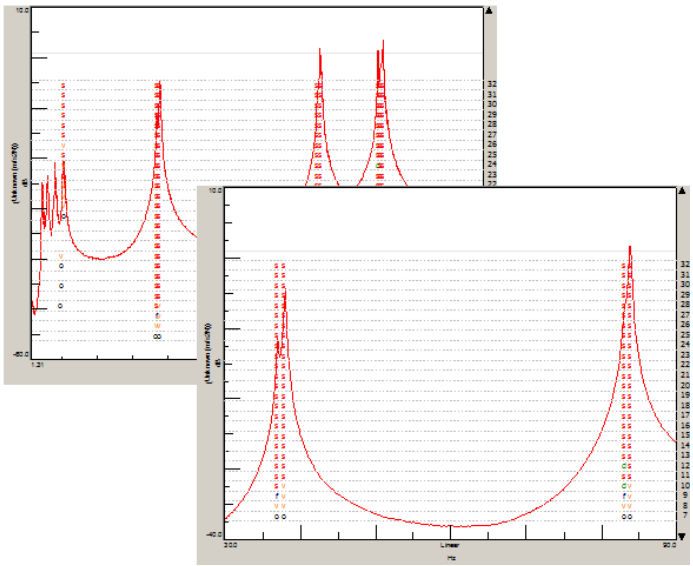

Figure 1 – Stability Diagram over 130 Hz Band and over 30 to 90 Hz Band

It is very clear that there are multiple roots at each of the frequencies. But this was not expected for this particular component. As we discussed the data you mentioned that there were multiple reference accelerometers but that the data from each reference was collected at different times and was not collected all at the same time.

This fact alone starts to lead me to believe that maybe there was a change in the overall test set up between the first test and the second test. Taking a closer look at that stability diagram especially in the range of 30 to 90 Hz in Figure 1 shows that there are indeed multiple poles at 36.96 Hz and 37.96 Hz with $3\Delta f$ spacing and multiple poles at 83.08 Hz and 83.8 Hz with $2\Delta f$ spacing. But the question is – are they really separate modes or is it a problem with the test set up?

In order to sort this out, we probably need to look at the data in a little more detail and try to sort out what may be happening with this data. Well the first thing to do is to look at the data from each of the references separately. When we do this what we see is that each of the individual references sees only one pole at each of the frequencies and that each of the references predicts that frequency at different values for each of the separate references. This seems to indicate that there is some type of a shift in all the modes of the system from the time the first test was conducted and when the second test was conducted. This is clearly seen in Figure 2 for the 30-90 Hz band.

In order to further confirm this, the rigid body mode frequencies were also evaluated. Now here is where there are some more obvious differences. When evaluating the two references separately, clearly there is a significant shift or change in the rigid body modes of the system as seen in Figure 3.

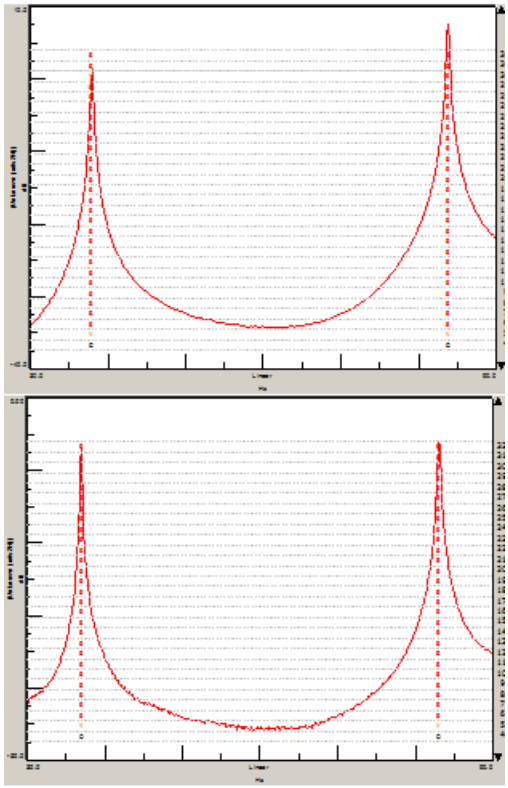

Fig 2 – Stability Diagram for Each Reference Separately

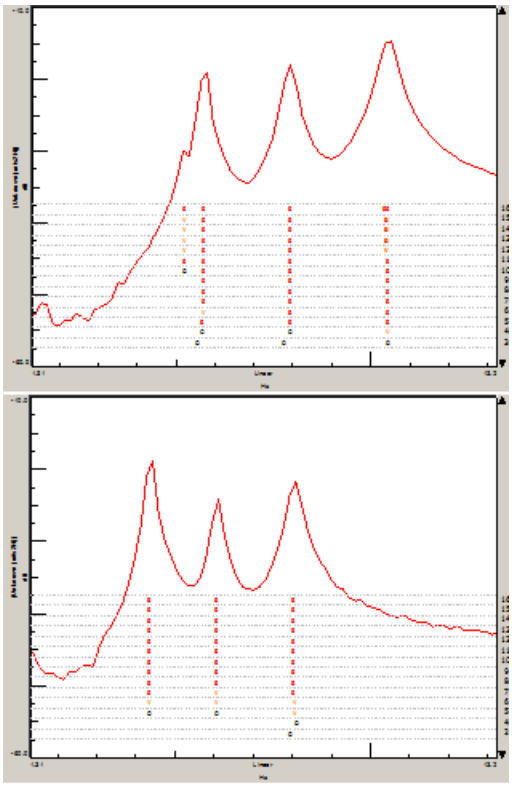

Fig 3 – Stability Diagram for Rigid Body Frequency Range for Each Reference Separately

So the change in the rigid body modes from the two different tests shows a dramatic change in the frequencies. From one reference set of data the rigid body modes observed were 4.3, 6.1and 8.1Hz and from the other reference they were 5.7, 7.9 and 10.4 Hz which is a significant shift in these frequencies from one test to another.

After some detective work on the test set up, the cause of the problem was likely due to the fact the air pressure in the structure support system was not maintained at the same pressure for both tests and caused the support stiffness to change significantly between the two tests. This is further highlighted when the sets of data are overlaid and compared between the two references as shown in Figure 4. Note that the blue FRFs are related to one reference set of data collected on one day and the red FRFs are related to the other reference collected on a different day. This highlights the obvious inconsistency in the two data sets that were collected on different days resulting in obvious differences.

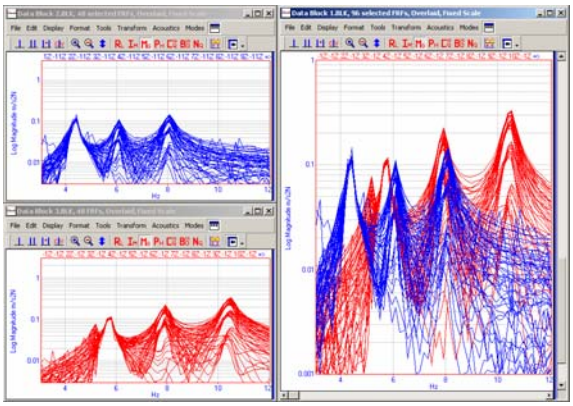

Fig 4 – Comparison of the FRFs from Two References

So now it is very clear that there are differences from the test set up which resulted in not only the rigid body modes shifting but also the flexible modes were significantly affected by the slight change in the test set up conditions.

Of course we could argue about which are the “real” set of frequencies for the structure but we really don’t know which are correct because the test set up does have an effect on the frequencies observed. What is more important to realize is that it is imperative to make sure that all the data is collected in a consistent fashion. This would have been best accomplished by collecting all of the data at the same time using the multiple reference impact test technique. This would have prevented the inconsistency that resulted from conducting two separate tests on two separate days in what ultimately appears to be in two essentially different configurations.

I hope this explanation helps you to understand the need to collect data in a consistent manner. If you have any other questions about modal analysis, just ask me.