

## MODAL SPACE - IN OUR OWN LITTLE WORLD

by Pete Avitabile



Illustration by Mike Avitabile

The Stability Diagram has poles that are not indicated by the MMIF or CMIF. Are they really modes?  
There are some concepts here that are important to discuss.

Now this is a problem that can very possibly occur and needs some discussion in order to sort out what is happening in this situation. We have discussed this before when the problem pertained to not measuring a significant portion of the structure. But in this example, we are going to see that even if we measure appropriately, there are additional issues that must be addressed.

For the example, I am going to use the same plate structure previously used that has two very closely spaced modes in order to show some situations that are possible. We just recently discussed all the mode indicator tools so their use is understood. This plate will be evaluated with several different references to illustrate some points.

For the first case, the plate will be evaluated with more references than needed in order to show the modes of interest. Three references will be used on the plate as shown in Figure 1.

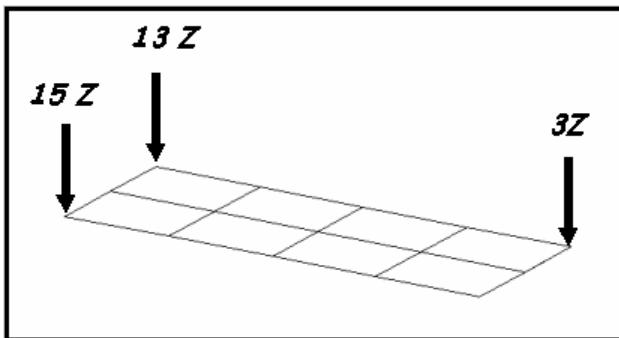


Figure 1 – Plate with Three References Identified

A typical SUM block (upper) and three drive point FRFs (lower) are shown in Figure 2 for reference. Now using these three references, the MMIF and CMIF both show that there are two closely spaced modes at that first frequency around 100 Hz as seen in Figure 3; only the CMIF is shown.

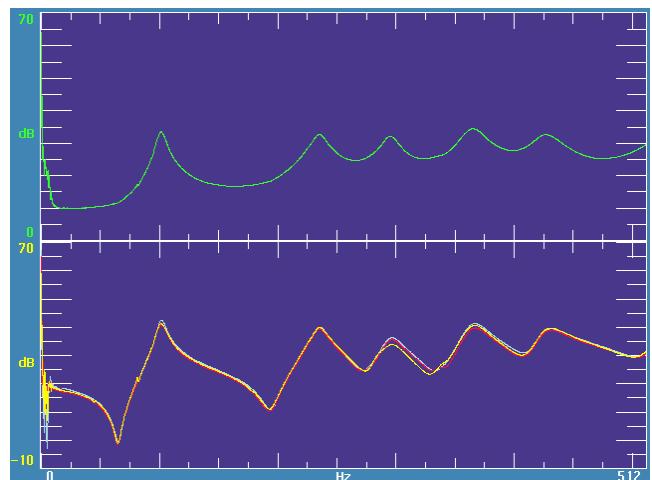


Figure 2 – SUM (upper) and FRFs (lower) for Plate Structure

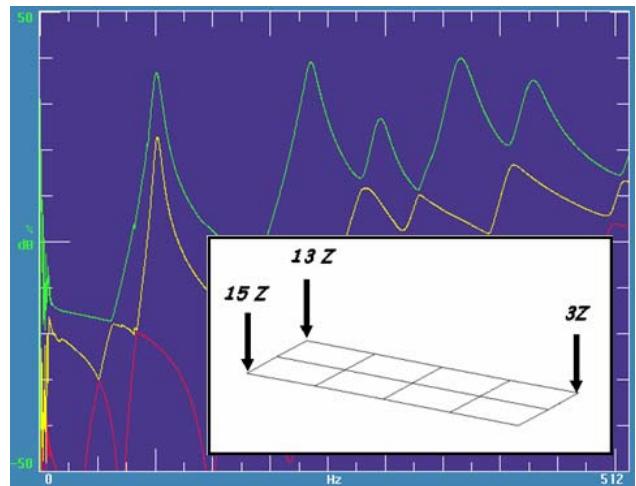


Figure 3 – MMIF and CMIF for Three references

The stability diagram very clearly shows that there are two modes present in that frequency range as shown in Figure 4.

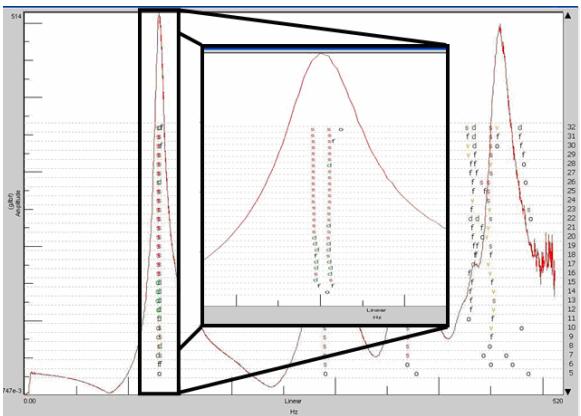


Figure 4 – Stability Diagram with Three References

The mode shapes corresponding to this frequency range are bending and torsion as indicated in Figure 5. These two modes occur at almost the same frequency and while not perfectly repeated, they do occur so close that they are referred to as “pseudo-repeated” roots.

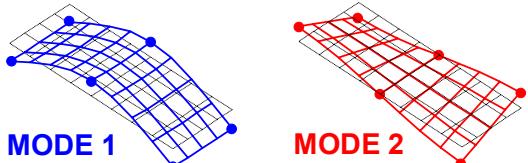
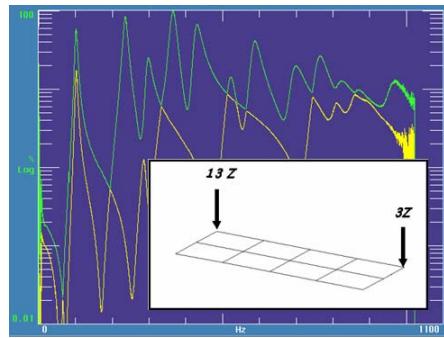


Figure 5 – Bending and Torsion Modes of the Plate

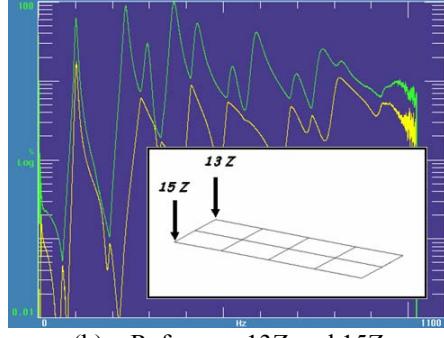
Now Figure 6 shows the CMIF with different combinations of only two of the three original references. Notice that the two references adjacent to each other in Figure 6a and 6b both show two modes in that frequency range but that the two references at opposite corners in Figure 6c do not. (Note that only the CMIF is shown for brevity but the MMIF which is not shown confirms the same results seen with CMIF. Also note that the stability diagram is essentially the same as Figure 4 using any two of the references shown in Figure 6.)

So why does this happen? Why do the MMIF and CMIF not clearly show the modes all the time? In order to answer this, the modes shapes of the structure must be discussed relative to the reference location.

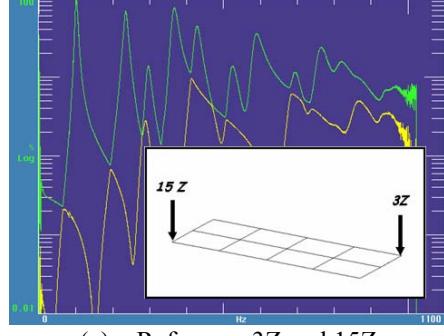
Consider the reference in Figure 6a. Notice that these two corners of the plate both have negative shape values for bending while the torsion has a negative and positive value for shape. The same is also true for the references in Figure 6b. But when looking at the mode shapes at the reference locations in Figure 6c, something different happens.



(a) – Reference 3Z and 13Z



(b) – Reference 13Z and 15Z



(c) – Reference 3Z and 15Z

Figure 6 – CMIF for Different References

In this case, the mode shape for the first mode has the same sign and direction - and the mode shape for the second mode also has the same sign and direction. Whether they are plus or minus is not important. What is important is that the points have the same phase. There is no way to distinguish the difference between mode 1 and mode 2 from the reference location in Figure 6c. But the references in Figure 6a and 6b can distinguish the difference in the mode shape because of the phase information at those reference locations.

So it is not enough to have two references on the structure in order to identify pseudo-repeated roots. The references must provide an independent view of the mode of the system from the reference location in order to distinguish the modes. But the stability diagram can still identify the fact that there are two roots at that frequency. So from this example, it is possible to have roots in the stability diagram that may not be seen in the MMIF and CMIF.

If you have any more questions on modal analysis, just ask me.