

MODAL SPACE - IN OUR OWN LITTLE WORLD

by Pete Avitabile

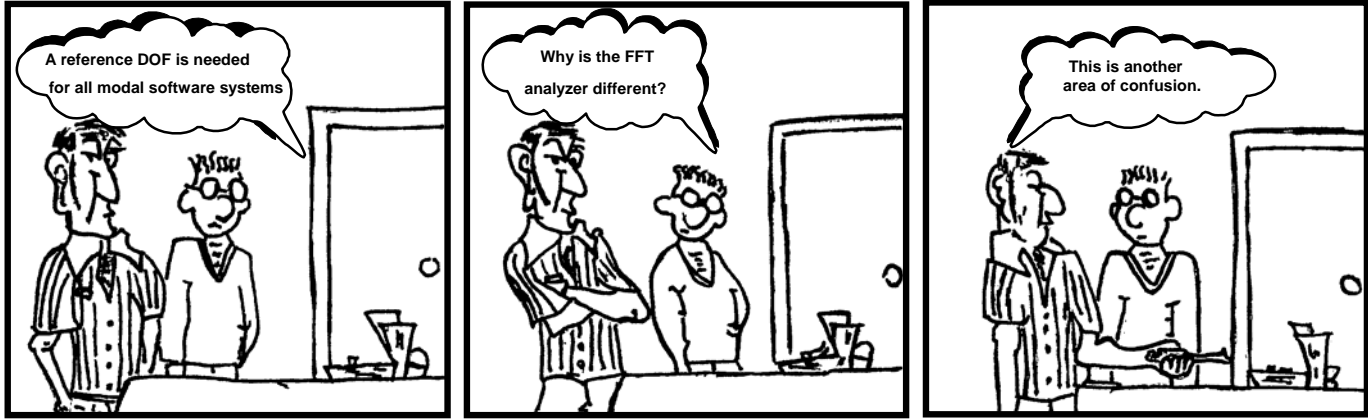


Illustration by Mike Avitabile

A reference DOF is needed for all modal software systems. Why is the FFT analyzer reference different? This is another area of confusion.

OK – so this is another area of confusion that people often stumble upon and it causes grief when trying to perform a modal survey and obtain results. Usually this is often encountered when data is collected separately from the modal analysis software system using an independent FFT analyzer. But it can also happen when collecting data in any modal analysis system.

Before we get into specifics, let’s just review a few basic items to try to put this problem in perspective. The problem really stems from the fact that the FFT analyzer is not used for just modal testing and the generation of mode shapes using a modal analysis software system. The FFT analyzer is a general purpose instrument that is used to generate frequency response functions for just about anything. The measurements can be general purpose signals for circuit analysis, acoustic measurements, transmissibility measurements, etc.

The concept of the analyzer is that measurements are made on two or more channels. The measurement ratio of output to input is typically what people are trying to obtain. That being said, the ratio of two signals is typically of interest.

Now let’s say that a measurement is being made where the output voltage of a circuit (filter) needs to be obtained relative to the voltage applied to the circuit as seen in Figure 1 for instance. (Notice that these measurements are general and not necessarily the typical force and acceleration that are often obtained for a modal test.) So I could put the input voltage into channel 1 of the FFT analyzer and the output voltage of the circuit into channel 2 of the FFT analyzer. Or I could swap those two channels because it really doesn’t matter.

But what does matter is that the frequency response measurement desired is that of the output voltage of the circuit “relative to” the applied input voltage. So in terms of the FFT

analyzer, the output voltage spectrum is measured relative to a “reference signal” which is the input voltage.

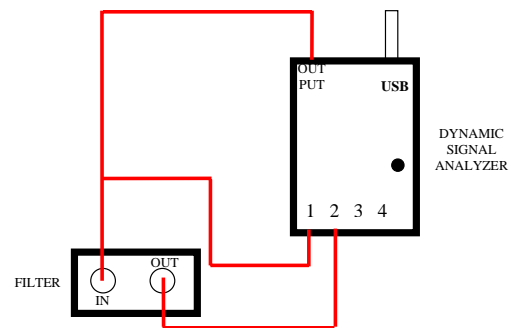


Figure 1 – Typical Input/Output Measurement Setup

For the FFT analyzer, the reference channel will depend on which channel was used to measure the input reference voltage – whether it be channel 1 or 2 or whatever. So the frequency response function measured might look something like that shown in Figure 2 where the output voltage of the filter is measured relative to the input signal.

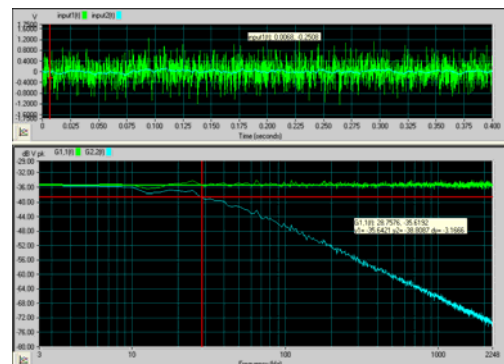


Figure 2 – Typical Input/Output FRF Measurement

So the reference for the FFT analyzer is related to the measurements of output to input. Now what is meant by reference for an experimental modal test? Generally, the reference is the item in the measurement that doesn't change. The typical measurements made for a modal test will depend on whether an impact test or shaker test is performed. The terms of the FRF matrix obtained for each are shown in Figure 3.

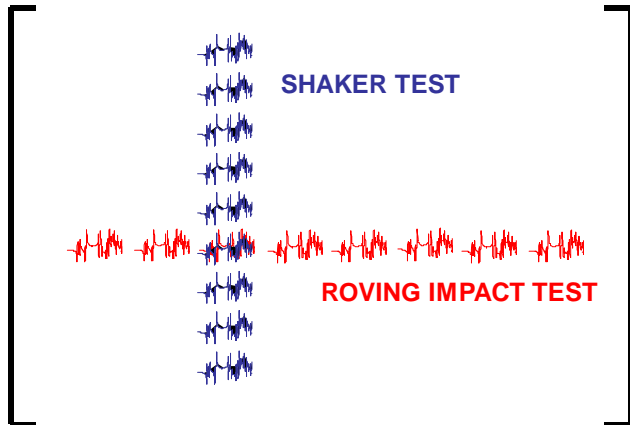


Figure 3 – FRF Matrix for Shaker and Impact Excitations

For a shaker test, the force is applied at the same location and the response is measured for all the measurement points desired. This is consistent with the FFT reference nomenclature.

But for a roving impact test, the hammer moves from one point to another but the accelerometer remains at a fixed location – so the accelerometer is called the “reference” for modal testing purposes but the FRF measured relates the output acceleration relative to the input force. So it is right here that the problem arises. The word “reference” means different things to different applications.

So depending on what FFT analyzer is used, there may be a procedure or recommended file naming convention that may need to be used in order to not “confuse” the modal software in regards to this “reference” notation.

Now of course everyone realizes that the measurements in the FRF matrix are reciprocal and that this reference notation is just an administrative procedure that needs to be addressed when data is transferred from an FFT analyzer to your particular modal analysis software package. But it is a frustrating administrative procedure that must be addressed in order to be able to use the measurements obtained from the FFT analyzer in the modal software package.

Once the proper procedure is identified, then it is a simple matter to document it so everyone realizes what needs to be done. I know that over the years I have generated many different schematics to remind myself of what procedure I needed to follow that particular day for the particular FFT analyzer that I was using that day. A typical (old) schematic is shown in Figure 4 where a file naming convention was used to clarify which measurement was which.

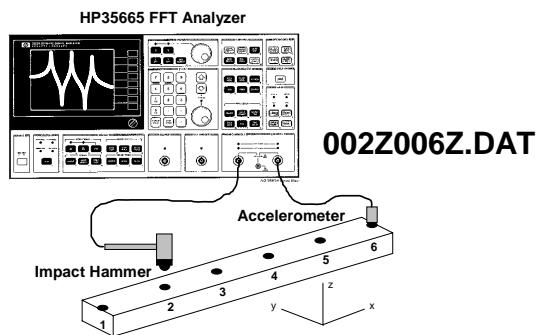


Figure 4 – Filename Convention Schematic

Now depending on the software package that you currently use, there are a variety of ways that the data may need to be handled in order to properly identify the “modal reference” for the measurements. Now this may get handled by a “swap” or “switch” command to obtain the proper “modal reference”.

Or it may be required that the measurements be written out to a universal file format with a specific organization of the measurements – or the manner in which the measurements are imported into the software may handle this issue. This may be through the identification of whether the measurements come from a “roving” hammer or “stationary” hammer reference location.

But how you need to handle this will depend on your particular FFT analyzer and modal software system used. But I can guarantee you that each of the modal software vendors all have to face the same issue and will have specific procedures to handle this commonly encountered problem. I guess the amazing thing about this is that it is very clear what the problem is and it should be a very simple fix for the software to handle this problem but all the different software packages require this one obvious step to be performed.

I hope that this clears up the confusion on references – whether it be on the FFT analyzer or modal software package. If you have any more questions on modal analysis, just ask me.