EDM Modal Test Case | Modal Analysis of Printed Circuit Board using EDM Modal

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The modal analysis of a unit under test is important because the information from natural frequencies, damping coefficients, and mode shapes is used to optimize the design and improve the structural behavior of a test unit. The modal parameters regarding the mechanical properties of a structure helps users understand its vibration characteristics during operating conditions.

In this case, the modal characteristics of a Printed Circuit Board (PCB) is acquired by performing experimental modal analysis. A hammer impact test is carried out with a single teardrop uni-axial accelerometer to study the modal behavior. The roving excitation method helps users completely avoid the mass loading effect that might be introduced with a roving response procedure. Since the PCB is lightweight, the selected hammer and sensor were chosen because they weigh considerably lesser than the board itself. To excite the higher frequency modes, a hard tip is chosen. The hammer impact test module (https://www.crystalinstruments.com/hammer-impact-test) of the EDM Modal suite (https://www.crystalinstruments.com/edm-modal-testing-and-analysis-software) assists in executing this test.

Figure 1. Hammer Impact Modal Test of the Printed Circuit Board

A geometry mesh configuration of 21 measurement points is uniformly distributed throughout the PCB to achieve good spatial resolution for the mode shapes. Using a thin wire, the PCB board is suspended vertically to imitate a free-free boundary condition (as shown in the experimental setup). The tiny uni-axial teardrop accelerometer is fixed to one point and the small impact hammer is roved through the measurement points. Measuring the excitation force and response acceleration in the vertical direction facilitates in obtaining the out-of-plane mode shapes.

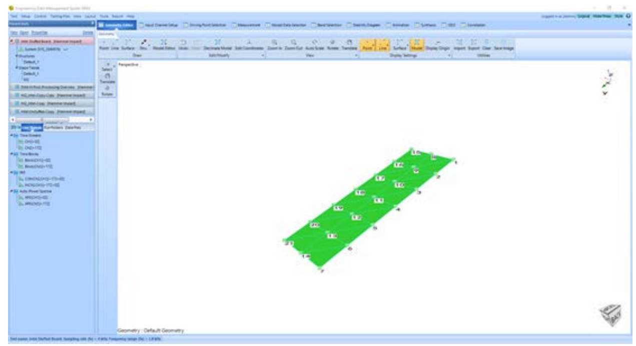


Figure 2. PCB Geometry

Since this PCB has modes in the higher frequency range, a sampling rate of 4 kHz is set. A block size of 4096 is selected to ensure that the response decays naturally and no windowing needs to be applied. A fine frequency resolution of 0.976 Hz is produced with these configuration settings. Measurements of higher accuracy and reduced noise are obtained by linearly averaging 3 blocks of data at each measurement DOF.

The hammer impact excitation imparts energy across a broad frequency range of 1.8 kHz. With this setup, there will be no leakage and a uniform window can be selected.

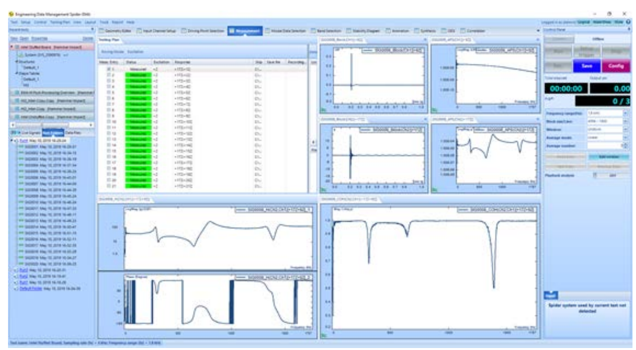


Figure 3. Hammer Impact Measurement of the PCB

The coherence plot helps validate the measurement results which looks good from the above screenshot. The valleys in the coherence plot occur at the anti-resonances which indicates that the response level is relatively lower at these corresponding frequencies. So overall, the inputs and outputs are well correlated in the desirable frequency range.

The FRF measurement shows four obvious resonance peaks in the desired frequency band. Plotting the imaginary part of all the FRFs guides users to observe the phase relationship between the measurement DOFs. The good alignment of the peaks on the imaginary portion of the FRFs indicates that there is no mass loading effect induced in the results.

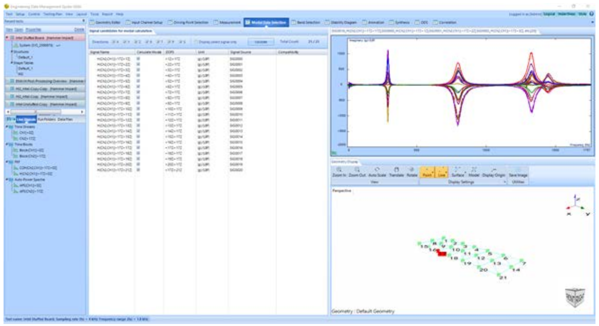


Figure 4. Modal Data Selection tab showing the imaginary part of all overlapped FRFs

The Poly-X (https://www.crystalinstruments.com/modal-analysis) method is used to curve-fit the FRF's to procure the following stability diagram. Four flexible modes are selected within the desired frequency range. Multivariate Mode Indicator Function (MMIF) is used to indicate the valleys at the natural frequencies.

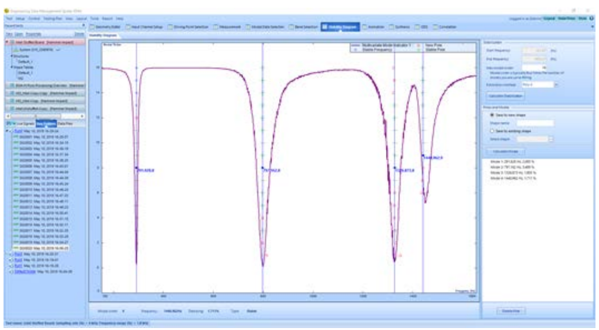


Figure 5. Stability Diagram for the four flexible modes

The Auto-MAC matrix helps users to validate the results. The Auto-MAC matrix below shows that the modes are orthogonal to each other (low off-diagonal elements) and are uniquely identified (high diagonal elements).

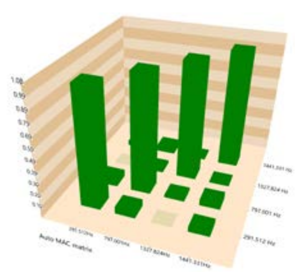
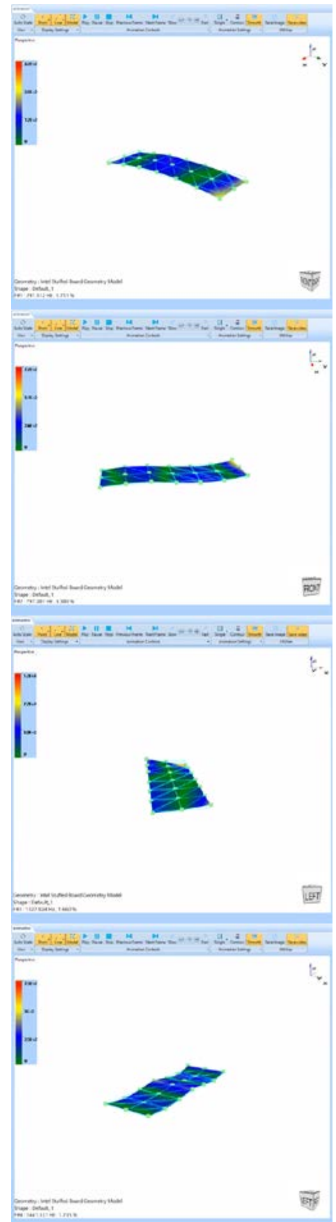


Figure 6. Auto MAC chart for the PCB Hammer Impact Modal Test

The animation of the first four mode shapes associated with the stable physical poles are shown below.



The results show the strength and efficiency of the EDM Modal software to execute sophisticated modal tests on small intricate structures.

To learn more about EDM Modal software, visit: www.crystalinstruments.com/edm-modal-testing-and-analysis-software/

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