Question 20

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Q: Can Femtet analyze the vibration test?

A: Yes, Femtet can do it with the harmonic analysis of the stress solver.

You can observe how the vibration pattern will change in response to the frequency of the forced vibration in the analysis result (See Example 50 of the stress analysis).

Performing the resonant analysis and harmonic analysis sequentially allows you to efficiently execute the vibration analysis while focusing on the resonant frequency.

See the detailed material for specific procedures.

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Vibration Test Analysis

General Process

- Modeling
- Resonant analysis to obtain resonant frequency
- Harmonic analysis to simulate the vibration test

Note

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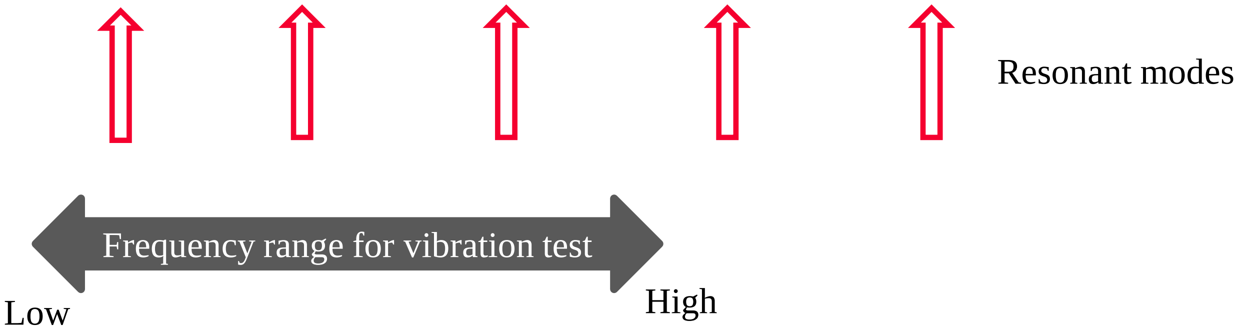
- The displacement and stress in the resonant analysis are relative values (Absolute values cannot be acquired).
- The displacement and stress in the harmonic analysis are absolute values (Mechanical loss must be set).
- If a resonant frequency is within the range of vibration test frequencies, the displacement and stress at the resonant frequency will be so large. Then sweeping the frequency by fine steps around the resonant frequency is required to catch the peaks of displacement and stress.
- When the frequency range A of the vibration test does not entirely include the frequency range B that covers the resonant frequencies acquired through the resonant analysis;

if B < A, change the number of modes in the resonant analysis and then perform the resonant analysis, and

if A < B, perform the harmonic analysis with frequency properly swept in the range of A without additional resonant analysis.

Procedure after Resonant Analysis (1)



Execute the harmonic analysis for the resonant modes of which frequencies are within the frequency range of the vibration test.
The diagram above represents that three resonant modes are selected.

Procedure after Resonant Analysis (2)

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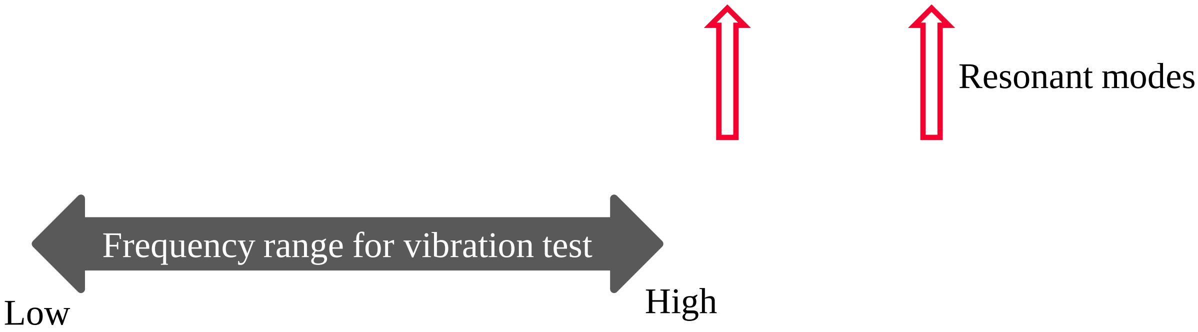

If the frequencies of the resonant modes are out of the frequency range for the vibration test,
perform the harmonic analysis with frequencies properly swept in the vibration test range.

Procedure after Resonant Analysis (3)

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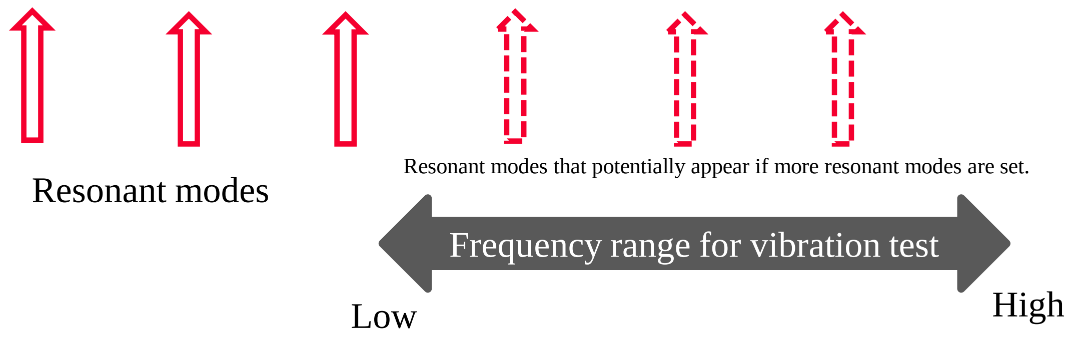
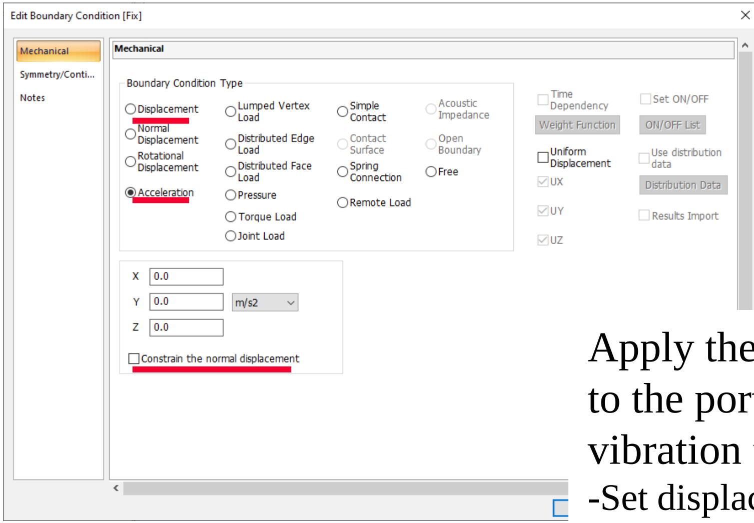


If the frequencies of the resonant modes obtained from the resonant analysis are lower than the frequency range for the vibration test, increase the number of modes for analysis.
Consequently, any resonant modes of which resonant frequencies are within the frequency range for the vibration test may be obtained.

Boundary Condition (Vibration Setting)



Apply the following boundary conditions to the portion, or face, mounted on the vibration test machine,

-Set displacement if an amplitude vibration,

-Set acceleration if an acceleration vibration.

To fix displacements in all directions except for the acceleration direction, select [Constrain the normal displacements].

Frequency Sweep in Harmonic Analysis

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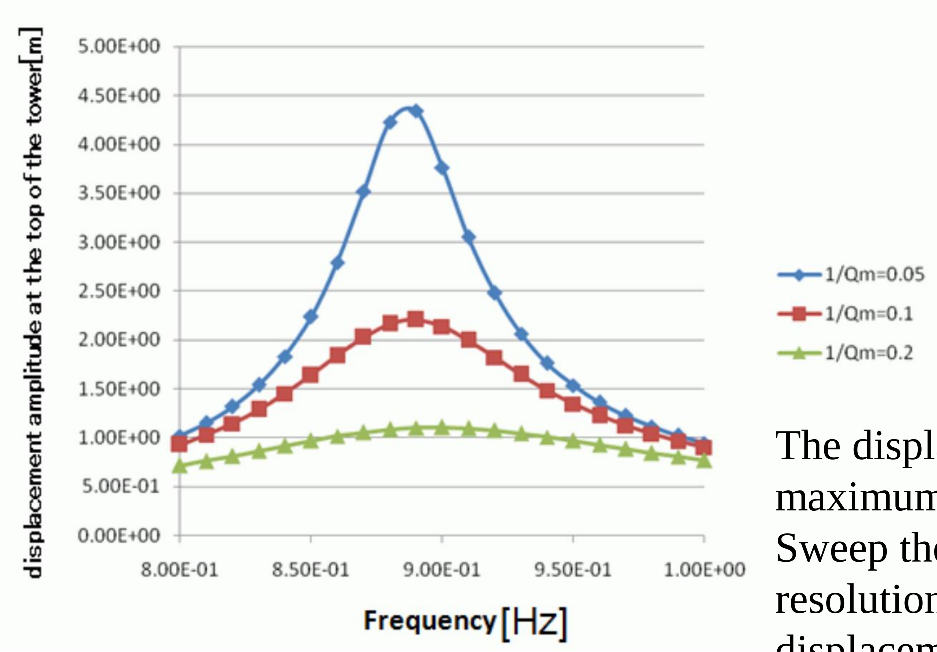
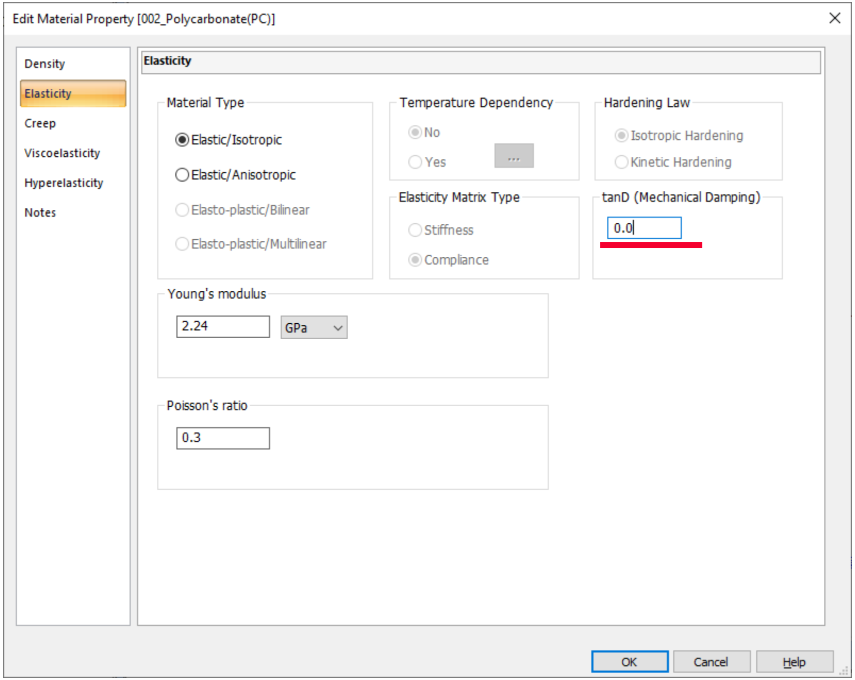


The displacement and stress become maximum at the resonant frequency. Sweep the frequency by such a resolution that the peak of the displacement and stress can be caught.

The sharpness of the peak depends on tanδ, or 1/Qm.

Mechanical Loss



If mechanical loss is zero, the displacement and stress at the resonance peak will be infinite.
If mechanical loss, or tanδ, is set, damping occurs to suppress the displacement and stress at the resonance peak to finite values.

Case Study

The case study below represents the following steps:

Obtain the resonant frequencies through the resonant analysis, and

Perform the harmonic analysis at the resonant frequencies.

Model（Resonant Analysis）

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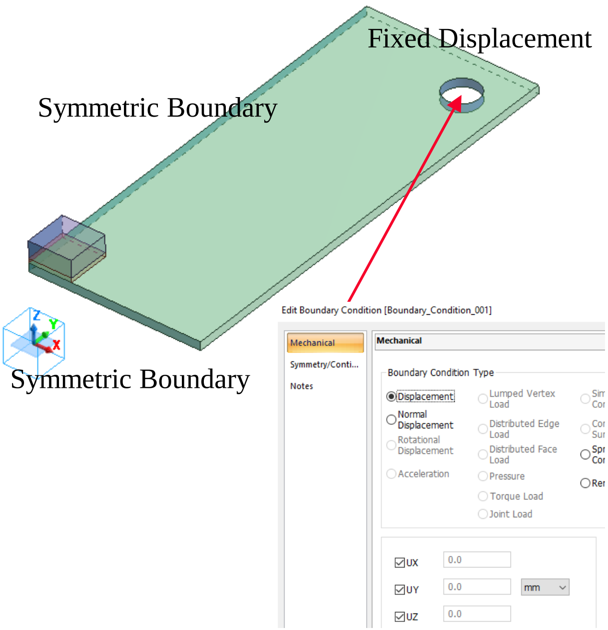

The model is a quarter-symmetric model of a substrate with a component mounted at the center.

The symmetric face is set with a symmetric boundary condition (Fix).

Fixed displacement boundary condition is set to the inner surface of the hole located at the corner of the substrate.

Analysis Condition（Harmonic Analysis）

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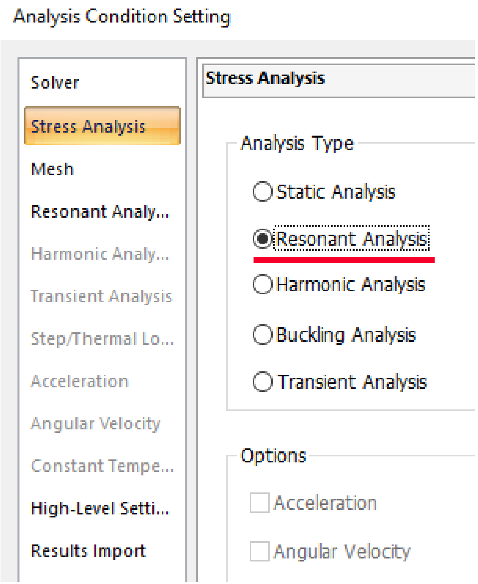
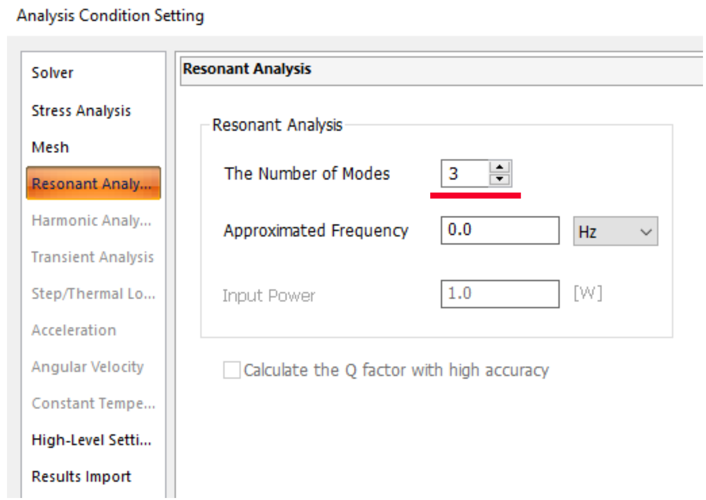
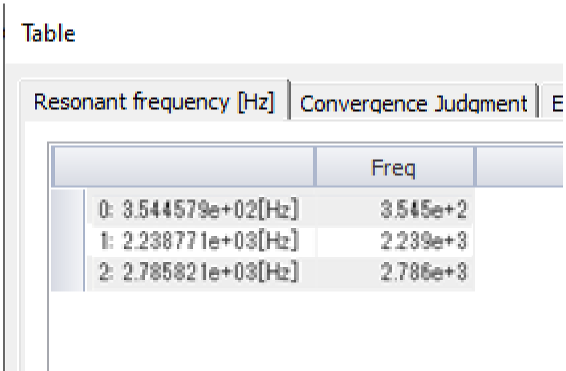




The number of precalculated modes can be changed at the number of modes on the [Resonant Analysis] tab.
The default is 3.

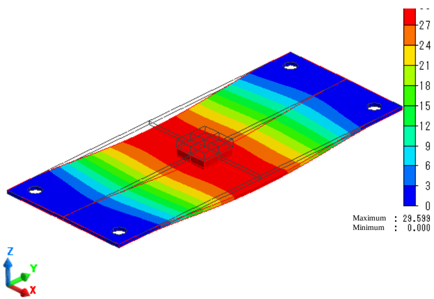
Result (Resonant Analysis)



Table

Resonant frequency [Hz] | Convergence Judgment | E

	Freq
0: 3.544579e+02[Hz]	3.545e+2
1: 2.238771e+03[Hz]	2.239e+3
2: 2.785821e+03[Hz]	2.786e+3



The resonant analysis indicates the fundamental frequency is 354.4579 Hz.

The displacement diagram shows the shape of a vibration mode.

(The displacements are relative values.)

Model (Harmonic Analysis)

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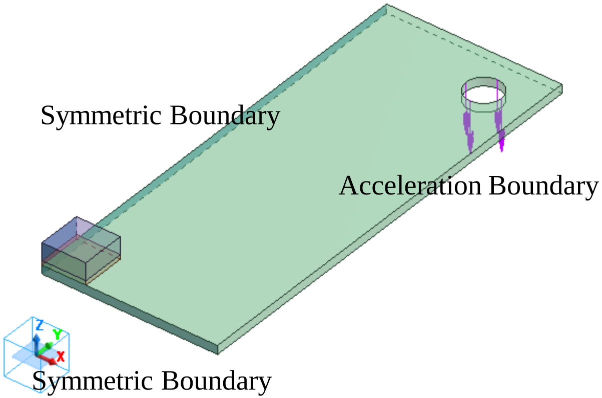


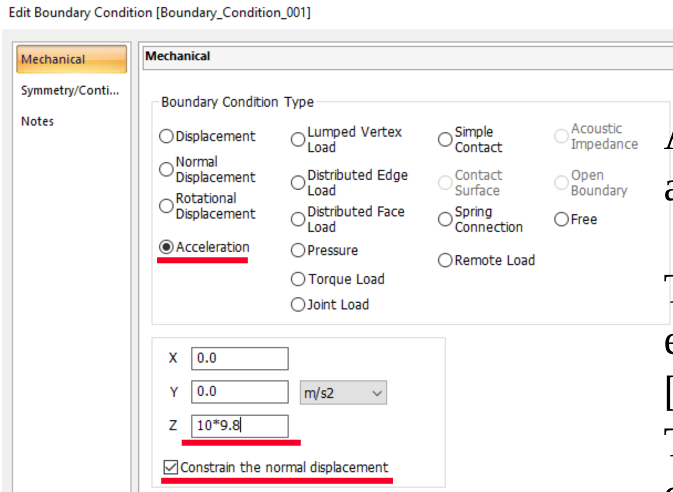
The model is a quarter-symmetric model of a substrate with a component mounted at the center.

The symmetric face is set with a symmetric boundary condition (Fix).

The acceleration boundary is set to the inner surface of the hole located at the corner of the substrate.

See the next slides for more information.

Boundary Condition (Acceleration)



A vibrational acceleration of 10 G is applied in the Z direction.

To fix displacements in all directions except for the acceleration direction, select [Constrain the normal displacements]. The diagram on the left indicates the displacements in the XY direction are constrained. *

* It represents the state where the substrate is fixed to the test fixture.

Analysis Condition（Harmonic Analysis）

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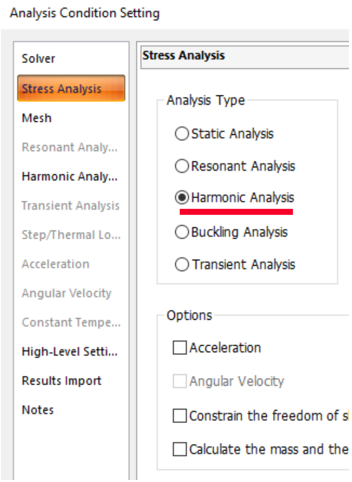
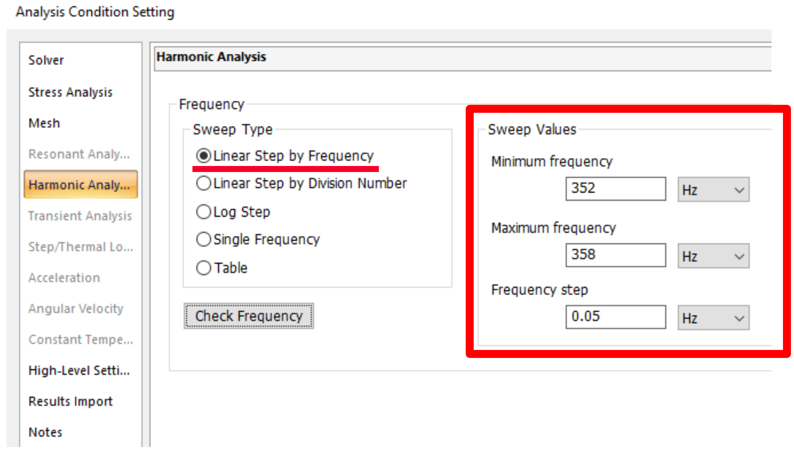
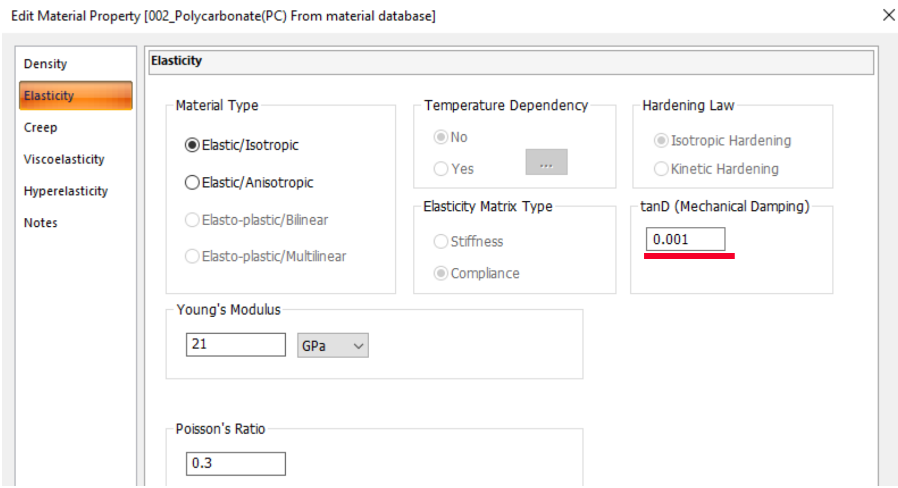




The sweep values are set such that the frequency of the peak for the resonant mode around 355 Hz falls within the frequency sweep range.

Mechanical Loss Setting



Calculating the absolute values of displacement and stress at the resonance peak requires setting mechanical loss.
The diagram above indicates the mechanical loss of the substrate of glass epoxy is set to 0.001.

Result（Harmonic Analysis）

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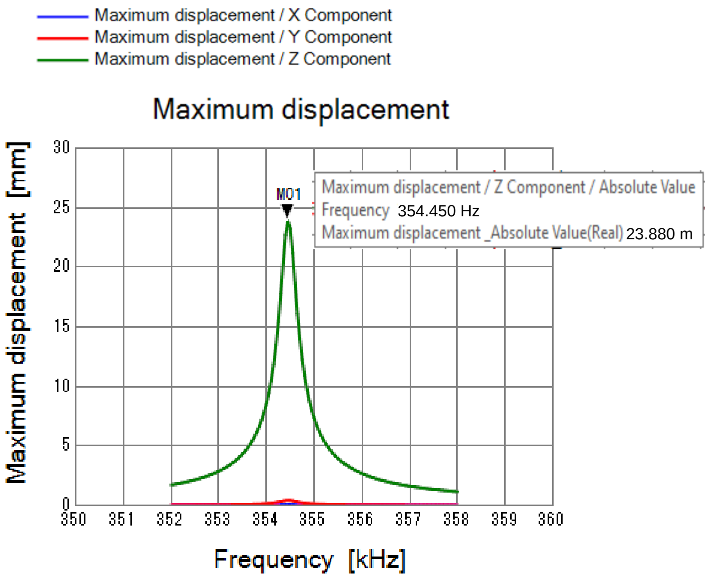

The graph is based on the maximum displacement listed in the numerical summary table.

It indicates a peak of maximum displacement at nearly the same frequency as the resultant frequency obtained from the resonant analysis.

Result (Harmonic Analysis)

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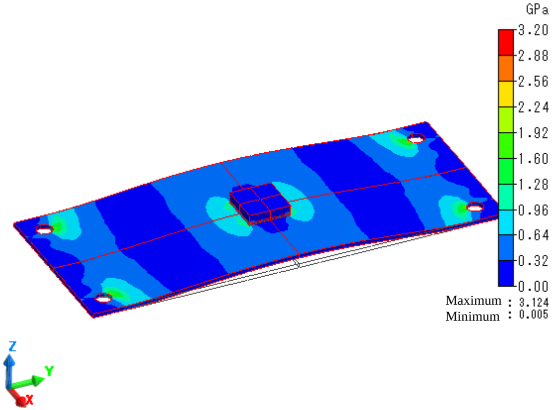

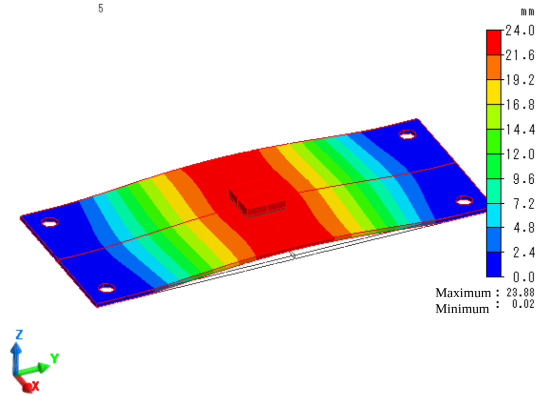

The diagrams show the maximum magnitudes of maximum principal stress and displacement at the resonance peak.
As the values of each field vary depending on the phase setting, select [Maximum] in the phase to display the maximum values.