Acoustic transmission through a baffled circular plate

Actran Student Edition Tutorial

Workshop description

Introduction

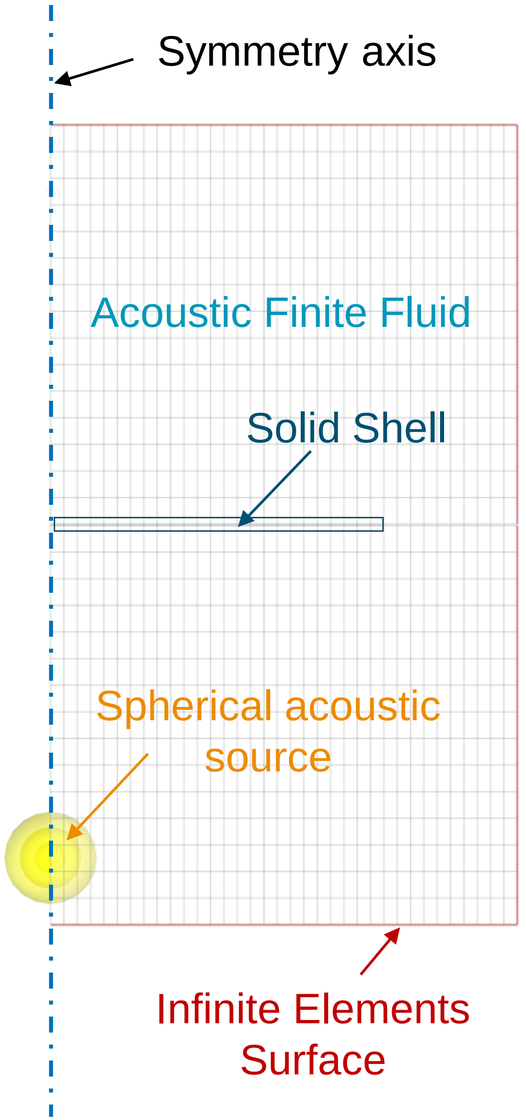
- The **objectives** of this workshop are the following:
  - Model a circular plate mounted in a rigid baffle and excited by an acoustic source
  - Use 2D geometry to model axi-symmetric 3D problem
  - Get introduced to acoustic transmission and insulation

- **Software version**:
  - Actran 2021.1 Student Edition

- **Pre-requisites** - before going through this presentation, the reader should have read and understood the following presentations:
  - Workshop: Monopole in free field
  - Workshop: Extraction of plate modes

Workshop Description

One acoustic domain is defined on each side of the baffle	• Two **finite fluid components** are defined • A zero displacement BC is defined
A free field condition is specified	• Two **infinite fluid components** are defined
The plate is modeled	• A **Solid Shell component** is defined • The thickness of the plate is modeled
An acoustic monopole source radiates	• A **spherical source** boundary conditions is defined



HEXAGON

Workshop pre-processing

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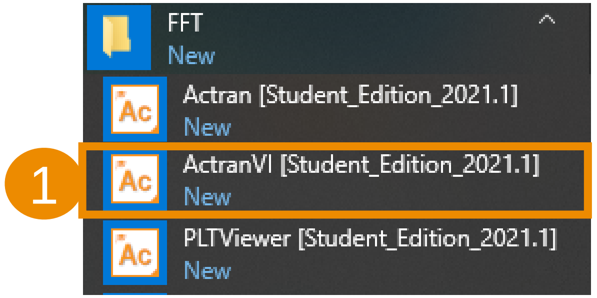
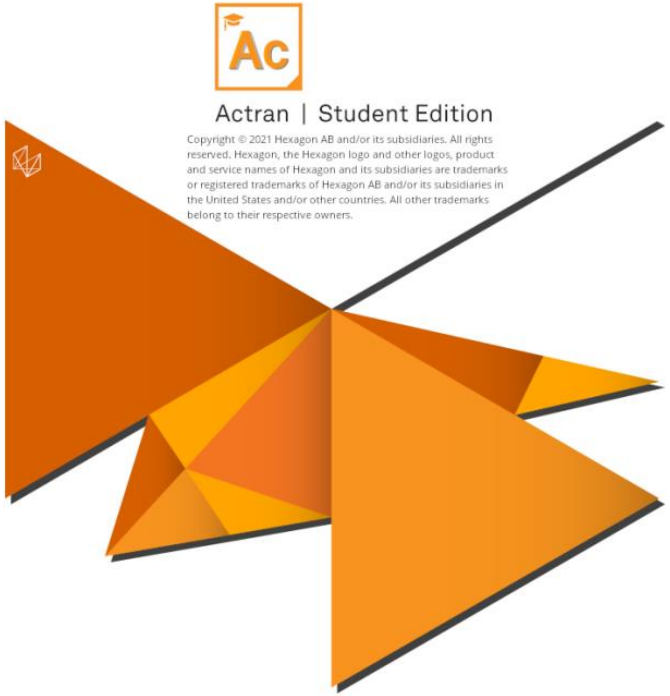
Start ActranVI

- Start ActranVI:
  - Shortcut is available through the Windows Start Menu



(Windows Start Menu)

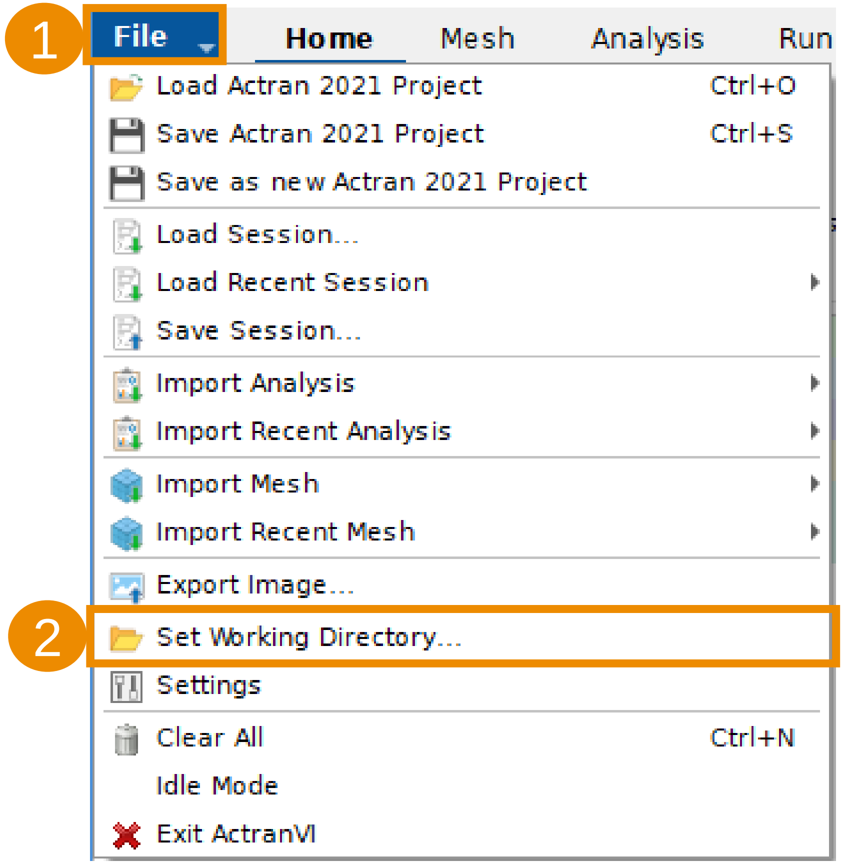


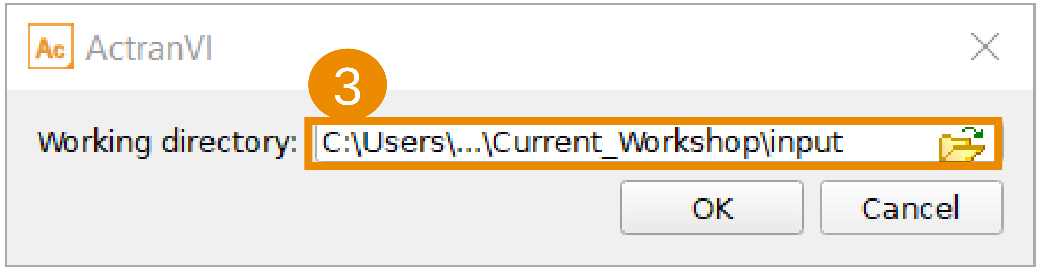
Set the working directory

Select the workshop input directory as the working directory

- The working directory is the project directory where all ActranVI related files are output

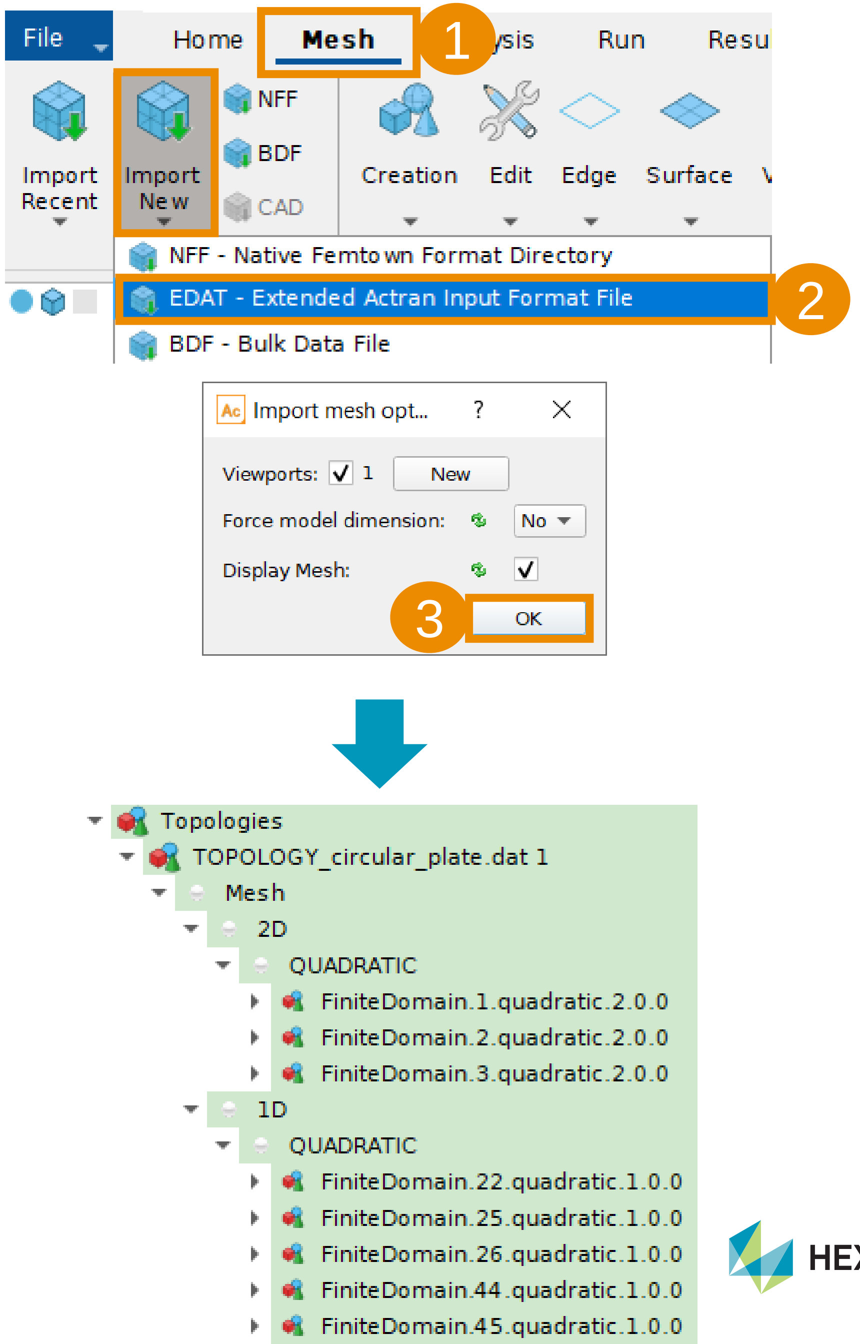
The working directory path should not contain any space or special character



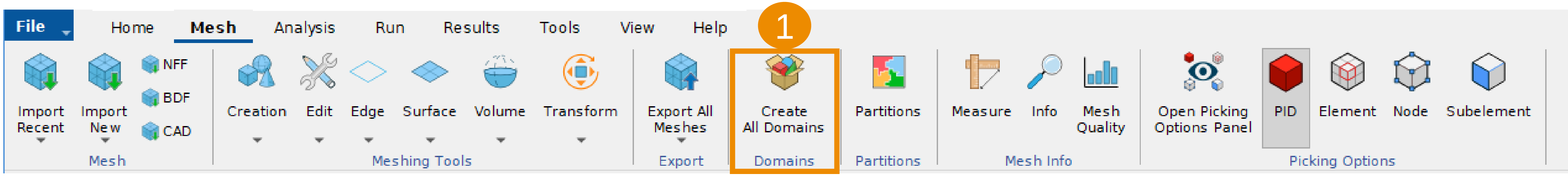


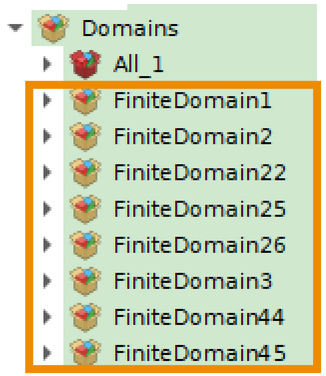
Import the mesh

- Import the provided **circular_plate.dat** mesh file in ActranVI
- A topology is created, and the different element sets are displayed
  - The 1D element set contains the elements supporting the infinite elements and the plate edges
  - The 2D elements set contains the two acoustic domains and the plate domain
- The maximum elements length is 0.02m for the acoustic mesh
- The mesh uses quadratic elements



Create the domains





Auto create domain

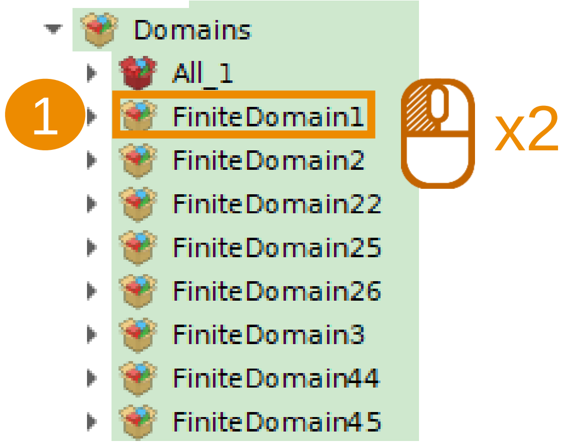
- Automatic domain creation based on PIDs
- One domain per PID

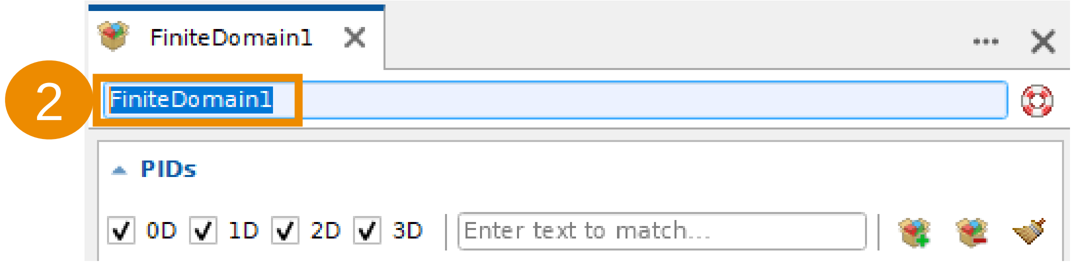
A ***Domain*** is a group of **one** or **several** PIDs

- *Domains* link PIDs to the analysis objects
- *Domains* decouple the topology from the analysis

Rename the domains

- Rename the domains with appropriate names



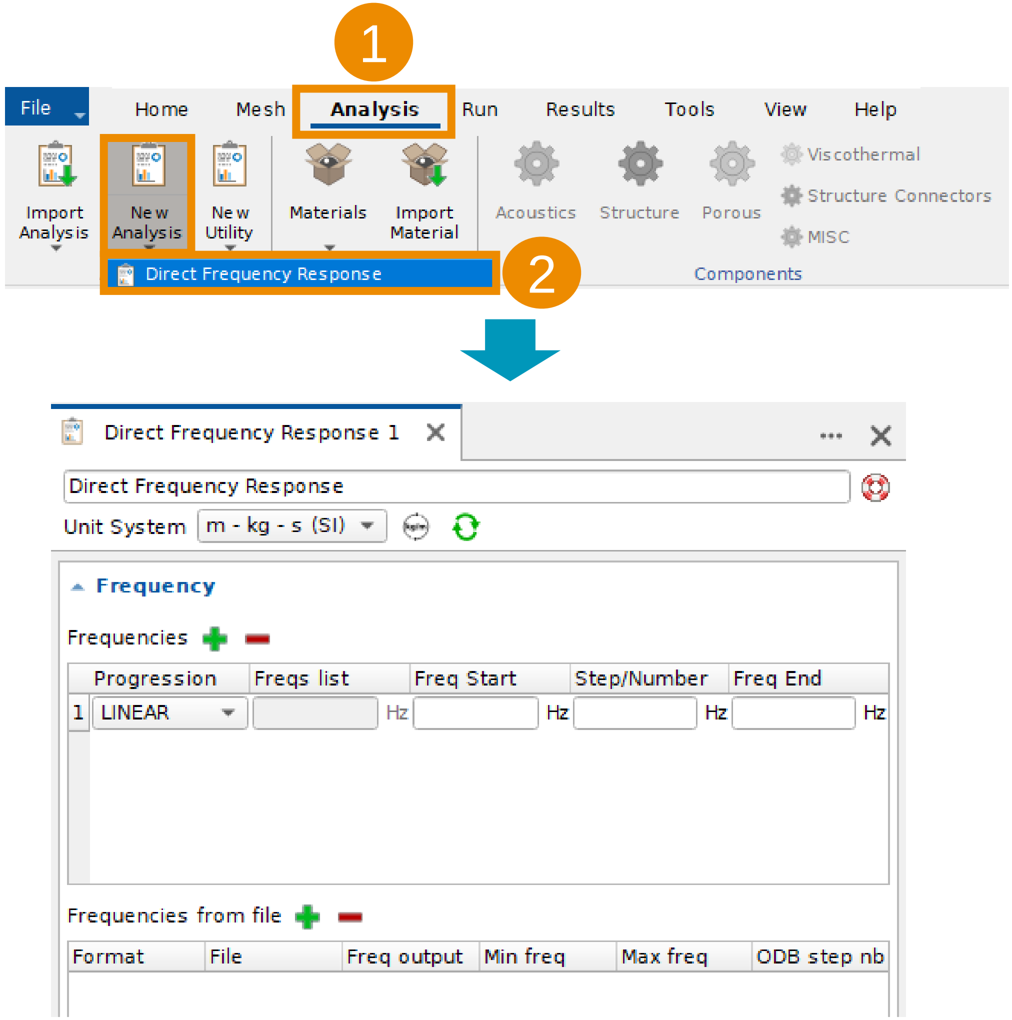


Default name	New name
FiniteDomain1	Acoustic_incident
FiniteDomain2	Plate
FiniteDomain22	DisplacementBC
FiniteDomain25	Transmitted_surface
FiniteDomain26	Incident_surface
FiniteDomain3	Acoustic_transmitted
FiniteDomain44	Infinite_surface_transmitted
FiniteDomain45	Infinite_surface_incident

Create the Actran analysis

Add a *Direct Frequency Response* analysis (DFR)

- A DFR is computation procedure which provides the response of an acoustic, vibro-acoustic or aero-acoustic system to a specific excitation in physical coordinates



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Specify the frequency range of interest

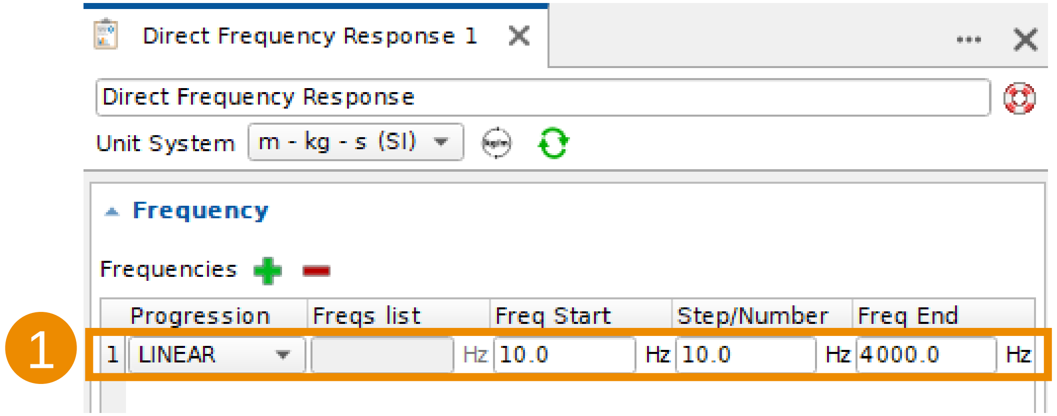
The acoustic fluctuations must be captured

- Maximum frequency (smallest wavelength) is driven by the largest element length
- For quadratic elements, 4 elements per wavelength can be used
- Mesh largest element length is 20 mm → maximum frequency is 4250 Hz

$$\left.\begin{aligned} f_{max} &= \frac{c}{\lambda_{min}} \\ L_{max} &= \frac{\lambda_{min}}{4} = 0.02\ m \end{aligned}\right\} \quad f_{max} = \frac{340}{4 * 0.02} = 4250\ Hz$$

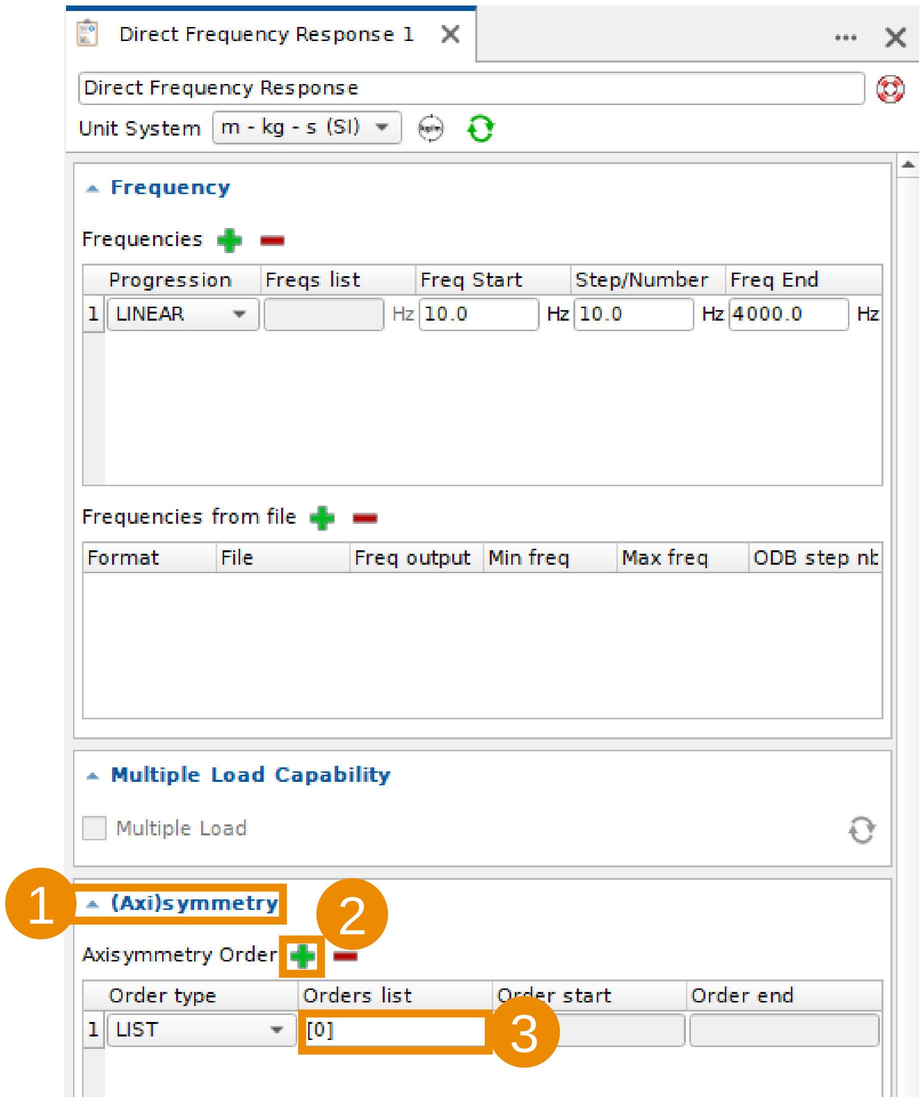
Set the computed frequencies in the analysis properties

- This analysis is performed from 10 Hz to 4000 Hz, with a step of 10 Hz



Axi-symmetry definition

- The Actran model is a 2D axi symmetric model
- This should be defined in the Direct Frequency Analysis properties
  - Set the Axisymmetry Order to 0
  - This specifies a constant solution with varied azimuthal angle in the duct cross section
- By default, the Y axis is always the axis of revolution
- The mesh of axisymmetric models must be in the right half (X > 0) of the XY plane



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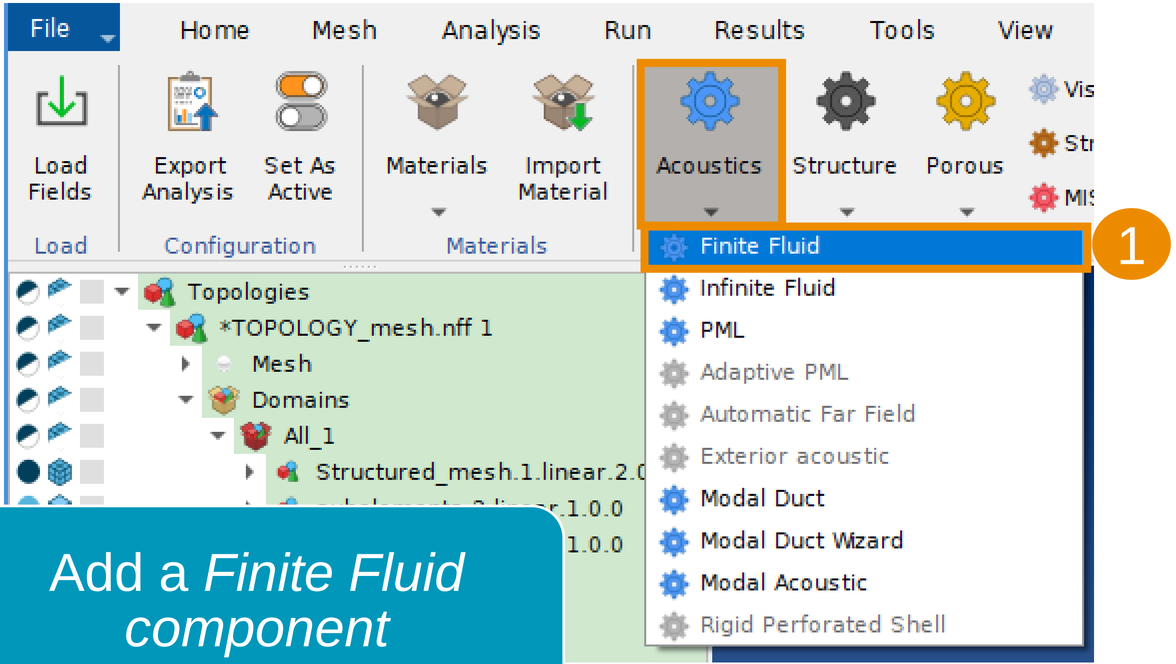
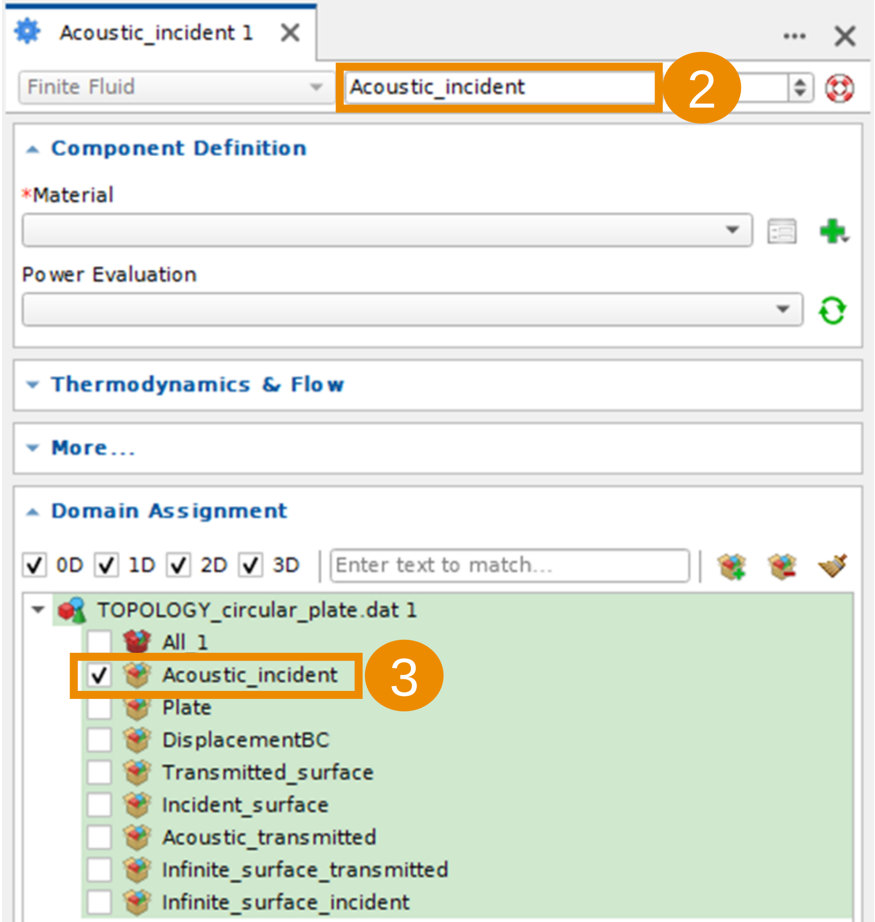
Create a Finite Fluid component for incident acoustic (1)





Add a *Finite Fluid component*

Set up the *Finite Fluid component* domain

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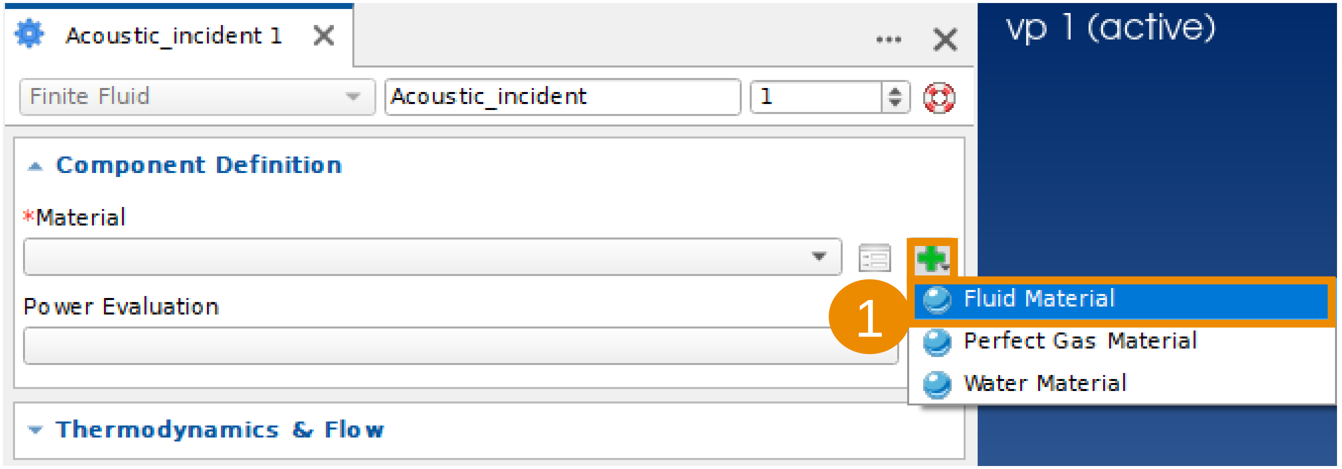
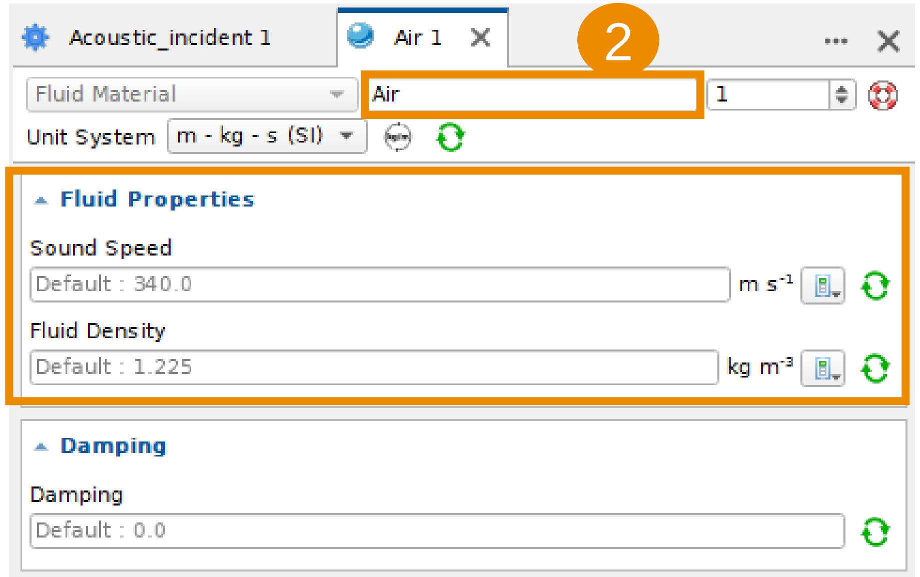
Create a Finite Fluid component for incident acoustic (2)





Define a material for the air

- Add a Fluid Material
- Let the values by default :
  - $c = 340\ m/s$
  - $\rho = 1.225\ kg/m^3$

Close both property windows (material & component)

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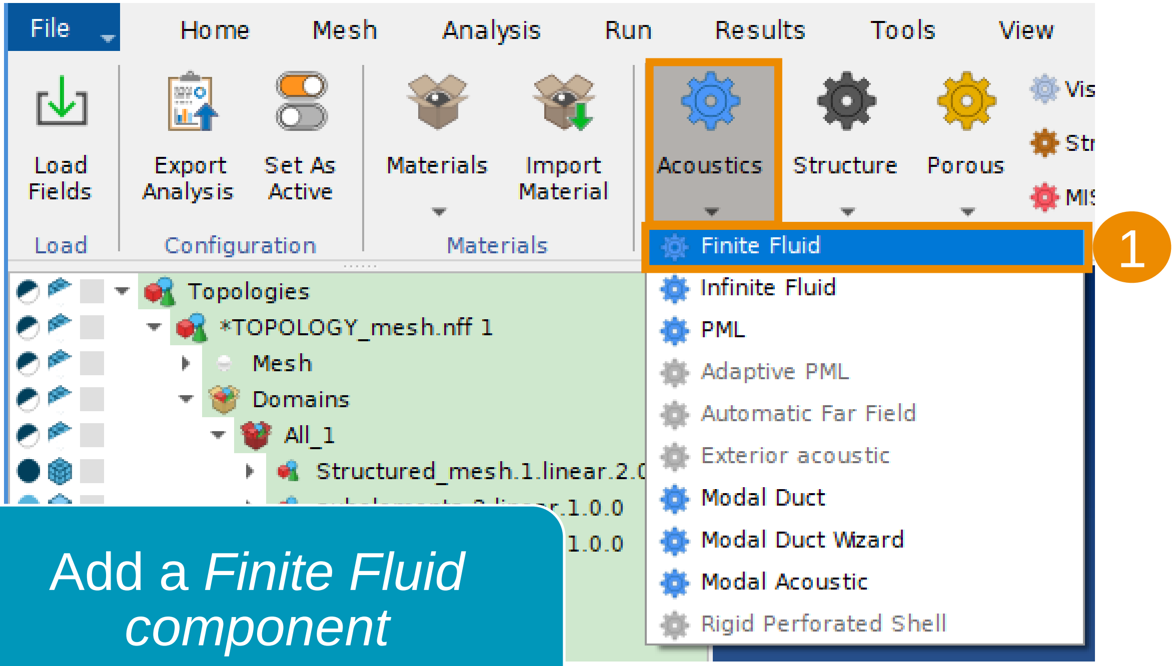
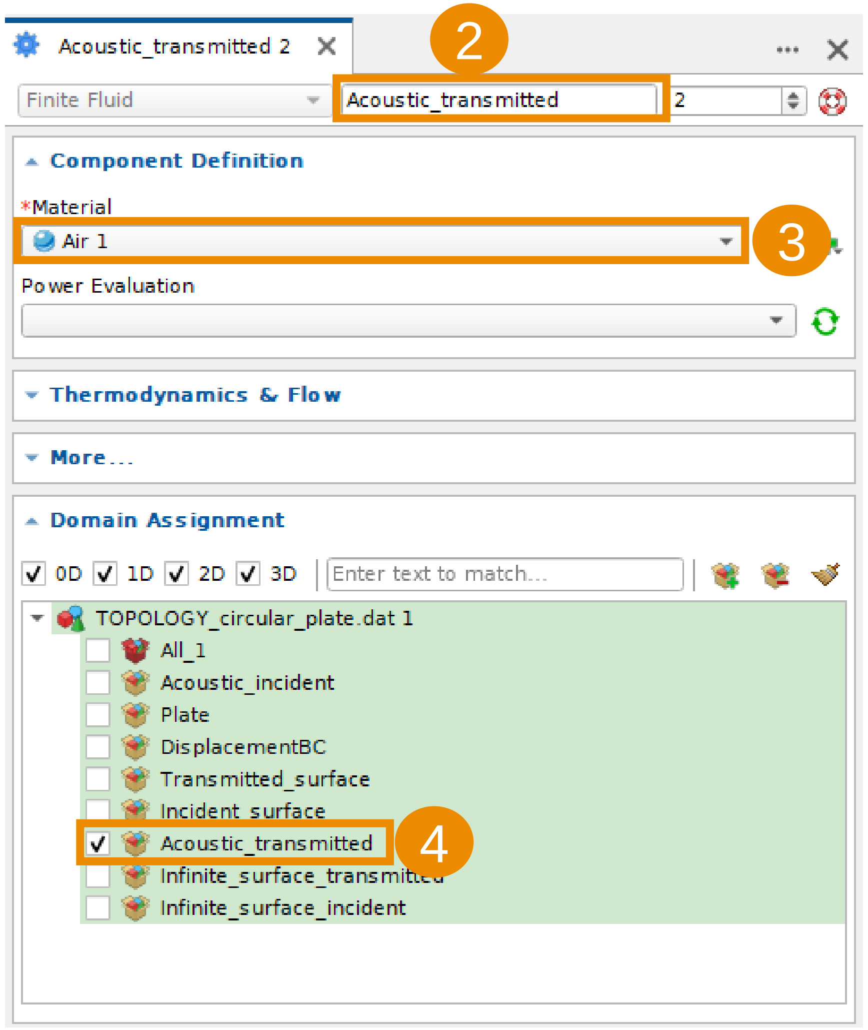
Create a Finite Fluid component for transmitted acoustic



Add a *Finite Fluid component*

Set up the *Finite Fluid component* properties and domain



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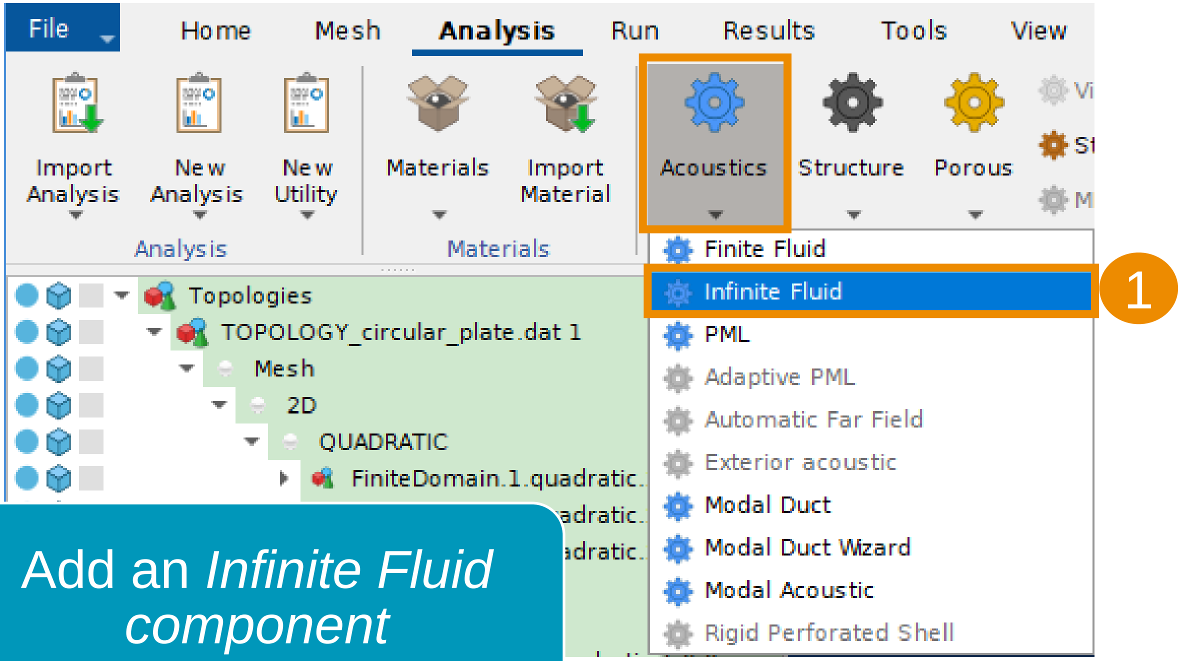
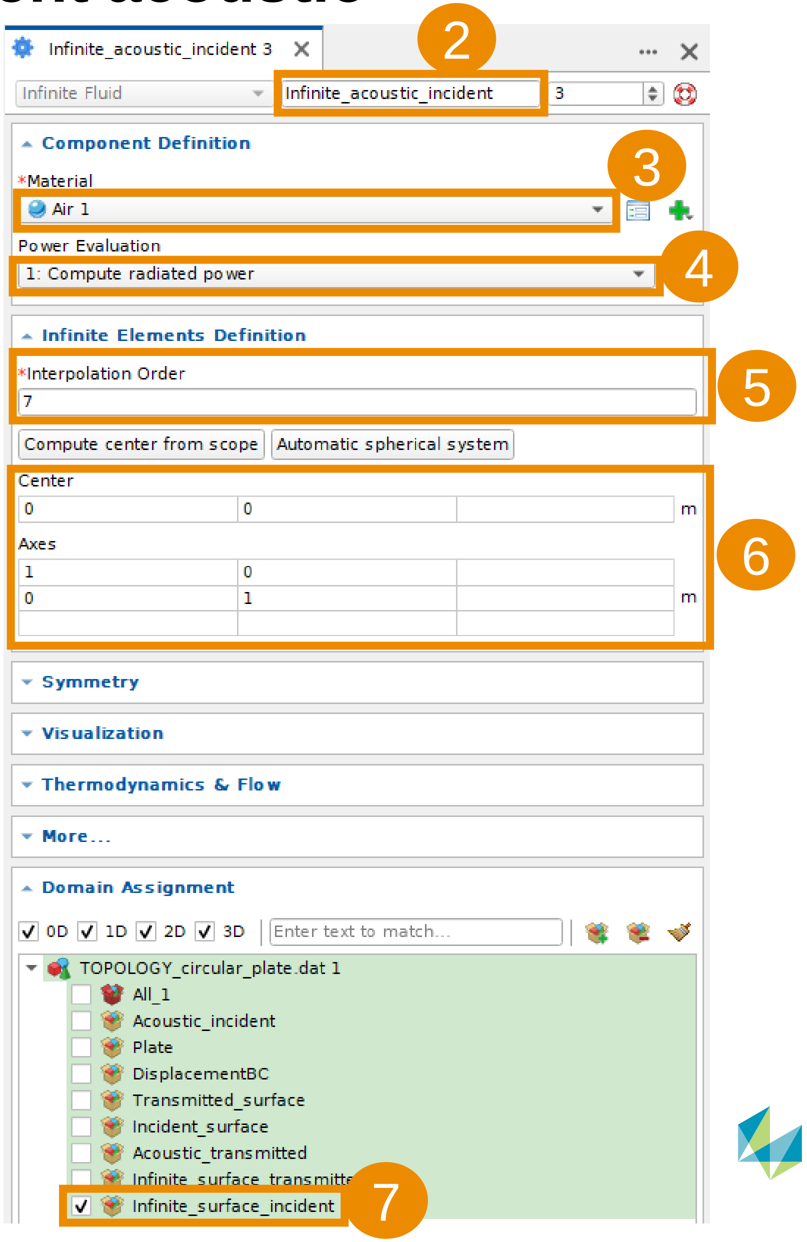
Create an Infinite Fluid component for incident acoustic



Add an *Infinite Fluid component*



Set up the *Infinite Fluid component* properties and domain

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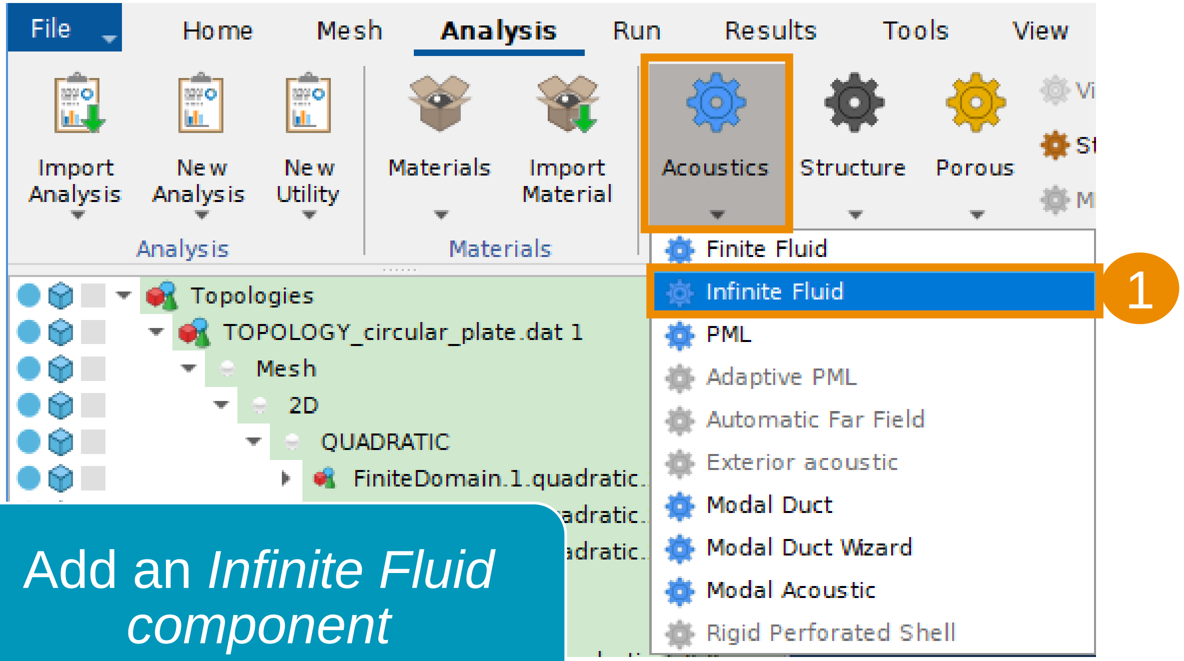
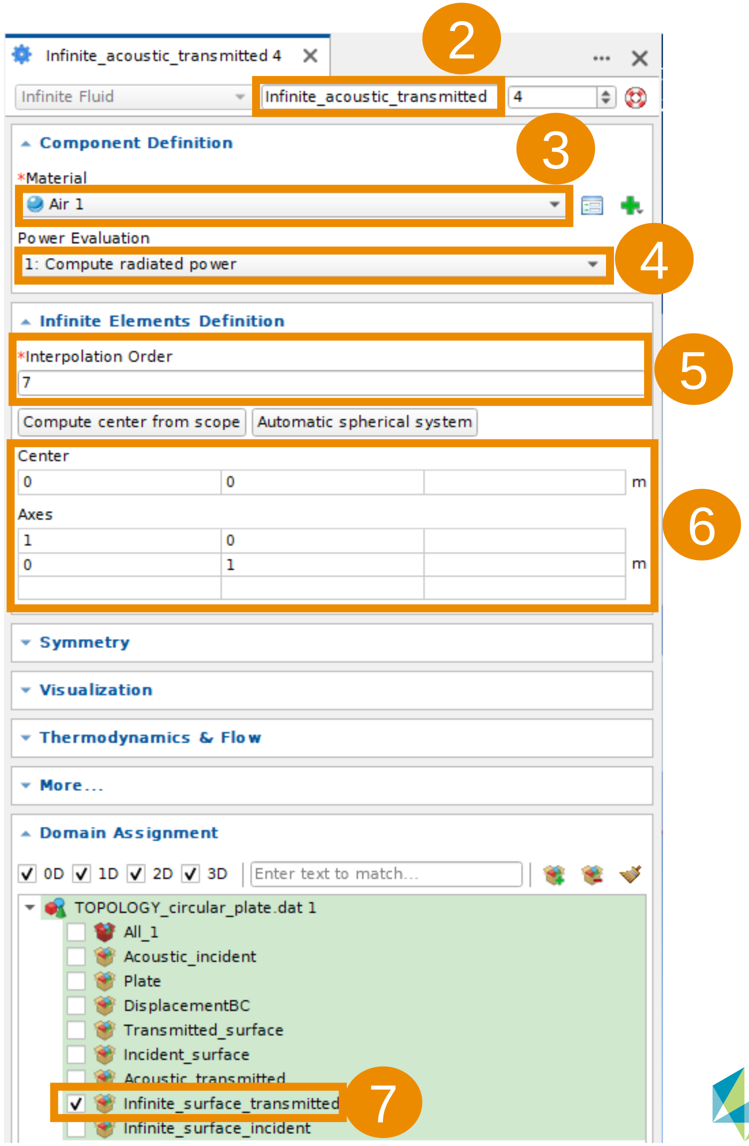
Create an Infinite Fluid component for transmitted acoustic

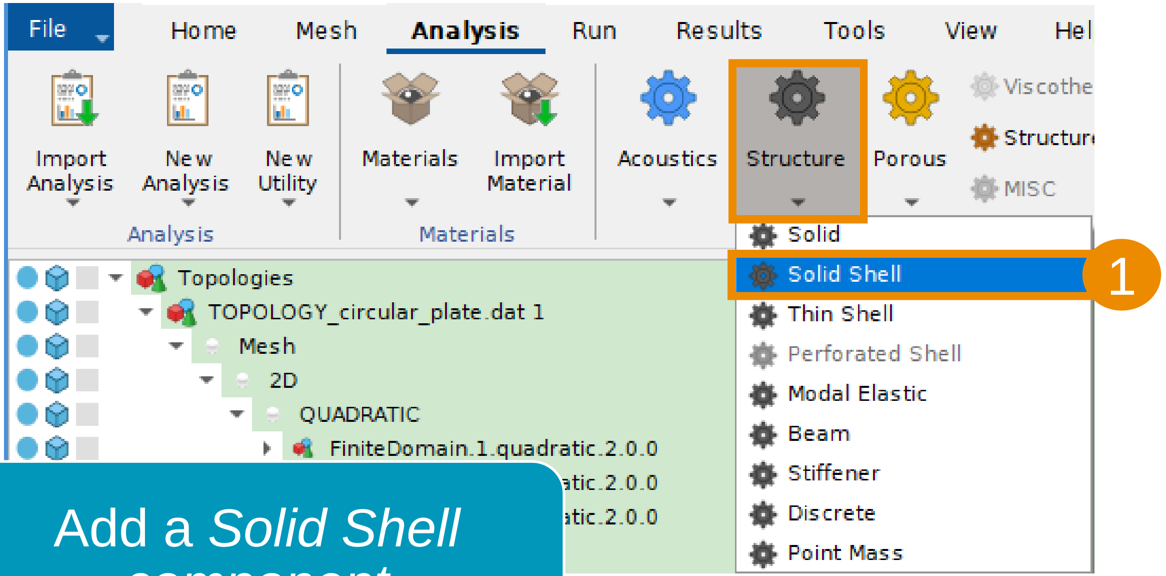


Add an *Infinite Fluid component*

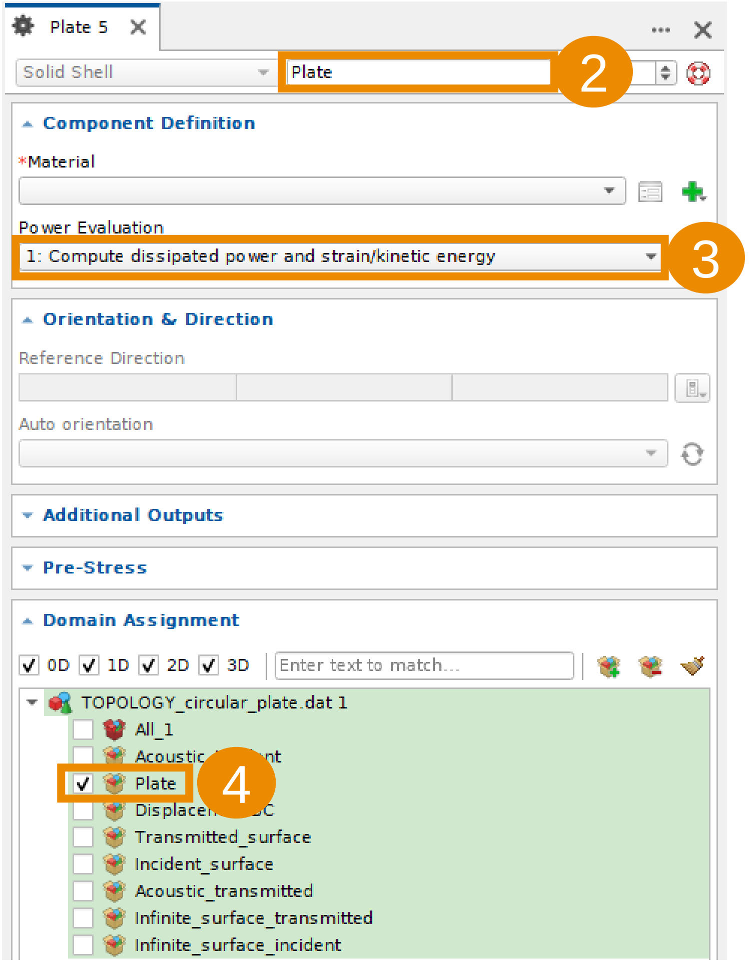
Set up the *Infinite Fluid component* properties and domain



Create the Solid Shell component (1)



Add a *Solid Shell component*



Set up the *Solid Shell component* properties and domain

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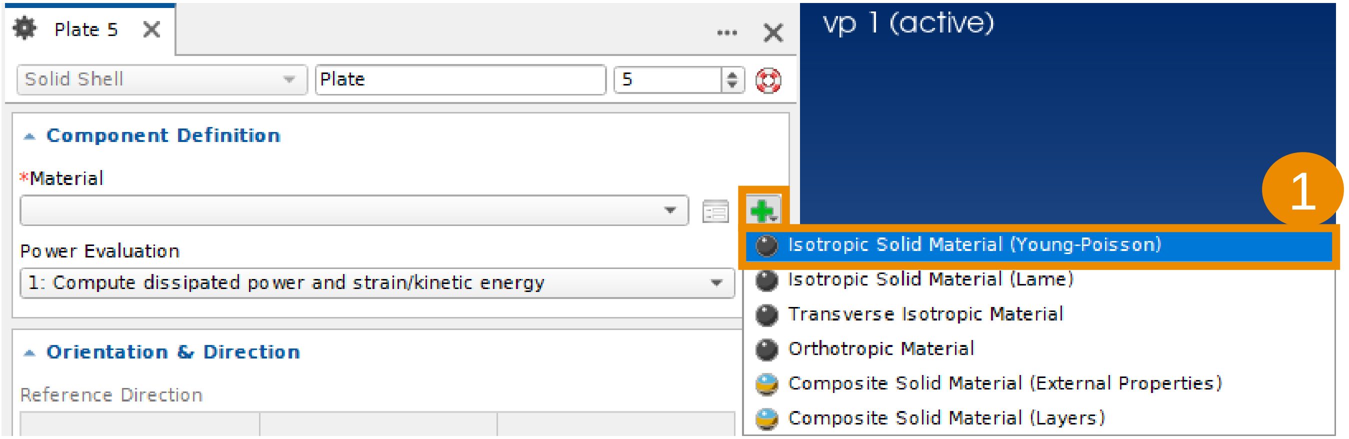
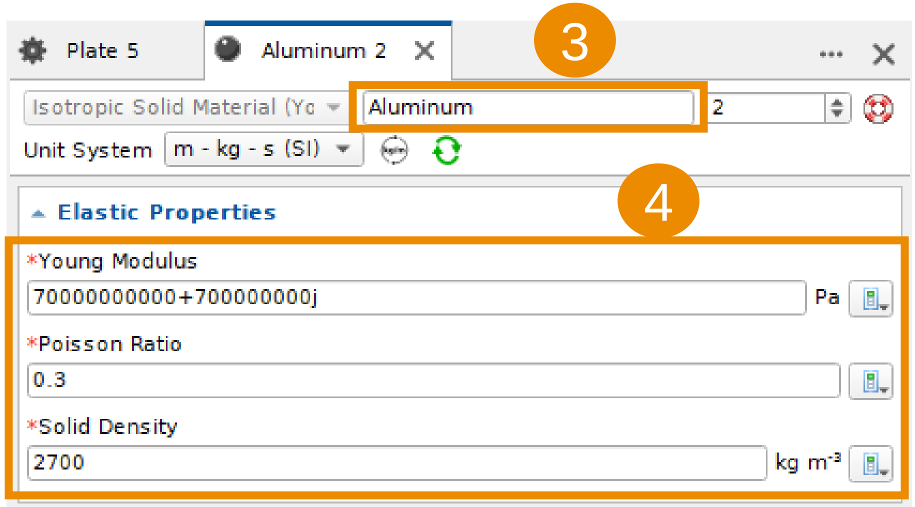
Create the Solid Shell component (2)

The complex Young's Modulus represents the structural damping and is set to 1%

NOTE





Define a material for aluminum

- Add an Isotropic Solid Material
- Specify the following values:
  - Young's modulus: E = 7e10+7e8j Pa
  - Poisson Ratio: ν =0.3
  - Solid density: ρ =2700 kg/m^3

Close both property windows (material & component)

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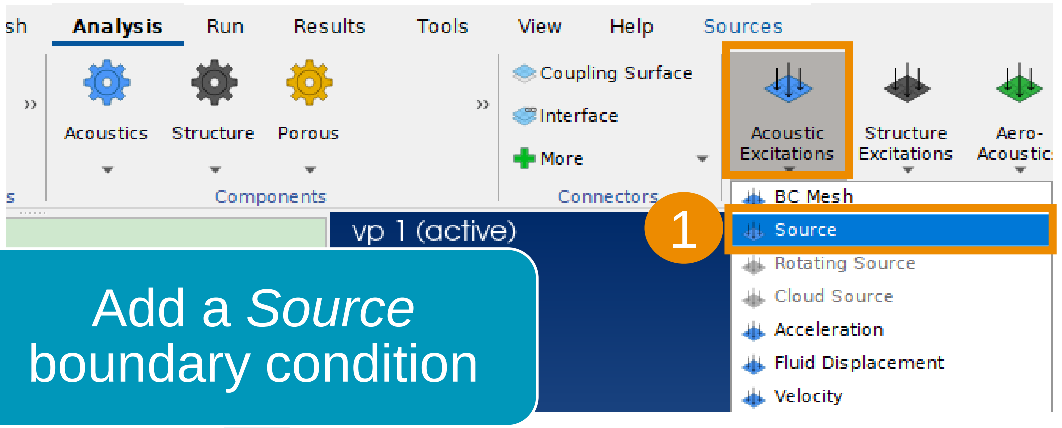
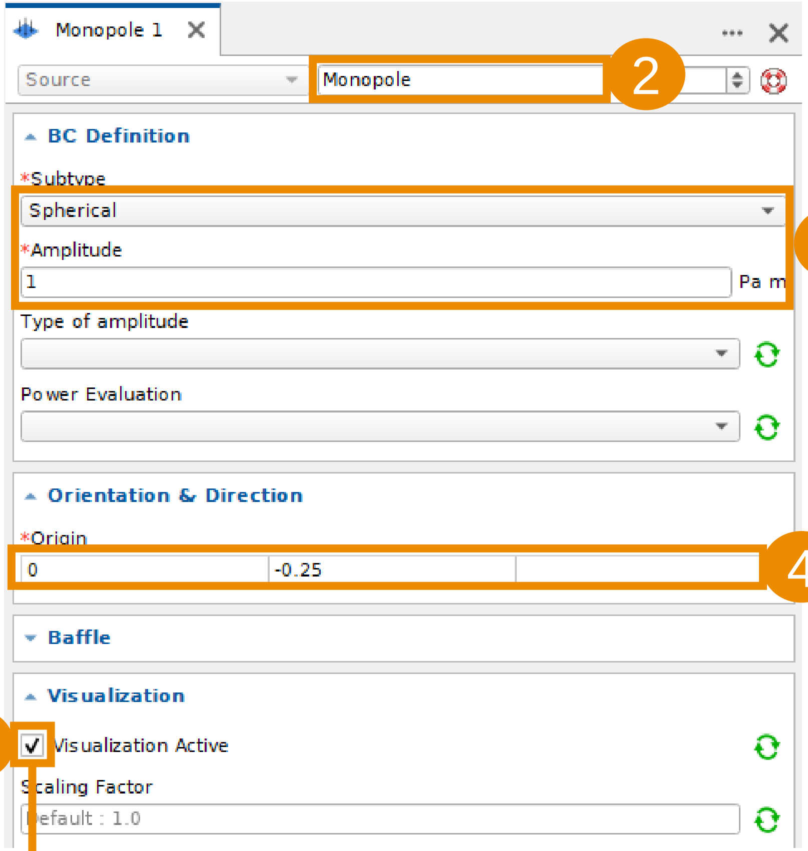
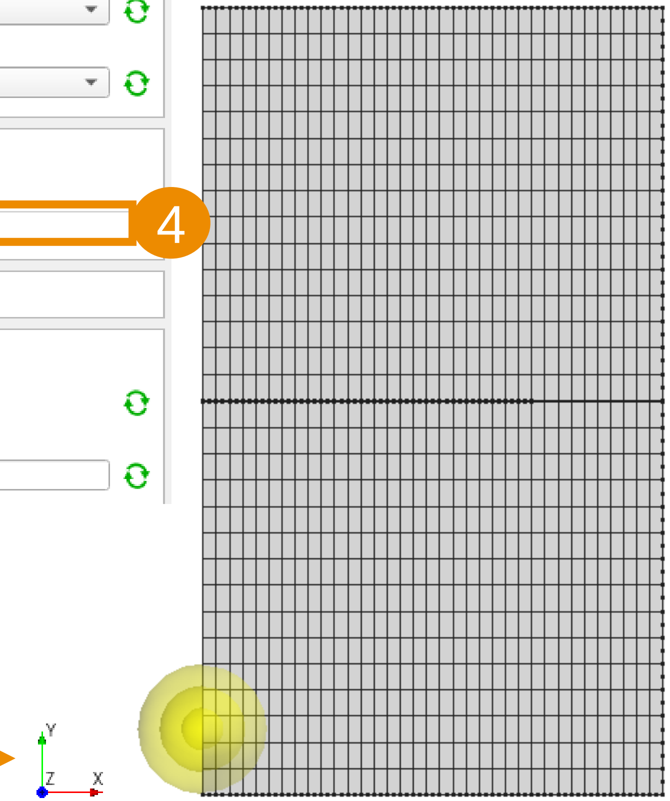
Create the spherical acoustic source



Add a *Source* boundary condition

Set up the *Source* properties and activate Visualization





NOTE

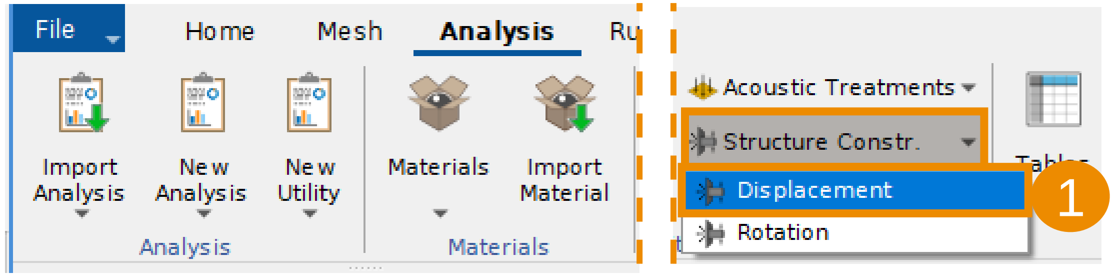
The Amplitude parameter specifies A in the equation

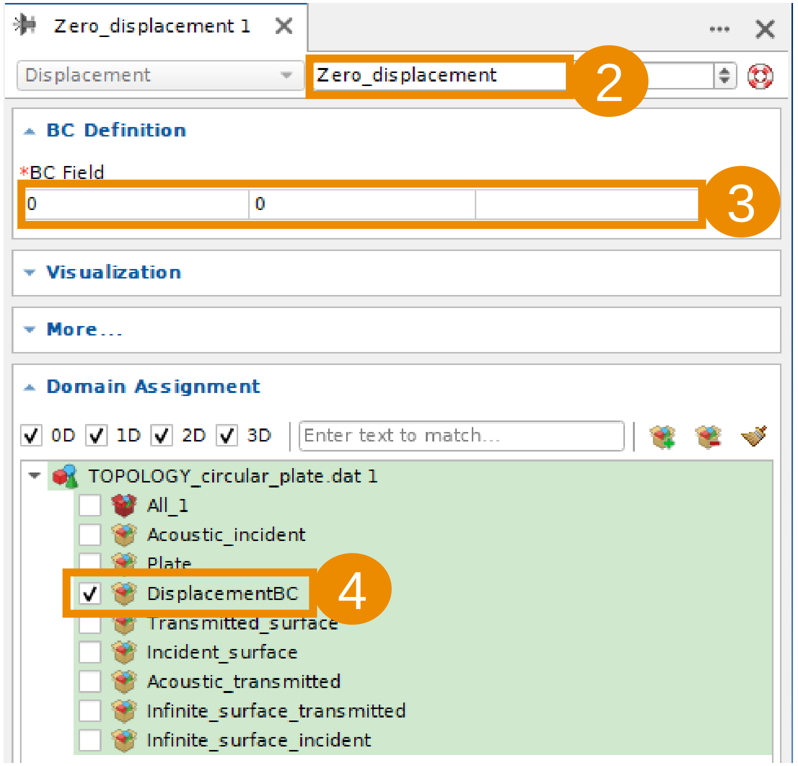
$$p_i = A\frac{e^{-ikr}}{r}$$

Create the zero-displacement boundary condition

Add a Displacement boundary condition

Set up the Displacement boundary condition properties and domain





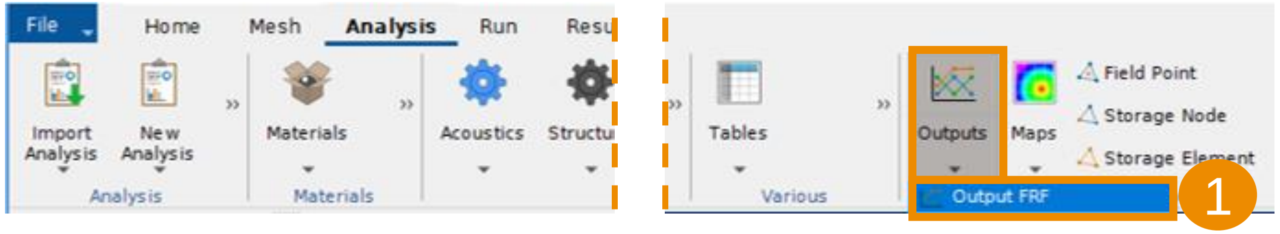
NOTE *The plate is clamped on the rigid baffle*

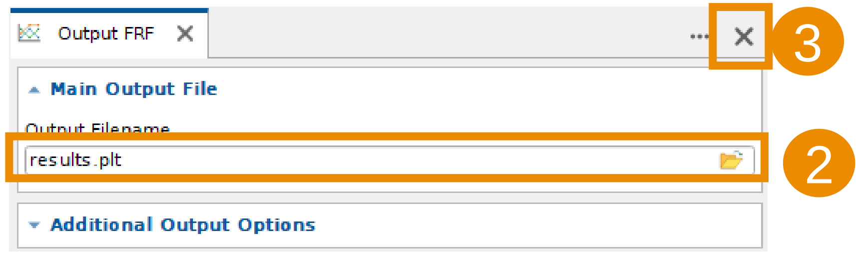
Post-processing parameters – FRF

Create an output FRF post-processing parameter

Specify the name of the output file

Close the property window





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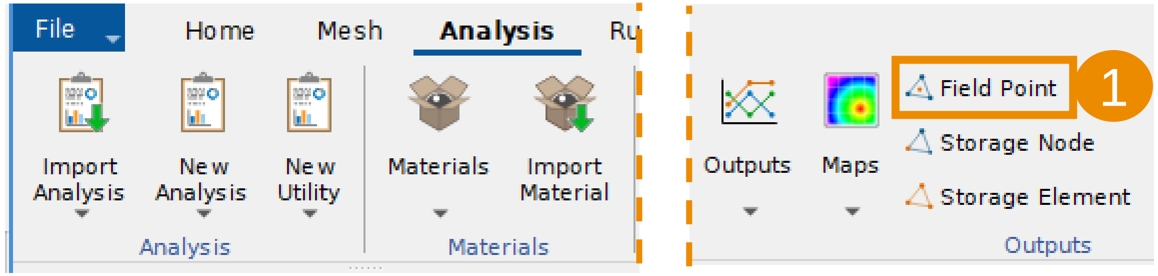
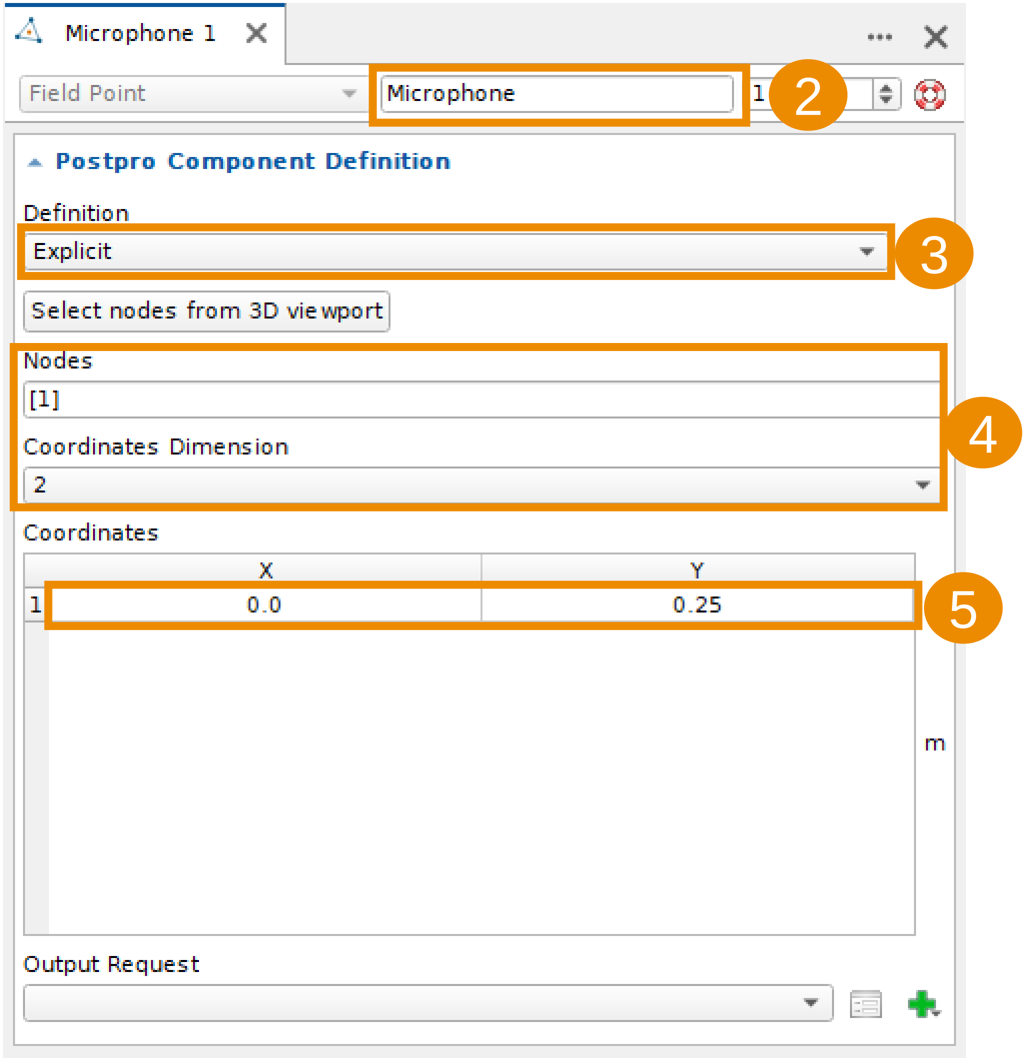
Post-processing parameters – Field point FRF



Add a *Field Point*

Set up the *Field Point* coordinates explicitly



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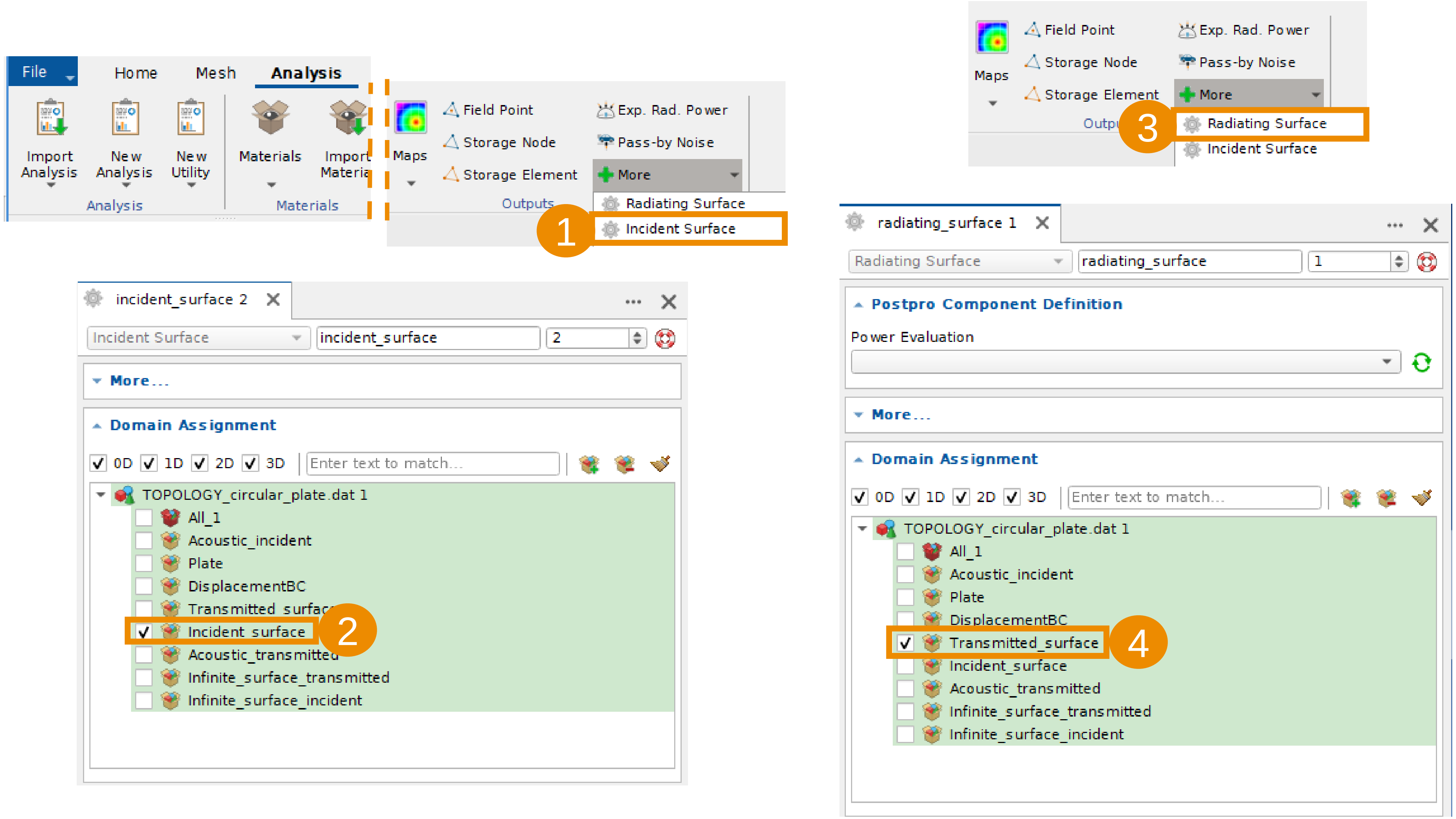
Post-processing parameters – Transmission loss calculation

Add *Incident* and *Radiating Surfaces*

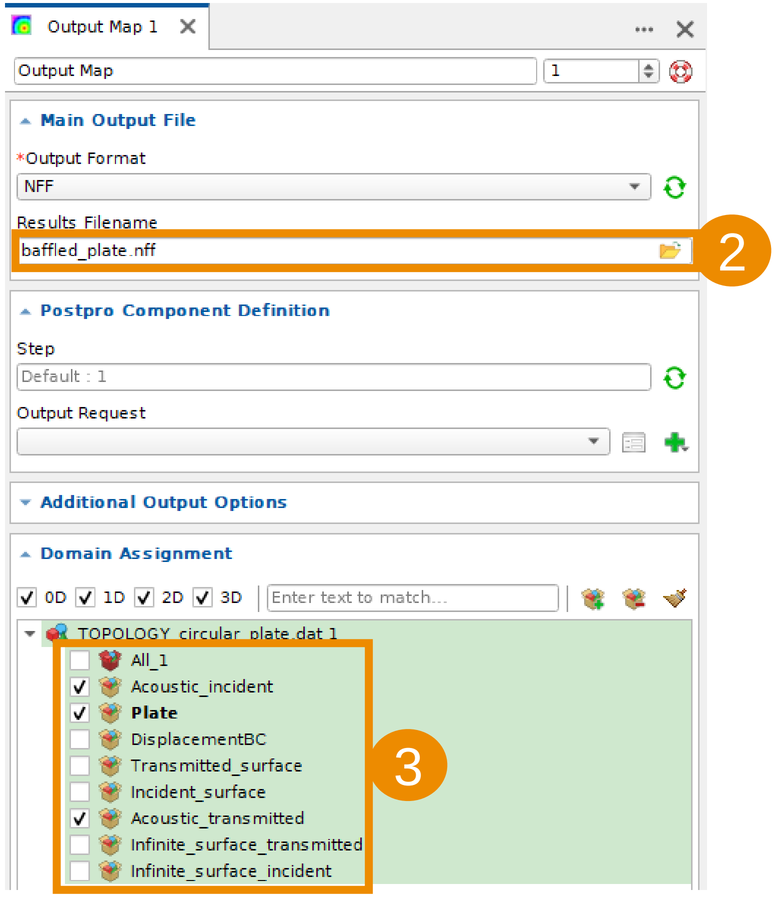
Assign them to their respective domain



Post-processing parameters – Maps

Add an *Output Map post-processing parameter*

Specify a map in *.nff format to be saved in the whole mesh, at each frequency step

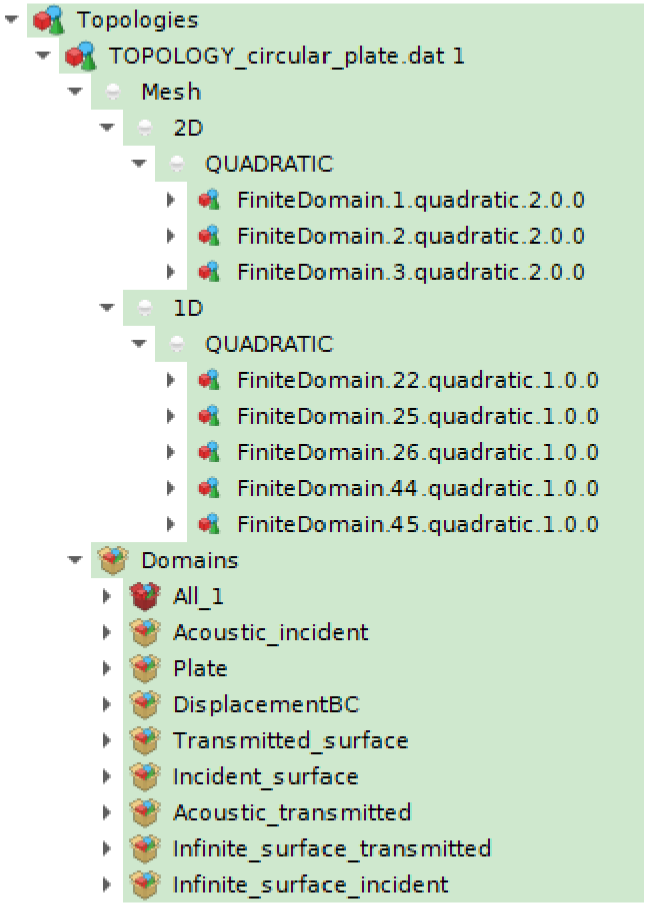


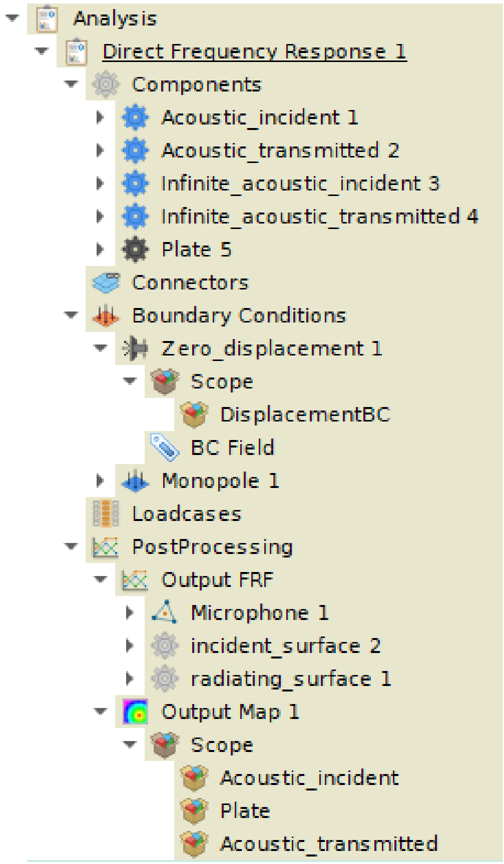
Check the analysis

The *Analysis* setup is now complete

All the parts of the *Analysis* are available and editable on the data tree panel

Check if the data tree is identical to the one shown





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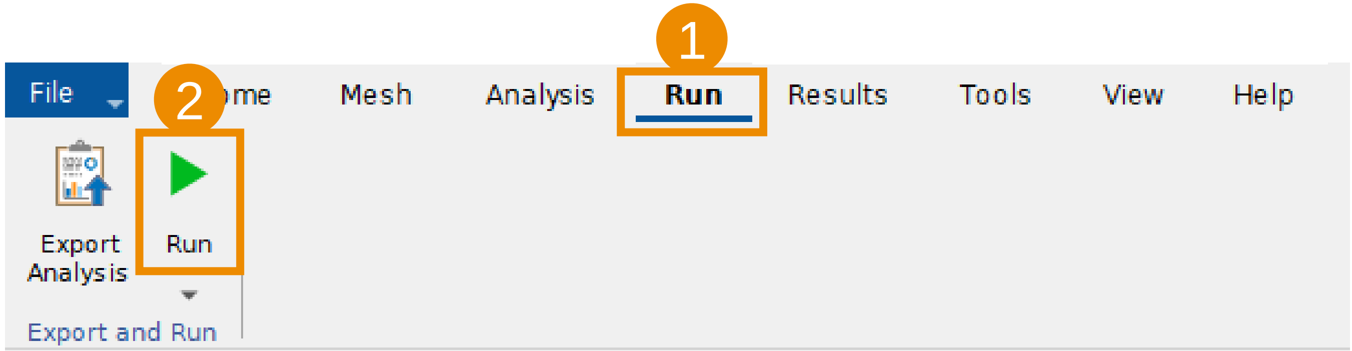
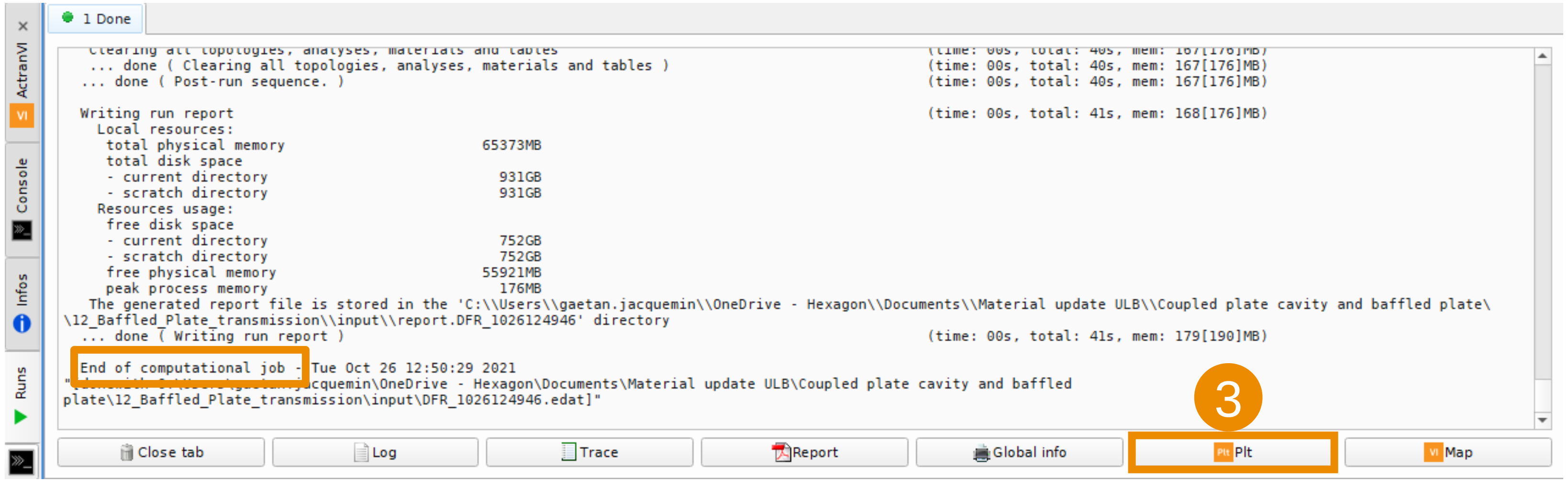
Launch the Actran analysis in ActranVI

Launch the computation

Check the log showing the computation progress

Import the *.plt computation result file





HEXAGON

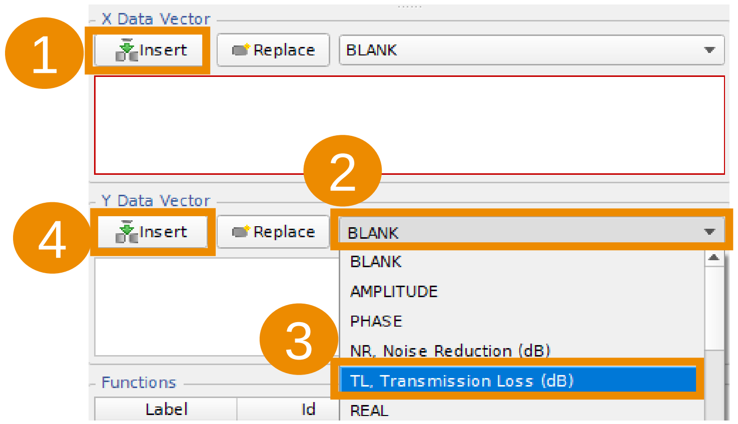
Post-processing

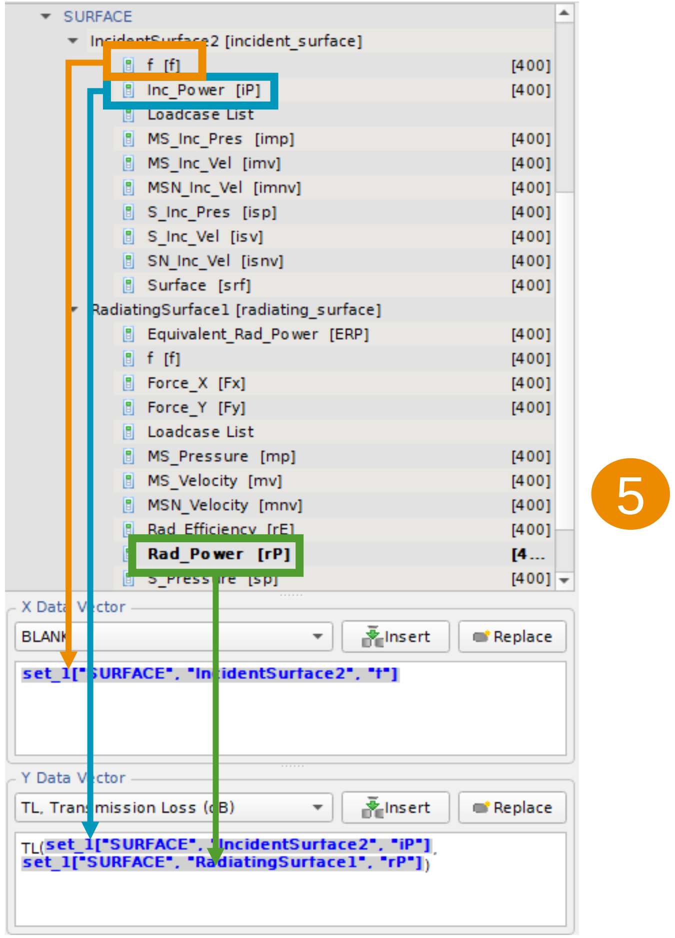
Compute the transmission loss in PLTViewer

Visualize pressure maps in ActranVI

Plot the Transmission Loss (TL)

Insert the PLTViewer **TL** function





Drag & drop the output quantities

- **X data**: Frequency range *f*
- **Incident power**: Incident surface *Inc_Power*
- **Transmitted power**: Radiating surface *Rad_Power*

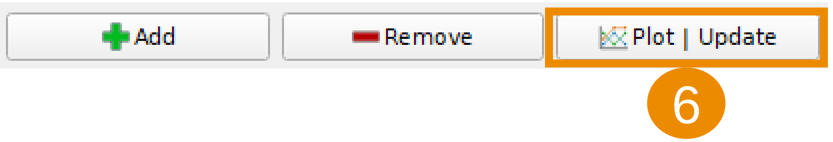


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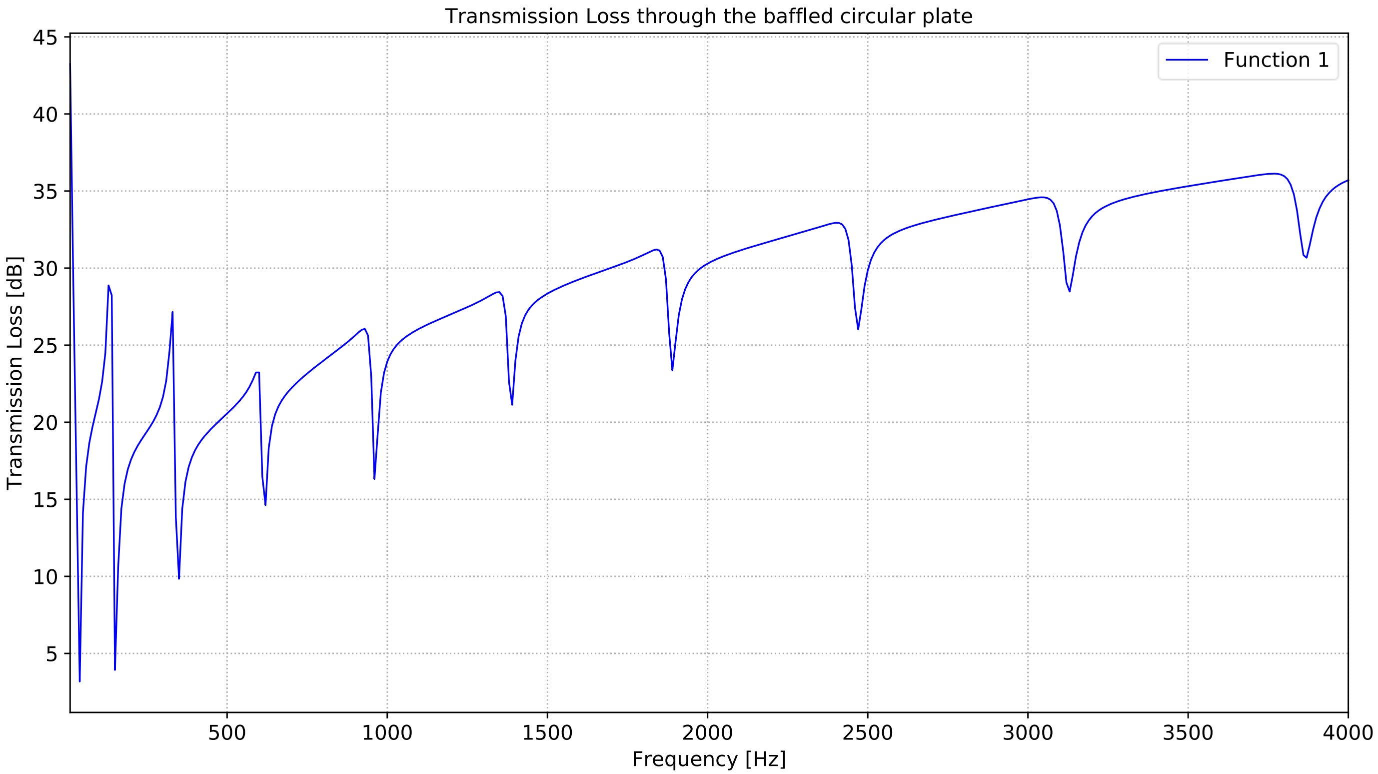
Plate TL results

- In the TL curve
  - High TL value means high noise reduction
  - Low TL value means low noise reduction



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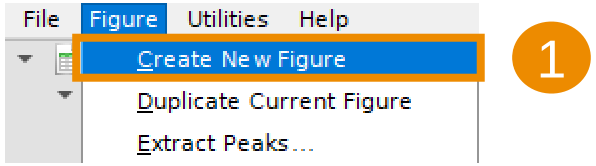
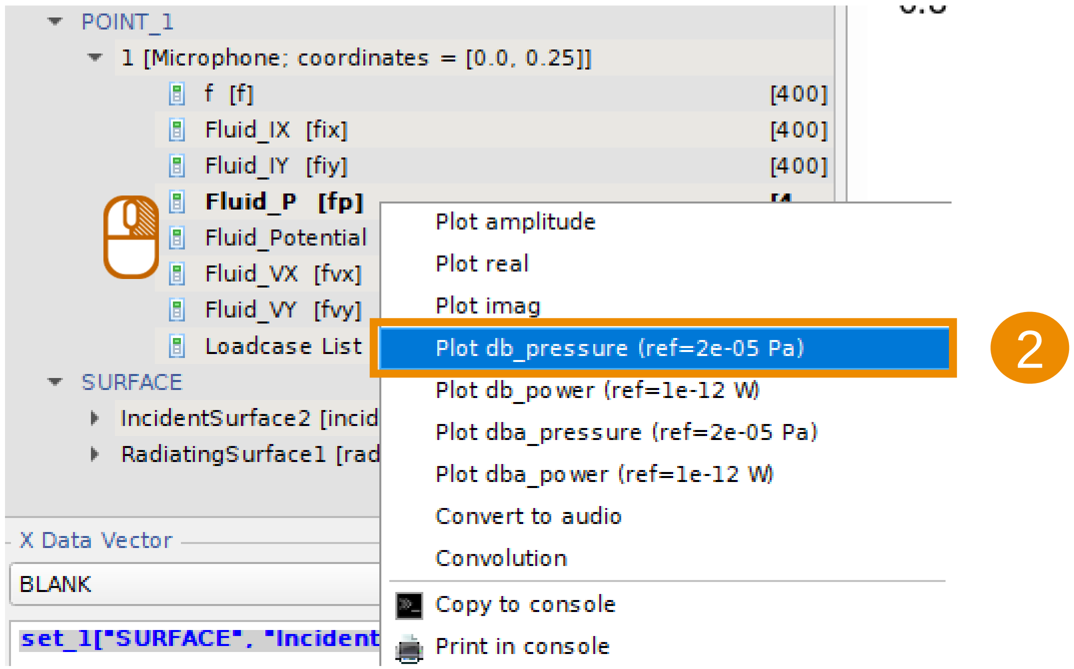
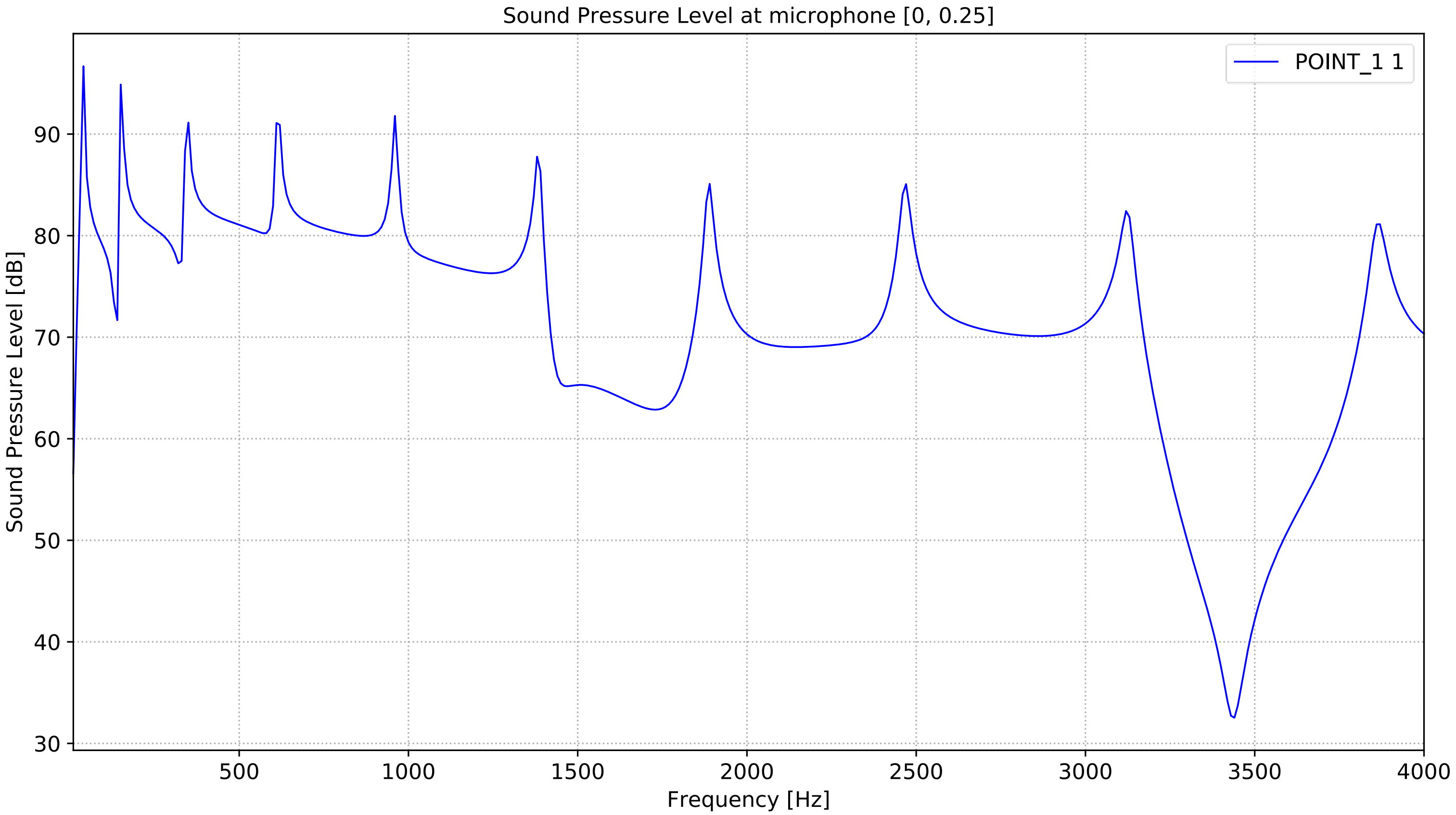
Results at microphone

- The sound pressure at point [0, 0.25] is output in the .plt file
- Plot the Sound Pressure Level (SPL) at microphone location





Results at microphone



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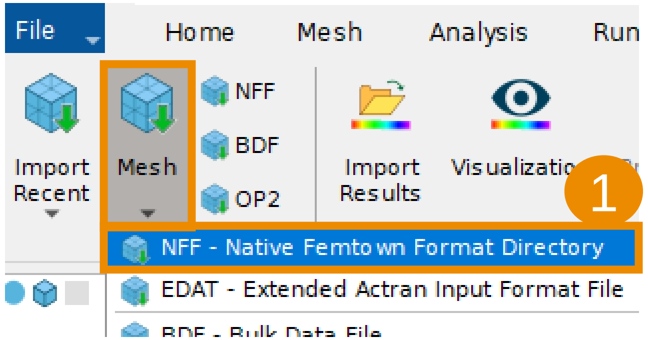
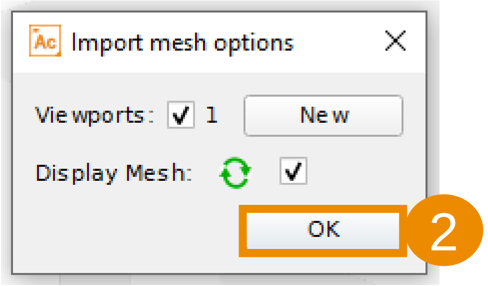
Display displacement results mesh

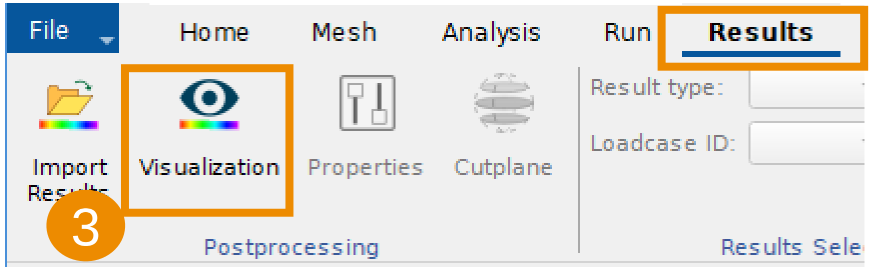
Load the map NFF database
baffled_plate.0.nff

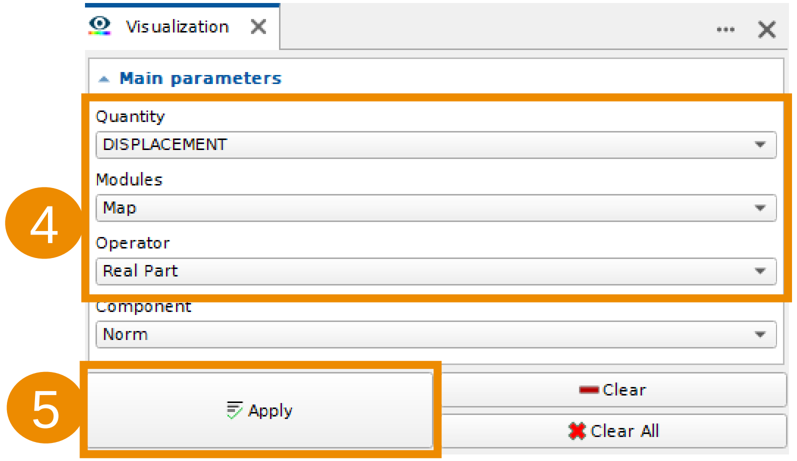
Display the real part of the displacement

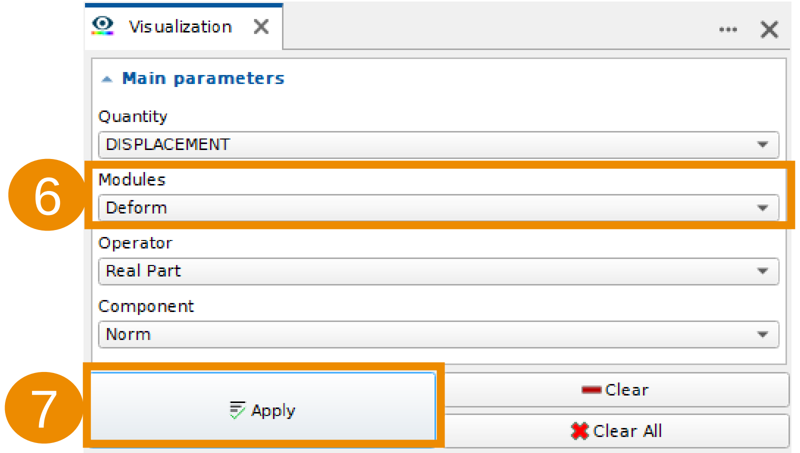
Display the deformation with a scale factor of 500

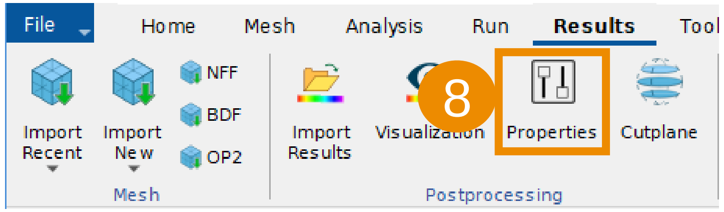












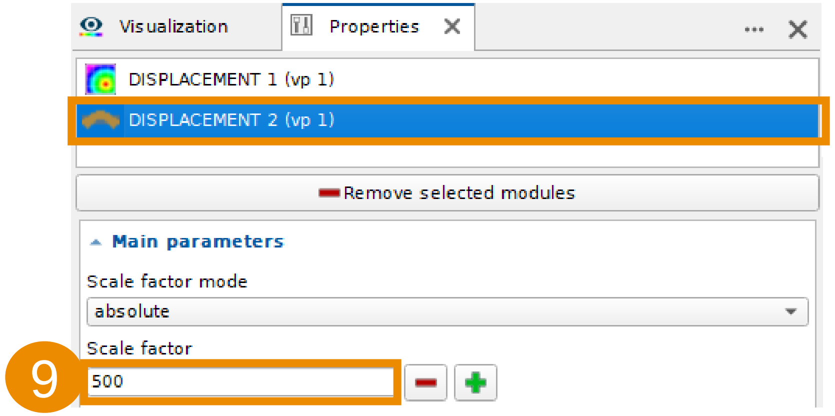
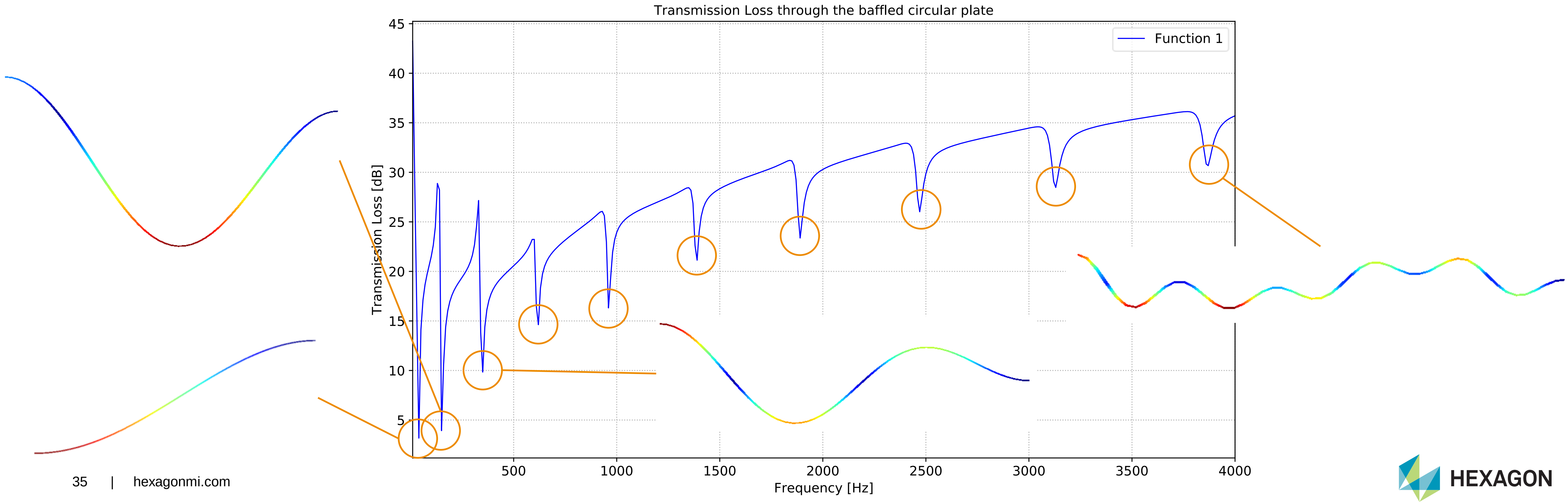


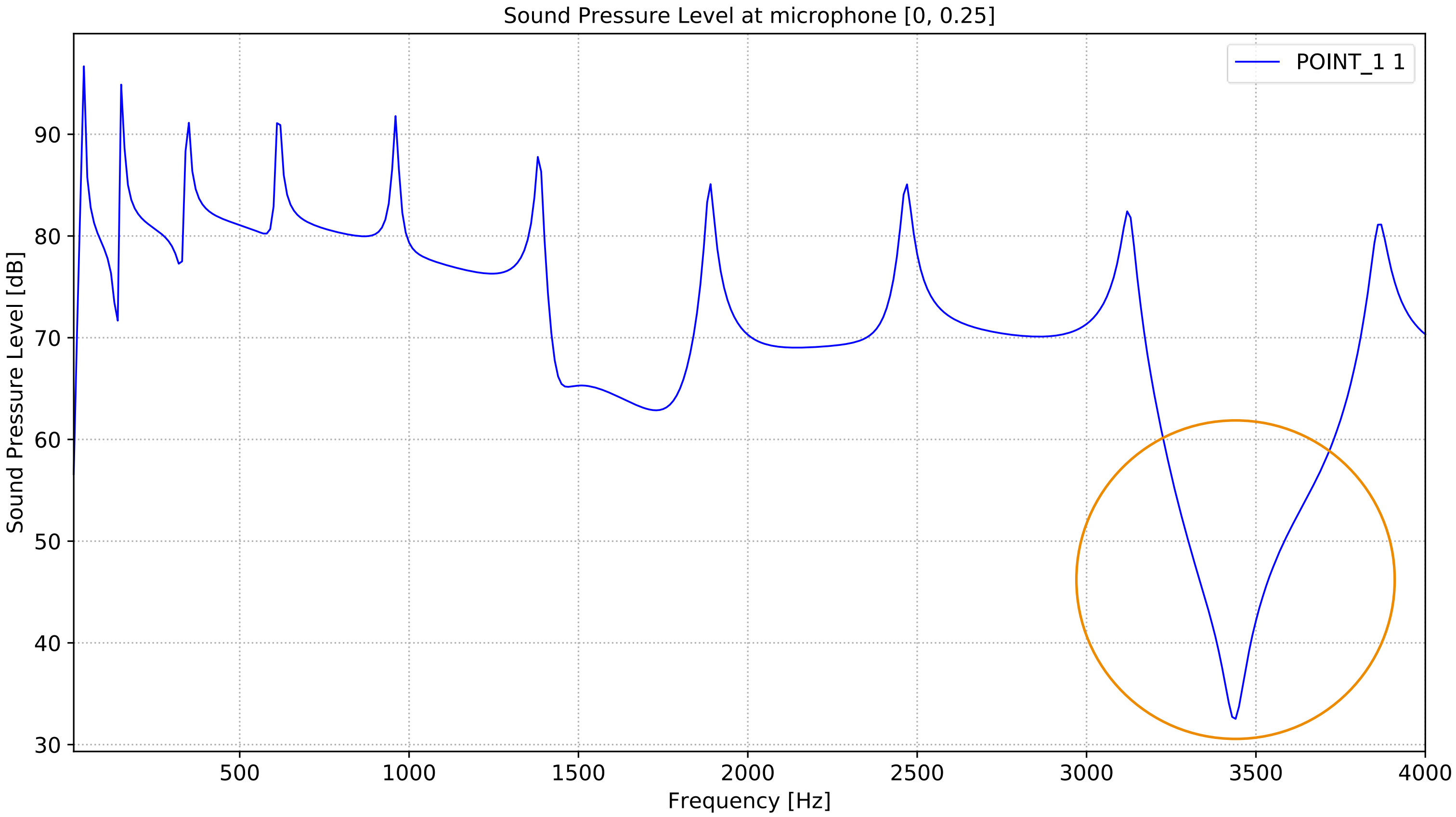
Plate deformation at eigenfrequencies vs TL

- Observe the plate deformation evolution and compare it to the TL
  - Frequencies for which the TL is low correspond to eigenfrequencies of the plate
  - These frequencies can be retrieved analytically (for simple problems) or by performing a modal extraction calculation in Actran (see Workshop “Extraction of plate modes”)



- The sound pressure level (SPL) at the microphone location plot with PLTViewer shows that the SPL is much lower between 3100 Hz and 3800 Hz

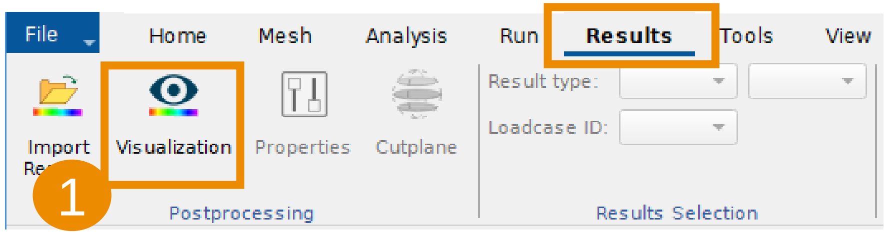
- In order to investigate this observation, the pressure field can be observed in ActranVI

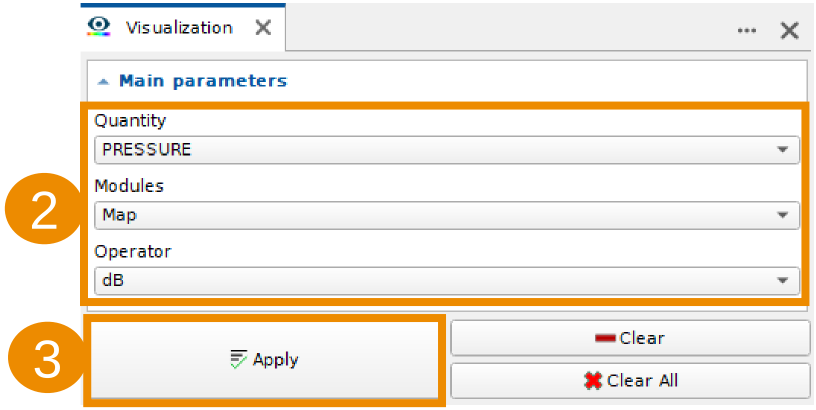


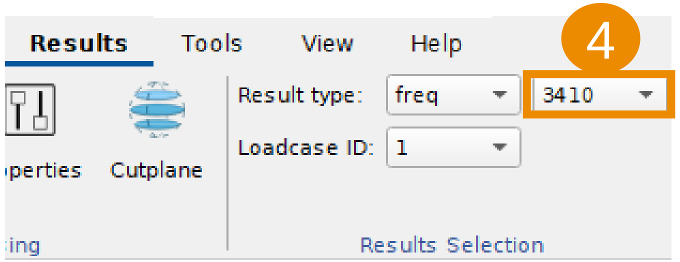
Visualize pressure

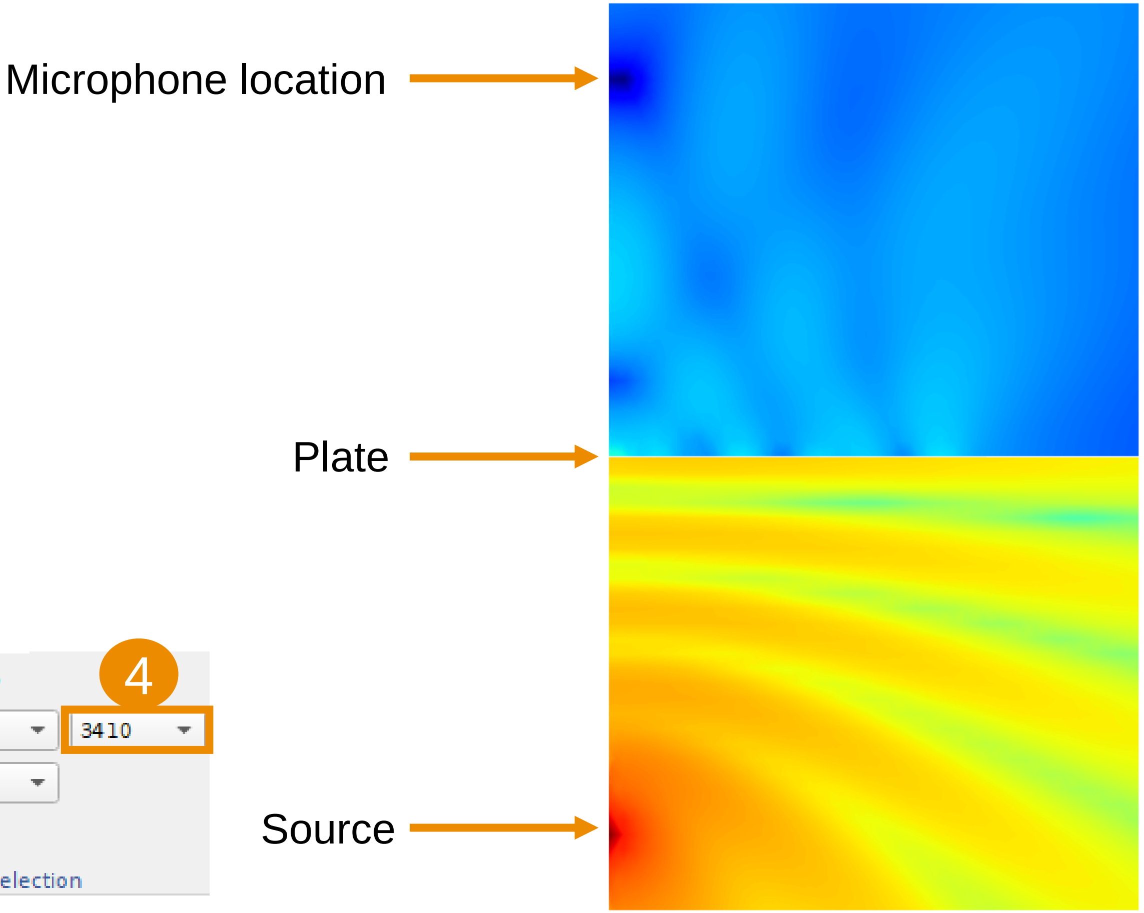
- Visualize pressure results in decibels

- The pressure map confirms that, between 3100 Hz and 3800 Hz, the sound pressure level around the microphone location is low



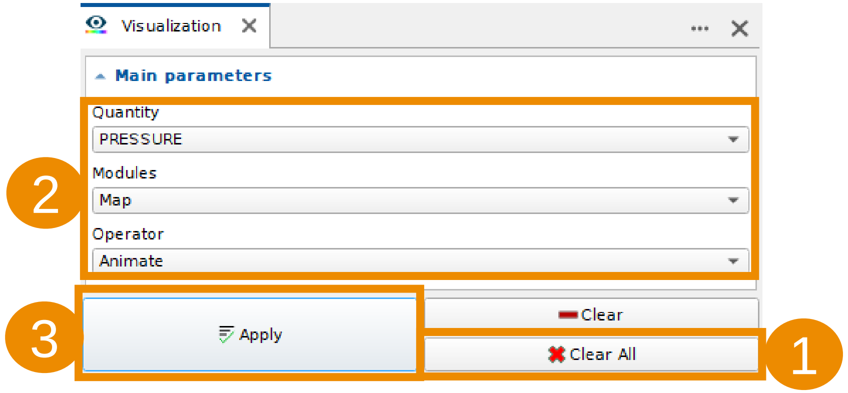




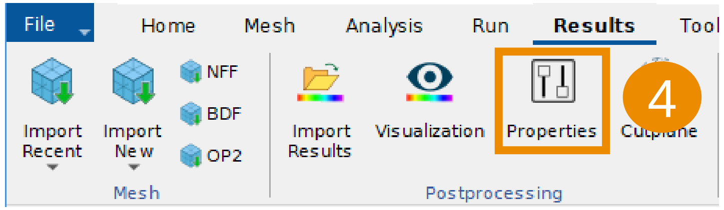


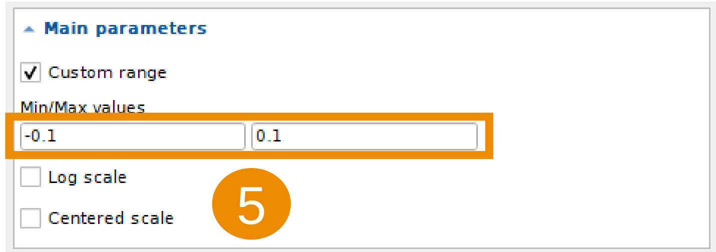
Animate pressure results

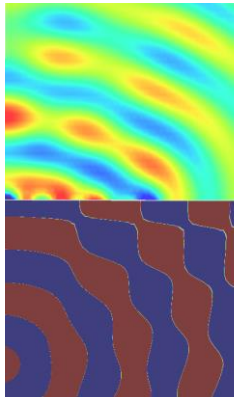
- Clear previous results and apply Animate operator



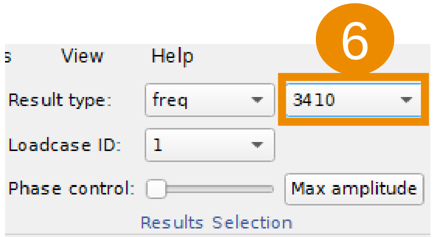
- Set a custom range for visualization: [-0.1, 0.1] Pa

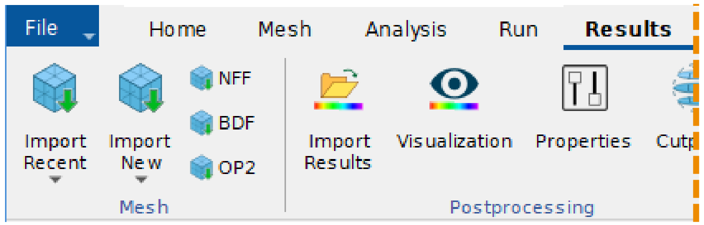


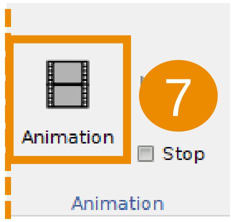


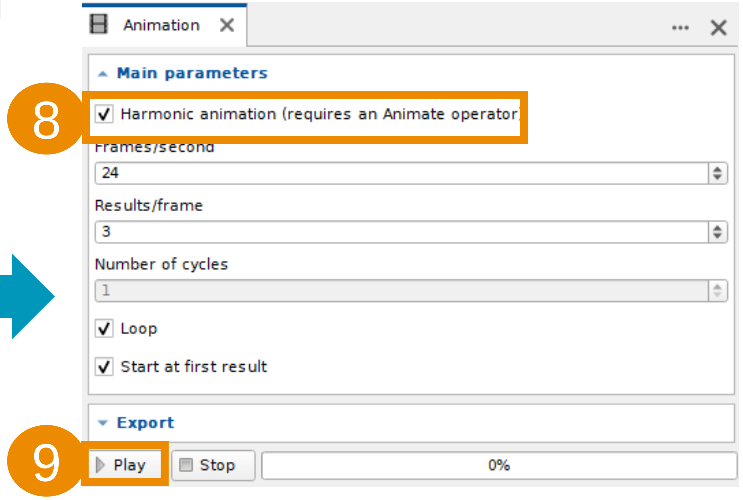


- Make a harmonic animation of pressure results at 3410 Hz









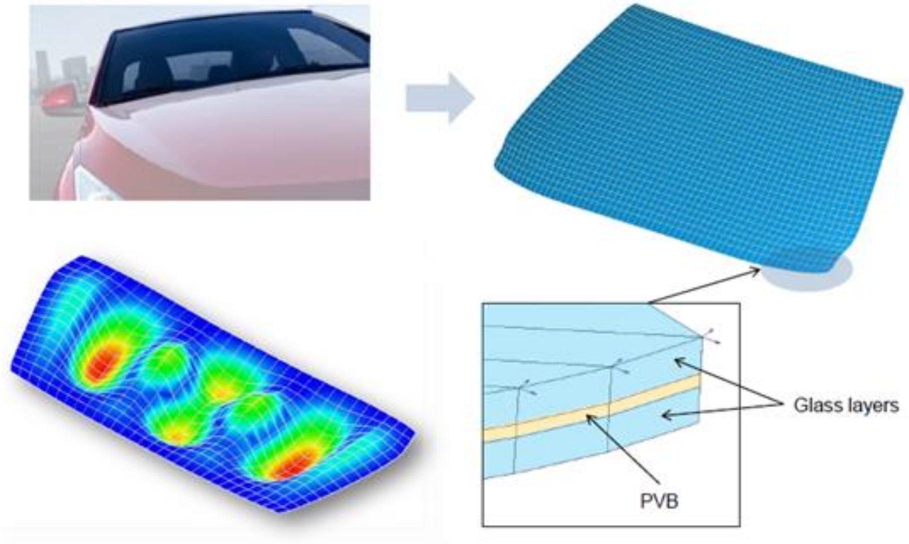
Going further…

Going further

- Visualize how the Transmission loss and the pressure field are modified if plate properties are changed
  - Change material type
  - Change damping factor (imaginary part of Young’s modulus)

An example of industrial application

- Simulation of Transmission Loss through a multilayer windshield structure
  - Different layers are meshed by solid elements, with different thickness values (by surface extrusion technique in most meshing tools)
  - The excitation can be simple source like in this tutorial or more complex and realistic sources like the random diffuse sound field excitation



HEXAGON