

2022 R1 What's New: Ansys NVH Solutions



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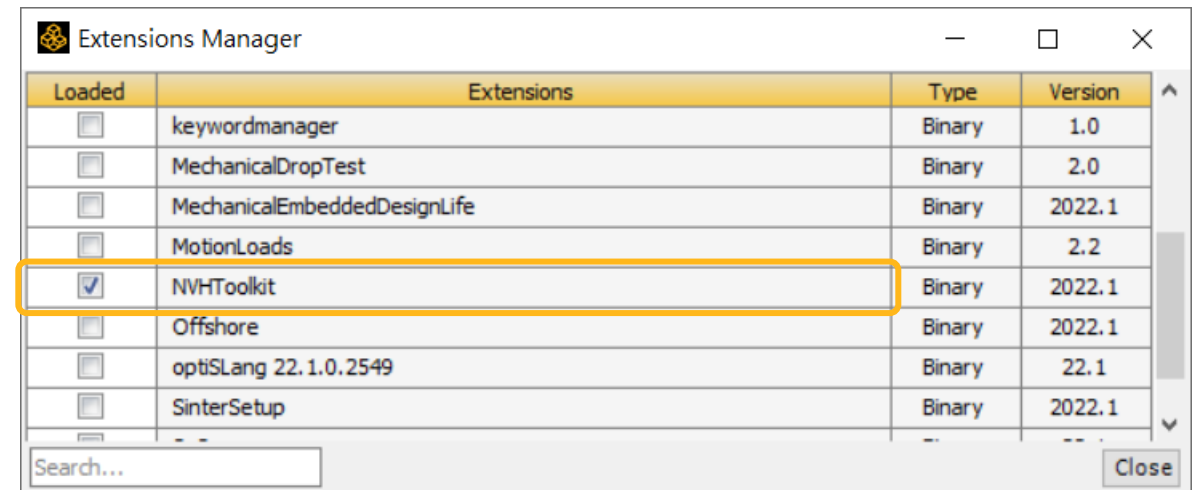
- NVH Toolkit
- Maxwell - Mechanical Integration
- Couple Field Systems Enhancements
- Mechanical Acoustics Enhancements
- Ansys LS-Dyna Acoustics Enhancements

NVH Toolkit



NVH Toolkit: MAC Calculator

- The MAC Calculator result object computes the Modal Assurance Criterion (MAC) between a Modal Analysis (rst file) and a test (unv file). It allows you to:
 - Mode selection and flip to order them
 - Mode pairing to identify matches
 - Node selection and position tuning of unv nodes
 - UNV model orientation (Coord. System, Rigid Body Transformation or 3 Node Alignment)
 - Cyclic Optimization specific workflow
 - Interactive MAC Table
 - Interactive side-by-side Mode Animation



NVH Toolkit: MAC Calculator – Comprehensive UI

The screenshot displays the Ansys NVH Toolkit MAC Calculator interface. The main window is titled "A : Modal - Mechanical [Ansys Mechanical Enterprise]". The top menu bar includes File, Home, Solution, Display, Selection, Automation, and NVH. The NVH tab is active, showing a toolbar with "MAC Calculator" and "Results Recovery".

On the left, the Outline pane shows a project structure with "Model (A4)" and "Modal (A5)". The "MAC Calculator" is highlighted under "Solution (A6)". Below the Outline, the "Details of 'MAC Calculator'" pane shows various options: File 1 Options (File Type: rst, File: D:\simp...), File 2 Options (File Type: unv, Units: Dataset..., File: D:\simp..., Orient By: Coordi..., Coordinate System: Coordi...), MAC Calculation Options (Node Matching Absolute Tolerance: 10 mm, Nearest Node match: No, Restrict to Nodal Named Selection: No, Degrees of Freedom: All Stru...), Mode Pairing Options (Pair Modes: No, MAC Limit: 0.9, Program...), and Optimization Options (Cyclic Optimization: No, Optimization Result: Alpha (Frequency term): 1, Objective Function (f): 0.1437).

Four main panels are visible:

- MAC Frequency Worksheet:** A table with columns "Reset Modes", "Pair Modes", "Frequency error", and "MAC". It lists modes with frequencies: 6.80 Hz, 42.49 Hz, 44.25 Hz, 119.41 Hz, 138.43 Hz, 235.14 Hz, 6.78 Hz, 42.37 Hz, 44.13 Hz, and 138.03 Hz.
- Mode Animation:** Two panels showing mode shapes. "Mode 5" has a frequency of 138.43 Hz and a maximum displacement of 5069.9 mm. "Mode 4" has a frequency of 138.03 Hz and a maximum displacement of 160.17 mm. Both panels include visualization options and a "Show/Hide Mesh" button.
- MAC Table:** A heatmap titled "Modal Assurance Criterion Modes - file.unv (Hz)". It shows a 5x5 matrix of MAC values for modes 6.8, 42.4, 44.1, 138.0, and 235.1 Hz. The color scale ranges from 0 (blue) to 1 (red).
- UNV Node Worksheet:** A table with columns "Check", "Node Number", "X (mm)", "Y (mm)", and "Z (mm)". It lists 8 nodes with their coordinates.

Annotations with orange arrows point to specific features:

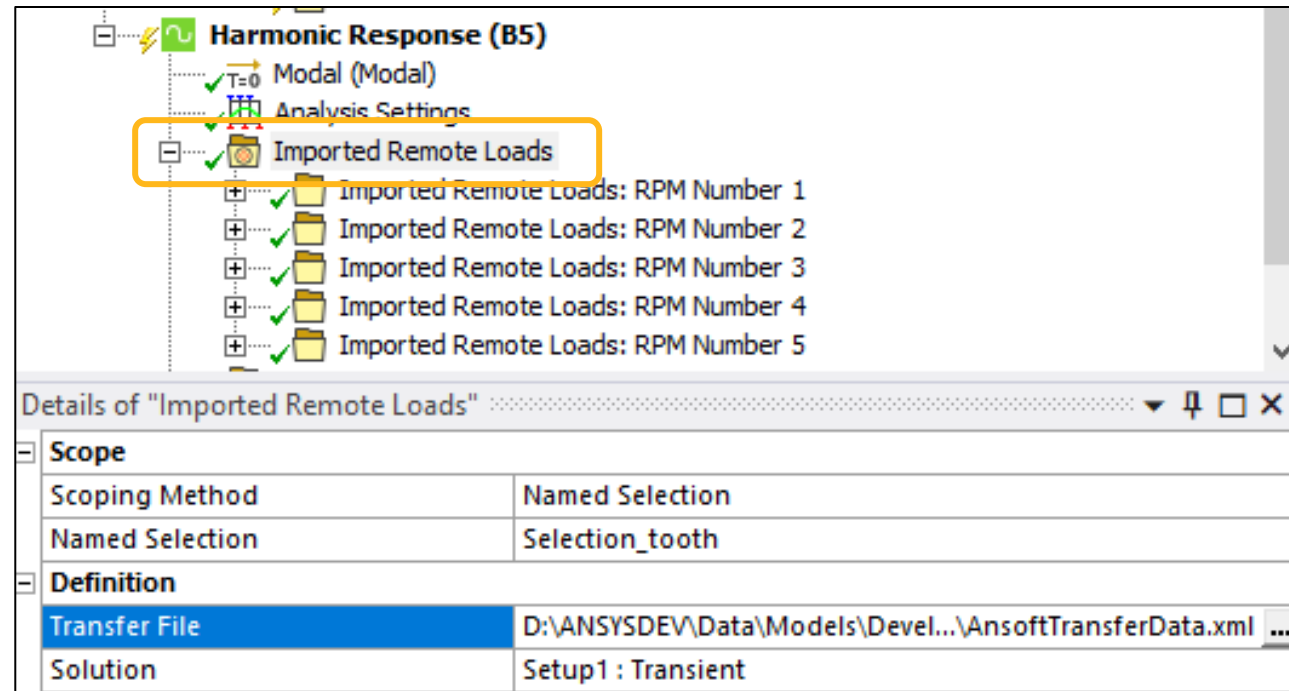
- "Frequency Worksheet" points to the MAC Frequency Worksheet panel.
- "UNV Node Worksheet" points to the UNV Node Worksheet panel.
- "Mode Animation" points to the Mode Animation panels.
- "2D MAC Table" points to the MAC Table panel.

Maxwell – Mechanical Integration



Maxwell: Mechanical Coupling

- Remote Forces / Moments can be generated from Maxwell exported file which eliminate the need of having both Maxwell and Mechanical models in the same Workbench project

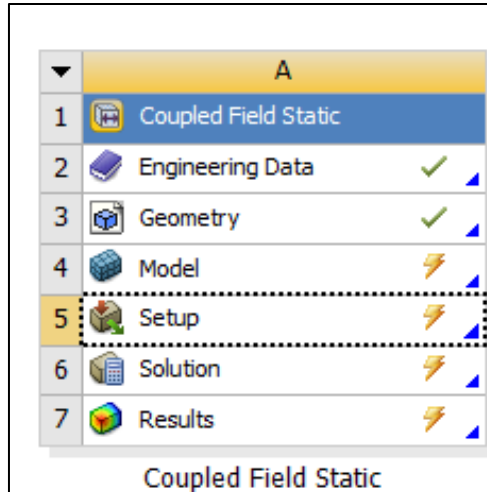


Couple Field Systems Enhancements

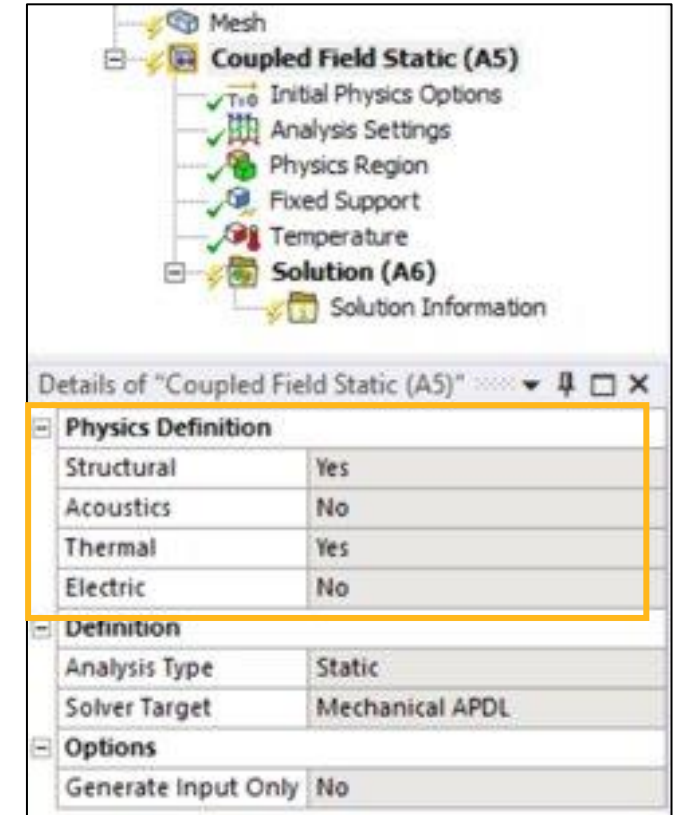


Coupled Field Static Analysis

- Piezoelectric coupling and Acoustics physics is supported for Coupled Field Static analysis

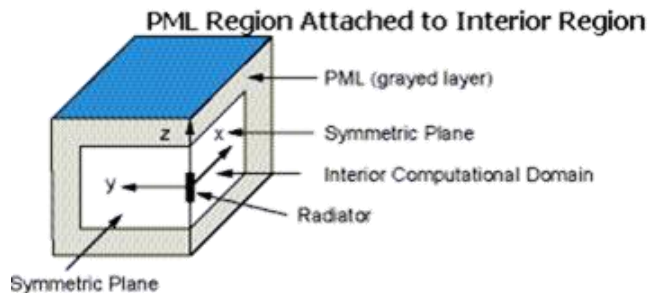


1	Property	Value
2	General	
3	Component ID	Setup
4	Directory Name	SYS
5	Update Condition Parameter (Beta)	None
6	Notes	
7	Notes	
8	Used Licenses	
9	Last Update Used Licenses	
10	System Information	
11	Physics	Multiphysics
12	Analysis	Static
13	Solver	Mechanical APDL
14	Physics	
15	Structural	☒
16	Acoustics	☐
17	Thermal	☒
18	Electric	☐



Physics Region and Analysis Settings

- PML settings are supported for respective Acoustics physics in the Physics region object
- Voltage and Charge convergence supported on Analysis settings
 - Program Controlled
 - On
 - Remove

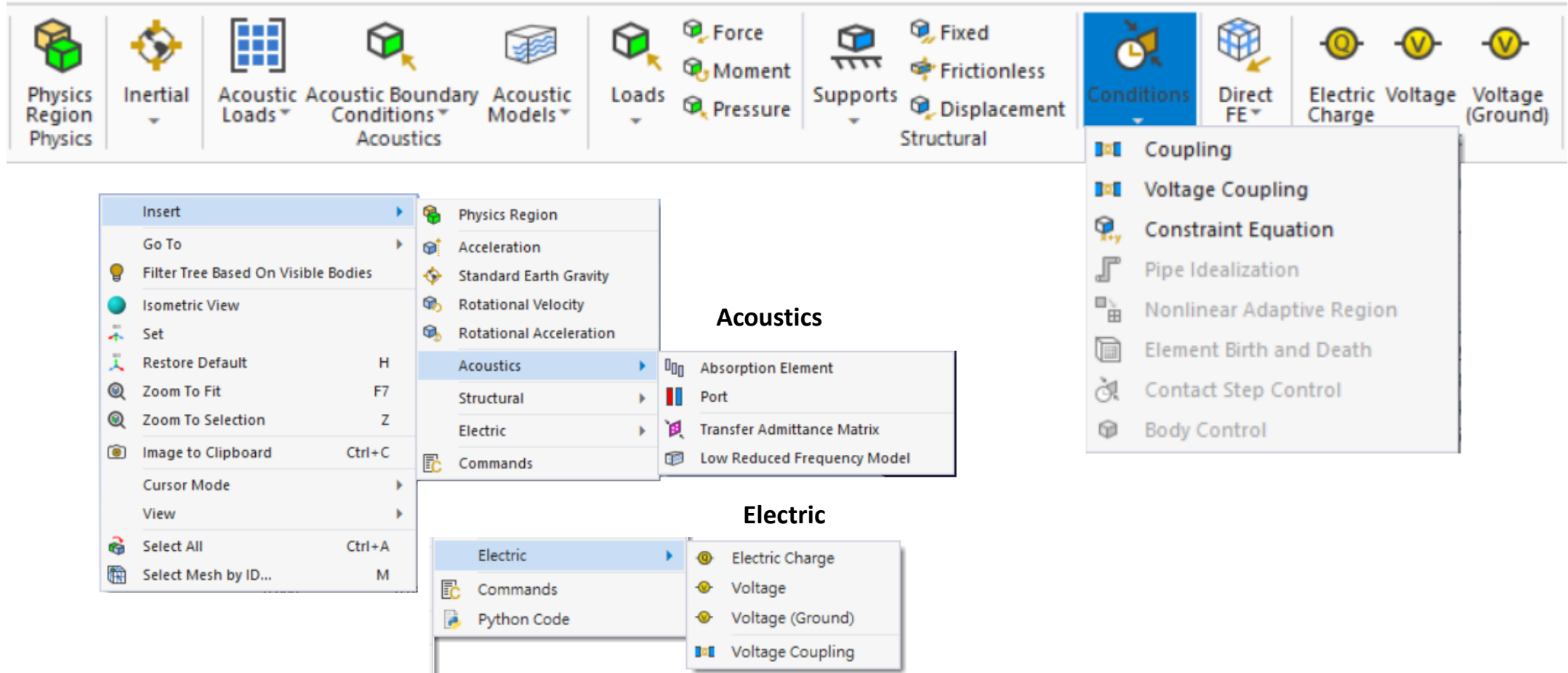


Details of "Physics Region"	
Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Structural	No
Acoustics	Yes
Thermal	No
Electric	No
Suppressed	No
Acoustic Domain Definition	
Artificially Matched Layers	Off
Element Morphing	Program Controlled
Advanced Settings	
☐ Reference Pressure	2.e-005 Pa
☐ Reference Static Pressure	1.0133e+005 Pa
Fluid Behavior	Compressible

Coupled Field Static (A5)	
Initial Physics Options	
Analysis Settings	
Physics Region	
Details of "Analysis Settings"	
Step Controls	
Solver Controls	
Restart Controls	
Nonlinear Controls	
Newton-Raphson Option	Program Controlled
Force Convergence	Program Controlled
Moment Convergence	Program Controlled
Displacement Convergence	Program Controlled
Rotation Convergence	Program Controlled
Line Search	Program Controlled
Stabilization	Program Controlled
Voltage Convergence	Program Controlled
Charge Convergence	Program Controlled
Advanced	
Output Controls	
Damping Controls	
Ignore Acoustic Damping	Yes
Analysis Data Management	

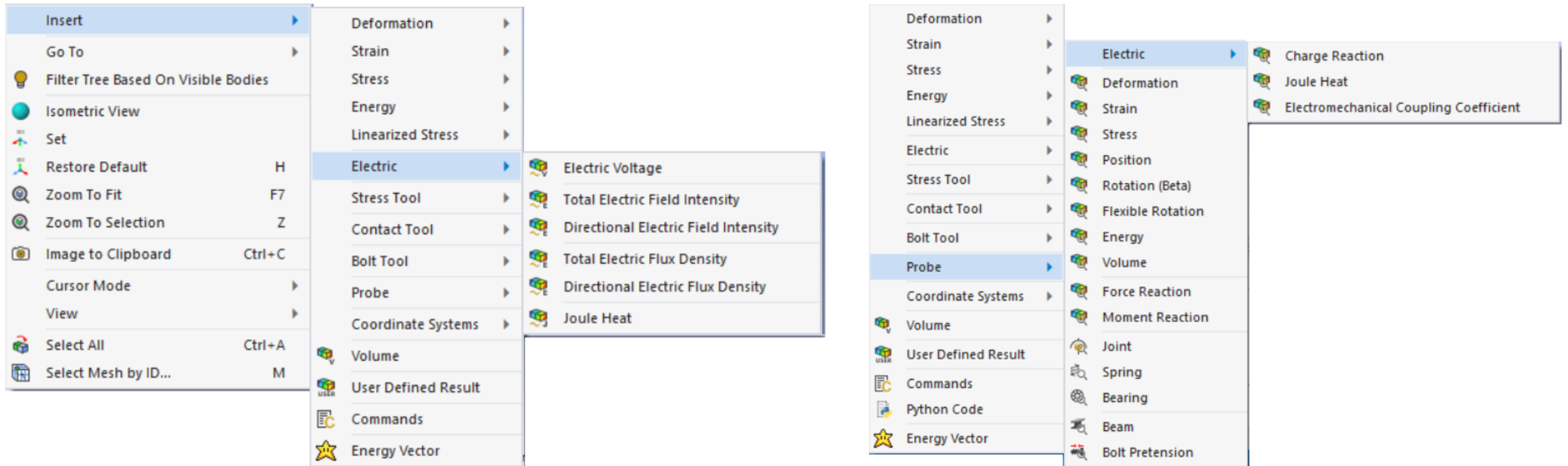
/ Boundary Conditions

- Electric and Acoustics boundary conditions are supported



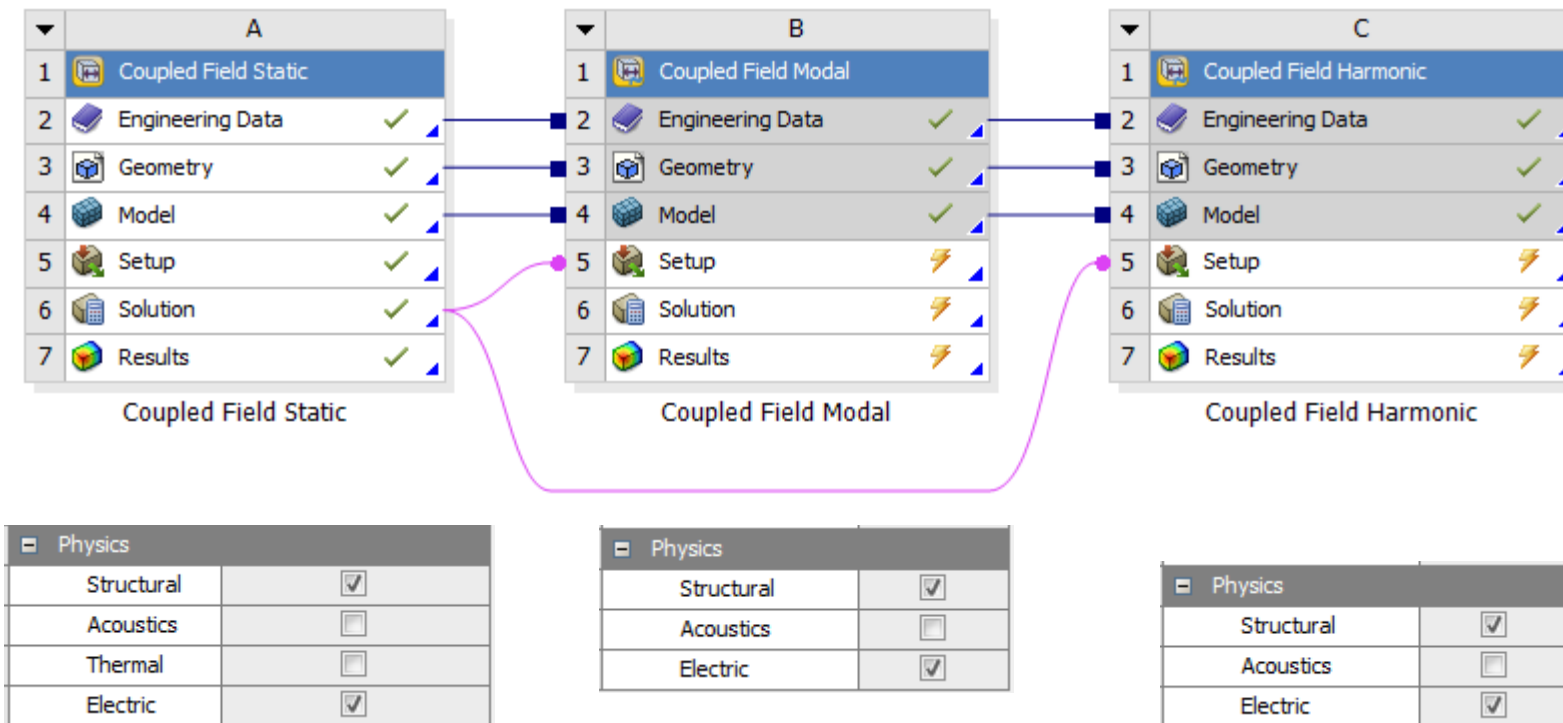
Results

- Electric results and probes are supported



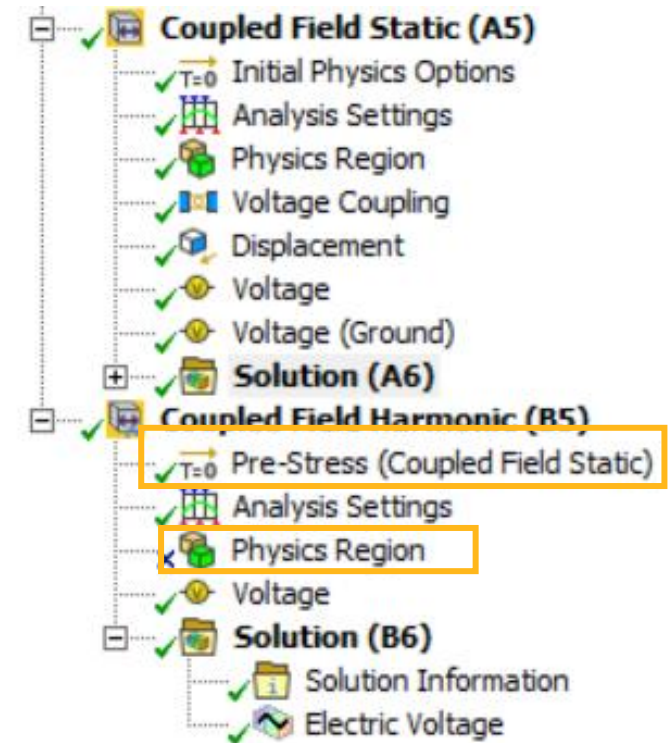
/ Pre-stress Coupled Field Analysis Enhancements

- Pre-stressed Coupled Field Modal and Pre-stress Coupled Field Harmonic (full harmonic) is supported by linking to upstream a Coupled Field Static analysis



/ Pre-stress Coupled Field Enhancements

- The physics combination which can be performed in Pre-stress Coupled Field analysis are:
 - Structural – Acoustics
 - Structural – Electric with Piezoelectric coupling
 - Acoustics with Piezoelectric coupling
- Physics region specified in the upstream coupled field static analysis will be automatically selected on downstream linked environment.
- Thermal physics selection in the coupled field static analysis will not support pre-stress workflow
- Linking on Coupled Field Modal and Harmonic can be done by selecting the pre-stress environment on the Initial conditions

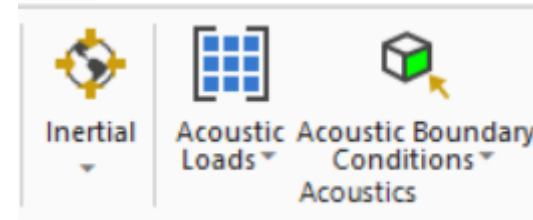


Boundary Conditions and Results for Pre-Stressed Analysis

Pre-stressed Coupled Field analysis supports these boundary conditions

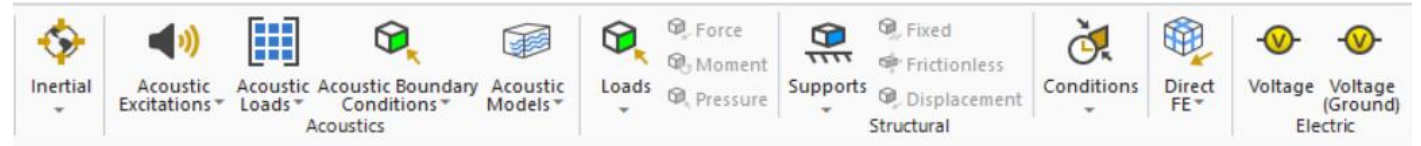
Pre-stress Coupled Field Modal

- Acoustic Boundary conditions



Pre-stress Coupled Field Harmonic

- Inertial Load, FE Loads
- Acoustic Boundary conditions
- Electric: Voltage and Voltage Coupling

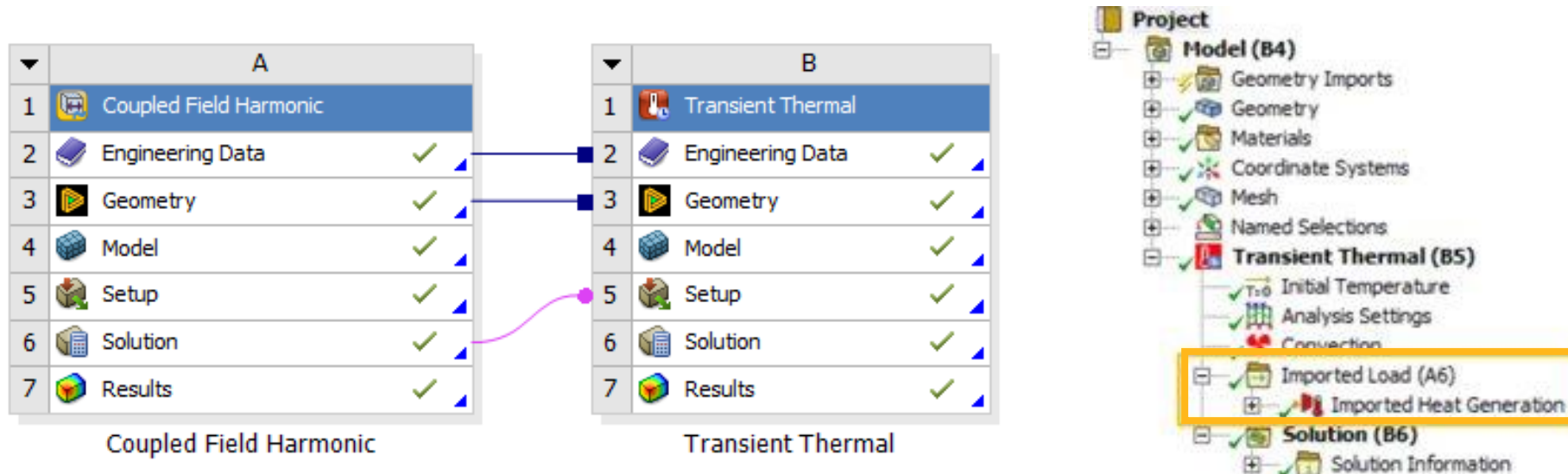


Results: All results supported for standalone analysis is applicable for pre-stress case



Imported Heat Generation Load from Coupled Field Harmonic

- Loss due to damping in the upstream Coupled Field Harmonic analysis can be imported as Heat Generation load in Transient Thermal analysis by linking the solution cell of Coupled Field Harmonic to setup of Transient Thermal analysis
- The losses are only considered from the coupled structural-electric bodies with Piezoelectric coupling and is applicable for dissimilar meshes. The source frequencies is split over equal time intervals in the transient thermal analysis when All option is selected from Worksheet of Imported Heat generation object



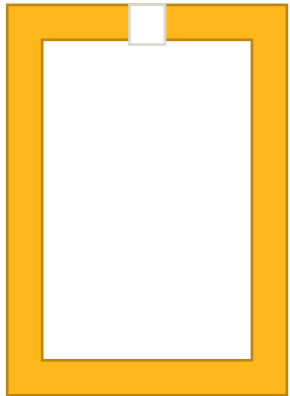


Acoustics Enhancements

Ansys

/ PML for Modal Acoustics [2022R1]

- Modal Acoustics PML
 - Resonance in a cavity with small apertures

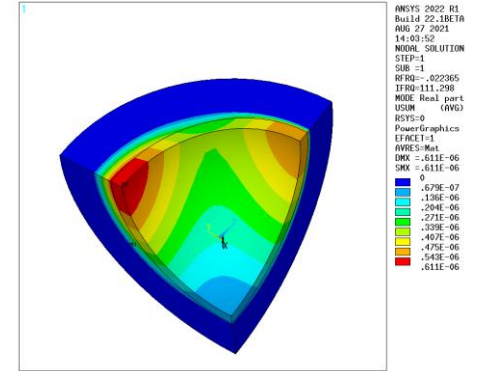
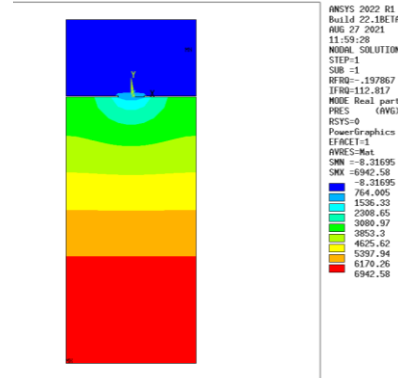


Eigen frequencies in ideal case

SET	TIME/FREQ	LOAD	STEP	
1	300.00	1	1	1
2	600.02	1	2	2
3	612.28	1	3	3
4	681.82	1	4	4
5	857.27	1	5	5

Eigen frequencies with PML

SET	TIME/FREQ	LOAD	STEP	
1	0.19787	1	1	1
2	<u>112.82</u>	1	1	1
3	0.19787	1	2	2
4	-112.82	1	2	2
5	0.93757E-01	1	3	3
6	<u>361.26</u>	1	3	3
7	0.93757E-01	1	4	4
8	-361.26	1	4	4
9	0.48481E-03	1	5	5
10	<u>614.58</u>	1	5	5

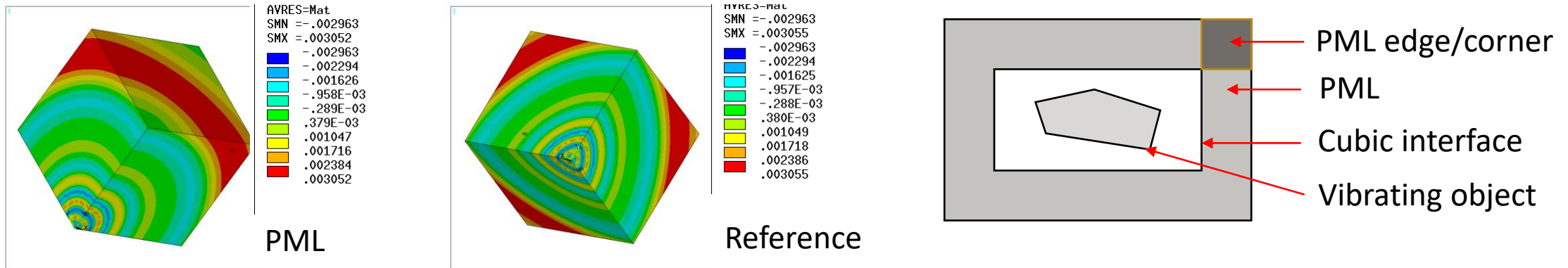


Eigen frequencies of shell+FSI+PML

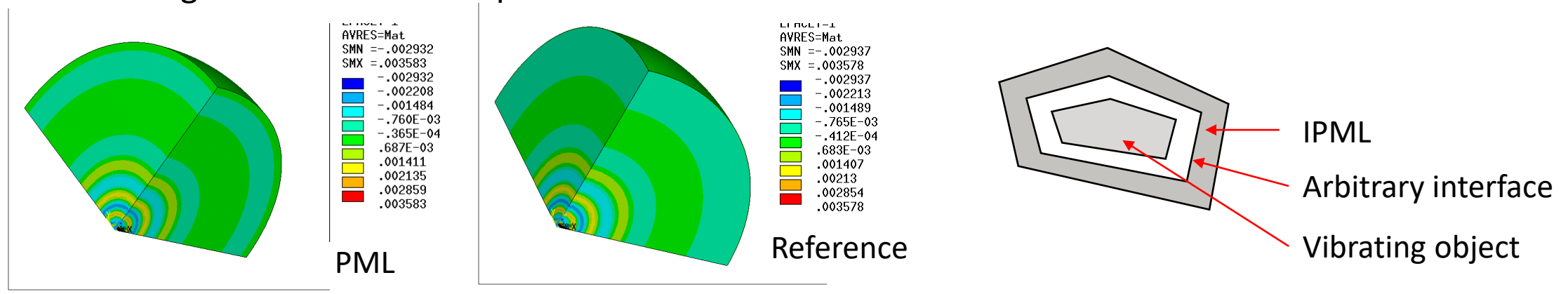
SET	TIME/FREQ	LOAD		
1	0.22365E-01	1	1	1
2	<u>111.30</u>	1	1	1
3	0.22365E-01	1	2	2
4	-111.30	1	2	2
5	0.23790E-01	1	3	3
6	<u>111.30</u>	1	3	3

PML for Transient Acoustics [2022R1]

- PML/IPML in transient - Truncate FEM domain with **P**erfectly **M**atched **L**ayers (PML) for outgoing waves
 - 3D rectangular PML for high absorption rate

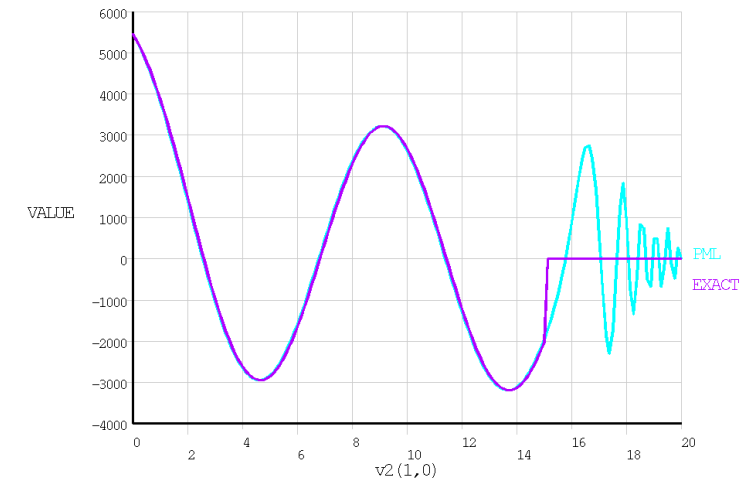
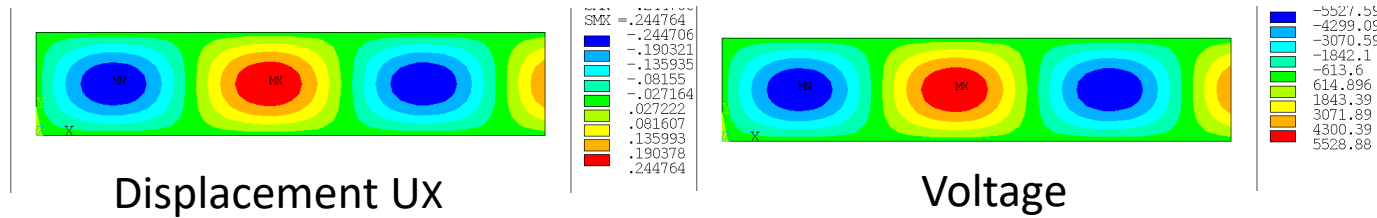


- 3D Irregular PML for better performance with fewer elements



/ PML for 2D piezoelectric elements in harmonic [2022R1]

- Piezoelectric waveguide



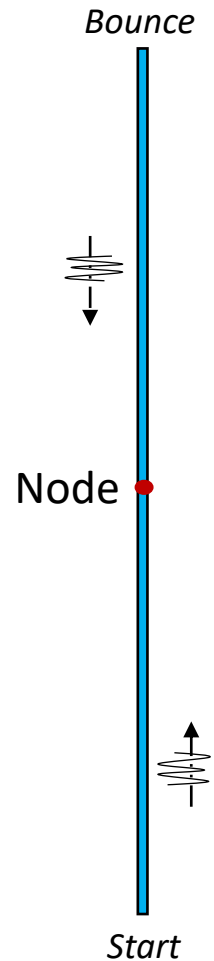
Ansys LS-Dyna Acoustics Enhancements



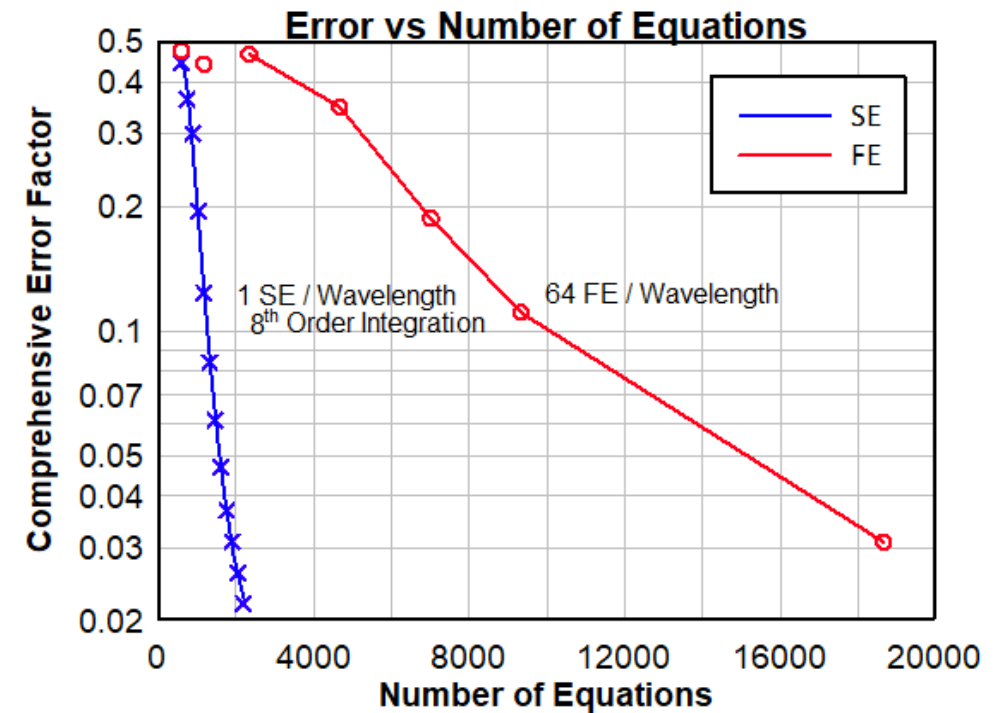
/ Acoustic Spectral Element Method (SEM)

- It is a sub-parametric FE
- The shape functions for the geometry are of a lower order than the interpolation functions for the element pressure
- The interpolation functions for the pressure employ Legendre polynomials of orders 2→15
- Element integration is with a Gauss-Lobatto-Legendre rule. Element dof are at those integration points.

*CONTROL_ACOUSTIC_SPECTRAL



Transient 1D Wave Propagation
(propagation of a 50KHz “chirp” in a
1m long column of air)



/ Acoustic spectral element method – application 1

Acoustic SE is capable of high accuracy with manageable resource requirements, and so is well suited to high frequency and ultrasonic applications where the wavelengths are often short relative to the dimensions of interest:

- Ultrasonic sensors
 - Autonomous driving / parking
 - Fingerprint recognition



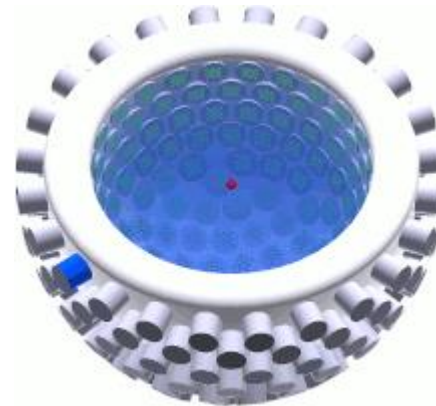
/ Acoustic spectral element method – application 2

- Medical imaging

USCT - Ultrasound Computer Tomography

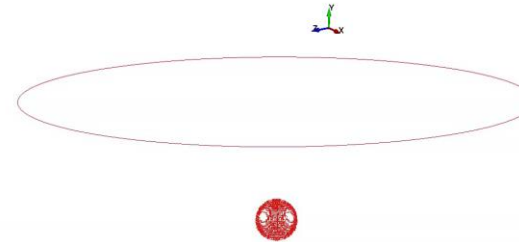
- Tissue in water
- Ultrasonic pulse from one transducer
- Scattered signal measured on all others
- Each transducer takes a turn

200 KHz pressure pulse

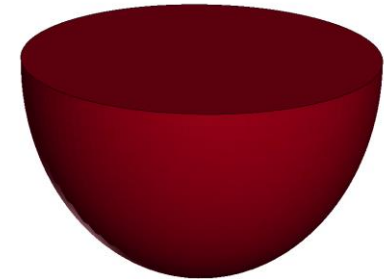


6,048,000 N=5 SE hexahedra
757,442,101 equations
Solution for 200 μ s (57,967 steps)
11 hrs 26 min wall time (112 cores)

USCT 200KHz Model
Time = 0
Isosurfaces of Pressure
min=0, at elem# 1
max=0, at elem# 1

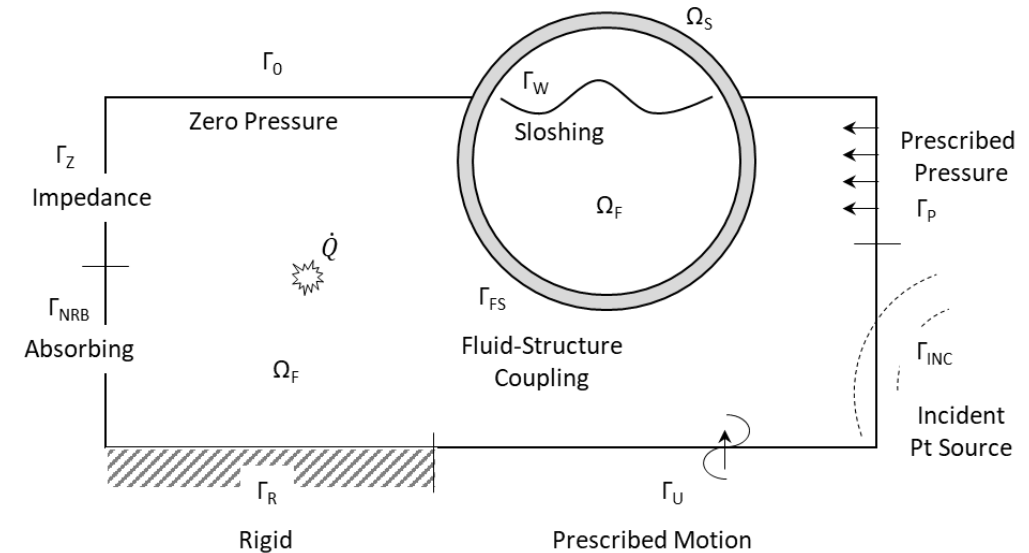


Pressure
1.200e+01
9.800e+00
7.600e+00
5.400e+00
3.200e+00
1.000e+00
-1.200e+00
-3.400e+00
-5.600e+00
-7.800e+00
-1.000e+01



/ New boundary / load conditions for acoustic analysis

Feature	Keyword
Structural Coupling - Γ_{FS}	*boundary_acoustic_coupling_mismatch *boundary_acoustic_coupling_spectral
Weak Structural Coupling - Γ_{FS}	*interface_acoustic *boundary_acoustic_interface
Prescribed Boundary Motion - Γ_U	*boundary_acoustic_prescribed_motion
Prescribed Boundary Pressure - Γ_P	*boundary_acoustic_pressure_spectral
Rigid Boundary - Γ_R	This is a natural condition
Impedance Boundary - Γ_Z	*boundary_acoustic_impedance *boundary_acoustic_impedance_complex *boundary_acoustic_impedance_mechanical
Absorbing Boundary - Γ_{NRB}	*boundary_acoustic_non_reflecting
Zero Pressure Boundary - Γ_0	*boundary_acoustic_free_surface
Linear Wave Boundary - Γ_W	*boundary_acoustic_free_surface
Internal Point Source - Q	*load_acoustic_source
Incident Wave Point Source - P_{inc}	*load_acoustic_source



New acoustic material models

*MAT_ACOUSTIC_COMPLEX

Complex, frequency-dependent density and bulk modulus

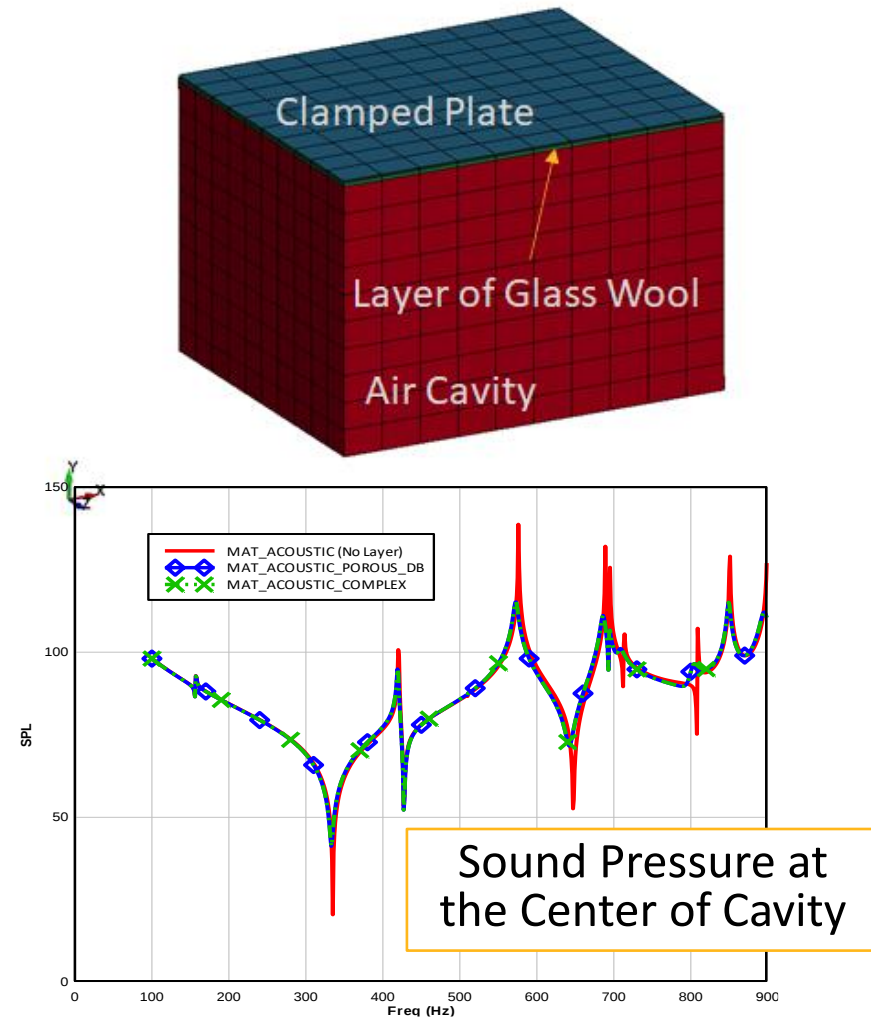
*MAT_ACOUSTIC_DAMP

Fluid damping defined by volumetric drag coefficient for direct steady state vibration analysis, or viscous damping defined for explicit transient acoustic analysis

*MAT_ACOUSTIC_POROUS_DB

Regression model for porous acoustic media of Delany-Bazley and the coefficients of Allard-Champoux

J.-F. DEU FIGURE 3 WITH SOUND SOURCE, POROUS D-B LAYER



SSD with multiple load cases

*FREQUENCY_DOMAIN_SSD_SUBCASE

*DATABASE_FREQUENCY_..._SUBCASE

Benefits:

- Save extra keyword input reading
- Save extra initialization
- Save extra MPP decomposition
- Other savings

```

*FREQUENCY_DOMAIN_SSD SUBCASE
$#  mdmin  mdmax  fnmin  fnmax  restmd  restdp  lcflag  relatv
$#      1    100    0.    2000.    0        0
$#  dampf  lcdam  lctyp  dmpmas  dmpstf
$#    0.01
$#                                     nout  notyp  nova

$#  caseid  title                                     nload
case1      The first loading case
$#      nid  ntyp  dof  vad  lc1  lc2  lc3  vid
subcase 1 → 131    0    3    0    100  200    lc3  2
             180    0    3    0    101  201
$#  caseid  title                                     nload
case2      The second loading case
$#      nid  ntyp  dof  vad  lc1  lc2  lc3  vid
subcase 2 → 200    0    3    0    101  201
$#  caseid  title                                     nload
case3      The third loading case
$#      nid  ntyp  dof  vad  lc1  lc2  lc3  vid
subcase 3 → 258    0    3    0    102  202

*DATABASE_FREQUENCY_ASCII NODOUT_SSD_SUBCASE
$#      fmin  fmax  nfreq  fspace  lcfreq
subcase 1 → 10.   140.   14
subcase 2 → 10.   140.   131
subcase 3 → 10.   140.   261

*DATABASE_FREQUENCY_ASCII ELOUT_SSD_SUBCASE
$#      fmin  fmax  nfreq  fspace  lcfreq
subcase 1 → 10.   140.   14
subcase 2 → 10.   140.   131
subcase 3 → 10.   140.   261

*DATABASE_FREQUENCY_BINARY D3SSD SUBCASE
$#  binary
$#      1
subcase 1 → $#      fmin  fmax  nfreq  fspace  lcfreq
subcase 2 → 10.   140.   14
subcase 3 → 10.   140.   131
    
```



Thank you for your attention