Ansys Mechanical 進階應用_新技術線上研討會

虎門科技技術團隊

黃國豐

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子模型分析
Substructuring

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What is Substructuring?

$$[\hat{M}]\{\ddot{\hat{u}}\}+[\hat{C}]\{\dot{\hat{u}}\}+[\hat{K}]\{\hat{u}\}=\{\hat{F}\}$$

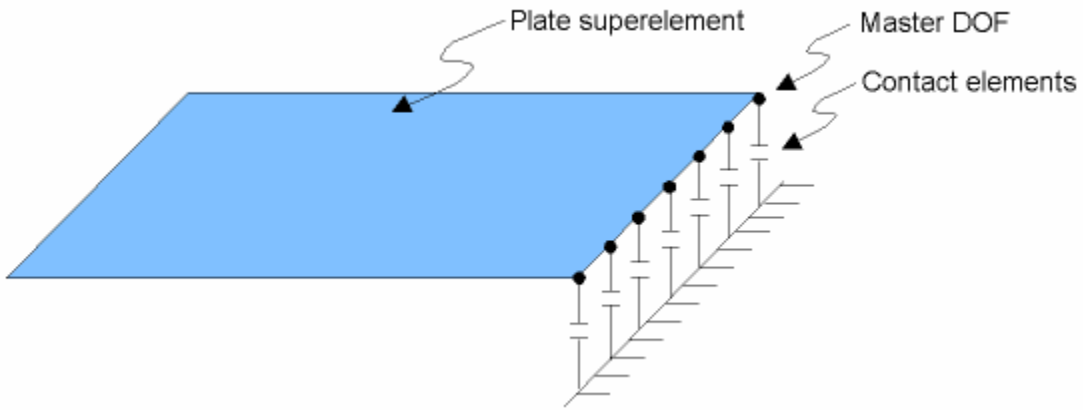
where:

$[\hat{K}]=[T]^T[K][T]$ = reduced stiffness matrix

$[\hat{M}]=[T]^T[M][T]$ = reduced mass matrix

$[\hat{C}]=[T]^T[C][T]$ = reduced damping matrix

$\{\hat{F}\}=[T]^T\{F\}$ = reduced load vector



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Why Substructuring?

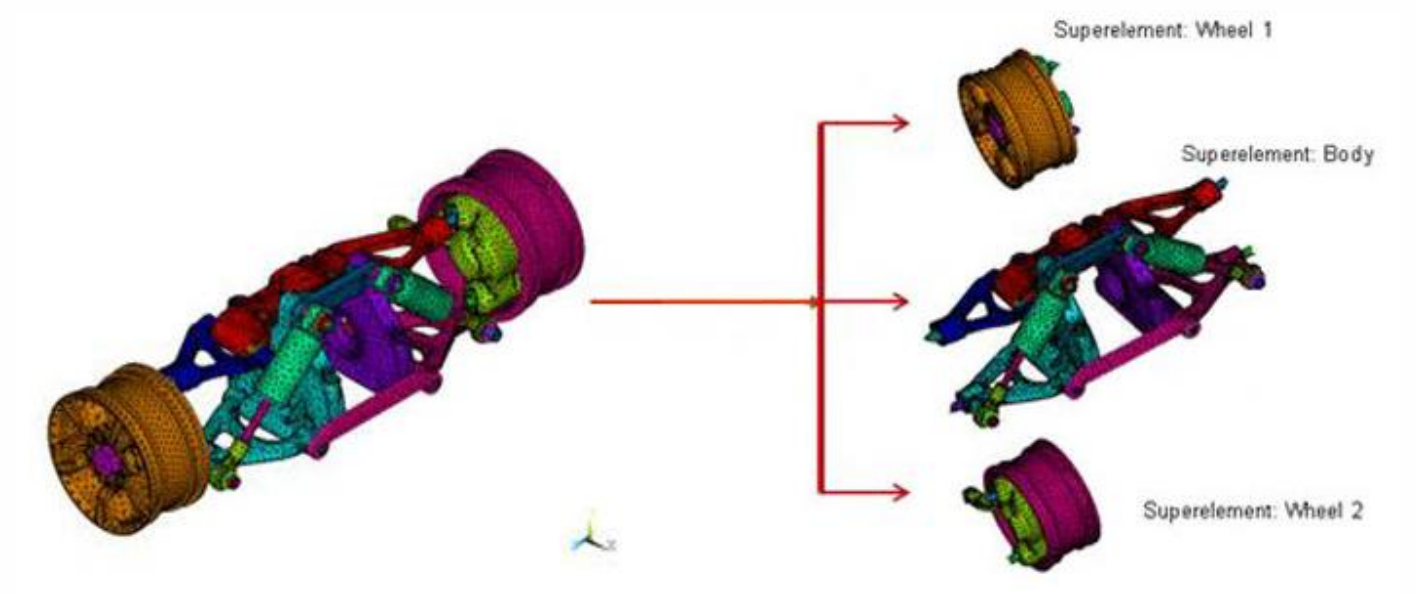

Table 2: Comparison of CPU and Elapsed Times for Modal Analysis

Number of Modes = 100	Full Model	CMS Fixed Interface	
CPU Time (s)	2034.280	Gen Pass	2022.670
		Use Pass	4.630
Elapsed Time (s)	1291.000	Gen Pass	1336.000
		Use Pass	3.000

Table 22.4: Comparison of CPU and Elapsed Times for Harmonic Analysis

Number of Modes = 20	Full Model	CMS Fixed Interface	
CPU Time (s)	13580.800	Gen Pass	2022.670
		Use Pass	1758.800
Elapsed Time (s)	7866.000	Gen Pass	1336.000
		Use Pass	1764.000

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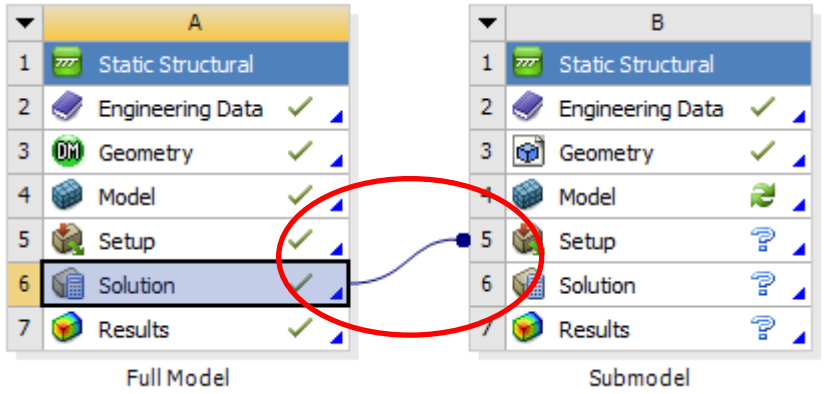
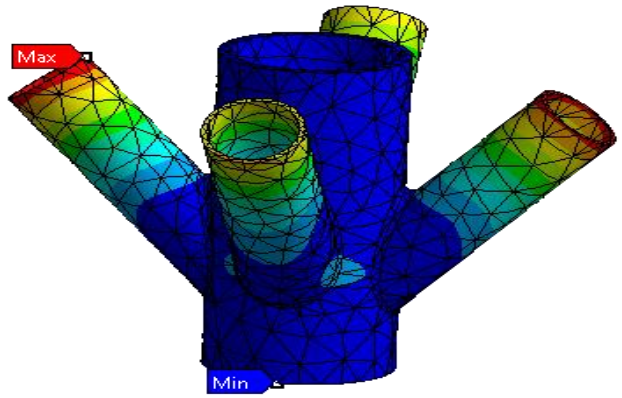
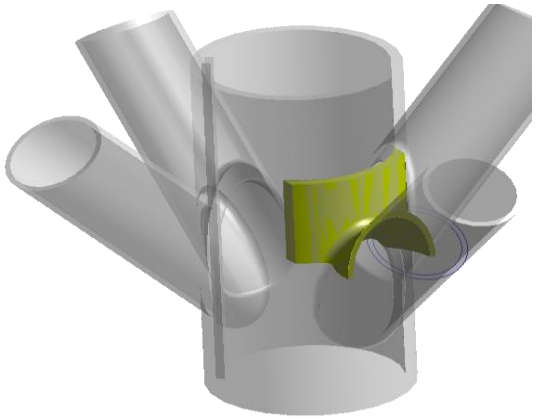
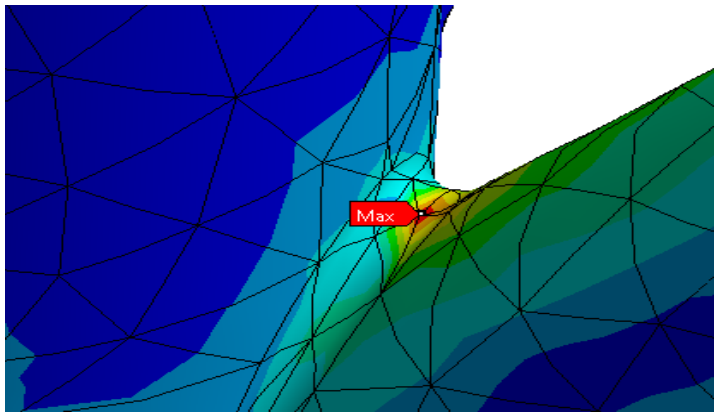
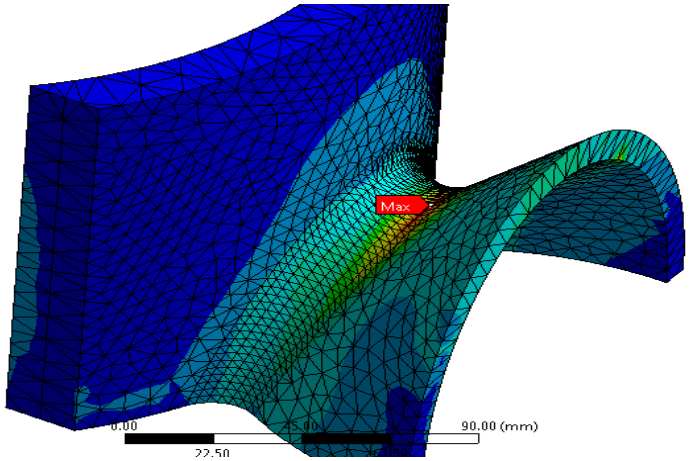
Submodeling











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Two methods of doing this

- **Substructuring analysis (Guyan reduction):** Static reduction which reduces the system matrices to a smaller set of nodal DOFs. Substructuring analysis applies to structural and non-structural analysis types. For structural analysis, this condensation method is also called Guyan reduction

- **Component mode synthesis (CMS):** reduces the system matrices to a smaller set of nodal DOFs complemented by a set of generalized coordinates. CMS applies to structural analysis only. CMS is more accurate than the Guyan reduction for modal, harmonic, and transient analyses because CMS includes truncated sets of normal mode generalized coordinates, which capture the basic modal characteristics of the components.

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Supported Analysis Types

- Harmonic Response (MSUP only)
- Modal
- Random Vibration
- Response Spectrum
- Rigid Dynamics

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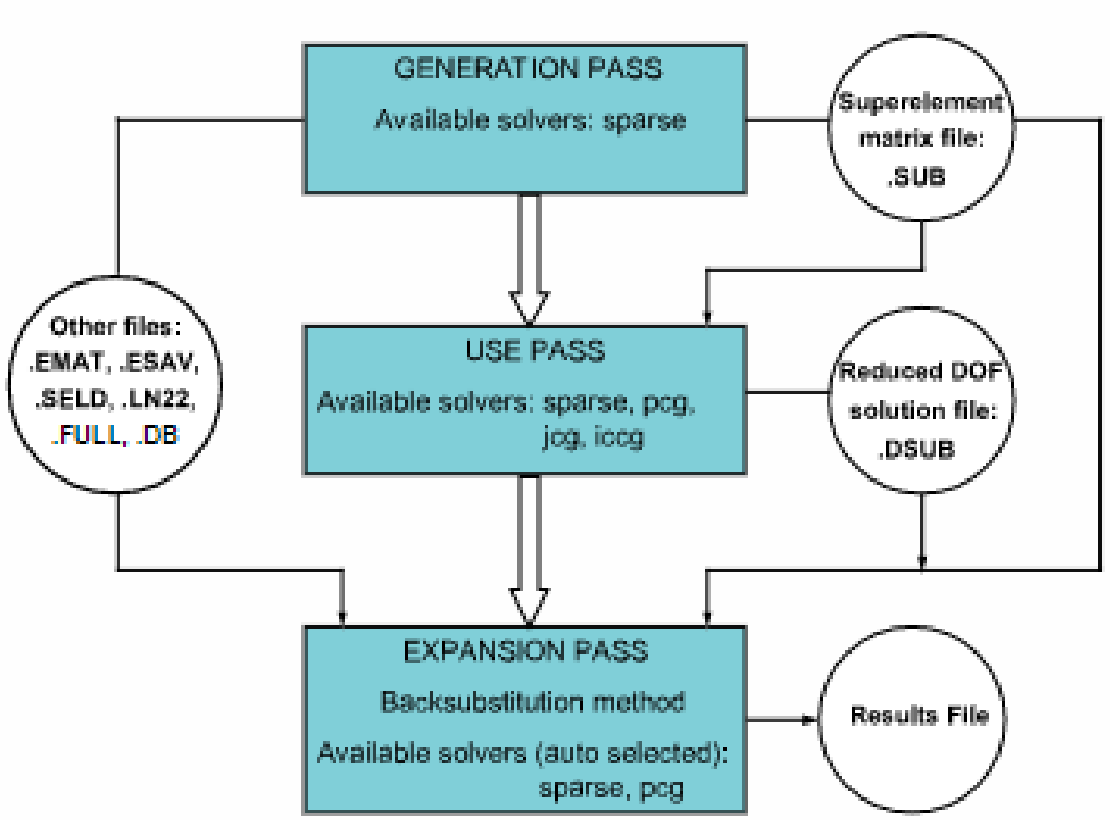
How to proceed substructuring?



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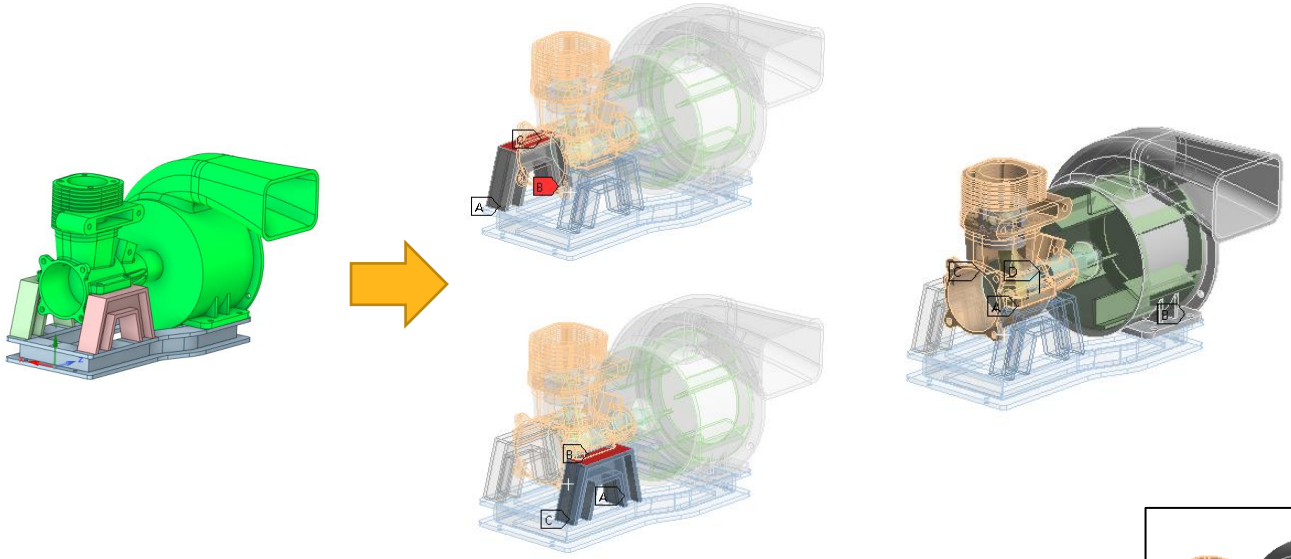
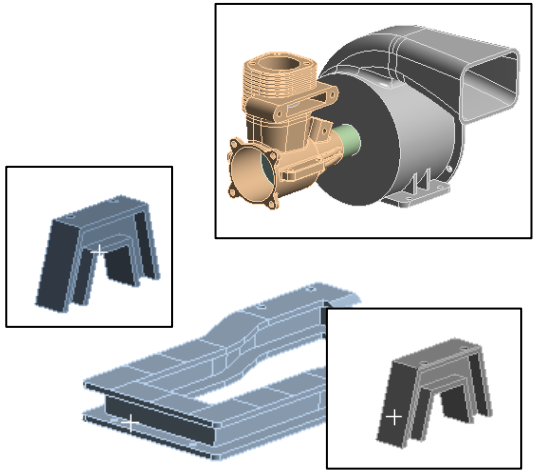
How to proceed substructuring?

- Top-down Substructuring:



- Bottom-up Substructuring:



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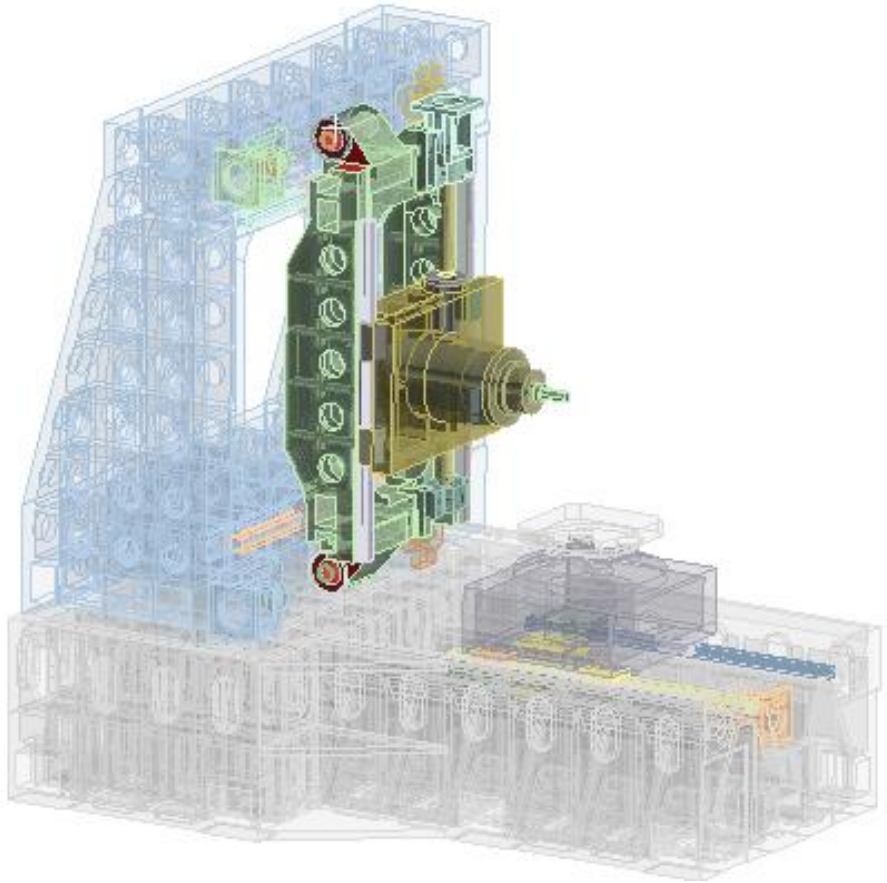
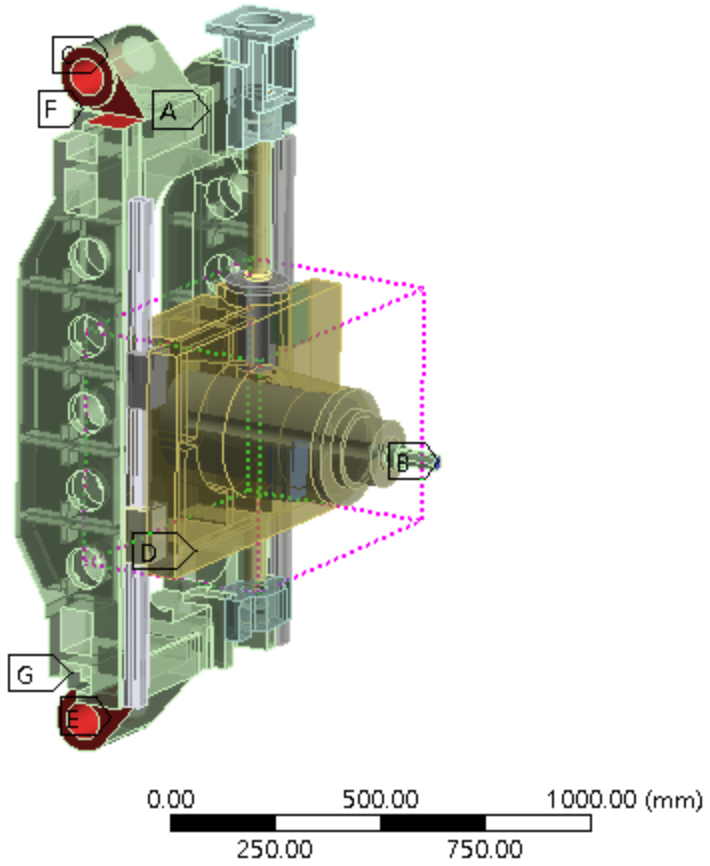
Condensed part



Condensed Part 3
2021/6/3 下午 03:56

- A Contact Region 4
- B Input_Tip_Ux
- C Contact Region 16
- D Contact Region 2
- E Contact Region 15
- F Contact Region 3
- G Contact Region



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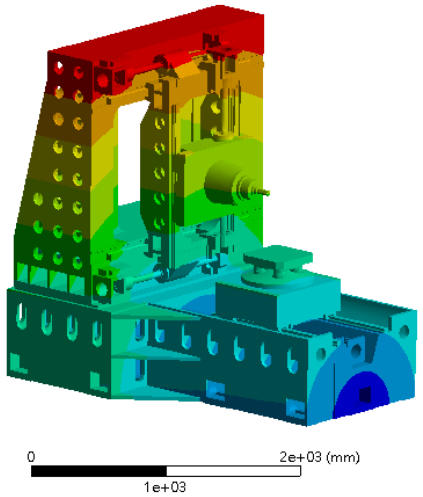
Comparison

B: Modal
Total Deformation
Type: Total Deformation
Frequency: 7.5986 Hz
Unit: mm
2021/6/3 下午 04:39

0.61577 Max
0.54749
0.47921
0.41094
0.34266
0.27438
0.2061
0.13782
0.069546
0.0012682 Min



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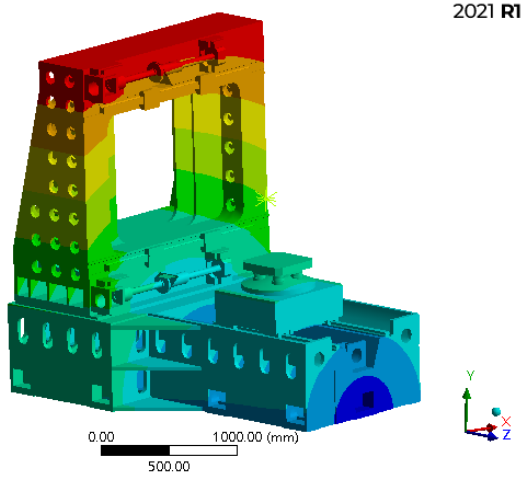
2021 R1

C: Copy of Modal
Total Deformation
Type: Total Deformation
Frequency: 7.5458 Hz
Unit: mm
2021/6/3 下午 04:44

0.61577 Max
0.54749
0.47922
0.41094
0.34266
0.27438
0.2061
0.13782
0.069546
0.0012673 Min



ANSYS
2021 R1

Tabular Data

	Mode	Frequency [Hz]
1	1.	7.5986
2	2.	8.893
3	3.	10.848
4	4.	87.421
5	5.	105.43
6	6.	113.15

Full model

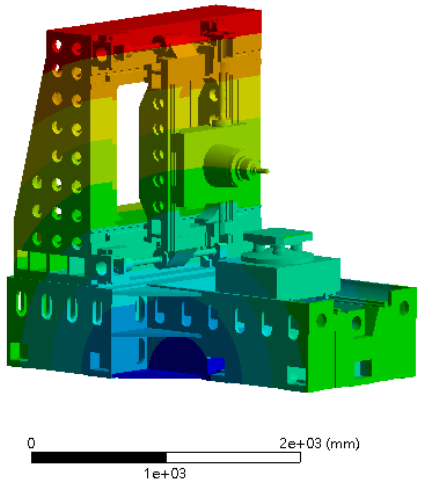
Tabular Data

	Mode	Frequency [Hz]
1	1.	7.5458
2	2.	8.8401
3	3.	10.844
4	4.	87.239
5	5.	105.33
6	6.	113.66

Bottom up CMS

B: Modal
Total Deformation 2
Type: Total Deformation
Frequency: 8.893 Hz
Unit: mm
2021/6/3 下午 04:40

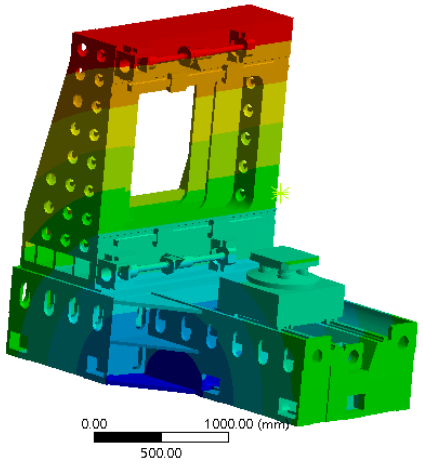
0.563 Max
0.5006
0.43821
0.37581
0.31342
0.25103
0.18863
0.12624
0.063843
0.0014491 Min



ANSYS
2021 R1

C: Copy of Modal
Total Deformation 2
Type: Total Deformation
Frequency: 8.8401 Hz
Unit: mm
2021/6/3 下午 04:44

0.56388 Max
0.50137
0.43885
0.37634
0.31383
0.25132
0.18881
0.1263
0.063788
0.0012766 Min



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2021 R1

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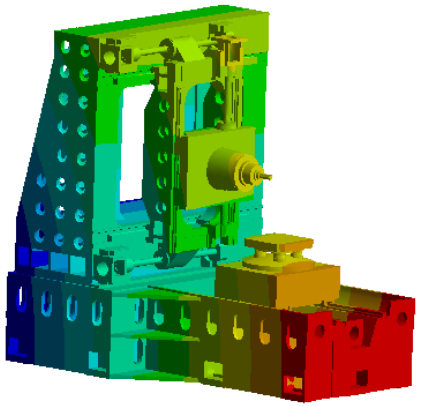
B: Modal
Total Deformation 3
Type: Total Deformation
Frequency: 10.848 Hz
Unit: mm
2021/6/3 下午 04:40

0.38489 Max
0.36478
0.34467
0.32457
0.30446
0.28435
0.26424
0.24414
0.22403
0.20392 Min



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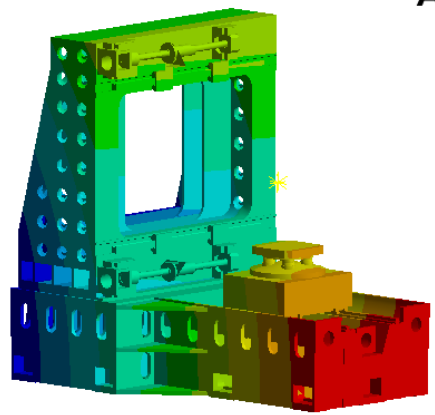
2021 R1

0 2e+03 (mm)
1e+03

C: Copy of Modal
Total Deformation 3
Type: Total Deformation
Frequency: 10.844 Hz
Unit: mm
2021/6/3 下午 04:45

0.38281 Max
0.36318
0.34356
0.32393
0.30431
0.28468
0.26506
0.24543
0.22581
0.20618 Min



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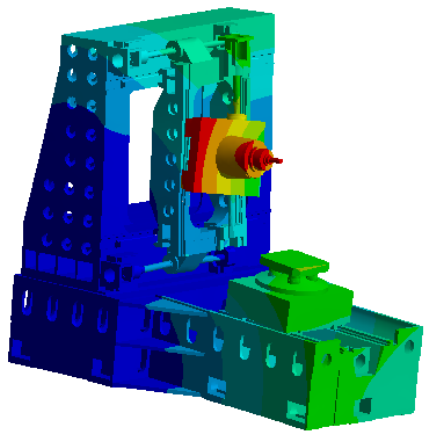
2021 R1

0.00 1000.00 (mm)
500.00

B: Modal
Total Deformation 4
Type: Total Deformation
Frequency: 87.421 Hz
Unit: mm
2021/6/3 下午 04:41

1.1056 Max
0.98286
0.86007
0.73728
0.61449
0.4917
0.36891
0.24612
0.12333
0.00053674 Min

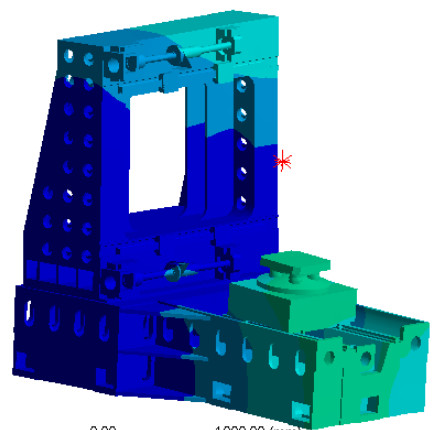


ANSYS
2021 R1

0 2e+03 (mm)
1e+03

C: Copy of Modal
Total Deformation 4
Type: Total Deformation
Frequency: 87.239 Hz
Unit: mm
2021/6/3 下午 04:45

1.2276 Max
1.0913
0.9549
0.81854
0.68218
0.54582
0.40946
0.2731
0.13674
0.00037834 Min



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2021 R1

0.00 1000.00 (mm)
500.00

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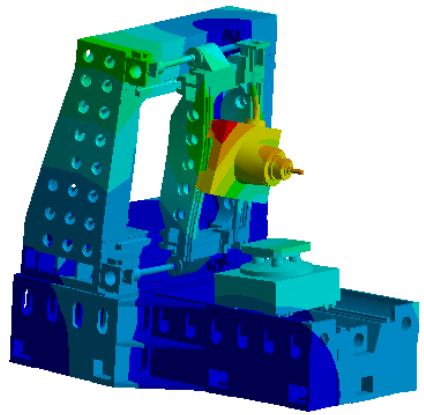
B: Modal
Total Deformation 5
Type: Total Deformation
Frequency: 105.43 Hz
Unit: mm
2021/6/3 下午 04:41

1.3883 Max
1.2342
1.0801
0.92601
0.77192
0.61783
0.46373
0.30964
0.15554
0.0014509 Min



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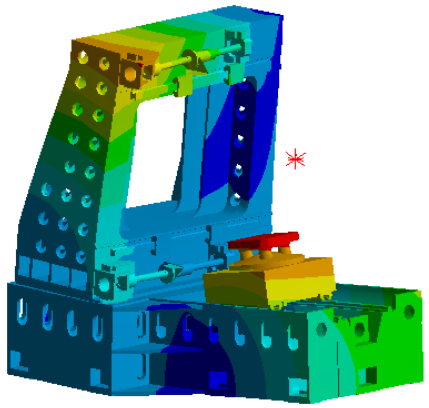
2021 R1

0 2e+03 (mm)

C: Copy of Modal
Total Deformation 5
Type: Total Deformation
Frequency: 105.33 Hz
Unit: mm
2021/6/3 下午 04:45

0.76542 Max
0.68072
0.59601
0.51131
0.42661
0.34191
0.25721
0.17251
0.087813
0.0031127 Min



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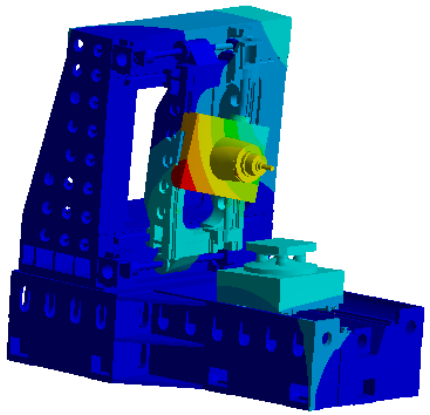
2021 R1

0.00 1000.00 (mm)

B: Modal
Total Deformation 6
Type: Total Deformation
Frequency: 113.15 Hz
Unit: mm
2021/6/3 下午 04:41

1.6819 Max
1.4952
1.3085
1.1218
0.9351
0.7484
0.5617
0.375
0.1883
0.001596 Min



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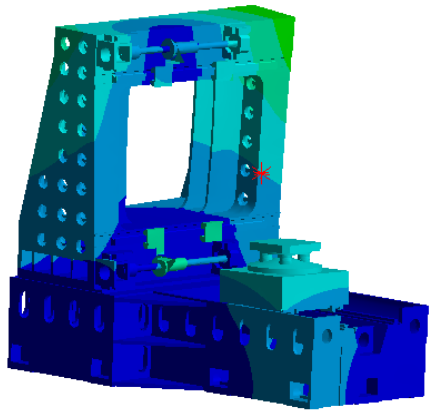
2021 R1

0 2e+03 (mm)
1e+03

C: Copy of Modal
Total Deformation 6
Type: Total Deformation
Frequency: 113.66 Hz
Unit: mm
2021/6/3 下午 04:46

1.1813 Max
1.0502
0.91901
0.78785
0.65669
0.52553
0.39437
0.2632
0.13204
0.00088365 Min



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0.00 1000.00 (mm)
500.00

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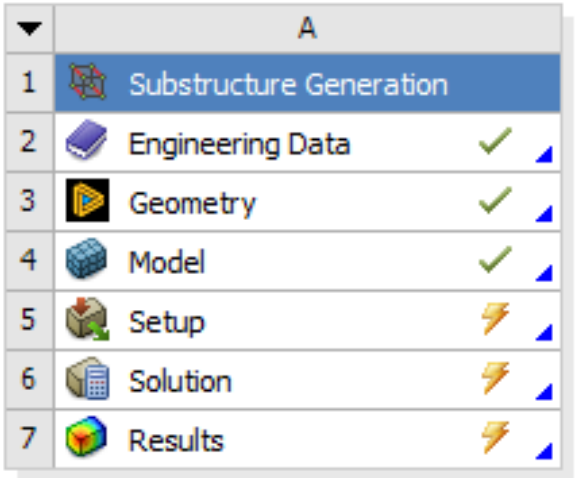
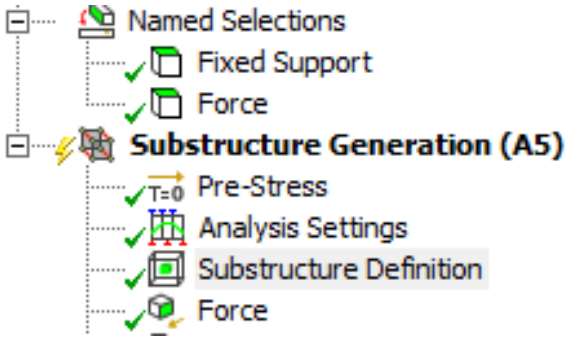
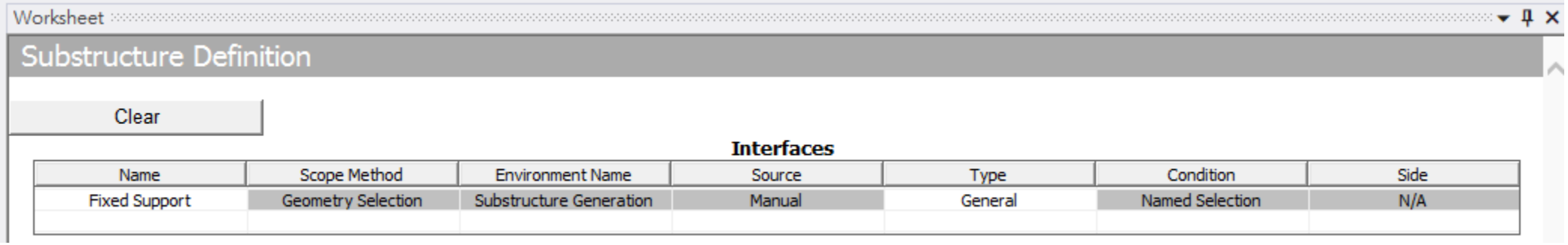
Substructure Generation



Substructure Generation





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Coupled Field Static Analysis

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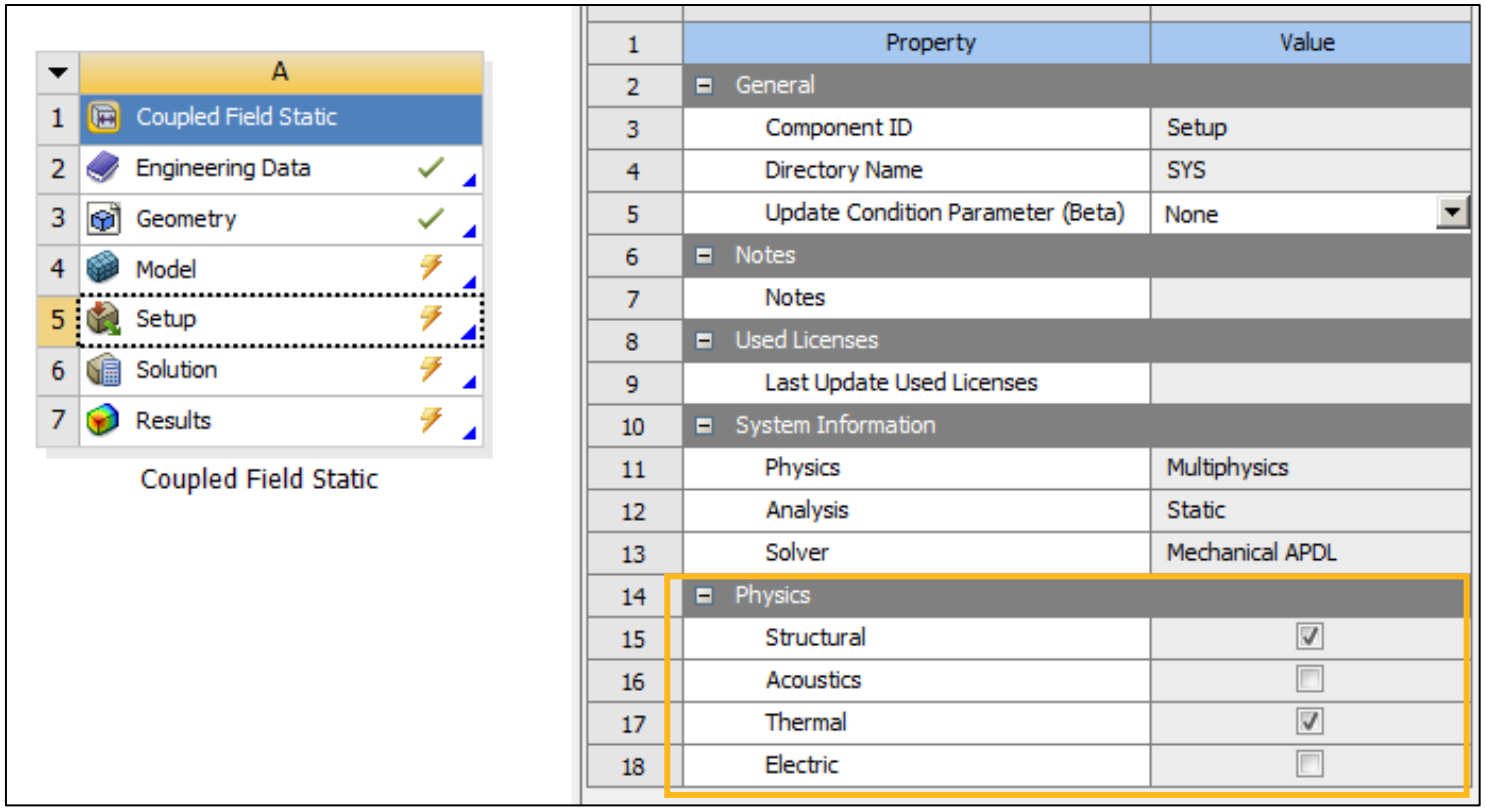
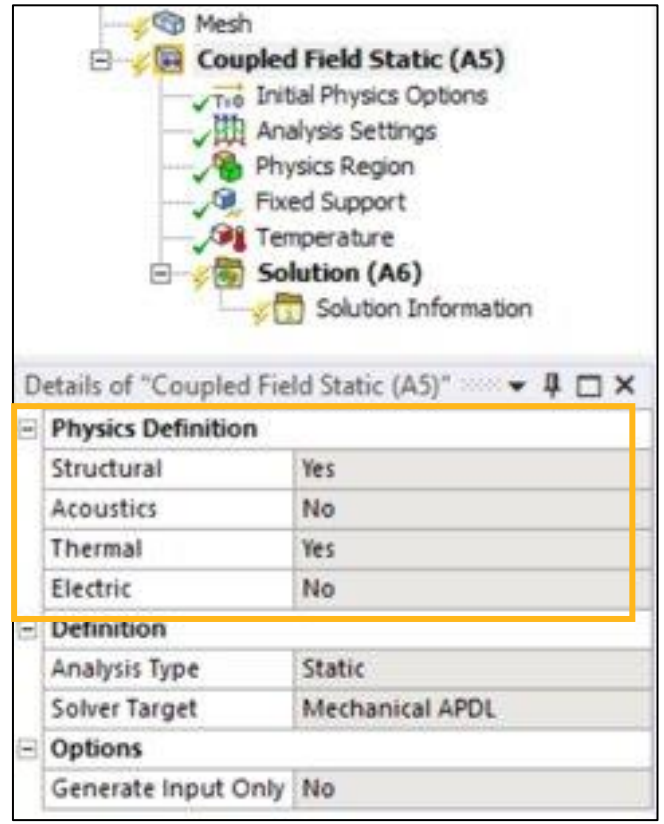
Coupled Field Static Analysis

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





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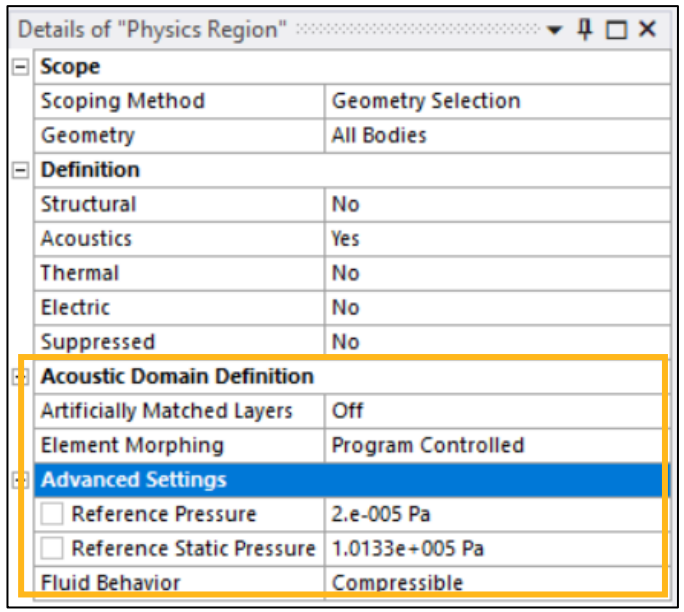
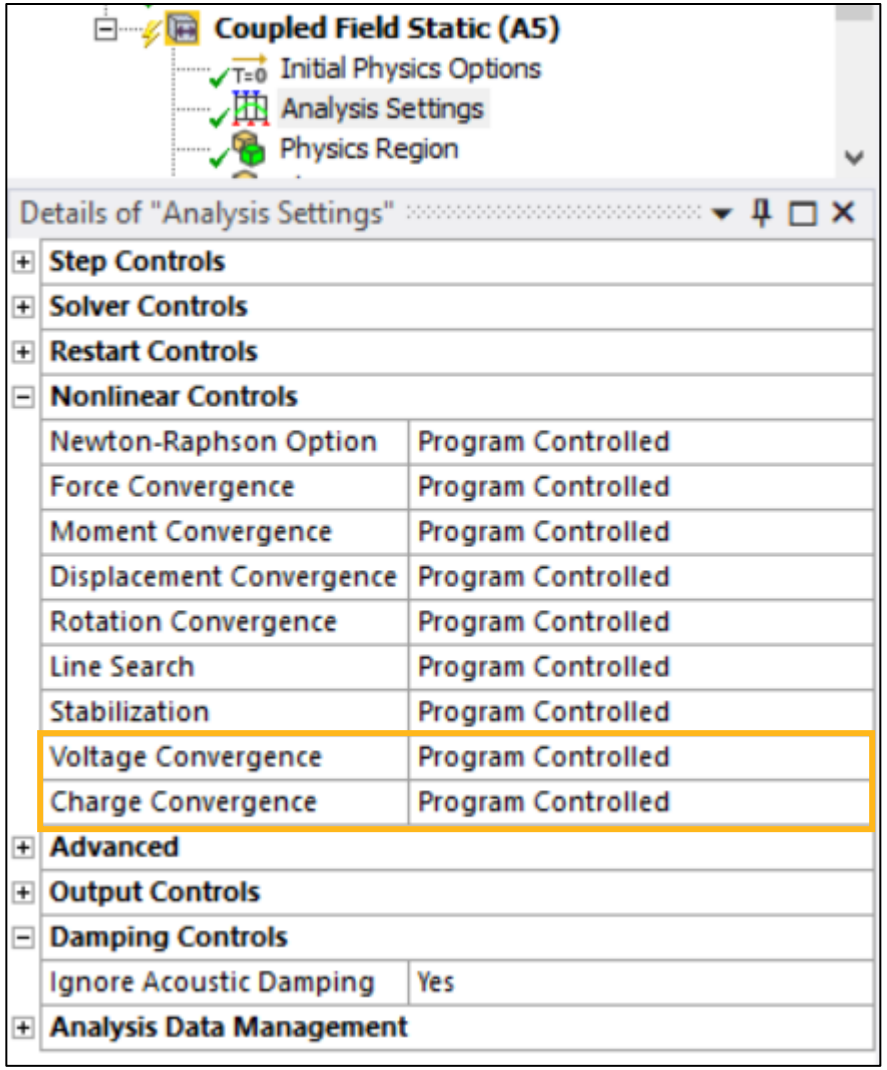
Physics Region and Analysis Settings

- 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





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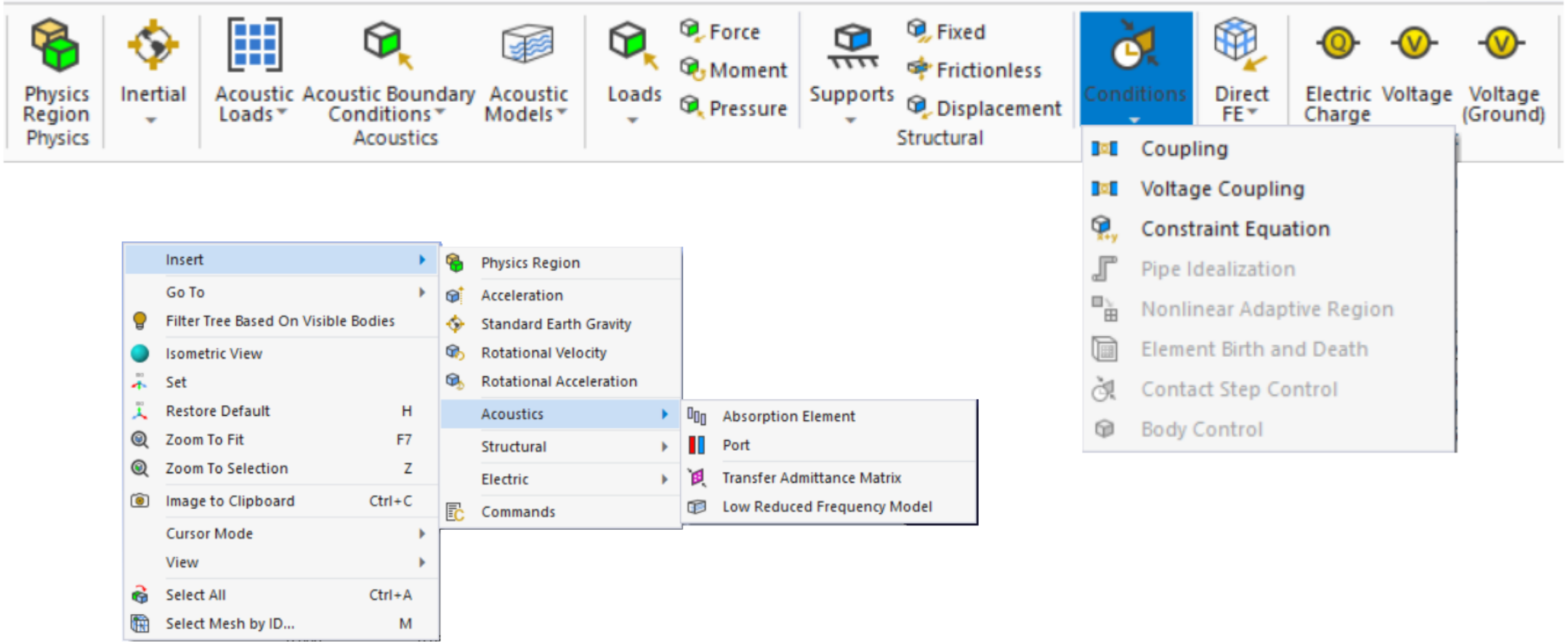
Boundary Conditions

- Electric and Acoustics boundary conditions are supported



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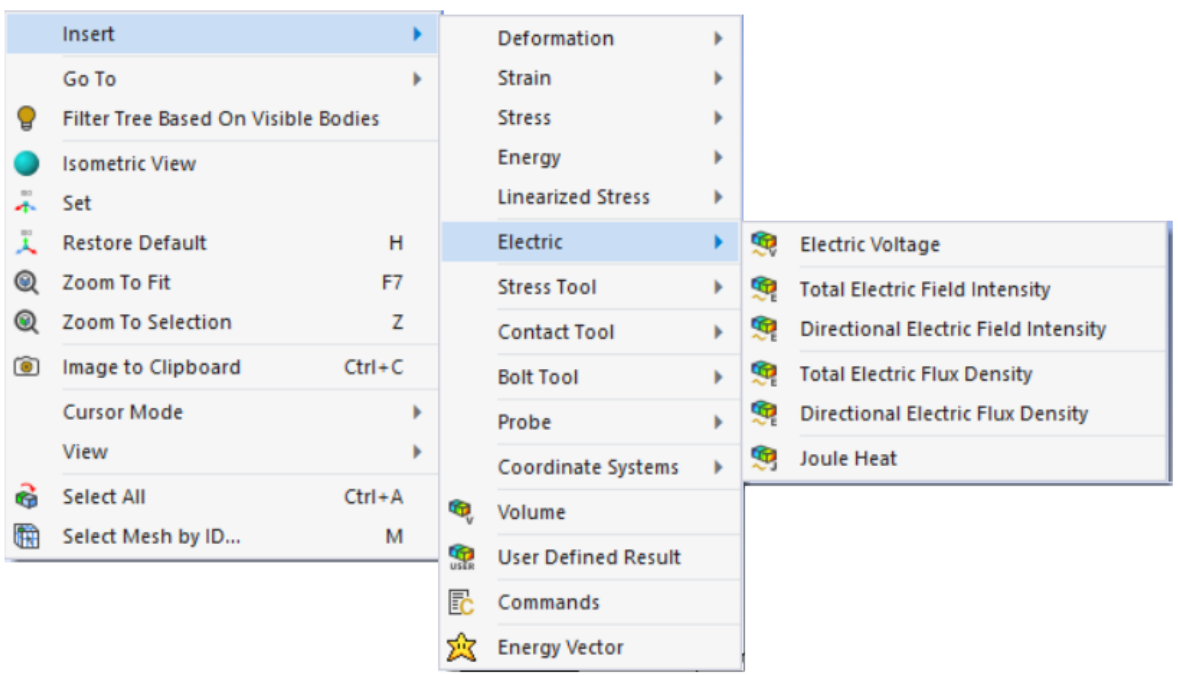
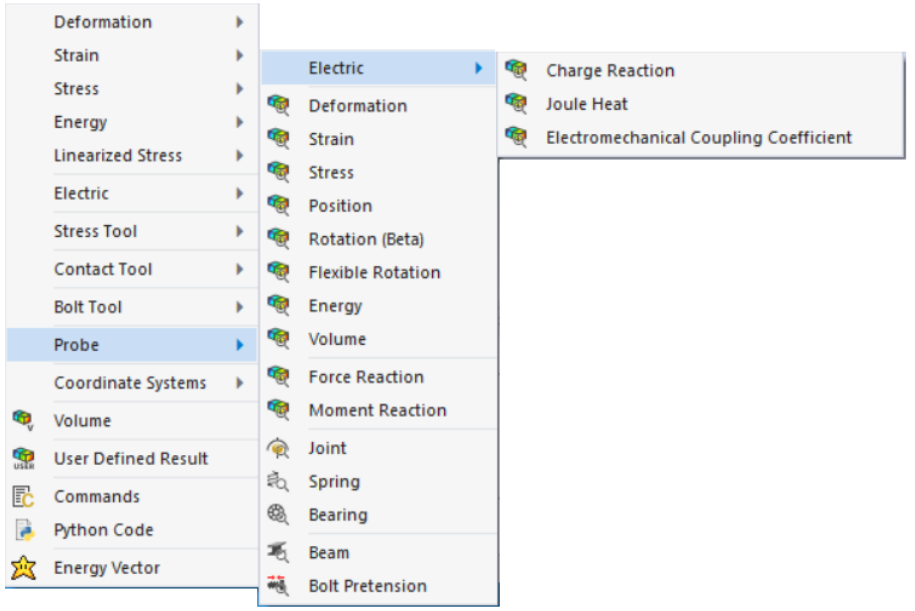
Results

- Electric results and probes are supported





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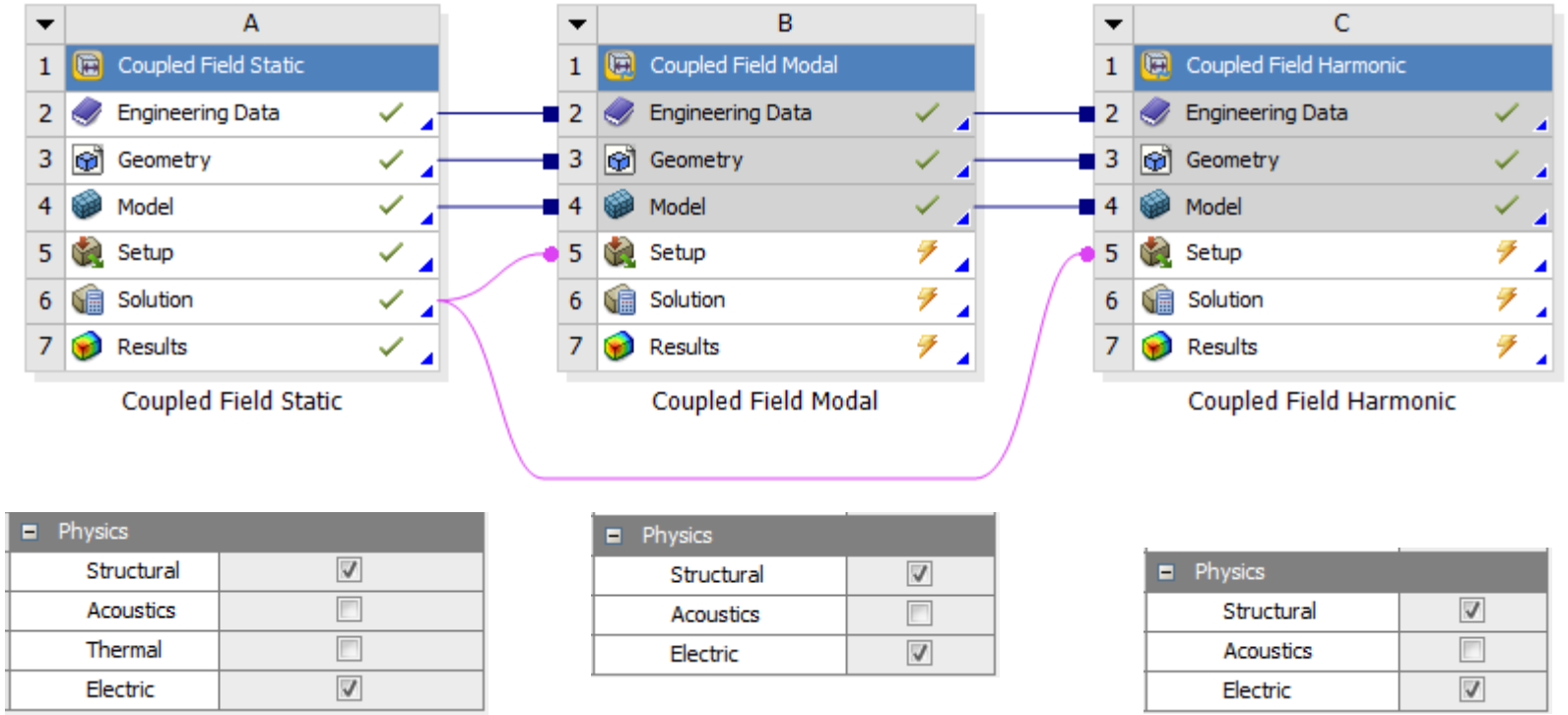
Pre-stress Coupled Field Analysis Enhancements

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



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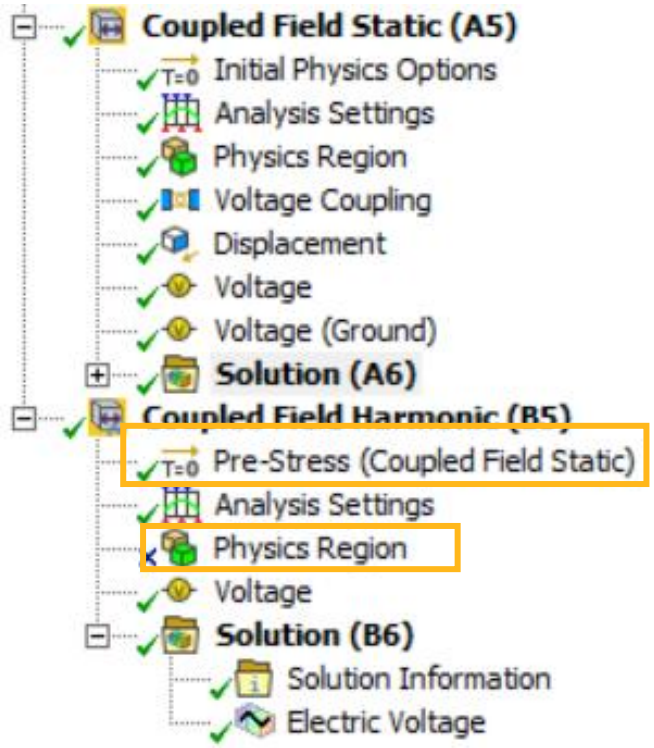
Pre-stress Coupled Field Enhancements

- The physics combination which can be performed in Pres-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



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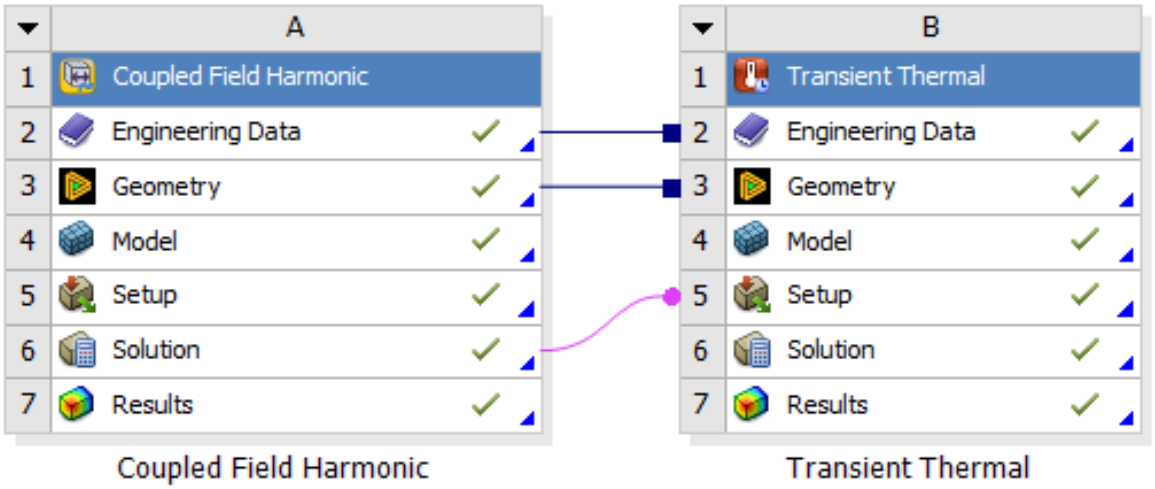
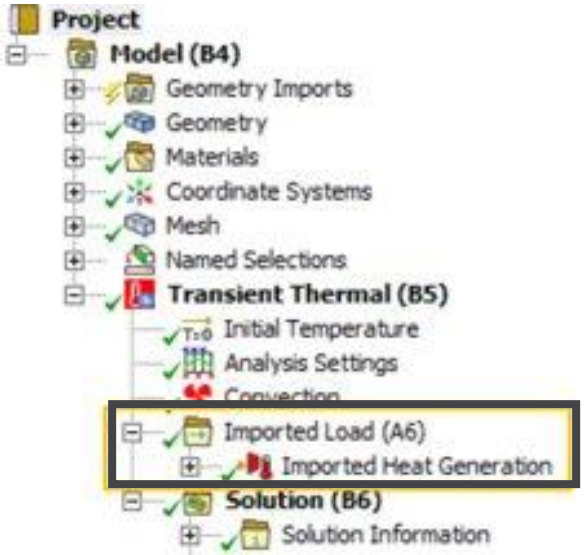
Imported Heat Generation Load from Coupled Field Harmonic

- 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





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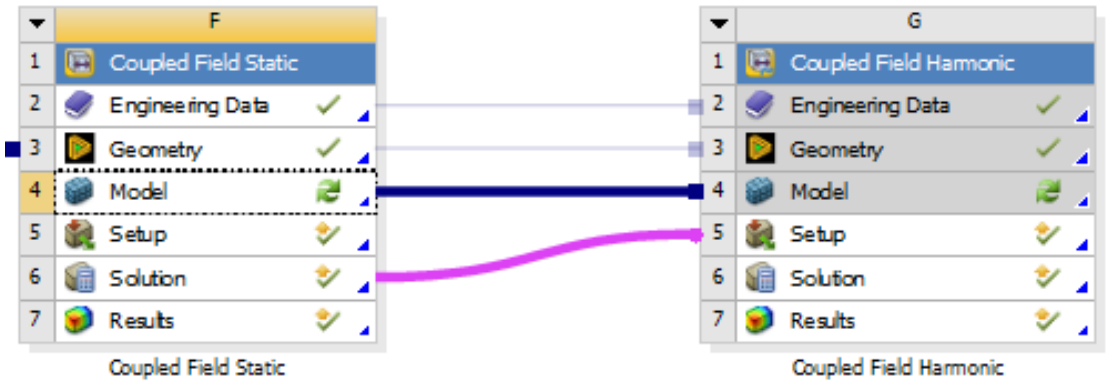
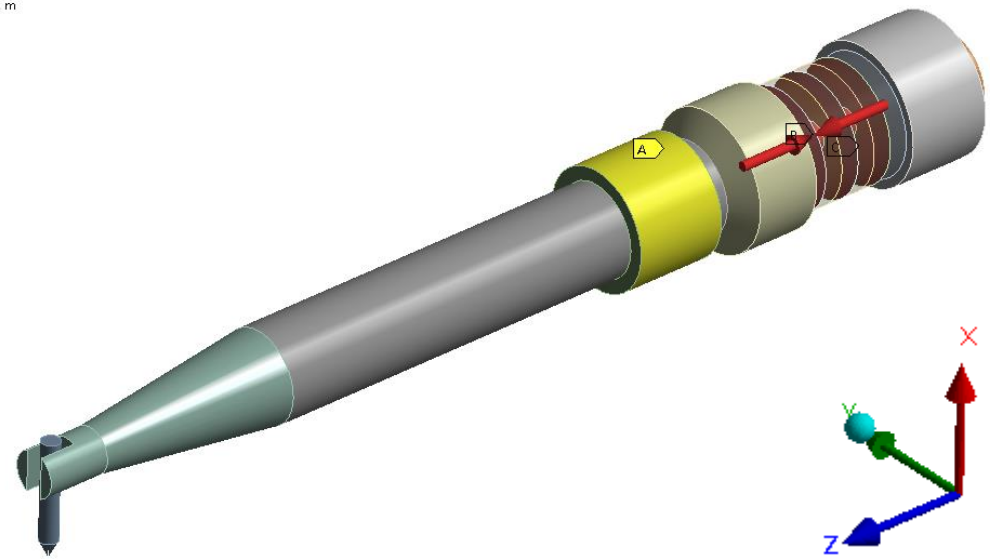
Prestress Wire Bonding Ultrasonic Transducer





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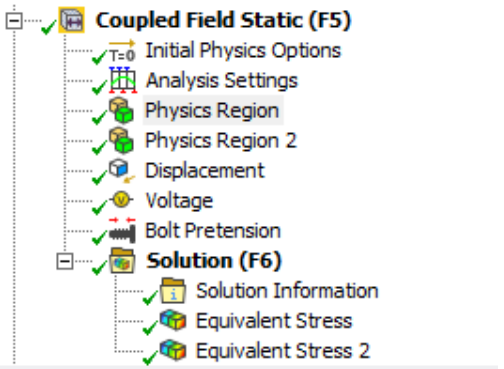
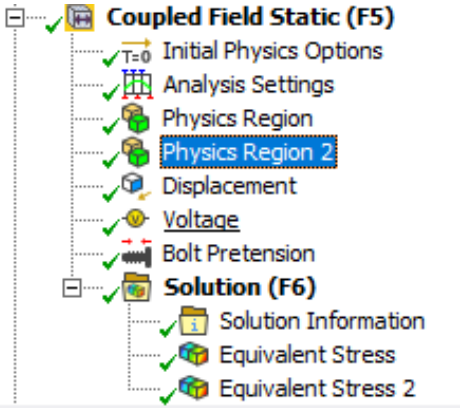
Define physics region



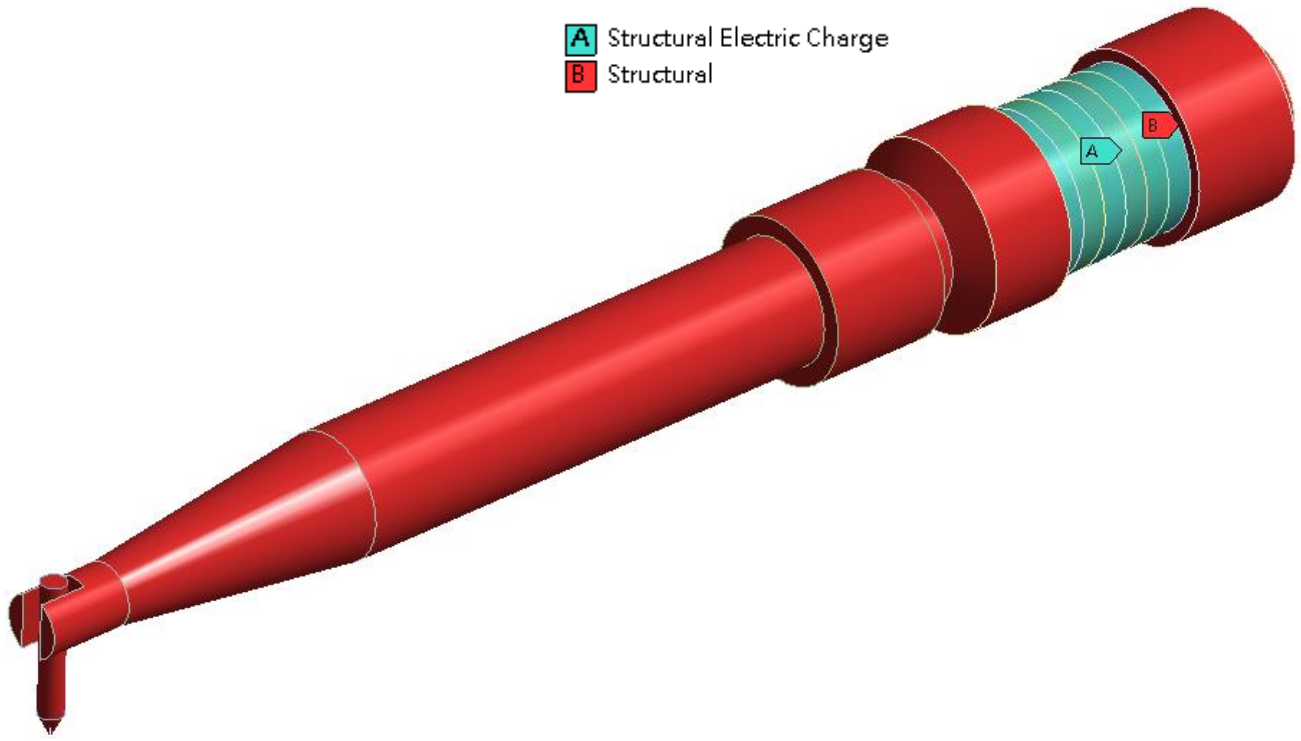
Details of "Physics Region"

Scope	
Scoping Method	Geometry Selection
Geometry	6 Bodies
Definition	
Structural	Yes
Acoustics	No
Thermal	No
Electric	Charge Based
Suppressed	No
Coupling Options	
Piezoelectric	On



Details of "Physics Region 2"

Scope	
Scoping Method	Geometry Selection
Geometry	7 Bodies
Definition	
Structural	Yes
Acoustics	No
Thermal	No
Electric	No
Suppressed	No



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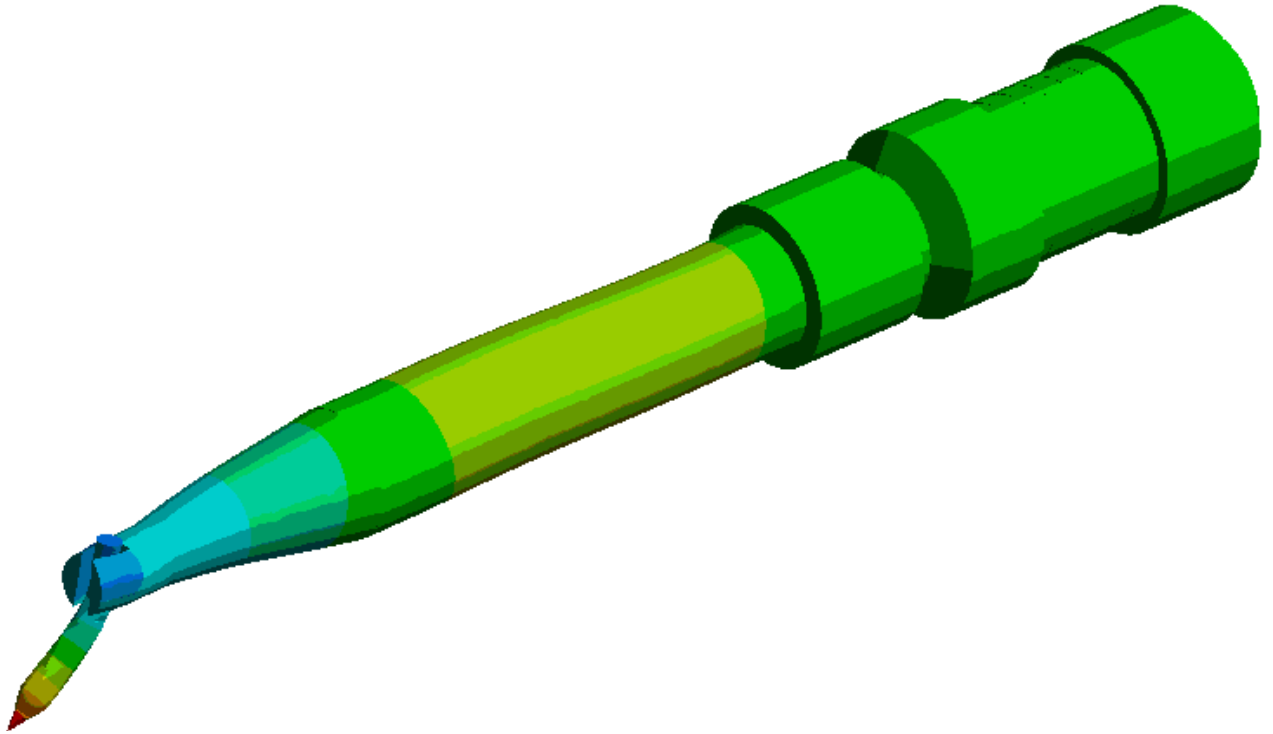
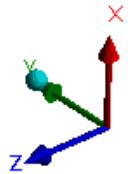
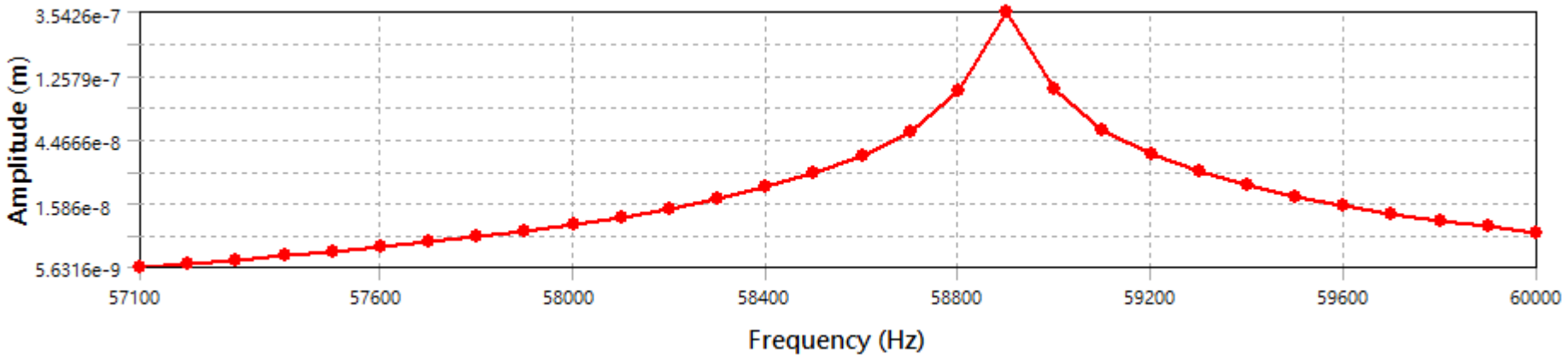
Harmonic result

G: Coupled Field Harmonic
Directional Deformation
Type: Directional Deformation(Z Axis)
Frequency: 58900 Hz
Sweeping Phase: 89.473 °
Unit: m
Global Coordinate System
2022/3/7 下午 04:33

3.5426e-7 Max
2.7554e-7
1.9681e-7
1.1809e-7
3.9362e-8
-3.9362e-8
-1.1809e-7
-1.9681e-7
-2.7554e-7
-3.5426e-7 Min







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非線性自適應網格劃分技術(NLAD)介紹

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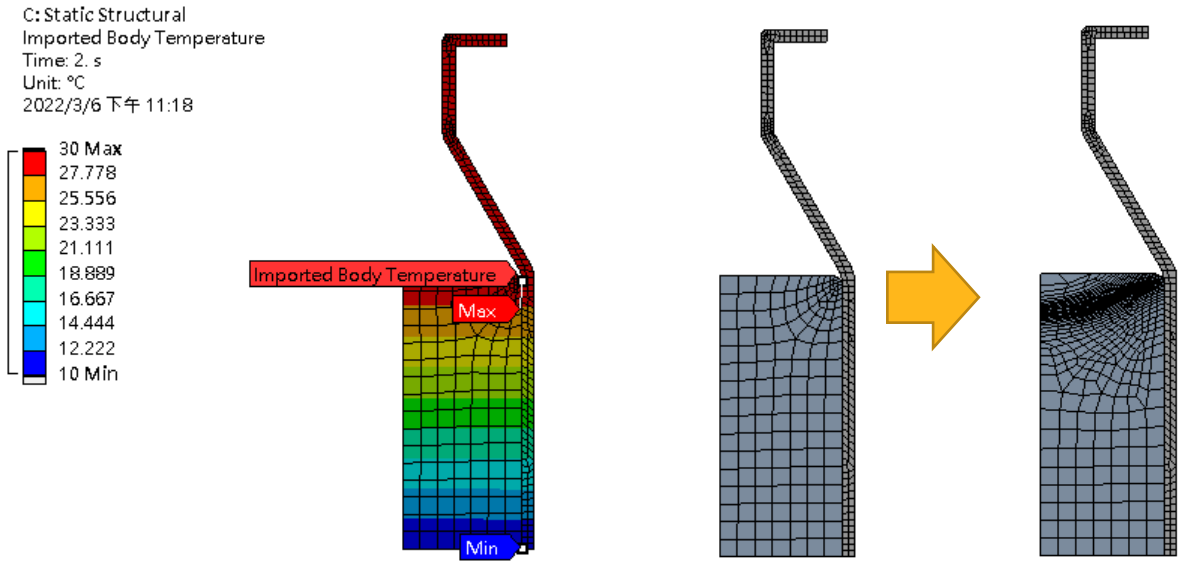
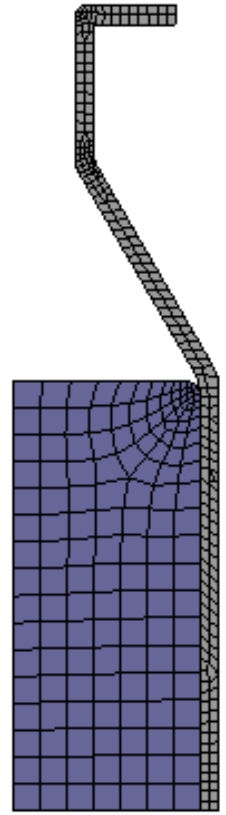
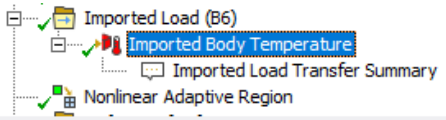
Imported Temperature







Details of "Imported Body Temperature"

Scope	
Scoping Method	Geometry Selection
Geometry	2 Bodies
Definition	
Type	Imported Body Temperature
Tabular Loading	Program Controlled
Apply to Initial Mesh	Yes

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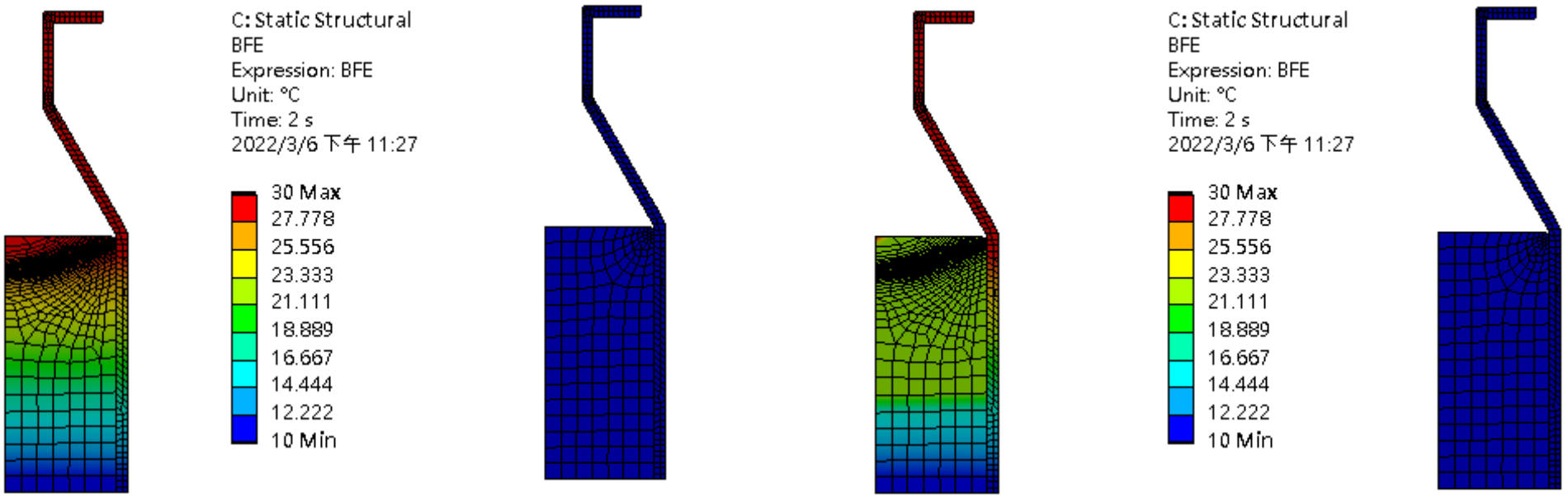
With and Without “Apply to initial mesh”



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