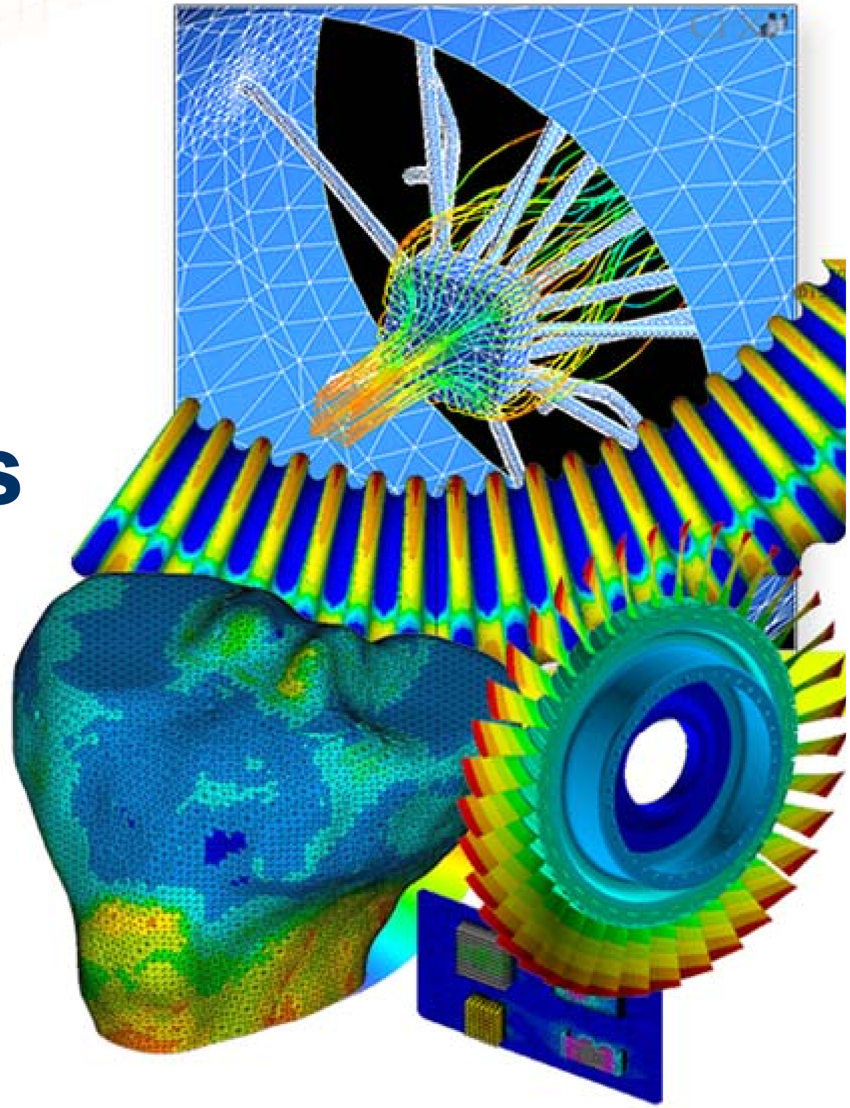
CAE ASSOCIATES

ENGINEERING ADVANTAGE

Base Acceleration Harmonic Response Analysis in Workbench

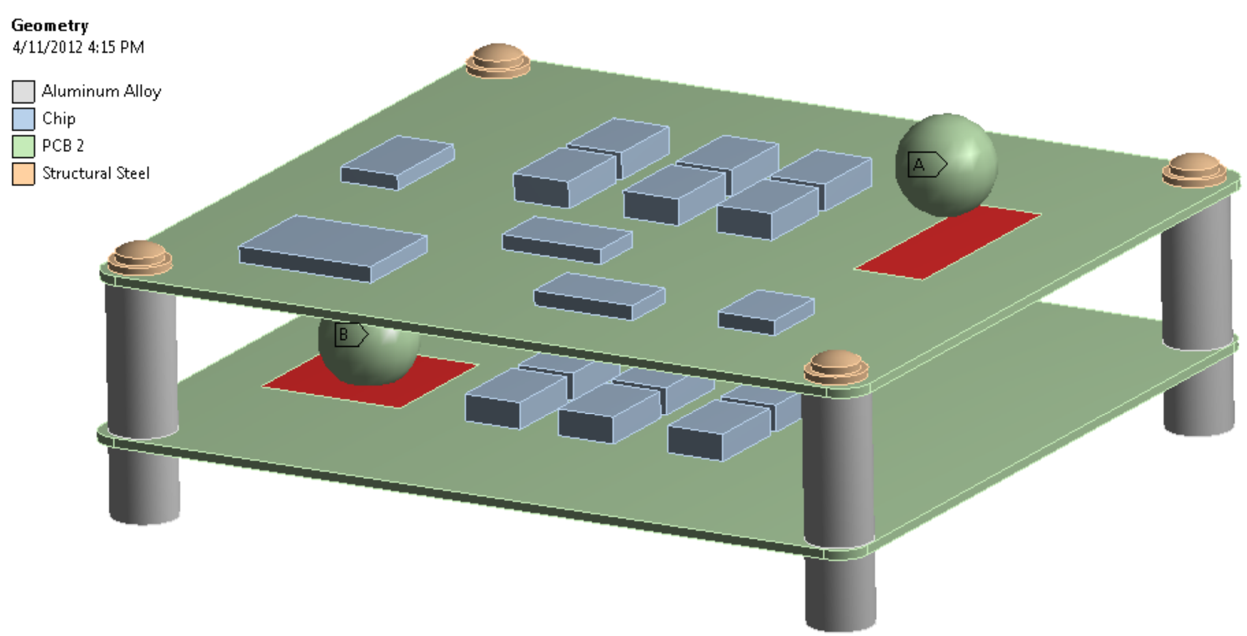


Steve Hale

CAE Associates, Inc.

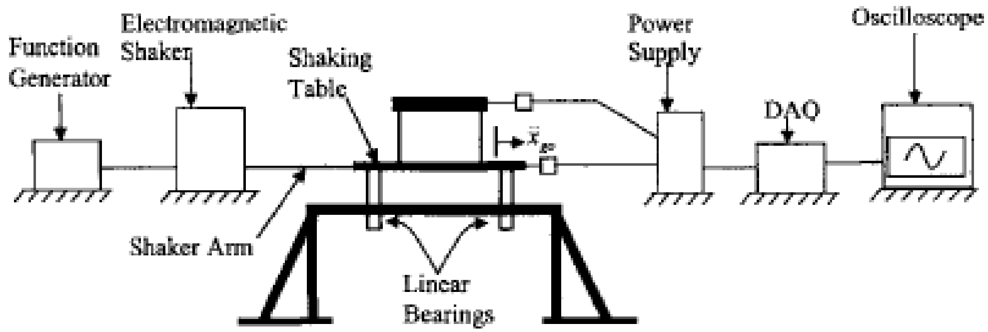
Base Acceleration Harmonic Analysis

- Goal:
  - Demonstrate methods for performing a prestress harmonic response analysis with a shaker table load (base acceleration load).
- Model:
  - Circuit board with attached mass points, a preload, and a shaker table load.



Base Acceleration Harmonic Analysis

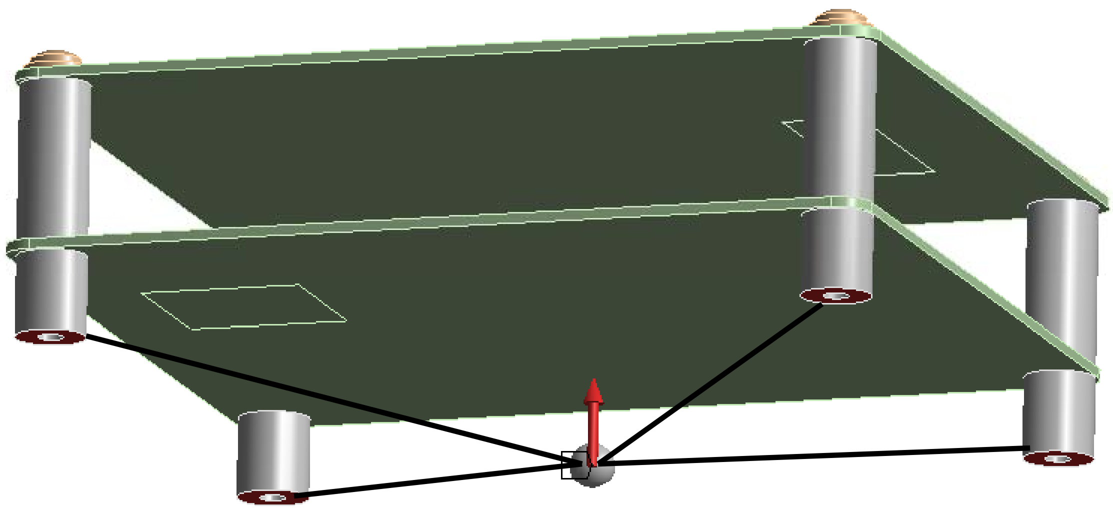
- Shaker tables are commonly used to test the dynamic response of a system to a range of excitation frequencies.



- Shaker table inputs are typically in the form of harmonic base acceleration loads.
  - PROBLEM: Harmonic base accelerations cannot be applied directly to mounting points in ANSYS Workbench.
- Two methods for simulating a shaker table response in Workbench will be presented.

Base Acceleration Harmonic Analysis

- Method 1: The Large Mass Method
  - This method uses a large point mass coupled rigidly to the mount points. A harmonic force load is applied to the mass point such that the force divided by the mass is equal to the desired acceleration load.



Base Acceleration Harmonic Analysis

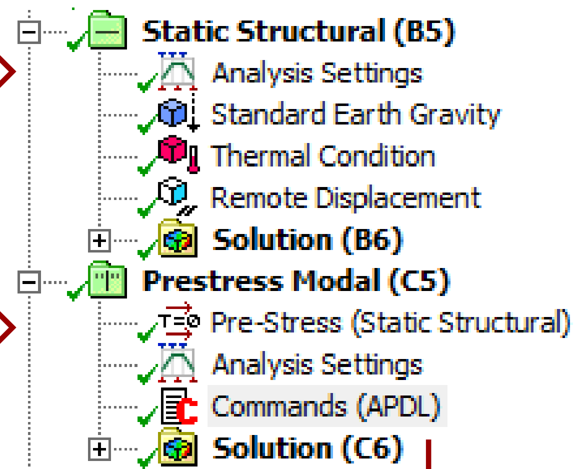
- Add a Remote Point at the large mass location.
  - A Remote Point can be used to couple a force load with a mass body to represent the shaker table excitation.
  - The Remote Point should be placed between the mount points and coupled to the faces or vertices of the mount points. A rigid connection should be used.
- Connect the large mass to the Remote Point.
  - The value of the large mass should be much greater than the real mass of the part (1.e6 times greater or more).

Details of "Point Mass"

Scope	
Scoping Method	Remote Point
Remote Points	Shaker_CG
Coordinate System	Global Coordinate System
X Coordinate	0. in
Y Coordinate	2.5 in
Z Coordinate	-2. in
Definition	
Mass	1.e+009 lbm
Mass Moment of Inertia X	0. lbm·in²
Mass Moment of Inertia Y	0. lbm·in²
Mass Moment of Inertia Z	0. lbm·in²
Suppressed	No
Behavior	Rigid
Pinball Region	All

Base Acceleration Harmonic Analysis

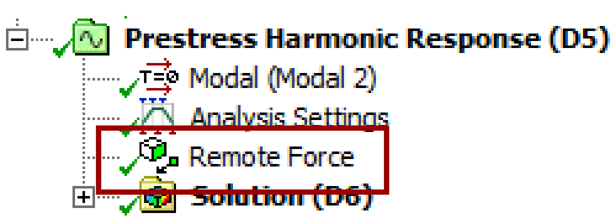
- Model: Workbench 14 archived database (*base_harmonic_LM.wbpz*)
- The analysis requires 3 phases
  - Phase 1: Static loading
    - A 1G gravitational load and a uniform temperature are applied.
    - Add a remote displacement item to fully constrain the large mass (Remote Point). This will effectively constrain the mount point.
  - Phase 2: Modal analysis
    - This is needed for the mode-superposition harmonic analysis in Phase 3.
    - The prestress conditions from Phase 1 are used to preload the structure.
    - Solve for frequencies up to at least two times the maximum frequency used in the harmonic analysis (Phase 3)
    - Add a command block to delete the fixed displacement at the large mass.




```
nsel,s,loc,z,-2.
ddel,all,uz
allsel
```

– Phase 3: Harmonic analysis

- Use a mode-superposition method with the modes obtained from Phase 2.
- Cluster results around the natural frequencies
  - — This provides an efficient method for capturing the peak response.
- Add a constant damping ratio = 0.02
- Add a Remote Force, attach it to the large mass (Remote Point), and enter a force value equal to the large mass multiplied by the desired base acceleration load.
  - — Desired base acceleration = 10G
  - — Force = 1.e10 lbf (= 1.e9 lbm*10G)



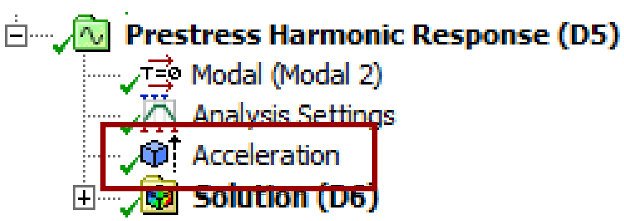
Details of "Analysis Settings"

Options	
Range Minimum	60. Hz
Range Maximum	100. Hz
Cluster Number	6
Solution Method	Mode Superposition
Cluster Results	Yes
Store Results At All Frequencies	Yes
Output Controls	
Damping Controls	
Constant Damping Ratio	2.e-002
Stiffness Coefficient Define By	Direct Input
Stiffness Coefficient	0.
Analysis Data Management	

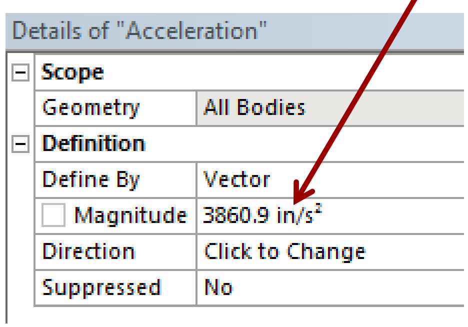
Details of "Remote Force"

Scope	
Scoping Method	Remote Point
Remote Points	Shaker_CG
Coordinate System	Global Coordinate System
X Coordinate	0. in
Y Coordinate	2.5 in
Z Coordinate	-2. in
Location	Click to Change
Definition	
ID (Beta)	1315
Type	Remote Force
Define By	Components
X Component	0. lbf
Y Component	0. lbf
Z Component	1.e+010 lbf

- Method 2: The Direct Acceleration Method
  - Apply the acceleration load directly to the entire structure.
    - This method is simpler than the Large Mass Method as it does not require a large mass, a remote point, a remote force, or a command block.
  - This method yields a solution that is equivalent to the solution for the large mass method.

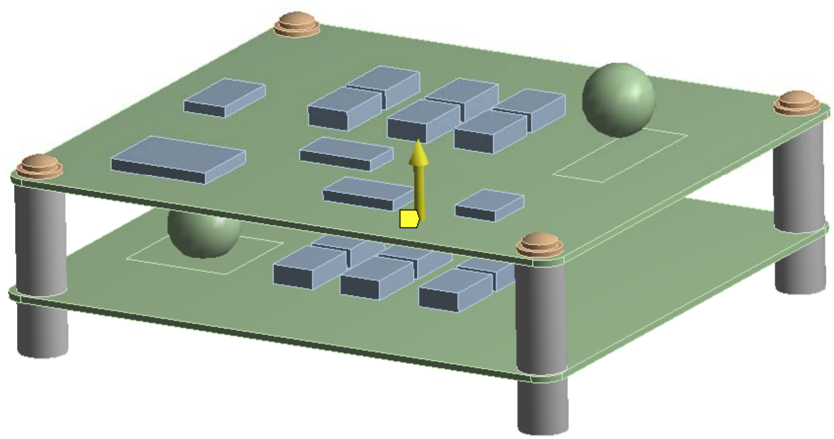


10G base acceleration applied to all bodies



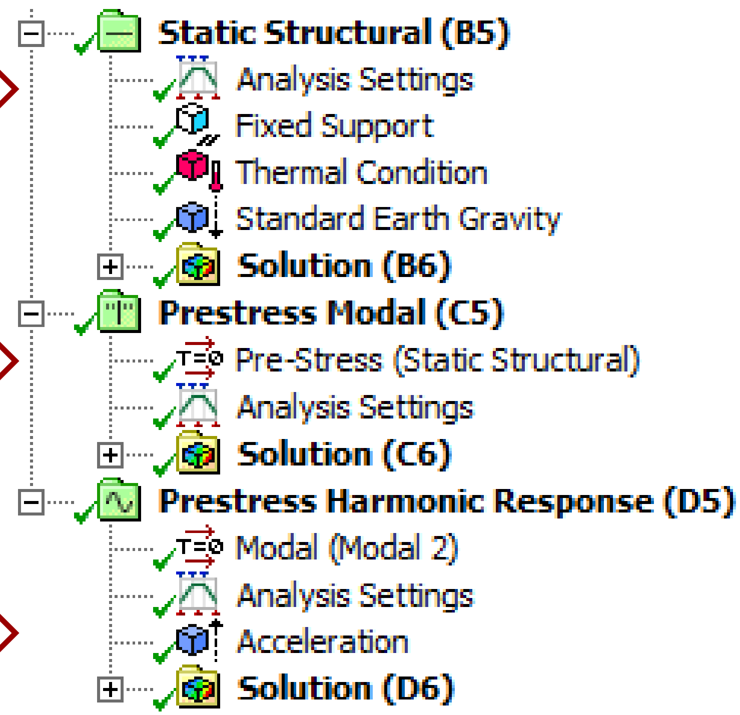
Details of "Acceleration"

Scope	
Geometry	All Bodies
Definition	
Define By	Vector
Magnitude	3860.9 in/s^2
Direction	Click to Change
Suppressed	No



Base Acceleration Harmonic Analysis

- Model: Workbench 14 archived database (*base_harmonic_DA.wbpz*)
- The analysis requires 3 phases
  - Phase 1: Static loading
    - A 1G gravitational load and a uniform temperature are applied.
  - Phase 2: Modal analysis
    - This is needed for the mode-superposition harmonic analysis in Phase 3.
    - The prestress conditions from Phase 1 are used to preload the structure.
  - Phase 3: Harmonic analysis
    - Use a mode-superposition method with the modes obtained from Phase 2. Cluster results as before.
    - Constant damping ratio = 0.02



- Results comparison: Maximum displacement (top face of upper board) vs. Frequency for the alternate method (acceleration only) and the large mass method. The results are identical.