Structural Design and Analysis of Mounting Structure for Flight Vehicle

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Abstract- **The project deals with the structural design and analysis of mounting structure for assembling of electronic packages in a flight vehicle section. The flight vehicle consists of various sections assembled to form an integrated vehicle. Different types of electronic packages to meet the requirements are assembled in different flight vehicle sections based on the flight vehicle configuration. One such type of flight vehicle section needs to be assembled with different electronic packages. The packages have to be rigidly mounted on a mounting structure in the flight vehicle section. The launch of a flight vehicle can be one of the most rigorous loads environments for which to design hardware. The high random vibration loads imparted on vehicle by the electronic packages during launch create an adverse design requirement that all hardware have a natural frequency greater than that of the vehicle, in order to avoid damage and failure due to dynamic coupling. Maximizing natural frequency is generally accomplished by creating as stiff and lightweight a design as possible. However, designing for the resultant high loads also requires a high strength intermediate structure for mounting the various components and subassemblies to the vehicle structure. These two opposing design requirements drive an optimization between a lightweight and high strength structure. The project comprises of design and analysis of the mounting structure. The mounting structure has to be designed to withstand the loads generated by the electronic packages. It also includes the design of mounting plate and brackets to withstand the given loads using CAD and CAE tools. Unigraphics software is used for modeling the flight vehicle section, packages and the mounting plate with brackets. The mounting plate and brackets are imported to ANSYS software for structural analysis. The mounting plate with brackets is applied with specified loads in different flight conditions like Pitch, Yaw and Roll moments. A finite element model was created to manually iterate several aspects of the design, such as geometric characteristics like thicknesses and fillet radii, to analyze the effects on weight and stress and converge on a successful design .The project elucides in detail the methodology adopted for the analysis of mounting structures for flight vehicles.**

***Keywords*:** PITCH, ROLL, YAW, PSD analysis.

I.Introduction

An aerospace vehicle is designed to move in a defined trajectory by means of guidance of control electronic components. These components have to be mounted inside the aerospace vehicle airframe as per the system configuration. These have to be mounted to withstand aerospace loads both static and dynamic. The main parts of the anatomy of an airframe are fuselage, the wing and the empennage. Each of the is in turn composed of various structural members. The area of interest in the current project is on the fuselage or the body of the aircraft in which in which electronic subsystems are mounted. In general, flight vehicle can be a air craft or rocket or missile. Mass properties are vital for the flight vehicle to travel in desired trajectory. The mass properties of the flight vehicle are Weight, Center of gravity and Moment of Inertia. Weight is the force generated by the gravitational attraction of the earth on the model rocket. The mass (and weight) is actually distributed throughout the rocket and for some problems it is important to know the distribution. But for rocket trajectory and stability, we only need to be concerned with the total weight and the location of the center of gravity. The center of gravity is the average location of the mass of the rocket.

The flight vehicle or Aerospace vehicle has three modes of motion viz. Pitch, Yaw and Roll. These terms frequently used in the flight vehicle are explained below. The below figure shows the three modes of motion.

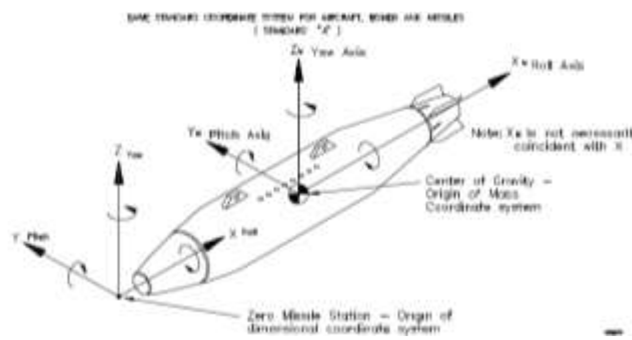


Figure 2 Three modes of motion in a flight vehicle

A. Pitch motion

In flight, any aircraft will rotate about its center of gravity, a point which is the average location of the mass of the aircraft. We can define a three dimensional coordinate system through the center of gravity with each axis of this coordinate system perpendicular to the other two axes. We can then define the orientation of the aircraft by the amount of rotation of the parts of the aircraft along these principal axes. The pitch axis is perpendicular to the aircraft centerline and lies in the plane of the wings. A pitch motion is an up or down movement of the nose of the aircraft.

The pitching motion is being caused by the deflection of the elevator of this aircraft. The elevator is a hinged section at the rear of the horizontal stabilizer. There is usually an elevator on each side of the vertical stabilizer. The elevators work in pairs; when the right elevator goes up, the left elevator also goes up.

As described on the shape effects slide, changing the angle of deflection at the rear of an airfoil changes the amount of lift generated by the foil. With greater downward deflection, lift increases in the upward direction. With greater upward deflection, lift increases in the downward direction. The lift generated by the elevator acts through the center of pressure of the elevator and horizontal stabilizer and is located at some distance from the center of gravity of the aircraft. The change in lift created by deflecting the elevator generates a torque about the center of gravity which causes the airplane to rotate. The pilot can use this ability to make the airplane loop. Or, since many aircraft loop naturally, the deflection can be used to trim or balance the aircraft, thus preventing a loop.

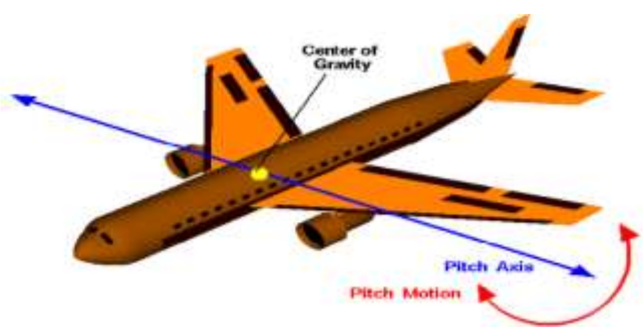


Figure 3 Flight vehicle- Pitch motion

On many aircraft, the horizontal stabilizer and elevator create a symmetric airfoil like the one shown on the left of the shape effects slide. This produces no lift when the elevator is aligned with the stabilizer and allows the combination to produce either positive or negative lift, depending on the deflection of the elevator. On many fighter planes, in order to meet their high maneuvering requirements, the stabilizer and elevator are combined into one large moving surface called a stabilator. The change in force is created by changing the inclination of the entire surface, not by changing its effective shape

B. Roll motion

In flight, any aircraft will rotate about its center of gravity, a point which is the average location of the mass of the aircraft. We can define a three dimensional coordinate system through the center of gravity with each axis of this coordinate system perpendicular to the other two axes. We can then define the orientation of the aircraft by the amount of rotation of the parts of the aircraft along these principal axes. The roll axis lies along the aircraft centerline. A roll motion is an up and down movement of the wings of the aircraft. The rolling motion is being caused by the deflection of the ailerons of this aircraft. The aileron is a hinged section at the rear of each wing. The ailerons work in opposition; when the right aileron goes up, the left aileron goes down. As described on the shape effects slide, changing the angle of deflection at the rear of an airfoil will change the amount of lift generated by the foil. With greater downward deflection, the lift will increase in the upward direction; with greater upward deflection, the lift will decrease in the upward direction. Since the ailerons work in pairs, the lift on one wing increases as the lift on the opposite wing decreases. Because the forces are not equal, there is a net twist, or torque about the center of gravity and the aircraft rotates about the roll axis. The pilot can use this ability to bank the aircraft which causes the airplane to turn.

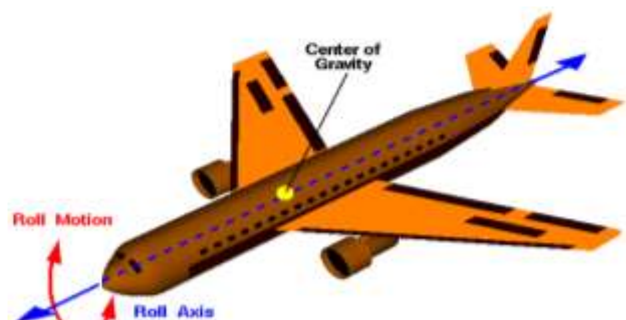


Figure 4 flight vehicle- roll motion

On this page we have demonstrated an aircraft roll induced by movement of the ailerons, but there are other ways to produce a rolling motion on an aircraft. The Wright brothers used a method called wing warping. Their wings were wired together in such a way that the outer panels of each wing could betwisted relative to the inner panel. The twisting changed the local angle of attack ofsections of thewing which changed the lift being generated by that section. Unequal forces on the wings caused the aircraft to roll. Many modern airliners use a spoiler to roll the aircraft. A spoiler is a plate that is raised between the leading and trailing edges of the wing. The spoiler effectively changes the shape of the airfoil, disrupts the flow over the wing, and causes a section of the wing to decrease its lift. This produces an unbalanced force with the other wing, which causes the roll. Airliners use spoilers because spoilers can react more quickly than ailerons and require less force to activate, but they always decrease the total amount of lift for the aircraft. It's an interesting trade! You can tell whether an airliner is using spoilers or ailerons by noticing where the moving part is located. At the trailing edge, it's an aileron; between the leading and trailing edges, it's a spoiler.

C. Yaw motion

In flight, any aircraft will rotate about its center of gravity, a point which is the average location of the mass of the aircraft. We can define a three dimensional coordinate system through the center of gravity with each axis of this coordinate system perpendicular to the other two axes. We can then define the orientation of the aircraft by the amount of rotation of the parts of the aircraft along these principal axes. The yaw axis is perpendicular to the wings and lies in the plane of the aircraft centerline. A yaw motion is a side to side movement of the nose of the aircraft.

The yawing motion is being caused by the deflection of the rudder of this aircraft. The rudder is a hinged section at the rear of the vertical stabilizer. As described on the shape effects slide, changing the angle of deflection at the rear of an airfoil changes the amount of lift generated by the foil. For the vertical stabilizer and rudder, the orientation of the airfoil causes a side force to be generated. With greater deflection of the rudder to the left, the side force increases to the right. With greater deflection to the right, the side force increases to the left.

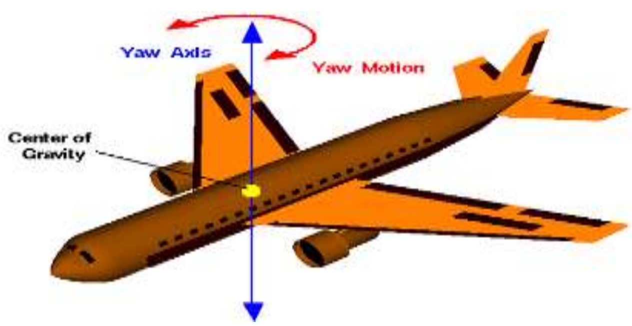


Figure 5 flight vehicle- yaw motion

The lift generated by the rudder acts through the center of pressure of the rudder and vertical stabilizer and is located at some distance from the center of gravity of the aircraft. The change in side force created by deflecting the rudder generates a torque about the center of gravity which causes theairplane to rotate. The pilot uses this abilityto keep the nose of the aircraft pointed in the direction of travel.

On all aircraft, the vertical stabilizer and rudder create a symmetric airfoil. This produces no side force when the rudder is aligned with the stabilizer and allows the combination to produce either positive or negative side force, depending on the deflection of the rudder. Some fighter planes have two vertical stabilizers and rudders because of the need to control the plane with multiple, very powerful engines

II. Specification of Flight Vehicle Section

The flight vehicle section has to be mounted with different electronic packages for controlling the flight vehicle in desired path. This section is of500mm length and 420 mm diameter with 4 mm thick Airframe. The electronic packages need to be mounted on a rigid structure.

A mounting structure need to be designed and analyzed to withstand the flight loads generated during the flight. The Mounting Plate is mounted over four Brackets which are attached to the Airframe forms the mounting structure. The mounting Plate carries few packages at the top surface and other packages at the bottom surface based on the configuration of the flight vehicle. The flight vehicle section configuration is shown in Fig.6 and Fig.7.

The weight of the Sub system under the longitudinal and lateral acceleration levels of 6g imparts external loading in the form of forces and moments over the structural elements like Mounting Plate, Brackets. These elements are designed and analyzed to withstand the specified loads. The flight vehicle with sections is shown in the below Fig.6.

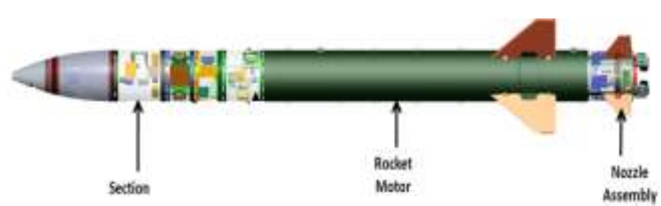


Fig 6 shows flight vehicle with section

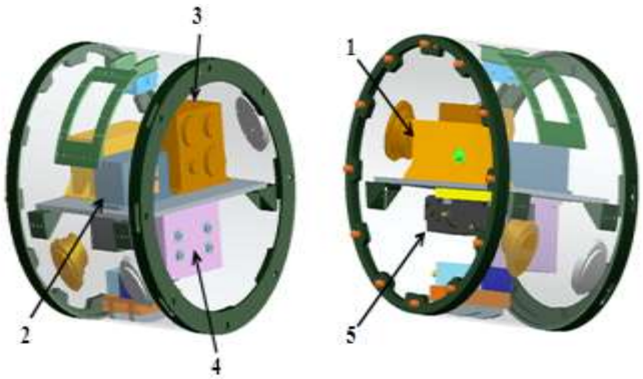


Fig 7 shows configuration of flight vehicle section

III. Material Properties

All the components of the Mounting structure Assembly are made using Aluminium alloy 24345 (IS: 737).All the components of the Mounting structure Assembly are assigned as per the below material properties.

Ultimate Tensile Strength = 425 MPa
0.2% Proof Stress = 345 MPa
Young's Modulus = 0.7e5 MPa
Density = 2.7e-9 Tonnes/mm^3

1. Acceleration level experienced by the flight vehicle is 6g.

2. The weights of the packages in Kg are: First: 3, Sec 5.2, third: 4.3, fourth: 4.6, fifth: 6.8.

IV. Methodology

1. Create 3D model of the mounting structure using NX-CAD software.

2. Create Finite element model of the mounting structure using ANSYS software.

3. Perform structural static analysis of the mounting structure for Pitch, Roll and Yaw conditions.

4. Perform Modal analysis to calculate natural frequencies and mass participations.

5. Perform PSD analysis of the mounting structure in X, Y and Z directions.

6. Perform RSA analysis of the mounting structure X, Y and Z directions.

V. 3D Modeling of Mounting Structure

The flight vehicle mounting structure is a mounting structure used to mount electronic equipment in the flight vehicles. The 3D model of the mounting structure assembly is created using UNIGRAPHICS NX software.UNIGRAPHICS NX is the world's leading 3D product development solution. This software enables designers and engineers to bring better products to the market faster. It takes care of the entire product definition to serviceability. NX delivers measurable value to manufacturing companies of all sizes and in all industries. NX is used in a vast range of industries from manufacturing of rockets to computer peripherals. With more than1lakh seats installed in worldwide many cad users are exposed to NX and enjoy using NX for its power and capability.

Fig 8 shows the 3d model of mounting structure assembly

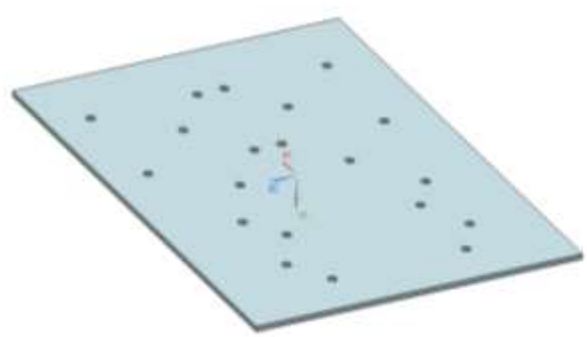


Fig 9 shows the 3d model mounting structure plate.

VI. Finite Element Model

A detailed Finite Element model was built with shell, mass and solid elements to idealize all the components of the Mounting structure assembly. The outer shell body and mounting Plate are modeled using elastic 4 node 3D Shell elements (Shell 63) a uniform thickness of 4 mm, 10 mm is given respectively. Lugs are modeled using a SOLID 10 node tetrahedral element (SOLID 92). Total of 23322 elements are used for this assembly with 2456 elements for the Plate and 5147 elements for the Lugs and 15719 elements for the total structure. The nodes of holes at the lugs to be interfaced with Airframe are arrested in all degrees of freedom and the nodes of holes interfacing Plate and lugs are coupled together in all degrees of freedom. Aluminium Alloy 24345 materials are used for shell, plate and lugs and its properties are given below. The finite element model of the mounting structure assembly is shown in Fig.10

Plate (IS: 736): UTS: 405 MPa, PS: 310 MPa, %e: 7

Lugs (IS: 733): UTS: 480 MPa, PS: 420 MPa, %e: 6

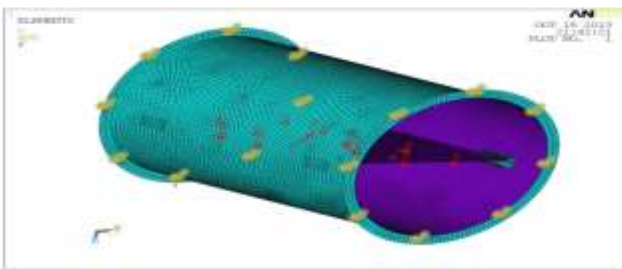


Fig 10 shows the FE model of mounting structure assembly

A. *Structural Static analysis for YAW condition*

In Yaw condition, direct load is applied on the plate by the respective packages on the mounted locations in both yaw left and right condition. Boundary conditions and the Forces applied over the plate in yaw direction along y - axes are shown in Fig. 11. The Stresses and deflections induced in the Plate and Lugs are shown in Fig. 12 to Fig. 13.

Weight of package 1 = 5.32 Kg

Force caused by package 1 in 6 g state = 5.32 * 9.81* 6 = 313.1 N

Load transfer to plate at each mounting hole = 313.1 / 4 = 78.3 N

Weight of package 2 = 1.66 Kg

Force caused by package 2 in 6 g state = 1.66 * 9.81* 6 = 97.7 N

Load transfer to plate at each mounting hole = 97.7 / 4

Weight of package 3 = 3.6 Kg

Force caused by package 3 in 6 g state = 3.6 * 9.81* 6= 212 N

Load transfer to plate at each mounting hole = 212 / 4

Weight of package 4 = 1.41 Kg

Force caused by package 4 in 6 g state = 1.41 * 9.81* 6 = 83 N

Load transfer to plate at each mounting hole = 83 /4

Weight of package 5 = 2.62 Kg

Force caused by package 5 in 6 g state = 2.62 * 9.81* 6 = 154.2 N

Load transfer to plate at each mounting hole = 154.2 / 4 = 38.6 N

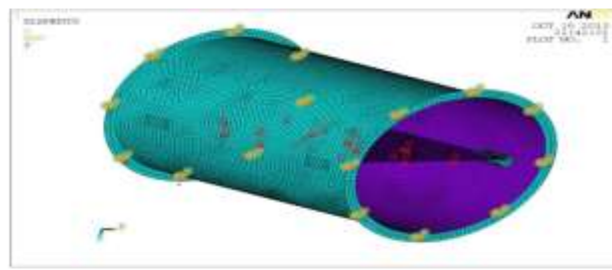


Fig 11 shows boundary conditions applied on the mounting structure for yaw condition

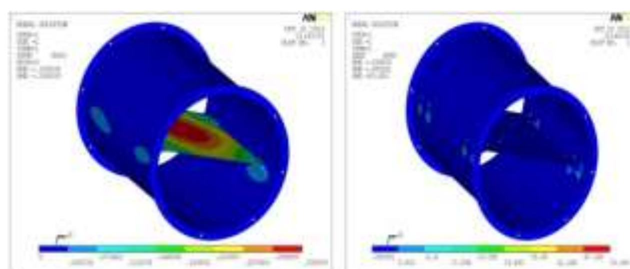


Fig 12 shows deflections & Stress plot of mounting structure for yaw condition

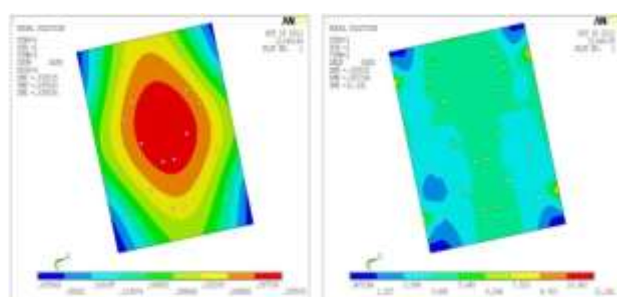


Fig 13 shows deflections & stress plot of mounting plate for yaw condition

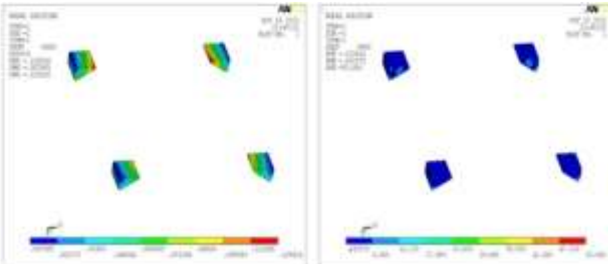


Fig 14 shows deflections & stress plot of lugs for yaw condition

- From the above figures the maximum deflection obtained for mounting structure, mounting plate and lugs is 0.33 mm, 0.33 and 0.125mm respectively for YAW condition.
- From the above figures Maximum VonMises Stress in the mounting structure, mounting plate and lugs is 53Mpa, 11.24Mpa and 53Mpa respectively for YAW condition.

B. Structural Static analysis for PITCH condition

During Pitch (Up & Down) condition, moments are calculated and applied on the plate generated by the packages mounted on the plate about z-axis. Analysis has been carried out for Pitch-Up condition and the same is applied for the Pitch-Down condition. Boundary conditions, Deflections and stresses are obtained and the plots are depicted from Fig. 15 to Fig. 18.

Weight of package 1 = 5.32 Kg

Force caused by package 1 in 6 g state = 5.32 * 9.81* 6 = 313.1 N

Moment caused by package 1 when Force acts through its CG = 313.14 x 45

Moment transferred via each fastener = 14091 / 4

Weight of package 2 = 1.66 Kg

Force caused by package 2 in 6 g state = 1.66 * 9.81* 6 = 97.71 N

Moment caused by package 2 when Force acts through its CG = 97.71 x 35

Moment transferred via each fastener = 3420/4

Weight of package 3 = 3.6 Kg

Force caused by package 3 in 6 g state = 3.6 * 9.81* 6= 212 N

Moment caused by package 3 when Force acts through its CG = 212 x 61

Moment transferred via each fastener = 12932 / 4

Weight of package 4 = 1.41 Kg

Force caused by package 4 in 6 g state = 1.41 * 9.81* 6 = 83 N

Moment caused by package 4 when Force acts through its CG = 83 x 55

Moment transferred via each fastener = 4565/ 4

Weight of package 5 = 2.62 Kg

Force caused by package 5 in 6 g state = 2.62 * 9.81* 6 = 154.2 N

Moment caused by package 5 when Force acts through its CG = 154.2 x 33

Moment transferred via each fastener = 5089/4

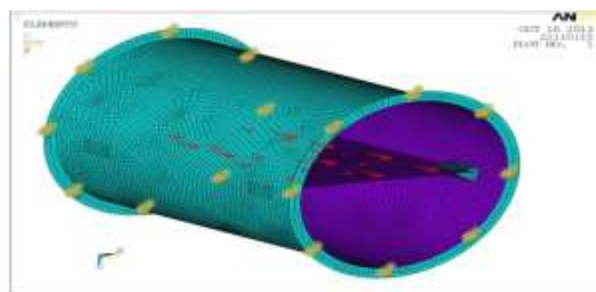


Fig 15 shows boundary conditions applied on the mounting structure for pitch condition

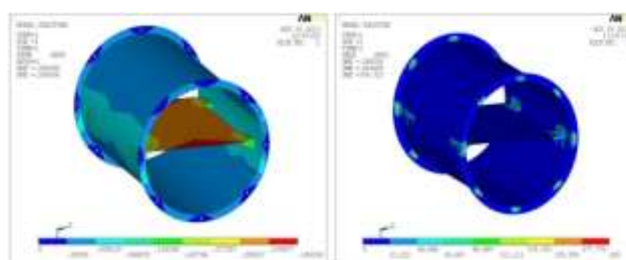


Fig 16 shows deflections & stress plot of mounting structure for pitch condition

= 3420 N-mm

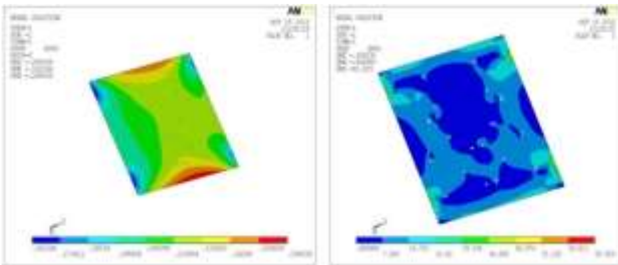


Fig 17 shows deflections & stress plot of mounting plate for pitch condition

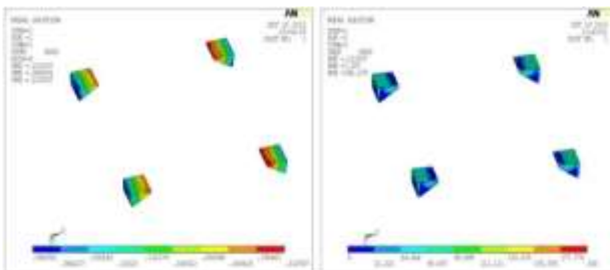


Fig 18 shows deflections & stress plot of lugs for pitch condition

- From the above figures the maximum deflection obtained for mounting structure, mounting plate and lugs is 0.26 mm, 0.26 and 0.21mm respectively for PITCH condition.
- From the above figures Maximum VonMises Stress in the mounting structure, mounting plate and lugs is 200Mpa, 65.9Mpa and 200Mpa respectively for PITCH condition.

C. Structural Static analysis for ROLL condition

During Rolling (CW & CCW) condition, moments are calculated and applied on the plate generated by the packages mounted on the plate about x-axis. Analysis has been carried out for Roll-CW condition and the same is applied for the Roll-CCW condition. Boundary Conditions, Deflections and stresses are obtained and the plots are depicted from Fig.19 to Fig.22.

Weight of package 1 = 5.32 Kg

Force caused by package 1 in 6 g state = 5.32 * 9.81* 6 = 313.1 N

Moment caused by package 1 when Force acts through its CG = 313.14 x 45

Moment transferred via each fastener = 14091 / 4

Weight of package 2 = 1.66 Kg

Force caused by package 2 in 6 g state = 1.66 * 9.81* 6 = 97.71 N

Moment caused by package 2 when Force acts through its CG = 97.71 x 35

Moment transferred via each fastener = 3420/4

Weight of package 3 = 3.6 Kg

Force caused by package 3 in 6 g state = 3.6 * 9.81* 6= 212 N

Moment caused by package 3 when Force acts through its CG = 212 x 61

Moment transferred via each fastener = 12932 / 4

Weight of package 4 = 1.41 Kg

Force caused by package 4 in 6 g state = 1.41 * 9.81* 6 = 83 N

Moment caused by package 4 when Force acts through its CG = 83 x 55

Moment transferred via each fastener = 4565/ 4

Weight of package 5 = 2.62 Kg

Force caused by package 5 in 6 g state = 2.62 * 9.81* 6 = 154.2 N

Moment caused by package 5 when Force acts through its CG = 154.2 x 33

Moment transferred via each fastener = 5089/4

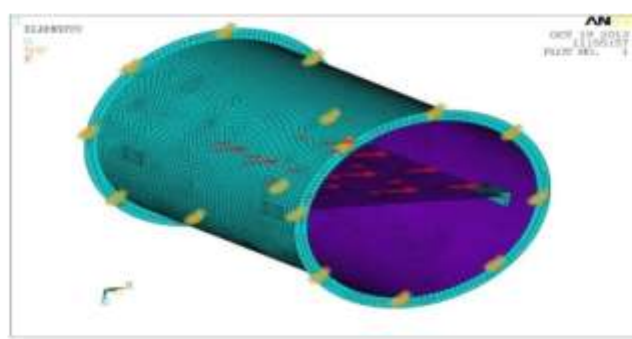


Fig 19 shows boundary conditions applied on the mounting structure for roll condition

= 14091 N-mm

= 3522.8 N-mm

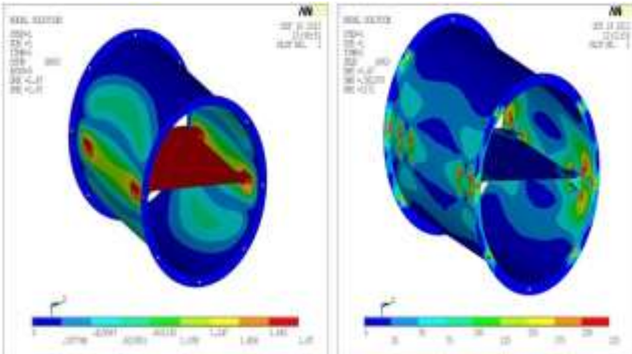


Fig 20 shows deflections & stress plot of mounting structure for rollcondition

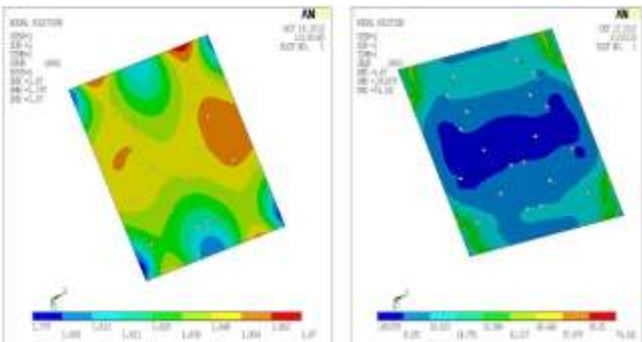


Fig 21 shows deflections & stress plot of mounting plate for roll condition

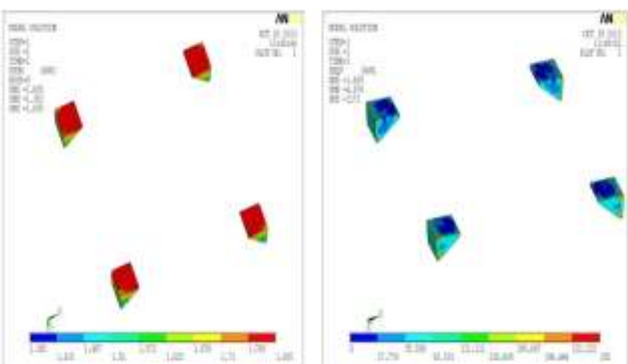


Fig 22 shows deflections & stress plot of lugs for roll condition

- From the above figures the maximum deflection obtained for mounting structure, mounting plate and lugs is 1.87 mm, 1.87 and 1.83mm respectively for ROLL condition.

- From the above figures Maximum VonMises Stress in the mounting structure, mounting plate and lugs is 225Mpa, 74.5Mpa and 225Mpa respectively for ROLL condition = 885 N-mFrom the above figures the maximum deflection obtained for mounting structure, mounting plate and lugs is 1.87 mm, 1.87 and 1.83mm respectively for ROLL condition

VII.ModalAnalysis

Modal analysis is used to determine the vibration characteristics (natural frequencies and mode shapes) of a structure or a machine component while it is being designed. It can also serve as a starting point for another, more detailed, dynamic analysis, such as a transient dynamic analysis, a harmonic response analysis, or a Spectrum analysis.

The mode shapes, frequencies and participation factors are shown below.

The mounting structure was studied to understand the natural frequencies between 0-300Hz.The Boundary condition used for modal analysis is shown in Fig.23.

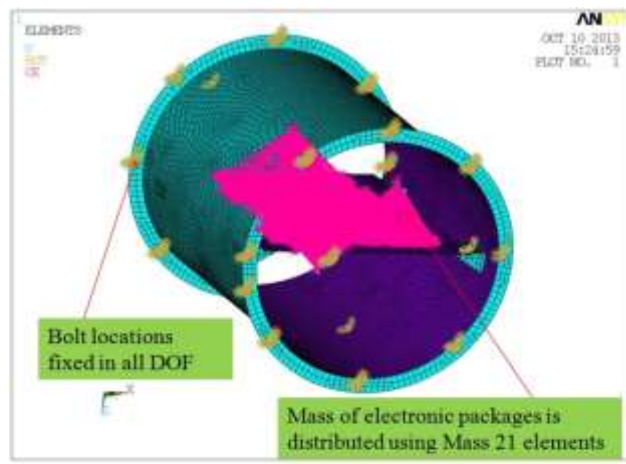


Fig 23 shows boundary conditions applied on the mounting structure for modal analysis

Mode 1@103.8Hz Mode 2@138.6Hz

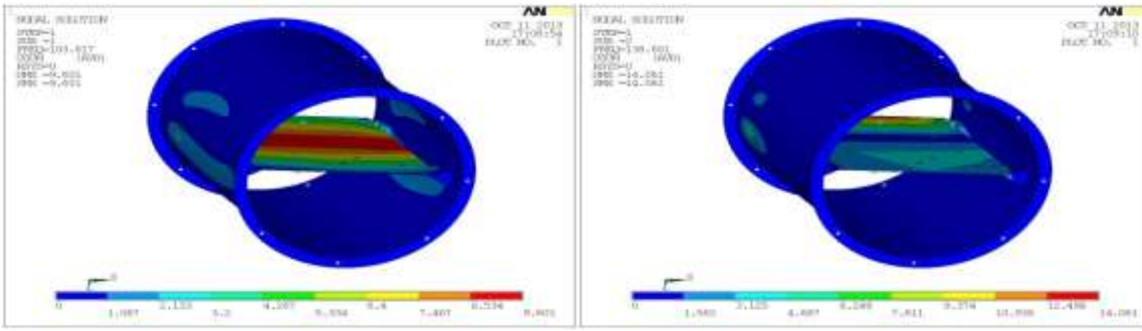


Fig 24 shows the 1st and 2nd mode shapes for modal analysis

Mode 3@166.52 Hz Mode 4@187.9Hz

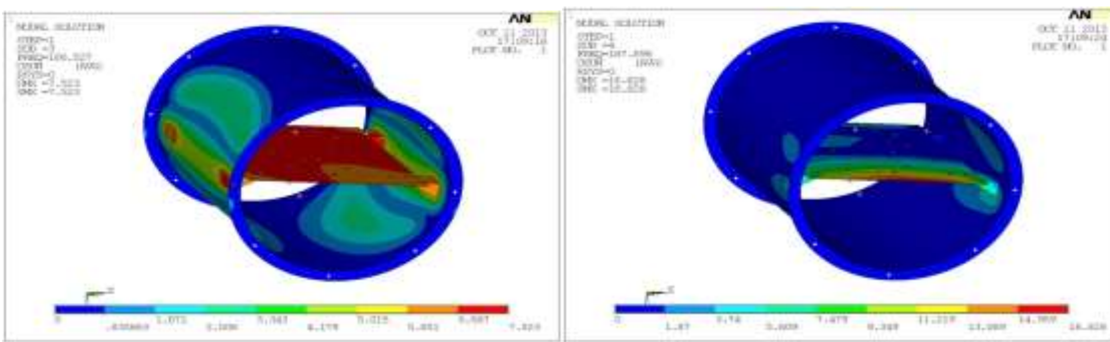


Fig 25 shows the 3rd and 4th mode shapes for modal analysis

Mode 5@231.2Hz Mode 6@261.5Hz

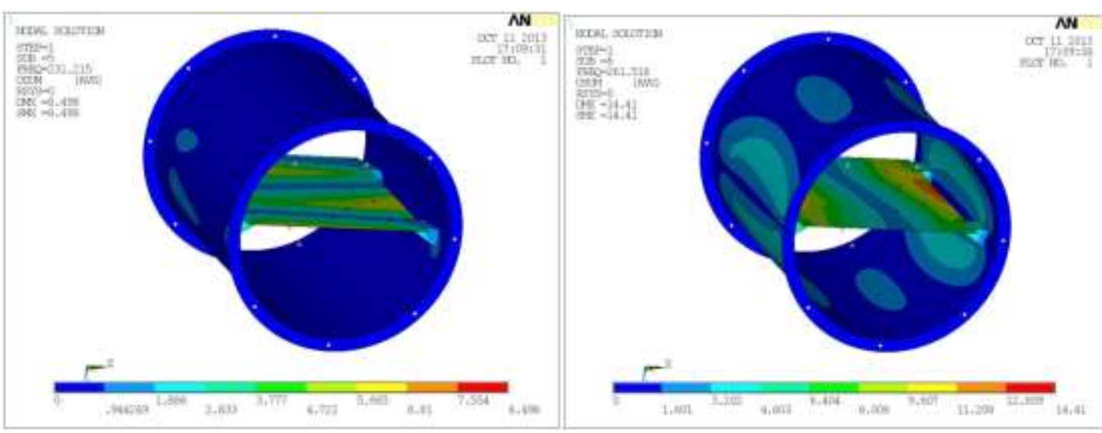


Fig 26 shows the 5th and 6th mode shapes for modal analysis

From the above results the fundamental natural frequency is occurring at 103 Hz. It is also observed that only 6 natural frequencies are present in the frequency range of 0 -300 Hz

The total weight of the mounting structure is 29.85Kgs.From the below participation factors table, it is observed that the mass participation of 19.2 kgs (64%) in X-direction, 14.6 kgs (49%) in Y-direction and 14.6 Kgs (49%) in Z-direction exists at the frequencies of 166.5Hz, 232.2Hz and 103Hz respectively.PSD analysis has been carried out to check the structure behavior for random vibrations in the frequency range of 0-300Hz.

MODE	FREQUENCY	PARTIC.FACTOR	RATIO	EFFECTIVE MASS
1	103.817	-0.24325E-02	0.017545	0.591729E-05
2	138.601	-0.11119E-02	0.008020	0.123640E-05
3	166.527	0.13864	1.000000	0.192221E-01
4	187.896	-0.71340E-02	0.051455	0.508937E-04
5	231.215	0.19543E-02	0.014096	0.381938E-05
6	261.518	0.12085E-01	0.087162	0.146035E-03

Table 1 Participation factors in X-direction

MODE	FREQUENCY	PARTIC.FACTOR	RATIO	EFFECTIVE MASS
1	103.817	-0.69197E-02	0.057235	0.478819E-04
2	138.601	-0.27172E-01	0.224750	0.738313E-03
3	166.527	-0.13834E-02	0.0114	0.191367E-05
4	187.896	0.35087E-02	0.029022	0.123110E-04
5	231.215	0.12090	1.000000	0.146164E-01
6	261.518	-0.12604E-01	0.104251	0.158855E-03

Table 2 Participation factors in Y-direction

A. PSD analysis along X- direction

PSD analysis is carried out on modified model with base excitation in X direction from 0-300Hz.The spectral values for random vibrations in X, Y and Z directions are given below.

Random	g2/Hz	Db/Oct
10	0.02	4
300	0.02	4

Table 4.spectral values for random vibrations in X,Y and Z directions

Boundary Conditions:

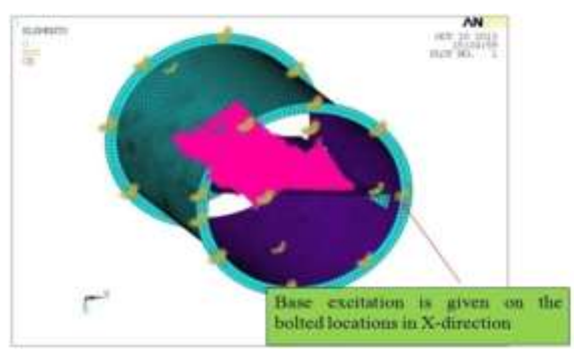
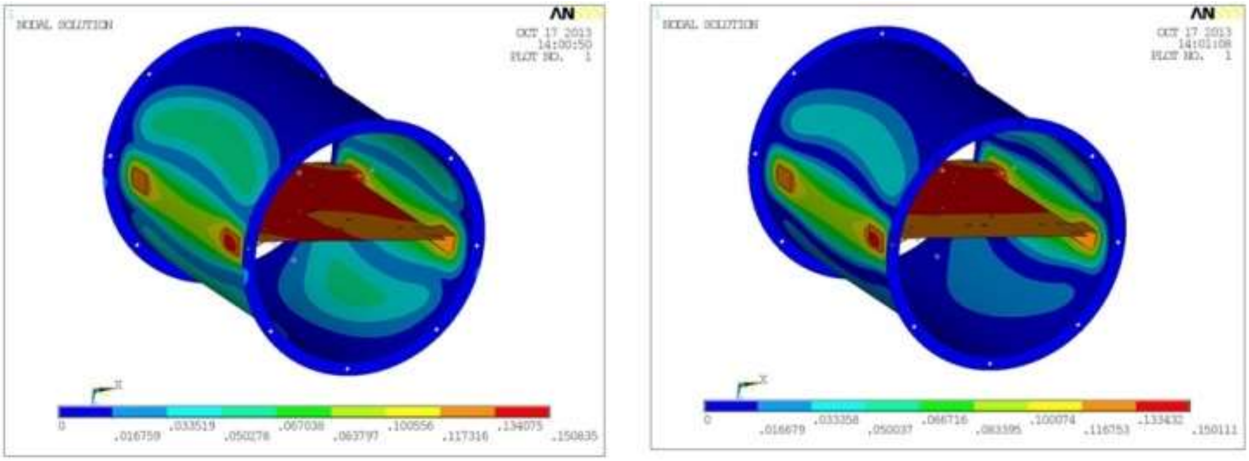


Fig 27 shows Boundary conditions applied on the mounting structure for PSD analysis in X-Direction



Results

Fig 28 shows 1 sigma displacement for PSD analysis in X-Direction

- 1 sigma deflection observed on the mounting structure= 0.15 mm
- Therefore 3 sigma deflection on the mounting structure = 0.45 mm
- This implies that only 0.3% of the time the mounting structure deflection reaches 0.45mm

VonMises Stress

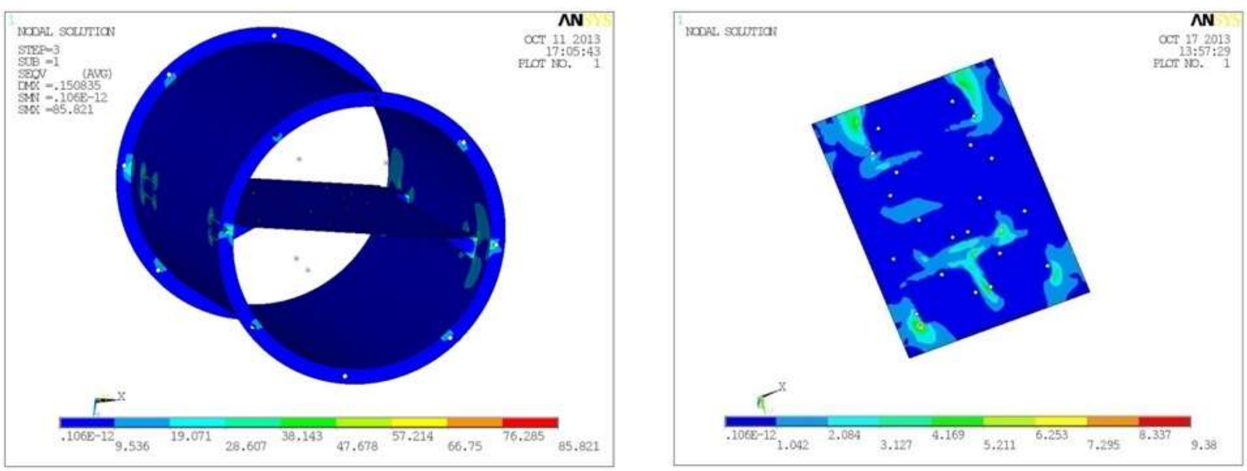


Fig 29 shows 1 sigma stress for PSD analysis in X-Direction

- 1 sigma stress observed on the mounting structure= 85 N/mm2
- Therefore 3 sigma stress on the mounting structure = 249 N/mm2
- This implies that only 0.3% of the time the mounting structure stress reaches 249 N/mm2

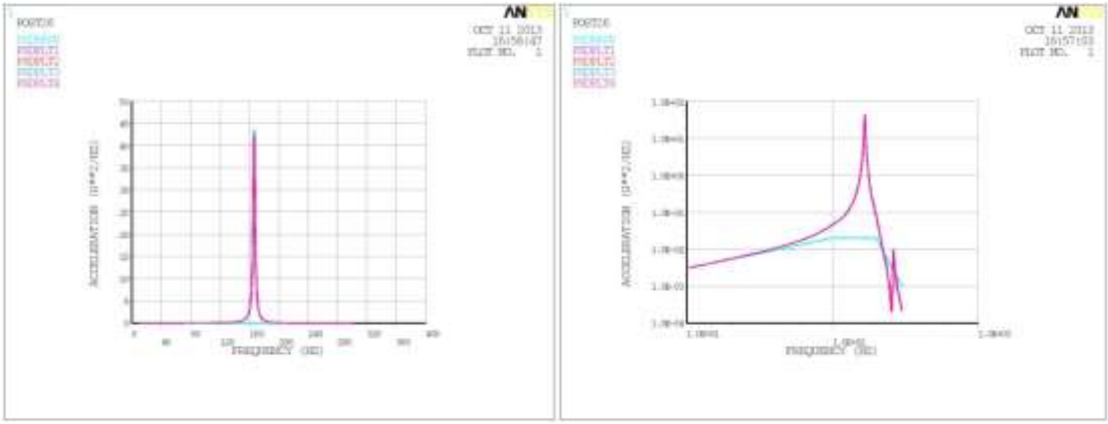


Fig 30. Shows PSD Response on plate on electronic packages in Linear and Logarithmic Scale

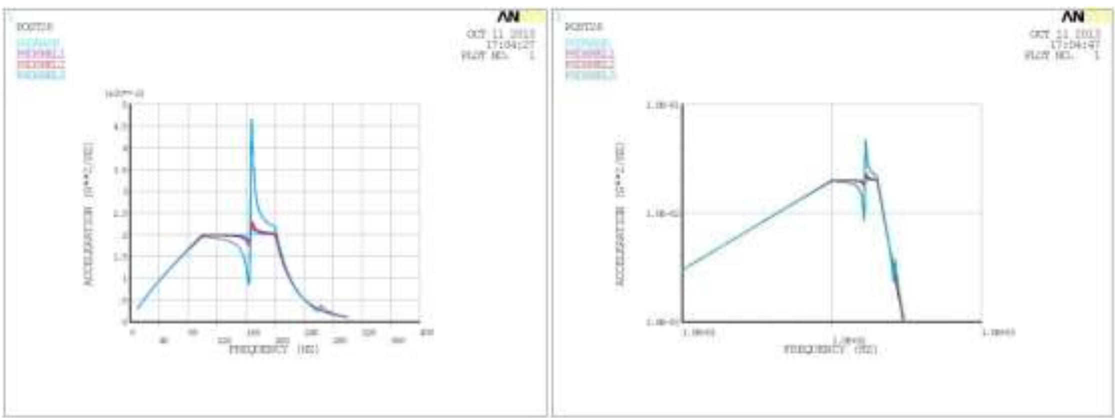


Fig 31. Shows PSD Response on outer shell in Linear and Logarithmic Scale

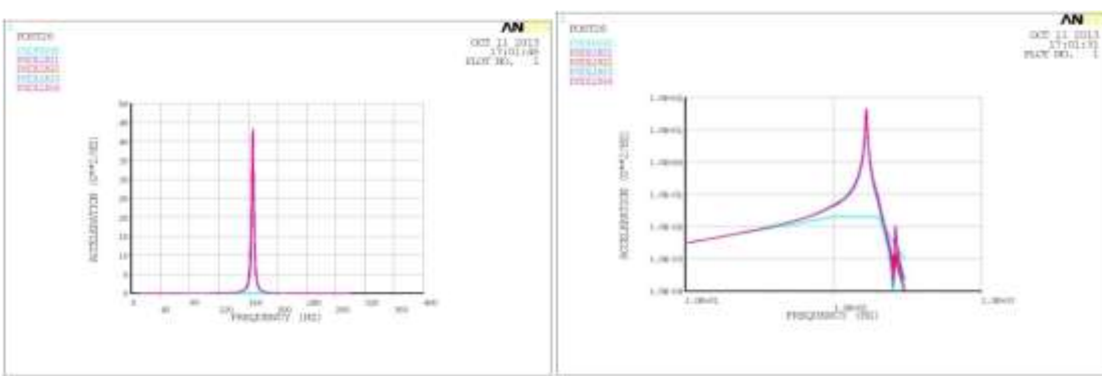


Fig 32. Shows PSD Response on lugs in Linear and Logarithmic Scale

From the above graphs it is seen that

- Maximum PSD response on the PLATE is 43.49 g2/Hz at a frequency of 170.5 Hz
- Maximum PSD response on the shell is 4.73 g2/Hz at a frequency of 170.5 Hz

- Maximum PSD response on the LUGS is 38.81 g2/Hz at a frequency of 170.5 Hz

From the above analysis the 3 sigma stress is well within the yield strength of the material. So We can conclude that the mounting structure is safe for random Vibrations in X-direction

B. PSD analysis along Y- direction

PSD analysis is carried out on modified model with base excitation in Y direction from 0-300Hz

Boundary Conditions:

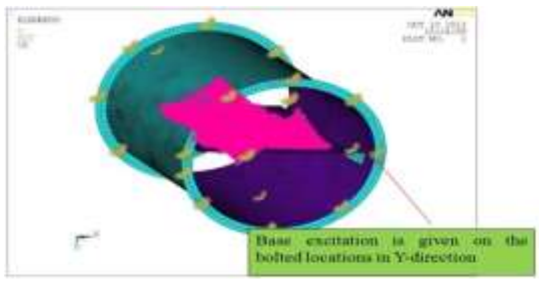


Fig 33. Shows Boundary conditions applied on the mounting structure for PSD analysis in Y-Direction

Results

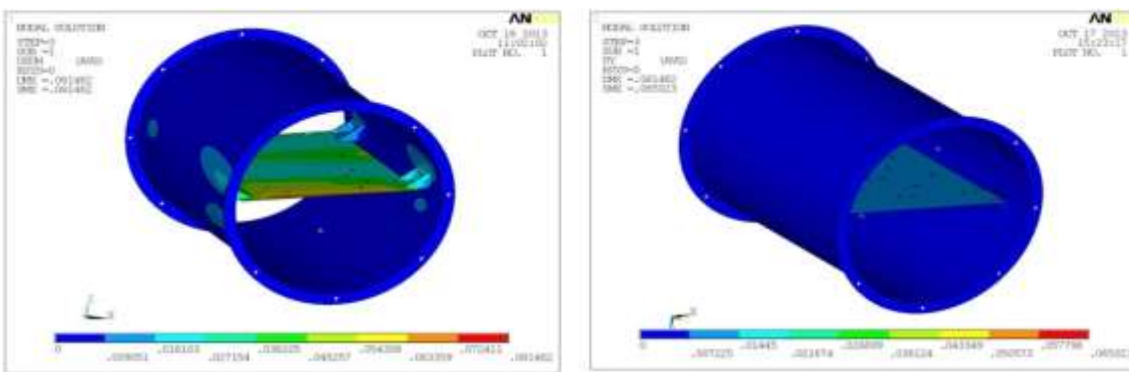


Fig 34 shows 1 sigma displacement for PSD analysis in Y-Direction

- 1 sigma deflection observed on the mounting structure= 0.08 mm
- Therefore 3 sigma deflection on the mounting structure = 0.24 mm
- This implies that only 0.3% of the time the mounting structure deflection reaches 0.24mm

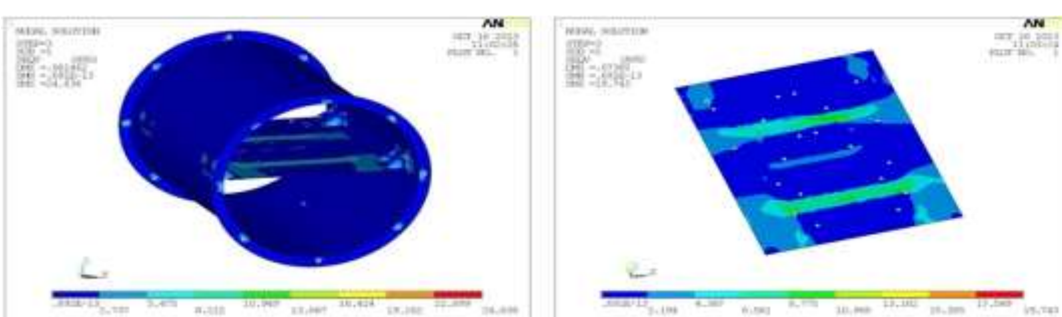


Fig 35 shows 1 sigma stress for PSD analysis in Y-Direction

- 1 sigma stress observed on the mounting structure= 24.6 N/mm2
- Therefore 3 sigma stress on the mounting structure = 73.8 N/mm2
- This implies that only 0.3% of the time the mounting structure stress reaches 73.8 N/mm2

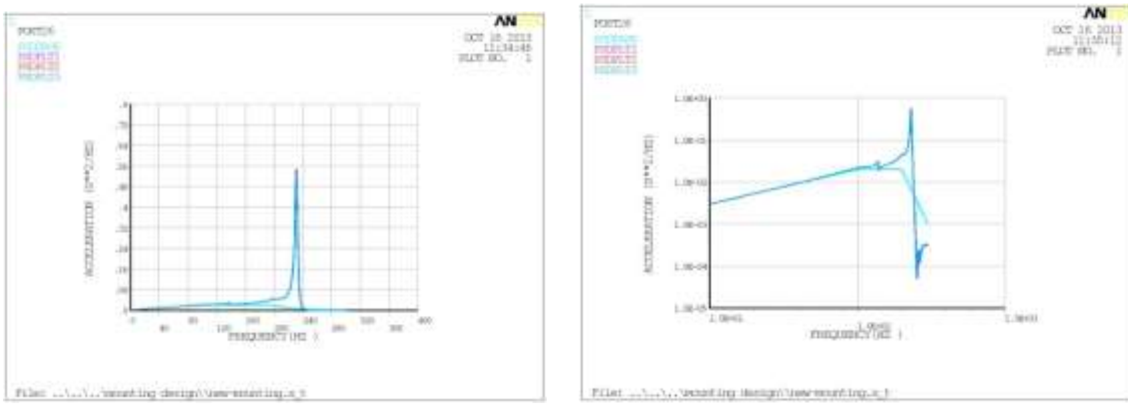


Fig 36 Shows PSD Response on plate on electronic packages in Linear and Logarithmic Scale

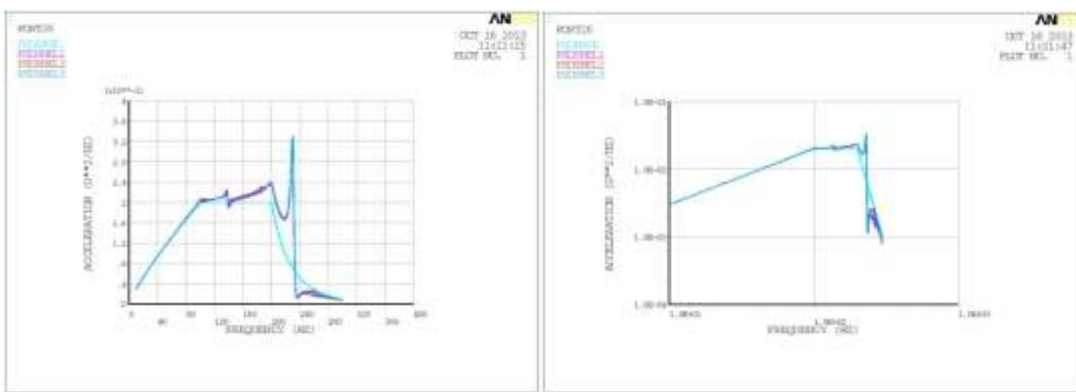


Fig 37 Shows PSD Response on plate on outer shell in Linear and Logarithmic Scale

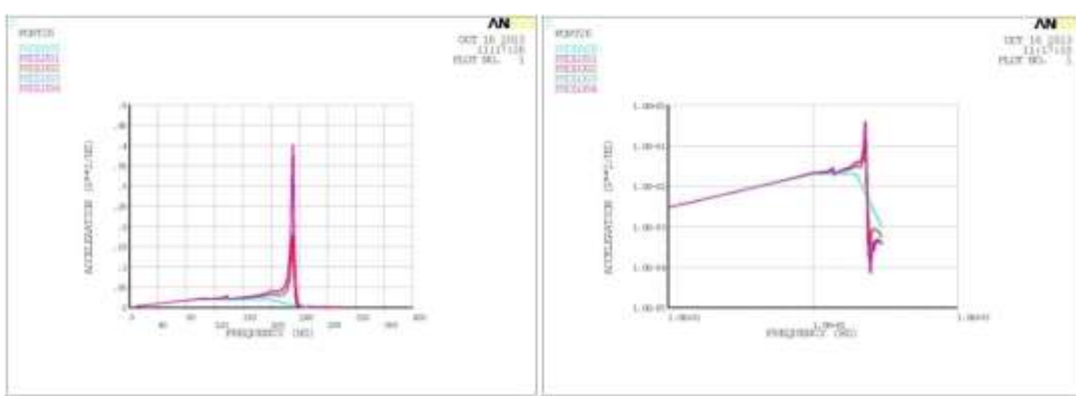


Fig 38 Shows PSD Response on plate lugs in Linear and Logarithmic Scale

From the above graphs it is seen that

- Maximum PSD response on the PLATE is 0.54 g2/Hz at a frequency of 230.5Hz
- Maximum PSD response on the shell is 3.3 g2/Hz at a frequency of 230.5 Hz
- Maximum PSD response on the lugs is 0.4 g2/Hz at a frequency of 230 Hz

C. PSD analysis along z- direction

PSD analysis is carried out on modified model with base excitation in Z direction from 0-300Hz

Boundary Conditions:

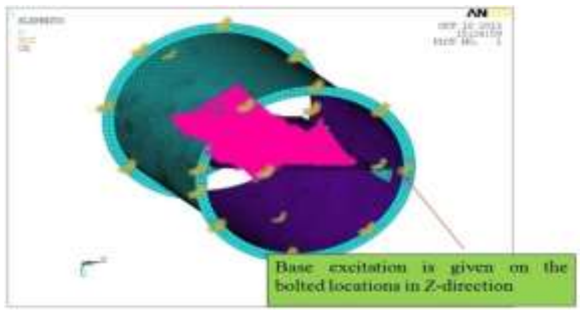


Fig 39 Shows Boundary conditions applied on the mounting structure for PSD analysis in Z-Direction

Results

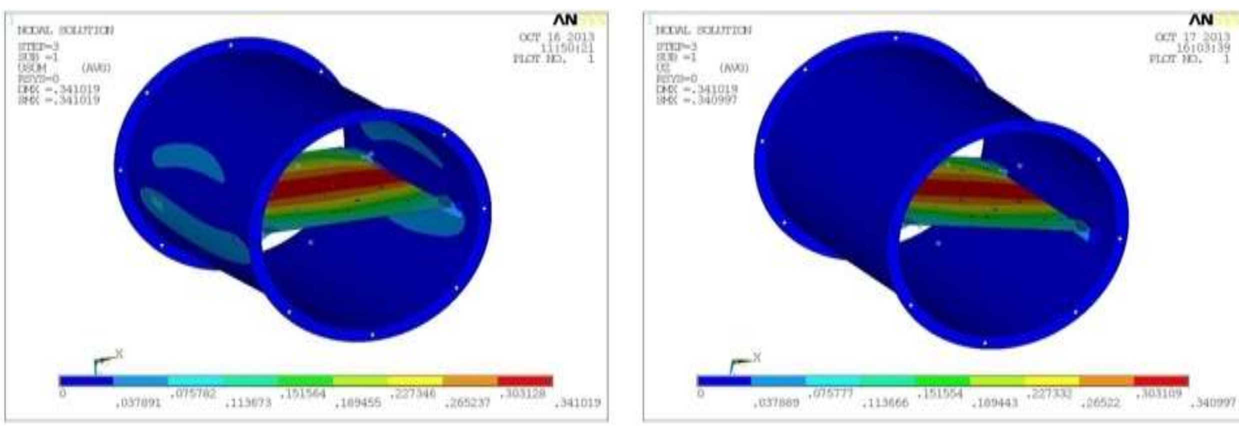


Fig 40 shows 1 sigma displacement for PSD analysis in Z-Direction

- 1 sigma deflection observed on the mounting structure= 0.34 mm
- Therefore 3 sigma deflection on the mounting structure = 1.02 mm
- This implies that only 0.3% of the time the mounting structure deflection reaches 1.02mm

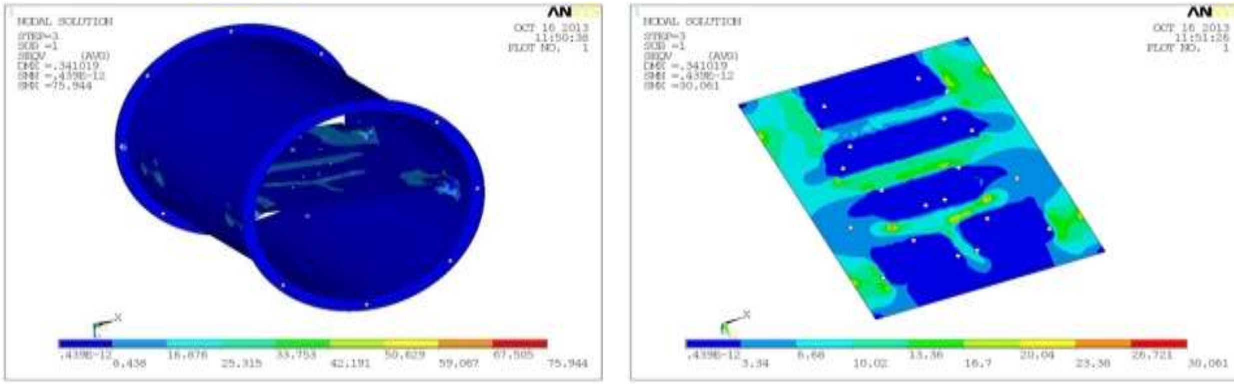


Fig 41 shows 1 sigma stress for PSD analysis in Y-Direction

- 1 sigma stress observed on the mounting structure= 75 N/mm2
- Therefore 3 sigma stress on the mounting structure = 225 N/mm2
- This implies that only 0.3% of the time the mounting structure stress reaches 225 N/mm2

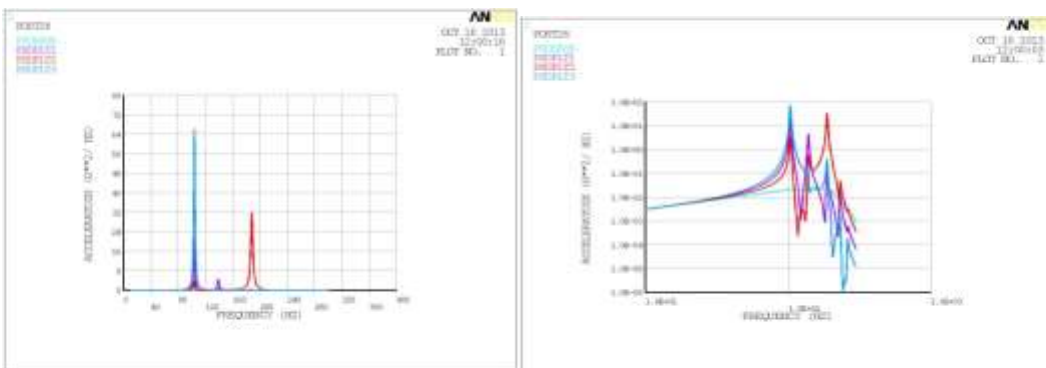


Fig 42 Shows PSD Response on plate on electronic packages in Linear and Logarithmic Scale

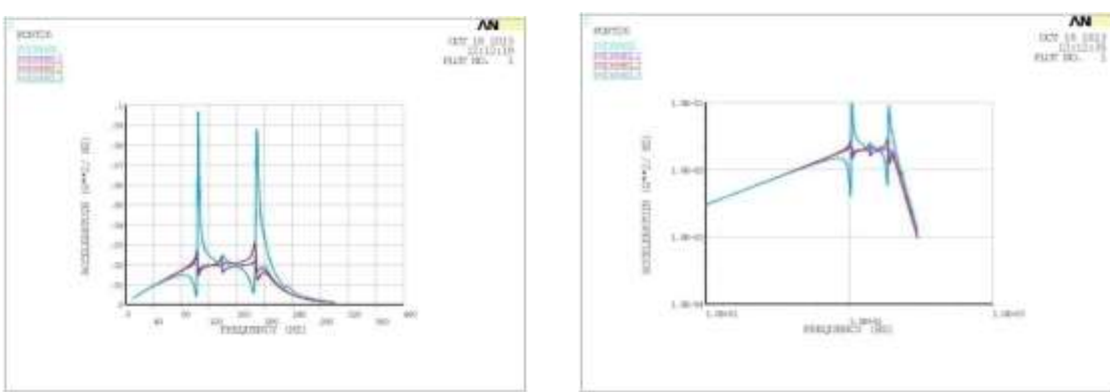


Fig43 Shows PSD Response on outer shell in Linear and Logarithmic Scale

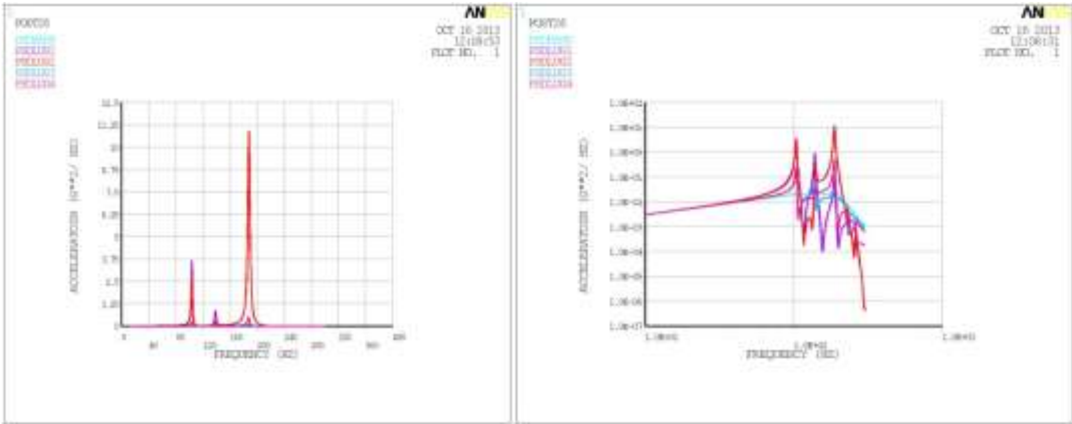


Fig 44 Shows PSD Response on lugs in Linear and Logarithmic Scale

From the above graphs it is seen that

- Maximum PSD response on the PLATE is 66.4 g2/Hz at a frequency of 103 Hz
- Maximum PSD response on the Shell is 0.1 g2/Hz at a frequency of 105 Hz
- Maximum PSD response on the lugs is 11.05 g2/Hz at a frequency of 180 Hz

VIII. Response Spectrum Analysis

A Response spectrum is simply a plot of the peak or steady-state response (displacement, velocity or acceleration) of a series of oscillators of varying natural frequency, that are forced into motion by the same base vibration or shock. The resulting plot can then be used to pick off the response of any linear system, given its natural frequency of oscillation. One such use is in assessing the peak response of buildings to earthquakes.

The mounting structure is subjected to a base excitation of 0.4mm in X, Y and Z directions. Response spectrum analysis has been carried out on the mounting structure to check the effectof mode combination of the existing natural frequencies.SRSS mode combination is used for the analysis. The boundary conditions used for the RSA are shown in Fig 45.

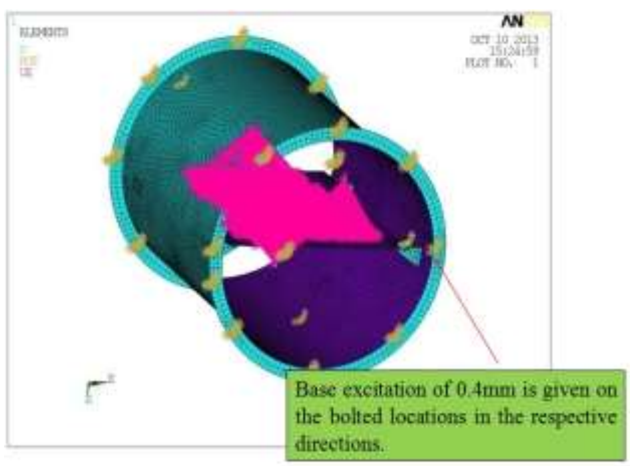


Fig 45Shows Boundary conditions applied on the mounting structure for RSA analysis

A. Results-RSA analysis along X- direction

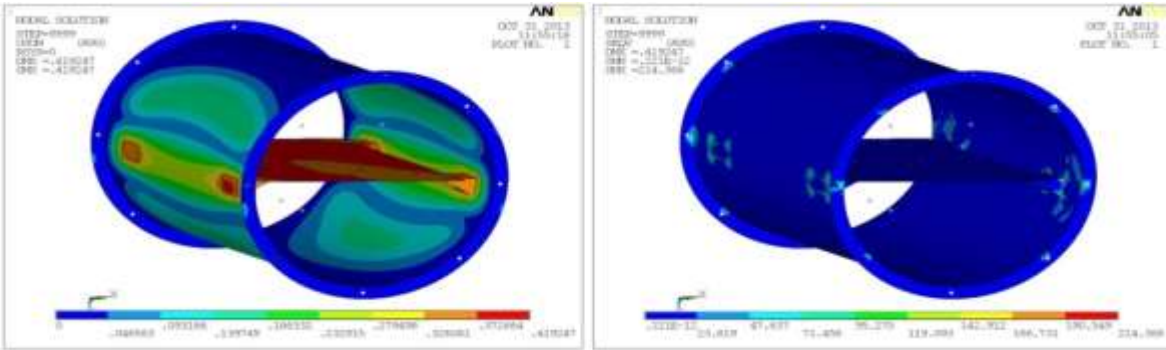


Fig 46 shows Deflections & Stress plot of mounting structure for X-Direction

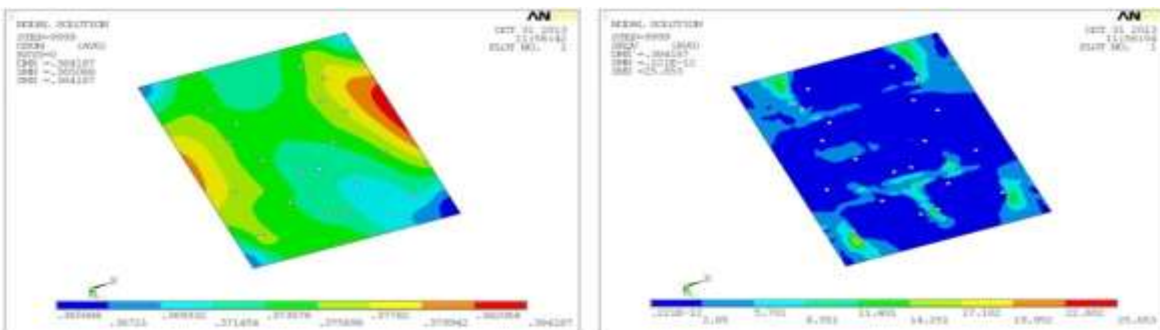


Fig 47 shows Deflections & Stress plot of mounting plate for X-Direction

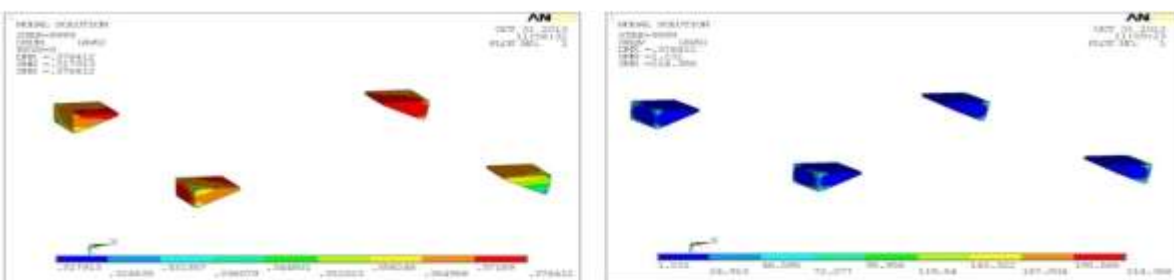


Fig 48 shows Deflections & Stress plot of lugs for X-Direction

B. Results-RSA analysis along Y- direction

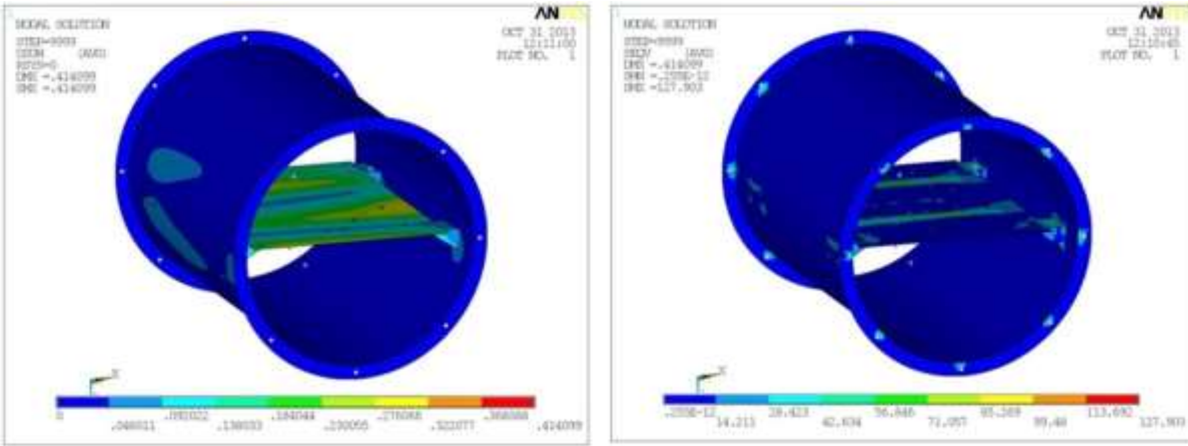


Fig 49 shows Deflections & Stress plot of mounting structure for Y-Direction

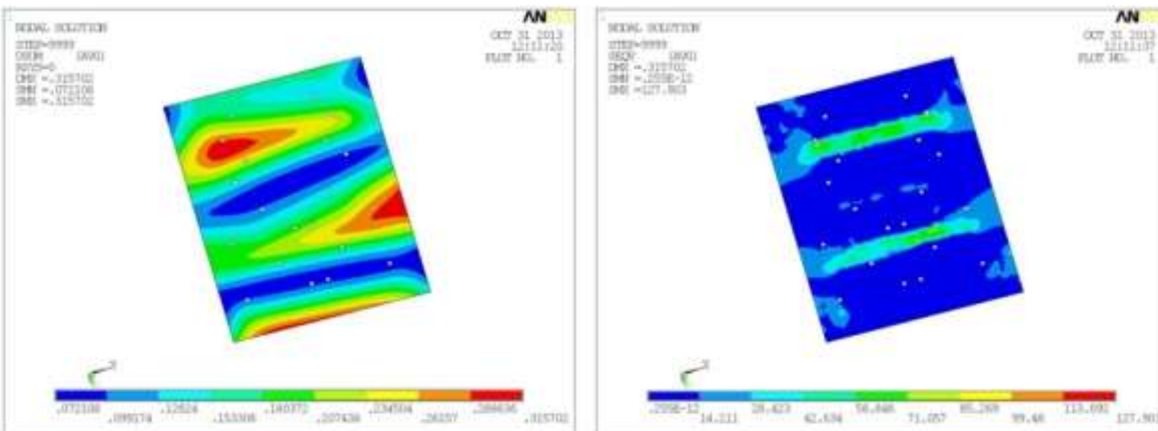


Fig 50 shows Deflections & Stress plot of mounting plate for Y-Direction

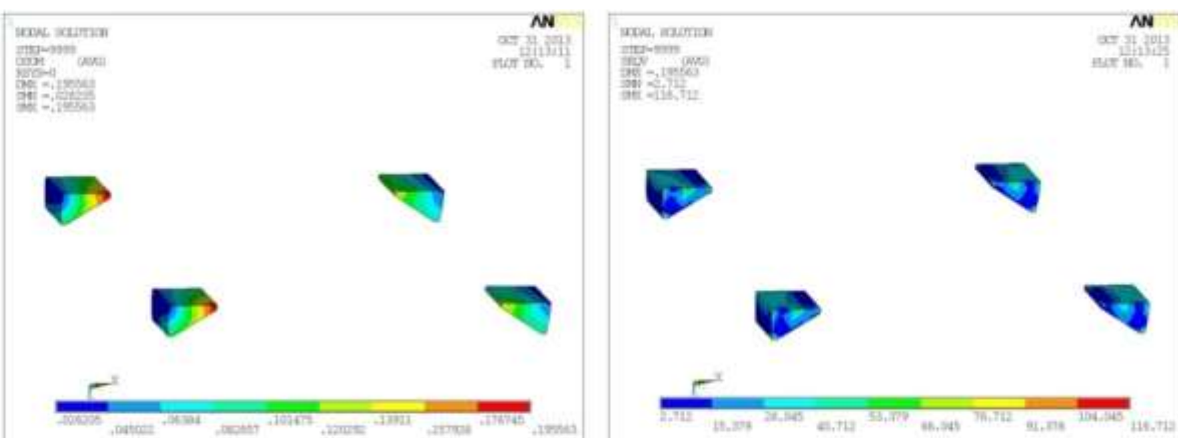


Fig 51 shows Deflections & Stress plot of lugs for Y-Direction

C. Results-RSA analysis along Z- direction

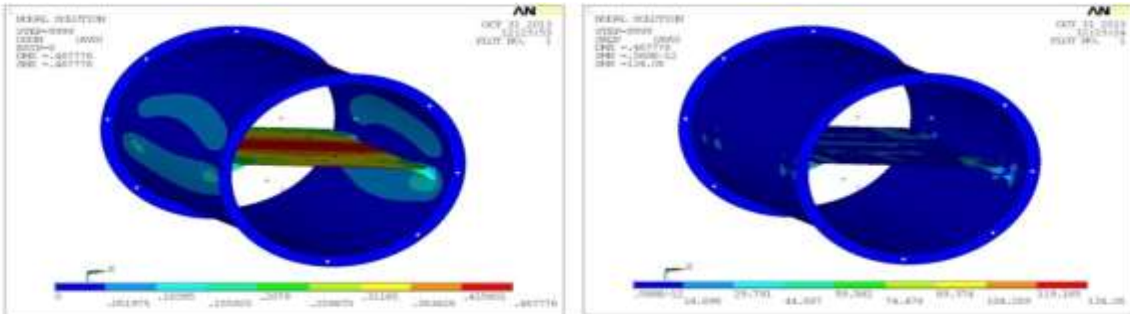


Fig 52 shows Deflections & Stress plot of mounting structure for Z-Direction

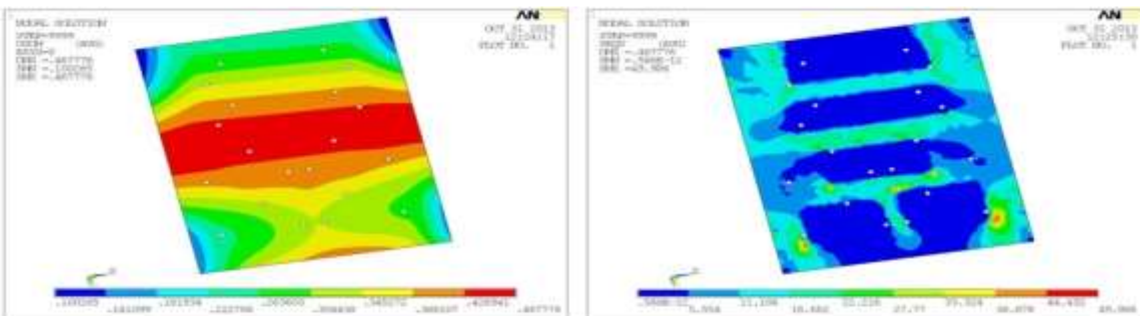


Fig 53 shows Deflections & Stress plot of mounting plate for Z-Direction

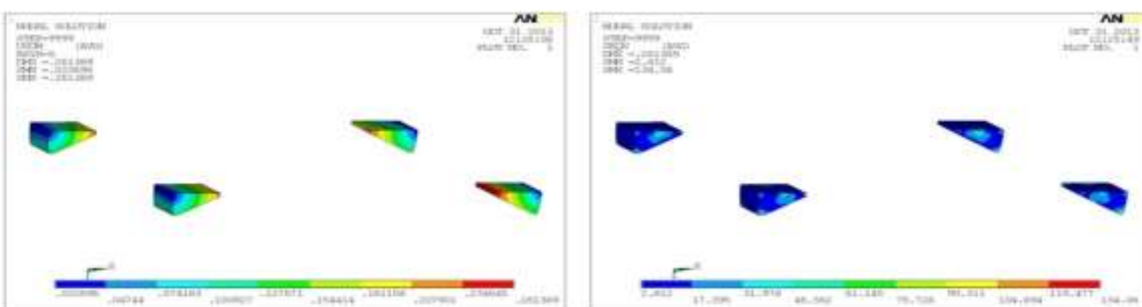


Fig 54 shows Deflections & Stress plot of lugs for Z-Direction

IX.Results and Discussions

To check the structural integrity of the mounting structure, the following analysis has been performed

- Structural static analysis of the mounting structure
- for YAW condition.
- Structural static analysis of the mounting structure for PITCH condition.
- Structural static analysis of the mounting structure for ROLL condition.

- Modal analysis of the mounting structure.
- PSD analysis of the mounting structure in X-direction.

The summary of the results obtained is shown in the below table.

STATIC ANALYSIS FOR YAW CONDITION			
S.No	Component	Total Deflection (mm)	VonMises Stress (N/mm2)
1	MOUNTING STRUCTURE	0.33	53
2	MOUNTING PLATE	0.33	11.2
3	LUGS	0.125	53
STATIC ANALYSIS FOR PITCH CONDITION			
S.No	Component	Total Deflection (mm)	VonMises Stress (N/mm2)
1	MOUNTING STRUCTURE	0.26	200
2	MOUNTING PLATE	0.26	65.9
3	LUGS	0.21	200
STATIC ANALYSIS FOR ROLL CONDITION			
S.No	Component	Total Deflection (mm)	VonMises Stress (N/mm2)
1	MOUNTING STRUCTURE	1.87	225
2	MOUNTING PLATE	1.87	74.5
3	LUGS	1.83	225

PSD analysis of the mounting structure in Y-direction.

- PSD analysis of the mounting structure in Z-direction.
- RSA analysis of the mounting structure in X-direction.
- RSA analysis of the mounting structure in Y-direction.
- RSA analysis of the mounting structure in Z-direction

PSD ANALYSIS IN X-DIR			
S.No	Component	Total Deflection (mm)	VonMises Stress (N/mm2)
1	MOUNTING STRUCTURE	0.45	249
2	MOUNTING PLATE	0.45	27
3	LUGS	0.45	249
PSD ANALYSIS IN Y-DIR			
S.No	Component	Total Deflection (mm)	VonMises Stress (N/mm2)
1	MOUNTING STRUCTURE	0.24	73.8
2	MOUNTING PLATE	0.24	60
3	LUGS	0.24	73.8

PSD ANALYSIS IN Z-DIR			
S.No	Component	Total Deflection (mm)	VonMises Stress (N/mm2)
1	MOUNTING STRUCTURE	1.02	225
2	MOUNTING PLATE	1.02	90
3	LUGS	1.02	225
RSA ANALYSIS IN X-DIR			
S.No	Component	Total Deflection (mm)	VonMises Stress (N/mm2)
1	MOUNTING STRUCTURE	0.4	214
2	MOUNTING PLATE	0.3	25
3	LUGS	0.37	214
RSA ANALYSIS IN Y-DIR			
S.No	Component	Total Deflection (mm)	VonMises Stress (N/mm2)
1	MOUNTING STRUCTURE	0.41	127
2	MOUNTING PLATE	0.31	127
3	LUGS	0.19	116
RSA ANALYSIS IN Z-DIR			
S.No	Component	Total Deflection (mm)	VonMises Stress (N/mm2)
1	MOUNTING STRUCTURE	0.46	134
2	MOUNTING PLATE	0.46	49
3	LUGS	0.26	134

Table 5.summary of the results on the mounting structure assembly

X.Conclusions

Finite element analysis plays a very vital role in designing the mounting structure used for flight vehicles. The forces developed due to pitch, roll and yaw can damage the structure. Similarly vibrations generated on the mounting structure are very harmful and can damage the structure, so they cannot be over looked. In the present study we have carried out the finite element analysis on the mounting structure assembly for static as well as vibration loads. From the above analysis the maximum stress observed is 249Mpa for PSD in X-direction. This stress is less than the yield strength of the material. So it can be concluded that the mounting structure assembly is safe for the for the above said loads.

Acknowledgments

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