



NUMERICAL ANALYSIS OF AN AIRCRAFT PROTOTYPE MODEL BY USING NX NASTRAN

¹B. Purna Chandra Sekhar, ²N Raghu Samrat, ³K Karthikeya

¹Asstt. Professor, Mechanical Department, ANU College of engineering and technology, Guntur

²Engineer (Technical Services), Designtech systems pvt.ltd

³PG Scholar, Mechanical Department, ANU College of engineering and technology, Guntur

Abstract: Main aim of this paper is to determine modal analysis and numerical simulation to verify the structural characteristics of an aircraft. This paper details about natural frequencies and vibration mode shapes were obtained via measurement in NX Nastran. The frequency response function were identified and computed, FEM modal analysis was also implemented and its numerical results convincingly presented the mode shape and natural frequencies of aircraft is to be mentioned. Vibration response to different rotation speeds have been collected, managed and analyzed through the use of NX Nastran. Evident Phenomena have been discovered including the resonance on which most analysis is focused because of its potential use to generate larger amplitude vibration of specific frequency or to avoid such resonant frequencies from a wide spectrum of response.

Index Terms - Aircraft, NX Nastran, FEM, Mode Shapes, Natural Frequencies.

1. INTRODUCTION

Our mechanical engineering program mechanical vibration course has been completely based in theory and vibration. In my paper on vibration to know how much these are important in engineering application whether it is advantage or disadvantage based on application and how much vibration technology is developed day to day application and conducting experiments to overcome in critical situations. Condition monitoring is a very useful concept to study of these vibrations and monitoring that the reason affecting the cause of vibrations. In this paper firstly creating FEM model and simulating in CAE software conducting the transient analysis, random analysis based on the number of modes that we required and plotting the results by using XY navigator.

Vibration controlling methods

- Forced reduction
- Mass addition
- Tuning
- Isolation
- Damping

2. CONDITION MONITORING

Condition monitoring is a process of monitoring a parameter of condition in machinery (Vibration and Temperature) in order to identify a significant change. It is major component of predictive maintenance. It refers to the continuous monitoring of the equipment state and operating parameters usually through dedicated sensors and monitoring tools. Its end goal is to identify changes that indicate damage, incorrect configuration or other safety impacting conditions, so that corrective maintenance repairs can be performed before a failure gets the change to occur.

Vibration Analysis/ Dynamic Monitoring

Equipment and parts respond to vibrations in a variety of ways that can be used to identify defects due to misalignments, imbalances or design flaws. Wear on machine parts, bearings, rotors and shafts cause these shafts to vibrate with specific patterns that can be recorded and analyzed. Different parts vibrate in different ways, and worn or out of balance parts have unique vibrations signatures that can be traced and used to predict parts failures.

Techniques Include

- Shock pulse analysis
- Fast Fourier Transform
- Broadband vibration analysis
- Ultrasonic analysis
- Power spectral density
- Time wave form analysis
- Spectrogram/spectrum analysis

Predictive maintenance

Predictive maintenance (PDM) is the process of monitoring the condition of machinery as it operates in order to predict which parts are likely to fail and when. In this way maintenance can be planned and there is an opportunity to change only those parts that are showing sign of deterioration or damage.

The main benefits of PDM are:

- Improved machine reliability through the effective prediction of equipment failures.
- Reduced maintenance cost by minimizing downtime through the schedule of equipment repairs.
- Increased production through greater machine availability.
- Low energy consumption.
- Extended bearing service life.
- Improved product quality.

Fast Fourier Transform

FFT defined as an algorithm used to calculate a spectrum from a time waveform. Any waveform is actually just the sum of series of simple sinusoids of different frequencies, amplitudes and phases. A Fourier series is that summation of sine waves, we use Fourier analysis or spectrum analysis to deconstruct a single into its individual sine wave components. The result is acceleration /vibration amplitude as a function of frequency, which allows performing analysis in the frequency domain to gain a deeper understanding of the vibration profile. Most vibration analysis will typically be done in frequency domain.

A discrete Fourier transform (DFT) computes the spectrum, but now a days this has become synonymous with the fast Fourier transform (FFT), which is just an efficient algorithm for the DFT.

The important thing to understand is that the number of discrete frequencies that are tested as a part of Fourier transform is directly proportional to the number of samples in the original waveform. With N being the length of the signal. The number of frequency lines or bins equal to $N/2$. These frequency bins occur at interval (Δf) equal to the sample rate of the raw waveform (F_s) divided by the number of samples (N) which is another way of saying that the frequency resolution is equal to the inverse of total acquisition (T).

In other words, its calculations intended to breakdown a signal into all its frequencies. Fast Fourier transform converts a signal from time domain into the frequency domain. Fast Fourier Transform is most often used for detecting machine faults like misalignment or unbalance.

Power Spectral Density

Power spectral density is calculated by multiplying the amplitude from the FFT by its different forms to normalize it with frequency bin width (bin width refers to grouped x-axis values). PSD actually compares random vibration signals that have different wavelength signals.

A lot of real-world vibration is considered "random" because it occurs at many frequencies simultaneously. Although FFTs are great at analyzing vibration when there are a fine number of dominant frequency components, power spectral densities (PSD) are used to characterize random vibration signals. A PSD is computed by multiplying each frequency bin in an FFT by its complex conjugate which results in the only spectrum of amplitude g^2 . The key aspect of PSD that makes it more useful than a FFT for a random vibration analysis is that this amplitude value is normalized to the frequency bin width to get units of g^2/Hz . Normalizing the result eliminates the dependency on bin width allowing for the comparison of vibration signals of different lengths.

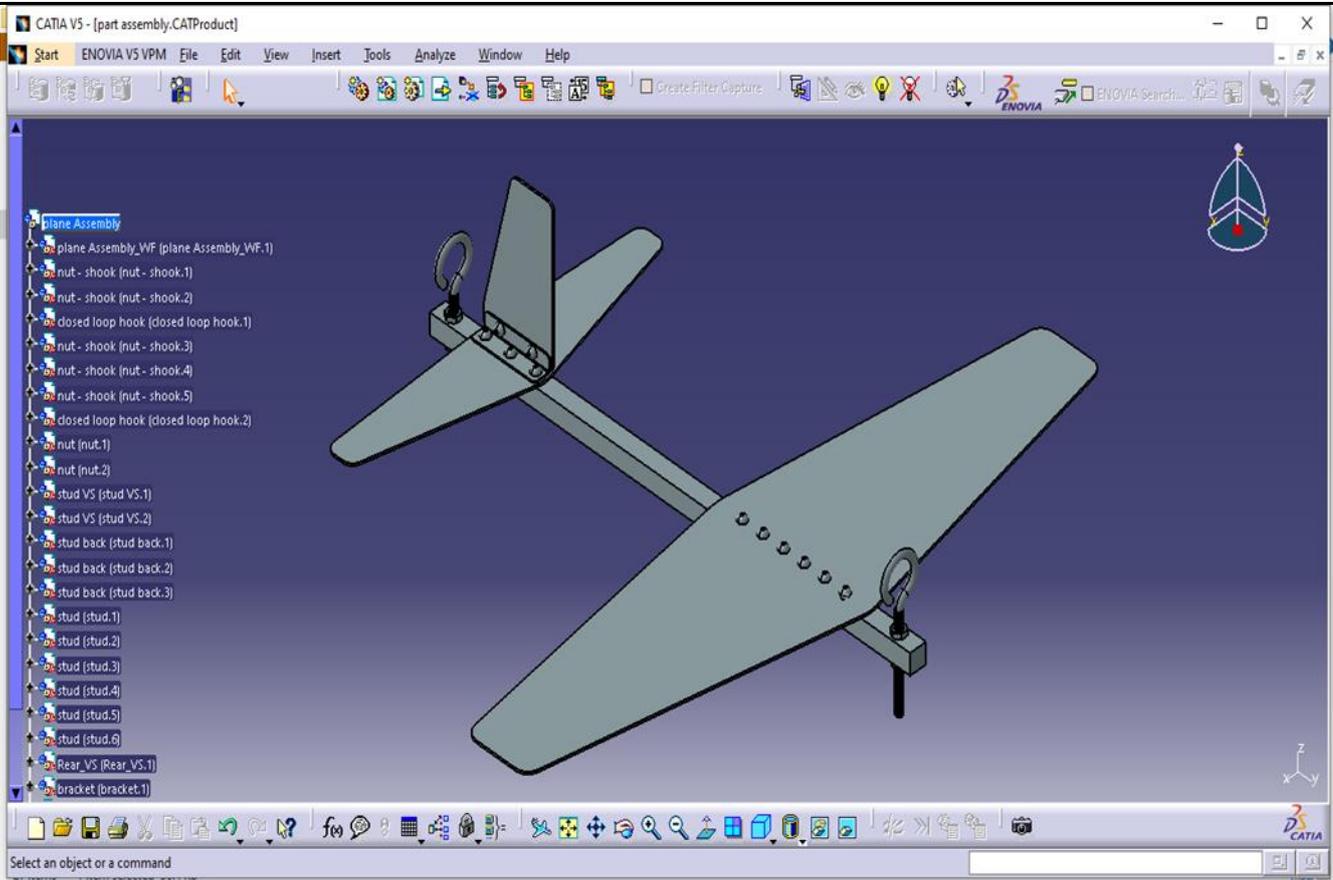
PSDs are powerful because the area under the curve in the frequency domain represents the RMS vibration level for the frequency range, and RMS vibration is related to the energy in the environment. PSDs are also often used in test standards because of how they cancel out the effect of bandwidth of a frequency spectrum.

In vibration analysis PSD stands for the Power Spectral Density of a signal. Each word is chosen to represent an essential component of the PSD.

Power refers to the fact that the magnitude of the PSD is the mean square value of the signal being analyzed. It does not refer to the physical quantity power. But since power is proportional to mean square value of some quantity, the mean-square value of any quantity known as the power of that quantity.

Spectral to the fact that the PSD is a function of the frequency. The PSD represents the distribution of a signal over a spectrum of frequencies just like a rainbow represents the distribution of light over a spectrum of wavelengths.

Density refers to the fact the magnitude of the PSD is normalized to a signal hertz bandwidth.

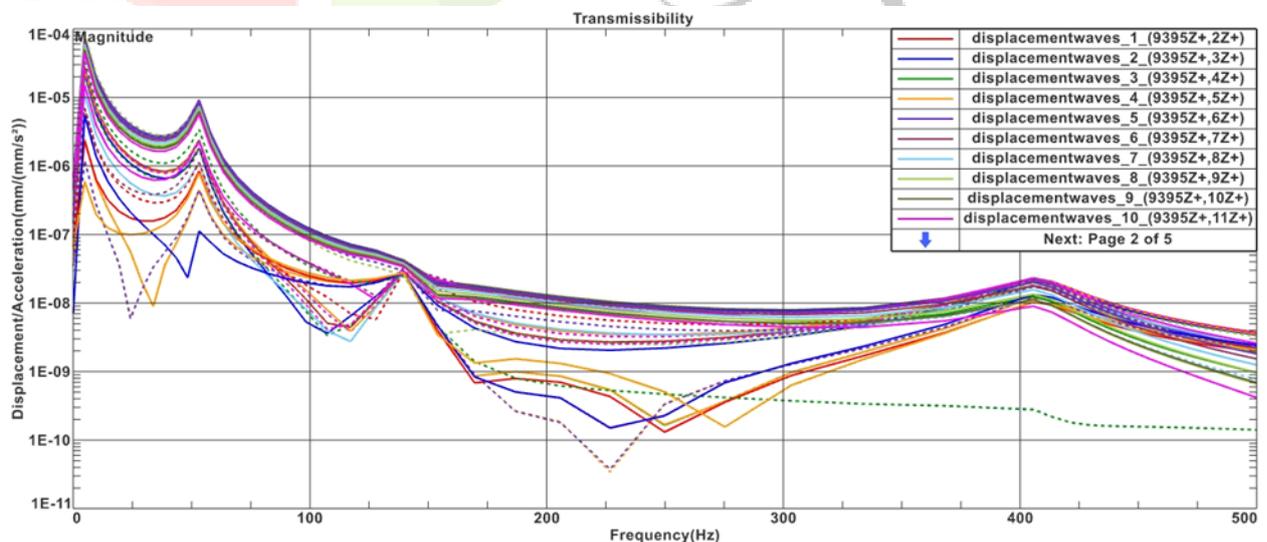


3D CAD MODEL

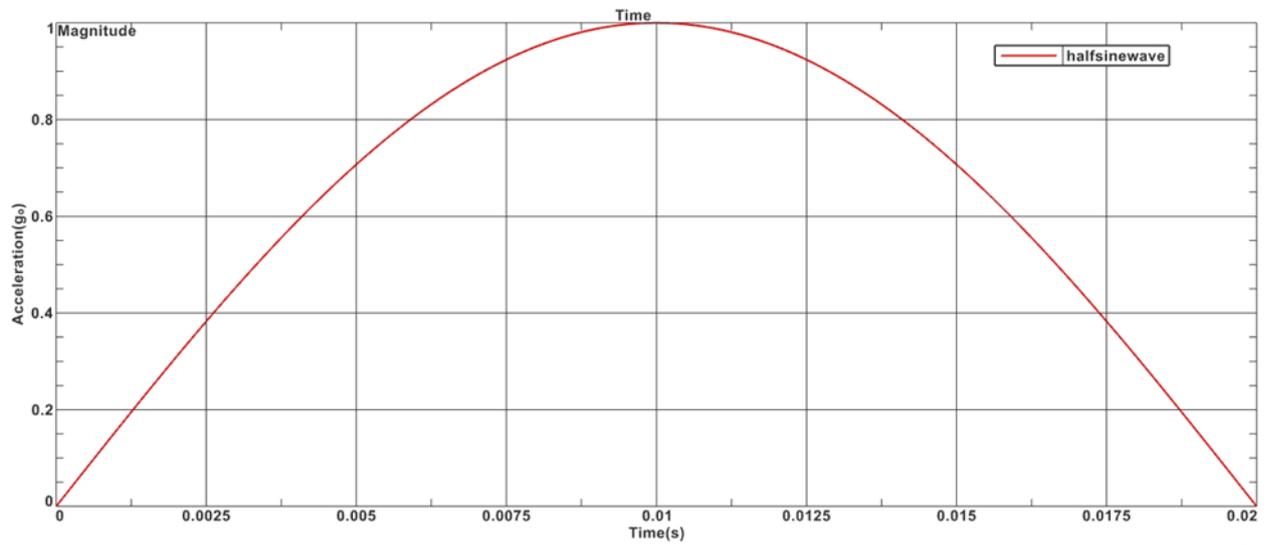
Component Name	Quantity
Bracket	1
Closed look hook	2
Front HS	1
Long Bar	1
Nut Shook	12
Rear HS	1
Stud	12

3. RESULTS

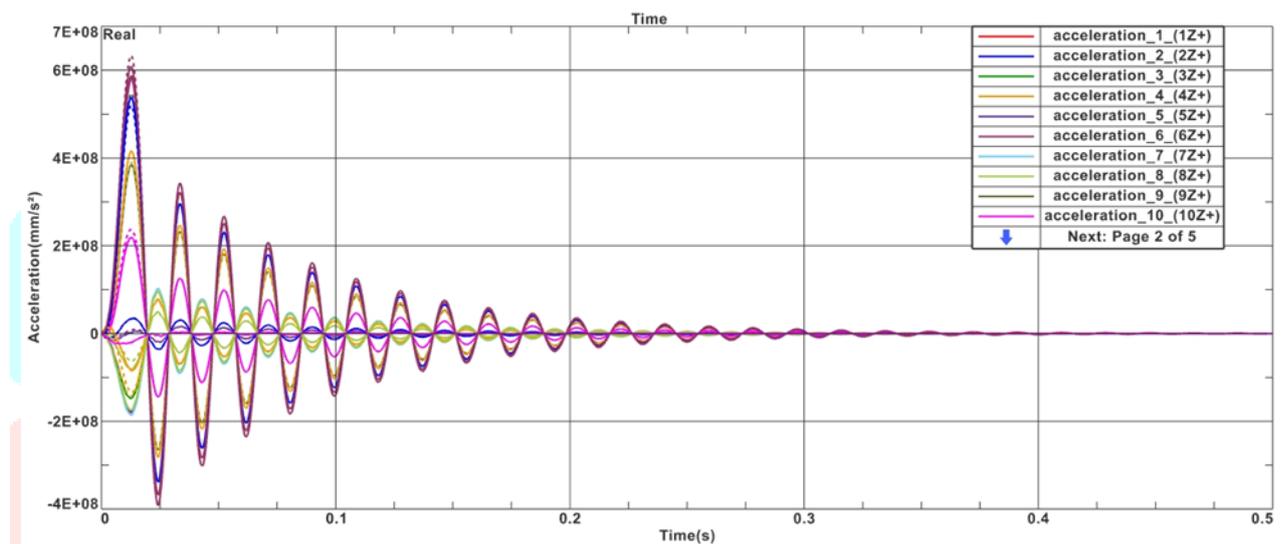
Based on ALUMINIUM



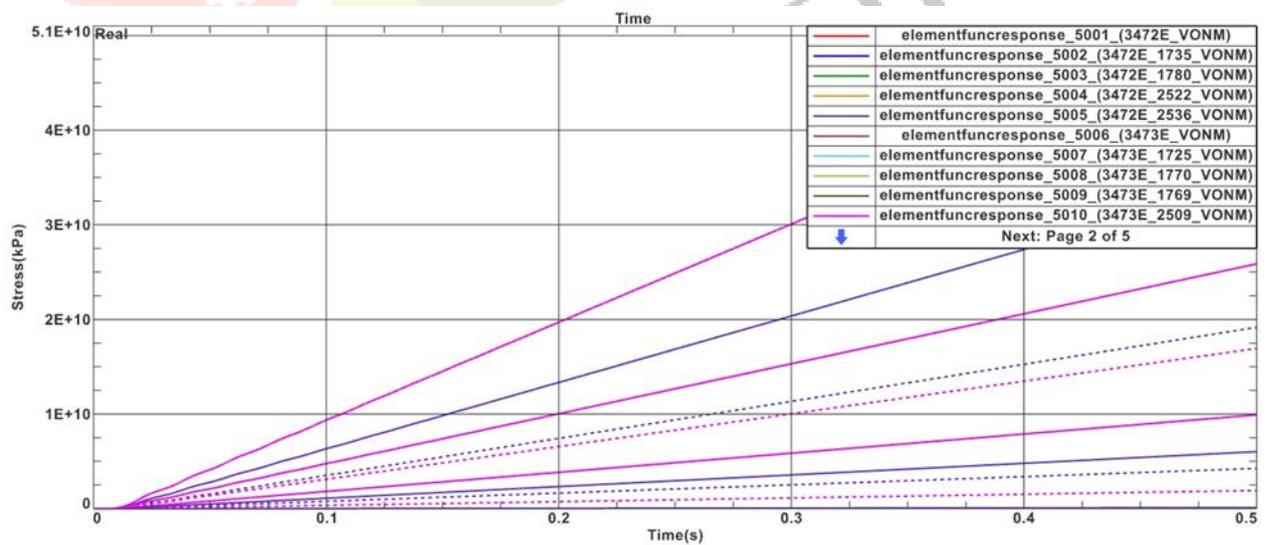
Transmissibility Graph



Half Sine Wave

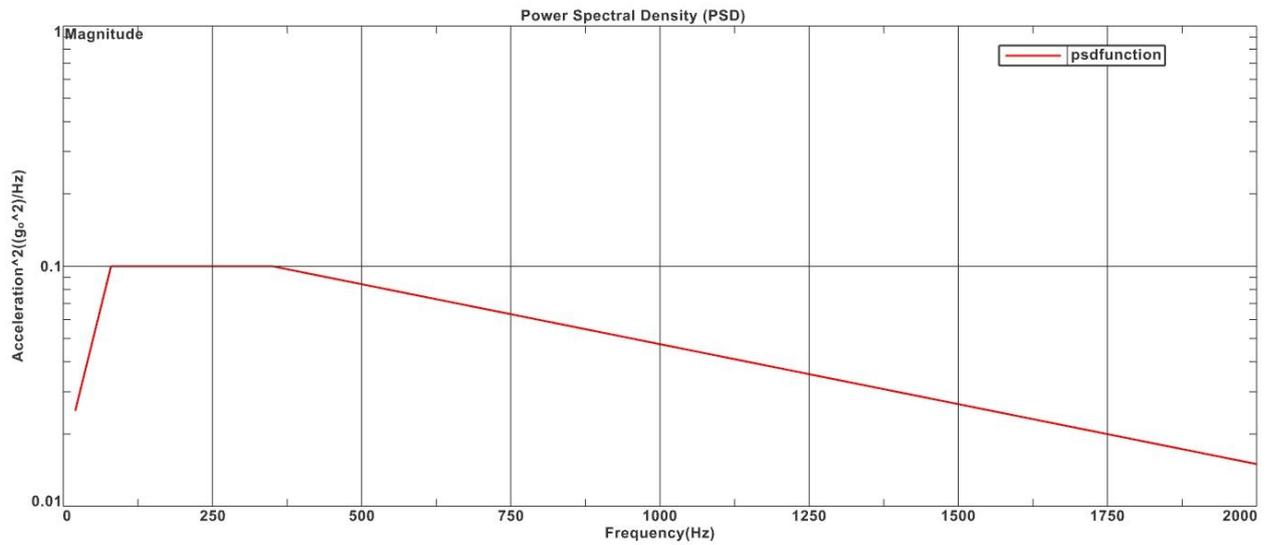


Nodal Response Function

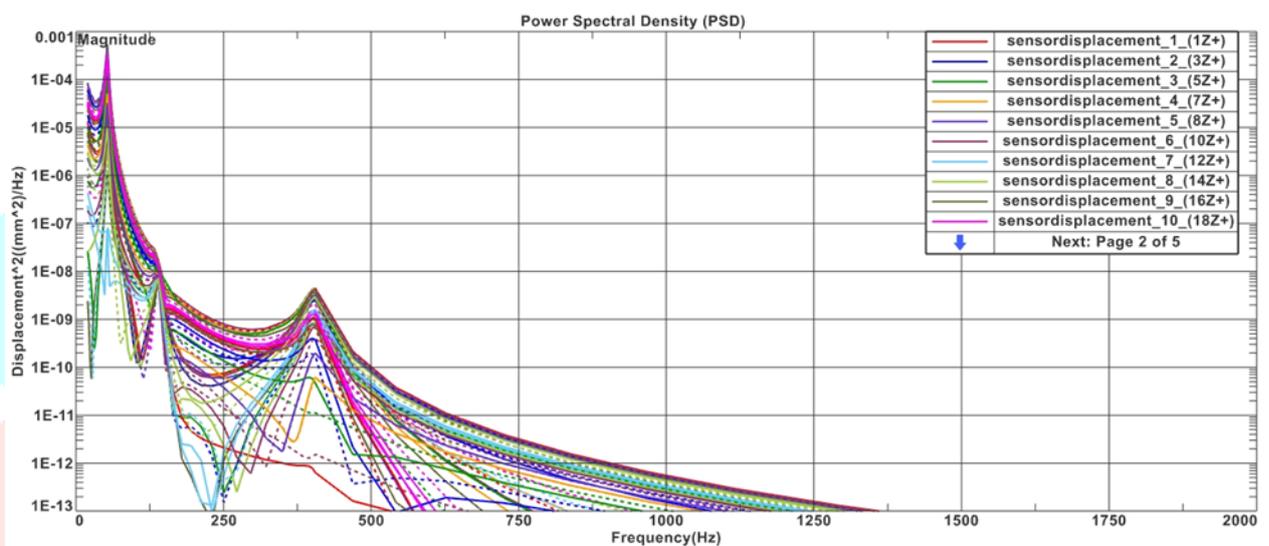


Element Response Function

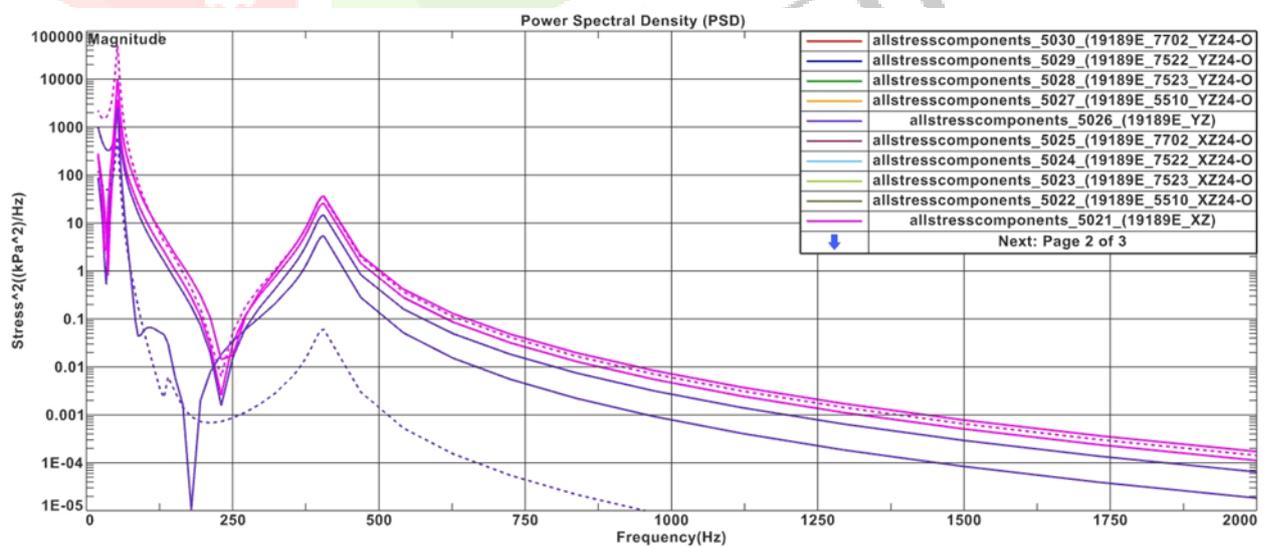
Random Analysis



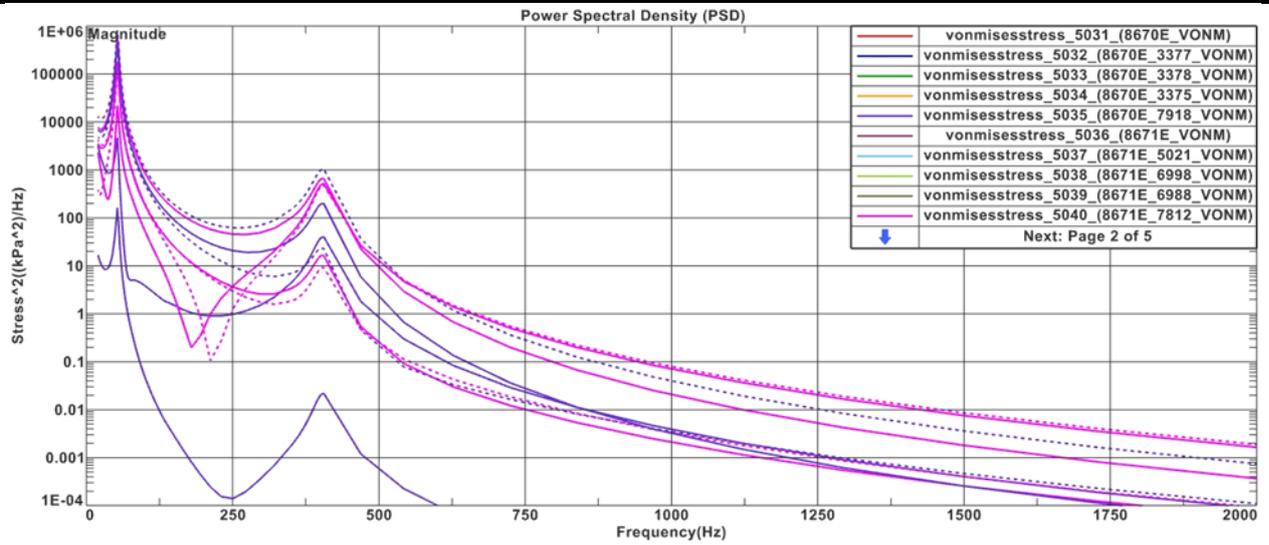
PSD Graph



Sensor Displacement Graph

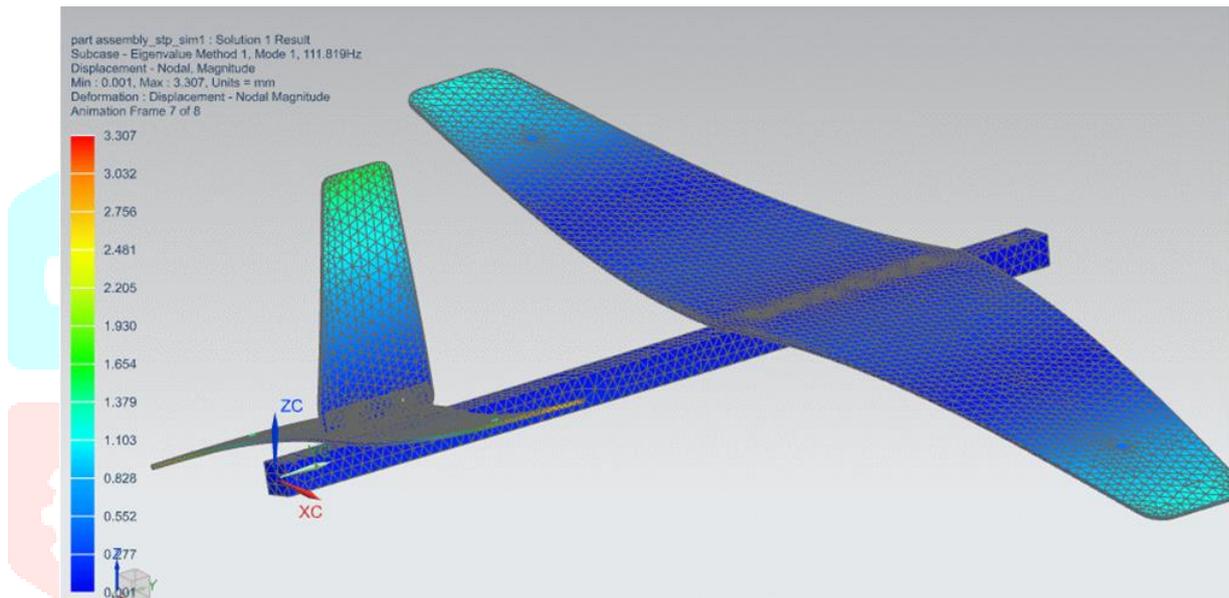


Stress in all directions at node 19189

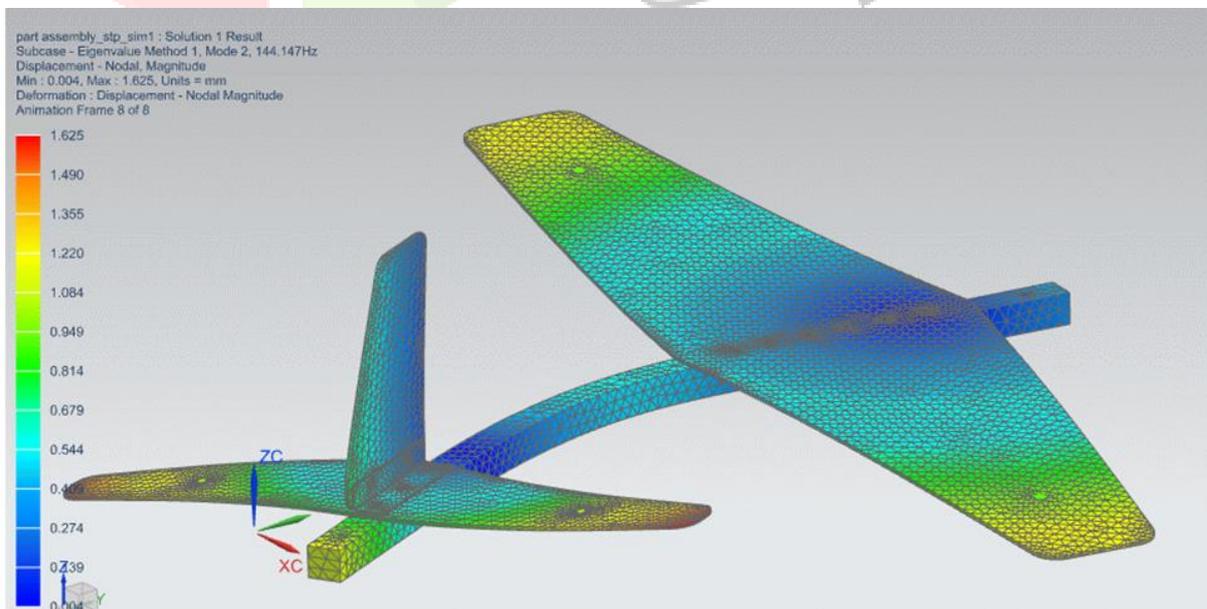


Vonmises stress at 8670

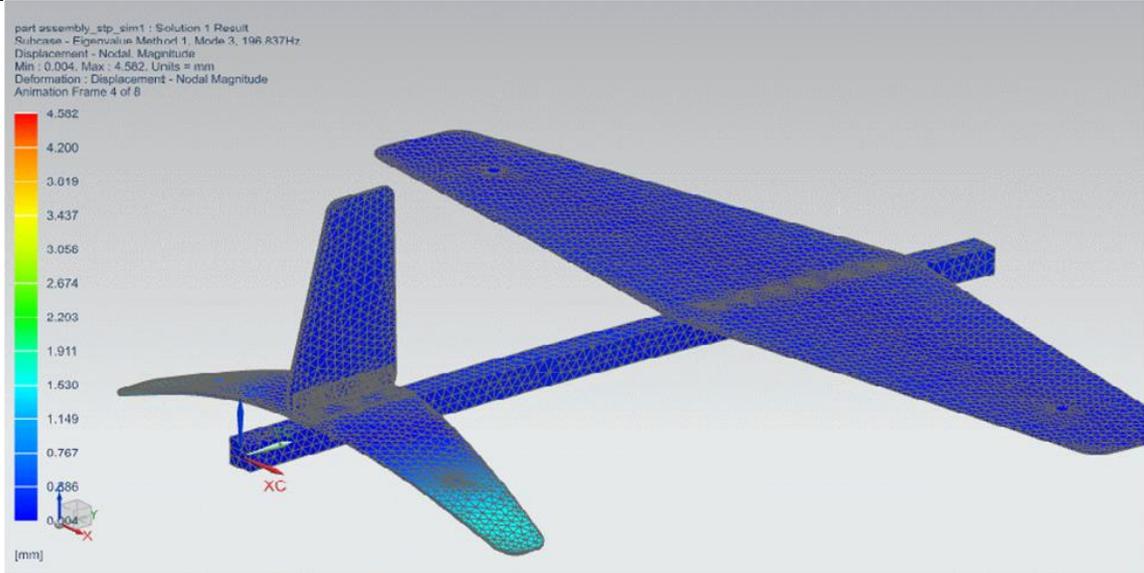
Modes for Aluminum



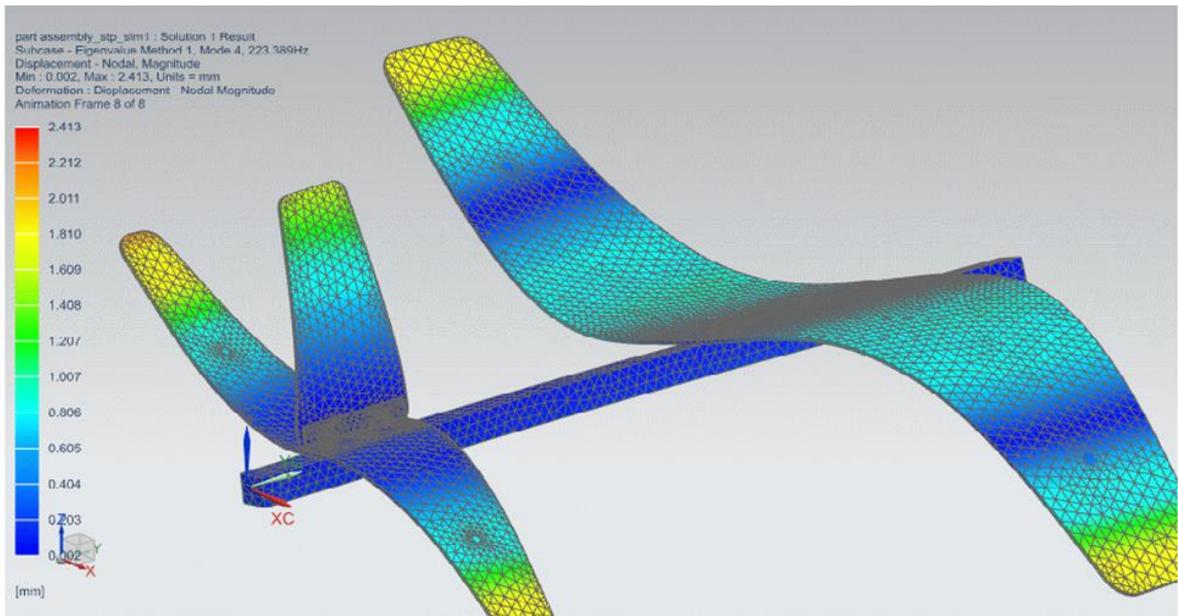
Mode1 111.819 Hz



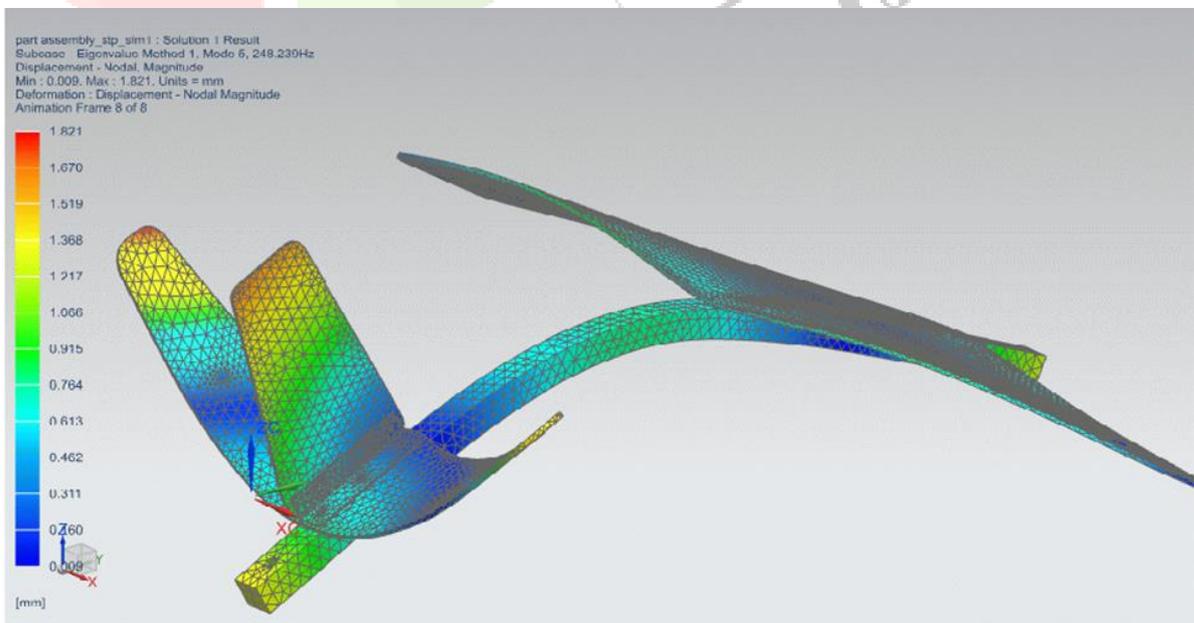
Mode2 144.147 HZ



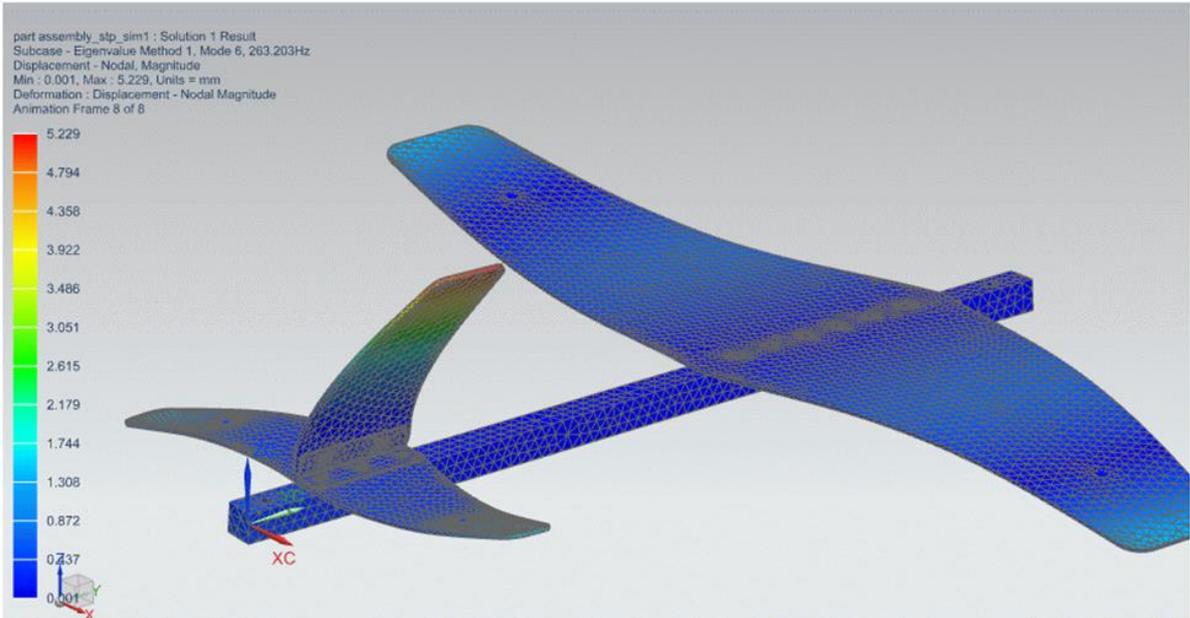
Mode3 196.837



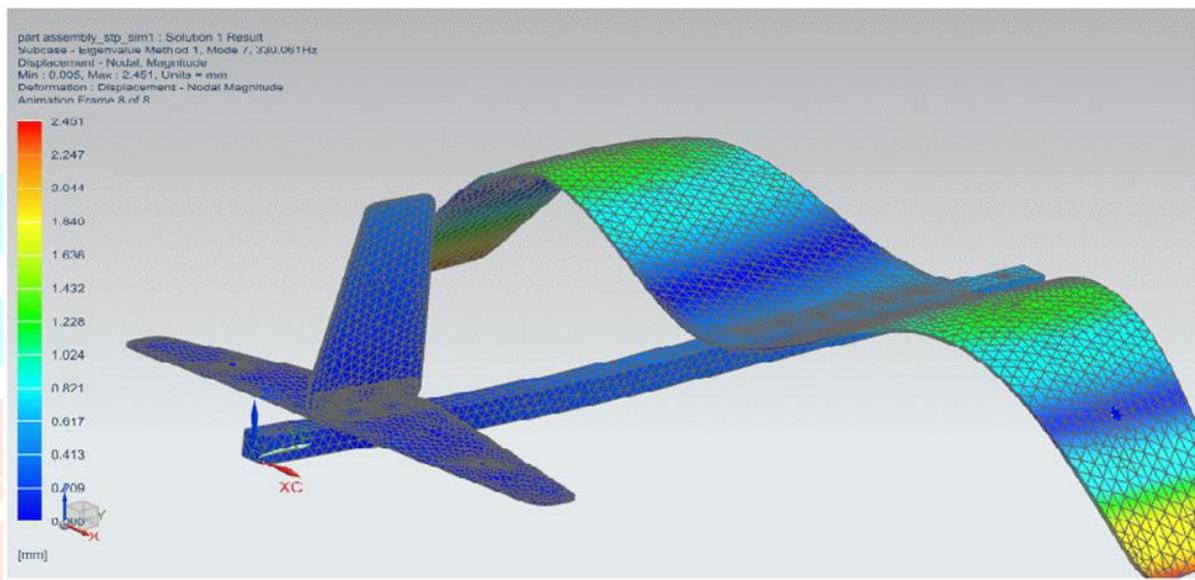
Mode4 223.389 HZ



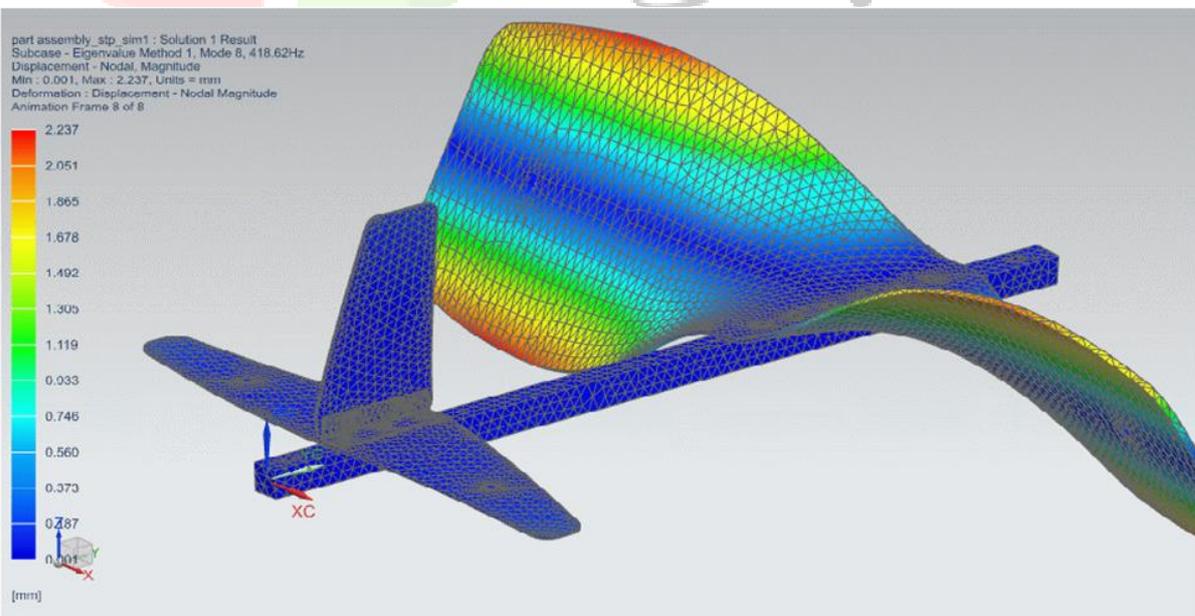
Mode5 248.239 HZ



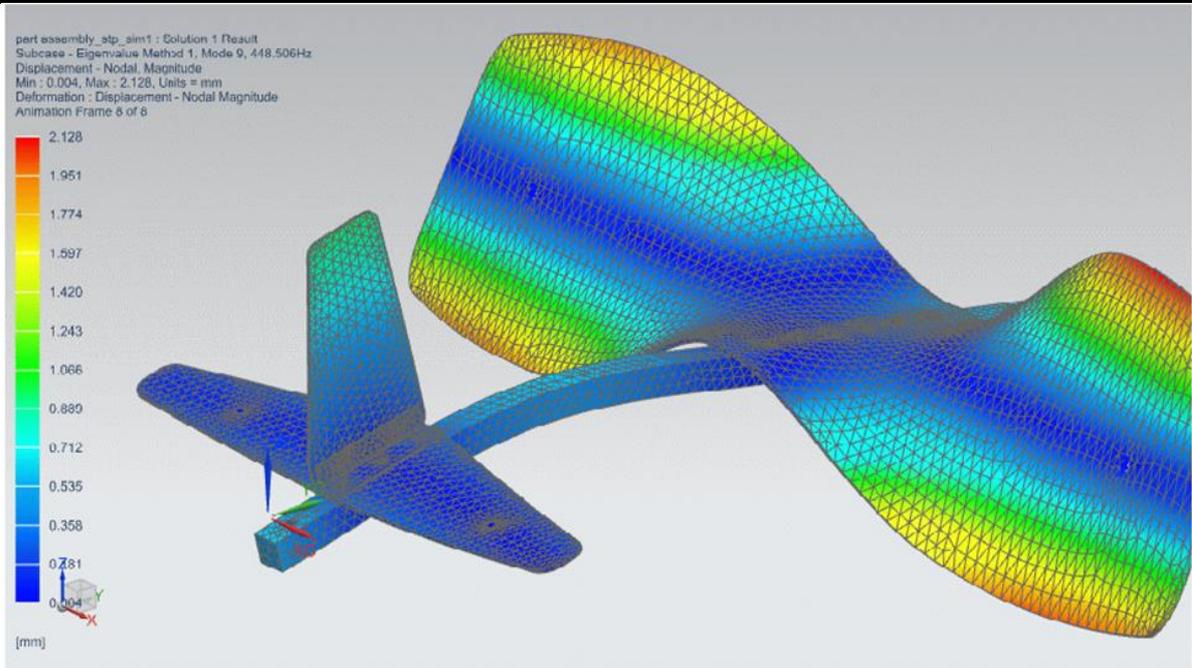
Mode6 263.203 HZ



Mode7 330.061 HZ

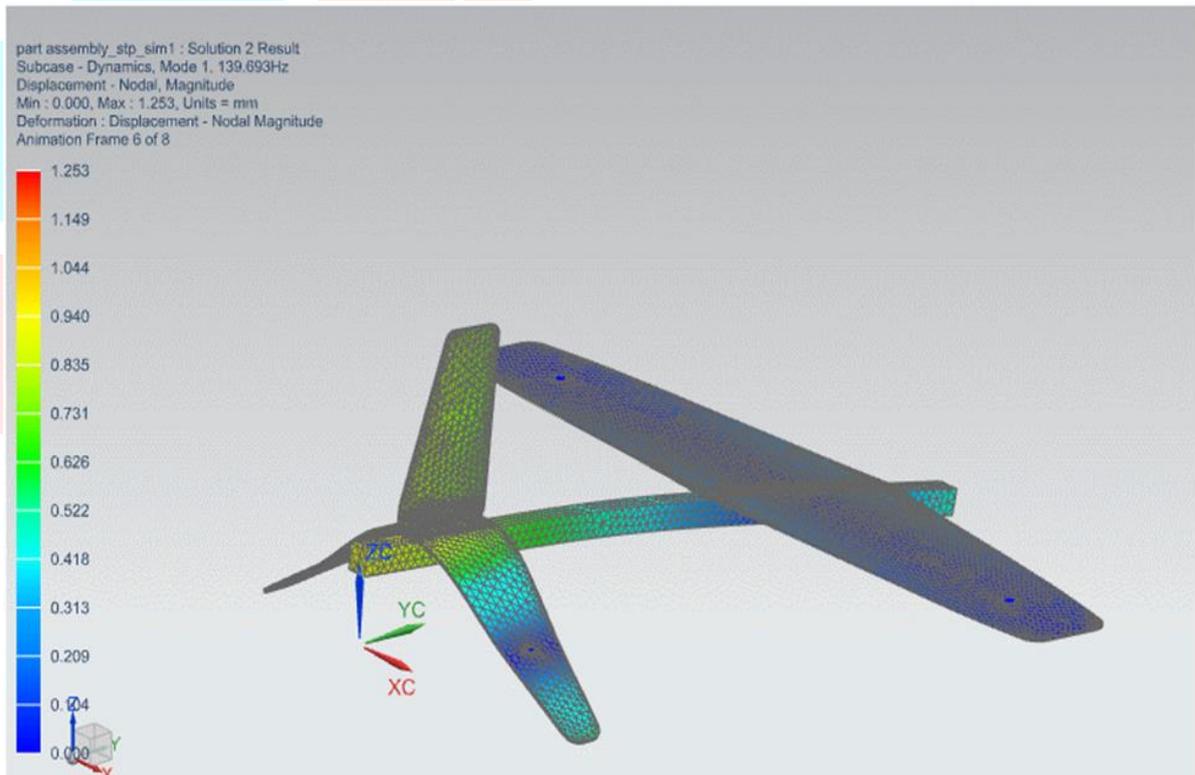


Mode8 418.62 HZ



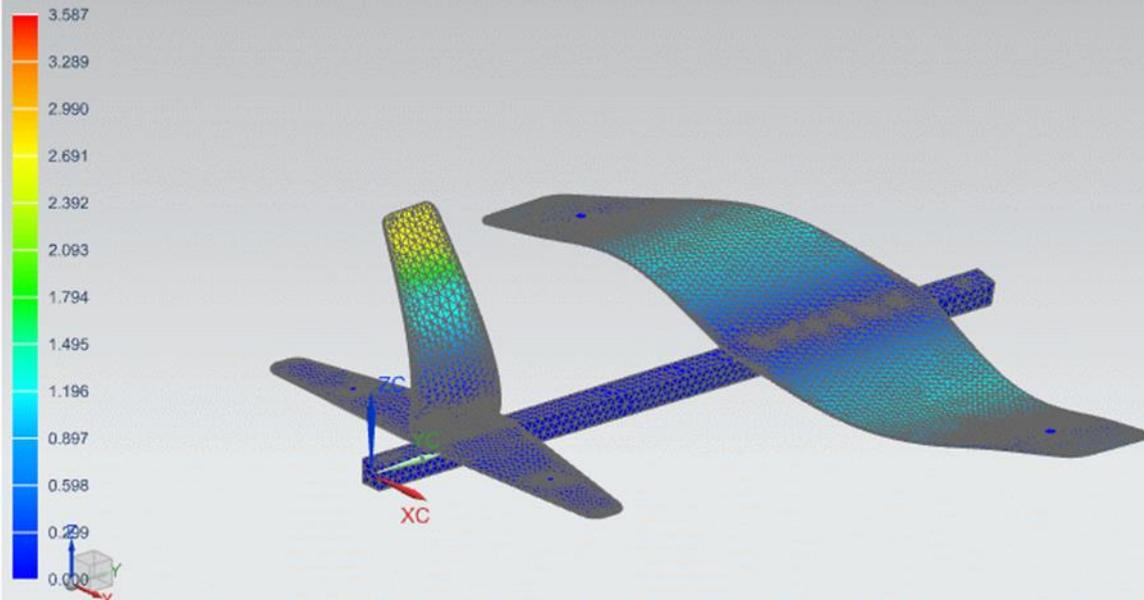
Mode9 448.506 HZ

Response Modes



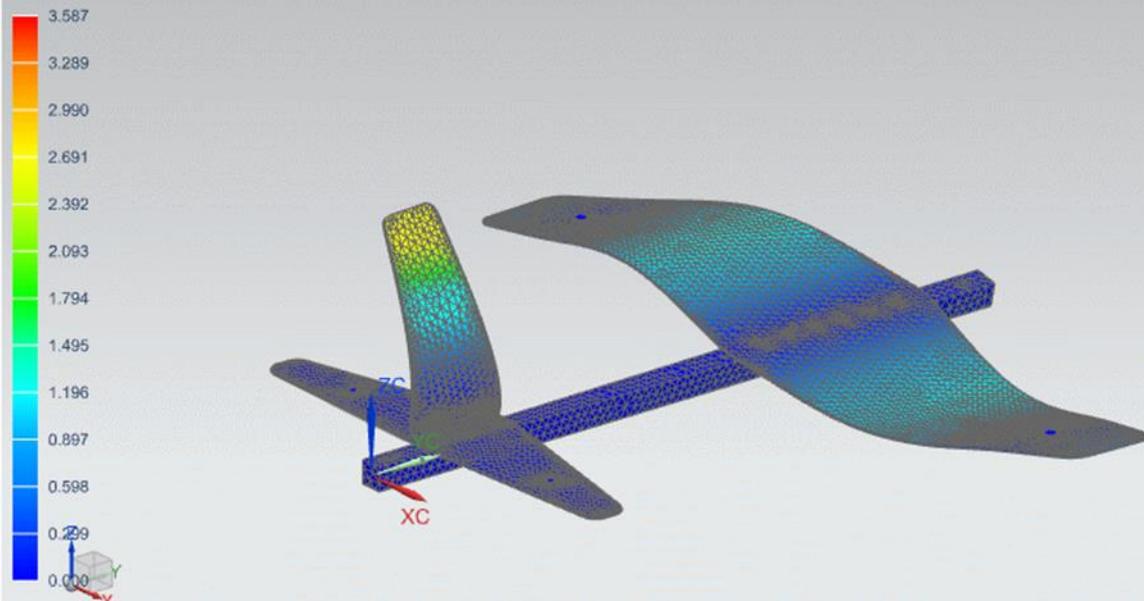
Model 139.69 HZ

part assembly_stp_sim1 : Solution 2 Result
Subcase - Dynamics, Mode 3, 278.95Hz
Displacement - Nodal, Magnitude
Min : 0.000, Max : 3.587, Units = mm
Deformation : Displacement - Nodal Magnitude
Animation Frame 7 of 8

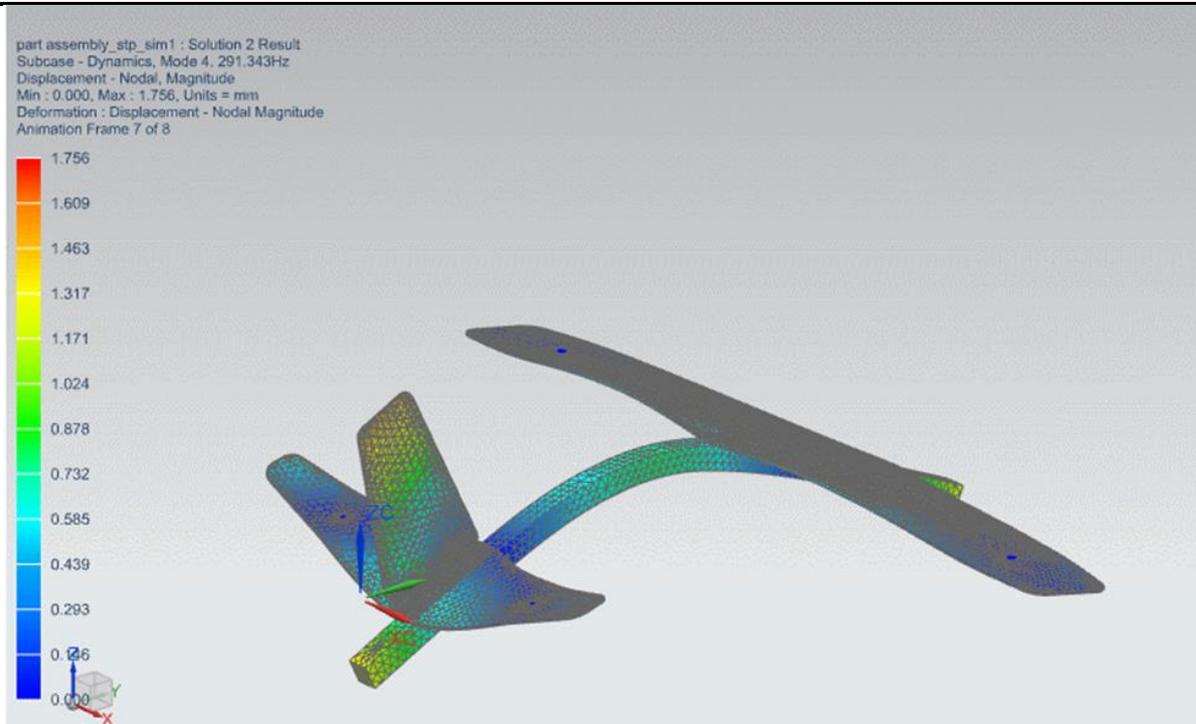


Mode2 226.581

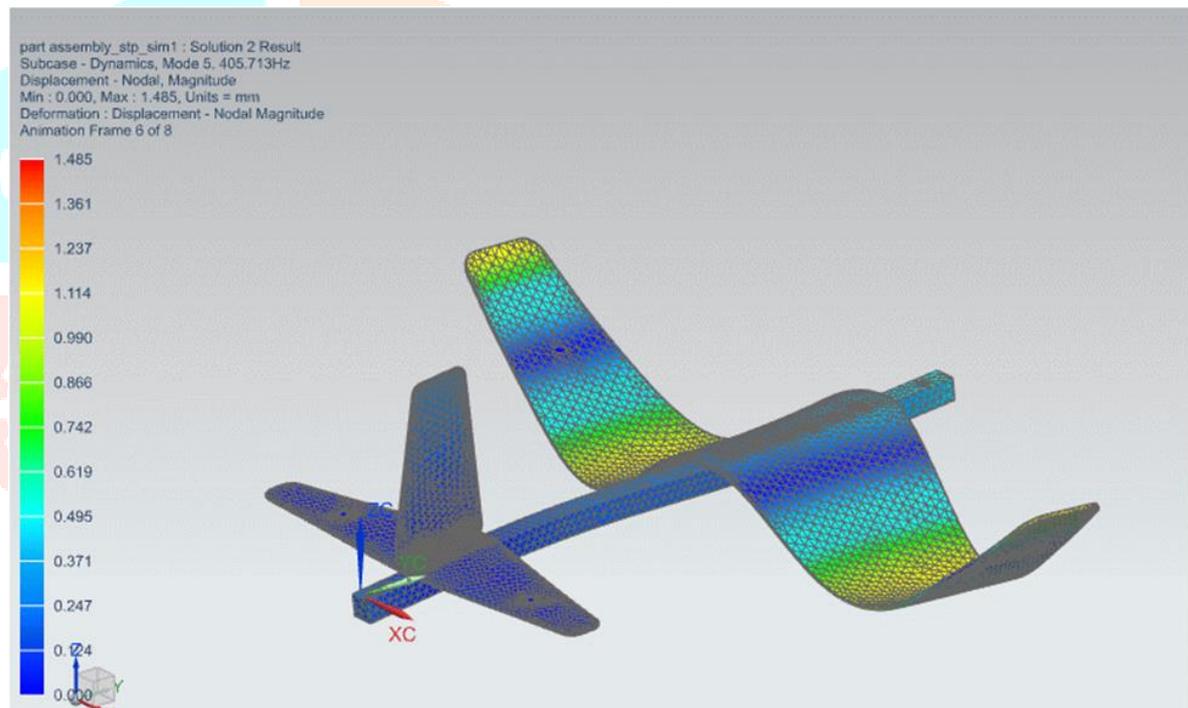
part assembly_stp_sim1 : Solution 2 Result
Subcase - Dynamics, Mode 3, 278.95Hz
Displacement - Nodal, Magnitude
Min : 0.000, Max : 3.587, Units = mm
Deformation : Displacement - Nodal Magnitude
Animation Frame 7 of 8



Mode3 278.95 Hz



Mode4 291.343



Mode5 405.713 HZ

4. CONCLUSION

To control vibrations on a machined parts or any mechanical components we have to choose the one of the vibration controlling methods as discussed above. In this paper I just prefer tuning method to control vibration i.e. lower the mass exhibits higher the frequency to collapse or to produce resonant frequency. As I explained above transient analysis, random analysis are one of the condition monitoring techniques to determine the vibration analysis. Choosing material is the most important because materials which exhibits lesser mass provides greater frequencies so among all the materials aluminum is the most preferable one to control vibrations as its exhibit high transmissibility, low nodal response (transient event), high PSD (Random event), when compared to another materials. Among all the aluminum alloys (2014, 5086, 6061, A356) aluminum alloy 5086 is preferable to control the vibrations with respect to other alloys of aluminum and other metals.

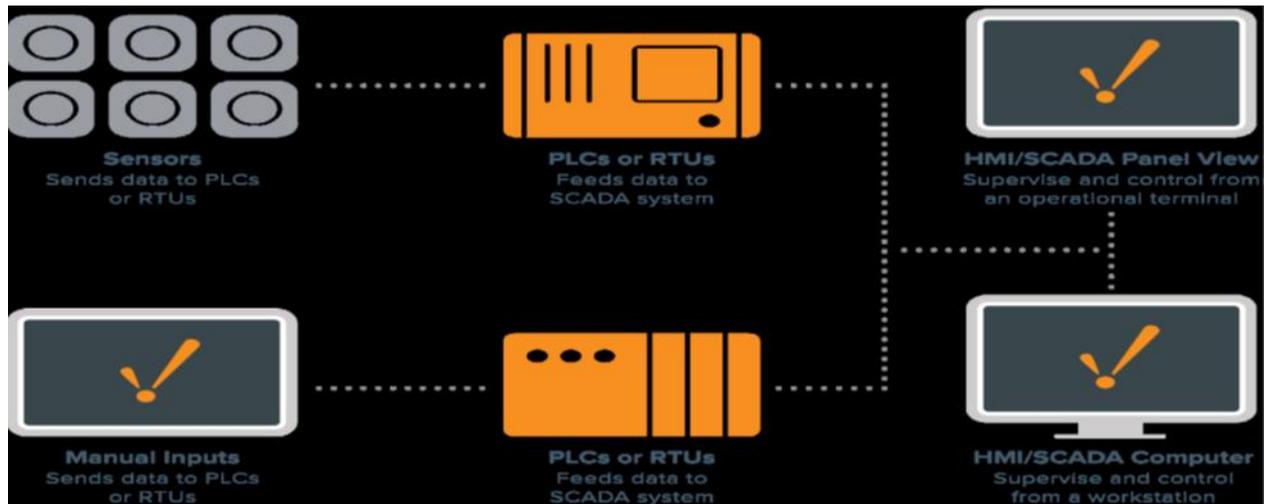
5. FUTURE SCOPE

This project can be extended by doing experimental analysis and compared the results with that we obtained from numerical solutions to verify transmissibility, transient event, random event. LMS test lab is used to conduct the experiment. Leuven Measuring System (LMS), SCADA data acquisition system capable of measuring (transducer electronic data reader).

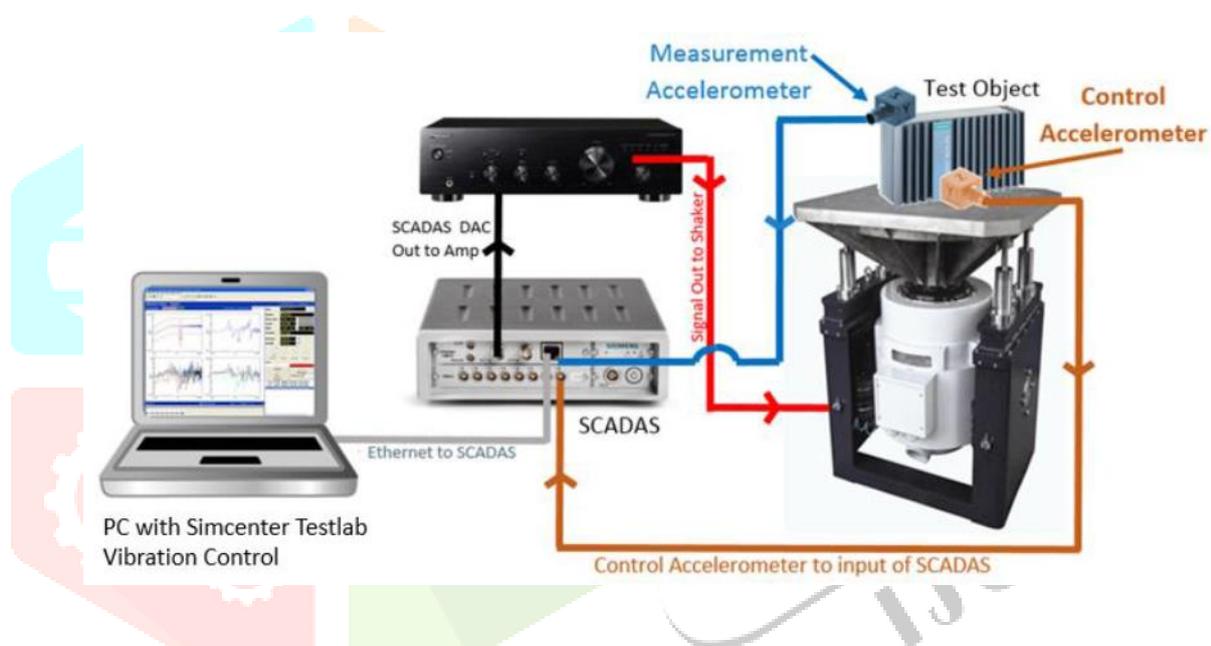
LMS test lab offers a complete integrated solution for test-based engineering that combines high speed multichannel data acquisition with a full suite of integrated testing, analysis and report generation tools. LMS test lab is designed to make testing more efficient and

more convenient and significantly increases its productivity by delivering more results even when availability of prototypes are dramatically reduced.

Combining multichannel data acquisition, comprehensive integrated testing solutions and data management for test-based engineering.



Basic SCADA Diagram



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