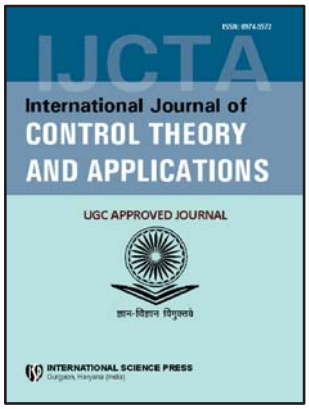

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Modal Analysis and Harmonic Analysis of a Conformal Antenna for Automobile Applications

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Abstract: Any mechanical structure will resonate depending on various environmental conditions. When we consider the conformal antenna as a mechanical structure which is placed and fixed on the outer body of automobile, the conformal antenna also resonates with excessive oscillatory motion due to inertial and elastic properties of materials used for constriction of conformal antennas. This resonance is the main cause of the vibration and problems which occurs due to noise in the mechanical structure. The designed conformal antenna requires mechanical product, structural dynamic testing to predict its real time behaviour. Thus in this paper first a single patch antenna is designed then a 2*4 patch antenna array is designed and finally modal and harmonic Analysis is performed for the designed conformal antenna array using Ansys 17.0 workbench tool.

Keywords: *Conformal Antenna, RT Duroid, Automobile, Modal Analysis, Harmonic Analysis.*

1. INTRODUCTION

Antenna is a passive element which transmits and receives electromagnetic signals. The antenna which conforms to the shape of the automobile or any shape is called conformal antenna. The conformal antenna at real time conditions has mechanical behaviour. This behaviour of conformal antenna which is to be fixed in an automobile at real time conditions is studied using Finite Element Analysis. Using Finite Element Analysis the approximate solutions for boundary value problems is obtained. The computer model of the conformal antenna array is designed and the various material properties are set to perform modal analysis and harmonic analysis.

2. SINGLE PATCH ANTENNA DESIGN

Patch Antenna is a two wire transmission line which is fed by a AC source at the point where impedance of the antenna is matched with free space impedance and radiation occurs. The patch antenna consists of 3 layers with a dielectric layer sandwiched between two conducting layers like copper. The RT Duroid material of thickness

0.8mm with dielectric constant of 2.2 is used as the dielectric material. The conducting layer at the top is called patch and the conducting layer at the bottom is the ground plane. Since the antenna is designed for vehicular communication application, the resonant frequency is 5.9GHz. The dimensions of the patch antenna depend on the dielectric constant, thickness of the dielectrics and resonating frequency. The dimensions of the patch antenna were determined using the design equations. The input parameters for finding the dimensions of the patch antenna are resonant frequency = 5.9GHz, thickness of the dielectric = 0.8mm and dielectric constant = 2.2 because the dielectric material used is RT Duroid. Using the input parameters in the design equations we get the dimensions of the patch antenna. The dimensions are given as input using Feko V 7.0 tool. The designed antenna and its radiation characteristics are shown in figure below.

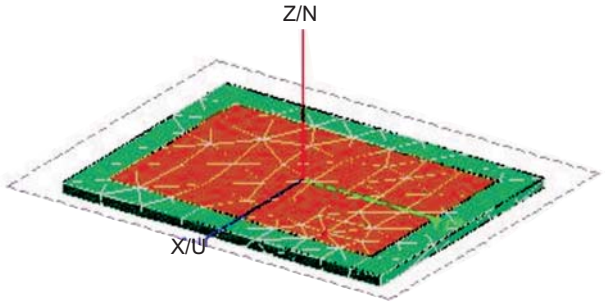

Figure 1: Designed Single Element Patch Antenna using FEKO V7.0 tool

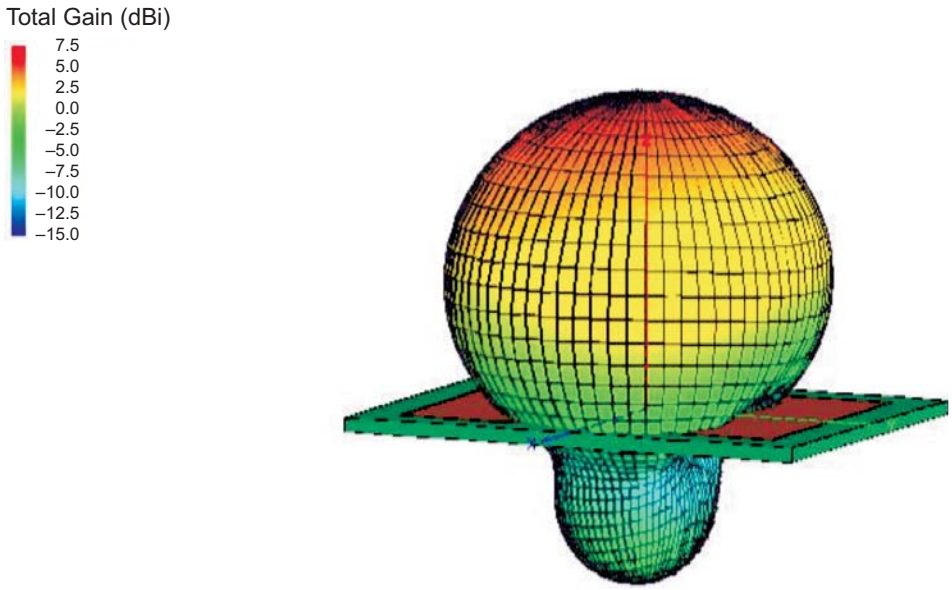

Figure 2: Far field pattern of the designed Single Element Patch Antenna using FEKO V7.0 tool

3. 2*4 PATCH ANTENNA ARRAY DESIGN

The length of the Antenna is directly proportional to the gain of the antenna. When the length of the antenna increases the gain and directivity is increased. The length of the antenna cannot be increased more than wavelength (λ) because undesired side lobes arise if we increase length of the antenna greater than λ . Therefore using an array instead of a single element patch antenna is the solution to increase the gain. In an array the radiation is directed in a particular direction and in all other directions the radiation will be cancelled. The desired direction of radiation can be changed by beam steering using complementary split ring resonator.

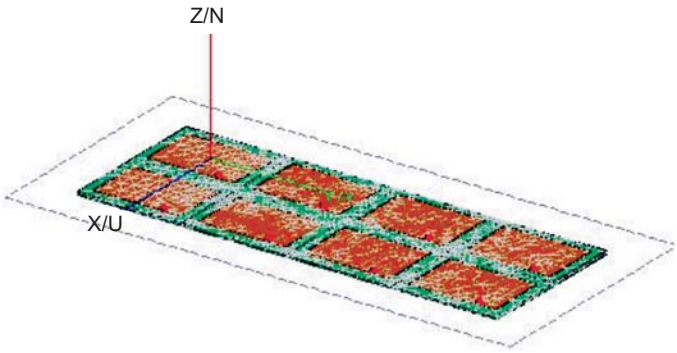

Figure 3: Designed 2*4 Patch Antenna Array using FEKO V7.0 tool

4. CORNFORMAL ANTENNA AND ARRAY

The planar antennas are low profile in nature and have many advantages like narrow bandwidth and low cost which are suitable for vehicular communication in automobiles. These planar antennas when placed on a not planar surface, the resultant antenna are a conformal antenna. The conformal antenna has advantages of causing no extra drag and less side lobe pattern. The designed conformal antenna and its radiation characteristics are shown in figure 4,5 and 6 below, where the planar antenna is mounted on a cylinder and sphere respectively. Similarly we can mount the planar antenna on the vehicle body.

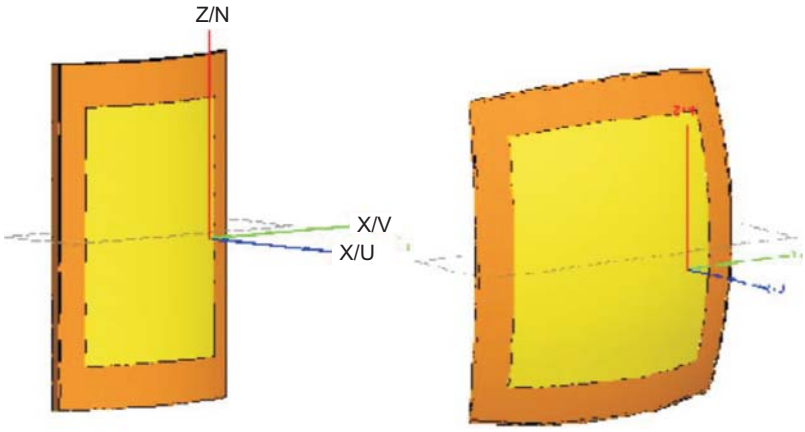

Figure 4: Designed Conformal Patch Antenna using FEKO V7.0 tool

Figure 5: Far Field Pattern of a Conformal Patch Antenna using FEKO V7.0 tool

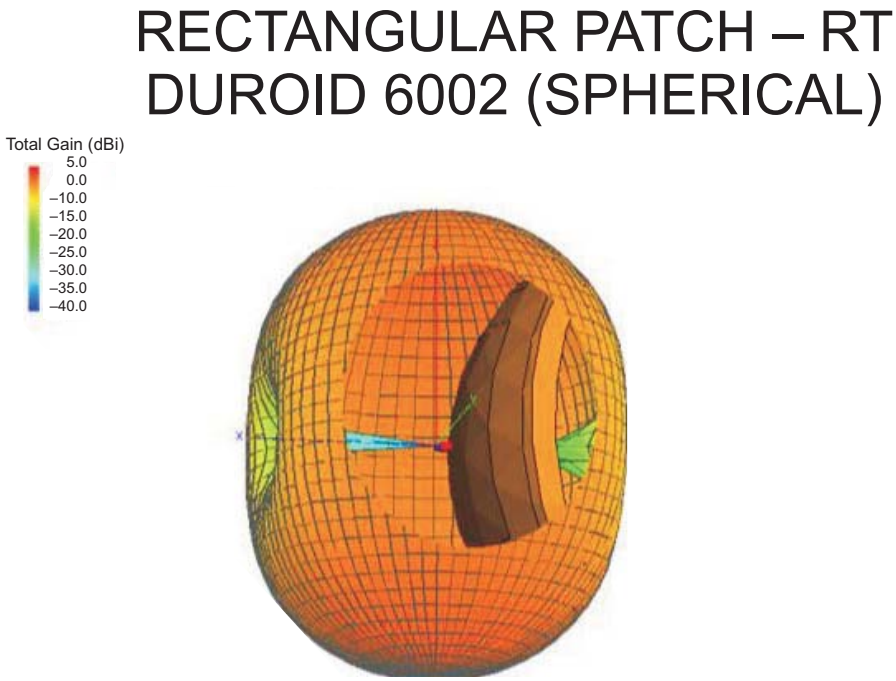

Figure 6: Far Field Pattern of a Spherical Conformal Patch Antenna using FEKO V7.0 tool

5. MODAL ANALYSIS

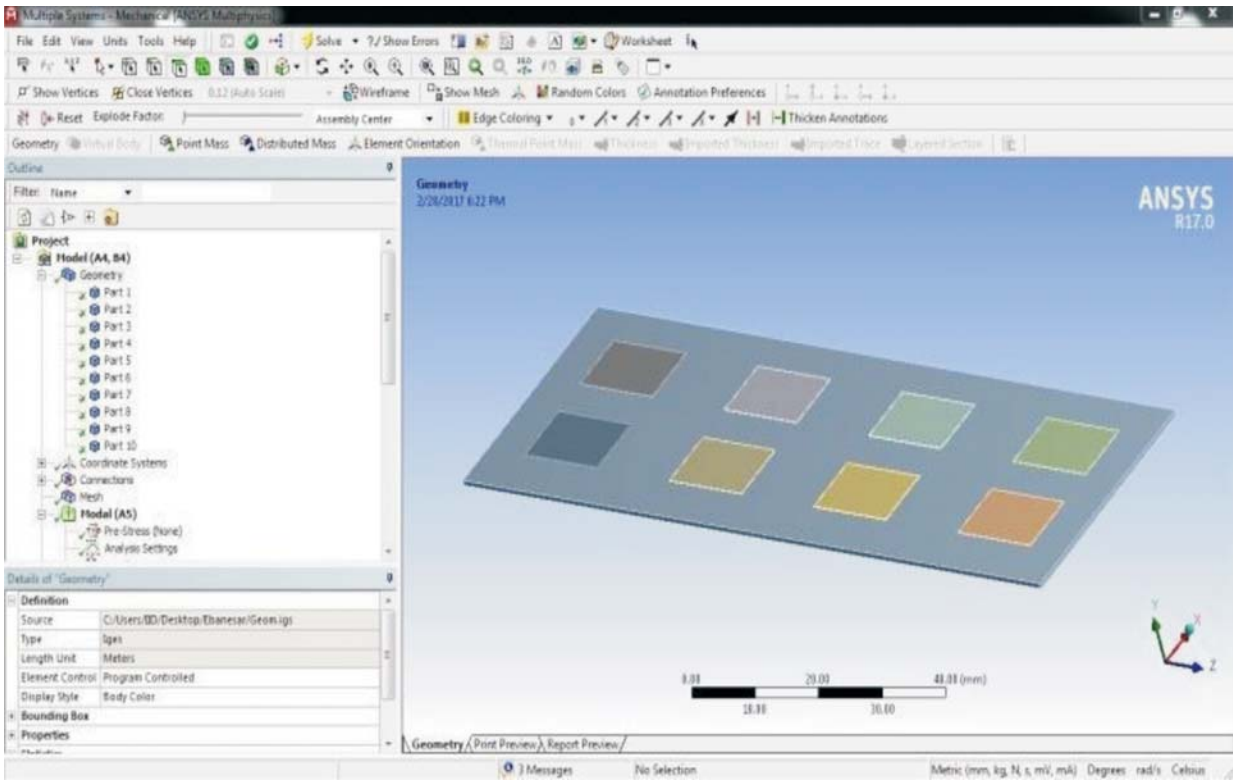

Figure 7: Design of a planar antenna which will be conformal to non-planar surfaces using Ansys 17.0

The conformal antenna which is designed will be placed on a fast moving vehicle. The antenna performance will be affected by various residual effects like Doppler shift, aerodynamic drag, etc. Therefore antenna placed on the vehicle behaves like a mechanical structure and hence need to be analysed mechanically. In ANSYS using FEM we analyse the mechanical characteristics of the conformal antenna by modal and harmonic analysis. Figure 7 below shows the conformal antenna designed in Ansys Hyper physics V17.0.The conformal antenna is made of a composite material hence the complex mechanical structure is reduce to smaller units by meshing. The meshed planar antenna to be mounted on a conformal surface is given in figure 8.The modal analysis is performed for different deformations and the natural frequency was found to be around 8.2 kHz which is very less compared to the resonant frequency of the antenna. Therefore the conformal antenna designed will work efficiently under the natural conditions. The modal analysis performed on the conformal antenna is shown in Fig 9.

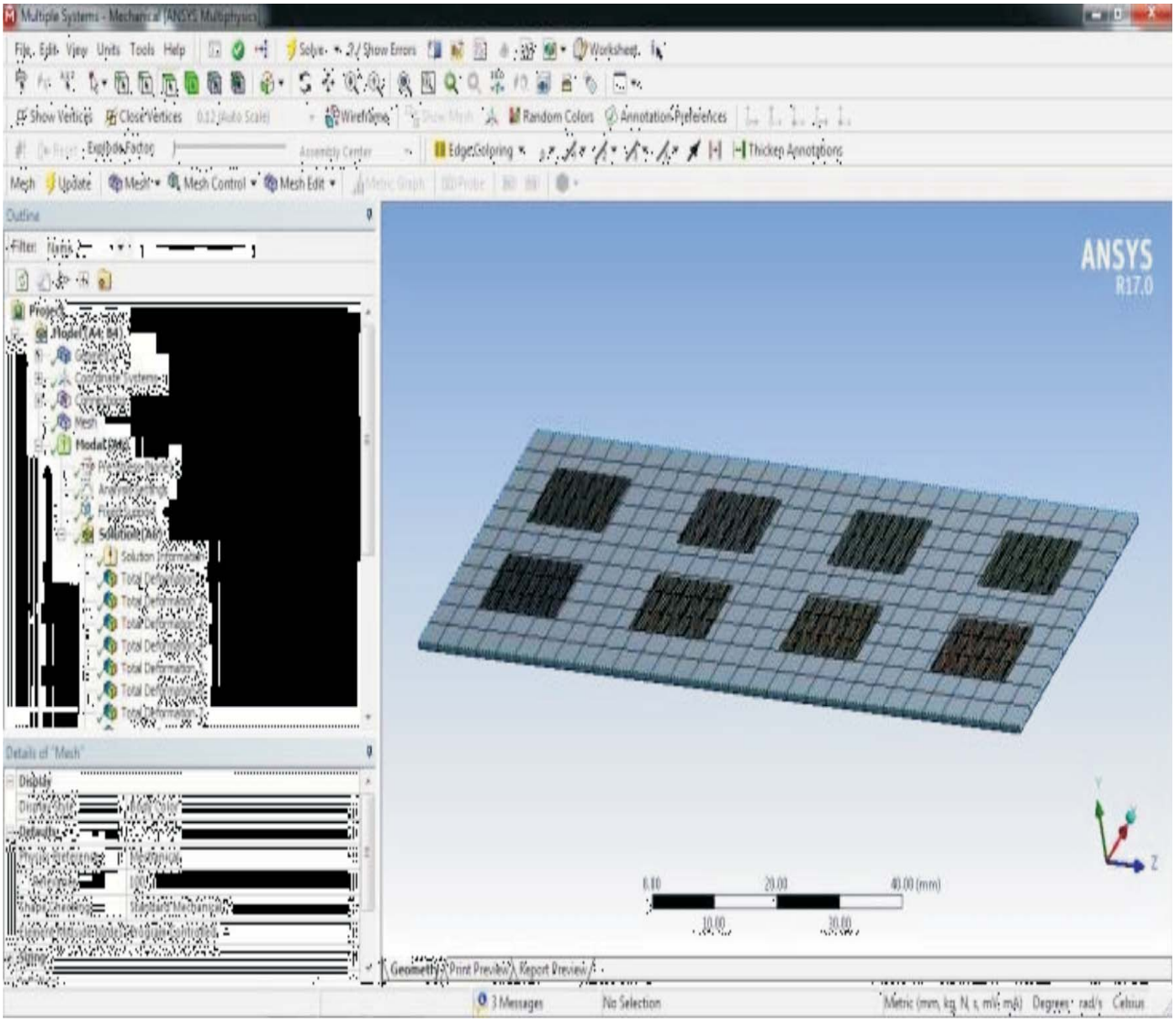

Figure 8: Meshed Planar antenna which will be conformal to non-planar surfaces using Ansys 17.0

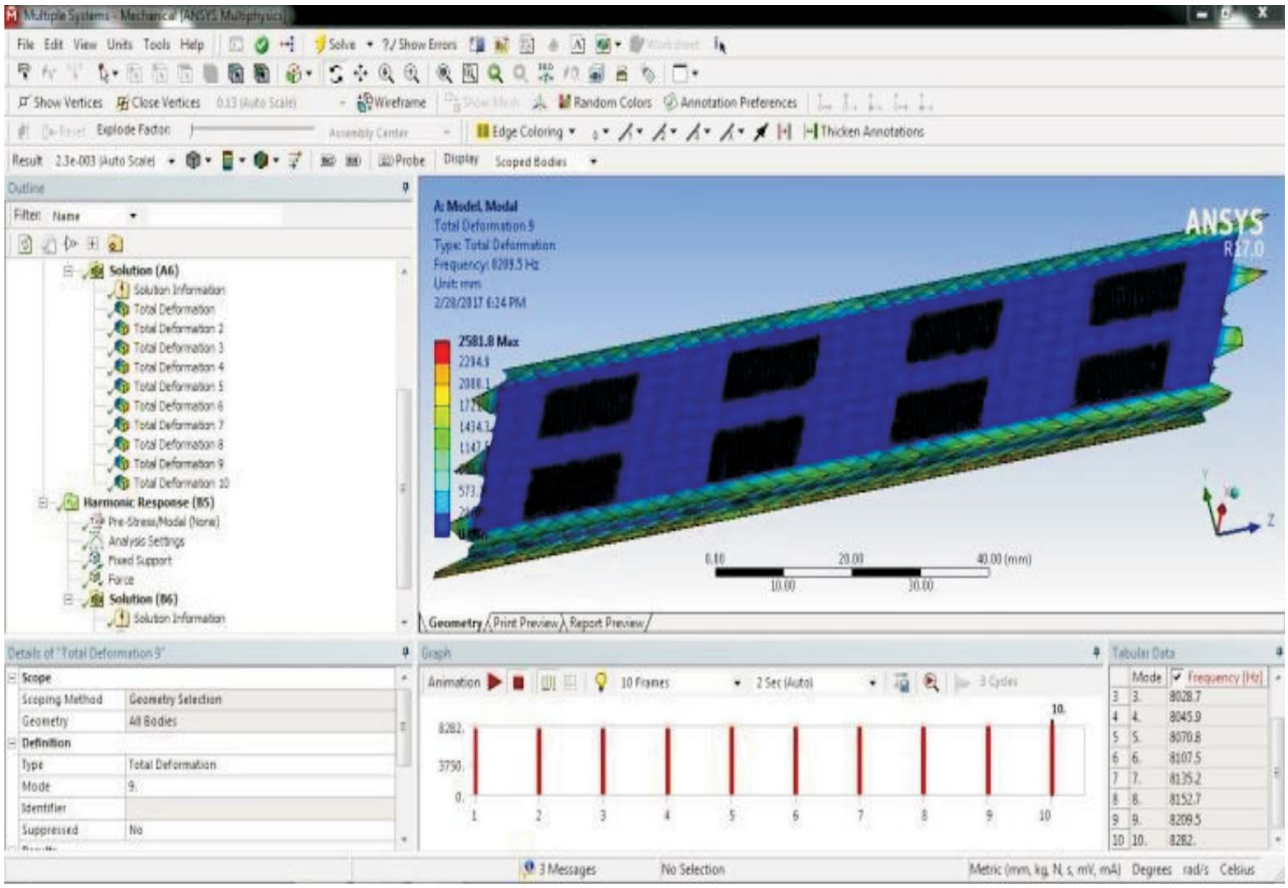

Figure 9: Modal Analysis of a planar antenna which will be conformal to non - planar surfaces

6. HARMONIC ANALYSIS

The vehicle travelling at high speed is bound to be affected by various harmonics. A harmonic can be a spike which can severely degrade the performance of the antenna. Hence the harmonic analysis for the conformal antenna is essential. The figure 10 & 11 below shows the phase and frequency response results by performing harmonic analysis. The results prove that the designed conformal antenna will work efficiently under the real time conditions.

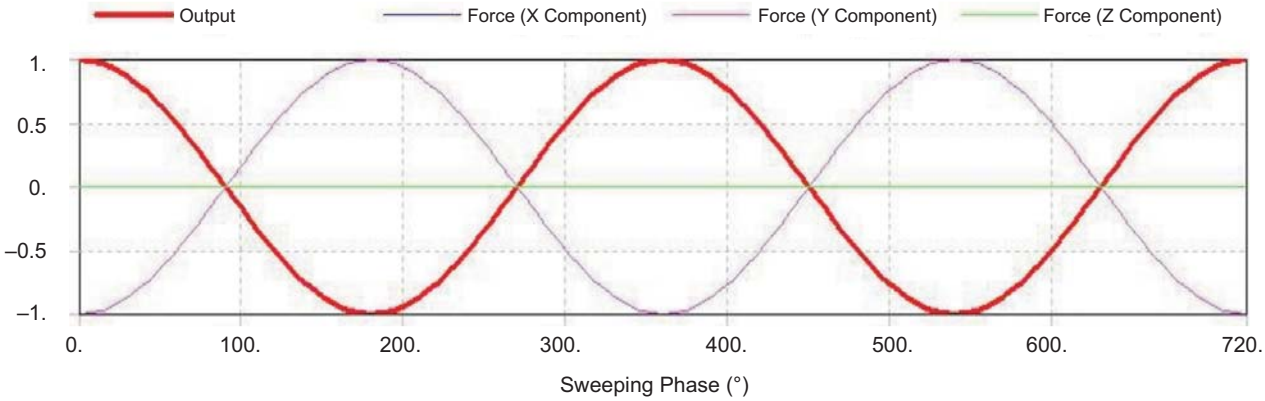

Figure 10: Phase response of planar antenna which will be conformal to non - planar surfaces

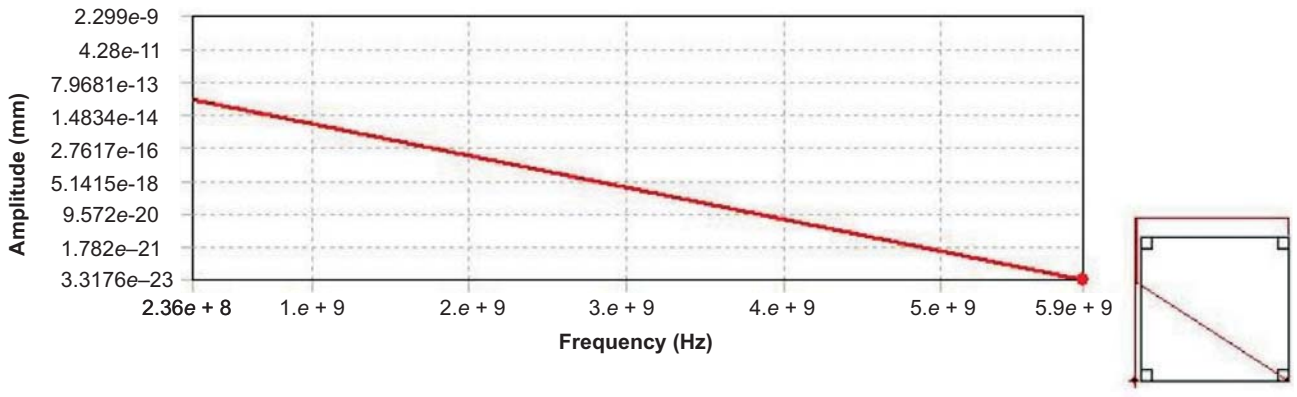

Figure 11: Frequency response of planar antenna which will be conformal to non-planar surfaces

7. CONCLUSION

The conformal antenna is mounted on moving platform hence the antenna needs to be evaluated both electromagnetically and mechanically. Hence in this paper modal and harmonic analysis for the conformal antenna to be placed on a vehicle travelling at high speed is performed and the results justify the working of the antenna under the real time conditions.

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