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# Design and Geometrical Analysis of Various Antennas For RF Application

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**Abstract:**

**In RF applications, the selection of an antenna depends on the geometrical variations in the output like S parameters, directivity, gain, impedance parameter, admittance and etc. This article gives the geometrical comparison of various antennas such as horn, reflector and micro strip antenna and it is designed for same frequency at 6.8GHz. ANSYS HFSS 19.0 version is used for design and analysis. The comparison chart gives the variation in the gain, directivity, VSWR and other parameters for the above three types of an antenna. Based on the parametersvariation antenna is decided for RF applications such as medical applications, communication, commercial and broadband applications.**

**Keyword: Microstrip Patch Antenna, Horn and Parabolic reflector antennas, Gain, Directivity, Polarization, S parameters, Z parameters, etc.**

## 1. INTRODUCTION

Wireless communication technology have taken over in various aspects of human civilisation. Wireless applications are in high demand, prompting the development of new requirements for transmitter and receiver design in radio communication systems [1]. Some of the RF applications are Electronic Surveillance, Broadband Spectrum, Monitoring Metrology, Environmental Monitoring, Multichannel for Broadband Communications, Wireless Systems, Mobile Communications, GPS and Navigation. Thousands of low-cost, high-tech satellites will soon fill the skies, providing broadband connectivity to locations on Earth where it is desperately needed, beaming data, voice, and video to millions of people living in both crowded and remote areas throughout the world. Passengers on transcontinental flights will have access to the internet, as well as increased performance for applications ranging from gaming to tactical awareness, thanks to intelligently adjusted beams.

HFSS is a high-performance full-wave electromagnetic (EM) field simulator that uses the familiar Microsoft Windows graphical user interface to model arbitrary 3D volumetric passive devices. It combines simulation, visualisation, solid modelling, and automation to quickly and accurately solve 3D EM problems. For all 3D EM issues, Ansys HFSS uses the Finite Element Method (FEM), adaptive meshing, and beautiful visuals to provide unrivalled performance and understanding. Gain, Directivity, Polarization, S parameters, Z parameters, Resonant Frequency, and Fields are all calculated using Ansys HFSS. For high-productivity research, development, and virtual prototyping, HFSS is the tool of choice [13].

This paper introduces a comparison of geometrical parameters of micro strip patch antenna, horn antenna, and parabolic reflector antenna. The following section details the antenna design and analysis. Section 2 provides the design and geometrical analysis of micro strip antenna, section 3 provides analysis of horn antenna and section 4 provides analysis of parabolic reflector antenna. Finally, section 4 discusses conclusions and comparison of various applications.

## 2. DESIGN AND ANALYSIS OF MICROSTRIP PATCH ANTENNA

### 2.1 DESIGN METHOD

A micro strip patch antenna is designed using HFSS on a given substrate ofthickness 1.6 mm and dielectric constant 2.09 at a frequency of 6.8GHz. Here online micro strip calculator is used to calculate the dimensions of an antenna (L, W) and axis of the antenna is x= 30mm, y= 40mm, z= 1.6mm. Thicker substrates with a lower dielectric constant offer higher efficiency and bandwidth at the cost of bigger element size. Thin substrates with higher dielectric constants result in lower element sizes and less coupling, but they are less efficient and have narrower bandwidths.

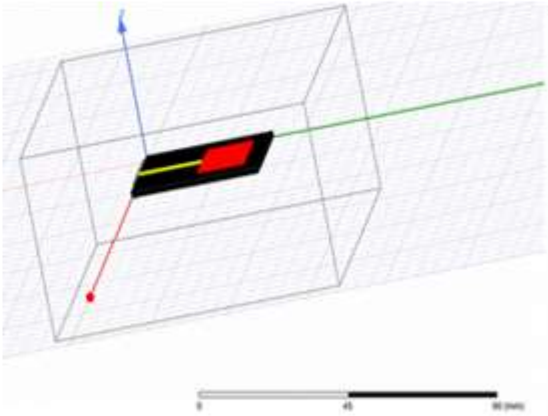

**Figure 1: Top view of MSA**

The figure 1 shows the top view of design of microstrip antenna which is designed for the frequency of 6.8GHz. Basic design equations of micro strip antenna is

$$W = \frac{1}{2f_r\sqrt{\mu_0\epsilon_0}}\sqrt{\frac{2}{\epsilon_r+1}} = \frac{\upsilon_0}{2f_r}\sqrt{\frac{2}{\epsilon_r+1}}$$

$$\frac{\Delta L}{h} = 0.412\frac{(\epsilon_{\text{reff}}+0.3)\left(\frac{W}{h}+0.264\right)}{(\epsilon_{\text{reff}}-0.258)\left(\frac{W}{h}+0.8\right)}$$

$$\epsilon_{\text{reff}} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-1/2}$$

$$L = \frac{1}{2f_r\sqrt{\epsilon_{\text{reff}}}\sqrt{\mu_0\epsilon_0}} - 2\Delta L$$

The antenna can then be created and simulated using a commercially available 3D EM simulator once the dimensions have been determined. Further optimization and fine tweaking of dimensions can be done to achieve the required frequency while maintaining an acceptable return loss.

## 2.2 RESULTS FOR MICROSTRIP PATCH ANTENNA

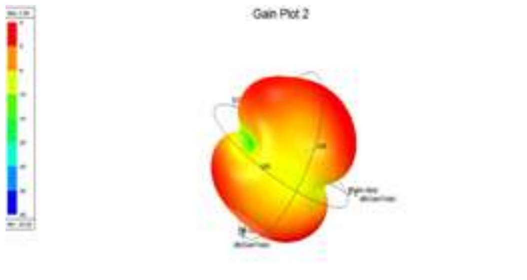


**Figure 2: Gain plot of MSA**

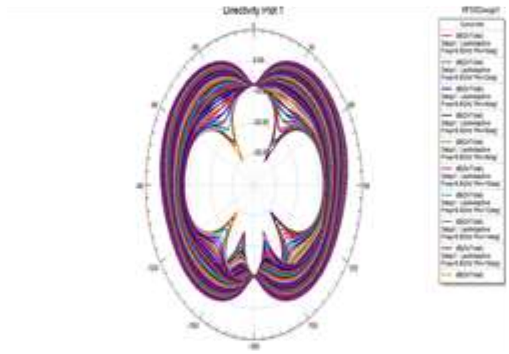

**Figure 3: Directivity plot of MSA**

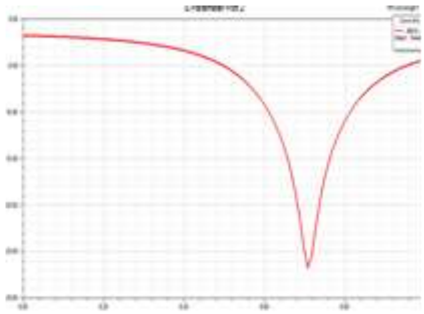

**Figure 4: S parameter plot of MSA**

## 3. DESIGN OF HORN ANTENNA

### 3.1 DESIGN METHOD

The antenna is optimised in this work to function in the X band (8 GHz to 12 GHz) by optimising the structure and characteristics of matching block and ridges, based on the standard quad-ridged horn antenna. According to simulation results, an antenna's impedance matches well within the working frequency range, and the far field gain is between 12 and 18 dBi [4].

The two basic types of horn are the pyramidal and conical horn antenna. The below designed diagram is pyramidal horn antenna for 6.8GHz. In conjunction with two slots etched at the top and bottom of the substrate, a piece of a rectangular waveguide is positioned in front of the SIW horn's radiating aperture. To limit backward radiation and to boost the antenna gain, a row of reflector nails is added [3].

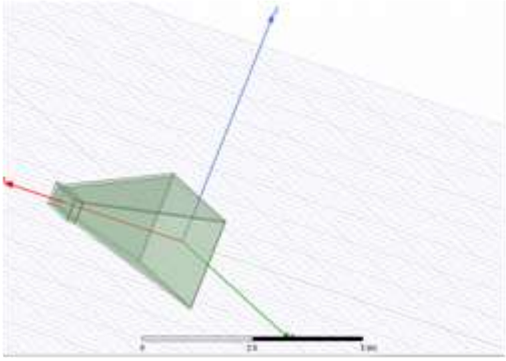

**Figure 5: Side view of Horn Antenna**

### 3.2 RESULTS OF HORN ANTENNA

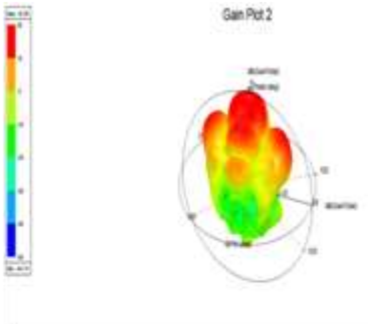

**Figure 6: Gain plot of Horn Antenna**

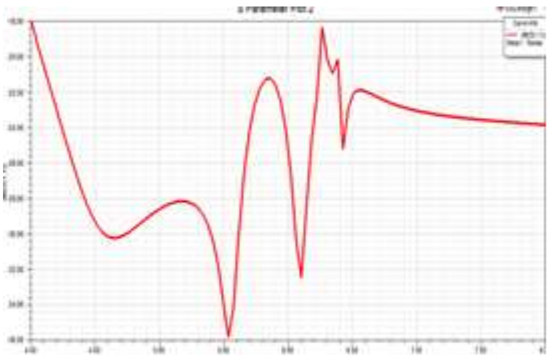

**Figure 7: S parameter plot of Horn Antenna**

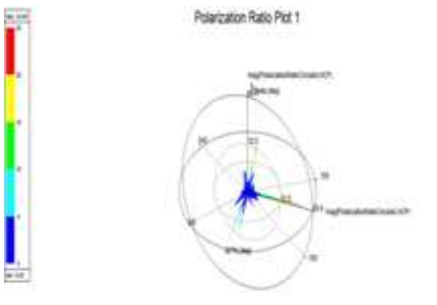

**Figure 8: Polarization plot of Horn Antenna**

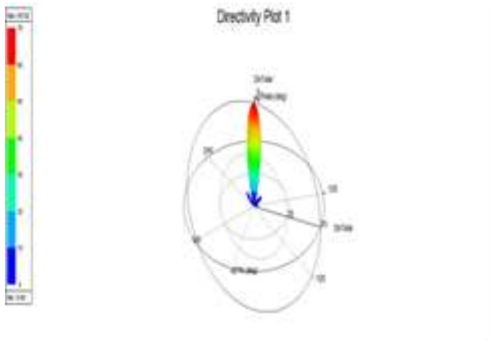


**Figure 9: Directivity plot of Horn Antenna**

## 4. DESIGN AND ANALYSIS OF PARABOLIC REFLECTOR WITH HORN FEED

### 4.1 DESIGN METHOD

Parabolic reflector is used for high power satellite communications and it is taken as secondary antenna and pyramidal horn antenna is used for primary feed. The below diagram shows the parabolic reflector with horn feed. It is designed using ANSYS HFSS 19.0 version[14].

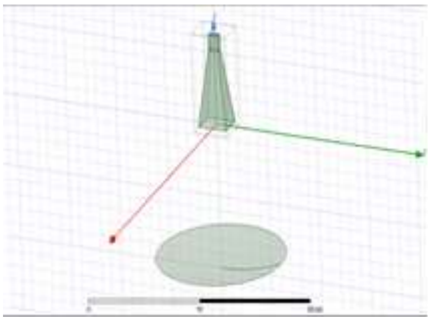

**Figure 10: Top view of Parabola with Horn Antenna**

The function of the horn antenna is employed to provide a uniform phase front with a bigger aperture than the waveguide which is resulting in higher directivity. The most popular and widely used antenna in satellite and radar communication is the parabolic dish antenna [5]. With the parameter, the beam separation angle and the focal-length-to-diameter ratio (F/D) of a parabolic reflector, the relationship between feed horn size and feed position displacement is numerically clarified. As a result, an antenna structure is obtained for escape feed horn overlapping. [6].

### 4.2 RESULTS FOR REFLECTOR WITH HORN FEED

The below diagram shows that the electric field of parabolic reflector with horn feed and it varies with phase of the parabola.

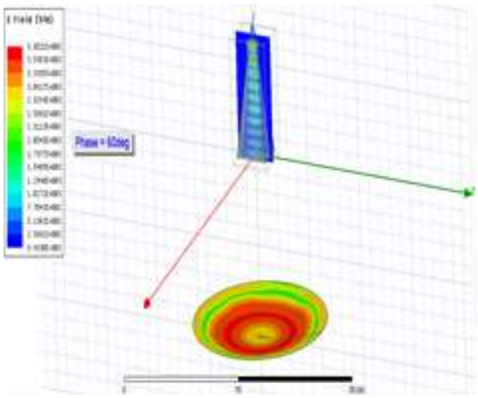


**Figure 11: Electric field Plot of Parabola with Horn feed Antenna**

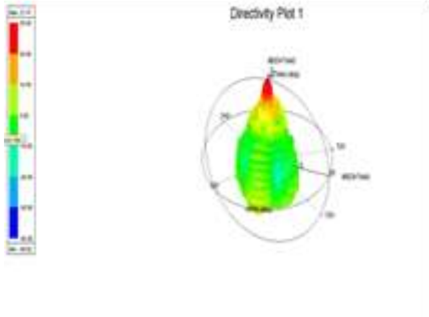


**Figure 11: Directivity Plot of Parabola with Horn feed Antenna**

The figure shows the directivity of reflector antenna and it seems the directivity of the reflector antenna is high as compared with micro strip antenna. The shaped footprint is designed by using multi beam technique where many feed horns are employed [6].

## 5. COMPARISON AND CONCLUSION

This article gives a spectacle analysis of geometrical parameter of micro strip, Horn and reflector antenna. The following table perceives the comparison of geometrical parameters for the frequency of 6.8GHz.

| Parameters | Micro strip antenna | Horn antenna | Reflector antenna |
|---|---|---|---|
| Directivity | 5dB | 63.52dB | 27.47dB |
| Gain | 2.58dB | 18.26dB | 27.53dB |
| Radiation Pattern | Omnidirectional | Unidirectional | Unidirectional with side lobes |

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