Design and Analysis of H Plane Horn Antenna at X Band Frequency

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Abstract— This paper presents a design of an H plane horn antenna for microwave system. The key purpose of the study is to design a H plane horn antenna which is used in paper moisture system. The proposed antenna operates within 8-12 GHz .Antenna known as directional antenna which is supported by rectangular waveguide. The H plane horn antenna is purposely chosen to design in order to increase the directivity of the antenna within 16 dB gain. This horn antenna is capable to produce return loss as minimum as possible. The antenna is designed and simulated using CST Microwave Studio. The simulation results show that the H plane horn antenna structure exhibits good radiation pattern over X GHz frequency band.

Key words: CST, TE10, H Plane

I. INTRODUCTION

The horn antenna represents a transition or matching section from the guided mode inside the waveguide to the unguided (free-space) mode outside the waveguide. The horn antenna, as a matching section, reduces reflections and leads to a lower standing wave ratio. There are three basic types of horn antennas: (a.) the E-plane sectoral horn (flared in the direction of the E-plane only), (b.) the H-plane sectoral horn (flared in the direction of the H-plane only), and (c.) the pyramidal horn antenna (flared in both the E-plane and H-plane). The flare of the horns considered here is assumed to be linear although some horn antennas are formed by other flare types such as an exponential flare. The horn antenna is mounted on a waveguide that is almost always excited in single-mode operation. That is, the waveguide is operated at a frequency above the cutoff frequency of the TE10 mode but below the cutoff frequency of the next highest mode The horn is widely used as feed element for large radio astronomy, satellite tracking and communication dishes due to its simplicity in construction, ease of excitation versatility, large gain and overall performance[1,2]. Different kinds of horns can be created by flaring the end of the waveguide in different ways for example in one dimension creates a sectoral horn, e.g.: horns flared in the E or H planes. Flaring the waveguide in both dimensions produces a pyramidal horn. If a circular waveguide is used the flare produces a conical horn.

II. DESIGN SPECIFICATION

H plane Horn Antenna is designed keeping in view certain specifications. The horn designed for X -band with center frequency of 10 GHz. The horn is designed in such a way that we get maximum radiation in particular direction. The inner dimensions of the waveguide aperture are a= 2.82 cm and b=1.01 cm.

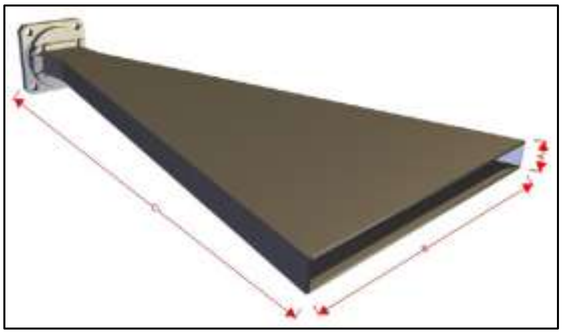

Fig. 1: Basic Diagram of H Plane Horn Antenna

III. METHODOLOGY

The antenna is designed using approximation method of gain. An approximation value of gain 15 dB is used to design the antenna as the gain determines the overall size of the horn antenna.

First of all, a rectangular waveguide should be design as to precede the basic horn antenna structure. In order to initiate the basic design, the feeding waveguide is chosen according to the frequency range of interest. The mid frequency is set to be 7 GHz. The inner dimension is chosen to be 2.81 cm x 1.01 cm which is closer to WR-90 that supports the frequency range of 8-12 GHz (X-Band).

In this design, 16 dB is selected. Approximately to keep the antenna dimensions small. Design calculations are given as:

1) At 10 GHZ G0= 16 dB WR-90 waveguide
2) a= 2.82 cm , b= 1.01 cm
3) G0(dB) = 16 = 10 log10 G0 ⇒ G0 = 39.81
4) χ(trial) = G0/(2π sqrt(2π)) ⇒ 2.52 cm
5) ρh = (λ* ((G0)^2)/8π3*χ) ⇒ 7.504 cm
6) ρ2 = ρh cos(ψh) ⇒ 6.498 cm
7) a1 = sqrt(3λρ2) ⇒ 8.12 cm

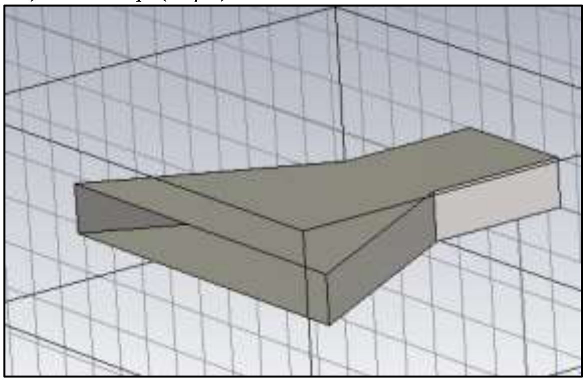

Fig. 2: CST Studio H Plane Horn Antenna

IV. RESULT AND DISCUSSION

Once the design completed, the antenna is simulated through the CST software. The results of parameters that obtained from simulation are the frequency, return loss, voltage standing wave ratio (VSWR), directivity, gain, and bandwidth and radiation pattern. The results shown below are the most significant figure that obtain from simulation which determine the strength of the signal transmitted through the horn antenna.

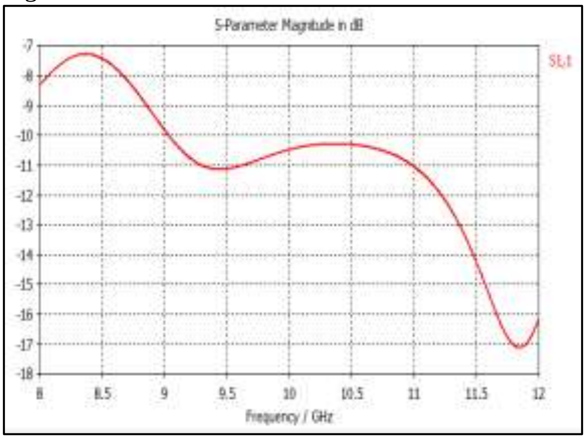

Fig. 3: Return Loss Vs Frequency

The Figure 3 above refers to the S11 parameter which means the return loss of the horn antenna. The amount of return loss from 9 GHz to 12 GHz is below -10 dB and it indicates that the strength of signal received during the transmission is stable enough to obtain a clear picture of data. In other words, almost 90% of signal transmitted through the antenna had been received with minimum loss. This is endorsed by the VSWR calculated during the simulation.

Antenna gain and directivity are the most important fundamental property of an antenna. An antenna has good matching but it will be useless if it does not radiate. The directivity refers to the region where the strongest emission of the signal radiated and the maximum gain produced. The directivity obtained from simulation is 16 dB respected to isotropic antenna. The directivity is always proportional to the gain. As the gain increase the directivity also increases. The higher directivity exhibits the more stronger signal radiated through the aperture of the horn antenna. The gain 16 dB is good enough for the antenna that will be used in paper moisture system. The ability of the signal to penetrate into the paper is influenced by the power gain of the antenna.

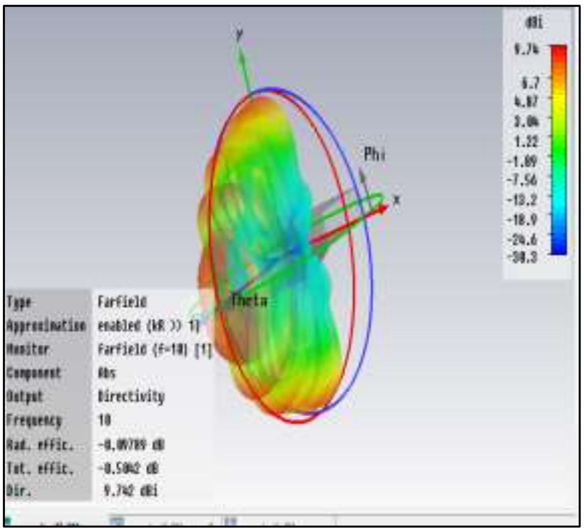

Fig. 4: Directivity of Antenna

Radiation pattern are graphical representation of electromagnetic power distribution in free space.

This pattern also can be considered to be representative of the relative field strengths of the field radiated by the antenna. The figure above shows the radiation pattern of horn antenna which consists of main lobe, side lobes and back lobe. The magnitude of the main lobe obtained is 9.8 dBi while side lobe is -1.0 dB. It shows that the main lobe is much larger than side lobes and back lobe. It means that more power are radiating through main lobe compared to other directions. The narrower main lobe indicates that the higher intensity of radiation.

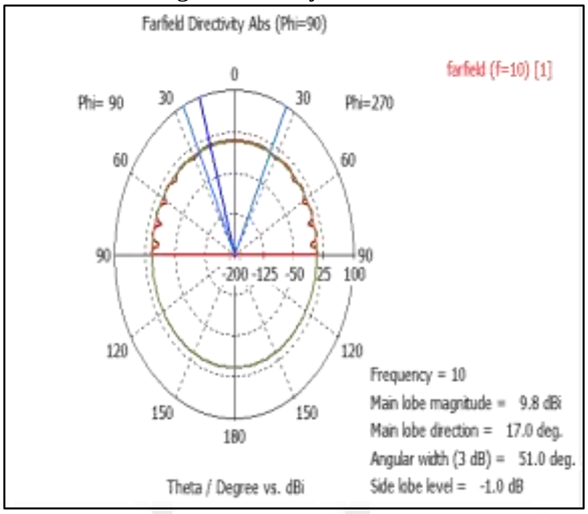

Fig. 5: Radiation Pattern

V. CONCLUSION

According to the results above, the designed H plane horn antenna is considered stable and suitable to be operated within given frequency range of 8 – 12 GHz. The lower return loss and voltage standing wave ratio assures that the signal radiated is almost in equilibrium state. It means that the signal transmitted and the signal received is almost perfect with lower attenuation. The antenna preferentially radiate in particular direction with higher radiated power. The higher directivity attained indicates the strengthen region where the maximum gain accumulated. In addition, the radiation pattern shown in polar form considered good with the main lobe is larger than side lobe and back lobe.

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