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Design and Implementation of Pyramidal Horn Antenna

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***Abstract*—This technical paper presents design and implementation of pyramidal horn antenna. Antenna is a transducer used to convert electrical signals into electromagnetic waves i.e. radio waves. Horn antenna supports wide range of frequency bands, because of this advantage horn antenna is used in number of applications like radar, EMI testing, satellite communication, television broadcasting etc. We have designed the horn antenna for frequency range 1.12 to 1.70 GHz. The design parameter of this antenna is discussed in this paper. The project is parted as; the simulation using CAD-FEKO software and hardware design.**
***Keywords*— CAD-FEKO software, SMA connector, frequency synthesizer, VSWR, transmission line, impedance matching**

I. INTRODUCTION

Now a day's technology is changing rapidly from wired to wireless. In this new era of technology wireless communication is heart and brain of the communication. The transmission and reception of signals in wireless communication is done by using the receiving and transmitting antenna. For the same purpose we choose the topic of pyramidal horn antenna for our last year engineering project. The reason behind selection of this pyramidal horn antenna is it provide a wide frequency range with high output gain. The objective of our project is to design more efficient pyramidal horn antenna which will support wide range of frequencies. First we have implemented the antenna using CAD-FEKO software and simulated it. Then we analysed the results obtained from the simulations. Afterwards we have implemented the pyramidal horn antenna physically and we compared the results of simulated antenna and hardware antenna.

A. Objective of the project

The main objectives of our project are mentioned below:

1) Operating frequency band 1.12 to 1.70 GHZ
2) Maintain a gain of 15 dB over the entire operating frequency range
3) Maintain voltage standing wave ratio (VSWR) of 2 or less over the entire operating frequency range
4) Maintain a half-power beam width (HPBW) that is below 20 degrees over the entire operating frequency range

II. LITERATURE SURVEY

During World War II, as microwave theory became more popular amongst researchers, articles on aperture and horn antennas started to appear in academic journals. The first of which to focus on a true horn antenna was "Theory of the Electromagnetic Horn" written by W.L. Barrow and L.J. Chu for the Proceedings of the Institute of Radio Engineers in January of 1939. This paper was a theoretical analysis of the operation of the horn antenna and provided the reader with a set of equations that could be used to design horns for radio communication. Since WWII, there have been many paper released on horn antennas focusing on both theory and applications. Methods have been derived for accurate calculation of many properties of these antennas such as gain and directivity.

III.METHODOLOGY

A. Proposed methodology

There are three types of rectangular horn antenna H-plane horn, E-plane horn, Pyramidal horn. The horns can be flared out linearly and exponentially. When the horn is exponentially flared it provides better impedance matching, but is more difficult to construct and more expensive. The rectangular horn the rectangular waveguide is ideal or most suitable feeder.

The SMA connector is connected to the rectangular waveguide as a feeder. For maximum power transfer the phenomenon called impedance matching plays vital role. To achieve maximum efficiency the cable impedance and antenna impedance should be matched. If the impedance mismatches then not all the waves are propagated some of them are reflected back. These reflected waves are known as standing waves. VSWR stands for voltage standing wave ratio. VSWR is defined as the ratio of the maximum voltage to the minimum voltage in the standing wave. The larger the impedance mismatch, the larger the amplitude of the standing wave.

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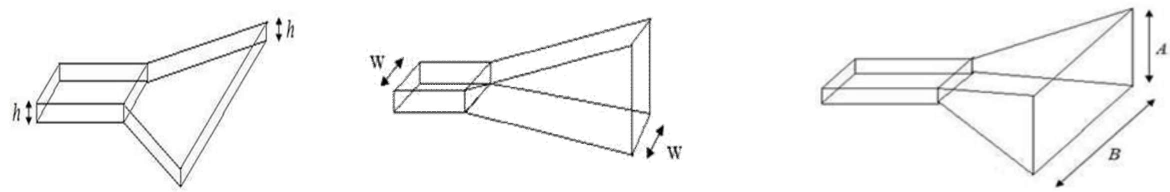
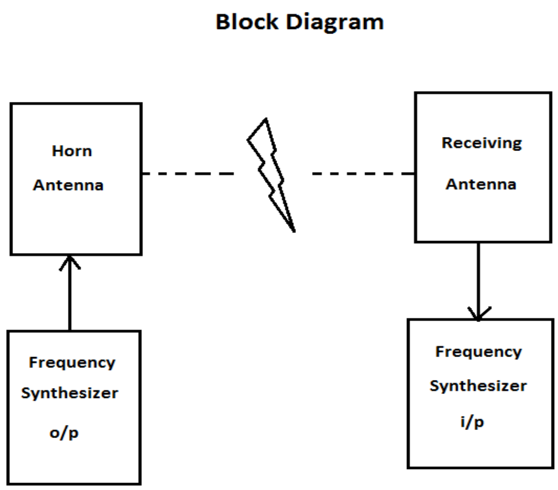
The types of horn are shown below.



a) E-plane horn b) H-plane horn c) Pyramidal horn

B. Block Diagram And Discerption



1) *Frequency Synthesizer:* Frequency synthesizer is nothing but frequency generator. It generates frequency which ranges from MHz to several GHz. The output of frequency synthesizer is given to the transmitter antenna. The received frequency is given to the input of frequency synthesizer. Frequency synthesizer has ability to calculate gain.
2) *Horn Antenna:* Horn antenna is used as transmitting antenna. The input to the horn antenna is input received from the frequency synthesizer in the form of electrical signal. Horn antenna converts the electrical signal into radio waves.
3) Receiving Antenna: We can use any antenna as a receiving antenna. It can be micro strip antenna, patch antenna, Yagi uda antenna, etc. The output of receiving antenna is applied to input of frequency synthesizer.

C. Design Procedure

1) *Directivity of an E-plane Horn:* The total power radiated from a E-plane horn can be found by,

$$P_{rad} = \frac{ab_1}{4\eta} |E_1|^2$$

Now that we have found the maximum radiation and the power radiated from the horn, we can find the directivity using the formula,

$$D_E = \frac{4\pi U_{\max}}{\mathrm{P}_{rad}}$$
$$= \frac{64a\rho_1}{\pi\lambda b_1} |F(t)|^2$$

2) *Directivity of an H-plane Horn*

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$$D_H = \frac{4\pi b\rho_2}{a_1\lambda}\left\{[C(u)-C(v)]^2+[S(u)-S(v)]^2\right\}$$

3) *Directivity of a Pyramidal Horn :* The final type of horn presented is the pyramidal horn antenna. This horn is a combination of the E-plane and H-plane horns and as such is flared in both directions.

The equations of interest for the pyramidal horn are,

$$U_{\max} = |E_0|^2\frac{\rho_1\rho_2}{2\eta}\left\{[C(u)-C(v)]^2+[S(u)-S(v)]^2\right\}$$
$$\times\left\{C^2(\frac{b_1}{\sqrt{2\lambda\rho_1}})+S^2(\frac{b_1}{\sqrt{2\lambda\rho_1}})\right\}$$
$$P_{rad} = |E_0|^2\frac{a_1b_1}{4\eta}$$
$$D_P = \frac{8\pi\rho_1\rho_2}{a_1b_1}\left\{[C(u)-C(v)]^2+[S(u)-S(v)]^2\right\}$$
$$\times\left\{C^2(\frac{b_1}{\sqrt{2\lambda\rho_1}})+S^2(\frac{b_1}{\sqrt{2\lambda\rho_1}})\right\}$$
$$=\frac{\pi\lambda^2}{32ab}D_ED_H$$

If the Pe and Ph are equal then the horn is physically realizable. Formulae of Pe and Ph are given below.

$$p_e = (b_1-b)\left[(\frac{\rho_e}{b_1})^2-\frac{1}{4}\right]^{\frac{1}{2}} \qquad p_h = (a_1-a)\left[(\frac{\rho_h}{a_1})^2-\frac{1}{4}\right]^{\frac{1}{2}}$$

IV. CONCLUSIONS

The pyramidal horn antenna is successfully implemented and simulated using CAD-FEKO. This paper attempts a study on the radiation pattern, designing process of horn antenna. According to the design a horn is simulated in CAD-FEKO and the results are provided. The simulated result and antenna output results are approximately matched. It is observed that the implemented antenna supports a frequency band from 1.2 to 1.7 GHz and the gain of the antenna is found to be 9.7dB. Frequency range of operation of the antenna could be improved by better impedance matching techniques.

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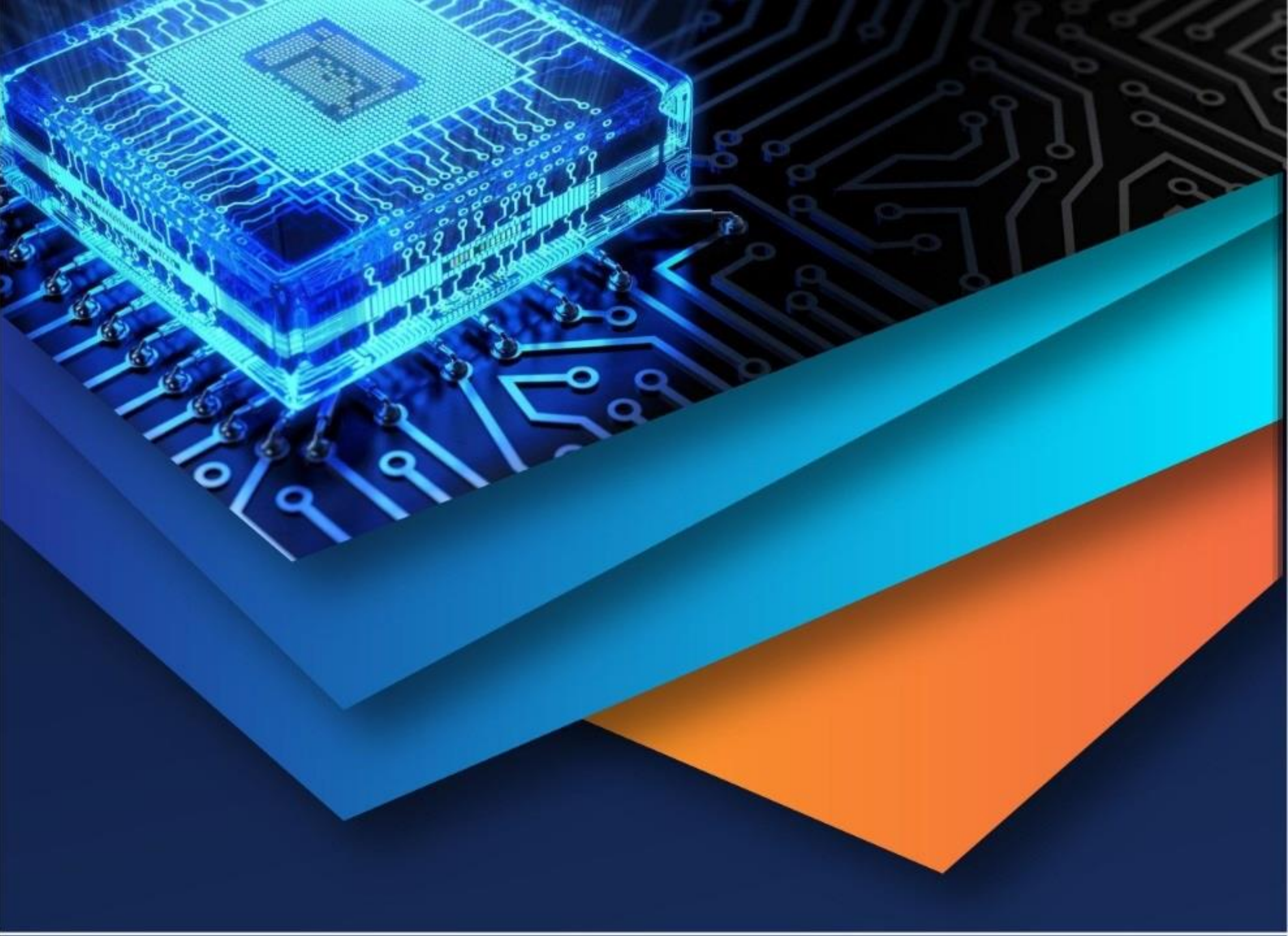

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