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Design of an Aperture (Pyramidal horn) antenna for wide band applications using CST

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Abstract

The aperture antenna is also known as pyramidal horn antenna that operates in microwave band i.e., 300 MHz to 300 GHz. They are extensively used in the fields of T.V broadcasting, microwave devices and satellite communication. Since horn antennas do not have any resonant elements they operate at wide range of frequencies and have a wide bandwidth. They are also used as high gain devices in phased arrays and as a feeder for reflector and lens antennas in satellite communication. The designed aperture antenna is functional for each UHF band applications and here it is having gain of 5dB operating at 2.8 GHz frequency. The performance parameters like Directivity, impedance, Efficiency, s-parameters are evaluated using CST.

Keywords:

Aperture (Pyramidal horn) antenna,
Gain, Bandwidth,
Beam width,
Radiation Pattern,
Computer Simulation Technology

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1. Introduction

Microwave communication is the transmission of signals via radio using a series of microwave towers. It is known as a form of “line of sight” communication, because there must be nothing obstructing the transmission of data between these towers for signals to be properly sent and received. The term microwave is associated to electromagnetic waves of frequency of the order of 100MHz to 1000GHz .Since the energy carried by the wave is directly proportional to their frequency they are of great use in distance communication. For a simple microwave communication system, a radiator, a reflector and one receiver antenna are essential. As the wave penetrates through the atmosphere a satellite reflector is usually used. Before the advent of fibre optics, these microwaves formed the heart of the long distance telephone transmission system. In its simplest form the microwave linkcan be one hop, consisting of one pair of antennas spaced as little as one or two kilo meters apart, or can be a backbone, including multiple hops,

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spanning several thousand kilo meters. A single hop is typically 30 to 60km in relatively flat regions for frequencies in the 2 to 8 GHz bands.

2. Research Method

The horn antenna may be considered as an RF transformer or impedance match between the waveguide feeder and free space which has an impedance of 377 ohms. By having a tapered or having a flared end to the waveguide the horn antenna is formed and this enables the impedance to be matched. Although the waveguide will radiate without a horn antenna, this provides a far more efficient match.

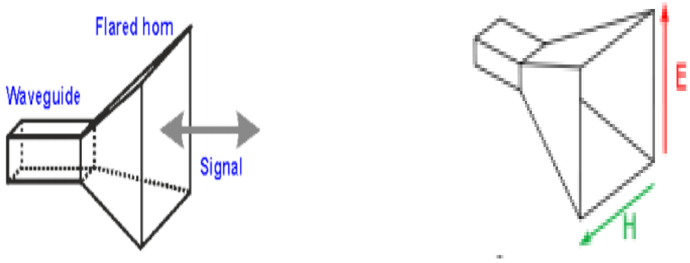


Fig: Out structure of Pyramidal Horn antenna

Pyramidal horn – A horn antenna with the horn in the shape of a four-sided. They are a common type, used with rectangular waveguides, and radiate linearly polarized radio waves. These have the characteristics of both H – plane and E – plane horns.

The most widely used horn is the one which is flared in both directions, as shown. It is widely referred to as a pyramidal horn, and its radiation characteristics are essentially a combination of the *E* and *H* -plane sectoral horns.

3. Design Considerations

Impedance matching is very desirable with radio frequency transmission lines. Standing waves lead to increased losses and frequently cause the transmitter to malfunction. When one considers a waveguide without a horn in operation, the sudden interface of the conductive walls or free air as the case may be for interception or transmission of microwaves cause an abrupt change in impedance at the interface.

Also when the flare angle becomes too large as it tends to 90 degrees, the operation tends to assume that of a hornless antenna thereby resulting in losses, reflections and standing waves.

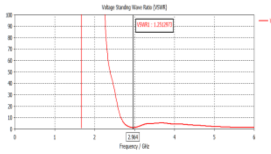
To realize an optimum pyramidal horn, the width of the aperture in either the E-field or the H-field direction is dependent on the intended wavelength and the slant length of the aperture in either direction as given below by the following expressions:

$$A_E = \sqrt{2\lambda L_E} \quad \text{And} \quad A_H = \sqrt{3\lambda L_H}$$

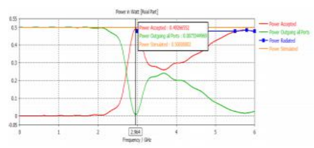
Where,AE = Width of the aperture in the E – field direction
LE = Slant length of the aperture in the E – field direction
AH = Width of the aperture in the H – field direction
LH = Slant length of the aperture in the H – field direction
λ = wavelength

4. Results and Analysis

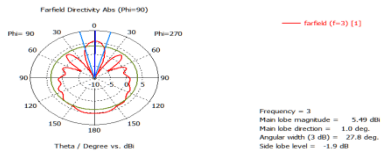
Due to impedance mismatch some energy is reflected back in the system which is called as return loss (dB).It is important in applications that use simultaneous bidirectional transmission. The value of -15 to-20 dB and higher are considered acceptable.



VSWR



Power Excitation signals



Far field Pattern in 2D and 3D at 3GHz

5. Conclusion

The implementation and simulation of aperture (pyramidal horn) antenna is successfully done by using Computer Simulation Technology (CST) and as a result, it is evident that signal integrity be intercepted or transmitted depend on the design considerations of the pyramidal horn antenna. These antennas can be enhanced using dielectric lens, good conductive materials and ridges. They are used significantly where directivity of signal is of main concern. CST is a useful tool for better 2D and 3D analysis and design of antenna structure within small time. By using CST simulation results, we have designed our antenna of gain 5dB with a resonant frequency of 2.8GHz, **VSWR is 1.254** and normalized impedance is 50 Ώ. The only limitation in the fast increasing application of these antennas is their size.

The theoretical calculations gave a gain of 9dB which is very close to our designed horn antenna of gain 5dB at 3GHz operating frequency. The experimental calculations of the constructed antennas have got notable variations with that of theoretical calculations. Hence our future scope is to make improvements in the design, so that the parameters of the antenna are comparable to the characteristics of an ideal antenna.

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