A Study on Reflector Antennas and Design of Reflector Antenna for 5GHz Band

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Abstract - *The wireless communication field is most widely researched and the study of communication systems is incomplete without knowing the operation and the use of different types of antenna. Although there are many types of antenna, antennas that are having light weight, long distance coverage, inexpensive and are capable of maintaining high performance over a wide range of frequencies are preferred. One of the antennas that fulfill the above mentioned criteria is the Reflector antenna.[1] This paper briefs about the reflector antennas, their feeding techniques and design of a feed antenna. The feed antenna at the reflector's focus is typically a low-gain type such as a half-wave dipole or more often a small horn antenna called a feed horn. A cylindrical horn is being designed for 5.5GHz using the concept of Coffee Can feed*.

Key Words: *Reflector antenna, Parabolic antenna, Coffee can feed, signal hound, ISM band.*

1. INTRODUCTION

Electromagnetic waves reflect after hitting some particular materials and by extracting the reflection properties of an electromagnetic wave to direct a wave in a particular direction one can achieve high gain and directivity. One way to do that is by using a reflective material (capable of reflecting EM waves) and can be called as antenna reflector. Antenna reflectors can be single device for reflecting RF (Radio Frequency) signals, or can be a part of an integrated antenna assembly.

With television systems been widely used everywhere in recent years the reflector antennas have gained popularity and are being used extensively. The applications of reflector antennas are not limited to television systems but these antennas has its advantages in several radio/wireless applications where frequencies are typically on top of regarding 1GHz wherever terribly high levels of RF antenna gain area unit needed beside slim beam-widths.[2] Though tougher to manufacture when compared to some antennas which are less complicated, but the applications of such antennas are inevitable.

As with any form of antenna, the parabolic reflector antenna has a number of advantages and disadvantages. These need to be considered against those of other antenna types before selecting the one that is optimum for the job. Parabolic reflector antennas are able to provide very high levels of gain. The larger the 'dish' in terms of wavelengths, the higher the gain. As with the gain, so too the parabolic reflector or dish antenna is able to provide high levels of directivity. The antenna needs to be manufactured with care. This can add cost to the system. The antenna is not as small as some types of antenna, although many used for satellite television reception are quite compact.

2. FEEDING TECHNIQUES

There are several different types of parabolic reflector feed systems that can be used. Each has its own characteristics that can be matched to the requirements of the application.[3]

2.1 Focal Feed System

The focal feed system consists of reflecting surface rather a reflector and a feed antenna rather a device that radiates signal to the reflecting surface, which can be a dipole, monopole, waveguide or a horn. This feed antenna must be placed at the focal point of the reflecting surface. Radiated signals from the diverging component are organized in order that it irradiate reflective surface. Once signals are mirrored it exits the antenna system in form of a very slim beam.

2.2 Off Axis or Offset Parabolic Antenna Feed

The offset feed system consists of reflecting surface rather a reflector and a feed antenna rather a device that radiates signal to the reflecting surface, which can be a dipole, monopole, waveguide or a horn. This feed antenna must be placed at the focal point of the reflecting surface. The placement of feed antenna would not be at the center focal point but at a focal point situated at one side of the reflector. The reflecting surface for this type of feed system is associate degree asymmetrical section of the parabola form.

2.3 Off Axis or Offset Parabolic Antenna Feed

The Gregorian reflector feed technique is incredibly kind of like the Cassegrain style. The foremost distinction is that except that the secondary reflector is dished or additional properly non-circular in form. Typical aperture potency levels of over seventieth are often achieved as a result of the system is in a position to produce a more robust illumination of all of the reflector surface.

2.4 Off Axis or Offset Parabolic Antenna Feed

The Cassegrain reflector feed technique consists of two reflecting surfaces and one radiating element. Although it requires two reflectors the total length of the antenna is less than that of a focal feed system antenna when compared the distance between both the reflectors and the distance between reflecting surface and the feed antenna. This will act as a plus point in some antenna systems.

3. FEED ANTENNA

The radiating element at the reflecting surfaces focus would usually be low-gain type examples: a half-wave dipole, small horn antenna. In design complexity issues of antennas, like Cassegrain and Gregorian, two reflectors are used to direct the signals from the radiating element or feed antenna which is away from the focus of the reflecting primary surface. The radiating element or feed antenna is excited by a RF transmitting device by means of cables, precisely coaxial cables.[4]

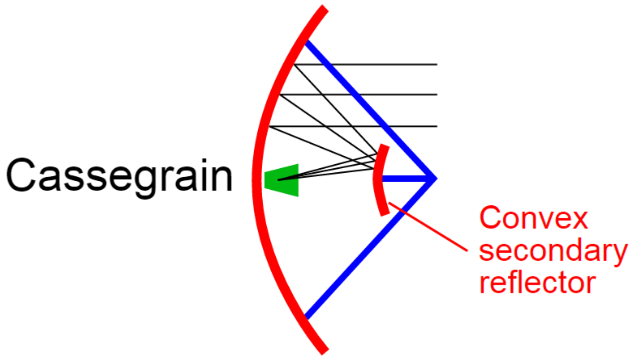

Fig -1: Cassegrain feed.

Another easy antenna helpful as a radiating element could be circular or cylindrical horn, an elegant name for a round pipe emitting or radiating from one open end. Round pipe acts as a cylindrical horn or a cylindrical waveguide if exited it with correct frequencies. Signals travelling through the waveguide would continue travelling till the open end, then disperse into free area. Feed antennas start with a simple and plain horn and then depending upon the applications the features to the antenna are added.

A circular pipe or a circular waveguide open at one end can be called as "Coffee can" feed. The diameter of round pipe or coffee can or tin can, supports waveguide propagation at particular frequencies, and the tin cans is solderable and readily booming, enabling less expensive home production of a radiating element with decent performance. The ready availability of cans and the simple construction of the feed inspired to work with this type of feed on higher frequencies also.[4][5]

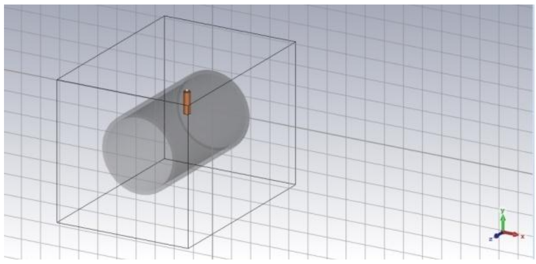

Fig -2: Perspective view of horn.

The illumination angle provided by a cylindrical horn feed is inversely proportional to the waveguide diameter, so that it can be tailored for a desired f/D by choosing the appropriate diameter. Estimation of waveguide diameter required illumination a dish requires a bit of calculation.

Feed horn for 5.5 GHz frequency is been designed and the dimensions are: the feed point to the cylinder(A) is 27.27mm, Length of the monopole(B) is 13.635mm, the diameter of the cylinder(D) is 41.45mm, the length of the cylinder(L) is 78.53mm.The feed point to the cylinder(A) must be as good as 1/2λ. Length of the monopole(B) is exactly 1/4λ. The diameter of the cylinder(D) is 0.76λ. The length of the cylinder(L) is uncritical but can be more than λ.[6]

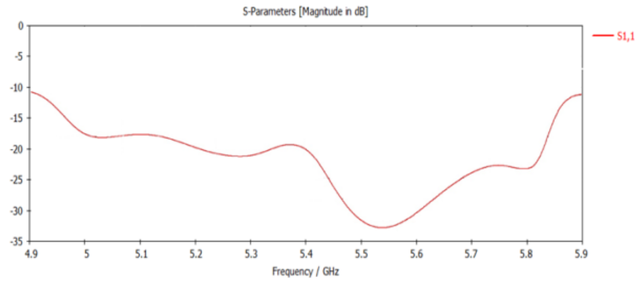

Fig -3: Return loss of feed horn.

The return loss of a feed horn is shown in the figure 8. The S11 at 5.53 Ghz is obtained around -33 dB.

4. PARABOLIC REFLECTOR ANTENNA

A dish antenna or more precisely a satellite dish antenna is the most widely used and known parabolic reflector antenna. The basic and very general structure of a parabolic reflecting surface with feed antenna or complete parabolic antenna is shown in Figure 3. The antenna is made up of a feed antenna which pointed backwards to the reflecting surface, and is often a horn or a waveguide.[7] The tool used for simulation is Computer Simulation Technology tool which is a 3D electromagnetic simulation software.[8]

Fig -4: A front feed parabolic reflector antenna.

The parabola is completely described by two parameters, the diameter D and the focal length F. Figure 4 shows illustration of parabola with two parameters.

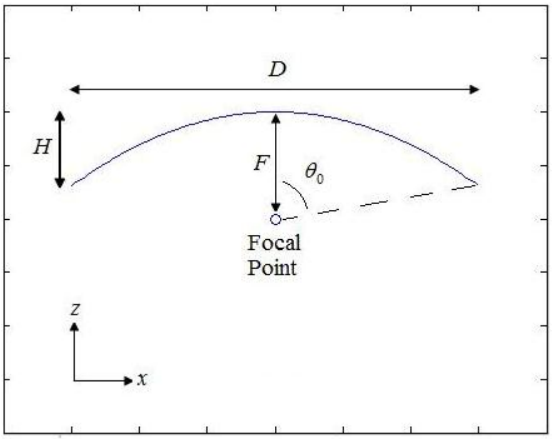

Fig -5: Illustration of parabola with defining parameters.

The relationship between these parameters is given by the equation as follows:

$$\frac{F}{D} = \frac{1}{4\tan(\theta_0/2)}$$

$$F = \frac{D^2}{16H}$$

Reflector antenna for 5.5 GHz frequency is been designed and the dimensions are: the feed point to the cylinder(A) of horn is 27.27mm, Length of the monopole(B) is 13.635mm. The software design and simulation of monopole antenna for above parameters is shown below:

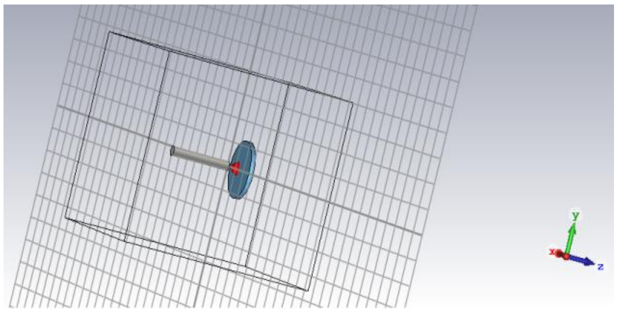

Fig -6: Side view of monopole.

The diameter of the cylinder(Dh) is 41.45mm, the length of the cylinder(Lh) is 88.53mm, the diameter of the dish(Dd) is 460mm, depth of the dish(H) is 80mm and focal length of the dish by the formula D2/16*H is 165mm. The software design and simulation of reflector antenna for above parameters is shown below:

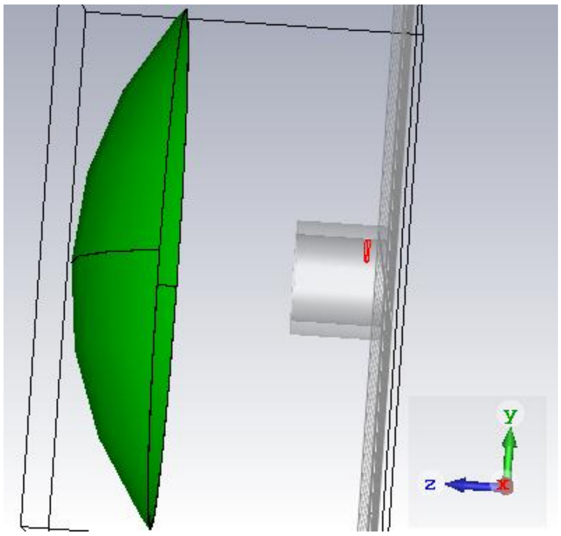

Fig -7: Perspective view of reflector antenna.

The return loss of a parabolic reflector antenna is shown in the figure 7. The negative peak of S11 from 5GHz is obtained around -29 dB. The bandwidth obtained is around 4.9GHz to 5.9GHz.

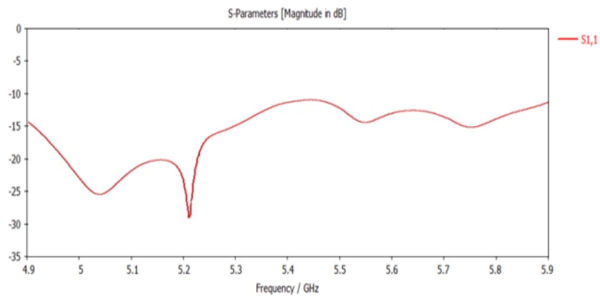

Fig -8: Return loss of reflector antenna.

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5. TESTING RESULTS

Testing is done using Signal Hound Scalar Network Analyzer.[9] The photographs of the prototype and the network analyzer result have been shown below.

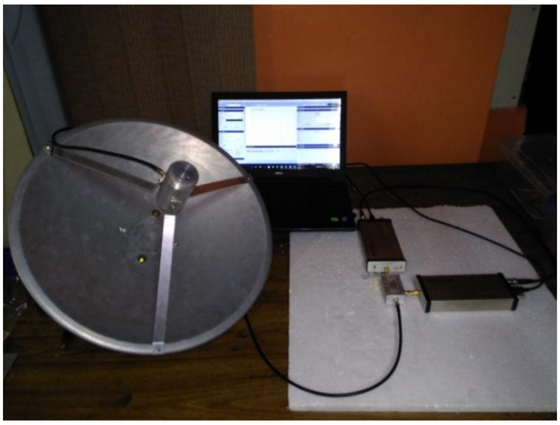

Fig -9: Experimental setup for return loss measurement of prototype.

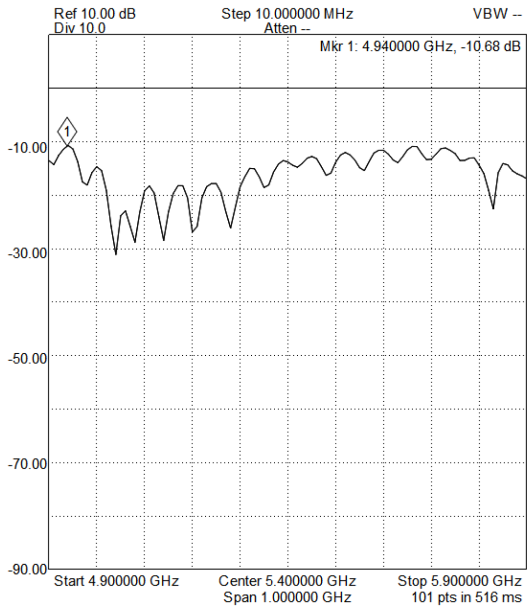

Fig -10: Return loss of reflector antenna (prototype).

3. CONCLUSIONS

The antenna prototype along with its basic specifications has been verified for 5GHz band and the design details are mentioned in the document. The reflector antenna for 5 GHz band is designed, simulated and tested. The monopole of the antenna is made up of copper, horn and reflector is made of aluminum in the prototype. The design is simulated using CST MWS software. The prototype is tested using Signal Hound tracking generator and Signal Hound scalar network analyzer. From both the simulation result and the experimental result the antenna is working over the complete band of 4.9 GHz to 5.9 GHz having a return loss less than -10dB over the complete frequency range.

Further this parabolic reflector antenna design can be extended to a dual polarized antenna. Hence, if developed, dual polarized will have vast and promising applications in the ISM / WLAN industry globally.

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