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VERTICALLY POLARIZED CAVITY BACKED SHORTED HEXAGONAL PATCH ANTENNA

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Abstract—A cavity backed conformal broadband compact hexagonal patch antenna is proposed that is fed using a co-axial probe. This horizontally mounted shorted antenna yields vertical polarization. The antenna yields 9.52% bandwidth centered around 1.05 GHz. The simulated results of electrical parameters of this antenna are in good agreement with measured ones. This vertically polarized antenna can be used for IFF airborne applications.

1. INTRODUCTION

Microstrip antennas (MSAs) are planar and conformal, which generally yield polarization based on the orientation of planarity of the host surface [1]. It is difficult to obtain vertical polarization from horizontally mounted MSAs. Besides, microstrip antennas are very narrowband. A practical application like IFF (Identification Friend or Foe) antenna used in military and commercial aircraft, requires an antenna that is conformal, broadband, omni-directional in azimuth plane and vertical polarization with minimum cross polarization levels [2, 3]. To avoid aerodynamic drag and to reduce radar cross section, IFF antenna is made flat with the surface of the fuselage or wings.

In order to meet all the above requirements, a novel cavity backed suspended hexagonal patch antenna has been designed as a conformal antenna, which covers the frequency band of 1 to 1.1 GHz. It has similar characteristics as that of a conventionally used vertical monopole blade antenna, with omni-directional azimuthal radiation

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pattern and minimum cross polarization level. It is compact and can be flush mounted below the skin of the aircraft. It satisfies all requirements of the application of IFF and can replace conventionally protruding blade antennas.

2. DESIGN OF ANTENNA CONFIGURATION

Cavity backed antennas have been reported to increase gain and bandwidth [4–6]. A circular cavity enclosed circular patch antenna has been reported to yield horizontal polarization, when mounted on a horizontal plane surface [4]. To obtain vertical polarization and to make the configuration compact, the patch has been designed with vertical shorting posts. It is envisaged that a slot formed between the patch and the cavity excites current on vertical shorting posts and would yield vertical polarization. The suspended configuration has been chosen, as the bandwidth requirement was around 9.52% (1.0 to 1.1 GHz). A hexagonal patch antenna approximates the circular one without reducing the aperture of the antenna [7]. Here, the hexagonal configuration has been chosen over the circular patch for the ease of fabrication. Rectangular and triangular patches were not considered as they have asymmetrical geometry. A single point shorting post on the periphery reduces the resonance frequency of the circular patch the maximum, by a factor of π, leading to the maximum reduction of size of the antenna [1]. At the same time a single shorting post introduces high level of asymmetry in the configuration, which leads to asymmetrical radiation patterns and high cross polarization levels. Thus, three alternate vertices of the hexagonal patch were shorted with straight shorting posts. Further, it is reported that a circular cavity also reduces the resonance frequency by about 5%, depending upon the diameter and the height of the rim of the cavity [4].

Keeping all these aspects in mind, an unshorted hexagonal patch was designed with side length of 4.45 cm and the height of patch from the ground plane was 3.0 cm. This patch resonates at 1.578 GHz. Next, this hexagonal patch was shorted to the ground plane by 3 cylindrical metal posts having height of 3.0 cm and diameter of 0.5 cm each, at three vertices of the patch as shown in Figure 1(a). The diameter of the co-axial feed at the centre of the hexagonal patch was optimized for good impedance matching over the entire band. The resonance frequency of this shorted hexagonal patch reduced to 1.231 GHz from 1.578 GHz. Finally, the antenna was placed inside the circular cavity. The diameter of the cavity and the height of the rim were optimised at 16 cm and 3.5 cm, respectively, to achieve the required resonance frequency of 1.05 GHz. The height of the patch from ground plane

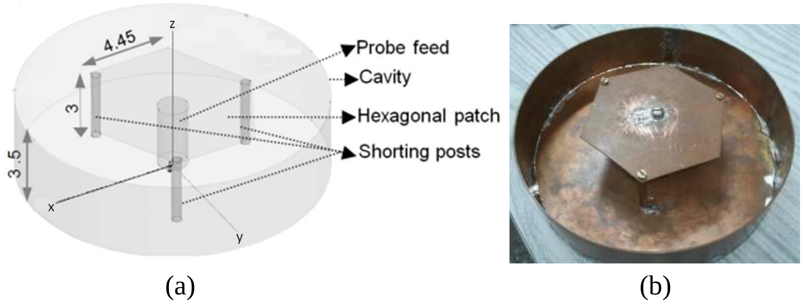

Figure 1. Cavity backed shorted hexagonal patch antenna. (a) Schematic diagram of the antenna (all dimensions in cm) and (b) photograph of the fabricated antenna.

is quite large, i.e., 3 cm. When an N-type co-axial connector with elongated centre conductor is used to feed the antenna, the input impedance becomes highly inductive and the impedance loci curve shifts upward on the Smith Chart and thus VSWR becomes high.

The radius of the centre conductor of the connector was optimized and increased from 0.16 cm to 0.8 cm to neutralize the inductive component in the input impedance and thus, improves input matching over the bandwidth. The cavity isolates the antenna from other objects, when it is mounted below the skin of the aircraft.

3. MEASURED AND SIMULATED RESULTS

The fabricated antenna is shown in Figure 1(b). Various simulated results, using HFSS software, are compared with measured ones [8]. The input VSWR plots and corresponding input impedance loci in the Smith Chart are shown in Figures 2(a) and 2(b), respectively, for the required frequency range of 1.0 to 1.1 GHz. The VSWR is less than 2 over the entire bandwidth, which is 9.52% at the centre frequency of 1.05 GHz. There is good agreement between simulated and measured plots.The simulated current distribution is shown in Figure 3.

The simulated and measured Azimuthal and Elevation radiation patterns, at 1.05 GHz, are compared in Figures 4(a) and 4(b), respectively, which are in good agreement. The azimuthal radiation pattern is omni-directional, whereas in elevation, it is a 'Figure of Eight' with a 3 dB beamwidth of 119.40°. Although the beamwidth in azimuth is similar to that of a dipole, the beamwidth in elevation is larger than that of a dipole. As a result, the antenna gain is around 1 dBi which is lesser than that of a dipole over the entire frequency

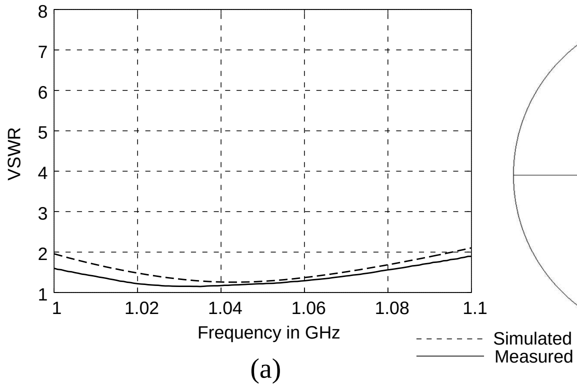

Figure 2. VSWR and input impedance. (a) VSWR of the cavity backed shorted hexagonal patch antenna and (b) impedance loci of the cavity backed shorted hexagonal patch antenna.

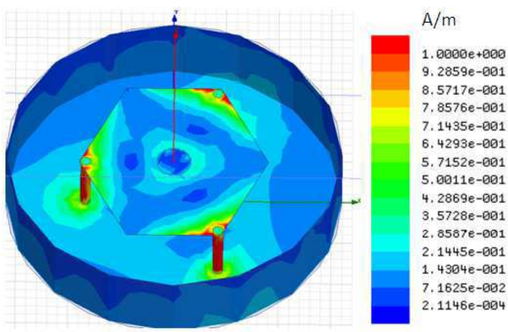

Figure 3. Simulated current distribution at 1.05 GHz.

range of 1.0 to 1.1 GHz. However, due to this larger coverage, the antenna is suitable for applications like IFF antenna. It is also noted from the plots, that the cross polarization levels in desired directions is more than 25 dB down as compared to the co-polarized levels. The radiation efficiency of the antenna is close to 100% as it is made up of copper and is almost loss-less at the design frequency. This horizontally mounted conformal antenna has all the characteristics similar to that of a vertically mounted protruding blade antenna, conventionally used for airborne IFF transponder application, but without high levels of wind drag.

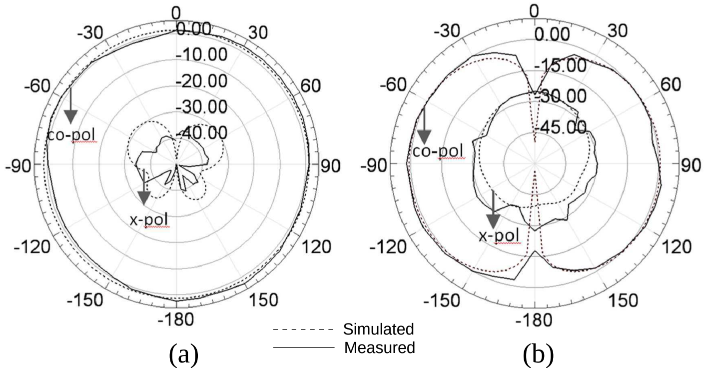

Figure 4. Radiation patterns of the cavity backed shorted hexagonal patch antenna at 1.05 GHz. (a) Azimuth and (b) elevation.

4. CONCLUSION

A cavity backed shorted suspended hexagonal patch antenna is proposed. It is conformal and yields an omni-directional radiation pattern with vertical polarization in the azimuth plane, similar to that of a blade antenna, over the entire frequency range of 1.0 GHz to 1.1 GHz. It also has low cross polarization levels. This antenna may be used as a conformal broadband antenna for airborne applications like an IFF antenna or various other applications, where conformability and omni-directional coverage with vertical polarization are required and an antenna having lesser wind drag is desired.

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