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Compact and Wideband Cylindrically Conformed Printed Elliptical Monopole Antenna with Modified-Shape Ground Plane

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Abstract

A compact and wideband cylindrically conformed antenna with a printed monopole structure is presented in this paper. The monopole consists of two parallel slots. Simulation results show that the antenna achieved an impedance bandwidth (**S_{11}≤-10db**) of 6.3 Ghz (6.1-12.4 Ghz) and percentage bandwidth of 68%. The proposed antenna shows omni-directional radiation pattern over the complete operating bandwidth. Simulations are done with different curvature of conformal antenna and with different substrate material. Radiation results have been simulated by using simulation software Ansoft HFSS Ver13.

Keywords: conformal antenna, wideband, elliptical monopole, HFSS ver13.

Introduction

Microstrip antennas are superior to conventional antennas due to their low profile, compactness, low cost, robustness, compatibility with MMIC design, versatility in terms of resonant frequency & conformability to planar and non-planar surface[10]-[12]. Beside these advantages these antenna have some drawbacks also such as, low efficiency, low power, narrow bandwidth etc, which restrict its practical applications in microwave industry. Lots of work have been done to overcome these shortcomings. Now-a-days more and more conformal antennas are used in communication and navigation technologies. The possibility of conforming them in a determined shape makes them attractive for aircraft, automobiles or ships, where aerodynamic may well be improved by adjusting the antennas to the contour of the vehicles. Other important feature of these antennas is their radiation characteristics. They usually provide broader beams than their planar counterparts [1][2]. This quality is an advantage when, for example, omni-directional patterns are required, which normally are achieved applying an array [9]. The use of conformal antennas for the same purpose provides simpler manufacturing since it may be only one single antenna with simpler performance, avoiding the ripple problems characteristic of arrays configurations. Other possible purpose for using these antennas is making them less disturbing, i.e. less visible to the human eye since there are integrated on the structure. This attribute might be useful for urban or military environments. Conformal antennas can be almost any geometry, although the main structures investigated so far are cylindrical, spherical and conical. In this paper we proposed an microstrip antenna on cylindrical surface. Lots of conformal antennas has been designed and analyzed for different applications [4]-[9]. In our case we propose an cylindrically conformed antenna which is compact enough and can work in C and X bands.

Antenna Design

Based on the elliptical monopole antenna [13] and small antenna with truncated ground plane [14] a new elliptical monopole antenna with modified ground plane is developed here. A wideband conformal printed elliptical monopole antenna with modified ground is presented in this article. Geometry of the proposed antenna is shown in fig 1. To achieve wide impedance bandwidth, while maintaining the small size of antenna, a semielliptical part is removed from the top edge of the ground plane. Also, to reduce the lower cut off frequency of the antenna, two narrow slits are cut in the middle of the elliptical radiation element, as shown in the fig 1 (a).

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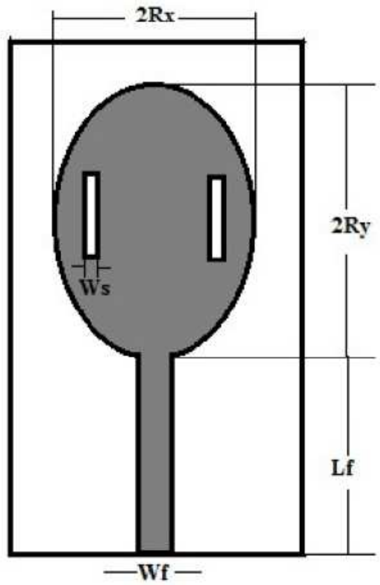
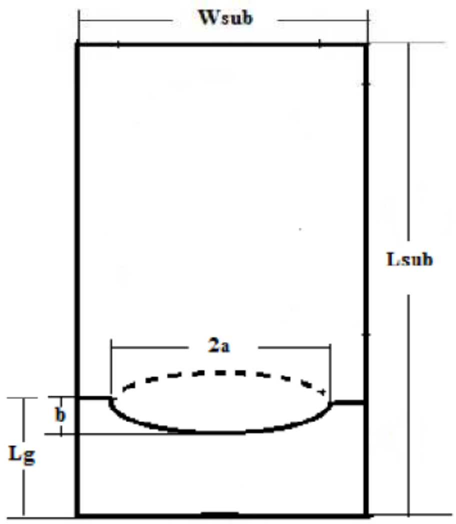


a). top view



b). bottom view

Figure 1 Geometry of the proposed antenna (a) top view (b) bottom

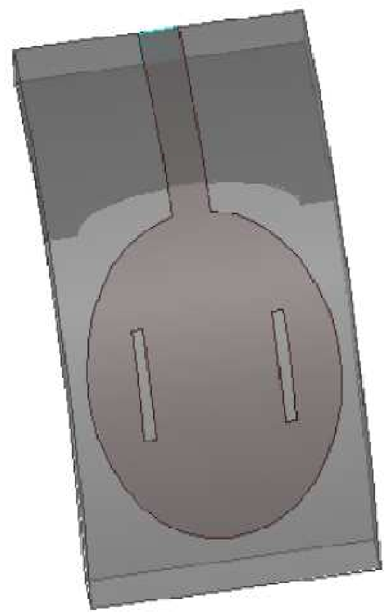
View

The proposed antenna height is kept constant at 1.524mm while antenna performance is analyzed for different substrate materials. Using CST Microwave Studio the structural parameters of the antenna are optimized to achieve an acceptable return loss over the whole operating band. The overall size of the optimized planar antenna structure is 11mm×22mm. Also detailed dimensions of the optimal design are shown in Table 1 below.

TABLE 1. Antenna design parameters

W_{sub}=11mm	L_{sub}=22mm	R_x=4.8mm	R_y=6mm
L_f=8mm	W_f=2mm	L_g=7mm	a=4.25mm
b=1.4mm	W_s=0.43mm	h=1.524mm	

Proposed conformal antenna is designed in two steps. In first step conformal antenna is analyzed at different central angle with constant substrate material. After this, in second step the antenna is analyzed with different substrate materials. Simulation results are discussed in next section in detail.



a). front view

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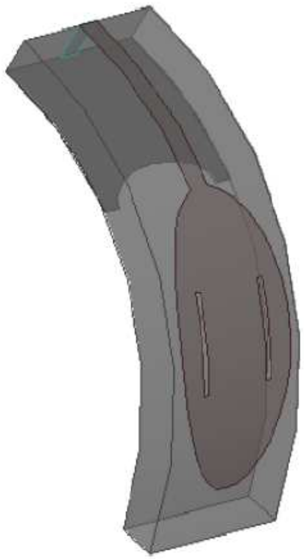

b). side view
fig 2. Conformal antenna model designed in CST.

Simulations and Results

The conformal antenna model designed in CST microwave studio is shown in fig 2. The proposed conformal antenna is designed and simulated by using CST microwave studio. S_{11} parameter variation due to change in central angle and substrate material are shown in fig 3 & 4. A

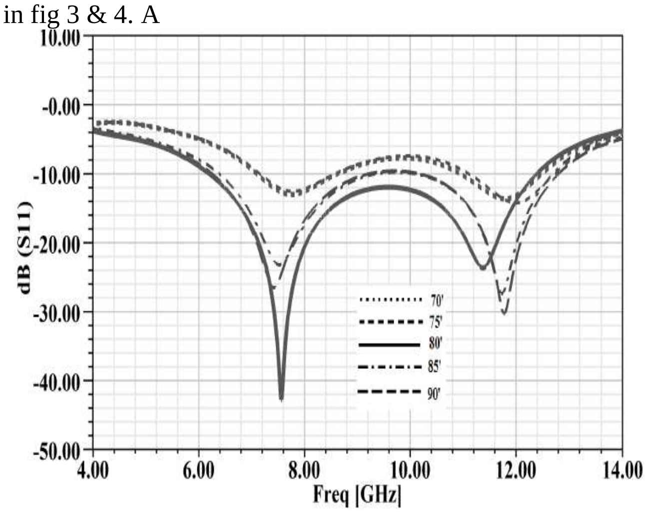

Fig 3. Variation of return loss with different central angle.

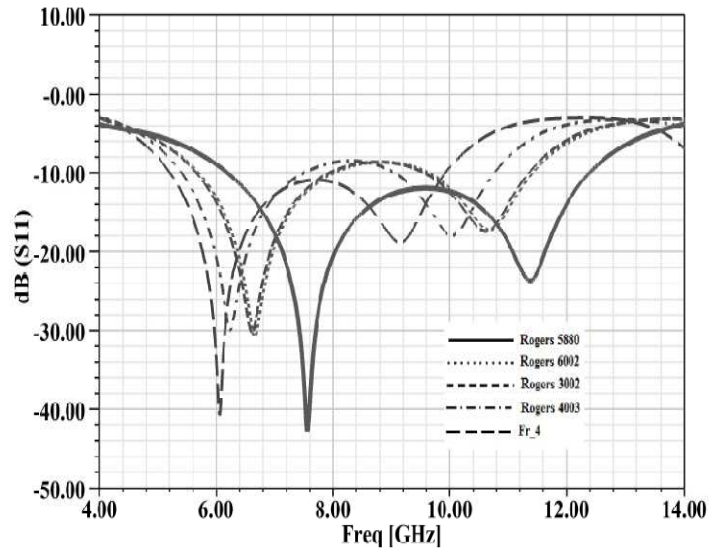

Fig 4. Variation of return loss with different substrate material.

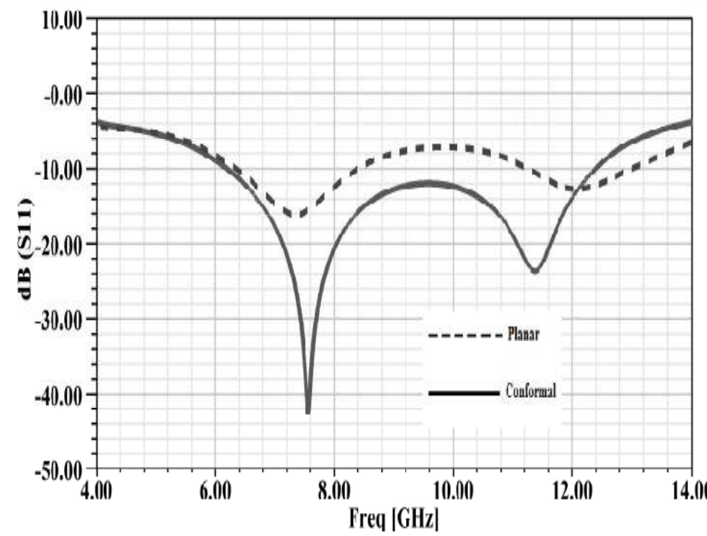

Fig 5. Comparison b/w return losses of planar and conformal antenna.

comparison b/w S_{11} parameter of planar antenna and its conformal counterpart is shown in fig 5.

In fig 3 variation of return loss is analyzed for various central angles from 70º to 90º. It can be seen that conformal antenna with 80º central angle shows better return loss of all, hence chosen for antenna design. In fig 4 variation of return loss with various substrate material is shown at a constant central angle 80º. It is clear from the plot that rogers RT/duroid 5880 (ε_r=2.2) shows better results than other substrate material. Finally in fig 5 we can see a comparison of return losses of proposed conformal antenna and its planar counterpart. Planar antenna shows double band characteristics with two bands of 2 Ghz and 0.7 Ghz. Whereas conformal antenna shows better results as it shows single band characteristics with impedance bandwidth of 6.3 Ghz (6.1 Ghz- 12.4 Ghz). Minimum return loss is going to be -43 dB for the conformal antenna which is far better than the return loss of planar one, which is -16 dB. The S_{11} plot of conformal antenna shows two resonant frequencies at 7.6 Ghz and 11.5 Ghz respectively. Fig 6 shows the radiation pattern of proposed conformal antenna. It is clear from the photograph that proposed antenna shows an omni-directional pattern that reaches to the isotropic pattern. Maximum gain of the antenna is calculated as 3.65 dB at the resonant frequency.

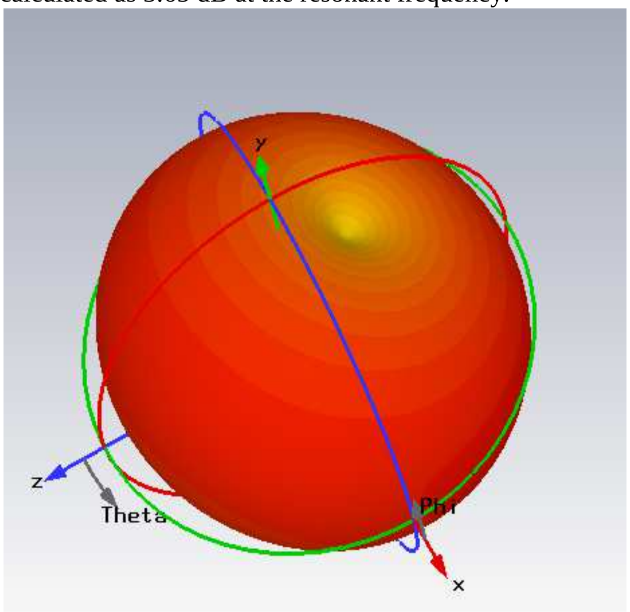

Fig 6. Radiation plot of proposed conformal antenna

Conclusion

A compact and wideband cylindrically conformed printed elliptical monopole antenna with modified-shape ground plane is presented in this paper. Antenna design is simple, compact and easy to apply. Impedance bandwidth of 6.3 Ghz (6.1-12.4 Ghz) is achieved with minimum RL of -43 dB. This antenna shows wideband characteristics and omni-directinal radiation patterns with low RCS. This antenna can be easily integrated on curved surface of aircrafts, missiles and other vehicle. Overall, it can be concluded that this type of antenna is excellent candidate for various wideband space communication and radar applications which is operating at C band and X band.

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