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Compact Cross Spoke Shaped Monopole Antenna

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ABSTRACT

In this paper a monopole antenna with omni directional radiation pattern for X Band is proposed. The structure is a simple ring with spoke designed on substrate FR4 with outer radius of 4mm and inner radius of 3.33mm and the spoke of 1.57mm and ground plane dimension 22mm×12mm ('Lg X Wg'). The impedance matching and radiation characteristics of the designed structure are investigated with the aid of IE3D software. The simulation results shows that the antenna offers excellent performance for almost covering X band range with return loss lower than -10dB. The VSWR is also less than 2.

Keywords:- X Band, Annular Patch, monopole, S-Parameter, omni-directional.

1. INTRODUCTION

The modern wireless communications system requires low profile, light weight, high gain, and simple structure antenna to assure reliability, mobility and high efficiency characteristics. Micro strip antenna satisfies such requirements. The key features of a micro strip antenna are relative ease of construction, light weight, low cost and either conformability to the mounting surface or, an extremely thin protrusion from the surface. This antenna provides all of the advantages of printed circuit technology. However micro strip antenna suffers from a number of disadvantages particularly narrow bandwidth.There are varieties of patch structures available but the rectangular, circular and triangular shapes [5] are most frequently used. In these requirements, these devices become smaller in size and hence the antenna required for transmit and receive signals has as to be smaller and light in weight. As a matter of fact, micro-strip we use circular patch antenna [3-7]. The objective of this work is to propose antenna with improved gain in X-band. In this starting with circular monopole antenna [2], a novel design of circular cross spoke antenna is designed. This spoke antenna is optimized for gain improvement by changing the shape of ground plane. Further antenna is modified with the reflector, because of which the gain of the antenna is increased. The X band is a segment of the microwave radio region of the electromagnetic spectrum. In some cases, such as in communication engineering, the frequency range of X band is rather indefinitely set at approximately 7.0 to 11.2 gigahertz (GHz). In radar engineering, the frequency range is specified by the IEEE at 8.0 to 12.0 GHz (8.9 to 9.1 Bel Hz). Historically X-band Satellite Communication has been reserved for military and government organizations and is known as a military band. The features and benefits of a Satcom network are designed specifically for military operations using secure satellite links in X-band which are vastly different when compared to other commercial frequencies. The most commonlyused patch structures are rectangular and circular. For rectangular patch elements there are two degrees of freedom to whereas for the circular patch elements there is one degree of freedom to control. Thus it is more convenient to design as well as to control the radiation pattern of the circular patch element [7]. Moreover the physical area of the circular patch is 16% less than that of the rectangular patch [9]. In the present paper a modified circular patch with a slot is proposed which is capable of giving reasonable gain and large bandwidth for a wide range of frequency values in X bands.

2. ANTENNA DESIGNING AND SIMULATION

Various frequency notched UWB antennas studied by many researchers are classified according to slot's locations such as radiating element, ground plane, feeding line and vicinity of the radiating element [1]. So inserting slot in such a manner to obtain X band from UWB, so first slotting the UWB circular monopole antenna into annular ring antenna as shown in figure 1.

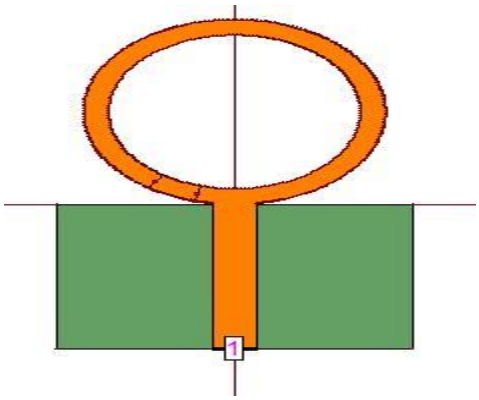


Figure 1 Geometry of monopole Antenna.

Figure 2 shows the evolution of the proposed printed monopole antenna. The structure is a compact form of wheel shaped antenna.

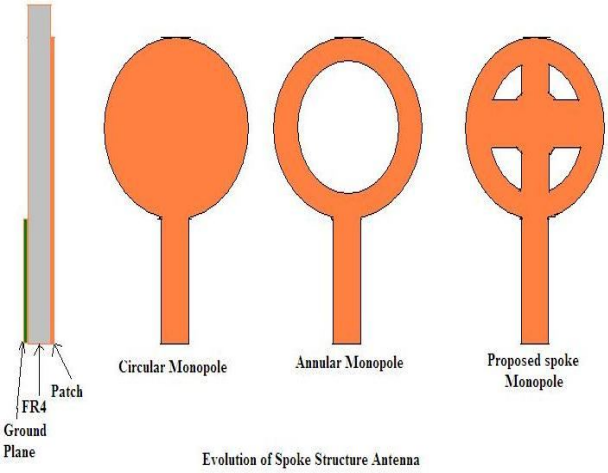


Figure 2 Proposed shape X band antenna

The proposed X Band antenna is a variation of circular monopole antenna as shown in figure 2. Since the current of circular monopole antenna is mainly concentrated along the periphery of the circular monopole antenna, therefore, central portion of the circular monopole of radius `r' can be removed with negligible effect on impedance bandwidth or radiation characteristics and resulting in an cross spoke shaped monopole antenna [8].

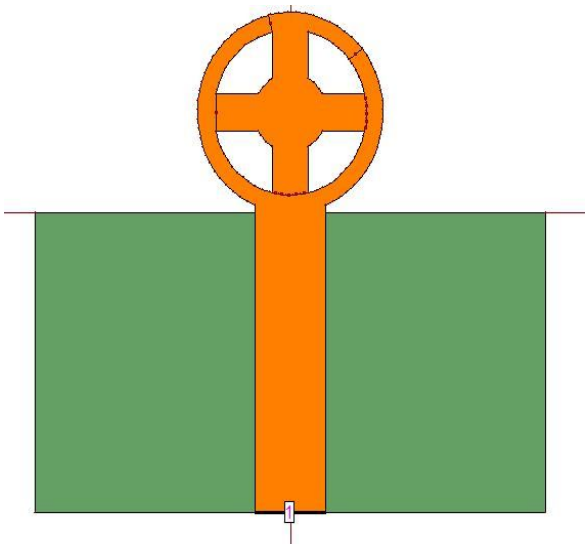


Figure 3 Geometry of compact circular cross spoke monopole Antenna.

The geometry of the proposed antenna is shown in Fig. 3 is fed by a 50ohm micro-strip line and fabricated on a 1.6-mm-thick FR4 substrate with 22 × 12 mm surface area. The relative permittivity and loss tangent of the substrate is 4.4

and 0.02, respectively. The antenna structure is a variation of a circular monopole antenna [2]. The radius (r) of the circular monopole is obtained by using the equation no 1.

$$\text{L.F} = \frac{7.2}{2.25 \times R + g} \qquad (1)$$

where L.F = Lower resonant frequency in GHz, R = Radius of a circular patch in centimeters, g = gap in centimeters between patch and ground plane. Radius calculated at 8 GHz for g = 0 is 4 mm. X band annular monopole antenna is designed with radius R1 = 4.1 mm and radius R2 = 3.33mm. It is further optimized to 4 mm [2]. The proposed monopole antenna is illustrated in Fig 3. Cross shaped spoke monopole antenna with outer radius 'R', inner radius 'r' and a micro-strip feed line are printed on the same side of the dielectric substrate (in this project, the FR4 substrate of thickness 1.6 mm and relative permittivity 4.4 with loss tangent of 0.02 is used). The width of the micro-strip feed line is fixed to achieve 50Ω impedance. On the other side of the substrate, the conducting ground plane with a length 'Lg' and width 'Wg'.

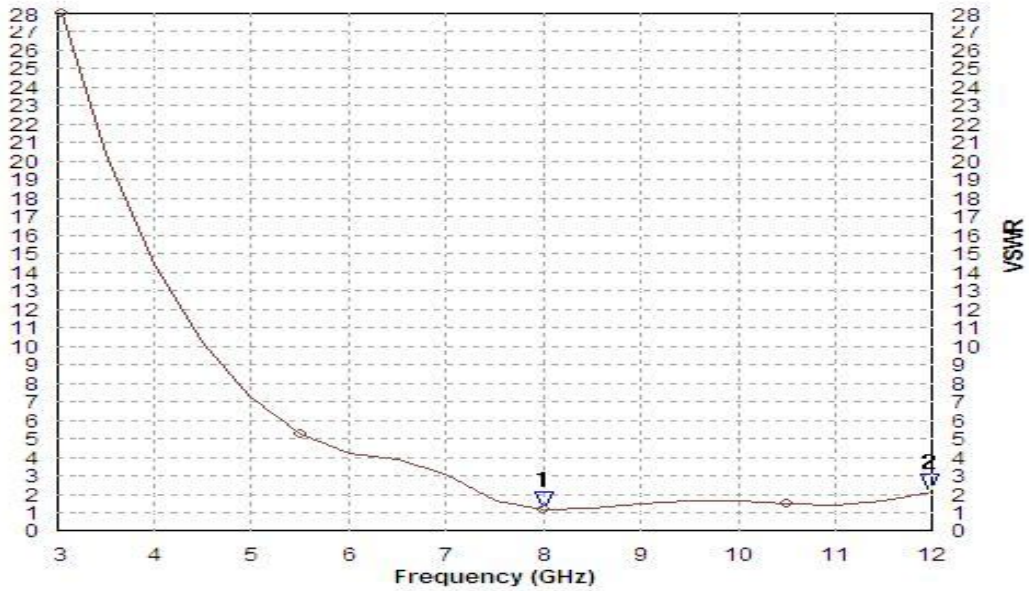
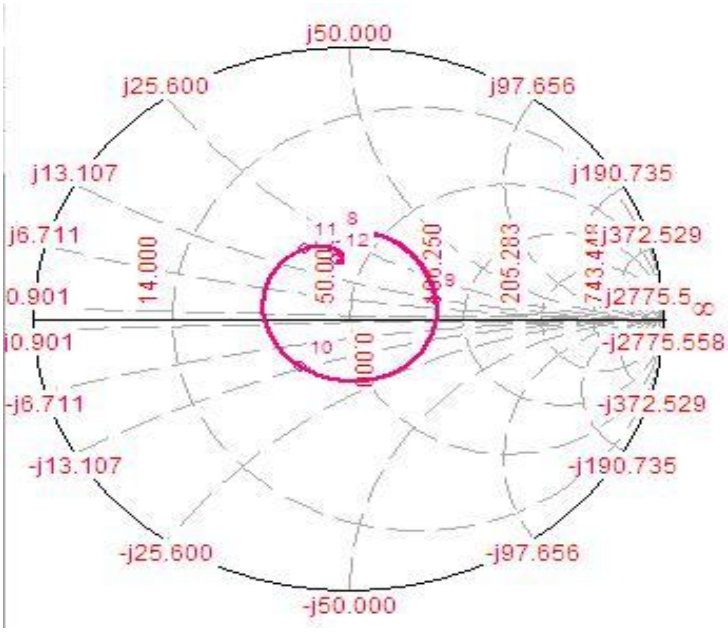


Figure 4 VSWR plot for our optimum design.

The acceptable range for VSWR is below 2 which is obtained in above design as shown in figure 4.



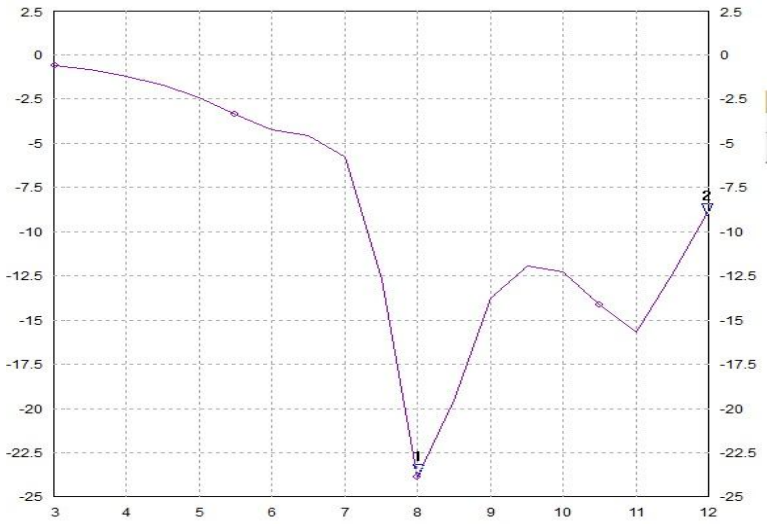


Figure 5 Smith Chart and Return loss graph for compact design

To get -10dB, return loss curve should be nearer to the center; hence from the figure 5, we get the curve nearer to the center.

3. PROPOSED DESIGN WITH DOME REFLECTOR

The purpose of this design is to propose an antenna which has the impedance bandwidth between 8 and 12 GHz, with a highly omni directional radiation pattern throughout the desired bandwidth, for use in near field near surface imaging applications. Geometry of the proposed antenna is illustrated in Figure 6.

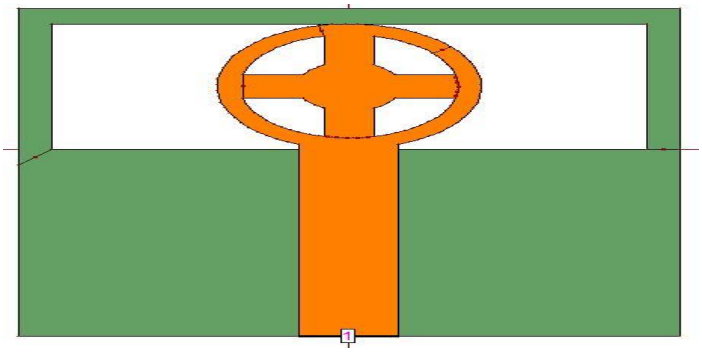


Figure 6 Compact monopole antennas with reflector

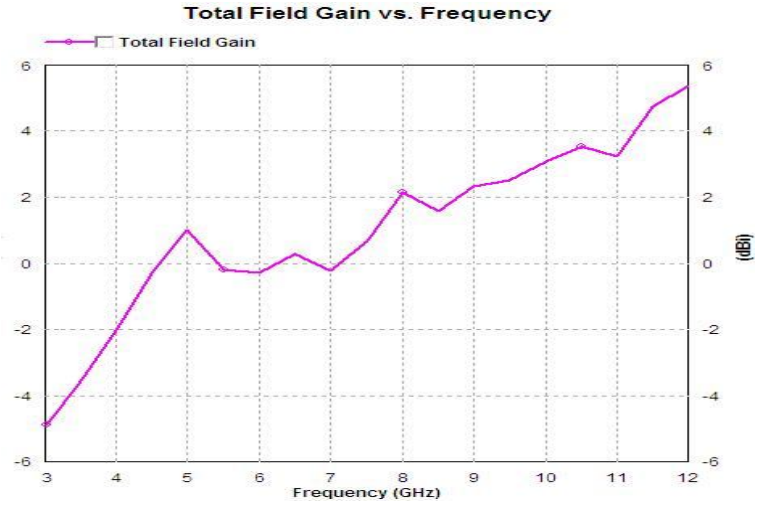


Figure 7 Gain graph of Compact Monopole Antenna with Reflector

The ground plane of 22 mmx12 mm and the reflector behind the main patch with the dimension of 2mmx 2mm.The extension of ground plane in rectangular dome shape is done to improve front to back ratio and gain of antenna. With the reflector behind the main patch in design helps in increasing the gain of the proposed antenna. And it is seen that the average gain of the antenna was increased from 2dBi to 5.2 dBi as shown in figure 7. This is one of the methods to enhance the gain of antenna.

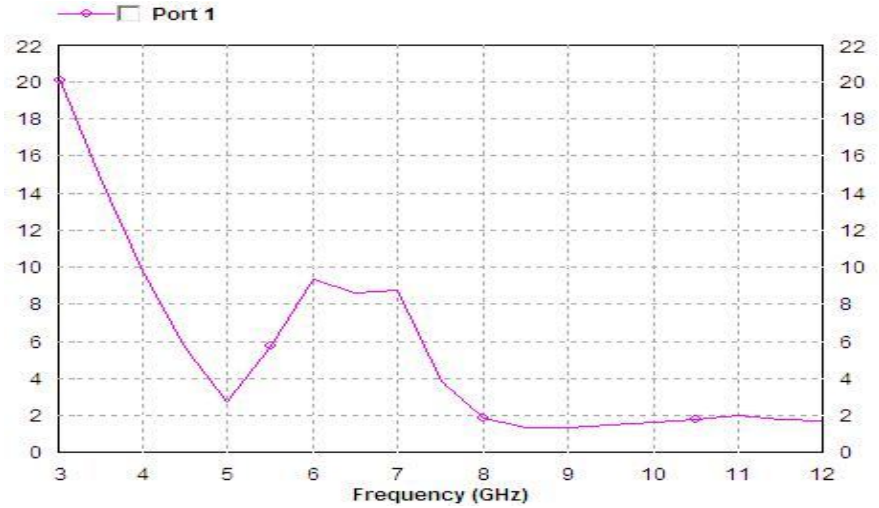


Figure 8 VSWR graph of compact monopole antenna with reflector

Figure 9 Return loss for the reflector design

Designed antenna shows almost Omni-directional radiation pattern as shown in following figure 10.

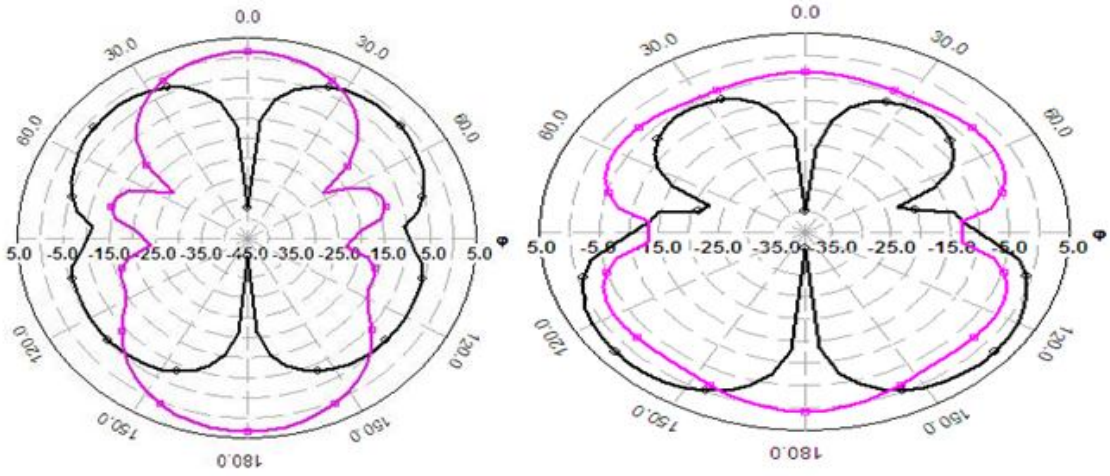


Figure (a) Frequency = 8 GHz

Figure (b) Frequency = 9 GHz

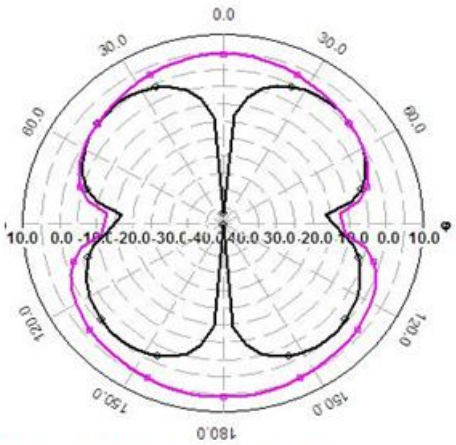


Figure (c) Frequency = 10 GHz
g (a): Frequency = 8 GHz

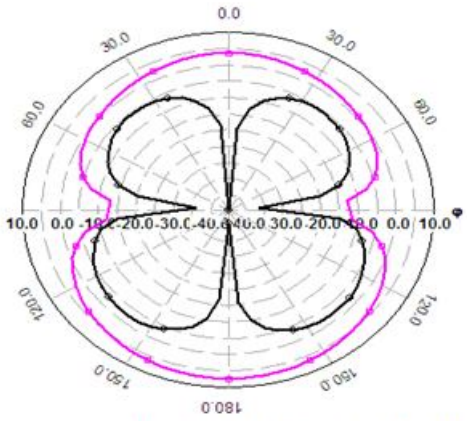


Figure (d) Frequency = 11 GHz
Fig (b): Frequency = 9 GHz

(c) freq. = 10 GHz

Figure10 2D Radiation pattern at various frequencies.

4. FUTURE SCOPE AND CONCLUSION

The compact circular cross spoke shaped monopole antenna fed by micro-strip line is investigated in this paper. It has been shown that the performance of the antenna is carried out in IE3d Software. The proposed antenna is fabricated on FR4 with εr=4.4, tanδ=0.02 and the thickness is 1.6mm with the proposed dimensions 22mm x12mm.From graph it is observed that this compact design notch out all higher UWB frequencies and is applicable only for X band application.. The simulated results of proposed antenna for return loss is less than -10 dB and VSWR is less than 2, satisfy the system requirements for X Band application. In future the effect of ground plane can be analyzed and studied with various shapes.

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