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Effect of Reflecting Sheet on the Back of Stripline fed Slotted Hexagonal Patch Antenna

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ABSTRACT

Since the Federal Communication Committee has released a bandwidth of 7.5 GHz from 3.10GHz to 10.60GHz, Ultra wideband technology (UWB) is advancing rapidly as a high data rate technology for wireless communication. The effect of placing a conducting reflecting sheet at the back of microstrip line fed slotted hexagonal patch antenna with finite ground for wireless application is presented here. It is shown that antenna design with reflecting sheet at the back of the radiating structure provides radiations with -10 dB return loss in the entire ultra wide band of 3.1GHz to 10.6GHz specified by FCC. The size of the ground plane considered is 34 X 29mm, which is suitable for portable wireless communication devices. The effect of placing a conducting reflecting sheet at the back of strip line fed slotted hexagonal patch antenna is investigated. It is shown that, the proposed antenna provide directional radiation pattern with acceptable level of back lobe with good impedance matching criteria. It is found that the antenna is matched with return loss (S_{11}) better than -10dB within the frequency range 3.10GHz to 10.60GHz.

Key Words: Reflecting sheet, ultra wideband, hexagonal patch, slotted.

1. INTRODUCTION

The Federal Communication Commission (FCC) has allotted a band width of 7.5GHz from 3.10GHz to 10.60GHz for wireless communication in 2002. In the case of conventional communication systems, an antenna design plays a crucial role in the UWB systems. There are more challenges in designing an ultra wideband antenna rather than a narrow band antenna. Narrow impedance bandwidth is the major disadvantage of micro strip patch antenna in spite of its small size and low weight [1],[2]. The ultra wide bandwidth can be improved using slotted antenna with finite ground. Microstrip antennas with slot on the ground or patch fed by coplanar wave guide have shown wide bandwidth and ultra wideband characteristics [3], [4. It is shown that band width and impedance matching of ultra wideband antennas can be improved by using radiating patches of E shape[5], elliptical [6], crescent [7], defected ground plane structure [8] etc. It is found that further improvement in ultra wide bandwidth is achieved by slotted antennas [9], [10]. A microstrip patch with rectangular slot fed by microstrip transmission line provided ultra wide bandwidths of 60% and 83% respectively [11],[12]. CPW fed hexagon slotted hexagonal patch antenna provided 100% ultra wide band bandwidth [13]. It is shown that by placing a conducting reflecting sheet at the back of the resonant structure reduces the back radiations to a great extend [1], [2]. In this paper, the effect of placing a reflecting sheet at the back of the microstrip line fed slotted hexagonal patch antenna is presented. It is shown that the proposed antenna provides 100% ultra wide band bandwidth with minimum back lobe.

2. ANTENNA GEOMETRY AND DESIGN

The geometry of the proposed antenna structure is shown in Figure.1. The antenna is fabricated using a FR4 Epoxy substrate with dielectric constant $\varepsilon_r = 4.4$, loss tangent $\tan \delta = 0.0025$and thickness of 1.6mm. The size of the antenna is 34 X 29mm. The proposed antenna is fed by a microstrip line. The characteristics impedance of the feed is 50Ω and the feed is designed with a feed line width of 3.60mm and length of the feed line is 10mm. It is easy to fabricate as the patch and feed structure are

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fabricated on the same plane. It is a slotted patch antenna with a finite ground structure. The resonating structure is backed by a conducting reflecting sheet of dimension 34mm X 29mm at a distance 'd' from the antenna. The spacing 'd' was varied from 5mm to 25 mm. Ansoft HFSS 15 is used to design and optimize the design. The radiation set up of the proposed antenna is shown in Figure 2.

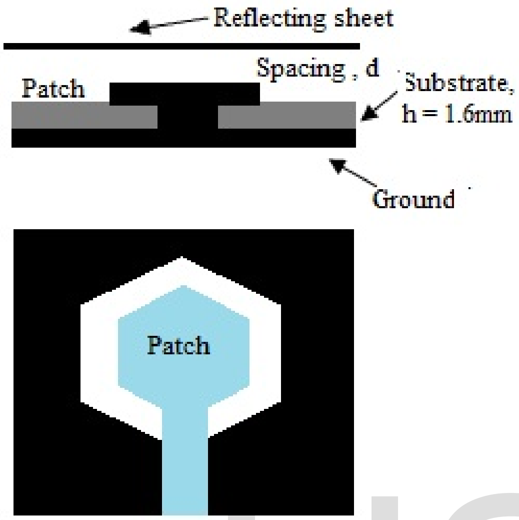

Figure1. Geometry of Proposed Antenna

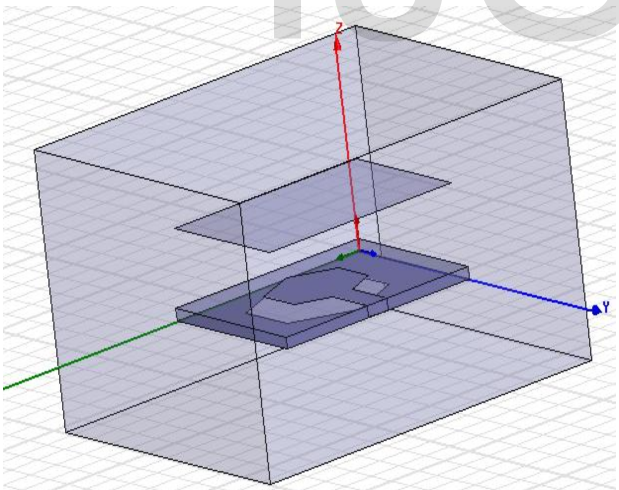

Figure 2. Radiation set up of Proposed Antenna

The total length 'L' and width 'W' [14] of the patch antenna is given by Equation (1) and (2)

$$W = \frac{c}{2fr}\sqrt{\frac{2}{\varepsilon r+1}} \quad (1)$$

where 'f_r' is the resonant frequency and 'c' = 3 x 10^8 m/s

$$L = \frac{c}{2fr\sqrt{\varepsilon reff}} - 2\Delta L \quad (2)$$

Where $\varepsilon_{reff} = \varepsilon_r \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2\sqrt{(1+{}^{12h}/_{w})}}$

(3)

$$\Delta L = h * 0.412\frac{(\varepsilon reff+0.3)[{}^{W}/_{h}+0.264]}{(\varepsilon reff-0.258)[{}^{W}/_{h}+0.8]} \quad (4)$$

$$L_{eff} = L + 2\Delta L \quad (5)$$

In order to design a hexagonal patch, design of a circular patch is introduced first because these two antennas are closely related to each other [15]. The fundamental resonance frequency of a circular patch antenna is given by

$$f_r = (X_{mn}/\ 2\pi a_e\sqrt{\varepsilon_r})c \quad (6)$$

where f_r is the resonant frequency of the patch, X_{mn} = 1.8411for the dominant mode $TM_{11.}$ ε_r is the relative permittivity of free space, c is the velocity of the light in free space and a_e is the effective radius of the circular patch given by

$$a_e = a\{1 - ((2h/\pi a\varepsilon_r)(\ln(\pi a/2h) + 1.7726)\}^{0.5} \quad (7)$$

where 'a' is the radius of the circular patch antenna and 'h' is the height of the substrate.

Equation (6) can be applied for designing a hexagonal microstrip patch antenna by relating the areas of the circular and hexagonal patches as shown in Equation (8).

$$\pi a_e^2 = (3\sqrt{3}/2) * S^2 \quad (8)$$

where 'S' is the side length of the Hexagonal patch. Equations (1), (2) and (8) are used to find the theoretical values of the ground plane and patch for the highest resonating frequency of 10Ghz with dielectric constant ε_r = 4.4. the design is optimized using HFSS.

3. SIMULATION RESULTS AND DISCUSSIONS

The proposed antenna with reflecting sheet on the back is simulated using HFSS 15.0 to approximately calculate its performance. The antenna was analysed by varying any one of the physical parameter keeping other parameters constant. Figure 3 and Figure 4 shows the calculated return loss and VSWR of the antenna proposed.

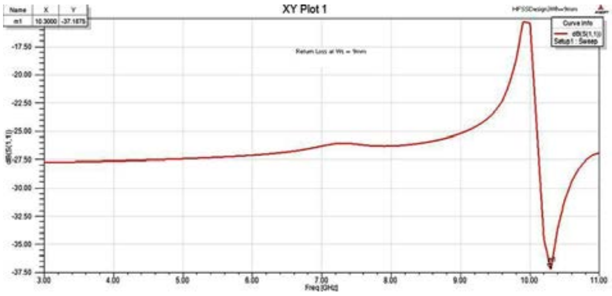

Figure 3. Return Loss – Proposed antenna

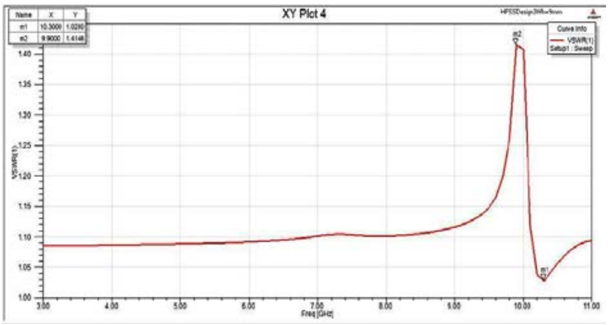

Figure 4. VSWR – Proposed antenna

From Figure 3., it is found that the proposed strip line fed slotted hexagonal patch antenna radiates effectively in the UWB range of 3.1GHz to 10.6GHz and it achieves a maximum return loss of -37.18dB. From Figure 4., it is evident that the calculated voltage standing wave ratio (VSWR) is less than 2 for the entire frequency range from 3.1GHz to 10.6GHz.

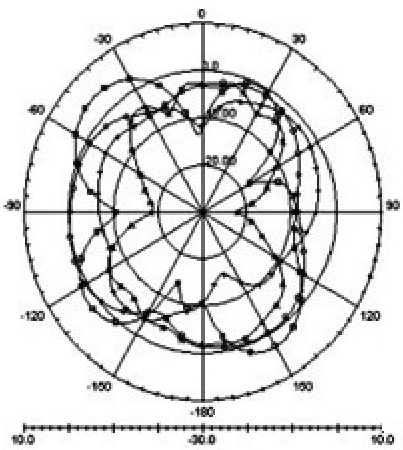

Figure 5. Radiation pattern of antenna without reflecting sheet on the back.

The calculated E plane pattern of the proposed antenna with out reflecting sheet on the back and with reflecting sheet on the back of the antenna at 10GHz are shown in Figure 5 and Figure 6 respectively. From Figure 5, it is found that the antenna without reflecting sheet has broad beamwidth with significant back propagation. For Figure 6, it is clear that the back prpagation can be reduced to a desired level by placing the reflecting sheet.

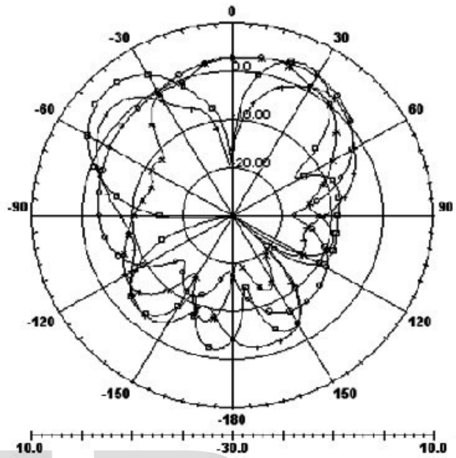

Figure 6. Radiation pattern of the antenna with reflecting sheet on the back.

5. CONCLUSION

In this paper, a microstrip line fed slotted hexagonal patch antenna with reflecting sheet at its back is proposed for ultra wideband applications. The size of the proposed antenna is 34 X 29 X 1.6mm. The estimated results proved that the proposed antenna satisfies the -10 dB return loss specified by Federal Communication Committee from 3.10GHz to 10.60GHz. Further by implementing a reflecting sheet on the back of the antenna, directive radiation patterns are obtained within the UWB range with good matching criteria. It also reduces the back lobe radiation of the antenna within the UWB range. This antenna is suitable for ultra wideband applications due to its small size, low manufacturing cost and sufficient bandwidth.

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