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Coplanar Waveguide Fed Wideband Minoan Double Axe Antenna for Wireless Applications

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ABSTRACT

A wide band Minoan double axe antenna fed by a Co- Planar Waveguide for achieving omni-directional radiation pattern is presented. The proposed antenna is suitable for WLAN 5.2(5.15-5.35GHz) band, WiMAX 2.5/3.5(2.5-2.69GHz, 3.4-3.69GHz) bands, HiperLAN2 (5.47-5.725 GHz) and HiSWaNa (5.15-5.25GHz) wireless application bands. The antenna offers 76% of 2:1 VSWR bandwidth from 2.7GHz to 5.7GHz. This configuration delivers broader bandwidth with acceptable gain and efficiency for a linearly polarized radiation. The simulated and measured reflection characteristics of the antenna along with the radiation patterns and gain are presented and discussed.

Key words: CPW, wideband, Wireless, printed antenna, WLAN, and Wi-MAX

INTRODUCTION

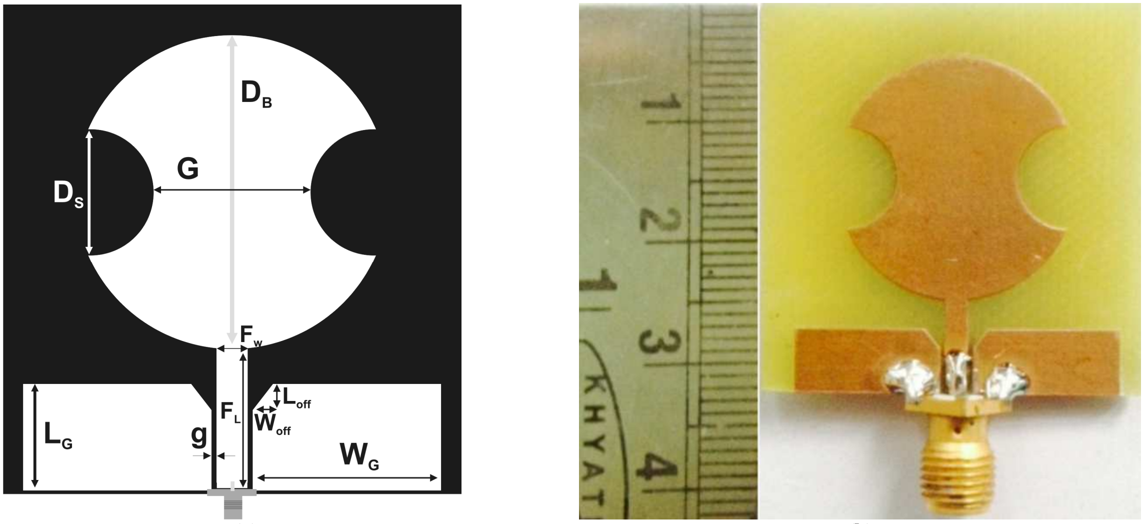
The backbone of modern wireless communication are the various commercial wireless standards used for its management and the allocated frequency bands that radio equipments use to transmit and receive data. Several demands are placed on modern antennas designed for multi-frequency and multi-mode devices. Primarily, antennas need to have high gain, broad bandwidth, embedded installation etc. depending on the type of application. The interest of using Coplanar Waveguide (CPW)-fed planar antennas have been increasing over in recent years since they have many attractive features like low radiation loss, less dispersion, ease of integration with monolithic microwave integrated circuits (MMIC's).

Extensive research has been done in the field of CPW-fed broadband antennas and investigated several designs using defective ground structure, parasitic elements and slots along the length of the monopole which are available in literature [1-3]. Planar monopole antennas have received much attention in ultra wideband applications due to the merits of wide impedance bandwidth and omni-directional radiation patterns. Different kind of UWB antennas, which makes uses stubs or slits or fractal elements to achieve UWB characteristics, have been reported in [4-6]. A triple band monopole antenna for wireless body area network applications was suggested in [7] using a complex miniascape structure. The use of fractal geometry in dielectric resonator antennas for bandwidth enhancement was reported in [8]. A CPW-fed broadband CP antenna presented in [9] for WiMAX, WLAN and other broadband communications. Design of a compact multiband elliptical patch antenna with a narrow slot working in three wireless communication bands allocated by IEEE 802.16 working group for Wi-Max application group is presented by Sharma et al [10]. Another approach for increasing the impedance bandwidth of an antenna is to utilize a log-periodic design [11]. CPW-fed slot antennas, having wideband radiation characteristics suited for WLAN and domestic wireless networks [12], are also more common in literature.

In all the above designs, the radiating structures are complex with modification in ground plane using slots or slits. In this paper a compact Minoan double axe radiating structure fed by a Co-Planar Waveguide for achieving omni-directional radiation pattern is proposed. Also, the single layer substrate is used which enables easy integration with active and passive devices. The proposed antenna is suitable for WLAN 5.2(5.15-5.35GHz) band, WiMAX 2.5/3.5(2.5-2.69GHz, 3.4-3.69GHz) bands, HiperLAN2 (5.47-5.725 GHz) and HiSWaNa (5.15-5.25GHz) wireless application bands. The radiation characteristics of the broadband antenna are measured using an HP8510C network analyzer. Details of the design and experimental results are presented and discussed in the following sections.

GEOMETRY OF THE ANTENNA

The geometry of the antenna fabricated on an FR-4 substrate of dielectric constant ε_r=4.4 with loss tangent (tanδ) = 0.02 and height h=1.6mm is shown in Fig. 1. The finite ground 50Ω CPW feed is designed for a gap of ***g*** between the signal strip of F_LX F_W and the coplanar ground plane with dimension L_G x W_G. A circle having diameter D_B is attached on the top of the CPW fed monopole geometry with a hemispherical metal exclusion D_S on the left and right edges separated by a distance of G from each other resulting in the Minoan structure. For the best bandwidth performance the ground plane is modified by cutting a right triangle of sides L_{off} and W_{off}.



(a) (b)

Fig. 1 (a) Geometry of the proposed antenna (b) Photograph of the fabricated antenna
(D_B=20, D_S=8, G=10, L_G=6.8, W_G=12, F_L=8.6, F_L8.6, F_W=2, g=0.3, L_{off}=1.7 and W_{off} = 1.3 all lengths are in mm)

RESULTS AND DISCUSSIONS

The proposed antenna is designed and optimized using a frequency domain three-dimensional full wave electromagnetic field solver (Ansoft HFSS). The simulated reflection characteristic of the antenna with and without notch in the coplanar ground plane is given in Fig. 2. It is observed that, without the notch, there exist two well matched resonances at 3.25 GHz and 5.35 GHz. By the introduction of the notch into the coplanar ground plane, the second resonance shifts to lower region and improve the input impedance by effectively suppressing the excess reactance at these resonances. At the optimum design, these resonances are merged together to achieve the maximum bandwidth.

The antenna is fabricated on a substrate of thickness 0.044 λ_0 and the measured reflection characteristics of the fabricated antenna along with the simulated result are shown in Fig 3. The optimum design features an impedance bandwidth of 76% at the centre frequency of 3.9GHz with sufficient gain and stable radiation characteristics. The small discrepancies between simulated and measured reflection characteristics of the antenna are due to the tolerance errors in antenna fabrication.

The current distribution at the two resonant frequencies of the designed antenna is shown in Fig. 4. A half- wave variation of current is noticeable in the resonating structure at 3GHz. Moreover, the intensity of current is maximum near the ground plane and minimum at the tip of monopole. The surface currents show full-wave variations along the monopole at 5GHZ with maximum intensity at the middle and minimum at the ends. In both cases, the radiation is primarily due to the y-component and hence it is polarized along y-direction at two resonant modes.

The parametric study for variation in dielectric thickness was carried out and the simulated reflection characteristics of the antenna are shown in Fig. 5. When the substrate height is 1.6 mm, the two resonant modes are equally well matched. It is also found that the substrate height influences the merging of the quarter wave and half wave resonant mode of the monopole.

The impedance matching of the antenna is well analyzed by varying the radius of Minoan exclusion. Figure 6 reveals the effect of hemispherical metal exclusion on antenna bandwidth. The resonances centered at 3GHz and 5GHz are equally well matched to achieve maximum impedance bandwidth only when D_S = 8mm.

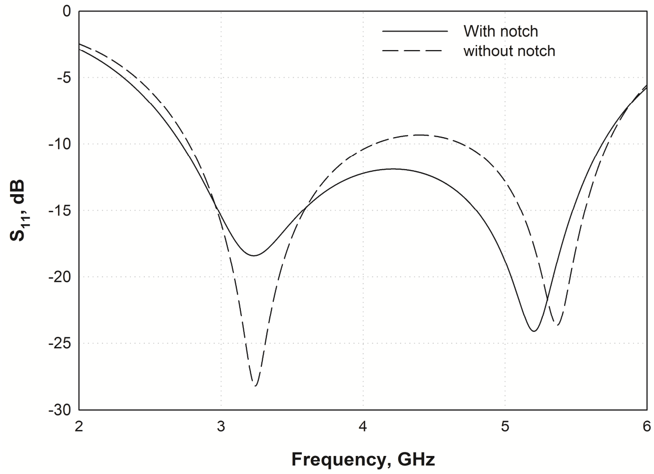


Fig. 2 Simulated reflection characteristics of the proposed antenna with and without notch

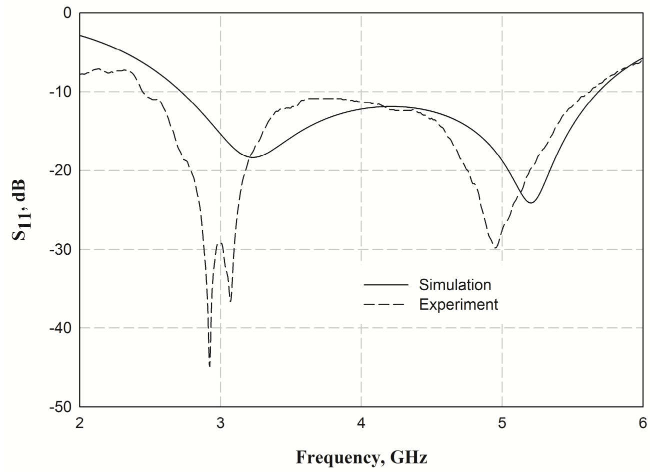


Fig. 3 Measured and simulated reflection characteristics of the proposed antenna

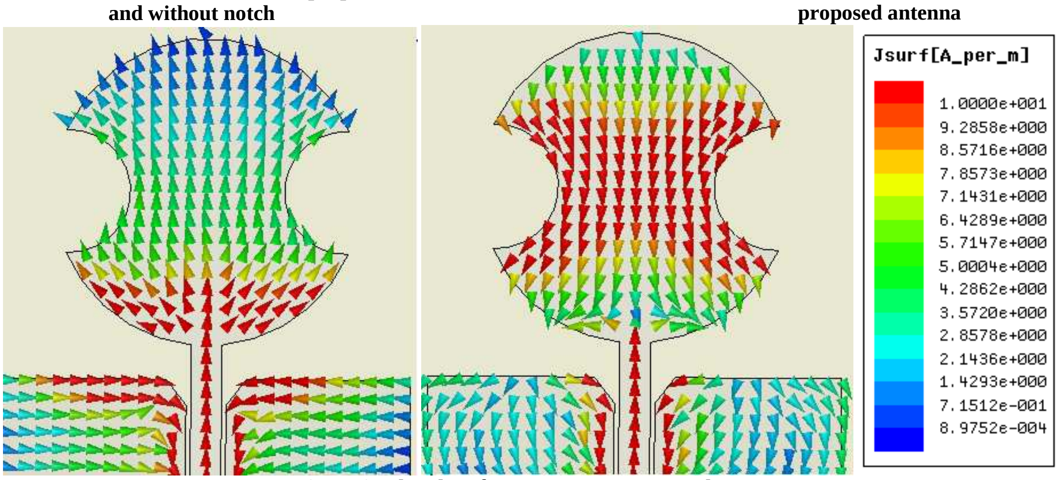


Fig. 4 Simulated surface current at 3GHz and 5GHz

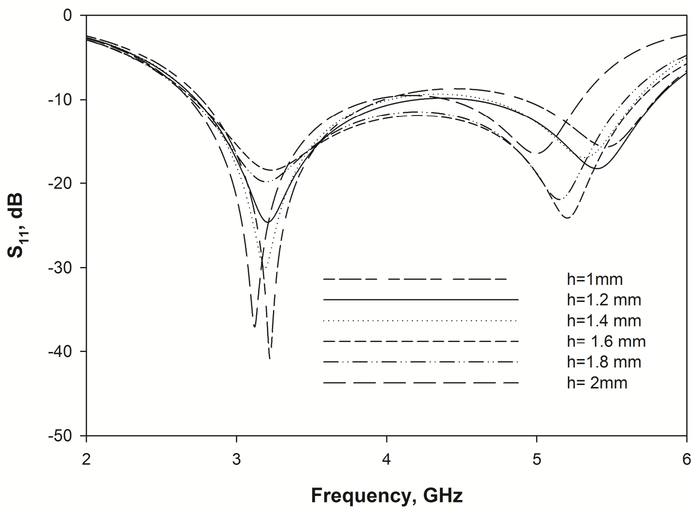


Fig. 5 Simulated reflection characteristics of the antenna with substrate height

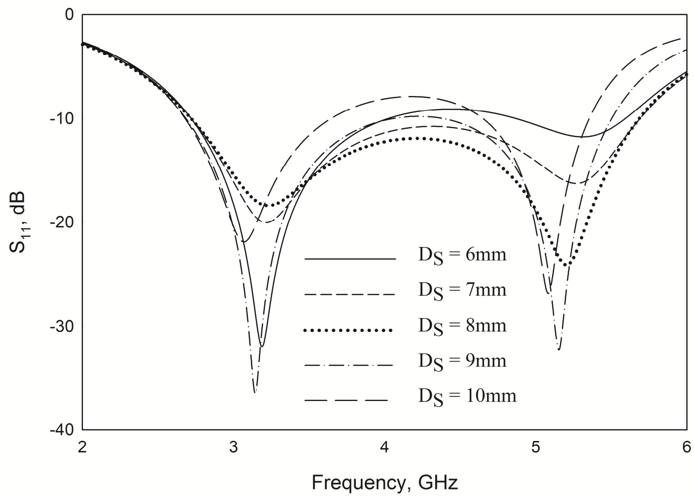
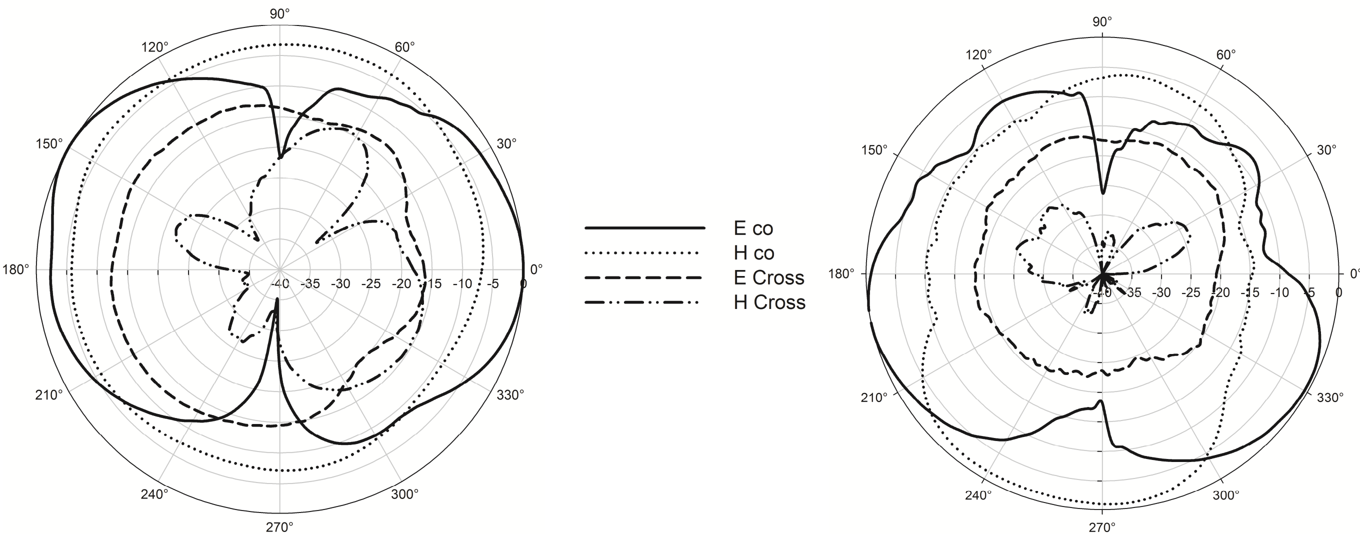


Fig. 6 Simulated reflection characteristics of the antenna with Minoan exclusion radius

Figure 7 shows the measured co-polar and cross-polar radiation pattern of the antenna at resonance for both the E and H planes at 3 GHz, and 5 GHz respectively. The pattern is found to be omni-directional. A constant gain pattern is obtained along the H-plane and along E-plane a pattern with two nulls at 90^0 and 270^0 degrees is obtained. The nulls are found to be above and below the lateral ground planes that means above the monopole and on the connector side. The antenna shows good cross polarization level of nearly 10dB along the bore-sight direction for both the frequencies along the principal planes. The measured gain of the antenna is given in Fig. 8. The designed antenna has a peak gain of 2.5 dBi and an average gain of 1.7dBi with an average efficiency greater than 80% in the operating frequency region.



(a) **(b)**

Fig.7 Measured radiation patterns at (a) 3GHz and (b) 5GHz

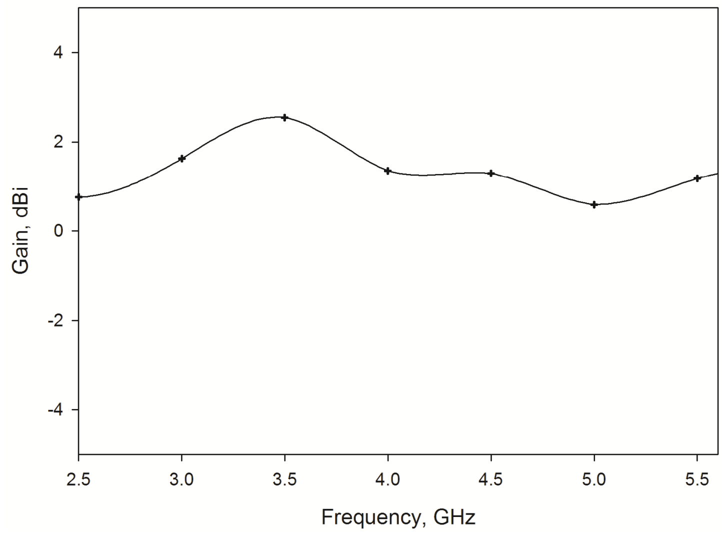


Fig. 8 Measured gain of the proposed antenna

CONCLUSION

A simple CPW fed monopole antenna structure, for achieving omni-directional radiation characteristics, suitable for WLAN 5.2(5.15-5.35GHz) band, WiMAX 2.5/3.5(2.5-2.69GHz, 3.4-3.69GHz) bands, HiperLAN2 (5.47-5.725 GHz) and HiSWaNa (5.15-5.25GHz) wireless application bands, having a 2:1 VSWR bandwidth of bandwidth of 76% from 2.7GHz to 5.7GHz. Small antenna design is always a compromise between size, bandwidth, and efficiency. This configuration delivers broader bandwidth with acceptable gain and efficiency for a linearly polarized radiation.

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