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A Wideband Circularly Polarized Printed Monopole Antenna with Symmetric Ground for WiFi/WiMAX Wireless Applications

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Abstract - *In this research, a wideband circularly polarized printed monopole antenna with symmetric ground for wifi/wimax wireless applications is designed and simulated for wider bandwidth applications ranging from 2.5 to 7 GHz. The proposed work introduces a methodology that increase of structures in patch increases the bandwidth and decreases the return loss. Communication systems require small size, Wideband and multiband antennas. CPW feed monopole have been used to fabricate Wide-band as well as wide-band antennas. In this work, we have investigated a new antenna proposed Wide-band properties. The proposed design is a loaded the geometry to a monopole CPW fed microstrip patch antenna with open symmetric ground plane. The simulation is performed via HFSS electromagnetic simulator software. The simulation proves that the proposed antenna is applicable in 2.5 to 7 GHz frequency range.*

Key Words: CPW-fed Microstrip Antenna, Wideband Antenna, Wideband Antenna Designing, Compact Antenna

1. INTRODUCTION

Recently, circularly polarized (CP) antennas have received much attention in numerous communication systems such as GPS, RFID, WLAN and WiMAX. In contrast with linearly polarized (LP), CP antennas produce distinct advantages such as insensitivity toward the equipment's orientation, resistance to inclement weather and mitigated multipath losses. In the past few years, printed monopole antennas, due to the advantages of low profile, low cost, broadband operating bandwidths and simple structure, have been studied in [1]-[3]. But the monopole antennas mentioned above are all in LP operation. In general, CP operation could be achieved by generating degenerate modes that are 90°out of phase. Many kinds of techniques have been presented for CP monopole antenna designs [4]-[10]. By utilizing the trapezoidal structure, a multi-band coplanar monopole antenna with LP and CP operations was proposed in [4]. In [5], a simple printed monopole antenna having two arms with different length was also reported to introduce CP operation. In addition, simply adjusting the width of the CPW ground-plane, CP operation at 1.57 GHz was excited by the asymmetrical ground plane in [6]. But the common problem among them is the narrow CP bandwidth. Several wideband CP monopole antennas were presented in literature [7]-[10]. By adopting a slot-monopole antenna, 30% AR bandwidth was obtained in [7]. But the employment of a power division network led to a complex geometry and large size. Another method to produce CP operation is cutting a horizontal slit and embedding a vertical stub on the ground plane, achieving a CP bandwidth of 44.9% [8]. Meanwhile, chifre-shaped [9] or moon-shaped [10] monopole antennas have also been proposed for broadband CP radiation.

However, most of the broadband CP monopole antennas in [7]-[10] mainly utilize complex radiator structures or ground planes with slots and stubs embedded.

2. ANTENNA DESIGN

In general, the bandwidth of a microstrip patch antenna is not very wide because it has only one resonance mode. Thus, to design a wideband radiator, two or more resonant parts with each part operating at its own resonance is essential, and the overlapping of these multiple resonances mode may lead to multiband or Wideband operations.

After the selection of three parameters based on application, i.e. frequency of operation, height of substrate and permittivity of dielectric material, next step is to calculate width and length of the patch.

Step 1: Calculation of Width (W)

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r+1}} \qquad 1$$

where, μ_0 is the free permeability, ε_0 is the free space permittivity and ε_r is relative permittivity.

Step 2: Calculation of Effective Dielectric Coefficient (ε_{reff}) the effective dielectric constant is

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{1/2} \qquad 2$$

Step 3: Calculation of Effective Length (Leff)

The effective length is

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}} \qquad 3$$

Step 4: Calculation of Length Extension (ΔL)

$$\frac{\Delta L}{h} = 0.412\,\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{rff}-0.258)(\frac{W}{h}+0.8)} \qquad 4$$

Step 5: Calculation of Length of Patch (L)

The actual length of radiating patch is obtained by

$$L = L_{eff} - 2\Delta L \qquad 5$$

Step 6: Calculation of Ground Dimensions (Lg, Wg)

$$L_g = 6h + L \ , \ W_g = 6h + W \qquad 6$$

Therefore, this design is chosen to generate two or more resonance bands for achieving wide bandwidth and multiband. In addition, the conventional wideband monopole antenna using a solid ground plane on the further side, in this design, the two grounds were designed on the same plane of the monopole as shown in Fig. 1(a) and (b). The design skills are introduced to obtained wideband accompanied with good impedance matching above the entire operating band.

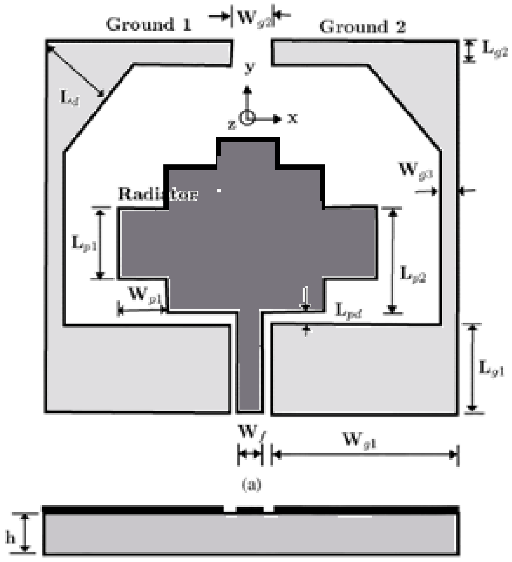


Fig. 1 (a). The proposed wideband microstrip antenna.

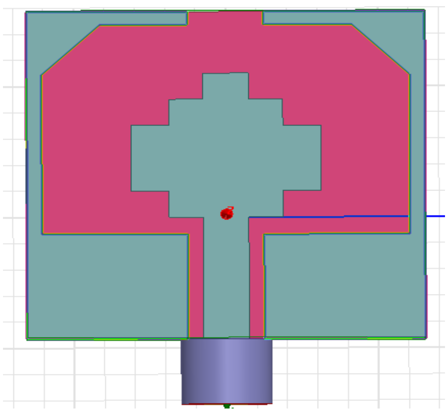


Fig 1(b). Proposed geometry

The basis of the monopole antenna is a rectangular patch, which has the specification of length Lp2 and width Wp3, and is produce with two inverted L-shaped structure strips from the patch's upper two sides. It comprises both the vertical and horizontal structure with dimensions of Lp1 x Wp1 and Lp2 x Wp2 , respectively.

As for the ground plane, distinct the general use of a solid rectangular plane for a microstrip line fed monopole antenna, ground planes are set in from the patch's left and right sides on the same plane of patch to provide the CPW feed. The overall size of the antenna is 25x25x1.6 mm3, and each of the surrounded grounds has a vertical section of 25 mm as well as a horizontal section at the upper and bottom structure of 10.5 and 10.6 mm, respectively. The width of the CPW microstrip feedline is fixed at 3.0 mm to achieve 50Ω characteristic impedance. Since the antenna is surrounded by a ground plane for reducing the antenna area, the small gap between the patch geometry and the ground plane is a major factor to cause very strong capacitive coupling. The horizontal feed section (x-axis) is separated from the ground by a gap of 0.4 mm (Fig. 1). The detailed dimensions of the proposed wideband antenna are listed in Table I. This WB antenna was simulated using HFSS software by keeping the substrate of a 1.6 mm thick, FR4_epoxy substrate permittivity of 4.4 and a loss tangent of 0.02.

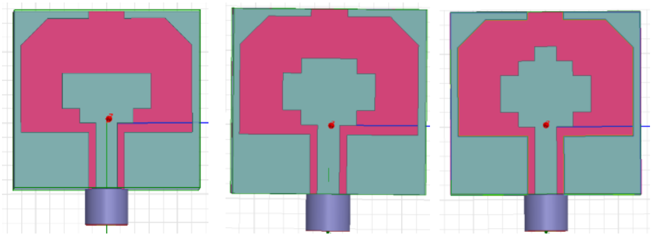
Table -1: Design Parameters of the Proposed Compact Wideband Microstrip Antenna Shown in Fig.1

Design Parameters						
Parameters	L_{p1}	L_{p2}	L_{g1}	L_{g2}	L_d	L_{pd}
Units(mm)	5	7	8	1	4	0.8
Parameters	W_{p1}	W_{p2}	W_{g1}	W_{g2}	W_{g3}	W_f
Units(mm)	2.5	12.5	10.6	4	1	3

3. SIMULATION AND RESULTS

The electromagnetic waves solver, Ansoft HFSS, is used to investigate and optimize the proposed antennas configuration. Fig. 3, shows the simulated return loss of the proposed antenna. HFSS solver was used to measure the performance of the proposed antenna such as impedance bandwidth, VSWR, and gain. Fig. 4 shows the simulated VSWR curves of the compact inverted L-strip WB antenna. The designed antenna has a wideband performance of 3-7 GHz.

Group delay is an important parameter in the design of the WB antenna since it gives the distortion of the transmitted pulses in the WB communication. For a good pulse transmission, group delay should be almost constant in the WB band.



a)Antenna 1 b) Antenna 2 c)Antenna 3

Fig.2 Three proposed of the monopole antenna

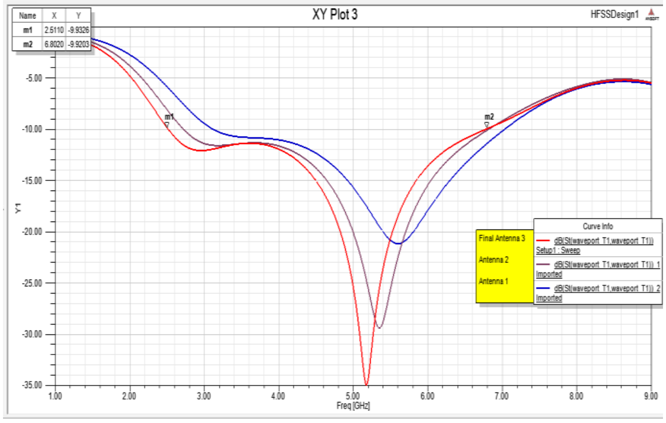


Fig.3 Return loss Vs frequency

This simulation confirms that the proposed WB antenna is suitable for Wideband Communication. Fig. 5 (a) and (b) shows the simulated 2-D far-field radiation patterns in the H and E-planes at sampling frequency of 5.2 GHz as resonance frequency.

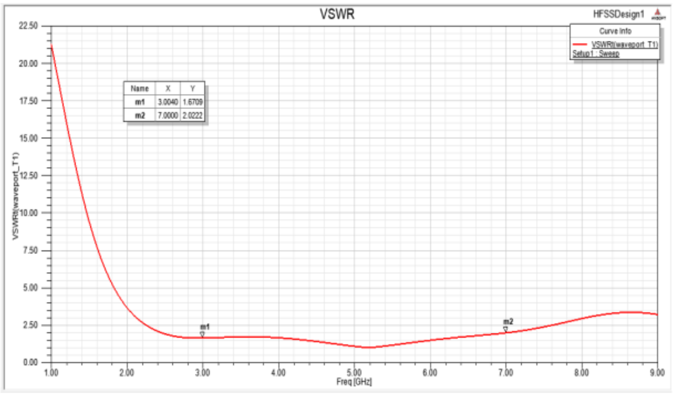


Fig.4 VSWR for proposed design.

It is found that the antenna has nearly good omni directional radiation patterns at all frequencies in the E-plane (xy -plane) and the H-plane (xz-plane). This pattern is suitable for application in most wireless communication equipment, as expected.

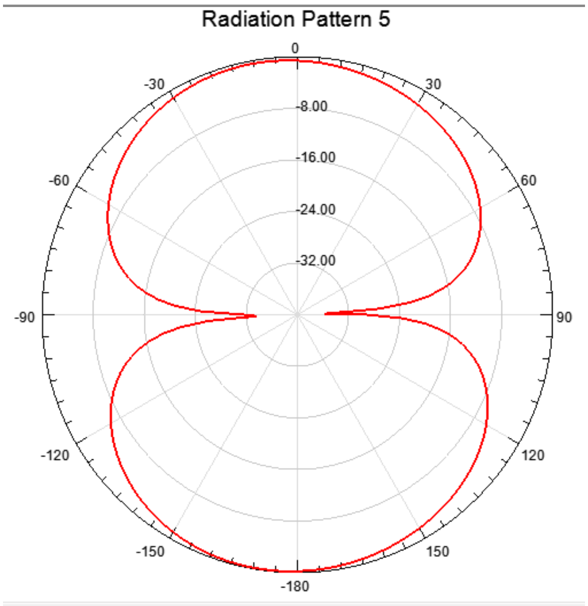


Fig. 5. (a) E plane 2D radiation pattern

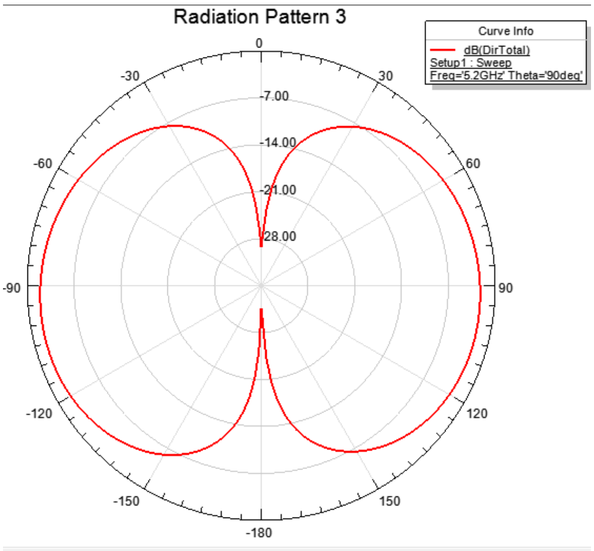


Fig. 5. (b) H Plane 2D radiation pattern

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