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A Compact Broadband Microstrip Antenna for Wireless Applications of 3 to 7 GHz

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Abstract— ***In this research, a compact size broadband microstrip antenna is designed and simulated for wider bandwidth applications ranging from 3 to 7 GHz. The proposed work introduces a methodology that reducing of structures increases the bandwidth and increases the return loss. Communication systems require small size, broadband and multiband antennas. CPW feed monopole have been used to fabricate broad-band as well as wide-band antennas. In this work, we have investigated a new antenna proposed broad-band properties. The proposed design is a loaded the geometry to a monopole CPW fed microstrip patch antenna with symmetric ground plane. The simulation is performed via HFSS electromagnetic simulator software. The simulation proves that the proposed antenna is applicable in 3 to 7 GHz frequency range.***

Index Terms— **CPW fed Microstrip Antenna, broadband Antenna, Wideband Antenna Designing, and Compact Antenna.**

I. Introduction

Antenna plays such a significant role in communication systems and one of the main part of Broadband (BB) communication systems. BB communication systems require smaller antennas with large bandwidth, thus the design, simulation and manufacturing of these antennas are very essential. This is the main reason of wide research on BB antennas in recent years. There are many techniques, One of the good technique is using CPW feed monopole patch antenna. In this paper, new geometry is proposed. By applying this fractal generator to proposed antenna elements, we have achieved a wideband and multiband antenna. The Finite Element Method (FEM) based electromagnetic simulator HFSS has been used for the design and simulation of the proposed antenna. This new antenna is applicable in 3 to 7 GHz.

II. 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 broadband operations.

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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 (L_{eff})
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 (L_g, W_g)

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

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. The design skills are introduced to obtained wideband accompanied with good impedance matching above the entire operating band.

The basis of the monopole antenna is a rectangular patch, which has the specification of length L_{p2} and width W_{p3}, 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 L_{p1} x W_{p1} and L_{p2} x W_{p2} , respectively.

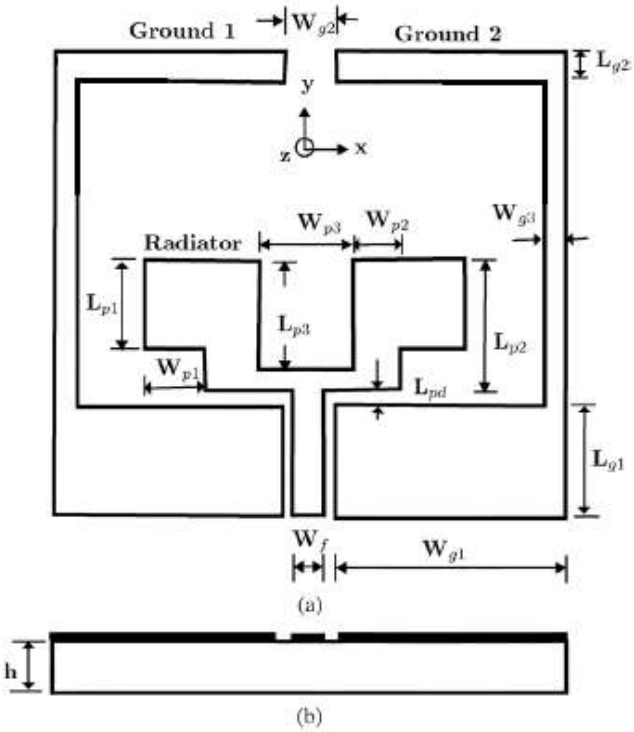

Fig. 1.The proposed wideband multiband microstrip antenna.

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 mm_3, 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 BB 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 I Design Parameters of the Proposed Compact Wideband Microstrip Antenna Shown in Fig.1

Parameters	L_{p1}	L_{p2}	L_{p3}	L_{g1}	L_{g2}	L_{pd}	
Unit(mm)	5	7	6.5	8	1	0.8	
Parameters	W_{p1}	W_{p2}	W_{p3}	W_{g1}	W_{g2}	W_{g3}	W_f
Unit (mm)	2.5	2.5	5	10.6	4	1	3

III. 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 BB antenna. The designed antenna has a wideband performance of 3-7 GHz.

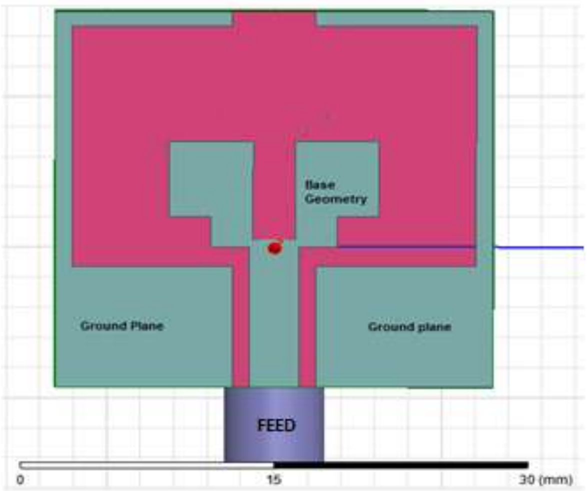

Fig.2 Proposed geomtery

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

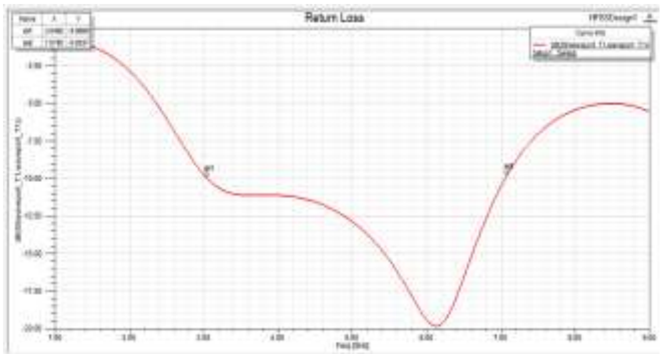

Fig.3 Return loss Vs frequency

This simulation confirms that the proposed BB antenna is suitable for Broadband 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 6.11GHz as resonance frequency.

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.

Table I Result Summary

Resonating freq (GHz)	**S_{11} (dB)**	**VSWR**	**Gain (dBi)**	**Bandwidth (MHz)**
6.11	-20	1.7	2.2	4000 (3 GHz to 7GHz)

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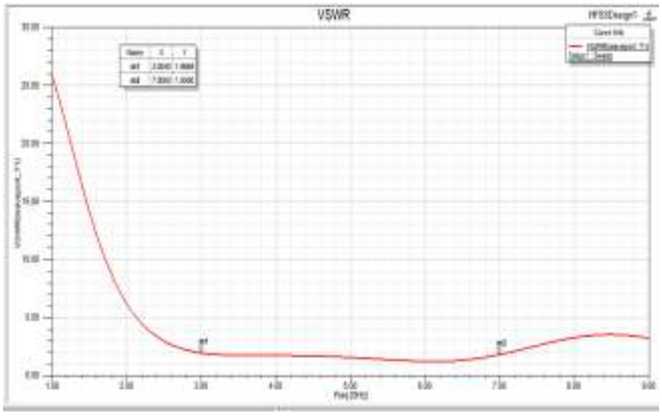

Fig.4 VSWR for proposed design.

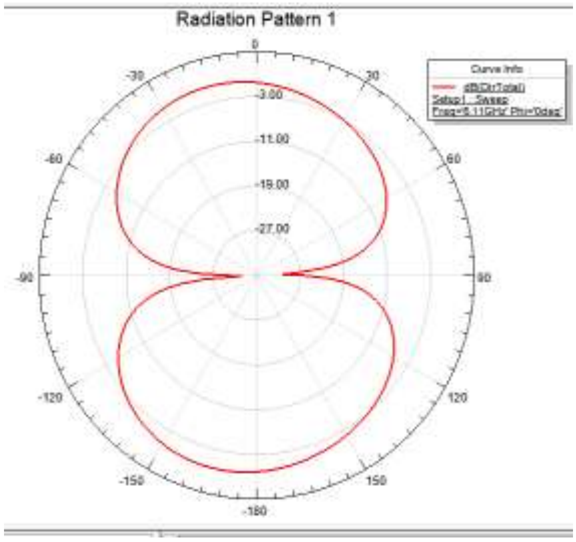

Fig. 5. (a) E plane 2D radiation pattern

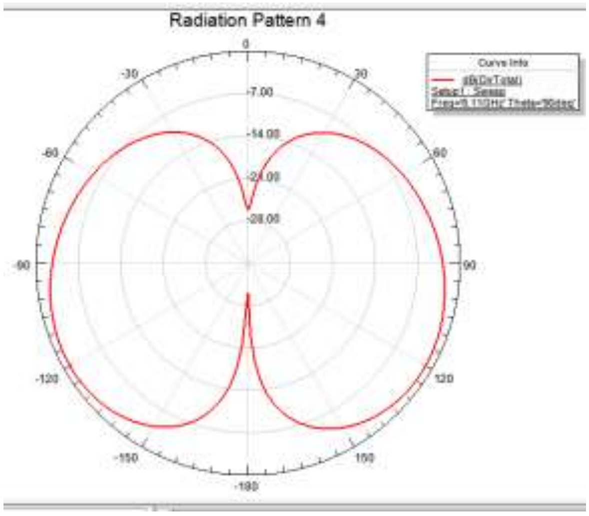

Fig. 5. (b) H Plane 2D radiation pattern

IV. CONCLUSION

In this paper, a compact Broadband microstrip antenna is proposed. The simulated results of the proposed antenna show stable radiation patterns over the whole of the wide band. The good impedance matching characteristic, constant gain, and an omnidirectional radiation patterns over the entire operating range 3-7 GHz make this antenna a good choice for WLAN, Wi Fi\WiMAX applications with overall bandwidth of 4000 MHz. This work presented a broadband slotted CPW fed antenna and its design procedure, which is based on simple monopole antenna design concepts. Each slot in monopole antenna can be designed individually for a specified operating frequency. The proposed design approach does not require repeated parameter tuning and time-consuming EM simulation, which are generally required for traditional broadband antenna design.

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