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A Triple-band Meander Line with two Rectangular Shapes Planar Monopole Antenna

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Abstract— ***A triple band planar monopole antenna for Global Positioning System GPS, Wireless Local Area Network (WLAN) and Worldwide Interoperability for Microwave Access (WIMAX) applications is proposed. The antenna configuration contains three shapes in resonance with three different frequency bands. The proposed antenna covers the frequency bands of the (1.525-1.585GHz, 3.43-4.04GHz and 5.2-5.8GHz), and has radiation patterns that like monopole pattern in the E-plane and H-plane. The meander line monopole in resonance with the 1.575GHz which is used by GPS application. The two rectangular shapes enhance the frequency range (5.2-5.8GHz) for WLAN application. Whereas the stub covers the third band (3.5GHz) for (WIMAX) application.***

Index Terms— **Triple band antennas, planar monopole antennas, Wireless local area network WLAN, Meander line.**

I. INTRODUCTION

In the last few years, the portable devices developed too fast. These portable devices present many advantages like small size, lightweight, low cost and support many applications like internet service, GPS and Bluetooth and other applications. These applications which working on specific frequency bands, are required antennas working at these bands. Because of the small size in the new wireless devices, the need for antennas working at multiband was the aim of the researchers in the last decade.

Taking the benefits of utilizing the self similarity property of a ring shapes dual band planar monopole antennas were proposed by [1]. Using slot structures to achieve multi-band characteristics was proposed in [2]-[4]. Many planar monopole and microstrip antennas were proposed to operate on dual or multi band [5]-[8]. In this paper, a new triple band planar monopole antenna for GPS, WLAN and WIMAX applications is proposed. The antenna has a meander line with two rectangular shapes and stub. The proposed antenna which operate at resonant frequencies (1.575 GHz, 3.5 GHz and 5.2-5.8 GHz), is investigated using CST software.

II. ANTENNA DESIGN

To assure the triple-band operation the antenna is formed of meander line, two rectangular shapes and stub. The meander line length is chosen such that its corresponds to the effective wavelength at the center of the GPS frequency band.

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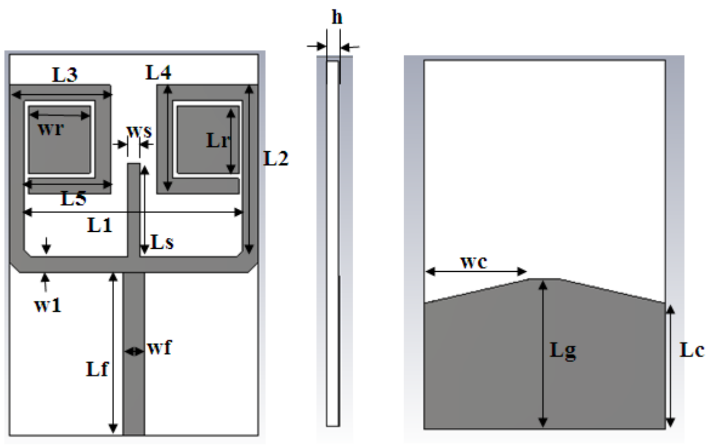
Two rectangular shapes were added to be in resonance with the WLAN band. The stub dimensions were chosen to be in resonance with the WIMAX band. The dimensions of the three forms can then be slightly changed or optimized to get better response using a software package. The antenna was constructed on the FR-4 substrate with a dielectric constant of 4.3, thickness of 1.6 mm, and tangent loss of 0.025. The width of the feed line for each antenna was fixed at 3mm to implement 50 Ohm characteristic impedance of the SMA connector. The CST software package was used to evaluate the characteristics of the antenna.

The geometry of the proposed antenna is shown in Fig. 1. Meander line, two rectangular shapes, the stub and the micro strip feed line are etched on the same surface of the substrate, and the tapered rectangular ground, is put on the opposite surface of the substrate. The parameters of this antenna are shown in Table 1.



a) b) c)

Fig. 1. Geometry of the proposed antenna. (a) Front View. (b) Side view. (c) Back view.

Table 1. Parameters of the proposed antenna. All dimensions are in millimeters.

Lf	wf	L1	L2	L3	L4	Lr	h
21	3	28	21	13	14	8.6	1.6
Wr	Ls	Ws	w1	Lg	Lc	wc	L5
7.9	12	1.5	2	20	16	14.5	10.5

The investigation starts by testing the effect of varying the length of the meander line. The return loss characteristics for various values of the length L5 which is representing the last part of the meander line are shown in Fig. (2). It can be seen that the reduction in length guide the first frequency band to increase.

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To show the effect of adding the stub and the two rectangular shapes a comparison between three different cases of the proposed antenna were made. The three different cases are shown in Fig. 3. The return loss characteristics for the three cases were shown in Fig. (4). It can be seen that a bandwidth of(3.4-4.04) reduced to smaller bandwidth and larger return loss (3.8-4.2) due to removing the stub, also the frequency of the first band increased. When removing the two rectangles as shown in Fig. (3c) the third band affected and the S_{11} magnitude not as good as the state when the two rectangular shapes were not removed.

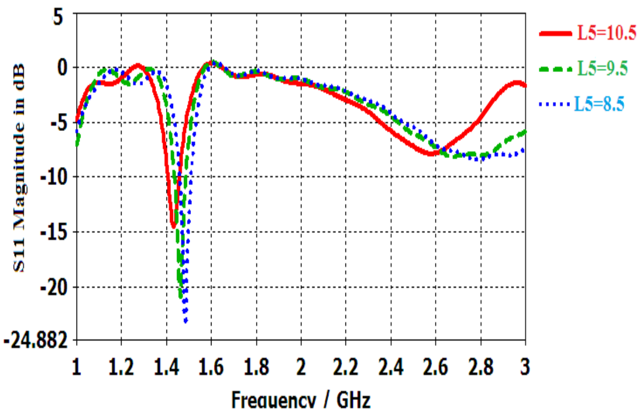
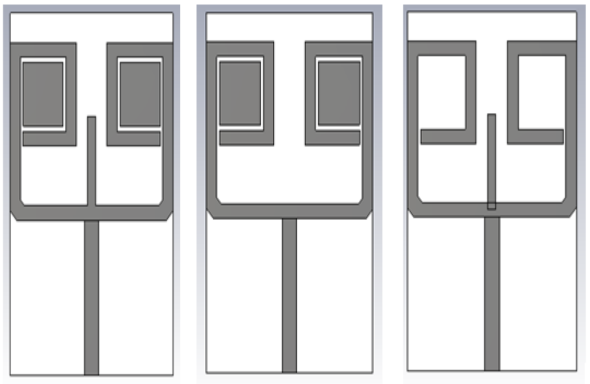


Fig. 2. S11 curves for various values of L5



a) b) c)

Fig. 3 Three different cases of the proposed antenna a) proposed antenna b) proposed antenna without stub c) proposed antenna without two rectangular shapes.

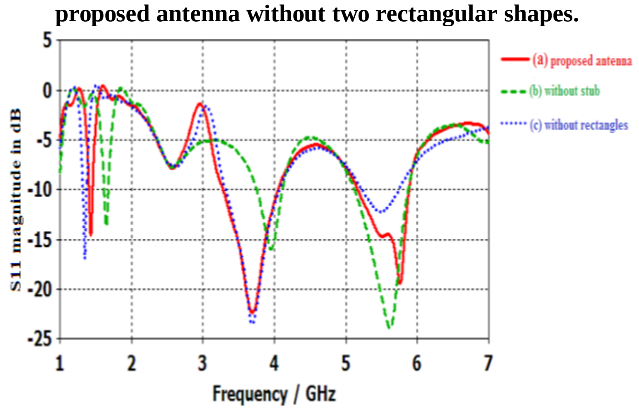


Fig. 4 Magnitude of S11 for the three different cases of the proposed antenna.

The effective wavelength λ_d in the substrate can be calculated using the following formula [9]:

$$\lambda_d = \lambda_o / \sqrt{\varepsilon_e} \quad ....(1)$$

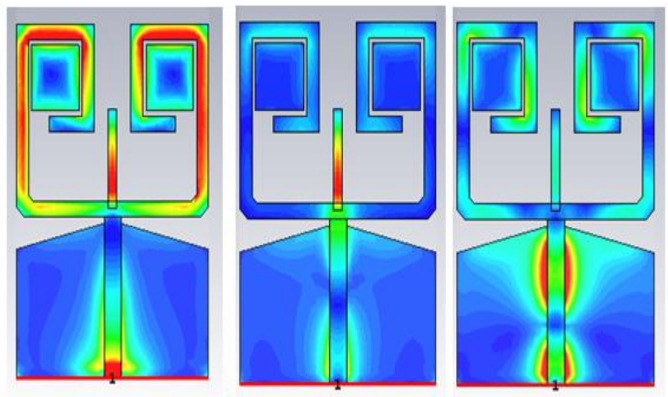
Where λ_o is the wavelength in air, and ε_e is the effective relative dielectric constant given by [7]:

$$\epsilon_e = \frac{\epsilon_r + 1}{2} \quad ....(2)$$

Equation (2) is mostly used in monopole antenna designs, while the following formula (3) has been used for micro strip antenna design [9].

$$\epsilon_e = \frac{\varepsilon r + 1}{2} + \frac{\varepsilon r - 1}{2}\left(1 + 12\frac{h}{W}\right)^{-1/2} \quad ......(3)$$

The estimation of surface current distribution across the proposed antenna was found using the CST software at different frequency bands as shown in Fig.(5). This distribution shows that the meander line in resonance with the lower frequency and the stub compatible with the WIMAX band and the upper part of the meander line with two rectangular shapes in resonance with the WLAN frequency band.



a) 1.55GHz b)3.5GHz c)5.2GHz

Fig. 5 Current distribution of the proposed antenna at different frequencies

The far field pattern of the designed antenna was calculated using the CST software, and the xz and yz results are shown in Fig. (6)-(7). The 3-dimensional radiation pattern was shown in Fig. 8.

The directivity versus frequency of the proposed antenna was calculated using the CST software, and the obtained results shown in Table (2).

Table 2. The directivity vs frequency of the propose antenna

Frequency (GHz)	1.55	3.5	5.2	5.5	5.8
Directivity (dB)	2.9	3.6	5.1	4.1	4

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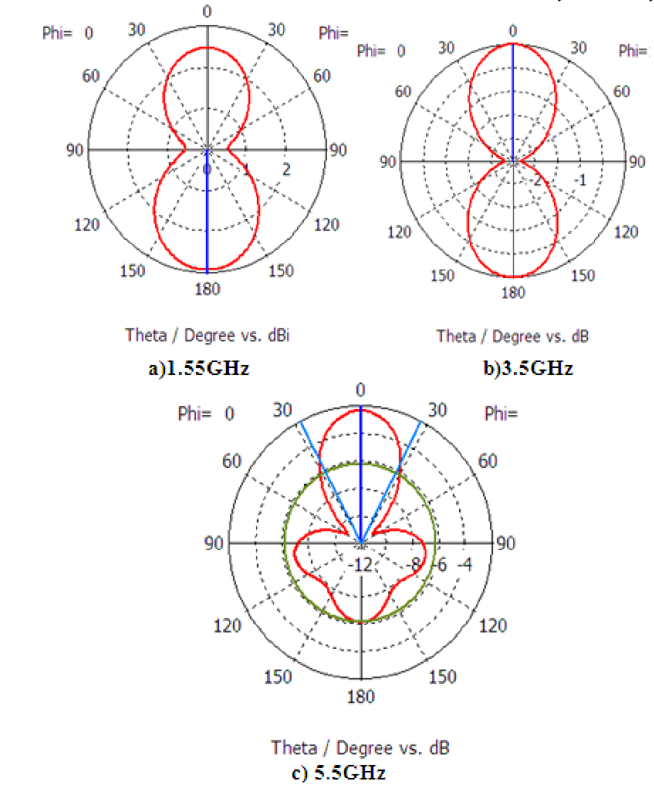

Fig. 6 The xz plane far field results of the proposed antenna a) at 1.55 GHz b) at 3.5 GHz c) at 5.5GHz.

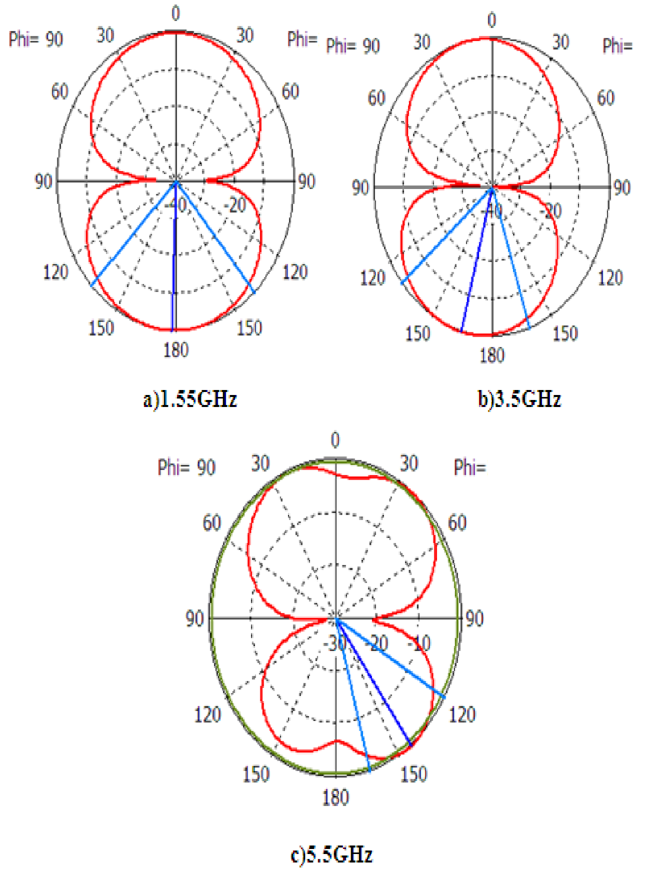

Fig. 7 The yz plane far field results of the proposed antenna a) at 1.55 GHz b) at 3.5 GHz c) at 5.5GHz.

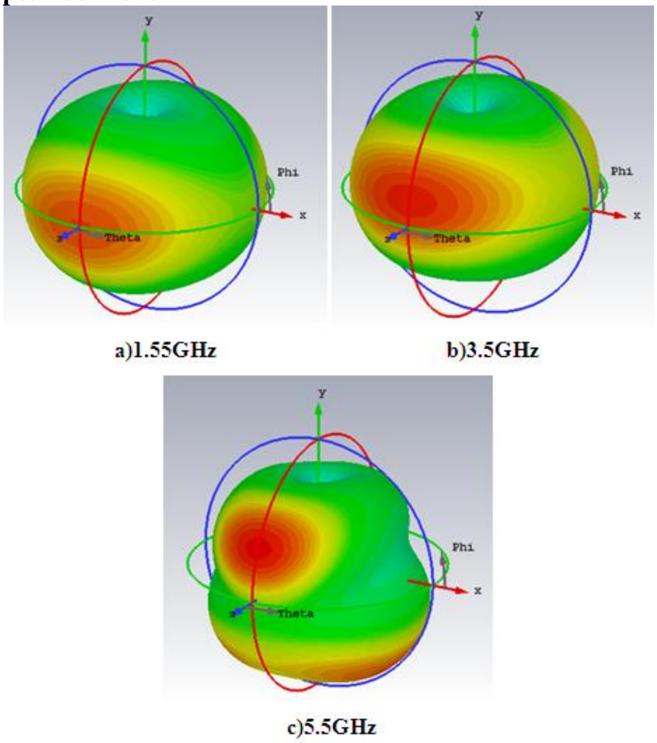

Fig. 8 The 3-D radiation pattern of the proposed antenna

III. CONCLUSION

The design of triple band meander line with two rectangles and stub antenna for WLAN, GPS and WIMAX applications has been demonstrated. The length of the meander line control the lower frequency band and the stub control the mid band while the upper band depends on the upper bending of the meander line which like rectangular slot and the two rectangular shapes inside this slot. The mutual coupling effect between the two rectangular shapes and the upper side of the meander line improve the return loss of the third band.

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