Metamaterial Inspired Triple Band Antenna For Wireless Communication

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Abstract: A compact Triple band CPW feed antenna is proposed for the wireless communication application. The proposed structure has a simple square patch with meandered slots at both sides and the entire structure is fed with 50 ohm microstrip. The proposed antenna is fabricated on FR 4 substrate and with a total size of 22.5 mm x 22.5 mm. Triple band characteristics is obtained with the help of meandered slot and with the help of Complementary omega shaped metamaterial the impedance matching is achieved in the WLAN band. This triple bands are suitable for application such as fixed microwave communication at 2 GHz, WiMAX at 3.5 GHz and WLAN at 5.5 GHz. The proposed antenna is validated with the simulated results of return loss, VSWR, surface current distribution, radiation pattern and directivity plot.

Index Terms: Wireless Communication, Rectangular Microstrip Patch, Metamaterial, Omega Shaped

1. INTRODUCTION
Now a days there is an snowballing mandate for the patch antenna because of its low cost and profile. Because of the advantage of the patch antenna, it can be easily integrated with both the planar and non planar circuits which operate in microwave frequency [1]. The multiband characteristics from a single radiating element is the current demand for the wireless communiacao devices, in order to make the devices more portabale. Many researches focus on the frequency bands such as 2 GHz Fixed microwave communication, 3.45 GHz WIMAX, 5.25 GHZ/ 5.8 GHz WLAN and 8.25 ITU Band [2-4]. Various techniques are utilized in order to obtain the multiband antenna [5,6] such as sloted ground plane, slotted radiating elment, parasitic strips, meandered structures and metamaterials. Metamaterial [7,8]are artificial man made structure with negatve permittivity and permeability characteristics which are anot available in nature. Various metamaterial structures are reported such as SRR (Split Ring Resonator) [9,10], CSRR Complementary Split Ring Resonator, S shaped resonator and spiral resonator in order to boost the various key constraints of the patch antenna. In this paper, a metamaterial inspired square monopole antenna is proposed. Because of the simple structure, radiation characteristics, impedance matching and compact size, the proposed structure is suitable to integrated with morder wireless communication devices. The proposed structure is fabricated on a FR4 substrate. The length and width of the

shaped metamaterial[11-13]. Further the paper is ordered as follows section 2 explains the design procedure of the Metamaterial proposed antenna, section 3 parametric analysis of the proposed structure is presented, section 4 the simulated results are discussed and section 5 the conclution is presented.

2. METAMATERIAL INSPIRED ANTENNA DESIGN:
The proposed antenna design has three stages of evolution[14-16]. The Antenna A, Antenna B aand Antenna C are the three stages. All the three stages are feed with CPW feed. Antenna A is a simple square patch designed to operate in 2.45 GHz which is the bluetooth band. The proposed antenna is designed on a low cost FR4 substrate with 22.5 mm x 22.5 mm x 1.6 mm as its total size. Antenna B is the designed by meandered the sides of the antenna A and finally antenna C is designed by including an Complementary omega shaped metamaterial structure in the radiating element of antenna B. Figure 1 depicts the three evolution stages of the proposed metamaterial inspired antenna. Figure 2 clearly shows the parameters of the projected metamaterial inspired antenna and Table 1 give the parameter values of the proposed antenna.

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The designed antenna A is resonating at the Bluetooth operating band from 2.15 GHz to 3.21 GHz, which is depicted in figure 3. The return loss value in the resonant frequency 2.45 GHz is about -17.13 dB. Antenna B is designed by meandering the sides of antenna A to form the strips. The antenn B is operating in triple band frequency 1.91 GHz – 2.15 GHz, 3.25 GHz – 3.85 GHz and 5 GHz - 7 GHz which is the operating bands of Fixed microwave communication, WiMAX and WLAN application respectively which is depicted in figure 4. The return loss of the above frequency bands are -11.5 dB, -16.2 dB and -14.8 dB[17-19]. Antenna C is designed by including the complementary omega shaped metamaterial in the radiating element where the surface current is maximum. The inclusion of Complementry omega shaped metamaterial structure, improve the impedance matching of the proposed structure in WLAN band from -14.8 dB to -18.2 dB, which is depicted in figure 5.
Figure 3 $S_{11}$ Plot of Antenna A

Figure 4 $S_{11}$ Plot of Antenna B

Figure 5 $S_{11}$ Plot of Metamaterial Inspired Antenna

Antenna A – VSWR Plot

Antenna B – VSWR Plot
In Figure 6, the VSWR plot of the antennas which are evolved during the design process of proposed metamaterial inspired antenna is depicted, from that we can clearly observe that the value of VSWR is within VSWR = 2. From which we can conclude that the proposed antenna has very good impedance matching. Figure 7 depicts the surface current distribution which clearly shows that the maximum surface current is distributed around the meandered strips and mega shaped metamaterial. This distribution of surface current which alters the current path is responsible for the multiband characteristics [20-23].

3 PARAMETRIC ANALYSIS
To find the value for the parameters which are critical for the proposed metamaterial inspired antenna design, the parametric analysis is used. The parameter chosen are the feed width (\( w_f \)), ground height (\( w_g \)) and Complementary omega slit width (\( d \)). First the feed width is increased from 1.6 mm to 2.00 mm in steps of 0.2 mm, it is found that the \( w_f=1.6 \) mm is giving good impedance matching in all the operating bands and hence it is chosen as the optimum value for feed width which is depicted in figure 8. Then, the ground height is varied from 10 mm to 10.5 mm insteps of 0.25 mm, and the value 10.25 mm is choosed as ground height since it has good impedance matching along with improved impedance bandwidth which is presented in figure 9. Then the Complementary omega slit width \( d =0.7 \) mm is choosed as the optimum value after the parametric analysis for the various values of \( d \) such as 0.3 mm, 0.5 mm and 0.7 mm. The value 0.7 mm is chosen for \( d \) since it can able
achieve the good impedance matching in all the operating bands. All the above analysis is presented in figure 10.

![Figure 8 Parametric Analysis of feed width](image1)

![Figure 9 Parametric Analysis of feed width](image2)

![Figure 10 Parametric Analysis of complementary omega split width](image3)

4 RESULT AND DISCUSSION

Antenna A is a simple square patch which operates in single Bluetooth band, with meandered strips at the adjacent side the antenna B operates in triple band and antenna C has improved impedance matching by including the Complementary omega shaped metamaterial. Figure 11 shows the surface current distribution of the proposed design which clearly shows that the current distribution is altered by meandering the sides of the patch to form the strips. The inclusion of the Complementary omega shaped metamaterial further changes the current path. The surface current distribution at 2.03 GHz clearly depicts that the most of the current is accumulated in radiating element. After meandering the sides of the radiating element maximum current is available in the meandered strips at 3.47 GHz. Then after including the Complementary omega shaped metamaterial element the current is centred around the Complementary omega shaped slot in the radiating element at 5.96 GHz. The surface current at the various operating bands are presented in figure 11, which proves that the multiple band characteristic is because of the meandering and the impedance matching is due to the inclusion of the Complementary omega shaped metamaterial.

![Surface current @2.03 GHz](image4)

![Surface current @3.47 GHz](image5)
In figure 12 the 3D radiation pattern is presented which shows that the maximum radiation is perpendicular to the antenna axis, which is a key requirement of the antenna which are used in wireless communication. In Figure 13 the E plane and H plane at the resonating bands are presented, which clearly depicts that the proposed antenna exhibits an omnidirectional pattern in E plane and bidirectional radiation pattern in H plane. In Figure 14 the directivity is piloted with respect to the frequency for the proposed antenna, from which we can observe that the directivity is above 3dB in the operating bands.
5 CONCLUSION
A compact triple band antenna for 2GHz Fixed microwave communication, 3.4 WiMAX application and 5.5 GHz WLAN application is proposed. The proposed antenna has very simple square radiating element and the sides are meandered in order to have a triple band application and then the complementary omega shaped metamaterial is included to achieve the good impedance matching. The proposed antenna with small size, good radiation pattern, good impedance bandwidth and matching, low cost and easily integrated with MMIC make it as the good candidate for the communication devices.

REFERENCES


