Design and simulation of folded printed dipole antenna with PBG structure for Ultra Wide Band (UWB) applications

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ABSTRACT
In this paper, folded printed dipole antenna with PBG operating for Ultra wide band applications. The geometry of the antenna is very simple for fabrication and printed circuit board integration that is only 42*36 mm, the proposed antenna are simplified structure with 50 Ω feed line. the PBG structure antenna working in the frequency at 3.2 GHz and 3.9 GHz with the bandwidth 68% and 50% respectively. In this proposed antenna has maximum gain 4.664 dBi and 3.8 dB at 3.2 GHz and 3.9 GHz respectively. The proposed radiation pattern is omnidirectional in the E-plane and H-plane due to the orthogonal configuration of the dipole strips. The folded printed dipole antenna with PBG structure antenna should be useful for the UWB applications. The radiation characteristics examined in further sections.

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Introduction
Last 10 years UWB antennas developed for wide spectrum communications. Ultra wide band communication technology used for large amount of digital data over a broad spectrum of frequency bands, the Ultra wide band antennas for the so many applications such as ground penetrating radar, medical imaging, UWB communication, vehicular radar systems, surveillance systems etc. because of their wide spectrum with data rate, Immunity multipath fading, low loss. FCC has assigned frequency band for UWB antennas are 3.17 GHz to 10.7 GHz in 2002 [4][10].

Recently, several Ultra Wide band (UWB) dipole configuration such as square, circular, hexagonal have been proposed for Ultra wide band (UWB) applications. In dipole antenna many feeding method available such as CPW, CPN and microstrip. In order to reduce the size of the structure microstrip feeding proposed in dipole antennas [11]. In this paper, we proposed feeding structure is microstrip feeding to increase the performance and reduce the size, many improved structure studied and reported such as special grounding structure [11], multi ground antenna array [12], wreath feed structure [12]. In these structure are improved structure for Ultra wide band (UWB) antenna but this are need additional structure for the broad band working. In this reported structures are increase the geometry of the antenna, the proposed structure is simplified PBG structure. It can improve the radiation characteristics such as gain, return loss, directivity, polarization etc. and it will operate at broad band [8].

Antenna Configuration
The geometry of the proposed folded dipole antenna with PBG structure with 50 Ω impedance matching feed shown in fig. 1. In figure we using less expensive substrate FR4 with dielectric constant 4.4. The proposed antenna printed on the FR4 substrate with thickness 1.2 mm. The proposed antenna using PBG structure which is mainly used to achieves better impedance matching, gain, directivity and radiation pattern. In this proposed microstrip feeding using for better radiation performance. The length and width of the proposed antenna calculated by using equation (1) and (2). In order to achieve resonant frequencies 3.1 GHz and 3.9 GHz by using this geometry given below.

The length of the antenna calculated by using this equation given below

\[ L_0 = \frac{0.42 \times c}{f_r \sqrt{\varepsilon_r}} \]  

\[ \frac{1}{2} \sqrt{\mu_r \varepsilon_r} \frac{2}{\varepsilon_r + 1} \] ..................................................(1)

To find the width of the antenna using this equation

\[ W = \frac{c}{2 \times f_r \sqrt{\mu_r \varepsilon_r}} \]  

\[ \frac{2}{\varepsilon_r + 1} \] ..................................................(2)

Where, 
- \( f_r \) = Resonant Frequency
- \( \varepsilon_r \) = Relative dielectric constant
- \( \varepsilon_r = 8.9 \times 10^{-12} \) C²/Nm²
- \( \mu_0 = 4\pi \times 10^{-7} \) Tm/A.

Width of the ground plane can be calculated by using this equation

\[ W_c = \frac{1.38 \times c}{f_r \sqrt{\varepsilon_r}} \]  

\[ \frac{2}{\varepsilon_c + 1} \] ..................................................(3)

Fig.1 Antenna Configuration Of Proposed printed dipole antenna with PBG Structure
Length of the ground plane can be calculated by using this equation

\[ L_g = \frac{0.36 * c}{f_r * \sqrt{\varepsilon_{eff}}} \] ...........................(4)

To calculate the feeding width is given below

\[ Rin = \frac{1}{G_12} \] .................(5)

Where calculate the Rin using \( G_12 \) given below

\[ G_{12} = \frac{1}{120\pi} \int_{0}^{\pi} \left[ \frac{\sin(K_1 \cos \theta)}{\cos \theta} \right] j_0 \left( K_1 L \sin \theta \right) \sin \theta d\theta \] .................(6)

To calculate the resonant frequency using this equation,

\[ f_r = \frac{14.4}{l+2r} \, GHz \] ...........................(7)

Where,

\[ r_1 = \frac{A_1}{2\pi \sqrt{\varepsilon_{eff}}} \]

\[ r_2 = \frac{A_2}{2\pi \sqrt{\varepsilon_{eff}}} \]

From the above equations we find the geometry of the antenna given below \( L \times W \) is 41 * 36 mm, length of the dipole arms is \( L_1=9.5 \, mm, L_2=17 \, mm, L_3=3 \, mm \), length of the micro strip feed line \( L_4=2 \, mm \), width of the micro strip feed line \( W_f=2 \, mm \), width of the antenna is \( W_1=3 \, mm, W_2=3 \, mm, W_4=22 \, mm, W_5=24 \, mm \), \( G_t=18 \, mm, L_s=3 \, mm \).

The total size of the antenna is 42*36mm, proposed antenna dimensions of the antenna designed by design equations for the patch antenna. The proposed antenna designed and simulated by using method of momentum(MOM) in ADS simulator software.

**Result And Discussions**

Based on the values of the proposed model of an antenna designed and simulated .The simulated return loss versus frequency for the proposed printed dipole PBG structure shown in fig.2 which indicate proposed antenna increase performance at 3.2 GHz and 3.9 GHz frequency range ,from simulated resonant frequencies covers the UWB frequency band 3.17 GHz to 10.7 GHz. The lower band frequency return loss is lower than that of the upper band frequency, proposed antenna simulated impedance bandwidth for the -20 dB for the lower band resonant frequency at 3.2 GHz (3.17 GHz to 4.76 GHz) and -14 dB for the upper band resonant frequency 3.9 GHz.

![Fig 3. (a) &Fig 3(b) surface current distribution forward and reverse direction of the proposed printed dipole antenna with PBG structure.](image)

![Fig 4.(a) and Fig 4.(b) E-plane radiation of the proposed printed dipole antenna with PBG structure at 3.2 GHz and 3.9GHz respectively](image)

![Fig 2. Return loss of the proposed printed dipole antenna with PBG structure.](image)
Fig. 5(a) and Fig. 5(b) H-plane radiation of the proposed printed dipole antenna with PBG structure at 3.2 GHz and 3.9 GHz respectively.

Fig. 6 Gain and directivity of the proposed printed dipole antenna with PBG structure.

The proposed antenna simulated far field radiation pattern in H-plane and E-plane for resonant frequencies at 3.2 GHz and 3.9 GHz shown in fig. 4(a), fig. 4(b), fig. 5(a) and fig. 5(b). In this E-plane and H-plane radiation pattern indicates the proposed antenna fairly omnidirectional pattern which is shown from simulated results of the proposed printed dipole antenna with PBG structure. The gain and directivity of the proposed antenna shown in fig. 6. Which is 4.66 dBi and 3.92 dBi gain and directivity respectively at 3.2 GHz and 4.0 dBi and 3.6 dBi gain and directivity respectively at 3.9 GHz resonant frequency. Hence simulated proposed antenna radiation characteristics clearly indicate perfectly suitable for the UWB applications.

Conclusion

Performance characteristics of a folded printed dipole antenna with PBG structure for Ultra Wideband (UWB) application have been studied by design and simulation. The proposed antenna is excited by microstrip feeding. The printed dipole antenna PBG structures covers the UWB frequency from 3.17 GHz to 10.7 GHz such resonant frequencies. 3.2 GHz and 3.9 GHz with return loss -20 dBi and -14 GHz proposed is omnidirectional radiation pattern and its exhibits the perfect radiation characteristics, such as perfect impedance matching, polarization.

Reference


