Design and Analysis of Dual Band Printed Microstrip Dipole Antenna for WLAN

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ABSTRACT
In today's technologically advanced era, microstrip fed rectangular microstrip dipole antenna is predominantly used in wireless communication. In this paper, a dual band printed microstrip dipole antenna is delineated using HFSS as Simulation software. The antenna has covered -10 dB impedance bandwidth of 245 MHz (18.71% at 2.4 GHz) and 1670 MHz (31.77% at 5.2 GHz). This aspect enables the antenna to cover the required bandwidth at the 2.4 GHz and 5 GHz band. Proposed antenna covers the 2.182-2.633 GHz and 4.465-5.899 GHz band . A simplified feed structure consists of a pair of parallel metal strips printed on the opposite sides of the dielectric substrate and connected to a 50 Ω microstrip line with partial ground plane. This feeding network does not depend upon additional conversion devices, such as power divider, tuning stub etc.

Keywords
Dipole antenna, impedance bandwidth, microstrip

1. INTRODUCTION
In recent years, there have been fast developments in wireless local area network (WLAN) applications. In order to satisfy the need of today's wireless application, multi band operation is needed. Antenna should cover the 2.4 GHz band of IEEE 802.11b/g and the 5 GHz band of 802.11a WLAN standards, dual-band operations in the 2.4 GHz (2400 –2484 MHz) and 5GHz (5150–5350MHz and 5725-5825 MHz) bands are demanded in practical WLAN for various applications.

A single antenna is highly advantageous if it can operate in double band mode. The antenna should be conformable, low profile, lightweight and compact therefore, the antenna can easily be fixed in the range of communication devices. There are various feeding methods but a basic feeding circuit is also an important component, because it is in planar form which reduces the transmission line length and the radiation losses. For this purpose, some printed antennas have been devised [3–12]. The antenna in [3] uses the printed dipole for dual frequency band. Antenna with sufficient gain covers only 2.4 GHz and 5.2 GHz band. In [4] the design concept of the printed dipole antenna with reflector has been discussed, which enables the transmission and reception of a single-band frequency, a parasitic element is embedded to enable the operation of dual-band and impedance matching is performed by adjusting the width of the microstrip line. In the design [5], the new structures with 50 ohm microtsrip feed line rectangular patch slot antenna for WLAN and WiMAX applications have been discussed, this antenna operates at dual frequency bands at 2.4 GHz and 3.2 GHz. The proposed antenna have omnidirectional radiation pattern. A dual-band printed dipole antenna is designed in this study by combining a rectangular and two "L" shaped radiating elements and are embedded on a single layer structure with relatively small size. Antenna has been supposed to be printed on an FR4 substrate with a thickness of 0.8 mm and relative permittivity of 4.6. The resulting antenna has been found to have a compact size of 25.75x22 mm². The antenna offers dual–band characteristics and antenna is fed by a standard 50 Ω microstrip line using a broadband microstrip-to coplanar strip line transition. The transition network is realized by a matched T-junction and a narrowband delay line, which not only increases the model complication but also requires long transmission lines. In [5, 6] the antenna consists of a printed monopole and a 50 Ω microstrip line with an open-circuited tuning stub. The tuning stub length was found to be efficient in controlling the coupling of the electromagnetic energy from the microstrip line to the monopole. In [7], a cavity backed double-sided printed dipole antenna is conferred, which impart broadband performance with compact antenna size. In [8] printed and doubled-sided dipole array wideband antenna in application of 5.2 GHz UNII band, operated in WLAN access point has been demonstrated .The printed dipole array antenna consists of one dipole array arranged back to back and can be easily framed by printing on both sides of a dielectric substrate and is suitable for integration with monolithic microwave integrated circuit (MMIC). In [9] a WLAN/WiMax printed antenna executed by using microstrip feeding and matching. In [10] design and simulation of microstrip dipole antenna at 2.4 GHz have been proposed. Frequency resonance has been also analyzed for different width of dipole arm. In [11] modification in two parameters bend on microstrip line and dipole's gap of known printed dipole antenna has been discussed. In [12] half wave microstrip dipole antenna with tapered arms has been designed at a frequency of 2.4 GHz. A dual-band compact bi-faced printed dipole antenna has been designed for Wi-Fi 802.11n.The return losses in proposed antenna match the frequency requirements in both bands (measured bandwidth of 10.8% at 2.5 GHz and 25.3% at 5.5 GHz), with nearly omnidirectional radiation patterns and efficiency 90% In this paper, a microstrip-fed dual-band printed dipole antenna is demonstrated. With a prick line fix into each arm of the dipole, a double-band operation is introduced on a single antenna. The suggested design does not have need of isolated dipole arms to acquire two separate operating bands, and it has a reduced length of arms than the design in [3]. The proposed antenna can easily be excited by a 50 Ω microstrip line and a pair of parallel metal strips between the dipole and the microstrip feed line; good impedance matching can be obtained for operating frequencies within both 2.4 and 5 GHz band.

2. ANTENNA DESIGN AND ANALYSIS
In this paper, microstrip dipole antenna is printed on double sided FR4 substrate having thickness 1.6 mm and dielectric

constant of 4.4. The geometry of microstrip dipole antenna is shown in figure 1. The width of the Microstrip dipole antenna is given as [2]

$$w = 0.05\lambda_0 \quad (1)$$

Where λ_0 is free space wavelength.

Effective dielectric constant (εreff) has been calculated by using equation (1) [1]

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-\frac{1}{2}} \quad (2)$$

Where ε_r = Relative dielectric constant of substrate.

h = height of substrate.

w = width of patch.

Effective length Leff has been calculated at particular resonant frequency f_r by using equation (2)

$$L_{eff} = \frac{v_0}{2f_r}\frac{1}{\sqrt{\varepsilon_{reff}}} \quad (3)$$

Incremented length of the patch is given by

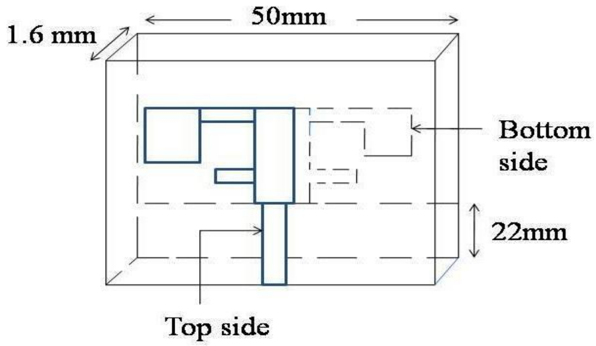
$$\Delta L_s = 0.412 * h\frac{(\varepsilon_{reff} + 0.3)}{(\varepsilon_{reff} - 0.258)}\frac{\left(\frac{w}{h} + 0.264\right)}{\left(\frac{w}{h} + 0.8\right)} \quad (4)$$

Actual length of patch L has been calculated by using equation (2) and (4)

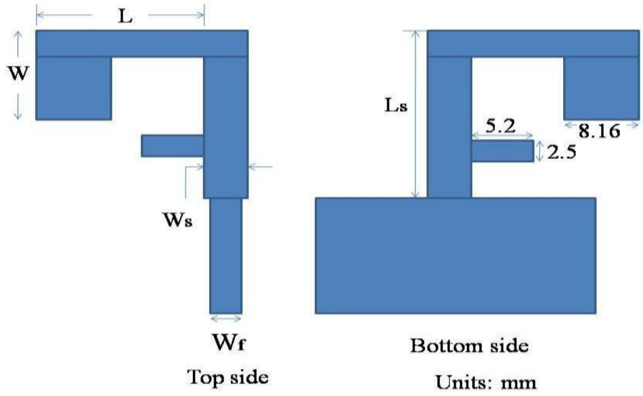
$$L = \frac{v_0}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L_s \quad (5)$$

2.1 Antenna Design

The configuration for printed dipole antenna with a spur line is shown in Fig. 1, which is printed on a FR4 substrate of thickness h=1.6 mm and relative permittivity ε_r = 4.4.The top side consists of a microstrip feed line, one of the parallel metal strips and one side of the arms of the printed dipole antenna. The base side consists of a truncated ground plane (50×22 mm), the other parallel metal strip, and the second arms of the dipole antenna printed on the area of L×W mm², and are printed on opposite side of a dielectric substrate. The feed structure is composed of a 50 Ω microstrip line and two parallel metal strips. The parallel strips have a uniform width of Ws (Ws = 3.5 mm) and a length of Ls (Ls = 16.6 mm in this study).



(a)



(b)

Fig. 1: (a) and (b) Geometry of dual band printed dipole antenna.

2.2 Measured Results

Fig. 2 shows the simulated return loss for the proposed double sided dipole antenna. Each resonant mode with good impedance matching can be seen. The simulated results obtained from simulation software HFSS. In this antenna design the dimensions of long and short dipoles are 14.16×6.25 mm² and 5.2×2.5 mm².These two long and the short dipole arms are designed for 2.4 and 5 GHz bands, respectively.

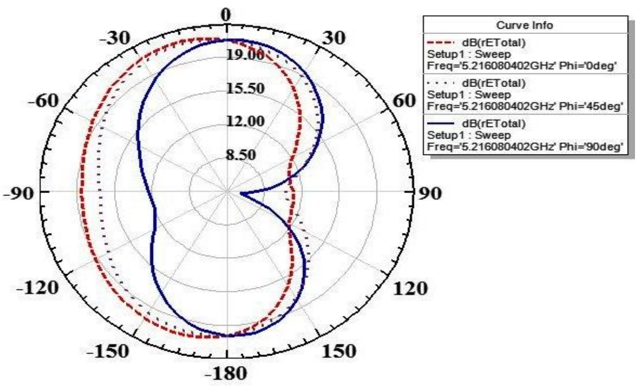


Fig. 2: Radiation pattern at 5.2 GHz

For the first and lower band having frequency range 2182 MHz to 2633 MHz and an impedance bandwidth of 18.7% (for S11<10 dB) was obtained. For the second and higher band having frequency range 4465 to 5899 MHz and an impedance bandwidth of 27.6% (for S11<10 dB), was also obtained. It shows that the impedance bandwidth of the lower and the higher bands covers the 2.4 and 5 GHz bands for WLAN operation. In addition, the overall length (2L+Ws) of the proposed antenna is about 0.25 λ_o (30 mm), where λ_o is about 125 mm. Figs. 4 and 5 show the measured and simulated radiation patterns at 2450 and 5250 MHz, respectively. It can be observed that the radiation patterns are dipole-like for the two operating bands. For the two frequencies, the patterns in the x–y plane (E-plane) still act as a dipole.

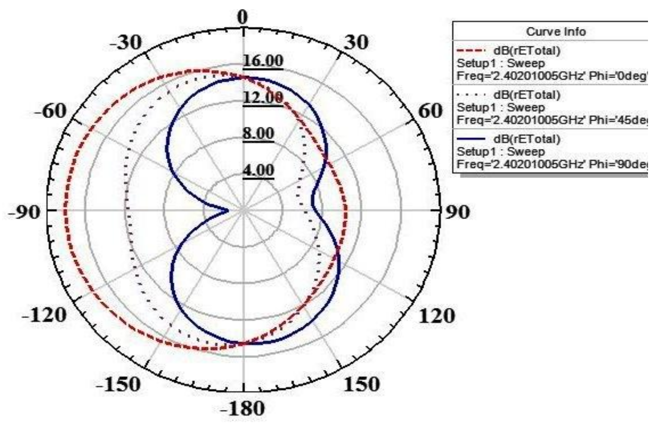


Fig. 3: Radiation pattern at 2.4 GHz

3. CONCLUSION

A dual-band printed dipole antenna has been proposed and simulated at 2.4 and 5 GHz. To obtain lower and higher operating modes longer and shorter dipole arms designed by using above equations in the proposed antenna. The proposed antenna has a simple feeding structure in design and has wide operational bandwidth, and has suitable radiation patterns such that it is commercially suitable for use in WLAN applications.

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