New Design of a Multiband Microstrip Antenna

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Abstract. This paper proposes a multiband microstrip patch antenna covers a multiple operating frequency bands PCS/DCS/LTE/WIFI. The overall dimension of the proposed antenna is 65×67.05mm^2 printed on an FR4 substrate, having 1.6 mm as thickness with a relative dielectric permittivity of 4.4 and 0.025 for loss tangent. The proposed antenna was study and validated by using electromagnetic software's CST-MW. Three bands (1.811-1.828 GHz, 2.631-2.749 GHz and 4.554-5.457 GHz) are achieved by inserting a slot on the top patch and ground. The radiation pattern has acceptable response with low cross polarization at both E-plane and H-plane.

Keywords: Microstrip patch antenna, Multiband planar antennas, DCS, PCS, WIFI.

1 Introduction

Nowadays the multiband antenna become more and more requested, all mobiles equipments required covering all communication service includes 2G/GSM900/PCS, 3G/UMTS/HSDPA/WiFi/ Bluetooth and 4G/LTE, In various mobile communication services, long-term evolution (LTE) is one of the widely used communication systems as a fourth-generation wireless service. Because each nation or wireless carrier uses different frequency bands, a multiband antenna is desirable [1]. Since each communication protocol may operate in distinctive frequency bands, instead of using several antennas, it is highly useful to have one multiband antenna to meet the need of multiple communication systems [2].

Microstrip patch antenna is promising to be a good candidate for the future technology. Microstrip patch antenna consists of a dielectric substrate, with a ground plane on the other side. Due to its advantages such as low weight , low profile planar configuration, low fabrication costs and capability to integrate with microwave integrated circuits technology, the microstrip patch antenna is very well suited for applications such as wireless communications system, cellular phones, pagers, Radar systems and satellite communications systems [3, 4].

To achieve the multiband characteristics many efforts has been made by the researchers in recent years [5]-[6]. The methods such as notch technique [7], slots technique [8] and fractal method [9] are used to design multiband antennas. By introducing these different types of methods and techniques in the geometry of microstrip patch antenna and proper selection of feeding technique helps to achieve the multiband characteristics easily [10].

In this paper, a compact multiband design of Microstrip patch antenna is proposed. The bandwidth has improved by adding slots and by fine tuning to some parameters to reach the best possible result. The multiband antenna covers following frequency bands: DCS/PCS (1.811-1.828 MHz), LTE2500 (2.631-2.749

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GHz), WIFI/Bluetooth (4.554-5.457 GHz) [11-12]. This design is fully planar, fairly compact, and low cost by using a low cost FR4 substrate material.

2 Antenna Design

Figure 1 shows the stricture of the proposed multi-band antenna for PCS/DCS/LTE/WIFI, where we can see the top and the bottom faces of the final circuit. The antenna is a planar microstrip patch antenna designed on an FR4 substrate having 1.6 mm as thickness with a relative dielectric permittivity of 4.4 and 0.025 for loss tangent. With dimensions of 65x67.05x1.6 mm^3 in FR4 substrate and 34.11x30.4 of antenna radiating part, a 50Ω microstrip line is used to feed the antenna for better impedance matching. The ground plane of the proposed antenna is modified and optimized to reach the multiband behavior in the suitable frequency bands.

With the help of the fundamental equations given in this paper [11] we find the first dimensions values of the patch antenna.

The width of the microstrip patch is finding by:

$$W = \frac{c}{2fr}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

Effective dielectric constant is given by:

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

The extension length (ΔL) is calculated by:

$$\Delta L = 0.412h\frac{(\varepsilon_r + 0.3)(\frac{w}{h} + 0.264)}{(\varepsilon_r - 0.258)(\frac{w}{h} + 0.8)}$$

Length L of the patch:

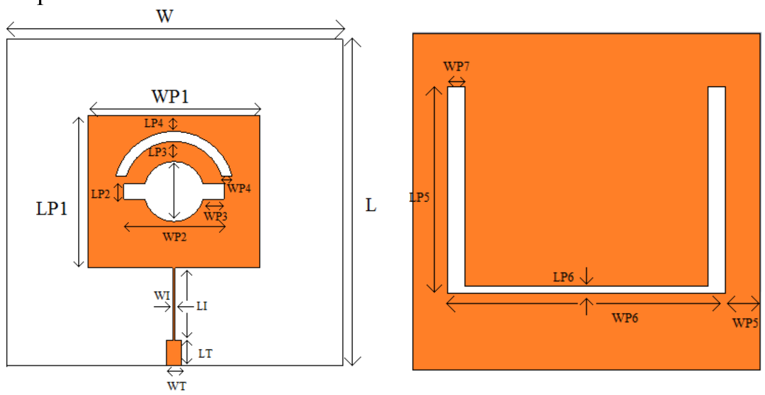
$$L = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L$$

The length and width of the ground plane is estimated by this equation:

$$w_g = 6h + w$$

$$L_g = 6h + L$$

After many series of optimization by using CST, we have obtained the different optimized parameters listed in Table1.



(a) Top view (b) Bottom view

Fig.1. Geometry of the proposed Antenna

Table1. Parameters of the proposed antenna (unit in mm)

Parameter	Value	Parameter	Value
L	65	**WP3**	4.19
W	67.05	**LP3**	4
WP1	34.11	**WP4**	2.079
LP1	30.04	**LP4**	3.5
WT	3	**WP5**	7.725
LT	5	**LP5**	40
WI	0.5	**WP6**	53.6
LI	14.5	**LP6**	1.5
WP2	20	**WP7**	3.3
LP2	3	**WS**	11.75

3 Results and Discussion

The proposed antenna is simulated by using cst microwave, whose numerical analysis is based on the Finite Element method [12]. Figure.2 shows the return loss simulation results of the proposed antenna. The simulation results ensure that the antenna covers multi-band frequencies for wireless applications. For a return loss less than 10 dB, we can deduce that the antenna operates in three frequency bands (1.811-1.828 MHz), (2.631-2.749 GHz) and (4.554-5.457 GHz), which covers DCS/ PCS/ WIFI/ Bluetooth/ WIMAX. The third band frequency is controlled by adjusting the total dimensions of the planar antenna but the first and second one are controlled by the geometry and dimensions of the ground plane.

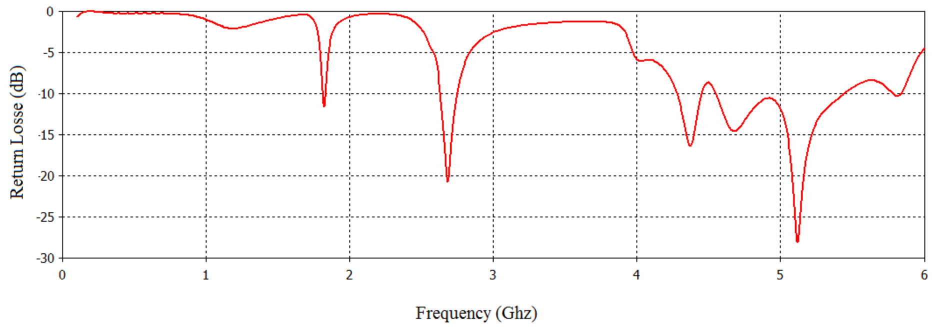


Fig.2. return losses obtained by CST-MW.

As depicted in Figure 2, The simulation results show that this antenna can be suitable for three frequency bands (1.811-1.828 GHz, 2.631-2.749 GHz and 4.554-5.457 GHz), which covers DCS/PCS/LTE/WIFI/Bluetooth for mobile phone applications.

Figure 3 shows the simulated three-dimensional (3D) radiation patterns of the proposed antenna at three resonant frequencies 1.87GHz, 2.637GHz and 5.126GHz. We can conclude that the proposed antenna can radiate unidirectional pattern at all the operating frequency bands. The simulated surface current of the proposed antenna, is presented in Figure 4.

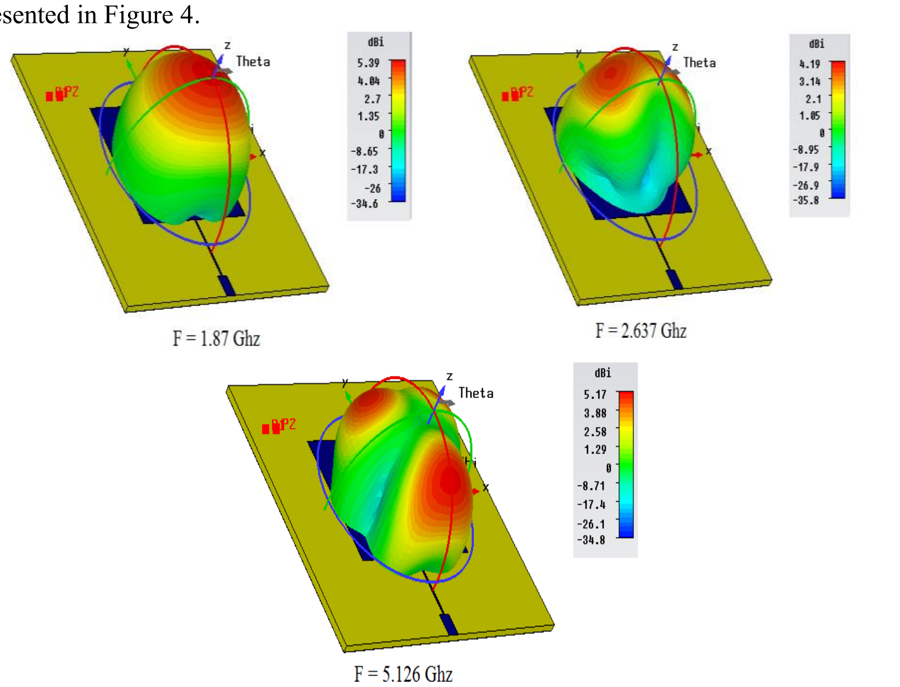
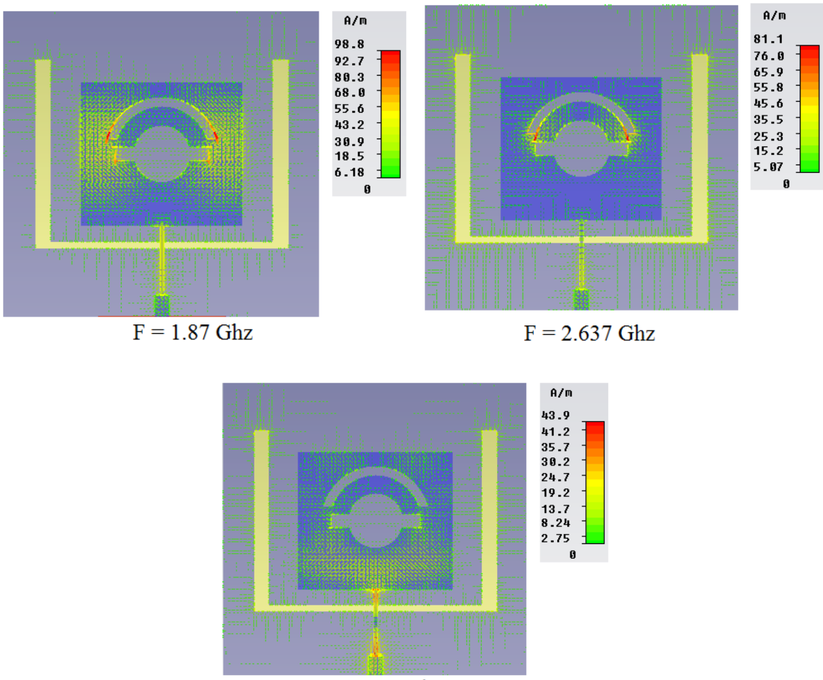


Fig.3. The simulated radiation patterns of the proposed antenna at different resonant frequencies.



F = 1.87 Ghz F = 2.637 Ghz

F = 5.126 GhZ

Fig.5. Simulated surface current of the proposed antenna at different resonant frequencies.

4 Conclusion

In this work, A multi-band compact patch with microstrip is presented for 1.87, 2.637, 5.126 GHz application and validated into simulation by using an electromagnetic solvers. Multiband was achieved by adding the slot in the patch and the ground. The antenna characteristic and radiation pattern is satisfactory for most of the wireless system because is unidirectional and can protect humane head. The different steps followed in this study can be used to validate an antenna for others frequency bands.

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