A Novel Design of Microstrip Patch Antenna for WLAN Application

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Abstract— A simple compact multiband microstrip patch antenna is proposed in this paper to support various communication standards as GSM/DCS/ISM/UMTS/PCS band for cellular phone system and WLAN (wireless local area network) standards by providing the desired bandwidth. A rectangular planer inverted F-shaped patch works as main radiator. This proposed antenna provide several advantages such as low profile, small in size, low in cost, compatible with integrated circuits and multiband functionality. For desired functioning all parameters such as return loss, VSWR, impedance matching, radiation pattern, gain and directivity are present.

Keywords— Microstrip Patch Antenna, Multiband, WLAN

1. Introduction

THIS current age of Science & Technology has developed the wireless communication system that demands for antenna capable to be embedded in portable devices because of their advantageous features like light weight, high gain and high efficient characteristics. Several types of microstrip multiband antennas are being proposed by researchers and process still going on. For ease of fabricating mobile handsets, printed planer internal antennas have been designed to be integrated with ground planes and system circuits on the same substrates [1-6]. Along with the several advantages of microstrip patch antenna it shows some disadvantages like narrow bandwidth, large size of patch for better performance and surface wave excitation due to surface wave losses [7-8].

Therefore, multiband antennas offers best option to overcome these drawbacks by using several techniques [9-10] like

1 resonance overlapping,
2 slot,
3 parasitic patch,
4 Vivaldi blending [11],
5 stepped notch,
6 rectangular and T-shape slits.

are used to enhance bandwidth of microstrip patch. Each technique's contribution towards the resulting bandwidth and its effect on the structure's gain, radiation efficiency and radiation patterns are also presented consecutively.

This paper proposes a planer inverted F-shaped multiband patch antenna, having all dimensions in mm. This proposed antenna is designed using a substrate FR4(ε_r =4.4, tanδ=0.02) resonating at different desired frequency, which can be used for GSM (Global System for Mobile communication) (880MHz-960MHz) and DCS (Digital cellular system) (1710-1880MHz) in Europe, PCS (Personal Communications Services/System) (1850-1990MHz) in USA wireless local area networks (WLAN)applications[12] namely in ISM band used by systems BLUETOOTH (2.4GHz-2.485GHz) and Wi-Fi (2.4GHz for802.11b/g/n).

2. PROPOSED DESIGN GEOMETRY

A. Antenna Configuration Process

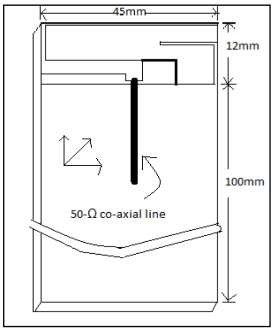
The proposed antenna consists of a planer radiating metallic patch at upper side of FR4 substrate 0.8-mm thick, 45-mm wide and 112-mm high with dielectric constant(ε_r=4.4), and loss tangent(tanδ=0.02) with ground plane size of 45×100mm^{2}on the lower side of this substrate which is fed using discrete fed as shown in fig.1. All specifications are chosen so as to get more efficient performance and higher bandwidth of proposed antenna.

The designed antenna may be divided as main radiator, a parasitic structure, and an impedance-adjustment structure as shown in fig.1. The main radiator M-N-O-P-Q is 80-mm long, 1-mm wide metal strip may be designed to resonant at about 960 and 2100 MHZ. But only this radiator does not cover the desired higher operating band for DCS, PCS, UMTS, and WLAN application. That's why designed structure use the parasitic structure R-S-T placed below the right side of patch is 1-mm wide grounded inverted-L metal strip implemented to excite one additional mode to widen the upper impedance band(i.e., for DCS, PCS, WLAN application). The impedance-adjustment structure A-B-P is a 0.5-mm wide inverted-L strip connected to the main radiator and ground plane as shown in fig.1 used to improve the impedance matching in lower impedance band. Since use of impedance-adjustment structure greatly improves the lower resonant band impedance matching but it downgrades impedance matching in upper impedance band so that designed is further improved to overcome this effect and OP and PQ part of main radiator is widened to 3-mm which gives better impedance match in upper resonant band. The main radiator is excited at point Q by discrete feed technique.

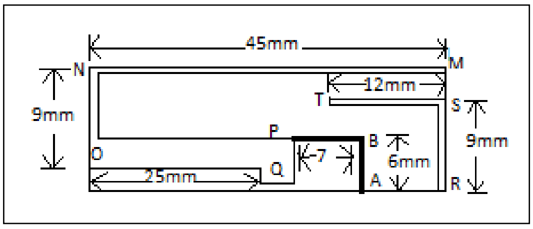
Table 1: The details of dimensions used:

Length MN, Width MN	45 mm, 1 mm
Length NO, width NO	9 mm, 1 mm
Length OP, width OP	25 mm, 3 mm
Length PQ, width PQ	6 mm, 3 mm
Length PB, width PB	7 mm,0.5 mm
Length AB, width AB	6 mm,0.5 mm
Length SR, width SR	9 mm, 1 mm
Length ST, width ST	12 mm, 1 mm

The proposed design structure:



(a)



(b)

Fig.1 (a, b) Microstrip planer inverted F-shape antenna

B. Design calculations

The design procedure of the proposed microstrip patch antenna using rectangular patch is as follows:

- **Calculation of width of patch:**

$$w = \frac{1}{2f_r\sqrt{\varepsilon_o\mu_o}}\sqrt{[\frac{2}{\varepsilon_r+1}]}$$

- **Calculation of effective dielectric constant:**

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

- **Calculation of effective length:**

$$f_r = \frac{1}{2L\sqrt{\varepsilon_r\varepsilon_o\mu_o}} = \frac{v_o}{2L\sqrt{\varepsilon_r}}$$

- **Calculation of length extension:**

$$\frac{\Delta L}{h} = .412\frac{(\varepsilon_{reff}+3)(\frac{w}{h}+.264)}{(\varepsilon_{reff}-.258)(\frac{w}{h}+.8)}$$

- **Calculation of actual length of patch:**

$$L_{eff} = L + 2\Delta L$$

- **Calculation of ground plane dimension:**

Size of the ground plane should be greater than the patch dimensions by approximately six times the substrate thickness all around the periphery so the results are similar to the one infinite ground plane.

$$L_g = 6h+L$$

$$W_g = 6h+W$$

Where,
h = substrate thickness

L = length of patch

L_{eff} = effective length

W = width of patch

c = speed of light

f_r = resonant frequency

ε_r = relative permittivity

ε_{reff} = effective permittivity

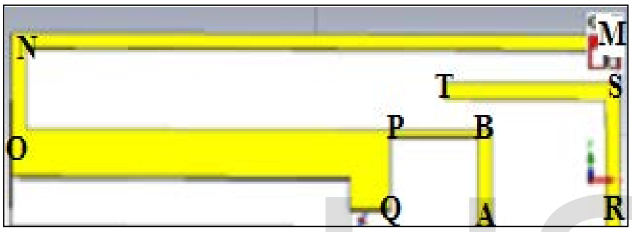
Lg = length of ground

Wg = width of ground

3. Result & Analysis

The proposed designed is simulated using Computer Simulation Technology (CST) Microwave Studio that provide result of designed antenna specification as given below.

The proposed design using CST:



a. Return Loss

It is a measure of the reflected energy from a transmitted signal which is expressed in dB and denoted by S11.

$$Return\ loss = 20\log|\tau|$$

The simulated result of return loss is as shown in fig.2

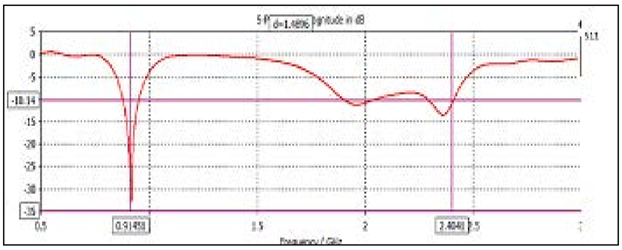


Fig.2: Return Loss of the antenna in dB

Impedance view of return loss (S11) is obtained as in fig.3.

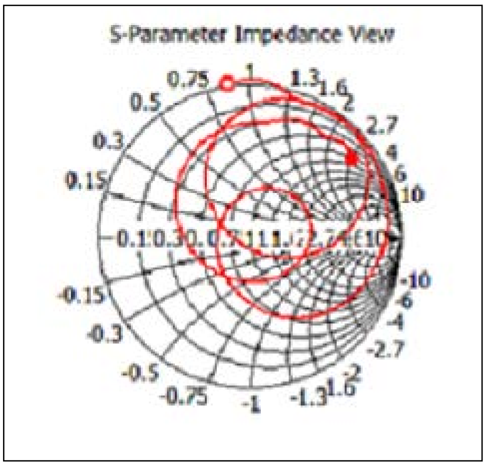


Fig.3: S-parameter impedance view of the antenna

b. VSWR

VSWR abbreviated as Voltage Standing Wave Ratio used for efficiency measure for transmission lines, electrical cables that conduct radio frequency signals etc. It describes the power reflected from the antenna. For perfect transmission of the signal its value should lie between 1 and 2.

$$VSWR = S = \frac{1+|\tau|}{1-|\tau|}$$

Simulated result of VSWR is shown in fig. 4

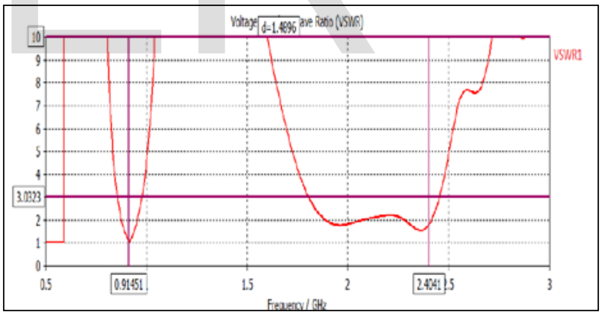


Fig.4: VSWR of the antenna

c. Directivity

It is defined as the ratio of radiated power density in a given direction to the power density of an isotropic reference antenna radiating the same total power. The result is as shown in fig.5.

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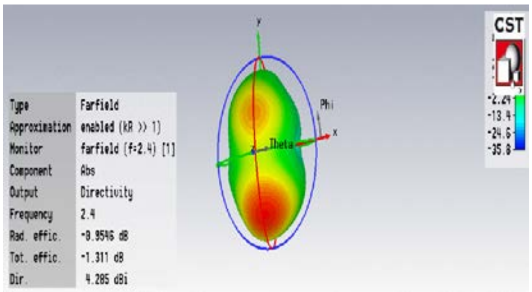

Fig.5: Directivity of the antenna

d. Gain

Directivity assumes a lossless antenna and ignores power reflected at the input port, whereas gain is the radiated power density relative to the power density of an isotropic antenna radiating not the total radiated power but rather the total forward power accepted by the antenna, which for a non-ideal antenna is greater than the total power radiated, so gain is less than directivity. Simulated result is as given below.

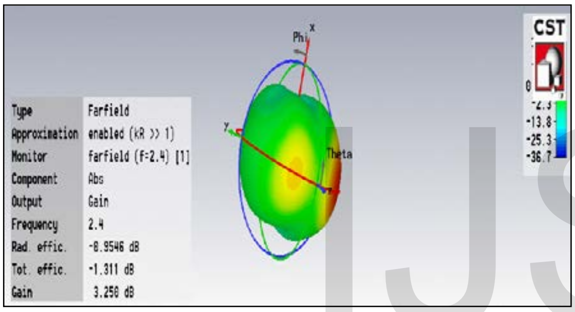

Fig.6: Gain pattern of the antenna

e. Radiation Pattern

An antenna radiation pattern is the angular distribution of the power radiated by an antenna.

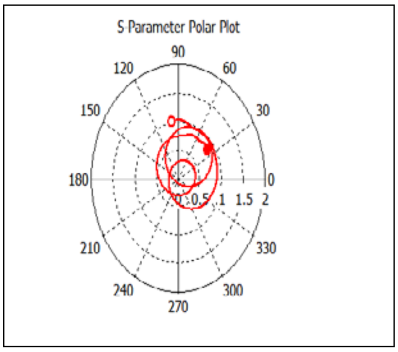

Fig.7: Polar plot of the antenna

4. CONCLUSION

The proposed novel multiband microstrip patch antenna has been successfully implemented using CST (computer simulation technology) microwave studio software. The antenna having S11 of -33.58dB at 0.9145 GHz with impedance bandwidth of approximately 300 MHz. Similarly at 1.98 GHz having S11 of -10.26dB with bandwidth of 300MHz and at 2.401 GHz S11 is 13.45dB with bandwidth of 300 MHz

The planner inverted F-shaped antenna has VSWR<2 suitable for GSM, DCS, UMTS, ISM and WLAN application

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