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Research paper

Multiband microstrip patch antenna with rectangular slots on patch for bluetooth and c-band applications

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Abstract

A Multiband Microstrip Patch Antenna with rectangular slots on patch is proposed for Bluetooth and C band applications. The proposed antenna is fabricated by etching rectangular patch of $0.192\lambda \times 0.2\lambda$ dimension on a lossy FR-4 substrate with dimensions 40 mm (L) × 40 mm (W) × 1.6 mm (h) , relative permittivity ε_r =4.4 and loss tangent δ = 0.025. 50 ohm microstrip feed line with inset feed is used for proper impedance matching. Proposed antenna is simulated on Computer Simulation Tool (CST) microwave studio suite software and measurement is done on Network Analyzer (VNA). The proposed multiband antenna can be used for IEEE 802.15.1 (operating in 2.402-2.480 GHz band), wireless local area network and other wireless communication applications.

Keywords: *Patch Antenna; Bluetooth; WLAN; FR-4; C-Band; Multiband Antenna.*

1. Introduction

Many research has been carried out for obtaining multiple operating bands to cover different applications from single antenna design for wireless communication system during last 3 to 4 decades. Most of the research has been done to get high performance for aircraft and satellite. Different types of substrate may be used for design of Microstrip antennas like FR4, RT duroid etc. depending upon design and application requirements. The radiating patch may consist the design like rectangular, circular, square, elliptical, triangular or any other configuration [3–5]. The proposed antenna is designed by etching rectangular patch of $0.192\lambda \times 0.2\lambda$ dimension on FR-4 material (ε_r=4.4 and loss tan δ = 0.025) of 40 x 40 mm^2 dimension and 50 Ω microstrip feed line is used for better impedance matching. Microstrip feed line is easy to fabricate and model.. The gain of the antenna improved by minimizing the loss due to surface wave propagation [6].
In this paper, a simple and compact design of symmetrical cut slot on patch with microstrip inset feed line is proposed that produces multiple bands resonating at 2.4 GHz, 5.5 GHz, 6.9 GHz, 9 GHz with return loss of -28dB, -21.7dB, -32.6dB and -14.9dB respectively [7].

2. Antenna configuration

The microstrip antenna usually composed of three layers that are patch, substrate and ground. Patch and ground layer is separated by substrate. Area of proposed antenna is 40 × 40 mm^2. The desired patch length and width is determined by using the following design equations. [8-15]

1) Width of the patch

$$W=\frac{c}{2.f_0\sqrt{\frac{\varepsilon_r+1}{2}}}$$

2) Effective dielectric constant is given as,

$$\varepsilon_{ref}=\frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-0.5}$$

3) Length extension due to the fringing field is given as,

$$\Delta L=0.412\frac{(\varepsilon_{ref}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{ref}-0.258)(\frac{W}{h}+0.8)}$$

4) Effective length due to the resonance is given as

$$L_{eff}=\frac{c}{2.f_0\sqrt{\varepsilon_{reff}}}$$

5) Actual length of the patch is given by,

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

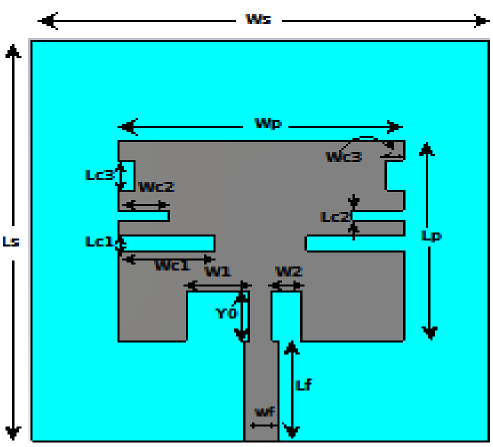

Fig. 1: Top View of Cut Slotted Multiband Microstrip Patch Antenna.

Table 1: Dimensions of Proposed Antenna

Parameter	(mm)
Length of Substrate L_s	40
Width of Substrate W_s	40
Length of Patch L_p	20
Width of Patch W_p	25
Length of Upper Slot L_{c3}	3
Width of Upper Slot W_{c3}	1.5
Length of Middle Slot L_{c2}	1
Width of Middle Slot W_{c2}	4.5
Length of Bottom Slot L_{c1}	1.5
Width of Bottom Slot W_{c1}	8.5
Width of feed line W_f	3
Length of feed line L_f	10
Length of inset feed y_o	05
Width of right inset Slot W_1	5.5
Width of left inset Slot W_2	2.5

3. Simulation results and analysis

The proposed antenna is simulated and performance is determined by using Computer simulation tool (CST) software. The various parameters for analysis of proposed antenna are observed like VSWR, S-Parameter, H-field radiation pattern with a frequency range of 0.5-10 GHz. This antenna shows resonance at four multiple bands resonating at 2.4 GHz, 5.5 GHz, 6.9 GHz and 9 GHz. The analysis is illustrated below.

a) Return Loss

The simulated return loss of the proposed antenna at multiple bands resonating at 2.4 GHz, 5.5 GHz, 6.9 GHz and 9 GHz with return loss of -28dB, -21.7dB, -32.6dB and -14.9dB respectively is given in Fig.2.

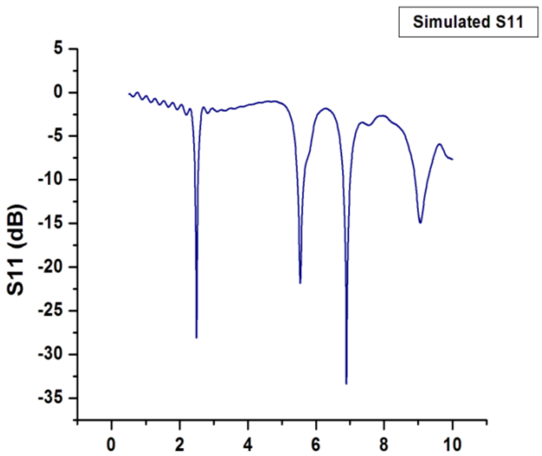

Fig. 2: Stimulated Return Loss of Proposed Antenna.

b) Surface Currents.

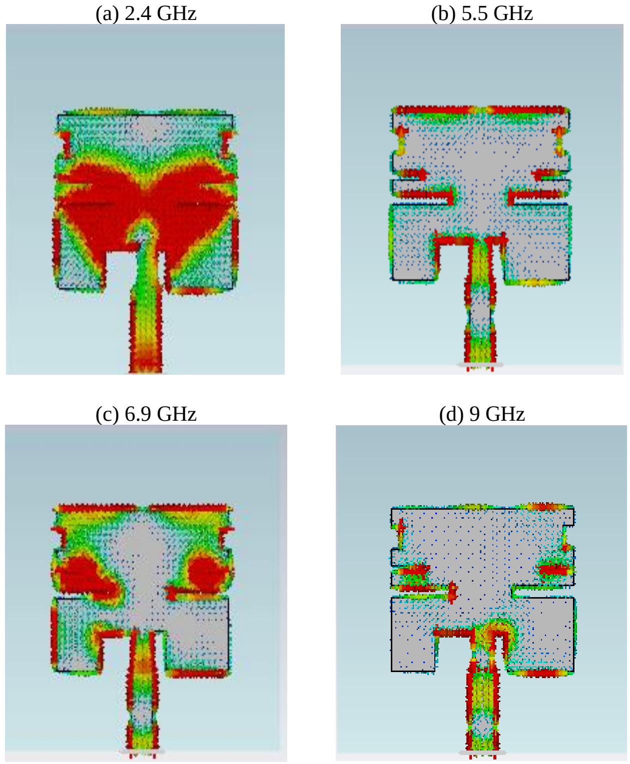

Fig. 3: Comparison.

c) Radiation Pattern

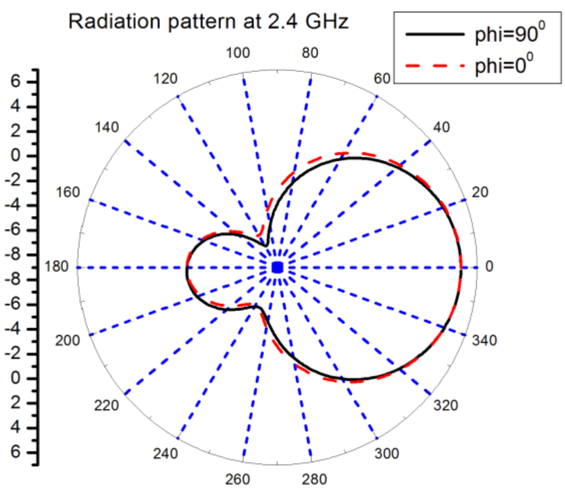

Fig. 4: Radiation Pattern at 2.4 GHZ for (Phi =0^0 and Phi=90^0.).

4. Measured results

Measurement of return loss of the fabricated design of proposed antenna is performed with the help of VNA. Measurement is performed for the range 1GHZ to10GHZ. Simulated and measured return loss results found good agreement and shown in figure 6.

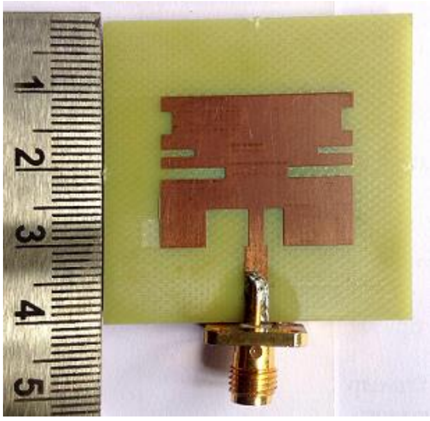

Fig. 5: Top View of Fabricated Design Structure of Proposed Antenna.

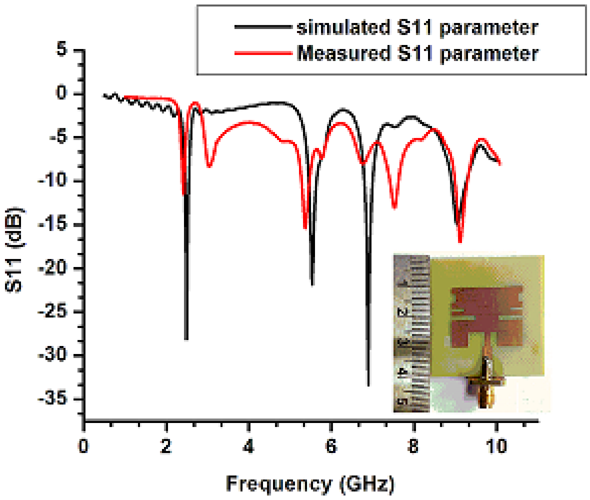

Fig. 6: Result.

5. Conclusion

Symmetrical cut slotted microstrip patch antenna with inset feed has been simulated, fabricated, results Verified and implemented for WLAN, Bluetooth, C-band (4-8GHZ) and radio navigation operating frequencies. Radiation pattern for θ and ϕ variations has been observed and presented. Performance parameters of proposed antenna like radiation pattern (at 2.4 GHz), surface current and return loss. Return loss are -28dB, -21.7dB, -32.6dB and -14.9dB obtained at respective frequencies and simulated v/s measured S_{11} shows good agreement.

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