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A Novel Printed Antenna for WLAN Applications at 2.45GHz

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Abstract— A novel single band microstrip antenna geometry for WLAN application is presented. A symmetrical antenna with its centre frequency at 2.45GHz is proposed. The proposed antenna is fabricated and the experimental results are reported. Important characteristics of the proposed antenna, such as radiation pattern, return loss, bandwidth, and efficiency have been investigated.

Index Terms— Antenna Design, HFSS, ISM Band, Microstrip Patch Antenna, Optimization, Symmetrical Antenna, WLAN.

1 Introduction

MINIATURIZATION and cost effective design are two of the most important challenges to the designer engineers everywhere. In this context, low cost, low profile and light weight antenna which can be easily integrated with the circuit is crucial in the development of modern wireless communication systems. Hence many of the researches are concentrated on the design of printed antennas. Due to its versatility, printed antennas find many applications in every field like wireless transmission, Bio-telemetry, Radio Frequency Identification Devices, short range radio devices and data links, wireless sensor networks etc…

Currently, the Industrial, Scientific and Medical(ISM) radio bands specifications [1], [2] are widely adopted in wireless communication. The applications based on these specifications are reported frequently in literature [1-10]. Its application is now expanding to outdoor also.

A popular geometry for realizing multi-band antennas for WLAN/WiMAX/HYPERLAN applications is Planar Inverted F Antenna (PIFA) [3], [4], [5]. In [6] two antenna structures - first one is a miniaturized rectangular patch by introducing slot and the second is a CPW fed monopole antenna – operating at 2.45GHz for RFID tag is analyzed and the methodology followed to miniaturize the antenna dimensions from basic rectangular patch is described. Design of an 80 x 60mm² patch antenna on RO3710 for ISM band at 2.45GHz is reported in [7]. An optimization technique using Particle Swarm Optimization (PSO) is demonstrated in [8]. An E – shaped patch antenna for 2.45GHz with 121.9MHz bandwidth is designed using this technique. Use of slotted ground for realizing multiple bands are presented in [9]. A triple band antenna for WLAN/WiMAX operation is reported in [10]. The antenna was implemented on a Teflon based substrate with an asymmetrical geometry.

This paper proposes a compact narrowband planar antenna of size 28 x 33 x 1.6 mm³ on FR4 substrate to operate in the ISM band at 2.45GHz. The geometry of the proposed antenna is discussed in section 2. The results of the numerical simulation and steps for optimization are presented in section 3. Section 4 narrates the conclusion and future scope of this work.

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2 Antenna Geometry

Top view and side view of the proposed symmetrical antenna is given in Fig. 1. FR4 glass epoxy of thickness 1.6mm, dielectric constant (ε_r) 4.4 and loss tangent (δ) 0.02 is used as substrate.

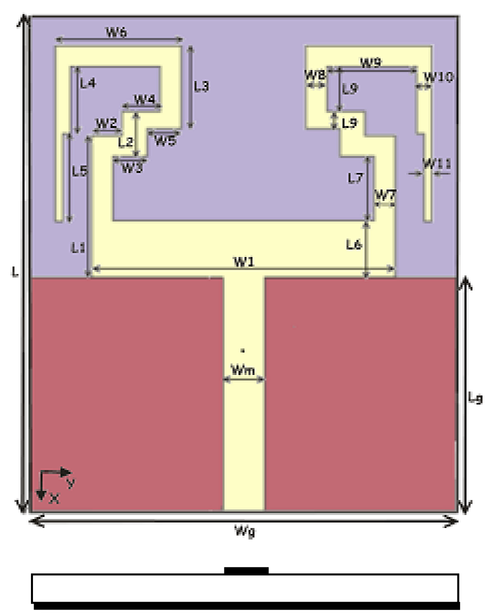


Fig. 1. Geometry of the proposed antenna

TABLE 1

OPTIMIZED PARAMETERS OF PROPSOED ANTENNA

L	L1	L2	L3	L4	L5	L6	L7
33	15.6	8	3.8	4.7	9.9	3	1
L8	L9	L10	W	W1	W2	W3	W4
3.8	11.75	4.5	28	12.2	20	8.3	5.9
W5	W6	W7	W8	W9	W10	W11	W12
2.5	2	2.25	2.25	1	0.5	2	1.4

Size of the antenna is 33mm X 28mm². Microstrip feed width is 2.8mm for a characteristic impedance of 50Ω. The antenna dimensions are optimized using parametric analysis and the optimal values are given in Table 1. All the dimensions are given in millimeters.

3 SIMULATION RESULTS

The numerical simulation of the antenna structure is carried out with Ansoft's High Frequency Structure Simulation (HFSS) v.12 software, which is based on Finite Element Method (FEM). The simulation results are discussed in sections 3.1 to 3.3.

3.1 Return Loss

Fig. 2 shows the return loss, S11, of the proposed antenna. The operating frequency is 2.44GHz. It exhibits a good impedance matching from 2.33GHz to 2.55GHz. At the central frequency, the return loss is as good as -20dB.

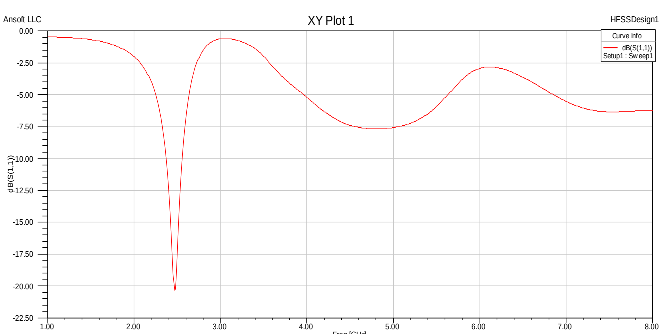


Fig. 2. Return loss (S11) Vs frequency in GHz

Current distribution in the geometry at 2.45GHz is shown in Fig. 3. From this result it is evident that the symmetrical stepped arms are responsible for the resonance at this frequency. It is also clear that the symmetrical structure only induces little current in the ground plane at the band of interest.

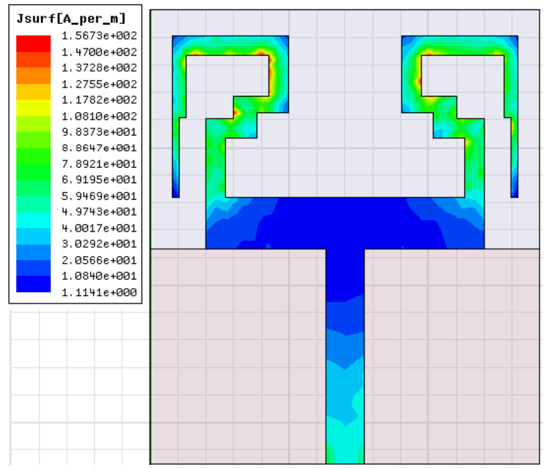


Fig. 3. Current distribution at 2.45GHz

3.2 Parametric Analysis

Through an extensive parametric analysis, L5, L6, W10 and W11 are identified as critical parameters in the geometry. Effect of L6 in operating band is shown in Fig. 4. It is clear that the resonant frequency is strongly affected by L6.

The influence of W10 is also equally important as shown in Fig. 5. In both the cases return loss is degrading significantly corresponding to a small change in the respective parameters. Together with the current distribution in Fig. 2 it is clear that the optimization of these two parameters is critically important in the design process.

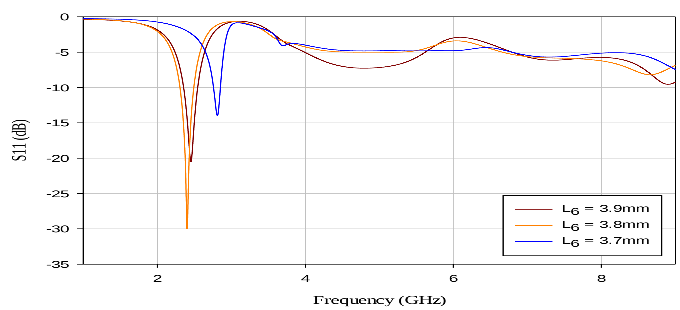


Fig. 4. Effect of L6 on resonant frequency

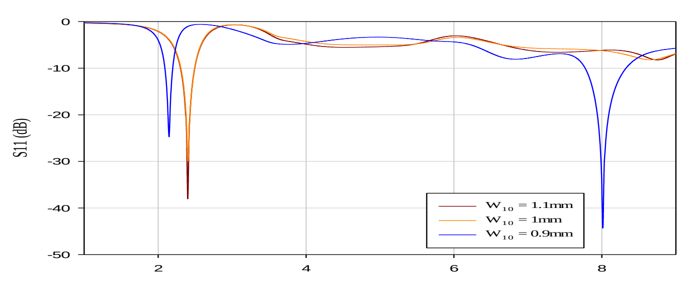


Fig. 5. Effect of W10 on the resonant frequency

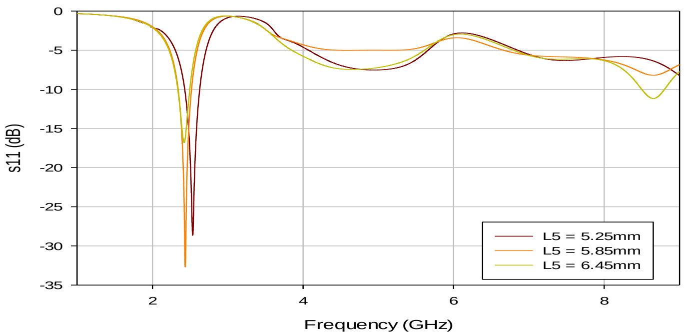


Fig. 6. Effect of L5 on the resonance

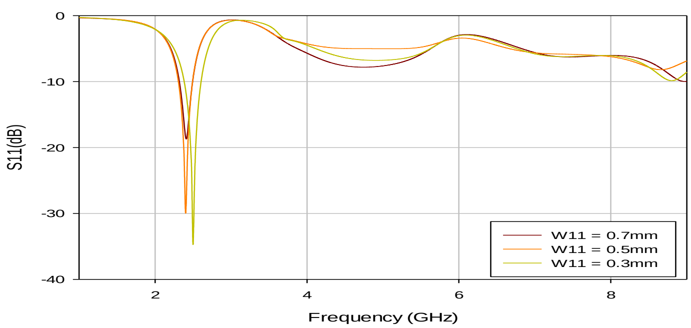
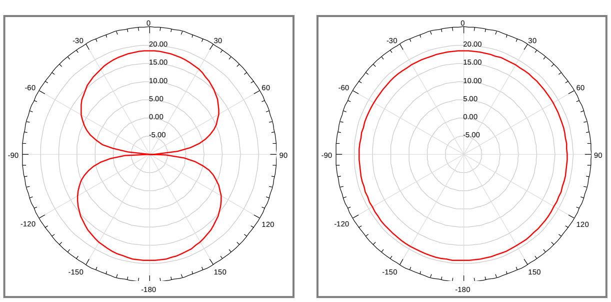


Fig. 7. Effect of W11 on the resonance

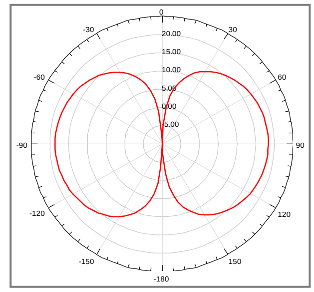
Influence of L5 and W11 are shown in figures 6 and 7 respectively. These parameters have no significant role in frequency tuning, but impedance in the referred band is not independent of these parameters.

3.3 Radiation Pattern

Radiation characteristics of the proposed antenna are analyzed. Fig. 8 shows the two dimensional radiation pattern in the elevation and azimuth planes at the operating frequency of 2.45GHz. Good far field radiation properties are achieved. The symmetrical structure resulted in an omnidirectional pattern in the xz plane.



yz plane xz plane



xy plane

Fig. 8. 2D Radiation Patterns in elevation and azimuth planes

3.4 Experimental Results

Fabrication of the antenna, as discussed earlier, was done by photolithographic process and the measurements were taken. The fabricated antenna and the measured return loss are shown in Fig. 9 and Fig. 10 respectively.

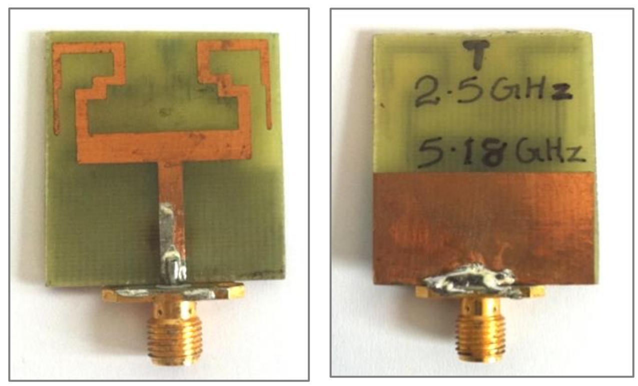


Fig. 9. Top View and Bottom View of fabricated antenna

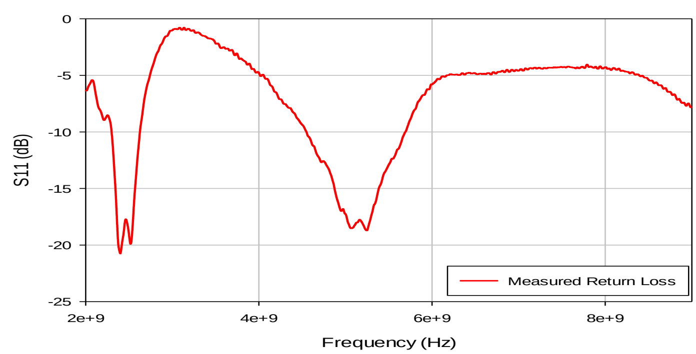


Fig.10. Measured Return Loss Vs Frequency

An unexpected band is found in addition to the designed one in the result (see Fig. 10 and Fig. 2). On further analysis, it was found that this additional band is produced due to the misalignment between the ground and resonating patch geometries.

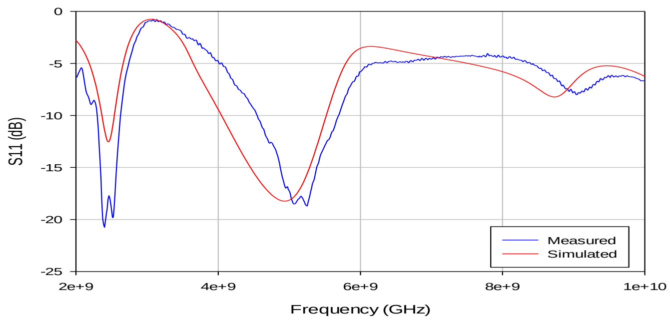


Fig. 11. Measured and Simulated Results with mis-alignment

In order to establish this assumption, the misalignment was manually measured and included in the further simulation. The simulation result obtained is in good agreement between the simulated and measured results as shown in Fig. 12 and hence validated the assumption.

4 Conclusion

In this paper, a novel single band cost effective and low profile microstrip antenna suitable for applications in ISM band at 2.45GHZ is presented. Extensive parametric analysis has been conducted and critical parameters identified. The optimized structure resonates at 2.44GHz with a band width of 22MHz starting from 2.33GHz which fully covers the ISM band at 2.45GHz. Due to the misalignment between the ground and the radiating patch an additional band 5.25GHz is resulted and which is validated through further simulation. Maximum radiation efficiency obtained from simulation report is 91%. The radiation properties are also promising for further investigations to develop compact multiband antenna suitable for WLAN/WiMAX/HYPERLAN applications together.

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