# Slotted Microstripline Antenna for ISM Band at 2.45GHz for Wireless Applications

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***Abstract***— In this paper, a slotted microstripline antenna is proposed for Industrial Scientific Medical band at 2.45GHz. This antenna design consists of different slots for radiation. TheFR4 substrate is used to design slotted antenna having relative permittivity is 4.4. The antenna is constructed on substrate height is 1.6mm, with small size of patch is 48.5mmx24mm. It operates in the ISM band operations have VSWR less than 2 and return loss less than -10 dB. The antenna parameters are simulated by ZELAND IE3D15.30 software. The results show radiation pattern and radiation gain are satisfy. The measured results of the proposed antenna can be applied to WLAN, RFID, GPS applications. As well as for biomedical and home automation connected appliances.

***Keywords***- *slotted; microstripline; WLAN; GP;microstrip antenna .*

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## I. INTRODUCTION

In electromagnetic history , the most exciting developments in antenna structure is with the microstrip antenna (known also as patch antenna) [1][2][3][4][5] are widely used in the microwave frequency region. The planar antenna is probably the most versatile solution to many antenna systems. Microstrip antenna falls into the category of printed antenna; it has a radiating element that utilizes printed circuit manufacturing processes to develop the feed and radiating structure. The work carried out by researchers to improve the antenna characteristics with the help of introducing different structures within the antenna geometry. The printed antennas, including dipole, slots, and tapered slots; Microstrip antenna is by far the most popular and adaptable for wireless communication system applications because the advantages of the microstrip antennas such as small size, low profile, lightweight, conformable to planar and non-planar surfaces conformability ,ease of fabrication, good radiation control, and low cost of production[6][7][8]. They are simple and cheap to manufacture using modern printed circuit board technology.

The four most popular techniques are microstrip line, coaxial probe, aperture coupling and proximity coupling [8]. Physically, the patch is a thin conductor that is an appreciable fraction of a wavelength in extent. The patch which has resonant behavior is responsible to achieve adequate bandwidth. Conventional patch designs yield few percent band widths. In most practical applications, patch antenna is rectangular or circular in shape; however, in general, any geometry is possible. However, the bandwidth and the size of an antenna are generally mutually conflicting properties, that is, improvement of one of the characteristics normally results in degradation of the other. The several techniques have been proposed to enhance the bandwidth. Utilizing the shorting pins or shorting walls on the unequal arms of a U-shaped patch, U-slot patch, or L-probe feed patch antennas, wideband and dual-band impedance bandwidth have been achieved with electrically small in size.

Next to this; section II describes the proposed antenna geometry design. Simulated results of proposed antenna are discussed in section III, while the measured and simulated parameters of the proposed antenna are compared in Section IV, followed by a conclusion of this design is in section V.

## II PROPOSED ANTENNA DESIGN

The patch antenna dimensions are calculated based on the equation and the dimension are adjusted for optimization. Design steps for rectangular patch antenna are as follows: [9]

Step1: Calculation of the width (W):

$$W = \frac{V0}{2fr}\sqrt{\frac{2}{\varepsilon r+1}} \tag{1}$$

Step2: Calculation of Effective dielectric constant:

$$\mathcal{E}_{reff} = \frac{\mathcal{E}_r+1}{2} + \frac{\mathcal{E}_r-1}{2}\left[\left(1+\frac{12}{\frac{W}{h}}\right)^{-\frac{1}{2}}\right] for \frac{w}{h} \geq 1 \tag{2}$$

Step 3: Calculation of Effective length ( Leff ):

$$\text{Leff} = \frac{V0}{2fr\sqrt{\mathcal{E}reff}} \tag{3}$$

Step 4: Calculation of Length extension (ΔL):

$$\frac{\Delta L}{h} = 0.412\frac{(\mathcal{E}_{reff}+0.3)(\frac{W}{h}+0.264)}{(\mathcal{E}_{reff}+0.3)(\frac{W}{h}+0.8)} \tag{4}$$

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Step 5: Calculation of actual length of the patch (L):

$$L = L_{eff} - 2\Delta L \quad (5)$$

Step 6: Calculation of ground plane dimensions (Lg and Wg):

$$Lg = 6h + L \quad (6)$$

$$Wg = 6h + W \quad (7)$$

where,
'L' is the length of patch,
'W' is the width of the patch,
'h' is the height of the substrate,
'Ɛr' is the relative permittivity of substrate,
'Ɛreff' is the effective relative permittivity of patch,
'vo' is the velocity of EM wave,
'Leff' is the effective length of patch
'fo' is the resonant frequency.

The transmission line model is applicable to infinite ground planes only. However, for practical considerations, it is essential to have a finite ground plane. Similar results for finite and infinite ground plane can be obtained if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around the periphery. Hence, the ground plane dimensions are given in step 6.

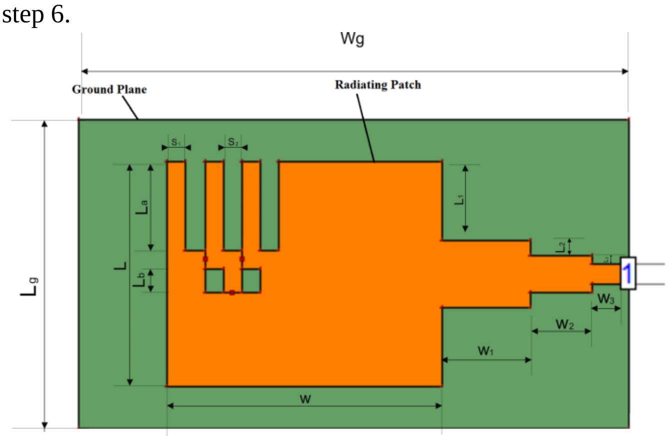


Fig.1 Proposed antenna Geometry with Ground plane

The proposed antenna provides the operating ISM band, covering (2.39-2.51GHz), all dimensions are as shown in Table I. The proposed antenna consists of a thin metal plate with a double-side layer and FR-4 substrate with thickness of 1.6mm Ɛr = 4.4 and loss tangent is 0.001(tan δ = 0.001).The slotted antenna consists of a strip line feeding with tapered structured transformer for impedance matching. The geometry of proposed slotted antenna with dimensions of 48.5mmx24 mm is as shown in Fig.1. The ground plane dimensions are length is of 59mm and width is 33mm, a tapered feed is used to excite the antenna.

The antenna radiator consists of five slots on rectangular patch. Three slots having dimensions of 2mm x 10mm and two are with the size of 2mm x 4mm inserting on the patch as shown in Fig.1. The microstripline feed is inserted with tapered stripline work as transformer for better impedance matching between patch and the port impedance of 50 ohm. This slotted antenna is designed for Industrial Scientific Medical (ISM) band, GSP, GSM, WLAN or satellite operation.

The design strategy of the proposed antenna with return loss, VSWR, surface current, and radiation pattern are discussed in the next section.

TABLE I. PATCH DIMENSIONS OF PROPOSED ANTENNA

| Sr. No. | Parameter | Dimensions in μm |
|---|---|---|
| 1 | W | 49.5 |
| 2 | L | 24 |
| 3 | S | 2 |
| 4 | W1 | 9.5 |
| 5 | L1 | 8.5 |
| 6 | W2 | 6.5 |
| 7 | L2 | 1.5 |
| 8 | W3 | 4 |
| 9 | L3 | 1 |
| 10 | La | 9.5 |
| 11 | Lb | 2.5 |
| 12 | Wg | 59 |
| 13 | Lg | 33 |

## III SIMULATED PARAMETRIC STUDY

The simulated parameters of the proposed antenna are studied in the presence of the stripline feeding structure. The return loss against frequency is shown if Fig.2 and VSWR of the proposed antenna is shown in Fig. 3. This slotted antenna gives the good return loss for the specified frequency range. The curve shows deep and wide dips response at 2.45 GHz frequency. The return loss obtained at 2.45 GHz frequency frequencies is -33 dB. The bandwidth achieved from this design is 5.5%.

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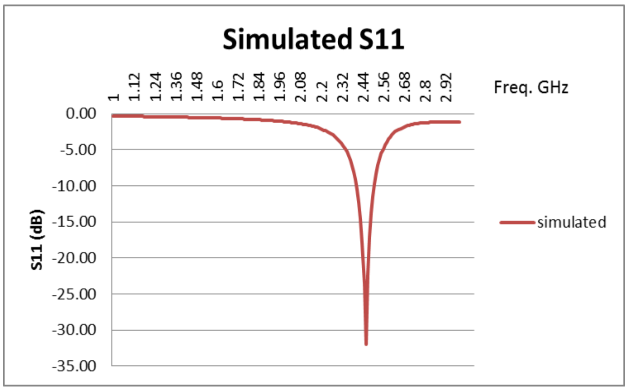


Fig.2. Simulated results of Return loss against frequency for slotted antenna

The return loss (RL) is less than -10dB used as the impedance matching bandwidth. As which is generally acceptable for practical antennas as shown in Fig.2.

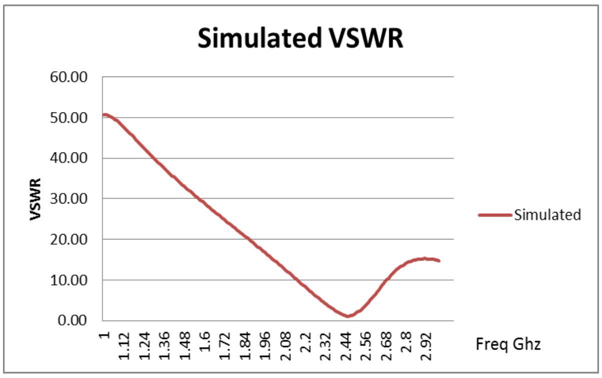


Fig.3. Simulated result of VSWR against frequency for slotted antenna

For practical antennas, 2:1 VSWR is used, which provides good impedance matching bandwidth, and which is generally acceptable as shown in Fig.3.

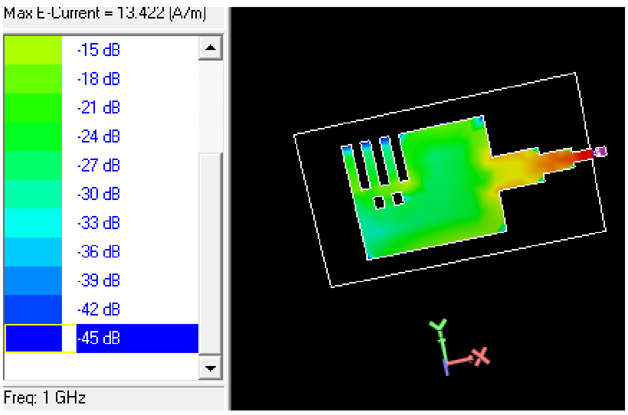


Fig.4. Simulated current distribution of the slotted antenna

The Fig.4 indicates the simulated current distributions on the metallic portion of the slotted antenna. At the slotted structure of the patch strong current distributions are observed. It shows the resonant mode occurs at 2.45GHz. The proposed printed slotted planar antenna is the structure which consists of tapered feeding structure, radiating patch with slotted structure, and the system ground plane. This complete effective radiating system of antenna configuration covers the band of Wireless Local Area Network (WLAN) band (2350-2485 MHz). The light color indicates the large resonant current distribution while dark color indicates the small one. The simulated radiation pattern of the planar slotted antenna at resonant frequency of 2.45 GHz is illustrated in Fig.5. The radiation patterns found from the simulation tells that at broadside it gets maximum radiation.

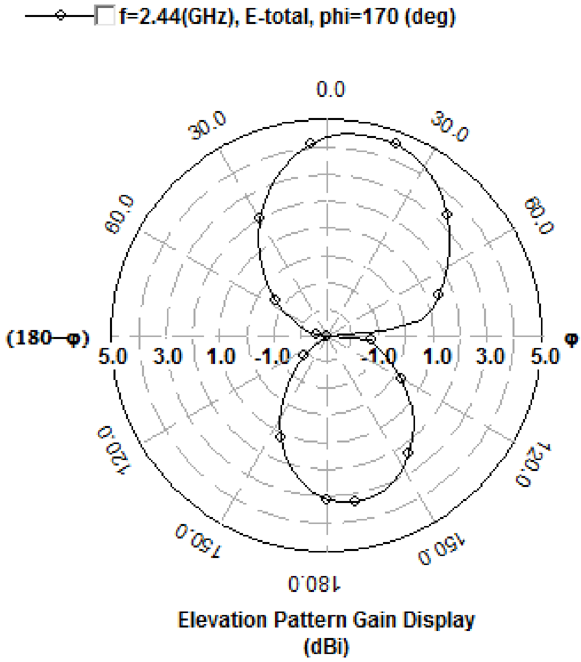


Fig.5. 2D Radiation Pattern for 2.44GHz Frequency

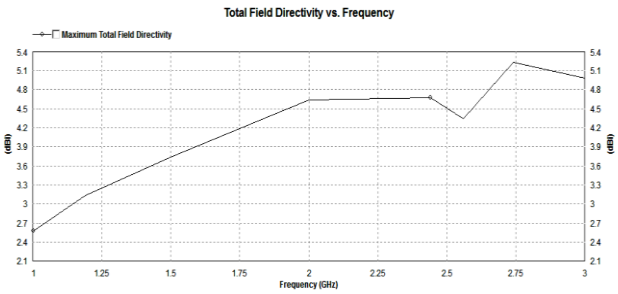


Fig.6. Simulated Directivity verses frequency for slotted antenna

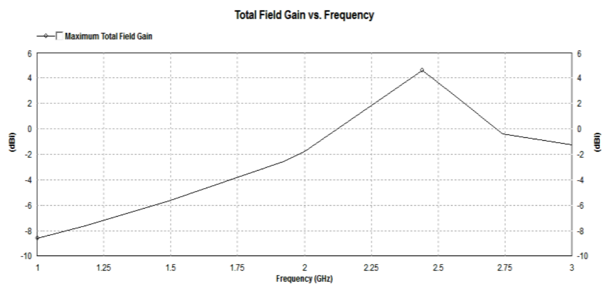


Fig.7 Simulated gain verses frequency for slotted antenna

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The simulated results of directivity and gain of are 5.5 dBi and 4 dBi respectively as shown in Fig.6 and Fig.7 respectively and it is clear that those are high in magnitude at 2.45GHz. The designed antenna produces broadside radiation pattern. The radiation and antenna efficiency both are very high, i.e.100% as shown in Fig.8.

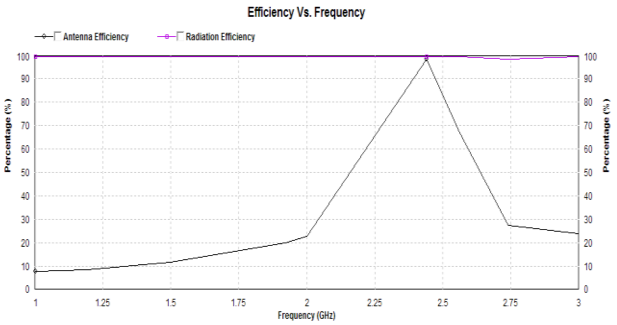
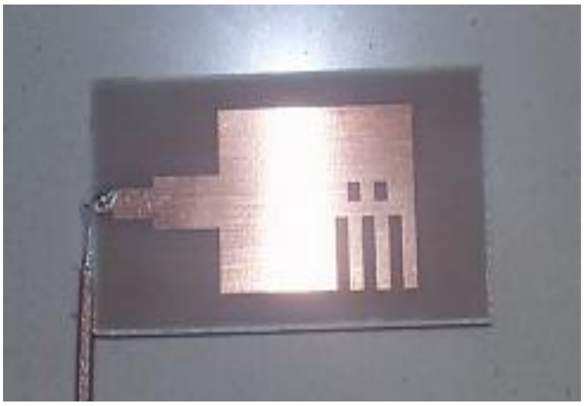



Fig.8. The radiation and antenna efficiency verses frequency of the slotted antenna

## IV MEASURED RESULTS

The proposed antenna provides good radiation efficiency is about 100% as shows in Fig.8, over the desired operating ISM band. That of antenna efficiency is about to 80%, for the WLAN application which is the good feature.



(a) Radiating Patch front side

(b) Back side

Fig.9 Photos of the manufactured planar slotted antenna

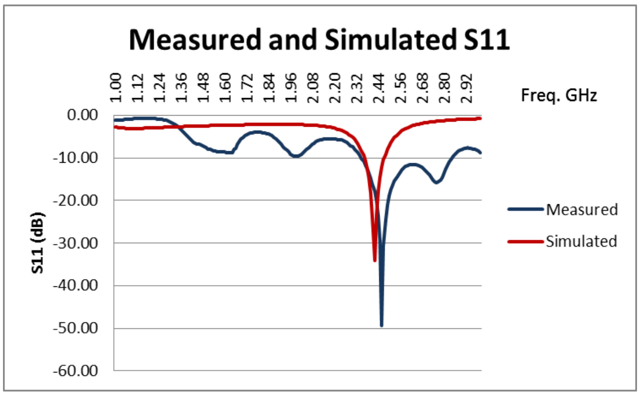



Fig.10 Simulated and measured return loss verses frequency for the slotted antenna

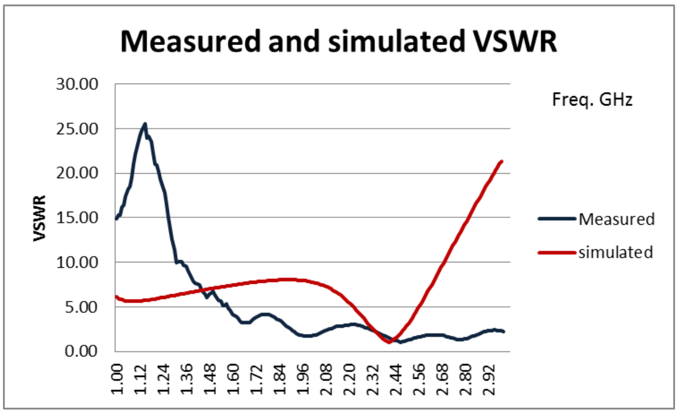
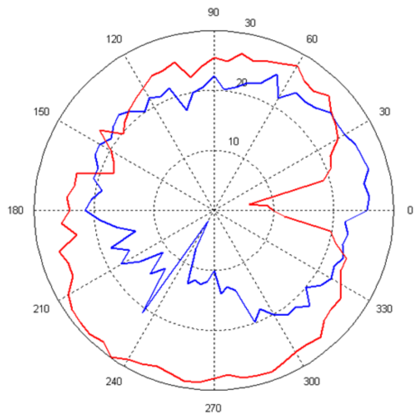



Fig. 11 Simulated and measured VSWR verses frequency for the slotted antenna

The measured and simulated results of return loss or VSWR are close to each other. The bandwidth of proposed antenna is 120MHz.



(a) Radiation pattern in XZ plane

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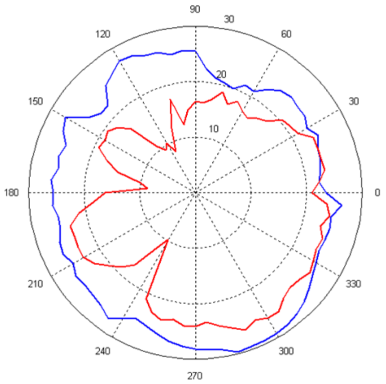


(b) Radiation pattern in YZ plane

Fig.12 Radiation Pattern in XZ and YZ plane

(Red color - Coplanar and Blue color – Cross Coplanar)

Fig.12 shows radiation pattern in both planes XZ and YZ plane. Red color graph indicates for Coplanar and Blue color graph for Cross Coplanar. This radiation pattern shows maximum normalized power of 30 in both XZ and YZ plane. Measured and simulated results of return loss or VSWR are not matched with each other because of some properties of substrate material used such as permittivity or loss tangent etc. Also these disagreements are due to effects of coaxial cable used at the time of testing.

## V Conclusion

The planar printed slotted antenna structure has a low profile of 48.5mmx24mm, is designed for 2.45GHz ISM band. The design parameters, return loss (-33dB) and radiation pattern, VSWR (<2) were simulated and measured. These results are validate the slotted stripline feed antenna for the ISM band of (2.39-2.51GHz). The surface current distribution of the radiating element verifies the resonant modes of the antenna. The practical antenna structure is fabricated for testing in VNA experimental set up. The measured antenna efficiency is about 80% and radiation efficiency is about 100% over the ISM operating band is the important features of an antenna. Antenna is attractive for ISM band, GSP, GSM, WLAN or satellite operation. Microstrip patch antennas have found number of application in wireless communication system.

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