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# Dual Band Resonating Structure Micro Strip Patch Antenna for Wlan Applications

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**Abstract:** *In this paper, a dual band linearly-polarized microstrip patch antenna is designed and simulated with Modified Resonating Structure using HFSS simulation software. Antenna parameters are examined in this which includes resonating frequency, impedances, VSWR and bandwidth of the designed and proposed resonating structure with probe feed. The antenna is proposed for wireless communication applications .This paper focuses on the designing of microstrip antenna with slot introduction on a ground plane to improve results as compared to conventional ground plane antenna and analysing the results like return loss S11, VSWR, bandwidth, impedance and radiation pattern (including 2D pattern) E- field at 1.35 GHz and 4.82 GHz.*

**Keywords:** *Resonating Structure, dual band, Microstrip Antenna, MSR, Modified Structure Resonator*

## I. Introduction

As the demand of wireless and portable devices are going to increase for the wireless applications [6], [11], [12] like WLAN, WiMAX, Wi-Fi, GSM etc. It is must to design the broadband, high gain antenna. WLAN is a wireless standard which was designed to provide the 60 Mbps data rate, attracts the user to satisfy their speed demand. IEEE 802.11 standard announces the five bands for WLAN applications, these are 2.4GHz, 3.6 GHz, 4.9 GHz, 5.2 GHz and 5.9 GHz[4]. Wireless local area network (WLAN) technology [10] is the most rapidly growing area in the modern wireless communication [1]. This gives users the mobility to move around within a broad coverage area and still be connected to the network. This provides greatly increased freedom and flexibility. For the home user, wireless has become popular due to ease of installation, and location freedom. As per the present trends in communication systems has been to develop minimum in cost, profile, weight commonly used dielectric material of FR4_Epoxy ($\varepsilon r$=4.4) that are capable of providing high performance over a wide range of frequencies. With a simple and easy geometry, microstrip patch antennas provide many advantages not generally exhibited in other antenna designs. Advantages of these microstrip resonating structures [2], [4] are low. profile, less expensive, light weight and simple to fabricate using modern day technology of printed circuit board, compatible with microwave circuits and millimetre-wave integrated circuits, and have the ability to match to resonating structures . In addition, once the shape, design and operating mode of the patch are selected, prototype become very specific in terms of resonating frequency, return loss, polarization, radiation pattern, gain, VSWR and impedance. Using the multi band microstrip patch antenna concept, in this paper a dual band modified resonating structure microstrip antenna is designed and simulated for analysis. There are few antenna simulation software available which allow the optimization of the antenna. HFSS is one of the most imperious electromagnetic software which allows designing and solving for radio signal and microwave application. The HFSS [13] simulator tool computes most of the useful parameters of interest such as radiation pattern, gain, input impedance, return loss, VSWR, etc.

## II. Design Equations Of Microstrip Antenna

**1: Calculation of Width (W) :-**

For an efficient radiator, practical width that leads to good radiation efficiencies is:-

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

where, $\mu_0$ is the free permeability, $\varepsilon_0$ is the free space permittivity and $\varepsilon_r$ is relative permittivity.

2: Calculation of Effective Dielectric Coefficient ( $\varepsilon_{reff}$ ) The effective dielectric constant is $\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}[1 + 12\frac{h}{W}]^{1/2}$

3: Calculation of Effective Length (Leff).The effective length

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

4: Calculation of Length Extension (ΔL)

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

5: Calculation of actual Length of Patch (L)

The actual length of radiating patch is obtained by

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

6: Calculation of Ground Dimensions (Lg, Wg)

The transmission line model [5] is applicable to infinite ground planes only. However, for practical considerations, it is essential to have a finite ground plane. The 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 given as:

$$L_g = 6h + L\ ,\qquad W_g = 6h + W$$

To obtain simulated result, ground plane is taken as infinite ground plane.

From simple circuit theory, the input impedance of the patch is then given by

$$\mathrm{W} = \frac{1}{2\mathrm{f_r}\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r+1}}$$

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To obtain simulated result, ground plane is taken as infinite ground plane.

From simple circuit theory, the input impedance of the patch is then given by

$$\boldsymbol{Z_{in}} = \mathrm{j}\omega L_p + \frac{R}{1+jQ\,(\mathrm{f_R}-\frac{1}{\mathrm{f_R}})}$$

Where, the frequency ratio is defined as $f_R = f/f_0$, with $f_0$ being the resonance frequency of the patch cavity (the resonance frequency of the RLC circuit). This is not the same as the impedance resonance frequency of the patch (the frequency for which the input reactance is zero), denoted as fr , due to the presence of the probe inductance. The term R represents the input resistance of the patch at the cavity resonance frequency $f_0$ ( $f_R = 1$), at which the input resistance is a maximum. CAD formulas for Lp, $f_0$, Q, and R are given At the impedance resonance frequency fr the input resistance will be slightly lower than the maximum value R according to the approximate formula

$$R_{in} = \frac{R}{1+(\frac{X_p}{R})^2}$$

where Xp = $\omega_0 L_p$ is the probe reactance. The probe reactance shifts the impedance resonance up from the cavity resonance by an amount $\Delta f = f_r - f_0$ given by the approximate formula

$$\frac{\Delta f}{f_0} = (\mathrm{BW})(\frac{1}{\sqrt{2}})(\frac{X_p}{R})$$

where,

$$BW=\frac{1}{\sqrt{2}\,Q}$$

BW is the bandwidth of the antenna (SWR < 2 definition) and Q is the total quality factor. The input impedance of the tank circuit along with its real and imaginary parts may be written in a normalized form as

$$Z_{RLC}=\frac{1}{1+jx} \qquad R_{RLC}=\frac{1}{1+x^2} \qquad X_{RLC}=\frac{-x}{1+x^2}$$

Where,

$$x=Q(f_R-\frac{1}{f_R})\approx 2Q(f_R-1)$$

$f_r$ is a normalized frequency term, and the bars over the impedance symbols denote that they have been normalized by dividing the impedances by R.

## III. Antenna Design

In particular, the microstrip antenna structure using a dual-band resonator rather than a regular one have become better due to miniaturization and good performance [6], [7]. However, the design methods of this antenna using the dual-mode resonating structures are not uncommon [9], [12]. The design of the proposed antenna is shown fig 3.1, which is designed on a FR4_Epoxy (εr = 4.4, tan loss=0.001) substrate with a height of 1.5 mm. The antenna is comprised of a probe feed and a symmetrical resonating structure. The antenna consist the repeated resonating structure metal line and slotted ground plane, to construct the simple unit cell as shown in Figure 3.2. Four identical MSR (microstrip resonators) are placed at every 90° of the center at a distance of 5.8mm to have a unique MSR. Dimension of substrate and model is 30mm×30mm×1.5mm and so is for the ground plane. Ground plane has two rectangular slot cuts of 1mm×10mm placed 2mm and another of 1mm×14mm placed 4mm distance from the centre of feed point of radius 1.3mm. Distance between the two rectangular slots [9] in ground is 1mm.

The magnitude of the return loss parameter S11 for the antenna is calculated by the commonly used electromagnetic simulation software HFSS. For example, the detailed dimensions of the antenna are listed in Table1. The thickness of all the lines is chosen to 0.375 mm

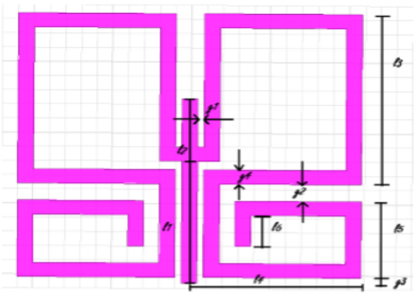

Figure-3.1Slot Pattern

Table 1 Dimension of Microstrip Resonator (units in mm)

| | | | | |
|---|---|---|---|---|
| l1=3.225 | l2=1.65 | l3=4.5 | l4=4 | l5=2.025 |
| l6=0.825 | g1=0.15 | g2=0.45 | g3=0.153 | g4=0.375 |

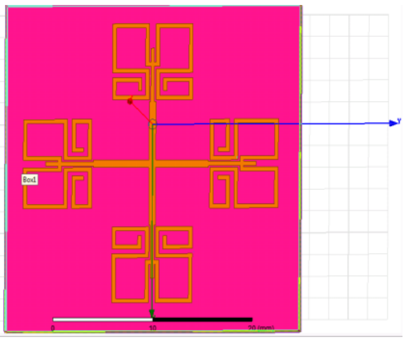

Figure- 3.2 Symmetrical Resonating Structure

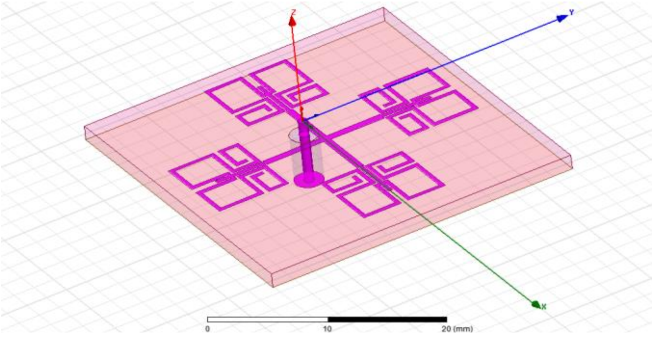

Figure-3.3 Resonating Structure in3D

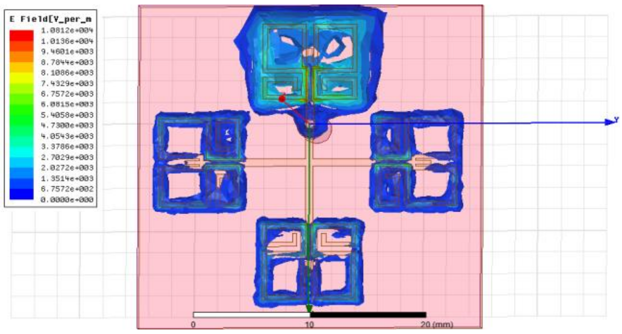

Figure 3.4 Electric field line for Resonator Structure for Dual Band Antenna

## IV. Type Of Feed

There are 3 common ways to feed [2], [3] the Patch antenna.

**1.Coaxial Probe Feed**- The coaxial feed or probe feed is a very common contacting scheme of feeding patch antennas. The configuration of a coaxial feed is shown in Fig. 4.1. The inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane.

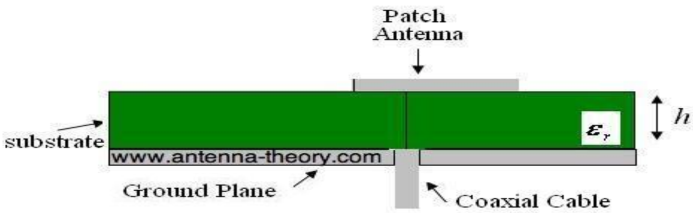


Figure 4.1 Probe Feed For Microstrip Patch.

**2. Aperture Coupled Feed**- In this type of feed technique, the radiating patch and the microstrip feed line are separated by the ground plane as shown in Fig 4.2. Coupling between the patch and the feed line is made through a slot or an aperture in the ground plane The coupling aperture is usually centered under the patch, leading to lower cross-polarization due to symmetry of the configuration. The amount of coupling from the feed line to the patch is determined by the shape, size and location of the aperture

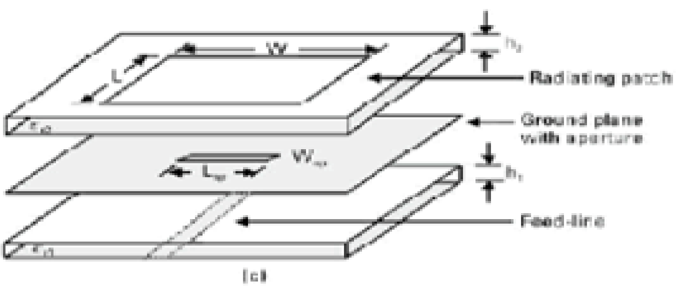


Figure 4.2 Aperture Coupled Feed for microstrip patch.

**3. Microstrip Line Feed**- In this type of feed technique, a conducting strip is connected directly to the edge of the microstrip patch . This strip is smaller in width as compared to the patch. The major advantage of this arrangement is that the feed can be etched on the same substrate to provide a planar structure.

## V. Result & Discussion

The proposed antenna is resonating structure used by HFSS and various parameters [10] (Loss, Gain, VSWR etc) are shown. The return loss for -29.96 and -35.22 which covers the minimum requires loss of -10 dB. The following parameter S11, VSWR, Gain, Directivity, R are observed and found to be satisfactory for WLAN application.

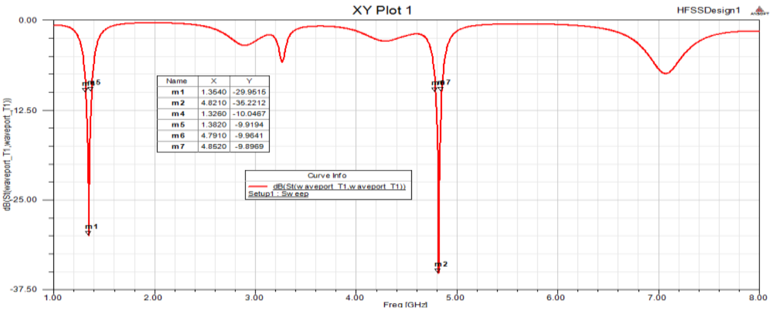

Figure 5.1 Return loss  S11 vs. frequency plot of 4 MSR Patch

The antenna simulation software HFSS, simulated and measured results of S11 are shown in Figure 5.1 with respect to frequency in Gigahertz for the range 1GHz to 5GHz, where two frequency bands are obtained for the designed antenna which is produced by adding the slots in ground plane. The antenna exhibits the characteristics of the dual-band operation, i.e., a measured -29.96 dB S11 and bandwidth 57.8 for the resonating frequency at 1.35 GHz,-29.95 dB S11 and a bandwidth of 54.5 MHz for the second resonating frequency at 4.82 GHz and -35.22 dB covering WLAN characteristics.

Figure 5.2 shows plot of VSWR. Voltage standing wave ratio can be evaluated by dividing maximum voltage with minimum voltage or we can find by using reflection coefficient. It is clear that VSWR <2 at resonant frequencies.

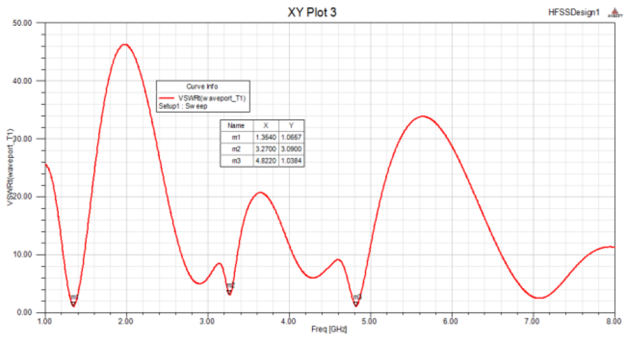

Figure 5.2 VSWR vs. frequency plot of Four Microstrip Resonating Patch

Figure 5.3 shows the Radiation Pattern diagram for proposed resonating Patch antenna

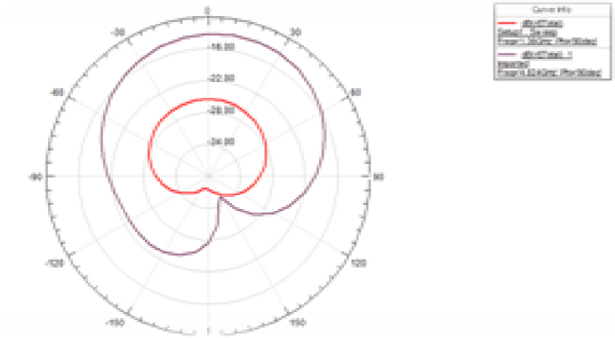


Figure5.3 Radiation Pattern Plot of MSR Patch

Table 2 Summary of Result of Simulated antenna

| S.No. | Antenna Parametre | Simulation | |
|---|---|---|---|
| | | F1 | F2 |
| 1 | Resonant Frequency | 1.35 | 4.82 |
| 2 | Return Loss $S_{11}$(db) | -29.96 | -35.22 |
| 3 | VSWR | 1.06 | 1.03 |
| 4 | Impedance (ohm) | 50 | 50 |
| 5 | Bandwidth | 57.8 | 54.5 |

## VI. Conclusion

In this paper, We have designed and simulated dual-band microstrip antenna with modified resonating structure which has a resonating frequency of 1.35 GHz and 4.82 GHz with return loss of -29.95 dB and -35.22 dB. This dual-band antenna has wide application in WLAN of wireless communication. Further optimizations are also possible to achieve required operating frequencies. The unique feature of this microstrip resonating structure antenna is its compact and small size to get better performance. This paper presents a geometric configuration of the Microstrip patch antenna for various wireless applications, which provides a means to gain multiple bands by having slots on ground plane without using special techniques.

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