Square Shaped Microstrip Patch Antenna at 2.45GHz

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Abstract: ***This paper communicates the design and study of parameters of square microstrip patch antenna. It is designed on FR4 substrate at resonance frequency of 2.45 GHz for ISM band using transmission line model. The thickness of substrate used is 1.542mm with dielectric constant ε_r = 4.4. The sides of patch are taken to be 29mm. The coaxial feeding is used for excitation of antenna. The proposed antenna was designed and analyzed by using the ANSOFT Designer SV 2.2. Software. The Return loss, VSWR, Smith chart and Radiation pattern for the designed antenna are simulated.***

Keywords: Antenna theory, Microstrip antennas, coaxial feeding, Return loss, Radiation pattern.

1. Introduction

The rapid development of microstrip antenna technology began in 1970. The basic microstrip antenna effects were established in early 1980s. Now a day's printed antennas have been studied due to their wide applications over the radiating antennas. These applications are light weight, low cost, miniaturization, conformability and integration with active device[1]. The microstrip patch antennas can be designed and analyzed by number of software tools. The microstrip fabrication technique is used to make patch antennas. In present communication the square microstrip patch antenna is designed and analyzed for parameters like return loss, VSWR, smith chart, and radiation pattern by using Ansoft Designer SV2.2[2].

2. Theory of Patch Antenna

The MPA is a radiating patch on one side of dielectric substrate with ground plane on the other side. The patch is made up of conducting material such as copper or gold[3]. The shapes of microstrip patch antenna are circular [4], rectangular [5], triangular [6] and square [7]. In present communication square shape is used to design. The dimensions of square patch length L, width W are taken to be equal. The thickness of patch is t on dielectric substrate of height h supported by ground plane. Such patch is depicted in Figure 1 [8].

Theoretically the length L of radiating patch is kept in between $0.333\lambda_0$ and $0.05\lambda_0$ (where λ_o is the free space wavelength) the thickness of patch is kept as $t << \lambda_0$ while height h of dielectric substrate is taken from $0.003\lambda_0$ to $0.05\lambda_0$. The dielectric constant ε_r of the substrate is kept in between 2.2 and 12. [3].

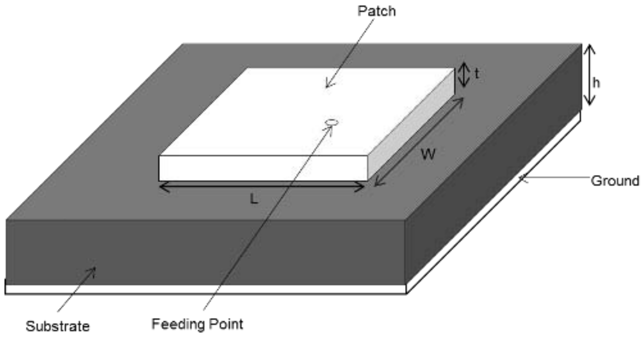

Figure 1: Geometry of Rectangular microstrip patch antenna.

The models used for analysis MPAs are transmission line model [8], cavity model [9] and full wave model or method of moments [10]. The proposed antenna is analyzed by using transmission line model. The fringing field between patch edge and ground plane makes the antenna to radiate. The effective dielectric constant ε_{reff} ranges from 1 to ε_r. The fringing fields present in dielectric substrate as well as spread in air as depicted in Figure 2.

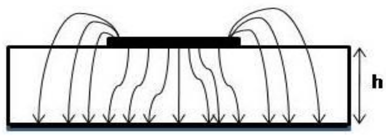

Figure 2: Electric field lines

To feed the antenna variety of methods are used. They are classified into two groups as contacting and non-contacting. The contacting methods are stripline and coaxial probe, while non-contacting are aperture coupling and proximity coupling [1]. In present communication coaxial probe feeding method is used as depicted in Figure1 [8].

The theoretical formulae for dimensions like width of patch W [11], Effective dielectric constant ε_{reff} [1], Extension length ΔL [12], Length of patch L [1] are given below.

$$W = \frac{c}{2 f_r \sqrt{\frac{(\varepsilon_r + 1)}{2}}} \quad (1)$$

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{\frac{1}{2}} \quad (2)$$

$$\Delta L = 0.412\frac{\left(\frac{W}{h} + 0.264\right)\left(\varepsilon_{reff} + 0.3\right)}{\left(\varepsilon_{reff} - 0.258\right)\left(\frac{W}{h} + 0.8\right)} \quad (3)$$

$$L = \frac{c}{2 f_r \sqrt{\varepsilon_{reff}}} - (2 \times \Delta L) \quad (4)$$

where $c =$ Velocity of light in air,

$f_r =$ Resonance frequency,

$h =$ Height of substrate.

The width of patch and length of patch of proposed square microstrip antenna is taken to be 29mm, dielectric material FR4 with $\varepsilon_r = 4.4$, height of substrate $h = 1.542762mm$. By using microstrip antenna calculator [13] the resonance frequency is analyzed to be $f_r = 2.45\ GHz$. These parameters are presented in Table I.

Table 1: Antenna Dimensions

Parameter	*Dimensions*
Dielectric Constant ε_r	4.4
Height of substrate h	1.542 mm
Resonance frequency f_r	2.45 GHz
Width of Substrate W	29.00 mm
Length of Substrate L	29.00 mm

3. Results and Discussion

Using Ansoft Designer SV2.2 software the proposed square microstrip antenna is designed; particular location of feed position for coaxial probe feeding is optimized and the parameters like return loss, VSWR, smith chart and radiation pattern of antenna are simulated [2].

3.1 Feed Point Location

The coaxial probe feed point is located at point where input impedance is 50 Ω at analyzed resonance frequency. The location of feed point coaxial feeding technique is optimized in such way that the return loss is more negative at resonance frequency at that point. Therefore, in coaxial probe feeding the feed point is varied inside square patch. The position of feed point was changed and the value of return loss for number of times was observed by trial and error method [14]. The more negative return loss is found at a point (10, 12) inside the square patch. Thus the coaxial feeding is fixed a point (10, 12). The geometry of designed square microstrip patch antenna of width and length of 29mm with proper feed position (10, 12) coaxial feeding is presented in Figure 3 .

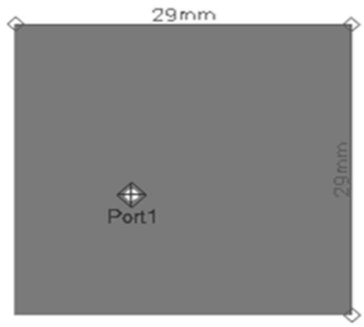

Figure 3: Geometry of the designed coaxial feed (10, 12) microstrip patch antenna.

The frequency range for simulation is selected between 2.0 GHz to 2.8GHz. The variation of return loss with frequency is presented in Figure 4. The resonance frequency of square microstrip patch antenna is observed to be 2.43GHz. for stripline feeding and 2.4GHz for coaxial feeding. The return loss at this resonance frequency is - 29.32 dB. With this return loss the maximum power transmitted to the antenna is 99.87% [15]. The 3dB and 10 dB % bandwidths are 6.58 and 2.05 respectively.

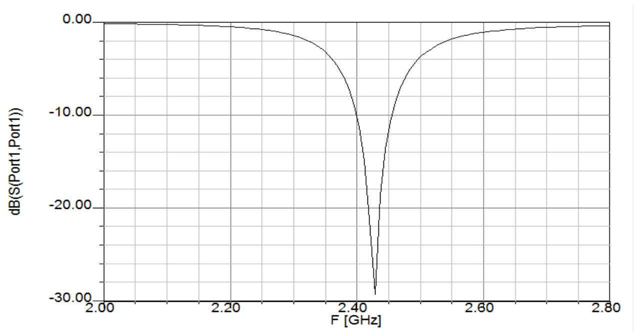

Figure 4: Variation of return loss with frequency

Figure 5 shows the variation of VSWR with frequency. The VSWR observed to be 1.29 at resonance frequency.

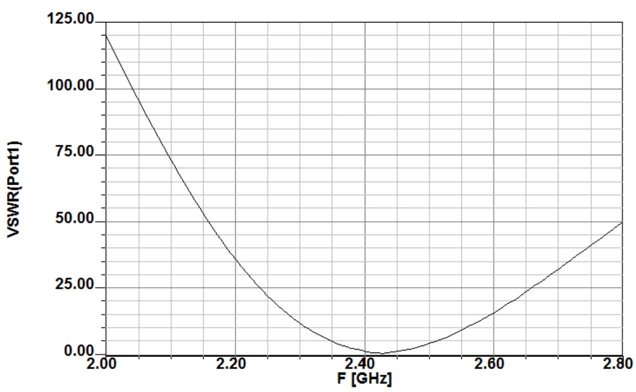

Figure 5: VSWR with frequency

The Smith chart of proposed square microstrip antenna is represented in Figure 6. From radiation pattern of designed square patch antenna presented in Figure 7, the half power beam width is 62º. All these parameters are listed in Table II.

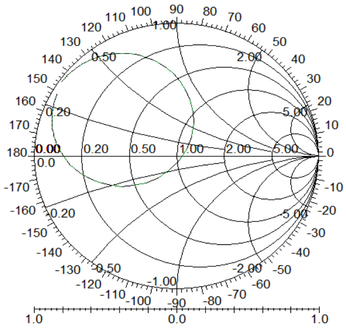

Figure 6: Smith chart

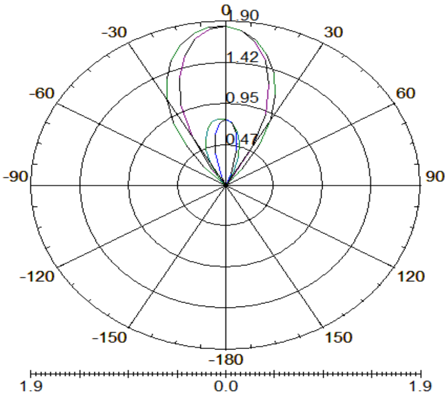

Figure 7: Radiation pattern

Table 2: Calculated Antenna Parameters

Serial	*Parameter*	*Dimensions*
1	Resonance Frequency	2.43GHz
2	Return loss	29.32dB
3	Power Transmitted	99.87%
4	3dB%Bandwidth	6.58
5	10dB%Bandwidth	2.05
6	VSWR	1.29
7	Half power beam width	62°

4. Conclusion

The coaxial line fed square microstrip patch antenna at 2.45GHz is designed on Flame Retardant 4 substrate with dielectric constant 4.4 for the application in ISM band. It is studied by using ANSOFT-Designer SV2.2. It is observed that resonance frequency is very close to analyzed resonance frequency. The maximum power transferred to antenna is 99.87%.

References

[1] Pozer D.M. and Schaubert D.H, Microstrip Antennas, the Analysis and Design of Microstrip Antennas and Arrays, IEEE Press, New York, USA.(1995)A.
[2] Ansoft Designer, www.ansoft.com.
[3] Constantine A. Balanis, Antenna Theory, Analysis and design, Third Edition John Wiley & Sons.
[4] Arun K. Bhattacharyya, "Analysis of circular patch antennas on electrically thick substrate," Computer Physics Communication, vol. 68, 1991, pp.485-495.
[5] Loran I. Basilio, Michael A. Khayat, Jeffery, T. Williams, Stuart A. Long " The Dependence of the Input Impedance on Feed Position of Probe and Microstrip Line-Fed Patch Antennas," IEEE Transactions on antenna and propagation, vol.49, No. 1, January 2001. pp. 45-47.
[6] K Alameddine, S. Abou Chahine, M. Rammal, Z. Osman "Wideband patch antennas for mobile communication," International. J. of Electron. Communication. (AEU) 60 (2006) pp.596-598.
[7] Deepak Sood, Gurpal Sing, Chander Charu Tripati, Suresh Chander Sood & Pawan Joshi, "Design, fabrication and characterization of microstrip square patch arrey for X-band applications," Indian Journal of Pure and Applied Physics, vol. 46, August 2008, pp. 593-597.
[8] K. O. Odeyemi, D.O. Akande, E.O. Ogunti "Design of an S-Band Rectangular Microstrip Patch Antenna,", European Journal of Scientific Research, vol.55 No.1 (2011), pp.72-79.
[9] Seungbae Park, Cheolbok Kim, Youngho Jung Hosang Lee, Dongki Cho, Munsoo Lee, "Gain enhancement of a microstrip using a Circularly periodic EBG structure and air Layer," Int. J. Electron. Commun. (AEU) 64 (2010) pp. 607- 613.
[10] Edward H. Newman, Pravit Tulit "Analysis of microstrip Antennas Using Moment Methods" IEEE Transaction on Antennas and propagation, Vol. AO-29, No.1, January 1981.
[11] James J. R. and Hall P.S. Handbook of Microstrip Antennas, Peter Peregrinus, London, UK. (1989).
[12] Ramesh G, Prakash B, Inder B, and Ittipiboon A Microstrip Antenna Design Handbook, Artech House. (2001).
[13] http://www.emtalk.com/mpacalc.php.
[14] V.V. Thakare & P. K. Singhal, "Analysis of Feed point coordinates of a coaxial feed Rectangular Microstrip Antenna using Mlpffbp Artificial Neural Network" ICIT 2011 The 5th International Conference on Information Technology.
[15] www.markimicrowave.com.