

DESIGN, SIMULATION AND FABRICATION OF INSET MICROSTRIP PATCH ANTENNA AT 5GHZ

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ABSTRACT-In this paper, an inset microstrip antenna is designed, simulated and fabricated at frequency 5 GHz. Substrate GML 1000 (lossy) with dielectric constant 3.2 and tangent loss 0.002 was taken. The design and simulation of the microstrip antenna were performed using CSTMW studio software. Further, antennawas fabricated and tested. Measured and simulated results are compared and presented in terms of return loss, e-plane and h-plane.

Keywords-Microstrip patch antenna, S11 parameters, VSWR, e and h plane.

INTRODUCTION

Microstrip or patch antennas are becoming increasingly useful and very widespread within the mobile phone market because they can be printed directly onto a circuit board operated on microwave frequencies (>1 GHz). These are narrowband wide beam antennas with benefits like, low cost, have a low profile, monolithic, easy to match by controlling, insert position and are easily fabricated. It may be in variety of shapes, but rectangular and circular are the most common. To design a rectangular microstrip patch antenna there are some essential parameters which are important to know, the operating frequency of the antenna, Dielectric constant of substrate (ϵ_r), height of the dielectric substrate (h), height of the conductor (t), calculation of width and length of the patch (W) and width and length of the ground plane and the substrate.

ANTENA DESIGN

There are various methods to analyse the microstrip patch antenna, the transmission line model, cavity models and method of moment. The transmission line model is easiest of among all. To design the microstrip inset feed line the input impedance is usually 50Ω and the width of the feedline W_o is 1.85 mm. The geometry of the patch antenna consists of ground and substrate with dimension (50 x 50) mm². Patch antenna is printed on substrate on 0.762 mm thick GML 1000 substrate with dielectric constant 3.2 and loss tangent 0.002. Initially, the optimum value of width is calculated by

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

where, f_r is the resonant frequency and ϵ_r is the dielectric constant. The effective dielectric constant due to fringing effect is given as

$$\epsilon_{r \text{ eff}} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left(\sqrt{1 + 12 \frac{h}{W}} \right)^{-1} \quad (2)$$

where, h is the height or thickness of the substrate.

The extension of length ΔL is given as,

$$\Delta L = h (0.412) \frac{(\epsilon_{r \text{ eff}} + 0.3) \left(\frac{w}{h} + 0.264 \right)}{(\epsilon_{r \text{ eff}} - 0.258) \left(\frac{w}{h} + 0.8 \right)} \quad (3)$$

L_{eff} is given as,

$$L_{\text{eff}} = L + 2\Delta L \quad (4)$$

For a given effective length resonance frequency, is given as:

$$f = \frac{c}{2L_{\text{eff}} \sqrt{\epsilon_{r \text{ eff}}}} \quad (5)$$

Where, c is the speed of light, 3×10^8 m/s. The input impedance should be accurately known so as to get good match between the element and the feed can be designed. The input impedance at the feed is given by:

$$(6)$$

$$R_{in}(y = y_0) = R_{in}(y = 0) \cos^2\left(\frac{\pi}{L}y_0\right)$$

The return loss (RL) is a parameter which indicates the amount of power that is lost to the load and does not return as a reflection. As waves are reflected leading to the formation of standing waves, when the transmitter and antenna impedance do not match. Hence the return loss is a parameter similar to the VSWR to indicate how good the matching between the transmitter and the antenna has taken place.

The RL is defined as

$$RL = -20 \log_{10} |\Gamma| \text{ dB} \tag{7}$$

Where, Γ is input reflection coefficient and it is a measure of reflected signal at the feed-point of the antenna.

DESIGNED ANTENNA PARAMETERS CALCULATIONS

Microstrip patch antenna designed at 5 GHz. The calculations are done with the help of the above mentioned equations. We are taking GML 1000 as dielectric material with dielectric constant 3.2 and height of the substrate 0.762, loss tangent = 0.002.

Antenna designed parameters	Antenna parameters calculated values
$\epsilon_r = 3.2$ $h = 0.762 \text{ mm}$ $f = 5 \text{ GHz}$ $\tan \delta = 0.002$	$W = 20.70 \text{ mm}$ $\epsilon_{eff} = 3.0161$ $\Delta L = 0.370 \text{ mm}$ $L = 16.56 \text{ mm}$ $L_{eff} = 17.3 \text{ mm}$

SIMULATED AND TESTED RESULT FROM DESIGNED ANTENNA

The inset microstrip antenna with above mentioned specifications has been designed on CST MW software 2017. The properties of antennas such as bandwidth, S-parameters, VSWR, near field and far field. Figure 1, shows inset microstrip antenna. In simulation result, return loss comes below -10 dB i.e. return loss value is about -24 dB at 5 GHz and VSWR = 1.92 with gain 4.58 dB with directivity 7.77 dB.

For practical measurement of return loss of the designed inset microstrip patch antenna was connected to vector network analyser through co-axial cable. From the result on VNA, it is clear that at 5 GHz frequency the return losses are -25 dB i.e. very close to the simulated values. So, the designed antenna is working properly with gain 5.514 dB. Figure 2, 3 and 4 shows the comparison of simulated and measured value with respect to return loss, e-plane and h plane (polar plot).

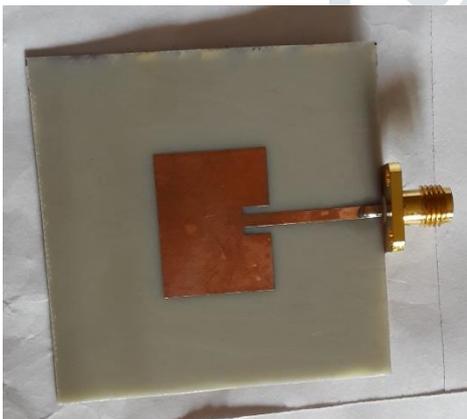


Figure 1: Inset microstrip antenna

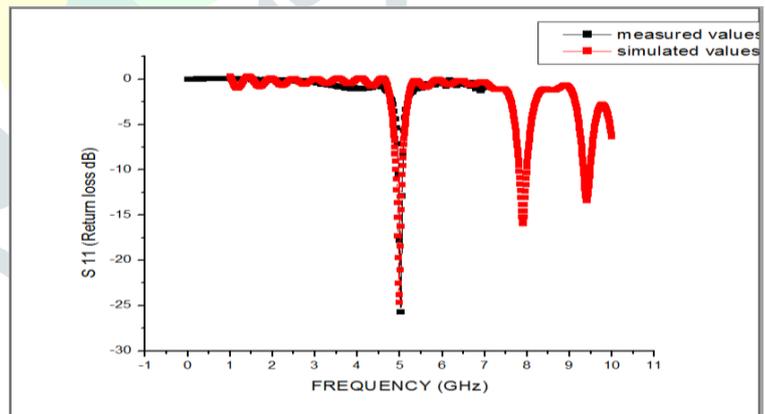


Figure 2: Comparison of S parameters for measured and simulated values

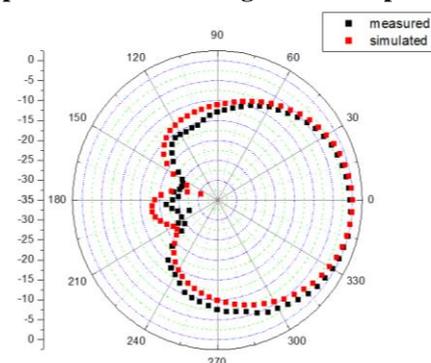


Figure 3 : Comparison of E-plane

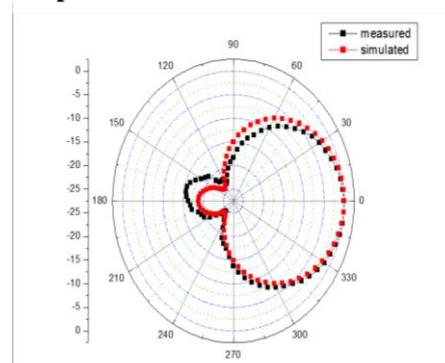


Figure 4: Comparison of H-plane

CONCLUSION:

The main aim of this paper is to design and test microstrip patch antenna (printed circuit board of type GML 1000 with dielectric constant 3.2 and thickness of 0.762 mm of double clad coper). The dimensions are of the patch are 20.07 mm (width) and 16.56 mm (length) and 0.154 GHz bandwidth. The microstrip antenna is designed by CST software on size 50x50(length and width) and 1.7 μm (0.017 mm) height. The thin film was obtained with i-cad software followed by the fabrication steps. After fabrication feed point was decided to polarize linearly and then connected sub miniature type-A (SMA) female RF connector of type radial R12540300 with the center conductor of diameter 1.27 mm. This has been soldered on Microstrip patch at a point where 50 Ω 's impedance is achieved. The ground plane is also soldered with the outer conductor of co-axial. And then the center conductors are checked to not have short circuit with the ground plane by an om meter for no short circuit. The antenna has been tested for impedance, bandwidth and return loss measurement by using a vector network analyzer. The test has been conducted for VSWR, return loss, impedance, gain and radiation pattern.

REFERENCES

- [1] C. A. Balanis. Antenna Theory: Analysis and Design, 3rd edition. Wiley India Pvt. Limited, 2009.
- [2] H. Pues and A. Van de Capelle, "Accurate transmission-line model for the rectangular microstrip antenna," in IEE Proceedings H (Microwaves, Optics and Antennas), vol. 131, pp. 334–340, 1984.
- [3] Y. T. Lo, D. Solomon, and W. Richards, "Theory and Experiment on Microstrip Antennas," IEEE Transactions on Antennas and Propagation, vol. 27, no. 2, pp. 137–145, 1979.
- [4] S. Zhigang and L. Ping, "Reduced-size microstrip antenna for mobilecommunication," *Proc. 4th International Conference on Microwave and Millimeter Wave Technology*, Aug. 2004, pp. 82-85.
- [5] R. Garg, et al., *Microstrip Antenna Design Handbook*, Norwood, MA, Artech House, 2001.
- [6] J. Q. Howell, "Microstrip Antennas", IEEE Trans. Antennas Propag. Vol. 23, no. 1, pp. 90-93, January 1975.
- [7] R.M. Barrett, "Microwave Printed Circuits-The Early Years". IEEE Trans. Microwave Theory Tech., vol. 32, no. 9, pp. 983-990, September 1984.

