

Design and Analysis of Microstrip Patch Antenna for Different Applications

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Abstract: As Microstrip Patch antenna (MPA) is low profile, less costly and low volume, it is used now a day for different applications. Microstrip Patch antenna is targeted for improving its performance based on various factors. A printed antenna can be used in wireless communication at different operating frequencies. In this speedy dynamic world of wireless communication, dual or multiband antenna has been playing a key role for wireless service applications. This paper demonstrate, the performance analysis of microstrip antenna for various parameters such as Return loss, VSWR and radiation pattern. Results are simulated on different antenna geometries. The analysis of antenna for physical parameters such as area of substrate, height of substrate, patch shape and dielectric constant of substrate been done by varying one of them and achieving improve result of performance.

Keywords: MPA, VSWR, Return Loss, Substrate, HFSS, VNA

1. Introduction

A microstrip patch antenna (MPA) is commonly used because it is lightweight, low profile and simple structure antennas with reliability, mobility and good efficiency [1]. The design of a microstrip antenna initiates by deciding used for the antenna so the size of the patch. There are many types of shapes in patch antenna. Circular, Rectangular and Square shapes are the traditional shapes. But elliptical, triangular, dipole, ring are also uses for patch antenna.

The performance of a patch antenna depend not only on the shape of antenna but dielectric constant of the substrate, dimensions of the dielectric substrate and ground also affects the performance of the patch antenna. It may be possible that all shapes gives different performance on different frequencies.

The most commonly employed micro strip patch antenna is a rectangular patch [6]. The rectangular patch antenna is approximately a one wavelength long section of rectangular microstrip transmission line.

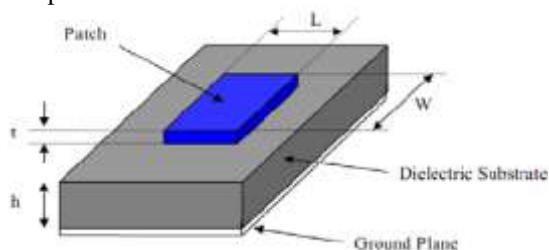


Figure 1: Structure of Microstrip patch Antenna

In above figure parameters are as follows.

Here, t = thickness of patch

h = height of dielectric substrate

L = length of patch

W = width of patch

Patch antenna consist of following:

- Patch (perfect electric conductor)
- Substrate
- Ground (perfect electric conductor)

2. System Analysis

Generally, a patch of the microstrip antenna is made from the radiating material. It is of conducting material such as copper or gold. The patch can be of any shape like circular, triangular, rectangular [4] and even alphabets like H, U, E, C, F etc.

Performance of microstrip patch antenna is based on the various parameters such as VSWR, Return loss, impedance Bandwidth and radiation pattern etc along with physical parameters such as width, height, length and design of patch, and length, height, width of substrate. So it becomes crucial to design appropriate microstrip patch antenna with improved VSWR & return for various application.

The patch of microstrip antenna for various shapes was design earlier and the result associated with it is calculated with respect to VSWR and Return loss. The table given below demonstrates the result for various shape of patch as follows.

Table 1: VSWR & Return loss for various shapes

Type of shape	VSWR	Return loss in dB
H	1.33	-16.34
I	1.37	-15.94
Star	1.43	-16.98
Mho	< 2	-15.83
V	1.08	-28
E	1.031	-34

3.1 Estimation of parameter

Step 1: Calculation of the width of Patch (W)-The width of the Micro strip patch antenna is given as

For $f_0=2.4\text{GHz}$, $s_r=4.4$

$$W = \frac{c}{2f_0 \sqrt{\frac{s_r+1}{2}}} \quad (1)$$

Step 2: Calculation of effective dielectric constant: Fringing makes the micro strip line look wider electrically

compared to its physical dimensions. Since some of the waves travel in the substrate and some in air, an effective dielectric constant is introduced, given as:

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

Step 3: Calculation of Length of Patch (L)-The effective length due to fringing is given as:

$$L_{eff} = \frac{c}{2f_0 \sqrt{\epsilon_{reff}}} \quad (3)$$

Substituting $\epsilon_{reff} = 4.4$, $c = 3.00e+008$ m/s and $f_0 = 2$ GH

Step 4: Calculation of ΔL - Due to fringing the dimension of the patch as increased by ΔL on both the sides, given by:

$$\Delta L = 0.412h \frac{(\epsilon_{reff} + 0.3) \left(\frac{W}{h} + 0.264 \right)}{(\epsilon_{reff} - 0.258) \left(\frac{W}{h} + 0.8 \right)} \quad (4)$$

Step 5: Calculation of Substrate dimension-

For this design this substrate dimension would be

$$L_s = L + 2 * 6h \quad (5)$$

Step 6: Calculation of VSWR

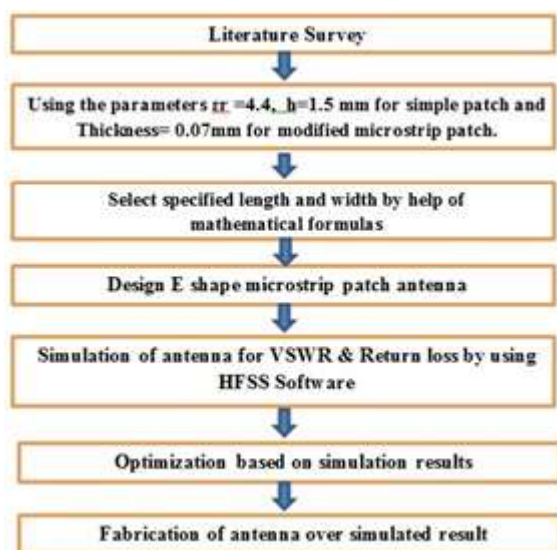
$$VSWR = \frac{1 + \tau}{1 - \tau} \quad (6)$$

Step 7: Calculation of Return loss

$$RL = 10 \log_{10}(\tau) dB \quad (7)$$

3.2 Structural flow

Work is started with analysis of various approaches for microstrip patch antenna [3]. At the beginning simple patch is designed using the parameters given below. After this length and width of patch is specified with help of mathematical formulas explained in the above section. Once E shape antenna is designed, simulation has been done on it with help of standard tools to calculate VSWR and Return Loss. Finally on the basis of optimized results fabrication is done.



3. Design and Fabrication of Antenna

The design of the E shaped patch antenna is shown in figure 2. The Defined double E- shape microstrip patch antenna having single edge rectangular slot cut at middle portion of it. This antenna is design using wave port feed technique. We have changed the width, length and height of substrate and thickness and shape of the patch.

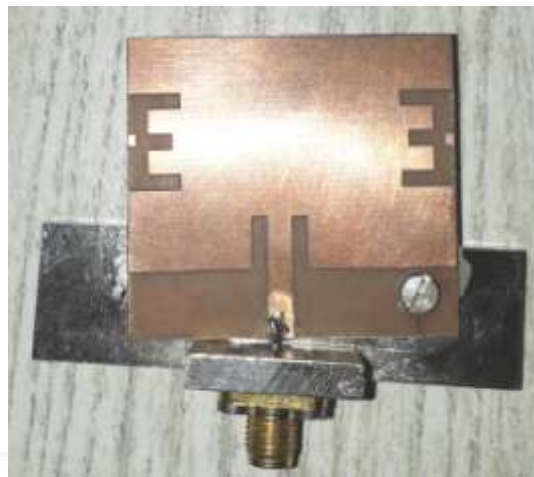


Figure 2: Double E shape Antenna



Figure 3: Testing of fabricated antenna

Rectangular microstrip patch antenna has a compact dimension of 40.00 mm x 28.85 mm (Width x Length), designed on FR4 substrate with thickness of 1.5 mm and dielectric constant (ϵ_r) of 4.4. The antenna is fed by a microstrip line of 3.00 mm cut width and 7.00 mm cut depth. The probe is used 50 Ω microstrip line printed on the partial grounded substrate with resonance frequency of 2.42 GHz. The results are obtained by using vector network analyzer (VNA) [2] as shown in figure 4 & 5 respectively

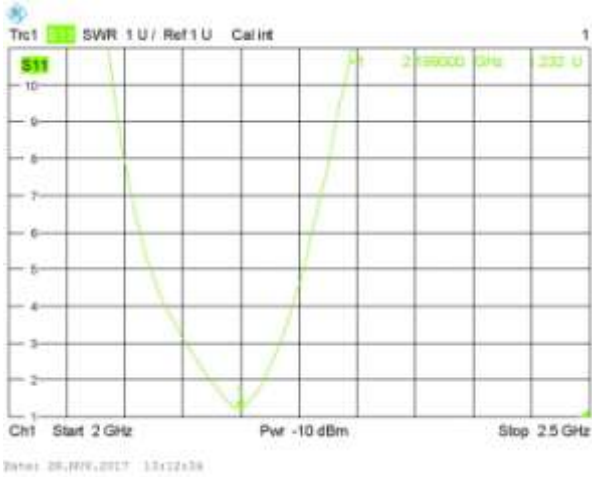


Figure 4: Fabricated results of VSWR

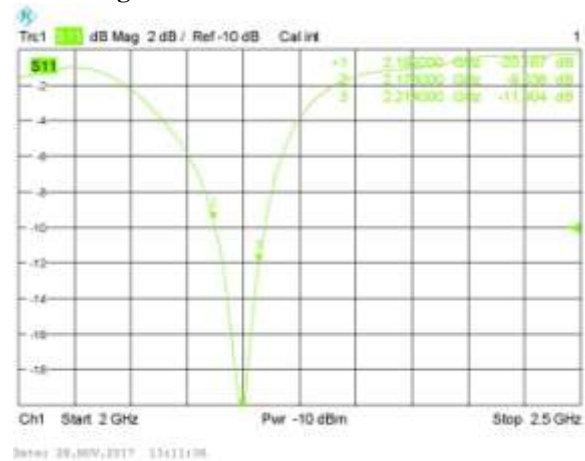


Figure 5: Fabricated results of Return Loss

Figure 5 gives the fabricated results of E shape antenna for VSWR and Return Loss respectively. In which VSWR is equals to 1.2 and return loss -20.87dB. Table no. 2 shows the specification of proposed antenna.

Table2: Specification of Antenna

Substrate	Width	42 mm
	Length	46 mm
	Thickness	1.5 mm
Patch	Width	40 mm
	Length	28.85 mm
	Thickness	0.07 mm
Dielectric constant	Substrate	4.4
Material used	Patch	Copper (cu)
	Substrate	Epoxy (FR4)

4. Simulation and Result

In order to evaluate the performance of the proposed E shape microstrip patch antenna, the antenna is simulated through the simulation tool HFSS V13. The analysis of the microstrip patch antenna for physical parameter has been done by varying one of them and keeping the others as constant.

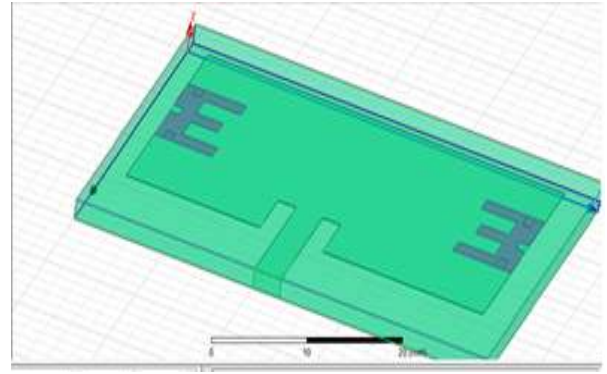


Figure 6: Simulated double E shape Antenna

After brief analysis of table given below it can easily determine that, the E shaped microstrip patch antenna with one middle slot having depth of patch 0.07 mm contains VSWR 1.06, Return Loss -53.9406. These values of VSWR and Return Loss are more optimized and improved over rest of all design.

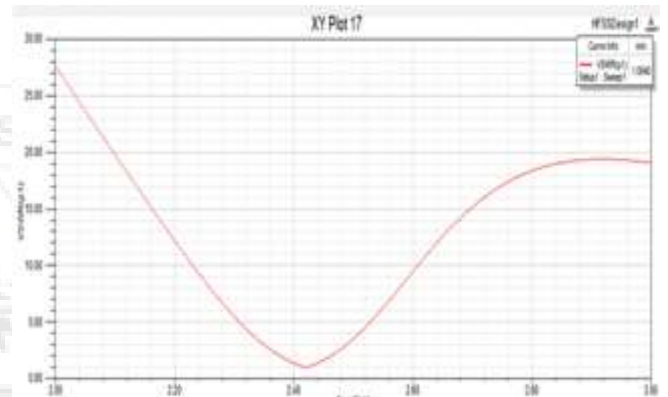


Figure 7: Simulated Result of VSWR

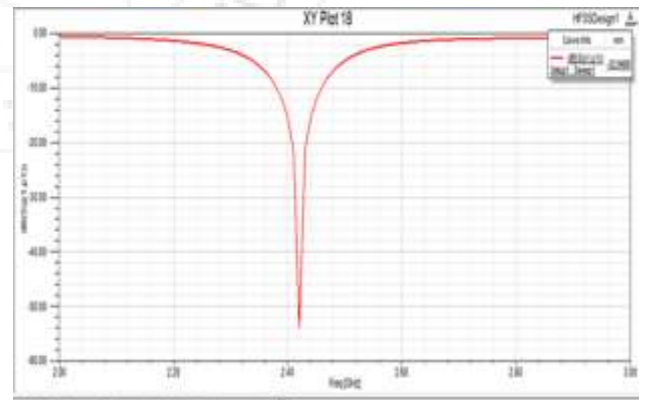


Figure 8: Simulated Result of Return Loss

Table 3: Comparative analysis of Microstrip patch Antenna

Sr. No.	Shape of Patch	VSWR	Return Loss in dB
1	E shaped with 2 slot	1.06	-29.067
2	E shaped with 1 slot at lower	1.03	-35.71
3	Plane E shaped	1.02	-36.51
4	E shaped with 3 slot	1.01	-42.71
5	Plane E shaped	1.008	-48.002
6	E shaped with 1 upper slot	1.0076	-48.0228
7	E shaped with 1 middle slot	1.004	-53.9406

5. Conclusion

An E shaped Microstrip Patch Antenna is designed using mirror Effect technique and studied the various microstrip patch antenna briefly. The practicality of this system is examined using the ANSYS HFSS V13 software. This shows the performance of the system with E shaped having single middle slot is best as compared to rest of all at resonant frequency 2.4 Hz.

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