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Implementation and Comparison of Microstrip Patch Antenna and Co-Planar waveguide Antenna

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Abstract - The aim of this work is to design a microstrip patch antenna (MPA) and coplanar waveguide antenna (CPW) and then compared the performance of both antennas. The performance metrics, on the basis of which the antennas are compared, are gain, directivity, radiation efficiency and return loss. The center frequency is 5.5GHz which is fixed for both antennas and the material used as substrate is Roger RT 5880. The directivity of microstrip patch antenna is 7.742dBi and that for coplanar waveguide is equal to 2.735dBi. The radiation efficiency of MPA is -1.758dB and for CPW is 0.051dB. The antennas are designed using CST MWS.

Keywords – Microstrip patch antenna, Co-planar waveguide antenna, Gain, Directivity, Radiation efficiency, Return loss

1. Introduction

As the technology is progressing size of the objects is shrinking and need for compact size efficient devices increases. In the field of antenna designing there is a need of developing compact and light weight antennas [1]. Due to the development of new algorithms and techniques in certain areas e.g. frequency hopping in communication, operating frequencies of the setup also keeps on changing, antenna needs to radiate efficiently in all desired frequencies. In this regard development of wide band antennas always remained the focus of research. The study of microstrip patch antennas has made great progress in recent years [2]. Compared with conventional antennas, microstrip patch antennas have more advantages and better prospects. They are lighter in weight, low volume, low cost, low profile, smaller in dimension and ease of fabrication and conformity [3]. Moreover, the microstrip patch antennas can provide dual and circular polarizations, dual-frequency operation, frequency agility, broad band-width, feed line flexibility and beam scanning omnidirectional patterning [4], [5]. Wireless communication systems attract a lot of attentions for the past Decades in the world because of their advantages, including convenience, low cost and easy operation. A Coplanar Waveguide structure consists of a median metallic strip of deposited on the surface of a dielectric substrate slab with two narrow slits ground electrodes running adjacent and parallel to the strip on the same surface [6]. CPW is one of these antennas having these qualities. A coplanar line is a structure in which all the conductors supporting wave propagation are located on the same plane, i.e. generally the top of a dielectric substrate [7]-[8]. CPW is composed of a median metallic strip separated by two narrow slits from an infinite ground plane.

The radiation efficiency and directivity of MPA and CPW are compared between these two antennas for diverse applications. Radiation efficiency and directivity of MPA are -1.758dB and 7.742dBi while that of CPW are 0.051dB and 2.7535dBi. Total efficiency of MPA is -1.824dB and CPW is 0.041dB respectively. The frequency range of CPW and MPA are from 4 to 10 GHz while the resonance frequencies for both these antennas are 5.5GHz.

Simulations are completed utilizing 3D EM Simulator Computer Simulation Technology Microwave Studio (CST-MWS)

2. Methodology

Microstrip antenna consists of three layers, Patch, Substrate and Ground plane as shown in Figure 1.1. Patch is the top layer of the antenna. It is a conductor usually copper [2]. The actual electromagnetic radiations emits from this layer. The length and width of the patch determine the operating frequency of the antenna. For lower frequencies the antenna size increases and as we move towards the higher frequencies the size decreases [5].

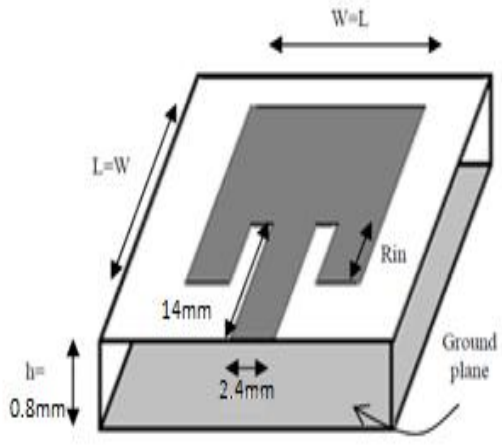


Figure 1.1: Microstrip Patch Design

To find the dimensions of the antenna i.e. the length and width the following equations are:

$$W = \frac{1}{2f_{r}\sqrt{\mu_0\epsilon_r}}\sqrt{\frac{2}{\epsilon_r+1}} \quad \ldots\ldots\ldots\ldots\ldots\ldots 1.1$$

The length of the antenna is found by using the following equation

$$L = \frac{1}{2f_r\sqrt{\epsilon_{reff}\sqrt{\mu_0\epsilon_0}}} - 2\Delta L \quad \ldots\ldots\ldots\ldots 1.2$$

ΔL is the extension of the length given by

$$\frac{\Delta L}{h} = 0.412\frac{(\epsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\epsilon_{reff}-0.3)(\frac{W}{h}+0.8)} \quad \ldots\ldots 1.3$$

The ports used for the feeding of antennas are mostly of impedance 50 ohms. Thus we have to match our antenna impedance to 50 ohms. Impedance of the antenna decreases as we move towards the center of the patch. The impedance at a specific point of antenna is found by using the following equations.

$$R_{in}(y = y_0) = R_{in}(y = 0)Cos^2(\frac{\pi}{L}y_0) \quad \ldots .1.4$$

Where

$$R_{in}(y = 0) = \frac{1}{2(G_1 \pm G_{12})}cos^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots 1.5$$

G_1 is found through the graph as shown in Figure 1.2.

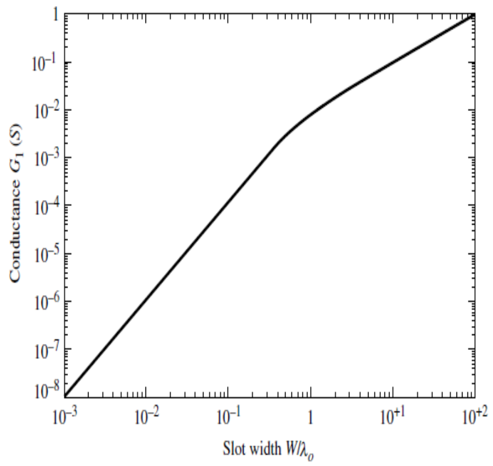


Figure 1.2: Conductances vs. Slot Width

$$G_{12} = \frac{1}{120\pi^2}\int_0^{\pi}\left[\frac{\sin\left(\frac{k_0 W}{2}\cos\theta\right)}{\cos\theta}\right]^2 j_0(k_0 L\sin\theta)\sin^3\theta\, d\theta$$

……1.6

When the point is determined an inset feed is inserted there, whose impedance is of 50 ohms. The length and width of the inset feed is found by using a software tool known as TX line. Equal space is left on both sides of the inset feed. The substrate used for Implementation of Antenna is ROGER DURIOD (RT-5880). Various parameters of ROGER DURIOD (RT-5880) are given in the following Table 1.1.

Table 1.1: ROGER DURIOD (RT-5880) Parameters

Dielectric Constant	2.2
Loss Tangent	0.001
Thickness of Substrate	0.8mm
Thickness of Copper	0.035mm
Copper Conductivity	5.88e7

The different parameter such as length and width are calculated by using the above formulae. The thickness of the substrate is taken as 0.8mm. The substrate used is ROGER DURIOD (RT-5880). The length and width of the patch is taken as the half of the substrate. The feed insertion length Fi is calculated through L/3 or L/2. The length, width of microstrip line, gap between feed and patch and height of the substrate is calculated by TXLINE tool. The thickness of the copper is 0.035mm. The designed MPA using CST MWS is shown in Figure 1.3.

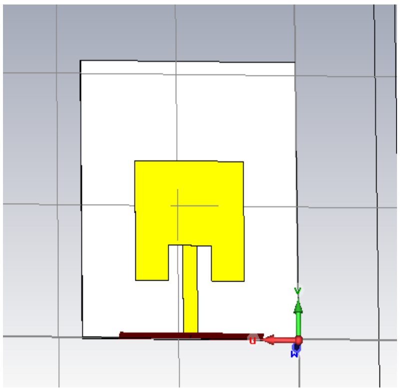


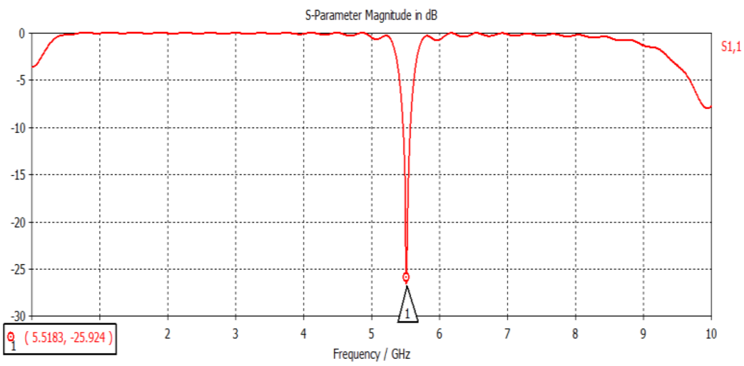
Figure 1.3: Designed MPA

The dimension of MPA is given is Table 1.2

Table 1.2: Calculated Values for Designed MPA

NAME	VALUE	DESCRIPTION
L	18.17mm	Length of Patch
W	18.14mm	Width of Patch
Fi	5.35mm	Feed Insertion Length
Lf	14mm	Length of Microstrip Line
Wf	2.4mm	Width of Microstrip Line
Gpf	2.4mm	Gap b/w Feed and Patch
H	0.8mm	Substrate Thickness
Mt	0.035	Copper Thickness

Impedance matching showed that the antenna resonates at 5.5GHz. The S11graph showed in Figure 1.4 that



losses are less than -10db at the resonance frequency 5.5 GHz.

Figure 1.4: Simulated S Parameter (Return loss)

CPW is composed of a median metallic strip separated by two narrow slits from an infinite ground plane. The CPW antenna model is shown in Figure 1.5.

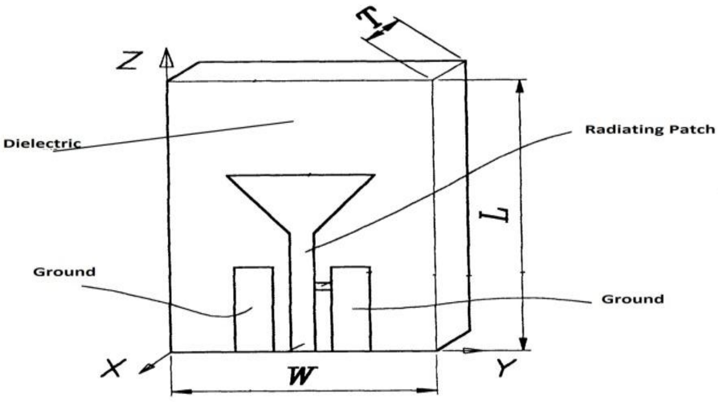


Figure 1.5: CPW Antenna model

The design is made by modifying the simple design as shown in Figure 1.6. Different cuts in the ground and patch are made. All the changes are made for getting better results. Different techniques are used for calculating of length and width of substrate and copper such as MATLAB codes and TX Line. After calculating length and width of substrate the length and width of transmission line is calculated through TX Line. The thickness of the substrate is calculated to be 1.6mm and that of copper thickness is to be 0.035mm. The substrate used in the designing of the CPW antenna is Roger Duroid (RT- 5880).

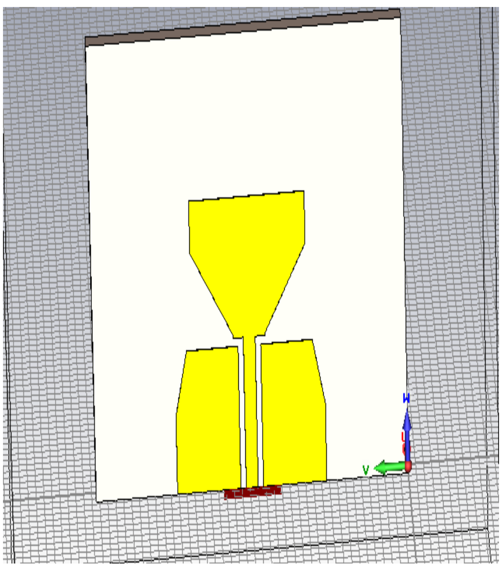


Figure 1.6: CPW Antenna

The following Table 1.3 shows the value of length, width of substrate, patch, upper diagonal, small brick and copper, gap between ground and transmission line.

Table 1.3: Calculated Values for Designed CPW

DESCRIPTION	VALUE
Length of Substrate	35mm
Width of Substrate	39.45mm
Gap	0.68mm
Length of Microstrip line	11.65mm
Width of Microstrip line	1.5mm
Ground Length	11mm
Ground Width	8mm
Ground Diagonal	5.22mm
Ground Upper Side Length	6.5mm
Ground Opposite Side Length	6mm
Width of Patch	14.501mm
Patch Length	4mm
Triangle Diagonal	8.44mm
Base Length	0.2mm
Base Width	1.25mm

The S11 graph showed in Figure 1.7 that the antenna resonates at 5.5GHz having -26.25dB magnitude. The losses are less than -10db in the range of 4 GHz to 10 GHz. This result is very accurate and with on the range for which it has been designed.

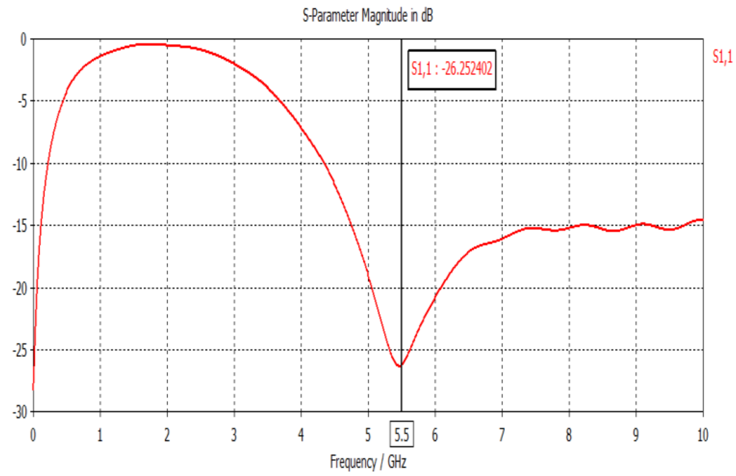


Figure 1.7: S Parameter

3. Result and Discussion

The S11 parameter of both antennas are less than -10dBi. At resonance frequency the return loss value of MPA and CPW is -25.29 dB and -26.25 dB as shown in Figure 1.8 and 1.9 respectively. The S11 for CPW is greater than MPA at resonance frequency 5.5GHz.

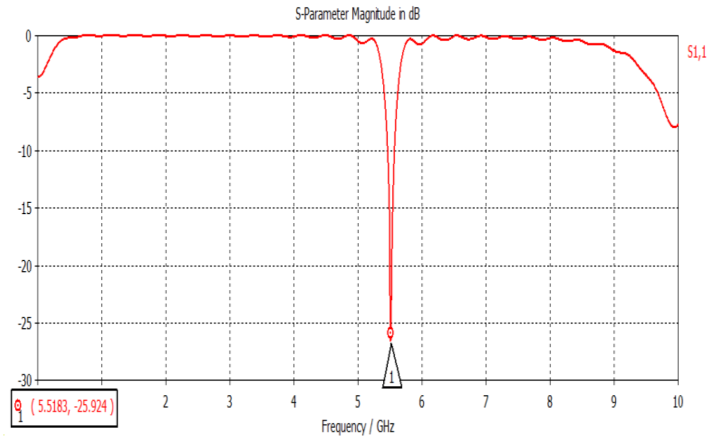


Figure 1.8: S11 of MPA

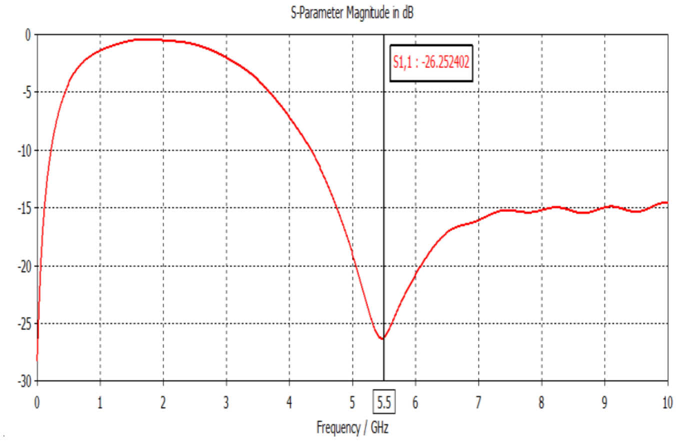


Figure 1.9: S11 of CPW

VSWR is very important in the properties of an antenna. In the same as S11are compared, VSWR of both antennas are also compared. The VSWR of MPA is equal to 1.09 and that for CPW is 1.102. The VSWR of MPA is less than CPW is given in Figure 1.10 and 1.11 respectively.

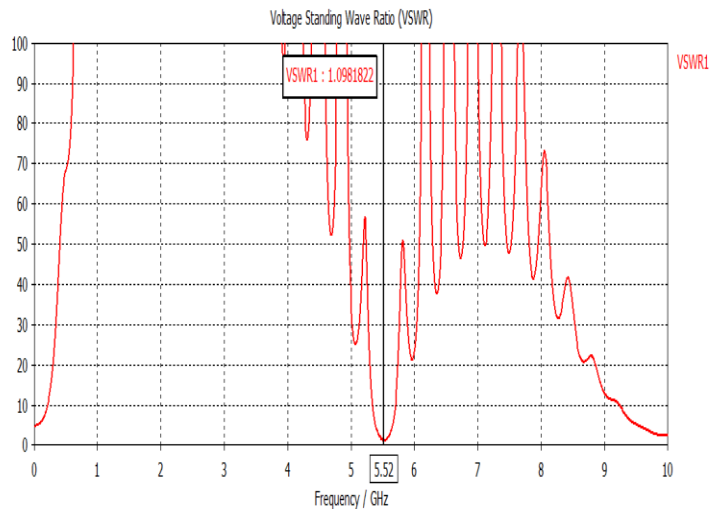


Figure 1.10: VSWR of MPA

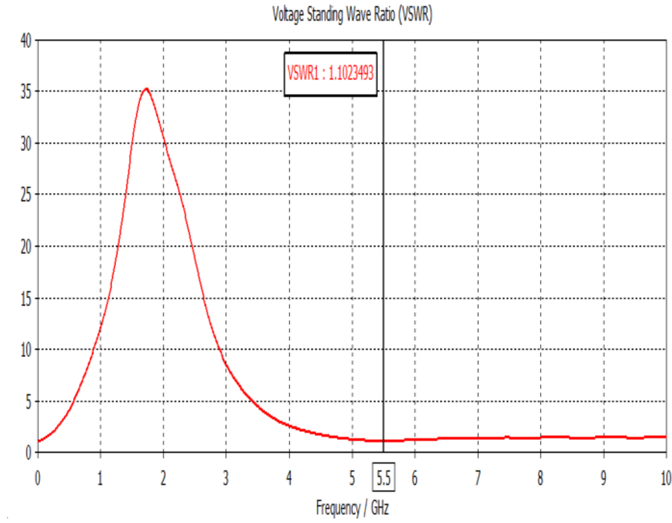


Figure 1.11: VSWR of CPW

The MPA is a single band antenna so its directivity is 7.742dBi and the CPW is a broad band antenna so its directivity is less than MPA which is 2.735dBi as shown in Figure 1.12 and Figure 1.13 respectively.

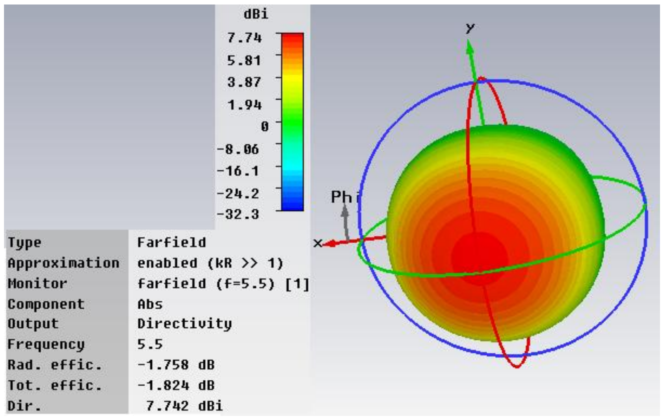


Figure 1.12: Radiation Pattern of MPA

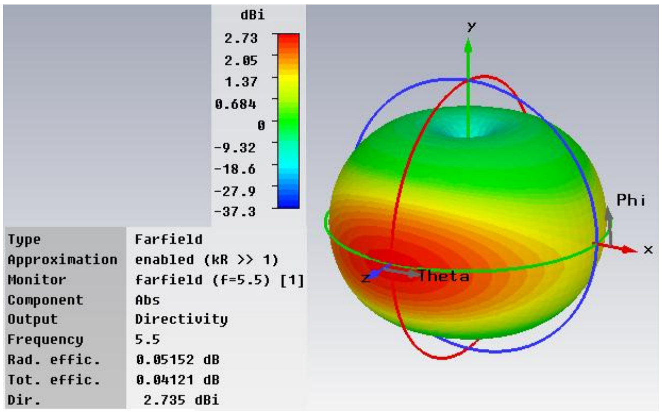


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Figure 1.13: Radiation Pattern of CPW

4. Conclusion

The comparison of MPA and CPW antenna at different results are compared such as Return Loss, Radiation Efficiency and VSWR. On the same resonance frequency 5.5GHz the directivity of MPA is equal to 7.742dBi and that for CPW is equal to 2.735dBi. The radiation efficiency of MPA at resonance frequency is -1.758dB and for CPW is 0.051dB. The summary is given in Table 1.4 for more convenient.

Table 1.4: The Basic Characteristics between MPA and CPW

S.No	Parameters	MPA	CPW
1	Frequency	5.5GHz	5.5GHz
2	Directivity	7.742dBi	2.735dBi
3	Radiation Efficiency	-1.758dB	0.051dB
4	Total Efficiency	-1.824dB	0.041dB
5	Main Lobe Magnitude	7.7dBi	2.7dBi
6	Side Lobe Level	-25.3dB	0dB
7	Angular Width	83.7 degree	73.7 degree
8	Main Lobe Direction	175 degree	0 degree

As the directivity of MPA is greater than CPW antenna but it has very small bandwidth as compared to CPW. Due to difference in wavelength both antennas are used in their own site. The site which is in need of small wavelength the MPA is taken into account and when the use of large wavelength is necessary the CPW antenna is considered.

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