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# Comparative Study of T Slot & Cross Slot Coupled Microstrip Patch Antenna

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***Abstract— In this paper we present a comparative study of cross slot micro-strip patch antenna and T slot coupled microstrip patch antenna, using proposed antenna design and probe feeding at proper position to find the resultant return loss, VSWR and bandwidth. We have observed that using slotted patch antenna and using probe feed at proper location we can get better return loss, VSWR and bandwidth. Some analysis has been presented on a circularly polarized microstrip antenna with T slot configurations & cross slot circular polarized antenna. Here we will study a T-slot coupled circularly polarized microstrip antenna in the frequency 1.575 GHz & cross slot microstrip patch antenna at the same frequency. The upper patch i.e. the radiating patch would be circular. Initially optimized dimension obtained for the antenna which provides satisfactory result further these dimensions of circular patch microstrip antennas are modified to obtain a good directivity as well as impedance matching at frequency 1.575 GHz. By varying the antenna parameters attention is also paid to obtained good axial ratio.***

***Keywords – Circular patch, microstrip antenna, directivity, impedance matching, axial ratio.***

## I. INTRODUCTION

Antennas are part of most microwave systems. An antenna provides a means of coupling between the microwave network and free space. A transmitting antenna radiates electromagnetic waves into free space and a receiving antenna collects energy from the incident waves. Therefore the miniaturization of the antenna has become an important issue in reducing the volume of entire communication system. Here, in this paper the symmetrical T-slot, asymmetrical T-slot coupled & cross slot circular patch microstrip antennas are discussed .The T-slot coupled circular patch microstrip antenna shown in figure 1. For symmetrical T-slot coupled antenna an axial ratio 2.096 dB at frequency 1.575 GHz is obtained. But for asymmetrical T-slot coupled antenna a good axial ratio (AR=1.16 dB) as well as impedance matching at frequency 1.575 GHz is obtained. Here we will describe a circularly polarized microstrip antenna with symmetric and asymmetric T- slot & cross slot.

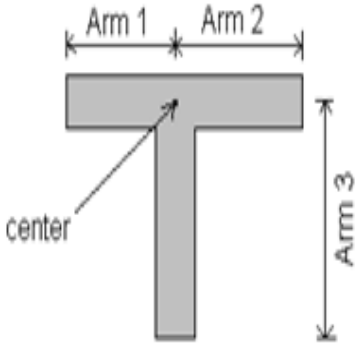


**Figure 1. Configurations of T-slot**

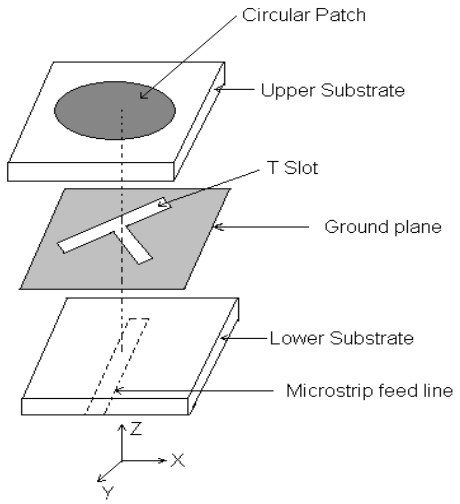


**Figure 2. T-slot coupled circular patch microstrip antenna**

Figure 3 below shows the patch antenna fed by the cross-slot using the microstrip line. The cross slot consists of slot A of length 24 mm and width 1.5 mm and slot B of length 18 mm and width 1.5 mm and is arranged under the center of the circular patch antenna for maximum coupling,. Both the two arms of the cross-slot are inclined with respect to the microstrip feed line with an angle of 45 degree. The patch antenna is a singly fed circularly polarized microstrip antenna.

 

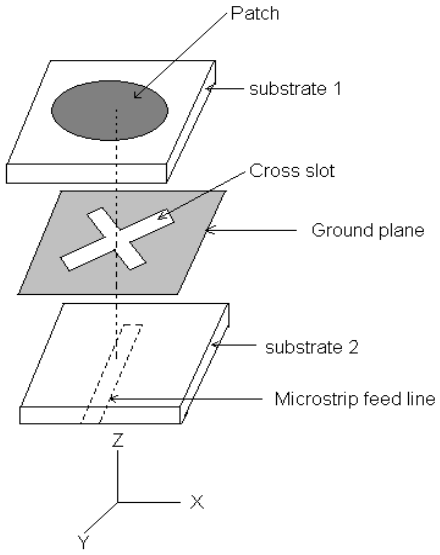


**Fig3. Cross-slot Coupled Circular Patch Antenna**

## II. DESIGN AND ANALYSIS

*A. Symmetric T-slot & Asymmetric T-slot coupled circular patch antenna*

A symmetrical T-slot & asymmetric T-slot coupled circular patch antenna is designed to operate at a frequency 1.575 GHz. We have chosen this particular frequency because this frequency range is used for GPS application. Symmetrical T-slot means the length of the arm1 and arm2 of the T-slot are equal as shown in figure 1 whereas asymmetrical T-slot means the length of the arm1 and arm2 of the T-slot are unequal. The patch radius for the symmetric T-slot antenna is adjusted to 32.1 mm for proper operation at frequency 1.575 GHz .The patch radius for the asymmetric T-slot antenna is adjusted to 32 mm. for proper operation at frequency 1.575 GHz .The other parameters such as slot dimensions, stub length etc. is also adjusted for obtaining good axial ratio as well as good impedance matching at the desired frequency.

*B. symmetric T-slot coupled circular patch antenna*

In figure 4 variation of VSWR with frequency is shown. From that figure it is seen that at the operating frequency 1.575 GHz VSWR is less than 2 dB so this antenna could be operated at that frequency. From that Figure it is also seen that VSWR is less than 2 dB in the frequency range from 1.55028 GHz to 1.60297 GHz. So the VSWR band width is 52.69 MHz which is equal to 3.34 % of the operating frequency.

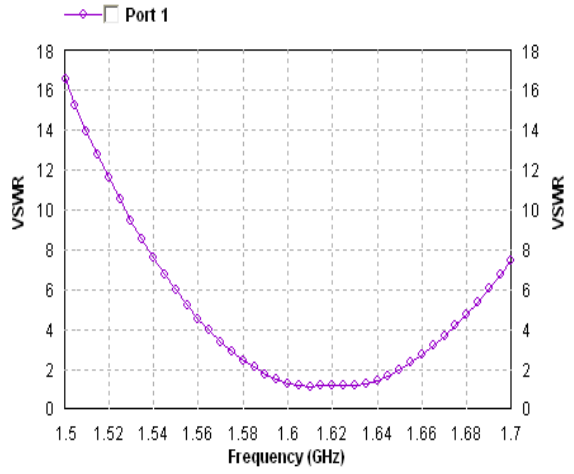


**Figure 4. Variation of VSWR with frequency**

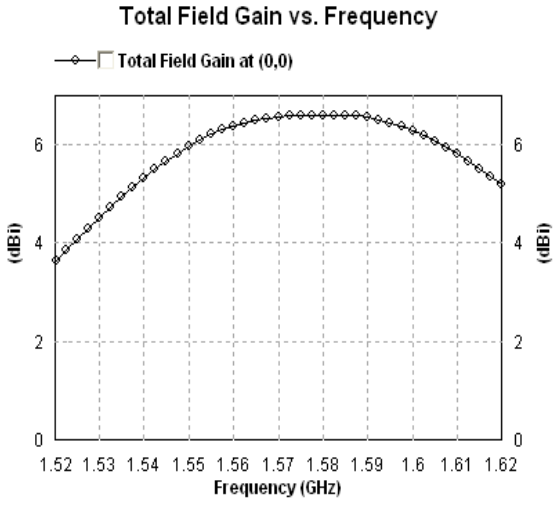


**Figure 5.Change in gain with frequency**

From frequency versus axial ratio plot it is seen that this antenna does not radiate good circularly polarized wave as shown in figure 5 at the frequency 1.575 GHz. From that plot it is seen that axial ratio at frequency 1.575 GHz is 2.096 dB which is less than 3dB also the VSWR at this frequency is nearly equal to 1.2 dB so the proposed antenna can be used as a circularly polarized antenna at frequency 1.575 GHz. Also we may calculate the axial ratio band width i.e. the frequency range over which axial ratio will be less than 3 dB. Axial ratio remains less than 3 dB for the frequency range from 1.57167 GHz to 1.58111 GHz. Therefore the 3 dB axial ratio band width calculated as 9.4 MHz which is 0.60 % of the operating frequency 1.575 GHz.

 

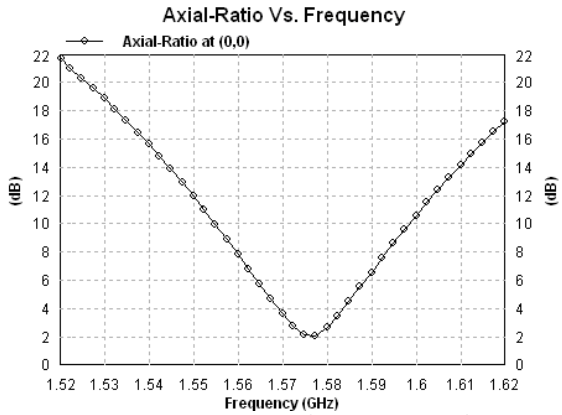


**Figure 6. Variation of axial ratio with frequency**

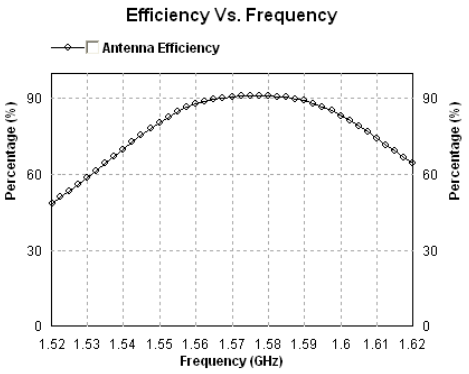


**Figure 7. Plot of antenna efficiency v/s frequency**

The change in antenna efficiency with the change in frequency is shown in figure 7. That plot depicts that the antenna efficiency is about 90 % at the operating frequency 1.575GHz.

*C. Asymmetric T-slot coupled circular patch antenna*

From frequency versus axial ratio plot it is seen that this antenna radiates circularly polarized wave as shown in figure 8 below at the frequency 1.575 GHz. From that plot it is seen that axial ratio at frequency 1.575 GHz is 1.15 dB which is less than 3dB also the VSWR at this frequency is nearly equal to 1.1 dB so the proposed antenna can be used as a circularly polarized antenna at frequency 1.575 GHz. Also we may calculate the axial ratio band width i.e. the frequency range over which axial ratio will be less than 3 dB. Axial ratio remains less than 3 dB for the frequency range from 1.5669 GHz to 1.5813 GHz. Therefore the3 dB axial ratio band width calculated as 14.4 MHz which is 0.93 % of the operating frequency 1.575 GHz.

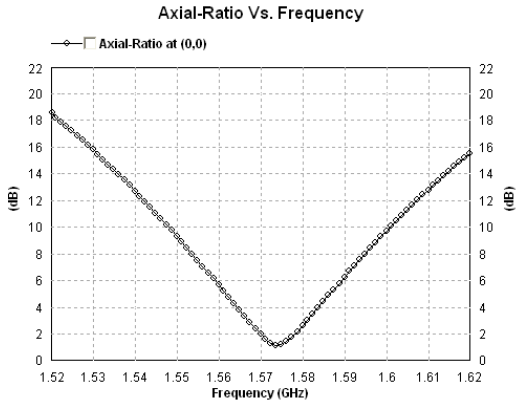


**Figure 8. Variation of axial ratio with frequency**

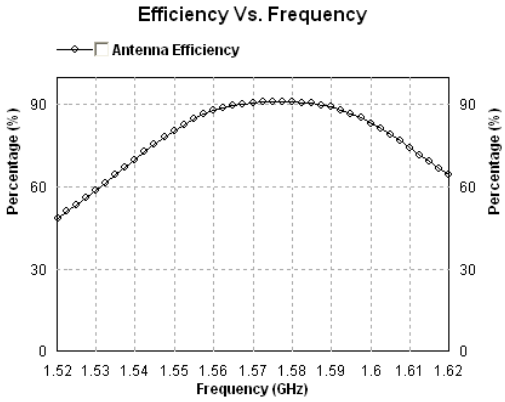


**Figure 9. Plot of antenna efficiency versus frequency**

*D. Cross-slot Coupled Circular Patch Antenna-*

While performing the simulation it is found out that for patch radius a=31.7 mm, the resonant frequency is 1.588 GHz. Since the desired frequency was not obtained the radius was adjusted to about 31.4 mm to get the resonant frequency 1.600 GHz for the patch radius 31.4 mm. The minimum axial ratio is 0.9235 at 1.625 GHz as shown in fig 10. At this frequency VSWR is less than 2 dB which is shown in fig 11.

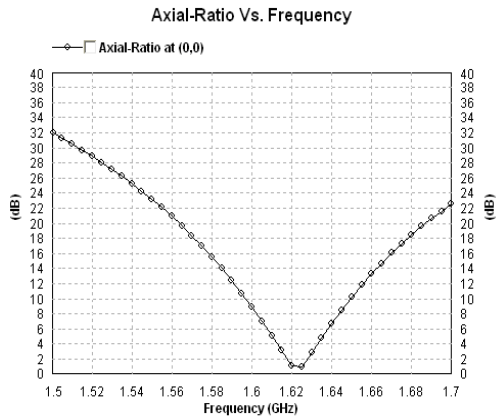


**Fig. 10. Plot of axial ratio versus frequency**

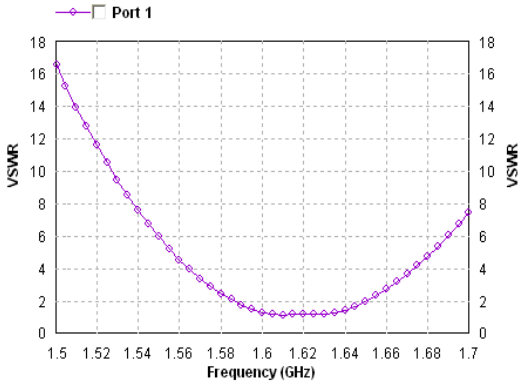


**Fig 11. Variation of VSWR with frequency.**

 

## III. RESULTS

So we studied various slot coupled circularly polarized circular patch microstrip antenna. In cross-slot coupled circular patch microstrip antenna , symmetrical & asymmetrical T-slot coupled circularly polarized microstrip antennas were described . The simulation results obtained in those investigations are compared here. The various parameters such as axial ratio, gain etc for different antennas described earlier are tabulated in table 1 below. Table below shows that the upper radiating patch is more for cross-slot coupled circular patch antenna where as that is less for symmetrical as well as asymmetrical T-slot coupled circular patch antenna. Electromagnetic wave radiated by the cross-slot coupled circular patch antenna has the minimum axial ratio at frequency 1.575 GHz. So we can say that cross-slot coupled antenna would radiate a good circular polarized wave. Gain is nearly equal for all the antennas described so far. Axial ratio bandwidth is nearly same for all the antennas described, except symmetrical T-slot coupled antenna. VSWR bandwidth is maximum for the asymmetrical T-slot coupled circular patch microstrip antenna. For a circularly polarized antenna asymmetrical T-slot coupled antenna would be better choice among the antennas described earlier. Though axial ratio of a cross-slot coupled antenna (0.2096 dB) is less than that for the asymmetrical T-slot coupled antenna (1.16dB) but the VSWR of the asymmetrical T-slot coupled antenna (1.12 dB) is less than that for the cross-slot antenna (1.70). So the good impedance matching is obtained in asymmetrical T-slot coupled circularly polarized circular patch microstrip antenna as well as an axial ratio which is below the 3 dB acceptable for the circular polarization at the frequency 1.575 GHz.

**Table-1 comparison of various microstrip antennas**

| | **Radius of the upper patch in mm.** | **Axial ratio at 1.575 GHZ (in dB)** | **Gain in the broadside direction (in dB)** | **Axial ratio band width ( in % of the operating frequency)** | **VSWR band width ( in % of the operating frequency)** |
|---|---|---|---|---|---|
| Cross-slot coupled antenna | 32.7 | 0.207 | 6.36 | 0.93 | 3.88 |
| Symmetrical T-slot coupled antenna | 32.1 | 2.096 | 6.58 | 0.60 | 3.34 |
| Asymmetrical T-slot coupled antenna | 32.1 | 1.15 | 6.56 | 0.93 | 4.23 |

## IV. CONCLUSION

In this paper various slot coupled circularly polarized antenna were described. It is seen from those simulation results asymmetrical T-slot coupled circular patch microstrip antenna can produce circular polarization and at the same time gives good impedance matching at the frequency 1.575 GHz. This proposed antenna can be used for mobile satellite communication. Since there is no external 90 degree hybrid coupler for generating the circular polarization, this antenna can be also used as an element of phased array antenna.

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