Project of single frequency single polarization, single frequency dual polarization and single frequency circular polarization microstrip antenna

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Resonant frequency: 3.9GHz

***Abstract*—Nowadays, microstrip antenna [1] has been widely used in all kinds of application due to its simplicity. In this paper, we will review the microstrip antenna model and use this microstrip antenna model to achieve single frequency single polarization, single frequency dual polarization and single frequency circular polarization microstrip antenna.**

***Index Terms*—single polarization microstrip antenna, dual polarization microstrip antenna, circular polarization microstrip antenna, resonant frequency, axial ratio**

I. Introduction

MICROSTRIP antenna (also known as a patch antenna) is one of the latest technologies in antennas and electromagnetic applications. It is widely used nowadays in the wireless communication system due to its simplicity and compatibility with printed circuit technology. So in this experiment, we design three kinds of microstrip antenna (single frequency single polarization, single frequency dual polarization and single frequency circular polarization) to deepen the understanding for microstrip antenna. In addition, the performance and operation of a microstrip antenna is dependent on the geometry of the printed patch [4] and the material characteristics of the substrate onto which the antenna is printed. In all the three sub-experiment, we set the material of the substrate is FR4 so we mainly adjust the structure parameters of the microstrip antenna to reach the corresponding resonant frequency. The requirement of resonant frequency for me is 3.9GHz. In the rest of the paper, we will explain the whole experiment process in different section in detail. Section II focuses on the two kinds of feeding modes we use in the three sub-experiment. Section III focuses on the geometric dimensions setting and process for the three sub-experiments. Section IV focuses on the analysis of the result of these three sub-experiments. Section V draws a conclusion for the whole experiment.

II. Two kinds of feeding modes for microstrip antenna

A. Microstrip Line Feed

In this type of feed technique, as shown in Figure 1, a conducting strip is connected directly [3] to the edge of the Microstrip patch. The conducting strip is smaller in width as compared to the size of the patch. This method is the easiest to fabricate as this feeding arrangement and radiating patch can be printed on same dielectric substrate. This arrangement provides a planar structure. Due to this advantage a large arrays may be designed using edge-fed patches. The drawback is the radiation from the feed line, which leads to an increase in the crosspolar level. Also, in the mm wave region of spectrum, the dimension of the feed line is equivalent to the dimension of the patch size, leading to increased undesired radiation. The feed arrangement to the patch may also have an inset cut in the patch. The purpose of the inset cut in the patch is to match the impedance of the feed line to the patch without the need for any additional matching element. This is achieved by properly controlling the inset position. This is an easy feeding scheme, because it provides ease of fabrication and simplicity in modelling as well as impedance matching.

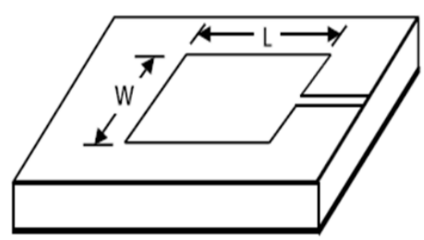

Fig. 1. Microstrip Antenna fed by Microstrip Line Feed

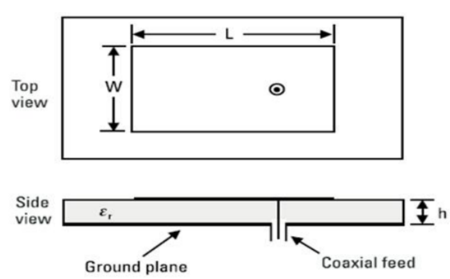

Fig. 2. Microstrip Antenna fed by Coaxial Probe Feed

B. Coaxial Probe Feed

The coaxial feed or probe feed [2] is the most common techniques used to feed printed patch antennas. It is shown in

Figure 2. This feed can be given at any desired location within the patch to achieve impedance matching. The inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane.

III. The geometric dimensions setting and process for the three sub-experiments

A. Single frequency single polarization microstrip antenna

In this sub-experiment, we use the microstrip line feed model. The model of the single polarization microstrip antenna is shown in the figure 3. We first create the floor whose material is FR4. Then we create a patch as the mircostrip antenna. Next, dig a hole in the middle edge of patch in convenience to feed. After establishing the line feed, we put a wave port in the middle edge of the floor connecting the line feed. Finally, we create a vacuum region as solve space. In order to evaluate the performance of our established model, we draw the S(1,1), resonant frequency and port impedance.

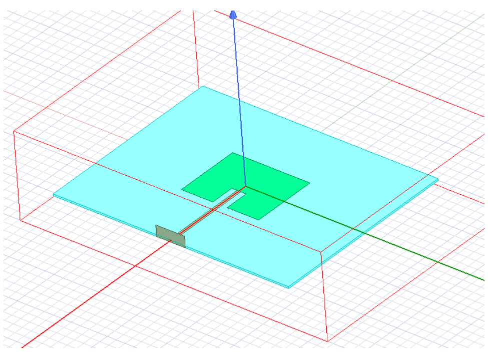

Fig. 3. The model of single polarization microstrip antenna. It consists of floor, feed port, the transmission line, patch, wave port and region.

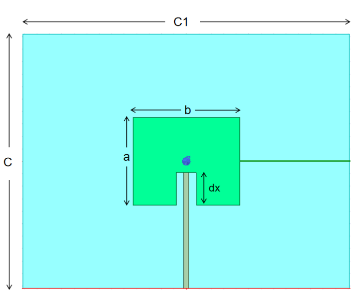

Fig. 4. The vertical view of single polarization. The parameters $C1$=131.22mm, C=102mm, b=43mm, a=35mm and dx=13mm

In detail, figure 4 shows the vertical view of the single polarization microstrip antenna and figure 5 shows the the front view of single polarization microstrip antenna. Given the requirement that the resonant frequency must reach to 3.9GHz, the impedance of both the feed port and the transmission line is 50 Ω, the S(1,1) lower than -10dB, the parameters are as follow: $C1$=131.22mm, C=102mm, b=43mm, a=35mm, dx=13mm, d=1mm, w=16mm and t=6mm. In the process of adjusting the geometric dimensions to satisfy the requirement, we find that the large the geometric dimensions a and b of single polarization microstrip antenna, the small resonant frequency. And the large dx, the deep S(1,1). In addition, the weigh of feed port and the transmission line controls the the impedance of themselves. So in the experiment, we repeatedly mainly adjust the parameter b, a, dx to reach the requirement.

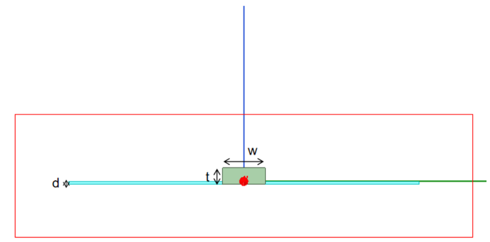

Fig. 5. The front view of single polarization. The parameters d=1mm, w=16mm and t=6mm

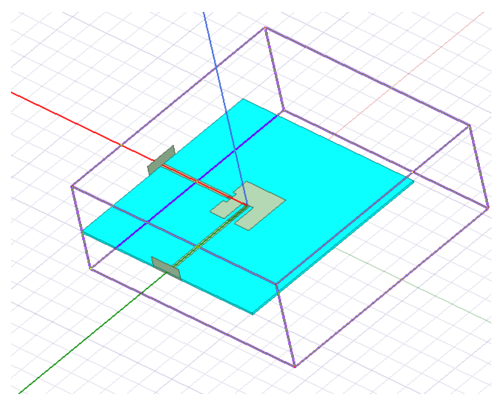

Fig. 6. The model of dual polarization.It consists of floor, two feed port, two transmission line, patch, two wave port and region.

B. Single frequency dual polarization microstrip antenna

In this sub-experiment, we use the microstrip line feed model. The model of the dual polarization microstrip antenna is shown in the figure 6. We first create the floor whose material is FR4. The we create a patch as the mircostrip antenna. Next, dig two hole in the adjacent middle edge of patch in convenience to feed. After establishing the two line feed, we put two wave port in the adjacent middle edge of the floor connecting the two line feed respectively. Finally, we create a vacuum region as solve space. In order to evaluate the performance of our established model, we draw the S(1,1), resonant frequency and the impedance of two port.

In detail, figure 7 shows the vertical view of the dual polarization microstrip antenna and figure 8 shows the front view of dual polarization microstrip antenna. Given the requirement that the resonant frequency must reach to 3.9GHz, the impedance of both the feed port and the transmission line is 50 Ω, the S(1,1) lower than -10dB, the parameters are as follow: $C1$=100mm, C=100mm, b=23mm, a=23mm, dw=2mm, $dw1$=12mm, d=1mm, w=16mm and t=6mm. In the process of adjusting the geometric dimensions to satisfy the requirement, we find that the large the geometric dimensions a and b of dual polarization microstrip antenna, the small resonant frequency. And the large dw and $dw1$, the deep S(1,1). In addition, the weigh of feed port and the transmission line controls the the impedance of themselves. So in the experiment, we repeatedly mainly adjust the parameter b, a, dw, $dw1$ to reach the requirement.

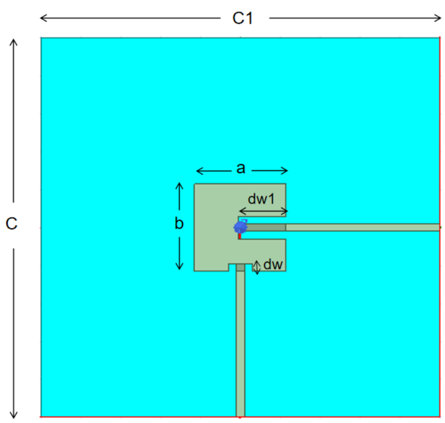

Fig. 7. The vertical view of dual polarization microstrip antenna.The parameters $C1$=100mm, C=100mm, b=23mm, a=23mm, dw=2mm and $dw1$=12mm.

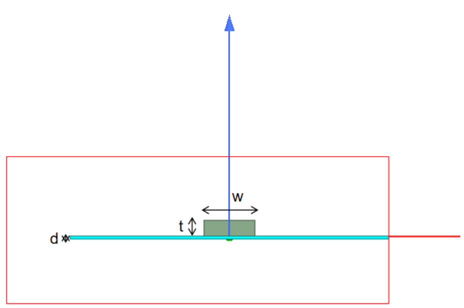

Fig. 8. The front view of dual polarization microstrip antenna. The parameters d=1mm, w=16mm and t=6mm

C. Single frequency circular polarization microstrip antenna

In this sub-experiment, we use the coaxial probe Feed model. The model of the circular polarization microstrip antenna is shown in the figure 9. We first create the floor whose material is FR4. The we create a patch as the mircostrip antenna. Next, dig a hole on the patch along x axis in convenience to feed. After establishing the hole feed, we put copper coaxial connecting the patch. As explaination, we achieve feed by one hole through a copper coaxial. Finally, we create a vacuum region as solve space. In order to evaluate the performance of our established model, we draw the S(1,1), resonant frequency, axial ration value and the impedance of the port.

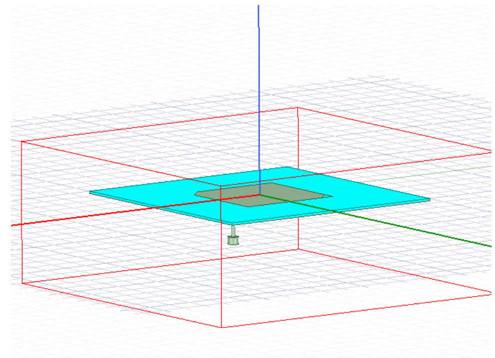

Fig. 9. The model of circular polarization microstrip antenna. It consists of a copper feed, a patch and a floor.

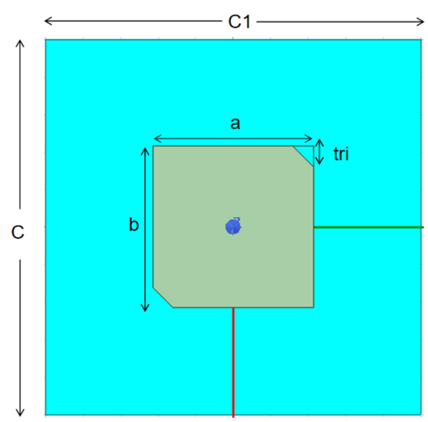

Fig. 10. The vertical view of circular polarization microstrip antenna. The parameters a=43mm, b=43mm, $C1$=100mm, C=100mm and tri=5.5mm.

In detail, figure 10 shows the vertical view of the circular polarization microstrip antenna, figure 11 shows the front view of circular polarization microstrip antenna and figure 12 shows the bottom view of circular polarization microstrip antenna. Given the requirement that the resonant frequency must reach to 3.9GHz, the impedance of both the feed port and the transmission line is 50 Ω, the S(1,1) lower than -10dB, the axial ration value lower than -3dB, the parameters are as follow: a=43mm, b=43mm, $C1$=100mm, C=100mm, tri=5.5mm, d=1mm, $h1$=3mm, $r1$=2.22mm, h=16mm and $x1$=13.48mm. In the process of adjusting the geometric dimensions to satisfy the requirement, we find that the large the geometric dimensions a and b of circular polarization microstrip antenna, the small resonant frequency. And the large tri, the deep S(1,1). Moreover, the parameter $x1$ represents the feed position of the copper. So the parameter $x1$ controls the axial ration value of the circular polarization microstrip antenna. In addition, the weigh of feed port and the transmission line controls the the impedance of themselves. So in the experiment, we repeatedly mainly adjust the parameter b, a, tri, $x1$ to reach the requirement.

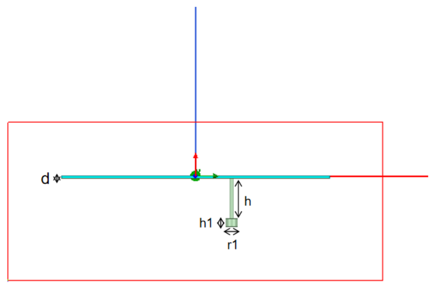

Fig. 11. The fromt view of circular polarization microstrip antenna. The parameters d=1mm, $h1$=3mm, $r1$=2.22mm and h=16mm

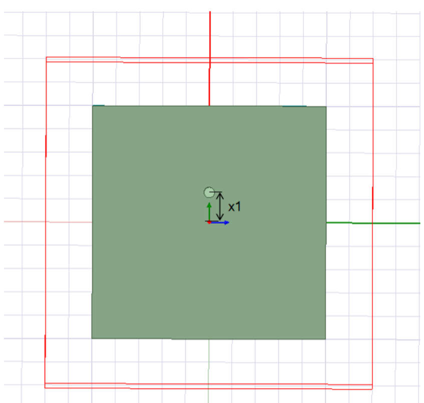

Fig. 12. The bottom view of circular polarization microstrip antenna. The parameters $x1$=13.48mm

IV. The analysis of the result of these three sub-experiment

A. Single frequency single polarization microstrip antenna

Figure 13 shows the resonant frequency of single polarization microstrip antenna with fixed parameters. From the figure 13, we observe that with the resonant frequency is 3.90GHz which is closed to 3.9GHz and the resonant depth reaches to -32.44dB. The resonant frequency and resonant depth (S(1,1)) of single polarization microstrip antenna with fixed parameters satisfy the requirement.

Figure 14 shows the port impedance of single polarization microstrip antenna with fixed parameters. From the figure 14, we observe that the port impedance may not be a straight line but its range of change is tiny. Consequently, if we scale the range of y axis, the port impedance will present a straight line. Roughly, the port impedance is around 48.92Ω which is closed to 50Ω. The port impedance of single polarization microstrip antenna with fixed parameters satisfy the requirement.

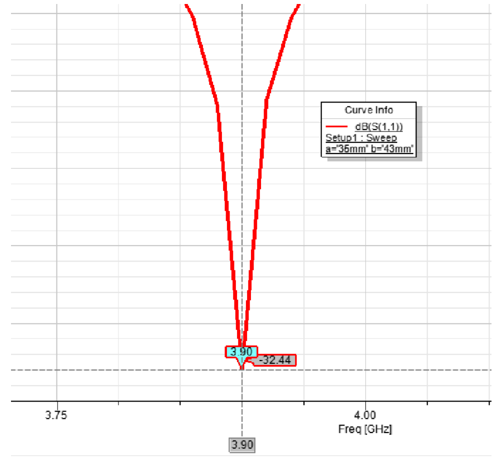

Fig. 13. The resonant frequency of single polarization microstrip antenna. The resonant frequency is 3.90GHz. The resonant depth is -32.44dB.

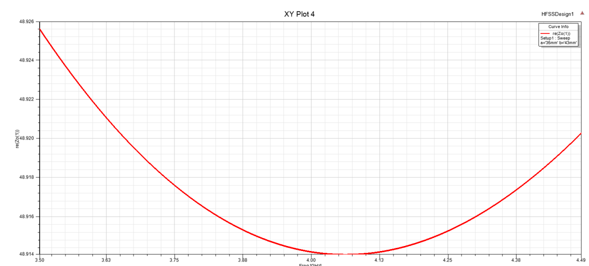

Fig. 14. The port impedance of single polarization microstrip antenna. The port impedance is around 48.92Ω.

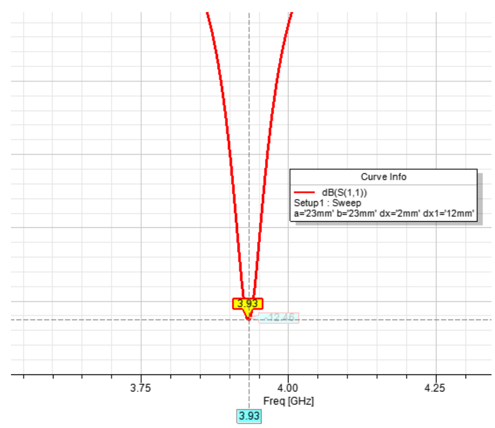

Fig. 15. The resonant frequency of dual polarization. The resonant frequency is 3.93GHz. The resonant depth is -12.46dB.

B. Single frequency dual polarization microstrip antenna

Figure 15 shows the resonant frequency of dual polarization microstrip antenna with fixed parameters. From the figure 15, we observe that with the resonant frequency is 3.93GHz which is closed to 3.90GHz and the resonant depth reaches to -12.46dB. The resonant frequency and resonant depth (S(1,1)) of dual polarization microstrip antenna with fixed parameters satisfy the requirement. In fact, it is hard to adjust the resonant frequency exactly equal to 3.9GHz. In most of the case, we view the resonant frequency around 3.9GHz (different from -0.3GHz to 0.3GHz) reaches requirement.

Figure16 shows the radiation pattern of dual polarization microstrip antenna at the resonant frequency.

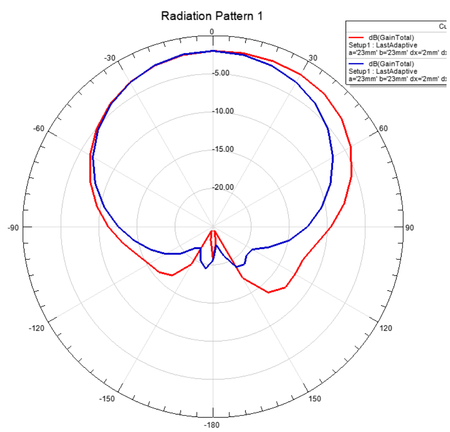

Fig. 16. The radiation pattern of dual polarization

Figure 17 and figure 18 shows the port impedance of dual polarization microstrip antenna with fixed parameters. From the figure 17 and figure 18, we observe that the two port impedance may not all be a straight line but its range of change is tiny. Consequently, if we scale the range of y axis, the two port impedance will present a straight line. Roughly, the two port impedance is around 49.192Ω and 49.210Ω respectively both of which is closed to 50Ω. The two port impedance of dual polarization microstrip antenna with fixed parameters satisfy the requirement.

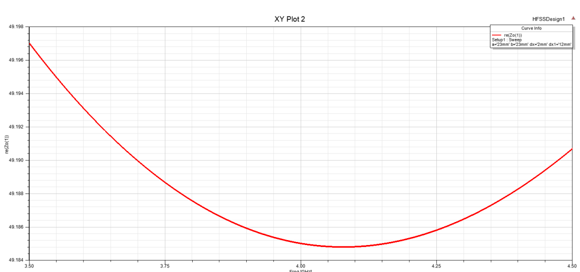

Fig. 17. The first port impedance of dual polarization. The first port impedance is around 49.192Ω.

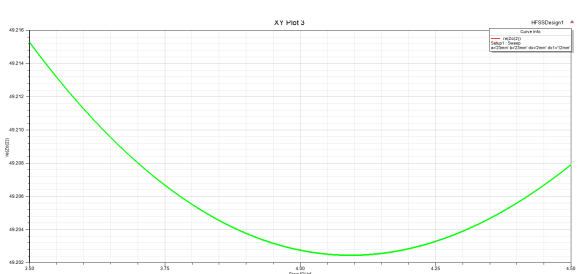

Fig. 18. The second port impedance of dual polarization. The second port impedance is around 49.210Ω.

C. Single frequency circular polarization microstrip antenna

Figure 19 shows the resonant frequency of circular polarization microstrip antenna with fixed parameters. From the figure 19, we observe that with the resonant frequency is 3.90GHz and the resonant depth reaches to -15.01dB. The resonant frequency and resonant depth (S(1,1)) of circular polarization microstrip antenna with fixed parameters satisfy the requirement.

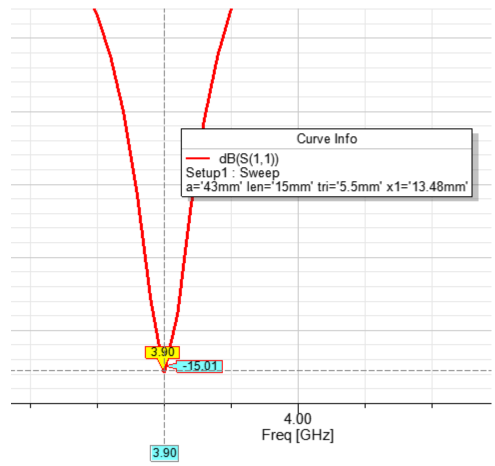

Fig. 19. The resonant frequency of the circular polarization microstrip antenna. The resonant frequency is 3.90GHz. The resonant depth is -15.01dB.

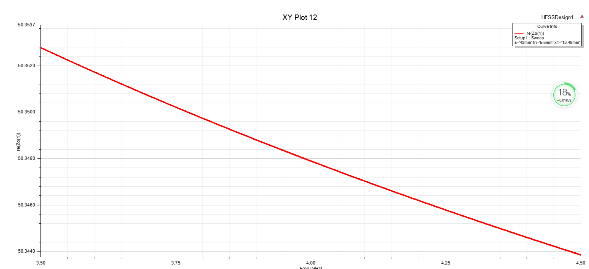

Fig. 20. The port impedance of circular polarization. The port impedance is around 50.35Ω.

Figure 20 shows the port impedance of the circular polarization microstrip antenna with fixed parameters. From the figure 20, we observe that the port impedance may not be a straight line but its range of change is tiny. Consequently, if we scale the range of y axis, the port impedance will present a straight line. Roughly, the port impedance is around 50.35Ω which is closed to 50Ω. The port impedance of circular polarization microstrip antenna with fixed parameters satisfy the requirement.

Figure 21 shows the axial ration value of the circular polarization microstrip antenna with fixed parameters. From the figure 21, we observe that the axial ration value is equal to 0.94dB when the resonant frequency is 3.91GHZ. So when the resonant frequency is 3.9GHz, the axial ration value also around 0.94dB which is less than 3dB. The axial ration value of circular polarization microstrip antenna with fixed parameters satisfy the requirement.

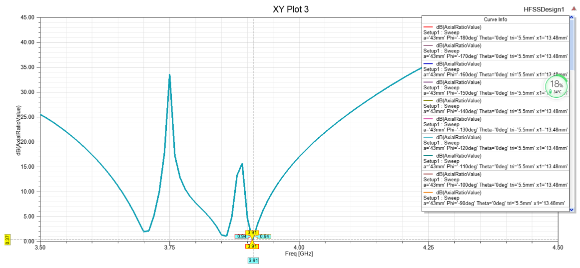

Fig. 21. The axial ration value of circular polarization. The axial ration value is 0.94dB.

V. Conclusion

In the project, we design three kinds of microstrip antenna including single frequency single polarization, single frequency dual polarization and single frequency circular polarization microstrip antenna. The geometric dimensions of these three models is as follow.

For single frequency single polarization microstrip antenna, $C1$=131.22mm, C=102mm, b=43mm, a=35mm, dx=13mm, d=1mm, w=16mm and t=6mm. The single frequency single polarization microstrip antenna model satisfy the requirement that the resonant frequency must reach to 3.9GHz, the impedance of both the feed port and the transmission line is 50 Ω, the S(1,1) lower than -10dB. And its resonant frequency is 3.90GHz, its impedance of both the feed port and the transmission line is 48.92Ω and its S(1,1) reaches to -32.44dB.

For single frequency dual polarization microstrip antenna, $C1$=100mm, C=100mm, b=23mm, a=23mm, dw=2mm, $dw1$=12mm, d=1mm, w=16mm and t=6mm. The single frequency dual polarization microstrip antenna model satisfy the requirement that the resonant frequency must reach to 3.9GHz, the impedance of both the feed port and the transmission line is 50 Ω, the S(1,1) lower than -10dB. And its resonant frequency is 3.93GHz, its impedance of both the feed port and the transmission line are 49.192Ω and 49.210Ω and its S(1,1) reaches to -12.46dB.

For single frequency circular polarization microstrip antenna, a=43mm, b=43mm, $C1$=100mm, C=100mm, tri=5.5mm, d=1mm, $h1$=3mm, $r1$=2.22mm, h=16mm and $x1$=13.48mm. The circular frequency circular polarization microstrip antenna model satisfy the requirement that the resonant frequency must reach to 3.9GHz, the impedance of both the feed port and the transmission line is 50 Ω, the S(1,1) lower than -10dB. And its resonant frequency is 3.90GHz, its impedance of both the feed port and the transmission line is 50.35Ω, its axial ration value is 0.94dB and its S(1,1) reaches to -15.01dB.

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