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Design X-Circular Polarized with Slanted Rectangular Slot by using Single Port

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Abstract- This technical paper present the design of circular patch with slanted rectangular slot (Design 1 and Design 2) and x-circular polarized with slanted rectangular slot (Design 3) by using single port at frequency 2.4GHz. For design 3, the combination of design 1 or design 2 by using quarter wave matching is introduced. The design simulated using Microwave CST software with dielectric constant dielectric constant, ε_r=4.3 and tan δ=0.019 and thickness of substrate, t=1.6mm. The simulation results such as return loss, bandwidth, gain, directivity, axial ratio and polarization have been compared.

1. Introduction

The development of wireless communication system has been rapidly growth in this era with increasing demand in the level of enhancement and performance. The concepts of Multiple Input Multiple Output (MIMO) system have been used since 1980's. They were first investigated by using computer simulation [1] and later many researchers explore about MIMO system [2]. In features, MIMO can be very important technology in wireless systems which is require high data rates such as wireless local area network(WLAN's), broadband wireless access network (WiMaX) and third and fourth generation cellular networks (3G and 4G) [1]. Types of polarizations are linear polarization, circular polarization and x-polarization. To get linear polarization are by using methods of coupled patch, slot and single fed method [3] [4] [5]. Circular polarization can occur when two signals of equal amplitude but have 90degree phase shifted. Method that usually using to get circular polarization are slot, double layer, aperture coupled patch, single feed and double feed method [6] [7] [8] [9] [10]. Dual polarization operation has been important in polarization diversity because can enhance system performance and can combat multipath effect in wireless communication. Design of compact dual polarized mircostrip antenna fed by two probe feed has been reported from G.S. Row [11] and design of dual polarization using single port inset feed has been found at [12]. Polarization diversity is combination of antennas with orthogonal polarization either in horizontal or vertical combination, ±45 degree combination or left or right hand combination [13] [14].

2. Design

The X-circular polarized with slanted rectangular slot design start with basic circular patch design. Then, the slanted rectangular slot has been embedded at the center of the circular patch. After that, 4 element of circular patch with slanted slot is arrange in ± 45 degree alignment and feed with 4 different microstrip transmission line. All the design is simulate by using Microwave CST Studio simulator software. The entire parameters antenna such as return loss, bandwidth, gain, directivity, radiation pattern and surface current were recorded.

2.1 Circular patch with slanted rectangular slot (Design 1 and Design 2)

Next, the rectangular slot which is slanted at -45 degree and +45 degree is embedded on the circular patch. Figures 1(a) Design 1 show the circular patch with -45 degree slanted rectangular patch and the position of feed line is at position (5, 5) from origin. Figure 1(b) Design 2 show the circular patch with +45 degree of slanted rectangular slot and the coordinate of feed line was at position (-5, 5) from origin. Diameter of patch, *d* is 16.4mm, length of slot, *a* is 15.6mm and width of slot, *b* is 1.2mm.

Feedline that have been used in design is 50Ω and length feedline, *L* is 43.7mm and width of feedline, *w* is 3mm.

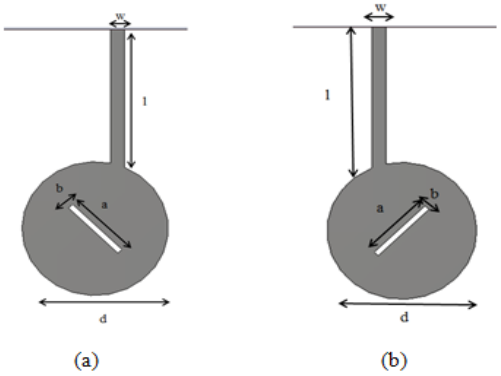


Figure 1 : (a) Circular Patch with -45 Degree Slanted Rectangular Slot (Design 1) (b) Circular Patch with +45 Degree Slanted Rectangular Slot (Design 2)

2.2 X-Circular Polarized with Slanted Rectangular Slot (Design 3)

After that, 4 element of circular patch with -45 degree slanted rectangular slot rotated at 45^0, 135^0, 225^0 and 315^0. All circular patches are connected with 4 different transmission lines. Then, all the transmission line is combine and feed with coaxial probe technique at the center of the antenna. In order to improve the transmission between feed probe and circular patch, the double stage quarter wavelength binomial transformer is implemented. The x-circular polarized microstrip patch which is shown in figure 2 is using one feeding point of 50Ω coaxial probe. Diameter of patch, *D* is 32mm, length, *L* and width, *d* of 50Ω feedline is 43.7mm and 3mm. Length of slot, *a* is 7.8mm and width of slot, *b* is 2mm. *c* is 16mm, length of transmission line, and width of transmission line is *e* is 2.27mm, *f* is 1.1mm and g is 1.3mm.

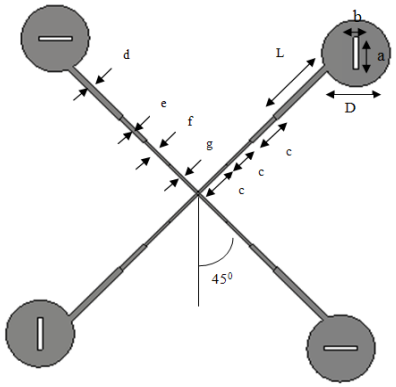


Figure 2: X-Circular Polarized Microstrip Patch Antenna Structure (Design 3)

3. Results

3.1 Circular patch with slanted rectangular slot (Design 1 and Design 2)

a. Return Loss and Bandwidth

Figure 3 show the return loss for design 1 and design 2. Design 2 have a better return loss compare to design 1 which is -25.47dB and -46.63 dB respectively. Bandwidth of design 2 is 40 MHz but for design 1 is 41.1MHz.

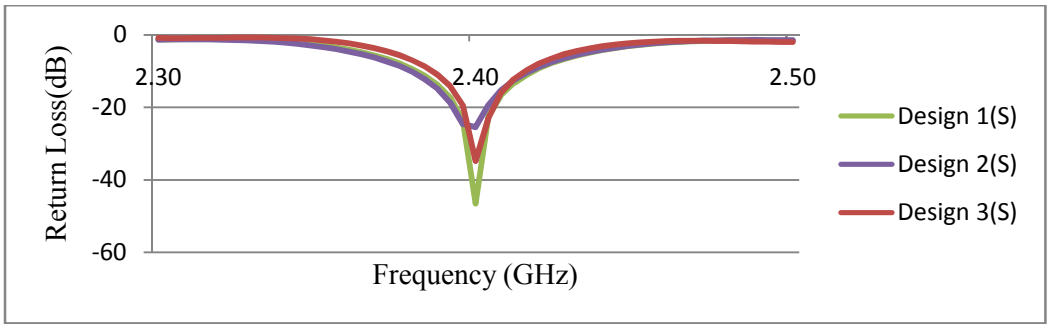


Figure 3: Return Loss for Design 1 and Design 2

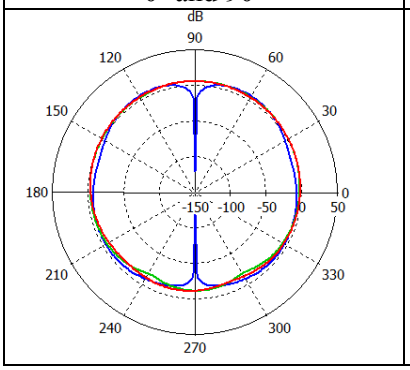
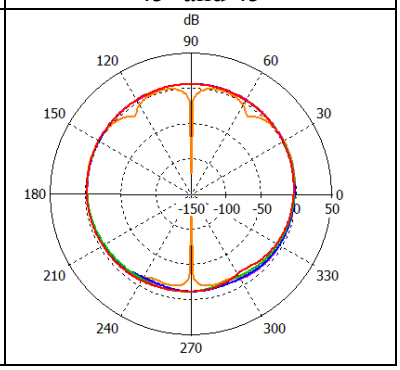
b. Gain, Directivity and Total Efficiency

The gain for design 2 is 6.49 dB and the directivity is 7.21dBi which is better compare to design 1. Gain for design 2 is 6.25dB and the directivity is 6.93 dBi. Total efficiency for design 2 is -0.72dB. However, for design 1 has total efficiency of 0.03dB higher compare to the design 1. Surface Current

c. Radiation Pattern

Table 1 represents the radiation pattern for design 1, design 2 and design 3 which is cut at 0 degree and 90 degree and another one is cut at -45 degree and 45 degree for comparison. For design 1, main lobe is 6.3dB at 3 degree and for HPBW is 86.2 degree. For design 2, main lobe is 6.5 dB at 359 degree and HPBW for design 2 is 80.8 degree. Main lobe and HPBW for design 3 is 6.8dB at 25 degree and 29.6 degree respectively.

Table 1: Radiation Pattern

0^0 and 90^0	-45^0 and 45^0
	

d. Axial Ratio

Figure 6 shows the simulated axial ratio versus frequency. For axial ratio lower than 3 dB, design 1 exhibits a simulated bandwidth of 2.85% or 68.8MHz. For design 2, the simulated bandwidth is 4.04% or 97MHz and for design 3, simulated bandwidth is 8.9% or 214.3MHz.

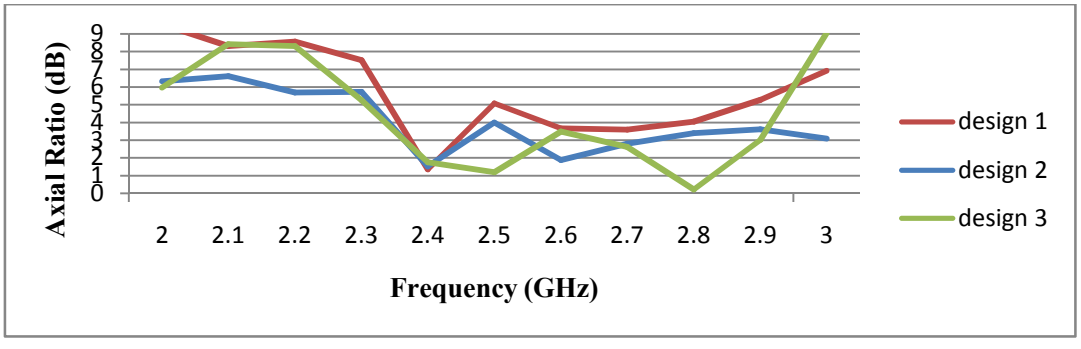


Figure 4: Axial Ratio for Design 1, Design 2 and Design 3

4. Conclusion

The design of basic circular patch, circular patch with ± 45 slanted rectangular slot (design 1 and Design 2) and x-circular polarized with slanted rectangular slot (Design 3) at frequency 2.4GHz have been presented and simulated by using CST software. The x-circular polarized can generate 4 circular radiation with gain and directivity of 6.79dB and 7.54dBi respectively.

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