International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 9, September - 2013

Gain and Bandwidth Enhancement Analysis of Slotted Circular Microstrip Antenna

Sudarshan Kumar Jain [1] ,Sandeep Toshniwal [2]

Abstract

A compact microstrip circular patch antenna with enhanced gain and bandwidth is presented in this paper. The antenna is analysed for the different sizes of the rectangular slots in the patch. The antenna is designed for a resonant frequency of 2.4 GHz using the FR4 substrate having a dielectric constant of 4.4. The bandwidth of 2.41-2.49 GHz for S_{11} < -10 dB, which can cover the 2.4-2.48 GHz frequency band of WLAN applications. It is observed that the gain of the designed antenna is greater than the conventional patch antenna. The bandwidth of the designed antenna is also very significant then the conventional patch antenna. The designed antenna is energized using the microstrip line feeding. Designed microstrip antenna has a VSWR <2. The different characteristics of the antenna such as gain, bandwidth, return loss, directivity and VSWR is analysed for both the designed antenna and the conventional patch antenna . The design is simulated by using the software High Frequency Structure Simulator (HFSS).

1. Introduction

Patch antennas are used in aircrafts, satellite, and mobile communication due to their many attractive features such as simple structure, light weight and robustness. Micro strip patch antenna consists of a metallic patch above a dielectric substrate. A patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit board, with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. They are usually employed at UHF and higher frequencies because the size of the antenna is directly tied to the wavelength at the resonant frequency As the dielectric constant of the substrate increases, the antenna bandwidth decreases which increases the Q factor of the antenna and therefore decreases the impedance bandwidth [2] When antenna is energized waves can propagate in all directions The antenna can be energized by using microstrip line, coaxial probe ,proximity coupling and aperture coupling. The microstrip line feed is easy to fabricate, simple to match by controlling the inset position. The coaxial probe is also easy to fabricate and match and has low spurious radiation. [1]

2. Antenna Design

The antenna is designed at a resonant frequency of 2.4 GHz having the following specifications-

Parameter	Value
Designed Frequency	2.4 GHz
Radius of the patch	18mm
Substrate	Fr4 Epoxy
Dielectric Constant	4.4
Substrate Size	100 x 100 mm
Feeding method	Microstrip Line

So a substrate of FR4 epoxy is used for the designing of this antenna having dielectric constant of 4.4 and a circular patch having the radius of 18mm. .The antenna was energized using the microstrip line feeding. The height of the substrate is 3.2 mm for the designed antenna. The characteristics of antenna are compared for the conventional and the designed antenna having the high gain and bandwidth property. In the designing of the antenna the different factors such as gain, bandwidth, and radiation efficiency effects due to slotted structure have been studied. Due to the improvement in the gain and bandwidth of the antenna this can be used for the different applications.

For increasing the gain and bandwidth of the antenna a rectangular slot in the circular patch have been introduced. The gain and the bandwidth of the antenna of the designed antenna was analysed for the different sizes of the rectangular slot taken on the circular patch having the radius of 18 mm.

3. Results and Discussion

The designed antenna is simulated by using the software HFSS (High Frequency Structure simulator). The simulated results for antenna gain, return loss, directivity, VSWR, magnetic field and the electric field are observed using the different curves. The return loss of antenna with respect to different resonant frequencies is shown below.

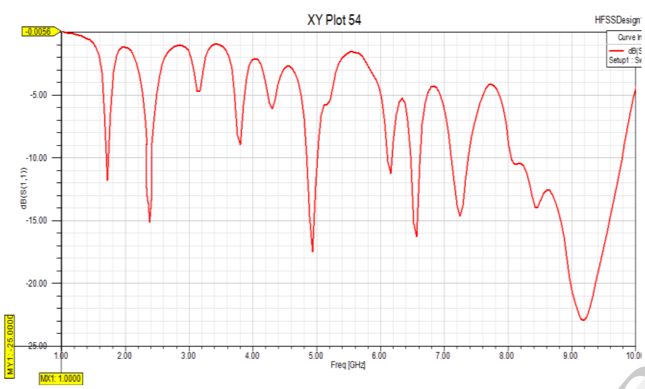

Fig.1 Return loss Vs frequency for the designed antenna

Name	Frequency(GHz)	Return Loss(dB)
M1	1.7236	-11.8060
M2	2.4142	-15.1542
M3	4.9347	-17.5108
M4	6.1558	-11.2561
M5	6.5628	-16.3036
M6	7.2412	-14.6728
M7	9.1859	-22.9274

Table.1 Return loss Vs frequency for the designed antenna

According to the above figure and table it is clear that the minimum return loss is -22.9274 dB. The VSWR for the designed antenna is < 2 and shown in fig.3. The value of VSWR with respect to different frequencies is shown in table-2. From the table it is can be seen that the VSWR for the different frequencies is less than 2. So the antenna gives good performance for these frequencies. Fig.4 shows the voltage standing wave ratio for the conventional antenna.

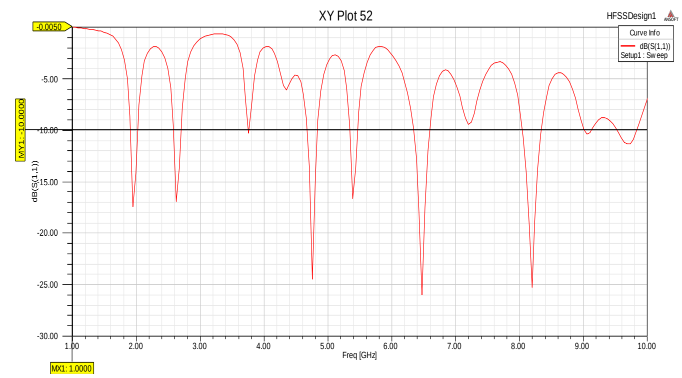

Fig.2 Return loss Vs frequency for Conventional antenna

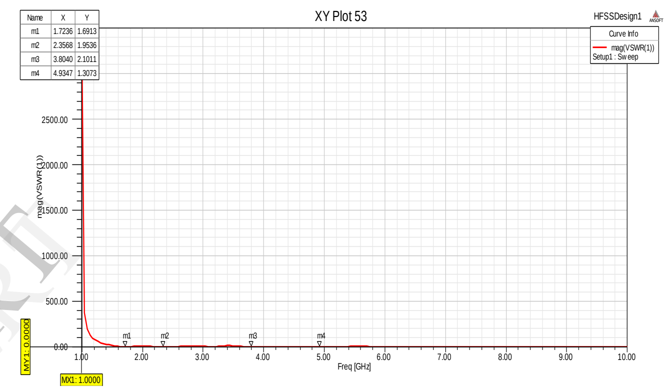

Fig.3 VSWR for the designed antenna

Name	Frequency(GHz)	VSWR
M1	1.7236	1.6913
M2	2.3568	1.9536
M3	3.8040	2.1011
M4	4.9347	1.3073
M5	6.1558	1.7535
M6	6.5176	1.4215
M7	7.1508	1.6882
M8	8.1457	1.8544
M9	8.5528	1.5901
M10	8.8241	1.4280

Table.2 VSWR Vs Frequency for designed antenna

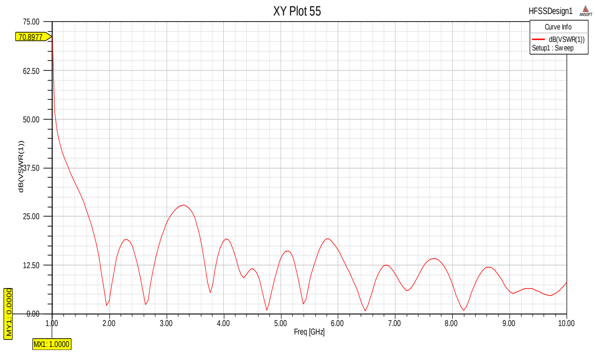

Fig.4 VSWR for the conventional antenna

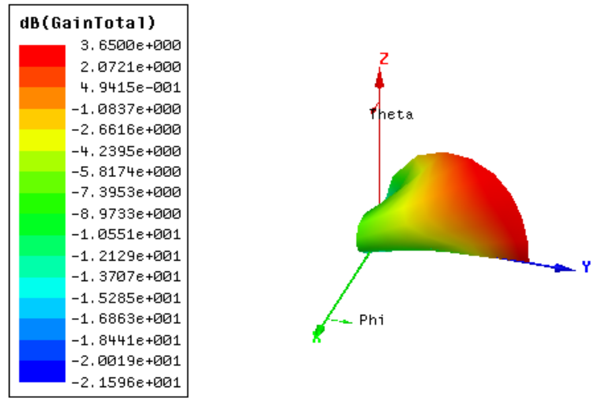

Fig.6 Gain of the conventional antenna

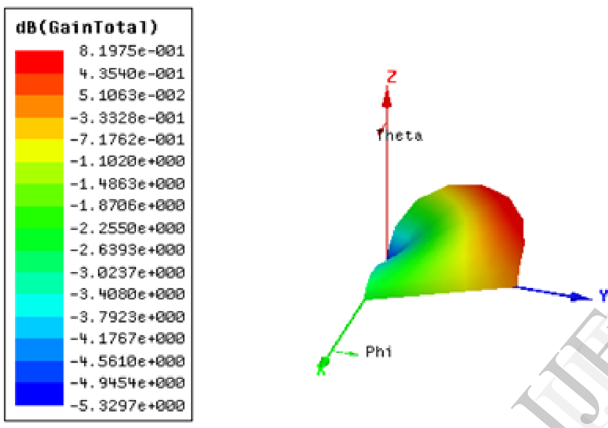

Fig.5 Gain of the designed antenna

Slot size (mm)	Gain (dB)	Directivity (dB)	B.W (MHz)	Return loss(dB)
15.98×3.62	8.19	3.58	1752.9	-22.92
12.98×3.62	6.91	3.53	1632.2	-19.72
3.98×3.62	3.56	6.80	1097.4	-30.10

Table.3

The above figure shows that the gain of the designed antenna is 8.19 dB whereas the gain of the conventional antenna is only 3.65dB. So gain is increased by 4.54 dB in the designed antenna as compared to the conventional antenna. Fig.6 shows the gain of the conventional antenna without introducing the slotted structure. The effect of the slot size on the gain and the bandwidth of the designed antenna can be analysed by the table.3

So from the above table it is clear that the maximum gain of 8.19dB is achieved for the slot size of 15.98×3.62 mm and maximum bandwidth is 1752.9 MHz with a return loss of -22.92 dB .The directivity for the maximum gain of antenna is 3.58 dB.

Figure.7 shows that the directivity of the designed slotted circular microstrip patch antenna is 3.58 dB.

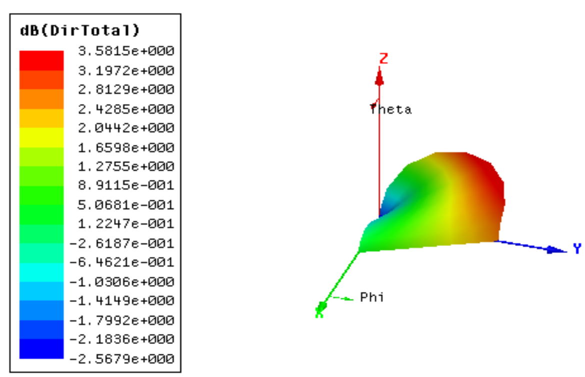

Fig.7 Directivity of the designed antenna

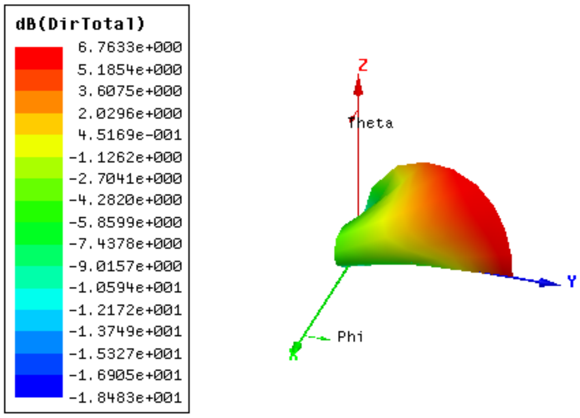

Fig.8 Directivity for the Conventional antenna

Maximum bandwidth of the antenna is received as 1752.9 MHz in the frequency range of (8.0492-9.8021) GHz.

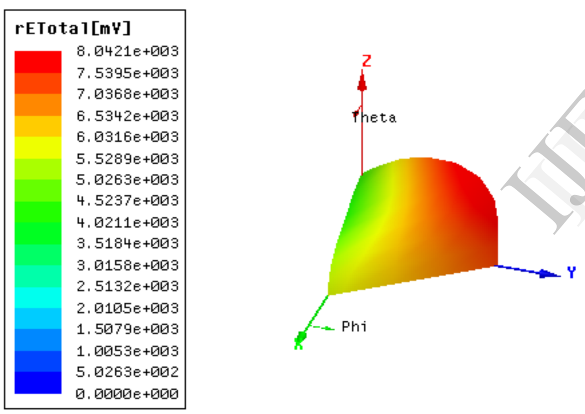

Fig.9 Total radiated E-field for designed antenna

Fig.9 and 10 shows the total radiated E- field for the designed rectangular slotted patch antenna and conventional patch antenna respectively.

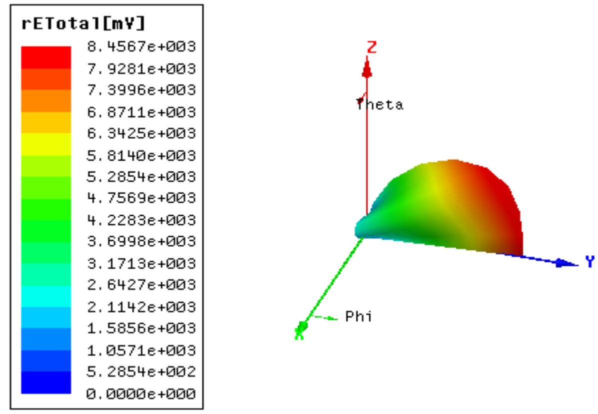

Fig.10 Total radiated E-field for Conventional antenna

Conclusion

So the designed antenna using rectangular slot gives an enhanced gain of 4.54 dB than the conventional patch antenna. By reducing the losses in the antenna the gain of the antenna can be increased significantly. So antenna gives a good return loss using the slot in the patch than the conventional antenna. The VSWR of the designed antenna is received below 2 which is very important for the antenna. The maximum bandwidth of the antenna is 1752.9 MHz .

References .

[1] Constantine A. Balanis, Antenna Theory, Analysis and Design,3rd edition, A John Wiley & Sons, Inc. , Publication, 2005
[2] Wikipedia.org/antenna gain
[3] K. R. Carver and J. W. Mink, "Microstrip antenna technology," IEEE Trans.,AP-29, pp. 2-24, Jan. 1981
[4] K. L. Wong and W. S. Chen,"Compact MicrostripAntenna with dual frequency operation", Electronics Letters Vol. 33, no. 8, April 1997, p. 64