EFFECT OF CIRCULAR SLOT ON RETURN LOSS, VSWR AND BANDWIDTH OF CIRCULAR MICROSTRIP PATCH ANTENNA FOR UWB APPLICATIONS

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Abstract – In this paper, Circular Microstrip Patch Antenna with and without circular slot is designed for Ultra Wide Band Application and effect of circular slot on Return Loss, VSWR and Bandwidth of Circular Microstrip Patch Antenna is studied. Microstrip feedline of 50Ω characteristic impedance is used to feed the patch. Partial ground plane technique is used to convert narrow band characteristics of Microstrip Patch antenna into wide band characteristics. FR-4 Epoxy Dielectric Substrate is used for design having ε_r = 4.4 and having standard thickness of 1.58mm. The design was optimized by using CST Microwave Studio TM 2011 software to obtain most suitable configuration in terms of desired value of Return Loss, VSWR and Bandwidth for antenna.

Index Terms- Circular Microstrip Patch Antenna, Partial Ground Plane, UWB, Bandwidth, Return Loss, VSWR, Gain.

I. INTRODUCTION

Today wireless gadgets has become part of human life. Majority of electrical and electronic devices around us are using wireless system to communicate or operate. Antenna is an essential unit of wireless system which radiates electromagnetic waves into the space by converting electric power given at the input into the radio waves. At the receiver side antenna again receive these radio waves and convert them back into the electrical power[1-2]. Antenna is widely used in cellular phones, smart phones, satellite communications, DTH service, spacecraft, radars, wireless door phones, laptops, tablets and wireless computer networks[3]. Microstrip antennas are perfect for these application as it is light weight and can be easily integrated into antenna arrays or into microwave printed circuit boards. But these have a major drawback of narrow frequency bandwidth[2]. Todays wireless systems works over wide band of frequency[4] and hence the antenna should be capable for the same. In this research, an attempt is made to modify a narrow band antenna to work as ultra wide band antenna. By using techniques like partial ground plane[5], slotting the patch, etc wide band characteristics have been observed[6]. In microstrip antenna, a metallic layer of particular shape is bonded on a dielectric substrate which forms a radiating element and another continuous metallic layer on the other side of substrate as ground plane. Not only the basic shapes but any continuous shape can be used as the radiating patch [7]. For satisfactory performance of antenna VSWR < 2 and Return Loss (R.L) < -10dB throughout the entire ultra wide band range[8].

II. DESCRIPTION OF WORK

A narrow band Circular Microstrip patch is designed. Then using partial ground plane technique wide band characteristics is observed by changing the parameters like length, width of antenna and length, width of ground plane. After that circular slot is made on Circular Microstrip Patch Antenna and effect of circular slot on Return Loss, VSWR and Bandwidth of Circular Microstrip Patch Antenna is studied and analysed. Performance Analysis of designed antenna has been optimized in CST Microwave Studio TM 2011 software which utilizes finite Integration Technique for Electromagnetic Computation[9]

III. ANTENNA DESIGN CONFIGURATION

3.1 Circular Microstrip Patch Antenna with and without circular slot:-

Circular Microstrip Patch Antenna with and without circular slot is shown in Fig1.(a,b). Except circular slot and its dimension, all dimensions of both antenna are same. Partial ground plane structure is used in place of ground plane structure to convert narrow band antenna into wide band antenna. FR-4 Epoxy Dielectric Substrate is used for design having ε_r = 4.4 and having standard thickness of 1.58mm. Microstrip feedline of 50Ω characteristic impedance is used to feed the patch. The antenna design process is started by initially taking 8.2 GHz as resonant frequency. Performance of designed antenna has been optimized by varying the parameters of antenna given below in table 1.

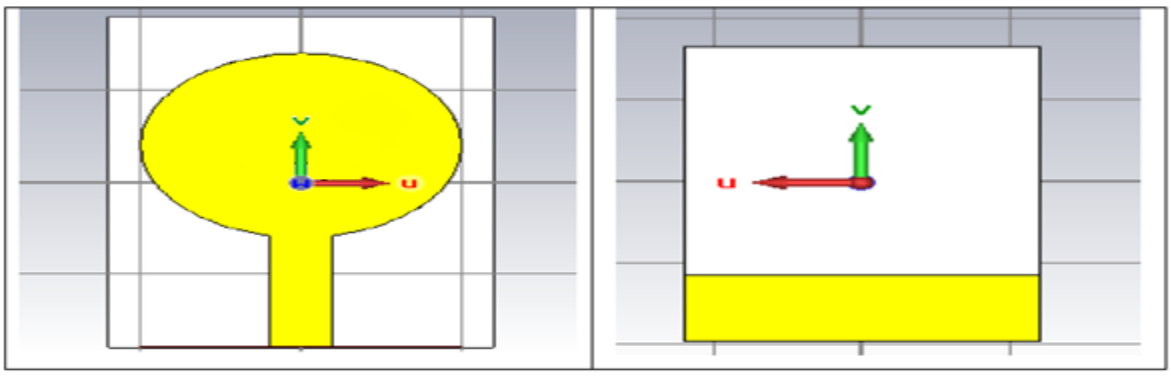


Fig. 1(a) Front and back view of Circular Microstrip Patch Antenna without circular slot.

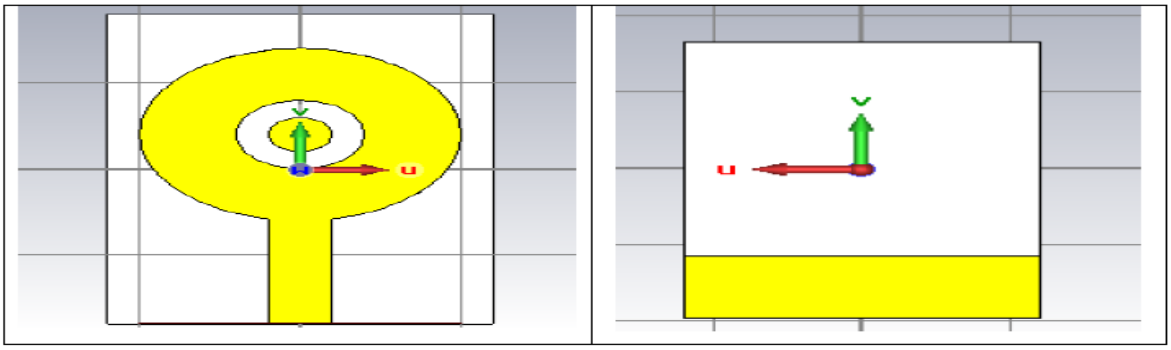


Fig. 1(b) Front and back view of Circular Microstrip Patch Antenna with circular slot.

3.2 Description of designed antenna:-

Except circular slot and its dimension, all dimension of both antenna are same.

Table 1 represents Dimension of designed Circular Microstrip Patch Antenna with and without circular slot.

Parameters	Description	Value(mm)
Lsub	Length of substrate	18
Wsub	Width of Substrate	12
Lf	Length of feedline	7
Wf	Width of feedline	2
a	Radius of Circular patch	5
Mt	Thickness of patch	0.07
h	Thickness of substrate	1.58
Lg	Length of ground plane	4
b	Outer slot radius	2
c	Inner slot radius	1

IV. RESULT AND DISCUSSION

The return loss, VSWR, gain and directivity plot of both designed antenna for resonant frequency of 8.2 Ghz is shown below.

4.1 Circular Microstrip Patch Antenna without circular slot on patch:-

The return loss, VSWR, gain and directivity of designed antenna for resonant frequency of 8.2 Ghz is shown below in Fig 2.(a, b, c, d) respectively. The design achieves return loss of -14.26 dB and the bandwidth of 8.43 GHz (4.74 - 13.17GHz) and corresponding VSWR is 1.48. The design antenna has Gain of 2.9 dB and Directivity of 3.6 dB. These results make it suitable for UWB application.

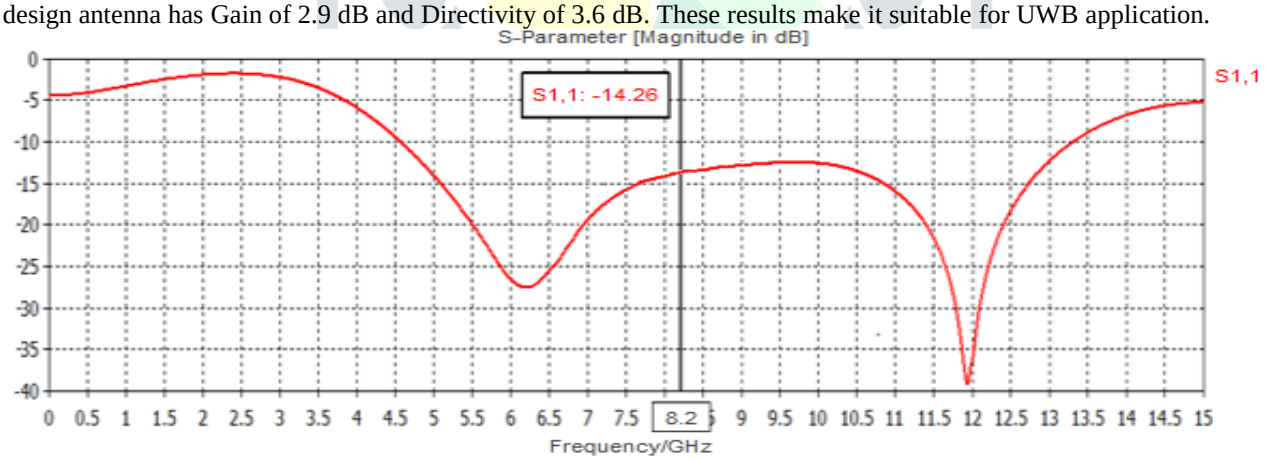


Fig. 2(a) Return Loss versus Frequency Plot, Return Loss = -14.26 dB

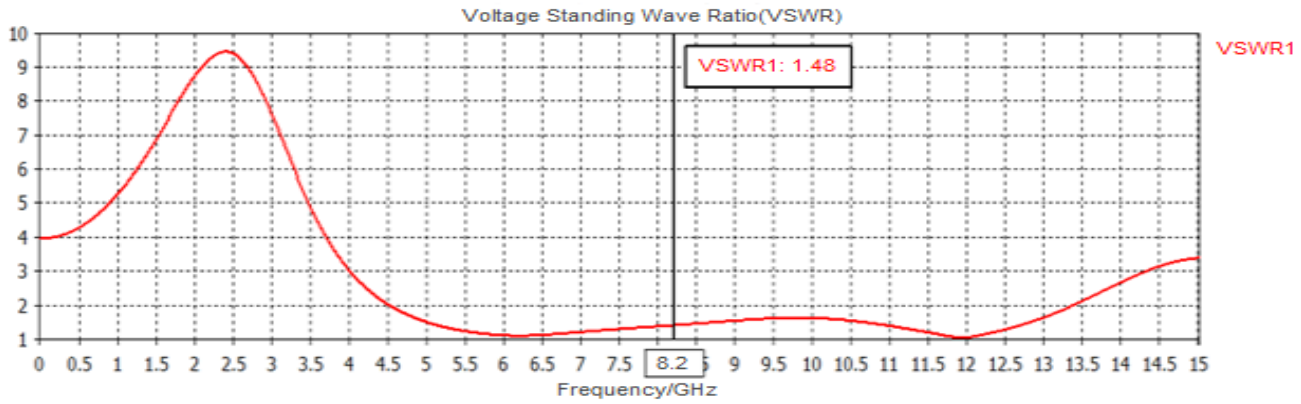
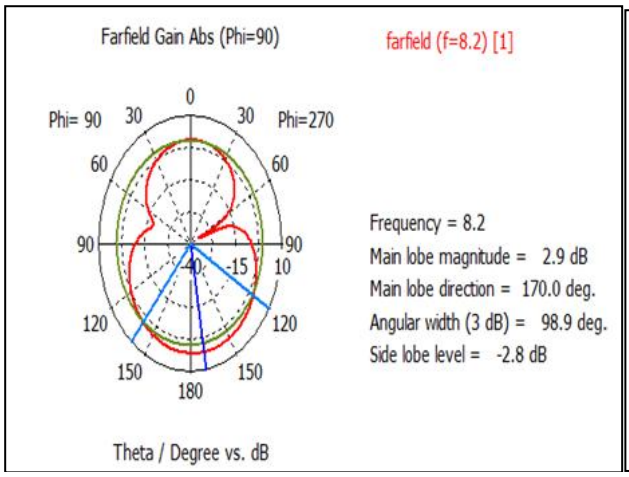
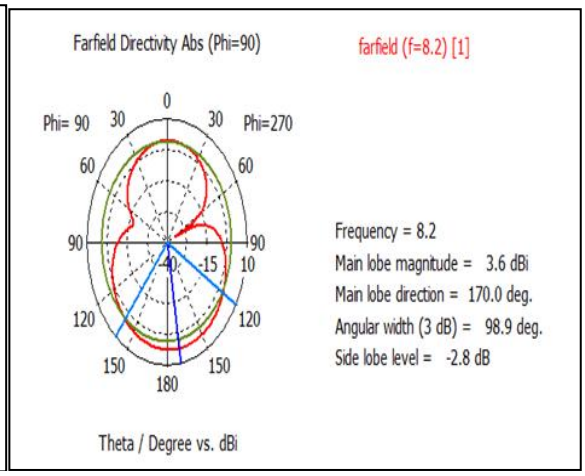


Fig. 2(b) VSWR versus Frequency Plot, VSWR =1.48





2D Radiation pattern plot for -Fig. 2(c) Gain= 2.9 dB **Fig. 2(d) Directivity = 3.6 dB**

4.2 Circular Microstrip Patch Antenna with circular slot on patch:-

The return loss, VSWR, gain and directivity of designed antenna for resonant frequency of 8.2 Ghz is shown below in Fig 3.(a, b, c, d) respectively. The design achieves return loss of -17.88 dB and the bandwidth of 8.11 GHz (4.89 - 13.0GHz) and corresponding VSWR is 1.29. The design antenna has Gain of 2.8 dB and Directivity of 3.5 dB. These results make it suitable for UWB application.

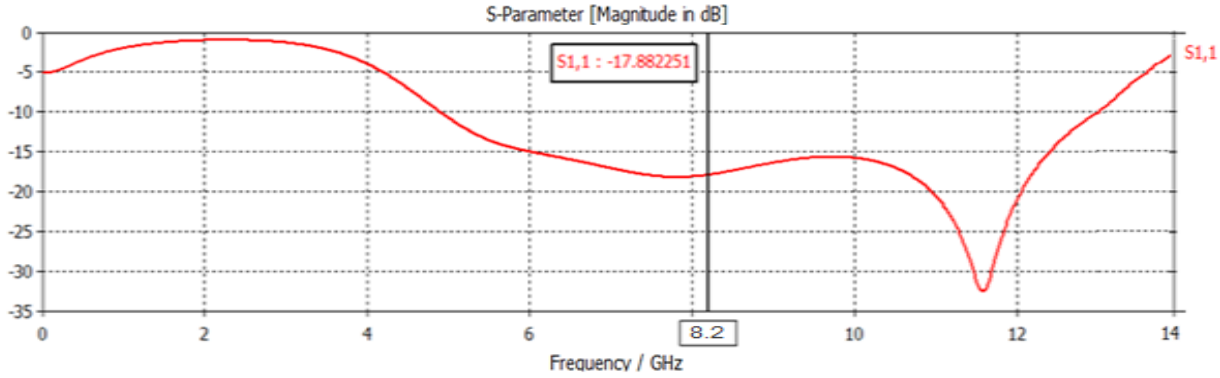


Fig. 3(a) Return Loss versus Frequency Plot, Return Loss = -17.88 dB

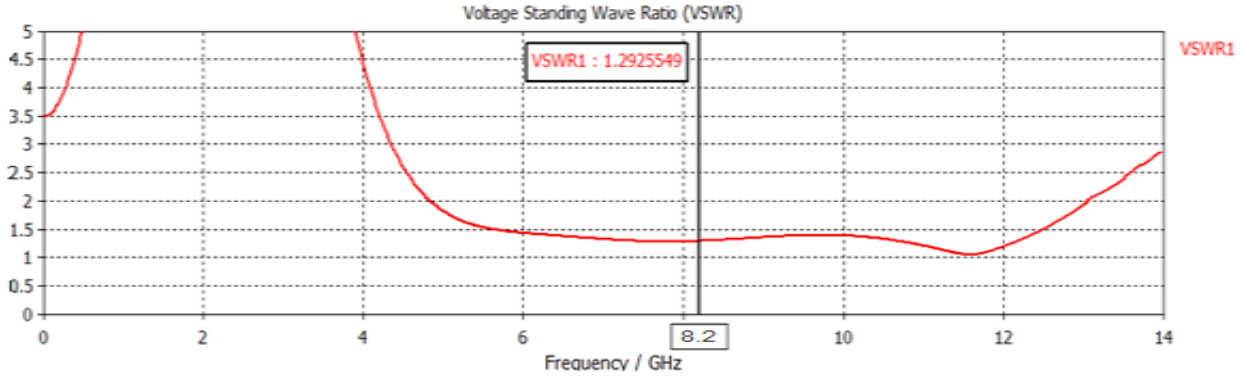
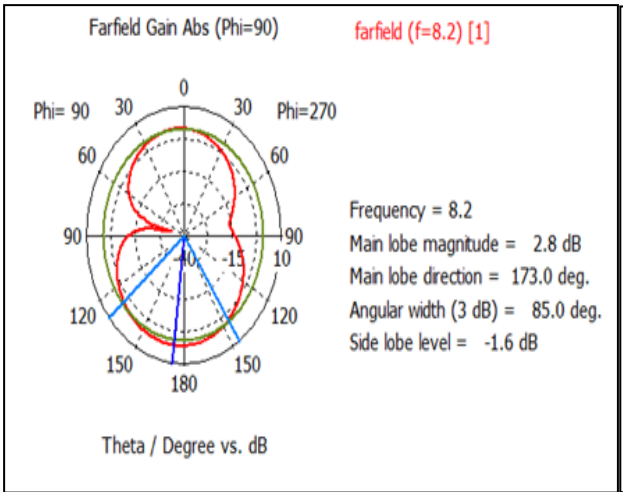
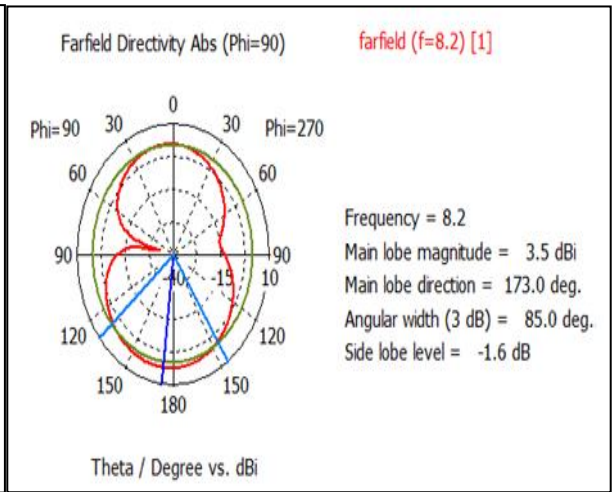


Fig. 3(b) VSWR versus Frequency Plot, VSWR =1.29





2D **Radiation pattern plot for - Fig. 3(c) Gain= 2.8 dB** **Fig. 3(d) Directivity = 3.5 dB**

4.3 Comparison of Simulated Result:-

The results of design are compared in below table3:-

Table 2 represents Comparison of Simulated Result

Antenna Parameter	Circular Patch Antenna without circular slot	Circular Patch Antenna with circular slot
Return Loss	-14.26 dB	-17.88 dB
Bandwidth	8.43 Ghz	8.11 Ghz
VSWR	1.48	1.29
Gain	2.9 dB	2.8 dB
Directivity	3.6 dB	3.5 dB
Area of Patch	78.54 mm^2	78.54 mm^2

4.4 Analysis of effect of circular slot on Return Loss, VSWR and Bandwidth of Circular Microstrip Patch Antenna:-

- **i.** Circular Microstrip Patch Antenna with circular slot provides better value of Return Loss and VSWR as compared to Circular Microstrip Patch Antenna without circular slot for equivalent design parameter, operating at same resonant frequency.
- **ii.** Circular Microstrip Patch Antenna with circular slot has better radiation efficiency as compared to Circular Microstrip Patch Antenna without circular slot for equivalent design parameter, operating at same resonant frequency.
- **iii.** Circular slot increases the value of Return Loss and VSWR of Circular Microstrip Patch Antenna and thus improves the radiation efficiency of antenna.
- **iv.** There is negligible change in Bandwidth, Gain and Directivity of Circular Microstrip Patch Antenna due to circular slot.
- **v.** Thus Circular slot improves overall characteristics & performance of Circular Microstrip Patch Antenna.

V. CONCLUSION

In this paper, circular microstrip patch antenna for UWB application is designed and simulated over CST microwave studio and effect of circular slot on Return Loss, VSWR and Bandwidth of Circular Microstrip Patch Antenna has been studied. Following conclusions can be made on the basis of above study:-

- **i.** Circular Microstrip Patch Antenna without circular slot on patch attains return loss of -14.26dB, bandwidth of 8.43 Ghz (4.74-13.17GHz) for resonant frequency of 8.2 Ghz and corresponding VSWR is 1.48 and hence can be used for UWB applications.
- **ii.** Circular Microstrip Patch Antenna with circular slot on patch attains return loss of -17.88 dB, bandwidth of 8.11GHz (4.89 - 13.0GHz) for resonant frequency of 8.2 Ghz and corresponding VSWR is 1.29 and hence can be used for UWB applications.
- **iii.** Circular slot increases the value of Return Loss and VSWR of Circular Microstrip Patch Antenna and thus improves the radiation efficiency of antenna.
- **iv.** There is negligible change in Bandwidth, Gain and Directivity of Circular Microstrip Patch Antenna due to circular slot.
- **v.** Thus Circular slot improves overall characteristics & performance of Circular Microstrip Patch Antenna.

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