ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526

IJIREEICE

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING
Vol. 3, Issue 7, July 2015

Performance of Circular Patch Antenna for Different Substrate Materials using HFSS

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Abstract: Due to the existence of growth in development of low cost, less weight, highly reliable, minimal profile antennas for wireless devices, it poses a new challenge for the design of antenna in wireless communications. This paper presents designs and simulations of a circular micro strip patch antenna at 14 GHz for wireless communications that provides a radiation pattern and achieves different gains for different substrate materials. The circular micro strip patch antenna was analysed using Ansys HFSS and also made a comparision among the different substrates which shows different results based on same parameters.

Keywords: Microstrip patch antenna, Frequency, Gain, Beamwidth, HFSS, Wireless communication.

1. INTRODUCTION

In recent years there is a need for more compact antennas due to rapid decrease in size of personal communication devices. As communication devices become smaller due to greater integration of electronics, the antenna becomes a significantly larger part of the overall package volume. This results in a demand for similar reductions in antenna size. In addition to this, low profile antenna designs are also important for fixed wireless application. The microstrip antennas used in a wide range of applications from communication systems to satellite and biomedical applications.

In order to simplify analysis and performance prediction, the patch is generally square,rectangular,circular, triangular, elliptical or some other common shape. The circular microstrip patch antenna is the widely used of all the types of microstrip antennas that are present The substrate material, dimension of antenna, feeding technique will detemines the performance of microstrip antenna. Hence among different feeding techniques,microstrip fed technique is used for the design of circular microstrip patch antenna at 14GHz.The different substrate materials. With The software tool HFSS is used because it is a high performance full wave electromagnetic (EM) field simulator for arbitrary 3D volumetric passive device modeling.

II. DESIGN CONSIDERATION

We have designed an circular patch antenna with center frequency of 14 GHz, height of substrate considered is 0.8mm. We have used different substrate materials like Air, RogersRT/duroid5880, RogersRT/duroid6002, FR4epoxy, Taconic. The three essential parameters for the design of microstrip patch antenna are:

1)Frequency of operation (f_0):

The resonant frequency of the antenna must be selected appropriately.

2)Dielectric constant of the substrate (ϵ_r):

In low dielectric constant gives fast substrate and high dielectric constant gives slow substrate.

3)

4)Height of dielectric substrate (H):

For the microstrip patch antenna the height of the dielectric substrate is critical since the antenna should not be bulky.

The transmission line model will be used to design the antenna.The microstrip feed line is used in this design.

Substrate Name	ϵ_r value
air	1
Rogers RT/duroid 5880	2.2
Rogers RT/duroid 6002	2.94
FR4	4.4
Taconic	10

Equations to calculate radius of patch :

$$F = \frac{8.791 \times 10^9}{f_r \sqrt{\varepsilon_r}}$$

$$a = \frac{F}{\left\{1 + \frac{2h}{\pi \varepsilon_r F}\left[\ln\left(\frac{\pi F}{2h}\right) + 1.7726\right]\right\}^{1/2}}$$

$$a_e = a\left\{1 + \frac{2h}{\pi \varepsilon_r a}\left[\ln\left(\frac{\pi a}{2h}\right) + 1.7726\right]\right\}^{1/2}$$

Antenna with different substrates:

1)Taconic substrate

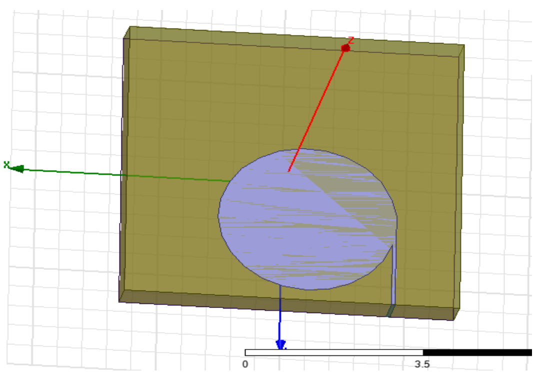

Fig 1. Antenna design with Taconic substrate

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Vol. 3, Issue 7, July 2015

2)FR4 epoxy substrate

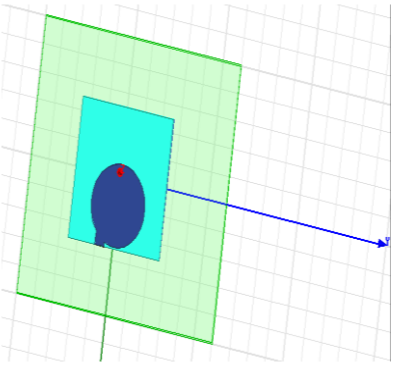

Fig 2. Antenna design with FR4 epoxy substrate

3)RogersRT/duroid5880

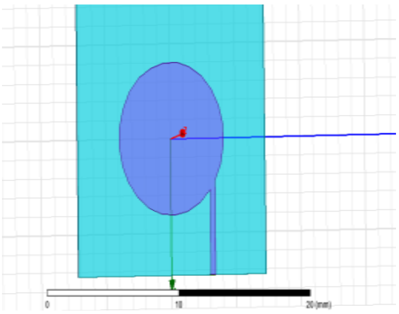

Fig 3. Antenna design with RogersRT/duroid5880 substrate

4)RogersRT/duroid6002

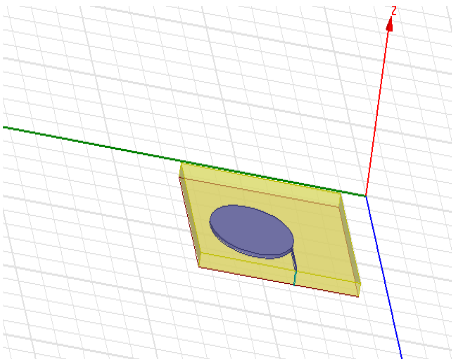

Fig 4. Antenna design with RogersRT/duroid6002 substrate

5)Air

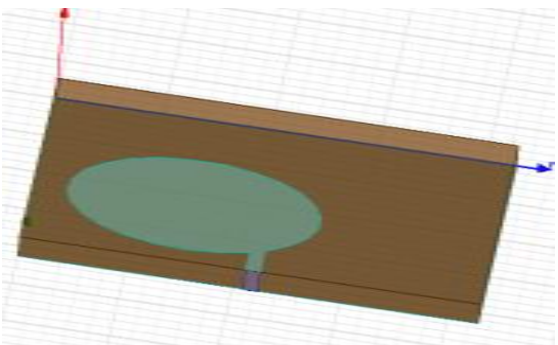

Fig 5. Antenna design with Air substrate

III. RESULTS

S-plot for different substrates:

The plot below shows the return loss plot for different substrates, observed a maximum return loss of -32 dB for FR4 and a minimum return loss of -20 dB for Rogers6002.

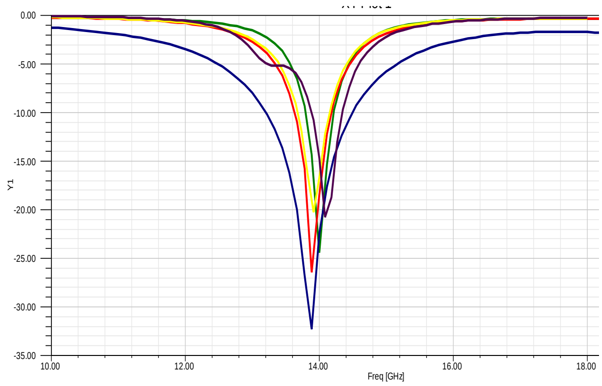

Fig 6. Return Loss for different substrates (Greeen-Rogers5880, Yellow-Rogers6002, Red-Air, Blue-FR4epoxy, Brown-Taconic)

VSWR plot with different substrate:

The plot below shows the VSWR plot for different substrates, observed a highest VSWR of 1.68 dB for Rogers6002 and a lowest VSWR of 0.82 dB for Air.

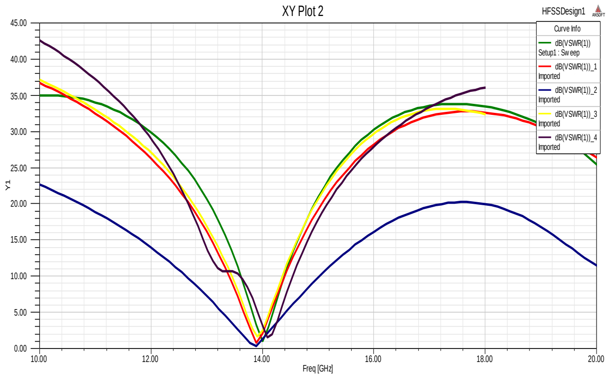

Fig 7. VSWR plot with different substrates (Greeen-Rogers5880, Yellow-Rogers6002, Red-Air, Blue-FR4epoxy, Brown-Taconic)

3D Polar Plot:

A total Gain of 4.49 dB is observed for antenna with Taconic substrate

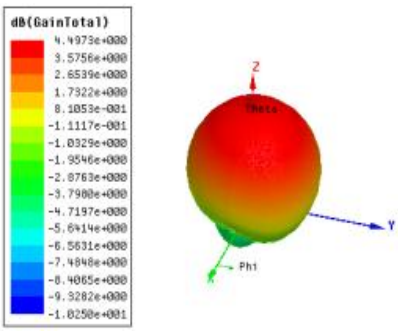

Fig 8. 3D Polar plot for Taconic substrate

ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526

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INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING
Vol. 3, Issue 7, July 2015

3D Polar Plot:
A total Gain of 9.79 dB is observed for antenna with air substrate

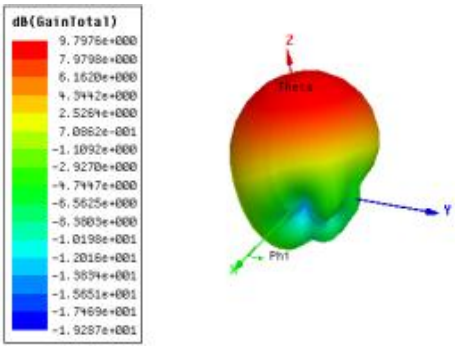

Fig 9. 3D Polar plot for Air substrate

3D Polar Plot:
A total Gain of 7.632 dB is observed for antenna with Rogers5880 substrate

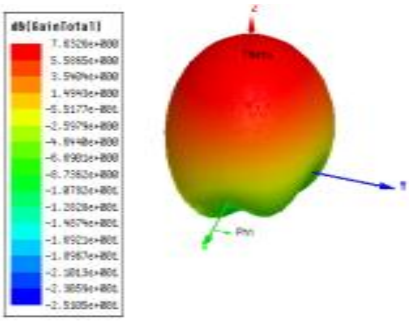

Fig 10. 3D Polar plot for Rogers5880 substrate

3D Polar Plot:
A total Gain of 7.370 dB is observed for antenna with Rogers6002 substrate

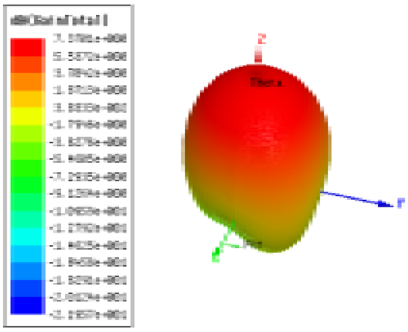

Fig 11. 3D Polar plot for Rogers6002 substrate

3D Polar Plot:
A total Gain of 5.763 dB is observed for antenna with FR4epoxy substrate

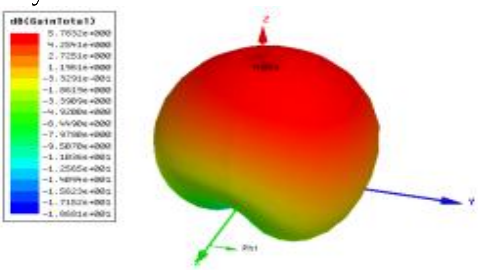

Fig 12. 3D Polar plot for FR4 Epoxy substrate

Radiation patterns of the antennas with different substrates are as shown below, observed a Omni directional radiation pattern for all the antennas

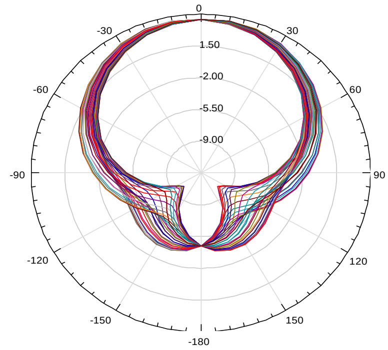

Fig 13. Radiation pattern for Taconic substrate

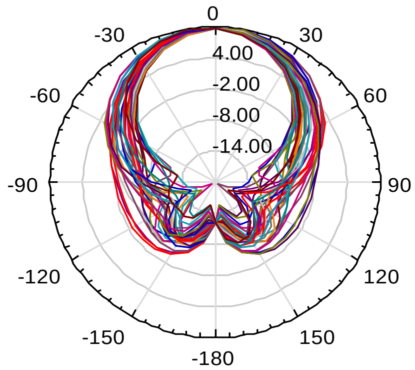

Fig 14. Radiation pattern for Air substrate

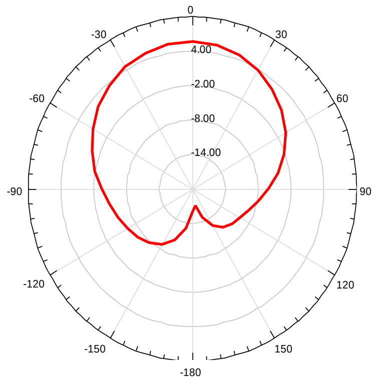

Fig 15. Radiation pattern for Fr4 Epoxy substrate

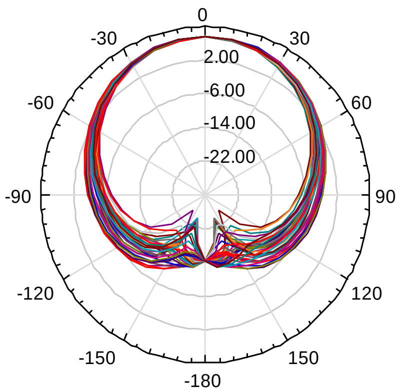

Fig 16. Radiation pattern for Rogers5880substrate

DOI 10.17148/IJIREEICE.2015.3710

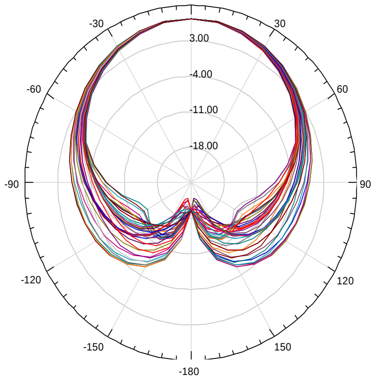

Fig 17. Radiation pattern for Rogers6002 substrate

Below table shows a comparision of GAIN, VSWR and S-Plot for different antennas.

SUBSTRATES	GAIN	VSWR	Return Loss
Taconic	4.497	1.592	-20.78
Air	9.797	0.8271	-26.4526
FR4epoxy	5.763	1.357	-32.28
Rogers5880	7.632	1.043	-24.484
Rogers6002	7.3701	1.6865	-20.842

Tabel 1. comparision of GAIN, VSWR and Return Loss

IV. CONCLUSION

Circular micro strip patch antenna for different substrates were analysed using Ansys HFSS and also made a comparision among the different substrates which shows different results based on same antenna parameters. Observed that antenna with Air as a substrate has a maximum gain and least VSWR, and observed that antenna with FR4 Epoxy as a substrate has a Good Return Loss.

ACKNOWLEDGMENT

Extending our grateful thanks to the authorities of Acharya Nagarjuna University for their support and encouragement to write this paper

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ISSN (Online) 2321 – 2004
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Vol. 3, Issue 7, July 2015

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