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Design and Analysis of Dual Band Microstrip Circular Patch Antenna

Sudarshan Kumar Jain

Assistant Professor

Department of Electronics and Communication Engineering
Jagannath University, Jaipur

Abstract: In this paper a dual band microstrip circular patch antenna with high gain is proposed. The antenna is designed at a frequency of 2.4 GHz and it has dual band characteristics. Due to the dual band characteristics, antenna can be used for the two resonant frequencies. The microstrip line feeding method is used here to energize the designed dual band antenna. Voltage standing wave ratio (VSWR) of the designed circular patch antenna is less than 2. The different characteristics of the antenna such as return loss(S_{11}), gain, bandwidth, directivity, radiated field and VSWR is analysed for the two substrates such as Rogers RT/duroid 5880 and Arlon AD250 having different dielectric permittivity. The gain of the designed antenna is 6.93dB and 7.12dB using Arlon AD250 and Rogers RT/duroid 5880 respectively.

Keywords: Micro strip antenna, Dual band, Micro strip feeding, VSWR

I. INTRODUCTION

Microstrip Patch antennas(MPA) are very simple in design, having light weight, low fabrication cost make it special so that it can be used for various applications such as satellite communication ,mobile communication, etc. In today's scenario due to continuous minimization in size of electronic systems, continuous demand of small and low cost antennas is increasing [1]. Microstrip Patch antennas are interesting antennas for integrated RF front-end systems due to their compatibility with microwave integrated circuits (MICs). Microwaves are used in various aspects of life for different applications. At microwave frequencies the physical size of high gain antenna becomes very small. To make practical the use of suitably shaped reflector can produce the desired directivity.Bandwidth of the antenna decreased as the dielectric constant of the substrate increases [2].

Multiple antennas can be replaced by single multiband or wide band antenna which can be used to support various wireless communications application[5-7].When antenna is excited using the appropriate feeding method electromagnetic(EM) waves propagate in all directions. Microstrip patch antenna (MSPA) can be energized by aperture coupling, microstrip line, coaxial probe method and proximity coupling. Out of these feeding methods microstrip line feeding method is more flexible, compact, easy to use and fabricate [3].

II. ANTENNA DESIGN

In the proposed paper antenna is designed and analysed at a resonant frequency of 2.4 GHz using the different substrates such as Rogers RT/duroid 5880(tm), Arlon AD250A(tm) and having the following dimensions

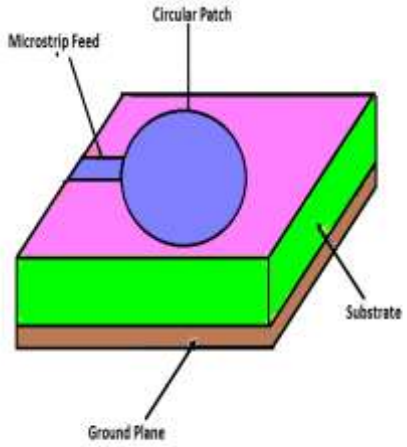

Fig.1 Microstrip Circular Patch antenna Structure

TABLE I
Designed Antenna Specifications

Parameter	Value
Frequency	2.4 GHz
Size of Substrate	100 x 100 mm
Excitation method	Microstrip Line feeding
Height of substrate	0.32cm

For the designing of antenna, Arlon AD250A is taken as the dielectric substrate having permittivity of 2.5. So the circular patch antenna radius for this dielectric substrate is 21.63mm. The different characteristics of the antenna such as bandwidth, return loss (S_{11}), gain, directivity, radiated field and voltage standing wave ratio (VSWR) is analysed for this designed antenna. It is observed from the simulation results that return loss curve of the antenna has dual band characteristics. The same antenna design is simulated using another substrate material Rogers RT/duroid 5880 having permittivity of 2.2. So the radius of the designed for this permittivity is 22.94mm. All the characteristics of the antenna are analysed for both substrate materials.

III. RESULTS AND DISCUSSIONS

The designed microstrip dual band circular patch antenna is simulated using two substrate materials having different dielectric permittivity and various results are obtained and analysed. The simulated results for antenna gain, return loss, voltage standing wave ratio (VSWR), directivity, electric field are observed. All the outputs received of the designed dual band microstrip circular patch antenna is shown below-

3.1. Outputs using Arlon AD250A:

As the antenna is designed for resonant frequency of 2.4GHz and dielectric permittivity for Arlon AD250A is 2.5 so the radius of the patch will be 21.63mm for the designed antenna. The return loss (S11), gain (dB), directivity (dB) and voltage standing wave ratio (VSWR) curve using Arlon AD250A as a substrate material is shown below.

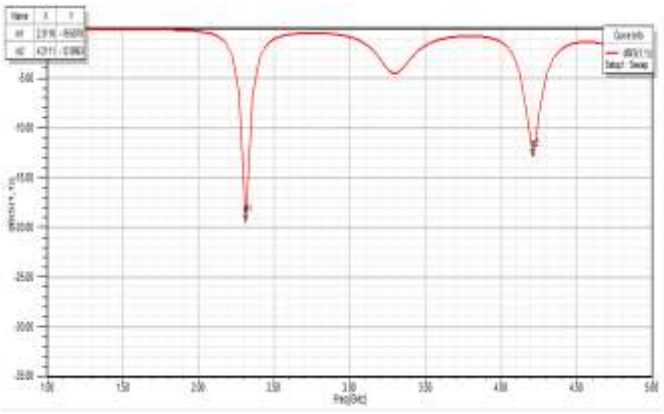

Fig.2 Frequency V/S Return Loss

TABLE II
Frequency V/S Return Loss

Name	Frequency(GHz)	Return Loss(dB)
M1	2.3116	-19.5078
M2	4.2111	-12.8953

It is clear from Fig. that two resonant frequencies are received where the value of return loss < -10dB.

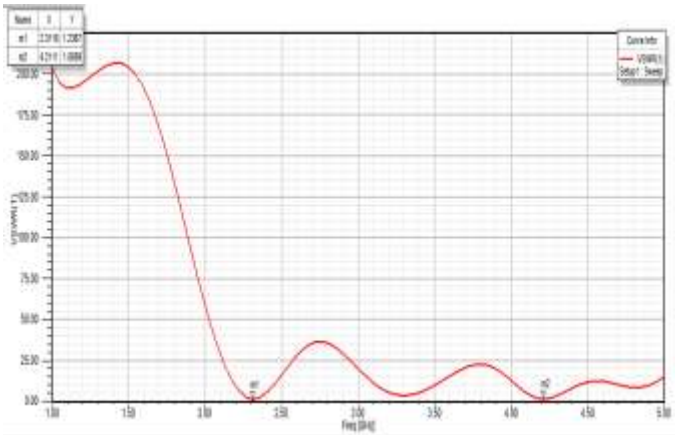

Fig.3 VSWR (Voltage Standing Wave Ratio)

From Figure 3 it is seen that voltage standing wave ratio is less than 2 for both the resonant frequencies and it is 1.236 and 1.586 respectively, which shows the minimum losses in the designed antenna.

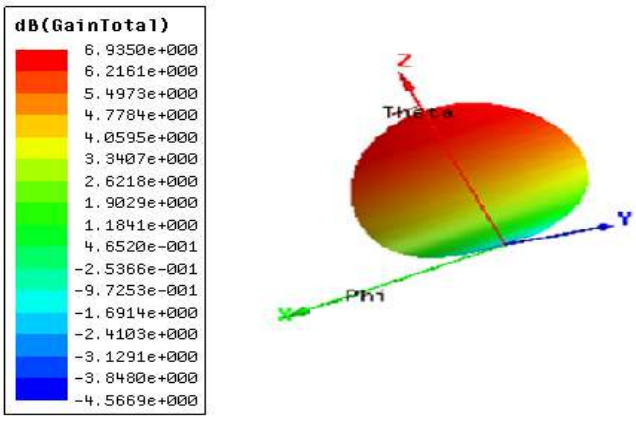

Fig.4 Antenna Gain

It is observed from the above 3-D polar plot that the maximum gain of 6.93 dB is achieved when Arlon AD250A is used as dielectric substrate for designing of the antenna.

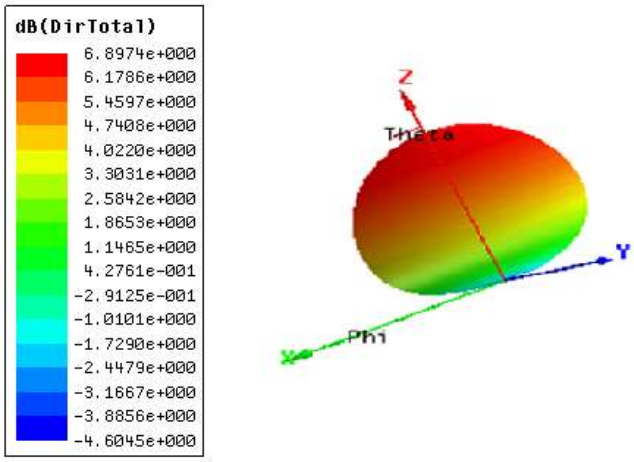

Fig.5 Directivity of Antenna

The maximum directivity of the designed antenna is 6.897 dB. This indicates good directional properties.

3.2. Outputs using Rogers RT/duroid 5880:

The antenna is designed for frequency of 2.4 GHz and dielectric permittivity for Rogers RT/duroid 5880 is 2.2, so the radius of the patch will be 22.94 mm. So using this radius the antenna is designed for dual band applications.

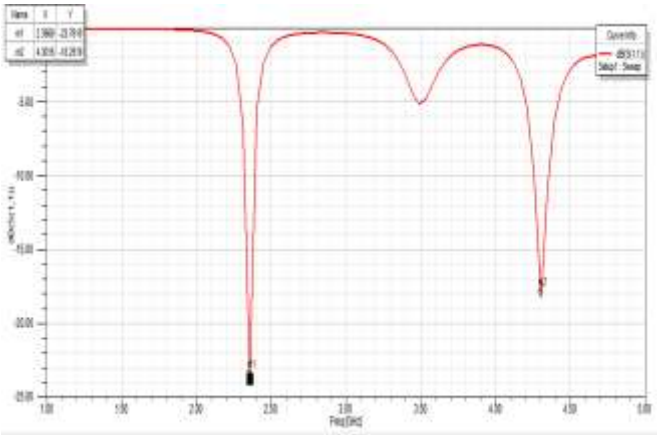

Fig.6 Return Loss of Dual Band Antenna

TABLE III
Frequency V/S Return Loss

Name	Frequency(GHz)	Return Loss(dB)
M1	2.3568	-23.7618
M2	4.3015	-18.2518

So from figure 6 it is clear that two resonant frequencies are received having the return loss < -10dB. The minimum return loss is -23.7618 dB at a frequency of 2.3568 GHz.

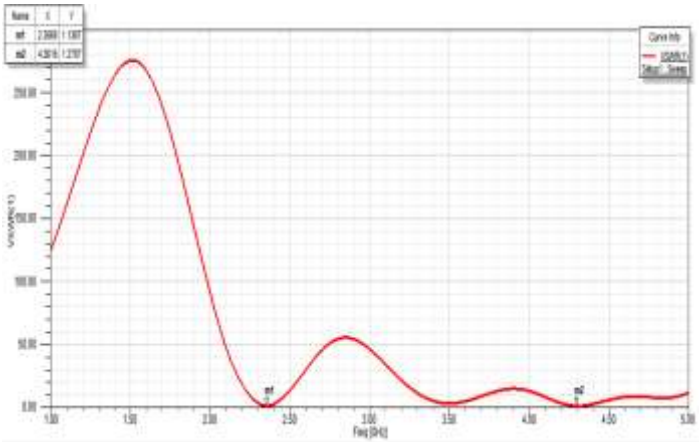

Fig.7 VSWR (Voltage Standing Wave Ratio)

So it can be seen from the above graph that voltage standing wave ratio (VSWR) is less than 2 for both the dual band and it is 1.1387 and 1.2787 respectively.

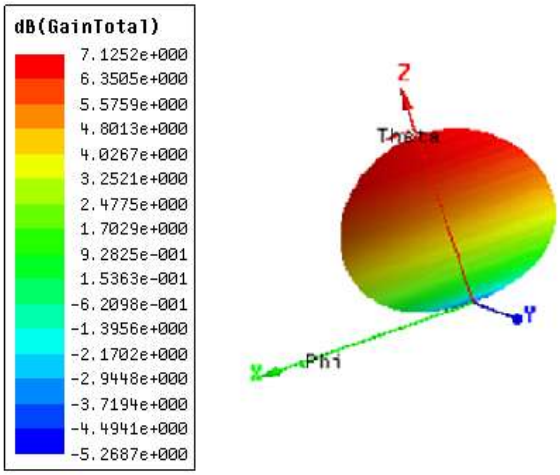

Fig.8 Antenna Gain

So it is clear from the above 3-D polar plot that maximum gain of 7.12 dB is attained when Rogers RT/ duroid 5880 is used as substrate for designing the antenna.

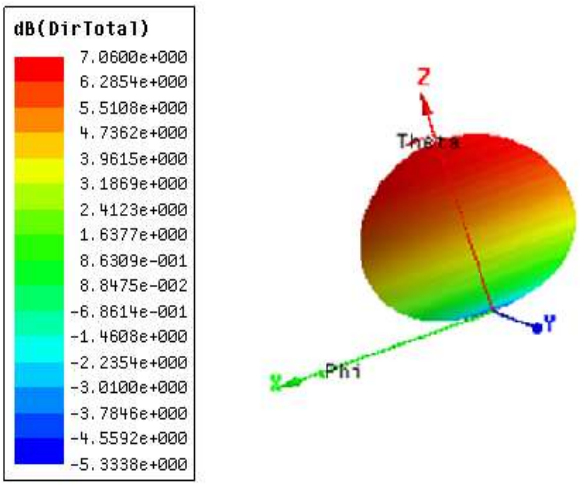

Fig.9 Antenna Directivity

The directivity of 7.06dB is achieved for the designed antenna when Rogers RT/ duroid 5880 is used as a substrate material.

TABLE IV
Comparison Chart of different Substrate Materials

Substrate Material	Minimum Return Loss(dB)	VSWR	Max. Gain (dB)	Directivity (dB)
Arlon AD250A	-19.50	<2	6.93	6.89
Rogers RT/duroid 5880	-23.76	<2	7.12	7.06

From the table IV it is clear that Rogers RT duroid gives the maximum gain and directivity when it is used in the designed antenna. Voltage standing wave ratio for both the substrate materials is less than 2. Fig.10 shows the comparison of two materials for various characteristics of designed antenna.

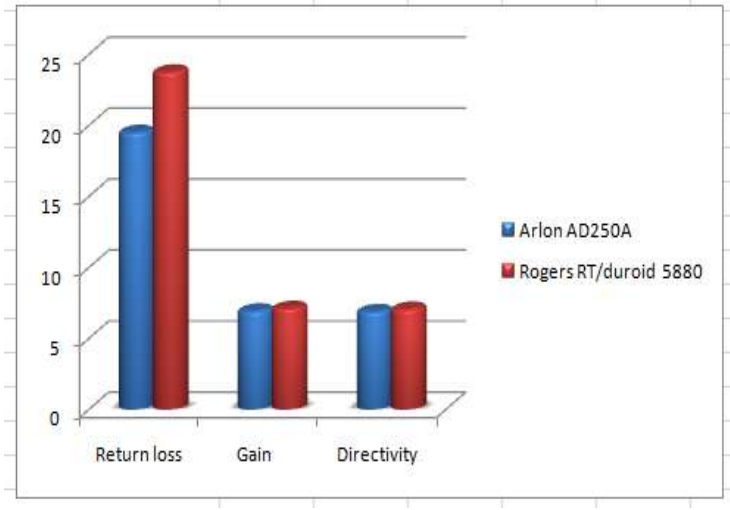

Fig.10 Comparison of two materials for return loss, Gain and Directivity of antenna

IV. CONCLUSION

So in the proposed paper a microstrip antenna having circular patch using two materials Arlon AD250A and Rogers's duroid gives the dual band characteristics for various applications. Here the gain of the designed antenna is analyzed for the different antenna characteristics such as voltage standing wave ratio (VSWR), gain (dB), return loss (S_{11}), directivity (dB) etc. From the simulation results it was observed that the Rogers RT/duroid 5880 provides the maximum gain and directivity 7.12dB and 7.06dB respectively for the resonant frequency of 2.4 GHz. Minimum S_{11} for the designed antenna is -23.76 dB.

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AUTHOR'S BIOGRAPHY

Sudarshan Kumar Jain received the B.E. degree in Electronics and Communication Engineering from Rajasthan University, Jaipur, India, in 2009, and the M.Tech. Degree (Hons.) from Rajasthan Technical University, Kota (Raj.) in 2014. He is currently working as Assistant Professor in Electronics & Communication Engineering Department at Jagannath University, Jaipur. He is active member of Institute of Electrical and Electronics Engineers (IEEE) and Society of Photo-Optical-Instrumentation Engineers (SPIE). His areas of interest are Microstrip patch antenna, thin film solar cells, Opto-Electronics.