DESIGN OF 4x2 ARRAY USING TWO DIFFERENT RADIATING PATCHES

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Abstract:

In this paper 4x2 microstrip patch antenna array is designed with dimensions of 6.33 mm x 7.28 mm x 0.508 mm and it is fabricate using RT duroid 5880 with microstrip fed line excitation. This is further implemented to arrays. It is one among the familiar methods for combining the radiation from a group of comparable antennas. Two different antennas are structured with two unique shapes of radiating patches. One antenna array is having rectangular radiating element and other is having circular radiating element. From the basic patch antenna 4*2 array is designed without disturbing the dimensions. This paper offers the detail steps of designing basic patch and 4*2 array antenna using HFSS Software. The reproduced outcomes results are shown that this paper is to analyse, design and validate the antenna array. The proposed antenna array offers accurate overall performance in phases of return loss, gain, VSWR and operating frequency.

Index Terms- RT duroid 5880, Antennas, Arrays , Return loss, Gain, VSWR, HFSS

1. INTRODUCTION

Since decades there was a huge improvement and advancement in the antenna research. Towards the accomplishments of high date rates and low signal power is been focusing on the development to fulfill the needs. In modern system of mobile communications, it became basic to have small antennas size and with weak assembling cost. It is notable that the plane and specific printed structures have several advantages compared to the conventional antennas like [1][2]

Their low cost

They are light and discrete (low thickness)

The innovation of their acknowledgment is compatible with conventional advances of printed circuits

Loop antennas

Patch antennas.

In this paper patch antennas technology is studied. A microstrip patch antennas consists of radiating patch contains one aspect of dielectric substrate that has ground plane on opposite side. The patch is commonly shaped from conducting material like either copper or gold. Patch antennas can radiate especially because of the reality of fringing fields between patch side and ground plane. The microstrip patch antennas are widely utilized in designing antennas because of its easy and low-cost fabrication and it is also facing some disadvantages like narrow bandwidth and less gain [2]. In antenna each radiating element is radiated individually whereas in arrays the radiating elements will sum up to form radiation beam which results high gain and better overall performance with minimal return loss [7][5].The configuration between the elements and the length of the elements as per the frequency are additionally to be remember while designing these antennas. In this proposed work initially a basic rectangular and circular patch is designed. With this assistance of single element, a 4x2 array antenna is designed which is resonating at multiple band with moderate gain.

2. DESIGN AND ANALYSIS ANTENNA

The microstrip patch antenna might be single layer structure which comprises of four section (patch, ground plane, substrate, and the feeding part). Patch antenna are often confidential as single element resonant antenna. Many shapes of patches are designed and most well-known one is the rectangular, square, and circular patch. A reference single element microstrip patch antenna is shown in Fig. (1). In this proposed design, the RT/duroid 5880 substrate was used. The substrate with height is 0.508 mm, εr=2.2 and a negligible tangent loss were utilized. The HFSS microwave studio tool was used to optimize the dimensions of the newly designed antenna.

Analysis of rectangular patch antenna:

The single patch antenna is outlined to works at resonant frequency of 29.2 GHz with input impedance of 50Ω using RT duroid substrate. RT duroid is used as substrate because of the low dielectric constant, low dissipation factor and immune to all solvents. The patch antenna parameters are calculated from the following antenna design equations [6][8].

i)Width of the patch(W)

$$W = \frac{c}{2f_0\sqrt{\frac{\varepsilon_r+1}{2}}} \quad (1)$$

where

ε_r=dielectric constant

c=free space velocity of light

f_o= operating frequency

ii) Length(L)

$$L = \frac{c}{2f_0\sqrt{\varepsilon_{eff}}} - 2\Delta L \quad (2)$$

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+\frac{12h}{W}\right]^{-1/2} \quad (3)$$

$$\Delta L = 0.412h\frac{(\varepsilon_{eff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{eff}-0.258)(\frac{W}{h}+0.8)} \quad (4)$$

L=actual length of patch

ε_{eff}=effective dielectric constant

h=substrate height

Minimum ground plane dimensions

L_g=6h+L (5)

W_g=6h+W (6)

As per the considerations the dimensions of the substrate are length Ls=6.33 mm and width is Ws=7.28 mm. A metal patch of length (L=3.28mm) and width (W=4.23 mm) was connected to 50Ω feed line with an inset on the top of the substrate. The dimensions of inset feed were Li=1.75 mm and Wi=1.62 mm. To meet the requirement of minimal return loss 1.1 mm gap is introduced within the patch as shown fig (1).

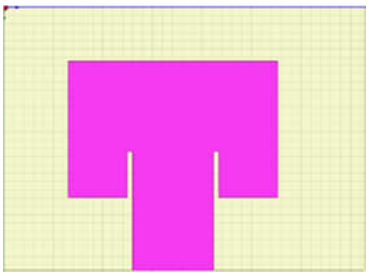

Fig (1): basic rectangular patch

Analysis of circular patch antenna:

During this typical design procedure of the microstrip patch antenna the specified resonant frequency, thickness and therefore the dielectric substrate are known initially. By the formulae the radius of circular antenna is determined. Dimensions of substrate are 6.33 mmX7.28 mmX0.508 mm and radius of circular patch is 1.6 mm.

Formulas for calculating radius (a) [6][8]

$$a = \frac{F}{\left\{1+\frac{2h}{\pi\varepsilon_r F}\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}^{1/2}} \qquad (8)$$

$$(f_r)_{110} = \frac{1.8412 v_0}{2\pi a_e \sqrt{\varepsilon_r}} \qquad (9)$$

With help of those formulae all the parameters that are needed to design an antenna are obtained. The dimensions of single patch are calculated as shown figure 2.

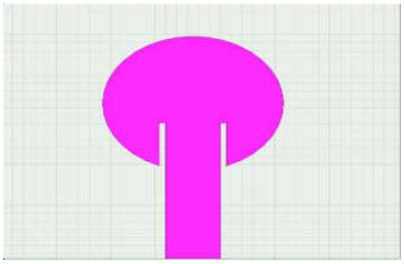

Fig (2): basic circular patch

Further, we also evaluated the Return loss, Gain, VSWR for single Circular Patch Antenna. Then individually extended the work to evaluate the above-mentioned parameters to 4x2 array by utilizing High Frequency Structure Simulator software. The elemental objective of this work is to extend the gain of the antenna through the implementation of arrays [5].

4x2 array:

To make comparison an equivalent substrate as in single element (εr=2.2 and thickness 0.508mm) is employed within the 4x2 array. To design an array the spacing between the elements is adjusted to Satisfy the requirements. The rectangular and circular patch antenna array with eight elements is used and these elements are encouraged by different edges in a feed network system. A microstrip fed feed is utilized in the design of the antenna. The effective feed line is utilized to associate all the eight elements. Defected ground structure is introduced by making small changes in the ground to get better results [7][3].

4x2 rectangular patch antenna array

A modified 4x2 element array microstrip patch antenna is illustrated in Fig. (3). This model is introduced for the purposes of enhancing the performance of the antenna such as increasing its gain without disturbing the substrate dimensions and patch dimensions are divided by eight because of utilizing 8 patches and ground is halved to get better results [3][6].

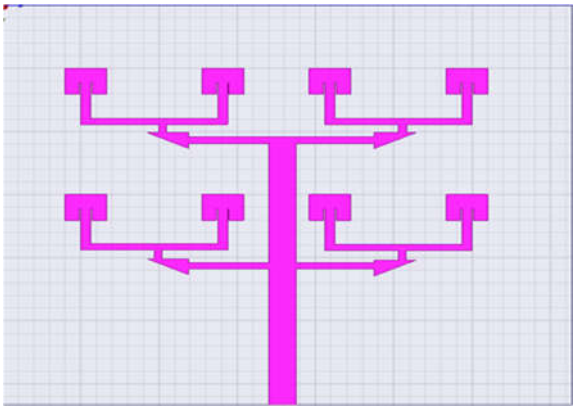

Fig (3):4x2 rectangular array antenna

4x2 Circular patch array antenna:

The gain of single element circular patch antenna is 6.8 dB. To increase the gain of antenna. The 4x2 circular patch array antenna is introduced is illustrated in fig (4).

The substrate dimensions are same and radius of the circle is 0.4 mm. The ground is halved which results minimal returns loss and more gain [3][6].

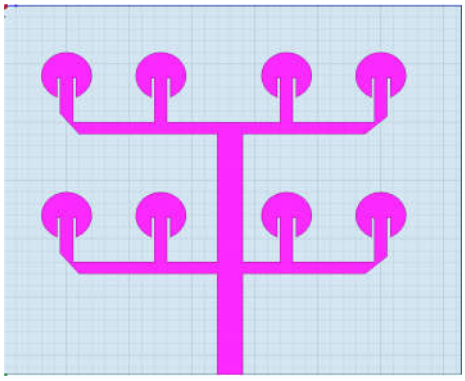

Fig (4): 4x2 circular patch array antenna

3. SIMULATION RESULTS

RETURN LOSS:

Fig.5(a) and (b) shows the Return Loss of proposed antenna in dB. S11 Gives the Return Loss at the feed position where the input to the Microstrip patch antenna was applied. It should be less than -10 dB for an acceptable operation. This S11 plot describes operating frequency from the dip range i.e. S11 <-10 dB.

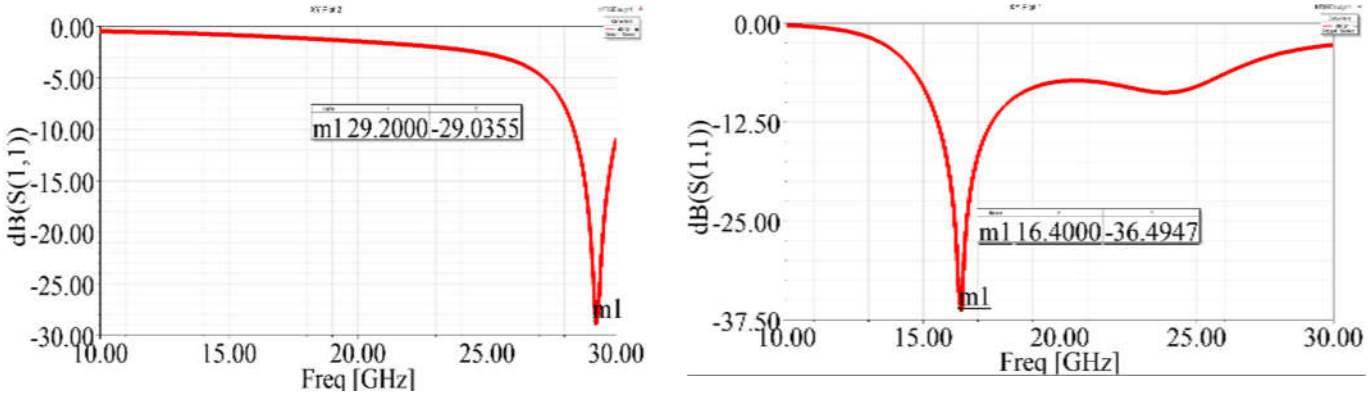

Fig.5(a): S11 of rectangular patch and circular patch antenna

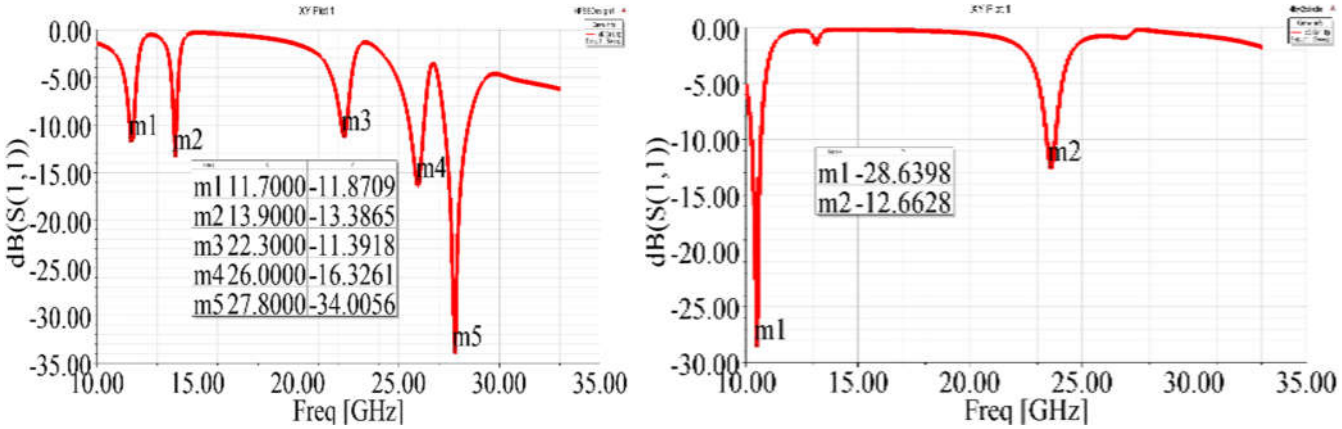

fig.5(b): S11 of 4x2 rectangular and circular patch array antenna

VSWR:

Fig.6. (a) and (b) shows the VSWR plot for the four cases of rectangular Single Patch Antenna, Circular Patch Antenna, 4X2 rectangular patch antenna array and 4x2 Circular Patch Antenna array respectively. VSWR value under 2 is acceptable for antennas.

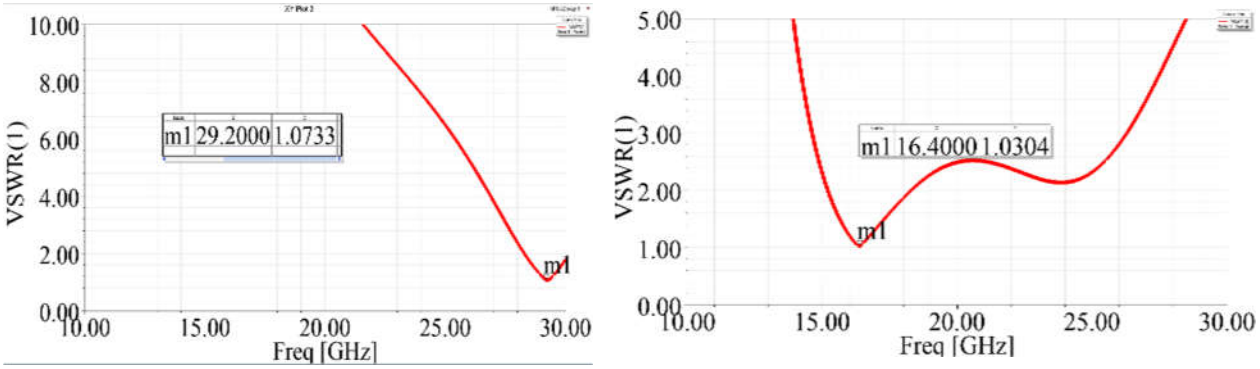

Fig.6(a): VSWR of rectangular patch and circular patch antenna

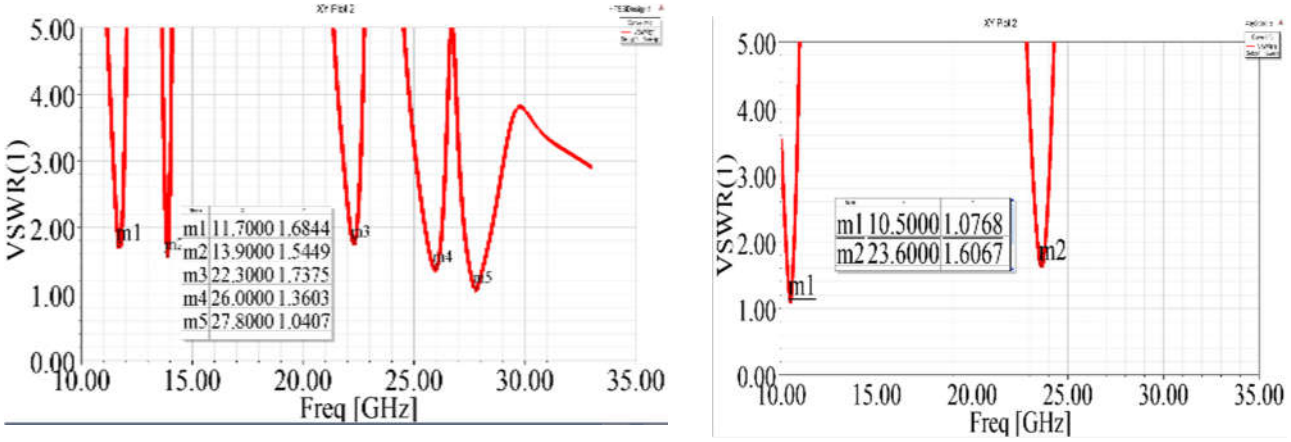

Fig.6(b): VSWR of 4x2 rectangular and circular patch antenna

GAIN:

The peak gain values of the single rectangular patch antenna, Circular Patch Antenna, 4x2 rectangular patch array and 4x2 Circular Patch Antenna array results are 6.1 dB, 6.8 dB, 7.0 dB and 8.1dB respectively that are introduced in fig. 7(a) and 7(b).

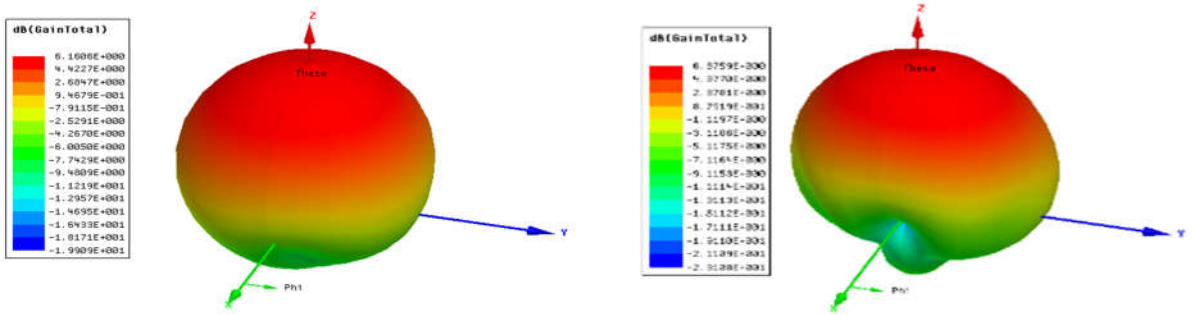

fig.7(a): VSWR of rectangular patch and circular patch antenna

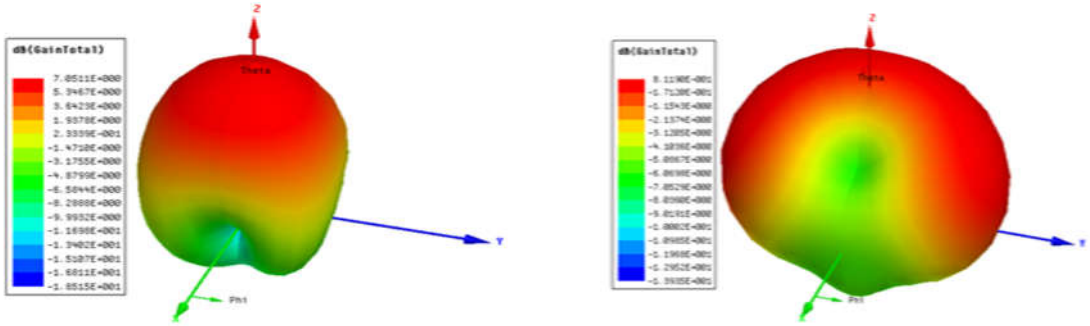

Fig.7(b): Gain of 4x2 rectangular and circular patch Antenna

Table: Comparison for designed antenna

Parameters	Rectangular patch	Circular patch	4*2 array rectangular	4*2 array Circular
Operating frequency (GHz)	29.2	16.4	11.7,13.9, 22.3,26.0,27.8	10.5, 23.6
Return loss(dB)	-29.0	-36.4	-11.8,-13.3, -11.3,-16.3,-34.0	-28.6, -12.6
VSWR	1.0	1.0	1.6,1.5,1.7,1.3, 1.0	1.0,1.6
Gain(dB)	6.1	6.8	7.0	8.1

4. CONCLISION

The design layouts and simulation of microstrip feed antennas was properly designed and analyzed using HFSS software. Comparative analysis was made by changing the shape of patch using RT duroid. These antenna arrays are optimized to obtain multiband frequencies with minimal return loss and gain. In this work, 4x2 array from the basic rectangular and circular patches. From the comparison table it seems that 4x2 rectangular patch array will get the multiple frequencies 11.7 GHz, 13.9 GHz, 22.3 GHz, 26.0 GHz and 27.8 GHz with gain of 7.0 dB. And from the 4x2 circular patch array the operating frequencies are 10.5 GHz and 23.6 GHz with high gain of 8.1 dB. The proposed layouts can be used for mm wave applications and also future 5G.Further the work will be carried out to design arrays with n elements to increase gain using other feeding techniques.

5. REFERENCES

[1] Awl, Halgurd N., and Rashad H. Mahmud. "New Configuration of Microstrip Patch Antenna Arrays." ZANCO Journal of Pure and Applied Sciences 31.s4 (2019): 30-33.

[2] Raj, Tej, and Brijlata Chauhan. "Review and Survey of Broadband Techniques of Microstrip Patch Antenna." International Journal of Computer Applications 94.5 (2014).

[3] Melkeri, Vidyadhar S., S. L. Mallikarjun, and P. V. Hunagund. "Microstrip Antenna with Defected Ground Structure: A Review." International Journal of Electrical Electronics and Telecommunication Engineering, ISSN (2015): 2051-3240.

[4] Darshan, Ravi Antil, and Devraj Gautam. "Design High Directive Rectangular Microstrip Patch Antenna with Superstrate." International Journal of Advanced Research in Electronics and Communication Engineering 3.8 (2014): 956-962.

[5] Anjaneyulu, G., and J. Siddartha Varma. "Design and simulation of multi band microstrip antenna Array for satellite applications." 2018 Second International Conference on Electronics, Communication and Aerospace Technology (ICECA). IEEE, 2018.

[6] Olaimat, Melad M. "Comparison between rectangular and circular patch antennas array." International Journal of Computational Engineering Research (IJCER) 6.9 (2016).

[7] Khatun, MstHasneara, ReefatInum, and NaziaTasnim. "Design of Rectangular Patch Antenna Array Using Different Feeding Technique." 2017 2nd International Conference on Electrical & Electronic Engineering (ICEEE). IEEE, 2017.

[8] Ayn, Qurratul, PA Nageswar Rao, and P. Mallikarjuna Rao. "Design and Analysis of High Gain 2x1 and 4x1 Circular Patch Antenna Arrays for 2.4 GHz Applications." International Journal of Innovative Research in Science, Engineering and Technology. 6.8 (2017).