DOI: 10.21917/ijme.2021.0199

DESIGN OF DUAL BAND ANTENNA AND ANTENNA ARRAY FOR 5G COMMUNICATION APPLICATIONS

H. Vinod Kumar and A.R. Aswatha
Department of Tele Communication Engineering, Dayanand Sagar College of Engineering, India

Abstract
In this work, the design of a dual-band microstrip patch antenna and antenna array for 5G (5th Generation) mobile communication applications is conferred. The prerequisite for 5G technology is higher data rate, enhanced efficiency, improved gain, wide bandwidth, and compact antennas. The Rogers RT/Duroid 5880 and FR4 substrate is used to design the proposed dual-band inset fed microstrip patch and antenna array resonates at mm-wave frequencies of 28,39.5 GHz and 29,49.8 GHz respectively. The dual-band single element antenna (Rogers) provided with 8.057, 7.337 dB, and 8×8 array antenna yields with 25.86, 26.28 dB superior gain and good impedance bandwidth of 1.5,4.3 GHz at 28 and 39.5 GHz resonating frequencies. Moreover, dual-band antenna and array antenna exhibits higher radiation efficiency and reflection coefficient of S11 less than -10 dB at both the frequency bands.

Keywords:
5G, RT/Duroid, Inset fed, mm-wave

1. INTRODUCTION

In this new generation of wireless communication era, more devices are interconnected and demand high data rates for several applications. To meet the exponential urge of data traffic, super-wideband and millimeter-wave frequency spectrum attract the research group as probable explication to the bandwidth and density concerns [1].

The world radio-communication conference 2015 pointed out frequency appropriation of 24 GHz to 86 GHz, for future millimeter-wave communication with devices and systems [2]. The microstrip patch is suitable for designing a millimeter-wave antenna for the 5G process, as it requires low profile, low cost, compact in size, and capabilities to blend with microwave circuits [3]. Demanded gain and directivity cannot be accomplished through a single microstrip patch antenna, hence an array antenna with suitable design and structures yields the formidable gain, bandwidth, and enhanced efficiency [4],[5].

The selection of substrate material plays a crucial role in designing antennas at millimeter-wave frequencies. The antenna array is implemented using FR4 substrate material in [6]-[10]. The loss tangent of FR4 material is 0.01-0.04, which inhibits the antenna performance at millimeter frequency bands [6] [11]. Low loss tangent material Rogers (RT/Duroid) best suited for array implementation [12],[13]. The array of 2×2 antennas designed with foam as a substrate material achieving a better gain of 23.8 dBi and 4 GHz bandwidth [14]. In other literature designed 4×4,8×8 antenna with a gain of 17 dB and 24 dBi [15] [16].

In this work, proposed a dual-band microstrip inset feed antenna resonating at dual bands. From the above discussion, the array antenna designed for 5G mobile communication with substrate material as Rogers RT/Duroid 5880 and FR4 using HFSS Software.

The article is arranged as follows: In section 2, the Design Procedure of the patch antenna is deliberated. In section 3 Antenna design of a single patch antenna and the array is presented. The single antenna and antenna array of 1×2, 2×2, 4×4 and 8×8 results are discussed in section 4. In section 5 Comparative analysis and Conclusion are covered in Section 6.

2. DESIGN PROCEDURE

The antenna design procedure compromises the radiating patch, feed line, and the matching element. The antenna design mainly depends on the dielectric constant of the substrate (ε_r), the height of the substrate (h_s), and the resonant frequency (f_r). The equations used for the designing of the antenna parameter are mentioned below [3] [17].

Step 1: The radiating patch width and length are calculated using the following Eq.(1) and Eq.(2) respectively. where (ε_0) is the permittivity of the free space, μ_0 is the permeability of the free space.

$$W_p = \frac{1}{2 f_r \sqrt{\mu_0 \varepsilon_0}} \sqrt{\frac{2}{\varepsilon_r + 1}} \tag{1}$$

$$L_p = \frac{1}{2 f_r \sqrt{\varepsilon_{eff}} \sqrt{\mu_0 \varepsilon_0}} - 2\Delta L \tag{2}$$

Since some part of the waves travel in a substrate and other waves travel in the air, effective dielectric constant ε_{eff} has been made known to detail the fringing effect. The range of effective dielectric constant is $1 << \varepsilon_{eff} << \varepsilon_r$. For most of the applications $\varepsilon_r \gg 1$ and ε_{eff} will be approaching the absolute dielectric constant of the substrate ε_r. The effective dielectric constant ε_{eff} is a function of frequency. For higher frequencies ε_{eff} will be approaching the value of ε_r but for the lower frequency, it is imperatively constant.

Step 2: The effective permittivity (ε_{eff}) of the substrate is calculated using Eq.(3), ΔL is the differential length which is calculated using Eq.(4).

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2\sqrt{1 + 12\dfrac{h_s}{W_p}}} \tag{3}$$

$$\Delta L = \frac{\left(\varepsilon_{eff} + 0.3\right)\left(\dfrac{W_p}{h_s} + 0.264\right)}{\left(\varepsilon_{eff} - 0.258\right)\left(\dfrac{W_p}{h_s} + 0.8\right)} * 0.412 h_s \tag{4}$$

Step 3: Impedance of the patch can be found from Eq.(5) [18]:

$$Z_a = 90\frac{\varepsilon_r^2}{\varepsilon_r + 1}\left(\frac{L_P}{W_P}\right)^2 \tag{5}$$

Step 4: Characteristic impedance of the transition section substituting Eq.(5) in Eq.(6):

$$z_T = \sqrt{50 + z_a} \tag{6}$$

The width of the quarter-wave transition line is evaluated from Eq.(7) which is used for the impedance matching of the line [18]:

$$z_T = \frac{60}{\sqrt{\varepsilon_r}}\ln\left(\frac{8d}{w_T} + \frac{w_T}{4d}\right) \tag{7}$$

The length of the quarter-wave transition line is calculated from Eq.(8):

$$l = \frac{\lambda_0}{4\sqrt{\varepsilon_{eff}}} = \frac{\lambda}{4} \tag{8}$$

Step 5: Width of the 50 Ω microstrip feed can be determined using Eq.(9):

$$Z_0 = \frac{120\pi}{\sqrt{\varepsilon_{eff}\left(1.393 + \frac{W_f}{hs} + \frac{2}{3}\ln\left(\frac{W_P}{h_s} + 1.444\right)\right)}} \tag{9}$$

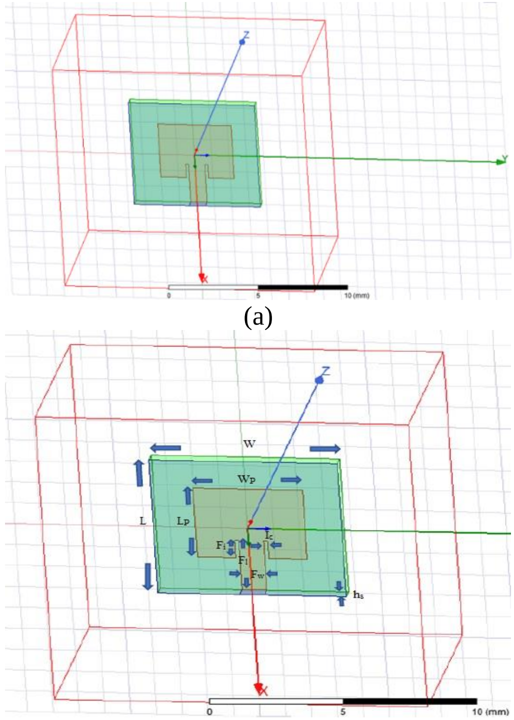
Step 6: Length of the microstrip transmission line from the edge of the patch (F_i) to distance from the center ranging LP/4 to LP/6 and cut-out width on both sides extending in to patch of the order LP/20 determined from the Eq.(10):

$$R_{in}\left(x = 0\right) = \left(\frac{z_0}{z_T}\right) = \cos^2\left(\frac{\pi}{L_P}\right) * F_i \tag{10}$$

3. ANTENNA DESIGN

3.1. SINGLE PATCH ANTENNA DESIGN

The dual-band microstrip inset feed patch antenna has been designed to operate at resonant frequencies of 28 GHz and 39.5GHz with an input impedance of 50Ω using Rogers RT/Duroid 5880 substrate with relative permittivity ε_r=2.2, dielectric loss tangent δ=0.0009 and height of substrate material h_s =0.508 mm. Here FR4 substrate material was also used to design dual-band patch antenna for 29 and 49.8 GHz resonant frequencies with dielectric relative permittivity ε_r=4.4, loss tangent δ=0.02, and h_s =0.8 mm. The optimized design parameters of the Rogers RT/Duroid 5880 substrate and values of FR4 substrates are tabulated in Table.1 using design equations from Eq.(1)-Eq.(10) [3] [17] [18]. The radiating portion of the antenna is resonating at 28GHz and inset cut symmetrically both the side of patch antenna resonates at 39.5 GHz using Rogers RT/Duroid 5880 substrate as shown in Fig.1. Similarly patch antenna designed using FR4 substrate material resonates at 29GHz and 49.8GHz as shown in Fig.2.



(a)

(b)

Fig.1. (a) Design of single patch antenna using Rogers RT/Duroid (b) Design specification

3.2. ANTENNA ARRAY

An array of 1×2,2×2,4×4,8×8 designed for the inset feed dual-band microstrip patch antenna resonating at 28GHz, 39.5GHz by using Rogers RT/Duroid 5880 substrate and 29 GHz, 49.8GHz using FR4 substrate. The finite element analysis and periodic boundary conditions were used for the analysis. In periodic boundary conditions, each element in an array will act as a unit cell and lattice system duplicating the simulation box throughout the spot [19]. In array, any two elements will have a distance of λ/2 to λ (d=7.28mm) as shown in Fig.3-Fig.6.

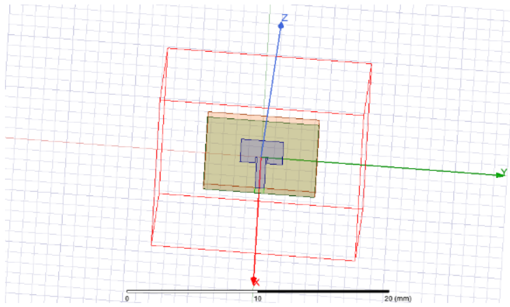


Fig.2. Design of single patch antenna using FR4

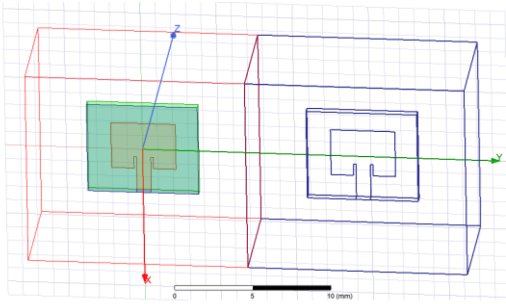


Fig.3. Design of 1×2 patch antenna array

Table.1. Parameter values of a single patch antenna

Parameters	**Values (in mm) Rogers RT/Duroid 5880**	**Values (in mm) FR4**
Substrate Length (L)	6.345	6.996
Substrate Width (W)	7.28	8.603
Substrate Height (h_s)	0.508	0.8
Length of Patch (L_P)	3.2320465	2.196
Width of Patch (W_P)	4.8543541	3.26
Feed Width (F_w)	0.95	0.71
Inset cut Width (I_c)	0.164	0.109
Inset Length (F_i)	0.792023	0.549
Feed Length (F_l)	1.55647	2.4

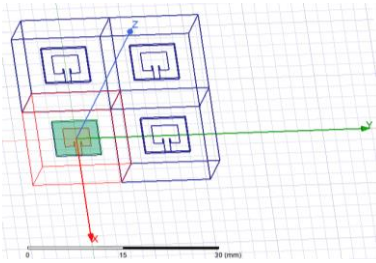


Fig.4. Design of 2×2 patch antenna array

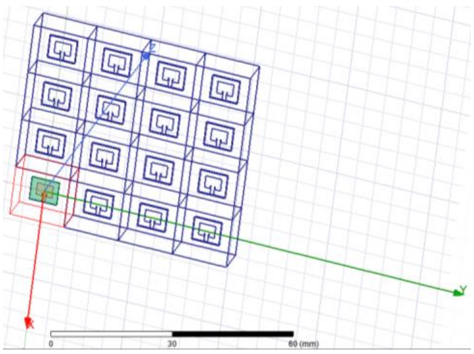


Fig.5. Design of 4×4 patch antenna array

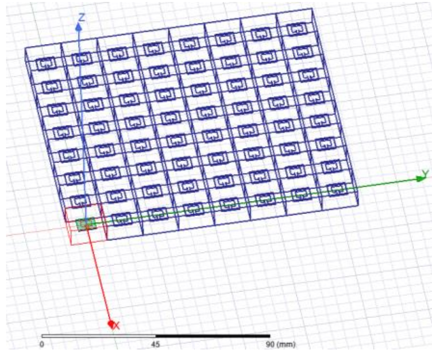


Fig.6. Design of 8×8 patch antenna array

4. RESULT ANALYSIS AND DISCUSSION

In this section result analysis of a single dual-band patch and array, antenna parameters were presented and the result shows a good agreement with the standard values.

4.1. SINGLE ANTENNA ELEMENT

The dual-band single patch antenna of two different substrate results was tabulated in Table.2. The dual-band single element antenna (Rogers substrate) resonates at 28 and 39.5 GHz with a reflection coefficient of S11 with -34.488 and -25.655 dB respectively as shown in Fig.7. The reflection coefficient of S11 (FR4 substrate) resonates at 29 and 49.8 GHz with -26.171, -37.063 dB respectively against the reference value of less than -10 dB shown in Fig.8. The good peak gain of dual-band (Rogers) antenna at 28 and 39.5 GHz with 8.057, 7.337 dB accordingly shown in Fig.9(a). The peak gain of FR4 substrate lower side compared to rogers substrate i.e. 4.322, 4.649 dB at resonating frequency of 29 and 49.8 GHz respectively shown in Fig.9(b) because of the higher dielectric constant degrades the gain of the antenna at mm-wave frequencies.

Table.2. Results of a single patch antenna

Antenna Parameter	**Single Patch (RogersRT/Duroid)**		**Single Patch (FR4)**	
Dimension in (mm)	6.345×7.28×0.508		6.996×8.603×0.8	
Frequency in (GHz)	28	39.5	29	49.8
Reflection Coefficient S11 in dB	-34.488	-25.655	-26.171	-37.063
Peak Gain in dB	8.057	7.337	4.322	4.649
VSWR	1.0385	1.1100	1.1034	1.0285
Radiation Efficiency in %	94.45	96.28	81.39	78.71
Bandwidth in GHz	1.5	4.3	2.5	7.5

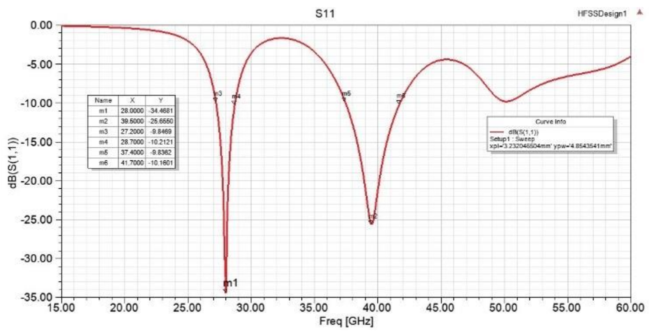


Fig.7. Reflection coefficient S11 (Rogers) of a dual-band antenna

The Fig.10-Fig.11 shows the radiation pattern in 3D and 2D for the resonating frequencies of rogers and FR4 substrate.

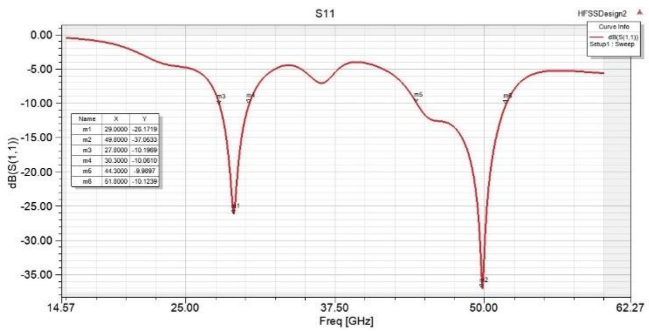
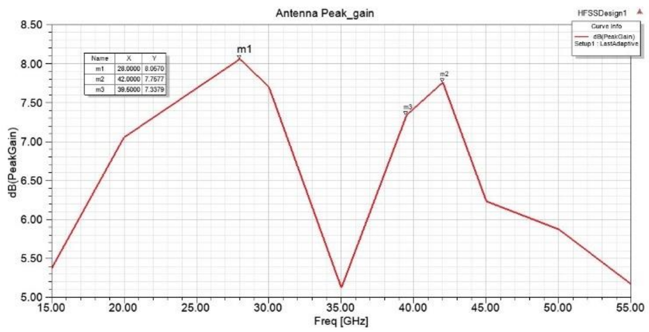


Fig.8. Reflection coefficient S11(FR4) of a dual-band antenna



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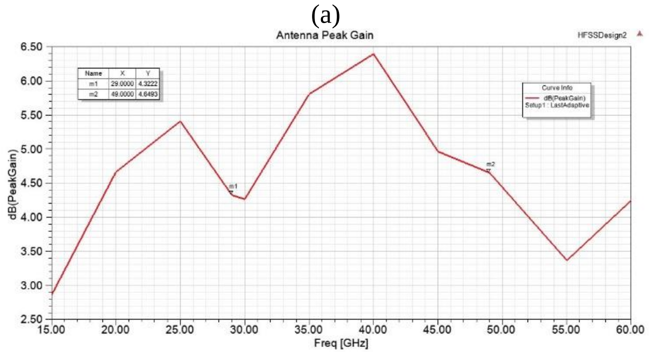
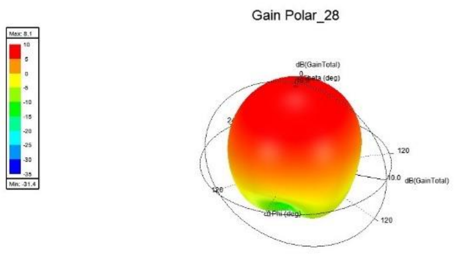


(b)

Fig.9. Peak gain of a dual-band single element antenna (a) Rogers Substrate (b) FR4 Substrate



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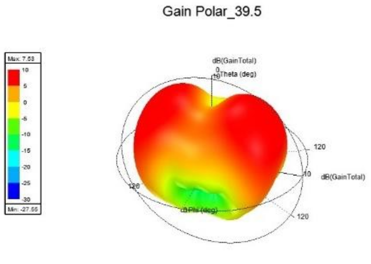

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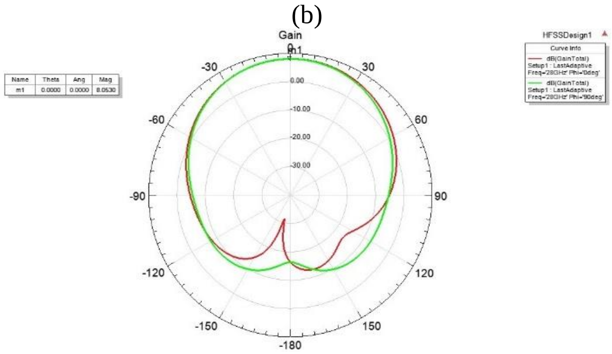

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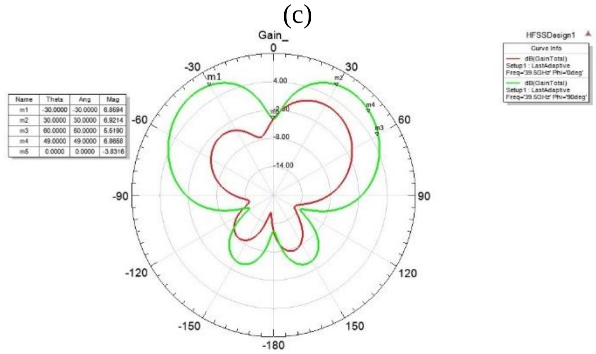
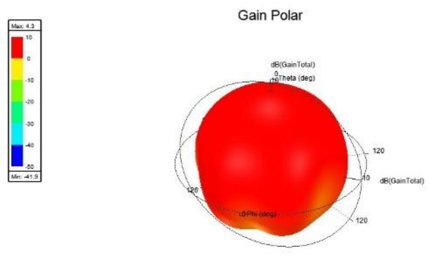
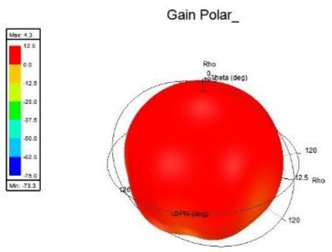


(d)

Fig.10. Radiation pattern in 3D and 2D for Rogers substrate (a) 3D plot at 28 GHz (b) 3D plot at 39.5 GHz (c) 2D plot at 28 GHz (d) 2D plot at 39.5 GHz



(a)



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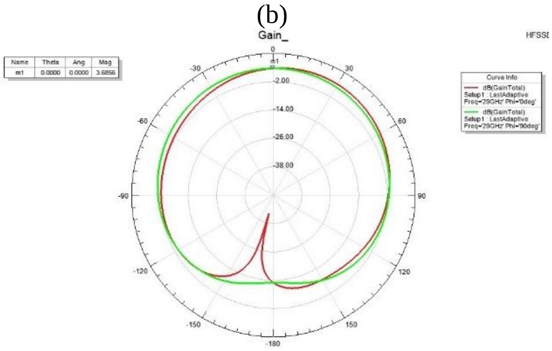

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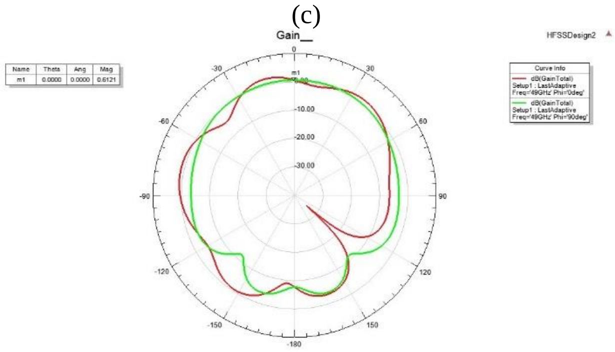
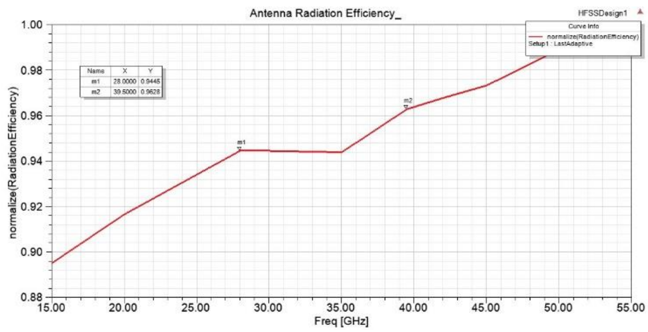


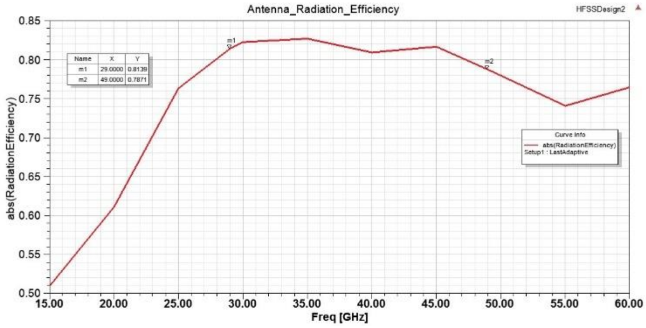
(d)

Fig.11. Radiation pattern in 3D and 2D for FR4 substrate (a) 3D plot at 29 GHz (b) 3D plot at 49.8 GHz (c) 2D plot at 29 GHz (d) 2D plot at 49.8 GHz

The bandwidth of the antenna at -10 dB level is tabulated in Table.2. The bandwidth for roger's substrate is 1.5,4.3 GHz at 28, 39.5 GHz, and 2.3,7.5 GHz for FR4 substrate resonating frequencies at 29, and 49.8 GHz respectively. The antenna efficiency of both the substrates shown in Fig.12.



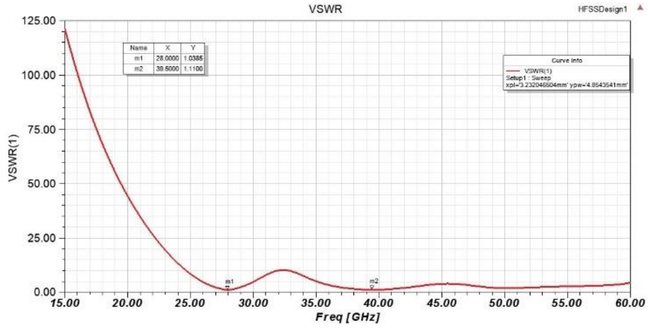
(a)



(b)

Fig.12. Radiation efficiency of (a) Rogers substrate (b) FR4 substrate

The dual-band antenna design offers better VSWR for both the substrate as shown in Table 2 compared to the standard value less than 2 as shown in Fig.13.



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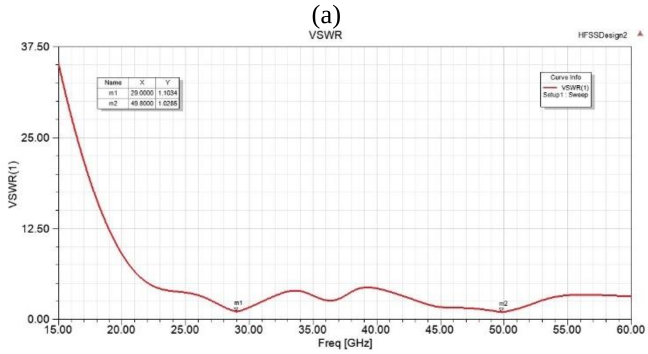


(b)

Fig.13. VSWR of (a) Rogers substrate (b) FR4 substrate

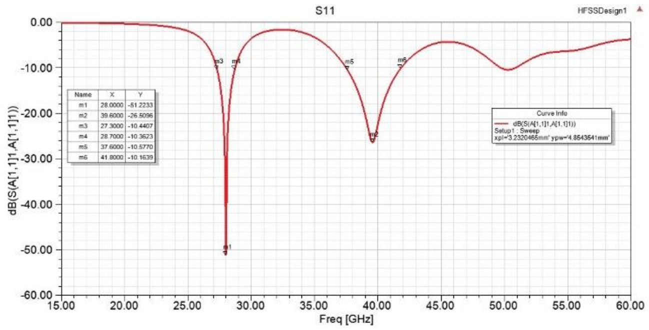
4.2. ANTENNA ARRAY 1×2

The antenna array of 1×2 (Rogers) resonates at 28,39.6 GHz with reflection coefficient S11 of -51.22, 26.50 dB, and 1×2(FR4) resonates at 29,49.8 GHz with S11 of -29.17, -37.92 dB respectively as shown in Fig.14. The comparison of the simulated array type is recorded in Table.3.

The 3D radiation pattern and VSWR of the 1×2 array shown in Fig.15 and Fig.16. The peak gain of the array antenna (Rogers) 10.91,10.90 dB, and 7.61,6.53 dB (FR4) respectively for the resonating frequencies are tabulated in Table.3. Better radiation efficiency and impedance bandwidth were reported in Table.3.

Table.3. Comparison of simulated array parameters

Antenna Parameter	1×2 (Rogers)		2×2 (Rogers)		4×4 (Rogers)		8×8 (Rogers)		1×2 (FR4)		2×2 (FR4)		4×4 (FR4)		8×8 (FR4)	
Dimension in (mm)	13×29		27×29		53×58		106×116		14×32		28×32		56×64		113×127	
Frequency in (GHz)	28	39.6	27.9	39.3	27.9	39.3	27.8	39.5	29	49.8	28.8	49.9	29	49.9	29	49.9
Reflection Coefficient S11 in - dB	51.22	26.50	37.87	31.24	36.42	30.59	32.75	29.84	29.17	37.92	25.54	35.74	26.2	34.38	26.52	34.87
Peak Gain in dB	10.91	10.90	13.88	13.78	19.84	20.14	25.86	26.28	7.61	6.53	8.62	6.69	14.02	13.15	20.04	19.25
VSWR	1.00	1.10	1.10	1.09	1.12	1.07	1.18	1.06	1.07	1.02	1.12	1.03	1.10	1.04	1.09	1.03
Radiation Efficiency in %	95.42	96.63	95.32	96.85	95.25	96.83	94.34	95.98	97.51	92.98	81.62	76.44	80.8	74.36	80.64	73.28
Bandwidth in GHz	1.4	4.2	1.4	4.5	1.4	4.4	1.5	4.3	2.5	7.5	2.6	7.5	2.5	7.6	2.5	7.5



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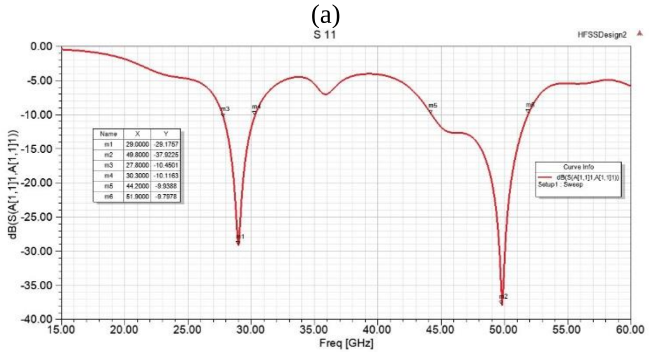

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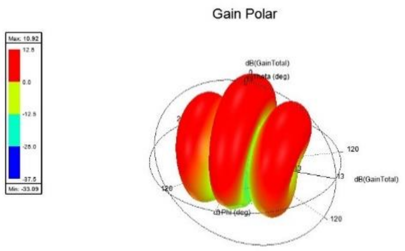
Fig.14. Reflection coefficient S11 of 1×2 array antenna (a) Rogers Substrate (b) FR4 Substrate



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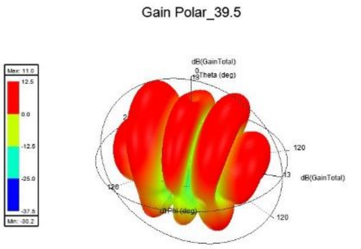

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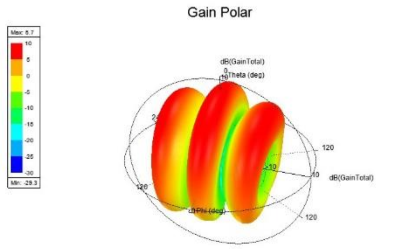

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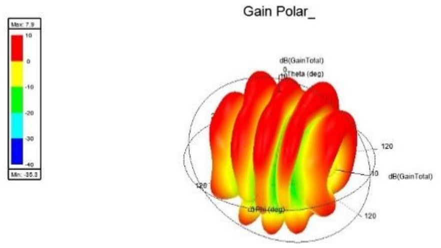
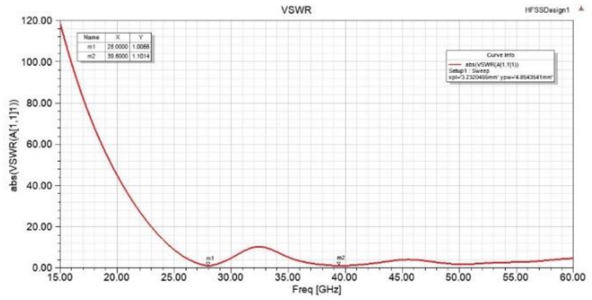


(d)

Fig.15. Radiation pattern in 3D (a) Rogers at 28 GHz (b) Rogers at 39.5 GHz (c) FR4 at 29 GHz (d) FR4 at 49.8 GHz



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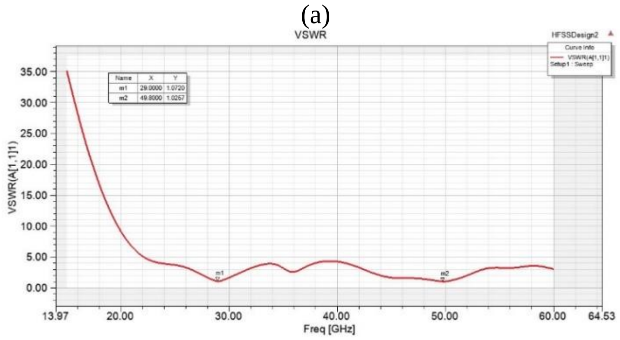
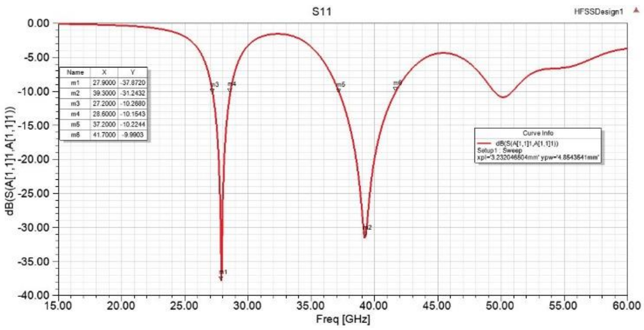


(b)

Fig.16. VSWR (a) Rogers Substrate (b) FR4 Substrate

4.3. ANTENNA ARRAY 2×2

The gain of the array antenna is enhanced by increasing the number of antenna elements in an array. The antenna array of 2×2 (Rogers) resonates at 27.9,39.3 GHz with reflection coefficient S11 of -37.87, -31.24 dB and 2×2(FR4) resonates at 28.8,49.9 GHz with S11 of -25.54, -37.92 dB respectively as shown in Fig.17.



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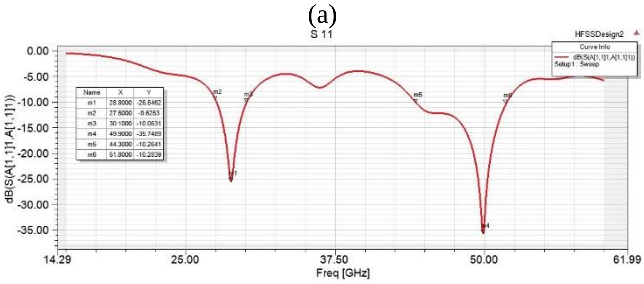
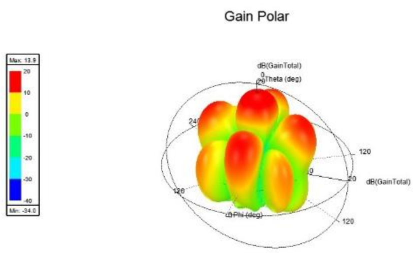


(b)

Fig.17. Reflection coefficient S11 of 2×2 array antenna (a) Rogers Substrate (b) FR4 Substrate

The 3D radiation pattern of the 2×2 array is shown in Fig.18. The peak gain of the array antenna (Rogers) 13.88, 13.78 dB, and 8.62,6.69 dB (FR4) respectively for the resonating frequencies were noted in table 3. The VSWR, impedance bandwidth at -10 dB, and efficiency of the 2×2 array antenna were recorded in Table 3.



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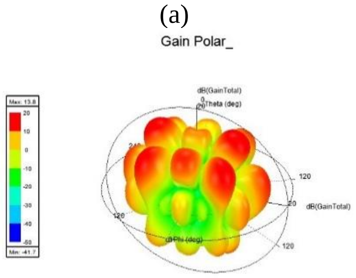
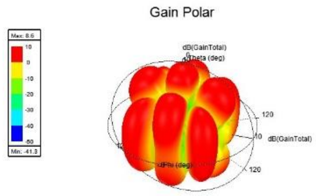


(b)



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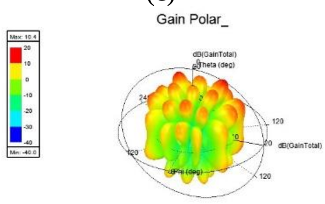
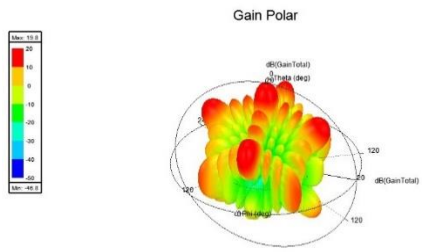


(d)

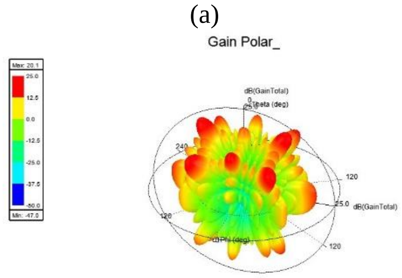
Fig.18. Radiation pattern in 3D (a) Rogers at 28 GHz (b) Rogers at 39.5 GHz (c) FR4 at 29 GHz (d) FR4 at 49.8 GHz

4.4. ANTENNA ARRAY 4×4

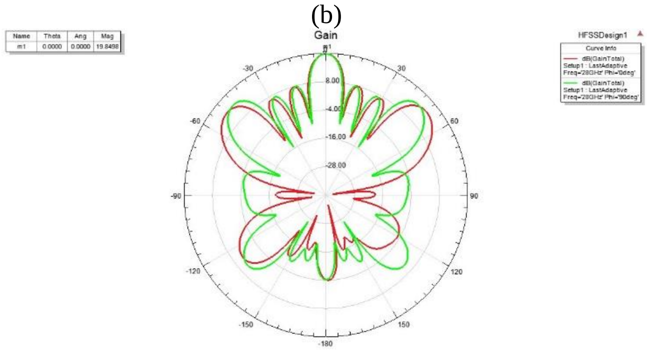
The 4×4 antenna array offers a gain of 19.84, 20.14 dB (Rogers) at 27.9, 39.3 GHz, and gain of (FR4) 14.02, 13.15 dB at 29, 49.9 GHz accordingly. The radiation pattern of 3D and 2D patterns at 00 and 900 are shown in Fig.19 and Fig.20.



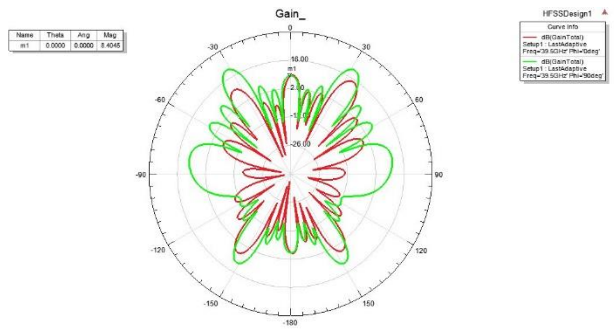
(a)



(b)

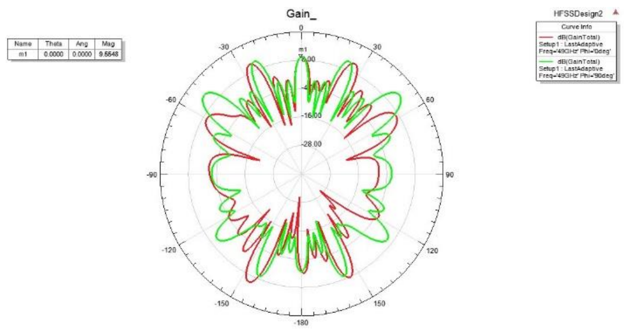


(c)



(d)

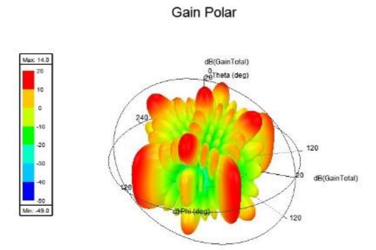
Fig.19. Radiation pattern in 3D and 2D for Rogers substrate (a) 3D pattern at 28 GHz (b) 3D pattern at 39.5 GHz (c) 2D plot at 28 GHz (d) 2D plot at 39.5 GHz



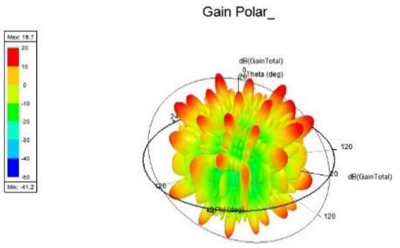
(d)

Fig.20. Radiation pattern in 3D and 2D for FR4 substrate (a) 3D pattern at 29 GHz (b) 3D pattern at 49.8 GHz (c) 2D plot at 29 GHz (d) 2D plot at 49.8 GHz

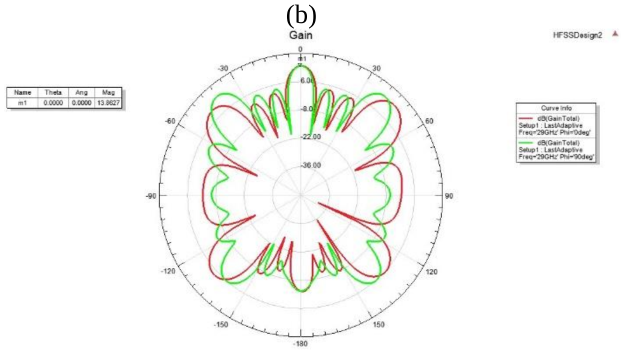
The return loss of S11 (Rogers) resonates at 27.9,39.3 GHz with -36.42, -30.59 dB, and (FR4) resonates at 29,49.9 GHz with S11 of -26.2, -34.38 dB respectively as shown in Fig.21. The radiation efficiency and impedance bandwidth were tabulated in Table.3.



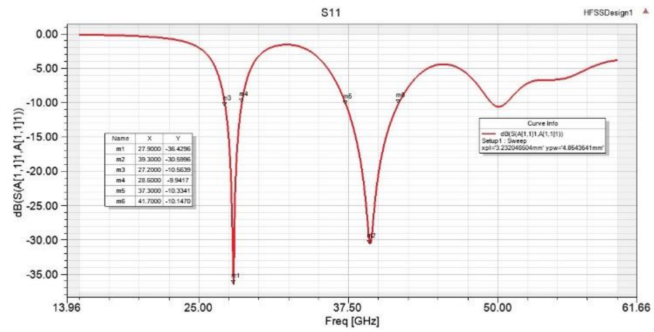
(a)



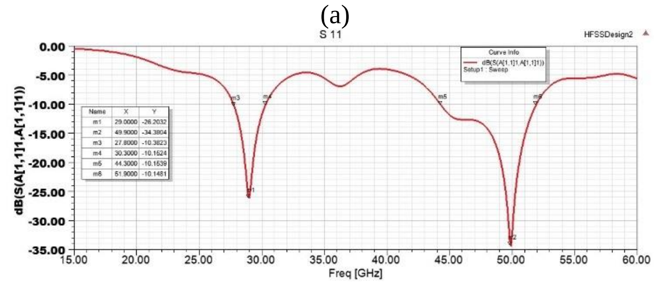
(b)



(c)



(a)

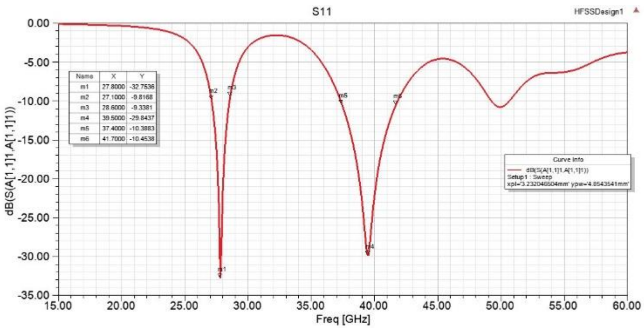


(b)

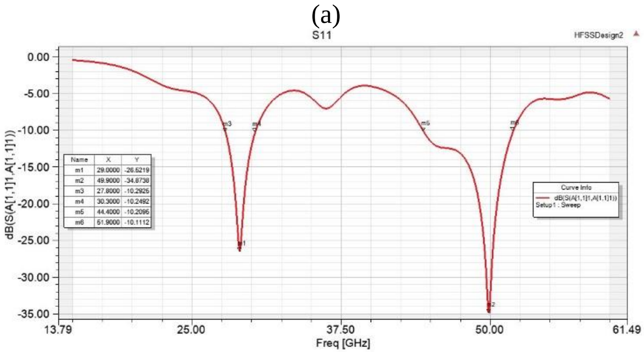
Fig.21. Reflection coefficient S11 of a 4×4 array antenna (a) Rogers Substrate (b) FR4 Substrate

4.5. ANTENNA ARRAY 8×8

The antenna array of 8×8 (Rogers) resonates at 27.8,39.5 GHz with reflection coefficient S11 of -32.75, -29.84 dB and (FR4) resonates at 29,49.9 GHz with S11 of -26.52, -34.87dB respectively as shown in figure 22. The VSWR and radiation efficiency of the antenna reported in Table.3. The 8×8 antenna array provides a gain of 25.86, 26.28 dB (Rogers) at 27.8, 39.5 GHz, and gain of (FR4) 20.04, 19.25 dB at 29, 49.9 GHz respectively. The radiation pattern of the 8×8 array in the 3D and 2D pattern is shown in Fig.23 and Fig.24.

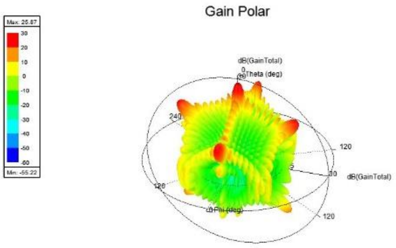


(a)

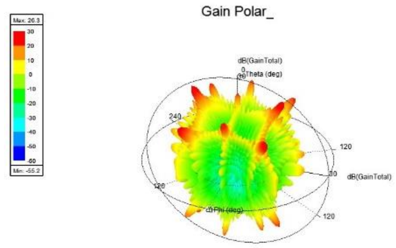


(b)

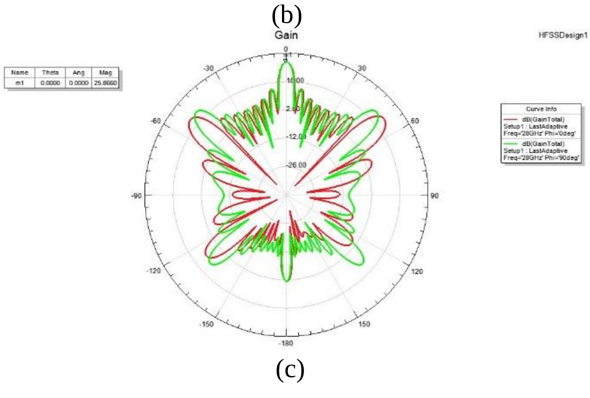
Fig.22. Reflection coefficient S11 of the 8×8 array antenna (a) Rogers Substrate (b) FR4 Substrate.



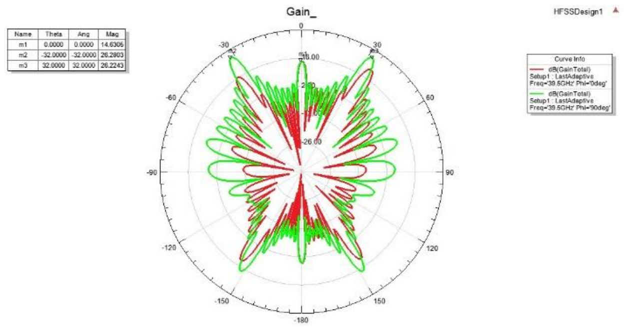
(a)



(b)

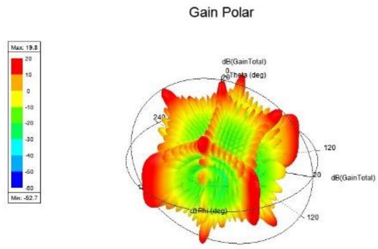


(c)

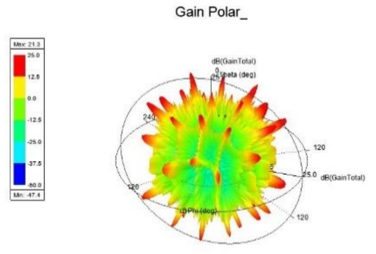


(d)

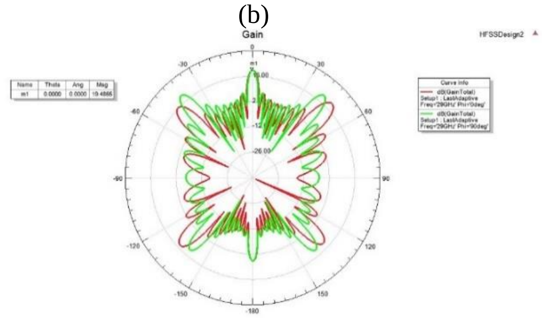
Fig.23. Radiation pattern in 3D and 2D for Rogers substrate (a) 3D pattern at 28 GHz (b) 3D pattern at 39.5 GHz (c) 2D plot at 28 GHz (d) 2D plot at 39.5 GHz



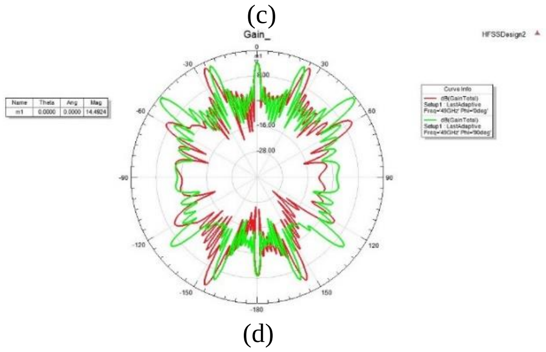
(a)



(b)



(c)



(d)

Fig.24. Radiation pattern in 3D and 2D for FR4 substrate (a) 3D pattern at 29 GHz (b) 3D pattern at 49.8 GHz (c) 2D plot at 29 GHz (d) 2D plot at 49.8 GHz

Table.4. Comparison of a proposed single antenna with existing work

Ref	Substrate	Dimension in (mm)	Frequency in (GHz)	Reflection Coefficient S11 in – dB	Peak Gain in dB	VSWR	Radiation Efficiency in %	Bandwidth in GHz
[7]	FR4	4.2×9	28.305	23.00	6.04	1.15	-	-
[12]	Rogers 5880	10×15×.25	28	19.5	7.32		-	1.09
[15]	Rogers 5880	3.58×4.02×.127	28	46.1	6.61	1.009	-	0.47
[20]	FR4	6.96×8.06×.8	28	39.38	6.37	1.02	86.73	2.48
[21]	Rogers 5880	3.2×4.23×.508	28	16	7.8 dBi	-	-	0.9
[22]	Rogers 5880	6×6×1.27	28.5	13	6.25 dBi	-	-	Approx. 2
			38.5	20	8.25 dBi	-	-	Approx. 2
This Work	Rogers 5880	6.345×7.28×0.508	28	34.488	8.057	1.0385	94.45	1.5
			39.5	25.655	7.337	1.1100	96.28	4.3
This Work	FR4	6.996×.603×0.8	29	26.171	4.322	1.1034	81.39	2.5
			49.8	37.063	4.649	1.0285	78.71	7.5

Table.5. Comparison of the proposed array antenna with existing work

Ref	Substrate	Dimension in (mm)	Number of Elements	Frequency in (GHz)	Reflection Coefficient S11 in – dB	Peak Gain in dB	VSWR	Radiation Efficiency in %	Bandwidth in GHz
[1]	Rogers 5880	40×40×0.25	4×4	27.8	14	18.41	-	90	0.66
[6]	FR4	18×14×0.71	2×2	28	18.5	14.4	-	-	3
[7]	FR4		1x8	28.005	15.52	14.2	1.40	-	
[8]	FR4	52×72×0.8	8×8	22.25	20	19	-	-	2.5
[12]	Rogers 5880	-	1x4	28.03	16.17	12	-	-	-
[15]	Rogers 5880	30.65×39.3×.127	4×4	28	16.37	17	1.35	-	0.308
[16]	Rogers 5880	-	8×8	28	-	24dBi	-	-	2
[21]	Rogers 5880	19.2×22.8×0.508	2×2	28	34	13.3dBi	-	-	1.3
This Work	Rogers 5880	53×58×0.508	4×4	27.9	36.42	19.84	1.12	95.25	1.4
				39.3	30.59	20.14	1.07	96.83	4.4
This Work	FR4	56×64×0.8	4×4	29	26.2	14.02	1.10	80.8	2.5
				49.9	34.38	13.15	1.04	74.36	7.6
This Work	Rogers 5880	106×116×0.508	8×8	27.8	32.75	25.86	1.18	94.34	1.5
				39.5	29.84	26.28	1.06	95.98	4.3
This Work	FR4	113×127×0.8	8×8	29	26.52	20.04	1.09	80.64	2.5
				49.9	34.87	19.25	1.03	73.28	7.5

5. COMPARATIVE ANALYSIS

The comparison of a dual-band single element antenna with previous works is enumerated in Table.4 [20]-[22]. The proposed dual-band single element antenna of Rogers/RT Duroid 5880 substrate shows better results than the tabulated works in Table.4. The gain of the proposed antenna 8.057, 7.337 dB at 28,39.5 GHz and reflection coefficient are better than previous works. The gain and other parameters of the FR4 substrate is low due to the high dielectric constant. The proposed array antenna of 4×4 and 8×8 are correlated with the previous works and results are superior to the tabulated works in Table.5.

6. CONCLUSION

In this article, the proposed inset fed microstrip dual-band patch antenna and antenna array of 1×2,2×2,4×4 8×8 with Rogers RT/Duroid 5880 and FR4 substrate material for 5G mm-wave frequency bands. The dual-band single element antenna provides peak gain (Rogers) at 28 and 39.5 GHz with 8.057, 7.337 dB accordingly. Also, the peak gain of FR4 substrate 4.322, 4.649 dB at resonating frequency of 29 and 49.8 GHz respectively. The 8×8 antenna array demonstrates a gain of 25.86, 26.28 dB (Rogers) at 27.8, 39.5 GHz, and gain of (FR4) 20.04, 19.25 dB at 29, 49.9 GHz in conjunction. The antenna and array show good agreement of return loss S11 less than -10dB and VSWR less than 1.5 compared to the standard value of 2. Moreover, high radiation efficiency and impedance bandwidth authenticates for 5G mobile communication application as it requires a low profile and compact antenna.

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