Comparative Analysis of Microstrip Patch Antenna with Coaxial and Micro Strip Line Feeding Technique for Proposed 5g Band

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Abstract- This work describes the performance analysis of micro strip rectangular patch antenna using coaxial feeding technique and micro strip line feeding technique for proposed 5G band. The Proposed antenna is designed using different substrates for proposed 5G band i.e.3.4GHz- 3.8GHz. The Gain, Bandwidth, Directivity and Reflection coefficient are simulated & comparison of all these parameters for strip line and coaxial feeding is studied. Simulation is done by using HFSS Electronic Desktop 2015.1.

Keywords- Microstrip Antenna, Feeding technique, Coaxial Feed, Microstrip feed line.

I. INTRODUCTION

The swing of wireless communication stems has increased exponentially.Existing cellular network is not in condition to satisfy the existing and future demand of users for variety of applications and services. Large bandwidth is required in order to achieve high data rate to satisfy the current and future demand. This bandwidth cannot achieved at low frequency band but can achieved at high frequency bands. Low frequency bands have more delay, small bandwidth whereas high frequency bands have negligible delay and large bandwidth. High frequency bands also have reduced coverage. To improve the existing data rate high frequency band 3.4 GHz - 3.8 GHzselected according to suggestions of ITU based on the conclusion of WRC-2015. Launching of next generation in this frequency band demandsupgradation of existing cellular network. As a vital part of these systems, designing of antenna needed within selected frequency range.The micro strip antennas are best suitable because of many advantages such as easy fabrication, less weight, compact structure and compatibility with microwave circuits [7]. Microstrip Antenna can be fed with different configurations. The most popular configurations are microstrip line and coaxial probe feed.

In this paper, Micro strip Patch Antenna (MPA) has designed with different feed and substrates to achieve better gain and bandwidth using HFSS software. ANSYS HFSS software is a renowned electromagnetic simulation software for designing and simulating high frequency electronic products. MPA is designed with coaxial and micro strip line feed at 3.5 GHz operating frequency. Once designed, simulation is performed to optimize performance parameters as mathematical calculation is different from practical simulation. After simulation, performance parameters are optimized and best result is noted. High gain and large bandwidth is obtained for both the feed for low dielectric constant substrate. It isobserved that Polymethacrylate foam/ Rohacell 51 has given best result in micro strip line feed with 10.78 dB gain and 70 MHz bandwidth. So this work gives a comparative analysis of coaxial and micro strip line feeding techniques.

II. MICROSTRIP PATCH ANTENNA AND FEEDS

Microstrip antennas are categorized by a large number of physical parameters. They are designed with different dimensions and geometrical shape. A microstrip patch antenna (MPA) has a ground plane on one side of a dielectric substratewith a conducting patch on the other side. Due to its planar configuration and ease of integration, MPAs is deeply studied and often used as elements of array[6]. The circular and rectangle patches are basic and commonly used microstrip antenna. In this work, rectangular patch is used for designing purpose.

Microstrip patch antenna can be fed into four ways i.e. coaxial probe, microstrip line, aperture coupled and proximity coupled. Coaxial feed and microstrip line feed is used for proposed work. Firstly, Microstrip patch antenna is designed with coaxial feed and same design is fed with microstrip line feed. In coaxial feed, extended inner conductor of a coaxial line is attached electrically to patch. Similarly in microstrip line feed, microstrip line is directly connected to edge of the patch. The impedance matching condition canbecontrolled by changing theposition of the feed point [8].

A. COAXIAL FEED

In coaxial-line feeding, inner conductor is attached to the Patch whereas Ground is connected to the outer conductor. The coaxial feed is easy to fabricate and has low spurious radiation. Although, it is quiet difficult to model and has narrow bandwidth, especially for thick substrates. The advantage of coaxial feed is that the feed can be allocated at any suitable position inside the patch in order to achieve impedance matching [7].

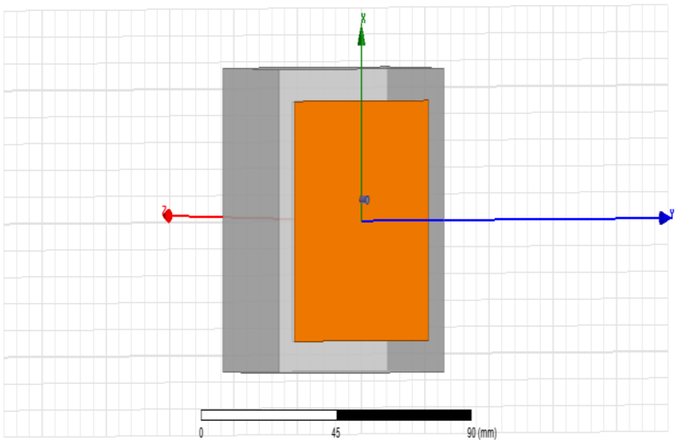


Fig.1: Design of coaxial feed

B. MICROSTRIP-LINE FEED

The microstrip-line feed is simple to model and fabricate,also easy to match by controlling inset position [7]. In this feeding technique, a conducting strip is connected to the patch and can be considered as extension of patch. The disadvantage of this technique is that it limits Bandwidth with increase in substrate thickness [6].

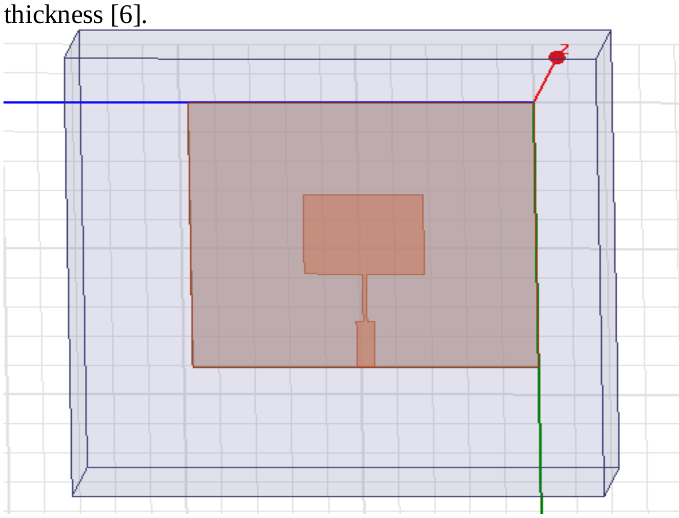


Fig.2: Design of microstrip line feed

III. DESIGN PROCEDURE

Input parameters of antenna design are dielectric constant (Ɛr), height of substrate (h), operating frequency (fo), Patch length (L), Patch width (W). The Substrate material decides basic input parameters such as dielectric constant (Ɛr) and height (h).Here different Substrate materials is considered i.e. Rogers RT/duroid 5880(tm), Rogers RO 3003(tm), FR4 Epoxy, Rogers RT duroidLz, Polymethacrylate foam/Rohacell 51 to visualize better quality of Antenna for cellular communication. Some factors and optimization are involved in the selection of feed location.

The length Lg and width Wg of ground is given by:

Lg= L+6h

Wg= W+6h

Antenna Design (Theoritically):

The micro strip antenna using transmission model is design by following formulae:

Step 1: A relation to calculate width of the patch (W):

$$W = \frac{c}{2f_o\sqrt{\frac{(\mathcal{E}r+1)}{2}}} \quad (1)$$

For FR4 Epoxy:

Input Parameters-

Ɛr= 4.4

h= 1.5

f_o= 3.5Ghz

$$W = \frac{3*10^8}{2*3.5*10^9\sqrt{\frac{(4.4+1)}{2}}} \quad (2)$$

W= 25.36mm

Step 2: An approximate relation for effective dielectric constant is:

$$\mathcal{E}reff = \frac{\mathcal{E}r+1}{2} + \frac{\mathcal{E}r-1}{2}(1+12\frac{\square}{W})^{-\frac{1}{2}} \quad (3)$$

For FR4 Epoxy:

$$\mathcal{E}reff = \frac{4.4+1}{2} + \frac{4.4-1}{2}(1+12\frac{1.5}{25.36})^{-\frac{1}{2}}$$
(4)

$\mathcal{E}reff$= 4

Step 3: Effective length on basis of fringing is given by function of Ɛreff and width to height ratio (W/h).A relation for normalized extension of length is given by:

$$\Delta L = 0.412\square\frac{(\mathcal{E}reff+0.3)(\frac{W}{\square}+0.264)}{(\mathcal{E}reff-0.258)(\frac{W}{\square}-0.8)} \quad (5)$$

For FR4 Epoxy:

$$\Delta L = 0.412 * 1.5 * \frac{(4+0.3)(\frac{25.36}{1.5}+0.264)}{(4-0.258)(\frac{25.36}{1.5}-0.8)} (6)$$

$$\Delta L = 0.757$$

Step 4: Actual length of the patch is then determined by solving the following equation:

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon reff}} \quad (8)$$

$$L = L_{eff} - 2\Delta L\text{n} \quad (9)$$

For FR4 Epoxy:

$$L_{eff} = \frac{3*10^8}{2*3.5*10^9\sqrt{4}} \quad (10)$$

$$L_{eff} = 21.42\text{mm} \quad (11)$$

$$L = L_{eff} - 2\Delta L \quad (12)$$

L = 21.42-2*0.75

L=19.906mm

A. SIMULATION RESULTS OF COAXIAL FEED

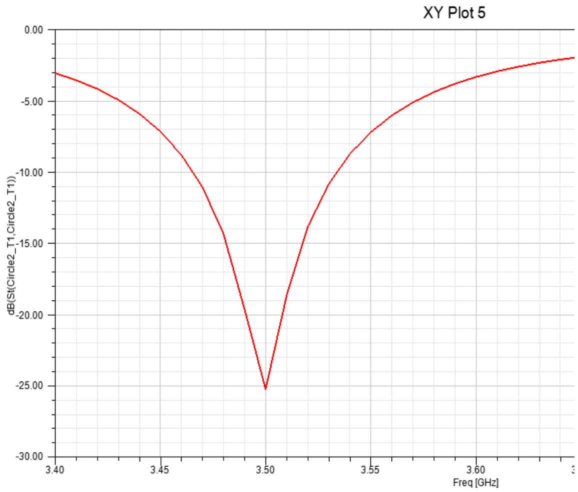
INPUT PARAMETERS (COAXIAL FEED)	THEROTICAL					PRACTICAL				
	FR4_epoxy	Rogers RO 3003	Rogers RT/duroid 5880	RT duroid LZ	Polymethacrylate foam/ Rohacell 51	FR4_epoxy	Rogers RO 3003	Rogers RT/duroid 5880	RT duroid LZ	Polymethacrylate foam/ Rohacell 51
Length of Patch L	19.90	24.19	28.15	29.9	39.89	18.5	23.125	27	27	38.5
Width of Patch W	26.08	30.3	33.8	35.2	42.12	25.5	34	34.5	34.5	42.12
Length of Ground Lg	37.9	42.19	46.15	47.71	55	36.5	41.125	45	45	52.9
Width of Ground wg	43.36	42.7	46	53.2	56.52	43.5	52	52.5	52.5	56.52

B. SIMULATION RESULTS OF MICRO STRIP FEED

INPUT PARAMETERS (MICRO STRIP FEED)	THEROTICAL					PRACTICAL				
	FR4_epoxy	Rogers RO 3003	Rogers RT/duroid 5880	RT duroid LZ	Polymethacrylate foam/ Rohacell 51	FR4_epoxy	Rogers RO 3003	Rogers RT/duroid 5880	RT duroid LZ	Polymethacrylate foam/ Rohacell 51
Length Aof Patch L	19.90	24.19	28.15	29.9	39.89	19.2	23.2	27.2	28.8	38.4
Width of Patch W	26.08	30.3	33.8	35.2	42.12	26.08	30.3	33.86	33.86	42.1
Length of Ground Lg	37.9	42.19	46.15	47.71	55	37.9	42.19	46.15	47.71	55
Width of Ground wg	43.36	42.7	46	53.2	56.52	43.36	42.7	46	53.2	56.52
Length of first feed Lm	12.43	14.39	16.18	16.89	20.94	12.43	14.39	16.18	16.89	16.18
Width of first feed Wm	0.49	0.8625	1.234	1.431	1.572	0.55	0.8625	1.11	1.3	1.234
Length of second feed Lf	11.173	13.78	15.65	16.41	20.86	11.173	13.78	15.65	16.41	15.65
Width of second feed Wf	3.059	3.771	4.622	5.168	5.679	2	3.771	5	5.679	4.622

IV. BEST SIMULATION RESULTS

1) Reflection Coefficient



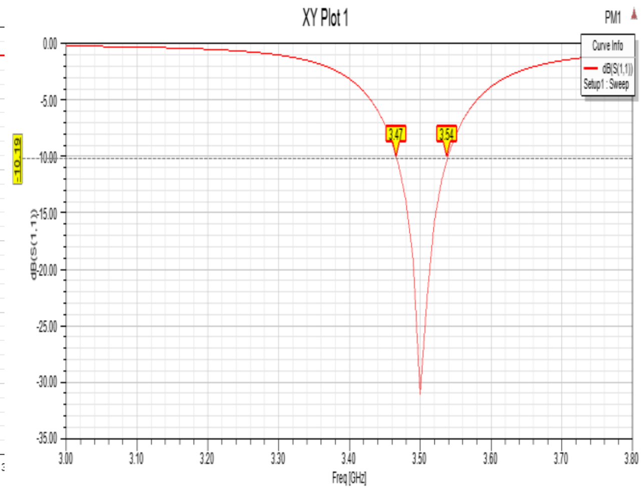
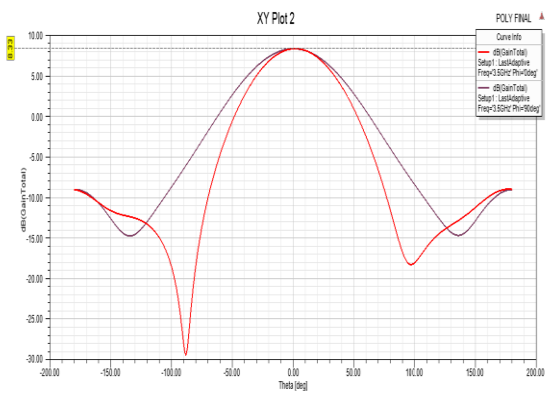


FIG.3:a) coaxial feed reflection coefficient: -25dB b) microstrip-line feed reflection coefficient: -31dB

2) Gain



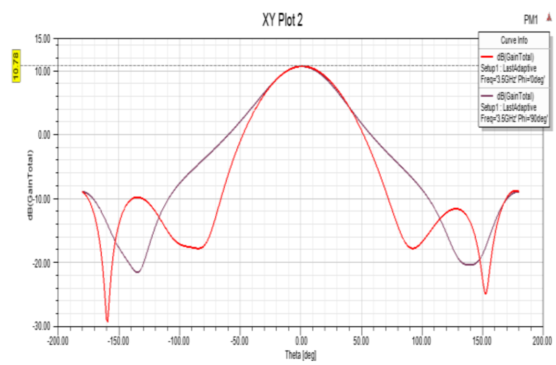
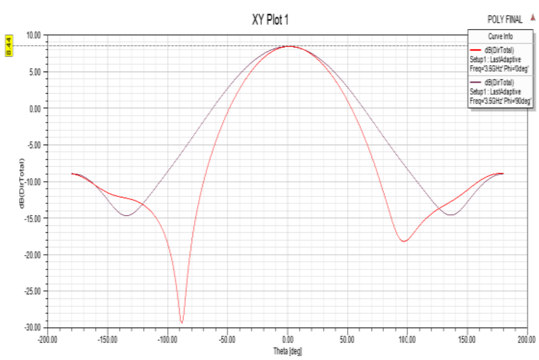


FIG.4: a) coaxial feed Gain b) microstrip-line feed Gain

3) Directivity



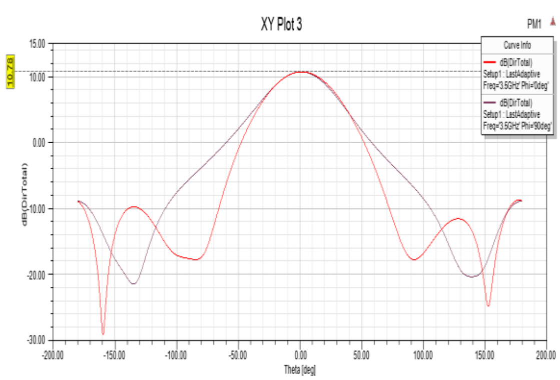


FIG 5: a) coaxial feed Directivity b) microstrip-line feed Directivity

V. COMPARITIVE ANALYSIS

PERFORMANCE PARAMETERS	SUBSTRATES									
	COAXIAL FEED					MICROSTRIP-LINE FEED				
	FR4_epoxy	Rogers RO 3003	Rogers RT/Duroid 5880	RT Duroid LZ	Polymethacrylate foam/Rohacell 51	FR4_epoxy	Rogers RO 3003	Rogers RT/duroid 5880	RT duroid LZ	Polymethacrylate foam/Rohacell 51
Reflection Coefficient(dB)	-24	-34	-33	-27	-25	-37	-28	-31	-29	-31
Gain	3.38	6.64	7.82	7.70	8.33	5	9.13	9.34	10	10.78
Bandwidth (MHz)	110	70	80	80	80	100	60	60	60	70
VSWR		0.35	1.0469	1.0482	1.116	1.03	1.09	1.05	1.28	1.051
Directivity	5.36	7.10	7.31	7.82	8.44	8.10	8.83	9.18	9.20	10.78

VI. RESULT AND CONCLUSION

The proposed microstrip patch antennawith coaxial feed and micro strip line feed is designed and simulated using HFSS Electronic Desktop 2015.1. The rectangular patch antenna is designed with different substrate material and are optimized for parameters of antenna such as Gain, Bandwidth, Directivity, and Reflection Coefficient. A process of design, optimization, and simulated result is presented in comparing two most common feeding techniques. The procedure has utilized equations and parametric analysis to achieve proposed operating frequency. The output parameters are analyzed, comparatively measured and PRESENTED in this work. Both antennas are operable in the 3.5 GHz at proposed 5G frequency band with adequate amount of gain and bandwidth.Overall substrate Polymethacrylate foam/ Rohacell 51 is giving better results for all antenna parameters with micro strip line feed mainly considering Gain along with Bandwidth and Directivity. Proposed microstrip patch antenna can be designed for various application [4] of upcoming 5G network.

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