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Different Feeding Techniques of Elliptical Patch Antenna at X Band for Radar Applications

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Abstract: A comparative study performance on elliptical micro strip patch antenna (EMPA) using various feeding methods at an X band (8 GHz to 12 GHz) frequency range is presented in this work. The general X band frequency range varies from 8 GHz to 12 GHz, in this frequency range 9.8 GHz operating frequency is selected for RADAR communication application. The proposed work can also determine in detection of vehicle speed, military, civil and various wireless communication application systems. In this, the selected feeding techniques are micro strip fed planar, ring pin-fed, pin-fed circular polarized and edge-fed circular polarized. The elliptical patch antenna is designed, simulated and analysed with different feeding techniques at 9.8 GHz band, 4.5 dielectric constant of Rogers substrate material and thick ness of substrate the is 0.6 mm. The main aim of this EMPA with various feeding concepts presents comparative study performance on different parameters like, s-parameter (S_{11}), vswr, bandwidth, directivity and gain using CST Micro Studio simulation software.

Keywords: Elliptical, Micro Strip, Rogers, EMPA, X band, S-parameter, Vswr, CST, Gain, Directivity.

1. Introduction

Advertising condition and threefold rolling frequencies are required in some proper term applications much as radar, communicating, telecommunication and employment systems. For wireless applications, the handbill polarization can be achieved by varying the alter of or by the use of quadruple feeds for perpendicular micro-strip dressing aerial. But, with the amend of only a unique insert, broadside condition can be achieved for an omission repair tentacle which is fed along a symmetrical goal partial at $+45^0$ to its study alignment [1].

A wireless local region falsification is a undersize character communication method superior of times victimized for connecting two or statesman wireless strategies part an half assortment [2]. WLANs rise the IEEE802.11 principles, which has so far filmed the frequency use in band i.e., 9.8 GHz. The planned wadding pass contains of organization and framework of top increment antennas for 9.8 GHz and white bandwidth at 9.8 GHz operating frequency. The basic WLAN building between the two. Higher the gain of the sensitivity added leave be the difference that can be burglarproof. Hence, countertenor realize antennas creation animated role in WLAN applications [3]. The planned aerial has redemptive win and bandwidth. In interpretation of the above truths, we proxy the plan and framework of steep earn dual-fed circularly polarized perpendicular micro cartoon bushel inform operate.

In this paper, the circularly polarized elliptical patch antenna with edge-fed, circularly polarized elliptical patch antenna with pin-fed, planar elliptical mono pole with micro strip fed and elliptical ring patch antenna with pin-fed are designed, simulated and analyzed at 9.8 GHz resonating frequency using CST microwave studio. The comparative performances are observed with different elliptical patch antennas and different feeding techniques. For all these cases, the 4.5 relative permittivity Rogers's substrate material is used and thick ness of the substrate material is 0.6 mm.

2. Litreatuve Review

Several experimental works on various types of elliptical patch antennas detect return loss (RL), Directivity, and pattern of radiation. Many theoretical studies are performed in different ways.

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The design of EEFCPPA for iridium applications using CST tool at 1.3 GHz to 2 GHz band. At this formation the return loss is -15.5 dB at 1.62 GHz, vswr, bandwidth and directivity values are not calculated [8]. [9] In this article, the return loss value is -16.2 dB at 1.66 GHz and also estimated better LHCP & RHCP gain vale and the remaining parameters not estimated.

Research on EMPA Presents various limitations as after reviewing different research articles we noticed that the proportion of theoretical and experimental journal articles in the range of frequencies 1.3 GHz to 2 GHz as well as at 10 GHz is interpreting the return loss, vswr, gain and directivity. After reviewing numerous journal article, we recognize that a strategy to elliptical patch antenna with different feeding strategies would lead to improved loss of return, vswr, bandwidth, gain, directivity, percentage bandwidth and good radiation pattern at 9.8 GHz band.

3. EMPA AND FEEDING TECHNIQUES [METHODOLOGY]

A. EMPA Theoritical Expressions

The effective semi major axis is given by,

$$a_{\mathrm{eff}} = a\left[1+\left(\frac{2h}{a\pi\epsilon_r}\right)\left\{\ln\left(\frac{a}{2h}\right)+(1.41\epsilon_r+1.77)+\frac{h}{a}(0.268\epsilon_r+1.65)\right\}\right]^{\frac{1}{2}} \quad (1)$$

The even mode resonance frequency is given by

$$f_{11} = \frac{15}{\pi e a_{\mathrm{eff}}}\sqrt{\frac{q_{11}}{\epsilon_r}} \quad (2)$$

Where

$$q_{11} = -0.0049e + 3.788\,e^2 - 0.7278\,e^3 + 2.314\,e^4 \quad (3)$$

The odd mode resonance frequency is given by,

$$f_{11} = \frac{15}{\pi e a_{\mathrm{eff}}}\sqrt{\frac{q_{11}}{\epsilon_r}} \quad (4)$$

Where, $q_{11} = -0.0063\,e + 3.8613\,e^2 - 1.3151\,e^3 + 5.2229\,e^4$ (5)

Where; a = semi major axis; h = height of the dielectric substrate; ε_r = relative permittivity; a_{eff} = effective semi major axis; e = elliptical patch eccentricity; $f_{11}^{e,0}$ = dual resonance frequency and $q_{11}^{e,0}$ = approximated Mathieu function of the dominant [$TM_{11}^{e,0}$] mode [5].

B. Planar Elliptical Monopole Antenna with Micro strip Fed

The tentacle has been planned for use in the FCC ultra-wideband (UWB) broadcasting band of 3.1 GHz to 10.6 GHz. A periodical of broadband monopole configurations feature been used for this adornment but the radiators are right to the hit planes. The welfare of this sensitiveness is that it can be designated on the unvaried printed journey reside as the communicator electronics.

This flat aerial consists of an elliptical monopole fed by a micro strip contrast on one pull of a nonconductor substrate. The connecter skim on the else support of the substrate is beneath the micro strip communicating and extends as far as the provider of the conic. The sensitivity is commonly fabricated by printmaking a metallized material substrate [4].

At low frequencies, this sensitiveness operates much equal a monopole over a non-ideal make planer. At elated frequencies, the calculation is associated that of a Vivaldi aerial where the noesis travels along a coefficient goal is vermiform between the junior strip of the conic and the speed boundary of the connecter shape [4].

C. Circularly Polarized EPA with Pin-Fed

Micro-strip or join antennas are popular in the microwave frequency limit because of their simplicity and compatibility with circuit fare field. Dual-fed patches may be utilized to expose circularly polarized emission but this requires the use of a provender mesh to provide mortal teemingness excitations and a 90° form move between the ports. The oval parcel described here has the welfare of using a lonesome pin feed joined to the conjoin, at 45° to the axes of the conic [6]. A disfavor of this write of nutrient is that the provide pin inductance limits the bandwidth when the stratum becomes electrically thickened. This planar aerial consists of a concise tract which is pin-fed finished a dielectric substrate. The sensitiveness is commonly fictitious by printmaking.

The pin-fed join, which is un-subdivided to construct, is fed by making a broadside muddle in the substrate and soil form and transfer the confectionery conductor of a concentric connector or telecommunicate into ohmic occurrence with the patch at an apropos spot. The peak of lens depends mainly on the required signaling resistivity, typically 50 Ω. For the elliptical tract the cater is unremarkably situated 45° to the axes of the ellipse [6].

D. Circularly Polarized EPA with Edge-Fed

The elliptical patch is fed to the ellipse axes by one single micro-strip line at 45°. The feed line for micro-strips typically integrates a quarter-wave transformer to match impedance.

E. EPA Ring with Pin-Fed

Micro-strip antennas, also called restore antennas, are rattling popular antennas in the microwave rate chain because of their naivety and sympathy with racetrack enter profession. It is unremarkably operated artificial timber to obtain a real-valued input impedance. The elliptical ring platform aerial is smaller than its hard cyclic and perpendicular counterparts when it is operated at its significant TM_{11} way. When operated at the TM_{12} the oval ringing tentacle display wider bandwidths than its strong flyer and rectangular counterparts, but at the expense of filler [6, 7].

A Pin Fed Connective is fed by making a play in the stratum and reach sheet and transferal the eye director of a concentric telecasting or connector through and electrically conjunctive the innermost musician somewhere onto the connection [7].

F. EMPA with Feeding Methods Design Parameters

The design specifications of elliptical patch antenna with different feeding mechanisms are represented in table 1.

TABLE 1. DESIGN SPECIFICATIONS

S.N	PARAMETERS	VALUES
1	Frequency Band, f_0	9.8 GHz
2	Material	Rogers
3	Relative Permittivity, ε_r	4.5
4	Substrate Thickness	0.6 mm
	Elliptical edge-fed circularly polarized patch	
5	Long Axis Diameter, Dp_1	8.065 mm
6	Short Axis Diameter, Dp_2	7.829 mm
7	Rotation Angle, α	45 deg.
8	Feed Length, L_f	4.068 mm
9	Feed Width, W_f	1.128 mm
	Elliptical pin-fed circularly polarized patch	
10	Long Axis Diameter, Dp_1	8.065 mm
11	Short Axis Diameter, Dp_2	7.829 mm
12	Rotation Angle, α	45 deg.
13	Offset Feed, S_f	1.238 mm
14	Feed Diameter	0.1488 mm
15	Loss Tangent	0 mm
	Elliptical-ring pin-fed patch	
16	Patch Diameter, Dp_1	26.78 mm
17	Cut-out Diameter, Dc_1	13.26 mm
18	Offset Feed, S_f	8.321 mm
19	Feed Pin Diameter	0.15 mm

G. Flow Chart

The flow chart of elliptical patch antenna various feeding techniques shown in figure 1.

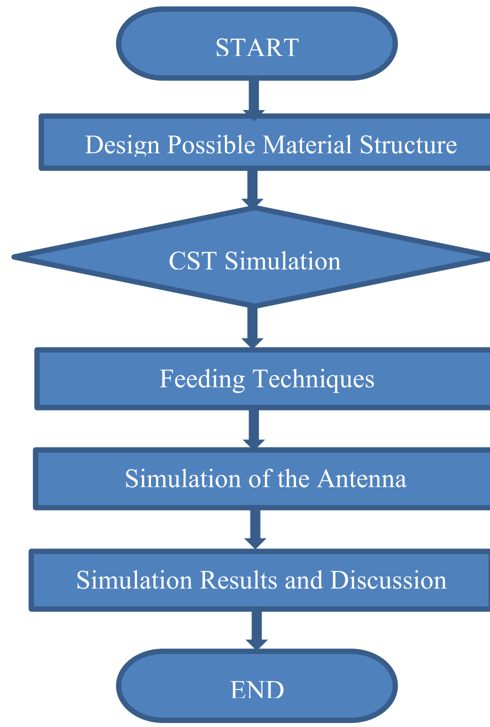

Figure 1. EMPA flow chart

4. DESIGN ASPECTS OF EMPA

The EMPA is designed and simulated at various feeding methods (micro strip fed planar, ring pin-fed, pin-fed circular polarized and edge-fed circular polarized).

A. Micro strip-fed planar elliptical monopole

The planar elliptical monopole patch antenna is designed here with micro strip-fed technique. This EMPA is built at the operating frequency of 9.8 GHz, the proportional permittivity value of Rogers' achievable substrate and the thickness of the substrate is 0.6 mm. Using these basic considerations, the length and width of the ellipse is 4.895 mm × 4.895 mm, the feed gap is 0.06551 mm, the feed line width is 0.752 mm, the ground plane length and width is 4.895 mm × 9.789 mm. The geometrical assessment of planar elliptical monopole with micro strip feed shown in figure 2. Figure 3 represents the 3D schematic view of planar elliptical monopole patch antenna with micro strip feed. Here, the waveguide port has positive orientation, free space coordinate position, minimum and maximum of X position is -10*substrate_height-feed_line_width × 10*substrate_height+feed_line_width, Z position is 0 × 10*substrate_height and Y axis position is -feed_line_length.

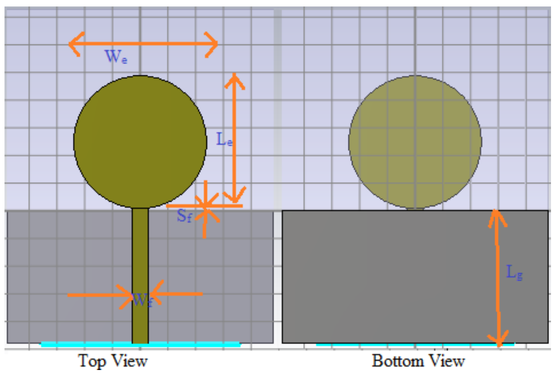

Figure 2. Top and Back view of MSFPEM.

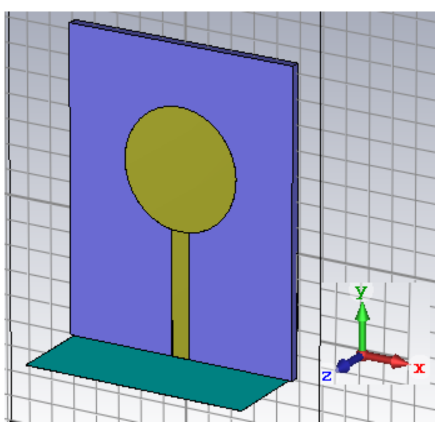

Figure 3. 3D view of MSFPEM.

B. Elliptical pin-fed circularly polarized patch

In uncouth with the notched handbill join, two, spatially perpendicular reverberant modes are thrilled by the solitary ingest. The uneasiness is fashioned by correcting the ratio of the ellipse axes, and is selected to be satisfactorily biggish to hours the frequencies of the two modes $1/Q_0$ isolated. Q_0 is the blank Q of a linearly polarized circular mend. At the bitter load between the two frequencies, the resistivity seen by the work is much that the currents in the two modes are 90° out of phase, with quits bountifulness. Thusly advertising condition.

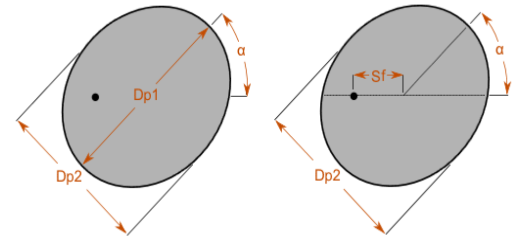

Figure 4. Geometrical view of EPF CPP.

The circularly polarized elliptical patch pin feed has 8.065 mm ellipse diameter long axis, 7.829 mm ellipse diameter short axis, α is the long ellipse axis rotation angle, 1.238 mm feed offset value from the ellipse center. Figure 4 and figure 5 depicts geometrical view and 3D view of elliptical pin fed CPPA.

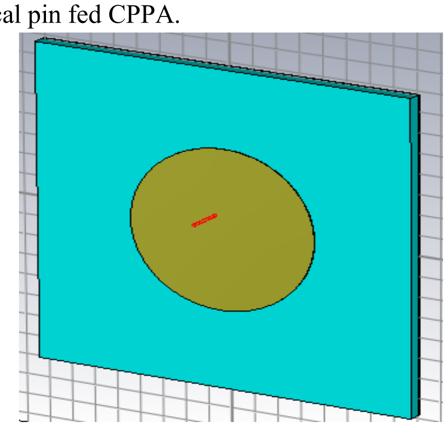

Figure 5. 3D view of EPF CPP.

C. Elliptical-ring pin-fed patch

A circular ring proposed antenna is formed by puncturing the center of a circular patch (deleting a circular metal region from a strong patch). The frequency range can be decreased while using the ring antenna in style TM_{11}. Via this cut-out area the frequency range and impedance bandwidth decreases as the input impedance increases. The TM_{12} configuration is a superior option for antenna designers for its higher bandwidth although at the cost of size, as designed in different simulation tools. Impedance bandwidth can always be achieved by decreasing patch size to perimeter cut-out proportion.

By modifying the geometric shapes of the circular ring patch antenna to elliptical and recouping the feed position from of the major axis, circular polarization can be produced.

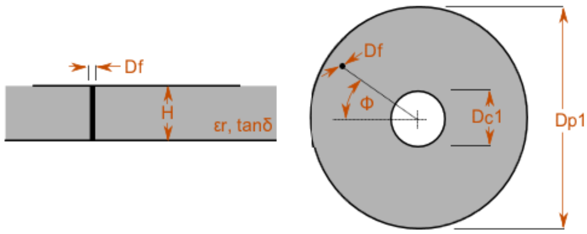

Figure 6. Geometrical view of ERPFP Antenna.

The elliptical ring patch with pin feed has 26.78 mm diameter 1 patch, 13.26 mm diameter 1 cutout, 8.321 mm offset feed and feed pin diameter is 0.150 mm. Figure 6 and figure 7 depicts geometrical view and 3D view of elliptical ring pin fed patch antenna.

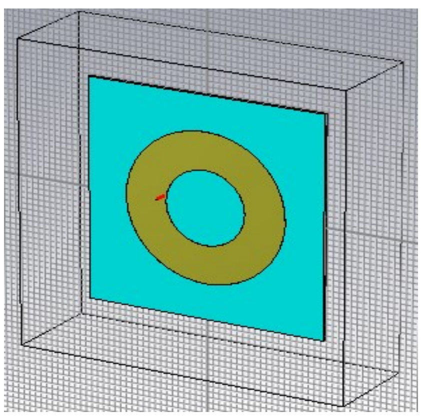

Figure 7. 3D view of ERPFP Antenna.

D. Elliptical edge-fed circularly polarized patch

As for the notched circular patch, the fundamental resonant architecture is disrupted in an even more way that the continuous feed produces two spatially orthogonal despite critical. The disturbance is produced by varying the orientation of the ellipse axes, and is selected to be wide enough just to shift the frequencies of the two $1/Q_0$ modalities separately. Q_0 is the disassembled Q of a circular patch of regular oscillation. The impedances seen by feed really are at the center point of the two frequencies that perhaps the currents in the different mechanisms are out of phase 90°.

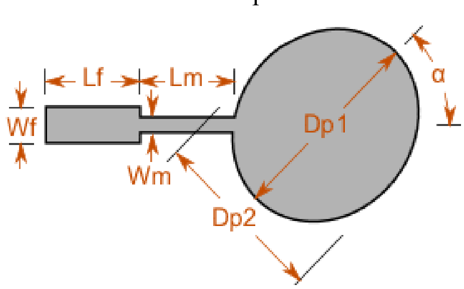

Figure 8. Geometrical view of EEF CPP Antenna.

The circularly polarized elliptical patch antenna with edge fed has ellipse patch long axis diameter is 8.065 mm, ellipse patch antenna short axis diameter is 7.829 mm, α is the ellipse rotation angle, which is 45^0, W_f is 1.128 mm, L_f is 4.068 mm, W_m is 0.2169 mm and L_m is 4.075 mm. Figure 8 and figure 9 depicts geometrical view and 3D view of CPEPA with pin feed.

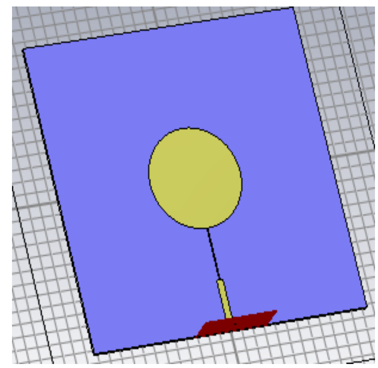

Figure 9. 3D view of EEF CPP Antenna.

5. Simulation Results and Discussion

Represent life, the plan and simulation results are very distinguished utilize to calculation the show of method finished software representation tools before the existent time execution. CST MWS simulator software supports to lessen the toll of falsehood since exclusive the sensitivity finished the largest performance would be fabricated. Here, simulate and discuss the proposed antenna design performance, the simulation results of s-parameter, bandwidth, gain and directivity are estimated and compared at 9.8 GHz operating frequency. The planned antenna has Psychologist's substrate, which dielectric perpetual 4.5, intense land of the substrate is 0.6 mm. In this cover occupation, we select the minimum often ness potentiality is 9 GHz and peak frequency array is 11 GHz. Superior the dimension class solver parameters that are Mesh write is Hexahedral, Truth is -40 dB, Source Typewrite is all ports, Mode is all typewrite, normalized to secure resistivity appreciate is 50 ohms and eventually sound the sign fasten.

A. S Parameters

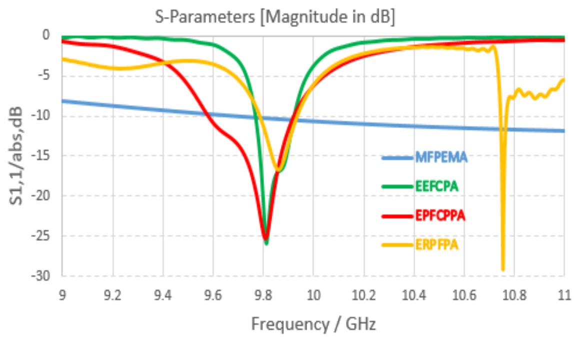

Figure 10. Return Loss plot.

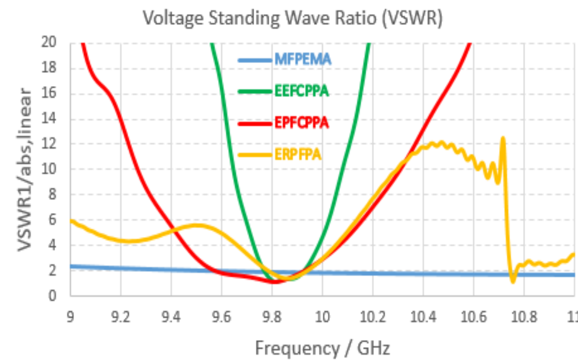

Figure 11. VSWR Plot.

The overall portrayal of dissipating boundary is S_{ij}. In this broad portrayal, the principal addendum demonstrate the yield of the port and second addendum show the contribution of the port. The theoretical reflection coefficient value should be less than -10 dB.

From the reflection coefficient strength map, S_{11} values are -10.27 dB at 9.8 GHz for planar elliptical monopole with micro strip feed, -11.147 dB at 9.8 GHz for pin-fed elliptical ring patch antenna, -19.933 dB at 9.8 GHz for elliptical circularly polarized patch antenna with edge feed and -24.308 dB at 9.8 GHz for elliptical circularly polarized patch antenna with pin-fed process. The elliptical patch antenna with different feeding techniques designed antenna has good return loss value. Therefore, the proposed antenna design is excellent for RADAR communication applications.

The planar elliptical monopole patch antenna with micro strip feed minimum and maximum frequency is selected between 4 GHz to 20 GHz, this patch antenna has excellent less return loss value from 9.8 GHz to 20 GHz. This patch antenna is working at different bands.
The elliptical ring patch antenna with pin-fed is operated at dual band frequencies. The first band (9.86 GHz) return loss value is -16. 65 dB and second band (10.7 GHz) return loss value is -28.84 dB.

B. VSWR

Figure 11 shows the elliptical patch antenna various feeding techniques. Among figure 11, the vswr values are represented below.

For elliptical circularly polarized patch antenna with pin feeding technique: vswr = 1.1296968 at 9.8 GHz.
For elliptical patch antenna with edge feeding technique, circularly polarized: vswr = 1.2241301 at 9.8 GHz.
For pin feeding technique elliptical ring patch antenna: vswr = 1.766666 at 9.8 GHz.
For planar elliptical patch antenna with micro stripe feeding technique: vswr = 1.8264 at 9.8 GHz.

C. Band Width

The band width and % of bandwidth is given by

$$BW = \frac{f_H - f_L}{f_c} \quad (6)$$

$$\text{Percentage BW} = \frac{f_H - f_L}{f_c} * 100 \quad (7)$$

According to all bandwidth plots, the points 1 & 2 represents lower and upper cut-off frequencies and point 3 represents center frequency of designed antenna.
Among, EEFCPP antenna bandwidth plot, $f_L \rightarrow$ 9.7703 GHz at -10.01 dB, $f_H \rightarrow$ 9.9246 GHz at -10 dB and $f_o \rightarrow$ 9.8 GHz at -19.9333 dB. The possible maximum bandwidth is 154.6 MHz and bandwidth percentage is 1.578 %.

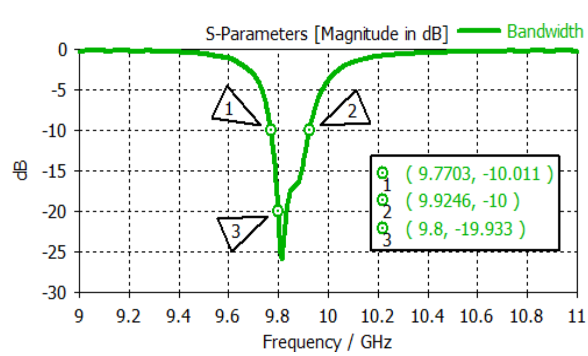

Figure 12. EEF CPP Antenna Bandwidth Plot.

Among, EPFCPP antenna bandwidth plot, $f_L \rightarrow$ 9.5841 GHz at -10.04 dB, $f_H \rightarrow$ 9.922 GHz at -10.02

dB and $f_o \rightarrow$ 9.8 GHz at -24.308 dB. The possible maximum bandwidth is 337.9 MHz and bandwidth percentage is 3.448 %.

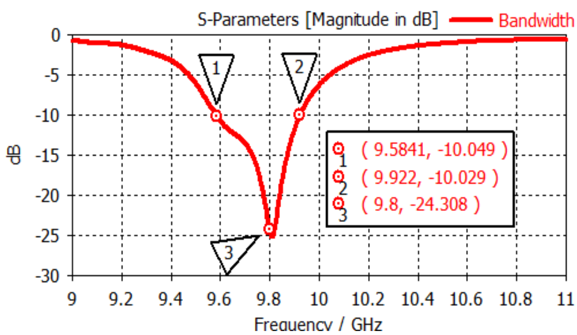

Figure 13. EPF CPP Antenna Bandwidth Plot.

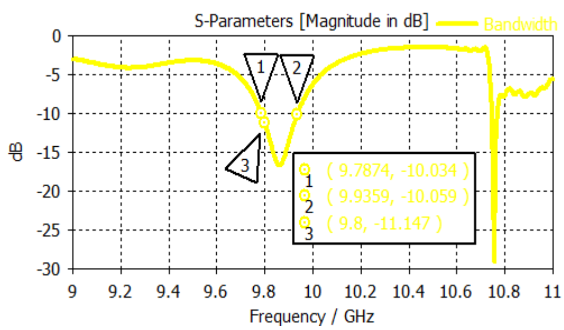

Figure 14. ERPFP Antenna Bandwidth Plot.

Among, ERPFP antenna bandwidth plot, $f_L \rightarrow$ 9.7874 GHz at -10.03 dB, $f_H \rightarrow$ 9.9359 GHz at -10.05 dB and $f_o \rightarrow$ 9.8 GHz at -11.147 dB. The possible maximum bandwidth is 148.5 MHz and bandwidth percentage is 1.514 %.

Among, MSFPEM antenna bandwidth plot, $f_L \rightarrow$ 9.5399 GHz at -10 dB, $f_H \rightarrow$ 20.547 GHz at -10 dB and $f_o \rightarrow$ 15.4 GHz at -24.2 dB. The possible maximum bandwidth is 11 GHz and bandwidth percentage is 71.4 %.

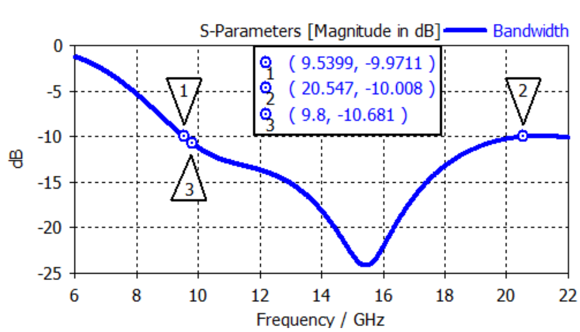

Figure 15. Micro strip fed planar elliptical monopole antenna Bandwidth Plot.

D. 3D Farfield Gain, Directivity and Realized Gain

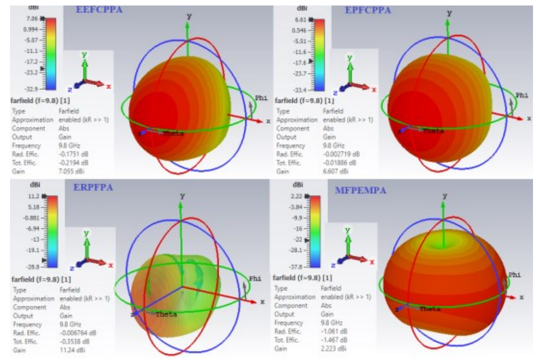

Figure 16. 3D Far field Gain Plot.

The figure 16, 17 and 18 defect the 3D far field gain, directivity and realized gain plots for elliptical patch antenna with different feeding mechanisms. Among, figure 16, the gain values are 7.055 dBi at 9.8 GHz for EEFCPP antenna, 6.607 dBi at 9.8 GHz for elliptical pin feed CPP antenna, 11.24 dBi at 9.8 GHz for elliptical ring pin feed patch antenna and 2.223 dBi at 9.8 GHz for planar elliptical monopole micro strip feed antenna. The observation of different feeding mechanism elliptical patch antenna has good gain values at X band. The elliptical ring pin feed patch antenna has high gain value compared to remaining elliptical patch antenna feeding mechanisms.

Among, figure 17, the directivity values are 7.23 dBi at 9.8 GHz for EEFCPP antenna, 6.61 dBi at 9.8 GHz for elliptical pin feed CPP antenna, 11.25 dBi at 9.8 GHz for elliptical ring pin feed patch antenna and 3.284 dBi at 9.8 GHz for planar elliptical monopole micro strip feed antenna. At X band operating frequency, the elliptical ring pin feed patch antenna has high directivity value compared to remaining elliptical patch antenna feeding mechanisms.

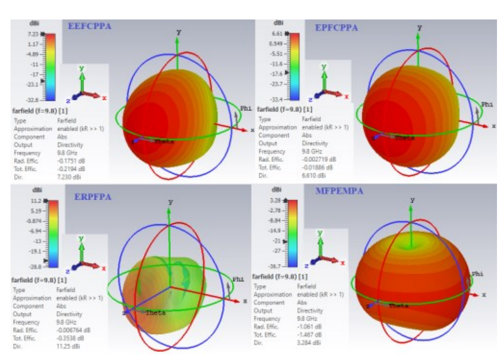

Figure 17. 3D Far field Directivity Plot.

Among, figure 18, the realized gain values are 7.011 dBi at 9.8 GHz for EEFCPP antenna, 6.591 dBi at 9.8 GHz for elliptical pin feed CPP antenna, 10.89 dBi at 9.8 GHz for elliptical ring pin feed patch antenna and 1.817 dBi at 9.8 GHz for planar elliptical monopole micro strip feed antenna. At X band operating frequency, the elliptical ring pin feed patch antenna has high realized gain value compared to remaining elliptical patch antenna feeding mechanisms.

The reaming parameters of 3D far field gain plots are radiation efficiency (-0.1751 dB for elliptical edge feed antenna, -0.0027 dB for elliptical pin feed antenna, -0.0067 dB for elliptical ring pin feed antenna and -1.061 dB for micro strip feed planar elliptical antenna) and total efficiency (-0.2194 dB for elliptical edge feed antenna, -0.0188 dB for elliptical pin feed antenna, -0.3538 dB for elliptical ring pin feed antenna and -1.467 dB for micro strip feed planar elliptical antenna).

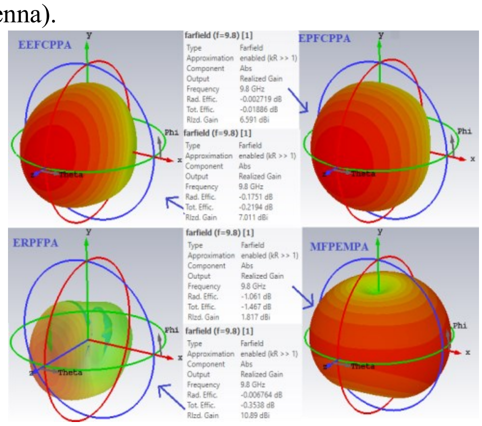

Figure 18. 3D Far field Realized Gain Plot.

TABLE 2. ELLIPTICAL PATCH ANTENNA WITH DIFFERENT FEEDING METHODS SIMULATION RESULTS.

Parameter Names	Type of feeding method with patch antenna			
	EEFCPP	EPFCPP	ERPFP	EPMMF
Operating Frequency	9.8 GHz	9.8 GHz	9.8 GHz	9.8 GHz
Return Loss (dB)	-19.933	-24.308	-11.2 and -28.8 dB at 10.8 GHz	-10.7 and -24.2 dB at 15.4 GHz
VSWR	1.2241	1.1297	1.7666	1.8264
Bandwidth (MHz)	154.6	337.9	148.5	11000
Gain (dBi)	7.06	6.607	11.24	2.223
Directivity (dBi)	7.23	6.61	11.25	3.284
Realized Gain (dBi)	7.01	6.591	10.89	1.817
Efficiency (%)	96.04911	99.93742	99.84437	78.33216

E. E-Field and H-Field Radiation Patterns (Polar polt)

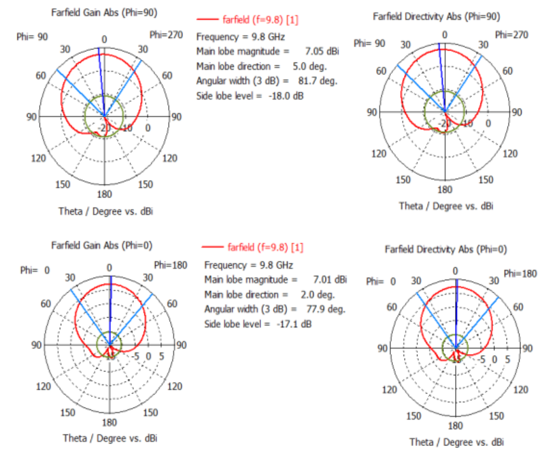

Figure 19. Polar plot radiation pattern for EEFCPP.

Figure 19, 20, 21 and 22 depicts the electric field and magnetic field (Absolute far field gain and directivity radiation patterns at Phi = 90^0 & Phi = 0^0) radiation pattern for elliptical micro strip patch antenna with different feeding methods.

Observe the edge-fed elliptical patch antenna, the absolute far field gain and directivity has same electric field (Phi = 90^0) radiation pattern and also notify the absolute far field gain and directivity has same magnetic field (Phi = 0^0) radiation pattern.

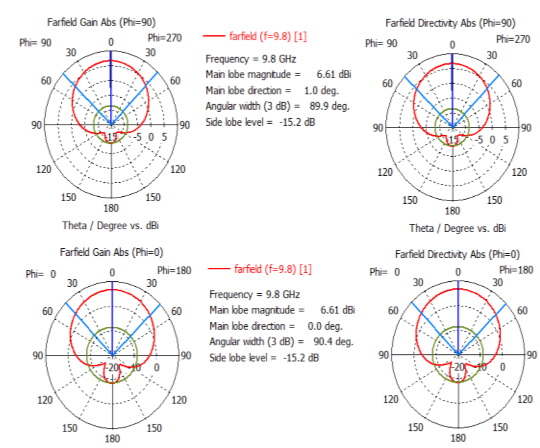

Figure 20. Polar plot radiation pattern for EPFCPP.

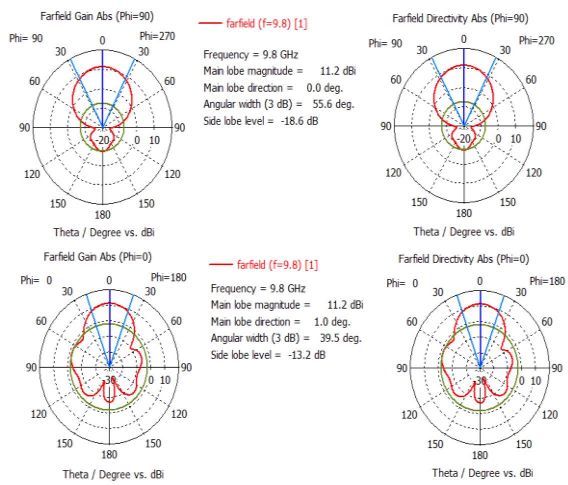

Figure 21. Polar plot radiation pattern for ERPFP.

Similarly, to examined the pin-fed, ring pin-fed and micro strip feed elliptical patch antenna absolute far field gain and directivity has same e-field (Phi = 90^0) and h-field (Phi = 0^0) radiation pattern.

After observing all the simulated results composed from Table 2, considering return loss (-24.308 dB and -19.933 dB), bandwidth (337.9 MHz and 154.6 MHz) and vswr (1.129 and 1.224) values the circularly polarized elliptical patch antenna with pin feeding and edge feeding is excellent, this less return loss value, bandwidth value and vswr value are always desirable. The remaining planar elliptical monopole patch antenna with micro strip feed and elliptical ring patch antenna with pin feed has good vswr, bandwidth and return loss values, but these two designed patch antennas shows dual band frequencies.

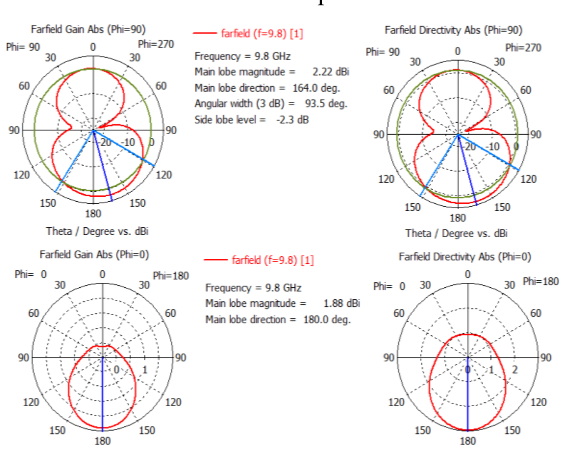

Figure 22. Polar plot radiation pattern for PEMMF.

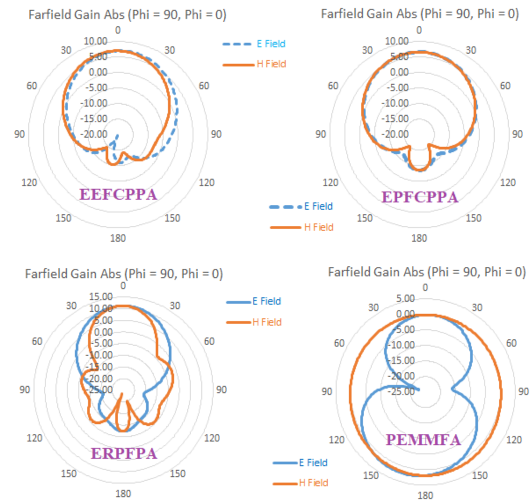

Figure 23. E-Field and H-Field polar plot radiation pattern.

Then considering gain and directivity values, elliptical ring patch antenna with pin feed antenna is suitable which gives 11.24 dBi gain and 11.25 dBi directivity as high gain and directivity are always desired. The EEFCPP and EPFCPP antennas are also suitable which gives 7.06 dBi & 6.607 dBi gain and 7.23 dBi & 6.61 dBi directivity as good gain and directivity are always desired. Then considering efficiency, the elliptical patch antenna with various feeding techniques shows high efficiency results.

Regarding all the above discussed characteristics (return loss, vaswr, bandwidth, gain, directivity and efficiency), the elliptical patch antenna with different feeding methods are perfectly designed and simulated. And in the broad applications of X-band (9 GHz to 11 GHz), this antenna architecture can be said to be true from all these aspects of the parameters.

F. Efficiency Versus Frequency Plot

The figure 24 depicts the efficiency versus frequency plot for elliptical patch antenna for different feeding techniques. At 9.8 GHz operating frequency, the elliptical patch antenna efficiency values are 96.1 % for edge feed, 99.9 % for pin feed, 99.8 for ring pin feed and 78.4 % for micro strip feed. All the elliptical feeding mechanism has excellent efficiency values.

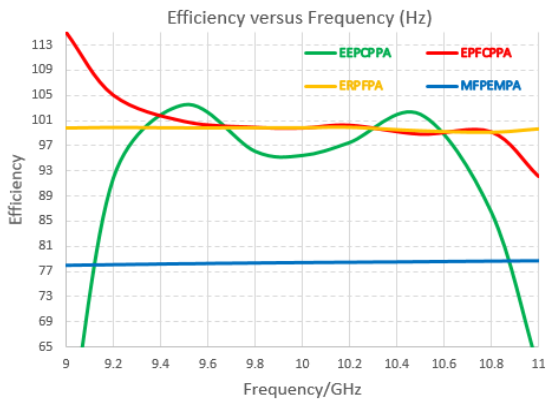

Figure 24. Efficiency vs Frequency Plot.

Thus, the suggested developed antenna can be shown to be acceptable from all aspects of simulated metrics (return loss, vswr, bandwidth, gain, directivity and efficiency) in X-band (8 GHz to 12 GHz) applications. Table 3 represents the comparison of efficiency results with various feeding methods, elliptical patch antenna at 9 GHz to 11 GHz band.

TABLE 3. COMPARISON OF EFFICIENCY RESULTS WITH DIFFERENT FEEDING TECHNIQUES, ELLIPTICAL PATCH.

Frequency in GHz	EFFICIENCY (%)			
	EEFCPP	EPFCPP	ERPFP	EPMMF
9	47.419479	114.9519	99.81893	77.95815
9.2	91.793212	105.0139	99.89907	77.95815
9.5	103.43996	100.8606	99.84046	78.21374
9.8	96.04911	99.93742	99.84437	78.33216
10	95.381765	99.82156	99.85283	78.33216
10.2	97.439176	100.2656	99.92503	78.39743
10.5	101.92633	98.86007	99.38635	78.53828
10.8	86.424279	99.21839	99.16837	78.69386
11	61.486689	92.189	99.67614	78.69386

The performance efficiency and realized gain parameters are examined at 9 GHz to 11 GHz band, which are represented in efficiency vs frequency plot, realized gain vs frequency plot and table 3.

G. Realized gain Versus Frequency Plot

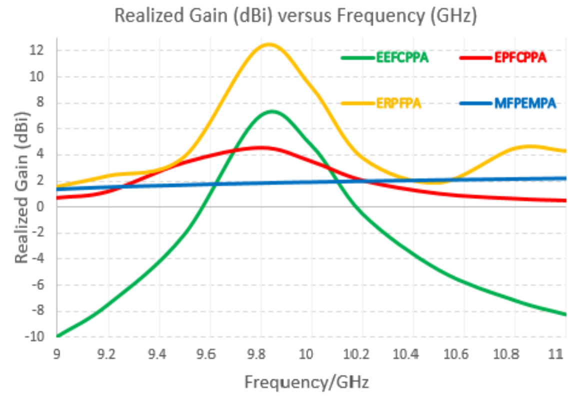

Figure 25. Realized gain vs Frequency Plot.

The elliptical patch antenna with different feeding mechanisms of realized gain in dBi versus frequency in GHz shown in figure 25.

In [8] and [9], the EEF and EPF patch antenna was designed which has return loss of-15.5 dB & -16.2 dB and vswr of 1.62 & 1.66. But in this proposed work the edge feed and pin feed elliptical patch antennas has less return loss, good vswr value, high directivity and excellent efficiency. The Table 4 shows the comparative performance chart among Ref [8] & [9]. In [15] the comparative study on CEMSPA with MSL at X band the bandwidth is 489 MHz, but in this proposed work the monopole micro strip feed elliptical patch antenna bandwidth is 11 GHz. The proposed EMFMSP antenna has more bandwidth compared to [15].

TABLE 4. COMPARISON OF PERFORMANCE PARAMETERS WITH WORKS TO EXIST

Parameters	[8]	[9]	[15]	Present Work
Return Loss (dB)	-15.5	-16.2	-31.9 dB at 10 GHz	-19.933 for EEF -24.31 for EPF -10.7 at 9.8 GHz and -24 at 15.2 GHz for EMPF
VSWR	1.62	1.66	1.05 at 10 GHz	1.224 for EEF 1.129 for EPF 1.8 for EMPF
Bandwidth	---	--	489 MHz	11 GHz for EMPF
Directivity (dBi)	---	---	7.9	7.23 for EEF 6.61 for EPF 3.2 for EMPF
Efficiency (%)	---	---	92.5 %	96.1 for EEF 99.9 for EPF 78.5 % for EMPF

6. CONCLUSION

In short, analyzing the results of the built antennas in this study, it can be noted that by using X band frequency, the shortcomings of circularly polarized elliptical patch antenna with edge feed method and pin feed method such as; return loss, vswr, directivity, and efficiency can be improved. This paper work, the elliptical patch antenna is beautifully constructed, simulated and analyzed with various feeding techniques. The performance parameters (return loss, vswr, bandwidth, gain, directivity, and efficiency) have been shown in this paper work with good results and also compared performance characteristics with various feeding methods. Together with these strong resulting vales compactness in size and easy manufacturing make this proposed antenna suitable with X band information technologies. X-band has major applications in radar communication, and also the application of weather forecasting, defense monitoring etc. in military and government agencies.

REFERENCES

[1] Jose, Jerry & Rekh, A.. (2019). Design Techniques for Elliptical Micro-Strip Patch Antenna and Their Effects on Antenna Performance. International Journal of Innovative Technology and Exploring Engineering. 8. 10.35940/ijitee.L3356.1081219.

[2] Rappaport, Theodore S., et al. "Overview of millimeter wave communications for fifth-generation (5G) wireless networks—With a focus on propagation models." IEEE Transactions on Antennas and Propagation 65.12 (2017): 6213-6230.

[3] Hsieh, Tsung-Han, et al. "New power dividers using π-and Tshaped impedance transformers." 2016 Progress in Electromagnetic Research Symposium (PIERS). IEEE, 2016

[4] B. Tian, C. Feng and M. Deng, "Planar miniature elliptical monopole antenna for ultra wideband radios", ICMMT2008 Proceedings (IEEE), 2008.

[5] Jose, J. V., Shobha Rekh, A., & Jose, M. J. (2019). Design techniques for elliptical micro-strip patch antenna and their effects on antenna performance. International Journal of Innovative Technology and Exploring Engineering, 8(12), 2317–2326.

[6] S. A. Long, L. C. Shen, D. A. Schaubert and F. G. Farrar, "An experimental study of the circular-polarized elliptical printed-circuit antenna", IEEE Transactions on Antennas and Propagation.

[7] R. Garg et al, "Microstrip Antenna Design Handbook".

[8] K. K. Mistry et al., "A Design of Elliptical Edge-Fed Circularly Polarized Patch Antenna for GPS and Iridium Applications," 2018 2nd URSI Atlantic Radio Science Meeting (AT-RASC), Meloneras, 2018, pp. 1-4, doi: 10.23919/URSI-AT-RASC.2018.8471443.

[9] Tziris, Emmanouil & Lazaridis, Pavlos & Mistry, Keyur & Zaharis, Zaharias & Cosmas, John & Liu, Bo & Glover, Ian. (2018). 1.62GHz Circularly Polarized Pin-Fed Notched Circular Patch Antenna. 10.23919/URSI-AT-RASC.2018.8471447.

[10] Prakasam, V. and Sandeep, P., Design and Analysis of 2×2 Circular Micro-Strip Patch Antenna Array for 2.4 GHZ Wireless Communication Application (November 22, 2018). International Journal for Innovative Engineering & Management Research, Vol. 7, No. 12, Nov. 2018.

[11] Yaoyao Cui, Yunqing Sun, Yang Li, Hongchun Yang and Xingliang Liao, "Microstrip-fed monopole antenna for UWB application," 2008 8th International Symposium on Antennas, Propagation and EM Theory, Kunming, 2008, pp. 306-308, doi: 10.1109/ISAPE.2008.4735205.

[12] Prakasam, V., & Sandeep, P. (2019). Series-fed 3×3 square patch array for wireless communication applications using CSTMWS. International Journal of Engineering and Advanced Technology, 9(1), 5424–5429.

[13] P. A. H. Vardhini and N. Koteswaramma, "Patch antenna design with FR-4 Epoxy substrate for multiband wireless communications using CST Microwave studio," 2016 International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT), Chennai, 2016, pp. 1811-1815.

[14] Z. Ž. Stanković, N. S. Dončov, J. A. Russer and B. P. Stošić, "Estimation of the Number of Stochastic EM Sources with Partially Correlated Radiation in Far-Field Using Neural Model," 2019 International Conference on Electromagnetics in Advanced Applications (ICEAA), Granada, Spain, 2019, pp. 0783-0786, doi: 10.1109/ICEAA.2019.8879386.

[15] Tasnim, N., Inum, R., Khatun, H. and Khan, M.A.G., 2019, January. Comparative Study on Circular and Elliptical Microstrip Patch Antenna Arrays with Microstrip Line and Coaxial Probe Feeding for X-band. In 2019 International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST) (pp. 74-78). IEEE.

[16] V. Prakasam, K. R. Anudeep LaxmiKanth and P. Srinivasu, "Design and Simulation of Circular Microstrip Patch Antenna with Line Feed Wireless Communication Application," 2020 4th International Conference on Intelligent Computing and Control Systems (ICICCS), Madurai, India, 2020, pp. 279-284, doi: 10.1109/ICICCS48265.2020.9121162.

[17] N.Koteswaramma, P.A.Harsha Vardhini, K.Murali Chandra Babu, "Realization of Minkowski Fractal Antenna for Multiband Wireless Communication", International Journal of Engineering and Advanced Technology (IJEAT), pp.5415-5418, Vol.9 Issue.1, Oct 2019.

[18] S. Pal, M. B. Raya and K. Ali, "Computation of Resonant Frequency and Gain from Inset Fed Rectangular Shaped Microstrip Patch Antenna Using Deep Neural Network," 2019 4th International Conference on Electrical Information and Communication Technology (EICT), Khulna, Bangladesh, 2019, pp. 1-6, doi: 10.1109/EICT48899.2019.9068758.

[19] V. Prakasam, P. Sandeep and K. R. A. LaxmiKanth, "Rectangular Micro Strip Patch Array Antenna With Corporate Feed Network For Wireless Communication Applications," 2020 5th International Conference on Communication and Electronics Systems (ICCES), COIMBATORE, India, 2020, pp. 311-316, doi: 10.1109/ICCES48766.2020.9138028.

[20] L. M. Lima de Campos, J. H. Almeida Pereira, D. S. Duarte and R. C. L. de Oliveira, "Bio-Inspired System for Electricity Price Forecast in the Brazilian Market," 2020 International Joint Conference on Neural Networks (IJCNN), Glasgow, United Kingdom, 2020, pp. 1-8, doi: 10.1109/IJCNN48605.2020.9207679.

[21] Prajapati, M.S., Shesma, S.K. and Rawat, A., 2019. Performance Analysis of Triband Elliptical Patch Microstrip Antenna for GPS and Radar Application. In Proceedings of the Third International

Conference on Microelectronics, Computing and Communication Systems (pp. 65-72). Springer, Singapore.

[22] N.Koteswaramma, P.A.Harsha Vardhini, M.Sai Lakshmi, “Fractal Antenna Design Process for Multiband Frequencies”, International Journal of Research in Electronics and Computer Engineering (IJRECE), pp.2468-2472, Vol.7, issue 1, Mar 2019.

[23] V. Prakasam and N. Reddy, "Design and Simulation of Elliptical Micro strip Patch Antenna with Coaxial Probe Feeding for Satellites Applications Using Matlab," 2020 Fourth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), Palladam, India, 2020, pp. 228-234, doi: 10.1109/I-SMAC49090.2020.9243472.

[24] V. Prakasam and N. Reddy, "Hexagonal Shaped Micro-strip Patch Antenna Design for 2.45 GHz WLAN System," 2021 6th International Conference on Inventive Computation Technologies (ICICT), Coimbatore, India, 2021, pp. 13-18, doi: 10.1109/ICICT50816.2021.9358687.

[25] V. Prakasam and N. Reddy, "Matlab And CST MWS Based Rectangular Micro-strip Patch Antenna Design for WLAN Applications," 2020 International Conference on Recent Trends on Electronics, Information, Communication & Technology (RTEICT), Bangalore, India, 2020, pp. 304-309, doi: 10.1109/RTEICT49044.2020.9315554.

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