International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-10 Issue-3, February 2021

Design a 90^0 Hybrid Feed Square Patch Stacked Antenna at 3GHz

V. Saidulu

Abstract*: Microstrip antennas find wide applications in high-speed vehicles, and missiles, tanks, satellite communications etc. The main advantage of these antennas over conventional microwave antenna are lightweight, low volume, low cost, planar structure and compatibility with integrated circuits. The present paper deals with the design and development of 90^o hybrid feed square patch stacked antenna. The design of square patch and 90^0 hybrid feed has been carried out at frequency of 3 GHz on epoxy glass substrate, the radiation pattern of the square patch has been experimentally studied. The effect of stacked patches placed above the square patch has been studied experimentally for different cases like 1,2,3 and 4 stacked patches placed one above other above the driven square patch. From the experimental result it has been found that performance of the case of 1 + 2 (one driven element and two parasitic element) is optimum with bandwidth of 16 % and VSWR 1.42 the performance degrades the no of practical elements is increased that is for case 1 + 3 and 1 + 4 etc., The performance of 1 + 2 case of also found to be superior to the performance 1+ 0 and 1+1 cases experimentally studied, also been carried out for cross Polarization and co – polarization.

***Keywords*: Bandwidth, Beamwidth, Gain, Resonant frequency, Radiation pattern etc**

I. INTRODUCTION

Microstrip devices have been used widely as microwave circuit elements such as transmission lines, filter, resonator etc. Microstrip antenna have received much attention in recent – years because of their many unique and attractive properties low profile, light in weight, compact and conformable in structure and easy to fabricate and to be integrated with solid state devices [1-7]. They are superior to the conventional antennas. Despite narrow band width and low efficiency. The microstrips find potential application in various diversified fields especially in high speed space vehicles, missiles, tanks and other strategic defense equipments. Since the inception, microstrip antenna attracted attention of large number of researches world over which has given stimulus to the research and development resulting into many diverse applications such as aircrafts missiles, space vehicles, satellite communications, telemetry, radars and other defense equipments[7-10]. The microstrip structures radiating circularly polarized waves play an important role in communication because in such cases problem of alignment is completely removed. Variety of microstrip antenna is one of those, which can provide circular polarization with hybrid feed. In the present endeavor, therefore an attempt has been made to design and develop a square microstrip patch for circular polarization. Cavity model is one of the most widely used methods in analyzing the performance of microstrip antennas[11-17]. The design square patch and 90^0 hybrid feed has been carried out at frequency of 3.0 GHz, an epoxy glass substrate, the radiation pattern of the square patch has been experimentally studied. The effect of stacked patches placed the above the square patch has been studied experimentally for different cases.

Manuscript received on February 21, 2021.
Revised Manuscript received on February 28, 2021.
Manuscript published on February 28, 2021
V. Saidulu*, Assistant Professor, Mahatma Gandhi Institute of Technology Email. saiduluvadtya@gmail.com

II. DESIGNOF 900 HYBRID

90^0 Hybrid can be designed so that its output impedance matches with the load at its output port. All the section of this hybrid are λ/4 long, λ being the center frequency in the dielectric. λ0 = wavelength in the free space. Referring to Fig 1, when power is fed at port(1), it gets divided equally between ports (2) and (3) no power is coupled to port (4) Therefore, $S_{11} = S_{14} = 0$

Good quality plagiarism software/ tool

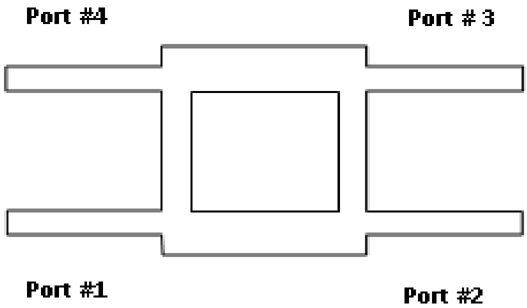

Fig.1. 90^o Hybrid

III. SPECIFICATIONS OF EPOXY GLASS SUBSTRATE

Height of the substrate (h) = 0.16cm
Thickness of the strip (t) = 0.001cm
Operating frequency (f) = 3.0 GHz
Free space velocity (C) = $3x10^{10}$ cm/sec.

IV. DESIGN OF STRIP WIDTHS

The strip widths have been calculated by using iterative method. The width of the patch, strip impedance and effective dielectric constant is shown in Table 1

Table- 1: Width of the patch, strip impedance and effective dielectric constant

Strip impedance (Ω)	Effective dielectric constant ($\in_e$)	Widths (cm)
50	3.425	0.216
35.35	3.460	0.386

V. FEED POINT

The feed point is determined by the geometry if the hybrid and the patch. The patch is square and the two feed points are λ/4 away on adjacent sides of the square and equal distance from the corner of the square. Thus one can get

$Z = \sqrt{2} \times 0.6719$

$= 1.12$cm

VI. QUARTER WAVE TRANSFORMER

The mismatch between the 50 Ω, stub and 35.598 Ω, patch is minimized by using a quarter wave transformer of impedance.

$Z = \sqrt{35.598 \times 50} = 42.981$

The width for this is found to be

W (42.98) = 0.4026 cm

VII. LENGTHS OF λ/4 SECTIONS

As the width are different for different impedance arms, so are their dielectric constants, hence the respective wavelengths are also different is shown in Table 2

Table -2: Impedance of the section and quarter wavelength

Impedance of the section (Ω)	Quarter wavelengths (cms)
50	1.3508
35.35	1.3438

The completes the design of the microstrip patch antenna with a branch line 90^0 hybrid as shown in Fig.2.

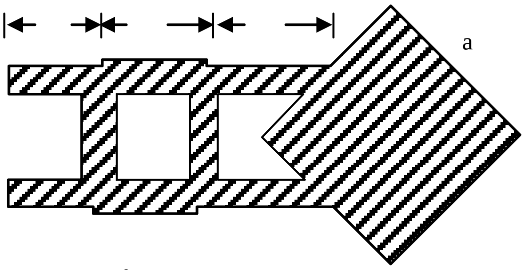

Fig. 2 90^0 hybrid square patch antenna

VIII. DESIGN OF THE PATCH

The patch size has been calculated by using iteration method. The approximate patch dimension is determined as

$a^1 = C/2f_0 \sqrt{\in_e} = 2.486$

To account for the fringing field, the change effective dimension is given be 2Δ, where

$a^1 = 0.00346$

Thus $a = a^1 - 2\Delta = 2.5$cm

Hence the patch size is $a \times a = 2.5 \times 2.5\text{cm}^2$

IX. INPUT IMPEDANCE

The input impedance at any arbitrary point, which is at a distance 'Z' from the corner, is given by

$$Y_{in}(z) = 2G\left[\cos^2(\beta z) + \frac{G^2 + B^2}{Y_o^2}\sin^2\beta Z - \beta/y_0 \sin(2\beta Z)\right]^{-1}$$

AT Z = 1.12 CM

$Y_{in}(1.12) = 0.0130$

$Z_{in}(1.12) = 70.183\Omega$

However, as the patch is fed at two points, the effective impedance seen as the feed points is parallel combination of two impedance of 70.183Ω. Hence the input impedance of the patch as seen at ports 1 or 4 is 35.598 Ω each.

X. EXPERIMENTAL MEASUREMENTS

During the experiment, the output of the source was fairly constant. The source of the microwave power was quite stable and the frequency variations were negligible small. Isolator was used to avoid the reflection from the antenna. The receiver system was kept in the far zone ($2d^2 / \lambda$). Using the set up the radiation patterns of the antenna were measured. The data of measured radiation pattern using different number of parasitic elements are shown in Tables 3 to 6, which are also shown plotted in Fig. 3 and Fig.4. Using the Fig. 3 to 4 calculated maximum radiated power in (dB), Beam-width (degree) actual ration and gain was shown in Table 8,9,10 and 11. The data VSWR was shown in Table 6 and also shown plot in Fig.5. Using the VSWR data, return-loss were we calculated. The data of return loss was shown in Table 12. Calculated the bandwidth from the plot of VSWR, The data of band width was shown in Table 14.

Table - 3: Data of co-polar radiation pattern for 90 Hybrid – Feed Square Patch Stacked Antenna

Angle (Degree)	Relative Power (dB)				
	Driven element	Driven element +1 parasitic	Driven element +2 parasitic z	Driven element +3 parasitic	driven element +4 parasitic
-90	-14.49	-12.78	-12.78	-13.7	-15.02
-80	-14.4	-10.36	-9.77	-11.28	-13.7
-70	-13.31	-10.56	-7.14	-12	-13.84
-60	-12	-8	-5.6	-9.38	-13.2
-50	-10.95	-6.1	-3.8	-8.33	-12.13
-40	-10.3	-4.92	-2.75	-6.95	-11.67
-30	-8.98	-3.93	-1.7	-6.03	-10.75
-20	-7.34	-3.28	-1.25	-5.25	-9.2
-10	-6.3	-2.49	-0.48	-4.46	-8.01
0	-5.6	-2	0	-4.07	-6.56
10	-6.49	-2.95	-0.483	-4.52	-7.15
20	-7.48	-3.75	-1.02	-5.64	-8.46
30	-9.31	-4.66	-1.9	-7.28	-10.23
40	-10.8	-6.03	-2.89	-8.4	-11.64
50	-12	-7.34	-4.46	-10.3	-12.66
60	-13.51	-9.25	-5.77	-11.2	-13.7
70	-14.03	-11.87	-8.98	-13.05	-13.7
80	-14.69	-11.93	-10.95	-12.46	-13.75
90	-14.62	-12.78	-12.13	-14.75	14.33

Retrieval Number: 100.1/ijeat.C22790210321
DOI:10.35940/ijeat.C2279.0210321
Journal Website: www.ijeat.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication

Table - 4: Data for cross-polarization radiation pattern 90° hybrid - feed square patch stacked antenna

Angle (Degree)	Relative Power (dB)				
	Driven element	Driven element +1 parasitic	Driven element +2 parasitic	Driven element +3 parasitic	Driven element +4 parasitic
-90	-17.4	-16.53	-16.45	-15.73	-17.69
-80	-16.36	-12.17	-11.26	-15.03	-17.76
-70	-16.71	-11.62	-11.05	-12.8	-16.15
-60	-14.06	-9.37	-7.69	-11.47	-15.1
-50	-12.37	-7.21	-5.45	-10.56	13 85
-40	-11.06	-6.05	-4.06	-8.88	-12.59
-30	-10.07	-5.2	-2.66	-8.04	-11.33
-20	-9.3	-4	-1.89	-6.85	-10.14
-10	-8.11	-3.13	-0.98	-5.52	-9.52

Angle (Degree)	Relative Power (dB)				
	Driven element	Driven element +1 parasitic	Driven element +2 parasitic	Driven element +3 parasitic	Driven element +4 parasitic
0	-7.06	-2.62	-0.45	-4.69	-7.9
10	-8.32	-3.36	-1.1	-5.73	-9.43
20	-9.86	-4.6	-2.13	-7.51	-10.84
30	-10.8	-6.36	-3.36	-9.23	-12.1
40	-13.08	-8.18	-4.8	-10.9	-14.2
50	-14.64	-11.38	-6.71	-13.32	-15.15
60	-15.58	-12.87	-10.4	-14.71	-16.02
70	-16.85	-11.96	-9.93	-15.38	-16.76
80	-16.64	-13.94	-12.87	-16.63	-17.48
90	-18.57	-16.38	-16.7	-17.22	-17.55

Table- 5: Data of return loss for 90 ⁰ hybrid feed square patch stacked antenna

Frequency (GHz)	Driven element	Driven element +1 parasitic	Driven element +2 parasitic	Driven element +3 parasitic	Driven element +4 parasitic
2	-1.434	-1.51	-1.52	-1.38	-1.28
2.1	-1.7	-1.76	-1.86	-1.62	-1.55
2.2	-1.99	-2.12	-2.29	-1.85	-1.79
2.3	-2.49	-2.65	-2.87	-2.21	-2.12
2.4	-3.18	-3.49	-3.74	-2.92	-2.65
2.5	-3.76	-4.12	-4.37	-3.78	-3.38
2.6	-4.37	-5	-5.07	-4.59	-4.18
2.7	-5.33	-6.46	-7.35	-5.61	-5.04
2.8	-6.72	-8.84	-10.35	-7.85	-6.36
2.9	-8.8	-11.28	-12.73	-10.16	-7.7
3	-11.5	-13.84	-15.2	-12.62	-10.58
3.1	-8.8	-10.88	-12.51	-9.84	-7.63
3.2	-6.15	-8	-9.31	-7	-5.26
3.3	-4.87	-5.95	-6.81	-5.43	-4.21
3.4	-3.67	-4.43	-5	-4.1	-3.25
3.5	-2.92	-3.39	-3.67	-3.13	-2.68
3.6	-2.49	-2.78	-2.92	-2.65	-2.29
3.7	-2.11	-2.43	-2.53	-2.27	-1.93
3.8	-1.82	-1.99	-2.12	-1.89	-1.72
3.9	-1.66	-1.76	-1.82	-1.7	-1.62
4.0	-1.41	-1.53	-1.59	-1.5	-1.34

Table - 6 : Data of vswr for 90° hybrid - feed square patch stacked antenna

Frequency (GHz)	Driven element	Driven element +1 parasitic	Driven element +2 parasitic	Driven element +3 parasitic	Driven element +4 parasitic
2	12.14	11.48	11.4	12.6	13.5
2.1	10.2	9.88	9.35	10.7	11.2
2.2	8.76	8.2	7.6	9.4	9.69
2.3	7	6.6	6.1	7.9	8.2
2.4	5.51	5.04	4.71	6	6.6
2.5	4.69	4.29	4.05	4.66	5.2
2.6	4.05	3.52	3.23	3.87	4.23
2.7	3.36	2.81	2.5	3.2	3.54
2.8	2.71	2.13	1.91	2.36	2.85
2.9	2.12	1.75	1.6	1.9	2.4
3	1.72	1.51	1.42	1.61	1.84
3.1	2.12	1.8	1.62	1.95	2.42
3.2	2.94	2.3	2.04	2.6	3.4
3.3	3.66	3.03	2.68	3.3	4.2
3.4	4.8	4	3.54	4.3	5.4
3.5	6	5.18	4.8	5.6	6.53
3.6	7	6.3	6	6.6	7.6
3.7	8.25	7.17	6.9	7.68	9
3.8	9.55	8.76	8.2	9.2	10.12
3.9	10.48	9.88	9.55	10.2	10.7
4.0	12.28	11.34	10.94	11.6	12.92

Table - 7 Data of axial ratio for 90 ⁰ hybrid – feed square patch stacked antenna

Angle (Degree)	Driven element	Driven element +1 parasitic	Driven element +2 parasitic	Driven element +3 parasitic	Driven element +4 parasitic
-90	-2.91	-3.75	-3.67	-2.03	-2.67
-80	-1.96	-1.81	-1.49	-3.75	-4.06
-70	-3.4	-1.06	-3.9	-0.8	-2.31
-60	-2.06	-1.37	-2.09	-2.09	-1.9
-50	-1.42	-1.11	-1.65	-2.23	-1.72
-40	-0.76	-1.13	-1.31	-1.93	-0.92
-60	-1.09	-1.27	-0.96	-2.01	-0.58
-20	-1.96	-0.72	-0.64	-1.6	-0.94
-10	-1.81	-0.64	-0.5	-1.06	-1.51
0	-1.46	-0.62	-0.45	-0.62	-1.34
10	-1.83	-0.41	-0.617	-1.21	-2.28
20	-2.38	-0.85	-1.11	-1.87	-2.38
30	-1.49	-1.7	-1.46	-1.95	-1.87
40	-2.28	-2.15	-1.91	-2.5	-2.56
50	-2.64	-4.06	-2.25	-3.02	-2.49
60	-2.07	-3.62	-4.63	-3.51	-2.32
70	-2.82	-0.09	-0.95	-2.33	-3.06

80	-1.95	-2.01	-1.92	-4.17	-3.73
90	-3.95	-3.6	-3.93	-2.47	-3.22

Table-8 : Data for Beam-Width (degree)

No. of Elements in 90⁰ Hybrid - feed square patch stacked antenna	Beam-width (Degree)	
	Co-Polar Plane	Cross-Polar Plane
1+0	59	56
1+1	79	64
1+2	98	65
1+3	69	60
1+4	50	53

Table- 9 : Data for Max. radiated power(dB)

No. of Elements in 90° Hybrid - feed square patch stacked antenna	Maximum radiated power(dB)	
	Co-Polar Plane	Cross-Polar Plane
1+0	-5.6	-7.06
1+1	-2	-2.62
1+2	0	-0.45
1+3	-4.07	-4.69
1+4	-6.56	-7.9

Table - 10: Data for Axial ratio(dB)

No. of Elements in 90 Hybrid - feed square patch stacked antenna	Axial ratio (dB)
1+0	-1.46
1 + 1	-0.62
1+2	-0.45
1+3	-0.62
1+4	-1.34

Table - 11: Data for Gain (dB)

No. of Elements in 90 Hybrid - feed square patch stacked antenna	Gain (dB)
1+0	8.95
1 + 1	7.11
1+2	6.10
1+3	7.97
1+4	9.91

Table - 12: Data for return – loss (dB)

No. of Elements in 90 Hybrid - feed square patch stacked antenna	Return-loss (dB)
1+0	-11.5
1 + 1	-13.84
1+2	-15.2
1+3	-12.62
1+4	-10.58

Table - 13: Data for VSWR

No. of Elements in 90 Hybrid - feed square patch stacked antenna	VSWR
1+0	1.72
1 + 1	1.51
1+2	1.42
1+3	1.61
1+4	1.84

Table - 14: Data for Band – Width

No. of Elements in 90 Hybrid - feed square patch stacked antenna	Band – Width (%)
1+0	5.33
1 + 1	10.66
1+2	16
1+3	8
1+4	2.66

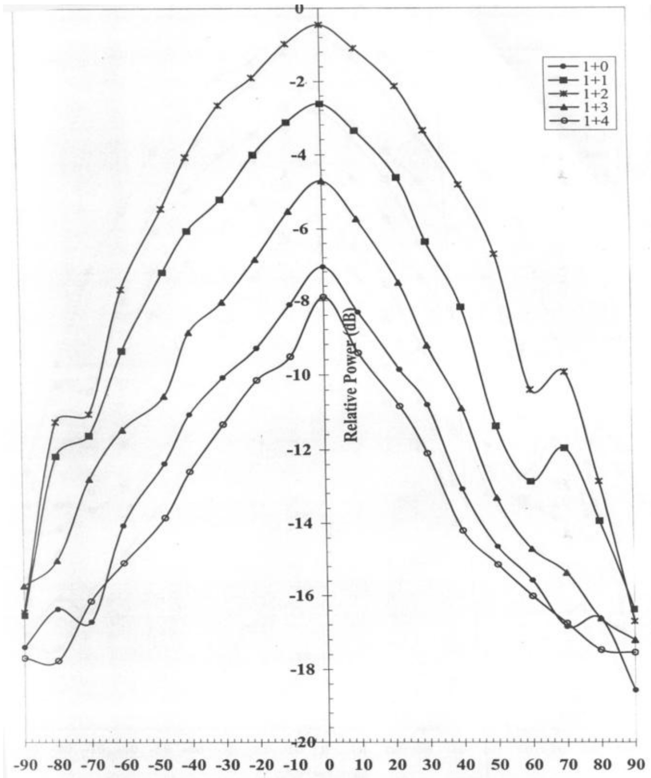

Fig. 3. Cross-polar radiation pattern of 90⁰ hybrid-feed square patch stacked antenna

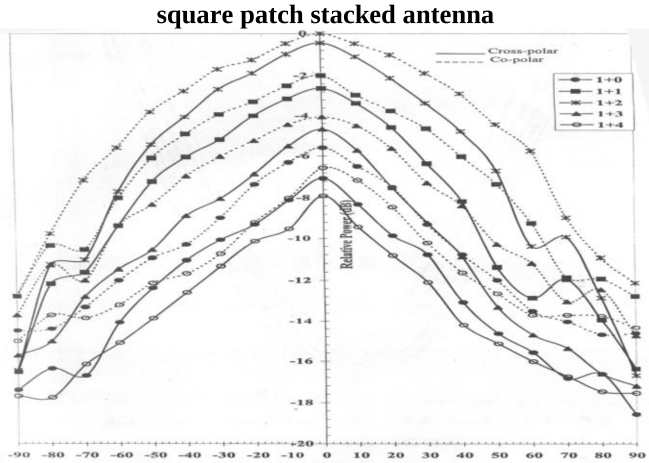

Fig.4. Radiation pattern of 90⁰ hybrid-feed square patch stacked antenna for co-polar and cross-polar

Retrieval Number: 100.1/ijeat.C22790210321
DOI:10.35940/ijeat.C2279.0210321
Journal Website: www.ijeat.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication

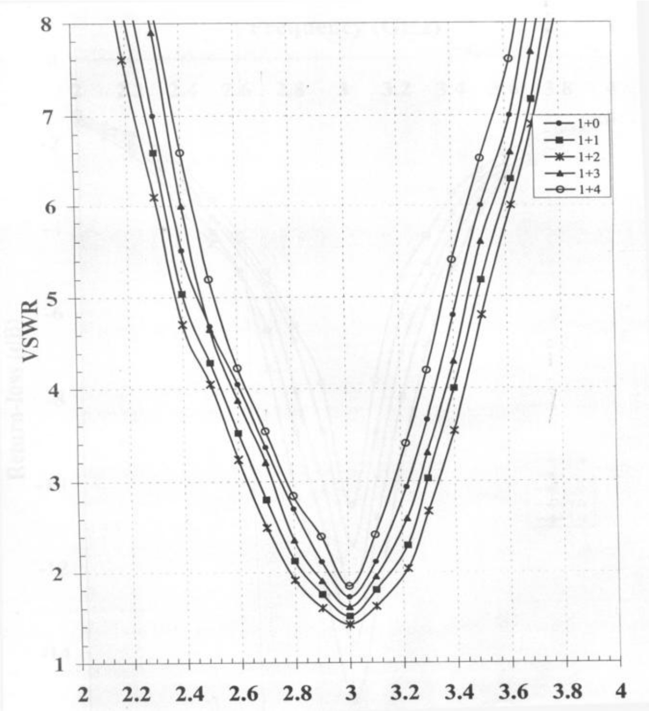

Fig.5. Variation of VSWR with Frequency for 90° hybrid-feed square patch stacked antenna

XI. RESULTS AND DISCUSSION

Measurement were made for various parameters such as co – polar and cross –polar radiation pattern, VSWR, Return – loss and Max. Radiated power and Axial – ratio which are shown in Fig. 3 to 4. The observation of Fig.3 and 4 indicates that Radiated power is maximum for the antenna with 2 parasitic elements. Initially the radiated power increase with parasitic elements and becomes maximum for 2 parasitic elements and decreases if number of parasitic element is increased. This is also observed from the VSWR data and return loss. VSWR is obtained at 3 GHz for the cases of optimum 2 parasitic element and return loss of found to be less than -15 dB. The variation of the Radiated power shown in Fig.3 and Fig.4 for co–polar and cross – polar cases. It is observed that radiation increases with parasitic element and becomes maximum for 2 parasitic elements loaded patch. The radiated power decreases with increasing value of parasitic elements. The Axial ratio is found to be maximum. for 3 parasitic elements antenna and value falls with increasing and decreasing no. of parasitic elements. However the axial ratio with the limits and radiation remains in circular – polarization.

XII. CONCLUSION

A 90 ^{0} hybrid – feed square patch stacked antenna has been designed on epoxy glass substrate. The patches are square patch, for feeding, a suitable point on patch is marked where input impedance is 50 ohm. The antenna is developed by using photolithographic process. From the experimental results it has been found that the performance of the square patch stacked with 2 parasitic elements is found to be optimum.

ACKNOWLEDGEMENTS

The author expresses his deep gratitude to the Department of ECE, MGIT, for their encouragement during this work

REFERENCES

1. J.R. James P.S Hall, Wood & A. Hounderron, "some recent development in microstrip antenna desing", IEEE Trans. AP, VoL. AP-29, Jan. 1981, pp. 124-27.
2. K.R. Karver, E.L. Cotfey, "Theoretical Investigation of Mirostrip Antenna", Physical and Science Lab., New Mexico State University, Tech. Report, PT – 00929, Jan. 1979.
3. E.O. Hammerstad, "Equations for microstrip circuit design", 5th European microwave conference, 1975, pp. 268 – 272.
4. A.G. Demeryd, "A theoretical investigation of the rectangular microstrip antenna element" RADC Tech. Report, TR77- 206, June 1977.
5. Y.T.Lo, D.D. Harrision, D. Solemon, G.A. Deschamps and F.R. Ore, "Study of Microstrip Antennas, Microstrip phases Arrays, and Microstrip Feed Network". RADC Tech. Report. 7R77-406, Oct. 21, 1977.
6. H. Gutton, G. Baizzinot, "Flat –aerial for ultra high frequencies", French Patent No. 703113, 1955.
7. L. Lewin. "Radiation from strip line discontinuities". Proc. IEEE Vol. 107, Pt. C. Feb.1960, pp. 163 – 170.
8. R.E. Munson, "Conformal microstip antenna and micorstrip phased arrays", **IEEE** Trans Ant. Prop, Vol AP – 22, Jan 1974, pp. 74 – 77.
9. J.R. Howell, "Microstrip antennas, "' **IEEE** Trans, AP, - 23, Jan 1975, pp. 90 – 93.
10. E.O. Hammerstad, "Eauations for microstrip circuit design, "5th European microwave conference, 1975, pp. 268 – 272.
11. Chaddhu & K.C Gupta, " Segmentation method using impedence matrices for analysis of planar microwave circuit," **IEEE** Trans Microwave theory & Tech, Vol MTT – 29, Jan 1981 pp. 71 – 74.
12. "Handbook of microwave and optical components," John Wiley and Sons, 1989, pp, 764 – 888.
13. A.G.Derneryad, "A theoretical investigation of the rectangular microstrip antenna element, "RADC Tech. Report, TR – 77 – 206, Jun 1997.
14. D.H Schaubart, F.G. Farrar, A Sindors and S.T Hays, "Microstrip antennas with frequency agility and polarization diversity," IEEE Trans Ant. Prop, Vol. AP – 29, Jan 1981 pp.118-23
15. V.Saidulu, "performance of co-axial probe fed rectangular microstrip antenna with radome thickness and dielectric constant" International journal of engineering science and research technology, July, 2017.
16. V.Saidulu, " Design microstrip patch antenna for ultra wideband applications"International journal of Innovative research in science, engineering and technology, Agust, 2017.
17. V.Saidulu, "Design, Simulation and Experimental Analysis on Rectangular Microstrip Patch Antenna with Superstrates" IJEAT, Vol.9, 2020.

AUTHORS PROFILE

Dr V. Saidulu received B.Tech and M.Tech degree from Nagarjuna University, A.P and Banaras Hindu University, U.P. respectively. He received his Ph.D degree from JNTUH, Hyderabad. Currently he is working as Sr. Assistant Prof. in ECE Department, MGIT, Hyderabad. His research area is antennas and mobile communications. He has more than 30 papers published to his credit.