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Investigation of Performance Parameters by Varying the Dimensions of Microstrip Rectangular Patch Antenna at Higher Frequency

[1]B.T.P.Madhav, [2] VGKM Pisipati, [3]P.Rakesh Kumar, [4]N.V.K.Ramesh, [5]Y.Joseph Manoj Reddy, [6]N.Srinivas Sri Chaitanya, [7]N.Krishna Chaitanya
[1, 2] LCRC-R&D, Department of ECE, K L University, Guntur DT, AP, India
[3]Assistant professor, Dept.of ECE, LBRC (Autonomous), Mylavaram, India
[4]Assistant Professor, Department of ECM, K L University, AP, India
[5, 6, 7] Project Students, Department of EEE, K L University, AP, India
[1]madhav.mtech@gmail.com

ABSTRACT

This present paper deals with the performance properties of a rectangular microstrip patch antenna that affected by varying the width to length ratio of patch. The analytically calculated dimensions provided good initial values of the rectangular patch antenna for further optimization using more accurate techniques. The design has been optimized at 70GHz for the investigated mesh density, boundary conditions and the port dimensions. A comparative study is done by taking different length to width ratio and all the antenna output parameters like Retunloss, VSWR, Gain and Radiation Patterns are presented.

Keywords*: Rectangular patch, performance parameters.*

1. INTRODUCTION

The primary goal of this research is to determine the dimensions of the rectangular microstrip patch antenna to obtain the optimal performance at 70GHz.

Microstrip patch can be designed either broadside radiator or end-fire radiator. For broadside radiator, the microstrip patch is designed in such a way that the pattern maximum is normal to the patch while for end-fire radiator the direction of maximum radiation is along the axis of the patch [1-4]. The performance properties of the patch antenna have been investigated for various length to width ratios of the patch at 70GHz. In order to obtain an optimum solution, each design of the microstrip patch antenna having various width to length ratios is optimized with the inset feed location[5-7]. Starting with a patch width 1.2 times to its length, the patch width is increased in equal steps up to 1.8 times to the patch length. The design is numerically optimized and further verified by parameters sweep of dimensions of patch [8-10].

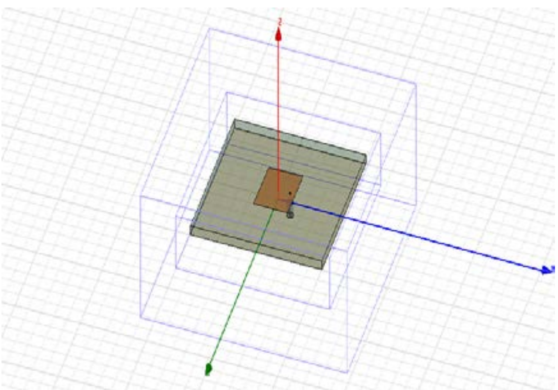

Figure (1) Basic model for the Microstrip patch antenna

2. ANALYSIS OF ANTENNA PARAMETERS WITH CHANGE IN PATCH WIDTH

2.1 Analysis of patch width for Wp=1.2Lp

Patch antenna is analyzed by keeping the patch width 1.2 times the patch length. The return loss of -12.97dB, VSWR of 1.57, and gain of 7.21dB is obtained with this model. With the optimized dimensions, the resonance is obtained at 70GHz with directivity of 7.246dBi.

2.2 Analysis of patch width for Wp=1.4Lp

Patch antenna is analyzed by keeping the patch width 1.4 times the patch length. The return loss of -22.02dB, VSWR of 1.17, and gain of 7.35dB is obtained with this model. With the optimized dimensions, the resonance is obtained at 70GHz with directivity of 7.37dBi.

Figure (2) and (3) shows the simulated Returnloss and VSWR curves.

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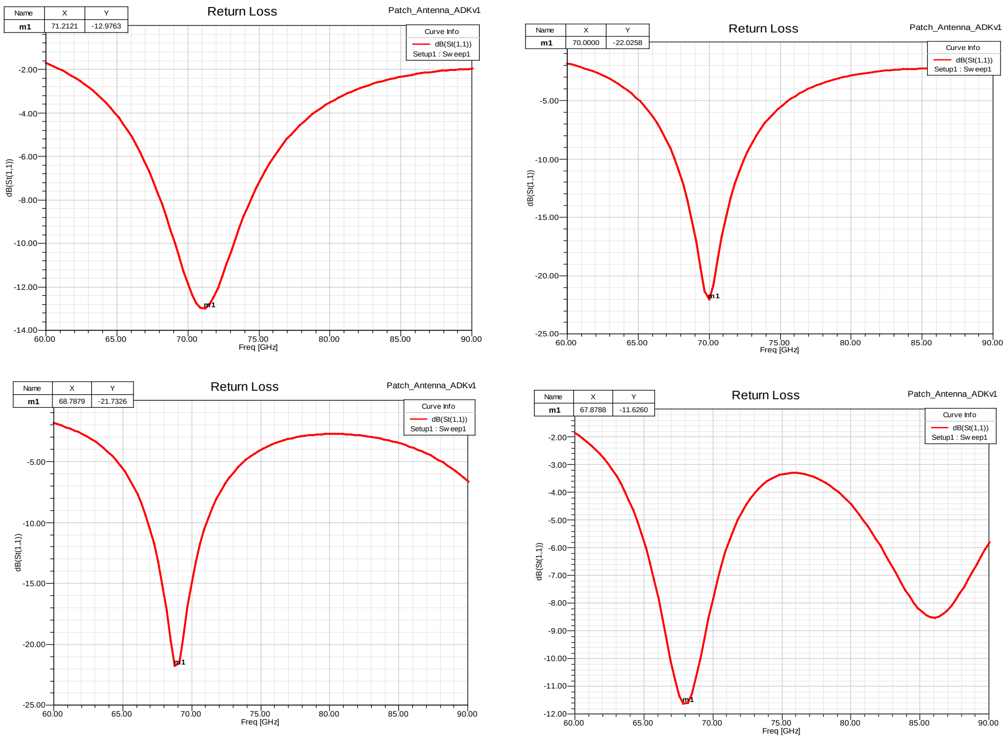

Figure (2) Frequency Vs Returnloss, (2a) Wp=1.2Lp, (2b) Wp=1.4Lp, (2c) Wp=1.6Lp, (2d) Wp=1.8Lp

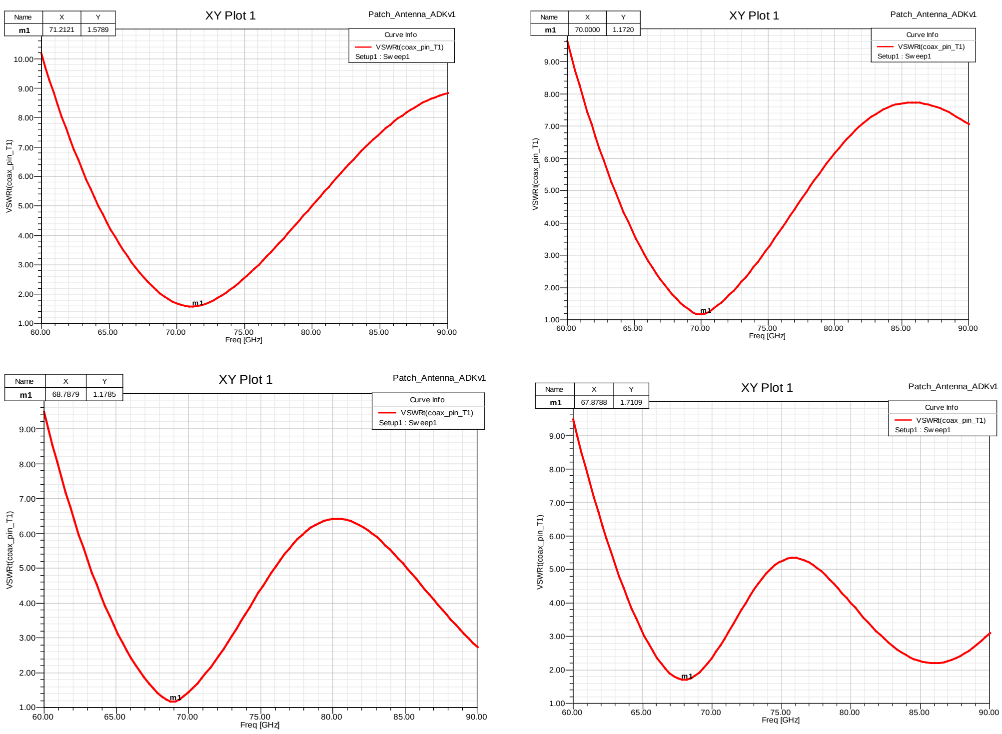

Figure (3) Frequency Vs VSWR, (3a) Wp=1.2Lp, (3b) Wp=1.4Lp, (3c) Wp=1.6Lp, (3d) Wp=1.8Lp

2.3 Analysis of patch width for Wp=1.6Lp

Patch antenna is analyzed by keeping the patch width 1.6 times the patch length. The return loss of -21.73dB, VSWR of 1.178, and gain of 7.36dB is obtained with this model. With the optimized dimensions, the resonance is obtained at 70GHz with directivity of 7.37dBi.

2.4 Analysis of patch width for Wp=1.8Lp

Patch antenna is analyzed by keeping the patch width 1.8 times the patch length. The return loss of -11.62dB, VSWR of 1.71, and gain of 6.82dB is obtained with this model. With the optimized dimensions, the resonance is obtained at 70GHz with directivity of 6.85dBi.

Table (1) and (2) shows the typical antenna performance results.

Table (1) performance results

Performance properties	Wp= 1.2Lp	Wp=1.4Lp	Wp=1.6Lp	Wp=1.8 Lp
Return loss dB	-12.97	-22.02	-21.73	-11.62
VSWR value	1.578	1.172	1.178	1.710
Max Gain (dB)	7.217	7.358	7.368	6.829
Max Directivity (dB)	7.246	7.379	7.378	6.853

Table (2) Parameters obtained from smith chart

Quantity	Wp=1.2Lp	Wp=1.4Lp	Wp=1.6Lp	Wp=1.8Lp
rms value	0.620	0.622	0.595	0.549
Phase margin	176.12	173.97	194.53	190.73
Gain crossover	60	60	60	60
Band width	63.37	62.79	62.51	62.47

3. RESULTS ANALYSIS

By looking at the results obtained from the simulation of the antenna with different width to length ratio, it is clear that the width is equal to 1.5 of length is having good results compared with the others. Width is equal to 1.4 of length and width is equal to 1.6 of length is having the better gain and return loss values from the figure (2) and table (1). The VSWR values are also showing 2:1 ratio of satisfactory results for all the cases.

The bandwidths for the second and third model are giving better ratio compared to first and the last model. Gain of 0.98% achievement obtained from second model with width is equal to 1.4times of length. 0.99% improvement in gain was obtained with the third model of width is equal to 1.6 times of length. For the last model with width is equal to 1.8 times of length, a gain of 0.93% of decay is obtained.

In the case of directivity also the second and third model are giving good results. All the output parameters obtained from the simulation are giving satisfactory results for width equal to 1.5 times of length and nearer to it. The patch length does not change significantly with changing width. The patch length is a critical parameter in a patch design and it determines the resonant frequency. It is observed that the when the patch width is increasing the location of inset feed approaching towards the radiating edge of the patch. The impedance at the radiating edge is higher as compared to the impedance of the microstrip feed line.

Figure (4) indicates the input impedance smith chart for the four models. Table (2) is obtained from the figure (4) results only. Figure (5) and (6) indicates the 3D and 2D gain results. From the figure (6) it is showing the gain values of 7.21, 7.35, 7.36 and 6.82 for the four models with change of width to length ratio. The rms values are increased from first model to second, but from that onwards it is decreasing as shown in the table (2).

Table (3) gives the antenna parameters at fixed frequency with change in width to length ratio. Figure (7) and (8) shows the radiation pattern of the antenna in co-polarization and cross polarization. The polar coordinates results of the radiation pattern are giving Omni-directional pattern in the entire region. Figure (7) shows the gain phi at 0 and 90 deg. Figure (8) shows the gain theta at 0 and 90 deg for the four models.

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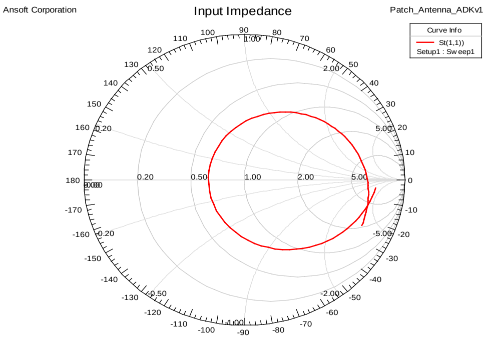
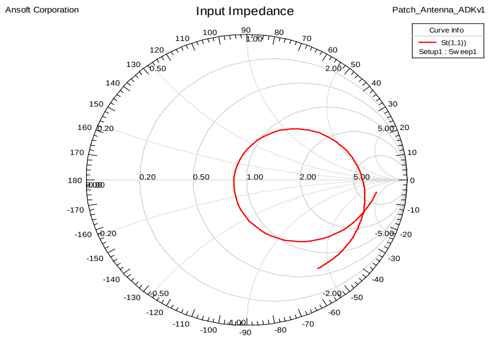


Figure (4a)



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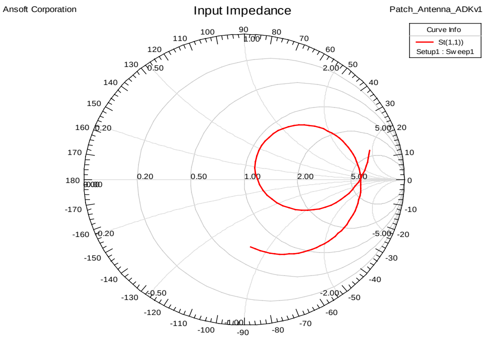

Figure (4c)

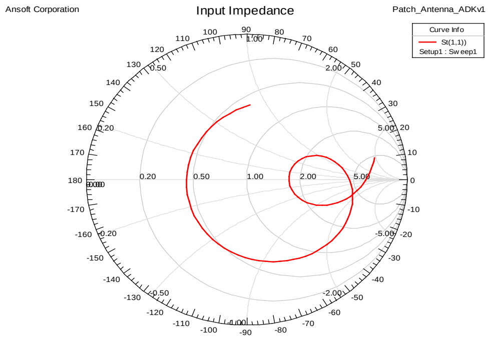

Figure (4d)

Figure (4) Input impedance smith chart (4a) Wp=1.2Lp, (4b) Wp=1.4Lp, (4c) Wp=1.6Lp, (4d) Wp=1.8Lp

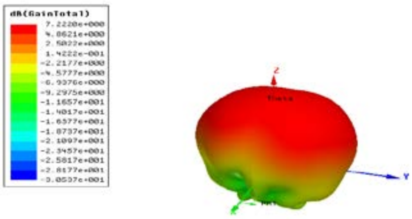

Figure (5a)

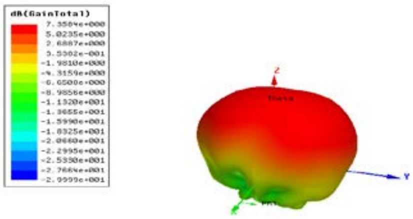

Figure (5b)

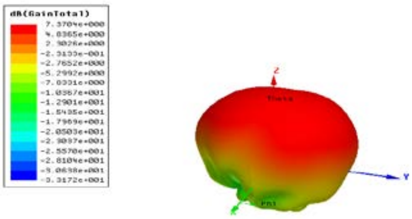

Figure (5c)

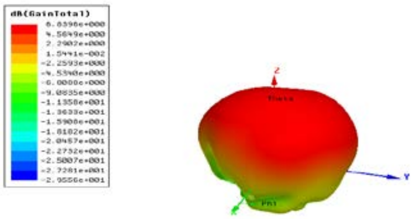

Figure (5d)

Figure (5) 3D gain, (5a) Wp=1.2Lp, (5b) Wp=1.4Lp, (5c) Wp=1.6Lp, (5d) Wp=1.8Lp

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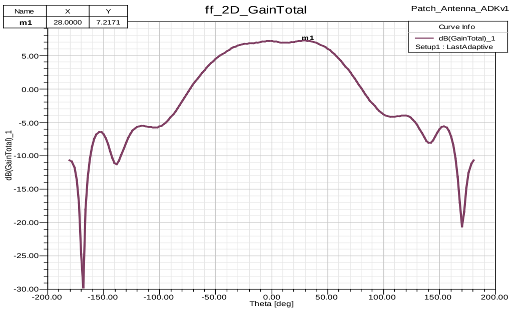
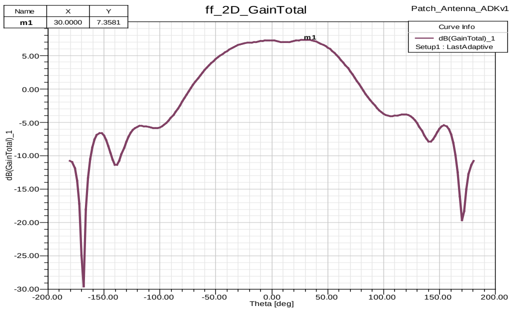


Figure (6a)



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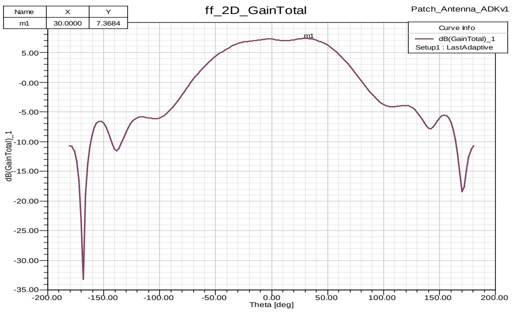

Figure (6c)

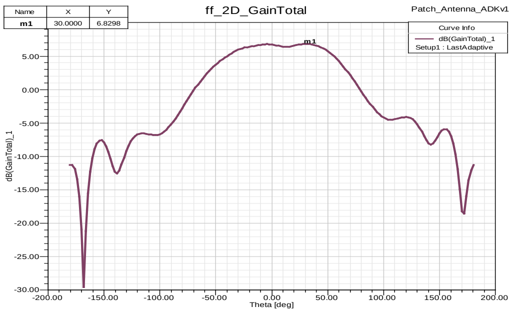

Figure (6d)

Figure (6), (6a) Wp=1.2Lp, (6b) Wp=1.4Lp, (6c) Wp=1.6Lp, (6d) Wp=1.8Lp

Table (3) Antenna Parameters

Quantity	Wp=1.2Lp	Wp=1.4Lp	Wp=1.6Lp	Wp=1.8Lp
Max U	0.0057 w/sr	0.0050 w/sr	0.0035 w/sr	0.0016 w/sr
Peak directivity	5.31	5.47	5.47	4.85
Peak gain	5.27	5.44	5.45	4.83
Peak realized gain	5.01	5.43	5.22	3.88
Radiated power	0.0136 w	0.0116 w	0.0081 w	0.0043 w
Accepted power	0.0137 w	0.0116 w	0.0081 w	0.0043 w
Incident power	0.0144 w	0.0116 w	0.0084 w	0.0054 w
Radiation efficiency	0.993	0.99	0.997	0.994

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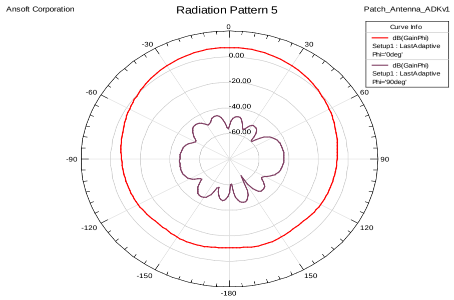

Figure (7a)

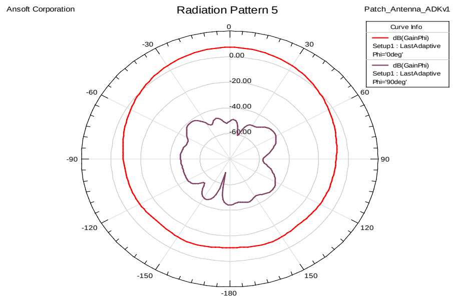

Figure (7b)

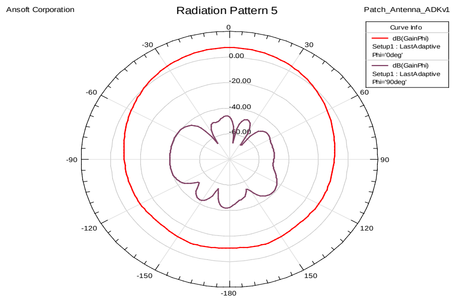

Figure (7c)

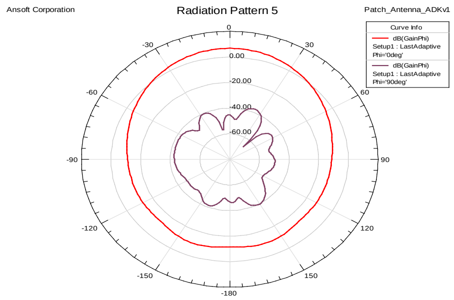

Figure (7d)

Figure (7) , (7a) Wp=1.2Lp, (7b) Wp=1.4Lp, (7c) Wp=1.6Lp, (7d) Wp=1.8Lp

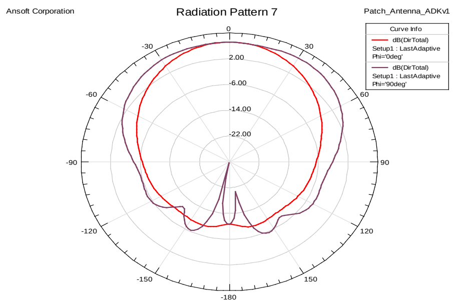

Figure (8a)

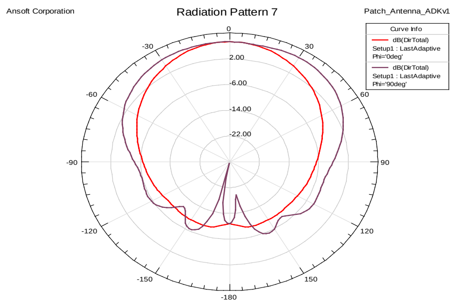

Figure (8b)

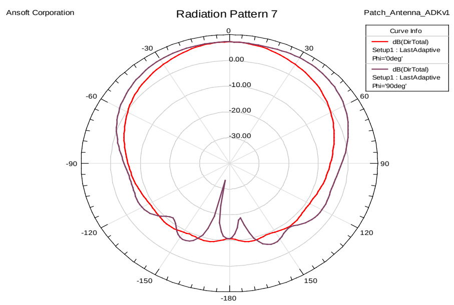

Figure (8c)

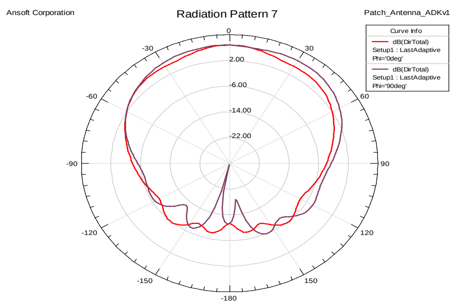

Figure (8d)

Figure (8) , (8a) Wp=1.2Lp, (8b) Wp=1.4Lp, (8c) Wp=1.6Lp, (8d) Wp=1.8Lp

The present investigation is giving all the simulated results for the antenna by varying the width to length ratio. More or less all the results are giving considerable amount of output parameters.

4. CONCLUSION

The optimum dimensions of a rectangular patch antenna at 70 GHz have been investigated. The performance properties are analyzed for the optimized dimensions. Various width to length ratios have been used to observe effect of variations in width on performance properties. It is observed that the patch length changed approximately 10µm with increasing width. It is seen that with increasing width, the inset feed location moves towards the edge. When patch width increased from W=1.6L to next then the gain, directivity and realized gain are decreased. The patch is still operated in the fundamental mode, but the other modes are excited along the width of the patch.

5. ACKNOWLEDGMENTS

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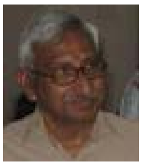
AUTHORS BIOGRAPHY

B.T.P.Madhav was born in India, A.P, in 1981. He received the B.Sc, M.Sc, MBA, M.Tech degrees from Nagarjuna University, A.P, India in 2001, 2003, 2007, and 2009 respectively. From 2003-2007 he worked as lecturer and from 2007 to till date he is working as Assistant Professor in Electronics Engineering. He has published more than 35 papers in International and National journals. His research interests include antennas, liquid crystals applications and wireless communications.



Prof. VGKM Pisipati was born in India, A.P, in 1944. He received his B.Sc, M.Sc and Ph.D degrees from Andhra University. Since 1975 he has been with physics department at Acharya Nagarjuna University as Professor, Head, R&D Director. He guided 22 PhDs and more than 20 M.Phils. His area of research includes liquid crystals, nanotechnology and liquid crystals applications. He visited so many countries and he is having more than 260 International research publications. He served different positions as academician and successfully completed different projects sponsored by different government and non-government bodies. He is having 5 patents to his credit.

N.V.K.Ramesh received MSC degree in electronics from Nagarjuna University in 1990. He also received M.Phil degree in electronics from Bharatidasan University in 2006. He received M.Tech degree in electronics and communication engineering from K L University in 2011. He worked as a head of the department at Sarada College from 1990 to 2008. He is currently working as an assistant professor in electronics and computer engineering at K L University. His contribution has appeared in a various journals and his research interest includes antennas and wireless communication.