ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering
Vol. 2, Issue 6, June 2013

Dielectric Resonator Antenna for X band Microwave Application

Archana Sharma[1], Kavita Khare[2] S.C.Shrivastava[3]

Research Scholar, Dept. of Electronics & Communication, MANIT, Bhopal, India[1]

Professor, Dept. of Electronics & Communication, MANIT, India[2]

Professor, Dept. of Electronics & Communication, MANIT, India[3]

ABSTRACT: A simple Dielectric Resonator Antenna (DRA) for X band frequency operation is proposed in this paper. X band is a microwave band lies between frequency range 8 to 12 GHz. In proposed DRA reflector plane is used beneath the microstrip feed line with a small air gap, introduced between feed substrate and reflector plane to reduce the back lobe. Slot coupling is used to excite this DRA. Proposed DRA design gives dual band operation in X band and resonates at frequency 8.6 GHz and 10.3 GHz. Antenna design offers minimum return loss of -20.3 db and -24.5 db at 8.6 GHz and 10.3 GHz respectively. It also offers high front to back ratio (FBR) of 12.35db and 9.83 db at 8.65 GHz and 10.3 GHz respectively. Return loss impedance bandwidth of 390 MHz (4.5%) for Band I and 730MHz (7.3%) for band II is obtained. Simple DRA design with high FBR is proposed here for X band application that shows a total bandwidth of 11.8%. DRA is analysed using Ansoft HFSS based on finite element method. Radiation characteristics of this DRA are observed at resonating frequencies. This DRA is useful at microwave X band application such as satellite communication.

Keywords: DRA, X band, microwave application, front to back ratio

I. INTRODUCTION

In recent years, researchers have got much attention on investigation of DRA due to its attractive features as light weight, small size, low loss and temperature stability. Dielectric resonators have received great interest in recent years for their potential applications in microwave and millimetre wave communication systems. They have been widely used as a tuning component in shielded microwave circuits such as filters, oscillators, and cavity resonators. With an appropriate feed arrangement, they can also be used as antennas, and they offer efficient radiation [1]. Also micro strip antenna at higher microwave band applications such as satellite communication and radar application usually offers high metallic losses. So, the DRA can be a good alternative for these requirements as it overcomes the problem of high losses due to minimum surface wave losses. DRA generally made up of temperature stable dielectric materials of high dielectric constants (10-100) for microwave applications. Resonant frequency of DRA can be easily varied by suitably choosing the dielectric constant of the resonator material and its dimensions [4]. DRAs of different shapes such as disc, hemispherical, rectangular, and ring have been presented in the literature [3],[4],[8],[9]. The rectangular dielectric resonators are preferred because they are easy to fabricate and offer more degree of freedom to control the resonant frequency and quality factor. Many investigations have been conducted to enhance bandwidth and gain of DRA [7],[8],[10],[13] but front to back ratio (FBR) of DRA has not been presented so far. Micro strip fed DRA act as a magnetic dipole and suffers with problem of back lobe. So in this paper reflector plane is used to improve the FBR. This paper presents a simple dielectric resonator antenna that operates at X band and useful in satellite communication. The proposed antenna is simulated using FEM based HFSS simulator and the various performance characteristics are observed and discussed.

The return loss band width of DRA can be calculated as

$$\% BW = \frac{fH - FL}{fc} * 100 \qquad \text{.......... (1)}$$

f_H - high cut off frequency
f_L - low cut off frequency
f_c - centre frequency

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering
Vol. 2, Issue 6, June 2013

II. ANTENNA GEOMETRY

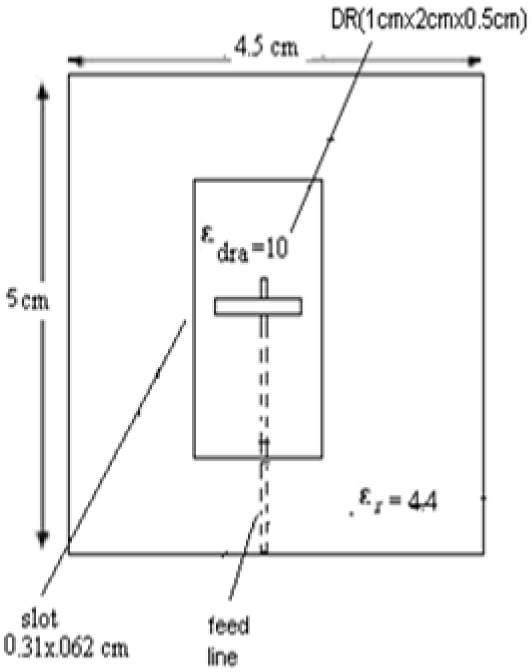
DRA design has a substrate of dimension 4.5 cm x 4.5 cm x 0.16 cm. FR4 epoxy having dielectric constant 4.4 is used here. DRA is chosen of rectangular shape with dimension 1cm x 2 cm x 0.5 cm. Dielectric material(sapphire) with high dielectric constant of 10 is used. High dielectric constant material improves coupling and reduces the size but also lowers Bandwidth. The DRA size (length, width & height) of the DRA has been chosen such that (L> W > h).The design parameters for the design is summarized in the table I shown below and geometry of the DRA is shown in figure 1. Foam is used to introduce air gap. The dimension of the DRA is approximated by relation given below [18].

$$hdra = \frac{\lambda 0}{4\sqrt{\varepsilon dra}} \text{ ....(2)}$$

TABLE I

DESIGN PARAMETERS OF PROPOSED DRA

DRA design parameters	Dimensions
Substrate (FR4 Epoxy)	Lsub=5cm,Wsub=4.5cm,hsub=0.16cm
Ground Plane	Lg=5cm,Wg=4.5cm
Slot	ls=0.31,Ws=0.062,
DRA	Ldra=1cm,Wdra=2 cm, hdra=0.5 cm
Stub length	Lstub=0.5 cm
Feedline	Lf=2.9cm,Wf=.06cm
Relector plane	Lr =5cm,Wr =4.5cm
Airgap(Foam)	0.05cm



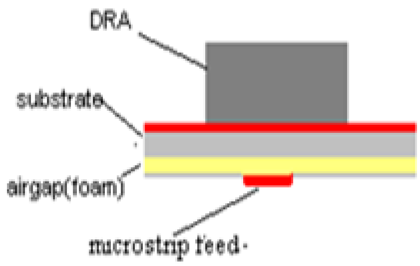


Fig. 1 Rectangular DRA (i) Front view (ii)) Side view

III. RESULTS AND DISCUSSION

To analyse the antenna performance, HFSS simulation tool based on FEM is used. The simulated results as return loss, VSWR, radiation pattern, gain plot are shown in this section. Figure 2 gives the return loss plot of the proposed DRA. It is clear from the figure that DRA is operating in X band with resonant frequencies 8.6 GHz and 10.3 GHz. The bandwidth obtained is 390MHz (8.81- 8.42GHz) and 730MHz (10.61- 9.88GHz).Minimum return loss of -20.3 db and

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering
Vol. 2, Issue 6, June 2013

-24.5 db is observed at 8.6 GHz and 10.3 GHz respectively. The VSWR versus frequency plot is also shown in figure 3 showing good agreement in specified bandwidth.

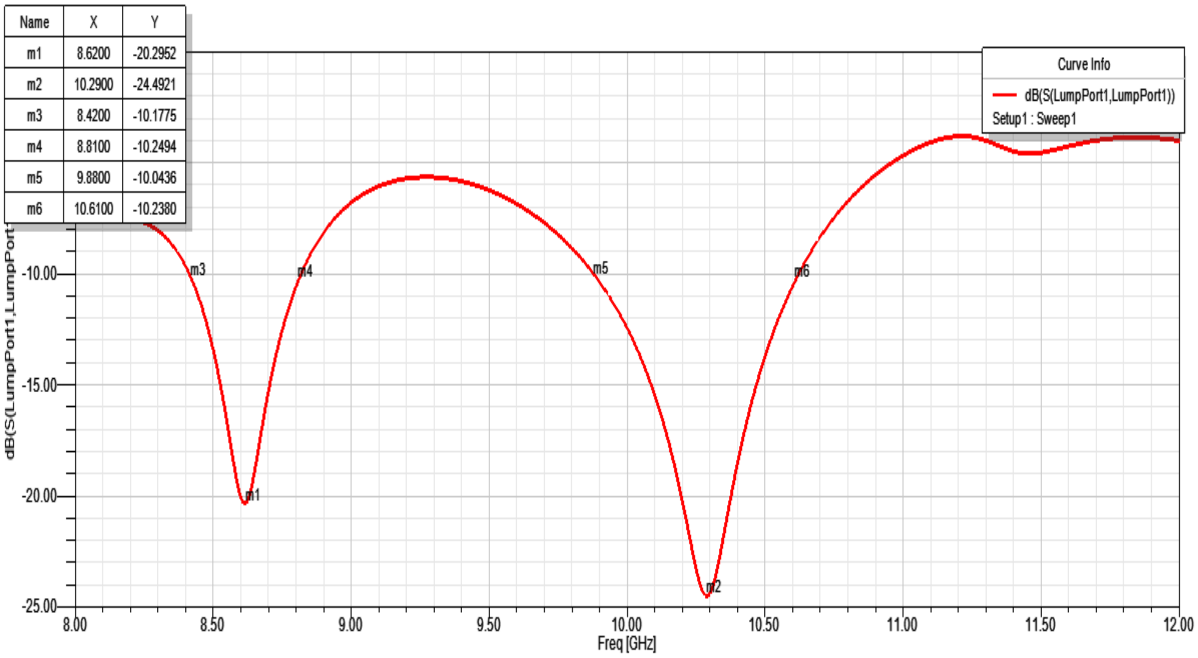


Fig. 2 Return loss Vs frequency plot

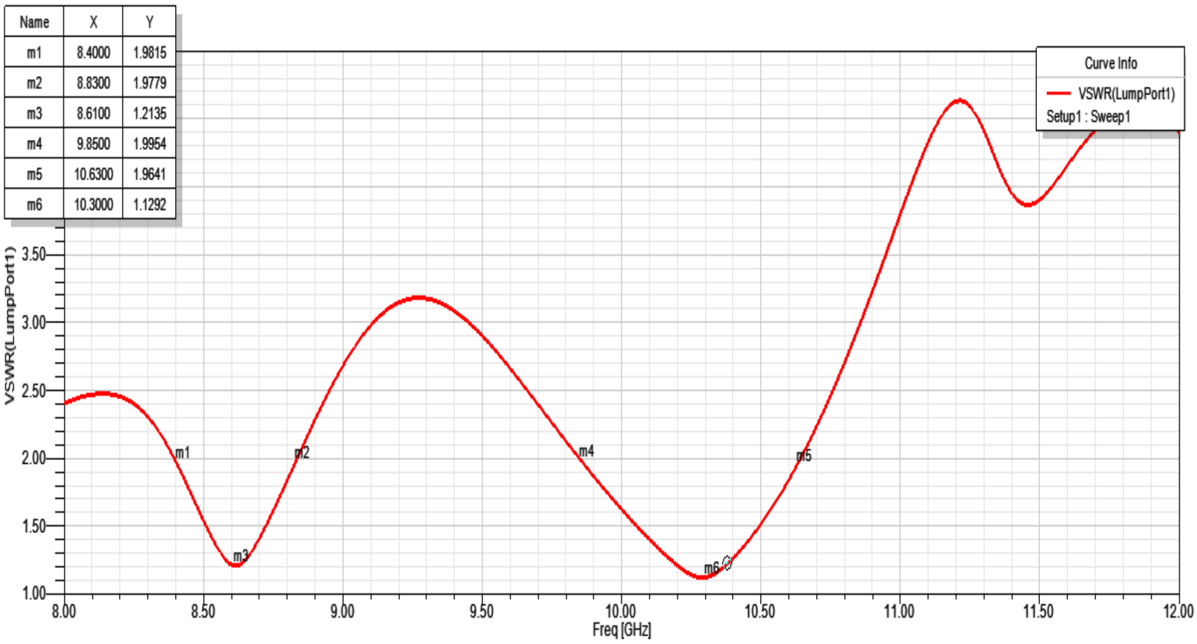


Fig. 3 VSWR Vs frequency plot

The radiation patterns of the proposed DRA at resonant frequencies 8.6 GHz and 10.3 GHz are shown below in fig. 4 & 5 respectively. It is radiating mostly in broadside direction. It is clear from fig. 4 and 5 that the back lobe is minimized due to the reflector plane and improved FBR of 12.35db and 9.83db is observed at 8.6 GHz and 10.3 GHz respectively. This DRA shows reasonably good radiation for $\Phi=0^o$ but radiation pattern is slightly broadened for $\Phi=90^o$. The 3 D plot of DRA is shown in fig. 6 showing overall radiation characteristic at 8.6 GHz. Simulated gain plot with respect to frequency for the DRA is also observed and given in figure7. Maximum gain of 3.9 db and 4.1db is observed for $\Phi=0$ degree and $\Phi = 90$ degree respectively.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering
Vol. 2, Issue 6, June 2013

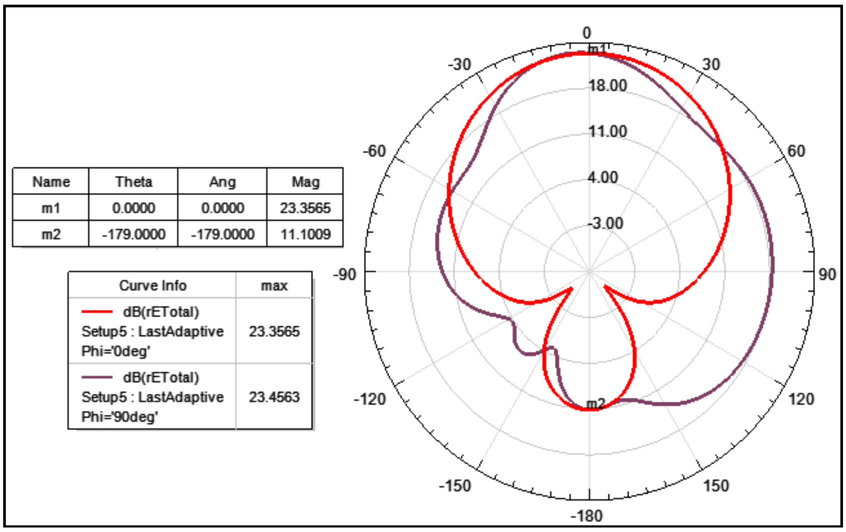


Fig. 4 Simulated radiation pattern of the proposed antenna at 8.6 GHz

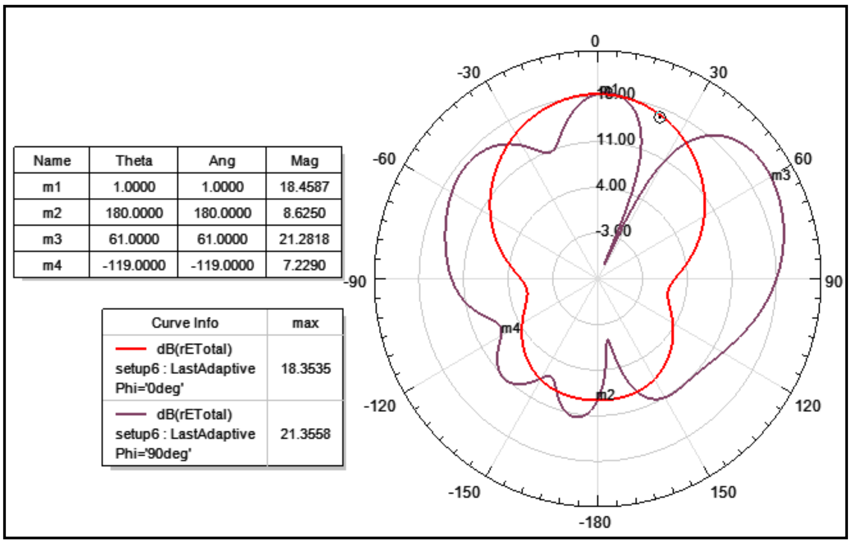


Fig. 5 Simulated radiation pattern of the proposed antenna at 10.3 GHz

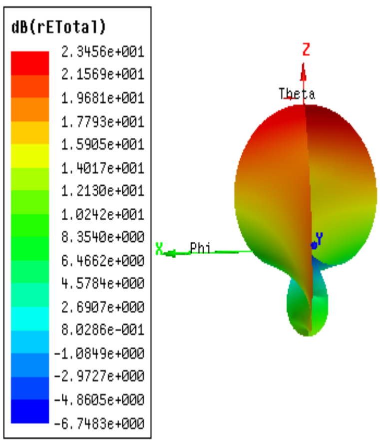


Fig. 6: Radiation Pattern (3 D) plot at 8.6 GHz

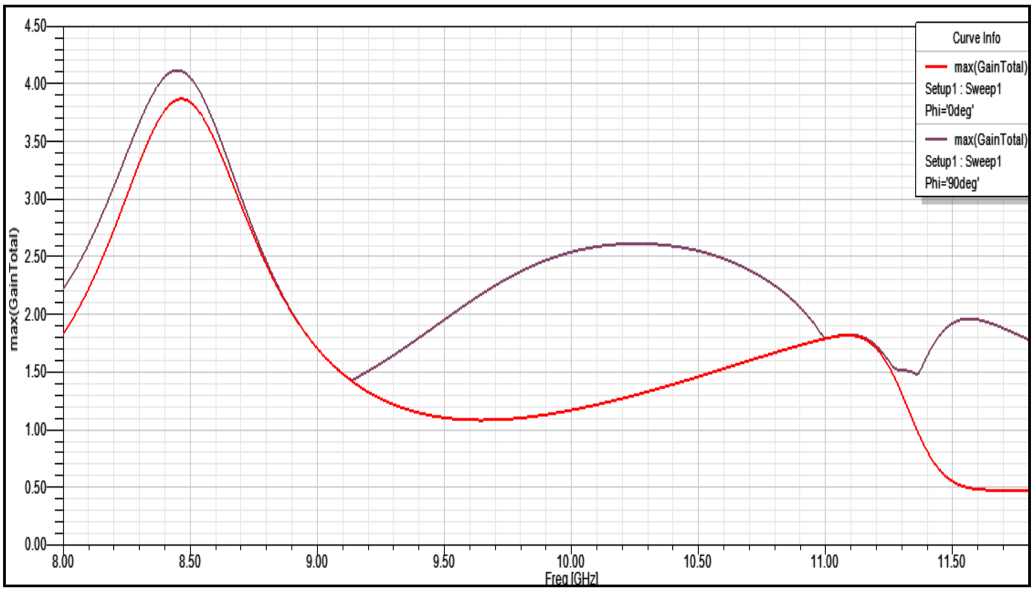


Fig. 7 Gain Vs Frequency plot of proposed DRA (Max Gain for $\Phi=0^0$ is 3.9db & $\Phi=90^0$ is 4.1db)

TABLE II
PERFORMANCE SUMMARY OF PROPOSED DRA

DRA with Reflector Plane	**Freq band (f_L- f_H) (GHz)**	**Resonant Freq(GHz)**	**Min Return Loss(db)**	**BW(MHz)**	**%BW**	**FBR (db)**
Band I	8.42-8.81	8.6	-20.3	390	4.6	12.35
Band II	9.88-10.61	10.3	-24.5	730	7.2	9.83

IV. CONCLUSION

A simple dielectric resonator antenna for X band operation has been proposed in this paper. The reflector plane with a small air gap, below the microstrip feed line has improved the performance of the DRA. The proposed DRA can be used for microwave applications typically used at X band where use of microstrip antenna offers the problem of high metallic losses. The main features of the proposed DRA are its small size and high microwave frequency operation. This DRA can be useful in satellite communication as it offers total BW of 11.8 %, high front to back ratio and good gain.

REFERENCES

[1] Batra, D., Sharma,S., and Kohli, A. K., “Dual-Band Dielectric Resonator Antenna for C and X Band Application” *International Journal of Antennas and Propagation*, Vol. 12, Article ID 914201, 7 pages,2012.

[2] Petosa, A., and Thirakoune, S., “Rectangular dielectric resonator antennas with enhanced gain,” *IEEE Transactions On Antennas And Propagation*, vol. 59, no. 4, pp. 1385-1389, 2011.

[3] Hadalgi, P. M., et al., “Slot fed wideband dielectric resonator for wireless application,” *Indian Journal of Radio & Space Physics*, Vol. 39, pp.372-375, 2010.

[4] Rashidian, A., and Klymyshyn, D. M., “On the two segmented and high aspect ratio rectangular dielectric resonator antennas for bandwidth enhancement and miniaturization,” *IEEE Transactions On Antennas And Propagation*, Vol. 57, no. 9, pp. 2775-2780, 2009.

[5] Nasmuddin and Esselle, K., “Antennas with dielectric resonators and surface mounted short horns for high gain and large bandwidth,” *IET Proc. Microw., Antennas Propag.*, Vol. 1, no. 3, pp. 723–729, Jun. 2007.

[6] Gao, Y.,,et al, “A compact Wideband Hybrid Dielectric Resonant Antenna”, ***Amelia*** *IEEE Microwave and wireless components Letters*, Vol. 16 No.4,pp. 227-229, 2006.

[7] Buerkle, A.,et al., “Compact slot and dielectric resonator antenna with dual resonance, broadband characteristics,” *IEEE trans. On Antennas and Propagation*, Vol.4, pp. 1020-1024, 2005.

[8] Sheng, X. Q., et al., “Analysis of waveguide-fed dielectric resonator antenna using a hybrid finite element method,” *IEE proc. Microwave Antenna Propagation*, Vol. 151, no. 1,pp. 91-95, 2004.

[9] Srivastava, K. V., et al, “A Modified Ring Dielectric Resonator With Improved Mode Separation In MIC Environment”, 34th European Microwave Conference - Amsterdam, pp. 609-612, 2004.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering
Vol. 2, Issue 6, June 2013

[10] Kishk, A. A., "Numerical analysis of stacked dielectric resonator antennas excited by a coaxial probe for wideband applications", *IEEE Trans. On Antennas and propagation*, Vol. 51, no.8, pp. 1996-2006, 2003.
[11] Ittipibon, P. A., "Recent advances in dielectric-resonator antenna technology," *IEEE Antennas and Magazine*, Vol. 40, no. 3, pp. 35-43, June 1998.
[12] Mongia, R. K., et al., "Theoretical and experimental investigations on rectangular dielectric resonator antennas," *IEEE Trans. On Antennas and propagation*, Vol. 45, no.9, pp. 1350-1355, 1997.
[13] Luk, K. M., Leung, K. W., and Chow, K. Y., "Bandwidth and gain enhancement of a dielectric resonator antenna with the use of a stacking element," *Microw. Opt. Technol. Lett.*, Vol. 14, no. 4, pp. 215–217, 1997.
[14] Mongia, R .K., "Resonant Frequency of Cylindrical Dielectric Resonator Placed In an MIC Environment", *IEEE Trans On. Microwave Theory And Techniques*, Vol 38,No. 6, 1990
[15] Long, S. A., McAllister, M. W., and Conway, G. L., "Rectangular dielectric resonator antenna," *Electronics Letters, Vol. 19, No. 6, 218*–219, 1983.
[16] Plourde, J. K., "Application of Dielectric Resonators in Microwave Components",*IEEE Trans. On Microwave theory and Techniques*, Vol. MTT-29, No. 8, August 1981.
[17] Cohn, S.B., "Microwave band pass filters containing high Q dielectric resonators," *IEEE Trans. Microwave Theory Tech.*, Vol. MTT-31, pp. 1023 -1029, 1968.
[18] Luk, K.M., & Lueng K.W., "Dielectric resonator antennas" Electronic & Electrical Engg. Research Series, pp 65-80, year 1967.

BIOGRAPHY

Archana Sharma received her B.E degree in Electronics and Communication Engineering in 2004 from RGPV, Bhopal. She received her M.Tech. degree in Microwave & Millimetre Waves from MANIT, Bhopal, India in 2008.She is currently pursuing Ph.D. degree from the same Institute. She has many publications in various international journals and conferences. Her research fields focus on various antenna design and analysis, microstrip antennas, dielectric resonator antennas, microwave and millimetre wave systems, wireless communication. She is presently working as Assistant Professor in Department of Electronics and Communication, RITS, Bhopal, India. She is a life member of IETE.

Dr. Kavita Khare received her B.Tech degree in Electronics and Communication Engineering in 1999.M.Tech degree in Digital Communication Systems in 1993 and PhD degree in the field of VLSI design in 2004.She has nearly 100 publications in various international conferences and journals. She is working as professor of Electronics & communication engineering in MANIT, Bhopal. Her fields of interest are VLSI Design and communication systems. Her research mainly includes design of arithmetic circuits and various communication algorithms related to synchronization, estimation and routing. Dr. Khare is a fellow IETE (India) and life member ISTE.

Dr. S.C. Shrivastava received his Bachelor and Master degree in Engineering from Government Engineering College, Jabalpur, India in 1968 and 1970 respectively and PhD degree in 1994 from Barkatullah University, Bhopal, India. He is a life member of IETE, IE and ISTE. He worked as a Professor and Head, Department of Electronics and Communications Engineering, Maulana Azad National Institute of Technology, Bhopal, India. Presently he is actively associated with many technical and professional bodies and also working as Development Director in TIT, Bhopal, India. He has authored several papers in national and international journals and conferences. His fields of interest are communication system, antenna designing, microwave & millimetre wave systems and satellite communication.