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Design and Fabrication of E-SLOT Microstrip Patch Antenna for WLAN Application

Shailander Singh Khangarot[1], Gajendra sujediya[2], Tejpal Jhajharia[3], Abhishek Kumar[4]

M. Tech Scholar (Digital Communication), ECE Department, R.I.E.T. Jaipur, India[1]

Assistant Professor, ECE Department, R.I.E.T. Jaipur, India[2,4]

Assistant Professor, ECE Department Manipal University Jaipur, India[3]

Abstract: This paper presents design of E slot microstrip patch Antenna for WLAN Application. The design requirements for the antennas include a VSWR < 2:1 for 50 Ω reference impedance and return loss is less than to -10 dB. The simulation of the proposed antenna is carried out using Ansoft HFSS. The E-slot microstrip patch antenna was then fabricated using microstrip line feed arrangement and to be measured by vector network analyser (VNA) to carry out its S_{11} and VSWR result. The design targets the WLAN IEEE 802.11 n frequency band (5.47 GHz) .An antenna is designed on a GIL GML 1032 (tm) substrate with thickness of 0.762 mm, dielectric constant (εr) 3.2 & loss tangent (tan δ) is 0.003. Proposed antenna has a compact size 29 × 24 mm^2 .Simulated design is working from 5.39 GHz to 5.49 GHz whereas fabricated antenna is working from 5.38 GHz to 5.5 GHz which covers the WLAN frequency band. The E-slot microstrip patch antenna has minimum simulated return loss is -23.574 dB at 5.44GHz whereas after fabrication minimum achieved return loss is -24.007 dB at 5.43 GHz. Achieved simulated Bandwidth is 100 MHz (1.83%) and after fabrication bandwidth increased and becomes 120 MHz (2.21%). Maximum simulated gain 6.49 dBi is achieved with the proposed geometry. The serious limitation of this microstrip antenna is narrow bandwidth which is few percent. The simulated 2-D and 3-D Radiation Pattern provides omnidirectional pattern. In this paper measured return loss, VSWR, bandwidth percentage is compared to simulated results for better understanding. The proposed E-slot microstrip patch antenna is very promising for various modern communication applications such as WLAN and in C- band applications.

Keywords: WLAN, E-Slot, HFSS, VSWR, Return Loss, Radiation Pattern, IEEE.

I. INTRODUCTION

Micro strip antennas have recently received much attention and are used as efficient radiators in many communication systems. The microstrip patch antenna is chosen because of its several advantages i.e. it is lightweight, has small volume, low profile planar configuration, ease of fabrication and conformity. Compared to conventional antennas, microstrip patch antennas have more advantages and better prospects. Moreover, the microstrip patch antennas can provide dual and circular polarizations, dual-frequency operation, frequency agility, broad band-width, feed line flexibility. The microstrip patch is generally square, rectangular, circular, triangular and elliptical or some other common shape. Microstrip patch antennas can be fed by two methods contacting and non-contacting. The four most popular feed techniques used are the microstrip line, coaxial probe (both contacting schemes), aperture coupling and proximity coupling (both non-contacting schemes) [1, 2]. For microstrip path antenna three types of methods of analysis are transmission line model, cavity model, and full wave model. In this proposed design transmission line model is used [1].

II. ANTENNA DESIGN

A Microstrip patch antenna in simplest form involves a radiation patch on one side of thin dielectric substrate and other side it have a ground plane. The proposed antenna is designed on a GIL GML 1032 (tm) substrate with thickness of 0.762 mm including copper thickness on both sides. Its dielectric constant is (ε_r) 3.2 & loss tangent is 0.003, it has very compact size of ($L_s \times W_s$) 29×24 mm^2. E-slot microstrip patch antenna fed by a microstrip line is shown in Fig. 1, Rectangular shape patch is sliced from substrate. Area consumed by rectangular patch ($L_p \times W_p$) is 18×18.5 mm^2. An alphabet E-slot is cut up from patch. Dimension of E-slot ($L_e \times W_e$) is 12× 9 mm^2. Size of Central & side arm of E- slot ($L_c \times W_c$) is 2 x 7 mm^2.

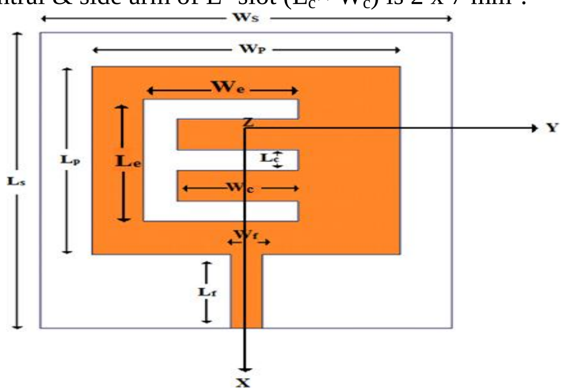

Fig. 1 Geometry of proposed microstrip-fed E-slot antenna (Front view)

Microstrip feed line is provide to this antenna. Dimensions of feed point ($L_f \times W_f$) is 7.25×1.83 mm^2. Feed is placed in the centre of the geometry. Geometry of back side of the proposed antenna is same as substrate as shown in figure

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4.2.Ground dimensions are taken as (W_{gnd}×L_{gnd}) is 29×24 mm^2.

The patch and the ground plane are separated by a dielectric sheet. A dielectric is considered by two basic parameters; the dielectric constant (ε_r) and the loss tangent (tan δ).Relative permittivity (ε_r) of dielectric is $2.2<\varepsilon_r<12$ and height h of the dielectric is usually 0.003 λo< h >0.05 λo [3,4]. We have GIL GML 1032 (tm) as a substrate because it is economical, high performance printed circuit substrate. Its dielectric constant low and constant.it have low insertion loss. Consider a Rectangular patch of Width W and Length L over grounded substrates with the thickness h and relative permittivity (ε_r). For a rectangular patch, the length L of the Patch is usually 0.3 λo<L< 0.5 λo, where λo is the free-space wavelength. λ depends on frequency of operation [1, 2].

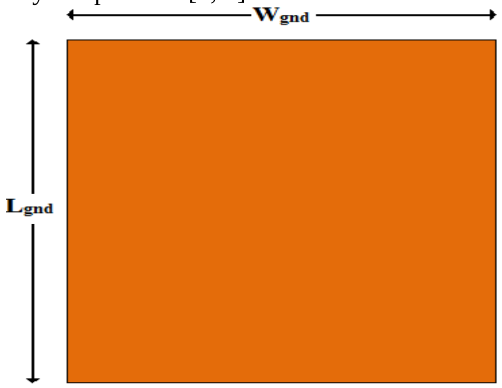

Fig. 2 Back view of proposed E-slot microstrip patch antenna

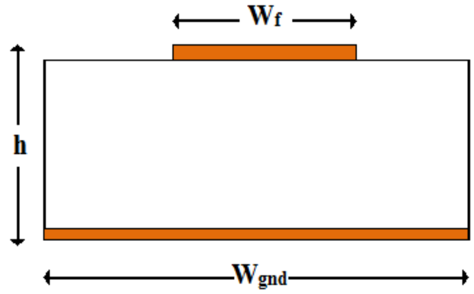

Fig. 3. Geometry of proposed microstrip-fed monopole antenna (Front View)

The actual design in Ansoft HFSS [7] is shown in fig. 3. For the simulation purposes, the ground plane and microstrip are considered to be made up of pec (perfect electric conductor) chosen from the material library of the HFSS. The required material for designing the antenna can be uploaded from the HFSS material library

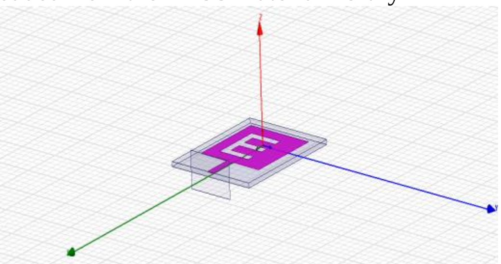
Fig.4 Actual simulated design in HFSS

Before cutting E-slot, firstly make a L-slot and evaluate all the results of it. After this process one thing found that it was not working in desired frequency range, than cut a one more slot, it becomes C-slot, after evaluate all the results of this slot. Again find that it was also not working in desired frequency range. Finally decides to make it E-slot. Fig.5 shows the dimensions of E-slot patch antenna from different positions.

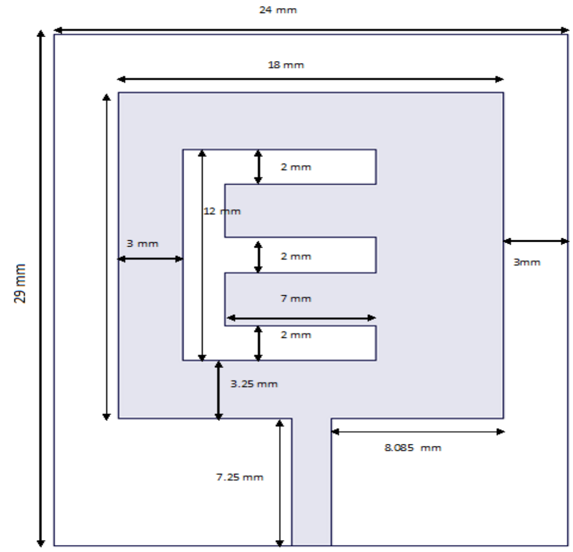

Fig.5 Dimensions of proposed E-slot patch antenna

Table I : List of design parameters of Antenna

Parameters	Value
substrate thickness h	0.762mm
dielectric constant ε_r	3.2
loss tangent tan δ	0.003
substrate size (L_s×W_s)	29×24 mm^2
patch size (L_p ×W_p)	18×18.5 mm^2
E- slot size (L_e×W_e)	12×9 mm^2
central arm & side arm size of E-slot (Lc ×Wc)	2×7 mm^2
feed size (L_f×W_f)	7.25×1.83 mm^2
ground size(Wgnd×Lgnd)	29 24 mm^2
frequency range	4 GHz – 7 GHz
step frequency	0.01 GHz

III. SIMULATED AND FABRICATED RESULTS

The proposed design as shown in fig.1 has been simulated by using Ansoft simulation software High Frequency Structural Simulator (HFSS) based on Finite Element Method (FEM) [7].

The results are very close to proposed design. It satisfying the theoretical result. There is a good agreement between theoretical and simulated result. The size of the ground plane is considered same as substrate size.

All simulated results are discussed one by one below

(A) Return loss: After simulation minimum Return loss is obtained -23.574 dB on 5.44 GHz.

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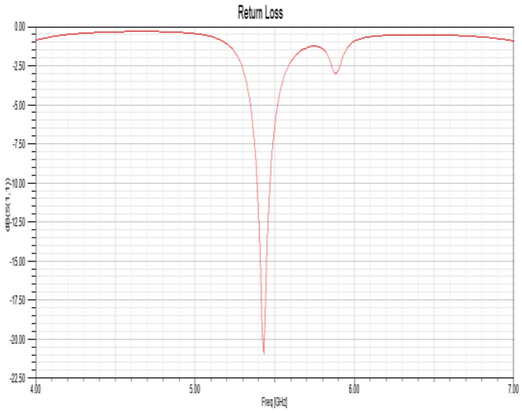

Fig. 6 Simulated plot of return loss

Table II : Simulated return loss

Frequency in GHz	Simulated Return loss (S11) in dB
5.39	-10.815
5.4	-12.631
5.41	-15.044
5.42	-18.364
5.43	-22.645
5.44	-23.574
5.45	-19.48
5.46	-15.967
5.47	-13.44
5.48	-11.565
5.49	-10.124

By studying the table 2 it is clear that proposed antenna provides the good result from 5.39 GHz to 5.49 GHz. All the obtained results of return loss are below -10 dB.

(B) VSWR: for a microstrip patch antenna voltage standing wave ratio should be below 2. It provides good results below 2

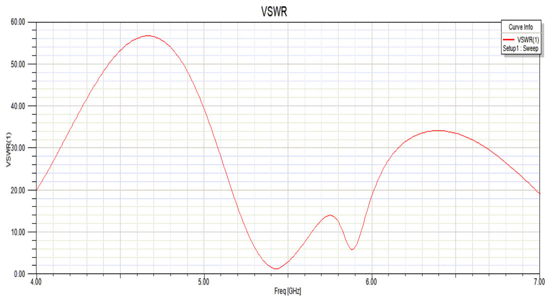

Fig.7. Simulated result of VSWR for proposed antenna

Table III : Simulated VSWR

Frequency in GHz	Simulated VSWR
5.39	1.8087
5.4	1.6096
5.41	1.4299
5.42	1.2746
5.43	1.1592
5.44	1.1419
5.45	1.2376
5.46	1.3784
5.47	1.5407
5.48	1.7177
5.49	1.9059

It shows that the lower and upper operating frequency is 5.39 GHz and 5.49 GHz where the VSWR is less than 2. It means VSWR is in acceptable range and satisfy the antenna design requirement.

(C) Current Distributions: It can be observed that the majority of the E field is concentrated around the central arm of E-SLOT. Animated view during simulation shows that current firstly start with feed then it flows on surface of patch and finally maximum flows at central arm.

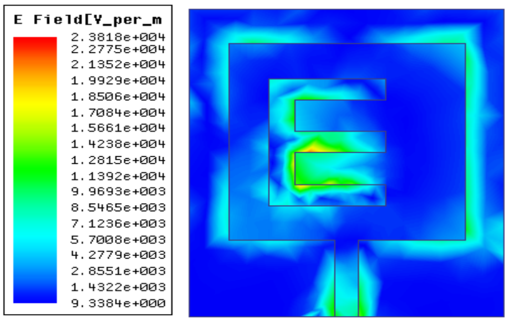

Fig.8. Simulated current distribution for the proposed E-slot patch antenna at 5.5 GHz

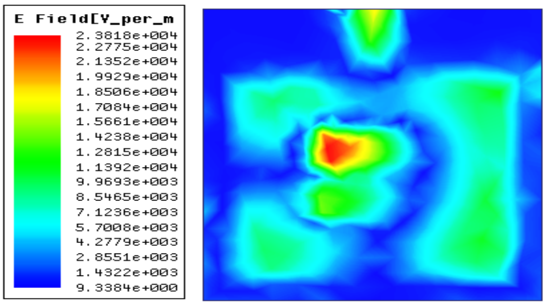

Fig.9. Simulated current distribution at ground 5.5 GHz

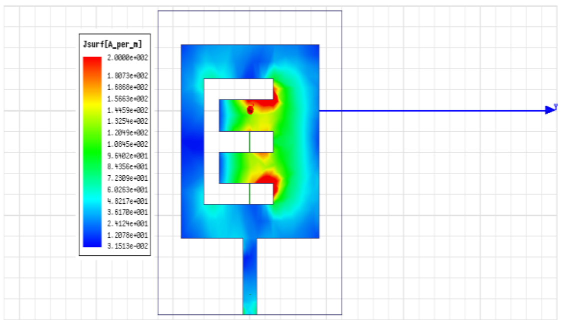
Fig.10. Simulated current density distribution for the proposed antenna at 5.4 GHz

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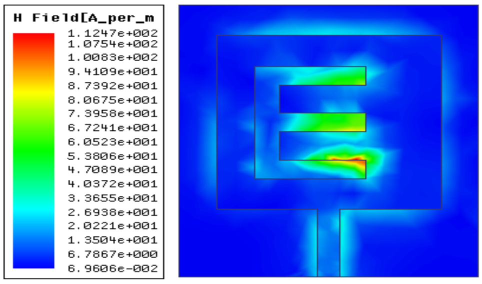

Fig.11.Simulated magnetic field distribution for the proposed antenna at 5.5 GHz

(D) Radiation pattern

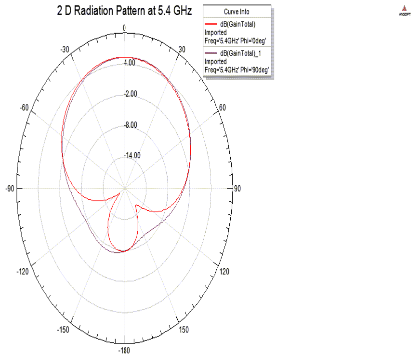

Fig. 12. Simulated 2-D radiation pattern at 5.4 GHz

(E) Gain

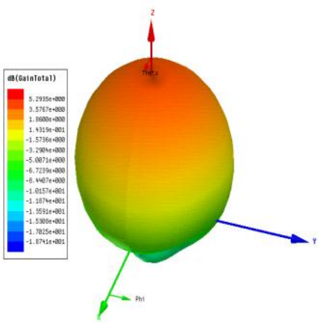

Fig. 13. Simulated 3-D radiation pattern of the E-slot patch antenna at 5.3 GHz

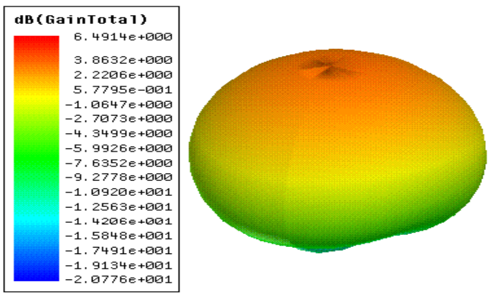

Fig. 14. Simulated 3-D radiation pattern of the E-slot patch antenna at 5.4 GHz

So as a result shown by 3-D radiation pattern plot it is clear that omnidirectional pattern is received and the maximum resulting gain approximately 6.49 dBi is achieved.

(F) Bandwidth

As discussed in return loss and VSWR, bandwith of the proposed antenna is varied from 5.39 GHz to 5.49 GHz. Narrow bandwidth is received. It is 100 MHz approx. 1.83%.

(G) Fabrication

Proposed design of E-slot microstrip patch antenna fabricated using the photolithographic technique. In this method unwanted metal areas of the metallic layer are removed through chemical etching process by which desired design is obtained. Before this process, select a proper substrate material for the proposed antenna design. A female SMA connector (brass metal) is connected in antenna to join feed and ground. SMA abbreviated as sub miniature version A, which provides electrical performance to antenna. This connector offers low reflections and constant 50 ohm impedance.

After fabrication process, all the parameters of proposed antenna are measured using vector network analyser (VNA). A VNA can measure return loss, VSWR etc. Measured results are discussed one by one below.

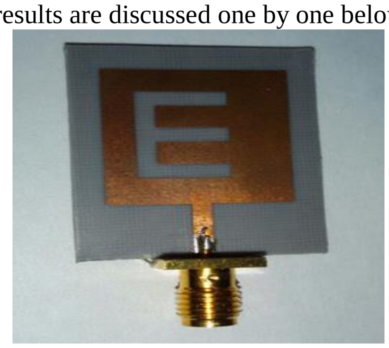

Fig.15. Front view of the fabricated prototype E-slot patch Antenna

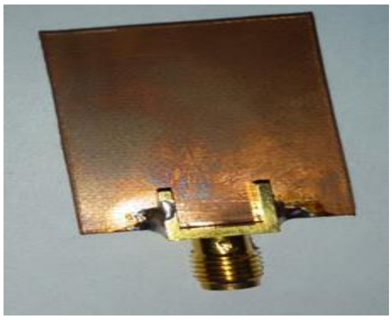

Fig.16. Back view of the fabricated prototype E-slot patch antenna

(H) Return loss

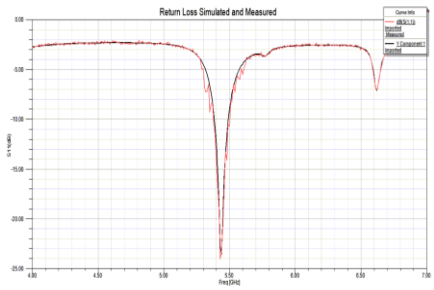

Fig.17. Diagram showing comparison between simulated and measured return loss

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Table IV : Measured return loss

Frequency in GHz	Measured Return loss (S_{11}) in dB
5.38	-10.395
5.39	-11.506
5.40	-14.585
5.41	-16.63
5.42	-19.035
5.43	-24.007
5.44	-23.345
5.45	-20.434
5.46	-17.508
5.47	-13.292
5.48	-14.133
5.49	-10.452
5.5	-10.712

It shows that minimum return loss -24.007 and -23.345 is obtained at 5.43 GHz and 5.44 GHz respectively

(I) VSWR

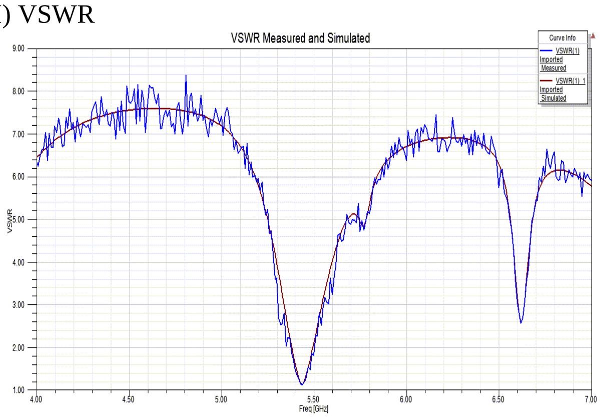

Fig. 18. Diagram showing comparison between simulated and measured VSWR

Table V : Measured VSWR

Frequency in GHz	Measured VSWR
5.38	1.866
5.39	1.7243
5.4	1.4586
5.41	1.3458
5.42	1.2516
5.43	1.1346
5.44	1.146
5.45	1.2103
5.46	1.3074
5.47	1.5526
5.48	1.4891
5.49	1.8579
5.5	1.8222

Maximum VSWR of acceptable range is 1.866 obtained at 5.38 GHz and lowest VSWR 1.1346 is received at 5.43 GHz.

IV .CONCLUSION

Design of E-slot microstrip patch antenna for WLAN application has been presented. It is simulated first and then successfully fabricated. The microstrip antenna resonates at 5.39 GHz to 5.49 GHz in simulated process and after fabrication it works in frequency range between 5.38 GHz to 5.5 GHz. It provides a good return loss, which is -23.574 dB at 5.44 GHz in simulation process and after fabrication -24.007 at 5.43 GHz. At 5.47 GHz (WLAN IEEE 802.11 n [5,6] return loss is -13.292 dB). The obtained lowest VSWR of the microstrip antenna after simulation is 1.1419 at 5.44 GHz and 1.1346 at 5.43 GHz. It have a simulated bandwidth is 1.83% and after fabrication its bandwidth is increased to 2.21 %. Maximum simulated gain is achieved 6.49 dBi. So, this antenna is useful in WLAN IEEE 802.11 n (5.47 GHz) [5,6] and C- band application. Its compact size reduces the fabrication cost. We can say that this antenna can be used in 5 GHz WLAN application. Future Efforts will focus to obtain whole WLAN frequency band (5 to 6 GHz). Design a reconfigurable E-slot microstrip patch antenna can be an objective of future work so it can work on dual frequency band. Future work may focus to achieve WLAN IEEE 802.11 b and WLAN IEEE 802.11 g (2.4 GHz) frequency band.

REFERENCES

[1] C. A. Balanis, "Antenna Theory, Analysis and Design," *ISBN 978-81-265-2422-8, John Wiley & Sons*, Inc., U.K., 2013.
[2] J. D. Kraus, R. J. Marhefka, A. S.Khan, "Antennas and Wave Propagation", *ISBN 978-0-07-067155-3*, McGraw Hill, India, 2014.
[3] Deepak Rana, Varun Punia, Surender Soni and Anuradha Sonker, "Performance Modeling On Rectangular and E Shaped Patch Antenna" *IEEE Transactions on Advanced Communication Control and Computing Technologies*, p.p. 754 – 757, May 2014.
[4] M. T. Sebastian, "Dielectric Materials for Wireless Communications", *ISBN 978-0-08- 045330-9,* Elsevier Publishers, Oxford, U.K., 2008.
[5] Bob O" Hara, Al Petrick, " IEEE 802.11 Handbook A Designers companion", *ISBN 978-0-7381-4449-8*, Willey, 2011
[6] William Stalling, " Wireless Communication and Networks", *ISBN 81-7808-560-7, Pearson,* Singapore, 2002
[7] Ansoft High Frequency Structural Simulator (HFSS) User"s Manual.

BIOGRAPHIES

S

Shailander singh Khangarot S/O Devendra singh. He completed his B.Tech Degree in Electronics and Communication Engineering from Rajasthan institute of Engineering & Technology, Under Rajasthan Technical University, Kota in year 2010. Presently, he is pursuing M.Tech in the field of Digital Communication. He has published Paper on ultra wideband Antenna in IETE National Conference on Future Trends in Communication Technologies at Manipal University Jaipur. He had attended various Workshops like Matlab & Simulink, Scientific Computational Techniques.

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Gajendra Sujediya S/O Laduram Sujediya He completed his B. Tech Degree in Electronics and Communication Engineering from Sri Balaji College of Engineering in year 2005 and Master Degree in Digital Communication from Sri Balaji College of Engineering in year 2013, Presently, he is working as Assistant Professor in Electronic and Communication Department at Rajasthan Institute of Engineering and Technology Jaipur. His area of interests includes Digital Communication, Mobile Communication and Wireless Communication. He has more than 7 years Academic/Research experience. He is a Life-Member of Indian Society of Technical Education (ISTE) and The Institution of Electronics and Telecommunication Engineers (IETE). He has guided several projects and dissertations in B. Tech and M. Tech courses.

Tejpal Jhajharia S/o Manaram. He completed his B.E. Degree in Electronics and Communication Engineering from Rajasthan university, in year 2004 and Master Degree in From Malviya national institute of Technology Jaipur, in year 2009. Presently, he is working as Assistant Professor in Electronic and Communication Department at Manipal University Jaipur, He is a Life-Member of The Institution of Electronics and Telecommunication Engineers (IETE). He has more than 8 years Academic/Research experience.