Volume-6, Issue-10, Oct., 2017
JOURNAL OF COMPUTING TECHNOLOGIES (JCT)
International Journal
Page Number: 01-08

A Hybrid Substrate Based U Shape Microstrip Patch Antenna for Wi-Fi and Wi-Max Range

Arvind Sahu[1] *(Ph.D. Scholar)*, Dr. Kavita Burse[2] *(Professor)*
[1] Ph.D Scholar, [2]*Dean Research, TIT Group, Bhopal*
[1,2]*Department of Electronics and Communication Engineering*
[1]*Dr K N Modi University (DKNMU, Newai), Rajasthan*
[2]*Technocrats Institute of Technology (TIT), Bhopal, M.P.*
sahuarvind28@gmail.com[1]. Kavitaburse14@gmail.com[2]

ABSTRACT – U shape microstrip patch antenna is one of the efficient antenna for 1 to 6 GHz. In the last decade there are different shape and size microstrip patch antenna introduced for Wi-Fi, WiMax ranges. In this range there are different bands occurs X, Ka and Ku etc. In the last decade researchers are try to improve the bandwidth and directivity of the microstrip patch antenna. For the improvement of the bandwidth researchers are used different substrate for like RT Duroid 5880, Teflon and PVC. In this research paper discuss noble combination of substrate for patch antenna. In the noble substrate use combination of FR4. Air and RT Duroid. When use this novel approach improve the number of bands, S-11 and VSWR. The proposed fusion of substrate apply in U shape microstrip patch with defected ground slot is presented. The proposed work also discuss different losses they are power loss, port loss, energy loss. Energy and power flow in the antenna in also discussed by the work. At the last compare the result of the proposed work with different previous methods that is shown in the table.

***Keywords*— Power loss, Energy losses, Metrals losses, Outgoing ports, Power Flow, Enegy Flow and RT duriod 5880.**

I. INTRODUCTION

In telecommunication, there are many varieties of microstrip antennas (also called written antennas) the foremost common of that is that the microstrip patch antenna or patch antenna. A patch antenna could be a narrowband, wide-beam antenna fabricated by etching the antenna component pattern in metal trace guaranteed to an insulating dielectric substrate, like a computer circuit board, with never-ending metal layer warranted to the other facet of the substrate that forms a ground plane. Common microstrip antenna shapes are square, rectangular, circular and elliptical, however any continuous form is feasible. Some patch antennas don't use a insulator substrate and instead are product of a metal patch mounted above a ground plane exploitation insulator spacers; the ensuing structure is a smaller amount rugged however features a wider information measure. as a result of such antennas have a really low profile, are automatically rugged and might be formed to evolve to the sinusoidal skin of a vehicle, they're usually mounted on the outside of aircraft and ballistic capsule, or are corporate into mobile radio communications devices. Microstrip printing operation is one Among the simpler strategies to fabricate because it could be a simply conducting strip connecting to the patch and so will be take into account as extension of patch. It's straightforward to model and simple to match by dominant the inset position. But the disadvantage of this technique is that as substrate thickness will increase, surface wave and spurious feed radiation will increase that limit the information measure

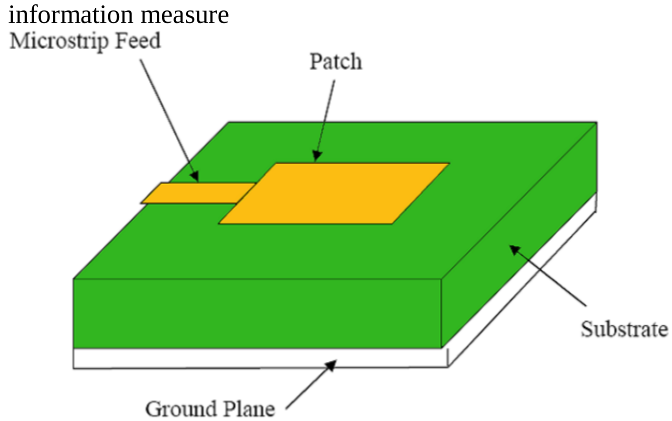

Fig 1: Microstrip line feed

II. SUBSTRATE OF MSP ANTENNA

A. FR-4 –epoxy

FR-4 or (FR-4) is a grade designation assigned to glass reinforced epoxy laminate sheets, tubes, rods and printed circuit boards (PCB). FR-4 could be a material composed of plain-woven covering material with an epoxy resin binder that's flame resistant (self-extinguishing). FR-4 glass epoxy may be a widespread and versatile aggressive thermo set plastic laminate grade with sensible strength to weight ratios. With close to zero water absorption, FR-4 is most typically used as an electrical dielectric possessing respectable mechanical strength. 4.4.2. With near zero water absorption, FR-4 is most commonly used as an electrical insulator possessing considerable mechanical strength.

B. Air

Many substrate materials are used for microstrip antennas. The dielectric constant ranges from 1.17 to about 25 and the loss tangent ranges from 0.0001 to 0.004. Commercially available substrates include Teflon /glass cloth (€r=2.5), RT/duroid-5880 (€r=2.2) and alumina ((€r= 9.8). An air-spaced patch antenna can also be built and in this case the dielectric is air ((€r=1). Two approaches usually used for design of microstrip antennas with dielectric will be presented using the case (€r=1). These approaches are known to be inaccurate when the dielectric is air, so we will try to find a good correlation between the results and derive a conclusion from the analyzed problem.

C. RT/Duroid 5880, 5870

RT/Duroid 5880 high frequency laminates are PTFE composites reinforced with glass microfibers. The arbitrarily adjusted microfibers lead to exceptional dielectric constant uniformity. The dielectric constant of those high frequency laminates is that the lowest of all product, and low material loss create them compatible for prime frequency/ broad band applications wherever dispersion and losses have to be compelled to be reduced.

Because of its very low tide absorption characteristics, RT/Duroid 5880 laminates are ideal for applications in high wet environments. RT/duroid 5880 laminates are simply cut, sheared and machined to form, and immune to all solvents and reagents ordinarily employed in etching written circuits or plating edges and holes. RT/duroid 5870 and 5880 laminates have very cheap electrical loss of any strengthened PTFE material, low wet absorption, are identical, and have uniform electrical properties over frequency.

D. Roggers TMM3 and TMM10i

TMM thermoset microwave materials are ceramic, hydrocarbon, thermoset polymer composites designed for high plated-thru-hole reliability strip-line and microstrip applications. TMM laminates are available in a wide range of dielectric constants and claddings. The electrical and mechanical properties of TMM laminates mix several of the advantages of each ceramic and ancient PTFE microwave circuit laminates, while not requiring the specialized production techniques common to those materials. TMM laminates don't need a metal napthanate treatment before electro-less plating.

.

E. Teflon

Teflon or similar product are, as a result of their extreme surface properties, used for applications during which a structuring of the Teflon is usually fascinating.

The hydrophobic surface properties but impede the coating with resist, since the resist that was spin-deposited retracts towards the center of the substrate. It's notwithstanding potential to coat additionally Teflon substrates, if a changed photoresist of the AR-P 3200 series is employed. The properties of this resist were adjusted consequently by varied the physical phenomenon an addition of adhesion promoter.

III. PROPOSED DESIGN

Proposed U Shape Micro Strip Antenna (U-MSA)

In this section discuss the proposed method view and explain design structure of the microstrip patch antenna. A explain the U shape patch antenna with microstrip feed line and triangle cuts and ground to reach bandwidth along with much gain and as substrate used FR-4 (ε_r-4.4). The main target of proposed work is work is to design efficient U Shape Patch antenna for 1 to 6 GHz for this used a different substrate material and simulate on CST. Micro-strip Patch Antenna, and effect of different substrate and its dimensions Length (L) (66mm) , Width (W) (112) and Height(H) (1.6) and substrate parameters relative Dielectric constant (4.4) to (ε_r-4.4),

Table.1 Dimension of Antenna Design

S. No.	Parameter	Dimension (m.m.)
1	Substrate	66X112X1.6
2	Ground	(66X34) –Sub. of T cuts
3	Patch	42X75) - (22X61)
4	Feed Line	2X37
5	Feed type	Microstrip feed Line

In the table 1 shows the all parameter of antenna design specification of proposed antenna. In this antenna substrate dimension are length (L), width (W) and height is 48mm, 40mm and 1.6 mm. The dimension of ground is 66 mm and 112 mm is used, then reduces the size of ground and apply two triangle cuts on ground and make a defected ground structure in this proposed antenna. The dimension of ground in which design the U-MSA which is made by the combination of different shapes which in deeply describe in the next section. The new fusions of substrate with proposed U shape design –

1st – Width of substrate –

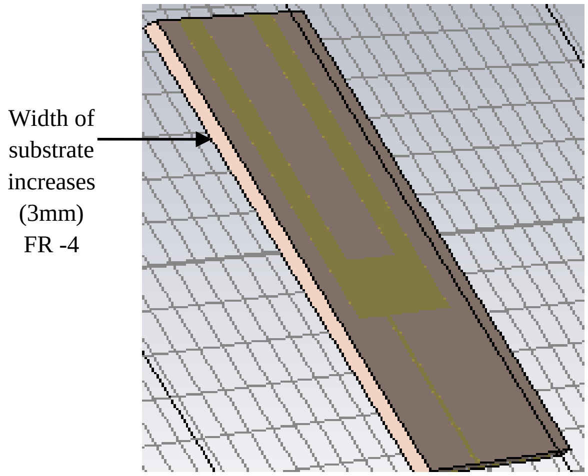

Fig. 2 – Width of substrate MSP antenna

The structure of the proposed antenna is chosen to be a rectangular plate member with the dimension length L and a width W. L sub and W sub are the size of the substrate and Lg Wg are the length of the base surface, the width of base surface, respectively. The dimension of base surface and dimension of substrate are approximately equal. In this design radiating element is excited by micro-strip feed. Patch dimensions are calculated by using broadcast line model. The above figure 2 shows the structure of the antenna. To design a rectangular micro-strip patch antenna according to parameters such as di-electric constant (εr), the resonance frequency (f_o) and the height (h) are taken into consideration for the calculation of the length and width of the room.

In the above figure 2 shows the structure of U shape microstrip, currently most of the cases use FR-4 substrate as a substrate. In the proposed hybrid substrate use FR-4, air and RT Duroid 5880 as a substrate. In the proposed design use combination of three substrates. For feeding of input use a microstrip port. This combination simulate on CST and calculate results.

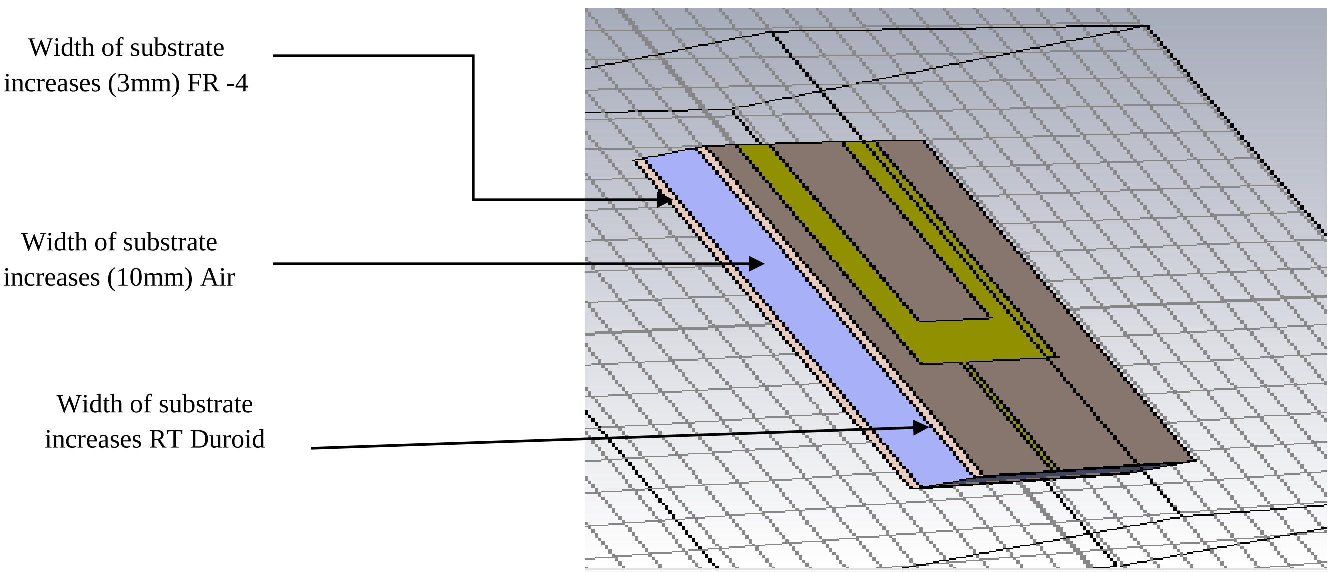

Fig. 3 – Proposed Hybrid Structure of Substrate

IV. Simulation and Result

In this section discuss the simulation and result of the proposed antenna. For analyzed the performance of proposed antenna important aspects are return loss (S-11), voltage standing wave ratio (VSWR) and energy distribution. First discuss the S -11 parameter of proposed antenna.

S -11 Parameter It is the power loss in the signal that is reflected due to discontinuity in the transmission line. As we already know, when impedance matching between the transmitter and antenna is not perfect, the radiations within the substrate results into the standing waves. In the below figure shows the S-11 result of proposed U shape patch antenna. Figure 2 shows S- 11 result of the proposed design,

VSWR Voltage standing wave ratio is also one of the most important parameter for performance calculation of proposed antenna. In the below figure shows the VSWR graph. In the graph clearly show the VSWR graph of the proposed antenna of given range is lie in between 1 to 2 in the range 1.1 to 4 GHz. Figure 3 discuss VSWR of the proposed antenna.

In the Proposed **Novel Design based on Substrate Fusion,** now discuss the result of novel design in below, also compare the proposed novel method with different previous design. The comparison with different methods shown in table 1. The below figure 4 shows the S–parameter. S–Parameter is the heart of RF and microwave measurement. The S- parameter shows that how to RF energy propagate in multi-port network. In the below shows that the resultant S-parameter of proposed antenna. In the proposed result figure X- axis shows the frequency range and Y axis shows the return loss in db. The result is well in between the range of 0.8GHz at -22db and 3.589GHz = -33.26dB.

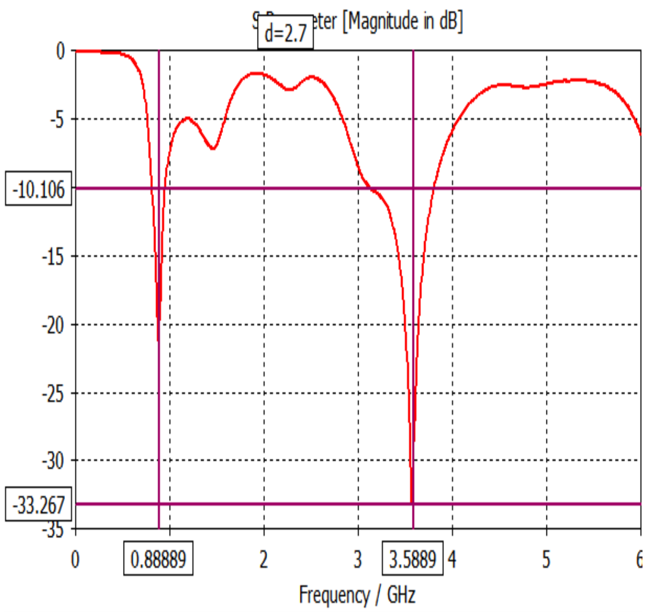

Fig. 4. S-11 Parameter of final design

Power and Loss Measurements

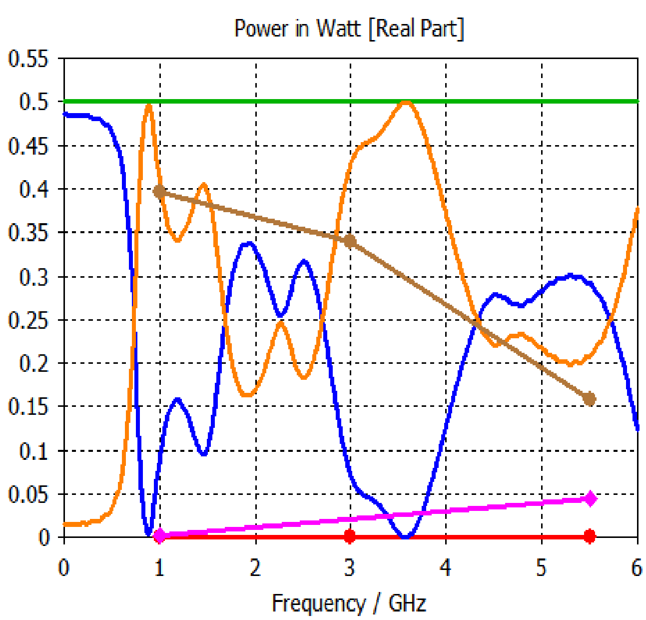

Fig. 5. Power and Loss Measurement

The above figure 5 shows the power and loss measurement of the proposed design.

- Red lines measure the Loss of metrals.
- Green line measure the loss of power simulated
- Blue lines measure the loss of outgoing ports
- Orange lline measure power accpected
- Pink lines measure the loss of dielectric
- Brown line measure the loss of radated

In the above result shows the measured different power and loss in metals. First one is losses in metals that is shown via red line. For any antenna design metal loss try to reduced or as lower as possible. In this design metal loss is near to zero (0). Second loss in figure 5 that is loss in dielectric, here seen that loss of dielectric is near to 0.1 that is also shows better result. Now discuss about the powers there are four different type of powers are calculated power radiated, power accepted, power outgoing and power stimulated.

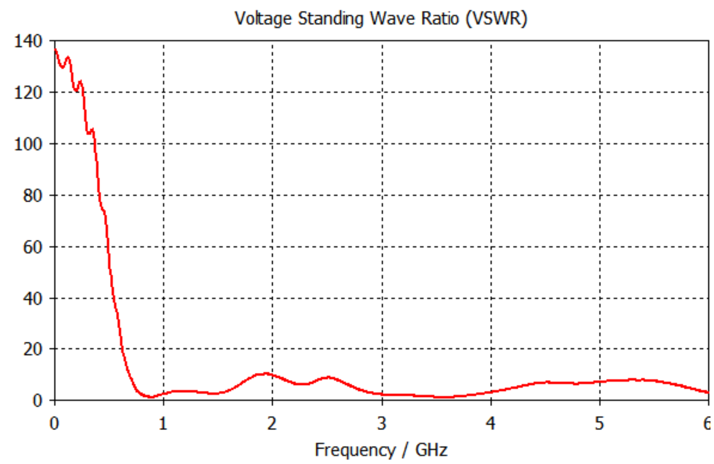

Fig. 6 VSWR of Final Design

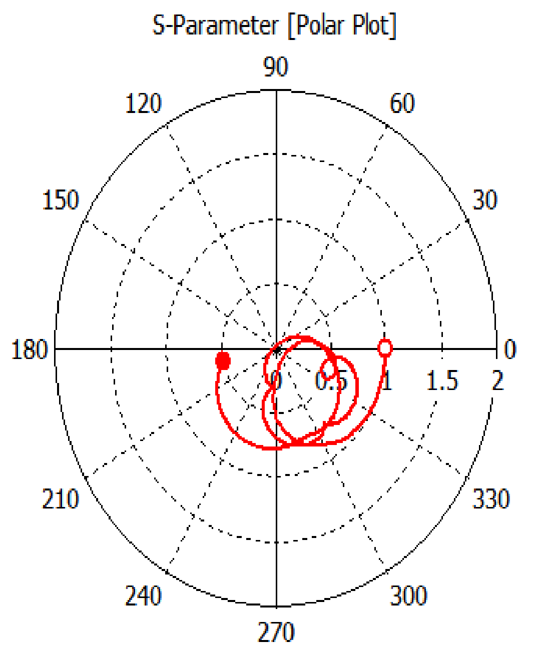

Fig. 7 (a) Polar Plot of Final Design

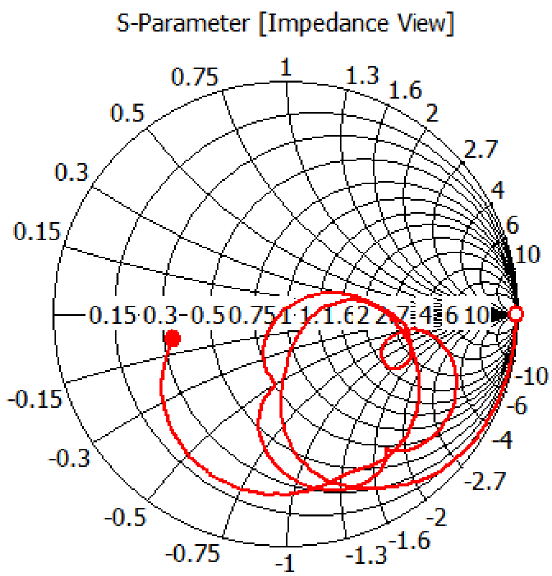

Fig. 7 (b) Impedance Chart Z- Smith chart of Proposed final design

Both the abvoe figure 7 (a) and (b) shows the polar plot and smith chart of the proposed design. In the polar plot clealy see that results are lying good region in polar plot. Similar that in the Smith chart also shows good results. After the discussion of 1 D results now discuss the 2D and 3D result of proposed design like directivity, gain and radition pattern of the antenna.

3D, 2D and 1D result of radiation pattern

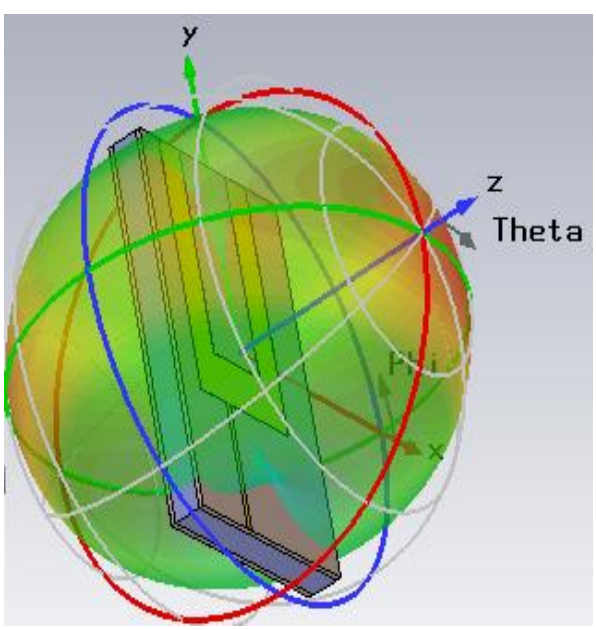

Fig. 8 (a) Directivity of proposed final design (dir. = 2.365 dBi)

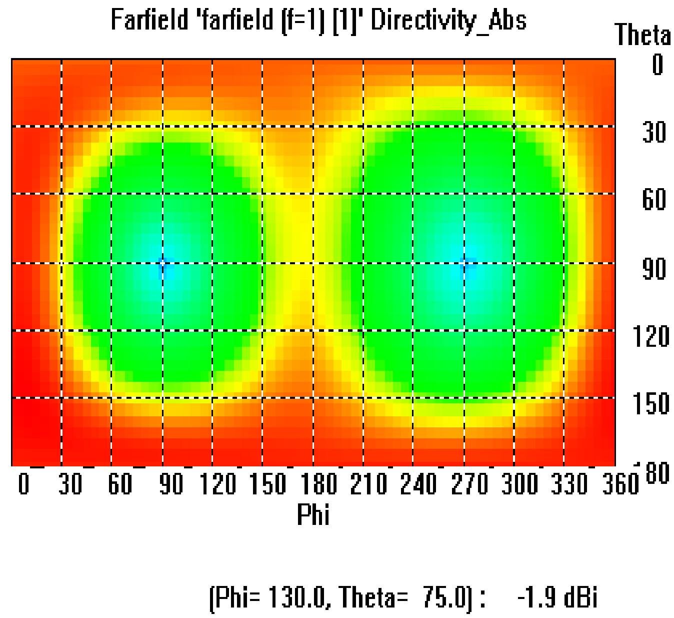

Fig.8 (b) Directivity plot in 2D of proposed final design

In the above figure 8 (a) and (b) discuss the directivity off the proposed antenna tat is near around 2.365 DBi. Also shows the directivity in the 1 D plot with the help of far field pattern which is shown in the below figure 8 (c). With the help of radition pattern also calcuate the main lobe and side lobe direction that is shown in below.

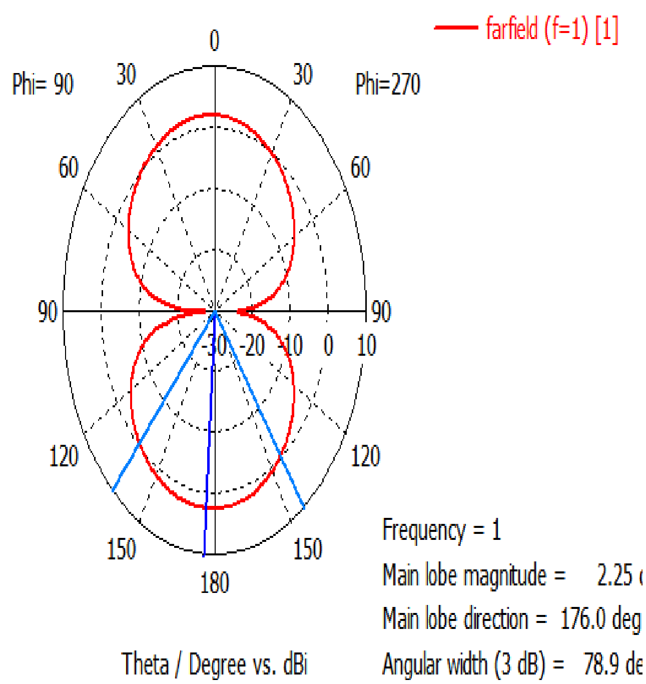

Fig. 8 (c) 1 –D plot of Directivity of proposed final design

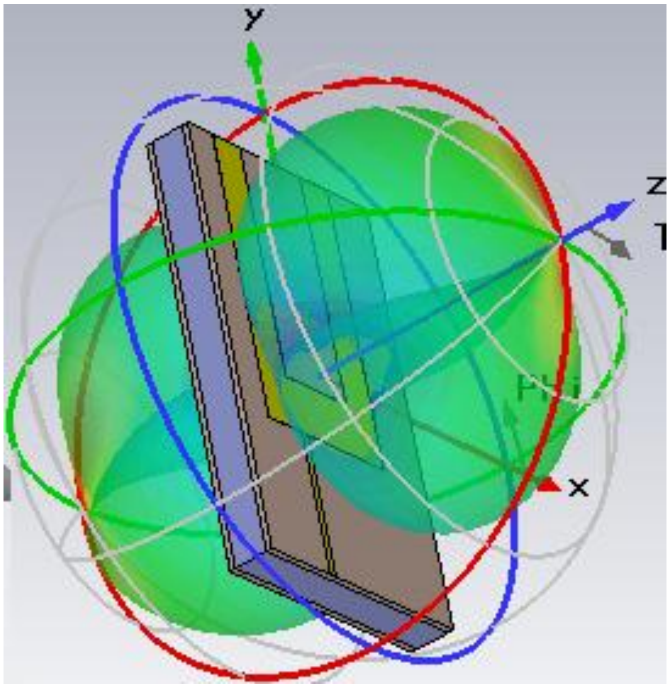

Fig. 9 (a) Far Field Directivity Pattern of theta of final design

In the abvoe figure 9 (a) shows the field directivity pattern of final design of proposed method. With the help of above figure visually see that the far field pattern of proposed antenna's directivity.

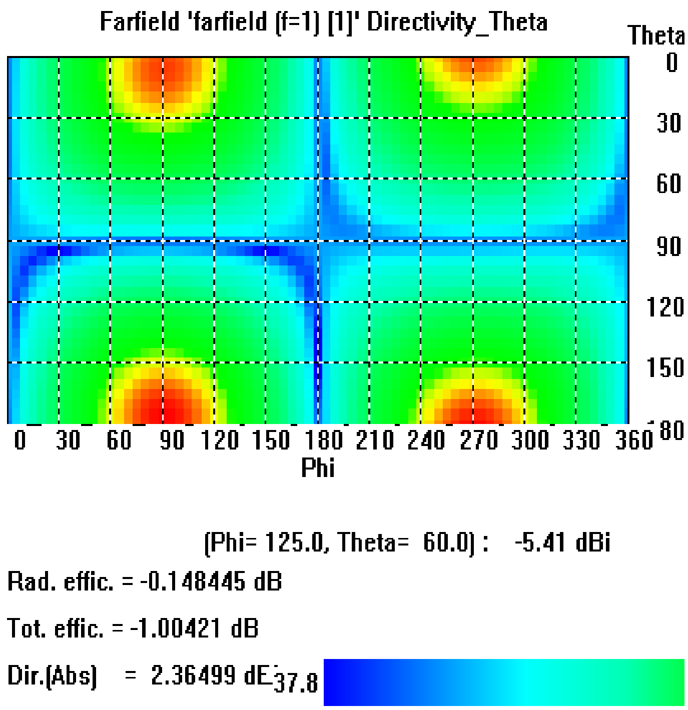

Fig. 9 (b) Far field of Directivity of final design 2D

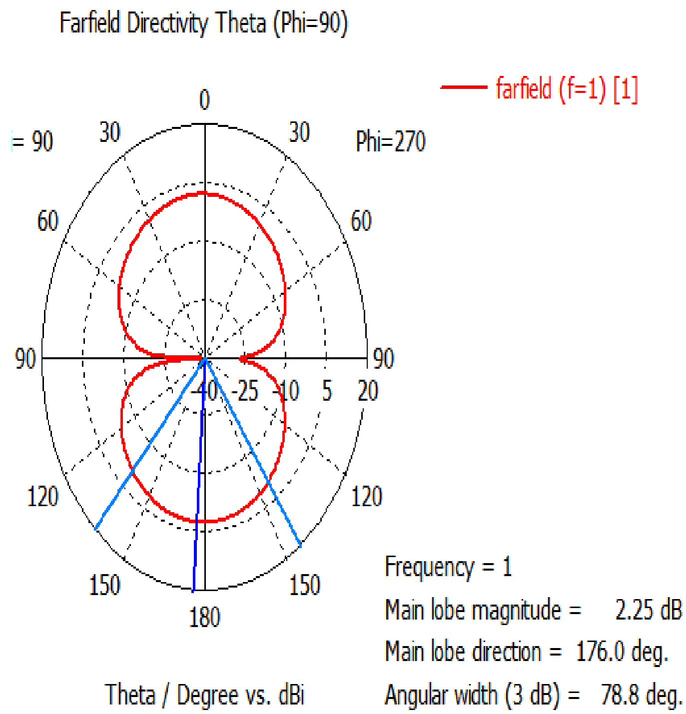

Fig. 9 (c) Far field 1D Pattern Directivity of final design

In the above figure 9 (a) (b) and (c) far field pattern in 1D, 2D and 3D. In the figure 9 (c) shows the radition pattern of proposed antenna, 9(b) shows the 2D directivity of the antenna. After the discussion of the diretivity now discuss the current flow of proposed method and power flow of proposed method.

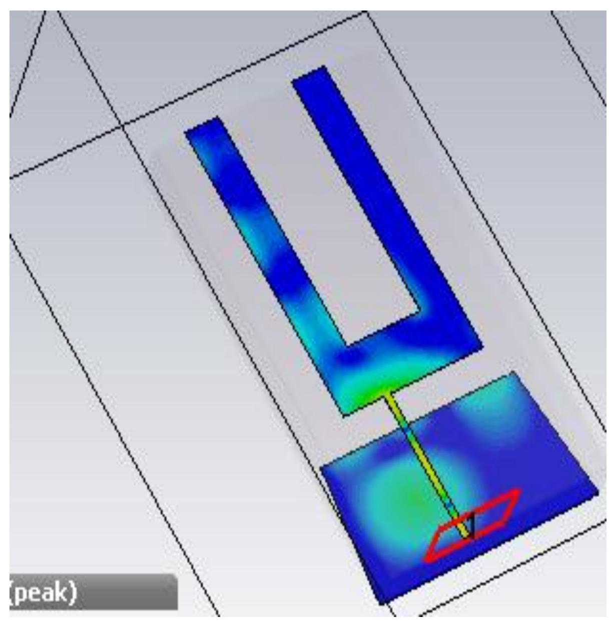

Fig. 10 (a) Current Flow pattern of proposed final design

In the above figure 10 shows the current flow pattern of proposed design.

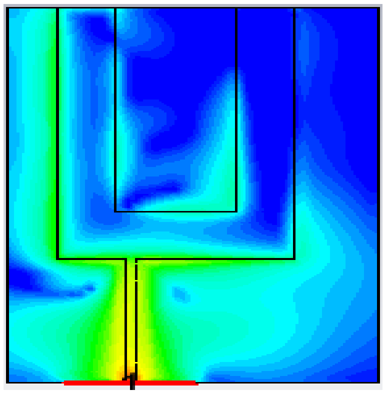

Fig. 10 (b) Power Flow in antenna

In the above figure 10 (a) and figure 10 (b) discuss the current and power flow of proposed design. The main impect of power and current flow in the design nearer to the strip line patch that is the above figure. Now discuss the comparsion of result of proposed method with different previous methods that is shown in table 1.The comparison of proposed method on different previous method shown in below.At the last compare our calculated results with other methods. That is shown in table 1.1. This table shows the compression on the basic parameters of antenna that is frequency range return losses and number of bands. Our proposed design shows better result as compare to other antenna.

V. CONCLUSIONS

In this proposed work present a U shaped micro-strip patch antenna defected ground structures designed, simulated, and tested for wireless applications. Antenna structure with and without defected ground plane are presented and compared. The measured and simulated resonant frequencies of the modes and respective impedance

Table 1.1 – Result Comparison of Proposed Design with different Previous Design

Year	Title	Antenna	Feed Technique	Range (GHz)	S – Parameter (S-11)	Band Width	No. of Bands
2017	**Proposed – U shape with fusion of different substrate**	**U Shape MSA with fusion of substrate**	**Microstrip Feed**	**1 to 6 GHZ**	**3.5GHz = -33.38 dB 0.8GHz = -21.136**	**Narrow**	**2**
2016 [20]	Characteristic Mode Analysis of a Class of Empirical Design Techniques for Probe-Fed, U-Shape MSA Antennas	U-Slot Microstrip Patch Antennas	Probe Fed	1.7-2.55 GHz	2 GHz = -20dB 4 GHz = -15dB	0.85G Hz	1
2015 [21]	Modified U-slot patch antennas with reduced cross-polarization.	U-slot patch antennas	coaxially fed	1.7-1.95GHz	1.8 GHz = -40dB	0.25G Hz	1
2015 [22]	Analysis of Broadband Variations of U-Slot Cut Rectangular MSA	U-Slot Cut Rectangular Microstrip Antennas	coaxial connector	1241=1941 MHz	2 GHz = -20dB	700M Hz	1
2012 [23]	Characteristic Mode Based Improvement of Circularly Polarized U-Slot and E-Shaped Patch Antennas	U-Slot and E-Shaped Patch Antennas		2.35-2.55 GHz	2.45 GHz = -16dB	0.20 GHz	1
2010 [24]	The Versatile U-Slot Patch Antenna	U-Slot Patch Antenna		2.24-2.46 GHz	2.43 GHz = -17dB	0.22G Hz	multi band

bandwidths of the patch antennas were observed to be in good agreement. The main focus of this work to improve the result parameters with the help of different substrate and a proposed novel fusion substrate with air. In future implement this work on hardware currently done only in the software basic on CST and HFSS based. IN future also try to implement different substrate.

REFERENCES

[1] E. H. Newman, “Small Antenna Location Synthesis Using Characteristic Modes”, IEEE Transaction Antennas Propagation., vol.27, no.4, pp. 530–531, July 1979.

[2] R. J. Garbacz and R. H. Turpin, “A Generalzied Expansion for Radiated and Scattered Fields”, IEEE Transaction Antennas Propagation action, vol. 19, no. 3, pp. 348-358, May 1971.

[3] R. F. Harrington and J. R. Mautz, “Theory of Characteristics Modes for Conducting Bodies,” IEEE Transaction Antennas Prop, vol. AP-19, no. 5, pp. 622–628, September 1971.

[4] R. F. Harrington and J. R. Mautz, “Computation of Characteristics Modes for Conducting Bodies”, bid., pp. 629–639.

[5] R. F. Harrington Field Computation by Moment Methods (Classic Reissue). NY, USA: IEEE Press, 1993.

[6] A. Yaghjian and S. Best, “Impedance, Bandwidth and Q of Antennas,” IEEE Transaction Antennas Propagation. vol. 53, no. 4, pp. 1298–1324, April 2005.

[7] M. Fabres, E. Daviu, A. Nogueria, and M. Bataller, “The Theory of Characteristic Modes Revisited: A Contribution to the Design of Antennas for Modern Applications,” IEEE Antennas and Propagation, vol. 49, no. 5, pp. 52–68, October 2007.

[8] H. Wang, X. B. Huang and D. Fang, “A Single Layer Wideband U-Slot Micro strip Patch Antenna Array”, IEEE AWPL, vol. 7, pp. 9–12, 2008.

[9] G. F. Khodaei, J. Nourinia and C. Khobadi, “A Practical Miniaturized U-Slot Patch Antenna with Enhanced Bandwidth, “PIERS, B, vol. 3, pp. 47–62, 2008.

[10] J. C´orcoles, M. A. Gonzalez, J. Rubio and J. Zapata, “Performance Characterization of Wideband, Wide-Angle Scan Arrays of Cavity backed U-Slot Micro strip Patch Antennas”, Intl. Jour. RF and Microw. Comp.-Aided Engineering, pp. 389–396, December 2008.

[11] K. F. Lee, S.Yang, A. Kishk, and K. M. Luk, “The Versatile U-Slot Patch Antenna,” IEEE Antennas Proper. Mag., vol. 52, no. 1, pp. 71–88, Feb. 2010.

[12] M. Koohestani and M. Golpur, “U-Shaped Micro strip Patch Antenna with Novel Parasitic Tuning Stubs,” IET Micro. Antennas Propagation, vol. 4, no. 7, pp. 938–946, 2010.

[13] E. A. Daviu and M. C. Fabres,“Modal Analysis and Design of Bandnotched UWB Planar Monopole Antennas”, IEEE Transaction Antennas. Propagation. vol. 58, no. 5, pp. 1457–1467, May 2010.

[14] K. F. Lee and K. M. Luk, Micro strips Patch Antennas. London, UK: Imperial College Press, 2011.

[15] J. Chalas, K. Sertel, and J. L. Volakis, “Computation of Q limits for Arbitrary-Shaped Antennas using Characteristics Modes,” Proc. IEEE Intl. Symp. Antennas Propagation. pp. 772–774, 2011.

[16] B. D. Raines, “Systematic Design of Multiple Antenna Systems Using Characteristic Modes,” PhD dissertation, Electrical and Computer Engineering, Ohio State University, Columbus, Ohio, USA, 2011.

[17] Y. Chen and C. Wang, “Characteristic Mode Based Improvement of Circularly Polarized U-Slot and E-Shaped Patch Antennas”, IEEE Antennas and Propagation action Letters, vol. 11, pp. 283–290, 2012.

[18] M. Gustafsson, M. Csimasu and B. L. G. Jonsson,“Physical Bounds and Optimal Currents on Antennas”, IEEE Transaction Antennas Propagation., vol. 60, no. 6, pp. 2672–2681, June 2012.

[19] Yadav P., Sharma S., Tiwari P., Dey N., Ashour A.S., Nguyen G.N. “A Modified Hybrid Structure for Next Generation Super High Speed Communication using TDLTE and Wi-Max”Big Data, Springer. 2017. https://link.springer.com/chapter/10.1007/978-3-319-60435-0_21#citeas

[20] Khan, Mahrukh, and Deb Chatterjee. "Characteristic mode analysis of a class of empirical design techniques for probe-fed, U-slot microstrip patch antennas." *IEEE Transactions on Antennas and Propagation* 64, no. 7 (2016): 2758-2770.

[21] Costanzo, Sandra, and Antonio Costanzo. "Compact MUSA: Modified U-slot patch antennas with reduced cross-polarization." *IEEE Antennas and Propagation Magazine* 57, no. 3 (2015): 71-80.

[22] Deshmukh, Amit, and K. P. Ray. "Analysis of broadband variations of U-slot cut rectangular microstrip antennas." IEEE Antennas and Propagation Magazine 57, no. 2 (2015): 181-193.

[23] Chen, Yikai, and Chao-Fu Wang. "Characteristic-mode-based improvement of circularly polarized U-slot and E-shaped patch antennas." *IEEE antennas and wireless propagation letters* 11 (2012): 1474-1477.

[24] Lee, Kai Fang, Shing Lung Steven Yang, Ahmed A. Kishk, and Kwai Man Luk. "The versatile U-slot patch antenna." *IEEE Antennas and Propagation Magazine* 52, no. 1 (2010): 71-88.

