KIET IJCE KIET International Journal of Communications & Electronics

Volume. No. 4, Issue No. 1, January-June 2016, ISSN: 2320 - 8996

CSRR Loaded UWB Monopole Antenna with Tri - Notch Characteristics for WLAN, WiMax and X Band Applications

Chhavi Gupta[1], Monika[2] and Jyoti Mishra[3]

M.Tech Student[1, 3], Assistant Professor[2]

Department of Electronics and communication Engineering, Jaypee Institute of Information Technology, Noida - 201307, India

[1]Chhavi01gupta@gmail.com, [2]moniktronics@gmail.com, [3]jyotimishra13@rediffmail.com

***Abstract* - In this work, a ultra-wideband planar monopole antenna with tri notch along with a metamaterial structure has been proposed with substrate height of 0.8mm.The antenna consist of semicircular radiating patch and a CSRR loaded ground plane. For verifying the implemented metamaterial structure possess the negative value of permeability and permittivity, Nicolson Ross Weir Method (NRW) has been used. By etching round shape slots on patch we get the characteristics at WLAN band(2.4-2.483GHz),(5.470-5.725GHz), WiMax band(2.5-2.69GHz),(5.25-5.85GHz) and C-band at uplink frequency of (5.9-6.4GHz).To get the notches at X-band having uplink and downlink(7.9-8.4GHz),(7.25-7.55GHz) respectively a pair of CSRR has been loaded on ground plane. The measured impedance bandwidth ranges is from 2.4-11.94GHz having the return loss of less than 10dB. The proposed antenna exhibits omnidirectional radiation pattern in the H-Plane and dipole like Radiation Pattern in E-Plane. The simulated Gain observed is stable output at UWB application. Software HFSS version 16 has been used for Simulation purpose.**

***Keywords* - Complimentary Split Ring Resonator (CSRR) Nicolson Ross Weir, Ultra Wide Band (UWB), Microstrip antenna, Metamaterial Antenna (MTM).**

I. INTRODUCTION

Although, the Microstrip patch Antenna have various advantages (low profile, low cost and Omni - directional radiation pattern),it exhibits some disadvantage like narrow bandwidth and low gain[4],[5]. To overcome this concept of metamaterials have been evolved by Veselgo. These materials do not exist in nature but their properties do exists. The simulated result of metamaterial structures has been implemented on MS-Excel approaching NRW Method, in which the negative value of permittivity and permeability has been shown. After that, this structure has been loaded on the ground of proposed patch antenna .As to enhance the data rate in wireless communication UWB antenna has been taken as the wide interest and the Federal Communication Commission(FCC) has released 3.1 to 10.6GHz as an unlicensed band for radio Communication[1].Due to low power emission level UWB can be easily interfered with WiMax band (2.5-2.69GHz), (5.25-5.85GHz), WLAN band (2.4-2.483GHz), (5.470-5.725GHz), C-band at uplink frequency of (5.9-6.4GHz) and X band uplink and downlink (7.9-8.4GHz), (7.25-7.55GHz) respectively. By the literature survey we came to know that by etching different slots on radiating patch and ground plane single, double, triple notch can been attain in UWB region. The notch band characteristics are obtained by radiating two round shape slots on patch and a pair of CSRR loaded on ground plane[3].The dimension of slot has been varied and the optimized result has been shown. The proposed Antenna exhibits nearly omnidirectional radiation pattern in H-Plane and dipole like radiation pattern in E-Plane.

II. NRW APPROACH

To find the value of permeability and permittivity, NRW method has been used. The value of Mu and epsilon is evaluated using equation 1,2and3. To extract the value of S-parameter the structure is placed in a waveguide. To create the internal environment of waveguide Perfect Electric and Magnetic boundaries have been formed around the structure [7], [8].The simulated S-parameters has been exported on Ms-Excel for verifying the properties of metamaterial structure.

Equations for calculating permittivity and permeability using NRW Method.

$$\mu_r = \frac{2c(1-v_2)}{\omega di(1+v_2)} \quad (1)$$

$$\varepsilon_r = \mu_r + \frac{2S_{11}ci}{\omega d} \quad (2)$$

$$v_2 = S_{21} - S_{11} \quad (3)$$

Where

ε_r = Permittivity

μ_r = Permeability

ω =Frequency in Radian

d=Thickness of the Substrate

c=Speed of Light

v_2 =Voltage Minima

III. ANALYSIS OF METAMATERIAL STRUCTURE

This structure has been analyzed on 7x7mm^2 Patch with the 0.8mm FR-4 Substrate Thickness. The width of the slot has been taken as 0.7mm.The simulated value of S11 and S21 has been exported on Ms-Excel and the negative value of permittivity and permeability has been verified by the above stated formulas.

Table 1.Dimensions of Unit Cell

Parameter	Dimension in mm
L	7
W	7
X	6
Y	6
g	0.7

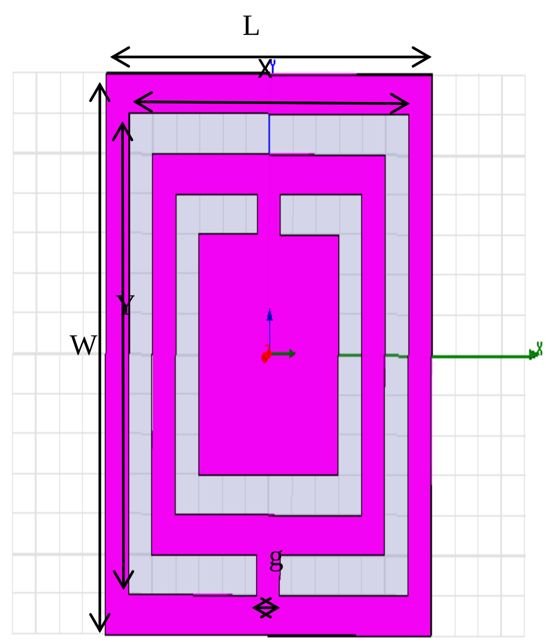

Figure 1: Design of Metamaterial Structure

KIET IJCE KIET International Journal of Communications & Electronics

Volume. No. 4, Issue No. 1, January-June 2016, ISSN: 2320 - 8996

Table2. Obtained valueof Permeability versus Frequency from the MS-Excel program.

S.No.	Frequency(GHz)	Permeability
1	4	1030511794
2	4.1	-949859018.7
3	4.2	-495348491.9
4	4.3	-334692726
5	4.4	-253966697.6
6	4.5	-205273597.2
7	4.6	-172541014.5
8	4.7	-148907874.3
9	4.8	-130960167.3
10	4.9	-116808649.7
11	5	-105322784.4
12	5.1	-95784114.14
13	5.2	-87713708.7
14	5.3	-80779615.91
15	5.4	-74744151.65
16	5.5	-69432357.05
17	5.6	-64712319.48
18	5.7	-60482447.29
19	5.8	-56662976.96
20	5.9	-53190138.68
21	6	-50012033.63

Table3. Obtained value of Permittivity versus Frequency from the MS-Excel program

S.No.	Frequency(GHz)	Permittivity
1	4	995420565.8
2	4.1	-980368390.5
3	4.2	-521739162.2
4	4.3	-357351258.1
5	4.4	-273219130.1
6	4.5	-221397777.1
7	4.6	-185776041.6
8	4.7	-159461354.1
9	4.8	-139013811.6
10	4.9	-122522628
11	5	-108839126.1
12	5.1	-97229381.24
13	5.2	-87201102.12
14	5.3	-78410633.29
15	5.4	-7060983.89
16	5.5	-63614484.69
17	5.6	-57283850.74
18	5.7	-51508222.54
19	5.8	-46199948.78
20	5.9	-41287420.57
21	6	-36710691.8

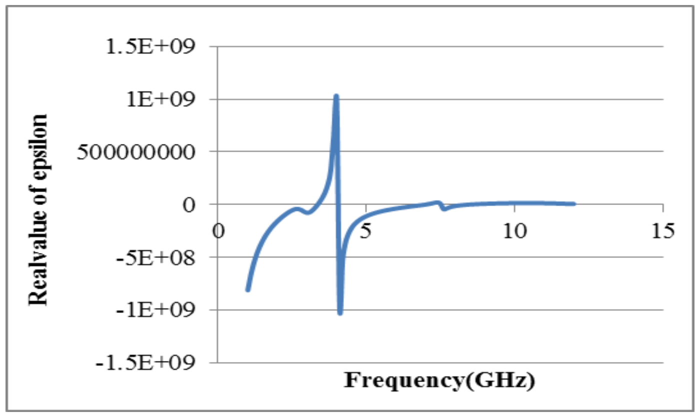

Figure 2: Permeability versus Frequency Graph

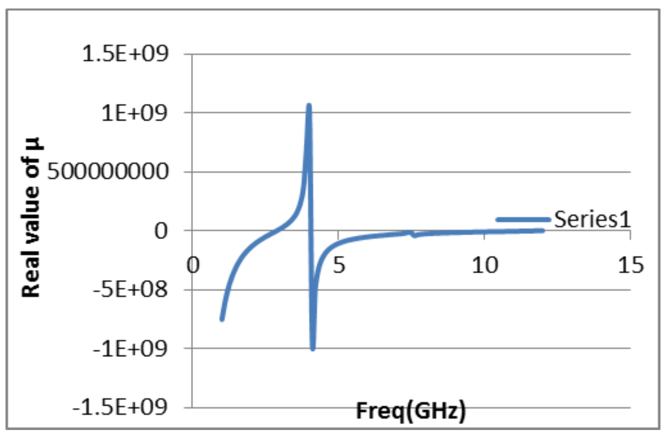

Figure 3: Permeability versus Frequency Graph

Volume. No. 4, Issue No. 1, January-June 2016, ISSN: 2320 - 8996

IV. DESIGN AND ANALYSIS LOADED WITH METAMATERIAL STRUCTURE

The Antenna has a size of 27x25mm^2.The antenna is designed on FR-4 Substrate of 0.8mm thickness having dielectric constant 0f 4.4 and loss tangent 0.02.The proposed antenna shows the advancement made in design[1].

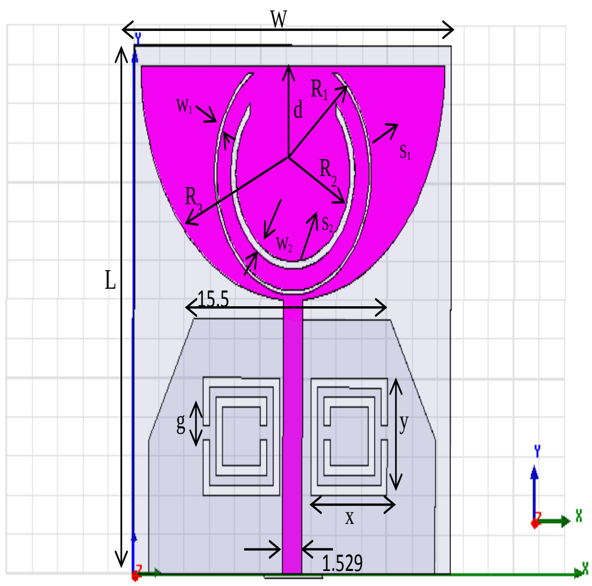

Figure 4:Proposed Antenna

Table 4.Dimensions of proposed Antenna

Parameter	**Dimension(mm)**
L	27
W	25
D	5.5
R_1	6
R_2	4.5
R_3	12
W_1	0.2
W_2	0.4
X	6
Y	6
G	0.7

V. RESULTS AND DISCUSSION

The Simulation has been done on Ansoft HFSS version 16.Two round slot S1 and S2 has been etched on a radiating patch, with a pair of CSRR Loaded on ground plane shown in fig.4.CSRR dimensions are taken same as described in NRW approach. The band in WiMax and WLAN range is achieved due to S1 and S2 Slot on radiating patch, the band achieved in X band and C band uplink range is due to CSRR loaded on ground plane. The gap of CSRR has been optimized using the e and d as optimizing variables shown in fig 5.The fig.6 shows the optimized simulated results. Fig.7 shows the gain vs frequency plot, which provides the stable gain while fig.8 shows the graph of radiation efficiency in upto 85% efficiency is attain in X band while 95% efficiency in WLAN, WiMax frequency ranges. The Radiation Pattern has been plotted in in different pass band frequencies like 2.5GHz, 3.3GHz, 4.4GHz, 5.5 GHz, 7.5GHz, 8.5GHz which provides bidirectional radiation pattern in E-plane and Omnidirectional in H-Plane. Current distribution has been observed at frequency ranges of our antenna applications. At 2.4GHz and 5.5 GHz surface current is distributed is over slot s1 and s2 while a very high current is observed at CSRR around 7.5GHz and 9.4GHz.

KIET IJCE KIET International Journal of Communications & Electronics

Volume. No. 4, Issue No. 1, January-June 2016, ISSN: 2320 - 8996

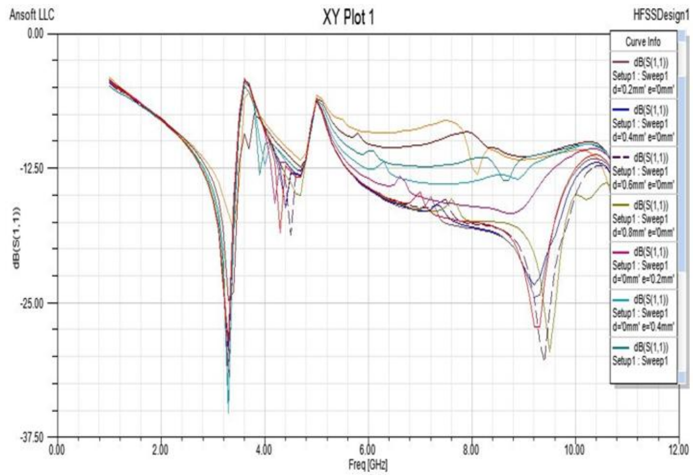

Figure 5:S11 with optimizing variable

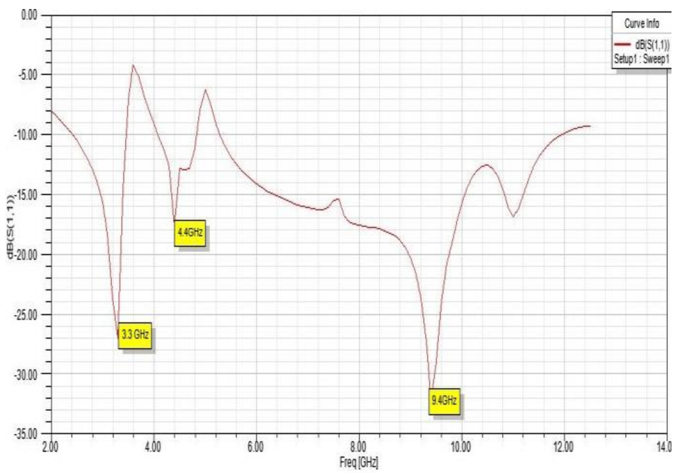

Figure 6:S11 with optimized variable

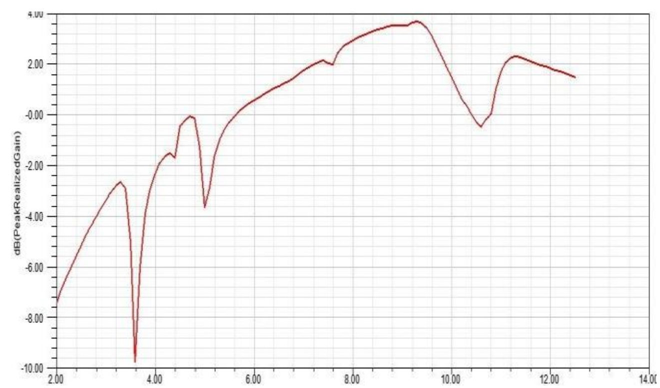

Figure 7:Gain vs Frequency

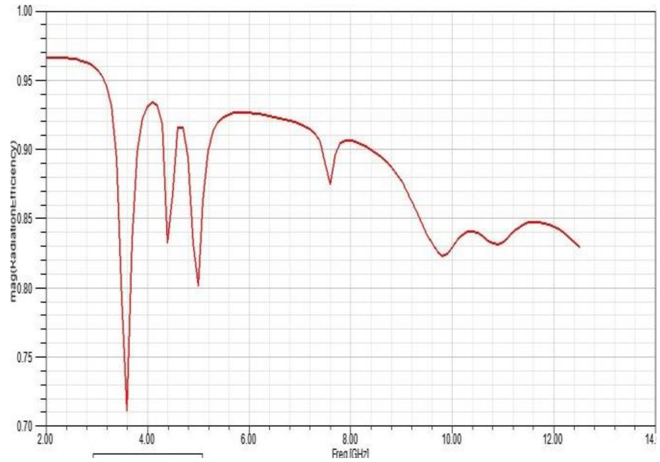

Figure 8: Radiation efficiency plot

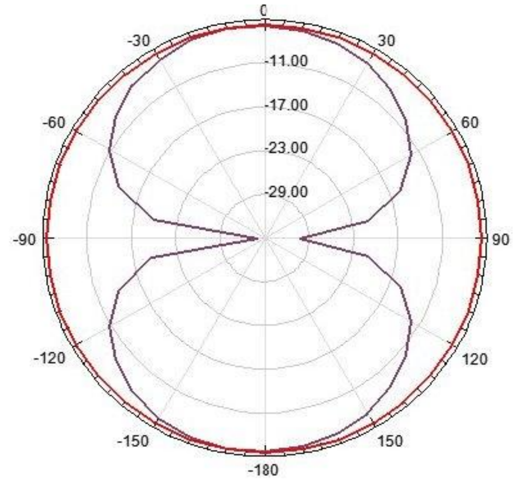

Figure 9: At 2.5GHz

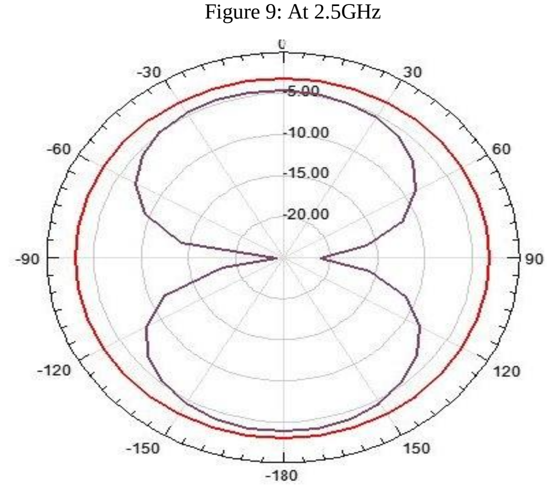

Figure 10: At 4.4GHz

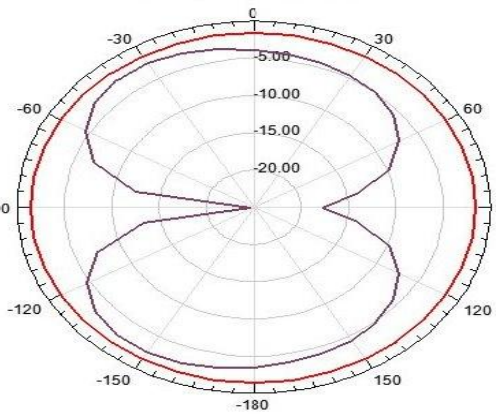

Figure 12: At 5.5GHz

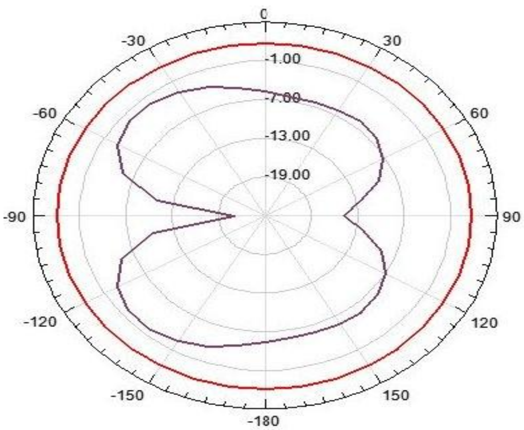

Figure 13: At 7.5GHz

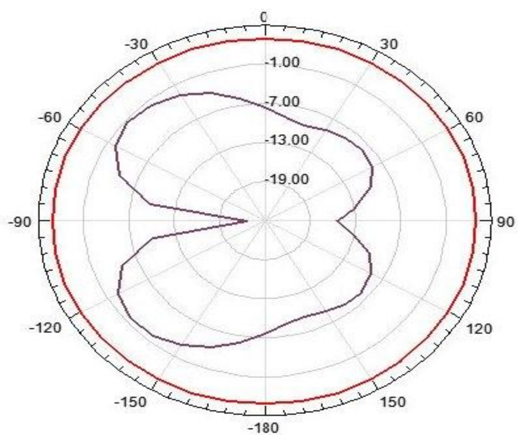

Figure 14: At 8.5GHz

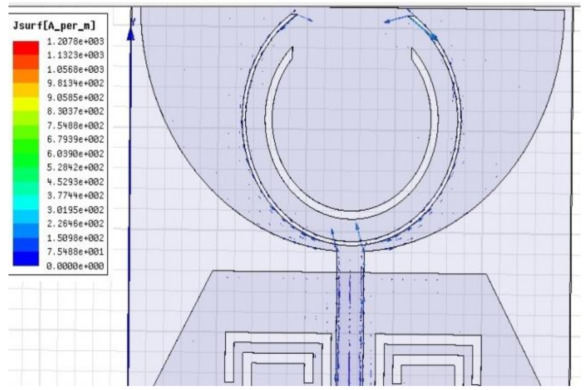

Figure 15: Current Distribution at 2.5GHz

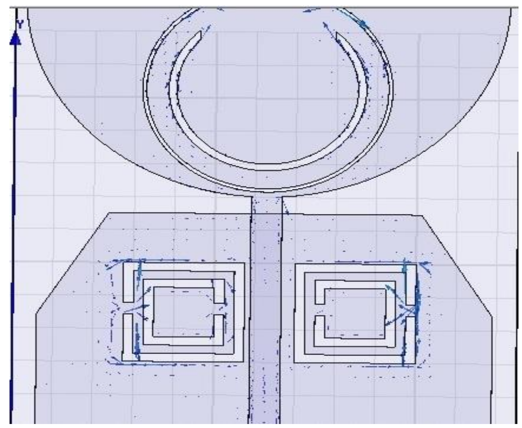

Figure 16: Current Distribution at 5.5GHz

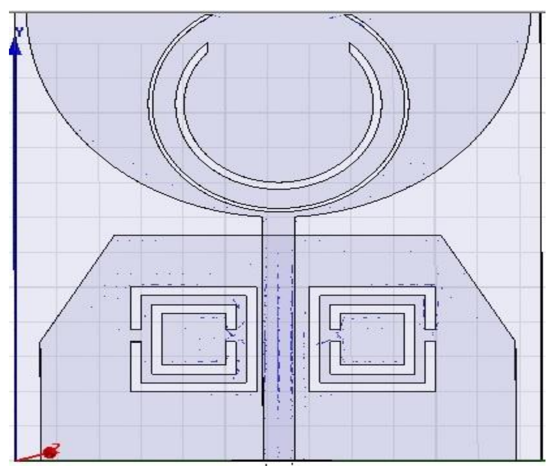

Figure 17: Current Distribution at 7.5 GHz

Volume. No. 4, Issue No. 1, January-June 2016, ISSN: 2320 - 8996

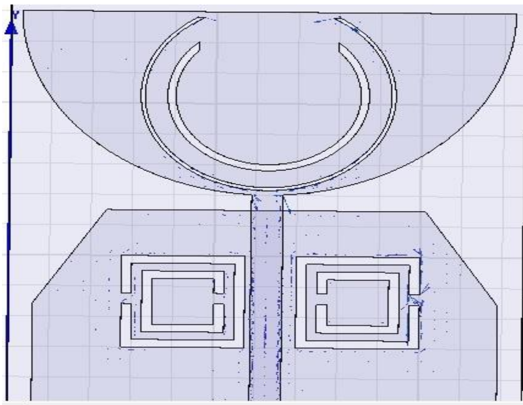

Figure 18: Current Distribution at 9.4 GHz

Table 4: List of Parameter extracted from simulated result at mid frequency of the applications covered by design antenna

Freq (GHz)	S11(dB)	VSWR	Gain(dB)	Directivity(dB)	Efficiency
2.5	-10.47	1.8	-5	-4.5	96%
5.5	-11.79	1.6	0	0.035	92%
6	-14.07	1.4	0.6	1	92.7%
7.5	-15.45	1.4	2.05	2.6	89%
8	-17.56	1.3	3.15	3.4	90%

VI. CONCLUSION

On the basis of simulated results, it is observed that we attain better results by loading CSRR on ground as compare to[1].The proposed design covers the WLAN and WiMax ranges as in[1],as well as it covers the whole X band including C band uplink frequency range. Improvement in return loss of -20 dB at 9.4GHz and -7dB at 4.4 GHz has been observed. It has been observed that by changing the width of CSRR slot, modification in notches can be made,without affecting the UWB band. The observed radiation pattern in H and E plane provides stable far field radiation pattern .The simulated radiation efficiency.75% to 96% Radiation efficiency is observed in different bands. The proposed antenna is suitable for UWB applications.

VII. REFERENCES

[1] SaiK.Venkata, MuktikantaRana, PritamS.Bakariya," Planar UWB Monopole antenna with Tri-Notch band Characteristics, "*Progress in Electromagnetics Research C"*, vol.46, pp.163-170, 2014.

[2] Yuandan Dong, Hiroshi Toyao and Tatsuo ltoh, "Design and Characterization of miniaturized patch antenna loaded with complimentary split-ring resonator", *IEEE Trans.Antenna and Propagation.*vol.60, pp.no.20-27, February 2012.

[3] Ricardo Marques, Ferran Martin and Mario Sorolla, "*Metamaterial with Negative Parameters*", first ed., Willey Series in Microwave and Optical Engineering, pp.155-172, 2007.

[4] Constantine A.Balanis, "*Antenna Theory Analysis and Design*", 3rd ed., Willey Student Edition, pp.1-24,811-876.

[5] Matthew N.O Sadiku, "*Principles of Electromagnetics*",4thed.,Oxford International student Edition,pp.479-480.

[6] Ramesh Garg, PrakashBhartia, InderBahl, ApisakIttipiboon,"*Microstrip Antenna Design*", first ed., Artec House Boston, London, pp.1-28.

[7] Shridhar E. Mendhe1 &Yogeshwar Prasad Kosta,"Metamaterial Properties and Applications", *International Journal of Information Technology and Knowledge Management,*January-June 2011, vol.4,no.1, pp. 85-89.

[8] BimalGarg, AnkitSamadhiya, Rahul DevVerma, *"*Analysis and design of microstrip patch antenna loaded with innovative metamaterial structure*", Research Journal of Physics and Applied Science,* vol.1, pp.013-019, August 2012.

[9] BimalGarg, AnkitSamadhiya, Rahul DevVerma,"Design of Rectangular Microstrip Patch Antenna Incorporated Metamaterial Structure for Dual band Operation and Amelioration in patch Antenna Parameter with Negative μ and ε ", *International Journal of Engineering and Technology*, vol.1, no.3, pp.205-216, 2012.

[10] S.Arslanagic,T.V.Hansen,N.A.Mortensen,A.H.Gregersen, O.Sigmud,R.W.Ziolkowski,andO.Breinbjerg,"A Review of the Scattering-parameter Extraction Method with Clarification of Ambiguity issues in Relation to Metamaterial Homogenization",*IEEE Antennas and Propagation Magazine*,vol.55,no.2,April 2013.

[11] A.M.Nicolson, G.F.Ross, "Measurement of the intrinsic Properties of Materials by Time-Domain Techniques", *IEEE Transaction on Instrumentation and Measurement*, vol.IM-19, no.4, November 1970.

[12] Chieh-Sen Lee and Chin-Lung Yang,"Single-Compound Complimentary Split-Ring Resonator for Simultaneously Measuring the Permittivity and Thickness of Dual-Layer Dielectric-Materials",*IEEE Transaction on Microwave Theory and Techniques*,vol.63,no.6,june 2015.

[13] Olli Luukkonen, StanislavI.Maslovski and Sergei A.Tretyakov, "A Stepwise Nicolson Ross Weir Based Material Parameter Extraction Method",*Antennas and Wireless Propagation Letters*, vol.10, 2011.

[14] Yuandan Dong and Tatsuo Itoh,"Metamaterial-Based Antennas",*Proceedings of the IEEE*,vol. 100, no.7, July 2012.

[15] Kaushal Gangwar1, Dr. Paras and Dr. R.P.S. Gangwar, "Metamaterials Characteristics, Process and Applications", *Advance in Electronic and Electric Engineering*,vol. 4, no.1, pp. 97-106, 2014.

[16] GyanPrakash, Sadhana Pal,"WiMax Technology and its Application", *International Journal of Engineering Research and Application*,vol.1,no.2,pp.327-336.