TABLE III

S.No	Dimensions of microstrip patch antenna		
	Parameter	***Symbol***	***Dimension(mm)***
1	Substrate width,	W	30
2	Substrate length,	L	35
3	Patch width,	Wp	15
4	Patch length,	Lp	14.5
5	Feedline width,	Wf	2.85
6	Feedline length,	Lf	13.5
7	Ground plane length,	Lg	12.5
8	Length	L1	12.5
9	Slot length	L4	9.5
10		L5	9.5
11		L6	0.25
12	Slot Width	W6	1.5
13		W7	0.25
14		W8	0.25

D. Microstrip patch Antenna for WIMAX and WLAN rejection

The antenna with partial ground plane is able to achieve wide frequency range from 3.3 GHz to 10.42 GHz. But from the simulation graph it is clear that the narrow frequency bands WIMAX and WLAN is not removed from the spectrum. The techniques to remove WIMAX and WLAN are already discussed above. In this antenna geometry both techniques are used together. The size of substrate and ground is same as above structure.

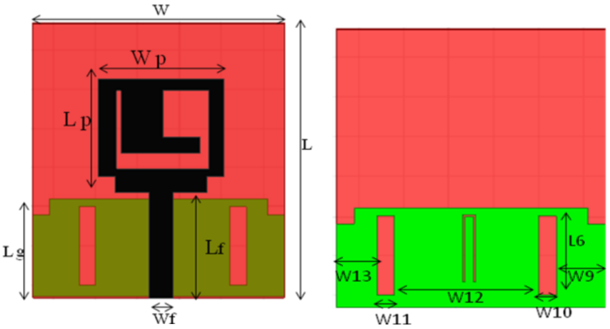


Figure 1.6. Proposed Microstrip patch antenna for WIMAX and WLAN rejection

There are some changes in the ground geometry. In the ground plane two rectangular slits is also removed to improve the directivity and bandwidth of antenna. The band main reason of altering the ground plane is to decrease the value of Q factor which increase the antenna bandwidth. The proposed antenna having a bandwidth 12.56GHz from 2.88GHz to 15.44GHz.The percentage bandwidth is 137% which more than the targeted bandwidth of dissertation. The Proposed antenna structure is given in the figure 1.7.

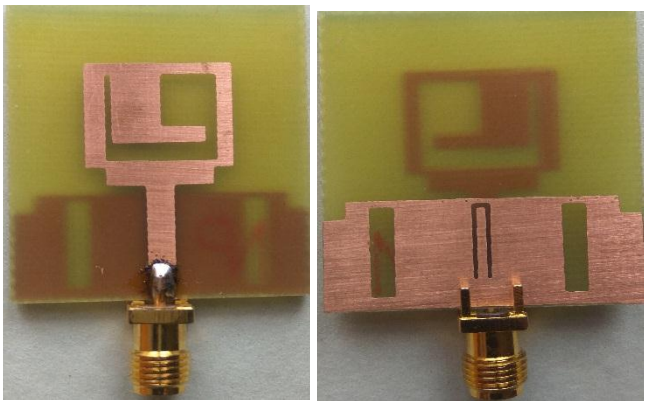


Figure 1.7. Fabricated Microstrip patch antenna for WIMAX and WLAN rejection

TABLE IV

S.No.	Dimensions of Proposed microstrip patch antenna		
	Parameter	***Symbol***	***Dimension(mm)***
1	Substrate width,	W	30
2	Substrate length,	L	35
3	Patch width,	Wp	15
4	Patch length,	Lp	14.5
5	Feedline width,	Wf	2.85
6	Feedline length,	Lf	13.5
7	Ground plane length,	Lg	12.5
8	Rectangular Slot length	L6	12.5
9	Width from corner	W9	5.5
10	Width of rectangular slots	W10,W11	2
11	Distance between rectangular slots	W12	16
12	Width from corner	W13	4.4

SIMULATION RESULTS

HFSS software used for simulation. HFSS is stands for high frequency structure simulator. It is electromagnetic (EM) field simulator for arbitrary three dimensional design modeling with high performance capability that takes lead among all well known Microsoft Windows graphical user interface. It employs the Finite Element Method (FEM), adaptive meshing, and impressive graphics to give us better performance and insight to our entire 3D EM problem Ansoft HFSS can be used to calculate parameters such as Return Loss, VSWR Parameters, Resonant Frequency, and Radiation Pattern.

The simulated and measured result of return loss and VSWR of optimized rectangular microstrip patch antenna is presented in Figure 1.8 (a) and 1.8(b) respectively. According to figure 1.8(a) the simulated antenna has broadband characteristic i.e. frequency band of 3.55 GHz – 11 GHz and bandwidth of 7.5 GHz at -10 dB level. The antenna has resonating frequencies at 4.84 GHz with S11 – 16.99dB and 10.06 GHz with S11 – 13.88dB and VSWR is obtained below 2. Figure 1.8. (b) shows the simulated VSWR of the microstrip patch antenna having partial ground plane as a function of frequency. VSWR of antenna in the entire bandwidth range from 3.55 GHz to 11GHz is well within desired 2:1 VSWR ratio.

The simulated and measured result of return loss and simulated result of VSWR of the microstrip patch antenna with L-stub is presented in Figure 1.10 (a) and 1.10 (b) respectively. From the Figure 1.10 (a), the proposed antenna has a bandwidth of 8.63 GHz ranging from 2.88 GHz – 15.2 GHz and WIMAX band is rejected in the range from 3.25 GHz – 3.83GHz.The percentage bandwidth of antenna is to 136%. The presence of L-stub caused a band notch in frequency range of 3.24 GHz to 3.87 GHz. VSWR graph of proposed antenna which is less than 2 for entire operating bandwidth except the range 3.24GHz - 3.87 GHz. The antenna has impedance matching at resonance frequencies 3.116 GHz with S11 -20.93 dB, 4.256 GHz with S11 -20.69dB and 7.905 GHz with S11 -33.68 dB using microstrip line feed.

The simulated and measured result of return loss and simulated result of VSWR of the microstrip patch antenna with U-slot is presented in Figure 1.12 (a) and 1.12 (b) respectively. From the Figure 1.12 (a), the proposed antenna has a bandwidth of 11.98 GHz ranging from 3.37 GHz – 15.35 GHz and WLAN band is rejected in the range from 5.1 GHz – 5.83GHz. The percentage bandwidth of antenna is to 127%. The presence of U- Slot caused a band notch in frequency range of 5.1 GHz to 5.83 GHz. VSWR graph of proposed antenna which is less than 2 for entire operating bandwidth except the range 5.1 GHz - 5.83 GHz. The antenna has impedance matching at resonance frequencies 4.08 GHz with S11 -34.99 dB and 8 GHz with S11 -31.27 dB using microstrip line feed.

The simulated result of return loss and VSWR of the microstrip patch antenna for WIMAX and WLAN rejection is presented in Figure 1.14 (a) and 1.14 (b) respectively. From the Figure 1.14 (a), the proposed antenna has a bandwidth of 12.56 GHz ranging from 2.88 GHz – 15.44 GHz. The percentage bandwidth of antenna is to 137%. From Figure 1.14(a) and 1.14(b) it is clear that for above geometry both WIMAX and WLAN rejected from the antenna spectrum. The antenna having a good impedance matching at frequencies 3.12GHz, 4.24GHz and 8.72 GHz with S11parmeter of -17.89dB, -32.39dB and -22.83dB. The radiation pattern or gain pattern is shown in Figure 1.16, 1.17and 1.17

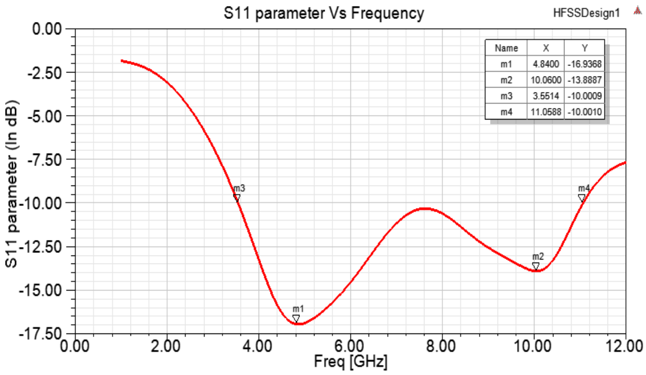


Figure 1.8. (a) S11 parameter variation w.r.t frequency for partial ground microstrip patch antenna

The bandwidth of the antenna can be said to be those range of frequencies over which the return loss is greater than - 10 dB (corresponds to a VSWR of 2). The bandwidth of the proposed patch antenna is 12.56 GHz. The maximum gain of 8.5dBi is at frequency 3.12GHz. This gain variation is at Phi = 0 deg and theta = 0 deg. The Value of Gain Varies from 9dBi to 11dBi in the frequency range 2.88GHz to 15.44GHz. The value of gain at 4.24GHz is 5.34dBi.

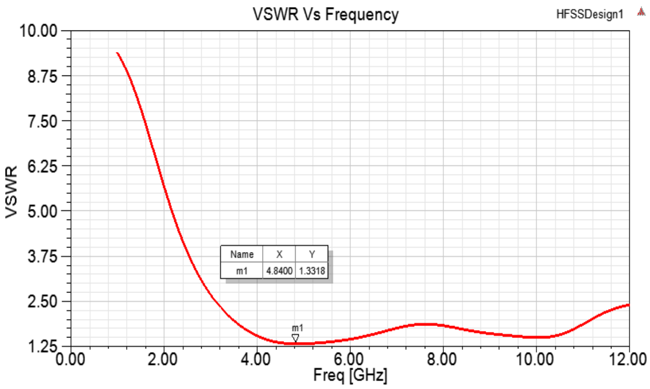
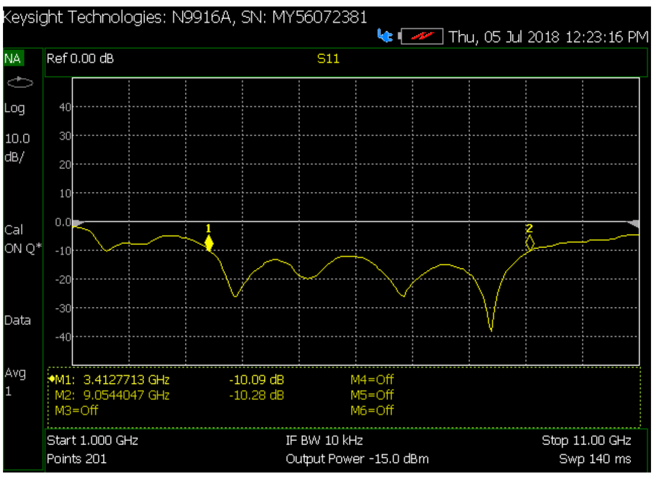
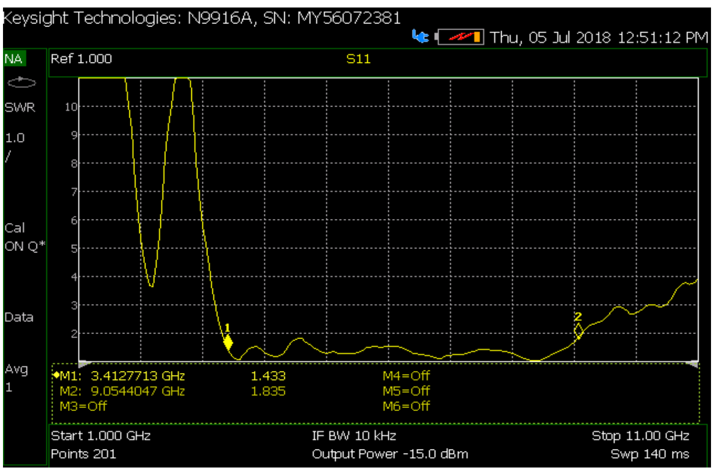


Figure 1.8. (b) VSWR variation w.r.t frequency for partial ground microstrip patch antenna





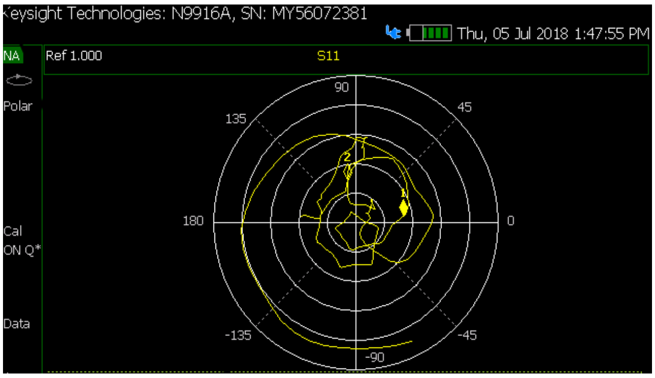


Figure 1.9. VNA Measured Result for partial ground structure

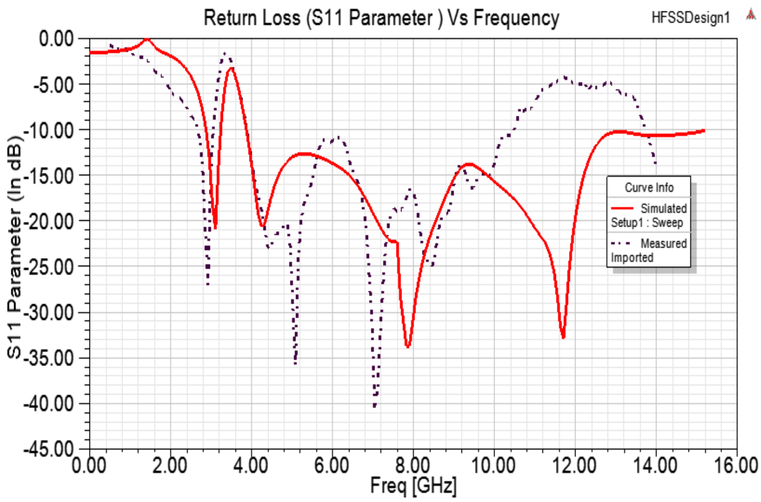


Figure 1.10. (a) S11 parameter variation w.r.t frequency with WIMAX rejection

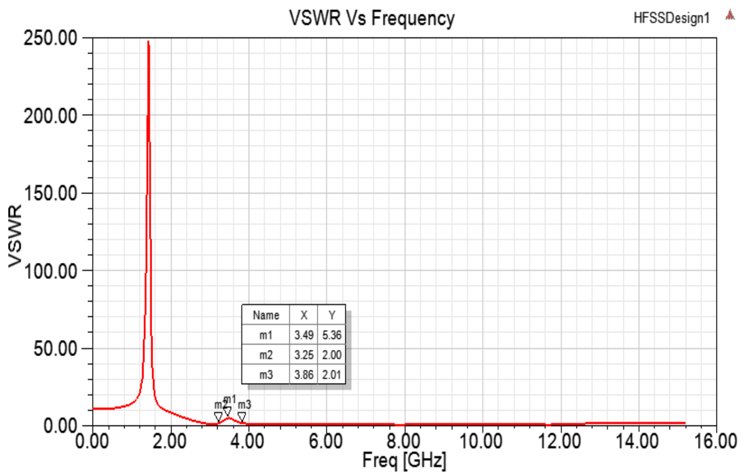


Figure 1.10. (b) VSWR variation w.r.t frequency with WIMAX rejection

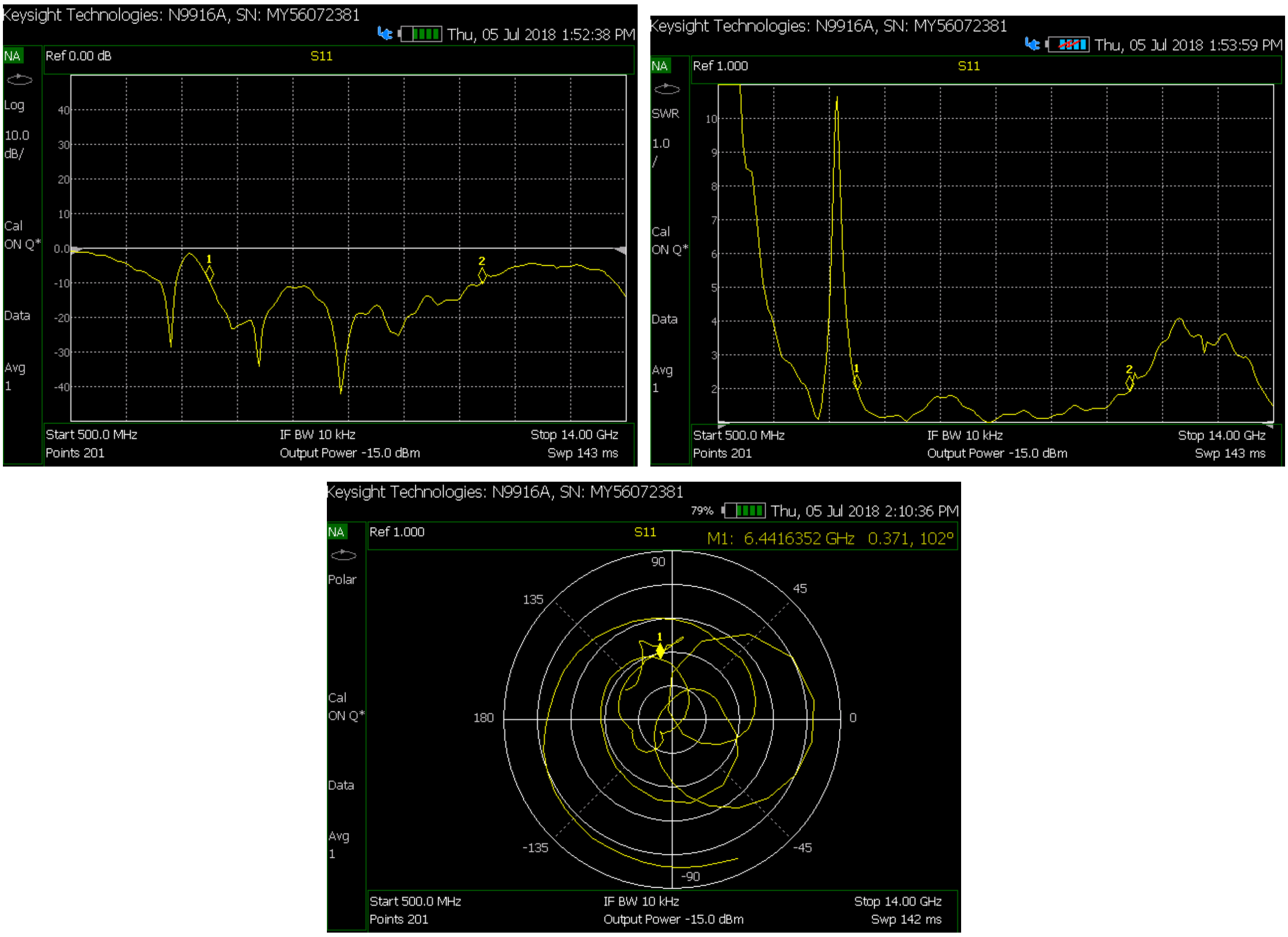


Figure 1.11. VNA Measured Result for WIMAX rejection MSA

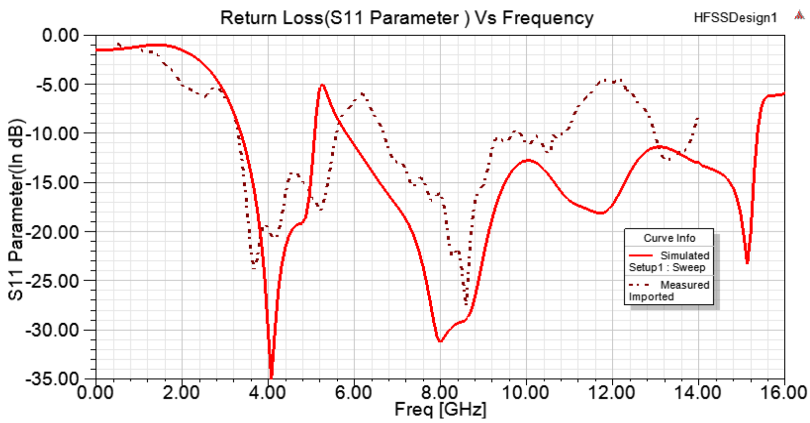


Figure 1.12. (a) S11 parameter variation w.r.t frequency with WLAN rejection

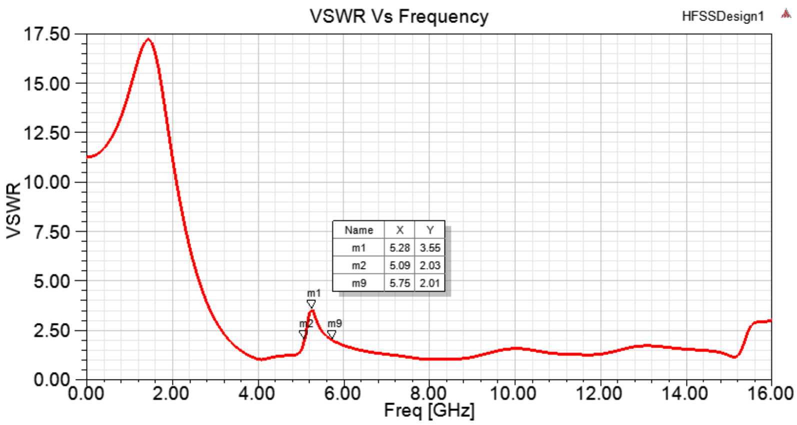


Figure 1.12. (b) VSWR variation w.r.t frequency with WLAN rejection

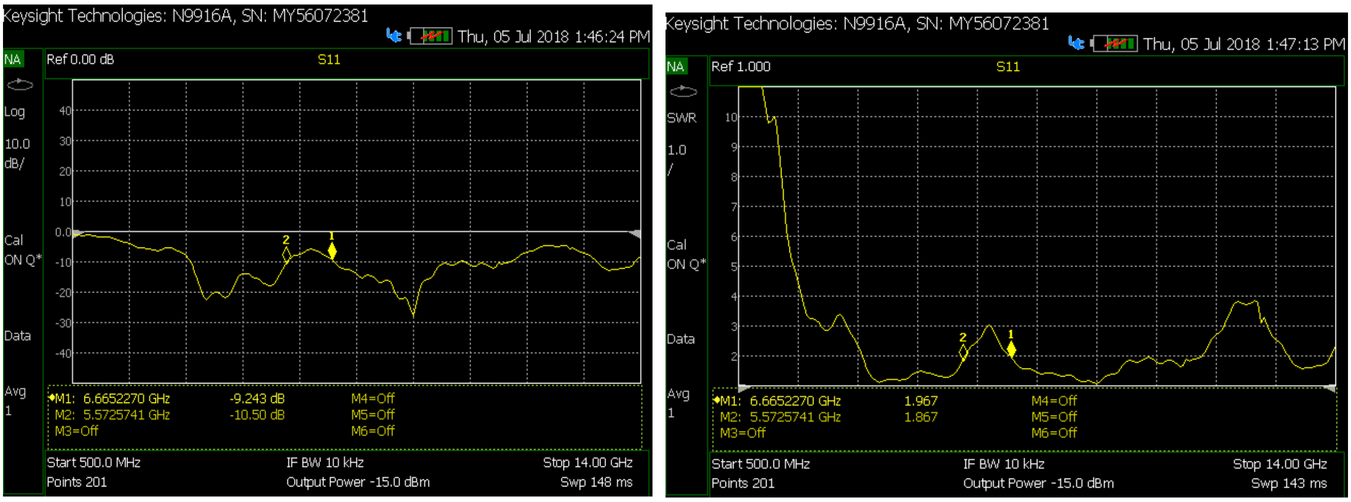


Figure 1.13. VNA Measured Result for WLAN rejection MSA

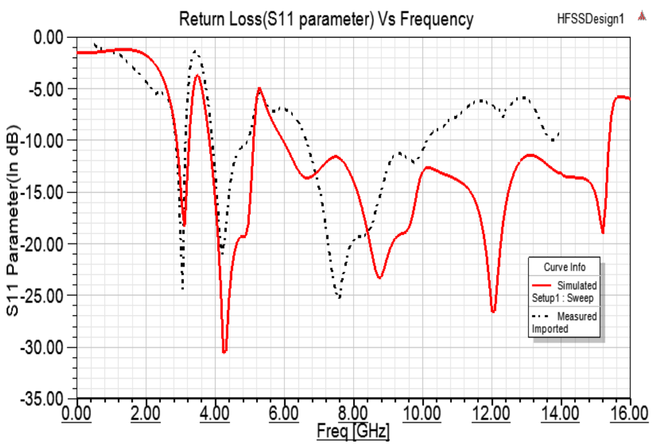


Figure 1.14. (a) S11 variation w.r.t frequency for Proposed antenna

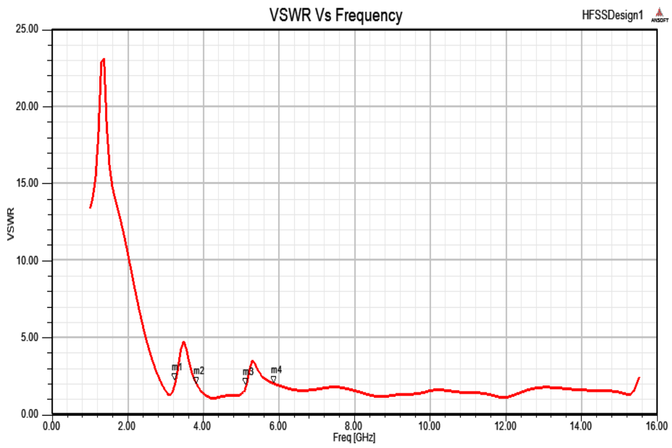


Figure 1.14. (b) VSWR w.r.t frequency for Proposed antenna

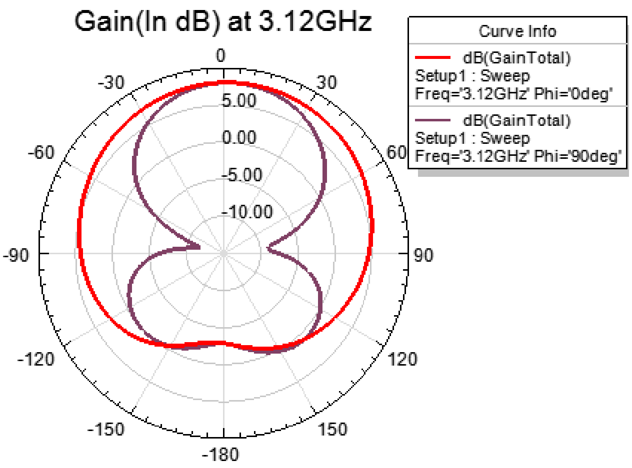


Figure 1.15. Radiation pattern at 3.12GHz for Proposed antenna

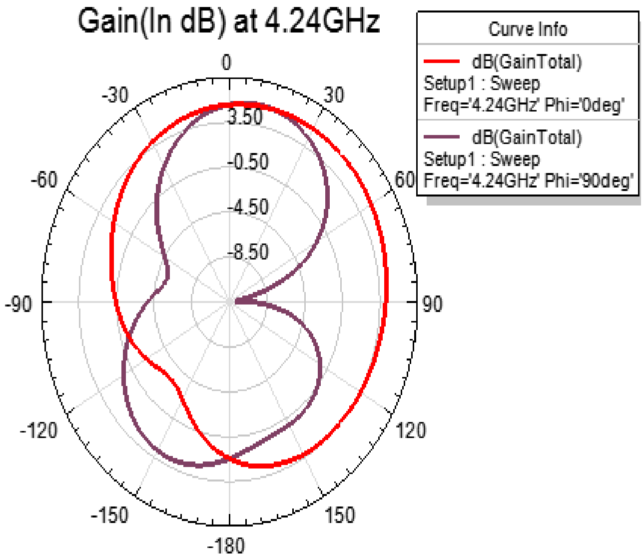


Figure 1.16. Radiation pattern at 4.24GHz for proposed antenna

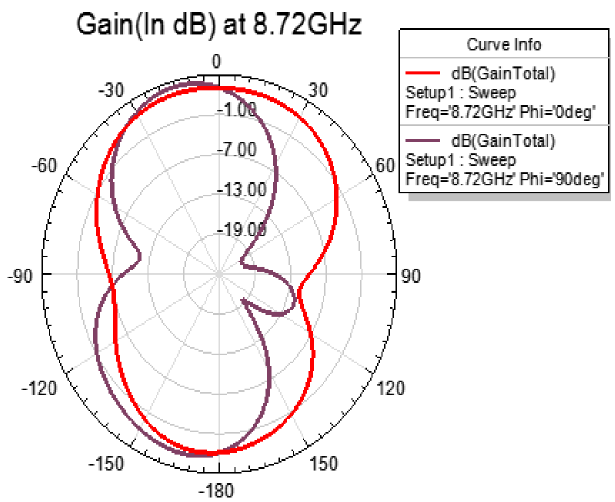


Figure 1.17. Radiation pattern at 8.72GHz for proposed antenna

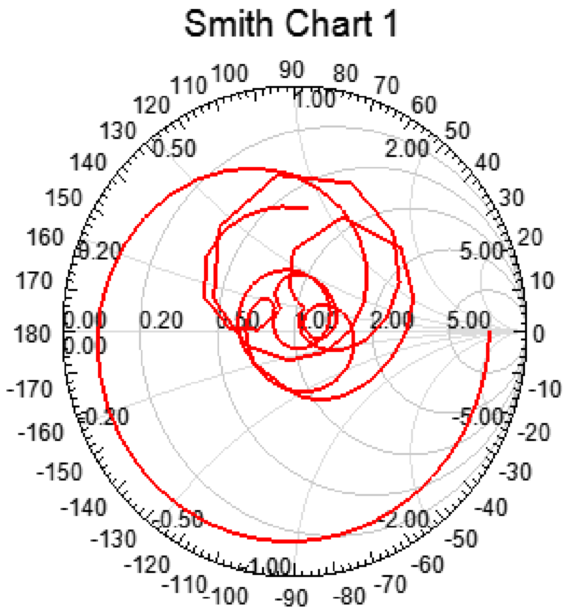


Figure 1.18. Smith Chart for proposed antenna

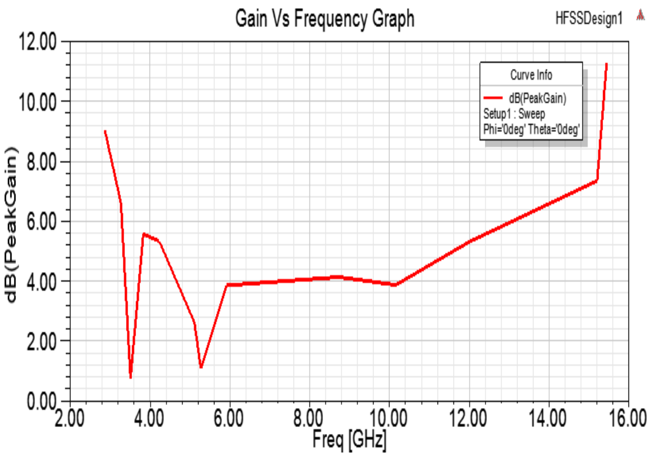


Figure 1.19. Gain Vs Frequency for proposed antenna

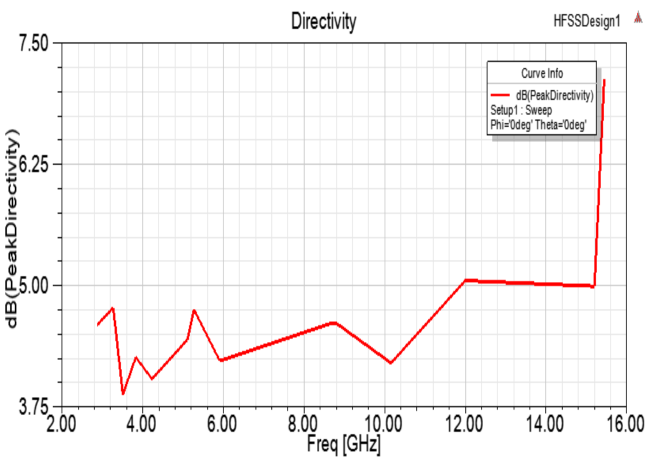


Figure 1.20. Directivity Vs Frequency for proposed antenna

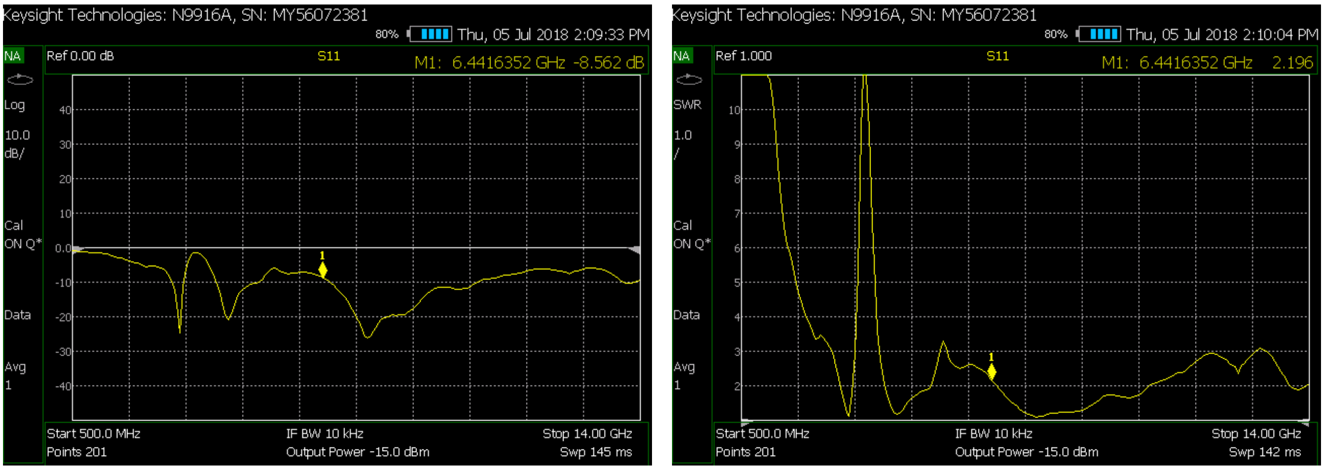


Figure 1.21. VNA Measured Result for Proposed MSA

CONCLUSION AND FUTURE SCOPE

The proposed antenna has a bandwidth of 12.56 GHz ranging from 2.88GHz – 15.44GHz .WIMAX frequency band is rejected in the range from 3.24GHz to 3.8GHz and WLAN band is rejected in the range from 5.1 GHz - 5.9 GHz. Percentage bandwidth of antenna is to 137 %. VSWR graph of proposed antenna which is less than 2 for entire operating bandwidth except the range 3.24GHz to 3.8GHz and 5.15 GHz - 5.83 GHz. Simulated results of proposed antenna such as Return Loss, VSWR, and Radiation pattern have satisfactory values within desired frequency band. For use of meta material and low dielectric constant material such as RT Duroid for more improvement in bandwidth.

REFERENCES

[1] Ketavath Kumar Naik, “Asymmetric CPW-fed SRR patch antenna for WLAN/WiMAX applications,” AEU - International Journal of Electronics and Communications, Vol.-93, pp. 103-108, September2018

[2] Constantine A.Balanis, “Antenna Theory, Analysis and Design”, 2nd ed., John Wiley and Sons, Inc., ISBN 0-471-59268-4, 1997.

[3] B. Karthik, S.P.Vijayaragavan and M.Sriram, “Microstrip Patch Antenna for Wireless LAN,” International Journal of Pure and Applied Mathematics, Vol. 118, No.-18, pp. 25-33, 2018.

[4] Purva R. Chopde and Mandar P. Joshi, “Design of Wideband Printed Rectangular Monopole Patch Antenna With Band Notch,” International Conference on Communication, Information & Computing Technology (ICCICT), Mumbai, India 2-3 Feb. 2018

[5] Tejbir Singh, Heena Choudhary, D.V. Avasthi and Vishant Gahlaut, “Design & parametric analysis of band reject ultra wideband (UWB) antenna using step impedance resonator,” Taylor & Francis, pp. 1-16 , 2017.

[6] Ying Suo, Wei Li,Hongyong Wang, “A Dual-Band Notched Ultra Wideband Microstrip

[7] Antenna, IEEE Trans.Antennas Propagation, pp. 1787-1788, 2017.

[8] Li Li, Xiaoliang Zhang, Xiaoli Yin, and Le Zhou, “A Compact Triple-Band Printed Monopole Antenna for WLAN/WiMAX Applications,” IEEE Antennas And Wireless Propagation Letters, vol. 15, pp. 1853-1855, 2016

[9] N. Ojaroudi and M. Ojaroudi, "Novel Design of Dual Band-Notched Monopole Antenna With Bandwidth Enhancement for UWB Applications," in IEEE Antennas and Wireless Propagation Letters,vol. 12, no. 12, pp. 698-701, 2013

[10] Hamidreza Dalili Oskouei and Alireza Mirtaheri, “A Monopole Super Wideband Microstrip Antenna with Band-notchRejection,” Progress In Electromagnetics Research Symposium — Fall (PIERS — FALL), Singapore, pp. 2019-2024, 19–22 November 2017

[11] Noor M. Awad and Mohamed K. Abdelazeez, “ Multislot microstrip antenna for ultra-wide band application,” Elsevier Journal of King Saud University – Engineering Sciences, pp. 1-8, December 2015.

[12] Sarkare, D., K. V. Srivastava, and K. Saurav, “A compact microstrip-fed triple band-notched,” IEEE Antennas and Wireless Propagation Letters, Vol. 13, 396–399, Feb. 2014, doi:10.1109/LAWP.2014.2306812.

[13] M., Zhang, F.-S. Zhang, W.-Z. Li, T. Quan, and H.-Y. Wu, “a compact UWB monopole antenna with WIMAX and WLAN band rejections,” Progress In Electromagnetics Research Letters, vol. 31, pp. 159–168, 2012.