Tri-Band Microstrip Antenna with S shaped Modified Resonating Structures for 3G/4G and IEEE 802.11ac with Ground Slots

Mritunjay Dwivedi[1] , Rachit Gaikwad[1] , Gaurav Morghare[2] , Mohd. Ahmed[3]
[1]M-Tech Research Scholar, [2]Research Guide, [3]HOD
[123]Department of Electronics & Communication, Oriental Institute of Science and Technology, Bhopal

Abstract - In this paper, a triple band linearly-polarized microstrip patch antenna is designed and simulated with Modified Resonating Structure using HFSS simulation software. Antenna parameters are examined in this which includes resonating frequency, impedances, VSWR and bandwidth of the designed and proposed resonating structure with probe feed. The antenna is proposed for wireless communication applications .This paper focuses on the designing of microstrip antenna with slot introduction on a ground plane to improve results as compared to conventional ground plane antenna and analysing the results like return loss S_{11}, VSWR, bandwidth, impedance and radiation pattern (including 2D pattern) E- field at 1.35 GHz, 3.31 GHz and 5.02 GHz.

Keywords: Resonating Structure, Tri band, Microstrip Antenna, MSR, Modified Structure Resonator, 3G/4G Microstrip antenna.

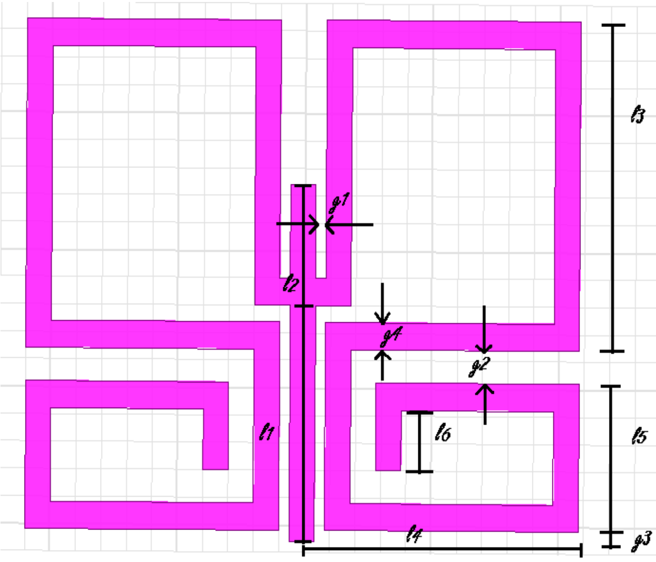
I. INTRODUCTION

In the last years, the development of W-CDMA, Wi-Max and Wi-Fi/WLAN represented one of the principal techniques in the information technology and communication field. As per the present trends in communication systems has been to develop minimum in cost, profile, weight commonly used dielectric material of FR4_EPOXY (εr=4.4) that are capable of providing high performance over a wide range of frequencies [1]. With a simple and easy geometry, microstrip patch antennas provide many advantages not generally exhibited in other antenna designs. Advantages of these microstrip resonating structures are low profile, less expensive, lightweight and simple to fabricate using modern day technology of printed circuit board, compatible with microwave circuits and millimetre-wave integrated circuits, and have the ability to match to resonating structures [1]. In addition, once the shape, design and operating mode of the patch are selected, prototype become very specific in terms of resonating frequency, return loss, polarization, radiation pattern, gain, VSWR and impedance [2]. Using the multi band microstrip patch antenna concept, in this paper a tri-band modified resonating structure microstrip antenna is designed and simulated for analysis. There are few antenna simulation software available which allow the optimization of the antenna. HFSS is one of the most imperious electromagnetic software which allows designing and solving for radio signal and microwave application. The HFSS simulator tool computes most of the useful parameters of interest such as radiation pattern, gain, input impedance, return loss, VSWR, etc.

II. ANTENNA DESIGN

In particular, the microstrip antenna structure using a tri-band resonator rather than a regular one have become better due to miniaturization and good performance. However, the design methods of this antenna using the tri-mode resonating structures are not common [3]. The design of the proposed antenna is shown in Figure 2.1, which is designed on a FR4_EPOXY (ε_r = 4.4, tan loss=0.001) substrate with a height of 1.5 mm. The antenna is comprised of a probe feed and a symmetrical resonating structure. The antenna consist the repeated curl shaped structure metal line and slotted ground plane, to construct the simple unit cell [4] as shown in Figure 2.1. Four identical MSR (microstrip resonators) are placed at every 90° of the center at a distance of 5.8mm to have a unique MSR. Dimension of substrate and model is 30mm×30mm×1.5mm and so is for the ground plane. Ground plane has two rectangular slot cuts of 1mm×10mm placed 2mm and another of 1mm×14mm placed 4mm distance from the centre of feed point of radius 1.3mm .Distance between the two rectangular slots in ground is 1mm.

The magnitude of the return loss parameter S_{11} for the antenna is calculated by the commonly used electromagnetic simulation software HFSS. For example, the detailed dimensions of the antenna are listed in Table 3.1. The thickness of all the lines is chosen to 0.375 mm.



l1=3.225	l2=1.65	l3=4.5	l4=4	l5=2.025
l6=0.825	g1=0.15	g2=0.45	g3=0.153	g4=0.375

Table 2.1 Dimensions of the MSR (units: mm)

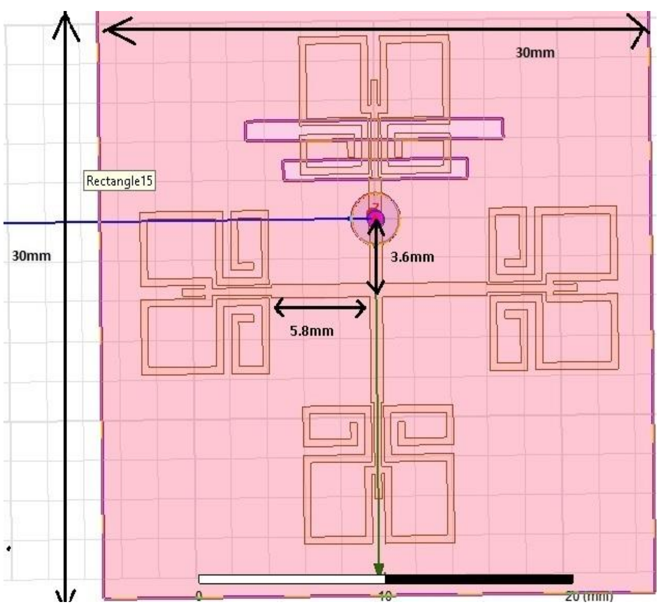


Figure 2.1: The configuration of patch of the proposed tri-band resonating structure microstrip antenna

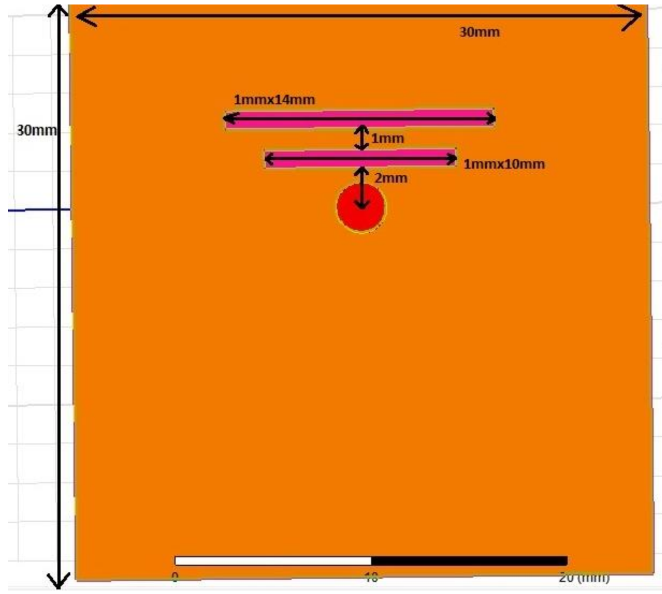


Figure 2.2: The configurationof ground of the proposed tri-band resonating structure microstrip antenna

III. PROPOSED METHODOLOGY

Patch consisted of 4 MSR at every 90°, 5.8mm away from centre(reference point) of all MSR slot as in Figure 2.1. No ground slot was introduced at first which resulted in the following characteristics of S_{11} (reflection coefficient or return loss in dBs) vs. frequency in Gigahertz yielding 2 resonating bands at 1.34 GHz and 3.33 GHz.

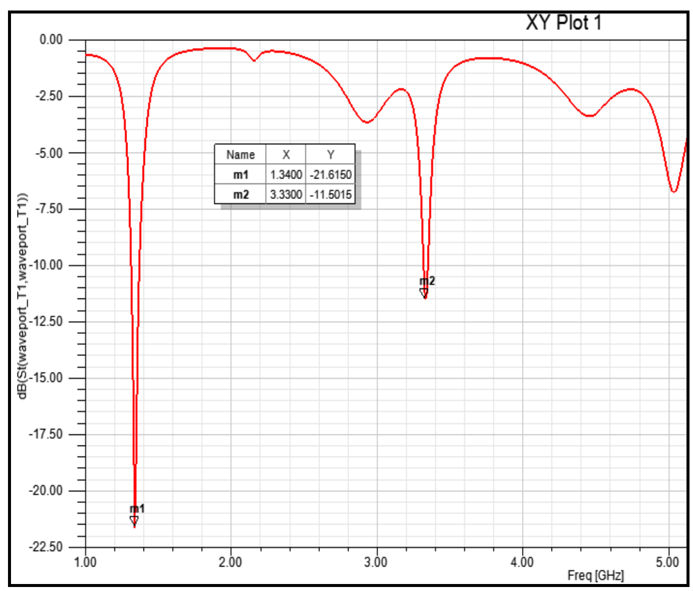


Figure 3.1 Return loss S_{11} vs. frequency plot of 4 MSR patch with no ground slot

Then ground slot of 1mmx10mm was introduced at a distance of 2mm from centre of the feed. Ground Plane area is generally taken twice the patch area to realize the effect of infinite ground which otherwise is practically impossible to implement considering compactness [6] .Ground plane acts as a signal return path and hence a ground slot, as discontinuity in return path, produces wave effect introducing slot impedance which shifts the resonant frequency lower and this shift is proportional to length of the slot [6].

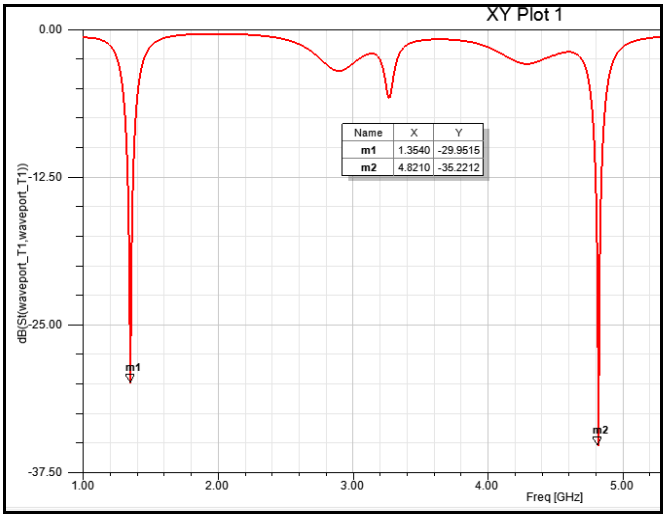


Figure 3.2: Return loss S_{11} vs. frequency plot of 4 MSR patch with one ground slot at 2mm from centre of feed

Then the existing ground slot on above design was replaced by another slot placed at 4mm from the center of feed point having dimension 1mm×14mm which resulted in following S_{11} vs. frequency characteristics.

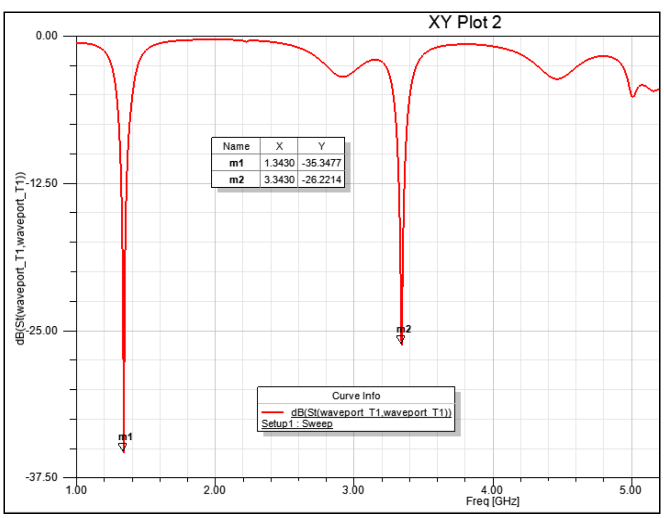


Figure 3.3: Return loss S_{11} vs. frequency plot of 4 MSR Patch with one ground slot at 4mm from centre of feed

IV. SIMULATION/EXPERIMENTAL RESULTS

The antenna simulation software HFSS, simulated and measured results of S_{11} are shown in Figure 4.1 with respect to frequency in Gigahertz for the range 1GHz to 7GHz, where three frequency bands are obtained for the designed antenna which is produced by adding the 2 slots in ground plane. The antenna exhibits the characteristics of the tri-band operation, i.e., a measured -44.9 dB S_{11} and bandwidth of 57.8 MHz for the first resonating frequency at 1.35 GHz,-23.62 dB S_{11} and a bandwidth of 54.5 MHz for the second resonating frequency at 3.31 GHz and -27.65 dB S_{11} bandwidth of 73 MHz for the third resonating frequency at 5.024 GHz covering the W-CDMA, Wi-Max and Wi-Fi/WLAN, characteristics of VSWR is shown in Figure 4.2. The results of return loss, VSWR and impedance are given in Table 4.1.

TABLE 4.1 RESULTS OF SIMULATED ANTENNA

S. No.	Antenna parameters	Simulation		
		f_1	f_2	f3
1.	Resonant frequency(GHz)	1.35	3.3175	5.024
2.	Return loss S_{11}(dB)	-44.9	-23.62	-27.65
3.	VSWR	1.0114	1.1543	1.0899
4.	Impedance (Ω)	50	50	50
5.	Bandwidth(MHz)	57.8	54.5	73

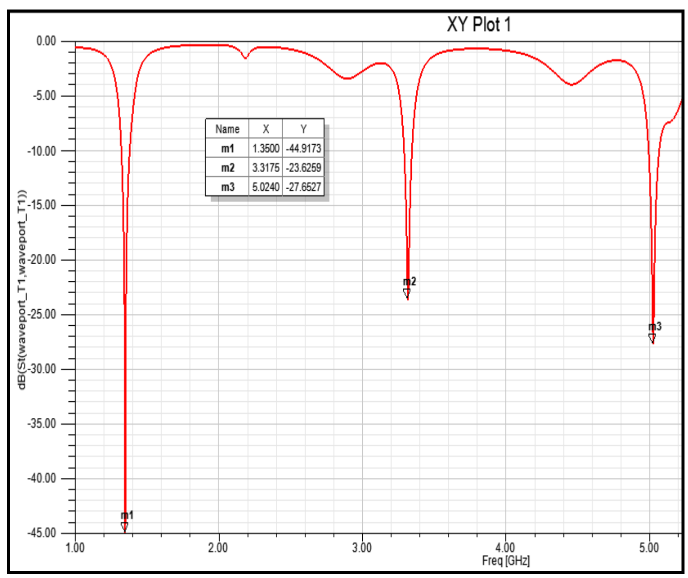


Figure 4.1: Return loss S_{11} vs. frequency plot of 4 MSR Patch with 2 ground slot at 2mm and 4mm from centre of feed

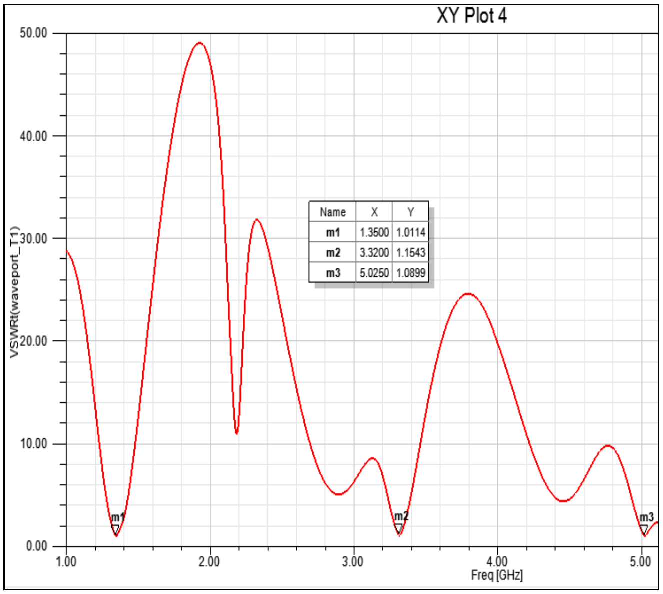


Figure 4.2: VSWR vs. frequency plot of 4 MSR Patch with 2 ground slot at 2mm and 4mm from centre of feed

It could be easily observed that the VSWR values at the resonating frequencies are lowest. The simulated radiation pattern of all the resonating frequencies for the proposed tri-band modified structure resonator microstrip antenna are plotted in Figures 4.3.

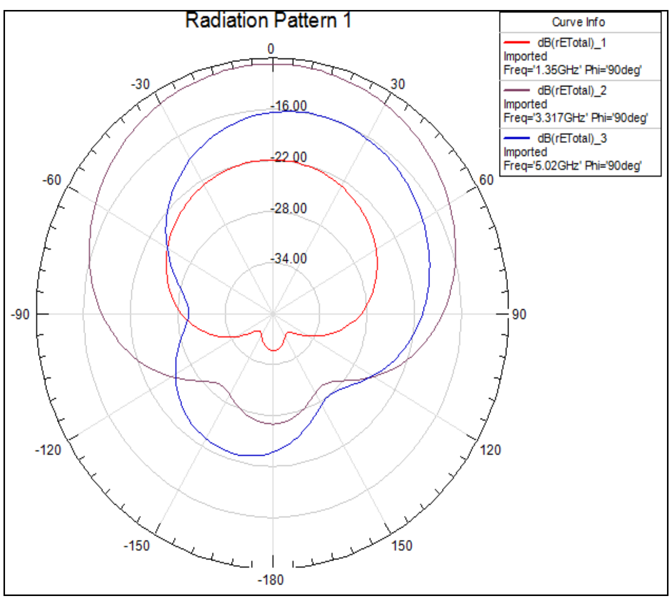


Figure 4.3: Radiation Pattern (E field strength) vs. frequency plot of 4 MSR Patch with 2 ground slot at 2mm and 4mm from centre of feed

V. CONCLUSION

We have designed and simulated tri-band microstrip antenna with modified resonating structure which has a resonating frequency of 1.35 GHz, 3.31 GHz and 5.02 GHz with return loss of -44.95 dB, -23.62 dB and -27.65 dB respectively. This tri-band antenna has wide application in W-CDMA, Wi-Max, Wi-Fi/WLAN of wireless communication. Further optimizations are also possible to achieve required operating frequencies. The unique feature of this microstrip resonating structure antenna is its compact and small size to get better performance. This paper presents a geometric configuration of the Microstrip patch antenna for various wireless applications, which provides a means to gain multiple bands by having slots on ground plane without using special techniques [7].

REFERENCES

[1] C.A. Balanis, Antenna Theory, 2nd Ed., John Wiley & sons, inc., New York.1982.

[2] G. Du, X. Tang, and F. Xiao, “Tri-Band Metamaterial – Inspired Monopole Antenna with modified S-Shaped Resonator”, Progress In Electromagnetics Research Letters, Vol. 23, pp39-48, 2011

[3] Jaemin An, Yuseon Kim, Hyunseong Pyo, Hyesun Lee, Yeongseog Lim, “ Determining Resonant Frequencies of Single Dual-Mode Resonator and its Application”, Proc. IEEE Antennas and Propagation , 2010

[4] Bin Yang, Yong-Chang Jiao, Wei Zhang, Huan-Huan Xie, Fu-Shun Zhang, “Dual-band ring-shaped antenna for WiMAX/WLAN applications”, IEEE trans . 2011

[5] Wen-Chung Liu, Chao-Ming Wu, and Yang Dai, “ Design of Tri-Frequency Microstrip-Fed Monopole Antenna Using Defected Ground Structure”, vol.59 ,no.7, July 2011.

[6] U. Chakraborty, Member, IEEE, A. Kundu, S. K. Chowdhury, and A. K. Bhattacharjee “Compact Dual-Band Microstrip Antenna for IEEE 802.11a WLAN Application”, IEEE Antennas And Wireless Propagation Letters, Vol. 13, 2014.

[7] Aiza Mahyuni Mozi, Dayang Suhaida, Awang Damit and Zafirah Faiza, “Rectangular Spiral Microstrip Antenna for WLAN Application”, IEEE Control and System Graduate Research Colloquium (ICSGRC 2012), 2012.

[8] Gaurav Morghare and Poonam Sinha, “Dual band optimized microstrip antenna with modified resonating structure using CADFEKO”, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 2, Issue 10, October 2013

[9] Gaurav Morghare and Poonam Sinha, “Design of Triband Miniature Microstrip Antenna with Modified Resonating Structure using CADFEKO”, International Journal of Scientific and Research Publications, Volume 4, Issue 1, January 2014.

[10] G. Jegan, A.Vimala Juliet, G. Ashok Kumar, “Multi B and Microstrip Patch Antenna for Satellite Communication”, IEEE tans. 2011

[11] Ansoft HFSS 13.0 Manual.