Indian Journal of Science and Technology, *Vol 9(37), DOI: 10.17485/ijst/2016/v9i37/93378, October 2016*

ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

A Novel Compact CPW- Fed Polarization Diversity Dual Band Antenna using H-Shaped Slots

Asa Jyothi[*], B. T. P. Madhav, M. Deepthi, C. Sindhoora and V. Jayanth

Department of ECE, K L University, Guntur - 522502, Andhra Pradesh, India

Abstract

Objective: Design with analysis of a new low profile co-planar waveguide fed antenna generally suitable to reduce polarization diversity problems in dual band applications is addressed in this work. **Methods/Analysis:** The designed antenna consisting of two similar monopoles that are been printed on a low loss substrate material with 3mm spacing and placed perpendicular to one another. H-shaped slots are placed on the ground plane as defected ground structure. Multiple input multiple output technology is incorporated to reduce the polarization diversity in the current structure. HFSS tool is used to model and simulate the proposed antenna model. **Findings:** In this paper, four models have been proposed and their S-parameters have been compared along with their gain. To enhance the gain characteristics of the proposed models, H-Shaped slots have been incorporated. The experimental result of the proposed Ultra wideband antenna of Model 4 is in good correlation with the simulated results from HFSS. **Novelty/Improvement:** Coplanar wave guide fed MIMO antenna is designed in this work. U-shaped radiating elements are used in the design with proper impedance matching of fifty ohms at the feed point. An H-Shaped slot placed on the ground plane will improve the proper impedance matching characteristics and radiation characteristics of the antenna.

Keywords: Coplanar Waveguide feeding (CPW), Dual Wideband, Gain, Multiple Input Multiple Output (MIMO), Polarization Diversity

1. Introduction

There is always demand for the high gain antennas with desired bandwidth for ultra wide band communication. The federal communication commission (FCC) proposed 3.1-10.6 GHz as ultra wide band range for communication operations[1,2]. So, number of researchers proposed different novel designs of micro strip antennas which can work in the desired band of operation. The main drawback in the design of wide band antennas for UWB communication applications lies in the gain characteristics of the antenna[3-5]. Generally for any antenna, if bandwidth is more, then obviously gain will be decreased. By keeping this point in the designer mind we proposed four novel structures of micro strip antenna designs which can work in the wide band region with considerable gain[6,7].

Antenna diversity generally is an effective way of solution to mitigate multipath fading signals and to enhance the overall system capacity. Various diversities such as space/spatial, pattern, and polarization diversity has been proposed and implemented to simultaneously will receive multiple types of transmissions. A proper UWB-WBAN diversity antenna generally should have minimal mutual coupling, that means high isolation between their branches and if there is higher the isolation, the better the diversity related performance and the generally higher the efficiency of the each branch[8,9].

2. Materials and Methods

Figure 1 gives the physical geometry of the designed antennas. It is the combination of two similar monopoles that are perpendicular to one other and printed on a lowloss RT/duroid 5870 substrate with minimum spacing of 3 mm. Each patch element comprises a semi-circle with rectangular shaped section on the top side. The two sides are fed through 50 ohms- coplanar waveguide lines. The bottom side of the substrate material is coated of

---

[*] Author for correspondence

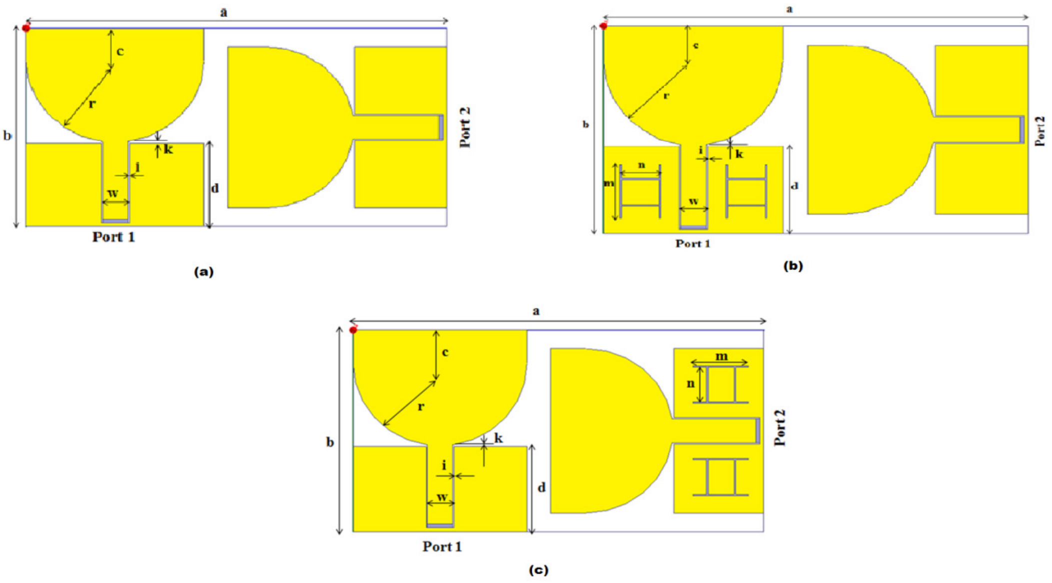


Figure 1. Block diagram of the proposed algorithm.

metallization. The overall area of the antenna structure is 27X52 mm^2. For Model 1 there is no H-slot. For Models 2, 3 and 4 H-shaped slots are created on the both sides of the rectangular section. The overall dimensions of four models are presented in Table 1. The H-shaped slots are with dimensions of 7*5 mm^2.

The final model of the proposed antenna shown in Figure 2 comprises of Symmetrical H-shaped slots on the ground plane of the MIMO antenna. The antennas possess a size of about 27*52 mm^2. The various characteristics of the antennas are further investigated. The physical dimensions of all the proposed models are shown in Table 1.

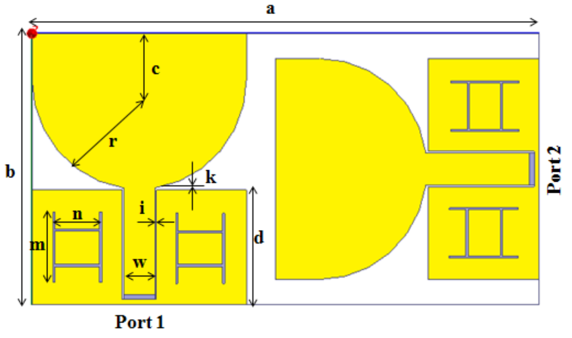


Figure 2. Final Model of the Proposed Antenna.

Table 1. Dimensions of the Proposed Antennas

Paramcter	a	b	c	d	r	w	i	k	m	n
Value-mm	52	27	4.5	11.4	11	3.2	0.15	0.1	0.7	0.5

3. Results and Analysis

The antennas are fabricated on Rogers RT duroid 5870 substrate with a compact size of about 27*52 mm^2. The various parameters of the antennas are simulated and the results are displayed below. The return losses of the antenna models are shown in Figure 3. The final proposed model antenna exhibits $S_{11} < -10$ dB in the frequency ranging from 3.1-12.28 GHz covering the Ultra-Wideband of operation with a notch in the 4.14-6.6 GHz eliminating interference from the WLAN band. The simulated results of the return loss indicated that the final antenna model covers the entire UWB with a notch in the WLAN band (5.15-5.85 GHz) compared to the other models.

The coupling coefficient is an important parameter of a MIMO antenna. For desired performance the coefficient of coupling indicated by $S_{21} < -15$ dB. From the Figure 4 we observed that the coupling coefficient is less than -15 dB for all the models of the proposed antenna, thereby satisfying the required MIMO performance.

Figure 5 illustrates the VSWR of all the models. We observed that the VSWR lies in the range of 1<VSWR<2 in the required band of operation satisfying the UWB requirement. The requirement is not satisfied in the notch band to eliminate interference from the WLAN band.

The 2-Dimensional radiation characteristics of the antennas are presented below. Figure 6 indicates the radiation patterns of the basic antenna at 3.2 GHz, 6.5

GHz and 9 GHz respectively. At the initial frequency of 3.2 GHz we observe Omni directional radiation characteristics in the azimuth plane and directional pattern in the elevation plane. The antenna exhibits a less omni-directional pattern as the frequency increases. The radiation pattern at 9 GHz is due to the presence of surface currents which came into existence.

Similarly the radiation patterns of the two models are displayed in Figure 7 and Figure 8 respectively. We observe a similar kind of radiation pattern for the two models when compared to the basic model. The presence of surface currents is the result of distorted radiation pattern at higher operating frequencies.

The optimized model radiation pattern is shown in Figure 9. We observe Omni directional radiation characteristics in the azimuth plane at initial frequency of 3.2 GHz and a twisted dumbbell shaped radiation pattern in the E-Plane. The presence of surface currents originating in the patch is responsible for distorted radiation pattern at 9 GHz.

Figure 10 shows the 3-D polar plots of the final proposed antenna at the three respective frequencies of 3.2 GHz, 6.5 GHz and 9 GHz. The gain from the observed 3-D polar plots attains a positive gain at higher frequencies i.e. as the frequency increases. The surface current distributions of the antenna models are simulated as shown in Figure.11, Figure 12 and Figure 13. The antenna which is the final proposed model exhibits a decent amount of interference between the two ports of a MIMO antenna system when compared with the other models. The amount of coupling from port-1 to port-2 is eliminated when the final proposed model is taken into consideration.

From the figure we observe that when one port is excited, the surface current distribution is concentrated along the patch element and along the edge of the feed lines. The surface current distribution is observed on the other ports when one port of a MIMO antenna is excited. But for the final proposed model we do not observe higher order surface currents on the other port element thereby eliminating coupling between the two ports.

The gain vs. frequency plot of the proposed antenna models is as shown in Figure 14. The basic antenna model attains a peak gain after the initial frequencies and maintains a constant gain of about 4 dBi. The final proposed antenna model with H-Shaped slots embedded in the ground plane exhibits a peak gain of about 9.5 dBi in the ultra-wideband of operation. The proposed final model is thus a suitable model for ultra-wideband applications. In addition, the frequencies vs. directivity of all the proposed antenna models are simulated as shown in Figure 15. The prototyped antenna model on PCB substrate is shown in Figure 16. The measured results of reflection coefficient and VSWR are taken from ZNB 20 vector network analyzer and presented in Figure 17 and Figure 18. Measured results are matching with the simulated results of the HFSS tool.

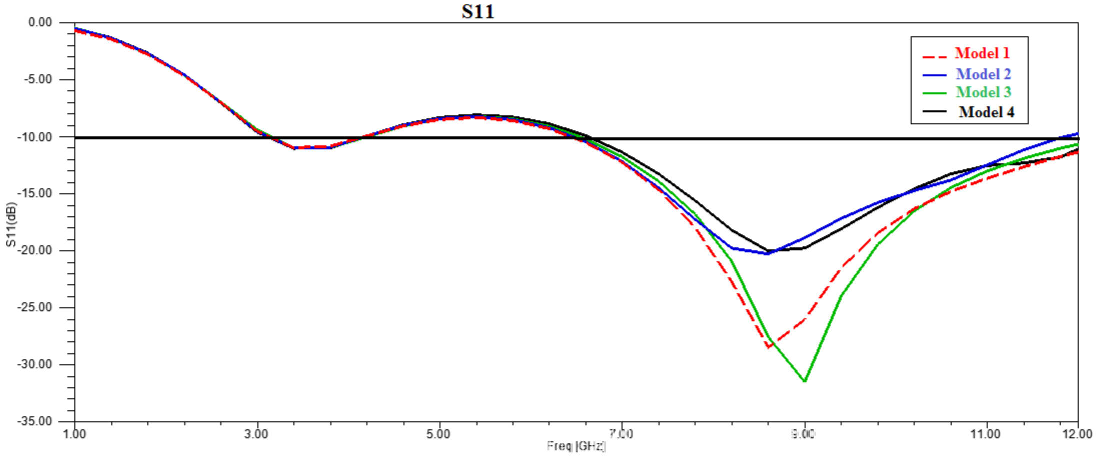


Figure 3. Simulated S-Parameters of the Proposed Antennas.

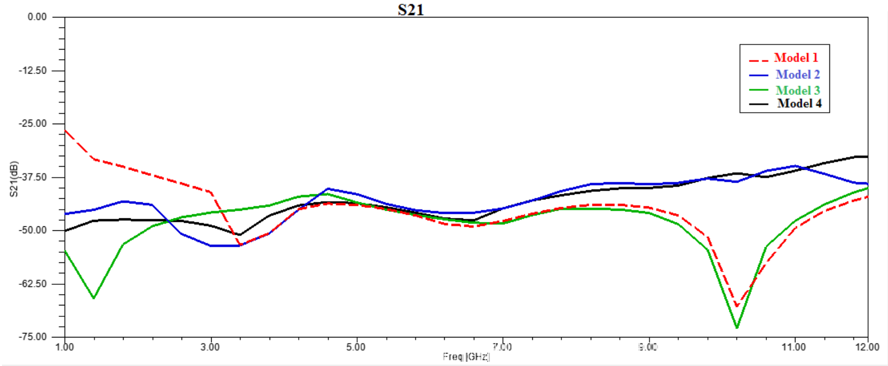


Figure 4. Simulated Coupling Coefficient of the Proposed Antennas.

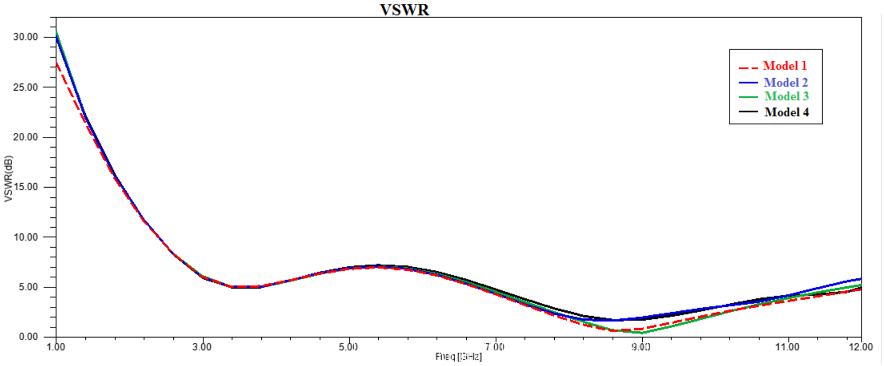
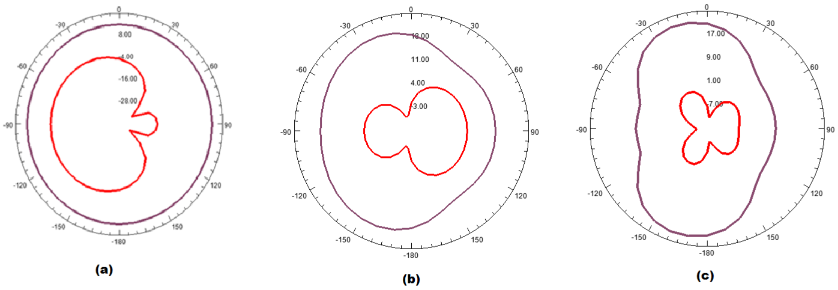


Figure 5. Simulated VSWR of the Proposed Antennas.

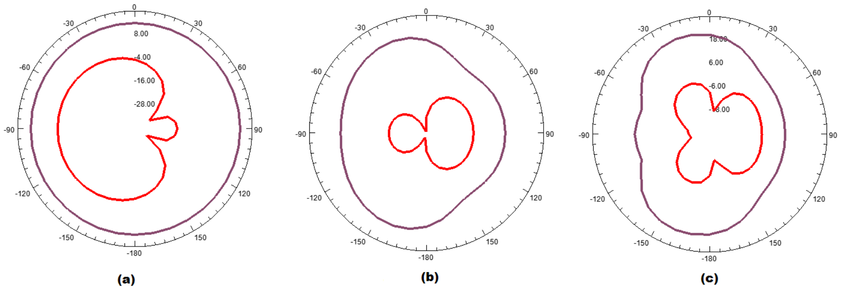


(a)

(b)

(c)

Figure 6. 2-D Radiation Patterns of the basic antenna at (a) 3.2 GHz (b) 6.5 GHz and (c) 9 GHz.



(a)

(b)

(c)

Figure 7. 2-D Radiation Patterns of the Model 1 antenna at (a) 3.2 GHz (b) 6.5 GHz and (c) 9 GHz.

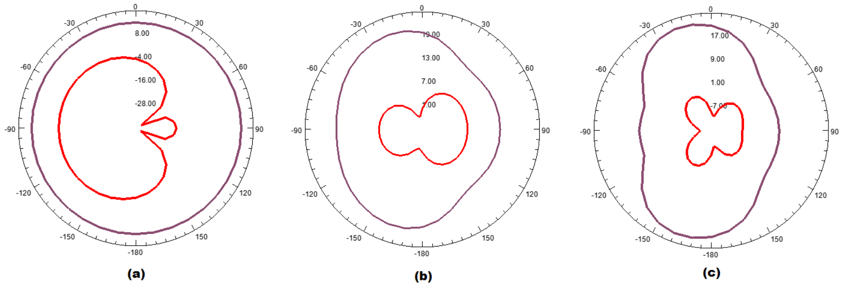


Figure 8. 2-D Radiation Patterns of the Model 2 antenna at (a) 3.2 GHz (b) 6.5 GHz and (c) 9 GHz.

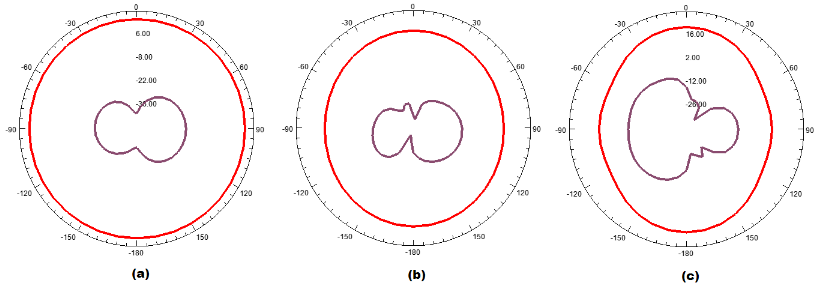


Figure 9. 2-D Radiation Patterns of the Final Proposed antenna at (a) 3.2 GHz (b) 6.5 GHz and (c) 9 GHz.

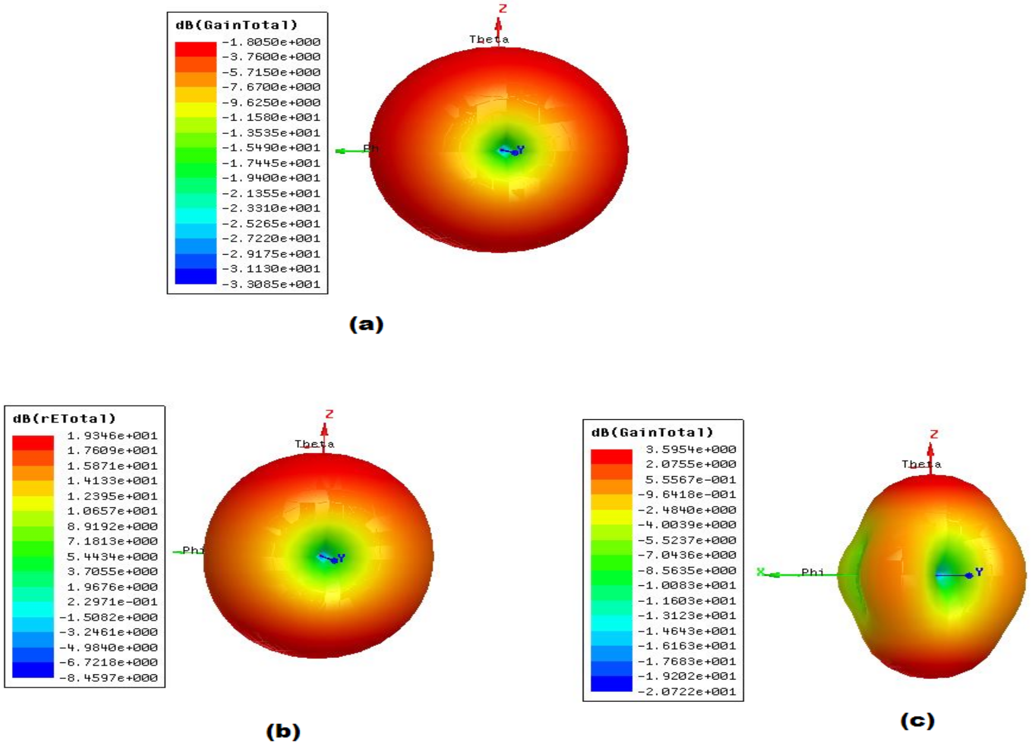


Figure 10. 3-D Polar Plot of the Final Proposed Antenna at (a) 3.2 GHz (b) 6.5 GHz and (c) 9 GHz.

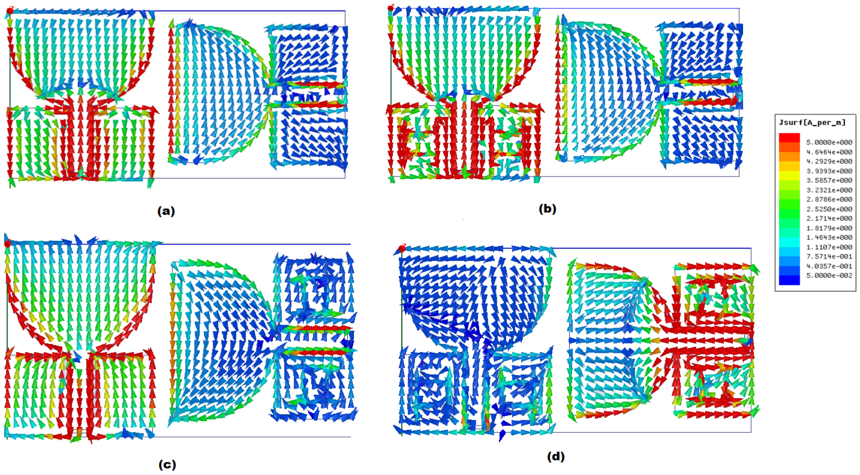


Figure 11. Surface current Distribution of the antenna models at 3.2 GHz (a) Basic Model (b) Model 1 (c) Model 2 (d) Final Proposed Model.

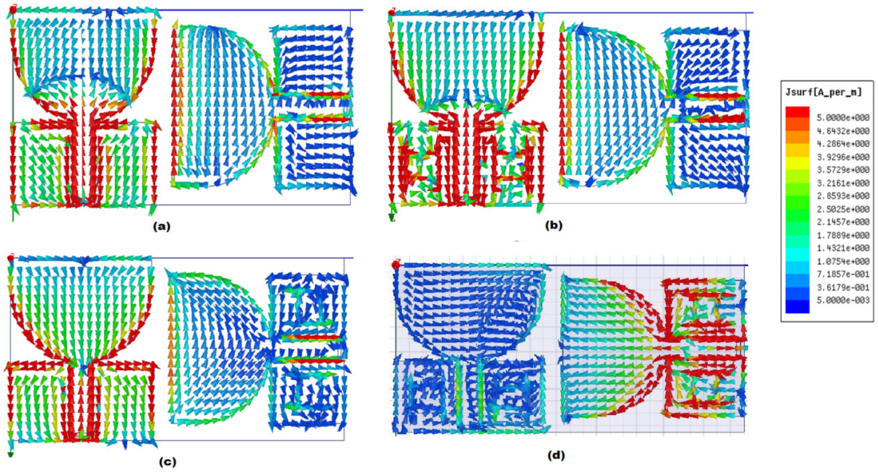


Figure 12. Surface current Distribution of the antenna models at 6.5 GHz (a) Basic Model (b) Model 1 (c) Model 2 (d) Final Proposed Model.

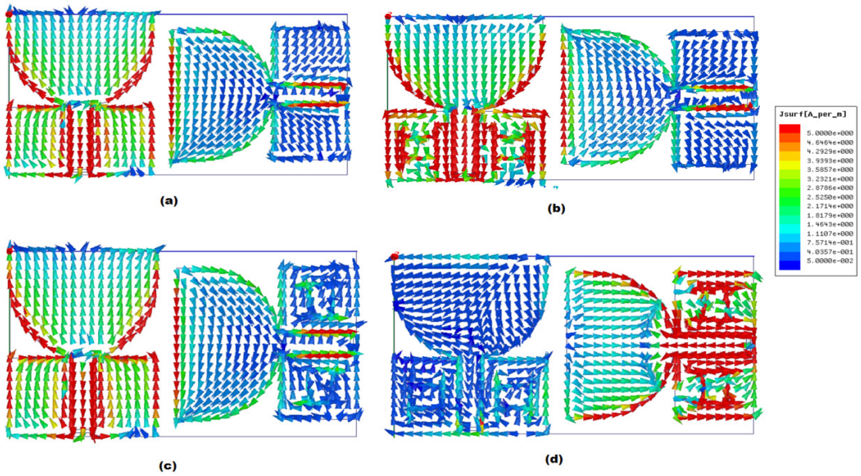


Figure 13. Surface current Distribution of the antenna models at 9 GHz (a) Basic Model (b) Model 1 (c) Model 2 (d) Final Proposed Model.

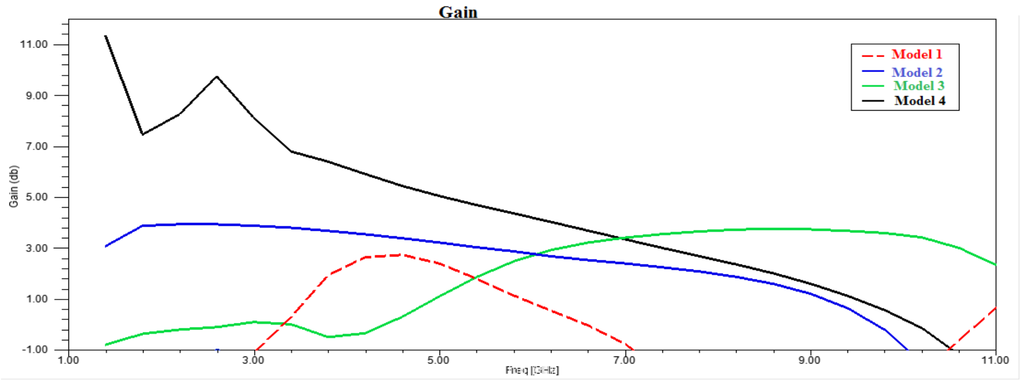


Figure 14. Gain vs. Frequency of the Proposed Antenna Models.

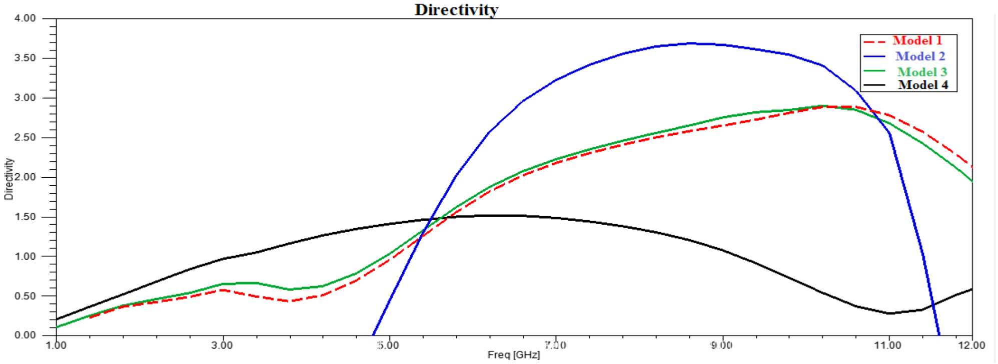


Figure 15. Frequency vs Directivity of the proposed antenna models.

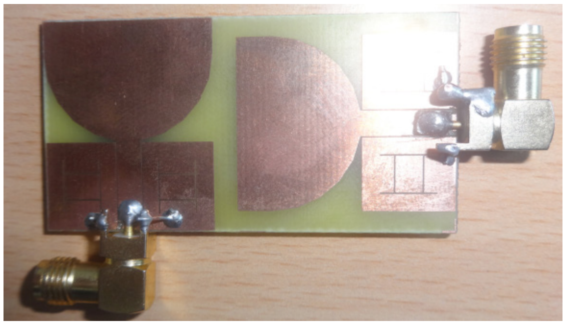


Figure 16. Prototyped Antenna on FR4 Substrate.

4. Conclusion

A CPW-FED ultra-wideband antenna with H-Shaped slots is presented in this paper. The basic antenna without slots in the ground plane is compared and simulated with that of the final proposed model. The final simulated MIMO antenna models exhibit -10 dB bandwidth in the frequency ranging from 3.1-12.8 GHz with a notch band ranging from 4.14-6.6 GHz. The final proposed antenna model also exhibits a decent gain in the required band of operation. Thus, the antenna is a suitable candidate for ultra-wideband applications.

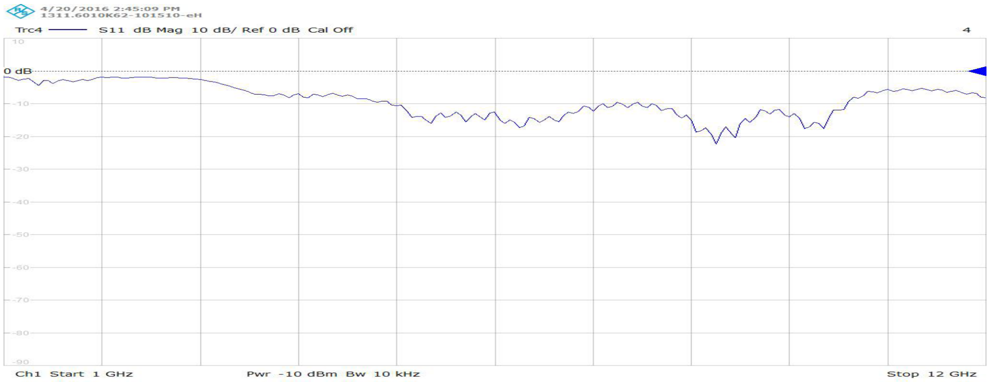


Figure 17. Measured Reflection Coefficient of the Antenna Model 4 on ZNB 20 VNA.

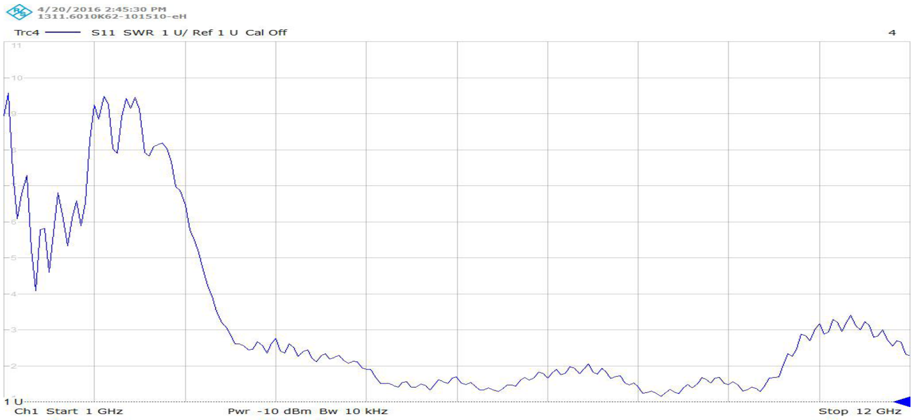


Figure 18. Measured VSWR of the Antenna Model 4 on ZNB 20 VNA.

5. Acknowledgements

Authors happy to express their thanks to K L University for their support in this work. Further we like to acknowledge DST FIST through grant SR / FST / ETI – 316 / 2012, ECR / 2016 / 000569.

6. References

1. Pasricha R, Sharma S. Linearization of Volterra Series Model Power Amplifier for Wideband WCDMA Base Stations. Indian Journal of Science and Technology. 2009 Mar; 2(3). Doi: 10.17485/ijst/2009/v2i3/29409.
2. Madhav BTP, Kaza H, Vaka JK, Sravan Kumar K, Sriharsha N, Jaswanth Kumar J, Siddharth DS, Sai Teja Reddy D. Design and Analysis of Compact Coplanar Wave Guide Fed Asymmetric Monopole Antennas. Research Journal of Applied Sciences, Engineering and Technology. 2015 Jun; 3(S10):247–52.
3. Karunakar G, Phani Kumar K. Slot Coupled H-plane Tee Junction Analysis. Indian Journal of Science and Technology. 2011 Aug; 4(8). Doi: 10.17485/ijst/2011/v4i8/30903.
4. Narasimha Nayak V, Madhav BTP, Sai Divya R, Nava Sai Krishna A, Rohith Ramana K, Mounika D. Compact Microstrip Rectangular Edge Fed Antenna with DGS Structure. International Journal of Applied Engineering Research. 2015; 10(S10). ISSN 0973-4562 pp. 24331-24348.
5. Choi J-Y. Design and Analysis of Squared Patch Antenna with Multi Squared Slots. Indian Journal of Science and Technology. 2015 Oct; 8(26). Doi: 10.17485/ijst/2015/v8i26/80432.
6. Rajaraman G, Anitha M, Mukerjee A, Sood K, Jyoti R. dual-band, miniaturized, enhanced-gain patch antennas using differentially-loaded meta structures. Indian Journal of Science and Technology. 2015; 8(1).
7. Sarva E, Sridevi PV. A Novel Triple Band Planar Microstrip Patch Antenna with Defected Ground Structure. Indian Journal of Science and Technology. 2016; 9(3).
8. Danideh A, Sadeghzadeh RA. CPW-fed slot antenna for mimo system applications. Indian Journal of Science and Technology. 2013 Jan; 6(1). Doi:10.17485 /ijst/ 2013 / v6i1/30557.
9. Krishna GV, Madhav BTP. Bandwidth enhanced antipodal vivaldi antenna for wide band communication applications. Indian Journal of Science and Technology. 2016; 9(31). Doi: 10.17485/ijst/2016/v9i31/85164.