World Applied Sciences Journal 32 (11): 2285-2290, 2014
ISSN 1818-4952
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DOI: 10.5829/idosi.wasj.2014.32.11.1334

Elliptical Shaped Coplanar Waveguide, Feed Monopole Antenna

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Abstract: Elliptical shaped compact wideband monopole antenna is designed and presented in this article. By placing different square spiral slots on the ground plane, the effective performance characteristics of the antenna and its radiation characteristics with improvement in the gain is clearly demonstrated. All these spiral slot orientations are compared and optimized by successive iterations of a computer aided analysis. Finite Element Method based Ansys HFSS 15 is used for the analysis at the wide frequency band from 2-20 GHz. The parametric analysis with respect to the performance characteristics of the antenna is also done and presented in this work.

Key words: Coplanar Wave Guide · Elliptical Monopole Antenna · Parametric Analysis · Finite Element Method

INTRODUCTION

There is lot of demand for the design of antennas with high bandwidth and gain. Ultra wideband technology opened the gates for researchers to design antennas for high data rate wireless communication systems [1-2]. Numerous methods and techniques are proposed to improve the performance of the antenna and optimized their characteristics. These techniques includes coplanar waveguide feeding with circular shaped, rectangular shaped, fork shaped different monopole antennas. However these antennas requires a relatively large ground plane structure that can be of various configurations typically in the shape of square, rectangular, circle or ellipse [3-4].

In this paper, we proposed a wideband antenna which covers frequency range from 2-20 GHz with excellent characteristics. The proposed model consisting of semi elliptical shaped radiating element with coplanar wave guide feeding [5]. Fig 1 shows the basic structure of the proposed model and spiral slotted models. The spiral slots of different orientations are placed on the ground plane for fine tuning of the antenna to improve the lower frequency and upper of the band [6-9]. The main radiating element is the combination of two semi elliptical shapes and its impedance bandwidth is improved by placing slot on the top side. By using this patch shape the additional resonances are excited and the bandwidth is improved [10-11]. The simulation is carried out by Ansys HFSS 15 electromagnetic tool [12] and the fabricated model is tested using R&S ZNB 20 vector network analyzer. In this design, a 2-20 GHz frequency range for VSWR<2 is obtained and radiation patterns in E and H-plane and gain measurements is also presented in detailed manner.

Antenna Geometry: Fig 1 shows the CPW fed configuration of elliptical shaped monopole antenna different orientations with spiral slots on the ground plane. Antenna is constructed on FR4 substrate with dielectric constant of 4.4 and thickness 1.6 mm. A gap of 0.2 mm is taken between feed line and ground plane in the models. The length and width of the substrate are 40 and 44 mm respectively. Width of the feed line W4=3 mm and width of the patch element W3 is 32 mm. W1=3 mm.

Results and Analysis: Fig 2 shows the frequency Vs reflection coefficient for all the four models. From the plot it is observed that the by placing spiral slots on the ground plane antenna performance characteristics at 5 GHz WLAN band (5.1 to 5.8 GHz) are improved. Fig 3 shows the simulated VSWR Vs frequency and it is observed that VSWR is less than 2 in the desired bands of frequency. By varying the lower ellipse in the patch the parametric analysis is done and it is presented in Fig 4.

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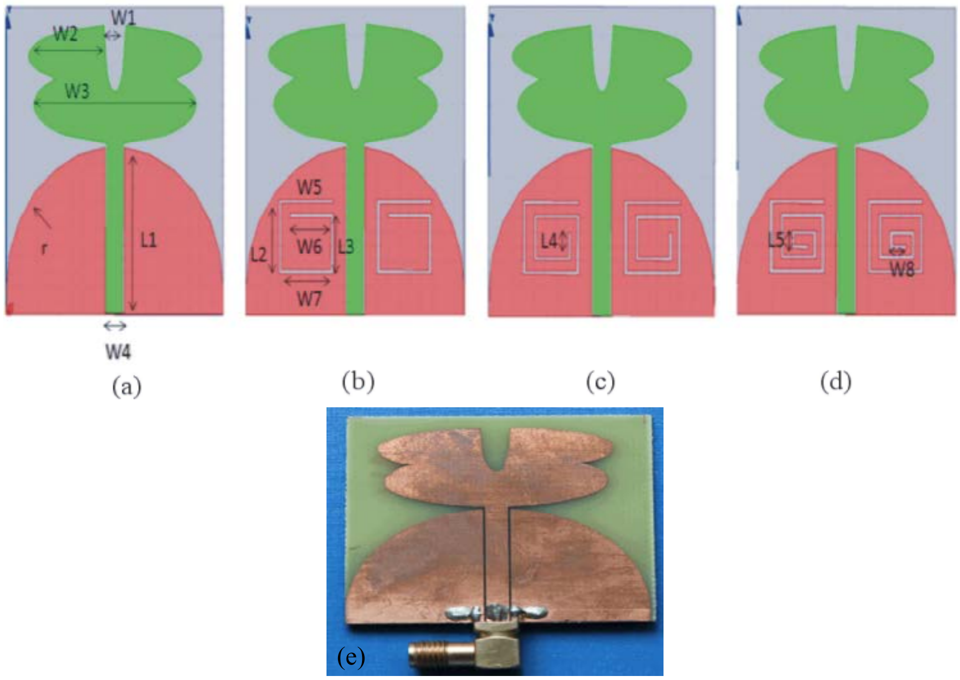

Fig. 1: (a) Elliptical Shaped Monopole model, (b) Single rounded spiral slot on ground, (c) Double rounded spiral slot on ground, (d) Triple rounded spiral slot on ground, (e) Fabricated Prototype

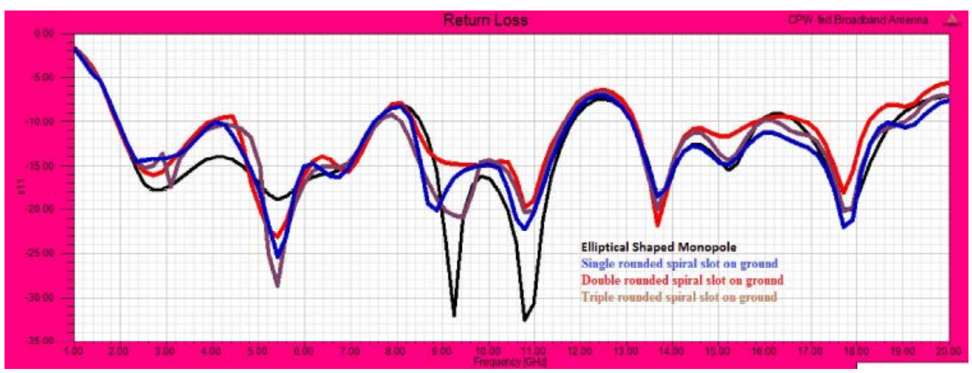

Fig. 2: Return loss Vs Frequency for four models

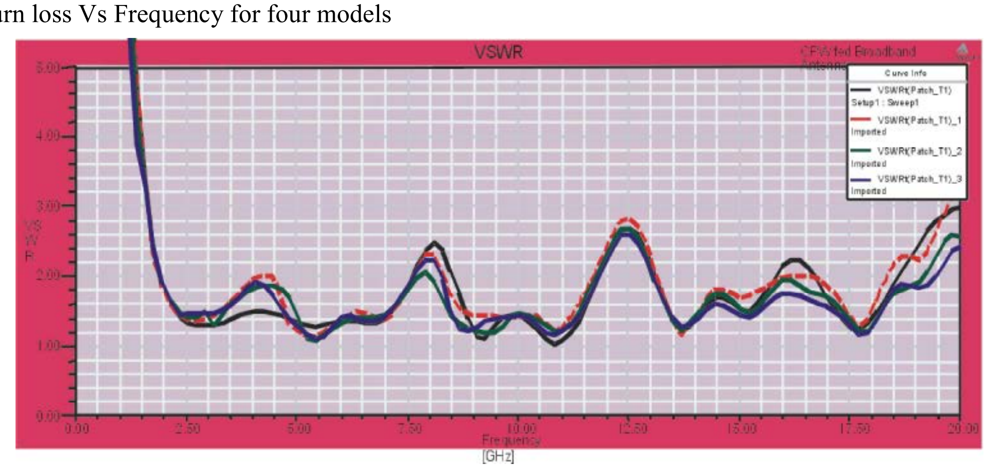

Fig. 3: VSWR Vs Frequency

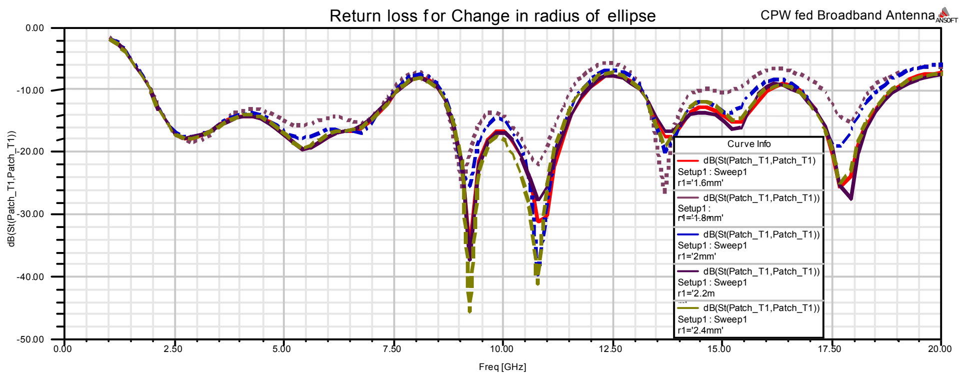

Fig. 4: Parametric analysis of Return loss for Elliptical Shaped Monopole model with change in radius of lower ellipse

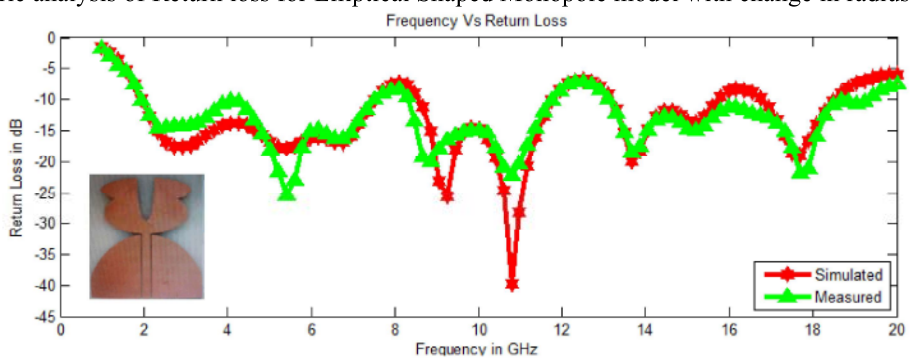

Fig. 5: Simulated and Measured Reflection Coefficient Vs Frequency

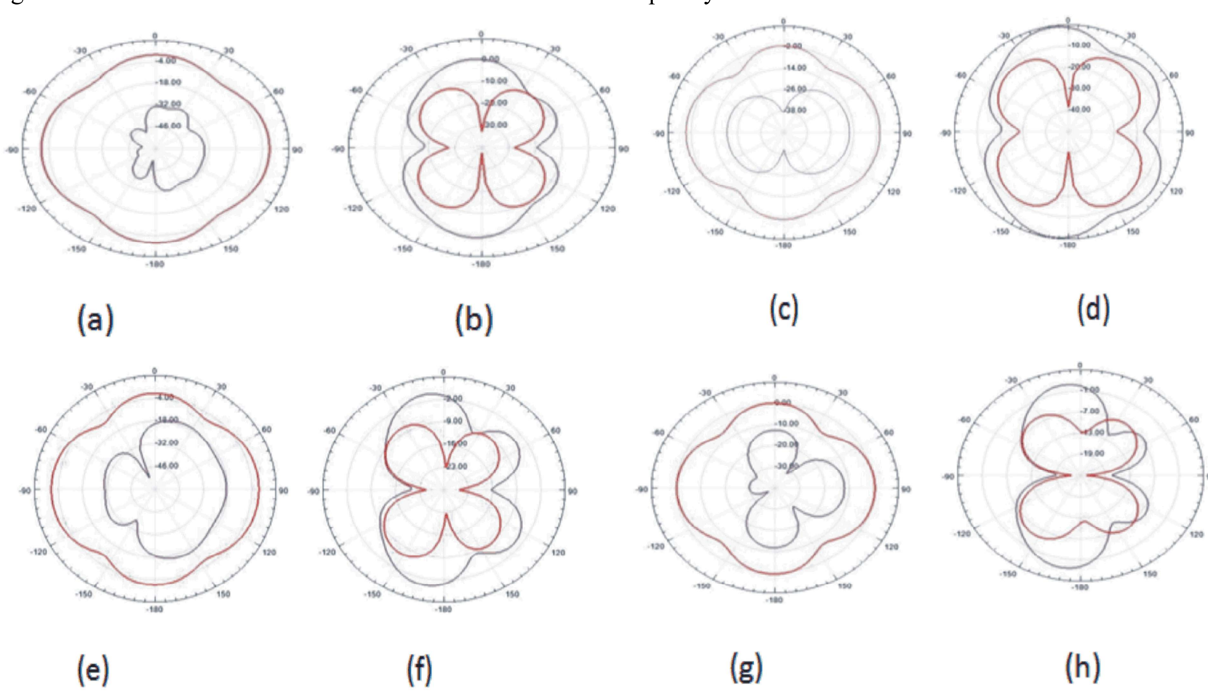

Fig. 6: (a) Elliptical shaped monopole E-plane radiation pattern (b) Elliptical shaped monopole H-plane radiation pattern (c) Single rounded spiral slot on ground E-plane radiation pattern (d) Single rounded spiral slot on ground H-plane radiation pattern (e) Double rounded spiral slot on ground E-plane radiation pattern (f) Double rounded spiral slot on ground H-plane radiation pattern (g) Triple rounded spiral slot on ground E-plane radiation Pattern (h) Triple rounded spiral slot on ground H-plane radiation pattern

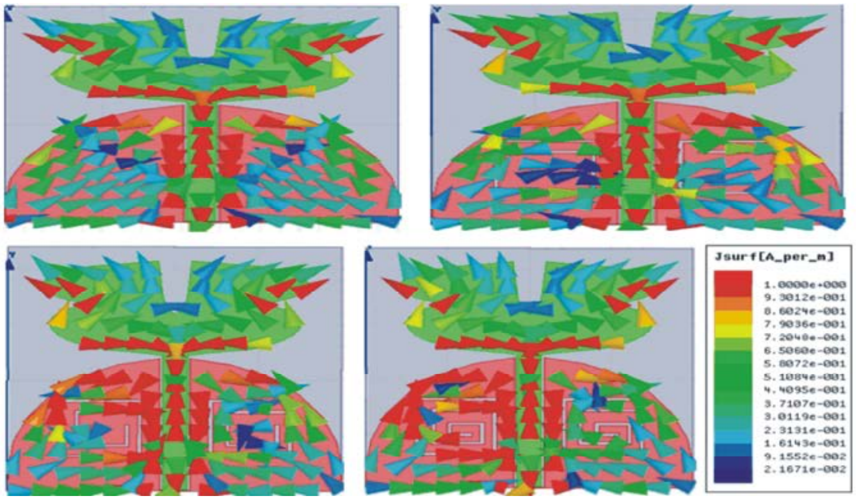

Fig. 7: Current distributions of all the models at frequency 7 Ghz

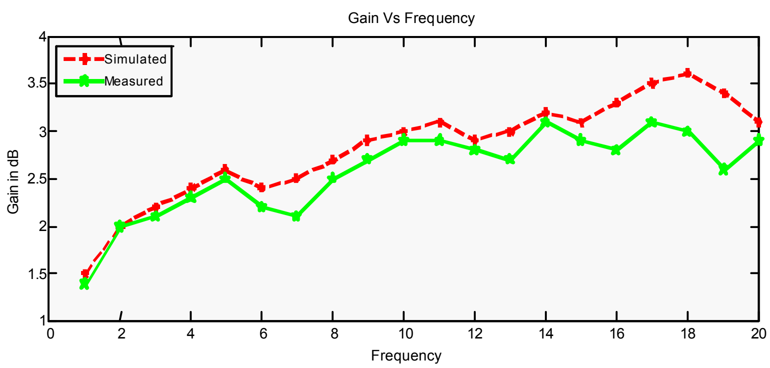

Fig. 8: Gain Vs Frequency

Antenna is fabricated on FR4 substrate and tested using R&S ZNB 20 Vector Network Analyzer. The impedance bandwidth of the tested antenna is from 2 to 20 GHz, which covers UWB and some other bands for communication applications. Fig 5 shows the evidence for the return loss performance characteristics of the antenna.

By placing the spiral slots on the ground plane, the performance evaluation is carried out and presented in this work. Single rounded, double rounded and triple rounded spiral shaped slots are placed on the ground plane to either sides of the feed line. This process will come under the defected ground structures configuration. Without any involvement of additional circuitry like filters, by placing slots on the ground plane the harmonic radiations can be minimized. Peak realized gain of 3.5 dB is obtained from basic model. By placing single rounded, double rounded and triple rounded spiral slots we observed a gain enhancement of 4, 4.2 and 4.5 dB respectively. This type of configuration is used in microwave integrated circuits where single substrate is used along with active devices and circuits.

Fig 6 shows the radiation characteristics of the antenna models in E and H plane at 5 GHz. By looking at the radiation pattern, omnidirectional pattern in E-plane and quasi omnidirectional pattern in H-plane is obtained. Fig 7 shows the current distribution on the patch surface at 7 GHz. Almost identical results in comparison with simulated gain is observed in the Fig 8. A peak realized gain of 3.3 dB in simulation and 3 dB in measurement is obtained in the UWB range for the elliptical shaped patch model. Fig 9 shows the antenna efficiency curve with respect to frequency for model 1. It is observed that almost 82% efficiency is obtained in the entire band. Table 1 showing antenna parameters at 7 GHz for all the four models.

Parametric Analysis of CPW Fed Curved Elliptical Monopole Antenna with Change in Substrate Permittivity: Parametric analysis for reflection coefficient with the change in substrate permittivity is presented in Fig 10. Except for Alumina substrate material, antenna is showing wideband characteristics for remaining materials.

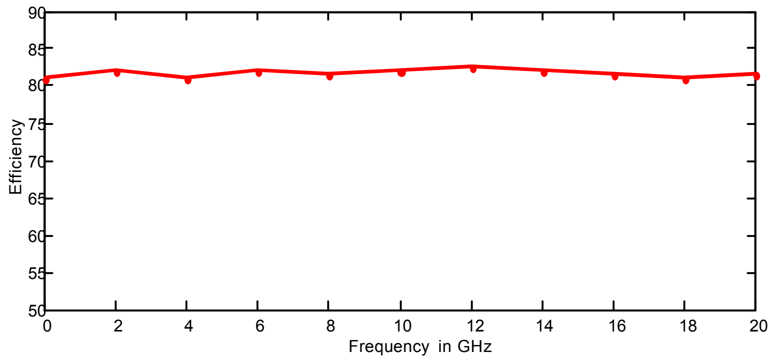

Fig. 9: Frequency Vs Efficiency

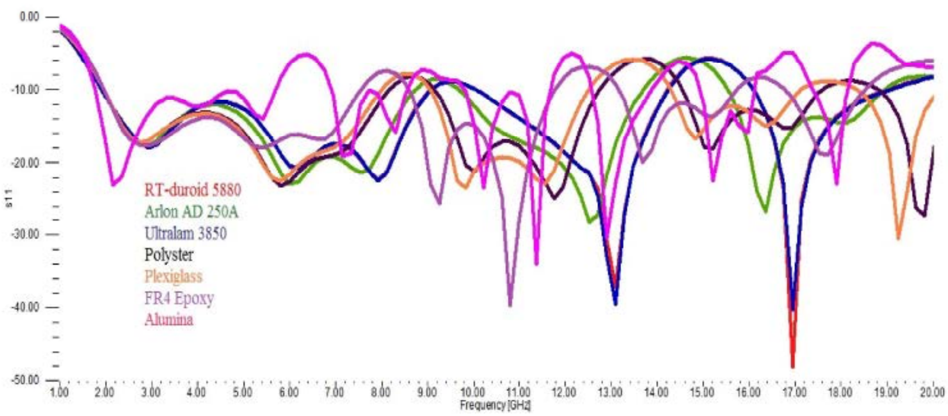

Fig. 10: Parametric Analysis of return loss for CPW fed curved elliptical monopole antenna with change in substrate permittivity

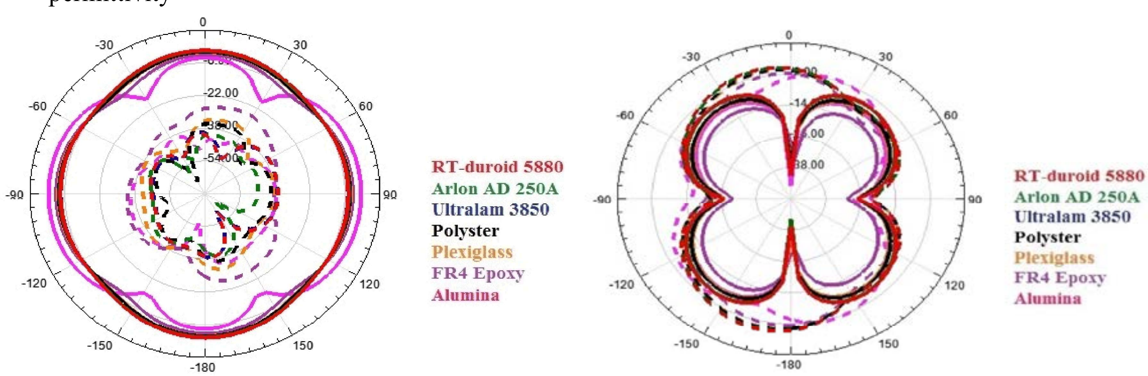

Fig. 4.11: Radiation pattern of CPW fed curved elliptical monopole antenna in E and H Plane with change in substrate permittivity

Table 1: Antenna Parameters at 7 GHz

S.No	Quantity	Model1	Model2	Model3	Model4
1	Max U	0.0024289	0.0025698	0.002645	0.002873
2	Peak Diversity	3.8687	4.6054	4.4952	4.7454
3	Peak Gain	3.0572	3.3151	3.7143	3.8876
4	Peak Realized Gain	3.0523	3.2294	3.6924	3.8744
5	Radiated Power	0.0078897	0.0070121	0.0077031	0.0076746
6	Accepted Power	0.0099838	0.0097416	0.0099193	0.0099545
7	Incident Power	0.01	0.01	0.01	0.01
8	Radiation Efficiency	0.79025	0.71981	0.81656	0.87097

Fig 11 shows the radiation pattern in E and H plane with different substrate materials. Change in permittivity [13] is causing variation in the radiation pattern has been observed from the current study.

CONCLUSION

A novel and simple coplanar waveguide fed elliptical shaped monopole antenna is designed and its performance characteristics are presented in this paper. By adjusting the elliptical shaped structure, the impedance bandwidth can be improved. By placing spiral slots on the ground plane, harmonic distortion is minimized and gain enhancement is observed. Wideband characteristics are observed from the current design and this current design is applicable for the UWB and other communication systems applications.

ACKNOWLEDGEMENTS

Authors like to express their gratitude towards the department of ECE and management of K L University for their continuous support and encouragement during this work. Madhav also likes to express his thanks to President K L University for providing facilities like Vector network analyzer, spectrum analyzer and measurement setup to carry out the real time analysis. Authors also like to express their thanks to the department of science and technology through SR/FST/ETI-316/2012 FIST program.

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