Design of Ultra-Wideband Microstrip Antennas with Slots and Fractal Based Ground Plane

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Abstract: *A rectangular microstrip antenna with slotted and fractal based ground plane has been introduced in this paper as a candidate for use in ultra-wideband applications. The slotted ground structure of the proposed antenna has been created on the radiating patch in two steps. At first, two slots have been made in the ground plane which offers a maximum impedance bandwidth (3.22 GHz to 10.6 GHz). In the second design, carpet Sierpinski type of the 2nd iteration are made in the ground plane the calculation bandwidth is (3.2 GHz to 12.6). The presented antenna has been fed with a single 50 Ohm* *strip line. The resulting antenna has a rectangular patch with dimensions of (11 mm x15mm). The characteristics of the proposed antenna structure have been predicated using full–wave numerical Method of Moment (MOM) by Microwave Office v. 7.5.*

Keywords: UWB, Microstrip antenna, Fractal Antenna

1. Introduction

With the rapid development in modern wireless and mobile communication, the ultra-wideband technology has become one of the most fascinating technologies in in-door communication due to its great advantages including large capacity of data, high speed data rate and small size, low power consumption and simple hardware configuration in communication systems for different applications[1,2]. However, the frequency band (3.1-10.6) GHz, was approved by the Federal Communications Commission (FCC) of USA in 2002 for unlicensed usage [3, 4]. Then, the interest in designing UWB antennas that operate over wide frequency range and that can be used for multiple channels or systems, has excelled [1]. Some UWB antennas are much more complex than other existing single band, dual band and multi-band antennas [5,6].

Recently, UWB technology with an extremely wide frequency range has been proposed for imaging radar, communications, and localized applications. Then the design of broadband antennas has become an attractive and challenging area in the research of the system design. In general, the antennas for UWB systems should have sufficiently broad operating bandwidth for impedance matching and high-gain radiation in desired directions [7].

There are many techniques of UWB antennas. The first technique is used four types of the patch shape in the microstrip fed UWB antennas such as rectangular, triangular, circular and elliptical. Choi S.H. Proposed a new ultra-wideband antenna, he shows microstrip fed monopole UWB antennas with rectangular patch [8]. Second, triangular patch and its modified structures of microstrip fed UWB antenna are introduced by Lin C.C. [9]. And the third, circular and elliptical patch antennas fed by the microstrip line are a good candidate for the UWB antenna design. Lianga J. designed by using a circular patch [10].

The second technique of UWB is the slot antennas. The patch radiator may be slotted to improve the impedance matching, especially at higher frequency. The slots cut from the radiators change the current distribution at the radiators so that the impedance at the input point and current path change [11]. This type of antenna has been realized by using microstrip line and CPW feeding structures. Chen W.F designed slot antenna for UWB applications which consisted of the ground plane with wide rectangular slot and microstrip feeding line with a fork-shaped tuning stub [12].

The third technique uses fractal structure. Lui W. J. Used the fractal structure to achieve both size reduction and frequency notched characteristic in UWB antenna [13]. The fourth technique that uses meta-material structures, split ring resonator (SRR), is also possible to notch some frequency band due to its unordinary properties. Kim J. inserted the SRR structure on the CPW feeding line and radiating element to obtain the notched function in UWB antenna [14]. Alibakhshi designed a simple and miniature ultra wide band (UWB) printed planar antenna using Met- material and obtained the impedance bandwidth about 140% between 1.2 and 6.8GHz [15]. Mimi designed ultra wideband (UWB) patch antenna based on the resonance mechanism of a meta-martial T.L. , he obtained the bandwidth (2.9- 9.9) GHz [16].

In this paper a novel UWB microstrip antenna with slots and fractal grounded is presented. From various bandwidth enhancement techniques, there are three techniques adopted for this proposed UWB antennas design. The three techniques are the use of truncation ground plane, slots, and fractal at the ground which can lead to a good impedance bandwidth. By selecting these parameters, the proposed slots can be tuned to operate in UWB frequency range.

The characteristics of the proposed antenna structure has been predicated using full–wave numerical Method of Moment (MOM) by Microwave Office v. 7.5, of the applied wave research includes a full wave electromagnetic solver that uses a modified spectral domain method of moments to accurately determine the multi-port scattering parameters for planar structure.

2. Antenna Structure

In this paper, three techniques are used to achieve wide bandwidth, these are: (i) Rectangular Microstrip Antenna over half ground (truncation ground plane), (ii) ground plane with slots and (iii) microstrip antenna with Fractal ground, which can lead to a good impedance matching.

A. Rectangular Microstrip Antenna with Truncation Ground plane

The proposed rectangular patch antenna parameters are calculated based on transmission line modal analysis and the detailed geometry and parameters are shown in Figure (1) and Table (1), respectively. For modeled rectangular patch antenna, the signal excites through SMA connector which is modeled based on simulation tools of microwave office. The radiating patch of the proposed antenna is separated from the ground plane by duriode substrate. The structure is composed of a rectangular patch fed by 50 Ohm strip line. The proposed antenna is constructed on duraid substrate with size (60 by 60mm), thickness h = 1.588 mm, and relative dielectric constant = 2.2.

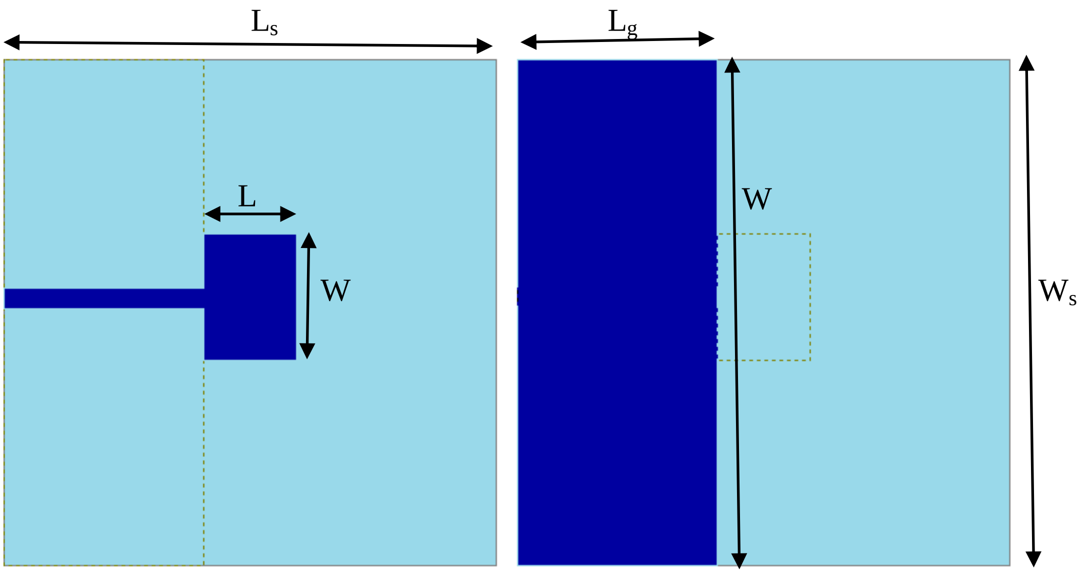


Figure (1) The design geometry of the proposed antenna patch with truncation ground plane

Table (1) The detailed parameters for proposed antenna patch with truncation ground plane .

Parameters	Size (mm)
L (length of the patch)	11
W (Width of the patch)	15
L_g (length of the ground plane)	24
W_g (width of the ground plane)	60
h (Height of substrate material)	1.6
L_s (length of the substrate material)	60
W_s (width of the substrate material)	60

B. Ultra-Wideband Rectangular Microstrip Antenna with Slots in Ground

The second step, design of rectangular microstrip antenna with ground which has two slots (upper slot and lower slot on ground plane) as shown in figure (2) and table (2) which show the detailed parameters for proposed antenna patch UWB antenna. The antennas that consist of a rectangular patch loaded with slot(s) on the ground.

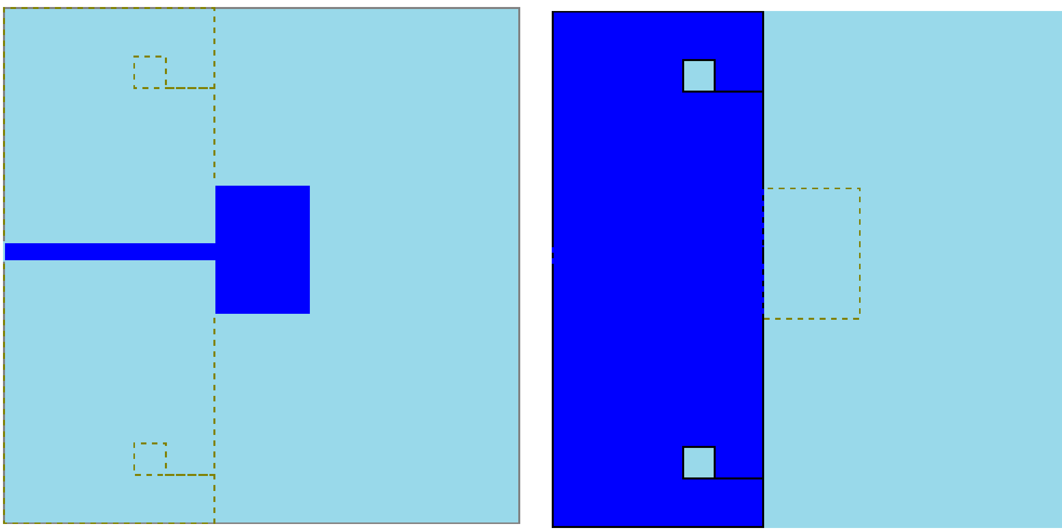


Figure (2) The design geometry of the proposed antenna patch with slot on ground plane.

Table (2) Ground Plane Specification.

Parameters	**Size (mm)**
L_{slot} (length of the slot)	3.75
W_{slot} (Width of the slot)	3.75
Position of upper slot (s)	9.5
Position of lower slot (s)	9.5

C. Microstrip Antenna with Fractal Ground

The third step, design of rectangular microstrip with fractal ground as shown in figure (3) which shows the configuration of the proposed ultra wide band antenna with fractal ground (carpet Sierpinski type of the 2nd iteration are made in the ground plane).

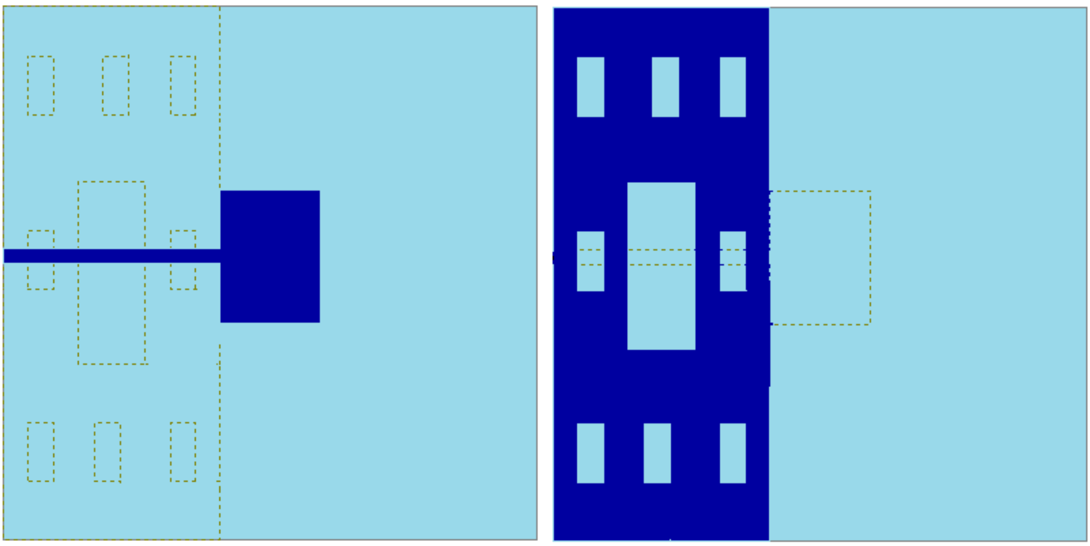
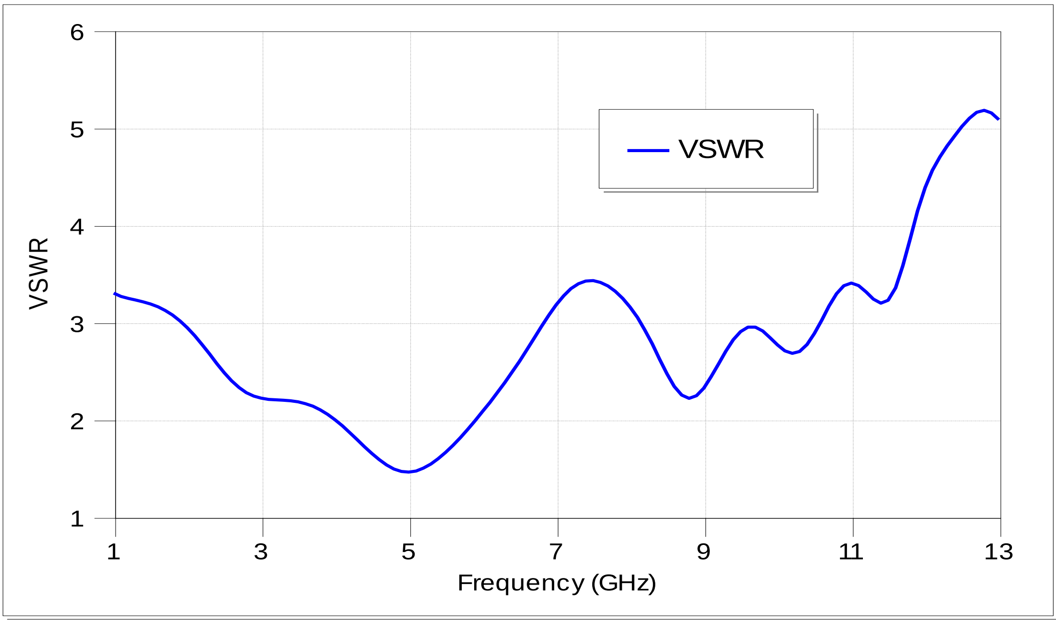


Figure (3) The design geometry of the proposed patch UWB antenna with fractal ground.

3. Results and Discussion

The results and discussion are divided into three parts which consist of parametric study. In the first case design of Ultra-Wideband Rectangular Microstrip Antenna with truncate ground plane, Figure (4) shows the relationship between VSWR and frequency**.** In this case the antenna operates in the band (4-5.9) GHz and this band don't satisfy the operation in UWB.



Figure(4)Relationship between VSWR and frequency Ultra-Wideband Rectangular Microstrip Antenna without slots through ground

In the second case of design Ultra-Wideband Rectangular Microstrip Antenna with slots ground plane, Figure (5) shows the relationship between VSWR and frequency for different values of s (position of slot), it is noticed when increase the position of slot the band is increased, the maximum bandwidth occurs at s=9.5 mm, and the measured bandwidth at this position is (3.22 GHz- 10.6 GHz).

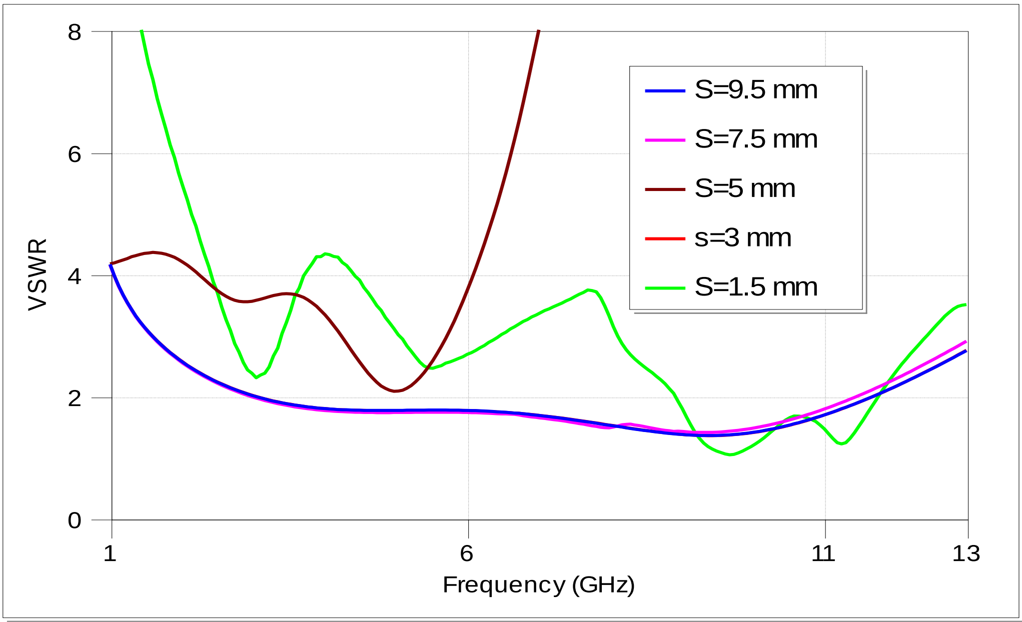


Figure (5) VSWR variation w.r.t frequency with slots in the ground plane

In the third case, design of Ultra-Wideband Rectangular Microstrip Antenna with fractal ground plane, Figure (6) shows the relationship between VSWR and frequency. It is noticed that the antenna operates within the band starts from (2.8-to-12.6) GHz. Figure (7) shows the relation between input impedance and frequency. Figure (9) Polar radiation pattern for Ultra-Wideband Rectangular Microstrip Antenna with fractal ground with different values frequency (start from 3.2 – to 12.6 GHz), and it is noticed that the pattern do not distortion along these frequencies.

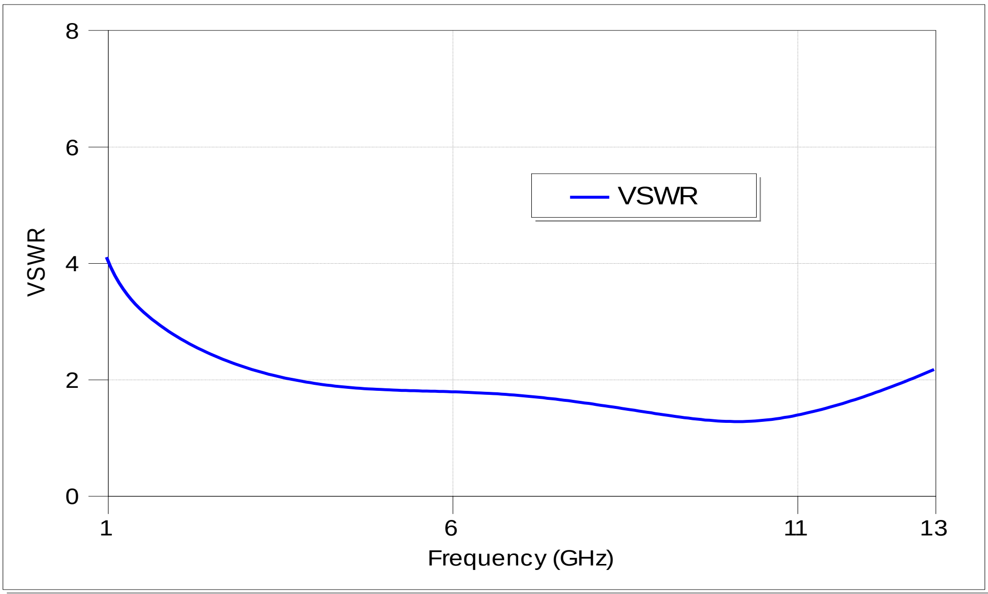
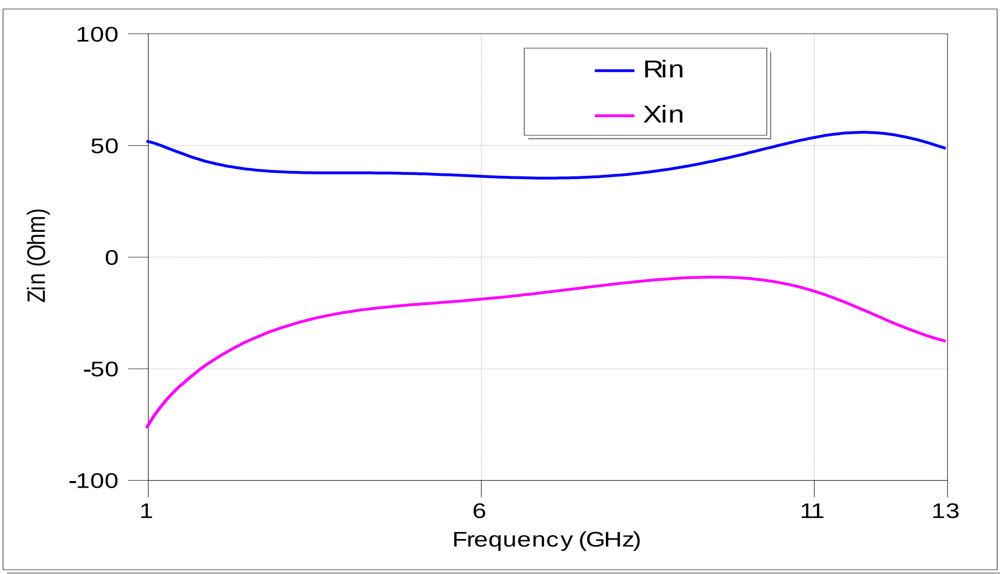
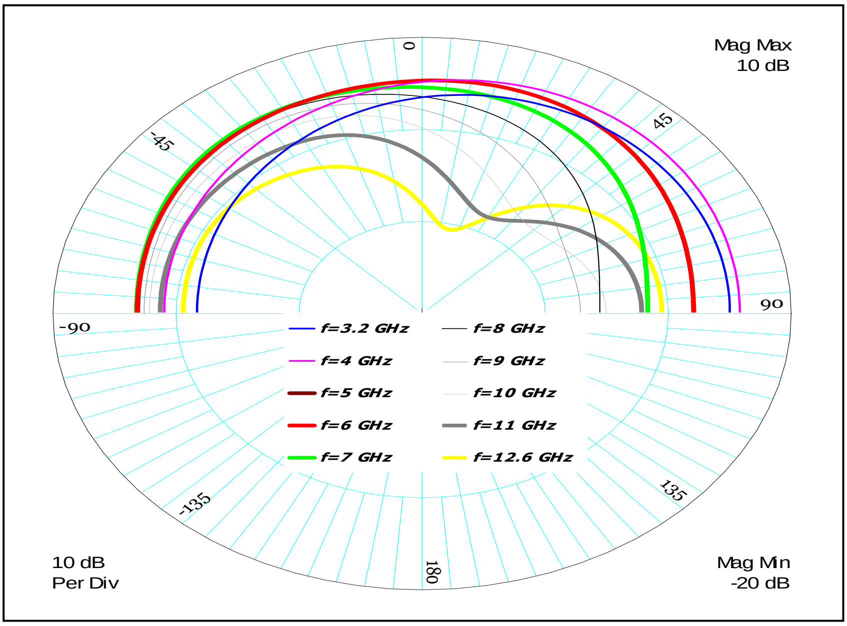


Figure (6) VSWR Variation w.r.t Frequency with Fractal Ground Plane



Figure(7) Relationship between Zin and frequency for Ultra-Wideband Rectangular Microstrip Antenna with fractal ground



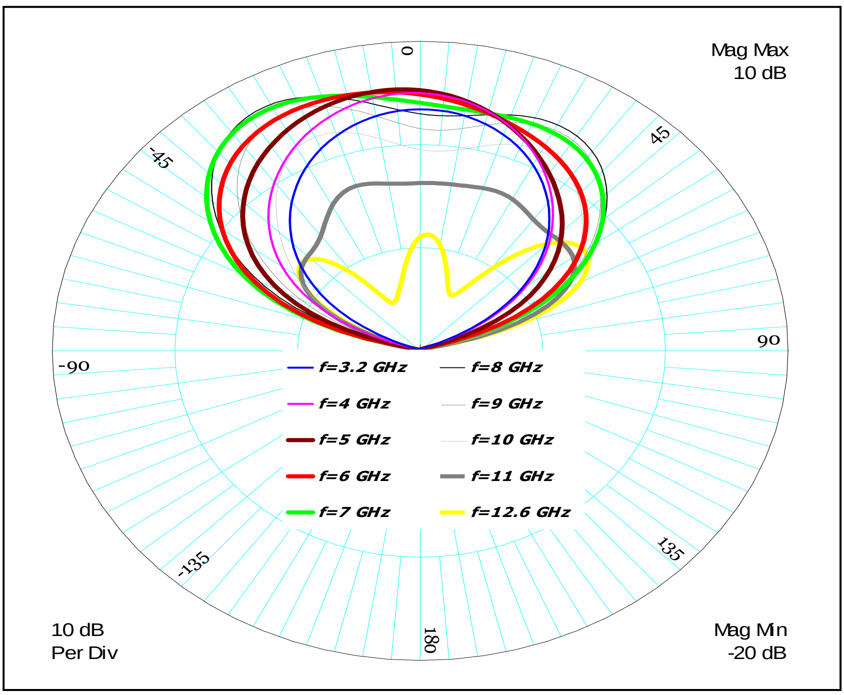


Figure (8) Polar radiation pattern for Ultra-Wideband Rectangular Microstrip Antenna with fractal ground with different values frequency

4. Conclusions

New ultra-wideband antenna using rectangular microstrip with slot ground plane and fractal ground plane is proposed. The antenna structure presented in this paper is compact, has low profile, light weight and is easy to be fabricated and have successfully demonstrated ultra-wideband (UWB) characteristics. The computed bandwidths are (3.22 GHz-10.6 GHz) for slotted ground plane design, while it is (3.2 GHz -12.6 GHz). The proposed antenna shows good radiation characteristics besides the UWB impedance bandwidth.

References:

1. Mohammed M. Mohanna, Deena A. Salem, Esmat A. F. Abdallah, and Hadia M. S. El-Henawy , " Novel Shape of UWB Microstrip Patch Antenna with Enhanced Gain Using EBG Structure," Progress In Electromagnetics Research Symposium Proceedings, Suzhou, China, Sept. 12-16, 2011.
2. J. Ma, Y.-Z. Yin, S.-G. Zhou, and L.-Y. Zhao, " A New Ultra-Wideband Microstrip-Line Fed Antenna with 3.5/5.5GHz Dual Band-Notch Function," Progress In Electromagnetics Research Letters, vol. 7, 79–85, 2009.
3. Ramu Pillalamarri, G. Sasi Bhushana Rao and S. Srinivasa Kumar, " Compact Printed Semicircular Disc Microstrip Line Fed Monopole Antennas for UWB Applications", Journal of Physical Sciences, vol. 13, 217-222 ISSN: 0972-8791: www.vidyasagar.ac.in/journal, 2009.
4. Federal Communications Commission: "First Report and Order, Revision of Part 15 of the Commission's

Rules regarding Ultra-Wideband Transmission Systems", Feb. , 2002.

5. Ramu Pillalamarri and R. S. Kshetrimayum , "Printed UWB Circular and Modified Circular Disc Monopole Antennas," accepted for IEEE Applied Electromagnetics Conference, Kolkatta, India, December 2007.
6. R. S. Kshetrimayum and Ramu Pillalamarri, "UWB Printed Monopole Antenna With A notch Frequency for Coexistence with IEEE 802.1a WLAN Devices," in Proc. 5th National Conference on Communications (NCC) 2009.
7. Lim K.-S., M. Nagalingam, and C.-P . Tan, " Design and Construction of Microstrip UWB Antenna With Time Domain Analysis," Progress In Electromagnetics Research M, Vol. 3, 153–164, 2008.
8. Choi S. H.; Park J. K.; Kim S. K. & Park J. Y.," A New Ultra Wideband Antenna For UWB Applications," Microwave and Optical Technology Letters, Vol. 40, No. 5 pp. 399-401, ISSN: 0895-2477, 2004.
9. Lin C. C.; Kan Y. C.; Kuo L. C. & Chuang H. R. ,"A Planar Triangular Monopole Antenna For UWB Communication", IEEE Microwave and Wireless Components Letters, Vol. 15, No. 10, pp. 624-626, ISSN: 1531-1309. 2005.
10. Lianga J.; Chiau C. C.; Chen X. & Parini C. G.," Study of a Printed Circular Disc Monopole Antenna for UWB Systems", IEEE Transactions on Antennas and Propagation, Vol. 53, No. 11, pp. 3500-3504, ISSN: 0018-926X, 2005.
11. Yusnita Rahayu , Razali Ngah and Tharek Abd. Rahman,"Slotted Ultra Wideband Antenna for Bandwidth Enhancement," www.intechopen.com.

12. Chen W.-F.; Ye Z.-S.; Wu J.-M. and Huang C.-Y., "Slot Antennas for UWB Applications," Proceedings of Asia-Pacific Microwave Conference pp. 1-4, ISBN: 0-7803-9433- X, Hong Kong, China, 16-20 Dec., 2008.
13. Lui W. J.; Cheng C. H. & Zhu H. B., "Compact Frequency Notched Ultra-Wideband Fractal Printed Slot Antennas", IEEE Microwave and Wireless Components Letters, Vol. 16, No. 4, pp. 224-226, ISSN: 1531-1309, 2008.
14. Kim J.; Cho C. S. & Lee J. W.," 5.2 GHz Notched Ultra-Wideband Antenna Using Slot-Type SRR", Electronics Letters, Vol. 42, No. 6, pp. 315-316, ISSN: 0013-519, 2006.
15. Alibakhshi M., Movahhedi M. and Naderian H.," A New Miniature Ultra Wide Band Planar Microstrip Antenna Based on the Metamaterial Transmission Line", IEEE Asia-Pacific Conference on Applied Electromagnetics , December 11 - 13, Melaka, Malaysia, 2012.
16. Mimi A. , Mohammad T. Islam, and Norbahiah M, "Design of A compact Ultra Wideband Metamatrial Antenna Based on The Modified Split-Ring Resonator and Capacitively Loaded Strips unit cell", Progress In Electromagnetics Research, Vol. 136, pp.157-173, 2013.

تصميم هوائي شريطي دقيق فائق الاتساع الترددي بفجوات وتركيب جزئي في مستوى التأريض

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المستخلص:

قدم في هذا البحث هوائي الشريطي الدقيق ذو الشكل المربع و ذو فتحات في المستوي الأرضي و المستوي الأرضي ذو الهندسة الجزيئية و كمقترح للاستخدام في تطبيقات ذات الحزمة الترددية الفائقة الوسع. تم إنشاء هيكل الأرضي للهوائي المقترح على مرحلتين. في البداية، تم عمل فتحتين في مستوى التأريض الذي يقدم عرض النطاق الترددي الحد الأقصى (3.22 GHz to 10.6 GHz) في حين، في التصميم الثاني، تم عمل سجادة Sierpinski بالتكرار الثاني في مستوي الأرضي وتم قياس عرض الحزمة و وجد انه يساوي (3.2 GHz to 12.6). وتم تغذية الهوائي بشريط تغذية 50 اوم. الهوائي الناتج يملك رقعة مربعة ذات ابعاد (15 mm x 11mm) . تم تحليل الهيكل المقترح باستخدام طريقة الموجة الكاملة المقدمة من حقيبة برامجيات المايكرويف v.7.5 .

الكلمات الرئيسية: الهوائي الشريطي الدقيق، حزم الترددات فائقة الاتساع، الهوائيات الكسورية.