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A Triple band Y-slot Patch Antenna for UWB Applications

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***Abstract*—Nowadays, wireless communication technologies are in demand of low profile, light weight and multiband antenna. To fulfil these requirements microstrip patch antennas are used. However, the microstrip patch antenna has limitations like low gain and narrow bandwidth. There are various techniques to improve the performance of patch antenna. The most commonly used method to realize patch antenna is loading slots and adding Koch fractal geometry on lower dielectric material. Among basic shape of patches, triangular patch antenna occupies less space on substrate. In this work, a triple band antenna is designed using fractal geometry on triangular patch. Proposed antenna covers resonant frequencies of 2.1 GHz, 3.6 GHz and 5.8 GHz with higher bandwidth. This coaxial feed antenna shows a maximum gain of 6.4 dB and directivity of 8 dB. ADS (Advanced Design System) software is used for design and simulation of proposed antenna. This antenna design is suitable for WLAN and UWB applications.**

***Keywords*— Microstrip, triangular, patch, UWB, coaxial feed**

I. Introduction

In current decade small, compatible and affordable microstrip patch antennas are urbanized in wireless communication industries keep on improving antenna performance. A patch antenna is a narrowband antenna with huge beam width. It is made-up by etching the antenna element pattern in metal trace which is attached to an insulating dielectric substrate such as a printed circuit board with a continuous metal layer bonded to the opposite side of the substrate known as ground plane. There are various shapes of patch elements such as rectangle, square, circle, triangle, oval, elliptical etc. Researchers found triangular patch structures are showing better results due to its reduced size in area, compactness and having three sharp edges. To improve the characteristics of antenna such as gain, directivity, return loss, bandwidth, various methods are used. Major techniques includes loading slots on patch element reduces return loss and improves bandwidth of antenna, adding Koch fractal geometry improves gain, directivity and rises number of frequency bands of an antenna, designing patch on lower dielectric material reduces the return loss of an antenna and using various types of feeding techniques like microstrip line feed, coaxial feed, aperture coupled feed and proximity coupling feed can increase the bandwidth of an antenna. In spite of several advantages of fractal antennas like multiband characteristics, good bandwidth and gain there are several disadvantages of fractal geometry where the benefits of antenna begin to decrease after few fractal iterations. Also by varying dielectric material and its height also shows acceptable changes in antenna parameters. Mostly substrate with lower dielectric constant is used so far. In this paper, a triangular patch with Y shaped slot is introduced.

Here second iteration Koch geometry is applied on three sides of a triangular patch. It shows improved gain and directivity with reduced return loss. The details of both antenna design and simulated results of proposed antenna are shown.

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II. Related Work

For achieving high performance gain and reduced return loss in microstrip patch antenna partial Koch fractals are applied. This type of design can be used in applications such as indoor LANs, GSM booster units etc [1].

Miniaturization of antenna size is a critical issue in the antenna field. Using fractal geometry shows the better solution for this challenge. It also improves the gain, directivity, reduced side lobe levels and reduced return loss comparing to antenna without fractal curves [2]. To achieve multiple frequency bands with better gain Koch fractal slot is designed instead of triangular slot geometry which lowers the frequency of operation and provides wideband matching. It indicates large impedance bandwidth with stable omnidirectional radiation patterns suitable for wireless communication applications [3].

Broader bandwidth in microstrip patch can be attained by loading slots of various shapes like U slot, V slot, E-slot etc., on conducting material [4]. Thus the slotted patch on thick substrate improved about 18% bandwidth comparing to antenna without slots. This slot loaded technique also achieves 40% miniaturization of size which mostly find wireless applications of WLAN and WiFi [5].

Wider bandwidth can be achieved by integrating 35^o angularly patch feed with a T- shaped patch. Size of antenna is reduced by using the shorting wall technique. Acceptable gain, stable radiation pattern with bandwidth of 107.46% (3.1 – 10.3 GHz) can be achieved [6].

III. Antenna Design Analysis

Microstrip antenna is designed with triangular patch with second iteration Koch fractal geometry. Coaxial feeding technique is used in the design because it is easy to obtain input matching by adjusting feed position. Input impedance is a major constraint to obtain required bandwidth. If it doesn't occur than the efficiency will be lower. Here the thickness of the substrate is kept 1.6mm to achieve maximum bandwidth. We choose FR4 epoxy material because it has dielectric constant (ε_r) minimum as relative permittivity is inversely proportional to bandwidth of antenna. Proposed antenna is shown in Fig. 1.

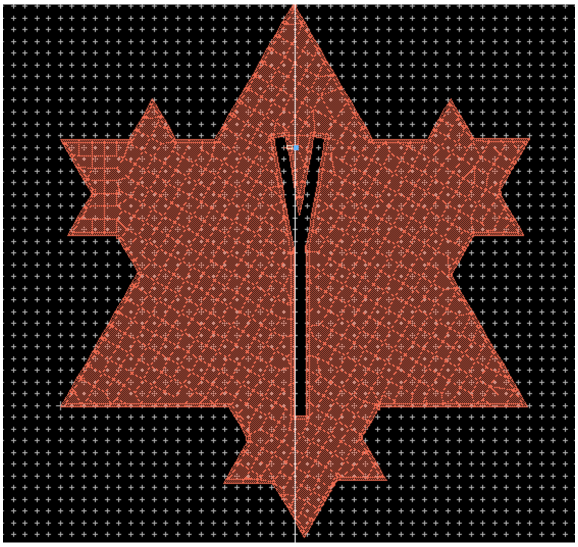

Fig. 1 Simulated layout of proposed antenna

A. Method of Analysis

The wavelength of free space: $\lambda = c / f$, where c is velocity of light in free space, 3×10^8 m/s.

Side of triangular patch:

$$a = \frac{2c}{3f_r\sqrt{\varepsilon_r}} \quad (1)$$

Since the patch is designed on FR4 epoxy material and its permittivity 4.4 is chosen. The resonant frequency 2.4 GHz is used for design consideration. Also Koch iterations are added to the triangular patch. With each iteration the length of the Koch is increased by its one third of its length. By adding second iteration Koch fractal, directivity of an antenna is increased.

The side of the triangle *a* is 40 mm. The side of the triangle is divided by 3 and its value is around 13 mm. It forms the first iteration Koch fractal antenna. For second iteration, side 13.3mm is divided by a fraction of 1/3 and its value is around 4.3mm. Second iteration Koch curve is formed by this value. Then the Y slot structure is loaded at centre of the designed star shaped patch shown in Fig. 2.

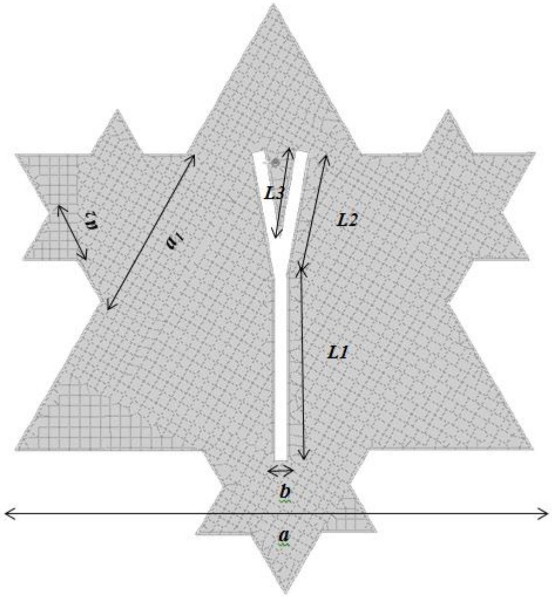

Fig. 2 Geometry of proposed antenna

TABLE I
DIMENSIONS OF PROPOSED ANTENNA STRUCTURE

Resonant frequency (f_r)	2.4 GHz
Side of triangle (a)	40 mm
Side of first iteration (a_1)	13.3 mm
Side of second iteration (a_2)	4.3mm
Length L1	14.2 mm
Length L2	8.8mm
Length L3	6.8mm
Breadth b	1mm

IV. SIMULATED RESULTS AND DISCUSSIONS

The antenna is simulated using advanced design system (ADS) and its parameters are studied. Fig. 3 shows the simulated results of return loss for proposed antenna.

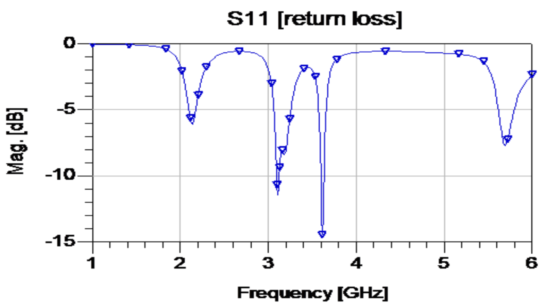

Fig. 3 Return loss of simulated proposed antenna

From the above figure, it shows the return loss value of various band of frequencies. The maximum reduced return loss of -15 dB is obtained at centre frequency of 3.6 GHz. Proposed antenna covers the centre frequency 2.1GHz and in UWB frequency band it covers two centre frequencies one at 3.6 GHz and another at approximately 5.8 GHz. This proposed antenna can be suitable for WLAN and UWB applications.

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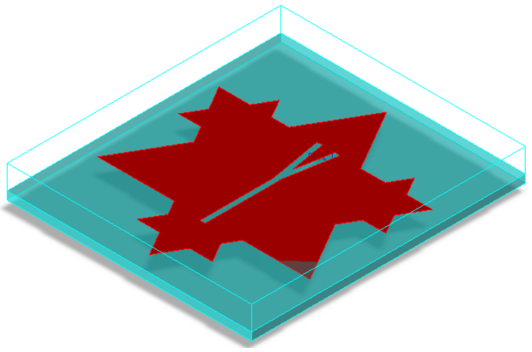

Fig. 4 Preview of 3D EM for proposed antenna

Figure 4 shows the 3D EM preview of proposed antenna structure. Here the grey shaded area represents 1.6 mm thickness of substrate layer and red shaded area represents the star shaped patch structure with Y- slot.

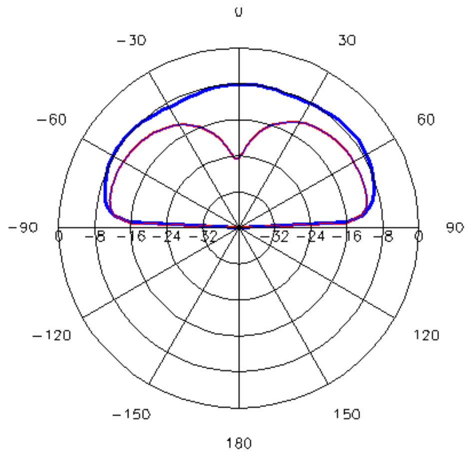

Fig. 5 2D radiation pattern of proposed antenna

For patch antenna design impedance matching is important to obtain better performance of antenna characteristics. The impedance of antenna is 50 ohm. Fig. 5 and 6 shows the two dimensional and three dimensional radiation pattern. It describes that the proposed antenna structure is omnidirectional radiation pattern since it covers all the directions over 360°. As already proven slotted patch antenna gives improved gain and directivity, this proposed antenna shows the maximum gain of 6.4 dB and directivity of 8 dB.

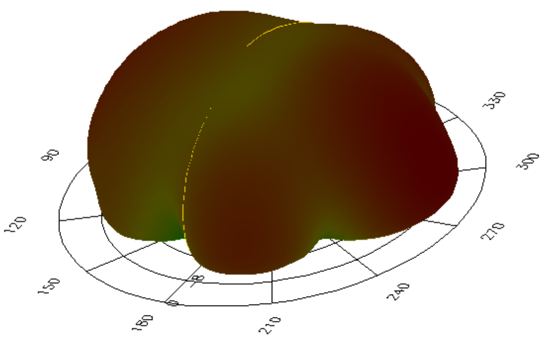

Fig. 6 3D radiation pattern of proposed antenna

Directivity and bandwidth of patch antenna can be improved by adding various iterations of Koch curve. In this paper, the proposed antenna shows maximum gain at 5.8 GHz. This antenna can also be suitable for UWB applications such as location tracking (GPS), Microwave imaging and Satellite communication applications.

V. CONCLUSION

In this paper a new triple antenna has been introduced. A Y–slotted triangular patch antenna and Koch fractal geometry have been combined to operate in multiband property with reduced return loss up to -15 dB. Simulated results of the return loss (S_{11}) and radiation pattern have been presented. Directivity of antenna is 7.9 dB and its maximum gain is 6.4 dB. The proposed antenna demonstrated wide bandwidth, suitable radiation characteristics and capable of covering various ISM band of range 2 GHz to 6 GHz. This Y slotted star shaped design finds applications of WLAN and UWB applications.

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