Design of Compact Self-Similar MIMO Antenna Analysis for Wireless Applications

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Abstract— This fractal geometry is designed by using iterated design function (IDF).The self-similarity dimension of proposed fractal geometry is 1.79, which is a fractional dimension. Self-similar fractal geometry is used there to achieve miniaturization and wide-band performance. A ground stub of T-shape with vertical slot enhances isolation and impedance band-width of proposed MIMO antenna. The antenna consists of 2 novel self-similar fractal monopole antenna elements and there metallic area is minimized by 29.68% at second iteration. This antenna has compact dimension of 24 x 32 mm2 and impedance band-width of 9.4GHz ranging from 3.1 to 12.5 GHz with isolation better than 16dB. There is a good agreement between measured and simulated results, which confirm that the proposed antenna is acceptable for UWB applications. The various diversity performance parameters are also determined. Thus a novel compact self-similar fractal ultra-wideband (UWB) multiple input multiple output (MIMO) antenna is presented.

Keywords: Fractal Antenna, Multiple-Input-Multiple-Output Antenna, Self-Similar Structure, Ultra-Wideband

I. Introduction

The vast majority of people on earth still do not have access to quality communication facilities. Copper wires, coaxial cable, fibre optics and power line communications all have technical limitations. So wireless connection is being seen as alternative. Multiple-input–multiple-output (MIMO) antenna has attracted significant research power in wireless field. The combination of UWB and Multiple Input-Multiple-Output (MIMO) significantly improves the data rate transmission capacity, spectrum efficiency and overall quality of the communication link in comparison to single antenna systems. It has two novel self-similar fractal planar monopole elements. A ground stub of T-shape is placed vertically between monopole elements for proper matching. The antenna has a ground plane with Koch fractal geometry to achieve miniaturization and wideband performance. In 2002, Federal communication commission (FCC) authorized to use unlicensed frequency spectrum from 3.1 to 10.6 GHz. But reflection and diffraction cause multipath fading problem between two antennas in UWB system. 2 MIMO system contains multiple antennas, which improve channel capacity and system reliability. Fractal gives the opportunity to design small and wideband antennas in restricted space because of its space- filling, self-affine, and self-similar properties. There is an increment in electrical path length when the fractal geometry is designed in a given small area. Various UWB antennas are designed using fractal geometries. Thus a self similar fractal structure is designed using Iterated Function System (IFS).

The square shaped two element monopole MIMO antennas are given which used a T-shaped and a cross-shaped9 ground stubs to enhance isolation better than 15 dB. Orthogonal placement of both the antenna elements with an L-shaped ground stub improves isolation by 15 dB .The Koch fractal geometry used to achieve miniaturization and wideband performance. From above-mentioned designs the proposed size is of 24 × 32 = 768 mm2. The remaining article is arranged as follows: The proposed antenna dimensions and generation steps are explained in Section 2. Section 3 shows the ground stub of T-shape on MIMO antenna performance. Section 4 show images of a prototype of proposed antenna with characteristics such as S-parameters, radiation patterns, and realized gain. Section 5 concludes the article.

II. Antenna Parameters and Configuration:

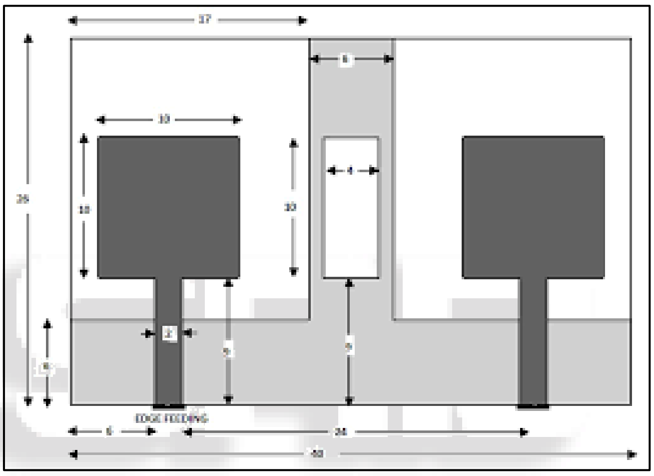

Fig. 1: Geometry of proposed antenna

Figure 1 shows the geometry of a novel self-similar fractal UWB MIMO antenna. The size of this antenna is 24 × 32 mm2. It is designed on FR4 substrate with dielectric constant, loss tangent, and height of 4.2, 0.02, and 0.75 mm, respectively, using simulation tool CST software. A ground stub of T-shape is placed vertically between monopole elements for proper matching. To improve isolation, a vertical slot is then cut in the ground plane. Table below lists the dimensions of the proposed self-similar fractal MIMO antenna and these dimensions are used to fabricate the prototype of the antenna .Fractal means irregular or broken fragments. The self-similar fractal structure is used in the antenna design because it provides desired miniaturization and wideband characteristics. Then the rectangle is scaled by a factor of four in both horizontal and vertical directions, creating 16 small rectangles, out of which four central rectangles removed. The metallic area of single rectangular monopole element is 7 × 9.5 = 66.5 mm2 at zero iteration, which is reduced to 46.757 mm2 by cutting slots. It is observed that metallic area of self-similar fractal monopole elements is reduced by 29.68%. .

III. STUDY OF MIMO ANTENNA PERFORMANCE

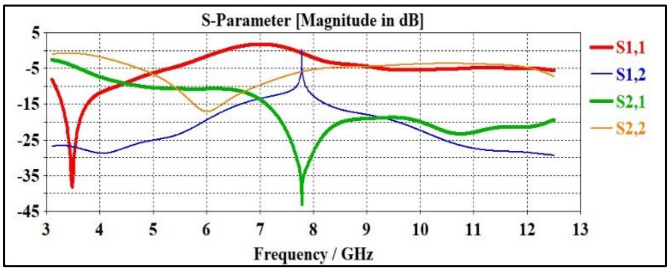

Fig. 2: S-Parameters results

The T-shaped ground stub provides better matching and enhancing isolation. A ground stub of T-shape is placed in-between the two self-similar fractal planar monopole elements as shown in Figure 2. The simulated results of S-parameters for the self-similar fractal MIMO antenna with ground stub of T-shape are in Figure 3. It is observed that lower cut-off frequency of S11 is changed from 4.37 to 3.23 GHz by using a T-shaped stub. It happens because the T-shaped ground stub is acting as a reflector. The mutual coupling, S12 should be less than or equal to −15 dB for MIMO antennas. S12 is suppressed below −15 dB by using a T-shaped ground stub for the entire operating frequency band. The ground slot cut to enhance isolation, Surface current distribution is observed to determine mutual coupling among the antenna elements of MIMO antenna. The direction of current flow is observed to know the amount of mutual coupling between antenna elements. It is observed that sufficient amount of current is coupled toward the T-shaped ground stub and ground slot, leading to reduction of surface current at second fractal monopole element. This results in less mutual coupling between the ports.

IV. RESULTS AND DISCUSSIONS

It is observed that measured and simulated S-parameters are comparable. The impedance bandwidth of proposed antenna is 9.4 GHz, which is ranging from 3.1 to 12.5 GHz (fractional bandwidth of 120.51%) with mutual coupling, S12 below −16 dB. Thus, proposed antenna is desirable for UWB applications. The E plane and H plane results are shown below

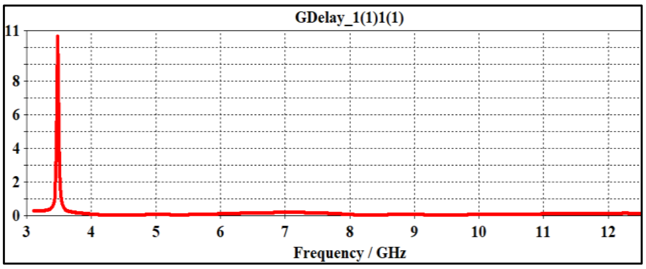

Fig. 3: Group delay

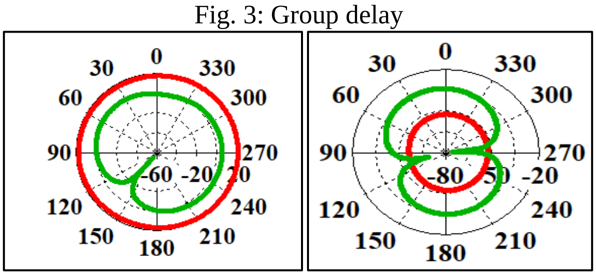

Fig. 4: Radiation pattern at 3.4854 GHz

V. CONCLUSION

A novel compact self-similar fractal UWB MIMO antenna with a size of 24 × 32 mm2 is designed. The two self-similar fractal geometry monopole elements are used to achieve UWB operations in the range of 3.1-12.5 GHz with a fractional bandwidth of 120.51%. The metallic area of monopole elements is reduced by 29.68% . A ground stub of T-shape with vertical slot enhances isolation better than 15 dB at the operating frequency. The various diversity performance parameters are also determined. There is good agreement between measured and simulated results, which confirms that the proposed antenna is acceptable for UWB applications.

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