Using Hilbert Curve Slot for Bandwidth Enhancement of Microstrip Patch Antenna

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***Abstract*—A standard microstrip patch antenna has narrow bandwidth thus making it inappropriate for many wireless communication systems. Therefore in this paper we present imprinting of Hilbert curve slot on patch antenna to analyze its effects on the bandwidth. Multiple iterations of Hilbert curve are being implemented and relationship between the iterations and bandwidth is studied. It is observed that increase in iteration will result in increase in bandwidth. As the number of iterations increase the total area of the slot decreases, whereas the length of the slot remain the same within the area. The simulated result depicts that -10 dB bandwidth is achieved at 2.4 GHz which is the operable frequency of WLAN and Bluetooth.**

***Index Terms*—Bandwidth Enhancement, Hilbert curve, Microstrip Patch Antenna, Slot Antenna.**

I. Introduction

THE microstrip patch antenna has gained importance since they can be easily fabricated and are small in size. One of the problems with microstrip patch antenna is that they do not support high bandwidth. There are two major factors which affect the bandwidth of a microstrip patch antenna; these are substrate height and dielectric constant of the substrate. However, with the restriction of available substrates, we can still increase the bandwidth by introducing slots in the conducting plane of the antenna.

In this paper we make the use of a Hilbert curve slot to analyze its effect on the bandwidth. The antenna under observation was developed in three stages. At each stage an iteration of the Hilbert curve slot was introduced in the patch. It has been observed that as the iteration increase, the bandwidth also increases. Fig. 1 shows the first four iterations of Hilbert curve.

Through simulated result we can observe that the bandwidth has significantly increased at the operable frequency of 2.4 GHz as compared to a conventional microstrip patch antenna. The achieved bandwidth is 143 MHz which is four times the bandwidth of a standard microstrip patch antenna.

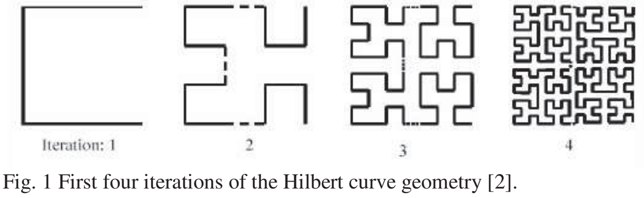

Fig. 1 First four iterations of the Hilbert curve geometry [2].

II. Survey of Related Works

The use of fractal geometry in microstrip patch antennas results in their economical miniaturization [1]. When implementing a Hilbert curve antenna the resonant frequency decreases and the bandwidth reduces as the iterations increase [2]. By using fractal geometry and implementing different feeding techniques, it is observed that the size of the antenna reduces and bandwidth narrows [2]. A mathematical modelling of Hilbert curve space filling geometry is proposed to predict the multiple resonance frequency [3].

III. Problem Statement and Main Contribution

There are a number of design configurations available for microstrip patch antenna but they do not have enough bandwidth to support the modern wireless communication systems.

We would like to know the effect of implementing a Hilbert curve slot and increasing its iterations on the bandwidth of microstrip patch antenna. We propose using a Hilbert curve fractal slot in the conducting plane to enhance the bandwidth of the patch antenna. One solution for increasing the bandwidth is by doing iterations in the slots in the radiating patch.

In order to perform analysis the main contribution is to observe the effect of Hilbert curve fractal slot on microstrip patch antenna, and carry out simulations using AWR Microwave Office v.8.0.

IV. Problem Solution

In order to increase the bandwidth we propose using a Hilbert curve fractal geometry slot on the radiating patch. The novelty of Hilbert curve geometry is that it is a space-filling curve which means that as the iterations increase the area of the slot decreases while the length of the slot increases.

A. *Modeling*

The proposed design consists of a rectangular patch on FR4 substrate having dielectric constant 4.7, and of thickness 1.6 mm. The dimensions of the radiating patch are calculated using the standard formulae, and thus the dimensions of the radiating patch are (56×56) mm. A standard (3×17) mm transmission line is used to excite the patch. Fig. 2 shows the third iteration of the proposed antenna. The design is made by adding iterations in the slot which help to enhance the

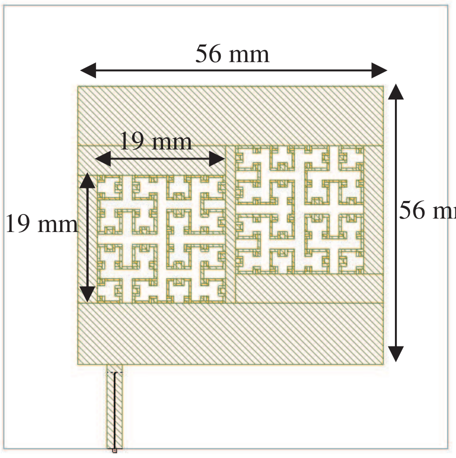

Fig. 2 Design of third iteration of Hilbert curve slot.

bandwidth. For Hilbert curve L shows the total length of the slot, n is the number of iteration, d is the length of each line segment and S is the sum of line segment. The formulas used for designing Hilbert curve are as follows [2]:

$$d = \frac{L}{2^n - 1}, \quad (1)$$

$$S = \left(2^n + 1\right)L, \quad (2)$$

Initially a (19×19) mm square slot is considered and iterations are increased in this slot by using (1) and (2).

B. *Implementation*

We used AWR Microwave Office to design the proposed antenna. The designed antenna was made in three phases and in each phase an iteration of the Hilbert curve is increased to observe the effect of iteration on the bandwidth of the antenna.

C. *Validation*

Fig. 3 depicts the return loss achieved in three iterations of the Hilbert curve slot, from which we can analyze that as the iterations increase the bandwidth of the antenna also increases at the resonating frequency of 2.4 GHz. The bandwidth for iteration 1 is 102 MHz which is 4.25%, for iteration 2 we get 127 MHz which is 5.3%, and for iteration 3 we get 143 MHz which is 6% of the resonant frequency.

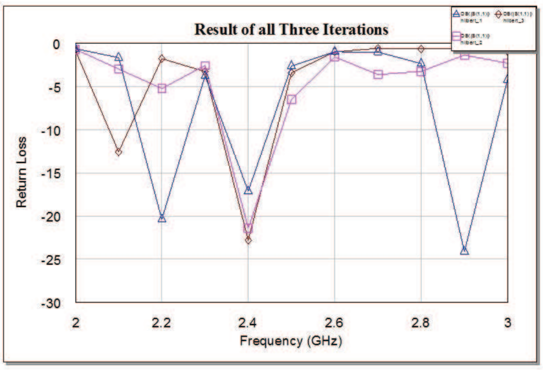

Fig. 3 Graph of return loss of all three iterations of Hilbert curve slot antenna

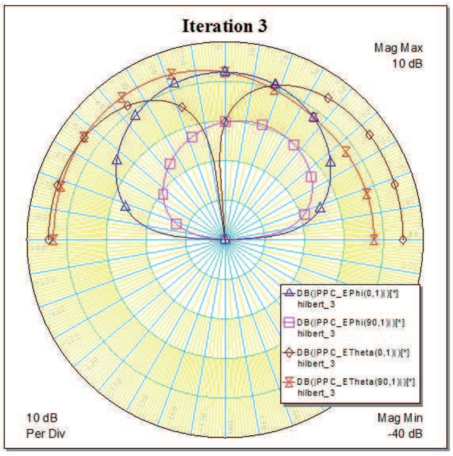

Fig. 4 Radiation pattern of third iteration

Fig. 4 is the radiation pattern of the third iteration of the proposed antenna at 2.4 GHz. It is observed from the radiation pattern that the antenna acts as a monopole because the antenna has a ground plane which prevents it from radiating backwards.

V. Conclusion

Hilbert fractal geometry has been implemented on a microstrip patch antenna to study its effect on bandwidth.

From the proposed technique it is observed that by adding a Hilbert curve slot in mictosrtip patch antenna and doing iterations one can achieve enhanced bandwidth. The simulated results in this paper show that after third iteration the achieved bandwidth is 143 MHz at the operable frequency of 2.4 GHz, which is four times more than standard Microstrip patch antenna.

The antenna presented here can easily be used for wireless communication systems such as Bluetooth and WLAN as it provides enough bandwidth to achieve an appreciable data rate.

For future work one can see the effect of further increasing iterations of Hilbert curve slot. The geometry of antenna can also be altered to optimize it for multiband operation to make it usable for multiple wireless communication systems. The effect on bandwidth of the designed antenna can also be observed by using different feeding technique such as coaxial probe or aperture coupled feed.

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