Chapter 3
Design and Analysis of an UWB Printed Monopole Antenna with Hilbert Curve Fractal Shaped Slots for Multiple Band Rejection Functionality

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ABSTRACT

In this chapter, a compact dual band notched Ultrawideband (UWB) antenna with fractal shaped Hilbert curve slots (HCS) is presented. The antenna covers the frequency band from 2.5 GHz to 12 GHz for VSWR≤2 and also shows stable radiation patterns throughout the operating frequency band. By introducing Hilbert Curve fractal Slots (HCS) in the antenna, band notch characteristics have been achieved. The HCS renders the capability to reject 5.15-5.825 GHz band assigned for IEEE 802.11a and HYPERLAN/2 and also 7.9-8.4 GHz band assigned for X-Band uplink satellite communication systems where the gain is suppressed very well in the desired WLAN and X-Band. The antenna gain varies from 3dBi to 5dBi over the operating band. Novelty of this design lies in achieving miniature notch structure which has higher degree of freedom for adjusting notch parameters and unsusceptible to coupling with other notches. The antenna can be used for various mobile communication services such as DCS, IMT-2000, UMTS, DMB and UWB.

INTRODUCTION

The inspiration for the development of fractal geometry (Sagan, 1994) came largely from an in depth study of patterns from nature. Fractals have been successfully used to model such complex natural objects like cloud, galaxies, mountain ranges, coastlines, trees, leaves, ferns and much more. Mandelbrot realized that it is very often impossible to describe nature using only Euclidian geometry in terms of

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straight lines, circles and cubes. He coined the term ‘fractal’ about 20 years ago in his book named ‘The fractal geometry of nature’ (Sagan, 1994). He proposed that fractals and fractal geometry could be used to describe real objects such as trees, lightening, river meanders and coastline and so forth. Recent efforts by several researchers around the world have combined fractal geometry with electromagnetic theory which have led to a plethora of innovative antenna designs (Karmakar, Verma, Pal, & Ghatak, 2012; Jahromi, Falahati & Edwards, 2011; Azad & Ali, 2005; Bor, Lu, Liu & Zeng, 2009; Chi, Chen, Wei, Lien, Hung, Bor & Chen, 2013; McVay, Engheta & Hoorfar, 2004) and led to an era of fractal antenna engineering which is primarily focussed in two broad areas: the design of fractal antenna elements and the application of fractal to the design of antenna arrays.

The adopted term Ultrawideband (UWB) in 1989 by the U.S department of defence has re-emerged the century-old concept for modern applications. The release of the 7.5 GHz unlicensed spectrum by the U.S. Federal Communications Commission (FCC 02-48, ET-Docket 98-153, 2002) for commercial usages, sparked a renewed interest of UWB in industries, universities and governments. In recent years, research in the area of Ultrawideband (UWB) system has generated a lot of interest among microwave engineers. February 2002 witnessed the allocation of the frequency band between 3.1 GHz to 10.6 GHz and the Equivalent Isotropic Radiated Power (EIRP) less than -41.3 dBm/MHz for the unlicensed indoor UWB wireless communication system which sparked a renewed interest in industries, universities and governments. According to the released regulation, UWB technology which is based on transmitting ultra short pulses with duration of only a few nanoseconds or less, has received great attention in various fields for the short-distance (< 10 m) wireless communications. Because of the ultra-wideband property, UWB technology has many benefits which are enlisted below.

- High data rates and large channel capacity
- Immunity to multipath interference
- Low complexity and minimal cost
- Low power consumption
- Coexistence with other wireless communication systems

The reasons causing high data rates in UWB are high signal power and low noise power. The maximum achievable data rate for ideal band limited additive white Gaussian noise channel (AWGN) is related to the bandwidth and signal to noise ratio (SNR) by Shanon-Nyquist criterion as shown in (1):

$$C = B\log_2(1 + SNR) \tag{1}$$

Where, *C* (b/s) is the maximum transmit data rate, *B* (Hz) the channel bandwidth. Consequentially, the transmit data rate can be increased by increasing the signal bandwidth and SNR. However, the transmit power cannot be readily increased because most of the portable devices are battery powered and also potential interference with other existing systems should be avoided. Thus a large signal bandwidth is the only solution to achieve high data rate. The major advantage of the UWB communication system is to use the large bandwidth which also is capable of working in harsh communication channels with low SNR. Thus, these conditions offer a large channel capacity which causes high data rates. UWB communication has excellent immunity to multipath interference. Impulse signals have low susceptibility to multipath interference in transmitting information in UWB communication system because the