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REGULAR PAPER

A high gain ultra-wideband monopole antenna

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ABSTRACT

This article deals with an ultra-wideband monopole antenna. It is composed of a circular ring shaped radiation element fed by microstrip line and hexagonal shaped ground plane. The simulated and measured results are in good agreement for the antenna's reflection coefficient, gain and radiation pattern. The antenna exhibits 154% impedance bandwidth with a maximum gain of 8 dBi.

1. Introduction

Ultra-wideband (UWB) wireless communication technology has been receiving wide attention from both academy and industry since the Federal Communication Commission (FCC) released of the frequency band from 3.1 to 10.6 GHz for commercial communication applications in February 2002 [1]. In an UWB system, the UWB antenna is one of the most important components and has attracted significant research power in the recent years. The wide-band antenna is simpler than dual-band or triple-band designs of narrow-band elements, which tend to get complicated and may be prone to proximity detuning in some circumstances. Also, some systems may demand more than triple-band operation. Ultra-wide-band (UWB) antenna is an attractive alternative in these cases. Moreover, ultra wideband is an emerging new technology for broad-band internet access and public safety applications, employing the spectrum in the region of 1.9 GHz to 10.6 GHz at extremely low power levels. The planar monopole antenna was first reported in 1976 by Dubost and Zisler [2] and planar disc antennas have been recently studied [3]. The dependency of the impedance band-width on feedgap separation has been analyzed [4] and the method of moments (MoM) employing a wire-grid and finite-gap voltage-feed has been shown to approximate the antenna behavior. Simple formulae have been proposed to determine the lower edge frequency for various planar geometries [5,6]. The bandwidth has been increased by adding a shorting post [7] and the use of planar bow-tie geometries have also been examined [8]. The use of parasitic elements has also been investigated [9,10] and the effect of employing various bevel angles on one or both sides of the feeding probe has been shown to significantly increase the impedance band-width [11].

In this paper a simple monopole antenna with circular ring patch on a hexagonal ground plane has been presented. The circular ring radiating patch is fed using microstrip line. This monopole antenna can radiate theoretically and practically at the frequency ranges of 1.94 GHz to 13.84 GHz and 1.82 GHz to 12.25 GHz, respectively, being the theoretical and practical percentage bandwidth of this antenna 151% and 154%, respectively. The minimum return loss between this frequency range is −40 dB. The bandwidth at −10 dB is more than 10 GHz. Simultaneously a gain with maximum value of 8 dBi and broad band with percentage bandwidth of 154% is achieved by this monopole antenna.

2. Antenna design

Fig. 1 shows the configuration of the proposed monopole antenna. The proposed antenna is designed using low cost glass epoxy(FR4) substrate material having thickness (h) of 1.6 mm, permittivity $\in_r = 4.4$. The proposed antenna consists of circular ring shaped radiating patch on the hexagonal ground plane. Dimensions of the radiating plane and ground plane in detail are mentioned in Table 1. These optimized dimensions are obtained after a good number of simulations with different dimensions.

The width of the circular ring patch is 5 mm. For better matching of input impedance; this radiating patch is placed in that position with respect to ground plane of the antenna which is shown in Fig. 1. The shapes and dimensions of the antenna are chosen after considering a lot of steps. First shape of the ground plane was considered as rectangle with different dimensions including 48 mm × 32 mm as one of them. The result with rectangular shapes for the case of 48 mm × 32 mm dimension is noted as shown in Fig. 3. However considering fractal concept when rectangular ground plane is

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Table 1
Specifications of antennas.

Ground plane dimension	*a*	*b*
	24 mm	20 mm
Patch dimensions	*c*	*d*
	24 mm	14 mm

modified to hexagonal one it exhibits better result. Dimensions of hexagonal ground plane have been optimized to exhibits best gain and bandwidth by several simulations. Next to choose the particular dimensions of ring shape radiating patch, different dimensions of diameters and widths are considered and results are noted in Figs. 4 and 5. From the curve it is clear that the optimized dimensions of the ring have been selected. The patch was fed by a strip line of dimensions 3 mm × 35 mm. The layout of the antenna has been drawn in Ansoft software designer. Simulated results have been obtained using the same Software.

The proposed monopole antenna has been fabricated on an FR-4 substrate. Though loss is high at high frequencies for FR4 substrate, still we have to choose the substrate as it is easily available for fabrication in our locality. However simulation with a low loss substrate has been done for comparison. Results are almost in agreement. Fig. 2 shows the photograph of the fabricated monopole antenna.

3. Measurement

The gain measurement of the fabricated monopole antenna is performed using a standard microwave test bench. The designed antenna is placed in receiving position. The transmitting horn antenna is connected to an Agilent microwave source. The designed

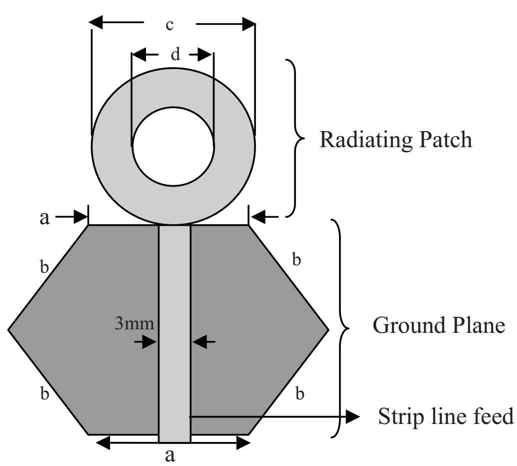

Fig. 1. Design of the proposed antenna.

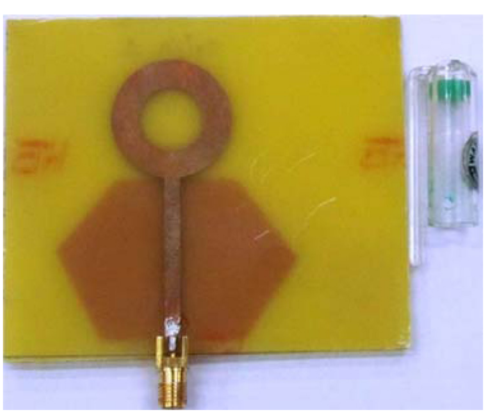

Fig. 2. Fabricated antenna.

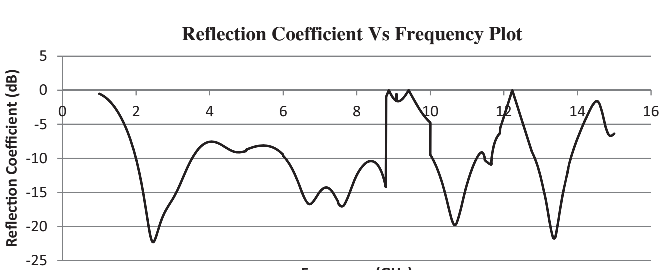

Fig. 3. Theoretical reflection coefficient vs frequency plot for rectangular ground plane (dim. 48 mm × 32 mm).

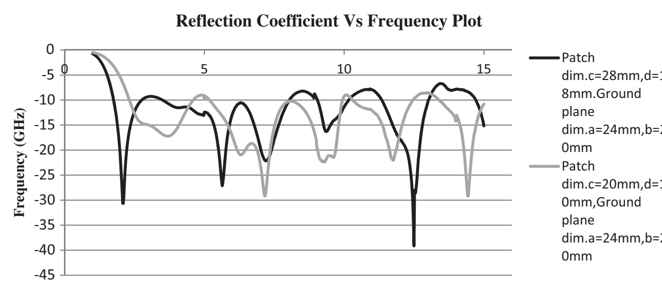

Fig. 4. Theoretical reflection coefficient vs frequency plot for different dimension of patch.

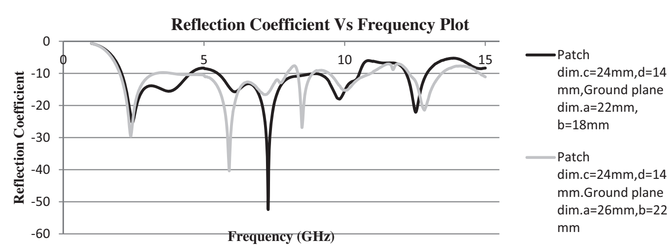

Fig. 5. Theoretical reflection coefficient vs frequency plot for different dimension of ground plane.

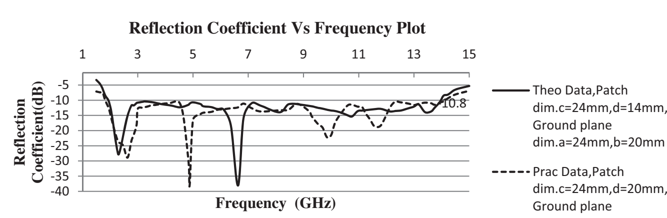

Fig. 6. Theoretical and practical reflection coefficient vs resonant frequency plot.

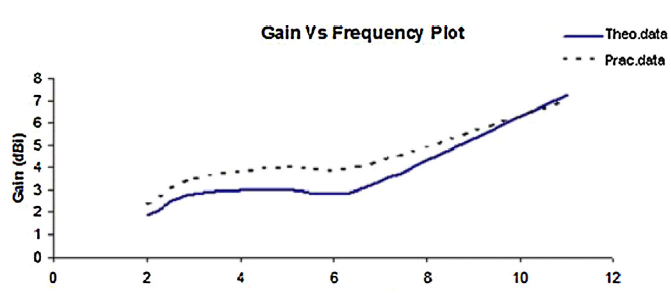

Fig. 7. Theoretical and practical gain vs frequency plot.