A Tree Shaped Monopole Antenna for GPR Applications

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***ABSTRACT*—In this paper, a UWB monopole antenna for GPR applications is presented. The antenna offers a large bandwidth from 250 MHz to more than 6 GHz and is relatively compact in size (20 cm x 22.5 cm) than other antennas operating in same frequency range. The time domain performance of this antenna is also analyzed for use it in impulse based radar systems. A prototype of antenna was manufactured and tested to validate simulation results.**

I. Introduction

In last few years, the latest wireless networks and high-resolution radar systems requires ultra-wide band (UWB) technology. UWB is vital requirement for modern high-resolution radar systems such as Ground Penetrating Radar(GPR). Its main principle is to generate a short duration pulse resulting in a large bandwidth in frequency domain.

GPR technology is used for detection of buried objects underneath the earth surface like cables, pipes, and hidden tunnels. There are two types of GPR systems are: (i) Impulse GPR system that works in time domain by generating a small duration impulse, (ii) Continuous Wave GPR System that works in frequency domain [1]. Impulse Radar systems have low design complexity and cost that is why they are used in most of the commercial GPR applications. For a GPR system ultimate perfromance also depends on characteristic of transmitting and receiving antennas especially in case of impulse GPR systems [2]. UWB antennas are required for better resolution and more penetration in earth surface. Different types of GPR antennas exist in literature including TEM horn antennas, bow-tie antennas, arm folded dipoles, and loaded dipole antennas because of their planner structures providing large bandwidth [1–3]. In recent years, some planner design for GPR antennas have been proposed that are providing better UWB performance in spite of their simple, light weight and low cost structure such as circular disc monopoles [3], mickey mouse monopole antenna [4] and tapered slot antennas (TSA) [5], [6].

This paper presents a modified tree shaped monopole antenna design for GPR applications operating at as low as 250 MHz, and providing a very large bandwidth from 250 MHz to 6 GHz and comparatively compact in size (20 cm x 22.5 cm) as compared to other antenna designs operating in same frequency range for GPR applications.

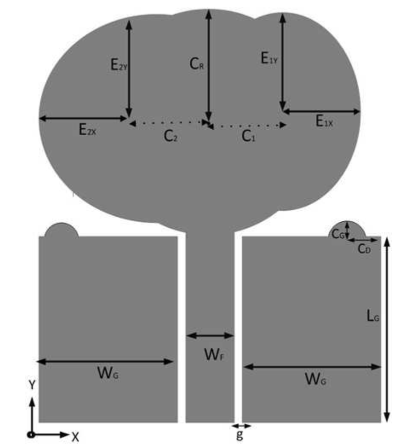


Fig. 1 Geometry of proposed GPR Antenna

TABLE I Antenna Dimensions

Antenna Parameters	Values (cm)
L_G	10.7
W_G	8
L_F	10.7
W_F	2.8
E_{1X}	5.7
E_{1Y}	4.5
E_{2X}	6.8
W_{2Y}	6
C_R	6.5
C_1	4.3
C_2	3
C_G	1
C_D	1.5
g	2

II. Antenna Configuration

The UWB antenna is composed of a circular patch antenna with coplanar waveguide feeding technique. The complete structure of the proposed GPR antenna is shown in Fig. 1.

Fig. 2 Measurement of reflection coefficient using network analyser

The antenna is constructed on FR4 substrate with relative permittivity of 4.3 having thickness of 1.5 mm. The complete proposed antenna looks like a tree, composed of intersection of one circle and two ellipses. This shape helps in lowering down operating frequency and hence increasing operating bandwidth without significant increase in physical antenna size. Other dimensions of antennas are listed in table I. The antenna is simulated using CST software. A prototype of antenna is manufactured and tested using vector network analyzer as shown in Fig. 2.

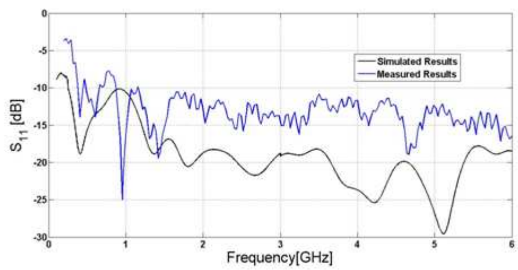


Fig. 3 Reflection coefficient S_{11} [dB] of the fabricated antenna

III. Results

The reflection coefficient S_{11} in dB of the proposed antenna is shown in Fig. 3, which clearly depicts that this antenna works in frequency range from 250 MHz to more than 6 GHz. The time domain characteristics of antenna can be evaluated by applying a plain wave in form of amplitude modulated Gaussian pulse on the antenna as shown in Fig. 4. It is clear that time duration for simulated input signal is 0.5 ns and has some minor reflections. The two-dimensional radiation pattern of this antenna at 0.5 GHz and 1.5 GHz are shown in Fig. 5 for YZ plane ($\phi = 90°$) and XY plane ($\theta = 90°$). The proposed antenna has omni-directional radiation pattern and it is not changed significantly by changing frequency. The radiation pattern can be made directional by placing a metal reflector at suitable distance from the antenna.

IV. Conclusion

In this paper, a new UWB GPR antenna has been proposed for GPR applications. The antenna has a bandwidth of 250 MHz to 6 GHz and is a good candidate for GPR applications.

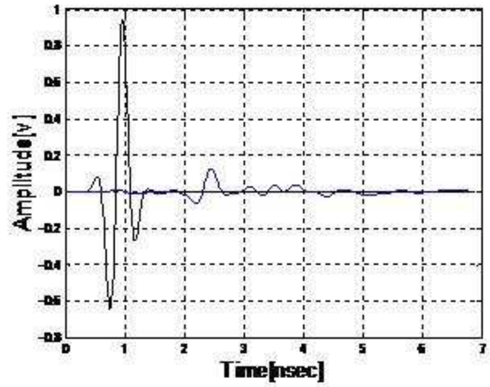
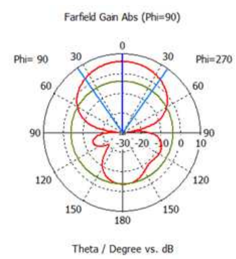
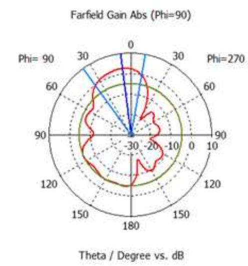


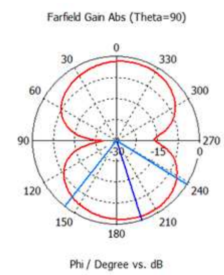
Fig. 4 Simulated time domain performance of the proposed antenna



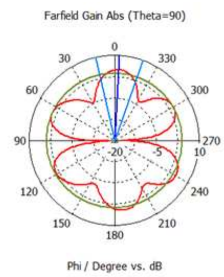
(a) 0.5 GHz



(b) 1.5 GHz



(c) 0.5 GHz



(d) 1.5 GHz

Fig. 5 2D radiation pattern for YZ plane ($\phi = 90°$) and XY plane ($\theta = 90°$) for 0.5 GHz and 1.5 GHz

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