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Analysis of novel small antenna for wideband transmission

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Abstract

Electrically small antennas have been an important part of communications engineering since the beginning. Whether they are small compared to the extremely long wavelengths used at the lowest radio frequencies, or intended to save space in GHz-range wireless devices, the basic principles are the same. This paper introduces antenna designs for Ultra Wideband 3.1-10.6 GHz communications. The inherent potential of Ultra Wideband systems and techniques for use in communication was demonstrated in various ways by many researchers in the past. An effort made in the direction of utilizing the entire wideband spectrum is presented through this paper. The antenna exhibits a -10 dB return loss bandwidth over the entire frequency band. The antenna is designed on FR4 substrate. The proposed antenna designs and performances are analyzed using a soft High Frequency structure Simulator (HFSS).

Keywords: Antenna and Wideband Transmission

Introduction

Most readers will be familiar with several common uses of small antennas. Loop antennas and short monopoles (whip) for medium wave (AM broadcast) reception are common in home and vehicle entertainment systems. With wavelengths in the 200 to 600 meter range, these antennas far exceed the $A/10$ criterion. Antennas for FM and television broadcast reception are sometimes reduced in size for convenience and portability.

Most of the existing systems permit narrowband operations since they cover only a fraction of the entire spectrum. Narrowband systems concentrate all of their power in fairly narrow channels. Due to the narrow bandwidth it is not possible to achieve high speed and high data rates to carry out communication [1]. The possible remedy is the use wide bandwidth. The word 'ultra-wideband' (UWB) commonly refers to signals or systems that have large bandwidths. Ultra Wideband is defined as any communication technology that occupies greater than 500 MHz of bandwidth, or greater than 25% of the operating centre frequency.

Although the research in UWB radio and Communication gained significant momentum in late 1999 [2], this technology dates back to more than a century. Electromagnetic communication actually started with UWB. In the late 1800s, the easiest way of generating an EM signal was to generate a short pulse: a spark-gap generator was used by Hertz in his experiments and by Marconi for the first EM data communication. Thus, the first practical UWB systems are really more than 100 years old [3]. However, after 1910, the general interest turned to narrowband communications and UWB research fell dormant. Ultra-wideband communication received renewed interest in the early 1970s. At that time it was called 'baseband' or 'carrier-free' communication. Around 1973, it was recognized that short pulses, which spread the signal over a large spectrum, are not significantly affected by the existing narrowband interferers, and do not interfere with them, either limited mostly to the military sector.

Frequency regulators all over the world assign narrow frequency bands to specific services and/or operators. UWB systems violate these frequency assignments as they emit radiation over a large frequency range, including the bands that have already been assigned to other services. A major concern for the frequency regulators was that the emissions from UWB devices would interfere with the other services [4]. The Federal Communications Commission (FCC) finally allocated. The 3.1-10.6 GHz spectrum used for Ultra Wideband (UWB) radio applications, in February 2002. This momentum shift presented a myriad of exciting opportunities and challenges for design in the communication arena, including antenna design [3]. Recognizing this trend early on, the Institute of Electrical and Electronics

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Engineers (IEEE) established a working group (IEEE 802.15.3a) with a task of standardizing a physical layer for high throughput wireless communications based on UWB. Thus, began a new era in the ultra-Wideband communication.

The UWB technology has undergone remarkable achievements during the past few years. In spite of all the promising prospects featured by UWB, there are still challenges in making this technology live up to its full potential. One particular challenge is the UWB antenna. In recent years, many varieties of UWB antennas have been proposed and investigated. They present a simple structure and UWB characteristics with nearly Omni-directional radiation patterns. However, for some space-limited applications, UWB antennas need to feature a compact size while maintaining UWB characteristics. The objective is to design and evaluate performance a compact sized antenna that operates in ultra-wideband range [5]. Several factors need to be considered while designing the antenna, including bandwidth, directivity, polarization, power gain, radiation pattern and return loss. The whole project can be divided in two parts - antenna simulation and measurement. The software HFSS would be used to simulate the proposed antenna. The simulated results would then be compared with the measured results of the practically fabricated antenna.

Antenna geometry

The geometry and parameters of the circular ring antenna are shown in Fig. 1. The antenna is supported by a dielectric substrate of a height equal to and a relative dielectric constant of 4.4 and dielectric loss tangent equal to 0.02. This UWB antenna has a structure similar to the micro strip patch antenna, it consists of three layers: the top is a radiator; the middle is a substrate with dielectric constant; the bottom is an etched ground plane. This type of antenna can easily be integrated into system circuits for a compact design and fabricated at a very low manufacturing cost. This antenna is optimized to cover UWB Bandwidth and to miniaturize the antenna size. The feed line is 3.5-mm wide for a characteristic impedance of 50 ohms. The patch is a circular with radius 9 mm. The rectangular part of the ground plane is 25mm×5mm. The result have been shown with the effect of ground plane keeping the operating frequency same. In S11 Parameter plot, Fig (2) has operating frequency of 7 GHz with ground plane along Y-axis is 5mm for which the simulated result is below -10 db for complete band. But in Fig. (3) and Fig. (4) as the ground plane changes the simulated result below -10 db is not for complete band. In VSWR Parameter, Fig. (5) Shows VSWR 1 at 5GHz, VSWR 0 for 7 GHz. Approximately VSWR is less than 2 for complete band. In Fig. (6) and Fig. (7), VSWR Changes with the change in ground plane.

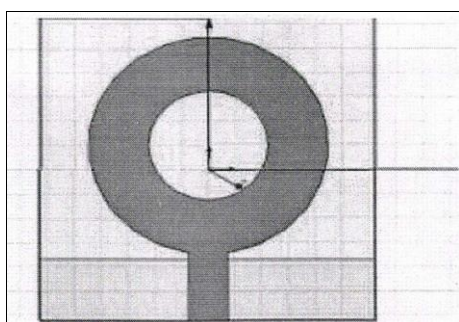


Fig 1: Circular Ring Antenna

Simulated result
A) S11 Parameter

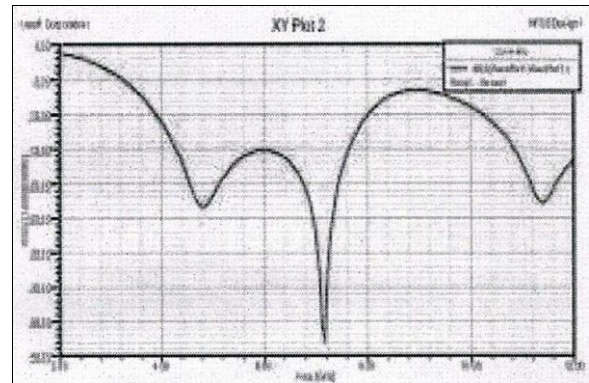


Fig 2: S11 parameter with ground plane 5mm

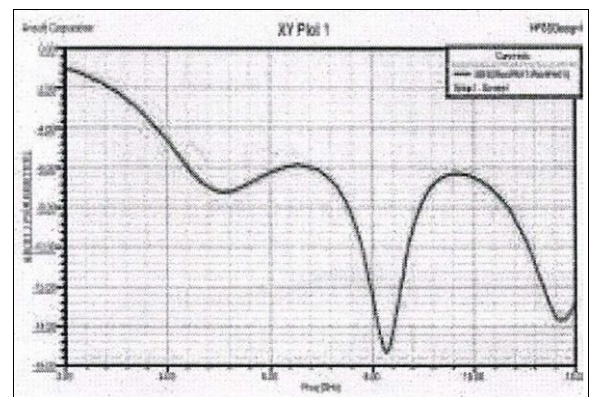


Fig 3: S11 parameter with ground plane 7mm

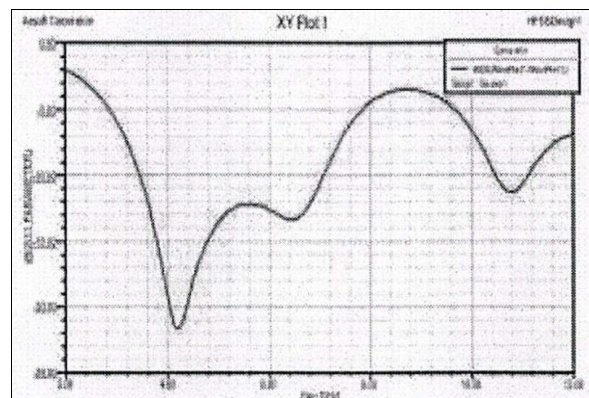


Fig 4: S11 parameter with ground plane 3mm

B) VSWR

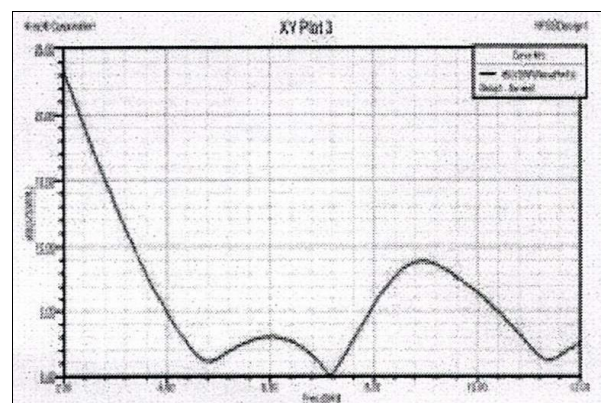


Fig 5: VSWR parameter with ground plane 5mm

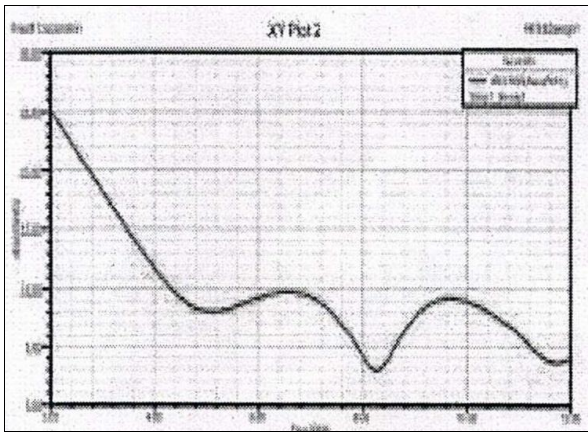


Fig 6: VSWR with ground plane 3mm

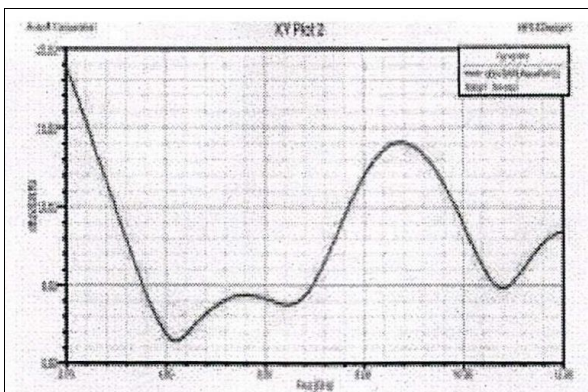


Fig 7: VSWR with ground plane 3mm

Conclusion

In this paper, the designed antenna has simple configurations and is easy to fabricate. It is demonstrated by simulation that the proposed antenna can yield an ultra-wide bandwidth, and that the radiation patterns are nearly Omnidirectional over the entire 10 dB return loss bandwidth. Here s11 parameter is obtained at 7GHz for the complete band from 3 GHz to more than 1. 0GHz. VSWR obtained is 1 at 5GHz and 0 for 7 GHz. Gain is 0db at 7GHz.

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