Progress In Electromagnetics Research, PIER 68, 161–167, 2007

CIRCULAR SLOT WITH A NOVEL CIRCULAR MICROSTRIP OPEN ENDED MICROSTRIP FEED FOR UWB APPLICATIONS

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Abstract—This paper presents the study of a circular slot antenna for ultrawide-band (UWB) applications. Antenna is fed by a circular open ended microstrip line. The frequency band considered is from 4 to 14 GHz, which has approved as a commercial UWB band. The proposed antenna has a return loss less than 10 dB, phased linear, and gain flatness over the above a frequency band.

1. INTRODUCTION

With the definition and acceptance of the ultrawide-band (UWB) impulse radio technology in the USA [1], there has been considerable research effort put into UWB radio technology worldwide.

Recently, the Federal Communication Commission (FCC)'s allocation of the frequency band 3.1–10.6 GHz for commercial use has sparked attention on ultra-wideband (UWB) antenna technology in the industry and academia. Several antenna configurations have been studied for UWB applications [2–6]. It is of a particular interest to design a compact antenna with good impedance matching

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characteristics over the whole UWB frequency range. Also, gain flatness and phase linearity are required for UWB antennas to suppress distortion waveforms.

Printed slot antennas have attracted much attention due to their low profile, lightweight and ease of integration with monolithic microwave integrated circuit (MMIC). However, their narrow bandwidth is a drawback.

Several techniques on bandwidth enhancement of the slot antennas have been reported, such as surface meandering, aperture coupled patches, or near frequency resonators [7]. These techniques increase the bandwidth up to several tens percent. One may think about increasing the substrate height, but this implies the appearance of surface waves, which reduce considerably the antenna efficiency. In this paper, we propose a new circular slot antenna fed by a circular open ended Microstrip line. Experimental prototype is designed, fabricated, and measured.

This paper is organized as follow. Section 2 presents the configuration of proposed antenna. Simulation and experimental results are presents in Section 3. Finally, section 4 concludes the paper.

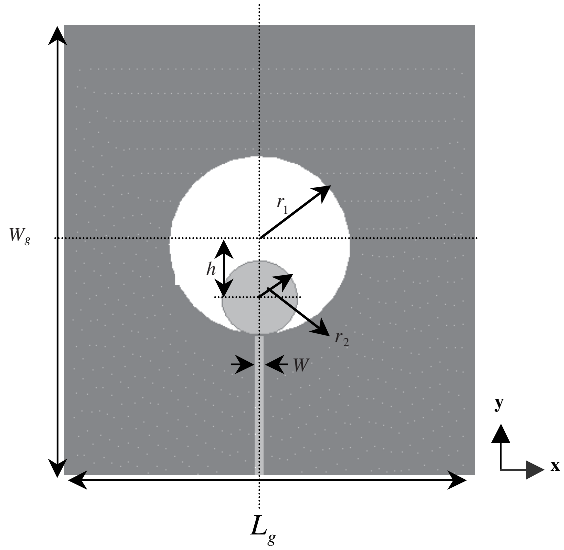
2. ANTENNA CONFIGURATION

Based on the idea presented in [3] for CPW circular slot, the circular slot antenna is developed. The geometry and photograph of the proposed antenna with its parameters is depicted in Fig. 1. The antenna is located in the xy plane and the normal direction is parallel to the z axis. The radiation element consists of a circular slot with a radius of r_1 that fed by a circular open ended microstrip-line with a radius of r_2. Circular open ended microstrip-line is connected to a 50Ω main line having dimensions $W_1 = 1.25\,\text{mm}$. The proposed circular slot antenna was fabricated on a $500\mu\text{m}$, RO4350B substrate with a dielectric constant of 3.4, loss tangent of .003, and ground plane size of $L_g \times W_g = 10\,\text{cm} \times 10\,\text{cm}$.

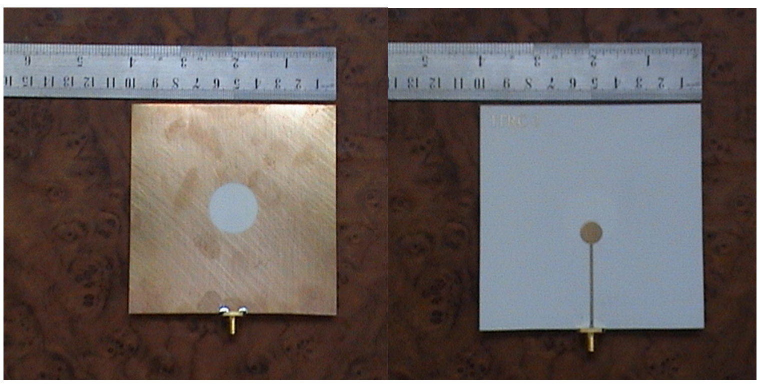
3. SIMULATIONS AND EXPERIMENTAL

3.1. Return Loss

Fig. 2 shows the simulated and measured return loss in terms of frequency for the designed antenna (with dimensions presented in Table 1). The structures are simulated with IE3D which utilized the moment method for electromagnetic computation. Also the return



(a)



(b)

Figure 1. (a) Antenna geometry, (b) Photograph — left handed: circular slot, right handed: feed network.

loss is measured by the Agilent 8722ES Network Analyzer (50 MHz–40 GHz).

As it is observed, there is a good agreement between numerical and experimental results. The measured bandwidth is from 4.2 to upper 14 GHZ. For shifting the lowers edge frequency below 3 GHz (to cover UWB band), the values of r_1, r_2, and h need to be future optimized.

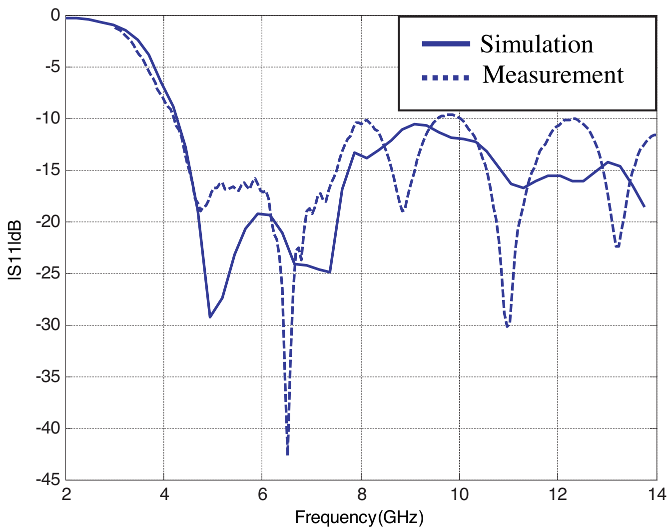


Figure 2. Simulated and measurement return loss for the proposed antenna shown in Fig. 1 (dimensions presented in Table 1).

3.2. The Effect of the Dimension of Antenna

The geometry of this antenna can be mainly determined by three parameters: r_1, r_2 and h. r_1 mainly determines the lowest operating frequency while impedance bandwidth is mostly affected by tuning r_2 and h (feed parameters). Fig. 3 presents the simulated return loss curves for different values of the radius r_1 and r_2. As shown in Fig. 3, by selecting the parameters r_1, r_2 and h to be 2, 5 and 7 mm, respectively, the lower edge frequency (f_l) of the impedance bandwidth obtained to be equal 4.2 GHz.

3.3. Radiation Patterns and Gain

The simulated and measurements normalized radiation patterns in both E- (or yz-) and H- (or xz-) planes at the frequencies of 4.2, 7, and 9 GHz are plotted in Figs. 4–5, respectively.

As shown in Figs. 4–5, radiation pattern in E- and H-planes are omni and bidirectional, respectively. But at higher frequencies, E-plane radiation pattern is degraded in its omnidirectional behavior because of the asymmetry of the configuration in the two orthogonal planes. On the other hand, the direction of maximum radiation shifts away from the boresight direction.

The gain of the antenna is presented in Fig. 6. The curve of total

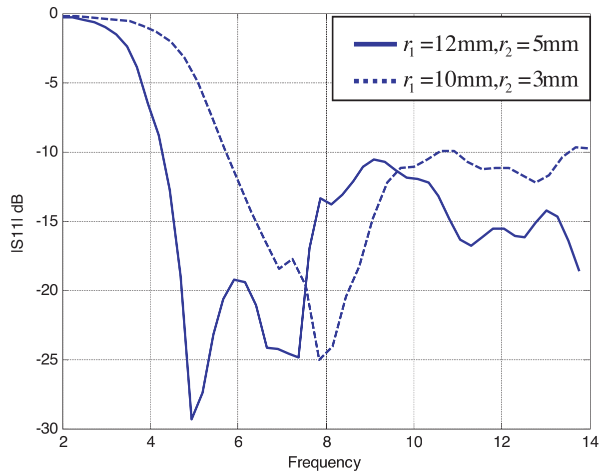


Figure 3. Simulated return loss as a function of r_1 and r_2.

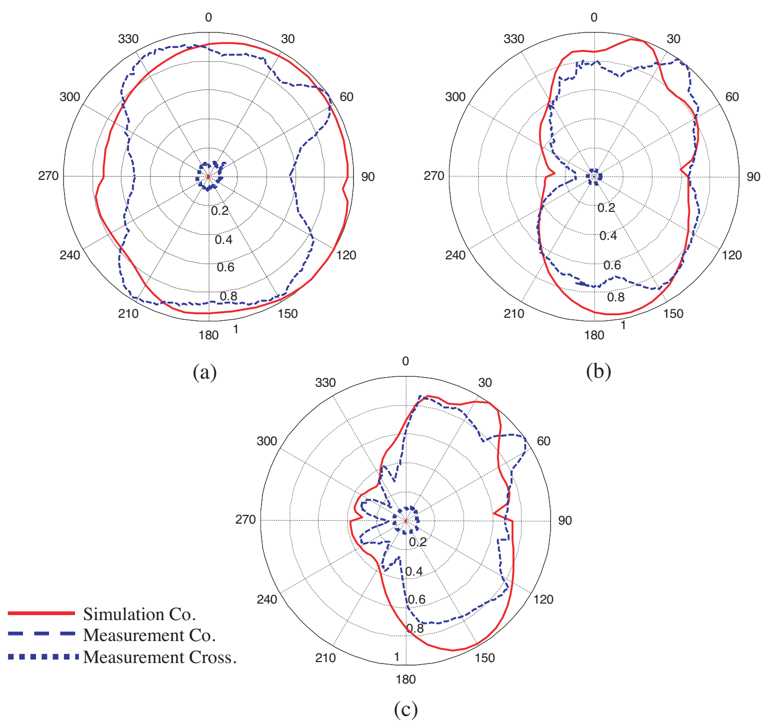


Figure 4. Simulated and measurement radiation patterns in E-plane at (a) 4.2 GHz, (b) 7 GHz, (c) 9 GHz.

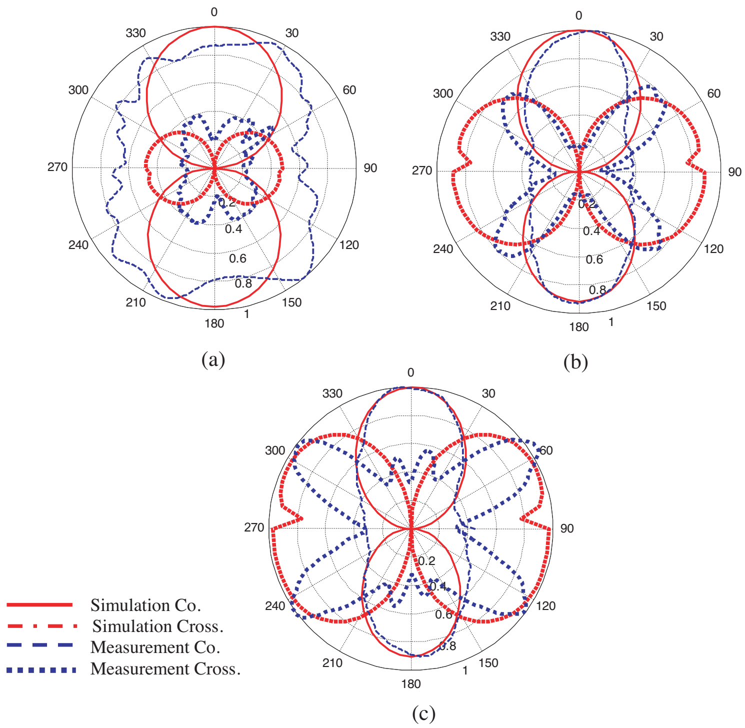


Figure 5. Simulated and measurement radiation patterns in H-plane at (a) 4.2 GHz, (b) 7 GHz, (c) 9 GHz frequencies.

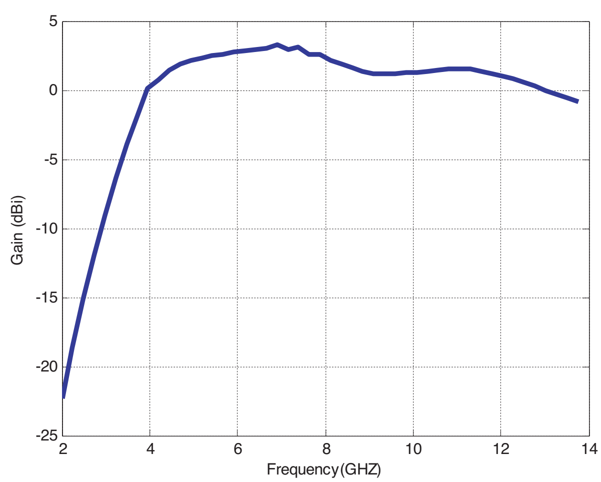


Figure 6. Total gain at boresight.

gain at boresight reveals that the gain (in dBi) is between 2 to 3.2 dBi for the proposed antenna in the 4.2 to 12.8 GHz frequency band.

4. CONCLUSION

The circular slot antenna fed by a circular shape open ended microstrip line is investigated. It has been shown that the performance of the antenna in the terms of its frequency domain is mostly dependent on the slot radius (r_1) and fed radius (r_2). It is demonstrated numerically and experimentally that the proposed antenna can yield an ultra wide bandwidth. It is observed that the radiation patterns are nearly omnidirectional in E-Plane and directional in H-Plane. The omnidirectional radiation pattern in E-plane, is degraded in higher frequency due to the asymmetry of the structure.

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