A Microstrip-Fed Ultra-Wideband Slot Antenna

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Introduction

Ultra-wideband (UWB) antennas have gained great interest since the US Federal Communication Commssion (FCC) released the generic admission for UWB in the frequency band between 3.1 GHz-10.6 GHz in 2002 [1]. In Europe a similar regulation standard with a reduced bandwidth (6 GHz-8.5 GHz) is available [2]. Due to the inherent wide bandwidth, communication systems with a high data rate and high resolution imaging systems are possible making this technology attractive for many different applications [3]. Printed UWB antennas are preferred because they lead to compact and low-cost front-ends. Electrically thick dipole antennas with circular [4] and more complex shapes [5,6] are suitable candidates for a broadband operation. Slot antennas with a complementary shape to such dipole shapes have the same radiation characteristics according to Babinet's principle; only the H- and E-field components are interchanged [7]. In [8,9] an UWB antenna is realized in such a manner, whereas the antenna is fed by a coaxial cable soldered directly to each side of the slot center. In this publication a similar antenna is presented with a leaf-shaped slot and a microstrip feeding. Due to the planar feeding structure a robust antenna structure is achieved and single-ended active and planar circuits can be easily integrated with the antenna. The radiation of this antenna type results from the current of a wire loop and is inductive. Therefore, the H-field is dominant in the near field of the antenna. This is advantageous for integrated systems as coupling due to electrical fields in the near field are less probable [10].

Design of the Antenna

This kind of slot antennas can also be considered as a wire antenna, where the metallization around the slot forms the wire. In the feeding point, a current is induced on both sides of the slot with opposite direction. As can be seen in Fig. 1, where the current distribution is depicted for 6.75 GHz, this current flows around the slot. The critical dimensions for a broadband operation are the shape of the slot and the metallization length and width around the slot.

Considering the presented antenna, the shape of the slot is obtained using a smooth transition from a narrow to broad slot line. The contour of the first part is achieved using a cosine function, and the second part is a semicircle with a diameter of W_s leading to the leaf shape of the slot. The outer dimensions of the antenna have a simple rectangular shape. This shape could be optimized for an even better performance.

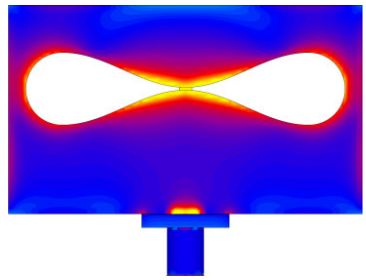

Fig. 1: Simulated current distribution for the slot antenna at 6.75 GHz.

The feeding of the slot is done by a 50 Ω microstrip line ending in a λ/4 open stub. This results in a maximum of the H-field at the slot. A circular shape of the stub is used for a broadband operation similar to [11]. The impedance of the slot at the junction with the microstrip line is chosen to be 100 Ω in order to achieve a good matching behavior. The tuning of all antenna parameters for wide bandwidth has been performed with Microwave Studio [12]. In Table 1, the obtained parameters are listed according to the sketch of the antenna in Fig. 2. The used substrate is RO4003 with a thickness of 0.81 mm.

L	**W**	**l**	**w**	**D**	**S**	**W_s**	**L_s**
51.7	30.3	20.1	1.85	5.4	0.4	10.5	46.6

Tab. 1: Dimensions of the antenna in mm.

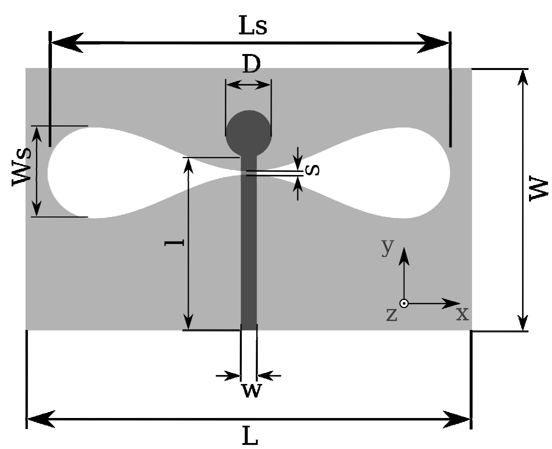

Fig. 2: Sketch of the leaf-shaped slot antenna including parameters.

Characterization of the Antenna

In order to characterize the antenna, a coaxial connector is soldered on the feeding microstrip, and a PVC holder is attached to be able to fix the antenna on a mount (see Fig. 3). As can be seen in Fig. 4, the measurement result shows a good agreement with the simulation for the reflection behavior of then antenna. Only at 8.5 GHz a slight difference occurs. Neglecting this difference a 10 dB bandwidth of 41% is obtained. Between 3.8 GHz and 11 GHz the matching performance is better 5 dB making this antenna even suitable for the FCC band.

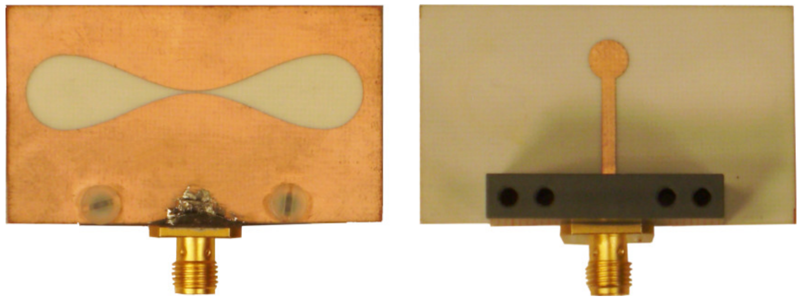

Fig. 3: Photograph of the manufactured antenna (front and back side).

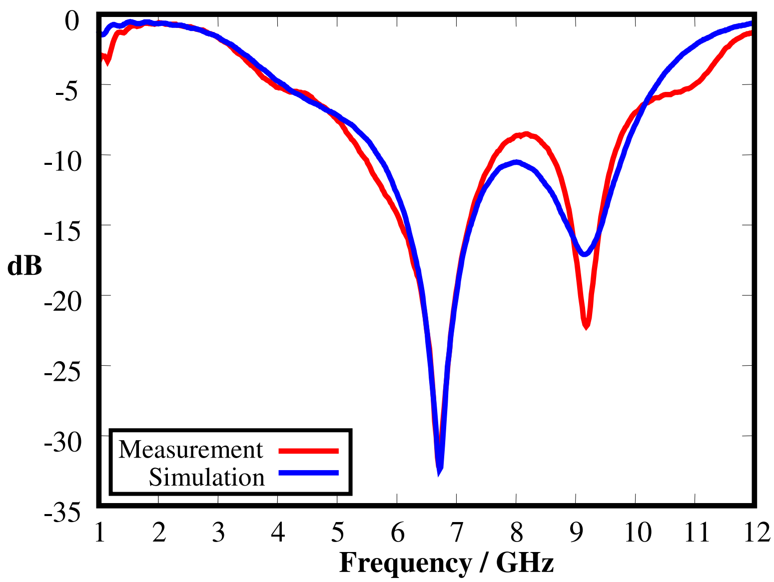

Fig. 4: Reflection coefficient for the realized antenna.

The simulated and measured radiation patterns of the antenna are depicted for the E-plane (yz-plane) and the H-plane (xz-plane) in Fig. 5 and Fig. 6, respectively. These diagrams are normalized to the maximum gain. The measured gain is 8.9 dBi. In contrary to the reflection behavior, a good radiation performance can only be obtained up to 9 GHz. There, the main beam splits into two beams in the H-plane, which is caused by the excitation of a higher order mode.

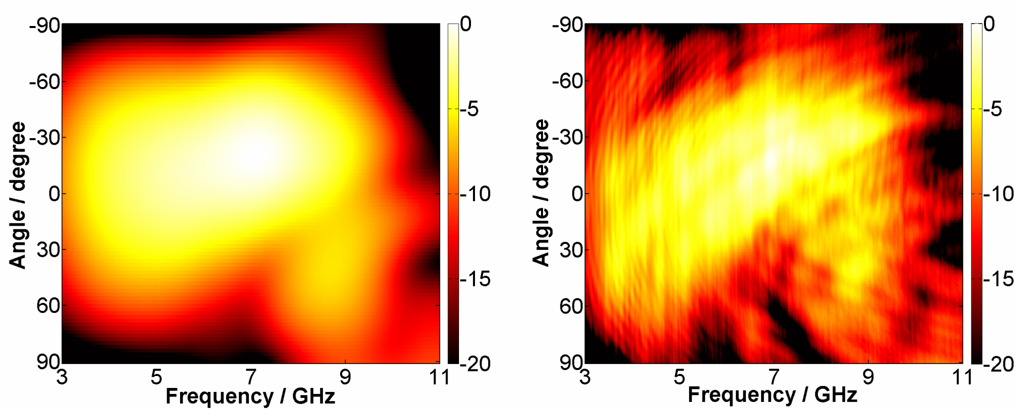

Fig. 5: Simulated (left) and measured (right) radiation pattern in dB (E-plane).

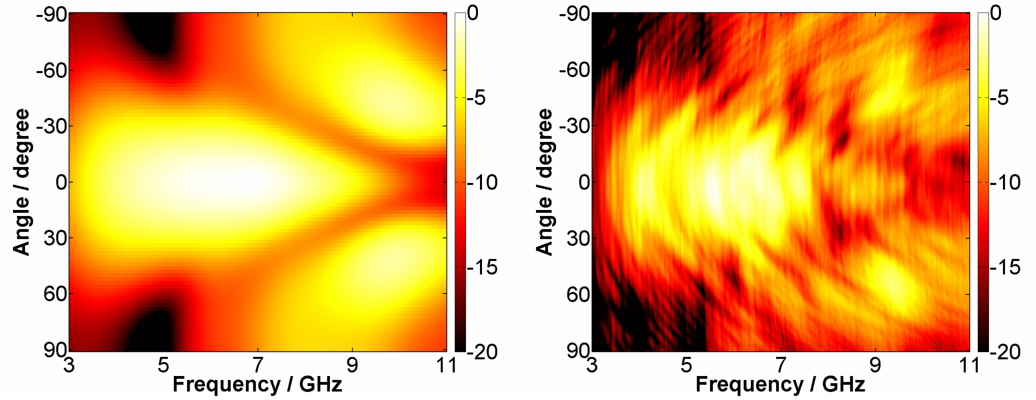

Fig. 6: Simulated (left) and measured (right) radiation pattern in dB (H-plane).

Conclusion

Due to the split of the main beam above 9 GHz the antenna cannot operate in the complete FCC frequency range from 3.1 GHz to 10.6 GHz, but is a well suited candidate for the ECC band from 6 GHz-8.5 GHz.

Acknowledgement

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