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Abraham Loutridis

*Technological University Dublin, d11125656@mydit.ie*

Matthias John

*Technological University Dublin, matthias.john@tudublin.ie*

Giuseppe Ruvio

*Technological University Dublin*

*See next page for additional authors*

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## Authors

Abraham Loutridis, Matthias John, Giuseppe Ruvio, and Max Ammann

# A 2.45/5.8 GHz Folded Monopole Antenna for WLAN Applications

Abraham Loutridis<sup>1,2</sup>, Matthias John<sup>2</sup>, Giuseppe Ruvio<sup>1</sup> and Max J. Ammann<sup>1</sup>

<sup>1</sup>Antenna & High Frequency Research Centre,

<sup>2</sup>CTVR the Telecommunication Research Centre

Dublin Institute of Technology,

Kevin Street, Dublin 8, Ireland

abraham.loutridis@mydit.ie

[matthias.john | giuseppe.ruvio | max.ammann]@dit.ie

**Abstract**—A probe-fed printed folded monopole antenna for WLAN applications is presented. The antenna operates at 2.45 GHz and 5.8 GHz, is compact and has omni-directional characteristics in both bands. A parametric study of key geometrical parameters is reported.

## I. INTRODUCTION

In recent years wireless communications industry has proliferated, with portable devices becoming smaller and more demanding in terms of data throughput and broadband operation. For the antenna designers it presents new challenges to design compact antennas covering smaller areas and maintaining good performance.

Because of the low profile and compact size of the planar and printed antennas [1], there is a strong preference to this type of antennas for applications such as WLAN, UWB, LTE and RFID [2]. Several dual-band and wideband printed and planar monopole antennas [3]-[5] were designed to meet the needs of these applications.

A conventional printed Inverted-F-Antenna (PIFA) [1], [6] covers almost all of these requirements, but usually demands one long dimension on the Printed Circuit Board (PCB) due to the aspect-ratio. A printed folded (hairpin) monopole antenna [7], [8] without the extensive horizontal arm offers smaller size, dual-band operation with a second resonance which is closer to the first resonance than the PIFA, good omnidirectional radiation characteristics, high efficiency and easy to manufacture.

In this paper, an investigation of the performance of a printed folded monopole antenna located on a conventional ground plane is presented. The effects of the geometrical characteristics of the folded monopole on the radiation performance of the antenna are investigated.

## II. ANTENNA DESIGN

A printed folded monopole was designed for the WLAN (2.45 and 5.8 GHz) frequency range and placed on a conventional ground plane. The structure and coordinate

system of the antenna is shown in Fig. 1. A 70 mm × 70 mm Brass ground plane with a thickness of 0.15 mm was used. The folded monopole is printed on FR-4 ( $\epsilon_r=4.3$ ,  $\tan\delta=0.025$ , thickness=1.6 mm) with dimensions 22.2 mm × 17 mm. The printed folded monopole antenna is designed for 2.45 GHz/5.8 GHz and the height of the monopole is  $h=20.2$  mm ( $\approx 0.165\lambda_0$ ). The width of the shorting strip of the antenna is  $s=0.5$  mm and the feeding strip width is  $f=1.98$  mm. The length of the horizontal arm of the antenna is  $l=10.5$  mm and the width  $a=3.57$  mm. The perimetric length of the antenna is 53.38 mm ( $\approx 0.44\lambda_0$ ). The monopole is fed via a 50  $\Omega$  SMA connector through the ground plane.

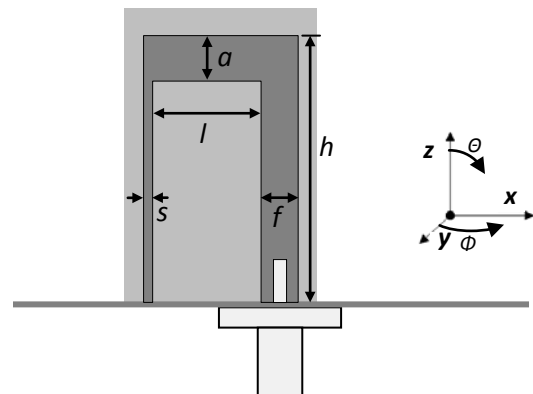


Fig. 1 Printed folded monopole antenna geometry and coordinate system

## III. RESULTS AND DISCUSSION

In Figs. 2 – 5 a parametric investigation of the variation of  $S_{11}$  with respect to the three most important geometric parameters of the printed folded monopole antenna are illustrated. Fig. 2 shows the simulated  $S_{11}$  (CST Microwave Studio, time domain solver) as a function of the height  $h$  of the antenna. The results indicate that both resonant frequencies can be effectively controlled by selecting the proper value of  $h$  but with greater sensitivity for the higher frequency.

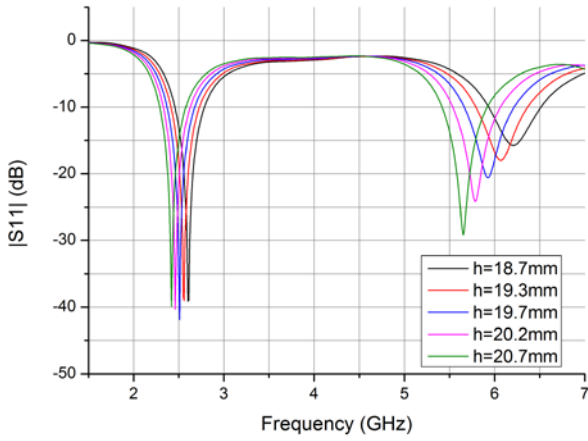


Fig. 2 The simulated S11 dependence on the height ( $h$ ) of the monopole

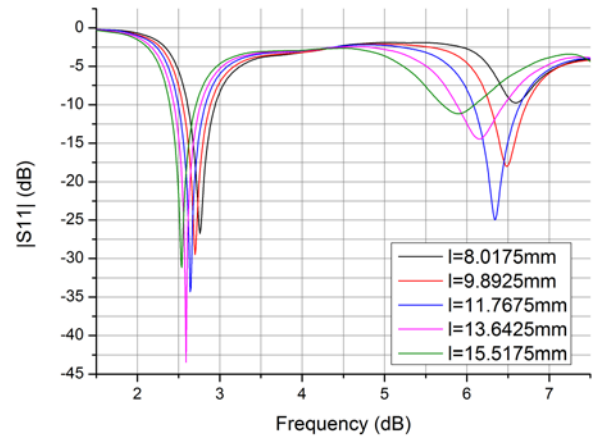


Fig. 4 The simulated S11 dependence on the length ( $l$ ) of the monopole.

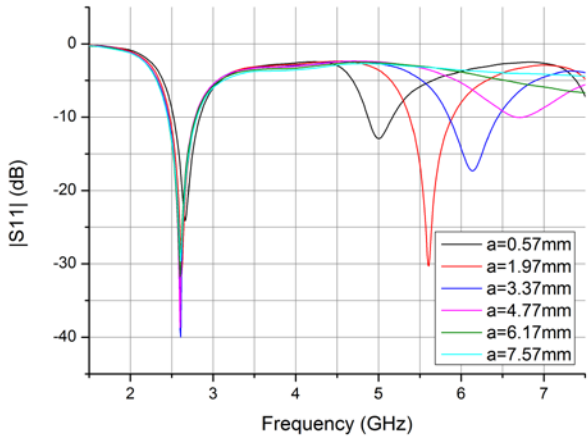


Fig. 3 The simulated S11 dependence on the width ( $a$ ) of the horizontal strip of the monopole

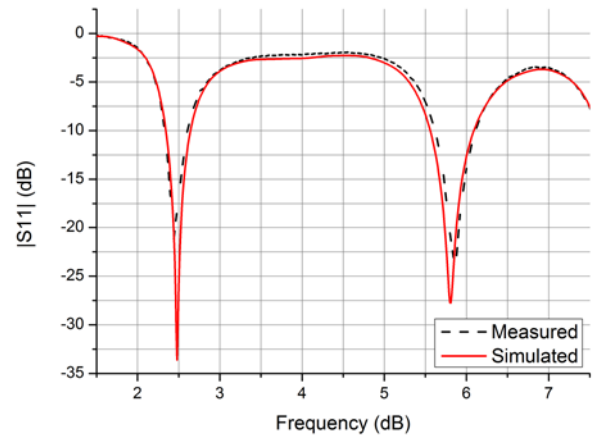


Fig. 5 Simulated and measured S11 for the printed folded monopole antenna

Fig. 3 shows the variation of the width  $a$  of the horizontal strip of the monopole. From the graph it is clearly visible that increasing the value  $a$  shifts the second resonance upwards with little effect on the lower resonance. The frequency ratio between the upper and the lower resonance  $f_R = f_2/f_1$  continuously increases from 1.879 to 3.819 as the value of  $a$  changes from 0.57 mm to 7.57 mm. Hence this antenna offers a large controllable frequency ratio range.

In Fig. 4, simulated results for length  $l$  varied from 8.0175 to 15.5175 mm are shown. Obtained results clearly show that both resonant frequencies can be effectively controlled (impedance matching and frequency shifting) by the parameter  $l$ .

Finally, Fig. 5 shows the simulated and measured S11 results of the proposed optimised antenna, which are in a good agreement. The lower band has a -10 dB impedance bandwidth of 300 MHz (2.34-2.64 GHz) for the simulated results and 280 MHz (2.32-2.6 GHz) for the measured results. For the upper band the simulated results provide 530 MHz (5.56-6.09 GHz) bandwidth, while the measured results provide 500 MHz (5.61-6.11 GHz) bandwidth.

In Figures 6 – 9 the simulated and measured azimuth ( $x$ - $y$ ) and elevation ( $x$ - $z$ ) plane radiation pattern at 2.45 and 5.8 GHz are illustrated for the antenna with dimensions given in Section 2. All the measured gain patterns are illustrated against the simulated patterns in 10dB/division scaled plots. Moreover, each radiation pattern cut is presented together with the cross-polar component.

At the lower frequency it is seen that the omnidirectional pattern provides good polarization discrimination in the azimuth plane. Cross-polar components in the higher frequency in both planes are due to the greater flow of current in the horizontal strip of the monopole. Simulated total efficiencies are 98% for the first resonance and 90% for the second resonance.

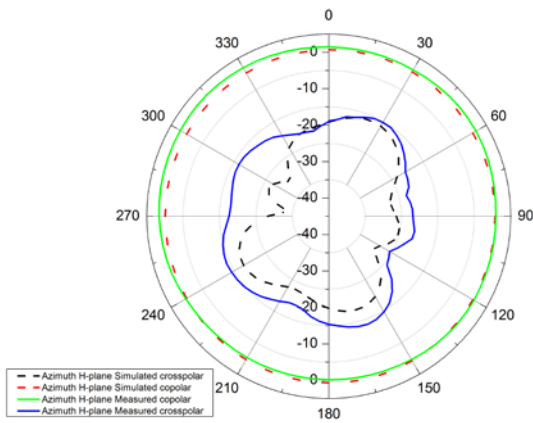


Fig. 6 Measured and simulated azimuth plane patterns at 2.45 GHz

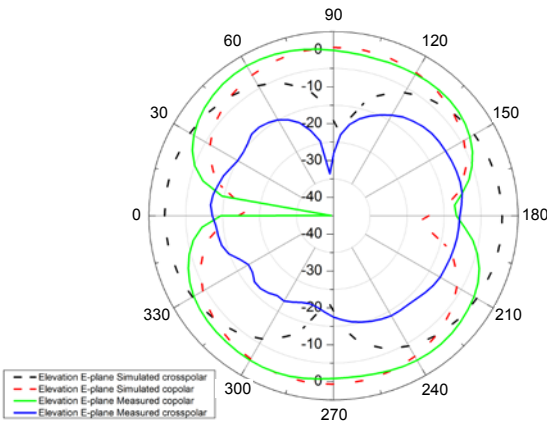


Fig. 7 Measured and simulated elevation plane patterns at 2.45 GHz

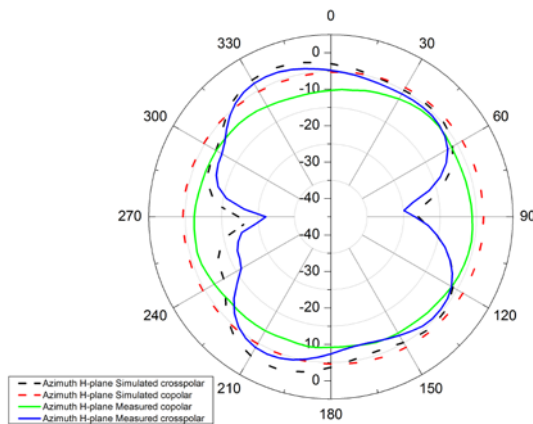


Fig. 8 Measured and simulated azimuth plane patterns at 5.8 GHz

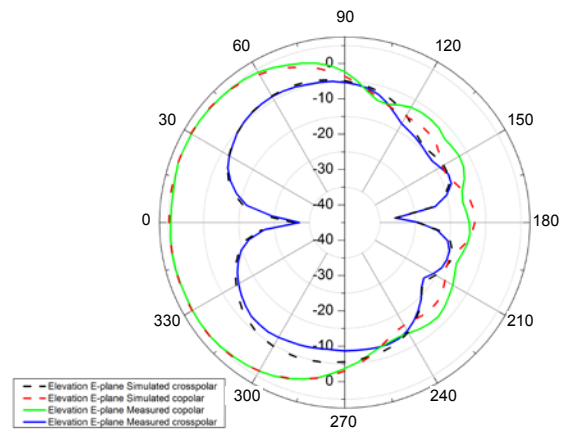


Fig. 9 Measured and simulated elevation plane patterns at 5.8 GHz

Considering the above results and compared with a typical Printed Inverted-F Antenna (PIFA) the proposed antenna offers a wide frequency ratio range with omnidirectional characteristics for both frequency bands.

#### IV. CONCLUSIONS

In this paper an investigation of the performance of a printed folded monopole antenna in the WLAN range is presented. A dual band operation has been obtained and good radiation characteristics have been observed in both frequencies. Moreover the proposed antenna is easy to manufacture at a low cost, with additional benefit of a large frequency ratio range which is easy to control.

#### ACKNOWLEDGMENT

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