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Four-band printed antenna for personal communication systems

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The paper describes a four-band, small-dimensions printed antenna intended to be integrated into modern wireless systems. The printed antenna has resonant slots, at slightly different frequencies, in order to provide a simultaneous response at four frequency bands in the operating spectral region. This type of antennas is proposed for the emerging multi-mode multi-band transceivers, which operate over a wide range of bands required by modern telecommunication systems. Measured data including return loss, antenna gain and radiation patterns are in good agreement with the simulated data.

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1. Introduction

Many new and innovative wireless systems are currently being developed in frequency bands, which have been recently assigned to be used for communication, imaging, radar and other remote sensing applications [1]. Consequently, there have been developed many techniques to characterize and optimize small antennas, in order to operate in a broadband spectral region, having optimal multi-band behavior.

There are special design considerations for antennas for the multi-band systems, especially for microwave wireless communications [2]. Due to the multi-band system behavior, there is a certain specificity of the requirements for the antenna design: for example, in the multi-band scheme, the consistent (or flat) gain response of the multi-band antennas is more important than a constant group delay or a linear phase response, which is, conversely, more important in the single band scheme.

In the present paper there is investigated a small planar antenna intended and designed to be used in multi-band, personal communications and remote sensing applications. There are underlined some important aspects regarding its physical configuration, simulated characteristics and measured parameters.

2. Antenna configuration

The antenna presented in this paper is a monopole-type antenna, related to the elliptical/circular monopoles [3] - [8]. However, unlike other devices, the proposed antenna is customized for being used in planar configurations, has reasonably small dimensions and, thus, presents the potential to be integrated in light, personal communications and remote sensing systems.

The antenna configuration, geometry and coordinate system are shown in Fig. 1.

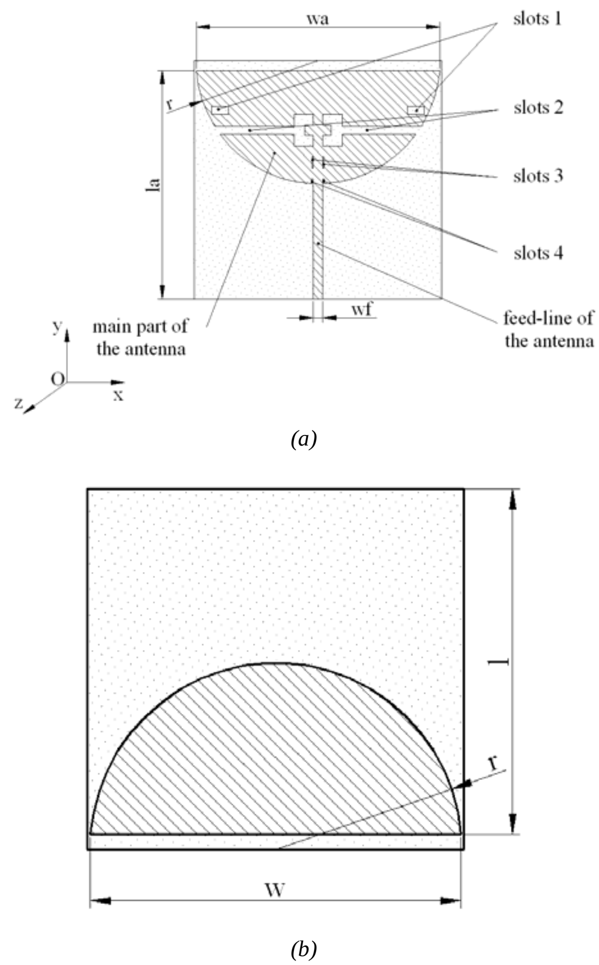

Fig. 1 Antenna geometry and configuration: (a) overall view of the antenna and main dimensions of the radiating element and its feed-line; (b) the ground plane (on the rear side of the antenna).

The 1.52 mm thick dielectric substrate exhibits a dielectric constant and a loss tangent of 2.0 and 0.002, respectively. The substrate is covered with a 35 μm Copper layer [9]. The substrate dimensions are *l* = 65 mm (length) and *w*=66 mm (width).

The radiative structure of the monopole semicircular antenna is printed on one side of the substrate. Four pairs of resonant slots (slots 1, 2, 3 and 4 in Fig. 1), each one having the role of enhancing the matching and, consequently, radiating proprieties of the antenna, in the regions of the operating frequency bands. The overall dimensions of the antenna are: length, *la* = 60 m; width, *wa* = 60 mm; radius of the main part of the antenna, *r* = 30 mm.

The feed-line of *wf* = 2.3 mm width is excited by an SMA launching connector.

The ground-plane, located at the other side of the dielectric substrate, has a semicircular shape, of radius *r* = 30 mm, as shown (see Fig. 1b).

3. Simulation and measurements

The main design objectives, according to the project specifications, were the following:

- simultaneous operation in the following frequency bands (at 3 dB ± 0.5 dB power level):
- 0.25 ÷ 0.5 GHz (UHF band – for special acquiring systems);
- 1.25 GHz ± 5 MHz (satellite communications for Global Position System – Pocket Personal Computer (GPS PPC) coding system);
- 2.48 ÷ 2.63 GHz (multimedia communication system needed for transmitting complex information);
- other frequency bands (in the 4 GHz frequency band region);
- spatial coverage characteristic according to the following requirements:
- vertical and horizontal coverage angle (at 3 dB power level): max 120^o;
- gain: max 3 dBi;
- voltage standing wave ratio (VSWR), max 2:1.

3.1 Return loss

The simulated antenna response was obtained by using the Finite Integration Technique (FIT) carried out trough CST Microwave Studio software [10]. The resonances of the monopole were found using this technique and were: 450 MHz, 1.082 GHz, 2.467 GHz and 3.83 GHz (see Fig. 2).

The one-port measurements were carried out using an Anritsu MS 2026A vector network analyzer. The measured return loss was less than -10 dB in the frequency bands centered around 515 MHz, 1.32 GHz, 2.66 GHz and 4 GHz, as shown in Fig. 2. The simulated and the measured response are in reasonable agreement.

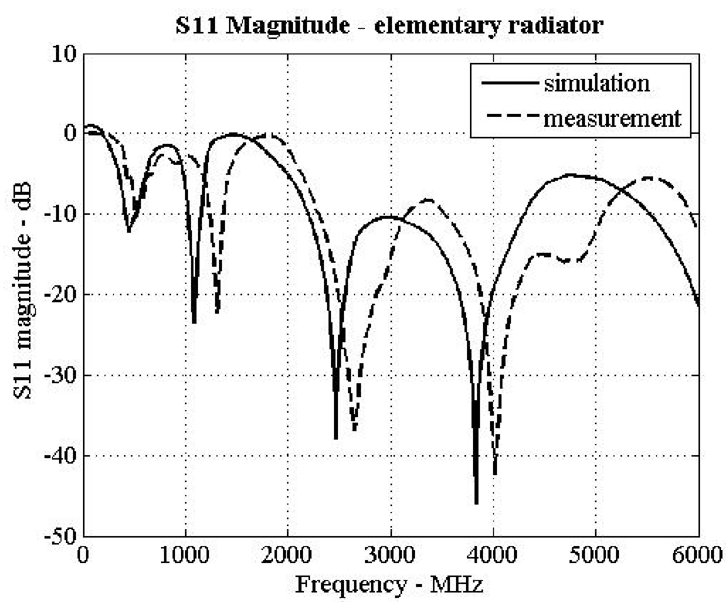

Fig. 2. Reflexion coefficient (magnitude) of the antenna: simulation and measurement.

3.2 Radiation patterns

The measured and simulated radiation patterns are normalized to maximum gain and are illustrated in Figs. 3-6 for all four frequency bands of interest.

The radiation pattern measurements were made at the frequencies where the measured reflection coefficient shows the minimum values at 515 MHz, 1.32 GHz, 2.66 GHz and 4 GHz, respectively. The maximum measured values of the gain of the antenna were 3dBi, which was the objective value, according to the project requirements.

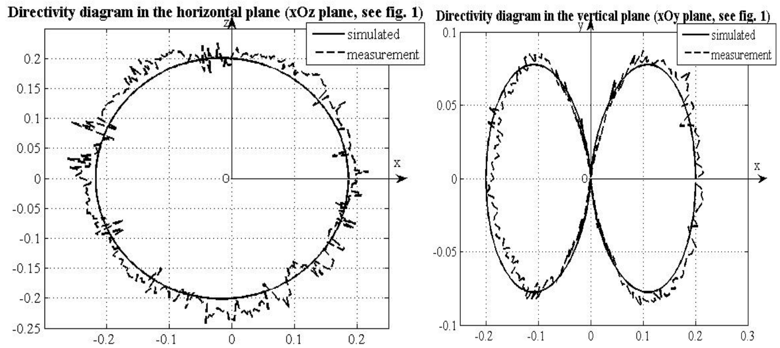

Fig. 3. Measured and simulated radiation patterns of the antenna at 515 MHz.

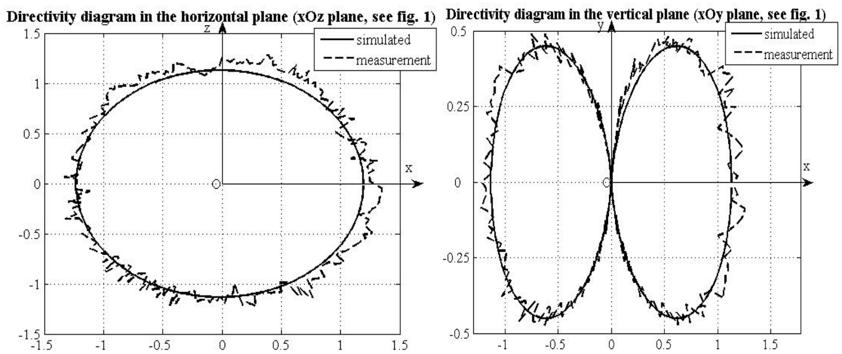

Fig. 4. Measured and simulated radiation patterns of the antenna at 1.32 GHz.

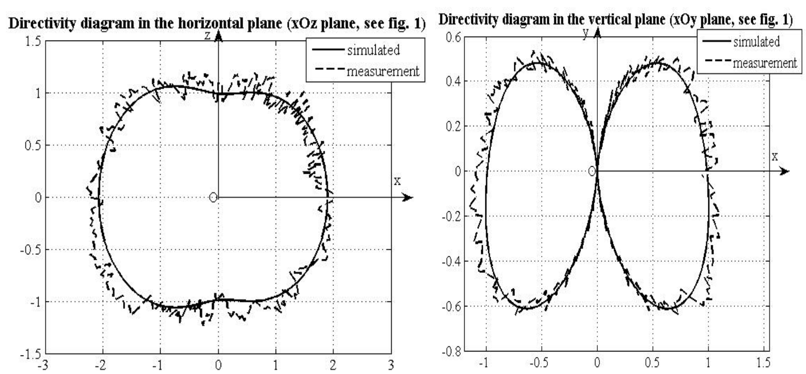

Fig. 5. Measured and simulated radiation patterns of the antenna at 2.66 GHz.

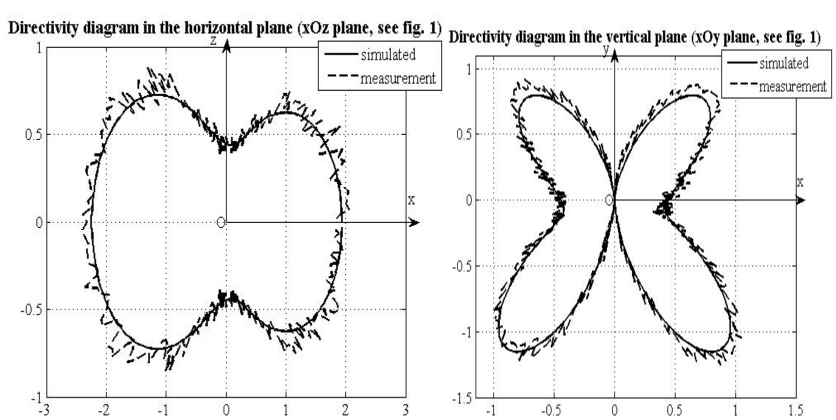

Fig. 6. Measured and simulated radiation patterns of the antenna at 4 GHz.

4. Conclusions

A multi-band low-profile planar antenna has been developed for communications, imaging, radar and other localization applications. The antenna was developed as a part of an electronic textile (e-textile) system to be used for communication in special situations. In this respect, there must be paid special attention to the interactions between the antenna system and the human body, taking into account various electrical and biomedical aspects [11].

The antenna has good operating characteristics in four frequency bands, achieving return loss values better than -10 dB in the operating frequencies. The bandwidth in each region is greater than 10%, which is in good agreement with the design specifications.

The directional patterns of the antenna shows the contribution of the slots: the slots behavior is a antenna array one, the slots assembly being, in fact, an array of elementary radiators of rectangular shape, placed horizontally and vertically (slots 1, 2 and 3, Fig.1). As a consequence, one may notice some specific issues to the array's field:

- main beam of the radiation pattern scanning, due to the frequency radiation (more obvious for the vertical plane diagrams);
- variation of the angular radiation pattern width (mainly in the vertical plane);
- behavior similar to response of the independent antennas, easy to be noticed in Fig. 6 (vertical plane), due to the small wavelength compared with the physical distances between slots.

The measured and simulated characteristics are in a reasonable agreement and can be considered a good basis for the future developments of the device.

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