Paper

Modified monopole ring antennas as a solution for HiperLAN1/2 and IEEE 802.11b/g standard devices

Anna Miskiewicz and Marek Kitliński

Abstract— A compact planar antenna for multisystem applications has been designed and manufactured. A modified feeding method has been used to meet the requirements of modern telecommunications devices. It has been shown, that by adjusting the size of the rings, required allocation of bands is possible. The proposed antenna is suitable for ISM band devices and gives perspectives for multi-standard operation. The antenna has been simulated using MoM 2.5D software Zeland IE3D, next fabricated and measured.

Keywords—fractal antennas, multiband antennas, HiperLAN, wireless LAN, modified monopole.

1. Introduction

In the past few years there has been a growing need for multiband and wideband antennas, as wireless networks have become much more popular and affordable for an end-user. Especially, wireless local area networks (WLAN) have increased the demand for compact, possibly omnidirectional antennas mounted over a small ground plane, working in two dedicated bands: 2.4 GHz (2.4–2.4835 GHz) and 5 GHz (5.15–5.35 GHz, 5.725–5.875 GHz for IEEE 802.11 standard and 5.18–5.32 GHz, 5.5–5.7 GHz for HiperLAN standard). In this paper a new configuration of ground plane and feeding is investigated to satisfy the requirements for WLAN applications using multiple ring antennas. Multiple ring antennas are usually compared with fractal antennas, such as Sierpinski or Parany gasket. However, they are not fractal antennas, but the way they are created can be as well described using an iterative procedure.

Basic configuration of a multiple ring antenna includes a number of rings (Fig. 1) with a common point, where the feeding line is connected to the radiating element. Usually, the radius of the following rings is in the ratio of 2:1 and there is no cut in the smallest circle. Therefore it can be said, the whole antenna is a set of single radiating elements, which should operate in different bands, hence the similarity to fractal antennas. It has been shown [1–3], that by changing the scale ratio of fractal antennas, operating frequencies of the antenna can be allocated, which has been the initial step for the design of the proposed multiple ring antenna.

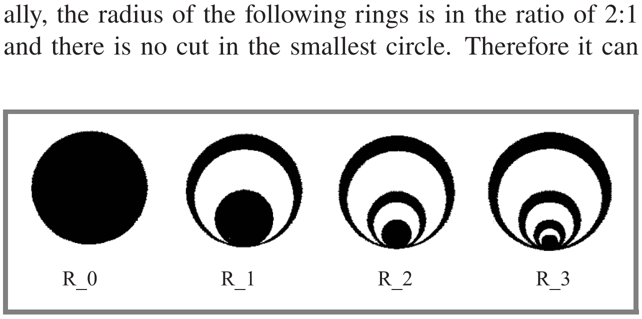

Fig. 1. Construction of multiple ring radiating element.

2. Antenna design

The antenna was fabricated using common substrate, TACONIC RF-35 of thickness $h = 0.762$ mm, relative permittivity $\varepsilon_r = 3.5$ @1.9 GHz and dielectric losses $tg\delta = 0.0018$. Parameters of the substrate used in the project were taken directly from the data sheet supplied with the material. Moreover, it has been assumed, that the permittivity does not change with the frequency, which made the calculations straightforward. So far, multiple ring antennas have been investigated using a configuration of a monopole perpendicular to finite ground plane [4], fed by a coaxial line. Since the need for miniaturization and compatibility, a modified solution had to be proposed.

A structure of a modified monopole has been used (Fig. 2). At the top of the substrate a microstrip line has been placed, which feeds the radiating rings. The characteristic impedance of the line has been calculated to be 50 Ω at the lower resonant frequency. At the bottom, the ground plane covers the surface underneath the microstrip line and does not exceed beyond it, which means, that there is no

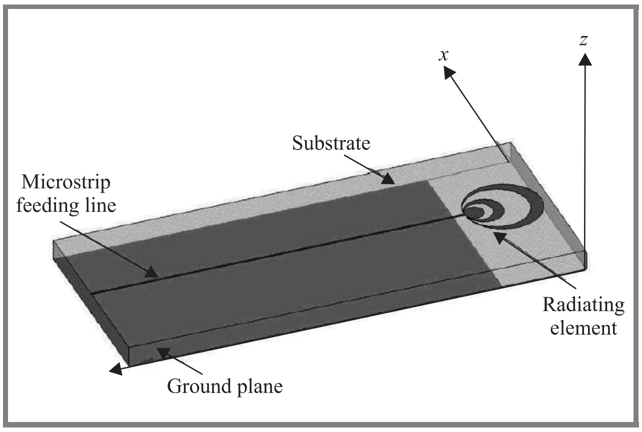

Fig. 2. Modified monopole structure using a multiple ring configuration.

ground plane below the radiating rings. Such configuration is known as modified monopole [5], and it has been shown, that it gives a good resemblance of characteristics with classical monopole configuration. This configuration is useful in wireless devices, such as mobile phones, wireless PC cards or multimedia applications, because it can be mounted at the back of the unit and receive and transmit signals in all directions. Moreover, there is no need to use additional air gap, which has been extensively used to broaden the operating bands [6, 7], as the chosen configuration of radiating elements fully satisfies the requirements, and even exceeds them. As it has been explained, multiple ring antennas are much the same as fractal antennas, because of the scale factor and iterative model of geometry.

For the project a number of configurations has been designed and numerically tested. To achieve two-band operation, two rings has been used, but a scale factor has been changed from 2 to 2.14 to get resonant modes near middle frequencies of both ISM-bands (Fig. 3). The size

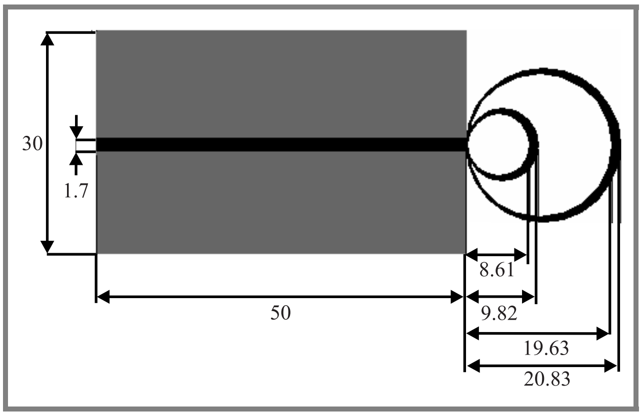

Fig. 3. Proposed multiple ring modified monopole antenna (all measurements in mm).

of the ground plane was chosen to fit the dimensions of a standard modern mobile phone. There is no ground plane below the radiating rings. To get the appropriate resonant modes, the perimeter P_o of the outer ring was calculated using the following equation:

$$P_o = \lambda_{2.45\,\mathrm{GHz}} = \frac{\mathrm{c}}{f\sqrt{\varepsilon_r}},$$

where: c is speed of light in the vacuum, $f = 2.45$ GHz and ε_r is the relative permittivity of the substrate.

The perimeter of the inner ring P_i was calculated as $\frac{P_o}{2.14}$. As there is no equation, which would describe the effective permittivity of the dielectric material in a configuration of a modified monopole, an assumption has been made, that the effective permittivity equals the relative permittivity of the substrate. However, if the permittivity of the material was high, additional tuning of the perimeters of the rings would have to be made.

3. Measured and experimental results

The proposed antenna presenting the most satisfying results for return losses and radiation characteristics has been fabricated and measured using a vector network analyzer Wiltron 37269A. The obtained results have been compared with the simulated ones from Zeland IE3D (Fig. 4). The highest frequency was set at 10 GHz with 15 cells per wavelength with additional meshing on edges to get sufficiently accurate results in reasonable time.

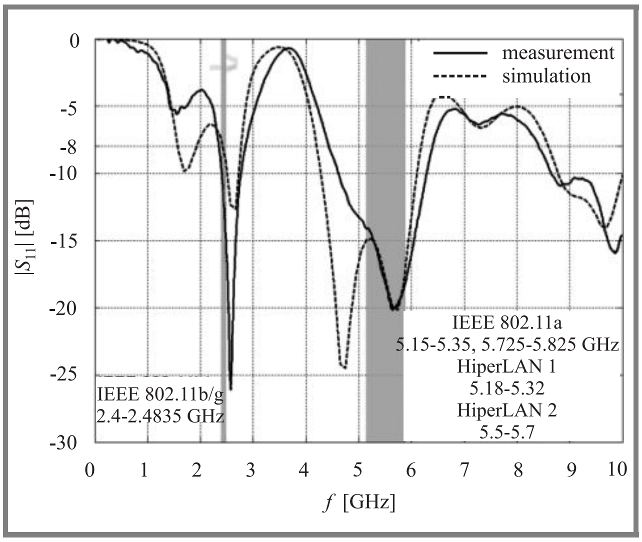

Fig. 4. Measured and simulated return losses $|S_{11}|$ of the proposed antenna.

For the maximum return losses of -8 dB a table was made presenting a comprehensive comparison of the predicted and measured parameters of the antenna (Tables 1 and 2), where $f_{\min}$ is a frequency of minimal return losses, f_0 is a middle frequency of the band calculated as an arithmetic mean of the band-defying frequencies.

Table 1
Simulated parameters of the proposed antenna

$f_{\min}$ [GHz]	f_0 [GHz]	B [%]
1.684	1.751	12.25
2.66	2.597	13.32
4.731/5.741	5.194	37.93

Table 2
Measured parameters of the proposed antenna

$f_{\min}$ [GHz]	f_0 [GHz]	B [%]
2.57	2.6	19.23
5.67	5.42	36

As predicted, the antenna exhibits multiband behaviour. Presented results show good agreement of simulation and measurements. The proposed antenna is matched in the bands of IEEE 802.11b/g and HiperLAN2 standards, as it was intended to. Due to equipment limitations far-field radiation patterns were measured at the frequency

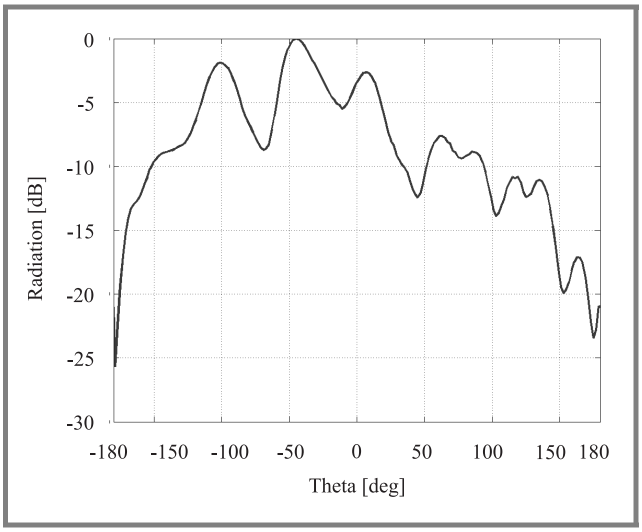

Fig. 5. Measured radiation pattern of total E-field in the elevation plane at 9.14 GHz.

of 9.14 GHz (Fig. 5). It can be seen, that the antenna radiates both front and backwards and has moderate small directivity.

4. Conclusions

A novel approach to monopole multiple ring antennas has been presented. It has been shown, that it is possible to allocate the required bands by adequate modifying the geometry to obtain compact planar antenna for mobile devices. The presented antenna is matched in the bands of IEEE 802.11b/g and HiperLAN1/2 standards. Finally, we should underline, that multiple ring antennas are a good example of construction, which can be used to design multiband or wideband antennas. Applying the new feeding technique it is possible to design and implement antennas which could operate in multi-standard terminals.

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