Open access • Journal Article • DOI:10.1049/EL:20073417

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V. Deepu, K.R. Rohith, J. Manoj, M. N. Suma ...+3 more authors

Institutions: Cochin University of Science and Technology

Published on: 18 Jan 2007 - Electronics Letters (IET)

Topics: Monopole antenna, Antenna efficiency, Antenna factor, Coaxial antenna and Patch antenna

Compact uniplanar antenna for WLAN applications

V. Deepu, K.R. Rohith, J. Manoj, M.N. Suma, K. Vasudevan, C.K. Aanandan and P. Mohanan

A compact dual-band uniplanar antenna for operation in the 2.4/5.2/5.8 GHz WLAN/HIPERLAN2 communication bands is presented. The dual-band antenna is obtained by modifying one of the lateral strips of a slot line, thereby producing two different current paths. The antenna occupies a very small area of $14.5 \times 16.6\ mm^2$ including the ground plane on a substrate having dielectric constant 4.4 and thickness 1.6 mm at 2.2 GHz. The antenna resonates with two bands from 2.2 to 2.52 GHz and from 5 to 10 GHz with good matching, good radiation characteristics and moderate gain.

Introduction: With the tremendous increase in the number of laptops and other portable devices the need for wire-free communication, devoid of wires and interconnections, has become inevitable. The availability of the ISM band as licence free has paved the way for the design of various communication devices working at these frequencies for short-range communication. This has created great demand for suitable antennas working at these frequencies. Also, with the process of miniaturisation in full swing, greater emphasis is given to compactness. Of available designs, planar antennas are preferred owing to advantages such as small volume, ease of fabrication and flush mounting facility. Various types of antenna designs complying with these requirements have been reported. The printed double T monopole presented in [1] consists of two stacked T shaped monopoles for achieving dual resonance in the 2.4/5.2 GHz WLAN bands using a microstrip feed with a $50 \times 75\ mm^2$ ground plane. The planar monopole antenna [2] uses a shorted parasitic inverted L wire to obtain resonances in the 2.4/5.2/5.8 GHz bands. Compared to other designs, uniplanar antennas have advantages such as lack of soldering points, easy fabrication, easy integration to MMICs and single metallic layer structure. The compact dual-band antenna for ISM applications reported in [3] consists of an asymmetric dipole having a total area of $15 \times 40\ mm^2$ and dual band is produced using the unbalanced current distribution in the asymmetric arms. The CPW fed dual-frequency antenna mentioned in [4] produces dual resonances connecting two monopoles to a single feed line.

In this Letter we propose a compact uniplanar antenna for WLAN applications. The proposed antenna design is obtained by modifying one of the lateral strips of a slot line. Ansoft HFSS is used for simulation and analysis of the structure. The proposed antenna resonates with two bands from 2.20–2.52 GHz and from 5.03–10.09 GHz which is wide enough to cover the IEEE 802.11b/g (2.400–2.484 GHz), IEEE802.11a (5.15–5.35, 5.725–5.825 GHz) and HIPERLAN2 (5.47–5.725 GHz) communication bands. Moreover, the antenna has a simple structure, occupies a very small area of $14.5 \times 16.6\ mm^2$ and can be easily printed into circuit boards.

Antenna design: The basic geometry of the antenna is derived from a slot line having lateral strip width 8 mm and slot width 0.6 mm printed on an FR4 substrate of relative dielectric constant $\epsilon_r = 4.4$ and thickness 1.6 mm excited using a 50Ω coaxial probe the inner feed conductor of which is connected to the point *S* and the outer ground shielding to the point *S*1. Two arms (a shorter vertical strip and a longer inverted L strip) are first attached to one of the lateral strips of the slot line to introduce two different resonant paths. This results in a dual-band antenna (Fig. 1) resonating at 3.16 and 6.4 GHz. To bring down the resonances to the required frequencies the structure is further modified. A narrow slot of 1 mm width is inserted in the structure to increase the resonant path and to bring down the resonances. The slot is shown in dotted lines in Fig. 1. The position of the slot is chosen to be at the position of minimum field intensity. It has to be noted that this technique does not affect the compactness of the antenna. The resulting antenna resonates at 2.44 and 5.5 GHz. From simulation and experimental studies, it is found that for the first resonance the meandered length ABCDE acts as a quarter-wave monopole with GHIJ as the ground plane and for the second resonance the strip AB and GHIJ acts as the arms of an asymmetric dipole. Also, it is noted that the horizontal strip DE has to be separated at least by a minimum distance of $0.2\lambda_1$ (where λ_1 corresponds to the first resonant wavelength) from the ground strip. This is to avoid coupling between the strip DE and the ground strip so that the impedance matching is not deteriorated. The length and width of the strips are optimised to achieve good performance.

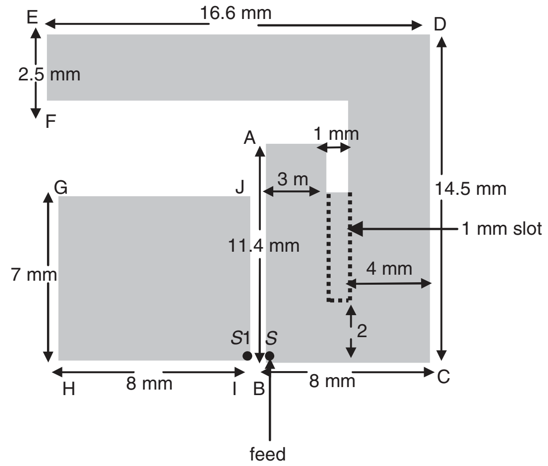

Fig. 1 *Geometry of proposed antenna*

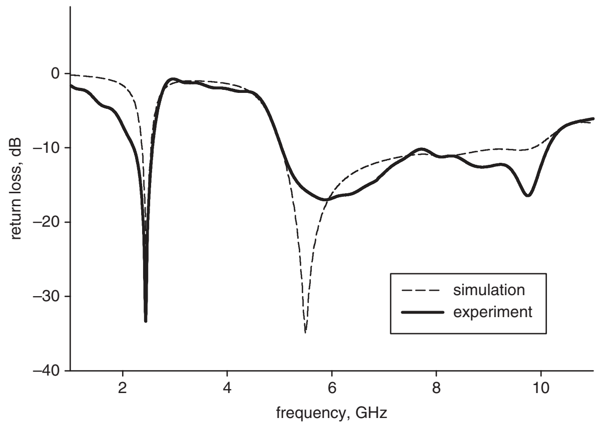

Fig. 2 *Simulated and measured return loss characteristics of antenna structure*

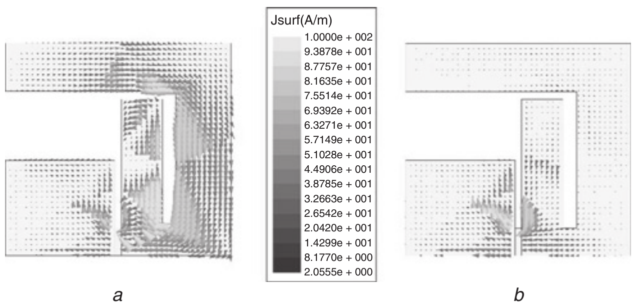

Fig. 3 *Current distribution of proposed antenna*

a 2.44 GHz
b 5.5 GHz

Results and discussion: The antenna is constructed on an FR4 substrate and tested. The simulated and experimental return loss characteristic of the final antenna is shown in Fig. 2. The experimental curve shows that a dual band is obtained from 2.2 to 2.52 GHz and from 5.03 to 10.09 GHz with good matching. The surface current distribution of the antenna for the two resonances is shown in Fig. 3. It is evident from Fig. 3 that at 2.44 GHz the strip ABCDE acts as a quarter-wave monopole with GHIJ as the ground whereas for the higher resonance the predominant effect is seen on the strips AB and GHIJ and they form a $\lambda/2$ asymmetric dipole. The large width of the strip GHIJ is responsible for the high bandwidth in the second resonance. From simulation studies it is found that the strip CDE does not have much effect on the higher resonance. The principal E- and H-plane patterns of the antenna at 2.44 and 5.5 GHz bands are shown in Fig. 4. A near omnidirectional pattern is obtained in the two bands. This projects the use of the antenna in mobile applications. The antenna is polarised along the *x*-axis in the lower band and along the *y*-axis in the higher band. The gain of the antenna is measured in the two bands and is 1.9 dBi at 2.44 GHz, 1.6 dBi at 5.2 GHz, 1.8 dBi at 5.6 GHz and 1.9 dBi at 5.8 GHz, respectively.

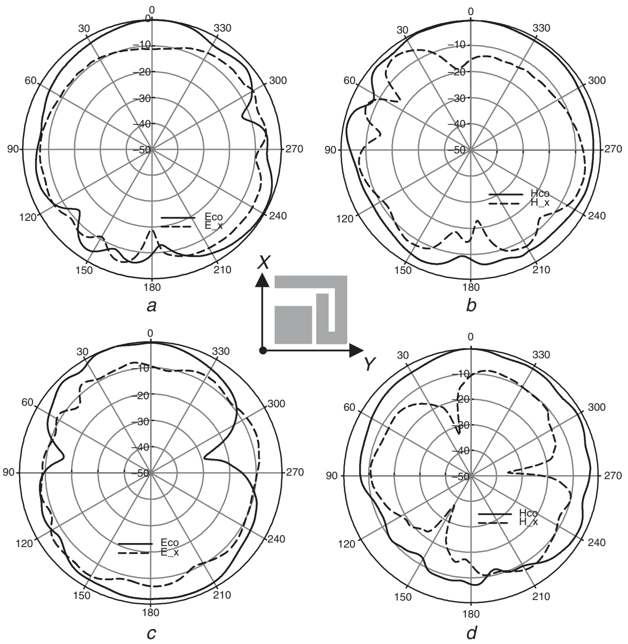

Fig. 4 *Measured radiation patterns*

a E-plane, 2.44 GHz
b H-plane, 2.44 GHz
c E-plane, 5.5 GHz
d H-plane, 5.5 GHz

Conclusion: A dual-band antenna for operation in the 2.4/5.2/5.8 GHz WLAN/HIPERLAN2 bands is presented and studied. The design is obtained by modifying a slot line thereby introducing two different current paths. The antenna has very compact dimensions of $14.5 \times 16.6 \times 1.6\ mm^3$ on an FR4 substrate. The simple, compact uniplanar structure and good radiation performance makes it useful in compact WLAN circuits.

Acknowledgments: The authors are grateful to the Defence Research and Development Organisation (DRDO), Government of India, UGC Government of India and the Kerala State Council for Science and Technology and Environment for providing financial assistance.

8 November 2006
Electronics Letters online no: 20073417
doi: 10.1049/el:20073417

V. Deepu, K.R. Rohith, J. Manoj, M.N. Suma, K. Vasudevan, C.K. Aanandan and P. Mohanan (*Department of Electronics, Cochin University of Science and Technology, Kochi 682022, Kerala, India*)

E-mail: drmohan@ieee.org

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