Volume 5, Issue 4, 2015 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Performance Investigation of a Planar Antenna for a Cheap WLAN USB Dongle

Er. Maninder Singh, Er. Gagandeep Kaur, Er. Daljit Kaur
A.P at Department of ECE, SSIE&T, Jalandhar,
Punjab, India

Abstract: Portable Computing Devices Such as Laptops, Palmtops, Tabs, Smartphone & even the Conventional PC are connected to internet via mostly wireless links as the fashion of Wireless fidelitygrows. Among the present technologies for such devices WLAN & Wi-Fi are famous. USB dongles still play a vital role. But one major challenge regarding the antenna design is to comply with a very small volume available and sometimes should also allow multiband operation. In this Paper author present a dual-band Wi-FiCompact Planar IFA-based antenna design for a low-cost USB dongle application. The methodology to handle the present manuscript was assisted by the use of Modern Electromagnetic Simulation software. A prototype is also fabricated on a fine antenna grade Laminate. The simulation results complied with the design constraints, presenting an impedance match quite stable regardless of the USB Dongle position alongside a laptop.

Keywords:* *USB Dongle, MIMO, Quasi-omni-directional, Auto-resonance.

I. INTRODUCTION

USB sticks or dongles represent a low-cost and simple way to provide network access to older desktops and notebooks or to computers with broken Wi-Fi card. In the scope of wireless LAN device technology development, they still draw some attention, especially regarding the radiator design. The typical aesthetic constraints force the device to be small. Therefore, compact antenna design techniques are unavoidable.

Many different approaches have been reported so far, mainly along the past decade. As a general basis for this kind of device, practical radiator designs only consider the availability of a small percentage of the dongle volume, since most of it must be reserved for the electronic circuitry. The constraints vary among the different solutions proposed, sometimes allowing the use of the available space more effectively. 3D meandered shaped radiators or multilayered printed circuit board (PCB) fit well in such cases. On the other hand, low-cost designs call for the use of single-layered PCB, restraining the antenna to be at most 2.5D shaped, with vias or other short connections between the front and the back planes. Sometimes, not even a back metal plane is present, leaving no choice for the antenna but to be planar.

Wi-Fi dongles may be either single or dual-banded. The 2.4GHz and 5.6GHz ISM bands cover such networks, with slight variations on the precise frequency limits from region to region. The most recent issues of the Wi-Fi standard include the possibility of MIMO system operation, and such feature is quite an active research field in the present scope. There are also some attempts to derive multiband antennas for USB dongles to allow not only Wi-Fi operation but also the access to other systems as well, such as LTE band 13 (0.746–0.787 GHz), GSM (0.88–0.96 GHz), UMTS (1.92–2.17 GHz),LTE/Wi-Max (2.5–2.7 GHz),or Wi-Max (3.4–3.6 GHz).

The design of compact antennas benefits from the presence of relatively large ground planes, which ease the constraints on what is usually considered as the radiator itself. Yet, when micro strip technology is chosen, the ground plane is expected to be in the back of the PCB. Indeed, most of the known low-cost Wi-Fi dongle radiator configurations rely on the use of a single-layered PCB with metal on both sides.

In the present scope, this work discusses an IFA-based antenna configuration for a dual-band WLAN USB dongle application. Only a single metal plane PCB was available, thus posing above-the-average constraints to the radiator design. Furthermore, the influences of the dongle case and of the laptop in which the dongle is expected to be plugged in during operation were both considered. As in virtually all related works, the antenna design was numerically assisted by the use of an electromagnetic field simulator.

II. ANTENNA DESIGN

Fig.1 illustrates the layout constraints of the USB dongle. The PCB area available was smaller than 17×60 mm^2, from which only the upper 17×10 mm^2 side was left for the radiator. Fabrication cost reduction was a priority; in such a way that only one metal layer was made available for both the antenna and all the due electronics, as stated in the introduction. No changes whatsoever were allowed in the area below the space reserved for the radiator. Briefly, the antenna had to be integrated to the PCB using the same single plane and sharing the ground with the electronic circuitry.

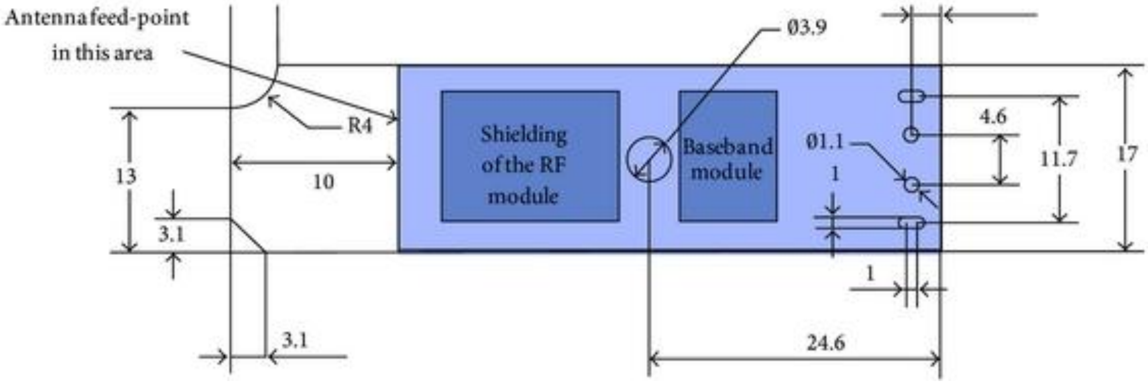
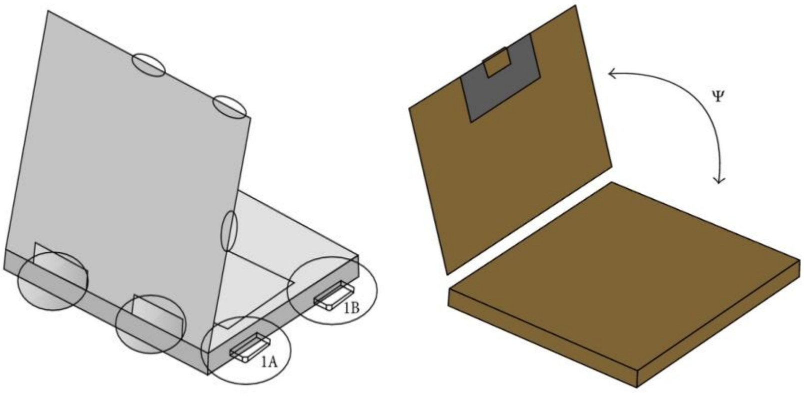


Fig. 1: Layout of a normal WLAN USB dongle circuit board (all dimensions in mm).

The imposed single plane PCB also restrained the antenna choice to a small set of planar configurations. PIFAs and other "2.5D" layouts were thus out of scope.In this antenna design, the dongle case had to be made of a low-cost injected plastic structure available. However, the electric properties of that material in the WLAN frequency bands were not known beforehand, thus posing an additional issue.

The USB dongle was supposed to operate in both WLAN ISM bands 2.4GHz and 5.6GHz. It was also expected that the impedance adaptation for a 50 Ω load should provide a reflection coefficient S11 no higher than −10 dB within the specified bands, though the −6 dB limit was acceptable, bearing in mind the natural performance limitations of compact antennas.

This relative flexibility on the S11 performance was allowed also due to the variety of scenarios in which the USB stick was supposed to operate, mainly regarding the laptop influence. Typically, any notebook has many USB ports spread along the keyboard panel sides or at its back, as illustrated in Fig.2. Furthermore, the screen is expected to form an angle around 90° to 120° with the keyboard, and such layout may also affect the antenna performance, particularly when the radiator is small, as was the case.



(a) (b)

Fig. 2: Possible positions of a WLAN dongle on a laptop and the features that can affect the performance of antenna: (a) USB ports positions and (b) screen-to-base angle.

III. METHODOLOGY

As in most of the other related works, the restricted geometrical specifications imposed led to a numerically assisted design methodology. The whole process carried out may be described as follows.

First taking into account the PCB layout provided in Fig. 1, a few basic planar single-band radiator configurations were chosen, based on the available knowledge on compact antennas. In this work, meander line and IFA layouts were tested, simulating such structures directly on the PCB layout provided, with the aid of the field analysis software. Then, a fine tuning of these configurations to the lower frequency band (2.4 GHz) was carried out, from which the IFA-based one presented the best performance, and, for that, it was selected for prototyping.The need for such initial set of tests was due to the absence of accurate information on the dongle case electrical properties. Therefore, an experimental procedure was set to estimate the resulting frequency shift due to the casing material that would wrap around the PCB. Basically, S11 measurements of the prototype PCB without and with the casing material were performed, from which a 5.4% downshift (around 130 MHz) was observed in the operating frequency (resonance or near resonance frequency) of the PCB&case set.The next step in the design process was the inclusion of another resonance in the upper 5.6GHz band, while also taking into account the expected frequency shift imposed by the dongle case. It is important to remark that, since no accurate values of the casing material permittivity were available, it was not directly considered in the supporting simulations. What has been done instead was to rescale the antenna to resonate around 5.4% above the WLAN central frequencies to compensate the lack of the dongle case in the simulation models. Therefore, in this stage of the process, the antenna should be designed to resonate close to 2.58 GHz at the lower band and 5.8 GHz at the upper band.

Since the upper WLAN band was more than an octave above the lower band, a feasible solution could be achieved by the insertion of a second smaller IFA in the same available space, followed by parametrical-based tuning. The fine-tuned layout that presented the best performance is sketched in Fig. 3. This proposed configuration has a higher frequency branch inserted in the lower frequency IFA (the largest segment) sharing a common return to ground, as well as the feed port. As it can be seen, both the largest and the shortest segments are actually not "F" shaped, since both had to be round bent at their ends in order to make the whole set fit to the restricted available area. It is also worth mentioning that, from what could be observed during the tuning simulations, the parameters that affected most critically the S11 performance were the feed gap width and the total length of each branch.

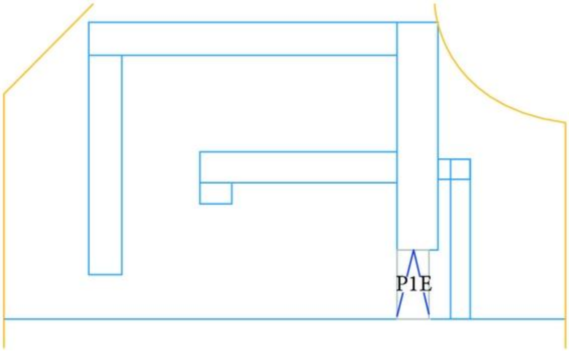


Fig. 3: Design layout of the proposed radiator configuration of the compact planar Antenna.

The radiator configuration in Fig. 3 was actually achieved after another set of tuning simulations needed in order to evaluate the effect of the laptop on the antenna performance. At this level, the simulations took into account the four relative USB ports indicated in Fig. 2, with the laptop screen angle of 90^0. The basic parameter observed to guide this final tuning round was S11, since typically there is not much that can be done regarding the pattern of compact antennas. Anyway, the radiation pattern behavior should be observed, with and without the influence of the laptop, in order to see how Omni-directional the dongle can be.Finally, the simulated layout that provided the best overall performance was picked for prototyping and qualification tests. These trials should include S11 measurements of the antenna impedance in a number of situations, particularly with the dongle plugged in different USB ports of a typical laptop, with its screen opened, as illustrated in Fig. 2. With proper lab facilities available such as an anechoic chamber, it is also desirable to measure radiation patterns and efficiency. In this work, the validation tests comprised both the impedance adaptation and radiation performance aspects, in realistic scenarios (dongle set assembled with its plastic casing and plugged in a laptop) as addressed in next Section.

IV. SIMULATION RESULTS

In this section, the simulated results of the best achieved configuration, sketched in Fig. 3 are presented. The discussion includes not only the antenna behavior on the dongle alone, but also the influence of a laptop, which corresponds to the more realistic operation scenario.Fig. 4 show the S11 simulation results of the proposed antenna. A dual-band operation was achieved, with the best impedance matching frequencies at 2.5GHz and 5.7 GHz. Since the dongle case was not directly taken into account in the simulator, the target center frequencies of the lower and higher operation bands were 2.58GHz and 5.8GHz, respectively. At this stage of the design process and bearing in mind that the laptop effect would be evaluated, these frequency values were acceptable enough.

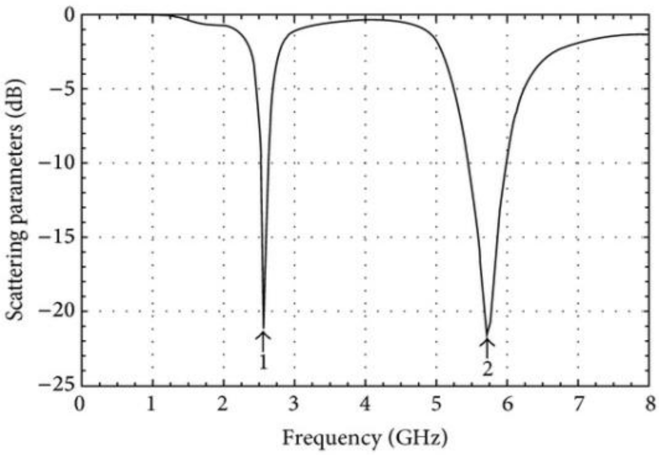


Fig. 4: S11 VS Frequency Plot of the proposed antenna.

Fig. 5 and 6 show the simulated radiation patterns of the dongle alone, without casing, and basically a dipole-like behavior is seen, as expected. The compact antenna limitation to radiate only the lowest order spherical modes is clearer in Fig. 5where the pattern is quasi-omni-directional, given that the radiator largest branch length (24 mm) is around five times shorter than the wavelength of the lower band (117 mm at 2.56 GHz).

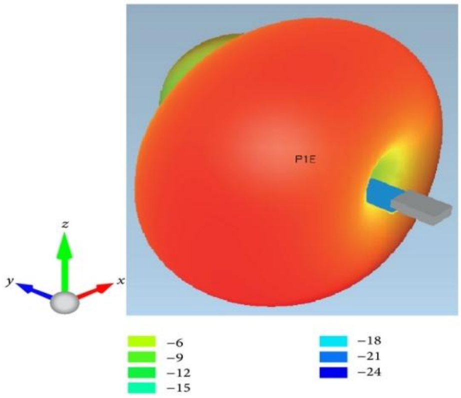


Fig. 5: Simulated 3D radiation pattern of the proposed antenna at 2.5GHz.

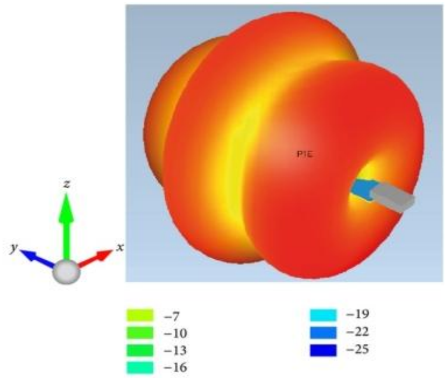


Fig. 6: Simulated 3D radiation pattern of the proposed antenna at 5.7GHz.

Electromagnetic field simulators such as the one used in this work also provide interesting information on the current density distribution. Important insights into the current paths may be drawn from the analysis of this parameter that may be helpful to retune the antenna, during the design phase. Fig.7 and 8 present the simulated distributions of the dongle alone at 2.5GHz and 5.7GHz, respectively.

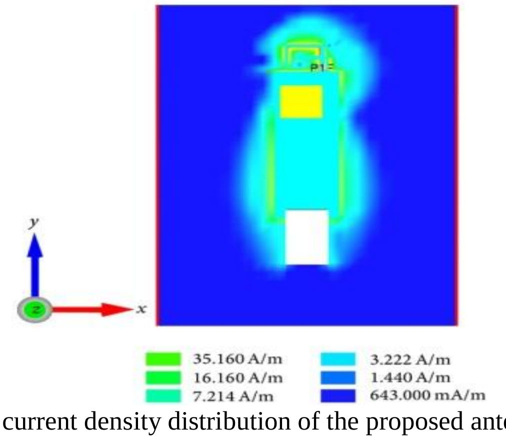


Fig. 7: Simulated current density distribution of the proposed antenna at 2.5GHz.

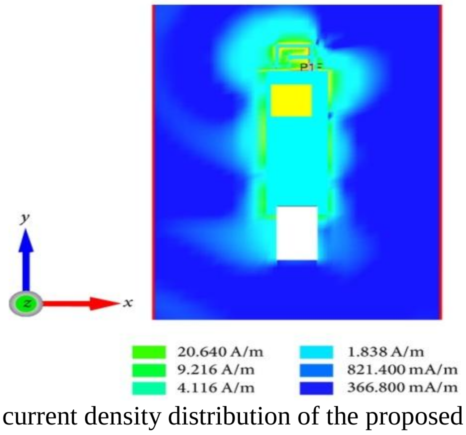


Fig. 8: Simulated current density distribution of the proposed antenna 5.7GHz.

Observing the current density distributions at each band, the smaller branch of the antenna is not so active in the lower band; see Fig. 7. Also, the distribution along the PCB edges is almost uniform. On the other hand, at the higher band, the small branch is active, while the current distribution along the edges of the PCB is not uniform anymore, as seen in Fig. 8. Thus, the radiation behavior seems to be the combination of a first order mode associated with the shorter tip-bent "F" branch with a second order mode related to the longer one.

V. CONCLUSION & FUTURE SCOPE

In this paper, the design of a novel compact dual-band planar antenna for a low-cost USB WLAN dongle was discussed. Among the main constraints, the radiator element had to fit within a space as small as $17x10mm^2$. Furthermore, the planar feature was actually imposed, since the antenna should be integrated to the device PCB, which had nothing but a single metal layer available. As a result, the set of pertinent basic antenna configuration choices at the beginning of the design process was more limited than usual. An IFA-based shape was the one that gave the best results, with the final shape actually resembling a tip-bent "F," since the largest branch of the radiator had to be bent to fit within the available area.The impedance matching performance of the prototype was coherent with the simulated results, presenting a desirable frequency stability regarding the laptop influence. That is, no matter the position where the dongle was plugged in, the S11 bandwidth was kept within acceptable limits.

Power patterns kept the quasi-omni-directional shape expected from simulations and from theory. Gain and efficiency were also measured, with good results for such a kind of compact radiator. Overall, the proposed IFA-based antenna proved to be a suitable choice for low-cost compact WLAN dongle devices.

REFERENCES

[1] Balanis, C. A., Antenna Theory, John Wiley & Sons, Inc, 1997.

[2] Kraus, J. D. and R. J. Marhefka, Antennas for All Applications, McGraw-Hill, 2002.

[3] Wong, K. L., Planar Antennas for Wireless Communication, John Wiley & Sons, Inc, 2003.

[4] Govind R. Kadambi& et al, "Miniaturized Dual ISM Band Internal antennas", IEEE – APS Magazine, Vol. 6, No.3, April 2003.

[5] Yen-Liang Kuo, Kin-Lu Wong, "Printed double-T monopole antenna for 2.4/5.2 GHz dual-band WLAN operations", IEEE Trans. Antennas Propagation, vol. 51, September 2003.

[6] Zheng, Y.-S, S.-J. Fang, "Dual-band rectangular patch antenna with a pair of L-shaped slots for WLAN application", IEEE International Symposium on Microwave, Antenna, Propagation and EMC Technologies for Wireless Communication, Vol. 1, 185-187, 2005.

[7] Juan Valenzuela-Valdes& et al, "Tunable dual-band printed tab monopole antennas forwireless communications", IEEE MELECON, Benalmádena (Málaga), Spain, May 16-19, 2006.

[8] E. Wang & et al, "A Novel dual-band Patch antenna for WLAN Communication", Progress In Electromagnetics Research C, Vol. 6, 93-102, 2009.

[9] Kekun Chang & et al, "WLAN and Bluetooth Antenna Design", PIERS Proceedings, Beijing, China, March 23-27, 2009.

[10] V. Rajeshkumar, K. Priyadarshini, G.Devakirubai, C.Anitha and P.Snekha (2012) 'Design and comparative study ofpin fed and line fed microstrip patch antenna for X-Band applications', International journal of applied informationsystems(IJAIS), vol. 5, pp. 21-25.

[11] SathiyamoorthyMurugan& et al, "Design and analysis of double U slot loaded dual frequency microstrip antenna", Progress In Electromagnetics Research C, Vol. 45, 2013.

