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Impact of Ground Plane Reduction in Antennas for Compact Terminals

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Abstract

In this paper, the impact of the ground plane reduction imposed by modern wireless terminals on the antenna performance is evaluated. Numerical results in terms of antenna efficiency and Q-factor are discussed for two different antenna geometries.

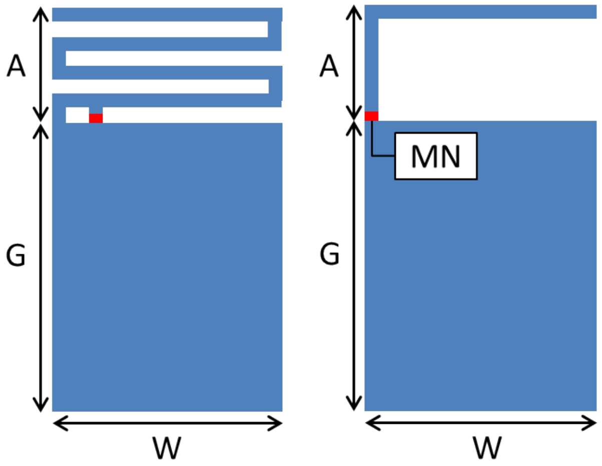
1 Introduction

Driven by the continuous progress of the mobile communication industry, the development of compact and multiband antenna for handheld terminals received great attention from the antenna design community in the last years. In order to obtain reliable results, the terminal ground plane must be modeled and carefully taken into account during the design process [1].

In the literature, most of the work have been focused on compact antenna integrated in a mobile phone terminal. In [2]-[4], for example, the terminals have all the same dimension of 115×60 mm^2, corresponding to $0.26\lambda \times 0.14\lambda$ [2] and $0.32\lambda \times 0.16\lambda$ [3],[4] at the lower operating frequency. Slightly different sizes can be found in [5] and [6], where the considered terminals are 120×65 mm^2 ($0.28\lambda \times 0.15\lambda$) and 100×50 mm^2 ($0.25\lambda \times 0.12\lambda$), respectively.

However, more recently, with the spreading of the internet-of-things (IoT) paradigm in which any kind of object will be connected to the internet, mobile terminals can be much smaller, while frequency bands are equivalent in term of wavelength. In [7], the design of a miniature dual-band antenna to be integrated in a compact position tracking device has been presented. The device has a very small dimension of 40×25 mm^2, while the space available for the antenna is only 12×25, mm^2, corresponding to $0.12\lambda \times 0.07\lambda$ and $0.03\lambda \times 0.07\lambda$, respectively, at 868 MHz, i.e., the operating frequency of the LoRa standard used to transmit the location information.

The objective of this paper is to discuss the effects of reducing the ground plane of miniature antennas to meet the physical constraints of IoT compact terminals. Towards this end, the performance in terms of antenna efficiency and quality factor are evaluated for two different antenna geometries and for different ground plane sizes.



(a) **(b)**

Figure 1. Antenna geometries: (a) the meandered inverted-F antenna (IFA) and (b) the short monopole (SM) with matching network (MN).

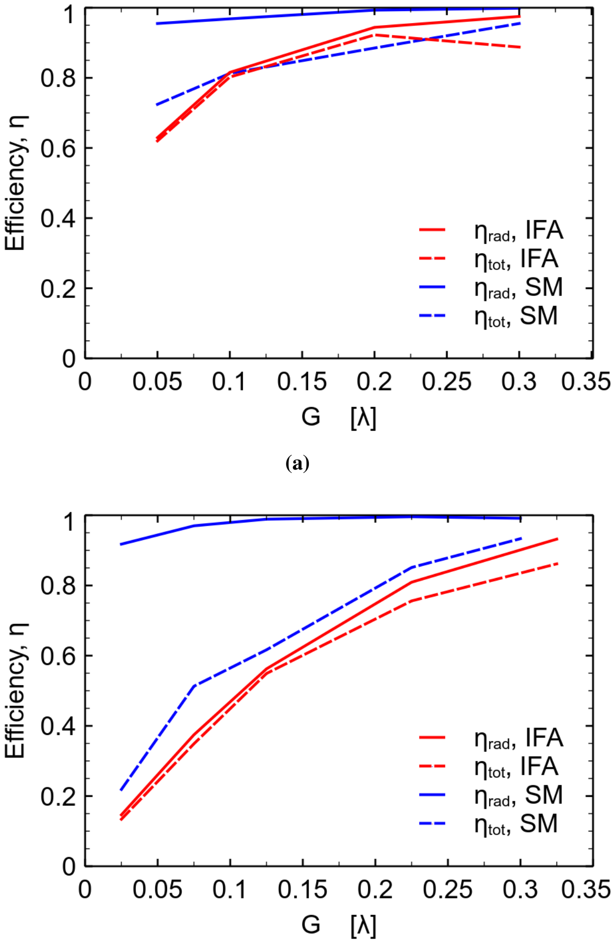
2 Antenna Geometries

The two terminal geometries considered in this study are shown in Fig. 1. In both of them, the antenna occupies a $A \times W$ rectangular space located above a coplanar ground plane of dimension $G \times W$. The antenna feeding points are highlighted in red.

The first antenna (Fig. 1a) is a classical inverted-F antenna (IFA), in which the resonant frequency and the impedance matching can be controlled by the length of the arm, the width of the line and the distance between the feeding and the shorting points. The second antenna (Fig. 1b) is based on a short monopole (SM) covering the top edge of the terminal. Such type of structure cannot be matched to 50 ohm with geometrical parameters, thus a matching network (MN) is used to match the antenna. All the components used in the MN have a $Q = 30$.

3 Numerical Analysis

The performance of the two antenna geometries have been evaluated for different terminal size. This is done by fixing



(a)

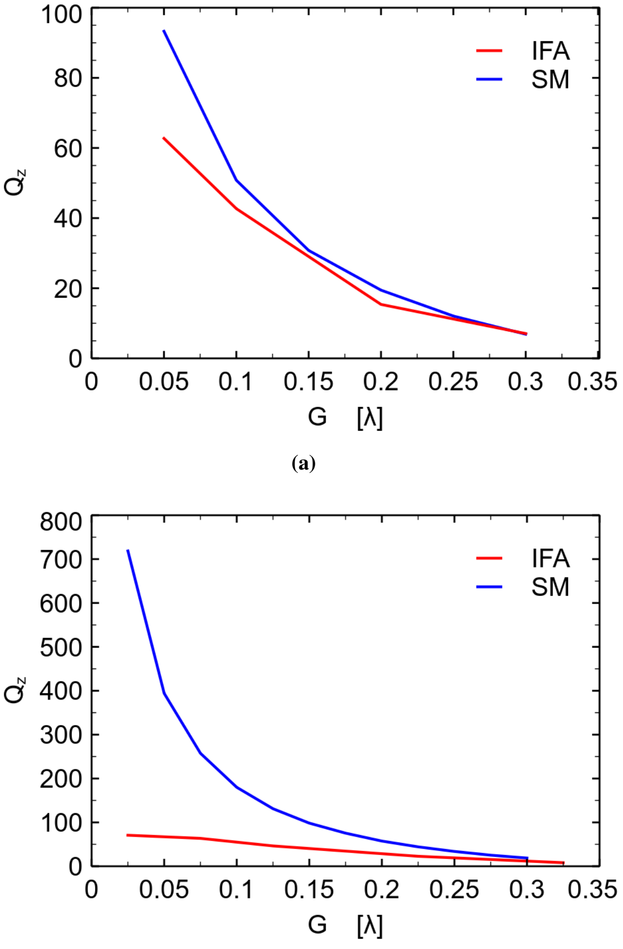
(b)

Figure 2. Radiation and total efficiencies for the two antenna geometries. a) $A = 0.05\lambda$ and b) $A = 0.025\lambda$

the antenna size and varying the ground plane dimension G. The width of the terminal has been fixed to $W = 0.1\lambda$ while $A = 0.05\lambda$ and $A = 0.025\lambda$ have been considered as the space available for the antenna.

Figs. 2 and 3 show the simulated antenna efficiency η and the Q-factor Q_z for the two antenna structures. In order to obtain a fair comparison, the reported values are those obtained when the antenna is matched ($S_{11} \leq -10$ dB) at the reference frequency of 868 MHz. The impedance matching is obtained by optimizing the line width and the feed-short distance for the IFA antenna, and the MN components' values for the SM structure.

As it can be noticed, in terms of total efficiency, the performance of both the IFA and the SM geometries are quite similar when $A = 0.05\lambda$ (Fig. 2a). However, when the space for the antenna is reduced ($A = 0.025\lambda$, Fig. 2b), the SM structure provides slightly better efficiency values, whatever the ground plane dimensions. Moreover, it is worth to notice that, as G reduces, the efficiency decrease is not linear. This must be carefully taken into account when antenna for small terminal (much smaller than standard mobile phones) must be designed.



(a)

(b)

Figure 3. Q-factor for the two antenna geometries. a) $A = 0.05\lambda$ and b) $A = 0.025\lambda$

On the other hand, the IFA antenna provides always lower Q-factors, and thus larger operating bandwidths, than the SM antenna (Figs. 3a and 3b).

4 Conclusion

In this paper, the effect of reducing the ground plane dimension of antennas for compact terminals has been evaluated on the performance of two different antenna geometries. The obtained results indicate that the SM antenna configuration allows a slightly higher total efficiency when the space for the antenna is limited at the price of a higher Q-factor. Moreover, the non-linear decrease of the antenna efficiency when the ground plane dimension reduces must be carefully taken into account during the antenna design process.

5 Acknowledgements

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