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Ground Plane Size Effect on a UWB Monopole Antenna

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Abstract - The effect of the ground plane size on a UWB monopole antenna, which is applied to the mobile terminal, is studied. The antenna performances, including its impedance bandwidth and radiation pattern are discussed when the length and width of the main ground plane are changed, especially the return loss for a range of quite different size of the ground plane. Based on the simulation results, a prototype of the monopole antenna with a 40x60mm^2 ground plane is fabricated and the simulated and measured return loss are given to show the validity of this study.

Index terms - UWB, monopole antenna, mobile, ground plane

I. Introduction

The monopole antenna is a very promising UWB candidate for applications to mobile wireless devices such as mobile phones, laptops and PDA phones, because of its low profile, easy fabrication, and multi-band usability. Different shapes of the monopole radiator, such as cylindrical monopole [1], Square Cylindrical monopole [2], and stubby monopole [3], etc, have been proposed. However, so far few studies ever discussed how the UWB antenna performance, including the impedance bandwidth and radiation pattern, depends on the ground plane size, which is an important factor because the antenna may have quite different size, due to its specific profile for different applications. For example, a pen style phone is very slim, which has a very narrow ground plane, while a smart phone usually has a very big display. In this study, a stubby monopole proposed by Liu [3] is used as a sample. When the width and length of its ground plane are changed, the simulated results show that an increased lower edge frequency and a resulting narrower impedance bandwidth are obtained when the size of the ground plane, especially the width rather than the length, is tailored. The radiation pattern is also slightly changed yet on the whole it keeps omnidirectional. A prototype of the stubby monopole with a 40x60mm^2 ground plane is fabricated and the simulated and measured return loss are given to show the validity of this study.

II. Simulation and Analysis

In [3], Liu proposed a stubby monopole using a single copper plate for mobile phone applications, whose geometry is shown in fig.1, with a very wide operating bandwidth of about 10.9 GHz (about 1.7-12.6 GHz), covering the mobile UMTS band (1920-2170 MHz) and the 2.4/5.2/5.8 GHz WLAN bands for WLAN dual-mode operation of a mobile phone. In his study, the size of the main ground plane is 70x100 mm^2. This paper studies the ground plane size effect on the stubby monopole antenna, based on the following three steps. Firstly, the width of the main ground plane is tailored from 70mm to 20mm by every 5mm, while the length is fixed to be 120mm. Next, the length is tailored from 120mm to 15mm by every 5mm, while the width is fixed to be 70mm. And finally, both the width and length of the main ground plane are changed simultaneously, by every 5mm and 10mm respectively. Thus, a range of quite different size of the ground plane, which is from 10x120mm^2, corresponding to an extremely slim pen style phone, to 60x20mm^2, the relatively big display which a smart phone may have, is covered. The simulation is conducted to every specific ground plane size using CST microwave studio and the impedance bandwidth and far field radiation pattern are recorded.

The simulated impedance bandwidth response, defined by -10dB return loss, exclusively to

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the width of the main ground plane change is shown in fig.2 (a), while the length of the main ground plane is kept as 120mm. Note that the lower edge frequency increases slightly, from 1.7918GHz to 2.1916GHz, as the width of the ground plane is gradually tailored from 70mm. However, when the width is further tailored to be less than 35mm, the lower edge frequency increases a bit more remarkably and the UMTS and 2.4GHz WLAN band can not be covered any more. Meanwhile, good impedance matching can not be achieved over the whole UWB frequency range, since a small frequency notch appears at around 3.28GHz. The upper edge frequency always remains to be about 12.1GHz during the width change so that the impedance bandwidth virtually depends almost merely on the lower edge frequency. It is similar in fig. 2 (b) when the length of ground plane is tailored, the width being kept as 70mm, and it is noted that the lower edge frequency begins to deteriorate when the length is cut to be less than 50mm. Fig.3 is the case when both width and length are changed simultaneously. When the main ground plane is very slim, for example 10x120mm^2, the lower edge frequency is as high as 4.6818GHz. As the width increases and length decreases, the impedance matching gets better at lower frequencies, and it should be noted that size of the width plays a relatively dominate role that affects the impedance bandwidth, compared to the length, only two exceptions being at the size 30x80mm^2 and 35x70mm^2. As the length is excessively tailored to be lower than 30mm, the lower edge frequency increases again.

The typical radiation pattern of the stubby monopole is already given in [3]. Generally, good omnidirectional radiation pattern is obtained for different ground plane size over the whole UWB band. However, when the main ground plane size is changed, slight differences still occur, which is required to be noted when different styles of antenna are designed. Limited to the space of the paper, a notable example is discussed here. Fig.4 plots the radiation pattern of y-z plane at the centre frequency (2045MHz) of the UMTS band, when the length of the ground plane is 120mm, 80mm, 40mm and 20mm, respectively. When the length of the ground plane is sufficiently large in z direction, the ground performs as a good reflector thus it shows a relative larger radiation in the lower hemisphere [1]. As the length is gradually tailored, the antenna tends to be more “omnidirectional” even on the vertical y-z plane. Thus based on the analysis above, a trade-off between perfect omnidirectional radiation and good impedance bandwidth may be taken when deciding the ground plane size for specific application in future monopole antenna design.

III. Prototype Fabrication and Its Return Loss

A prototype of the stubby monopole with a 40x60mm^2 main ground plane size is fabricated, the main ground plane size of which is relatively smaller than that in [3], as is shown in fig. 1. The simulated and measured return loss are plotted in fig. 5, which agree well with each other and one can find that both 2.4 GHz and 5.2/5.8 GHz WLAN bands are covered. The measured radiation pattern also exhibits a good omnidirectional property yet cannot be shown here, owing to the limitation of space.

IV. CONCLUSION

The effect of the main ground plane size on a UWB monopole antenna is studied. When the ground plane is gradually tailored, an increased lower edge frequency and a resulting narrower impedance bandwidth are obtained. The length change of the ground plane has a more evident effect on the impedance bandwidth, than the width. An even better omnidirectional radiation pattern could be obtained if the ground plane is tailored to be small. A prototype of the monopole antenna with a 40x60mm^2 main ground plane is fabricated and the simulated and measured return loss are given to show the validity of this study.

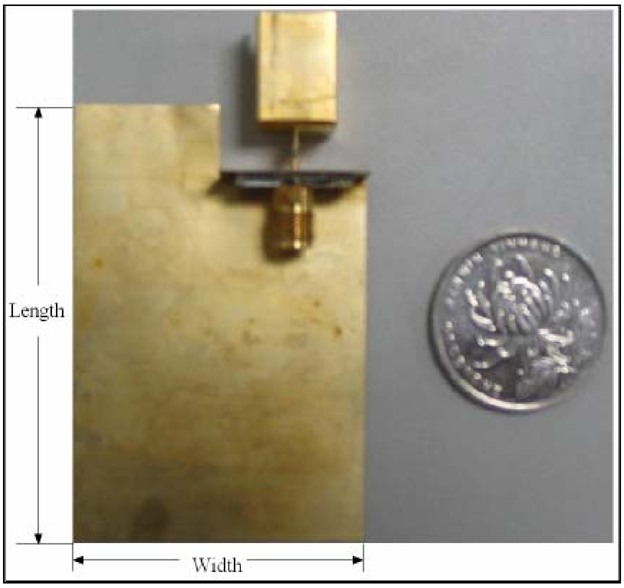

Fig. 1 Prototype of a stubby monopole antenna with a 40x60mm^2 main ground plane

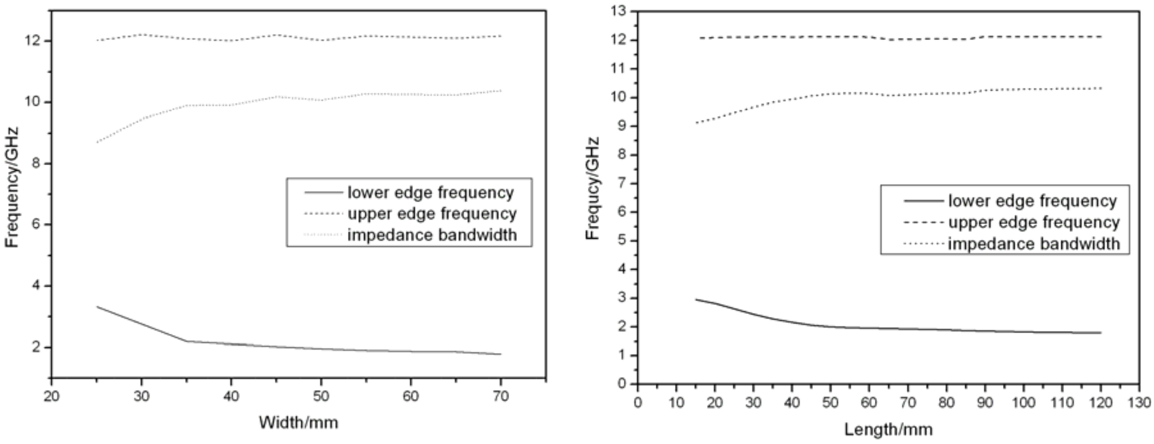

Fig. 2 The lower edge frequency, upper edge frequency and the resulting impedance bandwidth response to (a) the width change (b) the length change of the main ground plane

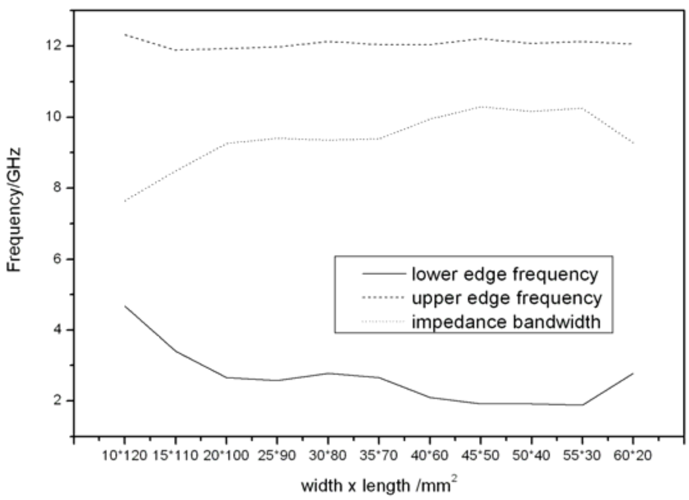

Fig. 3 The lower edge frequency, upper edge frequency and the resulting Impedance bandwidth response to the simultaneous change of width and length

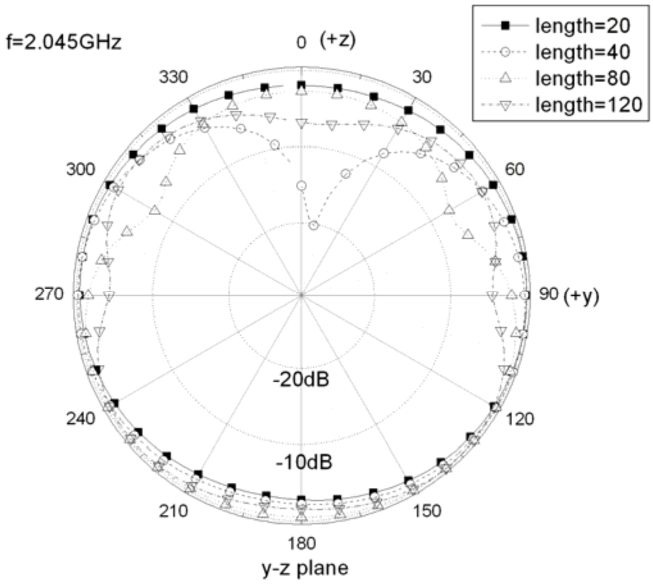

Fig. 4 Radiation pattern response on y-z plane to the length change of the main ground plane

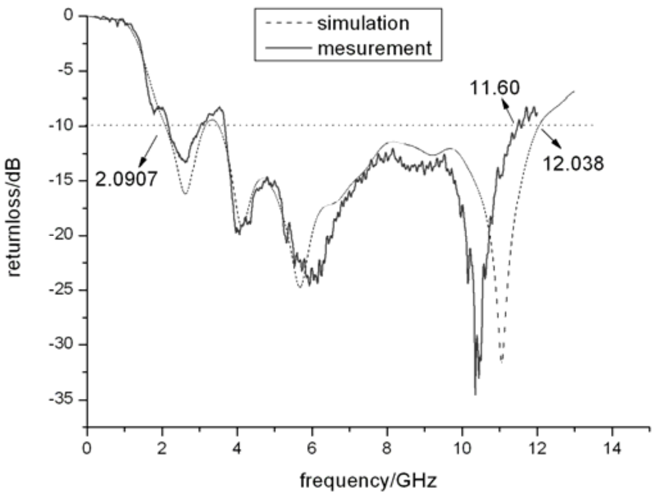

Fig.5. Simulated and measured return loss of the fabricated stubby monopole prototype

Acknowledgments

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