A Folded Dipole Antenna with a Feed Line for WiMAX

#Mio Nagatoshi[1], Hisashi Morishita[1] and Masao Sakuma[2]

[1] Department of Electrical and Electronic Engineering, National Defense Academy
1-10-20 Hashirimizu, Yokosuka, Kanagawa 239-8686, Japan, g48091@nda.ac.jp

[2]Wireless solution Engineering Department, Fujitsu Semiconductor Limited
Nomura Shin-Yokohama Building 2-10-23 Shin-Yokohama, Kohoku-Ku Yokohama, Kanagawa 222-0033, Japan, sakuma.m@jp.fujitsu.com

Abstract

We present the antenna characteristics of the folded dipole with a short feed line. It is shown that wideband characteristic and impedance transformation can be obtained without a quarter-wavelength feed line. The wideband antenna can operate on a ground plane in a similar way and be applied to the antenna for WiMAX.

Keywords : Folded dipole antenna Wideband WiMAX

1. Introduction

Recently, wireless communication technology is rapidly developed. The Worldwide Interoperability for Microwave Access (WiMAX) is one of the wireless communication standards. WiMAX covers the band of 2.5/3.5/5.5 GHz. The antennas with the multi-band operation and wideband characteristic are demanded. Moreover, the space, in which the antenna is mounted, is narrow. Space saving of the antenna is necessary in order that the antenna is mounted to the small terminals. As one of wideband and planar antennas, the folded dipole antenna with a feed line has been introduced [1]. The antenna is a half-wavelength folded dipole antenna with a quarter-wavelength feed line. The impedance of the folded dipole antenna can be easily transformed from 300 Ω to 50 Ω, and the wideband characteristic is obtained by adding the feed line to the folded dipole. However, it is difficult that the antenna is mounted to the small terminal because the feed line is too long. In this paper, we show that the antenna can transform the impedance and obtain a wideband characteristic by using a feed line whose length is under quarter-wavelength. We propose the folded dipole antenna which can cover the band from 2.3 GHz to 3.8 GHz, a part of the WiMAX operating bands, on the ground plane which represents a body for WiMAX.

2. Antenna structures

Figure 1 shows the configuration of the antenna analyzed in this study. Figure 1 (a) is the basic model, folded dipole antenna with a feed line [1]. First, we investigate the basic model. The antenna length is ***la***. The width of upper element, lower element and joint part between upper and lower element are $\boldsymbol{wa_1}$, $\boldsymbol{wa_2}$ and $\boldsymbol{wa_3}$, respectively. The space between the upper element and lower element is ***as***. The width of the feed line is ***wf***. The length is ***lf***. The gap between feed lines is ***wf***. In this study, the desired frequency is 3 GHz. The frequency is almost equal to the center frequency between minimum frequency (2.3 GHz) and maximum one (3.8 GHz). The wavelength of the desired frequency is 100 mm (λ_0). ***la*** is fixed to 50 mm, $\lambda_0/2$. The values of $\boldsymbol{wa_1}$, $\boldsymbol{wa_3}$, ***sa***, ***sf*** and ***wf*** are fixed to 3 mm. The length of feed line, ***lf***, is fixed to 9 mm, which is approximately $\lambda_0/12$. In this study, parametric studies of $\boldsymbol{wa_2}$ and ***wf*** are performed. Next, as shown in Fig.1 (b), we investigate the characteristics of the basic model which is mounted on a rectangle ground plane (GP). The antenna is on the same level of the GP. The GP size is 50 × 80 mm^2 and represents a body for WiMAX. The model is defined as the planar model. Then, as shown in Fig.1(c), the antenna part is mounted on the upper end of GP. The height from GP to antenna is the same as ***lf***. The model is defined as a 3D model.

3. Simulation results

The electromagnetic simulator FEKO based on the method of moments is used in the analysis. First, as shown in Fig. 1 (a), in the case that the values ***wf*** and $\boldsymbol{wa_2}$ are changed respectively, we investigate the characteristics of the basic model. Figure 2 shows the impedance characteristics of the basic model in the case that ***wf*** is varied from 3 mm to 15 mm. They are normalized by 50 Ω. On the smith chart, when the characteristic of the model without a feed line is compared to that with the feed line (***wf***=3 mm), it is shown that the feed line doesn't have enough length to transform the impedance from 300 Ω to 50 Ω. The impedance of ***wf***=3 mm is too high to obtain 50 Ω matching. When the value of ***wf*** is increased from 3mm, the moves to the left on the smith chart. Therefore, the impedance of the folded dipole with the feed line whose ***wf*** is over 3 mm becomes lower than that of ***wf***=3 mm. Figure 2 (b), VSWR characteristics, shows that the change of ***wf*** can obtain good impedance matching. The characteristic impedance of the feed line is obtained as

$$Zc = \frac{377}{\pi} \ln\left(\frac{D}{d} + \sqrt{\left(\frac{D}{d}\right)^2 - 1} \right) \quad (1)$$

where D is the distance between the centers of the wire feed line and d is the wire equivalent diameter of the planar feed line [2]. According to the equation, the wider the width of feed line is, the smaller the characteristic impedance of feed line is. Because the rotating center of the impedance transformation becomes small, the locus moves to the left on the smith chart. Figure 3 shows the impedance characteristics in the case that $\boldsymbol{wa_2}$ is widened from 3 mm. As shown in Fig. 3 (a), the locus rotates clockwise. When $\boldsymbol{wa_2}$ is wider than $\boldsymbol{wa_1}$, the step-up ratio is under 4 and the impedance of the folded dipole is less than 300 Ω. The rolling radius of the impedance transformation become small, and the impedance of the folded dipole becomes smaller than the characteristic impedance of the feed line. Therefore, the locus rotates clockwise on the smith chart.

Next, as shown in Fig1 (b), we investigate the characteristics when the basic model is mounted to the GP in the same plane. When the values of ***wf*** and $\boldsymbol{wa_2}$ is increased from 3 mm, the impedance characteristics changes as well as those of the basic model, as shown in Fig. 2 and 3. Figure 4 shows the impedance characteristics of the planar model on the smith chart. When the values of ***wf*** and $\boldsymbol{wa_2}$ are increased, the impedance locus moves to the left and rotates clockwise, respectively. The GP has a little effect on the antenna and we can easily adjust the impedance of the planar model. Moreover, adjusting of ***wf*** and $\boldsymbol{wa_2}$ together, the planar model can obtain wideband characteristic. Figure 5 shows the VSWR characteristic of the planar model when ***wf***=10 mm and $\boldsymbol{wa_2}$ =6 mm. In this instance, the VSWR characteristics is less than 3 from 2.06 GHz to 4.18 GHz, and the bandwidth can cover the bandwidth of WiMAX. Then, as shown in Fig. 1(c), the part of the feed line is bent and the part of the antenna is set above the GP. Figure 6 shows the impedance characteristics of the planar model and 3D models. When the planar model is just bent, the impedance characteristic degrades from 2.13 GHz to 2.63 GHz. The degradation can be improved by adjusting the values of ***wf*** and $\boldsymbol{wa_2}$ as well as the cases of the basic model and planar model. When ***wf***=10 mm and $\boldsymbol{wa_2}$=10 mm, the VSWR characteristic of 3D model is less than 3 from 2 GHz to 4.26 GHz and the bandwidth can cover the WiMAX bandwidth.

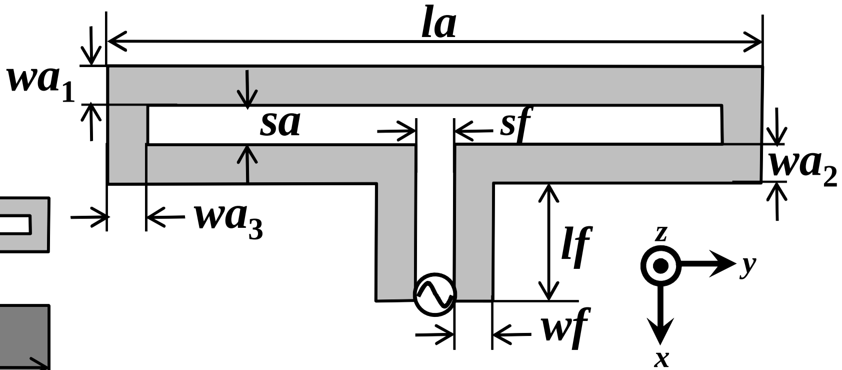
4. Conclusion

We investigate the folded dipole with a short feed line for WiMAX antenna. The impedance of folded dipole antenna can be transformed from 300 Ω to 50 Ω by adding a quarter-wavelength feed line to the folded dipole. When the feed line is shorter than quarter-wavelength, the impedance can't be transformed and is too high against 50 Ω. However, when the widths of folded dipole antenna and feed line are adjusted properly, the folded dipole antenna with the short feed line can have wideband characteristic and transform the impedance as well as the folded dipole with quarter-wavelength. When the antenna is set on the ground plane, the adjustment is useful, similarly. We can obtain the wideband antenna, which can cover the bandwidth of WiMAX, on the ground plane whose size is 50×80 mm^2.

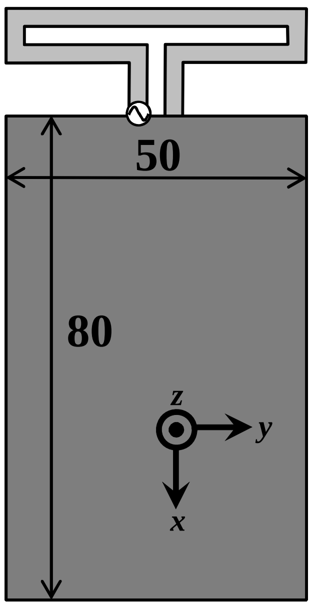
References

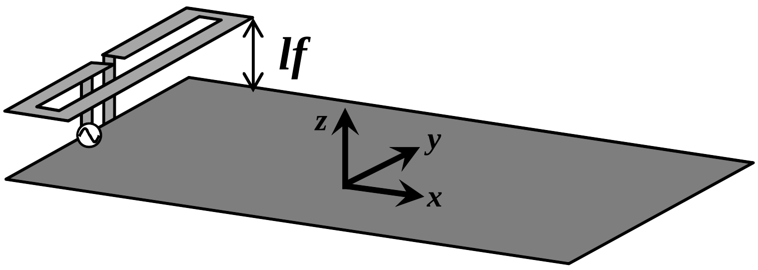
[1] M. Nagatoshi, S. Tanaka, S. Horiuchi and H. Morishita,"Broadband characteristics of a planar folded dipole antenna with a feed line", IEICE Trans., vol. E94, no.5, pp.1168-1173, 2011.A.

[2] R.E. Collin, Foundations for Microwave Engineering, 2nd edition, John Wiley & Sons, New York, pp.117,2000.



(a) Basic model.

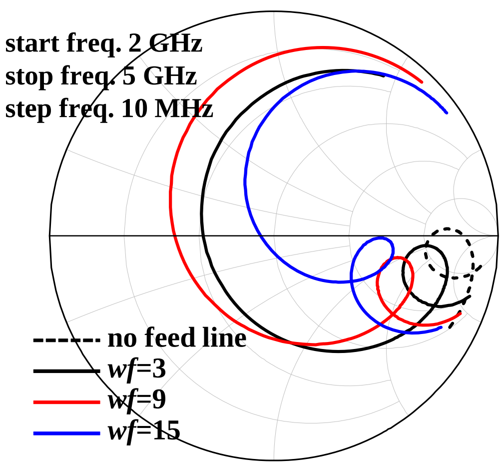


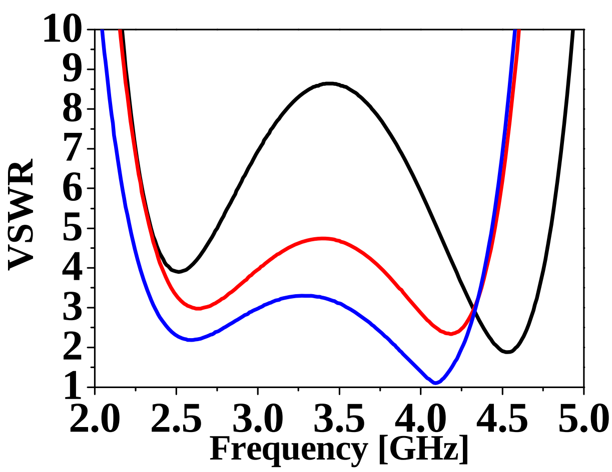


(b) Planar model.

(c) 3D model.

Figure1: Antenna structures.

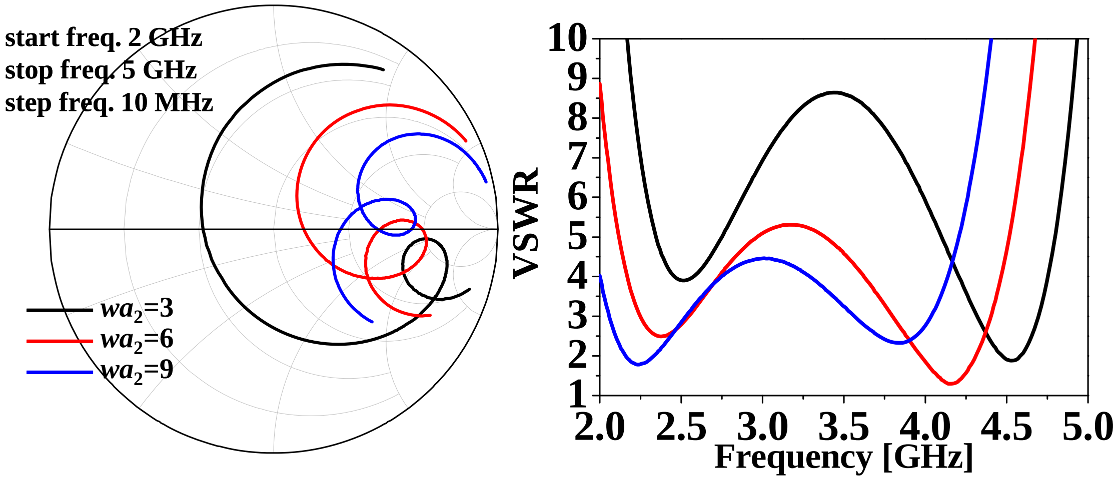




(a) On a smith chart.

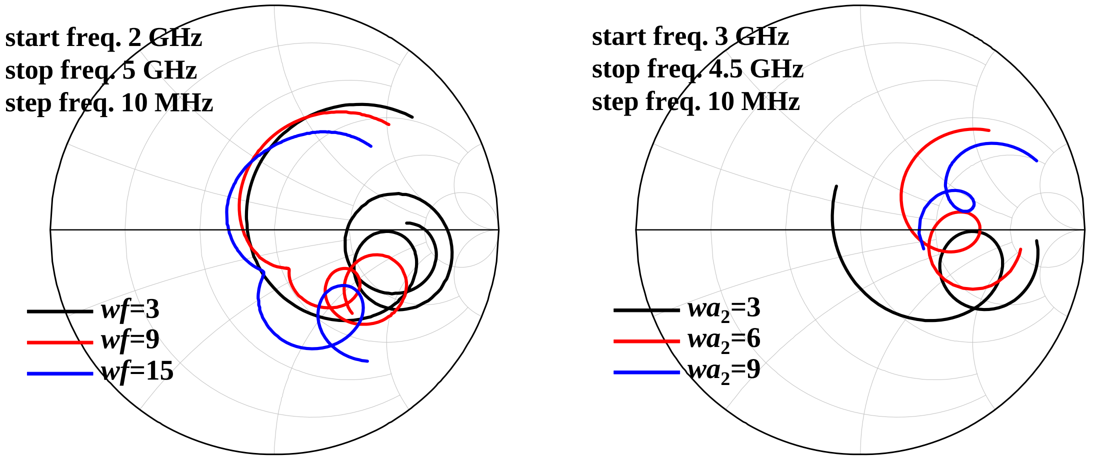
(b) VSWR characteristics.

Figure2: Input impedance characteristics of the basic model (variable: ***wf***).



(a) On a smith chart. (b) VSWR characteristics.

Figure3: Input impedance characteristics of the basic model (variable: $\boldsymbol{wa_2}$)



(a) Variable: ***wf***. (b) Variable: $\boldsymbol{wa_2}$.

Figure4: Input impedance characteristics of the planar model.

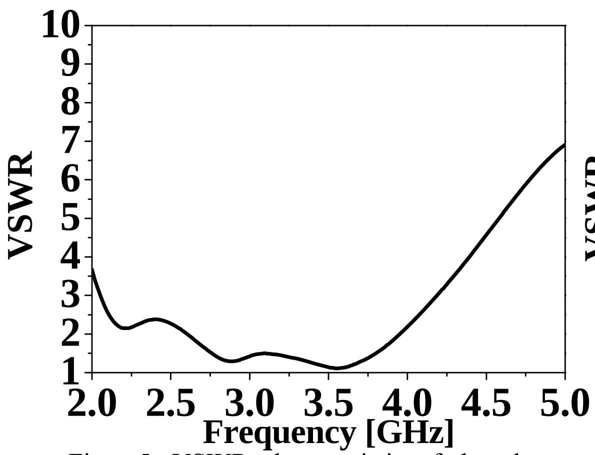


Figure5: VSWR characteristic of the planar model (***wf***=10, $\boldsymbol{wa_2}$=6).

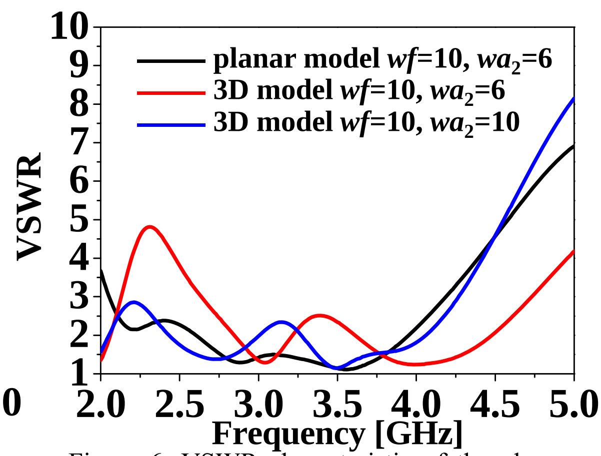


Figure 6: VSWR characteristic of the planar model and 3D model.