Current Reduction on the Ground Plane using Quarter-wavelength Element

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***Abstract* – This study presents a way to reduce the current on the ground plane of small terminal using a quarter-wavelength additional element in the vicinity of antenna element, which does not required a balun, specific antenna form or trimming of the ground plane. We analyze the basic antenna characteristics and confirm the effect of the additional element employing nearby object, such as human hand or infinite PEC ground plane. In this paper, it is confirmed that the current on the ground plane is reduced and the radiation efficiency and gain improve by loading the additional element.**

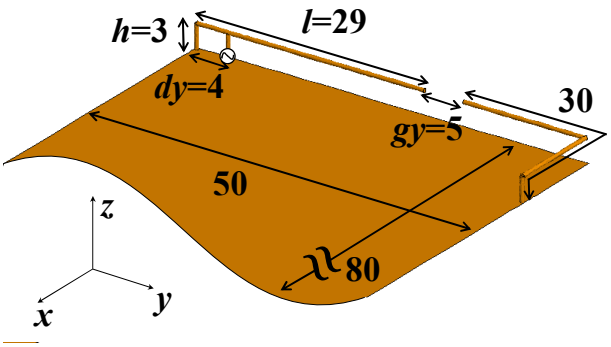
***Index Terms* — Current reduction, Quarter-wavelength element, Inverted-F antenna.**

I. INTRODUCTION

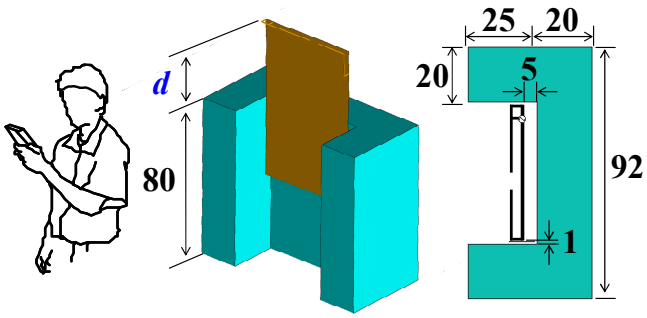
It is reported that the current on the conducting box deteriorates the antenna characteristics [1]. Then, many studies have proposed various methods to reduce the current on the ground plane [2]-[4]. On the other hand, a quarter-wavelength element is employed in the vicinity of folded monopole antenna element, and it is reported that the current on the ground plane decreases [5]. Thus, this method does not require a balun, specific antenna form, or trimming of the ground plane, which means that it is easy to implement to the antenna system. In this study, we apply the additional element (AE) to an inverted-F antenna (IFA), which is mounted on the ground plane of 50×80 mm^2 for a small terminal. Then, we investigate the basic antenna characteristics and analyze the effect of the additional element with nearby object such as human hand or infinite PEC ground plane.

II. ANTENNA CONFIGURATION

Figure 1 shows the configuration of IFA with the quarter-wavelength additional element and hand model which is used for calculating the effect of human hand. In Fig. 1(a), the antenna is mounted on the ground plane of 50×80 mm^2, which is assumed to a small terminal. Each parameter is adjusted so that the resonant frequency is 2.45 GHz, where is around center frequency in 2.4 GHz band of WLAN (2.4-2.48 GHz). The antenna height from the ground plane is 3 mm (≈0.025λ), and the length of AE is 30 mm (≈0.25λ). Also, the wire radius of the antenna element and additional element is 0.25 mm. The tips of IFA and AE are separated by 5 mm (≈0.041λ). The hand model is shown in Fig. 1(b). The hand model has the dielectric properties of relative permittivity of



(a) IFA with AE



(b) Hand model

Fig. 1. Antenna configuration.

54 and conductivity of 1.5 S/m [6]. We define the parameter *d* is the distance between the top edges of the ground plane and hand model. IFA without AE is also analyzed for the comparison in the following section with *dy*=2.5 and *l*=27.5.

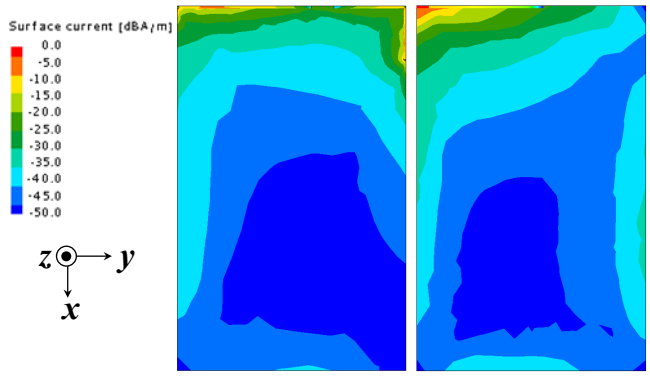
III. RESULT AND DISCUSSION

A. Current Distribution

Figure 2 (a) shows the current distribution on the ground plane of IFA with AE at 2.45 GHz. For the comparison, the current distribution of IFA without AE is also shown in Fig. 2(b). There is no hand model in both cases. From the figures, current reduction can be observed when AE is loaded near IFA in Fig. 2(a). Especially, the current on the edge of the ground plane is decreased.

B. Radiation Efficiency

Figure 3 shows the simulated radiation efficiency with respect to the parameter *d* between the models of with AE and without AE when there is hand model as can be seen in



(a) With AE (b) Without AE

Fig. 2. Current distribution on the ground plane at 2.45 GHz.

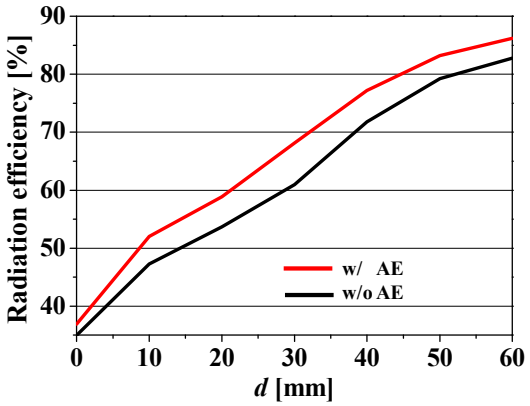


Fig. 3. Radiation efficiency at 2.45 GHz.

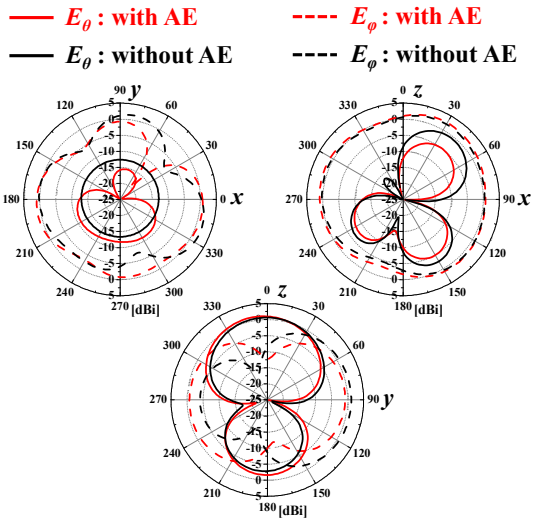
Fig. 1(b). Due to the power absorption by the hand model, the efficiencies at d=0 decrease to less than 40% in both cases, while radiation efficiencies are more than 98% when there is no hand in both cases. However, the efficiency of the model with AE is higher than that of the model of without AE averaging around 5%. At d=30 mm, the efficiency improves by up to 7.4%. It is considered that this is caused by current reduction at the edge of the ground plane.

C. *Radiation Pattern*

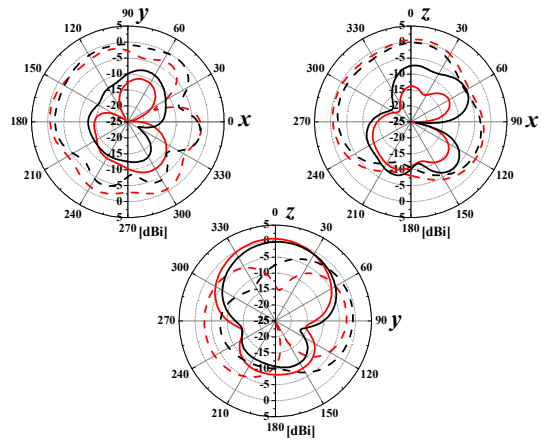
Figure 4 shows the radiation patterns at 2.45 GHz. From the figures, the radiation patterns between with AE and without AE do not change so much. However, the values of cross polarization component are smaller in *xy*/*xz*-planes when AE is added. As for the gain, however, the gains of with AE and without AE are respectively 2.55 dBi and 2.03 dBi when there is no hand. Similarly, the gains of with AE and without AE are respectively 0.912 dBi and 0.0607 dBi when there is hand model, which means that the gain improves by loading AE in the vicinity of IFA.

IV. Conclusion

In this study, we have presented the way to reduce the current on the ground plane and the improvement of radiation efficiency and the gain by applying the quarter-wavelength additional element near IFA element assuming that human hand holds the terminal. The principle of operation will be clarified, and the effect of other object such as infinite PEC ground plane will be analyzed in the next step.



(a) Without hand model



(b) With hand model

Fig. 4. Radiation patterns at 2.45 GHz.

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