Balance-fed built-in folded monopole antenna for handsets

Shogo Hayashida[1], Hisashi Morishita[1], Yoshio Koyanagi[2] and Kyohei Fujimoto[3]

[1]Department of Electrical Engineering, National Defense Academy
1-10-20, Hashirimizu, Yokosuka-shi, 239-8686 Japan
Tel: +81-468-41-3810 ext. 3382, Fax: +81-468-44-5911, e-mail: d03002@nda.ac.jp
[2]Panasonic Mobile Communications Co., Ltd.,5-3, Hikarinooka, Yokosuka-shi, 239-0847 Japan
[3]FAIS, University of Tsukuba, 586-9 Akatsuka, Tsukuba-shi, 305-0062 Japan

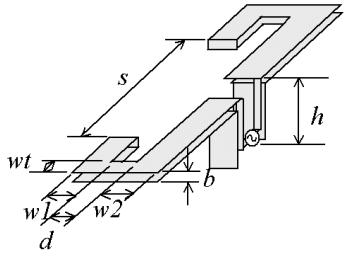
1.Introduction

A folded loop antenna (FLA) [1] has been introduced as one of balance-fed antennas for handsets, which is very effective to mitigate the antenna performance degradation due to the body effect. In addition, in order to meet these requirements for the latest such as a low profile and small size [2], built-in folded monopole antenna for handsets (BFMA) has been proposed [3]. BFMA can realize the similar bandwidth and smaller size comparing with PIFA, which is one of conventional built-in antennas for handsets. The physical volume is miniaturized up to approximately 42% of PIFA. The relative bandwidth is approximately 16%. However it is confirmed that BFMA also use the ground plane (GP) as a part of radiator, as PIFA does.

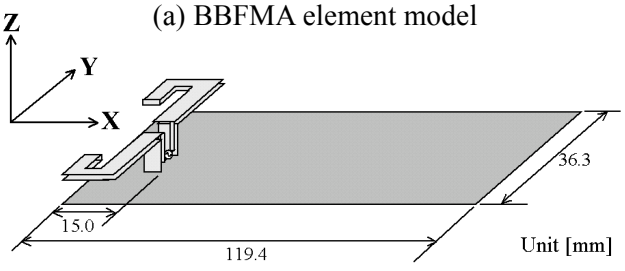
In this paper, balance-fed built-in folded monopole antenna for handsets (BBFMA) is newly developed. The BBFMA is a class of balanced antenna in which two BFMAs are excited oppositely in phase with equal amplitude. It will be expected that the antenna can reduce the current flows on the GP. In addition, the BBFMA is analyzed by slightly protruding the antenna element from the GP. In the analysis, the electromagnetic simulator based on the Method of Moment (MoM) is used.

2.Antenna structure

The configuration of BBFMA is shown in Fig.1, where (a) and (b) shows the BBFMA element model and the BBFMA model on the GP respectively. The antenna element is placed on the finite GP, which represents a shielding plate used in the handset unit. Two BFMAs, which are considered to be equivalently a folded monopole antenna, are arranged on the side plate adjacent to the upper plate. The BBFMA is a class of balanced antenna in which two BFMAs are excited oppositely in phase with equal amplitude. The antenna model, which slightly protruded the antenna element from the GP, is shown in Fig.2. The antenna element and GP are made of copper plate with thickness of 0.2mm, 0.5mm respectively.



(a) BBFMA element model



(b) BBFMA on the GP

Fig.1 Configuration of BBFMA
(*w1*=*w2*=*d*=5, *wt*=1.5, *b*=0.5, *h*=7, *s*=24 [mm])

ISBN: 89-86522-78-0 94460©KEES

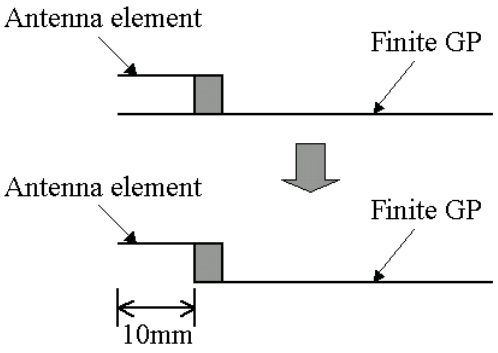
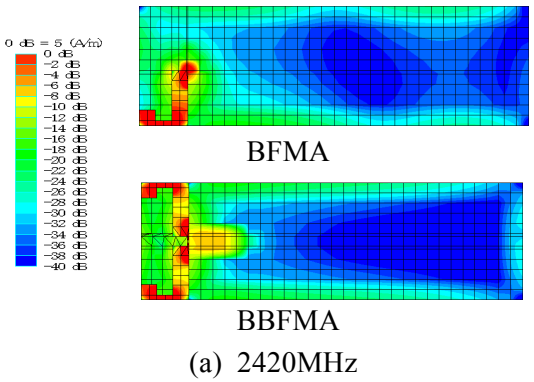
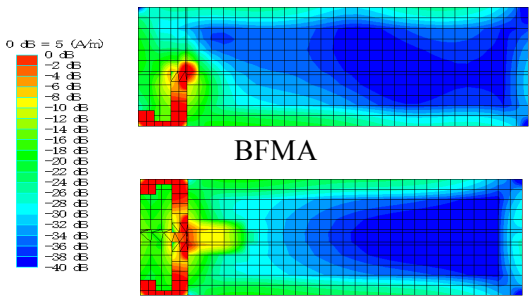


Fig.2 Antenna model, which slightly protruded the antenna element from the GP



(a) 2420MHz



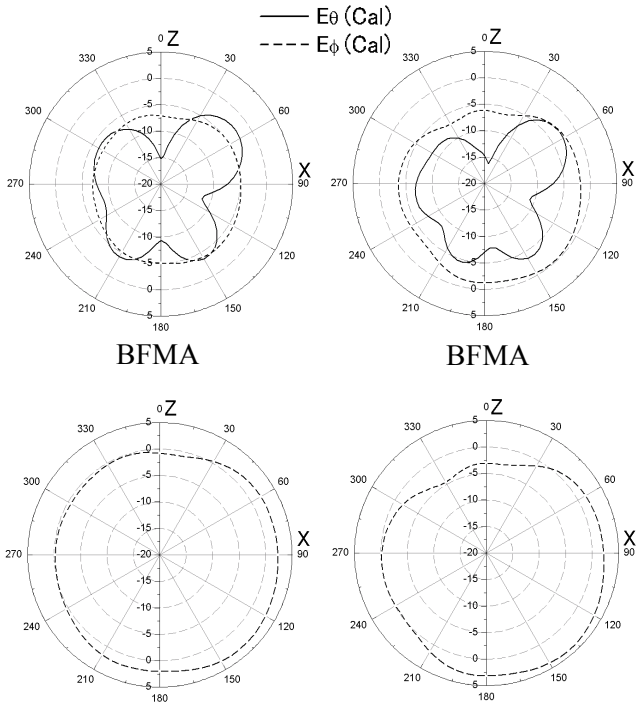
(b) 2860MHz

Fig.3 Calculated current distribution of BFMA and BBFMA

3. BBFMA characteristics compared with BFMA

The electromagnetic simulator based on MoM was used to calculate the BBFMA characteristics. Fig.3 (a) show the calculated current distribution of BFMA and BBFA at 2420MHz and 2860MHz and Fig 3 (b) show that at 2860MHz. The current is normalized to the maximum current value on the element. In the figures, a reduction in the current induced on the GP is observed for BBFMA. In particular, the BBFMA has a lower current value on the lower part of the body.

In order to confirm the effect of the above current reduction on the radiation characteristics, the calculated radiation patterns in xz plane are shown in Fig.4, where (a) and (b) shows for BFMA and BBFMA at 2420MHz and at 2860MHz, respectively. In Fig.4 (a), there is little E_θ component and an almost omni-directional pattern for E_ϕ component is observed for BBFMA, while four lobes for E_θ component are observed for BFMA. The similar results are observed in Fig.4 (b). From these results, the BBFMA is found to be equivalent to a horizontal dipole antenna on the GP. The current flow on the GP is cancelled due to the balanced operation.



(a) *f*=2420MHz (b) *f*=2860MHz

Fig.4 Calculated radiation patterns of BFMA and BBFMA at 2420MHz and 2860MHz

Fig.5 shows calculated VSWR characteristics of BFMA and BBFMA. In the figure, BFMA shows wider bandwidth than BBFMA. Two frequencies, which the VSWR becomes the lowest, are 2420MHz and 2860MHz for BBFMA.

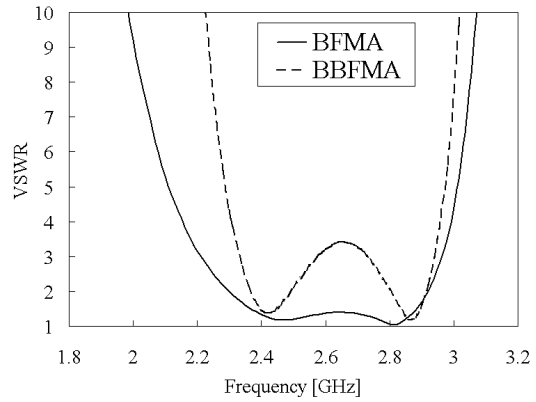


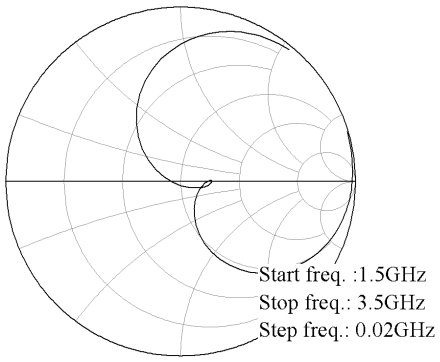
Fig.5 Calculated VSWR characteristics of BFMA and BBFMA

4. BBFMA characteristics in a case that the antenna element is protruded from the GP

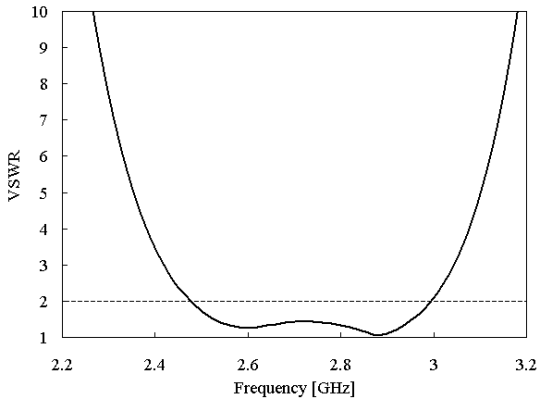
In this chapter, BBFMA is analyzed in a case that the antenna element is protruded from the GP as shown in Fig.2. In order to make it a lower profile, the height of BBFMA is varied from 7mm to 5mm. Fig.6 shows the input impedance characteristics in a case of that the parameters of BBFMA are $w1$=$w2$=d=5mm, wt=1.5mm, b=0.5mm, h=5mm, s=24mm, where (a) shows the smith chart and (b) shows the VSWR characteristics. In Fig.6 (a), the input impedance shows a small loop around 50Ω. In Fig.6 (b), the VSWR characteristics of BBFMA show a wide bandwidth. The relative bandwidth for VSWR≤2 is approximately 16%.

Fig.7 shows the calculated current distribution of BBFA at 2460MHz, 2730MHz and 3000MHz. In the figures, a reduction in the current induced on the GP is observed. It is confirmed that the current can be reduced at the frequencies for VSWR≤2.

Fig.8 shows the calculated radiation patterns of BBFA at 2460MHz, 2730MHz and 3000MHz. In the figures, the radiation patters of each plane

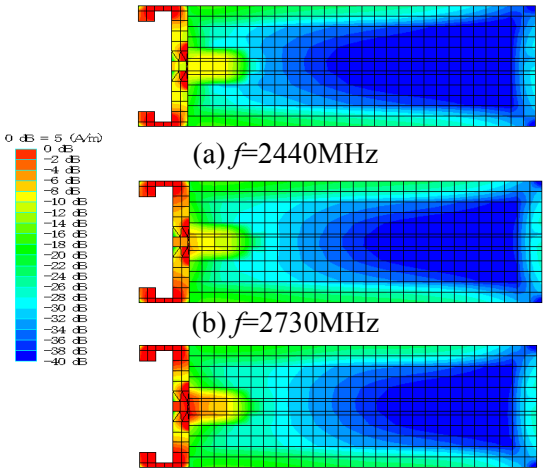


(a) Smith chart



(b) VSWR characteristics

Fig.6 Input impedance characteristics in a case of that BBFMA element are protruded from the GP



(a) f=2440MHz

(b) f=2730MHz

(c) f=3000MHz

Fig.7 Calculated current distribution of BBFMA

at 2440MHz, 2730MHz and 3000MHz
show the similar tendency each other at above three frequencies, even though the radiation is directed strongly to the x-axis direction.

5.Conclusion

In this paper, a balance-fed built-in folded monopole antenna for handsets (BBFMA) has been introduced and analyzed. BBFMA can reduce the current flows on the GP. In addition, BBFMA is analyzed in a case that the antenna element is protruded from the GP. BBFMA can make it a lower profile up to *h*=5mm. The bandwidth is evaluated to be approximately 16%. More details analysis for this antenna is continuous subjects to be studied.

References

[1] Y. Kim, H. Morishita, Y. Koyanagi, K. Fujimoto, "A folded loop antenna system for handsets developed and based on the advanced design concept," IEICE Trans. Communication, vol. E84-B, no.9, pp.2468-2475, Sep. 2001.

[2] K. Ogawa, "High-Performance Technologies for Portable Radio Antennas", Journal of IEICE, Vol.84, No.11, pp.775-781, Nov. 2001.

[3] S. Hayashida, T. Tanaka, H. Morishita, Y. Koyanagi and K. Fujimoto, "Characteristics of built-in folded monopole antenna for handsets", 2004 Interim international symposium on antenna and propagation, poster session.

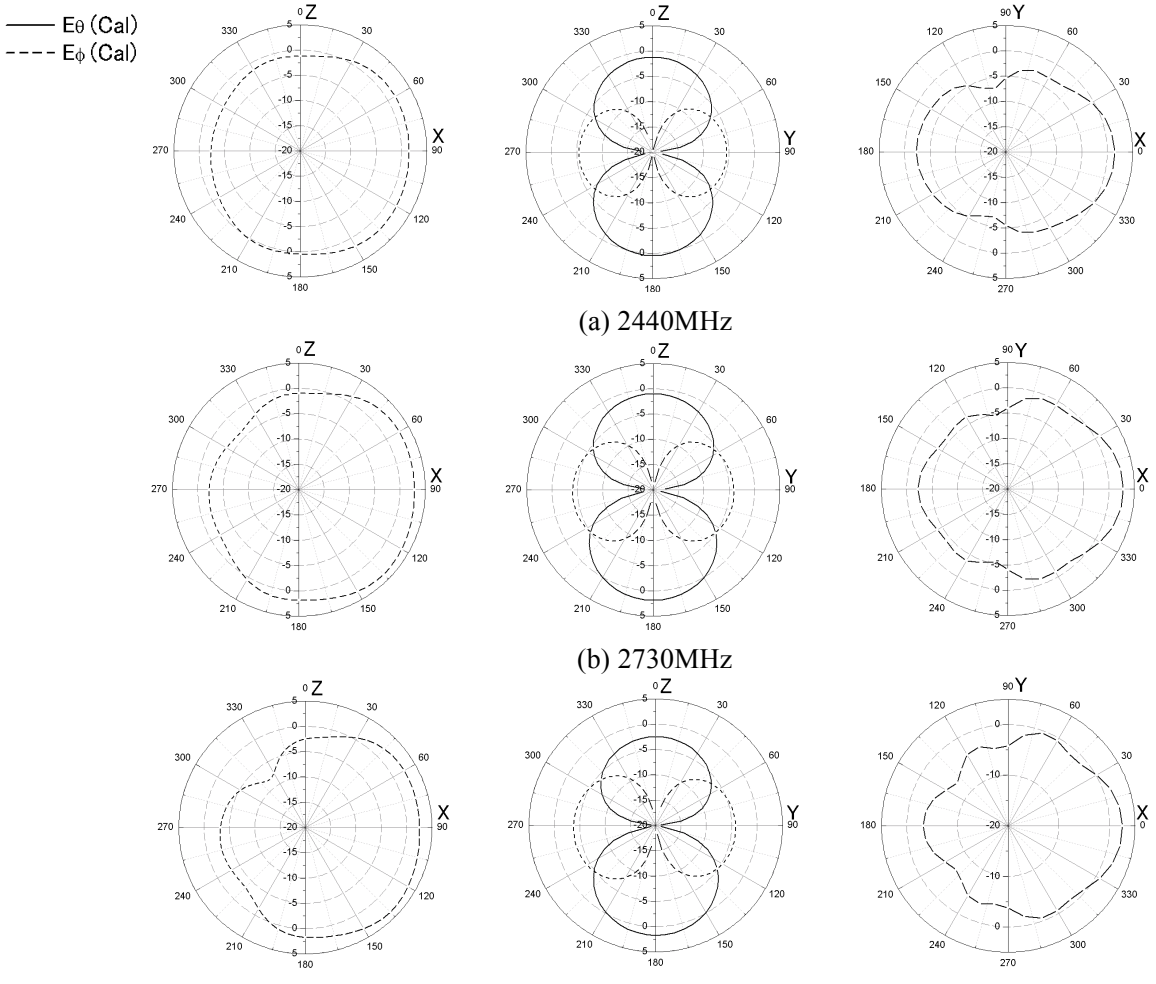


Fig.8 Radiation patterns of BBFMA at 2440MHz, 2730MHz and 3000MHz