Characteristics of Folded Antenna for Handsets with a Parasitic Element

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Abstract

A folded loop antenna for handsets has already been introduced and shown as one of balanced feed antennas for handsets, which is very effective to mitigate the antenna performance degradation due to the body effect. In addition, to be lower profile of folded loop antenna, Built-in folded dipole antenna, which has a structure folded loop elements sideway so that the antenna can be placed on the ground plane (GP), has been proposed. In this paper, as an improved impedance matching technique and more wideband antennas, characteristics of a folded dipole antenna and a folded monopole antenna for handsets by using a parasitic element are analyzed.

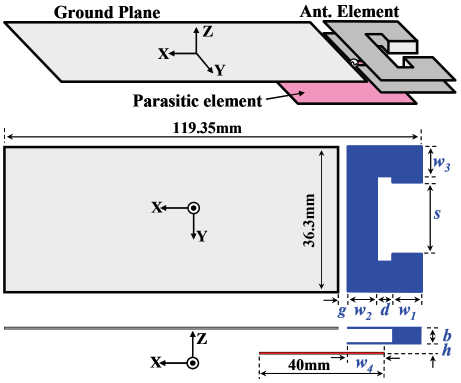
1. INTRODUCTION

In the previous paper, a folded loop antenna (FLA) has been introduced as one of the balanced-fed antennas for handset [1]. FLA, overall length of whose element is equal to one wavelength, is equivalent in performance to a folded half-wave dipole antenna and has a self-balanced structure so that unbalanced current flowing on the ground plane (GP) decrease [2], even if it is fed by an unbalanced line such as coaxial cable. To be lower profile and smaller structure including the GP, a built-in folded dipole antenna (BFDA) for handset has been also proposed [3]. BFDA consists of a folded loop element placed horizontally on the top of GP so that the height of an antenna is reduced up to 20% in comparison with FLA and has also a self-balanced effect. In addition, the adjustment of input-impedance can be flexible by introducing the folded structure of the antenna element. However, the relative bandwidth for VSWR ≤ 2 is 7.0% and 13% for the balanced and unbalanced feed, respectively.

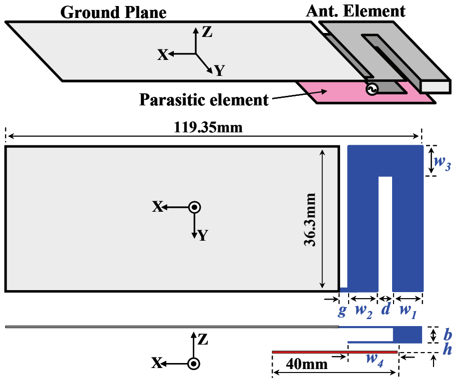
In this paper, to obtain improved impedance matching and wider bandwidth characteristic, a parasitic element placed under the antenna element is used. Two types of folded antenna for handset, a built-in folded dipole antenna (BFDA) and a built-in folded monopole antenna (BFMA), with a parasitic element are introduced and their characteristics are analyzed. In the analysis, the electromagnetic simulator based on the finite integration method is used. As a result, it is shown that improved input-impedance adjustment can be obtained and the relative bandwidth is enhanced to about 60% and 50% for the BFDA and BFMA, respectively.

2. CONFIGURATION OF ANTENNAS

Configuration of antennas with a parasitic element is shown in Fig.1, where (a) and (b) shows BFDA and BFMA, respectively. Both have the antenna element on the same plane as the rectangular GP, which represents a shielding plate used in the handset unit, and a parasitic element placed under the antenna element. BFMA in Fig.1 (b) is connected to



(a) Built-in Folded Dipole Antenna (BFDA)



(b) Built-in Folded monopole Antenna (BFMA)
Fig. 1: Configuration of Antennas

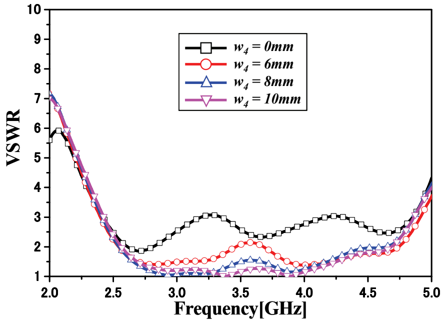
GP at the end of the upper antenna element. The antenna parameters are w_1=w_2=w_3=7mm, g=3mm, s=21mm, d=4.5mm, b=3mm, h=2mm. The volumes occupied spatially by the both BFDA and BFMA are equal to each other. The parameter w_4 shows the length of the section overlapped between the antenna element and the parasitic element. The overall length including the length of GP and the length of the parasitic element is 119.35mm and 40mm, respectively, and the width is 36.3mm. Antenna element, parasitic element, and GP of both antennas are made of copper plate with a thickness of 0.2mm. In the experiment, a semi-rigid coaxial cable with a diameter of 1mm is used.

3. RESULTS

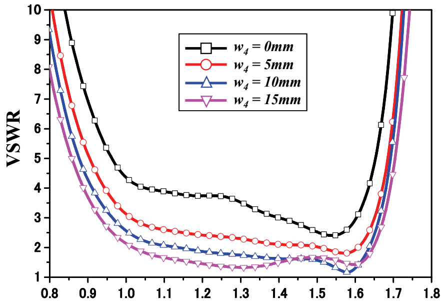
A. Input-Impedance Characteristics

Fig.2 shows the calculated VSWR characteristics versus frequency for different values of the parameter w_4, where (a) and (b) shows BFDA and BFMA, respectively. As can be seen in the figure, the resonance frequencies are adjusted to cover the 2,500-4,700MHz bands for BFDA and the 1,000-1,650MHz bands for BFMA by varying the parameter w_4.

The most improved VSWR for both antennas are shown in Fig.3, where w_4 is 10mm for BFDA and 15mm for BFMA. In both cases, close agreements between calculated and measured values are obtained. For the purpose to confirm the self-balanced effect the balanced feed BFDA using a parallel feed-line is analyzed additionally and, as can be seen in the Fig.3 (a), tendency of VSWR of both unbalanced and balanced feed BFDAs almost agree within the resonant frequency range. The relative bandwidth (VSWR≤2) is about 60% at the center frequency of 3,660MHz for BFDA and 50% at the center frequency of 1,300MHz for BFMA. Point to which special attention should be paid is that BFMA resonates at lower frequency than BFDA while occupying almost same space as BFDA. The relative bandwidths of each antenna are shown in Table.1.

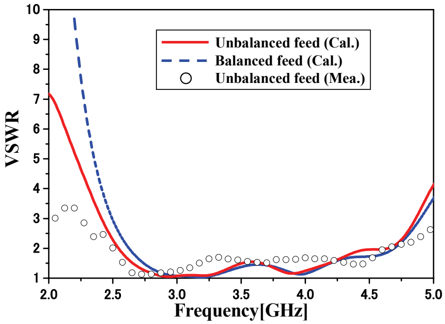


(a) Built-in Folded Dipole Antenna (BFDA)

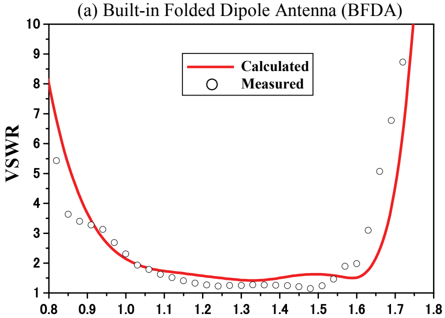


(b) Built-in Folded monopole Antenna (BFMA)

Fig. 2: VSWR vs. frequency for w_4



(a) Built-in Folded Dipole Antenna (BFDA)



(b) Built-in Folded monopole Antenna (BFMA)

Fig. 3: VSWR characteristics

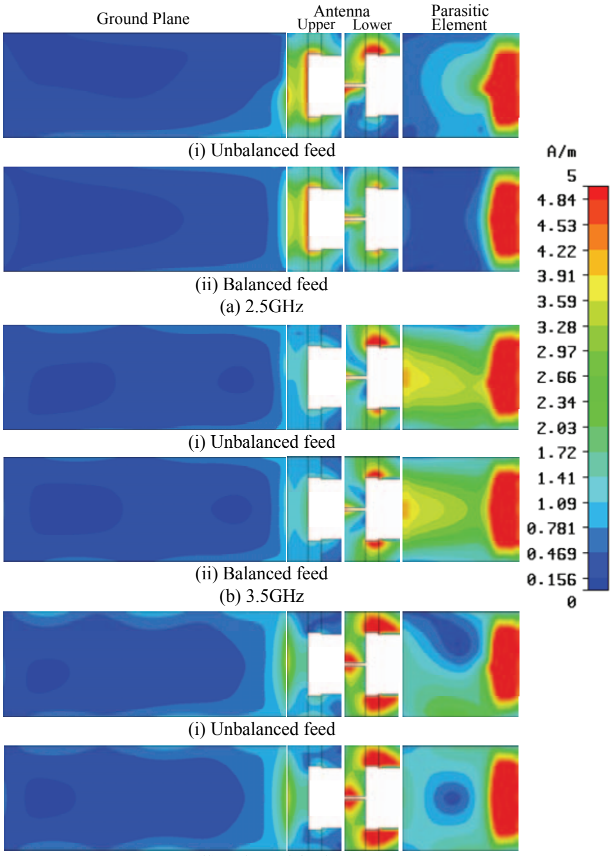
TABLE 1: THE RELATIVE BANDWIDTH

Antenna Type	Center Frequency	Relative Bandwidth	
		Calculated	Measured
BFDA	3,660MHz	58.1%	58.2%
BFMA	1.300MHz	47.1%	44.1%

It is found from the results that the enhanced bandwidth can be achieved and also the effect of multiplication in adjustment of input-impedance can be obtained by using a parasitic element and by introducing the folded structure.

B. Current Distribution

The calculated current distributions on the antenna elements, GPs and parasitic elements of both antennas are shown in Fig.4 and Fig.5, respectively. Each three frequencies are adopted from frequency range in which the antennas resonate. As can be seen in the Fig.4, in case of BFDA while only a slight difference is seen around the feed point between the current distributions in both unbalanced and balanced feed, at the other points they have almost same amplitude. In the unbalanced feed, the asymmetric current distribution appears on the GP and the parasitic element, but the amplitude is little as to be neglected. From those results, it can be seen as was confirmed in section 3-A that a self-balance effect is still maintained and hence the unbalanced current does not flows on the feed line and also on the GP. On the other hand, as shown in Fig.5, a little stronger current flow on GP in BFMA compared to BFDA.



(i) Unbalanced feed

(ii) Balanced feed

(a) 2.5GHz

(i) Unbalanced feed

(ii) Balanced feed

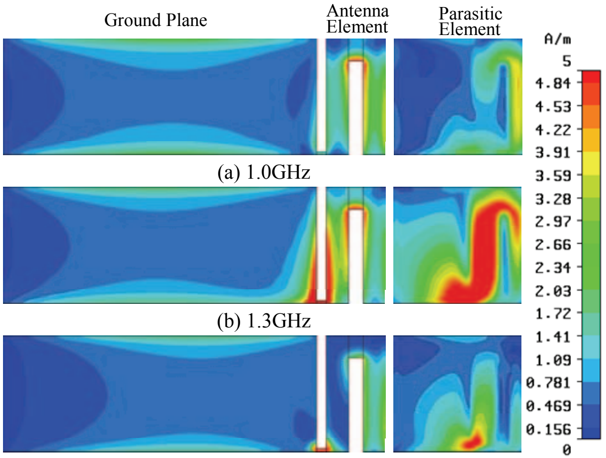
(b) 3.5GHz

(i) Unbalanced feed

(ii) Balanced feed

(c) 4.5GHz

Fig. 4: Current Distribution of BFDA



(a) 1.0GHz

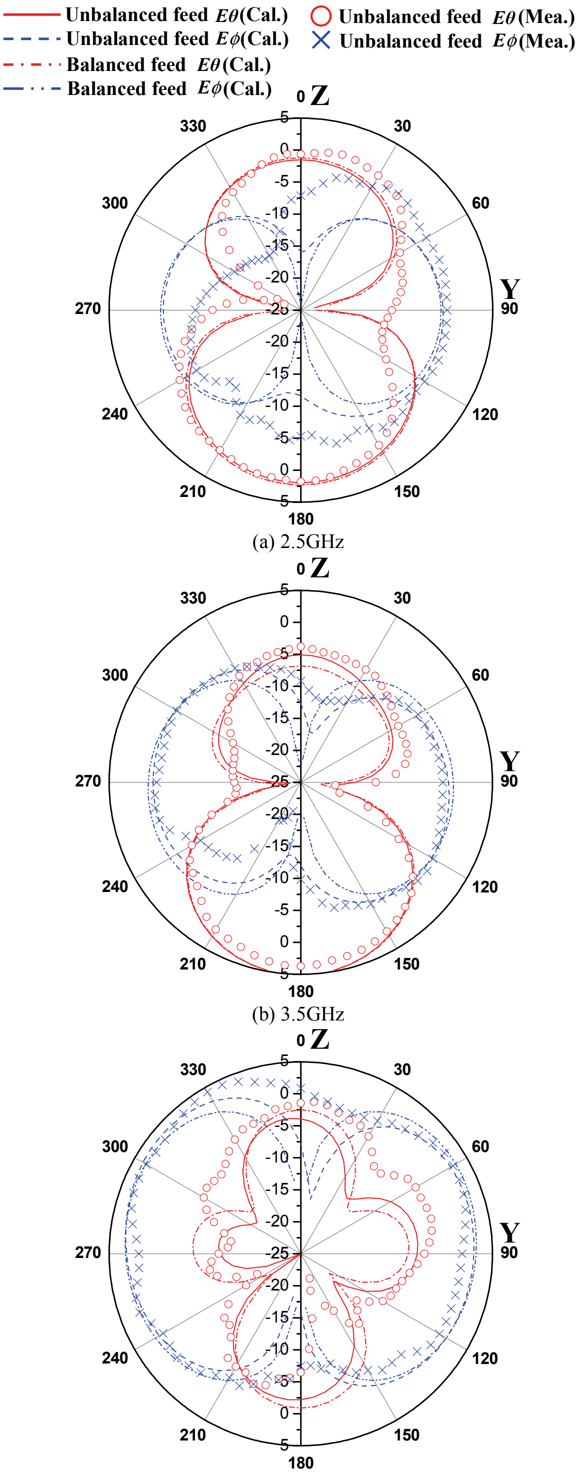
(b) 1.3GHz

(c) 1.6GHz

Fig. 5: Current Distribution of BFMA

C. *Radiation Pattern*

The calculated and measured radiation patterns of both antennas in the *yz*-plane are shown in Fig.6 and Fig.7, respectively. The frequencies at which the radiation patterns are shown are as same as those in section 3-B. The radiation patterns are expressed by the power gain [dBi]. As can be seen in these figures, the calculated radiation patterns in both BFDA and BFMA are quite similar to the measured results. The radiation patterns of both balanced and unbalanced feed

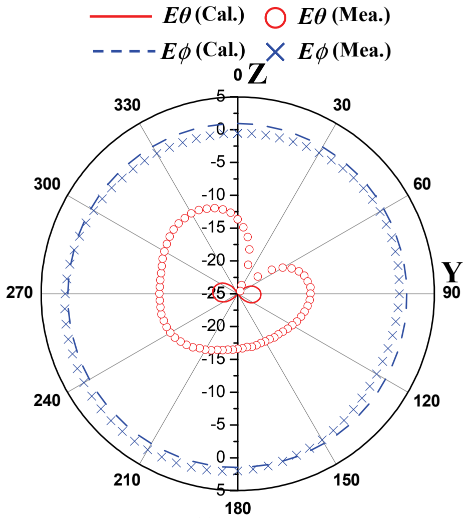


(a) 2.5GHz

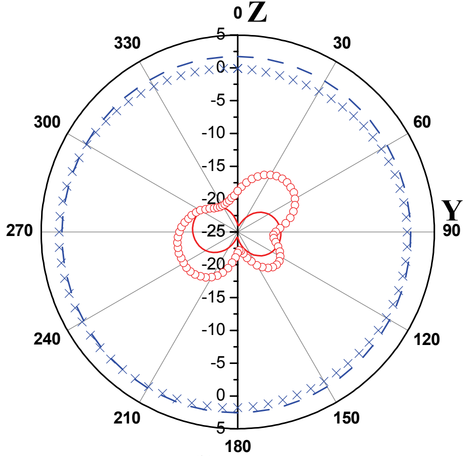
(b) 3.5GHz

(c) 4.5GHz

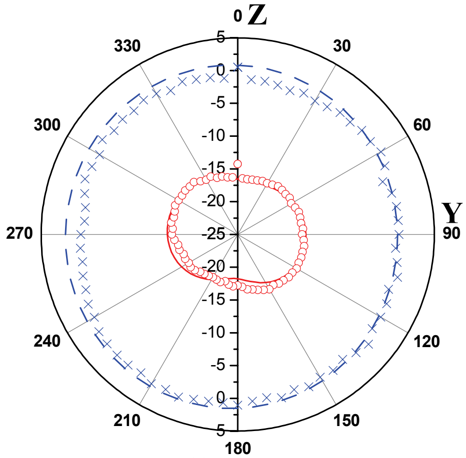
Fig. 6: Radiation Pattern of BFDA



(a) 1.0GHz



(b) 1.3GHz



(c) 1.6GHz

Fig. 7: Radiation Pattern of BFMA

are similar to each other in BFDA. As shown in Fig.6, the radiation toward –*z*-axis direction is increased compared to *z*-axis direction by 5-10dBi and it is considered that the parasitic element is operating as a wave director.

On the other hand, it is known that BFMA has an omnidirectional radiation pattern at all frequencies which is quite similar to those of monopole antenna and there is little effect from the parasitic element on the directivity of antenna.

D. The Effects of the GP on BFMA

Since BFDA has a self-balanced effect, it can be considered that there is no effect of the GP on the antenna performance. For the purpose to analyze the effects of the GP on BFMA, the VSWR characteristics for different lengths of GP (*L*) are shown in Fig.8. As can be seen in the figure, only slight difference appears in bandwidth even if the *L* is shortened to the length of 60%. As this result, it can be considered that the effect of GP is very small on BFMA also.

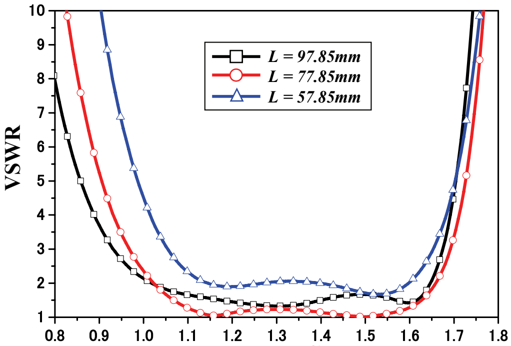


Fig. 8: VSWR vs. frequency for *L*

4. CONCLUSION

In this paper, as one of the antennas for handsets with which enhanced bandwidth and input-impedance adjustment can be obtained, built-in folded dipole and monopole antennas using a parasitic element are introduced and their characteristics are analyzed. BFDA with a parasitic element fed by unbalanced coaxial cable still has a self-balanced effect and the improved wideband characteristics are achieved. BFMA with a parasitic element has also wideband characteristics and resonates at lower frequency than that of BFDA even if volume occupied spatially by BFDA is as same as BFDA.

More detailed analyses are the next subjected to be studied.

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