Characteristics of built-in folded monopole antenna for handsets

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1.Introduction

The latest trends in handset unit used in the cellular phone and PHS (Portable Handy Phone System) is to reduce the size and the weight [1]. Antennas used for such handsets must also follow downsizing of the handset unit and yet keep the antenna performance unchanged or even improved. Furthermore, built-in antennas are becoming more intense requirement for handset antennas.

In the previous paper [2], a folded loop antenna (FLA) has been introduced as a balance-fed antenna element and basically has the performance of a folded half-wave dipole antenna. In this paper, FLA is modified to have low profile and small size structure. The performance is analyzed comparing with a planar inverted-F antenna (PIFA), which is one of conventional handset antennas. Low profile is achieved by folding a loop element sideways so that the antenna can be placed closely on the ground plane (GP). In addition, small size is achieved by consisting of the half of built-in folded dipole antenna (BFDA) [3], which folded a loop element sideways. In the analysis, the electromagnetic simulator based on FDTD method is used. As a result, it has been confirmed that the antenna, which is introduced here, has smaller size and broaden characteristics compared with PIFA. The bandwidth (VSWR≤2) is about 16% at the center frequency of 2250MHz and the antenna is 45% the size of PIFA. Moreover, the current distributions and radiation patterns are analyzed at the center frequency. The calculated results are in good agreement with the measured results.

2.Antenna structure

Configuration of the antenna, which consists of a half of BFDA, is shown in Fig.1, where FLA and BFDA are also illustrated for the comparison. The antenna has a structure, which folds a half-size of folded dipole antenna additionally so that small size and a low profile could be achieved. Furthermore, it is considered that the antenna has a self-balanced structure. The antenna element is placed very close to the rectangular GP, which represents a shielding plate used in the handset unit.

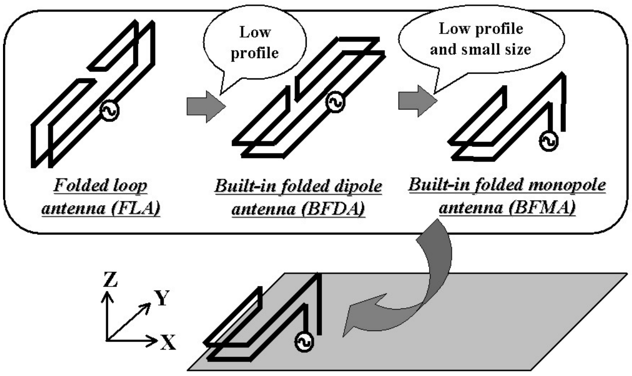
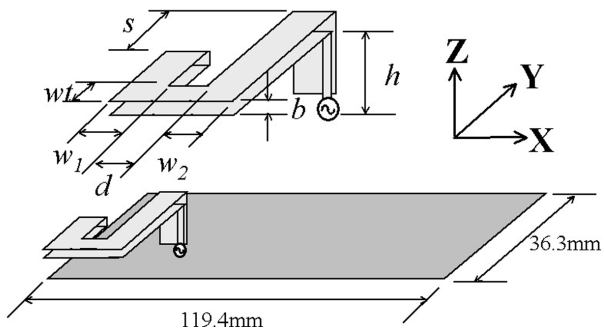
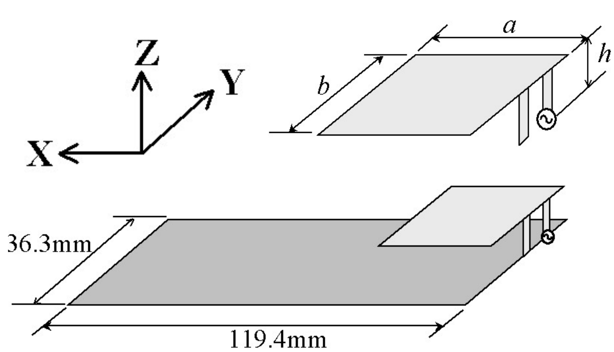


Fig.1 Antenna structure

The built-in folded monopole antenna (BFMA) and PIFA structure are shown in Fig.2 (a), (b) respectively. The antenna element and GP are made of copper plate with thickness of 0.2mm, 0.5mm respectively. In order to operate at the same center frequency, the parameters of BFMA are w_1 = w_2 = d = 5mm, wt = 1.5mm, h = 6.5mm, s = 12mm, b = 0.5mm, and those of PIFA are a = b = 19mm, h = 7.0mm. The antenna element is fed by a coaxial cable. In the experiment, a semi-rigid cable with diameter of 2mm is used. The center frequency f_0 is 2250MHz.



(a) BFMA



(b) PIFA

Fig.2 Antenna configuration

3.Results

3.1 Input impedance characteristics

In the calculation, analyses are done for cases where antennas are placed on the finite GP. The electromagnetic simulator, which is based on the FDTD method, is used for the analysis of the antenna.

Fig.3 shows a smith chart that plots calculated characteristics of input impedance for BFMA, where the span of frequency is 1.8GHz to 2.8GHz. As can be seen in figure, input impedance locus indicates two resonance modes by drawing small loop characteristics around 50Ω.

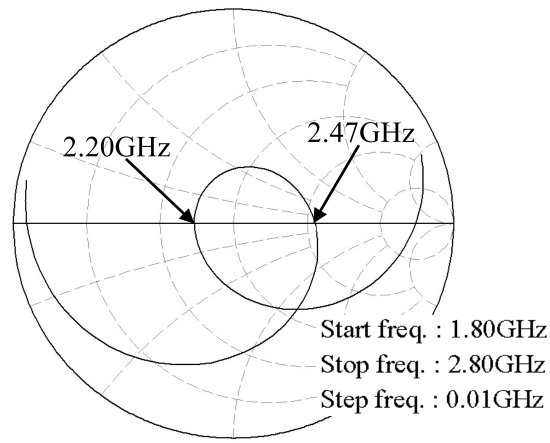


Fig.3 Characteristics of input impedance for BFMA

Fig.4 shows calculated and measured VSWR characteristics when fed by a 50Ω-transmission line. As can be seen in figure, the calculated results agree well with the measured results for both antennas. BFMA shows broaden characteristics comparing with PIFA. The bandwidth is evaluated to be approximately 16% for both calculated and measured results. Furthermore, Table.1 shows that the relation between the bandwidth and the volume for both antennas. The bandwidth of BFMA is broader than that of PIFA even though the volume of BFMA is miniaturized up to 45% of the PIFA.

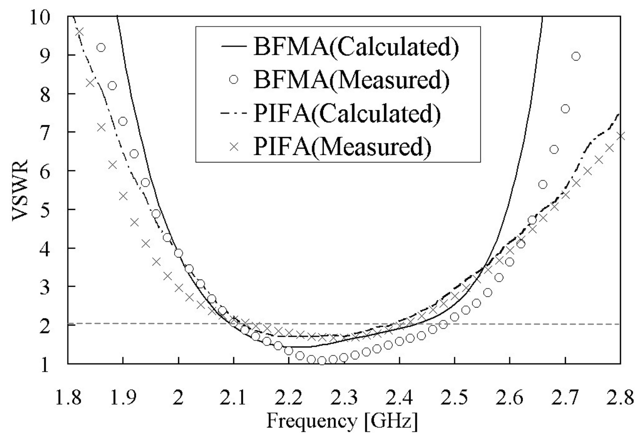


Fig.4 VSWR characteristics vs. frequency

Table.1 Relation between bandwidth and volume

	Bandwidth [MHz]	Bandwidth [%]	Volume [%]
BFMA (Cal))	360	16.0	44.3
BFMA(Mea)	380	16.9	44.3
PIFA (Cal)	280	12.4	100.0
PIFA (Mea)	260	11.6	100.0

3.2 Current distribution

Fig.5 shows that calculated current distribution on the BFMA element at the center frequency f_0. As can be seen in the figure, BFMA operates as a λ/4 monopole. Furthermore, BFMA is expected to reduce the unbalanced current, which flows on the GP, as the current flows are in-phase on the short and feed line.

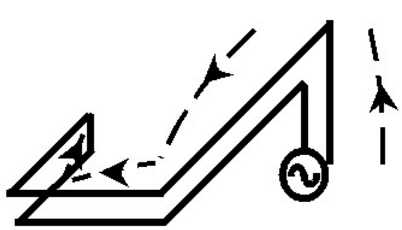
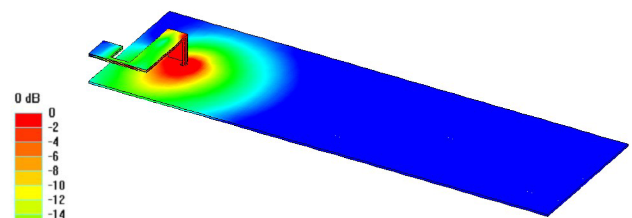
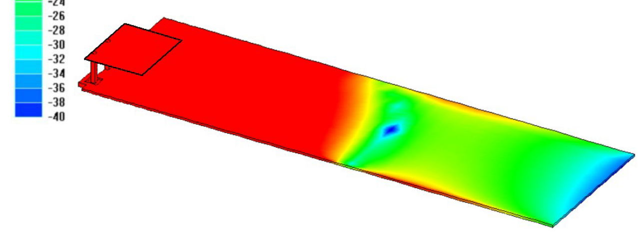


Fig.5 Current distribution for BFMA element

Fig.6 shows the calculated current distribution including the GP and antenna element at the center frequency f_0, where (a) shows that in BFMA and (b) shows that in PIFA. As can be seen in the figures, only small current flows are observed on the GP in BFMA, on the other hand much current flows in PIFA. Those results show that BFMA is very effective for reducing the current on the GP.



(a) BFMA



(b) PIFA

Fig.6 Current distribution on BFMA element

3.3 Radiation Pattern

Fig.7 shows the calculated and measured radiation patterns of the power gain (dBi) at the center frequency f_0, where (a) shows that in BFMA and (b) shows that in PIFA. The figures illustrate the radiation patterns at each plane. As can be seen in figures, the calculated results agree well with measured results. Average gain for BFMA is almost equal to PIFA in the main lobe.

4.Conclusion

In this paper, a built-in folded monopole antenna (BFMA) has been introduced and analyzed. The bandwidth is evaluated to be approximately 16% even though the volume of

BFMA is miniaturized up to 45% of the PIFA. In addition, it has been confirmed that BFMA can reduce the current on the GP. More details analysis for this antenna is continuous subjects to be studied.

References

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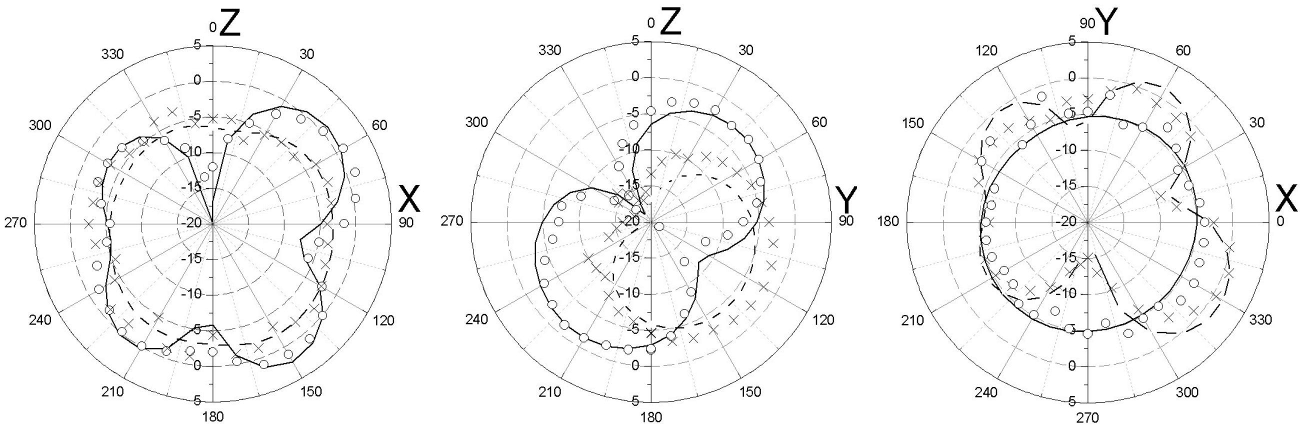
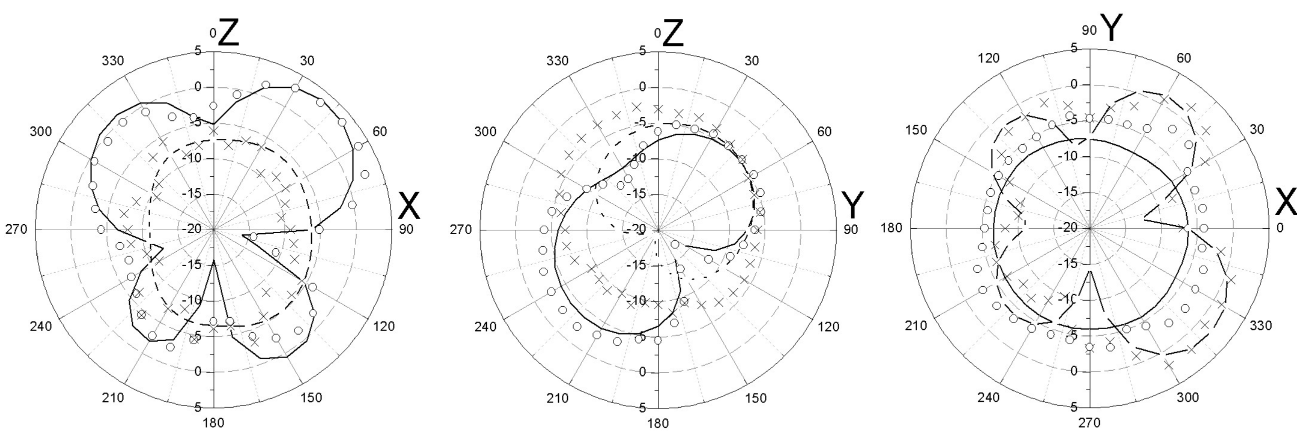


(a) BFMA



(b) PIFA

Fig.7 Radiation patterns