Self-balanced and wideband folded loop antenna for handsets

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Introduction

In the previous paper [1], a folded loop antenna system for handsets has been introduced and their characteristics have been analyzed. This antenna has a one-wavelength loop structure so that no unbalanced current may be produced on the feed line; that is to say, this antenna has a self-balanced structure [2], which is useful to reduce the current flow on the GP. In addition, since this antenna could be built in a small volume by constituting in a folded structure, small size and low profile could be achieved. Furthermore, use of a two-wire transmission can be made possible flexible adjustment of antenna impedance by changing parameter such as the length and the width of wires, and the distance between the two wires, and no balun is necessary. Bandwidth can be enlarged by taking a use of non-fed element. With a parasitic element, there is seen the enlargement in about two times on the bandwidth for both system; it changes into 97MHz (5.3%) for unbalanced system and 99MHz (5.4%) for balanced system. Moreover it is found that the bandwidth becomes wider as the width ratio w_1:w_2 is adjusted. The maximum bandwidth is obtained when the width ratio is 1:4. The bandwidth is about 50% only for the balanced feed [3].

In this paper, the wideband folded loop antenna which keeps a self-balanced effect is introduced and their characteristics are analyzed. In the analysis, the electromagnetic simulator IE3D based on the *Method of Moment* (MoM) is used. Both the theoretical and experimental analysis of the antenna performances such as current distribution, radiation pattern and input impedance are shown for cases of unbalance-and balance-fed antenna systems.

Antenna structure

A folded loop introduced in the previous paper [1] is essentially a two-wire transmission line, folded at about a quarter-wavelength to foam an equivalent half-wave folded dipole, and yet appears as a one-wavelength loop antenna, from which the antenna is referred to as a folded loop. A folded loop introduced here consists of two wide strips with the same widths. The folded strip element forms a very thin ($b \ll \lambda$) rectangular loop is considered as a folded dipole as shown in Fig. 1. By using the two-wire transmission, reactance component of the antenna impedance can be adjusted flexibly by selecting the length and the width of the strips and the distance of the two strips. This is important feature of this antenna, which is contributed by applying the integration technology.

Fig. 2 shows the configuration of the antenna element and the finite GP that represents a shielding plate used in the handset unit. The antenna element is placed very close to the rectangular GP, which has the perimeter of about three wavelengths. Both unbalanced and balanced type of feed are considered here as shown in Fig. 2 (a) and (b). The antenna element is fed by either a coaxial cable (Fig. 2 (a) or a parallel line (Fig. 2 (b)). In the experiment, a semi-rigid coaxial cable with a diameter of 0.02λ is used. The center frequency f_0 is 3040MHz.

Results

In calculation, analysis is made for cases on the finite GP and the simulator IE3D, which is based on the MoM, is used. A 1-V voltage source is applied at the feed point on the folded loop. For the unbalanced feed, the antenna has a wire shorted between the loop and the GP, while the balanced antenna has no wire.

Fig. 3(a) shows calculated VSWR in balanced system. Fig. 3(b) shows the calculated and measured VSWR in the unbalanced system when fed by a 50Ω transmission line. As can be seen in these figures, the calculated results of both systems coincide with each other. The calculated results agree well with the measured results in unbalanced system. In both systems, the bandwidth is 400MHz (13.2%).

The calculated current distributions on the GP at the center frequency are shown in Fig. 4, where (a) shows that in the balanced system and (b) show that in the unbalanced system. The figure illustrates the current distributions on the GP only, not including those of the antenna element. As can be seen in the figure, while slight difference is seen the feed point between the current distribution in the both unbalanced and balanced system, at the other point they have almost same amplitudes. From these results, it can be seen as was expected that a folded loop element with wide stripes has a self-balanced effect and hence the unbalanced current does not flow on the feed line and also on the GP, even this antenna has the unbalanced structure.

The calculated radiation patterns of the power gain (dBi) in the y-z plane for both balanced and unbalanced system are shown in Fig. 5 (a) and (b), where the measured pattern is also shown in the unbalanced system. As can be seen in these figures, the patterns of both balanced and unbalanced system is similar to each other. The calculated and measured results agree well except for a part of E_ϕ pattern in unbalanced system.

Conclusion

A folded loop antenna for handsets which has self-balanced effects has been analyzed to obtain a wider bandwidth. It has been shown that self-balanced folded loop antenna realizes a wide bandwidth. More details analysis for this antenna is continuous subjects to be studied.

References

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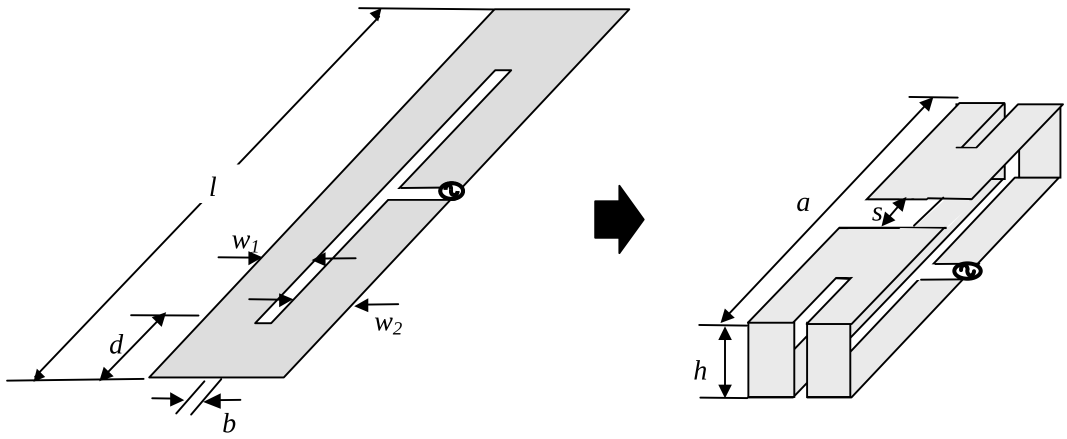


Fig. 1 Antenna element
(l=0.725λ, b=0.0101λ, d=0.0912λ, w_1=w_2=0.0303λ,
a=0.367λ, h=0.0405λ, s=0.0912λ, l-$2d$=0.543λ)

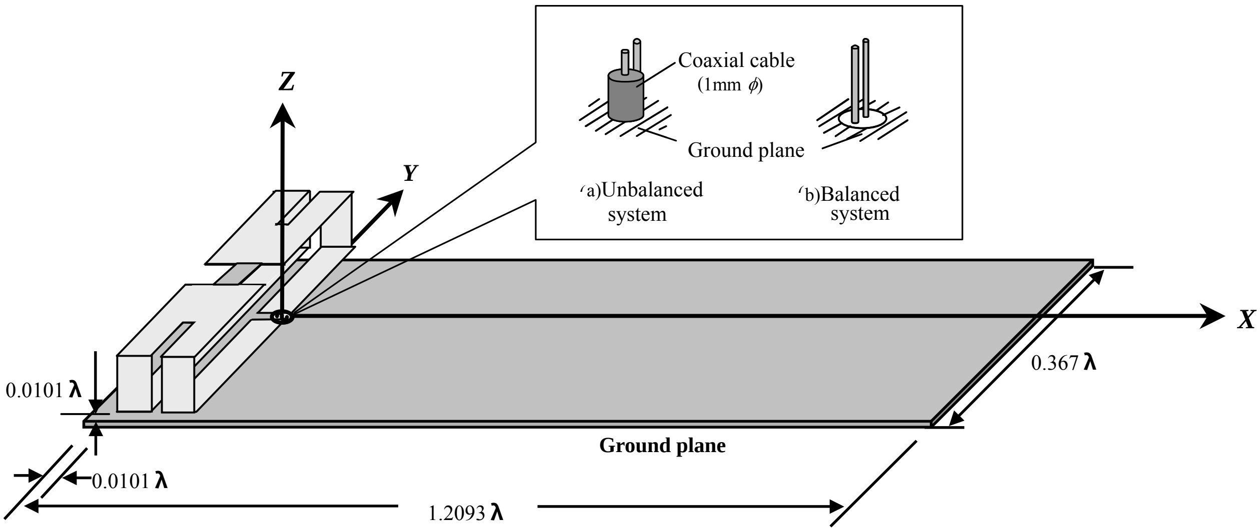
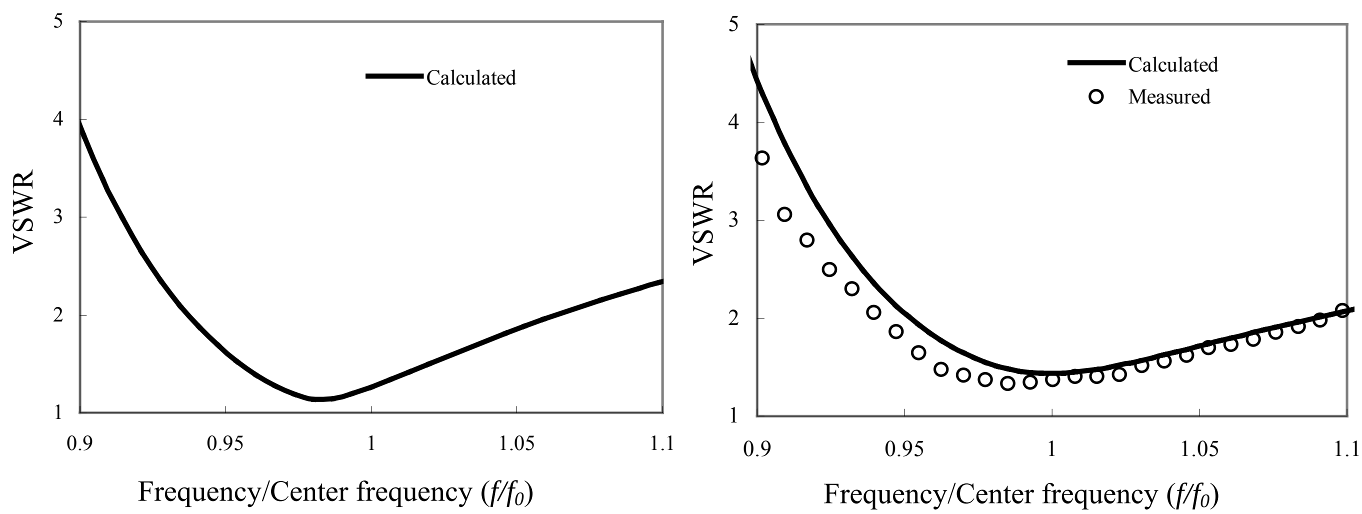


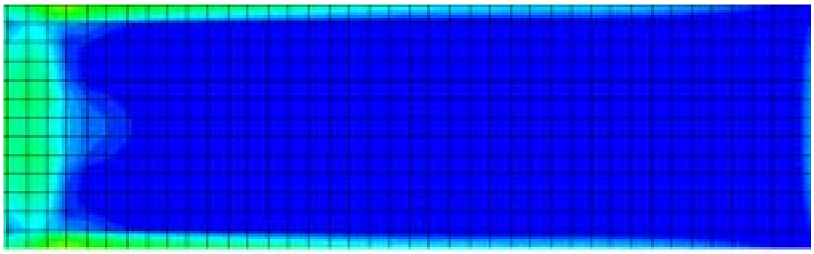
Fig. 2 Self-balanced and wideband folded loop antenna mounted on a finite ground plane.



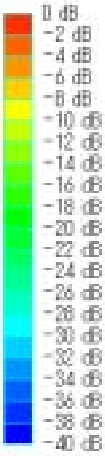
(a) balanced system

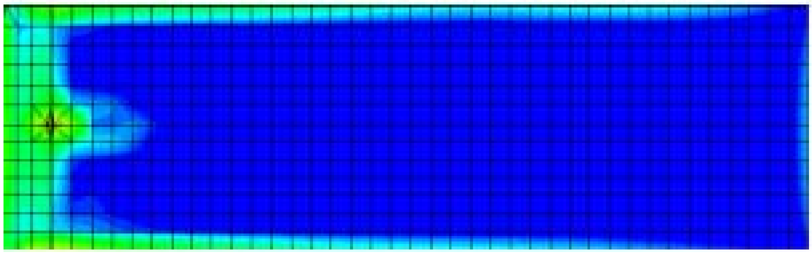
(b) unbalanced system

Fig. 3 VSWR vs. Frequency



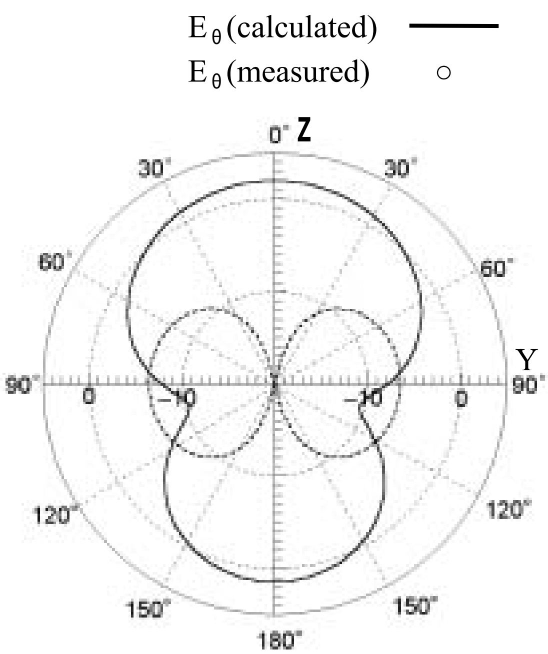
(a) balanced system



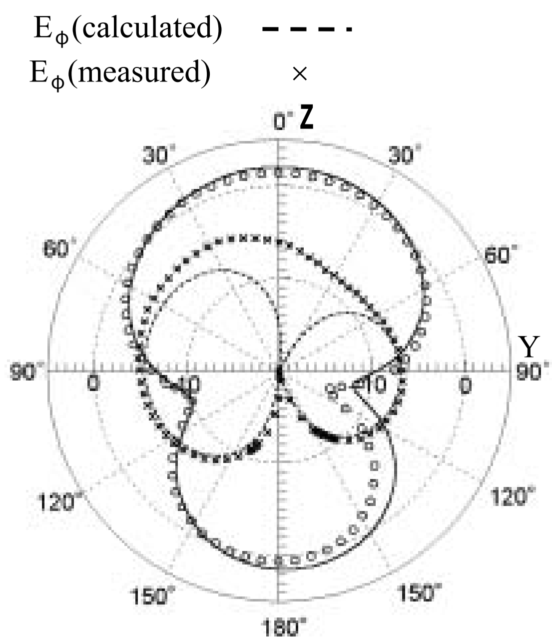


(b) unbalanced system

Fig. 4 Current distribution



(a) balanced system



(b) unbalanced system

Fig. 5 Radiation patterns at the center frequency f_0