Characteristics of Whip Antenna Fed by a Bent Slot Antenna with Electromagnetic Coupling

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1 Introduction

As mobile terminals become more popular, not only the performance but also the cost of the antennas of terminals becomes more important. A built-in antenna and a whip antenna have been conventionally used for mobile terminals. This whip antenna can be put in and out of the mobile terminals for portability. In conventional mobile terminals, there is a contact feed point between the whip antenna and the feed circuit to excite the whip antenna. This type of whip antenna tends to become expensive because the contact point requires high fabrication accuracy. Moreover, contact of the feed point becomes weakened after long term use, and performance of the antenna becomes worse.

A new type of antenna without the contact feed point has proposed for mobile terminals[1]. In [1], the slot antenna on a small conductor plate and a dipole antenna are proposed for the built-in antenna and the whip antenna, respectively. The built-in antenna acts as a radiator when the whip antenna is pulled in. The built-in antenna acts as not only a radiator but also an exciter for the whip antenna when the whip antenna is extended. In this antenna, the shortcoming of the conventional antenna with contact feed point disappears(Fig.1).

The built_in antenna proposed in [1] is hard to be fabricated in the mobile terminals for low frequency because the slot antenna has about $\lambda/2$ length. In this paper, the slot antenna is bent at two points and the length of the slot antenna is reduced to about $\lambda/4$ length(Fig.2). So the antenna proposed in this paper becomes easier to be built-in than that of [1].

2 Analysis and Measured model

The analyzed and measured model is shown in Fig. 2. This antenna is made of two parts. One is a rectangular conductor plate that has a slot. The conductor plate has $(2l + w_k)$ length and $(2w + w_s)$ width. The slot has $(2l_s + w_k)$ length and w_s width. The conductor plate is bent at two points to form the shape '⊐'. The other is a dipole antenna. It is set up at the center of the slot antenna without contact so as to align the bottom end of the dipole and top end of the slot. The gap between the slot and the dipole is defined as g.

The slot antenna shown in Fig. 2 has a finite conductor plate[2] and is bent. So the analysis of the antenna has to be taken account of these effects. In this paper, the numerical technique of moment method[3] is used to analyze the characteristics of the bent slot antenna. Further, the mutual coupling between the bent slot and the dipole antennas can be evaluated by this method. To analyze the antenna shown in Fig. 2 by the moment method, the conductor plate is approximated by a wire grid (Fig. 3). In this paper the conductor plate is divided into about five pieces in longitudinal direction and three pieces in lateral direction. We made sure that the more division does not implove the accuracy of numerical analysis.

In measurement, the antenna is fed by semi-rigid cable. The cable is extended along y-axis from feed point to $-y$ direction.

3 Calculated and measured results

Figure 4 shows radiation pattern for the antennas. The measured results are shown in the same figures to establish the validity of the calculation. The antenna seems to radiate as the z-directed dipole antenna in $x-y$ and $z-x$ planes. The agreement of the calculuated and measured radiation patterns is very good. However the measured pattern radiated to $-y$ direction is somewhat different from calculated one. The feed cable is guessed to disturb the pattern.

Figure 5 shows the calculated current distribution on the antennas. The x and y-directed currents on upper and lower sides of the slot (shown in Fig.2) flow in the opposite directions, so the power radiated from these currents is very small and negligible. Therefore the only z-directed currents are shown in the figure. Further the currents are normalized by that of feed point. This figure shows that the current on the dipole is greater than that on the conductor plate of the slot. These facts show that the dipole antenna is sufficiently excited by the bent slot antenna.

4 Conclusion

A combination antenna of the bent slot and the dipole antennas was proposed as a small and low cost antenna for mobile terminals. The current distribution of the combination antenna shows that the dipole antenna can be sufficiently excited by the slot antenna without contact.

References

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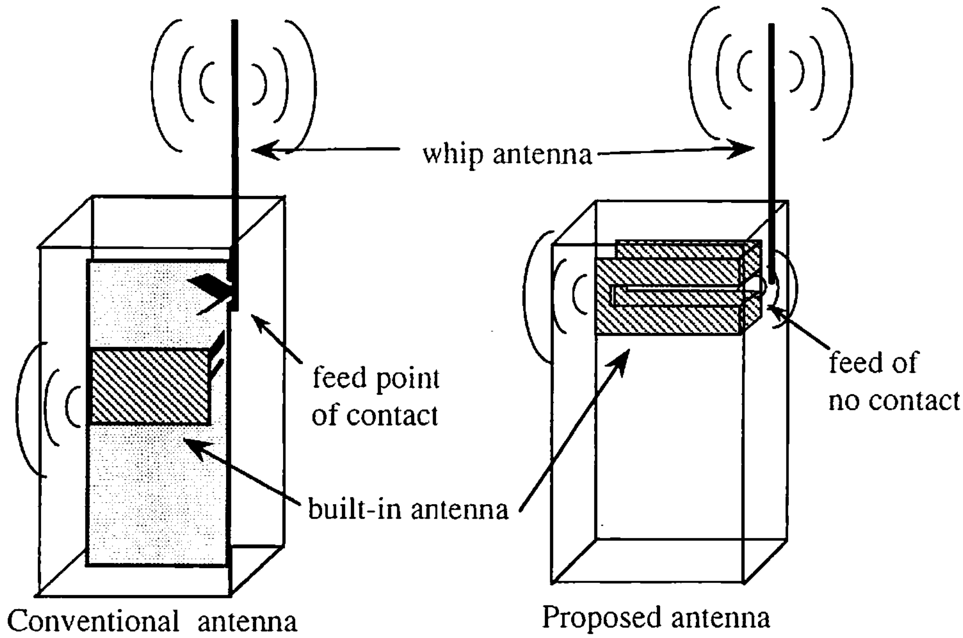

Fig.1 Proposed antenna and conventional antenna for mobile terminal

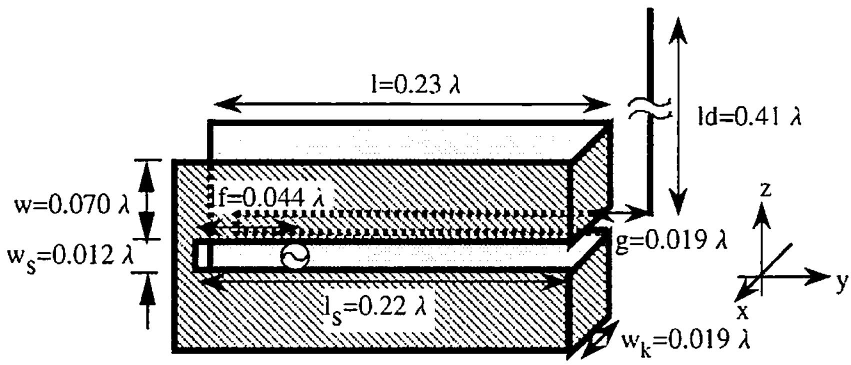

Fig.2 Combination of the bent slot antenna and the dipole antenna

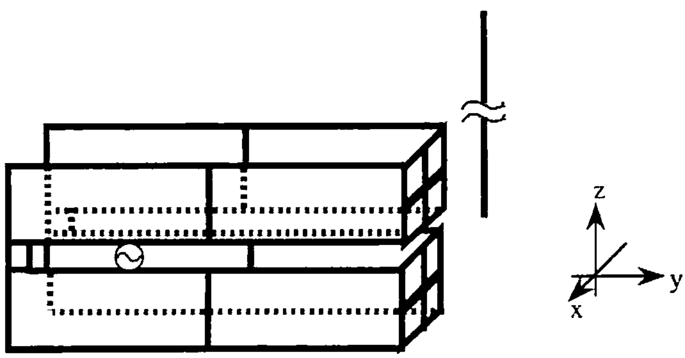

Fig.3 Wire grid model

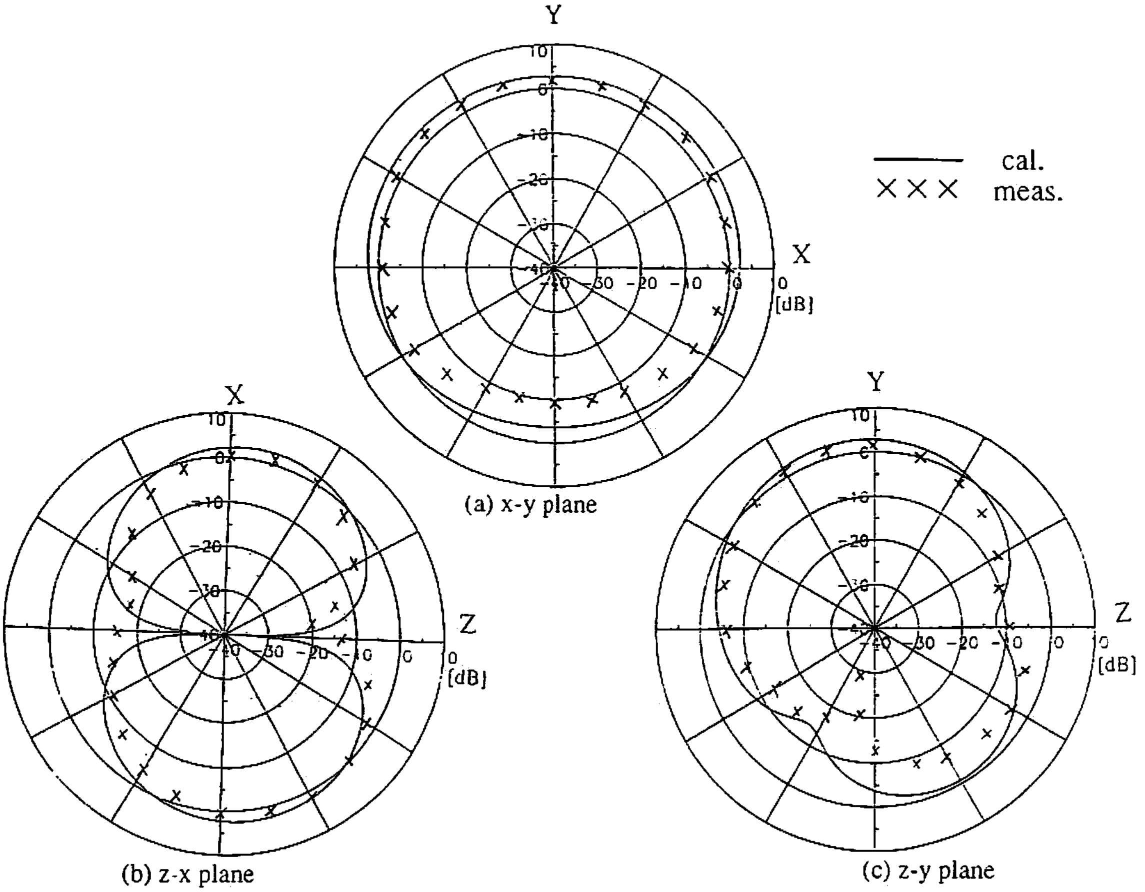

Fig. 4 Radiation pattens of the slot antenna

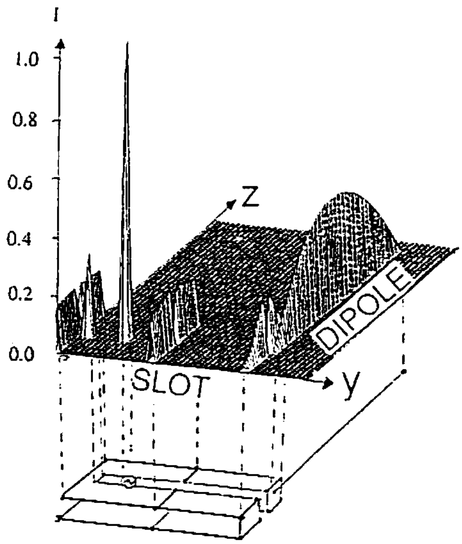

Fig. 5 Current distribution of the antenna