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Built-in antenna with switchable radiation pattern for portable phone

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1. Introduction

Portable phones are used for both the voice conversation and the mobile internet connection in recent years. Although portable phones are in the different attitude and have the different radiation pattern for each use, such as portable phones are in the vicinity of user's ear (talk position) and apart from one's body (viewer position), it's required for the portable phones to have high gain in a horizontal plane for each attitude. And since most of the base stations for mobile communication use vertical polarization, the high vertically polarized gain is emphasized in this paper.

An inverted-F antenna is applied in this paper because the space for the built-in antenna in a portable phone is limited to a small volume. The inverted-F antenna, however, radiates little vertically polarized gain at viewer position. Because small antennas on a finite ground plane mainly radiates horizontally polarized wave from the finite ground plane.

In this paper, a new antenna system which consists of the inverted-F antenna, one parasitic element and a MESFET switch is proposed. Although some antenna systems with plural active lumped elements and plural parasitic elements are reported [1], the use of single active lumped element and single parasitic element is more attractive for a small protable phone.

2. Proposed antenna

Figure 1 shows the geometry of the two kinds of proposed antennas, (1)Type-A and (2)Type-B. An inverted-F antenna is mounted on a 40mm×80mm finite ground plane placed on a horizontal xy-plane at viewer position. The parasitic element is mounted on the same side for the inverted-F antenna as shown in Fig.1 (1)type-A. And another is on the reverse side as shown in Fig.1 (2)type-B. The operating frequency of the inverted-F antenna is around 2GHz.

When using single active lumped element and single parasitic element, the difficulty of the design occurs by the trade-off between impedance matching and change of the radiation pattern. The radiation pattern is required to change much because the radiation patterns for talk position and viewer position are difference. However, when the coupling between the inverted-F antenna and the parasitic element is strong, althogh the radiation pattern changes much, the input impedance of the antenna can't keep matching. And when the coupling is weak, although the input impedance keeps matching, the radiation pattern changes little.

It's expected that the type-B can maintain the input impedance because of less spatial coupling between the inverted-F antenna and the parasitic element than in the case of the type-A, and the coupling can be changed mainly by the change of current mode on the finite ground plane. The end of the parasitic element distant from the inverted-F antenna is terminated to the finite ground plane through a MESFET switch as shown in Fig.1.

At talk position, the current on parasitic element changes under the influence of human head. A MESFET switch, however, is OFF at talk position as mentioned in the next section.

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3. Calculated results and discussion

Figures 2 and 3 show the vertically polarized actual gain of the type-B at talk position and viewer position, respectively. A human head is modeled by a half dielectric space at talk position and no human body at viewer position. The dielectric permittivity and electrical conductivity of the half dielectric space are 40.0 and 1.4[S/m], respectively. The MESFET switch is modeled with parallel circuit with 500Ω and 0.1pF for switch-OFF and 1Ω for switch-ON. Both models are calculated with the moment method. The left half of Fig.2 means that the phone is held with the left hand, and the right half means it is held with the right hand. With the MESFET switch-OFF at talk position, vertically polarized actual gain is higher than with the MESFET switch-ON at talk position.

Though the vertically polarized actual gain at viewer position as shown in Fig.3 is very low (about −10dBi) with the MESFET switch-OFF, the averaged vertically polarized actual gain improves about 3dB with the MESFET switch-ON. The overall performance of the type-B is superior to that of the type-A as shown in Table 1.

Table 1: Averaged vertically polarized actual gain [dBi]

position	talk position		viewer position	
MESFET switch	OFF	ON	OFF	ON
type-A	−4.4	−7.4	−9.4	−8.3
type-B	−4.4	−7.6	−9.1	−6.1

Figure 4 shows the vertically polarized actual gain of the type-A at viewer position. Both the gains for the MESET switch ON/OFF are lower than the gains of the type-B(Fig.3). It's considered that the factor is the loss caused by the current on the MESFET switch because each array factor in xy-plane is the same.

4. Conclusion

A novel antenna with switchable radiation pattern is proposed. The unique point is that the parasitic element is mounted on the reverse side for the inverted-F antenna. It's confirmed that averaged vertically polarized actual gain is improved compared with the antenna that has the parasitic element on the same side for the inverted-F antenna by numerical simulations.

References

[1] R. F. Harrington, "Reactively Controlled Directive Arrays," *IEEE Trans. Antennas Propagat.*, vol. AP-26, no. 3, pp. 390-395, May 1978

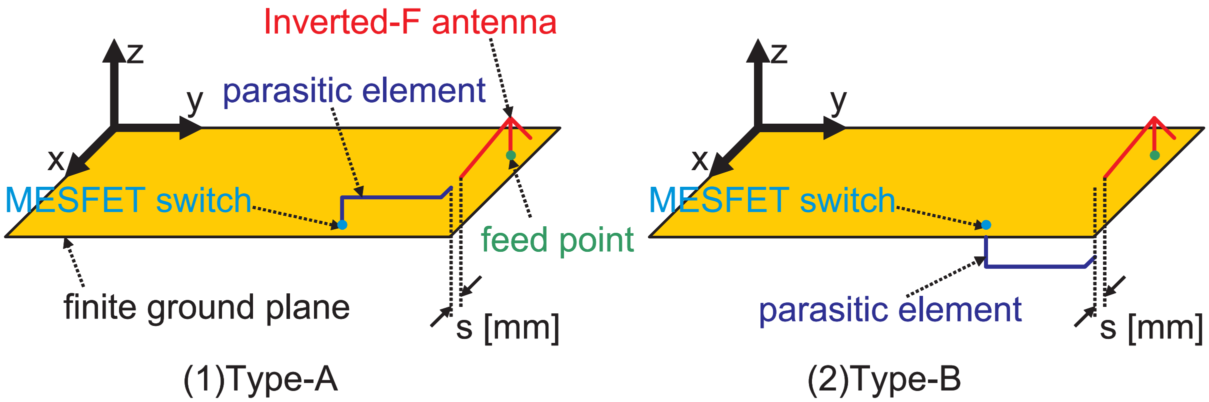

Figure 1: The proposed antenna (type-A consists of a dotted parasitic element instead of a solid parasitic element)

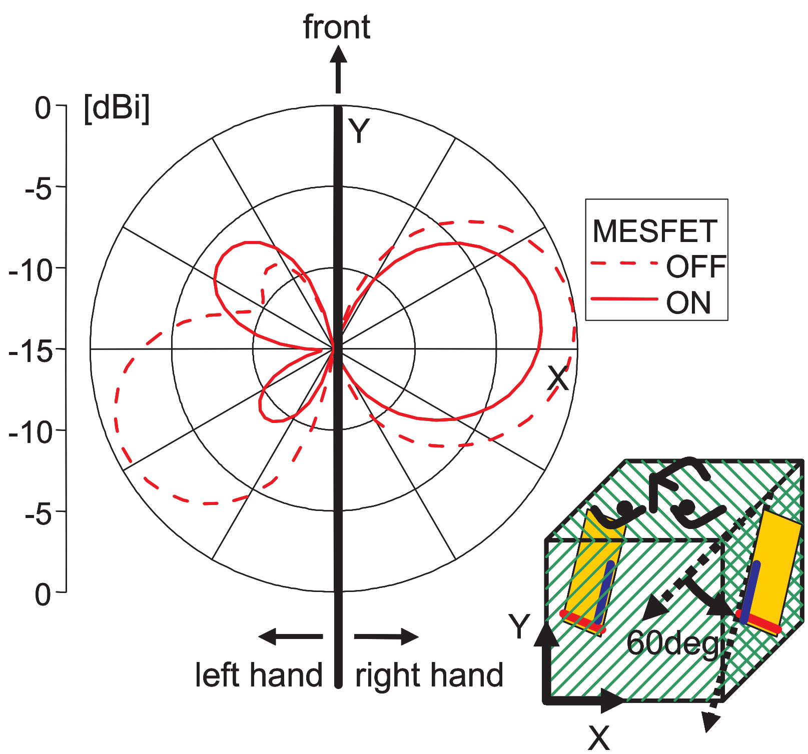

Figure 2: Vertically polarized actual gain of the type-B at talk position at 2GHz

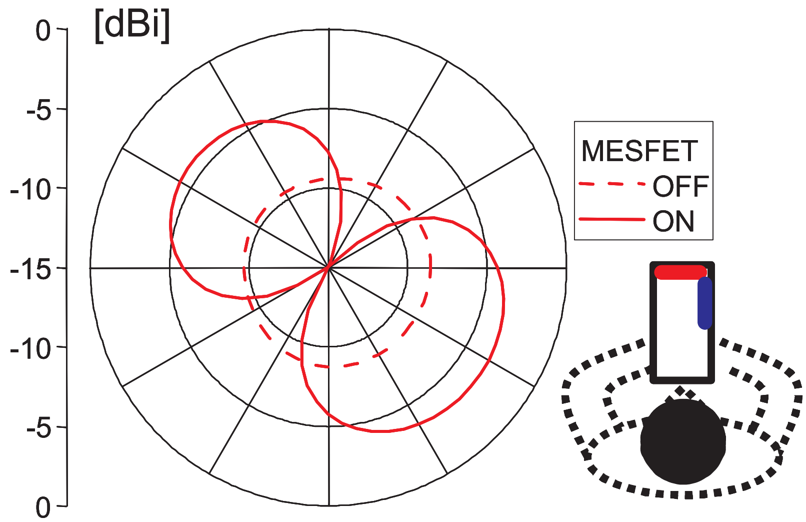

Figure 3: Vertically polarized actual gain of the type-B at viewer position at 2GHz

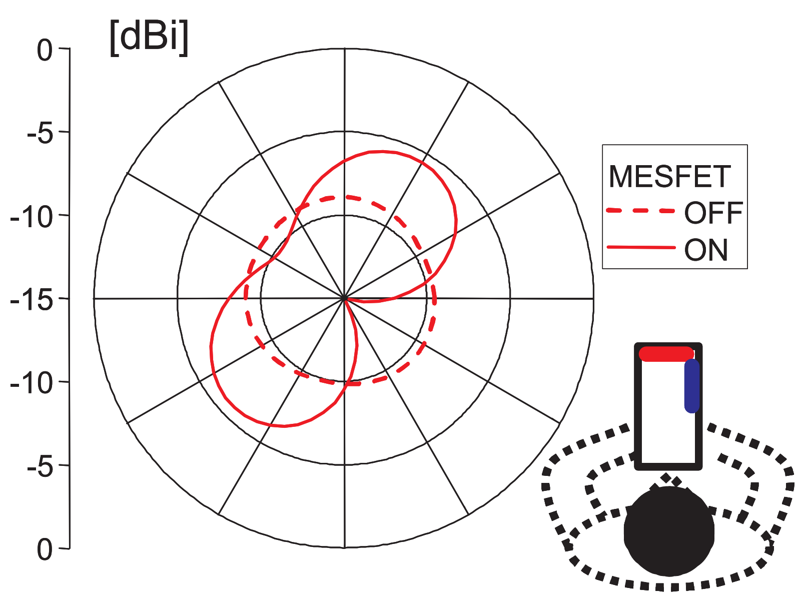

Figure 4: Vertically polarized actual gain of the type-A at viewer position at 2GHz