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Leakage Current Suppression by an Antenna with Parasitic Elements Mounted on a PCB

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1. Introduction

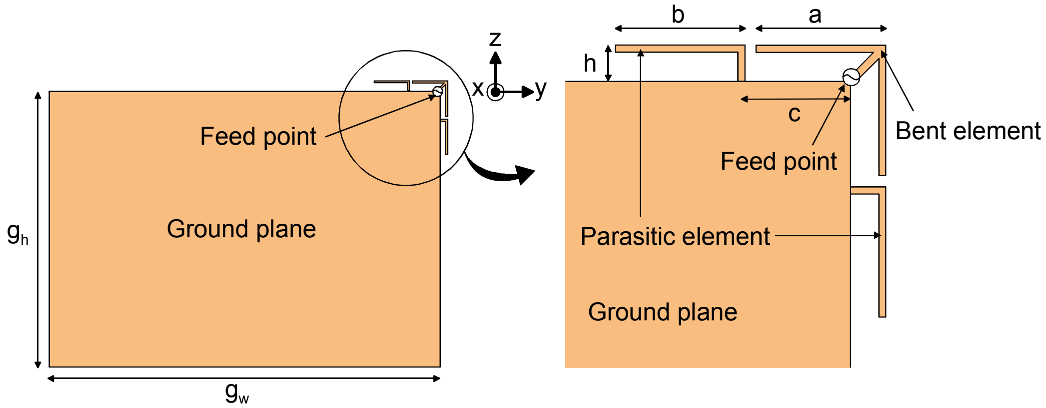
A ground plane set to the appropriate size can be used as a part of radiation elements [1]. For mobile terminals, omnidirectional pattern is generally desirable in a horizontal plane. However, if the ground plane size is larger than a wavelength, the radiation pattern is disturbed by the effect of the leakage currents on the ground plane. As a method to control these leakage currents, a notch on the conducting body has been reported [2], but the implementation may be difficult. Although an artificial magnetic conductor (AMC) has been proposed to suppress surface currents [3], the structure is complex.

In this paper, we propose a simple structure using parasitic elements at the appropriate position of the ground plane in order to improve the radiation pattern. The proposed antenna can be improved the radiation pattern due to reduction of the leakage currents on the ground plane. The good agreement of the impedance characteristics between the simulated and measured results is presented. The simulated and measured results show that the radiation pattern in the horizontal plane is better than that of the inverted-F antenna.

2. Antenna Design

Figure 1 shows the structure of the proposed antenna where g_h and g_w are the size of the ground plane, a, b and h are the length of the elements and c is the shorted position of the parasitic element. The bent element is fed at one corner of the ground plane. We can reduce leakage currents on the ground plane by setting the length (b+h) of the parasitic elements to $\lambda/4$ to work as open-ended stubs. Furthermore, the impedance matching is achieved by setting the shorted position (c) of the parasitic elements to about $\lambda/4$ from the feed point.

For example, the antenna for IEEE 802.11b/g on the upper PCB of a notebook PC is considered. The system operates in the 2.4GHz band (2400-2500MHz). Since the center frequency of the system is 2450MHz ($\lambda/4$ is about 31mm), the parameters in Figure 1 are shown in Table 1.



(a) Overall view (b) Magnified view around the feed point

Figure 1: Structure of the proposed antenna on the ground plane.

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Table 1: Design Parameters of the proposed antenna.

g_h	g_w	a	b	c	h
230mm	270mm	27mm	28mm	31mm	3mm

3. Input Impedance Characteristics

NEC2D [4] is employed to simulate the characteristics of the proposed antenna. The ground plane made of a copper plate in the measurements is treated as the wire mesh model. The diameter of the wires and the antenna elements is 0.45mm. Figure 2 shows the input impedance characteristics. The good agreement between the simulated and measured results can be seen. The proposed antenna has a 10dB return loss bandwidth ranging from 2400MHz to 2560MHz in the simulated result and from 2390MHz to 2580MHz in the measured result. Both are satisfied with the required bandwidth of IEEE 802.11b/g.

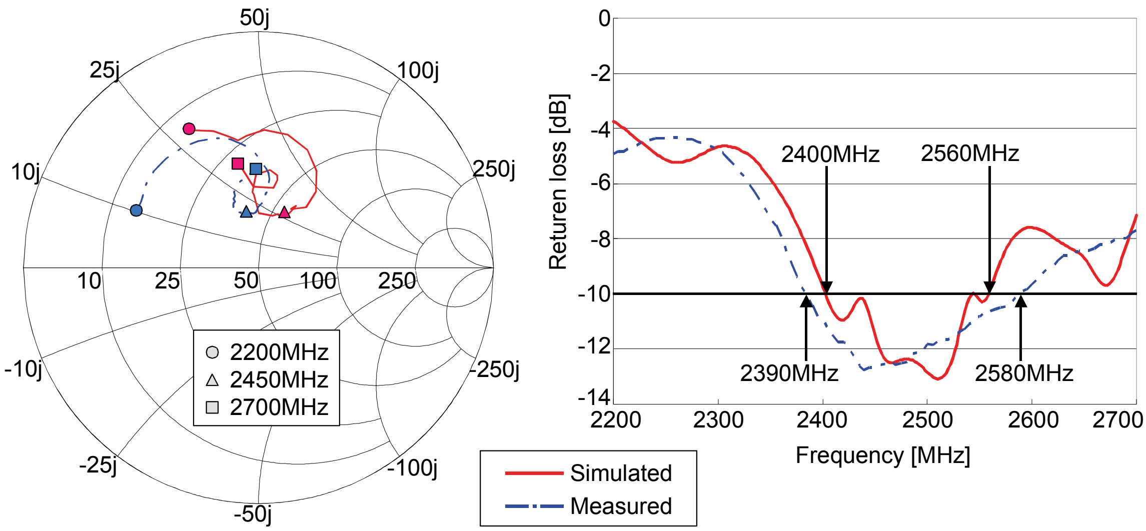


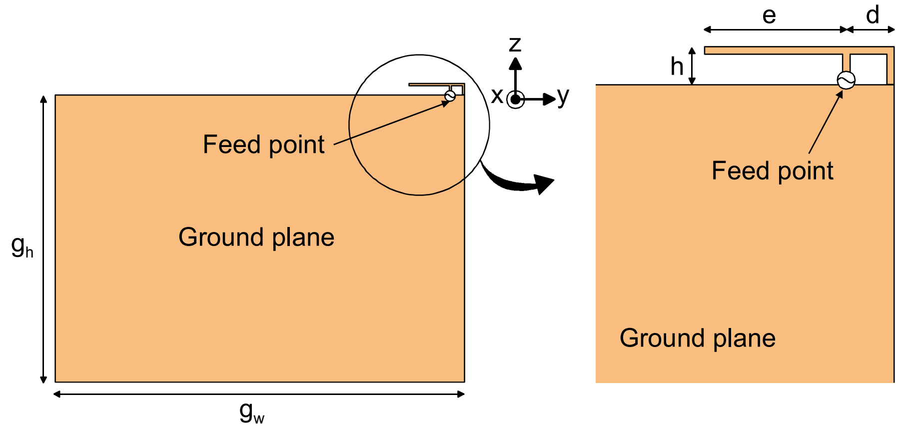
Figure 2: Input impedance characteristics of the proposed antenna.

4. Radiation Pattern

The radiation patterns of the proposed antenna are compared with those of an inverted-F antenna used as a low-profile antenna on a ground plane. Figure 3 shows the structure of the inverted-F antenna where g_h and g_w are the size of the ground plane and d, e and h are the length of the elements. The shorted point is one corner where is the distance d away from the feed point. The height of the inverted-F antenna is the same as that of the proposed antenna. As the input impedance matches at about 2450MHz, the parameters in Figure 2 are chosen in Table 2.

Table 2: Design parameters of the inverted-F antenna.

g_h	g_w	d	e	h
230mm	270mm	10mm	25mm	3mm



(a) Overall view (b) Magnified view around the feed point

Figure 3: Structure of an inverted-F antenna on the ground plane.

The corner with the feed point is defined as the coordinate origin and the ground plane is put in the yz-plane. Figure 4 and Figure 5 show the simulated and measured radiation patterns in the horizontal plane for vertical polarization (xy-plane) at 2450MHz, respectively. The radiation patterns of the inverted-F antenna have null points but they are improved in the proposed antenna.

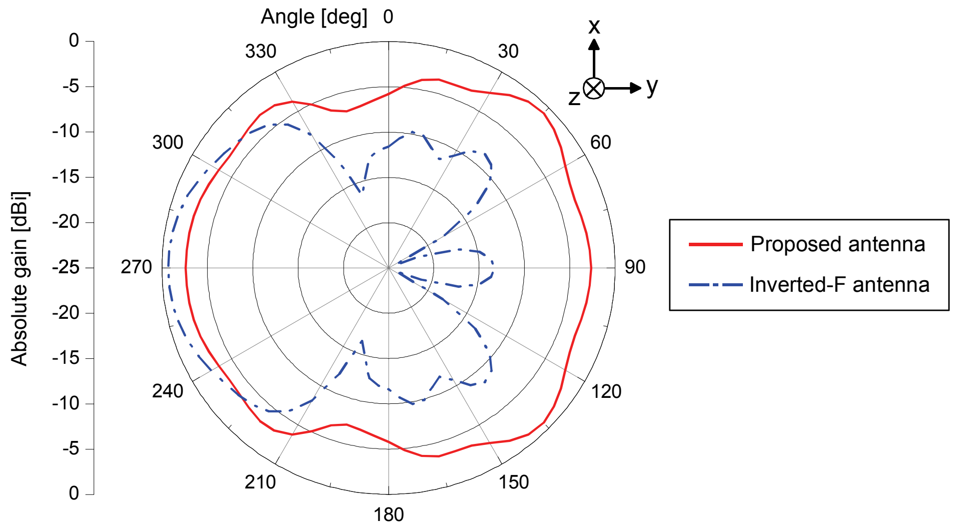


Figure 4: Simulated radiation pattern (V-pol.) in xy-plane.

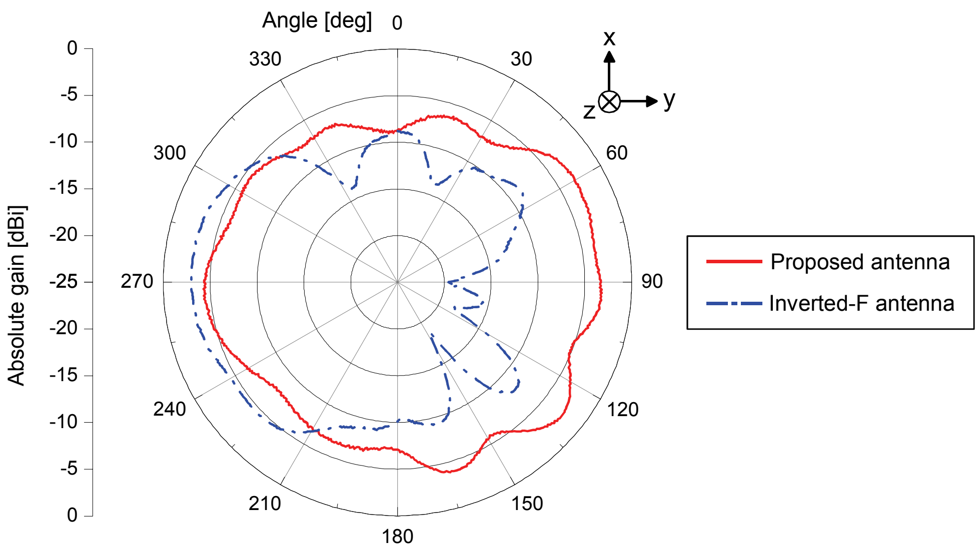


Figure 5: Measured radiation pattern (V-pol.) in xy-plane.

Figure 6 shows the simulated current distribution along the z axis. That is normalized with the maximum current amplitude. The leakage current on the ground plane can be reduced with the proposed antenna in comparison with the inverted-F antenna. This is why the distortion of the radiation pattern is improved in the proposed antenna.

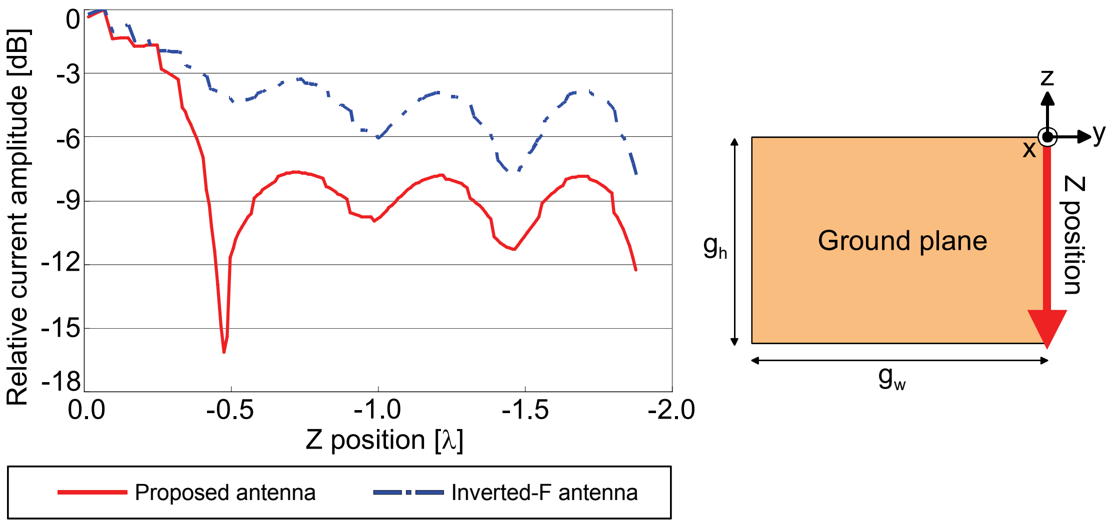


Figure 6: Simulated current distribution along z axis.

5. Summary

We have proposed an antenna structure with parasitic elements in order to improve the radiation pattern by suppression of the leakage current on the ground plane. The validity of the simulated result is shown by comparison with the measurement. The proposed antenna is satisfied with the required bandwidth of IEEE 802.11b/g. Since the leakage current on the ground plane is reduced with the proposed antenna in comparison with the inverted-F antenna, the radiation pattern in the horizontal plane for vertical polarization is improved.

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