Pattern Distortion Suppression of Multiband Base Station Antenna Using L-Shaped Choke

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Abstract

We investigate a pattern-distortion suppression method for multiband base station antennas. We investigate the relationship between the Half-Power Beam-Width (HPBW) frequency deviation and the induced current, and propose an L-shaped structure to suppress the current. We simulate the proper structure parameters and verify the HPBW deviation reduction effect.

Keywords: Multiband antenna, base-station antenna, radiation pattern characteristics

1. Introduction

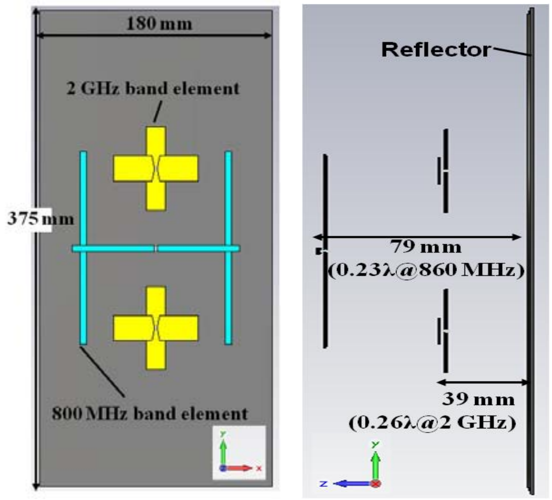
Dual polarized multiband base station antennas are becoming popular for mobile communication systems because they can conserve space in antenna deployments [1]. However, radiation patterns are generally distorted due to the influence from other frequency bands of the antenna elements.

This paper proposes a new antenna configuration that can suppress the distortion in the radiation pattern that appears in a high frequency band. The antenna comprises L-shaped chokes and the chokes are arranged on low frequency band elements. The effectiveness of the proposed antenna configuration is investigated by numerical analysis. In this study, a multiband antenna operating in the 800 MHz and 2 GHz bands is considered. This paper is organized as follows. First, the mechanism of the radiation pattern distortion in a high frequency band is described. Then, the proposed antenna structure is shown and the effectiveness of the L-shaped choke to suppress the Half Power Beam Width (HPBW) deviation is investigated. For the numerical analysis, CST MW-studio 2011 is used in this study [2].

2. Mechanism of Pattern Distortion in High Frequency Band

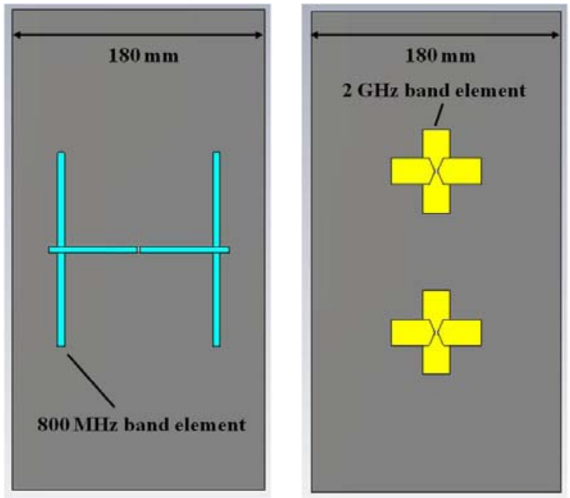
Figure 1 shows an analysis model of a dual polarized multiband base station antenna. The antenna comprises dipole elements for the 800 MHz and 2 GHz bands, and a plane reflector. The size and spacing of the elements and reflector are shown in the figure. To clarify the influence of the elements for the other frequency bands on the radiation pattern, the single-band antenna configurations shown in Fig. 2 are also considered. Figure 3 shows the HPBW characteristics in the azimuth plane in the 800 MHz and 2 GHz bands for the single band and multiband configurations. Figure 3 shows that the HPBW of the single band antenna configuration is identical to that for the multiband antenna configuration in the 800 MHz band. Thus, the dipole elements for the 2 GHz band do not affect the radiation pattern for the 800 MHz band. However, in the 2 GHz band, the HPBW characteristics for the multiband antenna configuration vary from those of the single band antenna configuration. The variation in the horizontal polarization is larger than that for the vertical polarization.

To clarify this phenomenon, we calculate the currents on the dipole elements. Figure 4 shows the current distribution on all the elements when the 2 GHz band horizontal elements are fed. As shown in Fig. 4, a strong induced current is observed on the horizontally polarized 800 MHz band element (red dashed circle in Fig. 4). The induced current on the 800 MHz band horizontal elements induces 2 GHz band radiation. The radiation characteristics from the 800 MHz band elements depend on the spacing between the element and the reflector. Generally, the spacing is designed to be around 0.25λ at the considered frequency to avoid beam splitting and obtain wideband characteristics [3]. For this reason, the spacing of the 800 MHz horizontal elements is set to 0.23λ at 860 MHz in this model. It becomes 0.5λ ~ 0.56λ for the 2 GHz band, and it is known that a broad beam is generated in the azimuth plane for such a spacing [4]. The combination of this radiation pattern and the original pattern makes the HPBW in the 2 GHz band broad. However, it is difficult to decrease the spacing because it is generally designed around 0.25λ considering the influence on the radiation pattern as previously mentioned.



(a) Front view (b) Side view

Figure 1: Structure of the Multiband Antenna.



(a) 800 MHz band (b) 2 GHz band

Figure 2: Structure of the Single-Band Antenna.

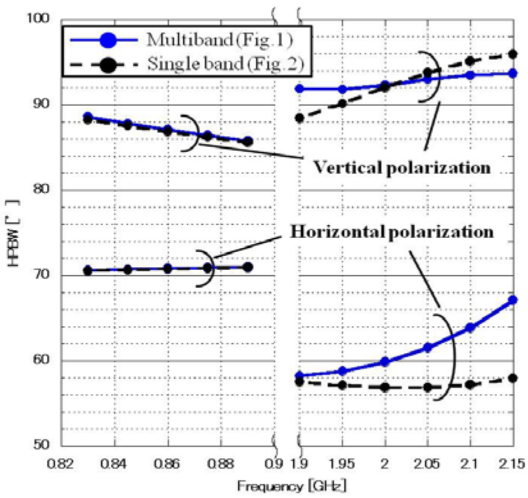


Figure 3: HPBW in the Azimuth Plane.

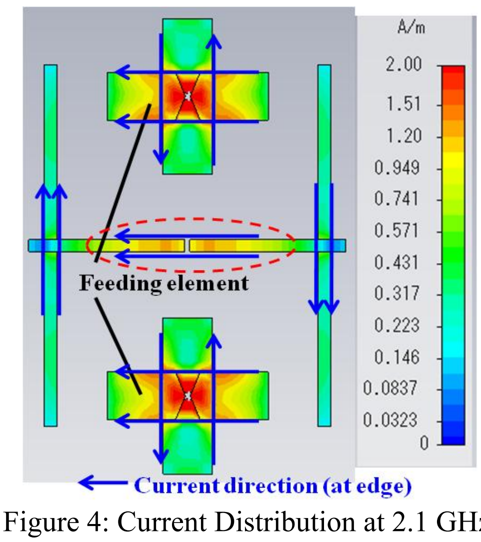


Figure 4: Current Distribution at 2.1 GHz.

3. Configuration and Effectiveness of L-Shaped Choke

Taking the above mechanism into consideration, we propose placing chokes on the 800 MHz antenna element to suppress the induced current. Figure 5 shows the proposed antenna structure. L-shaped chokes are placed on both sides of the 800 MHz dipole elements. The other antenna configurations are the same as those shown in Fig. 1. Hereafter, the influence of the structure parameters of the L-shaped choke on the variation in the HPBW in the 2 GHz band is investigated.

Figures 6 and 7 shows the influence of the length of the L-shaped choke. Figure 6 shows the current distributions of the proposed element at 2.1 GHz when length L of the L-shaped chokes is 25 mm, 28 mm, or 31 mm. Figure 8 shows the HPBW in the azimuth plane for horizontal

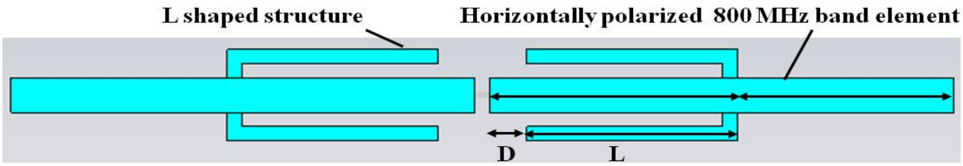


Figure 5: Structure of Proposed Element.

polarization in the 2 GHz band. The spacing (D) between the central part of the dipole element and the edge of the L-shaped choke, which corresponds to the position of the L-shaped choke, is fixed at 5 mm. As shown in Fig. 7, the HPBW characteristics are almost flat at L = 28 mm (red curve). This is because strong currents flow on the L-shaped chokes in the opposite direction from that of the central part of the 800 MHz dipole element as indicated by the blue arrows in Fig. 6. The currents cancel the radiation from the current induced on the 800 MHz dipole element. When L is 25 mm, the variation in the HPBW in the considered frequency range increases slightly (orange curve). This is because of the low current flow on the L shaped structure compared to that for the central part of the element as shown in Fig. 6. When L is 31 mm, the variation in the HPBW also increases (green curve in Fig. 7) and the HPBW decreases as the frequency increases. The reason for this is considered to be the contribution by the current at the edge of the element as indicated by the red dashed circles in Fig. 6 although there is a strong current flowing on the L-shaped choke.

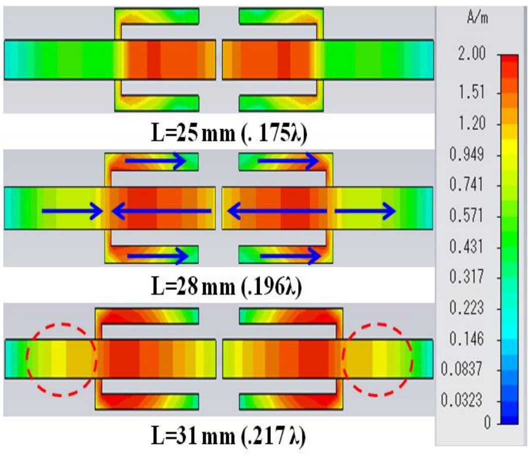


Figure 6: Current Distribution at 2.1 GHz due to *L*.

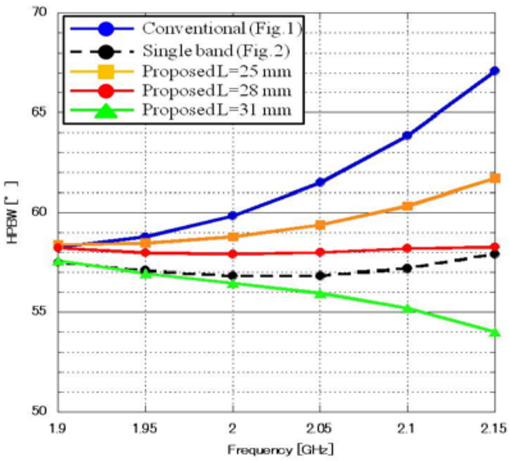


Figure 7: HPBW in Azimuth Plane due to *L*.

Figures 8 and 9 shows the influence of spacing D, which corresponds to the position of the L-shaped choke. Figure 8 shows the current distribution on the proposed element at 2.1 GHz when D is 0 mm, 5 mm, or 10 mm. Figure 9 shows the HPBW in the azimuth plane for horizontal polarization in the 2 GHz band. Length L is fixed at 28 mm. As shown in Fig. 9, the HPBW characteristic is almost flat when D = 5 mm (red curve). The HPBW decreases when spacing D is 0 mm (pink curve). This is because high currents flow on the edge of the element as shown in Fig. 8, which is similar to the L = 31 mm case. This suggests that it is reasonable that the HPBW decreases due to the increased current on the edge of the element. On the other hand, when spacing D increases (D = 10 mm), the variation in the HPBW slightly increases (purple curve). This is because the induced current remains at the central part of the element (blue dashed circles in Fig. 8) although the current at the edge of the element decreases.

Taking the above results into consideration, it is clear that there is a trade-off between the reduction in the induced current around the central part of the element and the increase in the current around the edge of the element. The ideal characteristics can be achieved by choosing the proper L and D parameters. Figure 10 shows the HPBW characteristics in the azimuth plane when L = 28 mm and D = 5 mm. Compared to the conventional case, the maximum HPBW frequency variation for horizontal polarization in the 2 GHz band can be reduced from 9 [deg.] to 0.5 [deg.]. Although there is little influence on the HPBW in other bands or in terms of polarization, the reduction effect of the proposed structure on the frequency deviation in the radiation pattern is verified.

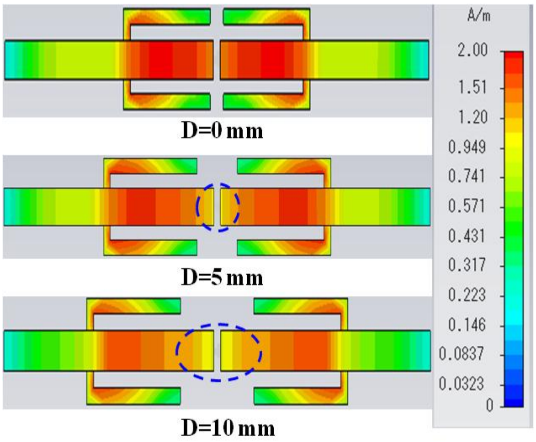


Figure 8: Current Distribution at 2.1 GHz due to *D*.

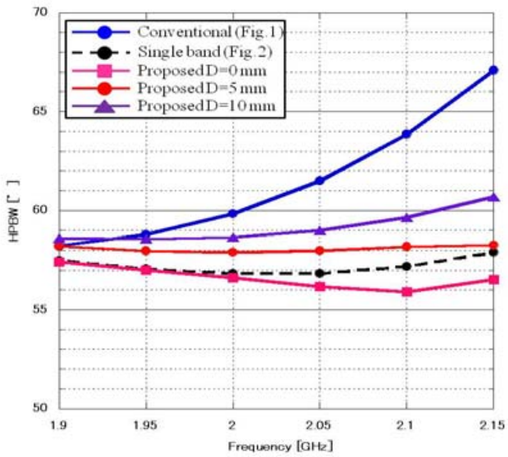


Figure 9: HPBW in Azimuth Plane due to *D*.

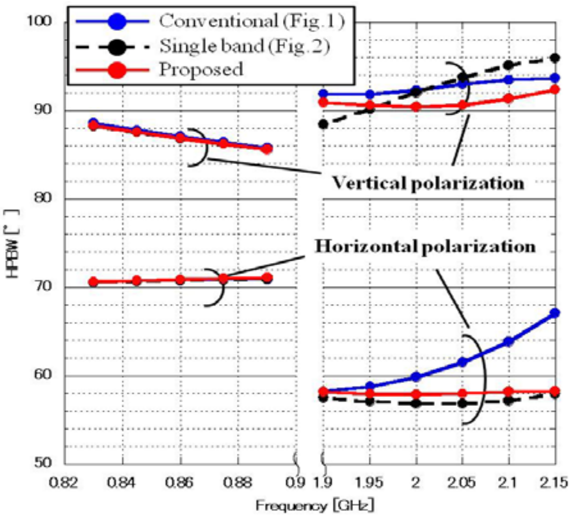


Figure 10: HPBW Characteristics of the Conventional and the Proposed Model.

4. Conclusion

This paper investigated the radiation pattern distortion characteristics that appear in a multiband antenna operating in the 800 MHz and 2 GHz bands. The mechanism of the pattern distortion was clarified and a new antenna configuration comprising an L-shaped choke to suppress the pattern distortion was proposed. The numerical results showed that the variation in the HPBW in the 2 GHz band can be reduced from 9 [deg.] to 0.5 [deg.] by choosing the proper structure parameters.

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