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Electromagnetically Transparent Dipole for Cross-Band Scattering Suppression in Dual-Band Array

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***Abstract*—In this paper, an electromagnetically transparent dipole working at the low-band (LB, 1.7-2.5 GHz) is proposed to suppress the cross-band scattering to the high-band (HB, 4.4-5.0 GHz) radiation in a dual-band array. Patches with vias and capacitively loaded loops (CLLs) are loaded on radiating arms and baluns of the LB dipole, which can introduce reversed induced-currents at the HB to restore the deteriorated HB radiation patterns. After the loadings, HB patterns are well recovered, showing great consistency with the patterns of the HB dipoles operating alone.**

Keywords—dual-band antenna array, pattern distortion, scattering suppression

I. Introduction

Nowadays, modern communication platforms usually accommodate several kinds of antennas working at different bands within one constrained platform. This inevitably leads to unwanted cross-band scattering, which deteriorate the radiation pattern of the HB antennas.

There have been many solutions proposed to address this cross-band scattering issue, which can be generally classified into two categories. The first kind of solution is to loading the LB antenna with various structures including mantle cloaks, slots, or chokes [1-3] to make the LB antenna transparent at the HB. The second one is to place HB antennas above the LB antenna to make sure the LB element not obstruct the main beam of the HB radiation [4]. The latter usually results in more complicated structure and higher cost compared to the former method. The former is more realistic although the bandwidth is narrower, and most works are implemented on the radiator of LB antennas. However, it is found in this work that the balun of the LB antenna also contributes to the pattern distortion and should not be neglected.

In this paper, an electromagnetic transparent LB dipole working is proposed with both modified radiating arms and baluns to further enhance its transparency at the HB. As shown in Fig. 1, a 1+1 arrangement is adopted to assess the scattering suppression ability, which excludes the potentially extra anti-scattering ability provided by the array topology. The HB element is placed under one LB radiating arm, in which case the scattering is the strongest.

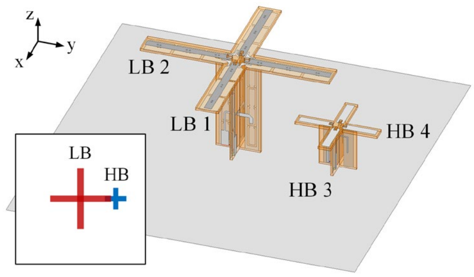

Fig. 1. 1+1 array arrrangment with one LB dipole and one HB dipole.

II. Scattering Suppression on LB Radiator

A. Structure of Loadings

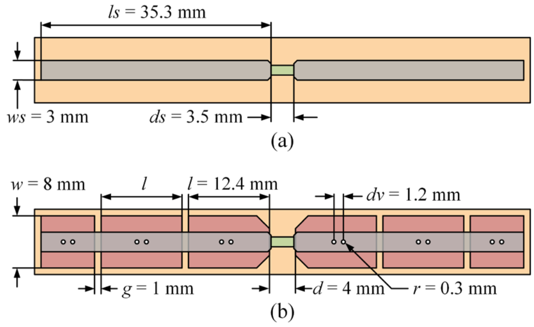

Fig. 2. Geometry of (a) the original LB dipole, (b) the loaded LB dipole.

Patches and vias are loaded on radiators of LB antenna as shown in Fig. 2. The radiators of LB antenna and the loaded patches are etched on the two sides of a 1 mm-thick FR4 substrate, and they are interconnected by metallic vias in the middle of each patch. The values of parameters after the optimization are labelled in the figure.

Under irradiation of *x*-polarized plane waves at HB, currents distributions are depicted in Fig. 3, and suppression mechanism can be elucidated. After the loading, the induced HB currents on the patches and the radiator have equal magnitudes but opposite phases. The secondary radiation of these induced currents cancels out with each other, achieving scattering suppression to HB radiation.

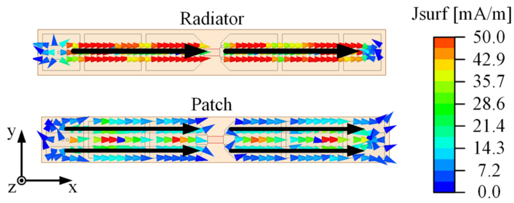

Fig. 3. Currents distributions on the loaded LB dipoles at 4.8 GHz.

B. Scattering Cross Section Analysis

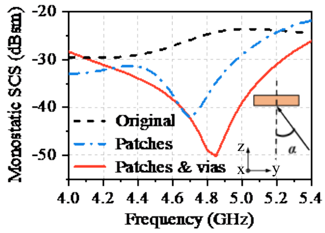

Fig. 4. Monostatic scattering cross section (SCS) of the LB dipole at 4.4-5.0 GHz.

The monostatic scattering cross section (SCS) of the loaded LB dipole is shown in Fig. 4. The LB dipoles are illuminated by *x*-polarized plane waves with the incidence angle of $\alpha = 61$ degree. Compared to the dipole without any loading, the LB dipole loaded with patches and vias can achieve the SCS reduction from 4.09 to 5.48 GHz. Loading only patches can also achieve the SCS reduction, but compared with loading patches and vias at the same time, the reduction value and bandwidth are smaller. These results show that the proposed loadings have good scattering suppression effect at the HB.

C. *Pattern Restoration*

The radiation patterns of the HB antenna before and after the loading of LB radiator are compared in Fig. 5 and 6. It should be noted that for this simulation the baluns are excluded. As shown in Fig. 6, the obvious distortions in Fig. 5 are substantially suppressed after the loading, and the patterns are consistent with the patterns of the HB dipoles working alone.

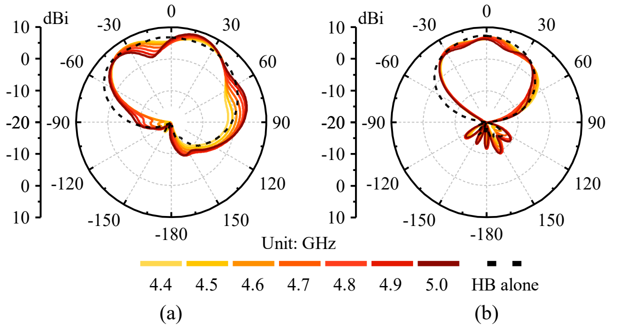

Fig. 5. Radiation patterns of (a) HB3 and (b) HB4 in the *yoz* plane at 4.4-5.0 GHz before loading the LB radiator.

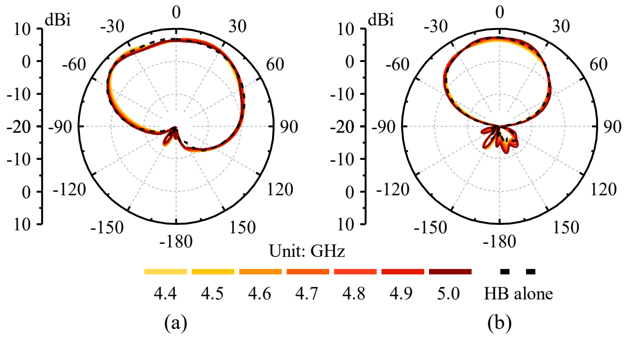

Fig. 6. Radiation patterns of (a) HB3 and (b) HB4 in the *yoz* plane at 4.4-5.0 GHz after loading the LB radiator.

III. Scattering Suppression on LB Balun

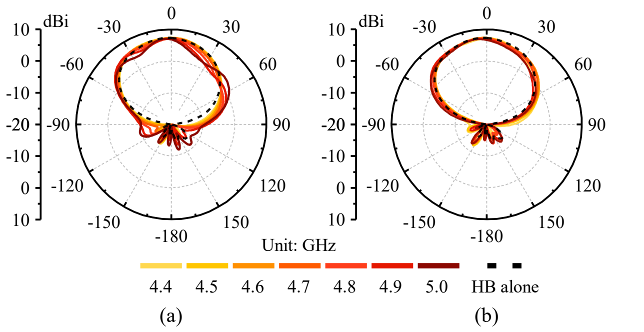

Fig. 7. Radiation patterns of the HB4 in the *yoz* plane (a) before and (b) after loading the LB balun with CLLs.

After modifying the LB radiator, the scattering problem is not resolved completely because the LB baluns also pose a negative effect on the HB radiation. When the LB baluns are presented, the radiation patterns of the HB4 encountered distortions again as illustrated in Fig. 7(a).

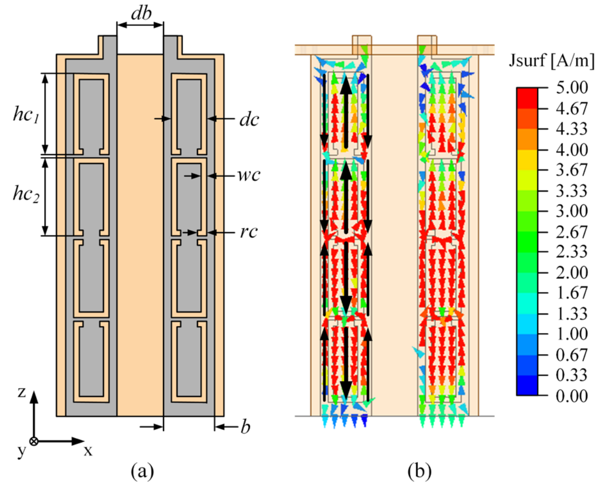

Fig. 8. (a) LB balun with CLLs, and (b) current distributions at 4.9 GHz on the CLL-loaded LB balun.

Therefore, capacitively loaded loops (CLLs) are etched on the LB balun as depicted in Fig. 8(a). The values of dimensions after the optimization are as follows: $db = 5$ mm, $hc_1 = 8.7$ mm, $hc_2 = 8.4$ mm, $dc = 3.8$ mm, $wc = 0.6$ mm, $rc = 1$ mm, $b = 5.5$ mm. Current distributions at 4.9 GHz on the LB balun with CLLs when excited by HB radiation are given in Fig. 8(b), which indicates that the mechanism of this suppression method is also to generate reversed currents with similar amplitudes on the inner and outer parts of the balun. After the alteration of LB balun, the patterns of HB4 come back to normal as shown in Fig. 7(b).

IV. Conclusion

An electromagnetically transparent LB dipole loaded with patches, vias and CLLs is proposed to suppress cross-band scattering to HB radiation and restore HB distorted radiation patterns. Both the LB dipole's radiating arms and the baluns scatter the HB radiation and they are addressed step by step. After the loadings, the LB dipole is made transparent to the HB radiation thus the HB patterns are well restored.

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