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Cross-Band Scattering Suppression for MultiBand Base Station Antenna Arrays

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***Abstract*— This paper presents a dual-band dual-polarized interleaved base station antenna array unit based on a filtering antenna for cross-band de-scattering. The array is configured as two columns of antenna arrays operating at a higher band from 1.71 GHz to 2.30 GHz interleaved with one column of antenna array operating at a lower band from 0.80 GHz to 0.96 GHz. By inserting low-pass high-stop filters into the low-band dipole arms, a filtering antenna that can efficiently suppress the radiation at the higher band is achieved. On one hand, the obtained filtering antenna has a slightly reduced gain and narrower bandwidth, which is attributed to the filters. On the other hand, the obtained filtering antenna working at the low band has minimum negative effect on the high band antenna performance.**

Keywords—Base station antenna (BSA); cross-band scattering; decoupling; dual-band; filtering antenna;

I. INTRODUCTION

As mobile communications standards evolve from generation to generation, and now move towards the fifth generation (5G), wideband and multiband base station antennas (BSAs) are required to simultaneously support different communication standards. To minimize the cost of antenna systems and address the pressure of visual space, the low band (LB) and high band (HB) antenna arrays are usually placed close to each other on one panel, as shown in Fig. 1. However, there is a penalty for the close proximity of the elements in the form of distortion of the pattern due to scattering of the signals of the HB by the antennas operating in the LB [1].

One method of minimizing the cross-band scattering is the use of mantle cloaking techniques, as described in [1]. The mantle cloaks are designed to produce an "anti-phase" scattering currents to cancel the scattering from radiator alone. They can largely suppress cross-band scattering while preserving performance of the cloaked radiator. However, the cloaks usually occupy large volumes. The other method of alleviate the scattering issue is to use filtering antennas [2-3]. Filtering antennas are designed by introducing filtering characteristics into the radiation aperture, thus have the potential to make the LB antenna invisible to the HB signals. In this way, distorted radiation patterns of the HB antennas can be recovered.

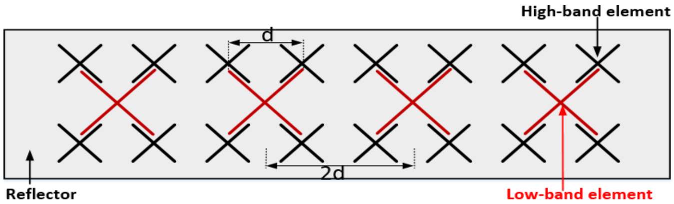

Fig. 1 A typical interleaved base station antenna (BSA) array configuration.

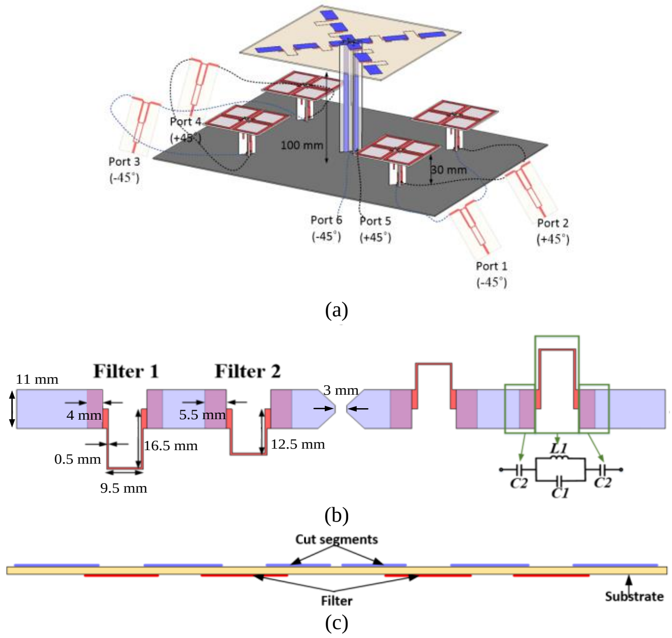

Fig. 2. (a) Perspective view of the interleaved BSA array section with modified filtering LB antenna. (b) Top and (c) side views of the LB dipole arms with inserted filters.

This paper introduces a filtering antenna working at the LB and demonstrates its ability to minimize the distortion of the HB antenna patterns when working in the typical dual-band interleaved BSA array shown in Fig. 1.

II. ANTENNA

Fig. 2(a) shows the perspective view of a section of the interleaved dual-band BSA array. The detailed top view and side view of the LB antenna are shown in Figs. 2(b) and 2(c), respectively. The selected LB and HB antennas are widely used cross-dipoles [4-6].

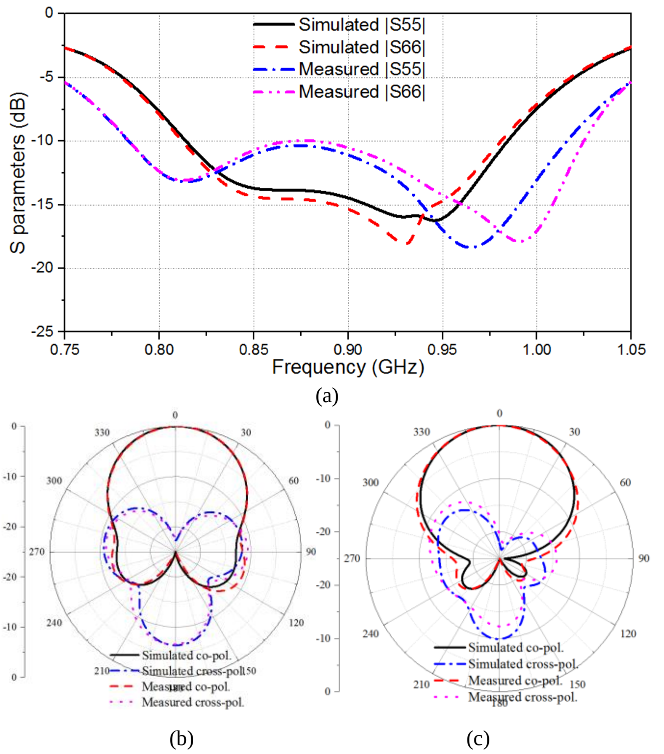

Fig. 3. Simulated and measured (a) reflection coefficients; and radiation patterns at (b) 0.82 GHz and (c) 0.96 GHz of the modified LB antenna.

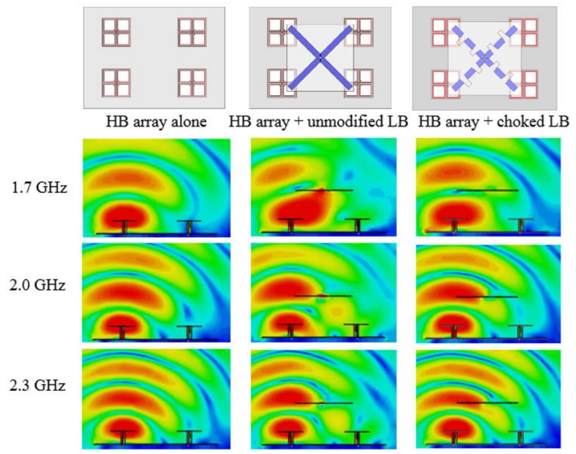

Fig. 4. E-field cuts at the high band in the *xz*-plane under different circumstances.

The LB radiator is modified by introducing chokes which effectively divide the conductors of the LB elements into short sections. These chokes should present an open circuit at the HB and a short circuit at the LB. The equivalent circuit of the chokes is illustrated in Fig. 2(b). Each choke consists of a parallel resonant at the HB comprising L_1 and C_1, and a series resonance at the LB with two additional capacitances C_2. By optimizing the values of L_1, C_1, and C_2, one can obtain the desired open-circuit and short-circuit frequency points at the high and low bands, respectively.

Once the values of L_1, C_1, and C_2 are determined, the chokes are then implemented using conducting strip structures, as shown in Figs. 2(b) and 2(c). The thin conducting strip and the capacitance across the gap provide L_1 and C_1, respectively. C_2 is realized by overlapping a piece of metal at the back side of the substrate with the dipole arm at the front side of the substrate. The dimensions are optimized considering three criteria, i.e., to maximize the HB suppression, to minimize the negative effect on the LB current, and to guarantee impedance matching. The optimized dimensions are presented in Fig. 2(b) and the substrate has a dielectric constant of 4.4, a loss tangent of 0.0025, and a thickness of 1.0 mm.

III. Results and Discussion

Despite the fact that the inserted chocks in the LB antenna make the impedance matching more difficult, the LB antenna is successfully matched across the band from 0.82 to 0.96 GHz using the filter-based matching technique [7-8], as shown in Fig. 3(a). Moreover, the radiation patterns of the modified LB antenna shown in Figs. 3(b) and 3(c) demonstrate that the chokes have little negative effect on the radiation pattern. However, it should be noted that the inserted chokes lead to a slight gain reduction.

To examine the effectiveness of the filtering antenna in suppressing the HB scattering, as shown in Fig. 4, a comparison of the E-fields in the horizontal plane is made between three cases, i.e., (i) HB array only; (ii) HB array with unaltered LB element; (iii) HB array with choked LB element. It is observed that the HB radiation patterns in the presence of choked LB element are almost the same as those of HB array alone, demonstrating the effectiveness of the filtering antenna in reducing HB pattern distortion across the band.

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