Compact High Gain Dual-Band Dual-Polarized Base Station Antenna

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Abstract—This paper presents a compact ±45° dual-band dual-polarized base station antenna. The lower band element is composed of two layer of patches. The upper layer patch provides a boresight radiation null in its higher band-edge for reducing the mutual coupling with higher band element. The higher band element is made up of 4 dipole antennas around the patch antenna. The balun feeding line of the dipole antenna is designed with a band-stop response in its lower band-edge by an open stub. In this way, compactness and high isolation can be obtained by the proposed dual-band filtering antenna unit. The proposed dual-band antenna is designed to fit the specification of DCS and WCDMA bands (1710-1880 MHz & 1920-2170 MHz for SWR<1.5). The overall width of the antenna is only 140 mm. The antenna gains are over 8.6 dBi; and the 3-dB beamwidths of the horizontal radiation patterns are 60°-69°. The cross-polarizations are all lower than -20 dB, and the front-to-back ratios are more than 25 dB. Without extra filtering circuit, an isolation between the two bands is 15 dB, and the isolations between the two polarizations can reach 30dB.

Index Terms—Filtering antenna, compactness, dual polarization, high isolation.

I. INTRODUCTION

In multi-band array designs, two typical methods have been employed. One approach is to use diplexers in cascade with a full-band antenna array to realize dual-band performance. Due to the design difficulty and complexity of diplexers for the two bands that are so close, the cost will be expensive. Moreover, the feed network is more complex and the array is heavy. The other approach is to use two sub-arrays placed side-by-side. Mutual coupling which has an effect on the isolation and radiation pattern is strong because of that the two bands are close. Although increasing the separation of antenna elements can reduce mutual coupling, the array becomes bulky.

Recently, without the decoupling network, stable radiation pattern was obtained with the filtering elements [1] using the array structure. However, dual polarization cannot be realized and the size is still large. To solve these problem, compact dual band and dual polarized antenna arrays were proposed in [2]-[5]. Although the size reducing and stable radiation pattern were achieved in this way, the two operating band should be far from each other, i.e., 820-960 MHz and 1710-2170 MHz. Due to existing serious mutual coupling, these designs becomes inapplicable when the two operating bands are close.

In this paper, a dual band and dual polarized antenna array embedded in a line with small frequency ratio is investigated. The proposed antenna array is composed of a patch antenna operating at 1710-1880 MHz and four dipole antennas at 1920-2170 MHz which are placed around the patch. The proposed patch antenna can provide a radiation null in its higher band-edge, while the dipole antenna can generate a radiation null in its lower band-edge. As a result, mutual coupling between two bands can be reduced and the port isolation is improved.

II. ANTENNA CONFIGURATION

Fig. 1 illustrates configuration of the proposed dual-band filtering antenna unit. It consists of a patch antenna operating at 1710-1880 MHz and four dipole antennas at 1920-2170 MHz which are placed around the patch. The five baseboards below the ground are for fixing the structure and connecting the coaxial cable. These baseboards have the same permittivity of $\varepsilon_r = 3.3$, a thickness of $t = 1.524$ mm. Hport1 and Hport3 are fed with the same amplitude and phase for realizing the $-45^\circ$ polarization, while the Hport2 and Hport4 are for $+45^\circ$ polarization. Similarly, in Fig. 1(b), Lport1 and Lport3 are fed with the same amplitude but differential phase for realizing the
-45° polarization, while the Lport2 and Lport4 are for +45° polarization. The metal walls with different heights (HG1 and HG2) around the ground are used for optimizing the front-to-back ratio and cross-polarization. The distance D between two dipoles in the same polarization is related to the beamwidth for HB element. According to the array synthesis theory [6], the smaller D is, the wider the beamwidth.

III. SIMULATED AND MEASURED RESULTS

Fig. 2 shows simulated reflection coefficients and isolation for the two bands of the proposed dual-band dual-polarized antenna. It can be seen from Fig. 2(a) that the reflection coefficients of |S11| < -15 dB for the two bands and two polarizations can be obtained. And the polarization isolations are lower than 30 dB. The isolations in different bands are shown in Fig. 2(b), two zeroes are found in the curves because of the filtering performance provided by the proposed filtering antennas. As a result, good isolations is achieved. With reference to the gain curves in Fig. 3, a quasi-elliptic filtering response has been achieved. The average gain within passband is ~9 dBi, and the out-of-band suppression level can reach 15 dB in the other operating band. High selectivity is obtained by two radiation nulls found at 1.85 GHz and 1.92 GHz, which are due to the balun feeding line and the stacked patch, respectively.

Fig. 4 shows the radiation patterns for the two operating bands. As can be observed, stable broadside radiation characteristics are obtained across the two passband. The co-polarized field is at least 20 dB stronger than the cross-polarized counterpart. The front-to-back ratio is more than 23 dB. The 3-dB beamwidths of the horizontal radiation patterns are 60°-69°, which is suitable to the base station system.

IV. CONCLUSION

In this paper, a compact dual-band dual polarization antenna operating at DCS band (1710-1880 MHz) and WCDMA band (1920-2170 MHz) has been proposed. More than 30 dB polarization isolation has been obtained by the symmetrical feeding method. And isolation in the different bands of -15 dB can be realized by utilizing filtering antennas, which can greatly reduce the pressure of filter design. The width of the present array is only 140 mm, 53% smaller than that (290 mm) of the industry products using non-filtering antenna elements. The radiation patterns are all stable for the base station application.

REFERENCES
