Compact Multibeam Antenna Array Based on Generalized Joined Coupler Matrix Using Stripline Structure

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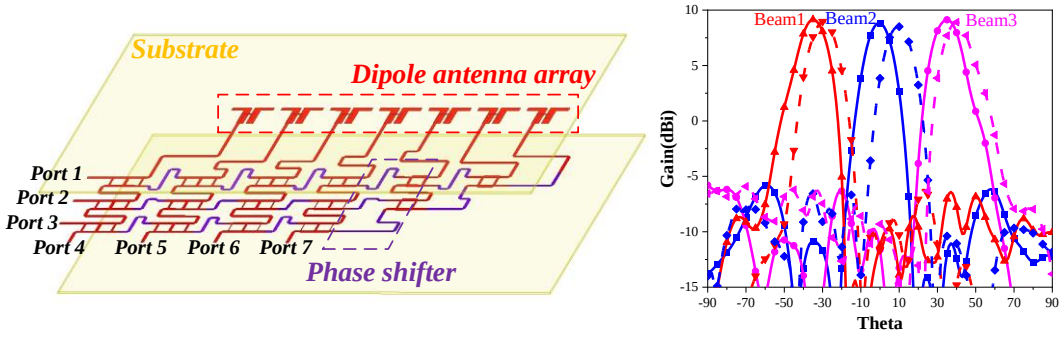
Space-based communication is becoming increasingly important in the current 5G landscape and the imminent arrival of the 6G mobile communication systems. They are expected to provide faster data transmission capabilities and expanded signal coverage. Multibeam feeding networks and antenna array play a crucial role in this system. Multibeam antennas (MBAs) and their associated beam-forming networks (BFNs) have a long history of research and industry development.

Various BFNs have been reported, including the Butler matrix [1], Nolen matrix [2] and Blass matrix [3]. Each of them comes with its advantages and disadvantages. For example, the Butler matrix requires additional crossovers, the Blass matrix incurs losses, and the Nolen matrix addresses these issues but exhibits mutual interference between beams. In [4], these challenges have been theoretically resolved, introducing a novel generalized joined coupler (GJC) matrix.

For the first time, an antenna array incorporating a 3x7 GJC matrix has been designed using a stripline structure, operating at a frequency of 12 GHz. Fig. 1(a) illustrates the structure of the antenna array integrated with the BFN, and beam steering can be achieved by changing the phase shift value of the phase shifters. A dipole antenna is selected as the unit of the antenna array, port 1 to port 3 are the input ports and port 4 to port 7 are supposed to connect the termination loads. Fig. 1(b) shows the beam directions before (solid line) and after (dash line) changing the phase shifters. The three beams correspond to directions of -35°, 0°, and 35° before steering, and -30°, 10°, and 40° after steering. The sidelobe levels (SLLs) for all beams are below -15 dB. The detailed results are listed in Table 1.



(a) (b)

Fig. 1: (a)3×7 MBA array based on GJC matrix layout; (b) Three steering beams before (solid line) and after (dash line) changing the phase shifters.

Table 1: Detailed results of the antenna array.

Beam direction (°)	-35	0	35	-30	10	40
Gain(dBi)	9.1	8.8	9.1	9.0	8.6	9
SLL(dB)	-17.6	-15.5	-15.3	-15.1	-15.2	-15.0

In this abstract, a novel MBA array based on a 3×7 GJC matrix using stripline is proposed. In order to achieve miniaturization so that this design can be integrated into satellites or handset devices, the BFN and antenna array are integrated together. Besides, for generating individually and independently controllable multiple beams, the GJC matrix design method is introduced, the beam can be tuned from -35°, 0°, and 35° to -30°, 10°, and 40° independently, which is a good candidate for space-terrestrial communication.

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[4] C. A. Guo and Y. J. Guo, "A General Approach for Synthesizing Multibeam Antenna Arrays Employing Generalized Joined Coupler Matrix," in *IEEE Transactions on Antennas and Propagation*, vol. 70, no. 9, pp. 7556-7564, Sept. 2022.