An Novel Ultra-Wideband Plane Wave Generator Antenna Array for OTA test

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Introduction

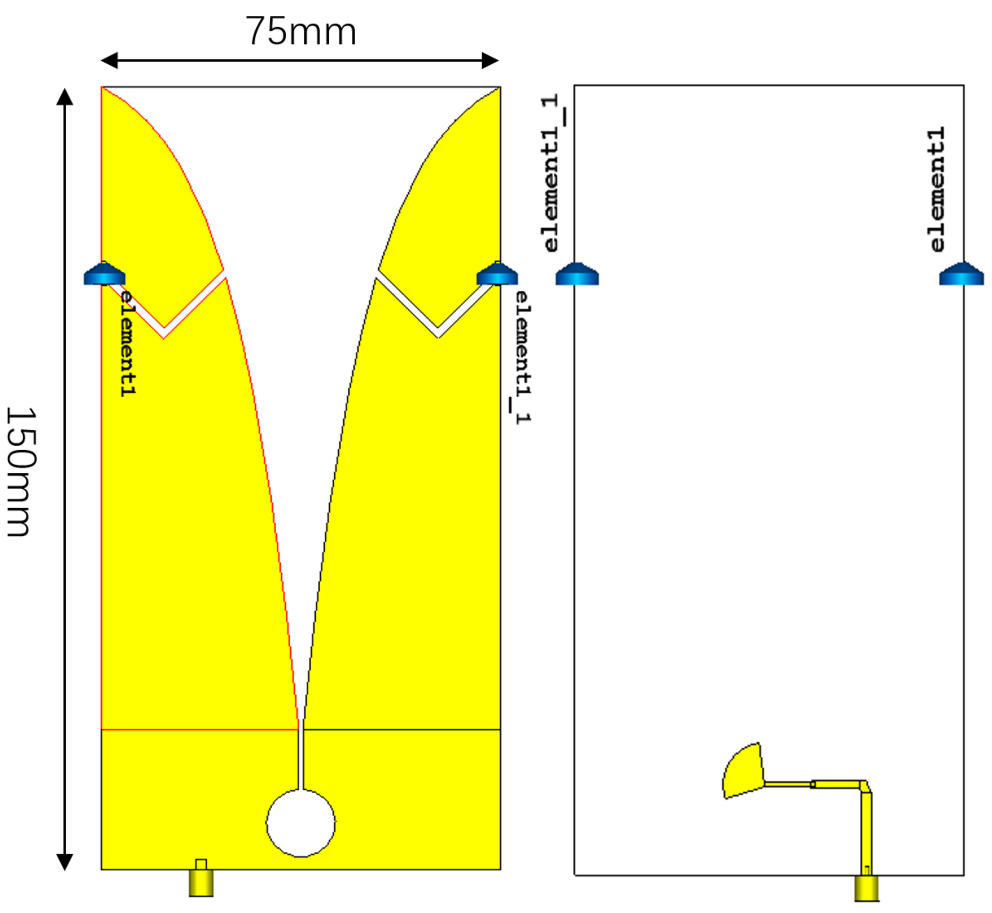
◆Due to the adoption of massive MIMO[1] technology and radio frequency front-end antenna integration technology, traditional conducted test cannot satisfy 5G equipment test requirement[2]. Over the air (OTA) test is a technique to solve the problem[3].

◆Plane wave generator(PWG) is a kind of phased array which can generate plane wave in near field.

◆This paper presents an ultra-wideband one-dimension plane wave generator (PWG) antenna array. Ten electrical small wideband Vivaldi antenna elements are employed. Both the coupling and environment effect are involved in the proposed plane wave excitations optimization method.

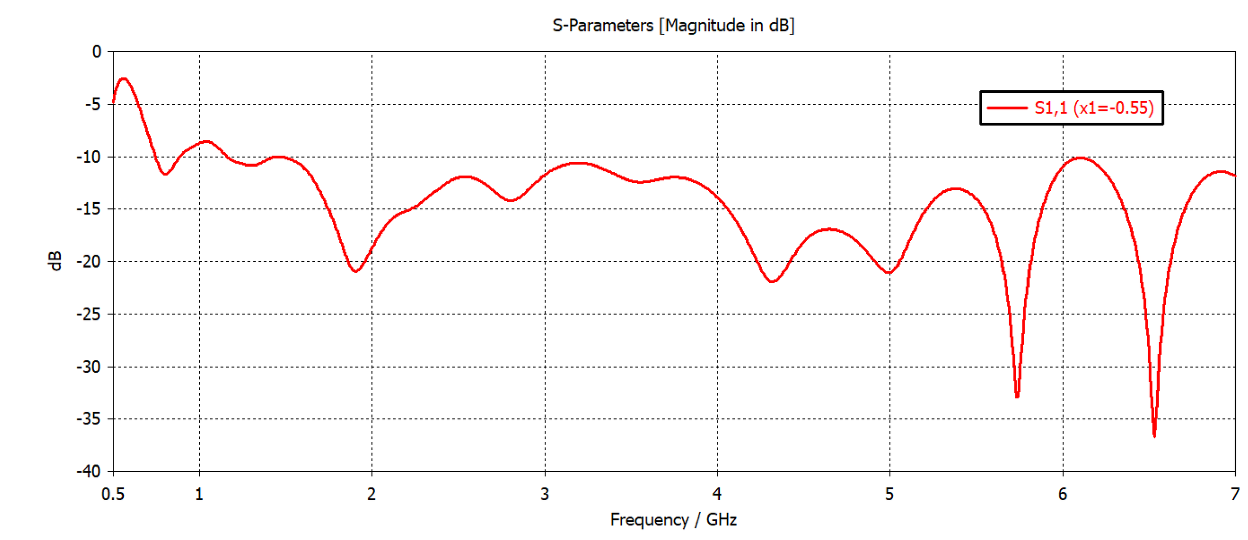
Design of Element and Array

A. Ultra-wideband Antenna Element



An ultra-wideband resistor loaded Vivaldi antenna is designed as the PWG antenna array element. A V-shaped groove is etched on the PCB close to the top of antenna. This design changes the current distribution of the antenna and decreases the VSWR of the antenna, so that the antenna can expand its working bandwidth to low frequency band.

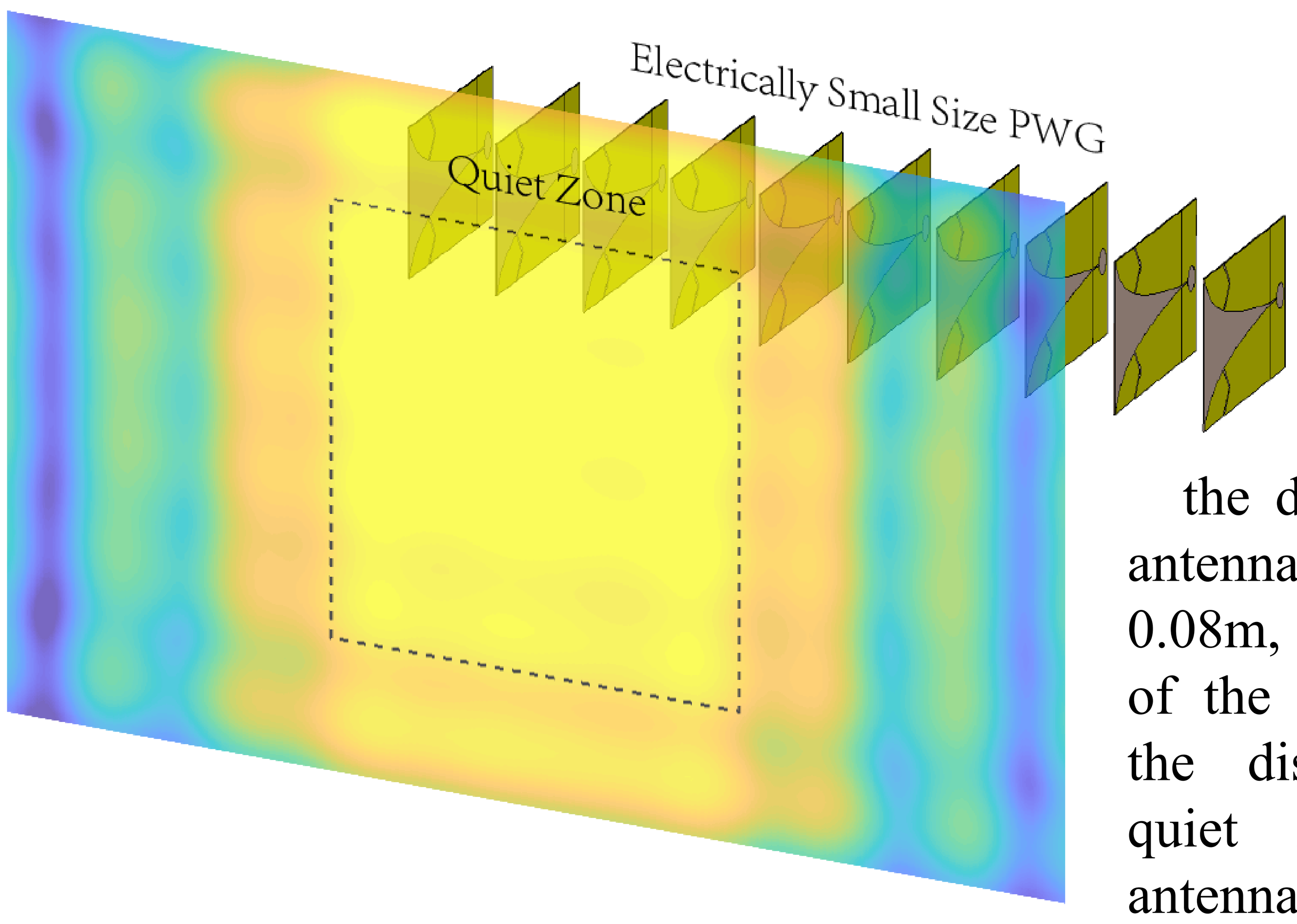
Fig. 1 Front and back view of ultra-wideband Vivaldi antenna



The -10dB bandwidth of the antenna covers 0.7GHz-7GHz. The gain of the antenna increases when frequency increasing.

Fig. 2 S parameter of Ultra-wideband Vivaldi antenna

B. Ultra-wideband Plane Wave Array



the distance between antenna elements is 0.08m, the total length of the array is 0.72m, the distance between quiet zone and the antenna aperture is 1m.

Fig. 3 Ultra-wideband plane wave array and quiet zone

There are 10 sampling points in the near field plane wave observation area, which symmetrically distribute at both sides of the quiet zone. The distance of each sampling point is 0.05m, and the total length of the quiet zone is 0.45m.

Novel Excitations Optimization Method

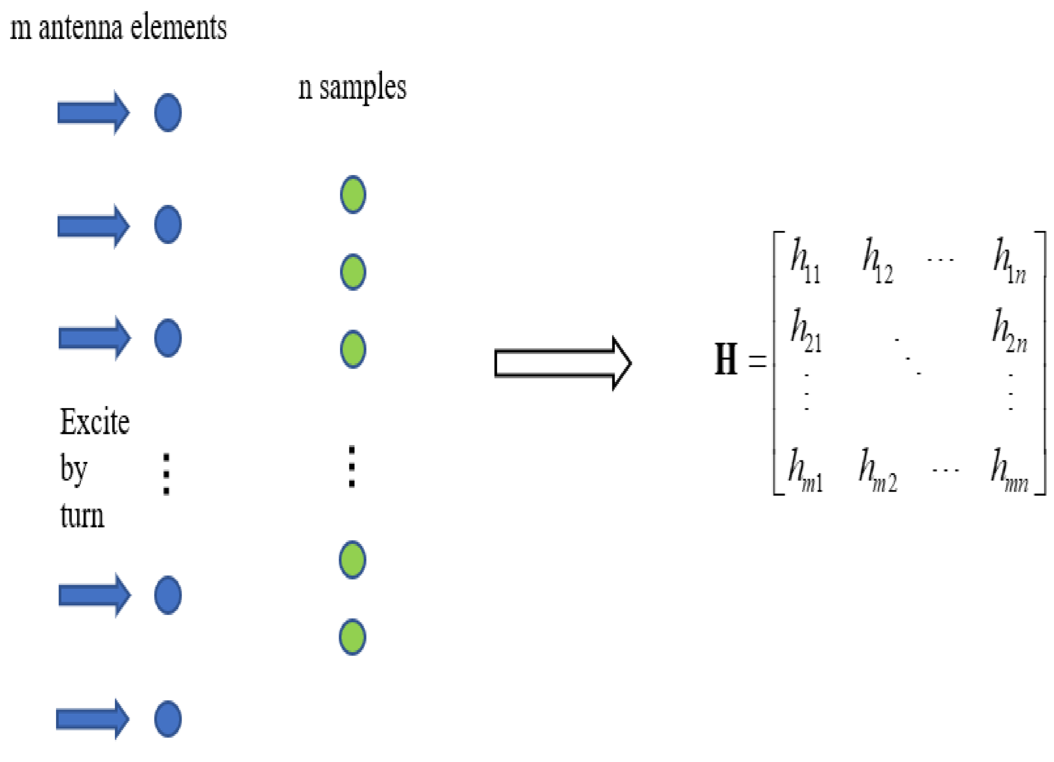


Fig.4 Extraction of transfer matrix

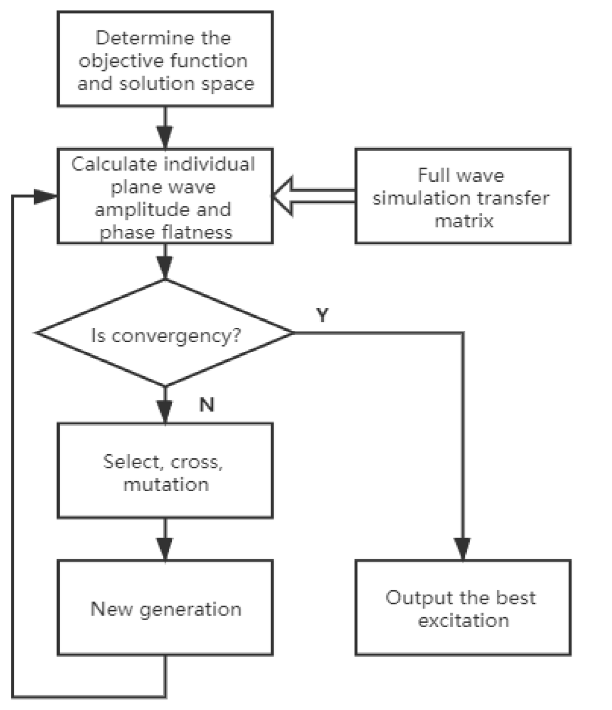


Fig. 5 Excitations optimization algorithm based on transfer matrix

As shown in Fig.4, excite every element by 0 amplitude and 0 phase and sample the electrical field in quiet zone then we can get the transfer matrix ***H*** which reflect the mutual coupling and other unideal factors. Finally genetic algorithm is used to get the best excitations amplitudes and phases.

Simulation, Measurement and Conclusion

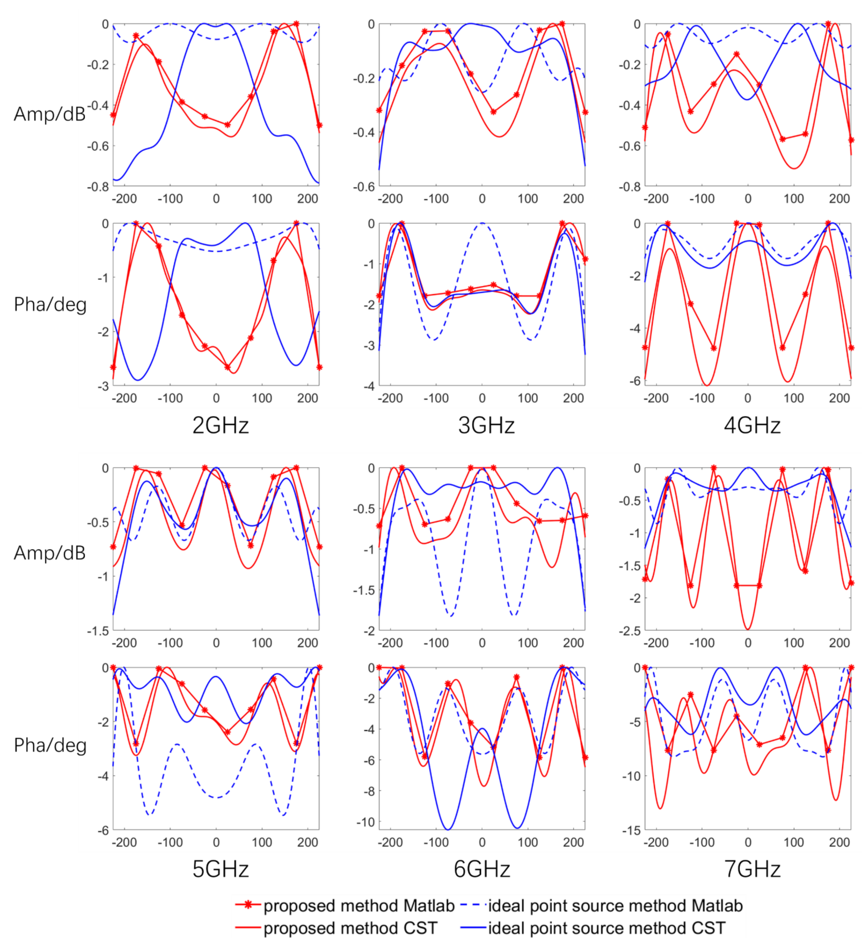


Fig. 6 Simulation results

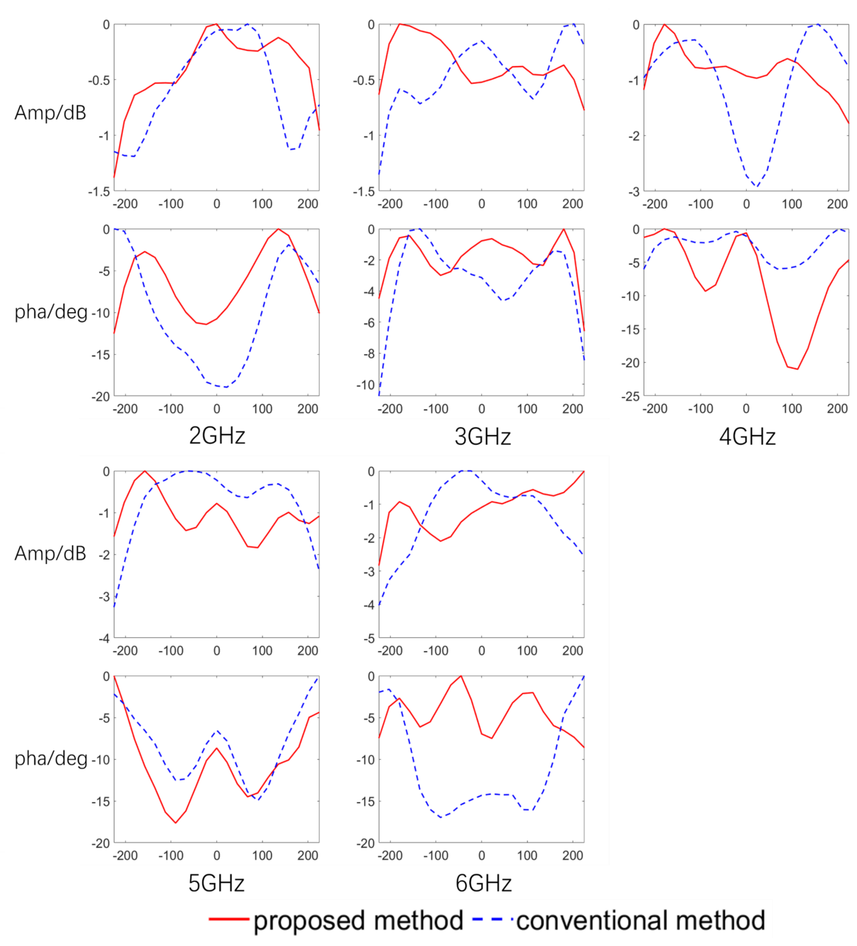


Fig.7 Measured results

TABLE I. COMPARISON OF PROPOSED METHOD AND CONVENTIONAL METHOD

	Proposed method		Conventional method	
	Amp variation	***Phase variation***	***Amp variation***	***Phase variation***
2GHz	±0.7dB	±6.5°	±0.6dB	±10°
3GHz	±0.4dB	±3.5°	±0.7dB	±5.5°
4GHz	±0.9dB	±10.5°	±1.5dB	±3°
5GHz	±0.95dB	±9°	±1.65dB	±7.5°
6GHz	±1.45dB	±4.4°	±2dB	±8.5°

The proposed method is superior to ideal point source method in most cases. The max amplitude variations of proposed method and conventional method are ±1.45dB and ±2dB respectively, the max phase variations of them are ±10.5° and ±10° respectively. In terms of the consistency between Matlab simulation results and CST simulation results, the proposed method is far superior to the ideal point source method.

Reference

[1] G. Gampala and C. J. Reddy, "Massive MIMO — Beyond 4G and a basis for 5G," in *2018 International Applied Computational Electromagnetics Society Symposium (ACES)*, 2018, pp. 1-2.

[2] W. Fan, P. Kyösti, L. Hentilä, and G. F. Pedersen, "MIMO Terminal Performance Evaluation With a Novel Wireless Cable Method," *IEEE Transactions on Antennas and Propagation,* vol. 65, no. 9, pp. 4803-4814, 2017.

[3] M. Gustafsson, T. Jämsä, and M. Högberg, "OTA methods for 5G BTS testing — Survey of potential approaches," in *2017 XXXIInd General Assembly and Scientific Symposium of the International Union of Radio Science (URSI GASS)*, 2017, pp. 1-4.