A Novel Monopulse Microstrip Antenna Array with Compound Feed Network

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Abstract— In this paper, a novel feed network design is presented, with which every microstrip line array of antenna is fed at the edge side with the middle of the row shorted and in E-plane the adjacent subarrays are fed with 180 degrees phase difference. This proposed feed network can suppress the near coupling problem in traditional monopulse microstrip antenna array design. Furthermore in order to minish the loss of substrate and microstrip feed line, a waveguide one-plane feed network and waveguide comparator are used, which is connected with every line array by SMA-waveguide connector. The simulated results have demonstrated that the -19 dB side-lobe level for the sum pattern and 32 dB null depth for the difference pattern have achieved.

1. INTRODUCTION

Microstrip structure has been developed for pulse antenna in monopulse radar system due to its lightweight low cost and convenient manufacture comparing with waveguide slot and Cassegrain parabolic antenna [1, 3].

The important function of monopulse antenna is to generate sum and difference beam, so the whole array plane is divided into four parts by two perpendicular symmetry axes every sub-array has own feed network in E and H-plane. For most monopulse microstrip antenna array in one layer, every line array is fed at the center side and E-plane feed network is placed between adjacent two patches of two sub-arrays [4], which may bring the significant near coupling between feed lines and sub-arrays, leading to deteriorate the side lobe and lower the efficiency of antenna to 20%. Pozar [5] mentioned that the sidelobe level and efficiency would be limited when the feed network and antenna elements were printed on eliminate the same substrate. Furthmore, the loss of substrate and microstrip feed line is unavoidable, which will significant reduce the gain especially in high frequency antenna with large aperture.

In this letter, a novel compound feed network of monopulse microstrip array is presented, in which the microstrip series line array is fed at the edge side with the middle of the row shorted in E-plane and the adjacent subarrays are fed with 180 degrees phase difference in H-plane. In order to minish the loss, a waveguide feed network in H-plane and waveguide comparator are all used,which connect with microstrip series line array by coaxial to waveguide adapter. The structure and simulated results of proposed array are presented as follow.

2. CONFIGURATION

The X-band monopulse microstrip antenna array as shown in Fig. 1 includes (1) microstrip radiator array divided into four sub-arrays; (2) the waveguide H-plane feed network, which is connected with every microstrip line array by coaxial to waveguide adapter respectively; (3) the waveguide comparator with four inputs connected to every sub-array and four outputs connected to the sum, H-plane difference, E-plane difference and matching load respectively. As shown in Fig. 1, in E-plane the adjacent subarrays are fed with 180 degrees phase difference. This proposed feed method can suppress higher order modes and decrease cross-polarization.

Every series line array is fed at the edge side with the middle of the row shorted as shown in Fig. 2. Due to the introduction of a shorted pin, there is a branch added to achieve good impedance match, the length and width of the branch are all important parameters in controlling the achievable bandwidth.

The distance between the shorted point and the adjacent patch is $\lambda_g/4$. The space between adjacent two patch which is designed to λ_g at center frequency, which will cause a discrepancy in gain between the higher and lower frequency.

The comparator is formed by using four 3 dB hybrid junctions which uses waveguide structure below the substrate in order to overcome the poor efficiency of microstrip line in high frequency.

The coaxial to waveguide adapter is shown in Fig. 3, the upside of the coaxial connector is connected with every line array, the underside of it is inside the waveguide below, which can be adjusted to be 100 Ω through changing the length of probe inside the waveguide.

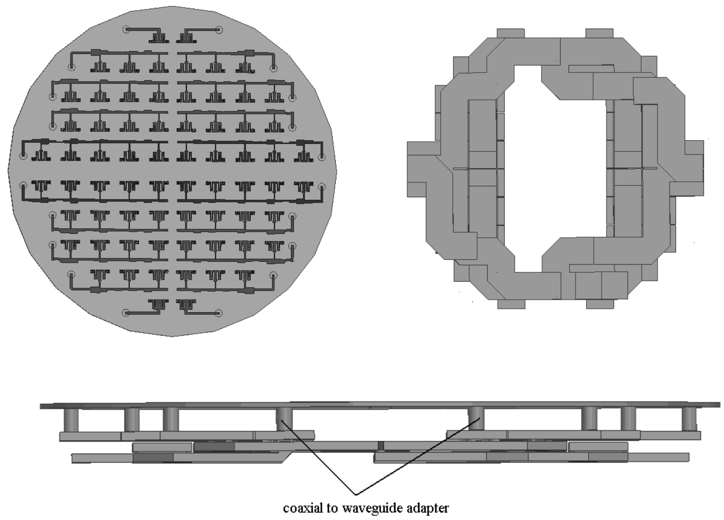


Figure 1: Structure of side feed monopulse antenna array.

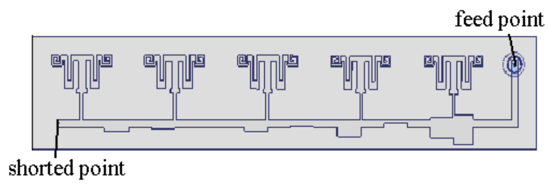


Figure 2: Structure of microstrip line array.

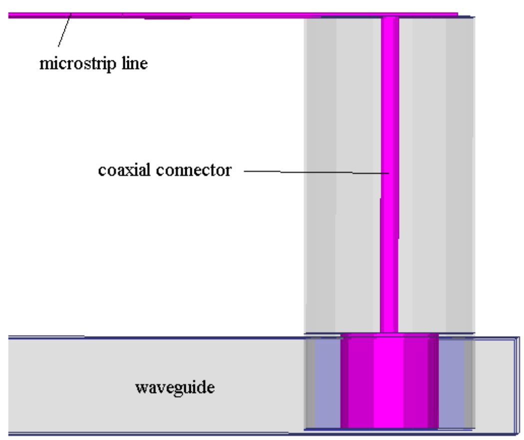


Figure 3: Coaxial to waveguide adapter.

3. SIMULATED RESULTS

In order to reduce the loss of substrate and microstrip line, the H-plane feed network use waveguide structure, which can accurate control the aperture excitation amplitude through changing the inclined angle of slots into the broad wall of waveguide.

The simulated amplitude distribution of H-plane feed network keeps constant basically during the operating band as shown in Fig. 4, which ensures the sidelobe levels of sum pattern stable between low frequency and high frequency.

The simulated vswr of comparator is less than 1.4 : 1 during the operating band as shown in Fig. 5.

The simulated maximum gain at center frequency is 23 dB as shown in Fig. 6, both for the

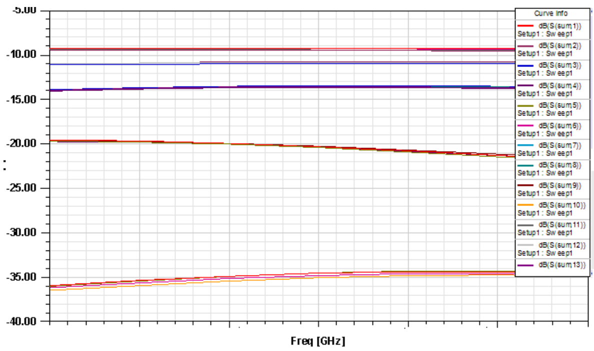


Figure 4: Simulated amplitude distribution of H-plane feed network.

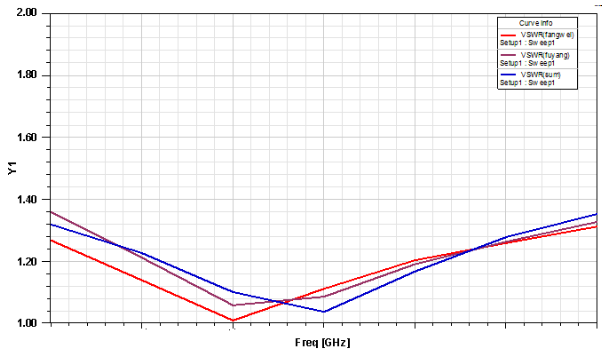
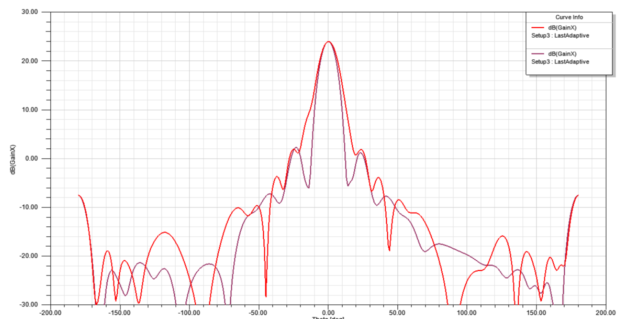
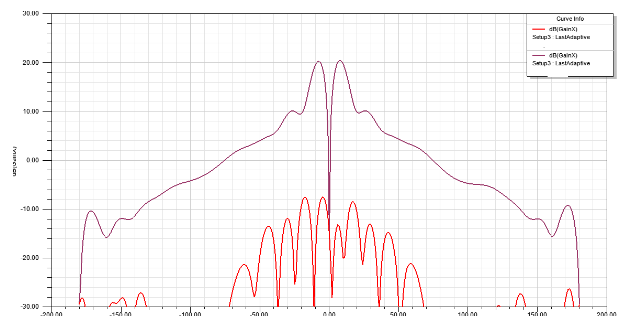


Figure 5: Simulated vswr curve of comparator.



(a)

(b)



(c)

Figure 6: Simulated sum and difference patterns at center frequency. (a) Simulated sum patterns. (b) Simulated difference patterns in E-plane. (c) Simulated difference in patterns H-plane.

E-plane and for the H-plane the sidelobe levels of sum pattern are less than -19 dB. The null depth of difference pattern are all below -32 dB. The efficiency of the array is 40%, which is almost similar with that of the conventional Cassegrain parabolic antennas antenna.

There will be about 2 dB deterioration between the simulated and measured sidelobe levels. The discrepancy is due to the introduction of coaxial to waveguide adapter which inducts about 15 degree phase unbalance among microstrip line arrays in H-plane.

4. CONCLUSION

A novel compound feed network design is presented, which can solve the near coupling problem in traditional monopulse microstrip antenna array design and minish the loss of substrate and microstrip line. The SMA-waveguide adapter is used to connect the microstrip line array with waveguide one-plane feed network and waveguide comparator. With this new compound feed network, a monopulse microstrip array has been designed in this paper. The -19 dB side-lobe level for the sum pattern and -32 dB null depth for the difference pattern have achieved in the simulation at center frequency.

ACKNOWLEDGMENT

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