2-1 D2 MUTUAL COUPLING OF E-PLANE SLOT ARRAY AND COMPENSATION METHOD OF THAT EFFECTS ON RADIATION PATTERNS

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Introduction

It is easy to calculate the field distribution factor which yields the desired radiation pattern. However, it is difficult to realize it in phased arrays, because there is a mutual coupling between element antennas. So it is essential to study the mutual coupling and how to compensate that effects.

Here, first, we obtain a theory to calculate the mutual coupling of E-plane slot antennas which are cut in a finite conductor plane and feeded with waveguides.

Next, using above knowledge of the mutual coupling, we can obtain the incident field distribution factor which gives the desired field distribution factor on array elements. It is simple to adjust precisely the incident field distribution factor, since this has no relation to the mutual coupling. Thus we can perform desired radiation patterns.

Mutual Coupling of E-plane Slot Antennas

A coupled field is assumed to be the scattered field of a coupled antenna, which is produced by the current [Hxn] with the coupled antenna absent. The coupled electric field is given as follows,

$$E_c = \frac{H_i}{Y_s + Y_d} , \qquad (1)$$

where Y_s is a admittance of a slot antenna and Y_d is a load admittance.

By definition, the mutual coupling is expressed as follows,

$$E_c\big|_{Y_s = Y_d} = \frac{H_i}{2Y_s} , \qquad (2)$$

Then, the problem is converted to obtain the incident magnetic field H_i, which is produced by a excited antenna without a coupled antenna.

This field on a finite conductor plane is superposition of radiation fields produced by a excited antenna in conductor wedges whose apex is at 1 and w-1 from the excited antenna. That is, the incident magnetic field is given as follows,

$$H_i(1) = H_s(1) + H_s(w-1) - 2H_o , \qquad (3)$$

where

$$H_s(1) = \frac{E_e a' b' \omega \varepsilon}{j\,\ell(\pi-\alpha)} \sqrt{\frac{k}{2\pi j|\rho-\ell|}} \sum_{v} \varepsilon_v J_v(k\ell) \cdot H_v^{(2)}(k\rho) \cos v(\phi'-\alpha) \cos v(\phi-\alpha) , \qquad (4)$$

$$2H_o = -\frac{E_e a' b' \omega \varepsilon}{j\pi} \sqrt{\frac{k}{2\pi j|\rho-\ell|}} H_0^{(2)}(k|\rho-\ell|) , \qquad (5)$$

(ρ, ϕ) is the position of a coupled antenna, $(1, \phi')$ is the position of a excited antenna, w is a width of a finite conductor plane, a' and b' are dimensions of the slot antenna, and 2α is wedge angle.

Fig. 1 shows the theoretical value and the experimental value of the mutual coupling of 20-element phased array.

Realization Method of Desired Radiation Pattern

Considering the mutual coupling,

the field distribution factor on element antenna [v] is given as follows,

$$[v]=[U+S][a] \quad , \qquad (6)$$

where [a] is a column matrix of the incident distribution factor, [S] is a scattering matrix of a phased array, whose diagonal elements are the reflection coefficients of elements and off-diagonal elements are the mutual coupling between elements, and [U] is a unit matrix.

The incident distribution factor represents the voltage amplitude of the incident travelling waves. This factor is uniquely determined by the power divider networks.

Thus, [a] is obtained as follows,

$$[a]=[U+S]^{-1}[v] \quad , \qquad (7)$$

When the distribution factor is known from a radiation pattern synthesis method, we can obtain the incident field distribution factor by equation (7).

Fig. 2 shows the experimental radiation pattern of sector pattern with -34 dB side lobe level.[1]

Conclusion

A theoretical expression for the mutual coupling of E-plane slot antenna in a finite conductor plane is obtained.

Good agreement has been obtained between the measured and theoretical values of the coupling coefficients.

A theory to realize the desired radiation pattern of finite size phased array was derived by compensating the effects of mutual coupling on a desired radiation pattern.

An experimental confirmation of this theory has been obtained from the radiation pattern measurements of -34 dB sector pattern.

Acknowledgements

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Reference

1. T. Chiba, "On a Pattern Synthesis Method for a Linear Array," 1966 IEEE International Convention Record, Part 5, pp 172~179, 1966.

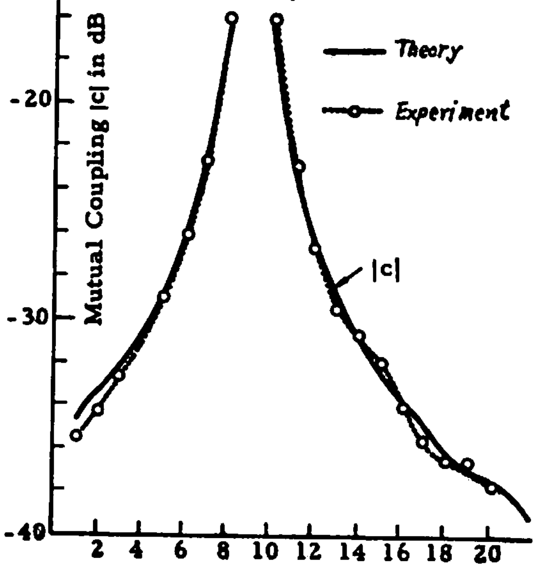

Fig. 1 Mutual Coupling of E-plane Slot Antenna

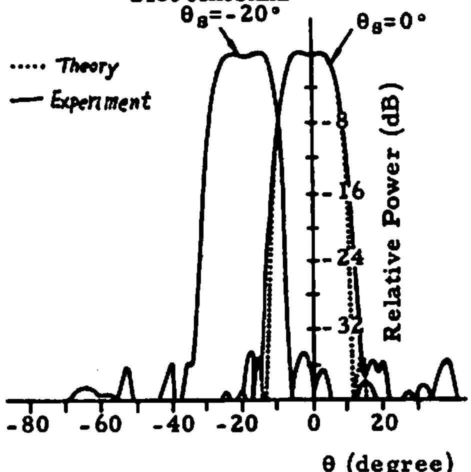

Fig.2 Theoretical and Experimental Radiation Patterns