MODULE SHARING DESIGN TECHNIQUE
FOR DUAL REFLECTOR ANTENNA

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Abstract  Module sharing technique for a dual reflector antenna is presented, which makes different apertured main reflectors of the same focus sharing one set of module by means of optimizing the subreflector. To optimize the subreflector, a fast convergence optimization method is given with a satisfactory result.

Key words  Antenna; Share; Optimization

I. Introduction

With the development and the popular use of satellite communication, needs for dual reflector antennas are increasing rapidly. How to reduce the cost and speed up the production is a practical problem that antenna engineering has to face. Since the production cost of the dual reflector is very high, especially for the main reflector module, which requires high precision. To solve the problem, sharing design is initiated, which is to use the same module to produce different apertured main reflectors of the same focus, and meanwhile to meet the given requirement for antenna efficiency.

As different main reflectors require different optimum subreflectors, sharing design is a time consuming task. To shorten the computing time, the mixing base optimization method is suggested. The base consisting of functions with different properties is called the mixing base. We construct a mathematical form that matches the object profile so that one can approach the physical model with the least terms, and thus make the module sharing technique realizable.

II. Computational Model

In Hilbert space, based on the Lorentz reciprocity theorem, an efficiency expression is obtained by means of physical optics approximation. It is

$$\eta = (J, J^*)$$

where

$$J = \iiint (E \times H) \cdot ds$$

$J^*$ is conjugation of $J$, $S$ subreflector illuminated by the electromagnetic wave, and $E$, the electric field in subreflector caused by a unit plane wave incident on the main reflector. In the condition of rotational symmetric main reflector, we have

$$E_1(r, \theta, \varphi) = f_1(r, \theta) \cos \varphi \hat{\theta} - f_2(r, \theta) \sin \varphi \hat{\phi} + f_3(r, \theta) \cos \varphi \hat{r}$$

(3)
where \( f_1(r, \theta), f_2(r, \theta), f_3(r, \theta) \) can be got by the spherical wave expansion method\(^{[2]}\).

\( (r, \theta, \varphi) \) is the point on the subreflector with origin at the main reflector focus.

\( H_i \) is the magnetic field on the subreflector caused by unit transmission power of feed

\[
H_i(r', \theta', \varphi') = g_1(r', \theta') \sin \varphi \, \hat{\varphi} + \cos \varphi \, \hat{\varphi},
\]

where \( (r', \theta', \varphi') \) is the point on the subreflector with origin at the feed phase center;

\( g_1(r', \theta'), g_2(r', \theta') \) are determined by the feed.

Thus we get

\[
J = -\pi \int_0^{\theta_s} \left( \left\{ f_2(r, \theta) g_1(r, \theta) \left[ \cos(\theta + \theta') + \sin(\theta + \theta') \right] \frac{1}{r} \frac{dr}{d\theta} \right\} r^2 \sin \theta \right)_{r_0}^{r} d\theta
\]

where \( \theta_s \) is the half flare angle from the main reflector focus to the subreflector edge, \( r = r(\theta) \) is the generating line equation of subreflector.

### III. The Mathematical Model and Method of Sharing Design

We rewrite Eq. (5) as

\[
J = \int_0^{\theta_s} F(\theta, D(\theta), r(\theta), r'(\theta)) d\theta
\]

Assume that the shape of the main reflector is a rotational symmetric parabolic one with focus \( f \), and initial shape of the subreflector is a hyperbolic one. Under the condition given above, the sharing design problem of main reflector module is realized through optimizing the subreflector to match the reflector. The problem can be expressed as follows:

\[
\{ \max B(D) \}_n = (J, J'), J = J(\theta, D), D(\theta) > 0, \eta \geq \eta_0
\]

where \( B(D) \) is the main reflector module aperture sharing interval under a specified focus; \( D = D(\theta) \) is the aperture equation of the main reflector; \( \eta_0 \) is the required antenna efficiency.

### IV. Calculation Process

It is a time consuming task to solve Eq. (7). In order to shorten the optimization time, the mixing base is initiated and a two-stage optimization is used; the calcula-