NASA Technical Memorandum 89920

Detection of Reflector Surface Error From Near-Field Data: Effect of Edge Diffracted Field

Alan R. Cherrette and Shong W. Lee
University of Illinois at Urbana-Champaign
Urbana, Illinois

and

Roberto J. Acosta
Lewis Research Center
Cleveland, Ohio

Prepared for the
1987 AP-S International Symposium
sponsored by the Institute of Electrical and Electronics Engineers
Blacksburg, Virginia, June 15-17, 1987

(NASA-TM-89920) DETECTION OF REFLECTOR SURFACE ERROR FROM NEAR-FIELD DATA: EFFECT OF EDGE DIFFRACTED FIELD (NASA) 6 p N87-22874
Avail: NTIS HC A02/MF A01 CSCL 20N 63/32 Unclas 0074233

NASA

DETECTION OF REFLECTOR SURFACE ERROR FROM NEAR-FIELD DATA:
EFFECT OF EDGE DIFFRACTED FIELD

Alan R. Cherrette, Shong W. Lee
Electromagnetics Laboratory
Dept. of Elec. and Comp. Engr.
Univ. of Illinois at Urbana-Champaign
Urbana, Illinois 61801

Roberto J. Acosta
National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio 44135

Introduction

The surface accuracy of large reflector antennas must be maintained within certain tolerances if high gain/low sidelobe performance is to be achieved. Thus, the measurement of the surface profile is an important part of the quality control procedure when constructing antennas of this type. An efficient method for surface profile measurement has been proposed by Parini et al. [1]. In this method, the reflector surface is calculated from the measured near-field phase data using the theory of geometric optics.

For a surface profile calculation of this kind, it is necessary to know the margin of error built into the method of calculation. This will enable a specification of the tolerance to which the surface profile can be determined. When calculating the surface profile from near-field phase data, there are two main sources of error. The first source of error is the measurement error in near-field phase data. The second source of error arises from the edge diffracted fields that are superimposed on the reflected fields in the measured near-field data. In this paper, we will examine the error in the calculated surface profile produced by the edge diffracted fields.

Theory and Calculated Results

The measured near-field amplitude and phase distribution consists of two parts in the high frequency limit: the reflected fields and the edge diffracted fields. If the edge diffracted fields are neglected, the reflector surface can be determined from the reflected fields in the following manner. Consider the geometry of Figure 1, if one reflection point, A, on the reflector surface is assumed to be known, then the length D is known and given by

$$D = |\vec{FA}| + |\vec{AA}_a| \tag{1}$$

For any other point P on the reflector surface

$$D' = |\vec{FP}| + |\vec{PP}_a| = \left[x^2 + y^2 + (z-f)^2\right]^{1/2} + \left[(x-x_a)^2 + (y-y_a)^2 + (z-z_a)^2\right]^{1/2} \tag{2}$$

If $\theta(P_a)$ is the phase measured at point P_a in the aperture and $\theta(A_a)$ is the phase measured at point A_a, then the following relation holds

$$D' = \frac{-1}{k}\left[\theta(P_a) - \theta(A_a)\right] + D \quad \text{where } k = \frac{2\pi}{\lambda} \tag{3}$$

Note that from the phase data, we also know the equations of the line passing through the points P and P_a

$$\frac{(x-x_a)}{m_x} = \frac{(z-z_a)}{m_z} \tag{4}$$

$$\frac{(y-y_a)}{m_y} = \frac{(z-z_a)}{m_z} \tag{5}$$

where $m_x = \frac{1}{k}\frac{\partial\theta}{\partial x}\Big|_{P_a}$

$$m_y = \frac{1}{k}\frac{\partial\theta}{\partial y}\Big|_{P_a}$$

$$m_z = \left[1 - m_x^2 - m_y^2\right]^{1/2}$$

Equations (3), (4), and (5) can be solved for the three unknowns x, y, and z yielding a point on the reflector surface.

In any near-field measurement, the diffracted fields are always present and will produce an error in the calculated surface values. To determine this error, the reflected and edge diffracted fields of a reflector antenna (Figure 2) with known distortion (Figure 3) were calculated at 30 GHz. The estimated reflector surface calculated by the method outlined above was then compared to the exact reflector surface. The difference is plotted in Figure 4. The dot shows the largest value of error in the estimated surface and corresponds to 2.79 mils. The rms error for this case is 0.968 mil. This result can be compared to the case where the edge diffracted fields are neglected when calculating the reflector surface (Figure 5). In this case the largest value of error in the estimated surface is 0.351 mil. The rms error is 0.118 mil. The error in this case is probably due to the error in parameter D of Equation (1).

Conclusion

The edge diffracted fields produce an error in the calculated surface profile that gets larger as the edge of the reflector is approached. This is due to the larger relative amplitude of the edge diffracted fields compared with that for the reflected fields near the edge of the near-field aperture. For a feed with approximately a 10 dB edge taper, operating at 30 GHz, the error in the surface calculation due to edge diffracted fields is less than 3 mils.

Reference

[1] C. G. Parini, A. K. K. Lau, and P. J. B. Clarricoats, "Reflector Antenna Surface Profile Tolerance Measurement by Ultrasound or Microwave Remote-Sensing," 1986 IEEE AP-S Symposium Digest, vol. 1, pp. 119-122.

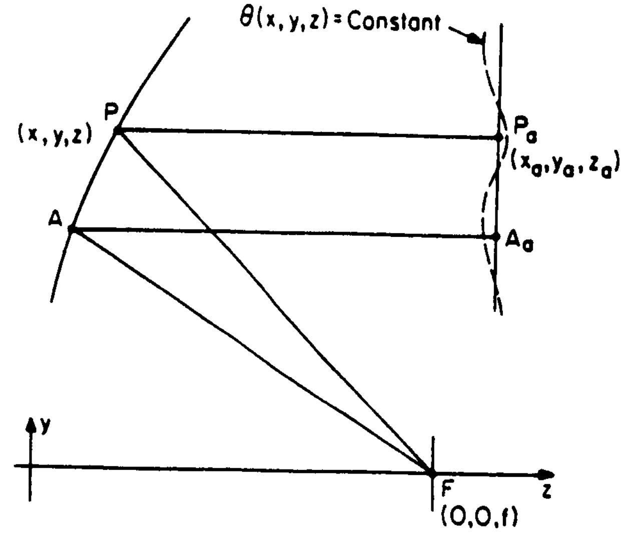

FIGURE 1. Geomrtry for Surface Calculation

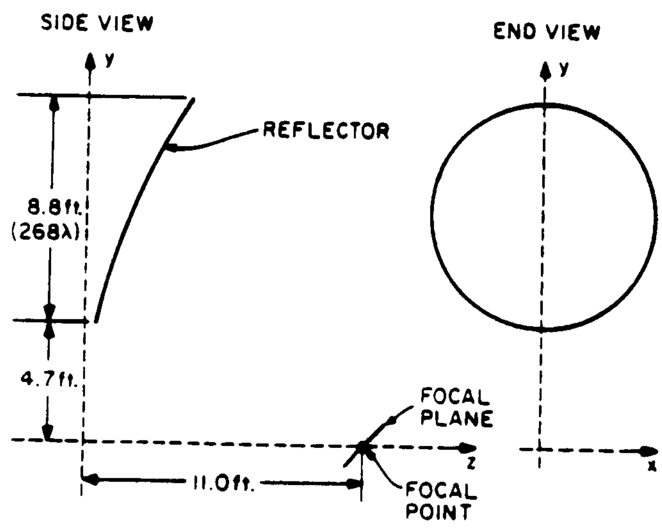

FIGURE 2. Reflector Geometry Used to Obtain the Numerical Results

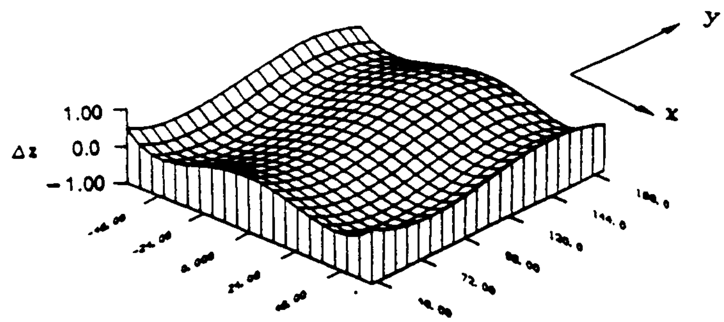

FIGURE 3. Distortion Function Superimposed on the Perfect Parabolic Reflector
(Height dimension in wavelengths @ 30 GHz, base dimension in inches)

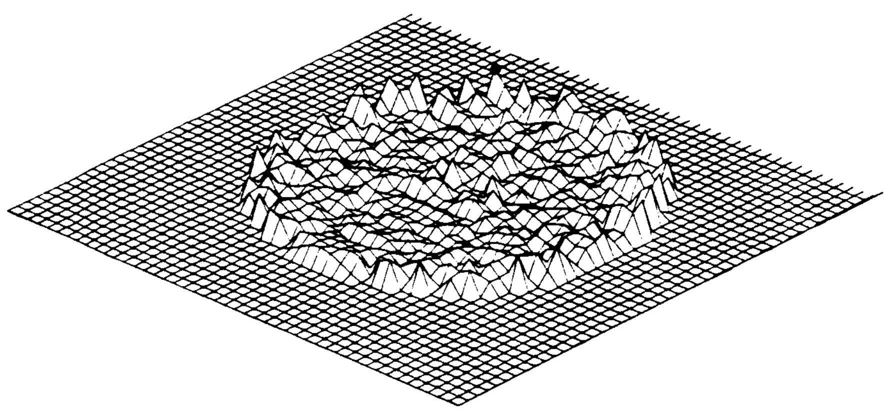

FIGURE 4. Error in the z-value of the Calculated Reflector Surface when Edge Diffracted Fields are Included

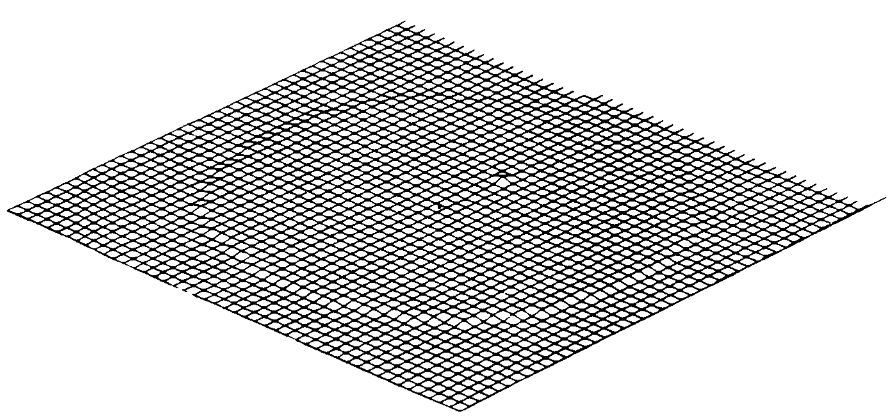

FIGURE 5. Error in the z-value of the Calculated Reflector Surface when Edge Diffracted Fields are Neglected

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM-89920		

4. Title and Subtitle	5. Report Date
Detection of Reflector Surface Error from Near-Field Data: Effect of Edge Diffracted Field	
	6. Performing Organization Code 506-58-22
7. Author(s) Alan R. Cherrette, Shong W. Lee, and Roberto J. Acosta	8. Performing Organization Report No. E-3616
	10. Work Unit No.
9. Performing Organization Name and Address National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio 44135	11. Contract or Grant No.
	13. Type of Report and Period Covered Technical Memorandum
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546	14. Sponsoring Agency Code

15. Supplementary Notes

Prepared for the 1987 AP-S International Symposium sponsored by the Institute of Electrical and Electronics Engineers, Blacksburg, Virginia, June 15-17, 1987. Alan R. Cherrette and Shong W. Lee, Electromagnetics Laboratory, Dept. of Elec. and Comp. Engr., Univ. of Illinois at Urbana-Champaign, Urbana, Illinois 61801; Roberto J. Acosta, NASA Lewis Research Center.

16. Abstract

The surface accuracy of large reflector antennas must be maintained within certain tolerances if high gain/low sidelobe performance is to be achieved. Thus, the measurement of the surface profile is an important part of the quality control procedure when constructing antennas of this type. An efficient method for surface profile measurement has been proposed by Parini et al. [1]. In this method, the reflector surface is calculated from the measured near-field phase data using the theory of geometric optics. For a surface profile calculation of this kind, it is necessary to know the margin of error built into the method of calculation. This will enable a specification of the tolerance to which the surface profile can be determined. When calculating the surface profile from near-field phase data, there are two main sources of error. The first source of error is the measurement error in near-field phase data. The second source of error arises from the edge diffracted fields that are superimposed on the reflected fields in the measured near-field data. In this paper, we will examine the error in the calculated surface profile produced by the edge diffracted fields.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Diffraction theory (GTD) Numerical analysis Antenna patterns	Unclassified - unlimited STAR Category 32

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of pages	22. Price*
Unclassified	Unclassified	5	A02

*For sale by the National Technical Information Service, Springfield, Virginia 22161