NASA Technical Memorandum 101458

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(NASA-TM-101458) ADAPTIVE FEED ARRAY COMPENSATION SYSTEM FOR REFLECTOR ANTENNA SURFACE DISTORTION (NASA) 7 p CSCL 20N

N89-17756

Unclas

G3/32 0188945

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Prepared for the
1989 IEEE AP-S International Symposium and
URSI Radio Science Meeting
San Jose, California, June 26-30, 1989

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INTRODUCTION

The feasibility of a closed loop adaptive feed array system for compensating reflector surface deformations has been investigated. The performance characteristics (gain, sidelobe level, pointing, etc.) of large communication antenna systems degrade as the reflector surface distorts mainly due to thermal effects from a varying solar flux. The compensating systems described in this report can be used to maintain the design performance characteristics independent of thermal effects on the reflector surface. The proposed compensating system employ the concept of conjugate field matching to adjust the feed array complex excitation coefficients.

GENERALIZED ADAPTIVE COMPENSATION SYSTEM

The feasibility of feed array compensation for reflector surface distortion has been extensively investigated [Refs. 1-6]. Basically there are two methods for obtaining the feed array complex excitation coefficients; namely the indirect conjugate field matching (ICFM) [Refs. 1-4] and the direct conjugate field matching (DCFM) [Refs. 5 and 6]. Graphical description of these two methods are presented in figures 1 and 2, respectively. These algorithms assume that the distorted reflector surface shape is known either in terms of a functional description or at discrete points. Some of the methods suggested to obtain the surface shape includes optical, photogrammetric, microwave holography, near-field measurement or other metrological techniques. For example, the near-field measurement technique [Ref.7] calculates the reflector surface shape from a measured near-field phase data. Figure 3 depicts a block diagram of a generalized adaptive compensation system, consisting of a detection and a compensation algorithm. The combination of these two algorithms provides a closed loop, on line control of the radiation performance of the antenna system in the presence solar radiation.

CONJUGATE FEED ARRAY

Detecting the shape of a distorted reflector may be a difficult task in the spacecraft environment. The concept of conjugate feed array (figure 4) can be employed to compensate for the degraded antenna performance without requiring surface point measurements. A block diagram representation of the concept is presented in figure 5. This compensating system can be described as follows: a pilot signal sent from the ground terminal is received by the spacecraft antenna and is detected by the conjugate feed array. The conjugate feed array acquires the amplitude and phase information at each element location, and their conjugate value serves as the transmitting compensating excitations. This is essentially the concept of conjugate field matching. If dipole sources are used as array elements the system can potentially compensate for pointing error and directivity loss. To control the sidelobe level (to a limited extend), the feed element pattern is designed to provide a correct taper of illumination on the reflector. To demonstrate this concept a simulated distorted reflector case is presented with several element patterns.

RESULTS

A simulated sinusoidal distortion (peak distortion of 0.25λ) was superimposed into an offset parabolic reflector configuration (figure 6). A hexagonal feed array of 37 elements (spacing = 1λ) was used in the simulation. Based on this configuration, numerical studies were conducted with different feed element patterns, and the results are shown in figures 7a-d. The array element pattern provided a limited control on the sidelobe level. In general the required undistorted sidelobe level is known and the corresponding feed element pattern can be selected accordingly. The most important feature of this compensating system is that it does not require the reflector surface shape to be known. The pilot signal from the ground need not be active all the time, since it is only needed at times when the distortions have changed appreciably. Above results indicate that the conjugate feed array concept will provide a closed loop adaptive control for the radiation performance of the antenna system. An experimental system prototype is being developed and will be used to verify the concept.

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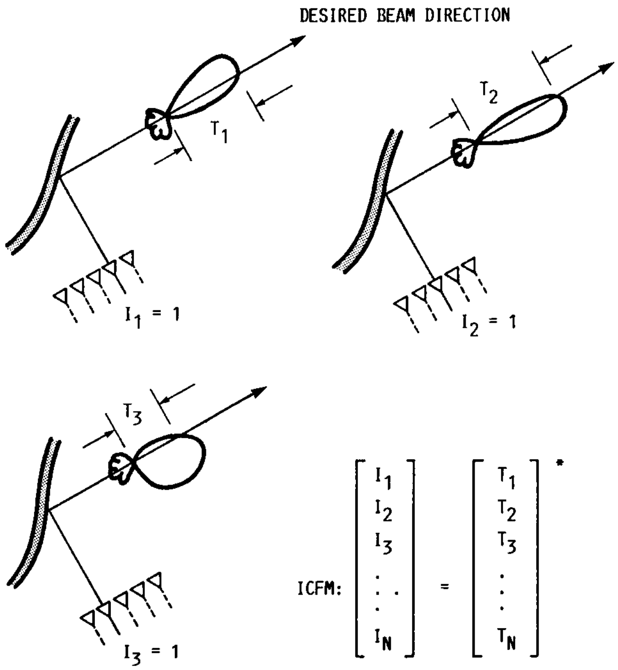
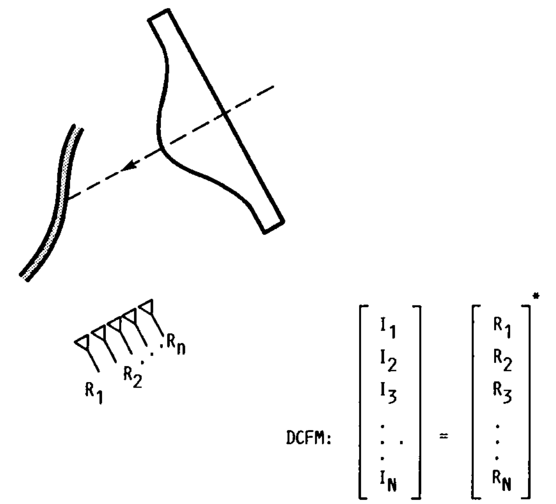


$$\text{ICFM: } \begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ \vdots \\ I_N \end{bmatrix} = \begin{bmatrix} T_1 \\ T_2 \\ T_3 \\ \vdots \\ T_N \end{bmatrix}^*$$

FIGURE 1. - ILLUSTRATION OF INDIRECT CONJUGATE FIELD MATCHING (ICFM) TECHNIQUE.



$$\text{DCFM: } \begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ \vdots \\ I_N \end{bmatrix} = \begin{bmatrix} R_1 \\ R_2 \\ R_3 \\ \vdots \\ R_N \end{bmatrix}^*$$

FIGURE 2. - ILLUSTRATION OF DIRECT CONJUGATE FIELD MATCHING (DCFM) TECHNIQUE.

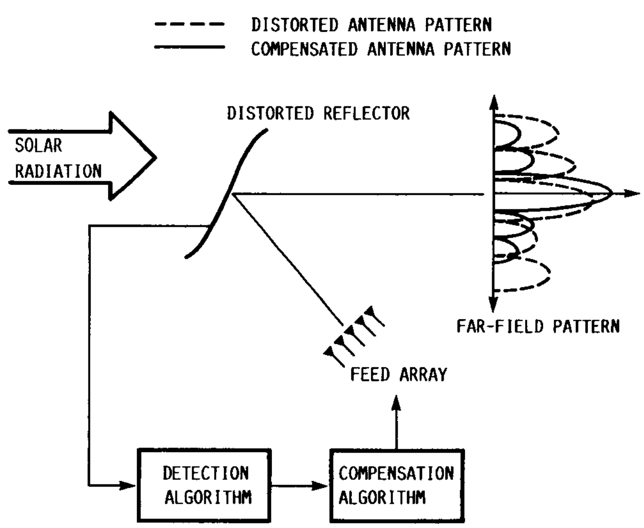


FIGURE 3. - BLOCK DIAGRAM OF A GENERALIZED ADAPTIVE COMPENSATION SYSTEM.

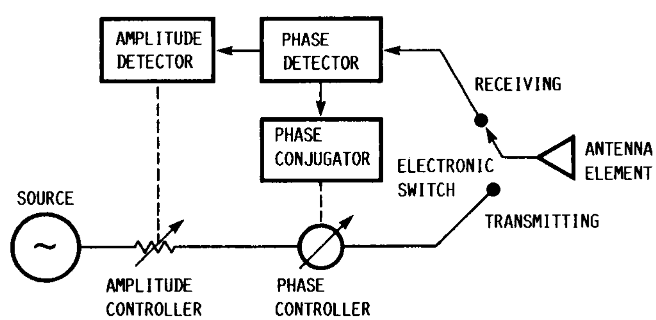


FIGURE 4. - TYPICAL CONJUGATE ARRAY ELEMENT.

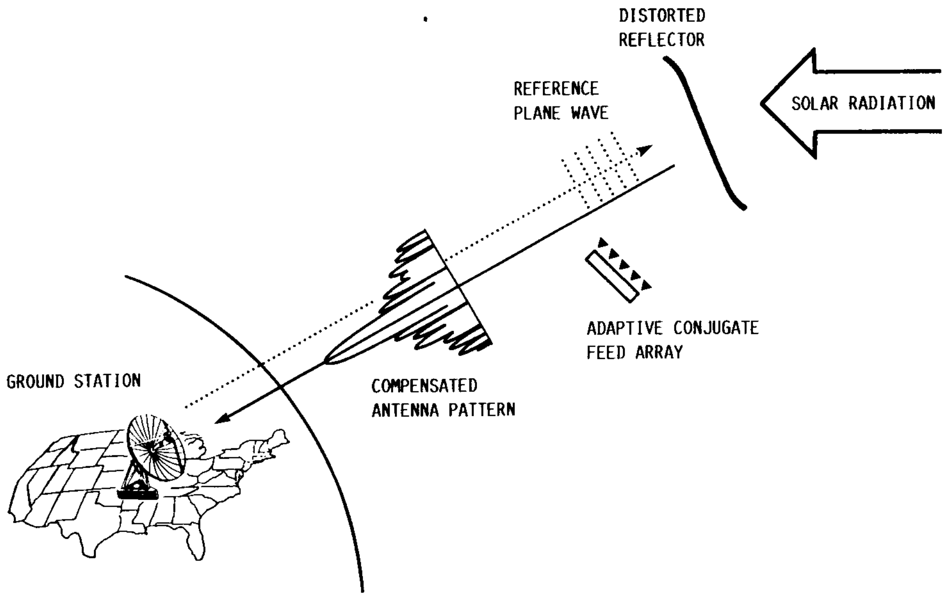


FIGURE 5. - ILLUSTRATION OF THE CONJUGATE ARRAY FEED COMPENSATION SYSTEM.

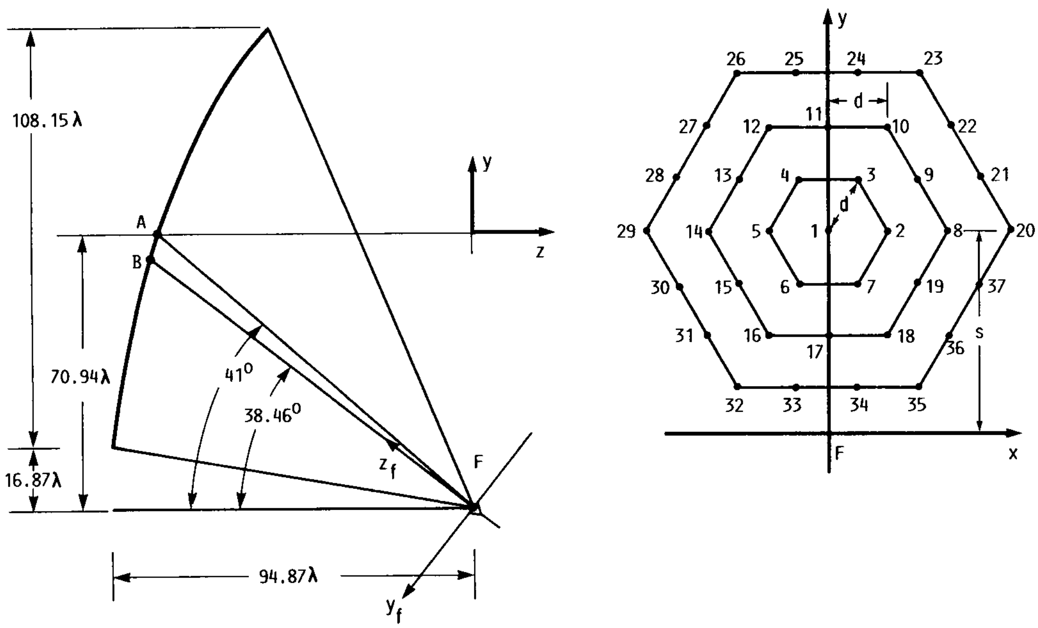


FIGURE 6. - REFLECTOR GEOMETRY.

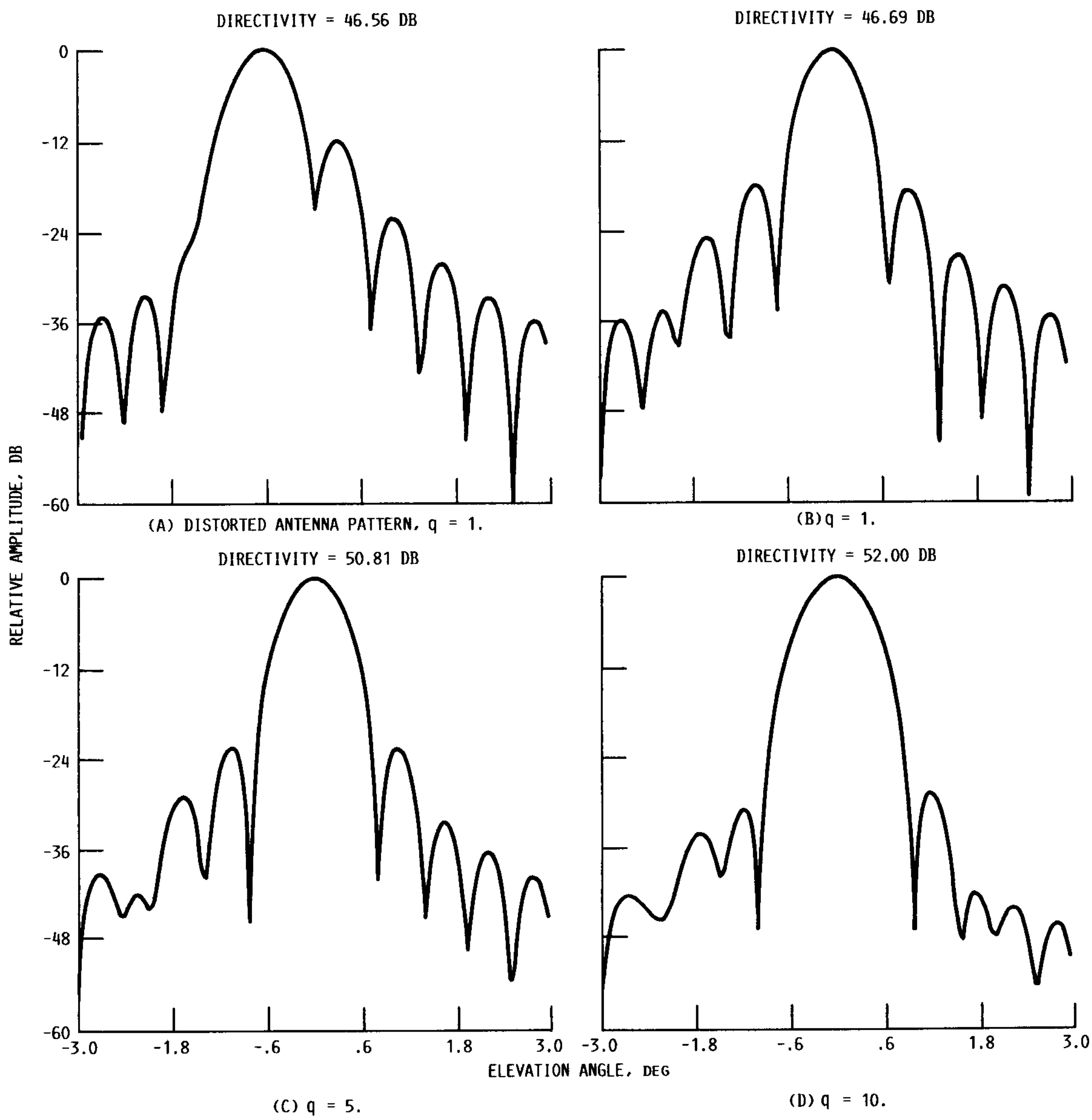


FIGURE 7. - COMPENSATED ANTENNA PATTERN.

National Aeronautics and Space Administration

Report Documentation Page

1. Report No. NASA TM-101458	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Adaptive Feed Array Compensation System for Reflector Antenna Surface Distortion		5. Report Date 6. Performing Organization Code
7. Author(s) Roberto J. Acosta and A. Zaman		8. Performing Organization Report No. E-4568 10. Work Unit No. 650-60-20
9. Performing Organization Name and Address National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio 44135-3191		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. 20546-0001		14. Sponsoring Agency Code

15. Supplementary Notes

Prepared for the 1989 IEEE AP-S International Symposium and URSI Radio Science Meeting, San Jose, California, June 26-30, 1989.

16. Abstract

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17. Key Words (Suggested by Author(s)) Antenna surface distortion Antenna surface compensation Far-field analysis	18. Distribution Statement Unclassified – Unlimited Subject Category 32

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No of pages	22. Price*
Unclassified	Unclassified	6	A02

NASA FORM 1626 OCT 86

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