# CONJUGATE FIELD APPROACHES FOR ACTIVE ARRAY COMPENSATION
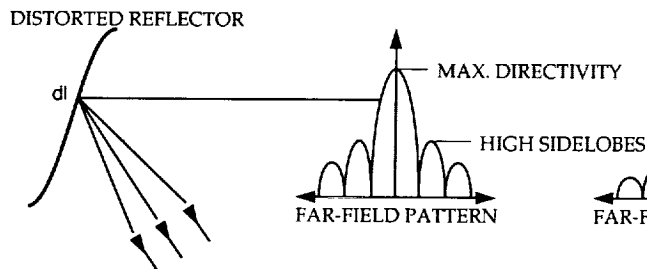
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# CONJUGATE FIELD APPROACHES FOR ACTIVE
# ARRAY COMPENSATION

Two approaches for calculating the compensating feed array complex excitations are namely, the indirect conjugate field matching (ICFM) and the direct conjugate field matching (DCFM) approach (Ref 1.). In the ICFM approach the compensating feed array excitations are determined by considering the transmitting mode and the reciprocity principle. The DCFM "in contrast" calculates the array excitations by integrating directly the induced surface currents on the reflector under a receiving mode. DCFM allows the reflector to be illuminated by an incident plane wave with a tapered amplitude. The level of taper can effectively control the sidelobe level of the compensated antenna pattern.
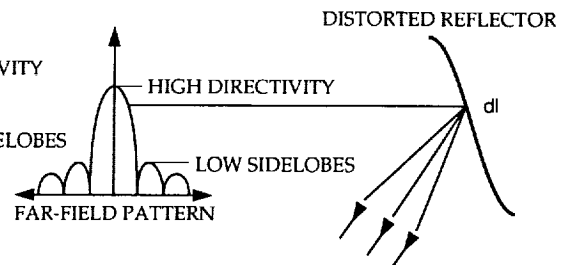
INDIRECT CONJUGATE FIELD MATCHING
(ICFM)

DIRECT CONJUGATE FIELD MATCHING
(DCFM)

DISTORTED REFLECTOR

dl

MAX. DIRECTIVITY

HIGH SIDELOBES

FAR-FIELD PATTERN

HIGH DIRECTIVITY

LOW SIDELOBES

FAR-FIELD PATTERN

DISTORTED REFLECTOR

dl

ICFM FEATURES

DCFM FEATURES

* RECIPROCITY APPLIES (TRANSMITTING CODES)

* MAXIMUM DIRECTIVITY IS ACHIEVABLE
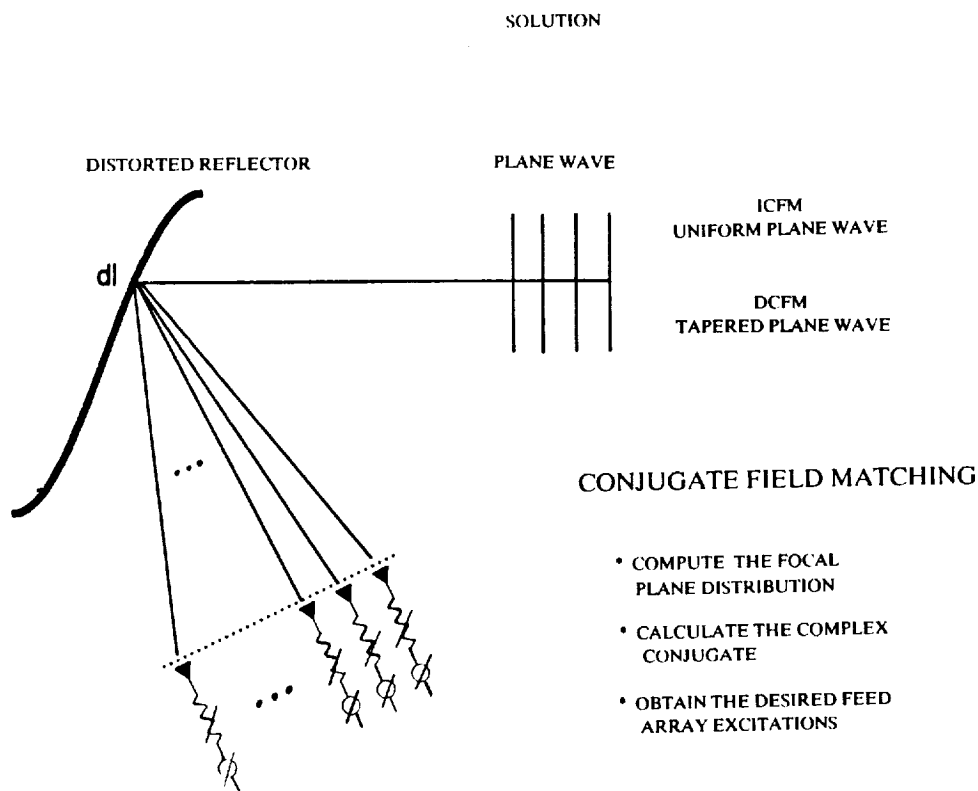
* DIRECT CONTROL OF SIDELOBES

* DIRECTIVITY WITHIN 2DB OF MAXIMUM

* EASY TO IMPLEMENT
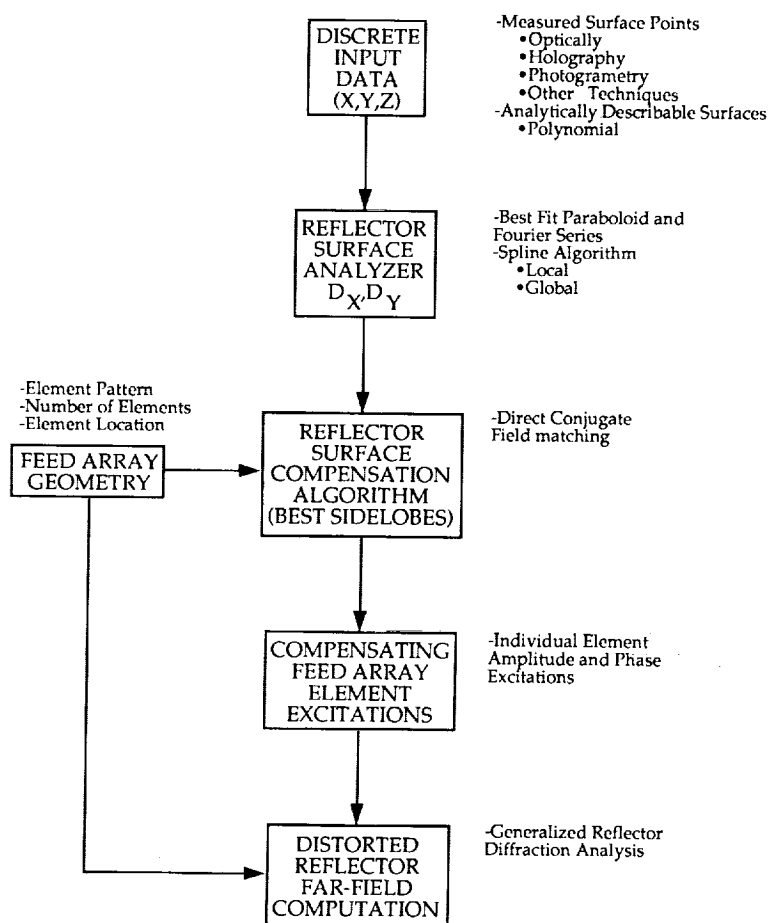
# CONJUGATE FIELD MATCHING PRINCIPLE

The DCFM approach is based on the receiving antenna mode, as outlined below. Let the distorted antenna be illuminated by an incident plane wave from a prescribed direction and with a prescribed polarization. That direction and polarization are those of the main beam when the antenna is in the transmitting mode. The plane wave has a planar phase front as in an ordinary plane wave case, but with the option of having a uniform amplitude (ICFM) or a tapered amplitude (DCFM). Using this concept, the resulting fields in the focal plane of the reflector antenna can be calculated by integrating the induced current distribution on the distorted reflector surface. The set of excitation coefficients of the compensating feed array is obtained as complex conjugate of the received focal plane electric field distribution.

SOLUTION

DISTORTED REFLECTOR         PLANE WAVE

dI

ICFM
UNIFORM PLANE WAVE

DCFM
TAPERED PLANE WAVE

## CONJUGATE FIELD MATCHING

• COMPUTE THE FOCAL
  PLANE DISTRIBUTION

• CALCULATE THE COMPLEX
  CONJUGATE

• OBTAIN THE DESIRED FEED
  ARRAY EXCITATIONS

ASSUMPTION : REFLECTOR DISTORTION KNOWN

# DIRECT CONJUGATE FIELD MATCHING
## COMPUTER IMPLEMENTATION

A block diagram of a numerical implementation for the DCFM approach is illustrated below. It determines the focal plane electric field distribution due to a tapered plane wave incident on the distorted reflector from a known observation direction. The algorithm uses physical optics technique for obtaining the focal region fields. The compensating feed array are obtained by assigning the complex conjugate values of the focal region fields at the corresponding feed element location. Basically, two inputs are to be defined, the feed array geometry and the distorted reflector surface points.

```
                    ┌──────────┐      -Measured Surface Points
                    │ DISCRETE │         •Optically
                    │  INPUT   │         •Holography
                    │  DATA    │         •Photogrametry
                    │ (X,Y,Z)  │         •Other Techniques
                    └──────────┘      -Analytically Describable Surfaces
                         │               •Polynomial
                         ▼
                    ┌──────────┐      -Best Fit Paraboloid and
                    │ REFLECTOR│       Fourier Series
                    │ SURFACE  │      -Spline Algorithm
                    │ ANALYZER │         •Local
                    │  Dx,Dy   │         •Global
                    └──────────┘
                         │
 -Element Pattern        │
 -Number of Elements     ▼
 -Element Location  ┌──────────┐      -Direct Conjugate
 ┌──────────┐       │ REFLECTOR│       Field matching
 │FEED ARRAY├──────▶│ SURFACE  │
 │GEOMETRY  │       │COMPENSATION
 └──────────┘       │ ALGORITHM│
      │             │(BEST SIDELOBES)
      │             └──────────┘
      │                  │
      │                  ▼
      │             ┌──────────┐      -Individual Element
      │             │COMPENSATING      Amplitude and Phase
      │             │ FEED ARRAY│      Excitations
      │             │ ELEMENT  │
      │             │EXCITATIONS
      │             └──────────┘
      │                  │
      │                  ▼
      │             ┌──────────┐      -Generalized Reflector
      │             │ DISTORTED│       Diffraction Analysis
      └────────────▶│ REFLECTOR│
                    │ FAR-FIELD│
                    │COMPUTATION
                    └──────────┘
```

$D_X, D_Y$

# EXAMPLE OF CALCULATION

Let us consider the undistorted offset parabolic geometry and surface error profile illustrated in the figure below. Also presented in the figure are the feed parameters and the undistorted E-plane radiation pattern obtained by placing a single feed at the focal point.
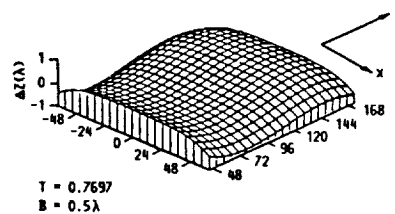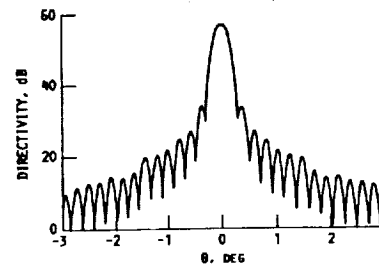
## PROBLEM DESCRIPTION
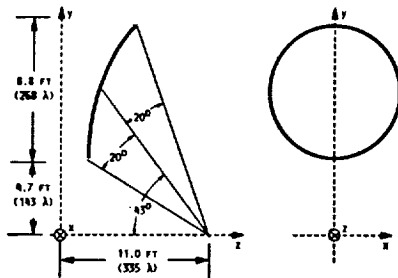


UNDISTORTED ANTENNA GEOMETRY



T = 0.7697
B = 0.5λ

SURFACE DISTORTION PROFILE



| | |
|---|---|
| OPERATING FREQUENCY, GHz | 30 |
| FEED POLARIZATION | LINEAR |
| E-PLANE PATTERN COS$^{qE}$(θ) | qE = 20 |
| H-PLANE PATTERN COS$^{qH}$(θ) | qH = 20 |
| FEED LOCATION (FOCUS), METERS | (0,0,3.35) |
| EDGE TAPER, dB | -11 |

SUMMARY OF FEED PARAMETERS



UNDISTORTED FAR FIELD PATTERN

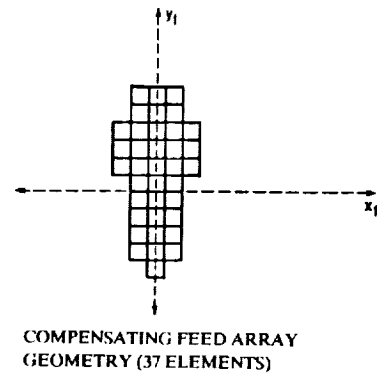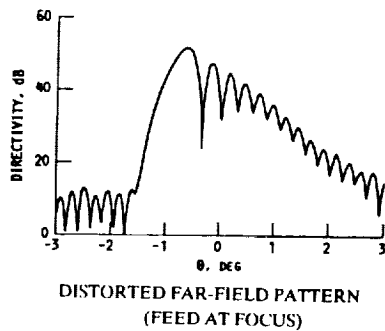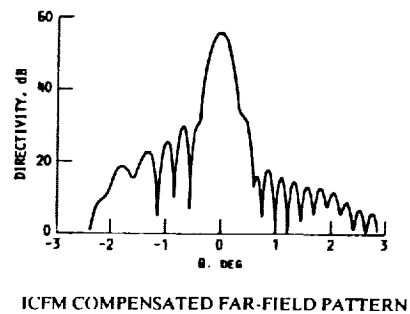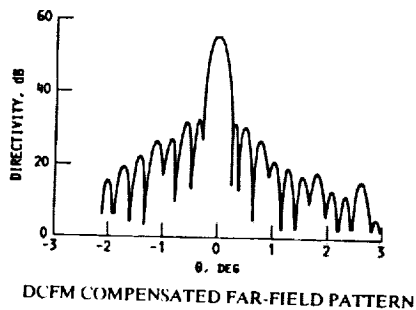269

# RESULTS

The figure below presents the distorted far-field, compensated far-field of DCFM solution, compensated far-field of ICFM solution and the compensating feed array geometry. The ICFM approach assumes a uniform plane wave incident on the distorted reflector. The compensated directivity for both approaches was within 2 DB of the undistorted value. The major differences occurred in the compensated sidelobe level envelope. Note that the sidelobe level for the DCFM approach was 3 to 5 DB lower than those produced by the ICFM approach. This result indicates that the amplitude tapering of the incident plane wave has a direct control over the compensated sidelobe envelope.

DISTORTED FAR-FIELD PATTERN
(FEED AT FOCUS)

COMPENSATING FEED ARRAY
GEOMETRY (37 ELEMENTS)

## RESULTS

DCFM COMPENSATED FAR-FIELD PATTERN

ICFM COMPENSATED FAR-FIELD PATTERN

# REFERENCE

1. Acosta, R. : Active Feed Array Compensation for Reflector Antenna   Surface Distortion.
   NASA   TM 100826, June 1986.