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PERFORMANCE PREDICTIONS FOR A PARABOLIC LOCALIZER ANTENNA ON RUNWAY 28R -- SAN FRANCISCO AIRPORT

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16. Abstract

The TSC ILS localizer model is used to predict the performance of the Texas Instruments "wide aperture" parabolic antenna as a localizer system for runway 28R at San Francisco International Airport. Course derogation caused by the new American Airlines hangar is calculated under the assumption that this structure is a metallic perfect reflector. It is found that the TI System operated with a "capture effect ratio" of 10 dB does not meet Category I requirements. If it is possible to operate the system within equipment limitations at a 16 dB capture effect ratio, performance should be adequate for Category I, but is still inadequate for Category II. This performance is inferior to that predicted for the Alford 22/8 array for the same situation in an earlier study.

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PREFACE

The work described in this report was performed in the context of an overall program to develop a user-oriented computer scale model to be used by the Federal Aviation Administration for the prediction of ILS performance with different antennas, in the presence of different airport structures, parked and taxiing aircraft, and different terrain conditions. This program is sponsored by the Department of Transportation through the Federal Aviation Administration, Systems Research and Development Service.

LIST OF ILLUSTRATIONS (CONT.)

PERFORMANCE PREDICTIONS FOR A PARABOLIC LOCALIZER ANTENNA ON RUNWAY 28R -- SAN FRANCISCO AIRPORT

In an earlier study, the TSC ILS localizer model was used to predict on-course CDI for runway 28R at San Francisco International Airport. Scattering from the new American Airlines hangar was estimated for a standard V-ring and for each of two Alford array combinations. The present report treats a Texas Instruments wide-aperture parabolic reflector localizer situated at the same location. This localizer transmitting system is comprised of three course-antenna elements radiating by reflection from a parabolic screen, and a four-element linear array employed in conjunction with the parabolic antenna to generate clearance radiation. The scattering situation is shown in Figure 1. The principal course derogating structure is the set of hangar doors which are treated here as a vertical metallic wall 560 feet wide by 135 feet high.

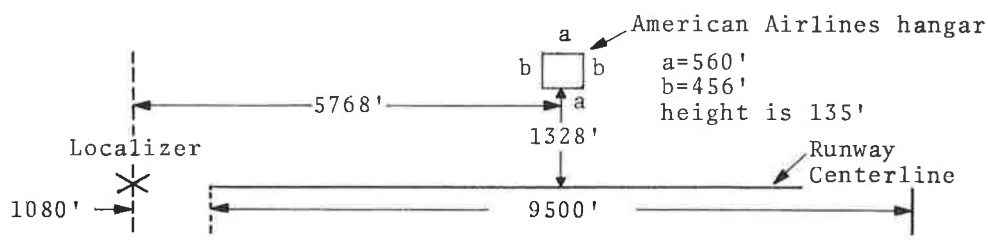

Figure 1. Scattering Schematic for Runway 28R

The four-element clearance array is centered at the localizer reference point 1080 feet beyond the stop end of the runway. The center element of the three-element directive array is located an additional 35.6 feet from the runway at a point which is the focus of the parabolic screen. The screen is assumed to be 17.8 feet high, to have an aperture of 176 feet and a focal length of 44.5 feet. The layout of this "wide aperture" localizer system is sketched in Figure 2.

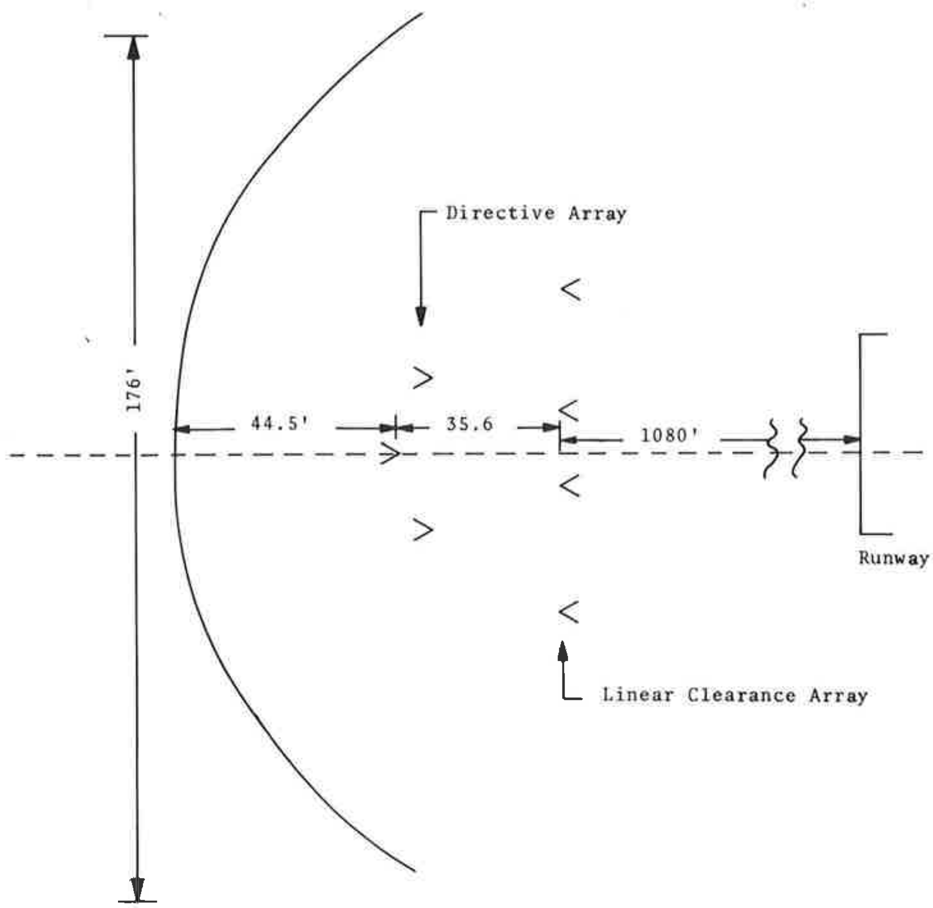

Figure 2. Sketch of Parabolic Localizer Layout

Antenna patterns for the CDI computations were obtained in two ways. First, a theoretical set of course and clearance patterns was synthesized by the use of approximate formulae for the diffraction pattern of the parabola, standard linear array equations, and system set-up prescriptions given in an undated Texas Instruments document entitled "Wide Aperture Parabola." The patterns so generated agree in major details with the patterns given in Texas Instruments literature. They are at variance, however, with measured data obtained at NAFEC by E. Zyzys. Both the TSC theoretical and NAFEC measured patterns were used in the on-course CDI calculations for the 747 hangar presented below.

Figure 3a shows the course and clearance carrier-plus-sidebands

(C+S) and sidebands-only (SO) patterns for the TSC theoretical parabolic localizer. The tailored course width is 3.78°. Figure 3b shows the corresponding orbit CDI pattern (without scattered radiation) at a range of 6 nautical miles and an elevation of 1000 feet. Figures 3c and 3d show the predicted on-course static and dynamic CDI with the 747 hangar present. The dynamic curve simulates the response of a receiver with a 0.4 second time constant and an approach speed of 120 knots. Figures 4a through 4d are corresponding graphs in which the NAFEC measured pattern is used.

It is evident that the predicted on-course CDI does not meet the requirements of Category I operations. However, as found in the earlier study of the Alford arrays, there are certain qualifying considerations. The Texas Instruments system, like the Alford antennas, are specified to operate conventionally with a clearance-to-course signal ratio of -10 dB. (In the case of the Texas Instruments localizer, this ratio applies to the on-course carrier intensity of the four-element linear array compared to the course signal carrier.) It was found that performance of the Alford 22/8 array is greatly improved if the ratio can be decreased to -16 dB. Figures 5a through 5d and 6a through 6d are analogous to Figures 3a through 4d. The clearance/course ratio has been changed to -16 dB. The effect is apparently not as dramatic as with the Alford antennas. The reason for this seems to be the amount of <u>course</u> sidebands-only energy radiated in the direction of the derogator; i.e., off course at 13°. The magnitude of this sidelobe radiation seems to depend critically on how well the antennas can be tuned (note the asymmetry of the measured course sidebands-only signal at ± 12° in Figure 4 a.2.). If it can be reliably demonstrated that the sidelobe radiation from the parabola can be effectively nulled in the direction of the hangar in question, a high level of performance from the Texas Instruments system may be expected. Figure 7 shows the course and clearance patterns of the Alford 22/8 array for comparison.

It should be noted that it has not been established that the Texas Instruments localizer can function reliably at a -16dB capture effect ratio. Whether or not such operation is possible has to be determined in light of the power output limitations of the course and clearance transmitters. The system must be able to meet FAA standards for minimum carrier strength at the limits of localizer usable range.

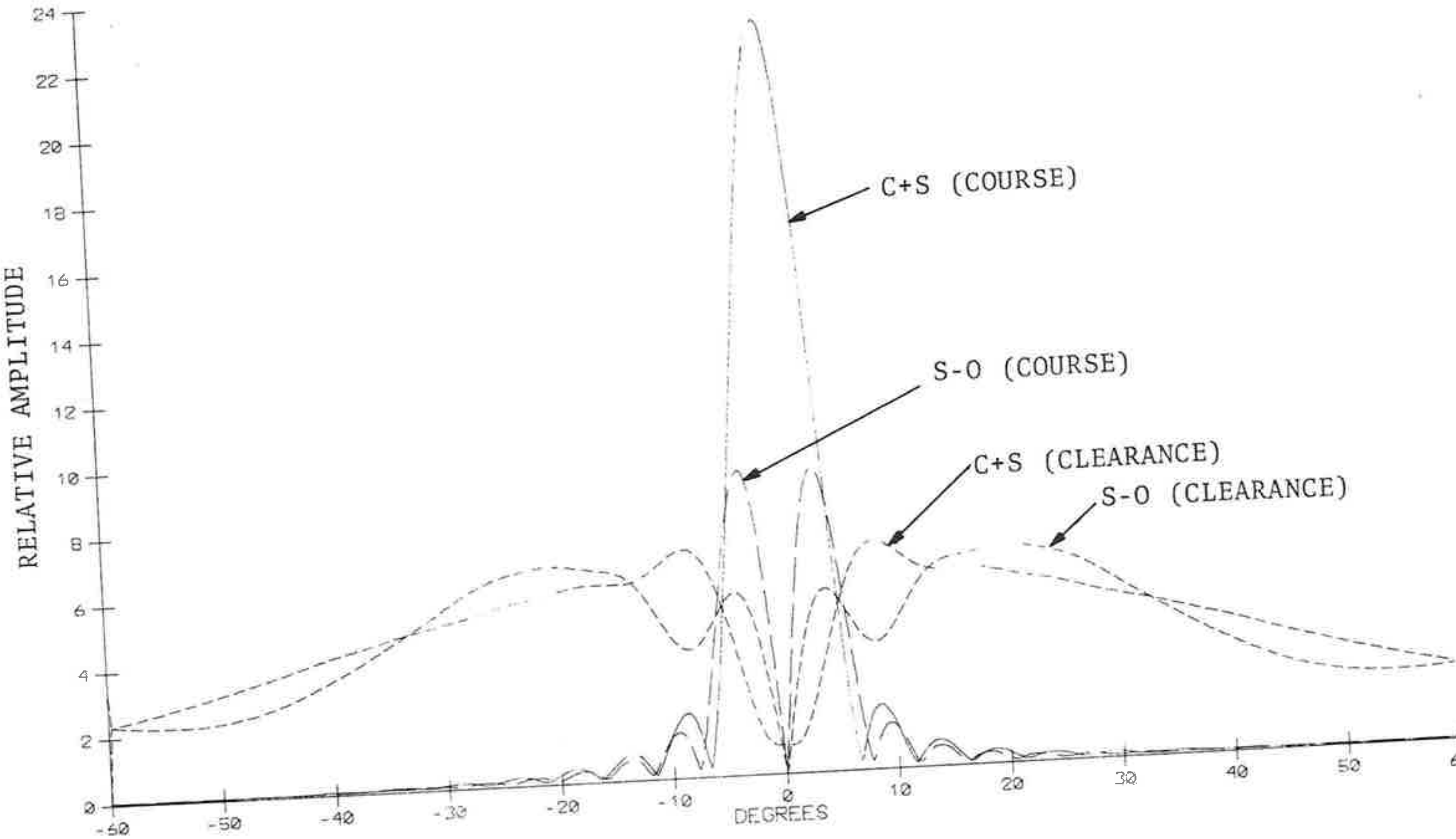

Figure 3a. Theoretical Course and Clearance Signal Patterns

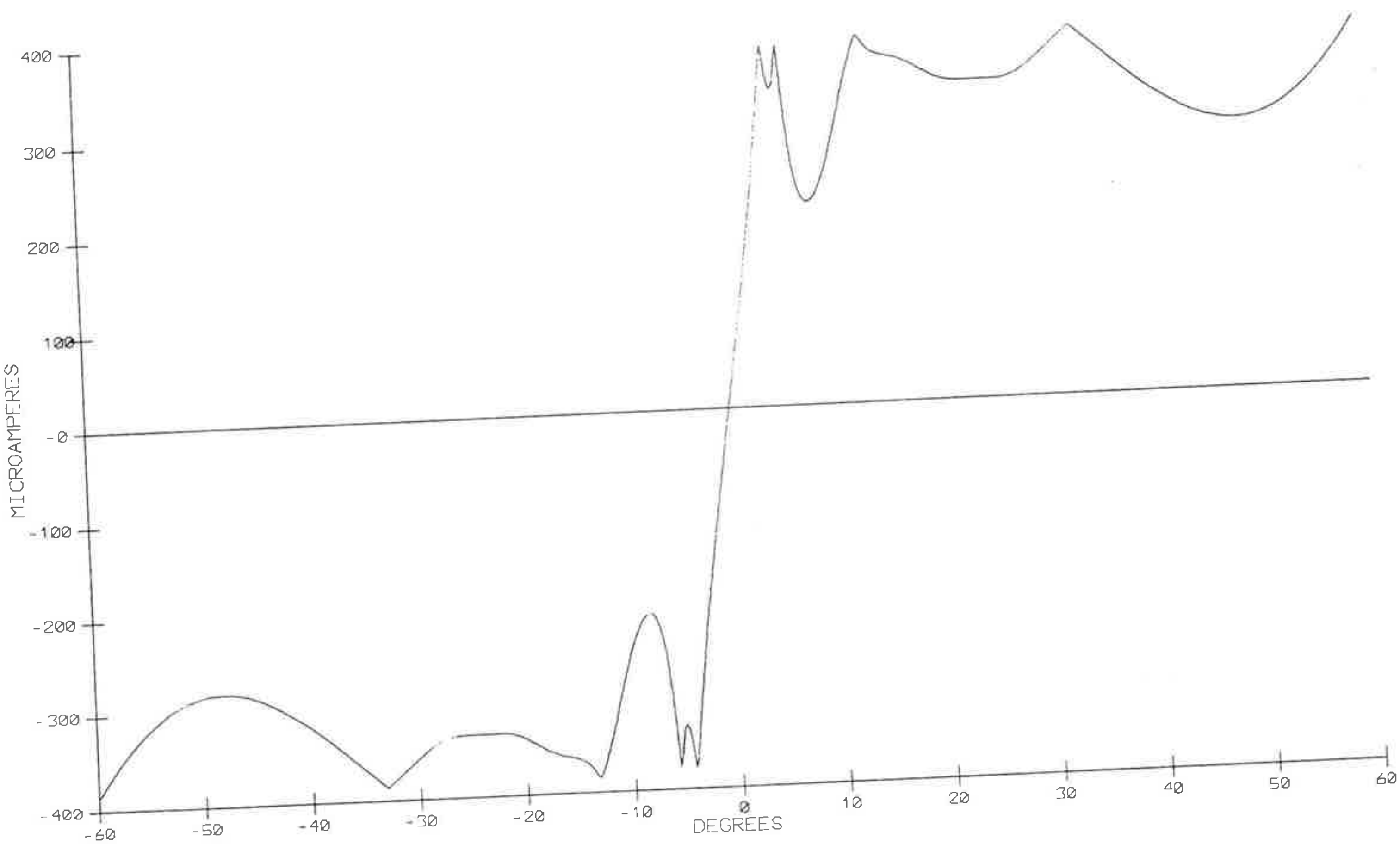

Figure 3b. Theoretical Orbit CDI Pattern at Range 6 nm, Elevation 1000 ft

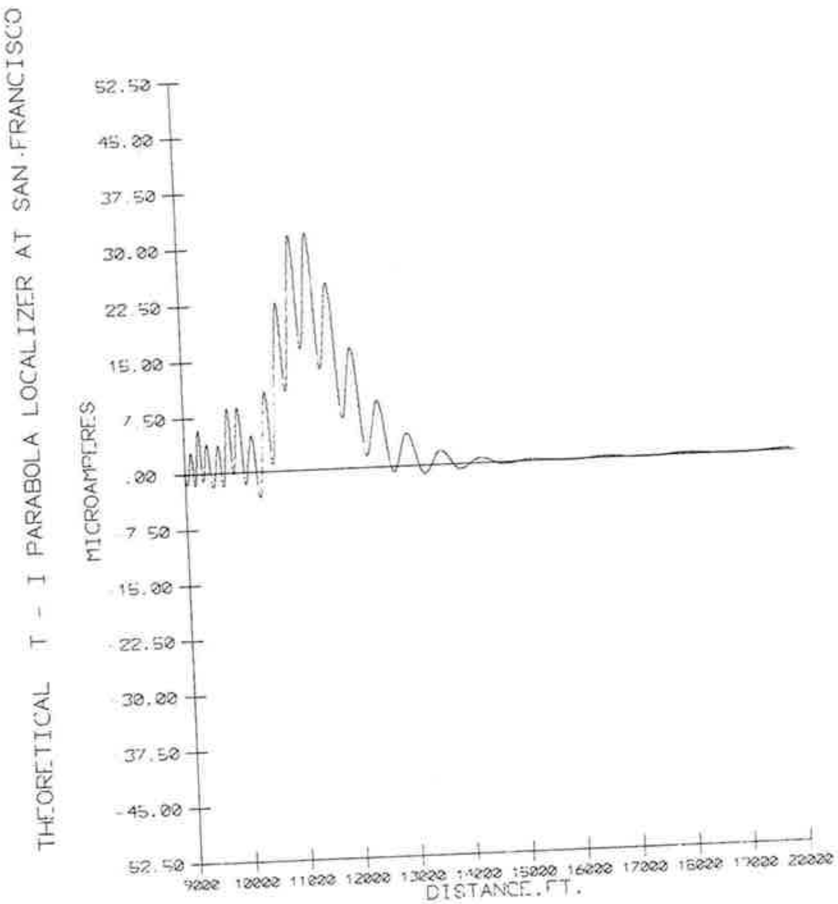

Figure 3c. Static On-Course CDI Predicted for Theoretical Localizer

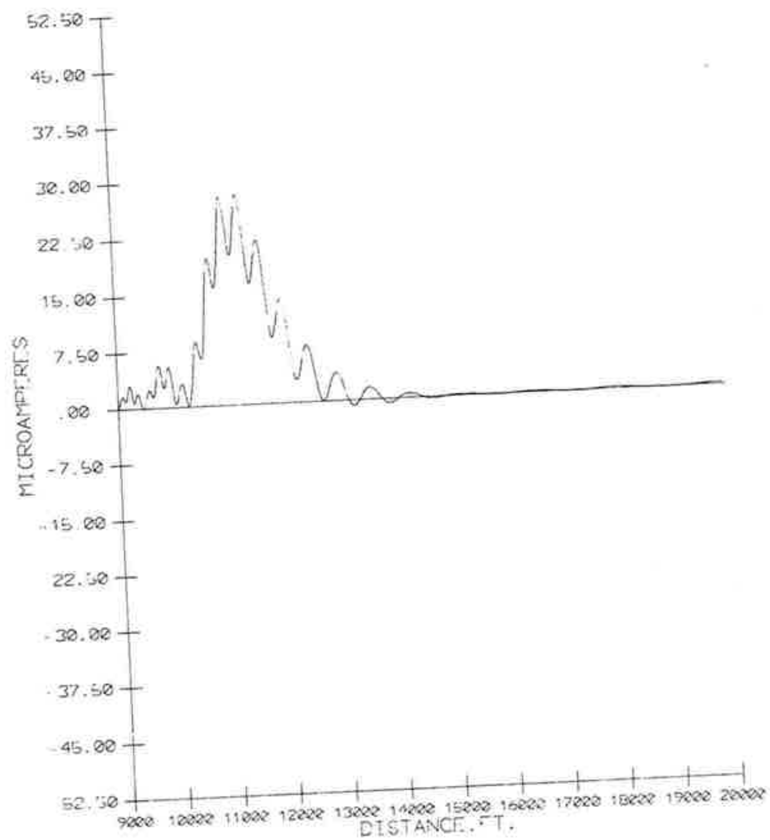

Figure 3d. Dynamic On-Course CDI Predicted for Theoretical Localizer

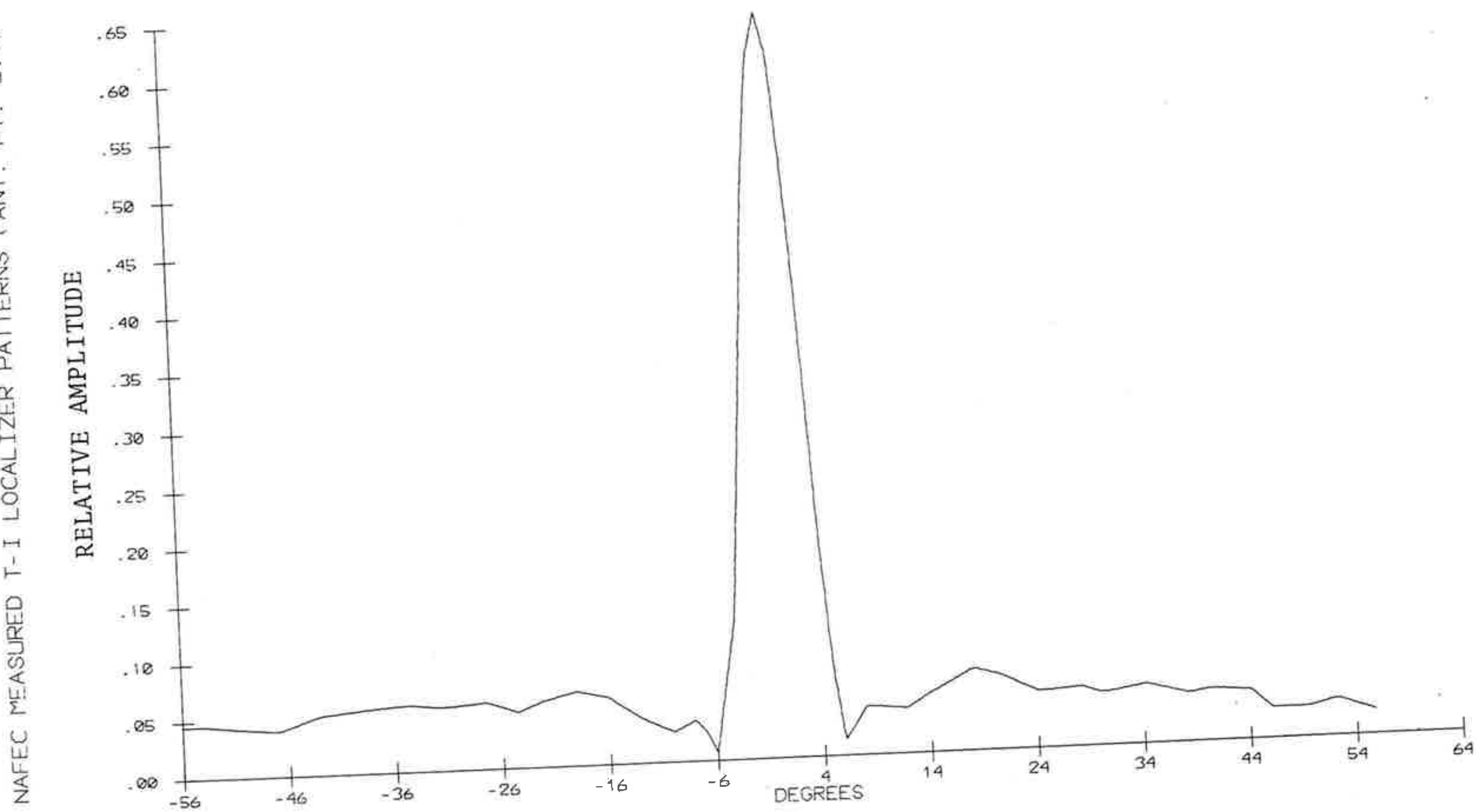

Figure 4a-1. NAFEC Measured Course Carrier-Plus-Sidebands Signal

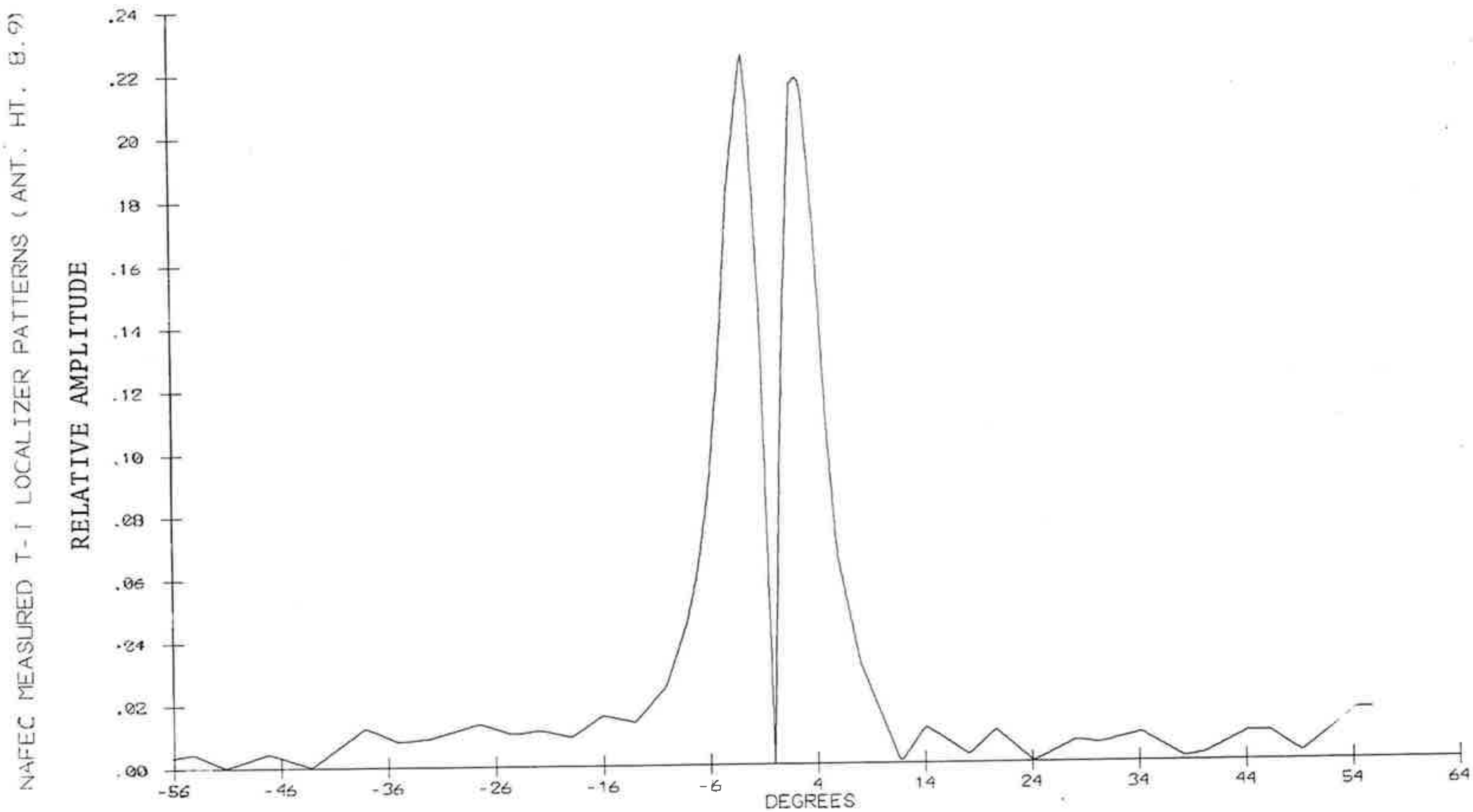

Figure 4a-2. NAFEC Measured Course Sidebands-Only Signal

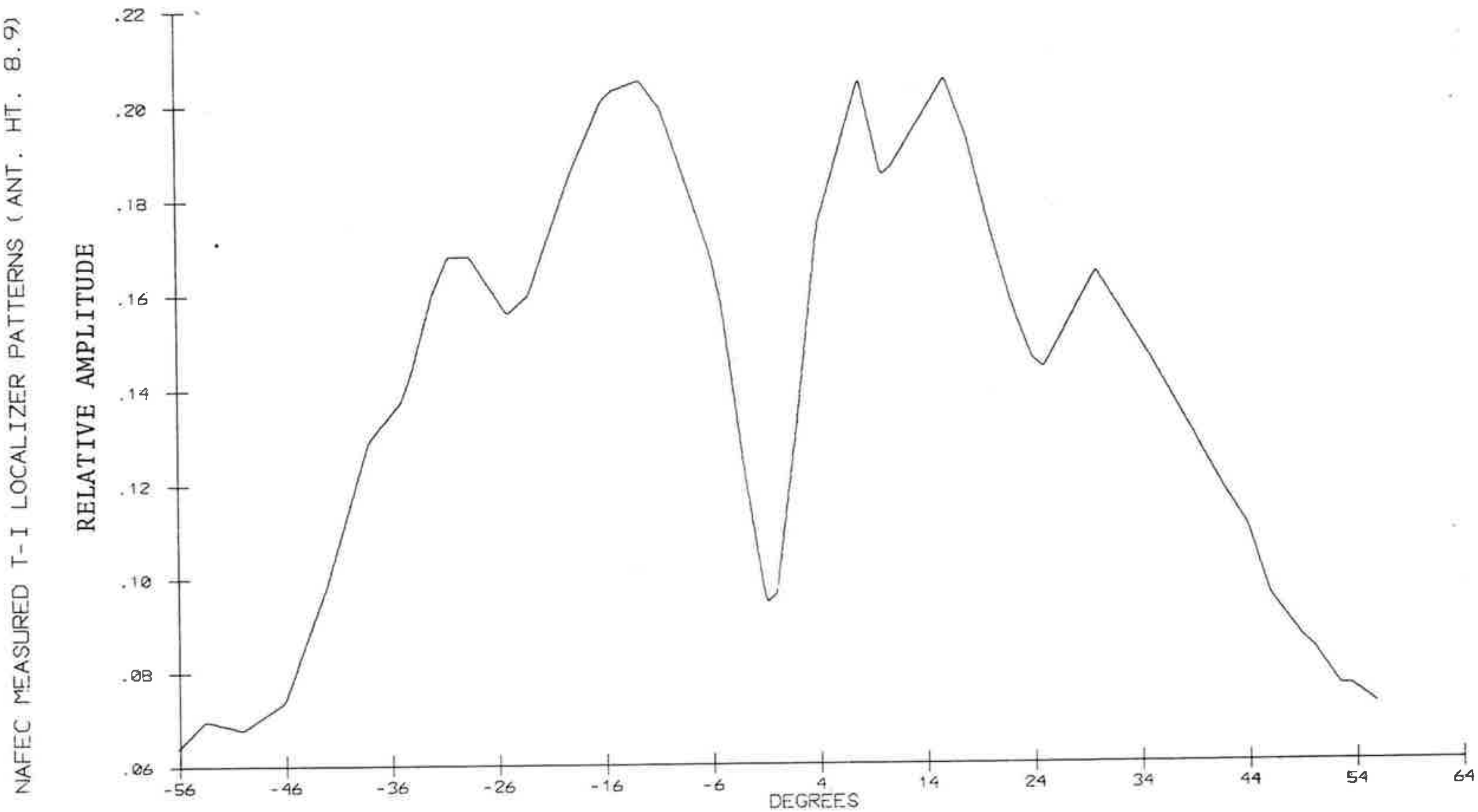

Figure 4a-3. NAFEC Measured Clearance Carrier-Plus-Sidebands Signal

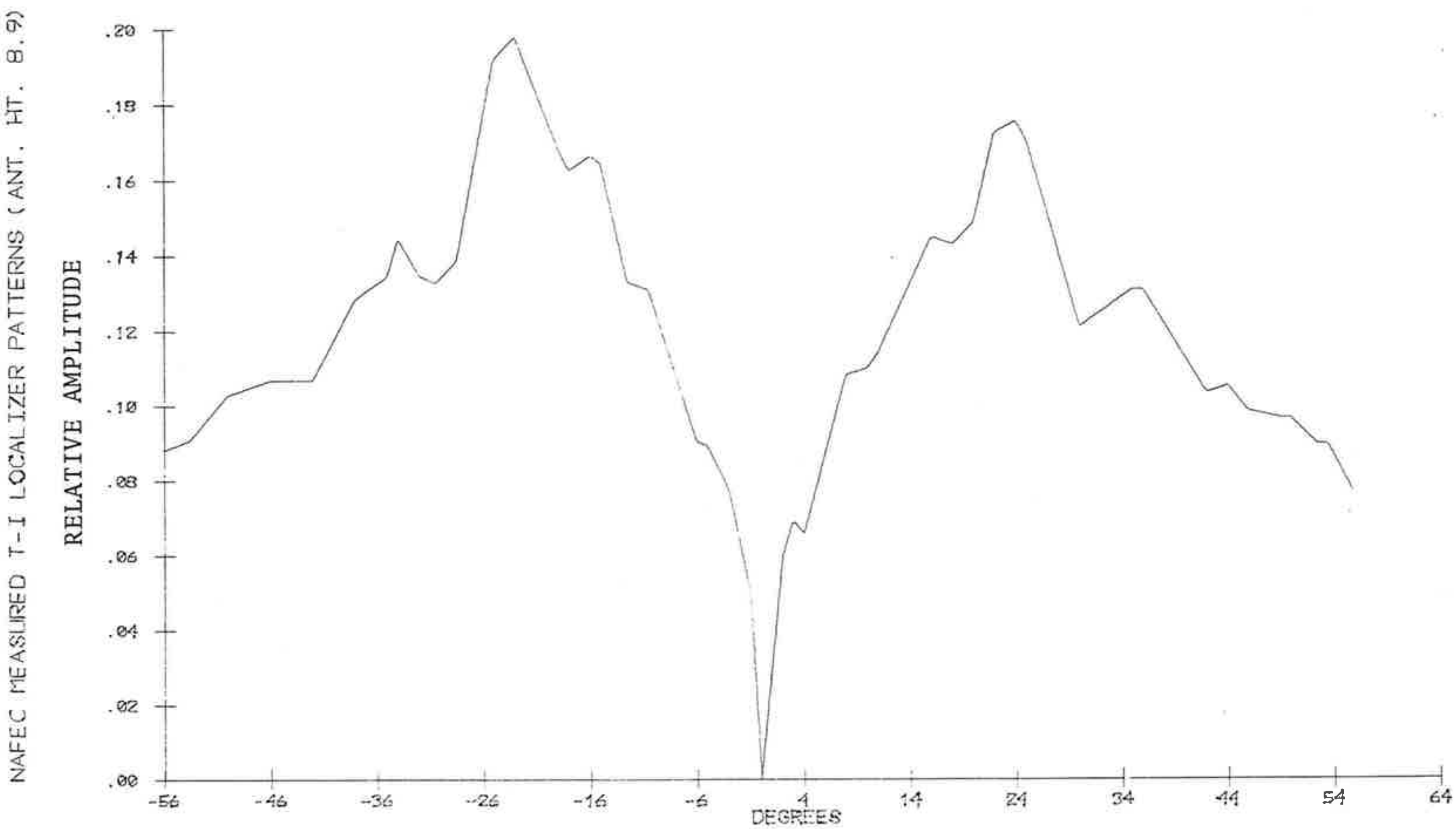

Figure 4a-4. NAFEC Measured Clearance Sidebands-Only Signal

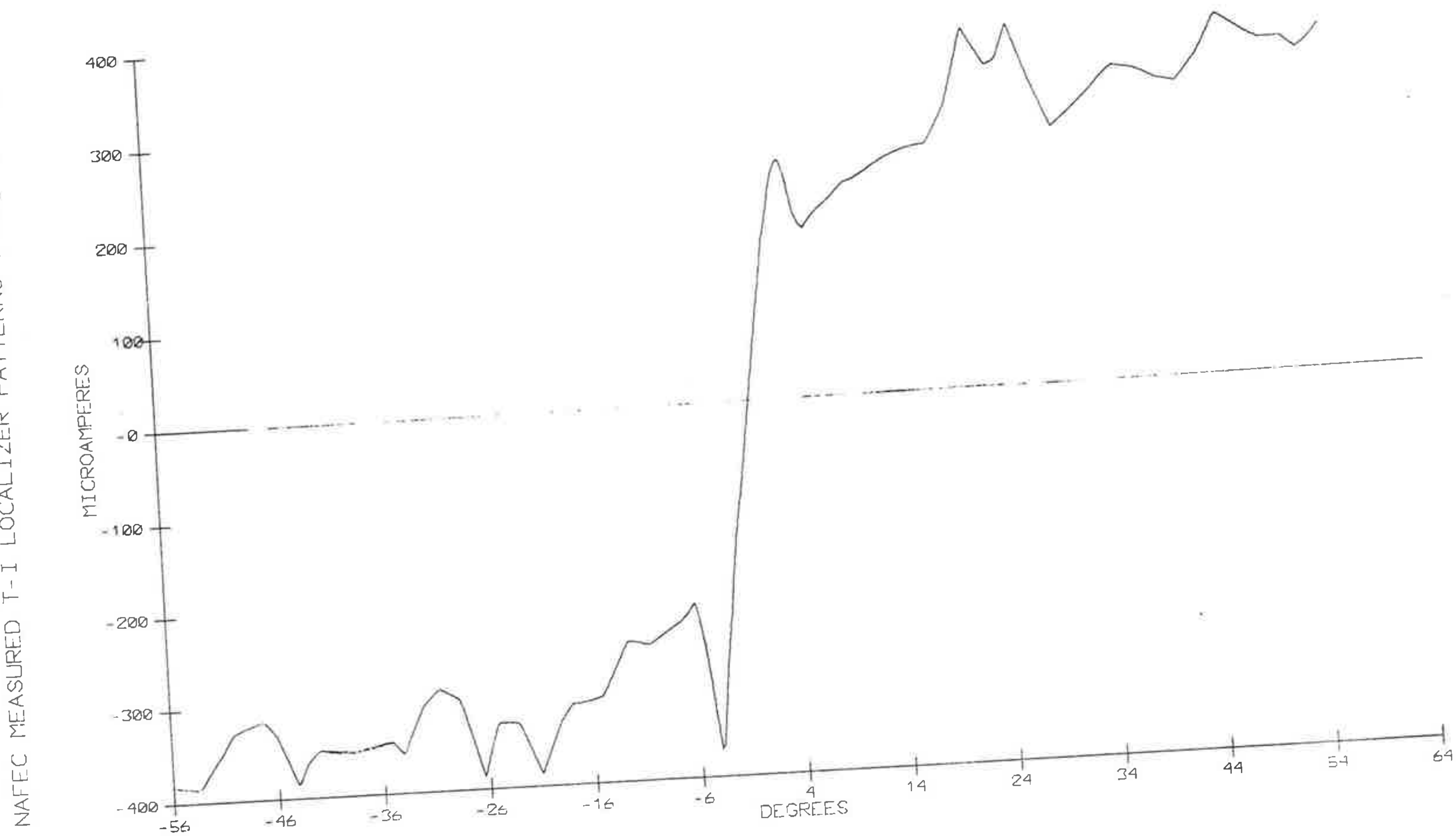

Figure 4b. Orbit CDI Pattern Calculated from NAFEC Measured Component Signal Patterns

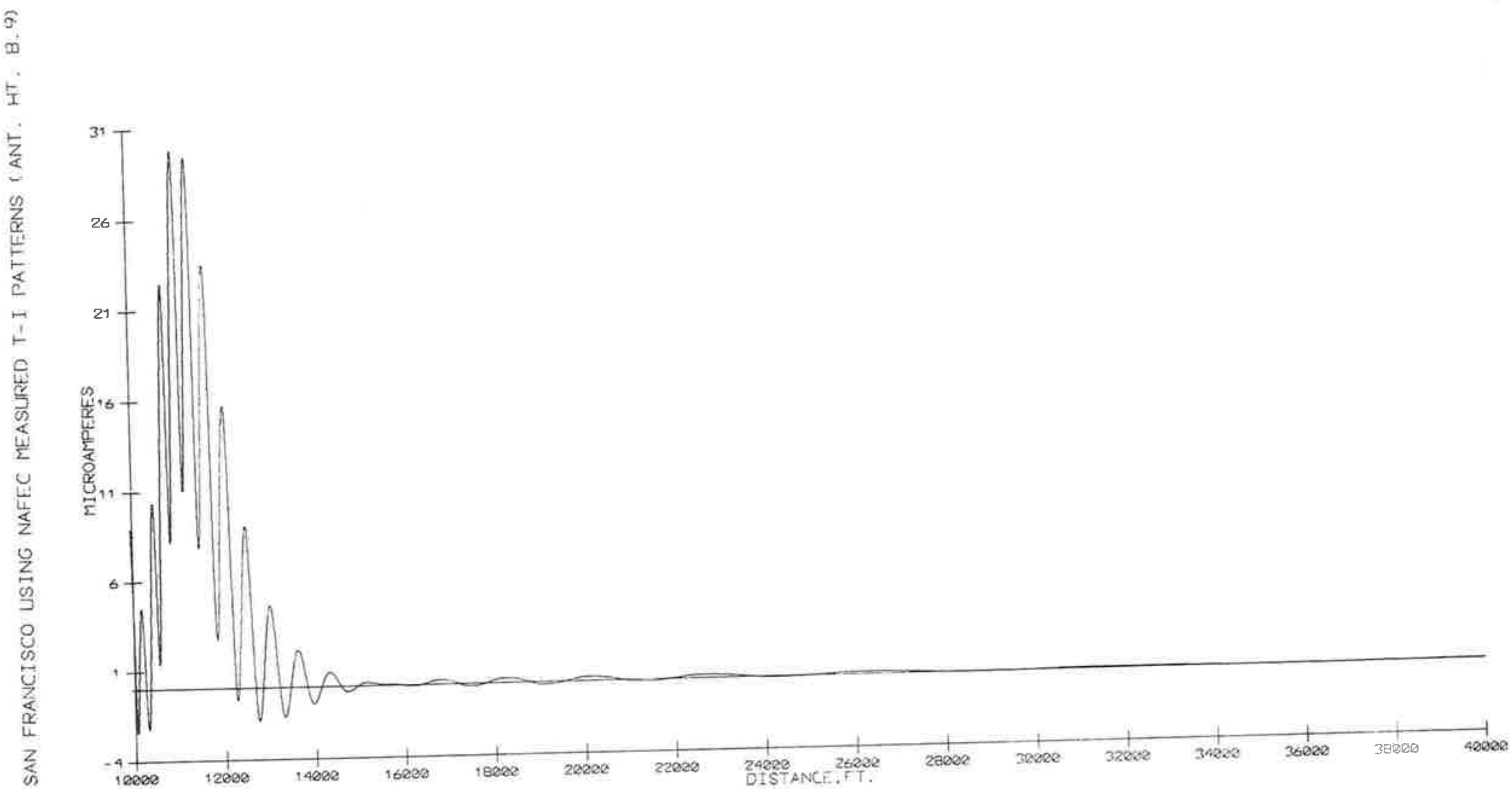

Figure 4c. On-Course CDI: Static Response Predicted for Measured Patterns

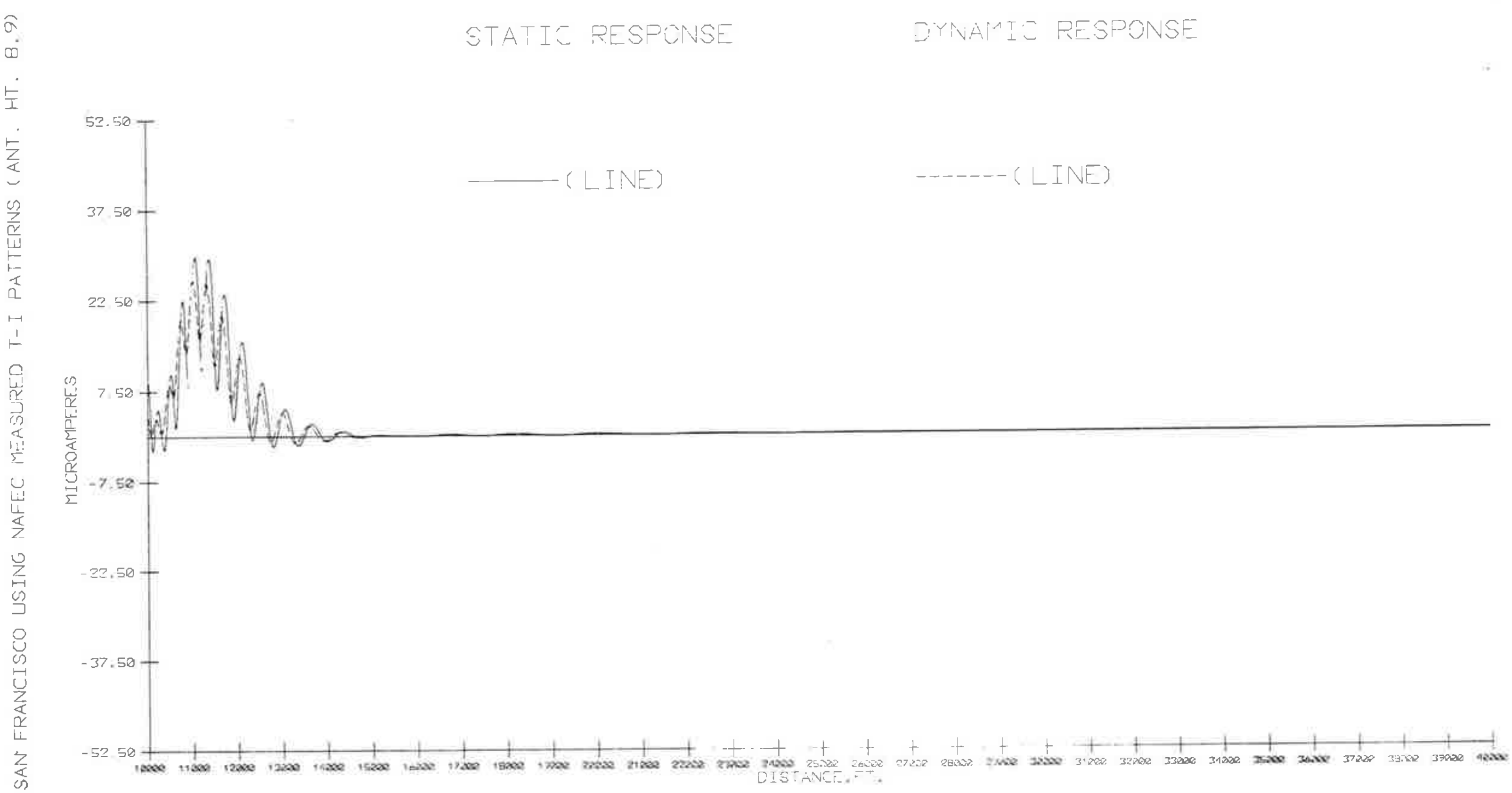

Figure 4d. On-Course CDI: Dynamic and Static Responses Compared

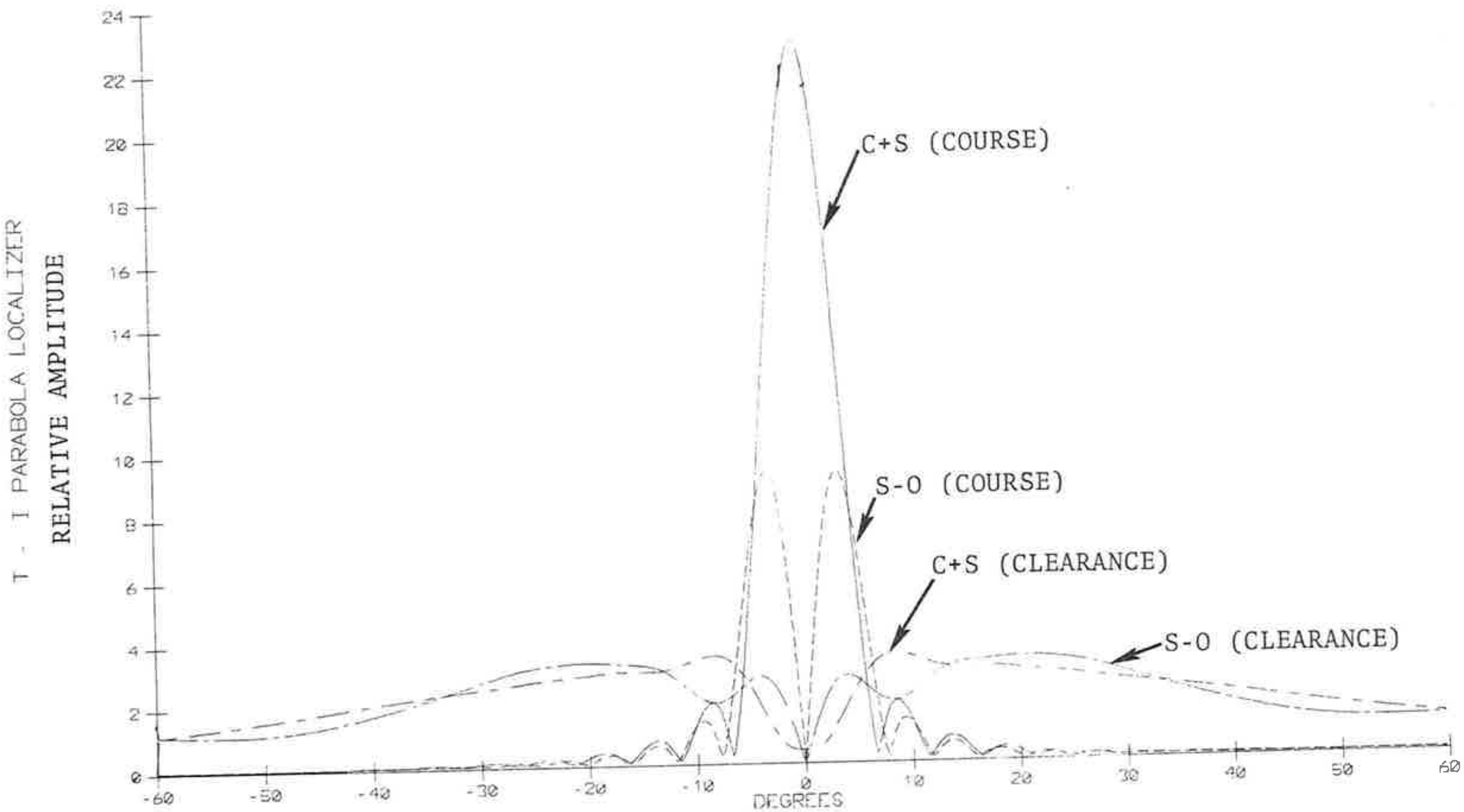

Figure 5a. Theoretical Patterns for -16dB Clearance/Course Ratio

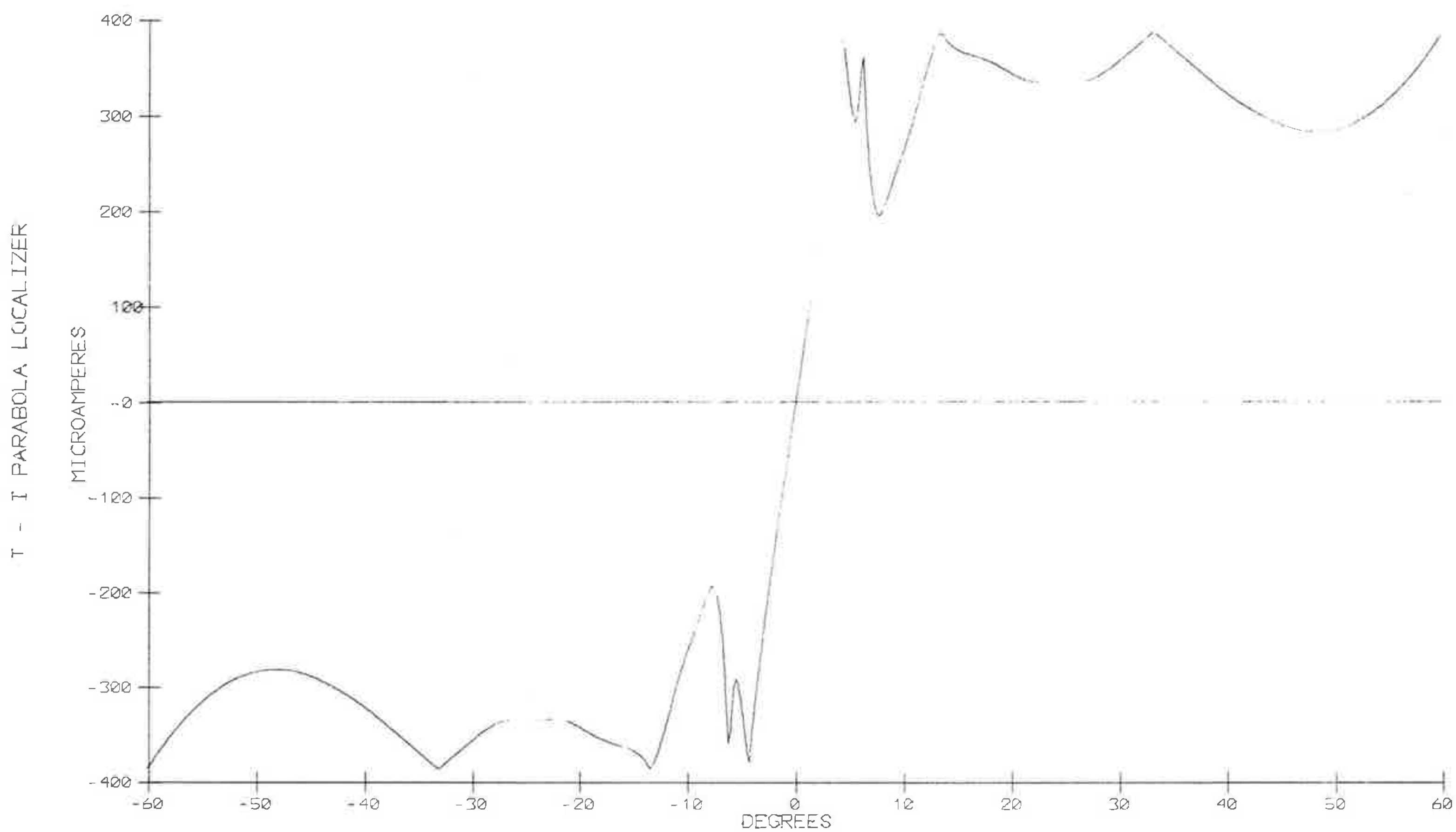

Figure 5b. Theoretical Orbit CDI Pattern with -16dB Clearance/Course Ratio

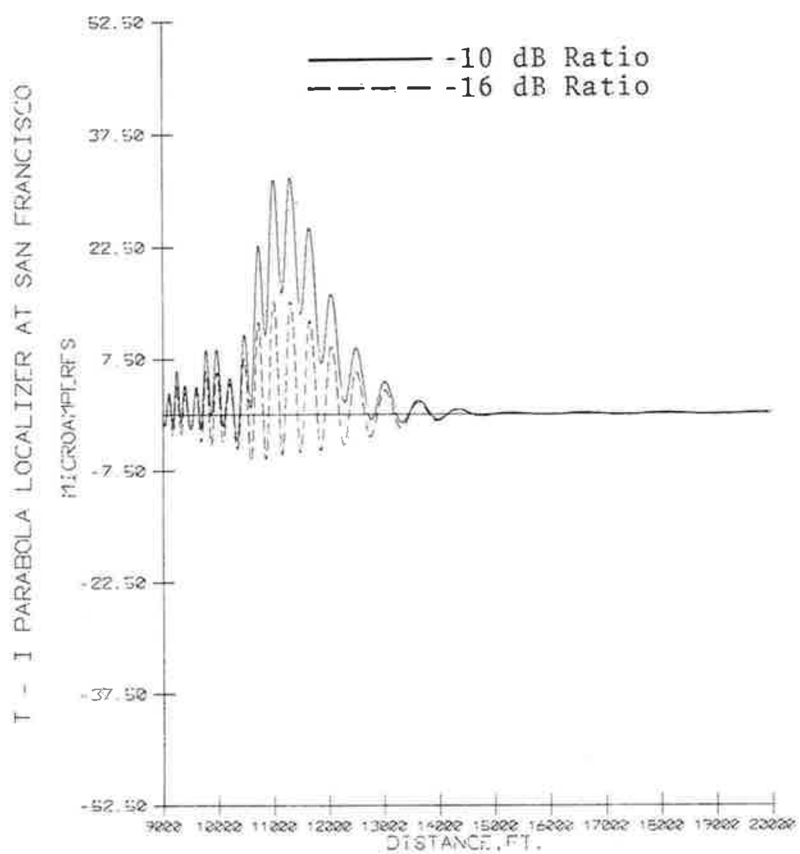

Figure 5c. On-Course CDI for Theoretical Localizer: -16dB and -10dB Clearance/Course Ratios Compared -- Static Response

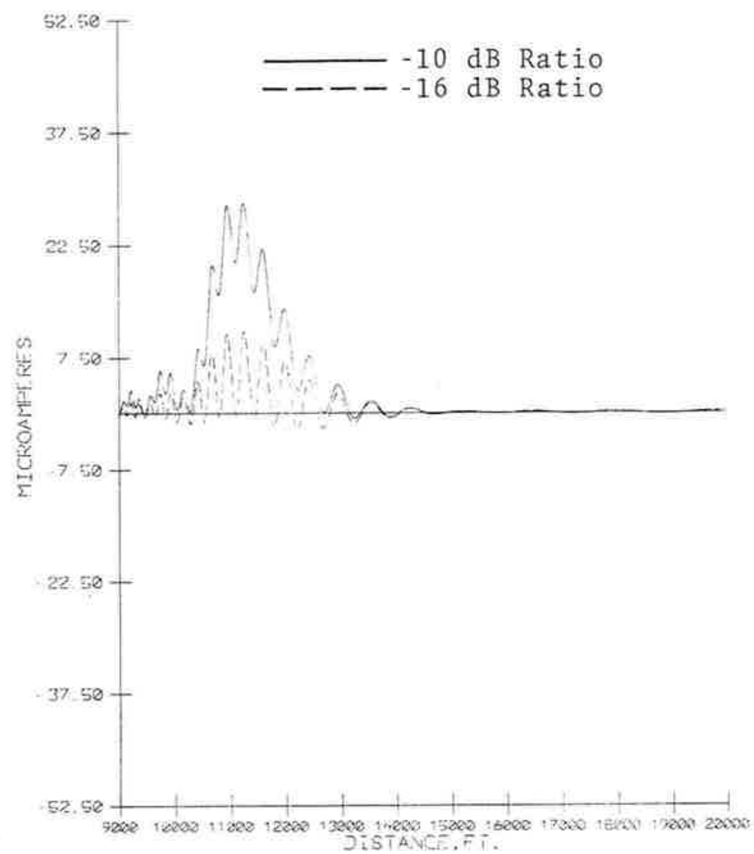

Figure 5d. On-Course CDI for Theoretical Localizer: -16dB and -10dB Clearance/Course Ratios Compared -- Dynamic Response

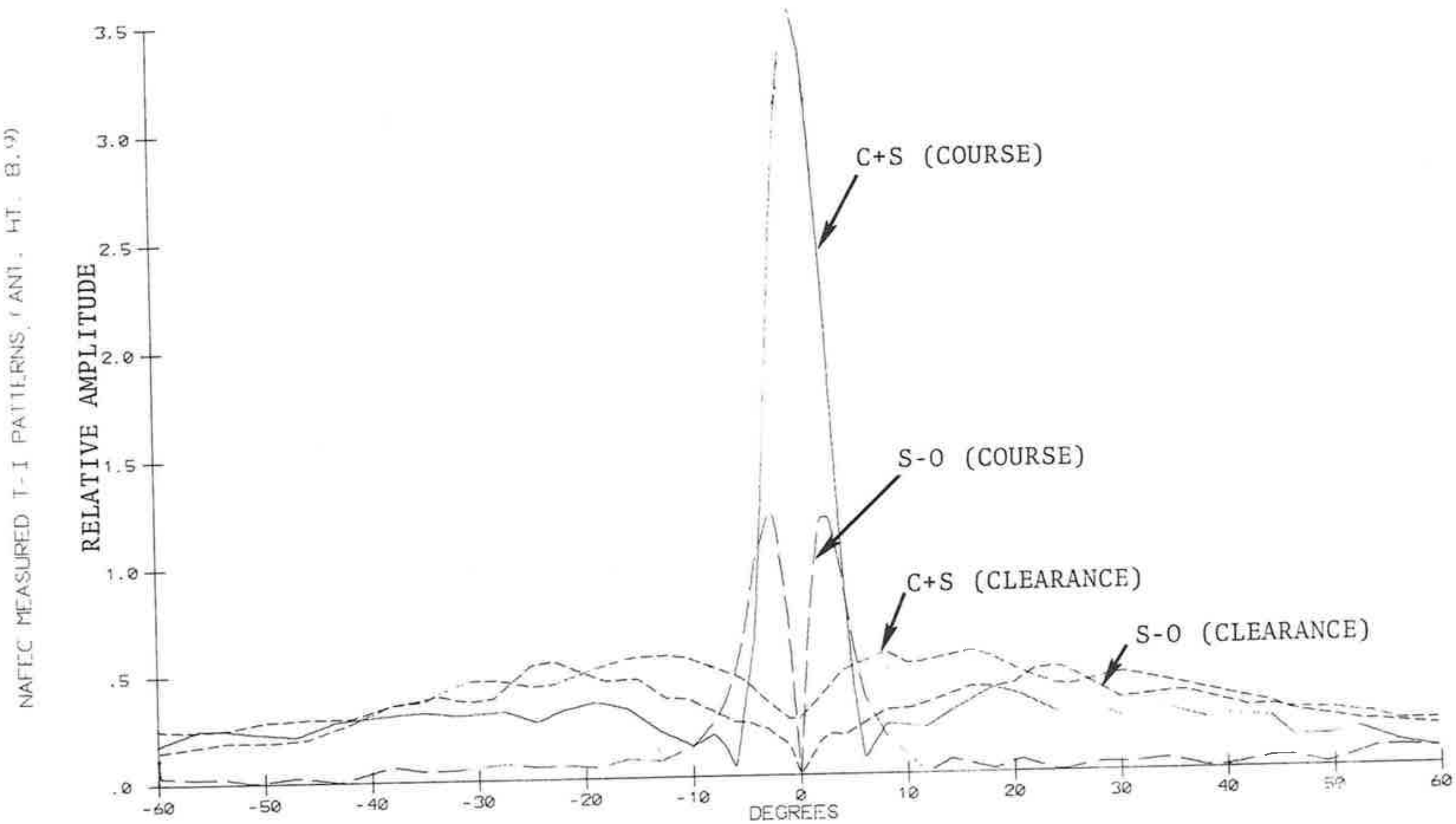

Figure 6a. NAFEC Measured Component Signal Pattern Adjusted to -16 dB Clearance/Course Ratio

SAN FRANCISCO USING NAFEC MEASURED T-I PATTERNS (ANT. HT. 8.9)

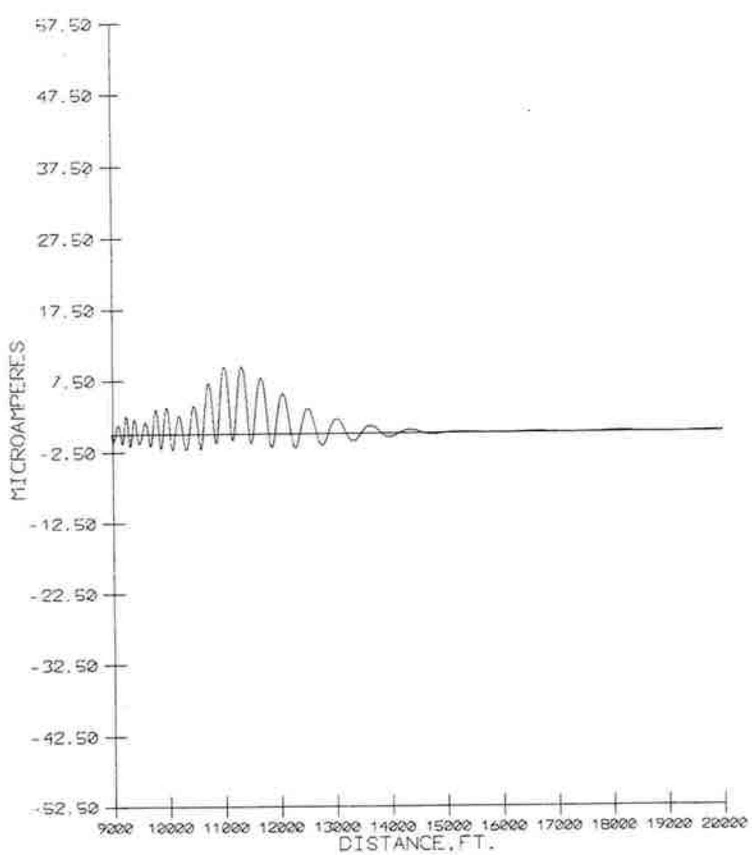

Figure 6c. On-Course Static CDI Using Measured Antenna Patterns with -16dB Clearance/Course Ratio

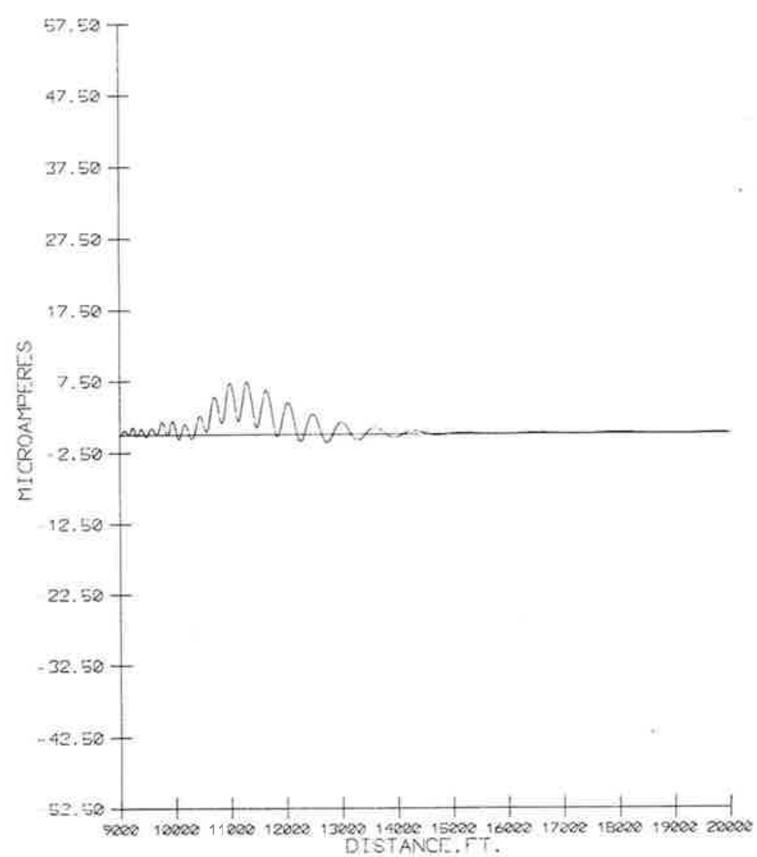

Figure 6d. On-Course Dynamic CDI Using Measured Antenna Patterns with -16dB Clearance/Course Ratio

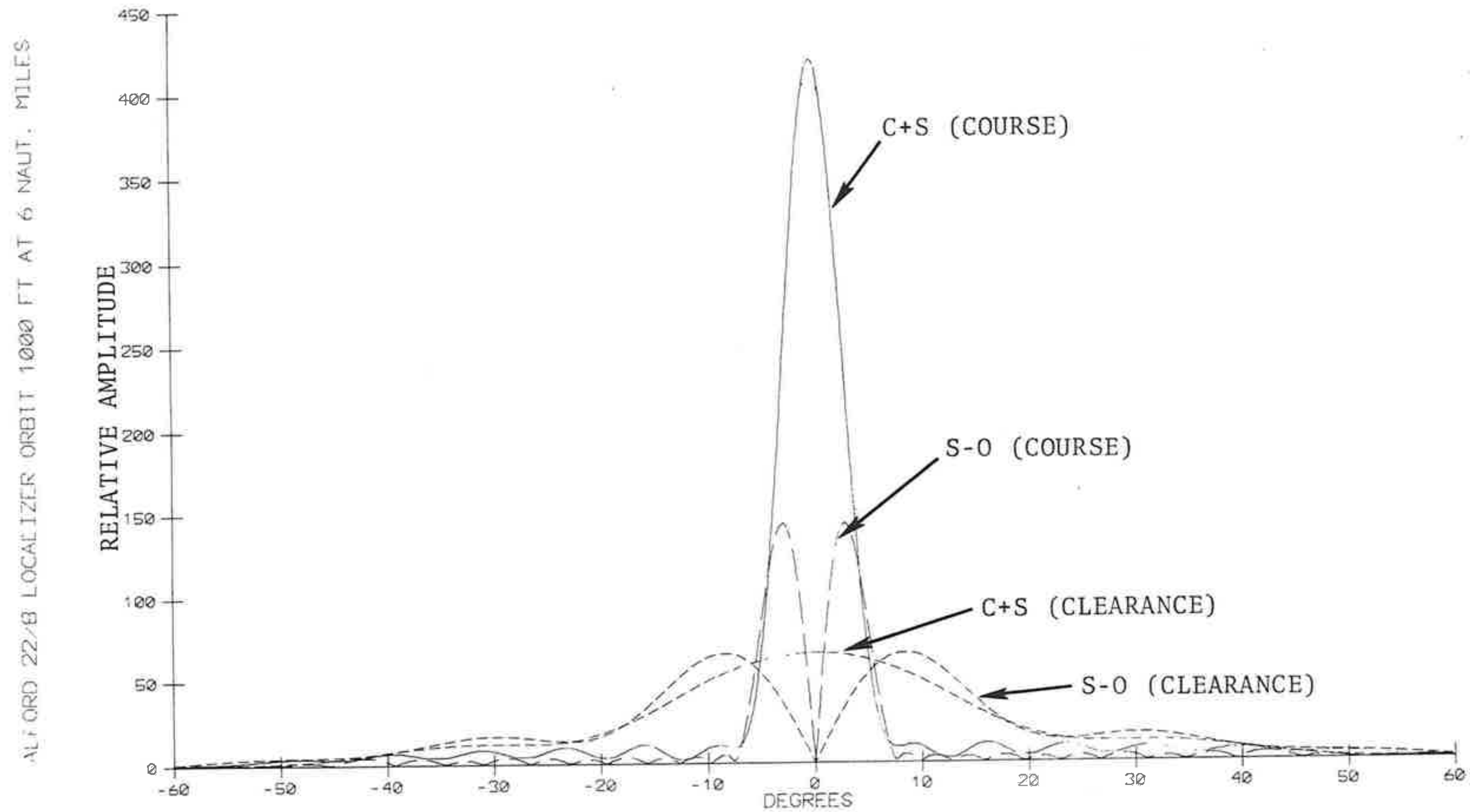

Figure 7a. Theoretical Component Signal Patterns
Alford 22/8 Array

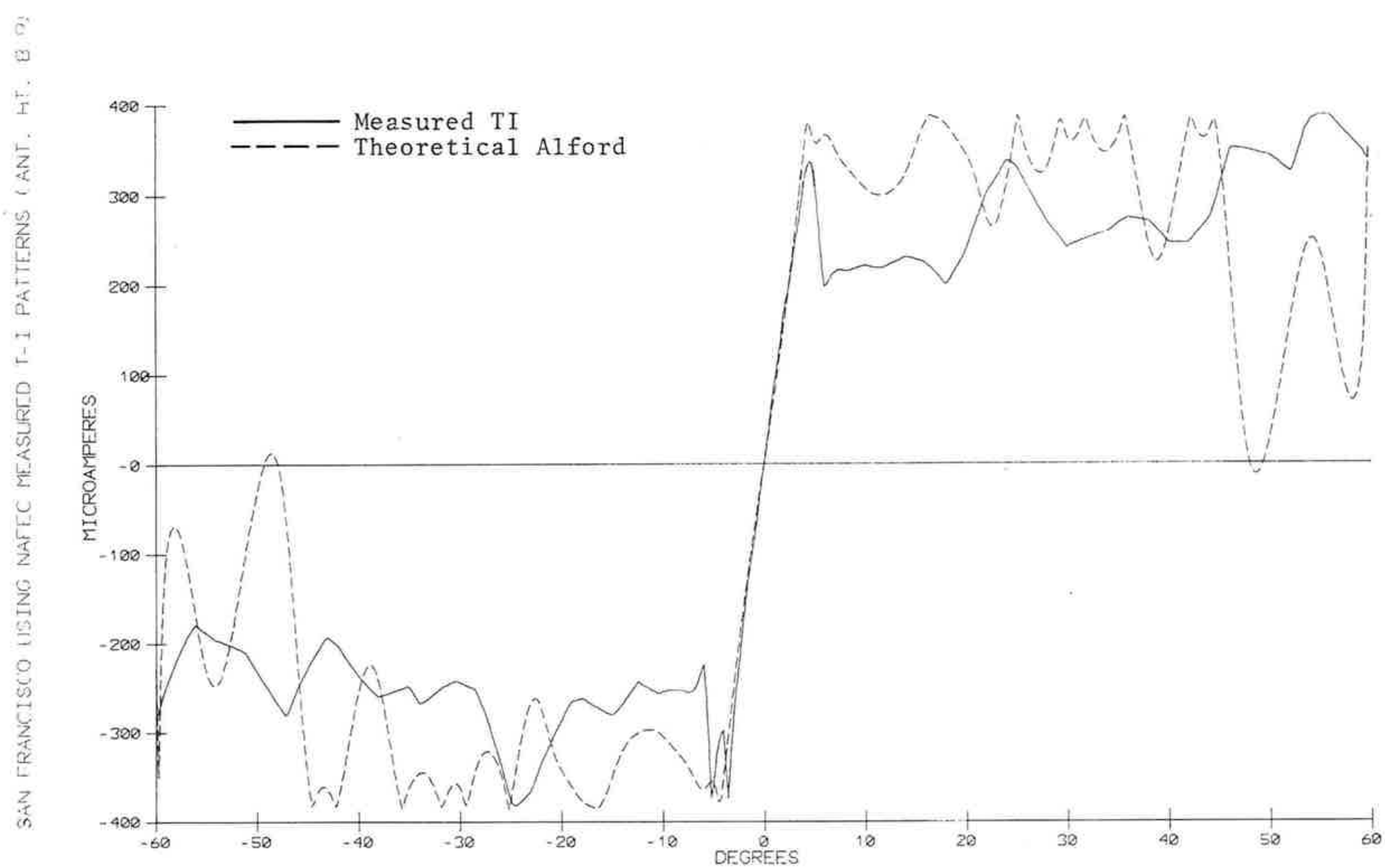

Figure 7b. Comparison of Alford and Texas Instruments Orbit CDI Patterns

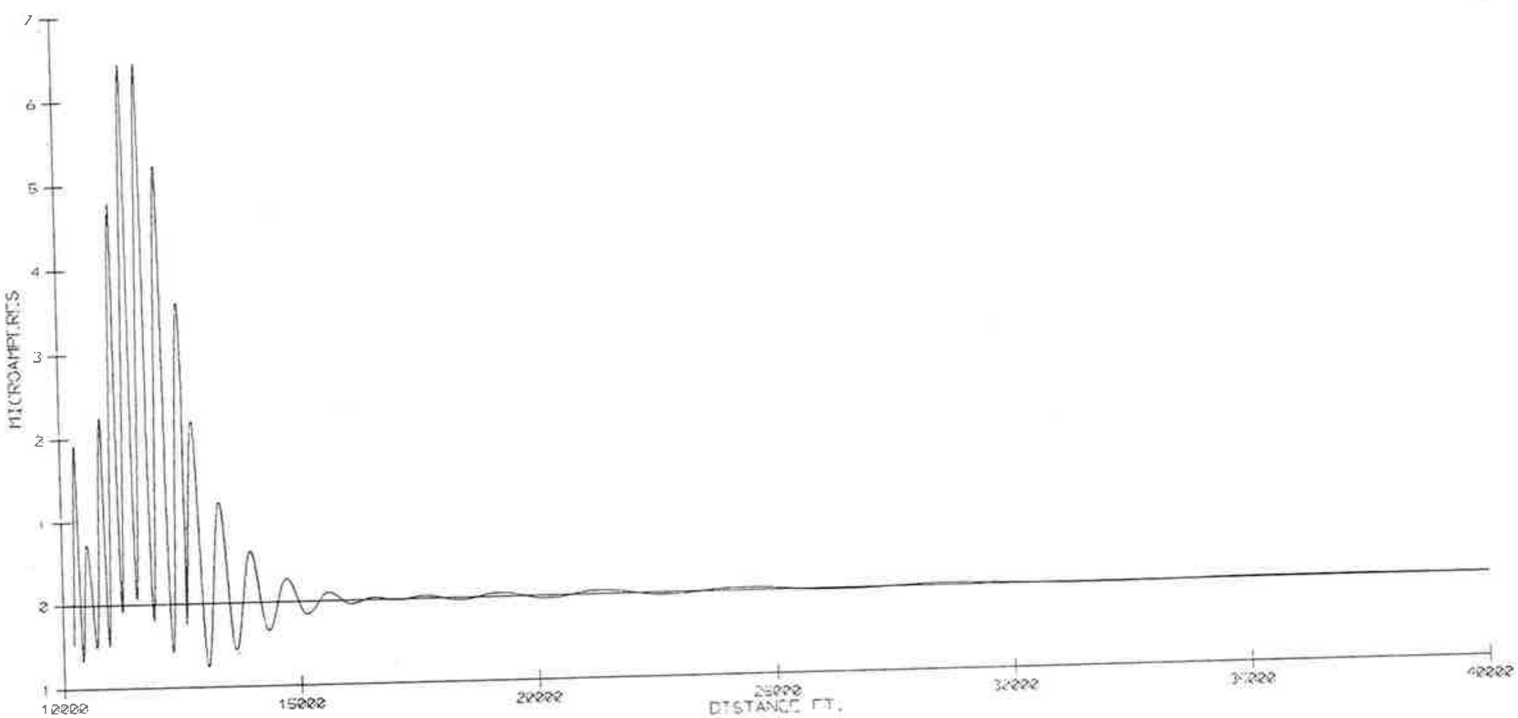

Figure 7c. On-Course CDI for an Alford 22/8 Array at San Francisco Operated at -16dB Clearance/Course Ratio -- Static Response