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An Improved HF Propagation Code for Ambient and Nuclear Stressed Ionospheric Environments

GTE Sylvania
189 "B" Street
Needham Heights, Massachusetts 02194

1 October 1976

Final Report for Period 19 April 1976 —30 September 1976

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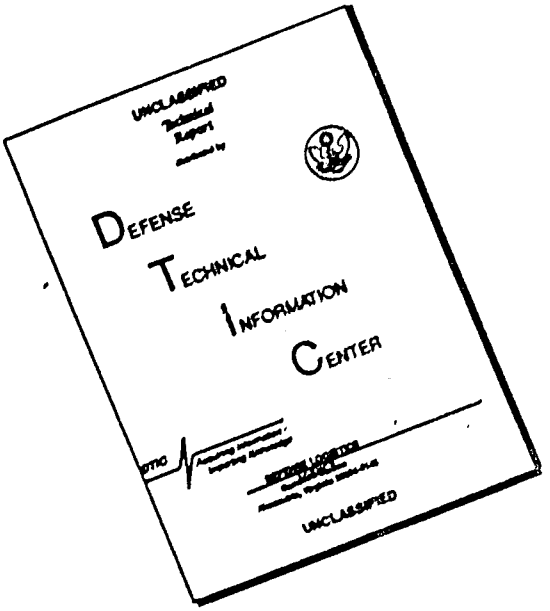
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The NUCOM/BREM computer code extends the NUCOM II HF propagation code to include direct ray and groundwave propagation modes for airborne and ground-based communications links. Provision is made for user-supplied airborne antenna patterns for both vertical and horizontal polarizations, and for corrected horizontal noise-factors for airborne terminals. A variety of airborne antenna patterns are included and sample links are evaluated. This

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20. ABSTRACT (Continued)

computer code greatly extends the usefulness of NUCOM II for the analysis of HF links employing airborne terminals and relay aircraft.

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SECTION 1.0

INTRODUCTION TO NUCOM/BREM

NUCOM II is a sophisticated and versatile HF communication prediction code for both ambient and nuclear stressed ionospheric environments [1,2]. However because NUCOM II considered only ionospherically propagated paths from ground-based terminals it could not be employed to predict the performance of groundwave and direct ray propagation between ground-based and elevated terminals. This limitation was particularly serious for the communication system analyst concerned with the performance of airborne HF assets in a nuclear environment.

A typical C^3 communications link employing an airborne terminal is shown in Figure 1-1. An HF link between an airborne command post and a ground entry point within radio line-of-sight is analyzed for nuclear induced propagation disturbances using both NUCOM II and NUCOM/BREM. Prior to the burst the dominant propagation mode found by each code is the 1E ionospheric skip mode which provides a received signal-to-noise ratio adequate for reliable communication. Five minutes after the detonation, however, the median signal-to-noise ratio predicted by NUCOM II is far below the acceptable threshold due to the high level of nuclear-induced nondeviative ionospheric absorption. The possibility that com-

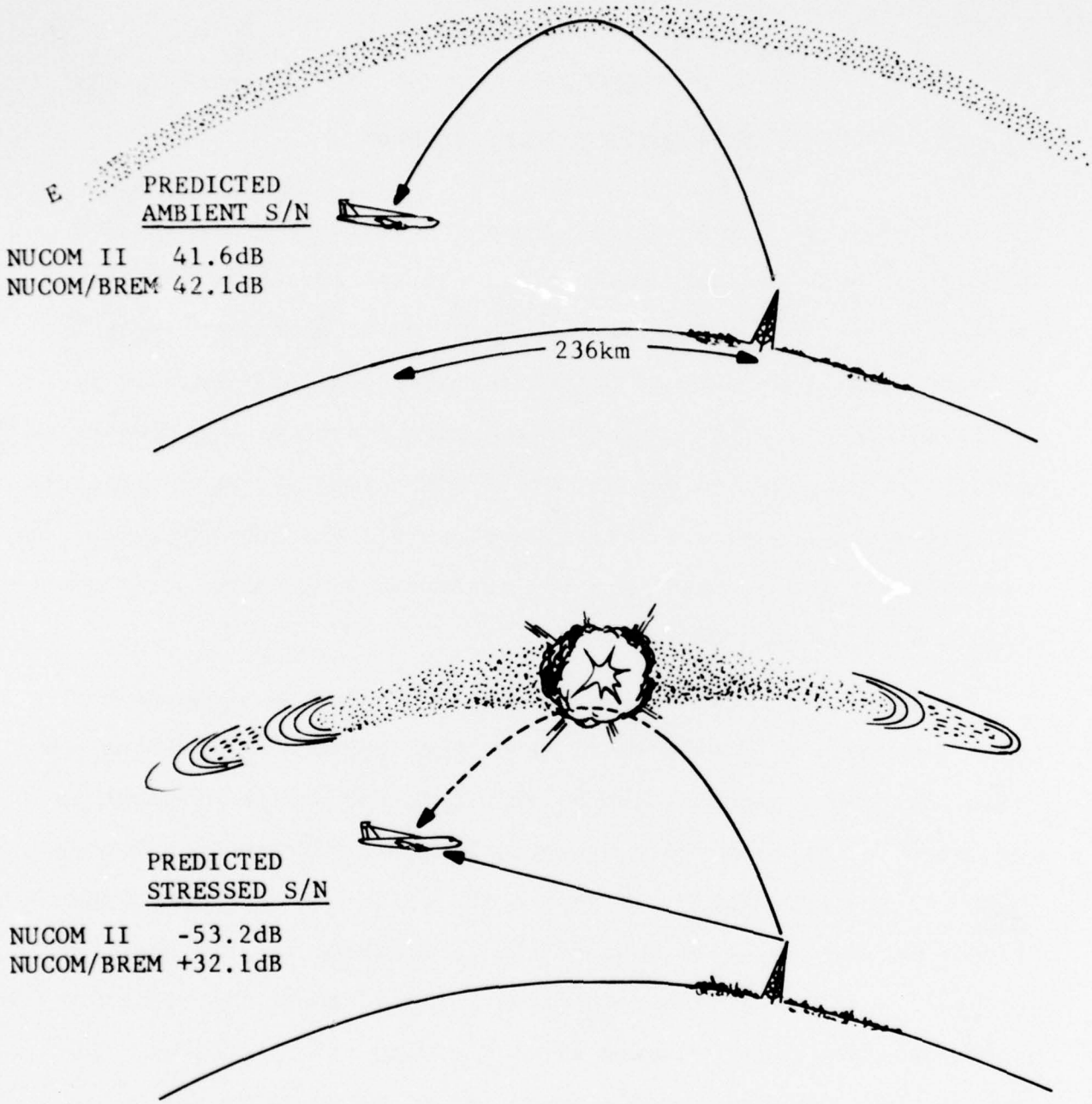


Figure 1-1. Comparison of Typical C^3 Links as Analyzed by NUCOM/BREM and NUCOM II

munication may continue through the post-attack environment via direct line-of-sight or extended groundwave modes is neglected by the unmodified NUCOM II code with the result that unduly pessimistic predictions of HF blackout result. This is especially important where elevated transmitters and/or receivers are concerned due to the substantial height gains which can provide extensive coverage using the groundwave mode. In fact the improved NUCOM/BREM code predicts that the direct signal ray path for the example will continue to support adequate HF communication in the absence of the ionospheric component as shown in Figure 1-1.

This neglect of nonionospheric propagation modes by the unmodified NUCOM II code and the resulting pessimistic predicted link performance for certain airborne assets in stressed environments is particularly troublesome in view of the critical importance of short distance air-to-ground airborne command post and TACAMO relay aircraft links in C^3 network analysis. Some typical types of C^3 circuits which cannot be analyzed by the unmodified NUCOM II code but are treated by NUCOM/BREM are illustrated in Figure 1-2.

The NUCOM/BREM propagation code described in this report extends the basic NUCOM II approach to include non-ionospheric HF propagation calculations for ground-to-ground, air-to-ground and air-to-air HF links. The groundwave and direct ray signal

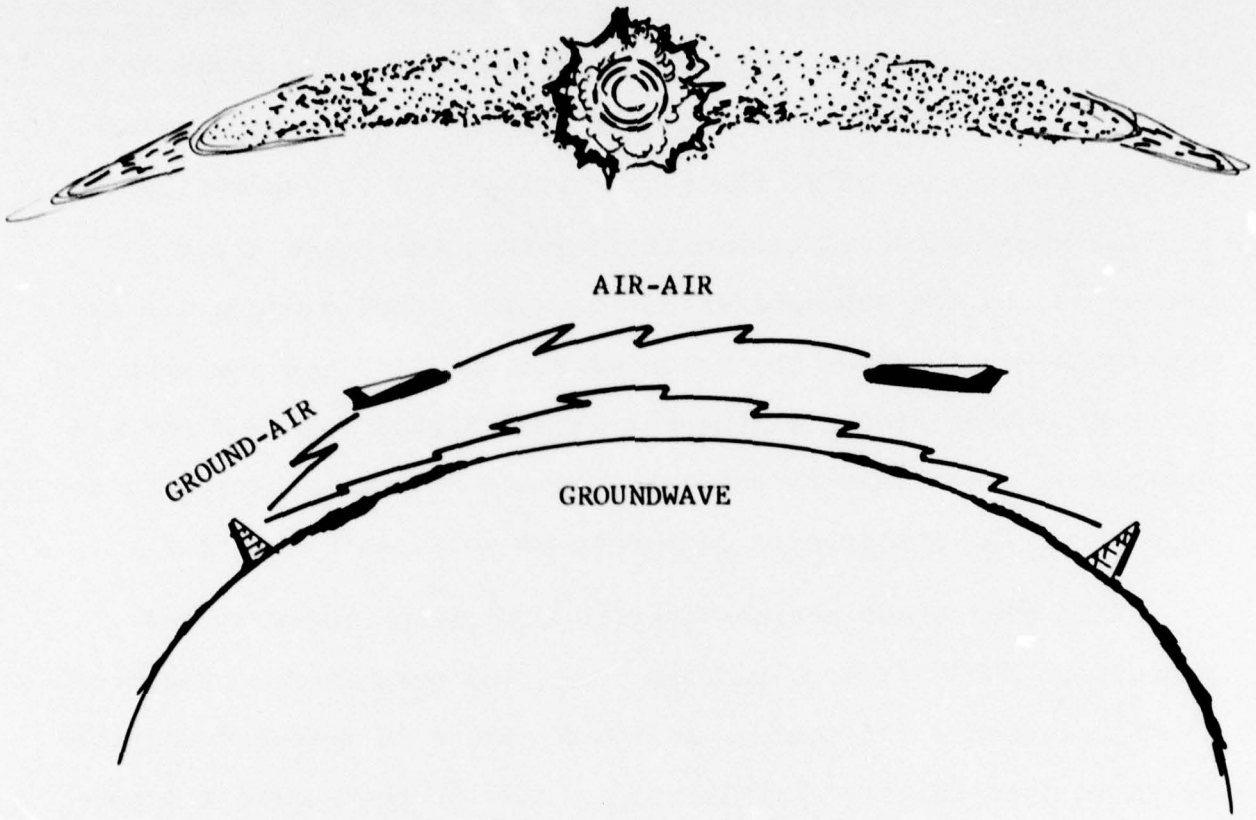


Figure 1-2. Types of C^3 radio links which cannot be analyzed by NUCOM II but are analyzed by NUCOM/BREM.

path field strengths are calculated with modified Bremmer[3] and van der Pol[4] equations independent of the normal ionospheric ray tracing calculations performed by the RAYTRACE subprogram of NUCOM II. The non-ionospheric HF signal paths are subsequently combined with the ionospheric ray paths in the COMEFF subprogram of NUCOM/BREM to yield a composite received signal power and an all mode signal-to-noise ratio. The overall computational architecture of NUCOM II and NUCOM/BREM is summarized in Figure 1-3. A more detailed description of the basic NUCOM II propagation code may be found in References 1 and 2.

Transmitting and receiving antenna gains may be either isotropic or arbitrary and specified in tabular format in both codes as provided by the user. The antenna vertical pattern input provisions for NUCOM II have been extended in NUCOM/BREM to also include negative radiation angles as required by elevated terminals. The input antenna pattern feature has been further modified to permit both horizontal and vertical polarization component pattern tables to be input independently. Direct ray and groundwave calculations are carried out separately for each polarization component in NUCOM/BREM since some elevated HF antennas may demonstrate strongly horizontal polarization patterns especially tail-to-fuselage wires, nose cap, and wing tip probes. Height gain functions for elevated terminals are calculated using

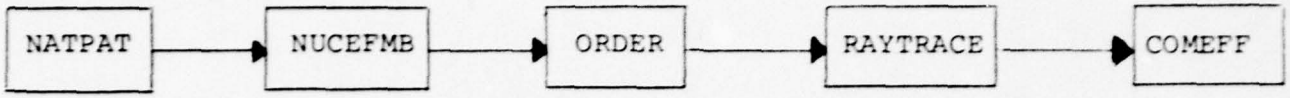


Figure 1-3. General Functional Program Architecture for NUCOM II and NUCOM/BREM

NATPAT - Calculates ambient ionospheric parameters control points along great circle path linking transmitter and receiver coordinates including atmospheric noise levels.

NUCEFMB - Calculates nuclear disturbances to ionospheric electron density vertical profiles.

ORDER - Orders nuclear-modified ionospheric profiles along the great circle circuit path between transmitter and receiver and includes shockwave effects (if present).

RAYTRACE- Calculates ionospheric ray paths through ambient and nuclear disturbed ionospheres and evaluates path losses for each ray path. Non-ionospheric ray path parameters are calculated in the NUCOM/BREM version.

COMEFF - Combines path loss and atmospheric noise level data from RAYTRACE with user input antenna and power information to calculate overall effects on received median signal-to-noise ratio.

modified Hankel functions of the first kind and order one-third [5].

The NUCOM/BREM code allows the user several options for the treatment of effective earth parameters for the calculation of groundwave field strengths. Effective ground conductivity and dielectric constants may be user input or automatically calculated from the ITS numerical world map data [6] in NUCOM/BREM. Two different methods of treatment for inhomogeneous ground paths are provided based upon the Suda [7] and Millington [8] techniques with the latter particularly suited for mixed land-sea signal paths.

A somewhat novel feature of NUCOM/BREM permits the user to assess the effects of sea state parameters on the apparent conductivity of the ocean surface for long distance groundwave signal paths. The condition of the sea surface along a groundwave path may be described by a user supplied average wind velocity which is used to compute the effective sea surface conductivity in the fashion of Barrick [9] and Kaliszewski [10].

Provision is also made in the NUCOM/BREM code for the inclusion of a user-specified horizontally polarized HF noise-height compensation factor to provide appropriate atmospheric noise level values for predominantly horizontally polarized airborne HF antennas.

The final output of the NUCOM/BREM code is the all-mode median received signal-to-noise ratio, P_{TA}, given by

$$P_{TA} = 10 \text{ Log}_{10} \left\{ \frac{P_{TI} + P_{TV} + P_{TH}}{P_{NV} + P_{NH}} \right\} \text{ dBW} \qquad (1\text{-}1)$$

where

P_{TI} is the total received ionospheric signal power density,

P_{TH} is the total received non-ionospheric signal power density polarized in the horizontal plane,

P_{TV} is the total received non-ionospheric signal power density polarized in the vertical plane,

P_{NV} is the received atmospheric noise density in the vertical plane and

P_{NH} is the received atmospheric noise density in the horizontal plane.

This report details the modifications to NUCOM II to incorporate these features and discusses the applicability and limitations of the non-ionospheric propagation calculations. Sample calculations are presented and discussed for typical link geometries and examples of airborne HF antenna patterns are provided for the guidance of the user.

NUCOM/BREM is coded in IBM FORTRAN IV G for the IBM System 370/145.

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SECTION 2.0

DESCRIPTION OF ANALYTIC APPROACH

2.1 Calculation of Uncompensated Field Strength

The NUCOM II subprogram RAYTRACE calculates an effective path loss for each ionospheric ray and incorporates this path loss figure into a power flux summation expression in COMEFF which gives the total received ionospheric signal power density for all propagating rays on the circuit, P_{TI}, as follows:

$$P_{TI} = \sum_{i=1}^{n} \frac{P_o(GT_i)(GR_i)c^2}{4\pi a \log_{10}(Li/10) * f^2 * 10^{12}} \quad \text{(Watts)} \qquad (1\text{-}2)$$

where

P_o = transmitter power density in W/Hz

GT_i = power gain of transmitting antenna at θ and ϕ in question, relative to isotropic

GR_i = power gain of receiving antenna at θ and ϕ in question, relative to isotropic

Li = path loss for i-th ray including free space loss, ground reflection, deviative and nondeviative absorption and defocussing losses

c = velocity of light

f = frequency in MHz

n = number of found ionospheric rays, and

ϕ, θ = elevation and azimuth angles respectively.

Because of reciprocity we may categorize all non-ionospheric paths in the present application as consisting of one or more of the following computational types:

a. Direct Ray (line-of-sight)

b. Groundwave, and

c. Reflected Ray.

The analytic approach of the Bremmer-van der Pol computational algorithms makes expression of the nonionospheric components in the formulation of Equation (1-2) somewhat awkward however. Instead we shall first calculate the groundwave and direct ray electric field strengths at the receiver assuming that radiation occurs from an optimally oriented elementary electric dipole radiating the ideal one kilowatt effective power as defined by Bremmer [3]. The resulting value of received field strength will then be compensated for user specified antenna gains and actual transmitted power density to yield a value of received power which can then be directly combined with the ionospheric ray power flux summation in COMEFF to yield the all mode expression shown in Equation 1-1. This process is repeated for each polarization component and the term uncompensated received field will be used to refer to the calculated basic Bremmer-van der Pol received electric field value before adjustment for actual transmitter powers and antenna gains. This approach has the additional advantage of readily permitting compari-

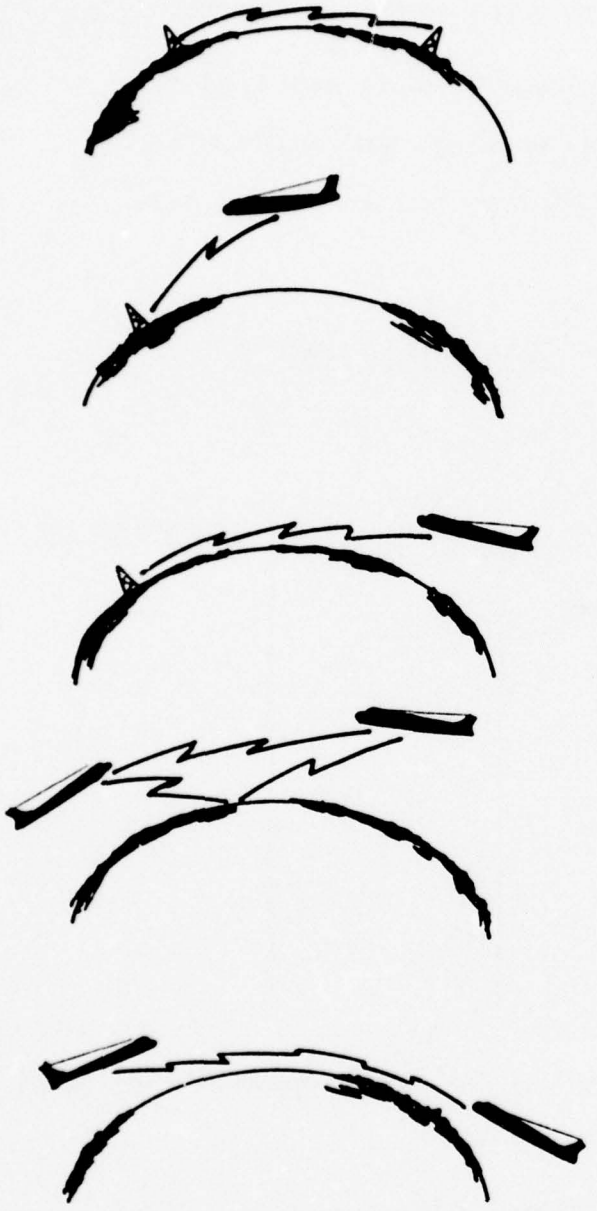


Figure 2-1 Types of Nonionospheric Computational Geometry

son of results with the tabulated values given by Bremmer [3].

Table 2-1 shows the types of computations required for each of the five different geometries which may exist with airborne terminals and which are illustrated in Figure 2-1.

TABLE 2-1

TYPES OF NON-SKY WAVE COMPUTATIONAL GEOMETRY

	Groundwave	Direct Ray	Reflected Way
Both terminals on ground	X		
One airborne terminal line of sight	X		
One airborne terminal, beyond horizon	X		
Both terminals airborne, line of sight		X	X
Both terminals airborne, beyond horizon	X		

In the following sections we discuss each computational type in turn.

2.1.1 Groundwave Field Strength Calculation

This computation employs the Bremmer-van der Pol equations with height gain evaluation using modified Hankel functions of

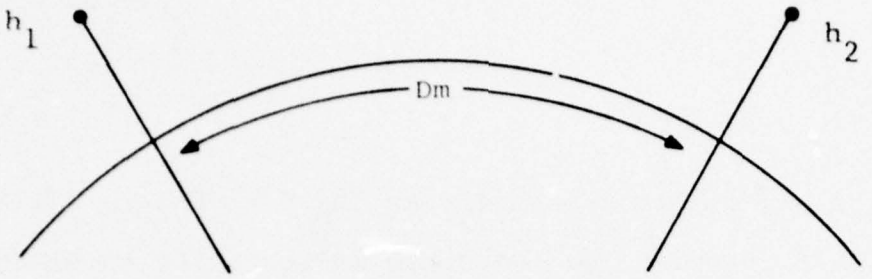


Figure 2-2 (a) Definition of variables in groundwave calculation.

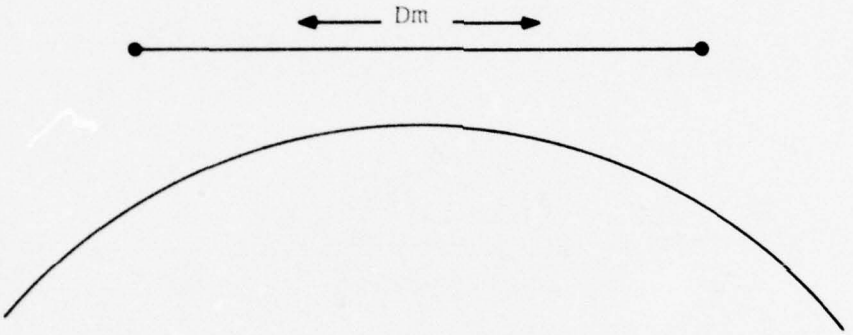


Figure 2-2 (b) Definition of variables used in direct ray analysis.

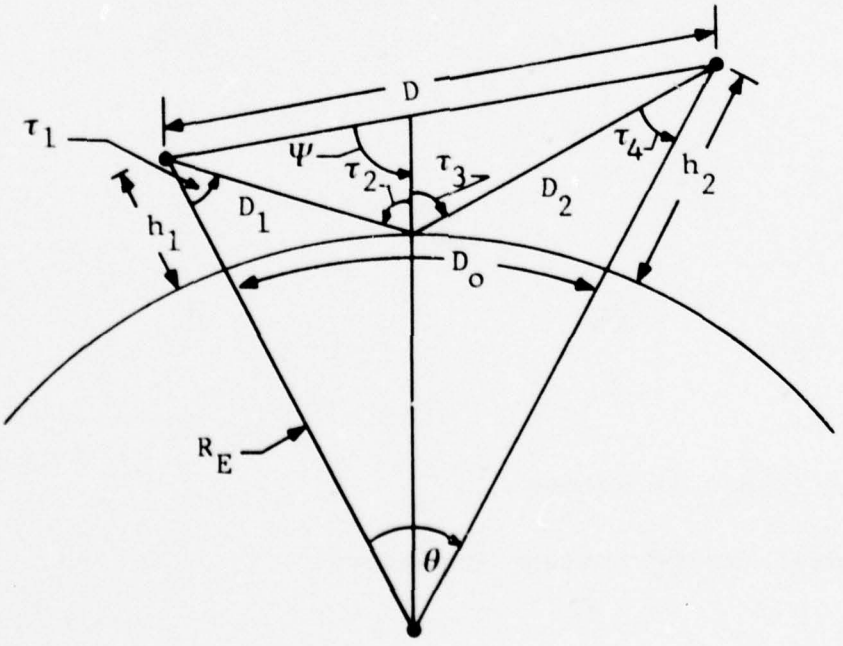


Figure 2-2 (c) Definition of variables used in reflected ray analysis.

the first kind and order one-third. As shown in Figure 2-2(a), for the standard one-kW transmitted ERP as specified by Bremmer and a short optimally oriented dipole of appropriate polarization orientation the uncompensated rms field strength (μV/m) as given by Bremmer (op. cit.) is:

$$E = \frac{752.0}{D_m} \sqrt{\chi} \left| \sum_{s=o}^{\infty} f_s(h_1) f_s(h_2) \frac{e^{i\tau_s \chi}}{2\tau_s - 1/\delta_e^2} \right| \quad \mu V/m \qquad (2\text{-}1)$$

$$K_e = 0.002924 \, \lambda_m^{1/3} \frac{\sqrt{\varepsilon^2 + 36 \cdot 10^{24} \sigma_e^2 \lambda_m^2}}{\sqrt[4]{(\varepsilon - 1)^2 + 36 \cdot 10^{24} \sigma_e^2 \lambda_m^2}} \qquad (2\text{-}2)$$

$$\psi_e = \arctan\left(\frac{\varepsilon}{6.10^{12} \sigma_e \lambda_m}\right) - \frac{1}{2} \arctan\left(\frac{\varepsilon - 1}{6.10^{12} \sigma_e \lambda_m}\right) \qquad (2\text{-}3)$$

$$\chi = 53.7 \frac{D_m}{\lambda_m^{1/3}} \qquad (2\text{-}4)$$

$$\delta_e = K_e e^{i(135^o - \psi_e)} \qquad (2\text{-}5)$$

D_m = distance in meters

ε = dielectric constant (relative)

σ_e = conductivity, e.m.u. units

λ_m = wavelength in meters

h_i = transmitter height in meters

h_2 = receiver height in meters

The values of τ_s follow from ($\tau_s = \mathrm{Re}\,\tau_s + i\,\mathrm{Im}\,\tau_s$)

(a) K_e small:

$$\mathrm{Im}\,\tau_o = 1.607 - K_e \sin(45^o + \psi_e) - 1.237\,K_e^3 \sin(75^o + 3\psi_e) + \\ + \tfrac{1}{2} K_e^4 \sin(4\psi_e) - 2.755\,K_e^5 \sin(75^o - 5\psi_e) \ldots$$

$$\mathrm{Im}\,\tau_1 = 2.810 - K_e \sin(45^o + \psi_e) - 2.163\,K_2^3 \sin(75^o + 3\psi_e) + \\ + \tfrac{1}{2} K_e^4 \sin(4\psi_e) - 8.422\,K_e^5 \sin(75^o - 5\psi_e) \ldots \qquad (2\text{-}6)$$

$$\mathrm{Im}\,\tau_2 = 3.795 - K_e \sin(45^o + \psi_e) - 2.921\,K_e^3 \sin(75^o + 3\psi_e) + \\ + \tfrac{1}{2} K_e^4 \sin(4\psi_e) - 15.36\,K_e^5 \sin(75^o - 5\psi_e) \ldots$$

$$\mathrm{Im}\,\tau_s \sim 1.932(s + 3/4)^{2/3} - K_e \sin(45^o + \psi_e) \ldots \quad (s > 2)$$

$$\text{Re}\,\tau_o = 0.928 + K_e\cos(45^o + \psi_e) + 1.237\,K_e^3\cos(75^o + 3\psi_e) -$$

$$- \tfrac{1}{2}K_e^4\cos(4\psi_e) - 2.775\,K_e^5\cos(75^o - 5\psi_e)\cdots$$

$$\text{Re}\,\tau_1 = 1.622 + K_e\cos(45^o + \psi_e) + 2.163K_e^3\cos(75^o + 3\psi_e) -$$

$$- \tfrac{1}{2}K_e^4\cos(4\psi_e) - 8.422\,K_e^5\cos(75^o - 5\psi_e)\cdots \qquad (2\text{-}6)$$

$$\text{Re}\,\tau_2 = 2.191 + K_e\cos(45^o + \psi_e) + 2.921\,K_e^3\cos(75^o + 3\psi_e) -$$

$$- \tfrac{1}{2}K_e^4\cos(4\psi_e) - 15.36\,K_e^5\cos(75^o - 5\psi_e)\cdots$$

$$\text{Re}\,\tau_s \sim 1.116(s + 3/4)^{2/3} + K_e\cos(45^o + \psi_e)\cdots \quad (s > 2)$$

(b) K_e large:

$$\text{Im}\,\tau_o = 0.7003 - 0.6183\,\frac{\sin(15^o - \psi_e)}{K_e} + 0.2364\,\frac{\cos(2\psi_e)}{K_e^2} -$$

$$- 0.0533\,\frac{\sin(15^o + 3\psi_e)}{K_e^3} - 0.00226\,\frac{\sin(60^o - 4\psi_e)}{K_e^4}\cdots$$

$$\text{Im}\,\tau_1 = 2.232 - 0.1940\,\frac{\sin(15^o - \psi_e)}{K_e} + 0.0073\,\frac{\cos(2\psi_e)}{K_e^2} +$$

$$+ 0.0120\,\frac{\sin(15^o + 3\psi_e)}{K_e^3} + 0.00160\,\frac{\sin(60^o - 4\psi_e)}{K_e^4}\cdots$$

$$\text{Im}\,\tau_s \sim 1.932\,(s + 1/4)^{2/3} - \frac{0.2241}{(s + 1/4)^{2/3}}\,\frac{\sin(15^o - \psi_e)}{K_e}\cdots \quad (s > 1)$$

$$\mathrm{Re}\,\tau_o = 0.4043 + 0.618\,\frac{\cos(15^o - \psi_e)}{K_e} - 0.236\,\frac{\sin(2\psi_e)}{K_e^2} -$$

$$- 0.0533\,\frac{\cos(15^o + 3\psi_e)}{K_e^3} + 0.00226\,\frac{\cos(60^o - 4\psi_e)}{K_e^4} \cdots \qquad (2\text{-}7)$$

$$\mathrm{Re}\,\tau_1 = 1.288 + 0.194\,\frac{\cos(15^o - \psi_e)}{K_e} - 0.0073\,\frac{\sin(2\psi_e)}{K_e^2} +$$

$$+ 0.0120\,\frac{\cos(15^o + 3\psi_e)}{K_e^3} - 0.00160\,\frac{\cos(60^o - 4\psi_e)}{K_e^4} \cdots$$

$$\mathrm{Re}\,\tau_s \sim 1.116(s + 1/4)^{2/3} + \frac{0.2241}{(s + 1/4)^{2/3}}\,\frac{\cos(15^o - \psi_e)}{K_e} \cdots (s > 1)$$

The height gain factor $f_s(h_1)$ is computed from

$$f_s(h_1) = \sqrt{\frac{\chi_1^2 - 2\tau_s}{-2\tau_s}}\;\frac{H_{1/3}^{(1)}\left\{\frac{1}{3}(\chi_1^2 - 2\tau_s)^{3/2}\right\}}{H_{1/3}^{(1)}\left\{\frac{1}{3}(-2\tau_s)^{3/2}\right\}} \qquad (2\text{-}8)$$

(for the value of $H_{1/3}$, see Appendix C; $\mathrm{Im}(\chi_1^2 - 2\tau_s) < 0$ and $\mathrm{Im}(-2\tau_s) > 0$)

in which

$$\chi_1^2 = 0.03674\,\frac{h_{1m}}{\lambda_m^{2/3}} \qquad (2\text{-}9)$$

or as follows when $|\delta| << 1$:

(a) approximately $h_{1\,m} > 60\lambda_m^{2/3}$:

$$f_s(h_1) = e^{-i\pi/4 + \frac{i}{3}(\chi_1^2 - 2\tau_s)^{3/2}}\{1 - i\frac{0.2083}{(\chi_1^2 - 2\tau_s)^{3/2}} - \frac{0.3342}{(\chi_1^2 - 2\tau_s)^3} \ldots\} -$$

$$A_s \frac{-e^{i\pi/4 - \frac{i}{3}(\chi_1^2 - 2\tau_s)^{3/2}}\{1 + i\frac{0.2083}{(\chi_1^2 - 2\tau_s)^{3/2}}\}}{\delta_e \sqrt[4]{\chi_1^2 - 2\tau_s}} \qquad (2\text{-}10)$$

$(-45^o < \arg \sqrt[4]{} < 0)$

$A_o = 0.3582\ e^{i120^o}$; $\qquad A_1 = 0.3129\ e^{-i60^o}$

$A_2 = 0.2903\ e^{i120^o}$ $\qquad A_3 = 0.2760\ e^{-i60^o}$

$$A_s = 0.3440\ \frac{(-1)^{s+1}}{(s + 3/4)^{1/6}}\ e^{-i\pi/3} \qquad (s > 3) \qquad (2\text{-}11)$$

(b) approximately $h_{1\,m} < 60\lambda_m^{2/3}$:

$$f_s(h_1) = 1 + 6.283\left(\frac{1}{x^{1/3}\,\delta_e} - \frac{1}{x}\right)\frac{h_1}{\lambda} - 39.48\ \frac{(1 - x^{2/3}\delta_\varepsilon \tau_s)}{x^{4/3}\delta_e}\left(\frac{h_1}{\lambda}\right)^2 \ldots,$$

in which

$$x = \frac{4.10^7}{\lambda_m}\ . \qquad (2\text{-}12)$$

The second height-gain factor is computed in the same way except that h_1 is replaced by h_2. The same formula apply to the horizontal dipole, δ_e being replaced by δ_m where

$$\delta_m = K_m e^{i(45^o + \psi_m)} \quad . \tag{2-13}$$

These expressions thus provide the uncompensated field strength at the receiver for each polarization mode. The received power density is then obtained by compensating the results of the above calculations for user specified antenna gains and actual power density as described in Section 2.3.

2.1.2 Direct Ray Calculation

The power flux due to an isotropic radiator at a distance d is given by:

$$P_F = \frac{P_T}{4\pi d^2} \quad \text{Watts/meter}^2 \tag{2-14}$$

when d is expressed in meters, and P_T is the total radiated power in Watts. The power gain of a short maximally oriented dipole relative to isotropic is 1.5 which gives a flux at the receiver of

$$P_F = \frac{1.5\ P_T}{4\pi d^2} \quad \text{Watts/meter}^2 \tag{2-15}$$

Equating this expression to power flux in terms of rms field strength and rearranging yields

$$E = \left[\frac{1.5\,\eta_o\,P_T}{4\pi d^2\sqrt{2}}\right]^{1/2} \quad \text{Volts/meter} \qquad (2\text{-}16)$$

where η_o is the characteristic impedance of free space ($\simeq 120\,\pi$). For the standard 1 kW ERP of Bremmer (op. cit.) this reduces to

$$E = \frac{1.50 * 10^5}{d} \quad \mu v/m \qquad (2\text{-}17)$$

where d is expressed in kilometers. This is the direct ray field strength at a distance D from a 1 kW ERP transmitter using a short optimally oriented dipole remote from ground. Note that the same expressions may be employed to predict both horizontal and vertical polarization components.

This expression is employed to evaluate the line-of-sight direct ray between airborne terminals as shown in Figure 2-2(b). The ground reflected component is evaluated separately as described in 2.1.3.

2.1.3 Reflected Ray Calculations

A line-of-sight signal path between elevated terminals may be decomposed into a direct and a reflected ray for each polarization type. The direct ray is subject only to free space transmission loss as discussed in Section 2.1.2.

The reflected ray losses may be considered to result from three sources: free space loss over the total path length, the

Fresnel reflection loss at the surface, and the defocusing or divergence loss at reflection due to the convex shape of the assumed perfectly spherical surface of the earth. For the standard 1 kW ERP of Bremmer and an optimally oriented dipole the received reflected field strength as shown in Figure 2-2(c) is given by Bremmer[3] as:

$$E = \frac{150}{D} \left| \alpha \frac{D}{(D_1 + D_2)} R(\tau_2) e^{2\pi i \frac{\Delta}{\lambda}} \right| \mu V/m \qquad (2\text{-}18)$$

$$\alpha = \frac{R_e (D_1 + D_2) \sqrt{\sin \tau_2 \cos \tau_2}}{\sqrt{b \cdot \gamma \cdot \theta (D_1 \gamma \cos \tau_4 + D_2 b \cos \tau_1)}} \qquad (2\text{-}19)$$

where τ_1, τ_2, τ_4, D_1, and D_2 are as defined in Figure 2-2(c) and

$a = R_e$ (or equivalent earth radius)

$b = R_e + h_t$

$\gamma = R_e + h_r$

in which

$$R(\tau_2) = \begin{cases} \dfrac{\mu^2 \cos\tau_2 - \sqrt{\mu^2 - \sin^2\tau_2}}{\mu^2 \cos\tau - \sqrt{\mu^2 - \sin^2\tau_2}}, & \text{(vertical dipole)} \\ \dfrac{\cos\tau_2 - \sqrt{\mu^2 - \sin^2\tau_2}}{\cos\tau_2 + \sqrt{\mu^2 - \sin^2\tau_2}}, & \text{(horizontal dipole)} \end{cases} \qquad (2\text{-}20)$$

$$\mu^2 = \sqrt{\varepsilon^2 + 36\cdot 10^{24}\,\sigma_e^2\lambda_m^2}\; e^{\,i \arctan(6\cdot 10^{12}\sigma_e\lambda_m/\varepsilon)},$$

or, for $\tau_2 \sim \pi/2$:

$$R(\tau_2) = -1 - 2\,ix^{1/3}\,\delta\cos\tau_2 + 2x^{2/3}\,\delta^2\cos^2\tau_2 \ldots \qquad (2\text{-}21)$$

$$\left(x = \frac{4\cdot 10^7}{\lambda_m}\;;\; \delta = \delta_e,\ \delta_m \text{ resp.}\right)$$

τ_2, D_1, D_2 and Δ are to be determined in succession from

$$\tan\tau_2 = \frac{D_o}{(h_1 + h_2)} + \frac{D_o\ km}{6366}\,\frac{(h_1^2 + h_2^2)}{(h_1 + h_2)^2}\left(1 + \frac{D_o^2}{2(h_1+h_2)^2}\right)\ldots, \qquad (2\text{-}22)$$

(D_o, distance measured along the earth's surface between the projections of the transmitter and the receiver)

$$\cos \tau_1 \sim \sqrt{\cos^2 \tau_2 + 3.142 \cdot 10^{-7} \sin^2 \tau_2 \, h_1 m} \,,$$

$$\cos \tau_4 \sim \sqrt{\cos^2 \tau_2 + 3.142 \cdot 10^{-7} \sin^2 \tau_2 \, h_2 m} \,, \qquad (2\text{-}22)$$

$$D_1 \text{ km} \sim 6366(\cos\tau_1 - \cos\tau_2) + 0.001 \cos\tau_1 h_1 m \,,$$

$$D_2 \text{ km} \sim 6366(\cos\tau_4 - \cos\tau_2) + 0.001 \cos\tau_4 h_2 m \,, \qquad (2\text{-}23)$$

$$\cot\psi = \frac{(D_2 - D_1)}{(D_2 + D_1)} \cot\tau_2, \qquad (2\text{-}24)$$

$$\Delta = \left(\frac{\sin_\psi}{\sin_2} - 1 \right) D \qquad (2\text{-}25)$$

and $R_E = 6366$ km.

2.2 Calculation of Effective Ground Parameters

The conductivity σ and dielectric constant ε on the surface of the earth determine not only the reflection coefficient for an HF signal reflected from the ground surface but also the rate of attenuation of a groundwave signal with distance. For a perfectly homogeneous spherical earth the groundwave predictive techniques of Bremmer and van der Pol provide excellent solutions. Except possibly for paths along smooth sea surfaces, however, real signal paths are usually inhomogeneous. The complete solution for groundwave propagation along an inhomogeneous unsmooth path whose ground parameters may vary with distance requires extensive numerical integration of the Volterra equations as well as a detailed description of both the ground parameters and vertical terrain profiles along the entire path [1,2]. Since few, if any, paths can be so completely specified, a variety of approximation techniques have been developed and tested against real measurements by various authors in an attempt to simplify the prediction of groundwave signal strengths over inhomogeneous paths. Both the Millington (op.cit.) and Suda(op. cit.) techniques have been extensively applied to practical broadcasting problems for many years and usually provide reasonable agreement with measurements. The reader is referred to Sections 2.2.2 and 2.2.3 and to the original papers by these authors for further details.

Depending upon the particular groundwave path to be analyzed by NUCOM/BREM the user has several options insofar as inhomogeneous groundwave analysis is concerned within the scope of the Suda and

Millington techniques. Generally speaking the Suda technique should provide more realistic predictions when the variations in surface parameters are relatively gradual along the path whereas the Millington approach is more suitable for sharp transitions such as mixed land-sea paths. The user is urged to compare the results of both techniques in questionable cases and to interpret the results for complex inhomogeneous paths with some care.

One particular type of inhomogeneous path geometry which deserves special comment is that featuring a sharp land-to-sea boundary. From the earliest days of radio research it has been known that transmission and reception at coastal stations sited near the sea often differs markedly from that at nearby sites further inland from the beach. Two types of anomalous behavior are commonly observed near land-sea interfaces: distorted direction finding behavior and anomalous variations of signal amplitude. While the rather misleading term "coastal refraction" continues to be used to describe these coastal effects, the work of Grunberg [3], Millington [4], Wait [5] and others [6,7] has shown both analytically and experimentally that these coastal phenomena must be described in terms of diffraction-like interface boundary effects. The "anomalous" amplitude variations near land-sea interfaces are generally termed "recovery effects" and are beyond the scope of the present analysis. Complete prediction of the HF field strength behavior near a land-sea boundary requires detailed description of the subsurface interface geometry as has been shown by Wait and Spies [8] although Millington [4] and others [9,10] have shown experimentally that the "Millington Technique" yields good results in areas away from the

interface region. It is suggested that calculations made by NUCOM/BREM employing the Millington technique (see Section 2.2.3) should be considered as possibly suspect within 100λ of the interface due to these boundary effects.

The groundwave calculation subroutines in NUCOM/BREM assume a homogeneous earth surface and require as input both conductivity σ and relative dielectric constant ε. NUCOM/BREM permits use of either a user specified set of ground constants or the calculation of effective mean homogeneous ground constants for nonionospheric paths from the ITS numerical map data in NUCOM/BREM using the method of Suda (op.cit.). Furthermore the user has the option of either a homogeneous path solution or an approximate inhomogeneous solution employing the method of Millington.

NUCOM II and NUCOM/BREM require ground constant data to calculate the Fresnel ground reflection loss coefficients in RAYTRACE as part of the determination of total ray path loss for ionospheric rays as well as for groundwave calculations of path loss. Figure 2-3 shows the program flow for the NUCOM II and NUCOM/BREM ground reflection calculations. NATPAT reads the ITS "Blue Binary" world ground numerical map [11] from logical unit 1 and transfers the coefficients to logical unit 4 for later use by RAYTRACE. These world map coefficients have been produced from geographical world maps of ground constants using the well-known spherical harmonic techniques of Jones and Gallet [12].

When RAYTRACE needs to calculate the ground loss at a geographical particular point on the surface of the earth it passes the geographical coordinates, frequency, and ray arrival angle to the

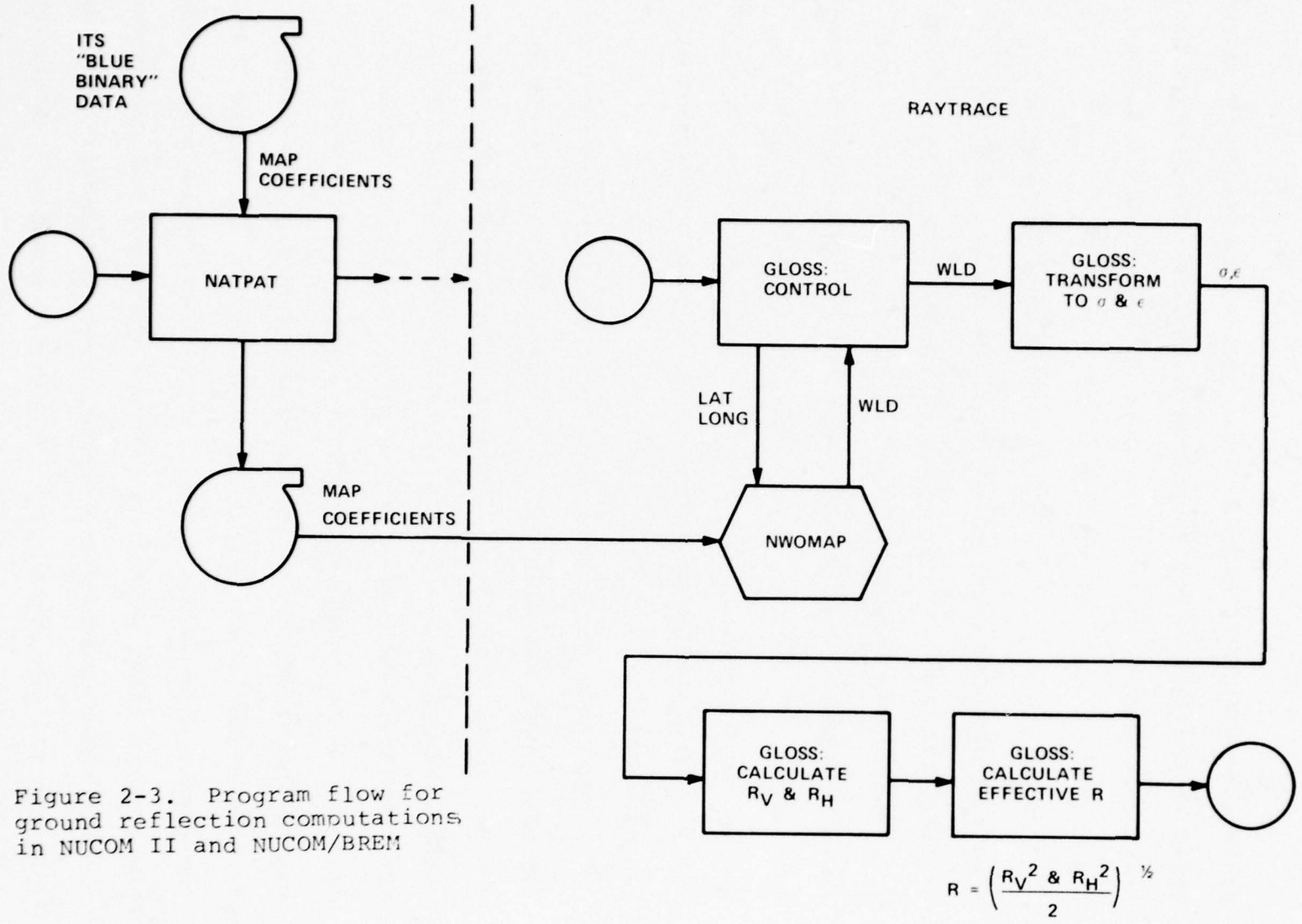


Figure 2-3. Program flow for ground reflection computations in NUCOM II and NUCOM/BREM

subroutine GLOSS. GLOSS, in turn, passes the geographical coordinates to the subroutine NWOMAP which applies the inverse mapping transformation to the coefficients read from unit 4 and returns a dimensionless variable WLD to GLOSS.

Using the conversion factors described in Section 2.2.1 GLOSS then converts the returned value of WLD to a conductivity and dielectric constant for the point in question as shown in Figure 2-3.

The subroutine GLOSS then applies the ordinary Fresnel reflection equations to the ground constants so determined to yield the horizontal and vertical reflection coefficients, R_H and R_V, whose RMS value is taken as the effective average reflection coefficient for a randomly polarized skywave approaching the ground at the point in question.

NUCOM/BREM determines the effective ground parameters needed for groundwave calculations as follows. The user first specifies whether he is providing his own effective ground constants or wishes them to be automatically calculated from the ITS world map data available on unit 4 from NATPAT. He further specifies whether the path is to be considered homogeneous or heterogeneous. If the user is providing the effective constants they are directly employed for the analysis and computation proceeds as in Figure 2-4(a). If the user wishes to use map data for a homogeneous path calculation the program calls NWOMAP to evaluate the numerical coefficients at each of the n points whose geographical coordinates have been defined by the particular path geometry in question. After conversion of the map variable values to ground parameters the effective mean

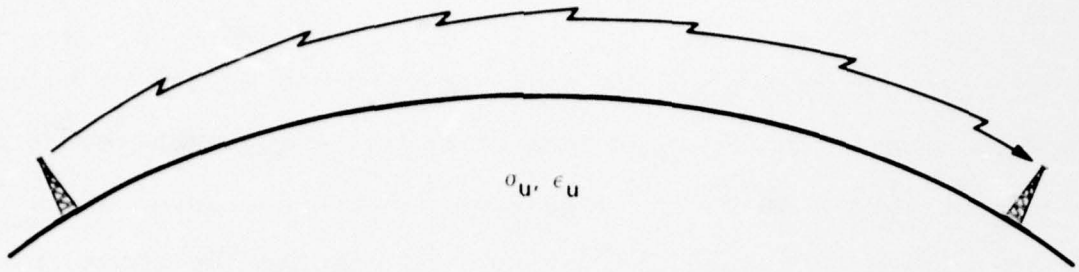
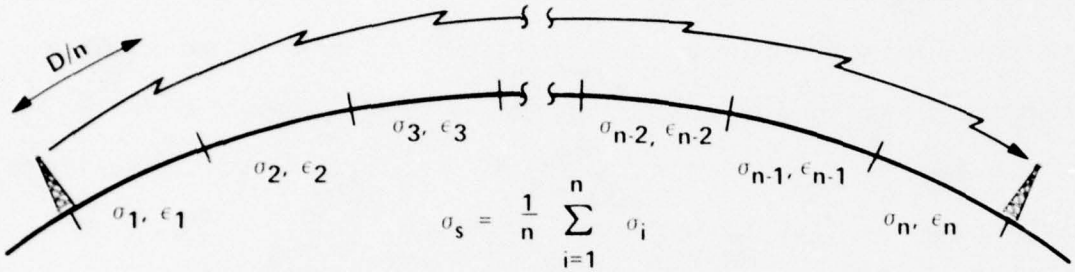


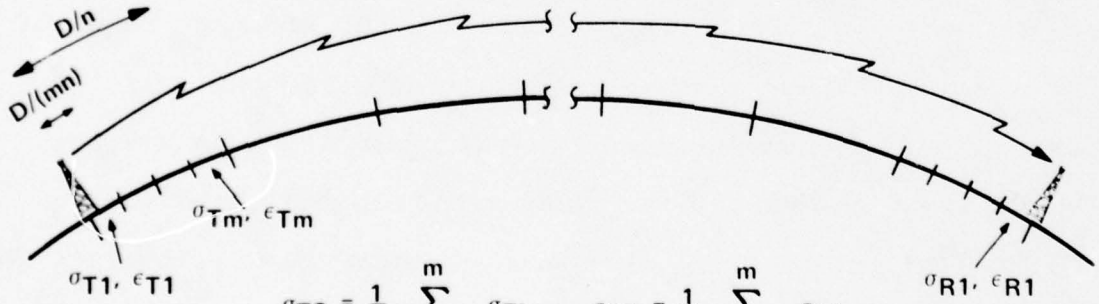
FIGURE 2-4(a). HOMOGENEOUS, USER SUPPLIED CONSTANTS



$$\sigma_s = \frac{1}{n} \sum_{i=1}^{n} \sigma_i$$

$$\epsilon_s = \frac{1}{n} \sum_{i=1}^{n} \epsilon_i$$

FIGURE 2-4(b). NONHOMOGENEOUS, SUDA METHOD



$$\sigma_{TS} = \frac{1}{m} \sum_{i=1}^{m} \sigma_{Ti} \qquad \sigma_{RS} = \frac{1}{m} \sum_{i=1}^{m} \sigma_{Ri}$$

$$\epsilon_{TS} = \frac{1}{m} \sum_{i=1}^{m} \epsilon_{Ti} \qquad \epsilon_{RS} = \frac{1}{m} \sum_{i=1}^{m} \epsilon_{Ri}$$

FIGURE 2-4(c). NONHOMOGENEOUS, MILLINGTON METHOD

constants are determined as the distance-weighted effective values as used by Suda in the special case of equal length path segments. Control then passes to begin evaluation of path characteristics using the effective ground parameters thus computed as shown in Figure 2-4(b).

In the event the user decides that a Millington approximate heterogeneous path calculation will be more appropriate (for example in the case of a mixed land-sea path) he must also input a quantity m which is the number of segments of length $d/(m \cdot n)$ into which the two path end segments are to be divided to calculate the required pair of effective ground constants for the Millington analysis as shown in Figure 2-4(c). The effective ground parameters at the receiver and transmitter path ends are thus calculated by the Suda method to provide the user an increased degree of spatial resolution control over the calculation.

The effects of wind on the apparent equivalent conductivity of the sea surface can substantially influence the coverage range of some HF signals. These effects are modelled using the Phillips isotropic ocean wave spectrum and the user may input an average wind velocity to compensate for known meterological conditions.

NUCOM/BREM provides the user with considerable flexibility in regard to the choice of ground parameters and inhomogeneous path analysis techniques. The parameter n controls the resolution of numerical map data employed by the Suda averaging technique and the parameter m is directly related to the effective ground parameter values in the region between the path ends and the boundaries of

the ground discontinuity in the Millington method. Thus the user has the option of either incorporating his own ground paramater data or relying on the ITS numerical map data with a selectable spatial smoothing function and the choice of Suda or Millington methods for inhomogeneous paths. This approach generalizes the conditions of applicability of the basic groundwave calculation techniques to include all reasonable situations with acceptable accuracy.

2.2.1 NWOMAP Data

NUCOM/BREM permits the user the option of either supplying his own effective ground parameters or permitting the data from the ITS Blue Binary data [11] to be automatically retrieved and used.

The ITS world conductivity numerical maps are held as spherical harmonic coefficients for a dimensionless variable WLD which is returned from the call to the subroutine NWOMAP.

The returned value of WLD is transformed by the subroutine GLOSS to an equivalent σ and ε value according to the algorithms given in Table 2-2. It should be noted that a linear relationship between σ and ε has been assumed a priori by ITS; this is consistent with a first order approximation to the empirical relationship between σ and ε of

$$\varepsilon \simeq 50\ (\sigma)^{1/5} \qquad (2\text{-}20)$$

as determined by Hanle, et al. [13]

It is left to the judgement of the user to decide whether the ground parameter data as returned from NWOMAP is adequate for his

TABLE 2-2

ALGORITHMS USED BY NUCOM II AND NUCOM/BREM TO DETERMINE σ AND ε FROM ITS WORLD NUMERICAL MAP COEFFICIENTS

VALUE OF WLD RETURNED FROM NWOMAP	-----TRANSFORMED GROUND PARAMETERS---- σ (MHO/m)	ε (NORMALIZED UNITS)
WLD $\geq$ 0.75	0.001	4.0
0.25 < WLD < 0.75 $\varepsilon = 3.985+15.203\sigma$	7.4995-9.998*WLD (0.001 $<\sigma<$ 5.0)	118-152*WLD (4 $<\varepsilon<$ 80)
0.25 $\leq$ WLD $\leq$ 0.25	$\sigma = 4.0$	80
-0.75 < WLD < -0.25 $\varepsilon = 3.998+15.200\sigma$	7.49995+9.9998*WLD (0.0001 $<\sigma<$ 5.0)	118+152*WLD (4 $<\varepsilon<$ 80)

particular application both in terms of data quality and spatial resolution. In order to provide guidance to the user NUCOM/BREM prints the values of σ and ε returned from NWOMAP for each point along the great circle path determined by the particular selection of n and m specified as input, as well as the Suda mean value when appropriate.

In order to help the user to visualize the ITS ground data we have performed the inverse mapping transformation on the world ground constant data in NUCOM II and NUCOM/BREM and present it as a geographical map in Appendix II of this report.

2.2.2 Inhomogeneous Path - Suda Method

The simplest commonly used technique to calculate the equivalent homogeneous ground parameters for an inhomogeneous path is the Suda method which provides essentially a distance weighted average value for ground constants along the path.

The user specified parameter n establishes the number of path segments of length (D/m) into which the path is to be segmented for Suda computation where D is the length of the path. The subroutines NWOMAP and GLOSS return the corresponding values of conductivity and dielectric constant for each segment of the path as described in Section 2.2.1. From these values are computed the homogeneous equivalent values defined as

$$\sigma_E = \frac{1}{n} \sum_{1}^{n} \sigma_i$$

and (2-21)

$$\varepsilon_E = \frac{1}{n} \sum_{1}^{n} \varepsilon_i .$$

According to Suda (op.cit.) this approach yields the best results when the values of ground parameters do not change rapidly along the path, for example on a transcontinental path which does not cross coastal boundaries or across the open sea.

In the case of groundwave signal paths which cross land-sea boundaries the Millington method is probably more appropriate.

2.2.3 Inhomogeneous Paths - Millington Method

Inhomogeneous groundwave paths which cross boundaries between regions with very different ground parameters such as paths across sea coasts are best handled with the semi-empirical Millington method [4].

Consider a nonhomogeneous path with ground parameters σ_T, ε_T at the transmitting end and σ_R, ε_R at the receiving end. Suppose the received signal field corresponding to a homogeneous path with parameters σ_R and ε_R is E_R, and the corresponding value for a uniform path with the parameters at the transmitter end of the path is E_T. Millington has shown that the field due to the two segment path is given by the geometrical mean of the received fields:

$$E = \sqrt{E_T E_R} \qquad (2\text{-}22)$$

as long as the field is measured distant from the boundary interface location.

NUCOM/BREM permits a combination of Suda and Millington techniques. In the case where the user wishes a Millington analysis he specifies both a segmentation parameter n and an end parameter m.

The code will then perform a Suda average based on m steps of equal length for the segments of length (d/n) at each end of the path. The resulting two values, one for each end of the path, are used then for the Millington calculation. Two independent groundwave calculations are then performed using each end value in turn and the inhomogeneous path value is taken as the geometrical mean of the two resulting field strength values as described above.

2.2.4 Sea State Correction

The classical theory of groundwave propagation as treated by van der Pol and Bremmer (op. cit.) assumes a smooth and electrically homogeneous spherical surface. For a propagation path over such a surface it is necessary only to specify two ground constants, conductivity σ and the relative dielectric constant ε. These two constants characterize the electrical properties of the path and its loss (absorption) properties.

An alternative way to characterize the propagation path is through the definition of the ground surface impedance. It can be shown that for a plane wave incident upon a homogeneous ground at the angle τ_o, the impedance has to be of the following form:

$$Z = \frac{\eta_o}{\mu}\left[1 - \frac{\cos^2 \tau_o}{\mu^2}\right]^{\frac{1}{2}} \qquad (2\text{-}23)$$

where

$$\mu = (\varepsilon - j\ 60\lambda\sigma)^{\frac{1}{2}}$$

$$\eta_o \cong 120\pi$$

and ε, σ, and λ are the relative dielectric constant, conductivity and the free space wavelength, respectively [14].

For grazing incidences ($\tau_o \simeq 0^o$) in a sea environment where the conductivity σ is very high and at frequencies below VHF the impedance expression takes an even simpler form [15]. Normalizing Z with respect to η_o, we can then write

$$Z/\eta_0 = \bar{\Delta} = R_\Delta - jX_\Delta$$

where (2-24)

$$R_\Delta = X_\Delta \simeq \frac{5.271*10^{-3}}{\sqrt{\sigma}} \sqrt{F_{MHz}} \quad .$$

In the above we have retained the conductivity explicitly instead of incorporating it into the constant. The reasons for this will become apparent shortly.

For homogeneous smooth surfaces the conductivity parameter σ accounts for the absorption due to ground losses. For rough surfaces such as the sea absorption is not the sole source of loss; scattering by the irregularities of the surface must also be accounted for. One approach to the problem of representing the losses over a rough finitely conducting surface is to postulate the existence of an apparent effective conductivity which represents all losses and is dependent on the surface roughness [15].

The criteria for surface roughness are usually expressed in terms of the mean height, the distribution of variation from the

mean, and the associated correlation function. For the sea surface formed only by surface winds a convenient and meaningful roughness criterion is that of the surface wind velocity. Assuming that the apparent conductivity is a function of the surface wind velocity, we may write

$$R_{\Delta\ (ROUGH)} \simeq \frac{5.271*10^{-3}}{\sqrt{\sigma(\nu)}} \sqrt{f_{MHz}} \qquad (2\text{-}25)$$

where

$$\sigma\Big|_{\nu=o} = 4 \text{ mho/m} ,$$

or, written differently,

$$R_{\Delta\ (ROUGH)} \simeq \beta(\nu) * \sqrt{F_{MHz}} \qquad (2\text{-}26)$$

and therefore

$$\sigma(\nu) = 2.778 * 10^{-5} \left(1/\beta(\nu)\right)^2 . \qquad (2\text{-}27)$$

To determine the precise form of the apparent conductivity the above functions must be derived from suitable models of the surface structure and impedances.

For the so-called Phillips (isotropic) ocean wave height spectrum and the model of the surface impedance as given by Barrick (op.cit), the following relation has been derived by Kaliszewski [15]:

$$\beta(\nu) = 2.635*10^{-3} + 8.784*10^{-5} \qquad (2\text{-}28)$$

where ν is the surface wind velocity in meters/second.

Expressions similar but not linear in ν can be obtained for the Neuman-Pierson ocean wave height spectrum [17].

Substitution of Eq. (2-28) into Eq. (2-27) then gives $\sigma(\nu)$. A plot of $\sigma(\nu)$ for the Phillips and Neuman-Pierson ocean wave height spectra is shown in Figure 2-5. The abscissa in that figure is labeled in both meters/second and sea state parameters.

We thus construct an equivalent smooth sea surface in place of a rough one and assigned to it the property of an apparent equivalent conductivity. As is evident from Figure 2-5, the value of the apparent conductivity is affected by the surface roughness and is smaller than the rougher (or more disturbed) sea surface. The difference in values of the conductivity for smooth and rough surface represents the contribution to the propagation losses of the surface scatter.

That such a difference can be significant can be seen from Figure 2-6 where we have plotted the difference in the propagation losses obtained via the NUCOM/BREM groundwave prediction program for the indicated parameters. The difference is termed the excess loss (i.e., relative to a smooth surface) and is shown as a function of frequency. Note the resonant nature of the curve with the peak at about 14 MHz. Also plotted are values obtained by Berrick (op. cit.) from a considerably more extensive computation involving the full complex surface impedance of the surface.

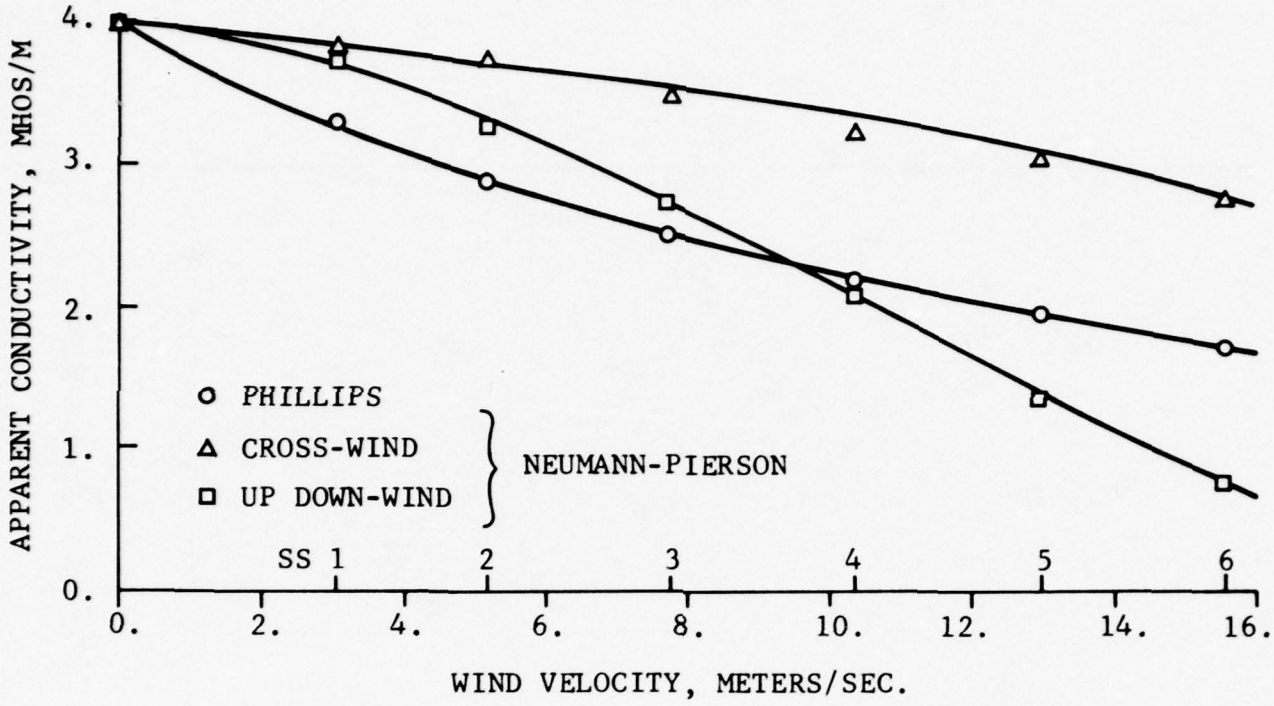


FIGURE 2-5. APPARENT CONDUCTIVITY OF A ROUGH SEA

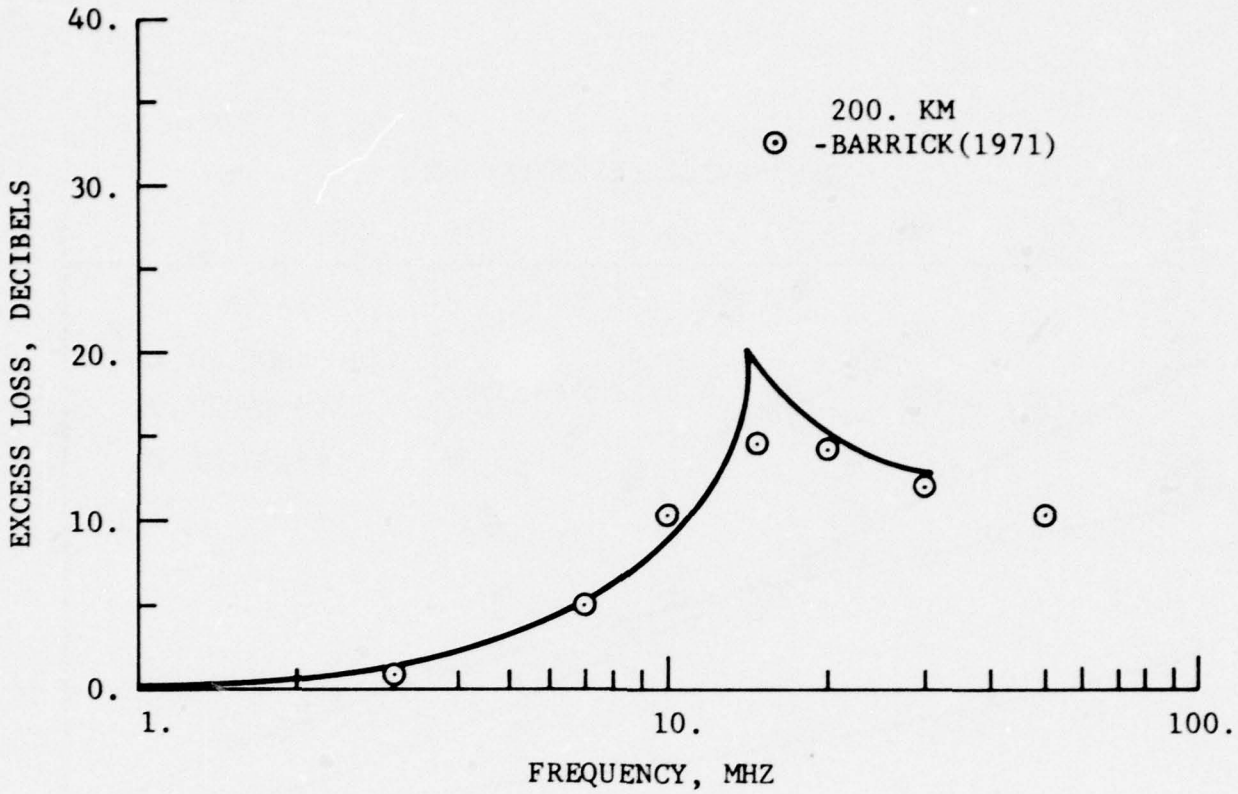


FIGURE 2-6. FREQUENCY DEPENDENCE OF EXCESS LOSS DUE TO ROUGH SEA. (GROUND-BASED, VERTICAL ANTENNAS)

In summary, NUCOM/BREM employs a computationally efficient groundwave prediction subroutine based on the analysis for a smooth, homogeneous earth and modifies it for use in rough sea environments. The modification takes the form of an algorithm for the apparent sea conductivity by which, in turn, is a function of the surface wind velocity (i.e., sea state). The input to NUCOM/BREM can take the form of a wind velocity, in meters/second, or a precalculated value of the apparent conductivity (say, from Figure 2-5).

It has been suggested by Wait [18] that the equivalent surface impedance approach to the disturbed sea surface may be unsuitable at the exact resonance frequency and the user should exercise caution in this special case.

2.3 Antenna Pattern Considerations

NUCOM II permits the user to specify two methods for treating antenna gains. Either he may specify that both transmitter and receiver are using isotropic antennas or alternatively he may supply his own antenna patterns. NUCOM II has a limited antenna pattern facility as shown in Figure 2-7(a). User supplied antenna pattern tables expressed in dB above isotropic are input for each one-degree of elevation angle (relative to the horizon) from 1^{o} to 40^{o}. For angles in the range $0^{o} \geq 1^{o}$ the value at 1^{o} is used; for angles $> 40^{o}$ the value at 40^{o} is used. The input antenna gain patterns supplied by the user are applied to the incoming ionospheric signal rays in NUCOM II by the power flux equation (Eq. 1-2) in subprogram COMEFF independent of signal polarization (which is assumed to be random).

Table 2-3 summarizes the additional antenna input features available in NUCOM/BREM. As shown in Figure 2-7(b), the range of input antenna gain elevations has been extended to $\pm 90^{o}$ and both vertical and horizontal polarization patterns may be input independently. Furthermore the previous restrictions on the amount of antenna pattern data input have been relaxed for NUCOM/BREM by allowing a user specified minimum and maximum angle separately for transmitter and receiver patterns.

We have chosen to maintain the antenna pattern card input formats and angular conventions from NUCOM II to eliminate conversion problems for pattern decks punched for NUCOM II. In particular we have retained the reference angle convention of 0^{o} corresponding to the local horizon.

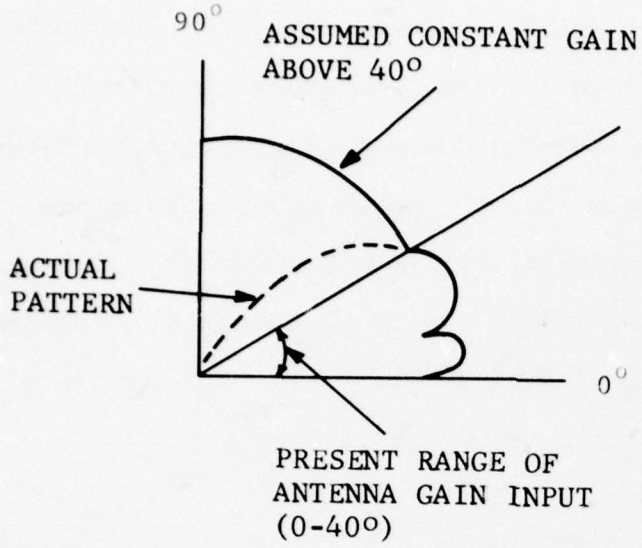


Figure 2-7(a). Original Antenna Pattern Limitations in NUCOM II

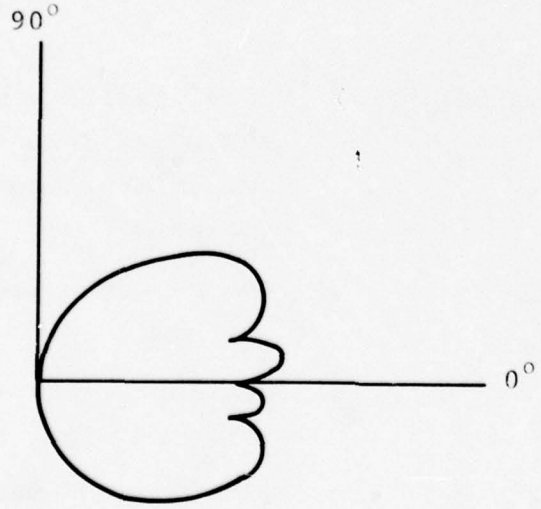


Figure 2-7(b). Extended Antenna Input Form Includes Data for Evaluations in the Range $-90^{\circ} \leq \theta \leq +90^{\circ}$

The official MIL coordinate system for airborne antenna patterns[21] is based upon the standard spherical (θ,ϕ) coordinate system and is shown in Figure 2-8. It is customary to describe θ measured from the local zenith and ϕ measured in a counterclockwise direction from the nose of the aircraft. Refining polarization components in this coordinate system avoids the ambiguity associated with the terms horizontal and vertical for angles near the zenith. Throughout the present work we shall use the terms "E_ϕ" and "horizontally polarized field" interchangeably.

Table 2-3

Comparison of input antenna features between NUCOM II and NUCOM/BREM

	NUCOM II		NUCOM/BREM
a)	Range limited to 1^o-40^o in 1^o steps	a)	Range $\pm$ 90^o in 1^o steps
b)	All 40 values must be supplied by user	b)	User specifies minimum and maximum values separately for transmitter and receiver patterns
c)	Full eight frequencies must be input	c)	One to eight frequencies may be input
d)	No polarization	d)	Horizontal and vertical gain patterns input independently
e)	Out of range values fixed by last value	e)	Out of range values assumed isotropic

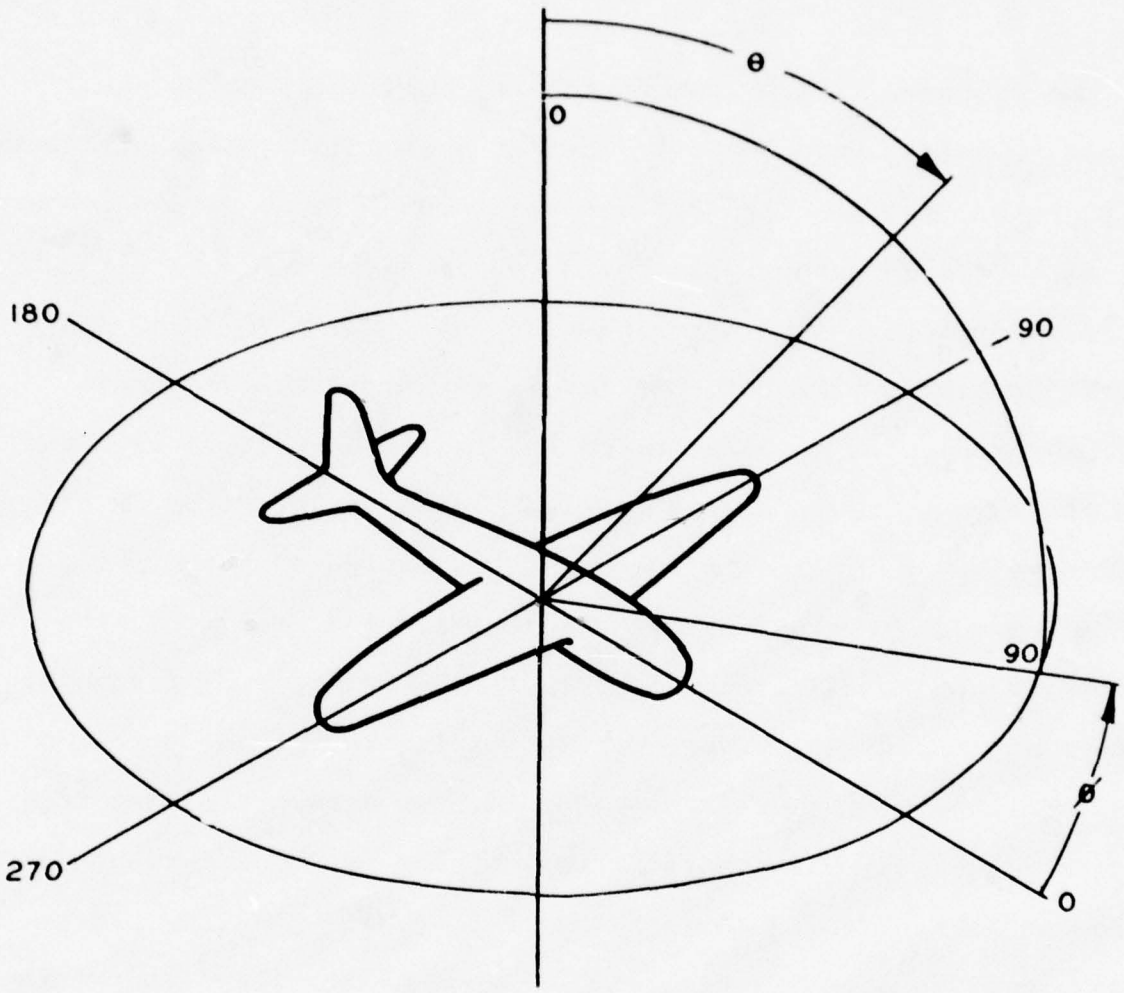


Figure 2-8. MIL coordinate system for airborne antennas.

The term "vertical polarization component" is generally used interchangeably with "E_θ" except in the context of ambiguous geometries where E_θ as defined as in Figure 2-8 will be used explicitly.

The airborne HF liaison antennas in popular usage at the present time fall into several distinct design categories although their performances tend to be rather similar. These categories are:

i) Notch antennas, e.g., wing or tail notch

ii) Cap antennas, e.g., wing tip, tail, and nose-caps, and

iii) Extended wire antennas, e.g., tail-to-fuselage wires.

The problem of calculation of the radiation pattern of a real airborne HF antenna is almost hopelessly intractable from an analytic point of view due to the influence of the airframe on the pattern. Figure 2-9 illustrates the charge separation and field fringing effects which are of particular concern in the lower HF frequency range where the signal wavelength is still fairly large compared with the dimensions of the airframe. Consider an aircraft flying through a uniform vertical electrostatic field. The field will result in a charge separation as shown in Figure 2-9(a) with positive charge on the lower portion of the body. Because of the field line fringing of the field about the airframe, the local field strength along the upper and lower centerlines will exceed the imposed field while the strength along the sides at the boundary of the charge separation region will approach zero.

The same pattern of charge distribution will result from the imposition of a relatively low HF frequency signal field except that the polarization will vary with $\cos(\omega t)$. If the impressed field were

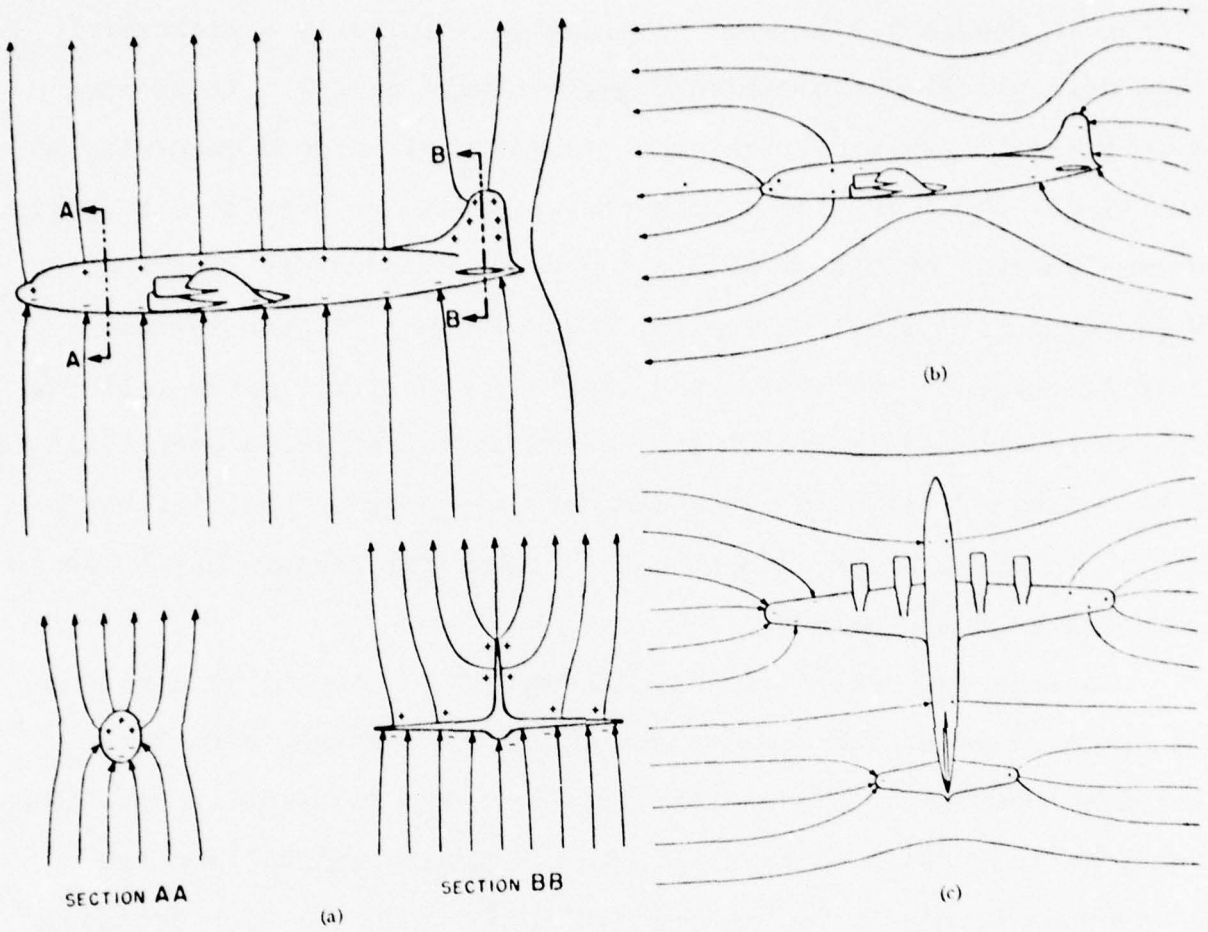
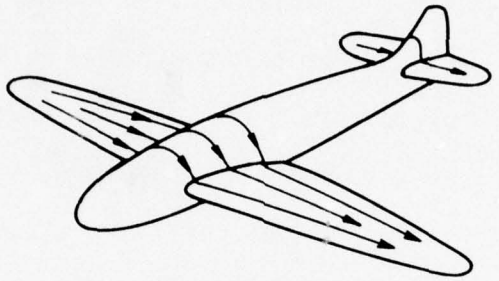


Figure 2-9. Charge separation and E-field fringing on airframe at HF.

polarized in the direction of flight, a charge distribution similar to that in Figure 2-9(b) will be produced; similarly a transverse field will polarize the airframe as in Figure 2-9(c). It is then obvious that a particular antenna element will respond generally to each of the three imposed components in a fashion dependent strongly on the location of the antenna element relative to the airframe. As discussed in detail by Granger and Bolljahn[22], the intense field fringing at the top of the vertical stabilizer makes tail cap antennas particularly useful when vertical polarization sensitivity is to be optimized; likewise wing-cap antennas perform well for horizontal fields although in both cases structural factors may outweigh communications advantages.

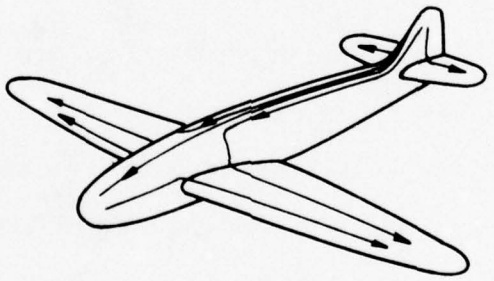
Numerous authors[23,24] have attempted to compute HF airborne antenna performances by decomposition of the airframe structural elements into elementary current filaments but the results have been disappointing. Much of the analytic difficulty arises from the near-resonant behavior of structural elements in the high frequency range. Figure 2-10 shows the two dominant types of resonance modes excited by HF fields which are conveniently classified as symmetric and antisymmetric[25]. Generally, both modes are excited by actual coupling elements and consequently the pattern symmetries to be expected from simple current decompositions are rarely observed in practice[26].

The outstanding failure of attempts to predict airborne antenna patterns has led to a variety of empirical methods for pattern determination and evaluation including electrostatic[27] and scale model RF[28] measurement procedures, and semi-empirical and statistical techniques[29-32].



(a)

SYMMETRIC MODES



(b)

ANTISYMMETRIC MODES

Figure 2-10. Dominant airframe resonance modes for HF range.

Wong [33] and Granger [25] have presented data showing the relative performances of various types of airborne antennas as expressed in terms of the "radiation pattern efficiency" which is defined as the ratio of power radiated in the elevation angle range of $\theta = 90^{\circ} \pm 30^{\circ}$ to the total radiated power. Figure 2-11(a) shows Wong's results for a CL-28 and Figure 2-11(b) presents Granger's data for a C-54. The marked resonant effect around 8 MHz of the phased wing caps on the C-54 is interpreted as a structural resonance.

Wong [33] has also evaluated the relative polarization efficiencies of a variety of antenna types on the CL-28. Figure 2-12 shows the ratio of vertically polarized power to total radiated power as a function of frequency. The complexity of structural resonance phenomena is quite evident.

As an aid to users of NUCOM/BREM we here provide some typical measured patterns for several classes of HF airborne liaison antennas to provide guidance in the modeling of airborne communications links. Tabulated patterns in the format required by NUCOM/BREM are listed in Appendix B.

Figures 2-13(a) through 2-13(c) present measured model patterns for a wing notch antenna on the Vulcan bomber. Figures 2-13(a) and (b) show the azimuthal (ϕ) pattern at 2.02 and 21.5 MHz respectively [34]. Note the essentially omnidirectional behavior at low frequencies and the conspicuous lobe-splitting at higher frequencies. Figure 2-13(c) shows the corresponding vertical plane pitch pattern for both polarization components at 2.02 MHz. The pattern nulls at $\theta = 0^{\circ}$ and 180° for the horizontal component are typical of wing notch pattern behavior [35].

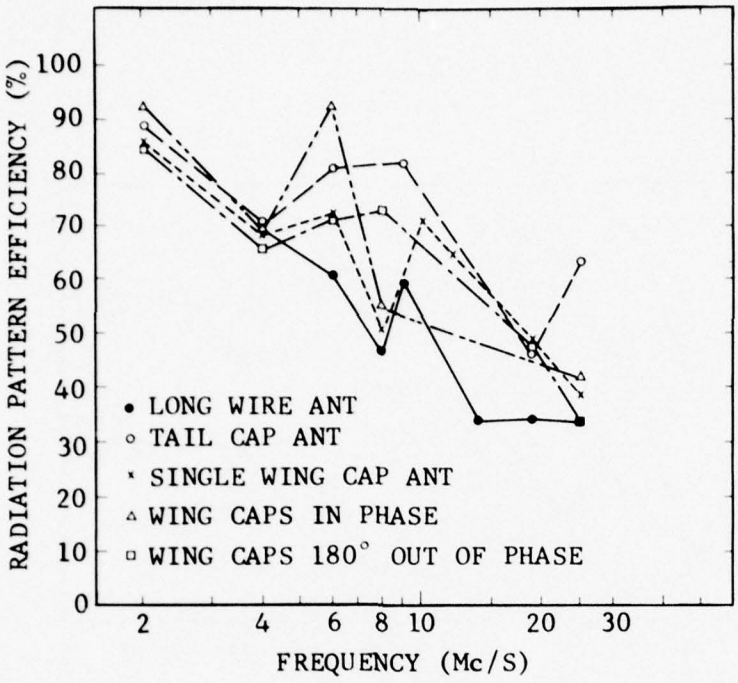


Figure 2-11(a). Relative pattern efficiencies for various types of airborne HF antennas on C-54 after Granger.

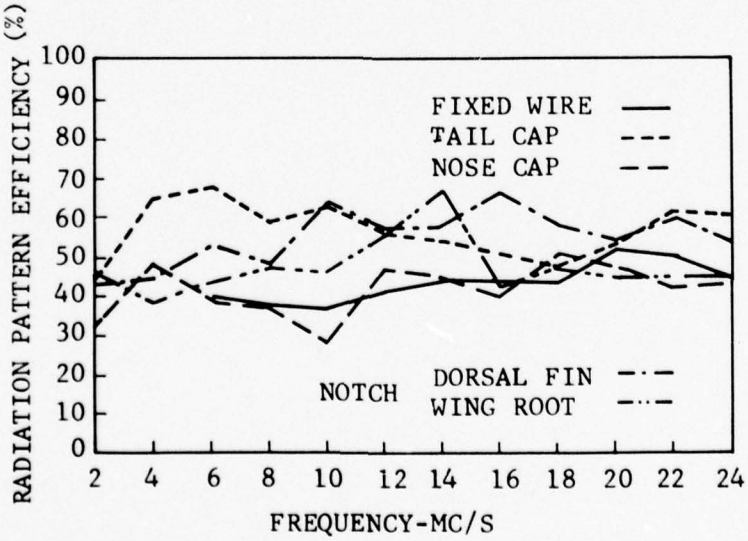


Figure 2-11(b). Relative pattern efficiencies for various types of airborne HF antennas on CL-28 after Wong.

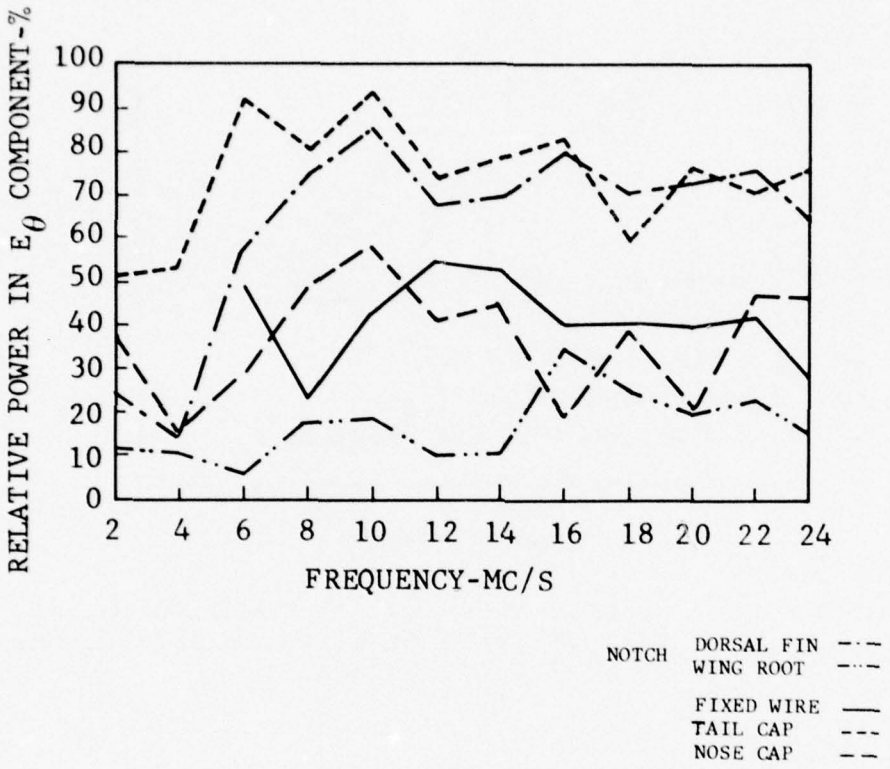


Figure 2-12. Relative power in vertical polarization component for various HF airborne antenna types after Wong.

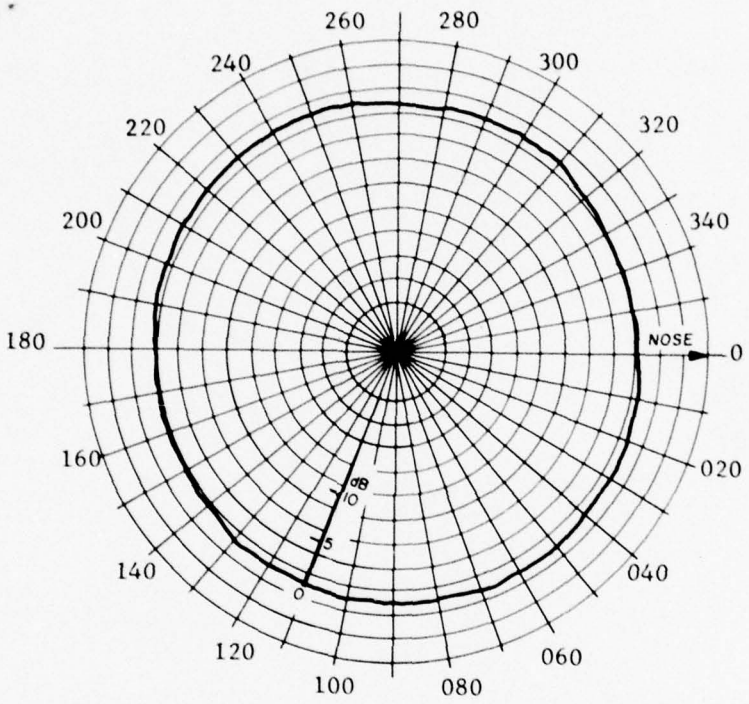


Figure 2-13(a). Azimuthal power pattern for using notch antenna; vertical component in dBi at 2.02 MHz.

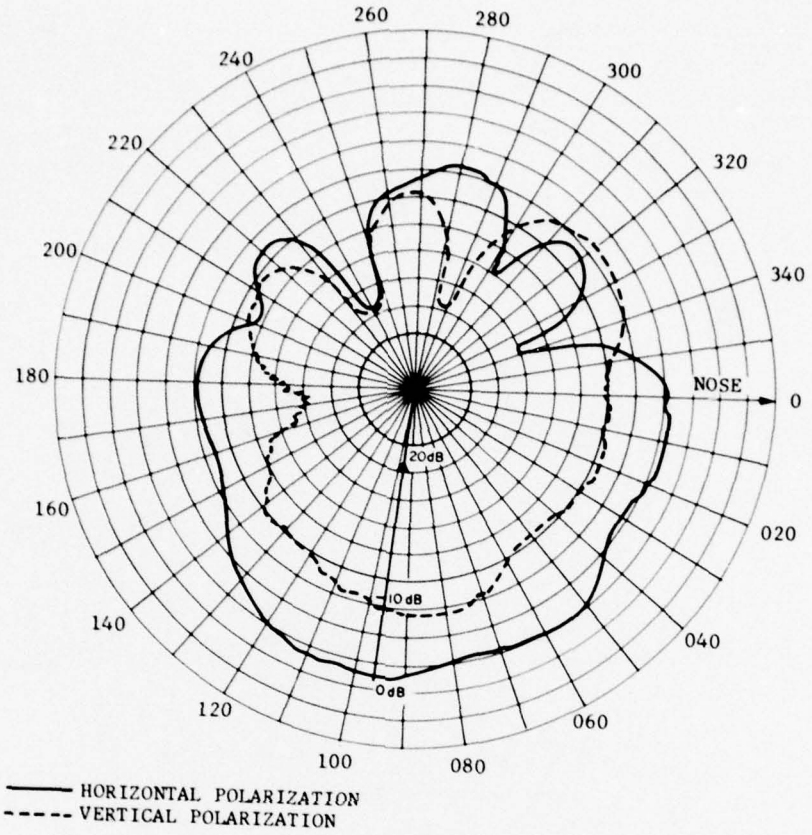


Figure 2-13(b) Azimuthal power pattern of wing notch antenna of 2-13(a) except at 21.5 MHz.

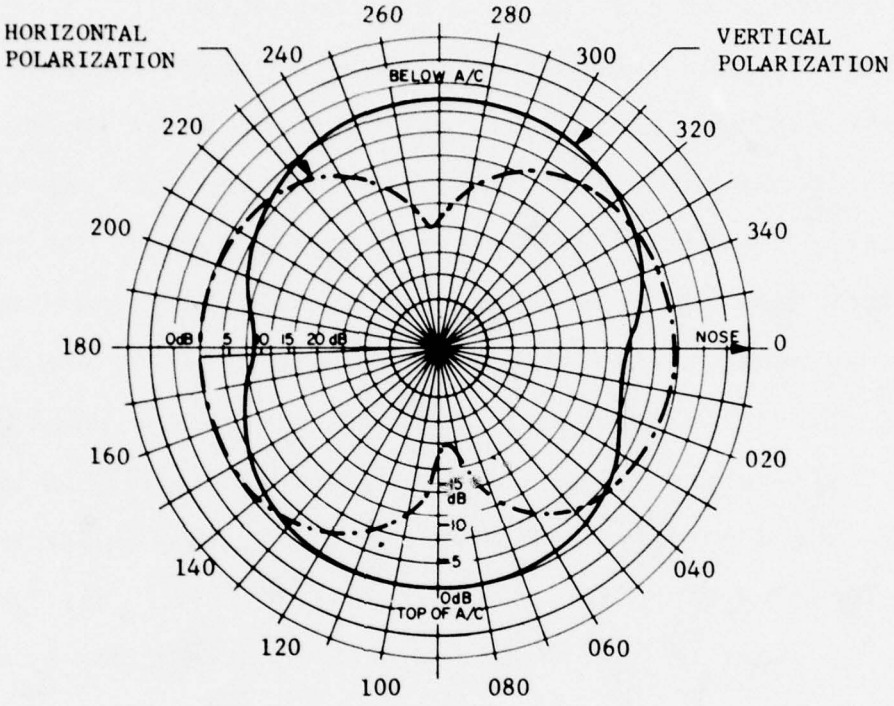


Figure 2-13(Vertical (E_θ) pattern for using notch antenna at 2.02 MHz.

Notch antennas are employed on the fuselage less commonly than on leading wing surfaces. Figures 2-14(a) and (b) show measured model azimuthal (Ø) patterns for a dorsal notch on the Vulcan airframe at 6.6 and 23.3 MHz respectively.

Whereas notch antennas consisting of short segments insulated from wing surfaces essentially act as shunt feeds to the structural elements of the airframe[36-38], the wing and tail cap antennas are usually actively driven against the airframe. The radiation efficiency of a cap antenna appears to depend strongly upon area of the cap segment insulated from the airframe[39] but the form of the pattern (i.e., shape) is supposedly rather invarient to the physical dimensions of the cap. Figures 2-15 and 2-16 show the model measured patterns for wing and tail cap antennas respectively for the Douglas DC series of airframes[28]. For this frequency (2 MHz) at least the patterns are seen to vary smoothly with cap area.

Extended wire antennas operating at frequencies near those of structural element resonances are probably the most difficult to generalize. Figures 2-17(a) through 2-17(b) show measured vertical polarization model gains on a 1/25 scale EC-135 for a single tail-fuselage wire[41]. These patterns extrapolated to $\theta = 0^{o}$ have been digitized and are presented in Appendix B in a format suitable for inclusion into NUCOM/BREM. The horizontal polarization component has been derived from the vertical component gain by applying the corrections due to Wong[33].

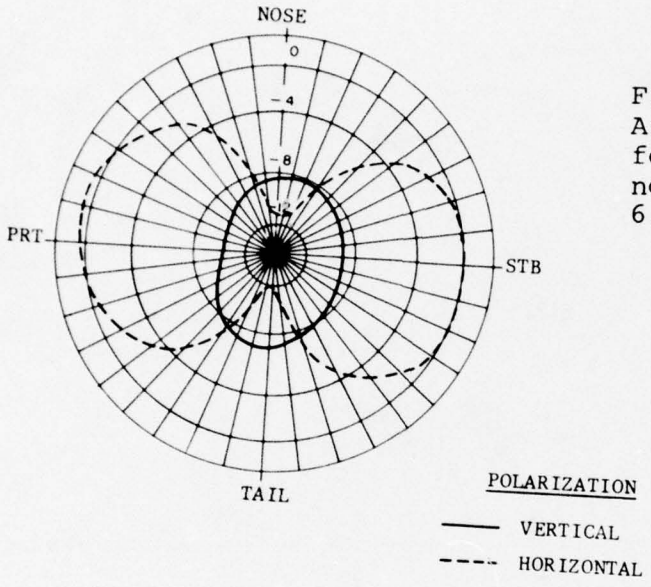


Figure 2-14(a). Azimuthal pattern for dorsal fuselage notch antenna at 6.6 MHz.

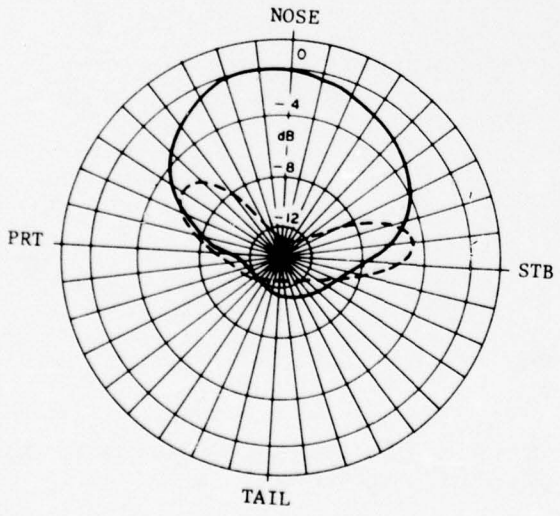


Figure 2-14(b). Azimuthal pattern for dorsal fuselage notch at 23.3 MHz.

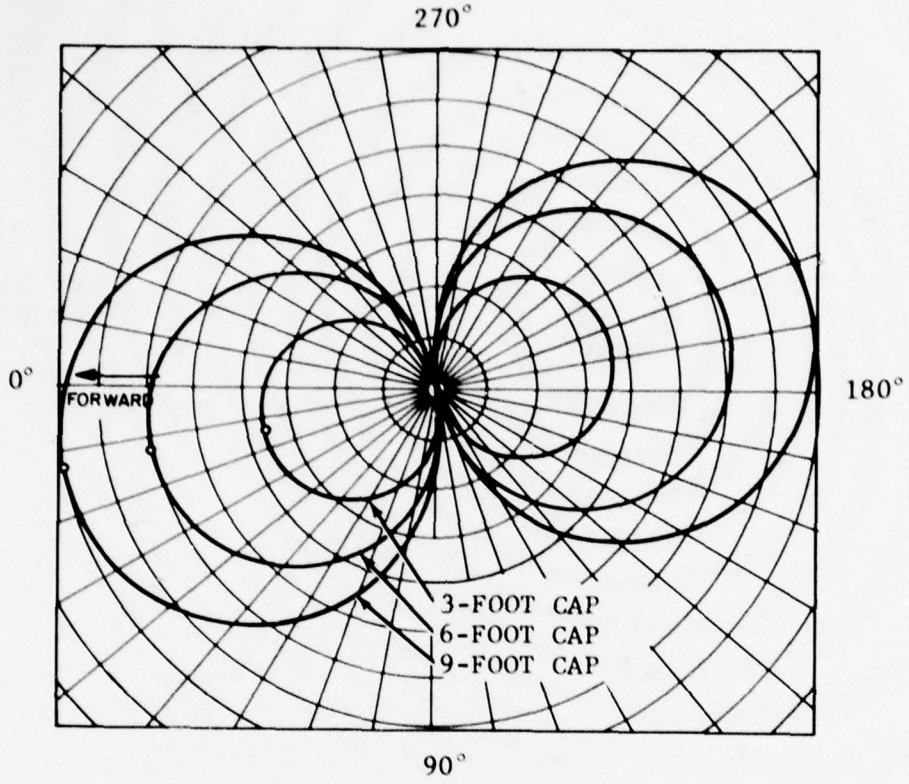


Figure 2-15. Measured pattern of using cap antenna on DC airframe as a function of cap area.

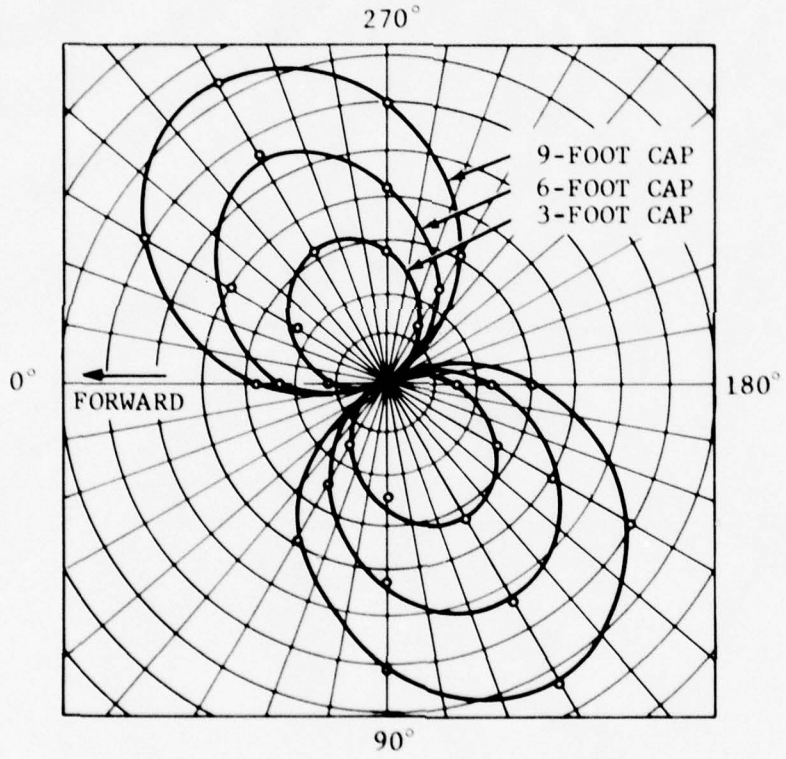


Figure 2-16. Measured pattern of tail cap antenna on DC airframe as a function of cap area.

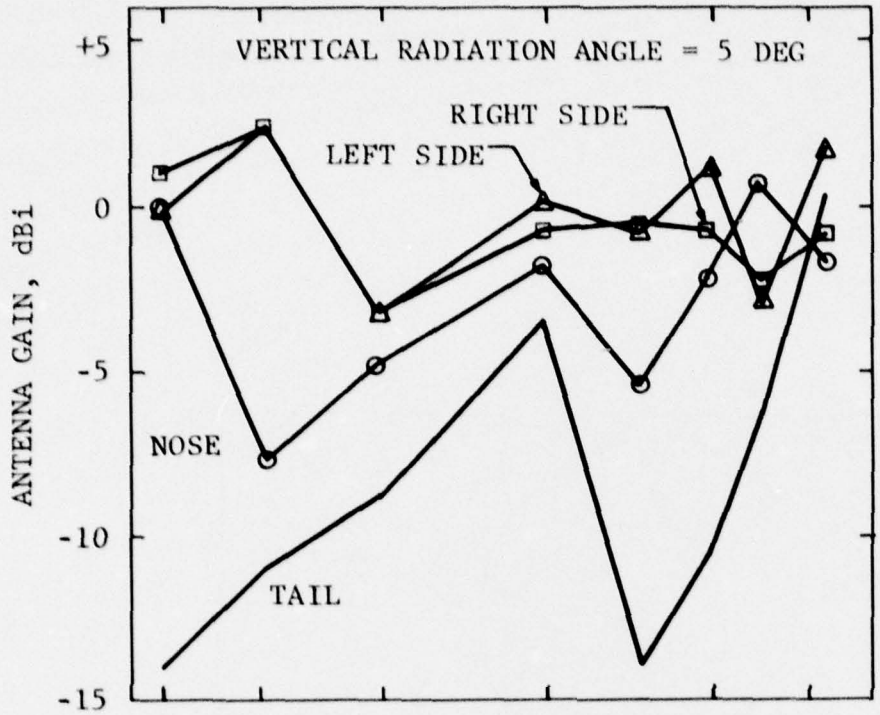


Fig. 2-17(a).

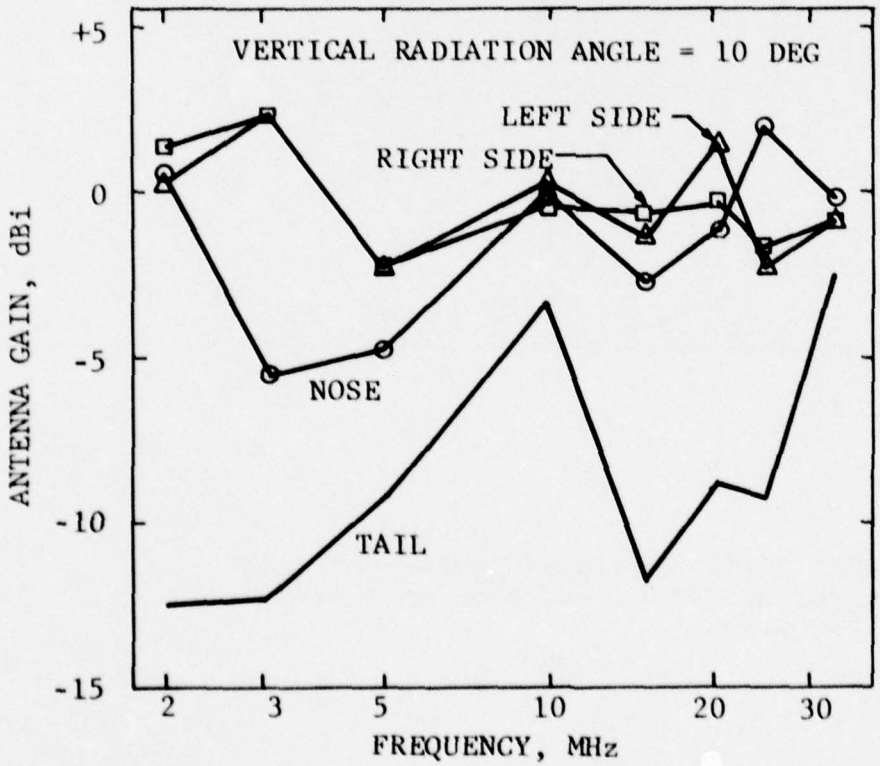


Fig. 2-17(b).

Figures 2-17(a)&(b) Measured model patterns for EC-135 tail-to-fuselage wire antenna.

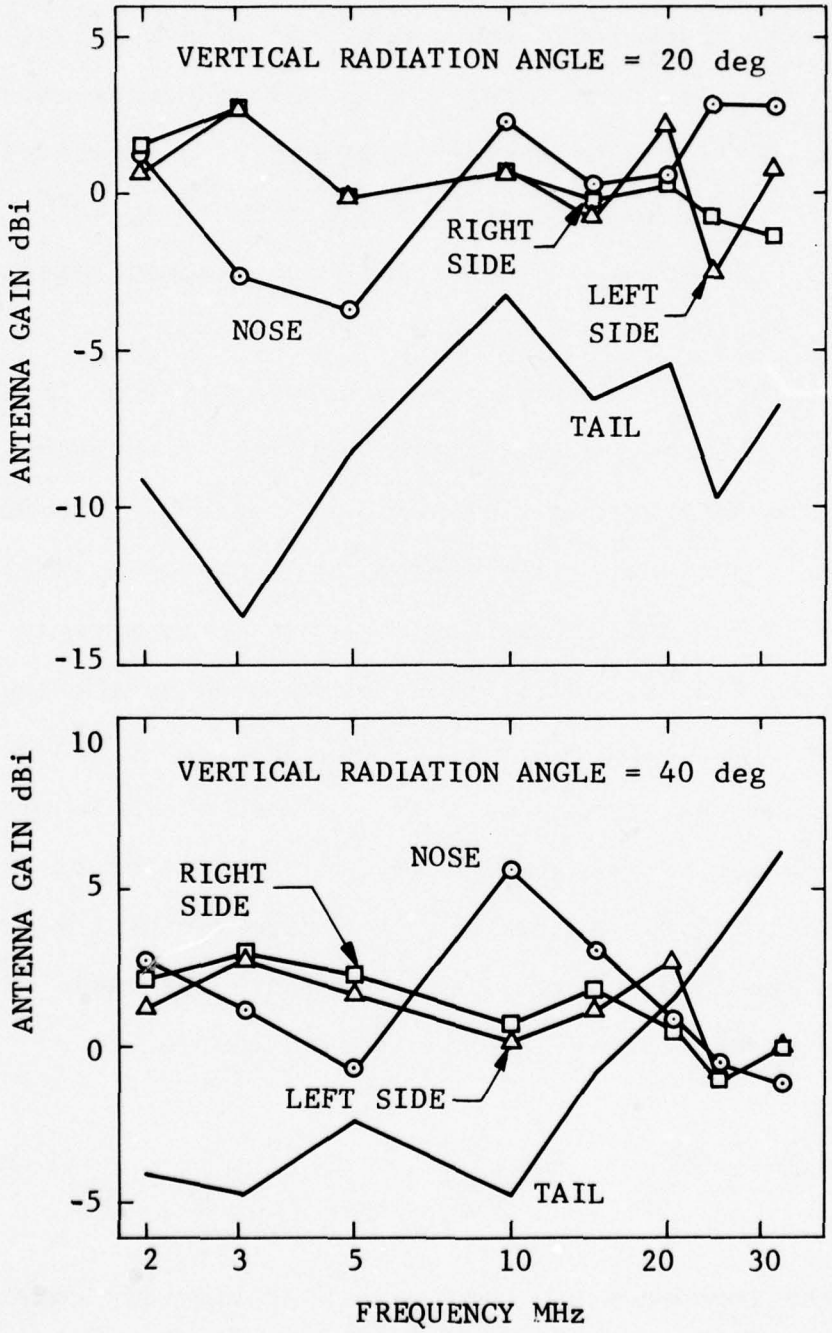


Fig. 2-17(c).

Fig. 2-17(d).

Figures 2-17(c)&(d). Measured model patterns for EC-135 tail-to-fuselage wire antenna.

2.4 Antenna and Power Compensations

NUCOM II and NUCOM/BREM calculate the total path loss for each ionospheric ray path assuming isotropic radiators at each terminal and unity transmitted power density. The vertical plane power patterns for both transmitting and receiving antennas are input to NUCOM II in the form of tables giving power gain in dBi for each one degree of elevation angle from 1^{o} to 40^{o}. Above 40^{o} and below 1^{o} the values at 40^{o} and 1^{o} are assumed respectively.

In NUCOM/BREM we have elaborated considerably upon this approach to permit the user to input both horizontal and vertical polarization component vertical plane power patterns independently. Furthermore the input angle calculation range has been extended to a full $\pm 90^{o}$ to permit inclusion of airborne antenna pattern effects for terminals located at elevation angles as high as the zenith.

Adjustment of uncompensated received signal power levels for user input antenna patterns and actual radiated power is performed as follows. Suppose the standard 1 kW ERP transmitter of Bremmer produces a calculated r.m.s. field at the receiver of E microvolts/meter from the standard short optimally oriented electric dipole radiator. The power flux at the receiver is then given by

$$P_F = \frac{E^2 * 10^{-12}}{\eta_o} \quad \text{Watts/m}^2 \qquad (2\text{-}28)$$

where η_o is the impedance of free space approximately equal to approximately 120Π or 377.0Ω. The power then received by an

isotropic radiator located at the receiver is then equal to the product of the power flux and the effective capture area of the isotropic antenna or,

$$P = \frac{2 * 10^{-12}}{\eta_o} * \frac{\lambda^2}{4\Pi} \qquad (2\text{-}29)$$

where λ is the wavelength.

Expressed in dBW this becomes

$$P = 20 \text{ Log}_{10} \lambda + 20 \text{ Log}_{10} E - 156.755 \text{ dBW} \qquad (2\text{-}30)$$

Since the gain of a short optimally oriented dipole is 1.761 dB relative to an isotropic radiator, the received compensated power may be expressed as

$$P_C = 20 \text{ Log}_{10} E + 20 \text{ Log}_{10} \lambda - 188.516 + G_R + G_T + P_T \text{ dBW} \qquad (2\text{-}31)$$

where G_R and G_T are the power gains in dB of the receiving and transmitting antennas relative to isotropic for the polarization component of interest and P_T is the actual radiated power density in dB relative to one Watt/Hz. This quantity P_C is then incorporated into the ionospheric ray received power sum to yield the total power for all received signal modes. Up to four nonionospheric power components may be involved: the horizontal and vertical components of the direct ray between elevated line-of-sight terminals and the corresponding components of the reflected ray.

In the most general case of two line-of-sight aircraft with ionospheric paths the all mode power sum becomes that of Equation 1-2,

$$P_{TA} = 10 \text{ Log}_{10} \left(\frac{P_{TI} + P_{TV} + P_{TH}}{P_{NV} + P_{NH}} \right) \text{ dBW} \qquad (2\text{-}32)$$

where

P_{TI} is the total received ionospheric power density,

P_{TV} is the total received non-ionospheric vertically polarized signal power density,

P_{TH} is the total received non-ionospheric horizontally polarized signal power density,

P_{NV} is the received atmospheric vertically polarized noise density, and

P_{NH} is the received atmospheric horizontally polarized noise density.

Each of the two non-ionospheric power components, P_{TV} and P_{TH}, will consist of both direct and reflected components,

$$P_{TV} = P_{DV} + P_{RV}, \text{ and}$$

$$P_{TH} = P_{DH} + P_{RH} \qquad (2\text{-}33)$$

where

P_{DV} is the compensated vertically polarized power density from the direct ray,

P_{DH} is the compensated horizontally polarized power density from the direct ray,

P_{RV} is the compensated vertically polarized power density from the reflected ray, and

P_{RH} is the compensated horizontally polarized power density from the reflected ray.

2.5 Horizontal Noise Corrections

Since the performance of HF links using both ionospheric and nonionospheric modes of propagation is usually limited by the received noise level, in the end the goodness of a propagation prediction made from a code such as NUCOM will depend as much upon the accuracy of the atmospheric or man-made noise level figures as it will upon the propagation analysis.

The noise figure values used in NUCOM II (and in all ionospheric propagation codes for that matter) are directly adapted from the data presented in CCIR Report 322 [42]. This data was taken by the worldwide ARN-2 instrumentation network and provides noise parameters assuming "a short vertical antenna over a perfectly conducting ground plane". As CCIR 322 is the international standard it is appropriate to quote their findings regarding noise polarization and directional effects,

> 8. The influence of the directivity and polarization of antennae
>
> All the noise information presented in this Report, including the examples given in the last section, relates to a short vertical receiving antenna. Although such an antenna may be used in practice at low frequencies, long-distance communication at high frequencies is normally achieved by the use of a highly-directional antenna. Some allowance must therefore be made for the effects of directivity and polarization on the signal-to-signal noise ratio.
>
> It is assumed that the signal gain is reasonably well-known, although it is dependent on the relative importance of the various propagation modes, which varies with time. The effective noise factor of the antenna, insofar as it is determined by atmospheric noise, may be influenced in several ways. If the noise sources were distributed isotropically, the noise factor would be independent of the directional properties. In practice, however, the azimuthal direction of the beam may coincide with the direction of an area where thunderstorms are prevalent, and

the noise factor will be increased correspondingly, compared with the omnidirectional antenna. On the other hand, the converse may be true. The directivity in the vertical plane may be such as to differentiate in favour of, or against, the reception of noise from a strong source. The movement of storms in and out of the antenna beam may be expected to increase the variability of the noise, even if the average intensity is unchanged.

Experimental information on the effects of directivity is scarce, and in some respects conflicting. In an equatorial region (Singapore), the median value of F_a for certain directional antennae was found to be somewhat higher (about 4 db on the average), than that for a vertical rod antenna over the same period. This figure is considerably lower than the maximum possible antenna over the same period. This figure is considerably lower than the maximum possible antenna gain, as would be expected from the widespread nature of the storms, but the fact that there was, on the average, some gain in noise in a wide range of storm conditions suggests that there was, on the average, some gain in noise in a wide range of storm conditions suggests that there was a tendency for the noise to be received more from the lower angles of elevation. In the F.R. of Germany also, directional antenna had, on the average, higher noise factors[43,44]. On the other hand, in experiments in Australia, the average noise factors of several antennae, beamed in different directions, were a few decibels lower than that of a vertical rod antenna, the interpretation being that there was significant noise incident at high angles[45]. It appears therefore that, in general terms, the gain in signal-to-noise ratio is likely to be approximately that in the signal alone (which may, however, be less than the optimum gain), and that if more precise figures are needed, it is necessary to take into account the storm locations and the critical frequencies of the ionosphere in addition to the antenna polar diagram. More investigations are required before the allowances can be made reasonably precise, but it appears that the differences will usually be less than 6 db.

Even less information is available on the effects of antenna polarization, but for a first approximation, it may be assumed that the received noise would be comparable with either polarization, provided the antenna height is large compared with the wavelength.

Gallenberger and Bickel [46] report that measurements of the vertical and horizontal components of noise at VLF to elevations of 20,000 feet indicate that that the horizontal component is down as much as 30 dB. It however must be pointed out that 20,000 feet is still less than $\lambda/2$ at VLF and that such behavior is not to be expected at HF, above a few wavelengths. It is therefore not unreasonable to assume that the noise power for horizontal polarization will be the same as that for vertical polarization above, say, 10λ or about 1 km. Below that height the amplitude of horizontally polarized noise will drop in amplitude to a low value near the surface of the earth, due to the behavior of the Fresnel reflection coefficient for horizontally polarized fields near the surface. The precise behavior of the horizontal noise value with height has not been experimentally investigated and will depend on some complex function of the precise reflective properties of the ground and the vertical and azimuthal disturbances of incoming ionospherically propagated HF noise.

It has been suggested by Bickel [47] that an exponential height model should be an acceptable first approximation for the behavior of horizontally polarized noise power at HF. We have therefore used an exponential function with a user specified height constant to allow fitting of empirical data should the user so desire. It should be pointed out however that the height regime where attenuation of the horizontal noise power due to ground effects is important at HF is below

the heights used for most C^3 airborne assets.

An even more uncertain question is that of the relationship between receiver antenna polarization and pattern characteristics and the received noise power P_N. Without a detailed description of the distribution of each polarization component of noise with both θ and ϕ no meaningful antenna correction can be accomplished. This no doubt explains why the CCIR figure RNOYS is employed in NUCOM II without further antenna pattern compensation.

Since airborne antennas may feature predominantly horizontal polarization characteristics, however, some form of rough pattern compensation is desirable. If the noise power is assumed to be isotropic then the received noise power is proportional to the noise power flux for the polarization component in question and also the effective area of the antenna. Thus, for example, a purely horizontal antenna will respond only to horizontally polarized noise, etc. If we further assume that the effective area of the receiving antenna is proportional to the gain averaged over θ and ϕ we may write

$$N_v \propto \frac{\overline{G_v}}{\overline{G_v}+\overline{G_h}} P \qquad (2\text{-}34)$$

and

$$N_h \propto \frac{\overline{G_h}}{\overline{G_v}+\overline{G_h}} P\,(1-e^{-kz}) \qquad (2\text{-}35)$$

Where N_v is the received noise power density (vertical)

N_h is the received noise power density (horizontal)

$\bar{G}_v$ is the average gain for vertical polarization

$\bar{G}_v$ is the average gain for horizontal polarization

P is the noise power density from NWOMAP (corrected for frequency and bandwidth)

K is the user specified horizontal height power factor and

Z is the height of the terminal above ground in kilometers.

The total received noise power as used in the all mode power sum (Eq.1-1) is then simply

$$N_a = N_v + N_h. \qquad (2\text{-}36)$$

A default value of k=3.1 is employed in NUCOM/BREM. This value corresponds to a recovery in horizontal noise power of 99% at a height of 10λ (at 2 MHz) or 1.5km.

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SECTION 3.0

SOFTWARE IMPLEMENTATION

Rather extensive modifications to certain parts of NUCOM II were necessary to implement the new features previously discussed. Approximately 1,100 new lines of code have been added to the RAYTRACE and COMEFF subprograms and several hundred more lines of existing code have been modified.

Because of the considerable complexity of the case stacking logic of the original NUCOM II code, every attempt was made to isolate the modifications required to calculate the nonionospheric modes in order to minimize the effects on the case control logic. The task of modifying NUCOM II has been simplified somewhat by its linear subprogram organizational structure which allowed us to limit the NUCOM/BREM modifications to the subprograms RAYTRACE and COMEFF without affecting the subprograms NATPAT, NUCEFMB, or ORDER.

All of the original NUCOM II features and outputs have been retained in NUCOM/BREM. The new nonionospheric calculations are made within the case control logic as if they were a special type of ionospheric ray path and the results of the nonionospheric analysis are presented independent of the original NUCOM II ionospheric analysis outputs.

Only the expanded antenna pattern elevation range feature directly enters into the ionospheric computations and then only to provide the user with the option of entering tabular pattern gain values for elevation angles as high as 90° instead of the maximum of 40° in NUCOM II. Computations using these high angle pattern

gains for ionospheric rays proceed as in NUCOM II.

The new or modified subroutines in RAYTRACE and COMEFF are heavily commented in the source code and subroutine structure has been kept as simple and straightforward as possible consistent with the constraints imposed by the preexisting code. The remainder of this Section details the software implementation of NUCOM/BREM; detailed descriptions of the unmodified code will be found in Reference 1 of Section 1.

NUCOM/BREM is coded in IBM FORTRAN IV G for the IBM System 370/145. The original IBM code is derived from the GE TEMPO version described in Reference 2 of Section 1.

3.1 Overview of NUCOM/BREM Software Modifications

The basic strategy in the modification of NUCOM II to include nonionospheric propagation modes is shown in Figure 3-1. Upon completion of ionospheric ray processing in the subroutine RAYTRACE of the last propagating ray for a case and frequency the main program flow is diverted to the control subroutine BREM10. It in turn calls other subroutines to calculate the power densities for the nonionospheric rays after calculating effective ground parameters where necessary. The nonionospheric path component power densities are flagged as "special" but otherwise are written onto unit 7 along with the normal ionospheric ray components for processing by the subroutine COMEFF. This approach results in minimal disruption of the case stacking logic and case control flow.

The "special" flagged components read from unit 7 by the subroutine COMEFF are processed separately to yield a total nonionospheric received compensated power density which in turn becomes a term in all mode signal to noise power calculation as shown in Figure 3-2. The subroutine COMEFF has been modified to read in extended elevation range antenna pattern tables for both vertical and horizontal polarization components and values interpolated from these tables are applied to each of the nonionospheric "special" components passed from unit 7 along with the user supplied power density correction to yield the compensated power density. The power density for each received component is combined in the nonionospheric power flux calculation in the subroutine COMEFF. After correcting the vertical noise

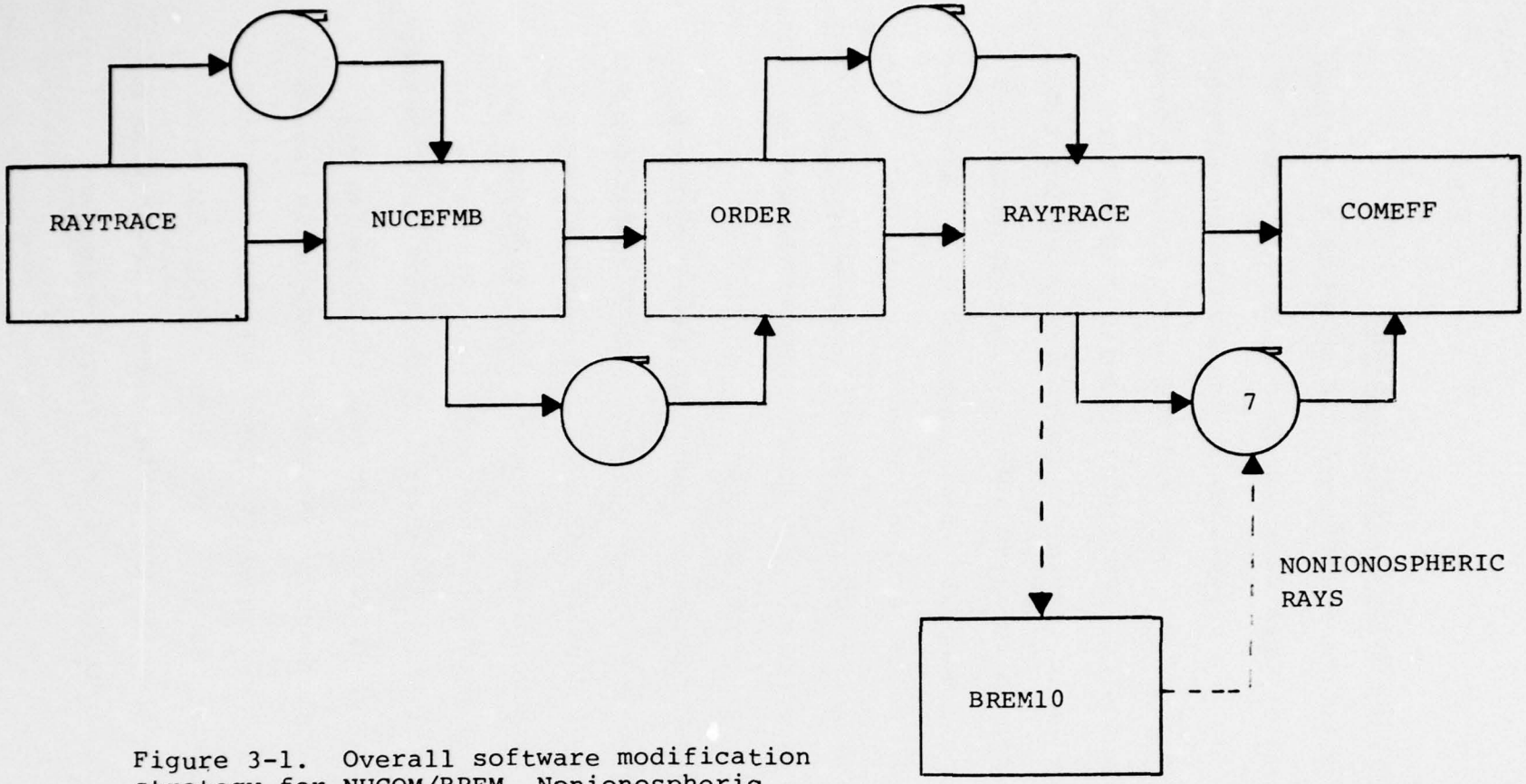


Figure 3-1. Overall software modification strategy for NUCOM/BREM. Nonionospheric propagation modes are calculated by BREM called by RAYTRACE; nonionospheric rays are written onto temporary storage as "special" ionospheric rays and input by COMEFF for power flux summation.

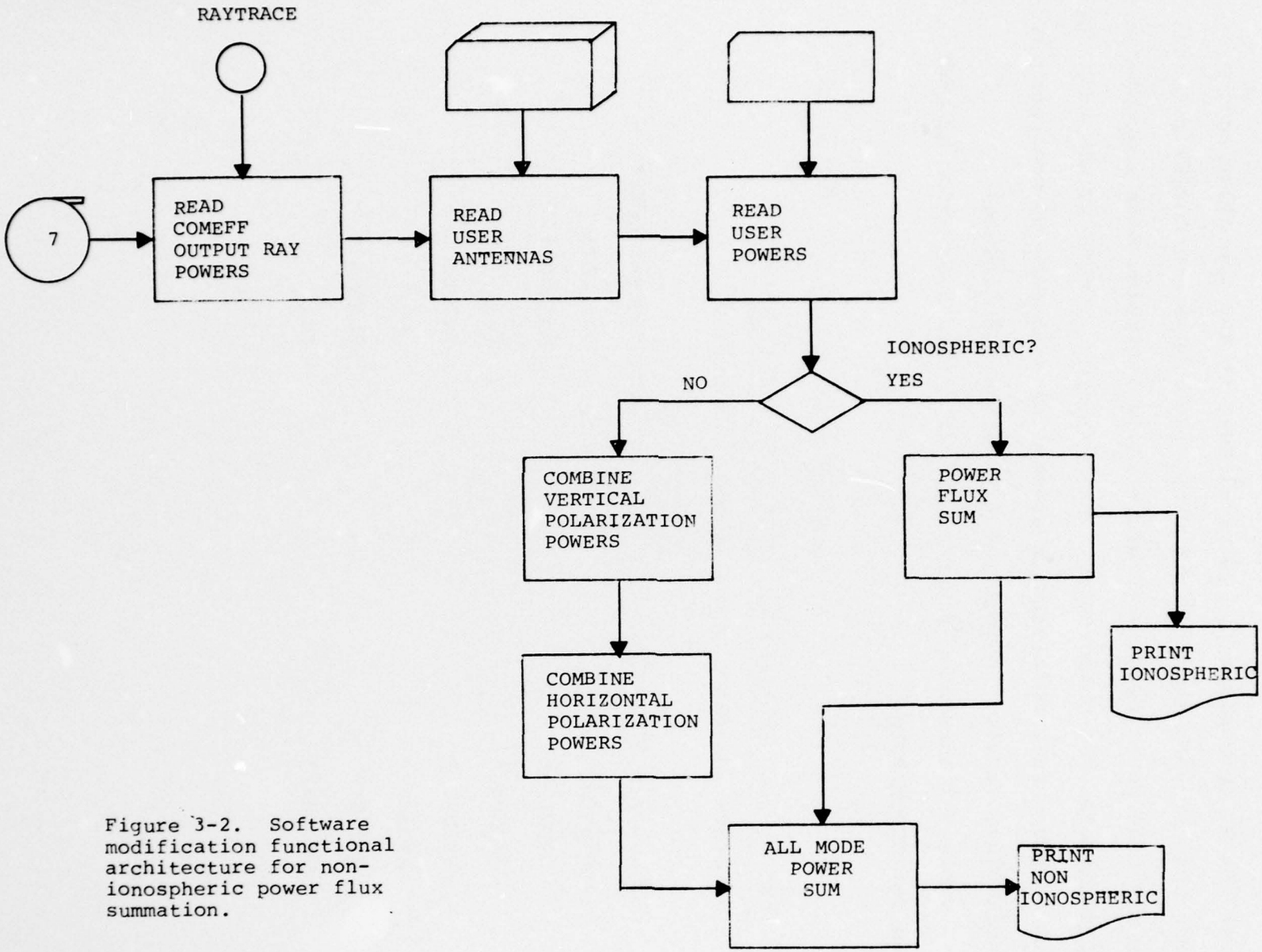


Figure 3-2. Software modification functional architecture for non-ionospheric power flux summation.

figure from the ITS Blue Binary Tape processed in the subroutine in NATPAT to compensate for terminal heights and the polarization ratio for the user supplied patterns, the subprogram COMEFF computes the all mode power density to noise ratio including both ionospheric and nonionospheric components. The subprogram COMEFF prints both the normal ionospheric mode outputs as well as a variety of nonionospheric intermediate results in addition to all the mode figures.

Table 3-1 shows the subroutines which have been added or modified for NUCOM/BREM.

Table 3-1

Subroutines Affected by NUCOM/BREM Modification

Asterisk indicates a wholly new subroutine.

Subprogram RAYTRACE	Subprogram COMEFF
ASGEPS *	BLK DATA
BREM1O *	CPOWER *
FSGEPS *	F1
GRNDWV *	INITLC
MDHNKL *	ONE
RAYTRA	RDATNA *
RFLXRA *	READ

3.2 Modifications to Subprogram RAYTRACE

The modifications to the subprogram RAYTRACE are concerned only with the calculation of nonionospheric mode signal powers. Aside from the addition of a new user input card to describe the type of groundwave treatment required (i.e., Suda or Millington) and to provide user sophisticated ground and sea state parameters, the modification to the subroutine RAYTRACE are strictly computational in nature. Table 3-2 summarizes the nature of the changes to preexisting subroutines and the function of the new subroutines. The overall flowchart of Figure 3-3 shows the effects of the NUCOM/BREM modification to the subprogram flow.

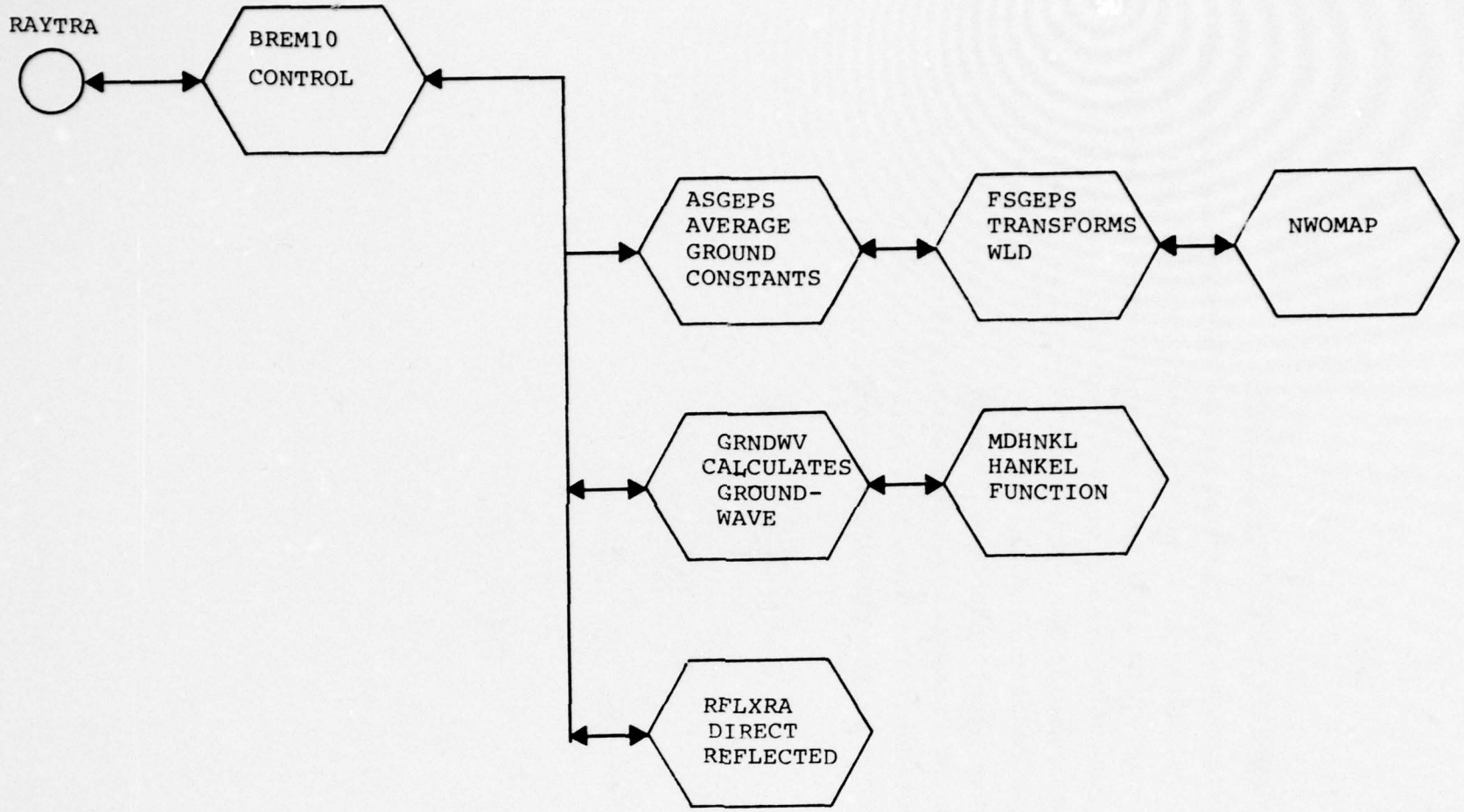


Figure 3-3. Subroutine calling flow for subprogram RAYTRACE calls to BREM10 for nonionospheric calculations

TABLE 3-2

New or modified subroutines in subprogram RAYTRACE

Subroutine	Changes/Description
ASGEPS	Did not previously exist. Calculates the effective ground constants at selected points along signal path using NWOMAP data andsea state corrections.
BREM10	Did not previously exist. This is the control subroutine for calculation of non-ionospheric signal powers. Determines the type of signal mode to be processed and prints intermediate results for user guidance.
FSGEPS	Did not previously exist. Transforms the dimensionless variable GAMMA returned by NWOMAP to effective ground parameters and applies sea state corrections for effective equivalent conductivity.
GRNDWV	Did not previously exist. Calculates ground-wave field strength for both polarization components using Bremmer - van der Pol equations. Calculates height gains using modified Hankel function routine MDHNKL.
MDHNKL	Did not previously exist. Calculates modified Hankel function of the first kind and order one-third for the evaluation of height gains for elevated terminals.
RAYTRA	Main line RAYTRACE control subroutine; one line modified to call BREM10 for nonionospheric power calculations.
RFLXRA	Did not previously exist. Calculates the reflected ray powers for elevated terminals using Fresnel and defocussing losses plus free space losses.

3.2.1 Subroutine ASGEPS

Description

Subroutine ASGEPS determines the effective ground constants at various points along the great circle signal path using NWOMAP and calculates the Suda average values including the effects of sea state disturbances if any. Given a pair of geographical end point coordinates XLOC and YLOC, the great circle bearing DIR, and step size SEGSIZE, ASGEPS uses the subroutine COOR to determine the geographical coordinates for each of ISGCNT segments. These coordinates are passed to NWOMAP and the returned dimensionless variable GAMMA is corrected to sigma and epsilon by FSGEPS. If a nonzero wind velocity WVEL is specified the correction is made in FSGEPS. The resulting averages values SOUT and EOUT are returned by ASGEPS. A flow chart for ASGEPS is presented in Figure 3-4.

Call Statement

```
CALL ASGEPS (SEGSIZ, ISGENT, XLOC, YLOC, DIR, WVEL, SOUT, EOUT)
```

Arguments

SYMBOL	TYPE	DESCRIPTION
SEGSIZ	Input	Great circle distance from end point, km
ISGCNT	Input	Number of segments of length SEGSIZ
XLOC	Input	Latitude of start point
YLOC	Input	Longitude of start point
DIR	Input	Great circle bearing of path from start point

SYMBOL	TYPE	DESCRIPTION
WVEL	Input	Wind velocity, km/sec.
SOUT	Out	Effective sigma
EOUT	Out	Effective epsilon

Common Storage Arguments Used

ERTHR, P1, RAD, DEG, P1BY2, TWOP1, REFIND, FREQ, BON, LONG, LAT, GAMMA, GMT, IO

Internal Subroutines Required

NWOMAP, COOR, FSGEPS

Number of Locations Required

940_{10}

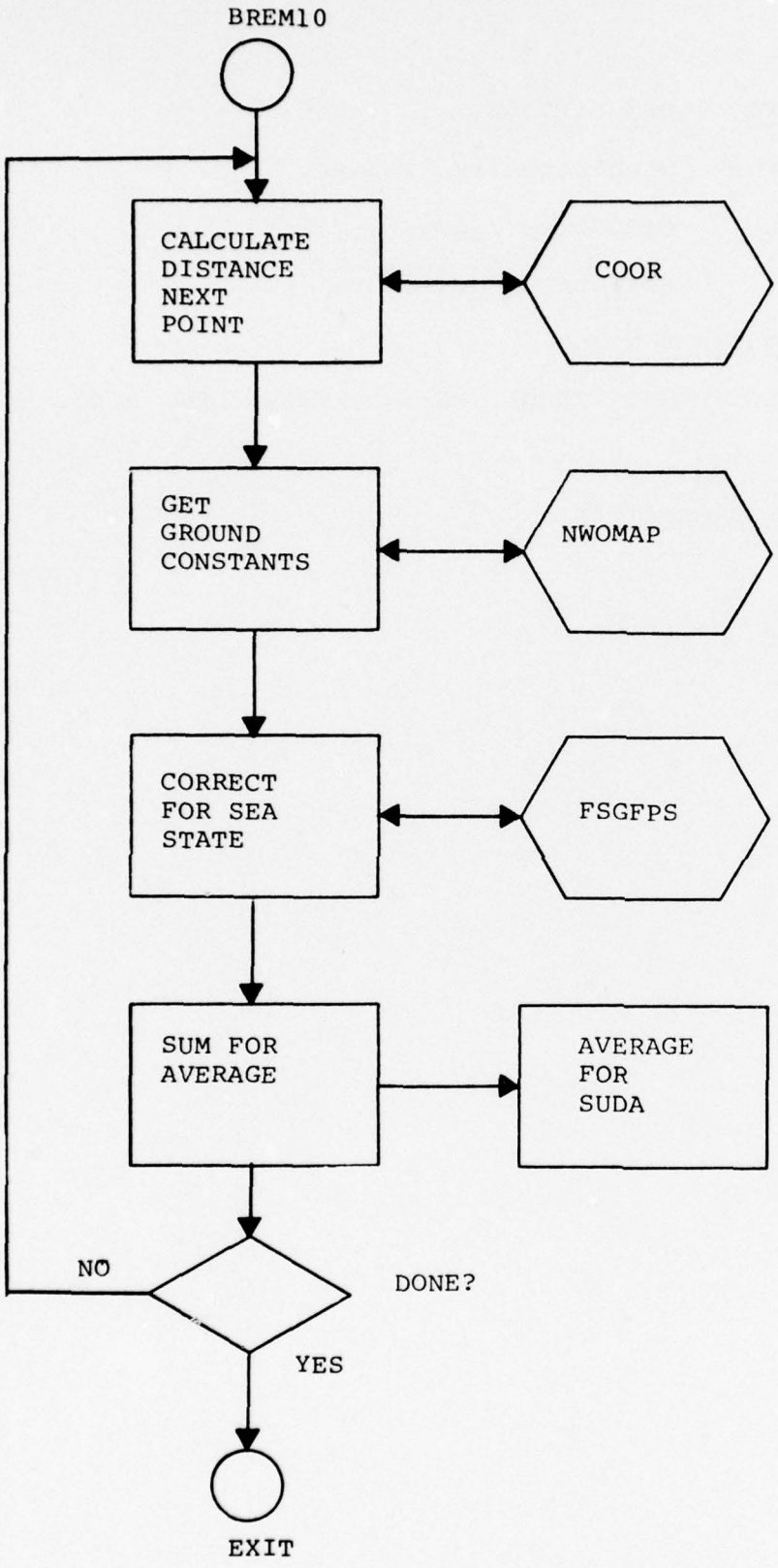


Figure 3-4. Flowchart for subroutine AGSEPS

3.2.2 Subroutine BREM10

Description

Subroutine BREM10 is the control program for the calculation of nonionospheric signal components in RAYTRACE. Given the coordinates and heights of the terminals BREM10 calculates the nonionospheric path geometry in order to determine computational types (i.e., line-of-sight, groundwave, reflected ray) to be computed. User supplied inputs for nonionospheric modes are read. If ground constants are required and are not user supplied BREM10 initiates calculation of the appropriate Suda or Millington values with corrections for sea state if necessary. The uncorrected field strengths for all relevant modes are calculated and corrected to unity power density. Computed nonionospheric mode powers and necessary elevation angles are written for COMEFF. BREM10 also prints relevant nonionospheric mode parameters including the segment values of ground constants and resulting effective homogeneous values for Suda or Millington treatments. A flow chart for BREM10 is presented in Figure 3-5.

Call Statement

```
CALL BREM10 (PLNGT, TLATD, TLONGD, RLATD, RLONGD, BER)
```

Arguments

SYMBOL	TYPE	DESCRIPTION
PLNGT	Input	Path length along great circle in kilometers
TLATD	Input	Transmitter latitude
TLONGD	Input	Transmitter longitude

SYMBOL	TYPE	DESCRIPTION
RLATD	Input	Receiver latitude
RLONGD	Input	Receiver longitude
BER	Input	Great circle bearing

User Supplied Input Common

SYMBOL	FORMAT	DESCRIPTION
THT	F10.3	Transmitter height, meters
RHT	F10.3	Receiver height, meters
SIGMA	F10.3	User supplied conductivity, Mho/m
EPSILON	F10.3	User supplied, dielectric constant, relative units
WNDVEL	F10.3	User supplied mean wind velocity, meters/second.
NSEGS	I5	Number of segments for Suda segmentation
MPTS	I5	Number of segments for Millington segmentation
FACHNZ	F10.3	User supplied horizontal noise height factor.

Output Variables to COMEFF

SYMBOL	FORMAT	DESCRIPTION
TTT	F6.0	Time (s)
FACHNZ	F10.3	Horizontal noise height correction factor
FREQ	F6.2	Frequency, MHz
BETA	F6.2	Last ionospheric transmitter beta (dummy)
DMY2	F6.2	Dummy
DMY3	F7.1	Dummy
THT	F7.1	Transmitter height, meters
RHT	F9.1	Receiver height, meters
RNOYS (IFCT)	F7.1	Noise power density

SYMBOL	FORMAT	DESCRIPTION
JHOUR	I5	Hour (GMT)
DMY6	F10.5	Dummy
DBV	G12.6	Power density (dBW), vertical component
DBH	G12.6	Power density (dBW), horizontal component
DBL	G12.6	Power density (dBW) for LOS component
TBD	F10.3	Angle of direct ray at transmitter
TBR	F10.3	Angle of reflected ray at transmitter
RBD	F10.3	Angle of direct ray at receiver
RBR	F10.3	Angle of reflected ray at receiver.

Common Storage Arguments Used

EARTHR, P1, RAD, DEG, P1BY2, TWOP1, REFIND, FREQ/BON/LONG, LAT, GAMMA, GMT, 10, /GWAVE/SIGMA, EPSILON, THT, RHT, DKM, DLOS, THETA, LAMBDA, J

/PO/ JK, KL, IFCT, GR LOSS, ALA1, ALA2, LLF, IHRC, P200, DB, HTCAL, JHOUR, RNOYS(80), FHNAME(12), BETA, TTT.

Internal Subroutines Used

RFLXRA, GRNDWV, ASGEPS, COOR

Number of Storage Locations Required

4126_{10}

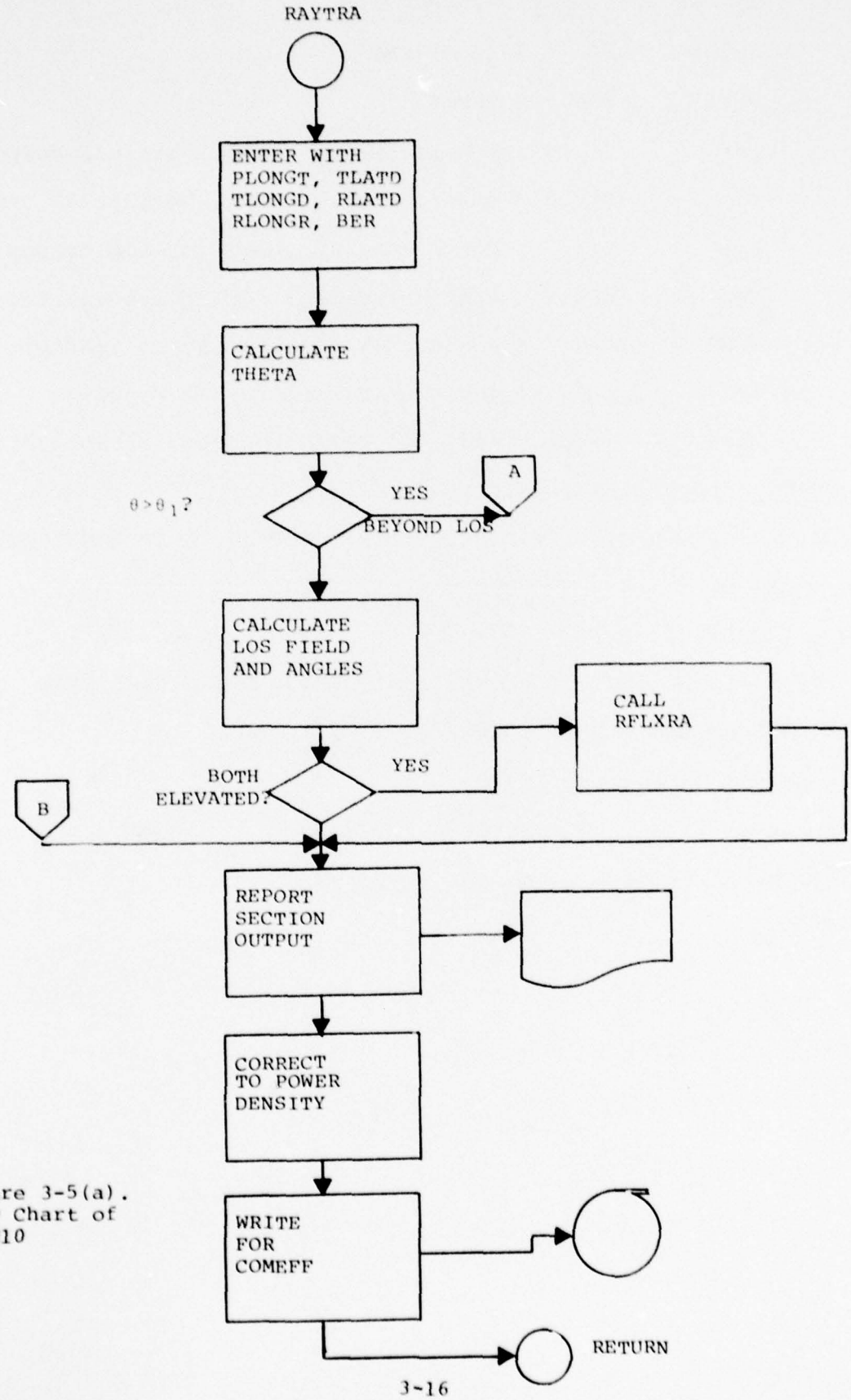


Figure 3-5(a). Flow Chart of BREM10

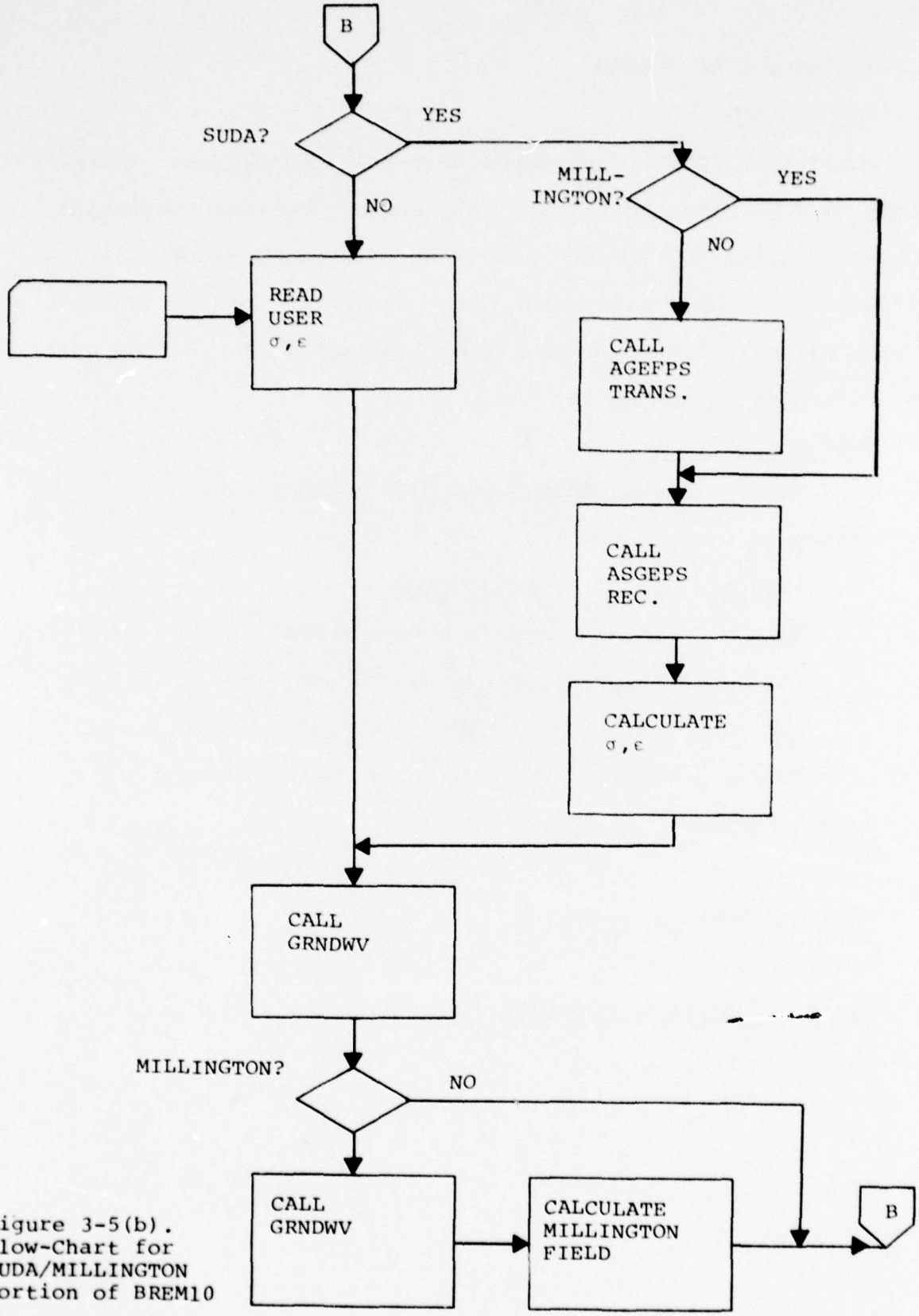


Figure 3-5(b). Flow-Chart for SUDA/MILLINGTON portion of BREM10

3.2.3 Subroutine FSGEPS

Description

Subroutine FSGEPS transforms from the dimensionless quantity GAMMA (= WLD) returned by the world ground constant subroutine NWOMAP to sigma and epsilon according to the algorithms described in Table 2-2. User input wind velocity corrections to conductivity are calculated per Equations 2-27 and 2-28. A flow chart for FSGEPS is presented in Figure 3-6.

Call Statement

```
CALL FSGEPS (GAMMA, SIGMA, EPSILON, WNDVEL)
```

Arguments

SYMBOL	INPUT	DESCRIPTION
GAMMA	Input	Returned from NWOMAP
SIGMA	Output	Calculated conductivity
EPSILON	Output	Calculated dielectric constant
WNDVEL	Input	Wind velocity, meters/second

Common Storage Arguments Used

None.

Internal Subroutines Used

None.

Number of Storage Locations Used

654_{10}

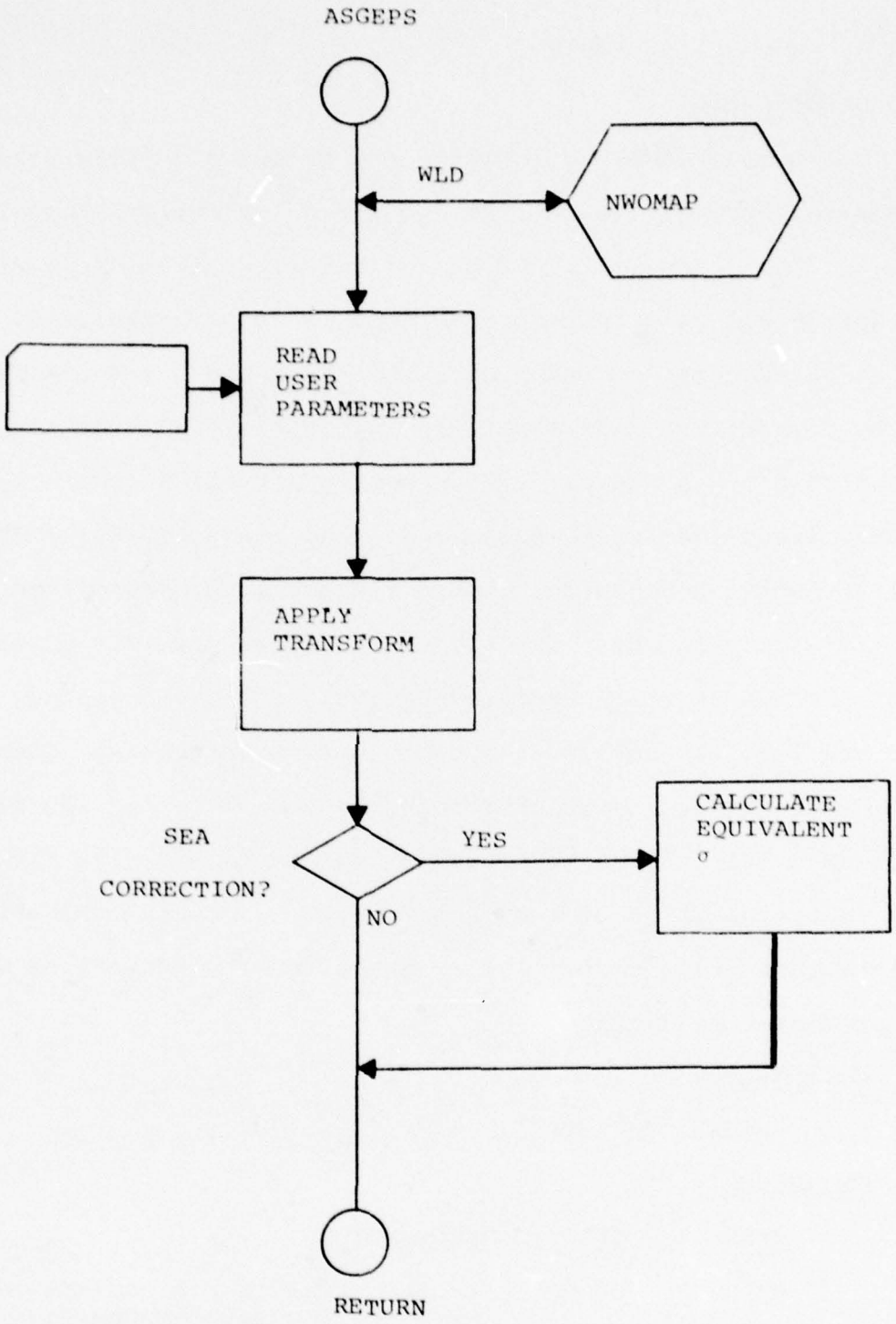


Figure 3-6. Flowchart of subroutine FSGEPS

3.2.4 Subroutine GRNDWV

Description

Subroutine GRNDWV calculates the groundwave field strength using the Bremmer- van der Pol equations as described in Section 2.1.1. The input switch POLAR determines whether the vertical or horizontal polarization component is to be calculated. The input parameters in COMMON describe the geometry of the path in terms of DKM, the path length in kilometers; THT, the transmitter elevation in meters; RHT, the receiver elevation in meters; SIGMA, the effective homogeneous ground conductivity; EPSLON, the effective homogeneous ground dielectric constant; and FREQ, the frequency in MHz. The output of GRNDWV consists of the arguments EV and EH which are the receiver site uncompensated fields the vertical and horizontal components respectively. Computation proceeds in a straightforward manner using the equations of Section 2.1.1 and the modified Hankel function of the first kind and order one-third as returned from the subroutine MDHNKL for height gain evaluation. A flow chart for the subroutine GRNDWV is presented in Figure 3-7.

Call Statement

CALL GRNDWV (EH, EV)

Arguments

SYMBOL	TYPE	DESCRIPTION
EH	Output	Electric field strength, rms, dB above 1μV/m, horizontal component
EV	Output	Electric field strength, rms, dB above 1μV/m, vertical component

Input Variables through Common

SYMBOL	TYPE	DESCRIPTION
SIGMA	Input	Effective ground conductivity
EPSLON	Input	Effective ground dielectric constant
THT	Input	Transmitter height, meters
RHT	Input	Receiver height, meters
DKM	Input	Path length on surface, kilometers
DLOS	Input	Line-of-sight distance, kilometers
THETA	Input	Central earth angle subtended by path, radians
LAMBDA	Input	Wavelength, meters

Internal Subroutines Used

MDHNKL

Number of Storage Locations Used

9412_{10}

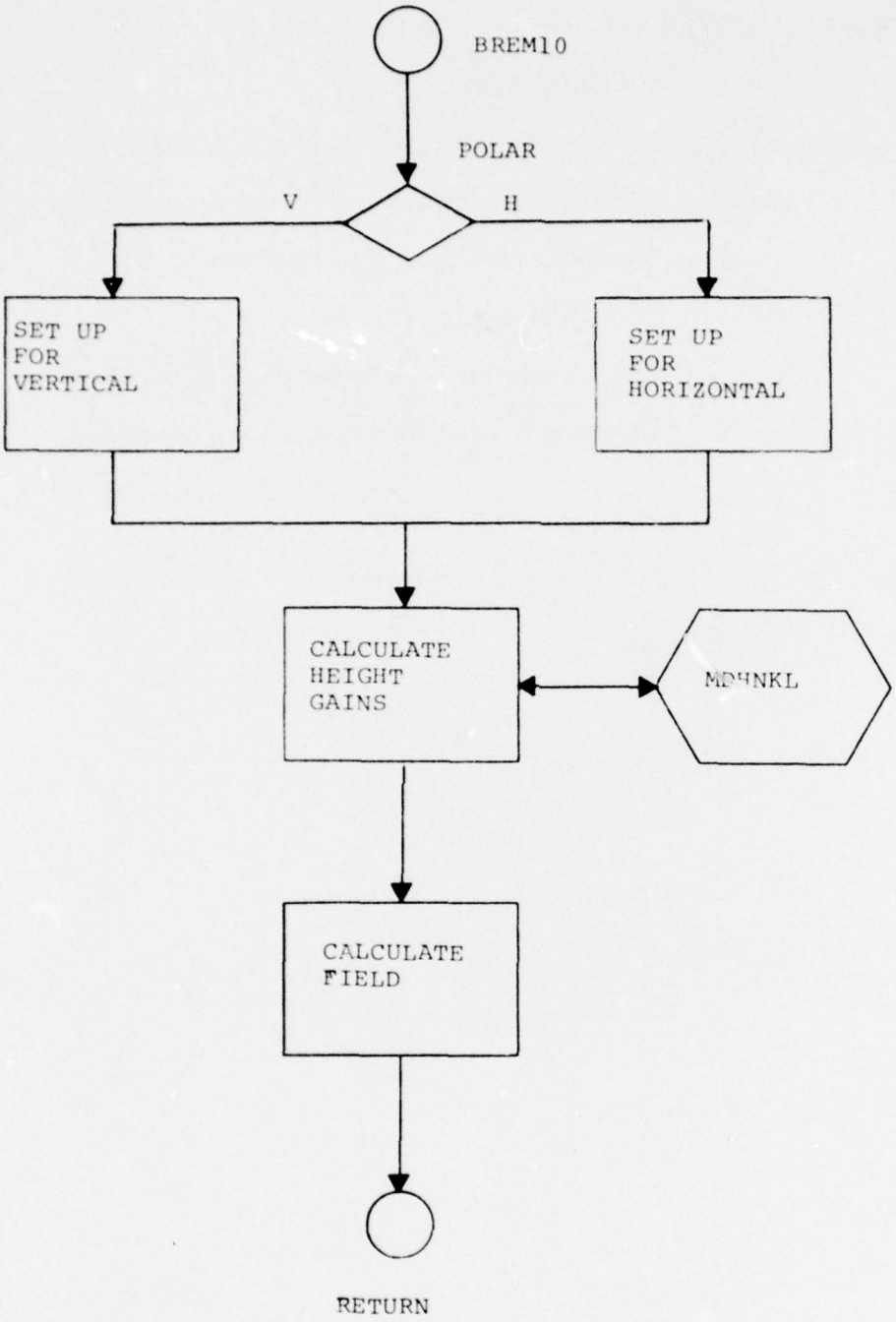


Figure 3-7. Flowchart of subroutine GRNDWV.

3.2.5 Subroutine MDHNKL

Description

The subroutine MDHNKL calculates the modified Hankel function of the first kind and order one-third, $H_{1/3}^{(1)}$, as described in Reference 5 of Section 1. The subroutine MDHNKL is called by the subroutine GRNDWV as part of the evaluation of the transmitter and/or receiver height gain functions given in Equations 2-8 through 2-13. A flow chart for this subroutine is presented in Figure 3-8.

Call Statement

CALL MDHNKL (Z, H1, H2, H1PRME, H2PRME).

Arguments

SYMBOL	TYPE	DESCRIPTION
Z	Input	Input argument to Hankel function
H1	Output	First Hankel solution
H2	Output	Second Hankel solution
H1PRIME	Output	Derivative of first Hankel
H2PRIME	Output	Derivative of second Hankel solution

(Note: All arguments double precision complex)

Internal Subroutines Used

None.

Number of Storage Locations Used

5684_{10}

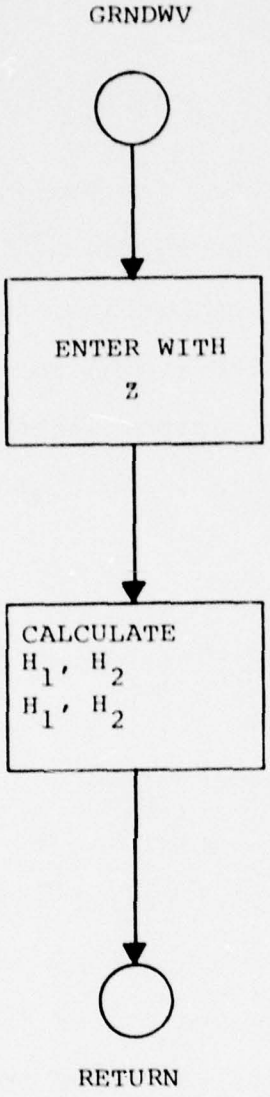


Figure 3-8. Flowchart of subroutine MDHNKL.

3.2.6 Subroutine RAYTRA

Description

RAYTRA is the MAIN subroutine for the subprogram RAYTRACE. The only modification to RAYTRA is the insertion of a one-line call to the subroutine BREM10 to initiate calculation of non-ionospheric comments. This call is made following computation of the last ionospheric ray for a case frequency time. This change is line 36670 RAYTRA.

3.2.7 Subroutine RFLXRA

Description

The subroutine RFLXRA calculates the field strength of the ground reflected ray when two elevated terminals are within line-of-sight. The computations follow directly from Equations 2-18 through 2-25 of Section 2.1.3 and Figure 2-2(c). Three distinct sources of loss are evaluated by RFLXRA: the free space loss, the Fresnel reflection loss, and the defocussing loss as defined by Equation 2-19. If the user has supplied the ground constants for the reflection point via card input, computation begins directly. Otherwise, the subroutines NWOMAP and FSGEPS are called to determine the ground parameters at the reflection point. The Fresnel angle of incidence, the geographical coordinate of the reflection point, and the angles τ_4 and τ_2 (TAU4 and TAU2) of Figure 2-3(c) then evaluated. The ground constants are corrected for wind effects if any by FSGEPS, and the resulting effective values used in the computation of first the horizontal and then vertical reflection coefficients and received uncompensated fields. A flowchart of RFLXRA is presented in Figure 3-9.

Call Statement

```
CALL RFLXRA (TRANSX, TRANSY, BER, WINDVEL, TBD, TBR,
RBD, RBR, EH, EV)
```

Arguments.

Symbol	Type	Description
TRANSX	INPUT	Transmitter latitude
TRANSY	INPUT	Transmitter longitude
BER	INPUT	Great circle bearing to receiver
WNDVEL	INPUT	Wind velocity for sea state correction, meters/second.
TBD	OUTPUT	Direct ray angle at transmitter measured relative to zenith.
TBR	OUTPUT	Reflected ray angle at transmitter measured relative to zenith.
RBD	OUTPUT	Direct ray angle at receiver measured relative to zenith.
RBR	OUTPUT	Reflected ray angle at receiver measured relative to zenith.
EH	OUTPUT	Uncompensated field strength for horizontal polarization component, μV/m.
EV	OUTPUT	Uncompensated field strength for vertical polarization component, μV/m.

Common Storage Arguments Used.

ER, THR, P1, RAD, DEG, P1BY2, TWOP1, REFIND, FMC
/BON/YLOC, XLOC, GAMMA, GMT, 10
IGWAVE/SIGMA, EPSILON, THT, RHT, DKM,
DLOS, THETA, LAMBDA, J

Internal Subroutines Used.

COOR, NWOMAP, FSGEPS

Number of Storage Locations Used.

2992_{10}

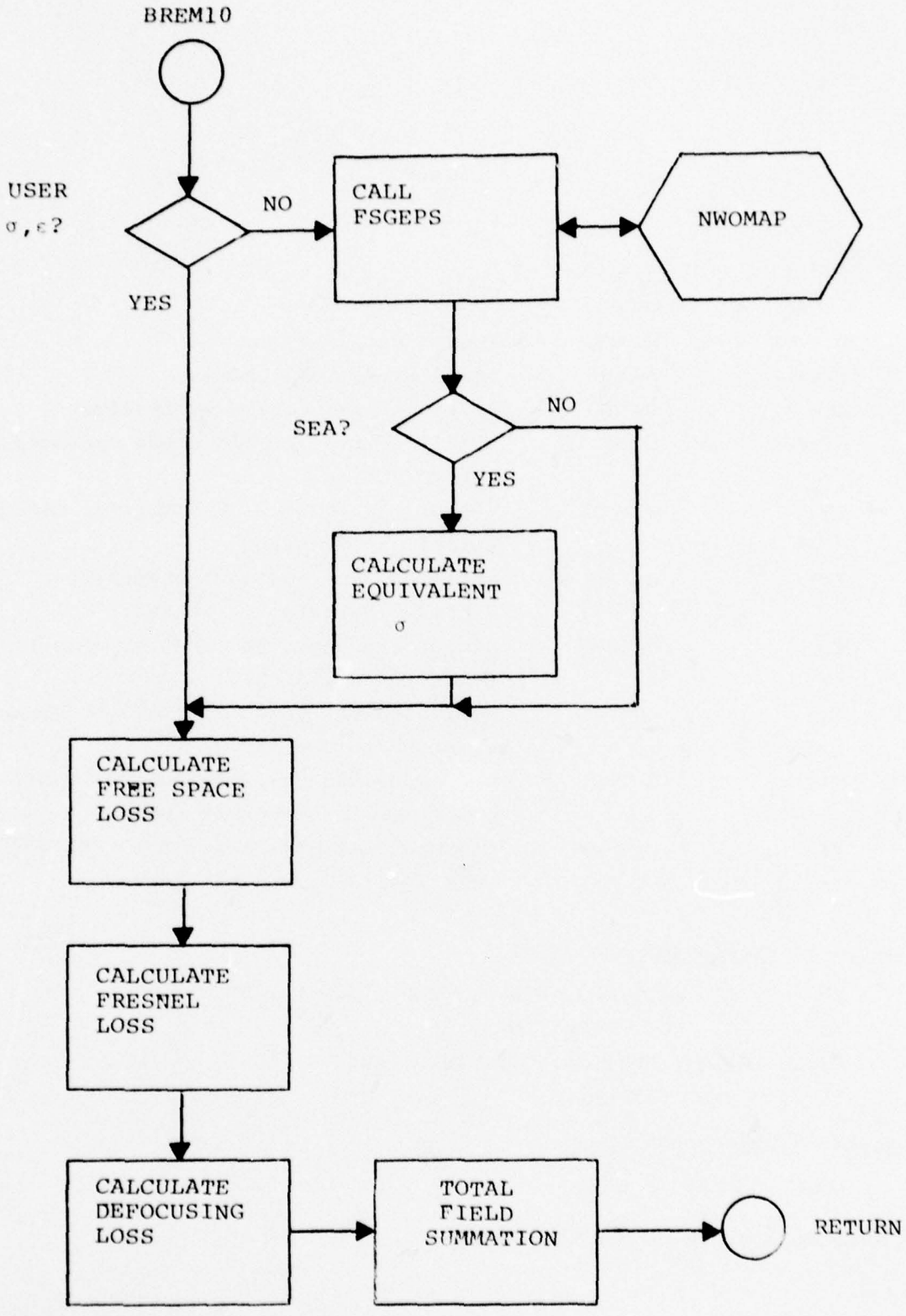


Figure 3-9. Flowchart of subroutine RFLXRA

3.3 Modifications to Subprogram COMEFF

The modifications to COMEFF fall into two broad areas: those concerned with incorporation of the nonionospheric components into the all mode power sum, and those concerned with the significantly expanded input antenna capability of NUCOM/BREM. Table 3-3 summarizes the changes to preexisting subroutines and the functions of the new subroutines. The overall flowchart of Figure 3-10 summarizes the effects of the NUCOM/BREM modification to such program flow.

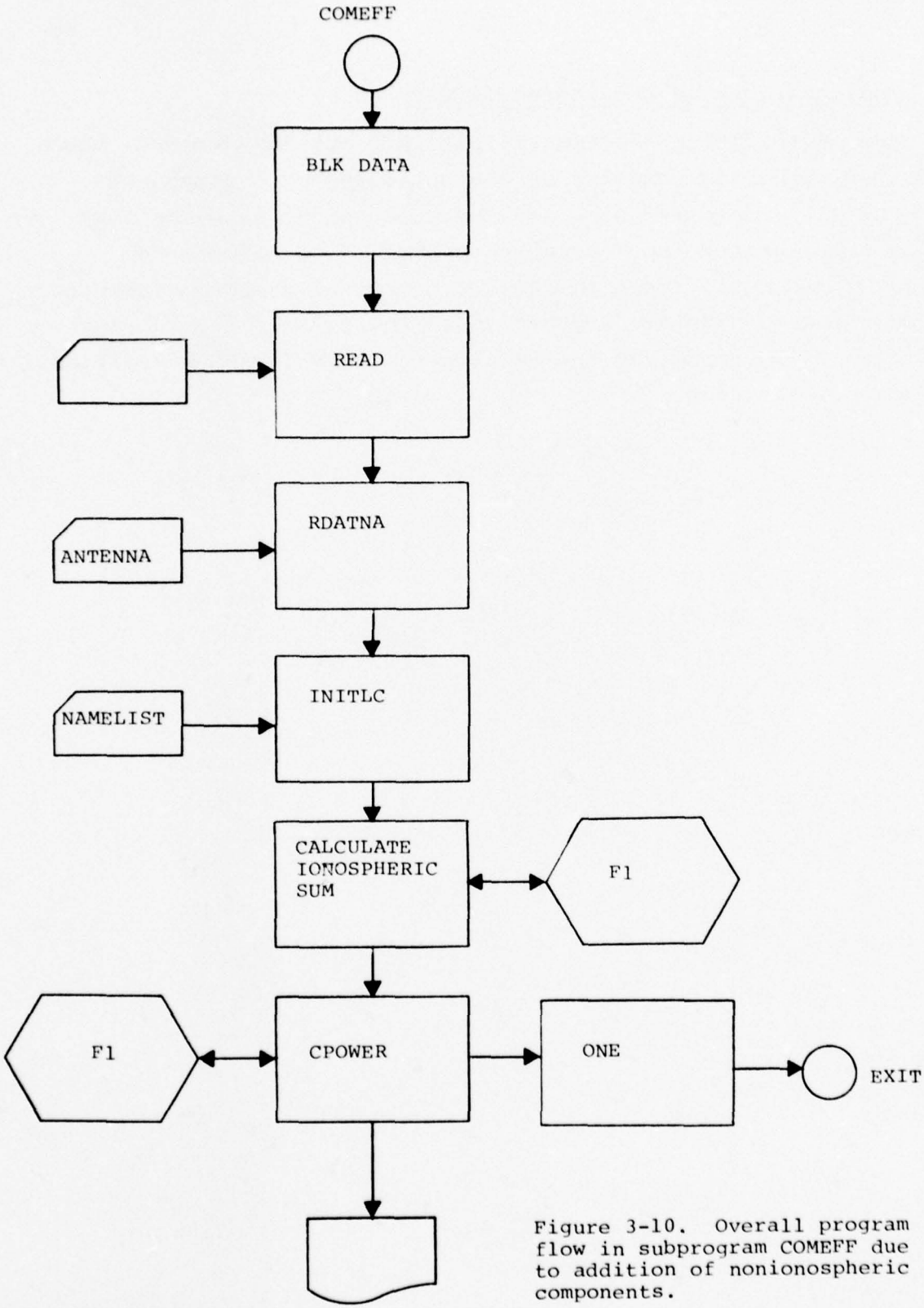


Figure 3-10. Overall program flow in subprogram COMEFF due to addition of nonionospheric components.

TABLE 3-3

New of modified subroutines in subprogram COMEFF

Subroutine	Changes/Descriptions
CPOWER	Did not previously exist. All calculations resulting from nonionospheric modes in RAYTRACE are handled in this subroutine.
F1 (FUNCTION)	Interpolates antenna gain values (or returns 1.0 for isotropic). Substantially rewritten to permit user specified antenna patterns to $\pm 90^{\circ}$, to permit distinct vertical and horizontal polarization patterns, to reduce restrictions on number of frequencies input, and to permit transmitter and receiver patterns to have different ranges.
INITLC	Rewritten to permit NAMELIST input of user specified parameters: transmitter antenna pattern range, receiver antenna pattern range, number of frequencies supplied, antenna file number. The antenna pattern input function is now contained in a new subroutine RDATNA.
ONE	Rewritten slightly to permit accumulation of ionospheric ray power for CPOWER.
RDATNA	New subroutines to permit increased antenna input features.
READ	New input card type and call to CPOWER to permit processing of nonionospheric components.
BLK DATA	Significantly expanded to accomodate new data structures.

3.3.1 BLK DATA

Description

BLK DATA establishes dimensions and data types for the new data structure in NUCOM/BREM. A flowchart of BLK DATA is presented in Figure 3-10.

Call Statement

Not Applicable

Arguments

Not Applicable

Common Storage Arguments Used

/DATA/C2, FOURPI, EFPL, TABLFR(15), 1 DUMM, MAX, IDEBUG
/SPPASS/NOFREQ, INPFIL, VGTOT, RGTOT, HGTOT
/SAVSIG/HIRAY P, IFLAG
/SWITCH/KSW1, KSW2, JF, 1 BETA, JCARD, NEWANT
/XLIT/AST, LIN, BLANK, STAR

Internal Subroutine Used

NONE

Storage Locations Used

238_{10}

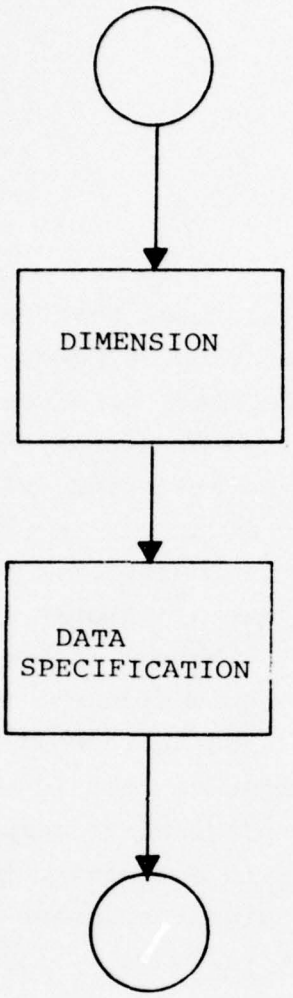


Figure 3-11. Flowchart of block data subprogram BLK DATA.

3.3.2 Subroutine CPOWER

Description

The subroutine CPOWER calculates the total received compensated power of each polarization type and the all mode power sum. Using input data from file JF, CPOWER calculates the total received signal power compensated for antenna gain and actual power density for direct, reflected, and groundwave rays of each polarization. Each compensated raytype power including the ionospheric power sum is then summed to provide the all mode signal power sum. The vertically polarized ionospheric noise power RNOIS from the ITS data is NWOMAP is corrected to compensate for the user-supplied noise height factor FACHNZ and the relative antenna pattern factor CONHNZ to provide the received horizontal noise power F_H. The power sum of the horizontal and vertical noise power densities is then used to compute the all mode signal to noise ratio. A considerable number of intermediate computations are printed to provide guidance to the user in evaluating the parameters which contribute to the final all mode signal to noise ratio. A flowchart of CPOWER is presented in Figure 3-12.

Call Statement

CALL CPOWER (P, TP, ALPSUM)

Arguments

Symbol	Type	Description
P	INPUT	User specified power density, W/Hz
TP	OUTPUT	Total received nonionospheric signal power, dBW
ALPSUM	OUTPUT	All mode power sum, dBW

Common Arguments Used

T, FACHNZ, FR, DT, DR, RHT, VNOIZ, THT
/SWITCH/KSW1, KSW2, 5F, IBETA
/SAVSIG/HIRAYP
/ANTDAT/TABL1V(181,8), TABL LH (181,8),
TABL2V(181,8), TABL2H (181,8)
/SPPASS/IANT, ANTFIL, UGTOT, RGTOT, HGTOT

Internal Subroutines Used

None

Number of Storage Locations Used

3404_{10}

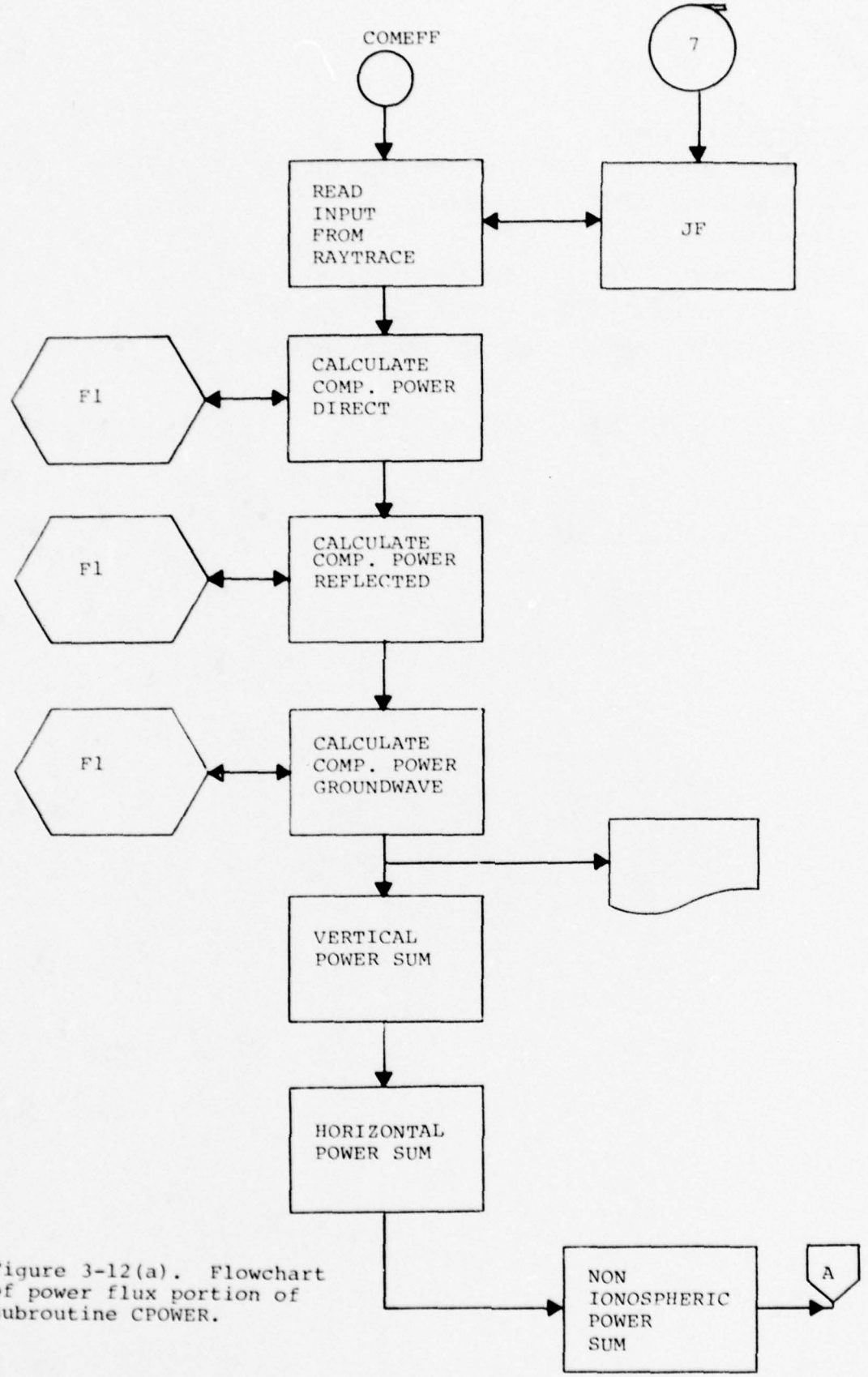


Figure 3-12(a). Flowchart of power flux portion of subroutine CPOWER.

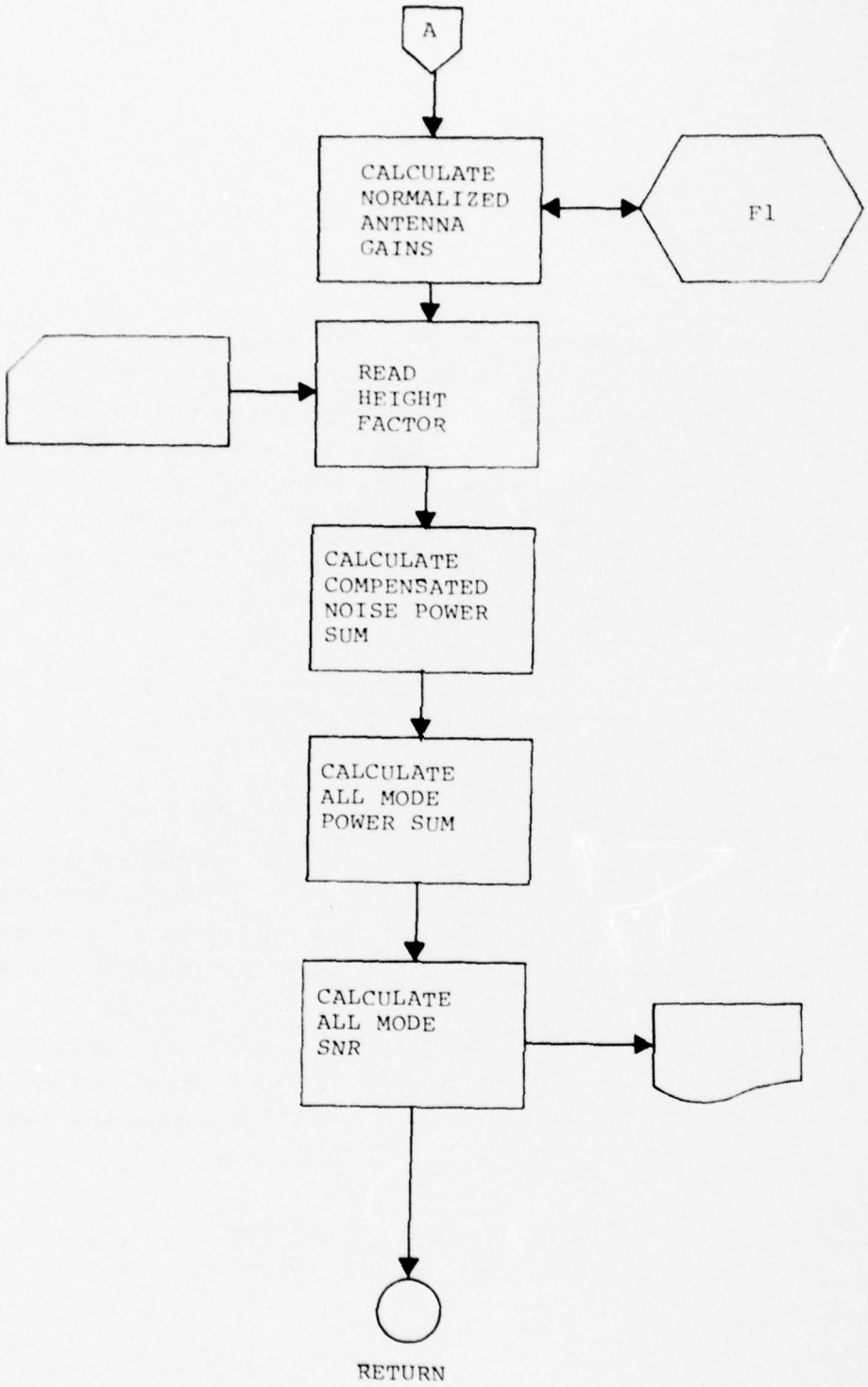


Figure 3-12(b). Flowchart of noise and SNR portion of subroutine CPOWER.

3.3.3 Function F1

Description

The function F1 provides the antenna gain for a particular angle, frequency, and polarization type. If no antenna patterns have been supplied or if the angle in question is outside the specifed range of antenna data, an isotropic gain is assumed and a warning is printed for the user. Interpolation on frequency and angle is performed with power ratios (not in dB) assuming linearity. The user input antenna patterns are printed in tabular format for energy 1 or 10 values depending upon the user parameter PRNT. A flowchart for the function F1 is given in Figure 3-13.

Call Statement

```
FUNCTION (X, TABL, NPAT)
```

Arguments

Symbol	Type	Description
X	INPUT	Angle for which gain is required
TABL	INPUT	Antenna table vector
NPAT	INPUT	Distinguishes between transmitter and receiver tables

Common Arguments Used

```
PT(1000, 3), A(1000), PHASET (1000), TAUS(1000),
MODE (60), TIME (30), FREQ (30), SIGTAU (20,20),
SIGNOI (20,20)
```

```
/ANTDAT/ TABL1V (181,8), TABL1H (181,8)
         TABL2V (181,8) TABL2H (181, 8)
         MXANGL (2), MNANGL(2), KRXN(2),
         NANGLS(2)
/SPPASS/NUMF
/SWITCH/ KSW1, KSW2, JF, BETA
/DATA/ C2, FOURPI, EFPL, TABLFR (15), ISW, MX1, IDEBUG
/NAMELIST/INTRPL/ IANGL, KANGL, DELNGL, DELFR, G1, G2, F1
```

Internal Subroutines Used

None

Number of Storage Locations Used

1828_{10}

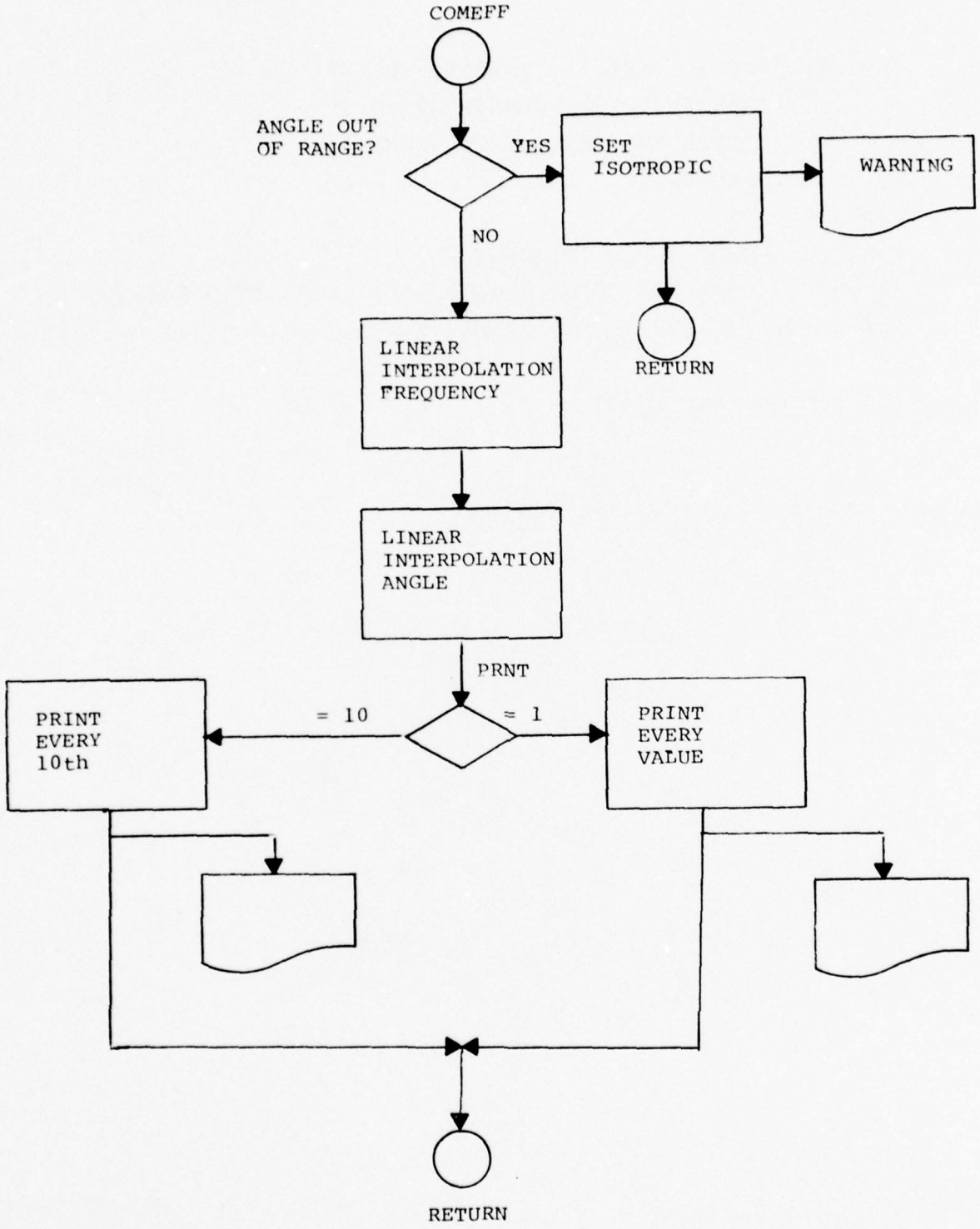


Figure 3-13. Flowchart for function F1.

3.3.4 Subroutine INITLC

Description

The subroutine INITLC initializes counters and arrays, prints the identification card and reads the antenna calibration tables when they are provided. ANTFIL is a new variable to allow reading of patterns from disk or tape files as well as card decks. Five spaces have been taken from the front of the KSW1 field for the ANTFIL parameter input. If ANTFIL is left blank or set equal to zero, and KSW1 is blank or zero, then the subroutine RDATNA will set ANTFIL equal to five and look for the input antenna patterns on the card input file. A flowchart for subroutine INITLC is presented in Figure 3-14.

Call Statement

```
CALL INITLC
```

Parameters

NONE

Common Arguments Used

```
PT (1000, 3), A(1000), PHASET (1000), TAUS(1000)
MODE (60), TIME (30), FREQ (30), SIG TAU (20,20),
SIGNO1 (20, 20)
/ANTDAT/TABL1V (181, 8), TABL1H (181,8),
        TABL2V (181, 8), TABL2H (181, 8),
        MXANGL (2), MNANGL (2), KRXN (2),
        NANGLS(2)

/CONTRO/   PLREJ

/DATA/  C2, FOURP1, EFPL, TABLFR(15), ISW, MX1, IDEBUG

/SWITCH/ KSW1, KSW2, JF, IBETA, JCARD, NEWANT
```

```
/SPPASS/ NOFREQ, ANTFIL, VGTOT, RGTOT, HQTOT

/NAMELIST/IINIT/NOFREQ, KSW1, KSW2,
                JCARD, NEWANT,
                MXANGT, MXANGR,
                ANTFIL, P, BAUD,
                PLRFJ, IBETA, MNANGT,
                MNANGR, IDEBUG
```

Internal Subroutines Used

RDATNA

Number of Storage Locations Used

1880_{10}

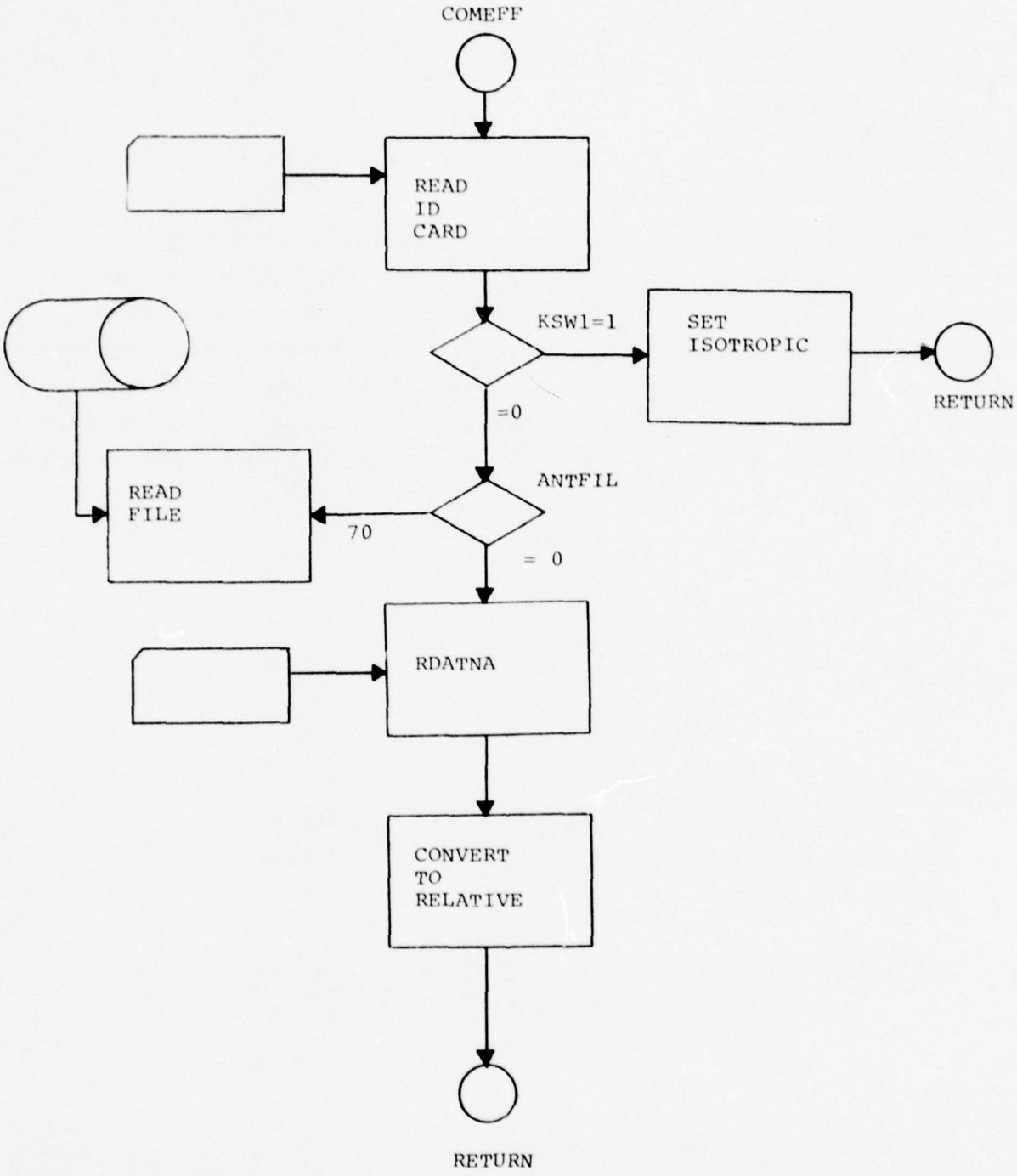


Figure 3-14. Flowchart of subroutine INITLC

3.3.5 Subroutine ONE

Description

Subroutine ONE performs the power flux summation for the ionospheric components. The modification for NUCOM/BREM consists of redefinitions of the antenna data arrays to permit the increased flexibility of the input antenna formats to be incorporated into the ionosperic components. The vertical polarization component antenna pattern takes the place of the original NUCOM II pattern for ionospheric rays. A flowchart showing the modifications to subroutine ONE is given in Figure 3-15.

Call Statement

```
CALL ONE
```

Arguments

NONE

Common Arguments Used

```
PT (1000. 3). A(1000). PHASET (1000). TAUS(1000).
MODE (60), TIME (30), FREQ (30), SIGTAU (20, 20),
SIGNOI (20, 20)

/ANT DAT/ TABL 1V (181, 8), TABL1H (181, 8),
          TABL 2V (181, 8), TABL2H (181, 8),
          MXANGL (2), MNANGL (2),
          KRXN(2), NANGLS (2)

/MIN/     DBMIN, DTMIN, DRMIN
/CONTRO/  PLREJ
/SAVSIG/  HIRAYP, IFLAG
/DATA/    C2, FOURPI, EFPL, TABLFR(15), IDUMM, MAX, IDEBUG
```

Internal Subroutines Used

None

Number of Storage Locations Used

3640_{10}

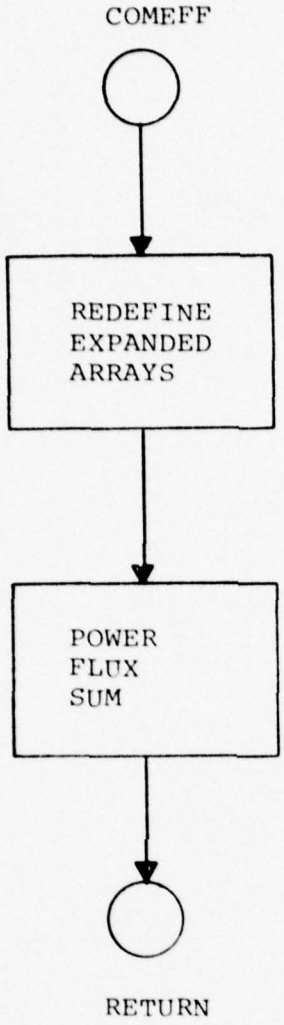


Figure 3-15. Flowchart for subroutine ONE modification.

3.3.6 Subroutine RDATNA

Description

The subroutine RDATNA reads in the antenna pattern tables if supplied. User supplied NAMELIST variables define the minimum and maximum angles for the transmitter and receiver patterns (which need not have the same values). Antenna pattern data must be supplied for every integer degree from the minimum to the maximum value. Pairs of cards are supplied for each angle, the first being the vertical component and the second the horizontal. Values are in dB relative to isotropic and blank values are assumed to be isotropic. Angles are defined relative to local horizontal as in NUCOM II except that the range of angles now extends to ±90°. The subroutine RDATNA reads the input tables for both receiver and transmitter and converts to relative power from dB. All inputs are checked for errors and appropriate warnings are printed in the event of incorrect deck setup. A flowchart of subroutine RDATNA is presented in Figure 3-16.

CALL STATEMENT

```
CALL RDATNA
```

Arguments

NONE

Common Arguments Used

```
/ANTDAT/TABL1V(181, 8), TABL1H (181, 8),
        TABL2V (181, 8), TABL2H (181, 8),
        MXANGL (2), MNANGL (2),
        KRXN(2), NANGLS (2)
/DATA/ C2, FOURPI, EFPL, TABLFR (15),
       1SW, MX1, IDEBUG
/SPPASS/ IANT, ANTFIL, VGTOT, RGTOT, HGTOT
```

Internal Subroutines Used

NONE

Number of Storage Locations Used

4740_{10}

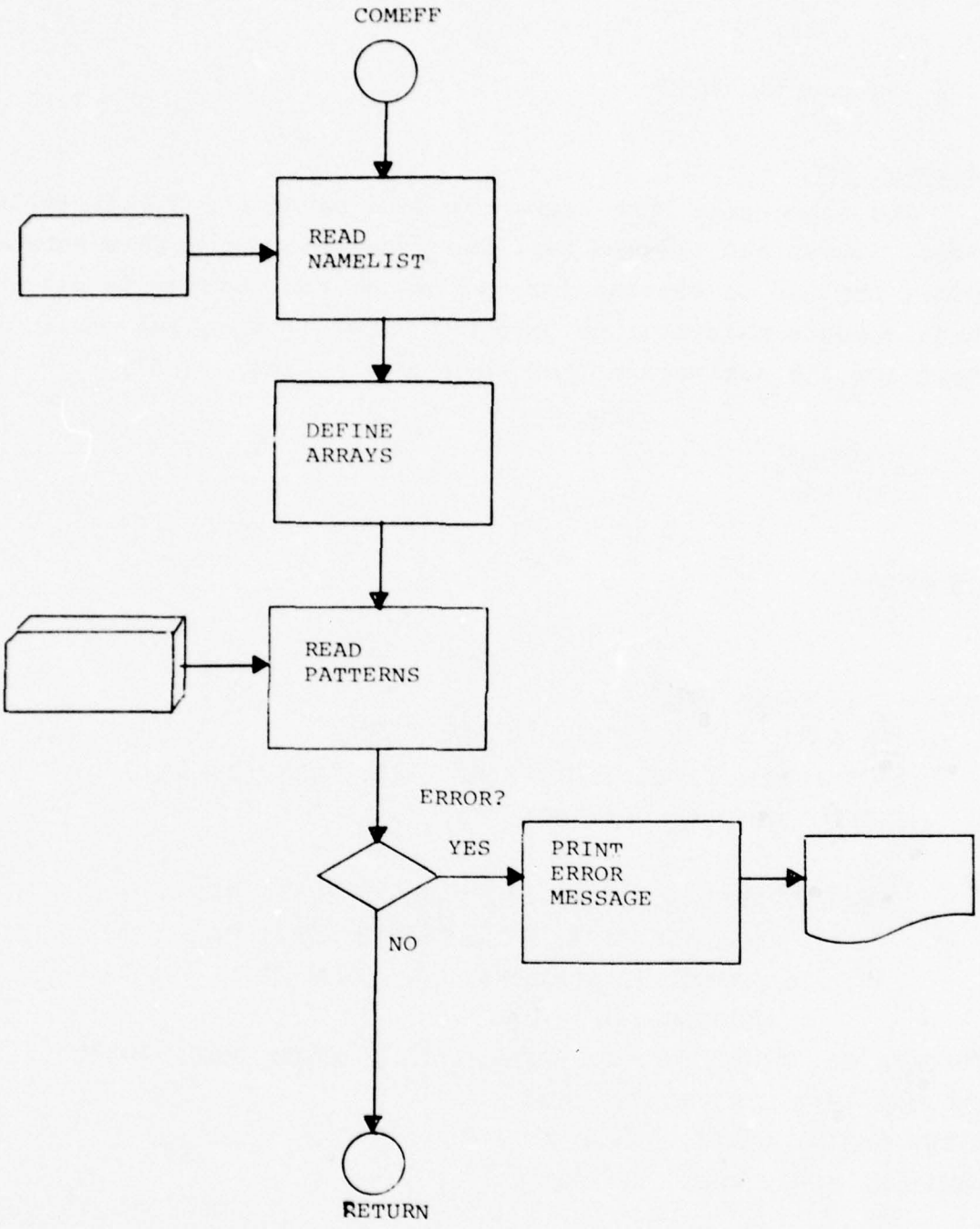


Figure 3-16. Flowchart of subroutine RDATNA.

3.3.7 Subroutine READ

Description

The subroutine READ reads the data cards and builds tables for modes, times, and frequencies. The modifications to this subroutine permit the use of aliases for the use of nonionospheric calculations. These changes maintain the original NUCOM II stacking logic. A flowchart for the subroutine READ is given in Figure 3-17.

Call Statement

```
CALL READ
```

Arguments

NONE

Common Arguments Used

```
PT (1000, 3), A(1000), PHASET (1000),
TAUS (1000), MODE (60), TIME (30), FREQ (30),
SIGTAU (20, 20),  SIGNOI (20, 20)

/ANTDAT/ TABL 1V (181, 8), TABL 1H (181, 8),
         TABL 2V (181, 8),  TABL2H (181, 8),
         MXANGL (2), MNANGL (2), KRXN(2),
         NANGLS (2)
/DATA/  C2, FOURPI, EFPL, TABLFR (15), IDUMM, MAX,  IDEBUG
/XLIT/  AST, LIN, BLANK, STAR
/MIN/ DBMIN, DTMIN, DRMIN
/SWITCH/ KSW1, KSW2, JF, BETA
```

Internal Subroutines Used

ONE

Number of Storage Locations Used

2174_{10}

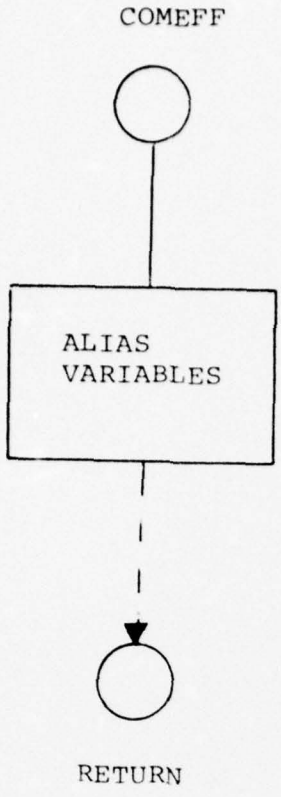


Figure 3-17. Flowchart for modification to subroutine READ.

SECTION 4.0

LIMITATIONS AND RESTRICTIONS IN NUCOM/BREM

The most important question of "just how good" a propagation prediction code is can never be fully resolved without extensive comparisons with observed data.

In most cases the accuracy of the predicted values of the nonionospheric components in NUCOM/BREM should far exceed the accuracy of the ionospheric predictions, particularly the nuclear-stressed predictions. While many of the limitations of NUCOM II are discussed in Reference 1 of Section 1, a short summary is desirable to permit comparison between uncertainties in ionospheric and nonionospheric propagation modes.

Areas of modelling uncertainty which may influence predicted values in a nuclear stressed environment include uncertainties in reaction rates and chemistry, the neglect of neutral wind drift of debris in the WEPH V phenomenology code, limited experimental data to confirm daytime and multiburst modelling, the neglect of bomb-induced field aligned E_s-like propagation modes, the neglect of deviated propagation paths due to large-scale ionospheric tilting and lateral electron density gradients, and the oversimplified modelling of shockwave effects.

For the ambient ionosphere significant areas of predictive uncertainty include the known deficiencies of the ITS world map ionospheric data, the use of a three layer parabolic isotropic ray tracing technique, the lack of modelling for ionospheric effects due to SID and auroral/geomagnetic activities, the neglect of

sporadic E and spread F modes, and the absence of modelling for deviated and chordal propagation paths. Many of these areas remain beyond the predictive abilities of any present day propagation codes.

The question of noise characterization in NUCOM II (and all other propagation codes for that matter) will also introduce uncertainties. As discussed in Section 2.5 the lack of precise knowledge of the directional and polarization properties of HF noise is perhaps as serious as all of the propagation uncertainties. The CCIR 322 data disagrees with similar measurements made by ITS[1] and recently by Raytheon Company[2] by as much as 10 dB. Furthermore, no verifiable models exist to predict the effects of nuclear disturbances on the worldwide radio noise distribution although observations of noise levels made during the Pacific Test Series suggest these effects are important.

Several areas of uncertainty exist for the nonionospheric component predictions as well. The use of the Bremmer-van der Pol equations for a smooth and homogeneous earth will limit prediction accuracy for propagation paths over highly irregular and inhomogeneous path terrain. Certain situations are to be avoided in the use of NUCOM/BREM. The seacoast transition region as discussed in Section 2. 4 should be avoided due to the recovery effects there. Our use of power flux summations for air-to-air links with ground reflections provides the envelope field and power but neglects the possible existence of deep interference nulls which may be present and modulated by aircraft motion.

Long paths over disturbed sea whose wave height spectral properties peak near the signal frequency are also to be avoided.

The modelling of the ionospheric paths from airborne terminals in NUCOM/BREM assumes the terminal to be close enough to the surface that the vertical ionospheric path geometry is not significantly changed. For realistic aircraft heights and path lengths this is not a serious limitation. By the same token the possibility of ground reflected rays then launched into the ionosphere from airborne terminals is ignored due to the obvious computational limitations in the raytracing portion of the code. Additional gain for the user supplied aircraft antenna patterns may be used to compensate for the ground reflected ionospheric components if desired.

REFERENCES

1. Amplitude and Time Statistics of Atmospheric and Man-Made Noise, R. T. Disney and A. D. Spaulding, ESSA Technical Report ERL 150-ITS 98, 1970.

2. Short-Term Stability of Noise and Interference in the 2-6 MHz Frequency Band, G. Meltz, et al, USNC-URSI Annual Meeting 1976, paper E2-1.

SECTION 5.0

SELECTED LINK EVALUATIONS

For the guidance of users of NUCOM/BREM we have included five sample link runs and one sample deck setup. The link examples have been chosen to show a variety of nonionospheric propagation modes which would be ignored by the unmodified NUCOM II code. NUCOM/BREM provides a substantial body of intermediate calculation outputs for the guidance of the user and these outputs are explained in the examples to follow.

5.1 Ground to Ground Link - Above MUF

This is an example of a short (100.02 km) HF path on a frequency sufficiently above the MUF for the path in question that no ionospheric propagation occurs.

All outputs are as from NUCOM II until RAYTRACE. The BREM input parameters are listed showing transmitter and receiver heights of zero and a Suda segmantation parameter of 10. Next appears the effective ground parameters from NWOMAP for each of the 10 Suda segments and the average value for the path. The BREM ANALYSIS RESULTS section gives the uncompensated signal powers for vertical and horizontal components and the arrived angles. The normal output from RAYTRACE indicates no ionospheric propagation for the path.

The COMEFF output shows first the NAMELIST variables input by the user, followed by the input antenna patterns, first for vertical and then for horizontal polarization. Then are given the uncompensated powers and power and antenna gain compensation factors used to obtain the compensated powers as given for vertical and horizontal components respectively. The SIGNAL ANALYSIS INCLUDING BREM ANALYSIS output gives total vertical and horizontal compensated powers at the receiver, the ionospheric signal sum, vertical and corrected noise levels, and the final corrected all mode signal to noise ratio. The last line is the normal RAYTRACE output for the situation where no ionospheric propagation occurs. The resulting all mode S/N of 10.2 dB predicts adequate copy for the 20 wpm CW transmitter of 20 kW average power modelled here.

TRANSMITTER		RECEIVER		MONTH	GMT	SSN	PATH(KM)	AZ	DELTAD	NO. CONTROL POINTS
-17.00	-128.20	-17.90	-128.20	6	12.20	20.00	100.02	180.00	100.00	2

GROUNDWAVE ONLY EXAMPLE SSP= 23.055

TIME(SEC)= -1.

HME	YME	FOE	CHI	HMF1	YMF1	FOF1	HMF2	YMF2	FOF2	ESU	ES	ESL	M(3000)	DIST
115.00	25.00	0.33	128.44	177.74	47.74	0.44	267.05	65.45	2.44	3.42	2.31	1.71	3.35	0.0
115.00	25.00	0.33	128.69	177.88	47.88	0.44	267.28	65.46	2.43	3.55	2.32	1.67	3.35	100.02

CD NO	CARD INPUT DATA							
1	0	0						
2	-17.00	-128.20	-17.90	-128.20	0.0	0.0		
3	4.00	1.00	4.00	0.10	1.00	75.00	0.60	1.00
5	1							
6	12.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	-1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0	0	0					
0	GROUNDWAVE ONLY EXAMPLE							

GROUNDWAVE ONLY EXAMPLE

90.00

GROUNDWAVE ONLY EXAMPLE MONTH 6 1211 GMT -1. SEC

PATH LENGTH 100.02 KM TX LAT -17.00 DEG TX LONG -128.20 DEG RX LAT -17.90 DEG RX LONG -128.20 DEG RX BEARING 180.00 DEG

FREQ	BETA XMTR	BETA RCVR	GROUP TIME	PHASE TIME	MISS DIST	NOIS	FSPCE LOSS	* NATURAL * GRND LOSS	NONDV ABS	DEV ABS	* NUCLEAR * NONDV ABS	E,F1 ABS	PATH LOSS
MHZ	DEG	DEG	SEC	SEC	KM	DBW	DB	DB	DB	DB	DB	DB	DB

BREM ANALYSIS INPUT

TRANS HEIGHT	RCVR HEIGHT	SIGMA	EPSILON	WIND VEL	SUDA	MILLINGTON
0.0	0.0	0.0	0.0	0.0	10	0

	LATITUDE	LONGITUDE	SIGMA	EPSILON
FROM TRANSMITTER				
	-17.0000	128.2000	0.0010	4.0000
	-17.0899	128.2000	0.0010	4.0000
	-17.1799	128.2000	0.0010	4.0000
	-17.2698	128.2000	0.0010	4.0000
	-17.3598	128.2000	0.0010	4.0000
	-17.4497	128.2000	0.0010	4.0000
	-17.5397	128.2000	0.0010	4.0000
	-17.6296	128.2000	0.0010	4.0000
	-17.7196	128.2000	0.0010	4.0000
	-17.8095	128.2000	0.0010	4.0000
	-17.8994	128.2000	0.0010	4.0000
	**********	**********	0.0010	4.0000

BREM ANALYSIS RESULTS

RELATIVE POWER COMPONENTS			RAY ZENITH ANGLES			
POLARIZATION		LINE OF SIGHT	TRANSMITTER		RECEIVER	
VERTICAL	HORIZONTAL		DIRECT	REFLECTED	DIRECT	REFLECTED
DBW	DBW	DBW	DEGREES	DEGREES	DEGREES	DEGREES
-149.	-180.		0.0		0.0	

FREQ	BETA XMTR	BETA RCVR	GROUP TIME	PHASE TIME	MISS DIST	NOIS	FSPCE LOSS	* NATURAL * GRND LOSS	NONDV ABS	DEV ABS	* NUCLEAR * NONDV ABS	E,F1 ABS	PATH LOSS
MHZ	DEG	DEG	SEC	SEC	KM	DBW	DB	DB	DB	DB	DB	DB	DB

NO PROPAGATION OCCURS FOR FREQUENCY AND TAKE OFF ANGLE RANGES SPECIFIED

LAST FREQ TRIED= 4.00

5.2 Ground to Air Link - Line of Sight, Below MUF

In this short link (245.0 km) both ionospheric and non-ionospheric modes exist. The transmitter is elevated at 10 km and a Suda parameter of 10 was chosen. The line of sight power figure (-92.8 dBW) is printed and the corresponding ray angles are given.

The COMEFF output indicates that we have not supplied receiver antenna pattern data for high enough angles to include the ionospheric rays; after printing the warning computation proceeds with an assumed isotropic gain for the missing values. In this case the nonionospheric power sum is close to the ionospheric mode and the net effect as shown in the all mode S/N is only a slight improvement. Were the ionospheric component to vanish, however, either through MUF failure or ionospheric stressing the nonionospheric components would of course remain.

TRANSMITTER		RECEIVER		MONTH	GMT	SSN	PATH(KM)	AZ	DELTAD	NO. CONTROL POINTS
21.00	-157.90	20.00	-160.00	6	12.00	20.00	245.20	243.42	100.00	4

NUCOM BREM AIR TO GROUND TEST SSP= 23.055

TIME(SEC)= -1.

HME	YME	FOE	CHI	HMF1	YMF1	FOF1	HMF2	YMF2	FOF2	ESU	ES	ESL	M(3000)	DIST
115.00	25.00	0.33	130.96	202.95	72.95	0.50	315.11	75.69	4.88	5.42	3.20	1.35	3.03	0.0
115.00	25.00	0.32	131.69	202.61	72.61	0.49	314.51	75.60	4.90	5.41	3.20	1.35	3.03	100.00
115.00	25.00	0.32	132.41	202.25	72.25	0.49	313.90	75.53	4.91	5.40	3.19	1.35	3.04	200.00
115.00	25.00	0.32	132.73	202.07	72.07	0.49	313.61	75.50	4.92	5.39	3.19	1.35	3.04	245.20

```
                    CARD INPUT
CD NO                DATA

 1          0          0
 2      21.00    -157.90      20.00    -160.00       0.0        0.0
 3       3.00       1.00       3.00       0.10       1.00      75.00       0.60       0.60
 4       3.00
 5          1
 6      12.00       0.0        0.0        0.0        0.0        0.0        0.0        0.0
 7      -1.00       0.0        0.0        0.0        0.0        0.0        0.0        0.0
 8          1          1          1
 9       3.00
 0        NUCOM BREM AIR TO GROUND TEST

   21.00  157.90   20.00  160.00  6    12.00    20.00   245.20   243.42  4 31 64  1  1

30. 32. 34. 36. 38. 40. 42. 44. 46. 48. 50. 52. 54. 56. 58. 60. 62. 64. 66. 68. 70. 72. 74. 76. 78. 80. 82. 84. 86. 88. 90. 92. 94.

96. 98.100.105.110.115.120.125.130.135.140.150.160.170.180.190.200.220.240.260.280.300.320.340.360.380.400.450.500.600.700.  0.

0.318E+03 0.237E+03 0.177E+03 0.133E+03 0.101E+03 0.766E+02 0.587E+02 0.452E+02 0.350E+02 0.272E+02 0.212E+02 0.165E+02 0.129E+02

0.100E+02 0.775E+01 0.597E+01 0.458E+01 0.349E+01 0.264E+01 0.198E+01 0.147E+01 0.108E+01 0.781E+00 0.560E+00 0.396E+00 0.276E+00

0.191E+00 0.132E+00 0.912E-01 0.631E-01 0.437E-01 0.304E-01 0.214E-01 0.153E-01 0.110E-01 0.797E-02 0.377E-02 0.193E-02 0.107E-02

0.650E-03 0.428E-03 0.307E-03 0.233E-03 0.184E-03 0.125E-03 0.904E-04 0.678E-04 0.515E-04 0.397E-04 0.305E-04 0.187E-04 0.119E-04

0.778E-05 0.525E-05 0.365E-05 0.256E-05 0.184E-05 0.134E-05 0.998E-06 0.754E-06 0.395E-06 0.219E-06 0.788E-07 0.332E-07 0.0

0.119E-04 0.143E-04 0.173E-04 0.210E-04 0.254E-04 0.307E-04 0.371E-04 0.448E-04 0.542E-04 0.651E-04 0.779E-04 0.931E-04 0.111E-03

0.131E-03 0.156E-03 0.185E-03 0.219E-03 0.258E-03 0.303E-03 0.357E-03 0.419E-03 0.492E-03 0.578E-03 0.678E-03 0.794E-03 0.930E-03

0.111E-02 0.133E-02 0.159E-02 0.190E-02 0.227E-02 0.276E-02 0.335E-02 0.327E-02 0.256E-02 0.201E-02 0.111E-02 0.611E-03 0.348E-03

0.196E-03 0.116E-03 0.665E-04 0.378E-04 0.212E-04 0.654E-05 0.193E-05 0.552E-06 0.155E-06 0.436E-07 0.122E-07 0.943E-09 0.727E-10

0.557E-11 0.427E-12 0.327E-13 0.249E-14 0.189E-15 0.144E-16 0.109E-17 0.831E-19 0.132E-21 0.209E-24 0.522E-30 0.130E-35 0.0

                                NUCOM BREM AIR TO GROUND TEST
```

IONOSPHERIC PROFILE FOR PATH NUCOM BREM AIR TO GROUND TEST 1200 GMT -1. SEC

NU DN	HME	YME	FOE	HMF1	YMF1	FOF1	HMF2	YMF2	FOF2	RANGE
0	115.00	25.00	0.3	202.95	72.95	0.5	315.11	75.69	4.9	0.0
0	115.00	25.00	0.3	202.61	72.61	0.5	314.51	75.60	4.9	100.0
0	115.00	25.00	0.3	202.25	72.25	0.5	313.90	75.53	4.9	200.0
0	115.00	25.00	0.3	202.07	72.07	0.5	313.61	75.50	4.9	245.2

90.00

NUCOM BREM AIR TO GROUND TEST MONTH 6 1200 GMT -1. SEC

PATH LENGTH 245.20 KM TX LAT 21.00 DEG TX LONG -157.90 DEG RX LAT 20.00 DEG RX LONG -160.00 DEG RX BEARING 243.42 DEG

											* NATURAL *			* NUCLEAR *		
		FREQ	BETA XMTR	BETA RCVR	GROUP TIME	PHASE TIME	MISS DIST	NOIS	FSPCE LOSS	GRND LOSS	NONDV ABS	DEV ABS	NONDV ABS	E,F1 ABS	PATH LOSS
		MHZ	DEG	DEG	SEC	SEC	KM	DBW	DB	DB	DB	DB	DB	DB	DB
FREQ	MODE	BETA XMTR	GRND DIST	BETA RECR	PER HGT										
3.0															
	4.	47.10	444.30	47.83	0.0										
	4.	48.10	430.35	48.83	0.0										
	4.	49.10	416.78	49.83	0.0										
	4.	50.10	403.53	50.82	0.0										
	4.	51.10	390.59	51.82	0.0										
	4.	52.10	377.93	52.82	0.0										
	4.	53.10	365.53	53.81	0.0										
	4.	54.10	353.37	54.81	0.0										
	4.	55.10	341.44	55.81	0.0										
	4.	56.10	329.70	56.82	0.0										
	4.	57.10	318.20	57.82	0.0										
	4.	58.10	306.89	58.82	0.0										
	4.	59.10	295.74	59.82	0.0										
	4.	60.10	284.77	60.82	0.0										
	4.	61.10	273.96	61.82	0.0										
	4.	62.10	263.29	62.82	0.0										
	4.	63.10	252.76	63.82	0.0										
	4.	64.10	242.34	64.82	0.0										
	4.	65.10	232.07	65.82	0.0										
	4.	66.10	221.89	66.83	0.0										
	44.	66.10	439.31	66.83	0.0										
	4.	67.10	211.84	67.82	0.0										
	44.	67.10	419.25	67.82	0.0										
	4.	68.10	201.88	68.82	0.0										
	44.	68.10	399.39	68.82	0.0										
	4.	69.10	192.01	69.82	0.0										
	44.	69.10	379.71	69.82	0.0										
	4.	70.10	182.23	70.82	0.0										
	44.	70.10	360.20	70.82	0.0										
	4.	71.10	172.51	71.81	0.0										
	44.	71.10	340.81	71.81	0.0										
	4.	72.10	162.84	72.82	0.0										
	44.	72.10	319.14	73.32	0.0										
	4.	73.10	153.24	73.82	0.0										
	44.	73.10	298.89	74.56	0.0										
	444.	73.10	440.94	74.56	0.0										
	4.	74.10	143.71	74.82	0.0										
	44.	74.10	279.95	75.56	0.0										
	444.	74.10	412.54	75.56	0.0										
.F2		3.0	63.83	64.55	1.954	1.845	-0.0	148.0	126.4	0.0	0.0	0.5	0.0	0.2	127.

MODE .F2 .....

3.000 MC 63.825 DEGREES

HEIGHT	RANGE
140.00	67.16

```
  275.47    129.15
  254.46    124.40
  130.00    184.70
   90.00    203.02
    0.0     245.20
NOTE--NEXT RAY IS MORE THAN   2. KM FROM REC

.F2 ..............................  3.0  73.10  73.82   1.954   1.822 -92.0 148.0 126.4    0.0  0.0  0.6     0.0   0.2   127.
MODE .F2 .....................................
  3.000 MC      73.100 DEGREES
  HEIGHT   RANGE
  140.00     41.58
  275.63     80.12
  253.53     78.20
  130.00    116.31
   90.00    127.51
    0.0     153.24

.F2 .F2 ..........................  3.0  75.93  77.39   3.693   3.416   0.2 148.0 131.9    0.1  0.0  1.2     0.0   0.3   133.
MODE .F2 .F2 .................................
  3.000 MC      75.934 DEGREES
  HEIGHT   RANGE
  140.00     34.30
  275.68     66.13
  254.03     64.72
  130.00     96.15
   90.00    105.31
    0.0     126.35
  140.00    158.83
  274.81    188.77
  253.32    187.44
  130.00    216.94
   90.00    225.58
    0.0     245.42
```

.F2 .F2 .F2 ..... 3.0 79.99 82.21 5.481 5.045 -0.9 148.0 135.3 0.1 0.0 1.9 0.0 0.5 138.

MODE .F2 .F2 .F2 .....

3.000 MC 79.991 DEGREES

HEIGHT	RANGE
140.00	24.17
275.74	46.62
254.63	45.75
130.00	67.66
90.00	73.97
0.0	88.47
140.00	110.85
275.15	131.54
254.14	130.73
130.00	150.81
90.00	156.61
0.0	169.93
140.00	190.49
274.57	209.43
253.68	208.68
130.00	226.93
90.00	232.21
0.0	244.35

BREM ANALYSIS INPUT

TRANS HEIGHT	RCVR HEIGHT	SIGMA	EPSILON	WIND VEL	SUDA	MILLINGTON
10000.000	0.0	0.0	0.0	0.0	10	0

BREM ANALYSIS RESULTS

RELATIVE POWER COMPONENTS			RAY ZENITH ANGLES			
POLARIZATION		LINE OF SIGHT	TRANSMITTER		RECEIVER	
VERTICAL	HORIZONTAL		DIRECT	REFLECTED	DIRECT	REFLECTED
DBW	DBW	DBW	DEGREES	DEGREES	DEGREES	DEGREES
		-92.8	-3.501		1.403	

CD NO		CARD INPUT DATA
1	0	1

ALL MODE COMEFF INPUT DATA FROM RAYTRACE

NUCOM BREM AIR TO GROUND TEST

```
          -1.       4.0  3.00 63.83 64.55  1.954  1.845    127.0  148.0 1200      127.0

          -1.      44.0  3.00 75.93 77.39  3.693  3.416    133.5  148.0 1200      133.5

          -1.     444.0  3.00 79.99 82.21  5.481  5.045    137.8  148.0 1200      137.8

       G  -1.     0.0    3.00  0.0   0.0     0.010000.0      0.0  148.0 1200        0.0

       &-.100000E+76-.100000E+76-92.7988        -3.501     0.0       1.403     0.0
&IINIT
NOFREQ=          1,KSW1=          0,KSW2=          0,JCARD=          0,NEWANT=          1,MXANGT=         30,MXANGR=         90,
ANTFIL=          5,P=  3.33300018    ,BAUD=  .100000016E-01,PLREJ=  2000.00000    ,IBETA=          0,MNANGT=        -30,MNANGR=
       0,IDEBUG=          0
&END
```

TRANSMITTER GAIN(DB) ANGLE(DEG) BY FREQUENCY(MHZ)
FREQUENCY

	3.0000
-30	5.97 0.77
-29	-2.44 -3.74
-28	-8.61 -4.81
-27	-6.86 -1.46
-26	1.19 3.23
-25	8.15 4.96
-24	7.62 2.12
-23	0.08 -2.66
-22	-7.53 -5.00
-21	-8.22 -2.74
-20	-1.35 2.04
-19	6.76 4.94
-18	8.65 3.30
-17	2.59 -1.38
-16	-5.85 -4.79
-15	-8.92 -3.80
-14	-3.78 0.68
-13	4.83 4.54
-12	9.00 4.22
-11	4.90 0.02
-10	-3.71 -4.20
-9	-8.90 -4.56
-8	-5.91 -0.73
-7	2.51 3.77
-6	8.63 4.80
-5	6.81 1.42
-4	-1.27 -3.27
-3	-8.18 -4.95
-2	-7.57 -2.08
-1	0.0 2.70
0	7.57 5.00
1	8.18 2.70
2	1.27 -2.08
3	-6.81 -4.95
4	-8.63 -3.27
5	-2.51 1.42
6	5.91 4.80

7	8.90	3.77
8	3.71	-0.73
9	-4.90	-4.56
10	-9.00	-4.20
11	-4.83	0.02
12	3.78	4.22
13	8.92	4.54
14	5.85	0.68
15	-2.59	-3.80
16	-8.65	-4.79
17	-6.76	-1.38
18	1.35	3.30
19	8.22	4.94
20	7.53	2.04
21	-0.08	-2.74
22	-7.62	-5.00
23	-8.15	-2.66
24	-1.19	2.12
25	6.86	4.96
26	8.61	3.23
27	2.44	-1.46
28	-5.97	-4.81
29	-8.89	-3.74
30	3.64	0.77

RECEIVER GAIN(DB) ANGLE(DEG) BY FREQUENCY(MHZ)
FREQUENCY

3.0000

0	7.57	5.00
1	8.18	2.70
2	1.27	-2.08
3	-6.81	-4.95
4	-8.63	-3.27
5	-2.51	1.42
6	5.91	4.80
7	8.90	3.77
8	3.71	-0.73
9	-4.90	-4.56
10	-9.00	-4.20
11	-4.83	0.02
12	3.78	4.22
13	8.92	4.54
14	5.85	0.68
15	-2.59	-3.80
16	-8.65	-4.79
17	-6.76	-1.38
18	1.35	3.30
19	8.22	4.94
20	7.53	2.04
21	-0.08	-2.74
22	-7.62	-5.00
23	-8.15	-2.66
24	-1.19	2.12
25	6.86	4.96
26	8.61	3.23
27	2.44	-1.46
28	-5.97	-4.81
29	-8.89	-3.74
30	3.64	0.77
31	4.96	4.57
32	9.00	4.17
33	4.76	-0.07
34	-3.85	-4.24
35	-8.93	-4.52

36	-5.79	-0.64
37	2.67	3.83
38	8.67	4.78
39	6.71	1.33
40	-1.43	-3.33
41	-8.25	-4.94
42	-7.49	-2.00
43	0.16	2.78
44	7.66	5.00
45	8.12	2.63
46	1.11	-2.16
47	-6.91	-4.96
48	-8.58	-3.20
49	-2.36	1.50
50	6.03	4.82
51	8.88	3.71
52	3.56	-0.81
53	-5.03	-4.59
54	-9.00	-4.15
55	-4.69	0.11
56	3.93	4.27
57	8.94	4.50
58	5.73	0.60
59	-2.74	-3.86
60	-8.70	-4.76
61	-6.65	-1.29
62	1.51	3.37
63	8.28	4.93
64	7.44	1.96
65	-0.24	-2.81
66	-7.70	-5.00
67	-8.08	-2.59
68	-1.03	2.20
69	6.97	4.97
70	8.56	3.17
71	2.28	-1.55
72	-6.09	-4.84
73	-8.87	-3.68
74	-3.49	0.86
75	5.09	4.61
76	9.00	4.12
77	4.63	-0.15
78	-4.00	-4.29
79	-8.94	-4.48
80	-5.67	0.55
81	2.82	3.88
82	8.72	4.75
83	6.60	1.25
84	-1.58	-3.40
85	-8.31	-4.92
86	-7.40	-1.92
87	0.32	2.85
88	7.74	5.00
89	8.05	2.55
90	0.95	-2.24

NUCOM BREM AIR TO GROUND TEST

***** ANGLE 63.83000 OUT OF SPECIFIED RANGE: 30 -- -30
***** ANTENNA CALIBRATION TABLES NOT USED *

***** ANGLE 63.83000 OUT OF SPECIFIED RANGE: 30 -- -30
***** ANTENNA CALIBRATION TABLES NOT USED *

***** ANGLE 75.92999 OUT OF SPECIFIED RANGE: 30 -- -30
***** ANTENNA CALIBRATION TABLES NOT USED *

***** ANGLE 75.92999 OUT OF SPECIFIED RANGE: 30 -- -30
***** ANTENNA CALIBRATION TABLES NOT USED *

***** ANGLE 79.99001 OUT OF SPECIFIED RANGE: 30 -- -30
***** ANTENNA CALIBRATION TABLES NOT USED *

***** ANGLE 79.99001 OUT OF SPECIFIED RANGE: 30 -- -30
***** ANTENNA CALIBRATION TABLES NOT USED *

PSV	OBV	OBH	OBL	TBD	TBR	RBD	RBR
8	-.100000E+76	-.100000E+76	-92.7988	-3.50100	.0	1.40300	.0

DB FROM PREM	P	TRANSMITTER GN	RECEIVER GAIN	COMPENSATED POWER
-92.7967976	5.2283525	-3.4693565	6.4992867	-84.5404816
-92.7987976	5.2283525	-4.0276051	1.3395395	-90.2584839

****

SIGNAL ANALYSIS INCLUDING BREM ANALYSIS

GROUND OR REFLECTED VERTICAL DBW	GROUND OR REFLECTED HORIZONTAL DBW	DIRECT VERTICAL DBW	DIRECT HORIZONTAL DBW	IONOSPHERIC SIGNAL SUM DBW	VERTICAL NOISE -DBW	CORRECTED NOISE -DBW	CORRECTED ALL MODE S/N RATIO
-.100000E+76	-.100000E+76	-84.5405	-90.2585	-86.7250	148.000	146.085	64.2695

****

GMT	TIME (SEC)	FREQ	NMODES	MGT (MS)	2*SIGMA (MS)	SIGNAL (-DBW)	S/N (DB)	EFPL (DB)	(S/N)MAX (DB)
1200	43200.	3.0	3	2.6405	2.5426	0.867E+02	0.613E+02	0.126E+03	0.197E+03

5.3 Air to Air Link - Line of Sight, Above MUF

This example shows a 600.08 km air to air link between elevated terminals at 10 km operating above the MUF. The output from RAYTRACE shows both direct line of sight and ground reflected signal components as well as the effective ground parameters at the reflection point as determined by NWOMAP and FSGEPS. The all mode S/N shown in the COMEFF section shows the nonionospheric mode ignored by the unmodified NUCOM II. The predicted value of 48.15 dB is excellent for the 3 kHz SSB link modelled.

TRANSMITTER		RECEIVER		MONTH	GMT	SSN	PATH(KM)	AZ	DELTAD	NO. CONTROL POINTS
-17.00	-128.20	-22.40	-128.20	6	12.10	20.00	600.08	180.00	100.00	7

AIR TO AIR LINE OF SIGHT EXAMPLE SSP= 23.055

TIME(SEC)= -1.

HME	YME	FOE	CHI	HMF1	YMF1	FOF1	HMF2	YMF2	FOF2	ESU	ES	ESL	M(3000)	DIST
115.00	25.00	0.32	129.82	177.92	47.92	0.42	267.38	65.49	2.50	3.43	2.32	1.72	3.35	0.0
115.00	25.00	0.32	130.06	178.08	48.08	0.42	267.62	65.50	2.49	3.56	2.33	1.68	3.35	100.00
115.00	25.00	0.31	130.30	178.33	48.33	0.42	268.04	65.55	2.48	3.67	2.30	1.63	3.34	200.00
115.00	25.00	0.31	130.52	178.69	48.69	0.41	268.66	65.63	2.48	3.76	2.25	1.58	3.34	300.00
115.00	25.00	0.31	130.73	179.15	49.15	0.41	269.46	65.74	2.48	3.82	2.17	1.52	3.33	400.00
115.00	25.00	0.31	130.93	179.70	49.70	0.41	270.42	65.88	2.48	3.85	2.07	1.47	3.33	500.00
115.00	25.00	0.30	131.12	180.34	50.34	0.41	271.54	66.04	2.49	3.86	1.96	1.42	3.32	600.08

CARD INPUT

CD NO	DATA							
1	0	0						
2	-17.00	-128.20	-22.40	-128.20	0.0	0.0		
3	4.00	1.00	4.00	0.10	1.00	75.00	0.60	1.00
5	1							
6	12.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	-1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0	0	0					
0	AIR TO AIR LINE OF SIGHT EXAMPLE							

AIR TO AIR LINE OF SIGHT EXAMPLE

90.00

BREM ANALYSIS INPUT

TRANS HEIGHT	RCVR HEIGHT	SIGMA	EPSILON	WIND VEL	SUDA	MILLINGTON
10000.000	10000.000	0.0	0.0	0.0	10	0

REFLECTED RAY CALCULATIONS:
AT LAT -19.279 AND LONG 128.200 SIGMA = 0.001 EPSILON = 4.000 (EFFECTIVE VALUES)

BREM ANALYSIS RESULTS

RELATIVE POWER COMPONENTS			RAY ZENITH ANGLES			
POLARIZATION		LINE OF SIGHT	TRANSMITTER		RECEIVER	
VERTICAL	HORIZONTAL		DIRECT	REFLECTED	DIRECT	REFLECTED
DBW	DBW	DBW	DEGREES	DEGREES	DEGREES	DEGREES
-108.	-107.	-103.	-2.708	-3.397	-2.708	-3.397

```
     ALL MODE COMEFF INPUT DATA FROM RAYTRACE


              AIR TO AIR LINE OF SIGHT EXAMPLE

           G   -1.      0.0     4.00  0.0    0.0      0.010000.0  10000.0  148.6 1206        0.0

           &-107.992     -107.297     -103.068         -2.708     -3.397     -2.708     -3.397
&IINIT
NOFREQ=           1,KSW1=           0,KSW2=           1,JCARD=           0,NEWANT=           1,MXANGT=           0,MXANGR=           0,
ANTFIL=           5,P=  3.33300018     ,BAUD=  .100000016E-01,PLREJ=  400.000000     ,IRETA=           0,MNANGT=          -5,MNANGR=
         -5,IDEBUG=           0
&END

     TRANSMITTER GAIN(DB)   ANGLE(DEG) BY FREQUENCY(MHZ)
                          FREQUENCY


                 4.0000
     -5     -3.50  -2.40
     -4     -3.40  -2.30
     -3     -3.30  -2.20
     -2     -3.20  -2.10
     -1     -3.10  -2.00
      0     -3.00  -1.90

     RECEIVER GAIN(DB)  ANGLE(DEG) BY FREQUENCY(MHZ)
                          FREQUENCY

5-26

                 4.0000
     -5     -3.50  -2.40
     -4     -3.40  -2.30
     -3     -3.30  -2.20
     -2     -3.20  -2.10
     -1     -3.10  -2.00
      0     -3.00  -1.90
```

KSW	DBV	DBH	DBL	TBD	TBR	RBD	RBR
&	-107.992	-107.297	-103.068	-2.70800	-3.39700	-2.70800	-3.39700

DB FROM BREM	P	TRANSMITTER GN	RECEIVER GAIN	COMPENSATED POWER
-103.067993	5.2283525	-3.2705603	-3.2705603	-104.380737
-103.067993	5.2283525	-2.1705599	-2.1705599	-102.180725
-107.992004	5.2283525	-3.3394241	-3.3394241	-109.442474
-107.296997	5.2283525	-2.2394238	-2.2394238	-106.547455

****

SIGNAL ANALYSIS INCLUDING BREM ANALYSIS

GROUND OR REFLECTED VERTICAL DBW	GROUND OR REFLECTED HORIZONTAL DBW	DIRECT VERTICAL DBW	DIRECT HORIZONTAL DBW	IONOSPHERIC SIGNAL SUM DBW	VERTICAL NOISE -DBW	CORRECTED NOISE -DBW	CORRECTED ALL MODE S/N RATIO
-109.442	-106.547	-104.381	-102.181	-.100000E+76	148.600	145.916	47.0728

****

GMT	TIME (SEC)	FREQ	NMODES	MGT (MS)	2*SIGMA (MS)	SIGNAL (-DBW)	S/N (DB)	EFPL (DB)	(S/N)MAX (DB)
1206	-1.	1.0	0	0.0	0.0	0.0	0.0	0.0	0.378E+02

5.4 Air to Air Link - Beyond Line of Sight, Above MUF

This 800.1 km link operates above the MUF between terminals at a height of 10 km and no ionospheric propagation occurs. A Suda factor of 10 has been chosen and the returned constants as shown indicate that a sea path is involved. The resulting all mode S/N of 17.7 dB is that of the groundwave mode only and indicates that the link in question which has been modelled as a 3 kHz SSB circuit with a 1 kW transmitter will maintain acceptable communications in the absence of skywave propagation.

TRANSMITTER		RECEIVER		MONTH	GMT	SSN	PATH(KM)	AZ	DELTAD	NO. CONTROL POINTS
-17.00	-128.20	-24.20	-128.20	6	12.10	20.00	800.10	180.00	100.00	9

AIR TO AIR BEYOND LOS EXAMPLE SSP= 23.055

TIME(SEC)= -1.

HME	YME	FOE	CHI	HMF1	YMF1	FOF1	HMF2	YMF2	FOF2	ESU	ES	ESL	M(3000)	DIST
115.00	25.00	0.32	129.82	177.92	47.92	0.42	267.38	65.49	2.50	3.43	2.32	1.72	3.35	0.0
115.00	25.00	0.32	130.06	178.08	48.08	0.42	267.62	65.50	2.49	3.56	2.33	1.68	3.35	100.0
115.00	25.00	0.31	130.30	178.33	48.33	0.42	268.04	65.55	2.48	3.67	2.30	1.63	3.34	200.0
115.00	25.00	0.31	130.52	178.69	48.69	0.41	268.66	65.63	2.48	3.76	2.25	1.58	3.34	300.0
115.00	25.00	0.31	130.73	179.15	49.15	0.41	269.46	65.74	2.48	3.82	2.17	1.52	3.33	400.0
115.00	25.00	0.31	130.93	179.70	49.70	0.41	270.42	65.88	2.48	3.85	2.07	1.47	3.33	500.0
115.00	25.00	0.30	131.12	180.34	50.34	0.41	271.54	66.04	2.49	3.86	1.96	1.42	3.32	600.0
115.00	25.00	0.30	131.30	181.05	51.05	0.40	272.79	66.21	2.50	3.83	1.83	1.37	3.31	700.0
115.00	25.00	0.30	131.46	181.83	51.83	0.40	274.15	66.40	2.52	3.78	1.70	1.32	3.30	800.1

CARD INPUT DATA

CD NO

```
1          0          0
2     -17.00   -128.20     -24.20   -128.20       0.0        0.0
3       4.00      1.00       4.00      0.10       1.00      75.00       0.60       1.00
5          1
6      12.10       0.0        0.0       0.0        0.0        0.0        0.0        0.0
7      -1.00       0.0        0.0       0.0        0.0        0.0        0.0        0.0
8          0          0          0
0       AIR TO AIR BEYOND LOS EXAMPLE
```

AIR TO AIR BEYOND LOS EXAMPLE

90.00

BREM ANALYSIS INPUT

TRANS HEIGHT	RCVR HEIGHT	SIGMA	EPSILON	WIND VEL	SUDA	MILLINGTON
10000.000	10000.000	0.0	0.0	0.0	10	0

	LATITUDE	LONGITUDE	SIGMA	EPSILON
FROM TRANSMITTER				
	-17.0000	128.2000	0.0010	4.0000
	-17.7195	128.2000	0.0010	4.0000
	-18.4390	128.2000	0.0010	4.0000
	-19.1586	128.2000	0.0010	4.0000
	-19.8781	128.2000	0.0010	4.0000
	-20.5976	128.2000	0.0010	4.0000
	-21.3171	128.2000	0.0010	4.0000
	-22.0367	128.2000	0.0010	4.0000
	-22.7562	128.2000	0.0010	4.0000
	-23.4757	128.2000	0.0010	4.0000
	-24.1952	128.2000	0.0010	4.0000
	**********	**********	0.0010	4.0000

BREM ANALYSIS RESULTS

RELATIVE POWER COMPONENTS			RAY ZENITH ANGLES			
POLARIZATION		LINE OF SIGHT	TRANSMITTER		RECEIVER	
VERTICAL DBW	HORIZONTAL DBW	DBW	DIRECT DEGREES	REFLECTED DEGREES	DIRECT DEGREES	REFLECTED DEGREES
-133.	-133.		0.0		0.0	

```
     ALL MODE COMEFF INPUT DATA FROM RAYTRACE


              AIR TO AIR BEYOND LOS EXAMPLE

          G   -1.      0.0     4.00  0.0    0.0      0.010000.0  10000.0  148.6 1206        0.0

          &-132.512     -132.891     -.100000E+76      0.0         0.0         0.0         0.0
$IINIT
 JOFREQ=           1,KSW1=           0,KSW2=           1,JCARD=           0,NEWANT=           1,MXANGT=           0,MXANGR=           0,
 INTFIL=           5,P=  3.33300018     ,BAUD=  .100000016E-01,PLREJ=  400.000000     ,IBETA=           0,MNANGT=          -5,MNANGR=
         -5,IDEBUG=           0
$END

    TRANSMITTER GAIN(DB)   ANGLE(DEG) BY FREQUENCY(MHZ)
                           FREQUENCY


                 4.0000
    -5        -3.50   -2.40
    -4        -3.40   -2.30
    -3        -3.30   -2.20
    -2        -3.20   -2.10
    -1        -3.10   -2.00
     0        -3.00   -1.90

    RECEIVER GAIN(DB)  ANGLE(DEG) BY FREQUENCY(MHZ)
                           FREQUENCY


                 4.0000
    -5        -3.50   -2.40
    -4        -3.40   -2.30
    -3        -3.30   -2.20
    -2        -3.20   -2.10
    -1        -3.10   -2.00
     0        -3.00   -1.90
```

KSW	DBV	DBH	DBL	TBD	TBR	RBD	RBR
&	-132.512	-132.891	-.100000E+76	.0	.0	.0	.0

DB FROM BREM	P	TRANSMITTER GN	RECEIVER GAIN	COMPENSATED POWER
-132.511993	5.2283525	-2.9999981	-2.9999981	-133.283600
-132.891006	5.2283525	-1.8999987	-1.8999987	-131.462631

****

SIGNAL ANALYSIS INCLUDING BREM ANALYSIS

GROUND OR REFLECTED VERTICAL DBW	GROUND OR REFLECTED HORIZONTAL DBW	DIRECT VERTICAL DBW	DIRECT HORIZONTAL DBW	IONOSPHERIC SIGNAL SUM DBW	VERTICAL NOISE -DBW	CORRECTED NOISE -DBW	CORRECTED ALL MODE S/N RATIO
-133.284	-131.463	-.100000E+76	-.100000E+76	-.100000E+76	148.600	145.916	16.6483

****

GMT	TIME (SEC)	FREQ	NMODES	MGT (MS)	2*SIGMA (MS)	SIGNAL (-DBW)	S/N (DB)	EFPL (DB)	(S/N)MAX (DB)
1206	-1.	1.0	0	0.0	0.0	0.0	0.0	0.0	0.378E+02

5.5 Air to Air Link - Beyond Line of Sight, Nuclear Stressed Ionosphere

The same 800.1 km link between 10 km elevated terminals is computed for a nuclear stressed ionosphere produced by detonation of a 1.3 Mt device at a height of 70 km midway along the path.

The output from ORDER indicates a nuclear stressed daytime ionosphere and the RAYTRACE output for the ionospheric components shows extremely high nonderivative absorption. The corrected all mode S/N now reflects just beyond the horizon groundwave component since the ionospheric rays have been blacked out. Again, the indicated S/N of 15.3 dB is adequate for communications on this circuit.

TRANSMITTER		RECEIVER		MONTH	GMT	SSN	PATH(KM)	AZ	DELTAD	NO. CONTROL POINTS
-17.00	-128.20	-24.20	-128.20	6	2.20	20.00	800.10	180.00	100.00	9

STRESSED TEST RUN AIR TO AIR SSP= 23.055

HME	YME	FOF	CHI	HMF1	YMF1	FOF1	HMF2	YMF2	FOF2	ESU	ES	ESL	M(3000)	DIST
115.00	25.00	1.52	91.99	169.05	39.05	1.91	273.18	84.60	7.74	5.86	3.40	2.36	3.29	0.0
115.00	25.00	1.51	92.35	167.52	37.52	1.87	269.82	83.54	7.55	5.68	3.30	2.32	3.32	100.00
115.00	25.00	1.49	92.71	166.10	36.10	1.84	266.70	82.55	7.34	5.52	3.20	2.28	3.34	200.00
115.00	25.00	1.48	93.07	164.80	34.80	1.81	263.82	81.63	7.11	5.37	3.08	2.22	3.36	300.00
115.00	25.00	1.46	93.42	163.62	33.62	1.78	261.19	80.76	6.88	5.23	2.97	2.16	3.38	400.00
115.00	25.00	1.45	93.78	162.57	32.57	1.75	258.80	79.95	6.64	5.12	2.85	2.10	3.40	500.00
115.00	25.00	1.44	94.14	161.64	31.64	1.72	256.66	79.19	6.41	5.01	2.74	2.04	3.42	600.00
115.00	25.00	1.42	94.49	160.84	30.84	1.70	254.74	78.49	6.17	4.93	2.63	1.98	3.43	700.00
115.00	25.00	1.41	94.85	160.15	30.15	1.67	253.05	77.83	5.95	4.85	2.53	1.92	3.44	800.10

DATA IS IN BEGIN COMPUTATION

TIME	HDB1	HDB2	HDB3	HDB5	RDB1	RDB2	RDB3	RDB5	DFB1	DFB2	DFB3	DFB5
60.	144.	0.	0.	0.	14.	0.	0.	0.	0.	0.	0.	0.

TRANSMITTER		RECEIVER		PATH AZIMUTH AND LENGTH	
-17.000	-128.200	-24.200	-128.200	180.000	800.10254

EVALUATION TIME (SEC) = 60.000

BURST TIME 0.0 LATITUDE -20.00 LONGITUDE -128.00 YIELD 1.30 ALTITUDE 70.00

DISTANCE OF FIELD POINT FROM BURST L = 334.04 DISTANCE FROM TRANSMITTER = 0.0

HT	AMBIENT	NUCLEAR	HT	AMBIENT	NUCLEAR	HT	AMBIENT	NUCLEAR	HT	AMBIENT	NUCLEAR	HT	AMBIENT	NUCLEAR
30.	0.40E-02	0.88E+01	70.	0.14E+03	0.86E+05	115.	0.29E+05	0.98E+05	215.	0.39E+06	0.40E+06	400.	0.30E+06	0.30E+06
35.	0.16E-01	0.39E+02	72.	0.16E+03	0.82E+05	125.	0.24E+05	0.99E+05	225.	0.50E+06	0.51E+06	425.	0.23E+06	0.23E+06
40.	0.54E-01	0.11E+03	75.	0.21E+03	0.74E+05	135.	0.21E+05	0.79E+05	240.	0.63E+06	0.63E+06	450.	0.18E+06	0.18E+06
45.	0.16E+00	0.24E+03	80.	0.40E+03	0.61E+05	145.	0.28E+05	0.67E+05	255.	0.71E+06	0.71E+06	500.	0.10E+06	0.10E+06
50.	0.42E+00	0.52E+03	85.	0.88E+03	0.58E+05	155.	0.39E+05	0.71E+05	270.	0.74E+06	0.74E+06	600.	0.35E+05	0.35E+05
55.	0.32E+01	0.24E+04	90.	0.19E+04	0.56E+05	165.	0.44E+05	0.69E+05	285.	0.73E+06	0.73E+06	700.	0.12E+05	0.12E+05
60.	0.22E+02	0.17E+05	92.	0.44E+04	0.59E+05	175.	0.44E+05	0.63E+05	300.	0.69E+06	0.69E+06			
62.	0.44E+02	0.34E+05	96.	0.12E+05	0.64E+05	185.	0.37E+05	0.53E+05	325.	0.59E+06	0.59E+06			
65.	0.97E+02	0.70E+05	100.	0.18E+05	0.70E+05	195.	0.13E+06	0.15E+06	350.	0.48E+06	0.48E+06			
68.	0.13E+03	0.86E+05	105.	0.24E+05	0.79E+05	205.	0.27E+06	0.28E+06	375.	0.38E+06	0.38E+06			

DISTANCE OF FIELD POINT FROM BURST L = 167.93 DISTANCE FROM TRANSMITTER = 500.00

HT	AMBIENT	NUCLEAR	HT	AMBIENT	NUCLEAR	HT	AMBIENT	NUCLEAR	HT	AMBIENT	NUCLEAR	HT	AMBIENT	NUCLEAR
30.	0.40E-02	0.51E+02	70.	0.14E+03	0.12E+06	115.	0.26E+05	0.12E+06	215.	0.38E+06	0.42E+06	400.	0.17E+06	0.17E+06
35.	0.16E-01	0.16E+03	72.	0.15E+03	0.11E+06	125.	0.22E+05	0.19E+06	225.	0.45E+06	0.48E+06	425.	0.13E+06	0.13E+06
40.	0.54E-01	0.33E+03	75.	0.19E+03	0.98E+05	135.	0.20E+05	0.24E+06	240.	0.51E+06	0.54E+06	450.	0.98E+05	0.98E+05
45.	0.16E+00	0.68E+03	80.	0.37E+03	0.73E+05	145.	0.27E+05	0.24E+06	255.	0.54E+06	0.54E+06	500.	0.55E+05	0.55E+05
50.	0.42E+00	0.14E+04	85.	0.79E+03	0.63E+05	155.	0.36E+05	0.25E+06	270.	0.54E+06	0.54E+06	600.	0.18E+05	0.18E+05
55.	0.32E+01	0.47E+04	90.	0.17E+04	0.59E+05	165.	0.38E+05	0.20E+06	285.	0.51E+06	0.51E+06	700.	0.55E+04	0.55E+04
60.	0.22E+02	0.25E+05	92.	0.40E+04	0.61E+05	175.	0.32E+05	0.16E+06	300.	0.46E+06	0.46E+06			
62.	0.44E+02	0.47E+05	96.	0.11E+05	0.66E+05	185.	0.10E+06	0.20E+06	325.	0.38E+06	0.38E+06			
65.	0.96E+02	0.97E+05	100.	0.17E+05	0.72E+05	195.	0.20E+06	0.27E+06	350.	0.30E+06	0.30E+06			
68.	0.13E+03	0.12E+06	105.	0.22E+05	0.84E+05	205.	0.30E+06	0.35E+06	375.	0.23E+06	0.23E+06			

INPUT TAPE ,RAYTRACE, COMPLETED FOR THIS TIME

TRANSMITTER		RECEIVER		PATH AZIMUTH AND LENGTH	
-17.000	-128.200	-24.200	-128.200	180.000	800.10254

LAT(DEGS)	LONG(DEGS)	DISTANCE FROM TRANSMITTER OF POINTS ON PATH
-17.000	-128.200	0.0
-17.900	-128.200	100.00000
-18.800	-128.200	200.00000
-19.700	-128.200	300.00000
-20.600	-128.200	400.00000
-21.499	-128.200	500.00000
-22.399	-128.200	600.00000
-23.299	-128.200	700.00000
-24.200	-128.200	800.10254

INPUT DATA CARDS

```
1       15          2          0          0          5         .5         1.
```

TRANSMITTER		RECEIVER		MON	GMT	SSN	DR	BETA	DELTAD	NAC
[illegible]	[illegible]	-24.20	-128.20	6	0.22E+01	0.20E+02	0.80E+03	0.18E+03	0.10E+03	9

STRESSED TEST RUN AIR TO AIR TIME= 60.0

INDICATOR 0=NITE-AMB 1=DAY -AMB 2=NITE-NUC 3=DAY -NUC X=F-REGION CALCULATIONS AND, + OR - 7 DEG OF EQUATOR

INDICATOR	DISTANCE	HME	YMF	FOE	HMF1	YMF1	FOF1	HMF2	YMF2	FOF2		ENEC DEN(65KM)
3	0.	121.	43.5	2.8	171.	25.2	2.4	274.	87.9	7.7		0.70E+05
3	100.	115.	32.3	2.9	178.	46.5	3.9	271.	92.3	7.5		0.81E+05
3	200.	115.	31.7	3.0	186.	55.5	6.1	266.	45.8	8.7		0.11E+06
3	300.	115.	34.8	3.0	188.	55.2	7.9	264.	41.1	9.0		0.19E+06
3	400.	115.	32.9	3.0	186.	54.9	7.3	264.	43.1	8.4		0.16E+06
3	500.	115.	31.7	2.9	147.	15.9	5.7	256.	108.9	6.6		0.97E+05
3	600.	129.	47.1	3.2	176.	23.6	1.4	259.	82.9	6.4	E3	0.77E+05
3	700.	118.	44.3	2.6	165.	20.3	2.0	255.	90.4	6.2		0.68E+05
3	800.	109.	49.4	2.2	166.	23.2	1.8	254.	87.9	5.9		0.60E+05

CARD INPUT DATA

CD NO								
1	0	0						
2	-17.00	-128.20	-24.20	-128.20	0.0	0.0		
3	4.00	1.00	4.00	0.10	1.00	75.00	0.60	0.60
5	1							
6	2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	60.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0	0	0					
0	STRESSED TEST RUN AIR TO AIR							

STRESSED TEST RUN AIR TO AIR

60.00

STRESSED TEST RUN AIR TO AIR MONTH 6 211 GMT 60. SEC

PATH LENGTH 800.10 KM TX LAT -17.00 DEG TX LONG -126.20 DEG RX LAT -24.20 DEG RX LONG -128.20 DEG RX BEARING 180.00 DEG

	FREQ	BETA XMTR	BETA RCVR	GROUP TIME	PHASE TIME	MISS DIST	NOIS	FSPCE LOSS	* NATURAL GRND LOSS	NATURAL NONDV ABS	* DEV ABS	* NUCLEAR NONDV ABS	* E,F1 ABS	PATH LOSS
	MHZ	DEG	DEG	SEC	SEC	KM	DBW	DB	DB	DB	DB	DB	DB	DB
.E	4.0	11.75	8.74	2.744	2.740	-1.1	151.	PATH LENGTH EXCEEDS				9000.		
NOTE--NEXT RAY IS MORE THAN 10. KM FROM REC														
.E	4.0	13.10	10.30	2.744	2.739	-81.4	151.	PATH LENGTH EXCEEDS				9000.		
.E .E	4.0	21.00	29.64	2.991	2.917	4.7	151.	PATH LENGTH EXCEEDS				9000.		
NOTE--NEXT RAY IS MORE THAN 10. KM FROM REC														
.E .E	4.0	28.10	32.21	3.004	2.910	-96.3	151.5	130.1	0.1	0.0	0.0	7732.9	22.0	7885.
NOTE--NEXT RAY IS MORE THAN 10. KM FROM REC														
.E .F2	4.0	45.10	57.91	4.076	2.871	-36.2	151.5	132.7	0.1	0.0	0.5	5361.4	61.2	5556.
NOTE--NEXT RAY IS MORE THAN 10. KM FROM REC														
.F1 .F1 $E .F2	4.0	46.10	42.32	4.155	2.882	81.1	151.5	132.9	0.1	0.0	0.2	5574.4	65.2	5773.

BREM ANALYSIS INPUT

TRANS HEIGHT	RCVR HEIGHT	SIGMA	EPSILON	WIND VEL	SUDA	MILLINGTON
10000.000	10000.000	0.0	0.0	0.0	10	0

	LATITUDE	LONGITUDE	SIGMA	EPSILON
FROM TRANSMITTER				
	-17.0000	128.2000	0.0010	4.0000
	-17.7195	128.2000	0.0010	4.0000
	-18.4390	128.2000	0.0010	4.0000
	-19.1586	128.2000	0.0010	4.0000
	-19.8781	128.2000	0.0010	4.0000
	-20.5976	128.2000	0.0010	4.0000
	-21.3171	128.2000	0.0010	4.0000
	-22.0367	128.2000	0.0010	4.0000
	-22.7562	128.2000	0.0010	4.0000
	-23.4757	128.2000	0.0010	4.0000
	-24.1952	128.2000	0.0010	4.0000
	**********	**********	0.0010	4.0000

BREM ANALYSIS RESULTS

RELATIVE POWER COMPONENTS			RAY ZENITH ANGLES			
POLARIZATION		LINE OF SIGHT	TRANSMITTER		RECEIVER	
VERTICAL	HORIZONTAL		DIRECT	REFLECTED	DIRECT	REFLECTED
DBW	DBW	DBW	DEGREES	DEGREES	DEGREES	DEGREES
-133.	-133.		0.0		0.0	

ALL MODE COMEFF INPUT DATA FROM RAYTRACE

STRESSED TEST RUN AIR TO AIR

```
          60.       2.0  4.00 11.75  8.74  2.744  2.740   9000.0  151.5  211   12754.8

          60.      22.0  4.00 21.00 29.64  2.991  2.917   9000.0  151.5  211    9335.6

       G  60.     0.0    4.00  0.0   0.0     0.010000.0  10000.0  151.5  211       0.0

       &-132.512    -132.891    -.100000E+76      0.0        0.0        0.0        0.0
&IINIT
NOFREQ=          7,KSW1=          0,KSW2=          1,JCARD=          0,NEWANT=          1,MXANGT=         40,MXANGR=         40,
ANTFIL=          5,P=  3.33300018    ,BAUD=  .100000016E-01,PLREJ=  400.000000    ,IBETA=          0,MNANGT=        -40,MNANGR=
      -40,IDEBUG=          0
&END
```

TRANSMITTER GAIN(DB) ANGLE(DEG) BY FREQUENCY(MHZ)
FREQUENCY

	2.0000		3.0000		4.0000		5.0000		7.0000		10.0000		15.0000	
-40	2.60	2.60	1.20	1.60	0.10	0.50	-1.00	-0.50	2.50	5.00	6.00	7.80	3.00	3.90
-39	2.55	2.50	1.02	1.40	-0.10	0.30	-1.13	-0.60	2.30	4.80	5.80	7.60	2.90	3.80
-38	2.49	2.50	0.84	1.20	-0.20	0.20	-1.26	-0.80	2.10	4.60	5.60	7.40	2.70	3.60
-37	2.44	2.40	0.66	1.10	-0.40	0.0	-1.39	-0.90	1.90	4.40	5.50	7.30	2.60	3.50
-36	2.38	2.40	0.48	0.90	-0.60	-0.20	-1.52	-1.00	1.70	4.20	5.30	7.10	2.40	3.30
-35	2.32	2.30	0.30	0.70	-0.70	-0.30	-1.65	-1.20	1.50	4.00	5.10	6.90	2.30	3.20
-34	2.27	2.30	0.12	0.50	-0.90	-0.50	-1.78	-1.30	1.30	3.80	4.90	6.70	2.20	3.10
-33	2.22	2.20	-0.06	0.30	-1.10	-0.70	-1.91	-1.40	1.10	3.60	4.70	6.50	2.00	2.90
-32	2.16	2.20	-0.24	0.20	-1.20	-0.80	-2.04	-1.50	0.90	3.40	4.60	6.40	1.90	2.80
-31	2.10	2.10	-0.42	0.0	-1.40	-1.00	-2.17	-1.70	0.70	3.20	4.40	6.20	1.70	2.60
-30	2.05	2.10	-0.60	-0.20	-1.60	-1.20	-2.30	-1.80	0.50	3.00	4.20	6.00	1.60	2.50
-29	1.99	2.00	-0.78	-0.40	-1.70	-1.30	-2.43	-1.90	0.30	2.80	4.00	5.80	1.50	2.40
-28	1.94	1.90	-0.96	-0.60	-1.90	-1.60	-2.56	-2.10	0.10	2.60	3.80	5.60	1.30	2.20
-27	1.89	1.90	-1.14	-0.70	-2.00	-1.60	-2.69	-2.20	-0.10	2.40	3.70	5.50	1.20	2.10
-26	1.83	1.80	-1.32	-0.90	-2.20	-1.80	-2.82	-2.00	-0.30	2.20	3.50	5.30	1.00	1.90
-25	1.77	1.80	-1.50	-1.10	-2.40	-2.00	-2.95	-2.50	-0.50	2.00	3.30	5.10	0.90	1.80
-24	1.72	1.70	-1.68	-1.30	-2.50	-2.10	-3.08	-2.60	-0.70	1.80	3.10	4.90	0.80	1.70
-23	1.66	1.70	-1.86	-1.50	-2.70	-2.30	-3.21	-2.70	-0.90	1.60	2.90	4.70	0.60	1.50
-22	1.61	1.60	-2.04	-1.60	-2.90	-2.50	-3.34	-2.80	-1.10	1.40	2.80	4.60	0.50	1.40
-21	1.56	1.60	-2.22	-1.80	-3.00	-2.60	-3.47	-3.00	-1.30	1.20	2.60	4.40	0.30	1.20
-20	1.50	1.50	-2.40	-2.00	-3.20	-2.80	-3.60	-3.10	-1.50	1.00	2.40	4.20	0.20	1.10
-19	1.45	1.50	-2.71	-2.30	-3.40	-3.00	-3.72	-3.20	-1.70	0.90	2.20	4.00	-0.10	0.80
-18	1.40	1.40	-3.02	-2.60	-3.60	-3.20	-3.84	-3.30	-1.80	0.70	1.90	3.70	-0.40	0.50
-17	1.35	1.40	-3.33	-2.90	-3.80	-3.40	-3.96	-3.50	-2.00	0.60	1.70	3.50	-0.80	0.10
-16	1.30	1.30	-3.64	-3.20	-4.00	-3.60	-4.08	-3.60	-2.10	0.40	1.40	3.20	-1.10	-0.20
-15	1.25	1.30	-3.95	-3.60	-4.20	-3.80	-4.20	-3.70	-2.30	0.30	1.20	3.00	-1.40	-0.50
-14	1.20	1.20	-4.26	-3.90	-4.40	-4.00	-4.32	-3.80	-2.40	0.10	1.00	2.80	-1.70	-0.80
-13	1.15	1.20	-4.57	-4.20	-4.60	-4.20	-4.44	-3.90	-2.60	-0.10	0.70	2.50	-2.00	-1.10
-12	1.10	1.10	-4.88	-4.50	-4.80	-4.40	-4.56	-4.10	-2.70	-0.20	0.50	2.30	-2.40	-1.50
-11	1.05	1.00	-5.19	-4.80	-5.00	-4.60	-4.68	-4.20	-2.90	-0.40	0.20	2.00	-2.70	-1.80
-10	1.00	1.00	-5.50	-5.10	-5.20	-4.80	-4.80	-4.30	-3.00	-0.50	0.0	1.80	-3.00	-2.10
-9	0.80	0.80	-6.00	-5.60	-5.56	-5.10	-4.80	-4.30	-3.20	-0.70	-0.40	1.40	-3.40	-2.50
-8	0.60	0.60	-6.50	-6.10	-5.92	-5.50	-4.80	-4.30	-3.40	-0.90	-0.80	1.00	-3.90	-3.00
-7	0.40	0.40	-7.00	-6.60	-6.28	-5.90	-4.80	-4.30	-3.60	-1.10	-1.20	0.60	-4.30	-3.40
-6	0.20	0.20	-7.50	-7.10	-6.64	-6.20	-4.80	-4.30	-3.80	-1.30	-1.60	0.20	-4.80	-3.90
-5	0.0	0.0	-8.00	-7.60	-7.00	-6.60	-4.80	-4.30	-4.00	-1.50	-2.00	-0.20	-5.20	-4.30
-4	-0.20	-0.20	-8.50	-8.10	-7.36	-7.00	-4.80	-4.30	-4.20	-1.70	-2.40	-0.60	-5.60	-4.70
-3	-0.40	-0.40	-9.00	-8.60	-7.72	-7.30	-4.80	-4.30	-4.40	-1.90	-2.80	-1.00	-6.10	-5.20
-2	-0.60	-0.60	-9.50	-9.10	-8.08	-7.60	-4.80	-4.30	-4.60	-2.10	-3.20	-1.40	-6.50	-5.60

-1	-0.80	-0.80	-10.00	-9.60	-8.44	-8.00	-4.80	-4.30	-4.80	-2.30	-3.60	-1.80	-7.00	-6.10
0	-1.00	-1.00	-10.50	-10.10	-8.80	-8.40	-4.80	-4.30	-5.00	-2.50	-4.00	-2.20	-7.40	-6.50
1	-0.80	-0.80	-10.00	-9.60	-8.40	-8.00	-4.80	-4.30	-4.80	-2.30	-3.60	-1.80	-7.00	-6.10
2	-0.60	-0.60	-9.50	-9.10	-8.10	-7.60	-4.80	-4.30	-4.60	-2.10	-3.20	-1.40	-6.50	-5.60
3	-0.40	-0.40	-9.00	-8.60	-7.70	-7.30	-4.80	-4.30	-4.40	-1.90	-2.80	-1.00	-6.10	-5.20
4	-0.20	-0.20	-8.50	-8.10	-7.40	-7.00	-4.80	-4.30	-4.20	-1.70	-2.40	-0.60	-5.60	-4.70
5	0.0	0.0	-8.00	-7.60	-7.00	-6.60	-4.80	-4.30	-4.00	-1.50	-2.00	-0.20	-5.20	-4.30
6	0.20	0.20	-7.50	-7.10	-6.60	-6.20	-4.80	-4.30	-3.80	-1.30	-1.60	0.20	-4.80	-3.90
7	0.40	0.40	-7.00	-6.60	-6.30	-5.90	-4.80	-4.30	-3.60	-1.10	-1.20	0.60	-4.30	-3.40
8	0.60	0.60	-6.50	-6.10	-5.90	-5.50	-4.80	-4.30	-3.40	-0.90	-0.80	1.00	-3.90	-3.00
9	0.80	0.80	-6.00	-5.60	-5.60	-5.10	-4.80	-4.30	-3.20	-0.70	-0.40	1.40	-3.40	-2.50
10	1.00	1.00	-5.50	-5.10	-5.20	-4.80	-4.80	-4.30	-3.00	-0.50	0.0	1.80	-3.00	-2.10
11	1.00	1.00	-5.20	-4.80	-5.00	-4.60	-4.70	-4.20	-2.90	-0.40	0.20	2.00	-2.70	-1.80
12	1.10	1.10	-4.90	-4.50	-4.80	-4.40	-4.60	-4.10	-2.70	-0.20	0.50	2.30	-2.40	-1.50
13	1.20	1.20	-4.60	-4.20	-4.60	-4.20	-4.40	-3.90	-2.60	-0.10	0.70	2.50	-2.00	-1.10
14	1.20	1.20	-4.30	-3.90	-4.40	-4.00	-4.30	-3.80	-2.40	0.10	1.00	2.80	-1.70	-0.80
15	1.30	1.30	-4.00	-3.60	-4.20	-3.80	-4.20	-3.70	-2.30	0.30	1.20	3.00	-1.40	-0.50
16	1.30	1.30	-3.60	-3.20	-4.00	-3.60	-4.10	-3.60	-2.10	0.40	1.40	3.20	-1.10	-0.20
17	1.40	1.40	-3.30	-2.90	-3.80	-3.40	-4.00	-3.50	-2.00	0.60	1.70	3.50	-0.80	0.10
18	1.40	1.40	-3.00	-2.60	-3.60	-3.20	-3.80	-3.30	-1.80	0.70	1.90	3.70	-0.40	0.50
19	1.50	1.50	-2.70	-2.30	-3.40	-3.00	-3.70	-3.20	-1.70	0.90	2.20	4.00	-0.10	0.80
20	1.50	1.50	-2.40	-2.00	-3.20	-2.80	-3.60	-3.10	-1.50	1.00	2.40	4.20	0.20	1.10
21	1.60	1.60	-2.20	-1.80	-3.00	-2.60	-3.50	-3.00	-1.30	1.20	2.60	4.40	0.30	1.20
22	1.60	1.60	-2.00	-1.60	-2.90	-2.50	-3.30	-2.80	-1.10	1.40	2.80	4.60	0.50	1.40
23	1.70	1.70	-1.90	-1.50	-2.70	-2.30	-3.20	-2.70	-0.90	1.60	2.90	4.70	0.60	1.50
24	1.70	1.70	-1.70	-1.30	-2.50	-2.10	-3.10	-2.60	-0.70	1.80	3.10	4.90	0.80	1.70
25	1.80	1.80	-1.50	-1.10	-2.40	-2.00	-3.00	-2.50	-0.50	2.00	3.30	5.10	0.90	1.80
26	1.80	1.80	-1.30	-0.90	-2.20	-1.80	-2.80	-2.00	-0.30	2.20	3.50	5.30	1.00	1.90
27	1.90	1.90	-1.10	-0.70	-2.00	-1.60	-2.70	-2.20	-0.10	2.40	3.70	5.50	1.20	2.10
28	1.90	1.90	-1.00	-0.60	-1.90	-1.60	-2.60	-2.10	0.10	2.60	3.80	5.60	1.30	2.20
29	2.00	2.00	-0.80	-0.40	-1.70	-1.30	-2.40	-1.90	0.30	2.80	4.00	5.80	1.50	2.40
30	2.10	2.10	-0.60	-0.20	-1.60	-1.20	-2.30	-1.80	0.50	3.00	4.20	6.00	1.60	2.50
31	2.10	2.10	-0.40	0.0	-1.40	-1.00	-2.20	-1.70	0.70	3.20	4.40	6.20	1.70	2.60
32	2.20	2.20	-0.20	0.20	-1.20	-0.80	-2.00	-1.50	0.90	3.40	4.60	6.40	1.90	2.80
33	2.20	2.20	-0.10	0.30	-1.10	-0.70	-1.90	-1.40	1.10	3.60	4.70	6.50	2.00	2.90
34	2.30	2.30	0.10	0.50	-0.90	-0.50	-1.80	-1.30	1.30	3.80	4.90	6.70	2.20	3.10
35	2.30	2.30	0.30	0.70	-0.70	-0.30	-1.70	-1.20	1.50	4.00	5.10	6.90	2.30	3.20
36	2.40	2.40	0.50	0.90	-0.60	-0.20	-1.50	-1.00	1.70	4.20	5.30	7.10	2.40	3.30
37	2.40	2.40	0.70	1.10	-0.40	0.0	-1.40	-0.90	1.90	4.40	5.50	7.30	2.60	3.50
38	2.50	2.50	0.80	1.20	-0.20	0.20	-1.30	-0.80	2.10	4.60	5.60	7.40	2.70	3.60
39	2.50	2.50	1.00	1.40	-0.10	0.30	-1.10	-0.60	2.30	4.80	5.80	7.60	2.90	3.80
40	2.60	2.60	1.20	1.60	0.10	0.50	-1.00	-0.50	2.50	5.00	6.00	7.80	3.00	3.90

RECEIVER GAIN(DB) ANGLE(DEG) BY FREQUENCY(MHZ)
FREQUENCY

	2.0000		3.0000		4.0000		5.0000		7.0000		10.0000		15.0000	
-40	2.60	2.60	1.20	1.60	0.10	0.50	-1.00	-0.50	2.50	5.00	6.00	7.80	3.00	3.90
-39	2.55	2.50	1.02	1.40	-0.10	0.30	-1.13	-0.60	2.30	4.80	5.80	7.60	2.90	3.80
-38	2.49	2.50	0.84	1.20	-0.20	0.20	-1.26	-0.80	2.10	4.60	5.60	7.40	2.70	3.60
-37	2.44	2.40	0.66	1.10	-0.40	0.0	-1.39	-0.90	1.90	4.40	5.50	7.30	2.60	3.50
-36	2.38	2.40	0.48	0.90	-0.60	-0.20	-1.52	-1.00	1.70	4.20	5.30	7.10	2.40	3.30
-35	2.32	2.30	0.30	0.70	-0.70	-0.30	-1.65	-1.20	1.50	4.00	5.10	6.90	2.30	3.20
-34	2.27	2.30	0.12	0.50	-0.90	-0.50	-1.78	-1.30	1.30	3.80	4.90	6.70	2.20	3.10
-33	2.22	2.20	-0.06	0.30	-1.10	-0.70	-1.91	-1.40	1.10	3.60	4.70	6.50	2.00	2.90
-32	2.16	2.20	-0.24	0.20	-1.20	-0.80	-2.04	-1.50	0.90	3.40	4.60	6.40	1.90	2.80
-31	2.10	2.10	-0.42	0.0	-1.40	-1.00	-2.17	-1.70	0.70	3.20	4.40	6.20	1.70	2.60
-30	2.05	2.10	-0.60	-0.20	-1.60	-1.20	-2.30	-1.80	0.50	3.00	4.20	6.00	1.60	2.50
-29	1.99	2.00	-0.78	-0.40	-1.70	-1.30	-2.43	-1.90	0.30	2.80	4.00	5.80	1.50	2.40
-28	1.94	1.90	-0.96	-0.60	-1.90	-1.60	-2.56	-2.10	0.10	2.60	3.80	5.60	1.30	2.20
-27	1.89	1.90	-1.14	-0.70	-2.00	-1.60	-2.69	-2.20	-0.10	2.40	3.70	5.50	1.20	2.10
-26	1.83	1.80	-1.32	-0.90	-2.20	-1.80	-2.82	-2.00	-0.30	2.20	3.50	5.30	1.00	1.90
-25	1.77	1.80	-1.50	-1.10	-2.40	-2.00	-2.95	-2.50	-0.50	2.00	3.30	5.10	0.90	1.80
-24	1.72	1.70	-1.68	-1.30	-2.50	-2.10	-3.08	-2.60	-0.70	1.80	3.10	4.90	0.80	1.70
-23	1.66	1.70	-1.86	-1.50	-2.70	-2.30	-3.21	-2.70	-0.90	1.60	2.90	4.70	0.60	1.50

-22	1.61	1.60	-2.04	-1.60	-2.90	-2.50	-3.34	-2.80	-1.10	1.40	2.80	4.60	0.50	1.40
-21	1.56	1.60	-2.22	-1.80	-3.00	-2.60	-3.47	-3.00	-1.30	1.20	2.60	4.40	0.30	1.20
-20	1.50	1.50	-2.40	-2.00	-3.20	-2.80	-3.60	-3.10	-1.50	1.00	2.40	4.20	0.20	1.10
-19	1.45	1.50	-2.71	-2.30	-3.40	-3.00	-3.72	-3.20	-1.70	0.90	2.20	4.00	-0.10	0.80
-18	1.40	1.40	-3.02	-2.60	-3.60	-3.20	-3.84	-3.30	-1.80	0.70	1.90	3.70	-0.40	0.50
-17	1.35	1.40	-3.33	-2.90	-3.80	-3.40	-3.96	-3.50	-2.00	0.60	1.70	3.50	-0.80	0.10
-16	1.30	1.30	-3.64	-3.20	-4.00	-3.60	-4.08	-3.60	-2.10	0.40	1.40	3.20	-1.10	-0.20
-15	1.25	1.30	-3.95	-3.60	-4.20	-3.80	-4.20	-3.70	-2.30	0.30	1.20	3.00	-1.40	-0.50
-14	1.20	1.20	-4.26	-3.90	-4.40	-4.00	-4.32	-3.80	-2.40	0.10	1.00	2.80	-1.70	-0.80
-13	1.15	1.20	-4.57	-4.20	-4.60	-4.20	-4.44	-3.90	-2.60	-0.10	0.70	2.50	-2.00	-1.10
-12	1.10	1.10	-4.88	-4.50	-4.80	-4.40	-4.56	-4.10	-2.70	-0.20	0.50	2.30	-2.40	-1.50
-11	1.05	1.00	-5.19	-4.80	-5.00	-4.60	-4.68	-4.20	-2.90	-0.40	0.20	2.00	-2.70	-1.80
-10	1.00	1.00	-5.50	-5.10	-5.20	-4.80	-4.80	-4.30	-3.00	-0.50	0.0	1.80	-3.00	-2.10
-9	0.80	0.80	-6.00	-5.60	-5.56	-5.10	-4.80	-4.30	-3.20	-0.70	-0.40	1.40	-3.40	-2.50
-8	0.60	0.60	-6.50	-6.10	-5.92	-5.50	-4.80	-4.30	-3.40	-0.90	-0.80	1.00	-3.90	-3.00
-7	0.40	0.40	-7.00	-6.60	-6.28	-5.90	-4.80	-4.30	-3.60	-1.10	-1.20	0.60	-4.30	-3.40
-6	0.20	0.20	-7.50	-7.10	-6.64	-6.20	-4.80	-4.30	-3.80	-1.30	-1.60	0.20	-4.80	-3.90
-5	0.0	0.0	-8.00	-7.60	-7.00	-6.60	-4.80	-4.30	-4.00	-1.50	-2.00	-0.20	-5.20	-4.30
-4	-0.20	-0.20	-8.50	-8.10	-7.36	-7.00	-4.80	-4.30	-4.20	-1.70	-2.40	-0.60	-5.60	-4.70
-3	-0.40	-0.40	-9.00	-8.60	-7.72	-7.30	-4.80	-4.30	-4.40	-1.90	-2.80	-1.00	-6.10	-5.20
-2	-0.60	-0.60	-9.50	-9.10	-8.08	-7.60	-4.80	-4.30	-4.60	-2.10	-3.20	-1.40	-6.50	-5.60
-1	-0.80	-0.80	-10.00	-9.60	-8.44	-8.00	-4.80	-4.30	-4.80	-2.30	-3.60	-1.80	-7.00	-6.10
0	-1.00	-1.00	-10.50	-10.10	-8.80	-8.40	-4.80	-4.30	-5.00	-2.50	-4.00	-2.20	-7.40	-6.50
1	-0.80	-0.80	-10.00	-9.60	-8.40	-8.00	-4.80	-4.30	-4.80	-2.30	-3.60	-1.80	-7.00	-6.10
2	-0.60	-0.60	-9.50	-9.10	-8.10	-7.60	-4.80	-4.30	-4.60	-2.10	-3.20	-1.40	-6.50	-5.60
3	-0.40	-0.40	-9.00	-8.60	-7.70	-7.30	-4.80	-4.30	-4.40	-1.90	-2.80	-1.00	-6.10	-5.20
4	-0.20	-0.20	-8.50	-8.10	-7.40	-7.00	-4.80	-4.30	-4.20	-1.70	-2.40	-0.60	-5.60	-4.70
5	0.0	0.0	-8.00	-7.60	-7.00	-6.60	-4.80	-4.30	-4.00	-1.50	-2.00	-0.20	-5.20	-4.30
6	0.20	0.20	-7.50	-7.10	-6.60	-6.20	-4.80	-4.30	-3.80	-1.30	-1.60	0.20	-4.80	-3.90
7	0.40	0.40	-7.00	-6.60	-6.30	-5.90	-4.80	-4.30	-3.60	-1.10	-1.20	0.60	-4.30	-3.40
8	0.60	0.60	-6.50	-6.10	-5.90	-5.50	-4.80	-4.30	-3.40	-0.90	-0.80	1.00	-3.90	-3.00
9	0.80	0.80	-6.00	-5.60	-5.60	-5.10	-4.80	-4.30	-3.20	-0.70	-0.40	1.40	-3.40	-2.50
10	1.00	1.00	-5.50	-5.10	-5.20	-4.80	-4.80	-4.30	-3.00	-0.50	0.0	1.80	-3.00	-2.10
11	1.00	1.00	-5.20	-4.80	-5.00	-4.60	-4.70	-4.20	-2.90	-0.40	0.20	2.00	-2.70	-1.80
12	1.10	1.10	-4.90	-4.50	-4.80	-4.40	-4.60	-4.10	-2.70	-0.20	0.50	2.30	-2.40	-1.50
13	1.20	1.20	-4.60	-4.20	-4.60	-4.20	-4.40	-3.90	-2.60	-0.10	0.70	2.50	-2.00	-1.10
14	1.20	1.20	-4.30	-3.90	-4.40	-4.00	-4.30	-3.80	-2.40	0.10	1.00	2.80	-1.70	-0.80
15	1.30	1.30	-4.00	-3.60	-4.20	-3.80	-4.20	-3.70	-2.30	0.30	1.20	3.00	-1.40	-0.50
16	1.30	1.30	-3.60	-3.20	-4.00	-3.60	-4.10	-3.60	-2.10	0.40	1.40	3.20	-1.10	-0.20
17	1.40	1.40	-3.30	-2.90	-3.80	-3.40	-4.00	-3.50	-2.00	0.60	1.70	3.50	-0.80	0.10
18	1.40	1.40	-3.00	-2.60	-3.60	-3.20	-3.80	-3.30	-1.80	0.70	1.90	3.70	-0.40	0.50
19	1.50	1.50	-2.70	-2.30	-3.40	-3.00	-3.70	-3.20	-1.70	0.90	2.20	4.00	-0.10	0.80
20	1.50	1.50	-2.40	-2.00	-3.20	-2.80	-3.60	-3.10	-1.50	1.00	2.40	4.20	0.20	1.10
21	1.60	1.60	-2.20	-1.80	-3.00	-2.60	-3.50	-3.00	-1.30	1.20	2.60	4.40	0.30	1.20
22	1.60	1.60	-2.00	-1.60	-2.90	-2.50	-3.30	-2.80	-1.10	1.40	2.80	4.60	0.50	1.40
23	1.70	1.70	-1.90	-1.50	-2.70	-2.30	-3.20	-2.70	-0.90	1.60	2.90	4.70	0.60	1.50
24	1.70	1.70	-1.70	-1.30	-2.50	-2.10	-3.10	-2.60	-0.70	1.80	3.10	4.90	0.80	1.70
25	1.80	1.80	-1.50	-1.10	-2.40	-2.00	-3.00	-2.50	-0.50	2.00	3.30	5.10	0.90	1.80
26	1.80	1.80	-1.30	-0.90	-2.20	-1.80	-2.80	-2.00	-0.30	2.20	3.50	5.30	1.00	1.90
27	1.90	1.90	-1.10	-0.70	-2.00	-1.60	-2.70	-2.20	-0.10	2.40	3.70	5.50	1.20	2.10
28	1.90	1.90	-1.00	-0.60	-1.90	-1.60	-2.60	-2.10	0.10	2.60	3.80	5.60	1.30	2.20
29	2.00	2.00	-0.80	-0.40	-1.70	-1.30	-2.40	-1.90	0.30	2.80	4.00	5.80	1.50	2.40
30	2.10	2.10	-0.60	-0.20	-1.60	-1.20	-2.30	-1.80	0.50	3.00	4.20	6.00	1.60	2.50
31	2.10	2.10	-0.40	0.0	-1.40	-1.00	-2.20	-1.70	0.70	3.20	4.40	6.20	1.70	2.60
32	2.20	2.20	-0.20	0.20	-1.20	-0.80	-2.00	-1.50	0.90	3.40	4.60	6.40	1.90	2.80
33	2.20	2.20	-0.10	0.30	-1.10	-0.70	-1.90	-1.40	1.10	3.60	4.70	6.50	2.00	2.90
34	2.30	2.30	0.10	0.50	-0.90	-0.50	-1.80	-1.30	1.30	3.80	4.90	6.70	2.20	3.10
35	2.30	2.30	0.30	0.70	-0.70	-0.30	-1.70	-1.20	1.50	4.00	5.10	6.90	2.30	3.20
36	2.40	2.40	0.50	0.90	-0.60	-0.20	-1.50	-1.00	1.70	4.20	5.30	7.10	2.40	3.30
37	2.40	2.40	0.70	1.10	-0.40	0.0	-1.40	-0.90	1.90	4.40	5.50	7.30	2.60	3.50
38	2.50	2.50	0.80	1.20	-0.20	0.20	-1.30	-0.80	2.10	4.60	5.60	7.40	2.70	3.60
39	2.50	2.50	1.00	1.40	-0.10	0.30	-1.10	-0.60	2.30	4.80	5.80	7.60	2.90	3.80
40	2.60	2.60	1.20	1.60	0.10	0.50	-1.00	-0.50	2.50	5.00	6.00	7.80	3.00	3.90

KSW	DBV	DBH	DBL	TBD	TBR	RBD	RBR
8	-132.512	-132.891	-.100000E+76	.0	.0	.0	.0

DB FROM BREM	P	TRANSMITTER GN	RECEIVER GAIN	COMPENSATED POWER
-132.511993	5.2283525	-8.7999954	-8.7999954	-144.883606
-132.891006	5.2283525	-8.3999968	-8.3999968	-144.462631

****

SIGNAL ANALYSIS INCLUDING BREM ANALYSIS

GROUND OR REFLECTED VERTICAL DBW	GROUND OR REFLECTED HORIZONTAL DBW	DIRECT VERTICAL DBW	DIRECT HORIZONTAL DBW	IONOSPHERIC SIGNAL SUM DBW	VERTICAL NOISE -DBW	CORRECTED NOISE -DBW	CORRECTED ALL MODE S/N RATIO
-144.884	-144.463	-.100000E+76	-.100000E+76	-.100000E+76	151.500	148.801	7.14290

****

GMT	TIME (SEC)	FREQ	NMODES	MGT (MS)	2*SIGMA (MS)	SIGNAL (-DBW)	S/N (DB)	EFPL (DB)	(S/N)MAX (DB)
211	60.	4.0	2	NO IONOSPHERIC PROPOGATION					

5.6 Sample of Deck Setup

The following listing shows a typical deck setup for NUCOM/BREM.

```
0001:  //GOUNT007 JOB (1391310,3126,C,,842),OREGAN,MSGLEVEL=1,
0002:  // CLASS=C,TIME=25
0003:  // EXEC NATPATS
0004:  //NATPATS.SYSIN DD *
0005:       -17.0    -128.2      -24.2    -128.2          6        2.2          20          0
0006:  0                                STRESSED TEST RUN AIR TO AIR BEYOND LOS
0007:  /*
0008:  // EXEC NUCEFMS
0009:  //STEPLIB DD DSN=COLATKL.G000.NUCEFM.A.LMOD,DISP=SHR
0010:  //NUCEFMS.SYSIN DD *
0011:  1        46           2           0           0           5         .5          1.
0012:
0013:  2      1.30         70.          .4          .1       -20.0     -128.0          0.
0014:  3         2         .75         .01
0015:  6        30          35          40          45          50          55          60
0016:  6        62          65          68          70          72          75          80
0017:  6        85          90          92          96         100         105         115
0018:  6       125         135         145         155         165         175         185
0019:  6       195         205         215         225         240         255         270
0020:  6       285         300         325         350         375         400         425
0021:  6       450         500         600         700
0022:  7        60
0023:  0
0024:   0
0025:  /*
0026:  //ORDER EXEC PGM=ORDER
0027:  //ORDER.SYSIN DD *
0028:    2.5     3          .5       -20.0     -128.0         200        1800     0     0        2000
0029:  /*
0030:  // EXEC RAYBREM
0031:  //STEPLIB DD DSN=U.G000.A9999999.RAYPLUS.V3T2.LMOD,DISP=SHR
0032:  //RAYBREM.SYSIN DD *
0033:  1          0           0
0034:  2      -17.0    -128.2      -24.2    -128.2
0035:  3        4.0         1.0         4.0         0.1         1.0        75.0          .6          .6
0036:  5          1
0037:  6        2.2
0038:  7         60
0039:  8          0           0           0
0040:  9        4.0
0041:  0  STRESSED TEST RUN AIR TO AIR
0042:     10000.0   10000.0    0.0         0.0         0.0         10     0
0043:  1          0           1
0044:  /*
0045:  //COMBREM EXEC PGM=COMEFF
0046:  //STEPLIB DD DSN=U.G000.A9707702.COMEFF.NEW2.LMOD,DISP=SHR
0047:  //FT01F001 DD USN=&&COMWRK,UNIT=SYSDA,SPACE=(TRK,(5,5)),DISP=(NEW,PASS)
0048:  //FT05F001 DD DDNAME=SYSIN
0049:  //FT06F001 DD SYSOUT=A
0050:  //FT07F001 DD USN=&&COMIND,DISP=(OLD,DELETE)
0051:  //FT09F001 DD USN=ANTENNA.FILE.DATA,DISP=SHR
0052:  //COMBREM.SYSIN DD *
0053:   &IINIT KSW1=0,KSW2=1,MNANGT=-40,MXANGT=40,MNANGR=-40,MXANGR=40,
0054:   NOFREQ=7,PLREJ=400.,NEWANT=1  &END
0055:  PRNT      1
0056:    2.0  3.0  4.0  5.0  7.0  10.0 15.0
0057:    -402.6001.200  0.1-1.00  2.5  6.0  3.0  1.2
0058:    -40  2.6  1.6  0.5 -0.5  5.0  7.8  3.9  3.1
0059:    -392.545 1.02 -0.1-1.13  2.3  5.8  2.9  1.2
0060:    -39  2.5  1.4  0.3 -0.6  4.8  7.6  3.8  3.1
```

```
0061:    -382.490 0.84 -0.2-1.26  2.1  5.6  2.7  1.1
0062:    -38  2.5  1.2  0.2 -0.8  4.6  7.4  3.6  3.0
0063:    -372.455 0.66 -0.4-1.39  1.9  5.5  2.6  1.1
0064:    -37  2.4  1.1 -0.0 -0.9  4.4  7.3  3.5  3.0
0065:    -362.380 0.48 -0.6-1.52  1.7  5.3  2.4  1.0
0066:    -36  2.4  0.9 -0.2 -1.0  4.2  7.1  3.3  2.9
0067:    -352.325 0.30 -0.7-1.65  1.5  5.1  2.3  1.0
0068:    -35  2.3  0.7 -0.3 -1.2  4.0  6.9  3.2  2.9
0069:    -342.270 0.12 -0.9-1.78  1.3  4.9  2.2  1.0
0070:    -34  2.3  0.5 -0.5 -1.3  3.8  6.7  3.1  2.9
0071:    -332.215-0.06 -1.1-1.91  1.1  4.7  2.0  0.9
0072:    -33  2.2  0.3 -0.7 -1.4  3.6  6.5  2.9  2.8
0073:    -322.160-0.24 -1.2-2.04  0.9  4.6  1.9  0.9
0074:    -32  2.2  0.2 -0.8 -1.5  3.4  6.4  2.8  2.8
0075:    -312.105-0.42 -1.4-2.17  0.7  4.4  1.7  0.8
0076:    -31  2.1  0.0 -1.0 -1.7  3.2  6.2  2.6  2.7
0077:    -302.050-0.60 -1.6-2.30  0.5  4.2  1.6  0.8
0078:    -30  2.1 -0.2 -1.2 -1.8  3.0  6.0  2.5  2.7
0079:    -291.995-0.78 -1.7-2.43  0.3  4.0  1.5  0.8
0080:    -29  2.0 -0.4 -1.3 -1.9  2.8  5.8  2.4  2.7
0081:    -281.940-0.96 -1.9-2.56  0.1  3.8  1.3  0.7
0082:    -28  1.9 -0.6 -1.6 -2.1  2.6  5.6  2.2  2.6
0083:    -271.885-1.14 -2.0-2.69 -0.1  3.7  1.2  0.7
0084:    -27  1.9 -0.7 -1.6 -2.2  2.4  5.5  2.1  2.6
0085:    -261.830-1.32 -2.2-2.82 -0.3  3.5  1.0  0.6
0086:    -26  1.8 -0.9 -1.8 -2.0  2.2  5.3  1.9  2.5
0087:    -251.775-1.50 -2.4-2.95 -0.5  3.3  0.9  0.6
0088:    -25  1.8 -1.1 -2.0 -2.5  2.0  5.1  1.8  2.5
0089:    -241.720-1.68 -2.5-3.08 -0.7  3.1  0.8  0.6
0090:    -24  1.7 -1.3 -2.1 -2.6  1.8  4.9  1.7  2.5
0091:    -231.665-1.86 -2.7-3.21 -0.9  2.9  0.6  0.5
0092:    -23  1.7 -1.5 -2.3 -2.7  1.6  4.7  1.5  2.4
0093:    -221.610-2.04 -2.9-3.34 -1.1  2.8  0.5  0.5
0094:    -22  1.6 -1.6 -2.5 -2.8  1.4  4.6  1.4  2.4
0095:    -211.555-2.22 -3.0-3.47 -1.3  2.6  0.3  0.4
0096:    -21  1.6 -1.8 -2.6 -3.0  1.2  4.4  1.2  2.3
0097:    -20 1.50-2.40 -3.2-3.60 -1.5  2.4  0.2  0.4
0098:    -20  1.5 -2.0 -2.8 -3.1  1.0  4.2  1.1  2.3
0099:    -19 1.45-2.71 -3.4-3.72 -1.7  2.2 -0.1  0.3
0100:    -19  1.5 -2.3 -3.0 -3.2  0.9  4.0  0.8  2.2
0101:    -18 1.40-3.02 -3.6-3.84 -1.8  1.9 -0.4  0.1
0102:    -18  1.4 -2.6 -3.2 -3.3  0.7  3.7  0.5  2.0
0103:    -17 1.35-3.33 -3.8-3.96 -2.0  1.7 -0.8  0.0
0104:    -17  1.4 -2.9 -3.4 -3.5  0.6  3.5  0.1  1.9
0105:    -16 1.30-3.64 -4.0-4.08 -2.1  1.4 -1.1 -0.2
0106:    -16  1.3 -3.2 -3.6 -3.6  0.4  3.2 -0.2  1.7
0107:    -15 1.25-3.95 -4.2-4.20 -2.3  1.2 -1.4 -0.3
0108:    -15  1.3 -3.6 -3.8 -3.7  0.3  3.0 -0.5  1.6
0109:    -14 1.20-4.26 -4.4-4.32 -2.4  1.0 -1.7 -0.4
0110:    -14  1.2 -3.9 -4.0 -3.8  0.1  2.8 -0.8  1.5
0111:    -13 1.15-4.57 -4.6-4.44 -2.6  0.7 -2.0 -0.6
0112:    -13  1.2 -4.2 -4.2 -3.9 -0.1  2.5 -4.1  1.3
0113:    -12 1.10-4.88 -4.8-4.56 -2.7  0.5 -2.4 -0.7
0114:    -12  1.1 -4.5 -4.4 -4.1 -0.2  2.3 -1.5  1.2
0115:    -11 1.05-5.19 -5.0-4.68 -2.9  0.2 -2.7 -0.9
0116:    -11  1.0 -4.8 -4.6 -4.2 -0.4  2.0 -1.8  1.0
0117:    -10  1.0-5.50-5.20-4.80 -3.0  0.0 -3.0 -1.0
0118:    -10  1.0 -5.1 -4.8 -4.3 -0.5  1.8 -2.1  0.9
0119:     -9  0.8 -6.0-5.56-4.80 -3.2 -0.4 -3.4 -1.2
0120:     -9  0.8 -5.6 -5.1 -4.3 -0.7  1.4 -2.5  0.7
```

```
0121:    -8   0.6 -6.5-5.92-4.80 -3.4 -0.8 -3.9 -1.5
0122:    -8   0.6 -6.1 -5.5 -4.3 -0.9  1.0 -3.0  0.4
0123:    -7   0.4 -7.0-6.28-4.80 -3.6 -1.2 -4.3 -1.7
0124:    -7   0.4 -6.6 -5.9 -4.3 -1.1  0.6 -3.4  0.2
0125:    -6   0.2 -7.5-6.64-4.80 -3.8 -1.6 -4.8 -2.0
0126:    -6   0.2 -7.1 -6.2 -4.3 -1.3  0.2 -3.9 -0.1
0127:    -5   0.0 -8.0-7.00-4.80 -4.0 -2.0 -5.2 -2.2
0128:    -5   0.0 -7.6 -6.6 -4.3 -1.5 -0.4 -4.3 -0.3
0129:    -4  -0.2 -8.5-7.36-4.80 -4.2 -2.4 -5.6 -2.4
0130:    -4  -0.2 -8.1 -7.0 -4.3 -1.7 -0.6 -4.7 -0.5
0131:    -3  -0.4 -9.0-7.72-4.80 -4.4 -2.8 -6.1 -2.7
0132:    -3  -0.4 -8.6 -7.3 -4.3 -1.9 -1.0 -5.2 -0.8
0133:    -2  -0.6 -9.5-8.08-4.80 -4.6 -3.2 -6.5 -2.9
0134:    -2  -0.6 -9.1 -7.6 -4.3 -2.1 -1.4 -5.6 -1.0
0135:    -1  -0.8-10.0-8.44-4.80 -4.8 -3.6 -7.0 -3.2
0136:    -1  -0.8 -9.6 -8.0 -4.3 -2.3 -1.8 -6.1 -1.3
0137:     0  -1.0-10.5 -8.8 -4.8 -5.0 -4.0 -7.4 -3.4
0138:     0  -1.0-10.1 -8.4 -4.3 -2.5 -2.2 -6.5 -1.5
0139:     1  -0.8-10.0 -8.4 -4.8 -4.8 -3.6 -7.0 -3.2
0140:     1  -0.8 -9.6 -8.0 -4.3 -2.3 -1.8 -6.1 -1.3
0141:     2  -0.6 -9.5 -8.1 -4.8 -4.6 -3.2 -6.5 -2.9
0142:     2  -0.6 -9.1 -7.6 -4.3 -2.1 -1.4 -5.6 -1.0
0143:     3  -0.4 -9.0 -7.7 -4.8 -4.4 -2.8 -6.1 -2.7
0144:     3  -0.4 -8.6 -7.3 -4.3 -1.9 -1.0 -5.2 -0.8
0145:     4  -0.2 -8.5 -7.4 -4.8 -4.2 -2.4 -5.6 -2.4
0146:     4  -0.2 -8.1 -7.0 -4.3 -1.7 -0.6 -4.7 -0.5
0147:     5   0.0 -8.0 -7.0 -4.8 -4.0 -2.0 -5.2 -2.2
0148:     5   0.0 -7.6 -6.6 -4.3 -1.5 -0.2 -4.3 -0.3
0149:     6   0.2 -7.5 -6.6 -4.8 -3.8 -1.6 -4.8 -2.0
0150:     6   0.2 -7.1 -6.2 -4.3 -1.3  0.2 -3.9 -0.1
0151:     7   0.4 -7.0 -6.3 -4.8 -3.6 -1.2 -4.3 -1.7
0152:     7   0.4 -6.6 -5.9 -4.3 -1.1  0.6 -3.4  0.2
0153:     8   0.6 -6.5 -5.9 -4.8 -3.4 -0.8 -3.9 -1.5
0154:     8   0.6 -6.1 -5.5 -4.3 -0.9  1.0 -3.0  0.4
0155:     9   0.8 -6.0 -5.6 -4.8 -3.2 -0.4 -3.4 -1.2
0156:     9   0.8 -5.6 -5.1 -4.3 -0.7  1.4 -2.5  0.7
0157:    10   1.0 -5.5 -5.2 -4.8 -3.0  0.0 -3.0 -1.0
0158:    10   1.0 -5.1 -4.8 -4.3 -0.5  1.8 -2.1  0.9
0159:    11   1.0 -5.2 -5.0 -4.7 -2.9  0.2 -2.7 -0.9
0160:    11   1.0 -4.8 -4.6 -4.2 -0.4  2.0 -1.8  1.0
0161:    12   1.1 -4.9 -4.8 -4.6 -2.7  0.5 -2.4 -0.7
0162:    12   1.1 -4.5 -4.4 -4.1 -0.2  2.3 -1.5  1.2
0163:    13   1.2 -4.6 -4.6 -4.4 -2.6  0.7 -2.0 -0.6
0164:    13   1.2 -4.2 -4.2 -3.9 -0.1  2.5 -1.1  1.3
0165:    14   1.2 -4.3 -4.4 -4.3 -2.4  1.0 -1.7 -0.4
0166:    14   1.2 -3.9 -4.0 -3.8  0.1  2.8 -0.8  1.5
0167:    15   1.3 -4.0 -4.2 -4.2 -2.3  1.2 -1.4 -0.3
0168:    15   1.3 -3.6 -3.8 -3.7  0.3  3.0 -0.5  1.6
0169:    16   1.3 -3.6 -4.0 -4.1 -2.1  1.4 -1.1 -0.2
0170:    16   1.3 -3.2 -3.6 -3.6  0.4  3.2 -0.2  1.7
0171:    17   1.4 -3.3 -3.8 -4.0 -2.0  1.7 -0.8  0.0
0172:    17   1.4 -2.9 -3.4 -3.5  0.6  3.5  0.1  1.9
0173:    18   1.4 -3.0 -3.6 -3.8 -1.8  1.9 -0.4  0.1
0174:    18   1.4 -2.6 -3.2 -3.3  0.7  3.7  0.5  2.0
0175:    19   1.5 -2.7 -3.4 -3.7 -1.7  2.2 -0.1  0.3
0176:    19   1.5 -2.3 -3.0 -3.2  0.9  4.0  0.8  2.2
0177:    20   1.5 -2.4 -3.2 -3.6 -1.5  2.4  0.2  0.4
0178:    20   1.5 -2.0 -2.8 -3.1  1.0  4.2  1.1  2.3
0179:    21   1.6 -2.2 -3.0 -3.5 -1.3  2.6  0.3  0.4
0180:    21   1.6 -1.8 -2.6 -3.0  1.2  4.4  1.2  2.3
```

0181:	22	1.6	-2.0	-2.9	-3.3	-1.1	2.8	0.5	0.5
0182:	22	1.6	-1.6	-2.5	-2.8	1.4	4.6	1.4	2.4
0183:	23	1.7	-1.9	-2.7	-3.2	-0.9	2.9	0.6	0.5
0184:	23	1.7	-1.5	-2.3	-2.7	1.6	4.7	1.5	2.4
0185:	24	1.7	-1.7	-2.5	-3.1	-0.7	3.1	0.8	0.6
0186:	24	1.7	-1.3	-2.1	-2.6	1.8	4.9	1.7	2.5
0187:	25	1.8	-1.5	-2.4	-3.0	-0.5	3.3	0.9	0.6
0188:	25	1.8	-1.1	-2.0	-2.5	2.0	5.1	1.8	2.5
0189:	26	1.8	-1.3	-2.2	-2.8	-0.3	3.5	1.0	0.6
0190:	26	1.8	-0.9	-1.8	-2.0	2.2	5.3	1.9	2.5
0191:	27	1.9	-1.1	-2.0	-2.7	-0.1	3.7	1.2	0.7
0192:	27	1.9	-0.7	-1.6	-2.2	2.4	5.5	2.1	2.6
0193:	28	1.9	-1.0	-1.9	-2.6	0.1	3.8	1.3	0.7
0194:	28	1.9	-0.6	-1.6	-2.1	2.6	5.6	2.2	2.6
0195:	29	2.0	-0.8	-1.7	-2.4	0.3	4.0	1.5	0.8
0196:	29	2.0	-0.4	-1.3	-1.9	2.8	5.8	2.4	2.7
0197:	30	2.1	-0.6	-1.6	-2.3	0.5	4.2	1.6	0.8
0198:	30	2.1	-0.2	-1.2	-1.8	3.0	6.0	2.5	2.7
0199:	31	2.1	-0.4	-1.4	-2.2	0.7	4.4	1.7	0.8
0200:	31	2.1	0.0	-1.0	-1.7	3.2	6.2	2.6	2.7
0201:	32	2.2	-0.2	-1.2	-2.0	0.9	4.6	1.9	0.9
0202:	32	2.2	0.2	-0.8	-1.5	3.4	6.4	2.8	2.8
0203:	33	2.2	-0.1	-1.1	-1.9	1.1	4.7	2.0	0.9
0204:	33	2.2	0.3	-0.7	-1.4	3.6	6.5	2.9	2.8
0205:	34	2.3	0.1	-0.9	-1.8	1.3	4.9	2.2	1.0
0206:	34	2.3	0.5	-0.5	-1.3	3.8	6.7	3.1	2.9
0207:	35	2.3	0.3	-0.7	-1.7	1.5	5.1	2.3	1.0
0208:	35	2.3	0.7	-0.3	-1.2	4.0	6.9	3.2	2.9
0209:	36	2.4	0.5	-0.6	-1.5	1.7	5.3	2.4	1.0
0210:	36	2.4	0.9	-0.2	-1.0	4.2	7.1	3.3	2.9
0211:	37	2.4	0.7	-0.4	-1.4	1.9	5.5	2.6	1.1
0212:	37	2.4	1.1	-0.0	-0.9	4.4	7.3	3.5	3.0
0213:	38	2.5	0.8	-0.2	-1.3	2.1	5.6	2.7	1.1
0214:	38	2.5	1.2	0.2	-0.8	4.6	7.4	3.6	3.0
0215:	39	2.5	1.0	-0.1	-1.1	2.3	5.8	2.9	1.2
0216:	39	2.5	1.4	0.3	-0.6	4.8	7.6	3.8	3.1
0217:	40	2.6	1.2	0.1	-1.0	2.5	6.0	3.0	1.2
0218:	40	2.6	1.6	0.5	-0.5	5.0	7.8	3.9	3.1
0219:	-40	1.9	2.6	2.4	2.2	1.4	0.7	1.7	1.8
0220:	-40	1.9	3.0	2.8	2.7	3.9	2.5	2.6	3.7
0221:	-39	1.9	2.6	2.3	2.1	1.3	0.7	1.6	1.8
0222:	-39	1.9	3.0	2.7	2.6	3.8	2.5	2.5	3.7
0223:	-38	1.8	2.6	2.3	2.0	1.3	0.7	1.5	1.8
0224:	-38	1.8	3.0	2.7	2.5	3.8	2.5	2.4	3.7
0225:	-37	1.8	2.6	2.2	1.8	1.2	0.7	1.4	1.8
0226:	-37	1.8	3.0	2.6	2.3	3.7	2.5	2.3	3.6
0227:	-36	1.8	2.6	2.2	1.7	1.2	0.7	1.3	1.7
0228:	-36	1.8	3.0	2.6	2.2	3.7	2.5	2.2	3.6
0229:	-35	1.8	2.6	2.1	1.6	1.1	0.7	1.2	1.7
0230:	-35	1.8	3.0	2.5	2.1	3.6	2.5	2.1	3.6
0231:	-34	1.7	2.6	2.0	1.5	1.0	0.6	1.1	1.7
0232:	-34	1.7	3.0	2.4	2.0	3.5	2.4	2.0	3.6
0233:	-33	1.7	2.6	2.0	1.4	1.0	0.6	1.0	1.7
0234:	-33	1.7	3.0	2.4	1.9	3.5	2.4	1.9	3.5
0235:	-32	1.7	2.6	1.9	1.2	0.9	0.6	0.9	1.6
0236:	-32	1.7	3.0	2.3	1.7	3.4	2.4	1.8	3.5
0237:	-31	1.6	2.6	1.9	1.1	0.9	0.6	0.8	1.6
0238:	-31	1.6	3.0	2.3	1.6	3.4	2.4	1.7	3.5
0239:	-30	1.6	2.5	1.8	1.0	0.8	0.6	0.7	1.6
0240:	-30	1.6	2.9	2.2	1.5	3.3	2.4	1.6	3.5

0241:	-29	1.6	2.5	1.7	0.9	0.7	0.6	0.6	1.6
0242:	-29	1.6	2.9	2.1	1.4	3.2	2.4	1.5	3.4
0243:	-28	1.5	2.5	1.7	0.8	0.7	0.6	0.5	1.5
0244:	-28	1.5	2.9	2.1	1.3	3.2	2.4	1.4	3.4
0245:	-27	1.5	2.5	1.6	0.6	0.6	0.6	0.4	1.5
0246:	-27	1.5	2.9	2.0	1.1	3.1	2.4	1.3	3.4
0247:	-26	1.5	2.5	1.6	0.5	0.6	0.6	0.3	1.5
0248:	-26	1.5	2.9	2.0	1.0	3.1	2.4	1.2	3.4
0249:	-25	1.5	2.5	1.5	0.4	0.5	0.6	0.2	1.5
0250:	-25	1.5	2.9	1.9	0.9	3.0	2.4	1.1	3.3
0251:	-24	1.4	2.5	1.4	0.3	0.4	0.5	0.1	1.4
0252:	-24	1.4	2.9	1.8	0.8	2.9	2.3	1.0	3.3
0253:	-23	1.4	2.5	1.4	0.2	0.4	0.5	-0.0	1.4
0254:	-23	1.4	2.9	1.8	0.7	2.9	2.3	0.9	3.3
0255:	-22	1.4	2.5	1.3	0.0	0.3	0.5	-0.1	1.4
0256:	-22	1.4	2.9	1.7	0.5	2.8	2.3	0.8	3.3
0257:	-21	1.3	2.5	1.3	-0.1	0.3	0.5	-0.2	1.4
0258:	-21	1.3	2.9	1.7	0.4	2.8	2.3	0.7	3.2
0259:	-20	1.3	2.5	1.2	-0.2	0.2	0.5	-0.3	1.3
0260:	-20	1.3	2.9	1.6	0.3	2.7	2.3	0.6	3.2
0261:	-19	1.3	2.5	1.1	-0.4	0.1	0.4	-0.3	1.1
0262:	-19	1.3	2.9	1.5	0.1	2.6	2.2	0.6	3.0
0263:	-18	1.2	2.5	0.9	-0.7	.0	0.4	-0.4	1.0
0264:	-18	1.2	2.9	1.3	-0.2	2.5	2.2	0.5	2.9
0265:	-17	1.2	2.5	0.8	-0.9	-0.1	0.3	-0.4	0.8
0266:	-17	1.2	2.9	1.2	-0.4	2.4	2.1	0.5	2.7
0267:	-16	1.1	2.5	0.6	-1.1	-0.2	0.3	-0.5	0.7
0268:	-16	1.1	2.9	1.0	-0.6	2.3	2.1	0.4	2.6
0269:	-15	1.1	2.5	0.5	-1.4	-0.3	0.2	-0.5	0.5
0270:	-15	1.1	2.9	0.9	-0.9	2.2	2.0	0.4	2.4
0271:	-14	1.1	2.5	0.4	-1.6	-0.4	0.1	-0.5	0.3
0272:	-14	1.1	2.9	0.8	-1.1	2.1	1.9	0.4	2.2
0273:	-13	1.0	2.5	0.2	-1.8	-0.5	0.1	-0.6	0.2
0274:	-13	1.0	2.9	0.6	-1.3	2.0	1.9	0.3	2.1
0275:	-12	1.0	2.5	0.1	-2.0	-0.6	0.0	-0.6	0.0
0276:	-12	1.0	2.9	0.5	-1.5	1.9	1.8	0.3	1.9
0277:	-11	0.9	2.5	-0.1	-2.3	-0.7	0.0	-0.7	-0.1
0278:	-11	0.9	2.9	0.3	-1.8	1.8	1.8	0.2	1.8
0279:	-10	0.9	2.5	-0.2	-2.5	-0.8	-0.1	-0.7	-0.3
0280:	-10	0.9	2.9	0.2	-2.0	1.7	1.7	0.2	1.6
0281:	-9	0.8	2.5	-0.4	-2.6	-1.0	-0.1	-0.6	-0.4
0282:	-9	0.8	2.9	0.0	-2.1	1.5	1.7	0.3	1.5
0283:	-8	0.7	2.5	-0.5	-2.7	-1.2	-0.2	-0.5	-0.5
0284:	-8	0.7	2.9	-0.1	-2.2	1.3	1.6	0.4	1.4
0285:	-7	0.7	2.5	-0.7	-2.8	-1.4	-0.2	-0.5	-0.5
0286:	-7	0.7	2.9	-0.3	-2.3	1.1	1.6	0.4	1.4
0287:	-6	0.6	2.5	-0.8	-2.9	-1.6	-0.3	-0.4	-0.6
0288:	-6	0.6	2.9	-0.4	-2.4	0.9	1.5	0.5	1.3
0289:	-5	0.5	2.5	-1.0	-3.0	-1.8	-0.3	-0.3	-0.7
0290:	-5	0.5	2.9	-0.6	-2.5	0.7	1.5	0.6	1.2
0291:	-4	0.4	2.5	-1.2	-3.1	-2.0	-0.3	-0.2	-0.8
0292:	-4	0.4	2.9	-0.8	-2.6	0.5	1.5	0.7	1.1
0293:	-3	0.3	2.5	-1.3	-3.2	-2.2	-0.4	-0.1	-0.9
0294:	-3	0.3	2.9	-0.9	-2.7	0.3	1.4	0.8	1.0
0295:	-2	0.3	2.5	-1.5	-3.3	-2.4	-0.4	-0.1	-0.9
0296:	-2	0.3	2.9	-1.1	-2.8	0.1	1.4	0.8	1.0
0297:	-1	0.2	2.5	-1.6	-3.4	-2.6	-0.5	0.0	-1.0
0298:	-1	0.2	2.9	-1.2	-2.9	-0.1	1.3	0.9	0.9
0299:	0	0.1	2.5	-1.8	-3.5	-2.8	-0.5	0.1	-1.1
0300:	0	0.1	2.9	-1.4	-3.0	-0.3	1.3	1.0	0.8

0301:	1	0.2	2.5	-1.6	-3.4	-2.6	-0.5	0.0	-1.0
0302:	1	0.2	2.9	-1.2	-2.9	-0.1	1.3	0.9	0.9
0303:	2	0.3	2.5	-1.5	-3.3	-2.4	-0.4	-0.1	-0.9
0304:	2	0.3	2.9	-1.1	-2.8	0.1	1.4	0.9	1.0
0305:	3	0.3	2.5	-1.3	-3.2	-2.2	-0.4	-0.1	-0.9
0306:	3	0.3	2.9	-0.9	-2.7	0.3	1.4	0.8	1.0
0307:	4	0.4	2.5	-1.2	-3.1	-2.0	-0.3	-0.2	-0.8
030A:	4	0.4	2.9	-0.8	-2.6	0.5	1.5	0.7	1.1
0309:	5	0.5	2.5	-1.0	-3.0	-1.8	-0.3	-0.3	-0.7
0310:	5	0.5	2.9	-0.6	-2.5	0.7	1.5	0.6	1.2
0311:	6	0.6	2.5	-0.8	-2.9	-1.6	-0.3	-0.4	-0.6
0312:	6	0.6	2.9	-0.4	-2.4	0.9	1.5	0.5	1.3
0313:	7	0.7	2.5	-0.7	-2.8	-1.4	-0.2	-0.5	-0.5
0314:	7	0.7	2.9	-0.3	-2.3	1.1	1.6	0.4	1.4
0315:	8	0.7	2.5	-0.5	-2.7	-1.2	-0.2	-0.5	-0.5
0316:	8	0.7	2.9	-0.1	-2.2	1.3	1.6	0.4	1.4
0317:	9	0.8	2.5	-0.4	-2.6	-1.0	-0.1	-0.6	-0.4
0318:	9	0.8	2.9	0.0	-2.1	1.5	1.7	0.3	1.5
0319:	10	0.9	2.5	-0.2	-2.5	-0.8	-0.1	-0.7	-0.3
0320:	10	0.9	2.9	0.2	-2.0	1.7	1.7	0.2	1.6
0321:	11	0.9	2.5	-0.1	-2.3	-0.7	0.0	-0.7	-0.1
0322:	11	0.9	2.9	0.3	-1.8	1.8	1.8	0.2	1.8
0323:	12	1.0	2.5	0.1	-2.0	-0.6	0.0	-0.6	0.0
0324:	12	1.0	2.9	0.5	-1.5	1.9	1.8	0.3	1.9
0325:	13	1.0	2.5	0.2	-1.8	-0.5	0.1	-0.6	0.2
0326:	13	1.0	2.9	0.6	-1.3	2.0	1.9	0.3	2.1
0327:	14	1.1	2.5	0.4	-1.6	-0.4	0.1	-0.5	0.3
032A:	14	1.1	2.9	0.9	-1.1	2.1	1.9	0.4	2.2
0329:	15	1.1	2.5	0.5	-1.4	-0.3	0.2	-0.5	0.5
0330:	15	1.1	2.9	0.9	-0.9	2.2	2.0	0.4	2.4
0331:	16	1.1	2.5	0.6	-1.1	-0.2	0.3	-0.5	0.7
0332:	16	1.1	2.9	1.0	-0.6	2.3	2.1	0.4	2.6
0333:	17	1.2	2.5	0.8	-0.9	-0.1	0.3	-0.4	.8
0334:	17	1.2	2.9	1.2	-0.4	2.4	2.1	0.5	2.7
0335:	18	1.2	2.5	0.9	-0.7	.0	0.4	-0.4	1.0
0336:	18	1.2	2.9	1.3	-0.2	2.5	2.2	0.5	2.9
0337:	19	1.3	2.5	1.1	-0.4	0.1	0.4	-0.3	1.1
0338:	19	1.3	2.9	1.5	0.1	2.6	2.2	0.6	3.0
0339:	20	1.3	2.5	1.2	-0.2	0.2	0.5	-0.3	1.3
0340:	20	1.3	2.9	1.6	0.3	2.7	2.3	0.6	3.2
0341:	21	1.3	2.5	1.3	-0.1	0.3	0.5	-0.2	1.4
0342:	21	1.3	2.9	1.7	0.4	2.8	2.3	0.7	3.2
0343:	22	1.4	2.5	1.3	0.0	0.3	0.5	-0.1	1.4
0344:	22	1.4	2.9	1.7	0.5	2.8	2.3	0.8	3.3
0345:	23	1.4	2.5	1.4	0.2	0.4	0.5	-0.0	1.4
0346:	23	1.4	2.9	1.8	0.7	2.9	2.3	0.9	3.3
0347:	24	1.4	2.5	1.4	0.3	0.4	0.5	0.1	1.4
0348:	24	1.4	2.9	1.8	0.8	2.9	2.3	1.0	3.3
0349:	25	1.5	2.5	1.5	0.4	0.5	0.6	0.2	1.5
0350:	25	1.5	2.9	1.9	0.9	3.0	2.4	1.1	3.3
0351:	26	1.5	2.5	1.6	0.5	0.6	0.6	0.3	1.5
0352:	26	1.5	2.9	2.0	1.0	3.1	2.4	1.2	3.4
0353:	27	1.5	2.5	1.6	0.6	0.6	0.6	0.4	.5
0354:	27	1.5	2.9	2.0	1.1	3.1	2.4	1.3	3.4
0355:	28	1.5	2.5	1.7	0.8	0.7	0.6	0.5	.5
0356:	28	1.5	2.9	2.1	1.3	3.2	2.4	1.4	3.4
0357:	29	1.6	2.5	1.7	0.9	0.7	0.6	0.6	.6
035A:	29	1.6	2.9	2.1	1.4	3.2	2.4	1.5	3.4
0359:	30	1.6	2.5	1.8	1.0	0.8	0.6	0.7	1.6
0360:	30	1.6	2.9	2.2	1.5	3.3	2.4	1.6	3.5

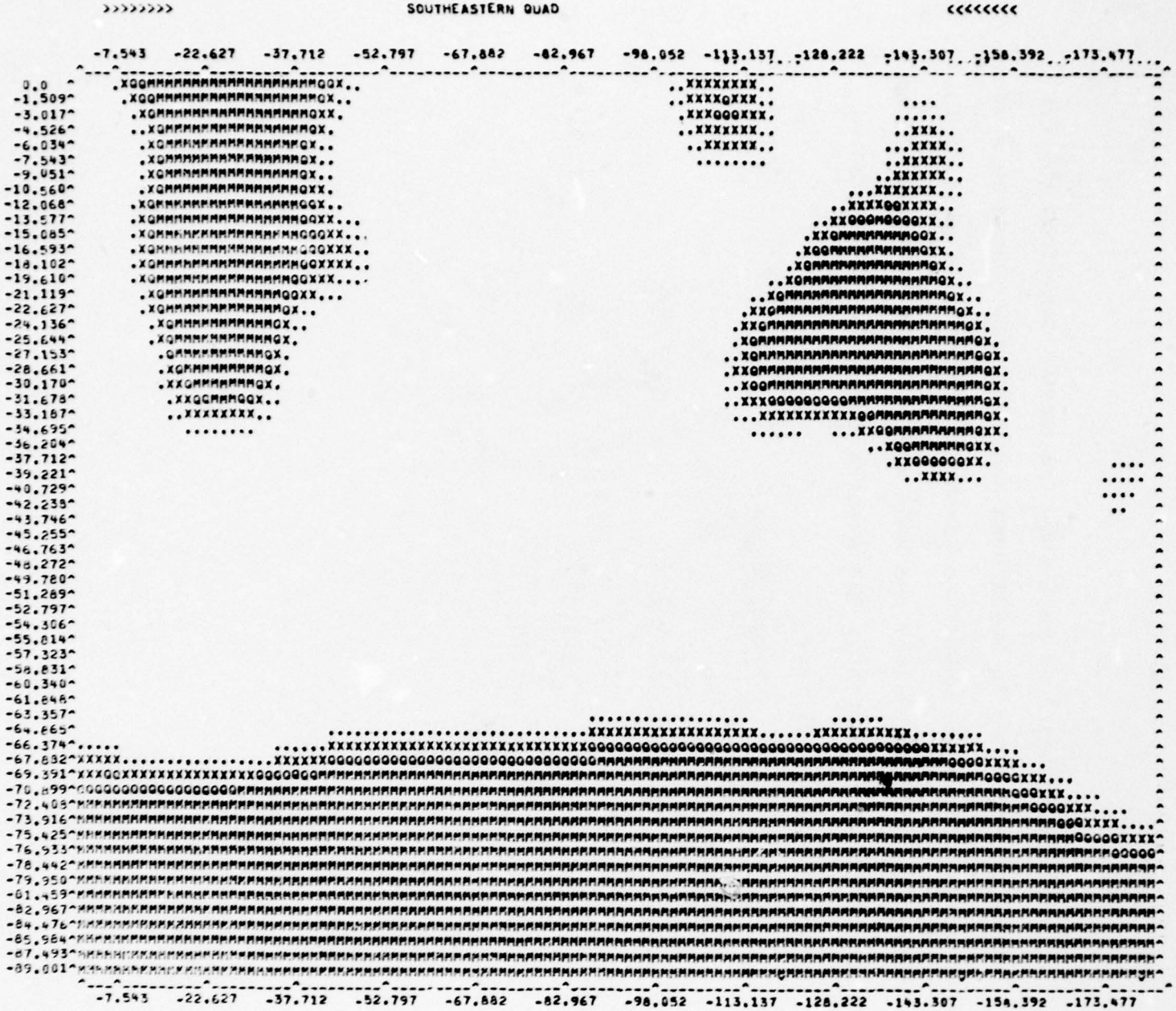
```
0361:      31  1.6  2.6  1.9  1.1  0.9  0.6  0.8  1.6
0362:      31  1.6  3.0  2.3  1.6  3.4  2.4  1.7  3.5
0363:      32  1.7  2.6  1.9  1.2  0.9  0.6  0.9  1.6
0364:      32  1.7  3.0  2.3  1.7  3.4  2.4  1.9  3.5
0365:      33  1.7  2.6  2.0  1.4  1.0  0.6  1.0  1.7
0366:      33  1.7  3.0  2.4  1.9  3.5  2.4  1.9  3.5
0367:      34  1.7  2.6  2.0  1.5  1.0  0.6  1.1  1.7
0368:      34  1.7  3.0  2.4  2.0  3.5  2.4  2.0  3.6
0369:      35  1.8  2.6  2.1  1.6  1.1  0.7  1.2  1.7
0370:      35  1.8  3.0  2.5  2.1  3.6  2.5  2.1  3.6
0371:      36  1.8  2.6  2.2  1.7  1.2  0.7  1.3  1.7
0372:      36  1.8  3.0  2.6  2.2  3.7  2.5  2.2  3.6
0373:      37  1.8  2.6  2.2  1.8  1.2  0.7  1.4  1.8
0374:      37  1.8  3.0  2.6  2.3  3.7  2.5  2.3  3.6
0375:      38  1.9  2.6  2.3  2.0  1.3  0.7  1.5  1.8
0376:      38  1.8  3.0  2.7  2.5  3.8  2.5  2.4  3.7
0377:      39  1.9  2.6  2.3  2.1  1.3  0.7  1.6  1.8
0378:      39  1.9  3.0  2.7  2.6  3.8  2.5  2.5  3.7
0379:      40  1.9  2.6  2.4  2.2  1.4  0.7  1.7  1.8
0380:      40  1.9  3.0  2.8  2.7  3.9  2.5  2.6  3.7
0381:  /*
0382:  //
```

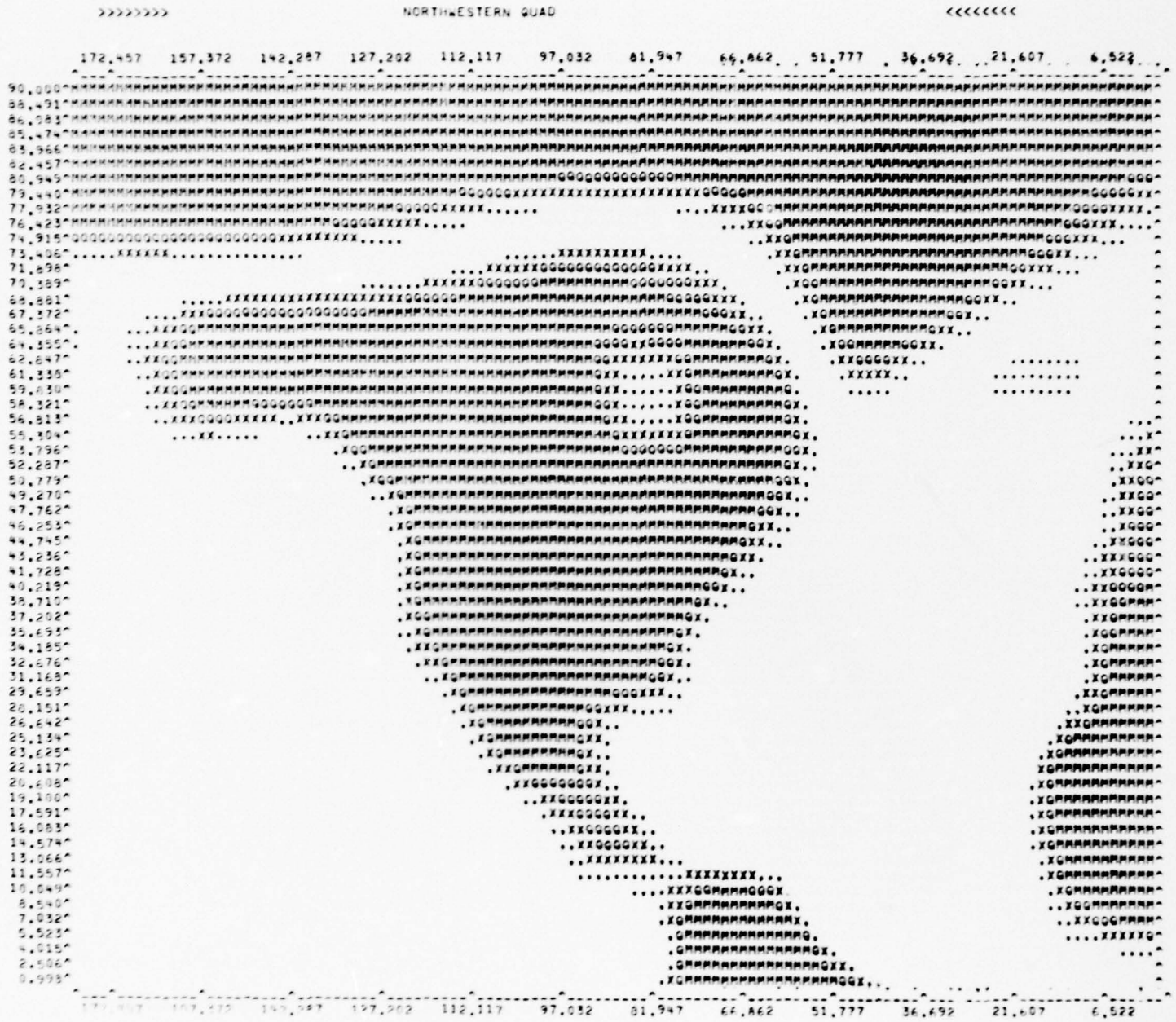
APPENDIX A

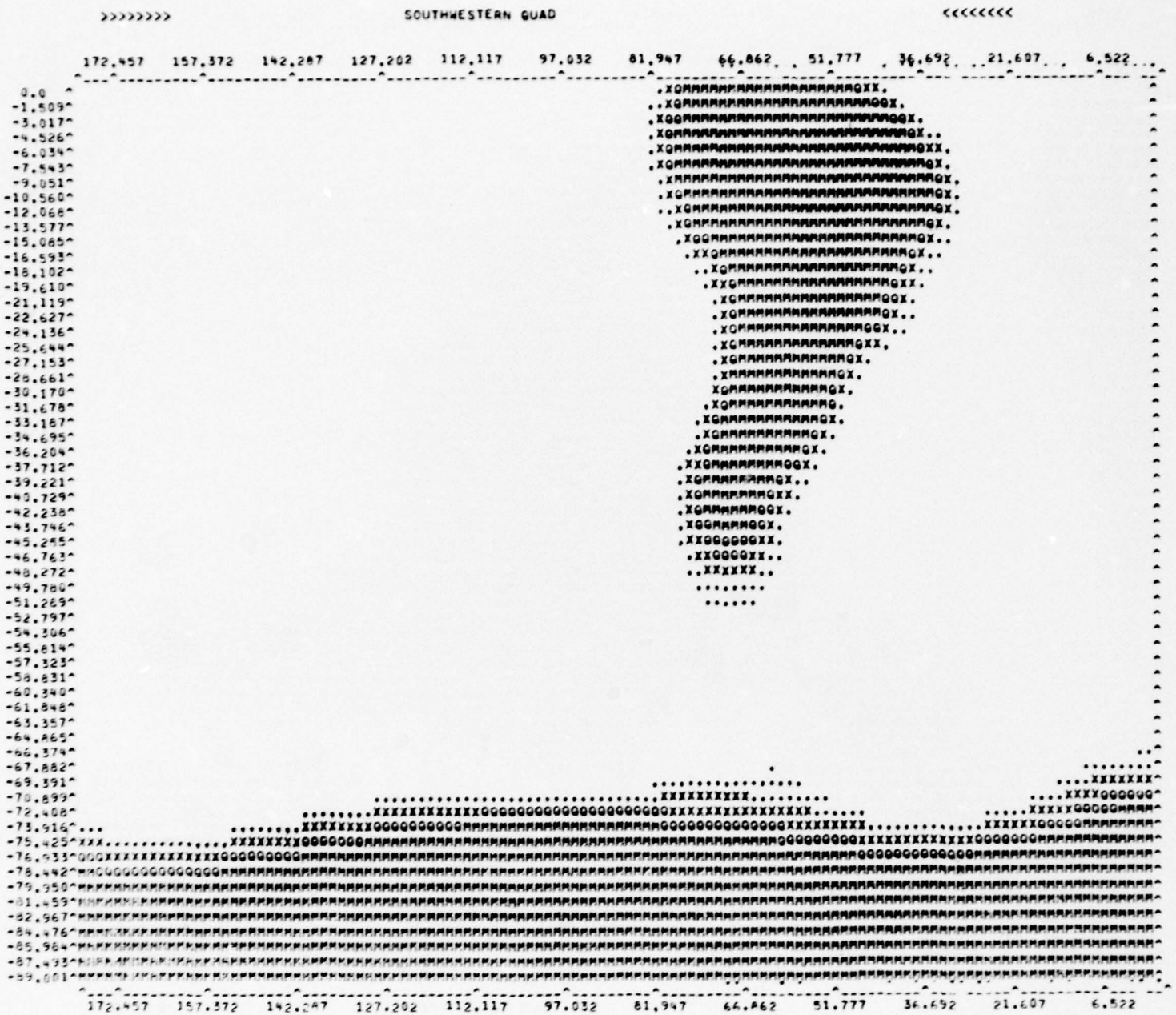
INVERSE MAPPING TRANSFORMATION FROM NWOMAP

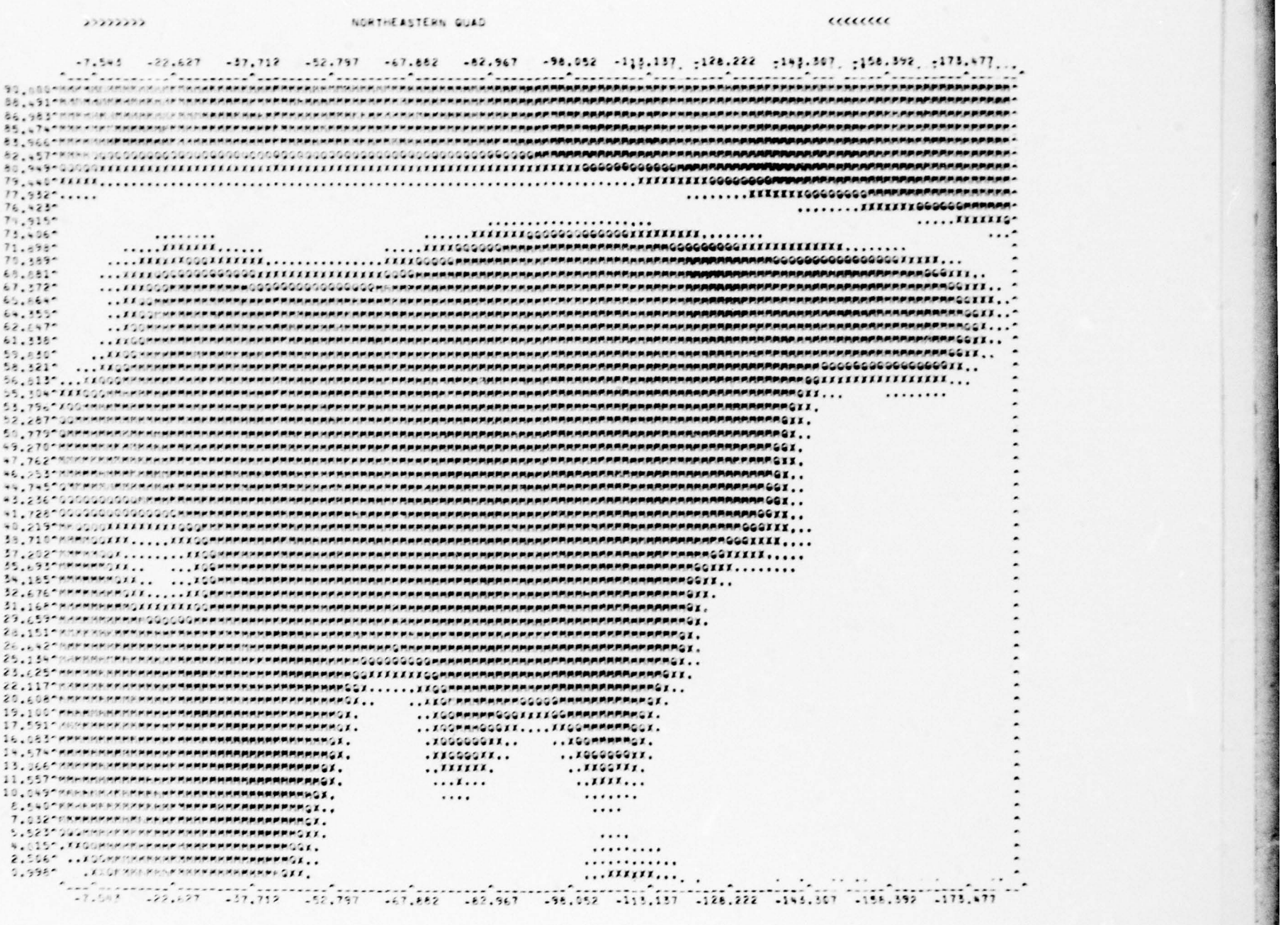
The following four maps show the NWOMAP data from the ITS numerical world map in NUCOM/BREM and NUCOM II. These maps were obtained by calling NWOMAP for each point on a fine grid of latitude and longitude values and then applying the transformations in FSGEPS to each point. The symbols are defined in terms of conductivity as follows:

SYMBOL	σ RANGE, Mho/m
Blank	5.0
"."	3.75-5.0
"X"	2.5-3.75
"Q"	1.25-2.5
"M"	0-1.25


>>>>>>>
SOUTHEASTERN QUAD
<<<<<<<<
-7.543 -22.627 -37.712 -52.797 -67.882 -82.967 -98.052 -113.137 -128.222 -143.307 -158.392 -173.477
0.0
-1.509
-3.017
-4.526
-6.034
-7.543
-9.051
-10.560
-12.068
-13.577
-15.085
-16.593
-18.102
-19.610
-21.119
-22.627
-24.136
-25.644
-27.153
-28.661
-30.170
-31.678
-33.187
-34.695
-36.204
-37.712
-39.221
-40.729
-42.238
-43.746
-45.255
-46.763
-48.272
-49.780
-51.289
-52.797
-54.306
-55.814
-57.323
-58.831
-60.340
-61.848
-63.357
-64.865
-66.374
-67.882
-69.391
-70.899
-72.408
-73.916
-75.425
-76.933
-78.442
-79.950
-81.459
-82.967
-84.476
-85.984
-87.493
-89.001
-7.543 -22.627 -37.712 -52.797 -67.882 -82.967 -98.052 -113.137 -128.222 -143.307 -158.392 -173.477


>>>>>>>
NORTHWESTERN QUAD
<<<<<<<<
172,457
157,372
142,287
127,202
112,117
97,032
81,947
66,862
51,777
36,692
21,607
6,522
90.000
88.491
86.981
85.474
83.966
82.457
80.949
79.440
77.932
76.423
74.915
73.406
71.898
70.389
68.881
67.372
65.864
64.355
62.847
61.338
59.830
58.321
56.813
55.304
53.796
52.287
50.779
49.270
47.762
46.253
44.745
43.236
41.728
40.219
38.710
37.202
35.693
34.185
32.676
31.168
29.659
28.151
26.642
25.134
23.625
22.117
20.608
19.100
17.591
16.083
14.574
13.066
11.557
10.049
8.540
7.032
5.525
4.016
2.508
0.999


>>>>>>>
SOUTHWESTERN QUAD
<<<<<<<<
172.457
157.372
142.287
127.202
112.117
97.032
81.947
66.862
51.777
36.692
21.607
6.522
0.0
-1.509
-3.017
-4.526
-6.034
-7.543
-9.051
-10.560
-12.068
-13.577
-15.085
-16.593
-18.102
-19.610
-21.119
-22.627
-24.136
-25.644
-27.153
-28.661
-30.170
-31.678
-33.187
-34.695
-36.204
-37.712
-39.221
-40.729
-42.238
-43.746
-45.255
-46.763
-48.272
-49.780
-51.289
-52.797
-54.306
-55.814
-57.323
-58.831
-60.340
-61.848
-63.357
-64.865
-66.374
-67.882
-69.391
-70.899
-72.408
-73.916
-75.425
-76.933
-78.442
-79.950
-81.459
-82.967
-84.476
-85.984
-87.493
-89.001


>>>>>>>
NORTHEASTERN QUAD
<<<<<<<<
-7.545
-22.627
-37.712
-52.797
-67.882
-82.967
-98.052
-113.137
-128.222
-143.307
-158.392
-173.477

APPENDIX B

AIRBORNE ANTENNA PATTERNS

This section contains digitized airborne antenna pattern data in a format suitable for direct inclusion in NUCOM/BREM. This data has been digitized from the graphical information in Section 2.

The tail-to-fuselage wire data for the EC-135 has been extrapolated by the assumption that the pattern is symmetrical about the $\Theta = 90^{\circ}$ plane. Horizontal powers have been obtained by application of the results of Wong (op.cit.).

The notch antenna patterns have been reduced from the data in Figure 2-47 for a frequency of 2.0 MHz.

EC-135 tail-fuselage wire, frequencies, 2.0, 3.0, 4.0, 5.0, 7.0, 10.0, 15.0 MHz. Pattern in $\phi = 0^{o}$ plane.

```
0001:     2.0   3.0   4.0   5.0   7.0   10.0  15.0
0002:    -402.600 1.200   0.1-1.00   2.5   6.0   3.0   1.2
0003:    -40   2.6   1.6   0.5 -0.5    5.0   7.8   3.9   3.1
0004:    -392.545 1.02  -0.1-1.13   2.3   5.8   2.9   1.2
0005:    -39   2.5   1.4   0.3 -0.6    4.8   7.6   3.8   3.1
0006:    -382.490 0.84  -0.2-1.26   2.1   5.6   2.7   1.1
0007:    -38   2.5   1.2   0.2 -0.8    4.6   7.4   3.6   3.0
0008:    -372.435 0.66  -0.4-1.39   1.9   5.5   2.6   1.1
0009:    -37   2.4   1.1  -0.0 -0.9    4.4   7.3   3.5   3.0
0010:    -362.380 0.48  -0.6-1.52   1.7   5.3   2.4   1.0
0011:    -36   2.4   0.9  -0.2 -1.0    4.2   7.1   3.3   2.9
0012:    -352.325 0.30  -0.7-1.65   1.5   5.1   2.3   1.0
0013:    -35   2.3   0.7  -0.3 -1.2    4.0   6.9   3.2   2.9
0014:    -342.270 0.12  -0.9-1.78   1.3   4.9   2.2   1.0
0015:    -34   2.3   0.5  -0.5 -1.3    3.8   6.7   3.1   2.9
0016:    -332.215-0.06  -1.1-1.91   1.1   4.7   2.0   0.9
0017:    -33   2.2   0.3  -0.7 -1.4    3.6   6.5   2.9   2.8
0018:    -322.160-0.24  -1.2-2.04   0.9   4.6   1.9   0.9
0019:    -32   2.2   0.2  -0.8 -1.5    3.4   6.4   2.8   2.8
0020:    -312.105-0.42  -1.4-2.17   0.7   4.4   1.7   0.8
0021:    -31   2.1   0.0  -1.0 -1.7    3.2   6.2   2.6   2.7
0022:    -302.050-0.60  -1.6-2.30   0.5   4.2   1.6   0.8
0023:    -30   2.1  -0.2  -1.2 -1.8    3.0   6.0   2.5   2.7
0024:    -291.995-0.78  -1.7-2.43   0.3   4.0   1.5   0.8
0025:    -29   2.0  -0.4  -1.3 -1.9    2.8   5.8   2.4   2.7
0026:    -281.940-0.96  -1.9-2.56   0.1   3.8   1.3   0.7
0027:    -28   1.9  -0.6  -1.6 -2.1    2.6   5.6   2.2   2.6
0028:    -271.885-1.14  -2.0-2.69  -0.1   3.7   1.2   0.7
0029:    -27   1.9  -0.7  -1.6 -2.2    2.4   5.5   2.1   2.6
0030:    -261.830-1.32  -2.2-2.82  -0.3   3.5   1.0   0.6
0031:    -26   1.8  -0.9  -1.8 -2.0    2.2   5.3   1.9   2.5
0032:    -251.775-1.50  -2.4-2.95  -0.5   3.3   0.9   0.6
0033:    -25   1.8  -1.1  -2.0 -2.5    2.0   5.1   1.8   2.5
0034:    -241.720-1.68  -2.5-3.08  -0.7   3.1   0.8   0.6
0035:    -24   1.7  -1.3  -2.1 -2.6    1.8   4.9   1.7   2.5
0036:    -231.665-1.86  -2.7-3.21  -0.9   2.9   0.6   0.5
0037:    -23   1.7  -1.5  -2.3 -2.7    1.6   4.7   1.5   2.4
0038:    -221.610-2.04  -2.9-3.34  -1.1   2.8   0.5   0.5
0039:    -22   1.6  -1.6  -2.5 -2.8    1.4   4.6   1.4   2.4
0040:    -211.555-2.22  -3.0-3.47  -1.3   2.6   0.3   0.4
0041:    -21   1.6  -1.8  -2.6 -3.0    1.2   4.4   1.2   2.3
0042:    -20  1.50-2.40  -3.2-3.60  -1.5   2.4   0.2   0.4
0043:    -20   1.5  -2.0  -2.8 -3.1    1.0   4.2   1.1   2.3
0044:    -19  1.45-2.71  -3.4-3.72  -1.7   2.2  -0.1   0.3
0045:    -19   1.5  -2.3  -3.0 -3.2    0.9   4.0   0.8   2.2
0046:    -18  1.40-3.02  -3.6-3.84  -1.8   1.9  -0.4   0.1
0047:    -18   1.4  -2.6  -3.2 -3.3    0.7   3.7   0.5   2.0
0048:    -17  1.35-3.33  -3.8-3.96  -2.0   1.7  -0.8   0.0
0049:    -17   1.4  -2.9  -3.4 -3.5    0.6   3.5   0.1   1.9
0050:    -16  1.30-3.64  -4.0-4.08  -2.1   1.4  -1.1  -0.2
0051:    -16   1.3  -3.2  -3.6 -3.6    0.4   3.2  -0.2   1.7
0052:    -15  1.25-3.95  -4.2-4.20  -2.3   1.2  -1.4  -0.3
0053:    -15   1.3  -3.6  -3.8 -3.7    0.3   3.0  -0.5   1.6
0054:    -14  1.20-4.26  -4.4-4.32  -2.4   1.0  -1.7  -0.4
0055:    -14   1.2  -3.9  -4.0 -3.8    0.1   2.8  -0.8   1.5
0056:    -13  1.15-4.57  -4.6-4.44  -2.6   0.7  -2.0  -0.6
0057:    -13   1.2  -4.2  -4.2 -3.9   -0.1   2.5  -1.1   1.3
0058:    -12  1.10-4.88  -4.8-4.56  -2.7   0.5  -2.4  -0.7
0059:    -12   1.1  -4.5  -4.4 -4.1   -0.2   2.3  -1.5   1.2
0060:    -11  1.05-5.19  -5.0-4.68  -2.9   0.2  -2.7  -0.9
```

```
0061:   -11  1.0 -4.8 -4.6 -4.2 -0.4  2.0 -1.8  .0
0062:   -10  1.0-5.50-5.20-4.80 -3.0  0.0 -3.0 -1.0
0063:   -10  1.0 -5.1 -4.8 -4.3 -0.5  1.8 -2.1  0.9
0064:    -9  0.8 -6.0-5.56-4.80 -3.2 -0.4 -3.4 -1.2
0065:    -9  0.8 -5.6 -5.1 -4.3 -0.7  1.4 -2.5  0.7
0066:    -8  0.6 -6.5-5.92-4.80 -3.4 -0.8 -3.9 -1.5
0067:    -8  0.6 -6.1 -5.5 -4.3 -0.9  1.0 -3.0  0.4
0068:    -7  0.4 -7.0-6.28-4.80 -3.6 -1.2 -4.3 -1.7
0069:    -7  0.4 -6.6 -5.9 -4.3 -1.1  0.6 -3.4  0.2
0070:    -6  0.2 -7.5-6.64-4.80 -3.8 -1.6 -4.8 -2.0
0071:    -6  0.2 -7.1 -6.2 -4.3 -1.3  0.2 -3.9 -0.1
0072:    -5  0.0 -8.0-7.00-4.80 -4.0 -2.0 -5.2 -2.2
0073:    -5  0.0 -7.6 -6.6 -4.3 -1.5 -0.2 -4.3 -0.3
0074:    -4 -0.2 -8.5-7.36-4.80 -4.2 -2.4 -5.6 -2.4
0075:    -4 -0.2 -8.1 -7.0 -4.3 -1.7 -0.6 -4.7 -0.5
0076:    -3 -0.4 -9.0-7.72-4.80 -4.4 -2.8 -6.1 -2.7
0077:    -3 -0.4 -8.6 -7.3 -4.3 -1.9 -1.0 -5.2 -0.8
0078:    -2 -0.6 -9.5-8.08-4.80 -4.6 -3.2 -6.5 -2.9
0079:    -2 -0.6 -9.1 -7.6 -4.3 -2.1 -1.4 -5.6 -1.0
0080:    -1 -0.8-10.0-8.44-4.80 -4.8 -3.6 -7.0 -3.2
0081:    -1 -0.8 -9.6 -8.0 -4.3 -2.3 -1.8 -6.1 -1.3
0082:     0 -1.0-10.5 -8.8 -4.8 -5.0 -4.0 -7.4 -3.4
0083:     0 -1.0-10.1 -8.4 -4.3 -2.5 -2.2 -6.5 -1.5
0084:     1 -0.8-10.0 -8.4 -4.8 -4.8 -3.6 -7.0 -3.2
0085:     1 -0.8 -9.6 -8.0 -4.3 -2.3 -1.8 -6.1 -1.3
0086:     2 -0.6 -9.5 -8.1 -4.8 -4.6 -3.2 -6.5 -2.9
0087:     2 -0.6 -9.1 -7.6 -4.3 -2.1 -1.4 -5.6 -1.0
0088:     3 -0.4 -9.0 -7.7 -4.8 -4.4 -2.8 -6.1 -2.7
0089:     3 -0.4 -8.6 -7.3 -4.3 -1.9 -1.0 -5.2 -0.8
0090:     4 -0.2 -8.5 -7.4 -4.8 -4.2 -2.4 -5.6 -2.4
0091:     4 -0.2 -8.1 -7.0 -4.3 -1.7 -0.6 -4.7 -0.5
0092:     5  0.0 -8.0 -7.0 -4.8 -4.0 -2.0 -5.2 -2.2
0093:     5  0.0 -7.6 -6.6 -4.3 -1.5 -0.2 -4.3 -0.3
0094:     6  0.2 -7.5 -6.6 -4.8 -3.8 -1.6 -4.8 -2.0
0095:     6  0.2 -7.1 -6.2 -4.3 -1.3  0.2 -3.9 -0.1
0096:     7  0.4 -7.0 -6.3 -4.8 -3.6 -1.2 -4.3 -1.7
0097:     7  0.4 -6.6 -5.9 -4.3 -1.1  0.6 -3.4  0.2
0098:     8  0.6 -6.5 -5.9 -4.8 -3.4 -0.8 -3.9 -1.5
0099:     8  0.6 -6.1 -5.5 -4.3 -0.9  1.0 -3.0  .4
0100:     9  0.8 -6.0 -5.6 -4.8 -3.2 -0.4 -3.4 -1.2
0101:     9  0.8 -5.6 -5.1 -4.3 -0.7  1.4 -2.5  0.7
0102:    10  1.0 -5.5 -5.2 -4.8 -3.0  0.0 -3.0 -1.0
0103:    10  1.0 -5.1 -4.8 -4.3 -0.5  1.8 -2.1  0.9
0104:    11  1.0 -5.2 -5.0 -4.7 -2.9  0.2 -2.7 -0.9
0105:    11  1.0 -4.8 -4.6 -4.2 -0.4  2.0 -1.8  1.0
0106:    12  1.1 -4.9 -4.8 -4.6 -2.7  0.5 -2.4 -0.7
0107:    12  1.1 -4.5 -4.4 -4.1 -0.2  2.3 -1.5  1.2
0108:    13  1.2 -4.6 -4.6 -4.4 -2.6  0.7 -2.0 -0.6
0109:    13  1.2 -4.2 -4.2 -3.9 -0.1  2.5 -1.1  1.3
0110:    14  1.2 -4.3 -4.4 -4.3 -2.4  1.0 -1.7 -0.4
0111:    14  1.2 -3.7 -4.0 -3.8  0.1  2.8 -0.8  1.5
0112:    15  1.3 -4.0 -4.2 -4.2 -2.3  1.2 -1.4 -0.3
0113:    15  1.3 -3.6 -3.8 -3.7  0.3  3.0 -0.5  1.6
0114:    16  1.3 -3.6 -4.0 -4.1 -2.1  1.4 -1.1 -0.2
0115:    16  1.3 -3.2 -3.6 -3.6  0.4  3.2 -0.2  1.7
0116:    17  1.4 -3.3 -3.8 -4.0 -2.0  1.7 -0.8  0.0
0117:    17  1.4 -2.9 -3.4 -3.5  0.6  3.5  0.1  1.9
0118:    18  1.4 -3.0 -3.6 -3.8 -1.8  1.9 -0.4  0.1
0119:    18  1.4 -2.6 -3.2 -3.3  0.7  3.7  0.5  .0
0120:    19  1.5 -2.7 -3.4 -3.7 -1.7  2.2 -0.1  0.3
```

```
0121:    19  1.5 -2.1 -2.0 -4.2  0.9  4.0  0.9  2.2
0122:    20  1.5 -2.4 -2.2 -4.6 -1.5  2.4  0.2  0.4
0123:    20  1.5 -2.0 -0.8 -4.1  1.0  4.2  1.1  2.3
0124:    21  1.6 -2.2 -2.0 -3.5 -1.2  2.6  0.2  0.4
0125:    21  1.6 -1.8 -0.6 -3.0  1.2  4.4  1.2  2.3
0126:    22  1.6 -2.0 -0.9 -3.2 -1.1  2.8  0.5  0.5
0127:    22  1.6 -1.6 -0.5 -2.8  1.4  4.6  1.4  2.4
0128:    23  1.7 -1.4 -0.2 -3.2 -0.9  2.9  0.6  0.5
0129:    23  1.7 -1.5 -0.2 -2.7  1.6  4.7  1.5  2.4
0130:    24  1.7 -1.7 -0.5 -3.1 -0.7  3.1  0.8  0.6
0131:    24  1.7 -1.3 -0.1 -2.6  1.8  4.9  1.7  2.5
0132:    25  1.8 -1.5 -0.4 -3.0 -0.5  3.3  0.9  0.6
0133:    25  1.8 -1.1 -0.0 -2.5  2.0  5.1  1.8  2.5
0134:    2   1.8 -1.3 -0.2 -2.8 -0.2  3.5  1.0  0.6
0135:    26  1.8 -0.9 -1.8 -2.0  2.2  5.3  1.9  2.5
0136:    27  1.9 -1.1 -0.0 -2.7 -0.1  3.7  1.0  0.7
0137:    27  1.9 -0.7 -1.6 -2.2  2.4  5.5  2.1  2.6
0138:    28  1.9 -1.0 -1.8 -2.6  0.1  3.8  1.2  0.7
0139:    28  1.9 -0.6 -1.6 -2.1  2.6  5.6  2.2  2.6
0140:    29  2.0 -0.8 -1.7 -2.4  0.2  4.0  1.5  0.8
0141:    29  2.0 -0.4 -1.2 -1.9  2.8  5.8  2.4  2.7
0142:    30  2.1 -0.6 -1.6 -2.2  0.5  4.2  1.6  0.8
0143:    30  2.1 -0.2 -1.2 -1.8  3.0  6.0  2.5  2.7
0144:    31  2.1 -0.4 -1.4 -2.2  0.7  4.4  1.7  0.8
0145:    31  2.1  0.0 -1.0 -1.7  3.2  6.2  2.6  2.7
0146:    32  2.2 -0.2 -1.2 -2.0  0.9  4.6  1.8  0.9
0147:    32  2.2  0.2 -0.8 -1.5  3.4  6.4  2.8  2.8
0148:    33  2.2 -0.1 -1.1 -1.9  1.1  4.7  2.0  0.9
0149:    33  2.2  0.3 -0.7 -1.4  3.6  6.5  2.9  2.8
0150:    34  2.3  0.1 -0.9 -1.8  1.2  4.9  2.2  1.0
0151:    34  2.3  0.5 -0.5 -1.3  3.8  6.7  3.1  2.9
0152:    35  2.3  0.3 -0.7 -1.7  1.5  5.1  2.3  1.0
0153:    35  2.3  0.7 -0.3 -1.2  4.0  6.9  3.2  2.9
0154:    36  2.4  0.5 -0.6 -1.5  1.7  5.3  2.4  1.0
0155:    36  2.4  0.9 -0.2 -1.0  4.2  7.1  3.3  2.9
0156:    37  2.4  0.7 -0.4 -1.4  1.9  5.5  2.6  1.1
0157:    37  2.4  1.1 -0.0 -0.9  4.4  7.3  3.5  3.0
0158:    38  2.5  0.8 -0.2 -1.3  2.1  5.6  2.7  1.1
0159:    38  2.5  1.2  0.2 -0.8  4.6  7.4  3.6  3.0
0160:    39  2.5  1.0 -0.1 -1.1  2.3  5.8  2.9  1.2
0161:    39  2.5  1.4  0.3 -0.6  4.8  7.5  3.8  3.1
0162:    40  2.5  1.2  0.1 -1.0  2.5  6.0  3.0   .2
0163:    40  2.6  1.6  0.5 -0.5  5.0  7.8  3.9  3.1
```

EC-135 tail-fuselage wire, frequencies 2.0, 3.0, 4.0, 5.0, 7.0, 10.0, 15.0 MHz. Pattern in $\emptyset = 180^{\circ}$ plane.

0001:	2.0	3.0	4.0	5.0	7.0	10.0	15.0		
0002:	-40	1.9	2.6	2.4	2.2	1.4	0.7	1.7	1.8
0003:	-40	1.9	3.0	2.8	2.7	3.9	2.5	2.6	3.7
0004:	-39	1.9	2.6	2.3	2.1	1.3	0.7	1.6	1.8
0005:	-39	1.9	3.0	2.7	2.6	3.8	2.5	2.5	3.7
0006:	-38	1.8	2.6	2.3	2.0	1.3	0.7	1.5	1.8
0007:	-38	1.8	3.0	2.7	2.5	3.8	2.5	2.4	3.7
0008:	-37	1.8	2.6	2.2	1.8	1.2	0.7	1.4	1.8
0009:	-37	1.8	3.0	2.6	2.3	3.7	2.5	2.3	3.6
0010:	-36	1.8	2.6	2.2	1.7	1.2	0.7	1.3	1.7
0011:	-36	1.8	3.0	2.6	2.2	3.7	2.5	2.2	3.6
0012:	-35	1.8	2.6	2.1	1.6	1.1	0.7	1.2	1.7
0013:	-35	1.8	3.0	2.5	2.1	3.6	2.5	2.1	3.6
0014:	-34	1.7	2.6	2.0	1.5	1.0	0.6	1.1	1.7
0015:	-34	1.7	3.0	2.4	2.0	3.5	2.4	2.0	3.6
0016:	-33	1.7	2.6	2.0	1.4	1.0	0.6	1.0	1.7
0017:	-33	1.7	3.0	2.4	1.9	3.5	2.4	1.9	.5
0018:	-32	1.7	2.6	1.9	1.2	0.9	0.6	0.9	1.6
0019:	-32	1.7	3.0	2.3	1.7	3.4	2.4	1.8	3.5
0020:	-31	1.6	2.6	1.9	1.1	0.9	0.6	0.8	1.6
0021:	-31	1.6	3.0	2.3	1.6	3.4	2.4	1.7	3.5
0022:	-30	1.6	2.5	1.8	1.0	0.8	0.6	0.7	1.6
0023:	-30	1.6	2.9	2.2	1.5	3.3	2.4	1.6	3.5
0024:	-29	1.6	2.5	1.7	0.9	0.7	0.6	0.6	1.6
0025:	-29	1.6	2.9	2.1	1.4	3.2	2.4	1.5	3.4
0026:	-28	1.5	2.5	1.7	0.8	0.7	0.6	0.5	1.5
0027:	-28	1.5	2.9	2.1	1.3	3.2	2.4	1.4	3.4
0028:	-27	1.5	2.5	1.6	0.6	0.6	0.6	0.4	1.5
0029:	-27	1.5	2.9	2.0	1.1	3.1	2.4	1.3	.4
0030:	-26	1.5	2.5	1.6	0.5	0.6	0.6	0.3	1.5
0031:	-26	1.5	2.9	2.0	1.0	3.1	2.4	1.2	3.4
0032:	-25	1.5	2.5	1.5	0.4	0.5	0.6	0.2	1.5
0033:	-25	1.5	2.9	1.9	0.9	3.0	2.4	1.1	3.3
0034:	-24	1.4	2.5	1.4	0.3	0.4	0.5	0.1	1.4
0035:	-24	1.4	2.9	1.8	0.8	2.9	2.3	1.0	3.3
0036:	-23	1.4	2.5	1.4	0.2	0.4	0.5	-0.0	1.4
0037:	-23	1.4	2.9	1.8	0.7	2.9	2.3	0.9	3.3
0038:	-22	1.4	2.5	1.3	0.0	0.3	0.5	-0.1	1.4
0039:	-22	1.4	2.9	1.7	0.5	2.8	2.3	0.8	3.3
0040:	-21	1.3	2.5	1.3	-0.1	0.3	0.5	-0.2	1.4
0041:	-21	1.3	2.9	1.7	0.4	2.8	2.3	0.7	3.2
0042:	-20	1.3	2.5	1.2	-0.2	0.2	0.5	-0.3	1.3
0043:	-20	1.3	2.9	1.6	0.3	2.7	2.3	0.6	3.2
0044:	-19	1.3	2.5	1.1	-0.4	0.1	0.4	-0.3	1.1
0045:	-19	1.3	2.9	1.5	0.1	2.6	2.2	0.6	3.0
0046:	-18	1.2	2.5	0.9	-0.7	.0	0.4	-0.4	1.0
0047:	-18	1.2	2.9	1.3	-0.2	2.5	2.2	0.5	2.9
0048:	-17	1.2	2.5	0.8	-0.9	-0.1	0.3	-0.4	0.8
0049:	-17	1.2	2.9	1.2	-0.4	2.4	2.1	0.5	2.7
0050:	-16	1.1	2.5	0.6	-1.1	-0.2	0.3	-0.5	0.7
0051:	-16	1.1	2.9	1.0	-0.6	2.3	2.1	0.4	2.6
0052:	-15	1.1	2.5	0.5	-1.4	-0.3	0.2	-0.5	0.5
0053:	-15	1.1	2.9	0.9	-0.9	2.2	2.0	0.4	2.4
0054:	-14	1.1	2.5	0.4	-1.6	-0.4	0.1	-0.5	0.3
0055:	-14	1.1	2.9	0.8	-1.1	2.1	1.9	0.4	-.2
0056:	-13	1.0	2.5	0.2	-1.8	-0.5	0.1	-0.6	0.2
0057:	-13	1.0	2.9	0.6	-1.3	2.0	1.9	0.3	2.1
0058:	-12	1.0	2.5	0.1	-2.0	-0.6	0.0	-0.6	0.0
0059:	-12	1.0	2.9	0.5	-1.5	1.9	1.8	0.3	1.9
0060:	-11	0.9	2.5	-0.1	-2.3	-0.7	0.0	-0.7	-0.1

0061:	-11	0.9	2.9	0.3	-1.8	1.8	1.8	0.2	1.8
0062:	-10	0.9	2.5	-0.2	-2.5	-0.8	-0.1	-0.7	-0.3
0063:	-10	0.9	2.9	0.2	-2.0	1.7	1.7	0.2	1.6
0064:	-9	0.8	2.5	-0.4	-2.6	-1.0	-0.1	-0.6	-0.4
0065:	-7	0.8	2.9	0.0	-2.1	1.5	1.7	0.3	1.5
0066:	-8	0.7	2.5	-0.5	-2.7	-1.2	-0.2	-0.5	-0.5
0067:	-8	0.7	2.9	-0.1	-2.2	1.3	1.6	0.4	1.4
0068:	-7	0.7	2.5	-0.7	-2.8	-1.4	-0.2	-0.5	-0.5
0069:	-7	0.7	2.9	-0.3	-2.3	1.1	1.6	0.4	1.4
0070:	-6	0.6	2.5	-0.8	-2.9	-1.6	-0.3	-0.4	-0.6
0071:	-6	0.6	2.9	-0.4	-2.4	0.9	1.5	0.5	1.3
0072:	-5	0.5	2.5	-1.0	-3.0	-1.8	-0.3	-0.3	-0.7
0073:	-5	0.5	2.9	-0.6	-2.5	0.7	1.5	0.6	1.2
0074:	-4	0.4	2.5	-1.2	-3.1	-2.0	-0.3	-0.2	-0.8
0075:	-4	0.4	2.9	-0.8	-2.6	0.5	1.5	0.7	1.1
0076:	-3	0.3	2.5	-1.3	-3.2	-2.2	-0.4	-0.1	-0.9
0077:	-3	0.3	2.9	-0.9	-2.7	0.3	1.4	0.8	1.0
0078:	-2	0.3	2.5	-1.5	-3.3	-2.4	-0.4	-0.1	-0.9
0079:	-2	0.3	2.9	-1.1	-2.8	0.1	1.4	0.8	1.0
0080:	-1	0.2	2.5	-1.6	-3.4	-2.6	-0.5	0.0	-1.0
0081:	-1	0.2	2.9	-1.2	-2.9	-0.1	1.3	0.9	0.9
0082:	0	0.1	2.5	-1.8	-3.5	-2.8	-0.5	0.1	-1.1
0083:	0	0.1	2.9	-1.4	-3.0	-0.3	1.5	1.0	0.8
0084:	1	0.2	2.5	-1.6	-3.4	-2.6	-0.5	0.0	-1.0
0085:	1	0.2	2.9	-1.2	-2.9	-0.1	1.3	0.9	0.9
0086:	2	0.3	2.5	-1.5	-3.3	-2.4	-0.4	-0.1	-0.9
0087:	2	0.3	2.9	-1.1	-2.8	0.1	1.4	0.8	1.0
0088:	3	0.3	2.5	-1.3	-3.2	-2.2	-0.4	-0.1	-0.9
0089:	3	0.3	2.9	-0.9	-2.7	0.3	1.4	0.8	1.0
0090:	4	0.4	2.5	-1.2	-3.1	-2.0	-0.3	-0.2	-0.8
0091:	4	0.4	2.9	-0.8	-2.6	0.5	1.5	0.7	1.1
0092:	5	0.5	2.5	-1.0	-3.0	-1.8	-0.3	-0.3	-0.7
0093:	5	0.5	2.9	-0.6	-2.5	0.7	1.5	0.6	1.2
0094:	6	0.6	2.5	-0.8	-2.9	-1.6	-0.3	-0.4	-0.6
0095:	6	0.6	2.9	-0.4	-2.4	0.9	1.5	0.5	1.3
0096:	7	0.7	2.5	-0.7	-2.8	-1.4	-0.2	-0.5	-0.5
0097:	7	0.7	2.9	-0.3	-2.3	1.1	1.6	0.4	1.4
0098:	8	0.7	2.5	-0.5	-2.7	-1.2	-0.2	-0.5	-0.5
0099:	8	0.7	2.9	-0.1	-2.2	1.3	1.6	0.4	1.4
0100:	9	0.8	2.5	-0.4	-2.6	-1.0	-0.1	-0.6	-0.4
0101:	9	0.8	2.9	0.0	-2.1	1.5	1.7	0.3	1.5
0102:	10	0.9	2.5	-0.2	-2.5	-0.8	-0.1	-0.7	-0.3
0103:	10	0.9	2.9	0.2	-2.0	1.7	1.7	0.2	1.6
0104:	11	0.9	2.5	-0.1	-2.3	-0.7	0.0	-0.7	-0.1
0105:	11	0.9	2.9	0.3	-1.8	1.8	1.8	0.2	1.8
0106:	12	1.0	2.5	0.1	-2.0	-0.6	0.0	-0.6	0.0
0107:	13	1.0	2.9	0.5	-1.5	1.9	1.8	0.3	1.9
0108:	13	1.0	2.5	0.2	-1.8	-0.5	0.1	-0.6	0.2
0109:	13	1.0	2.9	0.6	-1.3	2.0	1.9	0.3	2.1
0110:	14	1.1	2.5	0.4	-1.6	-0.4	0.1	-0.5	0.3
0111:	14	1.1	2.9	0.8	-1.1	2.1	1.9	0.4	2.2
0112:	15	1.1	2.5	0.5	-1.4	-0.3	0.2	-0.5	0.5
0113:	15	1.1	2.9	0.9	-0.9	2.2	2.0	0.4	2.4
0114:	16	1.1	2.5	0.6	-1.1	-0.2	0.3	-0.5	0.7
0115:	16	1.1	2.9	1.0	-0.6	2.3	2.1	0.4	2.6
0116:	17	1.2	2.5	0.8	-0.9	-0.1	0.3	-0.4	0.8
0117:	17	1.2	2.9	1.2	-0.4	2.4	2.1	0.5	2.7
0118:	18	1.2	2.5	0.9	-0.7	.0	0.4	-0.4	-.0
0119:	18	1.2	2.9	1.3	-0.2	2.5	2.2	0.5	2.9
0120:	19	1.3	2.5	1.1	-0.4	0.1	0.4	-0.3	1.1

EC-135 tail-fuselage wire, frequencies 2.0, 3.0, 4.0, 5.0, 7.0, 10.0, 15.0 MHz. Pattern in $\emptyset = 90^{\circ}$ plane (both sides averaged).

```
0001:     2.0   3.0   4.0   5.0   7.0  10.0 15.0
0002:    -40 -4.0 -4.5 -3.4 -2.5 -3.3 -4.5 -0.7  -.3
0003:    -40 -4.0 -4.1 -3.0 -2.0 -0.8 -2.7  0.2  3.2
0004:    -39 -4.3 -5.0 -3.8 -2.8 -3.4 -4.4 -1.0  1.0
0005:    -3a -4.3 -4.6 -3.4 -2.3 -0.9 -2.6 -0.1  2.9
0006:    -3A -4.5 -5.4 -4.1 -3.1 -3.6 -4.4 -1.3  0.6
0007:    -3A -4.5 -5.0 -3.7 -2.6 -1.1 -2.6 -0.4  2.5
0008:    -37 -4.8 -5.9 -4.5 -3.3 -3.7 -4.3 -1.6  0.3
0009:    -37 -4.8 -5.5 -4.1 -2.8 -1.2 -2.5 -0.7  2.2
0010:    -36 -5.0 -6.3 -4.8 -3.6 -3.9 -4.2 -2.0 -0.1
0011:    -3c -5.0 -5.9 -4.4 -3.1 -1.4 -2.4 -1.1  1.8
0012:    -3E -5.3 -6.8 -5.2 -3.9 -4.0 -4.2 -2.3 -0.4
0013:    -3E -5.3 -6.4 -4.8 -3.4 -1.5 -2.4 -1.4  -.5
0014:    -34 -5.5 -7.2 -5.5 -4.2 -4.2 -4.1 -2.6 -0.7
0015:    -34 -5.5 -6.8 -5.1 -3.7 -1.7 -2.3 -1.7  1.2
0016:    -33 -5.8 -7.7 -5.9 -4.4 -4.3 -4.0 -2.9 -1.1
0017:    -3x -5.8 -7.3 -5.5 -3.9 -1.8 -2.2 -2.0  0.8
0018:    -3> -6.0 -8.1 -6.2 -4.7 -4.5 -4.0 -3.2 -1.4
0019:    -32 -6.0 -7.7 -5.8 -4.2 -2.0 -2.2 -2.3  0.5
0020:    -31 -6.3 -8.6 -6.6 -5.0 -4.6 -3.9 -3.5 -1.8
0021:    -31 -6.3 -8.2 -6.2 -4.5 -2.1 -2.1 -2.6  0.1
0022:    -30 -6.5 -9.0 -7.0 -5.3 -4.8 -3.9 -3.9 -2.1
0023:    -3n -6.5 -8.6 -6.6 -4.9 -2.3 -2.1 -3.0 -0.2
0024:    -2e -6.8 -9.5 -7.3 -5.5 -4.9 -3.8 -4.2 -1.4
0025:    -2e -6.8 -9.1 -6.9 -5.0 -2.4 -2.0 -3.3 -0.5
0026:    -28 -7.0 -9.9 -7.7 -5.8 -5.0 -3.7 -4.5 -2.8
0027:    -28 -7.0 -9.5 -7.3 -5.3 -2.5 -1.9 -3.6 -0.9
0028:    -27 -7.3-10.4 -8.0 -6.1 -5.2 -3.7 -4.8 -3.1
0029:    -27 -7.3-10.0 -7.6 -5.6 -2.7 -1.9 -3.9 -1.2
0030:    -2c -7.5-10.8 -8.4 -6.4 -5.3 -3.6 -5.1 -3.5
0031:    -2c -7.5-10.4 -8.0 -5.9 -2.8 -1.8 -4.2 -1.6
0032:    -2E -7.8-11.3 -8.7 -6.6 -5.5 -3.5 -5.4 -3.8
0033:    -2E -7.8-10.9 -8.3 -6.1 -3.0 -1.7 -4.5 -1.9
0034:    -2A -8.0-11.7 -9.1 -6.9 -5.6 -3.5 -5.7 -4.1
0035:    -2A -8.0-11.3 -8.7 -6.4 -3.1 -1.7 -4.8 -2.2
0036:    -23 -8.3-12.2 -9.4 -7.2 -5.8 -3.4 -6.1 -4.5
0037:    -2x -8.3-11.8 -9.0 -6.7 -3.3 -1.6 -5.2 -2.6
0038:    -22 -8.5-12.6 -9.8 -7.5 -5.9 -3.3 -6.4 -4.8
0039:    -2> -8.5-12.2 -9.4 -7.0 -3.4 -1.5 -5.5 -2.9
0040:    -21 -8.8-13.1-10.1 -7.7 -6.1 -3.3 -6.7 -5.2
0041:    -21 -8.8-12.7 -9.7 -7.2 -3.6 -1.5 -5.8 -3.3
0042:    -20 -9.0-13.5-10.5 -8.0 -6.2 -3.2 -7.0 -5.5
0043:    -20 -9.0-13.1-10.1 -7.5 -3.7 -1.4 -6.1 -3.6
0044:    -1e -9.4-13.4-10.6 -8.1 -6.2 -3.3 -7.5 -5.9
0045:    -1e -9.4-13.0-10.2 -7.6 -3.7 -1.5 -6.6 -4.0
0046:    -1a -9.7-13.5-10.6 -8.2 -6.2 -3.4 -8.0 -6.2
0047:    -1a -9.7-12.9-10.2 -7.7 -3.7 -1.6 -7.1 -4.3
0048:    -17-10.1-13.1-10.7 -8.3 -6.1 -3.4 -8.4 -6.6
0049:    -17-10.1-12.7-10.3 -7.8 -3.6 -1.6 -7.5 -5.7
0050:    -16-10.4-13.0-10.7 -8.4 -6.1 -3.5 -8.9 -6.9
0051:    -1.-10.4-12.6-10.3 -7.9 -3.6 -1.7 -8.0 -5.0
0052:    -15-10.8-12.9-10.8 -8.5 -6.1 -3.6 -9.4 -7.3
0053:    -15-10.8-12.5-10.4 -8.0 -3.6 -1.8 -8.5 -5.4
0054:    -14-11.1-12.8-10.8 -8.6 -6.1 -3.7 -9.9 -7.6
0055:    -14-11.1-12.4-10.4 -8.1 -3.6 -1.9 -9.0 -5.7
0056:    -13-11.5-12.7-10.9 -8.7 -6.1 -3.8-10.4 -8.0
0057:    -13-11.5-12.3-10.5 -8.2 -3.6 -2.0 -9.5 -6.1
0058:    -12-11.8-12.5-10.9 -8.8 -6.0 -3.8-10.8 -8.3
0059:    -12-11.8-12.1-10.5 -8.3 -3.5 -2.0 -9.9 -6.4
0060:    -11-12.2-12.4-11.0 -8.9 -6.0 -3.9-11.3 -8.7
```

```
0061:    -11-12.2-12.0-10.6 -8.4 -3.5 -2.1-10.4 -6.8
0062:    -10-12.5-12.3-11.0 -9.0 -6.0 -4.0-11.8 -9.0
0063:    -10-12.5-11.9-10.6 -8.5 -3.5 -2.2-10.9 -7.1
0064:     -9-12.8-12.1-10.8 -9.0 -5.9 -4.0-12.2 -9.2
0065:     -9-12.3-11.7-10.4 -8.5 -3.4 -2.2-11.3 -7.3
0066:     -8-13.1-12.0-10.6 -9.0 -5.8 -4.0-12.7 -9.4
0067:     -8-13.1-11.6-10.2 -8.5 -3.3 -2.2-11.8 -7.5
0068:     -7-13.4-11.8-10.4 -9.0 -5.7 -4.0-13.1 -9.6
0069:     -7-13.4-11.4-10.0 -8.5 -3.2 -2.2-12.2 -7.7
0070:     -6-13.7-11.7-10.2 -9.0 -5.6 -4.0-13.6 -9.8
0071:     -6-13.7-11.3 -9.8 -8.5 -3.1 -2.2-12.7 -7.9
0072:     -5-14.0-11.5-10.0 -9.0 -5.5 -4.0-14.0-10.0
0073:     -5-14.0-11.1 -9.6 -8.5 -3.0 -2.2-13.1 -8.1
0074:     -4-14.3-11.3 -9.8 -9.0 -5.4 -4.0-14.4-10.2
0075:     -4-14.3-10.9 -9.4 -8.5 -2.9 -2.2-13.5 -8.3
0076:     -3-14.6-11.2 -9.6 -9.0 -5.3 -4.0-14.9-10.4
0077:     -3-14.6-10.8 -9.2 -8.5 -2.8 -2.2-14.0 -8.5
0078:     -2-14.9-11.0 -9.4 -9.0 -5.2 -4.0-15.3-10.6
0079:     -2-14.9-10.6 -9.0 -8.5 -2.7 -2.2-14.4 -8.7
0080:     -1-15.2-10.9 -9.2 -9.0 -5.1 -4.0-15.8-10.8
0081:     -1-15.2-10.5 -8.8 -8.5 -2.6 -2.2-14.9 -8.9
0082:      0-15.5-10.7 -9.0 -9.0 -5.0 -4.0-16.2-11.0
0083:      0-15.5-10.3 -8.6 -8.5 -2.5 -2.2-15.3 - .1
0084:      1-15.2-10.9 -9.2 -9.0 -5.1 -4.0-15.8-10.8
0085:      1-15.2-10.5 -8.8 -8.5 -2.6 -2.2-14.9 -8.9
0086:      2-14.9-11.0 -9.4 -9.0 -5.2 -4.0-15.3-10.6
0087:      2-14.9-10.6 -9.0 -8.5 -2.7 -2.2-14.4 -8.7
0088:      3-14.6-11.2 -9.6 -9.0 -5.3 -4.0-14.9-10.4
0089:      3-14.6-10.8 -9.2 -8.5 -2.8 -2.2-14.0 -8.5
0090:      4-14.3-11.3 -9.8 -9.0 -5.4 -4.0-14.4-10.2
0091:      4-14.3-10.9 -9.4 -8.5 -2.9 -2.2-13.5 -8.3
0092:      5-14.0-11.5-10.0 -9.0 -5.5 -4.0-14.0-10.0
0093:      5-14.0-11.1 -9.6 -8.5 -3.0 -2.2-13.1 -8.1
0094:      6-13.7-11.7-10.2 -9.0 -5.6 -4.0-13.6 -9.8
0095:      6-13.7-11.3 -9.8 -8.5 -3.1 -2.2-12.7 -7.9
0096:      7-13.4-11.8-10.4 -9.0 -5.7 -4.0-13.1 -9.6
0097:      7-13.4-11.4-10.0 -8.5 -3.2 -2.2-12.2 -7.7
0098:      8-13.1-12.0-10.6 -9.0 -5.8 -4.0-12.7 -9.4
0099:      8-13.1-11.6-10.2 -8.5 -3.3 -2.2-11.8 -7.5
0100:      9-12.8-12.1-10.8 -9.0 -5.9 -4.0-12.2 -9.2
0101:      9-12.8-11.7-10.4 -8.5 -3.4 -2.2-11.3 -7.3
0102:     10-12.5-12.3-11.0 -9.0 -6.0 -4.0-11.8 -9.0
0103:     10-12.5-11.9-10.6 -8.5 -3.5 -2.2-10.9 -7.1
0104:     11-12.2-12.4-11.0 -8.9 -6.0 -3.9-11.3 -8.7
0105:     11-12.2-12.0-10.6 -8.4 -3.5 -2.1-10.4 -6.8
0106:     12-11.8-12.5-10.9 -8.8 -6.0 -3.8-10.8 -8.3
0107:     12-11.8-12.1-10.5 -8.3 -3.5 -2.0 -9.9 -6.4
0108:     13-11.5-12.7-10.9 -8.7 -6.1 -3.8-10.4 -8.0
0109:     13-11.5-12.3-10.5 -8.2 -3.6 -2.0 -9.5 -6.1
0110:     14-11.1-12.8-10.8 -8.6 -6.1 -3.7 -9.9 - .6
0111:     14-11.1-12.4-10.4 -8.1 -3.6 -1.9 -9.0 -5.7
0112:     15-10.8-12.9-10.8 -8.5 -6.1 -3.6 -9.4 -7.3
0113:     15-10.8-12.5-10.4 -8.0 -3.6 -1.8 -8.5 -5.4
0114:     16-10.4-13.0-10.7 -8.4 -6.1 -3.5 -8.9 -8.9
0115:     16-10.4-12.6-10.3 -7.9 -3.6 -1.7 -8.0 -5.0
0116:     17-10.1-13.1-10.7 -8.3 -6.1 -3.4 -8.4 -8.6
0117:     17-10.1-12.7-10.3 -7.8 -3.6 -1.6 -7.5 -4.7
0118:     18 -9.7-13.3-10.6 -8.2 -6.2 -3.4 -8.0 -8.2
0119:     18 -9.7-12.9-10.2 -7.7 -3.7 -1.6 -7.1 -4.3
0120:     18 -9.4-13.4-10.6 -8.1 -6.2 -3.3 -7.5 -5.9
```

```
0121:     19 -9.4-13.0-10.2 -7.6 -3.7 -1.5 -6.6 - .0
0122:     20 -9.0-13.5-10.5 -8.0 -6.2 -3.2 -7.0 -5.5
0123:     20 -9.0-13.1-10.1 -7.5 -3.7 -1.4 -6.1 -3.6
0124:     21 -9.2-13.1-10.1 -7.7 -6.1 -3.3 -6.7 -5.2
0125:     21 -9.4-12.7 -9.7 -7.2 -3.6 -1.5 -5.9 -3.3
0126:     22 -9.5-12.6 -9.8 -7.5 -5.9 -3.3 -6.4 -4.8
0127:     23 -9.5-12.2 -9.4 -7.0 -3.4 -1.5 -5.5 -2.9
0128:     23 -9.3-12.2 -9.4 -7.2 -5.9 -3.4 -6.1 -4.5
0129:     23 -9.3-11.8 -9.0 -6.7 -3.3 -1.6 -5.3 -2.6
0130:     24 -9.3-11.7 -9.1 -6.9 -5.6 -3.5 -5.7 - .1
0131:     24 -9.2-11.3 -8.7 -6.4 -3.1 -1.7 -4.8 -2.2
0132:     25 -7.4-11.5 -8.7 -6.6 -5.5 -3.5 -5.4 -3.8
0133:     25 -7.4-10.4 -8.3 -6.1 -3.0 -1.7 -4.5 -1.9
0134:     26 -7.5-10.8 -8.4 -6.4 -5.3 -3.6 -5.1 -3.5
0135:     26 -7.5-10.4 -8.0 -5.9 -2.9 -1.8 -4.3 -1.6
0136:     27 -7.3-10.4 -8.0 -6.1 -5.2 -3.7 -4.8 -3.1
0137:     27 -7.3-10.0 -7.6 -5.6 -2.7 -1.9 -3.9 -1.2
0138:     28 -7.1 -9.4 -7.7 -5.8 -5.0 -3.7 -4.5 -2.8
0139:     28 -7.0 -9.5 -7.3 -5.3 -2.5 -1.9 -3.6 -0.9
0140:     28 -6.8 -9.5 -7.3 -5.5 -4.9 -3.8 -4.3 -2.4
0141:     29 -6.8 -9.1 -6.9 -5.0 -2.4 -2.0 -3.3 -0.5
0142:     30 -6.5 -9.0 -7.0 -5.3 -4.8 -3.4 -3.9 -2.1
0143:     30 -6.5 -8.6 -6.6 -4.8 -2.3 -2.1 -3.0 -0.2
0144:     31 -6.3 -8.6 -6.6 -5.0 -4.6 -3.4 -3.5 -1.8
0145:     31 -6.3 -8.2 -6.2 -4.5 -2.1 -2.1 -2.6  0.1
0146:     32 -6.0 -8.3 -6.2 -4.7 -4.5 -4.0 -3.2 -1.4
0147:     32 -6.0 -7.7 -5.8 -4.2 -2.0 -2.2 -2.3  0.5
0148:     33 -5.8 -7.7 -5.9 -4.4 -4.3 -4.0 -2.9 -1.1
0149:     33 -5.8 -7.3 -5.5 -3.9 -1.8 -2.2 -2.0  0.8
0150:     34 -5.5 -7.2 -5.5 -4.2 -4.2 -4.1 -2.6 -0.7
0151:     34 -5.5 -6.8 -5.1 -3.7 -1.7 -2.5 -1.7  1.2
0152:     35 -5.3 -6.8 -5.2 -4.0 -4.0 -4.2 -2.3 -0.4
0153:     35 -5.3 -6.4 -4.8 -3.4 -1.5 -2.4 -1.4  1.5
0154:     36 -5.0 -6.3 -4.8 -3.6 -3.9 -4.2 -2.0 -0.1
0155:     36 -5.0 -5.9 -4.4 -3.1 -1.4 -2.4 -1.1  1.8
0156:     37 -4.8 -5.9 -4.5 -3.3 -3.7 -4.3 -1.6  0.3
0157:     37 -4.8 -5.5 -4.1 -2.8 -1.2 -2.5 -0.7  2.2
0158:     38 -4.5 -5.4 -4.1 -3.1 -3.6 -4.4 -1.3  0.6
0159:     38 -4.5 -5.0 -3.7 -2.6 -1.1 -2.6 -0.4  2.5
0160:     39 -4.3 -5.0 -3.8 -2.9 -3.4 -4.4 -1.0  1.0
0161:     39 -4.3 -4.6 -3.4 -2.3 -0.9 -2.6 -0.1  2.9
0162:     40 -4.0 -4.5 -3.4 -2.5 -3.3 -4.5 -0.7  1.3
0163:     40 -4.0 -4.1 -3.0 -2.0 -0.8 -2.7  0.2  3.2
```

Notch antenna, Douglas DC series airframe, pattern in $\phi = 0^{\circ}$ plane. Frequency 2.0 MHz.

```
0001:    2.0
0002:  -90  0.5
0003:  -90-17.0
0004:  -89  0.5
0005:  -89-16.7
0006:  -88  0.5
0007:  -88-16.3
0008:  -87  0.5
0009:  -87-16.0
0010:  -86  0.5
0011:  -86-15.7
0012:  -85  0.6
0013:  -85-15.4
0014:  -84  0.6
0015:  -84-15.0
0016:  -83  0.6
0017:  -83-14.7
0018:  -82  0.6
0019:  -82-14.3
0020:  -81  0.6
0021:  -81-14.0
0022:  -80  0.6
0023:  -80-13.6
0024:  -79  0.6
0025:  -79-13.1
0026:  -78  0.6
0027:  -78-12.4
0028:  -77  0.6
0029:  -77-11.8
0030:  -76  0.6
0031:  -76-11.8
0032:  -75  0.6
0033:  -75-10.5
0034:  -74  0.6
0035:  -74 -9.8
0036:  -73  0.6
0037:  -73 -9.2
0038:  -72  0.6
0039:  -72 -8.5
0040:  -71  0.6
0041:  -71 -7.9
0042:  -70  0.6
0043:  -70 -7.3
0044:  -69  0.6
0045:  -69 -7.1
0046:  -68  0.6
0047:  -68 -6.8
0048:  -67  0.6
0049:  -67 -6.6
0050:  -66  0.6
0051:  -66 -6.3
0052:  -65  0.6
0053:  -65 -6.1
0054:  -64  0.6
0055:  -64 -5.9
0056:  -63  0.6
0057:  -63 -5.7
0058:  -62  0.6
0059:  -62 -5.4
0060:  -61  0.6
0061:  -61 -5.2
0062:  -60  0.6
0063:  -60 -4.9
0064:  -59  0.5
0065:  -59 -4.8
0066:  -58  0.5
0067:  -58 -4.7
0068:  -57  0.4
0069:  -57 -4.6
0070:  -56  0.4
0071:  -56 -4.6
0072:  -55  0.3
0073:  -55 -4.5
0074:  -54  0.3
0075:  -54 -4.4
0076:  -53  0.2
0077:  -53 -4.4
0078:  -52  0.1
0079:  -52 -4.3
0080:  -51  0.1
0081:  -51 -4.2
0082:  -50 00.0
0083:  -50 -4.2
0084:  -49 -0.1
0085:  -49 -4.0
0086:  -48 -0.2
0087:  -48 -3.8
0088:  -47 -0.3
0089:  -47 -3.6
0090:  -46 -0.4
0091:  -46 -3.5
0092:  -45 -0.5
0093:  -45 -3.4
0094:  -44 -0.5
0095:  -44 -3.2
0096:  -43 -0.6
0097:  -43 -3.0
0098:  -42 -0.7
0099:  -42 -2.9
0100:  -41 -0.8
0101:  -41 -2.7
0102:  -40 -0.9
0103:  -40 -2.5
0104:  -39 -1.1
0105:  -39 -2.3
0106:  -38 -1.3
0107:  -38 -2.2
0108:  -37 -1.4
0109:  -37 -2.1
0110:  -36 -1.6
0111:  -36 -2.0
0112:  -35 -1.7
0113:  -35 -1.8
0114:  -34 -1.9
0115:  -34 -1.7
0116:  -33 -2.0
0117:  -33 -1.6
0118:  -32 -2.2
0119:  -32 -1.4
0120:  -31 -2.4
0121:  -31 -1.3
0122:  -30 -2.5
0123:  -30 -1.2
0124:  -29 -2.8
0125:  -29 -1.2
0126:  -28 -3.0
0127:  -28 -1.2
0128:  -27 -3.3
0129:  -27 -1.2
0130:  -26 -3.5
0131:  -26 -1.2
0132:  -25 -3.7
0133:  -25 -1.1
0134:  -24 -4.0
0135:  -24 -1.1
0136:  -23 -4.2
0137:  -23 -1.1
0138:  -22 -4.4
0139:  -22 -1.1
0140:  -21 -4.6
0141:  -21 -1.1
0142:  -20 -4.8
0143:  -20 -1.1
0144:  -19 -5.0
0145:  -19 -1.1
0146:  -18 -5.2
0147:  -18 -1.1
0148:  -17 -5.5
0149:  -17 -1.1
0150:  -16 -5.7
0151:  -16 -1.1
0152:  -15 -6.0
0153:  -15 -1.0
0154:  -14 -6.2
0155:  -14 -1.0
0156:  -13 -6.4
0157:  -13 -1.0
0158:  -12 -6.6
0159:  -12 -1.0
0160:  -11 -6.9
0161:  -11 -1.0
0162:  -10 -7.1
0163:  -10 -1.0
0164:  -09 -7.2
0165:   -9 -1.0
0166:  -08 -7.3
0167:   -8 -1.0
0168:  -07 -7.4
0169:   -7 -1.0
0170:  -06 -7.5
0171:   -6 -1.0
0172:  -05 -7.5
0173:   -5 -0.9
0174:  -04 -7.6
0175:   -4 -0.9
0176:  -03 -7.7
0177:   -3 -0.9
0178:  -02 -7.8
0179:   -2 -0.9
0180:  -01 -7.9
0181:   -1 -0.9
0182:  -00 -8.0
0183:    0 -0.9
0184:    1 -8.0
0185:    1 -0.9
0186:    2 -8.0
0187:    2 -0.9
0188:    3 -8.0
0189:    3 -0.9
0190:    4 -8.0
0191:    4 -0.9
0192:    5 -8.0
0193:    5 -0.9
0194:    6 -8.0
0195:    6 -0.8
0196:    7 -8.0
0197:    7 -0.8
0198:    8 -8.0
0199:    8 -0.8
0200:    9 -8.0
0201:    9 -0.8
0202:   10 -8.0
0203:   10 -0.9
0204:   11 -8.0
0205:   11 -0.8
0206:   12 -7.9
0207:   12 -0.8
0208:   13 -7.9
0209:   13 -0.9
0210:   14 -7.9
0211:   14 -0.9
0212:   15 -7.8
0213:   15 -0.9
0214:   16 -7.8
0215:   16 -0.9
0216:   17 -7.8
0217:   17 -0.9
0218:   18 -7.7
0219:   18 -1.0
0220:   19 -7.7
0221:   19 -1.0
0222:   20 -7.6
0223:   20 -1.0
0224:   21 -7.4
0225:   21 -1.1
0226:   22 -7.1
0227:   22 -1.3
0228:   23 -6.9
0229:   23 -1.4
0230:   24 -6.6
0231:   24 -1.6
0232:   25 -6.4
0233:   25 -1.7
0234:   26 -6.1
0235:   26 -1.8
0236:   27 -5.9
0237:   27 -2.0
0238:   28 -5.6
0239:   28 -2.1
0240:   29 -5.4
0241:   29 -2.3
0242:   30 -5.1
0243:   30 -2.4
0244:   31 -5.0
0245:   31 -2.6
0246:   32 -4.9
0247:   32 -2.7
0248:   33 -4.9
0249:   33 -2.9
0250:   34 -4.7
0251:   34 -3.0
0252:   35 -4.5
0253:   35 -3.2
0254:   36 -4.4
0255:   36 -3.3
0256:   37 -4.3
0257:   37 -3.5
0258:   38 -4.2
0259:   38 -3.6
0260:   39 -4.1
0261:   39 -3.8
0262:   40 -4.0
0263:   40 -3.9
0264:   41 -3.8
0265:   41 -4.0
0266:   42 -3.6
0267:   42 -4.1
0268:   43 -3.4
0269:   43 -4.2
0270:   44 -3.2
0271:   44 -4.4
0272:   45 -3.0
0273:   45 -4.5
0274:   46 -2.9
0275:   46 -4.6
0276:   47 -2.7
0277:   47 -4.8
0278:   48 -2.5
0279:   48 -4.9
0280:   49 -2.3
0281:   49 -5.0
0282:   50 -2.1
0283:   50 -5.1
0284:   51 -2.0
0285:   51 -5.4
0286:   52 -1.9
0287:   52 -5.7
0288:   53 -1.8
0289:   53 -6.0
0290:   54 -1.7
0291:   54 -6.3
0292:   55 -1.6
0293:   55 -6.6
0294:   56 -1.6
0295:   56 -6.8
0296:   57 -1.5
0297:   57 -7.1
0298:   58 -1.4
0299:   58 -7.4
0300:   59 -1.3
0301:   59 -7.6
0302:   60 -1.2
0303:   60 -7.9
0304:   61 -1.1
0305:   61 -8.4
0306:   62 -1.0
0307:   62 -8.8
0308:   63 -0.8
0309:   63 -9.3
0310:   64 -0.7
0311:   64 -9.7
0312:   65 -0.6
0313:   65-10.2
0314:   66 -0.5
0315:   66-10.6
0316:   67 -0.4
0317:   67-11.1
0318:   68 -0.2
0319:   68-11.5
0320:   69 -0.1
0321:   69-12.0
0322:   70  0.0
0323:   70-12.4
0324:   71  0.0
0325:   71-13.0
0326:   72  0.0
0327:   72-13.7
0328:   73  0.0
0329:   73-14.3
0330:   74 00.0
0331:   74-15.0
0332:   75  0.0
0333:   75-15.6
0334:   76  0.1
0335:   76-16.3
0336:   77  0.1
0337:   77-17.0
0338:   78  0.1
0339:   78-17.7
0340:   79  0.1
0341:   79-18.4
0342:   80  0.1
0343:   80-19.1
0344:   81  0.1
0345:   81-19.0
0346:   82  0.1
0347:   82-18.9
0348:   83  0.1
0349:   83-18.8
0350:   84  0.1
0351:   84-18.7
0352:   85  0.1
0353:   85-18.6
0354:   86  0.2
0355:   86-18.6
0356:   87  0.2
0357:   87-18.5
0358:   88  0.2
0359:   88-18.4
0360:   89  0.2
0361:   89-18.4
0362:   90  0.2
0363:   90-18.3
```

REQUESTED OPTIONS: ID

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)
SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

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ISN 0002            SUBROUTINE BREM10(PLNGT,TLATD,TLONGD,RLATD,RLONGD,BER)                BRE00010
                C                                                                         BRE00020
                C   CONTROL PROGRAM FOR DIRECT RAY, REFLECTED RAY, AND                    BRE00030
                C   GROUND WAVE FIELD STRENGTH CALCULATION BY THE METHOD OF              BRE00040
                C   BREMMER AND VAN DER POL.                                             BRE00050
                C                                                                         BRE00060
                C   ------------------------------------------------------------------BRE00070
                C                                                                         BRE00080
                C   LIMITATIONS-ELEMENTARY TRANSMITTING DIPOLE, 1.KW ERP, DISTANCE      BRE00090
                C   MEASURED IN KILOMETERS ALONG THE GREAT CIRCLE PATH, CONDUCTIVITY     BRE00100
                C   MEASURED IN MHOS/METER, FREQUENCY IN MEGAHERTZ, ANTENNA HEIGHTS      BRE00110
                C   IN METERS, DIELECTRIC CONSTANT IS DIMENSIONLESS.                     BRE00120
                C   NOTE-IF ONE OF THE TERMINALS IS ON THE GROUND ASSUME IT TO BE THE  BRE00130
                C   TRANSMITTER.                                                        BRE00140
                C                                                                         BRE00150
                C   ------------------------------------------------------------------BRE00160
ISN 0003            REAL K,LAMBDA,LAT,LONG,MUIST                                          BRE00170
ISN 0004            COMPLEX DELTA,J                                                       BRE00180
ISN 0005            COMMON ERTHR,PI,RAD,DEG,PIBY2,TWOPI,REFIND,FREQ                       BRE00190
ISN 0006            COMMON /BON/ LONG,LAT,GAMMA,GMT,IO                                    BRE00200
ISN 0007            COMMON /GWAVE/ SIGMA,EPSLON,THT,RHT,DKM,DLOS,THETA,LAMBDA,J           BRE00210
ISN 0008            COMMON/PO/JK,KL,IFCT,GRLOSS,ALA1,ALA2,LLE,IHRC,P200,DB,HTCAL,JHOURBRE00220
                   1,RNOYS(80),FHNAME(12),BETA,TTT                                        BRE00230
ISN 0009            DATA DMY1, DMY2, DMY3, DMY4, DMY5, DMY6 /6*0.0/                       BRE00240
ISN 0010            J=(0.,1.)                                                             BRE00250
ISN 0011            IO=2                                                                  BRE00260
ISN 0012            EH = -1.000                                                           BRE00270
ISN 0013            EV = -1.000                                                           BRE00280
ISN 0014            ELNOST = -1.000                                                       BRE00290
ISN 0015            DBV = -1.E75                                                          BRE00300
ISN 0016            DBH = -1.E75                                                          BRE00310
ISN 0017            DBL = -1.E75                                                          BRE00320
ISN 0018            TBD = 0.0                                                             BRE00330
ISN 0019            TBR = 0.0                                                             BRE00340
ISN 0020            RBR = 0.0                                                             BRE00350
ISN 0021            RBD = 0.0                                                             BRE00360
ISN 0022            READ(5,30) THT,RHT,SIGMA,EPSLON,WNDVEL,NSEGS,MPTS,FACHNZ              BRE00370
ISN 0023           30 FORMAT(5F10.3,2I5,F10.3)                                            BRE00380
ISN 0024            PRINT 35, THT, RHT, SIGMA, EPSLON, WNDVEL, NSEGS, MPTS                BRE00390
ISN 0025           35 FORMAT(//56X,'BREM ANALYSIS INPUT',/,15X,'TRANS HEIGHT',3X,        BRE00400
                     1   'RCVR HEIGHT',8X,'SIGMA',9X,'EPSILON',7X,'WIND VEL',9X,       BRE00410
                     2   'SUDA',8X,'MILLINGTON',/16X,5(F10.3,5X),4X,I5,12X,I5)         BRE00420
                C                                                                         BRE00430
                C   IF EPSILON IS NOT PROVIDED, ZERO SIGMA TO TRIGGER COMPUTATION      BRE00440
                C                                                                         BRE00450
ISN 0026            IF(EPSLON.LE.0.) SIGMA = 0.                                           BRE00460
ISN 0028            IF(SIGMA.GT.2.0)                                                      BRE00470
                   1  SIGMA = 2.778E-05/((2.635E-03 + WNDVEL*8.784E-05)**2)             BRE00480
ISN 0030            ZT = THT*0.001 + ERTHR                                                BRE00490
ISN 0031            ZR = RHT*0.001 + ERTHR                                                BRE00500
ISN 0032            DKM = PLNGT                                                           BRE00510
ISN 0033            LAMBDA=300./FREQ                                                      BRE00520
ISN 0034            THETA = DKM/ERTHR                                                     BRE00530
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ISN 0035            THETA1=ARCOS(ERTHR/ZT)                                          BRE00540
ISN 0036            DLOS=SQRT((ZT**2)+(ZR**2)-2.*ZT*ZR*COS(THETA))                  BRE00550
                  C  IF RECEIVER IS BEYOND HORIZON GO TO NEXT LOGIC STEP            BRE00560
ISN 0037            IF(THETA.GT.THETA1) GO TO 150                                   BRE00570
                  C                                                                 BRE00580
                  C     COMPUTE LINE OF SIGHT VOLTAGE AND ZENITH ANGLES AT TRANSMITTER BRE00590
                  C         AND RECEIVER                                          BRE00600
                  C                                                                 BRE00610
ISN 0039            ELNOST = 1.5E05/DLOS                                            BRE00620
ISN 0040            SINX = ZT*SIN(THETA)/DLOS                                       BRE00630
ISN 0041            IF(SINX.GT.1.0000) SINX = 1.0000                                BRE00640
ISN 0043            RBD = PIBY2 - ARSIN(SINX)                                       BRE00650
ISN 0044            SINX = ZR*SIN(THETA)/DLOS                                       BRE00660
ISN 0045            IF(SINX.GT.1.0000) SINX = 1.0000                                BRE00670
ISN 0047            TBD = PIBY2 - ARSIN(SINX)                                       BRE00680
                  C                                                                 BRE00690
                  C     CORRECT QUADRANT ON DIRECT ANGLES UNLESS ONE IS UPGOING     BRE00700
                  C                                                                 BRE00710
ISN 0048            IF(THT.LE.RHT) RBD = - RBD                                      BRE00720
ISN 0050            IF(RHT.LE.THT) TBD = - TBD                                      BRE00730
ISN 0052            IF(RHT.LE.0.) GO TO 500                                         BRE00740
                  C                                                                 BRE00750
                  C     IF BOTH ANTENNAS ARE ELEVATED COMPUTE POWER AND ZENITH ANGLES BRE00760
                  C     FOR REFLECTED RAY ALSO                                      BRE00770
                  C                                                                 BRE00780
ISN 0054            CALL RELXRA(TLATD,TLONGD,BER,WNOVEL,TBR,RBR,EH,EV)              BRE00790
                  C                                                                 BRE00800
                  C  PROCEED TO REPORT SECTOR                                       BRE00810
ISN 0055            GOTO 500                                                        BRE00820
                  C                                                                 BRE00830
                  C     RECEIVER IS BEYOND HORIZON, COMPUTE HORIZON TRANSITION CRITERION BRE00840
                  C                                                                 BRE00850
ISN 0056          150 CONTINUE                                                      BRE00860
ISN 0057            DTHETA = THETA - THETA1                                         BRE00870
ISN 0058            DELX = ERTHR*SQRT((1./COS(DTHETA))**2 - 1.)                     BRE00880
ISN 0059            DELH = DELX*SIN(0.1*RAD)/COS(0.1*RAD + DTHETA)                  BRE00890
ISN 0060            TRANS = 1000.*(DELH + ERTHR*(1./COS(DTHETA) -1.))               BRE00900
                  C                                                                 BRE00910
                  C  IF RECEIVER IS BELOW LINE OF SIGHT MOVE ON TO GROUND WAVE LOGIC BRE00920
ISN 0061            IF(RHT.LE.TRANS) GOTO 200                                       BRE00930
                  C                                                                 BRE00940
                  C                                                                 BRE00950
                  C     COMPUTE LINE OF SIGHT VOLTAGE AND ZENITH ANGLES AT TRANSMITTER BRE00960
                  C         AND RECEIVER                                          BRE00970
                  C                                                                 BRE00980
ISN 0063            ELNOST = 1.5E05/DLOS                                            BRE00990
ISN 0064            SINX = ZT*SIN(THETA)/DLOS                                       BRE01000
ISN 0065            IF(SINX.GT.1.0000) SINX = 1.0000                                BRE01010
ISN 0067            RBD = PIBY2 - ARSIN(SINX)                                       BRE01020
ISN 0068            SINX = ZR*SIN(THETA)/DLOS                                       BRE01030
ISN 0069            IF(SINX.GT.1.0000) SINX = 1.0000                                BRE01040
ISN 0071            TBD = PIBY2 - ARSIN(SINX)                                       BRE01050
                  C                                                                 BRE01060
                  C     CORRECT QUADRANT ON DIRECT ANGLES UNLESS ONE IS UPGOING     BRE01070
                  C                                                                 BRE01080
ISN 0072            IF(THT.LE.RHT) RBD = - RBD                                      BRE01090
ISN 0074            IF(RHT.LE.THT) TBD = - TBD                                      BRE01100
ISN 0076            IF(THT.LE.0.) GO TO 500                                         BRE01110
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                C                                                                BRE01120
                C     IF BOTH ANTENNAS ARE ELEVATED COMPUTE POWER AND ZENITH ANGLES BRE01130
                C     FOR REFLECTED RAY ALSO                                     BRE01140
                C                                                                BRE01150
 ISN 0078             CALL REFXRA(TLATD,TLONGD,BER,WNDVEL,TBR,RBR,EH,EV)         BRE01160
                C                                                                BRE01170
                C  PROCEED TO REPORT SECTION                                     BRE01180
 ISN 0079             GO TO 500                                                  BRE01190
 ISN 0080           200 CONTINUE                                                 BRE01200
                C  DETERMINE SIGMA AND EPSILON VALUES FOR GROUND WAVE CALCULATIONS BRE01210
 ISN 0081             IF(SIGMA.LE.0.) GO TO 210                                  BRE01220
                C                                                                BRE01230
                C     USER PROVIDED SIGMA AND EPSILON; DETERMINE GROUNDWAVE FIELD VALUESBRE01240
                C                                                                BRE01250
 ISN 0083             CALL GRNDWV(EH,EV)                                         BRE01260
 ISN 0084             GO TO 500                                                  BRE01270
 ISN 0085           210 CONTINUE                                                 BRE01280
                C                                                                BRE01290
                C  SIGMA NOT PROVIDED USE METHOD OF SUDA OR WOM DEPENDING ON MPTS BRE01300
                C                                                                BRE01310
 ISN 0086             IF(NSEGS.LE.0)  GO TO 9901                                 BRE01320
 ISN 0088             PRINT 211                                                  BRE01330
 ISN 0089           211 FORMAT(//21X,'LATITUDE',6X,'LONGITUDE',9X,'SIGMA',9X,'EPSILON') BRE01340
 ISN 0090             PRINT 212                                                  BRE01350
 ISN 0091           212 FORMAT(//5X,'FROM TRANSMITTER'//)                        BRE01360
 ISN 0092             SEGLNT = PLNGT/NSEGS                                       BRE01370
 ISN 0093             IF(MPTS.GT.0.) GO TO 220                                   BRE01380
                C                                                                BRE01390
                C     USE THE METHOD OF SUDA WITH NSEGS + 1 POINTS               BRE01400
                C                                                                BRE01410
 ISN 0095             NSEGS = NSEGS + 1                                          BRE01420
 ISN 0096             CALL ASGEPS(SEGLNT,NSEGS,TLATD,TLONGD,BER,WNDVEL,SIGMA,EPSLON) BRE01430
 ISN 0097             CALL GRNDWV(EH,EV)                                         BRE01440
 ISN 0098             GO TO 500                                                  BRE01450
                C                                                                BRE01460
                C     USE  THE METHOD OF MILLINGTON TO DETERMINE SIGMA AND EPSILON BRE01470
                C                                                                BRE01480
 ISN 0099           220 CONTINUE                                                 BRE01490
                C                                                                BRE01500
                C   FUTHER SUBDIVIDE THE SEGMENTS INTO MPTS STEPS FOR AVERAGING VALUES BRE01510
                C                                                                BRE01520
 ISN 0100             MDIST =SEGLNT/MPTS                                         BRE01530
                C                                                                BRE01540
                C   DO CALCULATIONS ONCE FOR TRANSMITTER AND ONCE FOR RECEIVER   BRE01550
                C                                                                BRE01560
                C   AVERAGE SIGMA AND EPSILON VALUES DETERMINED AT MPTS + 1 POINTS BRE01570
                C    WITHIN ONE SEGLNGT OF THE TRANS/RCVR                        BRE01580
                C                                                                BRE01590
 ISN 0101             MPTS = MPTS + 1                                            BRE01600
 ISN 0102             CALL ASGEPS(MDIST,MPTS,TLATD,TLONGD,BER,WNDVEL,SIGMA,EPSLON) BRE01610
                C                                                                BRE01620
                C     SAVE 'E''S COMPUTED WITH TRANSMITTER VALUES FOR LATER USE  BRE01630
                C                                                                BRE01640
 ISN 0103             CALL GRNDWV(ETH,ETV)                                       BRE01650
                C                                                                BRE01660
                C   FIND STARTING POINTS FOR RECEIVER CALCULATIONS              BRE01670
                C                                                                BRE01680
 ISN 0104             DIST = (NSEGS - 1)*SEGLNT                                  BRE01690
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ISN 0105            CALL COOR(TLATD,TLONGD,BER,DIST,RLAT,RLONG)                    BRE01700
ISN 0106            PRINT 224                                                      BRE01710
ISN 0107          224 FORMAT(//5X,'TOWARD RECEIVER'//)                             BRE01720
ISN 0108            CALL ASGEPS(MDIST,MPTS,RLAT,RLONG,BER,WNDVEL,SIGMA,EPSLON)     BRE01730
ISN 0109            CALL GRNDWV(EH,EV)                                             BRE01740
ISN 0110            EH = SQRT(ETH**2 + EH**2)                                      BRE01750
ISN 0111            EV = SQRT(ETV**2 + EV**2)                                      BRE01760
                    C                                                              BRE01770
                    C     PROCEED WITH POWER CALCULATIONS AND REPORTING            BRE01780
                    C                                                              BRE01790
ISN 0112          500 CONTINUE                                                     BRE01800
                    C                                                              BRE01810
                    C     COMPUTE RECEIVED POWER IN 'DBW' ASSUMING                 BRE01820
                    C         A 1 WATT ISOTROPIC RATIATOR                          BRE01830
                    C                                                              BRE01840
ISN 0113            FLDK = -188.516 + 20.*ALOG10(LAMBDA)                           BRE01850
ISN 0114            IF(ELNOST.GT.0.0) DBL = 20.*ALOG10(ELNOST) + FLDK              BRE01860
ISN 0116            IF(EV.GT.0.0) DBV = 20.*ALOG10(EV) + FLDK                      BRE01870
ISN 0118            IF(EH.GT.0.0) DBH = 20.*ALOG10(EH) + FLDK                      BRE01880
                    C                                                              BRE01890
                    C       CONVERT RADIANS TO DEGREES FOR OUTPUT                  BRE01900
                    C                                                              BRE01910
ISN 0120            TBD = TBD*DEG                                                  BRE01920
ISN 0121            TBR = TBR*DEG                                                  BRE01930
ISN 0122            RBD = RBD*DEG                                                  BRE01940
ISN 0123            RBR = RBR*DEG                                                  BRE01950
ISN 0124            PRINT 9010                                                     BRE01960
                    C                                                              BRE01970
                    C     WRITE OUT RESULTS TO UNIT 7 FOR COMEFF                   BRE01980
                    C                                                              BRE01990
ISN 0125            WRITE(7,9100) TTT,FACHNZ,FREQ,BETA,DMY2,DMY3,THT,RHT,          BRE02000
                   1      RNOYS(IFCT),JHOUR,DMY6                                   BRE02010
ISN 0126            WRITE(7,9200) DBV,DBH,DBL,TBD,TBR,RBD,RBR                      BRE02020
ISN 0127            IF(DBL.GE.-1.E74) GO TO 510                                    BRE02030
                    C                                                              BRE02040
                    C     PRINTOUT FOR GROUNDWAVE                                  BRE02050
                    C                                                              BRE02060
ISN 0129            PRINT 9011, DBV,DBH,TBD,RBD                                    BRE02070
ISN 0130            RETURN                                                         BRE02080
ISN 0131          510 CONTINUE                                                     BRE02090
ISN 0132            IF(THT.GT.0.00.AND.RHT.GT.0.00) GO TO 520                      BRE02100
                    C                                                              BRE02110
                    C     PRINTOUT FOR LINE OF SIGHT ONLY CASE                     BRE02120
                    C                                                              BRE02130
ISN 0134            PRINT 9012, DBL, TBD, RBD                                      BRE02140
ISN 0135            RETURN                                                         BRE02150
ISN 0136          520 CONTINUE                                                     BRE02160
                    C                                                              BRE02170
                    C     PRINTOUT FOR LINE OF SIGHT AND REFLECTED RAY CASE        BRE02180
                    C                                                              BRE02190
ISN 0137            PRINT 9013,DBV,DBH,DBL,TBD,TBR,RBD,RBR                         BRE02200
ISN 0138            RETURN                                                         BRE02210
ISN 0139         9010 FORMAT(//56X,21HBREM ANALYSIS RESULTS,/28X,                  BRE02220
                   1   25HRELATIVE POWER COMPONENTS,38X,17HRAY ZENITH ANGLES,/18X,  BRE02230
                   2   12HPOLARIZATION,20X,13HLINE OF SIGHT,16X,11HTRANSMITTER,20X,  BRE02240
                   3   8HRECEIVER,/10X,8HVERTICAL,10X,10HHORIZONTAL,28X,          BRE02250
                   4   2(8X,6HDIRECT,7X,9HREFLECTED),/13X,3HDBW,16X,3HDBW,20X,3HDBW,  BRE02260
                   5   11X,4(4X,7HDEGREES,4X))                                    BRE02270
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ISN 0140      9011 FORMAT(1H0,4X,2(G15.3,5X),20X,F15.3,15X,F15.3)                    BRE02280
ISN 0141      9012 FORMAT (1H0,44X,G15.3,F15.3,15X,F15.3)                            BRE02290
ISN 0142      9013 FORMAT(1H0,4X,3(G15.3,5X),4F15.3)                                 BRE02300
ISN 0143      9100 FORMAT(1HG,F6.0,F10.3,3F6.2,2F7.1,F9.1,F7.1,I5,F10.1)             BRE02310
ISN 0144      9200 FORMAT(1H2,3G12.6,4F10.3)                                         BRE02320
ISN 0145           RETURN                                                          BRE02330
ISN 0146      9901 CONTINUE                                                        BRE02340
ISN 0147           PRINT 9902, FREQ,SIG,THT,RHT,NSEGS,MPTS                         BRE02350
ISN 0148      9902 FORMAT(//10X,'STOP : INSUFFICIENT DATA', 4F10.4//)              BRE02360
ISN 0149           STOP                                                            BRE02370
ISN 0150           END                                                             BRE02380
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REQUESTED OPTIONS: ID

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)
                   SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

   ISN 0002            SUBROUTINE RFLXRA(TRANSX,TRANSY,BER,WNDVEL,TBR,RBR,EH,EV)          BRE02390
                     C                                                                    BRE02400
                     C     THIS SUBROUTINE CALCULATES THE STRENGTH OF THE REFLECTED WAVE  BRE02410
                     C     WHEN THE RECEIVER IS IN LINE-OF-SIGHT OF THE TRANSMITTER.      BRE02420
                     C                                                                    BRE02430
                     C                                                                    BRE02440
   ISN 0003            REAL K,LAMBDA                                                      BRE02450
   ISN 0004            COMPLEX J,MUS,CFAC,CXRT,REF,EVAL,CONST                             BRE02460
   ISN 0005            COMMON ERTHR,PI,RAD,DEG,PIBY2,TWOPI,REFIND,EMC                     BRE02470
   ISN 0006            COMMON /BDN/ YLOC,XLOC,GAMMA,GMT,ID                                BRE02480
   ISN 0007            COMMON /GWAVE/ SIGMA,EPSLON,THT,RHT,DKM,DLOS,THETA,LAMBDA,J        BRE02490
   ISN 0008            POLAR = -1.                                                        BRE02500
                     C                                                                    BRE02510
                     C   FIND ANGLE OF INCIDENCE PLUS TAU1 AND TAU4                       BRE02520
                     C                                                                    BRE02530
   ISN 0009            ZT = ERTHR + THT*0.001                                             BRE02540
   ISN 0010            ZR = ERTHR + RHT*0.001                                             BRE02550
   ISN 0011            HSUM = THT + RHT                                                   BRE02560
   ISN 0012            HSUMS = THT**2 + RHT**2                                            BRE02570
   ISN 0013            HSSUM = (THT + RHT)**2                                             BRE02580
   ISN 0014            DSTOHT = 1000.*DKM/HSUM                                            BRE02590
   ISN 0015            ARGT2 = DSTOHT + THETA*(HSUMS/HSSUM)*(1. + (DSTOHT**2)/2.)         BRE02600
   ISN 0016            TAU2=ATAN(ARGT2)                                                   BRE02610
   ISN 0017            ARGT1=(ERTHR/ZT)*SIN(TAU2)                                         BRE02620
   ISN 0018            ARGT4=(ERTHR/ZR)*SIN(TAU2)                                         BRE02630
   ISN 0019            TAU1=ARSIN(ARGT1)                                                  BRE02640
   ISN 0020            TAU4=ARSIN(ARGT4)                                                  BRE02650
                     C                                                                    BRE02660
                     C    CALCULATE TRANSMITTER PROPOGATION ANGLES                        BRE02670
                     C                                                                    BRE02680
   ISN 0021            TBR = TAU1 - PIBY2                                                 BRE02690
                     C                                                                    BRE02700
                     C    CALCULATE RECEIVER ANGLES                                       BRE02710
                     C                                                                    BRE02720
   ISN 0022            RBR = TAU4 - PIBY2                                                 BRE02730
                     C                                                                    BRE02740
                     C  FIND SIGMA AND EPSILON IF THEY HAVE NOT BEEN PROVIDED             BRE02750
                     C                                                                    BRE02760
   ISN 0023            IF (SIGMA.GT.0.) GOTO 100                                          BRE02770
   ISN 0025            RFLXPT = ERTHR*(TAU2 - TAU1)                                       BRE02780
   ISN 0026            CALL COOR(TRANSX,TRANSY,BER,RFLXPT,DLAT,DLNG)                      BRE02790
   ISN 0027            XLOC = DLAT*RAD                                                    BRE02800
   ISN 0028            YLOC = DLNG*RAD                                                    BRE02810
   ISN 0029            CALL NWOMAP                                                        BRE02820
   ISN 0030            CALL FSGEPS(GAMMA,SIGMA,EPSLON,WNDVEL)                             BRE02830
   ISN 0031            PRINT 95, DLAT,DLNG,SIGMA,EPSLON                                   BRE02840
   ISN 0032           95 FORMAT(//15X,'REFLECTED RAY CALCULATIONS:'/20X,                  BRE02850
                        1   'AT LAT ',F8.3,'  AND LONG ',F8.3,                           BRE02860
                        2  '   SIGMA = ',F7.3,'   EPSILON = ',F8.3,' (EFFECTIVE VALUES)'//)BRE02870
   ISN 0033           100 CONTINUE                                                       BRE02880
                     C                                                                    BRE02890
                     C   PROCEED WITH VOLTAGE CALCULATIONS                              BRE02900
                     C                                                                    BRE02910
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   ISN 0034            D1=(ZT*COS(TAU1))-(ERTHR*COS(TAU2))                                    BRE02920
   ISN 0035            D2=(ZR*COS(TAU4))-(ERTHR*COS(TAU2))                                    BRE02930
   ISN 0036            DSUM = D2 + D1                                                         BRE02940
   ISN 0037            CTGPSI = (D2 - D1)*COTAN(TAU2)/DSUM                                    BRE02950
   ISN 0038            SINPSI = 1./SQRT(1. + CTGPSI**2)                                       BRE02960
   ISN 0039            DEL = DLOS*((SINPSI/SIN(TAU2)) - 1.)                                   BRE02970
   ISN 0040            ALPHA = ERTHR*DSUM*SQRT(SIN(TAU2)*COS(TAU2))/                          BRE02980
                      1    SQRT(ZT*ZR*SIN(THETA)*((D1*ZR*COS(TAU4)) + (D2*ZT*COS(TAU1))))  BRE02990
   ISN 0041            WRK = 60.0*SIGMA*LAMBDA                                                BRE03000
   ISN 0042            PHI = ATAN(WRK/EPSLON)                                                 BRE03010
   ISN 0043            MUS = SQRT(EPSLON**2 + WRK**2)*CEXP(J*PHI)                             BRE03020
   ISN 0044            CXRT = CSQRT(MUS - SIN(TAU2)**2)                                       BRE03030
   ISN 0045            CFAC = CEXP(2.*J*PI*DEL*1000./LAMBDA)                                  BRE03040
   ISN 0046            CONST = 1.5*ALPHA*CFAC/DSUM                                            BRE03050
               C     COMPUTE REF FOR HORIZONTAL POLARIZATION                                  BRE03060
   ISN 0047            REF = (COS(TAU2) - CXRT)/(COS(TAU2) + CXRT)                            BRE03070
   ISN 0048            XCOS = COS(TAU2)                                                       BRE03080
               C       PRINT 117                                                            BRE03090
               C 117 FORMAT(5X,'*****REFLECTED RAY*****')                                   BRE03100
               C       PRINT 118,XCOS,CXRT,REF                                              BRE03110
               C 118 FORMAT(5X,'COS(TAU2)=',F10.5,5X,'CXRT=',2F10.5,5X,'REF=',2F10.5)       BRE03120
   ISN 0049            GO TO 125                                                            BRE03130
   ISN 0050          120 CONTINUE                                                           BRE03140
               C       COMPUTE REF FOR VERTICAL POLARIZATION                                BRE03150
   ISN 0051                REF = (MUS*COS(TAU2) - CXRT)/(MUS*COS(TAU2) + CXRT)              BRE03160
               C       PRINT 119                                                            BRE03170
               C 119 FORMAT(5X,'VERTICAL POLARIZATION INGREDIENTS')                         BRE03180
   ISN 0052            XCOS = COS(TAU2)                                                     BRE03190
               C       PRINT 121,MUS,XCOS,CXRT,REF                                          BRE03200
               C 121 FORMAT(5X,'MUS=',2F10.5,5X,'COS(TAU2)=',F10.5,5X,'CXRT=',2F10.5,      BRE03210
               C     .   5X,'REF=',2F10.5)                                                  BRE03220
   ISN 0053          125 CONTINUE                                                           BRE03230
   ISN 0054            EVAL = CABS(CONST*REF)*100000.                                       BRE03240
   ISN 0055            IF(POLAR.GT.0.) GO TO 150                                            BRE03250
   ISN 0057            EH = EVAL                                                            BRE03260
   ISN 0058            POLAR = 1.                                                           BRE03270
   ISN 0059            GO TO 120                                                            BRE03280
   ISN 0060          150 CONTINUE                                                           BRE03290
   ISN 0061            EV = EVAL                                                            BRE03300
   ISN 0062            RETURN                                                               BRE03310
   ISN 0063            END                                                                  BRE03320

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)

*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

*STATISTICS*     SOURCE STATEMENTS =      62, PROGRAM SIZE =     3236, SUBPROGRAM NAME =RFLXRA

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                  112K BYTES OF CORE NOT USED
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REQUESTED OPTIONS: ID

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)
                   SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

   ISN 0002            SUBROUTINE GRNDWV(FH,FV)                                                  PRE03330
                 C     THIS SUBROUTINE CALCULATES THE FIELD OF THE GROUND WAVE WHEN THE          PRE03340
                 C     RECEIVER IS CLOSE TO OR BELOW THE HORIZON.                                PRE03350
                 C                                                                               PRE03360
   ISN 0003            DIMENSION TAUI(15),TAUR(15),EXPR(15),EXPIM(15),X1(15),X2(15)              PRE03370
   ISN 0004            REAL K, LAMBDA, LAT, LONG                                                 PRE03380
   ISN 0005            COMPLEX DELTA,J,TAU(15),HGFP(15),E1,E(15)                                 PRE03390
   ISN 0006            COMPLEX*16 Z0(15),Z1(15),Z2(15),H10(15),H11(15),H12(15),H2(15),           PRE03400
                      1H1P(15),H2P(15)                                                           PRE03410
   ISN 0007            COMMON ERTHR,PI,RAD,DEG,PIBY2,TWOPI,REFIND,FREQ                           PRE03420
   ISN 0008            COMMON /BON/ LONG,LAT,GAMMA,GMT,IO                                        PRE03430
   ISN 0009            COMMON /GWAVE/ SIGMA,EPSLON,THT,PHT,DKM,DLOS,THETA,LAMBDA,J               PRE03440
   ISN 0010            COEF1=0.333333                                                            PRE03450
   ISN 0011            COEF2=0.666666                                                            PRE03460
   ISN 0012            COEF3=0.62996053                                                          PRE03470
   ISN 0013            CHT=0.0537*DLOS/(LAMBDA**COEF1)                                           PRE03480
   ISN 0014            CHTS1 = THT*0.03674/LAMBDA**COEF2                                         PRE03490
   ISN 0015            CHTS2 = HHT*0.03674/LAMBDA**COEF2                                         PRE03500
   ISN 0016            WRK = 60.0*SIGMA*LAMBDA                                                   PRE03510
                 C                                                                               PRE03520
                 C     SET UP FOR HORIZONTAL POLARIZATION CALCULATIONS                           PRE03530
                 C                                                                               PRE03540
   ISN 0017            POLAR = -1.0                                                              PRE03550
   ISN 0018            PSY = (PI - ATAN((EPSLON - 1.)/WRK))/2.                                   PRE03560
   ISN 0019            K = 0.002924*(LAMBDA**COEF1)/SQRT(SQRT((EPSLON - 1.)**2 + WRK**2))       PRE03570
                 C     PRINT 122                                                                 PRE03580
                 C 122 FORMAT(5X,'GROUND WAVE'/5X,'HORIZONTAL POLARIZATION INGREDIENTS')         PRE03590
                 C     PRINT 123,PSY,K                                                           PRE03600
                 C 123 FORMAT(5X,'PSY=',F10.5,5X,'K=',F10.5)                                     PRE03610
                 C                                                                               PRE03620
                 C     CALCULATION OF COMPONENT FACTORS                                          PRE03630
                 C                                                                               PRE03640
   ISN 0020        100 CONTINUE                                                                  PRE03650
   ISN 0021            WRK2=0.25*PI+PSY                                                          PRE03660
   ISN 0022            WRK3=75.*PI/180.+3.*PSY                                                   PRE03670
   ISN 0023            WRK4=75.*PI/180.-5.*PSY                                                   PRE03680
   ISN 0024            WRK5=15.*PI/180.-PSY                                                      PRE03690
   ISN 0025            WRK6=60.*PI/180.-4.*PSY                                                   PRE03700
   ISN 0026            WRK7=4.*PSY                                                               PRE03710
   ISN 0027            WRK8=2.*PSY                                                               PRE03720
   ISN 0028            WRK9=15.*PI/180.+3.*PSY                                                   PRE03730
                 C                                                                               PRE03740
   ISN 0029            IF(K.GE.0.6) GO TO 120                                                    PRE03750
                 C                                                                               PRE03760
                 C     CALCULATIONS WHEN 'K' LESS THAN 0.6                                       PRE03770
                 C                                                                               PRE03780
   ISN 0031            TAUR(1)=0.928+K*COS(WRK2)+1.237*K**3.*COS(WRK3)-0.5*K**4.*COS(WRK7        PRE03790
                      1)-2.755*K**5.*COS(WRK4)                                                   PRE03800
   ISN 0032            TAUR(2)=1.622+K*COS(WRK2)+2.163*K**3.*COS(WRK3)-0.5*K**4.*COS(WRK7        PRE03810
                      1)-8.422*K**5.*COS(WRK4)                                                   PRE03820
   ISN 0033            TAUR(3)=2.191+K*COS(WRK2)+2.921*K**3.*COS(WRK3)-0.5*K**4.*COS(WRK7        PRE03830
                      1)-15.36*K**5.*COS(WRK4)                                                   PRE03840
   ISN 0034            TAUI(1)=1.607-K*SIN(WRK2)-1.237*K**3.*SIN(WRK3)+0.5*K**4.*SIN(WRK7        PRE03850
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                     1)-2.755*K**5.*SIN(WRK4)                                          BRE03860
   ISN 0035           TAUI(2)=2.810-K*SIN(WRK2)-2.163*K**3.*SIN(WRK3)+0.5*K**4.*SIN(WRK7BRE03870
                     1)-8.422*K**5.*SIN(WRK4)                                          BRE03880
   ISN 0036           TAUI(3)=3.795-K*SIN(WRK2)-2.921*K**3.*SIN(WRK3)+0.5*K**4.*SIN(WRK7BRE03890
                     1)-15.36*K**5.*SIN(WRK4)                                          BRE03900
   ISN 0037           DO 110 I = 4,15                                                   BRE03910
   ISN 0038           TAUR(I)=1.116*((I+0.75)**COEF2)+K*COS(WRK2)                       BRE03920
   ISN 0039           TAUI(I)=1.932*((I+0.75)**COEF2)-K*SIN(WRK2)                       BRE03930
   ISN 0040         110 CONTINUE                                                        BRE03940
   ISN 0041           GO TO 150                                                         BRE03950
                  C                                                                   BRE03960
                  C     CALCULATIONS WHEN  'K' GREATER THAN OR EQUAL TO 0.6           BRE03970
                  C                                                                   BRE03980
   ISN 0042         120 CONTINUE                                                        BRE03990
   ISN 0043           TAUR(1)=0.4043+0.618*COS(WRK5)/K-0.236*SIN(WRK8)/K**2.-0.0533*COS(BRE04000
                     1WRK9)/K**3.+0.00226*COS(WRK6)/K**4.                              BRE04010
   ISN 0044           TAUR(2)=1.288+0.1940*COS(WRK5)/K-0.0073*SIN(WRK8)/K**2.+0.0120*COSBRE04020
                     1(WRK9)/K**3.-0.00160*COS(WRK6)/K**4.                             BRE04030
   ISN 0045           TAUI(1)=0.7003-0.6183*SIN(WRK5)/K+0.2364*COS(WRK8)/K**2.-0.0533*SIBRE04040
                     1N(WRK9)/K**3.-0.00226*SIN(WRK6)/K**4.                            BRE04050
   ISN 0046           TAUI(2)=2.232-0.1940*SIN(WRK5)/K+0.0073*COS(WRK8)/K**2.+0.0120*SINBRE04060
                     1(WRK9)/K**3.+0.00160*SIN(WRK6)/K**4.                             BRE04070
   ISN 0047           DO 130 I = 3,15                                                   BRE04080
   ISN 0048           TAUR(I)=1.116*((I+0.25)**COEF2)+0.2241*COS(WRK5)/(K*((I+0.25)**   BRE04090
                     1COEF2))                                                          BRE04100
   ISN 0049           TAUI(I)=1.932*((I+0.25)**COEF2)-0.2241*SIN(WRK5)/(K*((I+0.25)**   BRE04110
                     1COEF2))                                                          BRE04120
   ISN 0050         130 CONTINUE                                                        BRE04130
                  C                                                                   BRE04140
                  C     CALCULATE E VECTOR COMPONENTS                                 BRE04150
                  C                                                                   BRE04160
   ISN 0051         150 CONTINUE                                                        BRE04170
   ISN 0052           DELTA = K*CEXP(J*(0.75*PI - PSY))                               BRE04180
   ISN 0053           DO 175 I = 1,15                                                 BRE04190
   ISN 0054           TAU(I)=CMPLX(TAUR(I),TAUI(I))                                   BRE04200
   ISN 0055           Z0(I)=-2.*COEF3*TAU(I)                                          BRE04210
   ISN 0056           Z1(I)=COEF3*CHIS1+Z0(I)                                         BRE04220
   ISN 0057           Z2(I)=COEF3*CHIS2+Z0(I)                                         BRE04230
   ISN 0058           CALL MDHNKL(Z0(I),H10(I),H2(I),H1P(I),H2P(I))                   BRE04240
   ISN 0059           CALL MDHNKL(Z1(I),H11(I),H2(I),H1P(I),H2P(I))                   BRE04250
   ISN 0060           CALL MDHNKL(Z2(I),H12(I),H2(I),H1P(I),H2P(I))                   BRE04260
   ISN 0061           HGFP(I)=H11(I)*H12(I)/H10(I)**2                                 BRE04270
   ISN 0062           EXPR(I)=REAL(J*TAU(I)*CHI)                                      BRE04280
   ISN 0063           EXPIM(I)=AIMAG(J*TAU(I)*CHI)                                    BRE04290
   ISN 0064           IF(EXPR(I).LT.-170.) GO TO 160                                  BRE04300
   ISN 0066           X1(I)=EXP(EXPR(I))                                              BRE04310
   ISN 0067           X2(I)=CABS(2.*TAU(I)-1./DELTA**2)                               BRE04320
   ISN 0068           IF((ALOG10(X1(I))-ALOG10(X2(I))).LT.-74.) GO TO 160             BRE04330
   ISN 0070           E(I)=(752./DLOS)*SQRT(CHI)*HGFP(I)*CEXP(J*TAU(I)*CHI)/          BRE04340
                     1(2.*TAU(I)-1./DELTA**2)                                          BRE04350
   ISN 0071           GO TO 170                                                       BRE04360
   ISN 0072         160 E(I) = (0.,0.)                                                BRE04370
   ISN 0073         170 CONTINUE                                                      BRE04380
                  C     PRINT 171,POLAR,I,E(I)                                        BRE04390
                  C 171 FORMAT(5X,'***** POLAR =',F5.1,5X,'E(',I2,')=',2G12.6)      BRE04400
   ISN 0074         175 CONTINUE                                                      BRE04410
                  C                                                                   BRE04420
                  C     SUM E VECTOR COMPONENTS                                       BRE04430
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                C                                                                BRE04440
   ISN 0075             F1=F(1)                                                  BRE04450
   ISN 0076             DO 180 I = 2,15                                          BRE04460
   ISN 0077             F1=F1+F(I)                                               BRE04470
   ISN 0078             F3=CABS(F1)*1.E03                                        BRE04480
   ISN 0079             IF(F3.LT.1.E-03) GO TO 200                               BRE04490
   ISN 0081           180 CONTINUE                                               BRE04500
   ISN 0082           200 CONTINUE                                               BRE04510
   ISN 0083             IF(POLAR.GT.0.) GO TO 220                                BRE04520
                C                                                                BRE04530
                C       SET UP FOR VERTICAL POLARIZATION                         BRE04540
                C                                                                BRE04550
   ISN 0085             FH = F3                                                  BRE04560
   ISN 0086             POLAR = 1.                                               BRE04570
   ISN 0087             PSY = ATAN(EPSLON/WRK) - ATAN((EPSLON - 1.)/WRK)/2.      BRE04580
   ISN 0088             K = K*SQRT(EPSLON**2 + WRK**2)                           BRE04590
                C       PRINT 124,PSY,K                                          BRE04600
                C 124 FORMAT(5X,'VERTICAL POLARIZATION COMPONENTS'/5X,'PSY=',F10.5,5X,'KBRE04610
                C     .=',F10.5)                                                 BRE04620
   ISN 0089             GO TO 100                                                BRE04630
   ISN 0090           220 CONTINUE                                               BRE04640
                C                                                                BRE04650
                C       SAVE VERTICAL FIELD AND RETURN                           BRE04660
                C                                                                BRE04670
   ISN 0091             EV = F3                                                  BRE04680
                C       PRINT 300,FH,EV                                          BRE04690
                C 300 FORMAT(//5X,'***** F HORIZONTAL',G12.6,5X,'VERTICAL',G12.6//)BRE04700
   ISN 0092             RETURN                                                   BRE04710
   ISN 0093             END                                                      BRE04720

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)

*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

*STATISTICS*      SOURCE STATEMENTS =      92, PROGRAM SIZE =    10142, SUBPROGRAM NAME =GRNDWV

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                  92K BYTES OF CORE NOT USED
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REQUESTED OPTIONS: ID

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)
                   SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

   ISN 0002            SUBROUTINE MOHNKL (Z,H1,H2,H1PRME,H2PRME)                                        BRE04730
                C                                                                                       BRE04740
                C      THIS SUBROUTINE CALCULATES THE MODIFIED HANKEL FUNCTION OF THE                   BRE04750
                C      FIRST KIND AND ORDER ONE-THIRD.CONSULT REFERENCE BELOW FOR                       BRE04760
                C      FURTHER INFORMATION.                                                             BRE04770
                C                                                                                       BRE04780
                C      REFERENCE-TABLES OF THE MODIFIED HANKEL FUNCTIONS OF ORDER ONE-                  BRE04790
                C      THIRD AND OF THEIR DERIVATIVES.                                                  BRE04800
                C      STAFF OF THE COMPUTATION LABORATORY AT CAMBRIDGE, MASS.                          BRE04810
                C      HARVARD UNIVERSITY, 1945.                                                        BRE04820
                C                                                                                       BRE04830
                C                                                                                       BRE04840
   ISN 0003            IMPLICIT REAL *8 (A-H,O-Z)                                                       BRE04850
   ISN 0004            COMPLEX*16 Z,I,H1,H2,H1PRME,H2PRME,ZPOWER,TERM1,TERM2,                           BRE04860
                      $           TERM3,ZTERM,TERM,SUM1,SUM2,SUM3,SUM4,SQRTZR,                          BRE04870
                      $           EXP1,EXP2,EXP3,EXP4,EXP5,GM2F,GPMFP,MPOWER,BETA,RTZ,                  BRE04880
                      $           CONST1,CONST2,CONST3,CONST4                                           BRE04890
   ISN 0005            DIMENSION A(23), B(23), C(23), D(23), CAP(14)                                    BRE04900
   ISN 0006            DATA A/                                                                          BRE04910
                      $   9.30436716930000D-01,3.10145572309700D 01,2.06763714873160D 02,BRE04920
                      $   5.74343652425450D 02,8.70217655190080D 02,8.28778719228640D 02,BRE04930
                      $   5.41685437404340D 02,2.57945446383020D 02,9.34584950663100D 01,BRE04940
                      $   2.66263518707400D 01,6.12100043005600D 00,1.15928038448000D 00,BRE04950
                      $   1.84012759441000D-01,2.48330309640000D-02,2.88420801000000D-03,BRE04960
                      $   2.91334142000000D-04,2.58274950000000D-05,2.02568600000000D-06,BRE04970
                      $   1.41557000000000D-07,8.87000000000000D-09,5.01000000000000D-10,BRE04980
                      $   2.60000000000000D-11,1.00000000000000D-12/                                   BRE04990
   ISN 0007            DATA B/                                                                          BRE05000
                      $   6.78298725140000D-01,1.13049787524000D 01,5.38332321543100D 01,BRE05010
                      $   1.19629404787350D 02,1.53371031778650D 02,1.27809193148800D 02,BRE05020
                      $   7.47422182157200D 01,3.23559786215200D 01,1.07853128738400D 01,BRE05030
                      $   2.85325737403000D 00,6.13603736351000D-01,1.09376800980000D-01,BRE05040
                      $   1.64229399550000D-02,2.10550512200000D-03,2.33167788000000D-04,BRE05050
                      $   2.25282890000000D-05,1.91567100000000D-06,1.44470000000000D-07,BRE05060
                      $   9.72900000000000D-09,5.89000000000000D-10,3.20000000000000D-11,BRE05070
                      $   2.00000000000000D-12,0.00000000000000D 00/                                   BRE05080
   ISN 0008            DATA C/                                                                          BRE05090
                      $   4.65218358460000D-01,6.20291144619000D 00,2.58454643591500D 01,BRE05100
                      $   5.22130593114000D 01,6.21584039421500D 01,4.87516893663900D 01,BRE05110
                      $   2.70842718702200D 01,1.12150194079600D 01,3.59455750255000D 00,BRE05120
                      $   9.18150064510000D-01,1.91281263439000D-01,3.31222966900000D-02,BRE05130
                      $   4.84244103800000D-03,6.05683682000000D-04,6.55501820000000D-05,BRE05140
                      $   6.19859000000000D-06,5.16550000000000D-07,3.82200000000000D-08,BRE05150
                      $   2.52800000000000D-09,1.50000000000000D-10,8.00000000000000D-12,BRE05160
                      $   0.00000000000000D 00,0.00000000000000D 00/                                   BRE05170
   ISN 0009            DATA D/                                                                          BRE05180
                      $   6.78298725140000D-01,4.52199150096200D 01,3.76832625801500D 02,BRE05190
                      $   1.19629404787350D 03,1.99382341312250D 03,2.04494709038206D 03,BRE05200
                      $   1.42010214609865D 03,7.11830649673510D 02,2.69632821846030D 02,BRE05210
                      $   7.98912064729000D 01,1.90217158268800D 01,3.71881052333900D 00,BRE05220
                      $   6.07648778323000D-01,8.42202048960000D-02,1.00262148690000D-02,BRE05230
                      $   1.03630127800000D-03,9.38678690000000D-05,7.51243500000000D-06,BRE05240
                      $   5.35074000000000D-07,3.41350000000000D-08,1.96200000000000D-09,BRE05250
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                     $   1.020000000000000D-10,5.000000000000000D-12/                    BRE05260
ISN 0010                 DATA CAP/                                                       BRE05270
                     $   1.041666666666670D-01,8.355034722222220D-02,1.282265745563270D-01,BRE05280
                     $   2.918490264641400D-01,8.816272674437580D-01,3.321408281862770D 00,BRE05290
                     $   1.499576298686260 01,7.892301301158700 01,4.744515386800000 02,BRE05300
                     $   3.207490091000000D 03,2.408654960000000D 04,1.989231200000000 05,BRE05310
                     $   1.791902000000000 06,1.748437700000000D 07/                     BRE05320
                 C                                                                       BRE05330
ISN 0011                 DATA I/(0.,1.)/                                                 BRE05340
ISN 0012                 DATA ROOT3/1.732050807568880 00/                                BRE05350
ISN 0013                 DATA ALPHA/8.536672188389510-01/                                BRE05360
ISN 0014                 DATA CONST1/( 2.588190451025220-01,-9.659258262890670-01)/      BRE05370
ISN 0015                 DATA CONST2/( 2.588190451025220-01, 9.659258262890670-01)/      BRE05380
ISN 0016                 DATA CONST3/(-9.659258262890670-01, 2.588190451025220-01)/      BRE05390
ISN 0017                 DATA CONST4/(-9.659258262890670-01,-2.588190451025220-01)/      BRE05400
                 C                                                                       BRE05410
ISN 0018                 ZPOWER=1.0                                                      BRE05420
ISN 0019                 SUM3=0.0                                                        BRE05430
ISN 0020                 SUM4=0.0                                                        BRE05440
ISN 0021                 ZMAG=CDABS(Z)                                                   BRE05450
ISN 0022                 IF(ZMAG .GT. 4.2) GO TO 70                                      BRE05460
ISN 0024                 IF(ZMAG .GE. 3.2) GO TO 10                                      BRE05470
ISN 0026                 N=12                                                            BRE05480
ISN 0027                 GO TO 30                                                        BRE05490
ISN 0028             10  IF(ZMAG .GE. 4.1) GO TO 20                                      BRE05500
ISN 0030                 N=15                                                            BRE05510
ISN 0031                 GO TO 30                                                        BRE05520
ISN 0032             20  N=23                                                           BRE05530
ISN 0033             30  SUM1=0.                                                        BRE05540
ISN 0034                 SUM2=0.                                                         BRE05550
ISN 0035                 ZTERM=-Z**3/200.0                                               BRE05560
ISN 0036                 DO 50 M=1,N                                                     BRE05570
ISN 0037                 SUM1=SUM1+A(M)*ZPOWER                                           BRE05580
ISN 0038                 SUM2=SUM2+B(M)*ZPOWER                                           BRE05590
ISN 0039                 SUM3=SUM3+C(M)*ZPOWER                                           BRE05600
ISN 0040                 SUM4=SUM4+D(M)*ZPOWER                                           BRE05610
ISN 0041                 ZPOWER=ZPOWER*ZTERM                                             BRE05620
ISN 0042                 IF(CDABS(ZPOWER) .LE. 1.0D-30) GO TO 60                         BRE05630
ISN 0044             50  CONTINUE                                                       BRE05640
ISN 0045             60  GM2F=I*(Z*SUM2-2.*SUM1)/ROOT3                                 BRE05650
ISN 0046                 GPMFP=I*(SUM4+2.*Z*Z*SUM3)/ROOT3                                BRE05660
ISN 0047                 H1=Z*SUM2+GM2F                                                  BRE05670
ISN 0048                 H2=H1-2.0*GM2F                                                  BRE05680
ISN 0049                 H1PRME=SUM4+GPMFP                                               BRE05690
ISN 0050                 H2PRME=H1PRME-2.0*GPMFP                                         BRE05700
ISN 0051                 RETURN                                                          BRE05710
                 C                                                                       BRE05720
ISN 0052             70  SUM1=1.0                                                       BRE05730
ISN 0053                 SUM2=1.0                                                        BRE05740
ISN 0054                 RTZ=CDSQRT(Z)                                                   BRE05750
ISN 0055                 SQRTZB=RTZ*Z                                                    BRE05760
ISN 0056                 ZTERM=I/SQRTZB                                                  BRE05770
ISN 0057                 MPOWER=1.0                                                      BRE05780
ISN 0058                 TERM=-1.5/Z                                                     BRE05790
ISN 0059                 DO 80 M=1,14                                                    BRE05800
ISN 0060                 ZPOWER=ZPOWER*ZTERM                                             BRE05810
ISN 0061                 MPOWER=MPOWER*(-ZTERM)                                          BRE05820
ISN 0062                 TERM1=CAP(M)*ZPOWER                                             BRE05830
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   ISN 0063            TERM2=CAP(M)*MPOWER                                          BRE05840
   ISN 0064            SUM1=SUM1+TERM1                                              BRE05850
   ISN 0065            SUM2=SUM2+TERM2                                              BRE05860
   ISN 0066            SUM3=SUM3+M*TERM1                                            BRE05870
   ISN 0067            SUM4=SUM4+M*TERM2                                            BRE05880
   ISN 0068      80    CONTINUE                                                     BRE05890
   ISN 0069            SUM3=SUM3*TERM                                               BRE05900
   ISN 0070            SUM4=SUM4*TERM                                               BRE05910
   ISN 0071            EXP1=CDEXP(2.*I*SQRT2R/3.)                                   BRE05920
   ISN 0072            EXP2=EXP1*CONST1                                             BRE05930
   ISN 0073            EXP3=CONST2/EXP1                                             BRE05940
   ISN 0074            EXP4=CONST3*EXP1                                             BRE05950
   ISN 0075            EXP5=CONST4/EXP1                                             BRE05960
   ISN 0076            BETA=ALPHA/CDSQRT(RTZ)                                       BRE05970
   ISN 0077            ZREAL=Z                                                      BRE05980
   ISN 0078            ZIMAG=-I*Z                                                   BRE05990
   ISN 0079            IF (ZREAL.GE.0.0.OR.ZIMAG.GE.0.0)GO TO 90                    BRE06000
   ISN 0081            H1=BETA*(EXP2*SUM2+EXP5*SUM1)                                BRE06010
   ISN 0082            H1PRME=BETA*(EXP2*(SUM2*(-0.25/Z+I*RTZ)+SUM4)+EXP5*(SUM1*(-0.25/Z BRE06020
                      $       -I*RTZ)+SUM3))                                        BRE06030
   ISN 0083            GO TO 110                                                    BRE06040
   ISN 0084      90    H1=BETA*EXP2*SUM2                                            BRE06050
   ISN 0085            H1PRME=BETA*EXP2*(SUM2*(-0.25/Z+I*RTZ)+SUM4)                 BRE06060
   ISN 0086      110   IF (ZREAL.GE.0.0.OR.ZIMAG.LT.0.0)GO TO 120                   BRE06070
   ISN 0088            H2=BETA*(EXP3*SUM1+EXP4*SUM2)                                BRE06080
   ISN 0089            H2PRME=BETA*(EXP3*(SUM1*(-0.25/Z-I*RTZ)+SUM3)+EXP4*(SUM2*(-0.25/Z BRE06090
                      $       +I*RTZ)+SUM4))                                        BRE06100
   ISN 0090            RETURN                                                       BRE06110
   ISN 0091      120   H2=BETA*EXP3*SUM1                                            BRE06120
   ISN 0092            H2PRME=BETA*EXP3*(SUM1*(-0.25/Z-I*RTZ)+SUM3)                 BRE06130
   ISN 0093            RETURN                                                       BRE06140
   ISN 0094            END                                                          BRE06150

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)

*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

*STATISTICS*      SOURCE STATEMENTS =      93, PROGRAM SIZE =     6642, SUBPROGRAM NAME =MDHNKL

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                  96K BYTES OF CORE NOT USED
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REQUESTED OPTIONS: ID

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)
                   SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

   ISN 0002            SUBROUTINE ASGEPS(SEGSIZ,ISGCNT,XLOC,YLOC,DIR,WVEL,SOUT,EOUT)      BRE06160
   ISN 0003            COMMON ERTHR,PI,RAD,DEG,PIBY2,TWOPI,REFIND,FREQ                    BRE06170
   ISN 0004            COMMON /BON/ LONG,LAT,GAMMA,GMT,IO                                 BRE06180
   ISN 0005            REAL LONG, LAT                                                     BRE06190
   ISN 0006            EPSLON = 0.                                                        BRE06200
   ISN 0007            SIGMA = 0.                                                         BRE06210
   ISN 0008            PTHDST = 0.                                                        BRE06220
   ISN 0009            DLAT = XLOC                                                        BRE06230
   ISN 0010            DLONG = YLOC                                                       BRE06240
   ISN 0011            DO 100 KCNT = 1, ISGCNT                                            BRE06250
   ISN 0012            LAT = DLAT*RAD                                                     BRE06260
   ISN 0013            LONG = DLONG*RAD                                                   BRE06270
   ISN 0014            CALL NWOMAP                                                        BRE06280
   ISN 0015            CALL ESGEPS(GAMMA,XSIG,XEPS,WVEL)                                  BRE06290
   ISN 0016            PRINT 115,DLAT,DLONG,XSIG,XEPS                                     BRE06300
   ISN 0017            SIGMA = SIGMA + XSIG                                               BRE06310
   ISN 0018            EPSLON = EPSLON + XEPS                                             BRE06320
   ISN 0019            PTHDST = PTHDST + SEGSIZ                                           BRE06330
   ISN 0020            CALL COOR(XLOC,YLOC,DIR,PTHDST,DLAT,DLONG)                         BRE06340
   ISN 0021        100 CONTINUE                                                           BRE06350
   ISN 0022            SOUT = SIGMA/ISGCNT                                                BRE06360
   ISN 0023            EOUT = EPSLON/ISGCNT                                               BRE06370
   ISN 0024            DLAT = 99999.9999                                                  BRE06380
   ISN 0025            DLONG = DLAT                                                       BRE06390
   ISN 0026            PRINT 115,DLAT,DLONG,SOUT,EOUT                                     BRE06400
   ISN 0027        115 FORMAT(15X,4(5X,F10.4))                                            BRE06410
   ISN 0028            RETURN                                                             BRE06420
   ISN 0029            END                                                                BRE06430

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)

*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

*STATISTICS*     SOURCE STATEMENTS =      28, PROGRAM SIZE =     878, SUBPROGRAM NAME =ASGEPS

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                  124K BYTES OF CORE NOT USED
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REQUESTED OPTIONS: ID

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)
                   SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

   ISN 0002            SUBROUTINE FSGEPS(GAMMA,SIGMA,EPSLON,WNDVEL)                    BRE06440
   ISN 0003            IF(GAMMA.LT.0.25) GO TO 15                                      BRE06450
   ISN 0005            IF(GAMMA.GT.0.75) GAMMA = 0.75                                  BRE06460
   ISN 0007            SIGMA = 7.4995 - 9.998*GAMMA                                    BRE06470
   ISN 0008            EPSLON = 118 - 152*GAMMA                                        BRE06480
   ISN 0009            GO TO 20                                                        BRE06490
   ISN 0010         15 IF(GAMMA.GE.-0.25) GAMMA = -0.25                                BRE06500
   ISN 0012            IF(GAMMA.LE.-0.75) GAMMA = -0.75                                BRE06510
   ISN 0014            SIGMA = 7.49995 + 9.9998*GAMMA                                  BRE06520
   ISN 0015            EPSLON = 118 + 152*GAMMA                                        BRE06530
   ISN 0016         20 CONTINUE                                                        BRE06540
   ISN 0017            IF(SIGMA.GT.2.0) GO TO 25                                       BRE06550
   ISN 0019            RETURN                                                          BRE06560
   ISN 0020         25 CONTINUE                                                        BRE06570
   ISN 0021            BETA = 2.635E-03 + WNDVEL*8.784E-05                             BRE06580
   ISN 0022            SIGMA = 2.778E-05/(BETA**2)                                     BRE06590
   ISN 0023            RETURN                                                          BRE06600
   ISN 0024             END                                                            BRE06610

*OPTIONS IN EFFECT*NAME(MAIN), NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)

*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

*STATISTICS*      SOURCE STATEMENTS =      23, PROGRAM SIZE =      600, SUBPROGRAM NAME =FSGEPS

*STATISTICS*  NO  DIAGNOSTICS GENERATED

***** END OF COMPILATION *****                                  124K BYTES OF CORE NOT USED
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REQUESTED OPTIONS: ID

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)
                   SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

   ISN 0002            SUBROUTINE CPOWER(P,TP,ALPSUM)                                    BRE06630
                  C...CALCULATES TOTAL RECEIVED COMPENSATED POWER(BOTH POLAR.)           BRE06640
                  C...AND ALL MODE POWER SUM                                             BRE06650
   ISN 0003            COMMON T,FACHNZ,FR,DT,DR,RHT,VNOIZ,THT                            BRE06660
   ISN 0004            COMMON /SWITCH/ KSW1,KSW2,JF,IBETA                                BRE06670
   ISN 0005            COMMON /SAVSIG/ HIRAYP                                            BRE06680
   ISN 0006            COMMON /ANTDAT/TABL1V(181,8),TABL1H(181,8),TABL2V(181,8),         BRE06690
                      *     TABL2H(181,8),OFFSET                                         BRE06700
   ISN 0007            COMMON /SPPASS/ IANT,ANTFIL,VGTOT,RGTOT,HGTOT                     BRE06710
   ISN 0008            DATA CRIT/-1.0E74/,DOUT/3HDIR/,ROUT/4HREFL/                       BRE06720
   ISN 0009            DIMENSION PVAL(4)                                                 BRE06730
   ISN 0010            EQUIVALENCE (PVAL(1),CRPREV), (PVAL(2),CRPREH), (PVAL(3),CRPDRV), BRE06740
                      $   (PVAL(4),CRPDRH)                                               BRE06750
   ISN 0011            DATA CRPDRV, CRPDRH, CRPREV, CRPREH /4*-1.0E75/                   BRE06760
   ISN 0012            REAL HNOIZ                                                        BRE06770
                  C...INPUT DATA FROM FILE JF                                            BRE06780
                  C...DBV,DBH,DBL=UNCOMPENSATED POWER FOR VERTICAL AND HORIZONTAL        BRE06790
                  C  POLARIZATION(REFLECTED OR GROUND), BOTH POLARIZATIONS(LINE OF SIGHT) BRE06800
                  C...TBD,RBD=RAY ANGLE OF DIRECT OR GROUNDWAVE(TRANS,REC)               BRE06810
                  C...TBR,RBR=RAY ANGLE OF REFLECTED(TRANS,REC)                          BRE06820
   ISN 0013            READ(JF,910) KSW,DBV,DBH,DBL,TBD,TBR,RBD,RBR                      BRE06830
   ISN 0014          910 FORMAT(A1,3G12.6,4F10.3)                                        BRE06840
   ISN 0015            PRINT 911                                                         BRE06850
   ISN 0016            PRINT 912,KSW,DBV,DBH,DBL,TBD,TBR,RBD,RBR                         BRE06860
   ISN 0017          911 FORMAT(3X,3HKSW,6X,3HDBV,11X,3HDBH,11X,3HDBL,                   BRE06870
                     *11X,3HTBD,11X,3HTBR,11X,3HRBD,11X,3HRBR)                         BRE06880
   ISN 0018          912 FORMAT(4X,A1,1X,7(1X,G13.6))                                    BRE06890
                  C...DIRECT RAY CALCULATIONS (IF DBL .GT. CRIT)                         BRE06900
                  C   #####     DEBUG                                                    BRE06910
                  C                                                                      BRE06920
   ISN 0019            PRINT 950                                                         BRE06930
   ISN 0020          950 FORMAT(//8X,'DB FROM BREM',12X,'P',12X,'TRANSMITTER GN ',6X,   BRE06940
                      $   'RECEIVER GAIN',4X,'COMPENSATED POWER'//)                     BRE06950
   ISN 0021          951 FORMAT(5(5X,F15.7))                                             BRE06960
   ISN 0022            IF(DBL.LE.CRIT)GO TO 10                                           BRE06970
                  C...CALCULATE GAINS AND COMPENSATED RECEIVED POWER                     BRE06980
   ISN 0024            GDIRTV= 10.0*ALOG10(F1(TBD,TABL1V,1))                             BRE06990
   ISN 0025            GDIRRV= 10.0*ALOG10(F1(RBD,TABL2V,2))                             BRE07000
   ISN 0026            CRPDRV=DBL+P+GDIRTV+GDIRRV                                        BRE07010
   ISN 0027            PRINT 951, DBL, P, GDIRTV, GDIRRV, CRPDRV                         BRE07020
   ISN 0028            GDIRTH= 10.0*ALOG10(F1(TBD,TABL1H,1))                             BRE07030
   ISN 0029            GDIRRH= 10.0*ALOG10(F1(RBD,TABL2H,2))                             BRE07040
   ISN 0030            CRPDRH=DBL+P+GDIRTH+GDIRRH                                        BRE07050
   ISN 0031            PRINT 951, DBL, P, GDIRTH, GDIRRH, CRPDRH                         BRE07060
   ISN 0032         10 CONTINUE                                                          BRE07070
                  C...REFLECTED RAY OR GROUND WAVE CALCULATIONS (IF DBV.GT.CRIT)         BRE07080
   ISN 0033            IF(DBV.LE.CRIT)GO TO 20                                           BRE07090
                  C...CALCULATE GAINS AND COMPENSATION                                   BRE07100
   ISN 0035            GTV= 10.0*ALOG10(F1(TBR,TABL1V,1))                                BRE07110
   ISN 0036            GRV= 10.0*ALOG10(F1(RBR,TABL2V,2))                                BRE07120
   ISN 0037            CRPREV=DBV+P+GTV+GRV                                              BRE07130
   ISN 0038            PRINT 951, DBV, P, GTV, GRV, CRPREV                               BRE07140
   ISN 0039         20 CONTINUE                                                          BRE07150
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                C...REFLECTED RAY OR GROUND WAVE CALCULATIONS (IF DBH.GT.CRIT)          BRE07160
  ISN 0040            IF(DBH.LE.CRIT)GO TO 30                                       BRE07170
                C...CALCULATE GAINS AND COMPENSATION                                  BRE07180
  ISN 0042            GTH= 10.0*ALOG10(F1(TBR,TABL1H,1))                            BRE07190
  ISN 0043            GRH= 10.0*ALOG10(F1(RBR,TABL2H,2))                            BRE07200
  ISN 0044            CRPREH=DBH+P+GTH+GRH                                          BRE07210
  ISN 0045            PRINT 951, DBH, P, GTH, GRH, CRPREH                           BRE07220
  ISN 0046          30 CONTINUE                                                     BRE07230
                C                                                                   BRE07240
                C      SET UP FOR COMPUTATION OF TOTAL COMPENSATED POWER BY         BRE07250
                C       ADDITION OF COMPONENTS NOT MORE THAN 100 DB DOWN FROM       BRE07260
                C       MOST SIGNIFICANT COMPONENT                                  BRE07270
                C                                                                   BRE07280
  ISN 0047            PLARGE = -1.0E75                                              BRE07290
  ISN 0048            PSMALL = 1.0E75                                               BRE07300
  ISN 0049            DO 50 I = 1,4                                                 BRE07310
  ISN 0050            IF(PVAL(I).GT.PLARGE) PLARGE = PVAL(I)                        BRE07320
  ISN 0052            IF(PVAL(I).LT.PSMALL) PSMALL = PVAL(I)                        BRE07330
  ISN 0054          50 CONTINUE                                                     BRE07340
  ISN 0055            DIF = PLARGE - PSMALL                                         BRE07350
  ISN 0056            IF(DIF.LE.100.00) GO TO 55                                    BRE07360
  ISN 0058            PSMALL = PLARGE - 100.00                                      BRE07370
  ISN 0059          55 CONTINUE                                                     BRE07380
                C                                                                   BRE07390
                C      RESET ORIGIN TO PREVENT OVERFLOW/UNDERFLOW                   BRE07400
                C                                                                   BRE07410
  ISN 0060            LBASE = PSMALL                                                BRE07420
  ISN 0061            TPCOMP = 0.00                                                 BRE07430
  ISN 0062            DO 100 I = 1,4                                                BRE07440
  ISN 0063            IF(PVAL(I).LT.PSMALL) GO TO 100                               BRE07450
  ISN 0065            DIF = PVAL(I) - LBASE                                         BRE07460
                C                                                                   BRE07470
                C    DEBUG                                                          BRE07480
                C      PRINT 94, I, PVAL(I), DIF                                    BRE07490
                C   94 FORMAT(/'*****     PVAL',I2,2X,G15.6,'   USING DIF = ',G15.6) BRE07500
                C                                                                   BRE07510
                C      CONVERT DB TO POWER AND ADD                                  BRE07520
                C                                                                   BRE07530
  ISN 0066            TPCOMP = TPCOMP + 10.00**(DIF/10.00)                          BRE07540
                C      PRINT 966, TPCOMP                                            BRE07550
                C 966 FORMAT(//10X,'*****     TPCOMP NOW = ',G15.6//)               BRE07560
  ISN 0067          100 CONTINUE                                                    BRE07570
                C                                                                   BRE07580
                C      CONVERT POWER TO DB AND CORRECT ORIGIN FOR TOTAL POWER       BRE07590
                C                                                                   BRE07600
  ISN 0068            TP = LBASE + 10.00*ALOG10(TPCOMP)                             BRE07610
                C  .....     CALCULATE ALL MODE POWER SUM .....                     BRE07620
  ISN 0069            IF(HIRAYP.GT.TP) GO TO 120                                    BRE07630
  ISN 0071            DIF = TP - HIRAYP                                             BRE07640
  ISN 0072            IF(DIF.LE.100.00) GO TO 110                                   BRE07650
  ISN 0074            ALPSUM = TP                                                   BRE07660
  ISN 0075            GO TO 150                                                     BRE07670
  ISN 0076          110 CONTINUE                                                    BRE07680
  ISN 0077            LBASE = HIRAYP                                                BRE07690
  ISN 0078            GO TO 140                                                     BRE07700
  ISN 0079          120 CONTINUE                                                    BRE07710
  ISN 0080            DIF = HIRAYP - TP                                             BRE07720
  ISN 0081            IF(DIF.LE.100.00) GO TO 130                                   BRE07730
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ISN 0083            ALPSUM = HIRAYP                                                 BRE07740
ISN 0084            GO TO 150                                                       BRE07750
ISN 0085          130 CONTINUE                                                      BRE07760
ISN 0086            LBASE = TP                                                      BRE07770
ISN 0087          140 CONTINUE                                                      BRE07780
ISN 0088            TPCOMP = 10.00**((TP - LBASE)/10.00)                            BRE07790
ISN 0089            TPCOMP = TPCOMP + 10.00**((HIRAYP - LBASE)/10.00)               BRE07800
ISN 0090            ALPSUM = 10.00*ALOG10(TPCOMP) + LBASE                           BRE07810
ISN 0091          150 CONTINUE                                                      BRE07820
                  C                                                               BRE07830
                  C   CALCULATE CORRECTED NOISE POWER AND S/N RATIO               BRE07840
                  C                                                               BRE07850
ISN 0092            CONHNZ = (1.00 - EXP( -FACHNZ*PHT))*(HGTOT/RGTOT)               BRE07860
ISN 0093            CONVNZ = VGTOT/RGTOT                                            BRE07870
                  C                                                               BRE07880
                  C   DEBUG OUTPUT .....                                          BRE07890
                  C                                                               BRE07900
                  C     PRINT 924, HGTOT,VGTOT,RGTOT,CONHNZ,CONVNZ                BRE07910
ISN 0094            TNOIZ = VNOIZ + 10.0*ALOG10(CONVNZ + CONHNZ)                    BRE07920
ISN 0095            CTOSNR = ALPSUM + TNOIZ                                         BRE07930
ISN 0096            PRINT 925                                                       BRE07940
ISN 0097            PRINT 930,(PVAL(I),I = 1,4),HIRAYP,VNOIZ,TNOIZ,CTOSNR           BRE07950
ISN 0098            PRINT 945                                                       BRE07960
ISN 0099            PRINT 902                                                       BRE07970
ISN 0100            RETURN                                                          BRE07980
ISN 0101          902 FORMAT (1H ,7X,3HGMT,3X,4HTIME,3X,4HFREQ,3X,6HNMODES,4X,3HMGT,  BRE07990
                     * 8X,7H2*SIGMA,8X,6HSIGNAL,9X,3HS/N,11X,5HEFPL ,8X,8H(S/N)MAX /  BRE08000
                     * 1H ,13X,5H(SEC),19X,4H(MS),8X,4H(MS),10X,6H(-DBW),9X,4H(DB),   BRE08010
                     * 10X,4H(DB),10X,4H(DB) //)                                    BRE08020
ISN 0102          924 FORMAT(//10X,'DEBUG',10(4H****),/20X,                         BRE08030
                     1   '  HGTOT         VGTOT         RGTOT         CONHNZ        CONVNZ',BRE08040
                     2   /20X,5(G10.5,3X),//15X,10(4H****))                        BRE08050
ISN 0103          925 FORMAT( /35X,15(4H****),//45X,'SIGNAL ANALYSIS INCLUDING BREM ',  BRE08060
                     1   'ANALYSIS',//10X,'GROUND OR REFLECTED',18X,'DIRECT',14X,    BRE08070
                     2   'IONOSPHERIC',5X,'VERTICAL',7X,'CORRECTED',6X,'CORRECTED',/8X,  BRE08080
                     3   2(1X,'VERTICAL',6X,'HORIZONTAL',5X),'SIGNAL SUM',7X,'NOISE',  BRE08090
                     4   10X,'NOISE',8X,'ALL MODE',/5X,5(6X,'DBW',6X),2(5X,'-DBW',6X),  BRE08100
                     5   3X,'S/N RATIO',//)                                        BRE08110
ISN 0104          930 FORMAT(9X,8(G12.6,3X)/)                                       BRE08120
ISN 0105          945 FORMAT(5X,30(4H****)//)                                       BRE08130
ISN 0106            END                                                             BRE08140
```

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NUMBER  LEVEL                    FORTRAN H EXTENDED ERROR MESSAGES

IFE307I  4(W)     NAME BBOOUT    THE DATA STATEMENT CONTAINS A VARIABLE THAT IS NOT REFERENCED.
IFE307I  4(W)     NAME BBOUT     THE DATA STATEMENT CONTAINS A VARIABLE THAT IS NOT REFERENCED.

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)

*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

*STATISTICS*     SOURCE STATEMENTS =     105, PROGRAM SIZE =     3474, SUBPROGRAM NAME =CPOWER

*STATISTICS*    2 DIAGNOSTICS GENERATED, HIGHEST SEVERITY CODE IS  4

****** END OF COMPILATION ******                                    104K BYTES OF CORE NOT USED
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REQUESTED OPTIONS: ID

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)
SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

```
ISN 0002            FUNCTION F1(X,TABL,NPAT)                                    BRE08150
                C                                                               BRE08160
                C       CALIBRATE THE ANTENNA.  IF THE ANTENNA CALIBRATION TABLES ARE  BRE08170
                C       NOT READ IN, SENSE SWITCH 1 IS ON AND THE ANTENNA GAIN WITH    BRE08180
                C       RESPECT TO ISOTROPIC IS SET TO 1.                       BRE08190
                C                                                               BRE08200
                C                                                               BRE08210
                C         VARIABLES WHICH ARE READ IN FROM CARDS                BRE08220
                C                                                               BRE08230
ISN 0003            COMMON T,M,FR,DT,DR,PL,N,PT1,TAU(60),GMT,BAUD,P             BRE08240
                C                                                               BRE08250
                C         VARIABLES WHICH ARE COMPUTED                          BRE08260
                C                                                               BRE08270
ISN 0004            COMMON LIMIT,NTIME,NFREQ,OLDT,OLDFR,OLDGMT,S1,S2,K,N1,NCDS  BRE08280
                C                                                               BRE08290
                C         VARIABLE ARRAYS                                       BRE08300
                C                                                               BRE08310
ISN 0005            COMMON PT(1000,3),A(1000),PHASET(1000),TAUS(1000),          BRE08320
                   *       MODE(60),TIME(30),FREQ(30),                          BRE08330
                   *       SIGTAU(20,20),SIGNOI (20,20)                         BRE08340
ISN 0006            COMMON /ANTDAT/ TABL1V(181,8),TABL1H(181,8),TABL2V(181,8),  BRE08350
                   *TABL2H(181,8),MXANGL(2),MNANGL(2),KRXN(2),NANGLS(2)         BRE08360
ISN 0007            COMMON /SPPASS/NUMF                                         BRE08370
ISN 0008            COMMON/SWITCH/KSW1,KSW2,JF,IBETA                            BRE08380
ISN 0009            INTEGER*4 GMT, OLDGMT, OFFSET                               BRE08390
ISN 0010            REAL N, MODE,M                                              BRE08400
ISN 0011            DIMENSION TABL(181,8)                                       BRE08410
ISN 0012            COMMON /DATA/ C2, FOURPI,  EFPL, TABLFR(15), ISW, MX1, IDEBUG  BRE08420
ISN 0013            DATA MESPRT /0/                                             BRE08430
ISN 0014            NAMELIST /INTRPL/ IANGL,KANGL,DELNGL,DELFR,G1,G2,F1         BRE08440
                C                                                               BRE08450
                C   IF ANTENNA CALIBRATION TABLES WERE NOT READ IN USE ISOTROPIC 1.00  BRE08460
                C                                                               BRE08470
ISN 0015            IF(KSW1.EQ.0) GO TO 100                                     BRE08480
ISN 0017            IF(MESPRT.GT.0) GO TO 50                                    BRE08490
ISN 0019            MESPRT = 1                                                  BRE08500
ISN 0020            PRINT 905                                                   BRE08510
ISN 0021         50 CONTINUE                                                    BRE08520
ISN 0022            F1 = 1.00                                                   BRE08530
ISN 0023            RETURN                                                      BRE08540
ISN 0024        100 CONTINUE                                                    BRE08550
ISN 0025            LFR = 1                                                     BRE08560
ISN 0026            IFR = 1                                                     BRE08570
ISN 0027            DELFR = 0.00                                                BRE08580
                C    FIRST CASE ONLY ONE FREQUENCY PROVIDED --                  BRE08590
                C       NO INTERPOLATION ON FREQUENCY                           BRE08600
                C                                                               BRE08610
ISN 0028            IF(NUMF.EQ.1) GO TO 200                                     BRE08620
                C                                                               BRE08630
                C   IF FREQUENCY IS OUT OF RANGE USE ISOTROPIC WITH WARNING     BRE08640
                C                                                               BRE08650
ISN 0030            IF(FR.LT.TABLFR(1).OR.FR.GT.TABLFR(NUMF)) GO TO 500         BRE08660
                C                                                               BRE08670
```

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                C   OTHERWISE BRACKET FREQUENCY AND DETERMINE DELTA (DELFR)                BRE08680
                C                                                                        BRE08690
 ISN 0032             DO 150 I = 2,NUMF                                                  BRE08700
 ISN 0033             IFR = I                                                            BRE08710
 ISN 0034             IF(FR.LE.TABLFR(IFR)) GO TO 160                                    BRE08720
 ISN 0036           150 CONTINUE                                                         BRE08730
 ISN 0037           160 CONTINUE                                                         BRE08740
 ISN 0038             LFR = IFR - 1                                                      BRE08750
 ISN 0039             DELFR = (FR - TABLFR(LFR))/(TABLFR(IFR) - TABLFR(LFR))             BRE08760
 ISN 0040           200 CONTINUE                                                         BRE08770
                C                                                                        BRE08780
                C   OTHERWISE DETERMINE DELTA                                           BRE08790
                C                                                                        BRE08800
 ISN 0041             IANGL = X                                                          BRE08810
                C                                                                        BRE08820
                C     IF X IS LESS THAN ZERO CORRECT IANGLE TO FIT                       BRE08830
                C        INTERPOLATION ASSUMPTIONS...                                    BRE08840
                C                                                                        BRE08850
 ISN 0042             IF(X.LT.0.00) IANGL = IANGL - 1                                    BRE08860
 ISN 0044             DELNGL = X - IANGL                                                 BRE08870
                C                                                                        BRE08880
                C   ADJUST IANGL SO THAT IT POINTS TO CORRECT ROW IN GAIN TABLE.         BRE08890
                C                                                                        BRE08900
 ISN 0045             MINANG = MNANGL(NPAT)                                              BRE08910
 ISN 0046             MAXANG = MXANGL(NPAT)                                              BRE08920
 ISN 0047             NUMANG = NANGLS(NPAT)                                              BRE08930
 ISN 0048             IANGL = IANGL + KRYN(NPAT)                                         BRE08940
 ISN 0049             KANGL = IANGL + 1                                                  BRE08950
                C                                                                        BRE08960
                C   IF ANGLE IS OUT OF RANGE USE ISOTROPIC WITH WARNING                 BRE08970
                C                                                                        BRE08980
 ISN 0050             IF(IANGL.GT.NUMANG.OR.IANGL.LT.1) GO TO 520                        BRE08990
                C                                                                        BRE09000
                C  IF IANGLE IS OK BUT KANGL IS TOO LARGE, F1 = G1                       BRE09010
                C                                                                        BRE09020
 ISN 0052             IF(KANGL.LE.NUMANG) GO TO 240                                      BRE09030
 ISN 0054             DELNGL  = 0.00                                                     BRE09040
 ISN 0055             G2 = 1000000.                                                      BRE09050
 ISN 0056             GO TO 250                                                          BRE09060
 ISN 0057           240 CONTINUE                                                         BRE09070
                C                                                                        BRE09080
                C   BRACKET GAIN                                                        BRE09090
                C                                                                        BRE09100
 ISN 0058             G2 = TABL(KANGL,LFR) + DELFR*(TABL(KANGL,IFR) - TABL(KANGL,LFR))   BRE09110
 ISN 0059           250 CONTINUE                                                         BRE09120
 ISN 0060             G1 = TABL(IANGL,LFR) + DELFR*(TABL(IANGL,IFR) - TABL(IANGL,LFR))   BRE09130
 ISN 0061             F1 = G1 + DELNGL*(G2 - G1)                                         BRE09140
 ISN 0062             IF(IDEBUG.GT.5) WRITE(6,INTRPL)                                    BRE09150
 ISN 0064             RETURN                                                             BRE09160
                C                                                                        BRE09170
                C   ERROR HANDLING                                                      BRE09180
                C                                                                        BRE09190
 ISN 0065           500 CONTINUE                                                         BRE09200
 ISN 0066             PRINT 901, FR, TABLFR(1), TABLFR(NUMF)                             BRE09210
 ISN 0067              GO TO 550                                                         BRE09220
 ISN 0068           520 CONTINUE                                                         BRE09230
 ISN 0069             PRINT 902, X, MAXANG, MINANG                                       BRE09240
 ISN 0070           550 CONTINUE                                                         BRE09250
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LEVEL 2.1  ( JAN 75 )        0000F1          OS/360  FORTRAN H EXTENDED          DATE 77.271/15.32.49       PAGE   3

   ISN 0071            PRINT 905                                                          BRE09260
   ISN 0072            F1 = 1.00                                                          BRE09270
   ISN 0073            RETURN                                                             BRE09280
   ISN 0074         901 FORMAT(//5X,'*****     FREQUENCY',F10.5,                         BRE09290
                     $    '  OUT OF SPECIFIED RANGE:',F10.5,' TO',F10.5)                 BRE09300
   ISN 0075         902 FORMAT(//5X,'*****     ANGLE',F10.5,'  OUT OF SPECIFIED RANGE:',  BRE09310
                     $   I5,'  --  ',I5)                                                  BRE09320
   ISN 0076         905 FORMAT(/10X,'*****     ANTENNA CALIBRATION TABLES NOT USED  *'/)  BRE09330
   ISN 0077            END                                                                BRE09340

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)

*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

*STATISTICS*      SOURCE STATEMENTS =      76, PROGRAM SIZE =     1814, SUBPROGRAM NAME =0000F1

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                          116K BYTES OF CORE NOT USED
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REQUESTED OPTIONS: ID

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)
                   SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

   ISN 0002            SUBROUTINE INITLC                                                    BRE09350
                     C                                                                      BRE09360
                     C       INITIALIZES COUNTERS AND ARRAYS, PRINTS THE IDENTIFICATION     BRE09370
                     C       CARD AND READS THE ANTENNA CALIBRATION TABLES WHEN THEY ARE    BRE09380
                     C       PROVIDED.                                                      BRE09390
                     C                                                                      BRE09400
                     C        DECLARATION STATEMENTS                                        BRE09410
                     C                                                                      BRE09420
                     C        VARIABLES WHICH ARE READ IN FROM CARDS                        BRE09430
                     C                                                                      BRE09440
   ISN 0003            COMMON T,M,ER,DT,DR,PL,N,PT1,TAU(60),GMT,BAUD,P                      BRE09450
                     C                                                                      BRE09460
                     C                                                                      BRE09470
                     C        VARIABLES WHICH ARE COMPUTED                                  BRE09480
                     C                                                                      BRE09490
   ISN 0004            COMMON LIMIT,NTIME,NFREQ,OLDT,OLDER,OLDGMT,S1,S2,K,N1,NCDS           BRE09500
                     C        VARIABLE ARRAYS                                               BRE09510
                     C                                                                      BRE09520
   ISN 0005            COMMON PT(1000,3),A(1000),PHASET(1000),TAUS(1000),                   BRE09530
                      *       MODE(60),TIME(30),FREQ(30),                                   BRE09540
                      *       SIGTAU(20,20),SIGNOI (20,20)                                  BRE09550
   ISN 0006            COMMON /ANTDAT/ TABL1V(181,8),TABL1H(181,8),TABL2V(181,8),           BRE09560
                      *TABL2H(181,8), MXANGL(2),MNANGL(2),KRXN(2),NANGLS(2)                 BRE09570
   ISN 0007            COMMON /CONTRO /  PLREJ                                              BRE09580
   ISN 0008            COMMON /DATA/ C2, FOURPI,  EFPL, TABLER(15), ISW, MX1, IDEBUG        BRE09590
   ISN 0009            COMMON/SWITCH/KSW1,KSW2,JF,IBETA,JCARD,NEWANT                        BRE09600
   ISN 0010            COMMON /SPPASS/ NOFREQ,ANTFIL,VGTOT,RGTOT,HGTOT                      BRE09610
   ISN 0011            NAMELIST /IINIT/ NOFREQ,KSW1,KSW2,JCARD,NEWANT,MXANGT,MXANGR,        BRE09620
                      1    ANTFIL,P,BAUD,PLREJ,IBETA,MNANGT,MNANGR,IDEBUG                   BRE09630
   ISN 0012            DATA BLNK/1H /, NCALLS /0/                                           BRE09640
   ISN 0013            DIMENSION HEADER(7)                                                  BRE09650
   ISN 0014            EQUIVALENCE (MXANGL(1),MXANGT),(MXANGL(2),MXANGR),                   BRE09660
                      1    (MNANGL(1),MNANGT),(MNANGL(2),MNANGR)                            BRE09670
   ISN 0015            REAL*8 HEADER                                                        BRE09680
   ISN 0016            INTEGER*4 OLDGMT,GMT,ANTFIL                                          BRE09690
   ISN 0017            REAL N                                                               BRE09700
   ISN 0018            REAL MODE,M                                                          BRE09710
   ISN 0019            ENTRY INITIA                                                         BRE09720
   ISN 0020            ER = 1.0                                                             BRE09730
   ISN 0021            P = 3.333                                                            BRE09740
   ISN 0022            BAUD = 0.01                                                          BRE09750
   ISN 0023            PLREJ = 0.0                                                          BRE09760
   ISN 0024            ISW=1                                                                BRE09770
   ISN 0025          4 DO 5 I = 1, 20                                                       BRE09780
   ISN 0026            DO 5 J = 1, 20                                                       BRE09790
   ISN 0027            SIGNOI (I,J) = 0.0                                                   BRE09800
   ISN 0028            SIGTAU(I,J) = 99999.0                                                BRE09810
   ISN 0029          5 CONTINUE                                                             BRE09820
                     C                                                                      BRE09830
                     C       IF INPUT POWER AND/OR BAUD LENGTH ARE LESS THAN OR EQUAL TO 0 BRE09840
                     C       ON INPUT CARD, SET POWER TO 3.333 AND/OR BAUD LENGTH TO 0.01. BRE09850
                     C       THESE VALUES DO NOT CHANGE UNTIL RESET BY AN INPUT CARD.      BRE09860
                     C                                                                      BRE09870
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ISN 0030            READ(5,IINIT)                                                BRE09880
ISN 0031            WRITE(6,IINIT)                                               BRE09890
ISN 0032            IF(NOFREQ.GT.8)NOFREQ=8                                      BRE09900
ISN 0034            IF(NOFREQ.LE.0)NOFREQ=1                                      BRE09910
ISN 0036            IF(JCARD.EQ.1)JF=5                                           BRE09920
                    C                                                            BRE09930
                    C   IF KSW1 IS NOT EQUAL TO 0 ANTENNA PATTERNS ARE NOT USED  BRE09940
                    C     WHEN KSW1 IS 0                                         BRE09950
                    C       AND NEWANT IS GREATER THAN 0 A NEW ANTENNA PATTERN IS TO BE READBRE09960
                    C     WHEN KSW1 IS 0                                         BRE09970
                    C       AND NEWANT IS 0 THE LAST ANTENNA PATTERN READ IS TO BE REUSED BRE09980
                    C          UNLESS NCALLS IS 0 INDICATING THAT NO ANTENNA PATTERN WAS BRE09990
                    C            PREVIOUSLY READ .  THEN ANTENNA PATTERNS WILL NOT BE USED. BRE10000
                    C                                                            BRE10010
ISN 0038            6 IF(KSW1 .NE. 0) GO TO 65                                   BRE10020
ISN 0040              IF(NEWANT.GT.0) GO TO 60                                   BRE10030
ISN 0042              IF(NCALLS.GT.0) GO TO 65                                   BRE10040
ISN 0044              KSW1 = 1                                                   BRE10050
ISN 0045              PRINT 935                                                  BRE10060
ISN 0046              GO TO 65                                                   BRE10070
ISN 0047            60 CONTINUE                                                  BRE10080
ISN 0048              NCALLS = NCALLS + 1                                        BRE10090
                    C                                                            BRE10100
                    C   ENTER TRANSMITTER AND RECEIVER ANTENNA GAIN PATTERNS USING BRE10110
                    C      SUBROUTINE RDATNA                                     BRE10120
                    C                                                            BRE10130
                    C   ANTFIL IS A NEW VARIABLE TO ALLOW READING OF PATTERNS FROM DISK OR BRE10140
                    C     TAPE FILES AS WELL AS CARD DECKS.  5 SPACES HAVE BEEN TAKEN BRE10150
                    C     FROM THE FRONT OF KSW1.  IF ANTFIL IS LEFT BLANK OR SET  BRE10160
                    C     EQUAL TO ZERO, AND KSW1 IS BLANK OR ZERO, THEN RDATNA WILL BRE10170
                    C     SET ANTFIL TO 5 AND LOOK FOR THE INPUT ANTENNA PATTERNS ON THE BRE10180
                    C     CARD INPUT FILE.   J. CLARK 11/76                      BRE10190
                    C                                                            BRE10200
ISN 0049            CALL RDATNA                                                  BRE10210
                    C                                                            BRE10220
                    C                                                            BRE10230
                    C         SET MODE AND TIME TABLES TO ZERO                   BRE10240
                    C                                                            BRE10250
ISN 0050            65 DO 70 I = 1, 30                                           BRE10260
ISN 0051              MODE(I) = 0                                                BRE10270
ISN 0052              TIME(I)=0.0                                                BRE10280
ISN 0053              FREQ(I)=0.0                                                BRE10290
ISN 0054            70 CONTINUE                                                  BRE10300
                    C                                                            BRE10310
                    C          INITIALIZE VARIABLES AND COUNTERS                 BRE10320
                    C                                                            BRE10330
ISN 0055              DO 80 J=1,1000                                             BRE10340
ISN 0056            80 A(J) = 0.                                                 BRE10350
ISN 0057              LIMIT = 0                                                  BRE10360
ISN 0058              NTIME=0                                                    BRE10370
ISN 0059              NFREQ = 0                                                  BRE10380
ISN 0060              NCDS = 0                                                   BRE10390
ISN 0061              OLDT=-1.0                                                  BRE10400
ISN 0062              OLDFR=-1.0                                                 BRE10410
ISN 0063              S1=0                                                       BRE10420
ISN 0064              S2=0                                                       BRE10430
ISN 0065              K=0                                                        BRE10440
ISN 0066              N1=0                                                       BRE10450
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ISN 0067            READ (JF,905) HEADER                                        BRE10460
ISN 0068            PRINT 906, HEADER                                           BRE10470
ISN 0069            MX1 = 0                                                     BRE10480
ISN 0070            RETURN                                                      BRE10490
ISN 0071         900 FORMAT (3F10.0)                                            BRE10500
ISN 0072         903 FORMAT(16F5.0)                                             BRE10510
ISN 0073         904 FORMAT (1H ,I4,F12.1,14F6.1)                               BRE10520
ISN 0074         905 FORMAT (7A8,I4,2F10.3)                                     BRE10530
ISN 0075         906 FORMAT (1H1, 10A8 //)                                      BRE10540
ISN 0076         910 FORMAT(2I5,2I10,I3,I4,I3,3F10.0,I10)                       BRE10550
ISN 0077         911 FORMAT(2X,15F5.0)                                          BRE10560
ISN 0078         912 FORMAT(' SW1=',I2,' SW2=',I2,' JCARD=',I2,' NOFREQ=',I2,' P=',  BRE10570
                    1 F10.3,' W/HZ,',2X,'BAUD=',E10.3,'SEC,  PLREJ=',E10.3,     BRE10580
                    2 'DB,  IBETA=',I2,/10X,' MAXANG= ',I3,'  ANTENNA FILE IS ',I5,  BRE10590
                    3 '  NEW ANT PAT = ',I3//)                                  BRE10600
ISN 0079         935 FORMAT(//5X,'*****     USE OLD ANTENNA PATTERNS REQUESTED',  BRE10610
                    1   'WHEN NO PREVIOUS PATTERNS AVAILABLE     .....',/20X,   BRE10620
                    2   'KSW1 SET SO THAT NO ANTENNA PATTERNS WILL BE USED     *****'/)BRE10630
ISN 0080            END                                                         BRE10640
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 LEVEL 2.1  ( JAN 75 )        INITLC          OS/360  FORTRAN H EXTENDED          DATE 77.271/15.33.00       PAGE   4

NUMBER   LEVEL                        FORTRAN H EXTENDED ERROR MESSAGES

IFE30/I   4(W)      NAME @@BLNK      THE DATA STATEMENT CONTAINS A VARIABLE THAT IS NOT REFERENCED.

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)

*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

*STATISTICS*      SOURCE STATEMENTS =       79, PROGRAM SIZE =     1932, SUBPROGRAM NAME =INITLC

*STATISTICS*    1 DIAGNOSTICS GENERATED, HIGHEST SEVERITY CODE IS  4

****** END OF COMPILATION ******                                        116K BYTES OF CORE NOT USED
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REQUESTED OPTIONS: ID

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)
SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

```
ISN 0002            SUBROUTINE ONE                                                  BRE10650
                    C                                                               BRE10660
                    C       MAKES CALCULATIONS FOR A RAYPATH, COMBINES THESE CALCULATIONS  BRE10670
                    C       FOR ALL RAYPATHS AT A GIVEN TIME AND FREQUENCY.         BRE10680
                    C                                                               BRE10690
                    C        DECLARATION STATEMENTS                                 BRE10700
                    C                                                               BRE10710
                    C        VARIABLES WHICH ARE READ IN FROM CARDS                 BRE10720
                    C                                                               BRE10730
ISN 0003            COMMON T,M,FR,DT,DR,PL,N,PT1,TAU(60),GMT,BAUD,P                 BRE10740
                    C                                                               BRE10750
                    C        VARIABLES WHICH ARE COMPUTED                           BRE10760
                    C                                                               BRE10770
ISN 0004            COMMON LIMIT,NTIME,NFREQ,OLDT,OLDFR,OLDGMT,S1,S2,K,N1,NCDS      BRE10780
                    C                                                               BRE10790
                    C        VARIABLE ARRAYS                                        BRE10800
                    C                                                               BRE10810
ISN 0005            COMMON PT(1000,3),A(1000),PHASET(1000),TAUS(1000),              BRE10820
                   *       MODE(60),TIME(30),FREQ(30),                              BRE10830
                   *       SIGTAU(20,20),SIGNOI (20,20)                             BRE10840
ISN 0006            COMMON /ANTDAT/ TABL1V(181,8),TABL1H(181,8),TABL2V(181,8),      BRE10850
                   *TABL2H(181,8),MXANGL(2),MNANGL(2),KRXN(2),NANGLS(2)             BRE10860
ISN 0007            DIMENSION  PATHLS (60), SIGDB(60)                               BRE10870
ISN 0008            INTEGER*4 OLDGMT,GMT                                            BRE10880
ISN 0009            REAL N                                                          BRE10890
ISN 0010            REAL MODE,M                                                     BRE10900
ISN 0011            REAL MODEF                                                      BRE10910
ISN 0012            COMMON/MIN/DBMIN,DTMIN,DRMIN                                    BRE10920
ISN 0013            COMMON /CONTRO /  PLREJ                                         BRE10930
ISN 0014            COMMON /SAVSIG/ HIRAYP, IFLAG                                   BRE10940
ISN 0015            COMMON /DATA/ C2, FOURPI,  EFPL, TABLFR(15), IDUMM, MAX, IDEBUG BRE10950
                    C                                                               BRE10960
                    C      ALOG10(C2/(FOURPI*1.E12))=3.8550326                      BRE10970
                    C                                                               BRE10980
                    C                                                               BRE10990
                    C           ENTER HERE FOR EACH CARD                            BRE11000
                    C                                                               BRE11010
ISN 0016            TAU(N1) = TAU(N1)* 0.001                                        BRE11020
ISN 0017            PT1 = PT1 * 1.0E-03                                             BRE11030
ISN 0018            NOLD = N                                                        BRE11040
                    C                                                               BRE11050
                    C       IF THE PATH LOSS IS GREATER THAN PLREJ DB OR IF THE TRANSMITTERBRE11060
                    C       OR RECEIVER CANNOT BE CALIBRATED, IGNORE THIS CARD.     BRE11070
                    C                                                               BRE11080
ISN 0019            IF(PL.LT.PLREJ) GO TO 5                                         BRE11090
ISN 0021            PATHLS(N1) = PLREJ                                              BRE11100
ISN 0022            GO TO 8                                                         BRE11110
ISN 0023          5 CONTINUE                                                        BRE11120
ISN 0024            GTV = F1(DT,TABL1V,1)                                           BRE11130
ISN 0025            GTH=F1(DT,TABL1H,1)                                             BRE11140
ISN 0026            GRV = F1(DR,TABL2V,2)                                           BRE11150
ISN 0027            GRH=F1(DR,TABL2H,2)                                             BRE11160
ISN 0028            SIGDB(N1) = 10.0*ALOG10(P*GTV*GRV/(FR*FR)) + 38.550326 - PL     BRE11170
```

```
ISN 0029            PATHLS(N1) = PL                                          BRE11180
                C                                                            BRE11190
                C   INITIALIZE VARIABLES FOR A GIVEN TIME AND/OR FREQUENCY   BRE11200
                C                                                            BRE11210
ISN 0030            IF(IFLAG.GT.0) GO TO 50                                  BRE11220
ISN 0032            IFLAG = 1                                                BRE11230
ISN 0033            HIRAYP = SIGDB(N1)                                       BRE11240
ISN 0034            SIGMAX = HIRAYP                                          BRE11250
ISN 0035            PATHMI = PL                                              BRE11260
ISN 0036            GO TO 8                                                  BRE11270
                C                                                            BRE11280
                C   UPDATE VALUES AS REQUIRED                                BRE11290
                C                                                            BRE11300
ISN 0037         50 CONTINUE                                                 BRE11310
ISN 0038            IF(PL.LT.PATHMI) PATHMI = PL                             BRE11320
ISN 0040            IF(SIGDB(N1).GT.SIGMAX) SIGMAX = SIGDB(N1)               BRE11330
ISN 0042            DIFF = SIGDB(N1) - HIRAYP                                BRE11340
ISN 0043            IF(DIFF.LT.-100.0) GO TO 8                               BRE11350
ISN 0045            IF(DIFF.LT.100.0) GO TO 60                               BRE11360
ISN 0047            HIRAYP = SIGDB(N1)                                       BRE11370
ISN 0048            GO TO 8                                                  BRE11380
ISN 0049         60 CONTINUE                                                 BRE11390
ISN 0050            PVAL = 1.00 + 10.0**(DIFF/10.0)                          BRE11400
ISN 0051            HIRAYP = HIRAYP + 10.0*ALOG10(PVAL)                      BRE11410
ISN 0052          8 K = K+1                                                  BRE11420
ISN 0053            TAUS(K) = TAU(N1)                                        BRE11430
ISN 0054            PT(K,1) = FR                                             BRE11440
ISN 0055            PT(K,3)=TIMEF(T)                                         BRE11450
ISN 0056            DO 821 I= 1,LIMIT                                        BRE11460
ISN 0057            IF (M.NE.MODE(I))  GO TO 821                             BRE11470
ISN 0059            GO TO 822                                                BRE11480
ISN 0060       821  CONTINUE                                                 BRE11490
ISN 0061            PT(K,2)= 0.0                                             BRE11500
ISN 0062       822  PT(K,2)=I                                                BRE11510
                C   PT(K,2)=MODEF(M)                                         BRE11520
ISN 0063            PHASET(K) = PT1                                          BRE11530
ISN 0064            RETURN                                                   BRE11540
                C                                                            BRE11550
                C        ENTER HERE ON CHANGE OF FREQUENCY OR TIME           BRE11560
                C                                                            BRE11570
ISN 0065            ENTRY TWO                                                BRE11580
ISN 0066            S3 = 0.0                                                 BRE11590
ISN 0067            TWOSIG  = 0.                                             BRE11600
ISN 0068            N1 = N1 - 1                                              BRE11610
ISN 0069            PATHDI =0.                                               BRE11620
ISN 0070            GTV= F1(DTMIN,TABL1V,1)                                  BRE11630
ISN 0071            GTH=F1(DTMIN,TABL1H,1)                                   BRE11640
ISN 0072            GRV= F1(DRMIN,TABL2V,2)                                  BRE11650
ISN 0073            GTR=F1(DRMIN,TABL2H,2)                                   BRE11660
ISN 0074            SNMAX=10.*ALOG10(P*GTV*GRV /(FR*FR))+38.550326-DRMIN+NOLD BRE11670
ISN 0075         17 IF (OLDFR.EQ.-1.0) GO TO 12                              BRE11680
ISN 0077            GO TO 20                                                 BRE11690
ISN 0078         12 OLDGMT = GMT                                             BRE11700
ISN 0079            OLDFR=FR                                                 BRE11710
ISN 0080            OLDT=T                                                   BRE11720
ISN 0081         20 CONTINUE                                                 BRE11730
ISN 0082            IF(IFLAG.EQ.0) GO TO 215                                 BRE11740
ISN 0084            MIN = MAX + 1                                            BRE11750
```

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ISN 0085            MX=MAX + N1                                                    BRE11760
                                                                                   BRE11770
                C
                C       J RELATES TO K-LOOP BETWEEN ASTERISKS, I TO N1-LOOP BETWEEN BRE11780
                C            TIMES AND FREQ                                        BRE11790
                C                                                                  BRE11800
ISN 0086            DO 210 J=MIN,MX                                                BRE11810
ISN 0087            I=J-MAX                                                        BRE11820
ISN 0088            IF(PATHLS (I).EQ.PLREJ) GO TO 210                              BRE11830
ISN 0090          201 IF(PATHLS (I).GT.(PATHMI +30.)) GO TO 202                    BRE11840
ISN 0092          200 PATHDI = 10.**((PATHMI -PATHLS (I))/10.) + PATHDI            BRE11850
ISN 0093          202 IF(SIGDB(I).LT.(SIGMAX-30.)) GO TO 210                       BRE11860
                                                                                   BRE11870
                C                                                                  BRE11880
                C       REDUCED AMPLITUTE A() CAN BE USED IN MEAN AND SIGMA CALC   BRE11890
                C                                                                  BRE11900
ISN 0095          205 A(J)=10.**((SIGDB(I)-SIGMAX)/10.)                            BRE11910
ISN 0096            S1 = S1 + A(J)                                                 BRE11920
ISN 0097            S2 = S2 + A(J)*TAU(I)                                          BRE11930
ISN 0098          210 CONTINUE                                                     BRE11940
                C                                                                  BRE11950
ISN 0099            IF(S1.GT.0.0) GO TO 82                                         BRE11960
ISN 0101          215 CONTINUE                                                     BRE11970
ISN 0102            S = -1.0E75                                                    BRE11980
ISN 0103            TAUBAR=0.0                                                     BRE11990
ISN 0104            TWOSIG=0.0                                                     BRE12000
                C     SN = -1.E100                                                 BRE12010
ISN 0105            SN = -1.E70                                                    BRE12020
ISN 0106            GO TO 25                                                       BRE12030
ISN 0107           82 TAUBAR = S2/S1                                               BRE12040
ISN 0108              IF (N1 .EQ. 1) GO TO 21                                      BRE12050
ISN 0110            9 DO 10 J = MIN, MX                                            BRE12060
ISN 0111              S3 = S3 + A(J) * (TAUS(J) - TAUBAR)**2                       BRE12070
ISN 0112           10 CONTINUE                                                     BRE12080
ISN 0113              TWOSIG =2.0*SQRT(S3/S1)                                      BRE12090
ISN 0114           21 S = SIGMAX + 10.*ALOG10(S1)                                  BRE12100
ISN 0115              SN = S + NOLD                                                BRE12110
ISN 0116           25 TAUBAR = TAUBAR * 1000.0                                     BRE12120
ISN 0117              S = -S                                                       BRE12130
ISN 0118              IF (N1 .EQ. 1) GO TO 29                                      BRE12140
ISN 0120           28 TWOSIG  = TWOSIG  * 1000.                                    BRE12150
ISN 0121           29 IF(PATHDI .EQ.0.) GO TO 27                                   BRE12160
ISN 0123           26 EFPL= PATHMI  - 10.*ALOG10(PATHDI )                          BRE12170
ISN 0124           27 IF(S1.EQ. 0.)  GO TO 265                                     BRE12180
ISN 0126              GO TO 275                                                    BRE12190
ISN 0127          265 PRINT 903, OLDGMT,OLDT,OLDFR,N1                              BRE12200
ISN 0128              GO TO 30                                                     BRE12210
ISN 0129          275 PRINT 900, OLDGMT,OLDT,OLDFR,N1,TAUBAR,TWOSIG ,S,SN,EFPL,SNMAX BRE12220
ISN 0130           30 I = FREQF(OLDFR)                                             BRE12230
ISN 0131              J = TIMEF(OLDT)                                              BRE12240
ISN 0132              SIGMDI (I,J) = SN                                            BRE12250
ISN 0133              SIGTAU(I,J) = TWOSIG  * .001                                 BRE12260
ISN 0134              EFPL = 0.0                                                   BRE12270
ISN 0135              DO 31 I=1,60                                                 BRE12280
ISN 0136              SIGDB(I)=0.0                                                 BRE12290
ISN 0137           31 PATHLS (I)= 0.0                                              BRE12300
ISN 0138              MAX=MX                                                       BRE12310
ISN 0139              TAU(1) = TAU(N1+1)                                           BRE12320
ISN 0140              OLDGMT = GMT                                                 BRE12330
ISN 0141              OLDFR=FR
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   ISN 0142            OLDT=T                                                  BRE12340
   ISN 0143            N1=1                                                    BRE12350
   ISN 0144            S1=0.0                                                  BRE12360
   ISN 0145            S2=0.0                                                  BRE12370
   ISN 0146            HIRAYP = -1.0E75                                        BRE12380
   ISN 0147            IFLAG = 0                                               BRE12390
   ISN 0148            RETURN                                                  BRE12400
   ISN 0149         900 FORMAT (1H ,I10,F7.0,F7.1,I6,2F12.4,4E15.3)            BRE12410
   ISN 0150         903 FORMAT (1H ,I10,F7.0,F7.1,I6,                          BRE12420
                       1   36H          NO IONOSPHERIC PROPOGATION)            BRE12430
   ISN 0151            END                                                     BRE12440

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)

*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

*STATISTICS*     SOURCE STATEMENTS =     150, PROGRAM SIZE =     4012, SUBPROGRAM NAME =@@@ONE

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                          104K BYTES OF CORE NOT USED
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REQUESTED OPTIONS: TD

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)
                   SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

   ISN 0002            SUBROUTINE RDATNA                                                    BRE12450
                     C                                                                      BRE12460
                     C   THIS SUBROUTINE READS ANTENNA PATTERNS WHEN THEY ARE SUUPLIED     BRE12470
                     C                                                                      BRE12480
   ISN 0003            COMMON /ANTDAT/ TABL1V(181,8),TABL1H(181,8),TABL2V(181,8),          BRE12490
                      *TABL2H(181,8),MXANGL(2),MNANGL(2),KRXN(2),NANGLS(2)                  BRE12500
   ISN 0004            COMMON /DATA/ C2, FOURPI,  EPSL, TABLER(15), ISW, MX1, IDEBUG       BRE12510
   ISN 0005            COMMON /SPPASS/ IANT,ANTFIL,VGTOT,RGTOT,HGTOT                       BRE12520
   ISN 0006            DIMENSION  ANGLGV(8), ANGLGH(8), LINVAL(4), NUMVAL(10)              BRE12530
   ISN 0007            INTEGER ANTFIL, OFFSET, PRINT                                       BRE12540
   ISN 0008            DATA PRINT/4HPRNT/                                                  BRE12550
   ISN 0009            NAMELIST /TRDATA/TABL1V,TABL1H,MAXANG,MINANG,OFFSET,NUMANG          BRE12560
   ISN 0010            NAMELIST /RCDATA/TABL2V,TABL2H,MAXANG,MINANG,OFFSET,NUMANG          BRE12570
   ISN 0011            VGTOT = 0.000                                                       BRE12580
   ISN 0012            HGTOT = 0.000                                                       BRE12590
   ISN 0013            K = 0                                                               BRE12600
   ISN 0014            LINES = 0                                                           BRE12610
   ISN 0015            LINCNT = -99999                                                     BRE12620
                     C                                                                     BRE12630
                     C   DEFAULT ANTFIL TO 5 TO READ PATTERNS FROM CARDS SO THAT          BRE12640
                     C     THIS CHANGE WILL BE INVISIBLE TO THE USER                       BRE12650
                     C                                                                     BRE12660
                     C                                                                     BRE12670
                     C   USE NUMANG = MAXANG + OFFSET AS END OF DATA MARKER              BRE12680
                     C     TO ALLOW FOR ZERO OR NEGATIVE ANGLES E.G. -PI/2                 BRE12690
                     C                                                                     BRE12700
                     C                                                                     BRE12710
                     C    INITIALIZE FREQUENCY VECTOR AND GAIN TABLES                      BRE12720
                     C                                                                     BRE12730
   ISN 0016            DO 25 I = 1, IANT                                                   BRE12740
   ISN 0017            TABLER(I) = 1.00                                                    BRE12750
   ISN 0018         25 CONTINUE                                                            BRE12760
   ISN 0019            DO 50 I = 1, 181                                                    BRE12770
   ISN 0020              DO 50 J = 1, IANT                                                 BRE12780
   ISN 0021                TABL1V(I,J) = 1.00                                              BRE12790
   ISN 0022                TABL1H(I,J) = 1.00                                              BRE12800
   ISN 0023                TABL2V(I,J) = 1.00                                              BRE12810
   ISN 0024                TABL2H(I,J) = 1.00                                              BRE12820
   ISN 0025         50 CONTINUE                                                            BRE12830
                     C                                                                     BRE12840
                     C     DETERMINE FEEDBACK REQUIREMENTS FOR ANTENNA PATTERNS            BRE12850
                     C                                                                     BRE12860
   ISN 0026            READ(5,902) NPRNT, LINES                                            BRE12870
   ISN 0027            IF(NPRNT.NE.PRINT) GO TO 80                                         BRE12880
   ISN 0029            IF(LINES.GT.NUMANG) LINES = NUMANG                                  BRE12890
   ISN 0031            LINCNT = LINES                                                      BRE12900
   ISN 0032            PRINT 905                                                           BRE12910
   ISN 0033         80 CONTINUE                                                            BRE12920
                     C                                                                     BRE12930
                     C READ FREQUENCY LIST                                                 BRE12940
                     C                                                                     BRE12950
   ISN 0034            READ(5,910) (TABLER(I), I = 1,IANT)                                 BRE12960
   ISN 0035            IF(NPRNT.NE.PRINT) GO TO 90                                         BRE12970
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ISN 0037            PRINT 915, (TABLFR(I),I = 1,IANT)                                  BRE12980
ISN 0038          90 CONTINUE                                                          BRE12990
                  C                                                                    BRE13000
                  C     READ GAIN DATA PRINT IF REQUIRED AND CONVERT TO RELATIVE POWER  BRE13010
                  C                                                                    BRE13020
ISN 0039            DO 95 ICT = 1,2                                                    BRE13030
ISN 0040              KRXN(ICT) = 1 - MNANGL(ICT)                                      BRE13040
ISN 0041              NANGLS(ICT) = MXANGL(ICT) + KRXN(ICT)                            BRE13050
ISN 0042          95 CONTINUE                                                          BRE13060
ISN 0043            NUMANG = NANGLS(1)                                                 BRE13070
ISN 0044            OFFSET = KRXN(1)                                                   BRE13080
ISN 0045            MAXANG = MXANGL(1)                                                 BRE13090
ISN 0046            MINANG = MNANGL(1)                                                 BRE13100
ISN 0047            DO 150 I = 1, NUMANG                                               BRE13110
ISN 0048            READ(ANTFIL,901,END=500) IANG, (ANGLGV(IFREQ), IFREQ = 1,IANT)     BRE13120
ISN 0049              IF(IANG.LE.MAXANG.AND.IANG.GE.MINANG) GO TO 105                  BRE13130
ISN 0051                PRINT 950                                                      BRE13140
ISN 0052                PRINT 951, IANG, (ANGLGV(IFREQ),IFREQ = 1,IANT)                BRE13150
ISN 0053                READ(ANTFIL,901,END=500) IANG, (ANGLGH(IFREQ), IFREQ = 1,IANT)BRE13160
ISN 0054                PRINT 951, IANG, (ANGLGH(IFREQ),IFREQ = 1,IANT)                BRE13170
ISN 0055                GO TO 150                                                      BRE13180
ISN 0056          105 CONTINUE                                                         BRE13190
ISN 0057            JANG = IANG                                                        BRE13200
ISN 0058            K = IANG + OFFSET                                                  BRE13210
ISN 0059            DO 115 J = 1,IANT                                                  BRE13220
ISN 0060              TABL1V(K,J) = 10.0**(ANGLGV(J)/10.0)                             BRE13230
ISN 0061          115 CONTINUE                                                         BRE13240
ISN 0062            READ(ANTFIL,901,END=500) IANG, (ANGLGH(IFREQ), IFREQ = 1,IANT)     BRE13250
ISN 0063              IF(IANG.EQ.JANG) GO TO 125                                       BRE13260
ISN 0065              IF(IANG.LE.MAXANG.AND.IANG.GE.MINANG) GO TO 120                  BRE13270
ISN 0067                PRINT 961, IANG, (ANGLGH(IFREQ), IFREQ = 1,IANT)               BRE13280
                  C                                                                    BRE13290
                  C   STOP PROCESSING BECAUSE HORIZONTAL IS OUT OF RANGE AND          BRE13300
                  C     OUT OF SYNC                                                  BRE13310
                  C                                                                    BRE13320
ISN 0068                STOP 00001                                                     BRE13330
ISN 0069          120 CONTINUE                                                         BRE13340
ISN 0070              PRINT 955, IANG, (ANGLGH(IFREQ), IFREQ = 1,IANT)               BRE13350
ISN 0071          125 CONTINUE                                                         BRE13360
ISN 0072            K = IANG + OFFSET                                                  BRE13370
ISN 0073            DO 135 J = 1,IANT                                                  BRE13380
ISN 0074              TABL1H(K,J) = 10.0**(ANGLGH(J)/10.0)                             BRE13390
ISN 0075          135 CONTINUE                                                         BRE13400
ISN 0076            LINCNT = LINCNT + 1                                                BRE13410
ISN 0077            IF(LINCNT.LT.LINES) GO TO 150                                      BRE13420
ISN 0079            LINCNT = 0                                                         BRE13430
ISN 0080            PRINT 920, IANG, (ANGLGV(J), ANGLGH(J), J=1,IANT)                  BRE13440
ISN 0081          150 CONTINUE                                                         BRE13450
ISN 0082            IF(IDEBUG.GT.10) WRITE(6,TRDATA)                                   BRE13460
                  C                                                                    BRE13470
                  C   READ AND PROCESS RECEIVER PATTERNS                             BRE13480
                  C                                                                    BRE13490
ISN 0084            IF(NPRNT.NE.PRINT) GO TO 190                                       BRE13500
ISN 0086            PRINT 925                                                          BRE13510
ISN 0087            LINCNT = LINES                                                     BRE13520
ISN 0088            PRINT 915, (TABLFR(I),I = 1,IANT)                                  BRE13530
ISN 0089          190 CONTINUE                                                         BRE13540
ISN 0090            NUMANG = NANGLS(2)                                                 BRE13550
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ISN 0091            OFFSET = KRXN(2)                                                BRE13560
ISN 0092            MAXANG = MXANGL(2)                                              BRE13570
ISN 0093            MINANG = MNANGL(2)                                              BRE13580
ISN 0094            DO 250 I = 1, NUMANG                                            BRE13590
ISN 0095            READ(ANTFIL,901,END=500) IANG, (ANGLGV(IFREQ), IFREQ = 1,IANT)  BRE13600
ISN 0096              IF(IANG.LE.MAXANG.AND.IANG.GE.MINANG) GO TO 205               BRE13610
ISN 0098                PRINT 950                                                   BRE13620
ISN 0099                PRINT 951, IANG, (ANGLGV(IFREQ),IFREQ = 1,IANT)             BRE13630
ISN 0100                READ(ANTFIL,901,END=500) IANG, (ANGLGH(IFREQ), IFREQ = 1,IANT)BRE13640
ISN 0101                PRINT 951, IANG, (ANGLGH(IFREQ),IFREQ = 1,IANT)             BRE13650
ISN 0102                GO TO 250                                                   BRE13660
ISN 0103          205 CONTINUE                                                      BRE13670
ISN 0104            JANG = IANG                                                     BRE13680
ISN 0105            K = IANG + OFFSET                                               BRE13690
ISN 0106            DO 215 J = 1,IANT                                               BRE13700
ISN 0107              PATVAL = 10.0**(ANGLGV(J)/10.0)                               BRE13710
ISN 0108              TABL2V(K,J) = PATVAL                                          BRE13720
ISN 0109              VGTOT = VGTOT + PATVAL                                        BRE13730
ISN 0110          215 CONTINUE                                                      BRE13740
ISN 0111            READ(ANTFIL,901,END=500) IANG, (ANGLGH(IFREQ), IFREQ = 1,IANT)  BRE13750
ISN 0112              IF(IANG.EQ.JANG) GO TO 225                                    BRE13760
ISN 0114              IF(IANG.LE.MAXANG.AND.IANG.GE.MINANG) GO TO 220               BRE13770
ISN 0116                PRINT 961, IANG, (ANGLGH(IFREQ), IFREQ = 1,IANT)            BRE13780
                  C                                                                 BRE13790
                  C   STOP PROCESSING BECAUSE HORIZONTAL IS OUT OF RANGE AND       BRE13800
                  C     OUT OF SYNC                                               BRE13810
                  C                                                                 BRE13820
ISN 0117                STOP 00002                                                  BRE13830
ISN 0118          220 CONTINUE                                                      BRE13840
ISN 0119                PRINT 955, IANG, (ANGLGH(IFREQ), IFREQ = 1,IANT)          BRE13850
ISN 0120          225 CONTINUE                                                      BRE13860
ISN 0121            K = IANG + OFFSET                                               BRE13870
ISN 0122            DO 235 J = 1,IANT                                               BRE13880
ISN 0123              PATVAL = 10.0**(ANGLGH(J)/10.0)                               BRE13890
ISN 0124              TABL2H(K,J) = PATVAL                                          BRE13900
ISN 0125              HGTOT = HGTOT + PATVAL                                        BRE13910
ISN 0126          235 CONTINUE                                                      BRE13920
ISN 0127            LINCNT = LINCNT +1                                              BRE13930
ISN 0128            IF(LINCNT.LT.LINES) GO TO 250                                   BRE13940
ISN 0130            PRINT 920, IANG,(ANGLGV(J), ANGLGH(J), J = 1,IANT)              BRE13950
ISN 0131            LINCNT = 0                                                      BRE13960
ISN 0132          250 CONTINUE                                                      BRE13970
ISN 0133            IF(IDEBUG.GT.10) WRITE(6,RCDATA)                                BRE13980
ISN 0135            RGTOT = VGTOT + HGTOT                                           BRE13990
ISN 0136            RETURN                                                          BRE14000
ISN 0137          500 CONTINUE                                                      BRE14010
ISN 0138            RGTOT = HGTOT + VGTOT                                           BRE14020
ISN 0139            IANG = K - OFFSET                                               BRE14030
ISN 0140            PRINT 522, IANG                                                 BRE14040
ISN 0141          522 FORMAT(//10X,50(1H*),//13X,                                   BRE14050
                     1   'DATA ENDS UNEXPECTEDLY WITH ANGLE =',I5,                  BRE14060
                     2   /15X,'DESIRED DATA MAY BE REPLACED BY ONES',               BRE14070
                     3  //10X,50(1H*)//)                                           BRE14080
ISN 0142            RETURN                                                          BRE14090
ISN 0143          901 FORMAT(I5,8F5.0)                                              BRE14100
ISN 0144          902 FORMAT(A4,I4)                                                 BRE14110
ISN 0145          905 FORMAT(/,5X,'TRANSMITTER GAIN(DB)   ANGLE(DEG) BY FREQUENCY(MHZ)',BRE14120
                     1   /25X,'FREQUENCY'/)                                        BRE14130
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   ISN 0146        910 FORMAT(BF5.0)                                                    BRE14140
   ISN 0147        915 FORMAT(/10X,8(2X,F10.4,2X))                                      BRE14150
   ISN 0148        920 FORMAT(3X,I4,3X,16(F6.2,1X))                                     BRE14160
   ISN 0149        925 FORMAT(/,5X'RECEIVER GAIN(DB)  ANGLE(DEG) BY FREQUENCY(MHZ)',    BRE14170
                      1   /25X,'FREQUENCY'/)                                          BRE14180
   ISN 0150        950 FORMAT(// 5X,'*****     ANGLE READ OUTSIDE OF SPECIFIED RANGE ', BRE14190
                      1 ' ..... VERTICAL AND HORIZONTAL DATA LOST AS FOLLOWS -')       BRE14200
   ISN 0151        951 FORMAT( 20X,I5,3X,8(G5.0,3X))                                    BRE14210
   ISN 0152        955 FORMAT(//5X,'*****     HORIZONTAL DATA OUT OF SYNC',            BRE14220
                      1   ' DATA SAVED AS FOLLOWS -',/20X,I5,3X,8(G5.0,3X))           BRE14230
   ISN 0153        961 FORMAT(//10X,'.....  STOP PROCESSING',                           BRE14240
                      1  ' HORIZONTAL ANGLE OUT OF SYNC AND OUT OF RANGE, SIC -',     BRE14250
                      2  /20X,I5,3X,8(G5.0,3X))                                       BRE14260
   ISN 0154            END                                                            BRE14270

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)

*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

*STATISTICS*      SOURCE STATEMENTS =     153, PROGRAM SIZE =     4432, SUBPROGRAM NAME =RDATNA

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                    96K BYTES OF CORE NOT USED
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REQUESTED OPTIONS: ID

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)
SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

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ISN 0002            SUBROUTINE READ                                                  BRE14280
                    C                                                                BRE14290
                    C     READS THE DATA CARD AND BUILDS TABLES FOR MODES, TIMES, AND BRE14300
                    C     FREQUENCIES.                                               BRE14310
                    C                                                                BRE14320
                    C                                                                BRE14330
                    C      DECLARATION STATEMENTS                                    BRE14340
                    C                                                                BRE14350
                    C      VARIABLES WHICH ARE READ IN FROM CARDS                    BRE14360
                    C                                                                BRE14370
ISN 0003            COMMON T,M,FR,DT,DR,PL,N,PT1,TAU(60),GMT,BAUD,P                  BRE14380
                    C                                                                BRE14390
                    C      VARIABLES WHICH ARE COMPUTED                              BRE14400
                    C                                                                BRE14410
ISN 0004            COMMON LIMIT,NTIME,NFREQ,OLDT,OLDFR,OLDGMT,S1,S2,K,N1,NCDS       BRE14420
                    C                                                                BRE14430
                    C      VARIABLE ARRAYS                                           BRE14440
                    C                                                                BRE14450
ISN 0005            COMMON PT(1000,3),A(1000),PHASET(1000),TAUS(1000),               BRE14460
                   *       MODE(60),TIME(30),FREQ(30),                               BRE14470
                   *       SIGTAU(20,20),SIGNOI (20,20)                              BRE14480
ISN 0006            COMMON /ANTDAT/ TABL1V(181,8),T BL1H(181,8),TABL2V(181,8),       BRE14490
                   *TABL2H(181,8),MXANGL(2),MNANGL(2),KRXN(2),NANGLS(2)              BRE14500
ISN 0007            COMMON /DATA/ C2, FOURPI,  EFPL, TABLFR(15), IDUMM, MAX, IDEBUG  BRE14510
ISN 0008            COMMON/XLIT/AST,LIN,BLANK,STAR                                   BRE14520
ISN 0009            DIMENSION LIN(20)                                                BRE14530
ISN 0010            INTEGER*4 AST,LIN,BLANK,STAR                                     BRE14540
ISN 0011            INTEGER*4 OLDGMT,GMT,GGG                                         BRE14550
ISN 0012            DATA GGG/1HG/                                                    BRE14560
ISN 0013            REAL N                                                           BRE14570
ISN 0014            REAL MODE, M                                                     BRE14580
ISN 0015            COMMON/MIN/DRMIN,DTMIN,DRMIN                                     BRE14590
ISN 0016            COMMON/SWITCH/KSW1,KSW2,JF,IBETA                                 BRE14600
                    C                                                                BRE14610
                    C   GIVE INPUT VARIABLES ALIASES FOR USE IN BREM CALCULATIONS    BRE14620
                    C                                                                BRE14630
ISN 0017            EQUIVALENCE (M,FACHNZ), (PT1,THT), (PL,RHT)                      BRE14640
ISN 0018          4 N1 = N1+1                                                        BRE14650
ISN 0019          5 READ(JF,900,END=50)ISW,T,M,FX,DT,DR,TAU(N1),PT1,PL,N,GMT,PLBETA  BRE14660
ISN 0020            IF(ISW.EQ.GGG)GO TO 200                                          BRE14670
ISN 0022          6 IF (ISW .EQ. STAR) GO TO 30                                      BRE14680
ISN 0024            WRITE(6,906)ISW,T,M,FX,DT,DR,TAU(N1),PT1,PL,N,GMT,PLBETA         BRE14690
ISN 0025          7 NCDS = NCDS + 1                                                  BRE14700
ISN 0026            FR=FX                                                            BRE14710
ISN 0027            IF(IBETA.EQ.1) PL=PLBETA                                         BRE14720
ISN 0029            IF(M) 62,62,8                                                    BRE14730
ISN 0030         62 DRMIN=PL                                                         BRE14740
ISN 0031            DTMIN=DT                                                         BRE14750
ISN 0032            DRMIN=DR                                                         BRE14760
ISN 0033            GO TO 5                                                          BRE14770
ISN 0034          8 CONTINUE                                                         BRE14780
ISN 0035            IF (NCDS .LE. 1000)  GO TO 20                                    BRE14790
ISN 0037            GO TO 100                                                        BRE14800
```

```
                C
                C         BUILD TABLE OF MODES                                  BRE14810
                C                                                               BRE14820
                C                                                               BRE14830
ISN 0038          20 IF (LIMIT .GT. 0) GO TO 21                                 BRE14840
ISN 0040             GO TO 23                                                   BRE14850
ISN 0041          21 DO 22 I = 1,LIMIT                                          BRE14860
ISN 0042             IF (M .NE. MODE(I)) GO TO 22                               BRE14870
ISN 0044             GO TO 24                                                   BRE14880
ISN 0045          22 CONTINUE                                                   BRE14890
ISN 0046          23 LIMIT = LIMIT + 1                                          BRE14900
ISN 0047             IF (LIMIT .GT. 60) GO TO 110                               BRE14910
ISN 0049          43 MODE(LIMIT) = M                                            BRE14920
                C                                                               BRE14930
                C         BUILD TABLE OF TIMES                                  BRE14940
                C                                                               BRE14950
                C                                                               BRE14960
                C         IF TIME = -1, USE GMT INSTEAD                         BRE14970
                C                                                               BRE14980
ISN 0050          24 IF (T .EQ. -1.0) GO TO 40                                  BRE14990
ISN 0052             GO TO 41                                                   BRE15000
ISN 0053          40 IGMT1 = GMT / 100                                          BRE15010
ISN 0054             IGMT2 = GMT - IGMT1 * 100                                  BRE15020
ISN 0055             T = IGMT1 * 3600 + IGMT2 * 60                              BRE15030
ISN 0056          41 IF (NTIME .GT. 0) GO TO 25                                 BRE15040
ISN 0058             GO TO 27                                                   BRE15050
ISN 0059          25 DO 26 I = 1, NTIME                                         BRE15060
ISN 0060             IF (T .NE. TIME(I)) GO TO 26                               BRE15070
ISN 0062             GO TO 28                                                   BRE15080
ISN 0063          26 CONTINUE                                                   BRE15090
ISN 0064          27 NTIME = NTIME + 1                                          BRE15100
ISN 0065             IF (NTIME .GT. 20) GO TO 120                               BRE15110
ISN 0067          44 TIME(NTIME) = T                                            BRE15120
                C                                                               BRE15130
                C          BUILD TABLE OF FREQUENCIES                           BRE15140
                C                                                               BRE15150
ISN 0068          28 IF (NFREQ.GT. 0)  GO TO 35                                 BRE15160
ISN 0070             GO TO 37                                                   BRE15170
ISN 0071          35 DO 36 I = 1, NFREQ                                         BRE15180
ISN 0072             IF (FR .NE. FREQ(I)) GO TO 36                              BRE15190
ISN 0074             GO TO 38                                                   BRE15200
ISN 0075          36 CONTINUE                                                   BRE15210
ISN 0076          37 NFREQ = NFREQ + 1                                          BRE15220
ISN 0077             IF (NFREQ .GT. 20) GO TO 130                               BRE15230
ISN 0079          45 FREQ(NFREQ) = FR                                           BRE15240
ISN 0080          38 RETURN                                                     BRE15250
                C                                                               BRE15260
                C         END OF FILE PROCESSING                                BRE15270
                C                                                               BRE15280
ISN 0081         200 CONTINUE                                                   BRE15290
ISN 0082             APOW=10.0*ALOG10(P)                                        BRE15300
ISN 0083             THT = 0.001*THT                                            BRE15310
ISN 0084             RHT = 0.001*RHT                                            BRE15320
ISN 0085             IF(FACHNZ.LE.0.00) FACHNZ = 0.02                           BRE15330
ISN 0087             CALL CPOWER(APOW,TP,ALPSUM)                                BRE15340
                C                                                               BRE15350
                C   RETURN TO READ NEXT INPUT WITHOUT INCREMENTING N1           BRE15360
                C                                                               BRE15370
ISN 0088             GO TO 5                                                    BRE15380
```

```
   ISN 0089        30 CALL TWO                                                    BRE15390
   ISN 0090           CALL PRINTP                                                 BRE15400
   ISN 0091           CALL INITIA                                                 BRE15410
   ISN 0092           GO TO 4                                                     BRE15420
   ISN 0093        50 CALL TWO                                                    BRE15430
   ISN 0094           CALL PRINTP                                                 BRE15440
   ISN 0095           STOP                                                        BRE15450
   ISN 0096       100 PRINT 902                                                   BRE15460
   ISN 0097           STOP 2                                                      BRE15470
   ISN 0098       110 PRINT 903                                                   BRE15480
   ISN 0099           STOP 3                                                      BRE15490
   ISN 0100       120 PRINT 904                                                   BRE15500
   ISN 0101           STOP 4                                                      BRE15510
   ISN 0102       130 PRINT 905                                                   BRE15520
   ISN 0103           STOP 5                                                      BRE15530
   ISN 0104       900 FORMAT (A1,F6.0,F10.0,3F6.2,2F7.3,F9.1,F7.1,I5,F10.1)       BRE15540
   ISN 0105       906 FORMAT (/2X,A1,F6.0,F10.0,3F6.2,2F7.3,F9.1,F7.1,I5,F10.1)   BRE15550
   ISN 0106       901 FORMAT(F10.3)                                               BRE15560
   ISN 0107       902 FORMAT (40H TOO MANY INPUT CARDS -- MAXIMUM = 1000  )       BRE15570
   ISN 0108       903 FORMAT (21H1TOO MANY MODES       )                          BRE15580
   ISN 0109       904 FORMAT (21H1TOO MANY TIMES       )                          BRE15590
   ISN 0110       905 FORMAT (21H1TOO MANY FREQUENCIES)                           BRE15600
   ISN 0111           END                                                         BRE15610

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)

*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

*STATISTICS*      SOURCE STATEMENTS =     110, PROGRAM SIZE =     2070, SUBPROGRAM NAME =@@READ

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                  108K BYTES OF CORE NOT USED
```

```
REQUESTED OPTIONS: ID

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0228K) AUTODBL(NONE)
                   SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT GOSTMT NOXREF NOALC NOANSF TERMINAL FLAG(I)

   ISN 0002            BLOCK DATA                                                              BRE15620
   ISN 0003            COMMON /ANTDAT/ TABL1V(181,8),TABL1H(181,8),TABL2V(181,8),              BRE15630
                      *TABL2H(181,8),MXANGL(2),MNANGL(2),KRXN(2),NANGLS(2)                     BRE15640
   ISN 0004            COMMON /DATA/ C2, FOURPI,  EEPL, TABLER(15), IDUMM, MAX, IDEBUG         BRE15650
   ISN 0005            COMMON /SPBASS/ NOFREQ,INPFIL,VGTOT,RGTOT,HGTOT                         BRE15660
   ISN 0006            COMMON /SAVSIG/ HIRAYP, IFLAG                                           BRE15670
   ISN 0007            COMMON/SWITCH/KSW1,KSW2,JF,IBETA,JCARD,NEWANT                           BRE15680
   ISN 0008            COMMON/XLIT/AST,LIN,BLANK,STAR                                          BRE15690
   ISN 0009            DIMENSION LIN(20)                                                       BRE15700
   ISN 0010            INTEGER*4 AST,LIN,BLANK,STAR                                            BRE15710
   ISN 0011            DATA AST/'****'/                                                        BRE15720
   ISN 0012            DATA LIN/'PHAS','E  *','DOPP','LER*','SIGL','AM *','SIGT','AU *',       BRE15730
                      1'SDBE','   *','DDBE','   *','SD3E','-DS*','DDBE','-DS*',4*'    '/     BRE15740
   ISN 0013            DATA BLANK/'    '/                                                      BRE15750
   ISN 0014            DATA STAR /1H*/                                                         BRE15760
   ISN 0015            DATA HIRAYP/-1.0E75/, IFLAG/-1/, NEWANT,KSW1/2*1/,JF/7/                 BRE15770
   ISN 0016            DATA KSW2, JCARD, IBETA/3*0/, INPFIL/5/, NOFREQ /1/                     BRE15780
   ISN 0017            DATA MXANGL, MNANGL, NANGLS /90, 90, -90, -90, 181, 181/                BRE15790
   ISN 0018            DATA  C2, FOURPI, EEPL, MAX /9.0E16, 12.5663706, 0.0, 0/                BRE15800
   ISN 0019            DATA VGTOT, RGTOT, HGTOT /3*1.0/, IDEBUG /0/                            BRE15810
   ISN 0020            END                                                                     BRE15820
```

APPENDIX D

Supplement to NUCOM II Users Guide

The modifications to NUCOM II to produce the NUCOM/BREM version were designed to minimize the changes to existing NUCOM II deck setup and case stacking logic. In RAYTRACE one new control card has been added to input the problem description for the nonionospheric modes.

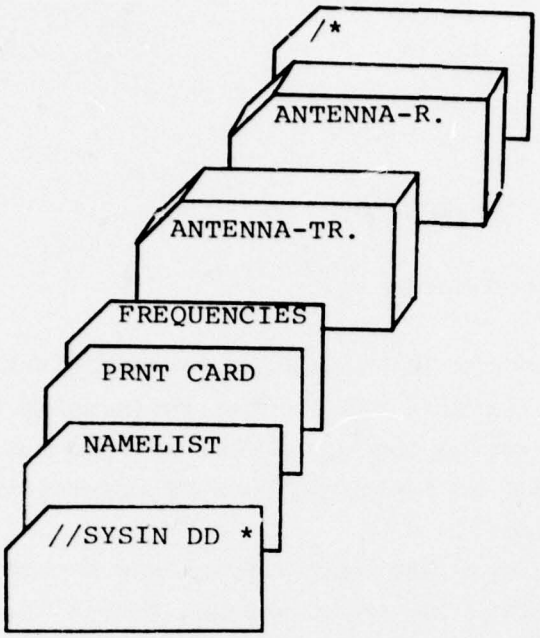
In COMEFF the CARD 1 input has been altered and a namelist input feature has been added. The input antenna format has been altered slightly to permit inclusion of horizontal as well as vertical polarization parameters.

These new input cards are described as follows:

BREM INPUT CARD - RAYTRACE

BREM DESCRIPTION

NAME	FORMAT	COLUMNS	DESCRIPTION	UNITS	COMMENTS
HTR	F10.3	1-10	TRANSMITTER HEIGHT	METERS	
HTT	F10.3	11-20	RECEIVER HEIGHT	METERS	
SIGMA	F10.5	21-30	USER SIGMA	Mho/m	TO OVERRIDE NWOMAP
EPSILON	F10.5	31-40	USER EPSILON		
WNDVEL	F10.5	41-50	WIND VELOCITY	m/sec	
SUDAM	I5	51-55	SUDA SEGMENT NUMBER		NUMBER OF PIECES INTO WHICH PATH WILL BE DIVIDED
MILLM	I5	56-60	MILLINGTON SEGMENT NUMBER		NUMBER OF SEGMENTS INTO WHICH SUDA END SEGMENTS ARE DIVIDED
FACHNZ	F10.5	61-70	USER SUPPLIED HORIZONTAL NOISE FACTOR	km^{-1}	DEFAULTS TO 0.06



NAME LIST INPUT FOR COMEFF.

The format for the name list is "VARIABLE NAME-VALUE" and successive name list variables are separated by commas. The namelist is initiated with the term '&IINIT" beginning in column 2. The namelist is terminated by the term "&END" anywhere. Namelist variables may appear in any order. The namelist variables may span more than one card but must always begin in column 2.

NAMELIST VARIABLE	FORMAT	DESCRIPTION	VALUES
KSW1	I1	ISOTROPIC OR INPUT ANTENNA PATTERNS	$\neq$ 0 ISOTROPIC = 0 INPUT PATTERNS
KSW2	I1	DOPPLER SHIFT	= 0 NO DOPPLER $\neq$ 1 DOPPLER OUTPUT
MNANGT	I2	LOWEST ANGLE FOR PATTERN SUPPLIED-TRANSMITTER	INTEGER VALUE IN DEGREES
MXANGT	I2	HIGHEST ANGLE FOR PATTERN SUPPLIED TRANS-MITTER	INTEGER VALUE IN DEGREES
MNANGR	I2	LOWEST ANGLE FOR PATTERN SUPPLIED-RECEIVER	INTEGER VALUE IN DEGREES
MXANGR	I2	HIGHEST ANGLE PATTERN SUPPLIED-RECEIVER	INTEGER VALUE IN DEGREES
NOFREQ	I2	NUMBER OF FREQ-UENCIES FOR WHICH ANTENNA PATTERNS VIGEN	INTEGER $\leq$ 8
PLREJ	F5.3	PATH LOSS LIMIT	RAY IGNORED IF PATH LOSS >PLREJ
P	F7.3	POWER DENSITY	WATTS/Hz DEFAULT=3.33
NEWANT	I2	NEW ANTENNA PATTERN	$\neq$ 0 USE PREVIOUS ANTENNA PATTERN = 0 INPUT NEW PATTERN
BAUD	F7.3	SIGNALLING ELEMENT DURATION	DEFAULT = 10msec

Example of NAMELIST INPUT:

```
&IINIT KSW=0, KSW2=1, MXANGT=40, MNANGT=-40  MXANGR=40, MNANGR=-40
P=10, NOFREQ=2, PLREJ=200, NEWANT=0 & END
```

PRNT CONTROL CARD

This parameter controls printing of input antenna patterns.

NAME	FORMAT	COLUMNS	VALUES
		1-4	"PRNT"
VBL	I1	9	a 1 in column 9 causes every tenth angle to be printed
VBL	I1	10	a 1 in column 10 causes every angle to be printed.

FREQUENCY INPUT CARD

This card describes the frequencies for which antenna pattern data is to be input. This card is similar to the original NUCOM II card except the fields are compressed.

NAME	FORMAT	COLUMNS	DESCRIPTION	COMMENTS
TABLFR(1)	F5.1	1-6	FIRST FREQUENCY	MHz
TABLFR(2)	F5.1	6-10	2nd FREQUENCY	MHz
TABLFR(3)	F5.1	11-15	3rd FREQUENCY	MHz
TABLFR(4)	F5.1	16-20	4th FREQUENCY	MHz
TABLFR(5)	F5.1	21-25	5th FREQUENCY	MHz
TABLFR(6)	F5.1	26-30	6th FREQUENCY	MHz
TABLFR(7)	F5.1	31-35	7th FREQUENCY	MHz
TABLFR(8)	F5.1	36-40	8th FREQUENCY	MHz

ANTENNA PATTERN INPUT

Each antenna pattern card includes an integer angle and one to eight values of power gain relative to isotropic as specified in the namelist variable NOFREQ. Pattern values must start with MNANGT for transmitter and MNANGR for receiver patterns and end with MXANGT for transmitter and MXANGR for receiver patterns. Transmitter patterns are given first and for each angle specified the first card corresponds to vertical polarization and the second card to horizontal polarization. The values of MNANGR and MNANGT, MXANGR and MXANGT need not be the same; this allows use of small pattern decks for air-to-air and air-to-ground links when no ionospheric rays are present.

Antenna Gain Pattern (MXANGT-MNANGT+1 cards)

NAME	FORMAT	COLUMN	DESCRIPTION	COMMENT
IANG	I5	1-5	ANGLE	in degrees
TABL1(1)	F5.1	6-10	antenna gains for vertical polarization for NOFREQ values of frequency	
TABL1(2)	F5.1	11-15		
TABL1(3)	F5.1	16-20		
TABL1(4)	F5.1	21-26		
TABL1(5)	F5.1	26-30		
TABL1(6)	F5.1	31-35		
TABL1(7)	F5.1	36-40		
TABL1(8)	F5.1	41-45		

A second card with identical format gives the horizontal component values. Examples of complete pattern decks will be found in APPENDIX C.

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