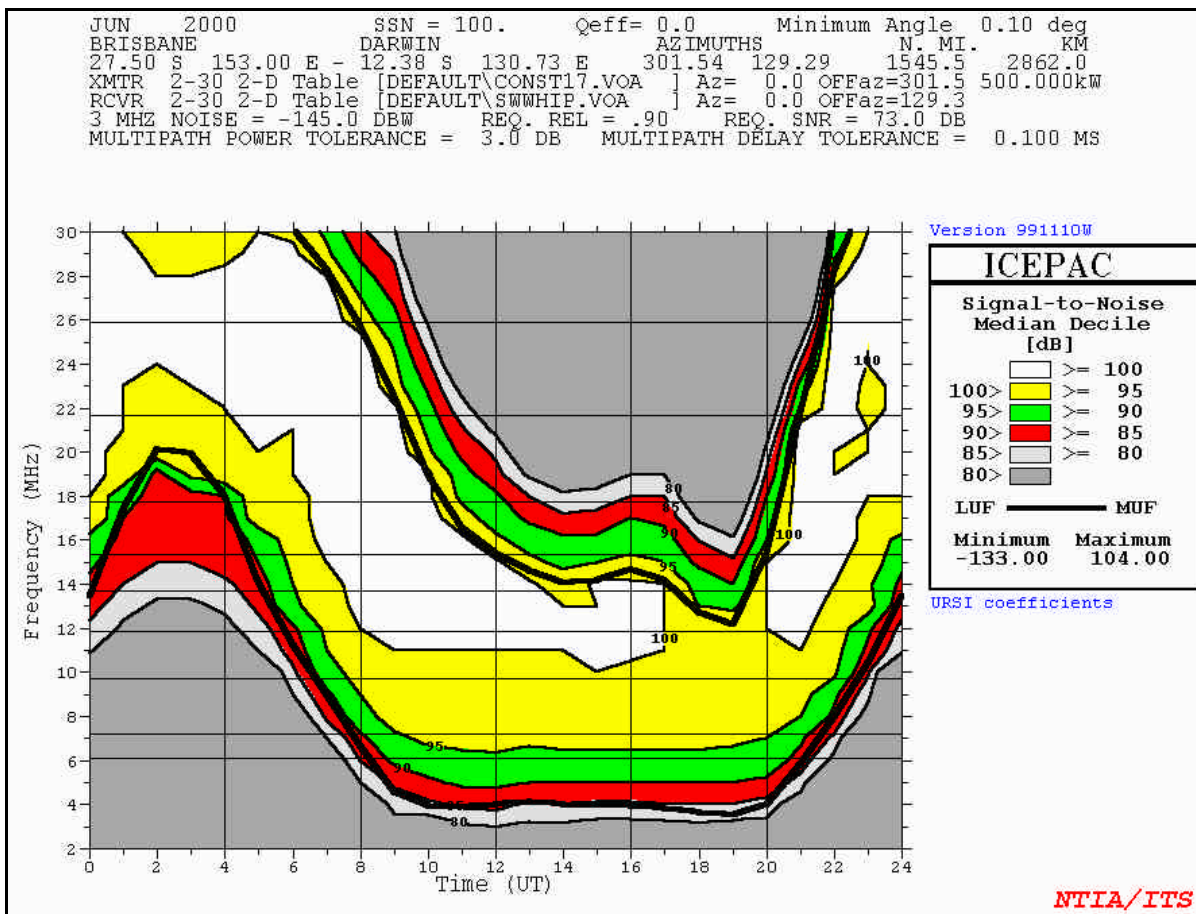
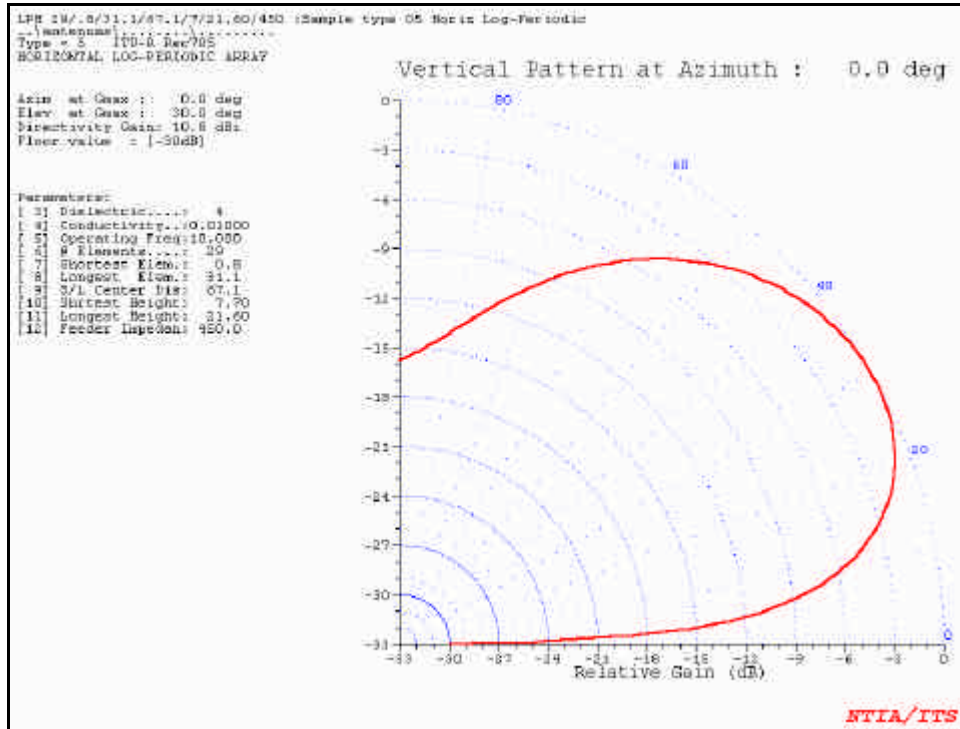


# IONOSPHERIC COMMUNICATIONS ENHANCED PROFILE ANALYSIS & CIRCUIT (ICEPAC)

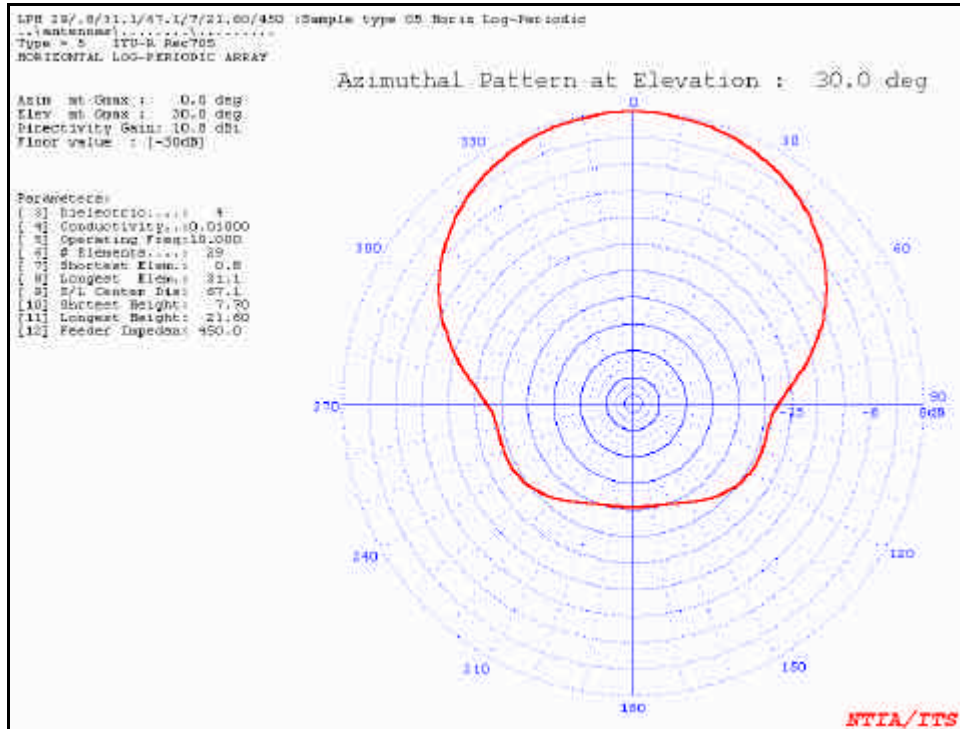
## PREDICTION PROGRAM



## USER'S MANUAL



## & HF ANTENNA MODEL PROGRAM



Provided in the  
 “ITS HF Propagation Package”

## PREFACE

The Institute for Telecommunication Sciences and its predecessors in the U.S. Department of Commerce have been collecting ionospheric data and developing methods to use these data in the prediction of the expected performance of high-frequency (HF) sky-wave systems since the start of World War II.

Much of these data and the techniques for using the data are stored for use by computers. Several "standard" output formats have also emerged to assist in the planning and operation of high-frequency systems using sky-waves. This report describes the use of the latest developed method - The "Ionospheric Communications Enhanced Profile Analysis and Circuit Prediction Program" (ICEPAC). The input and output characteristics in this report relate to ICEPAC version .10. The version number was generated to historically document the ICEPAC program as it currently exists and to facilitate a means of identifying subsequent versions of the program.

For many years, numerous organizations have been employing the HF spectrum to communicate over long distances. It was recognized in the late thirties that these communication systems were subject to marked variations in performance. The effective operation of long-distance HF systems increased in proportion to the ability to predict variations in the ionosphere, since such an ability permitted the selection of optimum frequencies, antennas, and other circuit parameters. A worldwide network of ionosondes was established to measure ionospheric parameters. Worldwide noise measurement records were taken, and observed variations in signal and amplitudes were recorded over various HF paths. The results of this research established that most variations in HF system performance were directly related to changes in the ionosphere, which in turn are affected in a complex manner by solar activity, seasonal and diurnal variations, as well as latitude and longitude. By 1948, a treatise of ionospheric radio propagation was published by the Central Radio Propagation Laboratory (CRPL) of the National Bureau of Standards. This document (CRPL, 1948) outlined the state of the art in HF propagation. Manual techniques were given for analyzing HF circuits of short, intermediate, and long distances. Because the manual methods were laborious and time consuming, various organizations developed computer programs to analyze HF circuit performance. All these programs were based on manual methods for short or

intermediate distances and used various numeric representations of the ionospheric data. The IONCAP program was the latest program developed and used in HF propagation predictions. The IONCAP prediction program had poor performance in the polar region and used some of the older profile structures.

The program described here is a direct descendant of the IONCAP program. Use of the Ionospheric Communications Enhanced Profile Analysis and Circuit Prediction Program (ICEPAC) is described in this report.

The Ionospheric Communications Enhanced Profile Analysis and Circuit Prediction Program (ICEPAC) is in modular form and coded in simple FORTRAN, following as much as possible the ANSI 77 standard. The modular form allows any subsection to be replaced without affecting the rest of the program. As much as possible, table look-up techniques are used to reduce computer run time, to facilitate the modular structure, and to assist in the detection of errors in any subsection. The program is divided into seven largely independent sections:

- 1     input subroutines,
- 2     path geometry subroutines,
- 3     antenna subroutines,
- 4     ionospheric parameter subroutines,
- 5     maximum usable frequency subroutines,
- 6     system performance subroutines, and
- 7     output subroutines.

The input subroutines handle the various input options. There are four inputs: Line command disk file, a long-term data disk file, corrected geomagnetic disk file, and an antenna disk file. The line command disk file contains the circuit parameters and control run options. The long-term data disk file contains numeric coefficients for ionospheric parameters and for atmospheric noise as well as tables of parameters needed for circuit performance. The corrected geomagnetic coordinate file provides geomagnetic latitude and longitude for the polar model. The antenna disk file contains optional antenna patterns which can either be generated by the ICEPAC program or obtained from some other source.

The path geometry subroutines determine the circuit geometry, select areas to sample the ionosphere, and evaluate the magnetic field at these sample areas.

The antenna subroutines process antenna data command lines, calculate antenna gains, and output antenna patterns. The program has the simple

subroutine from ITSA-1 (Lucas and Haydon, 1966) for the basic antenna models. These assume the antennas are associated with existing systems that have been properly designed.

The ionospheric parameter subroutines evaluate the ionospheric parameters needed by the program. Previous programs assumed an implicit two parabola ionosphere. An explicit electron density profile is used in this program. Observation indicates that absorption equations using the secant law require modification when frequencies do not traverse the entire absorbing region, i.e., with reflection heights lower than 90 km. An empirical modification to the secant law is included in this program.

The maximum usable frequency (MUF) subroutine is a direct determination of the junction frequency based on an electron density profile derived from monthly median parameters of the ionosphere rather than an iterative search. A corrected form of Martyn's theorem (Martyn, 1969) is used. The E, F1, and F2 layer MUFs are considered. There is also a separate sporadic-E MUF.

The system performance subroutines evaluate all the usual circuit performance parameters. There are two basic subroutines: one for shorter distances and one for long distances (greater than 10,000 km). The models for the shorter distances and the long distance models have previously been incorporated in the IONCAP computer program and are continued in the ICEPAC program. The short-distance models correspond to the manual method given by Haydon et al. (1969). A manual method somewhat like the long-distance models is given in NBS Report 462, (CRPL, 1948). The short-distance model evaluates all possible ray paths for the circuit, including high and low angle modes; E, F1, and F2 modes; above the MUF modes; and sporadic-E modes. Losses include regular D-E absorption (CCIR-252 loss), deviative losses, and sporadic-E losses. The CCIR-262 loss is basically for F2 modes. For E-layer modes, an adjustment of the absorption is required, and for frequencies which have low reflection heights (less than 90 km) a further correction to the frequency dependence is added. The noise at the receiver site is evaluated and combined with signal statistics to estimate the signal-to-noise statistics.

An extension of the single-hop model to long paths would lead to the expectation that failure of propagation at any of the reflection areas would cause propagation to fail altogether. Empirically, however, it has been found that propagation does not fail until the ionosphere either fails to launch a sky-wave or does not permit sky-wave reception; i.e., these are control areas about 2,000 km from each end of the path. The long-distance model evaluates a sky-wave launch capability at the transmitter and a sky-wave intercept

capability at the receiver, using an antenna-gain-minus-ionosphere-loss function at each end of the path. Losses are the same as for the short paths at each end of the path, with a loss per kilometer function used to fill in the path. Noise and signal statistics are the same for the short-distance or the long-distance paths.

The output subroutines generate all the output options as line printer images which can be printed or saved on disk. The available output options and the corresponding input required to generate the output is described in this report.

Much of the work completed is an incorporation of the combined efforts of various laboratories, both government and private, domestic and foreign. Although this program is coded so that revision of any sub-part is relatively easy, it is difficult to join so many diverse sub-models while maintaining consistency and continuity of the entire program. The whole in this case is much more than a sum of the parts.

The use of the program with a description of input and output options is described in this report. The underlying assumptions and the mathematical-physical models are described in a companion report.

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**LIST OF SYMBOLS**

The meanings of the most commonly used symbols are as follows (except as otherwise defined within the text for local usage) (where feasible the symbol definition is the same as in the list in Davies, 1969):

**GREEK LETTERS**

$\alpha$	Coefficient used in exponential tail of electron density profile, Section 3.2.
$-$	Euler constant 0.57721.
$\Delta$	Angle of elevation or take-off measured from earth's surface to ray.
$\epsilon$	Permittivity.
$\epsilon_0, \epsilon_r,$	Permittivity of free space.
$\epsilon'_h, \epsilon_0, \epsilon$	Errors used in correction of Martyn's theorem; Section 4.4.
$\Theta$	Angle measured from true ray path to earth's normal. (Positive for up going ray, negative for down going ray.)
$\theta_j$	A sampled $\theta$ in true ray path model, Section 5.0.
$\lambda$	Wavelength in a medium.
$\mu$	Refractive index (real part of n).
$\mu_0$	Permeability of free space.
$\mu'$	Group refractive index.
$\mu'(h, f)$	Corresponds to a particular true height h and operating frequency f, Section 4.2.
$\nu$	Electron collision frequency.
$\bar{\nu}$	Average $\nu$ in a region, used in loss equations, Section 6.1.
$\xi$	$\xi = f^2 - ff_h$
$\pi$	Pi, 3.14159...
$\rho$	Reflection coefficient.

$\sigma$	Standard deviation of various distributions.
$\tau$	Time constant.
$\phi_e$	Angle between virtual ray and earth's normal at true reflection height.
$\phi$	Angle between virtual ray and earth's normal at virtual reflection height. (Usually at one-half path distance.)
$\phi_j$	Angle between virtual ray and earth's normal at a virtual height corresponding to a sampled ground distance, Section 5.0.
$\chi$	Absorption index.
$\chi$	Sun's zenith angle.
$\chi^m$	Maximum sun's zenith angle at which median predicted F1 layer exists, Section 2.4.2.
$\Psi$	One-half of the angle subtended by a radio path at the center of the earth, i.e., one-half path ground distance divided by the radius of the earth.
$\omega$	Angular frequency.
$\omega_H$	Angular gyro-frequency.

**ROMAN LETTERS**

$A(f_v)$	Absorption factor corresponding to $f_v$ , Section 6.1.
$A$	Averaged absorption factor, Section 6.1.
$A_D$	Deviative loss absorption factor, Section 6.2.
$A_E$	E mode absorption factor for corrected loss, Section 6.2.
$A_T(f_v)$	Sum of absorption factors, Section 6.2.
$a$	Radius of the earth.
$B(f_v)$	Absorption factor for $A_D$ , includes averaged collision frequency ( $\nu$ ) profile, Section 6.2.
$C_E$	Coefficient for $B(f_v)$ in E region, Section 6.3.
$C_F$	Coefficient for $B(f_v)$ in F2 region.



$C_1$	Coefficient for $B(f_v)$ in F1 region, Section 6.3.
$C_2$	Coefficient for $B(f_v)$ in F2 region when F1 layer is present, Section 6.3.
$c$	Velocity of waves in free space.
$D$	Ground distance of a radio path.
$D_j$	Ground distance to a sampled point of a radio path, Section 5.0.
$E$	RMS field strength referred to one microvolt per meter.
$e$	Charge on the electron.
$F$	Coefficient used in exponential tail of electron density profile, Section 3.2.
fbEs	Sporadic E blanketing frequency.
$f_c$	Critical or penetration frequency.
$f_H$	Gyro-frequency.
$f_N$	Plasma frequency.
$f_{ob}$	Frequency of oblique radio path.
$f_v$	Vertical sounding frequency.
$f_pE$	Penetration frequency of E layer.
fmEs	Equivalent oblique frequency corresponding to foEs.
foE	Critical frequency of the ordinary component of the E layer.
foEs	Highest frequency of the ordinary component of the sporadic E layer.
foF1	Critical frequency of the ordinary component of the F1 layer.
foF2	Critical frequency of the ordinary component of the F2 layer.
$f_u, f_v$	Plasma frequencies used for filling in the valley in an electron density profile, Section 3.4.
$G_t$	Transmitting antenna power gain relative to an isotropic antenna in free space.
$G_r$	Receiving antenna power gain relative to an isotropic antenna in free space.
$h$	True or real height.
$h'$	Virtual height, equivalent height, group height.

$h_p$	Phase height.
$h'Es$	The minimum virtual height of the sporadic E layer.
$hmE,$	Height of maximum electron density of E layers.
$hmF1, hmF2$	Height of maximum electron density of F1 or F2 layers.
$h'E$	The minimum virtual height of the E layer.
$h'F$	The minimum virtual height of the F layer (F1 or F2).
$h'F2$	The minimum virtual height of the F2 layer.
$hpF2$	The virtual height of the F2 layer at a vertical sounding frequency $f_v = 0.834 f_{oF2}$ .
$h'_v$	Virtual height from vertical sounding as used in corrected Martyn's theorem, Section 4.3.
$h'_{ob}$	Corrected virtual height for an oblique radio path, Section 4.3.
$h_o$	Minimum height of electron density profile, Section 4.2.
$h_r$	True height upper limit of integration for a virtual height, Section 4.2.
$h_j$	A sampled true height integration for a virtual height, Section 4.2.
$h_2$	True height of F2 layer at $f_{oF1}$ , Section 3.5.
$h_u$	True height of F2 layer at a frequency of $f_u = X_u f_{oE}$ , used in valley of electron density profile, Section 3.4.
$h_v$	True height of top of E layer at $f_v = X_u f_{oE}$ , Section 3.4.
$(h'-h)_N$	Normalized height difference factor used in non-deviative loss, Section 6.2.
$I$	Absorption index.
$k$	Correction factor in oblique transmission curve.
$L_{bf}$	Free space basic transmission loss.
$L_b$	Basic transmission loss, i.e., system loss, $L_s$ , where actual antennas are replaced by isotropic, loss-free antennas.
$L(f_v)$	Ionospheric loss for an oblique radio path at frequ, $f_v$ , Section 6.1.
$L(f_{ob})$	Ionospheric loss for an oblique radio path at freq, $f_{ob}$ , Section

6.1.

$L_c$	Loss correction factor for E modes, Section 6.2.
$L_i$	Losses caused by ionospheric absorption.
$L_o$	Sporadic-E obscuration loss for a mode passing through the layer, Section 6.3.
$L_R$	Sporadic-E reflection loss for a mode reflection for the layer.
$L_s$	Signal power available at the receiving antenna terminals relative to the available power at the transmitting antenna terminals, in decibels. This excludes any transmitting or receiving antenna transmission line losses.
$M(D)$	M factor of a ground distance D, the ratio of $f_{ob}$ to $f_c$ .
$M(3000)F2$	M factor for F2 layer at a distance of 3000 km.
$m$	Exponent of nonlinear transformation used in integration, Section 42.
$N$	Electron density.
$n$	Complex refractive index, $(\mu - i\chi)$ .
$o$	Ordinary wave.
$P$	Phase path; power; probability.
$P'$	Virtual path; equivalent path; group path.
$R$	Sunspot number; retardation.
$SSN$	Sunspot number.
$S$	Quantity relating $hpF2$ and $M(3000)F2$ (usually taken as 1490.) Section 2.4.2.
$S_1$	Slope of a linear F1 layer, at a frequency of $foF1$ , Section 3.5.
$S_2$	Slope of a parabolic F2 layer, at a frequency of $foF1$ , Section 3.5.
$t$	Time.
$X_u$	Frequency ratio at F2 layer for valley fill, Section 3.4. que radio path at frequency, $f-$ , Section 6.1.
$X_v$	Frequency ratio at E layer for valley fill, Section 3.4
$X_j$	An abscissa for Gaussian integration, Section 4.2.
$w_j$	Weight for Gaussian integration, Section 4.2.

ym Half thickness of a parabola.

ymE Half thickness of a parabola for E layer.

ymF1, ymF2 Half thickness of a parabola for F1 or F2 layer.

**Ionospheric Communications Enhanced Profile Analysis and  
Circuit Prediction Program User's Manual**

This report describes the operation and use of the Ionospheric Communications Enhanced Profile Analysis and Circuit Prediction Program (ICEPAC). The computer program is an integrated system of subroutines designed to predict high-frequency (HF) sky-wave system performance and analyze ionospheric parameters. These computer-aided predictions may be used in the planning and operation of high-frequency communication systems using sky-waves.

This report contains instructions for the use of ICEPAC. A description of the input data requirements, including data definition, organization, and instructions for setup of the various analysis tasks, is presented. Procedures and formats are given for preparing the input data and executing the program. The various outputs are presented and described with an interpretation of the analysis results.

**Key Words:** *communications; computer model; high frequency; ionosphere; LUF; MUF; sky-wave; user's manual.*

**1. INTRODUCTION**

In the initial planning or in the modification of many communication systems, there may be an appreciable delay between the circuit planning and the actual circuit construction or modification. This is of particular importance for high frequency circuits which have marked time and geographic variations in optimum frequency, required power, and system performance. Predictions of ionospheric characteristics and techniques for using these characteristics are, however, available and may be used to anticipate the performance of HF communication circuits and thereby provide the lead time for necessary equipment selection, frequency selection, and frequency and time-sharing arrangements.

High-frequency radio communication depends upon the ability of the ionosphere to return the radio signals back to earth. Prediction of ionization levels in the various regions of the ionosphere is, therefore, essential to any prediction of HF sky-wave circuit performance. The maximum frequency returned from the ionosphere usually establishes the upper limit of the useful HF range. The degree of ionization in the various regions is useful in estimating

probable modes, and the transmission loss for these modes is combined with the antenna performance and transmitter power available to estimate the expected HF sky-wave signal available anywhere at any time.

The expected sky-wave signal may be compared with the expected radio noise environment to predict the likelihood that the circuit will operate satisfactorily. This likelihood may be used to select optimum frequencies, proper antennas, required transmitter power, optimum time of operation, and broadcast coverage as a function of time and/or frequency.

This user's manual is subdivided into several sections. Section 2 describes the primary program-related requirements, including a program operation review, computer implementation requirements, and data files used by ICEPAC. The input language definition, input data description, command line image formats, and input requirements (including data organization, maximum system size, restrictions, and default values) are presented in Section 3. The various ICEPAC task options and control parameters are also discussed in Section 3. Section 4 describes the output options and possible program termination error messages. Several applications for system performance predictions are presented in Section 6 along with a sample test case. The geometry of the internal antenna package, ITSA-1, and typical antenna patterns generated are presented in Figures 29 through 51. Section 5 also contains a summary of the tabular and graphical outputs available with the ICEPAC version IC.10 computer program. Section 6 briefly describes the data base file used with the program. Section 7 contains input examples to assist the user in constructing ICEPAC input.

## **2. PRIMARY PROGRAM RELATED REQUIREMENTS**

This section briefly describes the primary program related requirements of the ICEPAC program. Included are computer implementation requirements, data files used by ICEPAC, and a program operation review.

### **2.1 Computer Implementation Requirements**

The ICEPAC program was developed on the IBM PS2 Model 80 computer using FORTRAN 77. The computer code is as close to being ANSI 77 Standard FORTRAN as was possible to ease adaptation to other computers. The computer resources required to run this program are 512K bytes of memory with a hard disk or floppy disk. A math co-processor is not required for Version .10. The program

resides on disk as a single run module and does not require overlays.

## **2.2 Files Used By ICEPAC**

The primary input is from a disk file with records resembling card images. The file name is requested interactively from the user. The program execution is then controlled by the data on the disk file and operator intervention is not allowed until the complete file has executed. Each Command Line format consists of an alpha-numeric name of up to 10 characters, followed by up to 14 data fields of 5 columns each. Each floating point variable may have a decimal point inserted, while the integer variables must be right justified in the field. The name identifiers mentioned above constitute an input language which is the primary communications link between the user and the actual program analyses. It provides a means of controlling the extent of an analyses as well as the type and amount of output desired.

The secondary input is the long term ionospheric coefficients which are stored on disk files in monthly segments. Each segment represents one month for low and high sunspot number and all hours of the day. When the month and sunspot number are read from the primary input file, the coefficients for the particular month are read and interpolated for the sunspot number. The resulting coefficient data base is used for further ionospheric parameter calculation relative to time and geographic location. A complete description of these data base files can be found in Section 6. These data are not user-defined input.

The magnetic coordinate file is used in the polar model evaluation for converting from geomagnetic coordinates to corrected geomagnetic coordinates. The file is not specified by the user.

The output from the program is written to a disk file in an 80 column format. When the output format requires more than 80 columns, the output is either folded in half or out put as two separate pages. The output from MUF-FOT calculations for the full ionosphere has been completely reformatted to conform to the column limitations.

The antenna output file is created if specified by the user. This file contains antenna patterns created by the ICEPAC antenna package (ITSA-1). These antenna patterns can be saved as a permanent file and used as input to the ICEPAC program at a later date or possibly used as input to some other analysis program. This is discussed in Section 3.4.

The antenna input file is a permanent file used to read antenna patterns that have previously been created by ICEPAC or by some other antenna package or routine. If specified by the user, the antenna patterns are read from this file instead of being computed by the ICEPAC program (see ANTENNA control line subsection). Use of this option to input antenna patterns not generated by ICEPAC generally requires the user to create a software interface to ICEPAC.

### **2.3 Program Operation Review**

The first step in using the ICEPAC program is to assemble the appropriate data for the system configuration to be analyzed. These data are then prepared on command lines which are read as input directly to the computer program or perhaps stored on a disk file for reading as input to the program at a later date.

Each command line contains a name identifier that is used as a label to identify the specific type of data on that particular command line. A listing of all valid name identifiers is given in Table 2, and a complete description of each name identifier and the associated input data is given in Section 3.3.

The computer program checks the name identifier of each command on the input file with the internal table of valid name identifiers. If an invalid name identifier is located, the program responds with a command line error and terminates execution. Errors in the name identifier are most often caused by a spelling error in the identifier name.

At this time, there is little or no diagnostic check of the data contained on any command line. Only the name identifier is examined. Thus, program execution will continue if there are no name identifier errors even though there may possibly be errors in the actual input data. It is, therefore, essential for the user to examine each command line image to insure that it is typed correctly and that it contains the necessary data before attempting to execute the ICEPAC program. Once the configuration is complete, the analysis is performed.

The ICEPAC program performs four basic analysis tasks which are discussed in detail in the ICEPAC theoretical report and summarized below:

- (1) Ionospheric Parameters. The ionosphere is predicted using parameters which describe four ionospheric regions: E, F1, F2, and Es. For each sample area, the location, time of day, and all ionospheric parameters are derived. These may be used to find an electron density profile,



- which may be integrated to construct a predicted ionogram. These options are specified by methods 1 and 2 which are briefly described in Table 3.
- (2) Antenna Patterns. The user may precalculate the antenna gain pattern needed for the system performance predictions. These options are specified by methods 13, 14, and 15, which are briefly described in Table 3. If the pattern is precalculated, then the antenna gain is computed for all frequencies (1-30 MHz) and elevation angles. If the pattern is not precalculated, then the gain value is determined for a particular frequency and elevation angle as needed.
  - (3) Maximum usable frequency (MUF). The maximum frequency at which a sky-wave mode exists can be predicted. The 10% (FOT), 50% (MUF), and 90% (HPF) levels are calculated for each of the four ionospheric regions predicted. These numbers are a description of the state of the ionosphere between two locations on the earth and not a statement on the actual performance of any operational communications circuit. These options are specified by methods 3 to 12, which are briefly described in Table 3.
  - (4) Systems Performance. A comprehensive prediction of radio system performance parameters (up to 22) is provided. Emphasis is upon the statistical performance over a period of a month. A search to find the lowest usable high frequency (LUF) is provided. These options are specified by methods 16 to 29, which are briefly described in Table 3.

### **3. INPUT DATA REQUIREMENTS**

This section describes the general data requirements and the input language definition. It also includes a complete description of all user-defined input data and the corresponding command line input formats. The minimum input requirements and default values for each analysis and prediction method are presented, as are the data organization and input restrictions.

#### **3.1 General Data Requirements**

The data requirements of the ICEPAC program consist of a fixed data base and user-defined input data. Much of the basic data required to use the ICEPAC program is stored on the ionospheric long-term data base files. These data base files includes geographic and time variations of the ionosphere and of atmospheric noise levels, the relationship between the ionospheric

characteristics and the propagation path geometry and signal attenuation, and the theoretical performance of common antenna systems. The data base is fixed to the user and is not part of the user-defined input data. A complete description of the ionospheric long-term data base is contained in Section 6.

The user-defined input data consist of line commands and perhaps an optional antenna file and the input depends primarily on the complexity of the analysis or system performance prediction requested (see Section 3.4). As an example, to determine the upper useful frequency limits, only the geographic location of the circuit terminals and the time are required. For more complex predictions such as the expected reliability of communications, additional user-defined input data are required. This data would include frequency of operation, the type of antenna used, the transmitter power, the type of service required, and the man-made noise environment, among others. A complete description of all user-defined data is presented in Section 3.3, and the required user-defined input data for each analysis or prediction method are summarized in Section 3.4. The input required for each run option is given in Table 13. The details of each command line format are given in Section 3.5.

### **3.2 Input Language Definition**

The name identifiers mentioned in Section 2.3 constitute an input language which is the primary communication link between the user and the actual program analysis. The language provides the user with the means of describing complex Physical configurations in somewhat familiar terms. It also provides a means of controlling the type and the extent of the analysis to be performed as well as the type and amount of output desired. Desirable characteristics of the input language include (1) format simplicity of the input statement and (2) quasi-order independence of the input data for a particular system configuration. Thus, the input line commands can often be presented to the program in any order (with some restrictions) to describe the topology of a system configuration, the type of analysis to be performed, and the output desired. Once these characteristics for a particular configuration have been defined, the program can be executed. Another desirable characteristic is the ability to alter certain characteristics of the configuration without having to redefine all other characteristics. This allows the user to alter certain parameters in the system configuration while keeping other parameters fixed. The benefit of this is that it allows the user

to execute the program for several configurations that have common characteristics in the same run without redefining all characteristics of the system configuration.

### **3.3 Description of the User-defined Input Data**

The user-defined input data are in the form of line commands and perhaps an optional antenna data file. As mentioned in Section 2.3, each input line command contains a name identifier that is used as a label to identify the specific type of data on that particular line command. A listing of all valid name identifiers is presented in Table 2, and a complete description of each name identifier and the associated data is given in the following subsections along with line command formats and examples. Each input line command will henceforth be called a control line with the name identifier used as the name of the control line. Formats for each line command are given in Section 3.5. All commands start with a 10 column identifier. All data fields are five columns long.

#### **3.3.1 Program Control, Execution, and Termination Command Lines**

The following command line defines the analysis task to be performed, indicate when the task will be performed for the current system configuration, and indicate how the program will reach a normal termination.

##### METHOD command line

The METHOD command defines the analysis task to be performed for a particular system configuration. The parameter on the METHOD command line is (see Command Line 1. References to the command line contain an example of each command along with a table of the contents of the line):

- (a) METHOD is the parameter which controls the type of program analysis and predictions performed. At the present time there are 30 task options available. Many of these tasks differ only in the representation of the output and require the same (or nearly the same) computations. The basic tasks consist of (1) tabulation of ionospheric parameters and ionograms from the ionospheric data base file, (2) MUF-FOT calculation and graphs, (3) computation and tabulation of antenna patterns, (4) system performance predictions, and (6) LUF calculation and graphs. A brief description of each

method available is given in Table 3, and a presentation of the output generated by each method is given in Section 4.

EXECUTE command line

The EXECUTE command causes the program to perform the indicated analysis task for the currently defined system configuration. This requires the user to specify the program control command line and the system configuration command line prior to the EXECUTE command (see Command Line 10). There is only one parameter on the EXECUTE command line described as follows:

- (a) KRUN is the parameter that indicates the layers at the ionospheric parameters that are calculated. If KRUN is less than or equal to zero, then the parameters of all layers (E, F1, F2, and Es) are calculated; if KRUN = 1, then the parameters of the E layer, F1 layer, and F2 layers are calculated; if KRUN = 2, the parameters for the Es layer only are calculated; if KRUN is greater than or equal to three, then no ionospheric parameters are calculated. This allows the user to skip the calculation of ionospheric parameters and use the last set previously calculated or a set of ionospheric parameters entered with the command lines. The use of the KRUN option may require additional consideration beyond that presented here.

It is also often possible to cause program analysis to be performed by having two consecutive command lines with the same name identifier. The command lines that allow this are:

```
METHOD  
CIRCUIT  
EXECUTE
```

Thus, if the user desires to have both a tabulation of two circuits, he may accomplish this by having two consecutive CIRCUIT commands on the input file. The remainder of this system configuration is unchanged if this technique is used.

QUIT control command

The QUIT command causes termination of the ICEPAC program. It must,

therefore, be the last physical command line on the user-defined input file. This command is essential to the program since it is used as the program termination indicator. There are no data parameters on the QUIT command line (see Command line 16).

### 3.3.2 Diurnal, Month, and Solar Activity Control Lines

The following command lines define the time of day, the month, year, and sunspot number (solar activity) period of interest for which the analyses and predictions are performed.

#### TIME command line

The TIME command indicates the time of day for which the analysis and predictions are to be performed. The hours can be either universal time or local mean time at the transmitter, depending on an input parameter. There are four parameters on the TIME command line, described as follows (see Command line 6):

- (a) IHRO indicates the starting hour in universal time or in local mean time at the transmitter.
- (b) IHRE indicates the ending hour in universal time or in local mean time at the transmitter.
- (c) IHRS indicates the hourly increment. The hourly increment is added to the starting hour to determine the next hour. This incremental process continues until the ending hour is reached.
- (d) ITIM indicates that the specified time is universal time or local mean time. If ITIM is negative, then the specified times are local mean times (LMT) at the transmitter, otherwise the specified times are universal time (UT).

#### MONTH command line

The MONTH command indicates the year and months for which the analysis and prediction are to be performed. The year is used for identification purposes only and has no effect on the program calculations. June and December are typical of seasonal extremes for long-range planning. The parameters on the MONTH command line are as follows (see Command line 2):

- (a) NYEAR indicates the year, but has no effect on the program calculations.

- (b) MONTH is a variable where 1 represents January, 2 represents February, etc. The program analysis and predictions are performed for each of the months the user specifies. The desired month can be specified in any order. This, for example, allows the user to perform the analysis and predictions for December before January if he so desires.

#### SUNSPOT command line

The sunspot command line indicates the sunspot numbers of the solar activity period of interest and is the 12-month smoothed mean for each of the months specified. The second is the "effective" geomagnetic activity index ( $Q_E$ ). This parameter is derived from the value of the effective  $K_p$ . (See table 12 and figure 52 for derivation of  $Q_E$  from  $K_p$ . A sunspot number of 10 is typical for low solar activity and sunspot numbers between 110 and 130 are typical of high solar activity. NOTE: monthly or daily solar activity indices are not used, only the expected 12-month running average is used. When  $Q_E$  is not available, the value 0.0 is used, thus depicting an undisturbed period.

#### **3.3.3**    System Configuration Command Lines

The following command lines identify and define the system configuration to be analyzed. This includes a label to identify the system coordinates, the location of the transmitter and the receiver, and the actual system parameters necessary to define the system configuration.

#### LABEL command line

The LABEL command contains alphanumeric information used to describe the system location on both the input and output. A recommended usage of the LABEL command is to specify a label for each transmitter-receiver configuration used, where the alphanumeric information describes the location of the coordinates given on the CIRCUIT command line. The parameters on the LABEL command line are as follows (see Command Line 8):

- (a) ITRAN is an array of 20 alphanumeric characters used to describe the transmitter location.
- (b) IRCVR is an array of 20 alphanumeric characters used to describe the receiver location.

It should be noted that the information on the LABEL command line is used

for identification purposes only. Thus, the user is allowed a maximum of 40 alphanumeric characters to describe the transmitter-receiver location and need not be concerned with which characters are stored in ITRAN and which are stored in IRCVR.

CIRCUIT command line

The CIRCUIT command contains the geographic coordinates of the transmitter and receiver and a variable to indicate the user's choice between shorter or longer great circle paths from the transmitter to the receiver. Normally the short circle path is desired by the user. On the CIRCUIT command line, the symbol N denotes northern hemisphere, S denotes southern hemisphere, W denotes western hemisphere, and E denotes eastern hemisphere (the directions may be spelled out if desired; such as NORTH). The parameters on the CIRCUIT command lines are as follows (see Command Line 3):

- (a) TLATD indicates the latitude at the transmitter in degrees.
- (b) ITLAT indicates the northern (N) or southern (S) hemisphere at the transmitter.
- (c) TLONGD indicates the longitude at the transmitter in degrees.
- (d) ITLONG indicates the eastern (E) or western (W) hemisphere at the transmitter.
- (e) RLATD indicates the latitude at the receiver in degrees.
- (f) IRLAT indicates the northern (N) or southern (S) hemisphere at the receiver.
- (g) RLONGD indicates the longitude at the receiver in degrees.
- (h) IRLONG indicates the eastern (E) or western (W) hemisphere at the receiver.
- (i) NPSL indicates the user's choice between shorter or longer great circle paths from the transmitter to the receiver. The longer great circle path is used if the user specifies NPSL = 1, otherwise the shorter great circle path is used. Often desired is the shortest distance between transmitter and receiver. This is accomplished by leaving the variable NPSL blank, therefore, selecting the shorter great circle path by default.

SYSTEM command line

The SYSTEM command line includes parameters necessary to define the

system configuration. This includes the transmitter power, man-made noise level, minimum take-off angle, required circuit reliabilities, required signal-to-noise ratio, the maximum difference in delayed signal power for multi-path, and the maximum difference in delay time for multi-path. The parameters defined on the SYSTEM commands are described below (see Command Line 4):

- (a) PWR indicates the transmitter power in kilowatts. Note that this is the power delivered to the transmitting antenna. (The program internally converts this to decibels (db) above a kilowatt as needed for computations.)
- (b) XNOISE indicates the expected man-made noise level at the receiver in dBW (decibels below 1W) in a 1 Hz bandwidth at 3 MHz. XNOISE should be input as a positive value unless the user desires to designate the receiving location area as industrial, residential, rural, or remote un-populous by specifying:
  - XNOISE = -1. for industrial (the program then uses -125. dBW)
  - XNOISE = -2. for residential (the program then uses -136. dBW)
  - XNOISE = -3. for rural (the program then uses -148. dBW)
  - XNOISE = -4. for remote un-populous (the program then uses -164. dBW). In remote un-populous areas, cosmic noise will normally dominate over man-made noise.
- (c) AMIND indicates the minimum takeoff angle in degrees. The value is normally very small unless antenna performance is expected to be so poor at low angles that these angles should not be used in the estimation of upper useful frequencies, or if the horizon is so obstructed that low takeoff and reception angles appear unlikely. The program uses a default value of 3° if this parameter is not set by the user. A value of 0.001 will effectively give the full range of possible radiation angles and should be specified by the user if the 3° default is not required.
- (d) XLUFP indicates the required circuit reliability, which is an estimate of the percentage of days within the month that the signal quality will be acceptable, and should be specified for calculation of the LUF or time availability for service probability. (NOTE: XLUFP is expressed as a percentage.) The program uses a default value of 90 if this parameter is not set by the user.
- (e) RSN indicates the required signal-to-noise and is the ratio of the



hourly median signal power in the occupied bandwidth relative to the hourly median noise in a 1 Hz bandwidth, which is necessary to provide the type and quality of service required (expressed in decibels). Table 4 and Table 6 show typical required S/N ratios for radiotelephone service and radio-teletype service. NOTE: The S/N values in this report and in the computer model are the ratio of signal in occupied bandwidth to noise in a 1 Hz bandwidth.

- (f) The user may choose the multi-path computations. The multi-path probability is an estimate of the likelihood that two or more sky-wave modes will exist within the specified power tolerance and outside the time delay tolerance.

PMP indicates the maximum difference in delayed signal power in decibels between sky-wave modes to permit satisfactory system performance in the presence of multiple signals. If PMP is blank or zero, multi-path is not considered.

- (g) DMPX indicates the maximum difference in delay time in milliseconds between sky-wave propagation modes to permit satisfactory system performance in the presence of multiple signals. The program uses a default value of .86 if this parameter is not set by the user.

#### FREQUENCY command line

The FREQUENCY complement command line contains up to 11 user-defined frequencies that are used in the calculation. The FREQUENCY command is not necessary with the analysis and prediction options dealing only with ionospheric parameters, ionograms, MUFs, antennas, or LUFs. system performance requires the FREQUENCY command. The parameter on the FREQUENCY command is as described below (see Command Line 7):

FREL is the array of up to 11 user-defined frequencies in megahertz. If the first frequency on the command line is left blank, then the FOT is inserted as the first frequency. If the entire FREQUENCY command line is left blank, then the 11 frequencies used in the calculation are computed for each hour by the program. The computed frequency range then begins at 2 MHz and ends at the HPF on a non-linear scale based on the E-MUF and F-MUF values. It should be noted that, in this manner, a different frequency complement is generated for each hour.

ANTENNA command line

The ANTENNA command line defines whether the antenna is transmitting or receiving, specifies the type of the antenna, the ground conductivity, and dielectric constants in addition to the other parameters necessary to compute the necessary antenna patterns. Typical values for selected ground types are given in Table 6 where typical good ground is low hills with unforested rich soil or flat wet coastal regions; fair ground is medium hills or forested heavy soil; and typical poor ground includes rocky steep hills, sandy dry coastal regions, and city industrial areas. The ground constants are optional on each antenna command. If not specified by the user, they will be calculated with the land mass map from the ionospheric long-term data base file. The ground constants will be set to poor ground as a default if they are not specified by the user and the land mass map is not available. It is permissible for the user to specify up to three transmitter antennas and three receiver antennas to cover the frequency range considered for each system configuration. It is also possible to indicate that the antenna is to be input from an external antenna file instead of being calculated by the program. The input parameters required vary with antenna type. The basic ANTENNA command line parameters are described below, and the geometric description of each available antenna type is given in Figures 29 through 51, and Command lines 21 through 32:

- (a) IAT indicates whether the antenna is transmitting or receiving, IAT = 1 for transmitting, IAT = 2 for receiving.
- (b) IANTR indicates the number which corresponds to the antenna type desired. The user has the option to input the antenna pattern from the optional external antenna file as discussed in Section 3.4.
- (c) AETA indicates the antenna bearing in degrees from east of north. Negative denotes the off azimuth angle from the circuit path. Positive denotes the main beam direction.
- (d) ASIG indicates the ground conductivity ( $\sigma$ ) in mhos per meter.
- (e) AEPS indicates the relative dielectric constant.

The following parameters describe various characteristics dependent on the antenna type specified. The user should refer to Section 3.4 for the description of the following antenna parameters and the antenna characteristics required for each antenna type:

- (f) AND

- (g) ANL    The definition and description of these parameters
- (h) ANH    depend on the antenna type specified.
- (i) AEX
- (j) AFQB indicates the ending frequency when the user specifies more than one transmitting type or receiving antenna type for the frequency range considered. The next antenna type used for the transmitter or receiver would then begin at 1 MHz greater than the ending frequency specified here.
  
- (k) IAIN indicates the antenna number (up to 3) when the user specifies more than one transmitter or receiver antenna for the frequency range considered. This parameter is also used as a control parameter to specify the location on the optional external antenna file if one is used. This usage is discussed in Section 3.4.

#### 3.3.4 User-defined Data Base and system Override Commands

The following command lines allow the user to specify an external data base consisting of (1) the geographical and geomagnetic parameters relating to a specified sample area, (2) the critical frequency, semi-thickness, and height of maximum ionization for the E, F1, and F2 layers, (3) lower, median, and upper decile values of the critical frequency and the virtual height of reflection, and (4) the true height and electron density. The ionospheric long-term data base file is not necessary when these ionospheric parameters are defined by the user. The user may also override internal program characteristics such as (1) the integration scheme used for the E and F2 layers and (2) the critical frequency multipliers to adjust the heights of the ionospheric layers. These values can be obtained using METHOD equal to 1 in a previous run. Use of the command lines in this section require in-depth information of ionospheric parameters and would be avoided by most users. These command lines are used to alter the use of predefined ionospheric data.

#### EFVAR command line

The EFVAR command line allows the user to indicate the critical frequency, semi-thickness, and the height of maximum ionization for the E, F1, and F2 layers for a specified sample area. The user may specify the following parameters for each of the sample areas defined on the SAMPLE command lines (see Command Line 11):

- (a) I indicates the specific sample area number, 1 to 5.
- (b) FI(1,I) indicates the critical frequency for the E layer, foE, in megahertz for the specified sample area.
- (c) YI(1,I) indicates the semi-thickness for E layer, ymE, in kilometers for the specified sample area.
- (d) HI(1,I) indicates the height of maximum ionization for the E layer, hmE, in kilometers for the specified sample area.
- (e) FI(2,I) indicates the critical frequency for the F1 layer, foF1, in megahertz for the specified sample area.
- (f) YI(2,I) indicates the semi-thickness for the F1 layer, ymF1, in kilometers for the specified sample area.
- (g) HI(2,I) indicates the height of maximum ionization for the F1 layer, hmF1, in kilometers for the specified sample area.
- (h) FI(3,I) indicates the critical frequency for the F2 layer, foF2, in megahertz for the specified sample area.
- (i) YI(3,I) indicates the semi-thickness for the F2 layer, ymF2, in kilometers for the specified sample area.
- (j) HI(3,I) indicates the height of maximum ionization for the F2 layer, hmF2, in kilometers for the specified sample area.

ESVAR command line

The ESVAR command line allows the user to indicate lower, median, and upper decile values for the Es layer and the virtual height of reflection for a specified sample area. The user may specify the following parameters for each of the sample areas defined on the SAMPLE command lines (see Command line 12).

- (a) I indicates the specific sample area number, 1 to 5.
- (b) FS(1,I) indicates the lower decile critical frequency for the Es layer, foEs, in megahertz for the specified sample area (example lowest value = 2 MHz).
- (c) FS(2,I) indicates the median decile critical frequency for the Es layer, foEs, in megahertz for the specified sample area (example median value = 4 MHz).
- (d) FS(3,I) indicates the upper decile critical frequency for the Es layer, foEs, in megahertz for the specified sample area (example highest value = 6 MHz).

- (f) HS(I) indicates the virtual height of reflection for the Es layer in kilometers for the specified sample area (example vertical height = 110 kilometers).

EDP command line

The EDP command line allows the user to read and use an external electron density profile for a specified sample area. Current implementation restrictions prohibit defining more than one sample area if an external electron density profile is used. The user may specify the following parameters for one sample area (see Command line 13). A temporary parameter is used to switch to the internal electron density profile if desired.

- (a) JSAMP indicates the specific sample area number (=1).
- (b) ITEMP is a temporary parameter which causes the internal electron density profile to be used if the user specifies the word "OFF." Thus, this parameter acts as a switch to "turn off" the external electron density profile and "turn on" the internal electron density profile. If not "OFF," then the EDP command line is followed by eight lines which contain:

HTR is the array of 50 that indicates the true heights in kilometers (four lines, see Command line 13a).

FNSQ is the array of 50 that indicates plasma frequency squared in (MHz)<sup>2</sup> (four lines, see Command line 13b).

INTEGRATE command line

The INTEGRATE command line allows the user to specify model segment integration for the F2 layer instead of the slower Gaussian integration. Thus, the user can request fast integration for the E layer and for the F2 layer when the F1 is not present. The D-E layer is preset using calculations from the Gaussian integration. A temporary parameter is used to allow the user to alternate between the model-segment and Gaussian integration. The program performs the slow Gaussian integration as a default if no INTEGRATE command is present.

- (a) INTEG is the temporary parameter used to specify the integration method. If the user specifies "-1" on the INTEGRATE command line, then Gaussian integration is performed. If the user specifies a

value greater than or equal to zero, then model-segment integration is performed. If "OFF" is specified (variable ITEMP), the program returns to the fast integration (see Command line 9).

FPROB command line

The FPROB command line allows the user to adjust the heights of the E, F1, F2, and Es ionospheric layers. The predicted critical frequencies are multiplied by the parameters on the FPROB command to raise or lower each corresponding ionospheric layer. If the user-defined parameter is greater than one, the critical frequencies used by the program will be larger than the predicted critical frequencies. If the user-defined parameter is less than one, the critical frequencies used by the program will be smaller than the predicted critical frequencies. The user may remove the F1 and Es layers entirely by specifying the value "0.0" for the critical frequency multiplier for either layer. The user should not, however, specify the value "0.0" for the critical frequency multiplier for the E or F2 layers. The following default values are used if (1) the critical frequency multipliers are not specified by the user or (2) the value specified for the E or F2 layer is negative or zero. The program uses the default value of 1.0 for the critical frequency multipliers for the E, F1, and F2 layers. Thus, the actual predicted critical frequency values are used by the program and the corresponding ionospheric layer ionization is neither raised nor lowered. The default value of the critical frequency multiplier for the Es layer is 0.7 to allow for median losses. A temporary parameter is specified if the user desires to use the default values for the actual frequency multipliers rather than the values previously specified on the FPROB command. If the user indicates "OFF" on a subsequent FPROB command line, the default critical frequency multiplier values are used. The user may also redefine the critical frequency multipliers previously defined by providing a subsequent FPROB command line. The following parameters are on the FPROB command line (see Command line 18):

- (a) PSC(1) indicates the critical frequency multiplier for the E layer.
- (b) PSC(2) indicates the critical frequency multiplier for the F1 layer.
- (c) PSC(3) indicates the critical frequency multiplier for the F2 layer.
- (d) PSC(4) indicates the critical frequency multiplier for the Es

layer.

### 3.3.5 Input, Output, and Comment Command Lines

The following command lines allow the user to place comments in the input file, use auxiliary input and output files, and identify additional input/output options available to the user. These command lines are used to (1) create an external antenna pattern file and (2) allow the user to request the outputs of various program options without re-computing parameters.

#### COMMENT command line

The COMMENT command line permits the user to place comments anywhere in the user-defined input file. This may benefit the user in specifying the system configuration in terms of descriptive text, and any number of comment lines may be used. During program execution, the comment lines are listed along with the other command lines, but otherwise they have no effect on execution of the program (see Command line 15).

#### ANTOUT command line

The ANTOUT command line allows the user to write antenna patterns generated by the ICEPAC program to a separate binary file if the program option to generate antenna patterns is used (methods 13, 14, 15). This file could then be saved as a permanent file for use at a later date with the ICEPAC program, or possibly with some other analysis program. This may be a desirable capability for the user who plans to use the same antennas for several sets of read data or to use the same antenna configuration for several periodic runs. The user could generate and save the antenna patterns on a permanent file, then read the antennas from the permanent file when running each of his data sets. It is also possible for the file to be used as a working file for direct input to some other analysis program. The process of reading the antenna file is discussed in Section 6.

A temporary alphanumeric parameter on the ANTOUT command line is used to specify when antenna patterns are output to the antenna file (see Command line 14). If the temporary parameter is left blank, then all antenna patterns generated following the ANTOUT command are written to the file. If the temporary parameter is set to "OFF," then none of the antenna patterns generated following the ANTOUT command are written to the file. It is often

more efficient to generate the desired antenna patterns before performing other program analysis or predictions. This process is demonstrated in Figure 12, where transmitter/receiver antenna pattern pairs are generated.

The user should be aware that the antenna patterns are generated and written on the antenna file only if methods 13, 14, or 15 are specified. Thus, if the user has an ANTOUT command line but does not specify methods 13, 14, or 15, no antenna patterns are generated for output and consequently none are written to the antenna file. Also, should the user specify methods 13, 14, or 16 but not include an ANTOUT command line, then the antenna patterns are generated and written to the primary (or auxiliary) output file along with any other program generated output, but the patterns are not written to the binary antenna file. A method of using antenna patterns generated by the IONCAP program or by other means available to the user, is described in Section 6.3.

#### OUTGRAPH command line

The OUTGRAPH command line allows the user to specify the output of several methods without re-computing the variables. This is of particular use if several line printer graphs or other output forms are needed for various combinations of variables. A temporary alphanumeric parameter on the OUTGRAPH command line is used to indicate if additional output is requested for the current system configuration (see Command line 17). If the word "OFF" is specified, then no additional output is desired. If the user desires additional output, he simply indicates the method numbers (up to 12) of the output desired on the OUTGRAPH command. As an example, if method 7 is run, the output from methods 8, 9, and 10 can be obtained without any additional computing as is demonstrated in Figure 13.

KTOUT is an array of up to 12 method numbers of the desired output. The user should be aware that the particular program option specified on the METHOD command dictates the output that can be requested on the OUTGRAPH command. There are two limitations as to the output available with certain program analysis options. (1) The user may not request output on the OUTGRAPH command that requires computations which were not performed during the program analysis. As an example, the user may not request output for methods which require system performance if only the MUF was computed. (2) Several of the analysis options are performed within loops where the variables are not saved throughout the duration of the loop. Such analysis options cannot be requested



with the OUTGRAPH command since the loops are terminated before the output requested on the OUTGRAPH line is generated. This implies that the user cannot always obtain the additional output by using the OUTGRAPH command. It is, therefore, optimal to run the program analysis options (specified with the METHOD command) that are performed within the loops and specify any additional desired output with the OUTGRAPH command.

Should the user specify output for a method with the OUTGRAPH command which violates one of the above restrictions, the program ignores the particular request and attempts to process any additional user requests for output. Thus, as an example, if the user should specify output for methods which require system performance and only the MUF was computed, the program would ignore the requests. Table 7 indicates the output available for methods specified on the OUTGRAPH line for each of the program analysis task options and also indicates the optimal combinations. The user may request LUF output (methods 26-29) if system performance has been calculated by methods 16-25. The LUF obtained would not be the computed LUF but would be the first frequency in the frequency complement that has a computed reliability greater than or equal to the required circuit reliability. If none of the reliabilities are as large as the required reliability, the frequency with the largest reliability is chosen as the LUF. A designator is printed to indicate the reliability. The user would compute the actual LUF by specifying methods 26-29 rather than specifying this on the OUTGRAPH command line.

The OUTGRAPH command acts as a software implemented "sense switch." Once the user specifies a desired output on an OUTGRAPH line, the user "enables" the software implemented "sense switch" and will continue to obtain the specified output options (when permissible) for every program analysis task he performs. This process continues until the user specifies either (1) an additional OUTGRAPH command or (2) an OUTGRAPH command with the word "OFF" specified, which disables the software implementation "sense switch." Should the user obtain much more output than he believes he has requested when using an OUTGRAPH command and when processing several system configurations, it is probable that he needs an OUTGRAPH "OFF" command somewhere (usually following an EXECUTE command). Should the user obtain less output than he has requested on an OUTGRAPH line, it is caused by an invalid user request that the program has ignored. The OUTGRAPH command may be specified anywhere before the EXECUTE command to request additional output options; however, the additional output

will be generated after the current task option has been completed. If no OUTGRAPH command appears, the user receives only the output of the task option indicated on the METHOD command. The output requested on the OUTGRAPH command line may be written to the auxiliary output file by specifying a negative method on the OUTGRAPH command line.

#### TOPLINES command line

The TOPLINES command line allows the user to select the output header lines he desires to print when running method 23. The information output, for the most part, consists of the user-defined system configuration. This command line, along with the BOTLINES command line, allows the user to indicate the specific output lines he desires and thus together they constitute a user-defined output option. The user can select the output desired rather than those defined by other method numbers. There is one parameter array on the TOPLINES command line. This option may be useful if the user does not desire the exact output generated by the task options implemented (see Command line 19).

LINTP is an array of up to 8 user-selected header lines.

Table 8 describes the header lines available to the user, along with the corresponding values of the parameter LINTP. The user may redefine the header lines desired at any point in the input deck by specifying an additional TOPLINES command which overrides the previous specified lines. The user may also cancel the header lines previously selected by indicating the word "OFF" as the value of a temporary parameter on the TOPLINES command. The program has one default header line which consists of the program task option (METHOD), the program name and version number, as well as the page number. If the user does not include a TOPLINES command or specifies TOPLINES "OFF," the default header line is the only one printed when method 23 is indicated. The TOPLINES command has no effect on any program task option other than method 23.

#### BOTLINES command line

The BOTLINES command line allows the user to select the desired parameters to print when running method 23. The information output consists of the current values of the variables the user indicates. This command line, along with the TOPLINES command line, allows the user to indicate the specific output lines desired, and thus constitutes a user-defined output option. The user may, therefore, request the desired output rather than those specified by

other method numbers. This may be useful if the user does not desire the exact output generated by the other task options. There is one parameter array on the BOTLINES command (see Command line 20).

LINBD is an array of up to 14 user-selected variables.

Table 9 describes the variables available to the user along with the corresponding values of the parameter LINBD. The user may redefine the variables desired at any point by specifying an additional BOTLINES command which overrides the previous specified variables. The user also may cancel the variables previously selected by indicating the word "OFF" as the value of a temporary parameter on the BOTLINES command line. The program outputs only the frequency complement as the default if the user does not include a BOTLINES command or specifies BOTLINES "OFF" when method 23 is indicated.

The BOTLINES command has no effect on any program task option other than method 23. Table 10 describes the line numbers preset by using methods other than 23.

#### **4. OUTPUT OPTIONS**

There are 30 output options that may be specified by the user (Table 3). These are divided into four subsets:

- (1) ionospheric descriptions, METHOD = 1 or 2;
- (2) antenna patterns, METHOD = 13, 14, or 15;
- (3) MUF predictions, METHOD = 3 through 12; and
- (4) LUF and system performance predictions, METHOD = 16 through 29.

The input required for each of the four run option subsets is summarized in Table 11. All the output figures described in the next three subsections were generated using the command lines listed in Figure 2. Each individual antenna type is described and an example given in the last subsection 4.4. The first line of all the output options gives the method number, program version, and a page number, the start of which is specified by the user.

##### **4.1 Ionospheric Parameters Output Options, METHOD = 1 or 2**

There are two outputs, a list of ionospheric parameters (Figure 2) and an ionogram (Figure 3). The data on Figure 2 are divided into a set of header lines and a body of output lines.

Line 2.      The month, day, year, and sunspot number are given on the second line.

Line 3.      The first 40 characters on the third line are those specified by

the user on the LABEL command line.

Line 4.      The fourth line is the location of the transmitter and of the receiver. The azimuths, transmitter to receiver, and receiver to transmitter, are given in degrees east of north. The circuit distance is given in both nautical miles and kilometers.

Line 5.      The semi-thickness of the E layer, YE, the height of maximum ionization, HE, and the reflection height of the Es layer, HS, are given in kilometers.

The body of the figure consists of the result of sampling the ionosphere at one, three, or five areas along the path. The output consists of 21 columns for each hour. To display this output on an 80 column page, the output was folded at column 11 with the first 11 columns on line 1 and the last 10 columns on line 2 for each hour. (There is only one sample area for this specific example.) Columns 1 and 2 give the sample area location. Columns 3 and 4 give the local time at the sample area and universal time (same for all sample areas). Column 5 is the median E critical frequency, foE, in megahertz. Columns 6 7 and 8 are the F1-layer median critical frequency, foF1, in megahertz; semi-thickness, ymF1, in kilometers; and height of maximum ionization, hmF1, in kilometers. Column 9 is one-half the gyro-frequency, fH. Columns 10, 11, and 12 are F2 zero MUF, (foF2 - 1/2 fH), in megahertz; ymF2 in kilometers; and hmF2 in kilometers. Columns 13, 14, and 15 are the Pole-ward, Center, and Equator-ward boundaries of the auroral trough in degrees north latitude. Column 16 is the F2 M(3000) factor. Column 17 is the local geomagnetic time, TCGM, in hours. Column 18 is the ratio of hmF2 and ymF2. Column 19 is the zenith angle in degrees. Column 20 is the flag that shows the location of the reflection point. See the following table:

IFLAG = 0	Implies low lat/mid lat nighttime point
IFLAG = 1	Implies auroral zone nighttime point
IFLAG = 2	Is unused
IFLAG = 3	Is unused
IFLAG = 4	Implies low lat/mid lat sunrise/sunset point
IFLAG = 5	Implies auroral zone sunrise/sunset point
IFLAG = 6	Implies low lat/mid lat daytime point
IFLAG = 7	Implies auroral zone daytime point
IFLAG = 8	Is unused
IFLAG = 9	Implies polar cap point (all times)

Column 21 is the geomagnetic latitude.

The ionogram output option, method 2, is in Figure 3. Up to three ionograms are constructed from the up to five sample areas along the circuit path. The ionogram plots are printed on two pages. The first page contains the left half of the ionogram plot and the second page contains the right half of the ionogram plot. Lines 2, 3 and 4 are the same as for Figure 2. Line 5 gives the universal time, GMT, the local time at the sample area, the sample area location, the distances in kilometers from the transmitter at which the E and F parameters were taken, the type of integration used, and the manner in which the F1 layer was added to the electron density profile. The graph is vertical sounding frequency (in megahertz) versus true and virtual heights (in kilometers) where true and virtual height are represented by "." and "x" respectively in the graph. The Es layer is given by a line at the Es reflection height. The character "U" is used until the 90 percent value of foEs is exceeded; "M" is used until the 50 percent value is exceeded; and "L" is used until the 10 percent value is exceeded. The parameters for each layer are given in the upper left corner. The table on the right gives the sounding frequencies and the true and virtual heights.

#### **4.2 MUF Output Options, METHOD = 3 through 12**

The maximum usable frequency (MUF) output options include all mode information as well as the distributions of the MUF for each layer. First note that methods 3, 4 5 and 6 refer to the MUFs for the E(F1) and F2 layers using the old nomogram method. This assumes a virtual height of about 300 km. The results of this model are not always valid in the 4000-10000 km range. The other MUF output comes from a complete electron density profile. All information possible from the MUF calculation are given in Figure 4. Lines 2, 3, and 4 are as described for Figure 2. Line 5 is the minimum radiation angle used to determine the MUF.

The body of the figure is composed of four lines for each hour, consisting of MUF information for each layer. Column 1 is universal time. Column 2 is local time at the transmitter. The next seven columns are for the E layer on line one, the F1 layer on line 2, the F2 layer on line 3, and the Es layer on the following line. Column 3 is the 10 percent value of the MUF; i.e., the FOT, MHz. The MUF during a month is expected to exceed the FOT 90 percent of the days, and to be less than the FOT 10 percent of the days.

Column 4 is the 50 percent value of the MUF in megahertz. Column 5 is the 10 percent value of the MUF; i.e., the HPF in megahertz. Column 6 is the radiation angle in degrees. Column 7 is the virtual height of reflection in kilometers. Column 8 is the true height of reflection in kilometers. Column 9 is the equivalent vertical frequency in megahertz. Note that, if the F1 layer is missing, the E values are used. Figures 5, 6, 7, and 8 are diurnal plots and tables of some of these parameters that have proved useful to analysis in the past.

#### **4.3 System Performance Output Options, METHOD = 16 through 24**

The prediction of the performance of a communication system operating between two points on the earth's surface is the main output of the ICEPAC program. There are two principle forms of output: first, a table of up to 22 performance variables, and, second, a table or graph of the lowest usable high frequency (LUF). The program has been written in such a way that the user may specify the system performance lines desired. The header identification lines can also be selected. Table 8 shows the eight topline available; Table 9 shows the 22 system performance lines available; Table 10 shows the line types specified by using the METHOD command. Table 7 shows the diurnal graphs that may be combined with the line selections.

Figures 9, 10, and 11 show a typical run with system performance output (method 16 with precalculation of antenna patterns). Figures 9 and 10 are tables of antenna gain in decibels at frequencies from 2 to 30 MHz and radiation angles from 0 to 90 degrees. These patterns and the input for each antenna type are described in detail in Section 4.4.

In METHOD 16, the header line information is largely input data supplied by the user.

Line 0:        This appears on each output page and includes the method, program version, and page number.

User selected header lines are:

Line 1:        Month, day, year, and sunspot number.

Line 2:        Label as supplied by user, and headings for next line.

Line 3:        Transmitter location, receiver location, the azimuth of the transmitter to the receiver in degrees east of north; the azimuth of the receiver to the transmitter in degrees east of north; path distance in nautical miles and kilometers.

- Line 4:        Antenna subroutine used (defining the antenna module used in ICEPAC) and the minimum radiation angle in degrees.
- Line 5:        Transmitter antenna line; up to three may be printed. Information varies with antenna type (see Section 3.4). Typically, this is frequency range, antenna type, height of antenna above ground in meters (- is wavelengths), length of active part, an angle associated with the antenna structure in degrees, and the off main beam azimuth in degrees. Note, lengths specified should be "electrical" lengths.
- Line 5A:       Receiver antenna line. Up to three may be printed. The data are specified similar to the transmitter antenna line.
- Line 6:        System line which has: transmitter power in kilowatts, man-made noise level at 3 MHz in dBW, required reliability and required signal-to-noise ratio in decibels.
- Line 7:        Multi-path line which has required power tolerance in decibels and required delay time tolerance in milliseconds.

The system performance lines are repeated each desired hour until the page is filled. The process is repeated if additional pages are necessary. The columns are time (universal) and up to 12 frequencies in megahertz; the first is the MUF and the remainder the frequency complement. Figures 11 to 18 give the various system performance output defined by methods 16 to 23 as indicated in Table 3. All possible output lines for system performance are as follows and shown in Figure 15.

Line 0, FREQ: Time and frequency line as associated with each column (default line always printed). The first four lines always refer to the most reliable mode (MRM). The system performance parameter usually comes from the sum of all six modes. If no decision can be made, the selection of MRM is based on number of hops and then on SNR. All distribution refers to a diurnal period of an hour and a yearly period of a month.

Line 1, MODE: For the short path model, number of hop and mode type. E is E layer; F1 is F1 layer; F2 is F2 layer; ES is Es layer; N is a one hop Es with n F1 or F2 hops - (MRM). For the long path model (Figure 16), the mode at the transmitter end and the mode at the receiver end are given. The user can force the long path model by specifying method 21 regardless of the actual path length.

Line 2, ANGLE: The radiation angle in degrees; for long paths (Figure

16), two lines are given: the first for the transmitter end, and the second for the receiver end. (MRM)

Line 3, DELAY: Time delay in milliseconds. (MRM)

Line 4, V HITE: virtual height in kilometers. (MRM)

Line 5, F DAYS: The probability that the operating frequency will exceed the predicted MUF.

Line 6, LOSS: Median system loss in decibels for the most reliable mode.

Line 7, DBU: Median field strength expected at the receiver location in decibels above 1 microvolt per meter.

Line 8, S DBW: Median signal power expected at the receiver input terminals in decibels above a watt.

Line 9, N DBW: Median noise power expected at the receiver in decibels above a watt.

Line 10, SNR: Median signal-to-noise-ratio in decibels.

Line 11, RPWRG: Required combination of transmitter power and antenna gains needed to achieve the required reliability in decibels.

Line 12, REL: Reliability. The probability that the SNR exceeds the required SNR. Note this applies to all days of the month and includes the effect of all mode types: E, (F1), F2, Es, and over-the-MUF modes.

Line 13, MPROB: The probability of an additional mode within the multi-path tolerances (short paths only).

Line 14, S PRB: Service probability. The probability that the required reliability will be met.

Line 15, SIG LW: Lower decile signal power (field strength and loss) increment in decibels.

Line 16, SIG UP: Upper decile signal power (field strength and loss) increment in decibels.

A composite table of reliabilities only is given in Figure 19 which comes from the user-selecting method 24. A similar table for any one variable can be selected by running method 23 and selecting the desired line. However, a frequency line will be printed each hour.

If information for each mode is required, method 25 will produce the data in Figures 34 and 35. For each hour, the ionospheric data, as in method 1, is printed. For each frequency, the mode and signal parameters are printed for each mode up to six. The last column is the selected most reliable mode. The same information is provided for the MUF.



Methods 26, 27, 28, and 29 will calculate the LUF, the lowest frequency having a specified circuit reliability, usually 0.90. Figure 36 is a table of LUF values with the MUF distribution and the median Es layer MUF. Figures 37, 38, and 39 are available diurnal plots of MUF prediction along with the LUF. Figures 40 and 41 provide MUF and system performance predictions for a long path (greater than 10000 km).

#### **4.4 Antenna Output Options, METHOD = 13, 14, or 15**

The detailed description of each antenna pattern and the required input definitions are given in this section. The gain subroutines used in the ICEPAC are approximate models using the "one-term" theory and assume that the antenna parameters are within the design limits of each antenna and that the operating frequency is such that the antenna is close to resonance. These antenna models are appropriate when used in a propagation model where other uncertainties overshadow the uncertainties in the gain due to the antenna mode limitations. However, it is not appropriate to use these models to design antennas or to evaluate their performance outside of their design limits or far from resonance. Also, they will not typically produce accurate results for full-wavelength or multiple-full-wavelength antennas--again due to the limitations of one-term theory. The sub-module described here also assumes the main beams are pointed along the circuit path. The input command lines in Figure 28 were used to generate the patterns of this section. Because of the 80 column limits on the outputs, the antenna patterns are divided and placed on two consecutive pages. Frequencies 2 Mhz through 11 Mhz on the first page and frequencies 12 Mhz through 30 Mhz on the second page. Figures 29 to 51 are pairs for each pattern, the first giving the structure of the antenna and the second giving a sample pattern.

### **5. APPLICATIONS**

The primary application of the ICEPAC program is to use the system performance options to select a frequency complement. While intended mainly for program test and evaluation procedures, the other output options, if used with some interpretation, may provide the analyst with enough information to solve a particular problem. Some possible applications will be discussed in the same order as the program complexity; i.e., as

- (1) ionospheric descriptions,

- (2) MUF predictions,
- (3) system performance predictions, and
- (4) antenna applications.

### **5.1 Ionospheric Parameters Applications**

The ionospheric description output consists of a table of parameters (Figure 2) and a graph and table of ionograms (Figure 3). The parameters are the output of the long-term world maps of the ionospheric parameters. The accuracy of the maps were determined when they were generated. The ICEPAC theoretical report has details and references to these maps. The ionogram output includes the vertical sounding frequency and the virtual height, so that this ionogram may be compared to measured ionograms. Note, however, a monthly median may not be characteristic of that for a given day. The effect of the changes of critical frequencies from the maps may be studied using the FPROB command (Command 18) or by use of the EFVAR and ESVAR commands (Commands 11 and 12).

### **5.2 MUF Applications**

In the absence of any other criteria for the planning of a system using HF sky-wave, the first, and simplest, criteria is an estimate of the frequency having efficient ionospheric reflections. Normally, an estimate of the frequencies expected to have efficient ionospheric support 90 percent of the time, FOT, and those having efficient ionospheric support 50 percent of the time, MUF, are adequate estimates of upper frequency limits for system planning. Figures 4 through 8 show the possible MUF outputs. Note that Figure 4 (METHOD=7) gives all mode information and MUF distribution for each layer. These MUF calculations are only a description of the state of the ionosphere and do not include any system parameters. They should not be confused with the maximum operation frequency (MOF) for transmission between two points on an existing circuit. A full system performance calculation should be made to estimate the MOF or to compare with observed MOFs. If a full system performance computation is generated, the user should examine the frequency complement predictions rather than the MUF.

### **5.3 System Performance Applications**

### 5.3.1 Selecting an Optimum Frequency

The complexities of propagation, the diversity of service requirements, and the fluctuation of spectrum congestion preclude any clear simple criteria for the selection of optimum frequencies. An adequate signal-to-noise ratio at the receiver for the specified type and quality of service is often a useful criterion. In general, within the HF spectrum, radio noise tends to decrease as frequency is increased. During the daylight hours when HF power requirements are highest, the propagation loss tends to decrease as frequency is increased. Since the noise normally decreases and signal normally increases with frequency, it is a general rule for HF sky-wave circuits that the higher the frequency the better the signal-to-noise ratio until frequency is increased to a point where reflection from the ionosphere becomes improbable. A first approximation to the optimum frequency in the absence of interference may, therefore, be made by estimating the highest frequency having an efficient ionospheric reflection consistent with the circuit reliability required; i.e., the MUF calculations described in Section 6.2 above.

Since there is normally limited flexibility in the selection of frequencies and since the optimum frequency based on the probable upper useful frequency limit has mixed diurnal, seasonal, and other variations, it is desirable to establish the probable useful range of frequencies. The FOT as shown is based on a 90 percent probability of efficient ionospheric support and may be used as an estimate of the probable upper frequency limit; a corresponding lower useful frequency limit may be estimated by considering the probability that the available signal-to-noise ratio will be adequate. Since noise normally increases as frequency decreases and signal normally decreases as frequency decreases, there is usually a frequency below which the probability of an adequate signal-to-noise ratio is unacceptable. This probability is often set at 90 percent and the corresponding frequency is known as the lowest useful frequency (LUF). These limits; i.e., FOT and LUF, are shown in Figure 22 and graphically displayed in Figure 23.

### 5.3.2 Selecting a Frequency Complement for a Single Circuit in the Absence of Other Circuit Interference

The range of useful frequencies, such as shown in Figures 22 and 23, is basic to the selection of frequency complements and should be obtained for

representative months over the time period the circuit under consideration will be required to operate. For a semi-permanent operation, diurnal variation of the useful frequency range for seasonal extremes (e.g., June and December) and solar activity extremes (e.g., sunspot number 10 and 110) are normally adequate.

### **5.3.3**    Standard Frequency Complement

Absolute continuity of any radio service, however desirable, is improbable even with an unlimited choice of operation frequencies, when high frequency sky-wave propagation must be relied upon. Moreover, the return in improved continuity for an enlarged frequency complement beyond a certain size, depending upon the service, diminishes so rapidly that it can rarely be justified in the congested spectrum. Frequency complements can, however, be based on a concept of maximum feasible continuity; i.e., the theoretical increase in circuit continuity may be negligible if additional frequencies are added, but a significant decrease is possible if fewer frequencies are available. Since the required frequency complement depends upon the circuit parameters or usage, the following classification of circuits is introduced:

a.    Circuits requiring maximum feasible continuity. These are the usually heavily loaded telegraph and telephone circuits, which must be available with good traffic capacity at all times. Because of their loading, they employ relatively elaborate terminal equipment. Telegraph circuits of this category are operated at machine speeds, while the telephone circuits generally employ several channels of a single-side-band system and are extended to line networks. Such circuits are characterized by the use of large directional antenna systems, diversity reception in telegraphy, and high-powered transmitters. Some other circuits, notably those immediately concerned with safety of life, may have an urgent need for continuous availability, although not necessarily carrying continuous traffic. The standard frequency complement for these circuits provides at least one frequency between the LUF and FOT at all times, plus one or two additional frequencies to permit flexible operations in the event of interference and during ionospheric disturbances. The maximum complement for these circuits should rarely exceed four. If more than four frequencies are considered necessary, re-engineering of the circuit should be investigated.

b.    Circuits requiring moderate continuity.    Distinct from circuits

requiring maximum continuity, there exists a larger group of circuits which, by nature of their operation, require only moderate continuity. These circuits generally provide communication under circumstances where the needs are insufficiently critical to warrant the extension of wire, cable, or VHF facilities. Many such circuits are operated to provide occasional service to remote installations. There are also many circuits which may be designated nominally as continuous in operation, but on which the nature of the traffic is such as to allow occasional delays, reduction in transmitting speed, or rerouting. Judicious scheduling of traffic contributes significantly to the satisfactory operation of these circuits. Most circuits of an administrative nature belong in this category. For frequency-complement considerations, circuits (except safety services mentioned earlier) should generally be constrained to this category if they employ manual telegraphy or telephony not extended to line networks, or are equipped with simpler transmitting and receiving installations than are capable of providing maximum feasible continuity. Radio circuits of this kind have been operating on one or two frequencies in many parts of the world for many years, providing a quality of service consistent with particular needs. The standard frequency complement for these circuits is two, one day frequency and one night frequency.

#### **5.3.4**    Two-Frequency Complements

Two-frequency complements are recommended with the clear understanding that the services receiving such complements are of the kind which do not have sufficient traffic to justify attempts to operate them on a twenty-four hour basis. These circuits must nevertheless be assured of as many hours of communication per day as possible within the two-frequency limitation. Actually, in a very large number of cases during intermediate conditions of solar activity, two-frequency complements will give very nearly twenty-four hour service, except in the auroral regions where experience has shown that no complement of high frequencies can ever give a highly reliable service.

a.    General considerations. There is available, at the present state of our knowledge, enough information on propagation, if the other factors such as

terminal equipment, type of service, and actual operating conditions are known, to permit useful estimates of the total number of hours of satisfactory service, assuming no interference, to be expected from a given frequency over an average solar cycle. It is, however, impossible to estimate for any particular circuit the frequency that would give the maximum number of hours of useful service over the solar cycle. However, this frequency might not necessarily be one of the two frequencies assigned, since the cumulative number of hours of usefulness is a less urgent consideration than that of assuring operation during the normal peak traffic periods.

b. The day frequency. A simple method for selecting the day frequency consists of choosing a frequency just below the lowest daytime FOT curve. In the north temperate zone, this would be the FOT curve for June for the period of minimum solar activity. Simply choosing one frequency, or some small range of frequencies on this basis, ignores the situation with regard to LUF, and could lead, for an actual circuit, to failure to provide communication during the middle of the day in months of maximum absorption at the period of maximum solar activity. An improved method is derived from the opinion that, if possible, the day frequency should not fail to give service during the midday hours even at the condition of maximum normal absorption which occurs at the maximum levels of solar activity.

This approach suggests immediately that a band of particularly useful frequencies exists between the frequency which is just above the maximum midday LUF and the highest frequency that will provide essentially skip-free service during the middle period of the daylight hours in the months of minimum daytime FOT. The lowest frequency in such a band will provide the maximum hours of service, and such service may well exceed that obtained from a frequency selected only on the basis of minimum daytime FOTs. Fortunately, a useful band of frequencies does exist in nearly all cases, and the day frequency should be chosen in the lower part of this band.

The possibility of skip on frequencies chosen in this way is unlikely when consideration is given not only to normal FOTs, but also to the well-established role of sporadic-E reflections.

c. The night frequency. The choice of the night frequency is complicated, depending not only on the type of service, terminal equipment, and a number of propagational considerations, but also on the day frequency selected. As in the case of the selection of the best day frequency, it is not

sufficient to select a frequency that will give the maximum number of hours of service throughout a complete solar cycle. The solution is to make the best choice for those hours that the day frequency is not suitable.

At night ionospheric absorption is minimal, except in the high latitudes, and the LUFs are rather critically dependent on the type of service and equipment used, including the antennas and the required signal levels. Too high a night frequency will be subject to skip too much of the time. However, a very low and, therefore, virtually skip-free night frequency may make it impossible to deliver adequate signal-to-noise ratios to the receiving location for substantial periods of time. The selection problem for this single night frequency is one of deciding what constitutes a suitable balance of these conflicting considerations. For circuits of 4000 km or less in length, the difference in local time between the terminals can never be large in the regions of the world where the bulk of the HF circuits operate. It is reasonable that traffic handling during the predawn hours be avoided, since, apart from the usual erratic behavior of the ionosphere during these hours, normal activities at both terminals are at their diurnal minimum during this period. In view of this sort of consideration, it would seem incorrect to choose a night frequency so low that skip-free operation was safely assured during the predawn period of the months and solar activity conditions having the lowest FOTs at the expense of rendering communications impossible during other time periods because of high noise levels normally experienced at the lower frequencies.

It is recommended, therefore, that the night frequency be chosen as the highest frequency of which less than four hours of skip is indicated on the lowest of the FOT curves for the required months of operation. This is usually during the winter months; e.g., December in the northern hemisphere and June in the southern hemisphere.

### **5.3.5**    Three-Frequency Complement

Many radio circuits require a greater continuity of service than can generally be assured with two frequencies. This is especially true of telephone circuits intended for extension to line networks. The following suggestions are applicable to determining frequency complements for circuits less than 4000 km in length requiring maximum feasible continuity and employing telephony for extension to line networks, and also for speed of telegraphy for

services not seriously troubled by multi-path effects. Multi-path protection required for certain types of high-speed machine telegraphy and facsimile services is not necessarily provided by these three-frequency complement standards.

There is some justification for enlarging the complement to four frequencies in the case of telephony and manual telegraph services subject to the severe magnetic disturbances characteristic of the high latitude regions. In other regions, however, it is possible by a suitable choice of three frequencies to maintain the signal-to-noise ratio high enough to provide an entirely adequate service. This is possible because higher frequencies are generally usable in the lower latitudes as a consequence of the observed higher complement-limiting FOTs, daytime levels of which survive in many cases far into the night. This situation is in marked contrast with the high latitudes where circuits are in all cases significantly more difficult to operate.

a. The high frequency. The highest frequency of a three-frequency complement is purely a day frequency. Since a middle frequency is available, it is no longer necessary for the highest frequency of the complement to be constrained to give useful service at the minimum phases of the solar cycle. This frequency should give many hours per day of useful service at all seasons during the maximum phases of the solar cycle. The high frequency is the highest frequency which will be below the FOT at least four hours during all months during the period the circuit is to be operated.

b. The low frequency. The lowest frequency of a three-frequency complement is entirely a night frequency. It must be selected on a basis related to the minimum FOT during any month the circuit is required to operate. Select the frequency which indicates less than two hours of skip on the lowest of the FOT curves for the required months of circuit operation.

c. The middle frequency. The middle frequency is selected so as to maximize the number of hours during which at least one frequency is between the LUF and FOT during the required period of circuit operation.

d. A special case for modifying the low frequency. Certain special considerations may affect the choice of a low frequency for circuits between about 3600 and 4000 km in length. For such circuits, the vertical angles of departure and arrival for single-reflection F2-layer transmission at night become very low. With many antennas, very little energy can be transmitted or received at these low angles. For these antennas, transmission, when possible,



by two reflections from the F2 layer provides a superior service. If highly-directional broadside arrays, which are relatively efficient at low angles, are used at sites permitting use of low angles of departure and arrival, the single-reflection transmission remains useful. The possibility of site conditions which make impossible the use of low angles of arrival or departure should not be overlooked. During the conditions of lowest MUFs, unobstructed sites, and efficient low-angle antenna systems, the low frequencies for paths 3000-5000 km will remain useful, but there will usually be a skip on the higher vertical-angle two-reflection mode. With low-angle radiation or reception limited by inadequate antenna systems, terrain, etc., in the ways suggested, this skipping in the two-reflection mode may well interrupt the service. In these instances, where it appears that reliance must be placed on two-reflection transmission during the period of minimum MUFs, it is preferable to assign a frequency appropriate to two-reflection transmission. This frequency will be automatically displayed in Figure 4 or on graphs displayed in Figures 5 to 8 if the minimum vertical angle is set at the lower limit of adequate antenna performance; e.g., 3 to 6 degrees.

#### **5.3.6**    Four-Frequency Complements

Standard three-frequency complements are confined to a number of services, operated over paths less than 4000 km in length, where maximum feasible continuity of operation is required, but when the effects of multi-path propagation are not serious. Services which use high-speed digital transmission techniques are seriously affected by multi-path distortion, and a three-frequency complement may be insufficient. Many such services can, however, be adequately satisfied by a three-frequency complement with respect to both continuity and multi-path protection. This is particularly true for circuits in the 2000 to 4000 km range of lengths, where the probability of multi-path is low, and to a lesser extent for shorter circuits. Whether or not the three-frequency complement for a particular circuit provides the requisite multi-path protection for high-speed service may be determined by a system performance prediction for the frequencies selected (e.g., METHOD=23, Figure 18 using a multi-path tolerance of two milliseconds and a power tolerance of 10 db) and noting the multi-path probability for frequencies having an acceptable reliability.

It was suggested in the discussion on the applicability of three-

frequency complements that there is some justification, apart from multi-path considerations, for the assignment of a four-frequency complement to a circuit operating in high latitudes which has a critical need for maximum feasible continuity. If one or both terminals of a circuit lie above 60 degrees north geomagnetic latitude, the circuit may be regarded as sufficiently high latitude to merit consideration for a four-frequency complement.

a. The highest frequency. The highest frequency of a four-frequency complement is purely a day and evening frequency. Since three frequencies are available below it in a given complement, there is no longer any need that it give any important service at the minimum phases of the solar cycle, nor need it be the only frequency of the complement for service during maximum LUF periods. The main purpose of this frequency is to permit the reception of high-speed digital information free of destructive multi-path distortion. It is usually required in afternoon and evening periods when the second highest frequency--while giving a perfectly adequate signal-to-noise ratio--would be subject to multi-path distortion. This frequency must, therefore, be chosen with the maximum FOT in mind; it should nevertheless be as low as possible to give as much service as possible. In some of the complements, the highest frequency will give few cumulative hours of service over a solar cycle, though remaining indispensable to avoid multi-path. In other complements, it will give considerable cumulative service and prove to be particularly useful in obtaining a good signal-to-noise ratio.

In general, the highest frequency is chosen to exceed 65 percent of the maximum FOT during the required period of circuit operation. This procedure is intended to provide substantial protection against multi-path distortion on the highest frequency of the complement during hours and seasons of occurrence of maximum MUFs. At shorter distances, because of the impracticability of providing complete multi-path protection, the factor provides as much protection as can reasonably be afforded by a four-frequency complement, while at the same time providing a highest frequency that will have significant usefulness at the maximum phases of the solar cycle.

It is necessary to invoke a LUF-determined lower limit or floor value below which the highest frequency of the complement is not selected regardless of the results of the above procedure. This limit is intended to provide a minimum additional margin of signal-to-noise ratio over that provided by the second highest frequency for high-grade service during periods of maximum LUF.

The lower limit is set at 1.4 times the maximum LUF during the required period of circuit operation.

b. The second-highest frequency. The second-highest frequency of a four-frequency complement is the most important frequency of the complement in many ways. It is certainly the frequency likely to receive the greatest cumulative use over a solar cycle. It is low enough to provide reliable daytime operation at sunspot minimum during periods of minimum daytime MUF. While the frequency may receive considerable daytime use at sunspot maximum, it will also be needed during the evening and night transition periods at sunspot maximum to permit continuation of high-speed digital operation. Since there exists a frequency still higher in the complement and two lower, this frequency is chosen to remain just above the maximum LUF, as was the daytime frequency of the two-frequency complements. On some circuits, it can be expected that this frequency will provide service far into the night at sunspot maximum during much of the spring, summer, and autumn seasons. The principal use of this frequency is, nevertheless, as a day or evening frequency.

c. The third-highest frequency. The third-highest frequency of a four-frequency complement is probably the second most important frequency of the complement in terms of cumulative hours of use over a solar cycle. While this frequency may receive some use in the early morning under certain conditions, its main use is as an evening or night frequency. During sunspot maximum conditions, it will, in a large number of cases, cover the late night period even in winter; it will certainly be sufficiently low for summer night use, even down to sunspot minimum in many temperate regions. In the high-noise regions, this frequency will nearly always be sufficiently low to cover the predawn period at the noisiest seasons, and for this reason it has not been necessary to give special consideration to high-noise-region floors for night frequencies in this report.

This frequency is the geometric mean of the second-highest and the lowest frequency of the complement. This procedure results in frequency intervals which provide the maximum possible multi-path protection between these complement members. It provides, at the same time, a good order of frequencies for intended major usage during evening and night periods.

c. The lowest frequency. The lowest frequency of a four-frequency complement is entirely a night frequency. It must be relied upon at all times when the third-highest frequency is too high to carry

the service. It is selected just below the minimum FOT during the period the circuit is required to operate.

#### 5.3.7 Time Sharing on Circuits Separated Geographically

Since there are marked diurnal and geographical variations in the useful frequency range, it is often possible to use this variation to develop time sharing plans when circuits are separated geographically.

Tabulations or graphs of useful frequency range (Figures 21 and 22) should be obtained for the time period or time periods of interest. Whenever a frequency complement is such that it contains a frequency within the useful frequency range for one circuit, while outside the useful frequency range for the other circuit, this information may be used to develop time-sharing schedules. The time period may be extended whenever other frequencies in the complement are useful on the second circuit.

#### 5.3.8 Time Sharing in the Same Geographic Area

When long and short paths are involved in the same geographic area, the useful frequency ranges for each may differ sufficiently that sharing plans may be developed in a manner similar to that described above (see Section 5.3.7).

#### 5.3.9 Frequency Sharing

The development of frequency-sharing plans requires the prediction of the available signal along the unwanted as well as the wanted radio path, taking particular account of the expected antenna performance for the unwanted radio path. The circuit reliability estimates (e.g., METHOD=23) can be used to develop frequency-sharing plans (i.e., share whenever the reliability is high for the wanted paths but low for the unwanted paths).

A quick determination of a frequency sharing opportunity may sometimes be made by MUF-FOT computations for the wanted paths (e.g., Figure 5) and the HPF (frequency having efficient ionospheric support only 10 percent of the days) computation for the unwanted paths (e.g., Figure 6). Sharing should be possible if a frequency is below the FOT on the wanted path but above the HPF on the unwanted path.

#### 5.3.10 Broadcast Coverage

Circuit reliability is probably the most valuable single output from the

prediction program. As various parameters are fixed, a computation of circuit reliability as a function of a remaining variable will often assist in decision making. The question of broadcast coverage is a good example. With time, frequency, antenna, transmitter location, transmitter power, etc. fixed, circuit reliability to sample points within a geographic area of interest will describe the coverage of the area in terms of the percentage of days within the month that satisfactory reception may be expected. This process may be performed automatically by the computer to provide reliability tabulations over selected areas (e.g., one hemisphere). Although this output is not available as a "standard output", tabulations of this type can be made using a special input command line processor and output variable formatter.

#### **5.3.11**    Optimum Times for Communication

For given transmitter location, receiver location, antenna types, etc., the diurnal variation in circuit reliability may be used to choose optimum communication time (e.g., METHOD=23).

#### **5.3.12**    Selection of Relay Locations

Careful consideration should be given to increasing the frequency complement, increasing power, antenna redesign, etc. before relay stations are used. If there is no other solution, consider the use of relay stations. Normally, if possible, these relay stations should be separated by at least 3000 km and preferably not more than 7000 km. The relays should also assure the propagation path does not go to high latitudes; i.e., temperate or equivalent routes avoiding high noise regions are preferred. In the final selection, it is a question of computing circuit reliability for the direct path and making a comparison with potential relay sites.

#### **5.3.13**    Determination of Lowest Effective Transmitter Power

Compute circuit reliability as a function of transmitter power with other variables fixed and plot reliability versus transmitter power. The lowest effective power is the lowest power providing the required reliability. An alternative is to use the required power plus antenna gain output, RPWRG, line 11, using METHOD=23.

#### **5.4 Antenna Selection or Design**

For the frequency or frequencies under consideration, make predictions covering the required time period of operation using a constant gain antenna with a typical gain; e.g., 12 db. Determine the time or times the circuit reliability is the lowest. Using these times, repeat the computation for the antennas under consideration to select an antenna. Caution: the calculated vertical angle for the most reliable mode provides some guidance in determining the antennas to be considered, but this angle alone should never be used as the sole criterion for antenna selection. To select an antenna, repeat the computations for available antennas. To design an antenna, repeat computations for variables in the antenna design; e.g., antenna height, rhombic leg length, etc. Note, however, that these parameters must be part of a "well designed" antenna. See the comments in Section 4.4 above.

### **6. PROGRAM DATA FILES**

#### **6.1 Program and Data Base Files**

The ICEPAC program and data base is provided on 360kb diskettes or on DC-600A data tape cartridges for UNIX based systems. The programs are executable modules and the data bases are binary files.

#### **6.2 Long-Term Data Base File**

This section describes the long-term data file used with the ICEPAC program. Details of how each of the various parameters is used is given in the ICEPAC theoretical report. The data files used here has evolved over many years. The basic criteria used in retention or inclusion of any of the data sets are: availability on a worldwide basis over all the time cycles (diurnal, yearly, and solar cycle) availability of distributions of the data, and consistency between the data sets. There are 12 binary data files accessed from the hard disk, one for each month of the year. The names are as follows:

BCOEF01.DAT = January data base  
BCOEF02.DAT = February data base  
.  
.  
BCOEF12.DAT = December data base

Logical Record 1 - F1 layer and Land mass data base

This record contains the following arrays:

ANEW(3),BNEW(3),ACHI(2),BCHI(2),FAKMAP(29,16),  
ABMAP(2,3)

Logical Record 2 - Noise and Statistical data base

This record contains the following arrays:

F2D(16,6,6),DUD(5,12,5),FAM(14,12),SYS(9,16,6),  
PERR(9,4,6)

Logical Record 3 - Noise Data

This record contains the following array:

p(29,16,6) ABP(2,6)

Logical Record 4 - FOF2 data

This record contains the following arrays:

IKIM(10,6),XF2 COF(13,76,2)

Logical Record 5 - Median sporadic E (FoEs) and height ratio data

This record contains the following arrays:

XESMCF(7,61,2), XPMAP(29,16,2)

Logical Record 6 - Lower and upper decile of sporadic FoEs

This record contains the following arrays:

XESLCF(5,55,2), XESUCF(5,55,2)

Logical Record 7 - M(3000)F2

This record contains the following array:

XFM3CF(9,49,2)

Logical Record 8 - Regular E layer (FoE)

This record contains the following array:

XERCOF(9,22,2)

### 6.3 Antenna Patterns Stored on File

It is possible, but not mandatory, to execute the ICEPAC program using antenna patterns that have been previously computed by (a) ICEPAC using the ANTOUT command line discussed in Section 3.3.6, (b) some other analysis program that has been modified to create and write antenna patterns in the format expected by ICEPAC or (c) to use field measurements and interpolation to create and write antenna patterns in the format expected by ICEPAC. This use may require some in-depth knowledge of the working of ICEPAC.

The antenna pattern output file (defined by the ANTOUT command) is stored on disk as an external binary file. The user should assign the local file name on the ANTOUT command line prior to the execution of the ICEPAC program. The user would then specify antenna type 18 on the ANTENNA command line to indicate that the antenna pattern is to be input from the antenna file. The location of the desired antenna pattern on the antenna file is specified using variable IAIN for antenna type 18. (Note: This variable indicates from one to three antennas to cover the frequency range specified for the transmitter and receiver antennas for all antenna types except antenna type 18.)

It is necessary to specify the location of the desired antenna pattern on the antenna file since several antenna patterns could be written on the same antenna file. Locating the desired antenna pattern depends on whether the antenna pattern is beyond or before the current location on the antenna file. If the desired antenna pattern is beyond the current position on the antenna file, the variable IAIN indicates the number of antenna patterns to skip forward from the present position on the antenna file before reading the desired pattern. Thus, in this case, IAIN must be set to a positive number or zero by the user. For example, IAIN = 0 indicates that no antenna patterns are to be skipped from the current position, which means the next antenna pattern on the file is read. If IAIN = 3, then three antenna patterns are to be skipped from the current position before the desired antenna pattern is read. If the desired antenna pattern is before the current location on the antenna file, the variable IAIN indicates that the antenna pattern should be rewound before searching for the desired pattern. This is accomplished by setting IAIN negative. The negative number causes the file to be rewound, and the pattern read is specified by the absolute value of IAIN. For example, IAIN = -1 indicates that the antenna file is rewound before reading the desired antenna pattern and that the first pattern on the file is the antenna pattern read. If IAIN = -3, then the antenna file is rewound before reading the desired antenna



pattern and the third pattern on the file is the antenna pattern read.

## 7.    **SPECIFIC INPUT EXAMPLES**

This section is intended to demonstrate specific input options of the IONCAP program to reinforce information provided in earlier sections. Specific input requirements necessary to demonstrate particular IONCAP capabilities are discussed. References to corresponding output for each example is also presented.

### 7.1   **Ionospheric Parameter Example**

The input required to generate the ionospheric parameters for the control points of a particular circuit consists of the following control: METHOD, MONTH, SUNSPOT, TIME, LABEL, CIRCUIT, EXECUTE and QUIT. The input necessary to generate the similar output represented in Figure 2 consists of the following:

```
METHOD      1
MONTH         1970    1
SUNSPOT      100.    0.
TIME          1    24    1    -1
LABEL        BOULDER, COLORADO TO ST. LOUIS, MO.
CIRCUIT      40.03N    105.3W    38.67N    90.25W
EXECUTE
QUIT
```

It should be noted that the sporadic-E critical frequency has been multiplied by .7 to allow for median losses in this example by program default.

Figure 2, discussed earlier, is a presentation of the ionospheric parameters for this circuit without the sporadic-E critical frequency reduced.

### 7.2   **Antenna Pattern Example**

The input required to generate an antenna pattern for both a transmitter and receiver antenna consists of the following command lines: METHOD, ANTENNA, EXECUTE, and QUIT. The specific input necessary to generate the output represented in Figures 9 and 10 consists of the following:

```
METHOD      15
ANTENNA       1    2    .001    4.    -.5
ANTENNA       2    2    .001    4.    -.25
EXECUTE
```

QUIT

To generate the pattern of a transmitter antenna, only use method 13 and for a receiver antenna, only use method 14.

### 7.3 MUF Example

The input required to generate MUF predictions consists of the following command lines: METHOD, MONTH, SUNSPOT, TIME, LABEL, CIRCUIT, EXECUTE, and QUIT. The specific input necessary to generate the output represented in Figure 4 consists of the following:

```
METHOD      7
MONTH        1970    1
SUNSPOT     100.    0.
TIME         1    24    1    -1
LABEL       BOULDER, COLORADO TO St. LOUIS, MO.
CIRCUIT     40.03N   106.3W   38.67N   90.25W
EXECUTE
QUIT
```

### 7.4 System Performance Example

The input required to generate system performance predictions consists of the following command lines: METHOD, MONTH, SUNSPOT, TIME, LABEL, CIRCUIT, ANTENNA, FREQUENCY, EXECUTE, and QUIT. The input necessary to generate output similar to the output represented in Figure 11 consists of the following:

```
METHOD      16
MONTH        1970    1
SUNSPOT     100.    0.
TIME         12    24    12    -1
LABEL       BOULDER, COLORADO TO ST. LOUIS, MO.
CIRCUIT     40.03N   105.3W   38.67N   90.25W
ANTENNA      1     2     .001   4.     -.5
ANTENNA      2     2     .001   4.     -.25
FREQUENCY   2.0   3.0   5.0   7.5  10.0  12.5  15.0  17.5  20.0  25.0
30.0
EXECUTE
QUIT
```

It should be noted that the above input does not cause the transmitter

and receiver antenna patterns to be pre-computed as was the situation in Figure 11. (This is indicated by the absence of method 15 line to compute the gain pattern in this example.) The above input causes the antenna gain values to be computed as needed for specific frequencies and elevation angles. This indicates that the gain value for 7.6 MHz needed in Figure 11 was interpolated between 7 MHz and 8 MHz. The gain value for 7.5 MHz in the above example is computed as the frequency 7.5 MHz is processed. It should further be noted that this value would be re-computed for each hour specified in the above example. Thus, the gain is computed at each frequency and for each hour as needed.

### 7.5 User-Selected Output Example

The input required to generate user-selected system performance predictions consists of the following command lines: METHOD, TOPLINES, BOTLINES, MONTH, SUNSPOT, TIME, LABEL, CIRCUIT, ANTENNA, FREQUENCY, EXECUTE, and ED. The input necessary to generate output similar to the output represented in Figure 18 consists of the following:

```
METHOD      23
TOPLINES      1   2   3   4   6   6   7
BOTLINES      1   2   4  10  11  12
MONTH         1970   1
SUNSPOT       100.  0.
TIME          12  24  12  -1
LABEL         BOULDER, COLORADO TO ST. LOUIS, MO.
CIRCUIT       40.03N  106.3W  38.67N  90.25W
ANTENNA       1   2   .001  4.   -.5
ANTENNA       2   2   .001  4.   -.25
FREQUENCY     2.0  3.0  5.0  7.5  10.0  12.5  15.0      17.5
20.0  25.0  30.0
EXECUTE
QUIT
```

The header lines specified on the TOPLINES are given in Table 8 and are listed below:

- (1) month, day, year, and sunspot number
- (2) alphanumeric information on the LABEL command line
- (3) transmitter and receiver information (coordinates)

- (4)                    minimum takeoff angle
- (5)                    transmitter antenna information
- (6)                    receiver antenna information
- (7)                    transmitter power, man-made noise, required reliability, and  
                          required SNR.

The output predictions specified on the BOTLINES command are given in Table 9 and listed below:

- (1)                    number of hops and mode type
- (2)                    radiation angle and transmitter
- (4)                    virtual height of most reliable mode
- (10)                   median SNR
- (11)                   required power gain for most reliable mode
- (12)                   reliability.

It should be noted that the above input does not cause the antenna pattern to be pre-computed as was the case in Figure 18. (This is indicated by the absence of the method 15 command to compute the gain tables in this example.) The above input would compute the gain value of each frequency for each hour as needed. This has been discussed in Section 7.4.

### 7.6 LUF Example

The input required to generate LUF predictions consists of the following command lines: METHOD, MONTH, SUNSPOT, TIME, LABEL, CIRCUIT, ANTENNA, EXECUTE, and ED. The input necessary to generate output similar to the output represented in Figure 22 consists of the following:

```
METHOD        26
MONTH           1970    1
SUNSPOT        100.    0.
TIME            2     24    2    -1
LABEL          BOULDER, COLORADO TO ST. LOUIS, MO.
CIRCUIT        40.03N    105.3W    38.67N    90.25W
ANTENNA        1     2       .001    4.       -.5
ANTENNA        2     2       .001    4.       -.26
EXECUTE
QUIT
```

It should be noted that the above input does not cause the antenna pattern to be pre-computed as was the situation in Figure 18. (This is

indicated above by the absence of the method 16 command to compute the gain tables in this example.) The above input would cause the antenna gain to be computed for the LUF rather than interpolate in the gain table as was the case in Figure 18.

### 7.7 Outgraph Example

The input required to generate the MUF predictions given in Figures 4 through 8 consists of the following command lines: METHOD, OUTGRAPH, MONTH, SUNSPOT, TIME, LABEL, CIRCUIT, EXECUTE, and ED. The specific input necessary to generate the output represented in Figures 4 through 8 consists of the following:

```
METHOD      7
OUTGRAPH      8   9  10  11
MONTH         1970   1
SUNSPOT       100.   0.
TIME          1   24   1  -1
LABEL         BOULDER, COLORADO TO ST. LOUIS, MO.
CIRCUIT       40.03N   106.3W   38.67N   90.25W
EXECUTE
QUIT
```

The method command defines the predictions to be generated and the output form generated by that method. Therefore, the predictions generated consist of the MUF-FOT table for each ionospheric layer since method 7 was specified in this example. The user may select additional output providing that the computations for the output have already been generated. Therefore, in this case, the user can select the outputs of methods 8 through 11 consisting of the MUF-FOT graph, HPF-MUF-FOT graph, MUF-FOT-ANG graph, and MUF-FOT-Es graph, as is indicated in Table 7.

### 7.8 External Antenna File Example

The user may wish to save the antenna gain table of his antennas for use on a separate run. This may be particularly significant if the same antennas are used for several communication paths, or the predictions are generated with the same antennas each month, or the user has a specific antenna pattern created by another program, or possibly the actual measured antenna gain values. To create the antenna file corresponding to the patterns given in

Figures 9 and 10, the following input should be used:

```
METHOD      15
ANTOUT        ANTOUT.FIL
ANTENNA       1   2   .001  4.   -.5
ANTENNA       2   2   .001  4.   -.26
EXECUTE
QUIT
```

The user could then store the patterns generated on disk for reference at a later time. See the discussion of the ANTOUT command in Sections 3.3.5 and 6.3. Use of the antenna patterns previously generated and stored externally, can be done using the following input, which will also generate the system performance output represented in Figure 11.

```
METHOD      16
MONTH         1970   1
SUNSPOT      100.   0.
TIME          12   24   12   -1
LABEL        BOULDER, COLORADO TO ST. LOUIS, MO.
CIRCUIT      40.03N   106.3W   38.67N   90.25W
ANTENNA       1   18  ANTOUT.FIL
ANTENNA       2   18  ANTOUT.FIL
FREQUENCY    2.0   3.0   5.0   7.6 10.0 12.5 15.0 17.5 20.0 26.0
30.0
EXECUTE
QUIT
```

The difference in this example and the example presented in Section 7.4 is that the antenna patterns are read from a file instead of being computed. Section 6.3 explains this procedure in depth.

## **8. ACKNOWLEDGMENTS**

This report is the result of the efforts of many groups and individuals. It is an update of the IONCAP users manual with the orientation toward the PC computer use. The wording is sometimes a duplication of the older user manuals.

In regard to individuals, the following list may not include everyone, but hopefully the majority will be mentioned. The author wishes to acknowledge the contributions of Mr. A.F. Barghausen, Dr. Mark T. Ma, Mr. D.H. Zacharisen, Dr. E.L. Crow, Mr. G.W. Haydon, Mr. D.L. Lucas, Mr. J.L. Lloyd, Mr. G.R. Hand, Dr. A.D. Spaulding, Dr. R.K. Rosich, Mr. L.R. Teeters, Mr. R.M. Davis Jr., and many others who have been instrumental in the evolution of the propagation programs and documentation.

Input File for ICEPAC Prediction Program    Version IC.10

	1	2	3	4	5	6	7	8
12345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	234567890

```

COMMENT *****
COMMENT SAMPLE INPUT TO RUN ICEPAC IC.10 - ALL METHODS
COMMENT *****
LABEL BOULDER,COLORADO TO ST. LOUIS,MO.
CIRCUIT 40.03N 105.3W 38.67N 90.25W 0
SYSTEM 3000 150 .001 90 5500 1000 85
MONTH 1970 1
SUNSPOT 100. 0.
TIME 1 24 1 -1
FPROB 1.0 1.0 1.0 1.0
METHOD 1
EXECUTE
COMMENT CHANGE CRITICAL FREQUENCY MULTIPLIER FOR ES BACK TO PROGRAM DEFAULT
FPROB OFF
COMMENT ES CRITICAL FREQUENCY NOW IS MULTIPLIED BY .7 TO ALLOW FOR MEDIAN LOSS
METHOD 2
TIME 12 12 1 -1
EXECUTE
COMMENT *****
COMMENT METHODS 3 THROUGH 11 ARE MUF CALCULATIONS (METHOD 12 NOT IMPLEMENTED)
COMMENT METHODS 3,4,5 AND 6 ARE MUF USING NOMOGRAM AND AREN'T PRESENTED HERE
TIME 1 24 1 -1
METHOD 7
COMMENT OUTPUT METHODS 8 THROUGH 11 WITHOUT RECOMPUTATION USING "OUTGRAPH"
OUTGRAPH 8 9 10 11
EXECUTE
OUTGRAPH OFF
COMMENT *****
COMMENT METHODS 13 THROUGH 15 ARE ANTENNA PATTERN CALCULATIONS
COMMENT METHODS 13 AND 14 ARE ANTENNAS ONE AT A TIME AND AREN'T PRESENTED HERE
COMMENT ANTOUT ANTFIL.BIN
METHOD 15
ANTENNA 1 2 .001 4. -0.5
ANTENNA 2 2 .001 4. -0.25
COMMENT ANTENNA 1 18 ANTFIL.BIN
COMMENT ANTENNA 2 18 ANTFIL.BIN
EXECUTE
COMMENT ANTOUT OFF
COMMENT *****
COMMENT METHODS 16 THROUGH 23 ARE SYSTEM PERFORMANCE PREDICTIONS
FREQUENCY 2.0 3.0 5.0 7.5 10.0 12.5 15.0 17.5 20.0 25.0 30.0
TIME 12 24 12 -1
METHOD 16
EXECUTE
METHOD 17
EXECUTE
METHOD 18
EXECUTE
METHOD 19
EXECUTE
METHOD 20
EXECUTE

```

Figure 1. Input data commands for all output options.



```

COMMENT      METHOD 21 FORCES THE PROGRAM TO EXERCISE THE "LONG" PATH MODEL
METHOD       21
EXECUTE
COMMENT      METHOD 22 FORCES THE PROGRAM TO EXERCISE THE "SHORT" PATH MODEL
METHOD       22
EXECUTE
COMMENT      METHOD 23 ALLOWS THE USER TO SELECT THE DESIRED OUTPUT BY SPECIFYING
COMMENT      PREDEFINED LINE NUMBERS ON THE "TOPLINES" AND "BOTLINES" COMMANDS
COMMENT      LINES ARE NUMBERED IN ORDER AS IN METHOD 20 (SEE TABLES 8 AND 9)
METHOD       23
TOPLINES     1     2     3     4     5     6     7
BOTLINES     1     2     4    10    11    12
EXECUTE
COMMENT      *****
COMMENT      METHOD 24 IS THE MUF-RELIABILITY TABLE
COMMENT      *****
METHOD       24
TIME         1    24     1    -1
EXECUTE
COMMENT      *****
COMMENT      METHOD 25 IS THE ALL MODES TABLE
METHOD       25
COMMENT      NOTE THAT THE MUF ALL MODES TABLE IS ALSO PRINTED
FREQUENCY    3.0
TIME         12   12     1    -1
EXECUTE
COMMENT      *****
COMMENT      METHODS 26 THROUGH 29 ARE LUF PREDICTIONS
METHOD       26
COMMENT      OUTPUT METHODS 27, 28 AND 29 WITHOUT RECOMPUTATION USING "OUTGRAPH"
OUTGRAPH     27   28    29
TIME         2    24     2    -1
EXECUTE
OUTGRAPH     OFF
COMMENT      *****
COMMENT      INCLUDE A LONG PATH CIRCUIT EXAMPLE
LABEL        BOULDER,COLORADO TO AUCKLAND,N. Z.
CIRCUIT      40.03N    105.3W    36.92S    17475E
METHOD       7
TIME         6    18     6    -1
EXECUTE
FREQUENCY    2.0   3.0   5.0   7.5 10.0 12.5 15.0 17.5 20.0 25.0 30.0
METHOD       23
COMMENT      NOTE THAT THE PREVIOUSLY DEFINED "TOPLINES" AND "BOTLINES" STILL USED
EXECUTE
QUIT
    
```

Figure 1a. Input data commands for all output options.  
(Continued)

METHOD 1    ICEPAC IC.10    PAGE 1

JAN 1970                    SSN = 100.  
 BOULDER, COLORADO TO ST. LOUIS, MO.                    AZIMUTHS                    N. MI.                    KM  
 40.03 N 105.30 W - 38.67 N 90.25 W                    91.84 281.42                    702.6 1301.1  
 XMTR 2.0 TO 30.0 CONST. GAIN H                    .00 L                    .00 A                    .0 OFF AZ                    .0  
  
 YE = 20.0                    HE = 110.0                    HS = 110.0

LAT	LONG	LMT	UT	E	F1	Y1	H1	FH/2	F2Z	Y2
H2	PB	CEN	EB	M3000	TCGM	RAT	ZEN	FLAG	MAGL	
39.6N	97.7W	1.5	8.0	.58	.2	50.0	200.0	.7	4.4	68.7
317.4	72.7	71.4	70.0	2.97	1.4	4.6	153.4	0	50.1N	
39.6N	97.7W	2.5	9.0	.58	.2	50.0	200.0	.7	4.5	70.6
322.5	73.2	71.6	70.0	2.94	2.4	4.6	143.2	0	50.1N	
39.6N	97.7W	3.5	10.0	.61	.2	50.0	200.0	.7	4.1	73.5
328.5	73.7	71.9	70.0	2.89	3.4	4.5	131.9	0	50.1N	
39.6N	97.7W	4.5	11.0	.74	.2	50.0	200.0	.7	3.5	75.8
326.1	74.0	72.1	70.3	2.87	4.4	4.3	120.3	0	50.1N	
39.6N	97.7W	5.5	12.0	1.02	.2	50.0	200.0	.7	3.4	75.6
307.1	74.0	72.5	71.0	2.90	5.4	4.1	108.9	0	50.1N	
39.6N	97.7W	6.5	13.0	1.44	.2	50.0	200.0	.7	4.2	76.8
289.1	74.0	72.9	71.7	3.00	6.3	3.8	97.9	6	50.1N	
39.6N	97.7W	7.5	14.0	1.95	.2	50.0	200.0	.7	6.0	80.4
277.6	74.0	73.2	72.4	3.13	7.2	3.5	87.5	6	50.1N	
39.6N	97.7W	8.5	15.0	2.48	.2	50.0	200.0	.7	8.0	84.5
268.0	74.1	73.6	73.1	3.23	8.2	3.2	78.1	6	50.1N	
39.6N	97.7W	9.5	16.0	2.93	.2	50.0	200.0	.7	9.3	90.1
264.2	75.0	74.4	73.9	3.26	9.1	2.9	70.2	6	50.1N	
39.6N	97.7W	10.5	17.0	3.26	4.5	50.0	200.0	.7	10.2	96.8
267.6	75.9	75.2	74.6	3.23	10.1	2.8	64.4	6	50.1N	
39.6N	97.7W	11.5	18.0	3.44	4.6	50.0	200.0	.7	10.9	103.1
275.8	76.7	76.0	75.3	3.16	11.1	2.7	61.3	6	50.1N	
39.6N	97.7W	12.5	19.0	3.46	4.6	50.0	200.0	.7	11.4	95.9
283.9	77.5	76.7	76.0	3.11	12.1	3.0	61.3	6	50.1N	
39.6N	97.7W	13.5	20.0	3.28	4.4	50.0	200.0	.7	11.5	95.4
288.4	77.4	76.6	75.9	3.09	13.1	3.0	64.5	6	50.1N	
39.6N	97.7W	14.5	21.0	2.93	.2	50.0	200.0	.7	11.2	92.4
289.9	77.2	76.5	75.7	3.10	14.1	3.1	70.3	6	50.1N	
39.6N	97.7W	15.5	22.0	2.43	.2	50.0	200.0	.7	10.8	88.4
290.6	77.1	76.4	75.6	3.11	15.1	3.3	78.2	6	50.1N	
39.6N	97.7W	16.5	23.0	1.88	.2	50.0	200.0	.7	9.9	84.3
291.4	76.9	76.2	75.4	3.13	16.1	3.5	87.6	6	50.1N	
39.6N	97.7W	17.5	.0	1.38	.2	50.0	200.0	.7	8.7	80.3
292.8	76.1	75.2	74.3	3.13	16.9	3.6	98.0	6	50.1N	
39.6N	97.7W	18.5	1.0	.99	.2	50.0	200.0	.7	7.2	76.7
295.1	75.2	74.3	73.3	3.12	17.8	3.9	109.1	0	50.1N	
39.6N	97.7W	19.5	2.0	.74	.2	50.0	200.0	.7	6.0	73.7
299.3	74.4	73.4	72.3	3.10	18.6	4.1	120.5	0	50.1N	
39.6N	97.7W	20.5	3.0	.61	.2	50.0	200.0	.7	5.1	71.6
305.3	73.4	72.2	71.1	3.06	19.6	4.3	132.0	0	50.1N	
39.6N	97.7W	21.5	4.0	.55	.2	50.0	200.0	.7	4.3	70.2
311.4	72.8	71.6	70.4	3.01	20.7	4.4	143.3	0	50.1N	
39.6N	97.7W	22.5	5.0	.54	.2	50.0	200.0	.7	3.8	69.1
315.2	72.5	71.4	70.2	2.98	22.1	4.6	153.6	0	50.1N	
39.6N	97.7W	23.5	6.0	.56	.2	50.0	200.0	.7	3.8	68.3
316.0	72.2	71.1	70.1	2.97	23.3	4.6	160.7	0	50.1N	
39.6N	97.7W	.5	7.0	.58	.2	50.0	200.0	.7	4.1	67.9
315.9	72.2	71.1	70.0	2.97	.4	4.7	160.6	0	50.1N	

Figure 2                    Ionospheric parameters output                    (METHOD = 1)





METHOD 7 ICEPAC IC.10 PAGE 3

JAN 1970 SSN = 100.  
 BOULDER, COLORADO TO ST. LOUIS, MO. AZIMUTHS N. MI. KM  
 40.03 N 105.30 W - 38.67 N 90.25 W 91.84 281.42 702.6 1301.1  
 MINIMUM ANGLE .0 DEGREES  
 XMTR 2.0 TO 30.0 CONST. GAIN H .00 L .00 A .0 OFF AZ .0

UT	LT		FOT	MUF	HPF	ANGLE	VIRTL	TRUE	FVERT
8.0	1.0	E-LAYER	2.0	2.3	2.6	9.9	150.	103.	.6
		F1LAYER	2.0	2.3	2.6	9.9	150.	103.	.6
		F2LAYER	6.8	8.2	10.4	25.9	369.	299.	4.2
		ESLAYER	4.3	5.9	12.9	6.6	110.	110.	1.3
9.0	2.0	E-LAYER	2.0	2.3	2.6	9.9	150.	103.	.6
		F1LAYER	2.0	2.3	2.6	9.9	150.	103.	.6
		F2LAYER	6.6	8.1	9.5	26.8	382.	305.	4.3
		ESLAYER	4.0	5.7	12.0	6.6	110.	110.	1.2
10.0	3.0	E-LAYER	2.1	2.4	2.7	9.9	150.	103.	.6
		F1LAYER	2.1	2.4	2.7	9.9	150.	103.	.6
		F2LAYER	6.1	7.5	8.8	26.6	380.	310.	3.9
		ESLAYER	3.7	5.5	11.4	6.6	110.	110.	1.2
11.0	4.0	E-LAYER	2.5	2.9	3.3	9.8	149.	103.	.7
		F1LAYER	2.5	2.9	3.3	9.8	149.	103.	.7
		F2LAYER	5.2	6.4	7.5	26.7	382.	307.	3.4
		ESLAYER	3.4	5.4	11.1	6.6	110.	110.	1.2
12.0	5.0	E-LAYER	3.5	4.0	4.5	9.7	148.	103.	1.0
		F1LAYER	3.5	4.0	4.5	9.7	148.	103.	1.0
		F2LAYER	5.1	6.3	7.4	25.3	359.	288.	3.2
		ESLAYER	3.4	5.5	11.3	6.6	110.	110.	1.2
13.0	6.0	E-LAYER	4.9	5.7	6.4	9.7	147.	103.	1.4
		F1LAYER	4.9	5.7	6.4	9.7	147.	103.	1.4
		F2LAYER	7.0	8.2	9.2	24.2	342.	269.	4.0
		ESLAYER	3.7	6.0	11.9	6.6	110.	110.	1.3
14.0	7.0	E-LAYER	6.7	7.7	8.7	9.7	147.	103.	1.9
		F1LAYER	6.7	7.7	8.7	9.7	147.	103.	1.9
		F2LAYER	10.3	12.2	13.6	22.8	321.	259.	5.6
		ESLAYER	4.3	7.0	12.8	6.6	110.	110.	1.5
15.0	8.0	E-LAYER	8.5	9.8	11.0	9.7	147.	103.	2.4
		F1LAYER	8.5	9.8	11.0	9.7	147.	103.	2.4
		F2LAYER	13.9	16.4	18.4	22.0	310.	251.	7.4
		ESLAYER	5.0	8.2	13.6	6.6	110.	110.	1.8
16.0	9.0	E-LAYER	10.1	11.6	13.0	9.7	147.	103.	2.8
		F1LAYER	10.1	11.6	13.0	9.7	147.	103.	2.8
		F2LAYER	16.6	19.5	21.8	21.2	299.	248.	8.6
		ESLAYER	5.8	9.5	14.3	6.6	110.	110.	2.0
17.0	10.0	E-LAYER	11.2	12.9	14.6	9.4	144.	106.	3.1
		F1LAYER	8.8	10.0	11.3	21.5	303.	154.	4.2
		F2LAYER	17.6	20.4	23.3	22.5	318.	248.	9.3
		ESLAYER	6.6	10.6	14.6	6.6	110.	110.	2.3
18.0	11.0	E-LAYER	11.9	13.6	15.3	9.5	145.	106.	3.3
		F1LAYER	9.0	10.3	11.7	21.6	304.	152.	4.3
		F2LAYER	18.2	21.2	24.2	23.4	331.	253.	10.0
		ESLAYER	8.0	11.2	14.4	6.6	110.	110.	2.4

Figure 4. MUF complete output table (METHOD = 7)

19.0	12.0	E-LAYER	11.9	13.6	15.4	9.5	145.	106.	3.3
		F1LAYER	9.0	10.3	11.6	21.6	304.	152.	4.3
		F2LAYER	18.9	22.0	25.1	23.9	338.	260.	10.5
		ESLAYER	8.5	11.1	13.8	6.6	110.	110.	2.4
20.0	13.0	E-LAYER	11.3	13.0	14.6	9.5	145.	106.	3.1
		F1LAYER	8.7	10.0	11.3	21.6	304.	153.	4.2
		F2LAYER	18.7	21.8	24.8	24.7	350.	264.	10.6
		ESLAYER	8.0	10.5	13.0	6.6	110.	110.	2.3
21.0	14.0	E-LAYER	10.1	11.6	13.1	9.7	147.	103.	2.8
		F1LAYER	10.1	11.6	13.1	9.7	147.	103.	2.8
		F2LAYER	18.7	21.8	24.8	23.8	337.	268.	10.4
		ESLAYER	6.7	9.4	12.1	6.6	110.	110.	2.0
22.0	15.0	E-LAYER	8.4	9.6	10.8	9.7	147.	103.	2.3
		F1LAYER	8.4	9.6	10.8	9.7	147.	103.	2.3
		F2LAYER	18.0	20.9	23.8	23.9	337.	269.	10.0
		ESLAYER	5.0	8.2	11.4	6.6	110.	110.	1.8
23.0	16.0	E-LAYER	6.5	7.4	8.4	9.7	147.	103.	1.8
		F1LAYER	6.5	7.4	8.4	9.7	147.	103.	1.8
		F2LAYER	16.6	19.3	22.0	23.9	338.	270.	9.3
		ESLAYER	4.3	7.1	11.1	6.6	110.	110.	1.5
.0	17.0	E-LAYER	4.7	5.4	6.1	9.7	147.	103.	1.3
		F1LAYER	4.7	5.4	6.1	9.7	147.	103.	1.3
		F2LAYER	14.3	16.7	19.0	24.5	348.	271.	8.1
		ESLAYER	3.8	6.2	11.3	6.6	110.	110.	1.3
1.0	18.0	E-LAYER	3.4	3.9	4.4	9.7	148.	103.	.9
		F1LAYER	3.4	3.9	4.4	9.7	148.	103.	.9
		F2LAYER	11.0	13.9	17.8	24.5	348.	276.	6.8
		ESLAYER	3.5	5.7	11.9	6.6	110.	110.	1.2
2.0	19.0	E-LAYER	2.5	2.9	3.3	9.8	149.	103.	.7
		F1LAYER	2.5	2.9	3.3	9.8	149.	103.	.7
		F2LAYER	9.2	11.6	14.9	24.5	347.	280.	5.7
		ESLAYER	4.0	5.5	12.7	6.6	110.	110.	1.2
3.0	20.0	E-LAYER	2.1	2.4	2.7	9.9	150.	103.	.6
		F1LAYER	2.1	2.4	2.7	9.9	150.	103.	.6
		F2LAYER	7.6	9.6	12.3	25.3	360.	287.	4.8
		ESLAYER	4.1	5.5	13.6	6.6	110.	110.	1.2
4.0	21.0	E-LAYER	1.9	2.1	2.4	9.9	150.	103.	.5
		F1LAYER	1.9	2.1	2.4	9.9	150.	103.	.5
		F2LAYER	6.3	8.0	10.2	26.1	371.	293.	4.1
		ESLAYER	4.3	5.6	14.2	6.6	110.	110.	1.2
5.0	22.0	E-LAYER	1.8	2.1	2.4	9.9	150.	103.	.5
		F1LAYER	1.8	2.1	2.4	9.9	150.	103.	.5
		F2LAYER	5.8	7.0	8.9	26.1	372.	297.	3.6
		ESLAYER	4.6	5.7	14.5	6.6	110.	110.	1.2
6.0	23.0	E-LAYER	1.9	2.2	2.5	9.9	150.	103.	.5
		F1LAYER	1.9	2.2	2.5	9.9	150.	103.	.5
		F2LAYER	5.8	7.0	8.8	26.0	371.	298.	3.6
		ESLAYER	4.7	5.9	14.3	6.6	110.	110.	1.3
7.0	24.0	E-LAYER	2.0	2.2	2.5	9.9	150.	103.	.6
		F1LAYER	2.0	2.2	2.5	9.9	150.	103.	.6
		F2LAYER	6.3	7.6	9.6	26.0	371.	298.	3.9
		ESLAYER	4.6	5.9	13.8	6.6	110.	110.	1.3

Figure 4a.      MUF complete output table continued

METHOD 8 ICEPAC IC.10 PAGE 4

JAN 1970 SSN = 100.  
 BOULDER, COLORADO TO ST. LOUIS, MO. AZIMUTHS N. MI. KM  
 40.03 N 105.30 W - 38.67 N 90.25 W 91.84 281.42 702.6 1301.1  
 MINIMUM ANGLE .0 DEGREES  
 XMTR 2.0 TO 30.0 CONST. GAIN H .00 L .00 A .0 OFF AZ .0

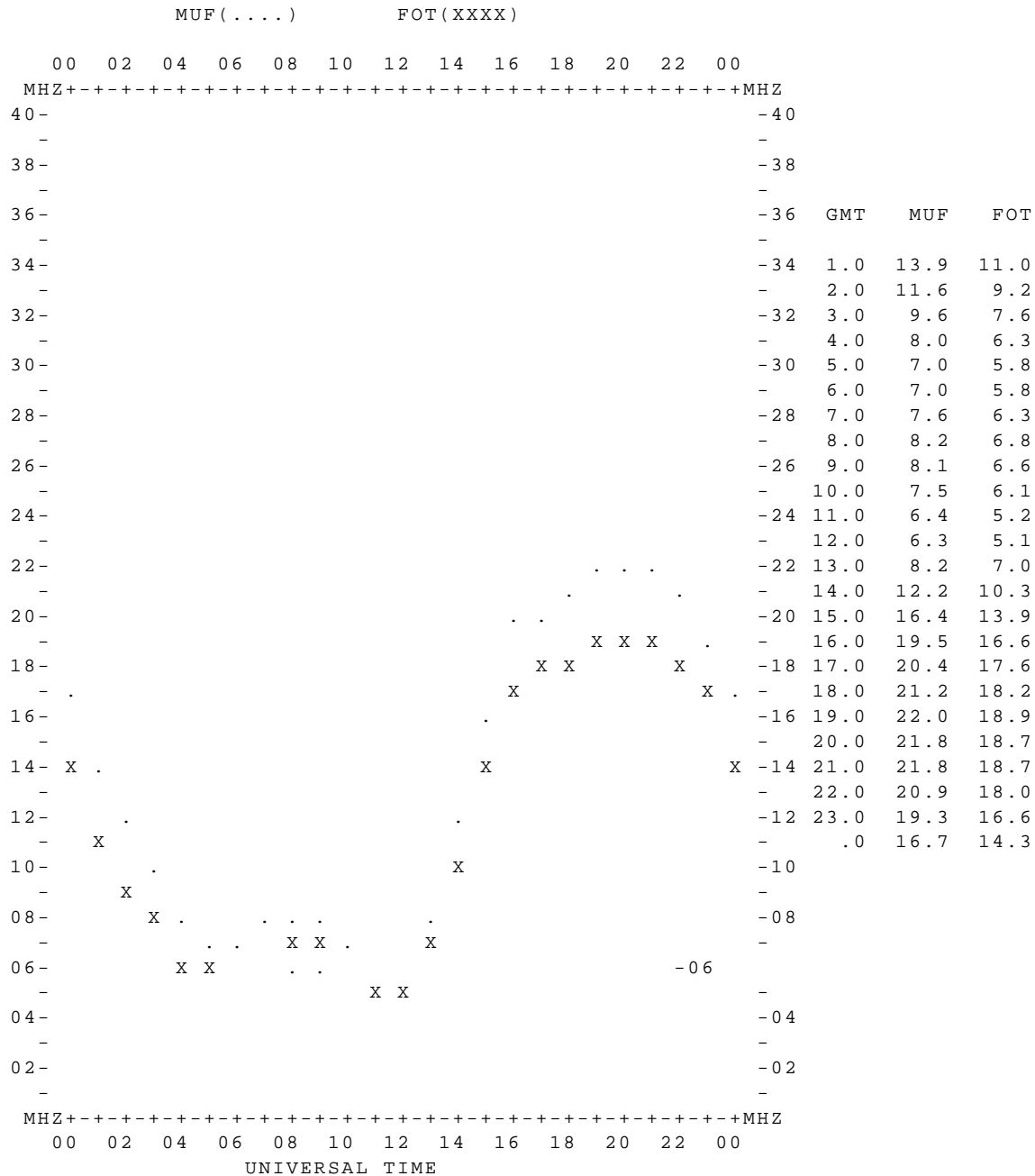


Figure 5. MUF-FOT graph (METHOD = 8)

METHOD 9 ICEPAC IC.10 PAGE 5

JAN 1970 SSN = 100.  
 BOULDER, COLORADO TO ST. LOUIS, MO. AZIMUTHS N. MI. KM  
 40.03 N 105.30 W - 38.67 N 90.25 W 91.84 281.42 702.6 1301.1  
 MINIMUM ANGLE .0 DEGREES  
 XMTR 2.0 TO 30.0 CONST. GAIN H .00 L .00 A .0 OFF AZ .0

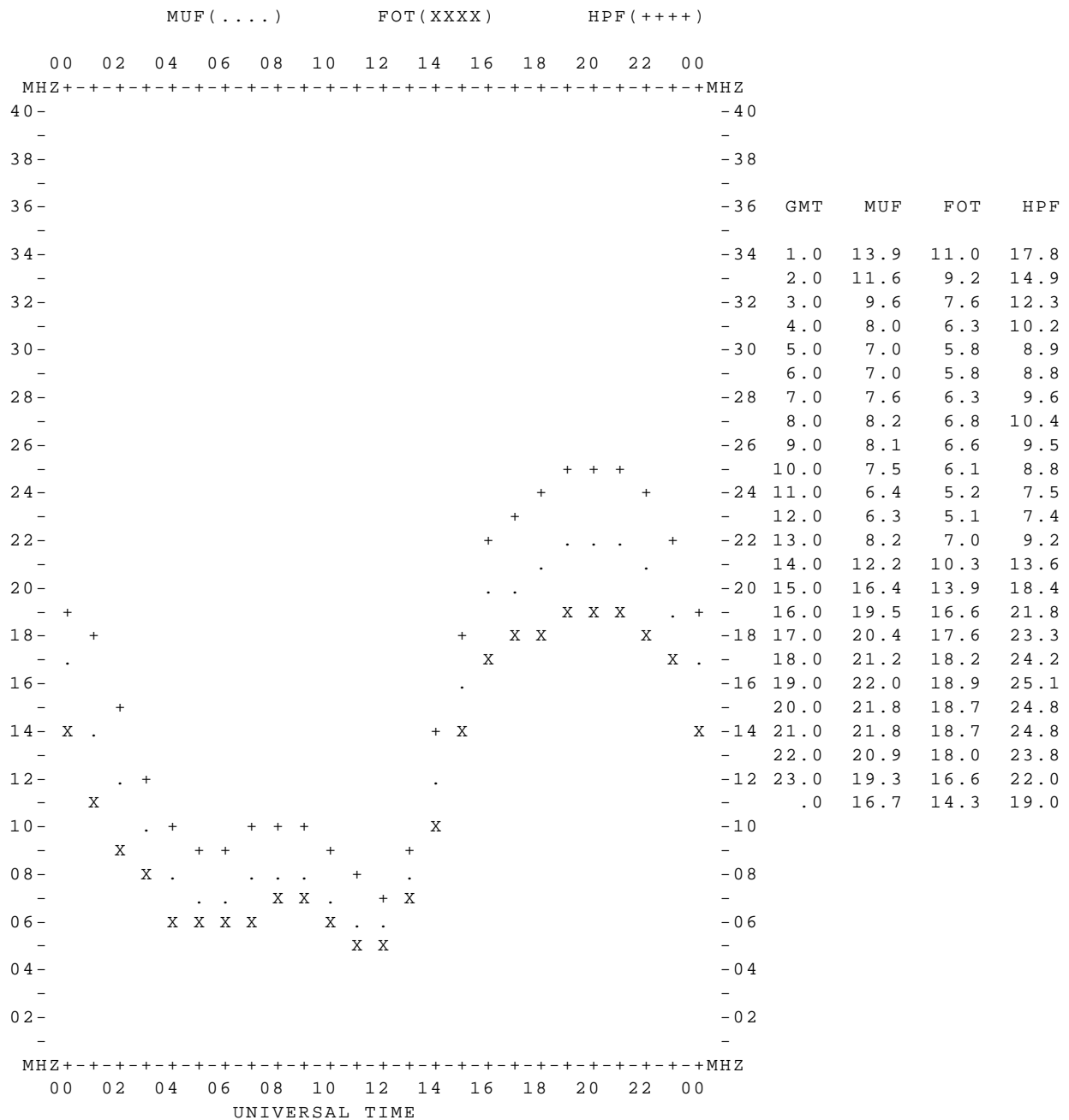


Figure 6. MUF-FOT-HPF graph (METHOD = 9)



METHOD 10 ICEPAC IC.10 PAGE 6

JAN 1970 SSN = 100.  
 BOULDER, COLORADO TO ST. LOUIS, MO. AZIMUTHS N. MI. KM  
 40.03 N 105.30 W - 38.67 N 90.25 W 91.84 281.42 702.6 1301.1  
 MINIMUM ANGLE .0 DEGREES  
 XMTR 2.0 TO 30.0 CONST. GAIN H .00 L .00 A .0 OFF AZ .0

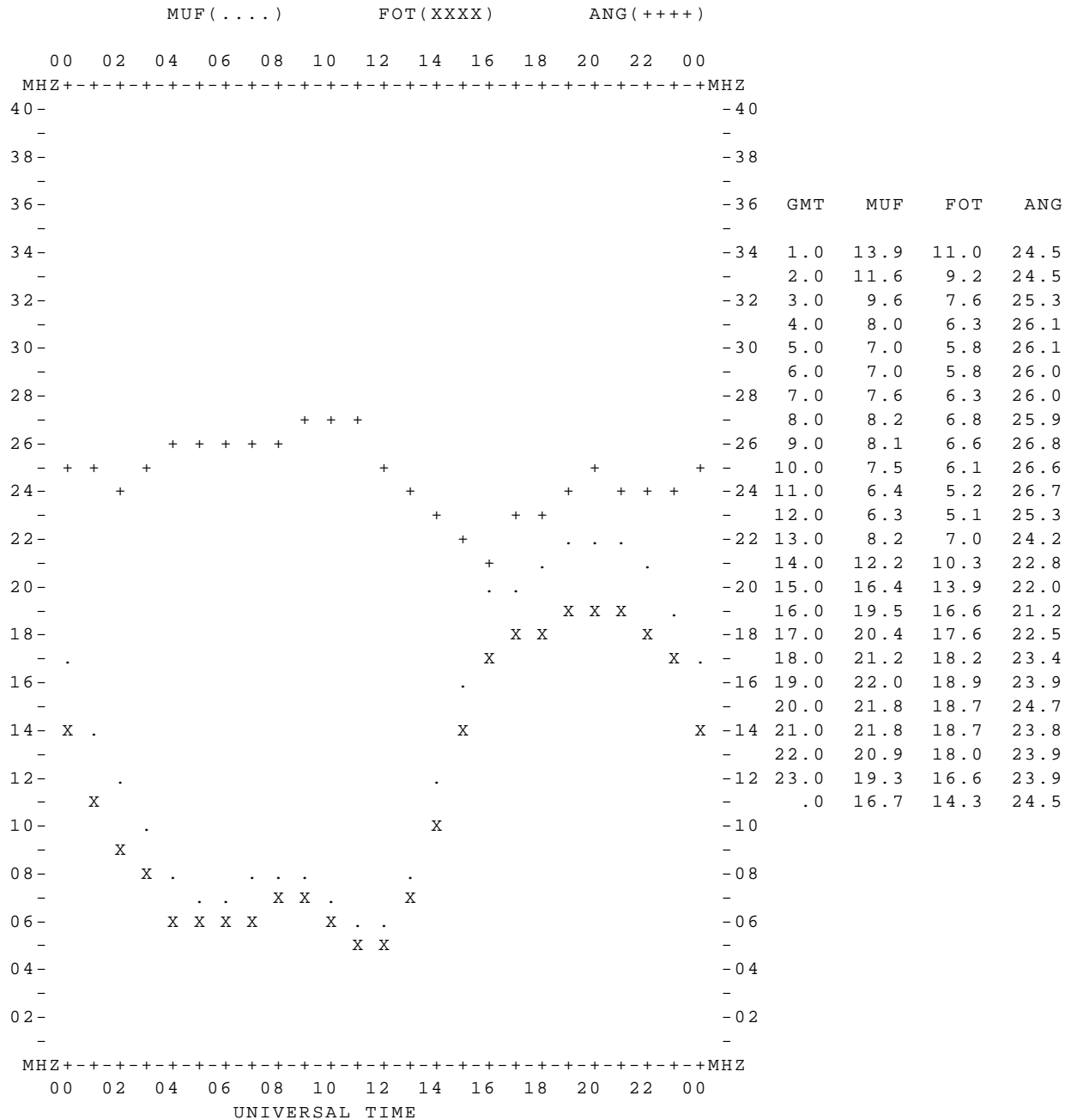


Figure 7. MUF-FOT-ANG graph (METHOD = 10)

METHOD 11 ICEPAC IC.10 PAGE 7

JAN 1970 SSN = 100.  
 BOULDER, COLORADO TO ST. LOUIS, MO. AZIMUTHS N. MI. KM  
 40.03 N 105.30 W - 38.67 N 90.25 W 91.84 281.42 702.6 1301.1  
 MINIMUM ANGLE .0 DEGREES  
 XMTR 2.0 TO 30.0 CONST. GAIN H .00 L .00 A .0 OFF AZ .0

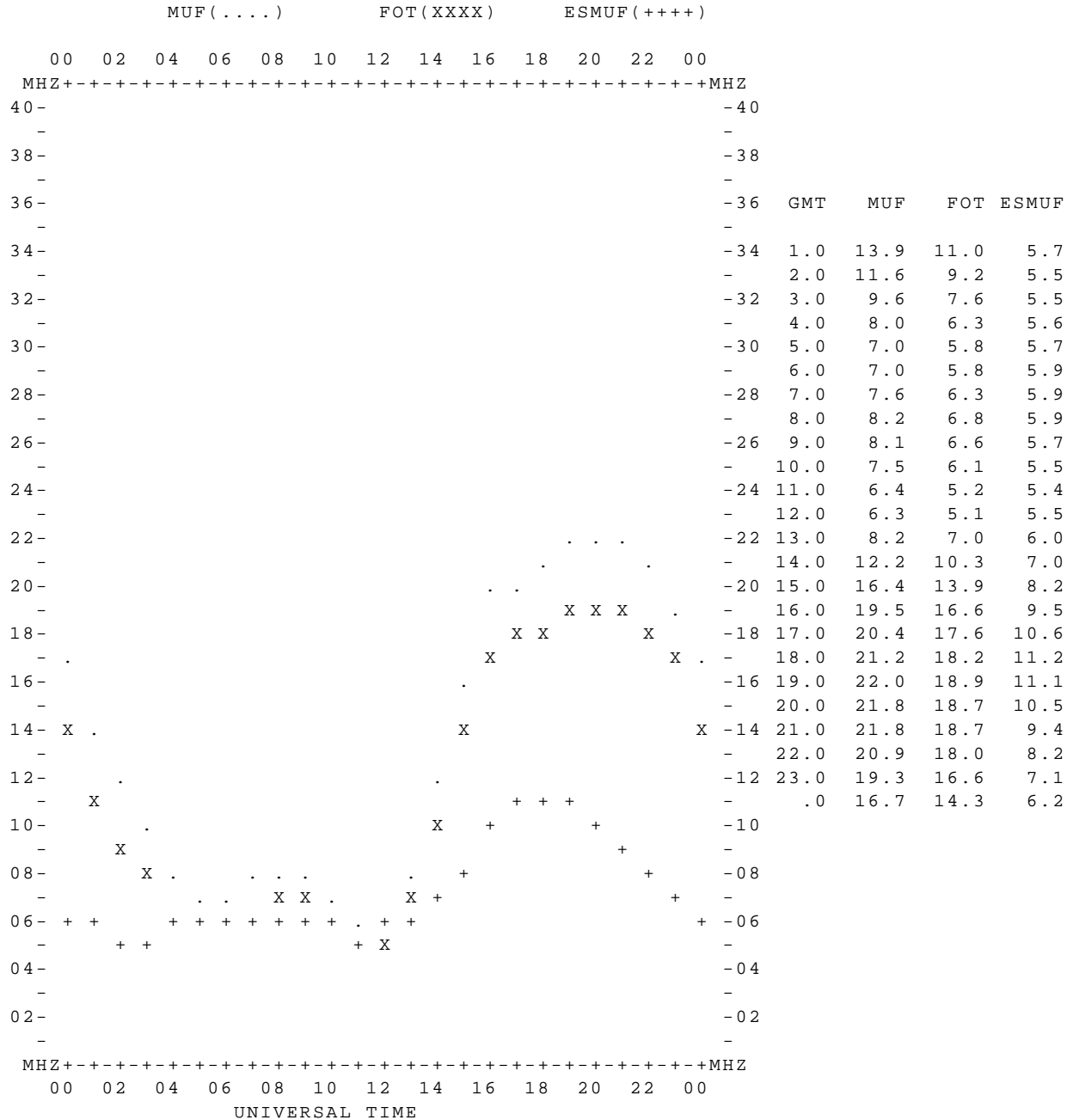


Figure 8. MUF-FOT-Es MUF graph. (METHOD = 11)

ITSA 1 ANTENNA PACKAGE			ANTENNA PATTERN							
FREQUENCY	RANGE	ANTENNA TYPE	HEIGHT		LENGTH		ANGLE			
2.0 TO	30.0	VER MONOPOLE	.000	-.500	.000	.000	.000	.000	.000	.000
2	3	4	5	6	7	8	9	10	11	
90	-50.0	-50.0	-50.0	-50.0	-50.0	-50.0	-50.0	-50.0	-50.0	-50.0
88	-36.5	-35.5	-35.0	-34.7	-34.5	-34.4	-34.3	-34.2	-34.2	-34.1
86	-30.5	-29.5	-29.0	-28.7	-28.5	-28.4	-28.3	-28.2	-28.2	-28.1
84	-27.0	-26.0	-25.5	-25.2	-25.0	-24.8	-24.8	-24.7	-24.6	-24.6
82	-24.6	-23.6	-23.0	-22.7	-22.5	-22.4	-22.3	-22.2	-22.1	-22.1
80	-22.7	-21.7	-21.1	-20.8	-20.6	-20.4	-20.3	-20.2	-20.2	-20.1
78	-21.2	-20.2	-19.6	-19.2	-19.0	-18.8	-18.7	-18.7	-18.6	-18.5
76	-20.0	-18.9	-18.3	-17.9	-17.7	-17.5	-17.4	-17.3	-17.2	-17.2
74	-18.9	-17.8	-17.1	-16.8	-16.5	-16.3	-16.2	-16.1	-16.1	-16.0
72	-18.0	-16.8	-16.1	-15.7	-15.5	-15.3	-15.2	-15.1	-15.0	-14.9
E 70	-17.2	-15.9	-15.2	-14.8	-14.5	-14.4	-14.2	-14.1	-14.0	-14.0
L 68	-16.4	-15.1	-14.4	-14.0	-13.7	-13.5	-13.3	-13.2	-13.1	-13.1
E 66	-15.7	-14.4	-13.6	-13.2	-12.9	-12.7	-12.5	-12.4	-12.3	-12.2
V 64	-15.0	-13.6	-12.9	-12.4	-12.1	-11.9	-11.7	-11.6	-11.5	-11.4
A 62	-14.3	-12.9	-12.2	-11.7	-11.4	-11.2	-11.0	-10.9	-10.8	-10.7
T 60	-13.6	-12.2	-11.5	-11.0	-10.7	-10.4	-10.3	-10.1	-10.0	-10.0
I 58	-12.8	-11.6	-10.8	-10.3	-10.0	-9.7	-9.6	-9.4	-9.3	-9.2
O 56	-12.1	-10.9	-10.1	-9.6	-9.3	-9.0	-8.9	-8.7	-8.6	-8.5
N 54	-11.3	-10.2	-9.4	-8.9	-8.6	-8.4	-8.2	-8.1	-8.0	-7.9
52	-10.6	-9.5	-8.8	-8.3	-8.0	-7.7	-7.5	-7.4	-7.3	-7.2
A 50	-9.8	-8.8	-8.1	-7.6	-7.3	-7.1	-6.9	-6.8	-6.6	-6.6
N 48	-9.0	-8.1	-7.4	-7.0	-6.7	-6.4	-6.3	-6.1	-6.0	-5.9
G 46	-8.2	-7.4	-6.8	-6.3	-6.0	-5.8	-5.6	-5.5	-5.4	-5.3
L 44	-7.4	-6.7	-6.1	-5.7	-5.4	-5.2	-5.1	-4.9	-4.8	-4.7
E 42	-6.7	-6.0	-5.5	-5.1	-4.9	-4.7	-4.5	-4.4	-4.3	-4.2
40	-6.0	-5.4	-4.9	-4.6	-4.3	-4.1	-4.0	-3.8	-3.7	-3.7
I 38	-5.3	-4.8	-4.4	-4.1	-3.8	-3.6	-3.5	-3.3	-3.2	-3.2
N 36	-4.7	-4.3	-3.9	-3.6	-3.3	-3.1	-3.0	-2.9	-2.8	-2.7
34	-4.1	-3.8	-3.4	-3.1	-2.9	-2.7	-2.6	-2.5	-2.4	-2.3
D 32	-3.6	-3.3	-3.0	-2.7	-2.5	-2.3	-2.2	-2.1	-2.0	-1.9
E 30	-3.1	-2.9	-2.6	-2.4	-2.2	-2.0	-1.9	-1.8	-1.7	-1.6
G 28	-2.7	-2.6	-2.3	-2.1	-1.9	-1.7	-1.6	-1.5	-1.4	-1.4
R 26	-2.4	-2.3	-2.1	-1.9	-1.7	-1.5	-1.4	-1.3	-1.2	-1.2
E 24	-2.1	-2.1	-1.9	-1.7	-1.5	-1.4	-1.3	-1.2	-1.1	-1.1
E 22	-2.0	-2.0	-1.8	-1.6	-1.5	-1.3	-1.2	-1.1	-1.1	-1.0
S 20	-1.9	-2.0	-1.8	-1.6	-1.5	-1.4	-1.3	-1.2	-1.1	-1.1
18	-1.9	-2.0	-1.9	-1.8	-1.6	-1.5	-1.4	-1.3	-1.3	-1.2
16	-2.1	-2.2	-2.1	-2.0	-1.9	-1.8	-1.7	-1.6	-1.5	-1.5
14	-2.4	-2.6	-2.5	-2.4	-2.3	-2.2	-2.1	-2.0	-2.0	-1.9
12	-2.9	-3.1	-3.1	-3.0	-2.9	-2.8	-2.7	-2.6	-2.6	-2.5
10	-3.6	-4.0	-3.9	-3.9	-3.8	-3.7	-3.6	-3.5	-3.4	-3.4
8	-4.7	-5.1	-5.2	-5.1	-5.0	-4.9	-4.8	-4.7	-4.7	-4.6
6	-6.4	-6.9	-6.9	-6.9	-6.8	-6.7	-6.6	-6.5	-6.5	-6.4
4	-9.1	-9.6	-9.7	-9.7	-9.6	-9.5	-9.4	-9.4	-9.3	-9.3
2	-14.3	-14.9	-15.0	-15.0	-14.9	-14.8	-14.8	-14.7	-14.7	-14.6
0	-50.0	-50.0	-50.0	-50.0	-50.0	-50.0	-50.0	-50.0	-50.0	-50.0

FREQUENCY IN MEGAHERTZ										
2	3	4	5	6	7	8	9	10	11	
.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
2	3	4	5	6	7	8	9	10	11	

ANTENNA EFFICIENCY										
2	3	4	5	6	7	8	9	10	11	
.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
2	3	4	5	6	7	8	9	10	11	

Figure 9. Transmitter antenna pattern. (METHOD = 15)

METHOD 15      ICEPAC IC.10      PAGE      9

AZIMUTH		EX(1)		EX(2)		EX(3)		EX(4)		CONDUCT.		DIELECT.	
.000		.000		.000		.000		.000		.001		4.000	
12	13	14	16	18	20	22	24	26	28	30			
-50.0	-50.0	-50.0	-50.0	-50.0	-50.0	-50.0	-50.0	-50.0	-50.0	-50.0	90		
-34.1	-34.1	-34.1	-34.0	-34.0	-34.0	-34.0	-34.0	-34.0	-34.0	-34.0	88		
-28.1	-28.1	-28.0	-28.0	-28.0	-28.0	-28.0	-28.0	-28.0	-28.0	-27.9	86		
-24.6	-24.5	-24.5	-24.5	-24.5	-24.5	-24.4	-24.4	-24.4	-24.4	-24.4	84		
-22.1	-22.0	-22.0	-22.0	-22.0	-21.9	-21.9	-21.9	-21.9	-21.9	-21.9	82		
-20.1	-20.1	-20.1	-20.0	-20.0	-20.0	-20.0	-20.0	-19.9	-19.9	-19.9	80		
-18.5	-18.5	-18.5	-18.4	-18.4	-18.4	-18.4	-18.3	-18.3	-18.3	-18.3	78		
-17.1	-17.1	-17.1	-17.0	-17.0	-17.0	-17.0	-17.0	-17.0	-16.9	-16.9	76		
-16.0	-15.9	-15.9	-15.8	-15.8	-15.8	-15.8	-15.8	-15.7	-15.7	-15.7	74		
-14.9	-14.9	-14.8	-14.8	-14.7	-14.7	-14.7	-14.7	-14.7	-14.6	-14.6	72		
-13.9	-13.9	-13.8	-13.8	-13.8	-13.7	-13.7	-13.7	-13.7	-13.6	-13.6	70		
-13.0	-13.0	-12.9	-12.9	-12.8	-12.8	-12.8	-12.8	-12.7	-12.7	-12.7	68		
-12.2	-12.1	-12.1	-12.0	-12.0	-11.9	-11.9	-11.9	-11.9	-11.9	-11.8	66		
-11.4	-11.3	-11.3	-11.2	-11.2	-11.1	-11.1	-11.1	-11.1	-11.0	-11.0	64		
-10.6	-10.6	-10.5	-10.5	-10.4	-10.4	-10.3	-10.3	-10.3	-10.3	-10.2	62		
-9.9	-9.8	-9.8	-9.7	-9.7	-9.6	-9.6	-9.5	-9.5	-9.5	-9.5	60		
-9.2	-9.1	-9.1	-9.0	-8.9	-8.9	-8.8	-8.8	-8.8	-8.8	-8.7	58		
-8.5	-8.4	-8.4	-8.3	-8.2	-8.2	-8.1	-8.1	-8.1	-8.1	-8.0	56		
-7.8	-7.7	-7.7	-7.6	-7.5	-7.5	-7.5	-7.4	-7.4	-7.4	-7.3	54		
-7.1	-7.1	-7.0	-6.9	-6.9	-6.8	-6.8	-6.8	-6.7	-6.7	-6.7	52		
-6.5	-6.4	-6.4	-6.3	-6.2	-6.2	-6.1	-6.1	-6.1	-6.0	-6.0	50		
-5.9	-5.8	-5.7	-5.7	-5.6	-5.5	-5.5	-5.5	-5.4	-5.4	-5.4	48		
-5.3	-5.2	-5.1	-5.1	-5.0	-4.9	-4.9	-4.9	-4.8	-4.8	-4.8	46		
-4.7	-4.6	-4.6	-4.5	-4.4	-4.4	-4.3	-4.3	-4.3	-4.2	-4.2	44		
-4.1	-4.1	-4.0	-3.9	-3.9	-3.8	-3.8	-3.7	-3.7	-3.7	-3.7	42		
-3.6	-3.5	-3.5	-3.4	-3.4	-3.3	-3.3	-3.2	-3.2	-3.2	-3.2	40		
-3.1	-3.1	-3.0	-2.9	-2.9	-2.8	-2.8	-2.8	-2.7	-2.7	-2.7	38		
-2.7	-2.6	-2.6	-2.5	-2.4	-2.4	-2.3	-2.3	-2.3	-2.3	-2.2	36		
-2.2	-2.2	-2.1	-2.1	-2.0	-2.0	-1.9	-1.9	-1.9	-1.9	-1.8	34		
-1.9	-1.8	-1.8	-1.7	-1.7	-1.6	-1.6	-1.6	-1.5	-1.5	-1.5	32		
-1.6	-1.5	-1.5	-1.4	-1.4	-1.3	-1.3	-1.3	-1.2	-1.2	-1.2	30		
-1.3	-1.3	-1.2	-1.2	-1.1	-1.1	-1.0	-1.0	-1.0	-1.0	-.9	28		
-1.1	-1.1	-1.0	-1.0	-.9	-.9	-.9	-.8	-.8	-.8	-.8	26		
-1.0	-1.0	-.9	-.9	-.8	-.8	-.7	-.7	-.7	-.7	-.7	24		
-1.0	-.9	-.9	-.8	-.8	-.7	-.7	-.7	-.7	-.6	-.6	22		
-1.0	-1.0	-.9	-.9	-.8	-.8	-.8	-.7	-.7	-.7	-.7	20		
-1.2	-1.1	-1.1	-1.0	-1.0	-.9	-.9	-.9	-.9	-.8	-.8	18		
-1.4	-1.4	-1.4	-1.3	-1.3	-1.2	-1.2	-1.2	-1.1	-1.1	-1.1	16		
-1.9	-1.8	-1.8	-1.7	-1.7	-1.7	-1.6	-1.6	-1.6	-1.6	-1.5	14		
-2.5	-2.4	-2.4	-2.4	-2.3	-2.3	-2.2	-2.2	-2.2	-2.2	-2.2	12		
-3.4	-3.3	-3.3	-3.2	-3.2	-3.2	-3.1	-3.1	-3.1	-3.1	-3.1	10		
-4.6	-4.6	-4.5	-4.5	-4.4	-4.4	-4.4	-4.4	-4.3	-4.3	-4.3	8		
-6.4	-6.4	-6.3	-6.3	-6.2	-6.2	-6.2	-6.2	-6.1	-6.1	-6.1	6		
-9.2	-9.2	-9.2	-9.1	-9.1	-9.0	-9.0	-9.0	-9.0	-9.0	-8.9	4		
-14.6	-14.5	-14.5	-14.5	-14.4	-14.4	-14.4	-14.3	-14.3	-14.3	-14.3	2		
-50.0	-50.0	-50.0	-50.0	-50.0	-50.0	-50.0	-50.0	-50.0	-50.0	-50.0	0		
12	13	14	16	18	20	22	24	26	28	30			

FREQUENCY IN MEGAHERTZ

ANTENNA EFFICIENCY											
.0		.0		.0		.0		.0		.0	
12	13	14	16	18	20	22	24	26	28	30	

FREQUENCY IN MEGAHERTZ

Figure 9a. Transmitter antenna pattern continued.

METHOD 15 ICEPAC IC.10 PAGE 10

ITSA 1	ANTENNA PACKAGE					ANTENNA PATTERN				
	FREQUENCY RANGE		ANTENNA TYPE			HEIGHT	LENGTH		ANGLE	
	2.0 TO	30.0	VER	MONOPOLE		-.250		.000		
	2	3	4	5	6	7	8	9	10	11
90	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6
88	-29.7	-30.0	-30.1	-30.2	-30.2	-30.2	-30.2	-30.2	-30.2	-30.1
86	-23.6	-24.0	-24.1	-24.2	-24.2	-24.2	-24.2	-24.2	-24.1	-24.1
84	-20.1	-20.4	-20.6	-20.7	-20.7	-20.7	-20.7	-20.6	-20.6	-20.6
82	-17.6	-18.0	-18.1	-18.2	-18.2	-18.2	-18.2	-18.1	-18.1	-18.1
80	-15.7	-16.0	-16.2	-16.2	-16.2	-16.2	-16.2	-16.2	-16.2	-16.2
78	-14.1	-14.4	-14.6	-14.7	-14.7	-14.7	-14.6	-14.6	-14.6	-14.6
76	-12.8	-13.1	-13.3	-13.3	-13.3	-13.3	-13.3	-13.3	-13.3	-13.3
74	-11.6	-11.9	-12.1	-12.2	-12.2	-12.2	-12.2	-12.1	-12.1	-12.1
72	-10.6	-10.9	-11.1	-11.2	-11.2	-11.2	-11.2	-11.1	-11.1	-11.1
E 70	-9.7	-10.0	-10.2	-10.3	-10.3	-10.3	-10.3	-10.2	-10.2	-10.2
L 68	-8.9	-9.2	-9.4	-9.4	-9.5	-9.5	-9.4	-9.4	-9.4	-9.4
E 66	-8.1	-8.5	-8.6	-8.7	-8.7	-8.7	-8.7	-8.7	-8.7	-8.7
V 64	-7.4	-7.8	-8.0	-8.0	-8.0	-8.0	-8.0	-8.0	-8.0	-8.0
A 62	-6.8	-7.2	-7.3	-7.4	-7.4	-7.4	-7.4	-7.4	-7.4	-7.4
T 60	-6.2	-6.6	-6.8	-6.8	-6.9	-6.9	-6.9	-6.8	-6.8	-6.8
I 58	-5.7	-6.1	-6.3	-6.3	-6.3	-6.3	-6.3	-6.3	-6.3	-6.3
O 56	-5.2	-5.6	-5.8	-5.8	-5.9	-5.9	-5.9	-5.8	-5.8	-5.8
N 54	-4.8	-5.2	-5.3	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4
52	-4.4	-4.7	-4.9	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0
A 50	-4.0	-4.4	-4.5	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6
N 48	-3.6	-4.0	-4.2	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3
G 46	-3.3	-3.7	-3.9	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0
L 44	-3.0	-3.4	-3.6	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7
E 42	-2.7	-3.2	-3.4	-3.4	-3.5	-3.5	-3.5	-3.5	-3.5	-3.4
40	-2.5	-2.9	-3.1	-3.2	-3.3	-3.3	-3.3	-3.3	-3.2	-3.2
I 38	-2.3	-2.8	-3.0	-3.0	-3.1	-3.1	-3.1	-3.1	-3.1	-3.1
N 36	-2.1	-2.6	-2.8	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9
34	-2.0	-2.5	-2.7	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8
D 32	-1.9	-2.4	-2.6	-2.7	-2.7	-2.8	-2.8	-2.8	-2.7	-2.7
E 30	-1.8	-2.3	-2.6	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7
G 28	-1.8	-2.3	-2.6	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7
R 26	-1.8	-2.4	-2.6	-2.7	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8
E 24	-1.9	-2.5	-2.7	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9
E 22	-2.0	-2.6	-2.9	-3.0	-3.1	-3.1	-3.1	-3.1	-3.1	-3.1
S 20	-2.2	-2.9	-3.1	-3.3	-3.3	-3.3	-3.4	-3.3	-3.3	-3.3
18	-2.5	-3.2	-3.5	-3.6	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7
16	-2.9	-3.6	-3.9	-4.0	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1
14	-3.4	-4.1	-4.5	-4.6	-4.7	-4.7	-4.7	-4.7	-4.7	-4.7
12	-4.1	-4.8	-5.2	-5.3	-5.4	-5.5	-5.5	-5.5	-5.5	-5.5
10	-5.0	-5.8	-6.1	-6.3	-6.4	-6.4	-6.4	-6.5	-6.4	-6.4
8	-6.2	-7.1	-7.5	-7.6	-7.7	-7.8	-7.8	-7.8	-7.8	-7.8
6	-8.0	-8.9	-9.3	-9.5	-9.6	-9.6	-9.7	-9.7	-9.7	-9.7
4	-10.7	-11.7	-12.2	-12.4	-12.5	-12.5	-12.5	-12.5	-12.5	-12.5
2	-16.0	-17.0	-17.5	-17.7	-17.8	-17.9	-17.9	-17.9	-17.9	-17.9
0	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6
	2	3	4	5	6	7	8	9	10	11
	FREQUENCY IN MEGAHERTZ									
	ANTENNA EFFICIENCY									
	-.6	-.6	-.6	-.6	-.6	-.6	-.6	-.6	-.6	-.6
	2	3	4	5	6	7	8	9	10	11
	FREQUENCY IN MEGAHERTZ									

Figure 10. Receiver-antenna pattern. (METHOD = 15)

METHOD 15      ICEPAC IC.10      PAGE 11

AZIMUTH		EX(1)		EX(2)		EX(3)		EX(4)		CONDUCT.		DIELECT.	
.000		.000		.000		.000		.000		.001		4.000	
12	13	14	16	18	20	22	24	26	28	30			
-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	90		
-30.1	-30.1	-30.1	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-29.9	88		
-24.1	-24.1	-24.1	-24.0	-24.0	-24.0	-24.0	-23.9	-23.9	-23.9	-23.9	86		
-20.6	-20.6	-20.5	-20.5	-20.5	-20.5	-20.4	-20.4	-20.4	-20.4	-20.4	84		
-18.1	-18.1	-18.0	-18.0	-18.0	-18.0	-17.9	-17.9	-17.9	-17.9	-17.9	82		
-16.1	-16.1	-16.1	-16.1	-16.1	-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	80		
-14.6	-14.6	-14.5	-14.5	-14.5	-14.5	-14.4	-14.4	-14.4	-14.4	-14.4	78		
-13.2	-13.2	-13.2	-13.2	-13.2	-13.1	-13.1	-13.1	-13.1	-13.1	-13.1	76		
-12.1	-12.1	-12.1	-12.0	-12.0	-12.0	-12.0	-11.9	-11.9	-11.9	-11.9	74		
-11.1	-11.1	-11.0	-11.0	-11.0	-11.0	-11.0	-10.9	-10.9	-10.9	-10.9	72		
-10.2	-10.2	-10.1	-10.1	-10.1	-10.1	-10.1	-10.0	-10.0	-10.0	-10.0	70		
-9.4	-9.4	-9.3	-9.3	-9.3	-9.3	-9.2	-9.2	-9.2	-9.2	-9.2	68		
-8.6	-8.6	-8.6	-8.6	-8.6	-8.5	-8.5	-8.5	-8.5	-8.5	-8.5	66		
-8.0	-7.9	-7.9	-7.9	-7.9	-7.9	-7.8	-7.8	-7.8	-7.8	-7.8	64		
-7.4	-7.3	-7.3	-7.3	-7.3	-7.3	-7.2	-7.2	-7.2	-7.2	-7.2	62		
-6.8	-6.8	-6.8	-6.7	-6.7	-6.7	-6.7	-6.7	-6.6	-6.6	-6.6	60		
-6.3	-6.3	-6.2	-6.2	-6.2	-6.2	-6.2	-6.1	-6.1	-6.1	-6.1	58		
-5.8	-5.8	-5.8	-5.7	-5.7	-5.7	-5.7	-5.7	-5.7	-5.6	-5.6	56		
-5.4	-5.3	-5.3	-5.3	-5.3	-5.3	-5.2	-5.2	-5.2	-5.2	-5.2	54		
-5.0	-4.9	-4.9	-4.9	-4.9	-4.9	-4.8	-4.8	-4.8	-4.8	-4.8	52		
-4.6	-4.6	-4.6	-4.5	-4.5	-4.5	-4.5	-4.5	-4.5	-4.4	-4.4	50		
-4.2	-4.2	-4.2	-4.2	-4.2	-4.2	-4.1	-4.1	-4.1	-4.1	-4.1	48		
-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.8	-3.8	-3.8	-3.8	-3.8	46		
-3.7	-3.7	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	-3.5	-3.5	44		
-3.4	-3.4	-3.4	-3.4	-3.4	-3.3	-3.3	-3.3	-3.3	-3.3	-3.3	42		
-3.2	-3.2	-3.2	-3.2	-3.2	-3.1	-3.1	-3.1	-3.1	-3.1	-3.1	40		
-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-2.9	-2.9	-2.9	-2.9	38		
-2.9	-2.9	-2.9	-2.9	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	36		
-2.8	-2.8	-2.8	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	34		
-2.7	-2.7	-2.7	-2.7	-2.7	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	32		
-2.7	-2.7	-2.7	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	30		
-2.7	-2.7	-2.7	-2.7	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	28		
-2.8	-2.8	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	26		
-2.9	-2.9	-2.9	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	24		
-3.1	-3.1	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	22		
-3.3	-3.3	-3.3	-3.3	-3.3	-3.3	-3.2	-3.2	-3.2	-3.2	-3.2	20		
-3.7	-3.7	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	18		
-4.1	-4.1	-4.1	-4.1	-4.1	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	16		
-4.7	-4.7	-4.7	-4.7	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6	14		
-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	12		
-6.4	-6.4	-6.4	-6.4	-6.4	-6.4	-6.4	-6.4	-6.4	-6.3	-6.3	10		
-7.8	-7.8	-7.7	-7.7	-7.7	-7.7	-7.7	-7.7	-7.7	-7.7	-7.7	8		
-9.6	-9.6	-9.6	-9.6	-9.6	-9.6	-9.6	-9.6	-9.6	-9.6	-9.6	6		
-12.5	-12.5	-12.5	-12.5	-12.5	-12.5	-12.5	-12.5	-12.5	-12.5	-12.4	4		
-17.9	-17.9	-17.9	-17.9	-17.9	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	2		
-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	0		
12	13	14	16	18	20	22	24	26	28	30			

FREQUENCY IN MEGAHERTZ

ANTENNA EFFICIENCY											
.6											
12	13	14	16	18	20	22	24	26	28	30	
.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	
12	13	14	16	18	20	22	24	26	28	30	

FREQUENCY IN MEGAHERTZ

Figure 10a.      Receiver-antenna pattern continued.

METHOD 16 ICEPAC IC.10 PAGE 12

JAN 1970 SSN = 100.  
 BOULDER, COLORADO TO ST. LOUIS, MO. AZIMUTHS N. MI. KM  
 40.03 N 105.30 W - 38.67 N 90.25 W 91.84 281.42 702.6 1301.1  
 ITSA 1 Antenna Package MINIMUM ANGLE .0 DEGREES  
 XMTR 2.0 TO 30.0 VER MONOPOLE H .00 L -.50 A .0 OFF AZ .0  
 RCVR 2.0 TO 30.0 VER MONOPOLE H .00 L -.25 A .0 OFF AZ .0  
 POWER = 30.000 KW 3 MHZ NOISE = -150.0 DBW REQ. REL = .90 REQ. SNR = 55.0  
 MULTIPATH POWER TOLERANCE = 10.0 DB MULTIPATH DELAY TOLERANCE = .850 MS

UT	MUF												FREQ	MODE	ANGLE	DELAY	V HITE	F DAYS	LOSS	DBU	S DBW	N DBW	SNR	RPWRG	REL	MPROB		
19.0	22.0	2.0	3.0	5.0	7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	FREQ															
	1F2	1 E	1 E	1ES	2F1	1F2	1F2	1F2	1F2	1F2	1F2	1F2	1F2	MODE														
	23.9	3.3	3.3	6.6	26.6	27.0	22.5	21.1	21.0	21.8	23.9	23.9	ANGLE															
	5.0	4.4	4.4	4.4	5.0	5.2	4.9	4.9	4.9	4.9	5.0	5.0	DELAY															
	338.	71.	72.	110.	176.	386.	318.	297.	296.	307.	338.	338.	V HITE															
	.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.97	.80	.11	.00	F DAYS															
	141.	209.	203.	183.	162.	139.	136.	135.	134.	135.	155.	202.	LOSS															
	41.	-38.	-29.	-6.	17.	37.	43.	44.	46.	47.	28.	-18.	DBU															
	-95	-162	-157	-137	-111	-92	-88	-89	-89	-88	-110	-157	S DBW															
	-173	-145	-150	-156	-161	-163	-163	-165	-168	-172	-175	-177	N DBW															
	78.	-18.	-8.	19.	49.	70.	74.	76.	79.	83.	66.	20.	SNR															
	-5.	79.	69.	42.	15.	-9.	-13.	-15.	-18.	-18.	15.	60.	RPWRG															
	.95	.00	.00	.00	.23	1.00	1.00	1.00	1.00	1.00	.70	.05	REL															
	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	MPROB															
7.0	7.6	2.0	3.0	5.0	7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	FREQ															
	1F2	1 E	1F2	1F2	1F2	1F2	1ES	1ES	1F2	1F2	1F2	1F2	MODE															
	26.0	7.0	19.0	20.2	25.3	26.0	6.6	6.6	26.0	26.0	26.0	26.0	ANGLE															
	5.1	4.4	4.8	4.8	5.1	5.1	4.4	4.4	5.1	5.1	5.1	5.1	DELAY															
	370.	115.	268.	284.	360.	371.	110.	110.	371.	371.	371.	371.	V HITE															
	.50	.86	1.00	.99	.52	.06	.14	.07	.00	.00	.00	.00	F DAYS															
	125.	120.	120.	118.	124.	144.	168.	192.	227.	228.	230.	231.	LOSS															
	52.	47.	46.	52.	52.	32.	15.	-7.	-47.	-47.	-47.	-47.	DBU															
	-75	-71	-73	-72	-74	-98	-122	-147	-181	-183	-184	-186	S DBW															
	-157	-138	-143	-149	-157	-163	-166	-169	-171	-173	-175	-177	N DBW															
	82.	67.	69.	77.	82.	64.	45.	23.	-10.	-10.	-9.	-8.	SNR															
	-16.	-4.	-8.	-16.	-16.	8.	25.	57.	72.	72.	71.	70.	RPWRG															
	1.00	.98	1.00	1.00	1.00	.76	.31	.06	.00	.00	.00	.00	REL															
	.00	.63	.89	.00	.00	.00	.00	.00	.00	.00	.00	.00	MPROB															

Figure 11. System performance. (METHOD = 16)

METHOD 17      ICEPAC IC.10      PAGE 13

JAN      1970      SSN = 100.  
 BOULDER, COLORADO TO ST. LOUIS, MO.      AZIMUTHS      N. MI.      KM  
 40.03 N 105.30 W - 38.67 N 90.25 W      91.84 281.42      702.6 1301.1  
 ITSA 1 Antenna Package      MINIMUM ANGLE      .0 DEGREES  
 XMTR 2.0 TO 30.0 VER MONOPOLE H      .00 L      -.50 A      .0 OFF AZ      .0  
 RCVR 2.0 TO 30.0 VER MONOPOLE H      .00 L      -.25 A      .0 OFF AZ      .0  
 POWER = 30.000 KW 3 MHZ NOISE = -150.0 DBW      REQ. REL = .90      REQ. SNR = 55.0  
 MULTIPATH POWER TOLERANCE = 10.0 DB      MULTIPATH DELAY TOLERANCE = .850 MS

UT	MUF													
19.0	22.0	2.0	3.0	5.0	7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	FREQ	
	1F2	1 E	1 E	1ES	2F1	1F2	1F2	1F2	1F2	1F2	1F2	1F2	MODE	
23.9	3.3	3.3	6.6	26.6	27.0	22.5	21.1	21.0	21.8	23.9	23.9	ANGLE		
.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.97	.80	.11	.00	F DAYS		
41.	-38.	-29.	-6.	17.	37.	43.	44.	46.	47.	28.	-18.	DBU		
78.	-18.	-8.	19.	49.	70.	74.	76.	79.	83.	66.	20.	SNR		
.95	.00	.00	.00	.23	1.00	1.00	1.00	1.00	1.00	1.00	.70	REL		
7.0	7.6	2.0	3.0	5.0	7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	FREQ	
	1F2	1 E	1F2	1F2	1F2	1F2	1ES	1ES	1F2	1F2	1F2	1F2	MODE	
26.0	7.0	19.0	20.2	25.3	26.0	6.6	6.6	26.0	26.0	26.0	26.0	ANGLE		
.50	.86	1.00	.99	.52	.06	.14	.07	.00	.00	.00	.00	F DAYS		
52.	47.	46.	52.	52.	32.	15.	-7.	-47.	-47.	-47.	-47.	DBU		
82.	67.	69.	77.	82.	64.	45.	23.	-10.	-10.	-9.	-8.	SNR		
1.00	.98	1.00	1.00	1.00	.76	.31	.06	.00	.00	.00	.00	REL		

Figure 12.      Condensed system performance, reliabilities.      (METHOD = 17)



METHOD 18      ICEPAC IC.10      PAGE 14

JAN      1970      SSN = 100.  
 BOULDER, COLORADO TO ST. LOUIS, MO.      AZIMUTHS      N. MI.      KM  
 40.03 N 105.30 W - 38.67 N 90.25 W      91.84 281.42      702.6      1301.1  
 ITSA 1 Antenna Package      MINIMUM ANGLE      .0 DEGREES  
 XMTR      2.0 TO 30.0 VER MONOPOLE H      .00 L      -.50 A      .0 OFF AZ      .0  
 RCVR      2.0 TO 30.0 VER MONOPOLE H      .00 L      -.25 A      .0 OFF AZ      .0  
 POWER = 30.000 KW      3 MHZ NOISE = -150.0 DBW      REQ. REL = .90      REQ. SNR = 55.0

UT	MUF	2.0	3.0	5.0	7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	FREQ
19.0	22.0	2.0	3.0	5.0	7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	FREQ
	1F2	1 E	1 E	1ES	2F1	1F2	1F2	1F2	1F2	1F2	1F2	1F2	MODE
	23.9	3.3	3.3	6.6	26.6	27.0	22.5	21.1	21.0	21.8	23.9	23.9	ANGLE
	.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.97	.80	.11	.00	F DAYS
	41.	-38.	-29.	-6.	17.	37.	43.	44.	46.	47.	28.	-18.	DBU
	78.	-18.	-8.	19.	49.	70.	74.	76.	79.	83.	66.	20.	SNR
	.56	.00	.00	.00	.16	.63	.76	.81	.84	.79	.31	.03	S PRB
7.0	7.6	2.0	3.0	5.0	7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	FREQ
	1F2	1 E	1F2	1F2	1F2	1F2	1ES	1ES	1F2	1F2	1F2	1F2	MODE
	26.0	7.0	19.0	20.2	25.3	26.0	6.6	6.6	26.0	26.0	26.0	26.0	ANGLE
	.50	.86	1.00	.99	.52	.06	.14	.07	.00	.00	.00	.00	F DAYS
	52.	47.	46.	52.	52.	32.	15.	-7.	-47.	-47.	-47.	-47.	DBU
	82.	67.	69.	77.	82.	64.	45.	23.	-10.	-10.	-9.	-8.	SNR
	.73	.53	.64	.84	.74	.34	.13	.04	.00	.00	.00	.00	S PRB

Figure 13.      Condensed system performance,      (METHOD = 18)  
 service probability.

METHOD 19      ICEPAC IC.10      PAGE 15

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JAN      1970      SSN = 100.
BOULDER,COLORADO TO ST. LOUIS,MO.      AZIMUTHS      N. MI.      KM
40.03 N  105.30 W - 38.67 N  90.25 W      91.84  281.42      702.6   1301.1
      MINIMUM ANGLE      .0  DEGREES
XMTR   2.0  TO  30.0  VER MONOPOLE H      .00 L      -.50 A      .0  OFF AZ      .0

UT  MUF
19.0 22.0  2.0  3.0  5.0  7.5 10.0 12.5 15.0 17.5 20.0 25.0 30.0  FREQ
      1F2  1 E  1 E  1ES  2F1  1F2  1F2  1F2  1F2  1F2  1F2  1F2  1F2  MODE
23.9  3.3  3.3  6.6 26.6 27.0 22.5 21.1 21.0 21.8 23.9 23.9  ANGLE
      5.0  4.4  4.4  4.4  5.0  5.2  4.9  4.9  4.9  4.9  5.0  5.0  DELAY
338.  71.  72. 110. 176. 386. 318. 297. 296. 307. 338. 338.  V HITE
      .50 1.00 1.00 1.00 1.00 1.00 1.00 1.00  .97  .80  .11  .00  F DAYS

7.0  7.6  2.0  3.0  5.0  7.5 10.0 12.5 15.0 17.5 20.0 25.0 30.0  FREQ
      1F2  1 E  1F2  1F2  1F2  1F2  1ES  1ES  1F2  1F2  1F2  1F2  1F2  MODE
26.0  7.0 19.0 20.2 25.3 26.0  6.6  6.6 26.0 26.0 26.0 26.0  ANGLE
      5.1  4.4  4.8  4.8  5.1  5.1  4.4  4.4  5.1  5.1  5.1  5.1  DELAY
370. 115. 268. 284. 360. 371. 110. 110. 371. 371. 371. 371.  V HITE
      .50  .86 1.00  .99  .52  .06  .14  .07  .00  .00  .00  .00  F DAYS
    
```

Figure 14. Propagation path geometry. (METHOD = 19)

METHOD 20      ICEPAC IC.10      PAGE 16

JAN      1970      SSN = 100.  
 BOULDER, COLORADO TO ST. LOUIS, MO.      AZIMUTHS      N. MI.      KM  
 40.03 N 105.30 W - 38.67 N 90.25 W      91.84 281.42      702.6      1301.1  
 ITSA 1 Antenna Package      MINIMUM ANGLE      .0 DEGREES  
 XMTR      2.0 TO 30.0 VER MONOPOLE H      .00 L      -.50 A      .0 OFF AZ      .0  
 RCVR      2.0 TO 30.0 VER MONOPOLE H      .00 L      -.25 A      .0 OFF AZ      .0  
 POWER = 30.000 KW 3 MHZ NOISE = -150.0 DBW      REQ. REL = .90      REQ. SNR = 55.0  
 MULTIPATH POWER TOLERANCE = 10.0 DB      MULTIPATH DELAY TOLERANCE = .850 MS

UT	MUF	2.0	3.0	5.0	7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	FREQ
19.0	22.0	2.0	3.0	5.0	7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	FREQ
	1F2	1 E	1 E	1ES	2F1	1F2	1F2	1F2	1F2	1F2	1F2	1F2	MODE
23.9	3.3	3.3	6.6	26.6	27.0	22.5	21.1	21.0	21.8	23.9	23.9		ANGLE
	5.0	4.4	4.4	4.4	5.0	5.2	4.9	4.9	4.9	4.9	5.0	5.0	DELAY
338.	71.	72.	110.	176.	386.	318.	297.	296.	307.	338.	338.		V HITE
	.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.97	.80	.11	.00	F DAYS
141.	209.	203.	183.	162.	139.	136.	135.	134.	135.	155.	202.		LOSS
	41.	-38.	-29.	-6.	17.	37.	43.	44.	46.	47.	28.	-18.	DBU
	-95	-162	-157	-137	-111	-92	-88	-89	-89	-88	-110	-157	S DBW
	-173	-145	-150	-156	-161	-163	-163	-165	-168	-172	-175	-177	N DBW
	78.	-18.	-8.	19.	49.	70.	74.	76.	79.	83.	66.	20.	SNR
	-5.	79.	69.	42.	15.	-9.	-13.	-15.	-18.	-18.	15.	60.	RPWRG
	.95	.00	.00	.00	.23	1.00	1.00	1.00	1.00	1.00	.70	.05	REL
	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	MPROB
	.56	.00	.00	.00	.16	.63	.76	.81	.84	.79	.31	.03	S PRB
	17.	2.	2.	2.	7.	3.	3.	3.	4.	9.	25.	25.	SIG LW
	8.	2.	2.	2.	4.	5.	3.	2.	2.	5.	16.	25.	SIG UP
	12.	10.	10.	10.	10.	10.	9.	8.	9.	10.	19.	27.	SNR UP
7.0	7.6	2.0	3.0	5.0	7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	FREQ
	1F2	1 E	1F2	1F2	1F2	1F2	1ES	1ES	1F2	1F2	1F2	1F2	MODE
26.0	7.0	19.0	20.2	25.3	26.0	6.6	6.6	26.0	26.0	26.0	26.0	26.0	ANGLE
	5.1	4.4	4.8	4.8	5.1	5.1	4.4	4.4	5.1	5.1	5.1	5.1	DELAY
370.	115.	268.	284.	360.	371.	110.	110.	371.	371.	371.	371.	371.	V HITE
	.50	.86	1.00	.99	.52	.06	.14	.07	.00	.00	.00	.00	F DAYS
125.	120.	120.	118.	124.	144.	168.	192.	227.	228.	230.	231.		LOSS
	52.	47.	46.	52.	52.	32.	15.	-7.	-47.	-47.	-47.	-47.	DBU
	-75	-71	-73	-72	-74	-98	-122	-147	-181	-183	-184	-186	S DBW
	-157	-138	-143	-149	-157	-163	-166	-169	-171	-173	-175	-177	N DBW
	82.	67.	69.	77.	82.	64.	45.	23.	-10.	-10.	-9.	-8.	SNR
	-16.	-4.	-8.	-16.	-16.	8.	25.	57.	72.	72.	71.	70.	RPWRG
1.00	.98	1.00	1.00	1.00	.76	.31	.06	.00	.00	.00	.00	.00	REL
	.00	.63	.89	.00	.00	.00	.00	.00	.00	.00	.00	.00	MPROB
	.73	.53	.64	.84	.74	.34	.13	.04	.00	.00	.00	.00	S PRB
	10.	3.	1.	2.	10.	16.	13.	24.	3.	3.	3.	3.	SIG LW
	6.	2.	4.	1.	6.	16.	25.	25.	11.	1.	1.	0.	SIG UP
	10.	9.	9.	7.	10.	18.	27.	27.	14.	10.	10.	10.	SNR UP

Figure 15.      complete system performance.      (METHOD = 20)

JAN 1970 SSN = 100.  
 BOULDER, COLORADO TO ST. LOUIS, MO. AZIMUTHS N. MI. KM  
 40.03 N 105.30 W - 38.67 N 90.25 W 91.84 281.42 702.6 1301.1  
 ITSA 1 Antenna Package MINIMUM ANGLE .0 DEGREES  
 XMTR 2.0 TO 30.0 VER MONOPOLE H .00 L -.50 A .0 OFF AZ .0  
 RCVR 2.0 TO 30.0 VER MONOPOLE H .00 L -.25 A .0 OFF AZ .0  
 POWER = 30.000 KW 3 MHZ NOISE = -150.0 DBW REQ. REL = .90 REQ. SNR = 55.0  
 MULTIPATH POWER TOLERANCE = 10.0 DB MULTIPATH DELAY TOLERANCE = .850 MS

UT	MUF												FREQ	MODE	
19.0	22.0	2.0	3.0	5.0	7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	FREQ		
	F2F2	E	E	E	E	F1	E	F1F1	F2F1	F2F2	F2F2	F2F2	F2F2	F2F2	MODE
	20.0	3.0	3.0	3.0	34.0	23.8	22.0	20.0	20.0	20.0	23.9	23.9	ANGLE		
	20.0	18.0	18.0	22.0	16.0	23.8	12.0	20.0	20.0	20.0	23.9	23.9	ANGLE		
	5.3	4.4	4.4	4.5	4.8	5.4	4.9	5.1	5.0	5.1	5.0	5.0	DELAY		
	313.	72.	74.	85.	203.	366.	248.	301.	295.	302.	338.	338.	V HITE		
	.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.97	.80	.11	.00	F DAYS		
	141.	235.	212.	182.	143.	132.	134.	132.	133.	135.	154.	201.	LOSS		
	42.	-74.	-47.	-13.	31.	43.	46.	47.	48.	46.	29.	-17.	DBU		
	-95	-189	-166	-137	-98	-87	-88	-87	-87	-90	-108	-156	S DBW		
	-173	-145	-150	-156	-161	-163	-163	-165	-168	-172	-175	-177	N DBW		
	78.	-44.	-16.	19.	63.	76.	75.	78.	81.	82.	67.	21.	SNR		
	-5.	106.	78.	42.	-2.	-4.	1.	-17.	-19.	-15.	14.	59.	RPWRG		
	.95	.00	.00	.00	.95	.94	.88	1.00	1.00	1.00	.73	.05	REL		
	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	MPROB		
	.56	.00	.00	.00	.46	.54	.47	.85	.85	.74	.33	.04	S PRB		
	17.	2.	2.	2.	3.	16.	21.	3.	5.	11.	25.	25.	SIG LW		
	8.	2.	2.	2.	2.	7.	15.	2.	3.	4.	16.	25.	SIG UP		
7.0	7.6	2.0	3.0	5.0	7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	FREQ		
	F2F2	F2F2	F2F2	F2F2	F2F2	F2F2	F2F2	F2F2	F2F2	F2F2	F2F2	F2F2	F2F2	MODE	
	22.0	18.0	18.0	18.0	22.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	ANGLE		
	22.0	18.0	18.0	18.0	22.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	ANGLE		
	5.3	5.1	5.0	5.2	5.2	5.1	5.1	5.1	5.1	5.1	5.1	5.1	DELAY		
	334.	276.	267.	282.	332.	371.	371.	371.	371.	371.	371.	371.	V HITE		
	.50	1.00	1.00	.99	.52	.06	.00	.00	.00	.00	.00	.00	F DAYS		
	134.	152.	143.	134.	133.	149.	182.	220.	229.	229.	230.	232.	LOSS		
	39.	9.	21.	35.	39.	26.	-6.	-42.	-49.	-48.	-48.	-48.	DBU		
	-89	-107	-98	-89	-88	-103	-137	-175	-183	-184	-185	-186	S DBW		
	-157	-138	-143	-149	-157	-163	-166	-169	-171	-173	-175	-177	N DBW		
	68.	32.	45.	60.	69.	59.	29.	-6.	-12.	-11.	-10.	-9.	SNR		
	-2.	31.	17.	1.	-2.	15.	49.	73.	74.	73.	71.	70.	RPWRG		
	.94	.00	.05	.84	.94	.61	.11	.00	.00	.00	.00	.00	REL		
	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	MPROB		
	.50	.02	.11	.41	.51	.28	.06	.00	.00	.00	.00	.00	S PRB		
	10.	3.	3.	4.	10.	19.	23.	11.	3.	3.	3.	3.	SIG LW		
	6.	1.	1.	1.	6.	16.	25.	25.	2.	1.	1.	1.	SIG UP		

Figure 16. forced long-path model. (METHOD = 21)

METHOD 22    ICEPAC IC.10    PAGE 18

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JAN      1970      SSN = 100.
BOULDER,COLORADO TO ST. LOUIS,MO.      AZIMUTHS      N. MI.      KM
40.03 N 105.30 W - 38.67 N 90.25 W      91.84 281.42      702.6 1301.1
ITSA 1 Antenna Package      MINIMUM ANGLE      .0 DEGREES
XMTR   2.0 TO 30.0 VER MONOPOLE H      .00 L      -.50 A      .0 OFF AZ      .0
RCVR   2.0 TO 30.0 VER MONOPOLE H      .00 L      -.25 A      .0 OFF AZ      .0
POWER = 30.000 KW 3 MHZ NOISE = -150.0 DBW REQ. REL = .90 REQ. SNR = 55.0
MULTIPATH POWER TOLERANCE = 10.0 DB MULTIPATH DELAY TOLERANCE = .850 MS
    
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UT	MUF	2.0	3.0	5.0	7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	FREQ
19.0	22.0	2.0	3.0	5.0	7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	FREQ
	1F2	1 E	1 E	1ES	2F1	1F2	1F2	1F2	1F2	1F2	1F2	1F2	MODE
	23.9	3.3	3.3	6.6	26.6	27.0	22.5	21.1	21.0	21.8	23.9	23.9	ANGLE
	5.0	4.4	4.4	4.4	5.0	5.2	4.9	4.9	4.9	4.9	5.0	5.0	DELAY
	338.	71.	72.	110.	176.	386.	318.	297.	296.	307.	338.	338.	V HITE
	.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.97	.80	.11	.00	F DAYS
	141.	209.	203.	183.	162.	139.	136.	135.	134.	135.	155.	202.	LOSS
	41.	-38.	-29.	-6.	17.	37.	43.	44.	46.	47.	28.	-18.	DBU
	-95	-162	-157	-137	-111	-92	-88	-89	-89	-88	-110	-157	S DBW
	-173	-145	-150	-156	-161	-163	-163	-165	-168	-172	-175	-177	N DBW
	78.	-18.	-8.	19.	49.	70.	74.	76.	79.	83.	66.	20.	SNR
	-5.	79.	69.	42.	15.	-9.	-13.	-15.	-18.	-18.	15.	60.	RPWRG
	.95	.00	.00	.00	.23	1.00	1.00	1.00	1.00	1.00	.70	.05	REL
	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	MPROB
	.56	.00	.00	.00	.16	.63	.76	.81	.84	.79	.31	.03	S PRB
	17.	2.	2.	2.	7.	3.	3.	3.	4.	9.	25.	25.	SIG LW
	8.	2.	2.	2.	4.	5.	3.	2.	2.	5.	16.	25.	SIG UP
7.0	7.6	2.0	3.0	5.0	7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	FREQ
	1F2	1 E	1F2	1F2	1F2	1F2	1ES	1ES	1F2	1F2	1F2	1F2	MODE
	26.0	7.0	19.0	20.2	25.3	26.0	6.6	6.6	26.0	26.0	26.0	26.0	ANGLE
	5.1	4.4	4.8	4.8	5.1	5.1	4.4	4.4	5.1	5.1	5.1	5.1	DELAY
	370.	115.	268.	284.	360.	371.	110.	110.	371.	371.	371.	371.	V HITE
	.50	.86	1.00	.99	.52	.06	.14	.07	.00	.00	.00	.00	F DAYS
	125.	120.	120.	118.	124.	144.	168.	192.	227.	228.	230.	231.	LOSS
	52.	47.	46.	52.	52.	32.	15.	-7.	-47.	-47.	-47.	-47.	DBU
	-75	-71	-73	-72	-74	-98	-122	-147	-181	-183	-184	-186	S DBW
	-157	-138	-143	-149	-157	-163	-166	-169	-171	-173	-175	-177	N DBW
	82.	67.	69.	77.	82.	64.	45.	23.	-10.	-10.	-9.	-8.	SNR
	-16.	-4.	-8.	-16.	-16.	8.	25.	57.	72.	72.	71.	70.	RPWRG
	1.00	.98	1.00	1.00	1.00	.76	.31	.06	.00	.00	.00	.00	REL
	.00	.63	.89	.00	.00	.00	.00	.00	.00	.00	.00	.00	MPROB
	.73	.53	.64	.84	.74	.34	.13	.04	.00	.00	.00	.00	S PRB
	10.	3.	1.	2.	10.	16.	13.	24.	3.	3.	3.	3.	SIG LW
	6.	2.	4.	1.	6.	16.	25.	25.	11.	1.	1.	0.	SIG UP

Figure 17.      forced short-path model.      (MODEL = 22)

METHOD 23    ICEPAC IC.10    PAGE 19

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      JAN      1970          SSN = 100.
BOULDER,COLORADO TO ST. LOUIS,MO.          AZIMUTHS          N. MI.          KM
40.03 N 105.30 W - 38.67 N 90.25 W          91.84 281.42          702.6 1301.1
ITSA 1 Antenna Package          MINIMUM ANGLE          .0 DEGREES
XMTR   2.0 TO 30.0 VER MONOPOLE H          .00 L   -.50 A          .0 OFF AZ          .0
RCVR   2.0 TO 30.0 VER MONOPOLE H          .00 L   -.25 A          .0 OFF AZ          .0
POWER = 30.000 KW  3 MHZ NOISE = -150.0 DBW  REQ. REL = .90  REQ. SNR = 55.0

      UT  MUF
19.0 22.0 2.0 3.0 5.0 7.5 10.0 12.5 15.0 17.5 20.0 25.0 30.0 FREQ
      1F2 1 E 1 E 1E5 2F1 1F2 1F2 1F2 1F2 1F2 1F2 1F2 1F2 MODE
23.9 3.3 3.3 6.6 26.6 27.0 22.5 21.1 21.0 21.8 23.9 23.9 ANGLE
338. 71. 72. 110. 176. 386. 318. 297. 296. 307. 338. 338. V HITE
78. -18. -8. 19. 49. 70. 74. 76. 79. 83. 66. 20. SNR
-5. 79. 69. 42. 15. -9. -13. -15. -18. -18. 15. 60. RPWRG
.95 .00 .00 .00 .23 1.00 1.00 1.00 1.00 1.00 1.00 .70 .05 REL

7.0 7.6 2.0 3.0 5.0 7.5 10.0 12.5 15.0 17.5 20.0 25.0 30.0 FREQ
      1F2 1 E 1F2 1F2 1F2 1F2 1ES 1ES 1F2 1F2 1F2 1F2 MODE
26.0 7.0 19.0 20.2 25.3 26.0 6.6 6.6 26.0 26.0 26.0 26.0 ANGLE
370. 115. 268. 284. 360. 371. 110. 110. 371. 371. 371. 371. V HITE
82. 67. 69. 77. 82. 64. 45. 23. -10. -10. -9. -8. SNR
-16. -4. -8. -16. -16. 8. 25. 57. 72. 72. 71. 70. RPWRG
1.00 .98 1.00 1.00 1.00 .76 .31 .06 .00 .00 .00 .00 REL
    
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Figure 18.      User-selected system performance.      (METHOD = 23)

JAN 1970 SSN = 100.  
 BOULDER, COLORADO TO ST. LOUIS, MO. AZIMUTHS N. MI. KM  
 40.03 N 105.30 W - 38.67 N 90.25 W 91.84 281.42 702.6 1301.1  
 ITSA 1 Antenna Package MINIMUM ANGLE .0 DEGREES  
 XMTR 2.0 TO 30.0 VER MONOPOLE H .00 L -.50 A .0 OFF AZ .0  
 RCVR 2.0 TO 30.0 VER MONOPOLE H .00 L -.25 A .0 OFF AZ .0  
 POWER = 30.000 KW 3 MHZ NOISE = -150.0 DBW REQ. REL = .90 REQ. SNR = 55.0

FREQUENCY / RELIABILITY

LT	MUF	2.0	3.0	5.0	7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	MUF
1	8.2	.98	1.00	1.00	1.00	.91	.34	.02	.00	.00	.00	.00	1.00
2	8.1	.99	1.00	1.00	1.00	.64	.11	.00	.00	.00	.00	.00	.98
3	7.5	.98	1.00	1.00	.93	.37	.04	.00	.00	.00	.00	.00	.93
4	6.4	.97	1.00	1.00	.69	.28	.02	.00	.00	.00	.00	.00	.89
5	6.3	.93	1.00	1.00	.64	.29	.03	.00	.00	.00	.00	.00	.88
6	8.2	.92	.97	1.00	1.00	.38	.07	.00	.00	.00	.00	.00	.89
7	12.2	.12	.21	.99	1.00	1.00	.76	.14	.00	.00	.00	.00	.82
8	16.4	.00	.01	.33	1.00	1.00	1.00	.99	.71	.19	.00	.00	.87
9	19.5	.00	.00	.09	1.00	1.00	1.00	1.00	1.00	.82	.05	.00	.86
10	20.4	.00	.00	.00	.24	1.00	1.00	1.00	1.00	.97	.37	.00	.93
11	21.2	.00	.00	.00	.26	1.00	1.00	1.00	1.00	.99	.56	.01	.95
12	22.0	.00	.00	.00	.23	1.00	1.00	1.00	1.00	1.00	.70	.05	.95
13	21.8	.00	.00	.00	.19	1.00	1.00	1.00	1.00	1.00	.66	.04	.96
14	21.8	.00	.00	.08	.99	1.00	1.00	1.00	1.00	1.00	.64	.03	.93
15	20.9	.00	.01	.36	.98	.99	.99	1.00	1.00	.97	.46	.00	.87
16	19.3	.15	.22	.93	.98	.99	1.00	1.00	.99	.81	.15	.00	.86
17	16.7	.47	.50	.95	.99	1.00	1.00	1.00	.77	.42	.00	.00	.93
18	13.9	.59	.87	.99	1.00	1.00	1.00	.91	.67	.38	.02	.00	.96
19	11.6	.65	.91	.99	1.00	1.00	.91	.60	.26	.04	.00	.00	.96
20	9.6	.82	.97	1.00	1.00	.95	.62	.20	.02	.00	.00	.00	.97
21	8.0	.98	1.00	1.00	1.00	.81	.34	.10	.00	.00	.00	.00	1.00
22	7.0	.97	1.00	1.00	.97	.55	.33	.13	.00	.00	.00	.00	1.00
23	7.0	.97	1.00	1.00	.97	.58	.34	.12	.00	.00	.00	.00	1.00
24	7.6	.98	1.00	1.00	1.00	.76	.31	.06	.00	.00	.00	.00	1.00

Figure 19. Reliability table output. (METHOD = 24)

METHOD 25    ICEPAC IC.10    PAGE 21

JAN    1970                    SSN = 100.  
 BOULDER, COLORADO TO ST. LOUIS, MO.                    AZIMUTHS                    N. MI.                    KM  
 40.03 N 105.30 W - 38.67 N 90.25 W    91.84 281.42                    702.6    1301.1  
 ITSA 1 Antenna Package                    MINIMUM ANGLE                    .0 DEGREES  
 XMTR    2.0 TO 30.0 VER MONOPOLE H                    .00 L                    -.50 A                    .0 OFF AZ                    .0  
 RCVR    2.0 TO 30.0 VER MONOPOLE H                    .00 L                    -.25 A                    .0 OFF AZ                    .0  
 POWER = 30.000 KW    3 MHZ NOISE = -150.0 DBW    REQ. REL = .90    REQ. SNR = 55.0

YE = 20.0                    HE = 110.0                    HS = 110.0

LAT	LONG	LMT	UT	E	F1	Y1	H1	FH/2	F2Z	Y2
H2	PB	CEN	EB	M3000	TCGM	RAT	ZEN	FLAG	MAGL	
39.6N	97.7W	12.5	19.0	3.46	4.6	50.0	200.0	.7	11.4	95.9
283.9	77.5	76.7	76.0	3.11	12.1	3.0	61.3	6	50.1N	

FREQ = 3.0 MHZ    UT = 19.0

	1. E	2. E	3. E	1. E
TIME DEL.	4.389	4.473	4.631	4.389
ANGLE	3.315	11.191	18.503	3.315
VIR. HITE	71.602	73.468	77.170	71.602
TRAN. LOSS	203.441	216.021	231.070	203.441
T. GAIN	-11.082	-3.442	-2.002	-11.082
R. GAIN	-13.177	-5.186	-3.081	-13.177
ABSORB	71.177	48.621	37.135	
FS. LOSS	104.376	104.542	104.844	
FIELD ST.	-28.750	-49.321	-66.475	-28.711
SIG. POW.	-158.000	-171.000	-186.000	-157.000
SNR	-8.108	-20.688	-35.737	-7.891
MODE PROB	1.000	1.000	1.000	1.000
R. PWRG	1000.000	1000.000	1000.000	69.371
RELIABIL	.000	.000	.000	.000
SERV PROB	.000	.000	.000	.000
SIG LOW	2.460	2.460	2.460	2.460
SIG UP	2.256	2.256	2.256	2.256
NOISE =	-150	S. POWER =	-157	
SIGNAL =	2.5	5.1	2.3 /	2.3    3.3    .7
NOISE =	9.7	-150.6	6.0 /	1.5    5.4    1.5
RELIAB =	10.0	-7.9	6.5	
SPROB =	29.3	-10.1	29.3	

Figure 20.    All modes output (user defined freq.)    (METHOD = 25)



METHOD 25    ICEPAC IC.10    PAGE 22

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JAN      1970          SSN = 100.
BOULDER,COLORADO TO ST. LOUIS,MO.          AZIMUTHS          N. MI.          KM
40.03 N 105.30 W - 38.67 N 90.25 W          91.84 281.42          702.6 1301.1
ITSA 1 Antenna Package          MINIMUM ANGLE          .0 DEGREES
XMTR   2.0 TO 30.0 VER MONOPOLE H          .00 L   -.50 A          .0 OFF AZ          .0
RCVR   2.0 TO 30.0 VER MONOPOLE H          .00 L   -.25 A          .0 OFF AZ          .0
POWER = 30.000 KW  3 MHZ NOISE = -150.0 DBW  REQ. REL = .90  REQ. SNR = 55.0
    
```

FREQ = 22.0 MHZ    UT = 19.0

	1.F2	1.ES	2.ES	1.F2
TIME DEL.	4.990	4.437	4.616	4.990
ANGLE	23.893	6.583	17.069	23.893
VIR. HITE	337.903	110.000	110.000	337.903
TRAN. LOSS	140.511	41260.370	82370.950	140.511
T. GAIN	-.734	-5.604	-1.026	-.734
R. GAIN	-2.819	-8.982	-3.786	-2.819
ABSORB	2.792	5.835	3.598	
FS. LOSS	122.808	121.787	122.132	
FIELD ST.	41.138	*****	*****	41.139
SIG. POW.	-95.000	*****	*****	-95.000
SNR	78.241	*****	*****	78.240
MODE PROB	.500	.000	.000	.500
R. PWRG	1000.000	1000.000	1000.000	-5.335
RELIABIL	.952	.000	.000	.952
SERV PROB	.000	.001	.001	.000
SIG LOW	17.053	2.460	2.460	17.053
SIG UP	7.595	25.000	2.256	7.595
NOISE =	-173	S. POWER =	-95	
SIGNAL =	2.5	5.1	2.3 / 2.3	3.3 .7
NOISE =	9.5	-174.0	5.5 / 1.4	4.8 1.6
RELIAB =	12.2	78.2	17.9	
SPROB =	29.3	-10.1	29.3	

Figure 21.      All modes output (MUF)      (METHOD = 25)

```

JAN      1970          SSN = 100.
BOULDER,COLORADO TO ST. LOUIS,MO.      AZIMUTHS      N. MI.      KM
40.03 N 105.30 W - 38.67 N 90.25 W      91.84 281.42      702.6 1301.1
ITSA 1 Antenna Package      MINIMUM ANGLE      .0 DEGREES
XMTR   2.0 TO 30.0 VER MONOPOLE H      .00 L      -.50 A      .0 OFF AZ      .0
RCVR   2.0 TO 30.0 VER MONOPOLE H      .00 L      -.25 A      .0 OFF AZ      .0
POWER = 30.000 KW 3 MHZ NOISE = -150.0 DBW  REQ. REL = .90  REQ. SNR = 55.0
    
```

UT	LT	FOT	HPF	ESMUF	MUF	LUF
1.0	18.0	11.00	17.82	5.68	13.92	3.47
3.0	20.0	7.57	12.26	5.45	9.58	2.29
5.0	22.0	5.85	8.94	5.72	7.04	2.00
7.0	24.0	6.28	9.60	5.93	7.56	2.00
9.0	2.0	6.60	9.53	5.75	8.15	2.00
11.0	4.0	5.19	7.50	5.42	6.41	2.00
13.0	6.0	6.97	9.18	6.04	8.19	2.00
15.0	8.0	13.93	18.35	8.19	16.39	7.11
17.0	10.0	17.57	23.28	10.60	20.43	8.33
19.0	12.0	18.94	25.11	11.15	22.03	8.75
21.0	14.0	18.74	24.84	9.41	21.79	8.76
23.0	16.0	16.63	22.05	7.05	19.34	4.67

Figure 22.      LUF-MUF table.

(METHOD = 26)

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JAN 1970 SSN = 100.  
 BOULDER, COLORADO TO ST. LOUIS, MO. AZIMUTHS N. MI. KM  
 40.03 N 105.30 W - 38.67 N 90.25 W 91.84 281.42 702.6 1301.1  
 ITSA 1 Antenna Package MINIMUM ANGLE .0 DEGREES  
 XMTR 2.0 TO 30.0 VER MONOPOLE H .00 L -.50 A .0 OFF AZ .0  
 RCVR 2.0 TO 30.0 VER MONOPOLE H .00 L -.25 A .0 OFF AZ .0  
 POWER = 30.000 KW 3 MHZ NOISE = -150.0 DBW REQ. REL = .90 REQ. SNR = 55.0

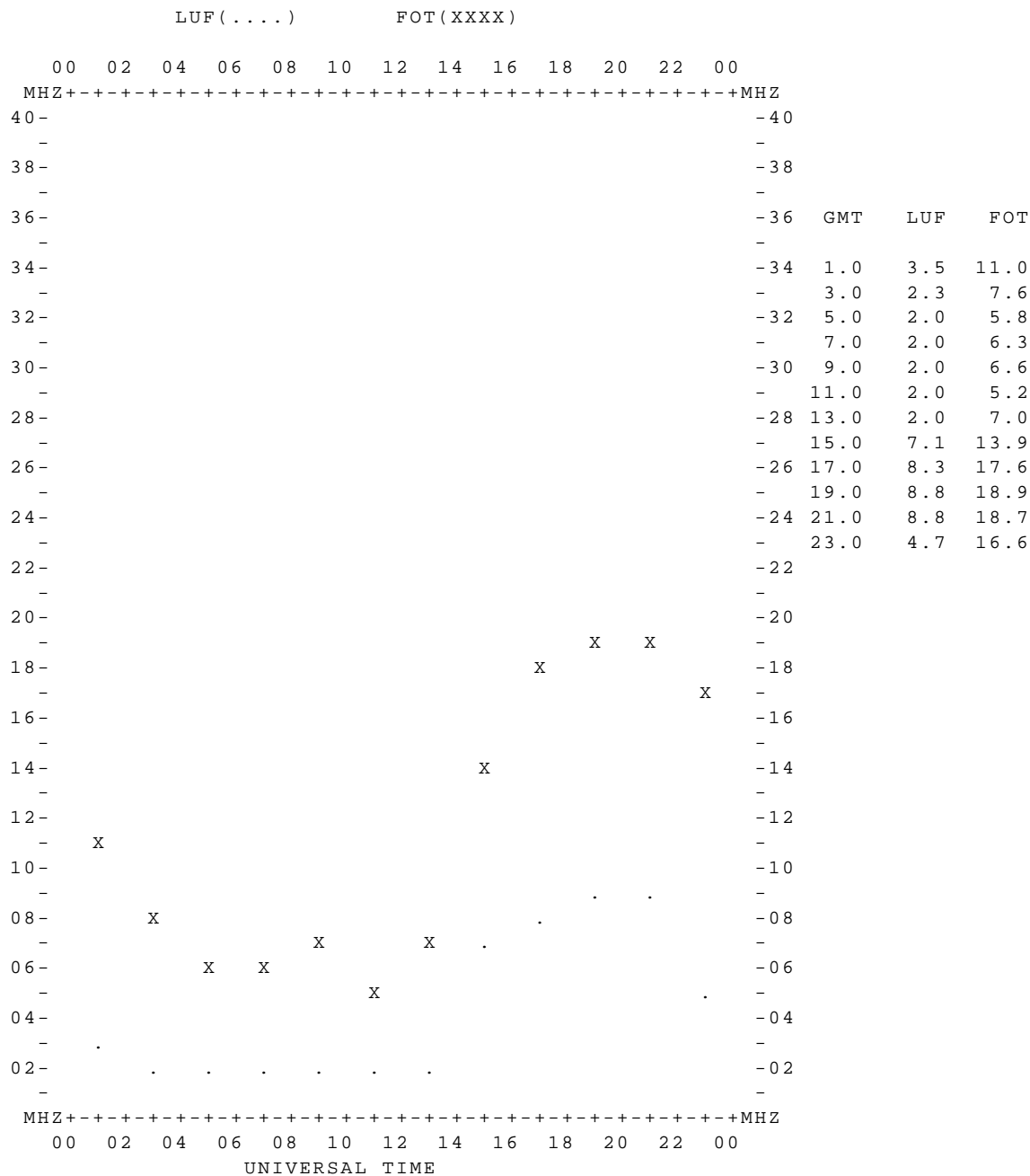


Figure 23. LUF-FOT graph.

(METHOD = 27)

METHOD 28    ICEPAC IC.10    PAGE 25

JAN    1970                    SSN = 100.  
 BOULDER, COLORADO TO ST. LOUIS, MO.                    AZIMUTHS                    N. MI.                    KM  
 40.03 N 105.30 W - 38.67 N 90.25 W                    91.84 281.42                    702.6    1301.1  
 ITSA 1 Antenna Package                    MINIMUM ANGLE                    .0 DEGREES  
 XMTR    2.0    TO    30.0    VER MONOPOLE H                    .00 L                    -.50 A                    .0    OFF AZ                    .0  
 RCVR    2.0    TO    30.0    VER MONOPOLE H                    .00 L                    -.25 A                    .0    OFF AZ                    .0  
 POWER = 30.000 KW    3 MHZ NOISE = -150.0 DBW    REQ. REL = .90    REQ. SNR = 55.0

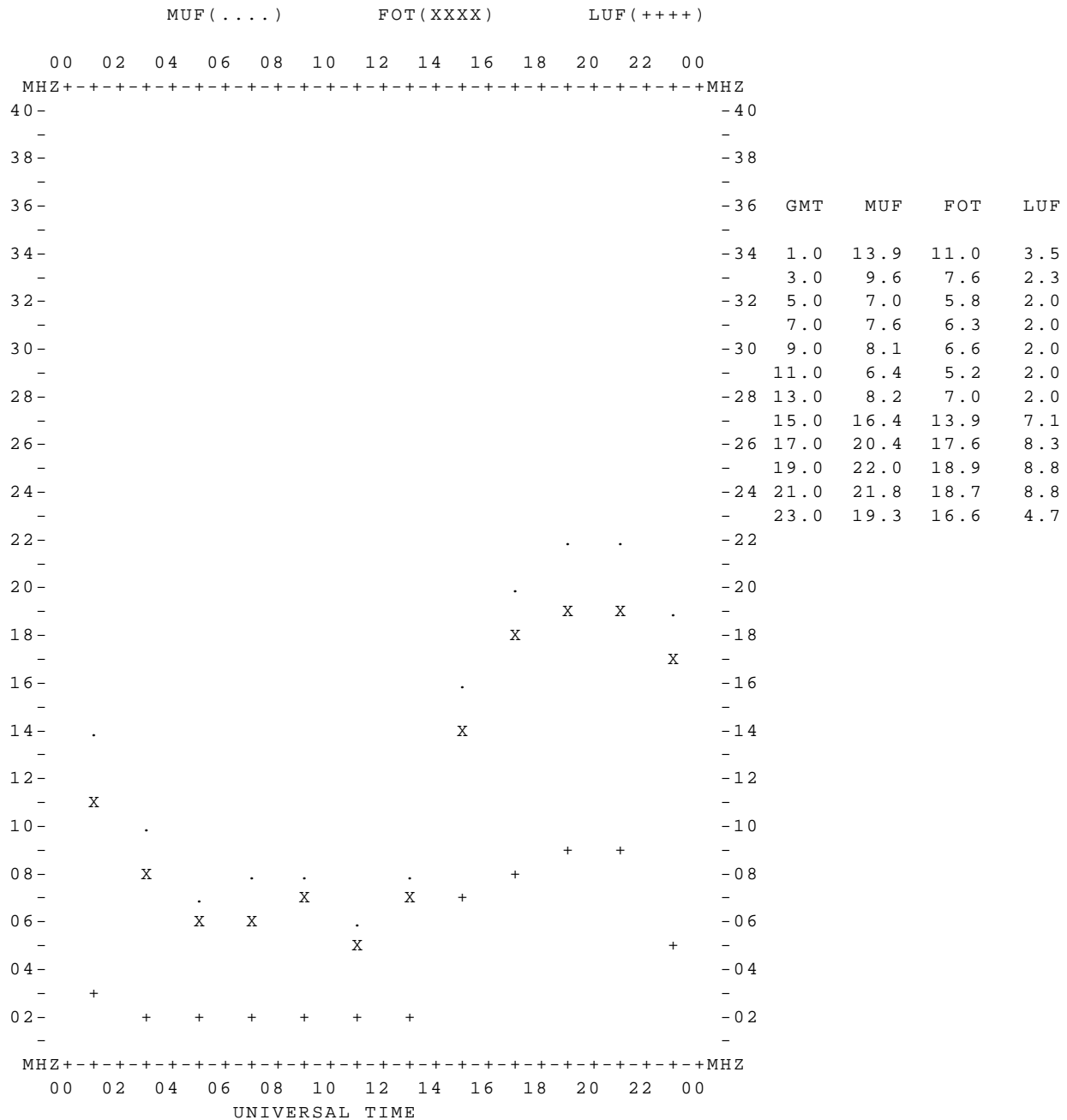


Figure 24.      LUF MUF FOT graph.                    (METHOD = 28)

JAN 1970 SSN = 100.  
 BOULDER, COLORADO TO ST. LOUIS, MO. AZIMUTHS N. MI. KM  
 40.03 N 105.30 W - 38.67 N 90.25 W 91.84 281.42 702.6 1301.1  
 ITSA 1 Antenna Package MINIMUM ANGLE .0 DEGREES  
 XMTR 2.0 TO 30.0 VER MONOPOLE H .00 L -.50 A .0 OFF AZ .0  
 RCVR 2.0 TO 30.0 VER MONOPOLE H .00 L -.25 A .0 OFF AZ .0  
 POWER = 30.000 KW 3 MHZ NOISE = -150.0 DBW REQ. REL = .90 REQ. SNR = 55.0

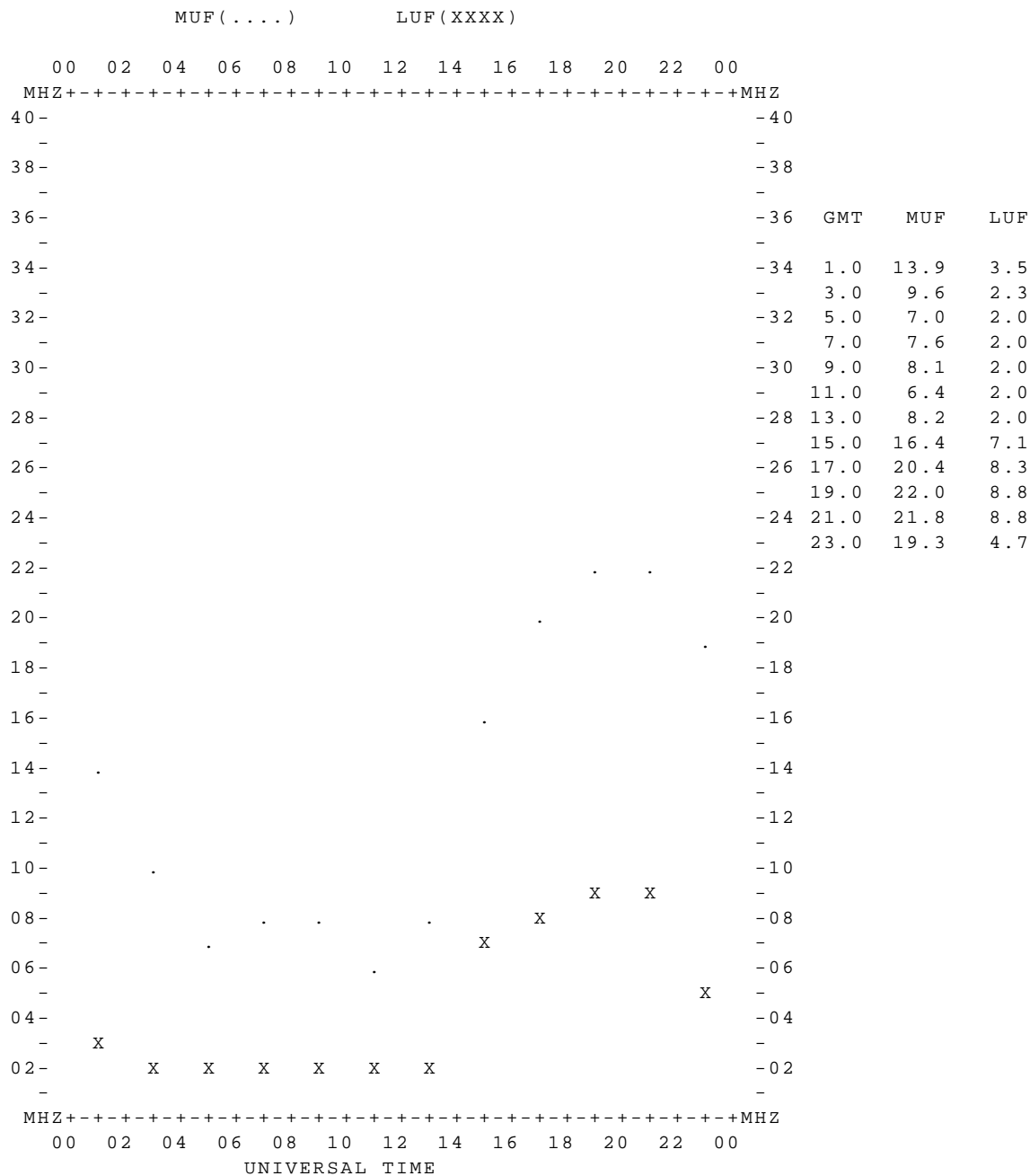


Figure 25. LUF MUF graph. (METHOD = 29)



METHOD 23 ICEPAC IC.10 PAGE 28

JAN 1970 SSN = 100.  
 BOULDER, COLORADO TO AUCKLAND, N. Z. AZIMUTHS N. MI. KM  
 40.03 N 105.30 W - 36.92 S 174.75 E 235.07 51.75 6377.8 11810.7  
 ITSA 1 Antenna Package MINIMUM ANGLE .0 DEGREES  
 XMTR 2.0 TO 30.0 VER MONOPOLE H .00 L -.50 A .0 OFF AZ .0  
 RCVR 2.0 TO 30.0 VER MONOPOLE H .00 L -.25 A .0 OFF AZ .0  
 POWER = 30.000 KW 3 MHZ NOISE = -150.0 DBW REQ. REL = .90 REQ. SNR = 55.0

UT	MUF												FREQ
13.0	11.3	2.0	3.0	5.0	7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	FREQ
	F2F2	EF2	EF2	F2F2	F2F2	F2F2	F2F2	F2F2	F2F2	F2F2	F2F2	F2F2	MODE
	3.0	3.0	4.0	10.0	12.0	10.0	2.1	2.1	2.1	2.1	2.1	2.1	ANGLE
	14.0	12.0	12.0	12.0	14.0	14.0	3.0	3.0	3.0	4.3	2.1		ANGLE
	374.	206.	197.	301.	318.	365.	373.	372.	380.	389.	484.	395.	V HITE
	36.	-23.	-7.	26.	39.	45.	30.	4.	-23.	-57.	****	****	SNR
	45.	85.	69.	36.	32.	36.	51.	77.	104.	138.	182.	198.	RPWRG
	.16	.00	.00	.00	.01	.22	.11	.01	.00	.00	.00	.00	REL
19.0	29.3	2.0	3.0	5.0	7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	FREQ
	F2F2	E E	E E	E E	E E	EF2	F1F2	F1F2	F2F2	F2F2	F2F2	F2F2	MODE
	13.7	.5	1.0	1.0	1.0	18.0	13.0	12.8	8.5	12.0	12.0	12.8	ANGLE
	5.0	1.0	1.0	1.0	4.0	12.2	10.0	10.0	12.0	12.0	8.0	3.0	ANGLE
	451.	71.	72.	74.	82.	238.	231.	338.	415.	314.	335.	455.	V HITE
	39.	****	****	****	****	-73.	-31.	10.	27.	31.	41.	33.	SNR
	42.	****	926.	550.	350.	137.	110.	70.	36.	33.	39.	48.	RPWRG
	.19	.00	.00	.00	.00	.00	.00	.02	.00	.00	.06	.14	REL
1.0	29.2	2.0	3.0	5.0	7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	FREQ
	F2F2	E E	E E	F2 E	F2 E	F2 E	F2 E	F2F1	F2F1	F2F2	F2F2	F2F2	MODE
	3.0	3.0	3.0	13.3	8.0	18.0	18.0	10.0	10.0	10.0	10.0	1.0	ANGLE
	16.0	.5	.5	.5	1.0	1.0	16.0	14.0	12.0	10.0	14.0	17.5	ANGLE
	413.	71.	74.	182.	161.	166.	210.	227.	275.	324.	355.	534.	V HITE
	35.	****	****	****	****	****	-48.	-9.	15.	29.	42.	27.	SNR
	46.	****	****	456.	284.	216.	112.	73.	49.	37.	39.	54.	RPWRG
	.16	.00	.00	.00	.00	.00	.00	.00	.00	.00	.10	.08	REL

Figure 27. User selected system performance (long path example). (METHOD = 23)





```

COMMENT
COMMENT   Terminated Sloping Vee Transmitter Antenna
COMMENT   Bearing of Antenna = 0 Degrees East of North,
COMMENT   Ground Conductivity = 0.001 MHOS/M, Dielectric Constant = 4,
COMMENT   Half Apex Angle = 22.5 Degrees, Antenna Leg Length = 121.9 Meters,
COMMENT   Antenna Height = 15.24 Meters, Terminated Height = 1.829 Meters,
COMMENT   Ending Frequency = 30 Mhz , Number of Antennas = 1
ANTENNA   1   7   .001  4.  22.5121.915.241.829   30.   1
EXECUTE
COMMENT
COMMENT   Inverted L Receiver Antenna
COMMENT   Bearing of Antenna = 0 Degrees East of North,
COMMENT   Ground Conductivity = 0.001 MHOS/M, Dielectric Constant = 4,
COMMENT   Antenna Length = 21.34 Meters, Antenna Height = 10 Meters,
COMMENT   Ending Frequency = 30 Mhz , Number of Antennas = 1
ANTENNA   2   8   .001  4.   21.34 10.0   30.   1
EXECUTE
COMMENT
COMMENT   Terminated Sloping Rhombic Transmitter Antenna
COMMENT   Bearing of Antenna = 0 Degrees East of North,
COMMENT   Ground Conductivity = 0.001 MHOS/M, Dielectric Constant = 4,
COMMENT   Half Large Interior Angle = 22.5 Degrees, Leg Length = 88.39 Meters,
COMMENT   Antenna Height = 16.76 Meters, Terminated Height = 8.382 Meters,
COMMENT   Ending Frequency = 30 Mhz (Default) , Number of Antennas = 1 (Default)
ANTENNA   1   9   .001  4.  22.588.3916.768.382
EXECUTE
COMMENT
COMMENT   Interlaced Rhombic Receiver Antenna
COMMENT   Bearing of Antenna = 0 Degrees East of North,
COMMENT   Ground Conductivity = 0.001 MHOS/M, Dielectric Constant = 4,
COMMENT   Half Large Interior Angle = 70 Degrees, Leg Length = 114 Meters,
COMMENT   Lower Antenna Height = 20 Meters, Vertical Displacement = 4 Meters,
COMMENT   Ending Frequency = 30 Mhz (Default) , Number of Antennas = 1 (Default)
ANTENNA   2  11   .001  4.  70.0114.0 20.0  4.0 33.0
EXECUTE
COMMENT
COMMENT   Constant Gain Transmitter Antenna
COMMENT   Gain Above an Isotropic = 10 db,
COMMENT   Ground Conductivity = 0.001 MHOS/M, Dielectric Constant = 4,
COMMENT   Antenna Efficiency = 0 db,
COMMENT   Ending Frequency = 30 Mhz (Default) , Number of Antennas = 1 (Default)
ANTENNA   1  12 10. .001  4.   0.
EXECUTE
COMMENT
COMMENT   Constant Gain Receiver Antenna
COMMENT   Gain Above an Isotropic = 10 db,
COMMENT   Ground Conductivity = 0.001 MHOS/M, Dielectric Constant = 4,
COMMENT   Antenna Efficiency = -1.9 db,
COMMENT   Ending Frequency = 30 Mhz (Default) , Number of Antennas = 1 (Default)
ANTENNA   2  12 10. .001  4.   -1.9
EXECUTE
QUIT

```

Figure 28a. Antenna pattern input commands (continued).

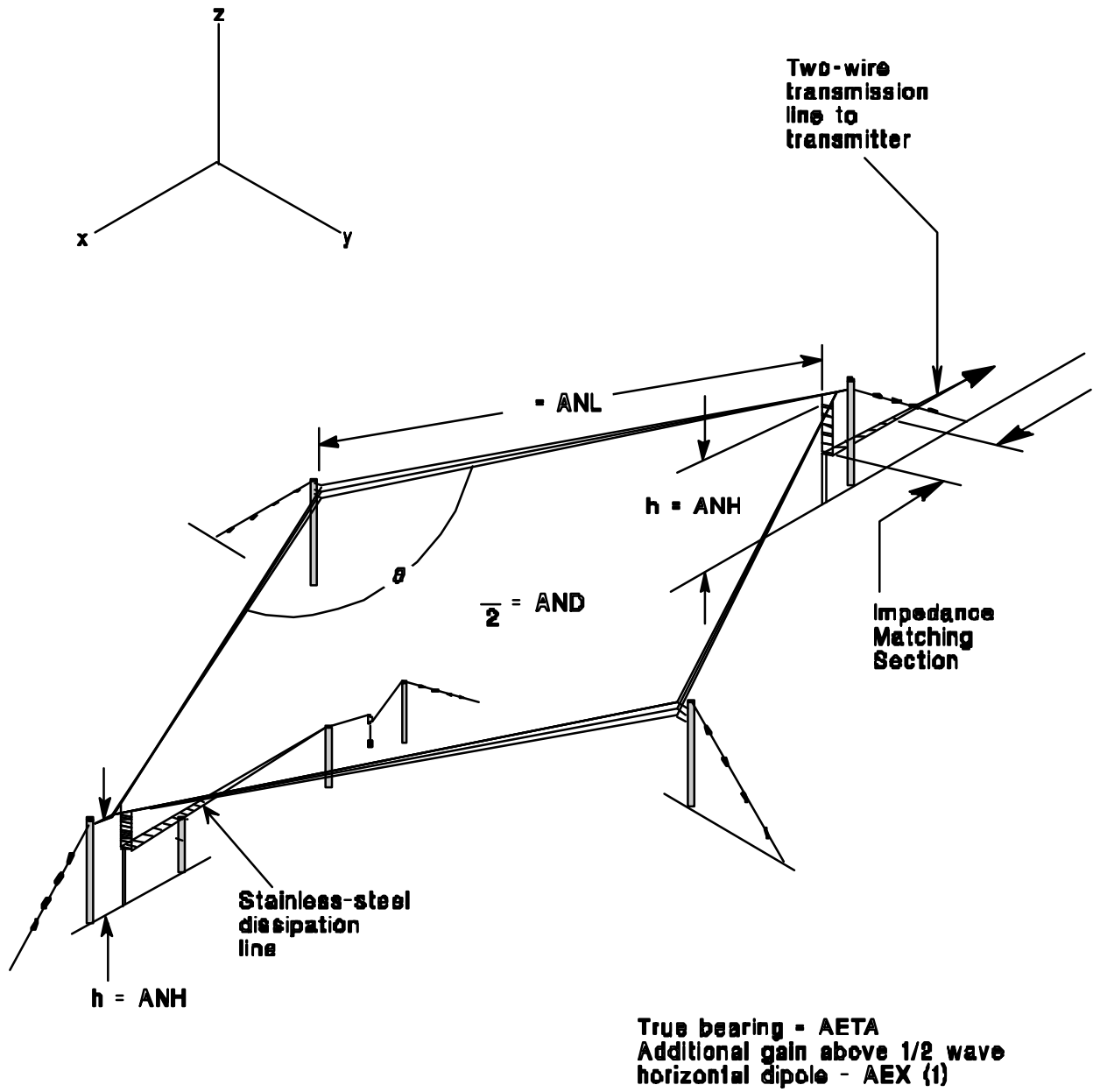


Fig. 29 Horizontal rhombic structure (1).

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ITSA 1 ANTENNA PACKAGE			ANTENNA PATTERN								
FREQUENCY RANGE		ANTENNA TYPE				HEIGHT	LENGTH			ANGLE	
2.0 TO 30.0		TER. RHOMBIC				16.760	88.390			67.500	
	2	3	4	5	6	7	8	9	10	11	
90	-3.7	-11.7	-11.7	-2.4	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	
88	-3.1	-11.7	-11.7	-2.5	-7.7	-11.7	-11.7	-8.8	-11.7	-11.7	
86	-2.7	-11.7	-11.7	-3.0	-5.4	-11.7	-11.7	-8.2	-11.7	-11.7	
84	-2.2	-11.7	-11.7	-4.0	-3.7	-11.7	-11.7	-8.8	-8.0	-11.7	
82	-1.9	-7.8	-11.7	-5.4	-2.7	-11.7	-11.7	-11.7	-5.8	-11.7	
80	-1.5	-5.9	-11.7	-7.4	-2.1	-9.5	-11.7	-11.7	-5.3	-7.6	
78	-1.3	-4.2	-11.7	-11.7	-2.1	-6.4	-11.7	-11.7	-6.3	-4.0	
76	-1.1	-2.8	-11.7	-11.7	-2.7	-4.3	-11.7	-11.7	-9.1	-2.6	
74	-.9	-1.6	-11.7	-11.7	-3.8	-3.0	-11.7	-11.7	-11.7	-3.1	
72	-.8	-.5	-11.7	-11.7	-5.6	-2.3	-8.0	-11.7	-11.7	-5.4	
E 70	-.8	.5	-8.0	-11.7	-8.3	-2.4	-5.4	-11.7	-11.7	-11.7	
L 68	-.8	1.2	-5.1	-11.7	-11.7	-3.1	-3.7	-11.7	-11.7	-11.7	
E 66	-.8	1.9	-2.7	-11.7	-11.7	-4.6	-2.9	-7.3	-11.7	-11.7	
V 64	-.9	2.5	-.7	-11.7	-11.7	-7.0	-2.9	-5.1	-11.7	-11.7	
A 62	-1.1	2.9	.9	-8.9	-11.7	-11.7	-3.7	-3.8	-7.1	-11.7	
T 60	-1.3	3.2	2.3	-4.9	-11.7	-11.7	-5.4	-3.4	-5.0	-8.4	
I 58	-1.6	3.5	3.4	-1.8	-11.7	-11.7	-8.4	-3.9	-3.9	-5.0	
O 56	-1.9	3.6	4.4	.7	-9.9	-11.7	-11.7	-5.4	-3.8	-3.4	
N 54	-2.2	3.7	5.1	2.7	-4.9	-11.7	-11.7	-8.2	-4.5	-3.0	
52	-2.6	3.7	5.7	4.3	-1.1	-11.7	-11.7	-11.7	-6.3	-3.7	
A 50	-3.1	3.6	6.2	5.6	1.8	-7.0	-11.7	-11.7	-9.5	-5.3	
N 48	-3.6	3.4	6.5	6.7	4.1	-2.0	-11.7	-11.7	-11.7	-8.0	
G 46	-4.2	3.1	6.7	7.5	6.0	1.7	-7.0	-11.7	-11.7	-11.7	
L 44	-4.8	2.8	6.7	8.2	7.5	4.5	-1.5	-11.7	-11.7	-11.7	
E 42	-5.5	2.3	6.6	8.6	8.6	6.8	2.6	-4.9	-11.7	-11.7	
40	-6.2	1.8	6.5	8.9	9.5	8.5	5.7	.6	-8.2	-11.7	
I 38	-7.0	1.3	6.2	9.0	10.1	9.9	8.1	4.6	-1.2	-11.7	
N 36	-7.8	.6	5.8	8.9	10.5	10.9	9.9	7.6	3.7	-2.6	
34	-8.7	-.1	5.3	8.7	10.8	11.6	11.3	9.9	7.3	3.1	
D 32	-9.7	-.9	4.7	8.4	10.8	12.1	12.4	11.7	10.0	7.2	
E 30	-11.7	-1.8	4.0	7.9	10.6	12.3	13.1	13.0	12.1	10.3	
G 28	-11.7	-2.8	3.2	7.3	10.3	12.3	13.5	13.9	13.6	12.6	
R 26	-11.7	-3.8	2.3	6.6	9.8	12.1	13.6	14.5	14.7	14.3	
E 24	-11.7	-5.0	1.3	5.8	9.2	11.7	13.5	14.7	15.4	15.5	
E 22	-11.7	-6.2	.2	4.9	8.4	11.1	13.2	14.7	15.7	16.2	
S 20	-11.7	-7.5	-1.0	3.8	7.5	10.4	12.7	14.4	15.7	16.6	
18	-11.7	-8.9	-2.3	2.6	6.4	9.5	11.9	13.9	15.4	16.6	
16	-11.7	-11.7	-3.8	1.3	5.2	8.4	11.0	13.1	14.9	16.3	
14	-11.7	-11.7	-5.3	-.2	3.8	7.1	9.9	12.2	14.0	15.6	
12	-11.7	-11.7	-7.0	-1.9	2.3	5.7	8.5	10.9	12.9	14.7	
10	-11.7	-11.7	-9.0	-3.7	.5	3.9	6.9	9.4	11.5	13.4	
8	-11.7	-11.7	-11.7	-5.9	-1.7	1.9	4.9	7.4	9.7	11.6	
6	-11.7	-11.7	-11.7	-8.6	-4.3	-.7	2.3	5.0	7.3	9.3	
4	-11.7	-11.7	-11.7	-11.7	-7.9	-4.3	-1.2	1.5	3.8	5.9	
2	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-7.2	-4.4	-2.1	.0	
0	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	
	2	3	4	5	6	7	8	9	10	11	
FREQUENCY IN MEGAHERTZ											
ANTENNA EFFICIENCY											
	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	
	2	3	4	5	6	7	8	9	10	11	
FREQUENCY IN MEGAHERTZ											

Figure 30. Horizontal rhombic pattern.

AZIMUTH	EX(1)			EX(2)			EX(3)			EX(4)			CONDUCT.	DIELECT.
.000	.000			.000			.000			.000			.001	4.000
12	13	14	16	18	20	22	24	26	28	30				
-3.0	-11.7	-11.7	-11.7	-11.7	-11.7	-2.5	-11.7	-11.7	-11.7	-11.7	90			
-3.1	-6.1	-11.7	-5.8	-11.7	-8.0	-6.8	-11.7	-8.2	-11.7	-3.1	88			
-5.6	-2.4	-11.7	-5.7	-11.7	-3.9	-11.7	-4.4	-11.7	-11.7	-7.3	86			
-11.7	-1.6	-6.7	-11.7	-11.7	-6.4	-11.7	-3.7	-11.7	-6.1	-11.7	84			
-11.7	-3.4	-2.2	-11.7	-8.8	-11.7	-3.4	-11.7	-9.2	-11.7	-6.1	82			
-11.7	-8.8	-1.1	-11.7	-7.4	-11.7	-1.2	-11.7	-5.9	-11.7	-2.5	80			
-11.7	-11.7	-3.0	-11.7	-11.7	-11.7	-7.3	-5.6	-11.7	-8.7	-11.7	78			
-6.9	-11.7	-9.0	-4.9	-11.7	-3.9	-11.7	-.7	-11.7	-6.8	-11.7	76			
-2.4	-11.7	-11.7	-1.9	-11.7	-4.4	-11.7	-4.9	-7.4	-11.7	-2.9	74			
-.6	-5.0	-11.7	-2.6	-11.7	-11.7	-1.7	-11.7	-2.2	-11.7	-5.3	72			
-.9	-.6	-11.7	-7.8	-6.2	-11.7	-.3	-11.7	-7.5	-7.2	-11.7	70			
-3.4	1.0	-2.2	-11.7	-3.8	-11.7	-6.5	.0	-11.7	-5.2	-11.7	68			
-8.7	.2	1.4	-11.7	-5.9	-7.3	-11.7	1.2	-7.4	-11.7	-4.1	66			
-11.7	-3.1	2.1	-8.0	-11.7	-4.5	-11.7	-6.4	1.4	-11.7	-9.8	64			
-11.7	-11.7	.2	-.2	-11.7	-6.6	-3.4	-11.7	.3	-2.8	-11.7	62			
-11.7	-11.7	-4.9	3.0	-11.7	-11.7	-1.2	-7.4	-11.7	1.1	-9.4	60			
-10.0	-11.7	-11.7	3.0	-2.2	-11.7	-5.2	1.1	-11.7	-5.5	-1.0	58			
-4.6	-11.7	-11.7	-.2	2.6	-11.7	-11.7	1.3	.2	-11.7	-3.7	56			
-2.1	-4.6	-11.7	-8.3	3.5	-2.7	-11.7	-5.8	4.2	-2.6	-11.7	54			
-1.3	-.8	-4.6	-11.7	.8	2.2	-11.7	-11.7	.5	5.0	-5.9	52			
-2.0	.6	.2	-11.7	-7.3	3.0	-1.9	-11.7	-11.7	3.7	4.9	50			
-3.8	.2	2.2	-3.5	-11.7	-.6	1.8	-5.4	-11.7	-7.9	5.2	48			
-6.7	-1.8	2.1	2.5	-11.7	-11.7	1.1	-.7	-5.0	-11.7	-4.9	46			
-11.7	-5.1	.3	5.1	-.2	-11.7	-5.4	.4	-1.1	-3.3	-11.7	44			
-11.7	-10.0	-3.4	5.2	5.4	-5.0	-11.7	-3.4	-.9	1.2	-1.2	42			
-11.7	-11.7	-8.9	3.2	7.6	4.4	-11.7	-11.7	-3.7	-.6	3.8	40			
-11.7	-11.7	-11.7	-1.0	7.2	8.5	3.0	-11.7	-11.7	-4.9	1.1	38			
-11.7	-11.7	-11.7	-7.9	4.4	9.4	8.9	2.0	-11.7	-11.7	-6.2	36			
-3.3	-11.7	-11.7	-11.7	-1.0	7.8	10.8	9.2	1.8	-11.7	-11.7	34			
3.0	-3.2	-11.7	-11.7	-11.7	3.4	9.9	11.9	9.7	2.6	-11.7	32			
7.5	3.4	-2.4	-11.7	-11.7	-4.6	6.2	11.4	12.8	10.7	4.4	30			
10.9	8.2	4.4	-8.3	-11.7	-11.7	-1.1	7.9	12.4	13.7	12.0	28			
13.3	11.6	9.2	1.3	-11.7	-11.7	-11.7	.7	8.9	13.1	14.5	26			
15.1	14.2	12.7	7.6	-1.4	-11.7	-11.7	-11.7	1.3	9.1	13.4	24			
16.3	16.0	15.2	12.1	6.4	-3.1	-11.7	-11.7	-11.7	.8	8.7	22			
17.1	17.2	16.9	15.2	11.7	6.0	-3.4	-11.7	-11.7	-11.7	-1.1	20			
17.4	17.9	18.0	17.4	15.4	11.9	6.3	-2.5	-11.7	-11.7	-11.7	18			
17.3	18.1	18.6	18.8	17.9	15.9	12.5	7.4	-.5	-11.7	-11.7	16			
16.9	17.9	18.7	19.5	19.4	18.5	16.5	13.4	8.9	2.1	-8.8	14			
16.1	17.3	18.3	19.6	20.2	20.0	19.0	17.2	14.5	10.5	4.6	12			
14.9	16.3	17.4	19.1	20.2	20.5	20.3	19.4	17.8	15.3	11.8	10			
13.3	14.8	16.0	18.1	19.4	20.2	20.5	20.2	19.3	17.8	15.6	8			
11.1	12.6	14.0	16.2	17.8	18.9	19.5	19.7	19.3	18.4	16.9	6			
7.7	9.3	10.8	13.1	15.0	16.3	17.1	17.5	17.5	17.0	16.0	4			
1.9	3.5	5.0	7.5	9.4	10.8	11.8	12.3	12.5	12.2	11.5	2			
-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	0			
12	13	14	16	18	20	22	24	26	28	30				
FREQUENCY IN MEGAHERTZ														
ANTENNA EFFICIENCY														
-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7				
12	13	14	16	18	20	22	24	26	28	30				
FREQUENCY IN MEGAHERTZ														

Figure 30a. Horizontal rhombic pattern continued.

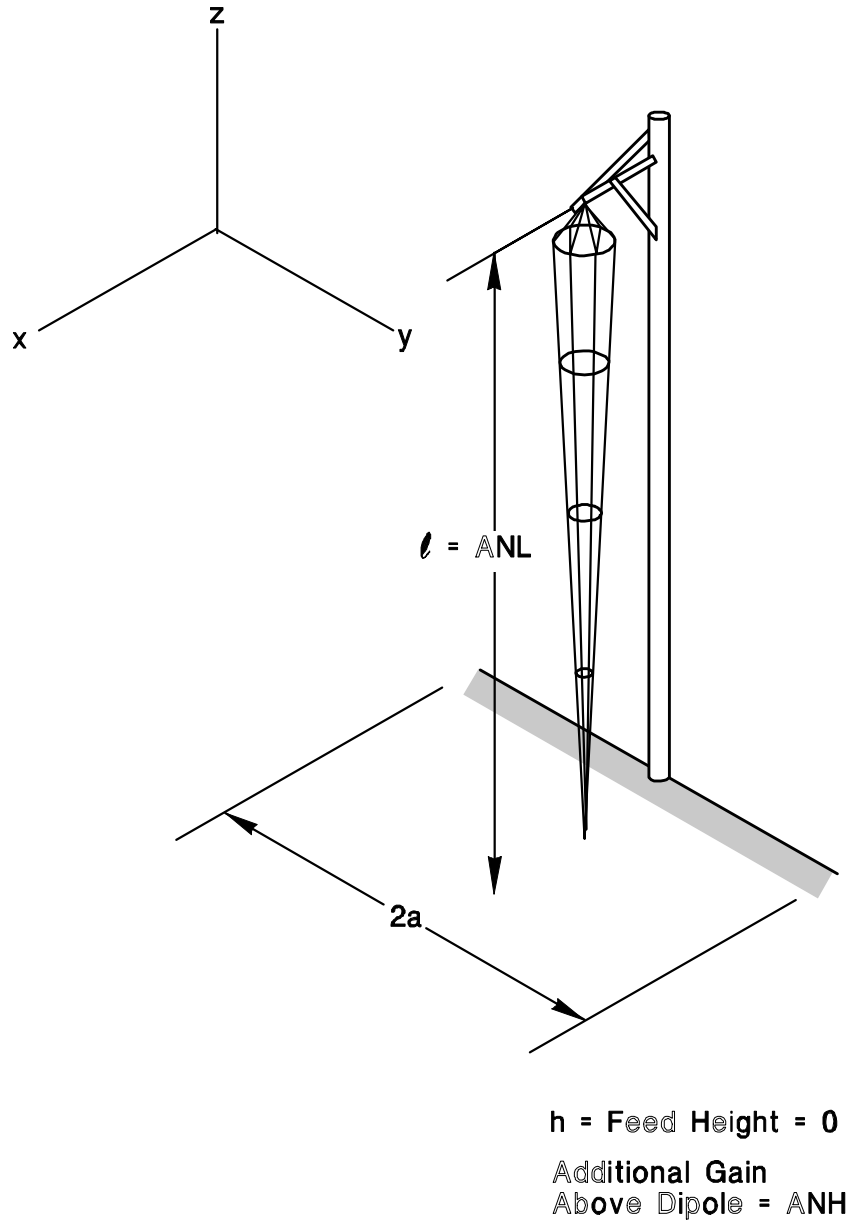


Fig. 31 Vertical monopole structure (2).

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METHOD 13 ICEPAC IC.10 PAGE 3

ITSA 1 ANTENNA PACKAGE			ANTENNA PATTERN							
FREQUENCY RANGE	ANTENNA TYPE				HEIGHT	LENGTH			ANGLE	
2.0 TO 30.0	VER MONOPOLE				.000	-.250			.000	
2	3	4	5	6	7	8	9	10	11	
90	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6
88	-29.7	-30.0	-30.1	-30.2	-30.2	-30.2	-30.2	-30.2	-30.2	-30.1
86	-23.6	-24.0	-24.1	-24.2	-24.2	-24.2	-24.2	-24.2	-24.1	-24.1
84	-20.1	-20.4	-20.6	-20.7	-20.7	-20.7	-20.7	-20.6	-20.6	-20.6
82	-17.6	-18.0	-18.1	-18.2	-18.2	-18.2	-18.2	-18.1	-18.1	-18.1
80	-15.7	-16.0	-16.2	-16.2	-16.2	-16.2	-16.2	-16.2	-16.2	-16.2
78	-14.1	-14.4	-14.6	-14.7	-14.7	-14.7	-14.6	-14.6	-14.6	-14.6
76	-12.8	-13.1	-13.3	-13.3	-13.3	-13.3	-13.3	-13.3	-13.3	-13.3
74	-11.6	-11.9	-12.1	-12.2	-12.2	-12.2	-12.2	-12.1	-12.1	-12.1
72	-10.6	-10.9	-11.1	-11.2	-11.2	-11.2	-11.2	-11.1	-11.1	-11.1
E 70	-9.7	-10.0	-10.2	-10.3	-10.3	-10.3	-10.3	-10.2	-10.2	-10.2
L 68	-8.9	-9.2	-9.4	-9.4	-9.5	-9.5	-9.4	-9.4	-9.4	-9.4
E 66	-8.1	-8.5	-8.6	-8.7	-8.7	-8.7	-8.7	-8.7	-8.7	-8.7
V 64	-7.4	-7.8	-8.0	-8.0	-8.0	-8.0	-8.0	-8.0	-8.0	-8.0
A 62	-6.8	-7.2	-7.3	-7.4	-7.4	-7.4	-7.4	-7.4	-7.4	-7.4
T 60	-6.2	-6.6	-6.8	-6.8	-6.9	-6.9	-6.9	-6.8	-6.8	-6.8
I 58	-5.7	-6.1	-6.3	-6.3	-6.3	-6.3	-6.3	-6.3	-6.3	-6.3
O 56	-5.2	-5.6	-5.8	-5.8	-5.9	-5.9	-5.9	-5.8	-5.8	-5.8
N 54	-4.8	-5.2	-5.3	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4
52	-4.4	-4.7	-4.9	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0
A 50	-4.0	-4.4	-4.5	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6
N 48	-3.6	-4.0	-4.2	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3
G 46	-3.3	-3.7	-3.9	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0
L 44	-3.0	-3.4	-3.6	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7
E 42	-2.7	-3.2	-3.4	-3.4	-3.5	-3.5	-3.5	-3.5	-3.5	-3.4
40	-2.5	-2.9	-3.1	-3.2	-3.3	-3.3	-3.3	-3.3	-3.2	-3.2
I 38	-2.3	-2.8	-3.0	-3.0	-3.1	-3.1	-3.1	-3.1	-3.1	-3.1
N 36	-2.1	-2.6	-2.8	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9
34	-2.0	-2.5	-2.7	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8
D 32	-1.9	-2.4	-2.6	-2.7	-2.7	-2.8	-2.8	-2.8	-2.7	-2.7
E 30	-1.8	-2.3	-2.6	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7
G 28	-1.8	-2.3	-2.6	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7
R 26	-1.8	-2.4	-2.6	-2.7	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8
E 24	-1.9	-2.5	-2.7	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9
E 22	-2.0	-2.6	-2.9	-3.0	-3.1	-3.1	-3.1	-3.1	-3.1	-3.1
S 20	-2.2	-2.9	-3.1	-3.3	-3.3	-3.3	-3.4	-3.3	-3.3	-3.3
18	-2.5	-3.2	-3.5	-3.6	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7
16	-2.9	-3.6	-3.9	-4.0	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1
14	-3.4	-4.1	-4.5	-4.6	-4.7	-4.7	-4.7	-4.7	-4.7	-4.7
12	-4.1	-4.8	-5.2	-5.3	-5.4	-5.5	-5.5	-5.5	-5.5	-5.5
10	-5.0	-5.8	-6.1	-6.3	-6.4	-6.4	-6.4	-6.5	-6.4	-6.4
8	-6.2	-7.1	-7.5	-7.6	-7.7	-7.8	-7.8	-7.8	-7.8	-7.8
6	-8.0	-8.9	-9.3	-9.5	-9.6	-9.6	-9.7	-9.7	-9.7	-9.7
4	-10.7	-11.7	-12.2	-12.4	-12.5	-12.5	-12.5	-12.5	-12.5	-12.5
2	-16.0	-17.0	-17.5	-17.7	-17.8	-17.9	-17.9	-17.9	-17.9	-17.9
0	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6
	2	3	4	5	6	7	8	9	10	11
	FREQUENCY IN MEGAHERTZ									
	ANTENNA EFFICIENCY									
	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6
	2	3	4	5	6	7	8	9	10	11
	FREQUENCY IN MEGAHERTZ									

Figure 32. Vertical monopole pattern.

METHOD 13 ICEPAC IC.10 PAGE 4

AZIMUTH		EX(1)		EX(2)		EX(3)		EX(4)		CONDUCT.		DIELECT.	
.000		.000		.000		.000		.000		.001		4.000	
12	13	14	16	18	20	22	24	26	28	30			
-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	90
-30.1	-30.1	-30.1	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-29.9	-29.9	-29.9	88
-24.1	-24.1	-24.1	-24.0	-24.0	-24.0	-24.0	-23.9	-23.9	-23.9	-23.9	-23.9	-23.9	86
-20.6	-20.6	-20.5	-20.5	-20.5	-20.5	-20.4	-20.4	-20.4	-20.4	-20.4	-20.4	-20.4	84
-18.1	-18.1	-18.0	-18.0	-18.0	-18.0	-17.9	-17.9	-17.9	-17.9	-17.9	-17.9	-17.9	82
-16.1	-16.1	-16.1	-16.1	-16.1	-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	80
-14.6	-14.6	-14.5	-14.5	-14.5	-14.5	-14.4	-14.4	-14.4	-14.4	-14.4	-14.4	-14.4	78
-13.2	-13.2	-13.2	-13.2	-13.2	-13.1	-13.1	-13.1	-13.1	-13.1	-13.1	-13.1	-13.1	76
-12.1	-12.1	-12.1	-12.0	-12.0	-12.0	-12.0	-11.9	-11.9	-11.9	-11.9	-11.9	-11.9	74
-11.1	-11.1	-11.0	-11.0	-11.0	-11.0	-11.0	-10.9	-10.9	-10.9	-10.9	-10.9	-10.9	72
-10.2	-10.2	-10.1	-10.1	-10.1	-10.1	-10.1	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	70
-9.4	-9.4	-9.3	-9.3	-9.3	-9.3	-9.2	-9.2	-9.2	-9.2	-9.2	-9.2	-9.2	68
-8.6	-8.6	-8.6	-8.6	-8.6	-8.5	-8.5	-8.5	-8.5	-8.5	-8.5	-8.5	-8.5	66
-8.0	-7.9	-7.9	-7.9	-7.9	-7.9	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	64
-7.4	-7.3	-7.3	-7.3	-7.3	-7.3	-7.2	-7.2	-7.2	-7.2	-7.2	-7.2	-7.2	62
-6.8	-6.8	-6.8	-6.7	-6.7	-6.7	-6.7	-6.7	-6.7	-6.6	-6.6	-6.6	-6.6	60
-6.3	-6.3	-6.2	-6.2	-6.2	-6.2	-6.2	-6.2	-6.1	-6.1	-6.1	-6.1	-6.1	58
-5.8	-5.8	-5.8	-5.7	-5.7	-5.7	-5.7	-5.7	-5.7	-5.7	-5.6	-5.6	-5.6	56
-5.4	-5.3	-5.3	-5.3	-5.3	-5.3	-5.2	-5.2	-5.2	-5.2	-5.2	-5.2	-5.2	54
-5.0	-4.9	-4.9	-4.9	-4.9	-4.9	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	52
-4.6	-4.6	-4.6	-4.5	-4.5	-4.5	-4.5	-4.5	-4.5	-4.4	-4.4	-4.4	-4.4	50
-4.2	-4.2	-4.2	-4.2	-4.2	-4.2	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	48
-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.8	-3.8	-3.8	-3.8	-3.8	-3.8	-3.8	46
-3.7	-3.7	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	-3.5	-3.5	-3.5	44
-3.4	-3.4	-3.4	-3.4	-3.4	-3.3	-3.3	-3.3	-3.3	-3.3	-3.3	-3.3	-3.3	42
-3.2	-3.2	-3.2	-3.2	-3.2	-3.1	-3.1	-3.1	-3.1	-3.1	-3.1	-3.1	-3.1	40
-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9	38
-2.9	-2.9	-2.9	-2.9	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	36
-2.8	-2.8	-2.8	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	34
-2.7	-2.7	-2.7	-2.7	-2.7	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	32
-2.7	-2.7	-2.7	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	30
-2.7	-2.7	-2.7	-2.7	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	28
-2.8	-2.8	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	26
-2.9	-2.9	-2.9	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	24
-3.1	-3.1	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	22
-3.3	-3.3	-3.3	-3.3	-3.3	-3.3	-3.2	-3.2	-3.2	-3.2	-3.2	-3.2	-3.2	20
-3.7	-3.7	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	18
-4.1	-4.1	-4.1	-4.1	-4.1	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	16
-4.7	-4.7	-4.7	-4.7	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6	14
-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	12
-6.4	-6.4	-6.4	-6.4	-6.4	-6.4	-6.4	-6.4	-6.4	-6.3	-6.3	-6.3	-6.3	10
-7.8	-7.8	-7.7	-7.7	-7.7	-7.7	-7.7	-7.7	-7.7	-7.7	-7.7	-7.7	-7.7	8
-9.6	-9.6	-9.6	-9.6	-9.6	-9.6	-9.6	-9.6	-9.6	-9.6	-9.6	-9.6	-9.6	6
-12.5	-12.5	-12.5	-12.5	-12.5	-12.5	-12.5	-12.5	-12.5	-12.5	-12.4	-12.4	-12.4	4
-17.9	-17.9	-17.9	-17.9	-17.9	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	2
-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	0
12	13	14	16	18	20	22	24	26	28	30			
FREQUENCY IN MEGAHERTZ													
ANTENNA EFFICIENCY													
.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6
12	13	14	16	18	20	22	24	26	28	30			
FREQUENCY IN MEGAHERTZ													

Figure 32a. Vertical monopole pattern continued.

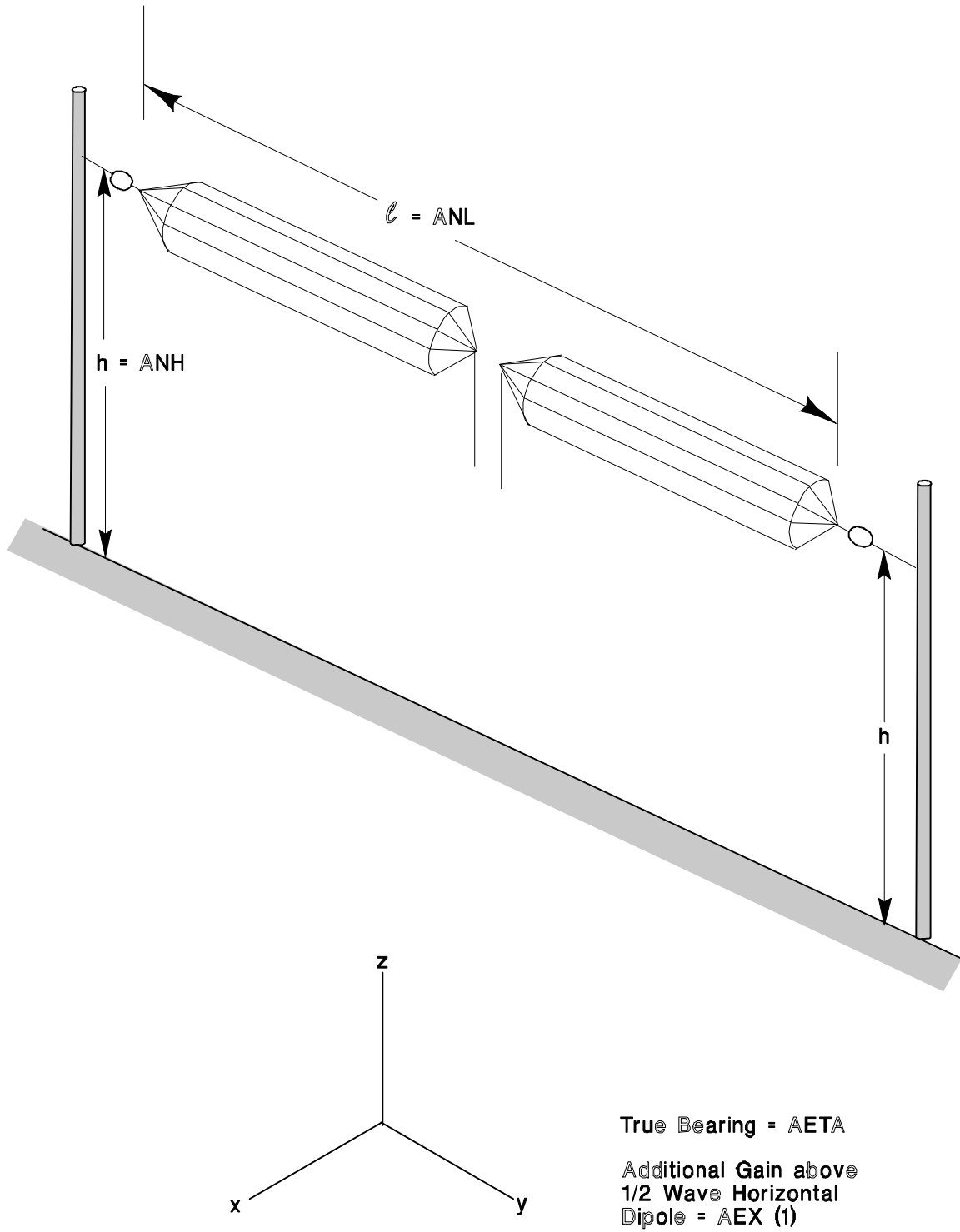


Fig. 33 Horizontal dipole structure (3).

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METHOD 13 ICEPAC IC.10 PAGE 5

ITSA 1	ANTENNA PACKAGE					ANTENNA PATTERN					
	FREQUENCY RANGE		ANTENNA TYPE			HEIGHT	LENGTH			ANGLE	
	2.0 TO	30.0	HORZ. DIPOLE			-.250	-.500			.000	
	2	3	4	5	6	7	8	9	10	11	
90	6.1	5.7	5.4	5.3	5.1	5.1	5.0	4.9	4.9	4.9	
88	6.1	5.7	5.4	5.3	5.1	5.1	5.0	4.9	4.9	4.9	
86	6.1	5.7	5.5	5.3	5.1	5.1	5.0	4.9	4.9	4.9	
84	6.1	5.7	5.5	5.3	5.2	5.1	5.0	5.0	4.9	4.9	
82	6.2	5.8	5.5	5.3	5.2	5.1	5.0	5.0	4.9	4.9	
80	6.2	5.8	5.5	5.3	5.2	5.1	5.0	5.0	5.0	4.9	
78	6.2	5.8	5.5	5.4	5.2	5.1	5.1	5.0	5.0	5.0	
76	6.2	5.8	5.6	5.4	5.3	5.2	5.1	5.0	5.0	5.0	
74	6.3	5.9	5.6	5.4	5.3	5.2	5.1	5.1	5.0	5.0	
72	6.3	5.9	5.6	5.5	5.3	5.2	5.2	5.1	5.1	5.0	
E 70	6.3	5.9	5.7	5.5	5.4	5.3	5.2	5.1	5.1	5.1	
L 68	6.4	6.0	5.7	5.5	5.4	5.3	5.2	5.2	5.1	5.1	
E 66	6.4	6.0	5.8	5.6	5.4	5.3	5.3	5.2	5.2	5.1	
V 64	6.4	6.1	5.8	5.6	5.5	5.4	5.3	5.2	5.2	5.1	
A 62	6.5	6.1	5.8	5.6	5.5	5.4	5.3	5.3	5.2	5.2	
T 60	6.5	6.1	5.9	5.7	5.5	5.4	5.3	5.3	5.2	5.2	
I 58	6.5	6.1	5.9	5.7	5.6	5.5	5.4	5.3	5.3	5.2	
O 56	6.5	6.2	5.9	5.7	5.6	5.5	5.4	5.3	5.3	5.2	
N 54	6.5	6.2	5.9	5.7	5.6	5.5	5.4	5.3	5.3	5.2	
52	6.5	6.2	5.9	5.7	5.6	5.5	5.4	5.3	5.3	5.2	
A 50	6.5	6.1	5.9	5.7	5.6	5.5	5.4	5.3	5.3	5.2	
N 48	6.4	6.1	5.9	5.7	5.6	5.4	5.4	5.3	5.2	5.2	
G 46	6.4	6.1	5.8	5.7	5.5	5.4	5.3	5.3	5.2	5.1	
L 44	6.3	6.0	5.8	5.6	5.5	5.4	5.3	5.2	5.1	5.1	
E 42	6.2	5.9	5.7	5.5	5.4	5.3	5.2	5.1	5.1	5.0	
40	6.1	5.8	5.6	5.4	5.3	5.2	5.1	5.0	5.0	4.9	
I 38	5.9	5.7	5.5	5.3	5.2	5.1	5.0	4.9	4.8	4.8	
N 36	5.7	5.5	5.3	5.2	5.0	4.9	4.8	4.8	4.7	4.7	
34	5.5	5.3	5.1	5.0	4.9	4.7	4.7	4.6	4.5	4.5	
D 32	5.3	5.1	4.9	4.8	4.6	4.5	4.4	4.4	4.3	4.3	
E 30	5.0	4.8	4.6	4.5	4.4	4.3	4.2	4.1	4.1	4.0	
G 28	4.6	4.5	4.3	4.2	4.1	4.0	3.9	3.8	3.8	3.7	
R 26	4.2	4.1	4.0	3.8	3.7	3.6	3.6	3.5	3.4	3.4	
E 24	3.8	3.7	3.5	3.4	3.3	3.2	3.1	3.1	3.0	3.0	
E 22	3.2	3.1	3.0	2.9	2.8	2.7	2.7	2.6	2.5	2.5	
S 20	2.6	2.6	2.5	2.4	2.3	2.2	2.1	2.1	2.0	1.9	
18	1.9	1.9	1.8	1.7	1.6	1.5	1.5	1.4	1.3	1.3	
16	1.1	1.1	1.0	.9	.8	.8	.7	.6	.6	.5	
14	.1	.1	.0	.0	-.1	-.2	-.2	-.3	-.3	-.4	
12	-1.0	-1.1	-1.1	-1.2	-1.2	-1.3	-1.3	-1.4	-1.4	-1.5	
10	-2.5	-2.5	-2.5	-2.5	-2.6	-2.6	-2.7	-2.8	-2.8	-2.8	
8	-4.3	-4.2	-4.2	-4.3	-4.3	-4.4	-4.4	-4.5	-4.5	-4.6	
6	-6.6	-6.6	-6.6	-6.6	-6.6	-6.7	-6.7	-6.8	-6.8	-6.9	
4	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	
2	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	
0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	

Figure 34. Horizontal dipole pattern.

AZIMUTH		EX(1)		EX(2)		EX(3)		EX(4)		CONDUCT.		DIELECT.	
.000		.000		.000		.000		.000		.001		4.000	
12	13	14	16	18	20	22	24	26	28	30			
4.9	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	90		
4.9	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	88		
4.9	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	86		
4.9	4.9	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	84		
4.9	4.9	4.9	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	82		
4.9	4.9	4.9	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	80		
4.9	4.9	4.9	4.9	4.9	4.8	4.8	4.8	4.8	4.8	4.8	78		
5.0	4.9	4.9	4.9	4.9	4.9	4.8	4.8	4.8	4.8	4.8	76		
5.0	5.0	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.8	4.8	74		
5.0	5.0	5.0	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	72		
5.0	5.0	5.0	5.0	4.9	4.9	4.9	4.9	4.9	4.9	4.9	70		
5.1	5.0	5.0	5.0	5.0	5.0	4.9	4.9	4.9	4.9	4.9	68		
5.1	5.1	5.0	5.0	5.0	5.0	5.0	5.0	4.9	4.9	4.9	66		
5.1	5.1	5.1	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	64		
5.1	5.1	5.1	5.1	5.0	5.0	5.0	5.0	5.0	5.0	5.0	62		
5.2	5.1	5.1	5.1	5.1	5.0	5.0	5.0	5.0	5.0	5.0	60		
5.2	5.2	5.1	5.1	5.1	5.0	5.0	5.0	5.0	5.0	5.0	58		
5.2	5.2	5.1	5.1	5.1	5.0	5.0	5.0	5.0	5.0	5.0	56		
5.2	5.2	5.1	5.1	5.1	5.0	5.0	5.0	5.0	5.0	5.0	54		
5.2	5.2	5.1	5.1	5.1	5.0	5.0	5.0	5.0	5.0	5.0	52		
5.2	5.1	5.1	5.1	5.0	5.0	5.0	5.0	5.0	4.9	4.9	50		
5.1	5.1	5.1	5.0	5.0	5.0	5.0	4.9	4.9	4.9	4.9	48		
5.1	5.1	5.0	5.0	5.0	4.9	4.9	4.9	4.9	4.9	4.8	46		
5.0	5.0	5.0	4.9	4.9	4.9	4.8	4.8	4.8	4.8	4.8	44		
5.0	4.9	4.9	4.9	4.8	4.8	4.8	4.7	4.7	4.7	4.7	42		
4.9	4.8	4.8	4.8	4.7	4.7	4.7	4.6	4.6	4.6	4.6	40		
4.8	4.7	4.7	4.6	4.6	4.6	4.5	4.5	4.5	4.5	4.5	38		
4.6	4.6	4.5	4.5	4.4	4.4	4.4	4.4	4.3	4.3	4.3	36		
4.4	4.4	4.4	4.3	4.3	4.2	4.2	4.2	4.2	4.2	4.1	34		
4.2	4.2	4.1	4.1	4.0	4.0	4.0	4.0	3.9	3.9	3.9	32		
4.0	3.9	3.9	3.8	3.8	3.8	3.7	3.7	3.7	3.7	3.7	30		
3.7	3.6	3.6	3.5	3.5	3.5	3.4	3.4	3.4	3.4	3.4	28		
3.3	3.3	3.3	3.2	3.2	3.1	3.1	3.1	3.0	3.0	3.0	26		
2.9	2.9	2.9	2.8	2.8	2.7	2.7	2.7	2.6	2.6	2.6	24		
2.5	2.4	2.4	2.3	2.3	2.2	2.2	2.2	2.2	2.1	2.1	22		
1.9	1.9	1.8	1.8	1.7	1.7	1.7	1.6	1.6	1.6	1.6	20		
1.3	1.2	1.2	1.1	1.1	1.0	1.0	1.0	1.0	.9	.9	18		
.5	.5	.4	.4	.3	.3	.3	.2	.2	.2	.2	16		
-.4	-.5	-.5	-.5	-.6	-.6	-.7	-.7	-.7	-.7	-.7	14		
-1.5	-1.6	-1.6	-1.6	-1.7	-1.7	-1.7	-1.8	-1.8	-1.8	-1.8	12		
-2.9	-2.9	-2.9	-3.0	-3.0	-3.1	-3.1	-3.1	-3.1	-3.2	-3.2	10		
-4.6	-4.6	-4.7	-4.7	-4.8	-4.8	-4.8	-4.8	-4.9	-4.9	-4.9	8		
-6.9	-6.9	-6.9	-7.0	-7.0	-7.1	-7.1	-7.1	-7.2	-7.2	-7.2	6		
-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	4		
-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	2		
-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	0		
12	13	14	16	18	20	22	24	26	28	30			

FREQUENCY IN MEGAHERTZ

ANTENNA EFFICIENCY											
.0		.0		.0		.0		.0		.0	
12	13	14	16	18	20	22	24	26	28	30	

FREQUENCY IN MEGAHERTZ

Figure 34a. Horizontal dipole pattern continued.

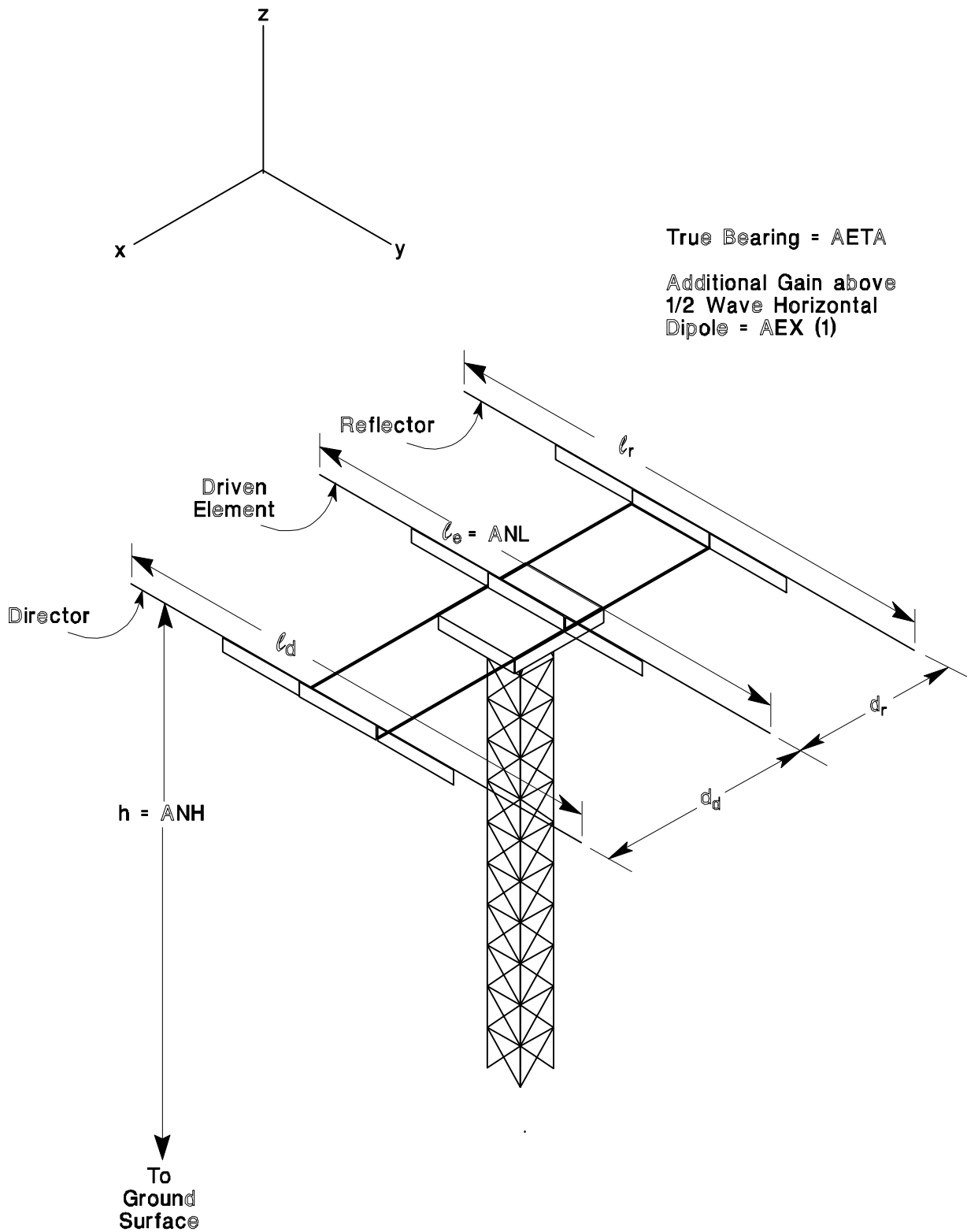


Fig. 35 Horizontal Yagi structure (4).

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ITSA 1 ANTENNA PACKAGE			ANTENNA PATTERN								
FREQUENCY RANGE		ANTENNA TYPE				HEIGHT	LENGTH			ANGLE	
2.0 TO	30.0	HORZ. YAGI				-.258	-.500			.000	
	2	3	4	5	6	7	8	9	10	11	
	90	6.0	5.6	5.4	5.2	5.1	5.0	4.9	4.9	4.9	4.8
	88	6.0	5.6	5.4	5.2	5.1	5.0	4.9	4.9	4.9	4.8
	86	6.0	5.6	5.4	5.2	5.1	5.0	4.9	4.9	4.9	4.8
	84	6.1	5.7	5.4	5.2	5.1	5.0	5.0	4.9	4.9	4.9
	82	6.1	5.7	5.4	5.2	5.1	5.0	5.0	4.9	4.9	4.9
	80	6.1	5.7	5.4	5.3	5.1	5.1	5.0	4.9	4.9	4.9
	78	6.1	5.7	5.5	5.3	5.2	5.1	5.0	5.0	4.9	4.9
	76	6.2	5.8	5.5	5.3	5.2	5.1	5.1	5.0	5.0	4.9
	74	6.2	5.8	5.5	5.4	5.2	5.2	5.1	5.0	5.0	5.0
	72	6.3	5.9	5.6	5.4	5.3	5.2	5.1	5.1	5.0	5.0
E	70	6.3	5.9	5.6	5.5	5.3	5.2	5.2	5.1	5.1	5.0
L	68	6.3	6.0	5.7	5.5	5.4	5.3	5.2	5.2	5.1	5.1
E	66	6.4	6.0	5.7	5.5	5.4	5.3	5.3	5.2	5.2	5.1
V	64	6.4	6.0	5.8	5.6	5.5	5.4	5.3	5.2	5.2	5.2
A	62	6.5	6.1	5.8	5.6	5.5	5.4	5.3	5.3	5.2	5.2
T	60	6.5	6.1	5.9	5.7	5.5	5.4	5.4	5.3	5.3	5.2
I	58	6.5	6.2	5.9	5.7	5.6	5.5	5.4	5.3	5.3	5.2
O	56	6.5	6.2	5.9	5.7	5.6	5.5	5.4	5.4	5.3	5.3
N	54	6.5	6.2	6.0	5.8	5.6	5.5	5.4	5.4	5.3	5.3
	52	6.5	6.2	6.0	5.8	5.6	5.5	5.5	5.4	5.3	5.3
A	50	6.5	6.2	6.0	5.8	5.6	5.5	5.5	5.4	5.3	5.3
N	48	6.5	6.2	6.0	5.8	5.6	5.5	5.4	5.4	5.3	5.3
G	46	6.4	6.2	5.9	5.7	5.6	5.5	5.4	5.3	5.3	5.2
L	44	6.4	6.1	5.9	5.7	5.6	5.5	5.4	5.3	5.2	5.2
E	42	6.3	6.0	5.8	5.6	5.5	5.4	5.3	5.2	5.2	5.1
	40	6.2	5.9	5.7	5.5	5.4	5.3	5.2	5.1	5.1	5.0
I	38	6.0	5.8	5.6	5.4	5.3	5.2	5.1	5.0	5.0	4.9
N	36	5.9	5.6	5.5	5.3	5.2	5.1	5.0	4.9	4.8	4.8
	34	5.7	5.5	5.3	5.1	5.0	4.9	4.8	4.7	4.7	4.6
D	32	5.4	5.2	5.1	4.9	4.8	4.7	4.6	4.5	4.5	4.4
E	30	5.1	5.0	4.8	4.7	4.5	4.4	4.4	4.3	4.2	4.2
G	28	4.8	4.6	4.5	4.4	4.3	4.2	4.1	4.0	3.9	3.9
R	26	4.4	4.3	4.1	4.0	3.9	3.8	3.7	3.7	3.6	3.6
E	24	4.0	3.8	3.7	3.6	3.5	3.4	3.3	3.3	3.2	3.2
E	22	3.5	3.3	3.2	3.1	3.0	2.9	2.9	2.8	2.7	2.7
S	20	2.8	2.8	2.7	2.6	2.5	2.4	2.3	2.3	2.2	2.1
	18	2.1	2.1	2.0	1.9	1.8	1.7	1.7	1.6	1.6	1.5
	16	1.3	1.3	1.2	1.1	1.0	1.0	.9	.8	.8	.7
	14	.3	.3	.3	.2	.1	.0	.0	-.1	-.1	-.2
	12	-.8	-.8	-.9	-.9	-1.0	-1.1	-1.1	-1.2	-1.2	-1.3
	10	-2.2	-2.2	-2.3	-2.3	-2.4	-2.4	-2.5	-2.5	-2.6	-2.6
	8	-4.0	-4.0	-4.0	-4.1	-4.1	-4.2	-4.2	-4.3	-4.3	-4.3
	6	-6.4	-6.4	-6.4	-6.4	-6.4	-6.5	-6.5	-6.6	-6.6	-6.6
	4	-9.8	-9.7	-9.7	-9.7	-9.8	-9.8	-9.8	-9.9	-9.9	-10.0
	2	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0
	0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0
	2	3	4	5	6	7	8	9	10	11	

FREQUENCY IN MEGAHERTZ

ANTENNA EFFICIENCY										
	2	3	4	5	6	7	8	9	10	11
	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	2	3	4	5	6	7	8	9	10	11

FREQUENCY IN MEGAHERTZ

Figure 36. Horizontal Yagi Pattern

AZIMUTH		EX(1)		EX(2)		EX(3)		EX(4)		CONDUCT.		DIELECT.	
.000		.000		.000		.000		.000		.001		4.000	
12	13	14	16	18	20	22	24	26	28	30			
4.8	4.8	4.8	4.8	4.8	4.7	4.7	4.7	4.7	4.7	4.7	90		
4.8	4.8	4.8	4.8	4.8	4.7	4.7	4.7	4.7	4.7	4.7	88		
4.8	4.8	4.8	4.8	4.8	4.8	4.7	4.7	4.7	4.7	4.7	86		
4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.7	84		
4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	82		
4.9	4.9	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	80		
4.9	4.9	4.9	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	78		
4.9	4.9	4.9	4.9	4.9	4.8	4.8	4.8	4.8	4.8	4.8	76		
5.0	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.8	4.8	4.8	74		
5.0	5.0	5.0	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	72		
5.0	5.0	5.0	5.0	4.9	4.9	4.9	4.9	4.9	4.9	4.9	70		
5.1	5.0	5.0	5.0	5.0	5.0	4.9	4.9	4.9	4.9	4.9	68		
5.1	5.1	5.1	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	66		
5.1	5.1	5.1	5.1	5.0	5.0	5.0	5.0	5.0	5.0	5.0	64		
5.2	5.1	5.1	5.1	5.1	5.0	5.0	5.0	5.0	5.0	5.0	62		
5.2	5.2	5.1	5.1	5.1	5.1	5.1	5.0	5.0	5.0	5.0	60		
5.2	5.2	5.2	5.1	5.1	5.1	5.1	5.1	5.0	5.0	5.0	58		
5.2	5.2	5.2	5.2	5.1	5.1	5.1	5.1	5.1	5.1	5.1	56		
5.3	5.2	5.2	5.2	5.1	5.1	5.1	5.1	5.1	5.1	5.1	54		
5.3	5.2	5.2	5.2	5.1	5.1	5.1	5.1	5.1	5.1	5.0	52		
5.3	5.2	5.2	5.2	5.1	5.1	5.1	5.1	5.1	5.0	5.0	50		
5.2	5.2	5.2	5.1	5.1	5.1	5.0	5.0	5.0	5.0	5.0	48		
5.2	5.2	5.1	5.1	5.1	5.0	5.0	5.0	5.0	5.0	5.0	46		
5.2	5.1	5.1	5.0	5.0	5.0	5.0	4.9	4.9	4.9	4.9	44		
5.1	5.1	5.0	5.0	4.9	4.9	4.9	4.9	4.8	4.8	4.8	42		
5.0	5.0	4.9	4.9	4.8	4.8	4.8	4.8	4.8	4.7	4.7	40		
4.9	4.9	4.8	4.8	4.7	4.7	4.7	4.7	4.6	4.6	4.6	38		
4.8	4.7	4.7	4.6	4.6	4.6	4.5	4.5	4.5	4.5	4.5	36		
4.6	4.5	4.5	4.5	4.4	4.4	4.4	4.4	4.3	4.3	4.3	34		
4.4	4.3	4.3	4.3	4.2	4.2	4.2	4.1	4.1	4.1	4.1	32		
4.1	4.1	4.1	4.0	4.0	3.9	3.9	3.9	3.9	3.8	3.8	30		
3.9	3.8	3.8	3.7	3.7	3.6	3.6	3.6	3.6	3.6	3.6	28		
3.5	3.5	3.4	3.4	3.3	3.3	3.3	3.3	3.2	3.2	3.2	26		
3.1	3.1	3.0	3.0	2.9	2.9	2.9	2.9	2.8	2.8	2.8	24		
2.7	2.6	2.6	2.5	2.5	2.4	2.4	2.4	2.4	2.3	2.3	22		
2.1	2.1	2.0	2.0	1.9	1.9	1.9	1.8	1.8	1.8	1.8	20		
1.5	1.4	1.4	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.1	18		
.7	.7	.6	.6	.5	.5	.5	.4	.4	.4	.4	16		
-.2	-.2	-.3	-.3	-.4	-.4	-.4	-.5	-.5	-.5	-.5	14		
-1.3	-1.3	-1.4	-1.4	-1.5	-1.5	-1.5	-1.6	-1.6	-1.6	-1.6	12		
-2.7	-2.7	-2.7	-2.8	-2.8	-2.8	-2.9	-2.9	-2.9	-2.9	-3.0	10		
-4.4	-4.4	-4.4	-4.5	-4.5	-4.6	-4.6	-4.6	-4.6	-4.7	-4.7	8		
-6.7	-6.7	-6.7	-6.8	-6.8	-6.8	-6.9	-6.9	-6.9	-6.9	-7.0	6		
-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	4		
-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	2		
-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	0		
12	13	14	16	18	20	22	24	26	28	30			

FREQUENCY IN MEGAHERTZ

ANTENNA EFFICIENCY													
.0		.0		.0		.0		.0		.0		.0	
12	13	14	16	18	20	22	24	26	28	30			

FREQUENCY IN MEGAHERTZ

Figure 36a. Horizontal Yagi Pattern continued.

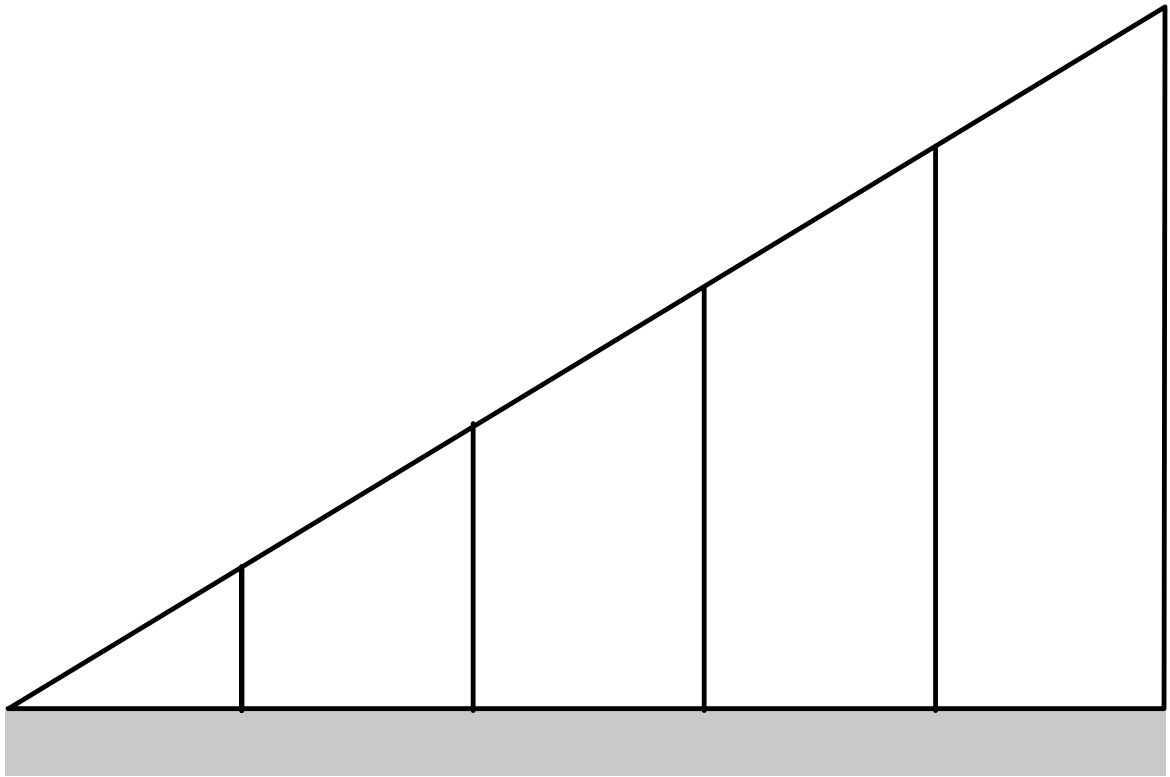


Fig. 37 Vertical log periodic structure (5).

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ITSA 1 ANTENNA PACKAGE			ANTENNA PATTERN							
FREQUENCY RANGE	ANTENNA TYPE				HEIGHT	LENGTH			ANGLE	
2.0 TO 30.0	V LOG PERIOD				.000	-.250			.000	
2	3	4	5	6	7	8	9	10	11	
90	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6
88	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6
86	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6
84	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6
82	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6
80	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6
78	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6
76	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6
74	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6
72	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6
E 70	-9.7	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6
L 68	-8.9	-9.2	-9.4	-9.4	-9.5	-9.5	-9.4	-9.4	-9.4	-9.4
E 66	-8.1	-8.5	-8.6	-8.7	-8.7	-8.7	-8.7	-8.7	-8.7	-8.7
V 64	-7.4	-7.8	-8.0	-8.0	-8.0	-8.0	-8.0	-8.0	-8.0	-8.0
A 62	-6.8	-7.2	-7.3	-7.4	-7.4	-7.4	-7.4	-7.4	-7.4	-7.4
T 60	-6.2	-6.6	-6.8	-6.8	-6.9	-6.9	-6.9	-6.8	-6.8	-6.8
I 58	-5.7	-6.1	-6.3	-6.3	-6.3	-6.3	-6.3	-6.3	-6.3	-6.3
O 56	-5.2	-5.6	-5.8	-5.8	-5.9	-5.9	-5.9	-5.8	-5.8	-5.8
N 54	-4.8	-5.2	-5.3	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4
52	-4.4	-4.7	-4.9	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0
A 50	-4.0	-4.4	-4.5	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6
N 48	-3.6	-4.0	-4.2	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3
G 46	-3.3	-3.7	-3.9	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0
L 44	-3.0	-3.4	-3.6	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7
E 42	-2.7	-3.2	-3.4	-3.4	-3.5	-3.5	-3.5	-3.5	-3.5	-3.4
40	-2.5	-2.9	-3.1	-3.2	-3.3	-3.3	-3.3	-3.3	-3.2	-3.2
I 38	-2.3	-2.8	-3.0	-3.0	-3.1	-3.1	-3.1	-3.1	-3.1	-3.1
N 36	-2.1	-2.6	-2.8	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9
34	-2.0	-2.5	-2.7	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8
D 32	-1.9	-2.4	-2.6	-2.7	-2.7	-2.8	-2.8	-2.8	-2.7	-2.7
E 30	-1.8	-2.3	-2.6	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7
G 28	-1.8	-2.3	-2.6	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7
R 26	-1.8	-2.4	-2.6	-2.7	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8
E 24	-1.9	-2.5	-2.7	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9
E 22	-2.0	-2.6	-2.9	-3.0	-3.1	-3.1	-3.1	-3.1	-3.1	-3.1
S 20	-2.2	-2.9	-3.1	-3.3	-3.3	-3.3	-3.4	-3.3	-3.3	-3.3
18	-2.5	-3.2	-3.5	-3.6	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7
16	-2.9	-3.6	-3.9	-4.0	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1
14	-3.4	-4.1	-4.5	-4.6	-4.7	-4.7	-4.7	-4.7	-4.7	-4.7
12	-4.1	-4.8	-5.2	-5.3	-5.4	-5.5	-5.5	-5.5	-5.5	-5.5
10	-5.0	-5.8	-6.1	-6.3	-6.4	-6.4	-6.4	-6.5	-6.4	-6.4
8	-6.2	-7.1	-7.5	-7.6	-7.7	-7.8	-7.8	-7.8	-7.8	-7.8
6	-8.0	-8.9	-9.3	-9.5	-9.6	-9.6	-9.7	-9.7	-9.7	-9.7
4	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6
2	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6
0	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6
	2	3	4	5	6	7	8	9	10	11
	FREQUENCY IN MEGAHERTZ									
	ANTENNA EFFICIENCY									
	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6
	2	3	4	5	6	7	8	9	10	11
	FREQUENCY IN MEGAHERTZ									

Figure 38. Vertical log periodic pattern.

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AZIMUTH	EX(1)		EX(2)		EX(3)		EX(4)		CONDUCT.	DIELECT.	
.000	.000		.000		.000		.000		.001	4.000	
12	13	14	16	18	20	22	24	26	28	30	
-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	90
-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	88
-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	86
-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	84
-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	82
-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	80
-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	78
-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	76
-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	74
-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	72
-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	70
-9.4	-9.4	-9.3	-9.3	-9.3	-9.3	-9.2	-9.2	-9.2	-9.2	-9.2	68
-8.6	-8.6	-8.6	-8.6	-8.6	-8.5	-8.5	-8.5	-8.5	-8.5	-8.5	66
-8.0	-7.9	-7.9	-7.9	-7.9	-7.9	-7.8	-7.8	-7.8	-7.8	-7.8	64
-7.4	-7.3	-7.3	-7.3	-7.3	-7.3	-7.2	-7.2	-7.2	-7.2	-7.2	62
-6.8	-6.8	-6.8	-6.7	-6.7	-6.7	-6.7	-6.7	-6.6	-6.6	-6.6	60
-6.3	-6.3	-6.2	-6.2	-6.2	-6.2	-6.2	-6.1	-6.1	-6.1	-6.1	58
-5.8	-5.8	-5.8	-5.7	-5.7	-5.7	-5.7	-5.7	-5.7	-5.6	-5.6	56
-5.4	-5.3	-5.3	-5.3	-5.3	-5.3	-5.2	-5.2	-5.2	-5.2	-5.2	54
-5.0	-4.9	-4.9	-4.9	-4.9	-4.9	-4.8	-4.8	-4.8	-4.8	-4.8	52
-4.6	-4.6	-4.6	-4.5	-4.5	-4.5	-4.5	-4.5	-4.5	-4.4	-4.4	50
-4.2	-4.2	-4.2	-4.2	-4.2	-4.2	-4.1	-4.1	-4.1	-4.1	-4.1	48
-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.8	-3.8	-3.8	-3.8	-3.8	46
-3.7	-3.7	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	-3.5	-3.5	44
-3.4	-3.4	-3.4	-3.4	-3.4	-3.3	-3.3	-3.3	-3.3	-3.3	-3.3	42
-3.2	-3.2	-3.2	-3.2	-3.2	-3.1	-3.1	-3.1	-3.1	-3.1	-3.1	40
-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-2.9	-2.9	-2.9	-2.9	38
-2.9	-2.9	-2.9	-2.9	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	36
-2.8	-2.8	-2.8	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	34
-2.7	-2.7	-2.7	-2.7	-2.7	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	32
-2.7	-2.7	-2.7	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	30
-2.7	-2.7	-2.7	-2.7	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	28
-2.8	-2.8	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	26
-2.9	-2.9	-2.9	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	24
-3.1	-3.1	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	22
-3.3	-3.3	-3.3	-3.3	-3.3	-3.3	-3.2	-3.2	-3.2	-3.2	-3.2	20
-3.7	-3.7	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	18
-4.1	-4.1	-4.1	-4.1	-4.1	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	16
-4.7	-4.7	-4.7	-4.7	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6	14
-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.3	12
-6.4	-6.4	-6.4	-6.4	-6.4	-6.4	-6.4	-6.4	-6.3	-6.3	-6.3	10
-7.8	-7.8	-7.7	-7.7	-7.7	-7.7	-7.7	-7.7	-7.7	-7.7	-7.7	8
-9.6	-9.6	-9.6	-9.6	-9.6	-9.6	-9.6	-9.6	-9.6	-9.6	-9.6	6
-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	4
-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	2
-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	0
12	13	14	16	18	20	22	24	26	28	30	
FREQUENCY IN MEGAHERTZ											
ANTENNA EFFICIENCY											
-.6	-.6	-.6	-.6	-.6	-.6	-.6	-.6	-.6	-.6	-.6	
12	13	14	16	18	20	22	24	26	28	30	
FREQUENCY IN MEGAHERTZ											

Figure 38a. Vertical log periodic pattern continued.



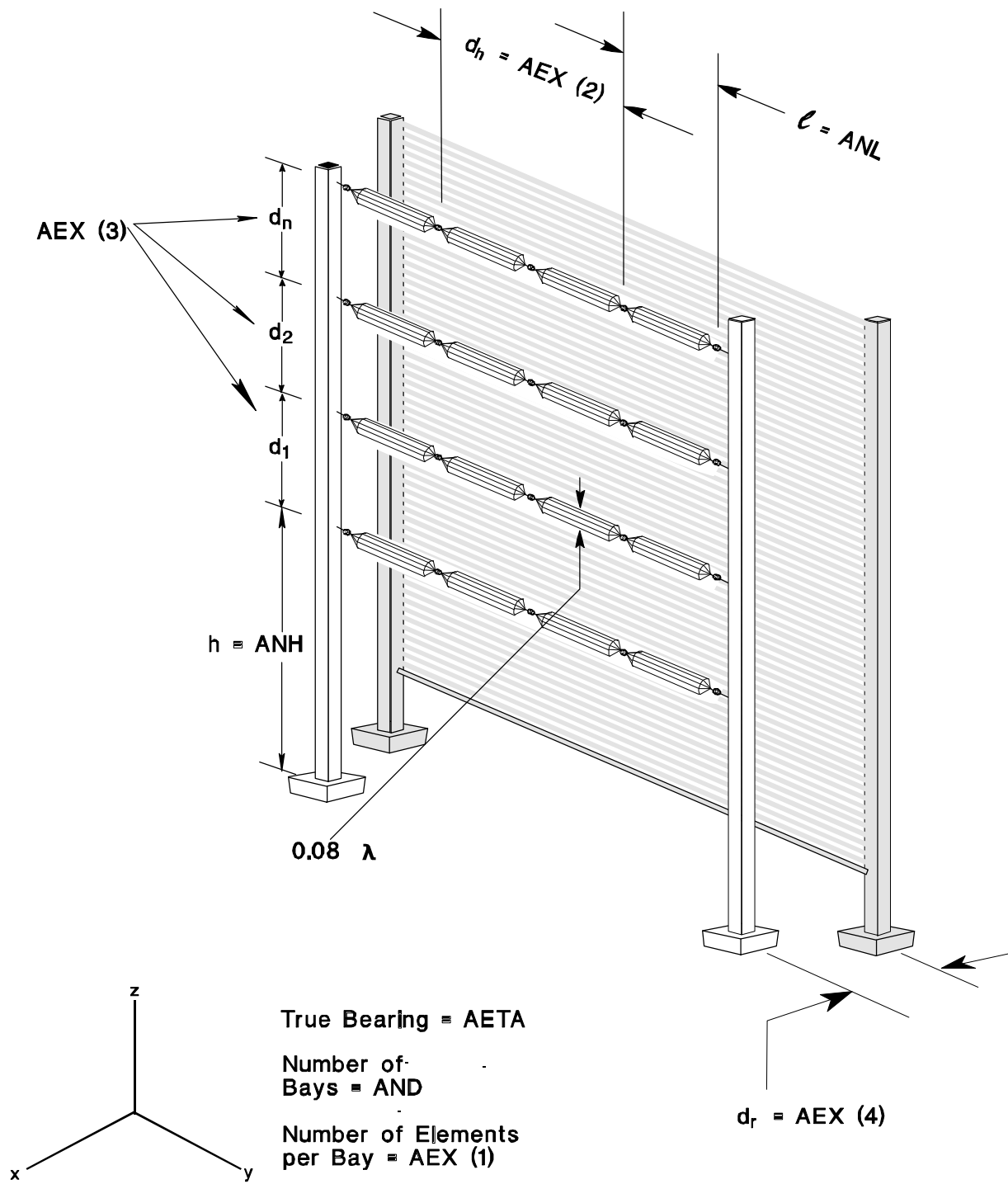


Fig. 39 Curtain structure (6).

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ITSA	ANTENNA PACKAGE					ANTENNA PATTERN					
	FREQUENCY RANGE		ANTENNA TYPE			HEIGHT		LENGTH		ANGLE	
	2.0 TO	30.0	CURTAIN ANT.			16.000	22.000	2.000			
	2	3	4	5	6	7	8	9	10	11	
90	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	
88	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	
86	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-9.2	-10.0	
84	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-8.6	-5.7	-10.0	
82	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-6.3	-3.1	-8.9	
80	-10.0	-10.0	-10.0	-10.0	-10.0	-9.8	-8.6	-4.7	-1.1	-6.1	
78	-10.0	-10.0	-10.0	-10.0	-10.0	-8.4	-6.8	-3.4	.6	-3.7	
76	-10.0	-10.0	-10.0	-10.0	-10.0	-7.3	-5.3	-2.5	1.9	-1.4	
74	-10.0	-10.0	-10.0	-10.0	-10.0	-6.4	-3.9	-1.9	3.0	.6	
72	-10.0	-10.0	-10.0	-10.0	-10.0	-5.8	-2.6	-1.4	3.9	2.5	
E 70	-10.0	-10.0	-10.0	-10.0	-10.0	-5.5	-1.4	-1.1	4.6	4.2	
L 68	-10.0	-10.0	-10.0	-10.0	-10.0	-5.4	-.4	-.7	5.1	5.7	
E 66	-10.0	-10.0	-10.0	-10.0	-10.0	-5.6	.5	-.2	5.3	6.9	
V 64	-10.0	-10.0	-10.0	-10.0	-10.0	-6.3	1.3	.5	5.2	7.9	
A 62	-10.0	-9.0	-10.0	-10.0	-10.0	-7.6	1.8	1.6	4.9	8.7	
T 60	-10.0	-8.2	-9.1	-9.6	-8.4	-9.8	2.1	2.8	4.3	9.1	
I 58	-10.0	-7.3	-7.7	-9.4	-6.8	-10.0	2.2	3.9	3.7	9.1	
O 56	-10.0	-6.5	-6.3	-9.0	-5.5	-10.0	1.8	5.0	3.5	8.8	
N 54	-10.0	-5.7	-4.9	-8.5	-4.5	-10.0	1.0	5.8	4.2	7.9	
52	-10.0	-5.0	-3.6	-7.6	-3.9	-9.7	-.5	6.3	5.5	6.7	
A 50	-10.0	-4.3	-2.3	-6.2	-3.5	-5.5	-3.3	6.3	6.9	5.6	
N 48	-10.0	-3.6	-1.1	-4.5	-3.4	-2.8	-9.0	5.8	8.1	5.7	
G 46	-10.0	-3.0	.1	-2.5	-3.6	-1.0	-10.0	4.5	8.9	7.2	
L 44	-10.0	-2.5	1.2	-.5	-3.7	.1	-7.4	2.0	8.9	9.0	
E 42	-10.0	-2.0	2.2	1.4	-3.1	.6	-1.7	-3.0	8.2	10.3	
40	-10.0	-1.5	3.1	3.3	-1.3	.4	1.3	-10.0	6.4	10.7	
I 38	-10.0	-1.1	4.0	4.9	1.3	-.2	2.9	-4.1	2.5	10.2	
N 36	-10.0	-.7	4.8	6.4	4.1	-.3	3.4	1.9	-8.0	8.3	
34	-10.0	-.4	5.5	7.8	6.6	1.5	2.9	4.6	-4.4	3.8	
D 32	-10.0	-.2	6.1	9.0	8.8	4.9	1.9	5.5	3.5	-10.0	
E 30	-10.0	-.1	6.6	10.1	10.8	8.4	2.9	4.8	6.4	.4	
G 28	-10.0	.0	7.0	11.0	12.4	11.3	7.0	3.3	6.9	6.3	
R 26	-10.0	.0	7.3	11.7	13.8	13.8	11.2	5.5	5.2	7.9	
E 24	-10.0	-.1	7.5	12.3	15.0	15.8	14.6	10.9	4.8	6.5	
E 22	-10.0	-.2	7.6	12.8	15.9	17.4	17.3	15.3	10.9	4.8	
S 20	-10.0	-.5	7.6	13.0	16.6	18.7	19.4	18.6	16.2	11.6	
18	-10.0	-1.0	7.4	13.1	17.1	19.6	20.9	21.1	20.0	17.5	
16	-10.0	-1.5	7.0	13.0	17.3	20.2	22.1	22.9	22.7	21.6	
14	-10.0	-2.3	6.4	12.6	17.2	20.5	22.7	24.1	24.6	24.3	
12	-10.0	-3.2	5.6	12.0	16.8	20.4	23.0	24.7	25.7	26.1	
10	-10.0	-4.5	4.5	11.1	16.0	19.8	22.7	24.8	26.2	26.9	
8	-10.0	-6.1	2.9	9.6	14.8	18.8	21.9	24.2	25.9	27.0	
6	-10.0	-8.4	.8	7.6	12.9	17.0	20.2	22.8	24.6	26.0	
4	-10.0	-10.0	-2.5	4.4	9.8	14.0	17.4	20.0	22.1	23.5	
2	-10.0	-10.0	-8.3	-1.3	4.1	8.4	11.8	14.5	16.7	18.2	
0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	

Figure 40. Curtain pattern.

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AZIMUTH		EX(1)	EX(2)		EX(3)		EX(4)	CONDUCT.		DIELECT.	
.000		4.000	26.000		13.000		7.000	.001		4.000	
12	13	14	16	18	20	22	24	26	28	30	
-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	90
-10.0	-10.0	-8.8	-10.0	-10.0	-4.8	-5.1	-10.0	-10.0	-10.0	-10.0	88
-10.0	-10.0	-2.9	-6.8	-9.3	1.2	.7	-4.6	-10.0	-10.0	-10.0	86
-10.0	-7.8	.4	-2.9	-6.8	4.7	3.7	-.9	-10.0	-10.0	-10.0	84
-10.0	-6.0	2.6	.1	-6.0	7.1	5.6	1.7	-10.0	-10.0	-10.0	82
-10.0	-4.8	4.0	2.7	-6.4	8.8	6.6	3.8	-10.0	-10.0	-10.0	80
-10.0	-4.2	5.0	4.9	-8.5	10.1	7.0	5.5	-10.0	-10.0	-10.0	78
-10.0	-3.9	5.5	6.9	-10.0	10.9	7.0	6.7	-10.0	-10.0	-10.0	76
-10.0	-3.9	5.6	8.7	-10.0	11.3	6.9	7.6	-10.0	-10.0	-10.0	74
-10.0	-4.0	5.3	10.2	-10.0	11.2	7.1	8.0	-10.0	-10.0	-10.0	72
-9.1	-4.3	4.6	11.5	-7.3	10.5	7.9	7.9	-10.0	-10.0	-10.0	70
-3.9	-5.1	3.4	12.5	-3.2	9.1	9.1	7.3	-9.2	-10.0	-7.2	68
.1	-7.1	1.9	13.1	.6	6.6	10.1	5.8	-7.7	-10.0	-3.8	66
3.2	-10.0	.4	13.4	4.3	2.6	10.6	3.6	-7.0	-10.0	-1.9	64
5.8	-10.0	-.8	13.1	7.6	-4.3	10.3	1.2	-7.1	-10.0	-1.6	62
7.8	-4.8	-2.1	12.3	10.2	-10.0	9.0	.6	-8.2	-10.0	-3.0	60
9.4	1.6	-5.0	10.7	12.1	-9.5	6.5	1.8	-10.0	-10.0	-5.5	58
10.6	5.7	-10.0	8.3	13.2	-3.3	2.1	2.4	-10.0	-10.0	-4.6	56
11.2	8.6	-6.2	4.9	13.5	2.1	-5.6	1.7	-10.0	-10.0	-1.9	54
11.3	10.7	2.6	1.4	12.8	6.3	-10.0	-.8	-10.0	-10.0	-1.3	52
10.7	12.0	7.4	-.8	11.0	8.9	-10.0	-5.7	-10.0	-10.0	-3.4	50
9.5	12.5	10.4	-4.2	7.7	10.0	-6.3	-10.0	-10.0	-10.0	-9.1	48
7.6	12.1	12.2	-10.0	2.7	9.6	-.6	-10.0	-10.0	-10.0	-10.0	46
6.3	10.8	12.9	.8	-2.0	7.5	2.3	-10.0	-10.0	-10.0	-10.0	44
7.5	8.5	12.4	7.4	-4.5	3.3	3.0	-10.0	-10.0	-10.0	-10.0	42
9.7	6.5	10.7	10.7	-10.0	-3.6	1.3	-10.0	-10.0	-10.0	-10.0	40
11.3	8.1	7.6	12.0	-1.0	-8.2	-3.1	-10.0	-10.0	-10.0	-10.0	38
11.8	10.7	6.4	11.5	5.9	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	36
10.9	12.2	9.5	8.8	8.6	-8.7	-10.0	-10.0	-10.0	-10.0	-10.0	34
8.0	12.0	11.8	4.4	8.6	.2	-10.0	-10.0	-10.0	-10.0	-10.0	32
.5	9.9	12.2	6.4	5.6	2.9	-10.0	-10.0	-10.0	-10.0	-8.0	30
-4.8	3.9	10.4	10.0	-.1	1.8	-8.8	-10.0	-10.0	-10.0	-8.2	28
5.8	-10.0	4.5	10.7	3.7	-3.7	-8.9	-10.0	-10.0	-10.0	-10.0	26
8.3	5.6	-10.0	8.2	6.8	-5.9	-10.0	-10.0	-10.0	-10.0	-10.0	24
6.9	8.4	5.9	-1.5	5.9	-.7	-10.0	-10.0	-10.0	-10.0	-10.0	22
5.0	6.3	7.9	-.2	-.9	-1.1	-10.0	-10.0	-10.0	-10.0	-9.2	20
13.2	6.4	4.1	5.7	-7.4	-8.2	-10.0	-10.0	-10.0	-10.0	-9.3	18
19.3	15.5	9.7	2.4	1.2	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	16
23.2	21.1	18.0	7.2	-3.6	-7.5	-10.0	-10.0	-10.0	-10.0	-7.7	14
25.7	24.6	22.8	16.6	5.4	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	12
27.1	26.6	25.6	21.4	14.0	.8	-10.0	-10.0	-10.0	-10.0	-10.0	10
27.5	27.4	26.8	23.9	18.0	7.0	-10.0	-6.9	-10.0	-10.0	-10.0	8
26.7	27.0	26.7	24.5	19.6	9.5	-5.9	.0	-10.0	-10.0	1.5	6
24.5	24.9	24.9	23.1	18.7	9.1	-3.9	1.9	-9.7	-10.0	7.2	4
19.3	19.8	19.9	18.4	14.3	4.9	-6.9	-1.1	-10.0	-10.0	5.7	2
-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	0
12	13	14	16	18	20	22	24	26	28	30	

FREQUENCY IN MEGAHERTZ

ANTENNA EFFICIENCY										
.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
12	13	14	16	18	20	22	24	26	28	30

FREQUENCY IN MEGAHERTZ

Figure 40a. Curtain pattern continued.

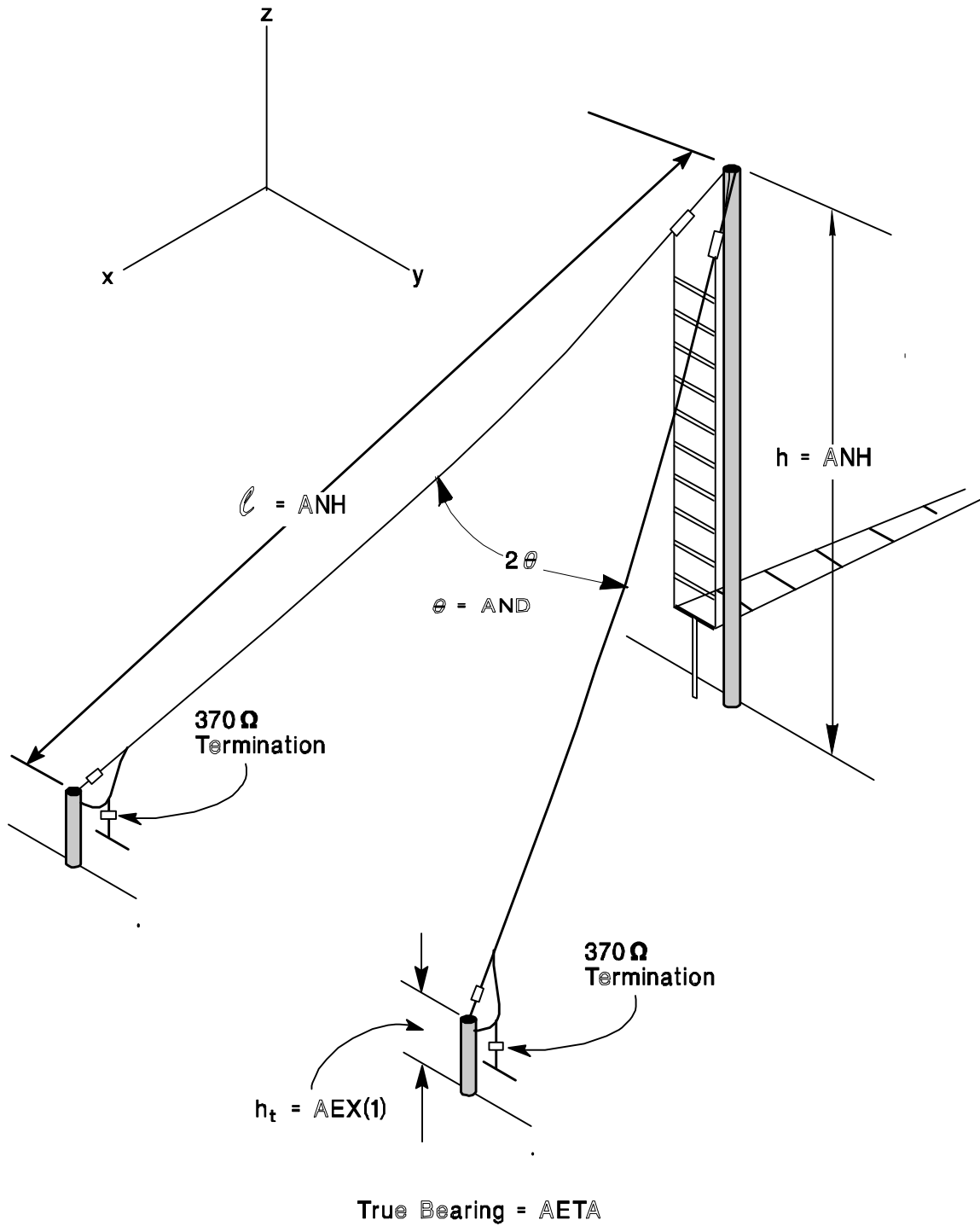


Fig. 41 Sloping vee structure (7).

n

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ITSA 1 ANTENNA PACKAGE			ANTENNA PATTERN							
FREQUENCY RANGE		ANTENNA TYPE				HEIGHT	LENGTH		ANGLE	
2.0 TO	30.0	TER	SLOP	VEE	15.240	121.900	22.500			
2	3	4	5	6	7	8	9	10	11	
90	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
88	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
86	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
84	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
82	-11.7	-11.7	-9.8	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
80	-11.7	-11.7	-9.6	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
78	-11.7	-11.7	-9.5	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
76	-11.7	-11.7	-9.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
74	-11.7	-11.7	-11.7	-9.1	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
72	-11.7	-11.7	-11.7	-8.3	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
E 70	-11.7	-11.7	-11.7	-7.8	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
L 68	-10.0	-11.7	-11.7	-7.7	-9.4	-11.7	-11.7	-11.7	-11.7	-11.7
E 66	-9.6	-11.7	-11.7	-7.7	-8.0	-11.7	-11.7	-11.7	-11.7	-11.7
V 64	-9.2	-11.7	-11.7	-8.1	-7.0	-11.7	-11.7	-11.7	-11.7	-11.7
A 62	-8.9	-9.3	-11.7	-8.7	-6.5	-9.2	-11.7	-11.7	-11.7	-11.7
T 60	-8.6	-8.3	-11.7	-9.4	-6.3	-7.3	-11.7	-11.7	-11.7	-11.7
I 58	-8.4	-7.5	-11.7	-11.7	-6.4	-6.1	-11.7	-11.7	-11.7	-11.7
O 56	-8.2	-6.8	-9.2	-11.7	-6.9	-5.5	-7.6	-11.7	-11.7	-11.7
N 54	-8.0	-6.2	-7.8	-11.7	-7.6	-5.3	-5.9	-11.7	-11.7	-11.7
52	-7.9	-5.6	-6.6	-9.5	-8.5	-5.5	-4.9	-7.4	-11.7	-11.7
A 50	-7.8	-5.2	-5.5	-8.0	-9.0	-6.1	-4.5	-5.4	-9.9	-11.7
N 48	-7.8	-4.8	-4.5	-6.4	-8.7	-6.9	-4.6	-4.3	-6.5	-11.7
G 46	-7.8	-4.4	-3.7	-5.0	-7.5	-7.5	-5.1	-3.8	-4.6	-8.0
L 44	-7.8	-4.2	-3.0	-3.7	-5.8	-7.5	-5.9	-4.0	-3.6	-5.1
E 42	-7.9	-4.0	-2.5	-2.6	-4.1	-6.3	-6.5	-4.7	-3.4	-3.6
40	-8.0	-3.9	-2.0	-1.7	-2.6	-4.5	-6.2	-5.5	-3.8	-3.0
I 38	-8.1	-3.8	-1.7	-.9	-1.3	-2.7	-4.7	-5.7	-4.6	-3.2
N 36	-8.3	-3.9	-1.4	-.3	-.3	-1.1	-2.7	-4.6	-5.1	-3.9
34	-8.6	-3.9	-1.3	.1	.6	.2	-.9	-2.6	-4.2	-4.5
D 32	-8.8	-4.1	-1.2	.5	1.2	1.3	.7	-.5	-2.2	-3.8
E 30	-9.2	-4.2	-1.2	.7	1.7	2.2	2.0	1.3	.0	-1.7
G 28	-9.5	-4.5	-1.3	.8	2.1	2.8	3.0	2.7	1.9	.7
R 26	-10.0	-4.8	-1.5	.7	2.3	3.2	3.7	3.8	3.5	2.7
E 24	-11.7	-5.2	-1.8	.6	2.3	3.5	4.3	4.6	4.6	4.3
E 22	-11.7	-5.7	-2.2	.4	2.2	3.6	4.5	5.2	5.5	5.5
S 20	-11.7	-6.3	-2.7	.0	2.0	3.5	4.6	5.5	6.0	6.3
18	-11.7	-7.0	-3.3	-.5	1.6	3.2	4.5	5.5	6.2	6.7
16	-11.7	-7.8	-4.0	-1.2	1.0	2.8	4.2	5.3	6.2	6.9
14	-11.7	-8.7	-4.9	-2.0	.3	2.1	3.6	4.9	5.9	6.7
12	-11.7	-9.9	-6.0	-3.0	-.7	1.2	2.8	4.1	5.3	6.2
10	-11.7	-11.7	-7.3	-4.3	-2.0	.0	1.7	3.1	4.3	5.3
8	-11.7	-11.7	-9.1	-6.0	-3.6	-1.6	.1	1.6	2.8	3.9
6	-11.7	-11.7	-11.7	-8.3	-5.9	-3.8	-2.0	-.5	.8	1.9
4	-11.7	-11.7	-11.7	-11.7	-9.2	-7.1	-5.3	-3.7	-2.4	-1.2
2	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-9.5	-8.2	-7.0
0	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
	2	3	4	5	6	7	8	9	10	11
FREQUENCY IN MEGAHERTZ										
ANTENNA EFFICIENCY										
	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7
	2	3	4	5	6	7	8	9	10	11
FREQUENCY IN MEGAHERTZ										

Figure 42. Sloping vee pattern.

AZIMUTH	EX(1)		EX(2)		EX(3)		EX(4)		CONDUCT.	DIELECT.	
.000	1.829		.000		.000		.000		.001	4.000	
12    13	14	16	18	20	22	24	26	28	30		
-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	90
-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-9.3	-11.7	-11.7	-11.7	88
-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	86
-11.7	-11.7	-11.7	-9.8	-11.7	-11.7	-11.7	-11.7	-9.6	-11.7	-11.7	84
-11.7	-11.7	-9.3	-11.7	-11.7	-11.7	-11.7	-8.5	-11.7	-11.7	-11.7	82
-11.7	-11.7	-10.0	-11.7	-11.7	-11.7	-9.7	-11.7	-11.7	-11.7	-11.7	80
-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-8.3	-11.7	-11.7	78
-11.7	-11.7	-11.7	-9.3	-11.7	-11.7	-11.7	-8.2	-9.7	-11.7	-11.7	76
-11.7	-8.9	-11.7	-8.0	-11.7	-11.7	-11.7	-9.1	-11.7	-8.4	-11.7	74
-11.7	-11.7	-8.6	-11.7	-11.7	-11.7	-11.7	-11.7	-7.1	-11.7	-11.7	72
-11.7	-11.7	-7.7	-11.7	-8.9	-11.7	-11.7	-8.9	-8.2	-11.7	-8.6	70
-11.7	-11.7	-9.5	-11.7	-8.0	-11.7	-11.7	-7.3	-11.7	-6.2	-11.7	68
-9.9	-11.7	-11.7	-7.1	-11.7	-11.7	-9.5	-11.7	-6.5	-11.7	-9.6	66
-11.7	-9.6	-11.7	-6.0	-11.7	-8.2	-11.7	-11.7	-6.4	-11.7	-6.8	64
-11.7	-8.2	-11.7	-8.1	-8.5	-11.7	-11.7	-7.1	-11.7	-4.4	-11.7	62
-11.7	-9.0	-7.2	-11.7	-5.2	-11.7	-9.0	-11.7	-7.4	-8.9	-5.4	60
-11.7	-11.7	-6.8	-11.7	-5.9	-9.2	-11.7	-11.7	-5.2	-11.7	-5.2	58
-11.7	-11.7	-8.8	-6.5	-11.7	-4.8	-11.7	-8.4	-11.7	-3.6	-11.7	56
-11.7	-11.7	-11.7	-4.4	-11.7	-5.5	-8.1	-9.7	-11.7	-6.3	-3.4	54
-11.7	-11.7	-11.7	-5.1	-5.3	-11.7	-4.6	-11.7	-6.2	-11.7	-3.5	52
-11.7	-9.6	-11.7	-8.8	-2.7	-11.7	-6.8	-6.3	-9.5	-4.9	-11.7	50
-11.7	-11.7	-8.9	-11.7	-3.2	-3.3	-11.7	-5.2	-9.4	-5.3	-4.1	48
-11.7	-11.7	-8.5	-11.7	-7.0	-1.3	-5.5	-11.7	-5.3	-11.7	-2.8	46
-9.5	-11.7	-11.7	-7.0	-11.7	-2.6	-.9	-9.1	-8.9	-6.2	-11.7	44
-5.7	-11.7	-11.7	-5.7	-8.5	-8.1	-.6	-1.2	-11.7	-7.1	-7.1	42
-3.6	-6.1	-11.7	-7.0	-4.2	-11.7	-4.0	.4	-1.6	-11.7	-5.7	40
-2.7	-3.6	-6.2	-11.7	-3.4	-3.8	-11.7	-1.9	1.0	-1.7	-11.7	38
-2.8	-2.5	-3.5	-9.9	-5.1	-1.4	-3.7	-8.5	-.8	1.4	-1.3	36
-3.5	-2.5	-2.3	-5.5	-8.6	-1.9	-.1	-3.4	-7.3	-.3	1.8	34
-4.1	-3.2	-2.3	-2.8	-7.7	-4.8	.2	1.0	-2.5	-6.9	-.3	32
-3.2	-3.7	-3.0	-1.8	-3.8	-7.9	-2.0	1.7	2.1	-1.1	-6.7	30
-.9	-2.5	-3.2	-2.0	-1.7	-4.6	-6.2	-.2	2.9	3.3	.7	28
1.5	.0	-1.6	-2.6	-1.3	-1.7	-4.9	-4.6	.9	3.9	4.4	26
3.6	2.5	1.1	-1.7	-1.7	-.7	-1.4	-4.5	-3.5	1.6	4.5	24
5.2	4.5	3.6	1.0	-1.3	-.8	.1	-.7	-3.3	-3.0	1.7	22
6.3	6.0	5.5	3.7	1.2	-.4	.3	1.1	.5	-1.6	-2.5	20
7.0	7.0	6.9	5.9	4.1	1.9	.8	1.6	2.4	2.1	.6	18
7.3	7.6	7.7	7.3	6.3	4.6	2.9	2.4	3.1	3.9	4.0	16
7.3	7.8	8.1	8.2	7.7	6.7	5.3	4.1	4.0	4.8	5.6	14
6.9	7.5	8.0	8.5	8.5	8.0	7.1	6.1	5.4	5.6	6.4	12
6.1	6.9	7.4	8.2	8.5	8.4	8.0	7.3	6.7	6.5	7.0	10
4.9	5.7	6.3	7.3	7.9	8.1	8.0	7.7	7.2	7.0	7.2	8
2.9	3.8	4.5	5.6	6.4	6.8	7.0	6.9	6.6	6.5	6.6	6
-.2	.7	1.5	2.7	3.6	4.2	4.5	4.6	4.5	4.5	4.6	4
-5.9	-5.0	-4.2	-2.9	-1.9	-1.2	-.9	-.7	-.6	-.6	-.5	2
-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	0
12    13	14	16	18	20	22	24	26	28	30		
FREQUENCY IN MEGAHERTZ											
ANTENNA EFFICIENCY											
-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	
12    13	14	16	18	20	22	24	26	28	30		
FREQUENCY IN MEGAHERTZ											

Figure 42a. Sloping vee pattern continued.

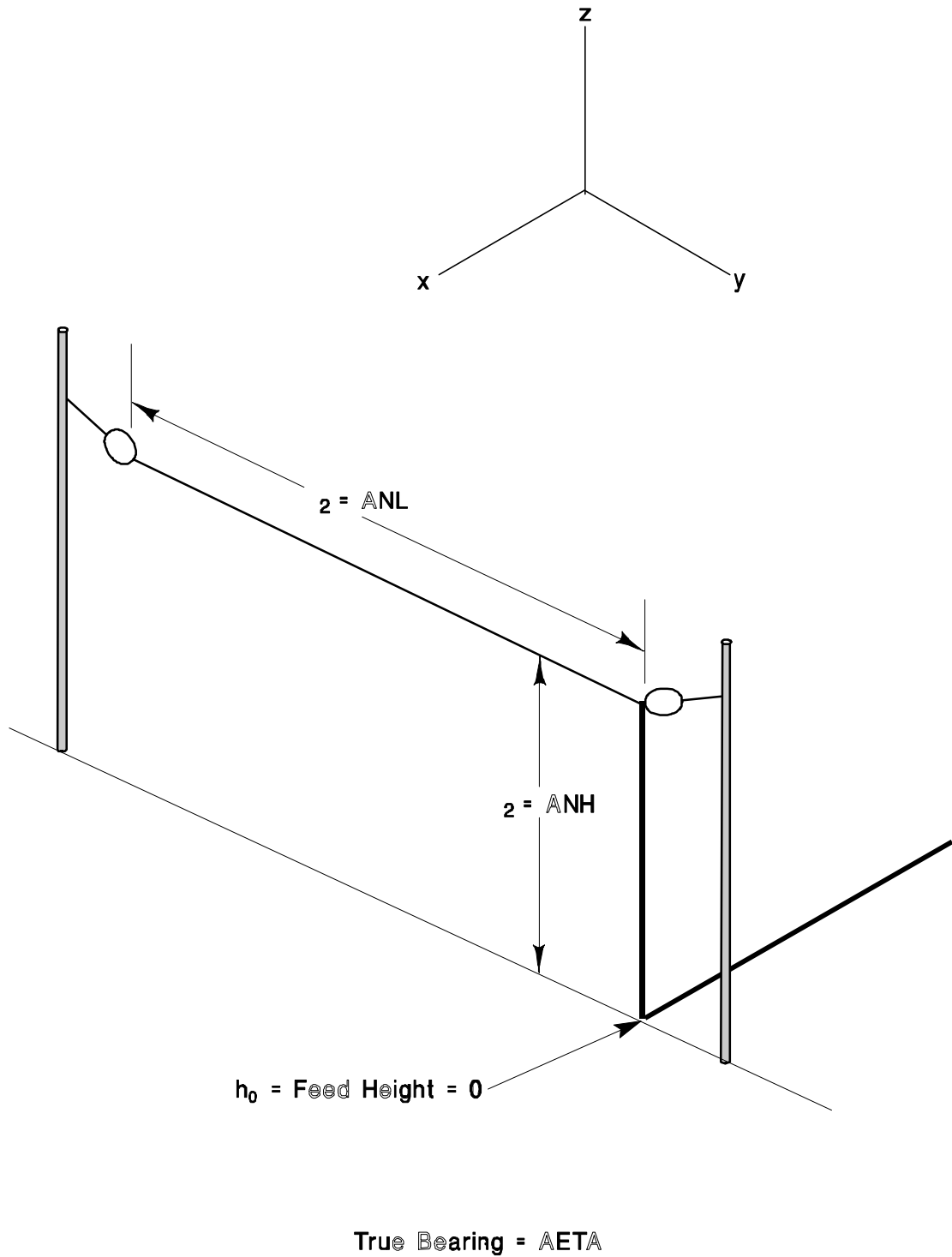


Fig. 43 Inverted L structure (8).

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ITSA 1 ANTENNA PACKAGE		ANTENNA PATTERN										
FREQUENCY RANGE		ANTENNA TYPE					HEIGHT		LENGTH		ANGLE	
2.0 TO	30.0	INVERTED L					10.000	21.340	.000			
	2	3	4	5	6	7	8	9	10	11		
	90	- .9	15.3	13.3	15.7	16.3	15.0	12.2	7.9	1.8	-7.6	
	88	-2.5	7.8	13.3	15.7	16.3	15.0	12.1	7.6	.9	-8.6	
	86	-2.2	7.9	13.3	15.7	16.3	15.0	12.2	7.6	.9	-8.6	
	84	-1.9	7.9	13.3	15.7	16.3	15.0	12.2	7.6	1.0	-8.5	
	82	-1.4	7.9	13.3	15.7	16.3	15.0	12.2	7.7	1.0	-8.3	
	80	- .9	8.0	13.3	15.7	16.3	15.0	12.2	7.7	1.1	-8.2	
	78	- .3	8.0	13.3	15.7	16.3	15.0	12.3	7.8	1.2	-8.0	
	76	.3	8.1	13.3	15.7	16.3	15.1	12.3	7.8	1.3	-7.8	
	74	.8	8.1	13.2	15.7	16.3	15.1	12.4	7.9	1.4	-7.5	
	72	1.4	8.2	13.2	15.7	16.3	15.1	12.4	8.0	1.5	-7.3	
E	70	1.9	8.3	13.2	15.6	16.3	15.1	12.5	8.1	1.6	-7.1	
L	68	2.4	8.3	13.2	15.6	16.3	15.2	12.5	8.2	1.8	-6.8	
E	66	2.9	8.4	13.1	15.6	16.3	15.2	12.6	8.3	1.9	-6.6	
V	64	3.4	8.5	13.1	15.6	16.2	15.2	12.6	8.4	2.1	-6.4	
A	62	3.8	8.5	13.1	15.5	16.2	15.2	12.7	8.5	2.2	-6.2	
T	60	4.2	8.6	13.0	15.5	16.2	15.2	12.7	8.6	2.4	-5.9	
I	58	4.6	8.7	13.0	15.4	16.2	15.2	12.8	8.7	2.6	-5.7	
O	56	4.9	8.7	12.9	15.4	16.2	15.2	12.8	8.8	2.7	-5.5	
N	54	5.2	8.8	12.8	15.3	16.1	15.2	12.9	8.9	2.9	-5.3	
	52	5.5	8.8	12.8	15.2	16.1	15.2	12.9	9.0	3.0	-5.2	
A	50	5.8	8.9	12.7	15.1	16.0	15.2	12.9	9.1	3.2	-5.0	
N	48	6.0	8.9	12.6	15.0	15.9	15.2	13.0	9.1	3.3	-4.8	
G	46	6.2	8.9	12.4	14.9	15.8	15.1	12.9	9.2	3.4	-4.7	
L	44	6.4	8.9	12.3	14.7	15.7	15.0	12.9	9.2	3.5	-4.6	
E	42	6.6	8.9	12.2	14.6	15.6	14.9	12.9	9.3	3.6	-4.5	
	40	6.7	8.9	12.0	14.4	15.4	14.8	12.8	9.3	3.7	-4.4	
I	38	6.8	8.8	11.8	14.2	15.3	14.7	12.7	9.2	3.7	-4.3	
N	36	6.9	8.8	11.6	14.0	15.1	14.5	12.6	9.2	3.8	-4.3	
	34	6.9	8.7	11.4	13.7	14.8	14.4	12.5	9.1	3.8	-4.3	
D	32	7.0	8.6	11.1	13.4	14.6	14.1	12.3	9.0	3.7	-4.3	
E	30	6.9	8.4	10.8	13.1	14.3	13.9	12.1	8.8	3.6	-4.4	
G	28	6.9	8.3	10.5	12.7	13.9	13.6	11.8	8.6	3.5	-4.5	
R	26	6.8	8.0	10.1	12.3	13.5	13.2	11.5	8.4	3.3	-4.6	
E	24	6.7	7.8	9.6	11.8	13.1	12.8	11.2	8.0	3.0	-4.8	
E	22	6.5	7.5	9.2	11.3	12.6	12.3	10.7	7.7	2.7	-5.1	
S	20	6.2	7.1	8.6	10.7	12.0	11.7	10.2	7.2	2.3	-5.5	
	18	5.9	6.6	8.0	10.0	11.3	11.1	9.6	6.6	1.8	-5.9	
	16	5.4	6.1	7.2	9.2	10.5	10.3	8.9	6.0	1.2	-6.5	
	14	4.9	5.4	6.3	8.2	9.5	9.4	8.0	5.1	.5	-7.2	
	12	4.2	4.6	5.3	7.0	8.4	8.3	6.9	4.1	-.5	-8.1	
	10	3.3	3.6	4.0	5.6	7.0	6.9	5.6	2.9	-1.7	-9.3	
	8	2.0	2.2	2.4	3.9	5.2	5.2	3.9	1.2	-3.2	-10.0	
	6	.2	.3	.2	1.6	2.9	2.9	1.7	-.9	-5.4	-10.0	
	4	-2.6	-2.7	-3.0	-1.8	-.5	-.4	-1.6	-4.2	-8.5	-10.0	
	2	-7.8	-8.0	-8.6	-7.6	-6.3	-6.2	-7.3	-9.9	-10.0	-10.0	
	0	-15.2	-12.2	-10.8	-10.3	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	
		2	3	4	5	6	7	8	9	10	11	
		FREQUENCY IN MEGAHERTZ										
		ANTENNA EFFICIENCY										
		-5.2	-2.2	-.8	-.3	.0	.0	.0	.0	.0	.0	
		2	3	4	5	6	7	8	9	10	11	
		FREQUENCY IN MEGAHERTZ										

Figure 44. Inverted L pattern.



METHOD 13    ICEPAC IC.10    PAGE 16

AZIMUTH		EX(1)		EX(2)		EX(3)		EX(4)		CONDUCT.		DIELECT.	
.000		.000		.000		.000		.000		.001		4.000	
12	13	14	16	18	20	22	24	26	28	30			
-3.9	-10.0	-10.0	-5.3	1.2	11.5	11.9	3.2	-10.0	-10.0	-9.9	90		
-10.0	-10.0	-10.0	-10.0	.0	11.3	11.8	2.1	-10.0	-10.0	-10.0	88		
-10.0	-10.0	-10.0	-10.0	.0	11.3	11.8	2.1	-10.0	-10.0	-10.0	86		
-10.0	-10.0	-10.0	-10.0	.0	11.3	11.8	2.2	-10.0	-10.0	-10.0	84		
-10.0	-10.0	-10.0	-10.0	.0	11.2	11.8	2.3	-10.0	-10.0	-10.0	82		
-10.0	-10.0	-10.0	-10.0	.0	11.1	11.9	2.4	-10.0	-10.0	-10.0	80		
-10.0	-10.0	-10.0	-10.0	.0	11.1	11.9	2.5	-9.1	-10.0	-9.4	78		
-10.0	-10.0	-10.0	-10.0	.0	11.0	11.9	2.6	-7.9	-10.0	-8.2	76		
-10.0	-10.0	-10.0	-9.3	.0	10.8	11.9	2.8	-6.9	-9.1	-7.3	74		
-10.0	-10.0	-10.0	-8.4	-.1	10.7	11.9	2.9	-6.0	-7.9	-6.5	72		
-10.0	-10.0	-10.0	-7.6	-.1	10.5	11.8	3.0	-5.3	-6.8	-5.9	70		
-10.0	-10.0	-10.0	-7.0	.0	10.2	11.8	3.2	-4.6	-5.7	-5.4	68		
-10.0	-10.0	-10.0	-6.4	.0	9.9	11.7	3.3	-4.1	-4.8	-5.0	66		
-9.8	-9.4	-10.0	-6.0	.0	9.6	11.6	3.4	-3.6	-3.9	-4.7	64		
-9.4	-8.7	-10.0	-5.5	.1	9.1	11.4	3.5	-3.3	-3.1	-4.4	62		
-8.9	-8.1	-9.4	-5.2	.2	8.7	11.2	3.5	-3.0	-2.3	-4.3	60		
-8.5	-7.5	-8.7	-4.9	.3	8.1	10.9	3.6	-2.7	-1.6	-4.1	58		
-8.2	-7.0	-8.0	-4.7	.5	7.5	10.5	3.6	-2.6	-.9	-4.0	56		
-7.9	-6.5	-7.3	-4.5	.7	6.8	10.1	3.5	-2.5	-.3	-3.9	54		
-7.7	-6.0	-6.7	-4.4	1.0	6.1	9.6	3.4	-2.4	.2	-3.7	52		
-7.5	-5.6	-6.0	-4.3	1.3	5.5	9.0	3.3	-2.5	.6	-3.4	50		
-7.3	-5.2	-5.4	-4.3	1.6	5.1	8.4	3.1	-2.5	1.0	-3.1	48		
-7.2	-4.8	-4.9	-4.2	2.0	5.2	7.8	2.9	-2.7	1.4	-2.8	46		
-7.1	-4.5	-4.4	-4.2	2.4	5.6	7.2	2.8	-2.8	1.6	-2.4	44		
-7.0	-4.2	-3.9	-4.2	2.8	6.5	7.0	2.6	-3.0	1.8	-2.0	42		
-7.0	-3.9	-3.4	-4.1	3.3	7.5	7.1	2.4	-3.2	1.9	-1.7	40		
-7.0	-3.7	-3.0	-4.1	3.7	8.6	7.5	2.4	-3.4	1.8	-1.4	38		
-7.1	-3.5	-2.6	-4.0	4.0	9.7	8.4	2.5	-3.6	1.8	-1.2	36		
-7.2	-3.4	-2.2	-3.8	4.4	10.7	9.3	2.7	-3.7	1.6	-1.2	34		
-7.3	-3.3	-1.9	-3.7	4.7	11.6	10.3	3.0	-3.8	1.3	-1.2	32		
-7.5	-3.2	-1.7	-3.5	4.9	12.4	11.3	3.4	-3.8	.9	-1.5	30		
-7.7	-3.2	-1.5	-3.3	5.1	13.0	12.1	3.9	-3.8	.5	-1.9	28		
-8.0	-3.2	-1.4	-3.1	5.2	13.5	12.8	4.4	-3.8	.1	-2.4	26		
-8.3	-3.3	-1.3	-2.9	5.3	13.9	13.4	4.8	-3.8	-.4	-3.1	24		
-8.7	-3.4	-1.3	-2.8	5.2	14.1	13.8	5.1	-3.9	-.9	-4.0	22		
-9.1	-3.7	-1.4	-2.8	5.0	14.2	14.0	5.3	-4.0	-1.3	-4.9	20		
-9.7	-4.0	-1.6	-2.8	4.7	14.1	14.1	5.4	-4.1	-1.8	-5.8	18		
-10.0	-4.4	-1.9	-3.0	4.3	13.8	14.0	5.3	-4.4	-2.1	-6.5	16		
-10.0	-5.0	-2.4	-3.3	3.7	13.4	13.6	4.9	-4.9	-2.6	-7.1	14		
-10.0	-5.7	-3.0	-3.8	2.8	12.6	13.0	4.4	-5.5	-3.1	-7.5	12		
-10.0	-6.7	-3.9	-4.6	1.7	11.6	12.0	3.4	-6.4	-3.8	-8.0	10		
-10.0	-8.0	-5.2	-5.8	.2	10.2	10.6	2.1	-7.7	-4.8	-8.8	8		
-10.0	-9.9	-7.0	-7.5	-2.0	8.1	8.6	.1	-9.5	-6.5	-10.0	6		
-10.0	-10.0	-9.9	-10.0	-5.1	4.9	5.5	-3.0	-10.0	-9.2	-10.0	4		
-10.0	-10.0	-10.0	-10.0	-10.0	-.8	-.2	-8.7	-10.0	-10.0	-10.0	2		
-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	0		
12	13	14	16	18	20	22	24	26	28	30			
FREQUENCY IN MEGAHERTZ													
ANTENNA EFFICIENCY													
.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0			
12	13	14	16	18	20	22	24	26	28	30			
FREQUENCY IN MEGAHERTZ													

Figure 44a. Inverted L pattern continued.

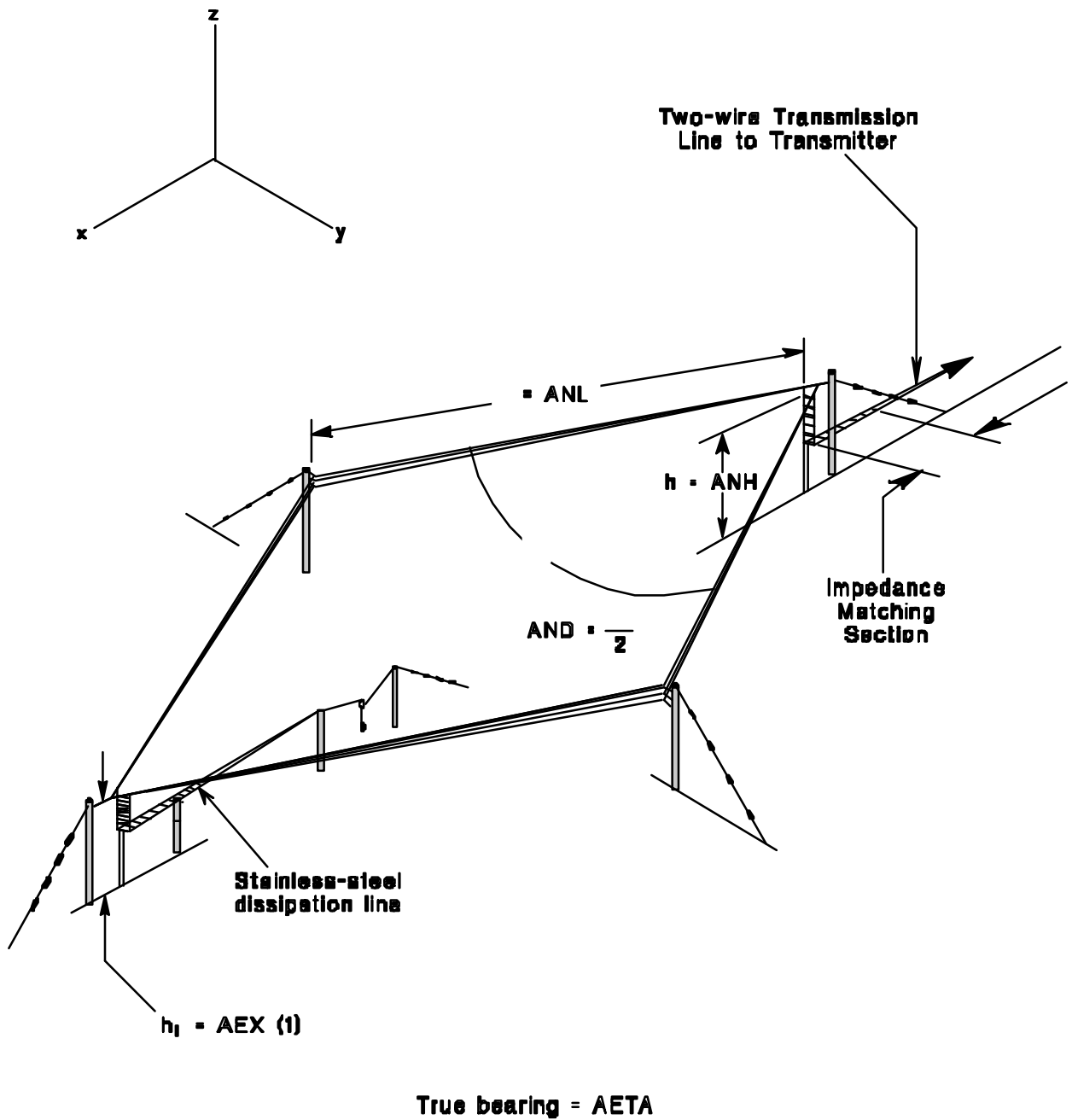


Fig. 45 Sloping rhombic structure (9).

0

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ITSA 1 ANTENNA PACKAGE			ANTENNA PATTERN							
FREQUENCY RANGE		ANTENNA TYPE				HEIGHT	LENGTH		ANGLE	
2.0 TO	30.0	TER	SLOP	RHM	16.760	88.390	22.500			
2	3	4	5	6	7	8	9	10	11	
90	-5.5	-11.7	-11.7	-2.4	-11.7	-11.7	-4.9	-11.7	-11.7	-6.6
88	-4.9	-11.7	-11.7	-2.3	-7.8	-11.7	-5.8	-8.5	-11.7	-9.1
86	-4.4	-11.7	-11.7	-2.5	-5.2	-11.7	-7.7	-6.2	-11.7	-11.7
84	-3.9	-11.7	-11.7	-3.2	-3.3	-11.7	-11.7	-4.9	-11.7	-11.7
82	-3.5	-9.8	-11.7	-4.3	-2.0	-11.7	-11.7	-4.8	-11.7	-11.7
80	-3.2	-7.8	-11.7	-5.9	-1.2	-8.6	-11.7	-6.0	-7.0	-11.7
78	-2.9	-6.1	-11.7	-8.1	-1.0	-5.3	-11.7	-8.7	-4.7	-11.7
76	-2.6	-4.6	-11.7	-11.7	-1.2	-2.9	-11.7	-11.7	-4.3	-11.7
74	-2.4	-3.3	-11.7	-11.7	-1.9	-1.3	-10.0	-11.7	-5.6	-5.4
72	-2.3	-2.2	-11.7	-11.7	-3.3	-.3	-6.1	-11.7	-9.2	-3.6
E 70	-2.2	-1.2	-9.8	-11.7	-5.3	.0	-3.1	-11.7	-11.7	-4.1
L 68	-2.2	-.4	-6.9	-11.7	-8.2	-.4	-1.0	-8.7	-11.7	-7.1
E 66	-2.3	.3	-4.4	-11.7	-11.7	-1.4	.2	-5.0	-11.7	-11.7
V 64	-2.3	.9	-2.4	-11.7	-11.7	-3.2	.7	-2.0	-9.4	-11.7
A 62	-2.5	1.4	-.7	-11.7	-11.7	-5.8	.3	.0	-6.0	-11.7
T 60	-2.6	1.7	.7	-6.4	-11.7	-9.7	-.8	1.0	-2.6	-8.8
I 58	-2.9	2.0	1.9	-3.3	-11.7	-11.7	-2.9	1.2	-.1	-6.1
O 56	-3.1	2.2	2.9	-.8	-11.7	-11.7	-6.1	.4	1.3	-2.5
N 54	-3.5	2.2	3.6	1.2	-6.0	-11.7	-11.7	-1.5	1.7	.3
52	-3.8	2.2	4.3	2.9	-2.3	-11.7	-11.7	-4.6	.9	1.8
A 50	-4.3	2.2	4.7	4.3	.6	-7.4	-11.7	-9.1	-1.1	2.0
N 48	-4.7	2.0	5.0	5.3	2.9	-2.8	-11.7	-11.7	-4.4	1.0
G 46	-5.3	1.7	5.2	6.2	4.8	.8	-6.7	-11.7	-9.4	-1.5
L 44	-5.8	1.4	5.3	6.8	6.3	3.6	-1.8	-11.7	-11.7	-5.7
E 42	-6.5	1.0	5.2	7.2	7.4	5.8	2.0	-4.2	-11.7	-11.7
40	-7.1	.5	5.0	7.5	8.2	7.5	5.0	.6	-5.9	-11.7
I 38	-7.8	.0	4.8	7.6	8.8	8.7	7.3	4.3	-.5	-6.7
N 36	-8.6	-.6	4.4	7.5	9.2	9.7	9.0	7.1	3.8	-1.0
34	-9.4	-1.3	3.9	7.3	9.4	10.4	10.3	9.3	7.1	3.7
D 32	-11.7	-2.1	3.3	7.0	9.4	10.8	11.3	10.9	9.6	7.4
E 30	-11.7	-2.9	2.7	6.5	9.2	10.9	11.9	12.0	11.5	10.1
G 28	-11.7	-3.8	1.9	5.9	8.8	10.9	12.2	12.8	12.8	12.1
R 26	-11.7	-4.8	1.0	5.2	8.3	10.6	12.2	13.2	13.7	13.6
E 24	-11.7	-5.8	.1	4.4	7.7	10.2	12.1	13.4	14.2	14.5
E 22	-11.7	-6.9	-.9	3.5	6.9	9.6	11.7	13.2	14.3	15.0
S 20	-11.7	-8.1	-2.1	2.5	6.0	8.8	11.1	12.9	14.2	15.2
18	-11.7	-9.4	-3.3	1.3	5.0	7.9	10.3	12.3	13.8	15.0
16	-11.7	-11.7	-4.6	.0	3.8	6.8	9.4	11.4	13.2	14.6
14	-11.7	-11.7	-6.1	-1.4	2.4	5.6	8.2	10.4	12.3	13.8
12	-11.7	-11.7	-7.7	-2.9	.9	4.1	6.8	9.1	11.1	12.8
10	-11.7	-11.7	-9.5	-4.7	-.8	2.4	5.2	7.6	9.6	11.4
8	-11.7	-11.7	-11.7	-6.9	-2.9	.4	3.2	5.6	7.8	9.6
6	-11.7	-11.7	-11.7	-9.5	-5.5	-2.2	.7	3.2	5.3	7.3
4	-11.7	-11.7	-11.7	-11.7	-9.1	-5.7	-2.8	-.3	1.9	3.9
2	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-8.8	-6.2	-4.0	-2.0
0	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
	2	3	4	5	6	7	8	9	10	11
FREQUENCY IN MEGAHERTZ										
ANTENNA EFFICIENCY										
	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7
	2	3	4	5	6	7	8	9	10	11
FREQUENCY IN MEGAHERTZ										

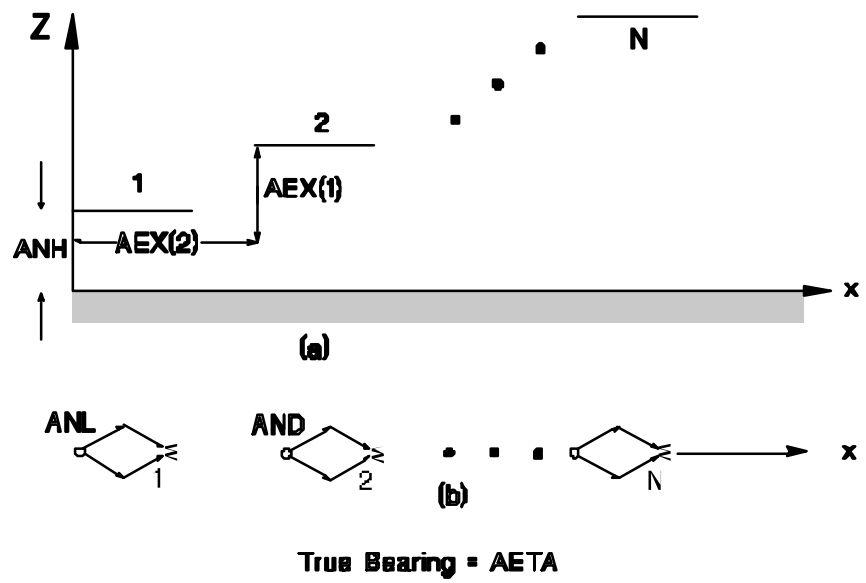
Figure 46. Sloping rhombic pattern.

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AZIMUTH	EX(1)		EX(2)		EX(3)		EX(4)		CONDUCT.	DIELECT.	
.000	8.382		.000		.000		.000		.001	4.000	
12	13	14	16	18	20	22	24	26	28	30	
-11.7	-11.7	-8.3	-11.7	-5.6	-11.7	-11.7	-8.1	-11.7	-6.9	-6.4	90
-8.0	-11.7	-11.7	-9.3	-5.8	-11.7	-5.8	-11.7	-11.7	-4.2	-11.7	88
-5.5	-11.7	-11.7	-5.6	-8.9	-11.7	-7.3	-11.7	-5.3	-11.7	-7.4	86
-6.2	-8.3	-11.7	-4.5	-11.7	-5.5	-11.7	-9.6	-9.3	-11.7	-2.4	84
-11.7	-4.9	-11.7	-6.4	-11.7	-4.6	-11.7	-5.1	-11.7	-4.2	-11.7	82
-11.7	-4.9	-6.9	-11.7	-6.0	-8.2	-11.7	-11.7	-11.7	-4.4	-11.7	80
-11.7	-8.7	-4.0	-11.7	-3.7	-11.7	-3.8	-11.7	-4.3	-11.7	-2.2	78
-11.7	-11.7	-4.2	-9.8	-4.3	-11.7	-6.3	-11.7	-9.1	-11.7	-3.6	76
-11.7	-11.7	-8.5	-5.9	-7.6	-4.9	-11.7	-3.9	-11.7	-2.7	-11.7	74
-11.7	-11.7	-11.7	-2.9	-11.7	-2.6	-11.7	-6.1	-11.7	-5.7	-7.0	72
-5.3	-11.7	-11.7	-2.6	-7.8	-4.2	-7.1	-11.7	-3.2	-11.7	-.5	70
-2.9	-9.6	-11.7	-5.7	-3.6	-7.9	-1.9	-11.7	-7.6	-8.8	-6.6	68
-3.3	-3.7	-11.7	-11.7	-1.4	-8.6	-3.2	-6.8	-11.7	-2.1	-11.7	66
-6.8	-1.9	-5.3	-9.2	-2.1	-4.3	-6.9	-1.2	-11.7	-9.1	-2.8	64
-11.7	-3.2	-1.7	-7.8	-5.7	-1.0	-8.2	-4.4	-3.2	-11.7	-1.5	62
-11.7	-8.8	-1.4	-5.8	-8.1	-.7	-4.3	-7.1	-1.6	-9.6	-8.6	60
-9.0	-11.7	-4.8	-1.6	-6.0	-3.1	-.2	-8.4	-9.1	-.6	-11.7	58
-8.0	-9.4	-11.7	.3	-3.6	-5.9	.2	-2.6	-6.6	-7.7	-1.0	56
-5.5	-7.4	-11.7	-1.2	-.3	-4.4	-2.1	1.1	-7.9	-6.7	-3.4	54
-1.5	-7.7	-6.4	-8.6	1.5	-1.3	-4.4	.4	.8	-11.7	-9.2	52
1.3	-3.8	-7.9	-11.7	.1	1.6	-2.3	-2.3	1.7	-.3	-11.7	50
2.5	.4	-6.4	-4.6	-6.9	2.5	1.2	-2.8	-.6	2.4	-1.2	48
2.1	2.5	-.6	-5.8	-8.3	.1	3.2	.7	-2.1	.1	2.8	46
.3	2.9	2.5	-11.7	-2.5	-7.6	2.7	3.5	.1	-1.1	.0	44
-3.3	1.5	3.4	-1.8	-4.7	-3.1	-1.7	4.0	3.6	-.1	-.3	42
-8.8	-1.7	2.3	2.9	-11.7	-.7	-3.8	1.4	4.8	3.8	-.1	40
-11.7	-7.1	-.8	4.3	.0	-6.6	.7	-2.4	3.1	5.4	4.1	38
-6.5	-11.7	-6.2	3.2	4.4	-4.9	-.9	1.4	-.4	4.2	6.0	36
-.8	-5.7	-9.2	-.3	5.1	3.6	-7.0	1.6	2.4	1.3	5.0	34
4.1	-.1	-4.4	-6.3	3.1	6.0	2.9	-3.6	3.2	3.5	2.6	32
7.9	4.9	1.1	-6.2	-1.9	5.1	6.5	2.8	-.8	4.4	4.8	30
10.8	8.8	6.0	-.8	-6.5	1.0	6.4	7.1	3.6	1.0	5.2	28
12.9	11.7	9.9	4.6	-1.6	-5.2	2.9	7.3	7.8	4.8	2.1	26
14.4	13.8	12.7	9.1	3.8	-1.7	-3.7	3.9	7.9	8.6	6.3	24
15.3	15.2	14.7	12.5	8.7	3.7	-1.4	-2.6	4.4	8.3	9.4	22
15.8	16.1	16.1	15.0	12.6	8.7	4.0	-.6	-2.0	4.4	8.5	20
15.9	16.5	16.9	16.7	15.3	12.8	9.1	4.7	.3	-1.6	3.9	18
15.7	16.6	17.2	17.6	17.2	15.7	13.2	9.7	5.5	1.3	-1.1	16
15.1	16.2	17.0	18.0	18.2	17.6	16.1	13.8	10.5	6.3	2.1	14
14.2	15.4	16.4	17.9	18.6	18.6	17.9	16.5	14.3	11.1	7.1	12
13.0	14.3	15.4	17.2	18.3	18.8	18.7	17.9	16.6	14.5	11.5	10
11.3	12.7	13.9	15.9	17.3	18.1	18.5	18.3	17.5	16.1	14.1	8
9.0	10.5	11.8	13.9	15.5	16.6	17.2	17.4	17.1	16.2	14.8	6
5.6	7.2	8.5	10.8	12.5	13.8	14.6	15.0	15.0	14.5	13.5	4
-.3	1.3	2.7	5.1	6.9	8.3	9.2	9.7	9.8	9.5	8.7	2
-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	0
12	13	14	16	18	20	22	24	26	28	30	
FREQUENCY IN MEGAHERTZ											
ANTENNA EFFICIENCY											
-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	
12	13	14	16	18	20	22	24	26	28	30	
FREQUENCY IN MEGAHERTZ											

Figure 46a. Sloping rhombic pattern continued.

■



**Fig. 47 Interlaced rhombic structure (11).**

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ITSA 1 ANTENNA PACKAGE			ANTENNA PATTERN							
FREQUENCY RANGE	ANTENNA TYPE				HEIGHT	LENGTH			ANGLE	
2.0 TO 30.0	TER	INTR	RHM		20.000	114.000		70.000		
	2	3	4	5	6	7	8	9	10	11
90	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-6.3	-11.7	-11.7
88	-9.1	-11.7	-9.7	-11.7	-11.7	-11.7	-11.7	-9.4	-7.3	-11.7
86	-7.6	-11.7	-9.1	-11.7	-11.7	-11.7	-11.7	-11.7	-4.9	-11.7
84	-6.2	-11.7	-9.1	-11.7	-11.7	-11.7	-11.7	-11.7	-5.5	-11.7
82	-4.9	-11.7	-9.5	-11.7	-11.7	-11.7	-11.7	-11.7	-9.2	-6.1
80	-3.9	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-4.8
78	-2.9	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-7.0
76	-2.1	-11.7	-11.7	-9.3	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
74	-1.3	-11.7	-11.7	-8.6	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
72	-.7	-11.7	-11.7	-8.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
E 70	-.2	-7.4	-11.7	-9.5	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
L 68	.3	-4.9	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
E 66	.6	-2.8	-11.7	-11.7	-9.8	-11.7	-11.7	-11.7	-11.7	-11.7
V 64	.9	-1.0	-11.7	-11.7	-9.6	-11.7	-11.7	-11.7	-11.7	-11.7
A 62	1.0	.5	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
T 60	1.1	1.8	-7.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
I 58	1.1	2.8	-4.0	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
O 56	1.1	3.7	-1.1	-11.7	-11.7	-11.7	-11.7	-9.5	-11.7	-11.7
N 54	.9	4.3	1.2	-11.7	-11.7	-11.7	-11.7	-8.4	-7.8	-11.7
52	.7	4.9	3.1	-5.6	-11.7	-11.7	-11.7	-8.9	-4.6	-8.2
A 50	.4	5.2	4.6	-1.5	-11.7	-11.7	-11.7	-11.7	-3.6	-2.9
N 48	.1	5.5	5.9	1.6	-9.5	-11.7	-11.7	-11.7	-4.6	-.6
G 46	-.4	5.5	6.8	4.1	-3.6	-11.7	-11.7	-11.7	-7.6	-.5
L 44	-.9	5.5	7.5	6.1	.7	-11.7	-11.7	-11.7	-11.7	-2.6
E 42	-1.4	5.4	8.1	7.6	4.0	-3.9	-11.7	-11.7	-11.7	-6.9
40	-2.1	5.1	8.4	8.8	6.5	1.1	-9.4	-11.7	-11.7	-11.7
I 38	-2.8	4.7	8.5	9.7	8.5	4.8	-2.1	-11.7	-11.7	-11.7
N 36	-3.6	4.2	8.5	10.3	10.0	7.7	3.0	-5.2	-11.7	-11.7
34	-4.5	3.6	8.3	10.6	11.1	9.9	6.8	1.3	-7.8	-11.7
D 32	-5.4	2.9	7.9	10.7	11.9	11.5	9.6	6.0	.1	-9.3
E 30	-6.4	2.1	7.4	10.6	12.3	12.7	11.8	9.5	5.6	-.4
G 28	-7.5	1.2	6.8	10.4	12.5	13.4	13.3	12.0	9.6	5.7
R 26	-8.7	.2	6.0	9.9	12.4	13.9	14.4	13.9	12.5	10.0
E 24	-11.7	-.9	5.1	9.3	12.1	14.0	15.0	15.2	14.6	13.2
E 22	-11.7	-2.1	4.1	8.4	11.6	13.8	15.2	16.0	16.0	15.5
S 20	-11.7	-3.5	2.9	7.5	10.9	13.4	15.2	16.3	16.9	17.0
18	-11.7	-4.9	1.6	6.3	9.9	12.7	14.8	16.3	17.3	17.9
16	-11.7	-6.5	.1	5.0	8.8	11.8	14.1	15.9	17.3	18.2
14	-11.7	-8.2	-1.5	3.5	7.5	10.6	13.2	15.2	16.8	18.1
12	-11.7	-11.7	-3.3	1.9	5.9	9.2	11.9	14.2	16.0	17.5
10	-11.7	-11.7	-5.3	-.1	4.1	7.5	10.4	12.8	14.8	16.5
8	-11.7	-11.7	-7.6	-2.3	2.0	5.5	8.4	10.9	13.1	14.9
6	-11.7	-11.7	-11.7	-5.0	-.7	2.9	5.9	8.5	10.8	12.7
4	-11.7	-11.7	-11.7	-8.7	-4.3	-.7	2.4	5.1	7.4	9.4
2	-11.7	-11.7	-11.7	-11.7	-11.7	-6.7	-3.6	-.9	1.5	3.6
0	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7
	2	3	4	5	6	7	8	9	10	11

FREQUENCY IN MEGAHERTZ

ANTENNA EFFICIENCY										
	2	3	4	5	6	7	8	9	10	11
	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7
	2	3	4	5	6	7	8	9	10	11

FREQUENCY IN MEGAHERTZ

Figure 48. Interlaced rhombic pattern.

AZIMUTH	EX(1)		EX(2)		EX(3)		EX(4)		CONDUCT.		DIELECT.	
.000	4.000		33.000		.000		.000		.001		4.000	
12	13	14	16	18	20	22	24	26	28	30		
-7.8	-11.7	-11.7	-11.7	-11.7	-6.3	-8.3	-11.7	-11.7	-9.0	-9.9	90	
-7.3	-11.7	-11.7	-11.7	-11.7	-6.9	-11.7	-11.7	-11.7	-11.7	-11.7	88	
-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-6.3	-11.7	-11.7	-11.7	86	
-11.7	-8.2	-11.7	-8.3	-11.7	-11.7	-5.5	-11.7	-11.7	-11.7	-11.7	84	
-11.7	-11.7	-9.7	-11.7	-11.7	-8.8	-11.7	-11.7	-5.9	-11.7	-11.7	82	
-11.7	-11.7	-7.1	-11.7	-11.7	-11.7	-11.7	-9.7	-8.9	-11.7	-11.7	80	
-7.3	-11.7	-11.7	-11.7	-6.3	-11.7	-11.7	-11.7	-11.7	-3.4	-11.7	78	
-4.8	-11.7	-11.7	-7.3	-8.6	-11.7	-11.7	-11.7	-6.7	-9.2	-11.7	76	
-6.4	-6.8	-11.7	-3.1	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-3.2	74	
-11.7	-4.4	-11.7	-5.9	-11.7	-8.1	-11.7	-11.7	-11.7	-2.6	-11.7	72	
-11.7	-6.5	-4.7	-11.7	-3.5	-11.7	-11.7	-11.7	-11.7	-11.7	-7.8	70	
-11.7	-11.7	-3.8	-11.7	-1.9	-11.7	-8.6	-11.7	-11.7	-11.7	-4.2	68	
-11.7	-11.7	-7.9	-9.1	-9.0	-5.3	-11.7	-7.0	-11.7	-11.7	-11.7	66	
-11.7	-11.7	-11.7	-3.0	-11.7	-1.3	-11.7	-5.2	-11.7	-11.7	-11.7	64	
-11.7	-11.7	-11.7	-3.4	-11.7	-7.4	-3.8	-11.7	-2.1	-11.7	-11.7	62	
-11.7	-11.7	-11.7	-11.7	-4.6	-11.7	-.7	-11.7	-7.6	-3.7	-11.7	60	
-11.7	-11.7	-11.7	-11.7	-3.8	-11.7	-9.6	.2	-11.7	-2.9	-6.9	58	
-11.7	-11.7	-9.3	-11.7	-9.5	-6.8	-11.7	-1.2	-2.4	-11.7	-1.1	56	
-11.7	-11.7	-8.6	-9.9	-11.7	-8.1	-9.4	-11.7	1.5	-6.7	-11.7	54	
-11.7	-11.7	-11.7	-7.0	-11.7	-11.7	-8.4	-11.7	-9.5	1.3	-11.7	52	
-9.4	-11.7	-11.7	-7.4	-8.8	-11.7	-11.7	-3.4	-11.7	-5.7	-.7	50	
-2.1	-11.7	-11.7	-9.6	-6.8	-11.7	-11.7	-8.2	-1.5	-11.7	-6.2	48	
1.4	-1.5	-11.7	-11.7	-9.3	-6.6	-11.7	-11.7	-1.9	-1.1	-11.7	46	
2.2	2.9	-.6	-11.7	-11.7	-7.6	-6.9	-11.7	-11.7	.6	-.9	44	
.8	4.2	4.2	-7.8	-11.7	-11.7	-3.0	-6.8	-11.7	-10.0	1.2	42	
-3.0	3.2	5.8	2.4	-11.7	-11.7	-8.6	.4	-5.8	-11.7	-11.7	40	
-11.7	-.5	4.8	7.0	-1.4	-11.7	-11.7	-1.8	3.0	-3.7	-11.7	38	
-11.7	-7.4	1.1	8.2	6.4	-5.9	-11.7	-11.7	1.9	5.1	-.9	36	
-11.7	-11.7	-6.3	6.5	9.6	5.3	-9.7	-11.7	-9.4	4.0	6.9	34	
-11.7	-11.7	-11.7	1.6	9.4	10.2	4.4	-11.7	-11.7	-8.2	4.7	32	
-9.6	-11.7	-11.7	-8.2	5.9	11.0	10.5	4.2	-11.7	-11.7	-11.7	30	
-.1	-8.6	-11.7	-11.7	-1.9	8.4	12.1	11.0	5.0	-8.6	-11.7	28	
6.3	1.0	-6.5	-11.7	-11.7	1.4	9.8	12.8	11.9	6.7	-4.0	26	
10.9	7.5	2.8	-11.7	-11.7	-11.7	2.9	10.4	13.4	13.0	9.1	24	
14.2	12.2	9.2	-.1	-11.7	-11.7	-11.7	3.1	10.5	13.8	14.2	22	
16.5	15.4	13.7	8.1	-1.7	-11.7	-11.7	-11.7	2.0	9.8	13.8	20	
17.9	17.6	16.7	13.5	7.8	-1.6	-11.7	-11.7	-11.7	-.5	8.3	18	
18.7	18.9	18.7	17.2	14.0	8.6	.2	-11.7	-11.7	-11.7	-5.1	16	
19.0	19.6	19.8	19.5	17.9	15.0	10.4	3.4	-7.2	-11.7	-11.7	14	
18.7	19.6	20.2	20.8	20.4	19.0	16.4	12.6	7.0	-1.2	-11.7	12	
17.9	19.0	20.0	21.2	21.6	21.2	20.0	17.9	14.8	10.4	4.1	10	
16.5	17.9	19.0	20.7	21.7	22.0	21.7	20.7	19.1	16.5	12.9	8	
14.5	15.9	17.2	19.3	20.7	21.5	21.8	21.5	20.7	19.3	17.1	6	
11.2	12.8	14.2	16.5	18.2	19.3	20.0	20.2	19.9	19.1	17.7	4	
5.5	7.1	8.6	11.0	12.8	14.2	15.0	15.5	15.5	15.0	14.1	2	
-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	-11.7	0	
12	13	14	16	18	20	22	24	26	28	30		
FREQUENCY IN MEGAHERTZ												
ANTENNA EFFICIENCY												
-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	
12	13	14	16	18	20	22	24	26	28	30		
FREQUENCY IN MEGAHERTZ												

Figure 48a. Interlaced rhombic pattern continued.

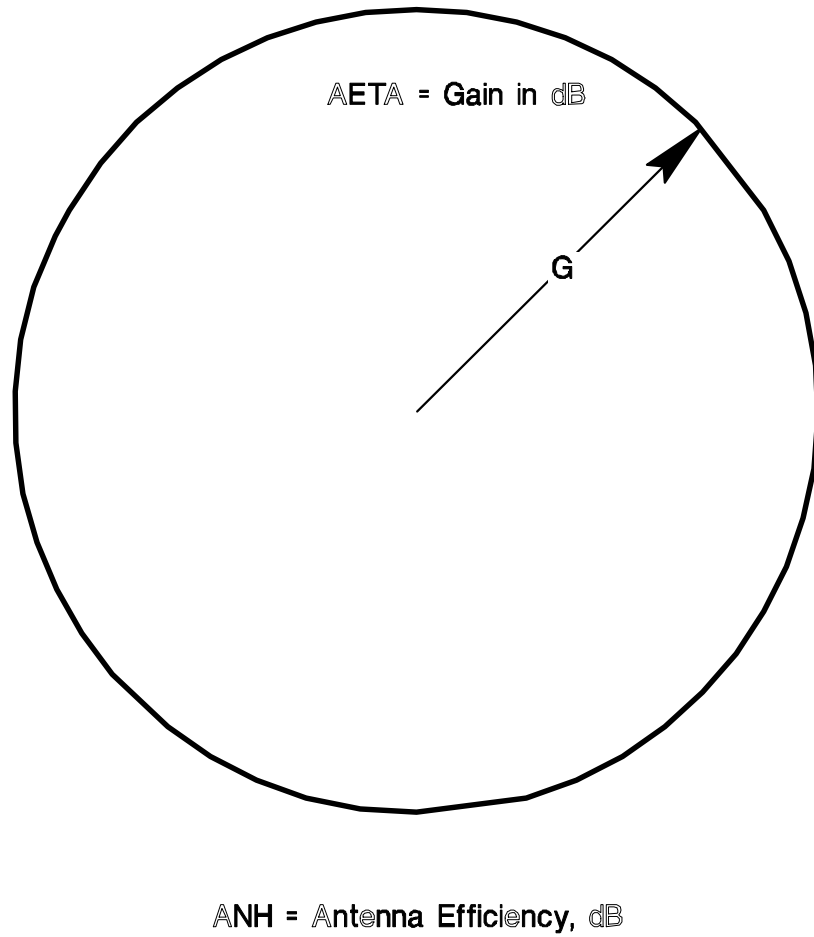


Fig. 49 Constant gain pictorial pattern (12).

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METHOD 13 ICEPAC IC.10 PAGE 21

ITSA 1 ANTENNA PACKAGE			ANTENNA PATTERN								
FREQUENCY RANGE		ANTENNA TYPE				HEIGHT	LENGTH			ANGLE	
2.0 TO	30.0	CONST. GAIN				.000	.000			.000	
2	3	4	5	6	7	8	9	10	11		
90	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
88	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
86	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
84	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
82	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
80	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
78	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
76	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
74	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
72	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
E 70	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
L 68	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
E 66	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
V 64	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
A 62	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
T 60	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
I 58	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
O 56	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
N 54	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
52	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
A 50	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
N 48	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
G 46	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
L 44	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
E 42	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
40	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
I 38	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
N 36	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
34	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
D 32	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
E 30	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
G 28	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
R 26	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
E 24	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
E 22	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
S 20	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
18	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
16	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
14	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
12	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
10	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
8	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
6	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
4	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
2	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	2	3	4	5	6	7	8	9	10	11	
FREQUENCY IN MEGAHERTZ											
ANTENNA EFFICIENCY											
.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	
2	3	4	5	6	7	8	9	10	11		
FREQUENCY IN MEGAHERTZ											

Figure 50. Constant gain pattern.

AZIMUTH		EX(1)	EX(2)		EX(3)		EX(4)	CONDUCT.		DIELECT.	
.000		.000	.000		.000		.000	.001		4.000	
12	13	14	16	18	20	22	24	26	28	30	
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	90
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	88
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	86
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	84
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	82
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	80
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	78
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	76
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	74
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	72
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	70
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	68
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	66
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	64
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	62
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	60
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	58
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	56
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	54
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	52
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	50
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	48
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	46
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	44
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	42
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	40
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	38
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	36
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	34
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	32
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	30
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	28
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	26
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	24
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	22
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	20
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	18
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	16
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	14
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	12
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	8
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	6
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	4
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	2
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	0
12	13	14	16	18	20	22	24	26	28	30	
FREQUENCY IN MEGAHERTZ											
ANTENNA EFFICIENCY											
.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	
12	13	14	16	18	20	22	24	26	28	30	
FREQUENCY IN MEGAHERTZ											

Figure 50a. Constant gain pattern continued.

ITSA 1	ANTENNA PACKAGE				ANTENNA PATTERN		ANGLE			
	FREQUENCY RANGE	ANTENNA TYPE		HEIGHT	LENGTH					
2.0 TO	30.0	CONST.	GAIN	-1.900	.000					
2	3	4	5	6	7	8	9	10	11	
90	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
88	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
86	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
84	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
82	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
80	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
78	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
76	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
74	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
72	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
E 70	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
L 68	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
E 66	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
V 64	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
A 62	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
T 60	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
I 58	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
O 56	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
N 54	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
52	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
A 50	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
N 48	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
G 46	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
L 44	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
E 42	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
40	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
I 38	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
N 36	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
34	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
D 32	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
E 30	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
G 28	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
R 26	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
E 24	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
E 22	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
S 20	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
18	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
16	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
14	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
12	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
10	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
8	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
6	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
4	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
2	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
0	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
	2	3	4	5	6	7	8	9	10	11

FREQUENCY IN MEGAHERTZ

ANTENNA EFFICIENCY										
-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9
2	3	4	5	6	7	8	9	10	11	

FREQUENCY IN MEGAHERTZ

Figure 51. Constant gain receiver antenna with antenna efficiency.

AZIMUTH		EX(1)		EX(2)		EX(3)		EX(4)		CONDUCT.		DIELECT.	
.000		.000		.000		.000		.000		.001		4.000	
12	13	14	16	18	20	22	24	26	28	30			
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	90
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	88
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	86
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	84
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	82
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	80
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	78
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	76
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	74
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	72
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	70
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	68
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	66
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	64
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	62
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	60
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	58
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	56
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	54
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	52
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	50
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	48
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	46
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	44
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	42
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	40
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	38
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	36
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	34
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	32
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	30
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	28
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	26
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	24
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	22
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	20
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	18
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	16
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	14
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	12
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	10
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	6
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	4
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	2
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	0
12	13	14	16	18	20	22	24	26	28	30			
FREQUENCY IN MEGAHERTZ													
ANTENNA EFFICIENCY													
-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9
12	13	14	16	18	20	22	24	26	28	30			
FREQUENCY IN MEGAHERTZ													

Figure 51a. Constant gain receiver antenna with antenna efficiency continued.

**TABLE 1. Files on Distribution Disks**

File #	File Name	Type	Description
1.	ICEPAC.EXE	Binary	ICEPAC program execution module
2.	IONINP.DAT	ASCII	Sample input data file
3.	BCOEF01.DAT	Binary	Long term input data for January
4.	BCPEF02.DAT	Binary	Long term input data for February
5.	BCOEF03.DAT	Binary	Long term input data for March
6.	BCOEF04.DAT	Binary	Long term input data for April
7.	BCOEF05.DAT	Binary	Long term inptp data for May
8.	BCOEF06.DAT	Binary	Long term input data for June
9.	BCOEF07.DAT	Binary	Long term input data for July
10.	BCOEF08.DAT	Binary	Long term input data for August
11.	BCOEF09.DAT	Binary	Long term input data for September
12.	BCOEF10.DAT	Binary	Long term input data for October
13.	BCOEF11.DAT	Binary	Long term input data for November
14.	BCOEF12.DAT	Binary	Long term input data for December
15.	CGLALOB.DAT	Binary	Corrected geomagnetic file
16.	IONPC.LST	ASCII	Output file formatted for output to printer

**TABLE 2. Valid Name Identifier**

IDENTIFIER	DESCRIPTION OF INPUT PARAMETERS
METHOD	Program run option and beginning page number
MONTH	Year and month
SUNSPOT	12 month smoothed mean sunspot number and effective Q index
CIRCUIT	Transmitter-receiver locations
SYSTEM	Power, noise, min. angle, req. reliability, SNR, time delay and power increment for multipath
TIME	Time of day loop (and indicator for LMT or UT)
ANTENNA	Transmitter or receiver, antenna type and parameters
FREQUENCY	Operating frequencies
LABEL	Alphanumeric label for identification
INTEGRATE	.GE. 0 will do a fast integration when no F1 is present
EXECUTE	Execute program with parameters currently set
SAMPLE	Optional geophysical samples (for a specified area)
EFVAR	Optional E, F1 and F2 parameters (for a specified area)
EDP	True heights and electron density (for a specified area)
ANTOUT	Write antenna patterns on a file
OUTGRAPH	Request output of several methods
COMMENT	Comment line in user defined input
QUIT	Termination of program execution
FPROB	Critical frequency multipliers
TOPLINES	User specified heading lines (for method 23)
BOTLINES	User specified output lines (for method 23)

**TABLE 3. Available Output Methods**

METHOD	DESCRIPTION OF METHOD
1.	Ionospheric parameters
2.	Ionograms
3.	MUF - FOT lines (nomogram)
4.	MUF - FOT graph
5.	HPF - MUF - FOT graph
6.	MUF - FOT - Es graph
7.	FOT - MUF table (full ionosphere)
8.	MUF - FOT graph
9.	HPF - MUF - FOT graph
10.	MUF - FOT - ANG graph
11.	MUF - FOT - Es graph
12.	MUF by magnetic indices, K (not implemented)
13.	Transmitter antenna pattern
14.	Receiver antenna pattern
15.	Both transmitter and receiver antenna patterns
16.	System performance (S.P.)
17.	Condensed system performance, reliability
18.	Condensed system performance, service probability
19.	Propagation path geometry
20.	Complete system performance (C.S.P.)
21.	Forced long path model (C.S.P.)
22.	Forced short path model (C.S.P.)
23.	User selected output lines (set by TOPLINES and BOTLINES)
24.	MUF-REL table
25.	All modes table
26.	MUF - LUF - FOT table (nomogram)
27.	FOT - LUF graph
28.	MUF - FOT - LUF graph
29.	MUF - LUF graph

**Table 4. Required SNR's for Radiotelephone Service**

Radio Telephone Description	GRADE OF SERVICE*			
	Operator-to-Operator**		Good Commercial Quality	
	No Diversity	Dual Diversity	No Diversity	Dual Diversity
6A3 Double Sideband - AM	51	48	75	70
3A3 Single Sideband - AM				
3A3a (reduced carrier)	49	46	73	68
3A3j (suppressed carrier)	48	45	72	67
6A3 Independent Sideband - AM				
6A3B (2-voice channels)	50	47	74	69
9A3B (3-voice channels)	50	47	74	69
12A3b (4-voice channels)	51	48	75	70

\* Required signal-to-Noise Ratio in occupied bandwidth relative to noise in a 1 Hz bandwidth (dB).

\*\* For 90% intelligibility of related words.



**TABLE 5. REQUIRED SNR'S FOR RADIOTELETYPE SERVICE**

Type of Transmission	GRADE OF SERVICE*					
	Character Error Rate**					
	10 <sup>-2</sup>		10 <sup>-3</sup>		10 <sup>-4</sup>	
No Diversity	Dual Diversity	No Diversity	Dual Diversity	No Diversity	Dual Diversity	
<b>1.1F1</b>						
FSK, 60 WPM, 1500-Hz filter						
Start-Stop	55	51	62	58	68	63
Synchronous	50	47	59	54	65	60
<b>3A7J</b>						
SSB, Supressed carrier 16- teletype subchannels each subchannel ±42.5 Hz FSK, 110-Hz filter, 100 WPM, 5 unit						
Start-Stop						
Synchronous	63	59	70	65	76	70
<b>6A9b</b>	58	54	66	62	73	68
ISB, 1-voice channel and 16-teletype subchannels each subchannel ±42.5 Hz, FSK, 110-Hz filter, 100 WPM						
Start-Stop						
Synchronous	64	60	71	66	77	71
<b>12A9b</b>	59	55	67	63	74	69
ISB, 2-voice channels and 32-teletype subchannels, each subchannel ±42.5 Hz, FSK, 110-filter, 100 WPM						
Start-Stop	66	62	73	68	79	73
Synchronous	61	57	69	65	76	71

\* Required Signal-to-Noise Ratio in occupied bandwidth relative to noise in a 1 HZ bandwidth (db)

\*\* 5-unit code, no error control schemes  
Power assumed equally divided between channels

TABLE 6. Typical Values of Ground Electrical Characteristics

GROUND TYPE	CONDUCTIVITY	DIELECTRIC CONSTANT
Sea Water	5.0 mhos/m	80
Good Ground	0.01	10
Poor Ground and Sea Ice	0.001	4
Polar Ice Cap	0.0001	1
Fresh Water	0.002	80

TABLE 7. OUTPUT COMBINATIONS FOR THE OUTGRAPH COMMAND

METHOD	OUTGRAPH COMMAND
PROGRAM TASK OPTION*	ADDITIONAL OUTPUT AVAILABLE FOR THE SPECIFIED TASK OPTION (SPECIFIED ON OUTGRAPH COMMAND)
3	4 5 6
4	3 5 6
5	3 4 6
6	3 4 5
7	8 to 11
8	9 to 11
9	8, 10, 11
10	8, 9, 11
11	8 to 10
16 to 25	8 to 11, 26 to 29**
26	8 to 11, 27 to 29
27	8 to 11, 26, 28, 29
28	8 to 11, 26 to 29
29	8 to 11, 26 to 28
30	

\* Optimal program task options for additional output.

\*\* LUF values set by first frequency in the frequency complement which has a computed reliability that is greater than or equal to the required system reliability. If none of the computed reliabilities are at least as large as that required, the frequency with the greatest reliability is chosen and a designator is printed to indicate the reliability. (Note that this occurs only when the user specifies 26 to 29 on the OUTGRAPH line and 16 to 25 on the METHOD command. The actual computed values for LUF are printed when the user specifies 26 to 29 on the outgraph line and 26 to 29 on the METHOD command.)

TABLE 8. Header Line Options for the TOPLINES Command

LINTP	DESCRIPTION OF HEADER LINE
1	Month, year, and sunspot number
2	Alphanumeric information on the label command
3	Transmitter and receiver information consisting of coordinates, azimuth, and great circle distance (in kilometers and nautical miles)
4	Minimum take-off angle (in degrees)
5	Transmitter antenna information consisting of the operating frequency range, antenna type (in mnemonics), height*, length*, off-azimuth angle, conductivity, dielectric constant as well as other antenna characteristics
6	Receiver antenna information consisting of the operating frequency range, antenna type (in mnemonics), height*, length*, off-azimuth angle, conductivity, dielectric constant as well as other antenna characteristics
7	Power, 3 MHz man-made noise, required reliability and required SNR
8	Multipath power tolerance and delay time tolerance

\*Height and length given in meters if positive and wavelength if negative

Table 9. System Performance Output Line Options for the BOTLINES Command

<u>LINEBDOUTPUT</u>	<u>MNEMONIC</u>	<u>VARIABLE DESCRIPTION</u>
1	MODE*	Number of hops for MUF and mode type
	MODE**	Mode type at transmitter end and at receiver end
2	ANGLE*	Radiation angle at transmitter, degrees
	ANGLE**	Radiation angle at transmitter and receiver end, degrees
3	DELAY	Time delay most reliable mode (MRM), milliseconds
4	V HITE	Virtual height MRM, kilometers
5	F DAYS	Prob. operating frequency exceeds the predicted MUF
6	LOSS	Median system loss, MRM, dB
7	DBU	Field strength, median, dBu
8	SDBW	Signal power, median, dBw
9	NDBW	Noise strength, median, dBw
10	SNR	Median SNR, dB
11	RPWRG	Required power gain for MRM, db
12	REL	Reliability
13	MPROB	Multipath probability (short paths only)
14	SPRB	Service probability
15	SIGLW	Signal (loss), lower decile, dB
16	SIGUP	Signal (loss), upper decile, dB
17	VHFDBU	VHF field strength, median, dBu
18	VHFLW	VHF field strength, lower decile, dB
19	VHFUP	VHF field strength, upper decile, dB
20	VHFMOD	VHF mode type
21	SNRLW	SNR, lower decile, dB
22	SNRUP	SNR, upper decile, dB

\* if short path

\*\* if long path

TABLE 10. SYSTEM PERFORMANCE OUTPUT LINE OPTIONS AS  
PRESET BY THE METHOD NUMBER

METHOD	LINES	DESCRIPTION
16	1 to 13	Detailed system performance
17	1, 2, 5, 7, 10, 12	Condensed S.P. with reliability
18	1, 2, 5, 7, 10, 14	Condensed S.P. with service prob.
19	1, 2, 3, 4, 5	Propagation path geometry
20	1 to 22 (all)	Complete S.P. output
21	1 to 16	Force long path submodule
22	1 to 16	Force short path submodule

TABLE 11. INPUT DATA REQUIRED FOR OUTPUT METHODS

DATA #	DESCRIPTION	OUTPUT/RUN TYPES			
1.	A YEAR OR SSN	R		R	R
	B MONTH	R		R	R
	C TRANSMITTER SITE, $\sigma$ , $\epsilon$		R	R	
	D RECEIVER SITE, $\sigma$ , $\epsilon$		R		
2.	A METHOD	R	R	R	R
	B BEGINNING HOUR	R			
	C END HOUR	R		R	R
	D HOUR INCREMENT	R		R	R
	E ANTENNA PATTERN				R
	F GREAT CIRCLE PATH	R		R	R
	G HEADER LINES				?
	H SYS. PER. LINES				?
3.	FREQUENCY COMP.				R
4.	A TRANSMITTER SITE	R	*	R	R
	B RECEIVER SITE	R	**	R	R
	C MIN. TAKE-OFF ANGLE			R	R
	D POWER				R
	E REQUIRED SNR				R
	F NOISE				R
	G REQUIRED RELIABILITY				?
	H MULTIPATH				?
	I MULTIPATH POWER				?
	J MULTIPATH TIME				?
5.	ANTENNA TYPES			R	R
6.	TRANSMITTING ANTENNAS			R	R
7.	RECEIVING ANTENNAS			R	R

where R denotes required  
 ? required only if that output is requested

\* Transmitter site is an optional requirement for Methods 13 and 15 if the transmitter antenna orientation is not off-azimuth from path.

\*\* Receiver site is an optional requirement for Methods 14 and 15 if the receiver antenna orientation is not off-azimuth from path.

TABLE 12. CALCULATION OF AN EFFECTIVE Kp VALUE

$Q_e$	$K_{peff}$
$Q_e \leq 0$	0.0
$Q_e < 2.0$	0.0
$2.0 \leq Q_e < 3.0$	$1.5 - (2.0 * (Q_e - 3.0) ** 2) / (Q_e = 3.0)$
$3.0 \leq Q_e < 6.0$	$Q_e - 1.5$
$6.0 \leq Q_e < 8.0$	$1.7 + 2/3 Q_e$
$8.0 \leq Q_e$	7.0

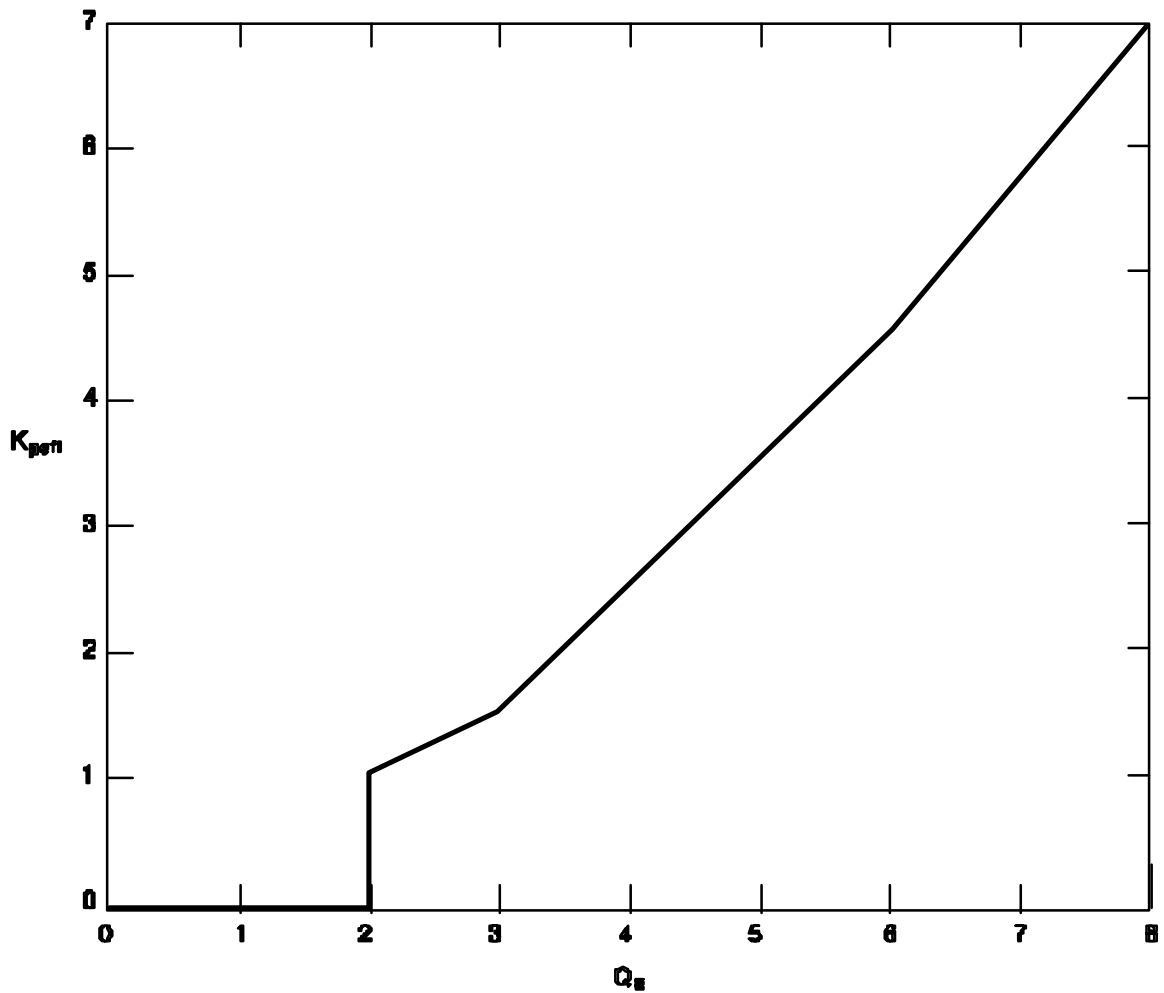


Fig. 52 Effective Kp Index as a function of effective Q index.



1. METHOD Command Line (3.3.1)

Columns	Name	Format	Description of Input Data
1-10		A10	"METHOD" command
11-15	Method	15	Program task option, 1 to 30

2. MONTH Command Line (3.3.1)

Columns	Name	Format	Description of Input Data
1-10		A10	"MONTH" command
11-15	NYEAR	I5	Year
16-20	MONTH	I5	Month where January is represented by 1, February by 2, etc.

3. SUNSPOT Command Line (3.3.2)

Columns	Name	Format	Description of Input Data
1-10		A10	"SUNSPOT" command
11-15	SSN	F5.1	12 month smooth mean sunspot #
16-20	EFFQ	F5.1	Effective Q value

4. CIRCUIT Command Line (3.3.3)

Columns	Name	Format	Description of Input Data
1-10		A10	"CIRCUIT" command
11-15	TLATD	F5.2	Latitude of transmitter, degrees
16	ITLAT	A1	N = north, S = south
21-25	TLONGD	F5.2	Longitude of transmitter, degrees
26	ITLONG	A1	E = east, W = west
31-35	RLATD	F5.2	Latitude of receiver, degrees
36	IRLAT	A1	N = north, S = south
41-45	RLONGD	F5.2	Longitude of receiver, degrees
46	IRLONG	A1	E = east, W = west
51-55	NPSL	I5	0 = shortpath, 1 = longpath

5. SYSTEM Command Line (3.3.3)

Columns	Name	Format	Description of Input Data
1-10		A10	"SYSTEM" command
11-15	PWR	F5.2	Transmitter power, kilowatts
16-20	XNOISE	F5.0	Man-made noise in dB below a watt (-dBW); -1 is industrial (125), -2 is residential (136), -3 is rural (148), -4 is remote (164)*
21-25	AMIND	F5.2	Minimum radiation angle, degrees
26-30	XLUFP	F5.0	Required reliability, percent
31-35	RSN	F5.2	Required SNR, dB
36-40	PMP	F5.2	Multipath power tolerance, dB
41-45	DMPX	F5.2	Multipath time delay increment, milliseconds
			*The user may indicate other man-made noise values by specifying a positive value in this field.

6. TIME Command Line (3.3.2)

Columns	Name	Format	Description of Input Data
1-10		A10	"TIME" command
11-15	IHRO	I5	Start time, hours
16-20	IHRE	I5	Stop time, hours
21-25	IHRS	I5	Hour increment, hours
26-30	ITIM	I5	If negative LMT at transmitter, otherwise UT

7. FREQUENCY Command Line (3.3.3)

Columns	Name	Format	Description of Input Data
1-10		A10	"FREQUENCY" command
11-15	FREL(1)	F5.2	Array of up to 11 frequencies, MHz,
16-20	FREL(2)	F5.2	if FREL(1) is zero, then the FOT replaces FREL(1)
21-25	FREL(3)	F5.2	
26-30	FREL(4)	F5.2	
31-35	FREL(5)	F5.2	
36-40	FREL(6)	F5.2	
41-45	FREL(7)	F5.2	
46-50	FREL(8)	F5.2	
51-55	FREL(9)	F5.2	
56-60	FREL(10)	F5.2	
61-65	FREL(11)	F5.2	

8. LABEL Command Line (3.3.3)

Columns	Name	Format	Description of Input Data
1-10		A10	"LABEL" command
11-20	ITRAN(1)	A10	For output identification only
21-30	ITRAN(2)	A10	For output identification only
31-40	IRCVR(1)	A10	For output identification only
41-50	IRCVR(2)	A10	For output identification only

9. INTEGRATE Command Line (3.3.4)

Columns	Name	Format	Description of Input Data
1-10		A10	"INTEGRATE" command
11-15	INTEG	I5	$\geq 0$ indicates fast integration; $< 0$ indicates Gaussian integration
	-or-		
11-20	ITEMP	A10	"OFF" indicates return to fast integration

10. EXECUTE Command Line (3.3.1)

Columns	9 Name	Format	Description of Input Data
1-10		A10	"EXECUTE" command
11-15	KRUN	I5	3 = no indices calculation; 2 = Es indices only; 1 = E, F1, F2 indices only; 0 = E, F1, F2, Es indices. (default is KRUN = 0 which indicates indices are calculated for each ionospheric layer)

11. EFVAR Command Line (3.3.4)

Columns	Name	Format	Description of Input Data
1-10		A10	"EFVAR" command
11-15	I	I5	Sample area 1 to 5
16-20	FI(1,I)	F5.2	foE, MHz
21-25	YI(1,I)	F5.1	ymE, km
26-30	HI(1,I)	F5.1	hmE, km
31-35	FI(2,I)	F5.2	foF1, MHz
36-40	YI(2,I)	F5.1	ymF1, km
41-45	HI(2,I)	F5.1	hmF1, km
46-50	FI(3,I)	F5.2	foF2, MHz
51-55	YI(3,I)	F5.1	ymF2, km
56-60	HI(3,I)	F5.1	hmF2, km

12. ESVAR Command Line (3.3.4)

Columns	Name	Format	Description of Input Data
1-10		A10	"ESVAR" command
11-15	I	I5	Sample area 1 to 5
16-20	FS(1,I)	F5.2	foEs, lower decile, MHz = lowest value, e.g., 2
21-25	FS(2,I)	F5.2	foEs median, e.g., 4., MHz
26-30	FS(3,I)	F5.1	foEs upper decile, MHz = highest value, e.g., 6.
31-35	HS(I)	F5.1	Virtual height of reflection, km, e.g., 110

13. EDP Command Line (3.3.4)

Columns	Name	Format	Description of Input Data
1-10		A10	"EDP" command
11-15	JSAMP	I5	Must = 1 (limitation on current implementation)
16-25	ITEMP	A10	If "OFF" return to use calculated EDP
			If not "OFF" followed by 8 lines; first four contain heights, second four contain square of plasma frequency

13a. Data for external electron density profile (3.3.4)

Columns	Name	Format	Description of Input Data
1-5	HTR(1)	F5.2	True heights, kilometers
6-10	HTR(2)	F5.2	
	.		
	.		
	.		Four lines containing 50 values

13b. Data for external electron density profile (3.3.4)

Columns	Name	Format	Description of Input Data
1-5	FNSQ(1)	F5.2	Plasma frequency squared (MHz) <sup>2</sup>
6-10	FNSQ(2)	F5.2	
	.		
	.		
	.		Four lines containing 50 values

14. ANTOUT Command Line (3.3.5)

Columns	Name	Format	Description of Input Data
1-10		A10	"ANTOUT" command
11-13	ITEMP	A3	If = "OFF" do not output any antenna patterns, otherwise pattern will be output to file
15-24	AOUTPT	A20	File name for antenna output

15. COMMENT Command Line (3.3.5)

Columns	Name	Format	Description of Input Data
1-10		A10	"COMMENT" command
11-80			User inserts description of the input file or other remarks and comments; not internally read by program

16. QUIT Command Line (3.3.1)

Columns	Name	Format	Description of Input Data
1-10		A10	"QUIT" command

17. OUTGRAPH Command Line (3.3.5)

Columns	Name	Format	Description of Input Data
1-10		A10	"OUTGRAPH" command
11-15	KTOUT(1)	I5	Indicates additional "methods" of desired graphical output (specify 1 to 12 methods)
16-20	KTOUT(2)	I5	
21-25	KTOUT(3)	I5	
26-30	KTOUT(4)	I5	(See Table 7 for valid output combinations)
31-35	KTOUT(5)	I5	
36-40	KTOUT(6)	I5	
41-45	KTOUT(7)	I5	
46-50	KTOUT(8)	I5	
51-55	KTOUT(9)	I5	
56-60	KTOUT(10)	I5	
61-65	KTOUT(11)	I5	
66-70	KTOUT(12)	I5	
	-OR-		
11-20	ITEMP	A10	If = "OFF", stop additional output

18. FPROB Command Line (3.3.4)

Columns	Name	Format	Description of Input Data
1-10		A10	"FPROB" command
11-15	PSC(1)	F5.1	Multiplier for foE > 0
16-20	PSC(2)	F5.1	Multiplier for foF1
21-25	PSC(3)	F5.S	Multiplier for foF2 > 0
26-30	PSC(4)	F5.1	Multiplier for foEs
	-OR-		
11-20	ITEMP	A10	"OFF" returns to default values of 1.0, 1.0, 1.0, 0.7. The values for foE and foF2 must be positive.

19. TOPLINES Command Line (3.3.5)

Columns	Name	Format	Description of Input Data
1-10		A10	"TOPLINES" command
11-15	LINTP(1)	I5	Header line number; 1 to 8 (refer to table 8 for description)
16-20	LINTP(2)	I5	Program will print those header lines specified when method 23 is used
21-25	LINTP(3)	I5	
26-30	LINTP(4)	I5	
31-35	LINTP(5)	I5	
36-40	LINTP(6)	I5	
41-45	LINTP(7)	I5	
46-50	LINTP(8)	I5	
51-55	LINTP(9)	I5	
56-60	LINTP(10)	I5	
61-65	LINTP(11)	I5	
66-70	LINTP(12)	I5	
71-75	LINTP(13)	I5	
76-80	LINTP(14)	I5	
11-20	ITEMP	A10	"OFF" indicates to discontinue printing the header line(s) specified on a previous "TOPLINES" command.



20. BOTLINES Command Line (3.3.5)

Columns	Name	Format	Description of Input Data
1-10		A10	"BOTLINES" command
11-15	LINBD(1)	I5	Line number, 1 to 22 (indicate parameter to output, see Table 9) when method 23 is used
16-20	LINBD(2)	I5	
21-25	LINBD(3)	I5	
26-30	LINBD(4)	I5	
31-35	LINBD(5)	I5	
36-40	LINBD(6)	I5	
41-45	LINBD(7)	I5	
46-50	LINBD(8)	I5	
51-55	LINBD(9)	I5	
56-60	LINBD(10)	I5	
61-65	LINBD(11)	I5	
66-70	LINBD(12)	I5	
71-75	LINBD(13)	I5	
76-80	LINBD(14)	I5	
11-20	ITEMP	A10	"OFF" indicates to discontinue printing the parameter(s) specified on a previous "BOTLINES" command

21. ANTENNA COMMAND, TERMINATED RHOMBIC

Columns	Name	Format	Description of Input Data
1-10		A10	"ANTENNA" 1
11-15	IAT	I5	1 for transmitter, 2 for receiver
16-20	IANTR	I5	Antenna type = 1
21-25	AETA	F5.1	Bearing of antenna, degrees, E of N
26-30	ASIG	F5.1	Ground conductivity, mhos/m
31-35	AEPS	F5.1	Relative dielectric constant
36-40	AND	F5.1	Tilt angle, degrees (1/2 the large interior angle)
41-45	ANL	F5.1	Antenna leg length, meters (wavelengths if negative)
46-50	ANH	F5.1	Antenna height, meters (wavelengths if negative)
51-55			Not used for this antenna
56-60			Not used for this antenna
61-65			Not used for this antenna
66-70			Not used for this antenna
71-75	AFQB	F5.1	Ending frequency when more than one antenna is used
76-80	IAIN	I5	Antenna number indicator (each transmitter or receiver antenna can be defined by up to three different antennas over the frequency range; default is one, if IAIN is left blank.

22. ANTENNA COMMAND, VERTICAL MONOPOLE

Columns	Name	Format	Description of Input Data
1-10		A10	"ANTENNA" 2
11-15	IAT	I5	1 for transmitter, 2 for receiver
16-20	IANTR	I5	Antenna type = 2
21-25			Not used for this antenna
26-30	ASIG	F5.1	Ground conductivity, mhos/m
31-35	AEPS	F5.1	Relative dielectric constant
36-40			Not used for this antenna
41-45	ANL	F5.1	Antenna height, meters (wavelengths if negative)
46-50	ANH	F5.1	Gain above a dipole, dB
51-55			Not used for this antenna
56-60			Not used for this antenna
61-65			Not used for this antenna
66-70			Not used for this antenna
71-75	AFQB	F5.1	Ending frequency when more than one antenna is used
76-80	IAIN	I5	Antenna number indicator (each transmitter or receiver antenna can be defined by up to three different antennas over the frequency range; default is one, if IAIN is left blank.

23. ANTENNA COMMAND, HORIZONTAL DIPOLE

Columns	Name	Format	Description of Input Data
1-10		A10	"ANTENNA" 3
11-15	IAT	I5	1 for transmitter, 2 for receiver
16-20	IANTR	I5	Antenna type = 3
21-25	AETA	F5.1	Bearing, degrees E of N
26-30	ASIG	F5.1	Ground conductivity, mhos/m
31-35	AEPS	F5.1	Relative dielectric constant
36-40			Not used for this antenna
41-45	ANL	F5.1	Antenna length, meters (wavelengths if negative)
46-50	ANH	F5.1	Antenna height, meters (wavelengths if negative)
51-55	AEX(1)	F5.1	Gain above 1/2 wavelength horizontal dipole, dB
56-60			Not used for this antenna
61-65			Not used for this antenna
66-70			Not used for this antenna
71-75	AFQB	F5.1	Ending frequency when more than one antenna is used
76-80	IAIN	I5	Antenna number indicator (each transmitter or receiver antenna can be defined by up to three different antennas over the frequency range; default is one, if IAIN is left blank.

24. ANTENNA COMMAND, HORIZONTAL YAGI

Columns	Name	Format	Description of Input Data
1-10		A10	"ANTENNA" 4
11-15	IAT	I5	1 for transmitter, 2 for receiver
16-20	IANTR	I5	Antenna type = 4
21-25	AETA	F5.1	Bearing of antenna, degrees E of N
26-30	ASIG	F5.1	Ground conductivity, mhos/m
31-35	AEPS	F5.1	Relative dielectric constant
36-40			Not used for this antenna
41-45	ANL	F5.1	Antenna length, meters (wavelengths if negative)
46-50	ANH	F5.1	Antenna height, meters (wavelengths if negative)
51-55	AEX(1)	F5.1	Gain above 1/2 wavelength horizontal dipole, dB
56-60			Not used for this antenna
61-65			Not used for this antenna
66-70			Not used for this antenna
71-75	AFQB	F5.1	Ending frequency when more than one antenna is used
76-80	IAIN	I5	Antenna number indicator (each transmitter or receiver antenna can be defined by up to three different antennas over the frequency range; default is one, if IAIN is left blank.

25. ANTENNA COMMAND, VERTICAL LOG PERIODIC ARRAY OF MONOPOLES

Columns	Name	Format	Description of Input Data
1-10		A10	"ANTENNA" 5
11-15	IAT	I5	1 for transmitter, 2 for receiver
16-20	IANTR	I5	Antenna type = 5
21-25			Not used for this antenna
26-30	ASIG	F5.1	Ground conductivity, mhos/m
31-35	AEPS	F5.1	Relative dielectric constant
36-40			Not used for this antenna
41-45	ANL	F5.1	Antenna height, must be 1/4 wavelength (-.25)
46-50			
51-55	AEX(1)	F5.1	Gain above 1/4 wavelength vertical
56-60			Not used for this antenna
61-65			Not used for this antenna
66-70			Not used for this antenna
71-75	AFQB	F5.1	Ending frequency when more than one antenna is used
76-80	IAIN	I5	Antenna number indicator (each transmitter or receiver antenna can be defined by up to three different antennas over the frequency range; default is one, if IAIN is left blank.

26. ANTENNA COMMAND, CURTAIN ANTENNA

Columns	Name	Format	Description of Input Data
1-10		A10	"ANTENNA" 6
11-15	IAT	I5	1 for transmitter, 2 for receiver
16-20	IANTR	I5	Antenna type = 6
21-25	AETA	F5.1	Antenna bearing degrees E of N
26-30	ASIG	F5.1	Ground conductivity, mhos/m
31-35	AEPS	F5.1	Relative dielectric constant
36-40	AND	F5.1	Number of bays
41-45	ANL	F5.1	Antenna element length, meters
46-50	ANH	F5.1	Antenna height to first element, meters
51-55	AEX(1)	F5.1	Number of elements per bay
56-60	AEX(2)	F5.2	Distance between elements centers, meters
61-65	AEX(3)	F5.1	Vertical spacing of elements, meters
66-70	AEX(4)	F5.1	Distance from screen, meters
71-75	AFQB	F5.1	Ending frequency when more than one antenna is used
76-80	IAIN	I5	Antenna number indicator (each transmitter or receiver antenna can be defined by up to three different antennas over the frequency range; default is one, if IAIN is left blank.

27. ANTENNA COMMAND, TERMINATED SLOPING VEE

Columns	Name	Format	Description of Input Data
1-10		A10	"ANTENNA" 7
11-15	IAT	I5	1 for transmitter, 2 for receiver
16-20	IANTR	I5	Antenna type = 7
21-25	AETA	F5.1	Bearing of antenna degrees E of N
26-30	ASIG	F5.1	Ground conductivity, mhos/m
31-35	AEPS	F5.1	Relative dielectric constant
36-40	AND	F5.1	1/2 apex angle in plane of wires
41-45	ANL	F5.1	Antenna leg length, meters
46-50	ANH	F5.1	Antenna height, meters
51-55	AEX(1)	F5.1	Terminated height
56-60			Not used for this antenna
61-65			Not used for this antenna
66-70			Not used for this antenna
71-75	AFQB	F5.1	Ending frequency when more than one antenna is used
76-80	IAIN	I5	Antenna number indicator (each transmitter or receiver antenna can be defined by up to three different antennas over the frequency range; default is one, if IAIN is left blank.



28. ANTENNA COMMAND, INVERTED L

Columns	Name	Format	Description of Input Data
1-10		A10	"ANTENNA" 8
11-15	IAT	I5	1 for transmitter, 2 for receiver
16-20	IANTR	I5	Antenna type = 8
21-25	AETA	F5.1	Antenna bearing degrees E of N
26-30	ASIG	F5.1	Ground conductivity, mhos/m
31-35	AEPS	F5.1	Relative dielectric constant
36-40			Not used for this antenna
41-45	ANL	F5.1	Antenna length, meters
46-50	ANH	F5.1	Antenna height, meters
51-55			Not used for this antenna
56-60			Not used for this antenna
61-65			Not used for this antenna
66-70			Not used for this antenna
71-75	AFQB	F5.1	Ending frequency when more than one antenna is used
76-80	IAIN	I5	Antenna number indicator (each transmitter or receiver antenna can be defined by up to three different antennas over the frequency range; default is one, if IAIN is left blank.

29. ANTENNA COMMAND, TERMINATED SLOPING RHOMBIC

Columns	Name	Format	Description of Input Data
1-10		A10	"ANTENNA" 9
11-15	IAT	I5	1 for transmitter, 2 for receiver
16-20	IANTR	I5	Antenna type = 9
21-25	AETA	F5.1	Antenna bearing degrees E of N
26-30	ASIG	F5.1	Ground conductivity, mhos/m
31-35	AEPS	F5.1	Relative dielectric constant
36-40	AND	F5.1	1/2 large interior angle in plane of wire
41-45	ANL	F5.1	Leg length, meters
46-50	ANH	F5.1	Antenna height, meters
51-55	AEX(1)	F5.1	Terminate height, meters
56-60			Not used for this antenna
61-65			Not used for this antenna
66-70			Not used for this antenna
71-75	AFQB	F5.1	Ending frequency when more than one antenna is used
76-80	IAIN	I5	Antenna number indicator (each transmitter or receiver antenna can be defined by up to three different antennas over the frequency range; default is one, if IAIN is left blank.

30. ANTENNA COMMAND, INTERLACED RHOMBIC

Columns	Name	Format	Description of Input Data
1-10		A10	"ANTENNA" 11
11-15	IAT	I5	1 for transmitter, 2 for receiver
16-20	IANTR	I5	Antenna type = 11
21-25	AETA	F5.1	Antenna bearing degrees E of N
26-30	ASIG	F5.1	Ground conductivity, mhos/m
31-35	AEPS	F5.1	Relative dielectric constant
36-40	AND	F5.1	1/2 large interior angle in plane of wire, degrees
41-45	ANL	F5.1	Leg length, meters
46-50	ANH	F5.1	Lower antenna height, meters
51-55	AEX(1)	F5.1	Vertical displacement, meters
56-60	AEX(2)	F5.1	Horizontal feed point displacement, meters
61-65			Not used for this antenna
66-70			Not used for this antenna
71-75	AFQB	F5.1	Ending frequency when more than one antenna is used
76-80	IAIN	I5	Antenna number indicator (each transmitter or receiver antenna can be defined by up to three different antennas over the frequency range; default is one, if IAIN is left blank.

31. ANTENNA COMMAND, CONSTANT GAIN

Columns	Name	Format	Description of Input Data
1-10		A10	"ANTENNA" 12
11-15	IAT	I5	1 for transmitter, 2 for receiver
16-20	IANTR	I5	Antenna type = 12
21-25	AETA	F5.1	Gain above isotropic, dB
26-30	ASIG	F5.1	Ground conductivity, mhos/m
31-35	AEPS	F5.1	Relative dielectric constant
36-40			Not used for this antenna
41-45			Not used for this antenna
46-50	ANH	F5.1	Antenna efficiency, dB
51-55			Not used for this antenna
56-60			Not used for this antenna
61-65			Not used for this antenna
66-70			Not used for this antenna
71-75	AFQB	F5.1	Ending frequency when more than one antenna is used
76-80	IAIN	I5	Antenna number indicator (each transmitter or receiver antenna can be defined by up to three different antennas over the frequency range; default is one, if IAIN is left blank.

32. ANTENNA COMMAND, ANTENNA READ FROM FILE

Columns	Name	Format	Description of Input Data
1-10		A10	"ANTENNA" 18
11-15	IAT	I5	1 for transmitter, 2 for receiver
16-20	IANTR	I5	Antenna type = 18
21-40			FILE NAME of antenna input file
76-80	IAIN	I5	Antenna type 18 If $IAIN \geq 0$ , then IAIN indicates the number of antennas to skip forward from position one on the antenna file before reading the desired pattern.

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