MF Broadcasting System Performance Model

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MF BROADCASTING SYSTEM PERFORMANCE MODEL

Eldon Haakinson, Susan Rothschild, and Brent Bedford*

An interactive program has been developed to evaluate the performance of medium frequency (MF) broadcasting systems. The model calculates both ground-wave and sky-wave signals. The user can select from three ground-wave methods: (1) smooth Earth, homogenous path; (2) smooth Earth, mixed path; and (3) irregular Earth, mixed path. The available sky-wave methods are: (1) FCC/Region 2, (2) CCIR, and (3) Wang. Three options are available for making the ground-wave and sky-wave predictions: (1) a point-to-point mode that allows the user to define all of the parameters and test the sensitivity of different parameters, (2) a point-to-point mode which compares the desired signal and interference signals at the reception point, and (3) an area mode that produces signal-to-interference or signal coverage plots. The program utilizes the characteristics of transmitting stations found in a Region 2 data base to make interference calculations. The program also incorporates a Region 2 ground conductivity data base, a Region 2 terrain elevations data base, and a worldwide atmospheric noise data base.

Key words: ground-wave propagation; MF antenna models; MF broadcasting; MF system characteristics; sky-wave propagation

1. INTRODUCTION

International broadcasting regulations have been developed to ensure compatible operation between broadcasters and to lessen potential interference to their listeners. The International Radio Consultative Committee (CCIR), under the International Telecommunication Union (ITU), has provided recommendations that assist administrations in developing telecommunication systems and managing the radio spectrum. Within the Western Hemisphere, administration members of the ITU have adopted radio regulations that pertain to their region of the world, specifically Region 2. Each administration in turn defines how a broadcast service is to be used within the confines of its country boundaries while conforming to the Region 2 radio regulations. Within the United States, the Federal Communications Commission (FCC) allocates and manages the broadcast spectrum.

If the CCIR recommendations, the ITU Region 2 radio regulations, and the FCC broadcast rules and regulations were all identical, then one broadcast system analysis method could be used to verify that a proposed station’s characteristics meet all of the

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national, regional, and international criteria. Unfortunately, interference requirements and propagation methods differ between the three levels of spectrum management. The Institute for Telecommunication Sciences (ITS) has developed a medium frequency (MF) broadcasting performance method covering the frequency band from 530 to 1750 kHz for the United States Information Agency's Voice of America (VOA). The model allows the VOA system planners to develop the characteristics of a proposed MF broadcast station and to ensure that the station satisfies different international criteria by selecting appropriate propagation methods.

In the next section of this report, the model in the ITS MF system analysis method is described. Following the description, the model organization, the prediction accuracies, and several sample problems are provided. The appendixes to this report describe the data bases, the channel occupancy algorithm, and the antenna algorithm needed and used by the model. The questions asked of the model user and their acceptable responses are also given in Appendix D.

2. MODEL DEVELOPMENT

2.1 System Performance

Due to changes in the ionosphere, an MF broadcast station has much greater signal coverage during the nighttime than during the daytime. While nighttime signal coverage is greater, the potential for interference to and from other stations is also greater at nighttime as compared to the daytime interference potential. During daytime, only ground-wave signals are considered in the analysis; whereas during the nighttime, both ground-wave and sky-wave signals must be considered. As will be shown, there are several acceptable methods to compute ground-wave and sky-wave signal strengths. The methods are described below and the model user has the option of selecting which methods are to be used during any particular analysis.

To study the performance of a proposed MF broadcast station, the analysis is divided into three phases: (1) initial parameter selection, (2) signal-to-interference calculations at the desired receiver location, and (3) signal coverage and signal-to-interference contour plots. For convenience, the three analysis methods for the three phases are called System 1, System 2, and System 3, respectively. The following paragraphs describe the purpose of each model.
System 1

System 1 allows the user to treat the MF broadcast circuit from the proposed transmitter to the desired receiver site as a point-to-point problem. The user is asked to select transmitter characteristics (including power, antenna configuration, etc.), site characteristics (including location, ground constants, etc.), receiver characteristics (including location, man-made noise environment, antenna type, etc.), and propagation models. Then with these initial parameter values, the field strength and received power at the receiver are calculated. Figure 1 shows a sample of the type of output System 1 provides.

<table>
<thead>
<tr>
<th>Season - Winter (December, January, February)</th>
<th>Ground-wave noise strength (dBW/Hz)</th>
<th>Sky-wave noise strength (dBW/Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local time - 1200</td>
<td>Rec'd power (dBuV/m)</td>
<td>Rec'd power (dBuV/m)</td>
</tr>
<tr>
<td>Site</td>
<td>10%</td>
<td>50%</td>
</tr>
<tr>
<td>Site</td>
<td>Rec'd power (dBm)</td>
<td>Rec'd power (dBm)</td>
</tr>
<tr>
<td>1</td>
<td>-122 -131 -138</td>
<td>57 -17</td>
</tr>
<tr>
<td>2</td>
<td>-122 -131 -138</td>
<td>42 -33</td>
</tr>
<tr>
<td>3</td>
<td>-122 -131 -138</td>
<td>30 -44</td>
</tr>
<tr>
<td>4</td>
<td>-122 -131 -138</td>
<td>20 -54</td>
</tr>
<tr>
<td>5</td>
<td>-122 -131 -138</td>
<td>11 -64</td>
</tr>
</tbody>
</table>

Figure 1. A sample output of System 1.

A complete sample of System 1 showing the input and associated output is given in Section 5 and Appendix E. The user can continue to modify any of the parameters with the purpose of testing the sensitivity of the parameters on the computed field strength or until the user believes an optimum set of transmitter parameter values has been achieved.

System 2

System 2 continues to treat the proposed transmitter and desired receiver site as a point-to-point problem but interference effects are included. All adjacent and co-channel transmitters within a user-specified search radius are used to compute signal-to-interference ratios at the receiver location. For each adjacent and co-channel transmitter, the model lists the computed signal-to-interference ratio as well as the amount the ratio exceeds or fails to exceed the required signal-to-interference ratio.
for the adjacent or co-channel case. Figure 2 shows a System 2 sample output. System 2 used the channel occupancy algorithm which is completely described in Appendix B.

**VOA MF Relay System Design model**

**Title:** VOA Test  
Proposed VOA transmit frequency: 1000 kHz  
Major population center to be covered: M  
VOA transmitter location: 1  
Daytime - groundwave predictions  
Groundwave method: Smooth earth

Noise at B is:
- 10% -119. dBW/Hz
- 50% -129. dBW/Hz
- 90% -136. dBW/Hz

Field strength from VOA transmitter at M is:

| Groundwave | 55.06 dBuV/m |

Figure 2. Sample output of System 2.

In the table portion of Figure 2 there are four columns labeled S/I, S/Ith - S/I, S/Smax, and S/(I+N). The value S refers to the proposed VOA transmitter's signal at the reception point and equals the ground-wave field strength during the daytime. At nighttime, S equals the maximum of the ground-wave field strength and the sky-wave field strength exceeded for 50 percent of the time. The value I refers to a non-VOA station whose characteristics are partially listed in the figure. For daytime calculations, I equals the ground-wave field strength. For nighttime calculations, I equals the root-sum-square (rss) value of the ground-wave signal and the sky-wave signal that is exceeded for 10 percent of the time. When S/I is greater than 0 dB, the desired VOA
transmitted signal is greater than the potential interference from the non-VOA station. Otherwise, when S/I is less than 0 dB, the non-VOA transmitted signal is greater than the VOA signal at the reception point. The next column, S/Ith - S/I, indicates how severe is the potential interference to the VOA signal.

S/Ith refers to the required signal-to-noise ratio threshold that is to be maintained to control objectionable interference. S/Ith is a function of frequency, and the relationship is given in Table 1.

<table>
<thead>
<tr>
<th>Interfering transmitter's frequency relative to desired transmitter's frequency (kHz)</th>
<th>Required signal-to-interference ratio to minimize objectionable interference S/Ith (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>26.0</td>
</tr>
<tr>
<td>5</td>
<td>29.0</td>
</tr>
<tr>
<td>10</td>
<td>0.0</td>
</tr>
<tr>
<td>15</td>
<td>-23.0</td>
</tr>
<tr>
<td>20</td>
<td>-29.5</td>
</tr>
<tr>
<td>25</td>
<td>-29.5</td>
</tr>
<tr>
<td>30</td>
<td>-29.5</td>
</tr>
</tbody>
</table>

In Figure 2, if the S/Ith - S/I value exceeds 0 dB then the interfering transmitter will cause objectionable interference to the proposed VOA transmitter's signal at the reception point. Values in this column that are less than 0 dB are not predicted to cause interference from the non-VOA station to the VOA station's signal. For example, the station whose call sign is XEMH is on frequency 970 kHz and the proposed VOA station is on 1000 kHz; the difference in carriers is 30 kHz. From Table 1, for a frequency difference of 30 kHz, the required S/I that is not expected to cause interference between the two stations is -29.5 dB; in this case, the interference can be 29.5 dB greater than the desired signal. The value in the S/I column shows a predicted -6.3 dB. Then S/Ith - S/I equals -29.5 - (-6.3) or -23.2 dB. The value is negative, so there is a safety margin of -23.2 dB before interference is predicted to be objectionable. Note, however, that station XENV is expected to cause interference.

Again in Figure 2, the column heading S/Smax refers to the potential interference from the proposed VOA transmitter to existing signals. If the non-VOA signal is
calculated to be so weak at the reception point that it is below the noise threshold for
the region, then the program will print "OK" in the column. If the non-VOA signal is
greater than the threshold, then the same checks are made as in the column to the left.
The desired signal is the non-VOA station's signal and the interference is the VOA's
signal. The values in Table 1 are required protection ratios. For example, with station
XEMH as the desired station, the desired signal-to-VOA interference ratio is 6.3 dB.
For the 30-kHz difference in carriers, the required protection is -29.5 dB from Table 1.
Thus, the required S/I of -29.5 dB minus the actual S/I of 6.3 dB gives -35.8 dB, which
states there is a margin of 35.8 dB before interference is expected. Station XENV, on
the other hand, is expected to receive interference from the VOA station.

The last column has the heading $S/(I+N)$. This is a calculation of the signal-to-
interference plus noise\(^1\) at the receiver's antenna terminals. The interference and noise
are summed on an rss basis. The noise term N has the units of dB/Hz and represents
the noise power in a 1-Hz bandwidth. To determine the actual $S/(I+N)$, the receiver's
audio bandwidth, say 5 kHz or 37 dBHz, would have to be known. For the calculations,
the program assumes an audio bandwidth of 5 kHz.

When interference does exceed the required ratios, the user can alter the
transmitter characteristics (such as the transmit frequency) and rerun the System 2
analysis. The process is repeated until a characteristic is found that satisfies the
desired signal level requirements at the receiver location and also meets the required
signal-to-interference ratios.

**System 3**

System 3 evolves from the System 2 analysis by treating the broadcast situation as
an area problem. The System 3 output is a map of the user-selected area showing
contours of signal coverage or signal-to-interference ratios. The area to be analyzed is

---

\(^1\) Noise is determined as the sum of atmospheric galactic and man-made noise (see
Appendix A and DeMinco (1986)). The model computes the noise power based on the
receiver's geographical location, frequency, the time of day, and the season. The noise
power density is a constant value regardless of the antenna that is used unless the
antenna's ground-wave gain is less than 0 dBi. Whenever this occurs, the noise power
density is reduced by the antenna's ground-wave gain. For example, if the noise power
density were -129 dBW/Hz and the ground-wave antenna gain were 20 dBi, the noise
power density would remain at -129 dBW/Hz. If the gain were -20 dBi, the noise power
density would be reduced to -149 dBW/Hz. Only the ground-wave antenna gain is used
to alter the noise power density, since for monopole antennas, for example, the sky-
wave gain can be negative at high elevation angles.
divided into a grid of cells with the map size selected by the user. Within each cell
the signal from the desired transmitter is computed as well as the total interference
from all the adjacent and co-channel interfering transmitters. The output plot shows
either the signal coverage in the desired reception region or the signal-to-interference
ratio contours. The plot also provides the user information about interference from the
proposed station to the reception areas of other existing stations. Figure 3 shows a
sample plot from System 3.

2.2 Ground-Wave Propagation

In the Western Hemisphere, which the ITU defines as Region 2, three sets of
ground-wave propagation curves are used, depending upon national (e.g., in the United
States, see FCC, 1982), regional (ITU, 1982), or international (CCIR, 1986a)
requirements. In each case to compute ground-wave field strength, the user interpolates
from the given curves using the three parameters of distance, frequency, and ground
conductivity. Depending upon the choice of values for the parameters, the user may
obtain different values of field strength from the three sets of curves. In recent years,
the FCC and CCIR have attempted to develop computer programs that interested parties
can use to compute field strength based on theoretical calculations rather than
interpolation of curves. Eckert (1986) has documented the FCC's program and
extensively compared the results of the CCIR's new ground-wave method (Rotheram,
1981) with those of the FCC's method and those of the ITS method developed
OT Technical Memorandum 78-247, January 1978, limited distribution). Eckert has
determined that the three methods give ground-wave field strength predictions
sufficiently close in value that they could be considered identical for propagation
purposes (private communication, 1986). If the FCC, IFRB Region 2, and CCIR all adopt
the new ground-wave algorithms, then calculations made by any of their methods should
match those calculations made by the ITS method.

The methods, as described in this report, calculate the theoretical field strength
from the given parameters rather than perform an interpolation from the field strength
curves. The methods utilize the ground-wave algorithm developed by Berry. A
discussion of the ground-wave analysis method used is contained in a companion
document by DeMinco (1986). Three modes of ground-wave predictions are available
from which the user can choose: (1) smooth Earth, homogeneous path, (2) smooth
Figure 3. A sample plot from System 3.
Earth, mixed path, and (3) irregular terrain, mixed path. Each mode is briefly defined below and is more fully described by DeMinco (1986).

Smooth Earth

This method is used for computing ground-wave field strengths over a smooth homogeneous Earth. The algorithm only needs a single set of ground constants for the entire path to make the computations.

Smooth Earth, mixed path

The smooth-Earth, mixed-path method is used when the path is made of sections having different ground constants. The field strength is computed for each section and then combined for a total field strength using an algorithm proposed by Millington (1949; CCIR, 1986a).

Irregular terrain, mixed path

If, along a particular path, the terrain irregularity is of the order of a wavelength or less, then smooth-Earth calculations are adequate (Knight, 1983). In mountainous conditions, the terrain irregularity can be several wavelengths.

Under these conditions, the field strength may not monotonically decrease with increasing distance from the transmitter. For some situations, this extra computational complexity may be required; for example, if the only location available for the proposed transmitter antenna were on the other side of a mountain ridge from the desired reception area, then the user would use the irregular-terrain, mixed-path method to compute signal coverage. The method uses an integral equation solution to the irregular terrain problem (Hill, 1982; Ott, 1971). As computation times can be quite long, the method should be used only when the path(s) warrant its use.

2.3 Sky-wave Propagation

During the daytime, i.e., the time period roughly from local sunrise to local sunset, the ionosphere does not reflect enough electromagnetic energy at MF to cause interference or to allow communications. Absorption of the MF energy by the D region of the ionosphere, the layer 50 to 90 km above the Earth's surface, is the principal reason that MF sky wave is not useful in the daytime. During the nighttime, however, the ionosphere will reflect MF signals because the D region disappears and the E region, the layer 90 to 130 km in altitude, supports MF reflections. This means the MF
broadcast service can provide signal coverage at long distances from the transmitter but also can cause severe disruptions of service to adjacent and co-channel stations with interference that would not be present during the daytime.

Various sky-wave field strength prediction methods are in use, with proponents of each method believing their method works specifically in their part of the world (CCIR, 1986c; PoKempner, 1980). The available methods in this model are: (1) the FCC's procedure for computing AM sky-wave field strengths (FCC, 1982), (2) the Region 2 procedure (ITU, 1982), (3) the CCIR recommended method (CCIR, 1986b), and (4) a new procedure proposed by Wang (1985) for use in the United States and Region 2. All of the procedures assume a reference field strength at 1 km from the transmitter in the development of their field strength curves (FCC and Region 2 methods) or of their field strength algorithms (CCIR and Wang methods). Then given the distance along the path plus other parameters that may be needed, such as frequency and geomagnetic latitude, the annual median field strength is found. This value is modified by the actual transmitter power relative to the reference power and by the antenna gain for the take-off angle needed to reach the reception area. Other factors such as excess polarization loss, and sea-gain correction, are applied in some cases.

In the following paragraphs, the procedures are described in more detail.

**FCC MF sky-wave signal strength prediction method**

The FCC method uses a curve of field strength versus distance developed from measurements made in 1935. The FCC applies the curve to all frequency assignment analyses for all MF frequencies at all latitudes within the United States; the curves of field strength exceeded for 50 and 10 percent of the year are shown in Figure 4. The FCC made additional measurements from 1939 to 1944 which show a dependence on latitude. Curves from those measurements are used by the FCC for interference analyses. No other terms are added to the field strength except for transmitter power and antenna gain. Note that the curves extend to 2600 mi (about 4200 km) from the transmitter.

**Region 2 MF broadcasting conference method**

The Region 2 method uses the FCC's 50 percent curve shown in Figure 4 out to a distance of 4250 km. For distances exceeding 4250 km, the method uses the expression
Figure 4. FCC sky-wave curves of field strength for 10 and 50 percent of the time.
\[
F_C = \frac{231}{3 + d/1000} - 35.5, \quad (1)
\]

where

\[F_C = \text{characteristic field strength, } \text{dBuV/m, referenced to } 100 \text{ mV/m at } 1 \text{ km, and}\]
\[d = \text{distance, km}.\]

This expression is adapted from the CCIR Cairo curves (Wang, 1985), the results of long-distance measurements made in the late 1930s across the Atlantic and from North to South America. The field strength that is exceeded for 10 percent of the time is found from (Wang, 1985)

\[
F(10\%) = F(50\%) + 8 \text{ dBuV/m}. \quad (2)
\]

The Region 2 field strength versus distance curve is shown in Figure 5 and is called the FCC/Region 2 curves.

CCIR MF sky-wave method

The development of the CCIR sky-wave field strength prediction method has been an evolutionary process since the 1930’s (Wang, 1985; PoKempner, 1980). The present method uses the so-called USSR method as its basis with modifications (such as the United Kingdom sea-gain correction). The field strength expression is

\[
F = V + G_s - L_p + A - 20\log(p) - 0.001(K_T)(p) - L_t \quad (3)
\]

where

\[F = \text{field strength, } \text{dBuV/m},\]
\[V = \text{transmitter cymomotive force above the reference } 300 \text{ V, dB},\]
\[G_s = \text{sea-gain correction, } \text{dB},\]
\[L_p = \text{excess polarization-coupling loss, } \text{dB},\]
\[A = 106.6 - 2\sin(\phi), \text{ where } \phi \text{ is the average of the transmitter and receiver geomagnetic latitudes, } \text{dB},\]
\[p = \text{slant-propagation distance, km},\]
\[K_T = \text{loss factor including ionospheric absorption, focusing and terminal losses, and losses between hops, } \text{dB}, \text{ and}\]
\[L_t = \text{hourly loss factor, } \text{dB}.\]
Figure 5. FCC/Region 2 sky-wave curve of median field strength versus distance.
For the time period from 4 h after sunset to 2 h prior to sunrise, the value of \( L_t \) is nearly 0 dB; so this term is ignored in the method. Over long distances of 1000 to 6000 km, sea gain can add from 3 to 10 dB to the predicted field strength if one of the terminals is on the coast. However, the present method does not have land-sea boundary information, so the sea-gain correction is set to 0 dB.

The CCIR method is both frequency and geomagnetic latitude dependent. Note also the method does not predict field strength values that are symmetrical about geomagnetic latitude equal to 0 deg. A family of field strength curves for 1000 kHz is shown in Figure 6. The CCIR (1986b) notes the CCIR field strength expression predicts greater field strength values at higher frequencies whereas measurements made in the United States show the opposite effect. Such results indicate why the CCIR has not found a consensus for a worldwide prediction method.

Wang MF sky-wave field strength method

Wang (1985) has investigated all of the available MF methods and attempted to develop one that is easy to use and is valid at least in Region 2. He notes, for example, the original FCC curves have a hump at roughly 1000 km. He attributes this to ground-wave interference that he believes was present in the 1935 data. When those data are removed, the curves become smoother. His expression for field strength is

\[
F_c = 95 - 20 \log(d) - [(6.28 + 4.95 \tan^2(\phi)) (d/1000)^{1/2},
\]

where

\[
F_c = \text{characteristic field strength, dBuV/m, referenced to 100 mV/m at 1 km,}
\]
\[
d = \text{distance, km,}
\]
\[
\phi = \text{mid-point geomagnetic latitude, deg.}
\]

He states that if \( d \) is less than 250 km, then the expression should be evaluated at 250 km. Also he limits \( \phi \) to no greater than 60 deg and no less than -60 deg. When compared to the CCIR expression, Wang's expression is symmetrical about \( \phi \) equal to 0 deg and is not dependent upon frequency. A family of field strength curves for several values of \( \phi \) is shown in Figure 7.
Figure 6. CCIR sky-wave curves of median field strength for several values of geomagnetic latitude and frequency of 1000 kHz.
Figure 7. Wang's sky-wave curves of median field strength for several values of geomagnetic latitude.
3. MODEL ORGANIZATION AND USAGE

Each of the models is available as a time-share computer program. When the user enters the program, guidance is provided by a menu of options. In general, the user would first input the desired parameter values. A summary of the parameters could be listed to verify selections. Next the data would be processed. After reviewing the results, the user could edit selected parameters and process the data again. This procedure will be shown in later examples.

The user can choose to have the program ask for parameter values using either verbose or concise questions. Concise questions usually only provide a question number, a short parameter description, and a default value, which is the user's last entered value or is supplied by the program. For example, the concise question might appear as

12) Conductivity (0.005 S/m) ?

The verbose question supplies more information for the user, for example

Conductivity for the path (between 0.001 and 10.0 Siemens(mhos)/meter)
0.001 for poor ground
0.005 for average ground
0.020 for good ground
5.000 for sea water
0.010 for fresh water
12) Conductivity (0.005 S/m) ?

In either case, the user can enter his/her own value followed by a carriage return or accept the value within the parentheses by merely typing a carriage return.

For questions wanting an alpha response rather than a numeric response, the user can usually type a single letter to indicate a desired selection. For example, typing an S to the following question

Tower structure
V = Vertical, simple antenna
T = Top-loaded antenna
S = Sectionalized antenna
44) Tower structure (Vertical, simple antenna) ? S

would cause the program to ask the user for information about a sectionalized antenna and use the data for later calculations.
Complete lists of the questions and their meanings for the three models, System 1, System 2, and System 3, are given in Appendix D, Tables D-1, D-2, and D-3, respectively. Each table lists the verbose question for every parameter asked of the user. For some parameters, additional information is provided to indicate to the user how the program will utilize the parameter or what additional questions have to be answered if various selections are made.

4. METHOD ACCURACIES

As the ground-wave methods and the sky-wave methods were developed, they were tested against available data to compare predictions with field strength measurements. In this section, the comparisons are discussed and the accuracies of the methods are provided to give the user some guidance when they are appropriate and adequate.

4.1 Ground-wave Method Accuracies

The smooth-Earth, ground-wave methods are functions of frequency, ground constants, and distance. The transmitting and receiving antennas are assumed to be at ground level and the refractive index is assumed to be decreasing exponentially with height. The only parameters that are not well known in the above list of variables are the ground constants, and in the MF band, ground conductivity is the critical ground constant. When the FCC developed M3, the map of ground conductivities for the United States (see Figure A-5 in Appendix A), the FCC elected to show contours of 2, 4, 8, 15, and 30 mS/m, because these levels give changes in field strength that nearly double between levels (or changes of 6 dB between levels) depending upon the distance from the transmitter, of course. For example, Table 2 compares the field strengths at 50 km from a certain transmitter operating at 1000 kHz.

Note from Table 2, as we change from one level to the next, the predicted field strength approximately doubles in linear units and increases by 6 dB in logarithmic units. Thus if the conductivity value is uncertain, say between 4 and 15 mS/m, then for this example there is an uncertainty of +/- 6 dB in the field strength value about the median value.
Field strength at 50 km from a specific transmitter operating at 1000 kHz

<table>
<thead>
<tr>
<th>M3 ground conductivity (mS/m)</th>
<th>Field strength at 50 km from a specific transmitter operating at 1000 kHz (dBuV/m)</th>
<th>(uV/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>48</td>
<td>251</td>
</tr>
<tr>
<td>4</td>
<td>54</td>
<td>501</td>
</tr>
<tr>
<td>8</td>
<td>61</td>
<td>1122</td>
</tr>
<tr>
<td>15</td>
<td>67</td>
<td>2238</td>
</tr>
<tr>
<td>30</td>
<td>70</td>
<td>3162</td>
</tr>
<tr>
<td>5000 (sea water)</td>
<td>74</td>
<td>5011</td>
</tr>
</tbody>
</table>

A CCIR document (CCIR, 1986e) shows the ground conductivities for North, Central, and South America. The figures from the atlas for Region 2 are reproduced in Appendix A. The figure showing the conductivities for the United States has levels that are more coarse than those in M3. The CCIR report suggests replacing the conductivity bands of all the administrations with a standard set of conductivity bands. These ground conductivity bands are shown in Table 3.

<table>
<thead>
<tr>
<th>FCC M3 map (mS/m)</th>
<th>CCIR atlas of conductivities for the United States (mS/m)</th>
<th>CCIR proposed standard values (mS/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>0.3 - 1.0</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2 - 6</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>7 - 15</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>15</td>
<td>20 - 30</td>
<td>5000</td>
</tr>
<tr>
<td>30</td>
<td>5000</td>
<td>5000</td>
</tr>
<tr>
<td>5000 (sea water)</td>
<td>5000</td>
<td>5000</td>
</tr>
</tbody>
</table>

If a user were to select the proposed 10 mS/m band of conductivities for a particular case and if the path crossed the boundary between 10 mS/m and 3 mS/m, for example, the change in field strength would be approximately 6 dB. If the same path were analyzed using the M3 map, the path might go from 15 mS/m to 2 mS/m, which would result in a change in field strength of approximately 20 dB. The uncertainty of conductivity can result in a large change in predicted field strength. On the other
hand, measurements of conductivity are difficult to make, and conductivity can change with the seasons.

The irregular-terrain, mixed-path ground-wave method has the added complexity of including the terrain elevations in the calculations of field strength. DeMinco (1986) and Ott et al. (1979) have compared measured data with predictions on irregular-terrain paths. Ott demonstrates that the prediction can be made to fit the measurements quite closely if the ground conductivity along the path is appropriately adjusted. This gives confidence to the irregular-terrain prediction method but it also shows how critical are the conductivity values along the path. As discussed in Appendix A, the terrain data base (NGDC, 1985) that is available for Region 2 has a grid size of 5 min in latitude and longitude. In other words, for increments of 5 min of latitude and longitude, the data base contains the arithmetic average elevation from contour charts for each 5 min by 5 min grid cell. DeMinco has compared the predictions made using the 5-min elevation data base with predictions using 30 sec spacing between elevations. His conclusion for the MF broadcast band is that there is little improvement in prediction accuracy when using the 5-min elevation data with the irregular-Earth method compared with using the smooth-Earth method.

Thus, if the user knows the terrain elevations along the path, then the irregular-terrain method could be used to provide a more accurate prediction compared with a smooth-Earth prediction, assuming, of course, that the ground conductivities are known along the path for either method. However, if the user is going to use the 5-min terrain elevation data base, then the irregular-terrain method will provide comparable predictions to the smooth-Earth method. The user will need to decide if the application warrants the use of the added complication of terrain with a spacing of 5 min between elevation values.

4.2 Sky-wave Method Accuracies

All of the sky-wave methods are functions of distance and all except the FCC method are latitude (actually geomagnetic latitude) dependent. Only the CCIR method has a frequency-dependent term. Report 1014 (CCIR, 1986d) discusses the various methods and rates their prediction abilities versus measured data. Table 4 is copied from the CCIR report and summarizes the findings where an error is defined as the difference between a measured field strength and the value predicted by a particular method. The table shows the errors by latitude bands, by inter-regional paths, and totals.
Table 4. Prediction Errors (Table II from CCIR (1986d))

<table>
<thead>
<tr>
<th>Case</th>
<th>FCC/Region 2 (dB)</th>
<th>CCIR (dB)</th>
<th>Wang (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 - 45 deg</td>
<td>9.9</td>
<td>7.8</td>
<td>8.2</td>
</tr>
<tr>
<td>45 - 52.5 deg</td>
<td>4.7</td>
<td>6.0</td>
<td>5.8</td>
</tr>
<tr>
<td>&gt; 52.5 deg</td>
<td>11.1</td>
<td>13.4</td>
<td>6.8</td>
</tr>
<tr>
<td>Subtotal</td>
<td>8.1</td>
<td>8.7</td>
<td>6.9</td>
</tr>
<tr>
<td>Inter-regional paths</td>
<td>13.6</td>
<td>17.2</td>
<td>8.9</td>
</tr>
<tr>
<td>Total</td>
<td>11.0</td>
<td>14.0</td>
<td>8.1</td>
</tr>
</tbody>
</table>

The CCIR report states that the FCC/Region 2 method will under-predict the field strength in the low-latitude areas, will work well in mid-latitude areas, and will over-predict in the high-latitude areas. Under-predict means the actual field strength is greater than that predicted and over-predict means actual field strength is less than predicted. The report has similar comments about the CCIR method.

The report notes that the Wang method works well for long and short paths. It calls the Wang method a blend of the CCIR field strength curve and the FCC/Region 2 curve, which results in the Wang method's overall usefulness.

4.3 Sky-wave Field-strength Variations

Measurements have been reported on the variations in sky-wave field strength due to fading, diurnal, and seasonal variations (CCIR, 1986c). Those variations are summarized here.

Fading rate

Fading rate is defined as the number of times that the signal increases through the median signal level per unit time. Although the fading rate for a specific path is a function of frequency and angle of incidence with the ionosphere, the fading rates of mid-band MF sky-wave signals have been measured at 10-30 fades per hour. During the fade, the field-strength amplitude follows the Rayleigh distribution. The night-to-night amplitude variation between 10 percent of the nights and 50 percent of the nights is typically 5.5 dB.

Wang (1985) has analyzed the field strength data from Region 2 to determine the signal variation with time. Table 5 shows his results.
Table 5. Measured Field Strength Variation with Time

<table>
<thead>
<tr>
<th>Geomagnetic latitude (deg)</th>
<th>Field strength exceeding the annual median field strength for stated percent of time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10% (dB)</td>
</tr>
<tr>
<td></td>
<td>1%  (dB)</td>
</tr>
<tr>
<td>0 - 40</td>
<td>6.</td>
</tr>
<tr>
<td>60 - 90</td>
<td>10.</td>
</tr>
<tr>
<td>average</td>
<td>8.</td>
</tr>
<tr>
<td></td>
<td>12.25</td>
</tr>
</tbody>
</table>

Diurnal variations

The CCIR method has a frequency-dependence term that reduces the predicted field strength with increasing frequency (for example, the field strength predicted for a 2000 km path at 30 deg latitude is 2 dB less at 1500 kHz than at 500 kHz). Wang (1985) notes measurements in United States have exactly the opposite result. He says signals at 1530 kHz measured at sunset or sunrise are about 15 dB greater than those at 700 kHz. The difference reduces to 3 - 5 dB at 2 h after sunset or 2 h before sunrise; also the difference is insignificant at midnight.

Seasonal variations

The measurements of field strength show a seasonal dependence. The field strength is at a minimum during the summer and reaches its maximum during spring and fall. Winter shows a reduction in field strength although not as much as in the summer. The difference between the summer minimum and the spring/fall maximums is about 15 dB at 500 kHz and reduces to about 3 dB at 1700 kHz.

5. SAMPLE DIALOGS WITH THE PROGRAMS

In Appendix E, sample dialogs with the three programs are provided to show how the programs may be used. Some comments about the dialogs and program usage apply to all of the programs:

1. At each point of the dialog when the program needs a response from the user, the program will print a parameter name or a statement followed by a question mark. The program then waits for the user to make a data entry.
2. The user must end each data entry with a carriage return.
3. Some questions will have a default value or data value in parentheses. If that value is satisfactory, the user can merely type a carriage return to have the program accept that value.

4. The questions are asked either in a concise form or a verbose form. The verbose form provides the most information about the question, whereas the concise form states the parameter, a default value for the parameter in parentheses, and a question mark. A user unfamiliar with the questions should select the VERBOSE DIALOG from the menu. By typing two questions marks (??), the verbose form of any question will be printed by the program.

5. The user can exit the questions at any time by typing two colons (::) in response to the questions. The program stops asking for input parameters and returns to the MENU question. To exit the program, the user should type "Q" for quit in response to the MENU question. At that point all of the user input data is lost and must be re-entered the next time the program is run.

6. A normal sequence of program use is to
   a. enter the VERBOSE DIALOG mode to supply data values for the parameters
   b. select SUMMARY to list the parameters by number, parameter name, and user-selected value
   c. select PROCESS to make the calculations and output the analysis results
   d. 1. choose EDIT if a few parameters are to have their values changed, then go to b. or
       2. choose VERBOSE or CONCISE if many values are to be changed, then go to b.
       3. select QUIT to exit the program

The following describes each sample dialog.

Sample #1

The first sample dialog uses the System 1 program to obtain the smooth-Earth ground-wave calculations on a path whose distance varies from 10 to 100 km in 10 km increments. The choice of sky-wave method is not important because the sky-wave methods produce a constant field strength at distances less than 250 km. In order to compare the ground-wave results with those of the CCIR (1986a), a fixed strength of 300 mV/m at 1 km is required from the transmitter. This is obtained by using the
transmitter antenna type set to the FIELD STRENGTH OPTION. The ground constants for the path are set to 0.003 S/m and 15.

Sample #2

The second sample dialog uses the System 1 program to calculate sky-wave field strength calculated by the ITU Region 2 method on a path whose distance varies from 100 to 1000 km in 100-km increments. To compare the results with the sky-wave curve of Figure 5, the field strength from the transmitter must be sent to the characteristic field strength of 100 mV/m at 1 km by setting the transmitter antenna to the FIELD STRENGTH OPTION and the ground constants to 5 S/m and 80.

Sample #3

This sample dialog used the System 1 program to calculate the field strength pattern of the three-monopole array antenna of Figure C-2 in Appendix C. The array characteristics are given on Figure C-2 and the field strengths are listed under the output table heading of ground-wave field strengths. Those field strengths are compared with the field strengths listed in Table 6, which has listed the field strengths for the same three-monopole array antenna. The field strengths listed in the output table under ground-wave are for an elevation angle of 0 deg. Although the program will calculate the field strength at 1 km for every elevation angle as needed by the calculations, there presently is no way to list out the field strengths for elevation angles other than 0 deg as shown in this sample. In this same sample, the EDIT mode is used to alter a few of the parameter values and to calculate the field strengths at 100 km from the transmitter.

Sample #4

Signal-to-interference calculations are made using the System 2 program. The dialog shows the input parameter values and the resultant calculations for a proposed transmitter in Central America at 14 deg, 05 min, 07 sec N and 89 deg, 45 min, 30 deg W. The explanation of the output table is give in Appendix B.

Sample #5

Sample #5 is a signal coverage map produced by using the System 3 program. The antenna shown in Figure C-2 is used with its main beam rotated 90 deg so that it points to the east. Close in to the transmitter, the ground-wave signal dominates while
Table 6. Field Strength Pattern for Three-monopole Array

<table>
<thead>
<tr>
<th>Azimuth (deg)</th>
<th>Field strength at 1 km (mV/m)</th>
<th>(dBuV/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>874</td>
<td>118.8</td>
</tr>
<tr>
<td>15</td>
<td>858</td>
<td>118.7</td>
</tr>
<tr>
<td>30</td>
<td>801</td>
<td>118.1</td>
</tr>
<tr>
<td>45</td>
<td>682</td>
<td>116.7</td>
</tr>
<tr>
<td>60</td>
<td>489</td>
<td>113.8</td>
</tr>
<tr>
<td>75</td>
<td>243</td>
<td>107.7</td>
</tr>
<tr>
<td>90</td>
<td>13</td>
<td>82.6</td>
</tr>
<tr>
<td>105</td>
<td>176</td>
<td>104.9</td>
</tr>
<tr>
<td>120</td>
<td>246</td>
<td>107.8</td>
</tr>
<tr>
<td>135</td>
<td>224</td>
<td>107.0</td>
</tr>
<tr>
<td>150</td>
<td>158</td>
<td>104.0</td>
</tr>
<tr>
<td>165</td>
<td>96</td>
<td>99.7</td>
</tr>
<tr>
<td>180</td>
<td>72</td>
<td>97.6</td>
</tr>
<tr>
<td>195</td>
<td>96</td>
<td>99.7</td>
</tr>
<tr>
<td>210</td>
<td>158</td>
<td>104.0</td>
</tr>
<tr>
<td>225</td>
<td>224</td>
<td>107.0</td>
</tr>
<tr>
<td>240</td>
<td>246</td>
<td>107.8</td>
</tr>
<tr>
<td>255</td>
<td>176</td>
<td>104.9</td>
</tr>
<tr>
<td>270</td>
<td>13</td>
<td>82.6</td>
</tr>
<tr>
<td>285</td>
<td>243</td>
<td>107.7</td>
</tr>
<tr>
<td>300</td>
<td>489</td>
<td>113.8</td>
</tr>
<tr>
<td>315</td>
<td>682</td>
<td>116.7</td>
</tr>
<tr>
<td>330</td>
<td>801</td>
<td>118.1</td>
</tr>
<tr>
<td>345</td>
<td>858</td>
<td>118.7</td>
</tr>
</tbody>
</table>

Further out the sky-wave signal dominates. For distance locations, the elevation angle or takeoff angle from the transmitter is close to the horizon where the antenna gain is at a maximum. As locations nearer to the transmitter are considered, the elevation angle increases, which results in decreased antenna gain. Thus, locations far from the transmitter have more basic transmission loss; they also have more antenna gain to counter the loss. Locations near the transmitter have less loss but also less antenna gain because of the steep takeoff angles. The results of the two opposing effects are shown on the map associated with Sample #5. The 60 and 70 dB V/m contours are good examples increasing losses opposed by increasing antenna gain and vice versa.

6. CONCLUSIONS

The MF broadcasting system performance model allows a user to develop the characteristics of an MF broadcasting station by

- computing the station's ground-wave and sky-wave field strengths according to nationally, regionally, and internationally recognized procedures
• determining the station's signal coverage and signal-to-interference ratios at a desired location or over a specified region
• verifying the signal-to-interference ratios meet Region 2 requirements for noninterfering operations

The model computes transmitter antenna array patterns based on Region 2 and FCC algorithms. Other transmitter and receiver antenna gains in the model are based on theoretical gains over a lossy Earth. The model contains a worldwide noise data base, a 5-min terrain elevation data base, and a ground conductivity data base for Region 2. The model operates as three separate user-interactive programs.

7. ACKNOWLEDGMENTS

The MF broadcasting system performance model was sponsored by the Voice of America (VOA). The assistance offered by Mr. George Lane and Mr. Hien Van Vo of the VOA was particularly valuable in developing the model. At ITS, Mr. Nicholas DeMinco, Ms. Janet Geikas, Mr. James Washburn, Dr. George Hufford, Dr. A. Donald Spaulding, and Mr. Bill Riddle (formerly at ITS) gave valuable suggestions and aid in producing the model.

8. REFERENCES


CCIR (International Radio Consultative Committee) (1986c), Methods for predicting sky-wave field strengths at frequencies between 150 kHz and 1705 kHz, CCIR Report 575-3, Vol. VI, International Telecommunication Union, Geneva, Switzerland (NTIS Order No. PB-87-14117-2).


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Millington, G. (1949), Ground wave propagation over an inhomogeneous smooth-Earth, J. IEE (London), Part IV, 96, pp. 53-64, January.

NGDC (1985), Topographic data, 5-minute elevation data, Data Announcement 85-TGB-01, National Geophysical Data Center, Boulder CO 80303.


APPENDIX A. DATA BASES

Terrain

A 5-min terrain elevation data base is available from the NGDC (1985) that includes northern South America, Central America, and most of North America. The elevation data base used by this program covers northern South America, Central America, Mexico, and the Caribbean. The actual coverage range is 8 to 31 deg N latitude and 60 to 120 deg W longitude as shown in Figure A-1. The X's on Figure A-1 indicate regions of no terrain data. Each terrain elevation represents the arithmetic mean of data digitized from contour charts of the elevations within a 5-min by 5-min grid cell.

Noise

The noise data base contains worldwide estimates of atmospheric noise values for each season and for each 4-h time block during the day. The noise values represent the lower decile, the median, and the upper decile of measured noise characteristics. The noise contours are provided in a CCIR booklet (CCIR, 1986a and the noise coefficients are available on magnetic tape (NTIS, 1986). To the estimate of atmospheric noise are added estimates of man-made and galactic noise. All three noise power values are frequency dependent, and man-made noise is a function of the environment. The four environment categories are business, residential, rural, and quiet rural. The resultant value of noise is given as a noise power density (dBW). To compute the actual noise at the receiver terminals, the noise power density would have to be multiplied by the receiver baseband bandwidth, if both are in linear units, or added if both are converted to decibels,

\[ P_n = PD_n + BW \]

where

- \( P_n \) = noise power at the receiver terminals, dBW,
- \( PD_n \) = noise power density, dBW/Hz, and
- \( BW \) = receiver baseband bandwidth, dBHz.

The algorithm used to predict the noise power in this program is described in greater detail by DeMinco (1986) and by Spaulding and Washburn (1985).
Figure A-1. Areas where 5-min terrain elevation data are available.
Ground conductivity

In the MF band, the ground constant that most affects the ground-wave field strength prediction is the ground conductivity value. For Region 2, ground conductivity data are available from the International Frequency Registration Board (IFRB, 1986) in a digitized format. Figures A-2 through A-4 show the ground conductivities for North America, Central America, and South America, respectively, as supplied by the CCIR (1986b). The FCC uses the ground conductivity map called M3 (FCC, 1982) which is reproduced in Figure A-5. The M3 map has different contours and levels than those in the CCIR map for North America. This program uses the ground conductivity data supplied by the IFRB.

Region 2 MF station characteristics

The IFRB maintains a file of characteristics of MF stations in Region 2. The file is available in a digitized format from the IFRB. The transmitter characteristics that are available are listed in Table A-1. There are sufficient data in the file to compute the transmitting antenna pattern based on the techniques described in Appendix C, Antenna Models. To be reasonably accurate, the file should be updated approximately every 3 months.

<table>
<thead>
<tr>
<th>Table A-1. Transmitter Characteristics from IFRB Station Data Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assigned frequency</td>
</tr>
<tr>
<td>Daytime operation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Nighttime operation</td>
</tr>
</tbody>
</table>

31
Table A-1. Continued

Data for array of towers
- ratio of the tower field to the field from the reference tower
- positive or negative difference in the phase angle of the field from the tower with
  the field from the reference tower
- electrical spacing of the tower from the reference point
- angular orientation of the tower from the reference point
- tower structure
  - simple vertical antenna
  - top-loaded antenna
  - sectionalized antenna

Data for augmented patterns
- radiation at the central azimuth of augmentation
- central azimuth of augmentation
- total span of the augmentation

Data for top-loaded antenna
- electrical height of the antenna tower
- height of lower section

Data for sectionalized antenna
- difference between apparent electrical height and actual height
- difference between apparent electrical height of lower section and actual height of
  lower section
- total height of antenna
- difference between apparent electrical height of the total tower and the actual
  height of the total tower

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applications of atmospheric radio noise data, Report 322-3, International
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Subpart A - AM broadcast stations, Rules and Regulations (Superintendent of

IFRB (International Frequency Registration Board) (1986), MF broadcasting prediction
methods and databases, International Telecommunication Union, Geneva,
Switzerland.

Figure A-2. Ground conductivities for North America.
Figure A-3. Ground conductivities for Central America.
Figure A-4. Ground conductivities for South America.
Figure A-5. The FCC ground conductivity map (M3) for the continental United States.
APPENDIX B. CHANNEL OCCUPANCY MODEL

The VOA has developed an MF channel occupancy model that is based upon Region 2 requirements. The model is described in a VOA Information Memo (informal communication, M. Weissberger, Dec. 1984); the information in the VOA memo is repeated below.

Parameter definitions:

\[ E_{V-S-50} = \text{Sky wave field of the VOA station that is exceeded 50% of the time.} \]
\[ E_{NV-S-50} = \text{Sky wave field of the non-VOA station that is exceeded 50% of the time.} \]
\[ E_{NV-S-10} = \text{Sky wave field of the non-VOA station that is exceeded 10% of the time.} \]
\[ E_{V-G} = \text{Ground wave field of the VOA station} \]
\[ E_{NV-G} = \text{Ground wave field of the non-VOA station.} \]

All quantities are in units of microvolts per meter.

Definition of Terms Appearing in the Output

\( S, \) in \( S/I: \)

This is the VOA field strength when it is considered as the desired signal. It is computed as shown below.

\[ \text{DAY} \quad \frac{E_{V-G}}{\text{NIGHT}} \quad \text{MAX} (E_{V-G}, E_{V-S-50}) \]

\( I, \) in \( S/I: \)

This is the field strength of the non-VOA station, when this station is considered as a source of interference to the VOA. It is computed as shown below.

\[ \text{DAY} \quad \frac{E_{NV-G}}{\text{NIGHT}} \quad \left[ (E_{NV-G})^2 + (E_{NV-S-10})^2 \right]^{1/2} \]

Note the rss value computed for night interference. Different thresholds are used to account for channel separations.
S/I th:

This is the desired minimum ratio (in dB) of the VOA signal to the non-VOA signal. (The letters "th" are an abbreviation for "threshold.") The ratio is a function of the frequency separation, delta-F, between the VOA and non-VOA stations. The values for separations of 0, 10, and 20 kHz are taken from the 1981 Region 2 Agreements. The values for separations of 5 and 15 kHz are taken for CCIR Recommendation 560-1, 1982. The Curve labeled "c", in Figure 1f of the CCIR Recommendation, was used. It is based on a compression that is realistic and a bandwidth that is consistent with the one assumed in the Region 2 Agreement. The S/I th values for frequency separations larger than 20 kHz are the same as the value for 20 kHz. The values versus the frequency separation between a VOA and non-VOA station are given in Table B-1.

<table>
<thead>
<tr>
<th>Delta-F (kHz)</th>
<th>S/I th (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>26.0</td>
</tr>
<tr>
<td>5</td>
<td>29.0</td>
</tr>
<tr>
<td>10</td>
<td>0.0</td>
</tr>
<tr>
<td>15</td>
<td>-23.0</td>
</tr>
<tr>
<td>20</td>
<td>-29.5</td>
</tr>
<tr>
<td>25</td>
<td>-29.5</td>
</tr>
<tr>
<td>30</td>
<td>-29.5</td>
</tr>
</tbody>
</table>

S in $S_{S_{max}}$:

This is the VOA field strength when it is considered as a source of interference. Its values are listed below.

**DAY**

$E_{V-G}$

**NIGHT**

$\left( (E_{V-G})^2 + (E_{V-S-50})^2 \right)^{1/2}$

$S_{max}$ in $S_{S_{max}}$:

This is the maximum VOA signal strength that will not produce interference to the specific non-VOA station that is being examined. $S_{max}$ is computed for the target city. The means of calculating $S_{max}$ are described below.
ENV', used in Determining \( S_{\text{max}} \):

This is the signal strength of the non-VOA signal, which is to be used in the determination of \( S_{\text{max}} \). It is computed as shown below.

\[
\begin{align*}
\text{DAY} & & \text{NIGHT} \\
E_{\text{NV-G}} & & \text{MAX} (E_{\text{NV-G}}, E_{\text{NV-S-50}})
\end{align*}
\]

Determining \( S_{\text{max}} \):

In some cases, the non-VOA signal level is so low that it is designated as unhearable and there is no restriction of the VOA signal strength, for the case being considered. These situations are determined by comparing the non-VOA signal level, \( E_{\text{NV'}} \), with the nominal usable signal strength, \( E_{\text{nom}} \).

(The Region 2 Agreements allow the root sum square, rss, approach to be used to determine hearability in certain situations. The present version of the Channel Occupancy Model does not include an rss algorithm. As a result, an interference assessment made using the model will be conservative in some cases, and equitable in all other cases. Leaving out the rss option permits the model runs to be made quickly. The rss algorithms might be added to the model later. Computer time requirements could be kept reasonable by using the option for studies of a few selected channels, rather than for across-the-band checks.)

The procedure for determining \( S_{\text{max}} \), using the nominal usable field strengths, is presented below.

A. Compute the signal strength of the non-VOA station, \( E_{\text{NV'}} \), using the rules presented before.

B. Determine the nominal usable field strength, \( E_{\text{nom}} \). This depends on the class of the non-VOA station, and the geographical location of the target reception point. The possible values are shown in Tables B-2 and B-3.

If the "target point" (assumed receiver location) is within both Central America and a Noise Zone, the data for the Noise Zone is to be used in the calculations.
Table B-2. Daytime Values of $E_{nom}$

<table>
<thead>
<tr>
<th>Station Class</th>
<th>Central America</th>
<th>Noise Zone 1</th>
<th>Noise Zone 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.500 mV/m</td>
<td>Co-channel 0.100 mV/m</td>
<td>Co-channel 0.250 mV/m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adj. channel 0.500 mV/m</td>
<td>Adj. channel 0.500 mV/m</td>
</tr>
<tr>
<td>B</td>
<td>Use Value for Noise Zone</td>
<td>0.500 mV/m</td>
<td>1.250 mV/m</td>
</tr>
<tr>
<td>C</td>
<td>Use Value for Noise Zone</td>
<td>0.500 mV/m</td>
<td>1.250 mV/m</td>
</tr>
</tbody>
</table>

Table B-3. Nighttime Values of $E_{nom}$

<table>
<thead>
<tr>
<th>Station Class</th>
<th>Central America</th>
<th>Noise Zone 1</th>
<th>Noise Zone 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.000 mV/m</td>
<td>0.500 mV/m</td>
<td>1.250 mV/m</td>
</tr>
<tr>
<td>B</td>
<td>Use Value for Noise Zone</td>
<td>2.500 mV/m</td>
<td>6.500 mV/m</td>
</tr>
<tr>
<td>C</td>
<td>Use Value for Noise Zone</td>
<td>4.000 mV/m</td>
<td>10.000 mV/m</td>
</tr>
</tbody>
</table>

C. If $E_{NV}$ is less than $E_{nom}$, then there are no restrictions on the VOA signal level. In order to quickly alert someone who is skimming a printout that there are no restrictions, the letters "OK" are printed in the column labeled $S/S_{max}$.

D. If $E_{NV}$ is greater than or equal to $E_{nom}$, then the term $S_{max}$ is calculated. $S_{max} = E_{NV}/PR$, where PR is the protection ratio needed for two signals separated by Delta-F (kHz). Values of PR are shown in Table B-4.

Table B-4. Protection Ratio versus Frequency Separation

<table>
<thead>
<tr>
<th>Delta-F (kHz)</th>
<th>PR (Dimensionless)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>19.95</td>
</tr>
<tr>
<td>5</td>
<td>28.18</td>
</tr>
<tr>
<td>10</td>
<td>1.0</td>
</tr>
<tr>
<td>15</td>
<td>1/14.13</td>
</tr>
<tr>
<td>20</td>
<td>1/29.85</td>
</tr>
<tr>
<td>25</td>
<td>1/29.85</td>
</tr>
<tr>
<td>30</td>
<td>1/29.85</td>
</tr>
</tbody>
</table>
APPENDIX C. ANTENNA MODELS

The programs have available five transmitting antenna models and four receiving antenna models. The models are listed in Table C-1.

<table>
<thead>
<tr>
<th>Transmitting Antennas</th>
<th>Receiving Antennas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical monopole</td>
<td>Vertical monopole</td>
</tr>
<tr>
<td>Standard monopole array</td>
<td>Ferrite loop</td>
</tr>
<tr>
<td>General monopole array</td>
<td>Field strength option</td>
</tr>
<tr>
<td>Field strength option</td>
<td>User gain input</td>
</tr>
</tbody>
</table>

The general monopole array model is based upon the array equations given by the FCC (1982) and the ITU (1982). To compute the array pattern, the model needs the following information:

- the number of monopoles
- the electrical height of each monopole
- the relative phasing between each monopole
- the relative spacing between each monopole
- the relative current amplitude between each monopole
- the relative angular orientation between each monopole
- if a monopole is sectionalized, the monopole characteristics
- if a monopole is top-loaded, the monopole characteristics
- if the pattern is augmented, the augmentation characteristics
- the rms field strength mV/m at 1 km.

Figure C-1 shows the monopole array pattern for the sample antenna characteristics given by the FCC (1982).

From the given data, the general monopole array pattern is computed and the antenna gain at any azimuth and elevation angle is calculated and used by the program. For all of the other antenna types, an equivalent antenna gain is calculated by first determining the desired antenna's gain relative to a reference dipole and then adding that gain to the dipole's gain over a lossy Earth. The technique is described by DeMinco (1986).

For the vertical monopole and the general monopole array, the gain changes with elevation angle. The standard monopole array antenna model assumes three-, four-, and six-monopole array geometries that are standard designs used by the VOA. Although the computed gain of the standard monopole array changes with azimuth, its gain in elevation is the same as the computed gain for the given azimuth.
Theoretical field strength in mV/m per kW at 1 km.

Characteristics and pattern for FCC array sample.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Tower 1</th>
<th>Tower 2</th>
<th>Tower 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field ratio</td>
<td>1.0</td>
<td>1.89</td>
<td>1.0</td>
</tr>
<tr>
<td>Phase (deg)</td>
<td>-128.5</td>
<td>0.0</td>
<td>128.5</td>
</tr>
<tr>
<td>Spacing (deg)</td>
<td>0.0</td>
<td>110.0</td>
<td>220.0</td>
</tr>
<tr>
<td>Orientation (deg)</td>
<td>0.0</td>
<td>285.00</td>
<td>285.0</td>
</tr>
<tr>
<td>Structure</td>
<td>simple</td>
<td>top-loaded</td>
<td>sectionalized</td>
</tr>
<tr>
<td>Height (deg)</td>
<td>120.0</td>
<td>120.0</td>
<td>120.0</td>
</tr>
<tr>
<td>A (deg)</td>
<td>120.0</td>
<td>20.0</td>
<td>220.0</td>
</tr>
<tr>
<td>B (deg)</td>
<td>20.0</td>
<td>20.0</td>
<td>15.0</td>
</tr>
</tbody>
</table>

Transmitter power = 5 kW
RMS field strength at 1 km = 685 mV/m

Figure C-1. Characteristics and pattern for FCC array sample.
The ferrite-loaded loop antenna is modeled to approximate the antenna found in MF receivers. The antenna is not directional and is very lossy, with gains of -40 to -80 dBi typically.

The user gain option allows the user to enter a fixed antenna gain relative to an isotropic that is used for all azimuths and elevations. The field strength option allows the user to specify a fixed field strength at a fixed distance from the transmitter whose transmitter power is at a fixed reference level. The algorithm then computes the equivalent antenna gain to be used in the calculations.

DeMinco (1986) defines the valid frequency ranges for the antenna models and gives the restrictions in their use. A summary is provided in Table C-2.

<table>
<thead>
<tr>
<th>Antenna Model</th>
<th>Valid Frequency range</th>
<th>Restrictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical monopole</td>
<td>0.01 - 30 MHz</td>
<td>monopole length &gt; .01 wavelength</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt; .7 wavelength</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ground screen &gt; .01 wavelength</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt; .6 wavelength</td>
</tr>
<tr>
<td></td>
<td></td>
<td>no. of radials &gt; 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt; 360</td>
</tr>
<tr>
<td>Ground screen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard monopole array</td>
<td>0.5 - 1.7 MHz</td>
<td>See Figure C-2 for array characteristics and patterns. Sky-wave gain equals ground-wave gain.</td>
</tr>
<tr>
<td>three-mono pole</td>
<td></td>
<td></td>
</tr>
<tr>
<td>four-mono pole</td>
<td></td>
<td>See Figure C-3 for array characteristics and patterns. Sky-wave gain equals ground-wave gain.</td>
</tr>
<tr>
<td>six-mono pole</td>
<td></td>
<td>See Figure C-4 for array characteristics and patterns. Sky-wave gain equals ground-wave gain.</td>
</tr>
<tr>
<td>Ferrite-loaded loop</td>
<td>0.5 - 1.7 MHz</td>
<td>length &lt; 25.4 cm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>diameter &lt; 2.54 cm</td>
</tr>
</tbody>
</table>
REFERENCES


Three-monopole array pattern

Theoretical field strength in mV/m per kW at 1 km.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field ratio</td>
<td>1.0</td>
<td>1.16</td>
<td>1.0</td>
</tr>
<tr>
<td>Phase (deg)</td>
<td>251.24</td>
<td>125.62</td>
<td>0.0</td>
</tr>
<tr>
<td>Spacing (deg)</td>
<td>0.0</td>
<td>100.0</td>
<td>200.0</td>
</tr>
<tr>
<td>Orientation (deg)</td>
<td>0.0</td>
<td>0.00</td>
<td>0.0</td>
</tr>
<tr>
<td>Structure</td>
<td>simple</td>
<td>simple</td>
<td>simple</td>
</tr>
<tr>
<td>Height (deg)</td>
<td>225.0</td>
<td>225.0</td>
<td>225.0</td>
</tr>
</tbody>
</table>

RMS field strength = 452 mV/m per kW at 1 km
                 = 281 mV/m per kW at 1 mi

Figure C-2. Characteristics and pattern for three-monopole array.
Theoretical field strength in mV/m per kW at 1 km.

Characteristics and pattern for four-monopole array.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field ratio</td>
<td>1.0</td>
<td>1.16</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Phase (deg)</td>
<td>62.0</td>
<td>0.0</td>
<td>0.0</td>
<td>62.0</td>
</tr>
<tr>
<td>Spacing (deg)</td>
<td>0.0</td>
<td>120.0</td>
<td>229.0</td>
<td>195.0</td>
</tr>
<tr>
<td>Orientation (deg)</td>
<td>0.0</td>
<td>0.00</td>
<td>38.4</td>
<td>90.0</td>
</tr>
<tr>
<td>Structure</td>
<td>simple</td>
<td>simple</td>
<td>simple</td>
<td>simple</td>
</tr>
<tr>
<td>Height (deg)</td>
<td>225.0</td>
<td>225.0</td>
<td>225.0</td>
<td>225.0</td>
</tr>
</tbody>
</table>

RMS field strength = 398 mV/m per kW at 1 km
= 247 mV/m per kW at 1 mi

Figure C-3. Characteristics and pattern for four-monopole array.
Six-monopole array pattern

Theoretical field strength in mV/m per kW at 1 km.

RMS field strength = 418 mV/m per kW at 1 km
                = 259 mV/m per kW at 1 mi

Figure C-4. Characteristics and pattern for six-monopole array.
APPENDIX D. MODEL PARAMETER QUESTIONS AND THEIR MEANINGS

Tables D-1, D-2, and D-3 contain all of the verbose questions asked of the user by the models, System 1, System 2, and System 3, respectively. The tables list the questions along with guidance as to their meanings and what additional parameters will require values if the user makes certain selections.

Table D-1. System 1 Questions, Their Meaning, and Acceptable Range of Values

<table>
<thead>
<tr>
<th>Questions description, acceptable value ranges, and default values</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title of the analysis (up to 30 characters)</td>
<td>The title will be printed on the analysis output. (Note a default value or the last value entered is given in parentheses. If that value is acceptable, merely type a carriage return in response to the question.)</td>
</tr>
<tr>
<td>1) Title (VOA Test)?</td>
<td></td>
</tr>
<tr>
<td>Length units:</td>
<td>All parameters dealing with length will be asked in the user-specified units. Enter either M or E.</td>
</tr>
<tr>
<td>M = Metric, kilometers and meters</td>
<td></td>
</tr>
<tr>
<td>E = English, statute miles and feet</td>
<td></td>
</tr>
<tr>
<td>2) Length units (Metric, kilometers and meters)?</td>
<td></td>
</tr>
<tr>
<td>Frequency (530.0 to 1750. kHz)</td>
<td>Predictions will be made at the selected frequency.</td>
</tr>
<tr>
<td>3) Frequency (1000. kHz)?</td>
<td></td>
</tr>
<tr>
<td>Groundwave model:</td>
<td>SMOOTH EARTH is the simplest prediction method. MIXED PATH requires ground constants to be given along the path. IRREGULAR TERRAIN requires ground constants and terrain elevations along the path.</td>
</tr>
<tr>
<td>S = Smooth earth</td>
<td></td>
</tr>
<tr>
<td>M = Mixed path, smooth earth</td>
<td></td>
</tr>
<tr>
<td>I = Irregular terrain, mixed path</td>
<td></td>
</tr>
<tr>
<td>4) Ground wave model (Smooth earth)?</td>
<td></td>
</tr>
<tr>
<td>Sky-wave model:</td>
<td>FCC and IFRB currently use the same prediction method and can be used for U.S. or Region 2 analyses. CCIR is the international method. WANG incorporates features of all the other methods.</td>
</tr>
<tr>
<td>F = FCC Interregional</td>
<td></td>
</tr>
<tr>
<td>C = CCIR Plenary Assembly</td>
<td></td>
</tr>
<tr>
<td>W = Wang</td>
<td></td>
</tr>
<tr>
<td>I = IFRB skywave</td>
<td></td>
</tr>
<tr>
<td>5) Skywave model (FCC Interregional)?</td>
<td></td>
</tr>
</tbody>
</table>
Transmitter site

Type site lat (followed by carriage return) and site lon (return) for each of the sites. Enter the reference site location first.

Limits are - 0N <= lat <= 90N
0S <= lat <= 90S
0W <= lon <= 180W
0E <= lon <= 180E

The default hemispheres are N and E. The S and W locations can be specified by adding an S to the latitude value or adding an W to the longitude value.

Inputs of the form X,Y,Z imply degrees, minutes and seconds.

Inputs of the form X.Y imply decimal degrees.

10) Transmitter lat (20.0000 deg N or 20 0 0 dms N)?
10) Transmitter lon (90.0000 deg W or 90 0 0 dms W)?

Note that N (north) and E (east) are the default hemispheres. Append N or S to latitude values and E or W to longitude values to ensure correct locations.

Receiver site(s)

Paths to be analyzed are defined from the transmitter site (ref site) to the receiver site(s). The transmitter site is defined by its latitude and longitude.

The receiver site(s) can be defined by:
L = Latitude longitude pairs
D = Distance - bearing pairs
IB = Incremental bearing at a fixed distance
ID = Incremental distance at a fixed bearing

11) Path option (Latitude - longitude pairs)?

The following Questions 12 and 13 depend upon the path option chosen in Question 11.

At each receiver site specified, the ground-wave and sky-wave field strengths and received powers will be computed. Signal-to-noise ratios and fade margins will be calculated.

If SMOOTH EARTH is chosen as the ground-wave method, the receivers can be specified in any of the four ways. Enter either L, D, IB, or ID.
If path option is LATITUDE-LONGITUDE pairs, then Question 12 will request receiver locations specified by their latitude and longitude.

Receiver sites to be included in the predictions:

- **L** = List current set of receiver sites
- **D** = Delete a receiver site
- **A** = Add a receiver site
- **C** = Change a receiver site
- **N** = No change

12) Receiver site (Add)?

Receiver site location

Type site **lat** (followed by carriage return) and site **lon** (return) for each of the sites. Enter the reference site location first.

Limits are - **ON** <= lat <= **90N**
- **0S** <= lat <= **90S**
- **0W** <= lon <= **180W**
- **0E** <= lon <= **180E**

The default hemispheres are **N** and **E**. The **S** and **W** locations can be specified by adding an **S** to the latitude value or adding an **W** to the longitude value.

Inputs of the form **X,Y,Z** imply degrees, minutes and seconds.

Inputs of the form **X.Y** imply decimal degrees.

12) Receiver lat (10.0000 deg N or 10 0 0 dms N)? 15
12) Receiver lon (85.0000 deg W or 85 0 0 dms W)? 90W

Enter a carriage return to terminate the entering of additional receiver sites. After the sites have been entered, typing an **L** will list the sites; typing a **C** or **D** will allow the sites to be changed or deleted; and typing an **N** for no changes will terminate Question 12.
Distance-bearing pairs

Receiver sites to be included in the predictions:

- **L** = List current set of receiver sites
- **D** = Delete a receiver site
- **A** = Add a receiver site
- **C** = Change a receiver site
- **N** = No change

12) Receiver site (Add)?

Receiver site location

Distance from reference site to terminal site (0.0 to 10000.0 km)

12) Distance (0.0 km)? 10

Bearing from reference site.
Enter in degrees clockwise from north.

(0.0 to 360.0 degrees)

12) Bearing (10.0 deg)?

Receiver site location

12) Distance (10.0 km)?

12) Receiver site (Add)? N

Incremental bearing, fixed distance

Receiver site location

Bearing from reference site.
Enter in degrees clockwise from north, i.e., north = 0, east = 90, south = 180, west = 270. Answer can be in decimal degrees (X.Y) or in deg., min., and sec. (X,Y,Z), and must be between 0.0 and 360 degrees.

Initial bearing.
Enter the bearing of your first terminal site.
Enter in degrees clockwise from north, i.e., north = 0, east = 90, south = 180, west = 270.

Answer can be in decimal degrees (X.Y) or in deg., min., and sec. (X,Y,Z), and must be between 0.0 and 359.0 degrees.

13) Min bear(0.0 deg)?

If path option is DISTANCE-BEARING PAIRS, then Question 12 will request receiver locations specified by their distance and bearing from the transmitter site.

If path option is INCREMENTAL BEARING, then Question 13 will ask for receiver locations specified by the minimum bearing, maximum bearing, and incremental bearing from the transmitter site. The distance from the transmitter, specified by the user, is fixed.
Final bearing.
Enter the bearing of your last terminal site.
Enter in degrees clockwise from north, i.e., north = 0, east = 90, south = 180, west = 270.
Answer can be in decimal degrees (X,Y) or in deg., min., and sec. (X,Y,Z), and must be between 0.0 and 359.0 degrees.
13) Max bear( 315.0 deg)?

Bear increment.
Enter the number of degrees you wish to increment. Answer can be in decimal degrees (X,Y) or in deg., min., and sec. (X,Y,Z), and must be between 1.0 and 180.0 degrees.
13) Bear inc( 45.0 deg)?

Distance from reference site to terminal site (0.0 to 10000.00 km)
13) Distance (10.0 km)?

If path option is INCREMENTAL DISTANCE, then Question 13 asks for the minimum distance, maximum distance, and distance increment from the transmitter at a fixed, user-specified bearing.

Incremental distance, fixed bearing

Receiver site location

Initial Distance (.1 to 10000.0 km)
13) Min Dist (.1 km)?

Final Distance (.1 to 10000.0 km)
13) Max Dist (500.0 km)?

Distance Increment (0.0 to 10000.0 km)
13) Dist Inc (100.0 km)?
13) Bearing (10.0 deg)?
The following Questions 14 through 17 depend upon the ground-wave method chosen in Question 4.

**Smooth Earth**

Conductivity for the path
(between .001 and 10.000 Siemens(mhos)/meter)
- 0.001 for poor ground
- 0.005 for average ground
- 0.020 for good ground
- 5.000 for sea water
- 0.010 for fresh water

14) Conductivity for the path (.005 S/m)?

Dielectric constant (between 1. and 81.)
- 4.0 for poor ground
- 15.0 for average ground
- 25.0 for good ground
- 81.0 for sea and fresh water

15) Dielectric constant for the path (15. S/m)?

**Mixed path or irregular terrain**

Conductivity and relative dielectric constants are needed for each section of the mixed path. Starting at the transmitter site (ref site at 0.0 km) and ending at the receiver site (at 400.1 km), give the length of each segment having different ground constants and the values of conductivity and dielectric constant for each segment. Up to 10 segments may be entered.

Segment 1 length (0.0 to 400.1 km)
16) Segment 1 length (400.1 km)? 200

Conductivity for the segment between 0.0 and 200.0 km (between .001 and 10.000 Siemens(mhos)/meter)
- 0.001 for poor ground
- 0.005 for average ground
- 0.020 for good ground
- 5.000 for sea water
- 0.010 for fresh water

If MIXED PATH or IRREGULAR TERRAIN is chosen, Question 16 will break the path into segments whose lengths are chosen by the user. For each segment, the user supplies the ground constants. The path can be as many as 10 segments. The program always defaults the segment length to the remaining path length.

This example, the distance from the transmitter to the receiver is 400.1 km. The user indicated the first segment is 200 km. The conductivity and dielectric constant for the segment must be supplied by the user.
Conductivity for the path between 0.0 and 200.0 km (.005 S/m)?

Dielectric constant for the segment between 0.0 and 200.0 km (between 1. and 81.)
- 4.0 for poor ground
- 15.0 for average ground
- 25.0 for good ground
- 81.0 for sea and fresh water

Dielectric constant for the segment between 0.0 and 200.0 km (15.)?
16) Segment 2 length (200.1 km)? 200

Conductivity for the path between 200.0 and 400.0 km (.005 S/m)?
Dielectric constant for the segment between 200.0 and 400.0 km (15.)?
16) Segment 3 length (.1 km)?

Conductivity for the path between 400.0 and 400.1 km (.005 S/m)?
Dielectric constant for the segment between 400.0 and 400.1 km (15.)?

17) Terrain elevation option (User-defined)? U

Repeat for the next segment(s). The program always shows the maximum segment length left in the path.

Irregular terrain

Terrain elevation options:
- U = User-defined terrain elevations
- D = Elevations obtained from data base
17) Terrain elevation option (User-defined)? U

Distance Increment (0.0 to 1000.0 km)
17) Dist Inc (10.0 km)?

Terrain elevations are needed along the irregular path. Starting at the transmitter site (ref site), give the distance from the ref site and the elevation values.
Elevation at 0.0 km (0.00 to 1000.0 m)?
Elevation at 0.00 km (0.00 m)?
Elevation at 100.00 km (10.00 m)?
Elevation at 200.00 km (20.00 m)?
Elevation at 300.00 km (30.00 m)?
Elevation at 400.00 km (40.00 m)?
Elevation at 400.10 km (50.00 m)?

The following Questions 19 through 56 ask for transmitter parameter values.

Transmitter power into the antenna terminals (1.00 to 10000.00 kW)
19) Transmitter power into the antenna terminals (1.00 kW)?

Antenna types:
VM = Vertical monopole
UG = User gain input
FS = Field strength option
GM = General monopole array
SM = Standard monopole array
21) Transmitter antenna type (Vertical monopole)?

If IRREGULAR TERRAIN is chosen, Question 17 allows the user to enter the path terrain elevations at a user-specified increment along the path. The terrain elevation data base has elevation values from Mexico to northern South America. The elevations are on a grid whose spacing is 5 minutes in latitude and longitude. If the path is outside of the region covered by the data base, the program will print that there are no topographic data along the path from the data base.

The user is asked to select the type of transmitter antenna from this list. After selecting an antenna type, the user will be asked for additional information. If the user has transmitter station data in the IFRB or FCC format, then select GM, the general monopole array gain calculations. The standard monopole array is a specific three- four- or six-monopole array antenna. For the field strength option, the user supplies the field strength at a reference distance and the program will compute an equivalent antenna gain. The user-defined gain, field strength option, and the standard monopole will use the same gain for the sky-wave calculations as for the ground-wave calculations. The general monopole array and vertical monopole antennas have sky-wave gains that depend upon the takeoff sky-wave signal.

For VERTICAL MONOPOLE, the antenna’s height and ground screen characteristics will be specified.
Transmitter antenna feed point height above ground (between 0.00 and 100.0 m)
22) Transmitter antenna feed point height above ground (0.00 m)?

Transmitter vertical monopole length (between 0.00 and 400.0 m)
23) Transmitter vertical monopole length (0.00 m)?

Transmitter antenna monopole efficiency (between 1.00 and 100.0 %)
23) Transmitter antenna monopole efficiency (100.0 %)?

Ground screen
Y = Yes
N = No
24) Ground screen (Yes)?

Transmitter antenna ground screen radius (between 1.00 and 2500.00 m)
25) Transmitter antenna ground screen radius (0.00 m)?

Transmitter antenna number of radials (between 5 and 360)
26) Transmitter antenna number of radials (0)?

User-specified gain option

For USER-SPECIFIED GAIN, the user will specify an antenna gain relative to an isotropic radiator. This single gain value is used for all ground-wave and sky-wave predictions regardless of azimuth or takeoff angle of the signal.

Transmitter antenna feed point height above ground (between 0.00 and 100.0 m)
22) Transmitter antenna feed point height above ground (0.00 m)?

Transmitter antenna power gain relative to an isotropic radiator (-100.0 to 100.0 dBi). If gain is known to a dipole, then dBi = dBd + 2.5
34) Transmitter gain (0.0 dBi)?
**Field strength option**

Transmitter antenna feed point height above ground (between 0.00 and 100.0 m)

22) Transmitter antenna feed point height above ground (0.00 m)?

Transmitter antenna field strength (.0010 to 100000000.0000 mV/m)

31) Transmitter antenna field strength (0.0000 mV/m)?

Transmitter antenna reference power (.001 to 10000.000 kW)

32) Transmitter antenna reference power (0.000 kW)?

Transmitter antenna reference distance (0.00 to 100.00 km)

33) Transmitter antenna reference distance (0.00 km)?

**General monopole array**

Hours of operation for which the given characteristics of the antenna are applicable:

- D = Day
- N = Night
- A = All

37) Hours of operation (Day)?

Reference point:

- C = Spacing and orientation are shown with respect to a common reference point which is generally the first tower
- P = Spacing and orientation are shown with respect to the previous tower

38) Definition point indicator (Common reference tower)?

The FIELD STRENGTH OPTION allows the user to specify the field strength at a reference distance with a given input power. The equivalent antenna gain is computed and used for all ground-wave and sky-wave predictions regardless of azimuth or takeoff angle of the signal. The transmitter antenna reference power is the power at the input to the antenna terminals.

The GENERAL MONOPOLE ARRAY should be used with IFRB- or FCC-format station data information.

This is a reminder to the user that many stations have different characteristics for day and night operations.

Most data are provided with the first tower as the reference, so C would be entered for COMMON REFERENCE.
Total number of towers (1 to 20)
39) Total number of towers (1)?

Tower #1

Ratio of the tower field to the field from the reference tower (0.0000 to 9.0000)
40) Tower field ratio (1.0000)?

Positive or negative difference in the phase angle of the field from the tower with respect to the field from the reference tower (-360.0000 to 360.0000 degrees)
41) Phase difference of the field (0.0000 degrees)?

Electrical spacing of the tower from the reference point (0.0000 to 360.0000 degrees)
42) Electrical tower spacing (0.0000 degrees)?

Angular orientation of the tower from the reference point (0.0000 to 360.0000 degrees from True North)
43) Angular tower orientation (0.0000 degrees)?

Tower structure
V = Vertical, simple antenna
T = Top-loaded antenna
S = Sectionalized antenna
44) Tower structure (Vertical, simple antenna)?

Electrical height of the tower under consideration (0.0 to 360.0 degrees)
45) Electrical height of tower (225.0 degrees)?

Questions 41 through 55 ask for parameters whose values have units of degrees. This is the same as portions of a wavelength where 360 degrees equals one wavelength.

Only question 45 is asked if the tower type is VERTICAL, SIMPLE ANTENNA.
Electrical height of antenna tower (0.0 to 360.0 degrees)?
50) Electrical height of antenna tower (120.0 degrees)?

Difference between apparent electrical height (based on current distribution) and actual height (0.0 to 360.0 degrees)
51) Difference between apparent electrical height and actual height (20.0 degrees)?

Height of the lower section (0.0 to 360.0 degrees)
52) Height of lower section (120.0 degrees)?

Difference between apparent electrical height of lower section (based on current distribution) and actual height of lower section (0.0 to 360.0 degrees)
53) Difference between apparent electrical height of lower section and actual height of lower section (20.0 degrees)?

Total height of the antenna (0.0 to 360.0 degrees)
54) Total height of antenna (220.0 degrees)?

Difference between apparent electrical height (based on current distribution) of the total tower (0.0 to 360.0 degrees)
55) Difference between apparent electrical height of the total tower (15.0 degrees)?

Augmentations to be included in the predictions:
L = List current set of augmentations
D = Delete an augmentation
A = Add an augmentation
C = Change an augmentation
N = No change
56) Augmentation (A)?

Questions 50 and 51 are asked if the tower type is TOP-LOADED ANTENNA.

Questions 52 through 55 are asked if the tower type is SECTIONALIZED ANTENNA.

Augmentations can be made to a directional antenna to enhance the gain in various directions. The user will have to supply the central angle of the augmentations, their total angular spans, and their radiated field strengths in mV/m at 1 km.
Radiation at the central azimuth of augmentation (mV/m at 1 km) (>= the value for the theoretical pattern)
Radiation at central azimuth of augmentation (1300.0 mV/m)?

Central azimuth of augmentation (center of the span) (0.0 to 360.0 degrees)
Central azimuth of augmentation (110.0 degrees)?

Total span of the augmentation. Half of the span will be on each side of the central azimuth of augmentation. If the spans overlap, augmentations are processed clockwise according to the central azimuth of augmentations. (0.1 to 360.1 degrees)
Total span of augmentation (40.0 degrees)?

Radiation at central azimuth of augmentation (10.0 mV/m)?

56) Augmentation (A)? N

**Standard monopole array**

Transmitter antenna number of poles (3, 4 or 6)
27) Transmitter antenna number of poles (3)?

Transmitter antenna boresight bearing (0.0 to 360.0 degrees east of north)
28) Transmitter antenna boresight bearing (0.0 degrees)?

The following Questions 61 through 70 ask for receiver parameter values.

Enter only a carriage return to terminate augmentation entries.

One of three STANDARD MONOPOLE ARRAYS can be chosen. The gain value determined at each azimuth will be used for both ground-wave and sky wave predictions.

The main beam pointing angle is to be specified by the user.
Antenna types:
VM = Vertical monopole
UG = User gain input
FS = Field strength option
FL = Ferrite loop

61) Receiver antenna type (Vertical monopole)?

Ferrite loop antenna

Receiver antenna feed point height above ground (between 0.00 and 100.0 m)
62) Receiver antenna feed point height above ground (0.00 m)?

Receiver antenna length of ferrite rod (0.00 to 25.40 cm)
69) Receiver antenna length of ferrite rod (0.00 cm)?

Receiver antenna diameter of ferrite rod (0.00 to 2.54 cm)
70) Receiver antenna diameter of ferrite rod (0.00 cm)?

The following Questions 80 through 82 are used to determine the man-made and atmospheric noise environment.

Man-made noise environment
B = Business (-127.2 dBW at 1 MHz)
RE = Residential (-131.5 dBW at 1 MHz)
RU = Rural (-136.8 dBW at 1 MHz)
Q = Quiet rural (-150.4 dBW at 1 MHz)

80) Man-made noise environment (Residential)?

Local time of day:
L = List current set of times
D = Delete a time
A = Add a time
C = Change a time
N = No change
81) Time of day (Add)?

The user will be asked to specify the receiver antenna type. The vertical monopole antenna, user-specified gain, and field strength option descriptions are the same as those for the transmitter antenna type.

The calculated antenna gain value of the ferrite loop is used for all ground-wave and sky-wave predictions regardless of azimuth or reception elevation angle of the signal.

The user selects the type of environment in which the receiver will be placed. The values in parentheses give the median man-made noise in 1 Hz bandwidths at 1 MHz. The value is adjusted for the selected frequency.

For each time entered, the program will compute the signal-to-noise ratio tables. This question only affects the noise calculations.
Up to 24 times (between 0 and 2300) (A carriage return exits this mode)
Time ( 200)? 23
Time ( 2300)? 22
Time ( 2200)?

81) Time of day (Add)? L
   Time(s)
   1) 2300
   2) 2200
81) Time of day (Add)? N

Seasons to be included in the predictions:
  L = List current set of seasons
  D = Delete a season
  A = Add a season
  C = Change a season
  N = No change
82) Season (Add)?

Seasons (up to 4 values)
  W = Winter (December, January, February)
  SP = Spring (March, April, May)
  SU = Summer (June, July, August)
  F = Fall (September, October, November)

Season (Winter (December, January, February))? SP
Season (Spring (March, April, May))? SU
Season (Summer (June, July, August))?
82) Season (Add)? N

Required reliability (between 0. and 100.%) 83) Required reliability ( 90.%)?

Earth radius ratio ( .500 to 3.000)
84) Earth radius ratio (1.330)?

Values between 1 and 24 or 100 and 2400 will be accepted.

For each season entered, the program will compute the signal-to-noise ratio tables. The question only affects the noise calculations.

The noise power is adjusted by the reliability. A 90 percent reliability implies that the computed signal-to-noise power ratio will be available for 90 percent of the time in a 1-hour/3-month season time block for the selected season, local time of day, and frequency.

The effective Earth radius to the actual Earth radius ratio is used in the ground-wave predictions. Use of 1.33 gives a standard refractive atmosphere and assumes a 4/3 effective to actual Earth radius ratio.
Table D-2. System 2 Questions, Their Meanings, and Acceptable Range of Values

<table>
<thead>
<tr>
<th>Question descriptions, acceptable value ranges, and default values</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title of the analysis (up to 30 characters) 1) Title (VOA Test)?</td>
<td>The title will be printed on the analysis output. Note a default value or the last value entered is given in parenthesis. If that value is acceptable, merely type a carriage return in response to the question.</td>
</tr>
<tr>
<td>Frequency (530 to 1750 kHz) 3) Frequency (1000 kHz)?</td>
<td>Predictions will be made at the selected frequency and the database will be searched for interfering transmitters within the range of 30 kHz above and 30 kHz below the selected frequency.</td>
</tr>
</tbody>
</table>
| Groundwave model: 4) Ground wave model (Smooth earth)? | S = Smooth earth  
M = Mixed path, smooth earth  
I = Irregular terrain, mixed path  
SMOOTH EARTH is the simplest prediction method. MIXED PATH requires ground constants to be given along the path. IRREGULAR TERRAIN requires ground constants and terrain elevations along the path. |
| Skywave model: 5) Skywave model (FCC Interregional)? | F = FCC Interregional  
C = CCIR Plenary Assembly  
W = Wang  
I = IFRB skywave  
FCC and IFRB currently use the same prediction method and they can be used for U.S. or Region 2 analyses. CCIR is the international method. WANG incorporates features of all the other methods. |
| Propagation conditions to be analyzed 6) Propagation conditions (Daytime)? | D = Daytime, groundwave only  
N = Nighttime, groundwave and skywave  
Interfering transmitters to be considered in the calculations will be those broadcasting during the day or both day and night. If only daytime is requested, there will be no skywave predictions made. |
Transmitter site

Country code for VOA transmitter site (2 characters).
11) VOA transmitter site country code (ZZ)?

Location description of VOA transmitter site (up to 14 characters)
12) VOA transmitter site location (Boulder, Co.)?

Code letter for VOA transmitter site (1 character)
13) VOA transmitter site ID (A)?

Type site lat (followed by carriage return) and site lon (return) for each of the sites. Enter the reference site location first.

Limit are - 0N <= lat <= 90N
0S <= lat <= 90S
0W <= lon <= 180W
0E <= lon <= 180E

The default hemispheres are N and E. The S and W locations can be specified by adding an S to the latitude value or adding an W to the longitude value.
Inputs of the form X,Y,Z imply degrees, minutes and seconds.
Inputs of the form X,Y imply decimal degrees.
14) VOA site lat (20.0000 deg N or 20 0 0 dms N)?
14) VOA site lon (90.0000 deg W or 90 0 0 dms W)?

The country code and location descriptions of the transmitter site are printed on the analysis summary of input parameters but not on the output tables.

The code letter for the transmitter site is printed on both the summary and the output tables.

Note that N (north) and E (east) are the default hemispheres. Append N or S to latitude values and E or W to longitude values to ensure correct locations.

Receiver site

Country code for population center site (2 characters)
21) Population center site country code (ZZ)?
Location description of population center site (up to 14 characters)
22) Population center site location (St. Louis, Mo.)?

The country code and the location description of the reception population center are printed on the summary of input values but not on the output tables.

Code letter for population center site (1 character)
23) Population center site ID (B)?

Type site lat (followed by carriage return) and site lon (return) for each of the sites. Enter the reference site location first.

Limits are - 0N <= lat <= 90N
0S <= lat <= 90S
0W <= lon <= 180W
0E <= lon <= 180E

The default hemispheres are N and E. The S and W locations can be specified by adding an S to the latitude value or adding an W to the longitude value.

Inputs of the form X,Y,Z imply degrees, minutes and seconds.
Inputs of the form X,Y imply decimal degrees.
24) Population center lat
(10.0000 deg N or
10 0 0 dms N)?
24) Population center lon
(85.0000 deg W or
85 0 0 dms W)?

Distance to be searched around population center for non-VOA transmitters (between 0.0 and 10000.0 km)
25) Distance to be searched around population center (100.0 km)?

The code letter for the population center is printed on both the summary and output tables.

A much larger search distance should be used for nighttime calculations compared with ground-wave daytime calculations.
Smooth earth

Conductivity for the path (between .001 and 10.000 Siemens/meter)
- 0.001 for poor ground
- 0.005 for average ground
- 0.020 for good ground
- 5.000 for sea water
- 0.010 for fresh water

30) Conductivity for the path (0.005 S/m)?

Dielectric constant (between 1. and 81.)
- 4.0 for poor ground
- 15.0 for average ground
- 25.0 for good ground
- 81.0 for sea and fresh water

31) Dielectric constant for the path (15.)?

If SMOOTH EARTH is chosen, Questions 30 and 31 will request the values of the ground constants to be used for all paths.

The following Questions 19 and 41 through 76 ask for transmitter parameter values

Transmitter power into the antenna terminals (1.00 to 10000.00 kW)
19) Transmitter power into the antenna terminals (1.00 kW)?
Antenna types:
- **VM** = Vertical monopole
- **UG** = User gain input
- **FS** = Field strength option
- **GM** = General monopole array
- **SM** = Standard monopole array

41) **Transmitter antenna type** (Vertical monopole)?

The user is asked to select the type of transmitter antenna from this list. After type selection, the user will be asked for additional information. If the user has transmitted station data in the IFRB or FCC format, then the user should select GM, the general monopole array gain calculations. The standard monopole array is a specific three-, four-, or six- monopole array antenna. For the field strength option, the user supplies the field strength at a reference distance and the program will compute an equivalent antenna gain. The user-defined gain, field strength option, and standard monopole will use the same gain for the sky-wave calculations as for the ground-wave calculations. The general monopole array and vertical monopole antennas have sky-wave gains that depend upon the takeoff angle of the sky-wave signal.

**Vertical monopole antenna**

Transmitter antenna feed point height above ground (between 0.00 and 100.0 m)

42) **Transmitter antenna feed point height above ground (0.00 m)?**

The antenna height is the actual height of the antenna feed point above the surrounding terrain. It is not necessarily the height of the structure.

Transmitter vertical monopole length (between 0.00 and 400.0 m)

43) **Transmitter vertical monopole length (1.00 m)?**

The antenna length should not be less than 0.01 wavelengths or greater than 0.7 wavelengths.
Transmitter antenna monopole efficiency (between 1.00 and 100.0 %)
43) Transmitter antenna monopole efficiency (100.0 %)?

Ground screen
Y = Yes
N = No
44) Ground screen (Yes)?

Transmitter antenna ground screen radius (between 1.00 and 2500.00 m)
45) Transmitter antenna ground screen radius (1.00 m)?

Transmitter antenna number of radials (between 5 and 360)
46) Transmitter antenna number of radials (10)?

User-specified gain antenna

Transmitter antenna feed point height above ground (between 0.00 and 100.0 m)
42) Transmitter antenna feed point height above ground (0.00 m)?

Transmitter antenna power gain relative to an isotropic radiator (-100.0 to 100.0 dBi). If gain is known to a dipole, then dBi = dBd + 2.5
54) Transmitter gain (1.0 dBi)?

Field strength option

The user can specify an antenna gain relative to an isotropic radiator. This single gain value is used for all ground-wave and sky-wave predictions regardless of azimuth or takeoff angle of the signal.

The field strength option allows the user to specify the field strength at a reference distance with a given input power. The equivalent antenna gain is computed and used for all ground-wave and sky-wave predictions regardless of azimuth or take-off angle of the signal. The transmitter antenna reference power is the power at the input to the antenna terminals.
Transmitter antenna feed point height above ground (between 0.00 and 100.0 m)

42) Transmitter antenna feed point height above ground (0.00 m)?

Transmitter antenna field strength (.0010 to 100000000.0000 mV/m)

51) Transmitter antenna field strength (300000 mV/m)?

Transmitter antenna reference power (.001 to 10000.000 kW)

52) Transmitter antenna reference power (1.000 kW)?

Transmitter antenna reference distance (0.00 to 100.00 km)

53) Transmitter antenna reference distance (0.00 km)?

General monopole array

Hours of operation for which the given characteristics of the antenna are applicable:

- D = Day
- N = Night
- A = All

57) Hours of operation (Day)?

Reference point:

- C = Spacing and orientation are shown with respect to a common reference point which is generally the first tower
- P = Spacing and orientation are shown with respect to the previous tower

58) Definition point indicator (Common reference tower)?

The general monopole array should be used with IFRB- or FCC-format station data information.

This is a reminder to the user that many stations have different characteristics for day and night operations.

Most data are provided with the first tower as the reference, so C would be entered for COMMON REFERENCE.
Total number of towers (1 to 20) 59
Total number of towers (1)?

Tower # 1

Ratio of the tower field to the field from the reference tower (0.0000 to 9.0000)
60) Tower field ratio (1.0000)?

Positive or negative difference in the phase angle of the field from the tower with respect to the field from the reference tower (-360.0000 to 360.0000 degrees)
61) Phase difference of the field (0.0000 degrees)?

Electrical spacing of the tower from the reference point (0.0000 to 360.0000 degrees)
62) Electrical tower spacing (0.0000 degrees)?

Angular orientation of the tower from the reference point (0.0000 to 360.0000 degrees from True North)
63) Angular tower orientation (0.0000 degrees)?

Tower structure
V = Vertical, simple antenna
T = Top-loaded antenna
S = Sectionalized antenna
64) Tower structure (Vertical, simple antenna)?

Electrical height of the tower under consideration (0.0 to 360.0 degrees)
65) Electrical height of tower (225.0 degrees)?

Questions 61 through 75 ask for parameters whose values have units of degrees. This is the same as portions of a wavelength where 360 degrees equals one wavelength.

Only question 65 is asked if the tower type is VERTICAL, SIMPLE ANTENNA.
Electrical height of the antenna tower (0.0 to 360.0 degrees)
70) Electrical height of antenna tower (120.0 degrees)?

Difference between apparent electrical height (based on current distribution) and actual height (0.0 to 360.0 degrees)
71) Difference between apparent electrical height and actual height (20.0 degrees)?

Height of the lower section (0.0 to 360 degrees)
72) Height of lower section (120.0 degrees)?

Difference between apparent electrical height of lower section (based on current distribution) and actual height of lower section (0.0 to 360.0 degrees)
73) Difference between apparent electrical height of lower section and actual height of lower section (20.0 degrees)?

Total height of antenna (0.0 to 360 degrees)
74) Total height of antenna (220.0 degrees)?
75) Difference between apparent electrical height of the total tower (15.0 degrees)?

Questions 70 and 71 are asked if the tower type is TOP-LOADED ANTENNA.

Questions 72 through 75 are asked if the tower type is SECTIONALIZED ANTENNA.
Augmentations to be included in the predictions:
L = List current set of augmentations
D = Delete an augmentation
A = Add an augmentation
C = Change an augmentation
N = No change

76) Augmentation (A)?

Radiation at the central azimuth of augmentation (mV/m at 1 km) (>= the value for the theoretical pattern)
Radiation at central azimuth of augmentation (1300.0 mV/m)?

Central azimuth of augmentation (center of the span) (0.0 to 360.0 degrees)
Central azimuth of augmentation (110.0 degrees)?

Total span of the augmentation. Half of the span will be on each side of the central azimuth of augmentation. If the spans overlap, augmentations are processed clockwise according to the central azimuth of augmentations.
Total span of augmentation (0.1 to 360.1 degrees)
Radiation at central azimuth of augmentation (10.0 mV/m)?

One of three standard monopole arrays can be chosen. The gain value determined at each azimuth will be used for both ground-wave and sky-wave predictions. The main beam pointing angle is to be specified by the user.
Transmitter antenna number of poles (3, 4 or 6)
47) Transmitter antenna number of poles (3)?

Transmitter antenna boresight bearing (0.0 to 360.0 degrees east of north)
48) Transmitter antenna boresight bearing (0.0 degrees)?

The following Questions 81 through 94 ask for receiver parameter values.

Antenna types:
VM = Vertical monopole
UG = User gain input
FS = Field strength option
FL = Ferrite loop
81) Receiver antenna type (Vertical monopole)?

Ferrite loop antenna

The calculated antenna gain value of the ferrite loop is used for all ground-wave and sky-wave predictions regardless of azimuth or reception elevation angle of the signal.

Receiver antenna feed point height above ground (between 0.00 and 100.0 m)
82) Receiver antenna feed point height above ground (0.00 m)?

Receiver antenna length of ferrite rod (0.00 to 25.40 cm)
89) Receiver antenna length of ferrite rod (0.00 cm)?

Receiver antenna diameter of ferrite rod (0.00 to 2.54 cm)
90) Receiver antenna diameter of ferrite rod (0.00 cm)?

The following Questions 95 through 99 are used to determine the man-made and atmospheric noise environment.
Man-made noise environment

B = Business (-127.2 dBW at 1 MHz)
RE = Residential (-131.5 dBW at 1 MHz)
RU = Rural (-136.8 dBW at 1 MHz)
Q = Quiet rural (-150.4 dBW at 1 MHz)

95) Man-made noise environment (Residential)?

Time of day to be used in calculations (between 0 and 2300)
96) Time (200)?

Seasons:
W = Winter (December, January, February)
SP = Spring (March, April, May)
SU = Summer (June, July, August)
F = Fall (September, October, November)
97) Season (Winter (December, January, February))? 

Required reliability (between 0 and 100.0)
98) Required reliability (90.0)?

Earth radius ratio (0.500 to 3.000)
99) Earth radius ratio (1.330)?

The user selects the type of environment in which the receiver will be placed. The values in parentheses give the median man-made noise in 1-Hz bandwidths at 1 MHz. The value is adjusted for the selected frequency.

This question affects the noise calculation for the signal-to-noise ratio tables.

The noise power is adjusted by the reliability. A 90-percent reliability implies that the computed signal-to-noise power ratio will be available for 90 percent of the time in a 1-hour/3-month season time block for the selected season, local time of day, and frequency.

The effective Earth radius to the actual Earth radius ratio is used in the ground-wave predictions. Use of 1.33 gives a standard refractive atmosphere and assures a 4/3 effective to actual Earth radius ratio.
Table D-3. System 3 Questions, Their Meanings, and Acceptable Range of Values

<table>
<thead>
<tr>
<th>Question descriptions, acceptable value ranges and default values</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title of the analysis (up to 30 characters)</td>
<td>The title will be printed on the analysis output.</td>
</tr>
<tr>
<td>1) Title (VOA Test)?</td>
<td>Predictions will be made at the selected frequency and the data base will be searched for interfering transmitters within the range of 30 kHz above and 30 kHz below the selected frequency.</td>
</tr>
<tr>
<td>Frequency (530 to 1750 kHz)</td>
<td>SMOOTH EARTH is the simplest prediction method. MIXED PATH requires ground constants to be given along the path. IRREGULAR TERRAIN requires ground constants and terrain elevations along the path.</td>
</tr>
<tr>
<td>Frequencies must be in increments of 10 kHz</td>
<td>SMOOTH EARTH is the simplest prediction method. MIXED PATH requires ground constants to be given along the path. IRREGULAR TERRAIN requires ground constants and terrain elevations along the path.</td>
</tr>
<tr>
<td>3) Frequency (1000 kHz)?</td>
<td>SMOOTH EARTH is the simplest prediction method. MIXED PATH requires ground constants to be given along the path. IRREGULAR TERRAIN requires ground constants and terrain elevations along the path.</td>
</tr>
<tr>
<td>Groundwave model:</td>
<td>SMOOTH EARTH is the simplest prediction method. MIXED PATH requires ground constants to be given along the path. IRREGULAR TERRAIN requires ground constants and terrain elevations along the path.</td>
</tr>
<tr>
<td>S = Smooth earth</td>
<td>SMOOTH EARTH is the simplest prediction method. MIXED PATH requires ground constants to be given along the path. IRREGULAR TERRAIN requires ground constants and terrain elevations along the path.</td>
</tr>
<tr>
<td>M = Mixed path, smooth earth</td>
<td>SMOOTH EARTH is the simplest prediction method. MIXED PATH requires ground constants to be given along the path. IRREGULAR TERRAIN requires ground constants and terrain elevations along the path.</td>
</tr>
<tr>
<td>I = Irregular terrain, mixed path</td>
<td>SMOOTH EARTH is the simplest prediction method. MIXED PATH requires ground constants to be given along the path. IRREGULAR TERRAIN requires ground constants and terrain elevations along the path.</td>
</tr>
<tr>
<td>4) Ground wave model (Smooth earth)?</td>
<td>SMOOTH EARTH is the simplest prediction method. MIXED PATH requires ground constants to be given along the path. IRREGULAR TERRAIN requires ground constants and terrain elevations along the path.</td>
</tr>
<tr>
<td>Skywave model:</td>
<td>FCC and IFRB currently use the same prediction method and can be used for U.S. or Region 2 analyses. CCIR is the international method. WANG incorporates features of all the other methods.</td>
</tr>
<tr>
<td>F = FCC Interregional</td>
<td>FCC and IFRB currently use the same prediction method and can be used for U.S. or Region 2 analyses. CCIR is the international method. WANG incorporates features of all the other methods.</td>
</tr>
<tr>
<td>C = CCIR Plenary Assembly</td>
<td>FCC and IFRB currently use the same prediction method and can be used for U.S. or Region 2 analyses. CCIR is the international method. WANG incorporates features of all the other methods.</td>
</tr>
<tr>
<td>W = Wang</td>
<td>FCC and IFRB currently use the same prediction method and can be used for U.S. or Region 2 analyses. CCIR is the international method. WANG incorporates features of all the other methods.</td>
</tr>
<tr>
<td>I = IFRB skywave</td>
<td>FCC and IFRB currently use the same prediction method and can be used for U.S. or Region 2 analyses. CCIR is the international method. WANG incorporates features of all the other methods.</td>
</tr>
<tr>
<td>5) Skywave model (FCC Interregional)?</td>
<td>FCC and IFRB currently use the same prediction method and can be used for U.S. or Region 2 analyses. CCIR is the international method. WANG incorporates features of all the other methods.</td>
</tr>
<tr>
<td>Propagation conditions to be analyzed</td>
<td>Interfering transmitters to be considered in the calculations will be those broadcasting during the day or both day and night. If only daytime is requested, there will be no sky-wave predictions made.</td>
</tr>
<tr>
<td>D = Daytime, groundwave only</td>
<td>Interfering transmitters to be considered in the calculations will be those broadcasting during the day or both day and night. If only daytime is requested, there will be no sky-wave predictions made.</td>
</tr>
<tr>
<td>N = Nighttime, groundwave and skywave</td>
<td>Interfering transmitters to be considered in the calculations will be those broadcasting during the day or both day and night. If only daytime is requested, there will be no sky-wave predictions made.</td>
</tr>
<tr>
<td>6) Propagation conditions (Daytime)?</td>
<td>Interfering transmitters to be considered in the calculations will be those broadcasting during the day or both day and night. If only daytime is requested, there will be no sky-wave predictions made.</td>
</tr>
</tbody>
</table>
Transmitter site

Country code for VOA transmitter site (2 characters)
11) VOA transmitter site country code (ZZ)?

Location description of VOA transmitter site (up to 14 characters)
12) VOA transmitter site location (Boulder, CO)?

Code letter for VOA transmitter site (1 character)
13) VOA transmitter site ID (A)?

Type site lat (followed by carriage return) and site lon (return) for each of the sites. Enter the reference site location first.
Limits are - 0N <= lat <= 90N
       0S <= lat <= 90S
       0W <= lon <= 180W
       0E <= lon <= 180E

The default hemispheres are N and E. The S and W locations can be specified by adding an S to the latitude value or adding an W to the longitude value.

Inputs of the form X,Y,Z imply degrees, minutes and seconds.
Inputs of the form X,Y imply decimal degrees.
14) VOA site lat ( 20.0000 deg N
or 20 0 0 dms N)?
14) VOA site lon ( 90.0000 deg
W or 90 0 0 dms W)?

Receiver site

Country code for population center site (2 characters)
21) Population center site country code (ZZ)?

Location description of population center site (up to 14 characters)
22) Population center site location (St. Louis, MO)?
Code letter for population center site (1 character)
23) Population center site ID (B)?

Western plot boundary
Limits are - 20 W <= lat <= 160W
24) Western plot boundary
(90.00 degrees W)? 106

Eastern plot boundary
Limits are - 20 W <= lat <= 160W
25) Eastern plot boundary (100.0 degrees W)? 100

Southern plot boundary
Limits are - 0 N <= lat <= 90N
Limits are - 0 S <= lat <= 90S
The default hemisphere is N. The S location can be specified by adding an S to the latitude value
26) Southern plot boundary
(90.00 degrees N)? 20

Northern plot boundary
Limits are - 0 N <= lat <= 90N
Limits are - 0 S <= lat <= 90S
The default hemisphere is N. The S location can be specified by adding an S to the latitude value
27) Northern plot boundary
(90.00 degrees N)?

Distance to be searched around population center for non-VOA transmitters (between 0.0 and 10000.0 km)
28) Distance to be searched around population center ( 100.0 km)?

The code letter for the population center is printed on both the summary and output tables.

Western boundary for the receiver sites.

Eastern boundary for the receiver sites.

Southern boundary for the receiver sites.

Northern boundary for the receiver sites.

The program searches for interfering transmitters both within the plot boundaries and the requested search distance surrounding the area. If a search distance of 0 is input, only the area within the plot boundaries will be searched.
If SMOOTH EARTH is chosen, Questions 30 and 31 will request the values of the ground constants to be used for all paths.

Conductivity for the path (between .001 and 10,000 Siemens(mhos)/meter):
- 0.001 for poor ground
- 0.005 for average ground
- 0.020 for good ground
- 5.000 for sea water
- 0.010 for fresh water

30) Conductivity for the path (0.005 S/m)?

Dielectric constant (between 1. and 81.):
- 4.0 for poor ground
- 15.0 for average ground
- 25.0 for good ground
- 81.0 for sea and fresh water

31) Dielectric constant for the path (15.)?

The following Questions 19 and 41 through 76 ask for transmitter parameter values.

Transmitter power into the antenna terminals (.10 to 10000.00 kW):
19) Transmitter power into the antenna terminals (1.00 kW)?

Antenna types:
- VM = Vertical monopole
- UG = User gain input
- FS = Field strength option
- GM = General monopole array
- SM = Standard monopole array
41) Transmitter antenna type (Vertical monopole)?

The user is asked to select the type of transmitter antenna from this list. After type selection, the user will be asked for additional information. If the user has transmitter station data in the IFRB or FCC format, then select GM, the general monopole array gain calculations. The standard monopole array is a specific three-, four-, or six-monopole array antenna. For the field strength option, the user supplies the field strength at a reference distance and the program will compute an equivalent antenna gain. The user-defined gain, field strength option, and the standard monopole will use the same gain for the sky-wave calculations as for the ground-wave calculations. The general monopole array and vertical monopole antennas have sky-wave gains that depend upon the take-off angle of the sky wave signal.

**Vertical monopole antenna**

Transmitter antenna feed point height above ground (between 0.00 and 100.0 m)

42) Transmitter antenna feed point height above ground (0.00 m)?

The antenna height is the actual height of the antenna feed point about the surrounding terrain. It is not necessarily the height of the structure.

Transmitter vertical monopole length (between 0.00 and 400.0 m)

43) Transmitter vertical monopole length (1.00 m)?

The antenna length should not be less than 0.01 wavelengths or greater than 0.7 wavelengths.
Transmitter antenna monopole efficiency
(between 1.00 and 100.0 %)
43) Transmitter antenna monopole
efficiency (100.0 %)?

Ground screen
Y = Yes
N = No
44) Ground screen (Yes)?

Transmitter antenna ground screen
radius (between 1.00 and 2500.00 m)
45) Transmitter antenna ground
screen radius (1.00 m)?

Transmitter antenna number of radials
(between 5 and 360)
46) Transmitter antenna number
of radials (1)?

User-specified gain antenna

Transmitter antenna feed point height
above ground (between 0.00 and
100.0 m)
42) Transmitter antenna feed point
height above ground (0.00 m)?

Transmitter antenna power gain relative
to an isotropic radiator (-100.0 to 100.0
dBi). If gain is known to a dipole, then
dBi = dBd + 2.5
54) Transmitter gain (1.0 dBi)?

Field strength option

The user can specify an antenna gain
relative to an isotropic radiator. This
single gain value is used for all
ground-wave and sky-wave predictions
regardless of azimuth or takeoff angle of
the signal.

The field strength option allows the user
to specify the field strength at a
reference distance with a given input
power. The equivalent antenna gain is
computed and used for all ground-wave
and sky-wave predictions regardless of
azimuth or take-off angle of the signal.
The transmitter antenna reference power
is the power at the input to the antenna
terminals.
Transmitter antenna feed point height above ground (between 0.00 and 100.0 m)
42) Transmitter antenna feed point height above ground (0.00 m)?

Transmitter antenna field strength (.0010 to 100000000.0000 mV/m)
51) Transmitter antenna field strength (3.0000 mV/m)?

Transmitter antenna reference power (.001 to 10000.000 kW)
52) Transmitter antenna reference power (1.000 kW)?

Transmitter antenna reference distance (0.00 to 100.00 km)
53) Transmitter antenna reference distance (0.00 km)?

General monopole array

Hours of operation for which the given characteristics of the antenna are applicable:
D = Day
N = Night
A = All
57) Hours of operation (Day)?

Reference point:
C = Spacing and orientation are shown with respect to a common reference point which is generally the first tower
P = Spacing and orientation are shown with respect to the previous tower
58) Definition point indicator (Common reference tower)?

The general monopole array should be used with IFRB- or FCC-format station data information.

This is a reminder to the user that many stations have different characteristics for day and night operations.

Most data are provided with the first tower as the reference, so C would be entered for COMMON REFERENCE.
Total number of towers (1 to 20)
59) Total number of towers (1)?

Tower # 1

Ratio of the tower field to the field from the reference tower (0.0000 to 9.0000)
60) Tower field ratio (1.0000)?

Positive or negative difference in the phase angle of the field from the tower with respect to the field from the reference tower (-180.0000 to 180.0000 degrees)
61) Phase difference of the field (0.0000 degrees)?

Questions 61 through 75 ask for parameters whose values have units of degrees. This is the same as portions of a wavelength where 360 degrees equals one wavelength.

Electrical spacing of the tower from the reference point (0.0000 to 360.0000 degrees)
62) Electrical tower spacing (0.0000 degrees)?

Angular orientation of the tower from the reference point (0.0000 to 360.0000 degrees from True North)
63) Angular tower orientation (0.0000 degrees)?

Tower structure
V = Vertical, simple antenna
T = Top-loaded antenna
S = Sectionalized antenna
64) Tower structure (Vertical, simple antenna)?

Electrical height of the tower under consideration (0.0 to 360.0 degrees)
65) Electrical height of tower (225.0 degrees)?

Only Question 65 is asked if the tower type is VERTICAL, SIMPLE ANTENNA.
Questions 70 and 71 are asked if the tower type is TOP-LOADED ANTENNA.

Questions 72 through 75 are asked if the tower type is SECTIONALIZED ANTENNA.
Augmentations to be included in the predictions:

L = List current set of augmentations
D = Delete an augmentation
A = Add an augmentation
C = Change an augmentation
N = No change

76) Augmentation (A)?

Radiation at the central azimuth of augmentation (mV/m at 1 km)
(>= the value for the theoretical pattern)

Radiation at central azimuth of augmentation (1300.0 mV/m)?

Central azimuth of augmentation (center of the span) (0.0 to 360.0 degrees)

Central azimuth of augmentation (110.0 degrees)?

Total span of the augmentation. Half of the span will be on each side of the central azimuth of augmentation. If the spans overlap, augmentations are processed clockwise according to the central azimuth of augmentations. (0.1 to 360.1 degrees)

Total span of augmentation (40.0 degrees)?

Radiation at central azimuth of augmentation (10.0 mV/m)?

76) Augmentation (A)?

Standard monopole array

Augmentations can be made to a directional antenna to enhance the gain in various directions. The user will have to supply the central angle of the augmentations, their total angular spans, and their radiated field strengths in mV/m at 1 km.

One of three standard monopole arrays can be chosen. The gain value determined at each azimuth will be used for both ground-wave and sky-wave predictions. The main beam pointing angle is to be specified by the user.
Transmitter antenna number of poles (3, 4 or 6)
47) Transmitter antenna number of poles (3)?

Transmitter antenna boresight bearing (0.0 to 360.0 degrees east of north)
48) Transmitter antenna boresight bearing (0.0 degrees)?

The following Questions 81 through 94 ask for receiver parameter values.

Antenna types:
VM = Vertical monopole
UG = User gain input
FS = Field strength option
FL = Ferrite loop
81) Receiver antenna type (Vertical monopole)?

The user will be asked to specify the receiver antenna type. The vertical monopole antenna, user-specified gain, and field strength option descriptions are the same as those for the transmitter antenna type.

Ferrite loop antenna

Receiver antenna feed point height above ground (between 0.00 and 100.0 m)
82) Receiver antenna feed point height above ground (0.00 m)?

Receiver antenna length of ferrite rod (0.00 to 25.40 cm)
89) Receiver antenna length of ferrite rod (0.00 cm)?

Receiver antenna diameter of ferrite rod (0.00 to 2.54 cm)
90) Receiver antenna diameter of ferrite rod (0.00 cm)?

The calculated antenna gain value of the ferrite loop is used for all ground-wave and sky-wave predictions regardless of azimuth or reception elevation angle of the signal.
Earth radius ratio (.500 to 3.000)
98) Earth radius ratio (1.330)?

Type of plot:
  C = Coverage
  I = Interference
99) Type of plot (Interference)?

The effective Earth radius to the actual Earth radius ratio is used in the ground-wave predictions. Use of 1.33 gives a standard refractive atmosphere and assures a 4/3 effective to actual Earth radius ratio.

A COVERAGE plot will plot the coverage of the VOA transmitter without searching for interfering non-VOA transmitters.
APPENDIX E. SAMPLE DIALOGS

Institute for Telecommunication Sciences
MF RESYDE
System 1
Voice of America
MF Relay System Design Model
Version 1.0

Choose from the menu:
H = Help
D = Program Description
C = Concise Dialog
V = Verbose Dialog
E = Edit Data
S = Summary of Data
P = Process Last Data Set Entered
Q = Quit

Menu (Verbose)?

Title of the analysis (up to 30 characters)
1) Title (VOA Test)? ground wave check

Length units:
M = Metric, kilometers and meters
E = English, statute miles and feet
2) Length units (Metric, kilometers and meters)?

Frequency (530.0 to 1750. kHz)
3) Frequency (1000. kHz)?

Groundwave model:
S = Smooth earth
M = Mixed path, smooth earth
I = Irregular terrain, mixed path
4) Ground wave model (Smooth earth)?

Skywave model:
F = FCC Interregional
C = CCIR Plenary Assembly
W = Wang
I = IFRB skywave
5) Skywave model (FCC Interregional)?
Type site lat (followed by carriage return) and site lon (return) for each of the sites. Enter the reference site location first.

Limits are:
- 0N <= lat <= 90N
- 0S <= lat <= 90S
- 0W <= lon <= 180W
- 0E <= lon <= 180E

The default hemispheres are N and E. The S and W locations can be specified by adding an S to the latitude value or adding an W to the longitude value.

Inputs of the form X,Y,Z imply degrees, minutes and seconds.
Inputs of the form X.Y imply decimal degrees.

10) Transmitter lat (20.0000 deg N or 20 0 0 dms N)?

10) Transmitter lon (90.0000 deg W or 90 0 0 dms W)?

Paths to be analyzed are defined from the transmitter site (ref site) to the receiver site(s). The transmitter site is defined by its latitude and longitude. The receiver site(s) can be defined by:

- L = Latitude longitude pairs
- D = Distance - bearing pairs
- IB = Incremental bearing at a fixed distance
- ID = Incremental distance at a fixed bearing

11) Path option (Latitude - longitude pairs)?

Receiver site location

Initial Distance (0.1 to 10000.0 km)

13) Min Dist (0.1 km)?

Final Distance (10.0 to 10000.0 km)

13) Max Dist (500.0 km)?

Distance Increment (0.0 to 10000.0 km)

13) Dist Inc (100.0 km)?

Bearing from reference site.
Enter in degrees clockwise from north, i.e. north = 0, east = 90, south = 180, west = 270.
Answer can be in decimal degrees(X,Y) or in deg. min. and sec. (X,Y,Z), and must be between 0.0 and 360.0 degrees

13) Bearing (10.0 deg)?
Conductivity for the path
(between .001 and 10.000 Siemens(mhos)/meter)
- 0.001 for poor ground
- 0.005 for average ground
- 0.020 for good ground
- 5.000 for sea water
- 0.010 for fresh water

14) Conductivity for the path (.005 S/m)? ___

Dielectric constant (between 1. and 81.)
- 4.0 for poor ground
- 15.0 for average ground
- 25.0 for good ground
- 81.0 for sea and fresh water

15) Dielectric constant for the path (15.)? ___

Transmitter power into the antenna terminals (.10 to 10000.00 kW)

19) Transmitter power into the antenna terminals (1.00 kW)? ___

Antenna types:
- VM = Vertical monopole
- UG = User gain input
- FS = Field strength option
- GM = General monopole array
- SM = Standard monopole array

21) Transmitter antenna type (Vertical monopole)? ___

Transmitter antenna feed point height above ground
(between 0.00 and 100.0 m)

22) Transmitter antenna feed point height above ground (0.00 m)? ___

Transmitter antenna field strength (.0010 to 100000000.0000 mV/m)

31) Transmitter antenna field strength (3.0000 mV/m)? ___

Transmitter antenna reference power (.001 to 10000.00 kW)

32) Transmitter antenna reference power (1.000 kW)? ___

Transmitter antenna reference distance (0.00 to 100.00 km)

33) Transmitter antenna reference distance (10.00 km)? ___

Antenna types:
- VM = Vertical monopole
- UG = User gain input
- FS = Field strength option
- FL = Ferrite loop

61) Receiver antenna type (Vertical monopole)? ___
Receiver antenna feed point height above ground
(between 0.00 and 100.0 m)
62) Receiver antenna feed point height above ground (0.00 m)? _____ ←

Receiver antenna power gain relative to an isotropic radiator
(-100.0 to 100.0 dBi). If gain is known to a dipole,
then dBi = dBd + 2.5
74) Receiver gain (3.0 dBi)? 0 ←

Man-made noise environment
B = Business (-127.2 dBW at 1 MHz)
RE = Residential (-131.5 dBW at 1 MHz)
RU = Rural (-136.8 dBW at 1 MHz)
Q = Quiet rural (-150.4 dBW at 1 MHz)
80) Man-made noise environment (Residential)? _____ ←

Local time of day:
L = List current set of times
D = Delete a time
A = Add a time
C = Change a time
N = No change
81) Time of day (Add)? _____ ←

Up to 24 times (between 0 and 2300)
(A carriage return exits this mode)
Time (200)? 1200 ←
Time (1200)? _____ ←
81) Time of day (Add)? n ←

Seasons to be included in the predictions:
L = List current set of seasons
D = Delete a season
A = Add a season
C = Change a season
N = No change
82) Season (Add)? _____ ←

Seasons (up to 4 values)
W = Winter (December, January, February)
SP = Spring (March, April, May)
SU = Summer (June, July, August)
F = Fall (September, October, November)
Season (Winter (December, January, February))? sp ←
Season (Spring (March, April, May))? _____ ←
82) Season (Add)? n ←
Do you want a summary of the input data (Y or N)? _Y_

**MF RESYDE**
**VOA MF Relay System Design Model**
**System 1 Calculations Summary**

1) Title: ground wave check
2) Units: Kilometers and meters
3) Transmit frequency: 1000. kHz
4) Ground wave model: Smooth earth
5) Sky wave model: FCC Interregional

10) Transmitter latitude: 40.0000 N 40 0 0 N
10) Transmitter longitude: 90.0000 W 90 0 0 W
11) Path options: Incremental distance at a fixed bearing
13) Receiver site(s)

<table>
<thead>
<tr>
<th>Site</th>
<th>Latitude (deg)</th>
<th>Longitude (deg)</th>
<th>Great circle Distance (km)</th>
<th>Bearing from Ref site (deg E of N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40.0900 N 40, 5,24 N</td>
<td>90.0000 W 90, 0, 0 W</td>
<td>10.0</td>
<td>0.0</td>
</tr>
<tr>
<td>2</td>
<td>40.1799 N 40,10,48 N</td>
<td>90.0000 W 90, 0, 0 W</td>
<td>20.0</td>
<td>0.0</td>
</tr>
<tr>
<td>3</td>
<td>40.2699 N 40,16,12 N</td>
<td>90.0000 W 90, 0, 0 W</td>
<td>30.0</td>
<td>0.0</td>
</tr>
<tr>
<td>4</td>
<td>40.3599 N 40,21,36 N</td>
<td>90.0000 W 90, 0, 0 W</td>
<td>40.0</td>
<td>0.0</td>
</tr>
<tr>
<td>5</td>
<td>40.4499 N 40,26,60 N</td>
<td>90.0000 W 90, 0, 0 W</td>
<td>50.0</td>
<td>0.0</td>
</tr>
<tr>
<td>6</td>
<td>40.5398 N 40,32,23 N</td>
<td>90.0000 W 90, 0, 0 W</td>
<td>60.0</td>
<td>0.0</td>
</tr>
<tr>
<td>7</td>
<td>40.6298 N 40,37,47 N</td>
<td>90.0000 W 90, 0, 0 W</td>
<td>70.0</td>
<td>0.0</td>
</tr>
<tr>
<td>8</td>
<td>40.7198 N 40,43,11 N</td>
<td>90.0000 W 90, 0, 0 W</td>
<td>80.0</td>
<td>0.0</td>
</tr>
<tr>
<td>9</td>
<td>40.8098 N 40,48,35 N</td>
<td>90.0000 W 90, 0, 0 W</td>
<td>90.0</td>
<td>0.0</td>
</tr>
<tr>
<td>10</td>
<td>40.8997 N 40,53,59 N</td>
<td>90.0000 W 90, 0, 0 W</td>
<td>100.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

14) Conductivity for the path: .003 S/m
15) Dielectric constant for the path: 15.
19) Transmitter power into the antenna terminals: 1.00 kW
21) Transmitter antenna type: Field strength option
22) Transmitter antenna height: 0.0 m
31) Transmitter antenna field strength: 300.0000 mV/m
32) Transmitter antenna reference power: 1.000 kW
Sample #1
Smooth Earth,
ground-wave calculations

33) Transmitter antenna reference distance: 1.00 km
61) Receiver antenna type: User gain input
62) Receiver antenna height: 0.0 m
74) Receiver antenna gain: 0.0 dBi

80) Man-made noise: Residential
82) Seasons:
   1) Spring (March, April, May)

81) Local times:
   1) 1200

83) Required reliability: 90.0
84) Earth radius ratio: 1.330

Do you want to process this data (Y or N)? Y

MF RESYDE
VOA MF Relay System Design Model
System 1 Calculations

Title: ground wave check

Transmit frequency: 1000. kHz

Transmitter latitude: 40.0000 N
Transmitter longitude: 90.0000 W

Transmitter input power: 1.000 kW

Transmitter antenna type: Field strength option
   Antenna height: 0.0 m
   Antenna field strength: 300.0000 mV/m
   Antenna reference power: 1.000 kW
   Antenna reference distance: 1.00 km

Receiver antenna type: User gain input
   Antenna height: 0.0 m
   Antenna gain: 0.0 dBi

Ground wave model: Smooth earth
   Ground constants
   Conductivity: .0030 S/m
   Dielectric constant: 15.0000

Sky wave model: FCC Interregional
Sample #1
Smooth Earth, ground-wave calculations

Discrete stations:

<table>
<thead>
<tr>
<th>Site</th>
<th>Latitude (deg)</th>
<th>Longitude (deg)</th>
<th>Great circle Distance (km)</th>
<th>Bearing from Ref site (deg E of N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40.0900 N</td>
<td>90.0000 W</td>
<td>10.0</td>
<td>0.0</td>
</tr>
<tr>
<td>2</td>
<td>40.1799 N</td>
<td>90.0000 W</td>
<td>20.0</td>
<td>0.0</td>
</tr>
<tr>
<td>3</td>
<td>40.2699 N</td>
<td>90.0000 W</td>
<td>30.0</td>
<td>0.0</td>
</tr>
<tr>
<td>4</td>
<td>40.3599 N</td>
<td>90.0000 W</td>
<td>40.0</td>
<td>0.0</td>
</tr>
<tr>
<td>5</td>
<td>40.4499 N</td>
<td>90.0000 W</td>
<td>50.0</td>
<td>0.0</td>
</tr>
<tr>
<td>6</td>
<td>40.5398 N</td>
<td>90.0000 W</td>
<td>60.0</td>
<td>0.0</td>
</tr>
<tr>
<td>7</td>
<td>40.6298 N</td>
<td>90.0000 W</td>
<td>70.0</td>
<td>0.0</td>
</tr>
<tr>
<td>8</td>
<td>40.7198 N</td>
<td>90.0000 W</td>
<td>80.0</td>
<td>0.0</td>
</tr>
<tr>
<td>9</td>
<td>40.8098 N</td>
<td>90.0000 W</td>
<td>90.0</td>
<td>0.0</td>
</tr>
<tr>
<td>10</td>
<td>40.8997 N</td>
<td>90.0000 W</td>
<td>100.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Man-made noise: Residential

Seasons:
Spring (March, April, May)

Local times:
1200

Earth radius ratio: 1.330

Season - Spring (March, April, May)
Local time - 1200

<table>
<thead>
<tr>
<th>Site</th>
<th>Receiver site noise density (dBW/Hz)</th>
<th>Groundwave field strength (dBuV/m)</th>
<th>Sky wave field strength (dBuV/m)</th>
<th>Rec'd field power (dBm)</th>
<th>Rec'd S/N (dB)</th>
<th>Fade margin (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10% 50% 90%</td>
<td>10% 50% 90%</td>
<td>10% 50% 90%</td>
<td>10% 50% 90%</td>
<td>10% 50% 90%</td>
<td>10% 50% 90%</td>
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<td>56.1 -21.4</td>
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<td>6</td>
<td>-122 -131 -138</td>
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<td>71.0 -6.9</td>
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<td></td>
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<tr>
<td>7</td>
<td>-122 -131 -138</td>
<td>46.2 -31.3</td>
<td>56.1 -21.4</td>
<td>71.0 -9.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>-122 -131 -138</td>
<td>43.5 -34.0</td>
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<td>71.0 -12.6</td>
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<td></td>
</tr>
<tr>
<td>9</td>
<td>-122 -131 -138</td>
<td>41.1 -36.4</td>
<td>56.1 -21.4</td>
<td>71.0 -15.0</td>
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<td></td>
</tr>
<tr>
<td>10</td>
<td>-122 -131 -138</td>
<td>39.0 -38.5</td>
<td>56.1 -21.4</td>
<td>71.0 -17.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Sample #2
Sky-wave calculations

Institute for Telecommunication Sciences

MF RESYDE
System 1
Voice of America
MF Relay System Design Model
Version 1.0

Choose from the menu:

H = Help
D = Program Description
C = Concise Dialog
V = Verbose Dialog
E = Edit Data
S = Summary of Data
P = Process Last Data Set Entered
Q = Quit

Menu (Edit)?

1) Title (ground wave check)? sky wave check
2) Length units (Metric, kilometers and meters)?
3) Frequency (1000. kHz)?
4) Ground wave model (Smooth earth)?
5) Skywave model (FCC Interregional)?

10) Transmitter lat ( 40.0000 deg N or 40 0 0 dms N)?
10) Transmitter lon ( 90.0000 deg W or 90 0 0 dms W)?
11) Path option (Incremental distance at a fixed bearing)?

Receiver site location

13) Min Dist ( 10.0 km)?
13) Max Dist ( 100.0 km)?
13) Dist Inc ( 10.0 km)?
13) Bearing ( 0.0 deg)?

14) Conductivity for the path (.0030 S/m)?
15) Dielectric constant for the path (15.)?
19) Transmitter power into the antenna terminals ( 1.00 kW)?
21) Transmitter antenna type (Field strength option)?
22) Transmitter antenna feed point height above ground ( 0.00 m)?
31) Transmitter antenna field strength ( 300.0000 mV/m)?
32) Transmitter antenna reference power ( 1.000 kW)?
33) Transmitter antenna reference distance ( 1.00 km)?
61) Receiver antenna type (User gain input)?
62) Receiver antenna feed point height above ground ( 0.00 m)?
74) Receiver gain ( 0.0 dBi)?
80) Man-made noise environment (Residential)?
81) Time of day (Add)?
Sample #2
Sky-wave calculations

82) Season (Add)? _n_
83) Required reliability (90%)? __________
84) Earth radius ratio (1.330)? ______

Do you want a summary of the input data (Y or N)? __Y__

MF RESYDE
VOA MF Relay System Design Model
System 1 Calculations Summary

<table>
<thead>
<tr>
<th>Site</th>
<th>Latitude (deg)</th>
<th>Longitude (deg)</th>
<th>Great circle Distance (km)</th>
<th>Bearing from Ref site (deg E of N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40.8997 N</td>
<td>40,53,59 N</td>
<td>90.000 W 90, 0, 0 W</td>
<td>100.0 0.0</td>
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<tr>
<td>2</td>
<td>41.7995 N</td>
<td>41,47,58 N</td>
<td>90.000 W 90, 0, 0 W</td>
<td>200.0 0.0</td>
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<tr>
<td>3</td>
<td>42.6992 N</td>
<td>42,41,57 N</td>
<td>90.000 W 90, 0, 0 W</td>
<td>300.0 0.0</td>
</tr>
<tr>
<td>4</td>
<td>43.5990 N</td>
<td>43,35,56 N</td>
<td>90.000 W 90, 0, 0 W</td>
<td>400.0 0.0</td>
</tr>
<tr>
<td>5</td>
<td>44.4987 N</td>
<td>44,29,55 N</td>
<td>90.000 W 90, 0, 0 W</td>
<td>500.0 0.0</td>
</tr>
<tr>
<td>6</td>
<td>45.3985 N</td>
<td>45,23,54 N</td>
<td>90.000 W 90, 0, 0 W</td>
<td>600.0 0.0</td>
</tr>
<tr>
<td>7</td>
<td>46.2982 N</td>
<td>46,17,54 N</td>
<td>90.000 W 90, 0, 0 W</td>
<td>700.0 0.0</td>
</tr>
<tr>
<td>8</td>
<td>47.1980 N</td>
<td>47,11,53 N</td>
<td>90.000 W 90, 0, 0 W</td>
<td>800.0 0.0</td>
</tr>
<tr>
<td>9</td>
<td>48.0977 N</td>
<td>48, 5,52 N</td>
<td>90.000 W 90, 0, 0 W</td>
<td>900.0 0.0</td>
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<tr>
<td>10</td>
<td>48.9975 N</td>
<td>48,59,51 N</td>
<td>90.000 W 90, 0, 0 W</td>
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</tr>
</tbody>
</table>

14) Conductivity for the path: 5.000 S/m
15) Dielectric constant for the path: 80.

19) Transmitter power into the antenna terminals: 1.00 kW
21) Transmitter antenna type: Field strength option
22) Transmitter antenna height: 0.0 m
31) Transmitter antenna field strength: 100.0000 mV/m
32) Transmitter antenna reference power: 1.000 kW
33) Transmitter antenna reference distance: 1.00 km
61) Receiver antenna type: User gain input
62) Receiver antenna height: 0.0 m
74) Receiver antenna gain: 0.0 dBi

80) Man-made noise: Residential

82) Seasons:
   1) Spring (March, April, May)

81) Local times:
   1) 1200

83) Required reliability: 90.
84) Earth radius ratio: 1.330

Do you want to process this data (Y or N)? Y

MF RESYDE
VOA MF Relay System Design Model
System 1 Calculations

Title: sky wave check
Transmit frequency: 1000. kHz
Transmitter latitude: 40.0000 N
Transmitter longitude: 90.0000 W
Transmitter input power: 1.000 kW
Transmitter antenna type: Field strength option
   Antenna height: 0.0 m
   Antenna field strength: 100.0000 mV/m
   Antenna reference power: 1.000 kW
   Antenna reference distance: 1.00 km
Receiver antenna type: User gain input
   Antenna height: 0.0 m
   Antenna gain: 0.0 dBi
Ground wave model: Smooth earth
Ground constants
   Conductivity: 5.0000 S/m
   Dielectric constant: 80.0000
### Sky wave model:

#### Discrete stations:

<table>
<thead>
<tr>
<th>Site</th>
<th>Latitude (deg)</th>
<th>Longitude (deg)</th>
<th>Distance (km)</th>
<th>Ref site (deg E of N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40.8997 N</td>
<td>90.0000 W</td>
<td>100.0</td>
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</tr>
<tr>
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<td>41.7995 N</td>
<td>90.0000 W</td>
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<td>300.0</td>
<td>0.0</td>
</tr>
<tr>
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<td>43.5990 N</td>
<td>90.0000 W</td>
<td>400.0</td>
<td>0.0</td>
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<tr>
<td>5</td>
<td>44.4987 N</td>
<td>90.0000 W</td>
<td>500.0</td>
<td>0.0</td>
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<tr>
<td>6</td>
<td>45.3985 N</td>
<td>90.0000 W</td>
<td>600.0</td>
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<tr>
<td>7</td>
<td>46.2982 N</td>
<td>90.0000 W</td>
<td>700.0</td>
<td>0.0</td>
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<tr>
<td>8</td>
<td>47.1980 N</td>
<td>90.0000 W</td>
<td>800.0</td>
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<tr>
<td>9</td>
<td>48.0977 N</td>
<td>90.0000 W</td>
<td>900.0</td>
<td>0.0</td>
</tr>
<tr>
<td>10</td>
<td>48.9975 N</td>
<td>90.0000 W</td>
<td>1000.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

### Man-made noise:

#### Residential

#### Seasons:
- Spring (March, April, May)

#### Local times:
- 1200

#### Earth radius ratio:
- 1.330

#### Season - Spring (March, April, May)

#### Local time - 1200

<table>
<thead>
<tr>
<th>Receiver site noise density (dBW/Hz)</th>
<th>Groundwave field strength (dBuV/m)</th>
<th>Sky wave field strength (dBuV/m)</th>
<th>Rec'd power (dBm)</th>
<th>Rec'd power (dBuV)</th>
<th>Fade margin (dB)</th>
<th>S/N ratio</th>
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<td>50%</td>
<td>90%</td>
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<td>50.1</td>
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<td>28.1 -49.4</td>
<td>43.1</td>
<td>15.5</td>
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</tr>
</tbody>
</table>
Institute for Telecommunication Sciences

MF RESYDE
System 1
Voice of America
MF Relay System Design Model
Version 1.0

Choose from the menu:
H = Help
D = Program Description
C = Concise Dialog
V = Verbose Dialog
E = Edit Data
S = Summary of Data
P = Process Last Data Set Entered
Q = Quit

Menu (Verbose)? v

Title of the analysis (up to 30 characters)
1) Title (VOA Test)? Antenna array fields at 1km

Length units:
M = Metric, kilometers and meters
E = English, statute miles and feet
2) Length units (Metric, kilometers and meters)?

Frequency (530.0 to 1750. kHz)
3) Frequency (1000. kHz)?

Groundwave model:
S = Smooth earth
M = Mixed path, smooth earth
I = Irregular terrain, mixed path
4) Ground wave model (Smooth earth)?

Skywave model:
F = FCC Interregional
C = CCIR Plenary Assembly
W = Wang
I = IFRB skywave
5) Skywave model (FCC Interregional)?
Type site lat (followed by carriage return) and site lon (return) for each of the sites. Enter the reference site location first.

Limits are - 0N <= lat <= 90N
  0S <= lat <= 90S
  0W <= lon <= 180W
  0E <= lon <= 180E

The default hemispheres are N and E. The S and W locations can be specified by adding an S to the latitude value or adding an W to the longitude value.

Inputs of the form X,Y,Z imply degrees, minutes and seconds.
Inputs of the form X,Y imply decimal degrees.

10) Transmitter lat (20.0000 deg N or 20 0 0 dms N)? 30
10) Transmitter lon (90.0000 deg W or 90 0 0 dms W)? 80w

Paths to be analyzed are defined from the transmitter site (ref site) to the receiver site(s). The transmitter site is defined by its latitude and longitude. The receiver site(s) can be defined by:

L = Latitude longitude pairs
D = Distance - bearing pairs
IB = Incremental bearing at a fixed distance
ID = Incremental distance at a fixed bearing

11) Path option (Latitude - longitude pairs)? ib

Receiver site location

Initial bearing.
Enter the bearing of your first terminal site.
Enter in degrees clockwise from north,
i.e. north = 0, east = 90, south = 180, west = 270.
Answer can be in decimal degrees(X,Y) or in deg. min. and sec. (X,Y,Z), and must be between 0.0 and 359.0 degrees
13) Min bear(0.0 deg)?

Final bearing.
Enter the bearing of your last terminal site.
Enter in degrees clockwise from north,
i.e. north = 0, east = 90, south = 180, west = 270.
Answer can be in decimal degrees(X,Y) or in deg. min. and sec. (X,Y,Z), and must be between 0.0 and 360.0 degrees
13) Max bear(315.0 deg)?
Bearing increment.
Enter the number of degrees you wish to increment.
Answer can be in decimal degrees (X.Y) or
in deg. min. and sec. (X,Y,Z), and must be
between 1.0 and 180.0 degrees
13) Bear inc( 45.0 deg)?  _15_ →

Distance from reference site to terminal site ( 0.0 to 10000.0 km)
13) Distance (2282.5 km)? _1_ →

Conductivity for the path
(between .001 and 10.000 Siemens(mhos)/meter)
0.001 for poor ground
0.005 for average ground
0.020 for good ground
5.000 for sea water
0.010 for fresh water
14) Conductivity for the path (.005 S/m)? _5_ →

Dielectric constant (between 1. and 81.)
4.0 for poor ground
15.0 for average ground
25.0 for good ground
81.0 for sea and fresh water
15) Dielectric constant for the path (15.)? _80_ →

Transmitter power into the antenna terminals (.10 to 10000.00 kW)
19) Transmitter power into the antenna terminals (1.00 kW)? ____ →

Antenna types:
VM = Vertical monopole
UG = User gain input
FS = Field strength option
GM = General monopole array
SM = Standard monopole array
21) Transmitter antenna type (Vertical monopole)? _gm_ →

Hours of operation for which the given characteristics of the antenna
are applicable:
D = Day
N = Night
A = All
37) Hours of operation (Day)? _a_ →
Sample #3
Field Strength Patterns

Reference point:
- C = Spacing and orientation are shown with respect to a common reference point which is generally the first tower
- P = Spacing and orientation are shown with respect to the previous tower

38) Definition point indicator (Common reference tower)? __

Total number of towers (1 to 20)
39) Total number of towers (0)? ___

Tower # 1

Ratio of the tower field to the field from the reference tower (0.0000 to 9.0000)
40) Tower field ratio (1.0000)? ___

Positive or negative difference in the phase angle of the field from the tower with respect to the field from the reference tower (-360.0000 to 360.0000 degrees)
41) Phase difference of the field (0.0000 degrees)? ___

Electrical spacing of the tower from the reference point (0.0000 to 360.0000 degrees)
42) Electrical tower spacing (0.0000 degrees)? ___

Angular orientation of the tower from the reference point (0.0000 to 360.0000 degrees from True North)
43) Angular tower orientation (0.0000 degrees)? ___

Tower structure
- V = Vertical, simple antenna
- T = Top-loaded antenna
- S = Sectionalized antenna
44) Tower structure (Vertical, simple antenna)? ___

Electrical height of the tower under consideration (0.0 to 360.0 degrees)
45) Electrical height of tower (225.0 degrees)? ___
Sample #3
Field Strength Patterns

Tower # 2

40) Tower field ratio (1.0000)? 1.16
41) Phase difference of the field (231.0000 degrees)? 125.6
42) Electrical tower spacing (0.0000 degrees)? 100
43) Angular tower orientation (0.0000 degrees)?
44) Tower structure (Vertical, simple antenna)?
45) Electrical height of tower (225.0 degrees)?

Tower # 3

40) Tower field ratio (1.1600)?
41) Phase difference of the field (125.6000 degrees)? 0
42) Electrical tower spacing (100.0000 degrees)? 200
43) Angular tower orientation (0.0000 degrees)?
44) Tower structure (Vertical, simple antenna)?
45) Electrical height of tower (225.0 degrees)?

Augmentations to be included in the predictions:
- L = List current set of augmentations
- D = Delete an augmentation
- A = Add an augmentation
- C = Change an augmentation
- N = No change

56) Augmentation (A)? n

Rms field strength at 1 km (0.0000 to 10000.0000 mV/m)
57) Rms field strength at 1 km (300.0000 mV/m)? 300.0000

Antenna types:
- VM = Vertical monopole
- UG = User gain input
- FS = Field strength option
- FL = Ferrite loop

61) Receiver antenna type (Vertical monopole)? ug

Receiver antenna feed point height above ground (between 0.00 and 100.0 m)
62) Receiver antenna feed point height above ground (0.00 m)?

Receiver antenna power gain relative to an isotropic radiator (-100.0 to 100.0 dBi). If gain is known to a dipole, then dBi = dBd + 2.5
74) Receiver gain (3.0 dBi)? 0
Man-made noise environment
B = Business (-127.2 dBW at 1 MHz)
RE = Residential (-131.5 dBW at 1 MHz)
RU = Rural (-136.8 dBW at 1 MHz)
Q = Quiet rural (-150.4 dBW at 1 MHz)
80) Man-made noise environment (Residential)?

Local time of day:
L = List current set of times
D = Delete a time
A = Add a time
C = Change a time
N = No change
81) Time of day (Add)?

Up to 24 times (between 0 and 2300)
(A carriage return exits this mode)
Time (200)? 1200
Time (1200)?
81) Time of day (Add)?

Seasons to be included in the predictions:
L = List current set of seasons
D = Delete a season
A = Add a season
C = Change a season
N = No change
82) Season (Add)?

Seasons (up to 4 values)
W = Winter (December, January, February)
SP = Spring (March, April, May)
SU = Summer (June, July, August)
F = Fall (September, October, November)
Season (Winter (December, January, February))? SP
Season (Spring (March, April, May))? 
82) Season (Add)?

Required reliability (between 0. and 100.%) 
83) Required reliability (90.%)?

Earth radius ratio (.500 to 3.000)
84) Earth radius ratio (1.330)?

Do you want a summary of the input data (Y or N)?
Do you want to process this data (Y or N)? Y

MF RESYDE
VOA MF Relay System Design Model
System 1 Calculations

Title: Antenna array fields at 1km

Transmit frequency: 1000.0 kHz

Transmitter latitude: 30.0000 N
Transmitter longitude: 80.0000 W

Transmitter input power: 1.000 kW

Transmitter antenna type: General monopole array

Hours of operation: All
Definition point indicator: Common reference tower

<table>
<thead>
<tr>
<th>No. of towers:</th>
<th>Tower no.</th>
<th>Field ratio</th>
<th>Electrical height (deg)</th>
<th>Relative phasing (deg)</th>
<th>Relative spacing (deg)</th>
<th>Relative orientation (deg)</th>
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<tbody>
<tr>
<td></td>
<td>1</td>
<td>1.0000</td>
<td>225.0</td>
<td>251.0</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td></td>
<td>2</td>
<td>1.1600</td>
<td>225.0</td>
<td>125.6</td>
<td>100.0</td>
<td>0.0</td>
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<td>1.0000</td>
<td>225.0</td>
<td>0.0</td>
<td>200.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Number of towers that are top-loaded: 0

No. of towers that are sectionalized: 0

No. of augmentations to antenna pattern: 0

Rms field strength at 1 km: 452.0000 mV/m

Receiver antenna type: User gain input
  Antenna height: 0.0 m
  Antenna gain: 0.0 dBi

Ground wave model: Smooth earth
  Ground constants
  Conductivity: 5.0000 S/m
  Dielectric constant: 80.0000
### Sky wave model:

#### FCC Interregional

<table>
<thead>
<tr>
<th>Site</th>
<th>Latitude (deg)</th>
<th>Longitude (deg)</th>
<th>Great circle Distance (km)</th>
<th>Bearing from Ref site (deg E of N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30.0090 N 30, 0,32 N</td>
<td>80.0000 W 80, 0, 0 W</td>
<td>1.0</td>
<td>0.0</td>
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<tr>
<td>2</td>
<td>30.0087 N 30, 0,31 N</td>
<td>79.9973 W 79,59,50 W</td>
<td>1.0</td>
<td>15.0</td>
</tr>
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### Man-made noise:

#### Residential

#### Seasons:

- Spring (March, April, May)

#### Local times:

- 1200

#### Earth radius ratio:

1.330

#### Season - Spring (March, April, May)
<table>
<thead>
<tr>
<th>Site</th>
<th>Receiver site noise density (dBW/Hz)</th>
<th>Groundwave field strength (dBuV/m)</th>
<th>Sky wave field strength (dBuV/m)</th>
<th>Rec'd field power (dBm)</th>
<th>Rec'd power (dBm)</th>
<th>Rec'd S/N (dBHz)</th>
<th>Fade margin (dB)</th>
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<td>119</td>
<td>15</td>
<td>-62</td>
<td>134</td>
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<td>-122 -131 -138</td>
<td>119</td>
<td>15</td>
<td>-62</td>
<td>133</td>
<td>103</td>
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<td>-122 -131 -138</td>
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<td>-62</td>
<td>133</td>
<td>103</td>
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<td>-62</td>
<td>133</td>
<td>103</td>
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Sample #3
Field Strength
Patterns

Title of the analysis (up to 30 characters)
1) Title (Antenna array fields at 1km)? Signals at 100 km

Question number? 13

Distance from reference site to terminal site (0.0 to 10000.0 km)
13) Distance (1.0 km)? 100

Question number? 14

Conductivity for the path
(between .001 and 10.000 Siemens/mhos)/meter)
0.001 for poor ground
0.005 for average ground
0.020 for good ground
5.000 for sea water
0.010 for fresh water
14) Conductivity for the path (5.000 S/m)? .005

Dielectric constant (between 1. and 81.)
4.0 for poor ground
15.0 for average ground
25.0 for good ground
81.0 for sea and fresh water
15) Dielectric constant for the path (80.)? 15

Question number?

Do you want a summary of the input data (Y or N)? n

Do you want to process this data (Y or N)? Y

---

MF RESYDE
VOA MF Relay System Design Model
System 1 Calculations

Title: Signals at 100 km

Transmit frequency: 1000. kHz

Transmitter latitude: 30.0000 N 30 0 0 N
Transmitter longitude: 80.0000 W 80 0 0 W

Transmitter input power: 1.000 kW
Transmitter antenna type: General monopole array

Hours of operation: All
### Sample #3
Field Strength
Patterns

**Definition point indicator:**

**No. of towers:**

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<th>Tower no.</th>
<th>Field ratio</th>
<th>Electrical height (deg)</th>
<th>Relative phasing (deg)</th>
<th>Relative spacing (deg)</th>
<th>Relative orientation</th>
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<td>1</td>
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<td>251.0</td>
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<td>1.0000</td>
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<td>0.0</td>
<td>200.0</td>
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</table>

**Common reference tower:**

3

**Number of towers that are top-loaded:**

0

**No. of towers that are sectionalized:**

0

**No. of augmentations to antenna pattern:**

0

**Rms field strength at 1 km:**

452.0000 mV/m

**Receiver antenna type:**

User gain input

**Antenna height:**

0.0 m

**Antenna gain:**

0.0 dBi

**Ground wave model:**

Smooth earth

**Ground constants**

Conductivity: 0.050 S/m

Dielectric constant: 15.0000

**Sky wave model:**

FCC Interregional

**Discrete stations:**

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<tr>
<th>Site</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Great circle distance (km)</th>
<th>Bearing from Ref site (deg E of N)</th>
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</tr>
<tr>
<td>2</td>
<td>30.8688 N</td>
<td>30,52, 8 N</td>
<td>79.7287 W 79,43,43 W</td>
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</tr>
<tr>
<td>3</td>
<td>30.7782 N</td>
<td>30,46,41 N</td>
<td>79.4764 W 79,28,35 W</td>
<td>100.0</td>
</tr>
<tr>
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<td>30.6342 N</td>
<td>30,38, 3 N</td>
<td>79.2606 W 79,15,38 W</td>
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<tr>
<td>5</td>
<td>30.4468 N</td>
<td>30,26,48 N</td>
<td>79.0962 W 79, 5,46 W</td>
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<td>78.9941 W 78,59,39 W</td>
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<td>78.9988 W 78,59,56 W</td>
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112
### Field Strength Patterns

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<th>Sample #3</th>
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<td>(dBuV/m)</td>
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<td>(dBm)</td>
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**Man-made noise:** Residential

**Seasons:**
Spring (March, April, May)

**Local times:**
1200

**Earth radius ratio:**
1.330

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<th>Season - Spring (March, April, May)</th>
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<td>Rec'd power (dBm)</td>
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113
Sample #3  
Field Strength Patterns

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</table>

Choose from the menu:

H = Help  
D = Program Description  
C = Concise Dialog  
V = Verbose Dialog  
E = Edit Data  
S = Summary of Data  
P = Process Last Data Set Entered  
Q = Quit

Menu (Edit)? _a_  

---

114
Choose from the menu:
H = Help
D = Program Description
C = Concise Dialog
V = Verbose Dialog
E = Edit Data
S = Summary of Data
P = Process Last Data Set Entered
Q = Quit

Menu (Verbose)?

Title of the analysis (up to 30 characters)
1) Title (VOA Test)? Guat. site

Frequency (530 to 1750 kHz)
Frequencies must be in increments of 10 kHz
3) Frequency (1000 kHz)? 900

Groundwave model:
S = Smooth earth
M = Mixed path, smooth earth
I = Irregular terrain, mixed path
4) Ground wave model (Smooth earth)?

Skywave model:
F = FCC Interregional
C = CCIR Plenary Assembly
W = Wang
I = IFRB skywave
5) Skywave model (FCC Interregional)?

Propagation conditions to be analyzed
D = Daytime, groundwave only
N = Nighttime, groundwave and skywave
6) Propagation conditions (Daytime)?

Sample #4
Signal-to-interference calculations
VOA TRANSMITTER SITE PARAMETERS

Country code for VOA transmitter site (2 characters)
11) VOA transmitter site country code (ZZ)? gt

Location description of VOA transmitter site (up to 14 characters)
12) VOA transmitter site location (Boulder, Co.)? Zee GT

Code letter for VOA transmitter site (1 character)
13) VOA transmitter site ID (A)? ___

Type site lat (followed by carriage return) and site lon (return) for each of the sites.
Enter the reference site location first.
Limits are - 0N <= lat <= 90N
0S <= lat <= 90S
0W <= lon <= 180W
0E <= lon <= 180E

The default hemispheres are N and E. The S and W locations
can be specified by adding an S to the latitude value or adding
an W to the longitude value.
Inputs of the form X,Y,Z imply degrees, minutes and seconds.
Inputs of the form X,Y imply decimal degrees.
14) VOA site lat (20.0000 deg N or 20 0 0 dms N)? 14,05,07
14) VOA site lon (90.0000 deg W or 90 0 0 dms)? 89,45,30w

POPULATION CENTER PARAMETERS

Country code for population center site (2 characters)
21) Population center site country code (ZZ)? SS

Location description of population center site (up to 14 characters)
22) Population center site location (St. Louis, Mo.)? Xusta

Code letter for population center site (1 character)
23) Population center site ID (B)? X

Type site lat (followed by carriage return) and site lon (return) for each of the sites.
Enter the reference site location first.
Limits are - 0N <= lat <= 90N
0S <= lat <= 90S
0W <= lon <= 180W
0E <= lon <= 180E
The default hemispheres are N and E. The S and W locations can be specified by adding an S to the latitude value or adding an W to the longitude value. Inputs of the form X,Y,Z imply degrees, minutes and seconds. Inputs of the form X,Y imply decimal degrees.

24) Population center lat (10.0000 deg N or 10 0 0 dms N)? 13
24) Population center lon (85.0000 deg W or 85 0 0 dms W)? 89.8

Distance to be searched around population center for non-VOA transmitters (between 0.0 and 10000.0 km)

Distance to be searched around population center (100.0 km)? 200

Conductivity for the path (between .001 and 10.000 Siemens(mhos)/meter)

- 0.001 for poor ground
- 0.005 for average ground
- 0.020 for good ground
- 5.000 for sea water
- 0.010 for fresh water

30) Conductivity for the path (.005 S/m)?

Dielectric constant (between 1. and 81.)

- 4.0 for poor ground
- 15.0 for average ground
- 25.0 for good ground
- 81.0 for sea and fresh water

31) Dielectric constant for the path (15.)?

TRANSMITTER ANTENNA

Transmitter power into the antenna terminals (between .10 to 10000.00 kW)

19) Transmitter power into the antenna terminals (1.00 kW)? 50

Antenna types:
- VM = Vertical monopole
- UG = User gain input
- FS = Field strength option
- GM = General monopole array
- SM = Standard monopole array

41) Transmitter antenna type (Vertical monopole)? vm

Transmitter antenna feed point height above ground (between 0.00 and 100.0 m)

42) Transmitter antenna feed point height above ground 0.00m)?
Transmitter vertical monopole length (between 0.00 and 400.0 m)
43) Transmitter vertical monopole length (3.00 m)? 187

Transmitter antenna monopole efficiency (between 1.00 and 100.0 %)
43) Transmitter antenna monopole efficiency (100.0 %)? 89

Ground screen
   Y = Yes
   N = No
44) Ground screen (Yes)?

Transmitter antenna ground screen radius
(between 1.00 and 2500.00 m)
45) Transmitter antenna ground screen radius (10.00 m)? 60

Transmitter antenna number of radials (between 5 and 360)
46) Transmitter antenna number of radials (10)? 36

RECEIVER ANTENNA

Antenna types:
   VM = Vertical monopole
   UG = User gain input
   FS = Field strength option
   FL = Ferrite loop
81) Receiver antenna type (Vertical monopole)?

Receiver antenna feed point height above ground
(between 0.00 and 100.0 m)
82) Receiver antenna feed point height above ground (0.00 m)?

Receiver antenna length of ferrite rod (0.00 to 25.40 cm)
89) Receiver antenna length of ferrite rod (3.00 cm)? 4.5

Receiver antenna diameter of ferrite rod (0.00 to 2.54 cm)
90) Receiver antenna diameter of ferrite rod (1.00 cm)? 1.25

Man-made noise environment
   B = Business (-127.2 dBW at 1 MHz)
   RE = Residential (-131.5 dBW at 1 MHz)
   RU = Rural (-136.8 dBW at 1 MHz)
   Q = Quiet rural (-150.4 dBW at 1 MHz)
95) Man-made noise environment (Residential)?

Time of day to be used in calculations (between 0 and 2300)
96) Time (200)? 1600
Seasons:
- **W** = Winter (December, January, February)
- **SP** = Spring (March, April, May)
- **SU** = Summer (June, July, August)
- **F** = Fall (September, October, November)

97) Season (Winter (December, January, February))? **SU**

Required reliability (between 0. and 100.%)  
98) Required reliability (90.%)?

Earth radius ratio (0.500 to 3.000)  
99) Earth radius ratio (1.330)?

Do you want a summary of the input data (Y or N)? **Y**

---

**MF RESYDE**  
**VOA MF Relay System Design Model**  
**System 2 Calculations Summary**

1) Title: Guat. site  
3) Frequency: 900

4) Ground wave model: Smooth earth  
5) Sky wave model: FCC Interregional  
6) Propagation conditions: Nighttime

**VOA TRANSMITTER SITE PARAMETERS**

11) VOA transmitter site country code: **GT**  
12) VOA transmitter site location: Zee GT  
13) VOA transmitter site ID: **X**

14) VOA site latitude: 14.0853 N  
15) VOA site longitude: 89.7583 W

**POPULATION CENTER PARAMETERS**

21) Population center site country code: **SS**  
22) Population center site location: Xuata  
23) Population center site ID: **X**

24) Population center latitude: 13.5000 N  
25) Population center longitude: 89.5000 W  
26) Distance to be searched around population center: 200.0 km

30) Conductivity for the path: 0.0050 S/m
Dielectric constant for the path: 15.0000

TRANSMITTER ANTENNA

19) Transmitter power into the antenna terminals: 50.00 kW
41) Transmitter antenna type: Vertical monopole
42) Transmitter antenna height: 0.0 m
43) Transmitter antenna length: 187.0 m
43) Transmitter antenna monopole efficiency: 89.00 %
44) Transmitter antenna ground screen: yes
45) Transmitter antenna length of screen: 60.00
46) Transmitter antenna number of radials: 36.

RECEIVER ANTENNA

81) Receiver antenna type: Ferrite loop
82) Receiver antenna height: 0.0 m
89) Receiver antenna length of ferrite rod: 4.50 cm
90) Receiver antenna diameter of ferrite rod: 1.25 cm

95) Man-made noise: Residential
96) Seasons: Summer (June, July, August)
97) Local times: 1600
99) Earth radius ratio: 1.330

Do you want to process this data (Y or N)? Y

MF RESYDE
VOA MF Relay System Design Model
System 2 Calculations

Title: Guat. site
Frequency: 900

Ground wave model: Smooth earth
Sky wave model: FCC Interregional
Propagation conditions: Nighttime

VOA TRANSMITTER SITE PARAMETER CALCULATIONS

VOA transmitter site country code: GT
VOA transmitter site location: Zee GT
Sample #4
Signal-to-interference calculations

VOA transmitter site ID: X
VOA site latitude: 14.0853 N 14 5 7 N
VOA site longitude: 89.7583 W 89 45 30 W

POPULATION CENTER PARAMETER CALCULATIONS

Population center site country code: SS
Population center site location: Xuata
Population center site ID: X
Population center latitude: 13.5000 N 13 30 0 N
Population center longitude: 89.8000 W 89 48 0 W
Distance to be searched around population center: 200.0 km
Conductivity for the path: .0050 S/m
Dielectric constant for the path: 15.0000

TRANSMITTER ANTENNA CALCULATIONS

Antenna height: 0.0 m
Antenna length: 187.0 m
Antenna monopole efficiency: 89.0 %
Antenna length of screen: 60.00 m
Number of radials: 36.

RECEIVER ANTENNA CALCULATIONS

Antenna height: 0.0 m
Antenna length of ferrite rod: 4.50 cm
Antenna diameter of ferrite rod: 1.25 cm

Man-made noise: Residential
Seasons: Summer (June, July, August)
Local times: 1600
Required reliability: 90.
Earth radius ratio: 1.330

MF RESYDE
VOA MF Relay System Design model

Title: Guat. site
Proposed VOA transmit frequency: 900
Major population center to be covered: X
VOA transmitter location: Nighttime - skywave and groundwave predictions
Propagation conditions: Smooth earth
Skywave model:  

FCC Interregional

Noise at X is:

- 10%: -110 dBW/Hz
- 50%: -126 dBW/Hz
- 90%: -140 dBW/Hz

For a required reliability of 90%,
an assumed receiver bandwidth of 5000 Hz,
and a ground wave antenna gain of -102.4 dBi,
the computed receiver noise power is -175.1 dBW

Field strength from VOA transmitter at X is:

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<tr>
<th></th>
<th>skywave/groundwave (dB)</th>
<th>signal/noise (50%) (dB)</th>
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<tbody>
<tr>
<td>groundwave</td>
<td>74.05 dBuV/m</td>
<td>40.2</td>
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<tr>
<td>skywave</td>
<td>10%: 61.4 dBuV/m</td>
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<td></td>
<td>50%: 53.4 dBuV/m</td>
<td>-20.6</td>
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---------- Non-VOA Station ----------

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<th>Call Sign</th>
<th>Class</th>
<th>Power (kW)</th>
<th>Location</th>
<th>Data Base</th>
<th>Dist. (km)</th>
<th>S/I (dB)</th>
<th>S/I (dB)</th>
<th>S/I (dB)</th>
<th>Smax (dB)</th>
<th>I+N (dB)</th>
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<td>870</td>
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<td>NUEVOMUNDO</td>
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<td>.50</td>
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<td>TGHU A</td>
<td>5.00</td>
<td>ESCUINTLA</td>
<td>IFRB</td>
<td>138.4</td>
<td>5.8</td>
<td>-5.8</td>
<td>14.0</td>
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<td>SANTA ANA 5</td>
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<td>.9</td>
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<td>IFRB</td>
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Sample #4  
Signal-to-interference calculations
Choose from the menu:
H = Help
D = Program Description
C = Concise Dialog
V = Verbose Dialog
E = Edit Data
S = Summary of Data
P = Process Last Data Set Entered
Q = Quit

Menu (Edit)? q
Institute for Telecommunication Sciences

MF RESYDE
System 3
Voice of America
MF Relay System Design Model
Version 1.0

Choose from the menu:
H = Help
D = Program Description
C = Concise Dialog
V = Verbose Dialog
E = Edit Data
S = Summary of Data
P = Process Last Data Set Entered
Q = Quit

Menu (Verbose)?

Title of the analysis (up to 30 characters)
1) Title (MF TEST)? System 3 sample run

Frequency (530 to 1750 kHz)
Frequencies must be in increments of 10 kHz
3) Frequency (1000 kHz)? 850

Groundwave model:
S = Smooth earth
M = Mixed path, smooth earth
I = Irregular terrain, mixed path
4) Ground wave model (Smooth earth)?

Skywave model:
F = FCC Interregional
C = CCIR Plenary Assembly
W = Wang
I = IFRB skywave
5) Skywave model (FCC Interregional)?

Propagation conditions to be analyzed
D = Daytime, groundwave only
N = Nighttime, groundwave and skywave
6) Propagation conditions (Daytime)?

VOA TRANSMITTER SITE PARAMETERS
Country code for VOA transmitter site (2 characters)
11) VOA transmitter site country code (ZZ)? US

Location description of VOA transmitter site (up to 14 characters)
12) VOA transmitter site location (Boulder, Co.)? Denver

Code letter for VOA transmitter site (1 character)
13) VOA transmitter site ID (A)?

Type site lat (followed by carriage return) and site lon (return) for each of the sites. Enter the reference site location first.
Limits are - 0N <= lat <= 90N
0S <= lat <= 90S
0W <= lon <= 180W
0E <= lon <= 180E

The default hemispheres are N and E. The S and W locations can be specified by adding an S to the latitude value or adding an W to the longitude value.
Inputs of the form X, Y, Z imply degrees, minutes and seconds.
Inputs of the form X, Y imply decimal degrees.
14) VOA site lat (20.0000 deg N or 20 0 0 dms N)?
14) VOA site lon (90.0000 deg W or 90 0 0 dms W)?

POPULATION CENTER PARAMETERS

Country code for population center site (2 characters)
21) Population center site country code (ZZ)? US

Location description of population center site (up to 14 characters)
22) Population center site location (St. Louis, Mo.)? Denver region

Code letter for population center site (1 character)
23) Population center site ID (B)?

Western plot boundary
Limits are - 20 W <= lat <= 160W
24) Western plot boundary (90.00 degrees W)?

Eastern plot boundary
Limits are - 20 W <= lat <= 160W
25) Eastern plot boundary (85.00 degrees W)?

Southern plot boundary
Limits are - 0 N <= lat <= 90N
Limits are - 0 S <= lat <= 90S
The default hemisphere is N. The S location can be specified by adding an S to the latitude value
26) Southern plot boundary (85.00 degrees N)?
Northern plot boundary
Limits are $0 \leq \text{lat} \leq 90^\circ \text{N}$
Limits are $0 \leq \text{lat} \leq 90^\circ \text{S}$
The default hemisphere is N. The S location can be specified by adding an S to the latitude value

27) Northern plot boundary (90.00 degrees N)? 49

Distance to be searched around population center for non-VOA transmitters (between $0.0$ and $10000.0$ km)
28) Distance to be searched around population center (100.0 km)? ____

Conductivity for the path (between $0.001$ and $10.000$ Siemens(mhos)/meter)
- 0.001 for poor ground
- 0.005 for average ground
- 0.020 for good ground
- 5.000 for sea water
- 0.010 for fresh water
30) Conductivity for the path (0.005 S/m)? ____

Dielectric constant (between 1. and 81.)
- 4.0 for poor ground
- 15.0 for average ground
- 25.0 for good ground
- 81.0 for sea and fresh water
31) Dielectric constant for the path (15.)? ____

**TRANSMITTER ANTENNA**

Transmitter power into the antenna terminals (0.10 to 10000.00 kW)
19) Transmitter power into the antenna terminals (1.00 kW)? 50

Antenna types:
- VM = Vertical monopole
- UG = User gain input
- FS = Field strength option
- GM = General monopole array
- SM = Standard monopole array
41) Transmitter antenna type (Field strength option)? gm

Hours of operation for which the given characteristics of the antenna are applicable:
- D = Day
- N = Night
- A = All
57) Hours of operation (Day)? N
Reference point:
C = Spacing and orientation are shown with respect to a common reference point which is generally the first tower
P = Spacing and orientation are shown with respect to the previous tower
58) Definition point indicator (Common reference tower)?

Total number of towers (1 to 20)
59) Total number of towers (1)?

Tower # 1

Ratio of the tower field to the field from the reference tower (0.0000 to 9.0000)
60) Tower field ratio (1.0000)?

Positive or negative difference in the phase angle of the field from the tower with respect to the field from the reference tower (-360.0000 to 360.0000 degrees)
61) Phase difference of the field (0.0000 degrees)? 251.24

Electrical spacing of the tower from the reference point (0.0000 to 360.0000 degrees)
62) Electrical tower spacing (0.0000 degrees)?

Angular orientation of the tower from the reference point (0.0000 to 360.0000 degrees from True North)
63) Angular tower orientation (0.0000 degrees)?

Tower structure
V = Vertical, simple antenna
T = Top-loaded antenna
S = Sectionalized antenna
64) Tower structure (Vertical, simple antenna)?

Electrical height of the tower under consideration (0.0 to 360.0 degrees)
65) Electrical height of tower (225.0 degrees)?

Tower # 2

60) Tower field ratio (1.0000)? 1.16
61) Phase difference of the field (251.2400 degrees)? 125.62
62) Electrical tower spacing (0.0000 degrees)? 100
63) Angular tower orientation (0.0000 degrees)? 90
64) Tower structure (Vertical, simple antenna)?
65) Electrical height of tower (225.0 degrees)?

Tower # 3

60) Tower field ratio (1.1600)?
61) Phase difference of the field (125.6200 degrees)? 0
62) Electrical tower spacing (100.0000 degrees)? 200
63) Angular tower orientation (90.0000 degrees)?

64) Tower structure (Vertical, simple antenna)?

65) Electrical height of tower (225.0 degrees)?

Augmentations to be included in the predictions:

L = List current set of augmentations
D = Delete an augmentation
A = Add an augmentation
C = Change an augmentation
N = No change

76) Augmentation (A)?

Rms field strength at 1 km (0.0000 to 10000.0000 mV/m)

77) Rms field strength at 1 km (300.0000 mV/m)?

Rms field strength at 1 km (0.0000 to 10000.0000 mV/m)

77) Rms field strength at 1 km (300.0000 mV/m)?

RECEIVER ANTENNA

Antenna types:

VM = Vertical monopole
UG = User gain input
FS = Field strength option
FL = Ferrite loop

81) Receiver antenna type (Field strength option)?

Receiver antenna feed point height above ground (between 0.00 and 100.0 m)

82) Receiver antenna feed point height above ground (0.00 m)?

Receiver antenna power gain relative to an isotropic radiator (-100.0 to 100.0 dBi). If gain is known to a dipole, then dBi = dBd + 2.5

94) Receiver gain (3.0 dBi)?

Earth radius ratio (.500 to 3.000)

98) Earth radius ratio (1.330)?

Type of plot:

C = Coverage
I = Interference

99) Type of plot (Interference)?

Do you want a summary of the input data (Y or N)?
MF RESYDE
VOA MF Relay System Design Model
System 3 Calculations Summary

1) Title: System 3 sample run
3) Frequency: 850

4) Ground wave model: Smooth earth
5) Sky wave model: Wang
6) Propagation conditions: Nighttime

<table>
<thead>
<tr>
<th>VOA TRANSMITTER SITE PARAMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>11) VOA transmitter site country code: US</td>
</tr>
<tr>
<td>12) VOA transmitter site location: Denver</td>
</tr>
<tr>
<td>13) VOA transmitter site ID: A</td>
</tr>
<tr>
<td>14) VOA site latitude: 39.0000 N</td>
</tr>
<tr>
<td>15) VOA site longitude: 105.3361 W</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>POPULATION CENTER PARAMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>21) Population center site country code: US</td>
</tr>
<tr>
<td>22) Population center site location: Denver region</td>
</tr>
<tr>
<td>23) Population center site ID: D</td>
</tr>
<tr>
<td>24) Western plot boundary: 115.00 W</td>
</tr>
<tr>
<td>25) Eastern plot boundary: 95.00 W</td>
</tr>
<tr>
<td>26) Southern plot boundary: 29.00 N</td>
</tr>
<tr>
<td>27) Northern plot boundary: 49.00 N</td>
</tr>
<tr>
<td>28) Distance to be searched around population center: 100.0 km</td>
</tr>
<tr>
<td>30) Conductivity for the path: .0050 S/m</td>
</tr>
<tr>
<td>31) Dielectric constant for the path: 15.0000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TRANSMITTER ANTENNA</th>
</tr>
</thead>
<tbody>
<tr>
<td>19) Transmitter power into the antenna terminals: 50.00 kW</td>
</tr>
<tr>
<td>41) Transmitter antenna type: General monopole array</td>
</tr>
<tr>
<td>57) Hours of operation: Night</td>
</tr>
<tr>
<td>58) Definition point indicator: Common reference tower</td>
</tr>
<tr>
<td>59) No. of towers: 3</td>
</tr>
</tbody>
</table>
### Sample #5

#### Signal Coverage

<table>
<thead>
<tr>
<th></th>
<th>TOWER 1</th>
<th>TOWER 2</th>
<th>TOWER 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>60) Tower field ratio:</td>
<td>1.0000</td>
<td>1.1600</td>
<td>1.0000</td>
</tr>
<tr>
<td>61) Phase difference of the field (deg):</td>
<td>251.2</td>
<td>125.6</td>
<td>0.0</td>
</tr>
<tr>
<td>62) Electrical tower spacing (deg):</td>
<td>0.0</td>
<td>100.0</td>
<td>200.0</td>
</tr>
<tr>
<td>63) Angular tower orientation (deg):</td>
<td>0.0</td>
<td>90.0</td>
<td>90.0</td>
</tr>
<tr>
<td>64) Tower structure:</td>
<td>Vertcl</td>
<td>Vertcl</td>
<td>Vertcl</td>
</tr>
<tr>
<td>65) Electrical height of tower (deg):</td>
<td>225.0</td>
<td>225.0</td>
<td>225.0</td>
</tr>
<tr>
<td>76) No. of augmentations to antenna pattern:</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>77) Rms field strength at 1 km:</td>
<td>10000.0000 mV/m</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### RECEIVER ANTENNA

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>81) Receiver antenna type:</td>
<td>User gain input</td>
</tr>
<tr>
<td>82) Receiver antenna height:</td>
<td>0.0 m</td>
</tr>
<tr>
<td>94) Receiver antenna gain:</td>
<td>0.0 dBi</td>
</tr>
<tr>
<td>98) Earth radius ratio:</td>
<td>1.330</td>
</tr>
<tr>
<td>99) Plot type:</td>
<td>Coverage</td>
</tr>
</tbody>
</table>

Do you want to process this data (Y or N)? Y

---

### VOACOM SYSTEM

**System 3 Calculations**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Title:</td>
<td>System 3 sample run</td>
</tr>
<tr>
<td>Frequency:</td>
<td>850</td>
</tr>
<tr>
<td>Ground wave model:</td>
<td>Smooth earth</td>
</tr>
<tr>
<td>Sky wave model:</td>
<td>Wang</td>
</tr>
<tr>
<td>Propagation conditions:</td>
<td>Nighttime</td>
</tr>
</tbody>
</table>

### VOA TRANSMITTER SITE PARAMETER CALCULATIONS

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
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<tbody>
<tr>
<td>VOA transmitter site country code:</td>
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<tr>
<td>VOA transmitter site location:</td>
<td>Denver</td>
</tr>
<tr>
<td>VOA transmitter site ID:</td>
<td>A</td>
</tr>
<tr>
<td>VOA site latitude:</td>
<td>39.0000 N 39 0 0 N</td>
</tr>
<tr>
<td>VOA site longitude:</td>
<td>105.3361 W 105 20 10 W</td>
</tr>
</tbody>
</table>
**POPULATION CENTER PARAMETER CALCULATIONS**

Population center site country code: US
Population center site location: Denver region
Population center site ID: D

Western plot boundary: 115.0 W
Eastern plot boundary: 95.0 W
Southern plot boundary: 29.0 N
Northern plot boundary: 49.0 N
Plot type: Coverage
Distance to be searched around population center: 100.0 km
Conductivity for the path: 0.0050 S/m
Dielectric constant for the path: 15.0000

**TRANSMITTER ANTENNA CALCULATIONS**

<table>
<thead>
<tr>
<th>Hours of operation:</th>
<th>Night</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition point indicator:</td>
<td>Common reference tower</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No. of towers:</th>
<th>Field ratio</th>
<th>Electrical height (deg)</th>
<th>Relative phasing (deg)</th>
<th>3 Relative spacing (deg)</th>
<th>Relative orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tower no.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.0000</td>
<td>225.0</td>
<td>251.2</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>2</td>
<td>1.1600</td>
<td>225.0</td>
<td>125.6</td>
<td>100.0</td>
<td>90.0</td>
</tr>
<tr>
<td>3</td>
<td>1.0000</td>
<td>225.0</td>
<td>0.0</td>
<td>200.0</td>
<td>90.0</td>
</tr>
</tbody>
</table>

Number of towers that are top-loaded: 0
No. of towers that are sectionalized: 0
No. of augmentations to antenna pattern: 0
Rms field strength at 1 km: 10000.0000 mV/m

**RECEIVER ANTENNA CALCULATIONS**

<table>
<thead>
<tr>
<th>Antenna height:</th>
<th>0.0 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antenna gain:</td>
<td>0.0 dBi</td>
</tr>
<tr>
<td>Earth radius ratio:</td>
<td>1.330</td>
</tr>
</tbody>
</table>

**WRITING OUTPUT TO TRPL16**

...
Choose from the menu:
H = Help
D = Program Description
C = Concise Dialog
V = Verbose Dialog
E = Edit Data
S = Summary of Data
P = Process Last Data Set Entered
Q = Quit

Menu (Edit)? q

Figure E-1. Sample #5 signal coverage map.
An interactive program has been developed to evaluate the performance of MF broadcasting systems. The model calculates both ground-wave and sky-wave signals. The user can select from three ground-wave models: 1) smooth Earth, homogenous path, 2) smooth Earth, mixed path, and 3) irregular Earth, mixed path. The available sky-wave methods are: 1) FCC/Region 2, 2) CCIR, and 3) Wang. Three options are available for making the ground-wave and sky-wave predictions: 1) a point-to-point mode which allows the user to define all of the parameters and test the sensitivity of different parameters, 2) a point-to-point mode which compares the desired signal and interference signals at the reception point, and 3) an area mode which produces signal-to-interference or signal coverage plots. The program utilizes the characteristics of transmitting stations found in a Region 2 data base to make interference calculations. The program also incorporates a Region 2 ground conductivity data base, a Region 2 elevations data base, and a world-wide atmospheric noise data base.

15. Key Words (Alphabetical order, separated by semicolons)
ground-wave propagation; MF antenna models; MF broadcasting; MF system characteristics; sky-wave propagation
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