AN AGREEMENT
BETWEEN
THE
UNITED STATES
AND
MEXICO
1986
AGREEMENT BETWEEN THE GOVERNMENT OF THE UNITED STATES OF AMERICA AND THE GOVERNMENT OF THE UNITED MEXICAN STATES AND RELATING TO THE AM BROADCASTING SERVICE IN THE MEDIUM FREQUENCY BAND
AGREEMENT BETWEEN THE GOVERNMENT OF THE UNITED STATES OF AMERICA
AND THE GOVERNMENT OF THE UNITED MEXICAN STATES RELATING TO
THE AM BROADCASTING SERVICE IN THE MEDIUM FREQUENCY SAND

The Government of the United States of America and the
Government of the United Mexican States, desiring to continue their
mutual understanding and cooperation concerning AM Broadcasting and
recognizing the sovereign right of both countries in the management
of their own services, taking into account the provisions of Article
31 of the International Telecommunication Convention, Nairobi, 1982
and Articles 6 and 7 of the Radio Regulations, 1982, annexed to the
Convention, in order to protect the broadcasting stations in the two
countries and to improve the utilization of the frequency band
535-1605 kHz allocated to this service, have agreed as follows:
ARTICLE 1

Definitions

For the purpose of this Agreement, the following terms shall have the meanings defined below:

**Administration:** The Federal Communications Commission of the United States of America and the General Directorate of Concessions and Permits of Telecommunications of the Secretariat of Communications and Transportation of the United Mexican States, respectively:

**Agreement:** This Agreement and its Annexes:

**I.F.R.B.:** The International Frequency Registration Board;

**Assignment in Conformity with the Agreement:** A frequency assignment appearing in the Plan;
Objectionable Interference: The interference caused by a signal that exceeds the maximum permissible field strength within the protected contour, in accordance with the values determined according to the provisions of Annex 2 to the Agreement;

Plan: The frequency assignment Plan as contained in Annex 1 to the Agreement and the modifications introduced as a result of the application of the procedures of Article 3 of the Agreement:

Rio de Janeiro Plan: The frequency assignment Plan as defined in the Regional Agreement for the Medium Frequency Broadcasting Service in Region 2 (Rio de Janeiro, 1981). 1/

1/ Any reference in this Agreement to the Regional Agreement of Rio de Janeiro does not prejudice the legal status of the Regional Agreement for either contracting party.
ARTICLE 2
Adoption of the Plan

The Plan set forth in Annex 1 to this Agreement consists of a list of assignments with technical parameters agreed upon by the two administrations. Broadcasting stations shall be brought into service only when in conformity with Annex 1 or any modification of it resulting from application of Article 3.

ARTICLE 3
Procedure for Modifications to the Plan

3.1 When an Administration proposes to modify the Plan, i.e.,

- to modify the characteristics of a frequency assignment to a station shown in the Plan, whether or not the station has been brought into use, or
-to introduce a new assignment into the Plan, or

-to cancel a frequency assignment to a station,

the following procedure shall be applied simultaneously with or prior to the notification to the I.F.R.B. (for modification to the "Rio de Janeiro Plan").

3.2 Proposals for modifications in the characteristics of an assignment and for the introduction of a new assignment.

3.2.1 The administration proposing to modify the characteristics of an assignment in the Plan or introduce a new assignment shall seek the agreement of the other Administration and shall send in accordance with Article 4 the necessary information via registered mail.

3.2.2 Any assignment in conformity with the Agreement shall be considered as adversely affected when calculations, based on Annex 2, indicate that objectionable interference would occur as a result of the proposed modification to the Plan.
If an Administration which received a notification considers that a proposed modification to the Plan is acceptable, it shall communicate its agreement to the other Administration as soon as possible and shall inform the I.F.R.B. accordingly. If the notified Administration considers that the proposed modification to the Plan is unacceptable, it shall communicate its reasons to the notifying Administration within 90 days from the date on which the notification by registered mail is received. If no comment has been received within the 90 day period, the notifying Administration may proceed with its modification and advise the I.F.R.B. that the agreement of the other Administration has been obtained. On those exceptional occasions when the period for responding to a notification is found to be insufficient the Administration which receives a notification may request an extension of such period.

The agreement referred to in 3.2.1 is not required for a proposed change in the characteristics of an assignment in conformity with the Agreement if it entails no increase in the radiated field strength in
any direction, and *if* a change in site of the station is involved, this change is limited to 3 km or 5% of the distance to the nearest point on the border of the other country, whichever is larger, up to maximum of 10 km. The distance is 'calculated from the site first registered in the Plan or subsequently registered in the Plan as a result of the application of the provisions of 3.2.1. In any event, such site change shall not produce a groundwave contour overlap prohibited under 4.9.4.2 of Annex 2 to this Agreement. However, no protection will be required beyond the level of protection which was already accepted before the proposed modification.

3.2.5 All Modifications to the Plan will be registered in it when the agreement of the other Administration has been obtained or when the time period for responding to the Notification established in 3.2.3 has expired and no such response has been received.

3.3 Cancellation of an Assignment

*When* an administration decides to cancel an Assignment in Conformity with the Agreement, it shall immediately
notify the other Administration. Any such notification of cancellation of an Assignment in Conformity with the Agreement will be considered an abandonment by the notifying Administration of any right arising from that assignment unless, simultaneously with such cancellation, the Administration notifies a new assignment of the same frequency to substitute for the cancelled assignment. In such case, the Administration shall retain, with respect to the substituting assignment, the rights and obligations of the cancelled assignment, including priority. However, such new assignment will not be permitted to cause objectionable interference to existing stations in the other country at a level in excess of that caused by the cancelled assignment, and which has been previously accepted.
ARTICLE 4

Notification Procedure

4.1 The date of a notification will be determined by the date on which the required information submitted in conformity with this Article is received by the other Administration. If a conflict exists between two or more valid notifications, priority will be given to the notification which has the earlier date of receipt.

4.2 The information required for the notifications referred to in Article 3 shall be provided in conformity with Annex 1 to this Agreement. In the case of a modification of technical characteristics, there shall be an indication of which parameter(s) are modified. In order to facilitate the verification of the data, directional antenna parameters shall be supplemented by sample radiation values calculated in five azimuths using the corresponding vertical angles, preferably in directions in which there is maximum and minimum radiation.
4.3 Any notification of the bringing into use of the modification of an Assignment in Conformity with the Agreement which involves a change in frequency shall have the effect of cancelling the former assignment and will constitute the simultaneous notification of a new assignment which shall be given the priority corresponding to the notification of a new assignment.

4.4 Each Administration shall notify the date that an Assignment in Conformity with the Agreement or a modification of an Assignment in Conformity with the Agreement begins or ceases operation. Such notification shall be made within sixty days following such date, and the I.F.R.B. shall be notified accordingly.

4.5 Any Assignment in Conformity with the Agreement shall be deleted from the Plan and cease to be protected from interference unless it is brought into use within five years from the date on which the respective station has been notified and accepted. This is without prejudice to the provisions of paragraph 4.7 of this Article.
4.6 Any modification of any Assignment in Conformity with the Agreement shall be deleted from the Plan and cease to be protected from interference unless it is brought into use within five years from the date on which the respective modification had been accepted.

4.7 For the purposes of paragraphs 4.5 and 4.6 the aforementioned periods may, in special cases, be extended for successive periods of one year upon notice to the other Administration within the effective period of the notification in question. Such notice must include a detailed description of the extraordinary circumstances which would justify such extension.

4.8 Any notification of a new or modified Assignment in Conformity with the Agreement which does not include all the required information set forth in Annex 1, shall be returned by the receiving Administration, and the assignment involved shall receive no protection or priority date. Nevertheless, if the Administration notifies a directional antenna and the complete information
is not provided, the notifying Administration shall submit Section II, Part II of Annex 1 with its initial notification. The receiving Administration may return this notification if the supplementary information is not received within 6 months after receiving the initial notification.

4.9 When an Administration notifies a modification to an Assignment in conformity with the Agreement which has been brought into use, the new notification will be protected from subsequent objectionable interference but will not supersede the previous Assignment in the Plan until it is brought into use.

4.10 When an Administration notifies a modification to an Assignment in conformity with the Agreement which has not been brought into use, the new notification will supersede the previous notification when it is accepted.
ARTICLE 5

Technical Criteria

5.1 The Administrations shall apply in carrying out this Agreement, the technical criteria contained in Annex 2, as may be amended from time to time pursuant to Article 9.

5.2 Notwithstanding the requirements of paragraph 4.9 of Annex 2, the Administrations agree to consider and analyze all reasonable measures to accommodate modifications of technical parameters agreed upon, of existing or authorized stations in order to ameliorate the impact of objectionable interference received from Administrations not parties to this agreement which seriously affect one or both parties to this agreement.
**ARTICLE 6**

Extended Hours of Operation

### 6.1 Scope

"Stations with extended hours of operation" are Class B and C stations operating during a period starting two hours before sunrise and ending two hours after sunset, local time, with protection requirements determined in accordance with Appendix 7 to Annex 2.

### 6.2 Protection

A notified and accepted station operating at nighttime shall have priority over extended hours of operation and shall be protected in accordance with 4.9 of Annex 2.
6.3 Notification

"Stations with extended hours of operation" that comply with the provisions of this Article shall be considered acceptable. Stations later found to be operating in a manner inconsistent with the protection requirements of this Agreement must make the necessary changes in their extended hours of operation to afford the required protection. Proposals for stations with extended hours of operation shall be notified in accordance with the applicable procedures established in Annex 1. Notification shall include the exact operating characteristics of each proposed station.

ARTICLE 7

Termination of Previous Agreements

This Agreement supersedes the existing Agreement between the United States of America and the United Mexican States Concerning Broadcasting in the Standard Broadcasting Band (535-1605 kHz) and the existing Agreement between the United States of America and the United Mexican States Concerning the Operation of Broadcasting Stations in the Standard Band (535-1605 kHz), During a Limited Period Prior to Sunrise and After Sunset, both signed on December 11, 1968.
ARTICLE 8
Resolution of Conflicts

In the case of any discrepancy between the provisions of this Agreement and the provisions of another bilateral or regional agreement relating to broadcasting in the frequency band 535-1605 kHz, the provisions of this Agreement will prevail insofar as mutual relations between the United States of America and the United Mexican States are concerned.
ARTICLE 9

Amendment of the Agreement and the Annexes

Except for modifications to the Plan, which are governed by Article 3, the Agreement and the annexes hereto may be amended by cooperative efforts of the two Administrations. These amendments would become effective when an exchange of Diplomatic Notes takes place between the Department of State of the United States of America and the Secretariat of External Relations of the United Mexican States.

ARTICLE 10

Coming into Force and Duration

This Agreement shall come into force on the date on which both parties notify each other through diplomatic channels that they have concluded their respective constitutional procedures and shall continue in force until a new agreement is substituted or until it is denounced by either party.
ARTICLE 11
Termination of the Agreement

Either Government may terminate this Agreement by written notice of denunciation to the other Government through diplomatic channels. The denunciation will be effective one year after receipt of the notice.

IN WITNESS WHEREOF, the respective Plenipotentiaries have signed this Agreement.

DONE in duplicate, in the English and Spanish languages, each having equal authenticity, at Mexico City, District Federal this ___ day of ___ 1986.

For the Government of the United States of America

For the Government of the United Mexican States
ANNEX 1

to the Agreement

INFORMATION TO BE CONTAINED IN LISTINGS AND IN FORMS FOR NOTIFICATION PURPOSES

For the purposes of this Agreement the forms to be used in accordance with Article 3 will be the same as those referred to in Annex 3 of the Regional Agreement Concerning Radio Service in the Broadcast Band in Region 2, signed at Rio de Janeiro, 1981.

As an exception, in the case of notification of stations operating during extended hours the form from Part V of this Annex will be used.

1. Parts I through V describe the data to be notified and the forms to be used in notification. Part VI describes the Plan.

2. An administration wishing to submit the equivalent information on magnetic tape or by other electronic means, shall submit such data only in the format accepted by the other administration.

3. Five forms and a List are adopted; each of which corresponds to the following information:

   **PART I**: General information on the transmitting station.

   **PART II**: Section I: Characteristics of directional antennas (when the antenna design is known). Section II: Radiated field in various sectors (for use when the antenna design is not yet known).

   **PART III**: Additional information for directional antennas with augmented (modified expanded) patterns.

   **PART IV**: Supplementary information for top-loaded or sectionalized towers used for directional and omnidirectional antenna systems.

   **PART V**: Supplementary information for extended hours of operation.

   **PART VI**: The Plan.

4. The Administration receiving the notification may return forms which have not been completed correctly.

5. When known, the IFRB Serial Number shall be inserted on each form by the notifying Administration. Otherwise, the space provided shall be left blank.
**General Information**

**Instructions for completing the forms**

**Box No.**

01  **Administration**
Indicate the name of the administration, the sheet number and the date on which the form was completed;

02  **Assigned frequency (kHz)**

03  **Name of the transmitting station**
Indicate the name of the locality or the name by which the station is known. Limit the number of letters and numerals to a total of 14;

04  **Call sign**
This information is optional. Limit the number of letters and numerals to a total of 7;

05  **Additional identification**
Indicate any additional information which may be considered essential for complete identification. Where this information is not essential, this box may be left blank;

06  **Station Class (A, B or C)**
Insert A, B or C according to the station classes defined in Chapter 1 of Annex 2 to the Agreement;

07  **Operational status**
Enter 0 for a station already in operation and enter P for a station to be brought into operation;

08  **Country**
Indicate the name of the country or geographical area in which the station is located. Use the symbols in Table 1 of the Reface to the International Frequency List;

09  **Geographical coordinates of the transmitting station**
Indicate the geographical coordinates (longitude and latitude) of the transmitting antenna site in degrees, minutes and seconds. Seconds need to be entered only if available. Delete the letter N or S, as appropriate. If no seconds are indicated, the IFRB will use a value of 0 in its calculations;

II  **Indicate the reason for the application of Article 4:**
a) New assignment:
b) Modification of the characteristics of an assignment recorded in the Plan:
c) Cancellation of an assignment:

12  **Indicate whether the modification is of the type specified in section 4.2.14 of Article 4 of the Agreement:**

13  **In the case of a new station, indicate the date of bringing into service. In the case of a change in the characteristics of a station already recorded in the Plan, indicate the date of start of operation with the modified characteristics or the date of cessation of operation:**

**DAYTIME OPERATION**

21  **Station power (kW)**
Indicate the carrier power supplied to the antenna for daytime operation (to the second decimal position for powers less than 1 kW):
25 r.m.s. value of radiation (mV/m at 1 km) for daytime station power:

26 Antenna type

Indicate here the type of antenna used for daytime operation. Use the symbols as follows:

A – Simple omnidirectional antenna;
B – Directional antenna when the design is known (complete Part II, Section I);
C – Directional antenna where the design is not known, indicated by sectors of radiation (complete Part II, Section II);
1 – Top-loaded omnidirectional antenna (complete Part IV);
2 – Sectionalized omnidirectional antenna (complete Part IV);

27 Simple vertical antenna electrical height

Indicate here the electrical height, in degrees, for a simple vertical antenna in use for daytime operation. In the case of an antenna other than A, this box should be left blank;

NIGHT-TIME OPERATION

31 Station power (kW)

Indicate the carrier power supplied to the antenna for night-time operation (to the second decimal position for powers less than 1 kW);

35 r.m.s. value of radiation (mV/m at 1 km) for night-time station power:

Antenna type

Indicate the type of antenna used for night-time operation (use the symbols in Box No. 26);

(See Box No. 27);

37 Remarks

Indicate here any necessary additional information, such as the identification of the synchronized network to which the station belongs. If shared time operation is intended, indicate in this box and identify the other assignment involved;

Coordination under article 4

Country – Indicate the name of the countries which may be affected and with which coordination is considered necessary, using the symbols in Table 1 of the Preface to the International Frequency List:

In progress – Add an “X” if coordination is under way with these countries:

Acceptance obtained – Indicate with an “X” if coordination has been successful.
# CHARACTERISTICS OF A BROADCASTING STATION

## PART I  GENERAL INFORMATION

<table>
<thead>
<tr>
<th>Administration</th>
<th>Form No.</th>
<th>Date</th>
</tr>
</thead>
</table>

### Transmitting station

<table>
<thead>
<tr>
<th>Assigned frequency (kHz)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name of the station</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Call sign</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Additional identification</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Station class (A, B or C)</strong></td>
<td></td>
</tr>
</tbody>
</table>

### Country

| Geographical coordinates of the transmitting station |   |

### Status

- **a) New assignment**
- **b) Modification of the characteristics of an assignment recorded in the Plan**
- **c) Cancellation of an assignment**

### Modification under Section 4.2.14

- **Yes**
- **No**

### Date of bringing into service or cessation of operation

Day Month Year

<table>
<thead>
<tr>
<th>Station parameters</th>
<th>Daytime operation</th>
<th>Night-time operation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Status of the station (0 or P)</strong></td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td><strong>Station power (kW)</strong></td>
<td>21</td>
<td>31</td>
</tr>
<tr>
<td><strong>r.m.s. value of radiation (mW/m² 1 km)</strong> (except when symbol B or C appears in box 26 or 36)</td>
<td>25</td>
<td>35</td>
</tr>
<tr>
<td><strong>Antenna type</strong></td>
<td>26</td>
<td>36</td>
</tr>
<tr>
<td><strong>Simple vertical antenna electrical height (degrees)</strong></td>
<td>27</td>
<td>37</td>
</tr>
</tbody>
</table>

### Remarks

<table>
<thead>
<tr>
<th>Country</th>
<th>Coordination under Article 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>In progress</td>
<td></td>
</tr>
</tbody>
</table>

(FRB Serial No.)
PART II

Description of the directional antenna

Radiation characteristics of the transmitting antenna

1. The form for Part II Section I is used when the design of the directional antenna is known. When a directional antenna is intended to be used, but the design is not yet known, the form Part II Section II should be used. The latter form should be replaced by a completed Part II Section I form as soon as the design parameters are determined.

2. Administrations are invited to use Part II of the form to furnish the electrical characteristics of the antenna. From the information thus furnished, the IFRB will determine the radiation pattern.

3. When Part II of the form is not suitable for describing a particular type of antenna, administrations may communicate the particulars of the antenna in question on a separate sheet, taking care that all the parameters necessary for the calculation of the radiation diagram have been included.

4. Radiation diagrams shall be used only when the information requested in Part II is not available. See Appendix 3 to Annex 2 to the Agreement.
PART II - SECTION I

**Description of the directional antenna consisting of vertical conductors**

**Instructions for completing the form**

**Box No.**

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Indicate the name of the transmitting station:</td>
</tr>
<tr>
<td>02</td>
<td>Country</td>
</tr>
<tr>
<td>03</td>
<td>Indicate the country or geographical area in which the station is located. Use the symbols in Table 1 of the Reference to the international Frequency List:</td>
</tr>
<tr>
<td>04</td>
<td>Indicate the hours of operation for which the given characteristics of the antenna are applicable. The symbols D or N shall be used to indicate that the station operates for the daytime or night-time period respectively. When the same operation is used for both daytime and night-time, enter the two symbols “D” and “N”:</td>
</tr>
<tr>
<td>05</td>
<td>Indicate the total number of towers constituting the array.</td>
</tr>
</tbody>
</table>

**Column No.**

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>05</td>
<td>This column shows the serial number of towers, as they will be described in columns 06 to 12:</td>
</tr>
<tr>
<td>06</td>
<td>Indicate here the ratio of the tower field to the field from the reference tower:</td>
</tr>
<tr>
<td>07</td>
<td>Indicate here, in degrees, the positive or negative difference in the phase angle of the field from the tower with respect to the field from the reference tower:</td>
</tr>
<tr>
<td>08</td>
<td>Indicate, in degrees, the electrical spacing of the tower from the reference point, defined in column 10:</td>
</tr>
<tr>
<td>09</td>
<td>Indicate, in degrees from True North, the angular orientation of the tower from the reference point indicated in column 10:</td>
</tr>
<tr>
<td>10</td>
<td>Define the reference point as follows:</td>
</tr>
<tr>
<td>11</td>
<td>Indicate the electrical height (degrees) of the tower under consideration:</td>
</tr>
<tr>
<td>12</td>
<td>Tower structure</td>
</tr>
</tbody>
</table>

This column should contain a code from 0 to 2 to indicate the structure of each tower:

0 = simple vertical antenna

1 = top-loaded antenna

2 = sectionalized antenna

Codes 1 and 2 are used in Part IV to indicate the characteristics of the various structures. They are also used for the identification of the appropriate formula for vertical radiation in Appendix 4 to Annex 2.

**Note:** In the absence of a specific code to refer to other types of sectionalized antennas, administrations may use the codes indicated in Appendix 6 to Annex 2.

**Box No.**

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>r.m.s. value of radiation (mV/m at 1 km):</td>
</tr>
<tr>
<td>15</td>
<td>Type of pattern:</td>
</tr>
<tr>
<td>16</td>
<td>Special quadrature factor for expanded and augmented (modified expanded) patterns in mV/m at 1 km (to replace the normal expanded pattern quadrature factor when special precautions are taken to ensure pattern stability):</td>
</tr>
</tbody>
</table>
FORM
TO BE USED IN APPLICATION OF ARTICLE 4 OF THE
MF BROADCASTING AGREEMENT
(BAND 535 - 1605 kHz)

CHARACTERISTICS OF A BROADCASTING STATION

PART II - section I

DESCRIPTION OF A DIRECTIONAL ANTENNA CONSISTING OF VERTICAL CONDUCTORS

<table>
<thead>
<tr>
<th>Form No.</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name of transmitting station</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tower No.</th>
<th>Tower field ratio</th>
<th>Phase difference of the field (± degrees)</th>
<th>Electrical tower spacing (degrees)</th>
<th>Angular tower orientation (degrees)</th>
<th>Definition point indicator</th>
<th>Electrical height of tower (degrees)</th>
<th>Tower structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

(Use a supplementary that in cases what there are more than 10 towers.)

<table>
<thead>
<tr>
<th>14</th>
<th>r.m.s. value of theoretical radiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>mV/m</td>
<td>at 1 km</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>15</th>
<th>Type of pattern (T, E or M)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>16</th>
<th>Special quadrature factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>mV/m</td>
<td>at 1 km</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>17</th>
<th>SUPPLEMENTARY INFORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PART II – SECTION II

Radiated field limitations in specific sectors
in the absence of information on directional antennas

1. In the absence of a detailed description of the directional antenna system, an indication of the radiated field limitations in specific sectors is required. In these cases, the radiation pattern (0°-360°) is subdivided in sectors with an indication of the maximum radiated field for each sector.

2. This form is to be used for a proposed station only ("P" entered in Pan I, Box 07).

3. The Sheet No. box is for the convenience of administrations. Indicate the date on which the form was completed.

Instructions for completing the form

<table>
<thead>
<tr>
<th>Box No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Name (usually town or locality) of transmitting station;</td>
</tr>
<tr>
<td>02</td>
<td>Country</td>
</tr>
<tr>
<td>03</td>
<td>Indicate the country or geographical area in which the transmitting station is located, using the symbols in Table 1 of the Preface to the International Frequency List:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Column No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Sectors of radiation in degrees from True North for daytime operation. The entire circumference from 0 to 360 degrees shall be specified;</td>
</tr>
<tr>
<td>19</td>
<td>Maximum radiated field strength in the sector indicated in column 18, in the horizontal plane in mV/m at 1 km: (see Appendix to this Annex);</td>
</tr>
</tbody>
</table>

**DAYTIME OPERATION**

| 18 | Sectors of radiation in degrees from True North for daytime operation. The entire circumference from 0 to 360 degrees shall be specified; |
| 19 | Maximum radiated field strength in the sector indicated in column 18, in the horizontal plane in mV/m at 1 km: (see Appendix to this Annex); |

**NIGHT-TIME OPERATION**

| 28 | Sectors of radiation in degrees from True North for night-time operation. The entire circumference from 0 to 360 degrees shall be specified; |
| 29 | Maximum radiated field strength in the vertical plane in the sector indicated in column 28, in mV/m at 1 km. |

Any further information which should be included in the IFRB weekly circular. Any further explanatory notes for the information of the IFRB may be attached.

Note: This form should be replaced by the form corresponding to Pan II, Section I, duly completed, as soon as the antenna design is known.
**FORM**

**TO BE USED IN APPLICATION OF ARTICLE 40F THE**
**MF BROADCASTING AGREEMENT**

(BAND 535 - 1 605 kHz)

**CHARACTERISTICS OF A BROADCASTING STATION**

**PART II - Section 2**

DESCRIPTION OF RADIATION CHARACTERISTICS IN THE ABSENCE OF ANY INFORMATION ON THE DIRECTIONAL ANTENNA DESIGN

<table>
<thead>
<tr>
<th>Form No.</th>
<th>Date</th>
</tr>
</thead>
</table>

**01**

Name of transmitting station

**02**

Country

**NOTE:** This form should only be used for planned stations (Symbol P in box 20 or 30 in part 1).

### Daytime operation

<table>
<thead>
<tr>
<th>Sector of radiation (degrees)</th>
<th>Maximum field strength in the horizontal plane (mW/m at 1 km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
</tr>
</tbody>
</table>

### Night-time operation

<table>
<thead>
<tr>
<th>Sector of radiation (degrees)</th>
<th>Maximum field strength in any vertical plane in the sector (mW/m at 1 km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

**20 SUPPLEMENTARY INFORMATION**
PART III

Description of the parameters of directional antennas with augmented (modified expanded) patterns

1. Part II of this Annex contains the information for directional antenna systems operating with theoretical and expanded patterns. However, some stations operate with augmented (modified expanded) directional antenna patterns. In these cases, additional calculations are performed, once the expanded radiation is calculated, to determine the radiation from the augmented (modified expanded) directional antenna pattern. This Pan contains the additional parameters required for augmented (modified expanded) patterns.

2. If Pan. III is submitted, a corresponding Pan II must also be submitted.

3. Part III should be submitted only if Box 15 of Section I of Pan II contains the symbol “M” for augmented (modified expanded).".

Box No.

01 Indicate the name of transmitting station:

02 Country

Indicate the country or geographical area in which the station is located, using the symbols in Table 1 of the Preface to the International Frequency List;

03 Indicate the hours of operation for which the antenna characteristics given are applicable. The symbols D or N shall be used to indicate that the station operates for the daytime and night-time. Enter the two symbols “D” and “N”;

04 Indicate the total number of augmentations which are used. It must be 1 or greater than 1.

Column No

05 Indicate the serial number of the augmentations, as they will be described in columns 06, 07 and 08 (see section 27 of Appendix 3 to Annex 2);

06 Indicate the radiation at the central azimuth of augmentation. This value should always be equal to or greater than the value from the theoretical pattern:

07 Indicate the central azimuth of augmentation. This is the centre of the span:

08 Indicate the total span of the augmentation. Half of the span will be on each side of the central azimuth of augmentation. Spans may overlap; if so, augmentations are processed clockwise according to the central azimuth of augmentations.

Box No.

09 Supplementary information. Indicate any supplementary information concerning augmented (modified expanded) patterns. If a supplementary sheet has been used for further augmentations, please indicate in this box.
### CHARACTERISTICS OF A BROADCASTING STATION

**PART III**

**DESCRIPTION OF THE PARAMETERS OF DIRECTIONAL ANTENNAS AUGMENTED (MODIFIED EXPANDED) PATTERNS, TO BE SUBMITTED WHENEVER THE SYMBOL M IS ENTERED IN PART II SECTION 1 BOX 13**

<table>
<thead>
<tr>
<th>Form No.</th>
<th>Date</th>
<th>Name of transmitting station</th>
<th>Country</th>
<th>Hours of operation (D, N or DN)</th>
<th>Total number of augmentations</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Augmentation No.</th>
<th>Radiation at central azimuth of augmentation (mV/m at 1 km)</th>
<th>Central azimuth of augmentation (degrees)</th>
<th>Total span of augmentation (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>03</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>04</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>06</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>07</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Use a supplementary sheet in cases where there are more than 20 augmentations.)

**SUPPLEMENTARY INFORMATION**
1. Where an omnidirectional antenna is top-loaded or sectionalized, the figures 1 or 2 will have been entered in Part I, Box 26 and/or 36. Proceed as for a single tower of a directional antenna.

2. When an antenna tower of a directional antenna is either top-loaded or sectionalized, column 12, Section I of Part II will contain either a figure 1 or a figure 2. These numerals describe the particular type of top-loaded or sectionalized antenna used, as described below:

Box No.

01 Name of the station:
02 Country
Indicate the country or geographical area in which the station is located, using the symbols in Table 1 of the Reface to the International Frequency List:
03 Indicate the hours of operation for which the given characteristics of the antenna are applicable. The symbols D or N shall be used to indicate that the station operates for the daytime or night-time period respectively. When the same operation is used for both daytime and night-time, enter the two symbols “D” and “N”.

Column No.

04 Tower number:
Columns 5 to 8 show the values of four characteristics of the elements constituting a top-loaded or sectionalized antenna. Each of these columns may contain a figure representing the value of a given characteristic as described below:

05 **Code used in Col. 12**
(Part II = Section I)
1 Electrical height of the antenna tower (degrees):
2 Height of lower section (degrees):

06 **Code used in Col. 12**
(Part II = Section I)
1 Difference between apparent electrical height (based on current distribution) and actual height (degrees):
2 Difference between apparent electrical height of lower section (based on current distribution) and actual height of lower section (degrees):

07 **Code used in Col. 12**
(Part II = Section I)
1 Blank:
2 Total height of antenna (degrees):
<table>
<thead>
<tr>
<th>Column No.</th>
<th>Code used in Col. 12. (Part 11 = Section I)</th>
<th>Description of the characteristic the value of which is indicated in the column (these values are used in the equations entered in Appendix 4 to Annex 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>08</td>
<td>Blank:</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Difference between apparent electrical height (based on current distribution) of the total tower and the actual-height of the total tower (degrees).</td>
<td></td>
</tr>
</tbody>
</table>

FORM

TO BE USED IN APPLICATION OF ARTICLE 4 OF THE MF BROADCASTING AGREEMENT

CHARACTERISTICS OF A BROADCASTING STATION

PART IV

DESCRIPTION OF TOP-LOADED OR SECTIONALIZED TOWERS USED FOR DIRECTIONAL OR OMNIDIRECTIONAL ANTENNA SYSTEMS

<table>
<thead>
<tr>
<th>Form No.</th>
<th>Date</th>
<th>Hours of operation (D, N or DN)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I-1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name of transmitting station</th>
<th>Country</th>
<th>Number of tower</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>01</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>03</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>06</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>07</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PART V

SUPPLEMENTARY INFORMATION FOR EXTENDED HOURS OF OPERATION

Annex I/p. 14
## CHARACTERISTICS OF A BROADCASTING STATION

### PART I  GENERAL INFORMATION

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assigned frequency (kHz)</td>
<td></td>
</tr>
<tr>
<td>Name of the station</td>
<td></td>
</tr>
<tr>
<td>Call sign</td>
<td></td>
</tr>
<tr>
<td>Additional identification</td>
<td></td>
</tr>
<tr>
<td>Station class (A, B or C)</td>
<td></td>
</tr>
<tr>
<td>Country</td>
<td></td>
</tr>
<tr>
<td>Geographical coordinates of the transmitting station</td>
<td></td>
</tr>
</tbody>
</table>

### Form 2

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>New assignment</td>
</tr>
<tr>
<td>b)</td>
<td>Modification of the characteristics of an assignment recorded in the Plan</td>
</tr>
<tr>
<td>c)</td>
<td>Cancellation of an assignment</td>
</tr>
</tbody>
</table>

### Form 3

- Date of bringing into service or cessation of operation: Day, Month, Year

### Station Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Daytime Operation</th>
<th>Night-time Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status of the station (0 or P)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Station power (kW)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>r.m.s. value of radiation (mV/m at 1 km)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antenna type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simple vertical antenna electrical height (degrees)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Remarks

- Extended Hours of Operation

### Coordination under Article 4

<table>
<thead>
<tr>
<th>Country</th>
<th>In progress</th>
<th>Acceptance</th>
</tr>
</thead>
</table>
PART VI

THE PLAN

1.- The Plan in its entirety consists of the assignments duly notified, coordinated and accepted by both 'Administrations.

2.- Both Administrations shall exchange lists periodically, as follows:

List 1: Every six months modifications to the Plan notified during such period shall be exchanged.

List 2: Every twelve months an amended Plan shall be exchanged which includes all accepted modifications to the Plan up to that date and shall supersede the Plan then in force.
APPENDIX  
(to Annex 1)

Typical radiation values of a directional antenna

1. Introduction

When an administration intends to propose a new station under Article 4, using a directional antenna, and the antenna design is not known, the form in Annex 3, Part IL, Section IL, is to be used. This form requires information on the arcs of suppression.

The following information may be used as a guide for determining realistic values which might be entered on the form.

2. Minimum radiation

When the radiated field is suppressed in one or more directions so as to afford protection to other stations, the minimum level of radiation achievable in practice ($E_{\text{min}}$) over arcs up to about 30 degrees, is given by the following equation:

$$E_{\text{min}} = 10 \sqrt{P} \text{ mV/m at 1 km}$$

where $P$ is the station power in kW. Thus the degree of suppression required by a planned scacion necessarily limits the station power to a practical value. When the maximum suppression is required over wide spans exceeding 30 degrees, a considerably more complex antenna array or lower power is usually required.

3. Maximum radiation

The radiated field in the direction generally opposite to the direction of suppression tends to increase such that the maximum field achieves an approximate value of 1.35 x the r.m.s. value of the theoretical radiation in mV/m at 1 km.

4. Radiation in the other directions

In the directions other than in the spans of $E_{\text{min}}$ and $E_{\text{max}}$, the radiated field may exceed the r.m.s. value of the radiation by more than 10 Percent.
5. **Table of typical values**

<table>
<thead>
<tr>
<th>Station power (kW)</th>
<th>Typical values of $E_{\text{rms}}$ (mV/m at 1 km)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$E_{\text{min}}$</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>2.5</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>22</td>
</tr>
<tr>
<td>10</td>
<td>32</td>
</tr>
<tr>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>50</td>
<td>71</td>
</tr>
</tbody>
</table>
ANNEX 2

AGREEMENT BETWEEN THE GOVERNMENT OF THE

UNITED MEXICAN STATES AND THE GOVERNMENT

OF THE UNITED STATES OF AMERICA RELATING

TO THE AM BROADCASTING SERVICE IN THE

MEDIUM FREQUENCY BAND

TECHNICAL CRITERIA

To be used in the application of the Agreement
1. **Definitions**

In addition to the definitions given in the Radio Regulations (1982), the following definitions and symbols apply to this Agreement.

1.1 **Broadcasting channel (AM)**

A part of the frequency spectrum, equal to the necessary bandwidth of AM sound broadcasting stations, and characterized by the nominal value of the carrier frequency located at its center.

1.2 **Objectionable interference**

Interference caused by a signal exceeding the maximum permissible field strength within the protected contour, in accordance with the values derived from this Annex.

1.3 **Protected contour**

Continuous line that delimits the area of primary or secondary service which is protected from objectionable interference.

1.4 **Primary service area**

Service area delimited by the contour within which the calculated level of the groundwave field strength is protected from objectionable interference in accordance with the provisions of Chapter 4.

1.5 **Secondary service area**

Service area delimited by the contour within which the calculated level of the field strength due to the skywave field strength 50% of the time is protected from objectionable interference in accordance with the provisions of Chapter 4.

1.6 **Nominal usable field strength 
\(E_{nom}\)**

Agreed minimum value of the field strength required to provide satisfactory reception under specified conditions, in the presence of atmospheric noise, man-made noise and interference from other transmitters. The value of nominal usable field strength has been employed as the reference for planning.

1.7 **Usable field strength 
\(E_u\)**

Minimum value of the field strength required to provide satisfactory reception under specified conditions in the presence of atmospheric noise, man-made noise, and interference in a real situation (or resulting from a frequency assignment plan).
1.8 **Audio-frequency protection ratio** (or **AF protection ratio**)

Agreed minimum value of the audio-frequency signal-to-interference ratio corresponding to a subjectively defined reception quality. This ratio may have different values according to the type of service desired.

1.9 **Radio-frequency protection ratio** (or **RF protection ratio**)

The desired radio-frequency signal-to-interference ratio which, in well-defined conditions, makes it possible to obtain the audio-frequency protection ratio at the output of a receiver. These specified conditions include various parameters such as the frequency separation between the desired carrier and the interfering carrier, the emission characteristics (type and percent modulation etc.), Levels of input and output of the receiver and its characteristics (selectivity, sensitivity to intermodulation, etc.).

1.10 **Class A station** (see Note L to Section 4.6)

A station intended to provide coverage over extensive primary and secondary service areas and which is protected against objectionable interference, accordingly.

1.11 **Class B station**

A station intended to provide coverage over one or more population centers and the contiguous rural areas located in its primary service area and which is protected against objectionable interference, accordingly.

1.12 **Class C station**

A station intended to provide coverage over a city or town and the contiguous suburban areas located in its primary service area and which is protected against objectionable interference, accordingly.

1.13 **Daytime operation**

Operation between the times of local sunrise and local sunset.

1.14 **Nighttime operation**

Operation between the times of local sunset and local sunrise.

1.15 **Synchronized network**

Two or more broadcasting stations whose carrier frequencies are identical and which broadcast the same program simultaneously.

In a synchronized network the difference in carrier frequency between any two transmitters in the network shall not exceed 0.1 Hz. The modulation delay between any two transmitters in the network shall not exceed 100 microseconds, when measured at either transmitter site.
1.16 **Station power**

Unmodulated *carrier power* supplied to the antenna.

1.17 **Groundwave**

Electromagnetic wave which is propagated *along* the surface of the Earth or near it and which has not been reflected by the ionosphere.

1.18 **Skywave**

Electromagnetic wave which has been reflected by the ionosphere.

1.19 **Skywave field strength, 10% of the time**

The value of a skywave signal which is not exceeded for more than 10% of the period of observation.

1.20 **Skywave field strength, 50% of the time**

The value of a skywave signal which is not exceeded for more than 50% of the period of observation.

1.21 **Characteristic field strength (E_c)**

The field strength, at a reference distance of 1 km in a horizontal direction, of the groundwave signal propagated along perfectly conducting ground for L kW station power, taking into account losses in a real antenna.

1.22 **Symbols**

- Hz : hertz
- kHz : kilohertz
- W : watt
- kW : kilowatt
- mV/m : millivolt/meter
- µV/m : microvolt/meter
- mS/m : millisiemens/meter
- km : kilometer
CHAPTER 2

Groundwave propagation

2.1 Ground conductivity

2.1.1 The maps of ground conductivity for Mexico and the U.S.A. are contained in Appendix 1.

2.1.2 Either Administration may modify its ground conductivity map at any time by notifying changes to the other Administration.

2.1.3 No assignment in the Plan shall at any time be required to be modified as a result of the incorporation of these changes.

2.2 Field strength curves for groundwave propagation

The curves shown in Appendix 2 are to be used for determining groundwave propagation in the following frequency ranges:

<table>
<thead>
<tr>
<th>Graph No.</th>
<th>kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>540 - 560</td>
</tr>
<tr>
<td>2</td>
<td>570 - 590</td>
</tr>
<tr>
<td>3</td>
<td>600 - 620</td>
</tr>
<tr>
<td>4</td>
<td>630 - 650</td>
</tr>
<tr>
<td>5</td>
<td>660 - 680</td>
</tr>
<tr>
<td>6</td>
<td>690 - 710</td>
</tr>
<tr>
<td>7</td>
<td>720 - 760</td>
</tr>
<tr>
<td>8</td>
<td>770 - 810</td>
</tr>
<tr>
<td>9</td>
<td>820 - 860</td>
</tr>
<tr>
<td>10</td>
<td>870 - 910</td>
</tr>
<tr>
<td>11</td>
<td>920 - 960</td>
</tr>
<tr>
<td>12</td>
<td>970 - 1030</td>
</tr>
<tr>
<td>13</td>
<td>1040 - 1100</td>
</tr>
<tr>
<td>14</td>
<td>1110 - 1170</td>
</tr>
<tr>
<td>15</td>
<td>1180 - 1240</td>
</tr>
<tr>
<td>16</td>
<td>1250 - 1330</td>
</tr>
<tr>
<td>17</td>
<td>1340 - 1420</td>
</tr>
<tr>
<td>18</td>
<td>1430 - 1510</td>
</tr>
<tr>
<td>19</td>
<td>1520 - 1610</td>
</tr>
</tbody>
</table>

2.3 Calculation of groundwave field strength

2.3.1 Homogeneous ground conductivity paths

The vertical component of the field strength for a homogeneous path is represented as a function of distance for various values of ground conductivity and is shown on graphs 1 to 19 which are standardized for a Characteristic field strength of 100 mV/m a; 1 km.
The distance **in** kilometers is **shown** on a logarithmic scale on the abscissa. The **field** strength is **shown** on a logarithmic scale on the **ordinate** in mV/m. The straight line marked "100 mV/m at 1 km" is the field strength on the **assumption** that the antenna is erected on a surface of perfect conductivity.

For omnidirectional antenna systems having a different characteristic field strength, correction **must** be made according to the following equations:

\[ E = \frac{E_0}{100} \]

where:

\[ E = \frac{E_c \sqrt{P}}{R} \]

for omnidirectional antenna systems

Note: For a directional antenna system, \( E_R \) is determined in accordance with Appendix 3.

where

- \( E \): resulting field strength in mV/m
- \( E_0 \): field strength read from graphs 1 to 19 in mV/m
- \( E_R \): actual radiated field strength at a particular azimuth at 1 km in mV/m
- \( E_c \): characteristic field strength in mV/m
- \( P \): station power in kW.

2.3.2 Non-homogeneous ground conductivity paths

In this case, the equivalent distance or Kirke **method** is **to** be used. To apply this method, graphs 1 to 19 are used.

Consider a path whose sections \( S_1 \) and \( S_2 \) have endpoint lengths corresponding to \( d_1 \) and \( d_2 - d_1 \), and conductivities \( \sigma_1 \) and \( \sigma_2 \) respectively, as shown on the following figure:

\[ \text{The method is applied as follows:} \]

**a)** Taking section \( S_1 \) first, we read the field strength corresponding to conductivity \( \sigma_1 \) at distance \( d_1 \) on the graph corresponding to the operational frequency.
b) As the field strength remains constant at the soil discontinuity, the value immediately after the point of discontinuity must be equal to that obtained in a> above. As the conductivity of the second section is \( \sigma_2 \), the curve corresponding to conductivity \( \sigma_2 \) gives the equivalent distance to that which would be obtained at the same field strength arrived at in a). This equivalent distance is \( d \). Distance \( d \) is larger than \( d_1 \) when \( \sigma_2 \) is larger than \( \sigma_1 \). Otherwise \( d \) is less than \( d_1 \).

c) The field strength at the real distance \( d' \) is determined by taking note of the corresponding curve for conductivity \( \sigma_2 \) similar to that obtained at equivalent distance \( d + (d_2 - d_1) \).

d) For successive sections with different conductivities, procedures b) and c) are repeated.
CHAPTER 3

Skywave propagation

3. The calculation of skywave field strength shall be conducted in accordance with the provisions which follow. (No account is taken in this Agreement of sea gala or of excess polarization coupling loss.)

3.1 List of symbols

d : short great-circle path distance (km)

\( \phi \) : characteristic field strength (mV/m at 1 km for 1 kW)

\( f(\theta) \) : radiation as a fraction of the value \( \theta = 0 \) (when \( \theta = 0 \), \( f(\theta) = 1 \))

\( f \) : frequency (kHz)

\( \bar{F} \) : adjusted annual median skywave field strength (\( \mu \)V/m)

\( F_c \) : field strength read from Figure 4 or Table III for a characteristic field strength of 100 mV/m at 1 km

\( F(50) \) : skywave field strength, 50% of the time (\( \mu \)V/m)

\( F(10) \) : skywave field strength, 10% of the time (\( \mu \)V/m)

3 : station power (kW)

\( \theta \) : elevation angle from the horizontal (degrees)

\( E_{exp}(\phi, \theta) \) : expanded pattern radiation at a particular azimuth, \( \phi \), and a particular elevation angle, \( \theta \) (mV/m)

3.2 General procedure

Radiation in the horizontal plane of an omnidirectional antenna fed with 1 kW (characteristic field strength, \( E_c \)) is known either from design data or, if the actual design data are not available, from Figure 1.

The angle of elevation, \( \theta \), can be determined from Table I or Figure 2.

Note: Table I and Figure 2 is derived from the formula:

\[
\theta = \arctan \left( 0.00752 \cot \left( \frac{d}{444.54} \right) \right) - \frac{d}{444.54} \quad \text{degrees} \quad (1)
\]

\( 0 \leq \theta < 90^\circ \)

The radiation \( f(\theta) \) expressed as a fraction of the value at \( \theta = 0 \) at a pertinent elevation angle \( \theta \) can be determined from Figure 3 or Table II.
The adjusted skywave field strength $F$ is given by:

$$F = F_c \frac{E_R}{100} (\mu V/m)$$  \hspace{1cm} (2)

where $F_c$ is the direct reading from the field strength curve in Figure 4 or Table III.

The formula $E_R = E_c F(\theta) \sqrt{P}$ is used for omnidirectional systems.

For a directional antenna system, $E_R$ is calculated in accordance with Appendix 3.

Note: Values of $F_c$ in Figure 4 and Table III are normalized to 100 $\mu V/m$

For distances greater than 4,250 km, it should be noted that $F_c$ can be expressed by:

$$F_c = \text{antilog} \left( \frac{231 - 1.77}{60 + d/50} \right) (\mu V/m)$$  \hspace{1cm} (3)

3.3 Skywave field strength, 50% of the time

The skywave field strength not exceeded 50% of the time:

$$F(50) = F (\mu V/m)$$  \hspace{1cm} (4)

3.4 Skywave field strength, 10% of the time

This factor is given by:

$$F(10) = F(50)(2.5) \hspace{1cm} (\mu V/m)$$  \hspace{1cm} (5)

3.5 Nocturnal variation of skywave field strength

Hourly median skywave field strengths vary during the night and at sunrise and sunset. The diurnal factor is determined using the time of day at the midpoint of the path between the site of the interfering station and the point at which interference is being calculated.

Diurnal factors are computed using the formula:

$$Df = a + bF + cF^2 + dF^3$$  \hspace{1cm} (6)

Where: $Df$ represents the diurnal factor,

$F$ is the frequency in MHz,

$a$, $b$, $c$, and $d$ are constants used in calculating the diurnal factors.
For the pre-sunrise and post-sunset periods, the constants are obtained from Figures 5c and 5d. The columns labeled \( T_{mp} \) represent the number of hours before and after \textit{sunrise} and \textit{set} at the path midpoint. Figures 5a and 5b depict the \textit{skywave} diurnal factors with respect to \textit{sunrise} and \textit{set} at the midpoint of the transmission path.

Figures 5a and 5b or Formula 6 shall be applied in determining field strengths of signals of stations engaging in extended hours of operation. However, the calculations made according to Formula 6 are controlling.

Diurnal factors greater than 1 will not be used in calculations, and interpolation is to be used between calculated values where necessary.

3.6 Sunrise and sunset time

To facilitate the determination of the Local. time of sunrise and sunset, Figure 6 gives the times for various geographical latitudes and for each month of the year. The time is the local meridian time at the point concerned and should be converted to the appropriate standard time.
CAMPOS CARACTERÍSTICOS DE ANTENAS VERTICALES
PARA 1 KW
A 1 KILOMÉTRO

Usado para una antena vertical omnidireccional sen- cilha con un sistema de tierra con, cuando menos, 120 radiales de la longitud indicada.

FIG. 1
Annex 2/p.11 a
A: Short vertical antenna

FIGURE la - Field strength at a distance of 1 km as a function of elevation angle for different heights of vertical antenna assuming a transmitter power of 1 kW
<table>
<thead>
<tr>
<th>Elevation Angle (Degrees)</th>
<th>Distance (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0.00</td>
</tr>
<tr>
<td>0.0</td>
<td>2.35</td>
</tr>
<tr>
<td>0.0</td>
<td>3.30</td>
</tr>
<tr>
<td>0.0</td>
<td>4.50</td>
</tr>
<tr>
<td>0.2</td>
<td>5.80</td>
</tr>
<tr>
<td>0.5</td>
<td>7.20</td>
</tr>
<tr>
<td>0.7</td>
<td>8.60</td>
</tr>
<tr>
<td>1.0</td>
<td>10.00</td>
</tr>
<tr>
<td>1.2</td>
<td>11.60</td>
</tr>
<tr>
<td>1.5</td>
<td>13.20</td>
</tr>
<tr>
<td>1.7</td>
<td>14.80</td>
</tr>
<tr>
<td>2.0</td>
<td>16.50</td>
</tr>
<tr>
<td>2.3</td>
<td>18.20</td>
</tr>
<tr>
<td>2.6</td>
<td>19.90</td>
</tr>
<tr>
<td>2.9</td>
<td>21.60</td>
</tr>
<tr>
<td>3.2</td>
<td>23.30</td>
</tr>
<tr>
<td>3.5</td>
<td>25.00</td>
</tr>
<tr>
<td>3.9</td>
<td>26.70</td>
</tr>
<tr>
<td>4.3</td>
<td>28.40</td>
</tr>
<tr>
<td>4.6</td>
<td>30.10</td>
</tr>
<tr>
<td>5.0</td>
<td>31.80</td>
</tr>
<tr>
<td>5.4</td>
<td>33.50</td>
</tr>
<tr>
<td>5.9</td>
<td>35.20</td>
</tr>
<tr>
<td>6.4</td>
<td>36.90</td>
</tr>
<tr>
<td>6.9</td>
<td>38.60</td>
</tr>
<tr>
<td>7.4</td>
<td>40.30</td>
</tr>
<tr>
<td>8.0</td>
<td>42.00</td>
</tr>
<tr>
<td>8.6</td>
<td>43.70</td>
</tr>
<tr>
<td>9.3</td>
<td>45.40</td>
</tr>
<tr>
<td>10.0</td>
<td>47.10</td>
</tr>
<tr>
<td>10.8</td>
<td>48.80</td>
</tr>
<tr>
<td>11.7</td>
<td>50.50</td>
</tr>
<tr>
<td>12.6</td>
<td>52.20</td>
</tr>
<tr>
<td>13.7</td>
<td>53.90</td>
</tr>
<tr>
<td>14.9</td>
<td>55.60</td>
</tr>
<tr>
<td>16.3</td>
<td>57.30</td>
</tr>
<tr>
<td>18.0</td>
<td>59.00</td>
</tr>
<tr>
<td>19.8</td>
<td>60.70</td>
</tr>
<tr>
<td>22.0</td>
<td>62.40</td>
</tr>
<tr>
<td>24.7</td>
<td>64.10</td>
</tr>
<tr>
<td>27.2</td>
<td>65.80</td>
</tr>
<tr>
<td>31.3</td>
<td>67.50</td>
</tr>
<tr>
<td>36.6</td>
<td>69.20</td>
</tr>
<tr>
<td>43.1</td>
<td>70.90</td>
</tr>
<tr>
<td>51.5</td>
<td>72.60</td>
</tr>
<tr>
<td>62.2</td>
<td>74.30</td>
</tr>
<tr>
<td>75.3</td>
<td>76.00</td>
</tr>
</tbody>
</table>

Table 1 - Elevation Angle vs Distance
Annex 2

FIGURE 3

Vertical plane radiation of simple vertical antennas as a function of electrical tower height for various values of elevation angle (θ)
### TABLE II - \( f(\theta) \) values for simple vertical antennas

<table>
<thead>
<tr>
<th>Elevation angle (degrees)</th>
<th>( f(\theta) )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( 0.11\lambda )</td>
</tr>
<tr>
<td>0</td>
<td>1.000</td>
</tr>
<tr>
<td>1</td>
<td>0.999</td>
</tr>
<tr>
<td>2</td>
<td>0.997</td>
</tr>
<tr>
<td>3</td>
<td>0.996</td>
</tr>
<tr>
<td>4</td>
<td>0.992</td>
</tr>
<tr>
<td>5</td>
<td>0.989</td>
</tr>
<tr>
<td>6</td>
<td>0.988</td>
</tr>
<tr>
<td>7</td>
<td>0.984</td>
</tr>
<tr>
<td>8</td>
<td>0.980</td>
</tr>
<tr>
<td>9</td>
<td>0.976</td>
</tr>
<tr>
<td>10</td>
<td>0.972</td>
</tr>
<tr>
<td>11</td>
<td>0.968</td>
</tr>
<tr>
<td>12</td>
<td>0.963</td>
</tr>
<tr>
<td>13</td>
<td>0.958</td>
</tr>
<tr>
<td>14</td>
<td>0.953</td>
</tr>
<tr>
<td>15</td>
<td>0.947</td>
</tr>
<tr>
<td>16</td>
<td>0.941</td>
</tr>
<tr>
<td>17</td>
<td>0.935</td>
</tr>
<tr>
<td>18</td>
<td>0.922</td>
</tr>
<tr>
<td>19</td>
<td>0.907</td>
</tr>
<tr>
<td>20</td>
<td>0.892</td>
</tr>
<tr>
<td>21</td>
<td>0.875</td>
</tr>
<tr>
<td>22</td>
<td>0.858</td>
</tr>
<tr>
<td>23</td>
<td>0.828</td>
</tr>
<tr>
<td>24</td>
<td>0.730</td>
</tr>
<tr>
<td>25</td>
<td>0.705</td>
</tr>
<tr>
<td>26</td>
<td>0.680</td>
</tr>
<tr>
<td>27</td>
<td>0.654</td>
</tr>
<tr>
<td>28</td>
<td>0.628</td>
</tr>
<tr>
<td>29</td>
<td>0.600</td>
</tr>
<tr>
<td>30</td>
<td>0.572</td>
</tr>
<tr>
<td>31</td>
<td>0.544</td>
</tr>
<tr>
<td>32</td>
<td>0.515</td>
</tr>
<tr>
<td>33</td>
<td>0.485</td>
</tr>
</tbody>
</table>

Annex 2/p. 11f
**TABLE II (continued) - \( f(\theta) \) values for simple vertical antennas**

<table>
<thead>
<tr>
<th>Elevation angle (degrees)</th>
<th>( f(\theta) )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.23 ( \lambda )</td>
</tr>
<tr>
<td>0</td>
<td>1.000</td>
</tr>
<tr>
<td>1</td>
<td>1.000</td>
</tr>
<tr>
<td>2</td>
<td>0.999</td>
</tr>
<tr>
<td>3</td>
<td>0.998</td>
</tr>
<tr>
<td>4</td>
<td>0.997</td>
</tr>
<tr>
<td>5</td>
<td>0.998</td>
</tr>
<tr>
<td>6</td>
<td>0.999</td>
</tr>
<tr>
<td>7</td>
<td>0.990</td>
</tr>
<tr>
<td>8</td>
<td>0.983</td>
</tr>
<tr>
<td>9</td>
<td>0.975</td>
</tr>
<tr>
<td>10</td>
<td>0.970</td>
</tr>
<tr>
<td>11</td>
<td>0.959</td>
</tr>
<tr>
<td>12</td>
<td>0.953</td>
</tr>
<tr>
<td>13</td>
<td>0.951</td>
</tr>
<tr>
<td>14</td>
<td>0.947</td>
</tr>
<tr>
<td>15</td>
<td>0.941</td>
</tr>
<tr>
<td>16</td>
<td>0.934</td>
</tr>
<tr>
<td>17</td>
<td>0.919</td>
</tr>
<tr>
<td>18</td>
<td>0.902</td>
</tr>
<tr>
<td>19</td>
<td>0.885</td>
</tr>
<tr>
<td>20</td>
<td>0.866</td>
</tr>
<tr>
<td>21</td>
<td>0.846</td>
</tr>
<tr>
<td>22</td>
<td>0.825</td>
</tr>
<tr>
<td>23</td>
<td>0.806</td>
</tr>
<tr>
<td>24</td>
<td>0.792</td>
</tr>
<tr>
<td>25</td>
<td>0.706</td>
</tr>
<tr>
<td>26</td>
<td>0.654</td>
</tr>
<tr>
<td>27</td>
<td>0.628</td>
</tr>
<tr>
<td>28</td>
<td>0.573</td>
</tr>
<tr>
<td>29</td>
<td>0.545</td>
</tr>
<tr>
<td>30</td>
<td>0.517</td>
</tr>
<tr>
<td>31</td>
<td>0.488</td>
</tr>
<tr>
<td>32</td>
<td>0.460</td>
</tr>
<tr>
<td>33</td>
<td>0.431</td>
</tr>
</tbody>
</table>

Annex 2/p. 11g
<table>
<thead>
<tr>
<th>Elevation angle (degrees)</th>
<th>$f(\theta)$ at $0.40\lambda$</th>
<th>$f(\theta)$ at $0.45\lambda$</th>
<th>$f(\theta)$ at $0.50\lambda$</th>
<th>$f(\theta)$ at $0.52\lambda$</th>
<th>$f(\theta)$ at $0.55\lambda$</th>
<th>$f(\theta)$ at $0.625\lambda$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>1</td>
<td>1.000</td>
<td>0.998</td>
<td>0.999</td>
<td>0.999</td>
<td>0.999</td>
<td>0.999</td>
</tr>
<tr>
<td>2</td>
<td>0.998</td>
<td>0.996</td>
<td>0.996</td>
<td>0.994</td>
<td>0.993</td>
<td>0.993</td>
</tr>
<tr>
<td>3</td>
<td>0.994</td>
<td>0.992</td>
<td>0.990</td>
<td>0.989</td>
<td>0.988</td>
<td>0.988</td>
</tr>
<tr>
<td>4</td>
<td>0.981</td>
<td>0.978</td>
<td>0.979</td>
<td>0.976</td>
<td>0.972</td>
<td>0.972</td>
</tr>
<tr>
<td>5</td>
<td>0.932</td>
<td>0.977</td>
<td>0.971</td>
<td>0.967</td>
<td>0.962</td>
<td>0.962</td>
</tr>
<tr>
<td>6</td>
<td>0.976</td>
<td>0.970</td>
<td>0.982</td>
<td>0.957</td>
<td>0.951</td>
<td>0.951</td>
</tr>
<tr>
<td>7</td>
<td>0.970</td>
<td>0.963</td>
<td>0.953</td>
<td>0.945</td>
<td>0.938</td>
<td>0.938</td>
</tr>
<tr>
<td>8</td>
<td>0.963</td>
<td>0.954</td>
<td>0.942</td>
<td>0.933</td>
<td>0.924</td>
<td>0.924</td>
</tr>
<tr>
<td>9</td>
<td>0.955</td>
<td>0.945</td>
<td>0.930</td>
<td>0.919</td>
<td>0.909</td>
<td>0.909</td>
</tr>
<tr>
<td>10</td>
<td>0.947</td>
<td>0.934</td>
<td>0.917</td>
<td>0.905</td>
<td>0.893</td>
<td>0.893</td>
</tr>
<tr>
<td>11</td>
<td>0.930</td>
<td>0.923</td>
<td>0.903</td>
<td>0.889</td>
<td>0.876</td>
<td>0.876</td>
</tr>
<tr>
<td>12</td>
<td>0.922</td>
<td>0.912</td>
<td>0.889</td>
<td>0.872</td>
<td>0.857</td>
<td>0.857</td>
</tr>
<tr>
<td>13</td>
<td>0.918</td>
<td>0.899</td>
<td>0.873</td>
<td>0.855</td>
<td>0.837</td>
<td>0.837</td>
</tr>
<tr>
<td>14</td>
<td>0.908</td>
<td>0.886</td>
<td>0.867</td>
<td>0.836</td>
<td>0.816</td>
<td>0.816</td>
</tr>
<tr>
<td>15</td>
<td>0.897</td>
<td>0.873</td>
<td>0.840</td>
<td>0.817</td>
<td>0.795</td>
<td>0.795</td>
</tr>
<tr>
<td>16</td>
<td>0.885</td>
<td>0.859</td>
<td>0.823</td>
<td>0.797</td>
<td>0.772</td>
<td>0.772</td>
</tr>
<tr>
<td>17</td>
<td>0.873</td>
<td>0.844</td>
<td>0.804</td>
<td>0.776</td>
<td>0.749</td>
<td>0.749</td>
</tr>
<tr>
<td>18</td>
<td>0.860</td>
<td>0.828</td>
<td>0.785</td>
<td>0.755</td>
<td>0.726</td>
<td>0.726</td>
</tr>
<tr>
<td>19</td>
<td>0.833</td>
<td>0.796</td>
<td>0.746</td>
<td>0.710</td>
<td>0.667</td>
<td>0.667</td>
</tr>
<tr>
<td>20</td>
<td>0.805</td>
<td>0.763</td>
<td>0.705</td>
<td>0.666</td>
<td>0.625</td>
<td>0.625</td>
</tr>
<tr>
<td>21</td>
<td>0.776</td>
<td>0.728</td>
<td>0.663</td>
<td>0.618</td>
<td>0.574</td>
<td>0.574</td>
</tr>
<tr>
<td>22</td>
<td>0.745</td>
<td>0.692</td>
<td>0.621</td>
<td>0.570</td>
<td>0.522</td>
<td>0.522</td>
</tr>
<tr>
<td>23</td>
<td>0.714</td>
<td>0.655</td>
<td>0.577</td>
<td>0.522</td>
<td>0.470</td>
<td>0.470</td>
</tr>
<tr>
<td>24</td>
<td>0.682</td>
<td>0.619</td>
<td>0.534</td>
<td>0.475</td>
<td>0.419</td>
<td>0.419</td>
</tr>
<tr>
<td>25</td>
<td>0.649</td>
<td>0.592</td>
<td>0.492</td>
<td>0.428</td>
<td>0.369</td>
<td>0.369</td>
</tr>
<tr>
<td>26</td>
<td>0.617</td>
<td>0.545</td>
<td>0.450</td>
<td>0.383</td>
<td>0.321</td>
<td>0.321</td>
</tr>
<tr>
<td>27</td>
<td>0.584</td>
<td>0.509</td>
<td>0.409</td>
<td>0.340</td>
<td>0.276</td>
<td>0.276</td>
</tr>
<tr>
<td>28</td>
<td>0.552</td>
<td>0.483</td>
<td>0.370</td>
<td>0.298</td>
<td>0.231</td>
<td>0.231</td>
</tr>
<tr>
<td>29</td>
<td>0.519</td>
<td>0.438</td>
<td>0.332</td>
<td>0.258</td>
<td>0.190</td>
<td>0.190</td>
</tr>
<tr>
<td>30</td>
<td>0.488</td>
<td>0.405</td>
<td>0.296</td>
<td>0.221</td>
<td>0.162</td>
<td>0.162</td>
</tr>
<tr>
<td>31</td>
<td>0.457</td>
<td>0.372</td>
<td>0.262</td>
<td>0.187</td>
<td>0.117</td>
<td>0.117</td>
</tr>
<tr>
<td>32</td>
<td>0.427</td>
<td>0.341</td>
<td>0.230</td>
<td>0.135</td>
<td>0.085</td>
<td>0.085</td>
</tr>
<tr>
<td>33</td>
<td>0.397</td>
<td>0.311</td>
<td>0.201</td>
<td>0.099</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
<td>34</td>
<td>0.369</td>
<td>0.283</td>
<td>0.174</td>
<td>0.076</td>
<td>0.009</td>
<td>0.009</td>
</tr>
<tr>
<td>35</td>
<td>0.341</td>
<td>0.257</td>
<td>0.149</td>
<td>0.055</td>
<td>0.010</td>
<td>0.010</td>
</tr>
<tr>
<td>36</td>
<td>0.316</td>
<td>0.232</td>
<td>0.126</td>
<td>0.037</td>
<td>-0.026</td>
<td>-0.026</td>
</tr>
<tr>
<td>37</td>
<td>0.289</td>
<td>0.208</td>
<td>0.106</td>
<td>0.027</td>
<td>-0.039</td>
<td>-0.039</td>
</tr>
<tr>
<td>38</td>
<td>0.265</td>
<td>0.186</td>
<td>0.087</td>
<td>0.008</td>
<td>-0.049</td>
<td>-0.049</td>
</tr>
<tr>
<td>39</td>
<td>0.241</td>
<td>0.162</td>
<td>0.068</td>
<td>-0.003</td>
<td>-0.056</td>
<td>-0.056</td>
</tr>
<tr>
<td>40</td>
<td>0.217</td>
<td>0.138</td>
<td>0.045</td>
<td>-0.011</td>
<td>-0.062</td>
<td>-0.062</td>
</tr>
<tr>
<td>41</td>
<td>0.193</td>
<td>0.112</td>
<td>0.022</td>
<td>-0.017</td>
<td>-0.064</td>
<td>-0.064</td>
</tr>
<tr>
<td>42</td>
<td>0.170</td>
<td>0.086</td>
<td>0.008</td>
<td>-0.022</td>
<td>-0.065</td>
<td>-0.065</td>
</tr>
<tr>
<td>43</td>
<td>0.146</td>
<td>0.061</td>
<td>-0.005</td>
<td>-0.025</td>
<td>-0.064</td>
<td>-0.064</td>
</tr>
<tr>
<td>44</td>
<td>0.123</td>
<td>0.036</td>
<td>-0.002</td>
<td>-0.025</td>
<td>-0.061</td>
<td>-0.061</td>
</tr>
<tr>
<td>45</td>
<td>0.099</td>
<td>0.011</td>
<td>-0.000</td>
<td>-0.026</td>
<td>-0.056</td>
<td>-0.056</td>
</tr>
<tr>
<td>46</td>
<td>0.075</td>
<td>-0.006</td>
<td>-0.000</td>
<td>-0.024</td>
<td>-0.051</td>
<td>-0.051</td>
</tr>
<tr>
<td>47</td>
<td>0.051</td>
<td>-0.012</td>
<td>-0.000</td>
<td>-0.022</td>
<td>-0.044</td>
<td>-0.044</td>
</tr>
</tbody>
</table>

*Note:* When the negative sign (-) appears in the Table, it signifies only the existence of a secondary lobe having the opposite phase from the main lobe in the vertical radiation pattern. In order to perform the calculation, ignore the negative (-) and use only the absolute value of $f(\theta)$ from the Table.
### TABLE III - Skywave field strength vs distance (from 100 to 10,000 km)
for a characteristic field strength of 100 mV/m at 1 km.

<table>
<thead>
<tr>
<th>d(km)</th>
<th>$F_c$ (μV/m)</th>
<th>d(km)</th>
<th>$F_c$ (μV/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50%</td>
<td></td>
<td>50%</td>
</tr>
<tr>
<td>100</td>
<td>179.11</td>
<td>3000</td>
<td>1.43</td>
</tr>
<tr>
<td>150</td>
<td>117.18</td>
<td>3100</td>
<td>1.33</td>
</tr>
<tr>
<td>200</td>
<td>92.06</td>
<td>3200</td>
<td>1.23</td>
</tr>
<tr>
<td>250</td>
<td>77.54</td>
<td>3300</td>
<td>1.15</td>
</tr>
<tr>
<td>300</td>
<td>68.82</td>
<td>3400</td>
<td>1.07</td>
</tr>
<tr>
<td>350</td>
<td>62.06</td>
<td>3500</td>
<td>1.00</td>
</tr>
<tr>
<td>400</td>
<td>57.08</td>
<td>3600</td>
<td>0.94</td>
</tr>
<tr>
<td>450</td>
<td>52.86</td>
<td>3700</td>
<td>0.88</td>
</tr>
<tr>
<td>500</td>
<td>49.65</td>
<td>3800</td>
<td>0.83</td>
</tr>
<tr>
<td>550</td>
<td>46.78</td>
<td>3900</td>
<td>0.79</td>
</tr>
<tr>
<td>600</td>
<td>44.36</td>
<td>4000</td>
<td>0.75</td>
</tr>
<tr>
<td>650</td>
<td>41.95</td>
<td>4100</td>
<td>0.71</td>
</tr>
<tr>
<td>700</td>
<td>39.54</td>
<td>4200</td>
<td>0.67</td>
</tr>
<tr>
<td>750</td>
<td>36.81</td>
<td>4300</td>
<td>0.64</td>
</tr>
<tr>
<td>800</td>
<td>34.40</td>
<td>4400</td>
<td>0.61</td>
</tr>
<tr>
<td>850</td>
<td>32.30</td>
<td>4500</td>
<td>0.58</td>
</tr>
<tr>
<td>900</td>
<td>29.89</td>
<td>4600</td>
<td>0.55</td>
</tr>
<tr>
<td>950</td>
<td>27.63</td>
<td>4700</td>
<td>0.53</td>
</tr>
<tr>
<td>1000</td>
<td>25.54</td>
<td>4800</td>
<td>0.51</td>
</tr>
<tr>
<td>1050</td>
<td><strong>23.56</strong></td>
<td>4900</td>
<td>0.48</td>
</tr>
<tr>
<td>1100</td>
<td>21.84</td>
<td>5000</td>
<td>0.46</td>
</tr>
<tr>
<td>1150</td>
<td>19.91</td>
<td>5100</td>
<td>0.45</td>
</tr>
<tr>
<td>1200</td>
<td>18.30</td>
<td>5200</td>
<td>0.43</td>
</tr>
<tr>
<td>1250</td>
<td>16.70</td>
<td>5300</td>
<td>0.41</td>
</tr>
<tr>
<td>1300</td>
<td>15.32</td>
<td>5400</td>
<td>0.40</td>
</tr>
<tr>
<td>1350</td>
<td>13.97</td>
<td>5500</td>
<td>0.38</td>
</tr>
<tr>
<td>1400</td>
<td><strong>12.71</strong></td>
<td>5600</td>
<td>0.37</td>
</tr>
<tr>
<td>1450</td>
<td>11.55</td>
<td>5700</td>
<td>0.36</td>
</tr>
<tr>
<td>1500</td>
<td><strong>10.33</strong></td>
<td>5800</td>
<td>0.34</td>
</tr>
<tr>
<td>1550</td>
<td>9.53</td>
<td>5900</td>
<td>0.33</td>
</tr>
<tr>
<td>1600</td>
<td>8.57</td>
<td>6000</td>
<td>0.32</td>
</tr>
<tr>
<td>1650</td>
<td>7.72</td>
<td>6200</td>
<td>0.30</td>
</tr>
<tr>
<td>1700</td>
<td>6.98</td>
<td>6400</td>
<td>0.28</td>
</tr>
<tr>
<td>1750</td>
<td>6.34</td>
<td>6600</td>
<td>0.27</td>
</tr>
<tr>
<td>1800</td>
<td>5.30</td>
<td>6800</td>
<td>0.25</td>
</tr>
<tr>
<td>1850</td>
<td>5.32</td>
<td>7000</td>
<td>0.24</td>
</tr>
<tr>
<td>1900</td>
<td>4.49</td>
<td>7200</td>
<td>0.23</td>
</tr>
<tr>
<td>1950</td>
<td>4.49</td>
<td>7400</td>
<td>0.22</td>
</tr>
<tr>
<td>2000</td>
<td><strong>4.14</strong></td>
<td>7600</td>
<td>0.21</td>
</tr>
<tr>
<td>2100</td>
<td>3.61</td>
<td>7800</td>
<td>0.20</td>
</tr>
<tr>
<td>2200</td>
<td><strong>3.18</strong></td>
<td>8000</td>
<td>0.19</td>
</tr>
<tr>
<td>2300</td>
<td>2.79</td>
<td>8200</td>
<td>0.18</td>
</tr>
<tr>
<td>2400</td>
<td><strong>2.55</strong></td>
<td>8400</td>
<td><strong>0.17</strong></td>
</tr>
<tr>
<td>2500</td>
<td>2.26</td>
<td>8600</td>
<td>0.17</td>
</tr>
<tr>
<td>2600</td>
<td>2.03</td>
<td>8800</td>
<td>0.16</td>
</tr>
<tr>
<td>2700</td>
<td>1.85</td>
<td>9000</td>
<td>0.15</td>
</tr>
<tr>
<td>2800</td>
<td>1.69</td>
<td>9200</td>
<td>0.15</td>
</tr>
<tr>
<td>2900</td>
<td>1.55</td>
<td>9400</td>
<td>0.14</td>
</tr>
<tr>
<td>3000</td>
<td></td>
<td>9600</td>
<td>0.14</td>
</tr>
<tr>
<td>3100</td>
<td></td>
<td>9800</td>
<td><strong>0.13</strong></td>
</tr>
<tr>
<td>3200</td>
<td></td>
<td>10000</td>
<td><strong>0.13</strong></td>
</tr>
<tr>
<td>3300</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3400</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3600</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3700</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3900</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4300</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4400</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4600</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4700</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4900</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5300</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5400</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5600</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5700</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5900</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6300</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6400</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6600</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6700</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6900</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7300</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7400</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7600</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7700</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7900</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8300</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8400</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8600</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8700</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8900</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9300</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9400</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9600</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9700</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9900</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Note: Factors given in terms of hours with respect to sunset at mid-point of transmission path.
<table>
<thead>
<tr>
<th>Temp</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>1.3084</td>
<td>.0083</td>
<td>.0155</td>
<td>.0144</td>
</tr>
<tr>
<td>-1.75</td>
<td>1.3165</td>
<td>-.4919</td>
<td>.6011</td>
<td>-.1884</td>
</tr>
<tr>
<td>-1.5</td>
<td>1.0079</td>
<td>.0296</td>
<td>.1488</td>
<td>-.0452</td>
</tr>
<tr>
<td>-1.25</td>
<td>.7773</td>
<td>.3751</td>
<td>-.1911</td>
<td>.0736</td>
</tr>
<tr>
<td>-1</td>
<td>.6230</td>
<td>.1547</td>
<td>.2634</td>
<td>-.1006</td>
</tr>
<tr>
<td>-.75</td>
<td>.3718</td>
<td>.1178</td>
<td>.3632</td>
<td>-.1172</td>
</tr>
<tr>
<td>-.5</td>
<td>.20571</td>
<td>-.0737</td>
<td>.4167</td>
<td>-.2577</td>
</tr>
<tr>
<td>+.25</td>
<td>.1504</td>
<td>-.2325</td>
<td>.5374</td>
<td>-.1729</td>
</tr>
<tr>
<td>+.5</td>
<td>.1057</td>
<td>-.2092</td>
<td>.4148</td>
<td>-.1239</td>
</tr>
<tr>
<td>+.75</td>
<td>.0642</td>
<td>-.1295</td>
<td>.2583</td>
<td>-.0699</td>
</tr>
<tr>
<td>+1</td>
<td>.0446</td>
<td>-.1002</td>
<td>.1754</td>
<td>-.0405</td>
</tr>
<tr>
<td>Temp</td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>d</td>
</tr>
<tr>
<td>------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>1.75</td>
<td>0.9495</td>
<td>0.0187</td>
<td>0.0720</td>
<td>-0.0290</td>
</tr>
<tr>
<td>1.5</td>
<td>0.7196</td>
<td>-0.3583</td>
<td>0.2280</td>
<td>0.0611</td>
</tr>
<tr>
<td>1.25</td>
<td>0.6756</td>
<td>0.1518</td>
<td>0.0279</td>
<td>-0.0163</td>
</tr>
<tr>
<td>1.0</td>
<td>0.5486</td>
<td>0.1401</td>
<td>0.0952</td>
<td>-0.0288</td>
</tr>
<tr>
<td>0.75</td>
<td>0.3003</td>
<td>0.4050</td>
<td>-0.0961</td>
<td>0.0256</td>
</tr>
<tr>
<td>0.5</td>
<td>0.1186</td>
<td>0.4281</td>
<td>-0.0799</td>
<td>0.0197</td>
</tr>
<tr>
<td>0.25</td>
<td>0.0382</td>
<td>0.3706</td>
<td>-0.0673</td>
<td>0.0171</td>
</tr>
<tr>
<td>s.s</td>
<td>0.0024</td>
<td>0.0278</td>
<td>0.0458</td>
<td>0.0173</td>
</tr>
<tr>
<td>-0.25</td>
<td>0.0203</td>
<td>0.0132</td>
<td>0.1166</td>
<td>-0.0340</td>
</tr>
<tr>
<td>-0.15</td>
<td>0.0152</td>
<td>0.0022</td>
<td>0.0786</td>
<td>-0.0185</td>
</tr>
<tr>
<td>-1.0</td>
<td>-0.0043</td>
<td>0.0452</td>
<td>-0.0040</td>
<td>0.0103</td>
</tr>
<tr>
<td>-1.25</td>
<td>0.0010</td>
<td>0.0135</td>
<td>0.0103</td>
<td>0.0047</td>
</tr>
<tr>
<td>-1.5</td>
<td>0.0018</td>
<td>0.0052</td>
<td>0.0069</td>
<td>0.0042</td>
</tr>
<tr>
<td>-1.75</td>
<td>-0.0012</td>
<td>0.0122</td>
<td>-0.0076</td>
<td>0.0076</td>
</tr>
<tr>
<td>-2.0</td>
<td>-0.0024</td>
<td>0.0141</td>
<td>-0.0141</td>
<td>0.0091</td>
</tr>
</tbody>
</table>
Local time at reflection point (hours)

FIGURE 6 - Times of sunrise and sunset for various months and geographical latitudes

Annex 2/p. 110
CHAPTER 4

Broadcasting Standards

4.1 Separation of Channels

This Agreement is based on a channel spacing of 10 kHz and carrier frequencies which are integral multiples of 10 kHz, beginning at 540 kHz.

4.2 Class of emission

This Agreement is based upon double-sideband amplitude modulation with full carrier A3E.

Classes of emission other than A3E, for instance to accommodate stereophonic systems, could also be used on condition that the energy level outside the necessary bandwidth does not exceed that normally expected in A3E emission and that the emission is receivable by conventional receivers employing envelope detectors without increasing appreciably the level of distortion.

4.3 Bandwidth of emission

This Agreement assumes a necessary bandwidth of 10 kHz, for which only a 5 kHz audio bandwidth can be obtained.

Note: It is noted that some stations have successfully employed wider bandwidth systems having occupied bandwidths of the order of 20 kHz without adverse effects.

4.3.1 Frequency tolerance: ±20 Hz. However, both Administrations recognize that it is desirable to implement the tolerance of ±10 Hz in accordance with the ITU Radio Regulations (1982).

4.4 Station power

4.4.1 Class A

- The power of any Class A station exceeding 100 kW day/50 kW night shall not be increased.

- The power of any Class A station not exceeding 100 kW day/50 kW night may be increased but shall not exceed those values.

- Any new Class A station shall have a power not exceeding 500 kW day/ 50 kW night.

4.4.2 Class 3

- The maximum station power shall be 50 kW.

4.4.3 Class c

- The maximum station power shall be 1 kW.
4.5 **Skywave interference calculations**

The values of interfering *skywave signals* shall be calculated on the basis of 10% of the time, in the manner prescribed in section 3.6.

4.6 Nominal usable *field strength*

4.6.1 **Class A station (1)**

**Groundwave**

Daytime: co-channel 100 $\mu$V/m and adjacent channel 500 $\mu$V/m

Nighttime: 500 $\mu$V/m

**Skywave**

Nighttime: 500 $\mu$V/m, 50% of the time

4.6.2 **Class B station (2)**

**Groundwave**

Daytime: 500 $\mu$V/m

Nighttime: 2500 $\mu$V/m

4.6.3 **Class C station (2)**

**Groundwave**

Daytime: 500 $\mu$V/m

Nighttime: 4000 $\mu$V/m

**Note (1)**: The nighttime contours, groundwave or *skywave* which ever is further are to be protected in the case of class A stations.

**Note (2)**: The protected contour during nighttime operation for class B and C stations shall be the higher of the groundwave contour in 4.6.2 and 4.6.3 respectively, or the groundwave *contour* corresponding to the usable field strength of the station as set forth in 4.7.
4.7 Use of the root sum square (RSS) method to determine the usable field strength resulting from the weighted interfering signals

4.7.1 General

The overall usable field strength $E_u$ due to two or more individual interference contributions is calculated on an RSS basis, using the expression:

$$E_u = \sqrt{(a_1E_1)^2 + (a_2E_2)^2 + \ldots + (a_iE_i)^2}$$

where:

- $E_i$ is the field strength of the $i$th interfering transmitter (in $\mu V/m$)
- $a_i$ is the radio-frequency protection ratio associated with the $i$th interfering transmitter, expressed as a numerical ratio of field strengths.

4.7.2.1 50% exclusion principle

The 50% exclusion principle allows a significant reduction in the number of calculations.

4.7.2.2 According to this principle, the values of the individual usable field strength contributions are arranged in descending order of magnitude. If the second value is less than 50% of the first value, the second value and all subsequent values are neglected. Otherwise an RSS value is calculated for the first and second values. The calculated RSS value is then compared with the third value in the same manner by which the first value was compared to the second and a new RSS value is calculated if required. The process is continued until the next value to be compared is less than 50% of the last calculated RSS value. At that point the last calculated RSS value is considered to be the usable field strength $E_u$.

4.7.2.3 Except as provided in section 4.7.2.4, if the contribution of a new station is greater than the smallest value previously considered in calculating the RSS value of assignments in the Plan, the contribution of the new station adversely affects assignments in conformity with this Agreement even if it is less than 50% of the RSS value. However, the new contribution does not adversely affect assignments in conformity with this Agreement if the RSS value determined by inserting the contribution of the new station in the list of contributors is smaller than the nominal usable field strength $E_{nom}$.

4.7.2.4 The contribution of a station engaging in extended hours of operation under Article VI of this Agreement shall not be taken into account in the calculation of the $E_u$.

---

1/ in due time, in accordante with Paragraph 5.2 of Article V of the present Agreement, consideration should be given to the contributions of stations of other countries in Region 2.
4.8 Channel protection ratios (desired to undesired)

4.8.1 Co-channel protection ratio

The co-channel protection ratio is 20:1

4.8.2 Adjacent channel protection ratio

The protection ratio for the first adjacent channel is 1:1
The protection ratio for the second adjacent channel is 1:30

4.8.3 Synchronized networks

In addition to the standards specified in this Agreement, the following additional standards apply to synchronized networks.

For the purpose of determining interference caused by synchronized networks, the following procedure shall be applied. If any two transmitters are less than 400 km apart, the network shall be treated as a single entity, the value of the composite signal being determined by the quadratic addition of the interfering signals from all the individual transmitters in the network. If the distances between all the transmitters are equal to or greater than 400 km, the network shall be treated as a set of individual transmitters.

For the purpose of determining skywave interference received by any one member of a network, the value of the interference caused by the other elements of the network shall be determined by the quadratic addition of the interfering signals from all of those elements. In any case, where groundwave interference is a factor it shall be taken into account.

The co-channel protection ratio between stations belonging to a synchronized network is 2.5:1

4.9 Application of protection criteria

4.9.1 Value of protected contours

Within the national boundary of a country, the protected contour shall be determined by using the appropriate value of nominal usable field strength, or as otherwise determined in Note 2 to paragraph 4.6 for class B and C stations.

4.9.2 Co-channel protection

4.9.2.1 Daytime protection of all classes of stations

During the daytime the groundwave contour of class A, B and C stations shall be protected against groundwave interference. The protected

2/See the matrix in Section 5 of Appendix 5 to Annex 2.
**4.9.2.2 Nighttime protection of Class A stations**

The groundwave contour or the **skywave contour** 50% of the time, whichever is farther from the **site** of the protected Class A station, shall be protected against **skywave** and possible **groundwave** interference during the nighttime.

The value of the protected contour corresponds to the nominal usable field strength. The **maximum permissible** interfering field strength at the protected contour is the value of the nominal usable field strength divided by the protection ratio. However, for Class A stations notified after the date of signing of this Agreement, the value of the protected contour corresponds to the nominal usable field strength or the usable field strength, whichever is greater.

The effect of each interfering signal shall be evaluated separately. Where the protected contour would extend beyond the boundary of the country in which the station is located, the **maximum permissible** interfering field strength at the boundary is the calculated field strength of the protected station along the boundary divided by the protection ratio. Two special cases of applying this principle are as follows:

(a) Where the primary service area extends beyond the boundary, the protected contour is calculated using the groundwave field strength, and the **skywave** contour is protected outside the primary service area.

(b) In cases where the protected **skywave** contour would extend beyond the boundary, the groundwave contour shall also be protected.

**4.9.2.3 Nighttime protection of class B and C stations**

During the nighttime, the groundwave contour or class 3 and C stations will be protected against **skywave** and possible groundwave interference. The protected contour is the groundwave **contour corresponding** to the value of the **greater** of the nominal usable field strength or the usable field strength **resulting from** the Plan of Annex 1 to this Agreement as determined at the site of the protected station **in accordance with** 4.7. The **maximum permissible** interfering field strength calculated at the site of the protected station in accordance **with** 4.7 shall not be exceeded at the protected contour where the protected contour is located within the boundary of the country in which the station is located. Where the protected contour would extend beyond the boundary of the country in which the station is located, the protected contour shall follow that part of the boundary and have
a value as calculated at the border. Where the maximum permissible interfering field strength is already exceeded at the protected contour by an existing station, any proposal for a change to that existing station shall not cause an increase in the interfering field strength at that portion of the protected contour.

4.9.2.4 Modification of assignments

If a station of one Administration causes interference to a station of the other Administration and such interference is permitted in accordance with the terms of this Agreement, then in the event of a modification being proposed to the assignment corresponding to the former station, it will not be necessary to protect the assignment corresponding to the latter station beyond the level provided before the proposed modification.

4.9.3 Adjacent channel protection 3/

During the daytime and nighttime, the groundwave contour of class A, B and C stations shall be protected against groundwave interference. The protected contour is the groundwave contour corresponding to the value of the nominal usable field strength determined as follows:

- for daytime protection of class A stations, the value specified in 4.6.1 for adjacent channel daytime groundwave;

- for nighttime protection of class A stations, the value specified in 4.6.1 for nighttime groundwave;

- for daytime and nighttime protection of class B stations, the value specified in 4.6.2 for daytime groundwave;

- for daytime and nighttime protection of class C stations, the value specified in 4.6.3 for daytime groundwave;

The maximum permissible interfering field strength at the protected contour is the value of the nominal usable field strength divided by the protection ratio. The effect of each interfering signal shall be evaluated separately.

Where the protected contour would extend beyond the boundary of the country in which the station is located, the maximum permissible interfering field strength at the boundary is the calculated field strength of the protected assignment along the boundary divided by the protection ratio.

If a station of one Administration causes interference to a station of the other Administration and such interference is permitted in accordance with the terms of this Agreement, then in the event of a modification being proposed to the assignment corresponding to the former station, it will not be necessary to protect the assignment corresponding to the latter station beyond the level provided before the proposed modification.

3/ See the matrix in section 5 of Appendix 5 to Annex 2.
4.9.4 Protection outside national boundaries

4.9.4.1 No station has the right to be protected beyond the boundary of the country in which the station is established.

4.9.4.2 No broadcasting station shall be assigned a nominal frequency with a separation of 10 or 20 kHz from that of a station in the other country if the 25,000 µV/m contours overlap.

4.9.4.3 In addition to the conditions described in 4.9.4.2, when the protected contour would extend beyond the boundary of the country in which the station is located, its assignment shall be protected in accordance with 4.9.2 and 4.9.3.

4.9.4.4 For protection purposes, the boundary of a country shall be deemed to encompass only its land area, including islands.
5. In carrying out the calculations indicated in Chapters 2 and 3, the following shall be taken into account:

5.1 Omnidirectional antennas

Figure 1 of Chapter 3 shows the characteristic field strength of a simple vertical antenna as a function of its length and of the radius of the ground system.

It is clear that the characteristic field strength increases as the loss in the ground system is reduced to zero and as the antenna height is increased up to 0.625 wavelengths.

The increased characteristic field strength for antenna lengths up to 0.625 wavelengths is obtained at the expense of reducing radiation at high angles as shown graphically in Figure 1a and numerically in Table II of Chapter 3.

5.2 Considerations of the radiation patterns of directional antennas

The procedures for calculating theoretical, expanded and augmented (modified expanded) directional antenna patterns are given in Appendix 3.

5.3 Top-loaded and sectionalized antennas

5.3.1 Calculation procedures are given in Appendices 4 & 6.

5.3.2 Many stations employ top-loaded or sectionalized towers, either because of space limitations or to vary the radiation characteristics from those of a simple vertical antenna. This is done to achieve desired coverage or to reduce interference.

5.3.3 The Administration using top-loaded or sectionalized antennas shall supply information concerning the tower structure of the antennas. Normally, one of the equations in Appendices 4 & 6 shall be employed to determine the vertical radiation characteristics of the antennas. Other equations may also be proposed by an Administration and shall be used in determining the vertical radiation characteristics of the antennas of that Administration, subject to the agreement of the other Administration.
APPENDIX 1

(to annex 2)

MAPS OF GROUND CONDUCTIVITY FOR MEXICO
AND THE UNITED STATES OF AMERICA.
FIELD-STRENGTH CURVES FOR GROUNDWAVE PROPAGATION
GROUND WAVE FIELD STRENGTH VERSUS DISTANCE

630-650 kHz
COMPUTED FOR 640 kHz

1000
700
600
500
400
300
200
100
50
10

1000
700
600
500
400
300
200
100
50
10

MILLIVOLTS/METER

KILOMETERS FROM ANTENNA

INVERSE DISTANCE 400 mV/m AT 1 KM

GRAPH 4
GROUND WAVE FIELD STRENGTH VERSUS DISTANCE

690-710 kHz

600 mV/m AT 1 km

KILOMETERS FROM ANTENNA

GRAPH 6
KILOMETERS FROM ANTENNA

INVERSE DISTANCE 100 mV/m AT 1 km

GROUND WAVE FIELD STRENGTH VERSUS DISTANCE
820-860 kHz
COMPUTED FOR 840 kHz
F = 15 AND SANDWELL CONDUCTIVITIES EXPRESSED IN ohm/m

GRAPH 9
GROUND WAVE FIELD STRENGTH VERSUS DISTANCE

920-960 kHz
COMPUTED FOR 940 kHz
E = 15 AND SENSITIVE CONDUCTIVITY EXPRESSED IN mS/m

INVERSE DISTANCE 100 mV/m AT 1 km

MILLIVOLTS/METER

KILOMETERS FROM ANTENNA

GRAPH 11
GROUND WAVE FIELD STRENGTH VERSUS DISTANCE

1180-1240 kHz
COMPUTED FOR 1210 kHz
K = 15 AND GROUND CONDUCTIVITY EXPRESSED IN MS/MT

INVERSE DISTANCE 100 mV/m AT 1 km

MILLIVOLTS/METER

KILOMETERS FROM ANTENNA

GRAPH 15
KILOMETERS FROM АнТЕННА

GROUND WAVE FIELD STRENGTH VERSUS DISTANCE

1250-1330 kHz
COMPUTED FOR 1290 kHz
X = 15 AND GROUND CONDUCTIVITIES EXPRESSED IN m/s.

INVERSE DISTANCE 100 mV/m AT 1 km

MULTIPLIER METER

KILOMETERS FROM ANTENNA

GRAPH 16
GROUND WAVE FIELD STRENGTH VERSUS DISTANCE

1340-1420 kHz

COMPUTED FOR 1360 kHz

f = 10 AM GROUND CONDUCTIVITIES EXPRESSED IN OHM METERS

INVERSE DISTANCE 100 mV/m AT 1 km

MILLIVOLTS/METER

KILOMETERS FROM ANTENNA

GRAPH 17
GROUND WAVE FIELD STRENGTH VERSUS DISTANCE

1520-1610 kHz
COMPUTED FOR 1565 kHz
(\lambda = 12 AND GROUND CONDUCTIVITIES EXPRESSED IN mhos/m)

INVERSE DISTANCE 100 mV/m AT 1 km

GRAPH 19
APPENDIX 3
(to Annex 2)

Calculation of directional antenna patterns

INTRODUCTION

This Appendix describes methods to be employed in calculating the field strength produced by a directional antenna at a given point.

1. General equations

The theoretical directional antenna radiation pattern is calculated by means of the following equation, which sums the field strength from each element (towers) in the array:

\[ E_T(\phi, \theta) = \sum_{i=1}^{n} \left( K_L \cdot F_i \cdot f_i(\theta) \right) \left( \frac{\psi_i + S_i \cos \theta \cos (\phi_i - \phi)}{1 - \cos \phi_i} \right) \]  

where:

\[ f_i(\theta) = \frac{\cos (G_i \sin \theta) - \cos G_i}{(1 - \cos G_i) \cos \theta} \]  

- \( E_T(\phi, \theta) \): theoretical inverse distance field strength at one kilometre in \( \text{mV/m} \) for the given azimuth and elevation;
- \( K_L \): multiplying constant in \( \text{mV/m} \) which determines the pattern size (see paragraph 2.5 below for derivation of \( K_L \));
- \( n \): number of elements in the directional array;
- \( i \): denotes the \( i \)th element in the array;
- \( F_i \): ratio of the theoretical field strength due to the \( i \)th element in the array relative to the theoretical field strength due to the reference element;
- \( \psi_i \): vertical elevation angle, in degrees, measured from the horizontal plane;
- \( f_i(\theta) \): ratio of vertical to horizontal plane field strength radiated by the \( i \)th element at elevation angle \( \theta \);
- \( G_i \): electrical height of the \( i \)th element in degrees;
- \( S_i \): electrical spacing of the \( i \)th element from the reference element in degrees;
- \( \phi_i \): orientation of the \( i \)th element from the reference element (with respect to True North), in degrees;
- \( \phi \): azimuth (with respect to True North) in degrees;
- \( \psi_i \): electrical phase angle of field strength due to the \( i \)th element (with respect to the reference element), in degrees.
Equations (1) and (2) assume that:
- the current distribution in the elements is sinusoidal,
- there are no losses in the elements or in the ground,
- the antenna elements are base-fed, and
- the distance to the computation point is large in relation to the size of the array.

2. Determination of values and constants

2.1 Determination of the multiplying constant $K$ for an array

The multiplying constant $K$ for the loss-free case may be computed by integrating the power flow over the hemisphere, deriving an r.m.s. field strength and comparing the result with the case where the power is radiated uniformly in all directions over the hemisphere.

Thus:

$$K = \frac{E_s \cdot \sqrt{P}}{e_h} \text{ mV/m}$$

where:

- $K$: no-loss multiplying constant (mV/m at 1 km);
- $E_s$: reference level for uniform radiation over a hemisphere, equal to 244.95 mV/m at 1 km for 1 kW;
- $P$: antenna input power (kW);
- $e_h$: root mean square radiation pattern over the hemisphere which may be obtained by integrating $e(\theta)$ at each elevation angle over the hemisphere. The integration can be made using the trapezoidal method of approximation, as follows:

$$e_h = \left[ \frac{\pi \Delta}{180} \left\{ \frac{1}{\int e(\theta) \, d\theta} \left[ e(0) \right]^2 \left[ \sum_{m=1}^{N} e(m\Delta)^2 \cos m\Delta \right] \right\} \right]^{\frac{1}{2}} \quad (3)$$

where:

- $\Delta$: interval, in degrees, between equally-spaced sampling points at different elevation angles $\theta$;
- $m$: an integer from 1 to $N$, which gives the elevation angle $\theta$ in degrees when multiplied by $\Delta$, i.e. $\theta = m\Delta$;
- $N$: one less than the number of intervals ($N = \frac{90}{\Delta} - 1$);
- $e(\theta)$: root mean square radiation pattern given by equation (1) with $K$ equal to 1 at the specified elevation angles.

Appendix 3/p.2
\[ a(\theta) = \left[ \sum_{i=1}^{n} \sum_{j=1}^{n} F_i(\theta) F_j(\theta) \cos \psi_{ij}(S_y \cos \theta) \right]^{\frac{1}{2}} \]  

where:

- \( i \): denotes the \( i \)th element;
- \( j \): denotes the \( j \)th element;
- \( n \): number of elements in the array;
- \( \psi_{ij} \): difference in phase angles of the field strengths from the \( i \)th and \( j \)th elements in the array;
- \( S_y \): angular spacing between the \( i \)th and \( j \)th elements in the array;
- \( J_0(S_y \cos \theta) \): the Bessel function of the first kind and zero order of the apparent spacing between the \( i \)th and \( j \)th elements. In equation (4), \( S_y \) is in radians. However, when special tables of Bessel functions giving the argument in degrees are used, the values of \( S_y \) should then be in degrees.

2.2 Relationship between field strength and antenna current

The field strength resulting from a current flowing in a vertical antenna element is:

\[ E = \frac{R_c I [\cos (G \sin \theta) - \cos G]}{2\pi \cos \theta} \times 10^3 \ \text{mV/m} \]  

where:

- \( E \): field strength in mV/m;
- \( R_c \): resistivity of free space \((R_c = 120\pi \ \text{ohms})\);
- \( I \): current at the current maximum, in amperes;\(^1\)
- \( G \): electrical height of the element, in degrees;
- \( r \): distinct from the antenna, in metres;
- \( \theta \): vertical elevation angle, in degrees.

At one kilometre and in the horizontal plane \((\theta = 0')\):

\[ E = \frac{120\pi I (1 - \cos G) \times 10^3}{2\pi (1000)} \ \text{mV/m} \]  

hence:

\[ E = 60 I (1 - \cos G) \ \text{mV/m} \]

\(^1\) \( I \) is the current at the maximum of the sinusoidal distribution. If the electrical height of the element is less than 90°, the base current will be less than \( I \).
2.3 **Determination of no-loss current at Current maximum**

For a tower of **uniform cross-section** or for a **similar** type of directional array element, the no-loss current at the current maximum is:

\[ I_1 = \frac{K_F}{60} (1 - \cos G_1) \]

Where:

- \( I_1 \): current at current maximum in amperes in the 1st element;
- \( K \): no-loss **multiplying constant** computed as shown in paragraph 2.1 above;

The base current is given by \( I_1 \sin G_1 \).

2.4 **Array power losses**

**Power** losses in a directional antenna system are of various types, including ground losses, antenna coupling losses, etc. The **loss** resistance for the array may be **assumed** to be inserted at the current maximum to allow for **all losses**. The power loss is:

\[ P_L = \frac{1}{1000} \sum_{i=1}^{n} R_i I_i^2 \]

Where:

- \( P_L \): total power loss in kilowatts;
- \( R_i \): assumed loss resistance in ohms (one ohm, unless otherwise indicated) for the \( i \)th tower*;
- \( I_i \): current at current maximum (or base current if the element is less than 90 degrees in electrical height) for the \( i \)th tower.

* The loss resistance shall in no way exceed a value such that the value of \( K_L \) (see paragraph 2.5) differs by more than ten percent from that calculated for a resistance of one ohm.
2.5 To allow for power loss in the antenna system, the multiplying constant \( K \) can be modified, as follows:

\[
K_L = K \left( \frac{P}{P + P_L} \right)^{1/2}
\]  

(10)

where:

\( K_L \) : multiplying constant after correction for the assumed loss

\( K \) : no-loss multiplying constant computed in paragraph 2.1 above;

\( P \) : array input power (kW)

\( P_L \) : total power loss (kW)

2.6 \( \text{r.m.s. value of radiation to be notified for directional antennas} \)

The radiation \( E_r \) for directional antennas is determined as follows:

\[
E_r = K_L e(\theta) \quad \text{mV/m at 1 kilometre}
\]

2.7 \( \text{Determination of expanded pattern values} \)

The expanded pattern is determined as follows:

\[
E_{\text{EXP}}(\phi, \theta) = 1.05 \left\{ \left[ E_T(\phi, \theta) \right]^2 + Q^2 \right\}^{1/2}
\]

(11)

where:

\( E_{\text{EXP}}(\phi, \theta) \) = expanded pattern radiation at a particular azimuth, \( \phi \) and a particular elevation angle, \( \theta \);

\( E_T(\phi, \theta) \) = theoretical pattern radiation at a particular azimuth, \( \phi \), and a particular elevation angle, \( \theta \);

\( Q \) = quadrature factor, computed as:

\[
Q = Q_o \cdot g(\theta)
\]

where

\( Q_o \) is the \( Q \) on the horizontal plane, and is normally the greatest of

\[
10.0 \quad \text{or} \quad 0.25K_L \left\{ \sum_{\lambda=1}^{n} F_{\lambda}^2 \right\}^{1/2}
\]

If the electrical height of the shortest tower is less than or equal to 180 degrees, then: 
\[ g(\theta) = f(\theta) \] for the shortest tower.

If the electrical height of the shortest tower is greater than 180 degrees, then:

\[ g(\theta) = \sqrt{\frac{f(\theta)}{1 + 0.0625}} \]

where \( f(\theta) \) for the shortest tower is used.

Note: In comparing the electrical height of the antenna towers to determine the shortest tower, the total apparent height (as determined by current distribution) is used for top-loaded and sectionalized towers.

2.0 Determination of augmented (modified expanded) pattern values

The purpose of the augmented (modified expanded) pattern is to put one or more "patches" on an expanded pattern. Each "patch" is referred to as an "augmentation". The augmentation may be positive (resulting in more radiation than that of the expanded pattern) or negative (resulting in less radiation than that of the expanded pattern). In no case shall the augmentation be negative that the augmented (modified expanded) pattern radiation is below the theoretical radiation pattern.

Spans of augmentation may overlap. That is, an augmentation may itself be augmented by a subsequent augmentation. To ensure that the calculations are properly made, the augmentations are handled in increasing order of central azimuth of augmentation, starting at True North. If several augmentations have the same central azimuth, then they are considered in order of decreasing span (i.e. the one with the largest span is handled first). If more than one augmentation has the same central azimuth and the same span, then they are considered in ascending order of their effect.
\[
E_{\text{mod}}(\phi, \theta) = \left\{ \left[ E_{\text{exp}}(\phi, \theta) \right]^2 + g^2(\theta) \sum_{i=1}^{a} A_i \cos^2 \left( 180 \Delta_i / \alpha_i \right) \right\}^{1/2}
\]

where:

- \( E_{\text{mod}}(\phi, \theta) \): augmented (modified expanded) pattern radiation at a particular azimuth, \( \phi \), and a particular elevation angle, \( \theta \);
- \( E_{\text{exp}}(\phi, \theta) \): expanded pattern radiation at a particular azimuth, \( \phi \), and a particular elevation angle, \( \theta \);
- \( g(\theta) \): same parameter as described for the expanded pattern (see paragraph 2.7);
- \( a \): number of augmentations;
- \( A_i \): difference between the azimuth at which the radiation is desired, \( \phi \), and the central azimuth of augmentation of the \( i \)th augmentation. It will be noted that \( A_i \) must be less than or equal to one-half of \( \alpha_i \);
- \( a_i \): total span of the \( i \)th augmentation;
- \( A_i \): is the value of the augmentation given by the expression:

\[
A_i = \left[ E_{\text{mod}}(\phi, \theta) \right]^2 - \left[ E_{\text{exp}}(\phi, \theta) \right]^2
\]

where:

- \( \phi \): central azimuth of the \( i \)th augmentation;
- \( E_{\text{mod}}(\phi, \theta) \): augmented (modified expanded) horizontal plane radiation at the central azimuth of the \( i \)th augmentation, after applying the \( i \)th augmentation, but before applying subsequent augmentations;
- \( E_{\text{exp}}(\phi, \theta) \): an interim value of radiation in the horizontal plane at the central azimuth of the \( i \)th augmentation. The interim value is the radiation obtained from applying previous augmentations (if any) to the expanded pattern, but before applying the \( i \)th augmentation.
Equations for the calculation of the normalized vertical radiation from top-loaded and typical sectionalized antennas

Basically, the equation is:

\[ f(\theta) = \frac{E_\theta}{E_0} \]

where:

- \( E_\theta \): radiation at a desired elevation angle \( \theta \);
- \( E_0 \): radiation in the horizontal plane.

Specific equations for top-loaded and typical sectionalized antennas are given below.

These equations use one or more of four variables \( A, B, C, \) and \( D \), the values of which are given in columns 6, 7, 8, and 9 respectively, of Part II-C of Annex I.

1. **Top-loaded antenna** (when column 12 of Part II-A of Annex I is 1)

\[ f(\theta) = \frac{\cos B \cos (A \sin \theta) - \sin \theta \sin B \sin (A \sin \theta) - \cos (A + B)}{\cos \theta \left[ \cos B - \cos (A + B) \right]} \]

where:

- \( A \): electrical height of the antenna tower:
- \( B \): difference between the apparent electrical height (based on current distribution) and the actual height \( A \):
- \( \theta \): the elevation angle with respect to the horizontal plane.

*Note*: When \( B \) is zero (i.e., when there is no top-loading), the equation reduces to that of a simple vertical antenna.

2. **Sectionalized tower** (when column 12 of Part II, Section 1)

\[ f(\theta) = \frac{\left[ \cos B \cos (A \sin \theta) - \cos (A + B) \right] \sin (C + D - A) + \sin B \left[ \cos D \cos (C \sin \theta) - \sin \theta \right] - \sin \theta \sin D \sin (C \sin \theta) - \cos (C + D - A) \cos (A \sin \theta) \sin (C + D - A)}{\cos \theta \left[ \cos B - \cos (A + B) \right] \sin (C + D - A) + \sin B \left[ \cos D - \cos (C + D - A) \right]} \]

where:

- \( A \): actual height of the lower section:
- \( B \): difference between the apparent electrical height (based on current distribution) of the lower section and the actual height of the lower section \( A \):
- \( C \): actual total height of the antenna:
- \( D \): difference between the apparent electrical height (based on current distribution) of the total tower and the actual height of the total tower \( C \):
- \( \theta \): vertical angle with respect to the horizontal plane.

3. **The Administration** proposing to use other types of antenna should furnish details or their characteristics together with a radiation pattern.
APPENDIX 5
(to Annex 2)

Additional technical information

This Appendix contains additional technical material and examples of methods of calculation which may be of assistance to Administrations.

1. Examples of field strength calculations for non-uniform paths (see paragraph 2.3.1 of Annex 2)

a) Determination of the electrical field strength at a given distance from a station

Consider a station with a power of 5 kW at 1240 kHz. The antenna has a characteristic field strength for 1 kW of 306 mV/m.

The field strength at a distance of 40 km is to be determined for a conductivity of 4 mS/m throughout the path.

From graph 15 (1180 - 1240 kHz) we obtain a field strength of 188 mV/m from the curve corresponding to 4 mS/m.

Therefore

\[ E = E_0 \frac{E_c \sqrt{P}}{100} = \frac{(188)(306) \sqrt{5}}{100} = 1286 \text{ mV/m} \]

b) Determination of the distance at which a given field strength is obtained

On the basis of the data from the preceding example, at what distance can a field strength of 500 µV/m be obtained?

Since the antenna involved has a characteristic field strength for 1 kW of 306 mV/m and the station power is 5 kW, i.e., conditions different, from those of graphs 1 to 19 (100 mV/m at 1 km), the field strength value must be determined before referring to the corresponding figure.

The calculated value is

\[ E_0 = \frac{100 E}{E_c \sqrt{P}} = \frac{(100)(500)}{(306) \sqrt{5}} = 73.1 \text{ µV/m} \]

Taking the corresponding curve at 4 mS/m in graph 15, we arrive at 73.1 µV/m at 62 km.
2. **Example of a field strength calculation for non-homogeneous paths** (see paragraph 2.3.2 of Annex 2).

Consider the following path:

![Diagram of an example of a field strength calculation for non-homogeneous paths.](image)

**a)** For a 25 kW station at 1000 kHz and an antenna with a characteristic field strength of 100 mV/m, what field strength is obtained at 60 km?

In graph 12 we obtain on the 40 mS/m curve a field strength of 2.8 mV/m at the point of discontinuity (30 km).

We obtain the same field strength at 9.5 km (d = 9.5 km) on the 2 mS/m curve.

The equivalent distance for \( d_2 = 60 \) km, is \( d + (d_2 - d_1) = 9.5 + (60 - 30) = 39.5 \) km.

From the 2 mS/m curve, we obtain a field of 141 µV/m at 39.5 km.

Lastly, we calculate the field strength:

\[
E = \frac{(E_o)(E_c)}{(100)^2} = (141)(100)\sqrt{25} = 705 \, \mu V/m
\]

**b)** Taking the preceding example, at what distance will the 500 µV/m contour be?

First we determine the field strength:

\[
E_o = \frac{100E_c\sqrt{F}}{E_c\sqrt{F}} = \frac{(100)(500)}{(100)\sqrt{25}} = 100 \, \mu V/m
\]

Following the 40 mS/m curve of graph 12, we note that at 30 km the field strength is 2.8 mV/m. This value is higher than the one we seek (0.1 mV/m) and therefore we shall have a distance greater than 30 km.

The equivalent distance for a 2 mS/m conductivity is 9.5 km.
Following the 2 mS/m curve, we find the 100 µV/m contour at 66 km giving us the equivalent distance. The true distance is 46 + (30 - 9.5) = 66.5 km.

3. Path parameters

If $a_T$ and $b_T$ respectively are the latitude and longitude of the transmitting terminal, and $a_R$ and $b_R$ are those of the receiving terminal, the parameters of the short great-circle path may be calculated. The North and East coordinates are considered positive and the South and West coordinates negative.

3.1 Great-circle path distance

$$d = 111.18 \times d^\circ \text{ km}$$

where:

$$d^\circ = \text{arc cos } \left[ \sin a_T \sin a_R + \cos a_T \cos a_R \cos (b_R - b_T) \right]$$

3.2 Azimuth of the path from either terminal

For the transmitting terminal, for example,

$$a_T = \text{arc cos } \left[ \frac{\sin a_T - \cos d^\circ \sin a_T}{\sin d^\circ \sin a_T} \right]$$

determined such that $0^\circ < a < 180^\circ$. The geographical bearing in ‘degrees East of North’ CO the receiving terminal is $a_T$ if $\sin (b_R - b_T) > 0$ or is $(360^\circ - a_T)$ if $\sin (b_R - b_T) < 0$. The same equation, with the latitudes reversed, is used for the receiving terminal.

3.3 Coordinates of a point on a given great-circle path at a distance, “d”, km, from a transmitter:

$$a = \text{arc sin } [ \sin a_T \cos d^\circ + \cos a_T \sin d^\circ \cos a_T ]$$

$$b = b_T + k$$

where:

$$d^\circ = \frac{d}{111.18} \text{ km}$$

$$k = \text{arc cos } \left( \frac{\cos d^\circ - \sin a_T \sin a}{\cos a_T \cos a} \right), \text{ if } \sin (b_R - b_T) > 0$$

$$k = -\text{arc cos } \left( \frac{\cos d^\circ - \sin, a_T \sin a}{\cos a_T \cos a} \right), \text{ if } \sin (b_R - b_T) < 0$$

Note that the transmitting location was used in these equations for $a$ and $b$, but alternatively the receiving location may be used.
<table>
<thead>
<tr>
<th>Item</th>
<th>1040</th>
<th>20 : 1</th>
<th>52</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Therefore, disregarded ( \sqrt{2} + C + \sqrt{n} ) less than 50% of Individual Contribution</td>
<td>1300</td>
<td>20 : 1</td>
<td>65</td>
<td>D</td>
</tr>
<tr>
<td>( \sqrt{2} + C + \sqrt{n} ) therefore, greater than 50% of Individual Contribution</td>
<td>4565</td>
<td>2500</td>
<td>125</td>
<td>F</td>
</tr>
<tr>
<td>( \sqrt{2} + C )</td>
<td>3821</td>
<td>2600</td>
<td>130</td>
<td>C</td>
</tr>
<tr>
<td>( \sqrt{2} )</td>
<td>2800</td>
<td>140</td>
<td>4</td>
<td>A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Remarks</th>
<th>( \frac{1/2}{m} )</th>
<th>( \frac{1/2}{m} )</th>
<th>( \frac{1/2}{m} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Construction Exclusion Principle</td>
<td>Interference Intensity</td>
<td>Interference Intensity</td>
<td>Interference Intensity</td>
</tr>
<tr>
<td>RSS Calculated</td>
<td>Protection Screen</td>
<td>Interference Intensity</td>
<td>Interference Intensity</td>
</tr>
<tr>
<td>Example Illustrating the Application of the 50% Exclusion Principle (see Section 4.7.2).</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5. The following matrix shows the conditions of application of the protection criteria as indicated in Sections 4. 9.2 and 4. 9.3.

<table>
<thead>
<tr>
<th>Section number</th>
<th>4. 9.2.1</th>
<th>4. 9.2.2</th>
<th>4. 9.2.3</th>
<th>4. 9.3</th>
<th>4. 9.3</th>
<th>4. 9.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel relationship</td>
<td>co-channel</td>
<td>co-channel</td>
<td>co-channel</td>
<td>all receive channel</td>
<td>all receive channel</td>
<td>all receive channel</td>
</tr>
<tr>
<td>Time</td>
<td>daytime</td>
<td>nighttime</td>
<td>nighttime</td>
<td>daytime</td>
<td>nighttime</td>
<td>daytime</td>
</tr>
<tr>
<td>Class of protected station</td>
<td>A, B, C</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Protective field</td>
<td>groundwave</td>
<td>daytime</td>
<td>groundwave</td>
<td>groundwave</td>
<td>groundwave</td>
<td>groundwave</td>
</tr>
<tr>
<td>Protected contour</td>
<td>groundwave contour corresponding to the greater of $E_{u}$ or $E_{n}$</td>
<td>groundwave contour</td>
<td>groundwave contour</td>
<td>groundwave contour</td>
<td>groundwave contour</td>
<td>groundwave contour</td>
</tr>
<tr>
<td>Value to be protected</td>
<td>$E_{E_{u}}$</td>
<td>$E_{E_{n}}$</td>
<td>greater of $E_{E_{u}}$ or $E_{E_{n}}$</td>
<td>adjacent channel daytime groundwave contour</td>
<td>$E_{E_{u}}$</td>
<td>$E_{E_{n}}$</td>
</tr>
<tr>
<td>How $E_{u}$ is calculated</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>$E_{E_{u}}$</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Where $E_{u}$ is calculated</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Station site</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
<tr>
<td>How protection is applied</td>
<td>Protection ratio applied separately</td>
<td>Protection ratio applied separately</td>
<td>Using $E_{E_{u}}$ the permissible field strength at the station site is not to be exceeded at the protected contour</td>
<td>Protection ratio applied separately</td>
<td>Protection ratio applied separately</td>
<td>Protection ratio applied separately</td>
</tr>
</tbody>
</table>

Notes:
1) groundwave or 50% skywave contour, whichever is farther from the site.

2) For Class A stations notified after the date of signing of this Agreement, the value of the protected contour corresponds to the usable field strength, $E_{u}$.
Appendix 6
(to Annex 2)

Method Used for Calculating Sectionalized Antenna Radiation Characteristics

(The columns referred to below are those of Part II, Section 1 of Annex 1)

1. Sectionalized tower, when the value entered in column 12 is 3.

\[ f(\theta) = \frac{2 \cos (\theta \sin \phi) \cos [(A + 90) \sin \theta] + \cos (\phi \sin \theta) - \cos A}{\cos \phi (3 - \cos A)} \]

where:
- \( A \): electrical height of bottom section:
- \( \phi \): elevation angle.

2. Sectionalized tower, when the value entered in column 12 is 4.

\[ f(\theta) = \frac{\cos (A \sin \phi) [\cos (\phi \sin \theta) - \cos A]}{\cos \phi (1 - \cos A)} \]

where:
- \( A \): electrical height of bottom section:
- \( \phi \): elevation angle.

3. Sectionalized tower, when the value entered in column 12 is 5.

\[ f(\theta) = \frac{\cos (A \sin \phi) - \cos A}{\cos \phi} + \frac{CD \cos \phi \{\cos (A \sin \theta) + \{\cos [(A + B) \sin \theta]\} \}}{C^2 - \sin^2 \phi} \]

where:
- \( A \): electrical height of bottom section:
- \( B \): electrical height of top section:
- \( C \): current distribution factor:
- \( D \): ratio of maximum current in top section to maximum current in bottom section:
- \( \phi \): elevation angle.
4. Sectionalized tower, when the value entered in column 12 is 6.

\[
f(\theta) = \frac{\cos (A \sin \theta) - \cos (A - B) \cos (B \sin \theta) + \sin \theta \sin (A - B) \sin (B \sin \theta)}{\cos \theta [1 - \cos (A - B)]}
\]

where:
- \( A \): total electrical height of tower;
- \( B \): electrical height of lower section;
- \( \theta \): elevation angle.

5. Sectionalized tower, when the value entered in column 12 is 7.

\[
f(\theta) = \frac{C [\cos (A \sin \theta) - \cos A] + \cos (B \sin \theta) \cos (B = A) \cos (A \sin \theta) + \sin (B - A) \sin \theta \sin (A \sin \theta)]}{C [1 - \cos A] + \cos \theta [1 - \cos (B - A)]}
\]

where:
- \( A \): electrical height of lower section;
- \( B \): total electrical height of antenna;
- \( C \): ratio of the loop currents in the two sections;
- \( \theta \): elevation angle.
Sectionalized tower, when the value entered in column 12 is 8.

If $\theta = 0$:

$$ f(\theta) = 1 $$

If $\theta > 0$:

$$ f(\theta) = \frac{\text{real component}^2 + \text{imaginary component}^2}{C} $$

The real component is equal to:

$$ \left[ \frac{2.28 \cos \theta}{1.14 \sin^2 \theta} \right] \{- \cos [1.14(B - A)] + 2 \cos (1.14B) \cos (A \sin \theta) - \cos ((A + B) \sin \theta)\} $$

The imaginary component is equal to:

$$ D \cos \theta \left( \frac{\sin [(A - B) \sin \theta]}{\sin e} \right) + \frac{1.14}{1.14^2 - \sin^2 e} \left[ \sin [1.14(B - A)] - 2 \sin (1.14B) \cos (A \sin \theta) \right. $$

$$ \left. + \frac{\sin e \sin ((A + B) \sin \theta)}{1.14} \right] $$

where:

- $A$: electrical height of lower section of tower;
- $B$: electrical height of upper section of tower;
- $C$: scaling factor so that $f(\theta)$ is 1 in horizontal plane;
- $D$: absolute ratio of the real component of current to the imaginary component of current at the point of maximum amplitude;
- $\theta$: elevation angle.

Note: $1.14$ is the ratio of velocity of light to propagation velocity along radiator.
Sectionalized tower, when the value entered in column 12 is 9.

\[ f(\theta) = \cos(A \sin \theta) \left[ \cos(B \sin \theta) + 2 \cos(A \sin \theta) \right] \]

\[ \frac{3 \cos \theta}{3 \cos \theta} \]

where:

- \( A \): electrical height of centre of bottom dipole:
- \( B \): electrical height of centre of top dipole:
- \( \theta \): elevation angle.
APPENDIX 7
(To Annex 2)

EXTENDED HOURS OF OPERATION

This Appendix contains special technical and operational criteria that apply to stations authorized for extended hours of operation pursuant to Article VI of this Agreement. Additionally, methods used for conducting interference calculations regarding such operations are described and exemplified.

Special criteria

A station authorized for extended hours of operation shall not receive protection for that operation.

During extended hours of operation, a station shall use its daytime or nighttime facilities with radiation adjusted downward as necessary to meet the protection requirements of Annex 2.

During extended hours of operation, a station shall provide full protection to each duly notified and accepted co-channel nighttime station in the other country in accordance with Annex 2 and this appendix. This protection is to be provided without regard to when the notification is made. Hence, it may be necessary to further adjust the operation of an extended hours station as a result of subsequent notifications.

Permissible levels of radiation from stations engaging in extended hours of operation may be determined by application of diurnal factors.

Diurnal factors are calculated from the formulas contained in Section 3.5 of Annex 2, and are represented graphically in Figures 5A and 5B of Annex 2.

Power radiated during extended hours of operation shall not exceed the highest power that provides the required protection and, in any event, shall not exceed 500 watts.
BASIC PROCEDURE

The following basic procedure and illustration describe the application of the diurnal curves when calculating protection required pursuant to Section 6.9.2.3 of Annex 2 for a class B station from a daytime-only station operating during the post-sunset period. A similar procedure may be used for the pre-sunrise period. If the protected station is a class A station, a similar approach for applying diurnal factors is applied except that protection will be determined in accordance with Section 4.9.2.2 of Annex 2.

1. Determine the nighttime RSS limitation of the co-channel nighttime station which may be affected by the proposed extended hours operation of the subject station. The individual limits which determine the RSS limitations of these nighttime stations shall also be identified.

2. The permissible interfering 10% skywave limit from the post-sunset operation of the subject station must not exceed either 50% of the existing RSS of the nighttime stations or the lowest individual limits which are part of the RSS determinations. Identify the most restrictive skywave limit which will not increase the RSS of any affected nighttime stations. Based on this most restrictive limit determine the permissible radiation from the subject station which will not exceed this limit toward the pertinent protected station for full nighttime protection.

3. Use of the diurnal curves will generally increase the permissible radiation of the proposed post-sunset operation. In order to apply the diurnal curves, it is necessary to determine the time of sunset at the mid-point of the path between the site of the subject station proposing extended hours operation and the site of the nighttime station to be protected. First, add the proposed period of extended operation to the local sunset time of the station proposing extended operation, then subtract the sunset time of the path mid-point from the time of the extended operation. With this time difference enter the diurnal factor curves, Figure 5B of Annex 2, with the appropriate frequency, and read the diurnal factor, or use the formula contained in Paragraph 3.5 of Annex 2 to calculate the proper diurnal factor. Diurnal factors greater than one shall not be used. The sunrise and sunset times for each month shall be determined as of the 15th day of each month and adjusted to the nearest quarter-hour.
4. Divide the permissible interfering skywave signal toward the protected station on the path selected, by the diurnal factor. This produces the permissible signal adjusted by the diurnal factor, which can be radiated during the post-sunset operating period. With the proposed permitted signal increased by the diurnal factor, the proposed post-sunset power may be calculated by direct ratio (using the square root of the power).

5. In lieu of making monthly power adjustments, a station may operate year-round with a uniform power not to exceed the power calculated on the basis of the "worstcase" month.
Assume that a **daytime-only station** operates in the **state of Chihuahua** with the following particulars:

- **Frequency:** 1590 kHz; **Power:** 1 kW; **RMS:** 309 mV/m
- **Coordinates:** 28°16'36" N 105°29'16" W
- **Antenna:** Non-directional with height of 90°

It is assumed further that it is desired to operate the station **60 minutes past sunset** and it is necessary to determine the **maximum power permissible** using the daytime antenna system that will provide *requisite protection* in accordance with Section 4.9 of Annex 2. The first step is to determine the **nighttime RSS limits of affected nighttime co-channel stations.** In order to demonstrate calculation procedures in accordance with Section 4.9 of Annex 2, assume that there is a **nighttime** station in the state of Texas.

Assume, for example, that the **RSS limitation of the station in Texas** is determined to be 4.58 mV/m and that the smallest contributor is 3.1 mV/m. The maximum new contribution may not exceed 50% of the nighttime RSS (which would be 2.29 mV/m) or the smallest contributor that is already in the RSS limitation (in this case 3.1 mV/m). Thus, the maximum new contribution permitted is 2.29 mV/m. A summary of the calculations is as follows:

(a) **Coordinates of protected Texas station:** 33°31'16" N; 101°46'28" W.

(b) **Site-to-site distance between stations:** 682.68 km.
   (From Appendix 5, Annex 2)

(c) **Coordinates of path mid-point:** 30°54'43" N; 103°40'21" W.
   (From Appendix 5, Annex 2)

(d) **Calculated sunset at Chihuahua site for December 15:** 17:07:57 CST.
   (From 3.6, Annex 2)

(e) **Calculated sunset at path mid-point for December 15:** 16:54:50 CST.
   (From 3.6, Annex 2)

(f) **The 10% skywave field strength (SWF) at 682.68 km:** 0.102 mV/m per 100 mV/m at 1 km. (From 3.4, Annex 2)

(g) **Elevation angle θ: 14°.** (From 3.2, Annex 2)

(h) \( f(θ) = 0.95. \) (From 3.2, Annex 2)

From the foregoing it is seen that when it is 60 minutes past sunset at the Chihuahua site it is 73.07 minutes (or 1.218 hr) past sunset at the path mid-point (SS + 1.213 hr). Using this value and Fig. 58 or Formula (6) the **diurnal factor** to be applied for the path to the Texas station is determined to be 0.9185.
Since the maximum ncv contribution must not exceed 2.29 mV/m in this example, the maximum 10X interfering signal under full nighttime condition is 2.29/20 or 0.1165 mV/m. Therefore, at the vertical angle, the permissible radiation for this condition is:

\[
\frac{(0.1145)(100)}{(0.102)} = 11.45 \text{ mV/m}
\]

In the horizontal plane the permissible radiation is:

\[
\frac{112.26}{(0.95)} = 118.16 \text{ mV/m}
\]

However, since the diurnal factor is less than one, it can be applied to increase the radiation that is permitted: \((118.16) / (0.9186) = 128.63 \text{ mV/m} \) which is the maximum post-sunset radiation permitted. Since this value is less than the 309 mV/m radiated by the station using its daytime 1 kW facilities, the power must be adjusted downward for the extended hours operation. This can be calculated as follows:

\[
\frac{(\text{permissible radiation})^2}{(1000)} = \frac{(128.63)^2}{(1000)} = 173.3 \text{ Watts}
\]

Thus, it is shown that the maximum power that the Chihuahua station could use during extended hours of operation is 173 Watts.

This same procedure would be applied to each of the affected co-channel nighttime stations. The lowest power calculated in this manner would be that which would be permitted.