minimum height requirements, or submit evidence that the present antenna system meets the minimum requirements with respect to field strength, before favorable consideration will be given thereto. (See § 73.186.) In the event it is proposed to make substantial changes in an existing antenna system, the changes shall be such as to meet the minimum height requirements or will be permitted subject to the submission of field strength measurements showing that it meets the minimum requirements with respect to effective field strength.

(2) These minimum actual physical vertical heights of antennas permitted to be installed are shown by curves A, B, and C of Figure 7 of § 73.190 as follows:

(i) Class C stations, and stations in Alaska, Hawaii, Puerto Rico and the U.S. Virgin Islands on 1230, 1240, 1340, 1400, 1450 and 1490 kHz that were formerly Class C and were redesignated as Class B pursuant to § 73.26(b), 45 meters or a minimum effective field strength of 180 mV/m for 1 kW at 1 kilometer (90 mV/m for 0.25 kW at 1 kilometer). (This height applies to a Class C station on a local channel only. Curve A shall apply to any Class C stations in the 48 conterminous States that are assigned to Regional channels.)

(ii) Class A (Alaska), Class B and Class D stations other than those covered in § 73.189(b)(2)(i), a minimum effective field strength of 215 mV/m for 1 kW at 1 kilometer.

(iii) Class A stations, a minimum effective field strength of 275 mV/m for 1 kW at 1 kilometer.

(3) The heights given on the graph for the antenna apply regardless of whether the antenna is located on the ground or on a building. Except for the reduction of shadows, locating the antenna on a building does not necessarily increase the efficiency and where the height of the building is in the order of a quarter wave the efficiency may be materially reduced.

(4) At the present development of the art, it is considered that where a vertical radiator is employed with its base on the ground, the ground system should consist of buried radial wires at least one-fourth wave length long. There should be as many of these radials evenly spaced as practicable and in no event less than 90. (120 radials of 0.35 to 0.4 of a wave length in length and spaced 3° is considered an excellent ground system and in case of high base voltage, a base screen of suitable dimensions should be employed.)

(5) In case it is contended that the required antenna efficiency can be obtained with an antenna of height or ground system less than the minimum specified, a complete field strength survey must be supplied to the Commission showing that the field strength at a mile without absorption fulfills the minimum requirements. (See § 73.186.) This field survey must be made by a qualified engineer using equipment of acceptable accuracy.

(6) The main element or elements of a directional antenna system shall meet the above minimum requirements with respect to height or effective field strength. No directional antenna system will be approved which is so designed that the effective field of the array is less than the minimum prescribed for the class of station concerned, or in case of a Class A station less than 90 percent of the ground wave field which would be obtained from a perfect antenna of the height specified by Figure 7 of § 73.190 for operation on frequencies below 1000 kHz, and in the case of a Class B or Class D station less than 90 percent of the ground wave field which would be obtained from a perfect antenna of the height specified by Figure 7 of § 73.190 for operation on frequencies below 750 kHz.

[28 FR 13574, Dec. 14, 1963, as amended at 31 FR 8069, June 8, 1966; 33 FR 15420, Oct. 17, 1968; 44 FR 36038, June 20, 1979; 50 FR 18844, May 2, 1985; 51 FR 2707, Jan. 21, 1986; 51 FR 4753, Feb. 7, 1986; 52 FR 10570, Apr. 2, 1987; 56 FR 64868, Dec. 12, 1991; 81 FR 2760, Jan. 19, 2016]

§ 73.190 Engineering charts and related formulas.

(a) This section consists of the following Figures: 2, r3, 5, 6a, 7, 8, 9, 10, 11, 12, and 13. Additionally, formulas that are directly related to graphs are included.

(b) Formula 1 is used for calculation of 50% skywave field strength values.

FORMULA 1. Skywave field strength, 50% of the time (at SS + 6):

The skywave field strength, $F_c(50)$, for a characteristic field strength of 100 mV/m at 1 km is given by:

$$F_c(50) = (97.5 - 20\log D) - \left(2\pi + 4.95\tan^2\phi_M\right)\sqrt{\left(\frac{D}{1000}\right)} \quad dB(\mu V/m) \qquad \text{(Eq. 1)}$$

The slant distance, D, is given by:

$$D = \sqrt{40{,}000 + d^2} \quad km \qquad \text{(Eq. 2)}$$

The geomagnetic latitude of the midpoint of the path, Φ_M, is given by:

Φ_M = arcsin[sin a_M sin 78.5° + cos a_M cos 78.5° cos(69 + b_M)]degrees (Eq. 3)

The short great-circle path distance, d, is given by:

$$d = 111.18d° \ km \qquad \text{(Eq. 4)}$$

Where:

$d°$ = arccos[sin a_T sin a_R + cos a_T cos a_R cos(b_R − b_T)]degrees (Eq.5)

Where:

a_T is the geographic latitude of the transmitting terminal (degrees)

a_R is the geographic latitude of the receiving terminal (degrees)

b_T is the geographic longitude of the transmitting terminal (degrees)

b_R is the geographic longitude of the receiving terminal (degrees)

a_M is the geographic latitude of the midpoint of the great-circle path (degrees) and is given by:

b_M is the geographic longitude of the midpoint of the great-circle path (degrees) and is given by:

$$a_M = 90 - \arccos\left[\sin a_R \cos\left(\frac{d°}{2}\right) + \cos a_R \sin\left(\frac{d°}{2}\right)\left(\frac{\sin a_T - \sin a_R \cos d°}{\cos a_R \sin d°}\right)\right] \qquad \text{(Eq. 6)}$$

$$b_M = b_R + k\left[\arccos\left(\frac{\cos\left(\frac{d°}{2}\right) - \sin a_R \sin a_M}{\cos a_R \cos a_M}\right)\right] \qquad \text{(Eq. 7)}$$

NOTE (1): If $|F_M|$ is greater than 60 degrees, equation (1) is evaluated for $|F_M|$ = 60 degrees.

NOTE (2): North and east are considered positive; south and west negative.

NOTE (3): In equation (7), $k = -1$ for west to east paths (*i.e.*, $b_R > b_T$), otherwise $k = 1$.

(c) Formula 2 is used for calculation of 10% skywave field strength values.

FORMULA 2. Skywave field strength, 10% of the time (at SS + 6):

The skywave field strength, $F_c(10)$, is given by:

$F_c(10) = F_c(50) + \Delta$ dB(μV/m)

Where:

$\Delta = 6$ when $|F_M| < 40$

$\Delta = 0.2\,|F_M| - 2$ when $40 \le |F_M| \le 60$

$\Delta = 10$ when $|F_M| > 60$

(d) Figure 6a depicts angles of departure versus transmission range. These angles may also be computed using the following formulas:

$$\theta° = \tan^{-1}\left(k_n \cot\frac{d}{444.54}\right) - \frac{d}{444.54}$$

Where:

d = distance in kilometers
n = 1 for 50% field strength values
n = 2 or 3 for 10% field strength values
and where
$K_1 = 0.00752$
$K_2 = 0.00938$
$K_3 = 0.00565$

NOTE: Computations using these formulas should not be carried beyond 0.1 degree.

(e) In the event of disagreement between computed values using the formulas shown above and values obtained directly from the figures, the computed values will control.

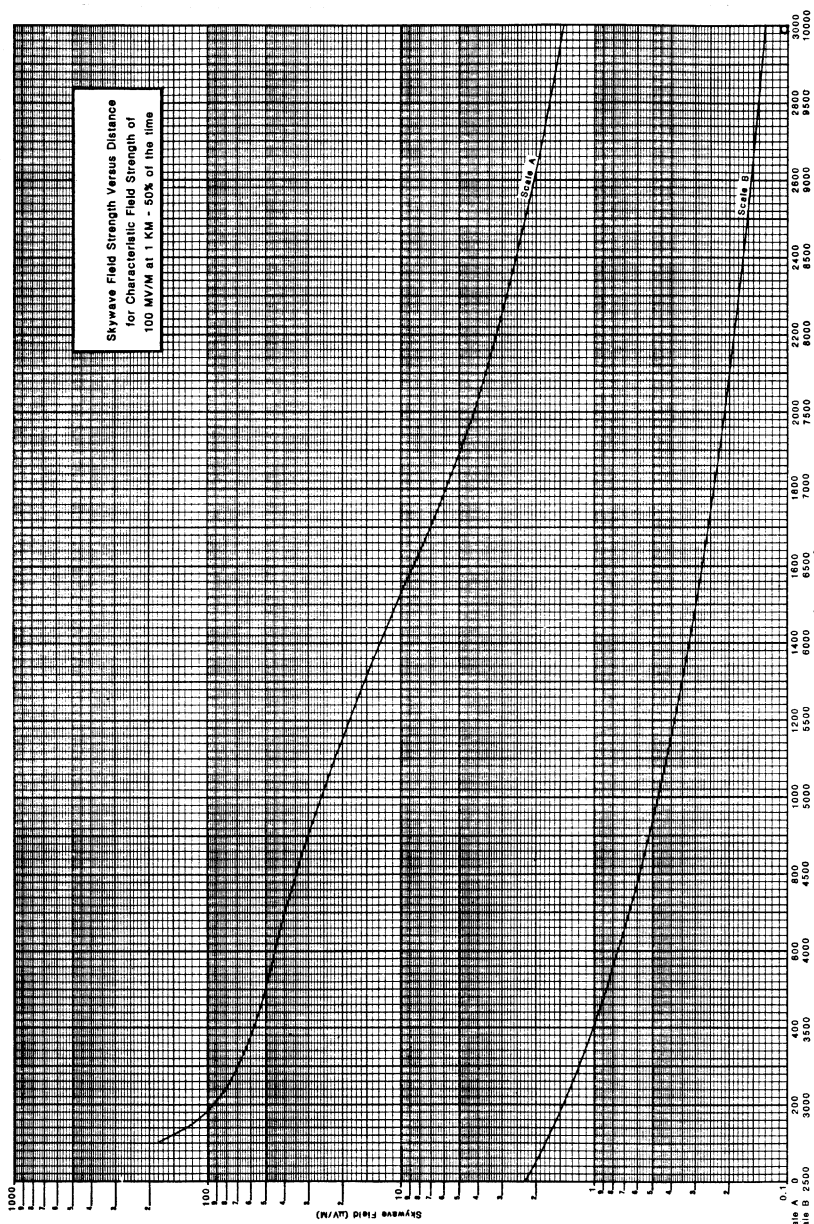

Skywave Field Strength Versus Distance
for Characteristic Field Strength of
100 MV/M at 1 KM - 50% of the time
Scale A
Scale B
Skywave Field (µV/M)
Distance (Kilometers)
Scale A 0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000
Scale B 2500 3000 3500 4000 4500 5000 5500 6000 6500 7000 7500 8000 8500 9000 9500 10000
1000
100
10
1
0.1

Figure 1a

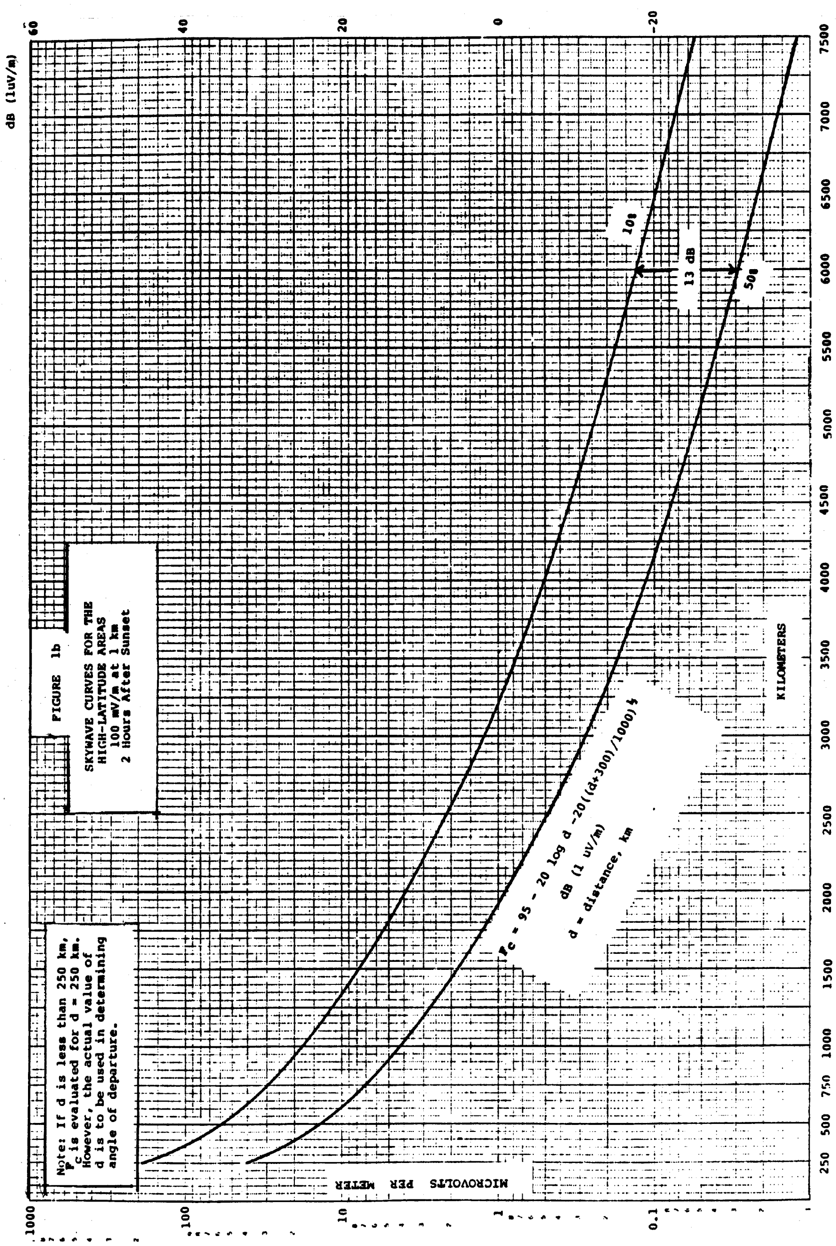
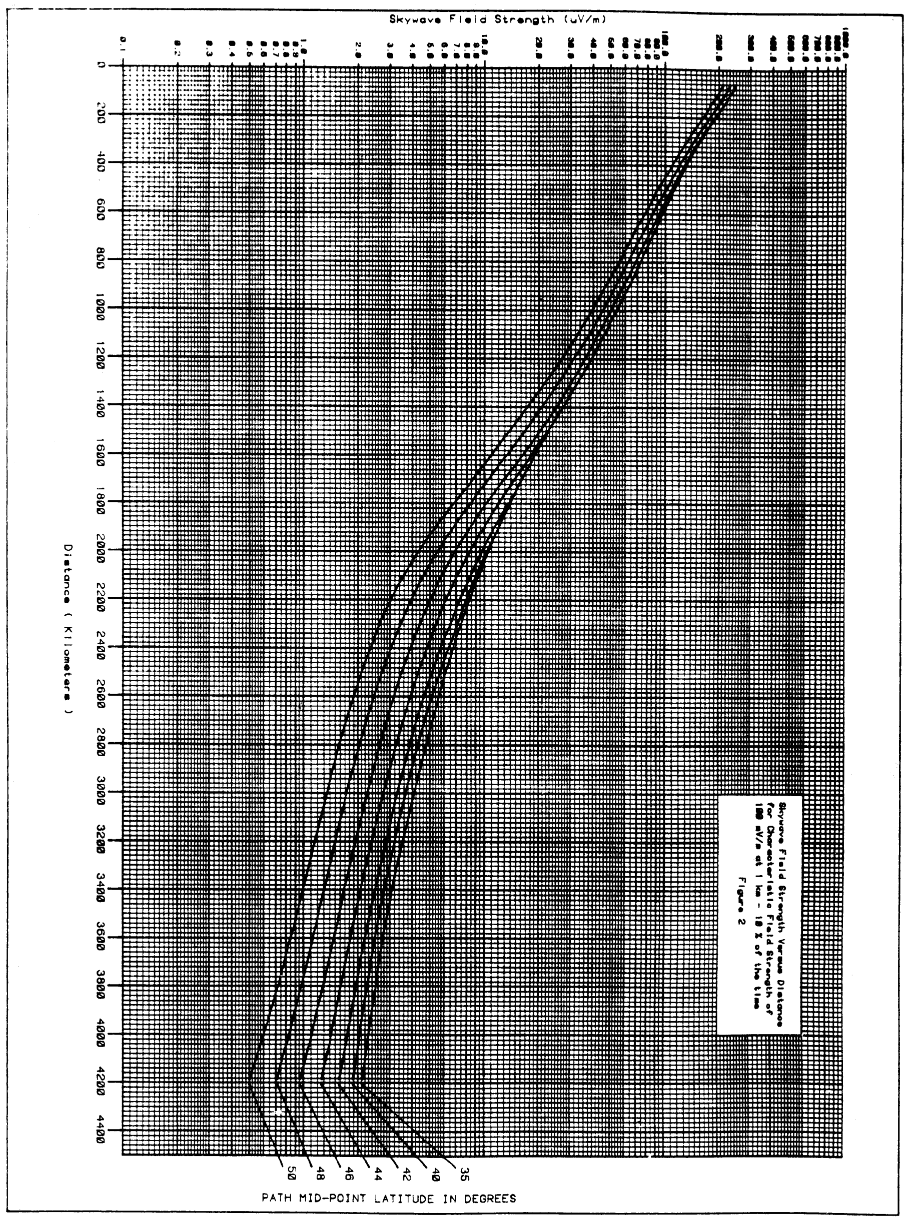


FIGURE 1b
SKYWAVE CURVES FOR THE HIGH-LATITUDE AREAS
100 mV/m at 1 km
2 Hours After Sunset
Note: If d is less than 250 km, Fc is evaluated for d = 250 km. However, the actual value of d is to be used in determining angle of departure.
Fc = 95 - 20 log d -20((d+300)/1000)½
dB (1 uV/m)
d = distance, km
10%
50%
13 dB
KILOMETERS
MICROVOLTS PER METER
dB (1uV/m)


Skywave Field Strength (uV/m)
Distance (Kilometers)
PATH MID-POINT LATITUDE IN DEGREES
50
48
46
44
42
40
35
Figure 2

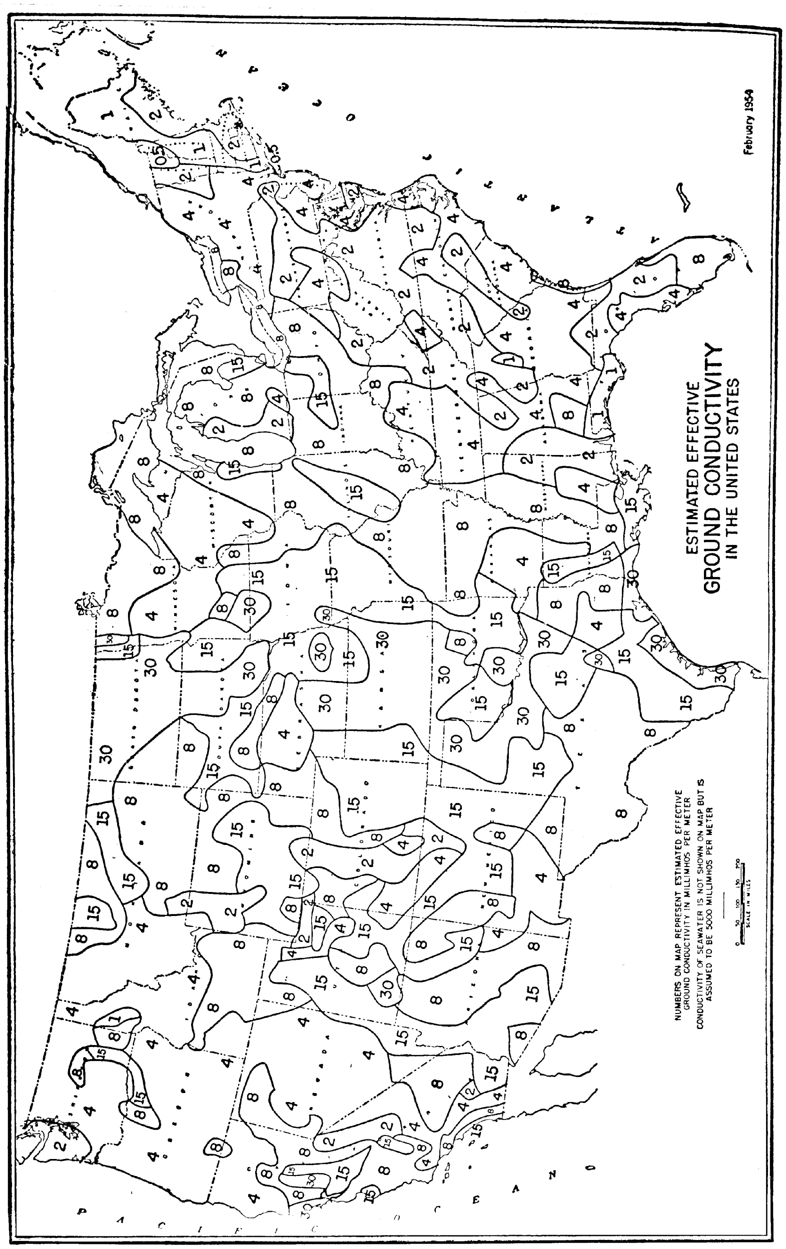

ESTIMATED EFFECTIVE
GROUND CONDUCTIVITY
IN THE UNITED STATES
NUMBERS ON MAP REPRESENT ESTIMATED EFFECTIVE GROUND CONDUCTIVITY IN MILLIMHOS PER METER
CONDUCTIVITY OF SEAWATER IS NOT SHOWN ON MAP BUT IS ASSUMED TO BE 5000 MILLIMHOS PER METER
February 1954

FIGURE R3.

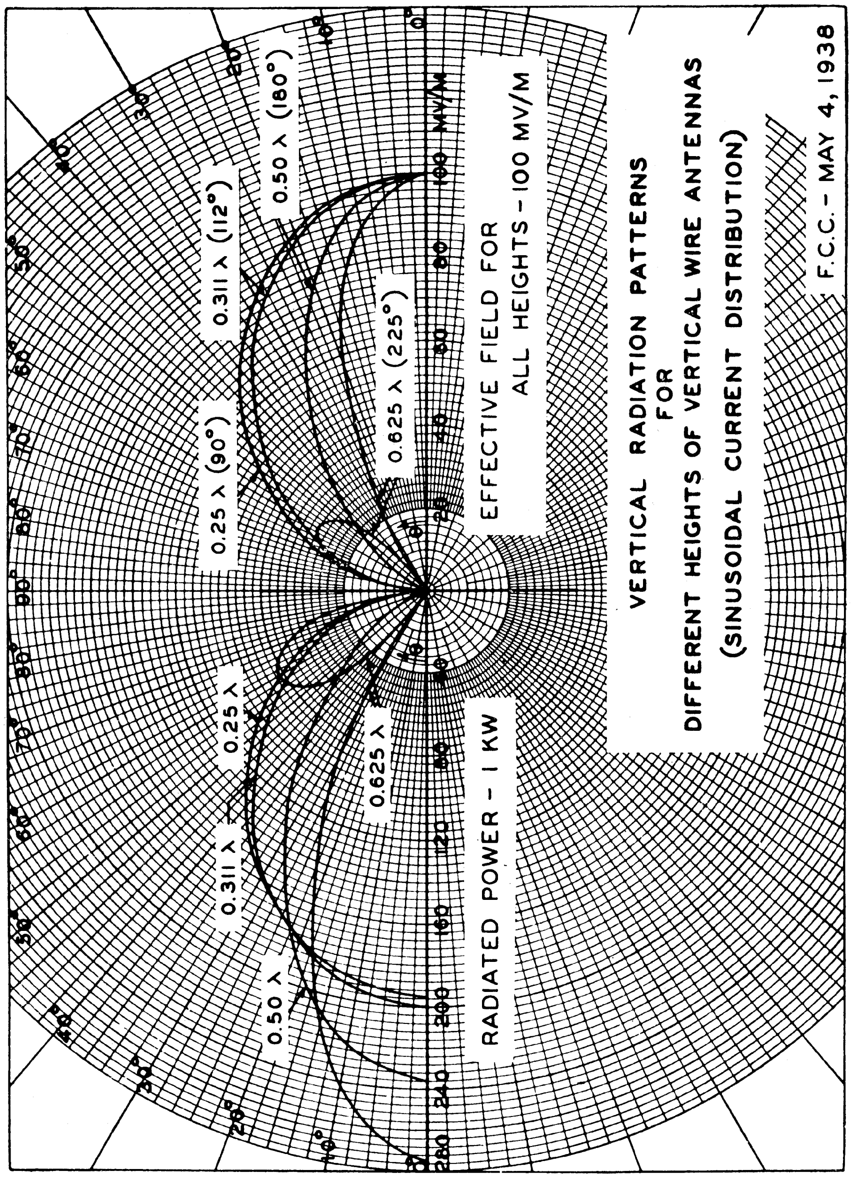
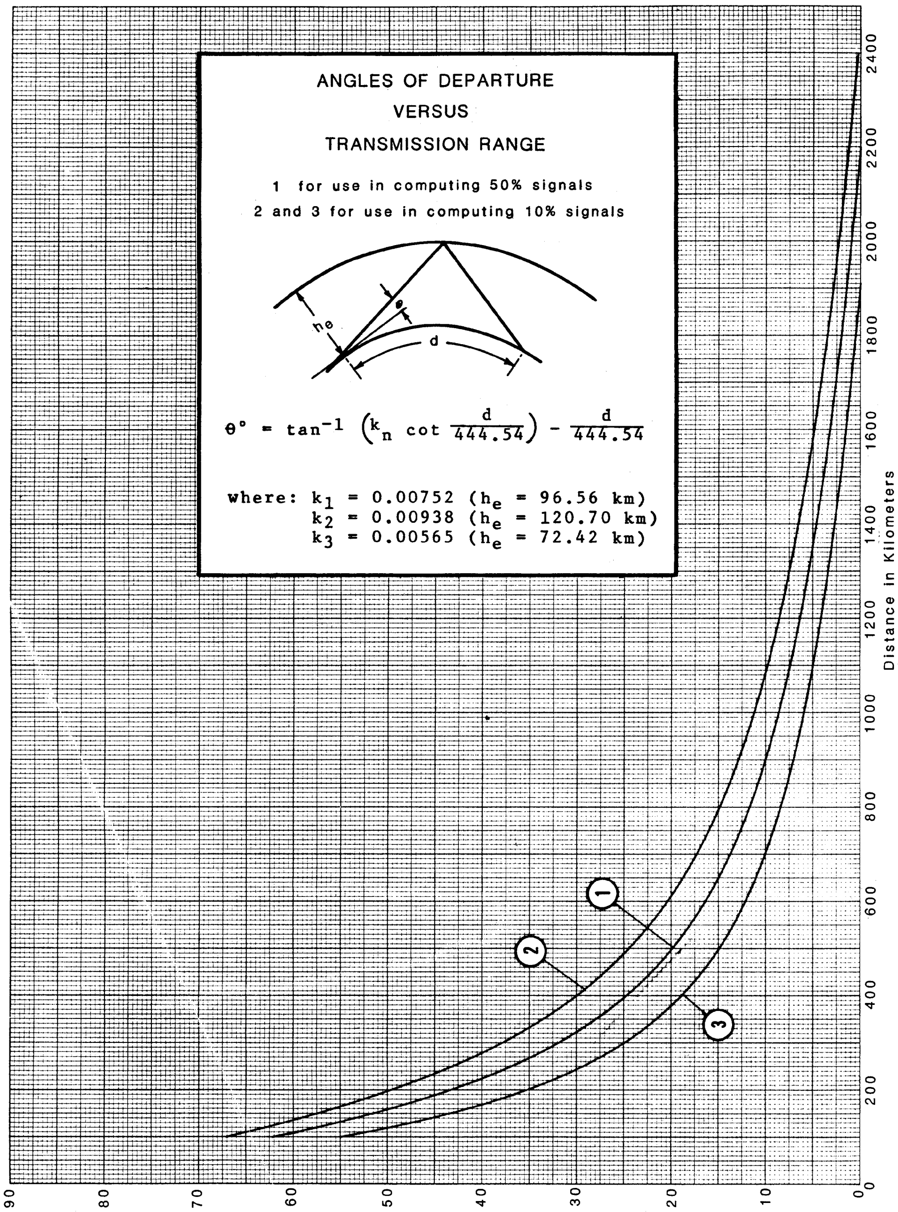

VERTICAL RADIATION PATTERNS
FOR
DIFFERENT HEIGHTS OF VERTICAL WIRE ANTENNAS
(SINUSOIDAL CURRENT DISTRIBUTION)
EFFECTIVE FIELD FOR
ALL HEIGHTS - 100 MV/M
RADIATED POWER - 1 KW
F.C.C. - MAY 4, 1938
0.25 λ (90°)
0.311 λ (112°)
0.50 λ (180°)
0.625 λ (225°)
0.25 λ
0.311 λ
0.50 λ
0.625 λ
MV/M

Figure 5



FCC §73.190 FIGURE 6a Corr. 11/86

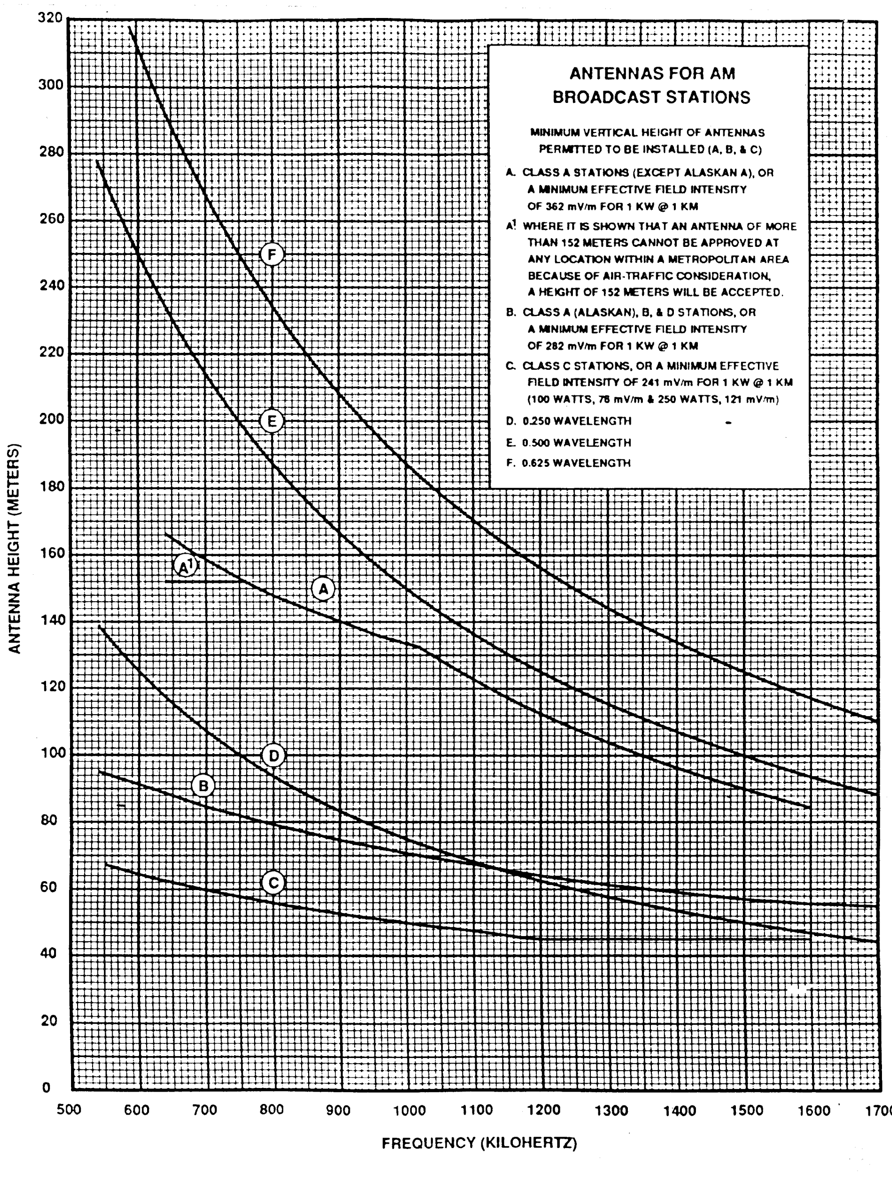

ANTENNAS FOR AM
BROADCAST STATIONS
MINIMUM VERTICAL HEIGHT OF ANTENNAS
PERMITTED TO BE INSTALLED (A, B, & C)
A. CLASS A STATIONS (EXCEPT ALASKAN A), OR
A MINIMUM EFFECTIVE FIELD INTENSITY
OF 362 mV/m FOR 1 KW @ 1 KM
A1 WHERE IT IS SHOWN THAT AN ANTENNA OF MORE
THAN 152 METERS CANNOT BE APPROVED AT
ANY LOCATION WITHIN A METROPOLITAN AREA
BECAUSE OF AIR-TRAFFIC CONSIDERATION,
A HEIGHT OF 152 METERS WILL BE ACCEPTED.
B. CLASS A (ALASKAN), B, & D STATIONS, OR
A MINIMUM EFFECTIVE FIELD INTENSITY
OF 282 mV/m FOR 1 KW @ 1 KM
C. CLASS C STATIONS, OR A MINIMUM EFFECTIVE
FIELD INTENSITY OF 241 mV/m FOR 1 KW @ 1 KM
(100 WATTS, 78 mV/m & 250 WATTS, 121 mV/m)
D. 0.250 WAVELENGTH
E. 0.500 WAVELENGTH
F. 0.625 WAVELENGTH
ANTENNA HEIGHT (METERS)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
FREQUENCY (KILOHERTZ)
F
E
A1
A
D
B
C

Figure 7

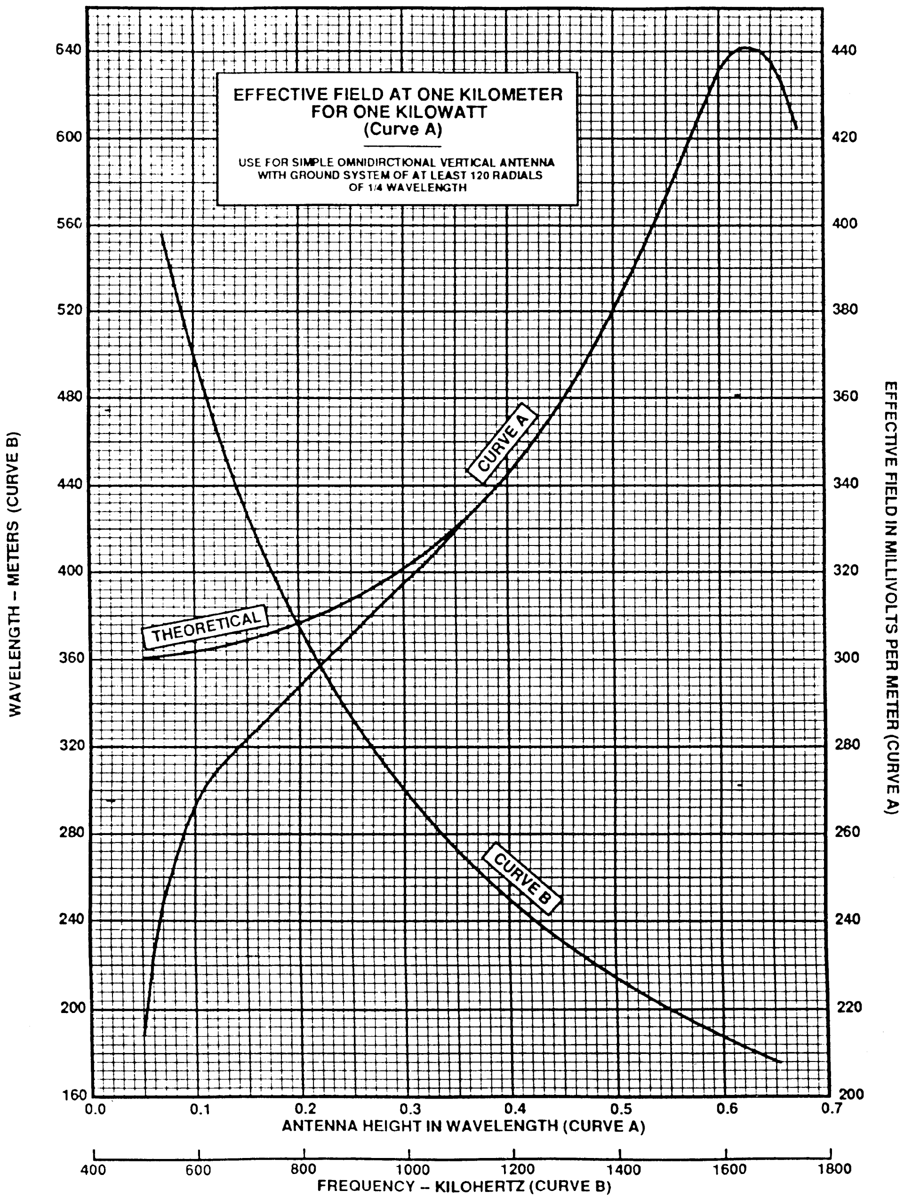

EFFECTIVE FIELD AT ONE KILOMETER
FOR ONE KILOWATT
(Curve A)
USE FOR SIMPLE OMNIDIRCTIONAL VERTICAL ANTENNA
WITH GROUND SYSTEM OF AT LEAST 120 RADIALS
OF 1/4 WAVELENGTH
THEORETICAL
CURVE A
CURVE B
WAVELENGTH – METERS (CURVE B)
640
600
560
520
480
440
400
360
320
280
240
200
160
EFFECTIVE FIELD IN MILLIVOLTS PER METER (CURVE A)
440
420
400
380
360
340
320
300
280
260
240
220
200
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
ANTENNA HEIGHT IN WAVELENGTH (CURVE A)
400
600
800
1000
1200
1400
1600
1800
FREQUENCY – KILOHERTZ (CURVE B)

Figure 8

PERMISSIBLE DAYTIME RADIATION
FOR CLASS II STATIONS

500 KC

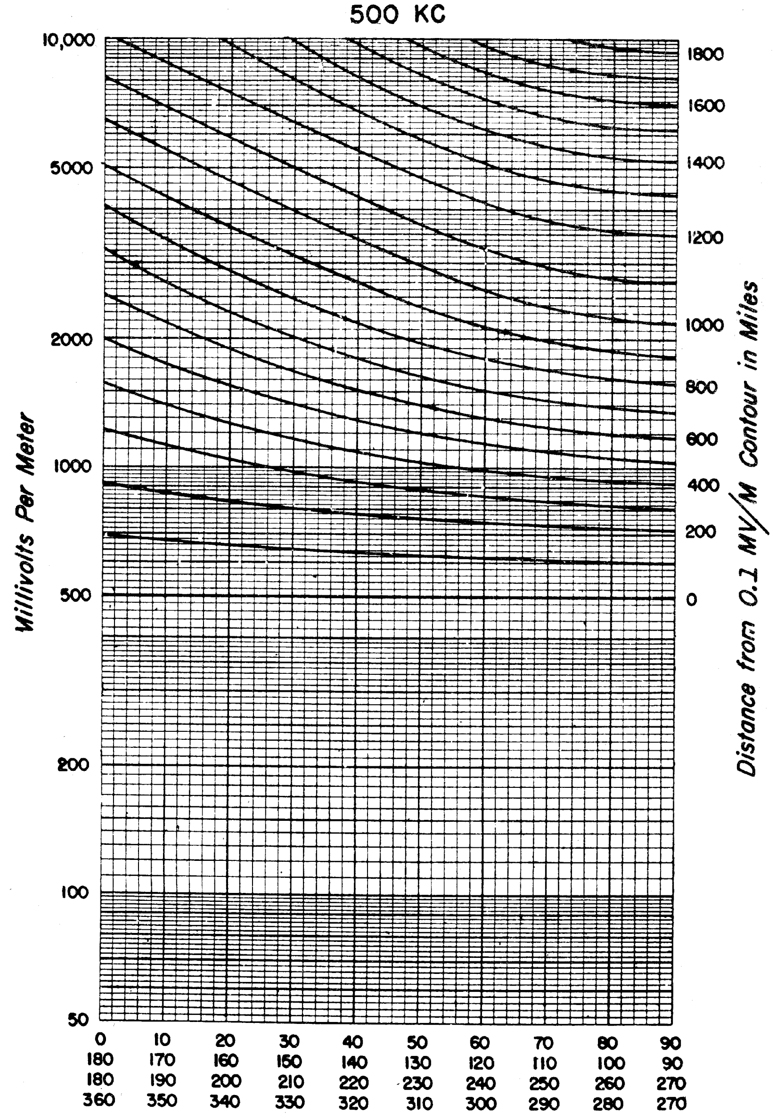


Figure 9

PERMISSIBLE DAYTIME RADIATION
FOR CLASS II STATIONS
1000 KC

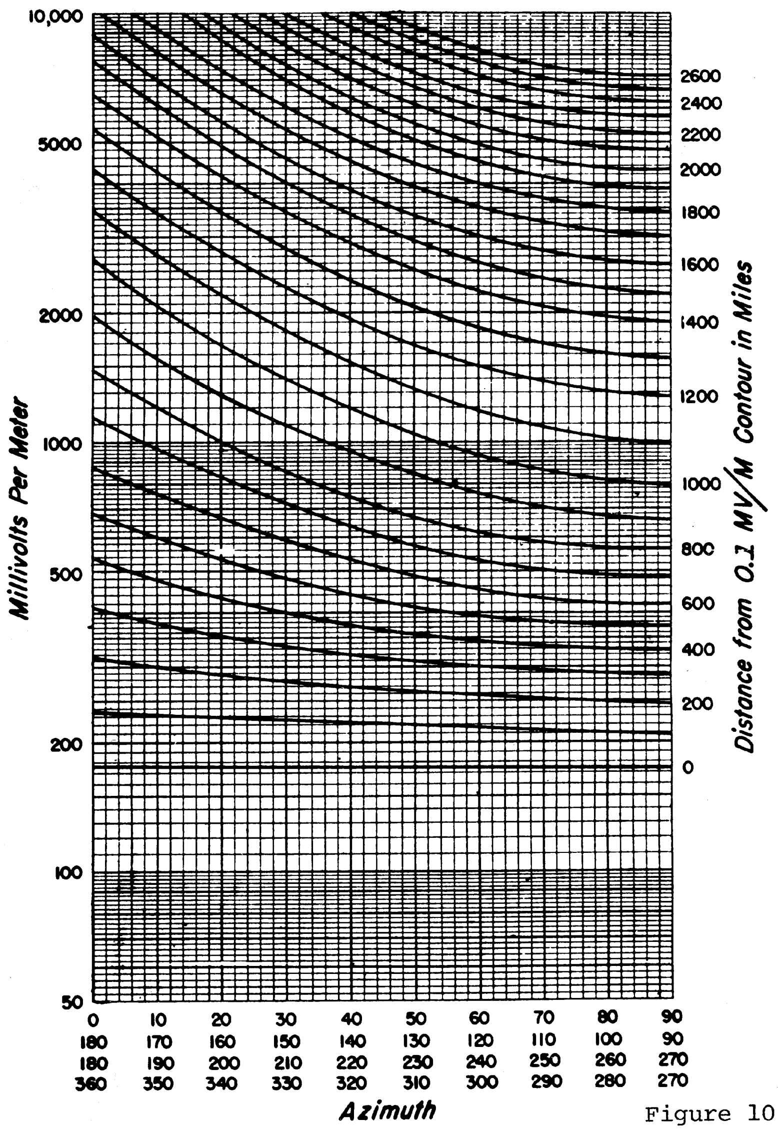


Figure 10

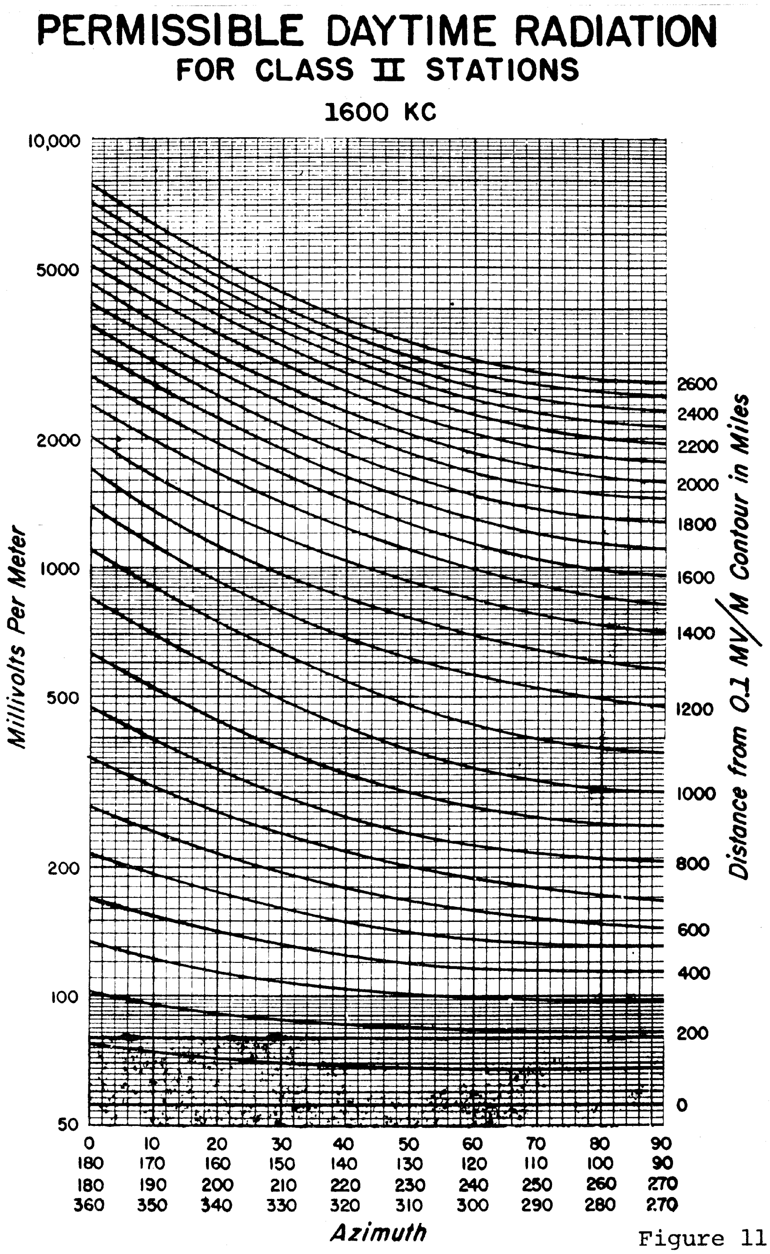
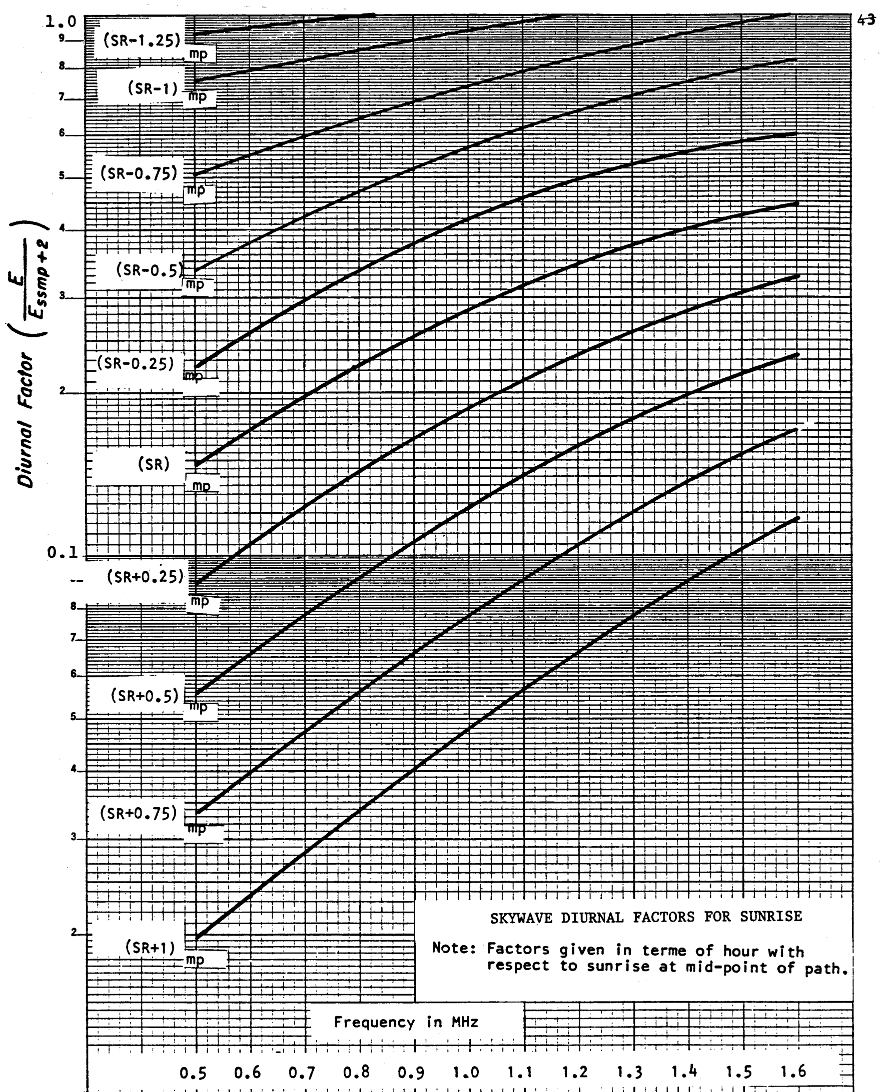
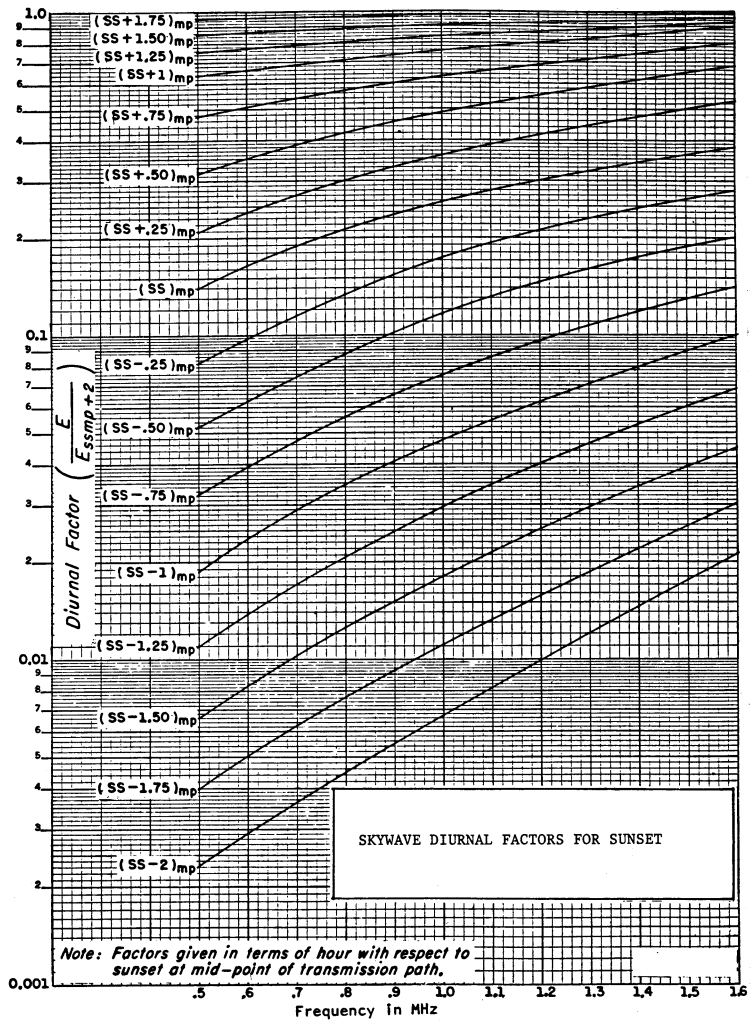

PERMISSIBLE DAYTIME RADIATION
FOR CLASS II STATIONS
1600 KC
Millivolts Per Meter
10,000
5000
2000
1000
500
200
100
50
Distance from 0.1 MV/M Contour in Miles
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0 10 20 30 40 50 60 70 80 90
180 170 160 150 140 130 120 110 100 90
180 190 200 210 220 230 240 250 260 270
360 350 340 330 320 310 300 290 280 270
Azimuth

Figure 11



FCC §73.190 Figure 12



FCC §73.190 Figure 13

[28 FR 13574, Dec. 14, 1963, as amended at 30 FR 12720, Oct. 6, 1965; 33 FR 15420, Oct. 17, 1968; 48 FR 42959, Sept. 20, 1983; 49 FR 43963, Nov. 1, 1984; 50 FR 18844, May 2, 1985; 51 FR 4753, Feb. 7, 1986; 52 FR 36879, Oct. 1, 1987; 56 FR 64869, Dec. 12, 1991]

Subpart B—FM Broadcast Stations

§ 73.201 Numerical designation of FM broadcast channels.

The FM broadcast band consists of that portion of the radio frequency spectrum between 88 MHz and 108 MHz. It is divided into 100 channels of 200 kHz each. For convenience, the frequencies available for FM broadcasting (including those assigned to noncommercial educational broadcasting) are given numerical designations which are shown in the table below:

Frequency (Mc/s)	Channel No.
88.1	201
88.3	202