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§ 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:

$$d = 111.18d^\circ \; km \qquad \text{(Eq. 4)}$$

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:

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

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

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:

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

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.

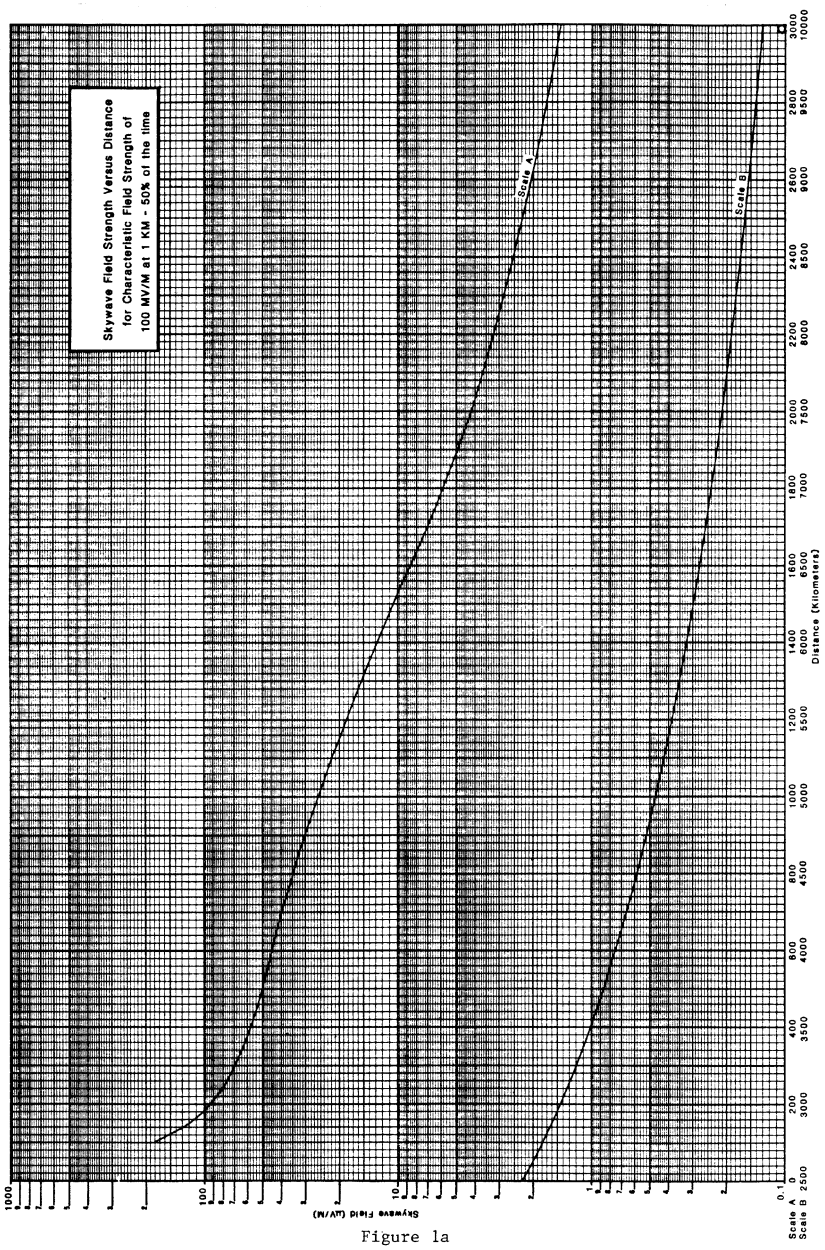

Skywave Field Strength Versus Distance
for Characteristic Field Strength of
100 MV/M at 1 KM - 50% of the time
Scale A
Scale B
Skywave Field (uV/M)
1000
100
10
1
0.1
Distance (Kilometers)
Scale A 0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000
Scale B 2500 3500 4000 4500 5000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

Figure 1a

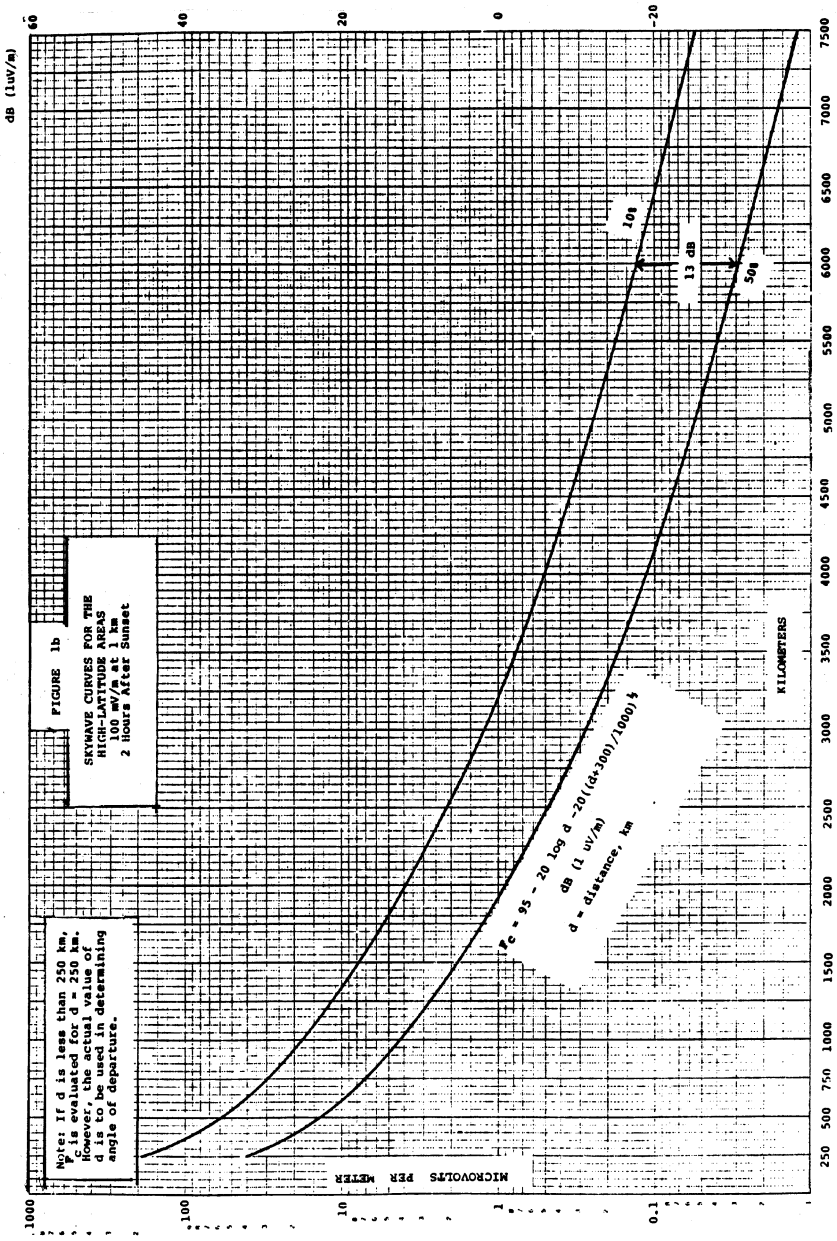
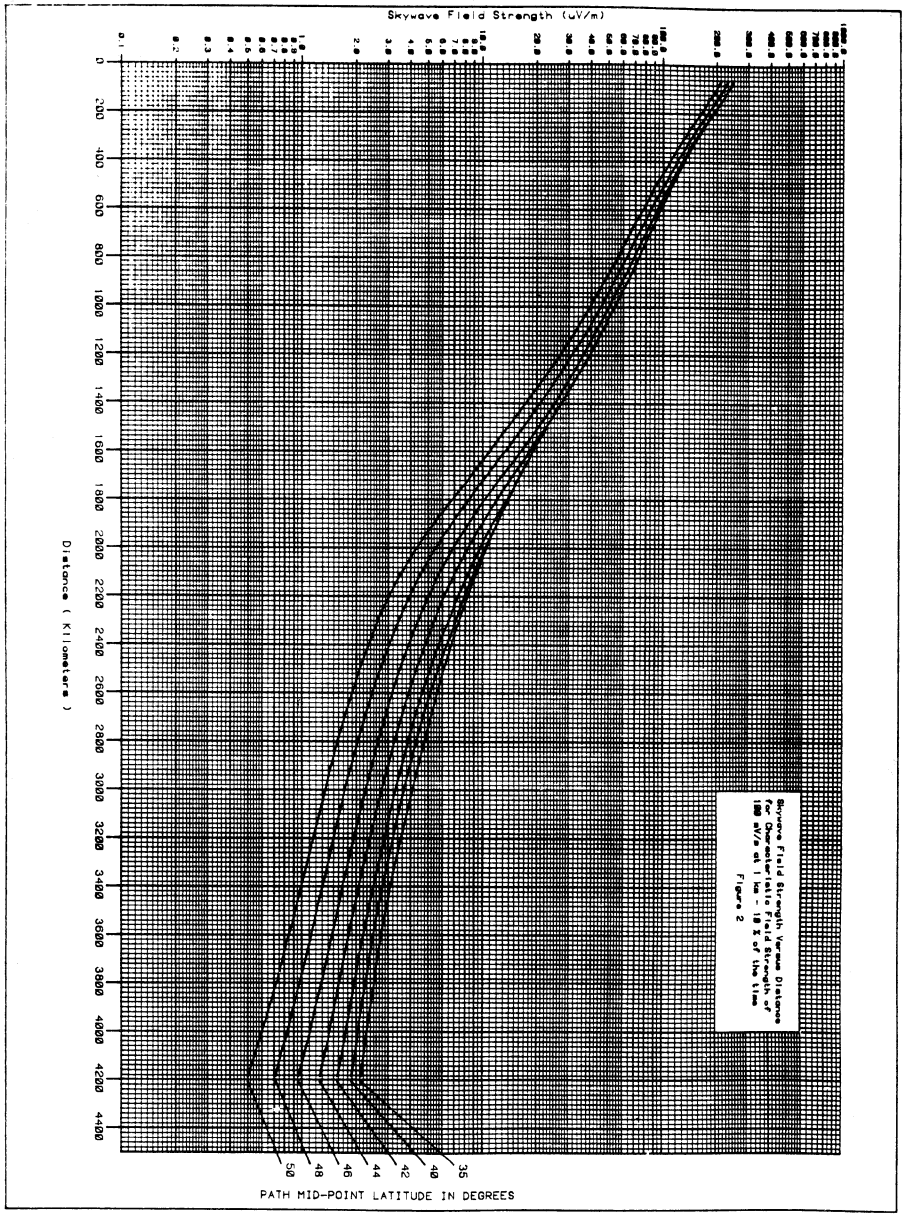


FIGURE 1b
SKYWAVE CURVES FOR THE HIGH-LATITUDE AREAS 100 mV/m at 1 km 2 Hours After Sunset
Note: If d is less than 250 km, Fc is evaluated for d = 250 km. However, the actual value of d is to be used in determining angle of departure.
Fc = 95 - 20 log d -20((d+300)/1000)½
dB (1 uV/m)
d = distance, km
10%
50%
13 dB
KILOMETERS
MICROVOLTS PER METER
dB (1uV/m)
60
40
20
0
-20
1000
100
10
1
0.1
250
500
750
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500


Skywave Field Strength Versus Distance
for Operational Field Strength of
100 mV/m at 1 hr - 10 % of the time
Figure 2
Skywave Field Strength (uV/m)
Distance (Kilometers)
PATH MID-POINT LATITUDE IN DEGREES
35
40
42
44
46
48
50

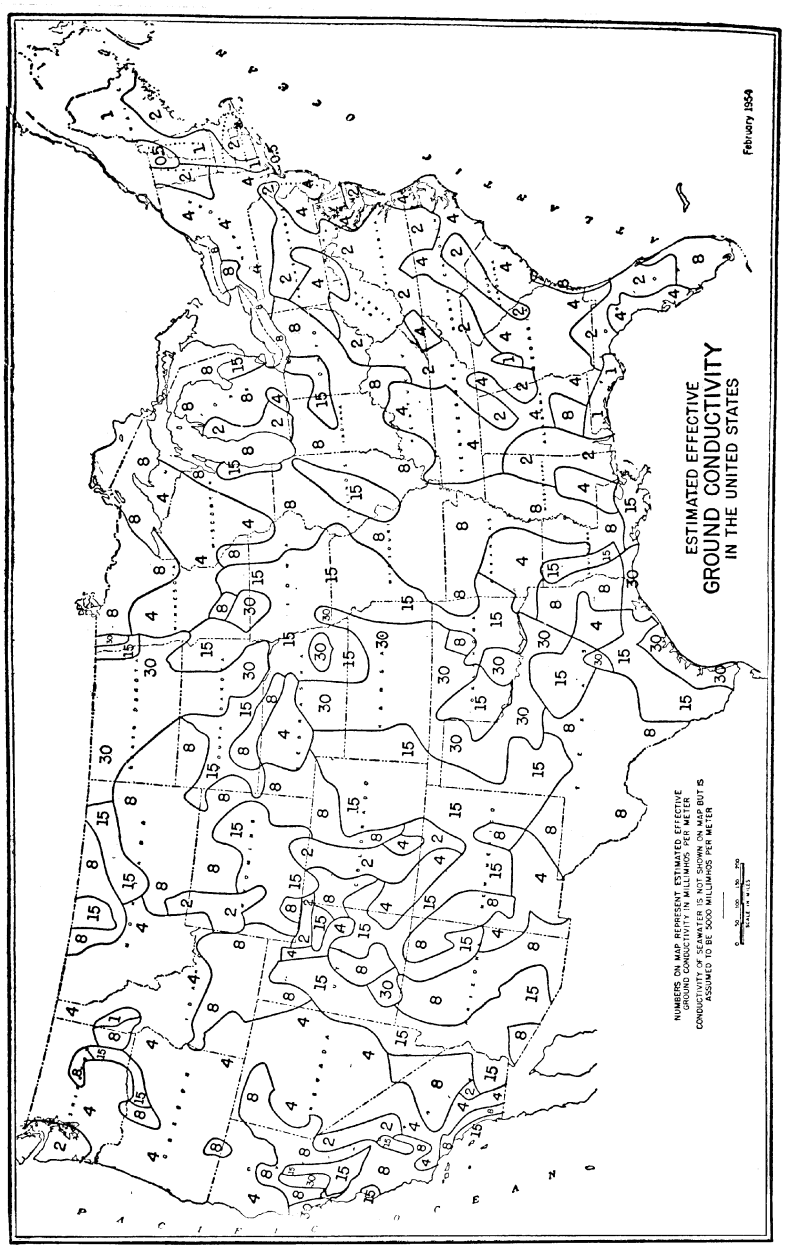

ESTIMATED EFFECTIVE
GROUND CONDUCTIVITY
IN THE UNITED STATES
February 1954
NUMBERS ON MAP REPRESENT ESTIMATED EFFECTIVE GROUND CONDUCTIVITY IN MILLIMHOS PER METER
CONDUCTIVITY OF SEAWATER IS NOT SHOWN ON MAP BUT IS ASSUMED TO BE 5000 MILLIMHOS PER METER

FIGURE R3.

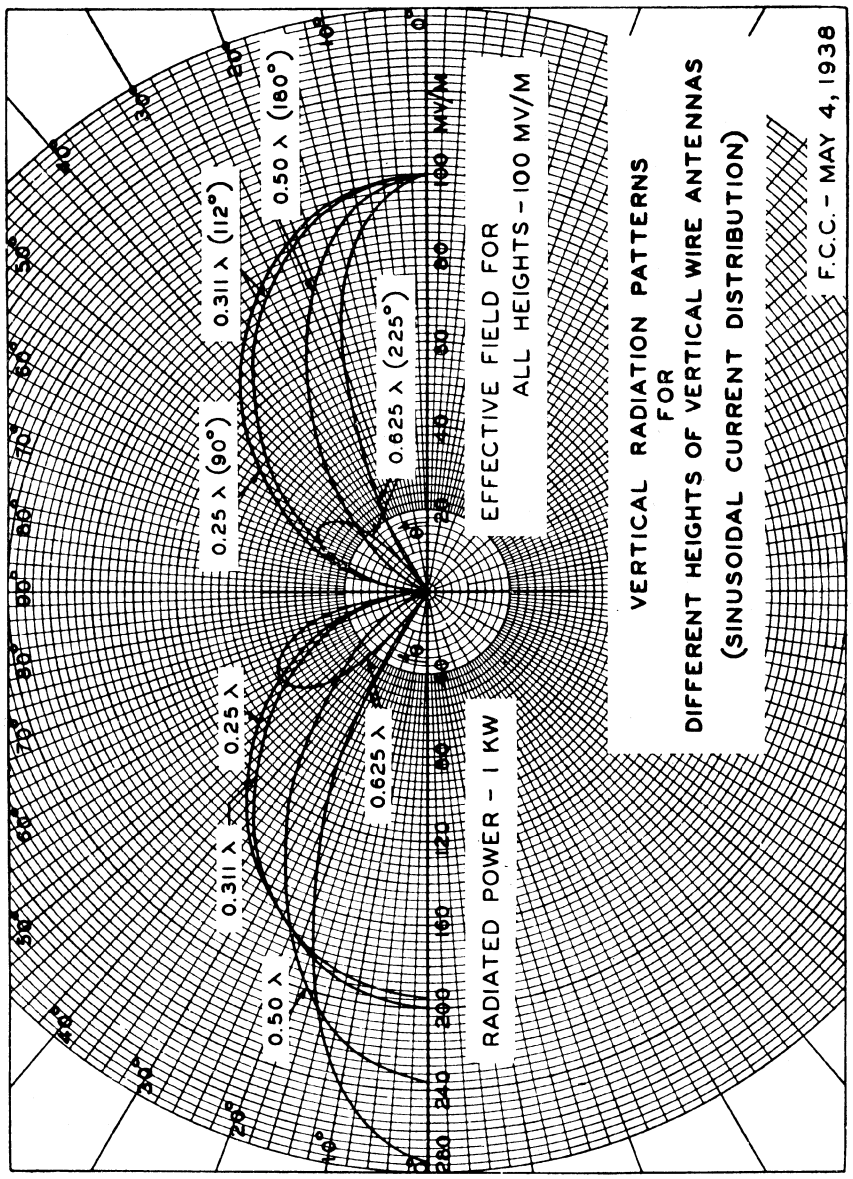
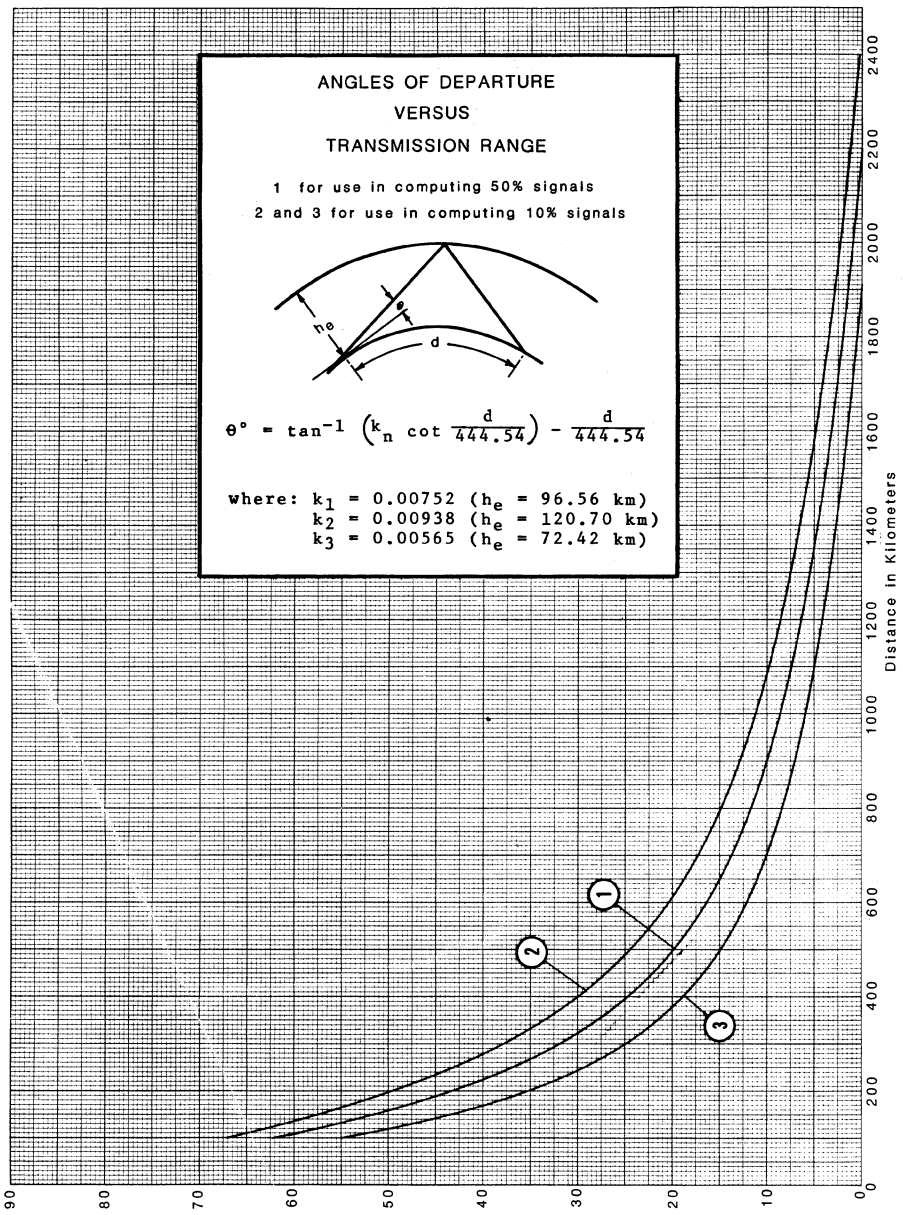

VERTICAL RADIATION PATTERNS
FOR
DIFFERENT HEIGHTS OF VERTICAL WIRE ANTENNAS
(SINUSOIDAL CURRENT DISTRIBUTION)
F.C.C. – MAY 4, 1938
RADIATED POWER – 1 KW
EFFECTIVE FIELD FOR
ALL HEIGHTS – 100 MV/M
0.311 λ
0.25 λ
0.50 λ
0.625 λ
0.25 λ (90°)
0.311 λ (112°)
0.625 λ (225°)
0.50 λ (180°)
MV/M

Figure 5



FCC §73.190 FIGURE 6a Corr. 11/86

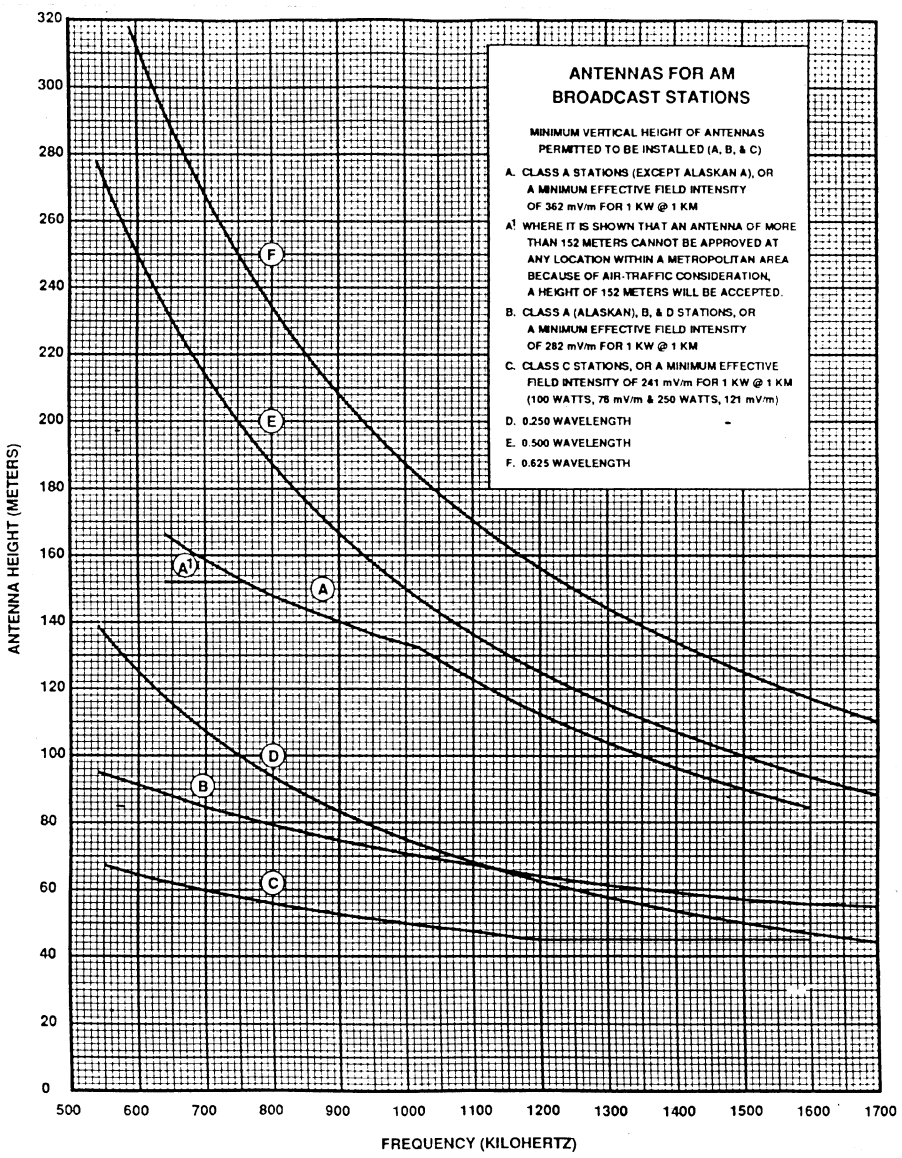

ANTENNAS FOR AM BROADCAST STATIONS
MINIMUM VERTICAL HEIGHT OF ANTENNAS PERMITTED TO BE INSTALLED (A, B, & C)
A. CLASS A STATIONS (EXCEPT ALASKAN A), OR A MINIMUM EFFECTIVE FIELD INTENSITY OF 362 mV/m FOR 1 KW @ 1 KM
A1 WHERE IT IS SHOWN THAT AN ANTENNA OF MORE THAN 152 METERS CANNOT BE APPROVED AT ANY 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, 76 mV/m & 250 WATTS, 121 mV/m)
D. 0.250 WAVELENGTH
E. 0.500 WAVELENGTH
F. 0.625 WAVELENGTH
ANTENNA HEIGHT (METERS)
FREQUENCY (KILOHERTZ)
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
A1
A
B
C
D
E
F

Figure 7

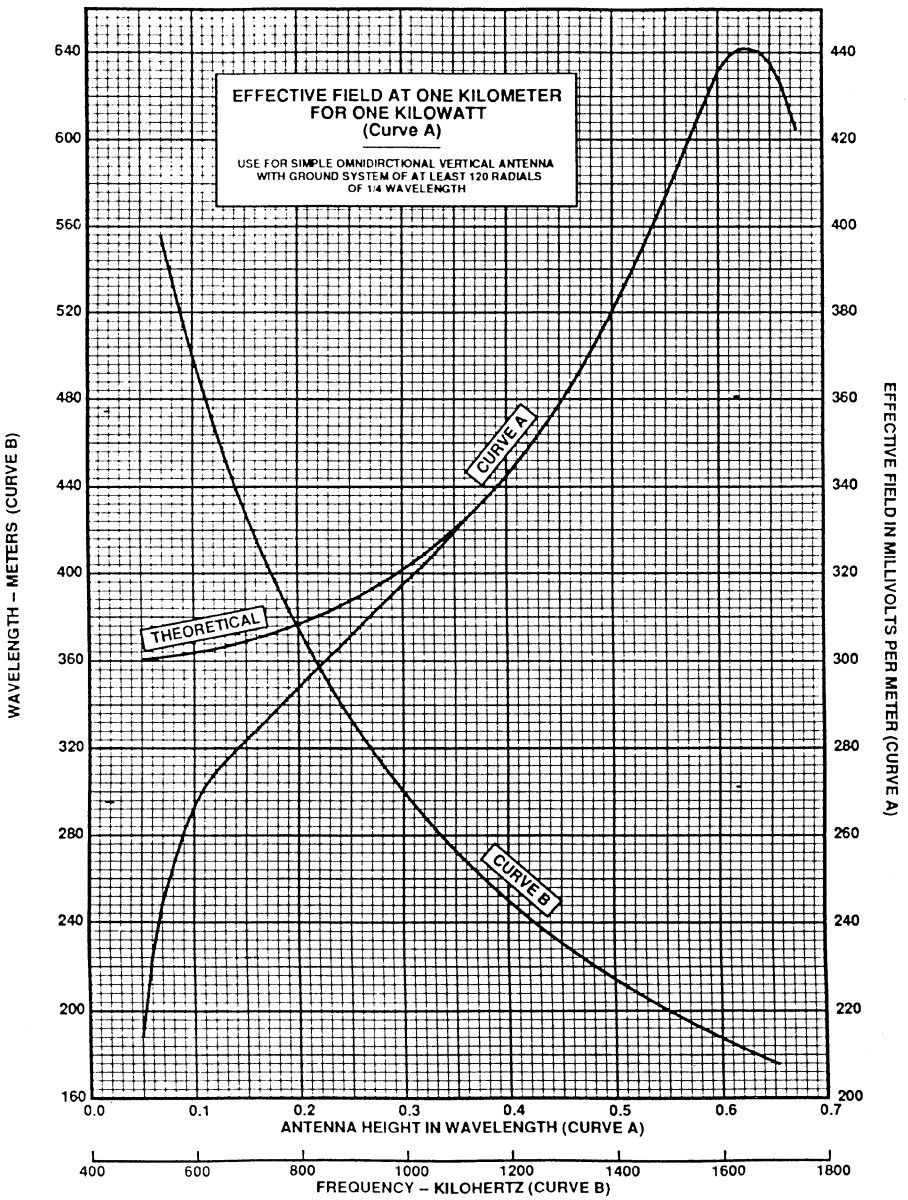

EFFECTIVE FIELD AT ONE KILOMETER
FOR ONE KILOWATT
(Curve A)
USE FOR SIMPLE OMNIDIRCTIONAL VERTICAL ANTENNA
WITH GROUND SYSTEM OF AT LEAST 120 RADIALS
OF 1/4 WAVELENGTH
CURVE A
THEORETICAL
CURVE B
WAVELENGTH – METERS (CURVE B)
EFFECTIVE FIELD IN MILLIVOLTS PER METER (CURVE A)
640
600
560
520
480
440
400
360
320
280
240
200
160
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

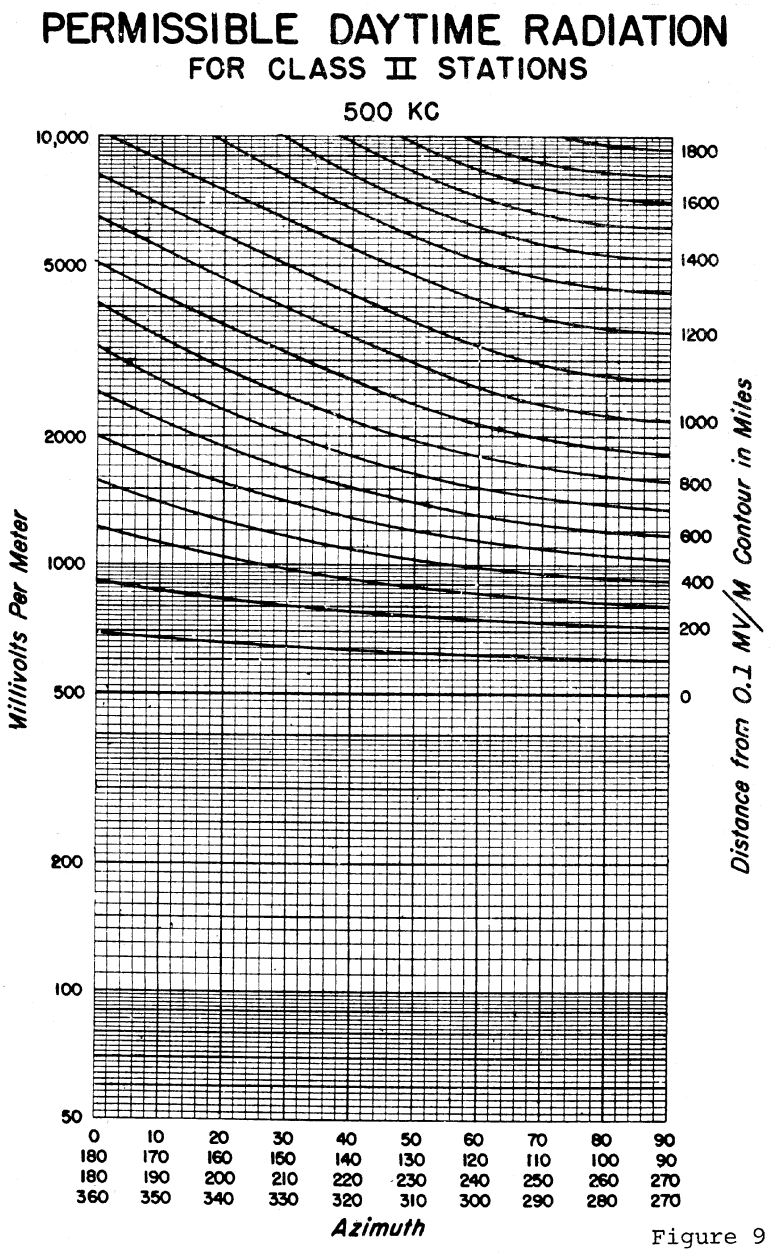

PERMISSIBLE DAYTIME RADIATION
FOR CLASS II STATIONS
500 KC
Millivolts Per Meter
10,000
5000
2000
1000
500
200
100
50
Distance from 0.1 MV/M Contour in Miles
1800
1600
1400
1200
1000
800
600
400
200
0
0 10 20 30 40 50 60 70 80 90
180 170 160 150 140 130 120 110 100 90
180 190 200 210 220 230 240 250 260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

Figure 9

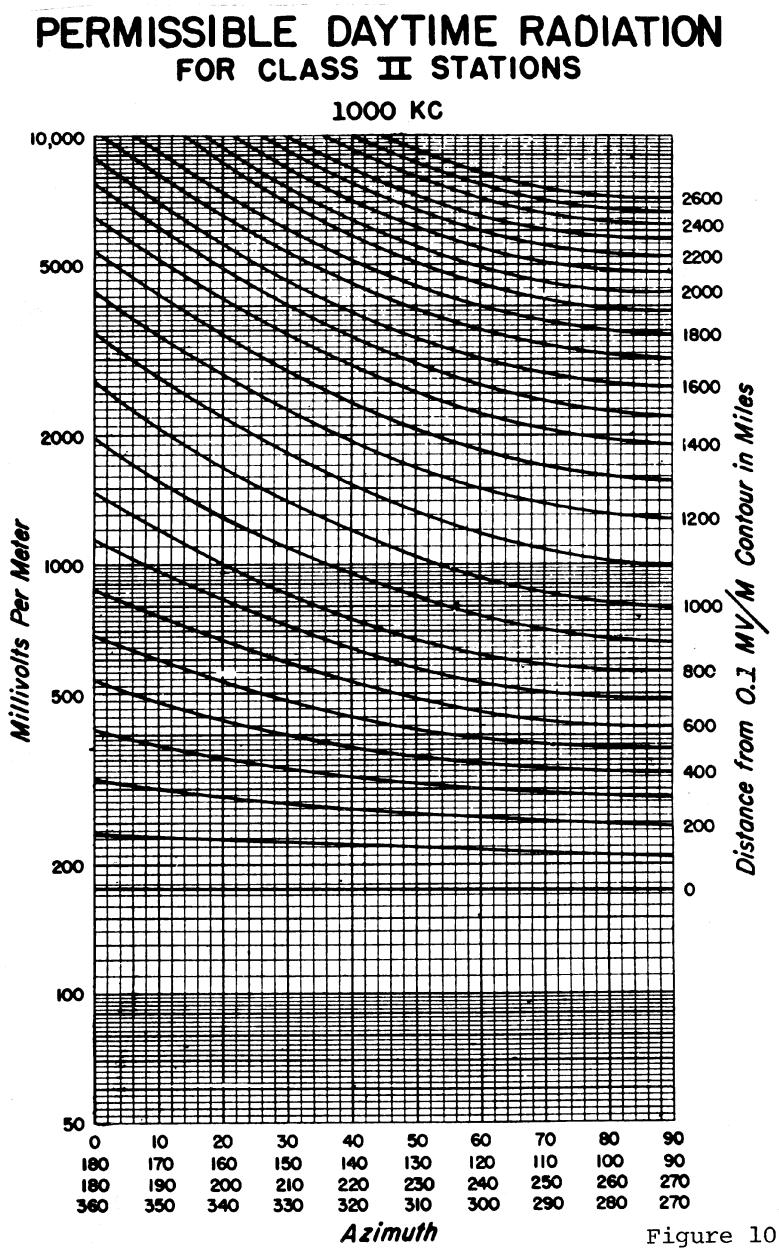

PERMISSIBLE DAYTIME RADIATION
FOR CLASS II STATIONS
1000 KC
Millivolts Per Meter
10,000
5000
2000
1000
500
200
100
50
Distance from 0.1 MV/M Contour in Miles
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0 10 20 30 40 50 60 70 80 90
180 170 160 150 140 130 120 110 100 90
180 190 200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

Figure 10

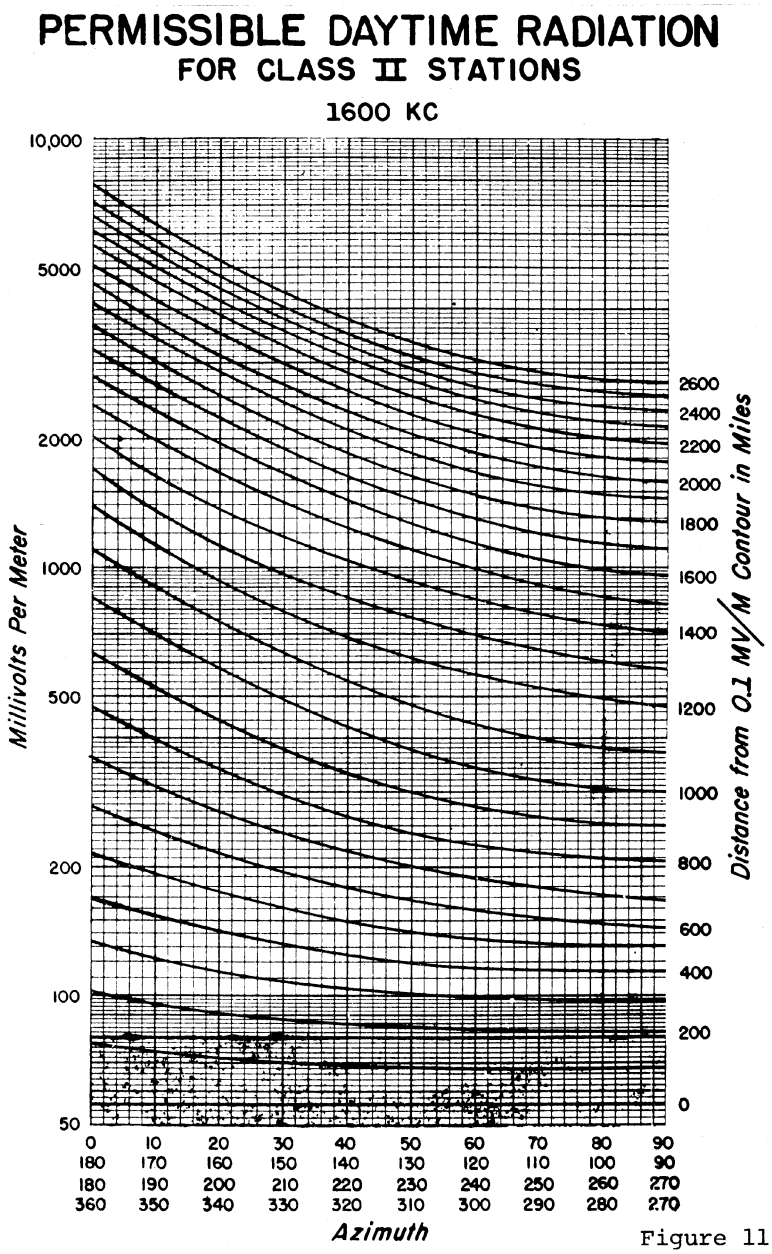
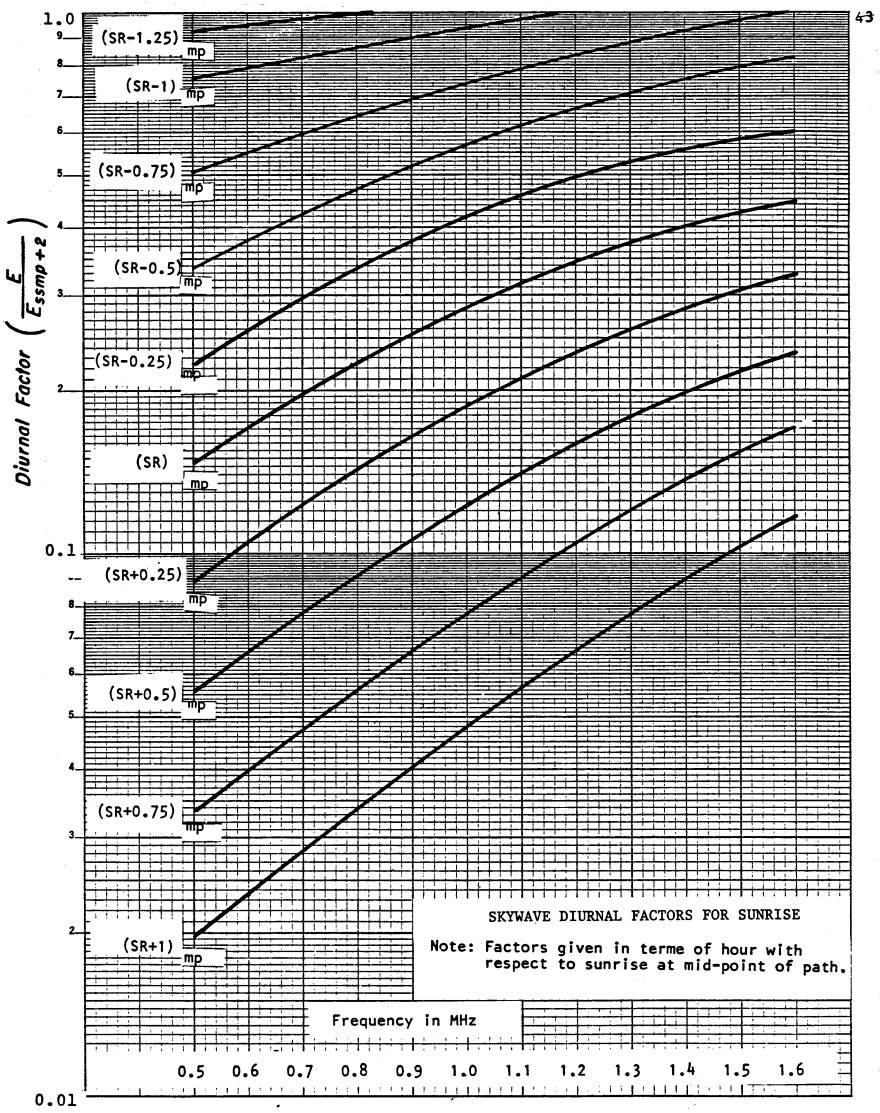
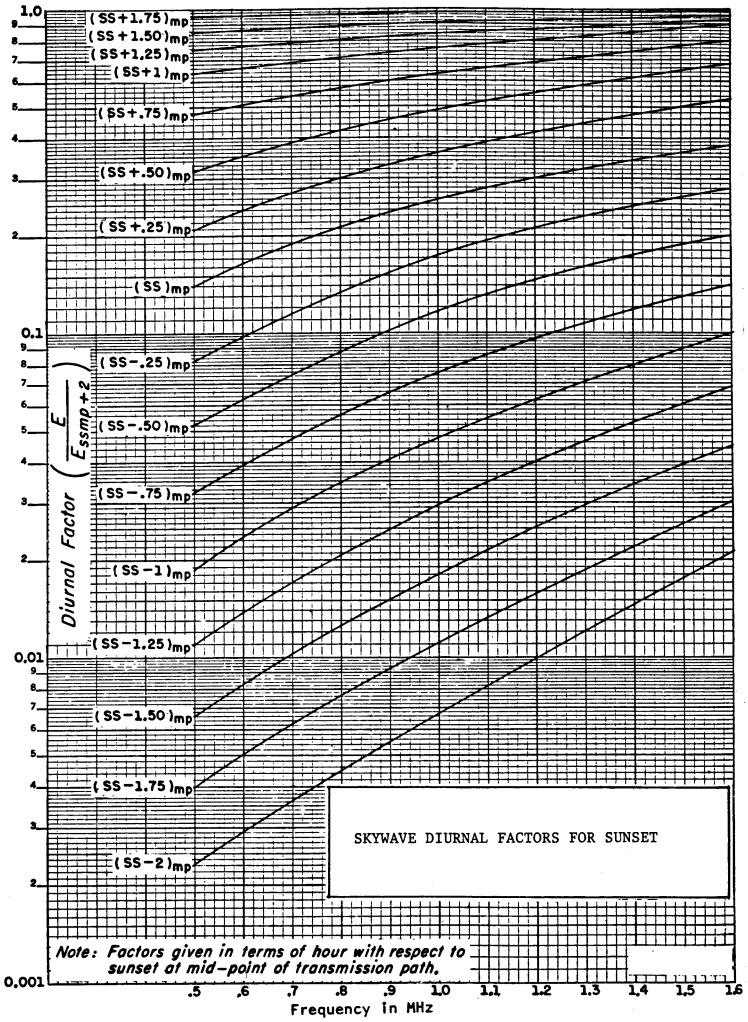

PERMISSIBLE DAYTIME RADIATION
FOR CLASS II STATIONS
1600 KC
Millivolts Per Meter
10,000
5000
2000
1000
500
200
100
50
Distance from 0.1 MV/M Contour in Miles
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0 10 20 30 40 50 60 70 80 90
180 170 160 150 140 130 120 110 100 90
180 190 200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