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DEVELOPMENT OF VHF AND UHF PROPAGATION CURVES
FOR TV AND FM BROADCASTING

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DEVELOPMENT OF VHF AND UHF PROPAGATION CURVES FOR TV AND FM BROADCASTING

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SUMMARY

New propagation curves for use in television and frequency modulation broadcasting were developed from an extensive analysis of data accumulated since these broadcasting services were established. A new method of applying terrain roughness factors for improving the accuracy of field strength predictions was developed for use with the new curves. The new curves apply for both the median and the field strength exceeded 10% of the time. At distances out to about 15 or 20 miles from the transmitter, the new VHF and UHF curves are nearly the same as those presently in the FCC Rules. At further distances, out to about 60 miles, the field strengths indicated by the new 500 foot VHF curves are within ± 2 dB of the present curves. The new 1000 and 2000 foot VHF curves are up to 6 dB lower than their existing counterparts out to 86 and 106 miles respectively for Channels 2-6, and out to 73 and 89 miles respectively for Channels 7-13, beyond which distances the new curves run up to 14 dB higher than the existing curves. For UHF the field strengths are somewhat lower than indicated by the present curves, reaching a maximum change at distances in the order of 60 miles. There is very little change for average UHF antenna heights for distances beyond 110 miles.

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INTRODUCTION

This revision of the FCC Report No. R-6502 (Ref. 1) presents the data and background material leading to the development of improved field strength propagation curves in the VHF and UHF bands, as proposed for use in television and frequency modulation broadcasting services by the Federal Communications Commission. The existing FCC rules contain VHF and UHF propagation curves developed in the late 1940's as a result of studies made by the Ad Hoc Committee for the evaluation of the radio propagation factors concerning television and frequency modulation broadcasting services in the frequency range 50-250 Mc/s, FCC Docket Nos. 8736, 8975, and 9175 (Ref. 2). Since then, additional field strength data have become available to the Commission and studies have been made to improve the accuracy of the existing curves. The first major step in this direction was taken in 1960 by the Radio Propagation Advisory Committee (RPAC) composed of engineers from the industry, the FCC, and other government agencies. Results of the RPAC efforts proved helpful in the subsequent work of the Commission's engineers in developing complete sets of VHF and UHF propagation curves, culminating in rule-making proceedings in Docket No. 16004 proposing the incorporation of the new curves in the FCC rules.

Subsequently, the Association of Federal Communications Consulting Engineers (AFCCE) filed a "Petition for Extension of Time for Filing Comments," indicating that the AFCCE could furnish additional measurement information, and requesting the Commission to call an Engineering Conference to consider the proposed new curves. This Conference was held on September 16, 1965. After reviewing the information available at the time, the Engineering Conference agreed to the formation of a Working Group consisting of a representative of AFCCE, FCC engineers, and volunteers from the industry and from other government agencies. This group made extensive studies of all information available, and developed new curves which incorporated a method of correction for terrain roughness. These curves were published in "Report of the Working Group for the Engineering Conference in Docket No. 16004, on the Development of New FM and TV Propagation Curves," dated April 12, 1966 (Ref. 3). This report also contained a nomogram for correcting the curves for other than average terrain, a brief description of the procedures used in developing the curves, and a recommendation that the curves and terrain corrections be adopted by the Commission for incorporation in the Rules and Regulations Governing Radio Broadcast Services.

In the present report, curves are shown for median locations and for field strength levels exceeded for 50 percent and 10 percent of the time. Values of field strength exceeded for 90 percent of the time may be obtained by assuming that the time fading follows the normal or Gaussian type of distribution, with symmetrical variation about the median level. In general, the fading ratios for VHF and UHF tend to follow the dB normal or Gaussian type of distribution, at least between the 10 percent and 90 percent levels. Throughout this report the median fields are indicated as F(50,50) fields and the interference fields as F(50,10) fields.

This nomenclature refers respectively to field strengths exceeded at 50 percent of the locations during at least 50 percent of the time, and at 50 percent of the locations during at least 10 percent of the time, following the general notation F(L,T) where L and T are location and time percentages.

TERRAIN ROUGHNESS

The new propagation curves are intended to be representative of propagation over average terrain in the United States. In order to make maximum use of the available data, which were taken over terrain of varying roughness, the data were adjusted by applying the correction factor described below. Several terrain roughness correction techniques were considered and the method described herein was found to be most readily adaptable to the job at hand. In this method the CCIR criterion for roughness (Ref. 4) was used to determine a terrain roughness factor for each radial.

Using this criterion for determining roughness, an analysis was made of data from VHF and UHF surveys involving 118 radials, with path-lengths ranging from about 10 to 90 miles. For each radial, the deviation of field strength from the overall average for the pertinent frequency range (low VHF, FM, high VHF and UHF) was found. There was no significant variation of the correction factor with distance from the transmitter. The deviations for all radials were plotted to determine the trends of field strength variations with wavelength and Δh. This analysis resulted in the derivation of the following equation:

$$\Delta F_o = 0.03 \ \Delta h \left[\frac{\lambda + 1}{\lambda}\right] = 0.03 \ \Delta h \left[1 + \frac{f}{300}\right]$$

where ΔF_o is the change in field strength due to variations in terrain roughness, in dB,
λ is the wavelength in meters,
f is the frequency in Mc/s and
Δh is the CCIR terrain roughness factor, i.e. the difference (meters) in elevation between the levels exceeded for 10 and 90 percent of the terrain along the radial in the range 10 to 50 kilometers (6 to 31 miles) from the transmitter. See Figure 1.

This equation is plotted in Figure 2, along with the data used in deriving it. In the development of the final propagation curves it was assumed that a value of Δh equal to 50 meters was appropriate for average terrain roughness in the United States, and the data were adjusted to this average using the above equation.

After the final field strength curves were derived, the root-mean-squares of the deviations of the mobile data from the F(50,50) curves, with and without the terrain roughness correction, were calculated for the various frequency ranges. These values are shown in Table I. Also shown in Table I are the root-mean-squares of the deviations for WHYN-FM and WHYN-TV, channel 40, Springfield, Massachusetts and channels 2, 7, and 31 in New York City. The Springfield data were included to show the effect of the roughness correction in areas where the terrain is extremely rough. The New York City data are of particular interest in correlating frequency with other parameters because measurements were made over the same paths for all three stations. It should be kept in mind that the values for individual stations may be in error due to uncertainty in determining the effective radiated power in a given direction.

TABLE I

	Without terrain roughness correction dB	With terrain roughness correction dB	Difference dB
Low VHF	9.0	7.7	1.3
High VHF	7.4	6.8	0.6
UHF	14.2	9.3	4.9
N. Y. Channel 2	5.8	4.4	1.4
N. Y. Channel 7	9.9	6.7	3.2
N. Y. Channel 31	10.6	7.3	3.3
WHYN-FM	17.2	12.1	5.1
WHYN-TV	22.6	10.8	11.8

The deviations used in calculating these values were for the average or median field strength over 10-mile radial segments from 10 to 60 miles from the transmitter. The relatively low values for high VHF were largely due to the fact that nearly all these data were taken over relatively smooth terrain.

The curves in Figure 3 may be used for adjusting the new propagation curves (Figures 17, 18, 19, 20, 29 and 30) for terrain roughness. Where greater detail is required in determining variations due to frequency, the curves in Figure 3 may be applied by interpolation within the frequency ranges for which the propagation curves were designed. This procedure would be especially useful for Channels 14 to 83 curves, where terrain variations have greater influence on propagation as affected by frequency The new propagation curves were designed to represent approximate centers of the respective frequency bands at 75, 195 and 650 Mc/s.

The corrections for terrain roughness are intended for application in estimating median (or average) field strengths over areas where the general character of the terrain is fairly uniform, or where there is no abrupt change in terrain roughness. It is not possible to accurately predict the field strength at any given receiver site. Useful predictions are possible when medians are required in describing the distributions of field strength over areas of appreciable extent. The standard error of estimate for median values will diminish when the area under consideration is increased.

The data available in formulating the empirical equation for ΔF_o provided information for distances out to about 60 miles, and for values of Δh up to 400 meters. At distances beyond 60 miles, for both the F(50,50) and F(50,10) curves, the terrain roughness corrections should be used with caution pending the development of better information from measurements which may be accumulated later for these distances.

It is recognized that many considerations other than overall terrain roughness, such as obstructions of hills, trees, etc., antenna heights, local structural environment, inclination of the land, and weather conditions over the propagation path, will all contribute toward variations of individual measurements of field strength. As further experience is gained in the study of these effects, greater accuracy in the prediction of field strength coverage will be possible.

DIURNAL AND RECEIVER LOCATION BIAS CORRECTIONS

A review of the available data indicated that the differential between the day and night field strengths was negligible in the VHF bands, insofar as any adjustment for mobile measurements taken in daylight hours was concerned. In the UHF band, a diurnal correction was applied for adjusting the daytime mobile measurements as follows:

$D - D_{LS}$ in Miles	Diurnal Correction in dB
Less than -15	0
-15 to 5	+1
5 to 15	+2
15 to 35	+3
35 to 45	+2
45 to 55	+1
More than 55	0

Most of the fixed-point, long-term measurements were made at sites which were engineered to take advantage of the surrounding terrain, thus making them in effect, "preferred" locations, while all other measurements were adjusted to conform with average terrain conditions in the derivation of the new curves. An examination of measurements taken at randomly selected locations at 85 and 125 miles from FM stations in Ohio (1959 TASO Report, Page 313; Ref. 5) provides information applicable to the correction of long-term measurements made at "preferred" locations. From this study it was estimated that the fixed-location, long-term data should be corrected by -4 dB on VHF, and by -6 dB on UHF.

GENERAL DEVELOPMENT PROCEDURES

The development of the curves was divided into three major parts: (1) Low band VHF, including the FM band, 54 to 108 Mc/s; (2) high band VHF, 174 to 216 Mc/s; and (3) UHF, 470 to 890 Mc/s. Examination of the available information and data in each of the three frequency ranges resulted in the determination of antenna height-gain relationships, of terrain correction factors, of fading ratios for the F(50,10) curves, and of frequency effects. The various curves for all these parameters were drawn and redrawn until the smoothest possible coherence was obtained, and until the best possible fit with the data was shown, considering the natural correlations between all these variable factors.

In this report the transmitter antenna height was considered to be the height of the electrical center of the antenna above the average of all elevations within the range from 2 to 10 miles from the antenna. When sufficient information was available, these elevations were taken along the radial in the direction of the receiver.

The details of the development of the VHF and UHF curves are treated separately later in this report. However, the general procedure was the same, namely, the derivation of a base curve through the corrected data and derivation of a family of curves from this base curve. These derivations were made in two steps; within-the-horizon curves, and beyond-the-horizon curves, with the two merged together near the radio horizon. For transmitting antennas within the radio horizon, linear height gain was assumed. For height gains beyond the horizon a $D - D_{LS}$ relationship described below was applied. Departure from linear height gain occurs close in where the curves are restricted from exceeding free-space fields, and near the horizon where one antenna is within line-of-sight and other lower antennas are beyond the line-of-sight.

For distances beyond the horizon, height gain was based on studies made by the Radio Propagation Advisory Committee, and by the National Bureau of Standards, which indicate that field strength is a function of distance between horizons (Refs. 5, 6, 7, 8). Using this concept, the attenuation of field strength well beyond the radio horizon can be represented as the result of two trends: a trend of 10 log D (D = transmitting distance) plus a trend with distances beyond the horizon, $D - D_{LS}$, where D_{LS} is the line-of-sight distance. All of the pertinent beyond-the-horizon data adjusted by 10 log D were plotted versus the appropriate $D - D_{LS}$ values, with best fit base curves drawn through such data (Figures 4, 5, 22 and 24). The long-term fixed-location data used in this project are listed in Tables II, III and IV. The relative weights indicated in these tables were assigned according to the degree in which the measurements were likely to contain seasonal or diurnal bias, ranging from 1 for little or no bias to 4 for heavily biased data.

For each frequency range, families of beyond-the-horizon field strength versus distance curves were derived from the appropriate best fit base curves for various heights of transmitting antennas in the following manner. For a given transmitting antenna height, the field strength at a distance D can be determined by reading the F + 10 log D value from the best fit base curve at a distance equal to $D - D_{LS}$, and subtracting 10 log D, where

F = field strength in dB above 1 microvolt/meter,

$D_{LS} = \sqrt{2H_t} + \sqrt{2H_r}$ (miles), and H_t, H_r are the transmitting and receiving antenna heights respectively in feet.

The mobile measurements were made along radials at intervals of about two miles, using the technique described by TASO (Ref. 5). At each of these road segments the mobile field strength measuring vehicle was driven slowly for a distance of about 100 feet with the antenna extended to a height of 30 feet above ground. Chart recordings were made for each of these runs. The sources of these data are shown in Table V.

TABLE II - Low Band VHF Data

Pt. No.	Transmitter Location	Receiver Location	Call Letters	Source	References	Recording From	Period To	Distance (miles)	Frequency Mc/s	H_t (feet)	H_r (feet)	$D-D_{IS}$ (miles)	F (1) (dBuV/m for 1 kw)	F (10) (dBuV/m for 1 kw)	F (50) (dBuV/m for 1 kw)	Relative Weight
1	Chicago, Ill.	Urbana, Ill.	WNBQ	CRPL		10/50	4/51	126.3	81.75	595	110	77.0	33.7	25.8	14.0	2
2	Omaha, Neb.	Gr. Island, Neb.	WOW	CRPL		4/51	6/51	130.7	81.75	570	30	89.2	10.6	5.3	0.5	3
3	Omaha, Neb.	Gr. Island, Neb.	KMTV	FCC		7/51	12/51	131.4	65.75	590	30	94.7	17.3	9.1	0.2	2
4	Houston, Texas	Austin, Texas	KPRC	CRPL		3/51	12/53	142.7	59.75	500	32	105.7	18.7	13.0	3.9	1
5	Detroit, Mich.	Allegan, Mich.	WJBK	CRPL		10/52	4/53	144.1	59.75	485	30	107.5	8.2	-0.5	-8.4	2
6	Chicago, Ill.	Urbana, Ill.	WBKB	U. of Ill.		1/52	1/53	126.6	71.75	650	90	75.8	28.4	19.4	9.8	1
7	Phila, Pa.	Laurel, Md.	WPTZ	FCC	TID 2.4.6	3/44	7/44	108.0	71.75	286	30	76.4		23.7	11.9	3
8	New York, N. Y.	Princeton, N. J.	WABD	FCC	TID 2.4.6	8/45	9/45	46.0	83.75	647	30	2.4	51.8	44.3	39.0	4
9	New York, N. Y.	Andalusia, Pa.	WABD	FCC	TID 2.4.6	8/45	9/45	71.0	83.75	647	30	27.4	44.6	30.1	17.6	4
10	New York, N. Y.	Laurel, Md.	WABD	FCC	TID 2.4.6	8/45	9/45	187.0	83.75	647	50	141.1	26.1	12.1	4.1	4
11	Chicago, Ill.	Allegan, Mich.	WBKB	FCC	TID 2.4.6	10/41	1/42	103.0	65.75	390	50	65.1		11.1	2.3	3
12	Alpine, N. J.	Laurel, Md.	W2XMN	FCC	TID 2.4.6	2/43	1/44	198	42.8	800	30	150.3	3.9	4.9	-11.7	1
13	Paxton, Mass.	Laurel, Md.	WGTR	FCC	TID 2.4.6	2/43	1/44	337	44.3	737	30	290.9	-14.4	-22.0	-31.0*	1
14	Phila. Pa.	Laurel, Md.	KYW-FM	FCC	TID 2.4.6	2/43	9/43	104	45.7	346	30	70.0	21.6	12.1	7.6	2
15	Milwaukee, Wis.	Allegan, Mich.	WMFM	FCC	TID 2.4.6	10/43	8/44	122	45.5	711	50	74.3	17.2	9.0	3.0	2
16	New York, N. Y.	Andalusia, Pa.	WABC-FM	FCC	TID 2.4.6	8/45	9/45	70	46.7	780	30	22.8	31.6	25.8	16.4	4
17	New York, N. Y.	Laurel, Md.	WABC-FM	FCC	TID 2.4.6	8/45	9/45	186	46.7	780	50	136.5	25.5	15.8	7.2	4
18	Milwaukee, Wis.	Deerfield, Ill.	WMFM	FCC	TID 2.4.6	8/45	9/45	76.3	45.5	390	30	40.7	35.3	30.5	19.2	4
19	New York, N. Y.	Riverhead, N. Y.	W2XWG	FCC	TID 2.4.6	2/41	6/42	70	45.1	1270	60	8.8	45.9	38.7	32.5	1
20	New York, N. Y.	Princeton, N. J.	WBAM	FCC	TID 2.4.6	5/46	5/47	45	47.1	600	50	0.4	41.6	33.6	30.7	1
21	New York, N. Y.	Southampton, Pa.	WBAM	FCC	TID 2.4.6	5/46	11/46	68	47.1	600	30	25.7	31.5	25.3	18.0	3
22	New York, N. Y.	Laurel, Md.	WBAM	FCC	TID 2.4.6	5/46	5/47	186	47.1	600	30	143.7	15.5	6.2	-6.1	1
23	Alpine, N. J.	Riverhead, N. Y.	W2XMN	FCC	TID 2.4.6	6/47	11/47	66	44.1	770	60	16.0	45.0	37.0	30.0	3
24	Alpine, N. J.	Riverhead, N. Y.	W2XMN	FCC	TID 2.4.6	6/47	11/47	66	44.1	770	30	19.2	38.0	30.0	22.0	3
25	Alpine, N. J.	Westhampton Beach, N.J.	W2XMN	FCC	TID 2.4.6	9/47	10/47	67	44.1	770	40	18.9	38.8*	35.2	28.0	4
26	Alpine, N. J.	Mt. Holly, N. J.	W2XMN	FCC	TID 2.4.6	2/49	3/49	80	44.1	800	40	31.0	24.1*	17.5	12.5	4
27	Cheyenne Mtn. S	Fayetteville, Ark.		CRPL		8/52	2/53	617.7	100.0	2271	38	541.6			-49.3	4
28	Fresno, Cal.	Livermore, Cal.	KARM-FM	FCC	Prog.Rpt#4	7/51	12/51	121.7	101.9	360	30	82.2	16.3	9.6	1.4	1
29	Chico, Cal.	Livermore, Cal.	KVCI-FM	FCC	" " "	7/51	12/51	138.5	101.1	482	30	119.0	15.1	8.0	-2.1	2
30	Chicago, Ill.	Allegan, Mich.	WENR-FM	CRPL		7/50	7/52	118.5	94.7	605	30	76.3	27.7	18.1	8.6	1
31	Anderson, S. C.	Powder Springs, Ga.	WCAC-FM	CRPL		4/51	9/52	127.5	101.1	375	30	92.4	23.5	14.2	5.3	1
32	St. Louis, Mo.	Urbana, Ill.	KXOK-FM	CRPL		1/51	6/52	146.5	93.7	550	90	99.9	19.0	12.0	5.0	1
33	Chicago, Ill.	Urbana, Ill.	WMBI-FM	CRPL		1/51	6/52	126.0	95.5	440	90	82.9	23.3	16.1	5.8	1
34	Columbus, Ind.	Urbana, Ill.	WCSI-FM	CRPL		7/50	6/52	139.0	93.7	250	90	103.2	15.4	8.5	-0.6	1
35	Youngstown, Ohio	Hudson, Ohio	WABN-FM	CRPL		1/51	11/52	44.9	98.9	592	30	2.7	43.7	37.9	35.0	1
36	Youngstown, Ohio	Hudson, Ohio	WFMJ-FM	CRPL		11/52	6/53	45.7	105.1	395	30	9.8	40.6	36.2	33.1	2

H_t = Average 2-10 mile height, transmitter

$D_{IS} = \sqrt{2H_t} + \sqrt{2H_r}$

F(1), F(10), F(50) = Field strength in dB above 1 uV/m for 1 kw exceeded for 1, 10, and 50 percent of time.

CRPL - FCC Project Prog. Report No. 4 10/1 to 12/31, 1951

H_r = Height above ground, receiver

* Extrapolated

TABLE II - Low Band VHF Data (Continued)

Pt. No.	Transmitter Location	Receiver Location	Call Letters	Source	Reference	Recoring From	Period To	Distance (miles)	Frequency Mc/s	H_t (feet)	H_r (feet)	$D-D_{LS}$ (miles)	F (1) (dBuV/m for 1 kw)	F (10) (dBuV/m for 1 kw)	F (50) (dBuV/m for 1 kw)	F(10)-F(50) dB	Relative Weight
37	Sacramento, Calif.	Livermore, Calif.	KXOA-FM	CRPL		8/53	6/54	62.0	107.9	187	30	34.9	27.3	22.2	16.3	5.9	2
38	Sacramento, Calif.	Livermore, Calif.	KCRA-FM	CRPL		7/53	6/54	63.6	96.1	392	30	27.9	46.5	41.1	35.0	6.1	1
39	San Antonio, Texas	Austin, Texas	KTSA-FM	CRPL		4/50	10/50	74.2	101.5	322	32	40.8	27.5	21.0	13.8	7.2	3
40	San Antonio, Texas	Austin, Texas	KYFM-FM	CRPL		9/49	4/50	78.1	101.5	472	32	39.4	>29.5	24.1	16.0	8.1	3
41	Reading, Pa.	Laurel, Md.	WEEU-FM	CRPL		9/51	11/52	95.6	92.9	534	30	55.2	27.5	19.9	12.0	7.9	2
42	Pittsburgh, Pa.	Hudson, Ohio	KDKA-FM	CRPL		2/52	6/53	96.7	92.9	736	30	50.6	23.1	13.5	3.7	9.8	1
43	Fresno, Calif.	Livermore, Calif.	KMJ-FM	CRPL		1/53	6/53	117.8	97.9	1042	30	64.4	11.2	5.3	-0.4	5.7	1
44	Fresno, Calif.	Livermore, Calif.	KRFM-FM	CRPL		8/52	9/52	135.5	93.7	1925	30	65.7	26.9	23.8	19.4	4.4	4
45	Detroit, Mich.	Allegan, Mich.	WDET-FM	CRPL		10/52	5/53	139.5	101.9	320	30	106.5	6.5	-0.3	-8.5	8.2	2
46	New York, N. Y.	Millis, Mass.	WEVD-FM	CRPL		9/52	5/53	167.9	197.5	340	30	134.1	19.3	2.4	-8.4	6.0	2
47	Tampa, Fla.	Ft. Lauderdale, Fla.	WDAE-FM	CRPL		8/52	9/53	185.7	100.7	390	30	150.1	20.3	14.2	7.9	6.3	1
48	Orlando, Fla.	Ft. Lauderdale, Fla.	WHOO-FM	CRPL		10/52	7/53	185.8	96.5	460	30	147.3	22.4	12.7	3.6	9.1	1
49	Clingman's Pk. N. C.	Powder Springs, Ga.	WMIT-FM	CRPL		5/52	7/53	189.5	106.9	3618	30	96.7	13.1	2.9	-3.6	6.5	1
50	Cheyenne Mtn. B	Kendrick, Colo.		CRPL		12/52	7/53	49.4	92.0	1376	37	-11.7	50.2	47.4	45.3	2.1	2
51	Cheyenne Mtn. B	Karval, Colo.		CRPL		11/52	7/53	70.2	92.0	1416	37	8.4	43.4	38.6	35.1	3.5	2
52	Cheyenne Mtn. S	Haswell, Colo.		CRPL		2/52	8/53	96.6	100.0	2271	19	23.0	41.6	33.0	27.6	5.4	1
53	Cheyenne Mtn. B	Haswell, Colo.		CRPL		2/52	3/52	96.8	92.0	1482	37	33.8	36.0	24.1	15.7	8.4	2
54	Cheyenne Mtn. S	Garden City, Kans.		CRPL		2/52	8/54	223.5	100.0	2271	19	152.9	-2.8	-10.7	<-17.1	6.4	1
55	Cheyenne Mtn. S	Marble, Colo.		CRPL		2/54	8/54	141.0	100.0	2271	32	65.7			16.7	---	3
56	Portland, Ore.	Seattle, Wash.	KOIN-FM	CRPL		6/51	6/53	141.1	101.1	1812	94	79.5	4.4	-0.1		---	1
57	Ft. Carson, Colo.	Garden City, Kans.		CRPL		8/52	2/53	223.5	100.0	40	19	208.5		-1.9	-8.9	7.0	4
58	Ft. Carson, Colo.	Anthony, Kans.		CRPL		8/52	2/53	390.7	100.0	40	39	372.9			-32.2	---	4
59	Cheyenne Mtn. S	Anthony, Kans.		CRPL		7/52	3/53	393.5	100.0	2271	39	317.3			-28.4	---	2
60	Ft. Carson, Colo.	Fayetteville, Ark.		CRPL		8/52	2/53	614.0	100.0	40	38	596.3			-52.4	---	4
61	Ft. Carson, Colo.	Kendrick, Colo.		CRPL		8/52	2/53	46.6	100.0	40	19	31.5		29.0	27.0	2.0	4
62	Ft. Carson, Colo.	Karval, Colo.		CRPL		2/54	3/54	68.0	100.0	40	19	52.9		25.3	21.8	3.5	4
63	Harrisburg, Pa.	Laurel, Md.	WABX-FM	FCC		7/51	8/51	75.8	100.9	52	30	57.9		4.4		---	4
64	Ft. Carson, Colo.	Haswell, Colo.		CRPL		8/52	3/54	93.8	100.0	40	19	78.7			2.0	---	3
65	Mobile, Ala.	Pwdr. Sprgs., Ga.	WABB-FM	FCC		9/52	3/53	291.2	102.1	285	30	260.0	-5.4	-18.7	-29.5	10.8	1
66	Pittsburgh, Pa.	Laurel, Md.	KDKA-FM	FCC				188.7	92.9	610	30	144.4		-5.7		---	4
67	Cheyenne Mtn. B	Garden City, Kans.		CRPL		2/52	3/54	226.6	92.0	1482	37	163.6	-11.7	-16.0	-20.4	4.4	2
68	Cheyenne Mtn. S	Anthony, Kans.		CRPL		2/52	3/53	393.5	100.0	2002	39	321.4			-37.3	---	4
69	New York, N. Y.	Princeton, N. J.	WBAM	FCC	TRR 2.4.12	5/46	5/47	45.0	106.5	600	50	0.4	52.0	47.1	43.0	3.1	1
70	New York, N. Y.	Southampton, Pa.	WBAM	FCC	TRR 2.4.12	5/46	11/46	63.0	106.5	600	30	25.7	45.1	35.6	26.0	9.6	2

H_t = Average 2-10 mile height, transmitter

$D_{LS} = \sqrt{2H_t} + \sqrt{2H_r}$

H_r = Height above ground, receiver

F(1), F(10), F(50) = Field strength in dB above 1uV/m for 1 kw exceeded for 1, 10, and 50 percent of time.

* Extrapolated

TABLE II - Low Band VHF Data (Continued)

Pt. No.	Transmitter Location	Receiver Location	Call Letters	Source	Reference	Recording From	Period To	Distance (miles)	Frequency Mc/s	H_t (feet)	H_r (feet)	$D-D_{LS}$ (miles)	F (1) (dBuV/m for 1 kw)	F (10) (dBuV/m for 1 kw)	F (50) (dBuV/m for 1 kw)	F(10)-F(50) dB	Relative Weight
71	New York, N. Y.	Laurel, Md.	WBAM	FCC	TRR 2.4.12	5/46	5/47	186.0	106.5	600	30	143.7	9.2	-4.2	-22.4*	18.2*	1
72	New York, N. Y.	Andalusia, Pa.	W2XRA	FCC	TRR 2.4.12	8/45	9/45	70.0	107.0	714	30	24.7	50.1	36.3	19.6	16.7	4
73	Portsmouth, Va.	Washington, D. C.	WSAP	FCC	TRR 2.4.12	5/48	1/49	152.0	99.7	360	32	112.4	27.8	17.0	5.3	11.7	2
74	Richmond, Va.	Washington, D. C.	WCOD	FCC	TRR 2.4.12	6/47	8/47	96.0	96.3	376	35	56.2	36.9	27.7	18.0	9.3	4
75	Alpine, N. J.	Riverhead, N. Y.	W2XEA	FCC	TRR 2.4.12	6/47	7/47	66.0	92.1	770	60	16.0	58.0*	43.0	33.0	10.0	4
76	Alpine, N. J.	Riverhead, N. Y.	W2XEA	FCC	TRR 2.4.12	6/47	11/47	66.0	92.1	770	30	19.2	45.0	34.5	24.0	9.5	3
77	New York, N. Y.	Riverhead, N. Y.	WNBC-FM	FCC	TRR 2.4.12	6/47	10/47	70.0	97.3	1270	60	8.8	48.5	41.0	31.0	10.0	3
78	Omaha, Neb.	Gr. Island, Neb.	KOAD	FCC	TRR 2.4.12	1/48	12/48	130.0	92.9	514	45	88.5	32.6	22.0	11.5	10.5	1
79	Alpine, N. J.	Mt. Holly, N. J.	W2XEA	FCC	Prog.Rep#4	2/49	3/49	80.0	93.1	800	40	31.0	23.2*	14.8	8.5	6.3	4
80	Greenville, S. C.	Powder Springs, Ga.	WMRC-FM	FCC	Prog.Rep#4	8/48	1/49	145.0	94.9	1173	30	83.8	8.6	7.7	1.0	6.7	3
81	Greenville, S. C.	Powder Springs, Ga.	WMRC-FM	FCC	Prog.Rep#4	7/51	11/51	146.2	94.9	1173	30	90.0	18.7	10.8	3.2	7.6	2
82	Greenwood, S. C.	Powder Springs, Ga.	WCRS-FM	FCC	Prog.Rep#4	8/48	1/49	145.0	95.7	409	30	108.4	12.7	5.5	-4.5	10.0	3
83	Cleveland, Ohio	Detroit , Mich.	WEWS-FM	FCC	Prog.Rep#4	10/48	5/49	96.0	102.1	640	30	52.5	35.6	24.0	9.6	13.6	3
84	Cleveland, Ohio	Detroit, Mich.	WJW-FM	FCC	Prog.Rep#4	10/48	1/49	97.0	104.1	730	30	51.1	36.3	26.9	15.3	11.6	3
85	Cleveland, Ohio	Detroit, Mich.	WHK-FM	FCC	Prog.Rep#4	6/49	7/49	97.5	100.7	670	30	53.3	44.3	31.0	15.4	15.6	4
86	Boston, Mass.	Riverhead, N. Y.	WBZ-FM	FCC	Prog.Rep#4	2/49	12/50	127.3	92.9	495	30	86.1	30.8	20.7	8.3	12.4	1
87	Boston, Mass.	Hauppauge, N. Y.	WBZ-FM	FCC	Prog.Rep#4	8/49	11/50	150.4	92.9	495	30	111.1	26.5	15.1	1.4	13.7	1
88	Alpine, N. J.	Riverhead, N. Y.	KE2XCC	FCC	Prog.Rep#4	6/49	12/50	67.2	93.1	795	30	19.7	46.6	36.1	26.3	9.8	1
89	Houston, Texas	Austin, Texas	KPRC-FM	CRPL		1/50	6/51	147.8	102.9	342	32	113.6	>20.5	12.5	5.1	7.4	1
90	Dallas, Texas	Austin, Texas	WFAA-FM	CRPL		11/49	8/50	174.2	97.9	525	32	133.8	7.8	-0.4	-4.4	4.0	1
91	Dallas, Texas	Austin, Texas	KIXL-FM	CRPL		1/51	6/53	175.9	104.5	440	32	138.2	>10.8	4.9	-2.7	7.6	1
92	Abilene, Texas	Austin, Texas	KRBC-FM	FCC		4/50	6/50	177.1	96.9	592	32	134.7	> 9.0	1.9	-3.8	5.7	4
93	Columbus, Ohio	Hudson, Ohio	WHKC-FM	CRPL		1/51	6/53	124.9	98.7	562	30	83.6	24.4	16.1	6.9	9.2	1
94	Columbus, Ohio	Hudson, Ohio	WCOL-FM	CRPL		1/51	6/53	121.2	92.3	380	30	86.9	27.5	19.7	9.7	10.0	1
95	Detroit, Michigan	Hudson, Ohio	WJR-FM	CRPL		1/51	6/53	112.8	96.3	430	30	74.1	36.1	24.3	12.1	12.2	1
96	Easton, Pa.	State College, Pa.	WEST-FM	CRPL		1/52	12/52	139.3	107.9	50	63	115.1	11.6	6.0	-1.0	7.0	1
97	Olean, N. Y.	State College, Pa.	WHDL-FM	CRPL		5/51	4/53	90.8	95.7	330	57	39.3	16.0	8.7	4.0	4.7	1
98	Pittsburgh, Pa.	State College, Pa.	WJAS-FM	CRPL		6/51	4/53	117.1	99.7	470	63	75.3	17.8	12.0	4.2	7.8	3
99	Washington, D. C.	State College, Pa.	WTOP-FM	CRPL		8/51	4/52	136.8	96.3	500	63	94.0	<11.0	<4.5	<-1.5	6.0	3
100	Washington, D. C.	State College, Pa.	WTOP-FM	CRPL		4/52	4/53	134.1	96.3	390	63	95.0	10.5	<3.5	<-3.0	6.5	1
101	Houston, Texas	Austin, Texas	KXYZ-FM	CRPL		6/51	12/52	147.8	96.5	440	32	110.2	>23.7	15.2	5.5	9.7	1
102	Shreveport, La.	Austin, Texas	KWKH-FM	CRPL		1/52	6/53	277.4	94.5	390	32	241.4	>0.8	-8.2	-13.0	4.8	3
103	Longview, Texas	Austin, Texas	KLTI-FM	CRPL		1/52	12/52	277.2	105.9	425	32	190.0	>2.4	-6.5	-11.2	5.7	1
104	Seattle, Wash.	Portland, Oreg.	KING-FM	CRPL		3/51	8/53	144.7	98.1	410	30	108.4	13.1	9.0	5.6	3.4	1
105	San Diego, Calif.	Santa Ana, Calif.	KFSD-FM	CRPL		3/51	6/53	84.7	94.1	425	30	47.8	42.5	35.3	23.6	11.7	1
106	Philadelphia, Pa.	Laurel, Md.	WIP-FM	CRPL		3/51	10/52	104.2	93.3	430	30	67.1	35.4	23.3	10.8	12.5	1
107	Hartford, Conn.	Millis, Mass.	WTIC-FM	CRPL		1/52	6/52	80.7	96.5	705	30	35.4	31.2	24.4	15.3	9.1	1
108	Lincoln, Neb.	Grand Island, Neb.	KFOR-FM	CRPL		2/51	7/52	93.2	102.9	230	30	64.1	31.2	19.3	8.6	10.7	1
109	Pittsburgh, Pa.	Laurel, Md.	WJAS-FM	FCC		11/52	6/53	191.3	99.7	686	30	146.6	2.1	-1.9	-8.0	6.1	2

H_t = Average 2-10 mile height, transmitter

$D_{LS} = \sqrt{2H_t} + \sqrt{2H_r}$

F (1), F (10), F (50) = Field Strength in dB above 1 uV/m for 1 kw exceeded for 1, 10, and 50 percent of time.

H_r = Height above ground, receiver

CRPL-FCC Project Prog. Report No. 4
10/1 to 12/31, 1951

*Extrapolated

TABLE III - High Band VHF Data

Pt. No.	Transmitter Location	Receiver Location	Call Letters	Source	References	Recording From	Period To	Distance (miles)	Frequency Mc/s	H_t (feet)	H_r (feet)	$D-D_{LS}$ (miles)	F (1) (dBuV/m for 1 kw)	F (10) (dBuV/m for 1 kw)	F (50) (dBuV/m for 1 kw)	F(10)-F(50)	Relative Weight
1	Birmingham, Ala.	Powder Springs, Ga.	WAFM-TV	FCC		7/51	12/51	121.8	215.75	875	30	72.3	21.8	13.1	4.1	9.0	1
2	Cincinnati, Ohio	Allegan, Mich.	WKRC-TV	FCC		4/51	6/53	252.6	203.75	650	30	203.9	-4.0	-17.0	-32.8	15.8	1
3	San Diego, Calif.	Santa Ana, Calif.	KFMB-TV	FCC		11/51	10/53	71.9	185.75	710	30	26.6	43.7	39.0	31.4	7.6	1
4	Wilmington, Del.	Laurel, Md.	WDEL-TV	FCC		6/53	7/54	81.9	209.75	480	30	43.2	49.0	32.2	17.4	15.8	1
5	Chicago, Ill.	Urbana, Ill.	WENR-TV	CRPL		7/51	6/53	127.0	179.75	660	90	77.2	34.2	23.5	11.3	12.2	1
6	Chicago, Ill.	Urbana, Ill.	WGN-TV	CRPL		7/51	6/53	127.0	191.75	585	75	80.7	31.7	20.7	9.4	11.3	1
7	Chicago, Ill.	Urbana, Ill.	WGN-TV	CRPL		7/51	6/53	127.0	191.75	585	100	78.8	38.5	26.0	13.2	12.8	1
8	Chicago, Ill.	Urbana, Ill.	WGN-TV	CRPL		7/51	6/53	127.0	191.75	585	125	77.1	36.1	26.8	12.6	14.2	1
9	Newark, N. J.	Millis, Mass.	WATV	FCC		11/51	10/52	179.8	215.75	595	30	137.6	14.3	2.1	-9.4	11.5	1
10	Philadelphia, Pa.	Laurel, Md.	WCAU-TV	FCC		3/51	2/52	103.9	197.75	670	30	59.6	28.1	6.0*	- -	- -	1
11	San Francisco, Calif.	Livermore, Calif.	KGO-TV	CRPL		7/51	9/54	38.2	179.75	1261	30	- -	45.5	40.8	37.0	3.8	1
12	Detroit, Mich.	Hudson, Ohio	WXYZ-TV	CRPL		5/50	6/53	111.8	179.75	485	33	72.6	43.3	29.4	13.5	15.9	1
13	Dallas, Texas	Austin, Texas	WFAA-TV	CRPL		4/51	6/53	175.1	185.75	350	32	140.6	1.5	-3.3	-10.2	6.9	1
14	New York, N. Y.	Riverhead, N. Y.		FCC	TRR 2.4.12	8/46	11/46	70.1	288.0	1260	70	8.1	48.0	31.2	24.9	6.3	2
15	Colo. Spgs., Colo.	Haswell, Colo.		CRPL		2/53	4/53	96.6	192.8	3050	17.5	12.6	42.2	37.3	30.0	7.3	2
16	Colo. Spgs., Colo.	Garden City, Kans.		CRPL		2/52	2/53	226.5	192.8	3050	17.5	142.5	10.2	-4.5	-12.1	7.6	4
17	Colo. Spgs. Colo.	Haswell, Colo.		CRPL		1/52	4/52	96.6	210.4	1700	36	29.9	33.2	26.0	17.5	8.5	4
18	Cheyenne Mtn. B	Kendrick, Colo.		CRPL		12/52	4/53	49.4	210.4	1396	36	-11.8	53.2	49.5	46.3	3.2	3
19	Cheyenne Mtn. B	Kendrick, Colo.		CRPL		2/54	8/54	49.4	236.0	1396	36	-11.8	- -	- -	49.8	- -	2
20	Cheyenne Mtn. B	Karval, Colo.		CRPL		1/53	4/53	70.2	210.4	1436	36	8.2	44.6	41.0	37.0	4.0	4
21	Cheyenne Mtn. B	Karval, Colo.		CRPL		2/54	8/54	70.2	236.0	1436	36	8.2	- -	49.3	41.4	7.9	3
22	Cheyenne Mtn. S	Haswell, Colo.		CRPL		2/54	8/54	96.6	230.0	2321	18	22.6	41.0	35.9	32.9	3.0	4
23	Cheyenne Mtn. B	Haswell, Colo.		CRPL		2/54	8/54	96.8	236.0	1502	36	33.4	- -	- -	22.0	- -	2
24	Cheyenne Mtn. S	Garden City, Kans.		CRPL		2/54	8/54	226.5	230.0	2321	18	152.5	- -	- -	-8.8	- -	2
25	Cheyenne Mtn. B	Garden City, Kans.		CRPL		12/52	4/53	226.6	210.4	1502	36	163.4	-10.7	-15.8	-24.5	8.7	3
26	Cheyenne Mtn. S	Marble, Colo.		CRPL		2/54	8/54	141	230	2321	32	69.0	- -	- -	21.9	- -	3
27	Cheyenne Mtn. S	Garden City, Kans.		CRPL		2/52	2/53	226.5	192.8	2321	18	152.4	7.0	-4.9	-11.0	6.1	1
28	Cheyenne Mtn. B	Anthony, Kans.		CRPL		2/53	3/53	393.6	210.4	1403	39	331.8	- -	- -	-37.4	- -	4
29	Cheyenne Mtn. B	Anthony, Kans.		CRPL		7/52	8/52	393.6	192.8	2321	39	316.5	- -	- -	-21.9	- -	4
30	Rome, Ga.	Powder Springs, Ga.	WROM-TV	FCC		6/57	12/57	38.8	191.75	720	30	-6.8	42.3	40.3	38.0	2.3	3
31	Chattanooga, Tenn.	Powder Springs, Ga.	WTVC-TV	FCC	TRR 2.4.18	2/58	1/59	86.0	191.75	1040	30	32.8	26.5	21.0	15.1	5.9	1
32	Kearney, Neb.	Grand Island, Neb.	KHOL-TV	FCC	TRR 2.4.18	11/56	7/57	48.6	214.75	550	30	7.8	48.1	42.8	39.0	3.8	1
33	Lincoln, Neb.	Grand Island, Neb.	KOLN-TV	FCC	TRR 2.4.18	6/55	7/57	66.2	197.76	1000	30	13.8	45.9	35.6	26.1	9.5	1
34	Hutchinson, Kans.	Grand Island, Neb.	KTVH-TV	FCC	TRR 2.4.18	2/55	9/56	198	209.75	810	30	150.1	7.5	-4.1	-15.0*	10.9*	2

H_t = Average 2-10 mile height, transmitter

H_r = Height above ground, receiver

$D_{LS} = \sqrt{2H_t} + \sqrt{2H_r}$

F(1), F(10), F(50) = Field strength in dB above 1 uV/m for 1 kw exceeded for 1, 10, and 50 percent of time.

*Extrapolated

TABLE IV - UHF Band Data

Pt. No.	Transmitter Location	Receiver Location	Call Letters	Source	*** References	Recording From	Period to	Distance (miles)	Frequency Mc/s	H_t (feet)	H_r (feet)	$D-D_{LS}$ (miles)	F(1)	F(10)	F(50)	F(10)-F(50)	Relative Weight
1	New York, N. Y.	Princeton, N. J.	W2XCT	RCA	9,17	6/3/46	9/12/46	45	700	909	50	-7.6	53.5	50.9	43.5	7.4	4
2	New York, N. Y.	Southampton, Pa.	W2XCT	FCC	17,8	5/10/46	9/14/46	68	700	909	30	17.6	51.4	33.2	12.0*	21.2*	4
3	New York, N. Y.	Hauppauge, N. Y.		RCA	21,10	8/43 and	2/44	42.5	474	1270	100	-17.9	73.1	70.7	67.6	3.1	2
4	New York, N. Y.	Riverhead, N. Y.		RCA	21,10,18	8/43 and	2/44	70.1	474	1270	124	4.1	63.0	52.0	36.5	15.5	2
5	Dans Rock, Md.	Laurel, Md.		FCC	18,8	4/14/49	10/31/49	115	400	2250	30	40.2	21.9	11.5	-4.9	16.4	3
6	Cedar Rapids, Iowa	Waukon, Iowa		Collins	11,18,8	Summer	1948	98	412	40+	10	84.6	50.5	30.0	14.1	15.9	4
7	Cedar Rapids, Iowa	Mitchellville, Iowa		Collins	11,18,8	Winter	1949-50	86.1	412	40+	10	72.7	26.6	13.4	1.2	12.2	4
8	Cedar Rapids, Iowa	Quincy, Illinois		Collins	11,18,8	Spring	1950	133.9	412	40+	10	120.5	15.6	6.7	-0.5	7.2	4
9	Cedar Rapids, Iowa	New London, Iowa		Collins	11,18,8	8/16/48	8/21/48	225	412	40+	10	211.6	21.9	0	- -	- -	4
10	San Pedro, Calif.	San Diego, Calif.		USN	12,18	8/29/44	10/4/44	92.1	547	100	100	63.8	69.5	56.7	32.8	23.9	4
11	Bridgeport, Conn.	Riverhead, N. Y.	KC2XAK	RCA	13,20	2/50	11/51	33	534.75	330	30	-0.5	53.4	49.4	47.1	2.3	1
12	Bridgeport, Conn.	Princeton, N. J.	KC2XAK	RCA	20,22	5/50	3/51	98	534.75	330	30	64.5	19.3	9.4	-2.7	12.1	1
13	Bridgeport, Conn.	Millis, Mass.	KC2XAK	FCC	20,22	7/50	8/52	116	534.75	330	35	82.5	13.2	-1.0*	- -	- -	1
14	Colorado Springs, Colo.	Haswell, Colo.	S1046-3	NBS	14,8	2/52	1/53	96.6	1046	2226	42.7	26.6	56.3	47.1	34.1	13.0	1
15	Colorado Springs, Colo.	Garden City, Kan.	S1046-4	NBS	14,8	2/52	1/53	226.5	1046	2226	42.7	150.5	8.3	-1.5	-9.6	8.1	1
16	Colorado Springs, Colo.	Anthony, Kan.	S1046-5	NBS	14,8	7/23/52	8/20/52	393.5	1046	2226	10	322.2	-14.6	-18.9	-26.0	7.1	4
17	Springfield, Mass.	Millis, Mass.	WWLP-TV	FCC	8	10/53	8/54	70.7	758	700	30	25.6	21.3	4.2*	- -	- -	4
18	New Britain, Conn.	Millis, Mass.	WNBC-TV	FCC	22	8/57	2/59	84.2	571.75	970	30	32.5	31.3	14.1	- -	- -	1
19	Columbus, Georgia	Powder Springs, Ga.	WDAK-TV	FCC	22	3/54	9/56	98.2	559.75	650	30	54.8	26.8	12.8	-4.5	17.3	1
20	Corpus Cristi, Texas	Kingsville, Texas	KVDO-TV	FCC	22	5/57	8/57	38.1	523.75	310	30	5.5	55.6	45.2	36.2	9.0	3
21	Springfield, Mass.	Millis, Mass.	WHYN-TV	FCC	22	6/54	6/55	67.5	721.75	900	30	17.4	21.4	9.8	-5.5*	15.3*	1
22	Adams, Mass.	Millis, Mass.	WCDC-TV	FCC	22	8/57	3/59	98.6	505.75	2120	30	25.9	32.5	23.1	17.2	5.9	1
23	Salisbury, Md.	Laurel, Md.	WBOC-TV	FCC	22	3/55	9/56	85.4	487.75	620	30	42.5	43.5	26.5	6.0*	20.5*	1
24	Fresno, Calif.	Livermore, Calif.	KMJ-TV	FCC	22	6/55	9/56	153.3	535.75	2290	30	78.0	17.9	11.2	3.4	7.8	1
25	South Bend, Indiana	Allegan, Michigan	WSBT-TV	FCC	22	6/58	5/59	69.4	523.75	540	30	28.8	40.3	15.5	- -	- -	1
26	Scranton, Pa.	Laurel, Md.	WDAU-TV	FCC	22	2/59	8/60	173.0	523.74	1350	30	113.4	-1.4	-10.6	- -	- -	1
27	Fresno, Calif.	Livermore, Calif	KJEO-TV	FCC	22	12/55	9/56	136.3	673.75	1789	30	68.8	13.2	7.8	1.5	6.3	1
28	Harrisburg, Pa.	Laurel, Md.	WHP-TV	FCC	22	10/57	9/58	81.0	721.75	910	30	30.7	23.6	12.6	5.0	7.6	1
29	Wilkes Barre, Pa.	Millis, Mass.	WBRE-TV	FCC	22	6/55	9/56	241.7	559.75	1220	30	184.6	-10.0*	- -	- -	- -	1
30	Wilkes Barre, Pa.	Laurel, Md.	WBRE-TV	FCC	22	3/55	7/56	150.0	559.75	1220	30	92.9	8.6	-4.0	-13.0	9.0	1
31	Wilkes Barre, Pa.	Laurel, Md.	WILK-TV	FCC	22	12/55	9/56	147.8	595.75	1095	30	93.4	4.5	-4.1	- -	- -	2
32	York, Pa.	Laurel, Md.	WSBA-TV	FCC	22	8/53	9/55	53.8	649.75	550	30	13.0	31.2	14.5	- -	- -	1
33	Peoria, Ill.	Allegan, Mich.	WEEK-TV	FCC	22	8/54	9/56	230.8	649.75	550	30	190.0	-11.2*	- -	- -	- -	1
34	Battle Creek, Mich.	Allegan, Mich.	WBKZ-TV	FCC	22	1/54	3/54	42.0	775.75	335	30	8.4	31.0	25.4	20.7	4.7	4
35	New York, N. Y.	Neshanic, N. J.		Bell	15,19	8/44	10/44	40.1	715	500	50	-1.5	66.0	65.0	63.0	2.0	3
36	Washington, D. C.	Baltimore, Md.	KG2XAL	Westinghse	16,19	2/21/49	6/11/49	30	508	365+	47	-6.7	36.1	32.0	26.4	5.6	3
37	New York, N. Y.	Princeton, N. J.	WUHF	FCC	**	2/62	10/62	44.3	573.25	1312	30	-14.7	59.5	57.0	52.5	4.5	2
38	New York, N. Y.	Oakford, Pa.	WUHF	FCC	**	3/62	8/62	67	573.25	1312	30	8.0	48.0	41.5	35.0	6.5	3
39	New York, N. Y.	Laurel, Md.	WUHF	FCC	**	1/62	3/63	186	573.25	1312	30	127.0	6.0	-2.0	-8.0	6.0	1

H_t = Transmitting antenna height above average 2-10 mile terrain (except where + denotes height above ground)

H_r = Receiving antenna height above ground.

$D_{LS} = \sqrt{2 H_t} + \sqrt{2 H_r}$

F(1), F(10), F(50) = Field strength in dB above 1 uV/m for 1 kw exceeded for 1, 10, and 50 percent of time.

* Extrapolated

** Not Previously Reported

*** See list of references at end of this report.

TABLE IV - UHF Band Data (Continued)

Pt. No.	Transmitter Location	Receiver Location	Call Letters	Source	*** References	Recording From	Period To	Distance (miles)	Frequency Mc/s	H_t (feet)	H_r (feet)	$D-D_{IS}$ (miles)	F(1)	F(10)	F(50)	F(10)-F(50)	Relative Weight
40	Fort Carson, Colo.	Haswell, Colo.	FC1046-3	NBS	23	8/25/54	8/28/54	93.8	1046	35	43	76.1	--	14.9	8.7	6.2	4
41	Pikes Peak, Colo.	Garden City, Kansas	PP1046-4	NBS	23	8/17/54	8/25/54	237.1	1046	7798	9	107.5	-1.7	-6.6	-12.3	5.7	4
42	Cedar Rapids, Iowa	Quincy, Illinois		NBS	23	3/51	12/51	134	418	41	10	120.2	28.5	14.5	5.2	9.3	2
43	Cedar Rapids, Iowa	Quincy, Illinois		NBS	23,24	1/52	5/53	134	418	39	30	117.1	36.8	18.2	5.5	12.7	1
44	Cedar Rapids, Iowa	Quincy, Illinois		NBS	23,24	1/52	5/53	134	418	39	165	106.7	29.7	15.2	4.0	11.8	1
45	Cedar Rapids, Iowa	Quincy, Illinois		NBS	23,24	1/52	5/53	134	418	39	365	97.8	37.2	20.8	6.7	14.1	1
46	Cedar Rapids, Iowa	Quincy, Illinois		NBS	23,24	6/52	--	134	418	39	465	94.4	57.0	40.7	15.3	25.4	4
47	Cedar Rapids, Iowa	Quincy, Illinois		NBS	23,24	1/52	5/53	134	418	39	565	91.2	35.6	17.1	7.5	9.6	1
48	Cedar Rapids, Iowa	Quincy, Illinois		NBS	23,24	5/52	5/53	134	418	39	665	88.7	41.8	25.9	9.4	16.5	1
49	Cheyenne Mtn. "S", Colo	Sheridan Lake, Colo.	S1046-7	NBS	23	2/14/54	3/2/54	141	1046	2261	32	65.7	67.5	38.0	20.4	17.6	4
50	Pikes Peak, Colo.	Sheridan Lake, Colo.	PP1046-7	NBS	23	8/19/54	8/24/54	151.5	1046	7798	32	18.6	66.6	58.8	45.2	13.6	4
51	Fort Carson, Colo.	Garden City, Kansas	FC1046-4	NBS	23	8/25/54	8/28/54	223.6	1046	35	9	211.2	-5.7	-9.6	-13.0	3.4	4
52	Cheyenne Mtn. "S", Colo	Garden City, Kansas	S1046-4	NBS	23	3/1/53	4/9/53	226.5	1046	2226	9	155.6	-9.3	-17.6	-23.4	5.8	4
53	Cheyenne Mtn. "S", Colo	Garden City, Kansas	S1046-4	NBS	23	8/24/54	8/29/54	226.5	1046	2226	26	152.5	20.2	-0.4	-4.1	3.7	4
54	Cheyenne Mtn. "S", Colo	Garden City, Kansas	S1046-4	NBS	23	8/24/54	8/29/54	226.5	1046	2226	33	151.7	--	2.4	-5.4	7.8	4
55	Cheyenne Mtn. "S", Colo	Garden City, Kansas	S1046-4	NBS	23	8/24/54	8/29/54	226.5	1046	2226	9	155.6	21.6	-0.4	-8.0	7.6	4
56	Cheyenne Mtn. "S", Colo	Kendrick, Colo.	S1046-1	NBS	23	2/15/52	8/30/53	49.3	1046	2226	43	-26.7	72.9	70.9	68.4	2.5	1
57	Cheyenne Mtn. "S", Colo	Karval, Colo.	S1046-2	NBS	23	2/1/54	3/2/54	70.2	1046	2226	5	0.3	56.1	52.5	49.7	2.8	4
58	Cheyenne Mtn. "S", Colo	Karval, Colo.	S1046-2	NBS	23	2/1/52	8/23/53	70.2	1046	2226	43	-5.8	72.0	68.8	65.3	3.5	1
59	Cheyenne Mtn. "S", Colo	Karval, Colo.	S1046-2	NBS	23	2/1/54	2/28/54	70.2	1046	2226	14	-1.8	62.8	61.3	58.8	2.5	4

H_t = Transmitting antenna height above average 2-10 mile terrain (except where + denotes height above ground).

H_r = Receiving antenna height above ground .

$D_{IS} = \sqrt{2 H_t} + \sqrt{2 H_r}$

F(1), F(10), F(50) = Field strength in dB above 1 uV/m for 1kw exceeded for 1, 10, and 50 percent of time.

* Extrapolated

** Not previously Reported

*** See list of references at end of this report.

TABLE V - List of Mobile Surveys

Transmitter Location	Call Letters	Source	Recording From	Period To	Frequency Mc/s	Ht. (feet)	Hr. (feet)
Baton Rouge, La.	WBRZ-TV	A. D. Ring	7-25-57	10-25-57	59.75	890	30
Madison, Wisc.	WISC-TV	and	10-25-57	12- 5-57	65.75	795	30
Baltimore, Md.	WBAL-TV	Associates	10-26-60	12- 5-60	203.75	730	30
Philadelphia, Pa.	WCAU-TV	"	1-11-61	3-16-61	197.75	979	30
Columbia, S. C.	WIS-TV	"	1-20-58	3-19-58	193.24	640	30
Wilkes-Barre, Pa.	WBRE-TV	"	6-17-57	8-20-57	559.75	1220	30
Columbia, S. C.	WNOK-TV	"	1-20-58	3-19-58	789.25	624	30
Buffalo, N. Y.	WBUF	"	6- 2-58	8-14-58	493.75	686	30
Madison, Wisc.	WMTV	"	9-25-57	12- 5-57	585.26	690	30
Philadelphia, Pa.	WHYY-TV	"	4-21-58	6-15-58	601.74	503	30
Springfield, Mass.	WHYN-TV	"	9-16-58	10-22-58	631.75	1000	30
Philadelphia, Pa.	WHYY-FM	"	4-21-58	6-15-58	90.9	463	30
Buffalo, N. Y.	WGR-TV	"	6- 2-58	8-14-58	59.75	380	30
Springfield, Mass.	WHYN-FM	"	9-16-58	10-22-58	93.1	968	30
Wilkes Barre, Pa.	WBRE-FM	"	6-17-57	8-20-57	98.5	1160	30
Detroit, Mich.	WJBK-TV	A.E.Cullum	9- 5-56	9-26-56	59.75	1000	30
Milwaukee, Wisc.	WISN-TV	Jr. and	8-23-55	10- 6-55	209.75	1000	30
Dallas, Tex.	WFAA-TV	Associates	6-26-56	10-27-56	185.75	1680	30
Boston, Mass.	WHDH-TV	"	7-15-58	8- 3-58	87.25	1140	30
St. Louis, Mo.	KWK-TV	"	12-1-54	12-14-54	71.75	520	30
Boston, Mass.	WNAC-TV	"	7-30-58	8- 5-58	179.75	480	30
Cleveland, Ohio	WJW-TV	"	10-25-56	11- 9-56	135.75	1000	30
New York, N. Y.	WCBS-TV	F.C.C.	11- 3-61	8-14-62	55.25	1330	30
New York, N. Y.	WABC-TV	" (Ref. 25)	11- 3-61	8-14-62	175.25	1330	30
New York, N. Y.	WUHF	"	11-26-61	10-31-62	573.25	1290	30
Richmond, Va.	WTVR-TV	J.C.McNary	May	1954	83.25	840	30
		Consulting					
		Engineer					

DEVELOPMENT OF THE VHF PROPAGATION CURVES

Figure 6 shows the plot of low VHF median field strengths from mobile surveys listed in Table V. These measurements generally started at 10 miles from the transmitter, going out to about 70 miles and were taken at the receiving antenna heights of thirty feet. The data were normalized by adjusting the various antenna heights to 1000 feet by means of the linear height gain relationship. The average transmitter antenna height for the VHF data was near 1000 feet. Each data point represents a median field strength value for a 10 mile segment at a given distance from a station for all the radials. All of these data were further corrected to correspond to average terrain (Δh = 50 meters) as described previously. Finally, a best fit curve was drawn through the data resulting in a base 1000 foot curve. Appropriate height gains were then applied to this base 1000 foot curve to obtain within-the-horizon curves for other transmitting antenna heights. Figure 7 shows a plot of the identically processed high VHF mobile data with the base 1000 foot curve.

These median within-the-horizon curves were subsequently merged smoothly with their beyond-the-horizon counterparts derived from Figures 4 and 5. The composite Low and High VHF band curves appear in Figures 8 and 9.

The final step of this development concerned the derivation of the composite F(50,10) curves, which were again constructed by merging of the within and beyond-the-horizon curves. To derive the within-the-horizon F(50,10) curves, it was necessary to apply appropriate fading ratios to the corresponding F(50,50) curves. Fading ratio is defined as the difference in decibels between the F(50,10) and F(50,50) fields. These ratios vary both with distance and antenna height as shown in Figure 10, following the general concept originated by the Central Radio Propagation Laboratory of the National Bureau of Standards. They were determined from long term measurements listed in Tables II and III and also using the F(50,10) minus F(50,50) values for corresponding transmitting antennas as obtained from the beyond-the-horizon curves. Since no VHF frequency trend was observed in the derivation of the fading curves, the same fading ratios were employed in the derivation of the low and high VHF F(50,10) curves. The composite low and high VHF F(50,10) curves are shown respectively in Figures 11 and 12.

Figures 13 and 14 show comparisons with measurements of the proposed and existing FCC F(50,50) low and high band VHF curves for transmitting antenna heights of 2000, 1000 and 500 feet. These measurements were corrected for terrain roughness and preferred location bias as previously described. The improvement resulting from the present treatment of the data is evident by examining together the plots for three ranges of antenna heights as shown in these Figures. The fit of the data to any one curve is not an adequate criteria, since the curves had to simultaneously satisfy consistent and smooth trends with distance, frequency and antenna height.

Figures 15 and 16 show comparisons with measured data of the proposed low and high band VHF F(50,10) curves for the same 3 transmitting antenna heights. There are no existing F(50,10) curves in the FCC rules. Curves of field strength versus transmitting antenna height for constant distances are shown in Figures 17, 18, 19 and 20, which are identical in form with those appearing in the present TV rules.

DEVELOPMENT OF THE UHF PROPAGATION CURVES

In the derivation of the new UHF propagation curves, the long-term fixed-point data shown in Table IV were corrected for preferred location bias, and mobile data from the surveys listed in Table V were corrected for terrain roughness and diurnal variations as previously described. In the graphs in this section each of the long-term data points represents measurements made over one path, and each mobile data point represents the median field strength of the 10 mile segments of all radials for one station.

The within-the-horizon data were normalized to a transmitting antenna height of 500 feet by assuming linear height gain and plotted versus distance as shown in Figure 21. The beyond-the-horizon data were plotted on a graph showing median field strength plus 10 times the logarithm of the distance, versus distance beyond the horizon as shown in Figure 22. A smooth curve was drawn through each plot and the two curves merged together near the horizon. The resulting 500-foot continuous curve was used as a base curve for deriving field strength versus distance curves for 100, 200, 1000, 2000, and 5000 feet.

In deriving these curves from the base curve, linear height gain was assumed within the radio horizon, and the $D - D_{LS}$ relationship described previously was assumed for distances beyond-the-horizon. The two resulting families of curves were then blended together to generate the final family of median field strength versus distance curves as shown in Figure 23.

In order to derive a base curve for 10 percent fields, the available 10 percent data were plotted on a graph of F(50,10) + 10 log D versus $D - D_{LS}$ and a smooth curve was drawn through the data. See Figure 24. Guided as far as possible by the available long-term measurements, a smooth fading curve of F(50,10) - F(50,50) versus distance for a 500-foot transmitting antenna height was drawn so as to yield a 10 percent curve which would merge into the 10 percent, beyond-the-horizon curve. For other antenna heights the same procedure as for the median curves was followed, with the necessity of obtaining a smooth set of fading curves taking precedence over the desirability of having linear height gain. The final F(50,10) versus distance curves are shown in Figure 25 and the fading ratio curves in Figure 26.

Figure 27 shows the F(50,50) versus distance curves for antenna heights of 2000, 1000 and 500 feet with the pertinent data, both long-term and mobile. Appropriate corrections as previously described were applied to the data plotted in these graphs. For comparison, this figure also shows the present curves as obtained from Figure 9, Section 73.699, of the FCC Rules and Regulations. Figure 28 shows the F(50,10) versus distance curves with the pertinent 10 percent, corrected data.

Figures 29 and 30 show the final UHF, F(50,50) and F(50,10) versus transmitting antenna height curves for various distances.

CONCLUSIONS

In the course of the development of the new TV and FM propagation curves, all available data were examined with respect to field strength variations with terrain roughness, path length, distance beyond the horizon, and antenna heights, as well as fading ratios and frequency trends.

By correlating these variable relationships in several different ways, maximum utilization of the data was possible, and natural trends in distance, antenna height, terrain roughness, time and fading were in reasonable coherence when these factors were applied to the data.

The new curves were designed for use either with average terrain conditions, or for conditions differing from average by applying roughness correction factors. In a test case with terrain considerably rougher than average, application of terrain roughness corrections resulted in an improvement of 5 dB for VHF and 12 dB for UHF in the root-mean-square deviations of measured data from the new curves.

The new graphs for estimating field strength may be used for general assignment purposes or for providing a rough estimate of the probable field strength distribution as applied to a proposed or existing facility. When so used, they will provide information which is believed to be substantially better than that provided by the existing graphs in the FCC Rules and Regulations. They cannot be used to predict with any accuracy the field which would be established by any specific operation over a particular path to any equally specific area, even when the terrain correction factor is employed. For such information, resort should be made to measurements wherever and whenever practicable.

ACKNOWLEDGMENTS

Some of the major concepts adopted in the development of the curves described in this report were formulated by the FCC Radio Propagation Advisory Committee which held a number of meetings during the years 1953-1960. Members of RPAC were listed in Report No. R-6502 (Ref. 1).

Valuable contributions toward the work described in this report were made by the Television Allocation Study Organization (1956-1960). Under the direction of Dr. George R. Town, TASO reported to the Commission on the results of extensive studies and research investigations made by several hundred engineers from industry and government agencies (Ref. 5).

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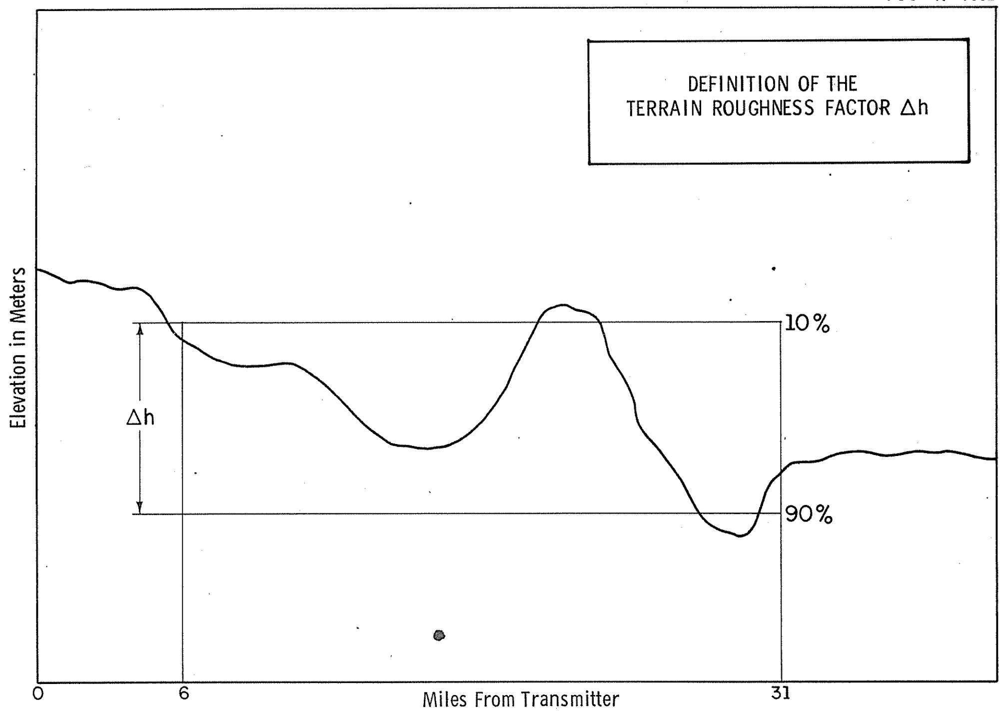


FIGURE 1

FCC-R-6602

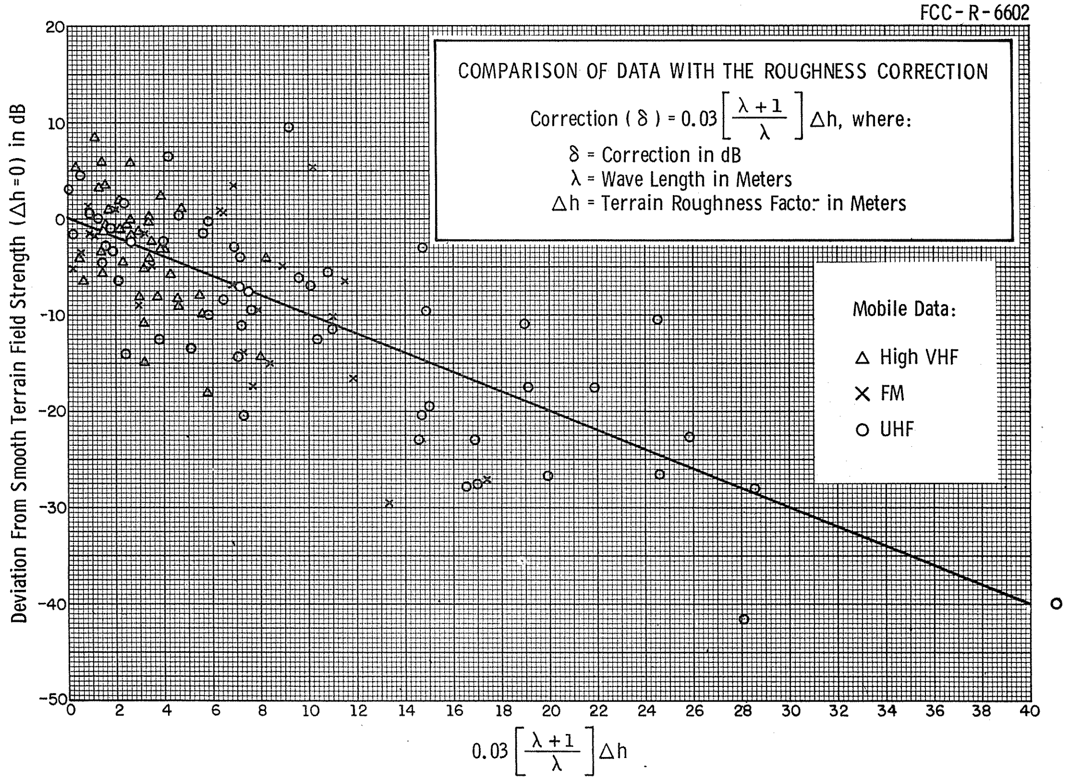
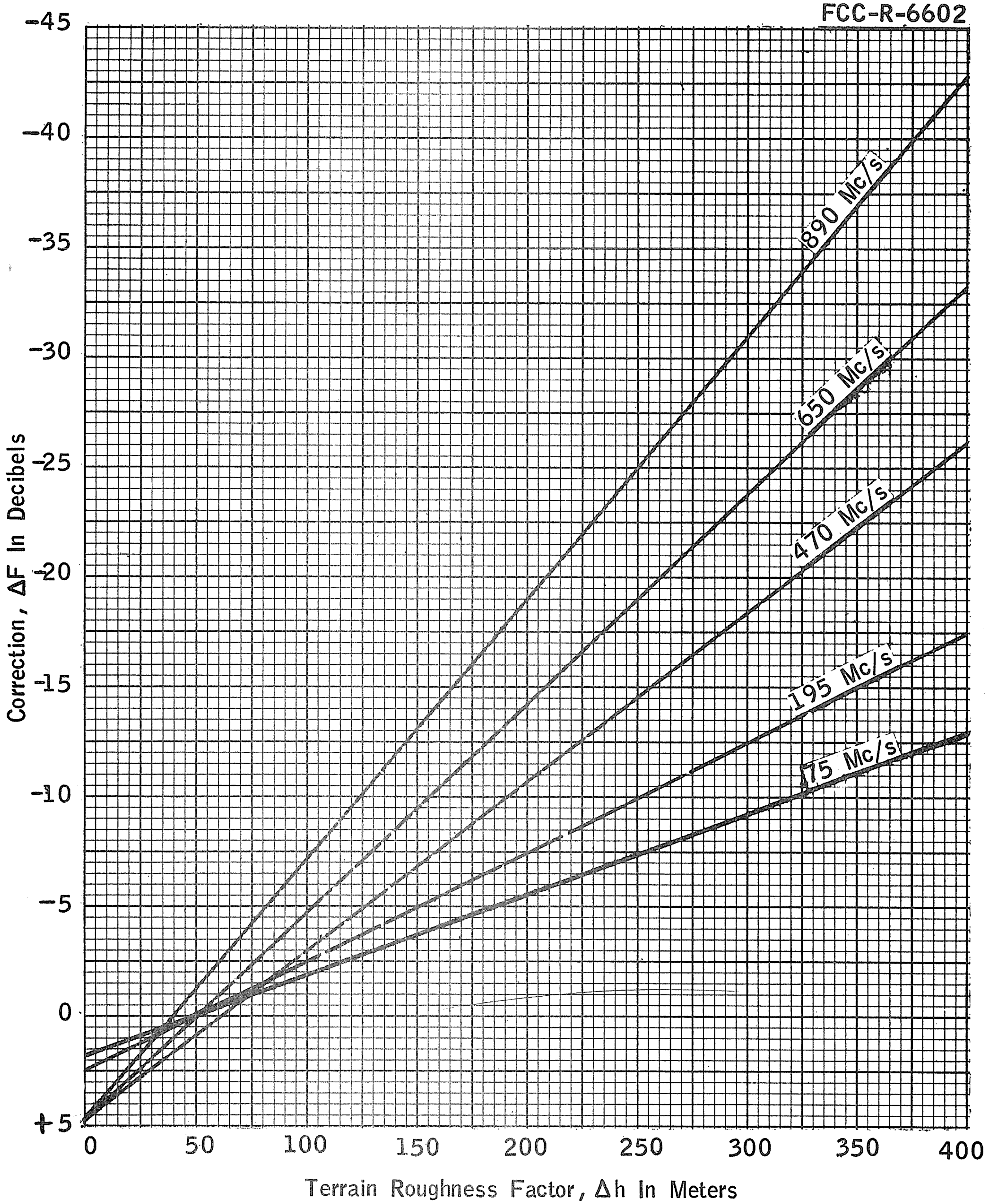


FIGURE 2



TERRAIN ROUGHNESS CORRECTION
for use with estimated F(50,50) and F(50,10) field strength curves

FIGURE 3

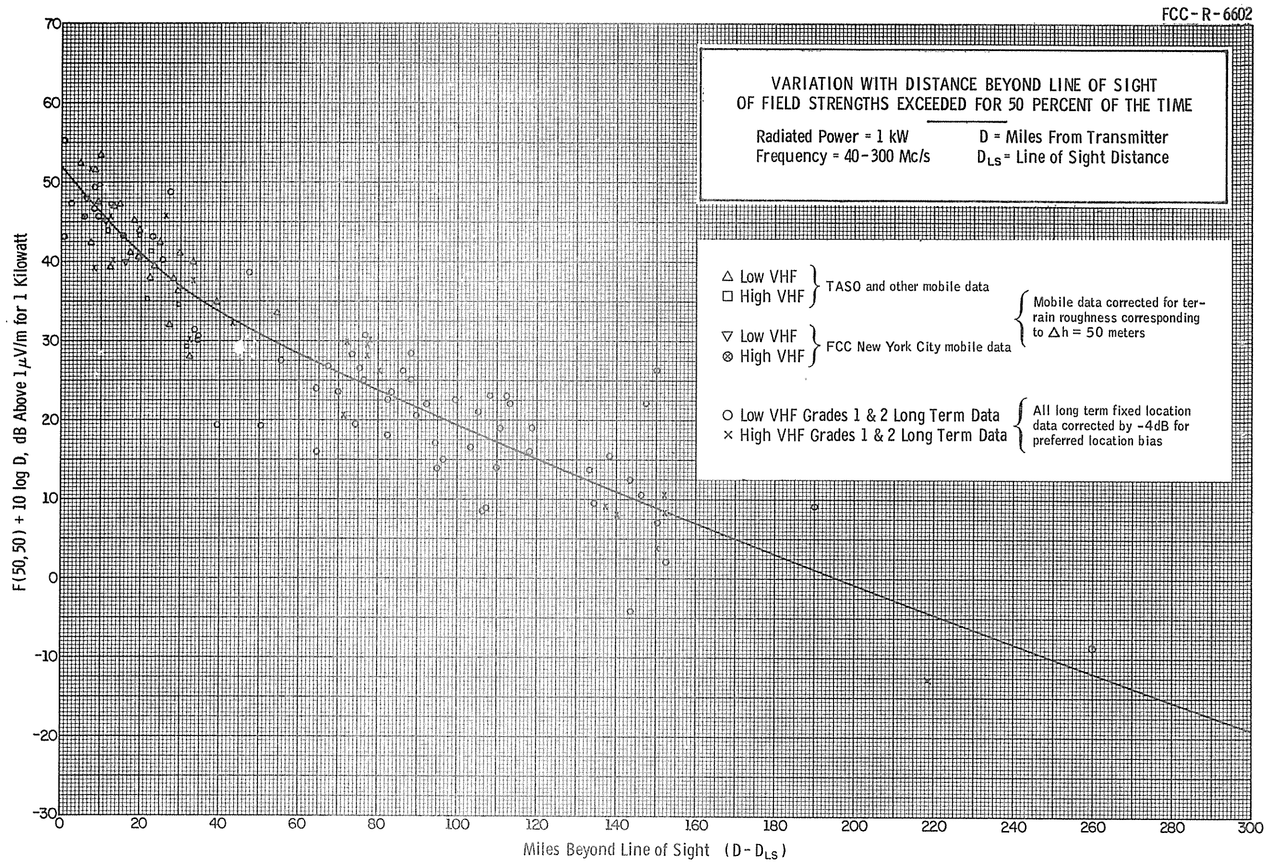


FIGURE 4

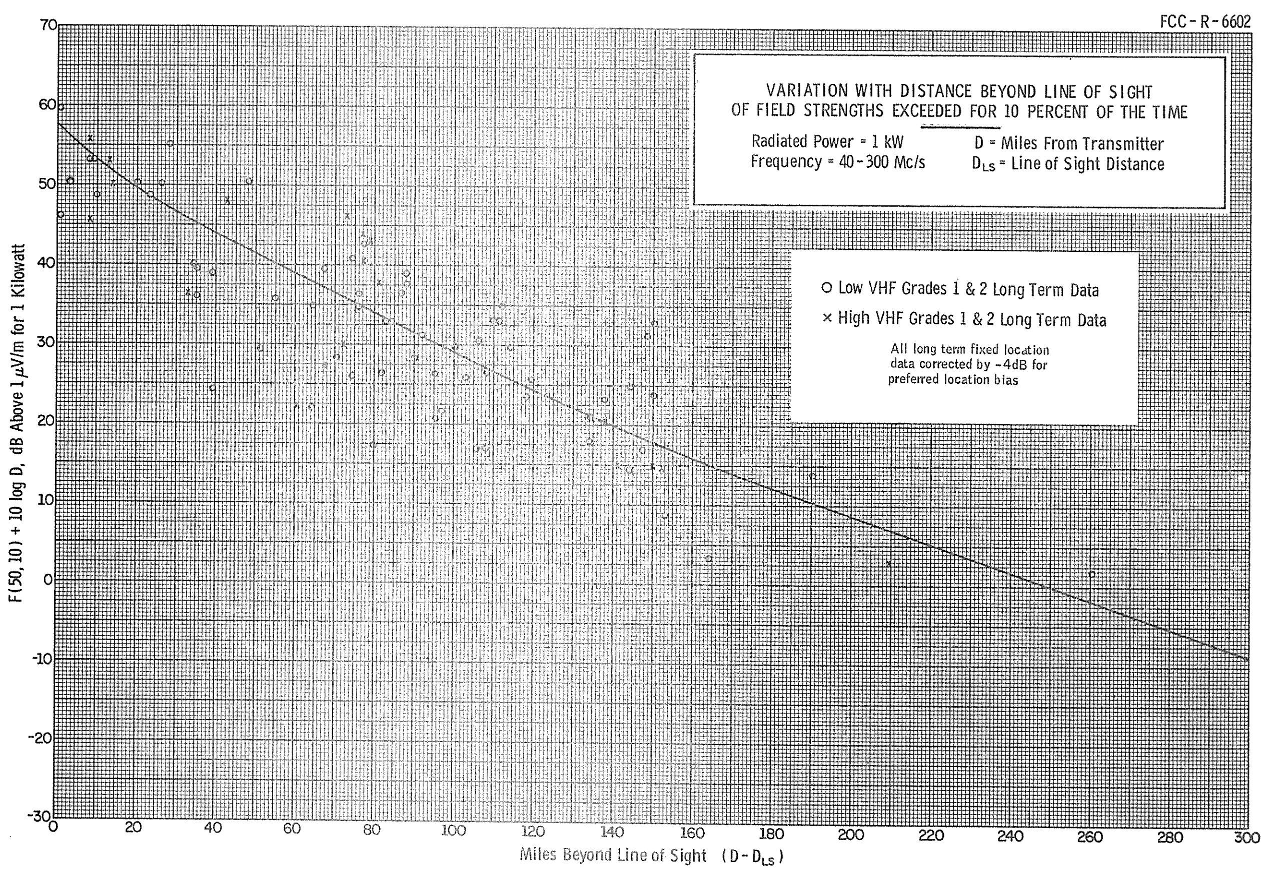


FIGURE 5

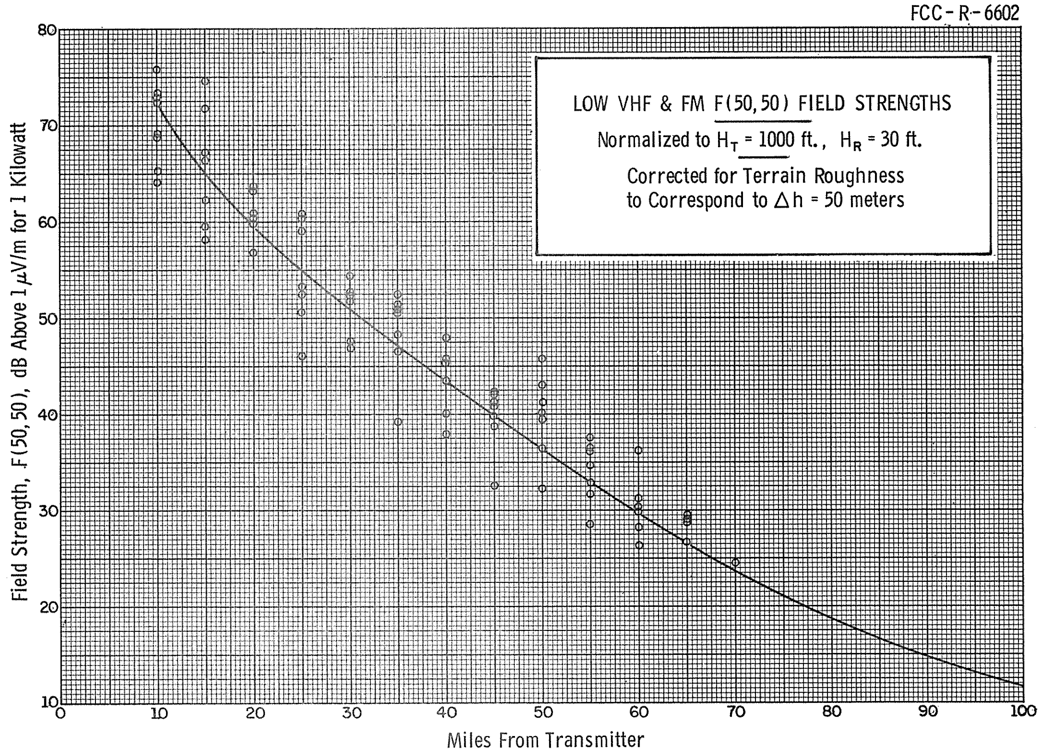


FIGURE 6

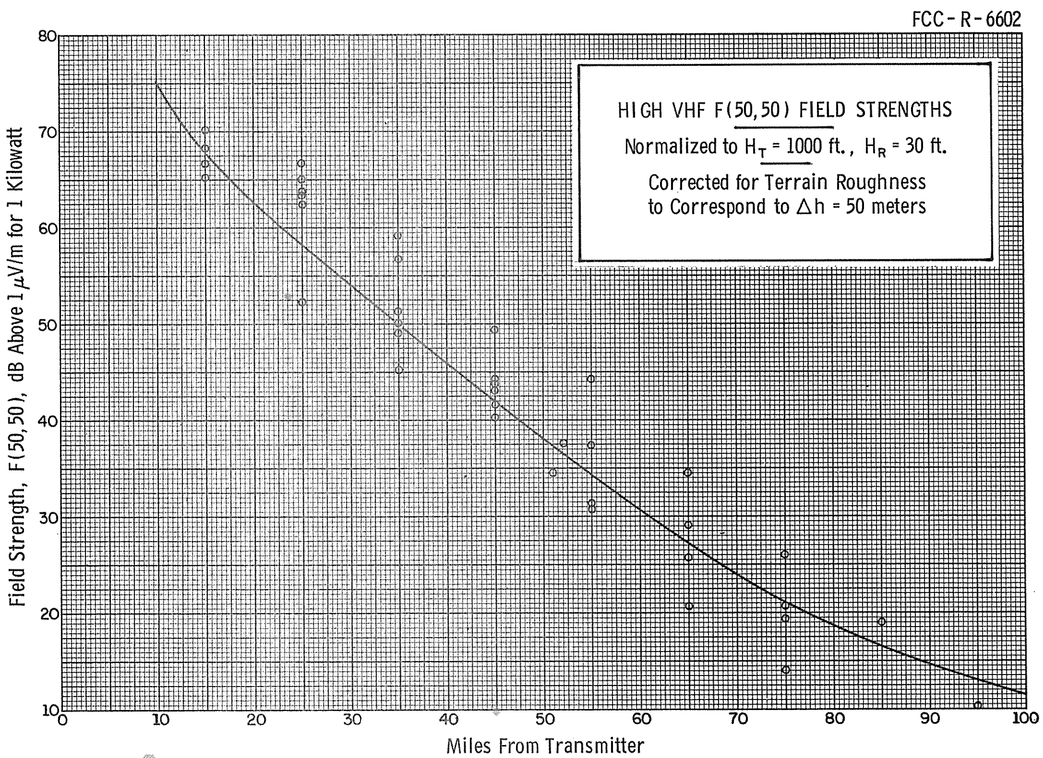


FIGURE 7

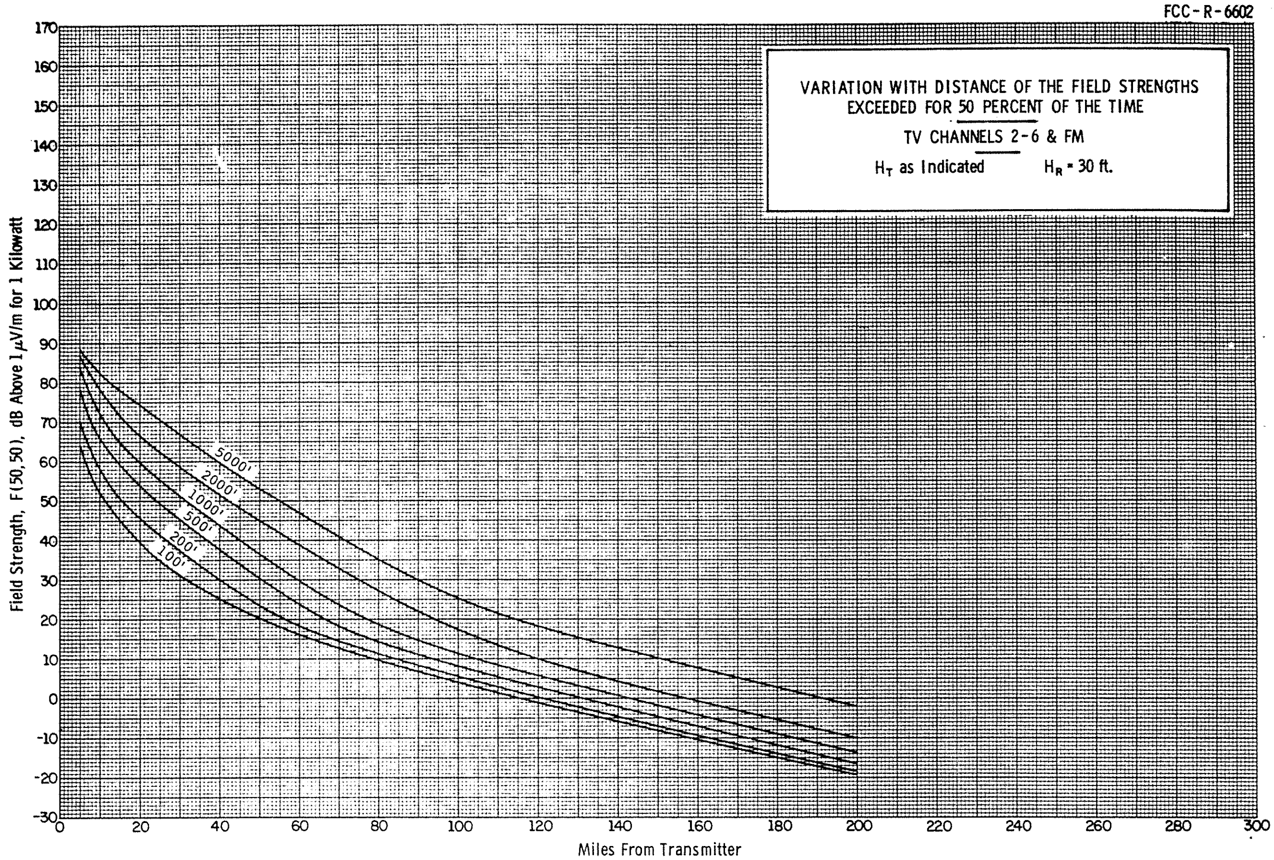


FIGURE 8

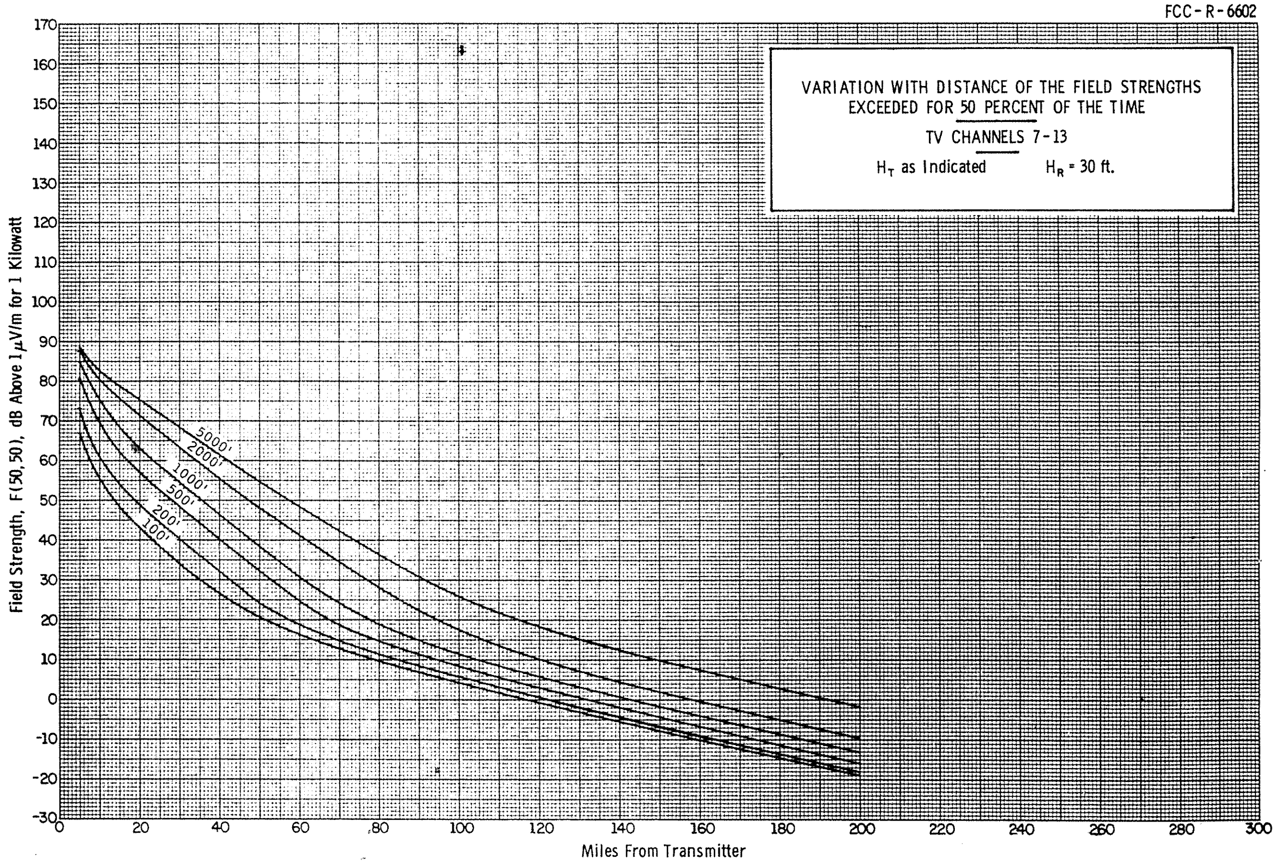


FIGURE 9

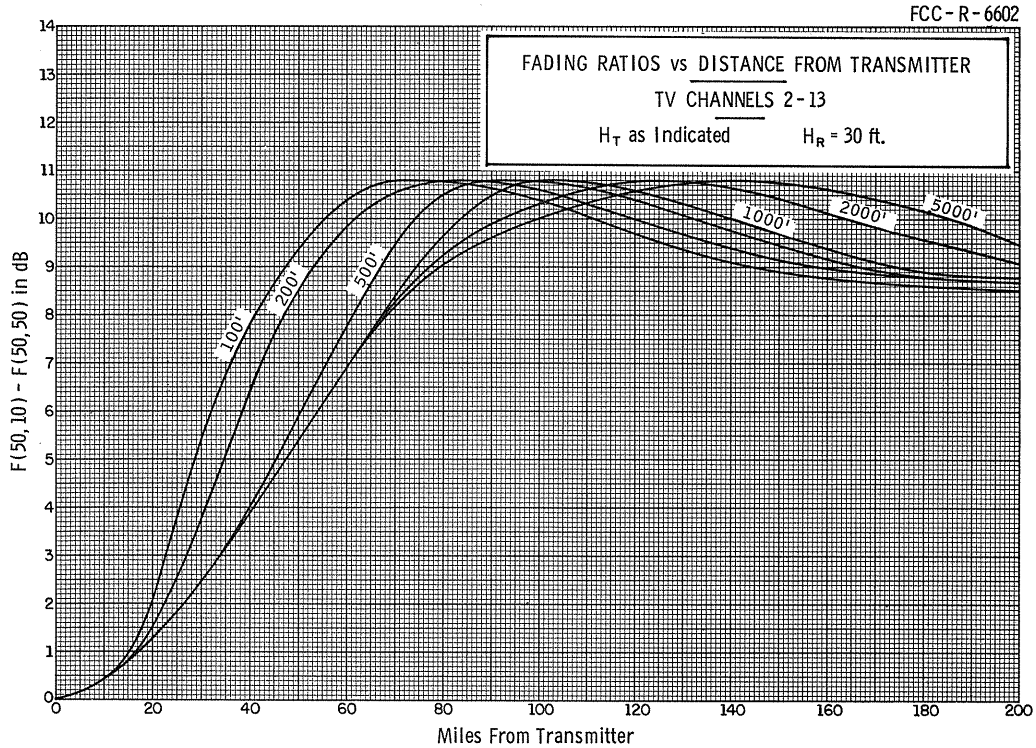

FADING RATIOS vs DISTANCE FROM TRANSMITTER
TV CHANNELS 2-13
H_T as Indicated H_R = 30 ft.
100'
200'
500'
1000'
2000'
5000'
F(50,10) - F(50,50) in dB
Miles From Transmitter
0
20
40
60
80
100
120
140
160
180
200
1
2
3
4
5
6
7
8
9
10
11
12
13
14

FIGURE 10

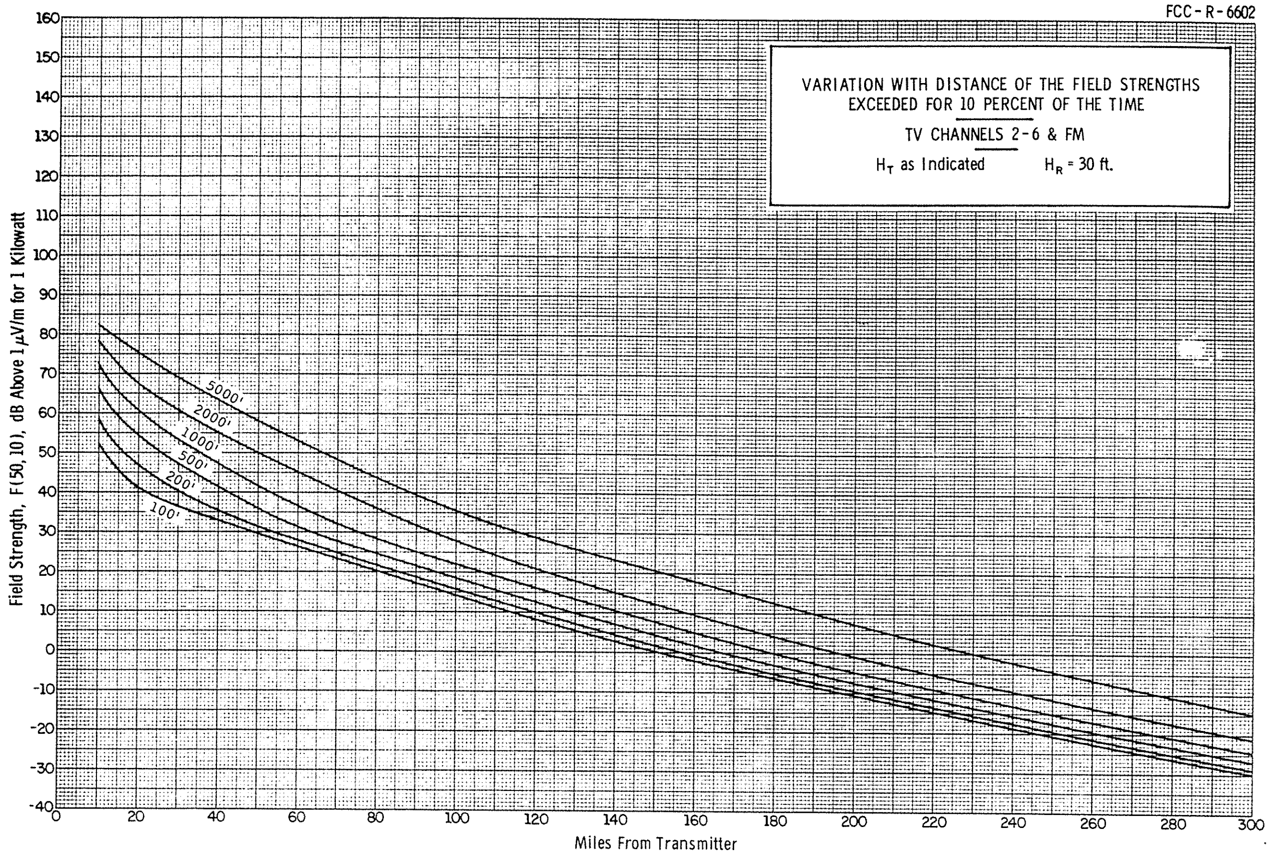


FIGURE 11

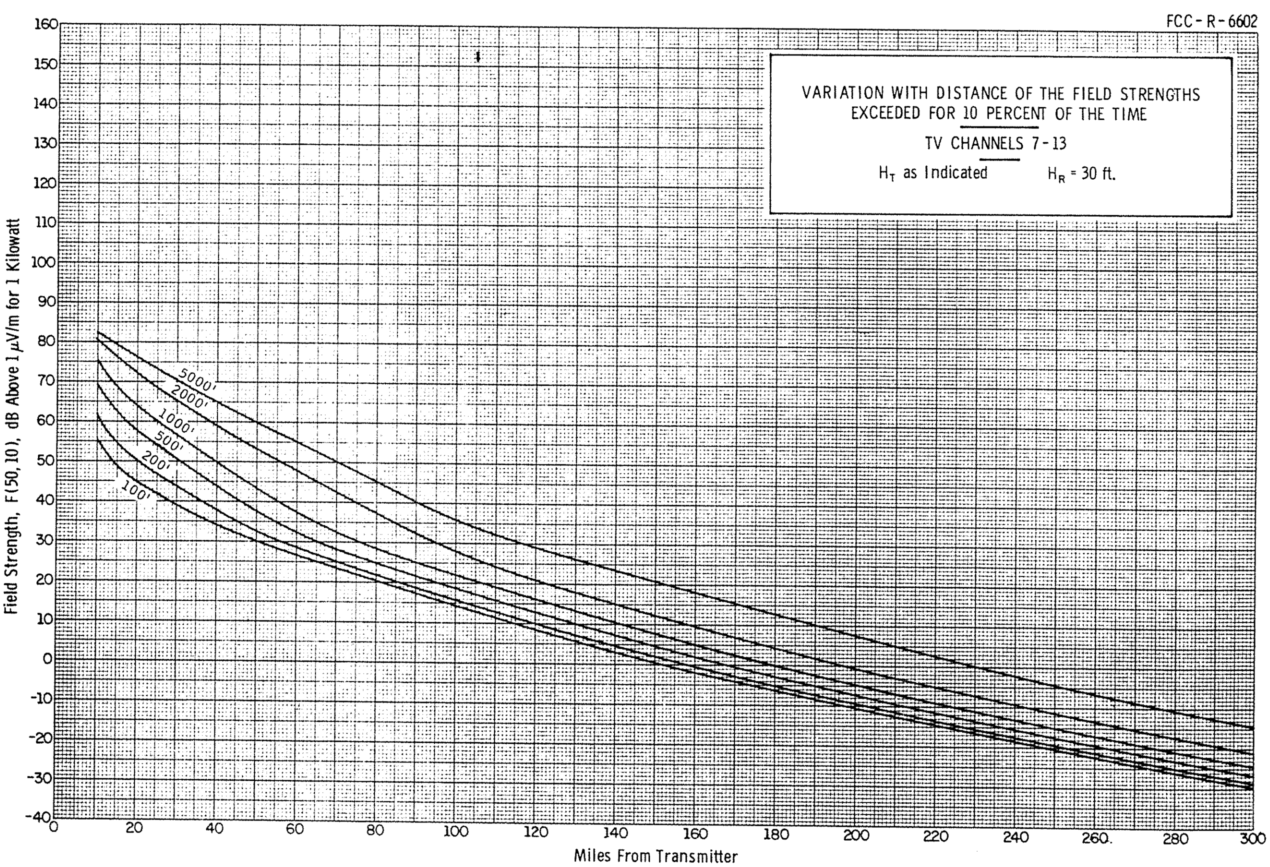


FIGURE 12

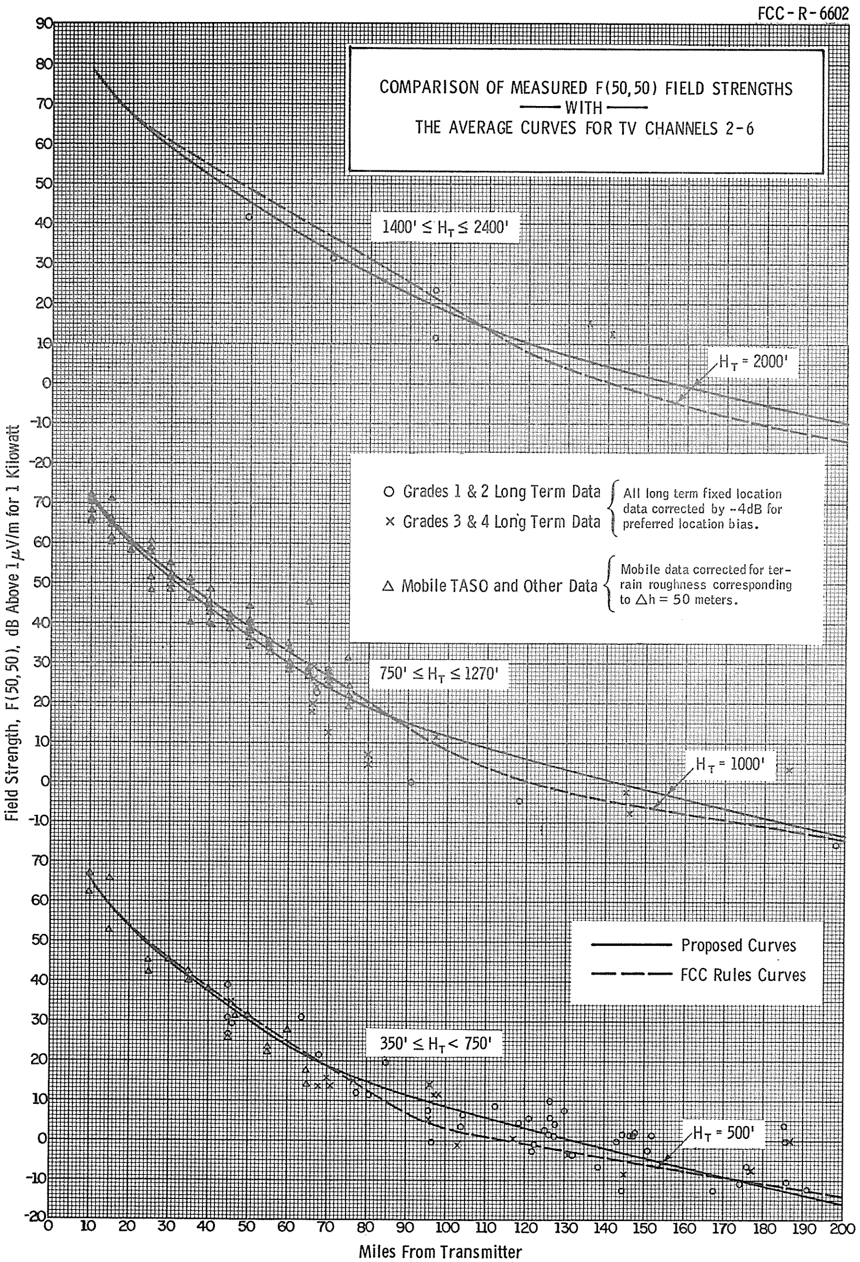


FIGURE 13

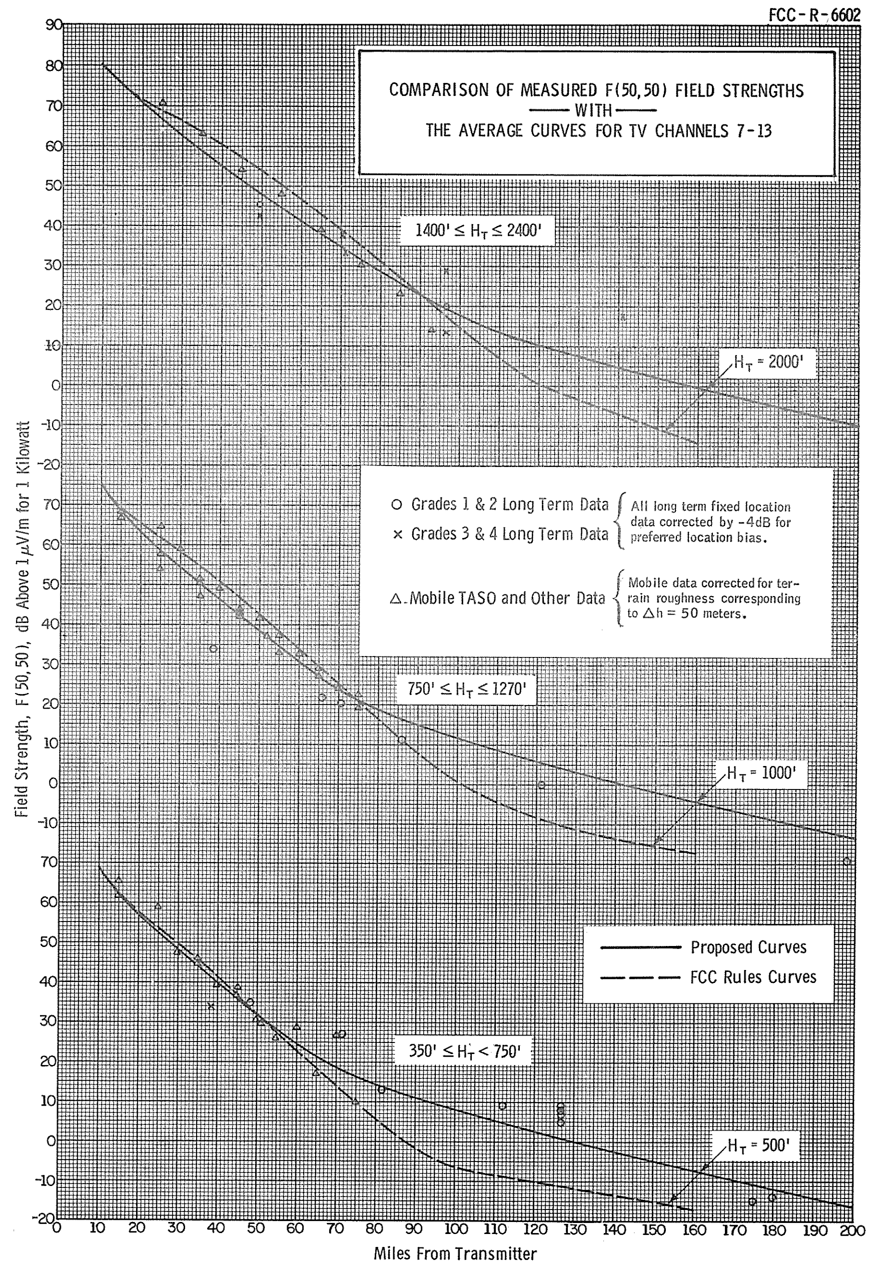


FIGURE 14

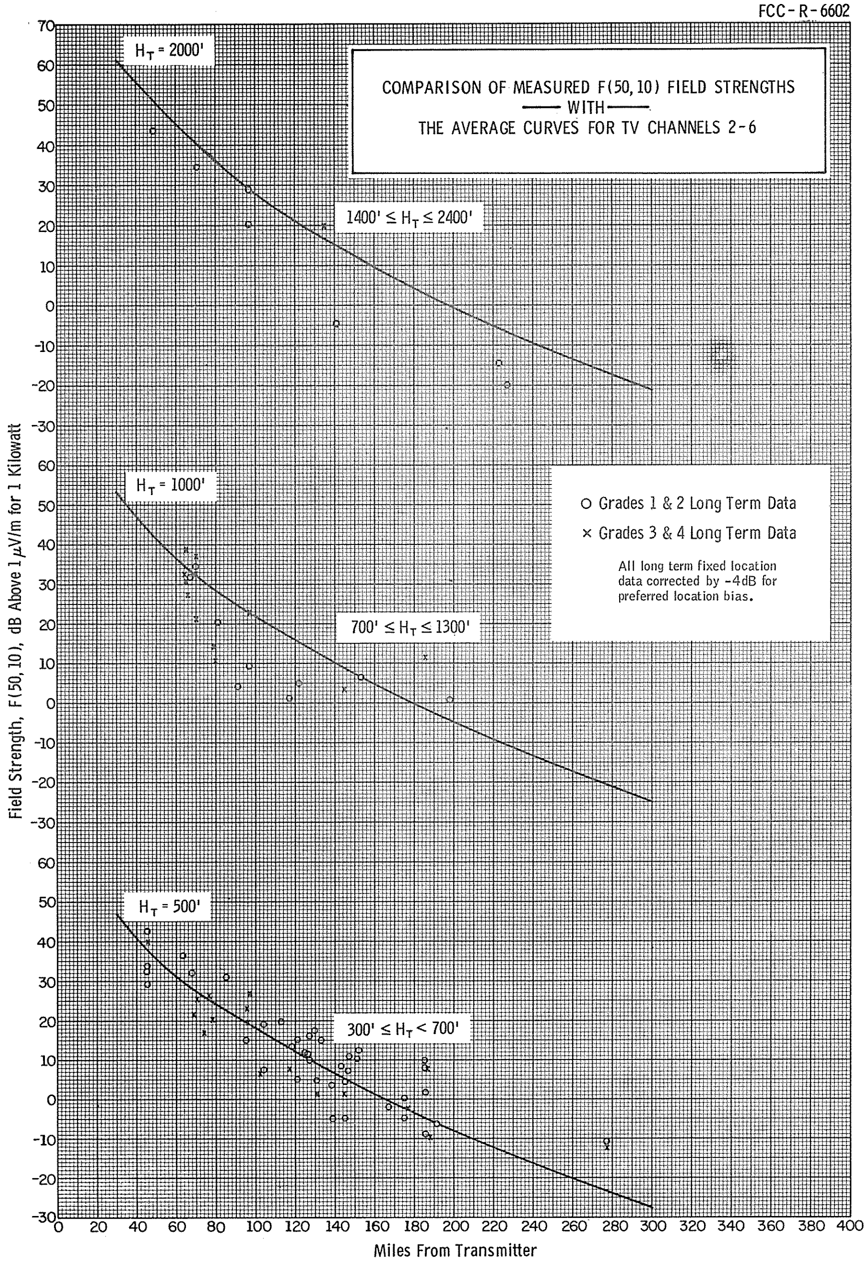


FIGURE 15

FCC-R-6602

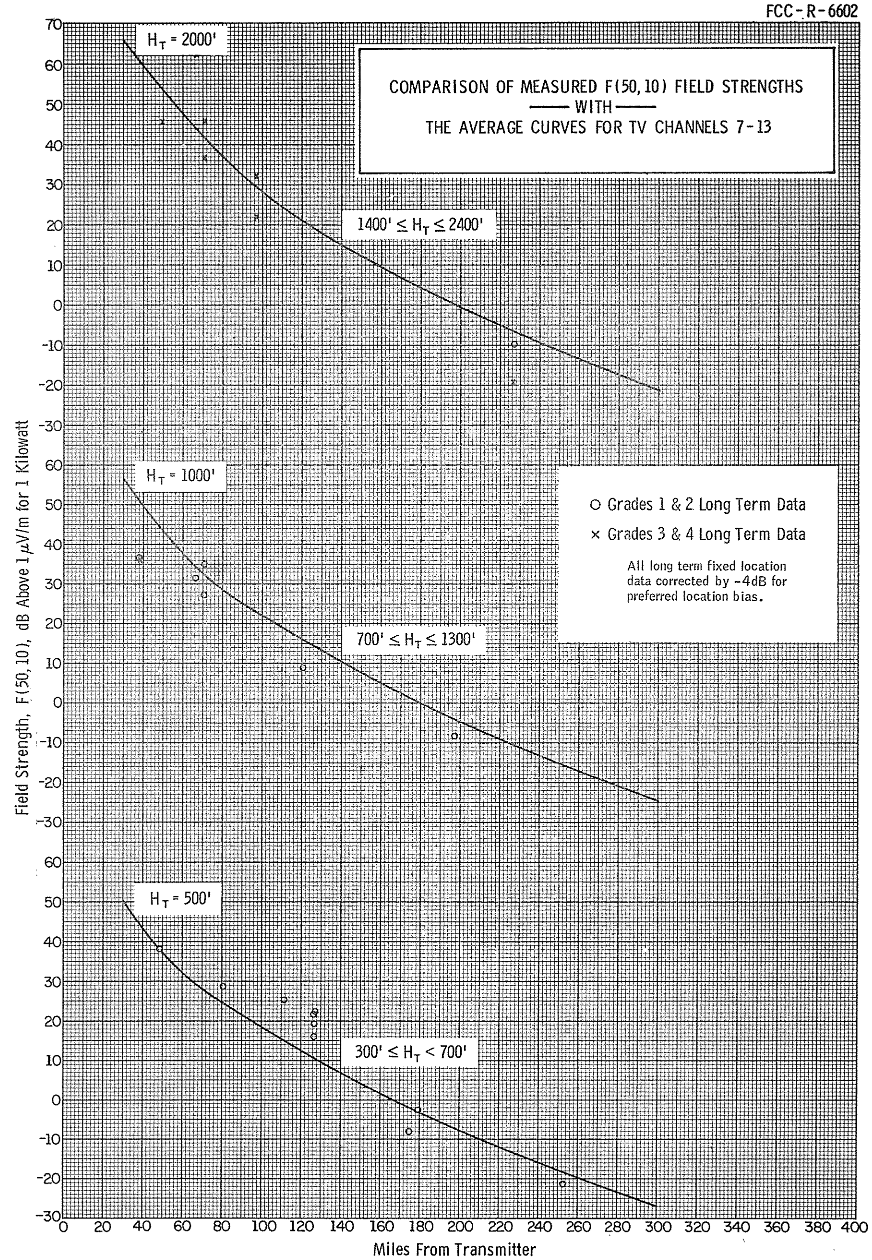
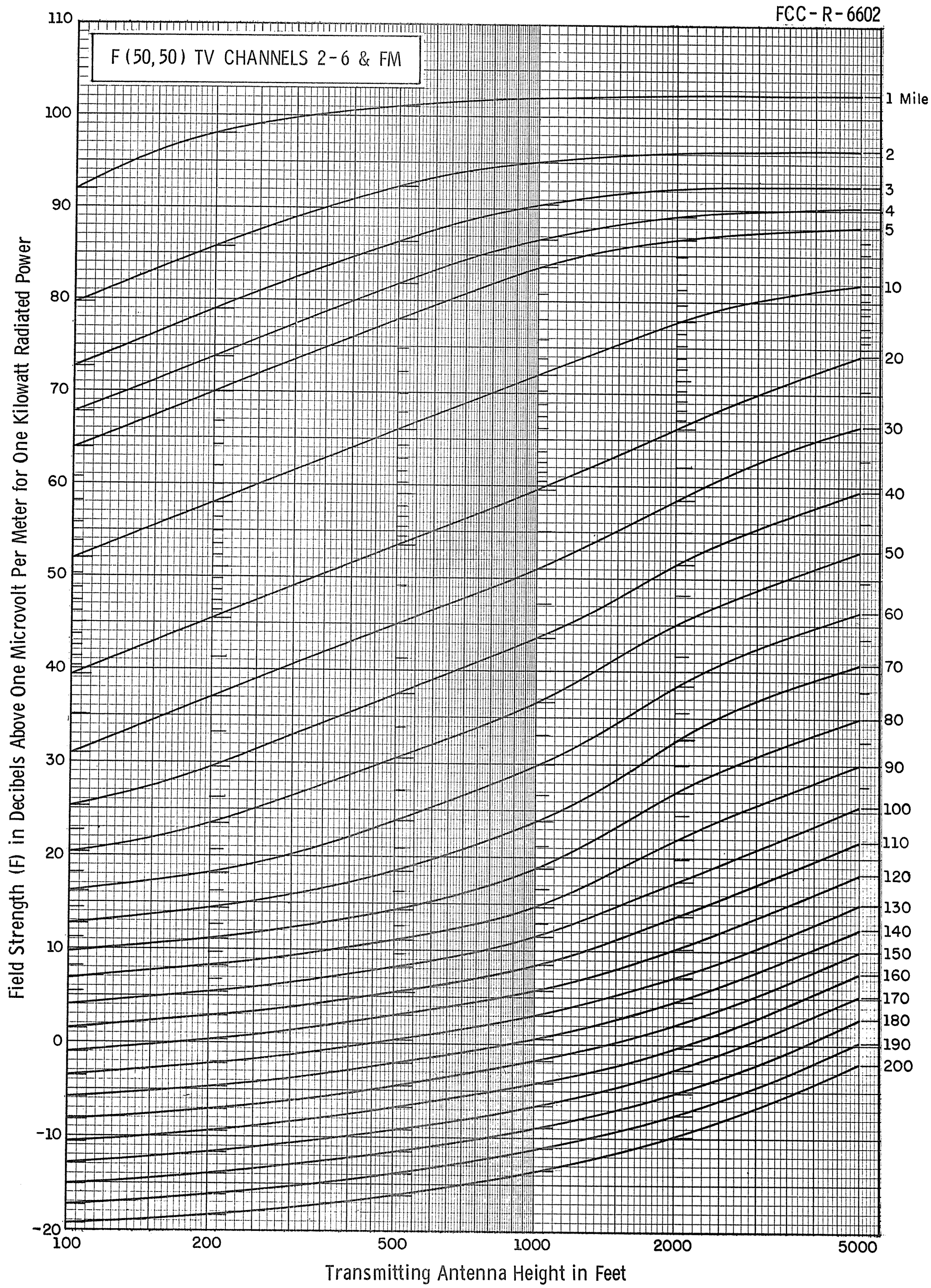


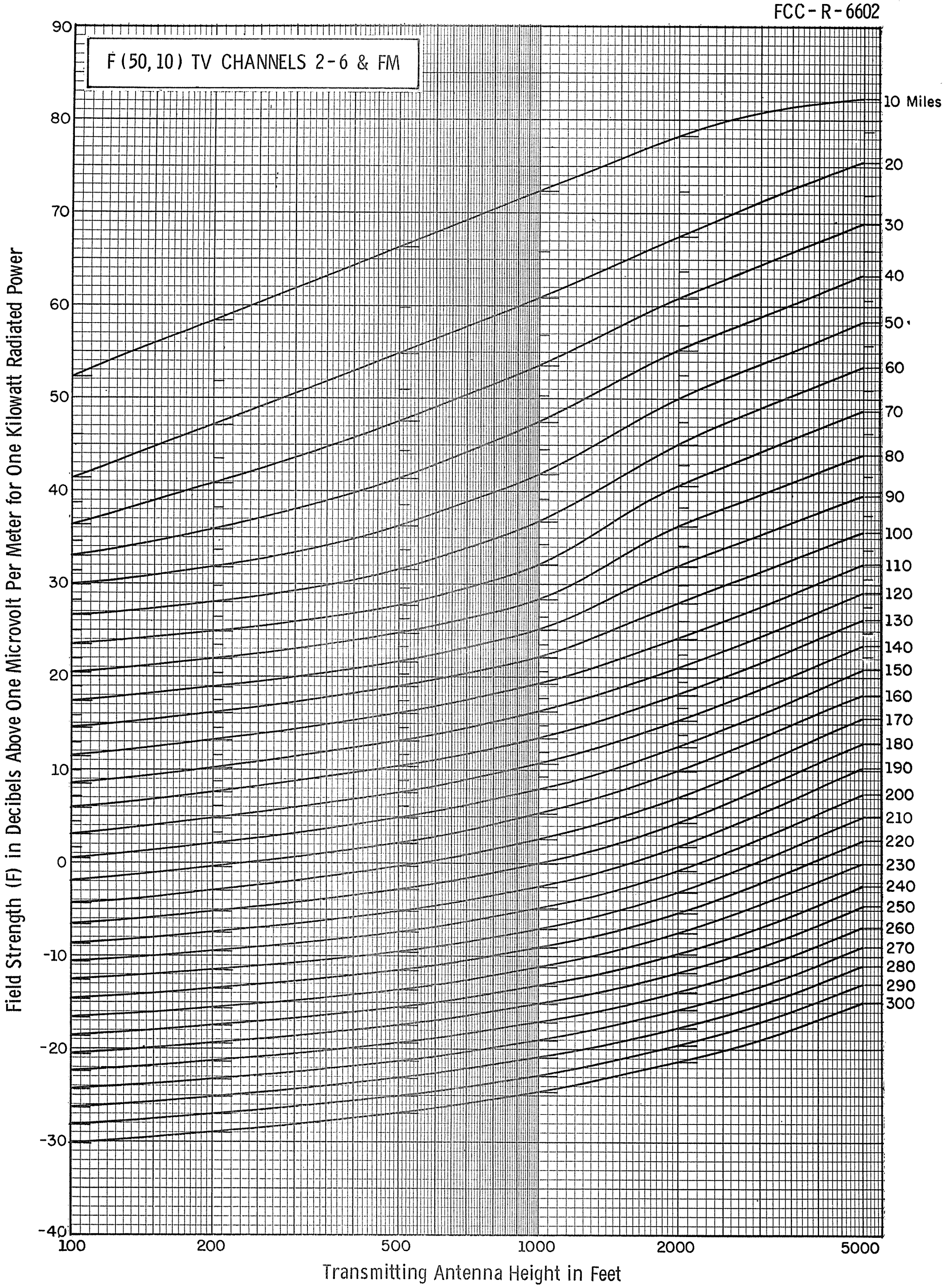
FIGURE 16



TELEVISION CHANNELS 2-6 & FM
ESTIMATED FIELD STRENGTH EXCEEDED AT 50 PERCENT
OF THE POTENTIAL RECEIVER LOCATIONS FOR AT LEAST 50 PERCENT
OF THE TIME AT A RECEIVING ANTENNA HEIGHT OF 30 FEET

April 12, 1966

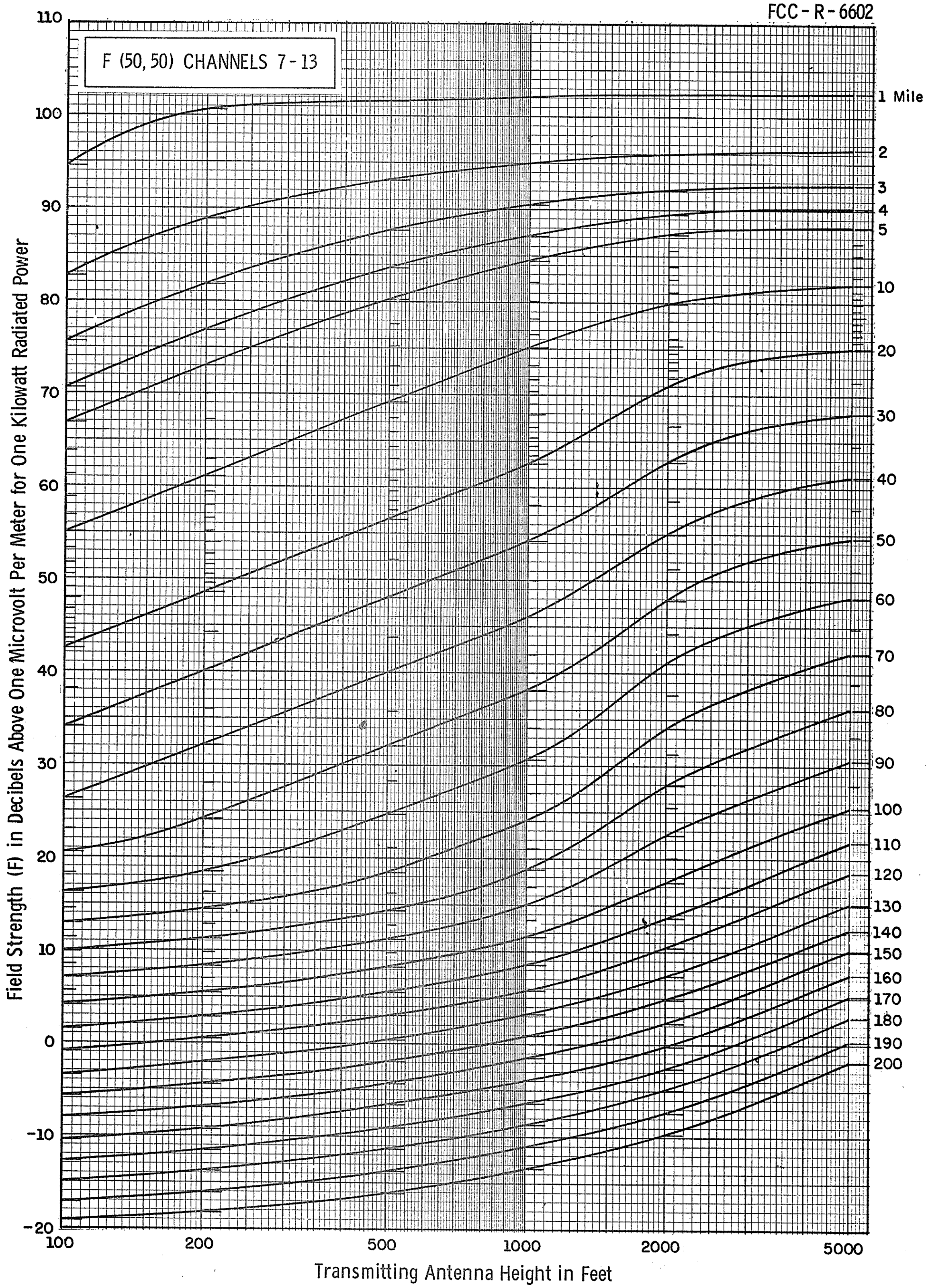
FIGURE 17



TELEVISION CHANNELS 2-6 & FM
ESTIMATED FIELD STRENGTH EXCEEDED AT 50 PERCENT
OF THE POTENTIAL RECEIVER LOCATIONS FOR AT LEAST 10 PERCENT
OF THE TIME AT A RECEIVING ANTENNA HEIGHT OF 30 FEET

April 12, 1966

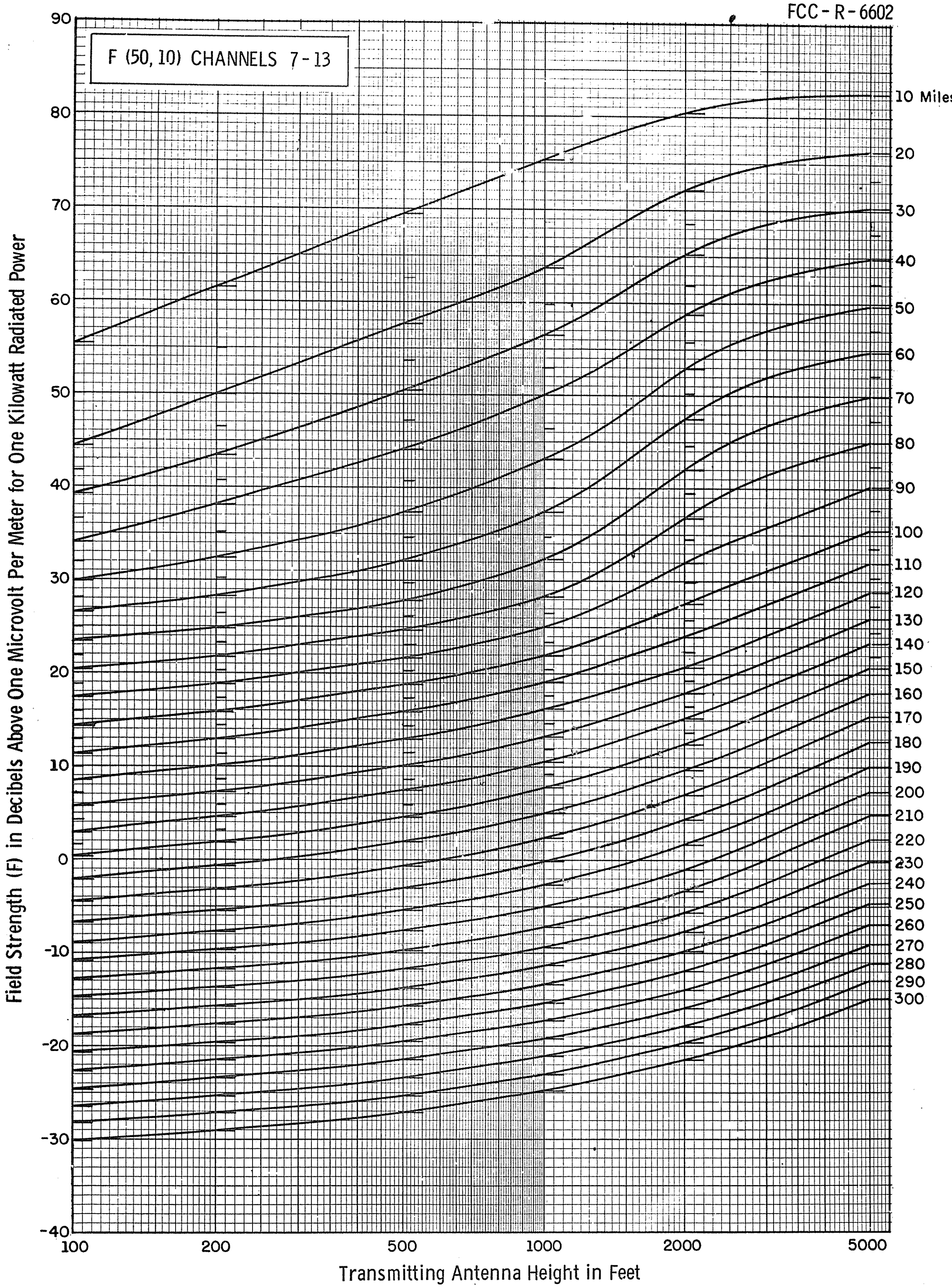
FIGURE 18



TELEVISION CHANNELS 7 - 13
ESTIMATED FIELD STRENGTH EXCEEDED AT 50 PERCENT
OF THE POTENTIAL RECEIVER LOCATIONS FOR AT LEAST 50 PERCENT
OF THE TIME AT A RECEIVING ANTENNA HEIGHT OF 30 FEET

April 12, 1966

FIGURE 19



TELEVISION CHANNELS 7 - 13
ESTIMATED FIELD STRENGTH EXCEEDED AT 50 PERCENT
OF THE POTENTIAL RECEIVER LOCATIONS FOR AT LEAST 10 PERCENT
OF THE TIME AT A RECEIVING ANTENNA HEIGHT OF 30 FEET

April 12, 1966

FIGURE 20

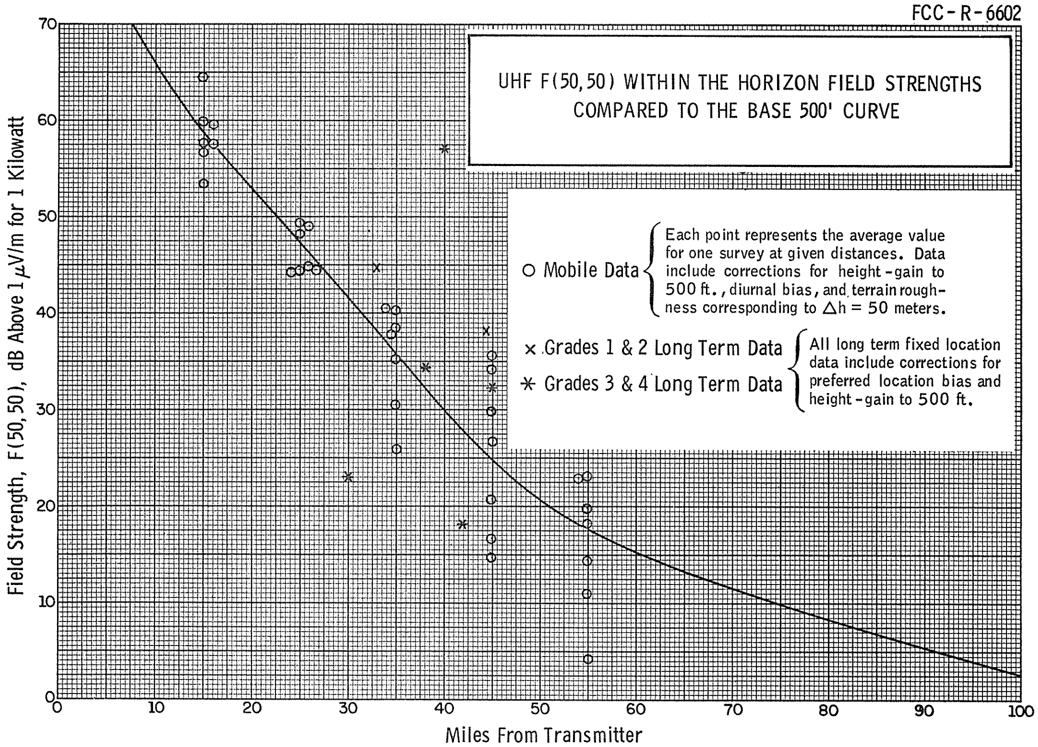

UHF F(50,50) WITHIN THE HORIZON FIELD STRENGTHS COMPARED TO THE BASE 500' CURVE
○ Mobile Data
Each point represents the average value for one survey at given distances. Data include corrections for height-gain to 500 ft., diurnal bias, and terrain roughness corresponding to △h = 50 meters.
× Grades 1 & 2 Long Term Data
✳ Grades 3 & 4 Long Term Data
All long term fixed location data include corrections for preferred location bias and height-gain to 500 ft.
Field Strength, F(50,50), dB Above 1 μV/m for 1 Kilowatt
Miles From Transmitter
0
10
20
30
40
50
60
70
80
90
100

FIGURE 21

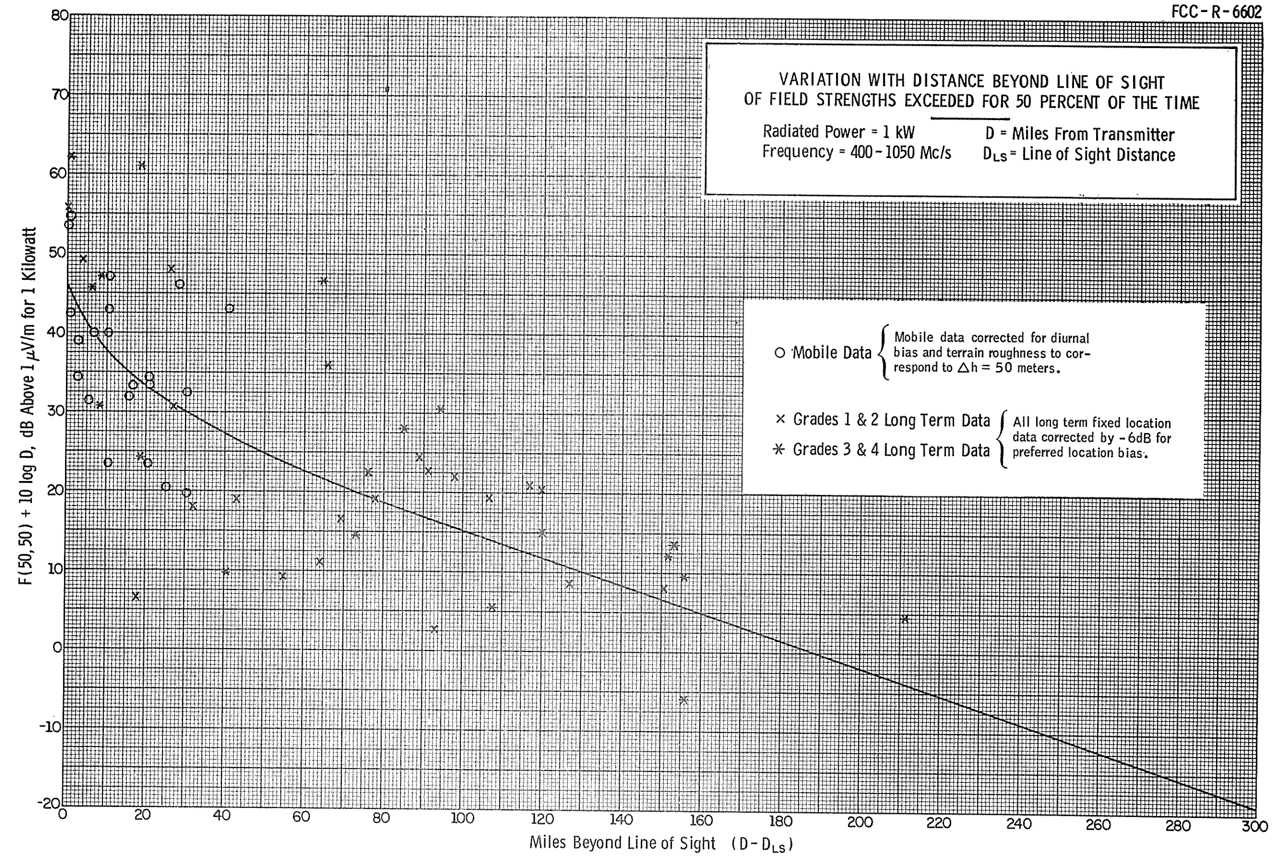


FIGURE 22

FCC-R-6602

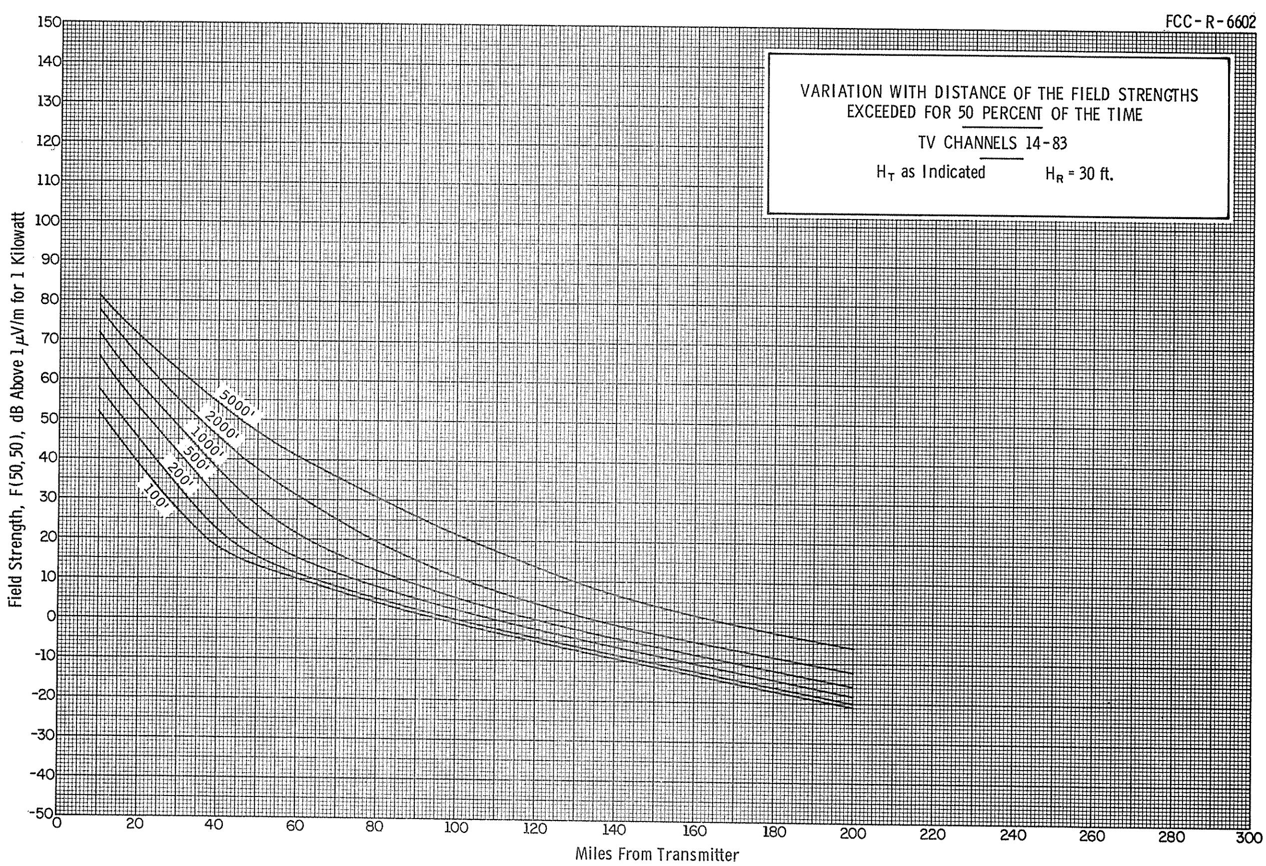


FIGURE 23

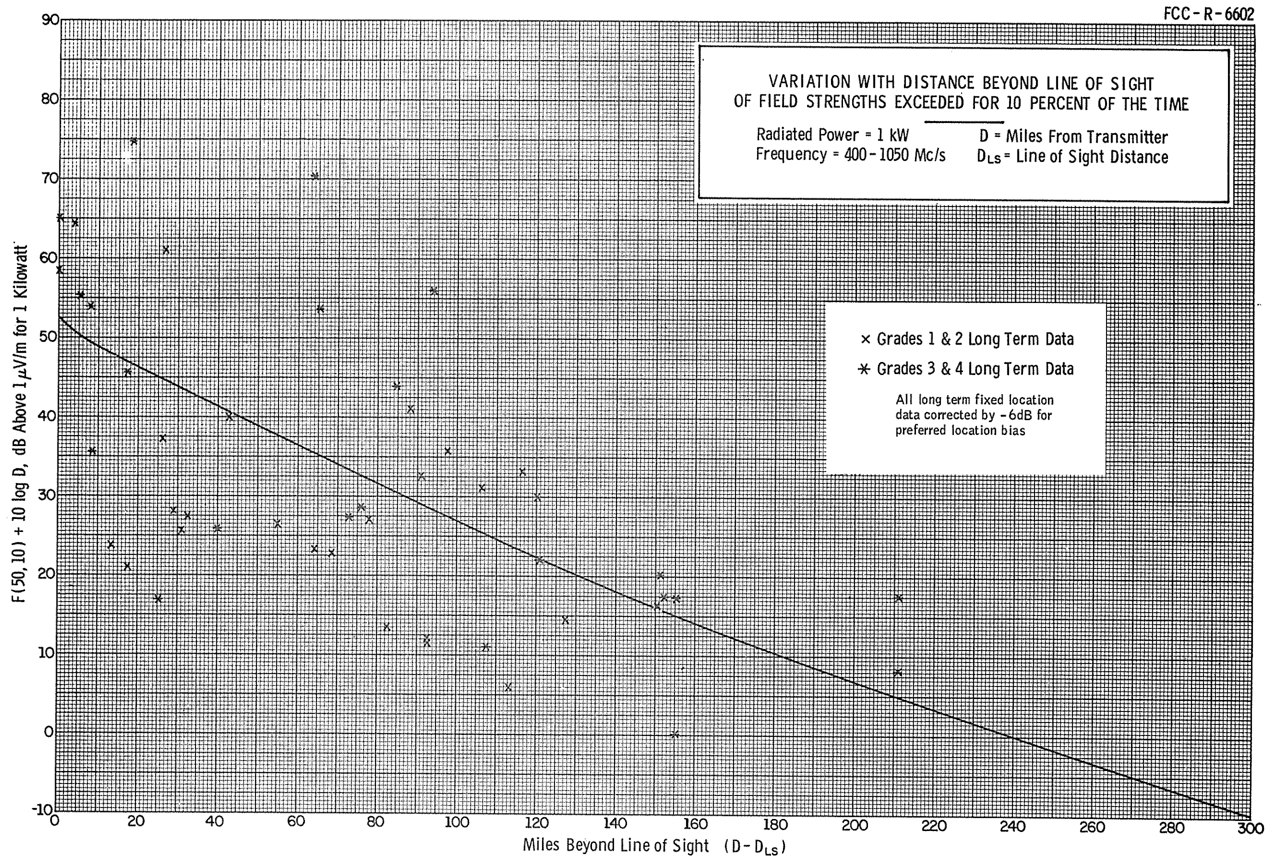


FIGURE 24

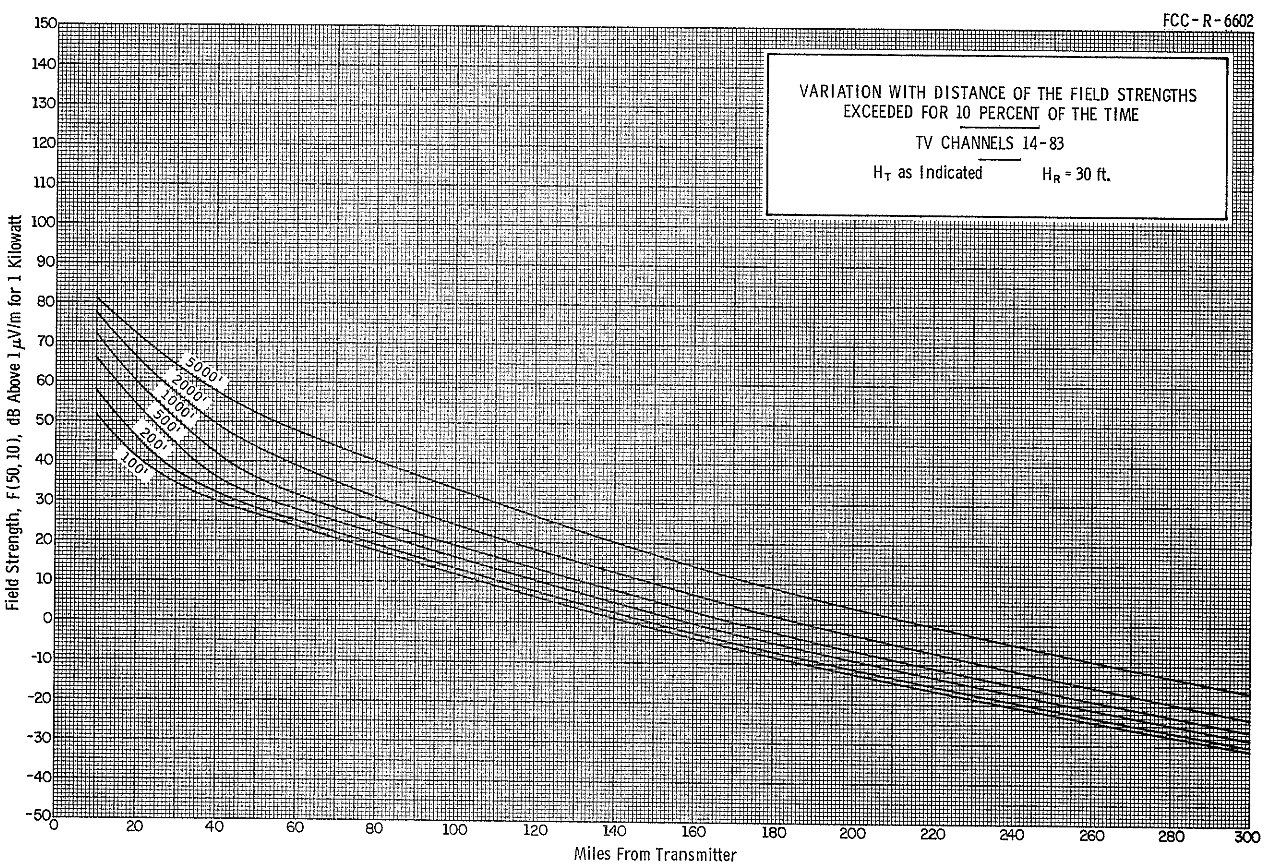


FIGURE 25

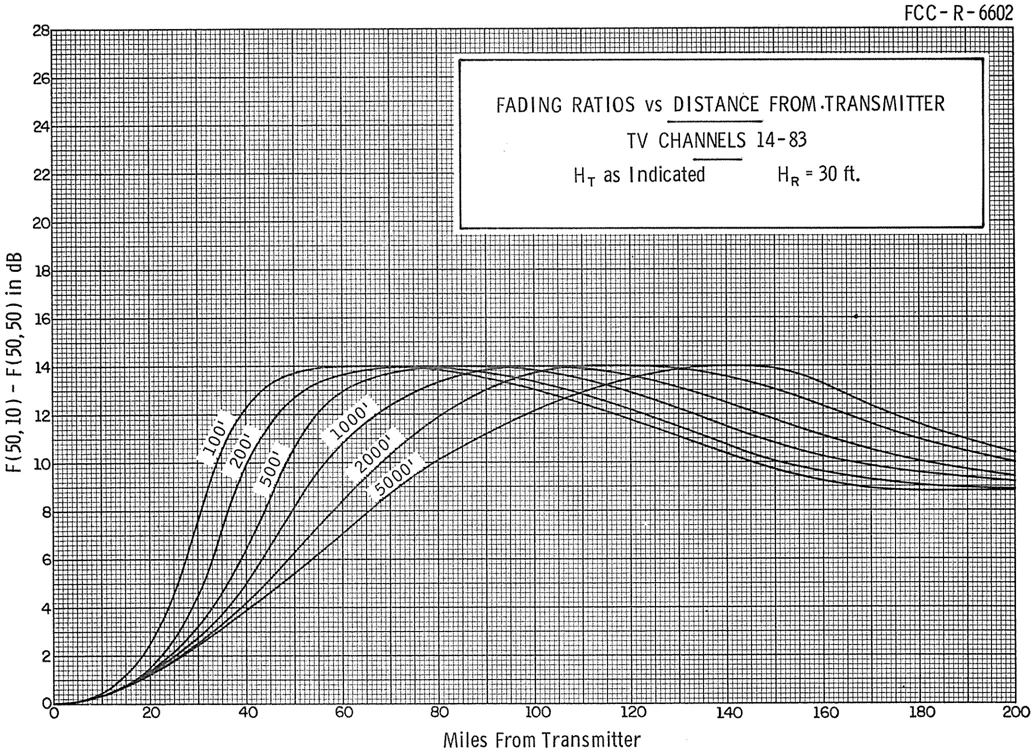

FADING RATIOS vs DISTANCE FROM TRANSMITTER
TV CHANNELS 14-83
H_T as Indicated H_R = 30 ft.
F(50,10) - F(50,50) in dB
Miles From Transmitter
100'
200'
500'
1000'
2000'
5000'
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
0
20
40
60
80
100
120
140
160
180
200

FIGURE 26

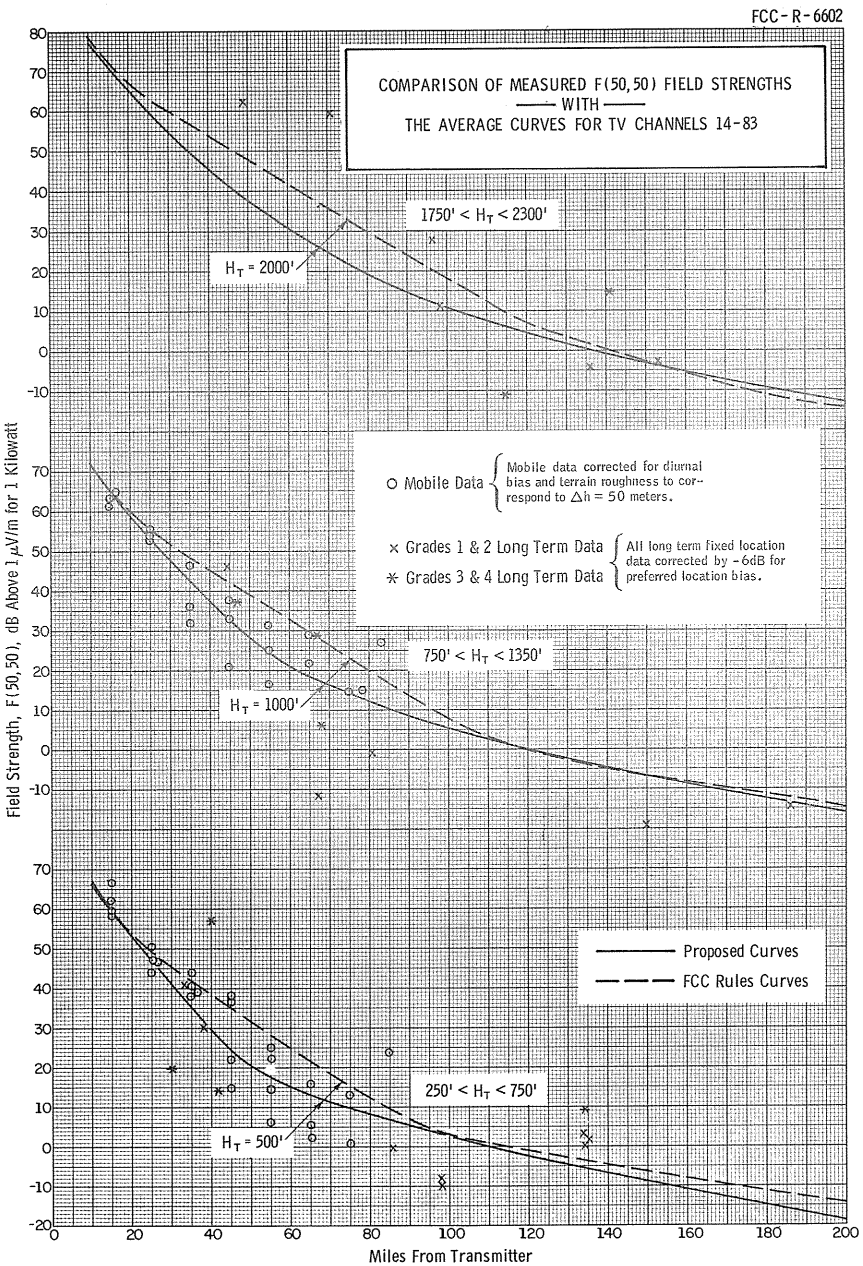


FIGURE 27

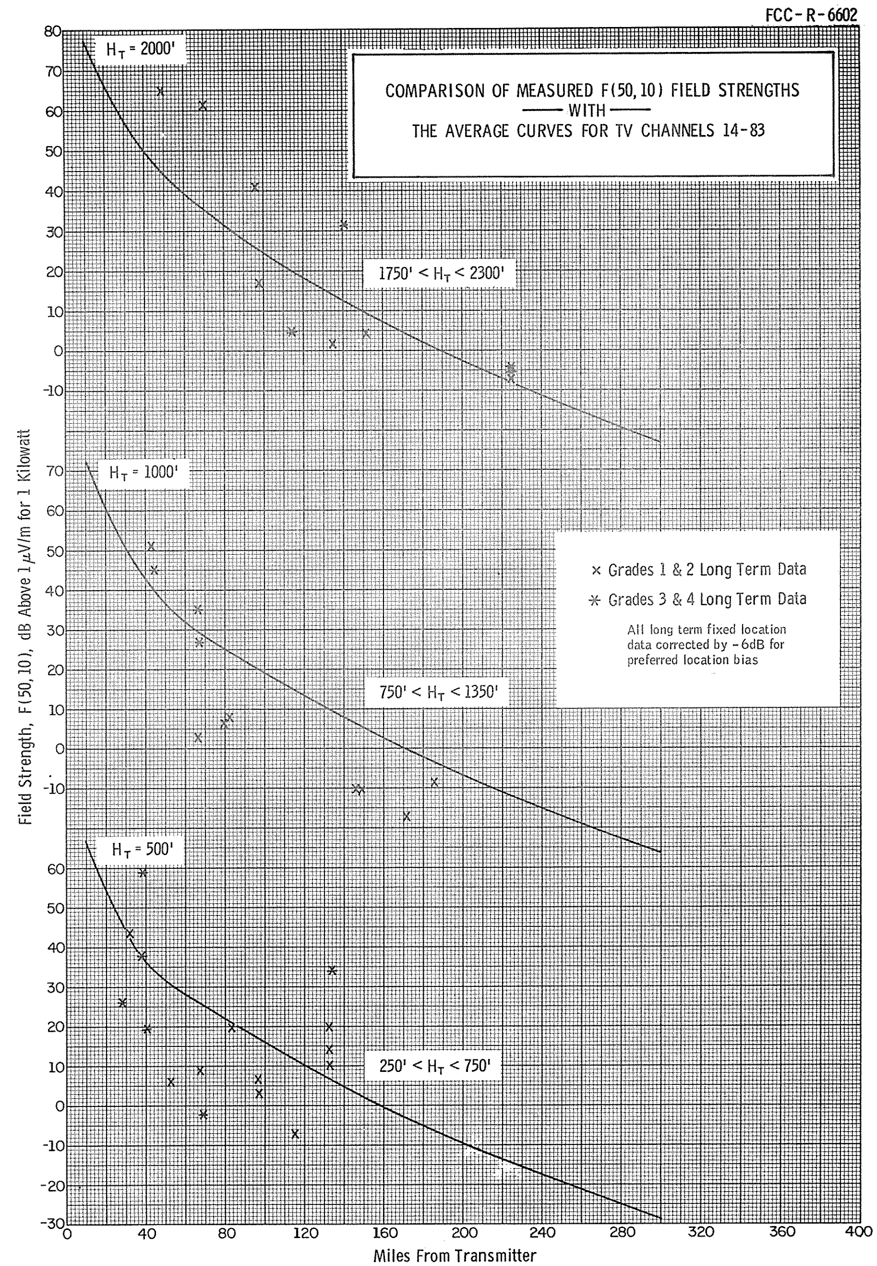
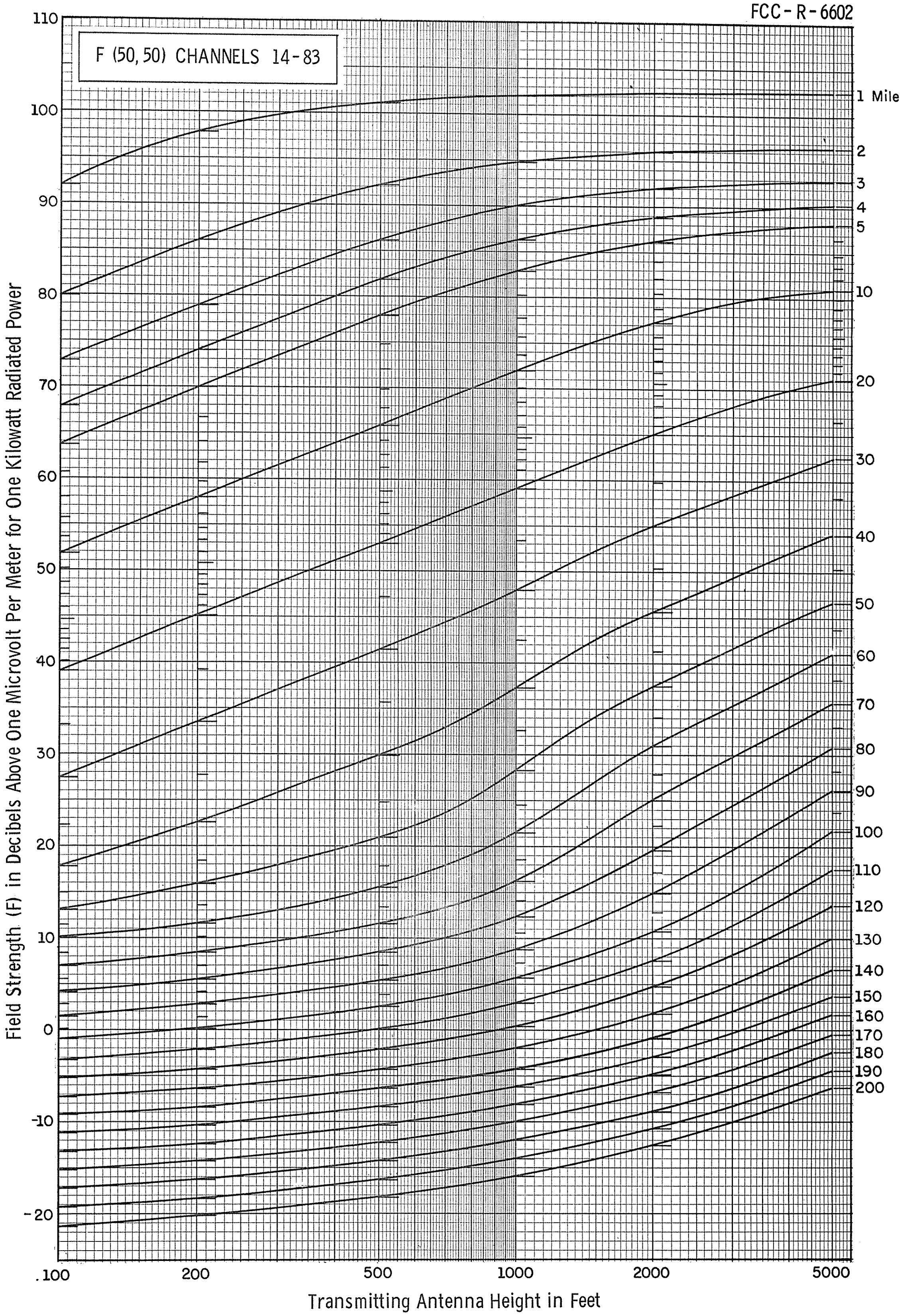


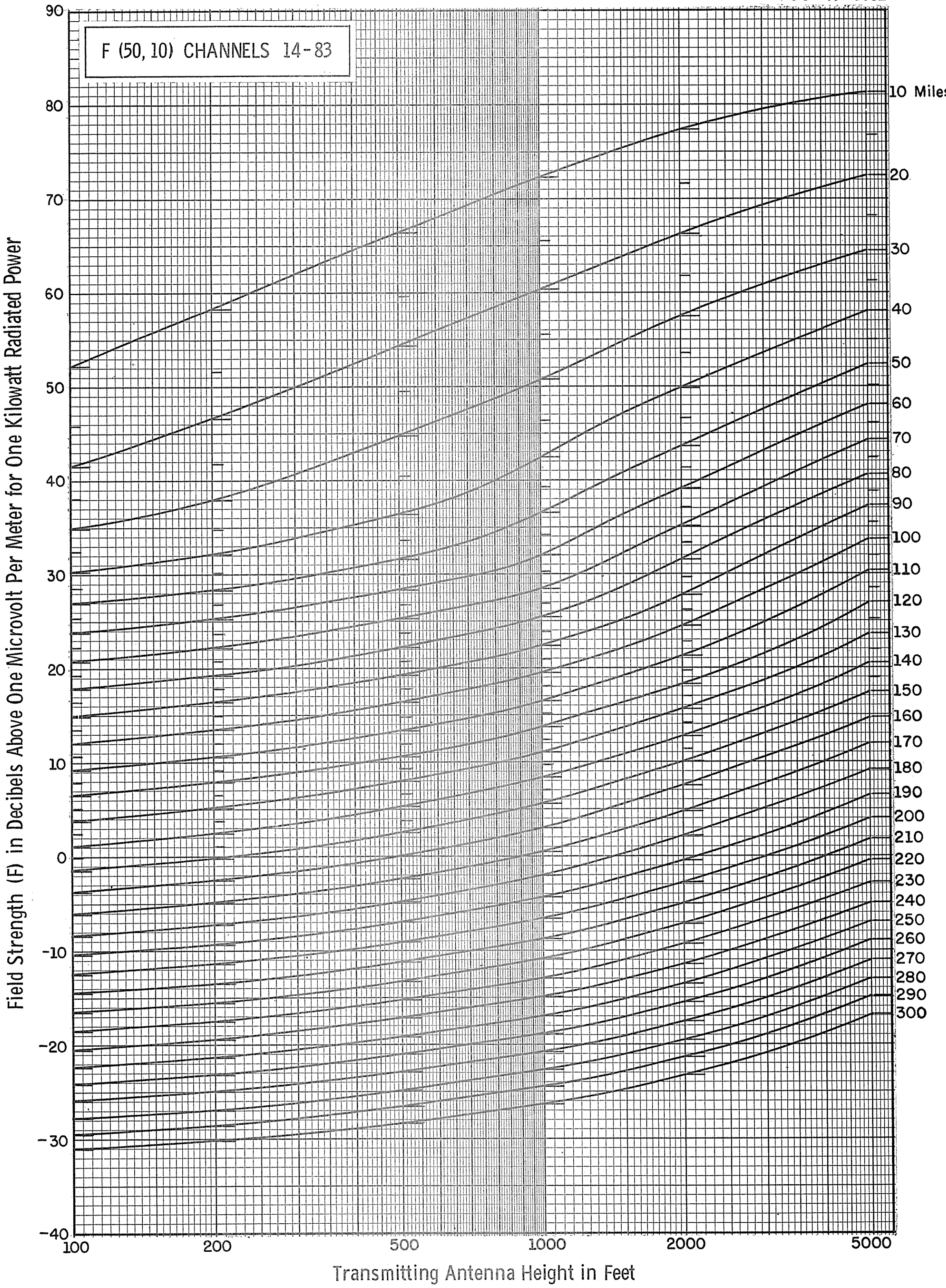
FIGURE 28



TELEVISION CHANNELS 14-83
ESTIMATED FIELD STRENGTH EXCEEDED AT 50 PERCENT
OF THE POTENTIAL RECEIVER LOCATIONS FOR AT LEAST 50 PERCENT
OF THE TIME AT A RECEIVING ANTENNA HEIGHT OF 30 FEET

April 12, 1966

FIGURE 29



TELEVISION CHANNELS 14-83
ESTIMATED FIELD STRENGTH EXCEEDED AT 50 PERCENT
OF THE POTENTIAL RECEIVER LOCATIONS FOR AT LEAST 10 PERCENT
OF THE TIME AT A RECEIVING ANTENNA HEIGHT OF 30 FEET

April 12, 1966

FIGURE 30