REFERENCE DATA FOR RADIOFREQUENCY EMISSION HAZARD ANALYSIS

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FOREWORD

Since the first commercial radio station began broadcasting in 1921, the number of radio and television broadcasting stations in this country has increased dramatically and now exceeds 6,400. The electromagnetic energy transmitted by these installations as well as that associated with civilian and government microwave and radar devices has become of concern because of possible health effects. Furthermore, most broadcast stations are located near large population concentrations, and in fact direct their emissions at the population.

The evaluation of the possible health hazards to a population in a particular location involves many variables and requires data from a number of sources. This document illustrates the methods employed in calculating power density and other values closely associated with environmental radiation from radiofrequency emitters and possible health effects. Graphs and tables of pertinent data used in the calculations are included.

Additional information concerned with irradiation and the biological factors associated with health effects are sought on a continuing basis. The comments of individuals interested in this or allied aspects of radiation protection of man and his environment are solicited.

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INTRODUCTION

Recent attention has been directed toward the environmental impact of nonionizing electromagnetic radiation, particularly the relationship between environmental exposure levels and possible health implications. Although the current status of biological effects research precludes any specific conclusions about what levels and frequencies of radiofrequency energy are definitely hazardous, certain general guidelines for exposure have been established.

Theoretical evaluation of exposure levels in the vicinity of various radiofrequency emitting devices must incorporate the effects of many variables. These variables include source parameters, geographical factors, and atmospheric effects; propagation models utilizing this information are often complex and are difficult to use for rapid estimation applications. The purpose of this report is to provide, in a single source, a collection of information which is helpful in the practical evaluation of environmental radiofrequency exposure levels from these emitters. For the most part, this information is in the form of graphs and tables indicating the relationship between selected parameters. Included is a glossary of commonly used terms. Two examples of mathematical solutions illustrate the data's applicability to hazard analysis.

DESCRIPTION OF DATA

TABLE 1

Table 1 provides a perspective to the radiofrequency (RF) hazards analysis area and illustrates various radiation protection guides in use throughout the world.

TABLE 2

Table 2 gives commonly used frequency band designations as adapted from the Radio Regulations of the International Telecommunications Union, Article 2, Section 11, Geneva; 1959. Reference (1).

TABLE 3

Power and voltage ratios are conveniently expressed in decibels (dB). The expressions relating power and voltage ratios and dB are:

$$dB = 10 \log_{10} \text{(Power ratio)}$$

$$dB = 20 \log_{10} \text{(Voltage ratio)}$$

Table 3 allows conversion of dB to power or voltage ratios, both greater and less than unity.

TABLE 4

Table 4 gives the general letter designations for the various microwave frequency bands within the range 225 MHz to 56 GHz. Reference (1).

GRAPH 1

For plane electromagnetic waves in free space, the electric field strength E is related to power density PD by the relationship

$$PD = \frac{E^2}{Z_o} = \frac{E^2}{377}, \text{ where}$$

E is expressed in terms of volts per meter; Z_o is the intrinsic impedance of vacuum which is 377 ohms; and PD, the power density, is in units of watts per square meter.

If field strength is specified in volts per meter and the power density is desired in units of mW/cm^2, the relation is simply

$$PD\ (mW/cm^2) = \frac{E^2}{3770}$$

The right-hand scale of Graph 1 provides the connection between expressing power density in mW/cm^2 and dBm/cm^2. Here 0 dBm is equal to 1 mW.

GRAPH 2

Graph 2 relates effective radiated power (ERP), distance from the source, and the equivalent free space power density for several selected levels. In this case, the term free space refers to the fact that the computed values of power density were obtained under the assumption that no reflecting surfaces, such as the ground, caused other than the directly radiated wave to impinge at the calculation point. Furthermore, the medium of propagation offered no attenuation to the radiated waves. The ERP is computed on the basis of transmitter output power, power fed to the transmitting antenna, and antenna power gain G according to the relation.

$$ERP = GP_t, \text{ where}$$

G is the power gain expressed as a factor (e.g., a 12 dB power gain antenna will enter as a factor of 15.85 as taken from Table 3) and P_t is the transmitter output power. The units of the calculated ERP will be in the same units as used for P_t (watts, kW, etc.).

From this value for ERP, the field density PD is arrived at from

$$PD = \frac{ERP}{4 \pi R^2}, \text{ where}$$

R represents the distance from the source.

Another useful formula is that for field strength in volts per meter: Field strength (V/m) = $\frac{\sqrt{30\ ERP}}{R}$, where ERP is expressed in watts at the desired radiation angle and R is the distance in meters.

GRAPH 3

Graph 3 indicates the variation in field strength with distance for a maximum power 50 kW AM broadcast station. Both frequency of emission and ground conductivity affect the ground level field strength from the source. Two curves are given to indicate the range in possible levels caused by variations in these two parameters. It has been assumed that the transmitting antenna is a single monopole radiator with an optimum height of 5/8 wavelength. These data are condensed from FCC information (2).

GRAPH 4

The radiated field strength from a vertical monopole radiator is a function of the current distribution on the radiator as well as the ground conductivity at the base of the tower and over the path of radiation to the reception point. This graph indicates the field strength of towers of various electrical heights for sinusoidal current distributions and high conductivity grounds. The optimum tower height is seen to be 0.625 λ. These data are condensed from the FCC Rules and Regulations (2).

GRAPH 5

Most television and FM broadcast stations employ transmitting antennas which exhibit gain in vertical planes. This means that the radiation field is restricted to some small vertical angle of emission; i.e., rather than radiating at useless, high vertical angles, the beam is flattened to propagate most of the energy in a narrow beam which is usually aimed at the horizon or some slightly lower angle. The radiation characteristics of the antenna are usually uniform in the horizontal plane, i.e., it radiates equally in all azimuthal directions. The primary power gain of such antennas is thus obtained in the vertical plane. This contrasts with vertical radiators, such as AM broadcast stations, in which horizontal directionality is sometimes desired and obtained by strategically placing a number of towers in a phased array.

Graph 5 illustrates the vertical gain pattern of a typical medium gain UHF TV transmitting antenna. Here, the ordinate is expressed as the relative field strength. Thus, for any particular depression angle, the field strength may be determined in relation to whatever the main beam field strength would be at the same distance from the tower. Ground level field strengths may thus be easily computed if the ERP in the main beam is known.

GRAPH 6

This graph related antenna depression angle to distance from the antenna for various antenna tower heights. Generally, broadcasting antennas for FM and television service are directive in the vertical plane; i.e., the antenna concentrates the power at some specific angle with respect to the horizontal plane. This means that the radiation intensity varies as a function of height above ground, for a given ground distance to the tower. The depression angle is defined as that angle below the horizontal plane at the antenna's height defined by a line drawn from the reception point on the earth's surface to the antenna. As the surface distance from the tower to the observation point decreases, the depression angle increases. This angle is used in evaluating the field strength of such an antenna at ground level, or any other level, which is not in the main beam of the antenna. A vertical gain pattern for the specific antenna is required in order that the appropriate power gain at the particular depression angle of interest may be used to compute the exposure level.

GRAPH 7

In a radar transmitter, the ratio of the average power to the peak power is called the duty factor, or

$$\text{Duty factor} = \frac{\text{P average}}{\text{P peak}}$$

Also, the duty factor is equal to the product of the pulse width and pulse repetition frequency (PRF). Various combinations of these radar parameters are given. Information from reference (1).

GRAPH 8

This graph allows estimation of the antenna power gain for parabolic dish-type radar and microwave antennas when the dish diameter is known. The right-hand scale yields the half-power beam width for the antenna. Information from reference (1).

EXAMPLES

EXAMPLE 1

Given:

A UHF TV station operates with a transmitter power output of +83 dBm into a medium gain antenna with a maximum power gain of 14 dB atop a 700 ft. tower. Find the ground level field strength and power density over flat terrain at a distance of 5.2 miles from the tower. Use the vertical gain antenna pattern of Graph 5 for this problem.

1. First find the output power in kW.

   $+83$ dBm = 80 dBm + 3 dBm = (10^8) (2)mW = 2×10^5 W = 2×10^2 kW Output Power = 200 kW

   dB's are additive; however, the power ratios are multiplicative as shown because of the logarithmic nature of the dB.

2. Next, the maximum effective radiated power is computed as

   $ERP_{max} = P_{out} \times G_{max} = 200$ kW $\times$ 25.12 = 5.024 MW

   The gain of 14 dB is expressed as a power ratio of 25.12.

3. Next, the depression angle is determined from Graph 6 as 1.5^o for the 700 ft. tower and ground distance of 5.2 miles.

4. The field strength is now computed for the main beam of the transmitting antenna at a distance of 5.2 miles as

$$\text{Field Strength} = \frac{\sqrt{30\ P_t}}{R\ (\text{meters})} = \frac{\sqrt{(30)(5.024\ \text{MW})}}{(5.2\ \text{miles})\ (1609\ \text{m/mile})}$$

= 1.467 volts/meter

5. Finally, the effective field strength at ground level is found by multiplying the main beam field strength as computed in 3 above by the relative field factor found from Graph 5 at a depression angle of 1.5^{o}.

   Ground level field strength = 1.467 V/m x 0.675 = 0.990 V/m. This is equivalent, from Graph 1, to 2.60×10^{-4} mW/cm^2.

EXAMPLE 2

Given:

A radar facility, utilizing a parabolic dish antenna approximately 4 ft. in diameter, has a peak transmitter output power of 2 MW. Assuming a PRF of 200 pulses per second and a pulse width of 5 μsec., find what target distance in the main beam of the radar antenna is associated with an average field density of 1 mW/cm^2, if the radar operates at 10 GHz.

1. From Graph 7 it is apparent that, for the above parameters, a duty factor of .001 exists for the system and, consequently, the average output power to the antenna is 2 kW.
2. Now, from Graph 8, it is determined that the parabolic dish exhibits a gain of 40 dB or a power factor of 10^4.
3. The average effective radiated power is now computed as

   $ERP_{ave} = P_t G = (2 \times 10^3)(10^4)\ W = 2 \times 10^7\ W = 2 \times 10^4\ kW$

4. Finally, from Graph 2, it is seen that for an ERP of 2×10^4 kW, an average power density of 1 mW/cm^2 will occur at 0.25 mile from the source, this being in the main beam of the transmitting antenna.

Country and Source	Radiation Frequency	Maximum Recommended Level	Condition or Remarks
USA (USASI)	10 MHz to 100 GHz	10 mW/cm^2 1 mW hr/cm^2	Periods of 0.1 hr. Averaged over any 0.1 hr. period
US Army and Air Force	---	10 mW/cm^2 10 to 100 mW/cm^2 100 mW/cm^2	Continuous exposure Maximum exposure time in minutes at W(mW/cm^2) = 6000W^{-2} No occupancy
Great Britain (Post Office Regulation)	30 MHz to 30 GHz	10 mW/cm^2	Continuous 8-hr. exposure, average power density
NATO (1956)	---	0.5 mW/cm^2	
Canada	10 MHz to 100 GHz	1 mW hr/cm^2 10 mW/cm^2	Averaged over any 0.1 hr. period Periods of 0.1 hr.
Poland	300 MHz	10 μW/cm^2 100 μW/cm^2 1 mW/cm^2	8 hr. exposure/day 2 to 3 hr/day 15 to 20 min/day
German Soc. Republic	---	10 mW/cm^2	
U.S.S.R.	0.1 to 1.5 MHz 1.5 to 30 MHz 30 to 300 MHz 300 MHz	20 V/m 5 amp/m 20 V/m 5 V/m 10 μW/cm^2 100 μW/cm^2 1 mW/cm^2	Alternating magnetic fields 6 hr/day 2 hr/day 15 min/day
Czech. Soc. Rep.	0.01 to 300 MHz 300 MHz	10 V/m 25 μW/cm^2 10 μW/cm^2	8 hr/day 8 hr/day, CW operation 8 hr/day, pulsed (for shorter exposures see Figures 11 and 12)

TABLE 1. MAXIMUM RECOMMENDED LEVELS FOR HUMAN EXPOSURE

TABLE 2

FREQUENCY BAND NOMENCLATURE

Frequency Range		Atlantic City Frequency Subdivision
3 - 30 kHz	VLF	Very-low frequency
30 - 300 kHz	LF	Low frequency
300 - 3,000 kHz	MF	Medium frequency
3,000 - 30,000 Khz	HF	High frequency
30 - 300 MHz	VHF	Very-high frequency
300 - 3,000 MHz	UHF	Ultra-high frequency
3,000 - 30,000 MHz	SHF	Super-high frequency
30 - 300 GHz	EHF	Extremely-high frequency
300 - 3,000 GHz	---	---

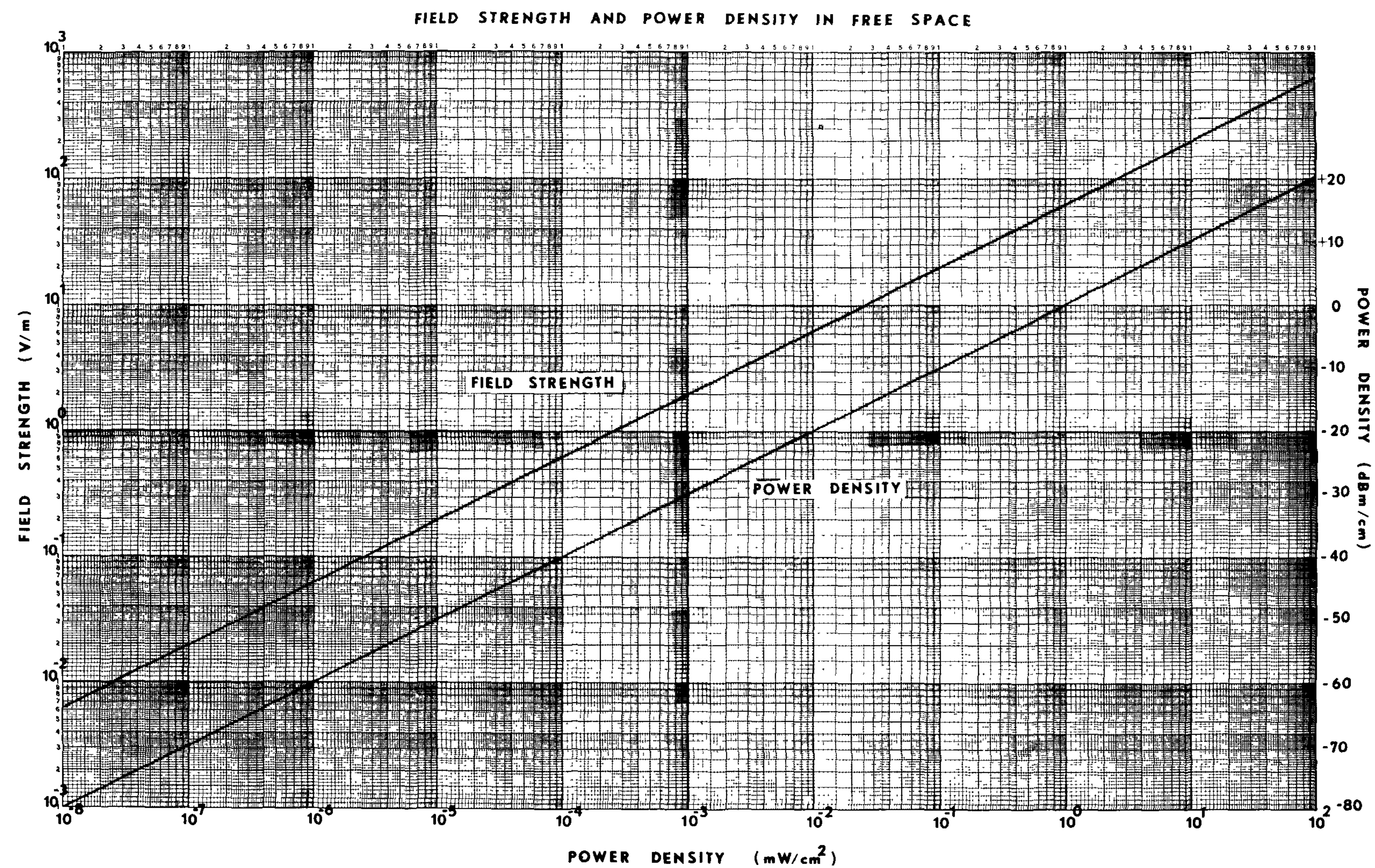
VOLTAGE RATIO	POWER RATIO	dB	VOLTAGE RATIO	POWER RATIO	VOLTAGE RATIO	POWER RATIO	dB	VOLTAGE RATIO	POWER RATIO
1.0000	1.0000	0.00	1.0000	1.0000	.5129	.2630	5.8	1.950	3.802
.9988	.9977	0.01	1.0012	1.0023	.5070	.2570	5.9	1.972	3.890
.9977	.9954	0.02	1.0023	1.0046	.5012	.2512	6.0	1.995	3.931
.9966	.9931	0.03	1.0035	1.0069	.4955	.2455	6.1	2.018	4.074
.9954	.9908	0.04	1.0046	1.0093	.4898	.2399	6.2	2.042	4.169
.9943	.9886	0.05	1.0058	1 0116	.4842	.2344	6.3	2.065	4.266
.9931	.9863	0.06	1.0069	1.0139	.4786	.2291	6.4	2.089	4.365
.9920	.9840	0.07	1.0081	1.0162	.4732	.2239	6.5	2.113	4.467
.9908	.9817	0.08	1.0093	1.0186	.4677	.2188	6.6	2.138	4.571
9897	.9795	0.09	1.0104	1.0209	.4624	.2138	6.7	2.163	4.677
.9886	.9772	0.1	1.012	1.023	.4571	.2089	6.8	2.188	4.786
.9772	.9550	0.2	1.023	1.047	.4519	.2042	6.9	2.213	4.898
.9661	.9333	0.3	1.035	1.072	.4467	.1995	7.0	2.239	5.012
.9550	.9120	0.4	1.047	1.096	.4416	.1950	7.1	2.265	5.129
.9441	.8913	0.5	1.059	1.122	.4365	.1905	7.2	2.291	5.248
.9333	.8710	0.6	1.072	1.148	.4315	.1862	7.3	2.317	5.370
.9226	.8511	0.7	1.084	1.175	.4266	.1820	7.4	2.344	5.495
.9120	.8318	0.8	1.096	1.202	.4217	.1778	7.5	2.371	5.623
.9016	.8128	0.9	1.109	1.230	.4169	.1738	7.6	2.399	5.754
.8913	.7943	1.0	1.122	1.259	.4121	.1698	7.7	2.427	5.888
.8810	.7762	1.1	1.135	1.288	.4074	.1660	7.8	2.455	6.026
.8710	.7586	1.2	1.148	1.318	.4027	.1622	7.9	2.483	6.166
.8610	.7413	1.3	1.161	1.349	.3981	.1585	8.0	2.512	6.310
8511	.7244	1.4	1.175	1.380	.3936	.1549	8.1	2.541	6.457
.8414	.7079	1.5	1.189	1.413	.3890	.1514	8.2	2.570	6.607
.8318	.6918	1.6	1.202	1.445	.3846	.1479	8.3	2.600	6.761
.8222	.6761	1.7	1.216	1.479	.3802	.1445	8.4	2.630	6.918
.8128	.6607	1.8	1.230	1.514	.3758	.1413	8.5	2.661	7.079
.8035	.6457	1.9	1.245	1.549	.3715	.1380	8.6	2.692	7.244
.7943	.6310	2.0	1.259	1.585	.3673	.1349	8.7	2.723	7.413
.7852	.6166	2.1	1.274	1.622	.3631	.1318	8.8	2.754	7.586
.7762	.6026	2.2	1.288	1.660	.3589	.1288	8.9	2.786	7.762
.7674	.5888	2.3	1.303	1.698	.3548	.1259	9.0	2.818	7.943
.7586	.5754	2.4	1.318	1.738	.3508	.1230	9.1	2.851	8.128
.7499	.5623	2.5	1.334	1.778	.3467	.1202	9.2	2.884	8.318
.7413	.5495	2.6	1.349	1.820	.3428	.1175	9.3	2.917	8.511
.7328	.5370	2.7	1.365	1.862	.3388	.1148	9.4	2.951	8.710
.7244	.5248	2.8	1.380	1.905	.3350	.1122	9.5	2.985	8.913
.7161	.5129	2.9	1.396	1.950	.3311	.1096	9.6	3.020	9.120
.7079	.5012	3.0	1.413	1.995	.3273	.1072	9.7	3.055	9.333
.6998	.4898	3 1	1.429	2.042	.3236	.1047	9.8	3.090	9.550
.6918	.4786	3.2	1.445	2.089	.3199	.1023	9.9	3.126	9.772
.6839	.4677	3.3	1.462	2.138	.3162	.1000	10.0	3.162	10.000
.6761	.4571	3.4	1.479	2.188	.2985	.08913	10.5	3.350	11.22
.6683	.4467	3.5	1.496	2.239	.2818	.07943	11.0	3.548	12.59
.6607	.4365	3.6	1.514	2.291	.2661	.07079	11.5	3.758	14.13
.6531	.4266	3.7	1.531	2.344	.2512	.06310	12.0	3.981	15.85
.6457	.4169	3.8	1.549	2.399	.2371	.05623	12.5	4.217	17.78
.6383	.4074	3.9	1.567	2.455	.2239	.05012	13.0	4.467	19.95
.6310	.3981	4.0	1.585	2.512	.2113	.04467	13.5	4.732	22.39
.6237	.3890	4.1	1.603	2.570	.1995	.03981	14.0	5.012	25.12
.6166	.3802	4.2	1.622	2.630	.1884	.03548	14.5	5.309	28.18
.6095	.3715	4.3	1.641	2.692	.1778	.03162	15.0	5.623	31.62
.6026	.3631	4.4	1.660	2.754	.1585	.02512	16.0	6.310	39.81
.5957	.3548	4.5	1.679	2.818	.1413	.01995	17.0	7.079	50.12
.5888	.3467	4.6	1.698	2.884	.1259	.01585	18.0	7.943	63.10
.5821	.3388	4.7	1.718	2.951	.1122	.01259	19.0	8.913	79.43
5754	.3311	4.8	1.738	3.020	.1000	.01000	20.0	10.000	100.00
.5689	.3236	4.9	1.758	3.090	.03162	.00100	30.0	31.620	1,000.00
.5623	.3162	5.0	1.778	3.162	.01	.00010	40.0	100.00	10,000.00
.5559	.3090	5.1	1.799	3.236	.003162	.00001	50.0	316.20	10^5
.5495	.3020	5.2	1.820	3.311	.001	10^{-6}	60.0	1,000.00	10^6
.5433	.2951	5.3	1.841	3.388	.0003162	10^{-7}	70.0	3,162.00	10^7
.5370	.2884	5.4	1.862	3.467	.0001	10^{-8}	80.0	10,000.00	10^8
.5309	.2818	5.5	1.884	3.548	.00003162	10^{-9}	90.0	31,620.00	10^9
.5248	.2754	5.6	1.905	3.631	10^{-5}	10^{-10}	100.0	10^5	10^{10}
.5188	.2692	5.7	1.928	3.715					

TABLE 3. dB CONVERSION CHART
REPRODUCED BY PERMISSION OF PACIFIC MEASUREMENTS INCORPORATED, PALO ALTO, CALIFORNIA

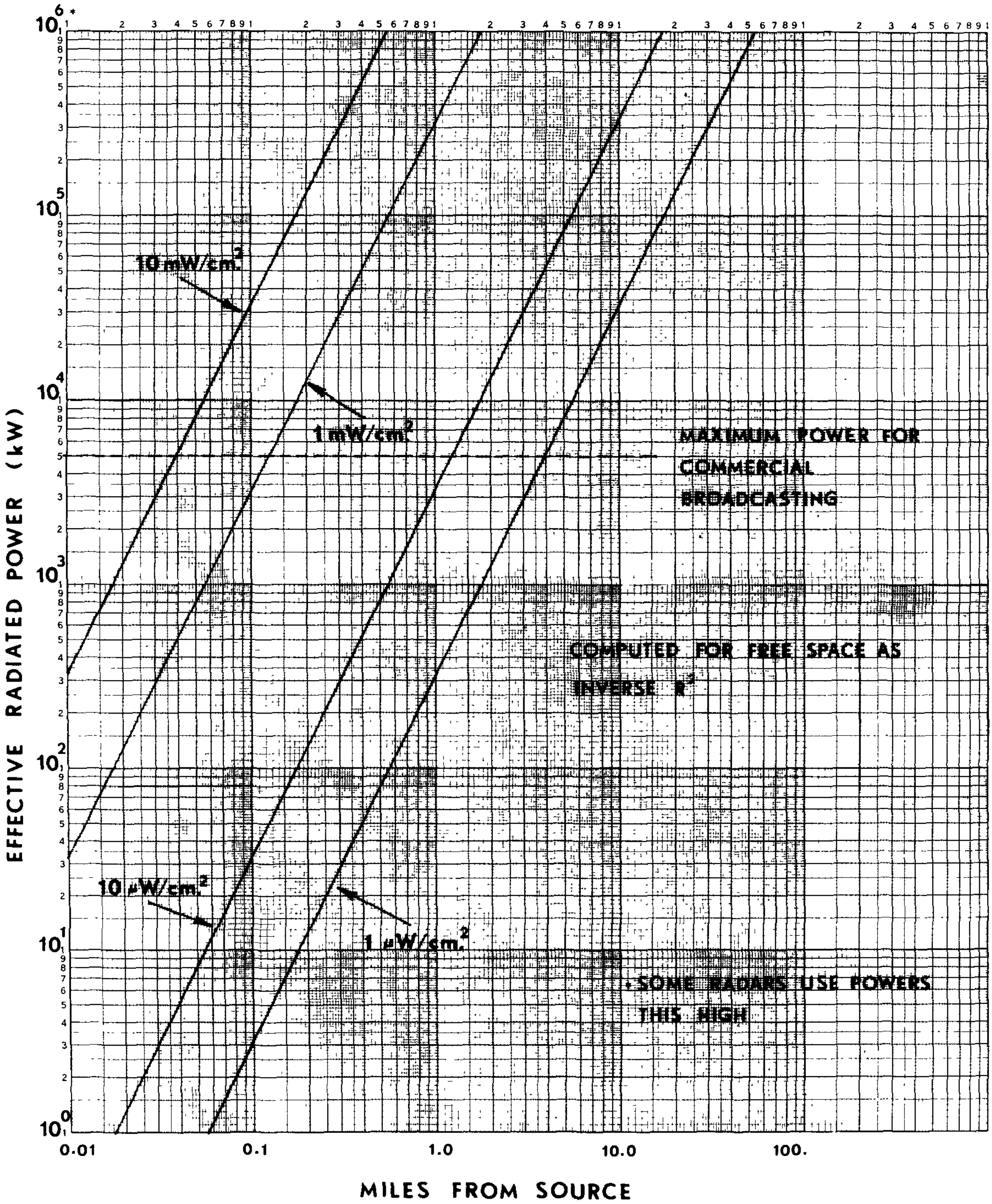
TABLE 4

MICROWAVE BAND DESIGNATIONS

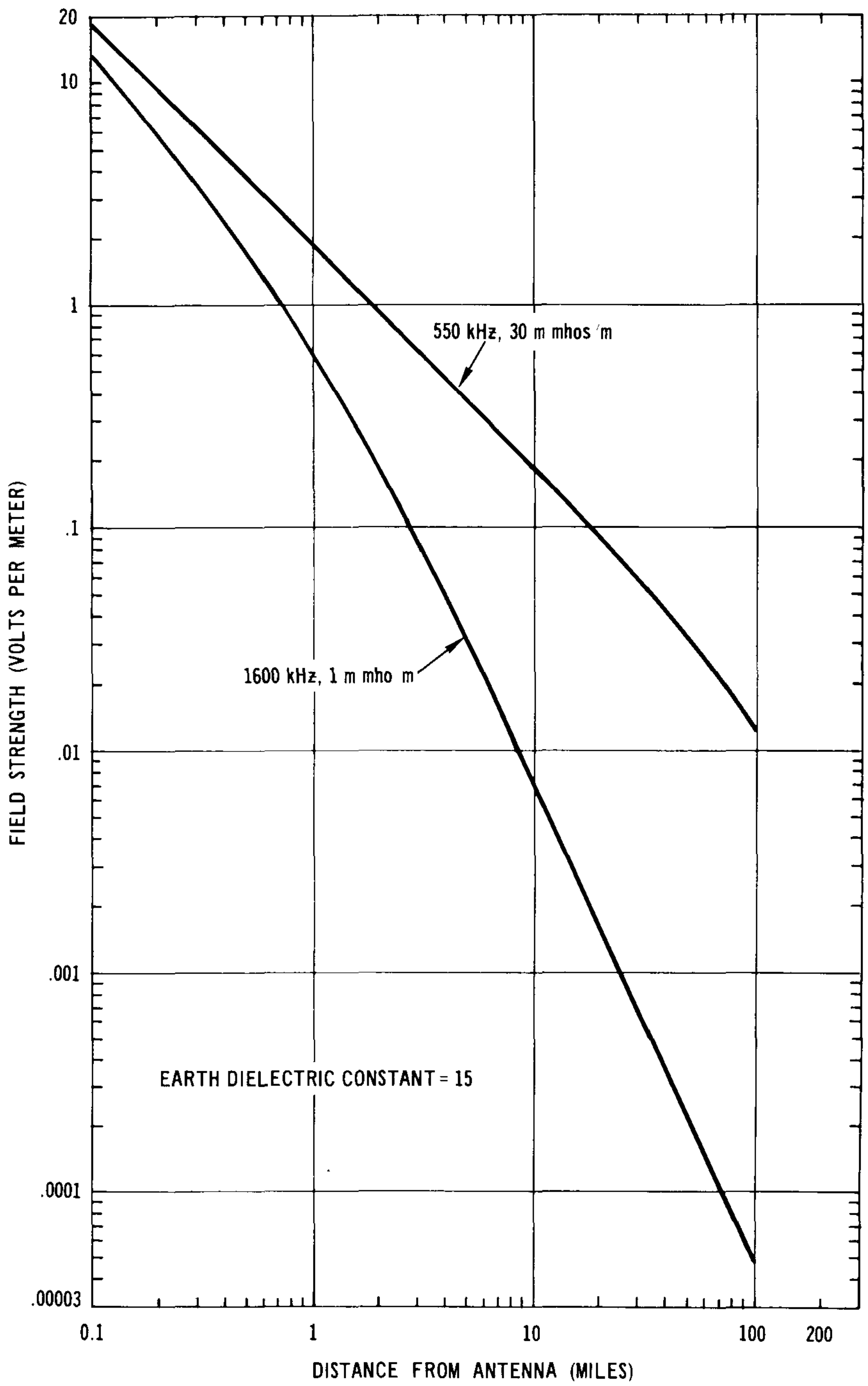
Letter Designation of Band	Frequency Range (GHz)
P	.225 - .390
L	.390 - 1.55
S	1.55 - 3.90
C	3.90 - 6.20
X	6.20 - 10.90
J	10.90 - 17.25
K	17.25 - 33.00
Q	33.00 - 46.00
V	46.00 - 56.00



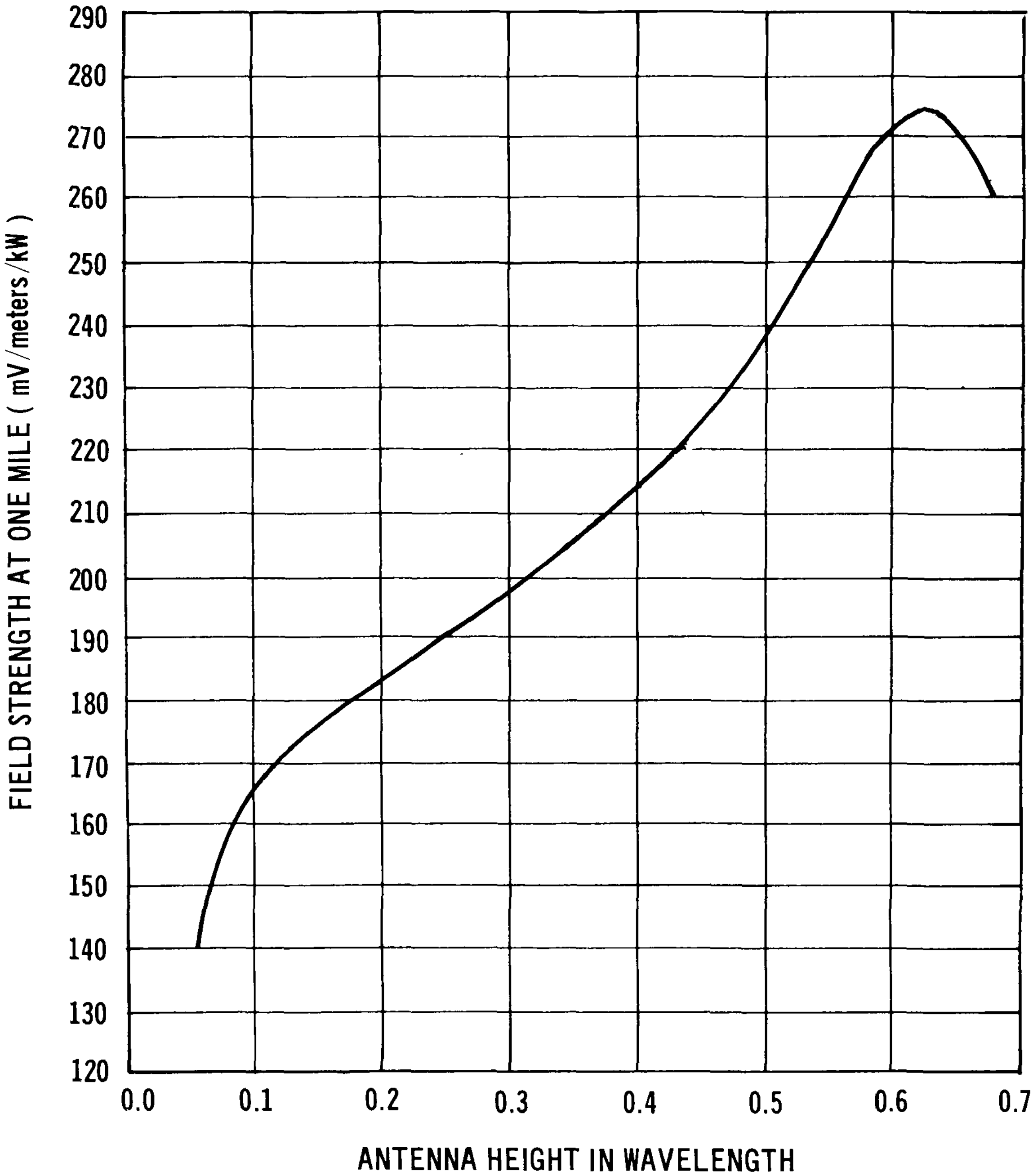
GRAPH 1. FIELD STRENGTH AND POWER DENSITY IN FREE SPACE



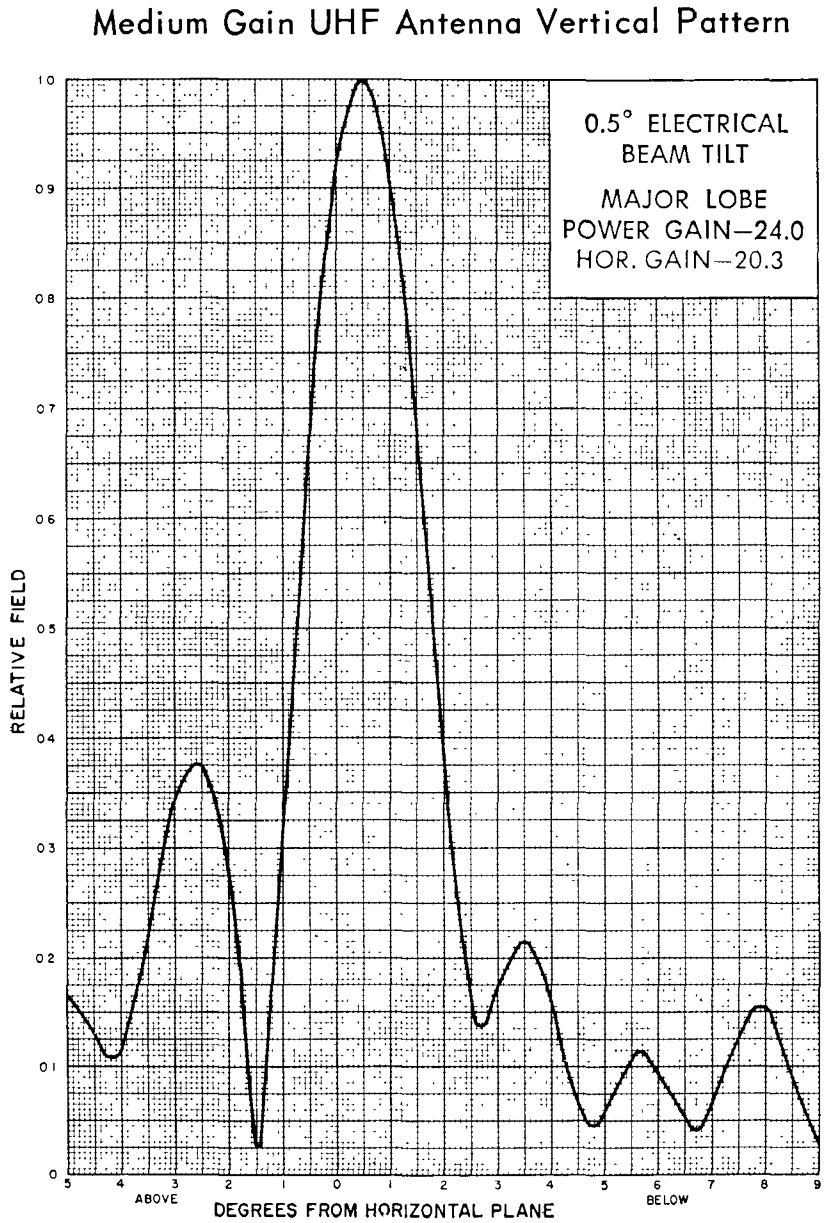
GRAPH 2. DISTANCE REQUIRED TO ESTABLISH VARIOUS POWER DENSITIES AS A FUNCTION OF ERP



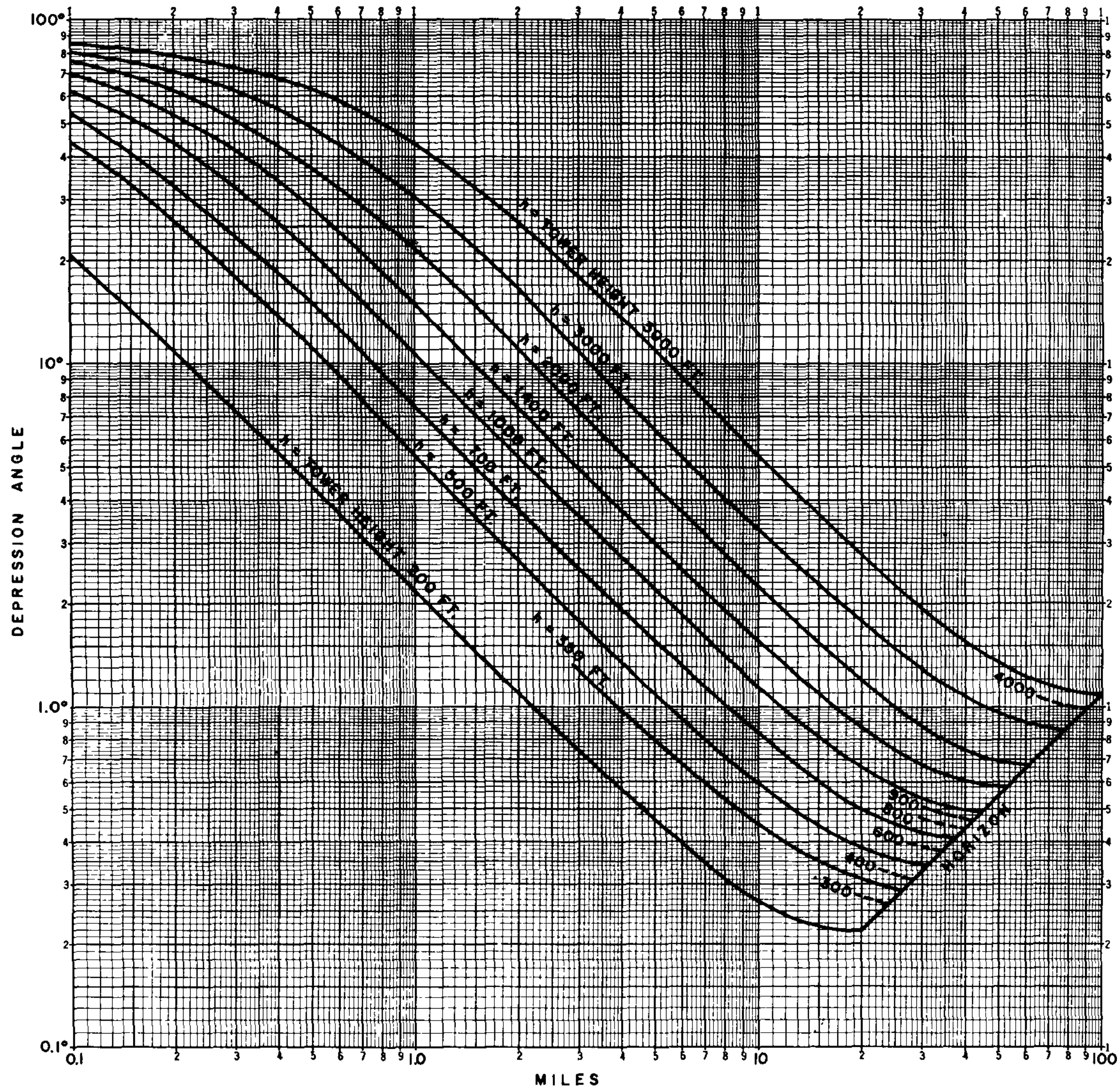
GRAPH 3. GROUND WAVE FIELD STRENGTH FOR 50 kW AM BROADCAST STATION



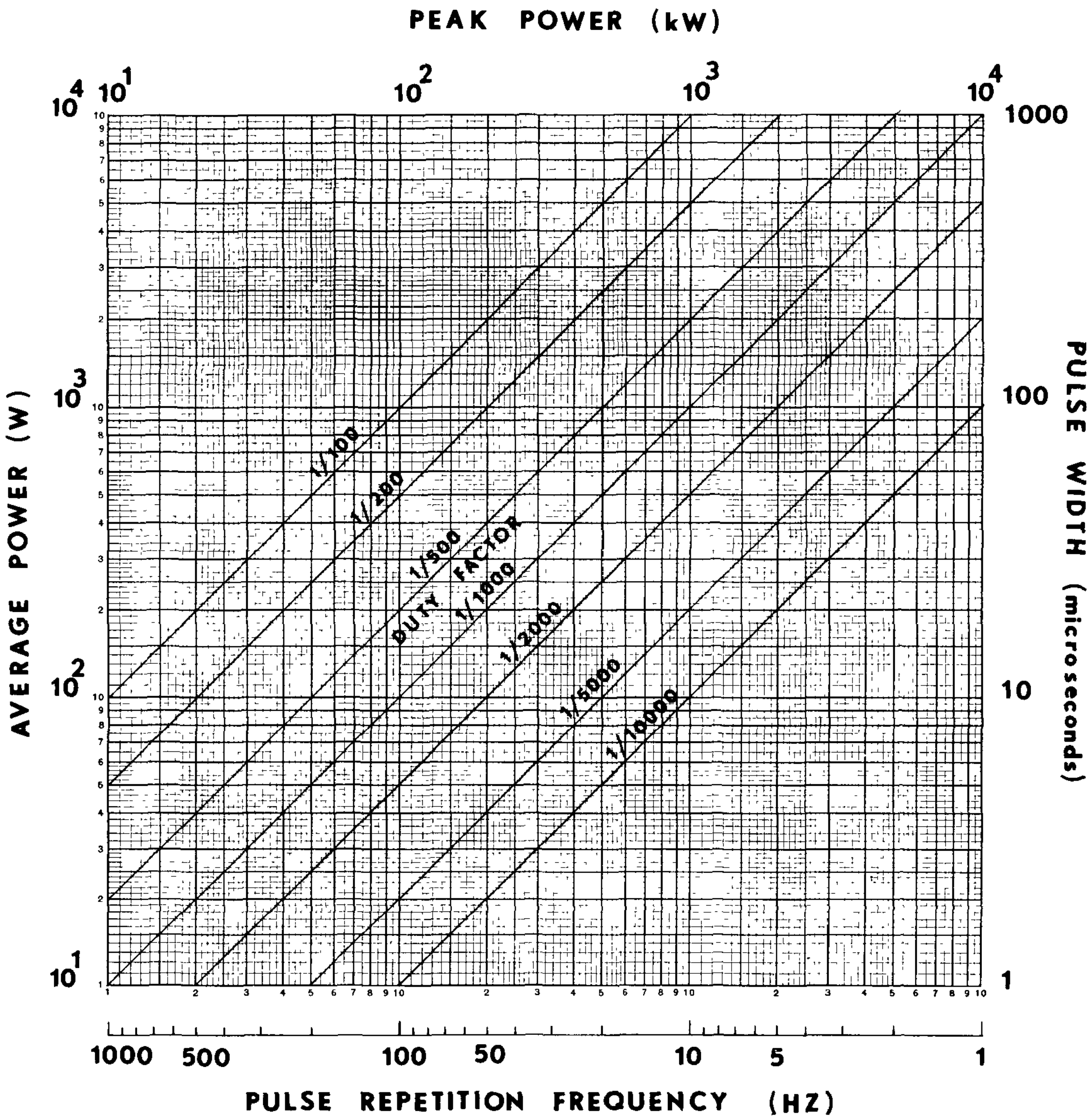
GRAPH 4. EFFECTIVE FIELD AT ONE MILE FOR SINGLE OMNIDIRECTIONAL MONOPOLE ANTENNA



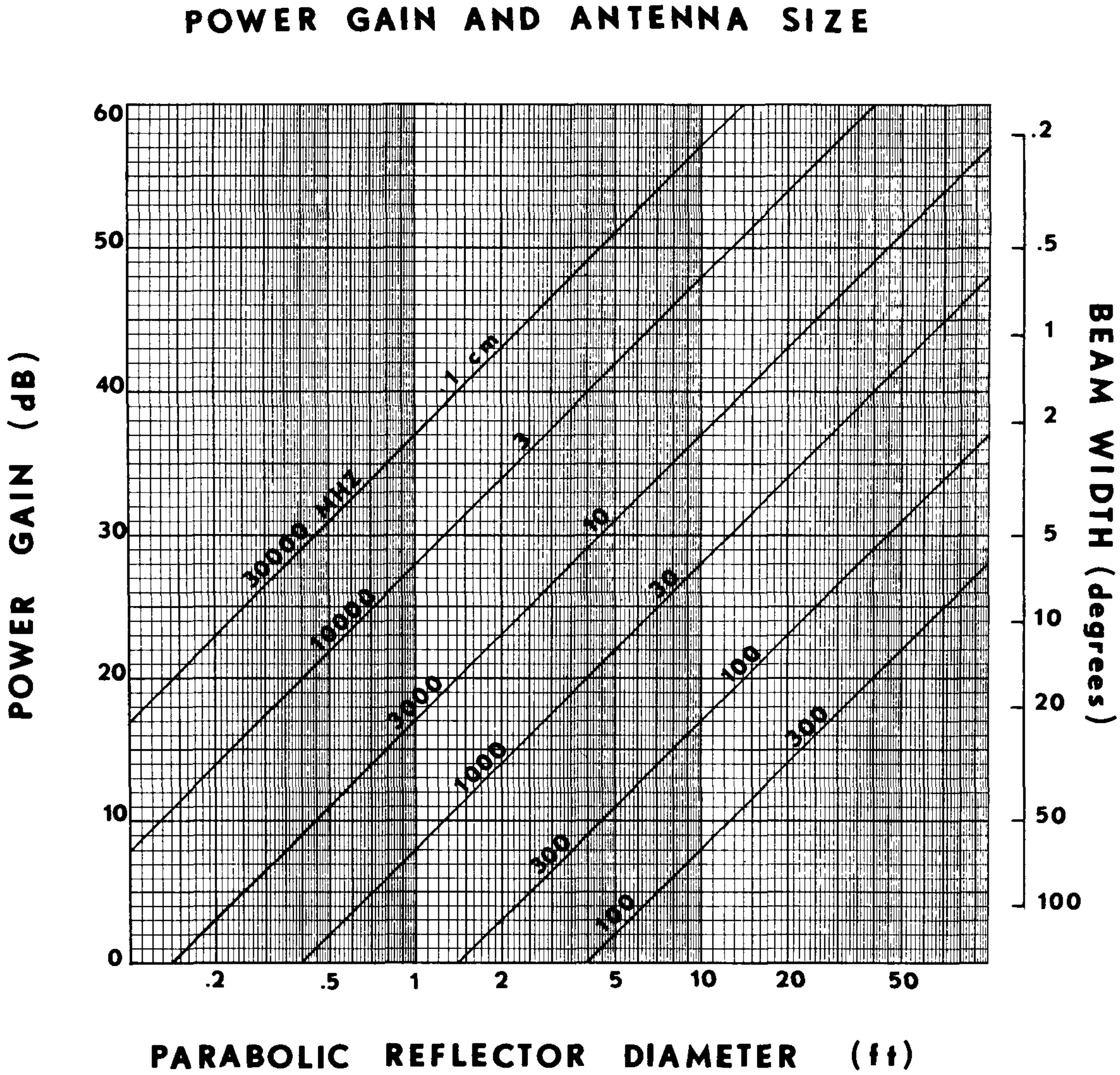
GRAPH 5. MEDIUM GAIN UHF ANTENNA VERTICAL PATTERN
COURTESY RCA CORPORATION, COMMUNICATIONS
SYSTEMS DIVISION, CAMDEN, NEW JERSEY



GRAPH 6. DEPRESSION ANGLE VERSUS DISTANCE FOR VARIOUS TOWER HEIGHTS



GRAPH 7. RELATIONSHIP OF VARIOUS RADAR PARAMETERS



GRAPH 8. PARABOLIC ANTENNA POWER GAIN AND SIZE

MISCELLANEOUS DATA

Basal Metabolic Rates for humans expressed on the basis of body surface area: (Reference 3)

20 year old male	4.62 mW/cm^2
20 year old female	4.10 mW/cm^2
30 year old male	4.37 mW/cm^2
30 year old female	4.06 mW/cm^2
60 year old male	4.13 mW/cm^2
60 year old female	3.89 mW/cm^2

Body weight, height, and surface area for 20-24 year old males. Reference 4.

Body weight	71.8 kg
Height	174.5 cm
Surface area	1.83 m^2

FCC requires minimum field strength at one mile for 1 kW power (Class I AM broadcast stations): 0.225 volts/meter (Reference 2)

Grade A television reception in UHF band - minimum field strength: 0.005 volts/meter (Reference 2)

Formula for calculating the distance to the far field from an antenna:

$$\text{Far-field distance} = \frac{2D^2}{\lambda} \quad \text{where}$$

D = maximum dimension of antenna

λ = wavelength of frequency in same units as D

The far field is arbitrarily defined as that point at which the impinging electromagnetic waves fronts exhibit no more than 22.5 degrees phase difference, i.e., they are essentially plane waves. It is also defined as that point at which the detected field intensity varies strictly as the inverse square of the distance. Thus, the beginning of the far field is not a precise distance from the transmitting antenna. The above equation computes this approximate distance.

GLOSSARY OF COMMON TERMS

Average Power - the time average effective power; i.e., that power which if converted to heat would produce the same amount of heat as some greater peak-pulsed power.

Beam Width - usually assumed to be that angle which defines the extent of beam divergence for an antenna, at which the radiated intensity is one-half of, or 3 dB below, the on-axis maximum radiated intensity, for a fixed distance from the antenna.

CW - strictly, continuous wave emission in which the radiated power is nonvarying in time. In practice, all signals which are not pulsed with very short pulse widths, i.e., radars.

dB - a ratio measure. For relationship of dB to voltage and power ratios, see text.

dBk - a measure of power ratio, referenced to 1 kW.

dBm - a measure of power ratio, referenced to 1 mW.

dBμV - a measure of voltage ratio, referenced to 1 μV.

Depression Angle - that angle below the horizontal plane at the antenna's height defined by a line drawn from the reception point on the earth's surface to the antenna.

Directive Array (DA) - any form of a system of radiating elements which when operated together, give a directional characteristic to the emitted wave. For example, some AM broadcast stations use more than one monopole to create a directive property to their signal, rather than radiating equally in all directions about the antenna.

Duty Factor - in a radar transmitter, the ratio of average power to peak pulse power. Also, the product of the pulse repetition frequency and the pulse width.

ERP - effective radiated power equal to the product of transmitter output power and antenna power gain.

Field Strength - a measure of radiation intensity in units of volts per meter. Normally used at lower frequencies, i.e., below 1,000 MHz.

Free Space - a space devoid of reflecting and attenuating properties and objects.

Gain, Antenna Power - a measure of the ability of an antenna to enhance radiation intensity in a particular direction with respect to an isotropic, omnidirectional radiator. Usually specified in dB.

Ground Conductivity - a measure of the soil's electrical conductive property, and therefore, its ability to reflect radio signals. The higher the conductivity the more reflective it is. Usually specified in mmhos/meter.

Input Power - usually refers to the final circuit electrical input power of a transmitter and is computed generally as the product of final amplifier stage current and voltage. This is always higher than the actual output power, according to the amplifier's efficiency.

Intrinsic Impedance - a measure of the wave interacting property of a medium. Also called characteristic impedance. For free space, 377 ohms.

mmho/meter - a measure of conductivity for a unit path length through a given material. A mho is equal to a reciprocal ohm.

Monopole - a single vertical type of radiating element, usually driven with respect to a series of buried radial conductors forming a ground plane antenna.

Peak Power - the maximum power in a single short duration pulse in any pulsed RF source.

PRF - pulse repetition frequency; i.e., the number of pulses occurring during one second.

Pulse Width - the time duration of a pulse usually measured in units of microseconds for radars.

Relative Absorption Cross-Section - a measure of the absorption properties for an absorbing object; a dimensionless number determined as the ratio of the actual effective area for power absorption to the geometrical cross-sectional area; may be greater or less than unity.

Sector Scan - a scan by a radar antenna which includes a fractional angular part of 360 degrees. The antenna oscillates back and forth over the particular sector of interest rather than revolving continuously.

Skin Depth - that distance below the surface of a conductor where the current density has diminished to 1/e of its value at the surface.

Vertical Pattern - normally the gain pattern of an antenna in the vertical plane. Most TV transmitting antennae employ some degree of vertical gain while maintaining omni-directional characteristics in the horizontal plane.

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