Instructions For The Use Of Compliance Design Inc. Roberts Antennas™

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Your antenna set consists of four antennas, covering the range from 30 to 1000 MHz. These antennas' baluns are used as follows:

Antennas 1	30 - 65 MHz. The extender rods should be used at the lower frequencies to achieve the proper length. This balun has an aluminum box at the base.
Antenna 2	65 - 180 MHz. This balun has a "fat head," but no box at its base.
Antenna 3	180 - 400 MHz. This balun has a "thin head," and no box at the base. The smallest detachable elements are used here.
Antenna 4	400 - 1000 MHz. This has its elements already attached.

Thank you for considering CDI. Our staff is always available to help you on any issues surrounding EMI compliance. If you have any questions, please do not hesitate to call us.

Length of Each Element
for
Resonant Setting Versus Frequency

Frequency MHz	Length of Each Antenna Element: Feet	Inches	Meters
30	7	11	2.413
35	6	9 7/8	2.080
40	5	11	1.803
45	5	3	1.600
50	4	8 5/8	1.438
60	3	11 1/8	1.197
70	3	4 3/8	1.026
80	2	11	0.889
90	2	7 1/8	0.791
100	2	4 1/8	0.714
120	1	11 1/8	0.587
125	1	10 1/4	0.565
140	1	7 7/8	0.505
150	1	6 3/8	0.467
160	1	5 3/8	0.441
175	1	3 3/4	0.400
180	1	3 3/8	0.392
200	1	1 7/8	0.352
250		11 1/8	0.283
300		9 1/4	0.235
400		6 7/8	0.175
500		5 5/8	0.143
600		4 5/8	0.117
700		4	0.102
800		3 1/2	0.089
900		3 1/8	0.079
1000		3	0.076

Table 1

II. USING YOUR ANTENNAS

To use your antennas, you must set them up either on a tripod for informal testing or on an adjustable mast, such as the Compliance Design M100 or M200, for formal compliance testing. The telescoping rods of the antenna then should be adjusted to be resonant at the frequency you desire to measure using the lengths in the attached table. (For frequencies between those listed, linear extrapolation can be used.) For example, if you would like to tune the antenna to 60 MHz, set either element of the antenna to 3 feet 11 and one-eighth inches.

The output of the antenna is made to plug into a 50 ohm receiver or a spectrum analyzer. The input of the receiver or spectrum analyzer will read in either uV, dBuV or dBm. For most of your measurements, you will be using the instrument in its log mode, reading out in dBm or dBuV. To the reading measured on the spectrum analyzer or receiver, you have to add the antenna factor, which converts the reading to a field strength. Copies of the antenna factor at various frequencies are shown in Table 2. For example, at 60 MHz, you would add 4.2 dB to the reading on the receiver or spectrum analyzer.

Where significant lengths of transmission line are used, the loss for the line has to be added to the antenna factor. Losses can be found in Table 4. For 30 feet of RG-58/u, a commonly used type and length, the losses can be found in Table 5.

To convert your receiver or spectrum analyzer reading to field strength (uV/m), you will want to use the charts in Tables 3, 4 and 5. For example, if the receiver or spectrum analyzer had read -70.5 dBm at 60 MHz, adding the antenna factor and cable loss for 30 feet of RG-58/u will give you a reading of -65 dBm/m. The conversion chart shows that a reading of -65 dBm/m will correspond to 125 uV/m.

Antenna Factors for the Roberts Antenna (TM)

Freq. (MHz)	AF (dB)
30	- 1.8
40	+ .6
50	+ 2.6
60	4.2
70	5.5
80	6.7
90	7.7
100	8.6
125	10.5
150	12.1
175	13.5
200	14.6
250	16.6
300	18.1
400	20.6
500	22.6
600	24.2
700	25.5
800	26.7
900	27.7
1000	28.6

Table 2

Conversion Chart Used by the FCC Laboratory Division
to Convert -dBm/meter to Microvolts Per Meter

dBm/m	uV/m	dBm/m	uV/m	dBm/m	uV/m	dBm/m	uV/m	dBm/m	uV/m
0	223,000	-25	12,500	-50	708	-75	39.8	-100	2.23
- 1	199,000	-26	11,200	-51	631	-76	35.5	-101	1.99
- 2	177,000	-27	10,000	-52	563	-77	30.6	-102	1.77
- 3	158,000	-28	8,910	-53	501	-78	28.2	-103	1.58
- 4	141,000	-29	7,940	-54	447	-79	25.1	-104	1.41
- 5	125,000	-30	7,000	-55	398	-80	22.3	-105	1.25
- 6	112,000	-31	6,310	-56	355	-81	19.9	-106	1.12
- 7	100,000	-32	5,630	-57	316	-82	17.7	-107	1.00
- 8	89,100	-33	5,010	-58	282	-83	15.8	-108	.891
- 9	79,400	-34	4,470	-59	251	-84	14.1	-107	.794
-10	70,800	-35	3,980	-60	223	-85	12.5	-110	.700
-11	63,100	-36	3,550	-61	199	-86	11.2	-111	.631
-12	56,300	-37	3,160	-62	177	-87	10.0	-112	.563
-13	50,100	-38	2,820	-63	158	-88	8.91	-113	.501
-14	44,700	-39	2,510	-64	141	-89	7.94	-114	.447
-15	39,800	-40	2,230	-65	125	-90	7.08	-115	.398
-16	35,500	-41	1,990	-66	112	-91	6.31	-116	.355
-17	31,600	-42	1,770	-67	100	-92	5.63	-117	.316
-18	28,200	-43	1,580	-68	89.1	-93	5.01	-118	.282
-19	25,100	-44	1,410	-69	79.4	-94	4.47	-119	.251
-20	22,300	-45	1,250	-70	70.8	-95	3.98	-120	.223
-21	19,900	-46	1,120	-71	63.1	-96	3.55	-121	.199
-22	17,700	-47	1,000	-72	56.3	-97	3.16	-122	.177
-23	15,800	-48	891	-73	50.1	-98	2.82	-123	.158
-24	14,100	-49	794	-74	44.7	-99	2.51	-124	.141

Table 3

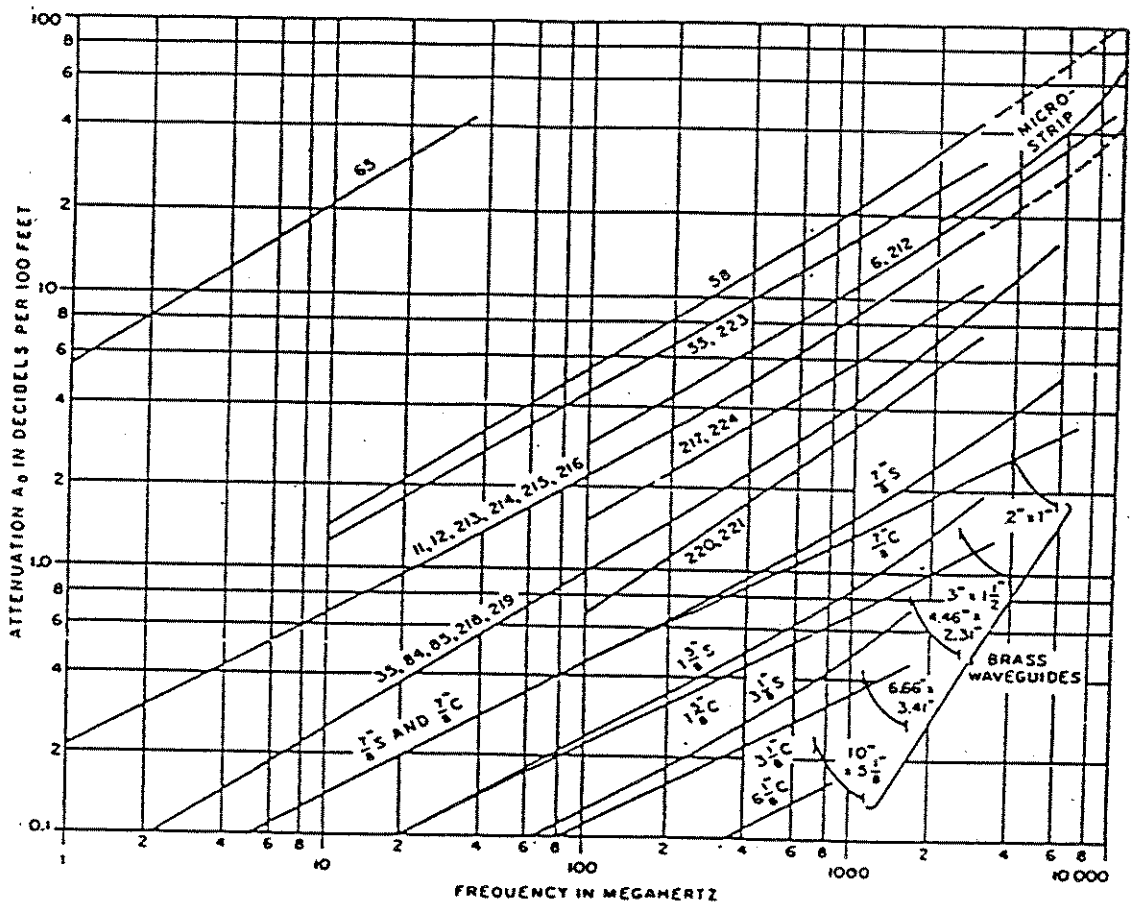

Table 4

Attenuation of various types of cables.
The "RG" numbers are shown.
(From Reference Data for Radio Engineers,"
Sixth Edition, Pg. 24-41)

III. CHECKING OUT AN EMI TEST SITE

For almost thirty years, the FCC has operated its own test site to measure emissions from devices like computing equipment. Because of this, the Commission can act as a ready source of empirical and theoretical information concerning the construction of test sites. Most of this information has been collected in FCC Document OST-55.

A History of the Creation of the FCC's Open Field Test Sites

The FCC first derived the theoretical results it should obtain for a simple test called site attenuation. This test demonstrates the propagation characteristics of a site. In this test, an antenna is placed at one end of the site, and it simulates a device under test. It is fed a signal (measured in volts of RF) from a signal generator. A second antenna is placed on the opposite end of the test site and the output from that antenna, also in terms of RF voltage, is read by a receiver or a spectrum analyzer. There is, of course, some loss. The difference between the signal voltage put into the transmitting antenna and what comes out of the receiving antenna is known as the "site attenuation" at that frequency.

The FCC derived a theoretical curve for the predicted site attenuation for frequencies between 30 MHz and 1000 MHz. In order to make the calculation simple, it was assumed that the antenna could be raised and lowered to achieve a height where the transmitted signal from the transmitting antenna arrived at the receiving antenna in phase with the signal bouncing off the ground plane. The receiving antenna therefore receives two signals, a direct wave and reflected wave. Raising and lowering the antenna finds the height where these two waves reinforce and yield maximum received signal strength.

The FCC generated this theoretical curve using the formulas later described in OST-55. The equation is quite simple and is listed below

$$\text{Attenuation (dB)} = 20 \log D + 20 \log F - 35.2 \text{ dB}$$

where

D = distance in meters (3 meters for OST-55)
F = frequency in MHz.

Basically, it says that site attenuation is a function of distance and frequency. At a particular distance, like three meters, the curve is a function of the log of the frequency, making a line that slopes up linearly on a log-log graph.

Loss of 30 Feet of RG-58/u Cable

Frequency (MHz)	Loss (dB)
30	.9
40	1.1
50	1.2
60	1.3
70	1.5
80	1.6
90	1.7
100	1.8
125	2.1
150	2.3
175	2.5
200	2.7
250	3.1
300	3.5
400	4.2
500	4.7
600	5.3
700	5.8
800	6.3
900	6.8
1000	7.2

Table 5

Unfortunately, when the FCC attempted to translate this theory into practice, things went awry. The actual curve they got when they attempted to perform site attenuation deviated from the theoretical curve. Early attempts made at three meters indicated a flattening site attenuation curve below 70 MHz. The antennas were too close together for the far field assumptions the Commission had made in producing the curves to be valid. The curve flattened at about 11 dB. That empirically derived asymptote has been included in OST-55.

Editorial Notes to Accompany OST-55

In performing site attenuation tests, you should keep the following in mind.

Site attenuation measurements described in OST-55 are really set up for three meters. Using similar equations, similar curves can be developed for ten and thirty meters.

Paragraph 6.0 of OST-55 is unfortunate. The FCC had little practical experience in such enclosures and assumed that most conservative conclusion -- that any metal objects within the ellipse had to be less than one-tenth of a wavelength of the highest frequency or less than three centimeters. Considering that this would eliminate the use of most nails, the restriction has been shown to be far too stringent. In our experience, metal objects close to the site should be limited in a rational way. Nails will not make much difference.

Baluns are almost always built into antennas by their manufacturers. For most antenna types, purchase of an extra balun is unnecessary.

The FCC accepts site attenuation curves which are within 3 dB of the curve drawn in OST-55. Good sites can be within 2 dB of this curve.

Section 15.38 of the FCC rules is a description of how to get your site "FCC approved." All the section requires is that you file data with the FCC which they keep in the public file. As you can see, this is really not FCC approval of a site at all; they simply act as a repository for certain public information.

Finally, as of the date of this writing (November, 1985), ANSI was preparing a more flexible site attenuation standard of its own. The FCC has declared its intent to adopt that standard, currently called the Open Area Test Site Amendment. The Roberts Antenna (TM) has been chosen by ANSI as the Reference Antenna for that document.

Federal Communications Commission, Office of Science and Technology, Washington, D.C. 20554

[Bulletin OST 55]

Characteristics of Open Field Test Sites

1.0 *Introduction*

1.1 *General*

FCC equipment authorization requirements often call for measurement of the field strength of radiated emissions at an open field measurement site. The characteristics of the site can affect the results of such measurements, sometimes leading to substantial measurement errors and false indication of compliance with FCC equipment standards. This bulletin is intended to provide guidance on the construction of open field test sites and present a method of evaluating site performance. It should be noted that §15.38 of the FCC Rules requires that a description of measurement facilities be filed for sites that are used for equipment certification. The text of Section 15.38 can be found in the appendix to this bulletin.

1.2 *Limitations*

This bulletin is limited in scope to test sites used for making radiated emissions measurements over the frequency range 25-1000 MHz at 3, 10 or 30 meters distance from the equipment under test. Such a site may not be appropriate for testing certain kinds of devices, such as broadcast transmitters, or some industrial, scientific and medical equipment subject to Part 18. The FCC rules or practical considerations would dictate when an alternate test method should be used.

Measurements below 25 MHz or above 1000 MHz are performed using somewhat different techniques than those discussed in this bulletin. Information can usually be found in published measurement standards, the FCC Rules or FCC bulletins that pertain to the equipment being tested.

1.3 *Anechoic chambers/alternative sites*

Anechoic chambers or sites other than open field may be suitable for performing field strength measurements under certain circumstances; however, this bulletin does not specifically address such alternative sites. It is limited strictly to actual open field sites. Nor does this bulletin suggest a method of correlating alternative sites to an open field site. It is left to the test engineer to devise an appropriate method to correlate an alternative site.

2.0 *Equipment test standards*

The test site must provide the necessary facilities and equipment called for in the measurement standards or procedures intended to be used at that site. If the equipment test standard and this bulletin are not in agreement on certain points, the standard shall take precedence.

3.0 *Characteristics of the site*

Various FCC requirements, particularly those in Part 15, call for measurement of the field strength of emissions at either 3, 10 or 30 meters from the equipment under test (EUT). The attached Figure 1 shows the recommended test site layout for each of these distances. The site should be clear of any obstructions such as trees, bushes or metal fences, at least within the elliptical boundary shown in Figure 1. Objects outside this boundary, such as buildings or parked automobiles, may still affect the measurements so care should be taken to choose a location as far as possible from large objects or metallic objects of any sort. Test sites of rectangular shape can also be used providing the length and width of the site are at least as large as the major and minor axes of the elliptical site shown in Figure 1.

4.0 *Ground plane*

The terrain of the test site should be reasonably flat and level. Any object (e.g. loose rock) greater than 5 cm in dimension is to be cleared from the

surface.

It is strongly recommended that sites be provided with a metal ground plane, particularly if the site is located atop pavement or on a rooftop. The metal ground plane should be at least the size of the obstruction free area. Acceptable performance may be achieved without a metal ground plane, provided that the ground plane is composed of homogeneous good soil (not sand or rock) free of buried metal.

Wire mesh, either ¼ " or ½ " in size, sometimes called hardware cloth, is well suited for constructing a ground screen. It is readily available and relatively inexpensive. Hardware cloth comes in rolls about 4 feet wide; it should be electrically bonded along the seams.

5.0 *Physical installation*

5.1 *Services to the EUT*

All electrical service, wires, cables and plumbing (if needed) to the EUT is to be run underground or underneath the ground plane to the maximum extent possible. For sites having a ground plane, the placement of these utilities underneath the ground plane is not critical. However, for sites with unburied utilities to the EUT, or sites without a ground plane, they should extend away from the measuring antenna along the site axis for at least 1.5 meters.

5.2 *Measurement antenna mast*

Most measurement procedures call for varying the height of the measurement antenna above ground to obtain a maximized addition of the direct and ground reflected signal components. See Figure 1. The site should be equipped with a mast that provides for continuous variation of antenna search height. Tripod antenna supports of the conventional type are generally unsuited for continuous variation of antenna height over the required range.

There are many ways to construct an inexpensive mast assembly. A wooden mast with rope and pulley used to control a carriage or trolley (with bracket for mounting the antenna) that rides along the mast is one method. Lightweight PVC pipe is another good material for a mast.

5.3 *Test stand*

The EUT is ordinarily required to be placed upon a table, the height of which is specified in the standard used to perform the measurements (usually about 1 meter above ground). A turntable arrangement, controlled either manually or by remote control, is required in most instances to rotate the EUT to find the direction of maximum radiation.

5.4 *Location of measurement equipment/test personnel*

For sites constructed with the ground screen at the same level as the surrounding terrain, the field strength measuring equipment and personnel should be positioned as shown in Figure 1: in the plane of the measuring antenna, at a right angle to the site axis and at least 3 meters from it. For sites having a measuring room underneath the ground screen, the placement of the room is not critical as long as it is completely covered by the ground screen. Service and signal outlets should be provided to the antennas and equipment under test at the level of the ground screen at the locations of the antennas and equipment under test. The positioning of the cable and conduit servicing these outlets is discussed in 5.1.

For sites having a ground screen raised above the level of the surrounding terrain, the above considerations also apply. However, if the measuring equipment and personnel are not to be housed beneath the ground plane, they should be positioned at a level lower than the ground screen and off to the side of the measuring area as discussed above.

LIMITED WARRANTY

Compliance Design, Incorporated warrants that its products, at the time of delivery, are free from defects of workmanship and material under normal use and service. CDI reserves a right, at its exclusive option, to replace or repair, in its own factory, any articles which are disclosed to CDI's satisfaction to be defective within one year of delivery. Transportation charges to CDI's factory shall be prepaid by the buyer.

THIS WARRANTY IS EXPRESSED IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING THE WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY AND/OR ANY AND ALL OBLIGATIONS OR LIABILITIES. CDI NEITHER ASSUMES NOR AUTHORIZES ANY OTHER PERSON TO ACT AS AGENT FOR CDI OR TO ASSUME ANY OTHER LIABILITIES IN CONNECTION WITH DELIVERY OF THIS PRODUCT.

This warranty is limited to 90 days on out-of-warranty repairs and shall not apply to any products which have been repaired or altered by the buyer, or which have been misused or subjected to neglect or accide

5.5 *Instrumentation*

Suitable instrumentation is required for performing field strength measurements. A field strength meter which conforms to ANSI standard C63.2-1980 is generally acceptable.[1] Alternatively, spectrum analyzers capable of meeting the same specifications may also be used. The instrument must be calibrated in accordance with the manufacturer's recommendations at regular intervals. A signal generator and power meter are useful for more frequent checks of calibration.

5.6 *Antenna*

For site attenuation measurements over the range 25-1000 MHz, it is recommended to use half wave dipoles. It is also recommended that these be used in measurement of radiation from equipment under test in this frequency range. Broadband antennas, such as the log periodic and biconical types, are acceptable, provided that the results can be correlated with the results obtained with a dipole. However, use of such antennas for site attenuation measurements often introduce greater uncertainty in the results. The log spiral antenna is not generally acceptable because it is not linearly polarized. Further details on appropriate antennas can be found in equipment test standards or in the FCC rules. See, for example, Part 15, Appendix A. [Replaced by MP-4]

6.0 *Weather protection enclosures*

A weather protection enclosure may be constructed over either the entire site or a portion thereof. Use of metal above the ground plane should be limited to objects having dimensions less than a tenth of a wavelength at the highest frequency of measurement (e.g. 3 cm at 1000 MHz). Fiberglass, plastics, treated wood or fabric are suitable materials for construction of an enclosure. It is good practice to perform preliminary site attenuation measurements before constructing an enclosure so that potential problems are detected before further investment is made.

7.0 *Site characterization*

7.1 *General*

The suitability of a test site used to make radiation measurements may be evaluated by measuring the site attenuation. This information will reveal the existence of ground discontinuities, spurious reflections, and inaccuracies in the measuring equipment set-up which could invalidate measurements of radiation. Site attenuation should be measured over the frequency range 25-1000 MHz at the distance(s) to be used for actual measurements (30, 10 or 3 meters). Measurements should be made at 10 MHz intervals in the range 25-100 MHz, 25 MHz intervals in the range 100-300 MHz, and at 50 MHz intervals in the range 300-1000 MHz.

7.2.0 *Site attenuation measurement procedure*

The procedure for making site attenuation measurements described herein calls for use of two half-wave dipole antennas. Other combinations of antennas, when properly used, may be employed to perform site attenuation measurements, but a detailed analysis of results using other antennas is beyond the scope of this bulletin. Bear in mind that the purpose of making the site attenuation measurement is to judge site performance, so it is best to keep the procedure as simple as possible.

7.2.1

See Figure 1. Place a signal generator on the turntable at the normal location of the equipment under test. Connect the output of a signal generator which is controlled by a standard at-

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[1] American National Standard C63.2-1980, *Specifications for Electromagnetic Noise and Field Strength Instrumentation,* 10 kHz to 1 GHz, available from: Standards Department, The Institute of Electrical and Electronic Engineers, 345 E. 47th St., New York, New York 10017.

tenuator to the half-wave dipole radiating antenna via a coaxial cable. Since a half-wave dipole is a balanced antenna, a balun must be used. (Commercially available dipoles usually have built-in baluns.) An impedance matching transformer may also be necessary if the impedance matching is not done with the balun.

7.2.2

The radiating antenna should be set up for horizontal polarization at height H as specified in Figure 1 and oriented for maximum radiation toward the location of the measuring instrument. The antenna should be adjusted to proper length at each frequency of measurement.

7.2.3

Connect a field strength meter or a spectrum analyzer (for brevity, FSM will be used to indicate either instrument) to the receiving half-wave dipole antenna via coaxial cable, again using a balun. Adjust the antenna to the frequency of the generated signal and tune the FSM to that signal.

7.2.4

Set the output level of the signal generator and the standard attenuator at a value that gives an FSM reading significantly above the ambient noise level or interfering signals from other sources. Record the attenuator setting.

7.2.5

Measure the horizontal component of the field strength at the location of the FSM. *Find the maximum value of the field strength by raising and lowering the measuring antenna over the search distance specified in Figure 1.* Record the reading of the FSM.

7.2.6

Disconnect the coaxial cables from the two antenna terminals and connect these cables together. (Depending upon the length of the cables with respect to the separation distance of the antenna, this connection may be possible without physical movement of the signal generator.) If the baluns can be disconnected at the antenna terminals, the baluns should be connected in the circuit as follows: Cable——>balun——>balun——>cable.

7.2.7

Adjust the standard attenuator to give the same FSM reading as that recorded in 7.2.4. Record the attenuator setting.

7.2.8

The site attenuation is the difference in dB between the standard attenuator setting recorded in 7.2.7 and that in 7.2.4. if the baluns or impedance matching transformers are removed or otherwise not included in the measurement described in 7.2.6 then the loss of these devices must be considered. See paragraph 7.4.3.

7.3 *Plot of site attenuation data*

Plot the site attenuation data on 2 cycle, semi-log graph paper with frequency as the abscissa on the log scale and site attenuation in dB as the ordinate on the linear scale. The data should be plotted over the range 25-1000 MHz at the frequency intervals prescribed in paragraph 7.1.

7.4 *Analysis of site attenuation data*

7.4.1 *Theoretical site attenuation*

Paragraph 7.4.2 provides an equation for calculating the theoretical site attenuation, based on a plane wave model. Empirical results have shown this equation is not representative of what occurs below about 80 MHz. the measured attenuation below 80 MHz can be expected to be up to a few decibels more than what the equation predicts. Paragraph 7.4.5 gives more information on how to analyze the results in the 25-80 MHz region. Further study of theoretical models of site attenuation is taking place at the time of this writing and a more appropriate model covering the

entire range 25-1000 MHz may be available in the near future.

7.4.2 *General equation for site attenuation*

The theoretical site attenuation above 80 MHz can be calculated from equation (1).

$A = 20 \log_{10}D + 20 \log_{10}F_m - G_s - G_r - 27.6 - R$ (1)

Where

A = Site attenuation in dB,

D = Distance in meters between the source (transmitting) antenna and receiving (FSM search) antenna.

F_m = Frequency in megahertz of the transmitted signal.

G_s = Gain in dB of the source antenna relative to isotropic.

G_r = Gain in dB of the receiving antenna relative to isotropic.

R = Contribution from ground reflected radiation.

If the baluns are integral parts of the antenna assemblies, their losses must be determined and included in equation 1. In some cases these losses have been determined by the manufacturers and are included in the manufacturer's specified gain factors. A further discussion of balun losses is given in 7.4.3.

The first five terms of equation 1 represent the attenuation that would be observed if the antennas were mounted in free space. The sixth term in the contribution to the received signal from radiation which is reflected from the ground plane. For 3, 10 and 30 meter site measurements, values of 4.3, 5.7 and 5.9 dB respectively can be used for the ground reflection contribution. These values were obtained using a geometrical model which assumes that the field at the receiving antenna is caused by a direct wave travelling a path, r_1, and a ground reflected wave travelling a path, r_2. On the basis of this model, the ground reflection contribution is

$$20 \log(1 + \frac{r_1}{r_2})$$

if we assume perfect ground reflection. Although the geometrical model ground reflection contribution varies with the height of the receiving antenna above ground, the actual range of values over which it varies is quite small (3.74 to 4.84 dB for a 3 meter site, 5.46 to 5.86 dB for a 10 meter site and 5.91 to 5.98 dB for a 30 meter site). The recommended values of 4.3, 5.7 and 5.9 dB stated above are the midpoint values of these ranges.

If two tuned dipoles are used as the source and receiving antennas $G_s = G_r = 2.15$ dB and equation (1) becomes:

$A = 20 \log_{10}D + 20 \log_{10}F_m - 31.9 - R$ (2)

Sample Calculation:

Consider the case where:

$D = 3$ m and $f_m = 100$ MHz

If the source antenna and receiving antennas are tuned dipoles and each antenna balun has a loss of 0.5 dB at 100 MHz, then the site attenuation can be calculated from equation 2 to be

$$A = 20 \log_{10}(3) + 20 \log_{10}(100) - 31.9 - 4.3 + 1.0$$
$$= 9.5 + 40 - 35.2$$
$$= 14.3 \text{ dB}$$

Note that the 1.0 dB balun loss has been included in the calculation.

7.4.3 *Cable and balun losses*

It may have been noticed that the site attenuation equation given in 7.4.2 does not account for cable losses. By connecting both antenna cables end to end as specified in 7.2.6, all cable losses are accounted for in the measurement of site attenuation and therefore need not be included in the theoretical equation. If a procedure different from that in 7.2.6 is used (e.g. only one of the cables is used to connect the signal generator to the FSM), the measured readings should be adjusted to account for cable loss. As baluns are usually wired directly into the antenna mounting structures, their losses cannot easily be determined without

disassembling the entire antenna structure. With the baluns which we have used in our measurements, we have found that their losses are usually quite small (1 dB or less) and that if we assumed a value of 1 dB for the total balun loss, our measured results would still be within the acceptance margin discussed in 7.4.4. However, if one uses baluns of a connective type, then they should be disconnected at the antenna terminals and connected in series with the cables when measuring the site attenuation as described in 7.2.6. In this case, the balun losses should not be included in equation 1.

7.4.4 *Sample site attenuation curve*

Figure 2 presents a sample theoretical site attenuation curve for a 3 meter test site. Below 80 MHz the curve can be expected to flatten out, as illustrated by the dashed line portion of the curve. There will be less flattening for 10 and 30 meter sites.

7.4.5 *Comparison of data with the theoretical model*

Although several approximations have been made in deriving equation 1, it does give good agreement with measured site attenuation values at frequencies from 80 to 1000 MHz. Using tuned dipoles and an adequate ground screen, we have had no difficulty in repeatably measuring site attenuation above 80 MHz to within ± 2 dB of the theoretical values. However, if other antennas are used or if the balun losses are not known accurately or if a ground screen is not used, then the differences between the experimental and theoretical values could be larger. However, discrepancies of more than 3 dB will perhaps indicate that there may be a problem with the site or with the method of measurement. Also any marked deviations from linearity above 80 MHz could be an indication of site or measurement difficulties.

Below 80 MHz, the data is useful not so much for comparison with theory, but for determining if there are frequency bands where there are sharp departures from a smooth curve. Sharp peaks or nulls in the curve should be investigated to find the cause.

Data below the lowest tunable frequency of the dipole may be disregarded. For example, many dipole sets will not physically tune below 27 MHz or thereabouts.

7.4.6 *Possible causes of excessive errors*

Check that the procedure for measuring site attenuation was followed properly, particularly that the height of the FSM antenna was varied as required. Perform measurements at smaller frequency intervals where significant discrepancies from the theoretical values are noticed. Common problems with the site itself are: inadequate ground plane, faulty antennas or test equipment; defective cables; and reflecting objects that are too close.

Appendix

§15.38 *Description of measurement facilities.*

(a) Each person making measurements to be filed with an application for certification of a device subject to regulations under this part, shall file a description of his measurement facilities with the Commission.

(b) The description shall include the following information:

(1) Location of the test site.

(2) Physical description of the test site accompanied by photographs 8″ by 10″ in size. Smaller photographs may be submitted if they clearly show the required details and are mounted on full size sheets of paper.

(3) Drawing showing the dimensions of the site, the physical layout of supporting structures and all structures within 5 times the distance between the measuring set and the device being measured.

(4) Description of supporting structures used to support the device being measured and the test instrumentation.

(5) List of measuring equipment used.

(6) Information concerning the calibration of the measuring equipment, i.e. when the equipment was last calibrated and frequency of calibration.

(7) A statement indicating whether this facility is available to do measurement work for others on a contract basis.

(c) This information shall be kept current at all times. At least every three years, the organization filing the data shall advise that the data on file is current.

(d) For certification of decoder device used for detecting the EBS Attention Signal as defined in §73.906 this Section will not apply.

Note.—FCC Bulletin OST 55 *Characteristics of Open Field Test Sites* provides further guidance on open field test sites.

The above site description should be sent to the Federal Communications Commission, P.O. Box 429, Columbia, MD 21045, ATTN: Equipment Authorization Branch.

[FR Doc. 82-22514 Filed 8-19-82; 8:45 am]

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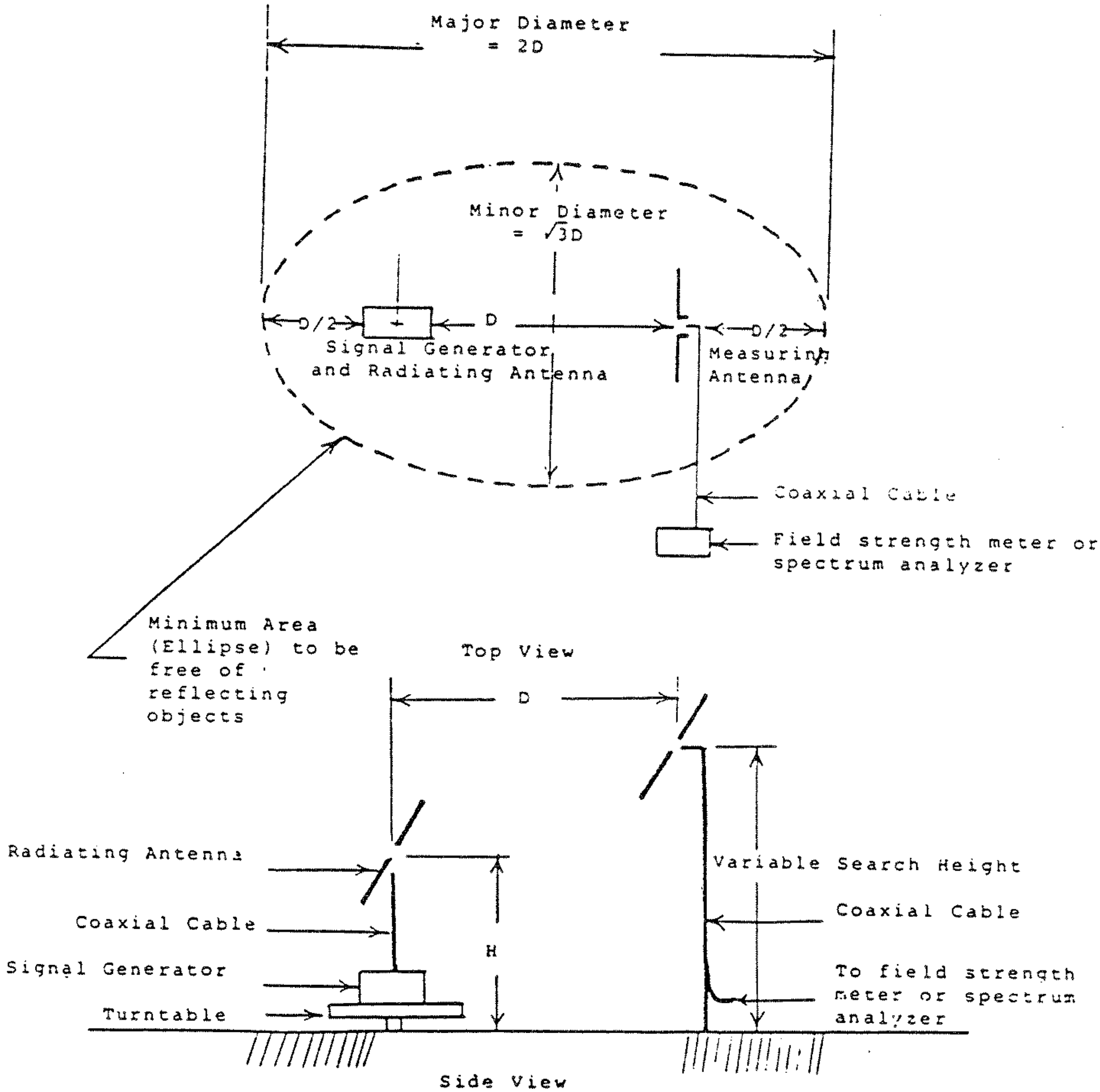

for D = 3m, H = 2m Search 1 - 4 meters
for D = 10m, H = 2m Search 1 - 4 meters
for D = 30m, H = 2m Search 2 - 6 meters

FIGURE 1. Equipment Arrangement for Measuring Site Attenuation of a Radiation Test Site

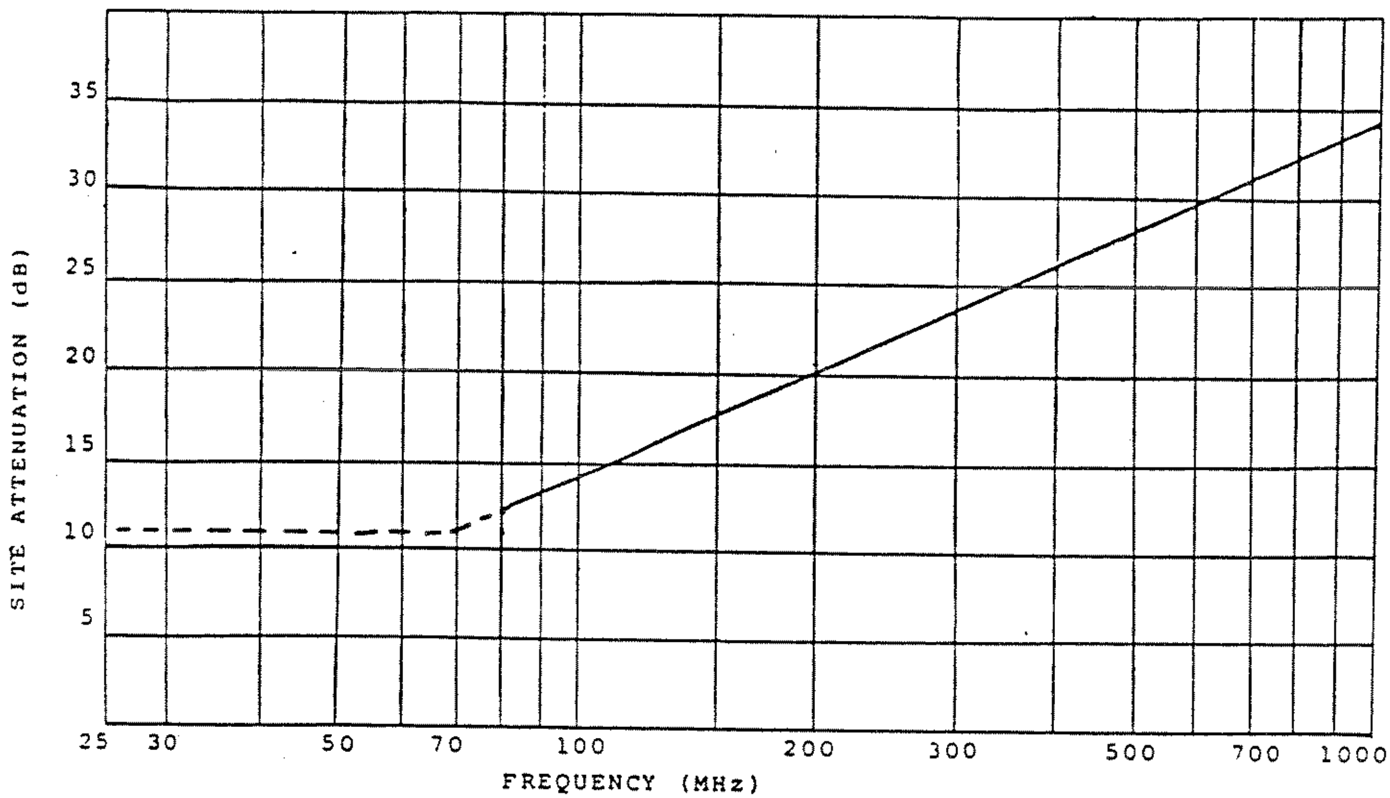

FIGURE 2. Sample Theoretical Site Attenuation Curve.
Both antennas tuned dipoles, D = 3m

The curve above 80 MHz was obtained from equation 1 using a value of 4.3 dB for the average ground reflection coefficient and 1.0 dB for the balun losses. The curve below 80 MHz is an approximation based upon experimental data.

Plot of equation 1 for D = 3m, R = -4.3 dB, Balun loss = +1.0:

Frequency	Site Attenuation
80	12.4
100	14.3
150	17.9
200	20.4
300	23.9
400	26.4
500	28.3
600	29.9
700	31.2
800	32.4
900	33.4
1000	34.3

From experimental data:

The region from 25 to 80 MHz is relatively flat at about 11 dB.