ANSI/IEEE Std 430-1986
(Revision of ANSI / IEEE Std 430-1976)

An American National Standard

IEEE Standard Procedures for the Measurement of Radio Noise from Overhead Power Lines and Substations

Sponsor
**Transmission and Distribution Committee
of the
IEEE Power Engineering Society**

Approved September 19, 1985
IEEE Standards Board

Approved February 28, 1986
American National Standards Institute

IEEE Standards documents are developed within the Technical Committees of the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Board. Members of the committees serve voluntarily and without compensation. They are not necessarily members of the Institute. The standards developed within IEEE represent a consensus of the broad expertise on the subject within the Institute as well as those activities outside of IEEE which have expressed an interest in participating in the development of the standard.

Use of an IEEE Standard is wholly voluntary. The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least once every five years for revision or reaffirmation. When a document is more than five years old, and has not been reaffirmed, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of all concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason IEEE and the members of its technical committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration.

Comments on standards and requests for interpretations should be addressed to:

Secretary, IEEE Standards Board
345 East 47th Street
New York, NY 10017
USA

Foreword

(This Foreword is not a part of ANSI/ IEEE Std 430-1986, IEEE Standard Procedures for the Measurement of Radio Noise from Overhead Power Lines and Substations.)

This standard was first issued as a trial-use standard in 1972 after a period of approximately 10 years in development. It became a full standard in 1976.

Experience with the previous edition of this standard indicated that a number of revisions and improvements were needed. The Accredited Standards Committee C63 on Radio-Electrical Coordination had adopted the IEC (International Electrotechnical Commission) CISPR (International Special Committee on Radio Interference) specifications for interference measuring apparatus for the frequency range 0.15–30 MHz. In addition, there was a need for the standard to be more specific as to measuring both the electric and magnetic field and as to what the measurement units should be. The previous version primarily covered ac lines, whereas this revision applies to both ac and dc lines. The section from 30–1000 MHz has been expanded to cover beth short-term and long-term surveys. Because of the need for conducting radio noise measurements around substations, two trial-use sections have been added to cover the frequency range 0.010–30 MHz and 30–1000 MHz.

This standard was developed by a task force of the Radio Noise Working Group of the Corona and Field Effects Subcommittee. This task force had the following membership:

V. L. Chartier, *Chair*

R. E. Carberry
F. M. Dietrich
P. S. Maruvada
T. J. McDermott
A. R. Morse
W. E. Pakala
A. I. Paldi
M. D. Perkins

When this standard was approved, the Radio Noise Working Group had the following membership:

T. J. McDermott, *Chair*

R. J. Bacha
R. Balshiki
A. C. Baker
S. Bernstein
W. E. Blair
M. E. Bulawka
R. J. Caola
V. L. Chartier
R. Cortina
L. B. Craine
M. D'Amore
F. M. Dietrich
C. H. Gary
J. F. Halls
W. Janischewskyj
N. Kolcio
P. S. Maruvada
E. Minichiello
A. R. Morse
R. G. Olsen
W. E. Pakala
A. I. Paldi
M. D. Perkins
M. Poland
M. A. Reavis
J. Reichman
J. P. Reilly
W. R. Roy
T. Sasano
W. R. Schlinger
S. A. Sebo
W. R. Vincent
F. W. Warburton
B. F. Whitney
P. S. Wong

The following persons were on the balloting committee that approved this document for submission to the IEEE Standards Board:

L. A. Belfore
V. L. Chartier
W. H. Cole
F. A. Denbrock
C. C. Diemond
J. J. Dougherty
G. V. Fantozzi
R. G. Rocamora
P. S. Maruvada
D. T. Michael
T. A. Pinkham
R. L. Retallack
C. F. Riederer
R. C. Seebald
D. D. Wilson

When the IEEE Standards Board approved this standard on September 19, 1985, it had the following membership:

CLAUSE PAGE

1. Purpose and Scope 1

2. References 1

3. Definitions 2

4. Measuring Instrumentation 2

4.1 Radio Noise and Field Strength Meter 2
4.2 Radio Noise Meter Calibration 3
4.3 Detector Function Selection 3
4.4 Units of Measurements 3
4.5 Monitoring 3

5. Measurement of Radio Noise (0.010–30 MHz) from Overhead Power Lines 3

5.1 Test Sites 4
5.2 Measurement Procedure 4
5.3 Background Data 8

6. Measurement of Radio Noise (30–1000 MHz) from Overhead Power Lines 9

6.1 Test Sites 9
6.2 Measurement Procedure 10
6.3 Background Data 13

7. Precautions in Measurements 13

7.1 Reader Location 13
7.2 Number of MeasuringLocations 14
7.3 Standing Waves 14
7.4 Background 15
7.5 Weather 15
7.6 Selection of Antennas 15
7.7 Additional Precautions 16

8. Measurement of Radio Noise (0.010–30 MHz) from Substations (for Trial Use) 16

8.1 Test Sites 16
8.2 Measurement Procedure 17
8.3 Reporting of Data 17

9. Measurement of Radio Noise (30–1000 MHz) from Substations (for Trial Use) 17

9.1 Test Sites 17
9.2 Measurement Procedures 17
9.3 Reporting of Data 18

Annex A (Informative) Vehicle-Mounted Antennas 19

An American National Standard

IEEE Standard Procedures for the Measurement of Radio Noise from Overhead Power Lines and Substations

1. Purpose and Scope

The primary purpose of this standard is to establish uniform procedures for the measurement of radio noise generated by corona from overhead power lines with meters that conform to ANSI C63.2-1980 [1].[1] A uniform procedure is a prerequisite to comparisons or validation, or both, of the radio noise performance of various overhead power lines and substations. Measurement procedures in this standard are also valid for other power-line noise sources such as gaps and harmonics; however, most of the precautionary information, analysis, and data plotting techniques were written and developed primarily for corona discharges. The procedures are not valid for measuring transient radio noise sources that occur during breaker or disconnect switching operations. The procedure applies in the frequency range of 0.010–1000 MHz; however, the emphasis is on the standard amplitude-modulation broadcasting (0.535–1.605 MHz) and television broadcasting (54–72 MHz, 76–88 MHz, 174–216 MHz, and 470–906 MHz) bands. The procedures described for measurements in and near substations are suggested procedures at this time until further information is obtained. This standard is applicable to both ac and dc transmission lines and substations.

2. References

The following publications shall be used in conjunction with this standard. When American National Standards referred to in this standard are superseded by a revision approved by the American National Standard Institute, Inc, the revision shall apply.

[1] ANSI C63.2-1980, American National Standard Specifications for Electromagnetic Noise and Field-Strength Instrumentation, 10 kHz to 1 GHz.[2]

[2] ANSI/IEEE Std 100-1984, IEEE Standard Dictionary of Electrical and Electronics Terms.

[3] ANSI/IEEE Std 539-1979, IEEE Standard Definitions of Terms Relating to Overhead-Power-Line Corona and Radio Noise.

[4] IEC/CISPR Pub 16-1977, Specifications for Radio Interference Measuring Apparatus and Measurement Methods.[3]

---

[1]The numbers in brackets correspond to those of the references listed in Section 2

[2]ANSI publications are available from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.

[3]IEC publications are available in the US from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.

[5] IEEE Std 291-1969, IEEE Standards Report on Measuring Field Strength in Radio Wave Propagation.[4]

[6] IEEE Std 473-1985, IEEE Recommended Practice for an Electromagnetic Site Survey (10 kHz to 10 GHz).

[7] SAE Pub ARP 958, Broadband Electromagnetic Interference Measurement Antennas; Standard Calibration Requirements and Methods.[5]

[8] IEEE Committee Report. Correlation of Various RI Meters and Reading Comparison of RI Meter Operators on a 735-kV Line. *IEEE Transactions on Power Apparatus and Systems,* vol PAS-87, no 5, May 1968, pp 1249–1259.

[9] IEEE Committee Report. A Field Comparison of RI and TVI Instrumentation. *IEEE Transactions on Power Apparatus and Systems,* vol PAS-96, no 3, May/June 1977, pp 863–875.

3. Definitions

For additional definitions see ANSI/IEEE Std 100-1984 [2] and ANSI/IEEE Std 539-1979 [3].

background noise: The total system noise independent of the presence or absence of radio noise from the power line or substation.

NOTE — Background noise is presumed to be reduced to a level of insignificance.

impulse bandwidth: The peak value of the response envelope divided by the spectrum amplitude of an applied impulse.

lateral profile: The radio noise field strength at ground level plotted as a function of the horizontal distance from, and at a right angle to, the power line conductors.

longitudinal profile: The radio noise field strength at ground level measured at constant horizontal distance from the power line and plotted as a function of distance along the line.

radio noise: Any unwanted disturbance within the radio frequency band, such as undesired electromagnetic waves in any transmission channel or device.

radiated noise: Radio noise energy in the form of an electromagnetic field including both the radiation and induction components of the field.

4. Measuring Instrumentation

4.1 Radio Noise and Field Strength Meter

Radio noise meters employed shall conform to requirements of ANSI C63.2-1980 [1]. In the frequency range of 0.15–30 MHz, ANSI C63.2-1980 [1] allows the use of two quasi-peak (QP) detectors. The preferred QP detector has a 1 ms charge and 160 ms discharge time constant, a 9 kHz bandwidth, and conforms to the requirements of IEC/CISPR Pub 16-1977 [4]. Measurements of power line noise made with the optional QP detector, which has 1 ms charge and 600 ms discharge time constants and a 4.5 kHz bandwidth, shall be reduced by 2 dB to agree with CISPR QP [8], [9]. Table 1, which was derived from ANSI C63.2-1980 [1], shows the nominal circuit time constants and bandwidths for the entire frequency range of 0.010–1000 MHz.

---

[4]IEEE publications are available from the Sales Department, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854.
[5]SAE publications are available from the Society of Automotive Engineers, Inc, 400 Commonwealth Drive, Warrendale, PA 15096.

Other instruments may be used for certain restricted or specialized measurements when correlation data have been taken to establish the methods of conversion of data to that achieved with meters conforming to ANSI C63.2-1980 [1].

4.2 Radio Noise Meter Calibration

The calibration of radio-noise meters should be checked frequently to assure accuracy. Adjustments should be made and correction factors applied in accordance with instructions contained in the manual for the radio-noise meter.

4.3 Detector Function Selection

The quasi-peak detector or the peak detector should be used. When measurements are made for the protection of radio and TV services, the quasi-peak detector function is preferred over the peak detector function. Other detectors such as average and rms can be used for evaluation of electromagnetic compatibility between overhead power line and other communication services according to individual requirements.

4.4 Units of Measurements

The indicated readings on the radio-noise meter shall be adjusted by appropriate correction factors (antenna factor, attenuation, etc) to express the result for the selected detector. Average and quasi-peak detector results shall be reported in dBμV / m or dBμA / m without bandwidth correction, but accompanied by a statement of the actual radio-noise meter bandwidth. Results for broadband impulse radio noise shall be normalized to a 1 MHz bandwidth when measured with a peak detector.

Table 1—Nominal Circuit Time Constants and Overall Bandwidth Quasi-Peak Detector

Frequency Range (MHz)	Bandwidth –6dB (kHz)	Charge Time Constant (ms)	Discharge Time Constant	Optional Discharge Time Constant (bandwidth)
0.010–0.15	200	45	500 ms ± 20%	
0.15–30	9	1	160 ms ± 20%	600 ms ± 20% (4.5 kHz)
30–515	120	1	550 ms ± 20%	
470–1000	120	1	550 ms ± 20%	

4.5 Monitoring

All radio-noise measurements shall be monitored using either a headset or a loudspeaker as an aid in detecting ambient signals and for selecting worst-case frequencies (see also Section 7). Precautions shall be taken to ascertain that the use of a headset or speaker during measurements does not affect the radio-noise meter indication.

5. Measurement of Radio Noise (0.010–30 MHz) from Overhead Power Lines

To properly characterize the radio-noise performance of overhead power lines from 0.010–30 MHz, both short-term and long-term surveys are needed.

5.1 Test Sites

Overhead power lines traverse all types of terrain and environment. They come near buildings, fences, trees, etc; underground cables, pipelines, etc; and other overhead power lines, telephone lines, etc. For characterizing the radio-noise performance of an overhead power line, it is preferable that the test site be free of all such objects.

5.2 Measurement Procedure

There are two measurement approaches usually adopted for obtaining information about the radio noise (0.010–30 MHz) produced by overhead power lines: short-term and long-term surveys.

5.2.1 Short-Term Surveys

In performing a short-term survey of radio noise (0.010–30 MHz) from an overhead power line, the goals should be to obtain a lateral profile and a frequency spectrum of that noise.

5.2.1.1 Lateral Profile

In taking a lateral profile of the radio noise from an overhead power line, the following procedures apply:

1) The lateral profile should be measured at a midspan test site, in a plane normal to the line.
2) The standard measurement frequency shall be 0.5 MHz ± 0.1 MHz.
3) Measurement of radio noise should be made out to a distance of 80 m from the outer phase conductor(s) for ac lines or the positive pole for dc lines. For two bipolar dc lines in close proximity that have the positive poles as the inner conductors, the measurements should be made out to 80 m from the outer (that is, negative) conductor(s).
4) A quasi-peak detector shall be used.
5) A loop antenna or vertical rod antenna may be used. If a loop antenna is used, the height of the antenna is not critical, but the base of the unit should be no more than 2 m above the ground. The loop antenna shall be positioned vertically and rotated about its vertical axis to obtain the maximum meter indication. The orientation of the antenna with respect to the power line should be recorded. If a vertical red antenna is used, it shall be positioned vertically and placed on the ground using an appropriate ground plane (usually available from the antenna manufacturer). Because of the difficulties in obtaining reliable measurements with a rod antenna, the loop antenna is preferred for lateral-profile measurements.
6) Measurements obtained with a loop antenna whose antenna factors are in terms of electric field units can be converted to magnetic field units by subtracting 51.5 dB from the measurements.
7) Lateral profiles should be plotted along with a sketch of the line configuration as shown in Fig 1 for ac lines and Fig 2 for dc lines. A lateral profile of radio noise may also be plotted using a logarithmic scale for distance from the conductor. Individual data points shall be shown on such plots.
8) Observe the precautions discussed in Section 7

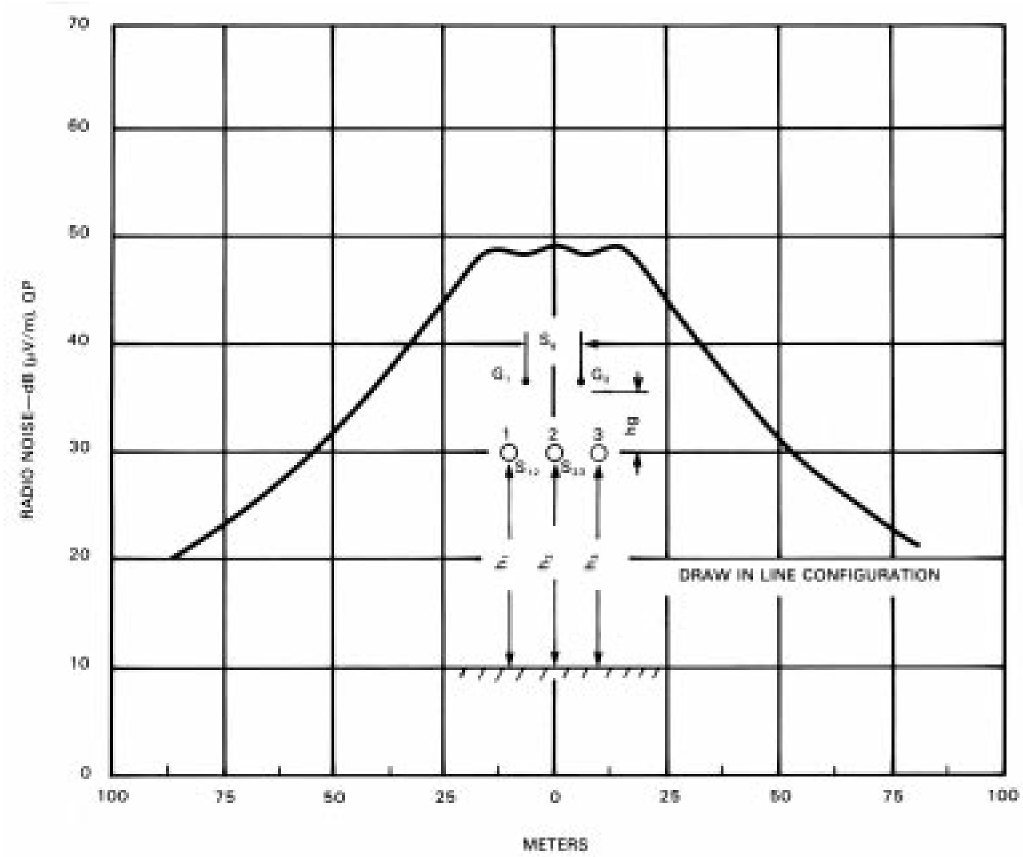

Figure 1—Example of Radio Noise Lateral Profile at 0.5 MHz: Fair Weather Conductor Corona, AC Line

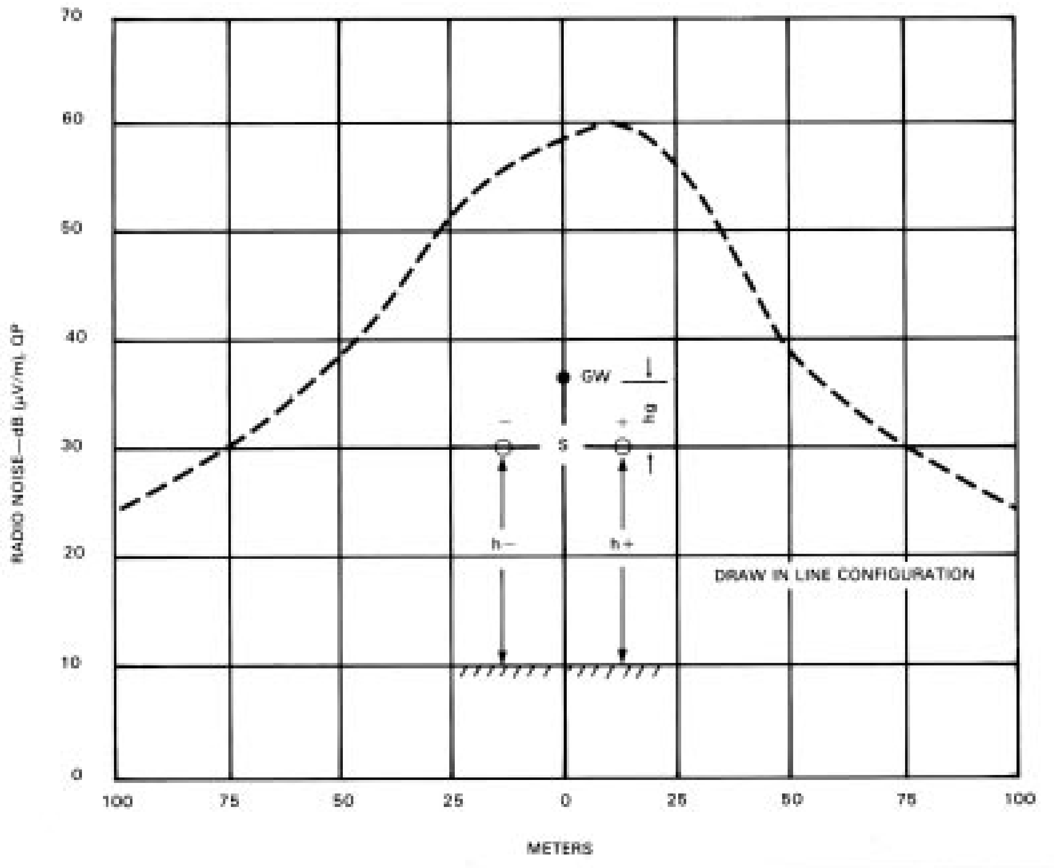

Figure 2—Example of Radio Noise Lateral Profile at 0.5MHz: Fair Weather Conductor Corona, DC Line

5.2.1.2 Frequency Spectrum

In taking a frequency spectrum of the radio noise from an overhead power line, the following procedures apply:

1) The radio noise spectrum shall be measured at a midspan test site at a lateral distance of 15 m as measured along the ground, from the outer phase conductor(s) for ac lines or the positive pole for dc lines. For two bipolar dc lines in close proximity that have the positive poles as the inner conductors, the measurements should be made to 15 m from the outer (that is, negative) conductor(s).
2) Measurements shall be made at no less than ten frequencies per decade. The frequencies selected shall be those at which the highest noise levels are observed between 0.010–30 MHz. Such frequency spectra can be obtained with X-Y plotters.
3) As discussed in 5.2.1.1, either a loop or vertical rod antenna may be used.
4) A quasi-peak detector shall be used.
5) Radio-noise spectra shall be obtained on beth sides of an overhead power line if abnormal noise sources are suspected.
6) Measurements obtained with a loop antenna whose antenna factors are in terms of electric-field units can be converted to magnetic-field units by subtracting 51.5 dB from the measurements.
7) The frequency spectrum of radio noise should be plotted as shown in Fig 3 with individual data points highlighted.
8) Observe the precautions discussed in Section 7

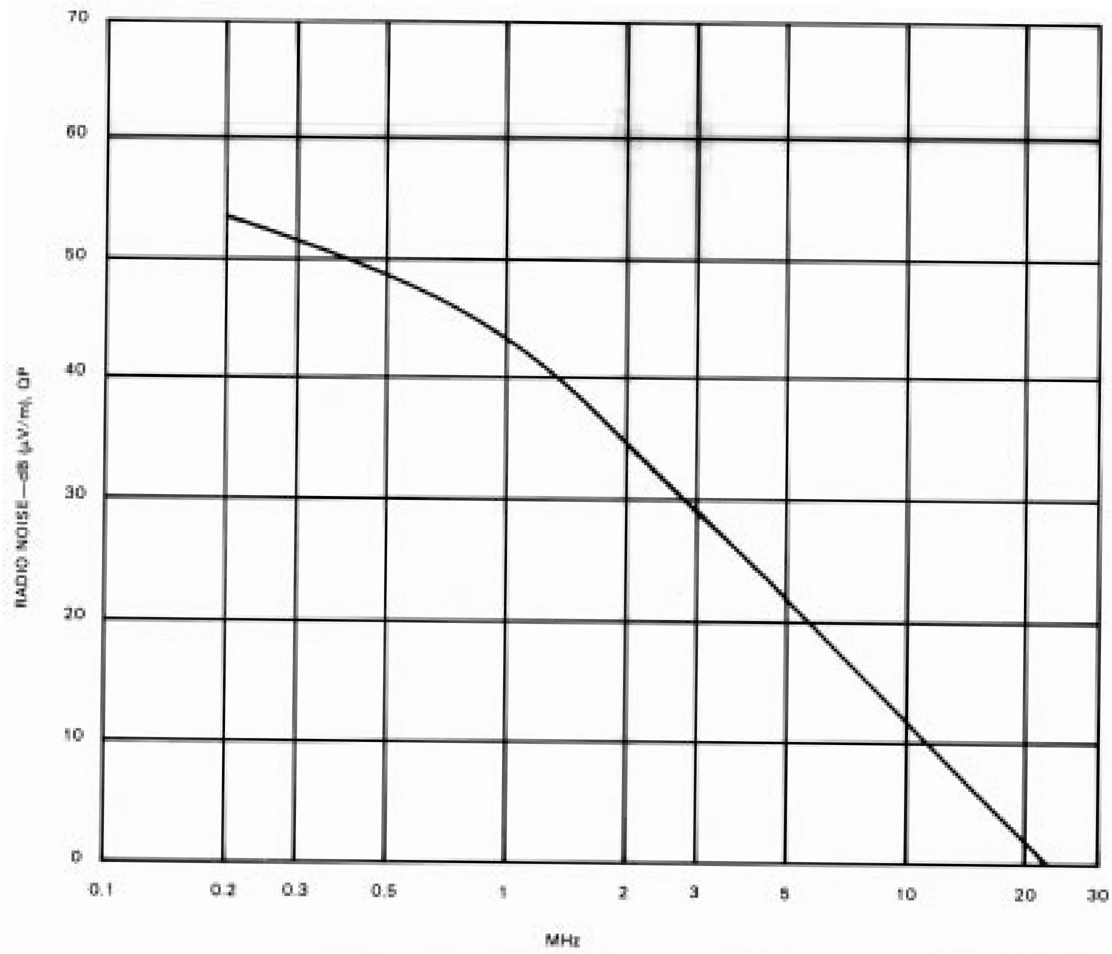

Figure 3—Example of Frequency Spectrum Between 0.15 and 30 MHz: Fair Weather Conductor Corona, AC or DC line

5.2.2 Long-Term Surveys

In performing a long-term survey of radio noise (0.010–30 MHz) from an overhead power line, the goal is to obtain statistical data on the level of radio noise over an extended period of time.

The procedure to be followed in performing the long-term survey is as follows:

1) The measurement location shall be at a midspan test site at a lateral distance of 15 m as measured along the ground from the outer phase conductor(s) for ac lines or the positive pole for dc lines. For two bipolar dc lines in close proximity that have the positive poles as the inner conductors, the measurements should be made at 15 m from the outer (that is, negative) conductor(s).
2) The standard measurement frequency shall be 0.5 ± 0.1 MHz.
3) A loop antenna shall be used. The mounting height of the antenna is not critical, but it is recommended that the base of the unit not exceed 2 m above ground.
4) Sampling rate shall be large enough and data shall be collected for a period long enough to reflect the normal distribution of weather conditions of the area.
5) A quasi-peak detector shall be used.
6) The units of measurement are normally expressed in terms of electric-field. If magnetic-field units are preferred, see 5.2.1.1 (6).

7) Observe the precautions discussed in Section 7
8) The recording method should not in any way affect meter performance.
9) Calibration of the entire measurement system shall be performed at least three times over the duration of the survey. In addition, the system shall be calibrated at the beginning and end of the survey. The loop antenna shall be calibrated by the standard-field method given in IEEE Std 291-1969 [5]. For automatic measurements, a calibrating signal should be recorded each time a recording of radio noise is made, unless the root of the variance of the calibration error is less than 1 dB.
10) The long-term data should be analyzed statistically and plotted as shown in Fig 4 with individual data points highlighted.

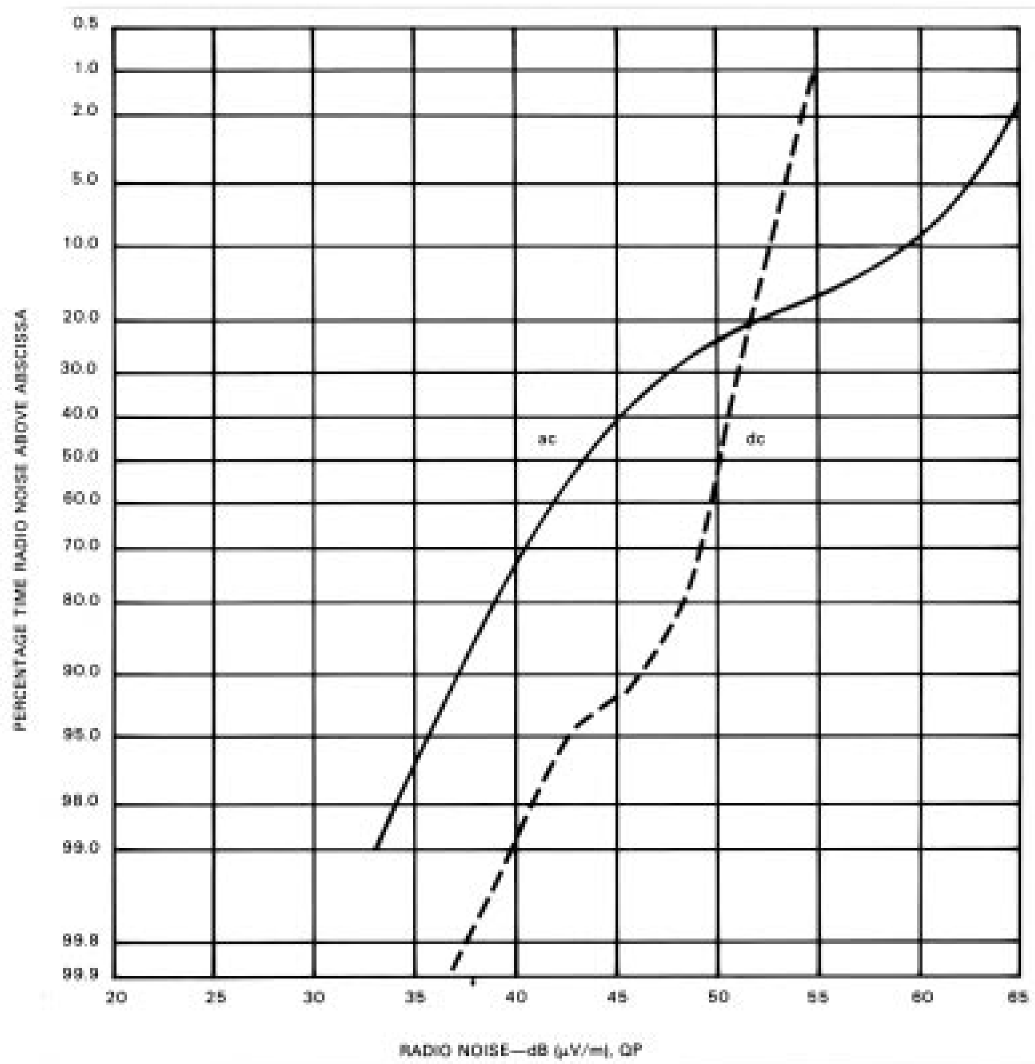

Figure 4—Example of All-Weather Radio Noise Cumulative Amplitude Distributions at 0.5 MHz: Conductor Corona

5.3 Background Data

The following information shall be recorded concerning the overhead power line's operating condition and characteristics, as well as the weather conditions at the time of measurements:

1) The line voltage of the power line (determined within 4% accuracy, if possible)

2) The geometrical parameters of the line configuration
3) The type and geometrical parameters of the phase conductors and shield wires (measured conductor heights for each site at time of radio noise measurements are preferred)
4) Tower material (wood, metal, concrete, etc)
5) Location of measuring point (that is, distance to nearest substation and angle structures, proximity to geographical feature)
6) Site elevation above sea level
   (The effect of altitude on radio noise due to corona is approximately 1 dB/300 m. Site elevation should be determined as accurately as possible from topographical maps; however, site elevations to the nearest 300 m are acceptable.)
7) Instrument and antenna used
8) Detector function(s) used
9) Weather conditions including:
   a) Temperature
   b) Humidity (optional for short-term surveys)
   c) Barometric pressure (optional for short-term surveys)
   d) Wind velocity and direction (optional for ac lines)
   e) Precipitation (fair, rain, snow, fog, etc)

A typical background data sheet is shown in Fig 5.

6. Measurement of Radio Noise (30–1000 MHz) from Overhead Power Lines

To properly characterize the radio-noise performance of overhead power lines from 30–1000 MHz, both short-term and long-term surveys are needed.

6.1 Test Sites

Overhead power lines traverse all types of terrain and environment. They come near buildings, fences, trees, etc; underground cables, pipelines, etc; and other overhead power lines, telephone lines, etc. For characterizing the radio-noise performance of an overhead power line, it is preferable that the test site be free of all such objects.

- A. Line Voltage, kV
  - 1. Nominal .... ________
  - 2. Actual .... ________
- B. Line Conductor
  - 1. Type .... ________
  - 2. Diameter, cm .... ________
  - 3. Gradient, Max, kV_{rms}/cm
    - a. Center Conductor .... ________
    - b. Outer Conductor .... ________
- C. Overhead Shield Wire
  - 1. Type .... ________
  - 2. Diameter, cm .... ________
- D. Atmospheric Conditions
  - 1. Temperature, °C .... ________
  - 2. Humidity, mm of Hg Vapor Pressure .... ________
  - 3. Weather Conditions
    - a. Fair (dry conductor) .... ________
    - b. Rain (light, medium, heavy, drizzle) .... ________
    - c. Snow (light, medium, heavy, flurries) .... ________
    - d. Fog (light, medium, heavy) .... ________
  - 4. Barometric Pressure, mm of Hg .... ________
  - 5. Wind Velocity, km/h and Direction .... ________
- E. Towers
  - 1. Metal .... ________
  - 2. Wood .... ________
  - 3. Others .... ________
- F. Site Elevation above Sea Level, m .... ________
- G. Distance to Nearest Substation, m .... ________
- H. Number of Measurements .... ________
- I. Instruments .... ________
  - 1. Instrument (make) .... ________
  - 2. Bandwidth (−6 dB impulse noise), kHz .... ________
  - 3. Type of Detector, QP, rms, Average, Peak, etc .... ________
  - 4. Frequency, MHz .... ________
  - 5. Antenna
    - a. Loop .... ________
    - b. Vertical .... ________
    - c. Dipole .... ________
    - d. Other .... ________
- J. Specify Any Unusual Conditions .... ________

Figure 5—Typical Background Data Sheet

6.2 Measurement Procedure

There are two measurement approaches usually adopted for obtaining information about the radio noise (30–1000 MHz) produced by overhead power lines: short-term and long-term surveys.

6.2.1 Short-Term Surveys

In performing a short-term survey of radio noise (30–1000 MHz) from overhead power lines, the goal should be to obtain a lateral profile and frequency spectrum of that noise.

6.2.1.1 Lateral Profile

In taking a lateral profile of the radio noise from an overhead power line, the following procedures apply:

1) Lateral profiles should be measured at a midspan test site and opposite a self-supporting tower in a plane normal to theline.
2) The standard measurement frequencies shall be 73.5 MHz and 150 MHz.
3) Measurement of radio noise should be made out to a distance of 80 m from the outer phase conductor(s) for ac lines or the positive pole for dc lines. For two bipolar dc lines in close proximity that have the positive poles as the inner conductors, the measurements should be made out to 80 m from the outer (that is, negative) conductor(s).
4) A quasi-peak detector shall be used.
5) Either a dipole or broadband antenna may
   be used. The antenna shall be placed in a horizontally polarized position and rotated to obtain the maximum meter indication. The orientation of the antenna with respect to the power line should be recorded.
   The mounting height of the antenna above ground should be at least 3 m. If a vehicle-mounted antenna is used, the antenna should be at least 2 m above the roof of the vehicle. The effects of vehicles on vehicle-mounted antennas have been found to be negligible if this minimum height of 2 m is maintained; however, the vehicle and antenna combination should be calibrated to confirm the antenna factors and to check for existence of azimuthal asymmetries in the antenna pattern, as described in Section 5 of IEEE Std 473-1985 [6].
6) Lateral profiles should be plotted as shown in Fig 6 with individual data points highlighted.
7) Observe the precautions discussed in Section 7

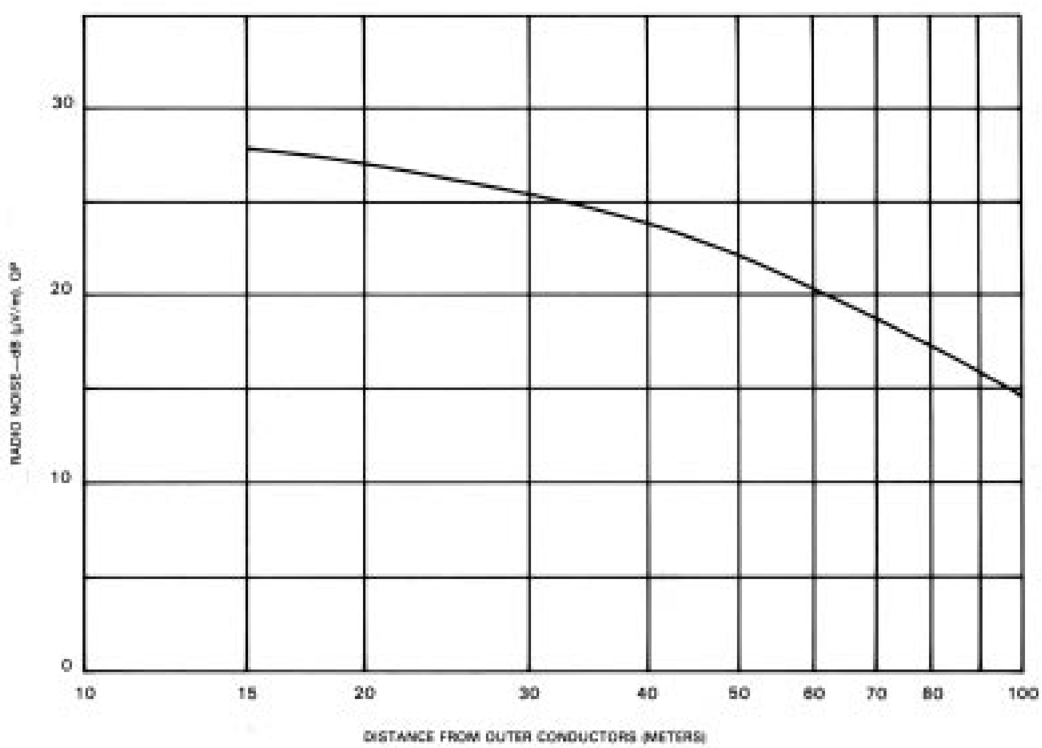

Figure 6—Example of Radio Noise Lateral Profile at 73.5 MHz: Rainy Weather, AC Line

6.2.1.2 Frequency Spectrum

In taking a frequency spectrum of the radio noise from an overhead power line, the following procedures apply:

1) The radio-noise spectrum shall be measured:
   a) at a midspan test site at a lateral distance of 15 m, as measured along the ground, from the outer phase conductor(s) for ac lines or

the positive pole for dc lines. For two bipolar dc lines in close proximity that have the positive poles as the inner conductors, the measurements should be made at 15 m from outer (that is, negative) conductor(s);

b) at a test site opposite a self-supporting tower at a lateral distance of 60 m, as measured along the ground, from the outer phase conductors) for ac lines or the positive pole for dc lines. For bipolar dc lines in close proximity that have the positive poles as the inner conductors, the measurements should be made at 60 m from the outer (that is, negative) conductor(s).

2) Measurements shall be made at no less than ten frequencies per decade. The frequencies selected shall be those at which the highest noise levels are observed between 30 and 1000 MHz. Such frequency spectra can be obtained with X-Y plotters.
3) As discussed in 6.2.1.1, one may use either a dipole or broadband antenna.
4) A quasi-peak detector shall be used.
5) Radio noise spectra shall be obtained on both sides of an overhead power line if abnormal noise sources are suspected.
6) The frequency spectrum should be plotted, as shown in Fig 7, with individual data points highlighted.
7) Observe the precautions discussed in Section 7

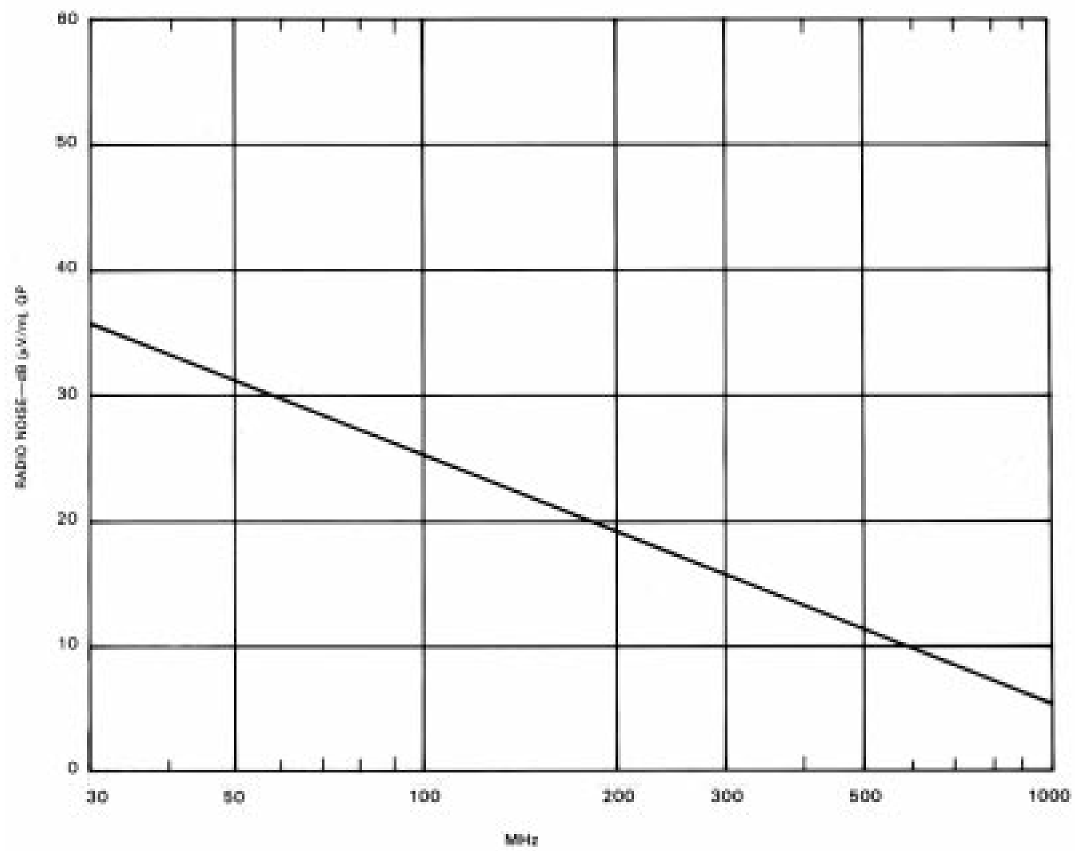

Figure 7—Example of Radio Frequency Spectrum Between 30and 1000 MHz: Rainy Weather, AC Line

6.2.2 Long-Term Surveys

In performing a long-term survey of radio noise (30–1000 MHz) from an overhead power line, the goal is to obtain statistical data on the level of radio noise over an extended period of time.

The procedure to be followed in performing the long-term survey is as follows:

1) The measurement location shall be at a midspan test site at a lateral distance of 15 m from the outer conductor(s) for ac lines or the positive pole for dc lines. For two bipolar dc lines in close proximity that have the positive poles as the inner conductors, the measurements should be made at 15 m from the outer (that is, negative) conductor(s).
2) The standard measurement frequency shall be 73.5 MHz. Measurements at 150 MHz are also desirable.
3) Either a dipole cr broadband antenna may be used. The antenna shall be placed in a horizontally polarized position and rotated to obtain the maximum meter indication. The orientation of the antenna with respect to the power line should be recorded. Mounting height of the antenna shall be 3 m above ground.
4) Sampling rate shall be large enough and data shall be collected for a period long enough to reflect the normal distribution of weather conditions of the area.
5) A quasi-peak detector shall be used.
6) Observe the precautions discussed in Section 7
7) The recording method should not in any way affect the meter performance.
8) Calibration of the entire measurement system shall be performed at least three times over the duration of the survey. In addition, the system shall be calibrated at the beginning and end of the survey. Broadband antennas built specifically for electromagnetic interference (EMI) measurements above 30 MHz are calibrated by the manufacturer according to the procedures in IEEE Std 291-1969 [5] and SAE Pub ARP 958 [7]. Periodic calibration of these antennas using the techniques appropriate to the antenna is required. For automatic measurements, a calibrating signal should be recorded each time a recording of radio noise is made, unless the root of the variance of the calibration error is less than 1 dB.
9) The long-term data should be analyzed statistically. For normal ac lines, the radio noise during fair weather is usually negligible; therefore, the foul weather data should be analyzed statistically and plotted, as shown in Fig 8, with individual data points highlighted. For dc lines, the radio noise above 30 MHz is usually negligible under all weather conditions.

6.3 Background Data

Line and weather information should be recorded identically to the requirements of 5.3.

7. Precautions in Measurements

7.1 Reader Location

Measurement and other personnel shall maintain sufficient distance from the antenna of the meter so they will in no way influence the meter reading.

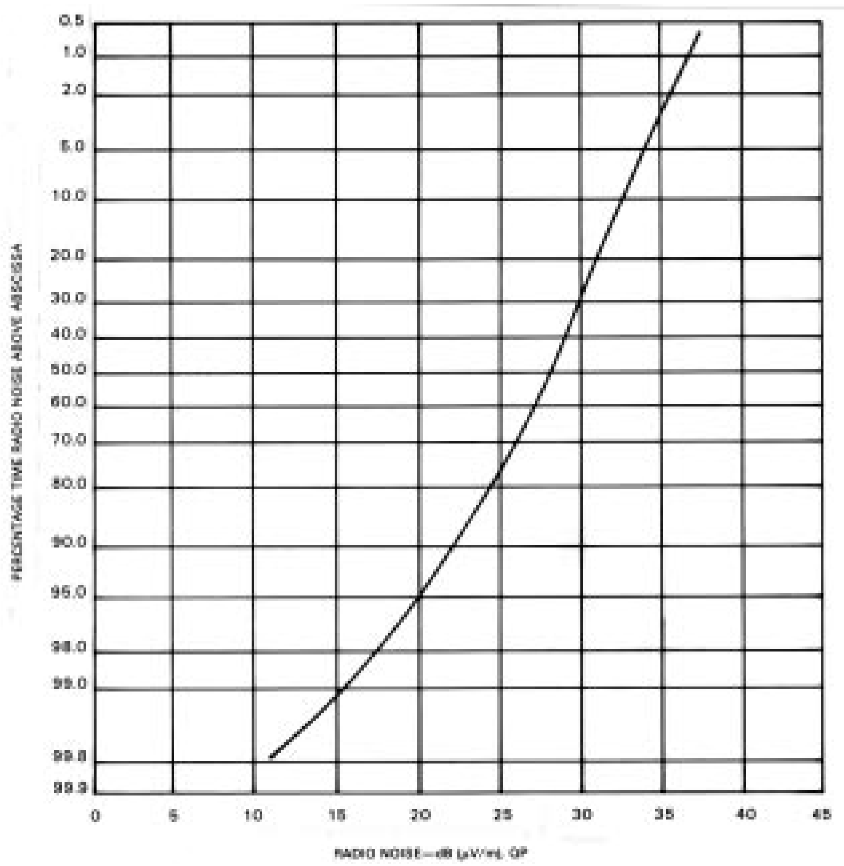

Figure 8—Example of Rainy Weather Radio Noise Cumulative Amplitude Distribution at 73.5 MHz, AC Line

7.2 Number of Measuring Locations

A minimum of three test sites, as equally spaced along the line as possible, should be used in short-term surveys to determine the lateral profile and the frequency spectrum at midspan and also opposite self-supporting towers in the 30–1000 MHz frequency range. Measurements should be made when conditions are constant all along the line.

7.3 Standing Waves

Line terminations, abrupt transpositions, traps, and other impedance discontinuities give rise to standing waves. In order to avoid standing waves, test sites should be selected with care and at some distance (10 km) along the line from these discontinuities. However, some lines are too short to enable this condition to be met. The results of measurements between 0.10 and 30 MHz indicate that the level of the radio noise in the absence of reflections corresponds to the geometric mean of the maximum and minimum values, in μV/m, of the frequency spectrum from a line with reflections. It may be found that considerable variations will occur even on long lines, with small changes in the measurement frequency. These variations may be found at the tower and are due to sources at the tower that are sufficiently intense to override the conductor corona radio noise.

7.3.1 Longitudinal Measurements

At a distance of 15–30 m from outer phase conductors (ac lines) or positive pole (dc lines) line and parallel with the line, measure radio noise at approximately ten equal consecutive increments for a distance of 150 m or one-half wavelength at the test frequency, whichever is greater, centered at midspan. (Use obtained data opposite towers with caution.) Standing waves are present if the plotted data versus distance for a single frequency approximates a sine wave with the negative half inverted.

7.3.2 Frequency Scan

At a distance of 15–30 m from outer phase conductors (ac lines) or positive pole (dc lines) at approximately midspan, carefully scan the frequency spectrum either manually or automatically for 0.2 MHz each side of the desired measuring frequency of 0.5 MHz. Standing waves are present if somewhat uniformly spaced peaks, with crest-to-valley ratios of greater than approximately 2:1, are observed.

7.4 Background

Background radio noise at test sites should be at least 6 dB below the line's radio-noise level.

7.5 Weather

Radio-noise levels are influenced by changing weather conditions. In case of corona discharge the most consistently reproducible radio-noise measurements for ac lines have been made in heavy and steady rainfall (greater than 5 mm / h). This radio-noise level constitutes the maximum level of noise for a particular ac line and is the upper limit of the statistical distribution. For dc lines, the corona noise during rain is less than during fair weather. Gap-type discharges are generally shorted out by moisture during foul-weather; therefore, the lines become quieter. When performing a short-term survey, one should be cognizant of the weather conditions and note them on the data sheets. Of particular importance is observing the type of precipitation and its rate. To properly characterize the radio-noise performance of a line, the atmospheric conditions should be approximately uniform along the line. Short-term measurements (at the reference frequency of 0.5 MHz) under foul weather conditions will be valid only if the precipitation extends over at least 10 km of the line on either side of the measuring site.

7.6 Selection of Antennas

Antennas shall conform with the requirements of 14.5.1 for rod antennas, 14.5.2 for loop antennas, 14.5.3 for dipole antennas, and 14.5.4 for broadband antennas in ANSI C 63.2-1980 [1].

7.6.1 Loop Antennas

Loop antennas shall be electrostatically shielded and shall be sensitive enough to satisfy the requirements of the measurement. The loop should be calibrated periodically according to a standard such as IEEE Std 291-1969 [5].

7.6.2 Vertical (Rod) Antennas

Vertical rod antennas not more than 1.5 m in physical length and adjusted to give an effective length of 0.5 m are normally used for electric field measurements over the frequency range of 0.010–30 MHz. The difficulty in using rod antennas is in determining the effective length of the antenna. The antenna factors supplied with rod antennas by the manufacturer are only valid for the mounting and ground plane conditions used by the manufacturer during calibration of the antenna. These antenna factors become invalid if other types of mountings are used, such as tops of tripods, vehicles (see the Appendix), etc, or if other ground conditions such as snow, heavy rain, etc, are prevalent.

When using rod antennas for short-term measurements, measurement personnel shall be sure that the site at which the antenna is located is free of all obstacles such as tall grass, fences, trees, bushes, etc, and even themselves. If the antenna is a remote antenna, it should be mounted on a ground plane (supplied by manufacturer) and placed on the ground. This procedure, along with the use of appropriate coaxial cable, allows the measurement personnel to be at least 3 m away from the antenna. If the antenna is mounted on the meter, the measurement personnel shall stay as far from the antenna as is physically possible.

Because of the difficulty in determining the effective length of rod antennas, they are not recommended for long-term measurements. If long-term electric field data is desired, then rod antennas shall be protected from the elements by placing them inside nonconductive buildings (fiberglass, for example). The building shall be designed so that snow does not pile up against it or over it. A good ground plane shall be established. For most consistent results, a metal ground plane should be used beneath the antenna with dimensions of the order of at least 1/6 wavelength (IEEE Std 291-1969 [5]). If a metal ground plane of this dimension is used, then the antenna could be elevated above the ground thereby avoiding the problem of the natural ground plane changing due to seasons of the year (snow, high water, etc).

7.6.3 Antennas Going into Corona

The tips of antennas, especially dipole and vertical antennas, can go into corona due to the high 60 Hz electric field produced by some overhead power lines. Precautions should be taken against this happening, for example, by replacing the small metal spheres on the tips of these antennas with larger spheres. Loop and broadband antennas are not normally susceptible to this problem; however, some broadband antennas will have gaps as a part of their impedance matching networks that can be broken down by the voltages induced on each of the antenna elements. This high capacitance discharge should be avoided not only from an unwanted interference standpoint, but because it can easily damage the front end of solid-state field-strength meters.

Since dc lines can produce ions, such ions or charged aerosols can discharge on rod or dipole antennas producing erratic and erroneous noise levels. This can be avoided by placing nonmetallic tubes over the antenna; however, the use of such tubes can change antenna factors or even be a collector of charges. This problem usually occurs when wind is blowing from the line towards the antenna; therefore, changes in wind direction may eliminate or increase the number of ions in the vicinity of the antenna.

7.7 Additional Precautions

Most ac transmission lines that are in corona will produce the same radio noise level on each side of the line. However, this is not the case for unsymmetrical ac lines. It is also not the case for dc lines since the positive pole produces the highest radio noise levels. Therefore, it may be necessary to measure the frequency spectrum on both sides of these lines (see 5.2.1.2 and 6.2.1.2). Frequency spectrums should also be measured on both sides of lines that have abnormal radio-noise sources such as gaps.

For the determination of lateral profiles, it is advisable to begin measurements at the greatest distance from the line. This is done to preclude interference from radio station signals.

In making radio-noise measurements, the radio-noise meter output should be monitored (identified) with headphones or equivalent means so that readings will not be taken that are affected by broadcast stations, radio beacons, radio communications, TV signals, or by broadband radio-noise sources such as vehicle-ignition systems, atmospherics, and electrical devices.

The use of antennas on top of vehicles should be used with caution. The Appendix provides a guideline for broadcast signal and noise measurements using vehicle-mounted antennas.

8. Measurement of Radio Noise (0.010–30 MHz) from Substations (for Trial Use)

8.1 Test Sites

Sites selected for the measurement of radio noise (0.010–30 MHz) should be at least 3 m from large metal objects, such as fences, buswork, transformers, etc.

8.2 Measurement Procedure

For measuring radio-noise levels (0.010–30 MHz) from a substation, the following procedures apply:

1) Measurements shall be taken at a lateral distance of 10 m from an energized bus or outside the substation at a lateral distance of 15 m from the perimeter of the fence that surrounds the substation.
2) Measurements shall be repeated at intervals not exceeding 10 m around the entire perimeter of the substation. If possible, radial measurements at these intervals should be measured away from the fence that surrounds the substation.
3) At each test site, the radio-noise level at 0.5 MHz shall be measured. A frequency spectrum shall be measured at the test site that gave the highest levels at 05.
4) A quasi-peak detector shall be used.
5) A loop antenna is the preferred antenna for this measurement. This antenna shall be mounted at a base height not exceeding 2 m and shall be rotated to obtain maximum meter indication.
6) Observe the precautions discussed in Section 7

8.3 Reporting of Data

A sketch of the substation showing the measurement points and the data collected at 0.5 MHz shall be provided. Data can also be plotted on polar paper as shown in Fig 9.

9. Measurement of Radio Noise (30–1000 MHz) from Substations (for Trial Use)

9.1 Test Sites

Sites selected for the measurement of radio noise (30–1000 MHz) should be free of large metal objects and at least 3 m from large metal objects, such as fences, buswork, transformers, etc.

9.2 Measurement Procedures

For measuring radio-noise levels (30–1000 MHz) from a substation, the following procedures apply:

1) Measurement shall be taken at a lateral distance of 10 m from an energized bus or outside the substation at a lateral distance of 15 m from the perimeter of the fence that surrounds the substation.
2) Measurements shall be repeated at intervals not exceeding 10 m around the entire perimeter of the substation.
3) At each test site, the radio-noise levels at 73.5 MHz and 150 MHz shall be measured. A frequency spectrum shall be measured at the test site that gave the highest levels at 73.5 MHz.
4) A quasi-peak detector shall be used.
5) Either a dipole or broadband antenna may be used. The antenna shall be placed in a horizontally polarized position and rotated to obtain the maximum meter indication. The orientation of the antenna with respect to the power line should be recorded.
   The mounting height of the antenna above ground should be at least 3 m. If a vehicle-mounted antenna is used, the antenna should be at least 2 m above the roof of the vehicle. The effects of vehicles on vehicle-mounted antennas has been found to be negligible if this minimum height of 2 m is maintained; however, the vehicle and antenna combination should be calibrated to confirm the antenna factors and to check for existence of azimuthal asymmetries in the antenna pattern, as described in Section 5 of IEEE Std 473-1985 [6].
6) Observe the precautions discussed in Section 7

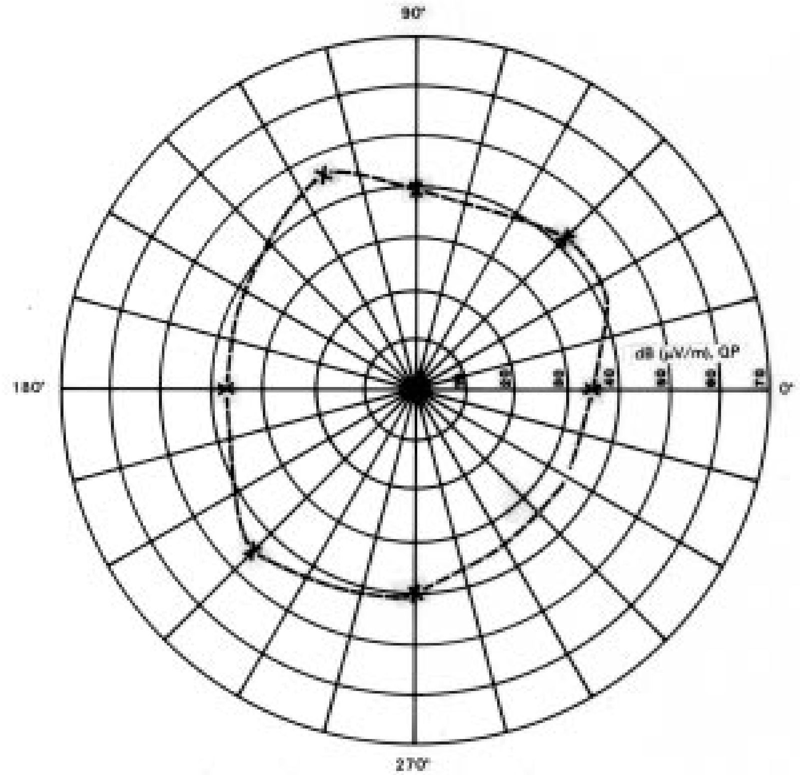

Figure 9—Example of Polar Profile of Substation Radio Noise at 0.5 MHz: Fair Weather Corona, AC Substation

9.3 Reporting of Data

A sketch of the substation showing the measurement points and the data collected at 73.5 MHz and 150 MHz shall be provided. Data can also be plotted on polar paper as shown in Fig 9.

Annex A Vehicle-Mounted Antennas

(Informative)

(This Appendix is not a part of ANSI/IEEE Std 430-1986, IEEE Standard Procedures for the Measurement of Radio Noise from Overhead Lines and Substations.)

A.1 General

It has become quite popular in recent years to use vehicles with antennas mounted on the roof. This technique is especially popular for measuring the strength of broadcast signals before and after a line is constructed. The purpose of this appendix is to give guidelines for proper use of vehicle-mounted antennas.

A.2 Measuring Broadcast Signals

A.2.1 AM Broadcast Signals

Preferred technique for measuring AM broadcast signals is to use a loop antenna. If a loop is used, it can be mounted on top of a vehicle and rotated from within the vehicle. The strength of the AM broadcast signal is independent of the height of the antenna; therefore, a loop can be placed on top of a vehicle, tripod, or anything else. Rod antennas should not be used to measure the strength of AM broadcast signals.

A.2.2 TV and FM BroadcastSignals

The Federal Communication Commission (FCC) field strength contours are based upon a receiving antenna height of 10 m. This height can be easily achieved by use of telescoping masts that are mounted as part of a vehicle. Air pneumatic masts are quite popular, although such devices as telescoping masts or hotsticks can also be used.

A.3 Measuring Radio Noise

A.3.1 0.010–30 MHz

Vehicle-mounted rod antennas should not be used for short-term surveys unless they are calibrated in that position. A technique for calibrating vehicle-mounted vertical antennas is described by G. H. Hagn in *Calibration of 9-Foot Rod Antenna for MF and HF EMC Measurements*, IEEE International Electromagnetic Compatibility Symposium Record, June 1968, pp 160–168.

Vehicle-mounted loop antennas are acceptable for measuring both the electric and magnetic fields in the far field. If the electric field has to be measured in the near field, then the rod antenna shall be mounted on a ground plane and placed on the ground.

A.3.2 30–1000 MHz

When using vehicle-mounted dipole or broadband antennas for measuring radio noise from overhead power lines above 30 MHz, the antenna height above the roof of the vehicle should be at least 2 m. Other than this requirement, the antenna height is not that critical, since the antenna is measuring the direct wave from the power line.