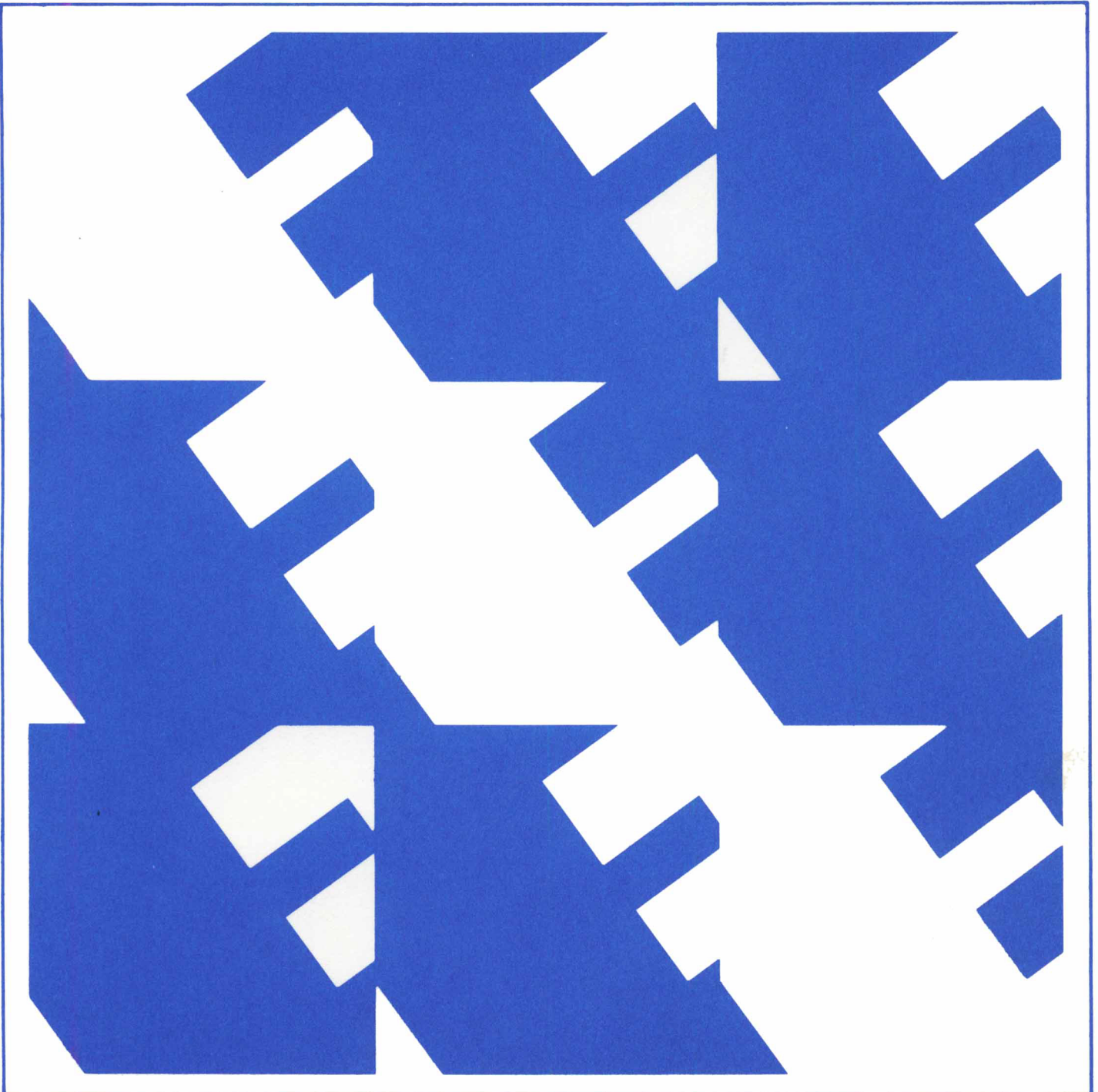


IEEE Recommended Practices for Measurement of Electric and Magnetic Fields from AC Power Lines

IEEE Std 644-1979



Published by The Institute of Electrical and Electronics Engineers, Inc. 345 East 47th Street, New York, New York 10017
November 16, 1979



Documents

Document Sharing Hub

Authorized licensed use limited to: Tsinghua University. Downloaded on February 25, 2026 at 21:51:11 UTC from IEEE Xplore. Restrictions apply.

IEEE
Std 644-1979

IEEE Recommended Practices for Measurement of Electric and Magnetic Fields from AC Power Lines

Sponsor
Transmission and Distribution Committee of the
IEEE Power Engineering Society

© Copyright 1979 by

The Institute of Electrical and Electronics Engineers, Inc

*No part of this publication may be reproduced in any form,
in an electronic retrieval system or otherwise,
without the prior written permission of the publisher.*

 **Documents**
Document Sharing Hub

Authorized licensed use limited to: Tsinghua University. Downloaded on February 25, 2026 at 21:51:11 UTC from IEEE Xplore. Restrictions apply.

Approved December 14, 1978

IEEE Standards Board

Joseph L. Koepfinger, *Chairman*

Irvin N. Howell, Jr, *Vice Chairman*

Ivan G. Easton, *Secretary*

William E. Andrus
C. N. Berglund
Edward J. Cohen
Warren H. Cook
David R. Dobson
R. O. Duncan
Charles W. Flint

Jay Forster
Ralph I. Hauser
Loering M. Johnson
Irving Kolodny
William R. Kruesi
Thomas J. Martin
John E. May

Donald T. Michael
Voss A. Moore
William S. Morgan
Robert L. Pritchard
Blair A. Rowley
Ralph M. Showers
B. W. Whittington

Foreword

(This Foreword is not a part of IEEE Std 644-1979, IEEE Recommended Practices for Measurement of Electric and Magnetic Fields from AC Power Lines.)

The working group is indebted to Martin Misakian and his task force of Luciano Zaffanella, Rod Baishiki, and Bruce Whitney for preparing an earlier version of this document which was presented at the 1977 IEEE Power Engineering Society Summer Meeting in Mexico City. The working group members acknowledge the contribution of the many participants to the field trips at the Bonneville Power Administration (BPA) and at the Electric Power Research Institute (EPRI) Project Ultra-High Voltage (UHV), particularly, Dr. Dan Bracken of BPA, Dr. Don Deno of Project UHV, members of the Energy Research and Development Administration (ERDA) sponsored *E-Field Project*¹ at The National Bureau of Standards (NBS), and the contribution of the participants to a special Field Strength Measurement Workshop organized by W. Johnson of EPRI. Contributions of working group members during the preparation of the document draft are also gratefully acknowledged.

The final manuscript was prepared on behalf of the working group at the National Bureau of Standards with support from the Department of Energy. Additional constructive suggestions from members of the General Systems Subcommittee, the Substations Committee, the Towers, Poles, and Conductors Subcommittee, the Radio Noise Subcommittee, and the Transmission and Distribution Committee have been incorporated into the present text.

At the time this document was approved, the members of the working group were:

L. R. Delaplace, *Chairman*

L. G. Akens
Charles Alexander
R. J. Bacha
W. E. Blair
J. E. Bridges
R. E. Carberry
C. C. Diemond
T. K. Fung
Claude Gary
E. T. B. Gross
Michael Hirakami

P. W. Hotte
Lowell Lingo
C. Malaguti
T. J. McDermott
Martin Misakian
J. T. Morgan
Mid Ouyang
M. D. Perkins
D. E. Perry
D. T. Poznaniak

R. F. Radigan
J. P. Reilly
R. J. Rusch
M. Sforzini
Mike Silva
J. R. Stewart
J. M. Van Name
B. J. Ware
B. F. Whitney
P. S. Wong
L. E. Zaffanella

¹ AC Transmission Line Field Measurements, NBS Report No HCP/T-6010/E1, 1977, available from NTIS, Springfield, Virginia 22161.

Contents

SECTION	PAGE
1. Purpose	7
2. Definitions	7
3. Electric Field Strength Meters	9
3.1 General Characteristics of Electric Field Strength Meters	9
3.2 Theory and Operational Characteristics.	9
3.3 Calibration of Electric Field Strength Meters	10
3.4 Immunity from Interference	13
3.5 Parameters Affecting Accuracy of Electric Field Strength Measurements	13
4. Electric Field Strength Measurement Procedures	15
4.1 Procedure for Measuring Electric Field Strength near Transmission Lines	15
4.2 Lateral Profile	15
4.3 Longitudinal Profile	16
4.4 Precautions and Checks during Field Measurements	16
5. Magnetic Field Meters	17
5.1 General Characteristics	17
5.2 Theory and Operational Characteristics.	17
5.3 Calibration of Magnetic Field Meters.	18
5.4 Immunity from Interference	20
5.5 Parameters Affecting Accuracy of Magnetic Field Measurements	20
6. Magnetic Field Measurement Procedures	20
6.1 Procedure for Measuring Magnetic Field near Transmission Lines	20
6.2 Lateral Profile	20
6.3 Longitudinal Profile	21
6.4 Precautions and Checks during B — Field Measurements.	21
7. Reporting Field Measurements.	21
8. Bibliography.	21
FIGURES	
Fig 1 A — Spherical E -Field Probe; B — Geometries of Commercial US E -Field Meters.	10
Fig 2 Normalized E -Field at Plate Surface and Midplane	11
Fig 3 Large Parallel Plates Used for Calibration of E -Field Strength Meter.	12
Fig 4 Current Injection Calibration Check	12
Fig 5 Known E -Field Strength for Large Parallel Plates and Tolerance Levels	13
Fig 6 Example of Lateral Profile of Vertical E -Field Strength at Midspan	16
Fig 7 Typical Plan View with Heights of Permanent Nearby Objects	16
Fig 8 Conducting Loop in Quasistatic Uniform B -Field	17
Fig 9 Coordinate System for Current Loop Generating Magnetic Field B_z	18
Fig 10 Percentage Departure of B_z from $B_z(0, 0, 0)$ for Positions in the Plane of a Square Current Loop 1 m $\times$ 1 m and 3 cm Above and Below the Plane	19
Fig 11 Schematic of Circuit for Calibration of Magnetic Field Meter.	20
TABLES	
Table 1 Normalized E -Field Strength Values at Midplane and Plate Surface	11
Table 2 Typical Background Data Sheet	14
APPENDIX	
Units and Conversion Factors.	23
APPENDIX TABLE	
Table A1 Conversion from Customary to SI Units	23

IEEE Recommended Practices for Measurement of Electric and Magnetic Fields from AC Power Lines

1. Purpose

The purpose of this document is to establish uniform procedures for the measurement of steady state electric and magnetic fields from alternating current overhead power lines and for the calibration of the meters used in these measurements. A uniform procedure is a prerequisite to comparisons of electric and magnetic fields of various alternating current overhead power lines. These procedures apply to the measurement of the near fields close to ground level. They can also be tentatively applied to electric field measurements near an energized conductor or structure with the limitations outlined in 3.5 of this document.

2. Definitions

For additional definitions, see ANSI/IEEE Std 100-1977, Dictionary of Electrical and Electronics Terms.

electric field. A vector field of electric field strength. The electric field (E -field) at a point is a space vector defined by its space components along three orthogonal axes. For steady state sinusoidal fields, each space component is a complex number or phasor. The magnitudes of the components, expressed by their rms values in volts per meter, and the phases need not be the same [1].²

²Numbers in brackets correspond to those of the Bibliography, Section 8 of this recommended practice.

NOTE: The space components (phasors) are not vectors. The space components have a time dependent angle while vectors have space angles. For example, the sinusoidal electric field $\vec{E}$ can be expressed in rectangular coordinates as

$$\vec{E} = \hat{a}_x E_x + \hat{a}_y E_y + \hat{a}_z E_z. \quad (\text{Eq 1})$$

The x -space component is

$$E_x = \text{Re} (E_{xo} e^{j\phi_x} e^{j\omega t}) = E_{xo} \cos (\phi_x + \omega t).$$

The magnitude, phase, and time dependent angle are given by E_{xo} , ϕ_x , and $(\phi_x + \omega t)$ respectively. In this representation the space angle is specified by the unit vector $\hat{a}_x$.

An alternative general representation of a steady state sinusoidal E -field derivable algebraically from Eq 1 and perhaps more useful in characterizing transmission line fields, is a vector rotating in a plane where it describes an ellipse whose semi-major axis represents the magnitude and direction of the maximum value of the electric field, and whose semi-minor axis represents the magnitude and direction of the field a quarter cycle later [1], [2]. The electric field in the direction perpendicular to the plane of the ellipse is zero. See **single phase** and **three phase ac fields**.

frequency. The number of complete cycles of sinusoidal variation per unit time. Electric and magnetic field components have a fundamental frequency equal to that of the transmission voltages and currents.

NOTE: For ac transmission the frequency is 60 Hz in North America and 50 Hz in Europe and other areas of the world.

harmonic content. Distortion of sinusoidal waveform characterized by indication of the magnitude and order of the Fourier series

terms describing the wave. The harmonic content of the electric field coincides with that of the line voltage. The harmonic content of the magnetic field coincides with that of the line current.

NOTE: For power transmission lines the harmonic content is small and of little concern for the purpose of field measurements except at points near large industrial loads (saturated power transformers, n-pulse rectifiers, aluminum and chlorine plants, etc) where certain harmonics may reach 10 percent of the line voltage. Laboratory installations may also have voltage or current sources with significant harmonic content.

magnetic field. A vector field of magnetic flux density (B -field) generated by the currents in the conductors of transmission lines. The vector properties of the field are the same as those given above for the electric field. The magnitudes of the field components are expressed by their rms values in tesla (10^{-7} T = 1 mG).

maximum value of the electric field strength. The maximum value of the electric field strength at a point is the rms value of the semi-major axis magnitude of the field ellipse. Its direction is along the major axis. See **electric field strength**.

maximum value of magnetic field. The maximum value of the magnetic field at a point is the rms value of the semi-major axis magnitude of the field ellipse. Its direction is along the major axis.

perturbed electric or magnetic field (3 Cases)

(1) **weakly perturbed field.** The field at a point will be regarded as weakly perturbed if the magnitude does not change by more than 5 percent or the direction does not vary by more than 5 degrees, or both, when an object is introduced into the vicinity. The electric field at the surface of the object is in general **strongly perturbed** (see (3) below) by the presence of the object. At power frequencies the magnetic field is not in general perturbed by the presence of objects which are free of magnetic materials. Exceptions to this are regions near the surface of nonmagnetic electric conductors which develop eddy currents because of the B -field time variation.

(2) **moderately perturbed field.** The field at a point will be regarded as moderately perturbed if the magnitude varies between 5 percent and 30 percent or the direction varies between 5 degrees and 30 degrees, or both,

when an object is introduced into the vicinity.

(3) **strongly perturbed field.** The field at a point will be regarded as strongly perturbed if the magnitude varies in excess of 30 percent or the direction varies in excess of 30 degrees, or both, when an object is introduced into the vicinity.

phasor. A phasor is a complex number. Unless otherwise specified, it is used only within the context of steady state alternating linear systems. In polar coordinates, it can be written as $Ae^{j\theta}$ where A is the amplitude or magnitude (usually rms but sometimes indicated as peak value) and θ is the phase angle. The phase angle θ should not be confused with the space angle of a vector. See **electric field strength**.

single-phase ac fields. A single-phase field is generated by high voltage electrodes energized by a single source of alternating voltage. All of the field space components are in phase. The field at any point can be described in terms of its direction in space and its time varying magnitude.

three-phase ac fields. Three-phase transmission lines generate a three-phase field whose space components are not in phase. The field at any point can be described by the field ellipse, that is, by the magnitude and direction of the semi-major axis and the magnitude and direction of its semi-minor axis. See **electric field strength**.

In a three-phase field, the electric field at large distances (≥ 15 m) away from the outer phases (conductors) can frequently be considered a single-phase field because the minor axis of the electric field ellipse is only a fraction (less than 10 percent) of the major axis when measured at a height of 1 m. Similar remarks apply for the magnetic field.

uniform field. A region is said to have a uniform field if at any instant in time and at all points defining the region, the magnitude and direction of the field are constant.

vertical component of the electric field strength. The vertical component of the electric field strength under a transmission line is the rms value of the component of the electric field along the vertical line passing through the point of measurement. This quantity is often used to characterize induction effects in objects close to ground level.