

IEEE Recommended Practice for Inductive Coordination of Electric Supply and Communication Lines

IEEE Power and Energy Society

Sponsored by the
Power System Communications and Cybersecurity Committee

IEEE Recommended Practice for Inductive Coordination of Electric Supply and Communication Lines

Sponsor

**Power System Communications and Cybersecurity Committee
of the
IEEE Power and Energy Society**

Approved 5 December 2018

IEEE-SA Standards Board

Abstract: The inductive environment that exists in the vicinity of electric power and wire-line telecommunications systems and the interfering effects that may be produced are addressed. An interface that permits either party, without need to involve the other, to verify the induction at the interface by use of a probe wire is presented. This recommended practice does not apply to railway signal circuits.

Keywords: communication lines, electric supply, IEEE 776™, inductive coordination

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Copyright © 2019 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 20 March 2019. Printed in the United States of America.

IEEE is a registered trademark in the U.S. Patent & Trademark Office, owned by The Institute of Electrical and Electronics Engineers, Incorporated.

PDF: ISBN 978-1-5044-5429-2 STD23482
Print: ISBN 978-1-5044-5430-8 STDPD23482

IEEE prohibits discrimination, harassment, and bullying.

For more information, visit <http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html>.

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.

Important Notices and Disclaimers Concerning IEEE Standards Documents

IEEE documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page, appear in all standards and may be found under the heading “Important Notices and Disclaimers Concerning IEEE Standards Documents.” They can also be obtained on request from IEEE or viewed at <http://standards.ieee.org/IPR/disclaimers.html>.

Notice and Disclaimer of Liability Concerning the Use of IEEE Standards Documents

IEEE Standards documents (standards, recommended practices, and guides), both full-use and trial-use, are developed within IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (“IEEE-SA”) Standards Board. IEEE (“the Institute”) develops its standards through a consensus development process, approved by the American National Standards Institute (“ANSI”), which brings together volunteers representing varied viewpoints and interests to achieve the final product. IEEE Standards are documents developed through scientific, academic, and industry-based technical working groups. Volunteers in IEEE working groups are not necessarily members of the Institute and participate without compensation from IEEE. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

IEEE Standards do not guarantee or ensure safety, security, health, or environmental protection, or ensure against interference with or from other devices or networks. Implementers and users of IEEE Standards documents are responsible for determining and complying with all appropriate safety, security, environmental, health, and interference protection practices and all applicable laws and regulations.

IEEE does not warrant or represent the accuracy or content of the material contained in its standards, and expressly disclaims all warranties (express, implied and statutory) not included in this or any other document relating to the standard, including, but not limited to, the warranties of: merchantability; fitness for a particular purpose; non-infringement; and quality, accuracy, effectiveness, currency, or completeness of material. In addition, IEEE disclaims any and all conditions relating to: results; and workmanlike effort. IEEE standards documents are supplied “AS IS” and “WITH ALL FAULTS.”

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.

In publishing and making its standards available, IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity nor is IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any IEEE Standards document, should rely upon his or her own independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

IN NO EVENT SHALL IEEE BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE PUBLICATION, USE OF, OR RELIANCE UPON ANY STANDARD, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

Translations

The IEEE consensus development process involves the review of documents in English only. In the event that an IEEE standard is translated, only the English version published by IEEE should be considered the approved IEEE standard.

Official statements

A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered or inferred to be the official position of IEEE or any of its committees and shall not be considered to be, or be relied upon as, a formal position of IEEE. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position of IEEE.

Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE. However, IEEE does not provide consulting information or advice pertaining to IEEE Standards documents. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since IEEE standards represent a consensus of concerned interests, it is important that any responses to comments and questions also receive the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to comments or questions except in those cases where the matter has previously been addressed. For the same reason, IEEE does not respond to interpretation requests. Any person who would like to participate in revisions to an IEEE standard is welcome to join the relevant IEEE working group.

Comments on standards should be submitted to the following address:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854 USA

Laws and regulations

Users of IEEE Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any IEEE Standards document does not imply compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Copyrights

IEEE draft and approved standards are copyrighted by IEEE under U.S. and international copyright laws. They are made available by IEEE and are adopted for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making these documents available for use and adoption by public authorities and private users, IEEE does not waive any rights in copyright to the documents.

Photocopies

Subject to payment of the appropriate fee, IEEE will grant users a limited, non-exclusive license to photocopy portions of any individual standard for company or organizational internal use or individual, non-commercial use only. To arrange for payment of licensing fees, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Updating of IEEE Standards documents

Users of IEEE Standards documents should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect.

Every IEEE standard is subjected to review at least every ten years. When a document is more than ten years old and has not undergone a revision process, 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.

In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit the IEEE Xplore at <http://ieeexplore.ieee.org/> or contact IEEE at the address listed previously. For more information about the IEEE-SA or IEEE's standards development process, visit the IEEE-SA Website at <http://standards.ieee.org>.

Errata

Errata, if any, for all IEEE standards can be accessed on the IEEE-SA Website at the following URL: <http://standards.ieee.org/findstds/errata/index.html>. Users are encouraged to check this URL for errata periodically.

Patents

Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken by the IEEE with respect to the existence or validity of any patent rights in connection therewith. If a patent holder or patent applicant has filed a statement of assurance via an Accepted Letter of Assurance, then the statement is listed on the IEEE-SA Website at <http://standards.ieee.org/about/sasb/patcom/patents.html>. Letters of Assurance may indicate whether the Submitter is willing or unwilling to grant licenses under patent rights without compensation or under reasonable rates, with reasonable terms and conditions that are demonstrably free of any unfair discrimination to applicants desiring to obtain such licenses.

Essential Patent Claims may exist for which a Letter of Assurance has not been received. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims, or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this standard are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

Participants

At the time this IEEE recommended practice was completed, the Wire-Line Working Group had the following membership:

John Fuller, *Chair*
Ernest Gallo, *Vice Chair*

Dan Ashton
Ben Bloom
Steven Blume
David Boneau
Joe Boyles
Timothy Conser
Bhimesh Dahal
Jean de Seve

Ernest Duckworth
Robert Farley
Russ Gundrum
Dave Hartmann
Robert Heinlin
Dan Jendek
Delavar Khomarlou
Richard Knight

William J. McCoy
Randall Mears
Percy E. Pool
Henry Randolph
Rudy Sadkowski
Mark Tirio
Thomas Vo
Larry Young

The following members of the individual balloting committee voted on this recommended practice. Balloters may have voted for approval, disapproval, or abstention.

Joe Boyles
Gustavo Brunello
Demetrio Bucaneg Jr.
William Bush
William Byrd
Robert Christman
Michael Dood
Gearold O. H. Eidhin
Kenneth Fodero
John Fuller
George Gela
Jalal Gohari
Randall Groves
Werner Hoelzl
Peter Kelly
Delavar Khomarlou

Jim Kulchisky
Chung-Yiu Lam
Lawrenc Long
Albert Martin
Michael Maytum
William J. McCoy
Joseph Mears
H. Nerhood
Michael Newman
James O'Brien
Lorraine Padden
Bansi Patel
Percy E. Pool
Craig Preuss
Iulian Profir

Charles Rogers
Bartien Sayogo
Jeremy Smith
Jerry Smith
Gary Smullin
Gary Stodter
David Tepen
Mark Tirio
John Vergis
Jane Verner
Daniel Ward
Kenneth White
Darren Woodhouse
Larry Young
Jian Yu
Luis Zambrano

When the IEEE-SA Standards Board approved this recommended practice on 5 December 2018, it had the following membership:

Jean-Philippe Faure, *Chair*
Gary Hoffman, *Vice Chair*
John D. Kulick, *Past Chair*
Konstantinos Karachalios, *Secretary*

Ted Burse
Guido R. Hiertz
Christel Hunter
Joseph L. Koepfinger*
Thomas Koshy
Hung Ling
Dong Liu

Xiaohui Liu
Kevin Lu
Daleep Mohla
Andrew Myles
Paul Nikolich
Ronald C. Petersen
Annette D. Reilly

Robby Robson
Dorothy Stanley
Mehmet Ulema
Phil Wennblom
Philip Winston
Howard Wolfman
Jingyi Zhou

*Member Emeritus

Introduction

This introduction is not part of IEEE Std 776-2018, IEEE Recommended Practice for Inductive Coordination of Electric Supply and Communication Lines.

Since the publication of joint reports of the National Electric Light Association (which became the Edison Electric Institute in 1933) and the Bell Telephone System during and following the 1920s, the joint responsibility of inductive coordination between power and telecommunication companies has generally been accepted. See Joint Subcommittee reports for additional information [B13]¹. However, the need has long been recognized for one document that defines the components of interference, provides specific procedures to predict levels of interference, provides specific methods to demonstrate cause and effect relationships, and defines a threshold for initiating coordination to mitigate interference. The Longitudinal Induction Working Group, which is under the direction of the Inductive Coordination and Electrical Protection (ICEP) Subcommittee of the Transmission Systems Committee of the Communications Society, has struggled to produce a fair and equitable approach to fill this need under the leadership of three different chairs. These chairs were, first, Harold C. Held, retired from Illinois Bell Telephone Company; second, the late James R. Wilson, formerly affiliated with South Central Bell Telephone Company; and third, David Lee Boneau of Southwestern Bell Telephone Company. Major contributions to the document were made by James R. Wilson, George Benz of Southern New England Telephone Company, and David Boneau. Members of the Oklahoma Power and Communications Association (originally the Oklahoma Inductive Coordination Association) furthered the development of the document by field testing and assuring the validity of the various calculations and measurement techniques (see Boneau [B3]). Many others have reviewed and helped to formulate a guide that is usable by both power and telecommunication company personnel. However, this Recommended Practice does not apply to railway signal circuits (which are outside the scope of the Sponsor), at the request of contributors from the railway industry to the original standard.

After publication of IEEE Std 776TM-1987, the guide provided a useful tool for those faced with inductive coordination problems. Questions arose about the stringent harmonic distribution used on the probe-wire interface described in Table 4 and Table 5. IEEE Std 776-1987 provided flexibility in the use of harmonic distributions in Table 4 and Table 5 to match the variety of existing environments and conditions. The general section was also rewritten in an effort to make it more understandable. Other sections were also improved editorially. These efforts and contributions were made by Dick Nelson, Harold Held, Bill McCoy, Charlie Nelson, Chrys Chrysanthou, and David Boneau.

The Longitudinal Induction Working Group dissolved in early 1996 with the majority of its members moving over to the Wire-Line Subcommittee. On October of 1996 the responsibility for this Recommended Practice was officially transferred from the TransAccess/ICEP Committee to the Power Systems Communication Committee's Wire-Line Subcommittee (under the Power Engineering Society). In 2017, the Wire-Line Subcommittee decided to revise this Recommended Practice to bring it in line with the latest IEEE-SA Style Manual and to make several editorial revisions to clarify the content.

In addition, because many noise specialists and subject matter experts have either retired or left the telecommunications industry in the recent past, the Wire-Line Subcommittee decided to include information on Harmonic Analysis in Annex D as well as activities on noise reduction investigations as Annex C in IEEE Std 1137TM-2018. Those activities are to be conducted prior to implementing the procedures outlined in this Recommended Practice. The information contained in Annex C of IEEE Std 1137-2018 may be considered a handy reference for those persons that have replaced the specialists that have left or are new to the field of inductive coordination or noise investigations.

¹ The numbers in brackets correspond to those of the bibliography in Annex A.

Contents

1. Scope	9
2. Normative references.....	9
3. Definitions, acronyms, and abbreviations	10
3.1 Definitions	10
3.2 Acronyms	10
4. General principles of induction	10
4.1 Inductive interference	10
4.2 Need for coordination	12
4.3 Mutual responsibility of parties involved	12
5. The inductive environment.....	13
5.1 Guidelines for an acceptable environment.....	13
5.2 Method of measurement	22
5.3 Methods of prediction.....	33
6. Coordination within the inductive environment	40
6.1 General coordination methods	40
6.2 Specific coordination methods	41
7. Administrative methods and procedures	43
7.1 Intercompany meetings and contacts	43
7.2 Mitigation of specific interference cases	44
Annex A (informative) Bibliography	46
Annex B (informative) Example calculations	48
B.1 Prediction calculations	48
B.2 Mitigation calculations.....	62
Annex C (informative) Decibel, power, and C-message noise.....	65
Annex D (informative) Harmonic analysis steps.....	68
D.1 Using a loop antenna	68
D.2 Using a probe wire.....	69

IEEE Recommended Practice for Inductive Coordination of Electric Supply and Communication Lines

1. Scope

This recommended practice addresses the inductive environment that exists in the vicinity of electric power and wire-line telecommunications systems and the interfering effect that may be produced thereby; guidance is offered for the control or modification of the environment and the susceptibility of the affected systems in order to maintain an acceptable level of interference. An acceptable level is defined as an amount of steady-state or surge induced longitudinal voltage or current that does not cause a personnel or public safety hazard, damage to cable or equipment, and/or circuit degradation or failure.

To aid the user of this recommended practice in calculating induction between power and telecommunication lines, the concept of an interface is developed. This recommended practice permits either party, without need to involve the other, to verify the induction at the interface by use of a probe wire. This recommended practice does not apply to railway signal circuits.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std 81™, IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.^{1,2}

IEEE Std 367™, IEEE Recommended Practice for Determining the Electric Power Station Ground Potential Rise and Induced Voltage from a Power Fault.

IEEE Std 487™, IEEE Standard for the Electrical Protection of Communications Facilities Serving Electric Supply Locations—General Considerations.

IEEE Std 820™, IEEE Standard Telephone Loop Performance Characteristics.

IEEE Std 1137™, IEEE Recommended Practice for the Implementation of Inductive Coordination Mitigation Techniques and Applications.

¹ The IEEE standards or products referred to in this clause are trademarks of The Institute of Electrical and Electronics Engineers, Inc.

² IEEE publications are available from The Institute of Electrical and Electronics Engineers (<http://standards.ieee.org/>).