IEEE Recommended Practice for the Analysis of In-Band and Adjacent Band Interference and Coexistence Between Radio Systems

IEEE Communications Society

Sponsored by the
IEEE Standards Coordinating Committee 41 on
Dynamic Spectrum Access Networks

1900.2™

IEEE
3 Park Avenue
New York, NY 10016-5997, USA

29 July 2008

IEEE Std 1900.2™-2008

IEEE Recommended Practice for the Analysis of In-Band and Adjacent Band Interference and Coexistence Between Radio Systems

Sponsor

IEEE Communications Society

and

IEEE Standards Coordinating Committee 41 on Dynamic Spectrum Access Networks

Approved 27 March 2008

IEEE-SA Standards Board

Abstract: Technical guidelines are provided in this recommended practice for analyzing the coexistence or, alternatively, the interference between radio systems, operating in the same spectrum assignment or between different spectrum assignments.

Keywords: adaptive radio, coexistence, cognitive radio, dynamic spectrum access, interference, policy-defined radio, software-defined radio, spectrum, spectrum access

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

PDF: ISBN 978-0-7381-5408-4 STD95777
Print: ISBN 978-0-7381-5409-1 STDPD95777

IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. The IEEE develops its standards through a consensus development process, approved by the American National Standards Institute, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and serve without compensation. While the IEEE administers the process and establishes rules to promote fairness in the consensus development process, the IEEE does not independently evaluate, test, or verify the accuracy of any of the information contained in its standards.

Use of an IEEE Standard is wholly voluntary. The IEEE disclaims liability for any personal injury, property or other damage, of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance upon this, or any other IEEE Standard document.

The IEEE does not warrant or represent the accuracy or content of the material contained herein, and expressly disclaims any express or implied warranty, including any implied warranty of merchantability or fitness for a specific purpose, or that the use of the material contained herein is free from patent infringement. IEEE Standards documents are supplied "**AS IS**."

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 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.

In publishing and making this document available, the IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity. Nor is the IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing this, and any other IEEE Standards document, should rely upon the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

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 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 societies and Standards Coordinating Committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration. 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, explanation, or interpretation of the IEEE.

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

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

Introduction

This introduction is not part of IEEE Std 1900.2-2008, IEEE Recommended Practice for the Analysis of In-Band and Adjacent Band Interference and Coexistence Between Radio Systems.

Introduction to IEEE SCC 41 and the IEEE 1900 series of standards

This recommended practice was developed under the auspices of IEEE Standards Coordinating Committee 41 (Dynamic Spectrum Access Networks, or DySPAN) (formerly IEEE 1900 Standards Committee on Next Generation Radio and Spectrum Management). SCC 41 (DySPAN) serves as a forum for the exchange of information in the area of dynamic spectrum access networks and to act as a sponsor for related standards projects. Taken together, current and future activities under the SCC 41 (DySPAN) will provide standards and recommended practices for addressing the many facets and issues introduced by DySPAN. Individual standards activities are designated as a series of p1900.x projects and include:

- Recommended practice for interference and coexistence analysis (this recommended practice)
- Recommended practice for dependability and conformance evaluation of regulatory compliance for radio systems with dynamic spectrum access
- Standard architectural building blocks enabling distributed decision making for optimized radio resource usage in heterogeneous wireless access networks
- Standard terms, definitions, and concepts for advanced radio spectrum management
- Other topics to be determined

Use and interpretation of this recommended practice (prepared by the IEEE P1900.2 Working Group) is expected to be aided and facilitated by referring to the products of the other, complementary projects under SCC 41 (DySPAN), as they are completed and published.

Introduction to IEEE Std 1900.2

Perhaps the critical question to be answered when analyzing interference is, at what point is there harmful interference among radio systems coexisting in common spectrum assignments? As it is commonly used, harmful interference is a broad concept, combining the physical facts of a situation with the economic perspective and values of the stakeholders involved. This document seeks to bring greater understanding and precision to the term and to apply more objective criteria to its assessment, particularly in a dynamic and changing coexistence environment.[a] This recommended practice addresses several elements necessary for making an analysis of the potential for harmful interference. It seeks, wherever possible, to require a scientific and objective approach for an interference and coexistence analysis. It is hoped that by stating and clarifying assumptions and by providing a normalized structure for engineering analysis that the determination of the relative importance of the benefits and risks will be facilitated.

[a]The imprecise nature of the concept is best addressed by first determining the facts, differing assumptions that might be made, and then allowing the relevant decision-making authority to make its decision within the range of credible conclusions. This standard primarily serves to identify the agreed on facts and to propose thresholds and objective criteria for a specific scenario.
In the International Radio Regulations (see IRR, Appendix 5 [B18]), and relevant ITU-R recommendations, the terms “harmful,” “permissible,” and “accepted interference” are defined, demonstrating the consensus of that body that levels of interference exist that are acceptable under conditions of static spectrum assignment. (See the international radio regulations of the ITU-R 1.166, ITU-R 1.167, ITU-R 1.168, and ITU_R 1.169.) This standard is intended to extend to spectrum assignments that may change dynamically, perhaps rapidly in time, depending on traffic or other local conditions, among a number of radio systems, coexisting in a common spectrum assignment.

.

Stated simply, an interference and coexistence analysis involves answering questions, such as:

— Where am I?

— Who else is around me?

— What do I have to worry about?

— What are my rights and responsibilities relative to others?

— What can help us get along?

This recommended practice provides a structure and describes a method for analyzing the interference between radio services under a variety of coexistence scenarios. Many variables to be used in this analysis will be detailed. The annexes provide helpful supportive material and examples of analysis using this document.

One reason for the analytical structure specified in this document is to provide an objective and uniform framework for assessing and analyzing interference and coexistence. From this framework, an understanding is gained of assumptions, dependencies, and relative importance of the variables of the problem.

In the end, a thorough interference and coexistence analysis provides an invaluable support when considering the acceptance of new technologies or systems that are to coexist in common, shared spectrum assignments.

Having this understanding of the physical reality and the technical facts, economic analysis or even a political formulation may be more effectively applied. To use the vernacular, you can figure out who pays whom and how much to make life good. Companies can also anticipate customer satisfaction and warranty costs for products that will be coexisting in dynamically assigned spectrum assignments.

Notice to users

Laws and regulations

Users of these documents should consult all applicable laws and regulations. Compliance with the provisions of this standard 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

Updating of IEEE documents

Users of IEEE standards 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. 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 Standards Association Web site at http://ieeexplore.ieee.org/xpl/standards.jsp, or contact the IEEE at the address listed previously.

For more information about the IEEE Standards Association or the IEEE standards development process, visit the IEEE-SA Web site at http://standards.ieee.org.

Errata

Errata, if any, for this and all other standards can be accessed at the following URL: http://standards.ieee.org/reading/ieee/updates/errata/. Users are encouraged to check this URL for errata periodically.

Interpretations

Current interpretations can be accessed at the following URL: http://standards.ieee.org/reading/ieee/interp/.

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 with respect to the existence or validity of any patent rights in connection therewith. A patent holder or patent applicant has filed a statement of assurance that it will grant licenses under these 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. Other Essential Patent Claims may exist for which a statement 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 are reasonable or non-discriminatory. Further information may be obtained from the IEEE Standards Association.

Participants

At the time this recommended practice was completed, the P1900.2 Working Group had the following membership:

H. Stephen Berger, *Chair*
Kalle R. Kontson, *Vice Chair*
Alexe E. Leu, *Secretary*

Timothy X. Brown
Fred Frantz
Donald M. Parker
Venkatesha Prasad
Dennis Stewart

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

David Baron
Hugh Barrass
H. Stephen Berger
Roger L. Boyell
Timothy X. Brown
Walter Buga
Joseph Calabria
John Chapin
Aik Chindapol
Keith Chow
Bryan P. Cook
Tommy Cooper
Mickey D. Cox
Dineen, Thomas
Carlo Donati
Johanna L. Dwyer
Marc Emmelmann
Bernard C. Eydt
Andre Fournier
Avraham Freedman
Devon Gayle
Michael Geipel
Fabrizio Granelli
Randall Groves
Edward Hare
Werner Hoelzl
James Hoffmeyer
Daniel Hoolihan
David Horvath
Sergiu Iordanescu
Efthymios G. Karabetsos
Paul Kolodzy
Kalle R. Kontson
Yeou Song Lee
Alexe E. Leu
Joseph Levy
Arthur Light
Daniel Lubar
Frederick L. Martin
Edward Mccall
Michael Mcinnis
Gary Michel
Apurva Mody
Markus D. Muck
Michael S. Newman
Paul Nikolich
Gary Nissen
Keith E. Nolan
Donald M. Parker
Przemyslaw Pawelczak
Eldad Perahia
Venkatesha Prasad
Jose Puthenkulam
Michael Roberts
Robert Robinson
Michael D. Rush
Bartien Sayogo
Stephen Schwarm
Douglas C. Sicker
Thomas Starai
David Steer
Carl Stevenson
Walter Struppler
Mark Sturza
Alourdes Sully
Darcy Swain
Lai King Anna Tee
Peter Tenhula
John Vergis
Barry Wallen
Stephen Weinstein
John C. Willis
Larry Young
Oren Yuen
Theodore Zeiss
Kevin Zheng Zhang

When the IEEE-SA Standards Board approved this recommended practice on March 27, 2008, it had the following membership:

Robert M. Grow, *Chair*
Tom A. Prevost, *Vice Chair*
Steve M. Mills, *Past Chair*
Judith Gorman, *Secretary*

Victor Berman
Richard DeBlasio
Andrew Drozd
Mark Epstein
Alexander Gelman
William R. Goldbach
Arnold M. Greenspan
Kenneth S. Hanus
James Hughes
Richard H. Hulett
Young Kyun Kim
Joseph L. Koepfinger*
John Kulick
David J. Law
Glenn Parsons
Ronald C. Petersen
Chuck Powers
Narayanan Ramachandran
Jon Walter Rosdahl
Anne-Marie Sahazizian
Malcolm V. Thaden
Howard L. Wolfman
Don Wright

*Member Emeritus

Also included are the following nonvoting IEEE-SA Standards Board liaisons:

Satish K. Aggarwal, *NRC Representative*
Michael H. Kelley, *NIST Representative*

Don Messina
IEEE Standards Program Manager, Document Development

Matthew J. Ceglia
IEEE Standards Program Manager, Technical Program Development

CONTENTS

IEEE Recommended Practice for the Analysis of In-Band and Adjacent Band Interference and Coexistence Between Radio Systems

1. Overview

1.1 Relationship to traditional spectrum management

The introduction to the 2005 edition of the ITU-R National Spectrum Management Handbook states:

> *Society's increasing use of radio-based technologies, and the tremendous opportunities for social development that these technologies provide, highlight the importance of radio-frequency spectrum and national spectrum management processes. Technological progress has continually opened doors to a variety of new spectrum applications that have spurred greater interest in, and demand for, the limited spectrum resource. Increased demand requires that spectrum be used efficiently and that effective spectrum management processes be implemented. In this framework, modern data handling capabilities and engineering analysis are important to accommodate the variety of potential users seeking access to the spectrum.*
>
> *Radio communications is heavily used in a growing number of services such as national defense, public safety, broadcasting, business and industrial communications, aeronautical and maritime radio communications, navigation, and personal communications. Radio communication links, as opposed to wireless telecommunications, are necessary in a dynamic or mobile environment, where wire-line telecommunication may not be available, or where telecommunications have been disrupted, such as in emergency or natural disaster situations. Radio communication systems may operate from satellites or from terrestrial platforms.*
>
> *If the spectrum is to be used efficiently, its use must be coordinated and regulated through both national regulations and the Radio Regulations of the International Telecommunication Union*

(ITU). The ability of each country to take full advantage of the spectrum resource depends heavily on spectrum management activities that facilitate the implementation of radio systems and ensure minimum interference. To this end, administrations should, as appropriate, make use of computerized spectrum management systems.

The demand for spectrum continues to increase dramatically, and with it, the importance of efficient spectrum management is increasing. Fixed, universal rules to coordinate spectrum are not efficient. The most efficient spectrum allocation is not fixed to a single set of rules for all locations and situations nor is it static over time. Optimally spectrum management would be adaptive to specific situations and variable to the specific conditions at a given time and place. Dynamic and adaptive management of spectrum is now possible. The development of computer science, radio engineering, and related disciplines has reached the point where spectrum usage can now be controlled automatically by coexisting radio systems in real time. This replaces the manual method in which human radio-frequency (RF) planners used static frequency assignments.

1.2 Introduction to this recommended practice

Interference between systems occurs when operation of one system affects the performance of another system.[1] Two or more radio systems successfully coexist when the level of performance of all systems is judged to be acceptable. There may be some interference, but it is generally judged to be within acceptable limits.

Emerging technologies such as cognitive radio, ad hoc wireless networks, as well as dynamic and adaptive systems complicate the interference and coexistence analysis. For example, if a network can reroute data so loss of a particular link has no impact on end-to-end user performance, does loss of that link constitute interference? If it is judged to be interference, does it constitute harmful interference? If so, what is the appropriate remedy?

This recommended practice provides a structure for interference and coexistence analysis. The purpose of providing such a structure is to guide the analyst in considering all relevant issues in a systematic way. Furthermore, a uniform structure makes the comparison of different analyses easier. When different analyses utilize a common structure and method of analysis the reasons for similarities or differences in conclusions are more quickly identified. Thus, focus may be brought to the critical elements, where more data or further analysis may either confirm results or aid in the understanding of differing conclusions.

1.3 Scope

1.3.1 Formal scope[2]

This recommended practice will provide technical guidelines for analyzing the potential for coexistence or in contrast interference between radio systems operating in the same frequency band or between different frequency bands.

1.3.2 Discussion of scope

This is a recommended practice for analyzing the interference and coexistence among radio systems. It establishes a structured framework for analyzing interference and coexistence. It also establishes a structured document format for presenting the analysis to others.

[1]Although the focus of this standard is interference and coexistence of radio systems, other kinds of systems utilize spectrum and are dependent on spectrum for their operation. The analytical methods proposed in this standard may be used when analyzing scenarios, including spectrum-dependent systems other than radio systems.
[2]The formal scope is the scope approved in the Project Authorization Request for this project.