

IEEE Recommended Practice for Power Quality Data Interchange Format (PQDIF)

IEEE Power and Energy Society

Sponsored by the
Transmission & Distribution Committee

IEEE Recommended Practice for Power Quality Data Interchange Format (PQDIF)

Sponsor

Transmission & Distribution Committee
of the
IEEE Power and Energy Society

Approved 8 February 2019

Abstract: A file format suitable for exchanging power quality related measurement and simulation data in a vendor independent manner is defined in this recommended practice. The format is designed to represent all power quality phenomena identified in IEEE Std 1159-2009, IEEE Recommended Practice on Monitoring Electric Power Quality, other power related measurement data, and is extensible to other data types as well. The recommended file format utilizes a highly compressed storage scheme to help reduce disk space and transmission times. The utilization of Globally Unique Identifiers (GUID) to represent each element in the file permits the format to be extensible without the need for a central registration authority.

Keywords: data interchange, file format, IEEE 1159.3, measurement, monitoring, power quality, PQDIF

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 1 May 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 978-1-5044-5562-6 STD23557
Print: ISBN 978-1-5044-5563-3 STDPD23557

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. A current 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 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 recommended practice was completed, the P1159.3 Task Force had the following membership:

Daniel Sabin, *Chair*
Joseph Grappé, *Secretary*

Richard Bingham
Ivan Bilić
Math Bollen
Thomas Cooke
Gary Chang
William Dabbs
Steven Johnson
William Howe

Theo Laughner
Kevin Kittredge
Alex McEachern
Jan Meyer
David Mueller
Mathew Norwalk
Marty Page

Scott Peele
Kenneth Sedziol
Michael Schwenke
Steve Tatum
Timothy Unruh
Wilsun Xu
Francisc Zavoda
David Zech

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

Ali Al Awazi
Richard Bingham
Joe Boyles
Gustavo Brunello
Demetrio Bucaneg, Jr
Mario Manana Canteli
Wen-Kung Chang
William Dabbs
Neal Dowling
Jorge Fernandez Daher
Kamal Garg
Mietek Glinkowski
Joseph Grappe
Thomas Grebé
Randall Groves
Werner Hoelzl

Ronald Hotchkiss
Steven Johnston
Laszlo Kadar
Innocent Kamwa
Peter Kelly
Tanuj Khandelwal
Yuri Khersonsky
Kevin Kittredge
Jim Kulchisky
John McDaniel
Bruce Muschlitz
Matthew Norwalk
Gary Nuzzi
Gearold O. H. Eidhin
Lorraine Padden
Bansi Patel
Craig Preuss

Lakshman Raut
Daniel Sabin
Sergio Santos
Bartien Sayogo
Kenneth Sedziol
Jerry Smith
Gary Smullin
Gary Stoedter
K. Stump
Steve Tatum
David Tepen
Timothy Unruh
James Van De Ligt
John Vergis
Francisc Zavoda
David Zech

When the IEEE-SA Standards Board approved this recommended practice on 8 February 2019, it had the following membership:

Gary Hoffman, *Chair*
Vacant Position, *Vice Chair*
Jean-Philippe Faure, *Past Chair*
Konstantinos Karachalios, *Secretary*

Masayuki Ariyoshi
Ted Burse
Stephen D. Dukes
J. Travis Griffith
Guido Hiertz
Christel Hunter
Thomas Koshy
Joseph L. Koepfinger*

Thomas Koshy
John D. Kulick
David J. Law
Joseph Levy
Howard Li
Xiaohui Liu
Kevin Lu
Daleep Mohla
Andrew Myles

Annette D. Reilly
Dorothy Stanley
Sha Wei
Phil Wennblom
Philip Winston
Howard Wolfman
Feng Wu
Jingyi Zhou

*Member Emeritus

Introduction

This introduction is not part of IEEE Std 1159.3-2019, IEEE Recommended Practice for Power Quality Data Interchange Format (PQDIF).

IEEE Std 1159.3-2003 provided the power quality industry with the specification for a Power Quality Data Interchange Format (PQDIF) for the transfer of power quality data between power quality monitoring instruments and computers. This transfer standard allows the processing and analysis of power quality measurements using multi-vendor and multi-device measurements. IEEE Std 1159.3 was reaffirmed in 2009.

The IEEE P1159.3 Working Group completed the following changes in this revision of IEEE Std 1159.3:

- Completed editorial changes and corrections to the 2003 edition of IEEE Std 1159.3
- Added new ID values for existing PQDIF tags in normative Annex B.
- Added new tags and ID values in normative Annex B.
- Added new quantity types in normative Annex B.
- Added an informative Annex C.2, which specifies an XML directory for PQDIF files that can be downloaded from a remote power quality monitor or remote file server.
- Added an informative Annex D on the representation of PQDIF in XML.
- Added an informative Annex E on PQDIF and its relationship to IEEE Std C37.111 COMTRADE.
- Added an informative Annex F on PQDIF and its relationship to IEC 61850.

The physical structure of PQDIF remains unchanged between IEEE Std 1159.3-2003 and this new edition, making PQDIF both backward and forwards compatible. Changes to the logical structure to support new capability are in the form of additional tag and ID values. This allows software that reads PQDIF to maintain compatibility by simply ignoring unrecognized tag and ID values.

The primary user of this standard will be engineers and software developers who are called upon to create software to encode and decode PQDIF files utilized for power quality data interchange using the guidelines in this recommended practice. Although the document is thorough and complete, detailed examples and source code can be quite helpful when implementing the format described herein. Therefore, reference and supporting documentation (header files, sample code, etc.) related to this standard can be found at the IEEE 1159.3 task force website, which at the time of this writing could be found at the following URL:
<http://grouper.ieee.org/groups/1159/3/docs.html>

More published information about PQDIF is available. An overview of IEEE Std 1159.3 is available in Gunther [B2].¹ An example of how PQDIF was used as part of electric utility power quality monitoring program is described in Veloso, Lebre, and Melo [B18]. An overview of the IEEE 1159.3 revision project is available in Sabin and Dabbs [B17].

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

Contents

1. Overview	10
1.1 Scope	10
1.2 Purpose	10
2. Normative references.....	10
3. Definitions	11
4. Physical structure.....	11
4.1 Overall file structure.....	11
4.2 Internal record structure.....	14
5. Logical structure.....	15
5.1 Logical record structure.....	15
5.2 Logical element structure	16
5.3 Logical structure of container record.....	16
5.4 Logical structure of data sources and observations	18
5.5 How to assemble a series.....	19
6. Compression.....	21
6.1 Compression algorithm—zlib.....	21
6.2 Record-level compression	22
7. Logical device modeling	22
7.1 General procedures.....	23
7.2 Representing a waveform recording	26
7.3 Representing a RMS variation recording.....	29
7.4 Representing periodically recorded steady state values.....	36
7.5 Representing magnitude-duration-time tables	41
Annex A (normative) Physical format definitions.....	44
A.1 Physical format definitions—pqdif_ph.h.....	44
Annex B (normative) Logical structure documentation	52
B.1 Logical format constant definitions—pqdif_lg.h.....	76
B.2 Constant IDs and GUIDS.....	99
Annex C (informative) PQDIF file storage and file download.....	159
C.1 File storage and management.....	159
C.2 PQDIF file server interfaces	162
Annex D (informative) Representation of PQDIF in XML.....	168
D.1 Examples	170
Annex E (informative) Relationship of PQDIF to COMTRADE	176
E.1 PQDIF to COMTRADE.....	176
Annex F (informative) Relationship of PQDIF to IEC 61850.....	181
F.1 IEC TR 61850-90-17.....	181
Annex G (informative) Bibliography	182

IEEE Recommended Practice for Power Quality Data Interchange Format (PQDIF)

1. Overview

1.1 Scope

This recommended practice specifies the PQDIF file format for the transfer of power quality data between instruments and computers. This includes raw, processed, simulated, proposed, specified, and calculated data. The transfer file format includes the power quality measurements as well as appropriate characterization parameters, such as sampling rate, resolution, calibration status, instrument identification, location, and other related data or characteristics. The recommended practice also provides guidelines for transferring power quality data.

1.2 Purpose

IEEE Std 1159.3 provides the power quality industry with the specification for PQDIF, which is an open and accepted data format standard for the transfer of power quality data between instruments and computers. This transfer standard allows the processing and analysis of power quality measurements using multi-vendor and multi-device data. Wider acceptance of PQDIF as a power quality data transfer format will significantly add to the value of power quality monitoring and open new opportunities for the resolution, planning, and understanding of power quality activities.

Being able to exchange data between software systems will allow other functions needed in a power quality monitoring campaign, including validation, trending, comparison, overlay, and more.

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.

IEC 61000-4-30, Electromagnetic compatibility (EMC)—Part 4-30: Testing and measurement techniques—Power quality measurement methods.¹

¹ IEC publications are available from the International Electrotechnical Commission (<http://www.iec.ch>) and the American National Standards Institute (<http://www.ansi.org/>).