

IEEE Standard for Uncontrolled Traction Power Rectifiers for Substation Applications Up to 1500 V DC Nominal Output

Sponsor

Rail Transit Vehicle Interface Standards Committee

of the

IEEE Vehicular Technology Society

Approved 9 November 2009

IEEE-SA Standards Board

Abstract: The design, manufacturing, and testing unique to the application of uncontrolled semiconductor power rectifiers for direct current (dc) supplied transportation substation applications up to 1500 V dc nominal output is covered in this standard. The standard is intended to address traction power substation rectifiers that are to be provided as part of a rectifier transformer unit or are provided separately. Application information and extensive definitions of related technical terms are included.

Keywords: commutating reactance, double-way, extra heavy traction, heavy traction, interphase transformer, light transition load, power rectifier, rectifier transformer unit, service rating, traction power substation

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

Copyright © 2010 by the Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 22 January 2010. 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 978-0-7381-6121-1 STD95997
Print: ISBN 978-0-7381-6122-8 STDPD95997

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.

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 or the soundness of any judgments 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 his or her 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.

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. A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered the official position of IEEE or any of its committees and shall not be considered to be, nor be relied upon as, a formal interpretation of the 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, 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 submitted to the following address:

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

Authorization to photocopy portions of any individual standard for internal or personal use is granted by The Institute of Electrical and Electronics Engineers, Inc., provided that the appropriate fee is paid to Copyright Clearance Center. To arrange for payment of licensing fee, 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.

Introduction

This introduction is not part of IEEE Std 1653.2-2009, IEEE Standard for Uncontrolled Traction Power Rectifiers for Substation Applications up to 1500 V DC Nominal Output.

The intention of the working group that developed this standard was to provide an up-to-date replacement for the rescinded NEMA Standards Publication RI 9 and the rescinded ANSI C34.2.^a To make this task more manageable, the scope of this effort was limited to uncontrolled (diode type) traction power rectifiers supplying power to direct current (dc)-supplied transportation equipment.

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

This document is copyrighted by the IEEE. It is made available 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 this document available for use and adoption by public authorities and private users, the IEEE does not waive any rights in copyright to this document.

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>.

^a Information on references can be found in Clause 2.

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/index.html>. 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/index.html>.

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. 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 standard was submitted to the IEEE-SA Standards Board for approval, the Traction Power Rectifier Working Group had the following membership:

Ralph W. (Benjamin) Stell, *Chair*
Steven Bezner, *Vice Chair*

Ted Bandy
Alan Blatchford
Gilbert Cabral
Yunxiang Chen
Ray Davis
John Dellas
Ramesh Dhingra
Mike Dinolfo
Rajen Ganeriwal
David Groves
Earl Fish
Robert Fisher
Paul Forquer

Charles Garten
Mark Griffiths
William Jagerburger
Sheldon Kennedy
Don Kline
Tristan Kneschke
Saumen (Sam) Kundu
Tom Langer
Peter Lloyd
Keith Miller
Jack Martin
Stephen Norton

Constantinos Orphanides
Chris Pagni
Dev Paul
Marcus Reis
Charles Ross
Subhash Sarkar
Jay Sender
Narendra Shah
Rick Shiflet
Steven Sims
Raymond Strittmatter
Gary Touryan
Tom Young

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

Roger Avery
William Aycock
Steven Bezner
Ted Burse
Yunxiang Chen
Ronald Clark
Mike Dinolfo
Paul Forquer
Lowell Goudge
David Groves
Mladen Jeftic
Andrew Jones

Walter Keevil
Sheldon Kennedy
Yuri Khersonsky
Ethan Kim
Saumen Kundu
Ming Li
Jose Marrero
Michael S. Newman
George Nourse
Michael Perez
D. Phelps

Gilbert Kevin Ratnasingham
Charles Ross
Edward Rowe
Alan Rumsey
Bartien Sayogo
Alexander Sinyak
James E. Smith
Rick Straubel
Gary Touryan
John Vergis
Matthew Zeedyk
Ahmed Zobaa

When the IEEE-SA Standards Board approved this standard on 9 November 2009, it had the following membership:

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

John Barr
Karen Bartleson
Victor Berman
Ted Burse
Richard DeBlasio
Andy Drozd
Mark Epstein

Alexander Gelman
Jim Hughes
Richard H. Hulett
Young Kyun Kim
Joseph L. Koepfinger*
John Kulick

David J. Law
Ted Olsen
Glenn Parsons
Ronald C. Petersen
Narayanan Ramachandran
Jon Walter Rosdahl
Sam Sciacca

*Member Emeritus

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

Howard L. Wolfman, *TAB Representative*
Michael Janezic, *NIST Representative*
Satish K. Aggarwal, *NRC Representative*

Lorraine Patsco
IEEE Standards Program Manager, Document Development

Patricia A. Gerdon
IEEE Standards Program Manager, Technical Program Development

Contents

1. Overview	1
1.1 Scope	1
1.2 Purpose	1
2. Normative references	2
3. Definitions	2
3.1 Basic rectifier components and equipment.....	2
3.2 Appurtenances and auxiliaries.....	3
3.3 Semiconductor rectifier diode characteristics.....	4
3.4 Rectifier circuit properties and terminology.....	6
3.5 Rectifier characteristics	8
3.6 Rectifier unit ratings	10
4. Symbols and abbreviations.....	10
4.1 Rectifier symbols.....	10
4.2 Rectifier protective device numbers	13
5. Rectifier circuits	13
5.1 General	13
6. Service conditions	15
6.1 Usual service conditions.....	15
6.2 Unusual service conditions.....	15
7. Ratings.....	16
7.1 Rating of rectifier units.....	16
7.2 Basis of rating.....	16
7.3 Standard service ratings.....	16
7.4 Operation above rated voltage.....	17

8. Performance characteristics	18
8.1 Efficiency and losses	18
8.2 Voltage regulation	19
8.3 Power factor	23
8.4 Tolerances and unbalance criteria	25
8.5 Auxiliaries	26
9. Nameplates	26
10. Interphase transformers	27
10.1 General	27
10.2 Specification information	27
10.3 Submittal information.....	28
11. Test procedures	28
11.1 Rectifier transformer tests	28
11.2 Interphase transformer tests.....	28
11.3 Rectifier tests	29
11.4 Rectifier unit tests.....	32
Annex A (informative) Recommended practice and design guide.....	41
Annex B (informative) Commutating reactance transformation constant and power factor specification....	45
Annex C (informative) Example of current unbalance calculation	46
Annex D (informative) Bibliography	48

IEEE Standard for Uncontrolled Traction Power Rectifiers for Substation Applications Up to 1500 V DC Nominal Output

IMPORTANT NOTICE: This standard is not intended to ensure safety, security, health, or environmental protection in all circumstances. Implementers of the standard are responsible for determining appropriate safety, security, environmental, and health practices or regulatory requirements.

This IEEE document is made available for use subject to important notices and legal disclaimers. These notices and disclaimers appear in all publications containing this document and may be found under the heading “Important Notice” or “Important Notices and Disclaimers Concerning IEEE Documents.” They can also be obtained on request from IEEE or viewed at <http://standards.ieee.org/IPR/disclaimers.html>.

1. Overview

1.1 Scope

This standard covers the design, manufacturing, and testing unique to the application of uncontrolled semiconductor power rectifiers for direct current (dc)-supplied transportation substation applications up to 1500 V dc nominal output.

1.2 Purpose

Currently, there are no suitable standards governing requirements for traction power rectifiers. This standard provides requirements specific to traction power rectifiers supplying power to dc-supplied transportation equipment.