



Interconnection of distributed energy resources and electricity supply systems



Legal Notice for Standards

Canadian Standards Association (operating as “CSA Group”) develops standards through a consensus standards development process approved by the Standards Council of Canada. This process brings together volunteers representing varied viewpoints and interests to achieve consensus and develop a standard. Although CSA Group administers the process and establishes rules to promote fairness in achieving consensus, it does not independently test, evaluate, or verify the content of standards.

Disclaimer and exclusion of liability

This document is provided without any representations, warranties, or conditions of any kind, express or implied, including, without limitation, implied warranties or conditions concerning this document’s fitness for a particular purpose or use, its merchantability, or its non-infringement of any third party’s intellectual property rights. CSA Group does not warrant the accuracy, completeness, or currency of any of the information published in this document. CSA Group makes no representations or warranties regarding this document’s compliance with any applicable statute, rule, or regulation.

IN NO EVENT SHALL CSA GROUP, ITS VOLUNTEERS, MEMBERS, SUBSIDIARIES, OR AFFILIATED COMPANIES, OR THEIR EMPLOYEES, DIRECTORS, OR OFFICERS, BE LIABLE FOR ANY DIRECT, INDIRECT, OR INCIDENTAL DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES, HOWSOEVER CAUSED, INCLUDING BUT NOT LIMITED TO SPECIAL OR CONSEQUENTIAL DAMAGES, LOST REVENUE, BUSINESS INTERRUPTION, LOST OR DAMAGED DATA, OR ANY OTHER COMMERCIAL OR ECONOMIC LOSS, WHETHER BASED IN CONTRACT, TORT (INCLUDING NEGLIGENCE), OR ANY OTHER THEORY OF LIABILITY, ARISING OUT OF OR RESULTING FROM ACCESS TO OR POSSESSION OR USE OF THIS DOCUMENT, EVEN IF CSA GROUP HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES.

In publishing and making this document available, CSA Group is not undertaking to render professional or other services for or on behalf of any person or entity or to perform any duty owed by any person or entity to another person or entity. The information in this document is directed to those who have the appropriate degree of experience to use and apply its contents, and CSA Group accepts no responsibility whatsoever arising in any way from any and all use of or reliance on the information contained in this document.

CSA Group is a private not-for-profit company that publishes voluntary standards and related documents. CSA Group has no power, nor does it undertake, to enforce compliance with the contents of the standards or other documents it publishes.

Intellectual property rights and ownership

As between CSA Group and the users of this document (whether it be in printed or electronic form), CSA Group is the owner, or the authorized licensee, of all works contained herein that are protected by copyright, all trade-marks (except as otherwise noted to the contrary), and all inventions and trade secrets that may be contained in this document, whether or not such inventions and trade secrets are protected by patents and applications for patents. Without limitation, the unauthorized use, modification, copying, or disclosure of this document may violate laws that protect CSA Group’s and/or others’ intellectual property and may give rise to a right in CSA Group and/or others to seek legal redress for such use, modification, copying, or disclosure. To the extent permitted by treaty or by law, CSA Group reserves all intellectual property rights in this document.

Patent rights

Attention is drawn to the possibility that some of the elements of this standard may be the subject of patent rights. CSA Group shall not be held responsible for identifying any or all such patent rights. Users of this standard are expressly advised that determination of the validity of any such patent rights is entirely their own responsibility.

Authorized use of this document

This document is being provided by CSA Group for informational and non-commercial use only. The user of this document is authorized to do only the following:

If this document is in electronic form:

- load this document onto a computer for the sole purpose of reviewing it;
- search and browse this document; and
- print this document if it is in PDF form.

Limited copies of this document in print or paper form may be distributed only to persons who are authorized by CSA Group to have such copies, and only if this Legal Notice appears on each such copy.

In addition, users may not and may not permit others to

- alter this document in any way, or remove this Legal Notice from the attached standard;
- sell this document without authorization from CSA Group; or
- make an electronic copy of this document.

If you do not agree with any of the terms and conditions contained in this Legal Notice, you may not load or use this document or make any copies of the contents hereof, and if you do make such copies, you are required to destroy them immediately. Use of this document constitutes your acceptance of the terms and conditions of this Legal Notice.



Standards Update Service

CSA C22.3 No. 9:20
January 2020

Title: *Interconnection of distributed energy resources and electricity supply systems*

To register for e-mail notification about any updates to this publication

- go to store.csagroup.org
- click on **Product Updates**

The **List ID** that you will need to register for updates to this publication is **24256-5**

If you require assistance, please e-mail techsupport@csagroup.org or call 416-747-2233.

Visit CSA Group's policy on privacy at www.csagroup.org/legal to find out how we protect your personal information.

Canadian Standards Association (operating as “CSA Group”), under whose auspices this National Standard has been produced, was chartered in 1919 and accredited by the Standards Council of Canada to the National Standards system in 1973. It is a not-for-profit, nonstatutory, voluntary membership association engaged in standards development and certification activities.

CSA Group standards reflect a national consensus of producers and users — including manufacturers, consumers, retailers, unions and professional organizations, and governmental agencies. The standards are used widely by industry and commerce and often adopted by municipal, provincial, and federal governments in their regulations, particularly in the fields of health, safety, building and construction, and the environment.

Individuals, companies, and associations across Canada indicate their support for CSA Group’s standards development by volunteering their time and skills to Committee work and supporting CSA Group’s objectives through sustaining memberships. The more than 7000 committee volunteers and the 2000 sustaining memberships together form CSA Group’s total membership from which its Directors are chosen. Sustaining memberships represent a major source of income for CSA Group’s standards development activities.

CSA Group offers certification and testing services in support of and as an extension to its standards development activities. To ensure the integrity of its certification process, CSA Group regularly and continually audits and inspects products that bear the CSA Group Mark.

In addition to its head office and laboratory complex in Toronto, CSA Group has regional branch offices in major centres across Canada and inspection and testing agencies in eight countries. Since 1919, CSA Group has developed the necessary expertise to meet its corporate mission: CSA Group is an independent service organization whose mission is to provide an open and effective forum for activities facilitating the exchange of goods and services through the use of standards, certification and related services to meet national and international needs.

For further information on CSA Group services, write to
CSA Group
178 Rexdale Boulevard
Toronto, Ontario, M9W 1R3
Canada



A National Standard of Canada is a standard developed by a Standards Council of Canada (SCC) accredited Standards Development Organization, in compliance with requirements and guidance set out by SCC. More information on National Standards of Canada can be found at www.scc.ca.

SCC is a Crown corporation within the portfolio of Innovation, Science and Economic Development (ISED) Canada. With the goal of enhancing Canada's economic competitiveness and social well-being, SCC leads and facilitates the development and use of national and international standards. SCC also coordinates Canadian participation in standards development, and identifies strategies to advance Canadian standardization efforts.

Accreditation services are provided by SCC to various customers, including product certifiers, testing laboratories, and standards development organizations. A list of SCC programs and accredited bodies is publicly available at www.scc.ca.

Standards Council of Canada
600-55 Metcalfe Street
Ottawa, Ontario, K1P 6L5
Canada



Standards Council of Canada
Conseil canadien des normes

Cette Norme Nationale du Canada est disponible en versions française et anglaise.

Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users to judge its suitability for their particular purpose.

**A trademark of the Canadian Standards Association, operating as “CSA Group”*

National Standard of Canada

CSA C22.3 No. 9:20

***Interconnection of distributed
energy resources and electricity
supply systems***



*®A trademark of the Canadian Standards Association,
operating as "CSA Group."*



*Published in January 2020 by CSA Group
A not-for-profit private sector organization
178 Rexdale Boulevard, Toronto, Ontario, Canada M9W 1R3*

*To purchase standards and related publications, visit our Online Store at store.csagroup.org
or call toll-free 1-800-463-6727 or 416-747-4044.*

*ICS 29.240.01; 29.240.99
ISBN 978-1-4883-1783-5*

*© 2020 Canadian Standards Association
All rights reserved. No part of this publication may be reproduced in any form whatsoever
without the prior permission of the publisher.*

Contents

Technical Committee on System Aspects of Electrical Energy Supply	4
Subcommittee on Interconnection of Distributed Energy Resources to Electricity Supply Systems	7
Preface	9
1 Scope	11
2 Reference publications	12
3 Definitions	14
4 General requirements	16
5 Site-specific conditions and interconnection limitations	17
6 Distribution system characteristics	17
6.1 General	17
6.2 Voltage	17
6.3 System frequency	17
6.4 Harmonics and flicker	17
6.5 Voltage regulation	18
6.6 Voltage unbalance	18
6.7 Fault levels	18
6.8 Grounding	18
6.9 Phasing	18
6.10 Automatic reclosing	18
6.11 Alternate source	19
6.12 Abnormal conditions	19
7 Requirements for the interconnection system	19
7.1 General requirements	19
7.1.1 General	19
7.1.2 Measurement location	19
7.1.3 Measurement accuracy	20
7.2 Power quality	22
7.2.1 Harmonics	22
7.2.2 Flicker	22
7.2.3 Voltage regulation and power factor	23
7.2.4 Voltage unbalance	33
7.2.5 Resonance and self excitation	34
7.2.6 DC current injection	34
7.3 Interconnection	34
7.3.1 Disconnecting means	34
7.3.2 Interconnection transformer	34
7.3.3 Grounding	34
7.3.4 Phasing and phase sequence	34

7.3.5	Interrupting device	35
7.4	Interconnection protection	35
7.4.1	General	35
7.4.2	Device ratings	35
7.4.3	Minimum protection requirements	35
7.4.4	Phase and ground fault protection	36
7.4.5	Open-phase condition	36
7.4.6	Frequency and voltage protection	36
7.4.7	Anti-islanding protection	43
7.4.8	Transformer winding configuration	44
7.4.9	Inadvertent energization	45
7.4.10	Transfer trip specification	45
7.4.11	Momentary closed transition switching	45
7.4.12	Speed regulation versus anti-islanding	45
7.4.13	Monitoring and information exchange	46
7.4.14	Electromagnetic interference (EMI)	46
7.4.15	Surge withstand	46
7.4.16	Batteries and auxiliaries	47
7.4.17	Protection scheme failure	47
7.4.18	Instrument transformers used for protection	47
8	Interconnection tests	48
8.1	Interconnection tests	48
8.1.1	General	48
8.1.2	Testing	48
8.1.3	Type and production testing	48
8.1.4	Commissioning tests	48
8.2	Test conditions for an interactive inverter or PCE	49
8.2.1	Connection	49
8.2.2	Impedance	49
8.2.3	Total harmonic distortion (THD)	49
8.2.4	Current-voltage characteristics	50
8.3	Type tests for an interactive inverter or PCE	50
8.3.1	General	50
8.3.2	Temperature stability	50
8.3.3	Response to abnormal frequency	50
8.3.4	Response to abnormal voltage	51
8.3.5	Synchronization and entering service	52
8.3.6	Surge withstand 15	52
8.3.7	Islanding	52
8.3.8	Open phase	53
8.3.9	Reconnect following abnormal condition disconnect	54
8.3.10	DC injection (for inverters without interconnection transformers)	54
8.3.11	Harmonics	54
8.3.12	Voltage and power control requirements	54
8.3.13	Flicker	55
8.3.14	Loss of control circuit power	56
8.3.15	AC output short circuit current contribution tests	56
8.3.16	Current unbalance test	57

8.4	Production tests	58
8.4.1	General	58
8.4.2	Response to abnormal frequency	58
8.4.3	Response to abnormal voltage	58
8.4.4	Synchronization or entering service	58
8.5	Verification of interconnection systems (commissioning tests)	58
8.5.1	General	58
8.5.2	Interconnection verifications and inspections	59
8.5.3	Disconnecting means operability	60
8.5.4	Energization cessation	61
8.6	Maintenance	61
8.7	Installation modification	61

9 Markings 62

9.1	General	62
9.2	Product markings	62
9.3	Installation, operating, and servicing instructions	62
9.3.1	Protection set points	62
9.3.2	Short-circuit contribution	62
9.3.3	Cease to deliver or disconnect	63
9.3.4	Current unbalance	63

Annex A (informative) — Single-line diagrams of typical DFR interconnections 66

Annex B (informative) — Reference tables 72

Annex C (informative) — Transformer winding connections for DER systems connected to distribution systems 75

Annex D (informative) — Engineer stamping of single line diagrams and related electrical drawings and documents 78

Preface

This is the second edition of CSA C22.3 No. 9, *Interconnection of distributed energy resources and electricity supply systems*. It supersedes the previous edition published in 2008, under the title *Interconnection of distributed resources and electricity supply systems*. It is one of a series of Standards issued by CSA Group under Part III of the *Canadian Electrical Code*.

Ongoing changes to electricity supply markets, including deregulation and the introduction of new market participants in the area of electricity generation, have created a need for standardized connection practices for connections to distribution systems operating at 50 kV or below. Prior to 2019, distributed energy resource (DER) interconnection requirements related to product certification and project impact assessment were distributed amongst three CSA Group standards: CSA C22.2 No. 107.1, CAN/CSA-C22.2 No. 257, and CSA C22.3 No. 9. CSA Group has revitalized CSA C22.3 No. 9 to consolidate all the requirements for DER interconnection in a single standard that will be referred to by utilities and system designers for interconnection and manufacturers for DER certification. This standard addresses key requirements for Canadian distributors and can be considered the new standard for interconnecting DER in Canada.

This Standard is intended to address this need by providing technical requirements for the interconnection of distributed energy generation systems and electricity supply systems.

Significant changes in this edition include:

- a) Revisions to Clause 6 (distribution system characteristics) regarding abnormal voltage and frequency operating conditions.
- b) Revisions to Clause 7 (requirements for the interconnection system) regarding
 - i) identifying DER grades with specific requirements for each grade based on their capabilities;
 - ii) reactive power control requirements for DERs at the point of common coupling;
 - iii) active power control function requirements for DERs;
 - iv) voltage and frequency disturbance mitigation requirements for DERs; and
 - v) intentional islanding protection requirements for DERs.
- c) Revisions to Clause 8 (interconnection tests) regarding
 - i) production and type testing for inverters updated from CSA C22.2 107.1;
 - ii) test requirements for intentional islanding; and
 - iii) provisional testing for advanced inverter functionality.

In addition, figures and tables were updated to reflect minimum industry requirements.

This Standard was prepared by the Subcommittee on Interconnection of Distributed Energy Resources to Electricity Supply Systems, under the jurisdiction of the Technical Committee on System Aspects of Electricity Supply and the Strategic Steering Committee on Power Engineering and Electromagnetic Compatibility, and has been formally approved by the Technical Committee.

This standard has been developed in compliance with Standards Council of Canada requirements for National Standards of Canada. It has been published as a National Standard of Canada by CSA Group.

Notes:

- 1) Use of the singular does not exclude the plural (and vice versa) when the sense allows.
- 2) Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.
- 3) This Standard was developed by consensus, which is defined by CSA Policy governing standardization — Code of good practice for standardization as “substantial agreement. Consensus implies much more than a simple

majority, but not necessarily unanimity". It is consistent with this definition that a member may be included in the Technical Committee list and yet not be in full agreement with all clauses of this Standard.

- 4) To submit a request for interpretation of this Standard, please send the following information to inquiries@csagroup.org and include "Request for interpretation" in the subject line:
- define the problem, making reference to the specific clause, and, where appropriate, include an illustrative sketch;
 - provide an explanation of circumstances surrounding the actual field condition; and
 - where possible, phrase the request in such a way that a specific "yes" or "no" answer will address the issue.

Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization and are available on the Current Standards Activities page at standardsactivities.csa.ca.

- 5) This Standard is subject to review within five years from the date of publication. Suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to inquiries@csagroup.org and include "Proposal for change" in the subject line:
- Standard designation (number);
 - relevant clause, table, and/or figure number;
 - wording of the proposed change; and
 - rationale for the change.

CSA C22.3 No. 9:20

Interconnection of distributed energy resources and electricity supply systems

1 Scope

1.1

This Standard specifies the technical requirements for the interconnection of distributed energy resources (DER) and distribution systems up to 50 kV line to line at the point of common coupling (PCC).

1.2

This Standard does not define the maximum DER capacity or the upper voltage limit for installations that are interconnected with a single PCC or connected to a given feeder.

1.3

The objective of this Standard is to specify minimum requirements for the

- a) safety of persons;
- b) continuity of service; and
- c) protection of property.

1.4

This Standard does not apply to secondary network connections and does not address

- a) protection of the power producer's facility;
- b) operating requirements for DER units;
- c) transmission system impact and upgrades;
- d) planning, design, or operation of the distribution system or DER system;
- e) metering, rates, tariffs, and other contractual or commercial issues associated with interconnection; or
- f) interconnection of distributed energy resources and distribution systems that are not ultimately connected to a province-wide or regional electricity grid (i.e., remote locations).

Note: *The wires owner of a remote grid might choose to apply this Standard in part or whole, where appropriate for the remote grid.*

1.5

In this Standard, "shall" is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the Standard; "should" is used to express a recommendation or that which is advised but not required; "may" is used to express an option or that which is permissible within the limits of the Standard.

Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material.

Notes to tables and figures are considered part of the table or figure and may be written as requirements. Annexes are designated normative (mandatory) or informative (nonmandatory) to define their application.