

Australian/New Zealand Standard™

Grid connection of energy systems via inverters

Part 2: Inverter requirements



AS/NZS 4777.2:2015

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee EL-042, Renewable Energy Power Supply Systems and Equipment. It was approved on behalf of the Council of Standards Australia on 17 September 2015 and on behalf of the Council of Standards New Zealand on 21 August 2015. This Standard was published on 9 October 2015.

The following are represented on Committee EL-042:

ACT Government—Environment and Planning Directorate
Australian Energy Market Operator
Australasian Fire and Emergency Service Authorities Council
Australian Industry Group
Australian PV Association
Australian Solar Council
Clean Energy Council
Clean Energy Regulator
Consumer Electronics Suppliers Association
CSIRO
Electrical Compliance Testing Association
Electrical Regulatory Authorities Council
Electrical Safety Organisation (New Zealand)
Electricity Engineers Association (New Zealand)
ElectroComms and Energy Utilities Industries Skills Council
Energy Networks Association
Engineers Australia
Institute of Electrical and Electronics Engineers
Institute of Electrical Inspectors
Institution of Professional Engineers New Zealand
Master Electricians Australia
Ministry of Business, Innovation and Employment (New Zealand)
National Electrical and Communications Association
New Zealand Electrical Institute
NSW Fair Trading
Office of the Technical Regulator, SA
Solar Energy Industries Association
Sustainable Electricity Association New Zealand
Sustainable Energy Association
University of New South Wales

Keeping Standards up-to-date

Standards are living documents which reflect progress in science, technology and systems. To maintain their currency, all Standards are periodically reviewed, and new editions are published. Between editions, amendments may be issued. Standards may also be withdrawn. It is important that readers assure themselves they are using a current Standard, which should include any amendments which may have been published since the Standard was purchased.

Detailed information about joint Australian/New Zealand Standards can be found by visiting the Standards Web Shop at www.saiglobal.com.au or Standards New Zealand web site at www.standards.co.nz and looking up the relevant Standard in the on-line catalogue.

For more frequent listings or notification of revisions, amendments and withdrawals, Standards Australia and Standards New Zealand offer a number of update options. For information about these services, users should contact their respective national Standards organization.

We also welcome suggestions for improvement in our Standards, and especially encourage readers to notify us immediately of any apparent inaccuracies or ambiguities. Please address your comments to the Chief Executive of either Standards Australia or Standards New Zealand at the address shown on the back cover.

This Standard was issued in draft form for comment as DR AS/NZS 4777.2:2015.

Australian/New Zealand Standard™

Grid connection of energy systems via inverters

Part 2: Inverter requirements

Originated in Australia as AS 4777.2—2002 and AS 4777.3—2002.
Previous editions 2005.
Jointly revised, amalgamated and designated as AS/NZS 4777.2:2015.

COPYRIGHT

© Standards Australia Limited/Standards New Zealand

All rights are reserved. No part of this work may be reproduced or copied in any form or by any means, electronic or mechanical, including photocopying, without the written permission of the publisher, unless otherwise permitted under the Copyright Act 1968 (Australia) or the Copyright Act 1994 (New Zealand).

Jointly published by SAI Global Limited under licence from Standards Australia Limited, GPO Box 476, Sydney, NSW 2001 and by Standards New Zealand, Private Bag 2439, Wellington 6140.

PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EL-042, Renewable Energy Power Supply Systems and Equipment, to supersede AS 4777.2—2005, *Grid connection of energy systems via inverters*, Part 2: *Inverter requirements*, and AS 4777.3—2005, *Grid connection of energy systems via inverters*, Part 3: *Grid protection requirements*, twelve months after its publication. During this twelve month period, this edition or AS 4777.2—2005 and AS 4777.3—2005 may be utilized.

The objective of this Standard is to specify minimum performance and safety requirements for the design, construction and operation of inverters intended for use in inverter energy systems for the injection of electric power through an electrical installation into the grid.

This Standard is part of a series on the grid connection of energy systems via inverters. The series is as follows:

AS/NZS

- 4777 Grid connection of energy systems via inverters
- 4777.1 Part 1: Installation requirements
- 4777.2 Part 2: Inverter requirements (this Standard)

There are many differences between this and the previous edition. They include but are not limited to the following:

- (a) Inclusion of a balance requirement for multiple phase systems.
- (b) Revised set-points and limits to match electricity distributor requirements.
- (c) Inclusion of provisions for demand response and power quality response modes.
NOTE: The demand response provisions in this Standard follow the framework in the AS/NZS 4755 series demand response capabilities and supporting technologies for electrical products. At present there is no overlap in the scope of AS/NZS 4777.2 and AS/NZS 4755. However, if in future a new part of the AS/NZS 4755 series is to be published that covers some of the products or functions within the scope of this Standard, it is intended that the coverage of the demand response aspects of those products or functions will then reference the relevant parts of AS/NZS 4755. This would be achieved by a future amendment to AS/NZS 4777.2.
- (d) Inclusion of requirements for electrical safety in accordance with IEC 62109-1 and IEC 62109-2.
- (e) Inclusion of requirements for multiple mode inverter operation and requirements for systems with energy storage to meet electrical safety requirements in accordance with AS 62040.1.1.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which they apply. A ‘normative’ appendix is an integral part of a Standard, whereas an ‘informative’ appendix is only for information and guidance.

CONTENTS

	<i>Page</i>
FOREWORD.....	4
1 SCOPE.....	5
2 APPLICATION.....	5
3 NORMATIVE REFERENCES	5
4 DEFINITIONS	6
5 GENERAL REQUIREMENTS	8
6 OPERATIONAL MODES AND MULTIPLE MODE INVERTERS	13
7 PROTECTIVE FUNCTIONS FOR CONNECTION TO ELECTRICAL INSTALLATIONS AND THE GRID	27
8 MULTIPLE INVERTER COMBINATIONS	33
9 INVERTER MARKING AND DOCUMENTATION	36
 APPENDICES	
A GENERAL TEST AND REPORTING REQUIREMENTS	42
B POWER FACTOR TEST.....	44
C HARMONIC CURRENT LIMIT TEST.....	46
D TRANSIENT VOLTAGE LIMIT TEST	49
E D.C. INJECTION TEST	51
F ACTIVE ANTI-ISLANDING TEST.....	53
G VOLTAGE AND FREQUENCY LIMITS (PASSIVE ANTI-ISLANDING PROTECTION) TESTS	59
H LIMITS FOR SUSTAINED OPERATION.....	64
I DEMAND AND POWER QUALITY RESPONSE MODE TESTING INCLUDING DISCONNECTION ON EXTERNAL SIGNAL	68
J MULTIPLE INVERTER TESTING	72
K RELATED DOCUMENTS	74
 BIBLIOGRAPHY.....	 75

FOREWORD

This Standard necessarily deals with existing types of inverter energy systems, but is not intended to discourage innovation or to exclude materials, equipment and methods that may be developed in the future. Revisions will be made from time to time in view of such developments, and amendments to this edition will be made when necessary.

STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard**Grid connection of energy systems via inverters****Part 2: Inverter requirements****1 SCOPE**

This Standard specifies requirements and tests for low voltage inverters for the injection of electric power through an electrical installation into the grid at low voltage. This Standard applies to inverters that have power flow in either direction between the energy source and the grid. General requirements relating to the test methods set out in Appendices B to J are specified in Appendix A.

NOTE: This Standard does not include the regulatory requirements mandated in Australia by the Australian Communications Media Authority (ACMA) and in New Zealand by Radio Spectrum Management. Refer to ACMA *Electromagnetic Compatibility—Information for suppliers of electrical and electronic products in Australia and New Zealand* for guidance.

2 APPLICATION

This Standard needs to be read in conjunction with the regulations, service and installation rules of the electricity distributor approving the connection. This Standard should also be read in conjunction with AS/NZS 3000.

3 NORMATIVE REFERENCES

The following are the normative documents referenced in this Standard:

NOTES:

- 1 Documents referenced for informative purposes are listed in the Bibliography.
- 2 Documents referred to in the preparation of this Standard are listed in Appendix K.

AS

60038	Standard voltages
62040	Uninterruptible power systems (UPS)
62040.1.1	Part 1.1: General and safety requirements for UPS used in operator access areas

AS/NZS

3000	Electrical installations (known as the Australian/New Zealand Wiring Rules)
3112	Approval and test specification—Plugs and socket-outlets
4777	Grid connection of energy systems via inverters
4777.1	Part 1: Installation requirements
5033	Installation and safety requirements for photovoltaic (PV) arrays
60320	Appliance couplers for household and similar general purposes
60320.1	Part 1: General requirements

IEC	
61000	Electromagnetic compatibility (EMC)
61000.3.3	Part 3.3: Limits—Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection
61000.3.11	Part 3.11: Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems—Equipment with rated current less than or equal to 75 A and subject to conditional connection
60038	IEC standard voltages
60309	Plugs, socket-outlets and couplers for industrial purposes
60309-1	Part 1: General requirements
62109	Safety of power converters for use in photovoltaic power systems
62109-1	Part 1: General requirements
62109-2	Part 2: Particular requirements for inverters
62116	Utility-interconnected photovoltaic inverters—Test procedure of islanding prevention measures

4 DEFINITIONS

For the purpose of this Standard, the following definitions and those of AS/NZS 3000 apply.

4.1 Active anti-islanding protection

A method of preventing islanding by actively varying the output of the inverter.

4.2 Displacement power factor

The cosine of the angle (ϕ) between the fundamental voltage and the fundamental current.

NOTE: Lagging power factor is defined to be when the inverter sinks reactive power from the grid; that is, when the inverter acts as an inductive load from the perspective of the grid. Leading power factor is defined to be when the inverter sources reactive power to the grid; that is, when the inverter acts as a capacitive load from the perspective of the grid.

4.3 Fixed equipment

Equipment fastened to a support, or otherwise secured in a specific location.

[IEV 826-07-07].

4.4 Grid

The portion of the electrical distribution system that is operated by an electrical distributor.

NOTE: An alternative term for 'grid' is 'electricity distribution network'.

4.5 Grid interactive inverter

An inverter or inverter function intended to operate in parallel to the grid for export or self-consumption of energy generated by the inverter energy system.

4.6 Grid test voltage

The voltage applied for testing of an inverter to this Standard.

4.7 Inverter

A device that uses semiconductor devices to transfer power between a d.c. source or load and an a.c. source or load.

NOTE: For the purposes of this Standard, a.c. to a.c. convertors transferring power between non-grid energy sources and an a.c. source or load that use semiconductor devices are considered to be inverters.

4.8 Inverter energy system

A system comprising of one or more inverters together with one or more energy sources (which may include batteries for energy storage), and controls, which satisfies the requirements of this Standard.

4.9 Islanding

Any situation where the electrical supply from a grid is disrupted or fails and one or more inverters maintains any form of electrical supply, be it stable or not, to any section of that grid or within the electrical installation.

NOTE: Prevention of the injection of energy and prevention of an unintentional island with the grid or part thereof when supply is disrupted is key to maintaining safety on the grid and within the electrical installation.

4.10 Multiple mode inverter (MMI)

An inverter that operates in more than one mode, for example having grid-interactive functionality when grid voltage is present and stand-alone functionality when the grid is de-energized or disconnected.

NOTES:

- 1 Inverters with battery storage ports are also considered multiple mode inverters.
- 2 As defined in IEC 62109-2, Clause 3.107.

4.11 Passive anti-islanding protection

A method of preventing islanding based on monitoring the grid.

4.12 Permanently connected

Electrically connected by means which can be detached only by the use of a tool.

NOTE: As defined in IEC 62109-1, Clause 3.53.

4.13 Pluggable equipment type A

Equipment which is intended for connection to the building installation wiring via a non-industrial plug and socket-outlet or a non-industrial appliance coupler, or both.

NOTE: As defined in IEC 62109-1, Clause 3.57.

4.14 Pluggable equipment type B

Equipment which is intended for connection to the building installation wiring via an industrial plug and socket-outlet or an appliance coupler, or both, complying with IEC 60309-1 or with a comparable national standard.

NOTES:

- 1 For the purposes of this Standard, appliance couplers and connectors within the scope of IEC 60320 or AS/NZS 60320 are not equivalent connectors to those complying with IEC 60309-1.
- 2 PV circuits that use connectors are considered pluggable type B or fixed equipment.
- 3 As defined in IEC 62109-1, Clause 3.57.

4.15 Port

Location giving access to a device or network where electromagnetic energy or signals may be supplied or received or where the device or network variables may be observed or measured.

NOTE: As defined in IEC 62109-1, Clause 3.64.

4.16 Portable equipment

Pluggable equipment intended to be moved from place to place.

NOTE: As defined in IEC 62109-1, Clause 3.65.