

AS/NZS 4777.2:2020



Australian/New Zealand Standard™

# Grid connection of energy systems via inverters

Part 2: Inverter requirements



AS/NZS 4777.2:2020

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 27 November 2020 and by the New Zealand Standards Approval Board on 10 December 2020.

This Standard was published on 18 December 2020.

The following are represented on Committee EL-042:

Australasian Fire and Emergency Service Authorities Council  
Australian Energy Market Operator  
Australian Industry Group  
Australian PV Institute  
Better Regulation Division — NSW Fair Trading  
Clean Energy Council  
Clean Energy Regulator  
Communications, Electrical and Plumbing Union — Electrical Division  
Consumer Electronics Suppliers Association  
Consumers Federation of Australia  
CSIRO  
Electrical Compliance Testing Association of Australia  
Electrical Regulatory Authorities Council  
Electrical Safety New Zealand  
Electricity Engineers Association of New Zealand  
Energy Efficiency and Conservation Authority of New Zealand  
Energy Networks Australia  
Engineers Australia  
Fire and Emergency New Zealand  
Institute of Electrical and Electronics Engineers  
Institute of Electrical Inspectors  
Joint Accreditation System of Australia and New Zealand  
Master Electricians Australia  
National Electrical and Communications Association  
Office of the Technical Regulator, SA  
Smart Energy Council  
Solar Energy Industries Association  
Sustainable Electricity Association New Zealand  
Sustainable Energy Association  
University of New South Wales  
Vector, New Zealand  
Wellington Electrical Association  
WorkSafe New Zealand

This Standard was issued in draft form for comment as DR AS/NZS 4777.2:2020.

### **Keeping Standards up-to-date**

Ensure you have the latest versions of our publications and keep up-to-date about Amendments, Rulings, Withdrawals, and new projects by visiting:

[www.standards.org.au](http://www.standards.org.au)

[www.standards.govt.nz](http://www.standards.govt.nz)

ISBN 978 1 76113 136 3

Australian/New Zealand Standard™

# **Grid connection of energy systems via inverters**

## **Part 2: Inverter requirements**

Originated in Australia in part as AS 4777.2—2003 and AS 4777.3—2003.  
Second editions 2005.  
Jointly revised, amalgamated and redesignated as AS/NZS 4777.2:2015.  
Fourth edition AS/NZS 4777.2:2020.

© Standards Australia Limited/the Crown in right of New Zealand, administered by the New Zealand Standards Executive 2020

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 (Cth) or the Copyright Act 1994 (New Zealand).

## 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/NZS 4777.2:2015, *Grid connection of energy systems via inverters, Part 2: Inverter requirements*. AS/NZS 4777.2:2015 will also remain current for 12 months after the date of publication of this Standard and after this time they will be superseded by AS/NZS 4777.2:202X. Regulatory authorities that reference this Standard in regulation may apply these requirements at a different time. Users of this Standard should consult with these authorities to confirm their requirements.

The objective of this Standard is to specify minimum performance and safety requirements for the design, construction and operation of inverters intended for grid connection of energy systems.

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

AS/NZS 4777.1, *Grid connection of energy systems via inverters, Part 1: Installation requirements*

AS/NZS 4777.2, *Grid connection of energy systems via inverters, Part 2: Inverter requirements* (this Standard)

The differences between this and the previous edition include but are not limited to the following:

- (a) Revision of sustained frequency response.
- (b) Revised set-points and limits to match electricity distributor and grid operator requirements.
- (c) Revision of provisions for demand response and power quality response modes.
- (d) Inclusion of requirements for electrical safety of non-PV energy sources in accordance with IEC 62477-1.
- (e) Inclusion of requirements for improved withstand capabilities including multiple voltage disturbances, rate of change of frequency and voltage phase shift.
- (f) Inclusion of requirements for measurement system accuracy and functional prioritization.
- (g) Inclusion of requirements for stand-alone inverters.
- (h) Inclusion of requirements for generation limit and export limit control function.
- (i) Revised and expanded testing procedures.

The following documents were used for information and guidance in the preparation of this Standard to ensure that features and requirements were aligned with international developments.

IEEE 1547-2018, *IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces*

VDE-AR-N 4105:2018-11, *Generators connected to the low-voltage distribution network — Technical requirements for the connection to and parallel operation with low-voltage distribution networks*

Standards Australia thanks the International Electrotechnical Commission (IEC) for permission to reproduce definitions from IEC Electropedia available from [www.electropedia.org](http://www.electropedia.org) and IEC 62109 Parts 1 and 2. These definitions are copyright of IEC, Geneva, Switzerland. All rights reserved. Further information on the IEC is available from [www.iec.ch](http://www.iec.ch). IEC has no responsibility for the placement and context in which the extracts and contents are reproduced by the author, nor is IEC in any way responsible for the other content or accuracy therein.

The terms “normative” and “informative” are used in Standards to define the application of the appendices 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

<b>Preface</b> .....	<b>ii</b>
<b>Section 1 Scope and general</b> .....	<b>1</b>
1.1 Scope.....	1
1.2 Application.....	1
1.3 Normative references.....	1
1.4 Terms and definitions.....	2
<b>Section 2 General requirements</b> .....	<b>7</b>
2.1 General.....	7
2.2 Electrical safety.....	7
2.3 Provision for external connections.....	7
2.3.1 General.....	7
2.3.2 Permanently connected equipment.....	7
2.3.3 Pluggable type B equipment.....	8
2.4 Earth fault/earth leakage detection.....	8
2.4.1 Photovoltaic (PV) array earth fault/earth leakage detection.....	8
2.4.2 Battery Energy Storage System (BESS) earth fault/earth leakage detection.....	9
2.5 Compatibility with electrical installation.....	9
2.6 Reactive power capability.....	9
2.7 Harmonic currents.....	10
2.8 Voltage fluctuations and flicker.....	11
2.9 Transient voltage limits.....	11
2.10 DC current injection.....	12
2.11 Current balance for three-phase inverters.....	13
2.12 Isolation of energy sources.....	13
2.12.1 General.....	13
2.12.2 Switch-disconnector.....	13
2.12.3 Circuit breaker.....	14
2.12.4 PV array ports.....	14
2.12.5 Battery system ports.....	14
2.13 Measurement accuracy.....	15
2.14 Prioritization of protection and operational modes.....	15
2.15 Firmware.....	15
<b>Section 3 Operational modes and multiple mode inverters</b> .....	<b>17</b>
3.1 General.....	17
3.2 Inverter demand response modes (DRMs).....	17
3.2.1 General.....	17
3.2.2 Interaction with demand response enabling device (DRED).....	17
3.3 Inverter power quality response modes.....	19
3.3.1 General.....	19
3.3.2 Volt response modes.....	20
3.3.3 Fixed power factor mode and reactive power mode.....	24
3.3.4 Power rate limit.....	24
3.4 Multiple mode inverter operation.....	27
3.4.1 General.....	27
3.4.2 Sinusoidal output in stand-alone mode.....	27
3.4.3 Volt-watt response mode for inverters with energy storage when charging.....	27
3.4.4 Stand-alone inverters.....	28
3.5 Security of operational settings.....	29
<b>Section 4 Protective functions for connection to electrical installations and the grid</b> .....	<b>30</b>
4.1 General.....	30
4.2 Automatic disconnection device.....	30
4.3 Active anti-islanding protection.....	31
4.4 Voltage and frequency limits (passive anti-islanding protection).....	31

4.5	Limits for sustained operation.....	32
4.5.1	General.....	32
4.5.2	Sustained operation for voltage variations.....	32
4.5.3	Sustained operation for frequency variations.....	33
4.5.4	Voltage disturbance withstand.....	41
4.5.5	Voltage phase angle shift withstand.....	43
4.5.6	Rate of change of frequency.....	43
4.6	Disconnection on external signal.....	44
4.7	Connection and reconnection procedure.....	44
4.8	Security of protection settings.....	44
4.9	Activation of protection settings.....	44
<b>Section 5</b>	<b>Multiple inverter combinations.....</b>	<b>46</b>
5.1	General.....	46
5.2	Inverter current balance across multiple phases.....	46
5.3	Grid disconnection.....	46
5.4	Grid connection and reconnection.....	46
5.5	Testing combinations.....	46
5.5.1	Single-phase combinations.....	46
5.5.2	Single-phase inverters used in three-phase combinations.....	47
5.5.3	Required tests for multiple inverter combinations.....	48
5.5.4	Multiple inverters with one automatic disconnection device.....	49
<b>Section 6</b>	<b>Generation control function.....</b>	<b>50</b>
6.1	General.....	50
6.2	Generation limit control.....	51
6.2.1	General.....	51
6.2.2	Soft limit.....	51
6.2.3	Hard limit.....	51
6.3	Export limit control.....	51
6.3.1	General.....	51
6.3.2	Soft limit.....	51
6.3.3	Hard limit.....	52
<b>Section 7</b>	<b>Inverter marking and documentation.....</b>	<b>53</b>
7.1	General.....	53
7.2	Marking.....	53
7.2.1	General.....	53
7.2.2	Equipment ratings.....	53
7.2.3	Ports.....	54
7.2.4	External and ancillary equipment.....	55
7.2.5	Residual current devices (RCDs).....	55
7.2.6	Demand response modes.....	55
7.3	Documentation.....	56
7.3.1	General.....	56
7.3.2	Equipment ratings.....	56
7.3.3	Ports.....	58
7.3.4	External and ancillary equipment.....	58
7.3.5	Residual current devices (RCDs).....	59
7.3.6	Multiple mode inverters.....	59
7.3.7	Multiple inverter combinations.....	59
7.3.8	Firmware.....	59
<b>Appendix A</b>	<b>(normative) General test and reporting requirements.....</b>	<b>60</b>
<b>Appendix B</b>	<b>(normative) Harmonic current limit test.....</b>	<b>63</b>
<b>Appendix C</b>	<b>(normative) Transient voltage limit test.....</b>	<b>66</b>
<b>Appendix D</b>	<b>(normative) DC injection test.....</b>	<b>68</b>

<b>Appendix E (normative) Demand response mode testing including disconnection on external signal</b> .....	<b>70</b>
<b>Appendix F (normative) Fixed power factor mode and reactive power mode test</b> .....	<b>74</b>
<b>Appendix G (normative) Power quality (voltage) response mode testing</b> .....	<b>77</b>
<b>Appendix H (normative) Active anti-islanding test</b> .....	<b>82</b>
<b>Appendix I (normative) Voltage and frequency limits tests</b> .....	<b>83</b>
<b>Appendix J (normative) Sustained operation test procedures</b> .....	<b>96</b>
<b>Appendix K (normative) Multiple inverter testing</b> .....	<b>107</b>
<b>Appendix L (normative) Generation control function testing</b> .....	<b>109</b>
<b>Appendix M (normative) Stand-alone inverters</b> .....	<b>123</b>
<b>Bibliography</b> .....	<b>132</b>

## NOTES

# Australian/New Zealand Standard

## Grid connection of energy systems via inverters

### Part 2: Inverter requirements

#### Section 1 Scope and general

##### 1.1 Scope

This Standard specifies device specifications, functionality, testing and compliance requirements for electrical safety and performance for inverters designed to facilitate connectivity between energy sources and/or energy storage systems and the grid, connected at low voltage. This includes electric vehicles that can operate as an energy source and energy storage system that can supply an electrical installation connected to the grid.

This Standard also applies to stand-alone inverters within an electrical installation that may be connected to the grid at low voltage via an a.c. input port.

General requirements relating to the test methods set out in [Appendices B to L](#) are specified in [Appendix A](#). [Appendix M](#) specifies requirements for stand-alone inverters.

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.

##### 1.2 Application

This Standard enables the inverters to be installed as part of an inverter energy system (IES) in accordance with the requirements of AS/NZS 4777.1. This Standard applies in conjunction with the requirements of the electricity distributor approving the connection. Relevant legislation and regulations also apply.

##### 1.3 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document.

NOTE Documents referenced for informative purposes are listed in the Bibliography.

AS 60038, *Standard voltages*

AS 60947.3, *Low voltage switch gear and control gear, Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units (IEC 60947-3:2015 (ED. 3.2) MOD)*

AS IEC 62040.3, *Uninterruptible power systems (UPS), Part 3: Method of specifying the performance and test requirements*

AS IEC 62196.2, *Plugs, socket-outlets, vehicle connectors and vehicle inlets — Conductive charging of electric vehicles, Part 2: Dimensional compatibility and interchangeability requirements for a.c. pin and contact-tube accessories*

AS/NZS 3000, *Electrical installations (known as the Australian/New Zealand Wiring Rules)*

AS/NZS 3112, *Approval and test specification—Plugs and socket-outlets*

AS/NZS 4777.1, *Grid connection of energy systems via inverters, Part 1: Installation requirements*

AS/NZS 5033, *Installation and safety requirements for photovoltaic (PV) arrays*