

Australian/New Zealand Standard™

Stand-alone inverters—Performance requirements



AS/NZS 5603:2009

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PREFACE

This Standard was produced by Joint Standards Australia/Standards New Zealand Committee EL-042, Renewable Energy Power Supply Systems and Equipment, with the assistance of the Research Institute for Sustainable Energy at Murdoch University, Western Australia, and the University of New South Wales.

The objective of this Standard is to provide manufacturers, test laboratories and users of inverters with a set of parameters and tests for assessing the performance of a stand-alone inverter.

The form in Appendix B, 'Stand-alone Inverter Performance Classification Schedule' may be reproduced freely for the purposes of reporting the results from the tests in this Standards.

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

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Australian/New Zealand Standard

Stand-alone inverters—Performance requirements

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies performance requirements for low voltage a.c. output inverters, both single-phase and three-phase, intended for use in stand-alone power systems with batteries. It applies to inverters with—

- (a) ratings up to 10 kVA for single-phase units, or up to 30 kVA for three-phase units;
- (b) a nominal a.c. voltage equivalent to the nominal supply voltage 230 V (single-phase) or 400 V (three-phase);
- (c) a nominal a.c. frequency of 50 Hz; and
- (d) nominal d.c. voltages up to 300 V between positive and negative or ± 300 V d.c. with respect to earth and connected to a battery.

NOTES:

- 1 Although this Standard does not apply to larger systems or systems of different nominal voltage or nominal frequency, similar principles apply to such equipment.
- 2 This Standard does not specify EMC requirements, which for Australia are covered by the requirements of the *Radiocommunications Act 1992* and for New Zealand by the *Radiocommunications Regulations 2001*. For further guidance on Australian requirements, see the Australian Communications and Media Authority's document *Electromagnetic Compatibility—Information for suppliers of electrical and electronic products in Australia and New Zealand*.

1.2 REFERENCED DOCUMENTS

The following normative documents contain provisions that, through reference in this text, constitute provisions of this Standard.

AS	
60038	Standard voltages
NZS/IEC	
38	IEC standard voltages
IEC	
61683	Photovoltaic systems—Power conditioners—Procedure for measuring efficiency

1.3 DEFINITIONS

For the purpose of this Standard, the definitions below apply.

1.3.1 Active mode

A mode of inverter operation whereby nominal voltage (plus/minus specified tolerances) is available/present on the a.c. terminals

1.3.2 Connect

An inverter connects when it goes from 'stop' mode to 'active' mode.

1.3.3 D.C. operating voltage range

The d.c. input voltage range that the inverter can sustain and that can deliver the nominal output characteristics (i.e. voltage, power, frequency and quality of supply) as declared by the manufacturer.

1.3.4 Disconnect

The inverter disconnects when it goes from 'active' mode to 'stop' mode.

1.3.5 EUT

Equipment under test.

1.3.6 Interactive inverter

Sine wave inverters that allow power flow in both directions and are capable of synchronizing their output with that of another a.c. source in order to manage the loading on the a.c. source as well as the battery.

1.3.7 Inverter

A device that uses semiconductor devices to convert d.c. power into a.c. power at standard mains voltage and frequency.

1.3.8 Inverter-charger

An inverter that operates as a battery charger in the presence of another a.c. source.

1.3.9 Maximum operating voltage

The upper limit of the d.c. operating range.

1.3.10 Minimum operating voltage

The lower limit of the d.c. operating range.

1.3.11 Motor load

A single motor, or a combination of motors connected in parallel, switched with a single switch that is used to test an inverter for motor-starting capability.

1.3.12 Nominal a.c. output voltage

The a.c. output voltage as declared by the manufacturer.

1.3.13 Nominal d.c. input voltage

The d.c. input voltage as declared by the manufacturer.

1.3.14 Nominal supply voltage

In Australia, the definition of AS 60038 shall apply.

In New Zealand, the definition of NZS/IEC 38 shall apply.

1.3.15 Nonlinear load

A load whose impedance varies with instantaneous voltage amplitude.

1.3.16 Rated current

The maximum continuous input or output current at 25°C.

1.3.17 Shut down

A 'stop mode' condition that is initiated by a protection function of the inverter.

NOTE: The shut-down condition may provide added protection by disconnecting circuits (e.g. by tripping a circuit-breaker). The inverter may restart once the instigating condition is removed or changed and/or may require the user to restart the inverter.

1.3.18 Stand-alone inverter

An inverter, connected to a battery, capable of supplying a.c. loads with or without the presence of another a.c. source.

1.3.19 Standby mode

A mode of inverter operation whereby the inverter determines the presence of a load. On detecting a load greater than a defined start threshold (P_{ACTIVE}), the inverter will change to an 'active' mode. When the load reduces below a lower threshold (P_{STANDBY}), the inverter will change back to 'standby' mode.

1.3.20 Stop mode

A mode of inverter operation whereby most control circuits within the inverter are active but no voltage is present on the a.c. load terminals.

1.3.21 Thermal stability

Thermal stability is deemed to have been reached when the temperatures in question have not changed by more than 1°C in 30 min. For cycling temperatures, thermal stability is deemed to have been reached when the average cycle temperature has not changed by more than 1°C in 30 min; if the cycle is 30 min or longer, thermal stability is deemed to have been reached when the average temperature between two consecutive cycles has not changed by more than 1°C.

1.4 NOTATION

The symbols used in this Standard are listed in Appendix M.

SECTION 2 GENERAL TEST REQUIREMENTS

2.1 GENERAL CONDITIONS FOR TESTS

The general conditions for tests contained in Appendix A shall apply to all tests in this Standard.

2.2 SPECIFICATIONS

For testing purposes, the manufacturer or importer shall provide the following values, where applicable.

NOTE: If any of the following values are adjustable, the range of values and the factory settings are to be provided.

- (a) Nominal d.c. input voltage.
- (b) D.C. operating voltage range.
- (c) Nominal a.c. output voltage (single-phase or three-phase).
- (d) Nominal a.c. frequency and frequency range.
- (e) Power factor range.
- (f) Rated d.c. charging current (interactive inverters and inverter-chargers only).
- (g) Continuous output power rating at unity power factor at 25°C for at least 5 h with nominal d.c. input voltage.
- (h) Continuous output power rating at unity power factor at 40°C for at least 5 h with nominal d.c. input voltage.
- (i) Continuous apparent power rating at 0.75 power factor at 25°C.
- (j) 30 min rating—the maximum output for a 30 min period with nominal d.c. input voltage.
- (k) Surge ratings—the maximum output for a 3 s period with nominal d.c. input voltage at 25°C and 40°C.
- (l) Demand start load and demand stop load (the load required to bring the inverter into active mode and standby mode respectively).
- (m) All d.c. input voltage disconnect and reconnect set points.
- (n) Battery charging stages, and the duration, voltage and/or current specifications for each charging stage.

NOTE: If values for (l), (m) and (n) are adjustable by adaptive control algorithms (e.g. temperature compensation of battery-charging points), the information required in order to test these settings needs to be provided.

SECTION 3 ELECTRICAL REQUIREMENTS

3.1 GENERAL

This Section sets out the electrical performance requirements for inverters intended to operate as stand-alone power systems.

Appendix B provides an example of a performance classification schedule for the use of manufacturers when reporting on their product's performance and ratings as determined by testing according to this Standard.

3.2 D.C. OPERATING VOLTAGE RANGE

The d.c. operating voltage range shall be as declared by the manufacturer. The inverter's nominal a.c. output voltage, output voltage harmonic distortion and output frequency shall be within the manufacturer's specifications at any voltage within the d.c. operating voltage range as declared by the manufacturer.

The inverter's maximum and minimum operating voltage set points shall allow the unit to operate within the d.c. operating voltage range specified by the manufacturer.

Compliance shall be verified by type testing in accordance with Appendix C.

3.3 D.C. VOLTAGE TRIP SET POINTS

3.3.1 D.C. overvoltage set points

The inverter high voltage disconnect and reconnect set points shall be declared by the manufacturer or be adjustable. The high voltage disconnect and reconnect voltage, if applicable, shall agree with the set points within $\pm 2\%$. Compliance shall be determined by type testing in accordance with the d.c. voltage disconnect and reconnect set points test described in Appendix D.

If the unit has adjustable set points, the default values, or a set point agreed with the client or manufacturer, should be used for testing purposes.

Where the inverter manufacturer has specified a temperature corresponding to the set points, this temperature shall be used as the reference temperature for the test. Where the inverter manufacturer has not specified such a temperature, a reference temperature of 25°C shall be used. Where the inverter manufacturer has specified a temperature coefficient for the set points, the inverter shall be tested with the battery temperature sensor at the reference temperature and at 40°C.

NOTE: Disconnect and reconnect overvoltage set points are often used in stand-alone power systems with batteries to protect the battery from overvoltage conditions.

3.3.2 D.C. under-voltage set points

The inverter shall have low input voltage disconnect and reconnect set points. These set points shall be declared by the manufacturer or be adjustable. The low voltage disconnect and reconnect voltages shall agree with the set points within $\pm 2\%$. Compliance shall be determined by type testing in accordance with the d.c. voltage disconnect and reconnect set points test described in Appendix D.

If the unit has adjustable set points, the default values, or a set point agreed with the client or manufacturer, should be used for testing purposes.

Where the inverter manufacturer has specified a temperature corresponding to the set points, this temperature shall be used as the reference temperature for the test. Where the inverter manufacturer has not specified such a temperature, a reference temperature of 25°C shall be used. Where the inverter manufacturer has specified a temperature coefficient for the set points, the inverter shall be tested with the battery temperature sensor at the reference temperature and at 40°C.

NOTE: Disconnect and reconnect under-voltage set points are required in stand-alone power systems with batteries to protect the battery from under-voltage conditions.

3.4 STANDBY AND NO-LOAD POWER LOSS

The inverter shall comply with the no-load power and standby power (where applicable) loss limits as specified in Clause 3.11 and Tables 4 and 5 when an input voltage equivalent to 110% of the d.c. nominal input voltage is applied on the d.c. terminals. P_{ACTIVE} and P_{STANDBY} shall be within 15% of $P_{\text{ACTIVE-SET}}$ and $P_{\text{STANDBY-SET}}$ respectively. Compliance and classification shall be verified by type testing in accordance with Appendix E.

3.5 EFFICIENCY AND POWER QUALITY

The inverter efficiency, output voltage total harmonic distortion and output voltage regulation shall be assessed on the basis of the limits specified in Clause 3.11 and Tables 6 to 8. The output frequency limits shall be ± 3 Hz from the nominal frequency as declared by the manufacturer. Measurements shall be made in accordance with the test schedule specified in Table 1.

Compliance and classification shall be assessed by type testing in accordance with Appendix F.

TABLE 1
EFFICIENCY AND POWER QUALITY TEST SCHEDULE

1	2	3	4	5	6	7	8
Type of load	Test temp.	Total load (% of continuous power rating at unity power factor at 25°C)					
		5%	10%	25%	50%	75%	100%
Resistive	25°C	X	X	X	X	X	X
Reactive PF 0.75	25°C	–	–	X	X	X	X
Nonlinear 25%	25°C	–	–	X	X	X	X
Resistive	40°C	X	X	X	X	X	X

3.6 LOAD-HANDLING AND TEMPERATURE RISE

The inverter shall be capable of supplying power for the loads for the minimum time specified in Table 2 without ‘shut-down’ events occurring. The test load shall be applied after the inverter has reached thermal stability at 50% of rated load at unity power factor. The supply voltage shall be the nominal d.c. input voltage $\pm 5\%$.

The inverter’s voltage regulation shall be maintained throughout Tests 1 and 5 and shall be used for classification purposes as specified in Clause 3.11, Table 8.

Compliance shall be verified by type testing as described in Appendix G.

TABLE 2
LOAD-HANDLING CAPABILITY TEST SCHEDULE

1	2	3	4
Test	Ambient temperature (°C)	Test load (load required to consume the power indicated)	Minimum test duration
1	25	Continuous power rating at 25°C as declared by the manufacturer (see Clause 2.2, Item (g); and Note 3)	5 h
2	25	30 min rating as declared by the manufacturer (see Clause 2.2, Item (j); and Note 1)	30 min
3	25	Surge load specified by the manufacturer (see Clause 2.2, Item (k); and Note 2)	3 s
4	40	Surge load specified by the manufacturer (see Clause 2.2, Item (k); and Note 2)	3 s
5	40	Continuous power rating at 40°C as declared by the manufacturer (see Clause 2.2, Item (h); and Note 3)	5 h

NOTES:

- 1 Where the manufacturer does not declare a 30 min rating (see Clause 2.2, Item (j)), the 30 min rating shall be taken as $1.25 \times$ the continuous power rating at 25°C as declared by the manufacturer.
- 2 Where the manufacturer does not declare surge ratings (see Clause 2.2, Item (k)), the surge rating shall be taken as $2.5 \times$ the continuous power rating at that temperature as declared by the manufacturer.
- 3 Where the manufacturer does not declare a 40°C rating (see Clause 2.2, Item (h)), the 40°C rating shall be taken as the same as the continuous 25°C power rating as declared by the manufacturer (see Clause 2.2, Item (g)).

3.7 STEP-LOAD TRANSIENT RESPONSE

The inverter output voltage shall remain within the limits of the time duration curve of Figure 1 when subjected to load step changes going from light rectifier load to light rectifier load + 80% resistive load and back to light electronic load only. Compliance shall be verified by type testing in accordance with Appendix H.

NOTE: The light electronic load is a nonlinear load of rectifier plus capacitor in accordance with Appendix H, Figure H1.

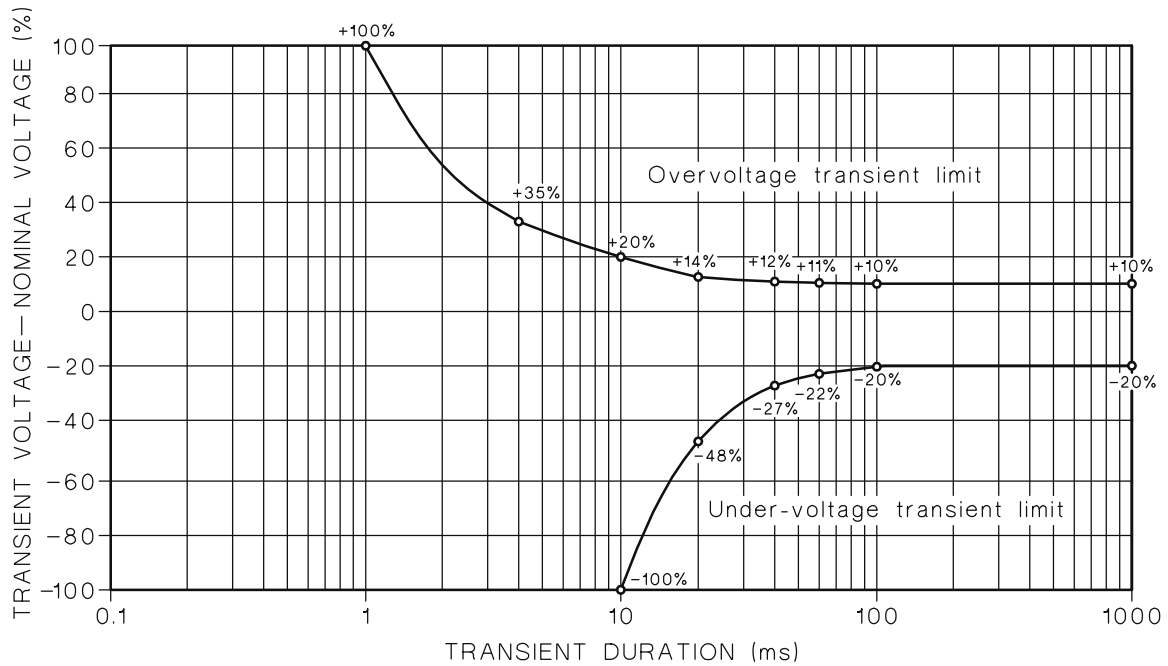


FIGURE 1 TRANSIENT VOLTAGE LIMITS FOR INVERTERS

3.8 MOTOR LOAD HANDLING

3.8.1 General

The inverter shall comply with Clause 3.8.2 or Clause 3.8.3.

3.8.2 Motor load handling requirements

The inverter output voltage shall remain within the limits of the time duration curve in Figure 1 when subjected to a motor load as specified in Table 3. The inverter shall be pre-loaded with a resistive load such that—

$$P_{\text{RES}} = S_{\text{INV-NOM}} - P_{\text{MOT-NOM}}$$

P_{RES} shall have a tolerance of $^{+0}_{-10\%}$.

$V_{\text{INV-AC}}$ shall remain within the limits for transient voltage specified in Clause 3.7 during t_{START} . Compliance with the motor load handling requirements shall be verified by type testing in accordance with Appendix J, where the motor load requirements are detailed.

TABLE 3
MOTOR LOAD REQUIREMENTS

1	2	3
Inverter power rating	$I_{\text{MOT-NOM}}$	
	Lower limit	Upper limit
$S_{\text{INV-NOM}} \leq 1 \text{ kVA}$	No motor test requirements	
$1 \text{ kVA} < S_{\text{INV-NOM}} \leq 10 \text{ kVA}$	$[(0.5 \times I_{\text{INV-AC-NOM}}) - 1.5 \text{ A}]$ or 2.5 A, whichever is greater	$(0.5 \times I_{\text{INV-AC-NOM}}) + 1.5 \text{ A}$

3.8.3 Statement of unsuitability to run motor loads

If the inverter is unsuitable for supplying motor loads, the operating instructions supplied with the inverter shall clearly state this.

3.9 CHARGING EFFICIENCY AND CURRENT *THD*

Interactive inverters and inverter-chargers shall be capable of transferring power from the a.c. terminals to the d.c. battery terminals with the charging efficiency as declared by the manufacturer.

The total harmonic distortion of the inverter a.c. current shall be assessed on the basis of the limits specified in Clause 3.11, Table 9.

Compliance shall be verified by type testing in accordance with Appendix K.

3.10 THREE-PHASE INVERTERS

A three-phase inverter shall be capable of supplying balanced three-phase voltages under the following loading conditions:

- (a) Balanced three-phase resistive load equal to 100% of the inverter rating.
- (b) Resistive load on one phase equal to 100% of the inverter's per phase rating and no-load on the remaining two phases. This loading condition applies to all three phases.

The voltage on each phase and neutral shall comply with the supply voltage requirements specified in AS 60038 for Australia and NZS/IEC 38 for New Zealand for a.c. systems having a nominal system voltage between 100 V and 1000 V under all loading conditions specified above. Compliance shall be verified by type testing in accordance with Appendix L.

3.11 PERFORMANCE CLASS

The inverter shall be classified as one of the following performance classes by means of evaluating its performance against the requirements of this Standard in respect of each of the following criteria: efficiency, no-load power losses, standby losses, voltage regulation, voltage harmonic distortion and current harmonic distortion (for charging mode only):

- (a) Performance Class A.
- or
- (b) Performance Class B.
- or
- (c) Performance Class C.

A performance class shall be assigned to each of the parameters in accordance with the classification criteria listed in Tables 4 to 9 below.

Table 4 lists the standby power loss limits applicable to each class.

TABLE 4
STANDBY POWER LOSS LIMITS

Class	Standby power loss limits
A	≤3.5 W or 0.35% of rated power, whichever is greater
B	≤8 W or 1% of rated power, whichever is greater
C	>8 W or 1% of rated power, whichever is greater