

Australian/New Zealand Standard™

**Stand-alone inverters—Performance requirements**



### **AS/NZS 5603:2009**

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 12 January 2009 and on behalf of the Council of Standards New Zealand on 15 January 2009. This Standard was published on 11 March 2009.

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*This Standard was issued in draft form for comment as DR 08211.*

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**Stand-alone inverters—Performance requirements**

First published as AS/NZS 5603:2009.

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Jointly published by Standards Australia, GPO Box 476, Sydney, NSW 2001 and Standards New Zealand, Private Bag 2439, Wellington 6020

ISBN 0 7337 9046 1

## 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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## STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

**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  $\pm 300$  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  $P_{ACTIVE-SET}$  and  $P_{STANDBY-SET}$  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  $\pm 3$  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.

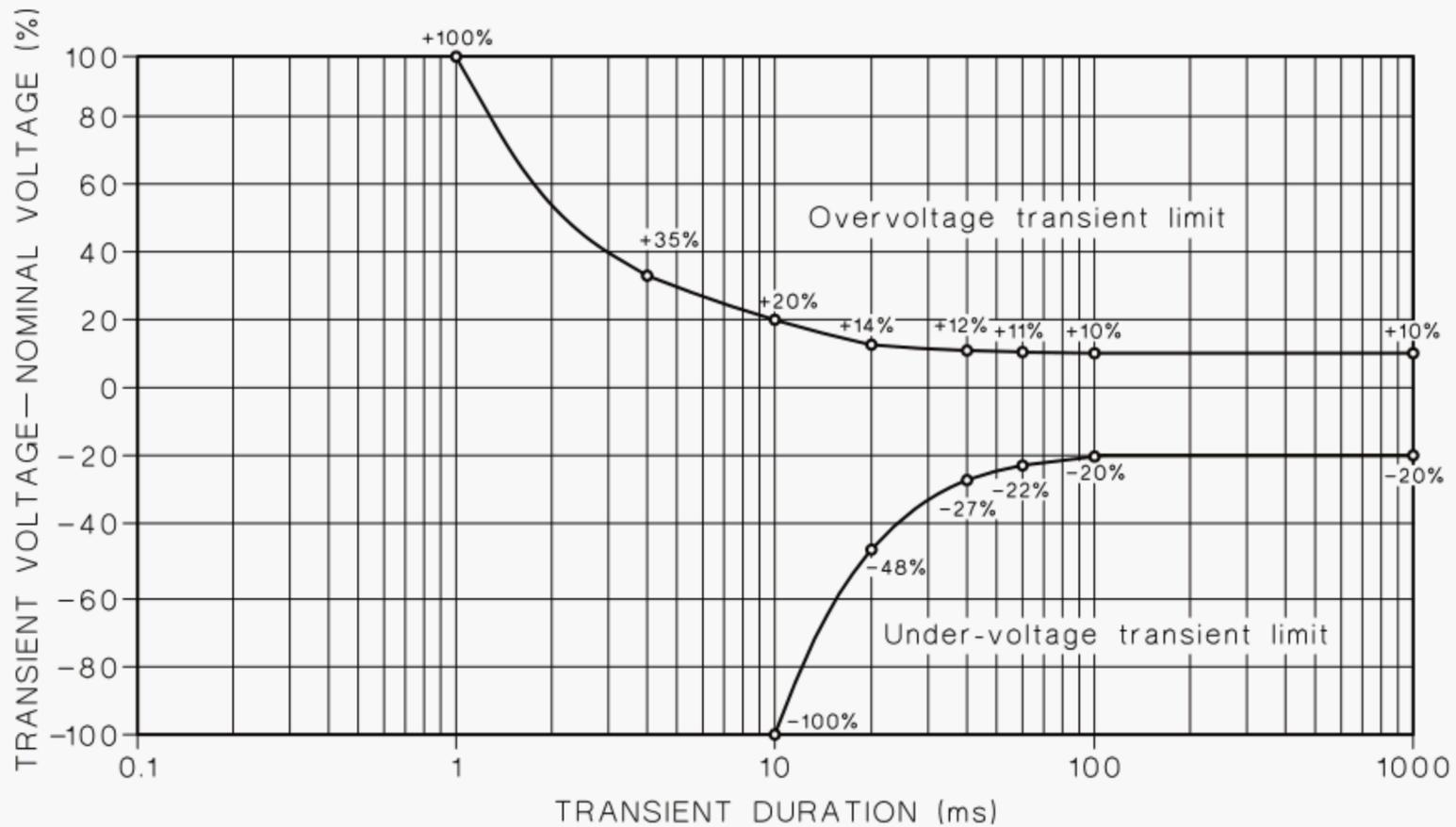


FIGURE 1 TRANSIENT VOLTAGE LIMITS FOR INVERTERS

### 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—

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

$P_{\text{RES}}$  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  $t_{\text{START}}$ . 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

Table 5 lists the no-load power loss limits applicable to each class.

**TABLE 5**  
**NO-LOAD POWER LOSS LIMITS**

1	2	3
Class	No-load power loss limit (%)	
	≤7.5 kVA single-phase	>7.5 kVA single-phase
	≤20 kVA three-phase	>20 kVA three-phase
A	≤5 W or 0.5% of rated power, whichever is greater	≤7 W or 0.7% of rated power, whichever is greater
B	≤15 W or 2% of rated power, whichever is greater	≤15 W or 2% of rated power, whichever is greater
C	>15 W or 2% of rated power, whichever is greater	>15 W or 2% of rated power, whichever is greater

Table 6 lists the total harmonic distortion (*THD*) applicable to each class.

**TABLE 6**  
**OUTPUT VOLTAGE *THD* FOR EACH PERFORMANCE CLASS**

Performance class	Voltage total harmonic distortion (%)
A	$THD_V \leq 5$
B	$5 < THD_V \leq 10$
C	$10 < THD_V$

A Performance Class C inverter (for output voltage  $THD_V$ ) shall not be described using the term ‘sine wave’ or any variants of this term, such as ‘modified sine wave’ or ‘pseudo-sine wave’.

Table 7 lists the efficiency limits applicable to each class.

**TABLE 7**  
**EFFICIENCY LIMITS FOR PERFORMANCE CLASS A, B AND C INVERTERS**

1	2	3	4
a.c. power (% of rated apparent power)	Test conditions (25°C)		
	Resistive	Reactive PF = 0.75	Nonlinear, 25% of rated VA
<b>Efficiency limits (%)—Class A inverters</b>			
25	$\eta \geq 90\%$	$\eta \geq 90\%$	$\eta \geq 90\%$
50	$\eta \geq 90\%$	$\eta \geq 90\%$	$\eta \geq 90\%$
75	$\eta \geq 90\%$	$\eta \geq 90\%$	$\eta \geq 90\%$
100	$\eta \geq 90\%$	$\eta \geq 90\%$	$\eta \geq 90\%$
<b>Efficiency limits (%)—Class B inverters</b>			
25	$\eta \geq 85\%$	$\eta \geq 85\%$	$\eta \geq 85\%$
50	$\eta \geq 85\%$	$\eta \geq 85\%$	$\eta \geq 85\%$
75	$\eta \geq 85\%$	$\eta \geq 85\%$	$\eta \geq 85\%$
100	$\eta \geq 85\%$	$\eta \geq 85\%$	$\eta \geq 85\%$
<b>Efficiency limits (%)—Class C inverters</b>			
25	$\eta \geq 80\%$	$\eta \geq 80\%$	$\eta \geq 80\%$
50	$\eta \geq 80\%$	$\eta \geq 80\%$	$\eta \geq 80\%$
75	$\eta \geq 80\%$	$\eta \geq 80\%$	$\eta \geq 80\%$
100	$\eta \geq 80\%$	$\eta \geq 80\%$	$\eta \geq 80\%$

Inverters that do not comply with the requirements for Classes A, B or C for efficiency are deemed to not comply with Clause 3.5 of this Standard.

Table 8 lists the voltage regulation limits applicable to each performance class.

**TABLE 8**  
**VOLTAGE REGULATION LIMITS FOR PERFORMANCE CLASS A, B AND C INVERTERS**

Performance class	Voltage regulation limits
A	$\pm 3\%$ of nominal value
B	$\pm 4.5\%$ of nominal value
C	$\pm 6\%$ of nominal value

These values apply from 5% to 100% of rated output apparent power.

Table 9 lists the total current harmonic distortion ( $THD_1$ ) in charging mode applicable to each class.

**TABLE 9**  
**A.C. CURRENT  $THD$  IN CHARGING MODE**  
**FOR EACH PERFORMANCE CLASS**

Performance class	Current total harmonic distortion (%)
A	$THD_1 \leq 5$
B	$5 < THD_1 \leq 10$
C	$10 < THD_1$

APPENDIX A  
GENERAL CONDITIONS FOR TESTS  
(Normative)

**A1 SET-UP AND PRECONDITIONING FOR TESTS**

Prior to each test, the inverter shall be mounted and installed according to the instructions supplied with the inverter. Where the inverter is intended to be installed in a particular manner or configuration (e.g. mounted on a wall), the test installation shall mimic such conditions.

Where the conditions for a test specify an ambient temperature, the inverter shall be installed in a temperature-controlled chamber. The test procedure shall not begin until the chamber and inverter temperatures have reached thermal stability.

After a test, the inverter temperature shall be allowed to return to a steady state before any further test is begun.

**A2 MEASUREMENT UNCERTAINTY**

Unless otherwise noted in the relevant Clause or Appendix of this Standard, the uncertainties of measurement shall be as follows:

A.C. voltage	$\pm 0.5\%$ of reading or better
A.C. current	$\pm 0.5\%$ of reading or better
A.C. power	$\pm 0.5\%$ of reading or better
A.C. power $\leq 20$ W	$\pm 0.1$ W or better
Reactive power	$\pm 0.7\%$ of reading or better
Frequency	$\pm 0.05$ Hz or better
D.C. voltage	$\pm 0.5\%$ of reading or better
D.C. current	$\pm 0.5\%$ of reading or better
D.C. power	$\pm 0.5\%$ of reading or better
D.C. power $\leq 20$ W	$\pm 0.1$ W or better
Ambient temperature	$\pm 2^\circ\text{C}$ or better
Surface temperature	$\pm 4^\circ\text{C}$ or better

**A3 MEASUREMENT OF TEMPERATURES**

The temperature of the inverter heatsink shall be measured on the heatsink to which the inverter's main power switches are thermally connected and as close as possible to the power switches.

The temperature of the inverter transformer winding shall be measured on the transformer winding surface and as close as possible to the centre of the windings. The exact position at which measurements are taken should be noted in the test results.

#### A4 D.C. POWER SOURCE FOR TESTING

The d.c. power source used for testing shall be a storage battery or a constant voltage source, or a combination of power supply and storage battery.

NOTE: When using a power supply to test a single-phase stand-alone inverter, consider the twice line frequency, large-magnitude current ripple that occurs on the d.c. side, as under this condition the ripple current might become negative for a portion of the cycle, particularly under reactive load conditions.

#### A5 THREE-PHASE INVERTERS

With the exception of those in Appendix L, all tests and test circuits are described as for a single-phase inverter. For a three-phase inverter, equivalent balanced three-phase circuits shall be used and the test procedures shall be appropriately modified.

#### A6 GENERAL TEST SET-UP

The general test set-up for the performance tests is as indicated in Figure A1. Any variations or modifications to the basic set-up for a particular test are specified in the corresponding appendix.

NOTES:

- 1 Voltage and current transducers are shown; however, most power analysers will be able to handle direct measurements of a.c. and d.c. voltages and a.c. currents. D.C. currents are relatively large for multi kVA rated inverters, and often require current transducers.
- 2 Ensure that there is only one MEN link in the circuit.
- 3 The load type(s) and value(s) applicable to each test are specified in the corresponding appendix.

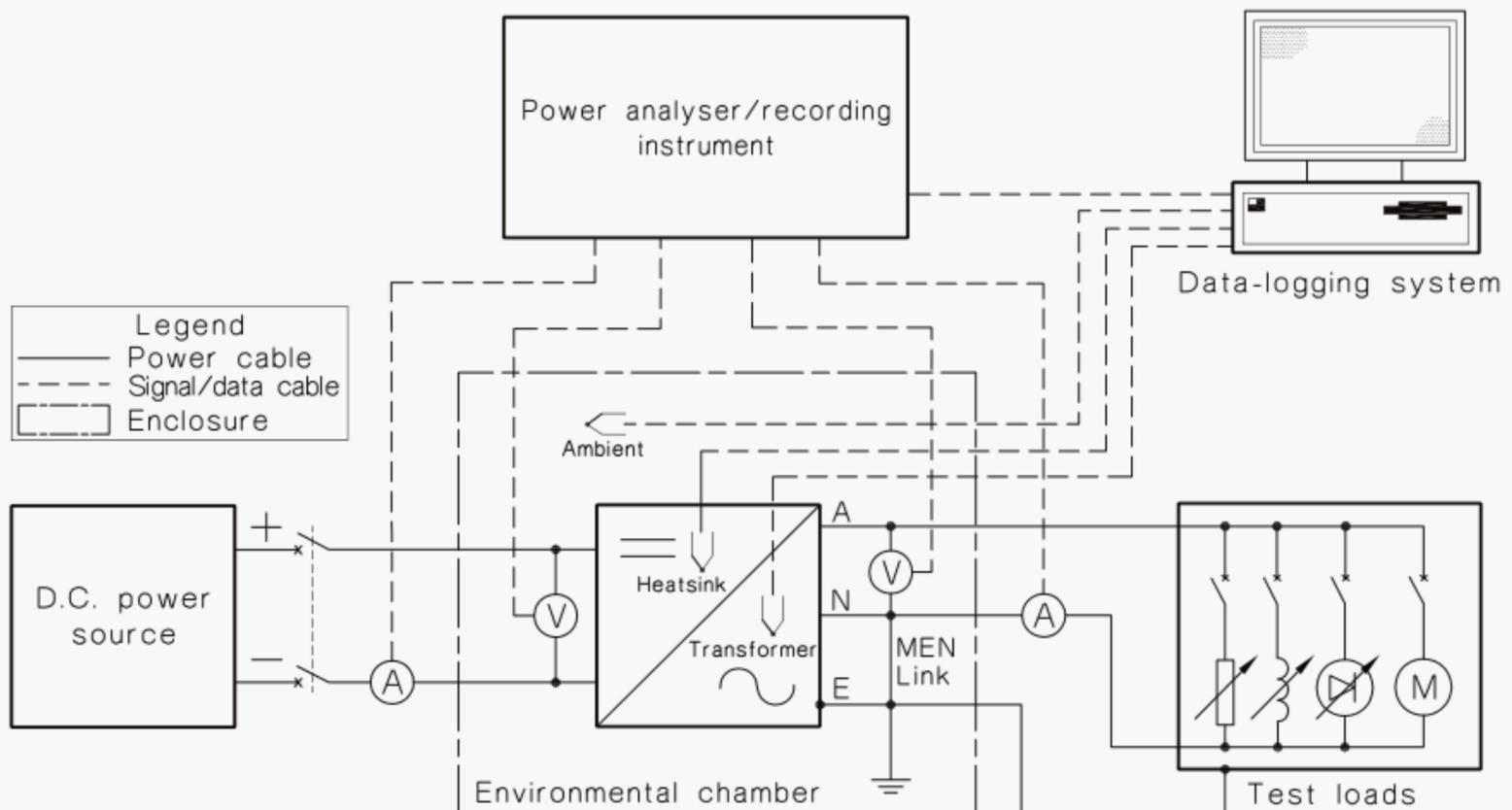


FIGURE A1 GENERAL TEST SET-UP

**A7 VOLTAGE MEASUREMENT SITE**

The inverter a.c. and d.c. voltage measurements shall be taken at the point to which the installer or user would make connection; that is, either at a terminal block within the inverter or its associated hardware, or at the end of the connection wires if the inverter is fitted with permanent connection wires, or at the socket/plug terminals if the inverter is fitted with connection sockets and/or plugs.

APPENDIX B  
PERFORMANCE CLASSIFICATION REPORTING  
(Informative)

<b>Stand-alone Inverter Performance Classification Schedule</b>			
NOTE: The classifications below have been determined by independent type testing according to the requirements of this Standard.			
Manufacturer:	GOOD Inverter Enterprises Pty Ltd		
Address:	Perth, Western Australia		
Contact	info@goodie.com.au		
Model number:	II-FFF-GGG		
<b>Inverter type</b>			
Operation mode	Stand-alone/Inverter-charger/Interactive inverter		Yes/No
<b>Load handling</b>	<b>Continuous</b>	<b>30 min</b>	<b>3 s</b>
25°C	1000 W	1350 W	2000 W
40°C	900 W	—	2000 W
Motor load suitable/not suitable to start a single-phase motor load			
<b>D.C. input voltage</b>	<b>Nominal</b>	<b>Minimum</b>	<b>Maximum</b>
D.C. operating range	24 V	20 V	30 V
<b>A.C. output</b>			
Nominal voltage	230 V	Single-phase	50 Hz
<b>Output power quality</b>	<b>Range</b>	<b>Performance class</b>	
Voltage regulation	±3%/±6%±10%	A/B/C	
Voltage total harmonic distortion	<5%/<10%/>10%	A/B/C	
3-phase operation (where applicable) balanced and unbalanced load capable (Yes/No or combination of)			
<b>Efficiency</b>	<b>Value</b>	<b>Performance class</b>	
Standby mode (optional)	10 W	A/B/C/not applicable	
No-load power loss	15 W	A/B/C	
Power efficiency (25°C)		A/B/C	
% of continuous load	25°C		
25%	93.50%		
50%	93.60%		
75%	91.80%		
100%	90%		
Charging efficiency	90%	Not applicable	

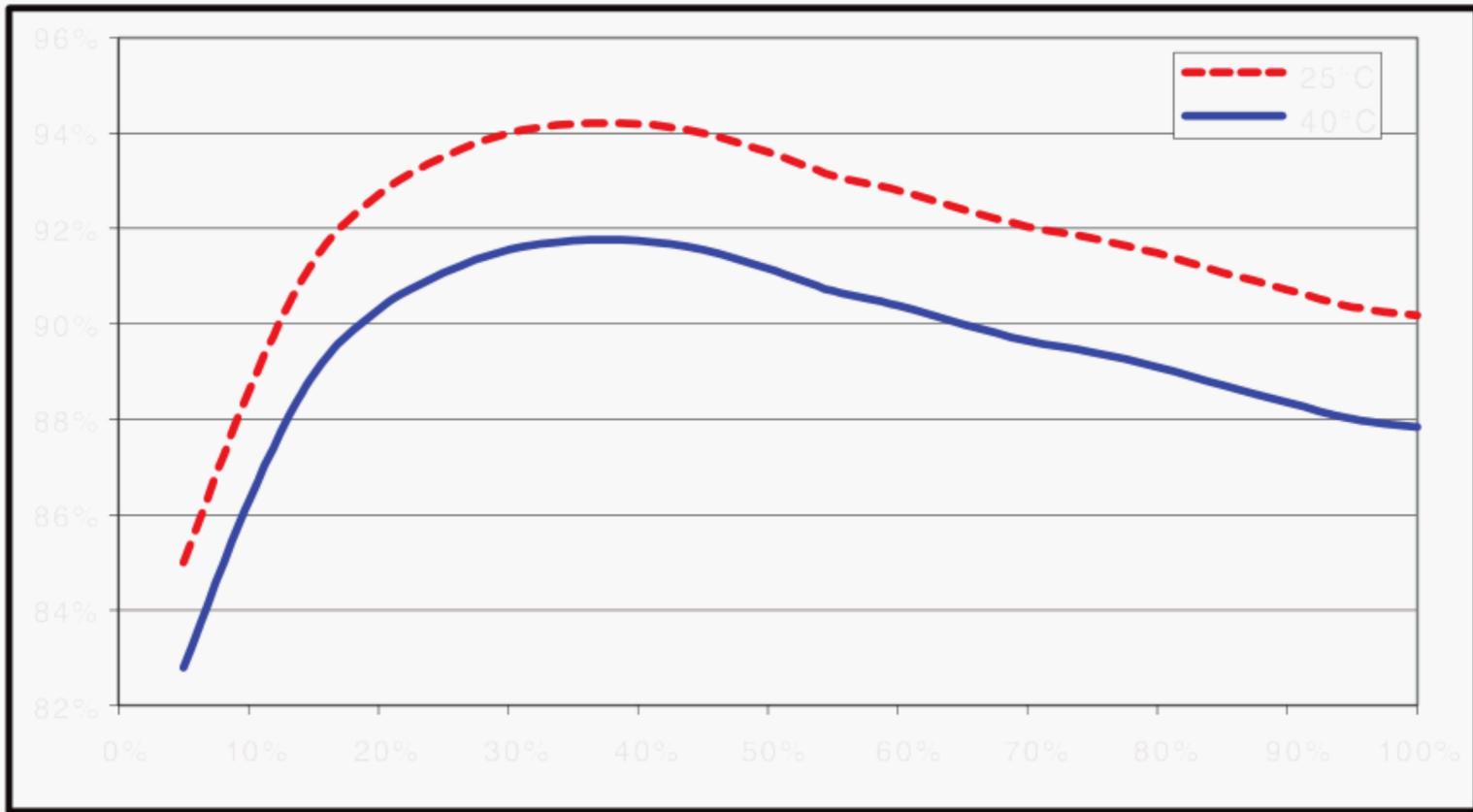


FIGURE B1 POWER EFFICIENCY CURVES AT 25°C AND 40°C

## APPENDIX C

## D.C. OPERATING VOLTAGE RANGE TEST

(Normative)

**C1 GENERAL**

The purpose of this test is to assess the operability of the inverter within the required d.c. operating range as required by Clause 3.2.

The test shall be carried out at an ambient temperature of 25°C.

**C2 TEST PROCEDURE**

The procedure shall be as follows:

- (a) If the low voltage disconnect and high voltage disconnect set points are user adjustable, adjust these values to the minimum and maximum values allowed by the inverter interface respectively.
- (b) The inverter shall be subjected to the procedures described in Paragraph A1 and connected into a test circuit similar to that shown in Figure A1.
- (c) The voltage of the d.c. supply shall be set to the nominal value  $\pm 1\%$ .
- (d) The input and output voltage, current and power, as well as output voltage harmonic distortion and frequency, shall be recorded under each set of test conditions described below.
- (e) A resistive load such that the inverter delivers  $100_{-5}^{+0}\%$  of its rated output power shall be applied to the inverter a.c terminals. Record the parameters specified in (d).
- (f) Adjust the d.c. input voltage to the mid-point between the nominal voltage and the low limit of the d.c. operating voltage range  $\pm 1\%$ . If required, adjust the resistive load such that the inverter delivers  $100_{-5}^{+0}\%$  of its rated output power. Record the parameters specified in (d).
- (g) Adjust the d.c. input voltage to  $100_{-0}^{+2}\%$  of the low limit of the d.c. operating voltage range. If required, adjust the resistive load such that the inverter delivers  $100_{-5}^{+0}\%$  of its rated output power. Record the parameters specified in (d).
- (h) Adjust the d.c. input voltage to the mid-point between the nominal voltage and the high limit of the d.c. operating voltage range  $\pm 1\%$ . If required, adjust the resistive load such that the inverter delivers  $100_{-5}^{+0}\%$  of its rated output power. Record the parameters specified in (d).
- (i) Adjust the d.c. input voltage to  $100_{-0}^{+2}\%$  of the high limit of the d.c. operating voltage range. If required, adjust the resistive load such that the inverter delivers  $100_{-5}^{+0}\%$  of its rated output power. Record the parameters specified in (d).

### **C3 REPORTING**

The following results shall be reported:

- (a) The measured values of inverter output voltage, inverter output voltage harmonic distortion and inverter output frequency, along with the manufacturer-specified tolerances under each of the test conditions specified in Paragraph C2, presented in the form of a table.
- (b) The EUT operational status under the test conditions specified in the procedure and, in particular, any alarms or shut-down events at the limits of the operating voltage range.
- (c) Any fault conditions that occurred during the test.

## APPENDIX D

## D.C. VOLTAGE DISCONNECT AND RECONNECT SET POINTS TEST

(Normative)

**D1 GENERAL**

This test is intended to verify the accuracy of the inverter disconnect and reconnect set points specified by the inverter manufacturer according to the requirements of Clause 3.3. If the inverter does not employ d.c. overvoltage protection, this part of the test may be disregarded and the lack of overvoltage protection noted in the report.

The test shall be carried out at an ambient temperature of 25°C or at the reference temperature specified by the manufacturer. In some instances, the inverter set points may adapt automatically on the basis of a control algorithm specified by the inverter manufacturer (e.g. temperature compensation). The test shall be repeated at an ambient temperature of 40°C if the manufacturer specifies a temperature coefficient for the set points. Where possible, the test shall be performed so that any adaptive behaviour is accounted for and verified.

**D2 TEST PROCEDURE**

The procedure shall be as follows:

- (a) The inverter shall be subjected to the procedures described in Paragraph A1 and connected into a circuit similar to that shown in Figure A1.
- (b) The test shall be conducted at 25°C or at the reference temperature if different.
- (c) Set the input voltage to the nominal value  $\pm 2\%$ .
- (d) Apply a resistive load to the inverter such that the inverter delivers  $10\% \pm 2.5\%$  of its rated power.
- (e) Decrease the inverter d.c. voltage stepwise until the inverter stops supplying power to the load. Record the voltage at which this occurs as the inverter 'low voltage disconnect' voltage.
- (f) If the inverter requires a manual reset or other user intervention after a shut-down, this should be done before the test is continued.
- (g) Increase the inverter d.c. voltage stepwise until the inverter begins supplying power to the load. Record the voltage at which this occurs as the inverter 'low voltage reconnect' voltage.
- (h) Increase the inverter d.c. voltage stepwise until the inverter stops supplying power to the load. Record the voltage at which this occurs as the inverter 'high voltage disconnect' voltage.
- (i) If the inverter requires a manual reset or other user intervention after a shut-down, this should be done before the test is continued.
- (j) Decrease the inverter d.c. voltage stepwise until the inverter begins supplying power to the load. Record the voltage at which this occurs as the inverter 'high voltage reconnect' voltage.

(k) If the inverter has temperature-compensated limits, the test shall be repeated at 40°C.

NOTE: For Steps (e) to (j), the time allowed between each voltage change and the voltage steps may vary, depending on the hysteresis characteristics of the inverter, the d.c. voltage and the inverter set points. When the d.c. voltage is well away from the set point, a time interval of 10 s and 2% voltage steps are appropriate. When the d.c. voltage is close to the set point, a time interval of 1 min or longer should be used and the voltage steps should be less than 0.5% of nominal voltage to reduce trip point measurement uncertainty.

### **D3 REPORTING**

The voltages measured at Steps D2 (d) to D2 (j) above shall be reported, along with the inverter disconnect and reconnect set points as specified by the inverter manufacturer, taking into account any adaptive behaviour. The deviation in % of the voltage disconnect and reconnect points with respect to the EUT set points shall be included in the report to assess compliance with the 2% tolerance as specified in Clause 3.3. The same values shall be recorded if the test is repeated at 40°C as required by Step (k) above.

APPENDIX E  
STANDBY AND NO-LOAD TESTS  
(Normative)

### E1 GENERAL

These tests are used to measure the inverter's no-load power consumption in active and standby modes of operation (where applicable), as required by Clause 3.4. In addition, these tests ensure that an inverter with a standby mode will enter and remain in standby mode when the load is decreased to  $P_{\text{STANDBY-SET}}$  and that the inverter will enter and remain in active mode when the load is increased to  $P_{\text{ACTIVE-SET}}$ .

The test shall be carried out at an ambient temperature of 25°C and at the default or factory settings.

### E2 TEST PROCEDURE

The procedure shall be as follows:

- (a) The inverter shall be subjected to the procedures described in Paragraph A1 and connected into a circuit similar to that shown in Figure A1.

NOTES:

- 1 This test set-up can expose very sensitive circuits in the test equipment (i.e. those that try to measure very small currents) to large transients. For example, allowing the d.c. capacitors within the inverter to charge via a shunt resistor in a power meter may damage the power meter.
  - 2 Auxiliary power sources (if any) are included in all power and energy measurements.
- (b) Set the EUT input voltage to 110% ±2% of the d.c. nominal input voltage.
- (c) Turn on the inverter and set it to standby mode, if applicable.
- (d) Measure the input energy to the inverter over a period of at least 5 min. The standby power loss shall be calculated as the measured energy divided by the measurement period.

NOTE: Power measured in standby mode is typically very small and pulsing. It is generally more accurate to measure energy over a long period of time.

- (e) Turn on the inverter and set it to active mode.
- (f) Measure the input power to the inverter.

NOTE: Where an inverter with a standby mode cannot be forced into an active mode other than by applying a load, the no-load power loss is equal to the input power minus the output power that causes it to change to the active mode; i.e. it is calculated as  $P_{\text{DC}} - P_{\text{ACTIVE}}$ .

- (g) Return the inverter to the standby mode of operation.
- (h) Apply a small resistive load to the inverter. Increase the load in steps of approximately 5% of  $P_{\text{ACTIVE-SET}}$ , allowing at least 10 s between each load change, until the inverter enters active mode. At each step, record the input and output power. Record the output power measurement taken after entering active mode as  $P_{\text{ACTIVE}}$ .
- (i) Decrease the load in steps of approximately 5% of  $P_{\text{ACTIVE-SET}}$ , allowing 10 s between each load change, until the inverter enters standby mode. At each step, record the input and output power. Record the output power measurement taken prior to entering standby mode as  $P_{\text{STANDBY}}$ .

**E3 REPORTING**

The following results shall be reported:

- (a) Standby power loss (in watts), measured in Step E2 (d).
- (b) No-load power loss (in watts), measured in Step E2 (f).
- (c)  $P_{\text{ACTIVE}}$  and  $P_{\text{STANDBY}}$ , measured in Steps E2 (h) and E2 (i) respectively.

APPENDIX F  
EFFICIENCY AND POWER QUALITY TESTS  
(Normative)

**F1 GENERAL**

The purpose of this test is to determine the efficiency, output voltage harmonic distortion, output voltage regulation and frequency regulation of the inverter over a range of loading conditions at nominal d.c. input voltage and reference ambient temperatures as required by Clause 3.5.

The efficiency measurements shall be power efficiencies in accordance with the test schedule shown in Table 1.

The following quantities shall be measured and recorded under each operating condition during the tests:

- (a) D.C. voltage.
- (b) D.C. current (average).
- (c) D.C. current peak (+ and –).
- (d) D.C. current (r.m.s.).
- (e) D.C. power.
- (f) A.C. voltage.
- (g) A.C. current.
- (h) A.C. frequency.
- (i) A.C. power (active and reactive).
- (j) A.C. voltage  $THD_v$ .
- (k) A.C. current  $THD_i$  (only for tests with a nonlinear load).

**F2 TEST PROCEDURE**

The purpose of the test procedure is to determine power efficiencies rather than conversion factors. That is, active input and output power at all frequencies shall be measured as opposed to fundamental power only. (For further information, see the section of IEC 61683 dealing with power efficiency and conversion factors.)

The procedure shall be as follows:

- (a) Place the inverter in a temperature-controlled chamber and connect it to a circuit similar to that shown in Figure A1.  
NOTE: A voltage-regulated d.c. power source is to be used to supply the d.c. input power.
- (b) Set the chamber temperature to the required test temperature according to Table 1.  
NOTE: Test temperatures are within  $\pm 2^\circ\text{C}$  of the required value.
- (c) The inverter shall be subjected to the procedures described in Paragraph A1.
- (d) Apply a resistive load such that the inverter supplies 50% of its rated power at the nominal input voltage  $\pm 2\%$ . Allow the unit to reach thermal stability.

- (e) Apply the loads according to the sequence specified in the test schedule shown in Table 1.

NOTES:

- 1 The inverter d.c. input voltage is to be maintained within the range  $(V_{DC-NOM} - 2.5) \leq V_{INV DC} \leq (V_{DC-NOM} + 2.5\%)$  during the test.
- 2 For each set of test conditions, measurements need to be triggered simultaneously and with the same averaging period. Measurements may be averaged over a period of up to 30 s to account for minor fluctuations.
- 3 After a load change has been made, wait for a few minutes before taking measurements to avoid the steep part of the temperature rise characteristic.
- 4 After measurements with one type of load have been completed, the EUT needs to be allowed to reach thermal stability at the initial load condition of 50% of rated output power before measurements are taken with the next type of load.
- 5 For nonlinear load tests, use the load circuit as specified in Paragraph F3. Adjust the nonlinear load to 25% of the continuous apparent power rating at 0.75 power factor. For readings above 25% of load, top up the nonlinear load with resistive load.

- (f) The test has now been completed.

### F3 NONLINEAR LOAD

The nonlinear load shall be a rectifier load that complies with the requirements of IEC 61683 (i.e.  $THD_{I-SOURCE} = [80 \pm 5]\%$ ) when tested with an a.c source with  $THD_{V-SOURCE} < 5\%$ .

### F4 REPORTING

The results shall be reported as follows:

- (a) A table of inverter efficiency values corresponding to each load percentage and set of test conditions.
- (b) A graph of inverter efficiency as a function of inverter output power for each of the test conditions.
- (c) A graph of inverter a.c. voltage as a function of inverter a.c. power for each of the test conditions.
- (d) A graph of inverter a.c. frequency as a function of inverter a.c. power for each of the test conditions.
- (e) A graph of inverter a.c. voltage  $THD_v$  as a function of inverter a.c. power for each of the test conditions.
- (f) Graphs of the harmonic spectrum at 50% and 100% a.c. power, of resistive load and of ambient temperature of 25°C. Alternatively, individual harmonic values may be reported in the form of a table.

NOTE: If plotting multiple values on one graph would render the graph illegible, values may be plotted on separate graphs as appropriate.

APPENDIX G  
STEADY-STATE LOAD-HANDLING TESTS  
(Normative)

**G1 GENERAL**

The purpose of these tests is to assess the inverter's ability to supply load as required by Clause 3.6.

**G2 TEST PROCEDURE**

The procedure shall be as follows:

- (a) The inverter shall be subjected to the procedures described in Paragraph A1 and connected into a circuit similar to that shown in Figure A1.
- (b) The d.c. input voltage shall be maintained within the range from ( $V_{DC-NOM} \pm 2.5\%$ ) to ( $V_{DC-NOM} + 5\%$ ) during the test.
- (c) Apply a resistive load with a power dissipation equal to 50% of the inverter's full rated power (i.e.  $50\% \pm 2.5\%$ ) to the inverter. Where the power dissipation of the resistive load is equal to  $P_{RES-50\%}$  ( $= 0.5 \times V_{INV AC NOM} \times I_{INV AC NOM}$ ), allow the inverter temperatures to reach thermal stability.
- (d) Operate the inverter under the conditions listed in Table 2 of Clause 3.6.
- (e) After each test, allow the EUT to cool down and reach thermal stability operating with  $P_{RES-50\%}$  load before starting the next test.
- (f) Measure the temperatures of the inverter heatsink (see Paragraph A3) and transformer winding during each test (except 200% or surge load tests). Record these temperatures at intervals no greater than 1 min.
- (g) Record the output voltage, output current, output power, output frequency, input voltage, input current and input power of the inverter during each test at intervals of 1 min or less, except for the surge load tests, where a logging period of 250 ms or less is required.
- (h) The test shall cease when either—
  - (i) the inverter shuts down via its internal overload protection; or
  - (ii) the minimum test duration listed in Table 2 of Clause 3.6 has been exceeded.

**G3 REPORTING**

The following results shall be reported:

- (a) A table recording the conditions of each test, the average input voltage during each test, the duration of each test and the final inverter temperatures measured at the end of each test, along with a note as to whether or not the test ceased as a result of the inverter overload protection or other protection modes.
- (b) For each test, a graph of inverter output voltage, output current and output power, as well as ambient, heatsink and transformer temperatures, plotted as a function of time.  
NOTE: If plotting multiple values on one graph would render the graph illegible, values may be plotted on separate graphs as appropriate.

APPENDIX H  
STEP-LOAD TRANSIENT RESPONSE TESTS  
(Normative)

### H1 GENERAL

The purpose of this test is to assess the stability of the inverter output when subject to a step change in load as required by Clause 3.7. The test load shall be a light electronic load (rectifier) and a step resistive load such that the inverter operates at 80% ( $\pm 5\%$ ) of its continuous apparent power rating.

Transient voltage waveforms shall be sampled at a frequency of at least 10 kHz.

The test shall be carried out at an ambient temperature of  $25^{\circ}\text{C} \pm 3^{\circ}\text{C}$ .

### H2 TEST LOAD

A light rectifier load as indicated in Figure H1 shall be used. If the light electronic load power draw is less than  $P_{\text{ACTIVE-SET}}$ , disable the inverter's load search feature. If the load search feature cannot be disabled, a small resistive load in parallel with the light electronic load may be added to make the inverter go from standby to active mode.

### H3 TEST PROCEDURE

The procedure shall be as follows:

- (a) The inverter shall be subjected to the procedures described in Paragraph A1 and connected into a circuit similar to that shown in Figure A1. The EUT input voltage shall be maintained at  $100\% \pm 5\%$  of the d.c. nominal input voltage.
- (b) Where applicable, disable standby mode. If standby mode cannot be disabled, set  $P_{\text{ACTIVE-SET}}$  to the minimum allowable value.
- (c) Turn on the inverter and apply a light electronic load as specified in Paragraph H2.
- (d) Allow the inverter a.c. voltage and current to reach steady-state conditions.
- (e) Connect a resistive load with a power consumption equivalent to  $80\% \pm 2.5\%$  of the inverter's continuous rated power to the inverter. Sample the inverter's output voltage at the rate of 10 000 samples per second or faster during the connection of the resistive load and until the output voltage reaches a steady state.
- (f) Disconnect the resistive load from the inverter. Sample the inverter's output voltage at the rate of 10 000 samples per second or faster during the disconnection of the resistive load and until the output voltage reaches a steady state.
- (g) Perform Steps (e) and (f) a total of three times.

### H4 CALCULATION OF VOLTAGE-DURATION CURVES

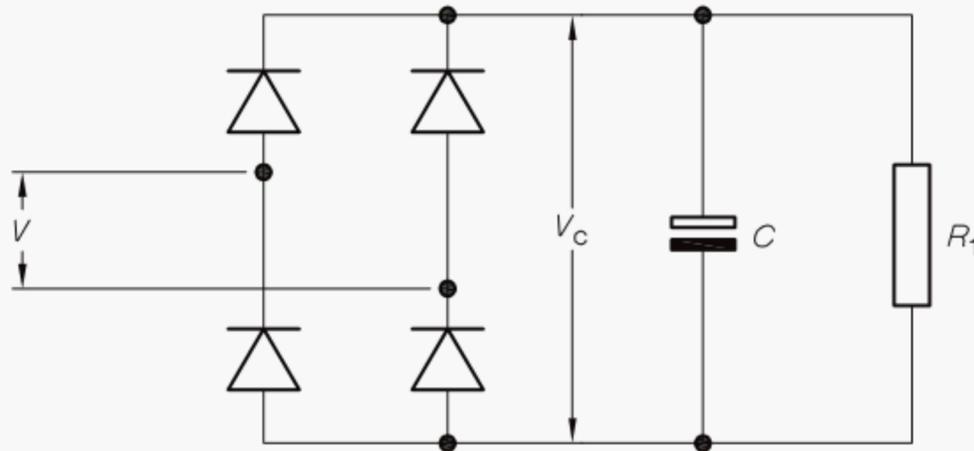
For transient overvoltage events less than or equal to 10 ms in duration, the voltage-duration curve shall be determined using the sampled instantaneous voltage measured at each step change recorded by this test. For each voltage, the number of samples greater than that voltage shall be counted. This number is then multiplied by the sample interval to derive the duration for that voltage. The voltage-duration curve is the locus of all points derived from this process.

For transient overvoltage events greater than 10 ms in duration, the voltage-duration curve shall be determined using the r.m.s. voltages from the sampled data, calculated using a half-cycle sliding window, starting half a cycle before closing the resistive load switch and ending one second later.

### H5 REPORTING

The worst case voltage-duration curves obtained during the step load connection and disconnection shall be reported in a graph that also shows the limits curves shown in Figure 1.

The inverter complies with the transient voltage limit test if the derived voltage-duration curve lies between the curves of Figure 1 at all points.



C = 100  $\mu$ F  
R1 = 560 k $\Omega$

FIGURE H1 LIGHT ELECTRONIC LOAD CIRCUIT DIAGRAM

APPENDIX I  
NOT USED

APPENDIX J  
MOTOR LOAD TESTS  
(Normative)

## J1 GENERAL

The purpose of this test is to assess the inverter's ability to start typical single-phase motor loads as required by Clause 3.8.

This test shall be done on single-phase and three-phase inverters that are not indicated by the manufacturer to be unsuitable for supplying motor loads (see Clause 3.8.3).

NOTE: For a three-phase inverter, the motor load is applied on a per phase basis, and all phases are monitored to assess the inverter's performance. The motor load is applied separately on each phase, and the test is repeated for each phase.

Transient voltage waveforms shall be sampled at a frequency of at least 10 kHz.

The test shall be carried out at an ambient temperature of  $25^{\circ}\text{C} \pm 3^{\circ}\text{C}$ .

## J2 EQUIPMENT REQUIRED

### J2.1 Motor

For this test, a single motor, or a combination of motors connected in parallel, that complies with the specifications in Clause 3.8.2 and with the provisions of Paragraph J2.2 shall be used.

### J2.2 Procedure for selection of motor load

#### J2.2.1 *Start current measurement procedure*

The procedure shall be as follows:

- (a) Connect the motor load via a switch to an a.c. source with an impedance of not more than  $0.2 \Omega$ . If this impedance is unknown, it is best estimated by observing the source voltage drop when the switch is closed, as described in Paragraph J2.2.2.

NOTE: The a.c. source voltage without the motor load should be within 7% of the inverter nominal voltage and the motor nominal voltage, and should have less than 5% THD.

- (b) Sample the instantaneous motor load voltage and current using a logging system at the rate of at least 10 000 samples/second.
- (c) With the motor load not rotating, start logging and close the switch. After the motor load has reached a steady-state speed, stop logging and open the switch. Allow the motor load to stop rotating. Repeat this for five trials and record the test data for each trial.

### J2.2.2 Start current magnitude

The data shall be examined and  $I_{\text{MOT\_START}}$  recorded for each trial.  $I_{\text{MOT\_START}}$  should occur within one cycle of the switch closing. The ratio between  $I_{\text{MOT\_START\_RMS}}$  and  $I_{\text{MOT-NOM}}$  shall fall within the following limits for all five trials for the motor load to be a suitable load for testing stand-alone inverters:

$$4.5 < \frac{I_{\text{MOT\_START\_RMS}}}{I_{\text{MOT-NOM}}} < 8$$

where

$$I_{\text{MOT\_START\_RMS}} = 0.707 \times I_{\text{MOT\_START}}$$

NOTE: Capacitor start induction motors, such as those used in some commercial angle grinders, have starting currents around six times their nominal current.

If the source impedance is unknown, estimate the difference in peak source voltage between the last cycle before the switch is closed and the first cycle after the switch is closed. Source impedance can then be estimated by dividing this difference by  $I_{\text{MOT\_START}}$ .

### J2.2.3 Start current duration

Examine the data and ensure that  $t_{\text{START}}$  falls within the following limits for each trial:

$$1 \text{ s} < t_{\text{START}} < 1.5 \text{ s}$$

If  $t_{\text{START}}$  falls outside these limits, some adjustment to the inertial load (usually a flywheel) may be required. If  $t_{\text{START}}$  cannot be altered to fall within these limits, the motor is not suitable for testing stand-alone inverters.

## J3 TEST PROCEDURE

The procedure shall be as follows:

- (a) The inverter shall be subjected to the procedures described in Paragraph A1 and connected to a circuit similar to that shown in Figure A1. The EUT input voltage shall be maintained at  $100\% \pm 5\%$  of the d.c. nominal input voltage.
- (b) With the inverter in active mode, connect a resistive load  $P_{\text{RES}}$  such that  $P_{\text{RES}} = S_{\text{INV-NOM}} \left( \begin{smallmatrix} +0 \\ -10 \end{smallmatrix} \% \right) - P_{\text{MOT-NOM}}$ .
- (c) Start recording  $V_{\text{INV-AC}}$ ,  $I_{\text{INV-AC}}$  and  $V_{\text{INV-DC}}$  just before connecting the motor load. The logging system shall sample at a rate of not less than 10 000 samples/second.
- (d) Connect the motor load as specified in Clause 3.8.2 and Paragraph J2.2 via a single-pole switch on the active conductor. If more than one motor is used as the motor load, the switch shall operate all the individual motors simultaneously (i.e. individual switches for each motor shall not be used).
- (e) After the motor has reached a steady state, cease logging and disconnect the motor load. Allow 1 min for the inverter to recover, during which time the motor must stop rotating. Repeat this step four more times, saving log files for each of the five trials.
- (f) Remove the resistive load and shut down the inverter.
- (g) An inverter's ability to supply high transient currents is strongly affected by  $V_{\text{INV-DC}}$  during the transient. Examine the data and ensure that, for each of the five trials,  $V_{\text{INV\_DC}}$  remains within the range  $100\% \pm 5\%$  of the d.c. nominal input voltage at all times after the switch is closed.

#### **J4 REPORTING**

The worst case voltage–duration curve obtained during the motor load test shall be reported in the same graph with the limits curves given in Clause 3.7. Transient voltages shall be calculated as r.m.s. voltages from the sampled data, using a half-cycle sliding window, starting half a cycle before closing the motor load switch and ending one second later, or half a cycle after  $I_{\text{MOT-NOM}}$  has been reached, whichever is greater.

APPENDIX K  
CHARGING EFFICIENCY TEST  
(Normative)

**K1 GENERAL**

The purpose of this test is to assess the charging efficiency of an inverter-charger or interactive inverter as required by Clause 3.9.

The test shall be carried out at an ambient temperature of 25°C.

**K2 TEST PROCEDURE**

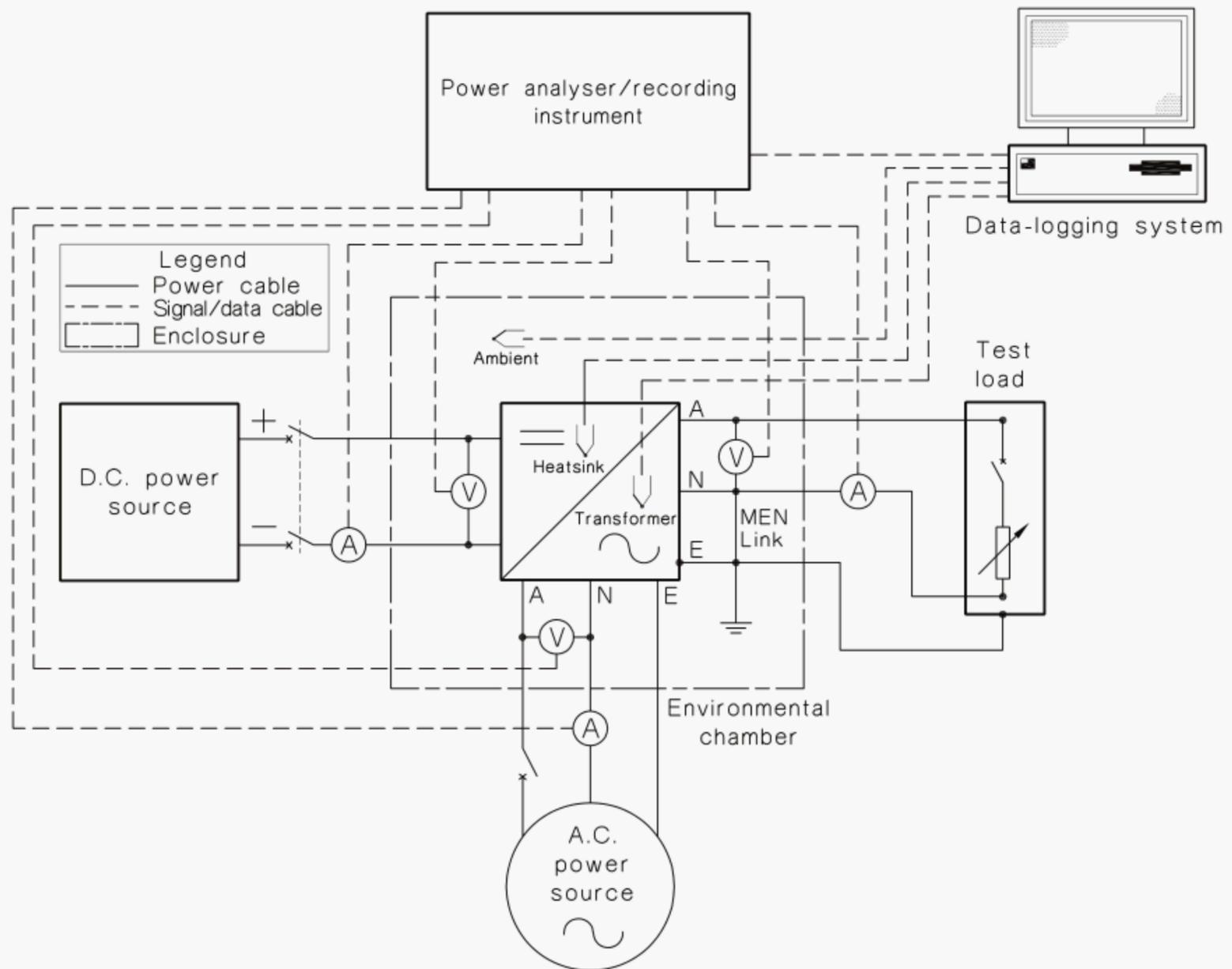
The procedure shall be as follows:

- (a) The inverter shall be subjected to the procedures described in Paragraph A1 and connected into a circuit similar to that shown in Figure K1. The a.c. source used shall be capable of supplying rated current and have an output voltage equal to the nominal value  $\pm 2\%$ , with a *THD*  $< 5\%$  and a frequency output equal to the nominal value  $\pm 1$  Hz.
- (b) Turn on the inverter and set it to operate in the reverse (charging) mode at 100% of the rated charging current. Maintain the EUT d.c. voltage at 110%  $\pm 5\%$  of the nominal d.c. input voltage.
- (c) Measure the input (a.c.) and output (d.c.) power of the inverter.

**K3 REPORTING**

The following results shall be reported:

- (a) The inverter input (a.c.) power, in watts, and the current total harmonic distortion.
- (b) The inverter output (d.c.) power, in watts.
- (c) The charging power efficiency of the inverter at the rated charging current.



## NOTES:

- 1 Voltage and current transducers are shown; however, most power analysers will be able to handle direct measurements of a.c. and d.c. voltages and a.c. currents. D.C. currents are relatively large for multi kVA rated inverters, and often require current transducers.
- 2 Ensure that there is only one MEN link in the circuit.

FIGURE K1 CIRCUIT FOR INTERACTIVE INVERTER AND INVERTER-CHARGER TEST

APPENDIX L  
THREE-PHASE INVERTER TEST  
(Normative)

**L1 GENERAL**

This test is used to assess the ability of a three-phase inverter to supply balanced and unbalanced loads as required by Clause 3.10.

The test shall be carried out at an ambient temperature of 25°C.

**L2 TEST PROCEDURE**

The procedure shall be as follows:

- (a) The inverter shall be subjected to the procedures described in Paragraph A1 and connected into a circuit similar to that shown in Figure A1.
- (b) Ensure that the nominal d.c. input voltage  $\pm 2\%$  is maintained at the inverter's input terminals throughout the test.
- (c) Load the inverter with a balanced three-phase resistive load equal to 100% of the inverter VA rating.
- (d) Measure the voltage between each phase and neutral.
- (e) Load the inverter with a resistive load equal to 100% of the inverter per phase VA rating on one phase and no-load on the remaining two phases.
- (f) Repeat Step (d).
- (g) Repeat Steps (e) and (f) for each phase.

**L3 REPORTING**

Measurements of all three phase-to-neutral voltages and the phase-to-phase voltages under each of the four loading conditions specified shall be reported.

The inverter output voltages from phase to neutral and phase to phase shall comply with the requirements of 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 during the test.

APPENDIX M  
GLOSSARY OF SYMBOLS AND TERMS  
(Normative)

Symbol	Description	Unit	Abbreviation
$I_{INV-AC}$	The measured a.c. current output of the inverter.	Ampere	A
$I_{INV-AC-NOM}$	The r.m.s. current rating of the inverter.	Ampere	A
$I_{MOT-NOM}$	The r.m.s. current ratings of the motor load. These will be provided by the motor manufacturer. Where the motor load comprises a number of motors, this figure is the sum of the individual motor r.m.s. current ratings.	Ampere	A
$I_{MOT-START}$	The peak of the surge current that occurs when the load is connected to a suitable a.c. source.	Ampere	A
$I_{MOT-START-RMS}$	$I_{MOT-START}$ divided by 1.41 so that it can be compared with $I_{MOT-NOM}$ (which is an r.m.s. value).	Ampere	A
$P_{ACTIVE}$	The continuous power load at which the inverter makes the transition from standby mode to active mode during the tests.	Watt	W
$P_{ACTIVE-SET}$	The continuous power load at which the inverter makes the transition from standby mode to active mode as quoted by the manufacturer or programmed in the EUT. A load greater than this should guarantee active mode.	Watt	W
$P_{DC}$	Input (d.c.) power.	Watt	W
$P_{INV}$	The output power of the inverter.	Watt	W
$P_{MOT-NOM}$	The power rating of the motor load. This will be provided by the motor manufacturer. Where the motor load is a number of motors, this figure is the sum of the motor power ratings.	Watt	W
$P_{RES}$	The power dissipation of a resistive load as a function of the resistance value and the nominal voltage of the system. For a resistive load ( $R$ ) applied to the a.c. output of an inverter, it is given by: $P_{RES} = \frac{(V_{INV-AC-NOM})^2}{R}$	Watt	W
$P_{STANDBY}$	The continuous power load at which the inverter makes the transition from active mode to standby mode during the tests.	Watt	W
$P_{STANDBY-SET}$	The continuous power load at which the inverter makes the transition from active mode to standby mode as quoted by the manufacturer or programmed in the EUT. A load less than this should guarantee standby mode.	Watt	W

<b>Symbol</b>	<b>Description</b>	<b>Unit</b>	<b>Abbreviation</b>
$S$	Apparent power.	Volt ampere	VA
$S_{\text{INV-NOM}}$	The VA rating of the inverter as provided by the inverter manufacturer.	Volt ampere	VA
$THD$	Total harmonic distortion.	%	
$THD_I$	Current total harmonic distortion.	%	
$THD_V$	Voltage total harmonic distortion.	%	
$t_{\text{START}}$	The time elapsed during the motor load test between the switch closing and the motor current (measured with a half-cycle sliding window) reaching $I_{\text{MOT-NOM}}$ .	second	s
$V_{\text{DC-NOM}}$	Nominal d.c. voltage.	Volt	V
$V_{\text{INV-AC}}$	The a.c. output voltage of the inverter measured at the inverter's output terminals.	Volt	V
$V_{\text{INV-AC-NOM}}$	The nominal r.m.s. a.c. output voltage of the inverter.	Volt	V
$V_{\text{INV-DC}}$	The d.c. voltage of the inverter measured at the inverter's d.c. terminals.	Volt	V

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ISBN 0 7337 9046 1

Printed in Australia