

Stabilized power supplies, d.c. output —

Part 4: Tests other than radio-frequency interference

UDC 621.311.024:621.316.721/.722.1

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW



Document Sharing Hub

Cooperating organizations

The Power Electrical Engineering Standards Committee, under whose direction this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

- Associated Offices Technical Committee
- Association of Short Circuit Testing Authorities
- British Electrical and Allied Manufacturers' Association (BEAMA)*
- British Railways Board*
- British Steel Corporation
- Department of Energy, Electricity
- Electrical Contractors' Association
- Electrical Contractors' Association of Scotland
- Electrical Research Association*
- Electricity Supply Industry in England and Wales*
- Engineering Equipment Users' Association*
- Institute of Purchasing and Supply
- Institution of Electrical Engineers
- Ministry of Defence
- National Coal Board*
- Trades Union Congress

The organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

- Accumulator Makers' Association
- Association of Consulting Engineers
- Association of Supervisory and Executive Engineers
- British Steel Industry
- Control and Automation Manufacturers' Association (BEAMA)
- Electric Vehicle Association of Great Britain
- Electronic Components Industry Federation
- Electronic Engineering Association
- Home Office
- London Transport Executive
- Post Office
- Scientific Instrument Manufacturers' Association

This British Standard, having been prepared under the direction of the Power Electrical Engineering Standards Committee, was published under the authority of the Executive Board and comes into effect on 28 February 1979

© BSI 10-1999

The following BSI references relate to the work on this standard:
Committee reference PEL/50
Draft for comment 77/28037 DC

ISBN 0 580 10467 2

Amendments issued since publication

Amd. No.	Date of issue	Comment

Contents

	Page
Cooperating organizations	Inside front cover
National foreword	ii
1 General remarks	1
2 General definitions	1
3 Instrumentation	1
4 Conditions of measurement	1
5 Set of test data	1
6 Time separation	2
Section 1. Load effect	
7 Definition	2
8 Conditions of measurement	2
9 Equipment required	2
10 Set-up and procedure (voltage-stabilized power supplies)	3
11 Set-up and procedure (current-stabilized power supplies)	3
12 Presentation of results	3
13 Alternates, precautions and error analysis	3
Section 2. Source effect	
14 Definition	3
15 Conditions of measurement	4
16 Equipment required	4
17 Set-up and procedure (voltage-stabilized power supplies)	4
18 Set-up and procedure (current-stabilized power supplies)	4
19 Presentation of results	4
20 Alternates, precautions and error analysis	5
Section 3. Periodic and random deviation (Pard)	
21 Definition	5
22 Conditions of measurement	5
23 Equipment required	5
24 Set-up and procedure	6
25 Alternates, precautions and error analysis	6
Section 4. Drift	
26 Definition	6
27 Conditions of measurement	6
28 Equipment required	7
29 Set-up and procedure	7
30 Alternates, precautions and error analysis	8
Section 5. Output impedance	
31 Definition	8
32 Conditions of measurement	8
33 Equipment required	8
34 Set-up and procedure for voltage-stabilized power supplies	9
35 Set-up and procedure for current-stabilized power supplies	9
36 Alternates, precautions and error analysis	9
Section 6. Temperature effect	
37 Definition	10
38 Conditions of measurement	10
39 Equipment required	10
40 Set-up and procedure	10

	Page
41 Alternates, precautions and error analysis	11
Section 7. Transient performance measurement	
42 General	11
43 Scope	12
44 Conditions of measurement	12
45 Equipment required	12
46 Set-up and procedure	12
47 Alternates, precautions and error analysis	13
Section 8. Settling effects	
48 Definition	13
49 Conditions of measurement	13
50 Equipment required	14
51 Set-up and procedure	14
52 Alternates, precautions and error analysis	14
Section 9. Other individual effects	
53 General	14
54 Conditions of measurement	15
55 Equipment required	15
56 Set-up and procedure	15
57 Alternates, precautions and error analysis	15
Section 10. Combined effects	
58 Definition	15
59 Conditions of measurement	16
60 Equipment required	16
61 Set-up and procedure	16
62 Alternates, precautions and error analysis	17
Section 11. Total effect	
63 Definition	17
64 Conditions of measurement	17
65 Equipment required	17
66 Set-up and procedure	17
Section 12. Measurement of quantities related to the source	
67 Definition	17
68 Conditions of measurement	18
69 Equipment required	18
70 Set-up and procedure	18
71 Alternates, precautions and error analysis	19
Section 13. Capacitance to source terminals	
72 Definition	19
73 Conditions of measurement	19
74 Equipment required	19
75 Set-up and procedure	19
Section 14. Capacitance to frame	
76 Definition	20
77 Conditions of measurement	20
78 Equipment required	20
79 Set-up and procedure	20

	Page
Section 15. Common-mode current	
80 Definition	21
81 Equipment required	21
82 Set-up and procedure	21
83 Alternates, precautions and error analysis	21
Section 16. Boundary condition measurements	
84 General	22
85 Threshold measurement	22
86 Conditions of measurement	22
87 Equipment required	23
88 Set-up and procedure for voltage-stabilized power supplies	23
89 Set-up and procedure for current-stabilized power supplies	23
90 Measurement of maximum limited values	23
91 Measurement of the value of the bounded output quantity for the extremity of load	24
92 Measurement of the peak value of the bounded output quantity	24
Section 17. Sound level	
93 Definition	24
94 Conditions of measurement	24
95 Equipment required	24
96 Set-up and procedure	24
97 Calculation of sound level	25
Section 18. Control effects	
98 General	25
99 Conditions of measurement	25
100 Equipment required	26
101 Set-up and procedure	26
Figure 1	27
Figure 2	28
Figure 3	28
Figure 4 — Load effect measurement set-up, voltage-stabilized power supply	29
Figure 5 — Load effect measurement set-up, current-stabilized power supply	29
Figure 6 — Source effect measurement set-up, voltage-stabilized power supply	30
Figure 7 — Source effect measurement set-up, current-stabilized power supply	30
Figure 8 — Set-up for voltage-stabilized power supplies	31
Figure 9 — Set-up for current-stabilized power supplies	32
Figure 10 — Typical plots of impedance versus frequency	33
Figure 11	34
Figure 12 — Set-up for measurement of quantities related to the source	35
Figure 13 — Measuring capacitance to source terminals	36
Publications referred to	Inside back cover

National foreword

This British Standard has been prepared under the direction of the Power Electrical Engineering Standards Committee. It is identical with Publication 478-4:1976 “*Stabilized power supplies, d.c. output*” Part 4 “*Tests other than radio-frequency interference*” published by the International Electrotechnical Commission (IEC).

“1.1 Scope” in the IEC text applies generally to all the Parts of IEC Publication 478. For the purposes of Part 4 the following should be added:

“This Part specifies tests other than those for radio frequency interference.”

Terminology and conventions. The text of the International Standard has been approved as suitable for publication, without deviation, as a British Standard. Some terminology and certain conventions are not identical with those used in British Standards; attention is especially drawn to the following.

Where the word “publication” appears, referring to this standard, it should be interpreted as “British Standard”.

Cross references. For each of the following International Standards referred to in the text, there is a corresponding British Standard; these are as listed below:

International Standard	Corresponding British Standard
IEC Publication 179:1973	BS 4197:1967 <i>as amended by AMD 1871:1976 A precision sound level meter</i> (Technically equivalent)
IEC Publication 443:1974	BS 5148:1975 <i>Method for specifying the performance of stabilized power supply apparatus</i> (Technically equivalent) BS 5654 <i>Stabilized power supplies, d.c. output</i>
IEC Publication 478-1:1974	Part 1:1978 <i>Terms and definitions</i> (Identical)
IEC Publication 478-2:1975	Part 2:1978 <i>Rating and performance</i> (Identical)

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 36, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 General remarks

1.1 Scope

This standard applies to stabilized power supplies designed to supply d.c. power from an a.c. or d.c. source for applications such as, but not necessarily limited to, the following:

- computers;
- telecommunications;
- laboratories;
- industrial equipment.

Calibrated stabilized power supplies for electrical measurement purposes are excluded from the scope of this publication.

1.2 Object

This standard sets forth suggested procedures by which certain performance characteristics associated with voltage-stabilized or current-stabilized power supplies can be measured. The methods outlined are not the only way of conducting each measurement, but represent a reliable means of obtaining data against which other test procedures may be judged. An attempt has been made to minimize the need for specialized equipment, and no specific instruments are recommended.

2 General definitions

In addition to those given in IEC Publication 478-1, Part 1: Terms and Definitions, the following definitions apply:

The performance characteristics of stabilized power supplies are determined in terms of the *effect* a varying influence quantity has upon the stabilized output quantity, *all other influence quantities* being held *constant or within a range of values* such that their cumulative influence on the stabilized output quantity is negligible. For purpose of measurement, the magnitude of the cumulative effect of all other influence quantities shall be less than one-tenth of the *specified* magnitude of the effect being observed.

The combined limit of error, composed of instrumentation accuracy and the cumulative effect of spurious influences, shall be regarded as the limiting tolerance on the accuracy of each measurement result.

When measurements are made for the purpose of establishing a value or specification, the value obtained shall be considered to be uncertain by an amount equal to this tolerance.

When measurements are made for the purpose of verification, the value shall be considered as verified if it does not exceed the limits of the specification by an amount equal to this tolerance.

3 Instrumentation

Measuring apparatus shall have sufficient resolution, stability and accuracy so as to ensure a limit of error not exceeding 10 % of the measured effect *specification*. For each test, though not individually specified, sufficient metering and monitoring shall be provided so as to ensure compliance with the test conditions.

4 Conditions of measurement

Quantities not described in the individual tests are as those specified in IEC Publication 478-2, Part 2: Rating and Performance, under “Reference conditions” of Tables I and II, under “Tolerance G”.

5 Set of test data

Measurements on variable-output supplies, subject to a variety of loads and other influences, inevitably require repetition of tests to form a set of data corresponding to the possible combination of outputs and important influences.

The individual test procedures will suggest a *minimum* set of tests, designed to yield data at situation extremes. Additional testing at closer data points to provide more information may be undertaken optionally.

6 Time separation

The response to a sudden *changing* influence will, in general, have three parts: a transient phase, a steady-state phase and (possibly) a settling phase.

The transient phase is characterized by an amplitude and time measurement and may be influenced by the rate at which the event occurs. The steady-state phase is generally the response of interest — the object of most test measurements. The settling phase represents the re-establishment of system equilibrium with its environment following changed operating conditions and is usually observed when altered dissipation requires establishment of a new thermal equilibrium.

Since measurement of a transient effect is quite different from the measurement of a steady-state effect, and because all of the transient effects are similar, a separate test for transient effects is described (Section 7) and the individual transient effects are excluded from the steady-state measurements.

Section 1. Load effect

7 Definition

Load effect is measured as the change in the stabilized output quantity caused by changes in load. All other influence quantities are held such that their cumulative influence is less than one-tenth of the *load effect* specification. The steady-state load effect is considered to exist at a time equal to five times the load effect recovery time and should be measured during the interval between $5t_r$ and $(5t_r + 10 \text{ s})$ (see Figure 1, page 27).

8 Conditions of measurement

8.1 Quantities not described are as those specified in IEC Publication 478-2 under “Reference conditions” of Tables I and II, under “Tolerance G”.

8.2 Source

Load effect measurements shall be made with the source voltage set to the lowest rated value and repeated with the source voltage set to the highest rated value.

8.3 Stabilized output quantity

If the power supply offers a selection of output settings, conduct the load effect measurement at maximum rated value and repeat with the stabilized output quantity set to minimum rated value. If the minimum value is zero, conduct the measurement at 1 % of maximum value.

8.4 Load

The variable influence quantity for this measurement is the load quantity (current or voltage) which is varied within its rated range and other ranges for which a load effect is specified.

8.5 Multiple output power supplies

Conduct a series of load effect measurements for each output with all other outputs set simultaneously to minimum and then to maximum value and loaded to the minimum and maximum amounts.

9 Equipment required

9.1 A means for detecting changes in the value of the stabilized output quantity. In order to observe a small change in the presence of a large static quantity, a differential instrument or balancing arrangement is recommended with suitable precautions to avoid exceeding the common-mode rating of the instrument.

9.2 A means of loading the power supply capable of switching through the range of required loads.

9.3 For measurements on current-stabilized power supplies, a suitable current monitoring means. A suggested means is a 4-terminal resistor chosen to drop the minimum voltage consistent with the 10 % limit of error.

9.4 In the case where the power supply under test cannot operate in the absence of a load, it should be assured, before switching on, that a minimum permanent safety load is applied to the output.

10 Set-up and procedure (voltage-stabilized power supplies)¹⁾

Connect load and measuring apparatus to the output terminals of the power supply in such a way that the current drawn by the load causes negligible error in the measured voltage.

In practice, a 4-terminal connection will be used such that the monitoring circuit does not include any conductor or part thereof that is also carrying load current.

Make the load effect measurement by varying the load current through its rated or specified range.

Measure the amplitude of the change in the stabilized output voltage during the interval $5t_r$ to $(5t_r + 10 \text{ s})$ following the load change. The load current should be varied from minimum to maximum and then from maximum to minimum, with a separate recording of value made for each direction. Repeat for each combination of source voltage and output setting to obtain a set of data.

11 Set-up and procedure (current-stabilized power supplies)

Connect the current monitoring means so that its indication is exclusively proportional to current. Connect the load in such a way that the voltage dropped across it causes negligible error in the measured current.

Make the load effect measurement by varying the load voltage through rated or specified range. Measure the amplitude of the change in the stabilized output current during the interval $5t_r$ to $(5t_r + 10 \text{ s})$ following the load change. The load voltage should be varied from minimum to maximum and then from maximum to minimum, with a separate recording of value made for each direction. Repeat for each combination of source voltage and output setting to obtain a set of data.

12 Presentation of results

Express the load effect either as a percentage of maximum output — or in units of a volt (or fractions thereof) for voltage-stabilized power supplies, or in units of an ampere (or fraction thereof) for current-stabilized power supplies. To express the load effect for variable output power supplies, both a percentage and absolute value shall be used.

13 Alternates, precautions and error analysis

13.1 In measuring load effect on voltage-stabilized supplies, avoid series resistance in the load path between the measuring point and the power supply output terminals. Care should be exercised in the placement of ammeters and leads to avoid such series resistance (see Figure 2, page 28).

13.2 In measuring load effect on current-stabilized power supplies, avoid shunt conductance across the load terminals between the measuring point and the power supply output terminals. Care should be exercised in the placement of voltmeters and other instrumentation to avoid such shunt conductance (see Figure 3, page 28).

13.3 When measuring voltage or current *limited* power supplies, or power supplies with combined characteristics (crossover point), care should be taken to ensure that the stabilized output quantity is not *limited* by the power supply's bounding circuit for any combination of source, output or load conditions of the test.

13.4 The voltage drop in the current monitoring resistor, used for measurements on current-stabilized power supplies, unavoidably restricts the amount of load voltage range, limiting the minimum load voltage to a non-zero value. This instrumentation limit is to be considered in making an error analysis.

Section 2. Source effect

14 Definition

Source effect is measured as the change in the stabilized output quantity caused by a change in the source voltage. All other influence quantities are held such that their cumulative influence is less than one-tenth of the *source effect* specification. The steady-state source effect is considered to exist at a time equal to five times the source effect recovery time and should be measured during the interval between $5t_r$ and $(5t_r + 10 \text{ s})$ similar to Figure 1, page 27, with the load step change replaced by a source step change.

¹⁾ See Figure 4, page 29.

15 Conditions of measurement

15.1 Quantities not described are as those specified in IEC Publication 478-2 under “Reference conditions” of Tables I and II, under “Tolerance G”.

15.2 Source

The variable influence quantity for this test is the source voltage which is varied within its rated and other ranges for which source effect is specified.

15.3 Stabilized output quantity

If the power supply offers a selection of output settings, conduct the source effect test at maximum rated value and repeat with the stabilized output quantity set to the minimum rated value. If the minimum rated value is zero, conduct the test at 1 % of maximum value.

15.4 Load

Two load settings should be used to create a set of data for the source effect measurement.

- Minimum or zero load.
- Maximum load.

15.5 Multiple output power supplies

Conduct a series of source effect measurements for each output with all other outputs set simultaneously to minimum and then to maximum value and loaded to the minimum and maximum amounts.

16 Equipment required

16.1 A source of primary energy for the power supply capable of varying the magnitude of the source voltage between the specified limits and of sufficient rating so that the loading imposed by the power supply does not result in significant change in either source amplitude or distortion.

16.2 A means of detecting changes in the stabilized output quantity. In order to observe a small change in the presence of a large static quantity, a differential instrument or balancing arrangement is recommended with suitable precautions to avoid exceeding the common-mode rating of the instrument.

16.3 For measurements on current-stabilized power supplies, a suitable current monitoring means. A suggested means is a 4-terminal resistor, chosen to drop the minimum voltage consistent with the 10 % limit of error.

17 Set-up and procedure (voltage-stabilized power supplies)

Connect load and measuring apparatus to the output terminals of the power supply in such a way that the current drawn by the load causes negligible error in the measured voltage. In practice, a 4-terminal connection will be used. Connect the power supply to the variable source.

Make the source effect measurement by varying the source voltage magnitude throughout its rated or specified range. Measure the amplitude of the change in the stabilized output voltage during the interval $5t_r$ to $(5t_r + 10 \text{ s})$ following the step change in the source voltage. Repeat for each combination of output voltage and load current to obtain a set of data.

18 Set-up and procedure (current-stabilized power supplies)

Connect the current monitoring means so that its terminal voltage (or indication) is exclusively proportional to current. Connect the load in such a way that the voltage dropped across it causes negligible error in the measured current.

Make the source effect measurement by varying the source voltage magnitude throughout its rated or specified range. Measure the amplitude of the change in the stabilized output current during the interval $5t_r$ to $(5t_r + 10 \text{ s})$ following the step change in the source voltage. Repeat for each combination of output current and load voltage to obtain a set of data.

19 Presentation of results

Express the *source effect* in terms of the percentage change of the stabilized output quantity and/or as the absolute magnitude of the measured change in the units of the stabilized output quantity.

20 Alternates, precautions and error analysis

20.1 In measuring the source effect on voltage or current *limited*, or automatic crossover power supplies, care should be taken to ensure that the stabilized output quantity is not *limited* by the power supply's bounding circuits for any combination of source, output or load condition of this test.

20.2 The voltage drop in the current monitoring resistor, used for measurements on current-stabilized power supplies, unavoidably restricts the amount of load voltage range, limiting the minimum load voltage to a non-zero value. The instrumentation limit is to be considered in making an error analysis.

20.3 If the power supply source connection is accomplished via terminals provided by the manufacturer, measurement of the source voltage should be made at these terminals. Otherwise, measurement of the source voltage is to be accomplished at the plug end of the power cord which the manufacturer provides or recommends for use with the power supply.

Section 3. Periodic and random deviation (Pard)

21 Definition

PARD is measured as the unprogrammed fluctuations in the stabilized output quantity of a power supply (previously "ripple and noise"). PARD is composed of such fluctuations as occur in the frequency range 20 Hz to 10 MHz. Fluctuations below 20 Hz are treated as *drift* (see Section 4) and those above 10 MHz are excluded.

22 Conditions of measurement

22.1 Quantities not described are as those specified in IEC Publication 478-2 under "Reference conditions" of Tables I and II, under "Tolerance G".

22.2 Source amplitude

PARD measurement shall be made with the source voltage set to the lowest specified value and repeated with the source voltage set to the highest specified value.

22.3 Source frequency

PARD measurement shall be made at the highest specified nominal source frequency and repeated at the lowest specified nominal source frequency.

22.4 Stabilized output quantity

If the power supply offers a selection of output settings, conduct the PARD measurement at the maximum rated value and repeat with the stabilized output quantity set to minimum rated value, if the minimum value is zero, conduct the test at 1 % of maximum value.

22.5 Load

Two load settings shall be used in generating the data set for the PARD measurements. A measurement with the load set to its maximum rated value, and a second with the load set to its minimum, rated value.

22.6 Multiple output power supplies

Conduct the series of PARD measurements for each output with all other outputs set simultaneously to minimum and then to maximum value and loaded to the minimum and maximum amounts.

23 Equipment required

23.1 A source of primary energy for the power supply capable of producing the rated extremes of both voltage and frequency, and of such construction that the loading imposed by the power supply does not result in significant change in either source amplitude or distortion.

23.2 A means of loading the power supply capable of switching through the range of required loads.

23.3 For measurements on current-stabilized power supplies, a suitable current monitoring means. A suggested means is a 4-terminal resistor, chosen to drop the minimum voltage consistent with the 10 % limit of error.

The current monitoring resistor shall be of non-reactive construction such that its impedance remains essentially constant over the 20 Hz to 10 MHz range. A comparison of its impedance at 10 MHz with its impedance at 20 Hz shall exhibit a difference less than one-tenth of the d.c. resistance — otherwise the test data must be compensated for frequency.

24 Set-up and procedure

24.1 Connect the variable source and load(s) to the power supply and monitor the PARD amplitude in the stabilized output quantity. For current-stabilized power supplies, use the current monitoring means.

Set the source voltage, source frequency, stabilized output and load to each specified value and repeat for each combination to form a set of data on PARD.

24.2 Express PARD in voltage units for voltage-stabilized power supplies, and in ampere units for current-stabilized power supplies.

25 Alternates, precautions and error analysis

25.1 A single ground point shall be used to avoid loops. Care must be exercised to be certain that the ground current does not flow in any conductor that also forms part of the PARD measuring circuit.

NOTE Suitable safety precautions must be taken to ensure the continuity of the grounding connection.

25.2 If differential-input measuring equipment is used, care must be exercised to ensure that the rated common-mode voltage is not exceeded and that the error introduced by the common-mode signal, multiplied by the instrument's rejection ratio, when combined in absolute magnitude with all other effects, does not exceed 10 % of the PARD specification.

25.3 The voltage drop in the current monitoring resistor, used for PARD measurements on current-stabilized power supplies, unavoidably restricts the minimum load voltage to a non-zero value. This is an instrumentation error and is to be considered in making an error analysis.

25.4 Shield as required, to prevent noise pickup from contributing a PARD component in excess of the 10 % cumulative limit of error.

25.5 For PARD measurements on voltage limited or current limited or automatic crossover power supplies, care must be taken to ensure that the controlled output quantity is not limited for any combination of source, output or load conditions of the test.

Section 4. Drift

26 Definition

Drift is measured as the change in the stabilized output quantity during a specified period of time — following warm-up — all other influence quantities held such that their cumulative influence is less than one-tenth of the *drift* specification. The drift measurement includes output perturbations in the frequency range d.c. to 20 Hz.

27 Conditions of measurement

27.1 Quantities not described are as those specified in IEC Publication 478-2 under “Reference conditions” of Tables I and II, under “Tolerance G”.

27.2 Stabilized output quantity

If the power supply offers a selection of output settings, conduct the *drift* measurement at maximum rated value and repeat with the stabilized output quantity set to minimum rated value. If the minimum value is zero, conduct the measurement at 1 % of maximum value.

27.3 Load

Method I: Set the load to the maximum rated value.

Method II: Operate the power supply unloaded.

27.4 Multiple output power supplies

Method I: Conduct the drift measurement with all outputs loaded to their maximum outputs.

Method II: Conduct the drift measurement with all outputs unloaded.

28 Equipment required

28.1 A means for detecting changes in the value of the stabilized output quantity whose own variations (drift) over the period of observation are sufficiently small that, combined in absolute magnitude with all other effects, they do not introduce a limit of error exceeding one-tenth of the power supply's *drift* specification.

The measuring means shall respond to perturbations in the frequency range from d.c. 0 to 20 Hz and shall exclude signals over 20 Hz by means of a low-pass filter whose response falls by at least 6 dB per octave.

A strip-chart readout of the measured changes in stabilized output quantity is recommended. If the upper frequency cutoff of the recorder is less than 20 Hz, supplemental observation shall be made with a cathode-ray oscilloscope, fitted with a 20-Hz low-pass filter. Such observation shall be made for a period of 5 min, once during the first hour of the measurement and again during the last hour.

28.2 A means for controlling the environment (particularly the temperature) of the power supply, such that the temperature effect, combined in absolute magnitude with all other effects, does not contribute an error exceeding one-tenth of the power supply's *drift* specification.

28.3 For measurements on current stabilized power supplies, a suitable current monitoring means. A suggested means is a 4-terminal resistor, chosen to drop the minimum voltage consistent with the 10 % limit of error.

29 Set-up and procedure

29.1 Operate the power supply under test conditions for the specified warm-up period. If no warm-up time is specified, allow half an hour for warm-up. During this period, adjust output setting, load, source and measuring instruments. No adjustments may be made once measurements have begun.

The completion of the turn-on transient settling effect (warm-up) should be determined by the method described in Section 8.

29.2 Record the changes in the stabilized output quantity for the specified interval of time. If no duration is specified, the recording shall be for a minimum of 8 h. During this period, the values of source voltage, load and environmental temperature shall be recorded at intervals no greater than 30 min. For current-stabilized power supplies, employ the current monitoring means.

29.3 The drift is the absolute measured difference between the maximum and minimum values of the stabilized output quantity occurring within the measurement time span. Report as a percentage change, or in the units of the stabilized output quantity, i.e. volts or amperes, or fractions thereof.

29.4 The drift measurement shall be identified as having been made in accordance with Method I of this standard, if it is accomplished in a temperature-controlled environment, fully loaded.

29.5 Identify the drift measurement as being in accordance with Method II of this standard, if it is accomplished in a temperature-controlled environment, not loaded.

29.6 In the event that a temperature-controlled environment cannot be provided, conduct the drift measurement as follows and identify the results as Method III of this standard.

Method III

Construct a draft shield, each dimension 1 m greater than that of the power supply and set up in the best air-conditioned space available. Measure the temperature at three points in the space surrounding the power supply and average. Multiply the observed (average) temperature change from the maximum to the minimum value during the drift measurement interval by the power supply's temperature effect coefficient and subtract the magnitude of the product from the magnitude of the observed change in the stabilized output quantity.

For Method III, the power supply should be operated so loaded as to minimize the self-heating of the immediate environment.

30 Alternates, precautions and error analysis

30.1 When measuring the drift of a stabilized output current, if necessary, the monitoring means shall be maintained in a temperature-controlled environment so that changes in its value combined in absolute magnitude with all other effects affect the drift measurement by an amount less than one-tenth of the power supply's *drift* specification.

30.2 For measurements on voltage-limited or current-limited or automatic crossover power supplies, care should be taken to ensure that the controlled output quantity is not limited for any combination of source, output and load condition of the test.

Section 5. Output impedance

31 Definition

Output impedance is measured as the ratio of the amplitude of a sinusoidally changing output voltage to the amplitude of the changing output current. It is the dynamic *load effect*, measured in the frequency domain. The output impedance is, generally, a variable function of frequency and is expressed by describing the function for a specified band of frequencies.

32 Conditions of measurement

32.1 Quantities not described are as those specified in IEC Publication 478-2 under "Reference conditions" of Tables I and II, under "Tolerance G".

32.2 Stabilized output quantity

If the power supply offers a selection of output settings, conduct the output impedance measurement at maximum rated value.

32.3 Load

The variable influence quantity for the output impedance measurement is the load which is varied or modulated in sinusoidal fashion about a fixed value equal to 50 % of its specified maximum or rated value.

The modulation amplitude shall be no larger than is sufficient for the measurement of the sinusoidal response variations in the stabilized output quantity, but shall not exceed 100 %. That is, the peak value of the varying load shall not exceed the maximum rating of the power supply, nor shall it go below zero or become negative.

32.4 Modulation frequency

The load shall be modulated over a sufficient band of frequencies so as to encompass any frequency for which information is required. In any event, the band of modulation frequencies shall be sufficient so as to clearly define the *slope* (rate-of-change) of output impedance versus frequency.

32.5 Number of measurements

Plotting points shall be sufficiently close so as to adequately depict irregularities or discontinuities in the output impedance slope.

33 Equipment required

33.1 A *source of primary energy* for the power supply of sufficient rating that the modulated loading imposed by the power supply does not result in significant change in source voltage. Particularly, source voltage changes in synchronism with the modulation waveform, multiplied by the source effect, shall contribute to a cumulative error less than one-tenth of the specified output impedance at the frequency.

33.2 A *means for loading* the power supply capable of being modulated over the required frequency range.

a) For voltage-stabilized power supplies

The load may take the form of a low impedance power amplifier able to swing the required current and suitably decoupled from the d.c. voltage of the power supply, *in parallel* with a resistive load set to draw 50 % of the rated current.