DEC STANDARD 002 REV.C

TITLE: AC POWER WIRING, SAFETY GROUNDING, RECEPTACLE AND ELECTRICAL RATING INFORMATION REQUIREMENTS

ABSTRACT: This standard defines requirements for ac power wiring and grounding. It specifies the types of outlets, power cords and plugs, and electrical rating information to be used on Digital's hardware products.

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1 INTRODUCTION

This standard defines requirements for ac power wiring and safety grounding, types of outlets, power cords and plugs, and name plates required for use on Digital's hardware products.

1.1 PURPOSE

The purpose of this standard is to assure acceptance for installation and use in compliance with various local and national electrical codes that relate to the subjects named in the title of this standard.

1.2 SCOPE

This standard applies to all Digital hardware products that are designed to connect to ac power sources. Specified requirements are in effect as of the approval date for this revision.

The grounding requirements specified by this standard relate only to product safety requirements. Signal grounding requirements are not included. For that information, refer to DEC STD 136, Signal Integrity.

1.3 RESPONSIBILITIES

1.3.1 Design Engineering

Design engineers who are responsible for new hardware products that are covered by this standard are responsible for assuring that their product will comply with this standard.

1.3.2 Product Managers

It is the Product Manager's responsibility and decision to determine the need for modifying existing hardware products to comply with the current requirements of this standard. In some cases, it may be necessary to make such modifications to assure that currently-produced hardware products will continue to be acceptable for installation and use in certain markets.

1.3.3 Power Supply Engineering

This standard is controlled and maintained by Digital's Power Supply Engineering group. For additional information, contact:

Frank Loya
ML3-4 E86 DTN 223-5116

1.4 REFERENCED STANDARDS AND DOCUMENTS

1.4.1 Digital Standards

DEC STD 060	Design and Certification of Hardware Products To National and International Regulations and Standards
DEC STD 119	Product Safety
DEC STD 122	AC Power Line Standard
DEC STD 136	Signal Integrity

Copies of the referenced Digital Standards can be obtained from:

Digital Standards Administration
ML3-2 E56 DTN 223-9475 RCS: VM1P

1.4.2 Other Documents

UL 478	Electronic Data-Processing Units and Systems
CEE 7, 17, and 22	International Commission On Rules For the Approval of Electrical Equipment Publications 7, 17, and 22

Copies of these documents can be obtained from:

International Regulations or Corporate Product Safety
PK3-2/H13 DTN 223-5966

1.5 CONFORMANCE

Any exceptions to or deviations from the requirements of this standard must be reviewed and approved by the Engineering Committee.

All hardware products that are designed to connect to an ac power source, either permanently or by means of detachable power cords, shall conform to the requirements in UL 478 and National Electrical Codes. The requirements of this standard are compatible with the requirements of DEC STD 113, Product Safety. However, compliance with this standard does not exempt the design engineer from the responsiblity of meeting the additional product safety requirements specified in DEC STD 113.

Note

Acceptance of a product by one agency, for example Underwriter's Laboratory (UL), does not mean the product will be automatically accepted or certified by any other agency. However, compliance with the requirements specified in this standard will result in compliance with most of the national and international regulations.

A complete summary of national and international product safety requirements is included in DEC STD 060.

2 COLOR AND PHASE SEQUENCE EQUIPMENT-REQUIREMENTS

2.1 FLEXIBLE AC POWER CORD CONDUCTORS

The following colors shall be used:

a. For 3-Phase Use in U.S., Canada, and Europe

Five Wire - 4 conductors plus ground
Line - 1 brown, 2 blacks
Neutral - 1 light blue
Ground - 1 green/yellow

b. For 2-Phase or Single-Phase in U.S., Canada, and Europe

Four Wire - 3 conductors plus ground
Line - 1 black, 1 brown
Neutral - 1 light blue
Ground - 1 green/yellow

c. For Single-Phase Use in U.S., Canada, and Europe

Three Wire - 2 conductors plus ground
Line - 1 brown
Neutral - 1 light blue
Ground - 1 green/yellow

2.2 PHASE SEQUENCE SENSITIVE EQUIPMENT

The designer of phase sequence sensitive equipment has the responsibility to provide phase sequence detection or other circuits that prevent damage to the equipment when connected to ac sources with reverse sequence.

3 WIRE SIZES REQUIRED FOR FLEXIBLE POWER CORDS

Table 1 lists wire size requirements for flexible cord. The following notes shall be used to determine wire sizes.

Table .. Ampacity of Flexible Cord Based on 30 C Ambient (e)

Wire Size AWG	Single Phase Circuits	Three Phase Circuits	
	Two Current Carrying Conductors	Three Current Carrying Conductors (c)	Four Current Carrying Conductors (d)
	Temperature Rating of Insulation (f)		
	105 C	105 C	105 C
18	10	7	5
16	13	10	8
14	18	15	12
12	25	20	16
10	30	25	20
8	40	35	28
6	55	45	36
4	70	60	48
2	95	80	64

Notes to Table 1

a. No ac power cord wire shall be smaller than 18 AWG (or 0.75 mm^2, if metric).

b. Currents listed in Table 1 are nominal rms values. The nominal rms value is the value required at nominal line voltage and full load.

c. A neutral conductor that carries only the unbalanced current (as is the case of balanced 3-phase linear loads) is not considered as a current-carrying conductor.

d. In multiphase circuits where the load currents are non-sinusoidal (as is the case with power supplies with capacitive input filter circuits), the neutral conductor may carry harmonic currents with an rms value that is a significant percentage of the phase currents. In these instances, the neutral conductor must be considered a current-carrying conductor.

e. The ampacities shown in Table 1 are taken from the National Electrical Code for flexible cords and cables.

f. The temperature rating of all power cord insulation shall be 105 C.

g. No derating of ampacity is required for power cords operating at ambients below 65°C. Above that ambient temperature, consult with Component Engineering.

4 POWER ENTRY REQUIREMENTS

Digital hardware products are designed to accept the following most common distribution voltages:

120 V	60 Hz	Single Phase
220 V	50 Hz	Single Phase
240 V	50 Hz	Single Phase
120/240 V	60 Hz	Single Phase, Center-Tapped
120/208 V	60 Hz	Three Phase, wye
220/380 V	50 Hz	Three Phase, wye
240/416 V	50 Hz	Three Phase, wye

For the most part, equipment is designed to accept multiple voltages after rewiring and/or making component changes in the ac input section. Power cords and plugs are also changed.

Where the end use and marketing requirements cover a narrow spectrum, the voltage conversion means and power entry method may be a straight-forward choice. For instance, a standalone product designed for operation only at 120 V, 60 Hz, an attached power cord with a NEMA configured plug is the logical choice.

Where the end use and marketing requirements cover a wide spectrum such as a product designed to be either a standalone device or cabinet mounted and which will accept either 120 V, 60 Hz or 240 V, 50 Hz, the voltage conversion and power entry method needs closer scrutiny for the following reasons:

a. To meet national and international safety standards and electrical codes.

b. To reduce problems in manufacturing.

c. To reduce problems in matching power cord and plugs to 50 Hz and 60 Hz voltage sources.

d. To make the product more acceptable for dock merge programs.

Subheads 4.1, 4.2, and 4.4 provide criteria and guidelines for power entry methods for use on Digital equipment to achieve uniformity through standardization in as much as it is possible to do so, realizing the diversity in power distribution voltages, the multiplicity of plug cap configurations, and differences in international requirements.

These criteria and guidelines apply to all Digital equipment that requires an ac power cord, whether that equipment is designed for:

Stand alone use only; cabinet mounting only; or both.
120 V input; 240 V input; or both
50 Hz, 60 Hz only, or both.

For some applications and specific equipment types, design requirements may preclude complying with the strategy described in subhead 4.4. In this case, the design requirement will dictate the means of power entry and power conversion method.

4.1 METHODS OF CONNECTION

4.1.1 Power Cords

The cord conductors are connected to terminals either by captive screws, nuts, or fast-on tabs. Fast-on tabs may only be used where less than 6-ampere steady state current is required but never on the safety ground conductors.

Power cords must always be provided with strain relief devices.

Power cords are attached either to terminals where entry into the equipment is not necessary or to terminals buried within the equipment.

The product may be designed to be shipped with the power cord attached, or to be attached on-site with appropriate instructions.

Equipment designed for power cords to be attached at the customer site must be in compliance with certain UL and European requirements. Refer to DEC STD 060 and DEC STD 119 for a summary of these requirements.

4.1.2 Power Cord Sets

The cord set is connected to the equipment using an appliance-type connector. The use of a cord set does not require entry into the equipment enclosure and thus allows easier replacement. Strain relief devices are not required. In multi-voltage equipment, the cord set is particularly advantageous because it simplifies matching power cord plugs to various international receptacle configurations.

Selecting the proper cord set for equipment intended for European markets is advantageous to both large programs besides the final international customer is able to unpack and make use of the equipment readily by connecting to the source with the cord set provided. Unfortunately, selection of a single cord set for all markets is impossible due to the variation in standards.

In countries where mandatory testing of products by an approved testing agency is required, the plug and/or cord set must also be approved.

4.1.3 General Compliance Information

Countries which require testing of power cords, cord sets, plugs, and cordage, and some of their testing agencies are listed below:

Country	Testing Agency
Australia	SECV
Austria	OVE
Belgium	CEBEC
Canada	CSA
Denmark	DEMKO
Finland	FEMKO
Germany	VDE
Netherlands	KEMA
Norway	NEMKO
Sweden	SEMKO
Switzerland	SEV
United States	UL

Equipment designed to use cord sets and destined for use in Europe must be provided with equipment connectors complying with CEE standards.

CEE 22 standard sheet V and VI covers appliance connectors for use in equipment rated at 6 amperes at 24J V. This connector type has UL and CSA approval for use to 15 amperes (derated to 12 amperes) at 12J V.

U.S. type connectors are not acceptable in Europe for connection to the mains power. However, they may be used in cabinet-mounted equipment where the cord set mates only with NEMA receptacles mounted in power controller equipment.

Cord sets will not be used for equipment rated greater than 16 amperes, and intended for direct connection to customer supplied power.

4.2 VOLTAGE CONVERSION METHODS

Unless approved otherwise by the Engineering Committee or by design constraints imposed by the nature of the equipment, all Digital hardware products must be designed to operate from Group 2 and 4 voltages specified in DEC STD 132.

Some of the methods used to accomplish the adaptation of products from one voltage to another voltage level are described in the following paragraphs.

4.2.1 Two Separate Units

The adaptation of a product from one voltage level to another voltage level is accomplished by replacing its main input power equipment. This is done where the power equipment is not easily converted. Examples are the 861B (240 V Power Controller) or 861C (120 V Power Controller.) Another example is the H7420A (120 V Power Supply) or the H7420B (240 V Power Supply).

4.2.2 AC Input Subassembly

The conversion is accomplished by replacing only a portion of the power system; usually that portion containing primary power components with singular voltage ratings; for instance 120 V contactors and 240 V contactors. For example, this method is used in the H765 Power Supply where the ac input subassembly 70-14420-00 is used for 120 V applications and 70-14420-01 for 240 V applications. Another example is the H7100 Power Supply where an ac input subassembly is used for easy conversion.

4.2.3 Voltage Selection Switch

The conversion is accomplished by a voltage select switch where the operation of the switch results in the complete conversion of the product or power equipment. For example, this method is used in the VT100 and some TU58 products. It is usually used in devices rated at less than 1500 VA and where the conversion can be made with minor circuit changes (accomplished by the switch).

4.2.4 Plug-In Jumper Blocks, Internal or External Surface

This method is a variation of the method described in subhead 4.2.3. The conversion is accomplished by plugging in a jumper block(s) with two possible orientations. This method is used in the RL01.

4.3 WARNING DECALS ON EQUIPMENT

Where equipment can be easily converted by voltage conversion methods described in subheads 4.2.3 and 4.2.4, and where these devices are easily accessible from outside the equipment by customers or Field Service personnel, a multilingual (English, French, German, Spanish) instruction decal shall be placed over or near the conversion device. Refer to DEC STD 119 for details.

4.4 POWER ENTRY METHODS

Power entry methods are presented in Table 2. The three columns of Table 2 refer to the physical location of the equipment.

Stand alone:	Refers to units designed for stand alone use. Examples are the VT100 and RP05.
Cabinet-mounted:	Refers to units designed for cabinet-mounting only. Examples are the H7420 Power Supply and 869 Power Controller.
Both:	Refers to units designed to be either standalone or cabinet mounted. For example, the PDP-11/03, RX01, (RX78).

The rows of the matrix consist of power level groups and voltage rating sub-groups.

Group A: Equipment rated up to 1.4 kVA and single phase
Sub-Group A1: Equipment designed for 120 V only.
A2: Equipment designed for 240 V only and 220 V.
A3: Equipment designed to accept 120 or 240 V (usually after conversion).

Group B: Equipment rated 1.4 kVA up to 3.7 kVA and single phase.

Group C: Equipment requiring three phases -

The number listed for each voltage rating sub-group for each type of physical equipment location relates to the following numbered power entry methods:

1. Use cord set.
Use CEE 22-6A type connector on equipment.
Use 125 V NEMA plug on cord set.

2. Use cord set.
Use CEE 22-6A type connector on equipment.

For Switzerland, ship cord set 17-00210-XX.
For UK, ship cord set (17-00209-XX) with 250 V BS1363 British plug.
For rest of Europe, ship cord set (17-00199-XX) with Schuko plug.
For Australia, ship cord set 17-00198-XX.

3. Use cord set.
Use CEE 22-6A type connector on equipment.
Use 250 V NEMA plug.

4. Use cord set.
Use CEE 22-6A type connector on equipment.
Use voltage conversion warning decal; refer to subhead 4.3.

For Switzerland, ship cord set (17-00210-XX).
For U.S. and Canada, ship cord set with 125 V NEMA plug.
For UK, ship cord set (17-00209-XX) with 250 V BS1363 British plug.
For rest of Europe, ship cord set (17-00199-XX) with Schuko plug.
For Australia, ship cord set (17-00198-XX).

5. Use cord set.
Use CEE 22-6A type connector on equipment.
Use voltage conversion warning decal; refer to subhead 4.3.
Use cord set with 250 V NEMA plug or 125 V NEMA plug.

6. Use attached power cord.
Use 125 V NEMA plug.

7. Use attached power cord.
Use Schuko type plug.

8. Use attached power cord.
Use 250 V NEMA plug.

9. Use attached power cord to the removable ac input power section (refer to 4.2.2).
Use voltage conversion warning decal; refer to subhead 4.3.

For Europe, ship with Schuko plug.
For UK, ship with BS1363 plug.
For U.S. and Canada, ship with 125 V NEMA plug.

10. Use attached power cord to the removable ac input power section (refer to 4.2.2).
Use voltage conversion warning decal; refer to subhead 4.3.
Use 125 V NEMA plug or 250 V NEMA plug.

11. Use appliance type connector on equipment, except on power controllers.
Use cord set with 125 V NEMA plug.

12. Use appliance type connector on equipment, except on power controllers.
Use cord set with 250 V NEMA plug.

13. Use appliance type connector on equipment, except on power controllers.
Use voltage conversion warning decal; refer to subhead 4.3.
Use cord set with 125 V or 250 V NEMA plug.

14. Use field accessible terminals with safety cover and strain relief.
Use voltage conversion warning decal (refer to 4.3 and 4.1.1).

15. Use field accessible terminals with safety cover and strain relief (refer to 4.1.1).

Some General Observations Regarding Table 2:

a. All equipment in Group A (1.4 kVA or less) uses the appliance connector and a cord set. This allows easy cord replacement in case of damage or to match the power source.

b. All equipment in [illegible] three-phase [illegible] accessible terminals. This [illegible] case of damage or to match the power source.

c. All equipment for which alone [illegible] that allows a [illegible]

Table 2. Matrix for Determining Power Entry Method

Power Level Group	Voltage Rating Sub-Group	*Power Entry Method For: Stand Alone	Cabinet Mounted	Both
A	1. 120 V 12 A, 60 Hz	1	1	1
Equipment Rated Up to 1.4 kVA and Single Phase	2. 240 V 6 A, 50 Hz	2	2	2 or 3
	3. Both of the above	4	4	4 or 5
B	1. 120 V 24 A, 60 Hz	6 or 11	6 or 11	6 or 11
Equipment Rated From 1.4 kVA to 5.7 kVA and Single Phase	2. 240 V 12 A, 50 Hz	7	8 or 12	7 or 8
	3. Both of the above	9 or 14	10 or 13	9 or 14
	4. 240 V 24 A,	15	9 or 12	9 or 15
C Three-Phase Equipment	1. 120/208 V, 3-phase, 60 Hz	16	17	16
	2. 220/380 V or 240/416 V 3-phase, 50 Hz	16	17	16

*Refer to notes in Subhead 4.4

4.5 STRAIN RELIEF

Attached and flexible power cords must be strain-relieved so that mechanical strain caused by pushing, pulling, twisting or bending will not be transmitted to terminals, splices, or internal wiring.

Strain reliefs of re-wirable, non-detachable power cords shall meet the following requirements:

a. The cable or cord cannot touch clamping screws in the strain relief if these screws are accessible or electrically connected to accessible metal parts.

b. The cable or cord cannot be clamped by a metal screw that bears directly on it.

c. When replacing power cords, at least one part of the strain relief is securely fixed to the equipment.

d. The strain relief must not require use of special tools.

e. The strain relief must accommodate the different types of cable or cord that are likely to be used for the equipment when its power cord is replaced.

f. The strain relief means shall withstand a pull of 35 pounds for one minute on the cable or cord while the cord connections within the unit are disconnected.

g. The jacket of the cord or cable must extend beyond the strain relief for a distance equal to at least to the diameter of the cord.

h. The strain relief must be keyed, or otherwise constructed to prevent turning.

4.6 TERMINAL MARKINGS

The equipment input terminals to which the power cord conductors are connected shall be marked to indicate their function.

Terminals for the neutral wire shall be marked by N.

Terminals for line connections shall be marked by L for single phase, and L1, L2 and L3 for multi-phase connections.

Terminals shall not be marked by the wire color that is to be connected to it, because differences exist in power cord color requirements and language of different countries. Refer to 5.6 for earth connection terminal marking.