USER MANUAL

PDX 1400 Generator with Load Match

5706047-F

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User Manual

PDX 1400 Generator with Load Match

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ADVANCED ENERGY®

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⚠ WARNING:

Read this entire manual and all other publications pertaining to the work to be performed before you install, operate, or maintain this equipment. Practice all plant and product safety instructions and precautions. Failure to follow instructions can cause personal injury and/or property damage. All personnel who work with or who are exposed to this equipment must take precautions to protect themselves against serious or possibly fatal bodily injury.

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Introduction

This manual documents how to safely install, operate, maintain, and troubleshoot the PDX 1400 Generator with Load Match. Retain this manual for future reference.

READ THIS SECTION!

To ensure safe operation, users should read and understand all of the information contained herein before attempting to install or operate the unit. At a minimum, read and heed the “Safety” section in this chapter.

INTERPRETING THE MANUAL

This manual is designed with distinguishing headings and subheadings and incorporates a comprehensive index to help users find the information they seek. In addition, the manual contains type conventions and icons to help users recognize unit features and important symbols.

Type Conventions

To quickly identify certain words and phrases in type that differ from the rest of the text, please note the following type conventions:

- Pin and signal names appear in capitalized italics (*DUTY CYCLE.A*).
- Unit labels (switches, indicators, etc.) generally appear in boldface capital letters (**MODIFY**); however, they appear as you see them on the unit. Exceptions are port names, which simply begin with a capital letter (User port).
- Functions appear in boldface lowercase letters (**analog input filtering**).
- Commands appear in small, bold capital letters (**START**)

Icons (Symbols)

This symbol represents important notes concerning potential harm to people, this unit, or associated equipment. It is found whenever needed in the manual.

Advanced Energy includes this symbol in Danger, Warning, and Caution boxes to identify specific levels of hazard seriousness.

DANGER:

This box identifies hazards that could result in severe personal injury or death.

WARNING:

This box identifies hazards or unsafe practices that could result in personal injury.

CAUTION:

This box identifies hazards or unsafe practices that could result in product or property damage.

The following symbols could appear on labels on your unit.

Hazardous Voltage

Short circuit protected

High voltage

1028

Protective earth ground

1029

CE label

1020

Troubleshooting label

Primary checklist for unit performance evaluation			
If *INTERLOCK* LED is not lit: 1) Turn on front panel power switch 2) Verify RF output cover is attached correctly	If *RF ON* LED does not light: 1) Verify interface cable is properly attached	If *SETPOINT* LED does not light: 1) Verify the tap setting and reflected power level	If *FAULT* LED lights when front panel power switch is turned on: 1) Verify fans are running and airflow is not blocked
Refer to troubleshooting flow chart in the manual			

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SAFETY

Do not attempt to install or operate this equipment without proper training.

- Ensure that this unit is properly grounded.
- Ensure that all cables are properly connected.
- Verify that input line voltage and current capacity are within specifications before turning on the power supplies.
- Use proper ESD precautions.
- BE CAREFUL AROUND THIS EQUIPMENT.

PRODUCT SAFETY/COMPLIANCE

Certain options of this unit have been tested for and comply with the following Electromagnetic Compatibility (EMC) directives and standards.

Directives and Standards

Table 1-1 lists the EMC and Safety directives.

Table 1-1. *Electromagnetic compatibility (EMC)*

Directive	Description
89/336/EEC	EC Council directive on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive).
EN 50082-2	Electromagnetic Compatibility (Generic Immunity Standard—Industrial)
EN 55011 (EN 50081-2)	Limits and Methods of Measurement of Radio Disturbance Characteristics of Industrial, Scientific, Medical (ISM) Radio Frequency Equipment (Class A, Group 2) (CISPR 11).

Table 1-2. *Safety directives*

Directive	Description
73/23/EEC	EC Council directive on the harmonization of the laws of the Member States relating to electrical equipment designed for use within certain voltage limits (LVD - Low Voltage Directive).
EN 50178	Electronic Equipment For Use In Electrical Power Installations
SEMI S2-93	Safety Guidelines for Semiconductor Manufacturing Equipment

This device must be installed and used only in compliance with the standards listed in addition to VDE 0113, EN 60204 (IEC 204), and applicable requirements.

Certification

This product is verified by:

- CE marking, self addressed by AE Compliance Engineering
- EMC measurements, verified by TÜV Product Services

For more information, refer to the letter of conformance (US) or declaration of conformity (EU) accompanying the product.

Installation Requirements

WARNING:
Operating and maintenance personnel must receive proper training before installing, troubleshooting, or maintaining high-energy electrical equipment. Potentially lethal voltages could cause death, serious personal injury, or damage to the equipment. Ensure that all appropriate safety precautions are taken.

WARNING:
RISK OF DEATH OR BODILY INJURY. Disconnect all sources of input power before working on this unit or anything connected to it.

Conditions of Use

To be in compliance with the stated directives and standards, you must meet the following conditions of use.

- This device must be used in an overvoltage category II installation only.
- Before making any other connection, connect the auxiliary Protective Earth ground conductor on the rear panel.
- Use only a shielded power cable on the output power connector.
- Use only a shielded cable on the input power connector.
- Use only a properly terminated, shielded cable on the generator user port.
- Install and operate this device only in a pollution degree 2 or better environment, which means an indoor location such as a computer room, office, or factory floor where only non-conductive pollution occurs during operation. Occasionally, a temporary conductivity caused by condensation occurs when the device is not operating.
- Non-standard connectors for input and/or output power must be inaccessible to the user.
- If your generator does not have a circuit breaker, install and operate it with an AE-approved circuit breaker on the ac input to provide the required over-current protection.

Chapter 2

Theory

This chapter describes the PDX 1400 unit, including its theory of operation.

GENERAL DESCRIPTION

The PDX 1400 is a CE-compliant, mid-frequency (MF), power delivery system that provides both MF generation and load match elements in one, compact enclosure. This manual includes four options of the system: option 141 (235 to 305 kHz) and options 143, 144, and 145 (325 to 375 kHz).

The PDX 1400 system is designed to regulate on the power delivered to the load, as measured at the output of the generator. Remote signals sent to the generator user connector control the PDX 1400 power control functions. In addition, the front panel features **TAP SELECT** and **FREQUENCY** controls. Since no moving match network elements are required, the system provides improved inherent reliability.

The PDX 1400 is designed to operate reliably with an ambient air temperature of +40°C max (maximum value of average over 24 hr = 35°C). If the PDX 1400 is enclosed in a cabinet, do not allow the temperature to exceed the maximum ambient temperature.

The PDX 1400 protects itself from damage under the following conditions:

- Any unmatched load condition occurring at the unit output. Output power fold-back (limiting) occurs as required by the generator protection circuits.
- Any internal over-current condition not directly related to the output load condition as protected by current limiting or fuse.
- Excessive internal temperature that may be caused by excessive ambient operating temperature.
- Any combination of input ac line phase drop out.
- Input line brown out (under-voltage) or over-voltage.

THEORY OF OPERATION

Figure 2-1 and Table 2-1 provide a high-level description of the operation of the PDX 1400.

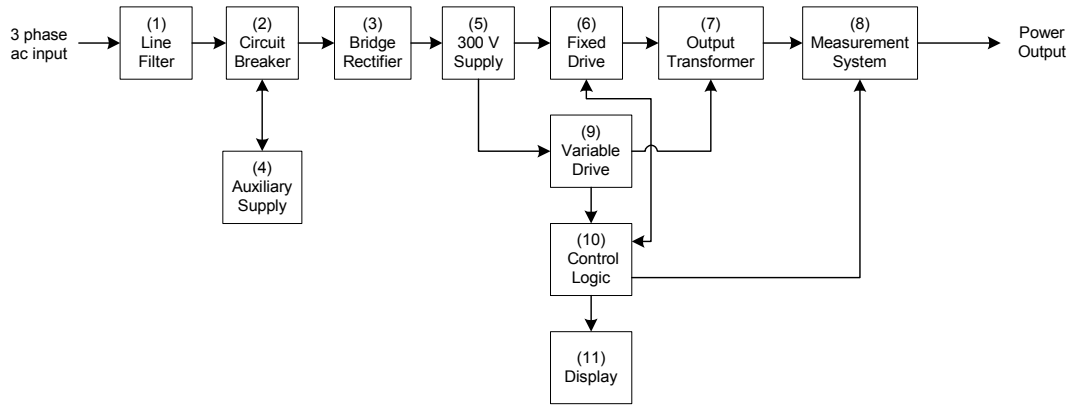

Figure 2-1. *Theory of operation block diagram*

Table 2-1. *Theory of operation block diagram explanation*

Block	Explanation
Line Filter (1)	The line filter keeps undesirable electrical emissions from being impressed on the incoming ac power line and is designed to meet CE requirements for conducted emissions and safety.
Circuit Breaker (2)	The circuit breaker protects the power supply from serious damage in the event that an internal over-current condition exists.
Bridge Rectifier (3)	The bridge rectifier converts the ac line voltage to dc.
Auxiliary Supply (4)	The auxiliary supply provides power to the internal control and logic circuits.
300 V Supply (5)	The 300 V supply provides the bus voltage for the fixed and variable drive circuits.
Fixed Drive (6)	The fixed drive chops the bus voltage at the desired output frequency and feeds one side of the output transformer.

Table 2-1. *Theory of operation block diagram explanation*

Block	Explanation
Output Transformer (7)	The output transformer combines the power from the fixed and variable drive outputs.
Measurement System (8)	The measurement system monitors output current and voltage and sends this feedback information to the logic board.
Variable Drive (9)	The variable drive chops the bus voltage just as the fixed drive does, but its phase is shifted according to the desired output power level.
Control Logic (10)	The logic board controls the output power and frequency and provides the outputs to the display.
Display (11)	The display provides visual feedback of the status of the generator and contains the necessary controls to change the output frequency or load match range.

Specifications

This chapter details the specifications for the PDX 1400 Generator with Load Match.

PHYSICAL SPECIFICATIONS

Table 3-1 lists the PDX 1400's physical specifications.

Table 3-1. *Physical specifications*

Description	Specification
Size	8.9 cm (H) x 48.3 cm (W) x 50.8 cm (D) 3.5" (H) x 19" (W) x 20" (D)
Weight	13.6 kg (30 lb) max
Mounting	Rack mounting ears are provided for standard 19" instrumentation rack.
Clearance	A clearance of 1" minimum is needed around the cooling fans and all exhaust-air vents to ensure minimum acceptable air flow. Cooling air should not be re-circulated. In any case, the cooling fan suction air temperature must not exceed 40°C (see ambient temperature specifications).
Connector/Cable Specifications:	
Load-match Output Connector	Type C female
AC Power Input	6´, 4-wire cable with a Hubbell Model 2721 connector. A bracket for holding the breaker handle in the on/off position is included.
User Port Connector	9-pin, subminiature-D, female

ELECTRICAL SPECIFICATIONS

Table 3-2 lists the electrical specifications for the PDX 1400.

Table 3-2. *Electrical specifications*

Description	Specification
Input Power	
Line Voltage	180 to 229 Vac, 50/60 Hz, 3 ϕ with ground
Line Frequency	50 to 60 Hz

Table 3-2. *Electrical specifications (Continued)*

Line Current	6.2 A, typical at nominal line
Line Power	2000 W at full rated output power (ac to RF efficiency, 70%)
Overcurrent Protection	10 A circuit breaker
Turn On/Off Protection	Bracket provided for mechanically locking in preferred breaker position
RF Output	
Frequency Range	235 to 305 kHz (option 141) or 325 to 375 kHz (options 143, 144, and 145)
Frequency Adjustment Linearity	1% over 70 kHz tuning range
Full Rated Output Power	1400 W load power into a low VSWR load
Output Power Range	25 to 1400 W
Output Impedance	40 to 200 Ω (7 steps) load match transformer; 1:1 VSWR (zero reflected power) for maximum power transfer; See Figure 2-1 for power derating into higher VSWR loads. Option 143 includes a 24 mH series load match inductor; option 144 includes a 10mH series load match inductor.
Regulation	Load power is regulated at ±1% of setpoint or ±1.4 W, whichever is greater, at 275 kHz (option 141) or 350 kHz (options 143, 144, and 145). From 235 kHz to 305 kHz (option 141) or 325 to 375 kHz (options 143, 144, and 145), the load power is regulated at ±2.5% of setpoint or ±3.5 W, whichever is greater.
Response Time	Risetime from 0% to 90% of full power is typically 130 ms
Warm-Up Time Delay	Approximately 500 ms from AC On to RF On
Reflected Power	280 W maximum (measured before load match transformer); accuracy is 2% of reflected power level, or 1 W, whichever is greater. The generator is capable of generating 280 W reflected power into an open load.
Command Power Repeatability	< 0.25% over time for same generator, ± 1% generator to generator
Output Voltage	300 V max
Output Current	6 A max
Stability	The generator is unconditionally stable into any VSWR.

Table 3-2. *Electrical specifications (Continued)*

Harmonics	At 1400 W and 275 kHz (option 141) and 350 kHz (options 143, 144, and 145), all harmonics are nominally greater than 40 dB below the fundamental output frequency; harmonics are highest at 235 kHz, where they are nominally greater than 35 dB below the fundamental output frequency.
Spurious Signals	Non-harmonic spurious and noise signals are typically -30 dBc (below the RF output signal) when operated into a 50 Ω, non-reactive load.
Transient Response	Less than 0.1% change in output power for a 10% change in the ac line voltage
Command Power Repeatability	< 0.25% over time for same generator, ± 1% generator to generator

Figure 3-1 graphically illustrates the PDX 1400's power derating curve.

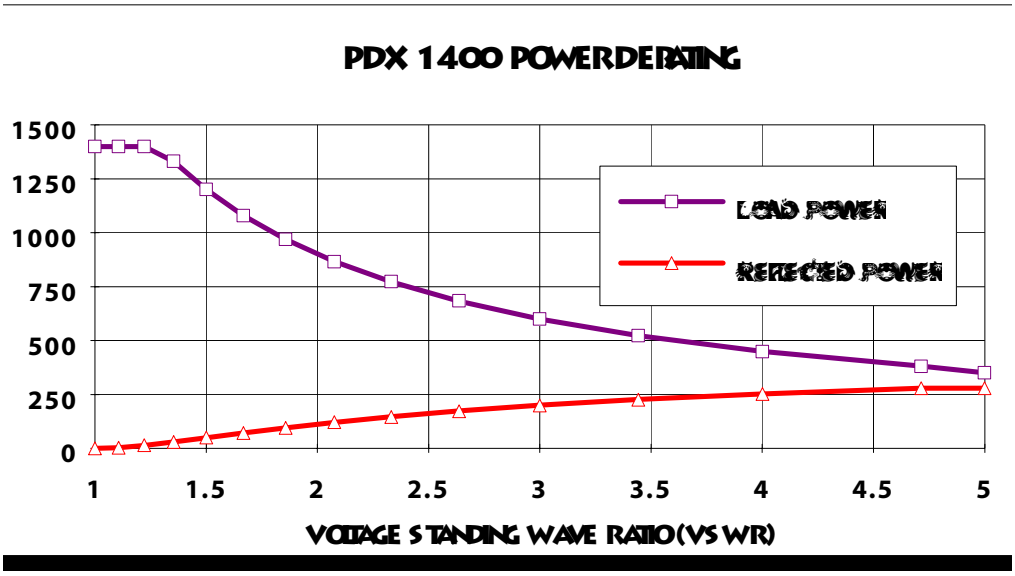

Figure 3-1. *PDX 1400 power derating curve*

ENVIRONMENTAL SPECIFICATIONS

Table 3-3 describes the environmental specifications for the PDX 1400.

Table 3-3. *Climatic specifications*

	Temperature	Relative Humidity	Air Pressure
Operating	Class 3K3 5°C to +40°C +41°F to +104°F	Class 3K2 10% to 85% +2 g/m^3 to +25 g/m^3	Class 3K3 80 kPa to 106 kPa 800 mbar to 1060 mbar (approximately 2000 m above sea level)
Storage	Class 1K4 -25°C to +55°C -13°F to +131°F	Class 1K3 35% to 95% +1 g/m^3 to +29 g/m^3	Class 1K4 80 kPa to 106 kPa 800 mbar to 1060 mbar (approximately 2000 m above sea level)
Transportation	Class 2K3 -25°C to +70°C -13°F to +158°F	Class 2K3 95% +60 g/m^3	Class 2K3 66 kPa to 106 kPa 660 mbar to 1060 mbar (approximately 3265 m above sea level)

Non-condensing
Maximum relative humidity when the unit temperature slowly increases, or when the unit temperature directly increases from -25°C to +30°C
Maximum absolute humidity when the unit temperature directly decreases from +70°C to +15°C

Controls, Indicators, and Interfaces

This chapter describes the controls, indicators, and interfaces for the PDX 1400 Generator with Load Match.

USER PORT

The User port is a 9-pin, subminiature-D, shielded, female connector. Figure 4-1 shows the user port, and Table 4-1 describes each pin.

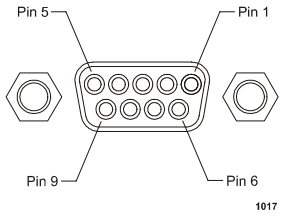

Figure 4-1. *User port*

Table 4-1. *User port pin descriptions*

Pin	Name	Description
1	*FAULT.D*	Digital output, opto-coupled collector
2	*LOAD POWER MONITOR.A*	Analog output, 1 V = 1 kW, load power
3	*FORWARD POWER MONITOR.A*	Analog output, 1 V = 1 kW, forward power
4	*CHASSIS GROUND*	Chassis ground
5	*CHASSIS GROUND*	Chassis ground
6	*+15V CURRENT LIMITED*	+15 V through 1 kΩ, series resistor
7	*SETPOINT.A*	Analog input, 1 V = 140 W
8	*FAULT REF.D*	Digital output, opto coupled emitter, reference to pin 1
9	*RF ON COMMAND.D*	Digital input, opto coupled; ground pin to enable RF, open connection or +15 V to disable RF

The following wiring diagrams will aid you in properly connecting the User port.

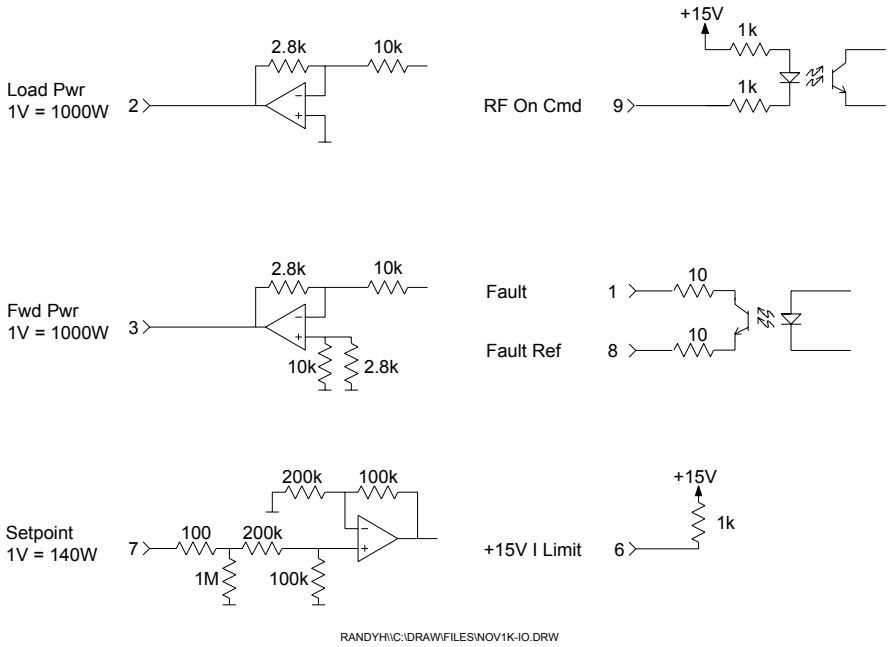

Figure 4-2. *Wiring diagrams*

SWITCHES AND INDICATORS

Table 4-2 describes the front panel controls (see also Figure 4-3, “Front view”).

Table 4-2. *Switches and indicators*

Control	Description
DISPLAY SELECT	View setpoint power, load power, reflected power, or frequency
FREQUENCY	Output frequency adjust
TAP SELECT	Load match range adjust per following table:

Table 4-3 lists the tap selection output impedance settings.

Table 4-3. *Tap selection*

Tap Number	Output Impedance (Ω)
1	40
2	52.3
3	68.4
4	89.4
5	117.0
6	152.9
7	200.0

FRONT VIEW

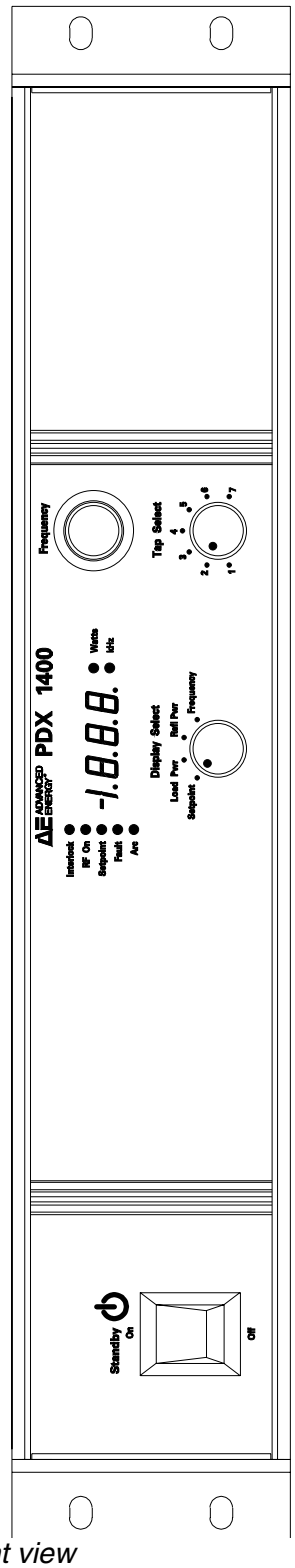

Figure 4-3. *Front view*

REAR VIEW

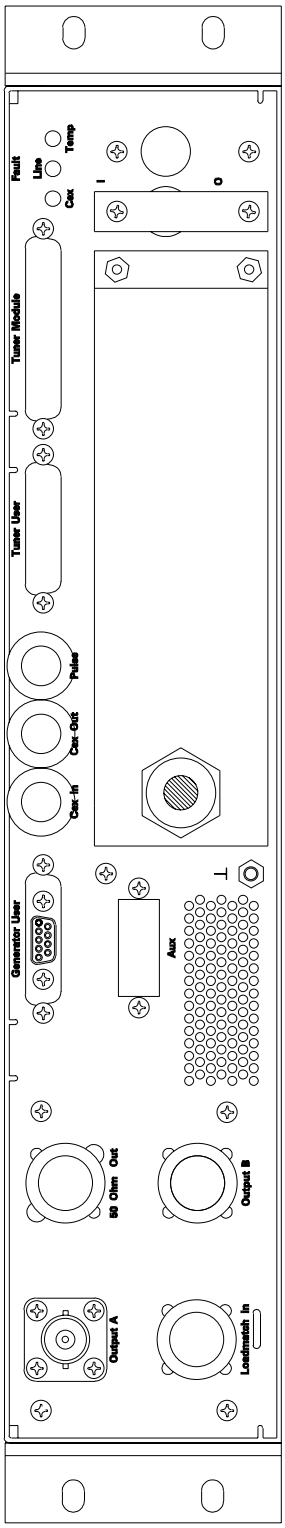

Figure 4-4. *Rear view*

Installation, Setup, and Operation

This chapter describes how to properly install, setup and operate the PDX 1400 Generator with Load Match.

WARNING:
RISK OF DEATH OR BODILY INJURY
Disconnect all sources of input power before working on this unit or anything connected to it.

UNPACKING

Unpack and inspect your generator carefully. Check for obvious physical damage. If no damage is apparent, proceed with the unit connections. If you do see signs of shipping damage, contact Advanced Energy Industries, Inc., and the carrier immediately. Save the shipping container for submitting necessary claims to the carrier.

GROUNDING

The unit provides an RFI ground stud. A suitable chassis ground connection made to this stud prevents or minimizes radio frequency interference.

Note: For more information about grounding, refer to AE Application Notes titled Grounding p/n 5600031A.

WARNING:
Do not attempt to turn on power until the generator is grounded.

SPACING REQUIREMENTS

Mount the PDX 1400 so that there is at least 1" clearance on the sides and front and rear panels. Any blockages could cause overheating.

This generator is air-cooled. Do not operate it until the cooling requirements are met.

CAUTION:
Make sure nothing is blocking the fan or any of the ventilation holes to prevent overheating.

CONNECTING OUTPUT POWER

WARNING:
Once the connections are complete and power is turned on, lethal voltages are present at the output connector. Be sure this connector is terminated and follow normal safety precautions when the system is operating.

Connect a type C female coupling connector, fixed with coaxial cable of type RG-8 (or equivalent cable capable of 6 A @ 600 V), to the connector labeled **OUTPUT A** on the rear panel. See Figure 4-4, “Rear view”, for the location of the output connector.

Install the output interlock cover.

Note: An interlock switch is used with the RF power output connector cover. If the RF connector is removed, the interlock circuit will be opened and prevent the unit from providing RF output.

CONNECTING AC INPUT POWER

WARNING:
Before making any input line power connection, turn off building circuit breakers supplying input power to the PDX 1400. Also, ensure that the power switch on the front panel is in the OFF position.

Connect the provided power cord to the three-phase, 208 Vac power source.

CONNECTING THE GENERATOR USER CONNECTOR

A 9-pin, subminiature-D, shielded, female connector is located on the PDX rear panel. Connect this to the system controller using only a properly terminated, shielded cable. If this cable is disconnected, RF output power will not come on.

Note: Option 141 has an additional 25-pin, subminiature-D, shielded, male connector; however, only one user port can be used at a time. Connect this to the system controller using only a properly terminated, shielded cable. If this cable is disconnected, RF output power will not come on.

FIRST TIME OPERATION

For first time operation, complete the following steps.

Start-up

⚠ WARNING:
The PDX 1400 must be hooked up to a dummy load or a properly configured chamber before you turn RF on.

If using a dummy load, connect the PDX 1400 to it with an RG-8 cable and an appropriate load.

If the PDX 1400 connects to a chamber, be sure to satisfy all chamber conditions for operation.

INITIAL FRONT PANEL SETTINGS

Set the controls on the front panel as follows.

⚠ CAUTION:
Verify that your control box is set to MINIMUM or 0 power output to prevent a power surge and damage to the PDX 1400.

1. Turn on circuit breakers.
2. Turn **STANDBY** switch to ON.
3. Turn the **DISPLAY SELECT** switch to **FREQUENCY**.

4. Adjust **FREQUENCY** control knob to a reading of 270 kHz (option 141) or 350 kHz (options 143, 144, and 145) on the display.
5. Select position 2 on the **TAP SELECT** switch.

NORMAL OPERATION

Operate the generator as your process requires while staying within the operating specifications of the PDX 1400.

Troubleshooting and Global Support

This chapter details how to troubleshoot the PDX 1400 Generator with Load Match and directs you to Global Support if your problem remains unresolved.

BEFORE CALLING AE GLOBAL SUPPORT

Before calling AE Global Support, perform the following steps or procedures.

> **WARNING:**
> **RISK OF DEATH OR BODILY INJURY. Disconnect all sources of input power before working on this unit or anything connected to it.**

Checks with the Power Off

Before turning on the generator, perform the following checks:

1. Check for visible damage on the unit, cables, and connectors.
2. Check to ensure that all connectors are installed correctly and tightly fastened.
3. Check to see if any fuses are blown.
4. Check the position of all switches and be sure they are in the correct position.
5. Check input power to be sure that it is present and meets specifications.
6. Check ground connections and ensure that they are adequate and secure.

Checks with the Power On

After checking with the power off, turn the power on and check the following:

1. Check input power to ensure the proper power is being supplied the unit.
2. Check LEDs and determine that the proper ones are lit.

DISPLAY DOES NOT INDICATE THAT THE UNIT IS FUNCTIONING

Cycle the circuit breakers OFF and then ON. Then check the position of the **STANDBY** switch on the front panel.

THE INTERLOCK LED IS NOT LIT

Verify that the RF output cable is attached correctly and that the output interlock cover is attached correctly.

THE RF ON LED IS NOT LIT

Verify that the interface cable is properly attached and that the **RF ON** switch is turned on at the remote control box.

THE FAULT LED LIGHTS WHEN THE FRONT PANEL STANDBY SWITCH IS ON

Verify that the **RF ON** LED is turned off and that the fans are running and airflow is not blocked.

OTHER PROBLEMS

Call AE Global Support for help or instructions for returning the unit for repair.

AE GLOBAL SUPPORT

Please contact one of the following offices if you have questions:

Table 6-1. *Global Support Locations*

Office	Telephone
AE, World Headquarters 1625 Sharp Point Drive Fort Collins, CO 80525 USA	Phone: 800.446.9167 or 970.221.0108 or 970.221.0156 Fax: 970.407.5981 Email: technical.support@aei.com
AE, Voorhees, NJ 1007 Laurel Oak Road Voorhees, NJ 08043 USA	Phone: 800.275.6971 or 856.627.6100 Fax: 856.627.6159
AE, California 491 Montague Expressway Milpitas, CA 95035 USA	Phone: 408.263.8784 Fax: 408.263.8992

Table 6-1. *Global Support Locations*

Office	Telephone
AE, Austin 8900 Cameron Road Suite 100 Austin, TX 78754	Phone: 512.231.4200 Fax: 512.719-9042
AE, GmbH Raiffeisenstrasse 32 70794 Filderstadt (Bonlanden) Germany	Phone: 49.711.77927.0 Fax: 49.711.7778700
AE, Japan KK TOWA Edogawabashi Bldg. 347 Yamabuki-cho Shinjuku-ku, Tokyo Japan	Phone: 81.3.32351511 Fax: 81.3.32353580
AE, Korea Ltd. Gongduk Building, 4th floor 272-6 Seohyun-Dong, Bundang-Gu, Sungam Si Kyunggi, 463-050 Korea	Phone: 82.31.705.1200 Fax: 82.31.705.276
AE, United Kingdom Unit 5, Minton Place, Market Court, Victoria Road Bicester, Oxon OX6 7QB UK	Phone: 44.1869.320022 Fax: 44.1869.325004

RETURNING UNITS FOR REPAIR

Before returning any product for repair and/or adjustment, ***first follow all troubleshooting procedures***. If, after following these procedures, you still have a problem or if the procedure instructs you to, call AE Global Support and discuss the problem with a representative. Be prepared to give the model number and serial number of the unit as well as the reason for the proposed return. This consultation call allows Global Support to determine whether the problem can be corrected in the field or if the unit needs to be returned. Such technical consultation is always available at no charge.

If you return a unit without first getting authorization from Global Support and that unit is found to be functional, you will be charged a re-test and calibration fee plus shipping charges.

To ensure years of dependable service, Advanced Energy® products are thoroughly tested and designed to be among the most reliable and highest quality systems available worldwide.

WARRANTY

Advanced Energy® (AE) products are warranted to be free from failures due to defects in material and workmanship for 12 months after they are shipped from the factory (please see warranty statement below, for details).

In order to claim shipping or handling damage, you must inspect the delivered goods and report such damage to AE within 30 days of your receipt of the goods. Please note that failing to report any damage within this period is the same as acknowledging that the goods were received undamaged.

For a warranty claim to be valid, it must:

- Be made within the applicable warranty period
- Include the product serial number and a full description of the circumstances giving rise to the claim
- Have been assigned a return material authorization number (see below) by AE Global Support

All warranty work will be performed at an authorized AE service center (see list of contacts at the beginning of this chapter). You are responsible for obtaining authorization (see details below) to return any defective units, prepaying the freight costs, and ensuring that the units are returned to an authorized AE service center. AE will return the repaired unit (freight prepaid) to you by second-day air shipment (or ground carrier for local returns); repair parts and labor will be provided free of charge. Whoever ships the unit (either you or AE) is responsible for properly packaging and adequately insuring the unit.

Authorized Returns

Before returning any product for repair and/or adjustment, call AE Global Support and discuss the problem with them. Be prepared to give them the model number and serial number of the unit as well as the reason for the proposed return. This consultation call will allow Global Support to determine if the unit must actually be returned for the problem to be corrected. Such technical consultation is always available at no charge.

Units that are returned without authorization from AE Global Support and that are found to be functional will not be covered under the warranty (see warranty statement, below). That is, you will have to pay a retest and calibration fee, and all shipping charges.

Warranty Statement

The seller makes no express or implied warranty that the goods are merchantable or fit for any particular purpose except as specifically stated in printed AE specifications. The sole responsibility of the Seller shall be that it will manufacture the goods in accordance with its published specifications and that the goods will be free from

defects in material and workmanship. The seller's liability for breach of an expressed warranty shall exist only if the goods are installed, started in operation, and tested in conformity with the seller's published instructions. The seller expressly excludes any warranty whatsoever concerning goods that have been subject to misuse, negligence, or accident, or that have been altered or repaired by anyone other than the seller or the seller's duly authorized agent. This warranty is expressly made in lieu of any and all other warranties, express or implied, unless otherwise agreed to in writing. The warranty period is 12 months after the date the goods are shipped from AE. In all cases, the seller has sole responsibility for determining the cause and nature of the failure, and the seller's determination with regard thereto shall be final.

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