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THE ADVANCED ENERGY® MDX-L MAGNETRON DRIVE

User Manual

PN: 5700339-C
March 2002

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THE ADVANCED ENERGY® MDX-L MAGNETRON DRIVE

User Manual

ADVANCED ENERGY INDUSTRIES, INC

1625 Sharp Point Drive
Fort Collins, Colorado 80525
800.446.9167

PN: 5700339-C
March 2002

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In the interest of providing even better equipment, Advanced Energy Industries, Inc., reserves the right to make product changes without notification or obligation. To the best of our knowledge, the information contained in this manual is the most accurate available as of the date on the title page.

For more information write Advanced Energy Industries, Inc., 1625 Sharp Point Drive, Fort Collins, CO 80525.

Returning Units for Repair

Before returning any product for repair and/or adjustment, call AE Customer Service and discuss the problem with a representative. Be prepared to give the serial number of the unit and the reason for the proposed return. This consultation call allows Customer Service 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 Customer Service and that unit is found to be functional, you will be charged a re-test and calibration fee plus shipping charges.

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For Customer Service or Support, call:

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AE, Colorado 1625 Sharp Point Drive Fort Collins, CO 80525 USA	(970) 221-0108 or 0156 ***Fax:*** (970) 407-5981
AE, California 491 Montague Expressway Milpitas, CA 95035 USA	(408) 263-8784 ***Fax:*** (408) 263-8992
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WARNING

SAFE OPERATING PROCEDURES AND PROPER USE OF THE EQUIPMENT ARE THE RESPONSIBILITY OF THE USER OF THIS SYSTEM.



DANGER! Operating and maintenance personnel must have the correct training before setting up and maintaining high-energy electrical equipment. THIS EQUIPMENT MUST BE INSTALLED ACCORDING TO APPLICABLE REQUIREMENTS.



This equipment must be operated in a pollution degree 1 environment, which means the cooling air must be free of corrosive vapors and particles, conductive particles, and moisture.

Advanced Energy Industries, Inc., provides information on its products and associated hazards, but it assumes no responsibility for the after-sale operation of the equipment or the safety practices of the owner or operator.

This equipment produces potentially lethal high-voltage and high-current energy. You should read this manual and understand its contents before you attempt to hook up or operate the equipment it describes. Follow all safety precautions. **Never defeat interlocks or grounds.**



Certain options of this device are tested and comply with safety standard EN50178. Devices so marked must be installed and used only in compliance with the standards listed, VDE0113, EN60204, and applicable requirements.

DO NOT BE CARELESS AROUND THIS EQUIPMENT.

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CONGRATULATIONS ...

on your purchase of AE's MDX-L magnetron drive, which is designed for continuous hard use into a vacuum environment. Advanced circuit design and calibrated instrumentation make these units the most accurate, most efficient, and most versatile in the world today.

The Advanced Energy® MDX-L magnetron drive provides exceptional efficiency from line to load, quick response to changes in the load, and extremely low stored energy in the the output filter. Its many optional configurations and standard features also make it a highly adaptable power supply.

This MDX-L has a passive front panel and is controlled through the analog user interface.

Each MDX-L is equipped with a built-in impedance-matching transformer. These transformers are available in low-impedance, standard-impedance, and high-impedance configurations.

The VARC arc-suppression circuitry provides outstanding suppression and quenching of arcs, cutting off the energy that feeds hot spots.

Typical applications include dc sputtering with RF bias, basic magnetron sputtering, cathodic-arc deposition (sputter etching), and dc-biased RF sputtering.

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CONTENTS

INTRODUCTION
- Read This Page! vii
- Overview of the Manual ix
- Interpreting the Manual xi

PART I GETTING TO KNOW YOUR MDX-L MAGNETRON DRIVE

1. WHAT IT IS
   - Table of Contents 1-3
   - General Description 1-5
   - Typical Applications 1-7
   - Specifications 1-13
2. HOW IT WORKS
   - Table of Contents 2-1
   - Theory of Operation 2-3
   - Connectors 2-5
   - Status Information 2-13

PART II OPERATING YOUR MDX-L MAGNETRON DRIVE

3. PREPARING FOR USE
   - Table of Contents 3-3
   - Setting Up 3-5
   - Making Rear Panel Connections 3-9
   - First-time Operation 3-27
4. CHOOSING MODES/SETTINGS
   - Table of Contents 4-1
   - Output Regulation 4-3
   - Program Mode 4-5
   - Impedance Options 4-7
   - Master/Slave Operation 4-10
5. USING THE SPECIAL FEATURES/OPTIONS
   - Table of Contents 5-1
   - Contactor Hold 5-3
   - Floating Negative Output Fault Detector 5-3
   - Differential Current Output Fault Detector 5-3

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PART III LEARNING MORE ABOUT YOUR MAGNETRON DRIVE

HOOK-UP NOTES
Grounding Grnd-1

Warranty and claims information

Index

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READ THIS PAGE!

We know that some of you want to start the magnetron drive now and that you don't feel you have time to read the entire manual. Below is a list of the subsections you will need to read to get started. We also think that you will find *Overview of the Manual* (page ix) and *Interpreting the Manual* (page xi) useful. They are very short sections, and are intended to guide you through the manual.

Overview of the Manual explains the organization of the manual, so that you can more quickly find what you need. *Interpreting the Manual* explains the type conventions (what it means when a word appears in capitalized italic type, for instance), and what the five icons (symbols) mean.

- Electrical specifications page 1-13
- Connectors page 2-5
- Setting up page 3-5
- Start-up procedures page 3-27
- Status indicator LEDs page 2-14

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OVERVIEW OF THE MANUAL

The main table of contents is a general outline of major topics covered in the manual. It contains only the main headings within each chapter so that you can skim it and get a general idea of what is contained here, without having to look at a lot of headings. When you turn to one of the five chapters, you will find a detailed table of contents that lists every heading in that particular chapter. This will help you to quickly decide which page contains the information you are looking for. Throughout the manual, the chapter titles are printed at the top right-hand corner of each odd-numbered page.

Part I contains two chapters: *What It Is*, and *How It Works*. *What It Is* gives a general overview of the MDX-L magnetron drive, its various features and configurations, and typical applications. A detailed description of the functional specifications and a list of the specifications are also included.

How It Works contains a functional block diagram and important information on connections, including listings of all input, output, and reference pins. Status indicators are also discussed.

Part II consists of three chapters: *Preparing for Use, Choosing Modes/Settings*, and *Using the Special Features*. *Preparing for Use* provides information on connections, spacing and cooling requirements, and start-up procedures.

Choosing Modes/Settings contains information on output regulation and setpoint levels, and *Using the Special Features* describes the **contactor hold** and **floating negative output fault detector** features.

Part III contains a technical operating note on grounding considerations.

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INTERPRETING THE MANUAL

Type Conventions

To help you quickly pick out what is being discussed, the manual presents certain words and phrases in type that is different from the rest of the text.

Pin and line names appear in capitalized italics (*COM.A*). Labels that are on the MDX-L (indicators, etc.) generally appear in boldface capital letters (**PWR ON**). Exceptions are port names, which simply begin with a capital letter (Custom Interface port).

Functions are printed in boldface lowercase letters (**contactor hold**).

How to Use the Symbols



Safety notes. Important notes concerning potential harm to people.

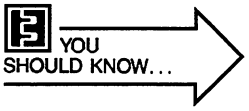


Warning notes. Important notes concerning possible harm to this unit or associated equipment.



Operating notes. More thoughts on how to use the extended features provided.

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Hook-up and interfacing notes. General practices concerning input and output power connections, or used in connecting communication and control interfaces.



Service notes. General practices to be used in maintaining this equipment in top running condition.

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PART I

GETTING TO KNOW YOUR MDX-L MAGNETRON DRIVE

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CONTENTS

General Description 1-5
Output Impedance Range 1-5
Output Regulation 1-5
Built-in Protection 1-6
Arc-suppression Circuitry 1-6
Sophisticated Features 1-6
Typical Applications 1-7
Basic Magnetron Sputtering 1-7
Factory Configuration (Negative Output) 1-7
Optimum Configuration (Negative Output) 1-8
DC Sputtering with RF Bias 1-9
DC-biased RF Sputtering 1-11
Specifications 1-13
Functional Specifications 1-13
Electrical Specifications 1-13
Physical Specifications 1-15
Environmental Specifications 1-16

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GENERAL DESCRIPTION

The dc magnetron drives in the MDX-L series prove just how convenient and efficient advanced high-frequency switchmode power supplies are.
They...

- Are light and compact
- Are highly efficient (low heat emission)
- Provide excellent regulation and stability
- Have a highly reliable solid state design
- Store very little energy in the output filter.

These magnetron drives exhibit superior output response time, low output ripple voltage, and considerable space savings over lower frequency designs.

Output Impedance Range

Each MDX-L unit is equipped with a built-in impedance-matching transformer. These transformers are available in high Z, standard Z, configurations. With the proper transformer, load impedances requiring voltages up to 525 V or 650 V can be accommodated. See page 4-7 for more information about output impedance ranges.

Output Regulation

The MDX-L unit can be used as a power, current, or voltage source, depending on the method of output regulation selected.

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Built-in Protection

The MDX-L unit has complete internal protection for output over-voltage and over-current conditions.

Arc-suppression Circuitry

VARC provides suppression and quenching of different types of arcs. An added advantage is that VARC reduces target burn-in time and material loss. By sensing a drop in impedance and immediately shutting the power off, this feature also prevents energy from being dumped into hot spots. Start-up after an arc is controlled so that the hot spots cool before power is re-applied, thus preventing repeated arcing.

Sophisticated Features

Contactor Hold. The contactor hold feature reduces wear and tear on the main and soft-start contactors.

Floating Negative Output Fault Detector. This feature protects the unit's capacitors by shutting down power if the positive output line of the MDX-L unit exceeds ground by more than 20 V.

Differential Current Output Fault Detector. This feature (available only on the MDX-L18) shuts down power if the current differential between the two coaxial cables exceeds 10 A. It assures that your cables are protected from over-current due to impedance differences in the cables or when only one cable is connected.

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TYPICAL APPLICATIONS

Basic Magnetron Sputtering

Two output configurations are possible for the MDX-L unit: negative output voltage and floating ground. Provisions within the MDX-L chassis allow you to tie the anode to ground; alternatively, you can let the output float with respect to ground by not grounding the anode. However, internal circuitry will inhibit output power when the anode floats more than 20 V above ground.



DANGER! An understanding of grounding and the proper hookup of grounds is essential to personnel safety and is necessary for the proper operation of your system (see Part III of this manual). In all cases you must connect the chassis ground stud on the rear of the MDX-L unit to earth-ground with the lowest possible impedance.

Factory Configuration (negative output)

Most MDX-L applications require a negative output voltage (Figure 1-1), which, in turn, requires that the anode be connected to ground. The MDX-L unit is shipped without a safety jumper installed.

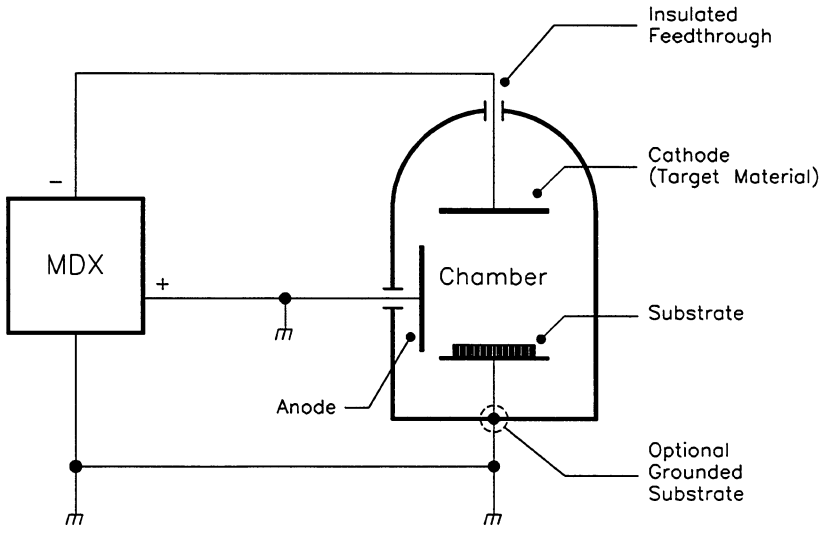


Figure 1-1. Factory configuration

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Optimum Configuration (negative output)

The configuration that AE recommends is illustrated in Figure 1-2, which shows an independently grounded anode at the chamber, forcing all return current through the anode return path. The design of the chamber may use the chamber wall, special internal shielding structure, or the substrate holder as the actual anode. With this setup, only one current path will exist, thus eliminating the problems caused by multiple returns.

Make certain that you have established a good ground at the chamber anode or the ground reference will be lost. The integrity of this ground connection should be checked as part of a periodic maintenance schedule to ensure continued optimum performance and safety. Whenever a system is configured in this manner, AE recommends that secondary dielectric shielding be installed over all parts of the coaxial cable and connectors that are exposed.

When this connection degrades, as it will over time, performance will be lost. This slow loss of performance can be subtle and very difficult to detect. Some indications of ground degradation are loss of instrumentation accuracy, symptoms of increased line noise (such as data-logging lines), development of secondary plasma between the target and the closest point at ground potential, change in the appearance of the chamber plasma at known power levels, and increasing signs of erratic behavior in the power supply or the system controller. If the positive lead floats more than 20 V above ground, the unit will shut down and the **OUTPUT** LED on the front panel will flash.

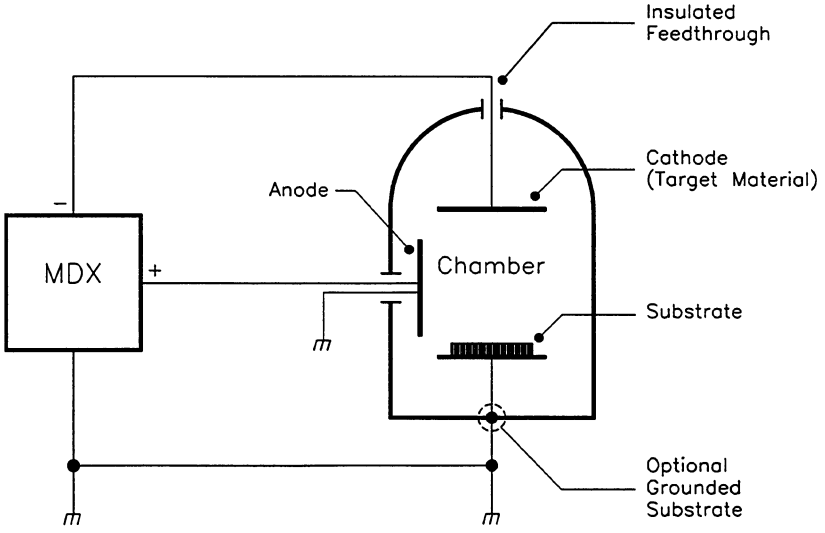


Figure 1-2. Optimum grounding configuration (negative output)

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DC Sputtering with RF Bias



WARNING! You must place an ac blocking filter in series with the output of the dc power supply if your system uses a dc power supply in combination with an ac power supply that has an output frequency greater than 50 kHz.

In this application (Figure 1-3), proper installation of the RF generator and tuner is critical to proper operation of the system. Proper installation includes good, solid, RF grounding and dc installation.

You must place an RF filter between the dc output and the chamber because 13.56 MHz can damage the typical dc magnetron power supply. There is no need to put a filter between the RF tuner output and the chamber because Advanced Energy® tuners provide a dc block.

The purpose of this type of installation is to elevate the potential on the biased substrate. With proper installation and programming, an Advanced Energy® RFX can control the developed dc bias on the substrate.

This extra control parameter (RF bias) may provide higher deposition rates or better film structure. The results will vary with each application. Biasing alters the ion and acceleration potentials, and these altered potentials provide the desired results.

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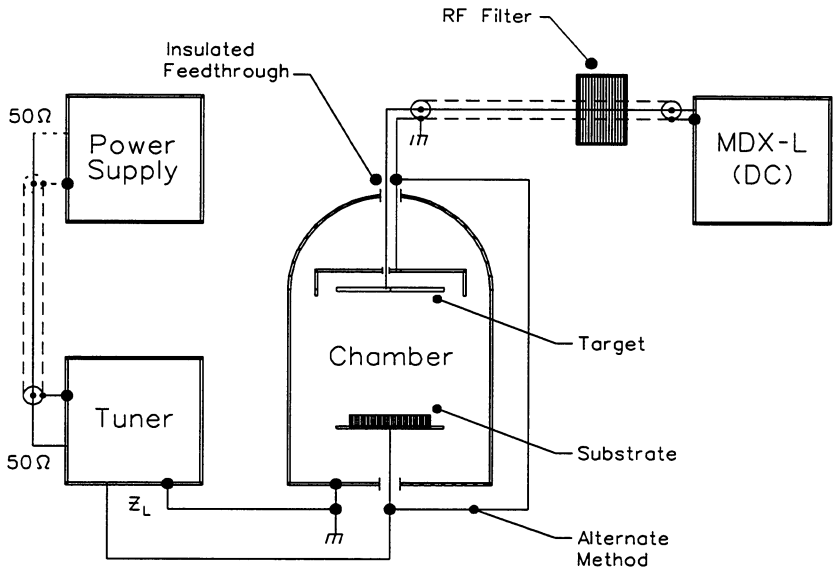


Figure 1-3. Typical configuration for dc sputtering with RF bias

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DC-biased RF Sputtering



WARNING! You must place an ac blocking filter in series with the output of the dc power supply if your system uses a dc power supply in combination with an ac power supply that has an output frequency greater than 50 kHz.

Figure 1-4 (on the next page) shows a typical RF sputtering application, where the target shield and chamber walls are referenced to ground, but the substrate is directly biased with a dc power supply. This could be a planar magnetron or an "S" gun installation.

Improper grounding of the tuner, chamber, and MDX-L unit will result in radio frequency interference (RFI), which is often evidenced in this application by erratic computer behavior or chattering valves.



DANGER! Lethal high-voltage potentials will be present if the tuner, chamber, and MDX-L unit are not properly grounded.

Some RF sputtering applications require a length of cable between the tuner output and the vacuum feedthrough. This type of connection should only be used—with extreme caution—if there is no way to mount the tuner directly to the vacuum feed through. The impedance transformation that takes place within the interconnect cable can create large circulating currents on this cable. The power dissipated is a function of I^2R losses. This formula shows that any increase in circulating current greatly increases the losses in the cable.

In light of this fact, we recommend using a Teflon® dielectric cable because Teflon has a more favorable thermal characteristic than other cable materials. The Teflon should minimize migration of the center conductor due to overheating, thus reducing the probability of the center conductor shorting to the outer sheath.

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A key consideration in any RF installation is the RF return path. ***Power supply/tuner connection:*** The power supply is usually connected to the tuning network through a coaxial cable, and the braided shield on this cable acts as an adequate RF return for this section of the circuit. ***Tuner/chamber connection:*** Pay special attention to the connection between the tuning network and chamber. On all Advanced Energy® tuners, the aluminum chassis provides the RF return path. Ideally, this chassis should be bolted directly onto the vacuum chamber, thus establishing good surface contact. If this is not possible, connect the tuner and chamber with a solid copper strap. Avoid using braid — the fine strands within the braid form a highly inductive path and may melt from overheating. Also avoid using stainless steel hardware — steel is a poor conductor at high frequencies because of its ferromagnetic properties.

Brass hardware is most commonly used because brass is a good conductor and is readily available.

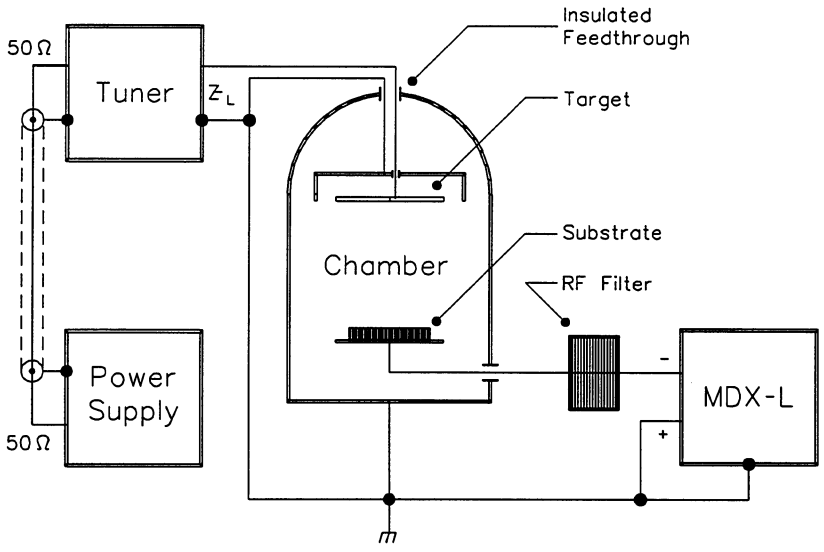


Figure 1-4. Typical configuration for RF sputtering with dc bias

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SPECIFICATIONS

Functional Specifications

Control Signal Source	Output can be controlled remotely from the 15-pin Custom User port or from the 37-pin User port.
Programmable Setpoints	An output level (up to the unit's maximum rated output) can be programmed for power.
Arc Suppression	Arc conditions are quickly detected and MDX-L output is quickly modified to prevent damage to the target and substrate.

Electrical Specifications

Input Voltages	200 V ac to 208 V ac, 50/60 Hz, three-phase; "Y" or delta connection; no neutral connection required
Input Current/Phase	MDX-L6: 25 A MDX-L12: 50 A MDX-L18: 75 A
Ignition Current	60 mA at 1500 V
Output Power	MDX-L6: 0 to 6,000 W MDX-L12: 0 to 12,000 W MDX-L18: 0 to 18,000 W
Ripple Voltage	5% rms
Ignition Voltage	1500 V

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Maximum Output Current	MDX-L6: 15 A MDX-L12: 30 A MDX-L12 HV1: 24 A MDX-L18: 45 A
Power Factor	MDX-L6: >0.9 for loads greater than 600 W MDX-L12: >0.9 for loads greater than 1.2 kW MDX-L18: >0.9 for loads greater than 1.8 kW
Arc Shut-down Time	8 ms
Switching Frequency	17 kHz to 31 kHz
Tap Range	MDX-L6: 525 V, 15 A (6 kW maximum) MDX-L12: 525 V, 30 A (12 kW maximum) MDX-L12 HV1: 650 V, 24 A (12 kW maximum) MDX-L18: 600 V, 45 A (18 kW maximum)
Accuracy of Actual Output to Setpoint Display	MDX-L6: ± 1% of setpoint display or 12 W, whichever is greater MDX-L12: ± 1% of setpoint display or 24 W, whichever is greater MDX-L18: ± 1% of setpoint display or 36 W, whichever is greater
Accuracy of Actual Output Voltage to *VOUT.A*	± 1% of *VOUT.A* reading or 2 V, whichever is greater
Accuracy of Actual Output Power to *POUT.A*	MDX-L6: ± 1% of *POUT.A* reading or 12 W, whichever is greater. MDX-L12: ± 1% of *POUT.A* reading or 24 W, whichever is greater. MDX-L18: ± 1% of *POUT.A* reading or 36 W, whichever is greater.
Regulation	± 0.2% from 10% to 100% of rated power.
Repeatability	Output power repeatability from run to run at a constant setpoint is 0.2% from 10% to

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	100% of rated power, within ± 0.2% of regulation specification
Analog Input Signals	0 V to 10.0 V (full scale)
Analog Output Signals	0 V to 10.0 V (full scale)
Methods of Control	Remote control
Output Connector	UHF type with interlock hardware (Optional stud output available: one positive and one negative terminal)
Output Cable (not provided)	AE recommends RG-8U coaxial cable
Input Connector	Lugged 5-wire cable with strain relief

Physical Specifications

Size	
6 kW, 12 kW	177.8 mm (H) x 482.6 mm (W) x 482.6 mm (D) (7 in (H) x 19 in (W) x 19 in (D))
18 kW	177.8 mm (H) x 482.6 mm (W) x 508 mm (D) (7 in (H) x 19 in (W) x 20 in (D))
Weight	MDX-L6: 23 kg (51 lb) MDX-L12: 25 kg (55 lb) MDX-L18: 33.5 kg (74 lb)

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Environmental Specifications

Noise	Noise generated by this unit is 82 dB (A)
Cooling	Forced air, front panel air intake; minimum air flow required is 200 cfm
Ambient Temperature:	
Operating	Intake air temperature, 0°C to 40°C (maximum value of average over 24 hr: 35°C); if the units are enclosed in cabinets, ensure that the units cannot overheat.
Storage	Class 1K4. Minimum -25°C, maximum 55°C.
Transportation	Class 2K3. Minimum -25°C, maximum 70°C
Pollution Degree	All units must be operated in a pollution degree **1** environment, which means the cooling air must be free of corrosive vapors and particles, conductive particles, and moisture.
Humidity:	
Operating	Class 3K2. (10 to 75% relative humidity; no pollution or only dry, non-conductive pollution.)
Storage	Class 1K3. (5 to 95% relative humidity)
Atmospheric Pressure:	
Operating	800 mbar minimum (approximately 2000 m above sea level).
Storage	800 mbar minimum (approximately 2000 m above sea level).
Transportation	660 mbar minimum (approximately 3265 m above sea level).

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CONTENTS

Theory of Operation 2-3
Connectors 2-5
Output Connector 2-5
Custom User Port (15-pin) 2-5
Pin-description Table—Custom User Port 2-6
User (Slave) Port (37-pin) 2-7
Pin-description Table—User (Slave) Port 2-8
Slave 1 and Slave 2 Ports (Master Units Only) 2-10
Pin-description Table—Slave 1 and Slave 2 Ports (Master Units Only) 2-11
Status Information 2-13
Status Signals—Custom User Port 2-13
Indicators 2-14
Status Indicator LEDs 2-14

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THEORY OF OPERATION

The MDX-L magnetron drive is a sophisticated and intelligent dc power supply designed exclusively for use into vacuum environments. Figure 2-1 and the following paragraphs outline the theory of operation.

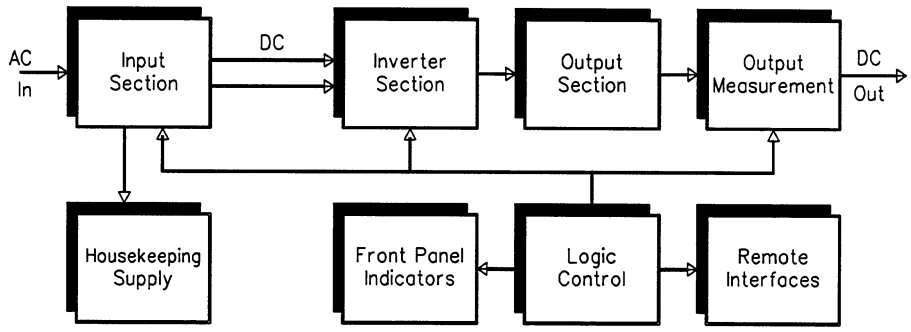


Figure 2-1. MDX-L functional block diagram

Input
In the input section, ac line voltage is applied through the circuit breaker to a three-phase contactor. The contactor, when closed, delivers the line voltage to a rectifier bridge, where it is converted to dc. The dc voltage is applied to bus capacitors. This bus provides dc voltage to the inverter section. The input section also supplies 208 V ac to the housekeeping and inverter sections.

Housekeeping Supply
The housekeeping supply section provides ±15 V dc to power the logic circuitry.

Inverter
The inverter section converts dc to pulse-width-modulated, 25-kHz ac voltage by alternating the current through two sets of switching transistors (Figures 2-2 and 2-3).

Output
In the output section, an isolation transformer steps up the 25-kHz ac voltage from the inverter section and sends it to a full-wave rectifier bridge. The resulting dc then passes out through a filter network and through the output measurement section.

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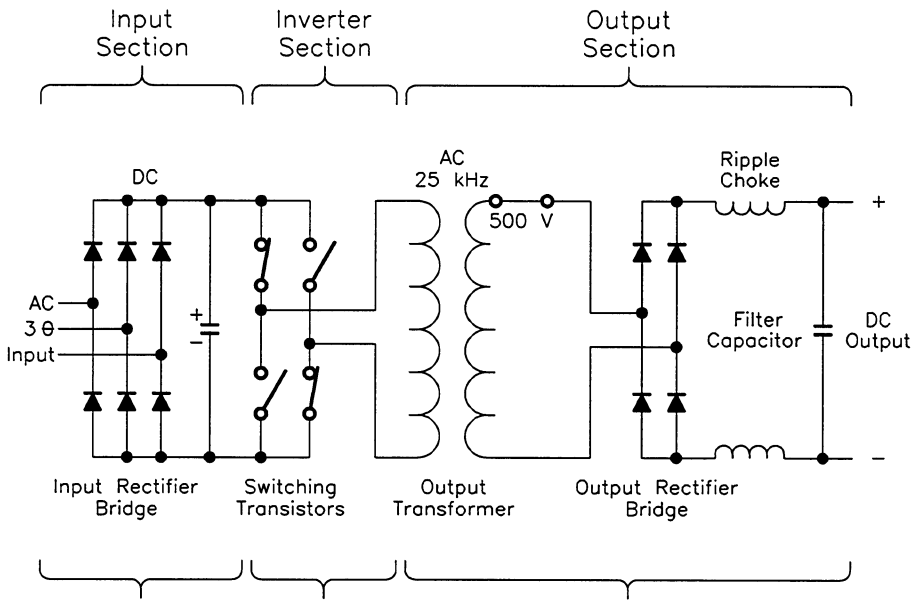


Figure 2-2. Illustration of switching theory

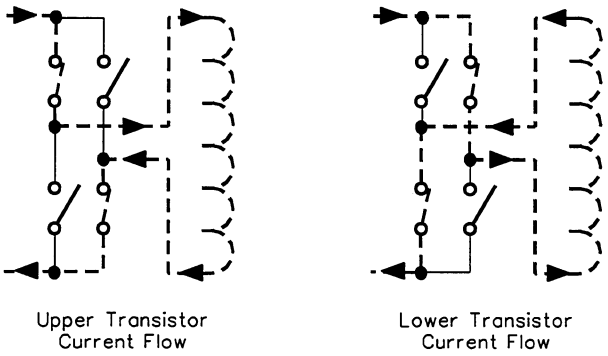


Figure 2-3. Detail of Figure 2-2, illustrating current flow through switching transistors (dashed lines represent flow)

Output Measurement

The output measurement section measures current and voltage, and calculates power. These signals are conditioned to 0 to 10 V dc and sent to both the logic control and remote interfaces sections.

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CONNECTORS

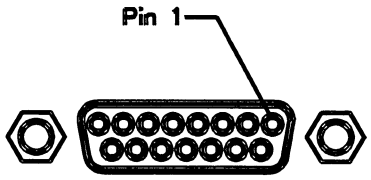
Output Connector

The MDX-L18 has two UHF-type output connectors on the rear panel; the MDX-L6 and MDX-L12 have one UHF-type output connector on the rear panel. (See the foldouts at the end of this chapter.)

The cable for the output connection is not included with the MDX-L unit, but can be purchased from AE separately.

Custom User Port

The Custom User port, located on the rear panel, is a 15-pin, female, subminiature-D connector. The table on page 2-6 provides information about each pin. See page 3-13 for details on making this connection.



The Custom User connector is primarily an "analog" interface that allows the use of a remote controller.

NOTE: In the following table, a ".A" appended to a pin name indicates an analog signal; a ".D" appended to the pin name indicates a digital signal. An over-line over the signal name indicates that the signal is true when low.

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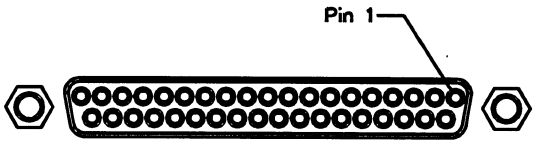
Pin-description Table—Custom User Port

Pin No.	Pin Name	Description	Refer to
1	*$\overline{\text{SETPOINT.D}}$*	**output**, indicates setpoint has been achieved; 0 or 15 V	p. 3-14
2	*VOUT.A*	**output**, indicates output voltage; 0 to 10 V	p. 3-14
3	*POUT.A*	**output**, indicates output power; 0 to 10 V	p. 3-14
4	*$\overline{\text{OUTPUT ENABLE.D}}$*	**input**, contact closure between this and *pin 9* turns on output; 0 or 15 V	p. 3-14
5	*XPROG.A*	**input**, sent through custom CMR buffer; 0 to 10 V	p. 3-14
6	*COM.A*	return reference for custom analog inputs and outputs	p. 3-14
7	*PWRON.D*	contact closure between *pin 7* and *pin 8* when power is on; 0.5 A maximum	p. 3-14
8	*PWRON COM.D*	return for *pin 7*	p. 3-14
9	*OUT ENABLE COM.D*	return reference for *pin 4*	p. 3-14
10	unassigned		
11	*$\overline{\text{INTERLOCK.D}}$*	**input,** custom interlock and power connector interlock	p. 3-15
12	*INTLK COM.D*	return reference for interlock, *CUSINT1.D*, and *CUSINT2.D* (*pins 11, 14,* and *15*)	p. 3-15
13	*$\overline{\text{OUTPUT.D}}$*	indicates output enable, 0 or 15 V	p. 3-15
14	*CUSINT1.D*	**input**, customer interlock for the number of expected units in a system, 0 or 15 V	p. 3-15
15	*CUSINT2.D*	**input**, customer interlock for the number of expected units in a system, 0 or 15 V	p. 3-15

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User (Slave) Port

The User (Slave) interface, located on the rear panel, is a 37-pin, female, subminiature-D connector. The table on the following page provides information about each pin.



Connecting the User (Slave) port on one MDX-L unit to the Slave 1 port or the Slave 2 port on another MDX-L unit converts the first unit into a slave unit (see page 4-10 for more information about master/slave configurations).

***NOTE*:** In the following table, a ".A" appended to a pin name indicates an analog signal; a ".D" appended to the pin name indicates a digital signal. An over-line over a signal name indicates that the signal is true when low.

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Pin-description Table—User (Slave) Port

Pin No.	Pin Name	Description	Refer to
1	*COVERINT.D*	**output/input**, interlock for slaving output, 0 or 15 V	p. 3-17
2	*$\overline{\text{OUTPUT.D}}$*	**output**, output enable, 0 or 15 V	p. 3-17
3	*$\overline{\text{SETPOINT.D}}$*	**output**, setpoint indication 0 or 15 V	p. 3-17
4	unassigned		
5	*$\overline{\text{I REG.D}}$*	**input**, used with pin 6 to select either current or voltage regulation mode, 0 or 15 V	p. 3-17
6	*$\overline{\text{P REG.D}}$*	**input**, used with *pin 5* to select either power or voltage regulation mode, 0 or 15 V	p. 3-17
7	*$\overline{\text{ON.D}}$*	**input**, power enable, 0 or 15 V	p. 3-17
8	unassigned		
9	*OUT COM.A*	dedicated return for analog outputs	p. 3-18
10	*IN COM.A*	dedicated return for analog inputs	p. 3-18
11	*$\overline{\text{AUX.D}}$*	**input**, auxiliary interlock, 0 or 15 V	p. 3-18
12	*$\overline{\text{VAC.D}}$*	**input**, vacuum interlock, 0 or 15 V	p. 3-18
13	*$\overline{\text{WATER.D}}$*	**input**, water interlock, 0 or 15 V	p. 3-18
14	*OFF.D*	**input**, off command, 0 or 15 V	p. 3-18
15	*REMOTE COM.A*	remote ground	p. 3-18
16	*$\overline{\text{C HOLD.D}}$*	**input**, holds the contactor engaged when the unit receives an "off" command, 0 or 15 V	p. 3-18
17	*COM.A*	auxiliary analog return	p. 3-18
18	*15 V PROT.D*	**output**, 15 V supply short circuit protected for external use (100 mA max.)	p. 3-18
19	*INTLK COM.D*	dedicated return for interlock string	p. 3-18
20	unassigned		

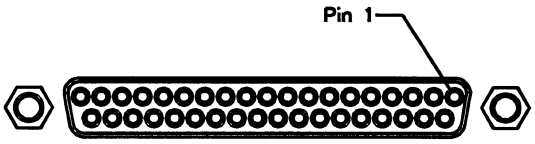
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Pin No.	Pin Name	Description	Refer to
21	*$\overline{ARC.D}$*	**output**, indicates an arc has occurred, 0 or 15 V	p. 3-19
22	unassigned		
23	*V OUT.A*	**output**, indicates output voltage, 0 to 10 V	p. 3-19
24	*P OUT.A*	**output**, indicates output power, 0 to 10 V	p. 3-19
25	*I OUT.A*	**output**, indicates output current, 0 to 10 V	p. 3-19
26	*RAMP.A*	**input**, sets turn-on ramp to 50 ms-1 sec., 0 to 10 V	p. 3-20
27	*LEVEL.A*	**input**, sets the output level of the supply, 0 to 10 V	p. 3-20
28	*INH.D*	digital input to inhibit power supply	p. 3-20
29	*I OUT SLAVE.A*	**output**, used for slaving, 0 to 10 V	p. 3-20
30	unassigned		
31	*LEVEL OUT.A*	**output**, verifies LEVEL.A command level, 0 to 10 V	p. 3-20
32	*REF.A*	10 V, reference level only (5 mA max.)	p. 3-20
33	*$\overline{VARC.D}$*	left open or tied low selects VARC mode; 15 V disables VARC	p. 3-20
34	*PWRIDN0.D*	**output**, power identification	p. 3-20
35	*PWRIDN1.D*	**output**, power identification	p. 3-20
36	*IN COM.D*	dedicated return for digital input	p. 3-20
37	*OUT COM.D*	dedicated return for digital outputs	p. 3-21

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Slave 1 and Slave 2 Ports

The Slave 1 and Slave 2 interfaces, located on the rear panel, are 37-pin, female, subminiature-D connectors. The table on the following page provides information about each pin.



Two cables (with corresponding male connectors) are shipped with each unit. Connecting the User (Slave) port on one MDX-L unit to the Slave 1 port or the Slave 2 port on another MDX-L unit converts the first unit into a slave unit (see page 4-10 for more information about master/slave configurations).

NOTE: In the following table, a ".A" appended to a pin name indicates an analog signal; a ".D" appended to a pin name indicates a digital signal. An over-line over a signal name indicates that the signal is true when low.

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Pin-description Table—Slave 1 and Slave 2 Ports (Master Units Only)

Pin No.	Pin Name	Description	Refer to
1	*COVERINT.D*	reads cover interlock outputs from the slave units	p. 3-23
2	*$\overline{\text{OUTPUT.D}}$*	reads slave *$\overline{\text{OUTPUT.D}}$* outputs	p. 3-23
3	*$\overline{\text{SETPOINT.D}}$*	reads slave *$\overline{\text{SETPOINT.D}}$* outputs	p. 3-23
4	unassigned		
5	*$\overline{\text{I REG.D}}$*	**output,** used with pin 6 to select either current or voltage regulation mode, 0 or 15 V	p. 3-23
6	*$\overline{\text{P REG.D}}$*	**output**, used with *pin 5* to select either power or voltage regulation mode, 0 or 15 V	p. 3-23
7	*$\overline{\text{ON.D}}$*	**output**, power enable, 0 or 15 V	p. 3-23
8	unassigned		
9	*OUT COM.A*	dedicated return for analog outputs	p. 3-23
10	*IN COM.A*	dedicated return for analog inputs	p. 3-23
11	*$\overline{\text{AUX.D}}$*	**output**, auxiliary interlock, 0 or 15 V	p. 3-23
12	*$\overline{\text{VAC.D}}$*	**output**, vacuum interlock, 0 or 15 V	p. 3-24
13	*$\overline{\text{WATER.D}}$*	**output**, water interlock, 0 or 15 V	p. 3-24
14	*OFF.D*	**output**, off command, 0 or 15 V	p. 3-24
15	*REMOTE COM.A*	remote ground	p. 3-24
16	*$\overline{\text{C HOLD.D}}$*	**output**, holds the contactor engaged when the unit receives an "off" command, 0 or 15 V	p. 3-24
17	*COM.A*	auxiliary analog return	p. 3-24
18	*15 V PROT.D*	**input,** 15 V supply short circuit protected from slave (100 mA max.)	p. 3-24

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Pin No.	Pin Name	Description	Refer to
19	*INTLK COM.D*	**input**, used to detect slave connection	p. 3-24
20	unassigned		
21	unassigned		
22	unassigned		
23	unassigned		
24	*P OUT.A*	**input**, reads slave output power, 0 to 10 V	p. 3-24
25	*I OUT.A*	**input**, reads slave output current, 0 to 10 V	p. 3-25
26	*RAMP.A*	**output**, sets slave turn-on ramp to 50 ms-1 sec., 0 to 10 V	p. 3-25
27	*LEVEL.A*	**output**, sets the output level of the slave, 0 to 10 V	p. 3-25
28	*INH.D*	digital output to inhibit slave supply	p. 3-25
29	*I OUT SLAVE.A*	**input**, reads slave output current, 0 to 10 V	p. 3-25
30	unassigned		
31	unassigned		
32	unassigned		
33	*$\overline{\text{VARC.D}}$*	disables slave VARC mode	p. 3-25
34	*PWRIDN0.D*	**input**, determines which type of slave is connected	p. 3-25
35	*PWRIDN1.D*	**input**, determines which type of slave is connected	p. 3-25
36	*IN COM.D*	dedicated return for digital input	p. 3-26
37	*OUT COM.D*	dedicated return for digital outputs	p. 3-26

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STATUS INFORMATION

The MDX-L unit can be externally monitored by means of output lines on the Custom User port. Digital signals are 0 or 15 V; analog signals are 0 to 10 V.

Status Signals—Custom User Port

Pin	Name	Functional Status
1	*SETPOINT.D*	Varying 0 or 15 V output indicating setpoint has been achieved.
2	*VOUT.A*	Varying 0 to 10 V analog output representing output voltage from custom CMR buffer circuit.
3	*POUT.A*	Varying 0 to 10 V analog output representing output power from custom CMR buffer circuit.
7	*PWRON.D*	Contact closure between *pin 7* and *pin 8*, 0.5 A maximum.
8	*PWRON.COM*	Return for *pin 7*.
13	*OUTPUT.D*	Varying 0 or 15 V digital indication of output enable.

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Indicators

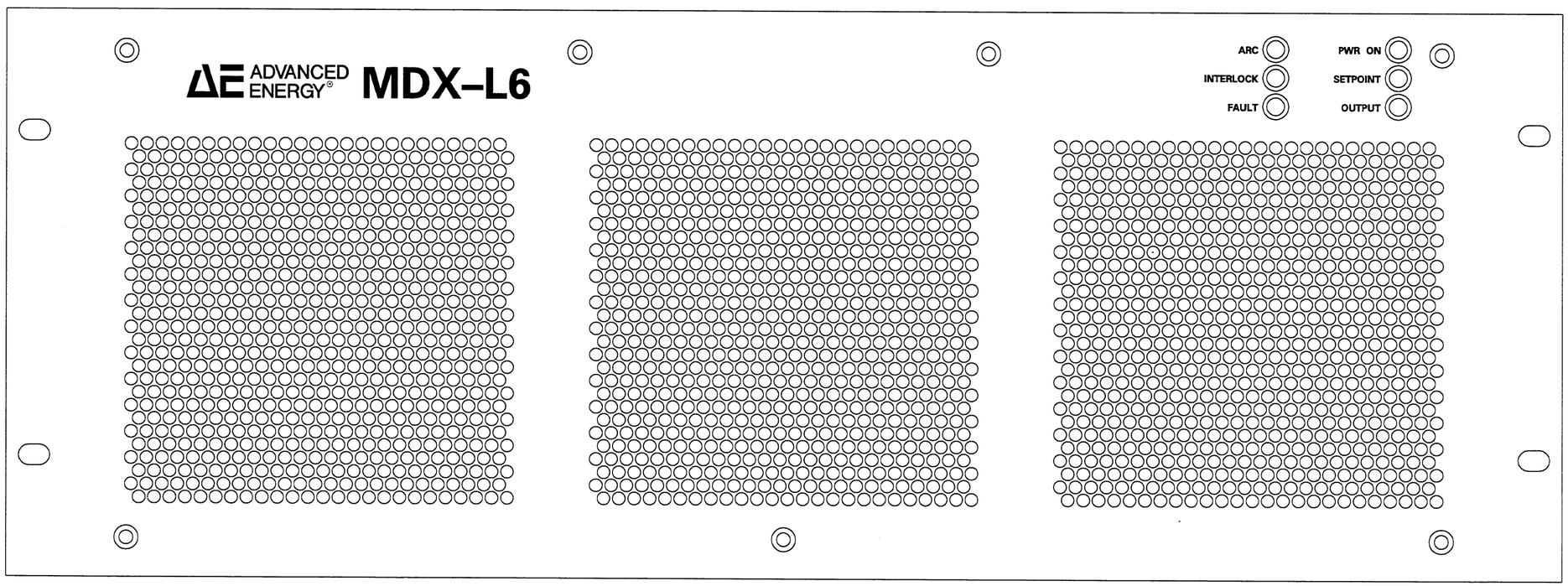
MDX-L functions can be monitored by checking the six status indicator LEDs that are in the center of the standard control panel (see foldout illustrations at the end of this chapter).

Status Indicator LEDs

A group of LEDs are clustered together on the control panel. The table below provides details.

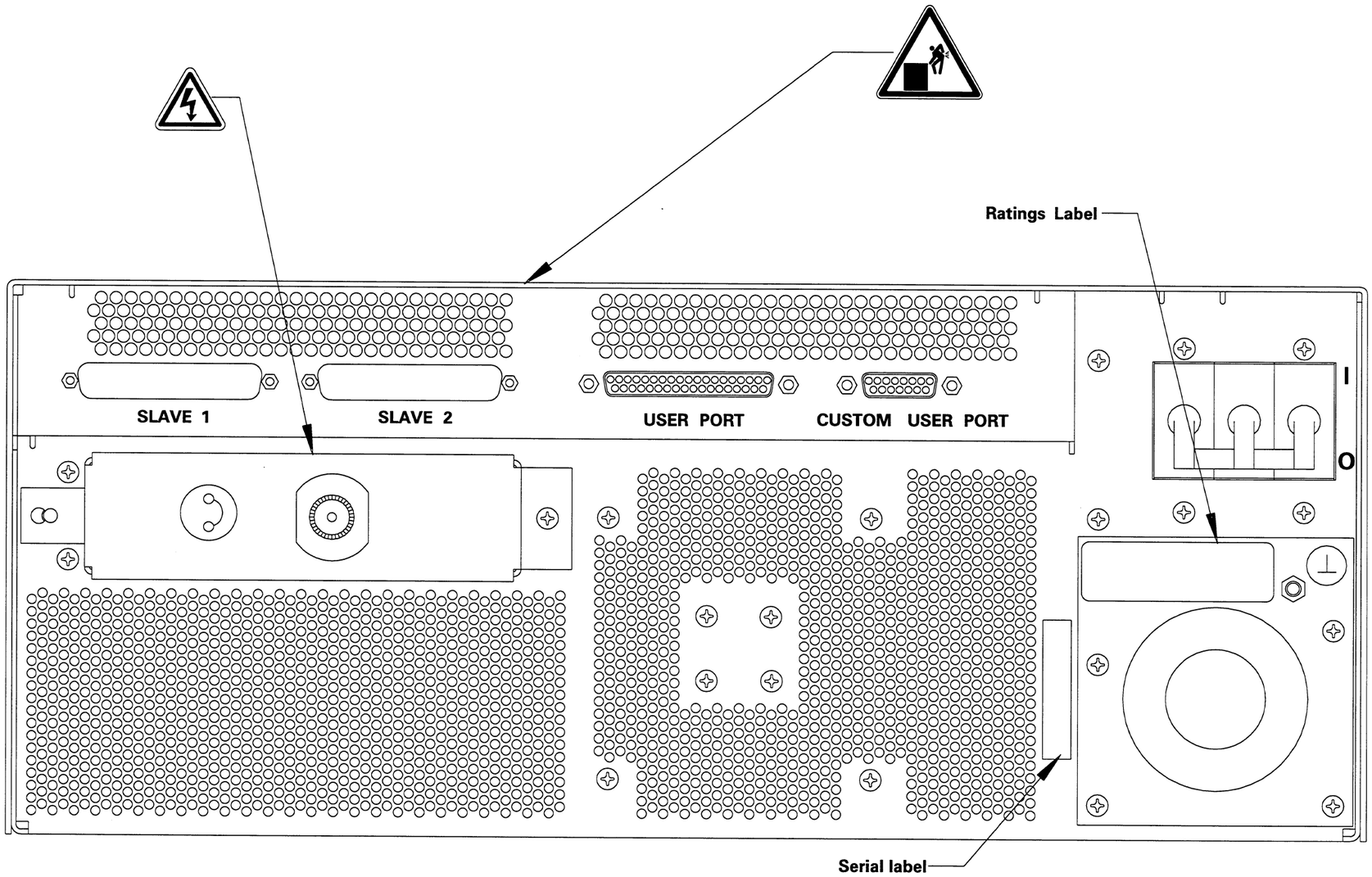
Status Indicator LED	Functional Status
ARC	Lights to indicate that the impedance of the chamber dropped enough to cause the output voltage of the MDX-L unit to drop below a built-in trip point; that is, this LED indicates that the unit has recognized an arc condition and activated the VARC circuit.
INTERLOCK	Lights to indicate that a system interlock condition has failed. ***NOTE:*** Output power cannot be turned on unless the **INTERLOCK** LED is off.
SETPOINT	Lights when output is equal to the programmed setpoint; flashes when the output is turned on and is not equal to the programmed setpoint
FAULT	Lights when a failure has occurred in the power circuit or when the internal temperature is too high
OUTPUT	Lights when the output is enabled; flashes when an output fault exists
PWR ON	Lights to indicate that the 208 V (main) power is on and the circuit breaker is closed

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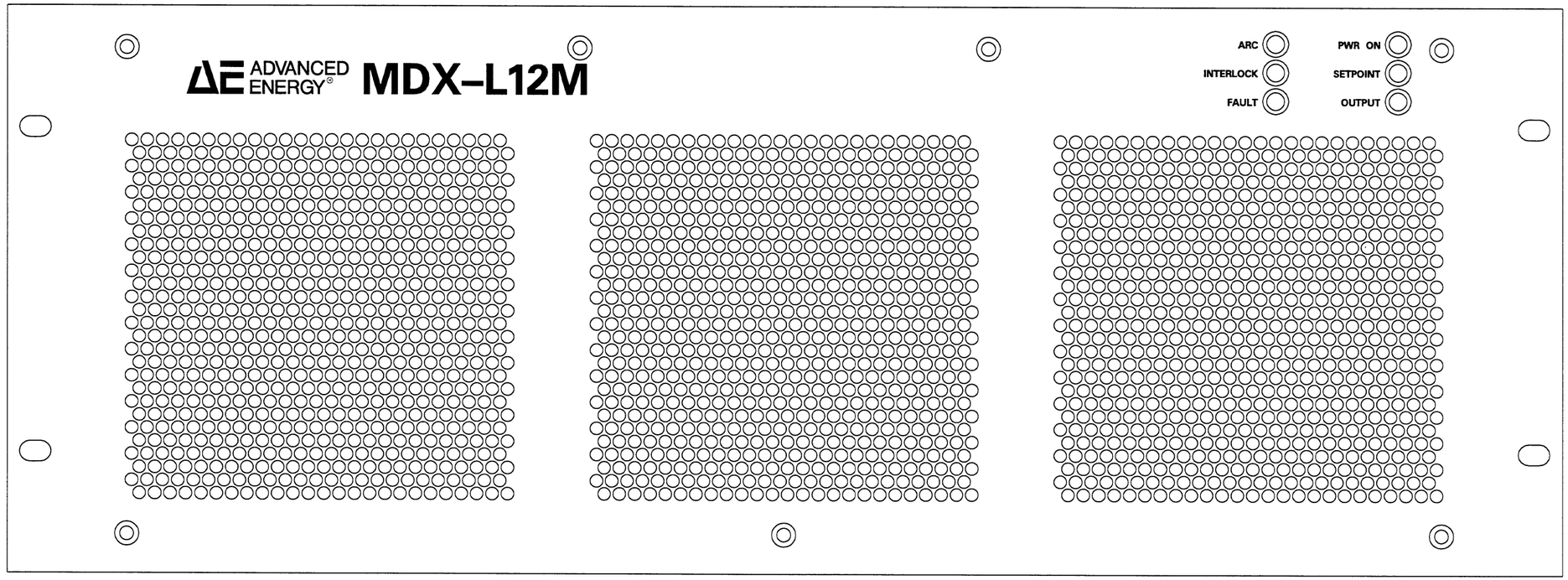
MDX–L6, Front View

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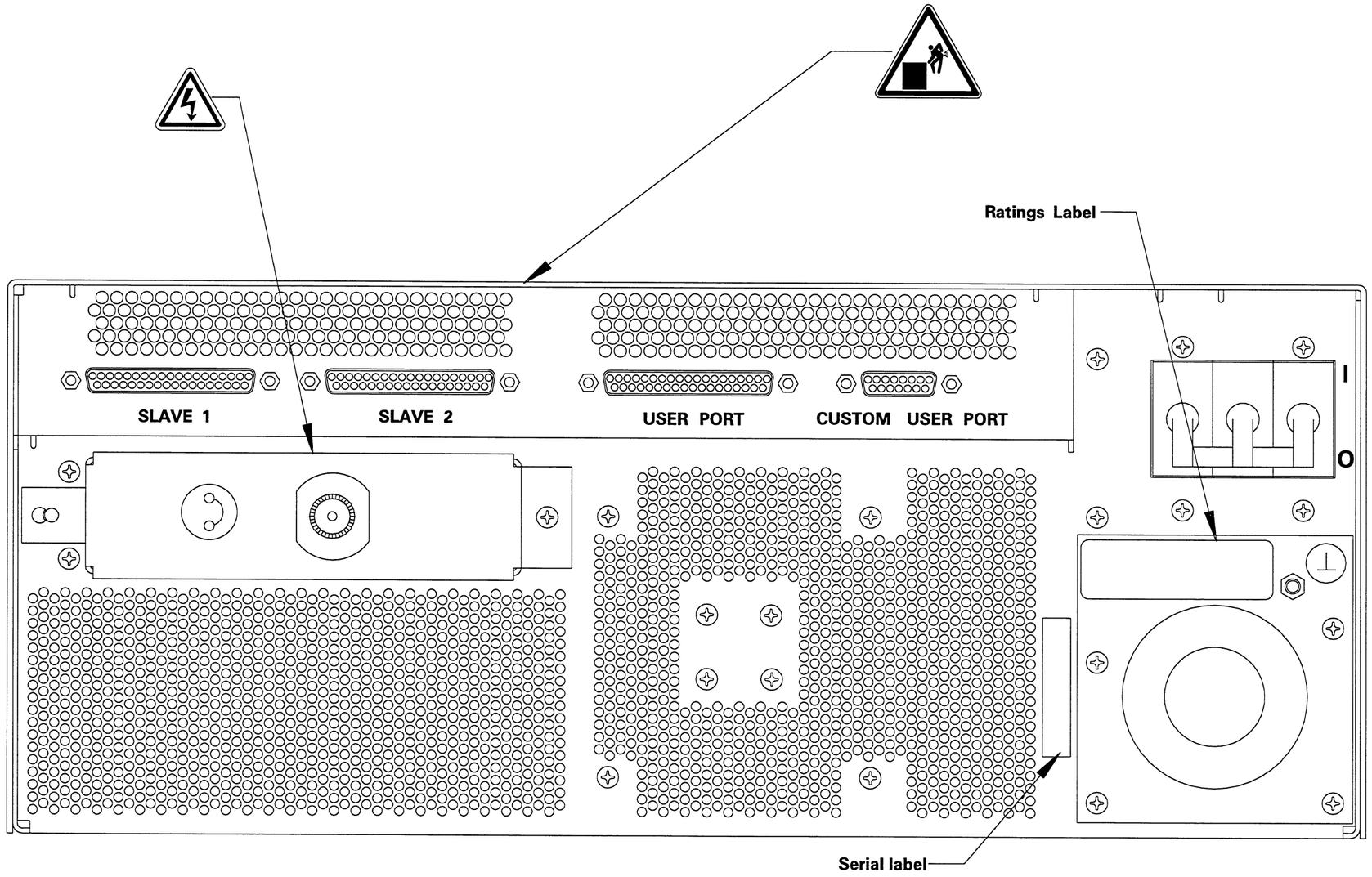
MDX–L6, Rear View

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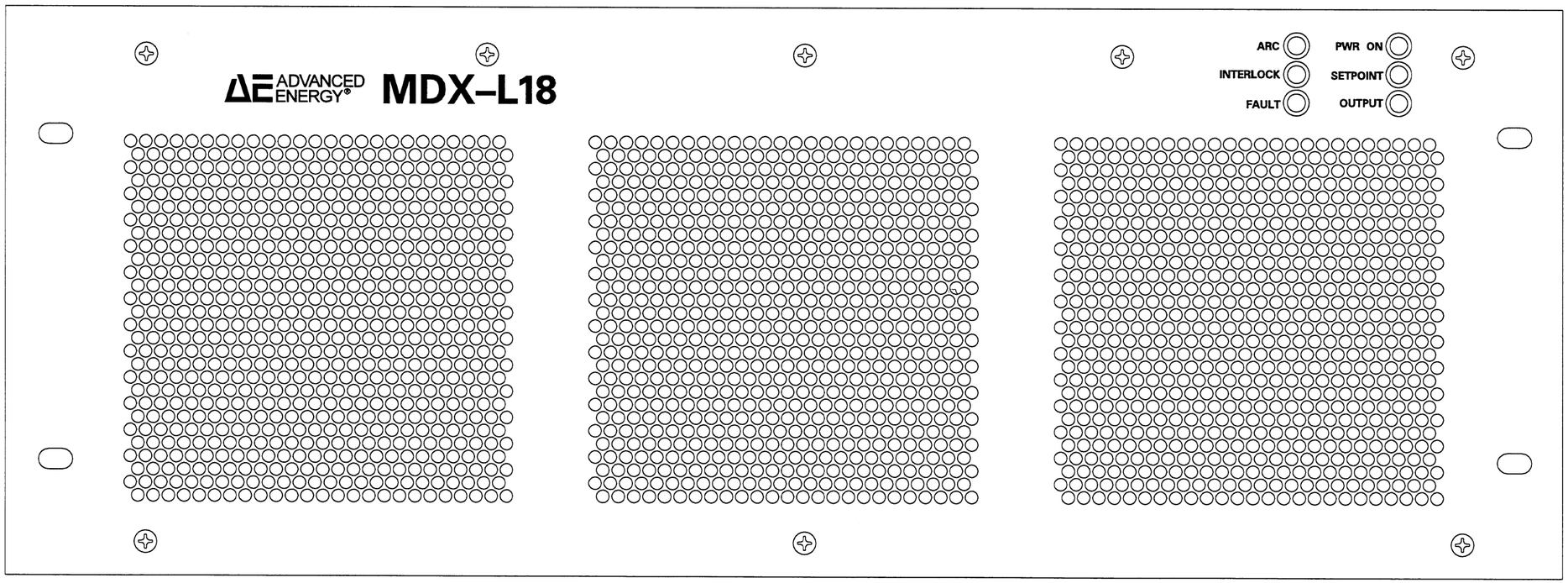
Master, MDX–L12, Front View

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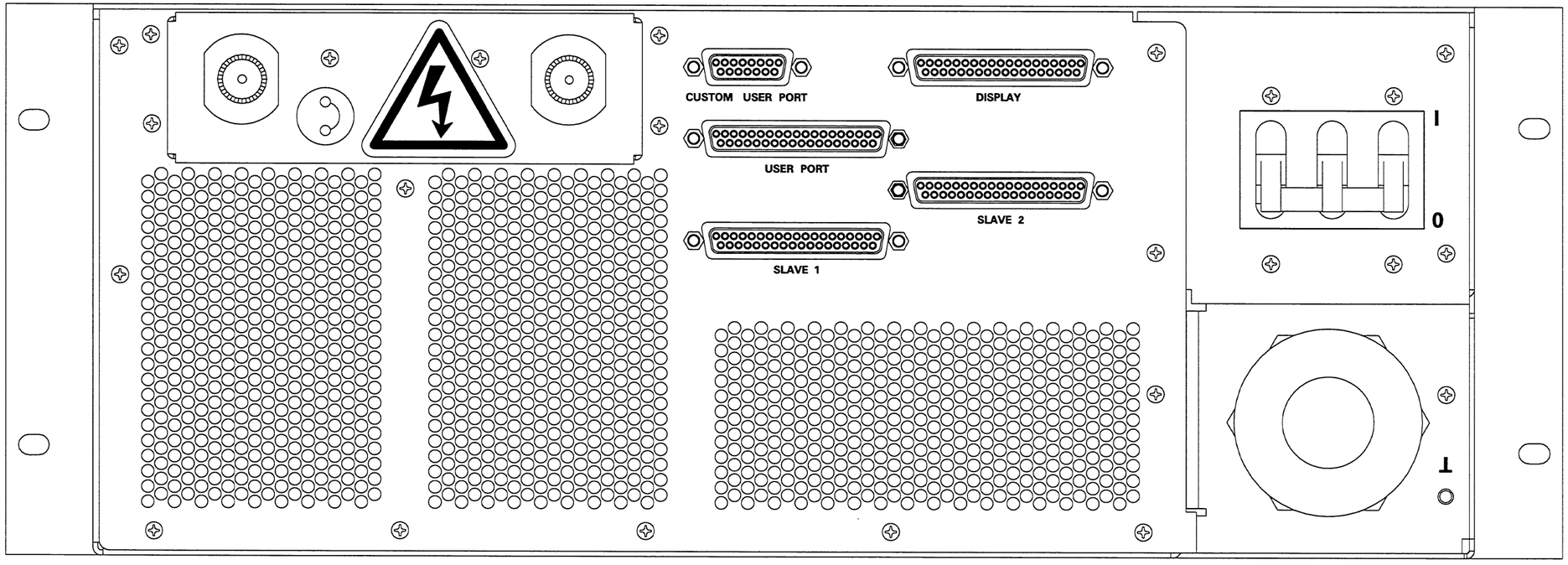
Master, MDX–L12, Rear View

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MDX–L18, Front View

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MDX–L18, Rear View

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PART II

OPERATING YOUR MDX-L MAGNETRON DRIVE

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CONTENTS

Setting Up 3-5
Unpacking 3-5
Design Considerations 3-5
Spacing Requirements 3-6
Cooling Requirements 3-7
Making Rear Panel Connections 3-9
Grounding 3-9
Connecting Input Power 3-10
Standard Connection 3-10
Connecting the Output 3-12
Connecting for Custom User (15-pin) Remote Control 3-13
Signal Descriptions—Custom User Pins 3-14
Connecting the User (Slave) Port 3-16
Signal Descriptions—User (Slave) Pins 3-17
Connecting the Slave 1 and Slave 2 Ports (Master Units Only) 3-22
Signal Descriptions—Slave 1 and Slave 2 Pins (Master Units Only) 3-23
First-time Operation 3-27
Start-up Procedure 3-27

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SETTING UP



DANGER! Operating and maintenance personnel must have the correct training before setting up and maintaining high-energy electrical equipment. THIS EQUIPMENT MUST BE INSTALLED ACCORDING TO APPLICABLE REQUIREMENTS.

Unpacking

Unpack and inspect your MDX-L magnetron drive power supply carefully. Check for obvious physical damage. If no damage is apparent, proceed to make the 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.

Design Considerations

All MDX-L models are designed to mount in a standard 19-inch (482.6 mm) rack by means of the rack ears attached to the power supply. The MDX-L unit is an air-cooled power supply, so it is important to ensure that adequate ventilation is provided. The information in the "Spacing Requirements" section on page 3-6 applies to both rack and cabinet mounting. For additional information about cabinet mounting, also see "Cooling Requirements" on page 3-7.

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Spacing Requirements

- The clearance between either side of the MDX-L unit and the enclosure must be 25 mm (1 in).
- No clearance is required between power supplies or between the top or bottom of a power supply and the enclosure; however, leaving some clearance will prevent cosmetic damage to the sheet metal finish.
- The clearance between the rear of the MDX-L unit and the enclosure must be 229 mm (9 in), with adequate ventilation.
- The clearance between the front panel of the MDX-L unit and the front enclosure doors must be 50 mm (2 in).

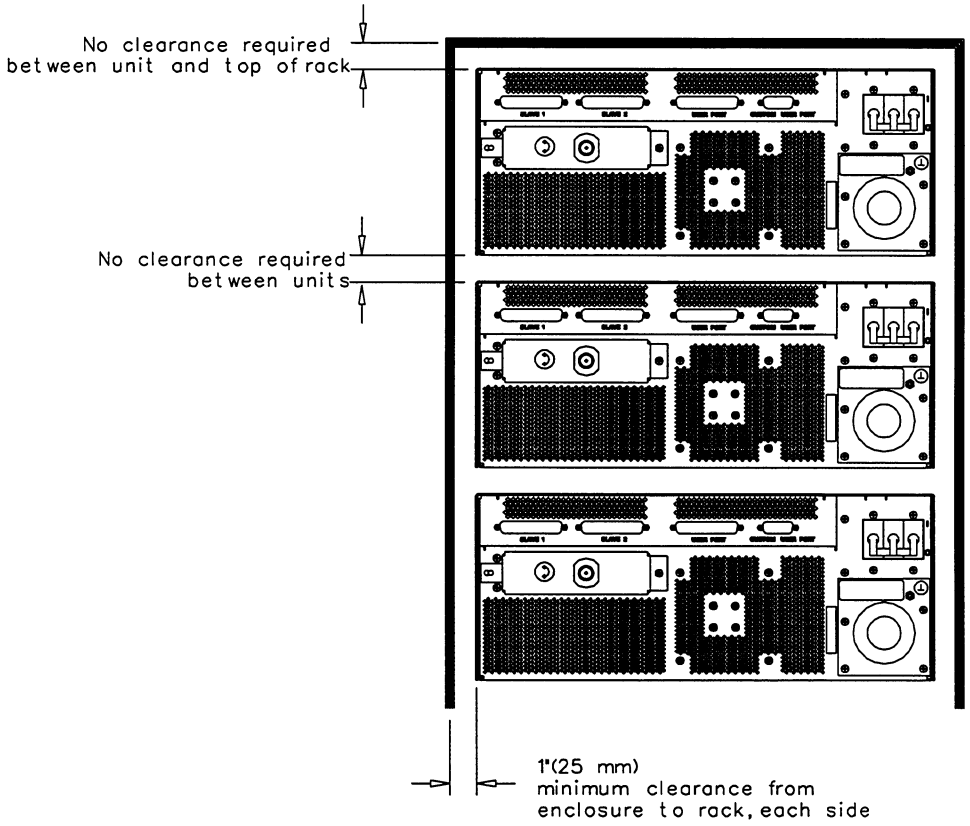


Figure 3-1. Illustration of top, side, and inter-unit clearance requirements for MDX-L units stacked in a cabinet

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Cooling Requirements

For the MDX-L unit to be sufficiently cooled, the cabinet must be configured to:

- bring in coolant air of the correct temperature (40°C maximum)
- distribute input (coolant) air to the power supplies
- exhaust the hot air from the cabinet with minimal air flow restriction

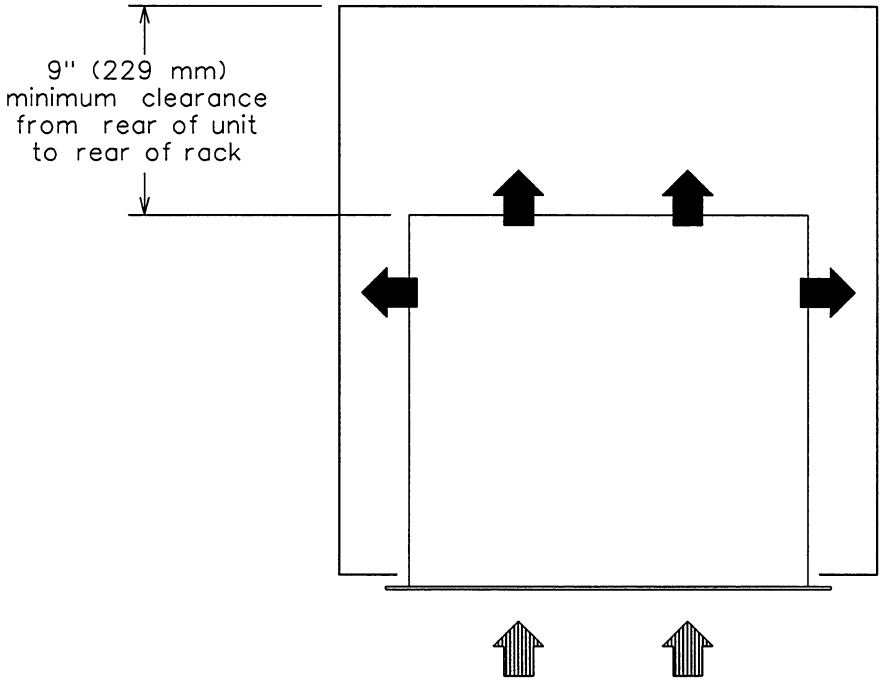


Figure 3-2. Graphic representation of the view looking down on the top of an MDX-L unit in a rack. The arrows show the direction of air flow

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The following is a synopsis of the principles to follow when designing a cabinet containing a "stack" of MDX-L power supplies.

Each MDX-L unit requires 200 CFM of inlet air. The internal dissipation of each unit is as follows:

- At a full load of 6 kW, the MDX-L6 dissipates 600 W.
- At a full load of 12 kW, the MDX-L12 dissipates 1200 W.
- At a full load of 18 kW. the MDX-L18 dissipates 1800 W.

Each unit produces 200 CFM of exhaust air.

As an example, a cabinet containing six MDX-L12 power supplies would require a total inlet area of 180 square inches (1161 cm^2) — that is, 6 units x 30 square inches per unit. One method would be to perforate a total area of 180 square inches (1161 cm^2) on the side or rear of the cabinet. An important consideration during cabinet design is the need for a physical barrier separating the hot exhaust air from the inlet air used for cooling. To be most effective, such a barrier should extend from the topmost power supply to the bottom power supply.



Note: Multiply the number of power supplies by 30 square inches (193.5 cm^2) to get the inlet area for **one side** of the cabinet. You will also need to provide the same exhaust area for the other side of the cabinet.

In this example, all six units will exhaust into the rear of the cabinet (6 units x 1.2 kW per unit = 7.2 kW total). We recommend that a fan or a blower be mounted near the top of the cabinet to help move the hot exhaust air out of the cabinet and away from the power supplies.



Note: 600 W is equal to 34.2 BTUs per minute.
1200 W is equal to 68.3 BTUs per minute.
1800 W is equal to 102.5 BTUs per minute.

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MAKING REAR PANEL CONNECTIONS

Grounding



DANGER! Connect the protective earth terminal on the MDX-L rear panel to protective earth/ground before making any other connection.



For optimum performance, ground the chassis stud to the chamber ground.

A protective earth terminal stud for chassis ground is located to the right of the main input cable connector (see foldout illustrations of the rear panels at the end of Chapter 2). AE recommends connecting this chassis ground to the chamber ground. An alternate configuration connects chassis ground to the system ground block (Figure 3-3).

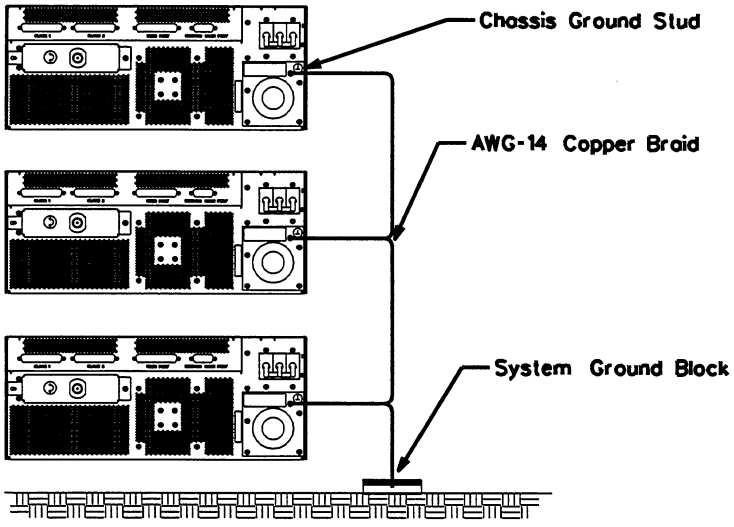


Figure 3-3. Grounding the MDX-L unit

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Connecting Input Power



DANGER! Before making any other connection, connect the ground wires to protective earth-ground. On MDX-L6 and MDX-L12 units, the sheath ground wire (blue) must be connected to the lug on the end of the input ground wire (green and yellow) before connecting the lug to protective earth-ground.



The MDX-L unit must be installed using a safety isolation transformer in accordance with IEC 742/EN 60742.

Standard Connection



DANGER! The input power cable must be installed so that it is not accessible to the operator.



The MDX-L unit must be installed with a permanent connection because its leakage current exceeds 3.5 mA.



To meet EMC requirements, you must terminate the input cable's sheath ground to earth ground (MDX-L6 and MDX-L12 units only).

The standard input connection can be a "Y" or a delta connection (Figure 3-4 on page 3-11). Before making either connection on MDX-L6 and MDX-L12 units, first connect the sheath ground wire (a small, blue wire) to the lug on the end of the input ground wire (a green and yellow wire). Then connect the ground lug to protective earth-ground. For all units, note that in the "Y" configuration, a neutral connection is not required. However, if neutral is present, you may tie it to ground at the ground lug.

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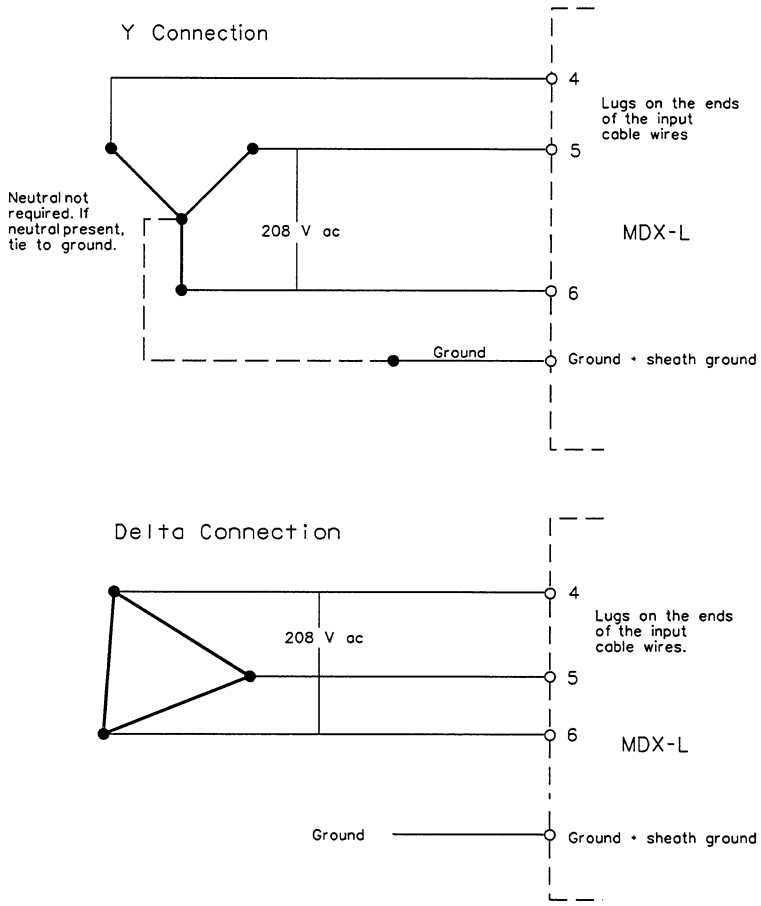
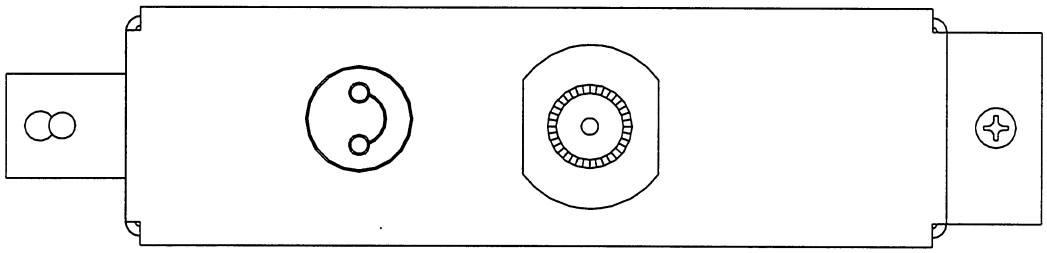


Figure 3-4. Standard input connections

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Connecting the Output

Two female UHF-type output connectors are standard on the MDX-L18. The MDX-L6 and MDX-L12 each have one UHF-type output connector as standard (illustration below). The output connection for these connectors should be made by means of a male UHF-type connector (Amphenol 83-822) (not provided). An optional stud output connector with one positive and one negative terminal also is available on MDX-L6 and MDX-L12 units. The cable for the output connection is not included with the MDX-L unit, but can be purchased from AE separately.



UHF, Female (provided)

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Connecting for Custom User Remote Control

YOU SHOULD KNOW...

A quick-reference pin-description table for this port is on page 2-6 .

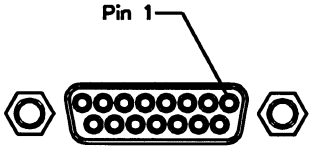
YOU SHOULD KNOW...

To meet EMC standards, you must use a shielded cable with a metal back shell and terminate the shield at both ends. A drain wire is not sufficient for grounding the shield.

YOU SHOULD KNOW...

Select a shielded cable that is designed to be used only with SELV (Safety Extra Low Voltage) or equivalent circuits not exceeding 25 V ac or 60 V dc.

A detailed description of Customer Interface connector (illustrated below) signals begins on the next page. Note that EMC standards require the use of shielded cable with this connector.



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Signal Descriptions—Custom User Port Pins

pin 1. SETPOINT.D. **Output.** By going low, this 0 or 15 V output signal indicates that the output is equal to the requested setpoint (the **SETPOINT** LED on the front panel will also light). It will sink 35 mA, and should be referenced to *OUT ENABLE COM.D (pin 9)*. It is internally pulled up to 15 V through a 10-kΩ resistor, and its impedance is 100 Ω.

pin 2. VOUT.A. **Output.** This pin provides a fully buffered 0 to 10 V signal representing output voltage: 10 V = 1000 V dc. It should be referenced to *OUT ENABLE COM.D (pin 9)*; its impedance is 100 Ω. When the open circuit output voltage is 1500 V dc, the voltage on *pin 2* is 12 V dc. It will sink and source 10 mA.

pin 3. POUT.A. **Output.** This pin provides a fully buffered 0 to 10 V signal representing output power: 10 V ± 1%, or 0.2% of full scale, whichever is greater, = maximum rated output for the supply (see the following table). It should be referenced to *OUT ENABLE COM.D (pin 9)*; its impedance is 100 Ω. It will sink and source 10 mA.

MDX-L Model Type	Maximum Rated Output (W)
MDX-L6 (all models)	6,000
MDX-L12 (all models)	12,000
MDX-L18	18,000

pin 4. OUTPUT ENABLE.D. **Input.** This input signal is used to turn on output power from the Custom User port. Closure between *OUTPUT ENABLE.D* and *OUT ENABLE COM.D (pin 9)* will turn on output power.

pin 5. XPROG.A. This signal is the 0 to 10 V analog setpoint input which is sent through the custom CMR buffer.

pin 6. COM.A. This signal is used as a remote ground. All analog inputs should be referenced to this pin.

pin 7. PWRON.D. When output power is enabled, a contact closure between *pin 7* and *pin 8* occurs. 0.5 A maximum.

pin 8. PWRON COM.D. This signal is the return for *pin 7*.

pin 9. OUT ENABLE COM.D. This signal is the return reference for *SETPOINT.D, VOUT.A, POUT.A, OUTPUT ENABLE.D* and *OUTPUT.D (pins 1, 2, 3, 4* and *13).*

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pin 10. unassigned.

pin 11. $\overline{\textit{INTERLOCK.D}}$. **Input.** This digital input signal provides an interlock and power connector interlock.

pin 12. $\overline{\textit{INTLK COM.D}}$. This signal is the return reference for the interlock signal on *pin 11*, *pin 14*, and *pin 15*.

pin 13. $\overline{\textit{OUTPUT.D}}$. **Output.** When high, this 0 or 15 V output signal indicates that the output is off. When low, it indicates that output is on and will ramp up to whatever setpoint has been specified (the **OUTPUT** LED on the front panel will also light). This signal will sink 35 mA, and should be referenced to *OUT ENABLE COM.D (pin 9)*. It is internally pulled up to 15 V through a 10-kΩ resistor, and its impedance is 100 Ω.

pin 14. CUSINT1.D. **Input**. See explanation below.

pin 15. CUSINT2.D. **Input**. See explanation below.

Inputs on *CUSINT1.D* (*pin 14*) and *CUSINT2.D* (*pin 15*), determine the number of units you expect to see connected in your system. If the number of units expected does not match the number of units detected in the system, the output is disabled and the **INTERLOCK** LED lights on the front panel. Adapters wired for two or three expected units are available and are listed below by their part number.

CUSINT1.D (*pin 14*)	*CUSINT2.D* (*pin 15*)	# of units expected	AE Adapter Part Number
High	High	One	No adapter required
High	Low	Master + 1	3521160
Low	High	Master + 2	3521161

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Connecting the User (Slave) Port

YOU SHOULD KNOW...

A quick-reference pin-description table for this port is on page 2-8 .

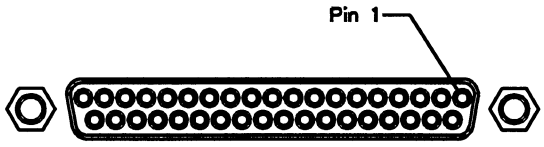
YOU SHOULD KNOW...

To meet EMC standards, you must use a shielded cable with a metal back shell and terminate the shield at both ends. A drain wire is not sufficient for grounding the shield.

YOU SHOULD KNOW...

Select a shielded cable that is designed to be used only with SELV or equivalent circuits not exceeding 25 V ac or 60 V dc.

A detailed description of each the User port (illustrated below) signals begins on the next page. For information about using the User (Slave) port to connect for a master/slave configuration see page 4-10.



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Signal Descriptions—User (Slave) Pins

pin 1. COVERINT.D. **Input/Output.** When pulled low, this 0 or 15 V line disables the power supply. When the output connector cover interlock has been opened, this line will be pulled low internally; other supplies connected to this line will also be disabled.

pin 2. $\overline{\textit{OUTPUT.D}}$. **Output.** When high, this 0 or 15 V signal indicates that the output is off (and that the contactor is open if **contactor hold** has not been selected). When low, it indicates that output is on (and that the contactor is closed, whether or not **contactor hold** has been selected) and that the unit will ramp up to whatever setpoint has been specified. This signal will sink 35 mA, and should be referenced to *OUT COM.D (pin 37)*. It is internally pulled up to 15 V through a 10-kΩ resistor, and its impedance is 100 Ω.

pin 3. $\overline{\textit{SETPOINT.D}}$. **Output.** By going low, this 0 or 15 V signal indicates that the output is equal to the requested setpoint (the **SETPOINT** LED on the front panel will also light). This signal will sink 35 mA, and should be referenced to *OUT COM.D (pin 37)*. It is internally pulled up to 15 V through a 10-kΩ resistor, and its impedance is 100 Ω.

pin 4. unassigned.

pin 5. $\overline{\textit{I REG.D}}$. **Input.** This signal is used with *pin 6 (P REG.D)* to set the method of output regulation (see the following table). An open input defaults high to 15 V; a low input is 0 V ± 0.5 V. It should be referenced to *IN COM.D (pin 36)*.

pin 6. $\overline{\textit{P REG.D}}$. **Input.** This signal is used with *pin 5 (I REG.D)* to set the method of output regulation (see the following table). An open input defaults high to 15 V; a low input is 0 V ± 0.5 V. It should be referenced to *IN COM.D (pin 36)*.

Pin Number	Current Regulation	Voltage Regulation	Power Regulation
5	Low	Low	High
6	High	Low	Low

pin 7. $\overline{\textit{ON.D}}$. **Input.** This signal is used to turn on output from the User (slave) port. Closure between $\overline{\textit{ON.D}}$ and *IN COM.D (pin 36)* will turn on output power if *OFF.D* (*pin 14*) is connected to *IN COM.D* .

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pin 8. unassigned.

pin 9. OUT COM.A. This signal is a dedicated return to internal system ground, then to chassis ground, and finally to protective earth/ground. All analog outputs should be referenced to this pin.

pin 10. IN COM.A. This signal is a dedicated return to internal system ground, then to chassis ground, and finally to protective earth/ground. All analog inputs should be referenced to this pin.

pin 11. $\overline{AUX.D}$. **Input.** This signal, with $\overline{VAC.D}$ (*pin 12*) and $\overline{WATER.D}$ (*pin 13*), monitors the system interlock string. If the interlock conditions are not all satisfied (auxiliary, vacuum, and water), either of the following occurs: 1) the main contactor will not close, or 2) if the contactor is already closed and **contactor hold** has not been selected, it will open when the interlock string is interrupted. If **contactor hold** has been selected, the contactor will remain closed but the supply will be inhibited. This pin should be referenced to *INTLK COM.D (pin 19)*.

pin 12. $\overline{VAC.D}$. See discussion of *pin 11 (*$\overline{AUX.D}$*).*

pin 13. $\overline{WATER.D}$. See discussion of *pin 11 (*$\overline{AUX.D}$*).*

pin 14. OFF.D. **Input.** When high, this signal overrides all commands and forces the MDX-L unit to shut off output power and resets interlocks. It should be referenced to *IN COM.D (pin 36)*.

pin 15. REMOTE COM.A. This signal is used as a remote ground.

pin 16. $\overline{C\ HOLD.D}$. **Input.** This signal is used to request **contactor hold**. When this signal is high, the main contactor closes and opens as output is turned on and off; when it is low, the contactor remains closed after the first time the dc bus is energized, regardless of whether output is being produced or not. This signal is internally pulled up to 15 V through a 10-kΩ resistor.

pin 17. COM.A. This signal is an auxiliary analog return.

pin 18. 15 V PROT.D. This signal supplies 15 V dc to the status LEDs on passive displays (both master and slave units). It will source a maximum of 100 mA.

pin 19. INTLK COM.D. This common is used interchangeably with *INCOM.D (pin 36)*. It is a dedicated return to internal system ground, then to chassis ground, and finally to protective earth/ground. We

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recommend that all signals in the interlock string be referenced to this pin.

pin 20. unassigned

pin 21. $\overline{ARC.D}$. **Output.** This 0 or 15 V signal goes low whenever an arc is detected at the MDX-L output and remains low until the arc is cleared. This signal will sink 35 mA and should be referenced to *OUT COM.D (pin 37).* It is internally pulled up to 15 V through a 10-kΩ resistor, and its impedance is 100 Ω.

pin 22. unassigned.

pin 23. V OUT.A. **Output.** This signal provides a fully buffered 0 to 10 V signal representing output voltage: 10 V = 1000 V dc. This signal should be referenced to *REMOTE COM.A (pin 15)*; its impedance is 100 Ω. When the open circuit output voltage is 1500 V dc, the voltage on *pin 23* is 12.5 V dc. It will sink and source 10 mA.

pin 24. P OUT.A. **Output.** This signal provides a fully buffered 0 to 10 V signal representing output power: 10 V = maximum rated output for the supply (see the following table) or the total output of a master/slave configuration. This signal should be referenced to *REMOTE COM.A (pin 15)*; its impedance is 100 Ω. It will sink and source 10 mA.

MDX-L Model Type	Maximum Rated Output (W)
MDX-L6 (all models)	6,000
MDX-L12 (all models)	12,000
MDX-L18	18,000

pin 25. I OUT. A. **Output.** This signal provides a fully buffered 0 to 10 V signal representing output current: 10 V = maximum output current the supply can produce (see the following table) or the total output of a master/slave system. This signal should be referenced to *REMOTE COM.A (pin 15);* its impedance is 100 Ω. It will sink and source 10 mA.

MDX-L Model Type	Maximum Output Current (A)
MDX-L6	15
MDX-L12	30
MDX-L12 HV1	24
MDX-L18	45

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pin 26. RAMP.A. **Input.** This signal is used to remotely program ramp time. A span of 0 to 10 V corresponds to ramp time: 10 V = maximum ramp time (1 sec. ± 5%). This signal should be referenced to *IN COM.A (pin 10)*.

pin 27. LEVEL.A. **Input.** This input signal is used to remotely program the output level. A span of 0 to 10 V corresponds to output: 10 V = actual maximum output level. This signal should be referenced to *IN COM.A (pin 10)*.

pin 28. INH.D. **Input.** This digital signal inhibits the power supply when pulled high.

pin 29. I OUT SLAVE.A. **Output.** This signal is specifically provided to drive a master unit. It provides a fully buffered 0 to 10 V signal representing output current the supply can produce. It will source and sink 5 mA through a 2-kΩ resistor. It should be referenced to *OUT COM.A (pin 9)*; its impedance is 100 Ω.

pin 30. unassigned.

pin 31. LEVEL OUT.A. **Output.** This signal provides a fully buffered 0 to 10 V signal representing the magnetron drive's programmed setpoint level: 10 V = maximum setpoint. This signal will source and sink 5 mA through a 2-kΩ resistor. It should be referenced to *OUT COM.A (pin 9)*; its impedance is 100 Ω.

pin 32. REF.A. This output signal provides an accurate 10 V reference (10 V ± 10 mV). It should be referenced to *IN COM.A (pin 10)*; its impedance is 100 Ω. ***NOTE:*** Limit current to 5 mA.

pin 33. $\overline{VARC.D}$. **Input.** This signal is a digital signal used to select shutdown for voltage-sensed arcs. If left open or pulled low, this pin is enabled (reference to *IN COM.D.*)

pin 34. PWRIDN0.D. This is a power identification (0) signal. It has a 1 kΩ termination to *OUT COM.D (pin 37).*

pin 35. PWRIDN1.D. This is a power identification (1) signal. It has a 1 kΩ termination to *OUT COM.D (pin 37).*

pin 36. IN COM.D. This common is used interchangeably with *INTLK COM.D (pin 19)*. It is a dedicated return to internal system ground, then to chassis ground, and finally to protective

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earth-ground. We recommend that all digital inputs, except the interlock signals, be referenced to this pin.

pin 37. OUT COM.D. This signal is a dedicated return to internal system ground, then to chassis ground, and finally to protective earth-ground. All digital outputs should be referenced to this pin.

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Connecting the Slave 1 and Slave 2 Ports



A quick-reference pin-description table for this port is on page 2-11 .

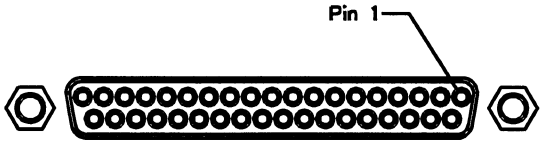


To meet EMC standards, you must use a shielded cable with a metal back shell and terminate both shields. A drain wire is not sufficient for grounding the shield.



Select a shielded cable that is designed to be used only with SELV or equivalent circuits not exceeding 25 V ac or 60 V dc.

A detailed description the Slave port connector (illustrated below) signals begins on the next page. For information about using the Slave 1 and Slave 2 ports to connect for a master/slave configuration see page 4-10.



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Signal Descriptions—Slave 1 and Slave 2 Pins (Master Units Only)

pin 1. COVERINT.D. **Input/Output.** When pulled low, this 0 or 15 V (input/output) line disables the master and the slave units.

pin 2. $\overline{\textit{OUTPUT.D}}$. **Input.** When high, this 0 or 15 V signal indicates that the slave output is off. When low, it indicates that the slave output is on and will ramp up to whatever setpoint has been specified.

pin 3. $\overline{\textit{SETPOINT.D}}$. **Input.** This 0 or 15 V signal indicates that the slave output is equal to the requested setpoint by going low (the **SETPOINT** LED on the front panel will also light).

pin 4. unassigned.

pin 5. $\overline{\textit{I REG.D}}$. **Output.** This signal is used with *pin 6 (P REG.D)* to set the method of output regulation (see the following table).

pin 6. $\overline{\textit{P REG.D}}$. **Output.** This signal is used with *pin 5 (I REG.D)* to set the method of output regulation (see the following table).

Pin Number	Current Regulation	Voltage Regulation	Power Regulation
5	Low	Low	High
6	High	Low	Low

pin 7. $\overline{\textit{ON.D}}$. **Output.** This signal is used to turn on the slave's output. Closure between $\overline{\textit{ON.D}}$ and *IN COM.D (pin 36)* will turn on output power if *OFF.D (pin 14)* is connected to *IN COM.D* .

pin 8. unassigned.

pin 9. OUT COM.A. This signal is a dedicated return to internal system ground, then to chassis ground, and finally to protective earth/ground.

pin 10. IN COM.A. This signal is a dedicated return to internal system ground, then to chassis ground, and finally to protective earth/ground.

pin 11. $\overline{\textit{AUX.D}}$. **Output.** This signal, with $\overline{\textit{VAC.D}}$ (*pin 12*) and $\overline{\textit{WATER.D}}$ (*pin 13*), controls the slave interlock string. The interlock lines to the master are paralleled to slave interlock so that when the

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master receives an interlock fault, the same fault is sent to the slaves.

pin 12. $\overline{VAC.D}$. See discussion of *pin 11 ($\overline{AUX.D}$).*

pin 13. $\overline{WATER.D}$. See discussion of *pin 11 ($\overline{AUX.D}$).*

pin 14. OFF.D. **Output.** When high, this signal overrides all commands and forces the MDX-L slave to shut off output power and resets interlocks.

pin 15. REMOTE COM.A. This signal can be used as a remote ground.

pin 16. $\overline{C\ HOLD.D}$. **Output.** This signal is used to request **contactor hold** on the slave unit. When this signal is high, the slave main closes and opens as output is turned on and off; when it is low, the slave contactor remains closed after the first time the dc bus is energized, regardless of whether output is being produced.

pin 17. COM.A. This signal is an auxiliary analog return.

pin 18. 15 V PROT.D. This signal receives the slave 15 V dc to determine if the slave is energized.

pin 19. INTLK COM.D. This signal reads the slave *INTLK COM.D* signal to determine if a slave is connected.

pin 20. unassigned.

pin 21. unassigned.

pin 22. unassigned.

pin 23. unassigned.

pin 24. P OUT.A. **Input.** This signal receives a 0 to 10 V signal representing slave output power: 10 V = maximum rated output for the supply (see the following table). Reference to *REMOTE COM.A (pin 15).*

MDX-L Model Type	Maximum Rated Output (W)
MDX-L6 (all models)	6,000
MDX-L12 (all models)	12,000
MDX-L18	18,000

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pin 25. I OUT. A. **Input.** This signal receives a 0 to 10 V signal representing slave output current the supply can produce (see the following table). Reference to *REMOTE COM.A (pin 15)*.

MDX-L Model Type	Maximum Output Current (A)
MDX-L6	15
MDX-L12	30
MDX-L12 HV1	24
MDX-L18	45

pin 26. RAMP.A. **Output**. This signal is used to remotely program slave ramp time. A span of 0 to 10 V corresponds to ramp time: 10 V = maximum ramp time (1 sec. ± 5%).

pin 27. LEVEL.A. **Output.** This signal is used to program the slave output level. A span of 0 to 10 V corresponds to output: 10 V = actual maximum output level.

pin 28. INH.D. **Output.** This digital signal inhibits the slave supply when pulled high.

pin 29. I OUT SLAVE.A. **Input.** This signal receives a 0 to 10 V signal representing slave output current the supply can produce.

pin 30. unassigned.

pin 31. unassigned.

pin 32. unassigned.

pin 33. $\overline{VARC.D}$. This signal pulls the slave $\overline{VARC.D}$ signal high to disable VARC mode in the slave units. In a master/slave configuration, VARC shutdown is controlled by the master only.

pin 34. PWRIDN0.D. **Input.** This signal (along with *pin 35*) indicates what kind of MDX-L unit is connected (as a slave) to the master unit.

pin 35. PWRIDN1.D. **Input.** This signal (along with *pin 34*) indicates what kind of MDX-L unit is connected (as a slave) to the master unit.

pin 36. IN COM.D. This signal is a dedicated return to internal system ground, then to chassis ground, and finally to protective earth-ground.

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pin 37. OUT COM.D. This signal is a dedicated return to internal system ground, then to chassis ground, and finally to protective earth-ground.

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FIRST-TIME OPERATION

Start-up Procedure

1. Make sure that the necessary external inputs are supplied (refer to Custom User signal descriptions on pages 3-14 and 3-15)

2. Connect the output connector(s) (see details on page 3-12).

3. Turn on the breaker at rear of unit. The **PWR ON** LED lights. Both monitors will display "OFF."



DANGER! The next step will result in high voltage levels at the output connector. Take appropriate steps to prevent electrical shock.

4. With an **on** command at the Custom User port, the main contactor will close, the **ARC** LED will momentarily light, and the **OUTPUT** LED will light. The output will ramp to the selected setpoint level, causing the **SETPOINT** LED to light.

5. An **off** command at the Custom User port will turn the unit off at any time.

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PART II

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CHOOSING MODES/SETTINGS

CONTENTS

Output Regulation 4-3
Program Mode 4-5
Setpoints. 4-5
Setpoint Level 4-5
Impedance Options 4-7
Master/Slave Operation 4-10
Status LEDs in the Master/Slave Configuration 4-12

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PART II

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OUTPUT REGULATION

The product of the MDX-L magnetron drive is referred to generically as "output" throughout this manual. Output of this MDX-L is always regulated as power. From the Custom User, *pin 4 (OUTPUT ENABLE.D)* must be low for the output to turn on and high for the output to turn off. When Custom User *pin 11 (INTERLOCK.D)* goes low, power regulation mode is automatically selected.

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PROGRAM MODE

Setpoints

Setpoint Level

You can program an output setpoint level whether or not output is being produced. You can change the method of output regulation (see page 4-3) while the output is off or on. If, however, you change the method of output regulation, the output of the unit will reflect what the setpoint is commanding for that particular method of regulation.

The **SETPOINT** status indicator LED (see page 2-14) lights when output is equal to the programmed setpoint; it flashes when the output is not equal to the programmed setpoint and the output light is on. When an **off** command is received, the **SETPOINT** LED is not illuminated.

Custom User:

Setpoint parameters that can be monitored from the Custom User port are as follows:

Parameter	Custom User
Setpoint level	*pin 5*
Whether programmed output setpoint level has been attained	*pin 1*

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IMPEDANCE OPTIONS

Each MDX-L is equipped with a built-in impedance-matching transformer. These transformers are available in high Z or standard Z configurations. With the proper transformer, load impedances requiring voltages from up to 525 V or 650 V can be accommodated. The standard range is 400 to 525 V for the MDX-L6 and the MDX-L12; the MDX-L18 has a standard range of 400 to 600 V (Figure 4-1 on page 4-8).

Plasma strike voltages are available on all transformers; open circuit voltage rating is 1500 V. The full rated power output for each MDX-L is available throughout the range.

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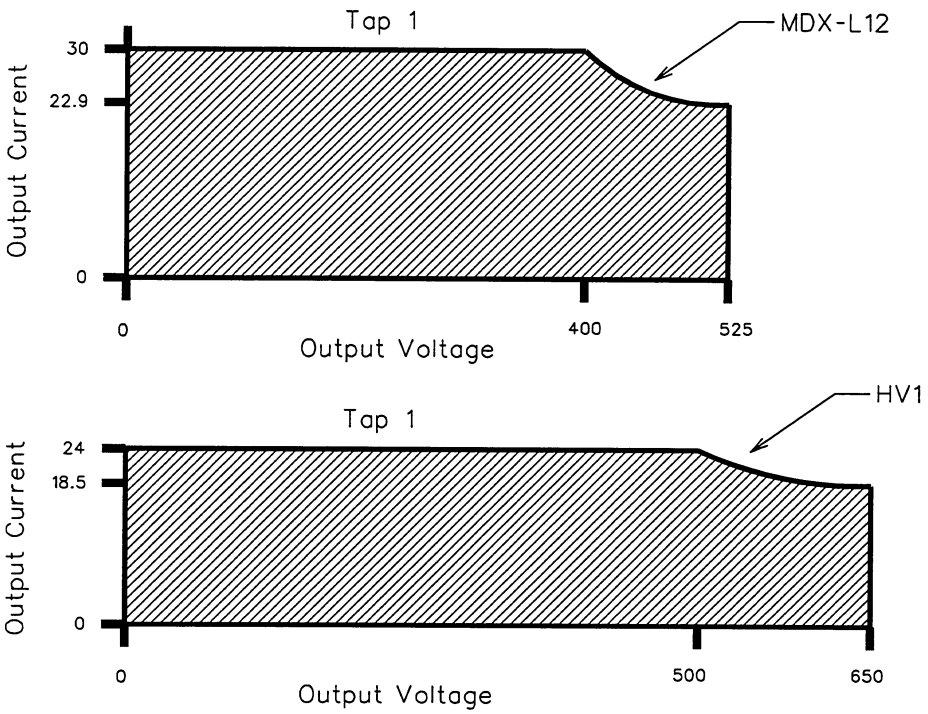
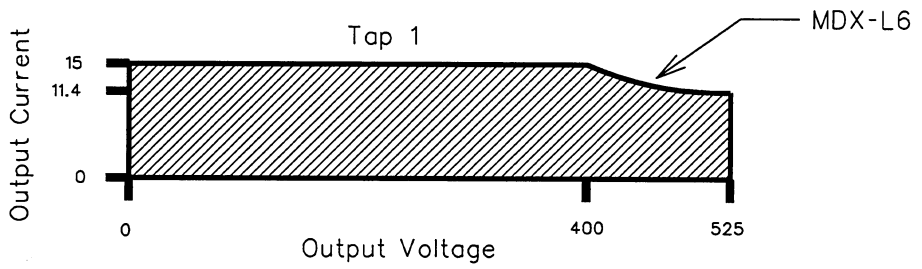


Figure 4-1. Impedance ranges for the MDX-L12 and MDX-L12 HV1

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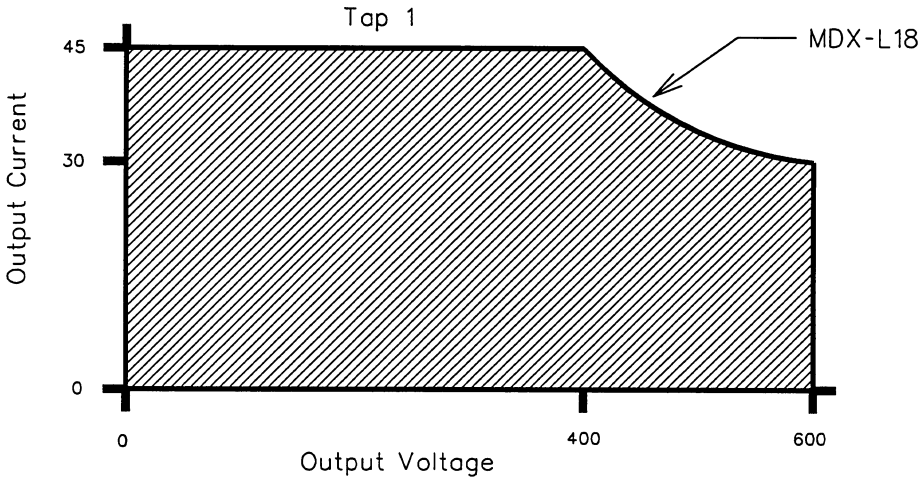


Figure 4-2. Impedance ranges for the MDX-L6 and the MDX-L18

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MASTER/SLAVE OPERATION

Your MDX-L unit can be used as a master, a slave, or a stand-alone unit. Three ports on the rear of the unit aid in configuring units for master/slave operation: the 37-pin User (Slave) port, and the Slave 1 and Slave 2 ports, which are electrically and functionally identical.

If you are planning to control your master/slave configuration from the Custom User port on the designated master unit, first ensure that you have the correct adapter for the number of units in your configuration (see the table on page 3-15 for details). Connect this adapter to the Custom User port and tighten the jack screws.

To interconnect units in a master/slave configuration, use a cable (equipped with a 37-pin male connector on each end) to connect the User (Slave) port of the unit to be designated as the slave to the Slave 1 port or the Slave 2 port of the unit to be designated the master unit. Two slaves can be connected to a master unit simultaneously (Figure 4-3 on page 4-11).

The designated master unit can be controlled remotely, either through the 15-pin Custom User port or the 37-pin User port. Connect your system controller to one of these ports. The combined power of the inter-connected units is represented by the signal on *pin 3* of the Custom User port or *pin 24* of the 37-pin User port.

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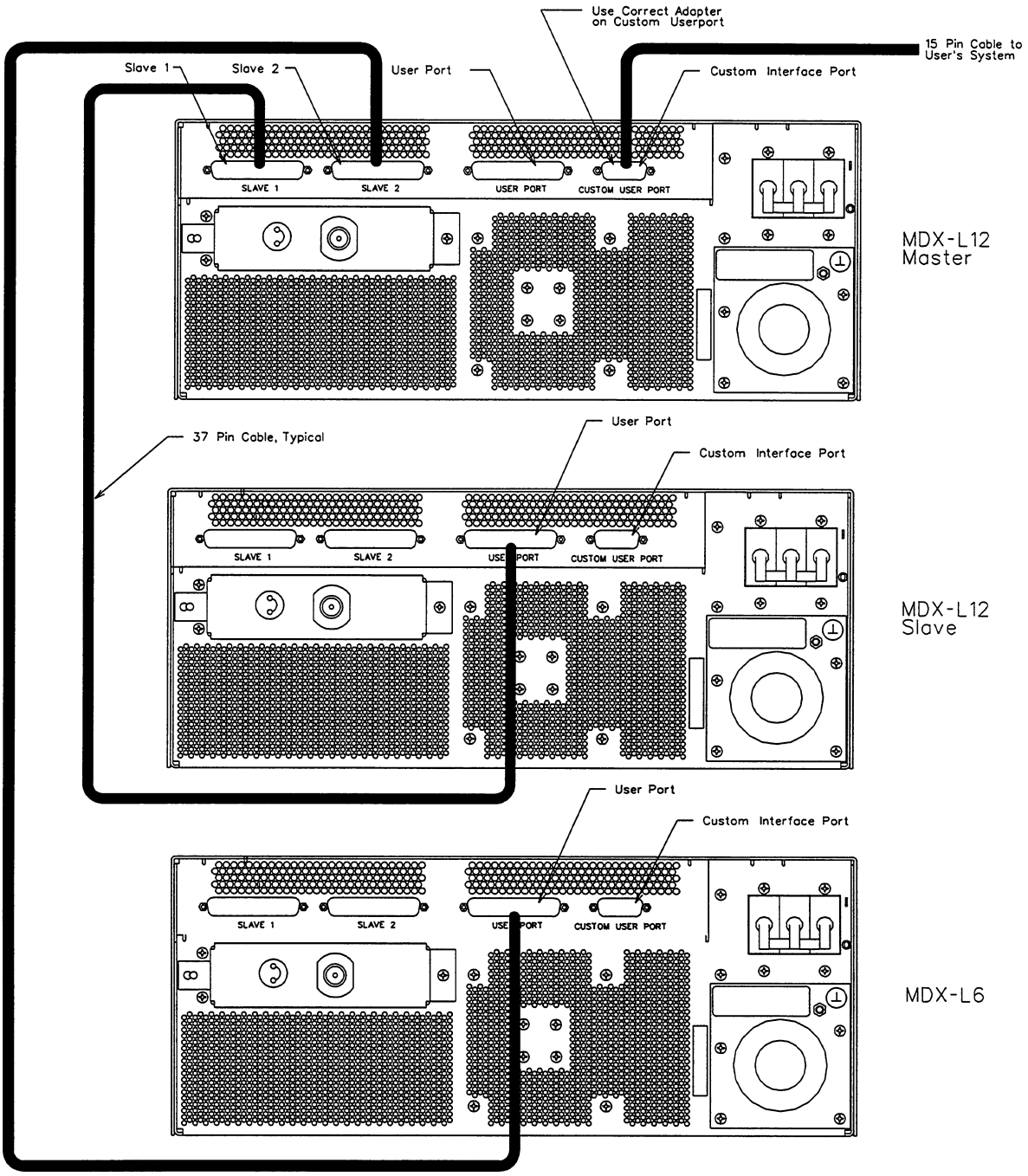


Figure 4-3. An example of a master/slave configuration

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Status LEDs in the Master/Slave Configuration

When the power to the MDX-L unit is first turned on, the **FAULT** and/or **INTERLOCK** LEDs may light. If no true fault exists, these LEDs will extinguish when the MDX-L unit receives the first *OUTPUT ENABLE.D* command (Custom User port *pin 4*).

If the **FAULT** and/or **INTERLOCK** LEDs remain lit after the unit has received the first *OUTPUT ENABLE.D* command, then a true fault exists and you must correct it before power can be enabled. After a fault or an interlock failure has been corrected, the **FAULT** and/or **INTERLOCK** LEDs are cleared when the next *OUTPUT ENABLE.D* command is received.

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USING THE SPECIAL FEATURES/OPTIONS

CONTENTS

Contactor Hold 5-3
Floating Negative Output Fault Detector 5-3
Differential Current Output Fault Detector 5-3

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USING THE SPECIAL FEATURES/OPTIONS

CONTACTOR HOLD

To help prolong the life of the main contactor, the MDX-L is equipped with a **contactor hold** feature. With this feature, the contactor will remain closed after the first time the dc bus is energized, regardless of whether output is being produced.

FLOATING NEGATIVE OUTPUT FAULT DETECTOR

When your system is configured for negative output, this feature is designed to prevent the output from coming on if the voltage on the positive output terminal is greater than 20 V above chassis ground (which generally indicates that the output cable has not been correctly connected). Similarly, if the output is already on when the fault occurs, it will be turned off. The **OUTPUT** LED will flash during an output fault.

DIFFERENTIAL CURRENT OUTPUT FAULT DETECTOR

This feature is available only on the MDX-L18. A differential current sensing circuit detects whether there is unequal current through the two coaxial cables connecting the MDX-L18 to the load, or if there is only one cable connected. If the differential current exceeds 10 A, the output is shut off protecting the cables from overcurrent. The **OUTPUT** LED will flash during an output fault.

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PART III

LEARNING MORE ABOUT YOUR MAGNETRON DRIVE

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DC BIAS

"Dc bias" refers to the dc component of the RF power that is developed between the cathode and the anode of a typical RF plasma vacuum system. This dc component is blocked from the RF generator by the capacitors that are used in the impedance-matching networks.

The dc potential is a controllable parameter. It is also a valuable indicator that itself changes in response to changes in other process parameters. Some of the parameters that affect dc bias are molecular densities and ratios of process gases, cathode/anode surface area ratios, pressure regimes and stability, and RF power densities. While some of these parameters are controllable, others are fixed and so must be worked around.

The amount of dc bias that is developed within a process system depends upon the system design or the process being run. Although a systems manufacturer can use modeling or empirical data to predict the dc bias that should be expected with a specific system or process, a power supply manufacturer cannot.

In any case, you can determine dc bias by measuring it yourself with a high-voltage probe.



DANGER! Lethal high-voltage and high-current potentials are present during the measurement of dc bias. Extreme caution is required to ensure the safety of yourself and of those working with you. Carelessness can cause severe burns, paralysis, or instant death.

Measure dc bias at the RF feedthrough. The farther the probe is from the feedthrough, the less accurate the measurement. This is because dc bias decreases with distance from the feedthrough due to electrical loss. A convenient point for taking this measurement, if you are using an Advanced Energy® impedance-matching network, is inside the impedance-matching network itself, at the output of the series capacitor.

Dc bias can be regulated in two ways, the choice of which depends upon the process or application. The mutually exclusive choices result in either maximum range or maximum resolution.

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If you choose maximum range, run the RF generator at maximum power when you measure dc bias. In the more advanced, microprocessor-controlled RF generators, a normalization (calibration) function makes it possible to tailor the process to the dc bias regulation. With one of these generators, maximum power will also equate with maximum dc bias. By normalizing for the maximum dc bias, the process will have the widest range of available dc biases.

If resolution of the dc bias control is more important, set your system up for a "typical" process before you measure dc bias. The new microprocessor-controlled generators will calibrate the dc bias over a smaller power cross section, thus providing a higher resolution over a smaller area of operation.

Since what is best for one application will not necessarily be best for another application, you may calibrate for either resolution or range, and then later repeat the process for the other possibility.

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Warranty Claims

Advanced Energy® 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 authorization number (see below) by AE Customer Service

All warranty work will be performed at an authorized AE service center (see list of contacts at the front of the manual). 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 Customer Service and discuss the problem with them. Be prepared to give them the serial number of the unit and the reason for the proposed return. This consultation call will allow Customer Service 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 Customer Service 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.

Upgrading Units

AE's products are continually changing as ways to improve them are discovered. AE is happy to upgrade older units so that they reflect recent improvements. The fee for upgrading a unit will be a percentage of the current list price, based on the age of the unit. Such an upgraded unit will carry a 6-month warranty (which will be added to any time remaining on the original warranty). Contact Customer Service for specifics on getting an older unit upgraded to the current revision level.

Warranty

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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INDEX

15 V dc supply 2-3

A

accuracy
  of actual output power to POUT.A 1-14
  of actual output to setpoint display 1-14
  of actual output voltage to VOUT.A 1-14
air flow . . . . . 3-7 - 3-8
applications, typical
  basic magnetron sputtering 1-7
  dc sputtering with RF bias . . . . . 1-9 - 1-10
  dc-biased RF sputtering . . . . . 1-11 - 1-12
arc detection
  from User port 3-19
ARC LED 2-14, 3-27
arc shut-down time 1-14
arc suppression 1-6, 1-13, 2-14
atmospheric pressure 1-16

B

block diagram 2-3

C

cabinet 3-5, 3-8
cables
  for Custom Interface 3-13
  for output 3-12
  input 1-15
  master/slave 2-10
  output 1-15, 2-5
connectors/ports
  Custom Interface . . . . . 2-5, 3-13 - 3-15
  input power 3-10
  output 1-15, 2-5, 3-12
  Slave 1 and Slave 2 . . . . . 2-10 - 2-11, 3-22 - 3-26, 4-10
  User (Slave) . . . . . 2-7 - 2-8, 3-16 - 3-21
contactor hold . . . . . 1-6, 3-17 - 3-18, 5-3
  from User port 3-18
  on slave unit 3-24
control methods 1-15

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coolant
flow parameters 1-16
temperature 1-16
cooling requirements . . . . . 1-16, 3-7 - 3-8
current
input 1-13
output 1-14
Custom Interface port
connecting 3-13
connector 2-5
monitoring parameters from 4-5
pin list 2-6
pin-description table 2-6
regulating output 4-3
selecting power regulation mode 4-3
setpoint parameters 4-5
signal descriptions . . . . . 3-14 - 3-15
status signals 2-13

D

description, general 1-5
design considerations 3-5
differential current detector 5-3

F

FAULT LED 2-14, 4-12
faults 4-12
floating ground configuration 1-7
floating negative output fault detector 1-6, 5-3
front panel
LEDs 2-14

G

grounding 1-7, 3-9
chassis stud 3-9
degradation 1-8
input 3-10

H

humidity 1-16

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I

ignition current 1-13
ignition voltage 1-13
impedance
  matching 1-5
  options 4-7
  range 1-5
indicators 2-14
input 2-3
  analog signals 1-15
  connecting 3-10
  connector 1-15
  current 1-13
  standard connection . . . . . 3-10 - 3-11
  voltage 1-13
  Y connection 3-10
installation 3-5
  cooling requirements 3-7
  design considerations 3-5
  RF bias 1-9
  RF sputtering 1-12
  spacing requirements 3-6
interlock
  from the User port 3-18
  slave 3-23
  through Custom Interface port 3-15
INTERLOCK LED 2-14, 3-15, 4-12

L

LEDs 2-14
  OUTPUT 1-8

M

maintenance 1-8
master/slave configuration 2-7, 2-10
master/slave operation . . . . . 4-10 - 4-12
  number of units 3-15
  User (Slave) port 2-7, 2-10

N

negative output voltage configuration 1-7

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O

operation 3-27
output
  analog signals 1-15
  connecting 3-12
  connector 1-15, 2-5, 3-12
  current 1-14
  Custom Interface signals 3-14
  frequency 1-9
  power 1-13
  regulation 4-3, 4-5
  User port signals 3-19
output impedance
  range 1-5
OUTPUT LED 1-8, 2-14, 3-15, 3-27, 5-3
output off
  from User port 3-18
  slave . . . . . 3-23 - 3-24
output on
  from User port 3-17
  slave 3-23
  through Custom Interface port 3-14
over-current 1-6
over-voltage 1-6

P

pin-description table
  Custom Interface port 2-6
  Slave 1 and Slave 2 ports 2-11
  User (Slave) port 2-8
planar magnetron 1-11
plasma strike voltages 4-7
power factor 1-14
power, output 1-13
programming setpoints 4-5
PWR ON LED 2-14, 3-27

R

rack 3-5
ramp time
  from the User port 3-20
  slave 3-25
rear panel

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connections 3-9
ground stud 3-9
regulation 1-15, 4-5
for slave 3-23
from Custom Interface port 4-3
from User port 3-17
regulation modes 1-5
remote control 2-5
remote control, connecting for 3-13
repeatability 1-15
ripple voltage 1-13

S

S gun 1-11
safety
danger . . . . . 1-7, 3-5, 3-9 - 3-10, 3-13, 3-16
warning 1-9, 1-11
setpoint
from the User port 3-20
SETPOINT LED 2-14, 3-14, 3-17, 3-23, 3-27, 4-5
setpoint level 4-5
setpoints 1-13, 4-5
setting up
See installation
signal descriptions
Custom Interface port . . . . . 3-14 - 3-15
Slave 1 and Slave 2 ports . . . . . 3-23 - 3-26
User (Slave) port . . . . . 3-17 - 3-18, 3-20 - 3-21
signals
scaling in 2-4
size 1-15
Slave 1 and Slave 2 ports
connecting 3-22
connector 2-10
master/slave operation 4-10
pin-description table 2-11
signal descriptions . . . . . 3-23 - 3-26
spacing requirements 3-6
specifications
electrical 1-13
environmental 1-16
functional 1-13
physical 1-13, 1-15
sputtering
basic magnetron . . . . . 1-7 - 1-8

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dc with RF bias . . . . . 1-9 - 1-10
dc-biased RF . . . . . 1-11 - 1-12
factory configuration 1-7
optimum configuration 1-8
start-up procedure 3-27
status information 2-13
See Custom Interface port
See LEDs
status indicator LEDs 2-14, 4-12
status signals 2-13
switching frequency 1-14

T

tap range 1-14
temperature
ambient 1-16
coolant 1-16
theory of operation . . . . . 2-3 - 2-4
switching theory 2-4
tuners 1-12

U

unpacking 3-5
User (Slave) port
connecting 3-16
connector 2-7
master/slave operation 4-10
pin-description table 2-8
signal descriptions . . . . . 3-17 - 3-21

V

VARC 1-6, 3-20
for slave units 3-25
voltage
ignition 1-13
input 1-13
plasma strike 4-7
ripple 1-13

W

weight 1-15

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