

THE
ADVANCED ENERGY[®]
STARBURST[™] ACCESSORY

User Manual

PN: 5702704-E
June 2007

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STARBURST[™] ACCESSORY

User Manual

ADVANCED ENERGY
INDUSTRIES, INC

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Fort Collins, Colorado 80525
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PN: 5702704-E
June 2007

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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.

To ensure years of dependable service, Advanced Energy® products are thoroughly tested and are among the most reliable and highest quality systems available worldwide. All parts and labor carry our standard 1-year warranty.

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|----------------|--|
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| | |
|------------------------------------|--|
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WARNING

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

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.**



DANGER! 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.

DO NOT BE CARELESS AROUND THIS EQUIPMENT.

CONGRATULATIONS ...

On your purchase of AE's Starburst™ product. The Starburst unit is designed to improve film quality and enhance the arc-handling capability of both the old SCR type as well as new MDX power supplies.

The Starburst product is designed to clear arcs within microseconds, before they become hard arcs. A stabilizing effect can be observed on chamber plasmas when the Starburst unit is operating in the system. This stabilizing effect translates into fewer film defects and particulates. Arc handling is also improved with the Starburst unit in the circuit, even when the Starburst unit is turned off. When off, the Starburst unit circuitry is bypassed and the new ARC-OUT enhancement circuitry is functional.

Sputtering processes where the Starburst unit has been shown to be effective include:

- Reactive
- ITO, Ta₂O₅, TiN, Al₂O₃, ZnO, TiW, SiO₂, ZrO₂
- Carbon
- Rare earth compounds

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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, without having to look at a lot of headings. When you turn to a chapter, there is a detailed table of contents listing 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 Starburst accessory and its various features and configurations. A detailed description of the functional specifications and a list of the physical specifications are also included.

How It Works contains important information on connections, including listings of all input, output, and reference pins. Status indicators are briefly discussed.

Part II contains information on preparation for use, including information on connection and wiring options, spacing and cooling requirements, and start-up procedures.

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 (*SELFRUN.D*). Labels that are on the Starburst (indicators, etc.) generally appear in boldface capital letters (**INTERLOCK**).

How to Use the Symbols



Safety notes. Important notes concerning potential harm to people.



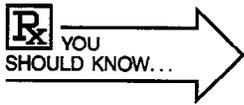
Warning notes. Important notes concerning possible harm to this unit or associated equipment.



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



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.

GETTING TO KNOW YOUR
MDX STARBURST
ACCESSORY

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PART I

GENERAL DESCRIPTION

The Starburst™ unit is an add-on accessory for the Advanced Energy® magnetron drive power supplies with output currents up to 120 A. Its main function is to enhance the arc-handling capability of the MDX power supply. Even though MDX power supplies exhibit excellent arc-handling characteristics (such as low output energy storage and recovery response time to hard arcs of under 10 ms), the need for improved film quality with even fewer defects has arisen. This demand has led to the development of the Starburst unit technology, which clears arcs in microseconds and dramatically reduces the number of hard arcs. The Starburst front panel provides adjustable settings to optimize arc-handling in your process.

Self-run Mode

The self-run mode is the Starburst unit's primary operating mode. When this mode is selected, the Starburst unit shorts out and reverses the target voltage at a 20 kHz rate for the time you have selected. This reversal of voltage prevents charge buildup on the target surfaces, slows the growth of insulative films on the target, and extends target life. In the self-run mode, reverse voltage time, and crow-bar delay times are adjustable.

Active Arc Mode

In active arc mode, the target current is immediately shunted away from the target when an arc is detected. When the current source is removed and the target voltage is reversed for a short time, the arcs are quenched quickly. In this mode, reverse voltage time is selectable at the front panel from 5 to 15 μ s in 1 μ s steps. Crow-bar delay time is adjustable from 1 μ s to 60 μ s in 1 μ s steps. (See page 3-10.)



Passive Mode

For certain target materials, some arc energy is required to initially clean the target of arcing sites. In these cases, the Starburst unit, operating in its self-run or active arc mode, is so effective in lowering arc energy that a longer period is necessary to condition a new target. Experience has shown that when AE's ARC-OUT™ enhancement circuitry in the Starburst is used with the passive mode selected on the Starburst unit, the target is cleaned more quickly than with a standard MDX supply alone. The Starburst unit's passive mode can also be used with older power supplies not having this circuitry. When the Starburst unit is in passive mode, the ARC-OUT enhancement circuit in the Starburst unit is automatically switched on. ARC-OUT reverse time is fixed at 8 to 10 μ s with a resonant time period of approximately 20 μ s.

Control

The Starburst unit may be controlled locally (from the the Starburst unit front panel) or remotely (through a User port). The User port connector is a 25-pin, male, subminiature-D located on the side of the Starburst unit. Details of each User port signal and function are described in Chapter 2.

Arc Counting

You can monitor the front panel display to find the number of hard arcs, micro arcs, or total arcs.

Supervisory Circuit

An internal supervisory circuit within the Starburst unit monitors the unit's function in the self-run and active arc-handling modes. The purpose of this circuit is to notify the operator that the Starburst unit is not functioning properly (see the list of internal failure modes on page 3-13); this prevents yield loss in critical processes. When the active arc-handling mode is selected, the Starburst executes a single self-run pulse every 10 seconds to confirm that the switch is functional. This pulse is not recorded as an arc. In the case of a unit malfunction, the **SUPERVISORY** LED on the the Starburst unit front panel lights and a low signal is produced at the Starburst User port. Input voltage must exceed 150 before the supervisory circuit becomes operational.

SPECIFICATIONS

Functional Specifications

| | |
|-------------------------------------|--|
| Control Mode | Local (from the front panel) or remote (through the User port) |
| Arc-handling Characteristics | 25,000 arcs/sec. maximum; 5 to 15 μ s selectable arc reverse voltage; 1,800 V absolute maximum input dc voltage; 150 V minimum to 1250 V maximum output operating range; 10 μ s delay before next arc can be processed |
| Arc Counting | Counts and displays micro arcs, hard arcs, and total arcs up to 9,999 |
| Reverse Voltage Time: | |
| Self-run | Adjustable from 5 μ s to 15 μ s (1 μ s increments) |
| Active arc | Adjustable from 5 μ s to 15 μ s (1 μ s increments) |



PART I

| | |
|-----------------------------|---|
| Passive | Fixed at 8 to 10 μ s |
| Reverse Voltage: | |
| Self-run | Fixed at 20% of operating dc input voltage; fixed at 10% for option 004 units only |
| Active arc | Fixed at 20% of operating dc voltage; fixed at 10% for options 004 units only |
| Passive | Not applicable |
| Crow-bar Delay Time: | |
| Self-run | Adjustable from 1 μ to 60 μ s (1 μ s increments) |
| Active arc | Adjustable from 1 μ to 60 μ s (1 μ s increments) |
| Passive | Not applicable |
| Frequency: | |
| Self-run | Fixed at 20 kHz |
| Active arc | Not applicable |
| Passive | Resonant time period approximately 20 μ s |

Physical Specifications

| | |
|--|---|
| Size | 406.4 mm (H) x 702.04 mm (W) x 355.6 mm (D) (16" (H) x 27.64" (W) x 14" (D)) (splash proof enclosure) |
| Weight | 68 kg (150 lb) |
| DC Input and Output Connectors | UHF type, female, Amphenol part number 83-1R (12X) for option 004 only 3/8" studs for all other options |
| Cable Connector for DC Input and Output | UHF type, male, Amphenol part number 83-822 (12X) for option 004 only 3/8" ring lug terminals for all other options |
| DC Input and Output Cables | RG-8 coaxial cable; output cable from the Starburst unit to chamber not to exceed 4.57 m (15 ft) option 004 only Cable OD to 18.5 mm with the distance to the chamber not to exceed 3.5 m (10 ft) for all other options. |
| Cooling Connectors | |
| Inlet | 1/2" male NPT required to mate with 1/2" female NPT block on the unit |
| Outlet | 1/2" male NPT required to mate with 1/2" female NPT block on the unit |

Electrical Specifications

| | |
|-------------------------|---|
| AC Input Voltage | 115 V ac, 60 Hz, single phase, 500 mA fast-blow fuse or 230V ac, 50 Hz, single phase, 250 mA fast-blow fuse (Internally selectable with line cord attached to the unit) |
| DC Input Voltage | -150 to -1250 V |



PART I

DC Current

120 A steady state maximum; no minimum current is required for operation.

Input and Output DC Polarity

Negative output (positive at ground);
Negative output (positive floating less than 100 V from ground)



WARNING! Positive voltage output with a negative ground is prohibited. Hardware damage will occur.

Cooling Water Flow Rate

One gallon per minute minimum

Pressure

6 bars (87 psi) maximum

Temperature

10° to 35° C

Environmental Specifications

| | |
|------------------------------|---|
| Noise | Less than 88 dB |
| Ambient Temperature: | |
| Operating | Class 3K3. Minimum 0°C, maximum 40°C (maximum value of average over 24 hr: 35°C). If the unit is enclosed in a cabinet ensure that the maximum ambient temperature is not exceeded. |
| Storage | Class 1K4. Minimum -25°C, maximum 55°C |
| Transportation | Class 2K3. Minimum -25°C, maximum 55°C (for short periods of up to 24 hr, the maximum is 70°C). |
| Humidity | Class 3K3. 5-85% relative humidity; no condensation or icing |
| Atmospheric Pressure: | |
| Operating | 800 mbar minimum (approx. 2000 m above sea level) |
| Storage | 800 mbar minimum (approx. 2000 m above sea level) |
| Transportation | 660 mbar minimum (approx. 3265 m above sea level) |



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PART I

THEORY OF OPERATION

The Starburst unit is installed in series between the power supply output and the chamber. The Starburst unit must be located within ten to fifteen feet of the chamber because its circuitry responds to arcs within microseconds and greater distances affect its response time. The Starburst unit functions by monitoring the chamber voltage in relation to the input voltage. When the output drops below 50% of the input, the arc energy from the chamber is diverted away from the chamber through the Starburst unit. This prevents arc damage from occurring.

The Starburst unit has three modes of operation that are selected from the front panel or the User port. They are Passive, Active Arc, and Self-Run.

Passive Mode

The ARC-OUT enhancement circuitry is active when the Starburst unit is in Passive mode. Because Passive mode allows some energy to be delivered to an arc, this mode can be used to clean targets. The Passive circuitry consists of passive components and clamp rectifiers only. During an arc, the resonant nature of the circuit causes the current to reverse which, commutates off the arc. The target voltage and current for this mode are shown in Figure 2-1 and Figure 2-2.



Figure 2-1. Chamber voltage during Passive mode.

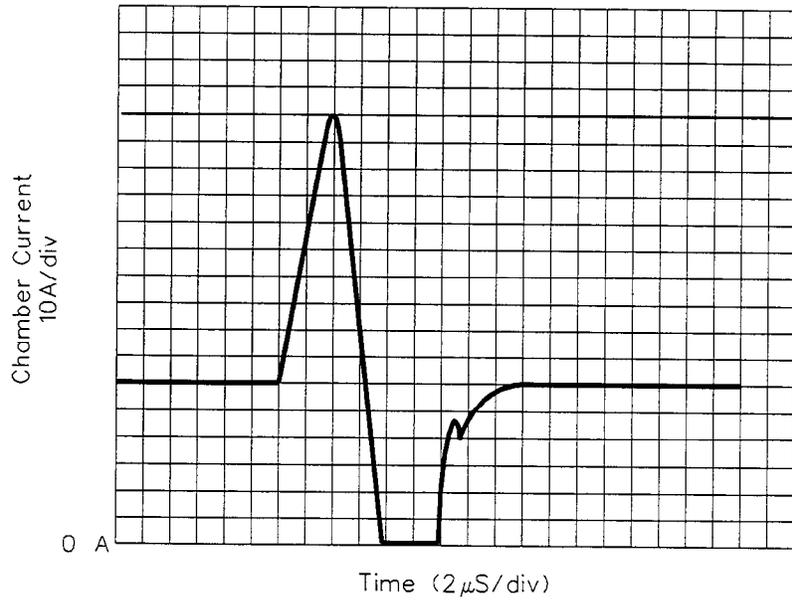


Figure 2-2. Chamber current during Passive mode.

Active Arc Mode

In the active arc mode, when the Starburst unit detects an arc, it immediately diverts the target current and starves the arc. By removing the current source and, for a short time, reversing the target voltage, the arcs are quenched quickly. Up to 25,000 arcs can be handled per second with a 10 μs delay between arcs. The target voltage and current for this mode are shown in Figure 2-3 and Figure 2-4.

HOW IT WORKS

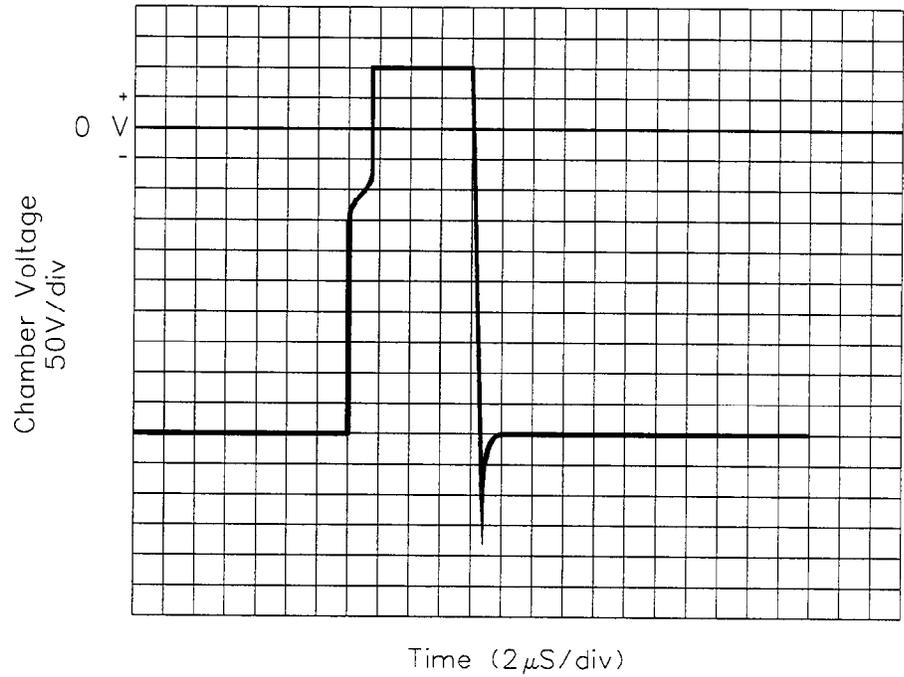


Figure 2-3. Chamber voltage during active arc-handling mode.

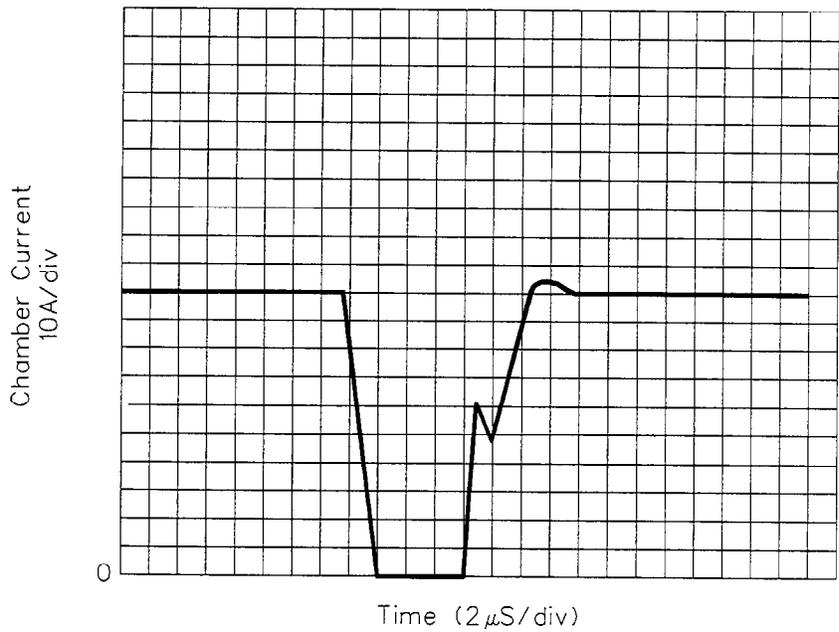


Figure 2-4. Target current during active arc-handling mode.

Self-Run Mode

Self-Run mode is used for sputtering applications with insulative oxide coatings, cleaning new targets, and preventing arcs. The Starburst unit also handles micro arcs that occur between pulses within the self-run frequency; the unit responds to these arcs just as it does when it is in active arc mode. When in the self-run mode, a fixed 20 kHz frequency oscillator is engaged, triggering the Starburst unit power switches at that frequency. This action produces output characteristics similar to those that exist when an arc starts. The Starburst unit first discharges the chamber capacitance and then reverses the chamber voltage for the amount of time you select (5 to 15 μ s). This voltage reversal on the target prevents charge build-up on the system surfaces and slows insulating film build-up. The target voltage for this mode is shown in Figure 2-5.

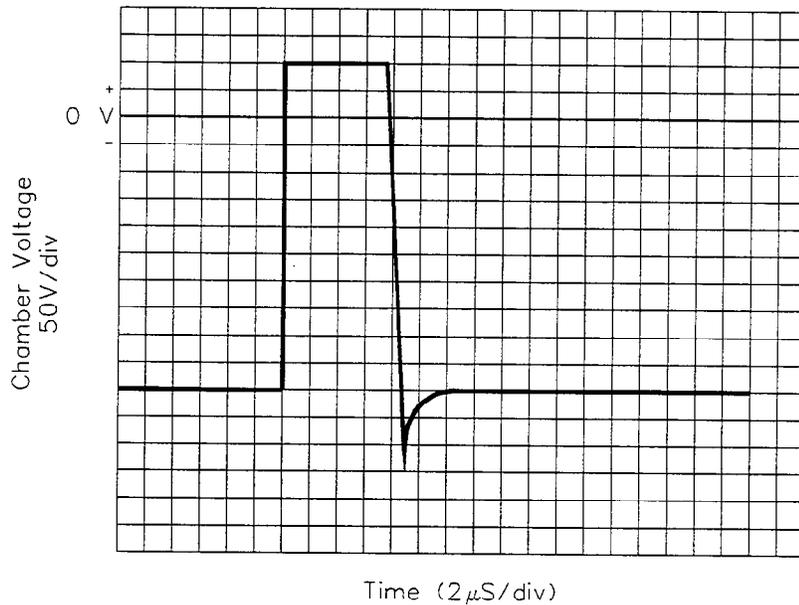


Figure 2-5. Chamber voltage during Self-run mode.

CONNECTORS

Input AC Power Connector

The ac line input connection is made through a line cord without a plug. When a unit is purchased, it is internally connected for the correct line voltage at the factory and then supplied with a line cord. A label, located next to the line cord connector, indicates the voltage for which the unit has been wired. The range of input line voltages for each case is listed below.

- 90 to 127 V ac, 500 mA, 60 Hz; fused with a 500 mA fast-blow fuse
- 180 to 253 V ac, 250 mA, 50 Hz; fused with a 250 mA fast-blow fuse

Changing the AC Line Voltage to 115 V

If you need to change the input line voltage to 115 V, unplug the connector (located on the Starburst housekeeping PCB) and then re-plug the connector into the 115 V position (pins 1 through 9). See Figure 2-6.

Changing the AC Line Voltage to 230 V

If you need to change the input line voltage to 230 V, unplug the connector (located on the Starburst housekeeping PCB) and then re-plug the connector into the 230 V position (pins 3 through 11). See Figure 2-6.

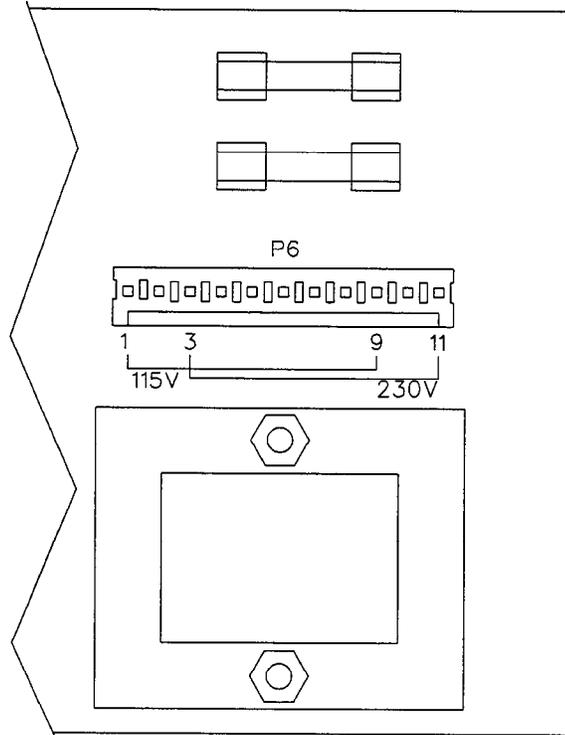


Figure 2-6. Changing the AC Line Voltage (115 V or 230 V)

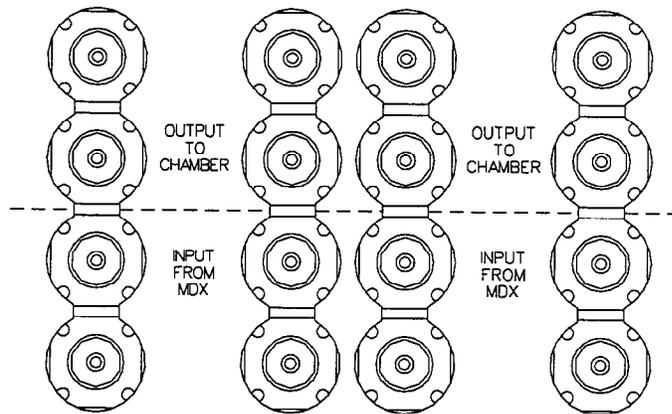
Input DC Power Connector

The output of the MDX magnetron power supply becomes the input dc to the Starburst unit (at the connector labeled "INPUT FROM MDX" on the side of the unit). The Starburst unit has two options: 04 and 05. The input dc connectors for option 04 are eight standard UHF female connectors (Amphenol 83-1R) with insulating safety shields that fit over the UHF connector (Figure 2-7). Option 05 includes 3/8" studs for ring lug terminals for both the positive and negative input dc (Figure 2-8).

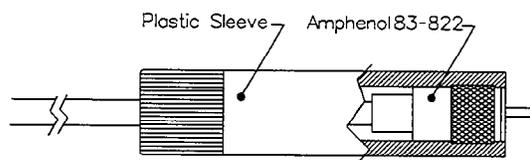
HOW IT WORKS



WARNING! Ensure that the input dc power connector is connected to the Starburst unit's input connector labeled "INPUT FROM MDX" and that the output dc power connector is connected to the Starburst unit's output connector labeled "OUTPUT TO CHAMBER." Failure to correctly connect input and output power could result in damage to the unit.



UHF, female, provided



Sleeve Assembly (provided)
8 each input, 8 each output

Figure 2-7. Input DC Power Connectors for Option 04

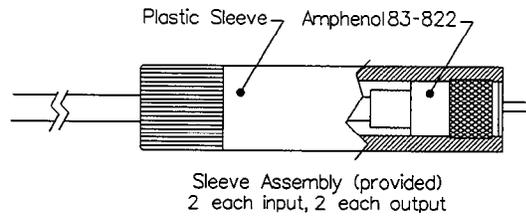
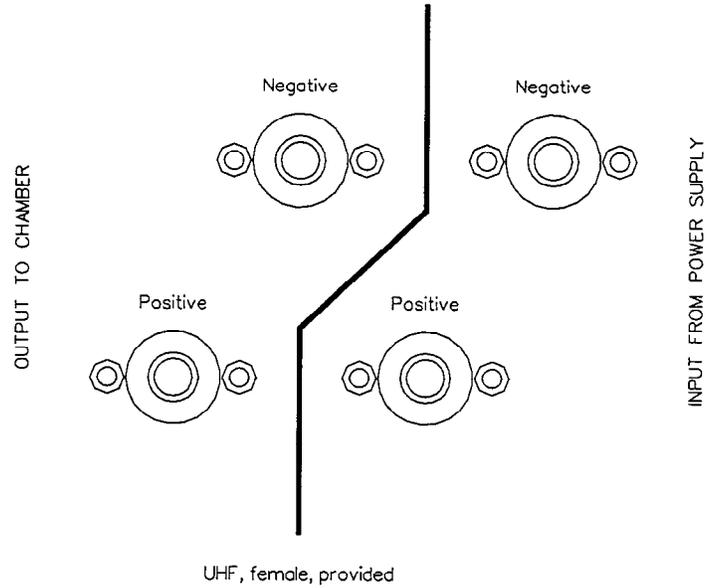


Figure 2-8. Input DC Power Connectors for Option 05

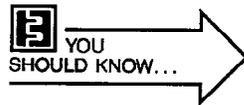
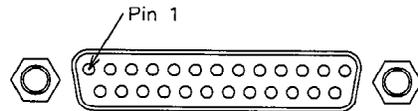
Output DC Power Connector

For the 004 option, the output dc power connector (labeled "OUTPUT TO CHAMBER") is the same type of female UHF connector with insulating sleeve as is used for the input. See Figure 2-7.

For the 005 option, the output power connectors are the same 3/8" studs as those used on the input. (Terminals are provided for both the positive and negative output polarities.) See Figure 2-8.

User Port Connector

Connections for remote control of the Starburst unit are made through a 25-pin, male, subminiature-D connector.



To meet EMC standards, you must use a shielded cable and terminate the shield at the Starburst unit. A drain wire is not sufficient for grounding the shield.



WARNING! When the unit is in Local mode (Local/Remote switch is closed), 24 V is sent to pin 6. To prevent the 24 V from destroying the User circuit, we recommend that you connect a blocking diode, with the cathode side facing pin 6, to pin 6.

The following table provides information about each pin in the User connector. The User connector is primarily a “digital” interface that allows the use of a remote controller. The Description column provides information about usage of the pin.



PART I

Digital Inputs

A digital low ("0") is shorting an input pin to common through a resistance of $90\ \Omega$ or less. A digital high ("1") is leaving the pin open where it is pulled up through an internal $10\ \text{k}\Omega$ resistor from +15 V dc to +30 V dc by a user supplied power supply.

| | | |
|-----------------|-------------|---|
| Digital Inputs | Logical "0" | -30 V to +5 V 1.0 mA maximum leakage |
| | Logical "1" | +13 V to +30 V 2 mA to 15 mA |
| Digital Outputs | Logical "0" | +3 V maximum 0.2 mA maximum leakage |
| | Logical "1" | +13 V to +30 V 2 mA to 15 mA |

Pin Description Table

| Pin No. | Pin Name | Description |
|---------|------------------|--|
| 1 | +24 V dc | This is a +24 V dc, 50 mA, user supplied voltage, which must be applied to the unit's interface circuits. |
| 2 | Not used | |
| 3 | OUTCOM.D | This is a dedicated return line. |
| 4 | OUTCOM.D | This is a dedicated return line. |
| 5 | OUTCOM.D | This is a dedicated return line. |
| 6 | LCL/RMT.D | Digital input. "1" sets the unit to User port control; "0" sets the unit to front panel control. |
| 7 | ACTIVEARC.D | Digital input. "1" sets the unit to active arc handling mode. |
| 8 | SELFRUN.D | Digital input. "1" sets the unit to self-run mode. |
| 9 | PASSIVE.D | Digital input. "1" sets the unit to passive mode. |
| 10 | RESET.D | Digital input. "1" clears and resets the Starburst unit's logic functions. |
| 11 | SUPERVISOR.D | Output. "0" indicates the unit is not functioning properly. |
| 12 | Not used | |
| 13 | OVERTEMP/ACPWR.D | Digital output. "0" indicates overtemperature condition exists or that the AC line cord has been disconnected. |
| 14 | Not used | |
| 15 | Not used | |
| 16 | Not used | |
| 17 | UNDERVOLT.D | Output. "0" indicates input undervoltage condition exists. |
| 18 | INTERLOCK.D | Output. "0" indicates interlocked panel has been removed. |
| 19 | INHIBIT.D | Output. "1" indicates that the crow-bar SCR has been triggered. The signal shuts down the input power supply and allows the internal SCR crow-bar switch to recover to the off state. |
| 20 | MODEOVER.D | Output. "1" indicates overvoltage condition exists and the IGBT pulsing gate has been inhibited. |
| 21 | Not used | |
| 22 | Not used | |
| 23 | Not used | |
| 24 | VARCDET.ISO | Output. Isolated pulse transformer. Pulses high when an arc occurs (5 V, 5 μ s). Intended for an oscilloscope monitor or trigger. |
| 25 | VARDETRTN.ISO | Output. Isolated return for <i>pin 24</i> signal. |

Remote Crow-bar Trigger Option

This option provides a separate fiber optic port for energizing an SCR crow-bar located in the supplying power supply. Pulses are supplied at a 10 kHz rate with an adjustable duration of 10 to 1000 μ s. Fiber optic cable and receiver hardware must be ordered as an option.

Local/Remote Switch

A separate SPDT switch, located above the User port on the right side of the unit (see panel views at the end of this chapter), locks out front panel parameter changes from unauthorized people. In the LOCAL position, all parameter changes can be programmed from the front panel. In the REMOTE position, no changes to parameters can be made from the front panel, except for the resetting of arc-counting registers and the clearing of errors.



WARNING! When the unit is in Local mode (Local/Remote switch is closed), 24 V is sent to pin 6. To prevent the 24 V from destroying the User circuit, we recommend that you connect a blocking diode, with the cathode side facing pin 6, to pin 6.

HOW IT WORKS

Front Panel Indicators

There are eighteen LED indicators on the Starburst unit front panel. In the following table, each indicator is listed by section. See the panel drawings at the end of this chapter for LED locations.

| Status Indicator LED | Functional Status |
|--------------------------|--|
| FUNCTION | |
| TOTAL ARC COUNT | Lights to indicate the TOTAL ARC COUNT function is selected; the four-digit display shows the number of arcs that have occurred since the counter was reset |
| MICRO ARC COUNT | Lights to indicate the MICRO ARC COUNT function is selected; the four-digit display shows the number of micro arcs that have occurred since the counter was reset. |
| HARD ARC COUNT | Lights to indicate the HARD ARC COUNT function is selected; the four-digit display shows the number of hard arcs that have occurred since the counter was reset. |
| ARC HANDLING MODE | Lights to indicate that the ARC HANDLING function is selected. The four-digit display shows one of three values: SE for self-run, AC for active arc, and PA for passive. |

HOW IT WORKS

| <u>Status Indicator LED</u> | <u>Functional Status</u> |
|--------------------------------|---|
| REVERSE TIME (us) | Lights to indicate that the REVERSE TIME function is selected; the four-digit display indicates the present reverse time in μ s. |
| CROW BAR DELAY (us) | Lights to indicate that the CROW BAR DELAY function is selected; the four-digit display shows the present crow-bar delay in μ s. |
| CONTROL MODE | Lights to indicate that the CONTROL MODE function is selected; the four-digit display shows the present control mode: LOC for local, or USE for User port. |
| <i>MODE</i> | |
| <u>CONTROL</u> | |
| LOCAL | Lights to indicate that the Starburst unit is operating from the front panel. |
| REMOTE | Lights to indicate that the Starburst unit is operating from the User port. |
| <u>ARC HANDLING</u> | |
| SELF RUN | Lights to indicate that SELF RUN mode has been selected. |
| ACTIVE ARC | Lights to indicate that ACTIVE ARC has been selected. |
| PASSIVE | Lights to indicate that PASSIVE mode has been selected. |



PART I

Status Indicator LED

Functional Status

STATUS

MODE OVERRIDE

Indicates that the Starburst unit has one of the following faults: switch overvoltage or overtemperature. When a fault condition occurs, the Starburst unit switches are disabled, but power to the load is not interrupted. When the fault condition clears, the Starburst unit automatically turns on again in the prior operating mode, and this LED goes out.

CROWBAR

Lights for approximately 5 ms every time a crow-bar event occurs.

UNDERVOLTAGE

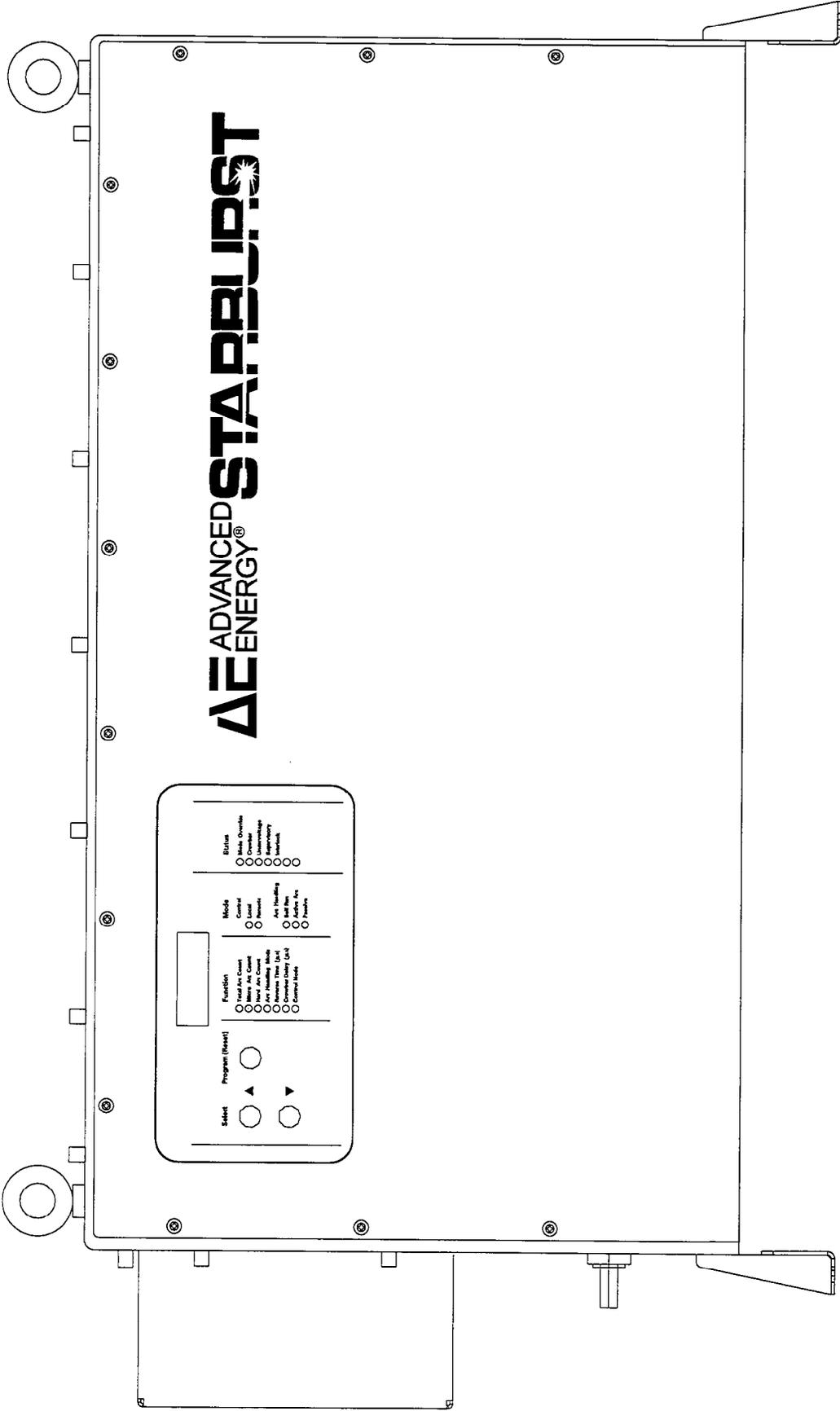
Lights when the dc input voltage is lower than 150 V.

SUPERVISORY

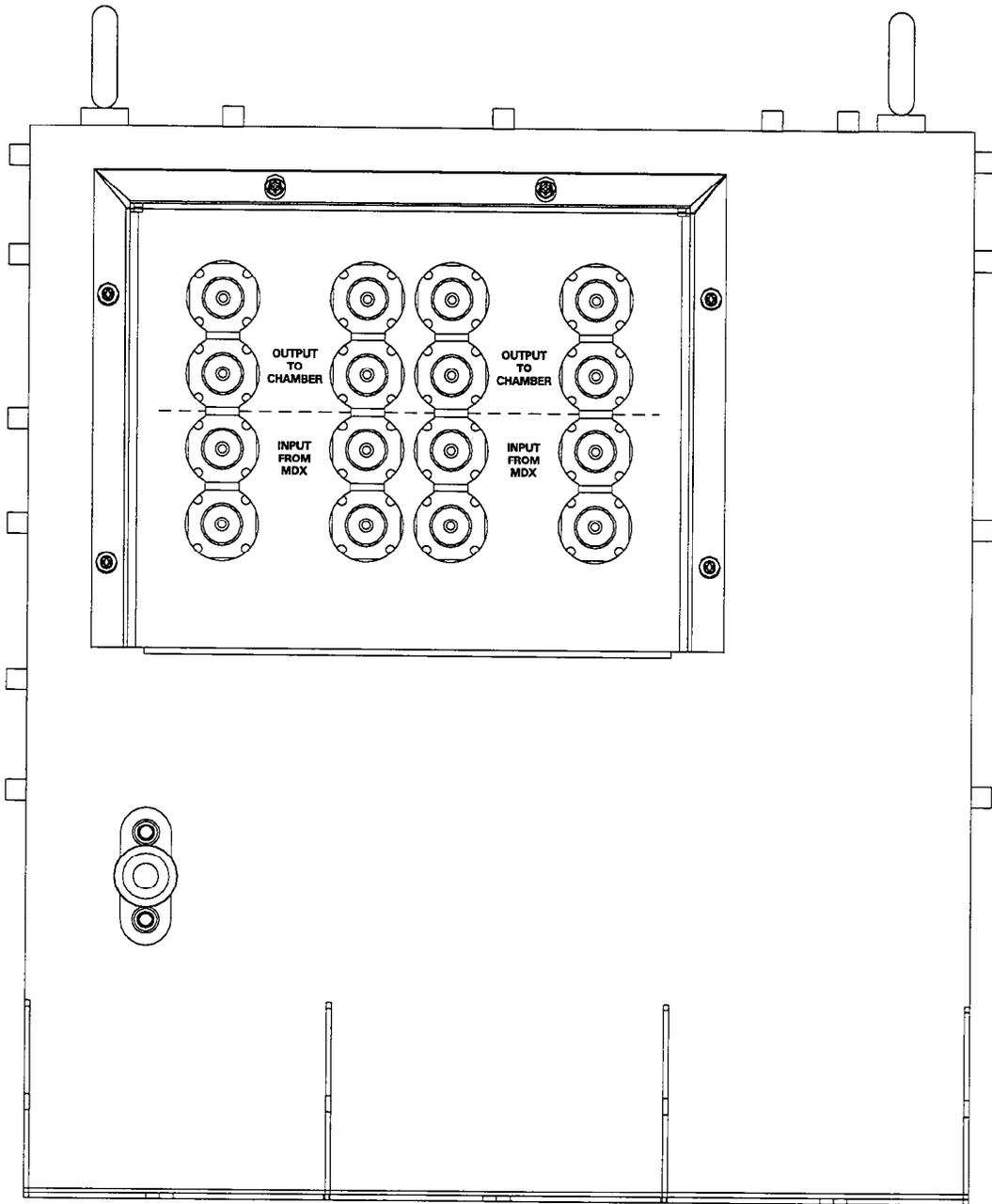
Indicates, when continuously lit, that the Starburst unit has an internal malfunction. **NOTE:** This indicator may blink occasionally during hard arcing. It only indicates a problem if it is continuously lit.

INTERLOCK

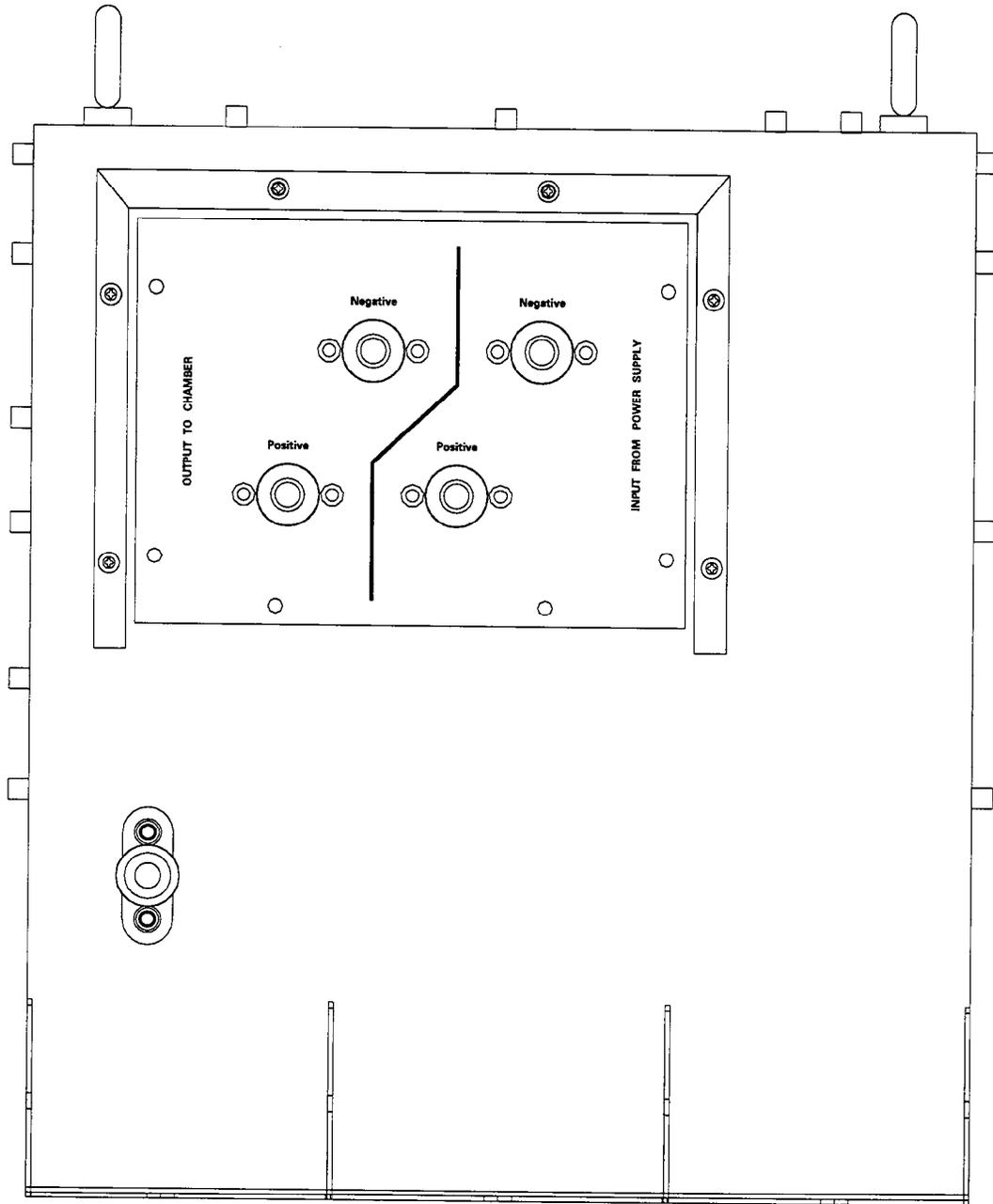
Lights when the cover on the power connectors is off.



Starburst, Front View



Starburst, Option 4, Left Side View



Starburst, Option 5, Left Side View

OPERATING YOUR MDX
STARBURST ACCESSORY

ΔE[®]



PREPARING FOR USE

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PART II

PREPARING FOR USE

SETTING UP

Unpacking

Unpack and inspect your MDX Starburst accessory 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 damaged shipping container for submitting necessary claims to the carrier.

Design Considerations

The Starburst unit technology performs best when it is located within 3.05 m (10 ft) of cable distance from the chamber cathode. The Starburst unit box is made to mount on the chamber or on the floor near the chamber.

Cooling Requirements

The Starburst unit requires water for cooling. When you install the Starburst unit on your system, be sure it is in a location where its maximum ambient temperature is not exceeded and where sufficient cooling water pressure is available.

Interlock Switch

The cover over the input and output connectors engages an interlock switch. Although an interlock fault in the Starburst unit does not turn off the MDX, you should turn off the MDX if an interlock fault is indicated on the Starburst unit front panel or use the User port signal to shut off the MDX.



We recommend that the interlock string be connected from the Starburst unit to the MDX to prevent injury to persons and or equipment.

MAKING REAR PANEL CONNECTIONS

Grounding

A protective earth 3/8" terminal stud is located next to the input/output connector. This terminal is connected internally to the chassis and the input line cord ground wire at the ac line cord connector.



For safety reasons, a wire at least 34 mm² or 2 AWG must be connected from the ground stud to the protective earth ground.



DANGER! Connect the protective earth terminal on the Starburst chassis to protective earth-ground before making any other connection.



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

Connecting Input Power

Each Starburst unit is supplied with its own ac line cord without a plug. Check the label on the side of the unit to make sure the unit is set for the proper voltage.



Each unit can be configured internally for either 90 to 127 V ac or 180 to 253 V ac. Make sure the unit you ordered matches your needs.

It is important to note that for the Starburst unit to operate in its self-run and active arc-handling mode, ac input power must be present. Operation of the system with the Starburst unit line cord unplugged restricts it to Passive mode operation only.

PREPARING FOR USE

Connecting the Input and Output

Input and output dc power connections are made through either UHF connectors (option 004) or 3/8" studs with ring lug terminals (option 005). We recommend you use a 34 mm² or 2 AWG cable for option 005.



To meet EMC requirements, power cables must be shielded and the shield must be tied to ground on the Starburst unit.



FRONT PANEL OPERATIONS

Communicating with the Starburst unit is easy through the front panel. The four-digit display, three push button controls, and three sections of LEDs allow you to read current settings, choose new settings, and get status information. The following section explains how to perform these tasks.

Select and Program (Reset)

The two **SELECT** push buttons allow you to move up or down through the **FUNCTION**, **MODE**, and **STATUS** sections. The **PROGRAM (RESET)** button is used for programming new settings or resetting error codes, fault LEDs, or arc counters. Later in this section, detailed instructions are given for programming each setting.

Mode

Control

You must choose **LOCAL** control to operate your Starburst unit from the front panel.

- Using either **SELECT** button, toggle up or down, until the **CONTROL MODE** LED is lit under the Function section.
- Press **PROGRAM (RESET)**. The LED starts flashing.
- Press either **SELECT** button until the **LOCAL** LED is lit under the **MODE** section. The display shows **LOC** for local control (or **USE** for remote control.)
- Press **PROGRAM (RESET)** again.
- The LED stops flashing and the Starburst unit is now in **LOCAL** control mode.

Choose **REMOTE** control in the same manner if you will operate your Starburst unit from the User port.

PREPARING FOR USE

Arc Handling

You can choose self-run, active arc, or passive mode from the front panel.

- Using either **SELECT** button, toggle up or down until the **ARC HANDLING MODE** LED under the Function section is lit.
- Press **PROGRAM (RESET)**. The LED starts flashing.
- Press either **SELECT** button until the arc-handling mode you want is lit under the **MODE** section. At the same time, the display shows **SE** for self-run, **AC** for active arc, and **PA** for passive mode.
- Press **PROGRAM (RESET)** again.
- The LED stops flashing and the arc-handling mode is programmed.

Function

Total Arc Count, Micro Arc Count, and Hard Arc Count

The Starburst unit tracks the number of hard arcs, micro arcs, and total arcs since the counter was last reset or up to 9,999 arcs maximum.

- Using either **SELECT** button, toggle up or down until the **TOTAL ARC COUNT, MICRO ARC COUNT, or HARD ARC COUNT** LED is lit.
- The display shows the number of arcs for each choice.
- To clear the counters, press **PROGRAM (RESET)** when any one of the three arc count LEDs are lit. All three counters are cleared simultaneously.

Frequency

The frequency is internally fixed at 20 kHz and is not adjustable.

Reverse Voltage Time

Reverse Voltage Time (RVT) is adjustable in self run mode and active arc mode. In setting RVT, you can choose 5 to 15 μs in 1 μs increments. Figure 3-1 is an example of an RVT timeline.

- Using either **SELECT** button, toggle up or down until the **REVERSE TIME** LED is lit.
- Press the **PROGRAM (RESET)** button.
- The **REVERSE TIME** LED starts flashing.
- Press either **SELECT** button until the reverse time you want is displayed.
- Press **PROGRAM (RESET)** again.
- The reverse time you chose is now programmed.

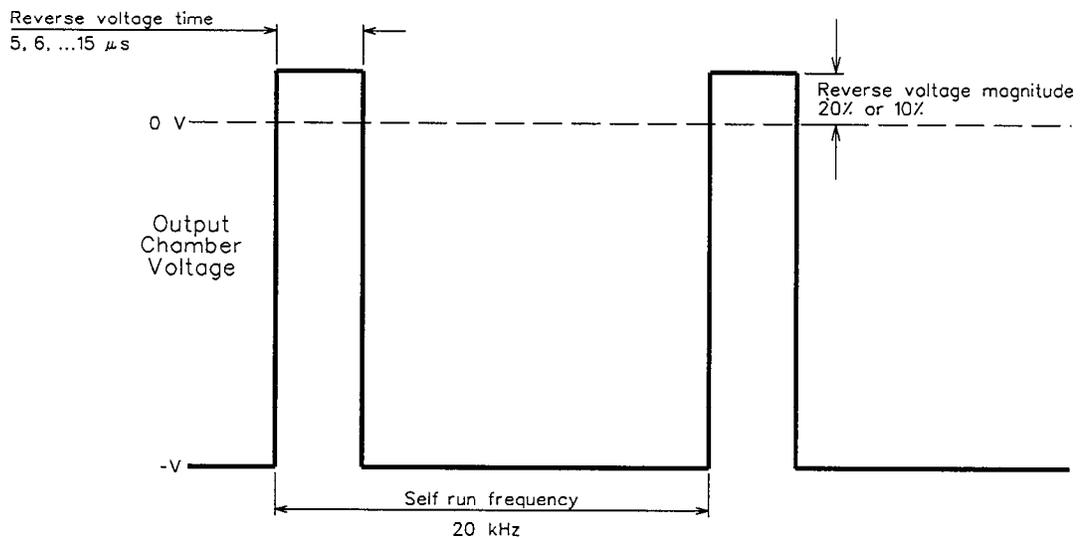


Figure 3-1. Reverse Voltage Time (RVT) example

Crow-bar Delay (Time Before Firing)

Crow-bar delay time starts 3 μs after the reverse voltage time. If the output voltage has not returned to its original value within the sampling 3 μs time period, the crow-bar delay timer will start. The crow-bar delay time before firing can be set from 1 μs to 60 μs . Note that the Starburst unit will attempt to clear an arc 10 μs after the first try unless the crow-bar delay time is set to less than 7 μs . A crow-bar firing forces a short circuit on the power

PREPARING FOR USE

supply, causing it to momentarily shut off. This event is recorded as a hard arc. See Figure 3-2 for a delay timing example.

- Using either **SELECT** button, toggle up or down until the **CROWBAR DELAY LED** is lit.
- Press **PROGRAM (RESET)**. The LED starts flashing.
- Press either **SELECT** button, until the crow-bar delay time you want is displayed.
- Press **PROGRAM (RESET)** again.
- The crow-bar delay time you chose is now programmed.

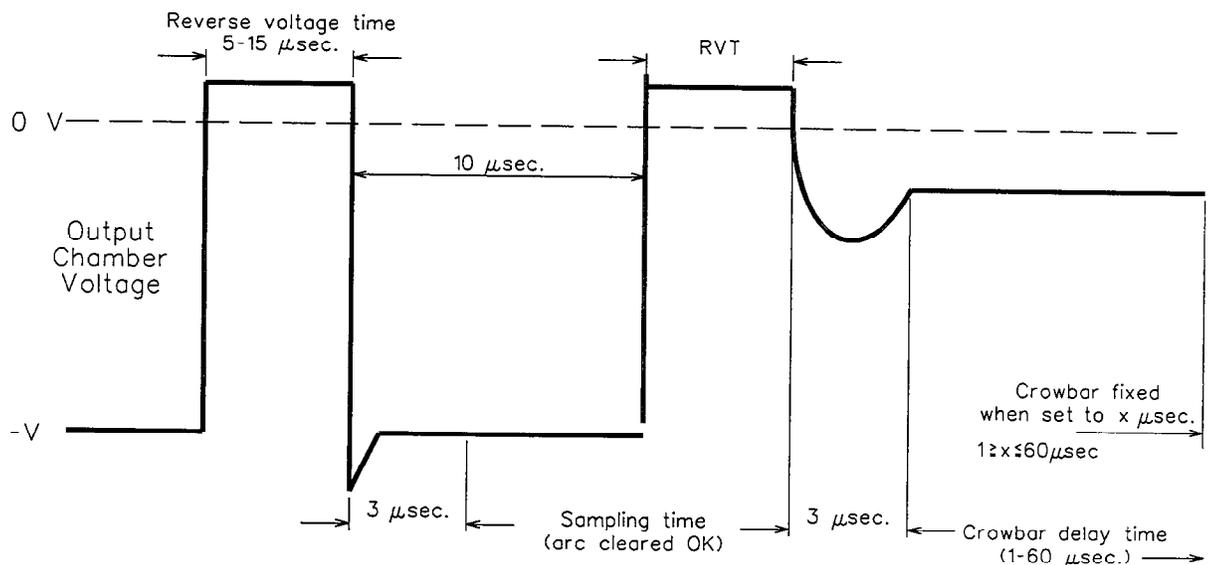


Figure 3-2. Crow-bar Delay Time example

The example in Figure 3-2 works as follows.

- The first arc is detected, but the output voltage returns to normal within the 3 μs. (The crow-bar delay timer is not activated.)
- The second arc is detected, and the Starburst unit tries to clear the arc for a time equal to the RVT selected from the front panel. However, the output voltage does not return to normal.
- The crow-bar delay timer starts (power still applied) (3 μs after RVT).
- If the voltage does not return during the crow-bar delay time period (x), the crow-bar is fired.
- If the crow-bar is fired, the power supply is forced to turn off, clearing the hard arc. The power supply automatically restarts after 10 ms.



Status

Mode Override

Error codes E01-E06 are displayed on the front panel to indicate when limits have been exceeded. The two options of the Starburst (004 and 005) use different software and therefore treat errors differently. In general, error codes will flash for either 10 seconds (and then clear) or until you press PROGRAM (RESET), depending on which option you have.

Option 004

Error codes E01-E06 flash in the display until the error condition is no longer present and until you press PROGRAM (RESET). If you don't clear an error, the error code continues to display. The error code that appears first stays on the display, even if other errors occur later.

Error codes E01-E06 cause the Starburst unit to crow-bar (fire its internal SCR to short out the input driving voltage). The internal Starburst IGBT is also activated to short out energy being delivered to the load. Since the crow-bar is fired for all these error codes, the CROWBAR LED remains lit until it's reset.

Option 005

Error codes E01-E06 display as the error occurs. The error code displays for 10 seconds or less and then clears, as long as the error condition is no longer present.

Error codes E01-E06 cause the Starburst unit to crow-bar (fire its internal SCR to short out the input driving voltage). The internal Starburst IGBT is also activated to short out energy being delivered to the load. Since the crow-bar is fired for all these error codes, the CROWBAR LED remains lit until the error clears itself.

Note: An error will not automatically clear for an UNDERVOLTAGE.

Options 004 and 005

Error codes E-09, E12, and E13 require a manual reset or a reset from the User port. A Mode Override indicates an error code E11 and will clear the display when the voltage returns to normal operating levels. A SUPERVISORY error causes both the Status Indicator LED to light and a signal to be sent to the User port. No error codes are displayed. The Starburst will not crow-bar or shut down until requested to by the operator or system logic. When the Starburst unit is in any mode, the IGBT will

PREPARING FOR USE

not activate for error code E01.

Error Codes

| Code | Condition | Description |
|------|--------------------------|---|
| E01 | Input overvoltage | When the input dc voltage exceeds 1800 V, the Starburst is crow-barred to protect the unit. |
| E02 | Switch overvoltage | When the switch voltage exceeds 1800 V, the Starburst is crow-barred to protect the switches. |
| E03 | Input overcurrent | When the input current exceeds 140 A, the Starburst is crow-barred. |
| E04 | Switch overcurrent | When the IGBT switch current exceeds 220 A, the Starburst is crow-barred. The IGBT is turned off after reaching this trip level. |
| E05 | Crow-bar delay/time out | The Starburst is crow-barred when arcs cannot be cleared by the IGBTs within the time set as crow-bar delay time. |
| E06 | Over input power | The Starburst is crow-barred when the input power exceeds 60 kW. |
| E09 | Xilinx not running | The Starburst is not crow-barred; however, the unit does not operate. |
| E11 | Switch overvoltage | This condition exists when the output voltage is over 1400 V and less than 1800 V. The IGBT gate signals are inhibited from turning on until the output voltage drops below 1400 V. This condition is known as "Mode Override." |
| E12 | Bias supply undervoltage | The IGBT gate signals are inhibited until this condition clears. |
| E13 | Overtemperature | The IGBT gate signals are inhibited until this condition clears. Check for proper water flow and water temperature. |

Internal Failure Modes

Dedicated internal circuits monitor and report failed critical components within the Starburst unit. The purpose of these circuits is to inhibit the Starburst unit from functioning improperly and thus adversely affecting the process or process products. The failure codes and the conditions which cause them are listed in the following table.



PART II

| Code | Condition | Description |
|------|--------------------------|---|
| E24 | Snubber diodes | The failure of either the loss-less snubber or choke coil snubber diodes will cause a high reverse current to be detected. Once it is detected, the Starburst SCR is turned on continuously to short out the driving power supply. The Starburst unit will continue to fire the SCR crow-bar until a <i>RESET</i> signal (pin 10) is generated, either from the front panel or through the User port. An error signal will be displayed on the front panel and the <i>SUPERVISOR.D</i> line (pin 11) output is driven low to indicate that the unit is not functioning properly. |
| E25 | Blocking diode | The failure of the output blocking diode would normally be of little concern on most chambers. However, on chambers where high reverse currents could exist (cathode to shield shorts, other plasma energy sources, cathodic arc systems, and so on), reverse currents should be minimized. The failure of this diode in those systems will cause a high reverse current to be detected. Once it is detected, the action taken is exactly as that stated for E24, except that the error message will be displayed as E25. |
| E26 | Excessive Output Current | The Starburst unit's output exceeds 200 A. Again, once the failure is detected, the response is the same as for E24 and E25, except that the error code will be displayed as E26. |

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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