OPERATOR'S MANUAL

MODEL PA05039

HIGH-VOLTAGE POWER AMPLIFIER

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Safety

Review the following safety precautions to maintain safety and prevent damage to the instrument or equipment connected to it.

The safety features of this instrument may be ineffective if the equipment is not operated in the manner stated in this manual.

Refer all maintenance procedures to qualified personnel. This instrument contains no user serviceable parts inside. Please refer all service inquires to the Smart Material by calling 1 (941) 365-9121.

Safety Precautions

Use the Power Cord Provided

To avoid fire hazard, use only the power cord provided with this instrument.

Avoid Electric Overload

To avoid electric shock or fire hazard, do not apply a voltage to a terminal that is outside the range specified for that terminal.

Avoid Electric Shock

To avoid electric shock, do not touch the high-voltage output connector or the load circuit while the instrument is on.

Ground the Product

This product is electrically grounded through the ground conductor of the power cord. To avoid electric shock, the ground conductor must be connected to earth ground. Before making connections to the input and output terminals of the product, ensure that the product is properly grounded.

Safety Precautions (cont.)

Do Not Operate Without Covers

To avoid electric shock or fire hazard, do not operate this instrument with the covers removed.

Use Proper Fuses

To avoid fire hazard, use only the fuse type and rating specified for this instrument.

Indoor Use Only

This instrument is intended for indoor use only.

Do Not Operate in Wet or Damp Conditions

To avoid electric shock, do not operate this instrument in wet or damp conditions.

Do Not Operate in an Explosive Environment

To avoid injury or fire hazard, do not operate this instrument in an explosive environment.

Product Protection Precautions

Use the Proper Power Source

Do not operate this instrument from a power source that is different than the voltage specified on the serial number tag.

Provide Proper Ventilation

To prevent the instrument from overheating, provide proper ventilation.

Do Not Operate with Suspected Failures

If you suspect there is damage to this instrument, have it inspected by qualified personnel.

Safety Terms and Symbols

Terms in the Manual

These terms may appear in this manual:

Warning: Warning statements identify conditions or practices that could result in injury or loss of life.

Caution: Caution statements identify conditions or practices that could result in damage to this product or other equipment.

Symbols on the Product

These symbols may appear on the instrument:

Warning, risk of electric shock

Caution, refer to Operator's Manual

CAT I Installation category I (overvoltage category): Classification for the operation of a unit using voltage systems or circuits with required standardized limits for transient voltages. Category I pertains to voltages supplied at the peripheral level, with smaller tolerances for transient voltages as specified by the Low-Voltage Safety standard (EN 61010-1).

CAT II Installation category II (overvoltage category): Classification for the operation of a unit using voltage systems or circuits with required standardized limits for transient voltages. Category II pertains to using voltage supplied on the local level (example: local wall outlets) with smaller tolerances for transient voltages as specified by the Low-Voltage Safety standard (EN 61010-1).

CE This symbol refers to the compliance of the equipment to the European Council (E.C.) standards.

Preface

This manual provides user information for the Model PA05039 High-Voltage Amplifier. It contains the following chapters and appendixes:

- ***General Information*** contains a brief product description and an incoming confidence test that can be used to verify the instrument was not damaged during transit.
- ***Installation*** describes how to set up the instrument for operation. Information is included on mounting the instrument, the load connection, and the various input and output connections.
- ***Operation*** contains a description of the product's features and a detailed explanation of proper operating procedures.
- ***Specifications*** contains a technical description of product performance levels and necessary operating requirements.
- ***Maintenance*** provides information on periodic maintenance procedures and fuse replacement.
- ***Appendix A: Accessories*** describes other products that are useful with the Model PA05039.
- ***Appendix B: Warranty Statement*** describes the terms and conditions of the Smart Material one-year warranty.

Section I General Information

Danger: *These high-voltage generating instruments are not designed, rated, or qualified to be operated in an environment or atmosphere which contains combustible or explosive materials or gases which may be ignited by electrical discharges.*

This manual provides instructions to install and operate the Model PA05039 High-Voltage Power Amplifier. We recommend you take the time to read this manual to take full advantage of the features and benefits of the instrument.

Introduction

The Model PA05039 is a DC-stable, high-voltage power amplifier designed to provide precise control of output voltages in the range of: -500 V to +1500 V, DC or peak AC, with an output current in the range of: 0 to ±35 mA DC or 0 to ±50 mA peak AC.

The Model PA05039 is configured as a noninverting amplifier with a fixed gain of 200 V/V and features an all solid-state design for high slew rate, wide bandwidth, and low-noise operation. The four-quadrant, active output stage sinks or sources current into reactive or resistive loads throughout the output voltage range. This is essential for achieving the accurate output response and high slew rates demanded by reactive loads.

This unit is protected against overvoltage and overcurrent conditions that may be generated by active loads or by output short circuits to ground.

Precision voltage and current monitors provide low-voltage representations of the high-voltage output and load current for monitoring purposes or for use as feedback signals in a closed-loop system.

A Digital Enable feature provides a connection for a remote device to turn ON and OFF the high voltage of the instrument. This makes the Model PA05039 useful for automated or computer controlled systems.

A Dynamic Adjust feature can be used to optimize the AC response of the output signal. The Model PA05039 is designed to be operated on a bench top.

Incoming Inspection

Visually inspect the instrument for physical damage such as dents, nicks, scratches, broken fittings, etc. External damage may indicate more serious damage has occurred within the instrument. In the event of damage, notify the factory and request instructions. Do not attempt to use a damaged instrument.

Incoming Confidence Test

The Model PA05039 undergoes extensive checks and adjustments at the factory, and no initial calibration should be required. However, you may wish to perform an incoming confidence test as part of the incoming inspection on the instrument. An incoming confidence test of this nature is intended to confirm that the instrument was not damaged in transit.

We recommend that you familiarize yourself with the information in Section II and Section III before performing this test.

Operating the Model PA05039 as a high-voltage supply and measuring the voltage at the OUTPUT MONITOR connector would constitute a reasonable incoming confidence test.

Warning: *Do not plug in the PA05039 or turn it on until instructed to do so. To do so before the appropriate point in time could result in an electrical shock and/or damage to the instrument.*

Caution: *Ensure that the PA05039 has been configured for the proper nominal line voltage for your area. Damage to the system may result if it is operated at an incorrect line voltage. Refer to "Power Connection" on page II-1 for instructions to check the line voltage setting.*

1. Ensure that the POWER switch is in the OFF position.
2. Connect a digital voltmeter to the VOLTAGE MONITOR output connector on the front panel.
3. Plug the power cord into the power receptacle on the rear panel.
4. Plug the power cord into the power source.

Warning: *Make no attempt to bypass the ground feature in the AC line cord. This is a protective ground and any attempt to negate it could result in electrical shock.*

Note: *The Dynamic Adjust potentiometer must be at the zero position.*

Incoming Inspection

Incoming Confidence Test (cont.)

5. Apply a 1 Volt DC signal into the INPUT SIGNAL connector on the front panel.

6. Turn ON the PA05039.

7. The voltmeter should measure 1 Volt.

Warning: *The HIGH VOLTAGE OUTPUT connector carries high voltage. Do not touch the HIGH VOLTAGE OUTPUT connector or the load circuit while the PA05039 is operating. Always turn off the PA05039 before making changes to the load connections.*

This completes the incoming confidence test. Turn OFF the POWER switch.

Section II Installation

Mounting

The Model PA05039 is designed for operation on a benchtop.

The PA05039 is air cooled. Allow approximately 25 mm (1 inch) of free air space around the vent holes and fans on the back panel of the instrument.

Power Connection

The Model PA05039 is operated at a line voltage of 90 to 250 V AC, 50/60 Hz.

Caution: *The PA05039 may be damaged if operated at an incorrect line voltage. Check the voltage rating on the serial number tag on the rear panel to ensure that the PA05039 is configured to operate at the line voltage in your area.*

The supplied line cord is un-terminated and follows the International (ICC) designations:

HOT	Brown
Neutral	Blue
Earth GROUND	Green with Yellow Stripes

Perform power connections to conform to the site of local operation for the unit.

1. Ensure that the POWER switch is off before connecting the power cord to a power source.

2. Plug the power cord into the power connector on the rear panel.

3. Connect the (un-terminated) end of the power cord into the power source.

Warning: *Make no attempt to bypass the ground prong in the power cord. This is a protective ground and any attempt to negate it could result in an electrical shock.*

Load Connection

A high-voltage cable assembly is provided for connection to the HIGH VOLTAGE OUTPUT connector on the front to the load device.

1. Return the low side of the load device to ground, either through the shield of the SHV connector or to the ground jack terminal on the rear or front panel of the unit.

2. Connect the free, un-terminated end to the load device.

   Note: *Ensure that the connection to the load device does not allow high-voltage hazards to be accessible.*

3. Connect the terminated end of the cable assembly to the HIGH VOLTAGE OUTPUT connector.

Warning: *The HIGH VOLTAGE OUTPUT connector carries high voltage. Do not touch the HIGH VOLTAGE OUTPUT connector or the load circuit while the PA05039 is operating. Always turn off the PA05039 before making changes to the load connections.*

Input Connection

The Model PA05039 is configured as a noninverting amplifier with a fixed gain of 200 V/V. Apply a -2.5 V to +7.5 V DC or peak AC to produce a high-voltage output of -500 V to +1500 V

Connect the signal source to the center conductor of the INPUT SIGNAL receptacle on the rear panel. If the signal voltage can exceed 12 V, the signal source should be current limited to 50 mA. The Model PA05039 has a built-in input signal limiter to protect the internal circuitry of the unit.

Note: *The voltage applied to the INPUT SIGNAL receptacle must not exceed ±12 V.*

Voltage Monitor Connection

The VOLTAGE MONITOR connector on the front panel is a buffered output providing a low-voltage replica of the high-voltage output. The scale factor is 1/200th of the high-voltage output.

Connect a monitoring device, such as an oscilloscope, to this connector to monitor the high-voltage output. The signal at this connector can also be used as a feedback signal in a closed-loop system.

Note: *The maximum voltage at the OUTPUT MONITOR is ±15 V.*

Current Monitor Connection

The CURRENT MONITOR connector on the front panel is a buffered output providing a low-voltage representation of the load current. 0.2 V at this connector represents 1 mA of load current.

Connect a monitoring device, such as an oscilloscope, to this connector to monitor the load current. The signal at this connector can also be used as a feedback signal in a closed-loop system.

Note: *The maximum voltage at the CURRENT MONITOR is ±15 V.*

Digital Enable Connection

The DIGITAL ENABLE connector on the rear panel is used for connection of a remote device to turn on and off the high-voltage output.

A TTL high (or open) will turn off the high-voltage output. A TTL low will turn on the high-voltage output.

Note: *The voltage applied to the DIGITAL ENABLE receptacle must not exceed 5.5 V.*

Section III Operation

Front Panel Features

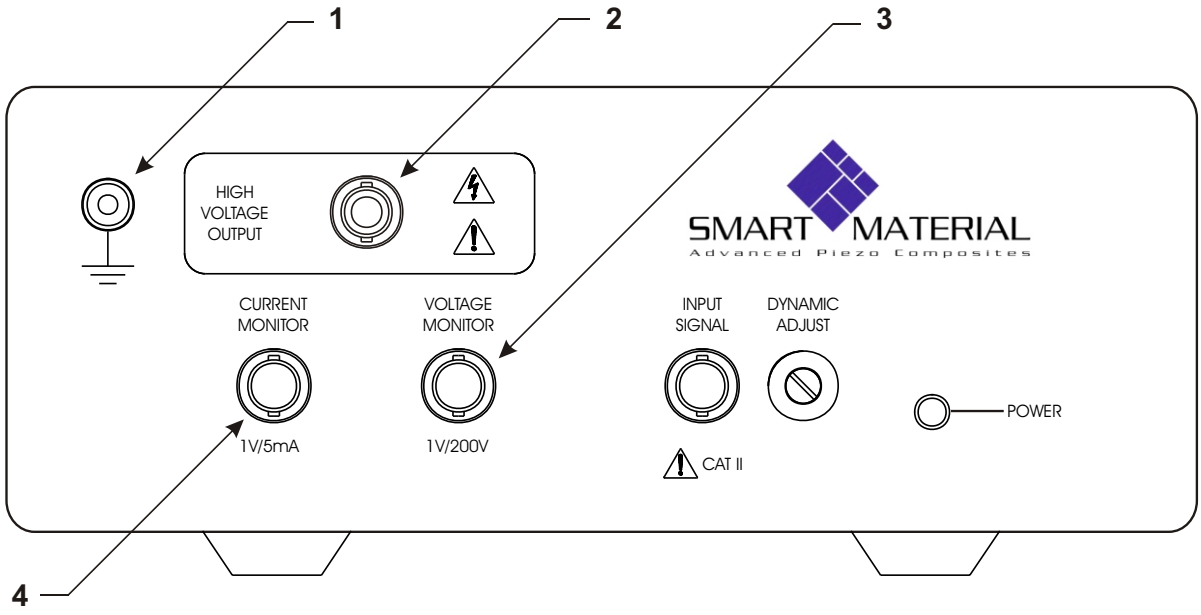

Figure 3-1: Model PA05039 front panel (features 1 through 4)

1. ***GROUND Jack:*** This ground jack is a functional earth terminal and can be used as a ground return point for the load circuit or a ground reference point for other equipment. For convenience, an identical ground jack is found on the rear panel.

2. ***HIGH VOLTAGE OUTPUT Connector:*** This SHV connector is for connection of the load device using the high-voltage output cable assembly provided.

3. ***VOLTAGE MONITOR Connector:*** This BNC provides a buffered, low-voltage replica of the high-voltage output.

4. ***CURRENT MONITOR Connector:*** This BNC provides a buffered, low-voltage representation of the load current.

Front Panel Features (cont.)

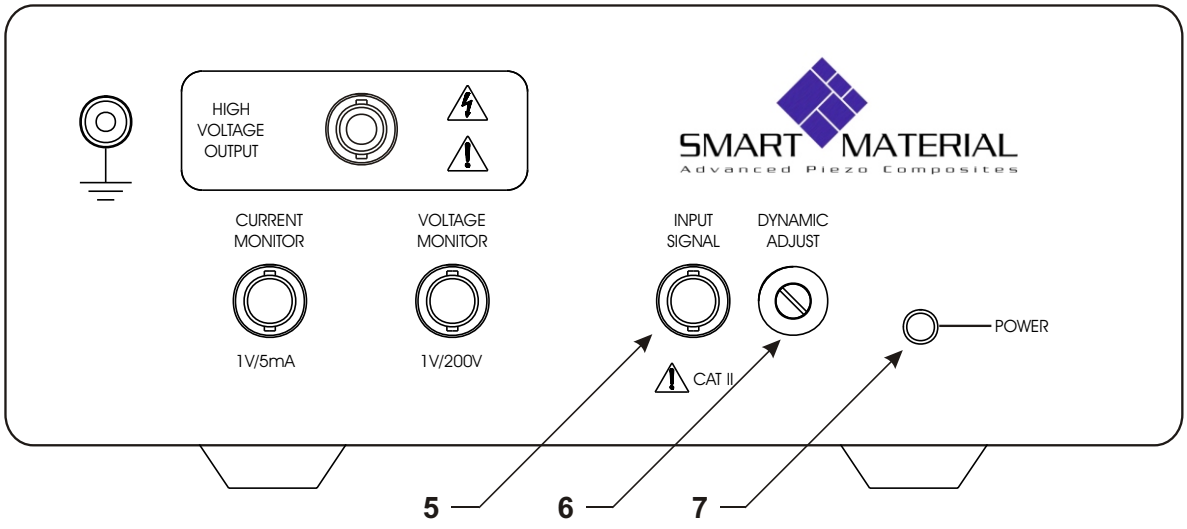

Figure 3-2: Model PA05039 front panel (features 5 through 7)

5. ***INPUT SIGNAL Receptacle:*** This BNC receptacle is for connection of the external voltage signal to be amplified. The input range of the PA05039 is -2.5 V to +7.5 V DC or peak AC.

6. ***DYNAMIC ADJUST:*** This potentiometer is used to optimize the AC response characteristics of the output voltage waveform. The setting is adjusted for various parameters.

7. ***POWER Indicator:*** This indicator will illuminate when the rear panel switch is powered ON. ***Note:*** *When not utilizing the Digital Enable HV On/Off remote capabilities, the shorting cap must be on the Digital Enable BNC connector to allow operation.*

Rear Panel Features

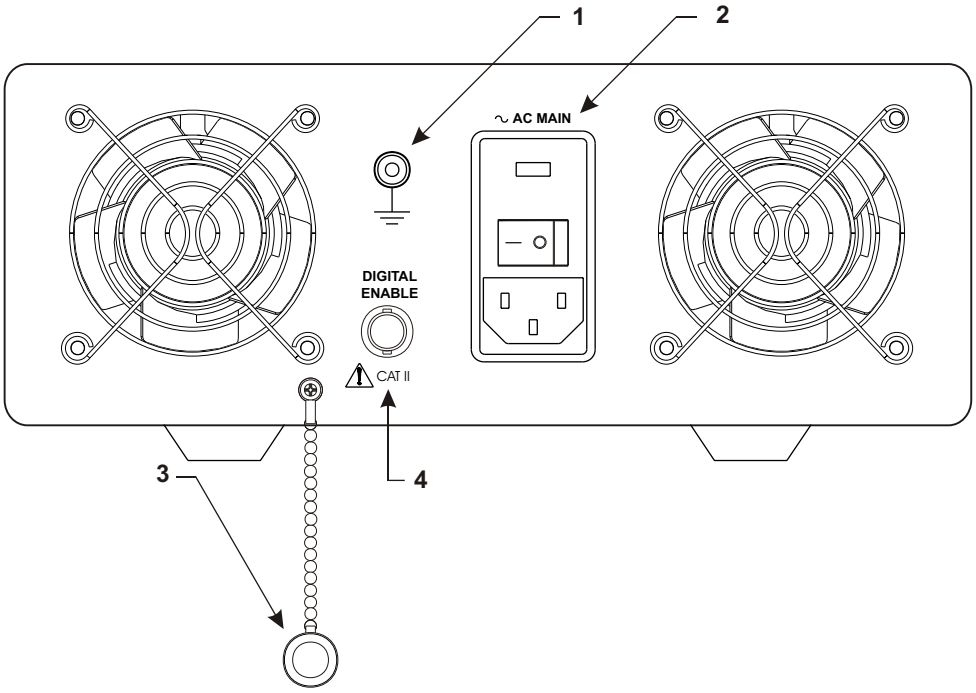

Figure 3-3: Model PA05039 rear panel

1. ***GROUND Jack:*** This ground jack is a functional earth terminal and can be used as a ground return point for the load circuit or a ground reference point for other equipment. For convenience, an identical ground jack is found on the front panel.

2. ***POWER Entry Module:*** This switch turns ON and OFF the AC power to the Model PA05039. The receptacle is a standard three-prong power connector with an integral fuse holder. ***Note:*** *When not utilizing the Digital Enable HV On/Off remote capabilities, the shorting cap must be on the Digital Enable BNC connector on the rear panel to operate the unit.*

3. ***SHORTING CAP for the DIGITAL ENABLE Receptacle:*** This cap must be on the Digital Enable connector when not utilizing the HV On/Off remote feature.

4. ***DIGITAL ENABLE Receptacle:*** This BNC is for connection of a remote device to turn ON and OFF the high-voltage output.

Normal Operation

The following instructions assume that the instrument has been installed according to the instructions given in Section II, INSTALLATION.

Warning: *The HIGH VOLTAGE OUTPUT connector carries high voltage. Do not touch the HIGH VOLTAGE OUTPUT connector or the load circuit while the PA05039 is operating. Always turn off the PA05039 before making changes to the load connections.*

Generating a High-Voltage Output

A low-voltage signal is applied to the INPUT SIGNAL receptacle on the front panel. The signal is amplified by the gain ratio of the amplifier to generate a high-voltage output signal. The Model PA05039 is configured as a noninverting amplifier with a fixed gain of 200 V/V. Apply a -2.5 V to +7.5 V DC or peak AC to produce a high-voltage output of -500 V to +1500 V

Warning: *The HIGH VOLTAGE OUTPUT connector carries high voltage. Do not touch the HIGH VOLTAGE OUTPUT connector or the load circuit while the PA05039 is operating. Always turn off the PA05039 before making changes to the load connections.*

The shorting cap must be on the Digital Enable BNC connector when not utilizing the digital enable function of the amplifier.

Remotely Turning On and Off the High-Voltage Output

When the DIGITAL ENABLE is utilized, the high-voltage output can be turned ON and OFF by a TTL signal.

Apply a TTL low to the DIGITAL ENABLE receptacle to turn ON the high-voltage output.

A TTL high (or open) turns OFF the high-voltage output.

Normal Operation (cont.)

Monitoring the Output Voltage

A buffered, low-voltage replica of the output voltage is provided at the VOLTAGE MONITOR output connector on the front panel.

The voltage at this voltage monitor connector is 1/200th the voltage at the HIGH VOLTAGE OUTPUT connector.

Monitoring the Load Current

A buffered, low-voltage representation of the load current is provided at the CURRENT MONITOR connector on the front panel.

0.2 V at this connector represents 1 mA of load current.

Automatic Power Limit

A control feature which automatically limits internal power dissipation to protect the Model PA05039 from overheating. The following graph illustrates the Model PA05039 automatic output power limit range.

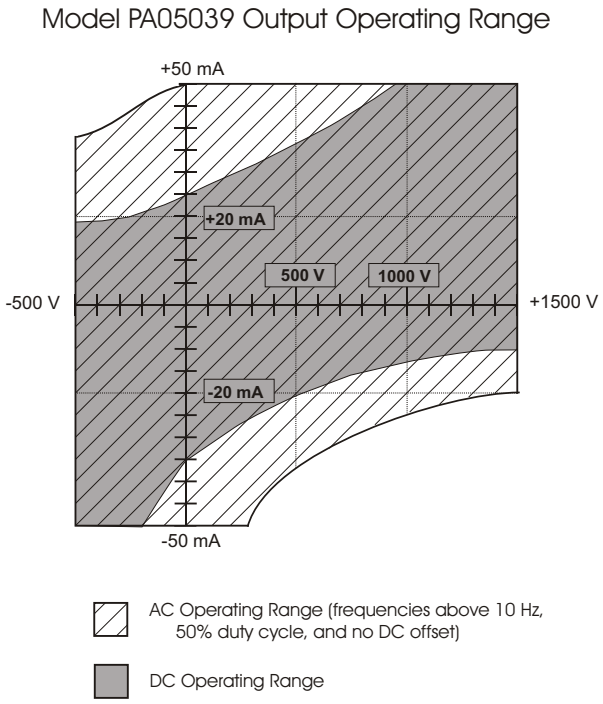

Figure 3-4: Automatic Power Limit

Making Load Compensation Adjustments

The Model PA05039 has been factory calibrated for no load. The Dynamic Adjust potentiometer on the front panel must be adjusted to optimize the AC response characteristics of the output voltage waveform when using a capacitive load device or when changing load devices with different capacitive values.

Monitoring the output voltage from the VOLTAGE MONITOR output, adjust the Dynamic Adjust potentiometer for the optimized AC response for a square wave.

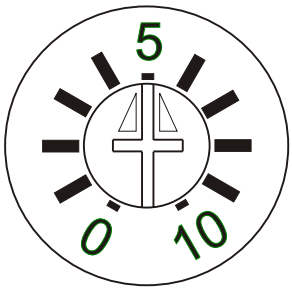

Figure 3-5: Dynamic Adjust

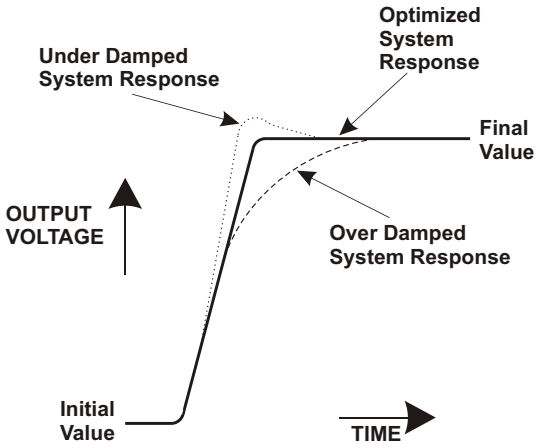

Figure 3-6: System Response

Section IV Specifications

All specifications are with no load unless otherwise noted.

OUTPUT

Output Voltage Range	-500 V to +1500 V.
Output Current Range	0 to ±35 mA DC. 0 to ±50 mA peak AC.

AMPLIFIER INPUT

Input Voltage Range	-2.5 V to +7.5 V DC or peak AC.
Input Impedance	25 k , nominal.

FEATURES

Dynamic Adjust	A graduated one-turn potentiometer is used to optimize the AC response of the PA05039 for various load parameters.
Digital Enable	A BNC input to provide a connection for a TTL compatible signal to turn on and off the high-voltage output. At TTL high (or open), the high-voltage output is OFF. At TTL low, the high-voltage output is ON.

Specifications (cont.)

FEATURES (cont.)

Voltage Monitor	A buffered output provides a low-voltage replica of the high-voltage output.
Scale	1/200th of the high-voltage output.
DC Accuracy	Better than 0.1% of full scale.
Offset Voltage	Less than 25 mV.
Output Noise	Less than 25 mV rms (measured using the true rms feature of the Hewlett Packard Model 34401A digital multimeter).
Output Impedance	Less than 0.1 .
Current Monitor	A buffered output provides a low-voltage representation of the load current.
Scale	0.2 V/mA.
DC Accuracy	Better than 1% of full scale.
Offset Voltage	Less than 25 mV.
Output Noise	Less than 50 mV rms (measured using the true rms feature of the Hewlett Packard Model 34401A digital multimeter).
Output Impedance	Less than 0.1 .

Specifications (cont.)

PERFORMANCE

DC Voltage Gain	200 V/V (noninverting).
DC Voltage Gain Accuracy	Better than 0.1% of full scale.
Offset Voltage	Less than 1 V.
Output Noise	Less than 75 mV rms with a 5 nF load (measured using the true rms feature of the Hewlett Packard Model 34401A digital multimeter).
Slew Rate (10% to 90%, typical)	Greater than 50 V/µs.
Large Signal Bandwidth (-3 dB)	DC to 10 kHz.
Small Signal Bandwidth (-3dB)	DC to 30 kHz.
Settling Time to 1%	Less than 300 µs for a 0 to 500 V step.
Stability	
Drift with Time	Less than 100 ppm/hr, noncumulative.
Drift with Temperature	Less than 50 ppm/°C.

Specifications (cont.)

PERFORMANCE

Automatic Power Limit Function

A control feature which automatically limits internal power dissipation to protect the Model PA05039 from overheating. The following graph illustrates the Model PA05039 automatic output power limit range.

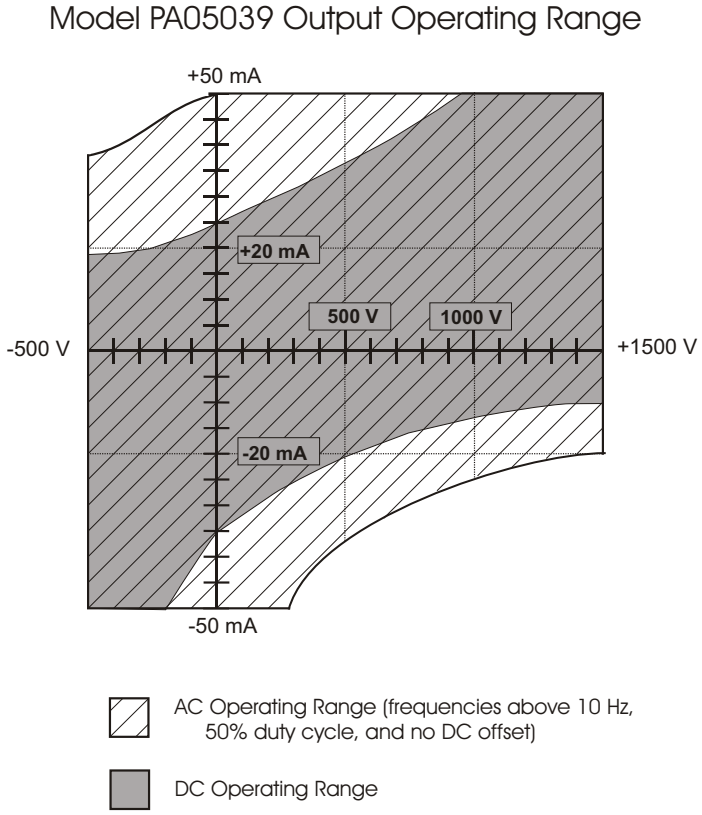

Figure 4-1: Automatic Power Limit

Specifications (cont.)

GENERAL

Dimensions	203 mm W x 98.3 mm H x 361 mm D (8 W x 3.87 H x 14.2 D).
Weight	2.3 kg (5 lb).
Power Requirements	
Line Voltage	The Model PA05039 is operated at a line voltage of 90 to 250 V AC, 50/60 Hz.
Power Consumption	75 VA, maximum.
Operating Conditions	
Temperature	0 °C to 40 °C.
Relative Humidity	To 85%, noncondensing.
High-Voltage Output Connector	SHV high-voltage connector.
Amplifier Input	BNC connector.
Voltage Monitor	BNC connector.
Current Monitor	BNC connector.
Digital Enable Connector	BNC connector.
Power Receptacle	Standard three-prong power connector with an integral fuse holder.

Specifications (cont.)

Certification and Compliance

Certification	The manufacturer certifies that each Model PA05039 is tested and calibrated to specifications using measurement equipment traceable to the National Institute of Standards and Technology or traceable to consensus standards.
Low Voltage Safety Compliance	
Installation Category	CAT II: Local-level mains, appliances, portable equipment.
Pollution Category	Degree 1: Operate in environments where no pollution or only dry, nonconductive pollution occurs.

Section V Maintenance

Safety

Observe the following safety precautions when performing maintenance procedures on the Model PA05039:

1. Always turn off the PA05039 and disconnect it from its power source before cleaning or inspecting it. Failure to observe this precaution could result in an electrical shock.

2. Refer all maintenance procedures to qualified personnel.

Maintenance Assistance

Customer Service Assistance

In the event that you require assistance on a maintenance item, direct your request for assistance to the factory.

Refer all maintenance procedures to qualified personnel. This instrument contains no user serviceable parts inside. Please refer all service inquires to Smart Material Corp by calling 1 (941) 870-3337.

Maintenance Assistance (cont.)

Repairs

The terms and conditions of the warranty are stated in Appendix B.

Note: *The warranty is voided if the instrument seals are broken within the warranty period by anyone other than Smart Material.*

In the event of a malfunction, and the instrument must be returned for repair:

1. Notify Smart Material, giving full details about the difficulty, including the model number and serial number of the instrument. Customer Service will issue a return authorization number.

2. Forward the instrument (prepaid), with the return authorization number prominently displayed on the shipping container and the packing list.

Preventative Maintenance

Cleaning the Instrument

Remove line power from instrument prior to cleaning or inspecting.

Preventative maintenance consists of inspecting and cleaning the instrument. Preventative maintenance performed on a regular basis may prevent instrument failure and improve reliability.

INSPECTION: Visually inspect the instrument for loose or damaged controls and connectors or other undesirable conditions.

CLEANING: Disconnect the unit from all external connections prior to cleaning. Clean the PA05039 as operating conditions require. Clean the exterior of the instrument with a soft cloth dampened with water. Use only water to dampen the cloth. The use of solvents may damage the finish or plastic components. A small brush is effective in removing dirt from the front and rear panel controls and connectors.

Servicing the Fuses

Refer servicing the fuses to qualified personnel.

Always replace the fuses with fuses of the same type and rating.

Always unplug the power cord from the power source before attempting to change the fuses.

Warning: *Never attempt to service the fuses when the instrument is plugged into the power source. An electrical shock could result.*

The line fuses are contained in a compartment in the power entry module on the back panel. Use a small flat head screwdriver in the notch at the bottom of the fuse compartment door to lift the door and gain access to the fuses. These are the only user serviceable fuses.

Please refer to the chart below for replacement of any blown fuses.

	Model PA05039
90 to 250 V AC at 50/60 HZ	1 A, 250 V AC 5 mm x 20 mm (T) IEC 60127-2, Sheet III

If the fuses continually blow, a more serious problem exists within the instrument. In this instance contact Customer Service at Smart Material.

Appendix A Accessories

Included Accessories

Item	Part Number
Operator's Manual	23350
High-Voltage Output Connector (SHV mating connector)	43874
Un-terminated Line Cord (90 to 250 V AC operation)	N5017*
Two (2) 1 A, 250 V(T) 5 mm x 20 mm fuses	H0013

* AC line cord plug is determined by the geographical destination for the unit.

Appendix B Warranty Statement

Instruments sold by Smart Material (hereinafter called the "Company") are warranted only as stated below:

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or in the Company's sole discretion, by replacement, any defect of material or workmanship which develops within one year from the date of original purchase by the customer (user), provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use. Repair or replacement are the exclusive remedies under this warranty (batteries are not included under this warranty).

The exceptions and conditions mentioned are as follows:

(a) The Company makes no warranty concerning components or accessories not manufactured by itself.

(b) The Company is released from all obligations under this warranty in the event that repairs or modifications are made by persons other than its own or authorized personnel, unless such repairs by others are made with the prior written consent of the Company. In the event of a failure, and the customer neglects to take prompt and reasonable actions to prevent further damage, the Company cannot be responsible for consequent damage.

(c) THERE ARE NO OTHER WARRANTIES WHICH EXTEND BEYOND THOSE EXPRESSLY PROVIDED FOR HEREIN AND THE AFORESAID WARRANTY AND THE COMPANY'S OBLIGATIONS AND LIABILITIES THEREUNDER ARE IN LIEU OF, AND CUSTOMER WAIVES ALL OTHER WARRANTIES AND GUARANTEES AND ALL OTHER LIABILITIES THEREFORE, EXPRESS OR IMPLIED, ARISING BY LAW OR OTHERWISE, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, AND ALL OBLIGATIONS AND LIABILITIES WITH RESPECT TO LOSS OF USE, REVENUE OR PROFIT, OR INDIRECT, CONSEQUENTIAL OR INCIDENTAL DAMAGES OF ANY KIND AND FROM ANY CAUSE WHATSOEVER ARISING OUT OF OR IN ANY WAY CONNECTED WITH THE MANUFACTURE, SALE, HANDLING, REPAIR, MAINTENANCE OR REPLACEMENT OF SAID PRODUCTS.

(d) Representation and warranties made by any person, including dealers and representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including, but not limited to, the limitations of the liability of the Company as set forth above), shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(e) This warranty shall be governed by the laws of the State of New York.