# Model 556
# High Voltage Power Supply
# Operating and Service Manual

## WARNING

This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the instruction manual, may cause interference to radio communications. As temporarily permitted by regulation it has not been tested for compliance with limits for Class A computing devices pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference. Operation of this equipment in a residential area is likely to cause interference, in which case the user, at his own expense, will be required to make whatever measures may be required to correct the interference.

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Manual Revision K

# Advanced Measurement Technology, Inc.

a/k/a/ ORTEC®, a subsidiary of AMETEK®, Inc.

## WARRANTY

ORTEC* warrants that the items will be delivered free from defects in material or workmanship. ORTEC makes no other warranties, express or implied, and specifically NO WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

ORTEC's exclusive liability is limited to repairing or replacing at ORTEC's option, items found by ORTEC to be defective in workmanship or materials within one year from the date of delivery. ORTEC's liability on any claim of any kind, including negligence, loss, or damages arising out of, connected with, or from the performance or breach thereof, or from the manufacture, sale, delivery, resale, repair, or use of any item or services covered by this agreement or purchase order, shall in no case exceed the price allocable to the item or service furnished or any part thereof that gives rise to the claim. In the event ORTEC fails to manufacture or deliver items called for in this agreement or purchase order, ORTEC's exclusive liability and buyer's exclusive remedy shall be release of the buyer from the obligation to pay the purchase price. In no event shall ORTEC be liable for special or consequential damages.

## Quality Control

Before being approved for shipment, each ORTEC instrument must pass a stringent set of quality control tests designed to expose any flaws in materials or workmanship. Permanent records of these tests are maintained for use in warranty repair and as a source of statistical information for design improvements.

## Repair Service

If it becomes necessary to return this instrument for repair, it is essential that Customer Services be contacted in advance of its return so that a Return Authorization Number can be assigned to the unit. Also, ORTEC must be informed, either in writing, by telephone [(865) 482-4411] or by facsimile transmission [(865) 483-2133], of the nature of the fault of the instrument being returned and of the model, serial, and revision ("Rev" on rear panel) numbers. Failure to do so may cause unnecessary delays in getting the unit repaired. The ORTEC standard procedure requires that instruments returned for repair pass the same quality control tests that are used for new-production instruments. Instruments that are returned should be packed so that they will withstand normal transit handling and must be shipped PREPAID via Air Parcel Post or United Parcel Service to the designated ORTEC repair center. The address label and the package should include the Return Authorization Number assigned. Instruments being returned that are damaged in transit due to inadequate packing will be repaired at the sender's expense, and it will be the sender's responsibility to make claim with the shipper. Instruments not in warranty should follow the same procedure and ORTEC will provide a quotation.

## Damage in Transit

Shipments should be examined immediately upon receipt for evidence of external or concealed damage. The carrier making delivery should be notified immediately of any such damage, since the carrier is normally liable for damage in shipment. Packing materials, waybills, and other such documentation should be preserved in order to establish claims. After such notification to the carrier, please notify ORTEC of the circumstances so that assistance can be provided in making damage claims and in providing replacement equipment, if necessary.

## CONTENTS

## SAFETY INSTRUCTIONS AND SYMBOLS

This manual contains up to three levels of safety instructions that must be observed in order to avoid personal injury and/or damage to equipment or other property. These are:

**DANGER** Indicates a hazard that could result in death or serious bodily harm if the safety instruction is not observed.

**WARNING** Indicates a hazard that could result in bodily harm if the safety instruction is not observed.

**CAUTION** Indicates a hazard that could result in property damage if the safety instruction is not observed.

Please read all safety instructions carefully and make sure you understand them fully before attempting to use this product. In addition, the following symbol may appear on the product:

**ATTENTION – Refer to Manual**

**DANGER – High Voltage**

Please read all safety instructions carefully and make sure you understand them fully before attempting to use this product.

## SAFETY WARNINGS AND CLEANING INSTRUCTIONS

| | |
|---|---|
| **DANGER** | Opening the cover of this instrument is likely to expose dangerous voltages. Disconnect the instrument from all voltage sources while it is being opened. |

| | |
|---|---|
| **WARNING** | Using this instrument in a manner not specified by the manufacturer may impair the protection provided by the instrument. |

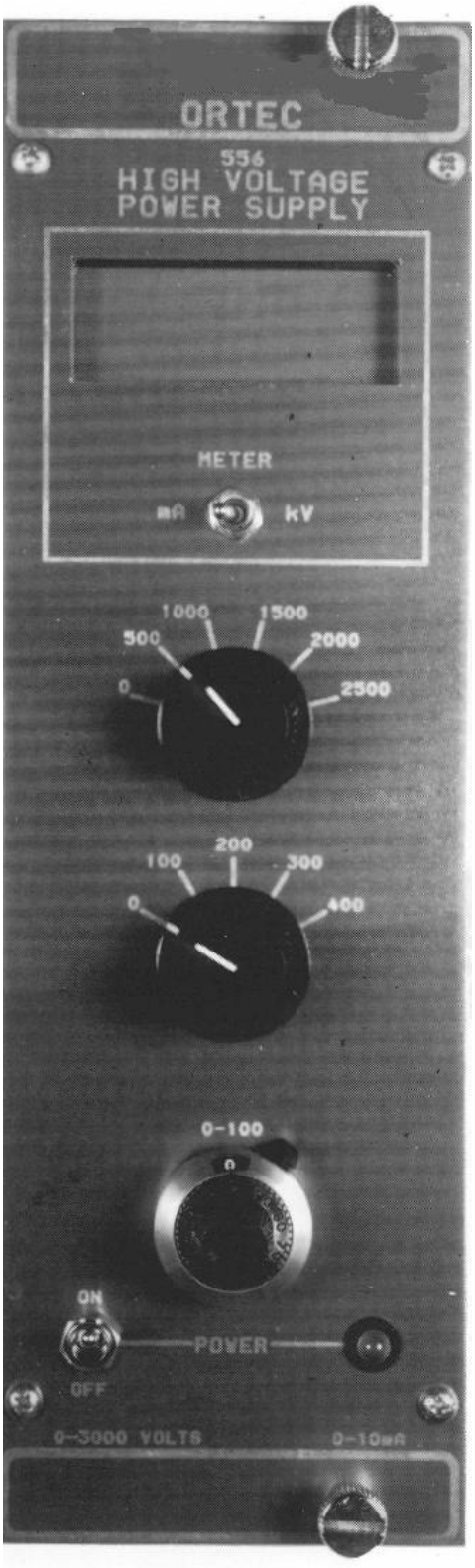
**Cleaning Instructions**

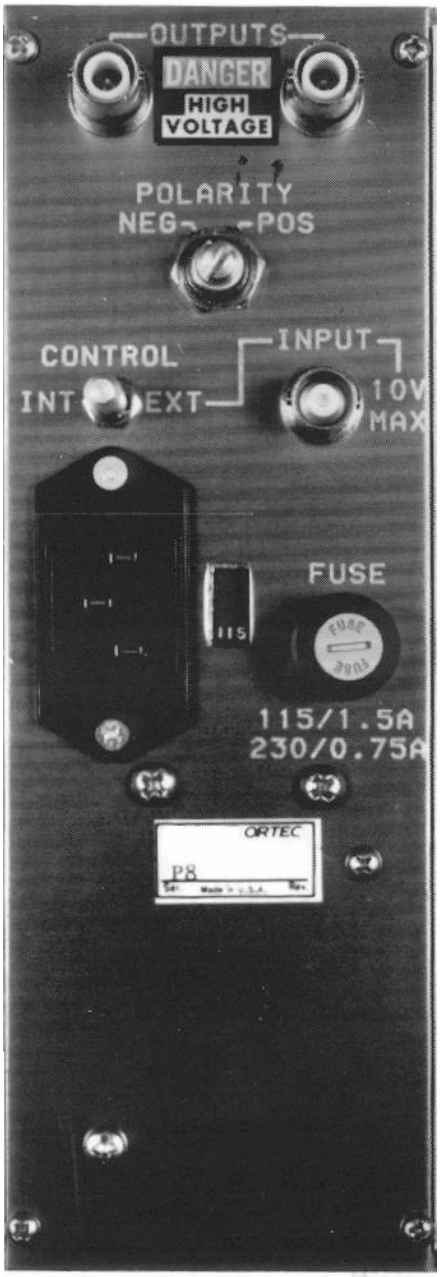
To clean the instrument exterior:

- Unplug the instrument from the ac power supply.
- Remove loose dust on the outside of the instrument with a lint-free cloth.
- Remove remaining dirt with a lint-free cloth dampened in a general-purpose detergent and water solution. Do not use abrasive cleaners.

| | |
|---|---|
| **CAUTION** | To prevent moisture inside of the instrument during external cleaning, use only enough liquid to dampen the cloth or applicator. |

- Allow the instrument to dry completely before reconnecting it to the power source.


ORTEC
556
HIGH VOLTAGE
POWER SUPPLY
METER
mA
kV
0
500
1000
1500
2000
2500
0
100
200
300
400
0-100
ON
OFF
POWER
0-3000 VOLTS
0-10mA


OUTPUTS
DANGER
HIGH
VOLTAGE
POLARITY
NEG
POS
CONTROL
INT
EXT
INPUT
10V
MAX
115
FUSE
115/1.5A
230/0.75A
ORTEC
P8

# ORTEC MODEL 556
# HIGH VOLTAGE POWER SUPPLY

## 1. DESCRIPTION

The ORTEC Model 556 High Voltage Power Supply is a standard double-width NIM module that provides either polarity of output voltage from 50 V to 3000 V, 0 to 10 mA. The adjusted output voltage of the selected polarity is available simultaneously through two SHV rear-panel connectors. A rear-panel slide switch permits operation on either 115 V or 230 V ac input power, furnished through a removable power line cord and connector.

The Model 556 features a front-panel LCD meter which can be programmed via a front-panel toggle switch to display either output voltage or load current. The output voltage can be programmed by an external control via a rear-panel BNC connector.

The Model 556 provides the extremely stable, low-noise, high voltage that is required for proper bias of photomultiplier tubes, ionization chambers, and semiconductor detectors.

# DANGER

**THIS INSTRUMENT PRODUCES EXTREMELY HAZARDOUS VOLTAGES AT A POTENTIALLY LETHAL CURRENT LEVEL. NEVER CONNECT OR DISCONNECT THE HIGH VOLTAGE OUTPUT CONNECTOR WITH THE POWER SWITCH ON. NEVER CHANGE THE OUTPUT POLARITY SWITCH WITH THE POWER SWITCH ON. ALWAYS SWITCH POWER OFF AND WAIT AT LEAST 30 SECONDS BEFORE CONNECTING OR DISCONNECTING CABLES AND BEFORE CHANGING THE OUTPUT POLARITY.**

## 2. SPECIFICATIONS

### 2.1. PERFORMANCE

**OUTPUT POLARITY** Positive or negative, selected by switch on rear panel.

**OUTPUT RANGE** 50 to 3000 V; minimum usable voltage 10 V.

**OUTPUT LOAD CAPACITY** 0 to 10 mA.

**REGULATION** $\leq$0.0025% variation in output voltage for combined line and load variations within operating range at constant ambient temperature.

**TEMPERATURE INSTABILITY** $\leq\pm$50 ppm/°C after 30 min warmup; operating range 0 to 50°C.

**LONG-TERM DRIFT** <0.01%/hour and <0.03% per 24 hr variation in output voltage at constant input line voltage, load, and ambient temperature after 30 min warmup.

**OUTPUT RIPPLE** 15 mV peak-to-peak, 20 Hz to 20 MHZ.

**OVERLOAD PROTECTION** Internal circuitry protects against overloads including short circuits.

**RESETTABILITY** Output voltage can be reset to within 0.1%.

### 2.2. CONTROLS

**POWER** Front-panel switch energizes unit when power cord is connected to appropriate source, and an adjacent red LED lamp indicates when power is

applied.

**OUTPUT LEVEL** One 6-position switch, one 5-position switch, and one 10-turn precision potentiometer; output level is the sum of the 3 settings.

**METER** Front-panel switch selects display of output voltage in kV or load current in mA.

**POLARITY** Rear-panel switch selects either positive or negative output polarity.

**CONTROL** Rear-panel locking switch selects the reference source for the output voltage.

- **Int** Selects the internal reference source; the front-panel controls select the output amplitude.

- **Ext** Selects the external reference source; output voltage is proportional to magnitude of reference input.

**AC VOLTAGE** Rear-panel slide switch selects either 115 V or 230 V ac input voltage.

## 2.3. INPUTS

**AC POWER** 103–129 V or 206–258 V, 47–63 Hz, 70 W nominal at full output power; supplied through international standard IEC power connector on rear panel. Fuse rating: 1.5 A (FAST) (250V) size 3AG for 115V or 0.75A(F) (250V) size 5×20 mm for 230V ac operation.

**EXTERNAL CONTROL** Full range of output voltage can be based on an external dc reference level furnished through a rear-panel BNC connector; control voltage range is 0 through ±6.9 V dc; control voltage polarity must be the same polarity as that selected by the rear-panel Polarity switch; this input protected against over-voltages >±7 V. Input impedance >45 kΩ.

## 2.4. OUTPUTS

**REGULATED DC OUTPUT** The adjusted and regulated voltage, with selected polarity, is furnished simultaneously to the two SHV connectors on the rear panel.

## 2.5. INDICATOR

**METER** Front-panel LCD display indicates output voltage in kV ±10 V or load current in mA ±10 µA. Load current is sum of external load current and internal load current. Internal load resistance is ~5 MΩ.

## 2.6. ELECTRICAL AND MECHANICAL

**POWER REQUIREMENTS** 115 or 230 V ac, 47–63 Hz, 70 W nominally.

**WEIGHT**

- **Net** 3.6 kg (8 lb)
- **Shipping** 4.5 kg (10 lb)

**DIMENSIONS** Standard double-width NIM module, per DOE/ER-0457T.

## 2.7. ACCESSORIES AVAILABLE

Two 3.66 m (12 ft) adapter cables are available from ORTEC for connecting to the Model 556 SHV output connectors:

1. ORTEC C-34-12 cable assembly: RG-59 A/U (75 Ω) cable with one C-37 SHV female plug and one C-26 MHV male plug.

2. ORTEC C-36-12 cable assembly: RG-59 A/U (75 Ω) cable with two C-37 SHV female plugs.

## 2.8. RELATED EQUIPMENT

Each of the two outputs of the Model 556 can be used as a power source for any application that is within the operating limits of the power supply. Both output levels are identical and of the same polarity. The load on the Model 556 output circuit is the sum of the individual loads connected to the output connectors, and the load current can be monitored by the front panel LCD meter.

This power supply is ideal for use with either one detector or a pair of detectors where the voltage level requirements are the same for both detectors. The appropriate types of detectors for which the Model 556 is designed include photomultiplier tubes, ionization chambers, and semiconductor detectors.

# 3. INSTALLATION

## 3.1. GENERAL

The Model 556 is normally used in conjunction with other modular electronics and may be installed in a standard NIM bin such as an ORTEC Model 4001A. Since the bin may be rack mounted, any high temperature equipment that may be installed in the same rack as the bin must be sufficiently cooled by circulating air to prevent exceeding the +50°C (120°F) maximum operating temperature of the 556. The ORTEC M127/N NIM Fan is available for forced-air cooling of a rack of equipment.

## 3.2. CONNECTION TO POWER

The Model 556 requires a grounded ac-power source of nominal 115 V ac or 230 V ac. A rear panel international-standard IEC connector allows the connection of many different types of line cords between the ac outlet and the 556. A rear-panel slide switch allows the choice of 115 V ac or 230 V ac input voltages. The 556 is shipped with a choice of two fuse holder caps to accommodate either 3AG or 5×20 mm size fuses. On 115 V ac operation a 1.5 A (FAST) (250V) size 3AG fuse should be used; on 230 V ac operation, a 0.75A(F) (250V) size 5×20 mm fuse should be used.

This power supply may be operated entirely removed from the 4001A bin if desired, since it is totally self-contained and requires no dc-operating power levels from the NIM bin. However, precautions should be taken to ensure that personnel is aware of the shock hazard at the rear connectors, and that air space should be provided at the top and bottom of the instrument.

## 3.3. CONNECTING INTO A SYSTEM

1. Check to see that the power switch is in the Off position.

2. Check rear panel 115/230 V ac switch and set to appropriate position.

3. Install a 1.5 A, 250 V fuse for 115 V ac setting or a 0.75 A, 250 V fuse for 230 V ac setting in the rear-panel-mounted fuse holder.

4. Check the polarity switch on the rear panel and set it for either positive or negative output polarity as required for the application.

5. Connect a high-voltage cable from either output connector on the 556 to the instrument to be powered. Use the other output connector if a second instrument is to be operated at the same output voltage.

6. Set the front-panel selector switches and potentiometer for the desired voltage level. This is normally specified for the instruments to which the voltage is to be applied. The adjusted output voltage will be the sum of the settings of all three controls.

7. Turn on the power with the switch on the front panel. The indicator lamp next to the switch will light to show that input power is being applied. The indicating meter at the top of the front panel will also indicate the polarity and amplitude of either the 556 output voltage or load current, depending on the setting of the meter switch.

## 3.4. CONNECTING AN EXTERNAL REFERENCE INPUT

The Model 556 output voltage level can be controlled by an external reference level that is furnished through the rear-panel BNC connector when the Control locking switch is set at Ext. The range of input voltage is 0 to 6.9 V to provide an output from 0 to 3000 V. The front- panel voltage level controls are ineffective for external reference operation.

For positive output the polarity selector switch on the rear panel is set at Pos, and the external reference should be positive. For negative output the polarity switch is set at Neg and the external reference should be negative. The external reference voltage should be stable and filtered since the output is linearly proportional to this reference. The external reference should be capable of driving the 45 kΩ input impedance.

# 4. CIRCUIT DESCRIPTION

Figure 2 is a simplified block diagram of the Model 556 circuits.

The 556 requires an ac power input, regardless of the use of an internal or external reference level. The selected reference level is applied to a precision regulator and controls the low voltage input level to an internal 24-kHz oscillator. The oscillator output voltage is stepped up for the high voltage output through a converter transformer, and this signal is rectified and filtered to produce the output to each output connector.

The front panel meter (M1) is connected to the output connectors through R65, R85, and R66 when monitoring output voltage. R66 is used to calibrate the front-panel display meter. In the load current display mode, the output ground return current is sensed by R69. The sensed voltage is inverted by S7 and fed to meter M1.

Two feedback loops, one for preregulation and one for output regulation, operate simultaneously. To maintain the output voltage at a constant voltage, U1 compares the sampled output voltage against the reference voltage appearing at its input terminals. The resulting error signal is amplified by U2, Q1, and Q5. The output (emitter) of Q5 feeds the input of the high frequency dc-to-dc converter. The converter is made up of a free-running oscillator (Q6-9) driving chopper MOSFETs Q10 and Q11, which alternately switch on to transfer energy through high-voltage transformer T2. The converter output consists of the rectified, filtered, and doubled high voltage at C17. R53 and C18 further filter the output voltage.

A preregulator circuit is necessary to limit the power dissipation by Q5. Therefore its collector and emitter voltages are compared at U3(5 and 6). The resulting output represents a request for more Q5 collector voltage.

U3(1) is synchronized with the power line frequency. This signal clocks JK flip-flop U4 and when U3(7) is high, SCR Q12 is fired in synchronization with the power line through Q2, Q3, and D8. When SCR Q12 fires, current flows through R3 and C1, boosting the collector voltage at Q5.

Current limiting transistor Q4 monitors the current through R4 and prevents damage during output overload by conducting current away from the base of Q5. Also, if a high voltage output should become shorted to ground, transistors Q14 and Q15 will conduct current away from the base of Q5. Current

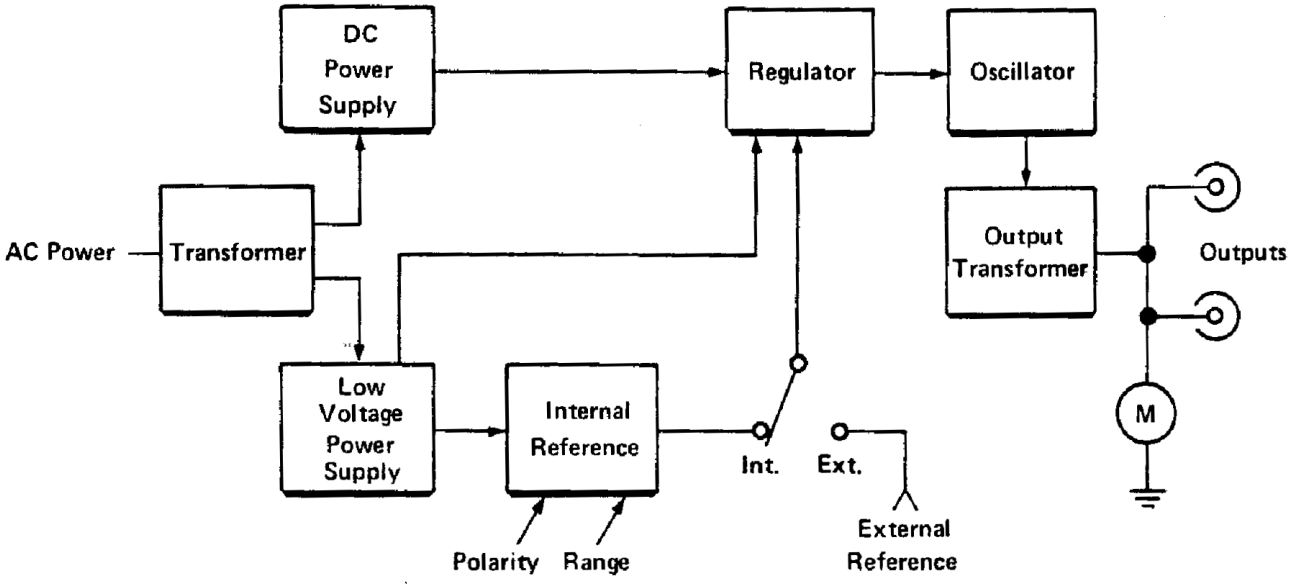



**Fig. 2. Model 556 Block Diagram.**

pulses in the ground return path during a short circuit condition produce voltage pulses across R69 which are of sufficient amplitude to turn either Q14 or Q15 On, depending upon the setting of the POLARITY switch (R.P.). Q15 will become active if the switch is set for POS and Q14 will be active if the switch is in the NEG position. Regulators U5 and U6 provide the necessary internal ±12 V power to operate the control circuitry, the reference circuit, and the oscillator.

# 5. MAINTENANCE AND TROUBLESHOOTING

## 5.1. GENERAL

The Model 556 should not require maintenance other than cleaning to prevent leakage paths from being created by dust collection. If an apparent malfunction is noted, it is important to determine if it is within the 556 power supply by disconnecting it from its load and performing routine diagnostic tests. The 556 is short-circuit protected, and with a short-circuit load the output voltage will drop to zero. If an external short circuit has been applied to the output, the short circuit must be removed before the 556 will again produce its adjusted voltage.

## 5.2. TROUBLESHOOTING SUGGESTIONS

Only service technicians trained and experienced in the service of high-voltage circuitry should attempt trouble-shooting this unit. **EXTREMELY DANGEROUS VOLTAGE LEVELS ARE PRESENT INSIDE THE 556 CHASSIS! OBSERVE GREAT CAUTION WHEN ANY PROTECTIVE COVERS ARE REMOVED WITH POWER APPLIED!**

To troubleshoot the 556, check the internal ±12 V supplies first, then check for symmetrical conduction times for oscillator output MOSFETs Q10 and Q11. With the 556 set for, positive polarity, the voltages at U1 (2 and 3) should be nearly identical and equal to the reference voltage setting. If this is not the case, check components through the two regulating feedback loops described in Section 4.

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