

**Model 428  
Detector Bias Supply  
Operating and Service Manual**

# **Advanced Measurement Technology, Inc.**

a/k/a/ ORTEC<sup>®</sup>, a subsidiary of AMETEK<sup>®</sup>, 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.

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## 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.

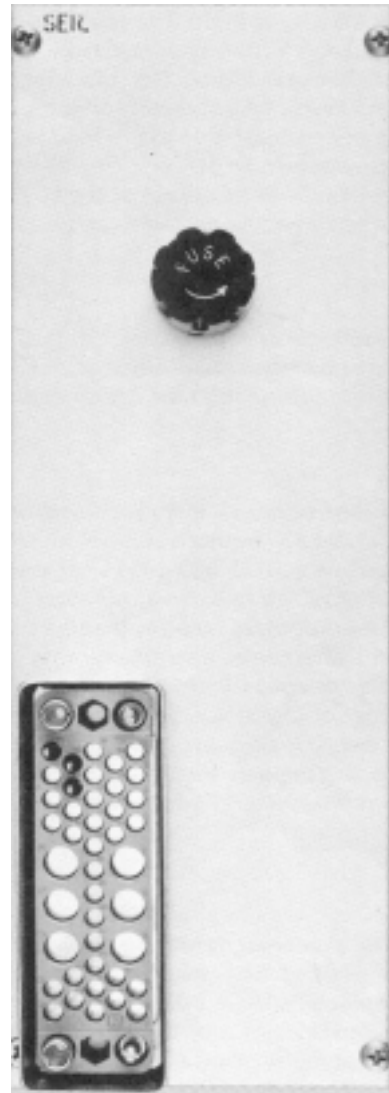
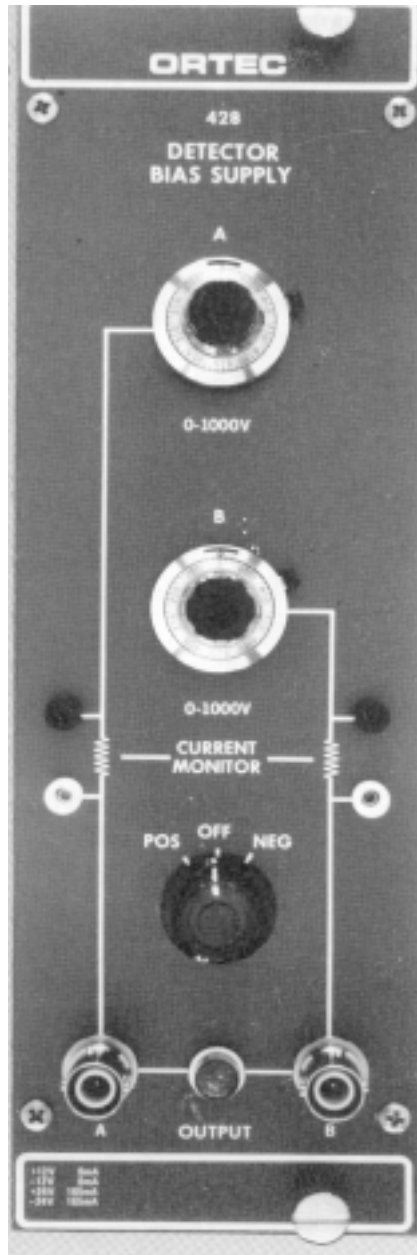
### Cleaning Instructions

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 MODEL 428 DETECTOR BIAS SUPPLY

## 1. DESCRIPTION

The ORTEC 428 Detector Bias Supply provides bias voltage of either polarity for two semiconductor detectors. The voltages are selected independently by 10-turn, direct-reading potentiometers. The polarity is controlled by a front panel switch. Jacks are provided on the front panel for external monitoring of the current in each detector. The output of the 428 is short-circuit proof and has an impedance of approximately 1.3 M $\Omega$ . The 428 is a double-width module designed to meet the recommended standards outlined in DOE Report TID-20893 (Rev.). It receives the necessary operating power from the ORTEC 4001/4002 Bin and Power Supply through the rear module connector.

## WARNING

*This instrument produces voltages that can be hazardous. Always have power switched off before connecting or removing cables to or from the 428 and the units to which its high voltage outputs are applied. Observe the same precautions when using the test points for any purpose.*

## 2. SPECIFICATIONS

### PERFORMANCE

**NOISE AND RIPPLE** <0.0002%

**TEMPERATURE STABILITY** 0.03%/°C, 0 to 50°C.

**LINE STABILITY** Directly proportional to dc power supply stability (<0.02% for 105 to 125 V ac when using ORTEC 4002A).

### CONTROLS

**BIAS CONTROLS (A and B)** 10-turn direct-reading potentiometers.

**POS/OFF/NEG** Front panel switch to control bias polarity. Off position provides standby condition for the power supply.

### OUTPUTS

**OUTPUTS A AND B** Two independent circuits, short-circuit proof, with front panel SHV connector; range 0 to 1000V; polarity positive or negative (both outputs same polarity), selectable by front panel Pos/Off/Neg switch. Output impedance ~1.3 M $\Omega$ .

**CURRENT MONITOR** Front panel jacks for external monitoring of the current in each detector.

### ELECTRICAL AND MECHANICAL

**POWER REQUIREMENTS** +24 V, 165 mA; -24 V, 165 mA.

**WEIGHT (Shipping)** 7 lb, 4 oz (3.3 kg).

**WEIGHT (Net)** 4 lb (1.82 kg).

**DIMENSIONS** NIM-standard double-width module (2.70 by 8.714 in.) Per TID-20893 (Rev.)

### RELATED EQUIPMENT

The 428 is compatible with ORTEC detectors and ORTEC preamplifiers that have provisions for an external detector bias voltage.

### 3. INSTALLATION

#### 3.1. GENERAL

The 428 contains an internal power supply that must be used in conjunction with a Nuclear-Standard Bin and Power Supply such as the ORTEC 4001/4002. The 428 is intended for rack mounting; therefore if vacuum tube equipment is operated in the same rack, there must be sufficient cooling air circulating to prevent any localized heating of the all-transistor circuitry used throughout the module. The temperature of equipment mounted in racks can easily exceed the recommended maximum unless this precaution is taken. The 428 should not be subjected to temperatures in excess of 120°F (50°C).

#### 3.2. CONNECTION TO POWER

Turn off power when inserting or removing modules. The ORTEC 4000 Series is designed so that it is not possible to overload the Bin Power Supply with a full complement of modules in the Bin; since, however, this may not be true when the Bin contains modules other than those of ORTEC design, the Power Supply voltages should be checked after the modules are inserted. The ORTEC 4001/4002 has test points on the Power Supply control panel to monitor the dc voltages.

#### 3.3. CONNECTIONS TO THE 428

The ORTEC 428 is compatible with ORTEC detectors and with preamplifiers that have provisions to accept bias voltage for the detector. All operating controls and bias voltage output connectors are located on the front panel. The output connectors are the type SHV and are not compatible with ordinary BNC connectors. A perforated shield encloses the unit so that high voltages are not exposed.

#### WARNING

***Do not operate this unit without the protective covers, since lethal voltages are exposed inside the instrument.***

Tip jacks are provided for monitoring the current in each detector. See Section 4.5 for information on appropriate dc meters. Always have power for the 428 turned off before connecting or removing meter leads. Any meter used as a current monitor is connected in shunt with 1 M $\Omega$  on the output circuit, and reduces the output impedance.

### 4. OPERATING INSTRUCTIONS

#### 4.1. INITIAL TESTING

Refer to Section 5.1 of this manual for information concerning testing performance.

#### 4.2. POLARITY SELECTION

The Polarity Switch is located on the front panel and also serves as an On-Off switch for power to the 428. When changing the polarity of the output bias voltage, stop the switch in the Off position for a few seconds before switching to the other polarity. This pause in the Off position is necessary to allow the ac starting circuit for the dc to dc converter to recharge.

#### 4.3. BIAS VOLTAGE INDICATOR LIGHT

The Bias Voltage indicator light is a neon light located between the two front panel SHV output connectors and indicates that the power is turned on. If the 428 is turned on and the Bias Voltage indicator light does not illuminate, turn the Polarity Selection switch to the Off position for approximately 2 sec and then return it to the desired polarity. This pause in the Off position is necessary to allow the ac starting circuit for the dc to dc converter to recharge.



#### 4.4. BIAS VOLTAGE SELECTORS

The desired bias voltage for each output is selected by its associated 10-turn potentiometer. The voltage at each output is read directly from its corresponding dial. The 10-turn potentiometers have a linearity of  $\pm 0.25\%$ . The output impedance is approximately  $1.3 \text{ M}\Omega$ , which will normally be negligible compared to the detector load resistor in the preamplifier. This resistor typically ranges from 22 to  $2000 \text{ M}\Omega$ . The voltage at the output connector of the 428 can be calculated by the formula

$$V_o = V_{\text{dial}} - I_D (1.3 \times 10^6),$$

where  $V_o$  = output voltage,  $V_{\text{dial}}$  = voltage indicated by 10-turn dial, and  $I_D$  = detector current.

The output impedance of this unit can be decreased by methods given in Section 6.2.

#### 4.5. CURRENT MONITOR JACKS

Tip jacks are provided on the front panel as a convenience for monitoring each detector current. Typical leakage currents for ordinary room-temperature surface-barrier detectors range from 0.1 to  $1 \mu\text{A}$ . Semiconductor detectors cooled to liquid nitrogen temperature have leakage currents ranging from 0.1 to  $10 \text{ nA}$ . This current is measured by connecting a floating ammeter or voltmeter to the Current Monitoring jacks as shown in Fig. 4.1.

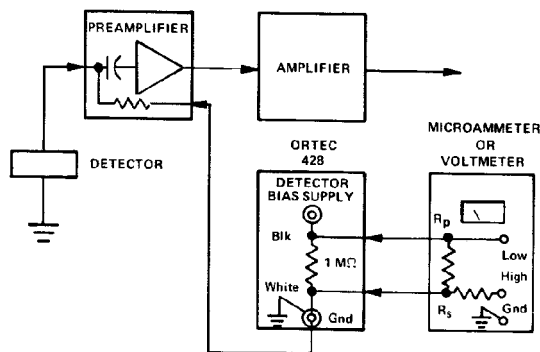


Fig. 4.1. Semiconductor Detector Bias and Current Measuring Circuit Using a Floating Meter.

If an electronic type of meter operated from the power line is used, the input circuit must be capable of floating above earth and power line ground so that the leakage to ground does not load the bias supply. The low impedance side of the meter must be connected to the black tip jack rather than to the white jack; otherwise, the leakage current of the instrument from the low terminal to power line ground will be indicated incorrectly as detector current. If the detector current is measured with an ammeter,

$$I_D = \frac{I_M (R_S + 1 \times 10^6)}{1 \times 10^6}$$

where  $I_D$  = detector current,  $I_M$  = ammeter current, and  $R_S$  = input resistance of ammeter.

If  $R_S$  is very much less than  $1 \text{ M}\Omega$ , the meter current can be interpreted as detector current. Since the smaller  $R_S$  is connected directly in parallel with  $1 \text{ M}\Omega$  of the output circuit,  $Z_o$  is reduced.

When a voltmeter is used to measure the detector current,

$$I_D = \frac{V_M (R_p + 1 \times 10^6)}{R_p (1 \times 10^6)},$$

where  $I_D$  = detector current,  $V_M$  = measured voltage, and  $R_p$  = input resistance of voltmeter.

If  $R_p$  is much greater than  $1 \text{ M}\Omega$ , then

$$I_D = V_M \times 10^6 \text{ ampere.}$$

If a meter that will not float above powerline and chassis ground is used to measure the detector current, it should be a microammeter connected as shown in Fig. 4.2. Do not use the current monitor jacks unless the meter can be isolated from ground.

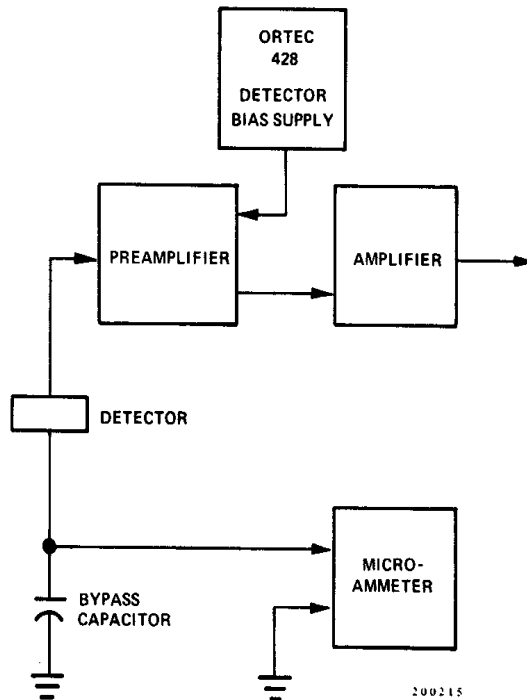


Fig. 4.2. Semiconductor Detector Bias and Current Measuring Circuit Using a Nonfloating Meter.

#### 4.6. UNDESIRABLE LEAKAGE CURRENTS

Teflon-insulated current monitoring jacks and SHV connectors are used in an effort to reduce leakage currents to a minimum in the 428. Insulation resistance of  $1 \times 10^{13} \Omega$  or greater is desirable to measure a detector leakage current of 1 nA at 1000 V. In order to maintain insulation resistances of this magnitude, the insulators will have to be cleaned frequently. Either Freon or methyl alcohol is a good cleaning agent.

It may not be practical to reduce the leakage in external cables and connections to a negligible magnitude. In such cases it may suffice to note the residual leakage current with all wiring in place except the detector itself, and then subtract this residual current from the indicated current to obtain the actual detector current. If the leakage phenomenon is essentially a resistance, then its value may be computed from Ohm's law for use in determining the residual current at various voltages, without the necessity of actual measurements.

#### 4.7. DETERMINATION OF ACTUAL DETECTOR BIAS

In addition to its use as an indicator of physical condition of the detector, the detector current allows accurate determination of the actual bias voltage across the detector. This actual voltage differs from that indicated by the bias selector dials by the amount of drop in voltage across the detector load and filter resistors due to the detector current. Accurate determination of actual detector voltage is important, since it is an important parameter in both the depleted (sensitive) depth of the detector and the collecting field strength.

To obtain the actual detector voltage, one must know the sum of all series resistances in the circuit between voltage source and detector. The resistance of the internal circuit of the 428 may be approximated by  $1.3 \text{ M}\Omega$ , unless this has been reduced by a current monitor (Section 4.5). Detector load resistors may vary from  $10 \text{ M}\Omega$  to  $200 \text{ M}\Omega$  in ordinary applications, and may be several thousand megohms in special applications involving cooled detectors. In addition, there is usually a filter resistor of  $1 \text{ M}\Omega$  or more near and in series with the load resistor. The values of these resistors can usually be ascertained from the schematic diagram of the preamplifier used. Once having determined the total series resistance, the loss of bias in that resistance can be calculated by Ohm's law.

#### 4.8. GUARD-RING VOLTAGE SUPPLY

When detectors that require a separate bias connection to a guard ring are used, the 428 will prove convenient in that the signal electrode bias can be taken from one bias output connector and the guard-ring potential taken from the other. In this way the two potentials can be varied independently of each other to determine the optimum biasing condition. The usual optimum is obtained when both are nearly the same, but a small difference is sometimes beneficial. In general, that setting which minimizes the signal electrode current will be near optimum.

#### 4.9. DETECTOR CONSIDERATIONS AT HIGH BIAS VOLTAGES

Semiconductor radiation detectors that utilize more than a few hundred volts bias generally require some care in the application of that bias to reduce the risk of damaging the detector. It is helpful to observe the noise output of the main amplifier with

an oscilloscope while the bias voltage is advanced. Small breakdown phenomena which die out in less than a minute can be observed after a bias increase. For greatest safety, it is advisable to approach the final operating bias in small increments, with brief aging periods between increments.

### 5. MAINTENANCE

#### 5.1. TESTING PERFORMANCE OF BIAS SUPPLY

The following paragraphs are intended as aids in the installation and checkout of the 428. These instructions include information on the front panel controls, output voltages, and internal adjustments.

The following or equivalent test equipment is needed:

Nuclear-Standard Bin and Power Supply, such as the ORTEC 4001/4002.

Oscilloscope with an input coupling capacitor rated at more than 500 V.

Voltmeter with input impedance of 100 M $\Omega$  or greater on the 1000-V scale.

Before making the performance tests, take the following preliminary steps:

1. Visually check the module for possible damage due to shipment.
2. Connect ac power to Nuclear Standard Bin, ORTEC 4001/4002.
3. Plug module into Bin and check for proper mechanical alignment.
4. Ensure that the Polarity Selection switch on the ORTEC 428 is in the Off position.
5. Switch on the ac power and check the dc Power Supply. voltages at the test points on the 401 Power Supply control panel.

To check the performance of the 428, make the following tests:

1. Set the bias selector potentiometers to zero.
2. Set the voltmeter to the 1000-V scale and connect it to output A.
3. Rotate the Polarity Selection switch to Pos.
4. Increase the potentiometer associated with output A to 1000 and check the output voltage for approximately 1000 V. The loading effect of the voltmeter on the circuit should be considered. For example, a voltmeter with an input impedance of 100 M $\Omega$  will produce a 10- $\mu$ A current drain on the output. This output current will produce an 11-V drop across the series. 1.1-M $\Omega$  output resistance (R15 and R18); therefore the voltmeter should read 989 V. If the output voltage is not in agreement with the dial reading, see Section 6.2 for calibration procedure.
5. Reduce the potentiometer back to zero and check the potentiometer linearity by comparing the output voltage versus the potentiometer dial reading.
6. Connect the voltmeter to output 8 and repeat steps 4 and 5.
7. Turn the Polarity-Selection switch to Off for about 2 sec and then to Neg and repeat steps 4, 5, and 6.
8. Set the output voltage to zero and connect output A to the ac-coupled input of an oscilloscope with a coaxial cable. Increase the output voltage to 500 V and check the ripple. It should be less than 1 mV peak to peak.

## 5.2. ADJUSTMENTS

If the output voltage does not agree with the dial reading, it should be recalibrated using the following procedure:

1. Ensure that the 428 Polarity Selection switch is in the Off position.
2. Apply power to the 428 through a 401 C-3 or equivalent extender cable. (The module must be out of the Bin when this adjustment is made.)
3. Switch on the ac power and check the dc Power Supply voltages at the test points on the 4002 Power Supply control panel.
4. Select the 1000-V scale on a voltmeter and connect it to output A. The input impedance of the voltmeter should be 100 M $\Omega$  or greater on this scale.
5. Rotate the Polarity Selection switch to Pos.
6. Increase the potentiometer associated with output A to 1000 and check the output voltage for approximately 1000 V. The loading effect of the voltmeter on the circuit should be considered before the voltage is adjusted. For example, a voltmeter with an input impedance of 100 M $\Omega$  will produce a 10- $\mu$ A current drain on the output. This output current will produce an 11-V drop across the series 1.1-M $\Omega$  output resistance (R15 and R18); therefore the voltmeter should read 989 V.
7. If the voltmeter does not read 989 V, calibrate the output voltage by adjusting resistor R12. Access to R12 is available through a hole in the top cover of the module. CAUTION: Use only an insulated screwdriver to make this adjustment, as lethal voltages exist inside. This adjustment will calibrate the unit for both positive and negative polarity.

8. Reduce the potentiometer to zero and check the output voltage versus the potentiometer dial reading at several points. Resistors R15 and R 17 provide a method of measuring the detector current with a voltmeter. (See Section 4.5 for details.) If these resistors are shorted the output impedance will be reduced by 1 M $\Omega$ . Resistors R 18 and R 19 limit the current at the current monitoring jacks and prevent these voltages from being lethal. The output impedance will be reduced to 110 K, but the voltages at the current monitoring jacks will be, lethal because they are not protected by current limiters.

## 5.3. TROUBLESHOOTING SUGGESTIONS

1. Ensure that the proper dc voltage is supplied to the module.
2. Turn the Polarity Selection switch to the Off position for approximately 2 sec and ensure that the output is not shorted.
3. Return the Polarity Selection switch to the desired polarity.
4. Transistors Q1 and Q2 have been selected for a  $V_{cbo}$  greater than 140 V. Replacement transistors should be selected for the same high  $V_{cbo}$ .

## 5.4. REPAIRS

This instrument can be returned to the ORTEC factory for service and repair at a nominal cost. Our standard procedure for repair ensures the same quality control and checkout that are used for a new instrument. Always contact Customer Services at ORTEC, (865) 482-4411, before sending in an instrument for repair to obtain shipping instructions and so that the required Return Authorization Number can be assigned to the unit. Write this number on the address label and on the package to ensure prompt attention when it reaches the ORTEC factory.

**Bin/Module Connector Pin Assignments For  
Standard Nuclear Instrument Modules per  
DOE/ER-0457T.**

<b>Pin</b>	<b>Function</b>	<b>Pin</b>	<b>Function</b>
1	+3 V	23	Reserved
2	- 3 V	24	Reserved
3	Spare bus	25	Reserved
4	Reserved bus	26	Spare
5	Coaxial	27	Spare
6	Coaxial	*28	+24 V
7	Coaxial	*29	- 24 V
8	200 V dc	30	Spare bus
9	Spare	31	Spare
*10	+6 V	32	Spare
*11	- 6 V	*33	117 V ac (hot)
12	Reserved bus	*34	Power return ground
13	Spare	35	Reset (Scaler)
14	Spare	36	Gate
15	Reserved	37	Reset (Auxiliary)
*16	+12 V	38	Coaxial
*17	- 12 V	39	Coaxial
18	Spare bus	40	Coaxial
19	Reserved bus	*41	117 V ac (neutral)
20	Spare	*42	High-quality ground
21	Spare	G	Ground guide pin
22	Reserved		

Pins marked (\*) are installed and wired in ORTEC's 4001A and 4001C Modular System Bins.