



**Model 659  
5-kV Detector Bias Supply  
Operating and Service Manual**

# **Model 659 5-kV Detector Bias 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.

# Standard Warranty

for  
EG&G ORTEC Instruments

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

EG&G ORTEC's exclusive liability is limited to repairing or replacing at EG&G ORTEC's option, items found by EG&G ORTEC to be defective in workmanship or materials within **one year** from the date of delivery. EG&G 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 EG&G ORTEC fails to manufacture or deliver items called for in this agreement or purchase order, EG&G 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 EG&G ORTEC be liable for special or consequential damages.

## Quality Control

Before being approved for shipment, each EG&G 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, EG&G ORTEC must be informed, either in writing, by telephone [(423) 482-4411], or by facsimile transmission [(423) 483-0396], 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 EG&G 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 nearest EG&G 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 will be repaired at the standard charge unless they have been grossly misused or mishandled, in which case the user will be notified prior to the repair being done. A quotation will be sent with the notification.

## Damage in Transit

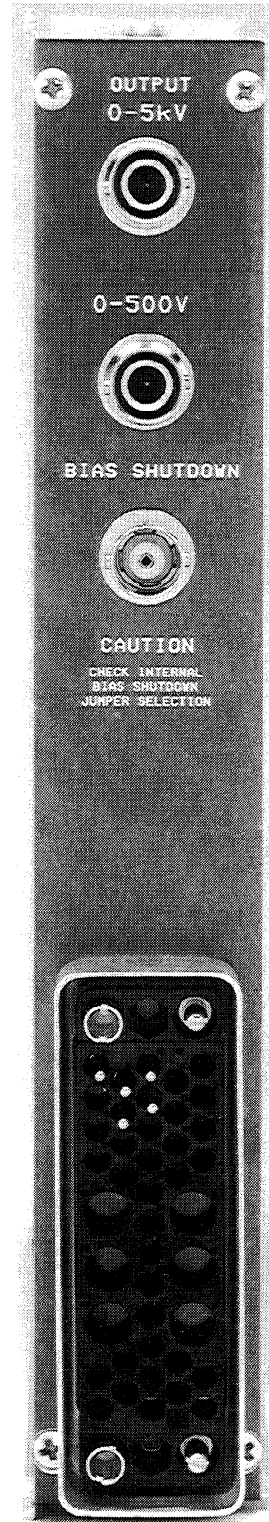
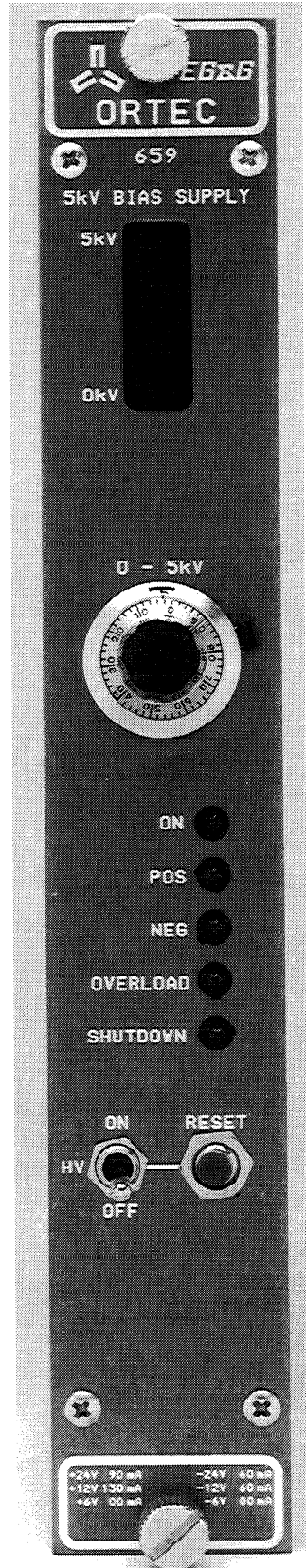
Shipments should be examined immediately upon receipt for evidence of external or concealed damage. The carrier making delivery should be notified immediately of any such damage, since the carrier is normally liable for damage in shipment. Packing materials, waybills, and other such documentation should be preserved in order to establish claims. After such notification to the carrier, please notify EG&G 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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## EG&G ORTEC MODEL 659 5-kV DETECTOR BIAS SUPPLY

### 1. DESCRIPTION

The EG&G ORTEC Model 659 5-kV Detector Bias Supply furnishes bias voltage for germanium detectors, silicon detectors, or ionization chambers. It can be used with any detector that draws less than 100  $\mu\text{A}$  of current, and whose gain is insensitive to the applied voltage. The output voltage is continuously adjustable from zero to full scale with a calibrated and locking 5-turn dial. Separate outputs are provided for the 0–5 kV and the 0–500 V ranges. A 10-segment bar-graph indicator verifies that the selected voltage is being supplied at the output.

Security against accidentally changing the output polarity to the wrong state is ensured by two features. The selected output polarity is indicated by front-panel LEDs whenever the NIM bin power is turned on. Thus, the correct polarity can be verified before the HV ON/OFF switch is used to turn on the bias voltage to the detector. In addition, the side panel must be removed in order to alter the output polarity. This discourages unintentional changes.

The Model 659 includes a remote shutdown feature to protect the preamplifier FET against damage when a cooled germanium or Si(Li) detector warms up. A BIAS SHUTDOWN input that is compatible with the standard warmup sensor output on EG&G ORTEC preamplifiers is provided. When the preamplifier signals a warmup

condition, the Model 659 shuts off the bias voltage and turns on a SHUTDOWN indicator light. The bias voltage remains off, independent of the signal from the preamplifier warmup sensor, until the shutdown mode is manually cancelled by pressing the RESET push-button. This protects the preamplifier FET if the detector is cooling down with the HV ON/OFF switch accidentally left on. For further protection against operator error in the ORTEC shutdown mode, the bias shutdown input interprets a disconnected cable or a shorted cable as a warm detector, and responds by turning off the bias voltage. Some detector manufacturers provide a TTL logic level output from their detector warmup sensor. A board-mounted jumper in the Model 659 can be moved to the TTL position to make the bias shutdown input compatible with detectors supplying a TTL output. It is also possible to disable the bias shutdown feature by moving the board jumper to the BYPASS position. The Model 659 is shipped from the factory in the ORTEC mode.

Both high voltage outputs are protected against overload. When the bias supply senses an excessive output current demand, it turns on the overload light and reduces the output voltage until the output current is within tolerable limits. Recovery from overload is automatic when the excessive current demand is eliminated.

### 2. SPECIFICATIONS\*

#### 2.1. PERFORMANCE

**BIAS VOLTAGE RANGES** 0–5 kV, or 0–500 V, on separate outputs, with each output controlled by a common, 5-turn, direct-reading, precision potentiometer located on the front panel.

**BIAS VOLTAGE POLARITY** Positive or negative. Internally selectable. Polarity indicated by front-panel LEDs whenever bin power is on.

**RATED OUTPUT CURRENT** 0–100  $\mu\text{A}$ .

**OUTPUT LINEARITY** Within  $\pm 3\%$  of dial setting from 10% to full range.

**TEMPERATURE SENSITIVITY OF OUTPUT VOLTAGE**  $\leq \pm 0.08\%/^{\circ}\text{C}$  through 10° to 50°C operating range.

**VOLTAGE STABILITY**  $\leq \pm 0.1\%/h$  variation in output voltage with constant temperature, constant load, and constant input voltages from the bin supply.

**NOISE AND RIPPLE**  $< 10$  mV peak-to-peak from 2 Hz to 50 MHz.

**OUTPUT VOLTAGE RISE TIME** Nominally 500 ms.

#### 2.2. INDICATORS

**0 kV – 5 kV** Front-panel, 10-segment, bar-graph display indicates actual output voltage at the 0–5 kV output. Each segment corresponds to a 0.5-kV increment in output voltage, starting with 0.5 kV to turn

\*Subject to change without notice.

on the first segment, and ending with 5 kV to turn on the tenth segment.

**POS** Front-panel LED is lit when the bin power is on, if the positive output polarity has been selected.

**NEG** Front-panel LED is lit when the bin power is on, if the negative output polarity has been selected.

**ON** Front-panel LED indicates when the output bias voltage is turned on. This LED turns off when the HV ON/OFF switch is turned off, the bin power is off, or the shutdown mode has been activated.

**OVERLOAD** Front-panel LED turns on when the bias supply senses an excessive output current demanded by the external load. Under overload, the output voltage is reduced automatically until the output current is within tolerable limit. Recovery from overload is automatic when the overload is eliminated.

**SHUTDOWN** Front-panel mounted LED turns on when the shutdown mode has been activated to turn off the output voltage. The shutdown mode is activated by the appropriate signal level on the rear-panel, BIAS SHUTDOWN input, or whenever the bin power is turned off and on.

### 2.3. CONTROLS

**0-5 kV** Front-panel, 5-turn, direct-reading, locking potentiometer with 500 dial divisions adjusts the output voltages simultaneously for the 0-500 V and the 0-5 kV outputs.

**HV ON/OFF** Front-panel toggle switch turns the 0-500 V and the 0-5 kV outputs on or off. For added safety, the RESET push-button must be pressed after turning the HV ON/OFF switch to the ON position, in order to turn on the output voltage. The output voltage will not turn on if a shutdown condition is present at the BIAS SHUTDOWN input.

**RESET** Pressing this front-panel push-button switch enables the high voltage to turn on after the bin power has been turned on, the HV ON/OFF switch has been turned on, or the supply has been disabled by the BIAS SHUTDOWN input. If a shutdown condition is still present at the BIAS SHUTDOWN input, the RESET button will be ineffective.

**ORTEC/TTL/BYPASS** Internal printed wiring board jumper selects the operating mode of the BIAS SHUTDOWN input for compatibility with the warmup sensor in the associated Ge detector. The ORTEC position is used for ORTEC detectors. The TTL position is for detectors employing TTL levels. The BYPASS position disables the BIAS SHUTDOWN input, but does not alter the function of the RESET button. The Model 659 is shipped with this jumper in the ORTEC mode.

**OUTPUT VOLTAGE POLARITY** The output polarity is changed between positive and negative by changing the position of a daughter board in the module.

### 2.4. INPUTS

**BIAS SHUTDOWN INPUT** Rear-panel BNC connector accepts signals from warmup sensors in cooled germanium detectors. When a warmup is signalled, this input turns off the detector bias voltage in order to protect the preamplifier FET input. The ORTEC/TTL/BYPASS jumper selects the operating mode of the BIAS SHUTDOWN input for compatibility with the warmup sensor in the associated Ge detector.

**ORTEC Mode** The input is compatible with the warmup sensor output on ORTEC germanium detectors. For added safety, an open or shorted coaxial cable on the BIAS SHUTDOWN input will also cause the supply to shut down.

**TTL Mode** A source supplying  $>+2$  V or an open circuit will allow the Model 659 to produce the full output voltage. A source supplying  $<+0.8$  V and capable of sinking 700  $\mu$ A will shut down the high voltage output.

**BYPASS Mode** The BIAS SHUTDOWN input is rendered inactive, and cannot trigger a bias shutdown.

### 2.5. OUTPUTS

**0-5 kV** Rear-panel SHV connector furnishes the adjusted output voltage in the 0 to 5 kV range through an output impedance of approximately 2 M $\Omega$ . A voltage foldback circuit protects the output against demands for excessive output current. Recovery from overload is automatic when the overload is eliminated.

**0-500 V** Rear-panel SHV connector furnishes the adjusted output voltage in the 0 to 500 V range through an output impedance of approximately 700 k $\Omega$ . A voltage foldback circuit protects the output against demands for excessive output current. Recovery from overload is automatic when the overload is eliminated.

### 2.6. ELECTRICAL AND MECHANICAL

**POWER REQUIREMENTS** The Model 659 derives its power from a NIM bin/power supply. Required dc voltages and currents are: +24 V at 80 mA, +12 V at 80 mA, -12 V at 65 mA, -24 V at 35 mA.

#### WEIGHT

Net 0.68 kg ( 1.5 lb).

Shipping 1.1 kg ( 2.5 lb).

**DIMENSIONS** NIM-standard single-width module 3.43  $\times$  22.13 cm (1.35  $\times$  8.714 in.) front panel per DOE/ER-0457T.

### 3. INSTALLATION

#### 3.1. GENERAL

The Detector Bias Supply is normally used in conjunction with other modular electronics and is installed in a Model 4001A/4002A NIM Bin/Power Supply. The NIM Bin/Power Supply is intended for rack mounting. Therefore, any other equipment that may be installed in the same rack must be sufficiently cooled by circulating air to prevent any localized heating of the circuits in the Model 659. The temperature of equipment operating in racks can easily exceed the recommended maximum of 50°C (120°F) unless these precautions are taken.

#### 3.2. CAUTION

Removal of the module side panel exposes components that operate at voltages up to 5 kV. Always turn power Off before removing the side panel, and connect a grounded wire to each output.

#### 3.3. SELECTION OF OUTPUT POLARITY

The polarity of the output voltage of the Model 659 is determined by the location of a printed wiring board that plugs onto the main printed wiring board. Access to the board is obtained by removing the right side panel of the module (viewed from the front). When the polarity PWB is moved to the forward position, positive polarity is selected. When the polarity PWB is moved to the rear position, negative polarity is selected (Fig. 1). The selected output is indicated by two front-panel-mounted LEDs. POS indicates positive high voltage and NEG indicates negative high voltage. The capacitors on this board can retain substantial voltages even after power is turned off. Observe the precautions in Section 3.2 to avoid injury.

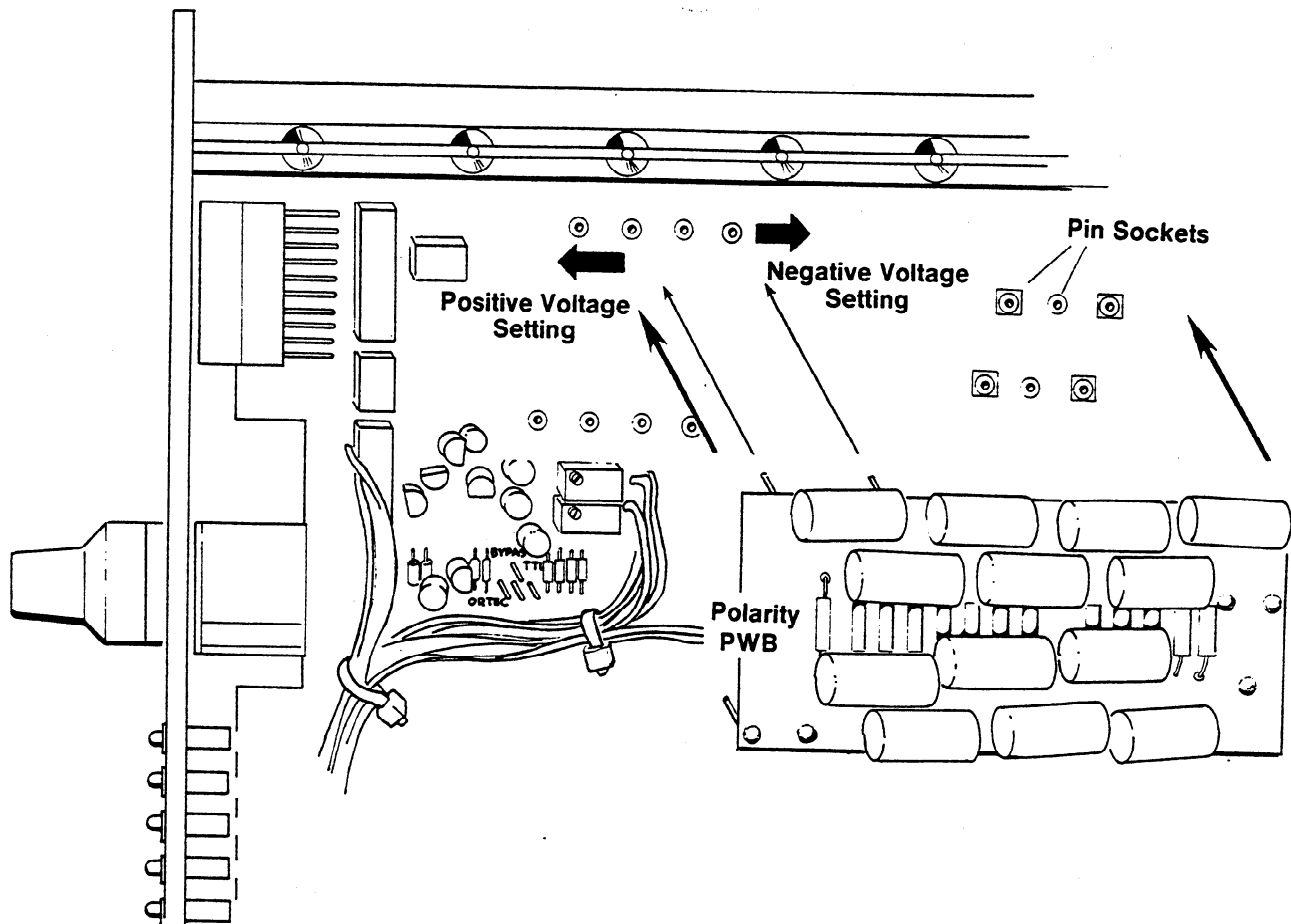


Fig. 1. Changing the High Voltage Output Polarity: (A) For Positive HV, plug the Printed Wiring Board (PWB) into the leftmost (toward the front of the module) set of pin sockets; (B) For Negative HV, plug the PWB into the rightmost (toward the rear of the module) set of pin sockets.



### 3.4. SELECTION OF BIAS SHUTDOWN MODE

The selection of the Bias Shutdown mode is accomplished via a printed wiring board (PWB) jumper located on the main PWB (Fig. 2). Access to the jumper is obtained by removing the right side panel (viewed from the front). Its three alternate locations ORTEC, TTL, and BYPASS are marked on the PWB. Follow the precautions prescribed in Section 3.2.

The ORTEC mode provides compatibility with all EG&G ORTEC detectors having a Bias Shutdown output. In this mode, the high voltage output is reduced to zero volts, and a front-panel SHUTDOWN LED indicates a shutdown condition exists if the coaxial cable connecting the ORTEC detector to the Bias Shutdown input becomes open or shorted, or the detector shutdown circuitry indicates a warm detector. The Model 659 is shipped from the factory in the ORTEC mode.

The TTL mode is provided to interface with Bias Shutdown circuits compatible with TTL logic levels. In this mode, the high voltage output is reduced to zero volts, and a front-panel SHUTDOWN LED indicates a shutdown condition exists if a logic "0" is applied to the center pin of the Bias Shutdown input. A logic "1" (or open collector) applied to the center pin allows normal operation of the high voltage.

The BYPASS mode allows normal operation of the high voltage output without Bias Shutdown protection.

### 3.5. CONNECTION TO POWER

This instrument obtains its dc operating power from the standard Bin and Power Supply in which it is installed. Always turn bin power Off and the Model 659 HV ON/OFF switch OFF before inserting or removing the module. After insertion, turn on the bin power, but leave the Model 659 HV ON/OFF switch in the OFF position. This ensures that the polarity selection of the Model 659 will be indicated by an LED on the front panel before high voltage is actually furnished to its output connectors. The adjusted high voltage is available through the output connectors as soon as the Model 659 HV ON/OFF switch is turned ON and the RESET push button is pressed.

### 3.6. OUTPUT CONNECTION

The Model 659 5-kV Bias Supply is compatible with all ORTEC preamplifiers that include provision to accept the high voltage for the detector. The output controls are located on the front panel, and the output connectors are located on the rear panel. The output cables require a type SHV connector at the power supply end, which is the type furnished with each ORTEC preamplifier for that purpose.

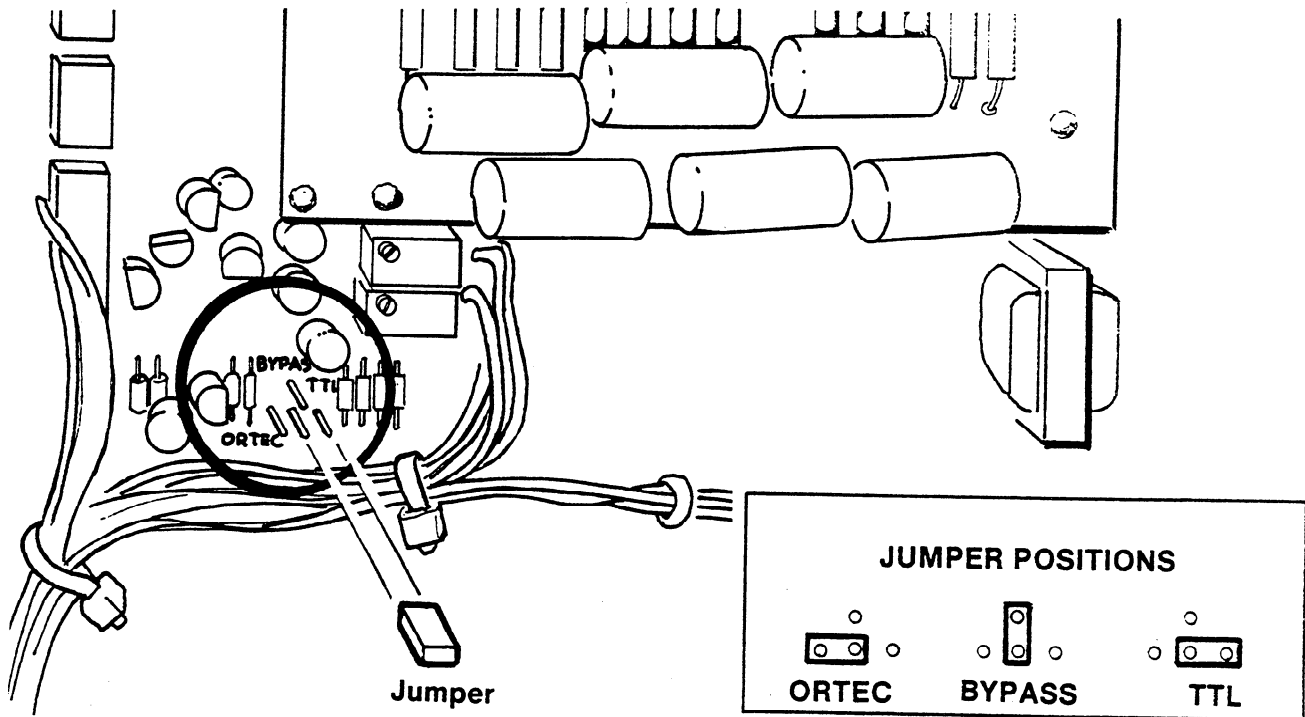


Fig. 2. Jumper Positions for Selecting the Proper Bias Shutdown Configuration.

## 4. OPERATION

### CAUTION

**Always have the high voltage turned off before connecting the cable to or disconnecting it from the preamplifier.**

**Make sure the output high voltage setting of the Model 659 does not exceed the safe limits for the preamplifier or detector to which it is connected.**

#### 4.1. SILICON SURFACE-BARRIER DETECTORS

Operating bias voltage for a silicon surface-barrier detector should be obtained from the 0 to 500-V output connector located on the rear panel. The voltage should not be applied as a large step, but should instead be advanced gradually from zero up to the recommended operating potential. With the Model 659, set the front-panel control at zero before switching the power On and pressing RESET. Then gradually advance the setting of the 5-turn potentiometer to the recommended level for the detector. It is a good idea to monitor the noise from the surface-barrier detector as the high voltage is gradually increased. A rapid increase in noise warns of impending breakdown in the detector. The noise should be monitored through the associated preamplifier and amplifier by observation on an oscilloscope.

To remove the detector bias, reduce the setting of the 5-turn control to zero at the Model 659 while the output cable is still connected to the preamplifier.

#### 4.2. OTHER TYPES OF DETECTORS

Operating bias for germanium detectors can be applied as a step from zero to the full operating value. For

these applications the 5-turn potentiometer can be adjusted to the required output voltage level while the power switch is turned Off, and then power can be applied by simply turning the Model 659 HV ON/OFF switch to ON and pressing the RESET push-button.

#### 4.3. RECOVERY FROM BIAS SHUTDOWN

When the BIAS SHUTDOWN mode is triggered by the germanium detector's warmup sensor, the HV ON/OFF switch should be turned OFF. After the detector has been cooled down long enough to ensure a safe vacuum in its cryostat, the HV ON/OFF switch should be turned ON. Usually, it is necessary to wait well past the time at which the warmup sensor indicates a cooled detector in order to ensure a safe vacuum, particularly on older detectors. Consult the detector manufacturer's instructions regarding the safe waiting period. Once the HV ON/OFF switch is ON, pressing the RESET button restores the bias voltage to the detector and turns off the SHUTDOWN LED. If the detector is still signalling a warmup condition, the RESET button is not able to cancel the shutdown mode.

## 5. CIRCUIT DESCRIPTION

The Model 659 uses a dc-to-dc converter to charge a Cockcroft-Walton multiplier circuit. The primary of transformer T1 is driven from the switched-mode power supply control circuit (U1) operating at approximately 20 kHz. Transistors Q1 and Q2 are the switching transistors for transformer T1.

The output voltage is adjusted by controlling the voltage applied to the primary of the transformer. Potentiometer R34 controls the primary voltage through transistors Q7 and Q4.

The circuitry in the transformer secondary consists of a 7-stage Cockcroft-Walton<sup>1</sup> multiplier circuit. Polarity selection is made with a plug-in printed wiring board (PWB) that completes the necessary circuits for either polarity by its orientation on the main PWB. Schematic No. 747170 at the back of this manual shows the alternate circuit connections. For polarity reversal, the input and output terminals of the Cockcroft-Walton circuit are interchanged.

The 0-500 V output is taken from the first stage of the multiplier circuit so that this output will always have the same polarity as the 0-5 kV output.

Calibration of the output voltage is accomplished with trim pots R30 (HI CAL) and R37 (LOW CAL). Set the 5-turn output adjust potentiometer (FP) to 5 kV. Adjust R30 for 5 kV at the 0-5 kV output connector. Set the 5-turn output adjust potentiometer (FP) to 500 V and adjust R37 for 500 V output at the 0-5 kV output connector. Since these controls interact with each other, this adjustment may have to be repeated.

The 10-segment bar-graph display is intended as an approximate visual indication of the output voltage. The sampled voltage is derived directly from the high voltage present at the output connector. Resistors R29, R33, and R65 form a voltage divider/calibration network. The calibrated output reference voltage is input to U2, a unity-gain buffer amplifier. Amplifier U3 functions as a unity-gain inverting buffer when negative polarity is selected, and as a unity-gain noninverting buffer when positive polarity is selected. This configuration assures that the reference voltage supplied to the display driver is always positive. The display driver, U4, senses the output reference voltage and drives a 10-segment LED bar-graph, providing an analog display of the high voltage output.

The calibration of the 10 segment bar-graph display on the front panel is made with trim pot R65 (Display Cal).

Set the 5-turn output adjust potentiometer to 2500 V, and adjust R65 until the 5th segment in the display just begins to turn on.

Upon initial power-up (the bin supply is turned on), U5B is latched to a "shutdown" condition by Q12, R40, and C11, the power-up preset circuitry. In a shutdown condition, U5 pin 5 is held low inhibiting the switching output of U1 (and thus the high voltage output), Q8 is turned Off, and the front-panel ON LED will not light. U5A provides a shutdown signal from the remote shutdown circuitry. Pressing the front-panel RESET push button sets U5 to a "operate" condition. U5 pin 5 is high, allowing the switching output of U1 and Q8 to turn On, causing the front-panel ON LED to light.

If the Bias Shutdown Input circuit is used, it will latch the output voltage of both of the Model 659 output circuits to zero volts when the external driving circuit signals that a shutdown condition exists. Jumper W1, located on the printed wiring board, selects which type of external bias shutdown driver circuit is used.

In ORTEC mode, the HV output will be disabled when the bias shutdown circuitry senses a -24 V to +5 V transition at the center contact of the Bias Shutdown connector (-24 V indicates a cold detector, +5 V indicates a warm detector). The input source must be capable of driving approximately 1.5 mA. This turns on Q13 and Q10. With Q10 turned On, U5A is latched to a "shutdown" condition, signaling U5B to turn the high voltage Off. Transistor Q15 is turned On, causing the front-panel Shutdown LED to light. This condition will remain "latched" until the external circuit indicates a cold detector condition and the operator pushes the front-panel RESET push button. U5A is then preset to an "operate" condition awaiting the next shutdown signal from the external source.

In TTL mode, the HV output is turned off when the external circuit supplies a logic "0" to the center contact of the Bias Shutdown connector. The input source must be capable of sinking approximately 700  $\mu$ A. This turns on both Q11 and Q9. With Q9 turned On, U5A is latched to a "shutdown" condition, signaling U5B to turn the high voltage Off. Transistor Q15 is turned On, causing the front-panel Shutdown LED to light. This condition will remain "latched" until the external circuit supplies a logic "1" to the center contact of the BNC connector, and the operator pushes the front-panel RESET push button. U5A is then preset to an "operate" condition awaiting the next shutdown signal from the external source.

In BYPASS mode, the remote shutdown circuitry is bypassed, allowing the high voltage supply to operate without remote shutdown protection.

<sup>1</sup>Everhart and Lorrain, "The Cockcroft-Walton Voltage Multiplying Circuit," Rev. Sci. Instr. 24(3), 221(1953).

Overcurrent protection is accomplished by Q5, Q6, and D16. Diode D16 sets a voltage reference for Q5. When an overcurrent condition exists, the voltage drop across R21 becomes sufficient to turn Q5 and Q6 On. This reduces the duty cycle of the switching oscillator (thus

reducing the output current) and causes the Overload LED to light. When the overload condition is removed, Q5 and Q6 turn Off, returning the switching oscillator to normal operation and extinguishing the Overload LED.

## **6. FACTORY REPAIR SERVICE**

This instrument can be returned to the EG&G 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 EG&G ORTEC Customer Service, (615) 482-4411, before sending 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 EG&G ORTEC factory.

**BIN/MODULE CONNECTOR PIN ASSIGNMENTS  
FOR STANDARD NUCLEAR INSTRUMENT  
MODULES PER DOE/ER-0457T**

Pin	Function	Pin	Function
1	+3 volts	23	Reserved
2	-3 volts	24	Reserved
3	Spare Bus	25	Reserved
4	Reserved Bus	26	Spare
5	Coaxial	27	Spare
6	Coaxial	*28	+24 volts
7	Coaxial	*29	-24 volts
8	200 volts dc	30	Spare Bus
9	Spare	31	Spare
*10	+6 volts	32	Spare
*11	-6 volts	*33	117 volts 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 volts	38	Coaxial
*17	-12 volts	39	Coaxial
18	Spare Bus	40	Coaxial
19	Reserved Bus	*41	117 volts ac (Neut.)
20	Spare	*42	High Quality Ground
21	Spare	G	Ground Guide Pin
22	Reserved		

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