Models 402A and 402D
Power Supplies
Operating and Service Manual

This manual applies to instruments marked
402A “Rev 47” on rear panel
402D “Rev 30” on rear panel
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 or by telephone (615) 482-4411, 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.
CONTENTS

402A POWER SUPPLY

WARRANTY ................................................................. 2
PHOTOGRAPH ............................................................ 4
1. DESCRIPTION ......................................................... 5
2. SPECIFICATIONS ...................................................... 5
3. INSTALLATION ......................................................... 6
4. OPERATING INSTRUCTIONS .......................................... 6
5. CIRCUIT DESCRIPTION ............................................... 7
6. MODIFICATION ......................................................... 8
   Schematic
   402A-1100-S1 ........................................................... 9

402D POWER SUPPLY

PHOTOGRAPH ............................................................ 10
1. DESCRIPTION .......................................................... 11
2. SPECIFICATIONS ...................................................... 11
3. INSTALLATION ........................................................ 12
4. OPERATING INSTRUCTIONS ......................................... 13
5. CIRCUIT DESCRIPTION ............................................... 13
6. MAINTENANCE ......................................................... 14
   Schematics
   402D-0201-S1 ........................................................... 17
   402D-0301-S1 ........................................................... 19
EG&G ORTEC 402D POWER SUPPLY

1. DESCRIPTION

The EG&G ORTEC 402D Power Supply is designed to be mounted in the space provided on the rear of the 4001A(B) Modular System Bin. The Supply was designed to exceed the recommended power supply specifications, Appendix A of TID-20883 (Rev 3), Type V-H, adopted by the AEC Committee on Nuclear Instrument Modules (adopted by DOE).

The 402D was designed for worldwide usage. Input voltage mains of 117 V ac or 230 V ac, 47-63 Hz, may be used. A convenience indicating switch clearly identifies the intended main to use.

The Supply furnishes six standard dc voltages, +24 V at 1 A, -24 V at 1 A, +12 V at 2 A, -12 V at 2 A, +6 V at 8 A and -6 V at 8 A, with a maximum power capability of 132 W at 50°C. The dc outputs are regulated, short-circuit protected, current limited, and thermal protected.

The 117 V ac is supplied to the Bin connector independent of input mains. The 117-V ac power available is limited only by the Power Supply fuse when operating from 117-V ac mains. When operating from 230-V ac mains, the 117-V ac is derived by autotransformer action and is limited to 60 VA output with a dc load on the Power Supply of 132 W.

A control panel is provided on the EG&G ORTEC 4001A(B) Bin for operating and monitoring the 402D Power Supply. An On-Off switch, a power indicating lamp, a thermal warning lamp, and convenience dc monitor jacks are provided. The thermal warning lamp is lighted when the internal temperature rises to within 20°C of the maximum safe operating temperature. The Power Supply is automatically cut off by an internal switch should the temperature exceed the maximum safe operating temperature.

The power transistors are virtually indestructible due to their power handling capability, current limiting, and short-circuit protection. Silicon semiconductors, 85°C capacitors with conservative working voltage ratings, high-quality carbon resistors, and metal film resistors are combined to produce the 402D Power Supply, which exceeds the TID-20883 (Rev) requirements.

The dc output voltages are adjustable through holes in the top of the Power Supply cover plate, over a ±2% range from their nominal ratings. The adjustment potentiometers are 20-turn cermet potentiometers for superior adjustment resolution and re-settable adjustment of the output voltages.

2. SPECIFICATIONS

**INPUT** 100 to 129 V ac, 57-63 Hz, or 200 to 258 V ac, 47-53 Hz. Input current at 117 V is 3.5 A for a 132-W dc output.

**DC OUTPUTS** The Supply provides six simultaneous dc outputs with the following current ratings:

<table>
<thead>
<tr>
<th>VOLTAGE (V)</th>
<th>CURRENT (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+24.00</td>
<td>0 to 1</td>
</tr>
<tr>
<td>-24.00</td>
<td>0 to 1</td>
</tr>
<tr>
<td>+12.00</td>
<td>0 to 2</td>
</tr>
<tr>
<td>-12.00</td>
<td>0 to 2</td>
</tr>
<tr>
<td>+6.00</td>
<td>0 to 8</td>
</tr>
<tr>
<td>-6.00</td>
<td>0 to 8</td>
</tr>
</tbody>
</table>

Maximum output power from 0 to 50°C ambient is 132 W. Operation to 60°C ambient, with current derated not more than 3%/°C for temperatures above 50°C.

**117-V AC OUTPUT** 117-V ac output is limited only by the Supply fuses when operating from 117-V ac mains. Output is limited to 60 VA at 132-W dc load while operating from 230-V ac mains.

**REGULATION** ±0.1% (typically ±0.05%) for ±12 V and ±24 V, and ±0.2% (typically ±0.1%) for ±6 V over the combined range of zero to full load and input voltage of 100 to 129 V ac or 200 to 258 V ac, when measurements are made within a period of 1 min.

±0.3% (±12 V and ±24 V) and ±0.6% (±6 V) over any 24-hr period at constant ambient temperature over the combined range of no load to full load and input voltage of 100 to 129 V ac or 200 to 258 V ac, after a 60-min warmup.

**STABILITY** Long-term stability over a 6-month period is better than ±0.5% after a 1-hr warmup at constant load, line, and ambient temperature.
OUTPUT IMPEDANCE <0.15Ω for the ±6-V outputs and <0.3Ω for all other outputs at any frequency to 100 kHz.

TEMPERATURE COEFFICIENT <0.02%/°C over a range of 0 to 60°C.

TEMPERATURE PROTECTION A thermal warning switch will close when the supply temperature approaches within 20°C of the safe operating value. A thermal cutout switch disables the Power Supply when the temperature exceeds the safe operating value.

NOISE AND RIPPLE <3 mV peak-to-peak for all six outputs, as observed on a 50-MHz bandwidth oscilloscope.

VOLTAGE ADJUSTMENTS ±2% minimum range, repeatability ±0.05% of Supply voltage.

RECOVERY TIME <100 µs to return to within ±0.1% of rated voltage for all six outputs for any change in input voltage and load current from 10% to 100% full load.

CIRCUIT PROTECTION Both sides of the input line to the power supply are fused. In addition, output current foldback limiting to prevent damage to the Supply and automatic recovery when the demand is removed are provided by electronic circuitry.

All six supplies are protected so that any one can be shorted to any other one without resulting in permanent damage.

Overvoltage protection is provided on ±6 V so that these outputs will not exceed 7.5 V maximum.

OUTPUT CONNECTOR All power and control circuits terminate in a connector, specified by TID-20893 (Rev 3), which mates the Bin interface connector, completing the necessary control and Power Supply wiring.

DIMENSIONS Conform to AEC drawing ND-515 and paragraph L, page A-10, of TID-20893 (Rev 3).

WEIGHT Net 8.9 kg (20 lb); with 4001A(B) 13.6 kg (30 lb).
Shipping 12.3 kg (27 lb); with 4001A(B) 19.5 kg (43 lb).

3. INSTALLATION

The 402D Power Supply is normally supplied factory-connected to an EG&G ORTEC 4001A(B) Modular System Bin. However, the Supply is designed to TID-20893 (Rev) specifications and may be attached, in the space provided, to any bin manufactured to TID-20893 (Rev) specifications.

For attachment to other than an EG&G ORTEC 4001A(B) Bin, refer to the appropriate instruction manual. The On-Off switch and other controls necessary to operate the supply are part of the Bin and are not furnished with the Power Supply.

For attachment to the EG&G ORTEC 4001A(B) Bin the following steps are advised:

1. Place the Bin on a table with the back part facing you. Place the Power Supply in the proper mounting position, leaving enough space between it and the Bin to attach the interface connector.

2. Mate the interface connector, being careful to align the polarizing pins. Fold and form all wiring close to the connector edges to prevent any wires from being pinched and producing a short circuit in succeeding steps.

3. Mount the Supply to the Bin by securely tightening the four 10-32 screws, being careful not to pinch any wires or to use undue force on any parts.

Unless otherwise specified, the 402D is shipped with transformer connections appropriate for operation on nominal 117 or 230 V mains, according to the selection made with the rear panel slide switch. To change the connections for operation on 100 or 200 V power mains, use the following steps:

1. Remove the top cover.
2. Move the wires from lug #3 of T1 to its lug #2.
3. Move the wires from lug #6 of T1 to its lug #5.
4. Replace the top cover.
5. Set the rear panel slide switch at 117 for 100 V operation or at 230 for 200 V operation.
4. OPERATING INSTRUCTIONS

4.1 POWER SUPPLY LIMITATIONS

The available current from the Power Supply is given in Section 2. Care must be used to ensure natural convection of heat dissipated by the heat sinks and power transformer. For best results, when using at maximum power loadings, the Bin and Power Supply should be in an open space, placed upon blocks at least 1 in. off the table mounting surface to allow maximum ventilation. When used in a rack, maximum attention should be paid to placement of other heat-generating equipment. Adequate unobstructed space on all sides is necessary for convection ventilation and cooling. If the Bin contains other heat-generating equipment, a blower may be advisable to remove the dissipated heat.

When it is necessary to rack-mount several bins and power supplies, especially when other heat-generating equipment is located within the rack, the term "ambient temperature" becomes less clearly defined. A better guide to maximum power loading capability is to monitor the heat sink temperature. Never allow the heat sink temperature to continuously run above 100°C. Although this is not the maximum operation temperature, any additional temperature rise due to other conditions of the system may force the Supply out of tolerance and may cause it to automatically shut down operation. Should your operation produce a temperature of 100°C, a blower to remove the dissipated heat is recommended.

4.2 6-V POWER SUPPLIES CROWBAR OPERATION

Both the +6-V and the -6-V outputs are protected against overvoltage. If for any reason one of these output voltages exceeds 7.5 V maximum in absolute value an internal "crowbar circuit" is triggered, which places a short-circuit across the output of the corresponding voltage. Since this circuit contains an SCR, normal operation, after suppression of the cause of the overvoltage, can be resumed only by turning the power switch of the 4001 Bin to Off for a couple of seconds, and then turning it to On again.

If in normal operation it is suddenly discovered that the +6-V or -6-V output is missing, first check whether it can be restored by following this procedure, after having removed all the modules from the Bin. The crowbar protection circuit of the corresponding voltage may have been triggered by a temporary fault in one module or even by a strong spurious voltage transient.

5. CIRCUIT DESCRIPTION

5.1. GENERAL DESCRIPTION

The 402D Power Supply produces six dc output voltages: ±12 V, ±24 V, and ±6 V. A power transformer reduces the input ac line voltage into six separate low voltage sources. Each voltage source has a separate full-wave bridge, a filter capacitor, and an electronic series regulator. Each regulator is composed of discrete solid-state devices and is completely independent from all other output regulators.

The six regulators are packaged on three plug-in printed circuit boards. The board closest to the heat sink includes regulators for the ±6 V supplies. The board in the middle includes regulators for the negative 12 and 24 V supplies. The board for the positive 12 and 24 V supplies. The 12 V and 24 V regulator boards are identical and may be interchanged.

The rectifiers, series pass transistors, sense resistors, and the SCRs for the 6 V supplies are all located on the large heat sink. The filter capacitors for the 12 V and 24 V supplies are located on their regulator boards. The filter capacitors for the 6 V supplies are mounted in the power supply chassis.

5.2. OPERATION OF REGULATORS

The operation of the ±12 V and ±24 V regulators are all identical. The ±24 V regulator is discussed here as an example that is typical for all four of these supplies. The circuit is shown on schematic 402D-0201-31.

The circuit consists of two parts; these are the voltage regulator and the current foldback circuit. The voltage regulator includes Q10, Q11, Q3, Q4, Q2, Q1, and Q101. The current foldback circuit includes Q5, Q7, Q8, Q6, and Q9.

Transistors Q10 and Q11 operate as a differential amplifier, comparing the voltage from the reference diode, D4, at the base of Q10 to the output voltage divided down by resistors R21, R22, and R23. Potentiometer R22 is used to adjust the output voltage to the desired level. The difference voltage is amplified by Q3 and Q4 to reduce the current through Q2 and to increase the output voltage or
to increase the current through Q2 and to then decrease the output voltage. Q2 drives emitter follower Q1 to supply drive current for series pass element Q101.

In the current limiting mode, the voltage across sense resistor R101 is applied between the bases of Q6 and Q9. When the current level is less than the rated current, Q6 and Q7 conduct. If the output current exceeds its rated value, the voltage at the base of Q6 goes higher than the voltage at the base of Q9 and Q9 conducts. This turns Q8 on to increase the current through Q2 and to decrease the current drive to the base of Q1. The amount of current that the series pass element, Q101, can supply is reduced. When the over-current condition is corrected, normal regulation returns automatically.

The ±6 V regulators operate much the same as the ±24 V regulator. The circuit for the ±6 V regulators is shown on schematic 402D-0301-S1. The sense amplifier of the ±6 V regulator includes Q11, Q10, Q9, Q26, Q4, Q5, Q2, Q1, and Q3. The operation is the same as for the ±24 V regulator. The addition of Q9 and Q26 provides a constant current for reference diode D11.

In the current limiting mode, operation is the same as for the ±24 V regulator. Resistors R105 through R108 are used to balance the current in the four series pass transistors, Q105 through Q108. R108 is also used as a sense resistor. The four transistors are used to keep the power dissipated in each device below the maximum rated value.

The "crowbar" circuit is used for over-voltage protection. It includes Q12, D12, and SCR D107. If the output voltage exceeds the zener voltage of D12 (~6.8 V), Q12 turns on and triggers the gate of the SCR. When the SCR turns on, it appears as a short across the supply output and causes the current to fold back. After the cause of the over-voltage has been removed, the supply must be switched off for two seconds and can then be turned on again to restore its normal operation.

6. MAINTENANCE

6.1. ACCESS

The top cover of the 402D Power Supply is attached with sixteen 4-40 Phillips-head machine screws. When all 16 screws are removed the cover can be lifted for access to the plug-in regulator boards. Each regulator board has keying pins to prevent reversal of position in the connector and to prevent insertion into the incorrect location. Be very careful to prevent breaking or removing the keying pins from the connector during either removal or return of the board.

There are copper clips attached to some of the transistors on the printed circuit boards. Their purpose is to ensure equal operating temperatures for these transistors. Do not remove the copper clips from these transistors.

Most of the components mounted on the heat sink can be replaced easily. If access is required to the chassis side of the heat sink, remove the 14 mounting screws that secure it to the chassis and carefully fold the heat sink away from the chassis to prevent breaking any of the wire leads or the soldered connections.

6.2. TROUBLESHOOTING

Any of the three transistor boards may be operated separately without requiring the other boards to be installed in the power supply.

If an output voltage is high and cannot be adjusted down to its proper level, its series pass transistor, mounted on the heat sink, may be shorted. This condition will usually cause damage to the regulator that is mounted on the printed circuit board. Check the emitter-base junction of the series pass transistor with an ohmmeter if a short is suspected. Do not install another regulator board if the transistor is shorted, or the new board will be damaged.

Since the positive 12/24 V regulator board is identical to the negative 12/24 V regulator board, the boards can be interchanged for troubleshooting. Replacement regulator boards are available from EG&G ORTEC.

6.3. TYPICAL VOLTAGES

Tables 6.1 and 6.2 list typical voltages that were measured with respect to ground potential and they are given here as an aid in troubleshooting. These voltage levels are typical of a circuit that is operating properly, but the precise values will vary between individual circuits.

The 12/24 V table indicates the voltages on the board when it is installed at the positive location, furthest from the heat sink. Line voltage is 117 V ac. The 24 V supply is loaded for 1 A and the 12 V supply is loaded for 2 A. All measurements are referenced to chassis ground and are made with a voltmeter that has a 10 MΩ input impedance.

The regulator board for the ±6 V supplies operates in the location closest to the heat sink. The following voltages assume a line voltage of 117 V. Each supply, +6 V and −6 V, is loaded for 8 A. All measurements are referenced to chassis ground and are made with a voltmeter that has a 10 MΩ input impedance.
6.4 FACTORY REPAIR

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 the Customer Service Department at EG&G ORTEC, (615) 482-4411, before sending in an instrument for repair to obtain shipping instructions and the required Return Authorization Number. Write this number on the address label and on the package to ensure proper handling when the instrument reaches the factory.