ORTEC

Models 124 and 125 Preamplifiers

Operating and Service Manual

Printed in U.S.A.

1269 02C 1071 04

STANDARD WARRANTY FOR ORTEC INSTRUMENTS

ORTEC warrants its instruments other than preamplifier FET input transistors, vacuum tubes, fuses, and batteries to be free from defects in workmanship and materials for a period of twelve months from date of shipment provided that the equipment has been used in a proper manner and not subjected to abuse. Repairs or replacement, at ORTEC option, will be made on in-warranty instruments, without charge, at the ORTEC factory. Shipping expense will be to the account of the customer except in cases of defects discovered upon initial operation. Warranties of vacuum tubes and semiconductors made by their manufacturers will be extended to our customers only to the extent of the manufacturers' liability to ORTEC. Specially selected vacuum tubes or semiconductors cannot be warranted. ORTEC reserves the right to modify the design of its products without incurring responsibility for modification of previously manufactured units. Since installation conditions are beyond our control, ORTEC does not assume any risks or liabilities associated with methods of installation or with installation results.

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.

ORTEC must be informed in writing of the nature of the fault of the instrument being returned and of the model and serial numbers. Failure to do so may cause unnecessary delays in getting the unit repaired. Our 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 ORTEC repair center. Instruments 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 ORTEC of the circumstances so that we may assist in damage claims and in providing replacement equipment if necessary.

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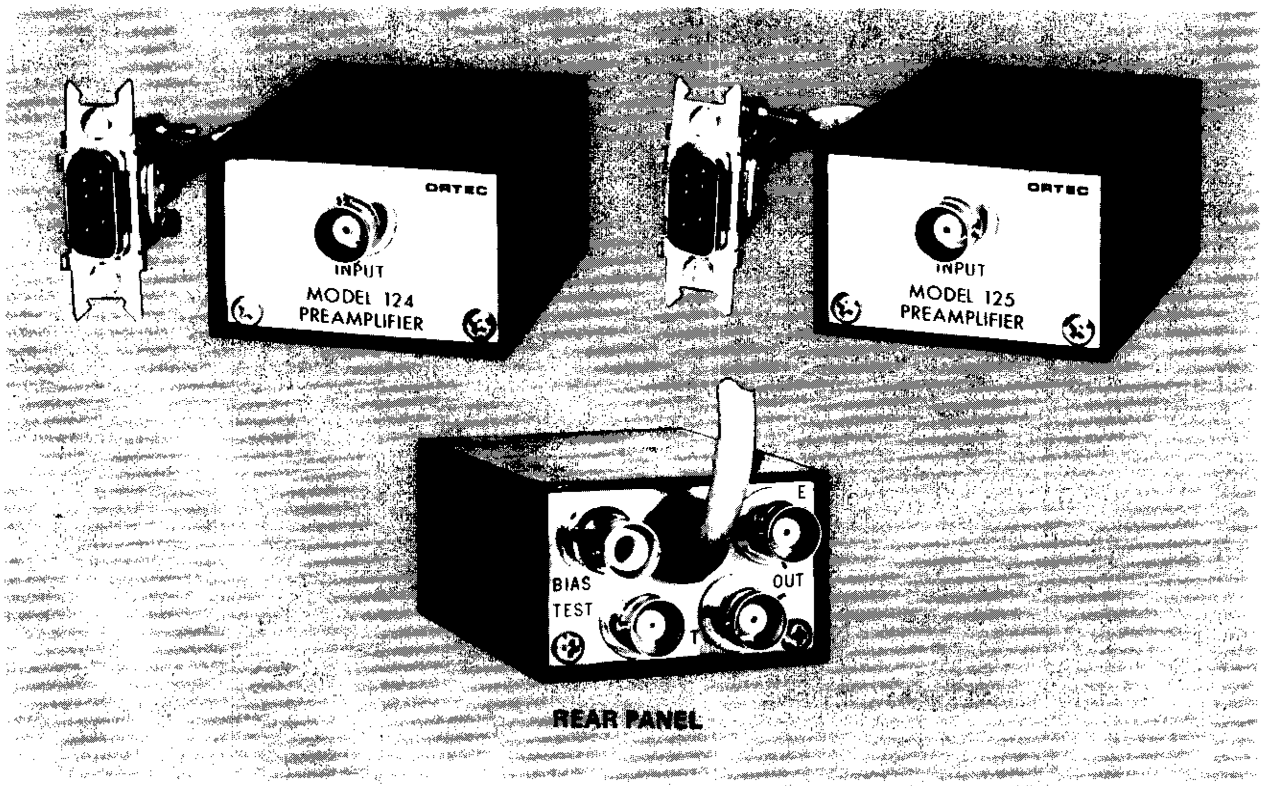


NOTICE

This preamplifier has been shipped to you with its protection circuit connected into the input circuit. The protection circuit makes it almost impossible to destroy the input FET under normal operating conditions and imposes only a slight resolution degradation. The preamplifier is thus immune to almost anything the operator is likely to do that causes transients either at the detector input connector or at the bias input connector.

The protection circuit does not protect the detector, but even if the detector breaks down as a result of overvoltage, the preamplifier will survive the resulting large transients if the protection circuit is in. This, of course, is not true if the protection circuit is out, in which case the input FET is very susceptible to destruction by transients at the detector input connector.

If the slight degradation of resolution cannot be tolerated, the protection circuit can be removed by simply moving the plug-in jumper on the printed circuit board from in to out.

Warranty is voided if the protection circuit is out unless the following precautions are taken:

1. COMPLETELY DISCHARGE the detector bias circuitry before connecting a low impedance or a cable, capacitor, or other capacitive device to the Detector Input connector on the preamplifier.

2. Discharge the detector bias circuitry before making ANY connections to the Detector Input connector and before disconnecting the preamplifier from the detector.

3. To discharge the detector bias circuitry, connect a low impedance (short circuit preferably) for at least 20 seconds across the Detector Bias connector on the preamplifier.

The input transistor will be destroyed if the Detector Input connector is shorted while the detector bias components are charged. Such a short could result from connecting a detector, cable, capacitor, or other capacitive device such as a voltmeter probe. A short circuit, short term or continuous, will cause the applied bias voltage (stored on C4) to be coupled through C4 directly to the input transistor, causing catastrophic breakdown.

If a variable supply is used, merely turning down the voltage control to zero and leaving it for at least 20 seconds will suffice, since the bias circuitry can discharge itself through the output impedance of the bias supply.

Sometimes it is necessary to simply disconnect the bias supply, such as when using batteries for bias. This situation leaves no discharge path; so a path must be provided by placing a short circuit or low impedance across the Detector Bias connector on the rear panel of the unit. DO NOT SHORT the Detector Input on the front panel.

ORTEC 124 AND 125 PREAMPLIFIERS

1. DESCRIPTION

The ORTEC 124 and 125 Preamplifiers are the charge-sensitive type and are designed for use with room-temperature-operated silicon surface-barrier detectors. The 124 is designed especially for low-capacitance detectors and has a low intercept and a moderate slope. The 125 is designed especially for high-capacitance detectors and high-energy measurements and has a moderate intercept and a low slope. The 125 has a lower charge sensitivity and a faster rise time than the 124. Both preamplifiers will operate within the full dynamic range of input capacitance, but one will be superior to the other inside its specifically designated range of input capacitance.

The energy range expected in typical applications is from 0 to 200 MeV. Two simultaneous outputs are provided; one is for energy measurements and the other is for timing applications. Either or both outputs may be used as desired, since their circuits are isolated from each other.

A bias circuit is included to accept the operating voltage required by the detector and to furnish this bias out to the detector through the signal input cable. The bias input circuit in the preamplifier includes a 100 MΩ load resistor, R2, and any detector leakage current will have to pass through this resistance. A considerable voltage drop will be expected across this 100 MΩ resistor for a high-leakage detector, and a smaller value of resistance can then be substituted for R2. A 10 MΩ resistor is furnished as an accessory to the preamplifier for this use when it is required (see Section 4.1).

An input protection circuit is built into the preamplifier circuits. This will protect the input FET from any large transient voltages that would otherwise damage the transistor. This is discussed in the Notice at the front of the manual.

2. SPECIFICATIONS

PERFORMANCE

NOISE Based on silicon equivalent of $\epsilon = 3.6$ eV at $\tau = 2\ \mu$s.

124

Detector Capacity (pF)	Typical Noise (keV)	Maximum Noise Guaranteed (keV)
0	1.8	1.95
20	2.25	2.4
50	2.95	3.1
100	4.1	4.25

Typical intercept, 1.8 keV
Typical slope, 23 eV/pF

125

Detector Capacity (pF)	Typical Noise (keV)	Maximum Noise Guaranteed (keV)
0	3.0	3.2
100	4.3	4.6
200	5.8	6.4
500	11.0	12.2
1000	20.0	21.2

Typical intercept, 3.0 keV
Typical slope, 17 eV/pF

RISE TIME Based on a ±5-V maximum signal into an open circuit and measured from 10% to 90% of peak amplitude.

124 ⩽20 ns at 0 pF; ⩽60 ns at 100 pF.
125 ⩽20 ns at 100 pF; ⩽80 ns at 500 pF.

CONVERSION GAIN (Nominal)

124 45 mV/MeV.
125 10 mV/MeV.

INTEGRAL NONLINEARITY ⩽0.05% for 0 to ±8 V open circuit or ±4 V terminated.

TEMPERATURE STABILITY ±50 ppm/°C, 0 to 50°C.

DETECTOR BIAS ISOLATION ±1500 V.

DYNAMIC INPUT CAPACITANCE

124 ⩾5 000 pF.
125 ⩾50 000 pF.

INPUTS

SIGNAL Accepts inputs from semiconductor charged-particle detector and extends operating bias to the detector.

BIAS Accepts the detector bias voltage from a power supply.

TEST Accepts input pulses from a pulse generator for instrument and system calibration; $R_{in} = 93\Omega$.

OUTPUTS

E OUT Furnishes the output signals through $R_0 = 93\Omega$ for energy measurements.

T OUT Furnishes the output signals through $R_0 = 93\Omega$ for timing measurements. Note: The same signal is furnished through both output connectors, and they are isolated and short-circuit proof.

CONNECTORS

SIGNAL, TEST, and OUTPUTS BNC (UG-1094/U).

BIAS SHV (AMP 51494-2) or ORTEC type C-38.

POWER CABLE 10-ft captive power cable, ORTEC 121-C1; longer power cable lengths available from ORTEC on special order.

ELECTRICAL AND MECHANICAL

POWER REQUIRED Furnished from any ORTEC main amplifier or from an ORTEC 114 Power Supply through the built-in cable.

Note: The 124 and 125 must be powered by the ORTEC 114 Preamplifier Power Supply when not powered by the companion ORTEC main amplifier. The standard ORTEC 115 will not work since it does not have ±12 V and must therefore be modified if used with the 124 or 125. With its power output of ±24 V at 200 mA and ±12 V at 100 mA, the 114 can power any two ORTEC preamplifiers.

124 +24 V, 20 mA; +12 V, 10 mA; -24 V, 10 mA; -12 V, 10 mA.
125 +24 V, 40 mA; +12 V, 10 mA; -24 V, 10 mA; -12 V, 10 mA.

DIMENSIONS 1.25 x 2 x 2.875 in., plus 10-ft cable.

WEIGHT (Shipping) 2 lb 12 oz (1.25 kg).

WEIGHT (Net) 12 oz (0.32 kg).

RELATED EQUIPMENT

Both the 124 and 125 Preamplifier will operate satisfactorily for surface-barrier detectors that have capacitances of between 0 pF and 1000 pF. However, as shown in Fig. 2.1, the 124 will be preferred for lower capacitance detectors in the range of 0 to 100 pF, while the 125 will be advantageous for higher capacitance detectors. Both types accept the detector bias voltage from a supply such as the ORTEC 428 (or the 456 for requirements of 1000 V or more) through the SHV connector marked Bias.

The signal input is accepted through a type BNC connector, and the cable used for the connection between the detector and the preamplifier should be as short as possible, since input capacity increases with cable length.

The outputs can be connected to any ORTEC main amplifier and to time derivation instruments. Either type of measurement can be made separately, or both may be made simultaneously with identical signals being furnished through both output connectors simultaneously.

Any ORTEC pulse generator can be connected to the Test input of the preamplifier to furnish pulses for testing and calibrating the system. For convenience, this input circuit has an impedance of 93Ω built in, and the pulse generator output can be connected directly to the Test input without an external terminator.

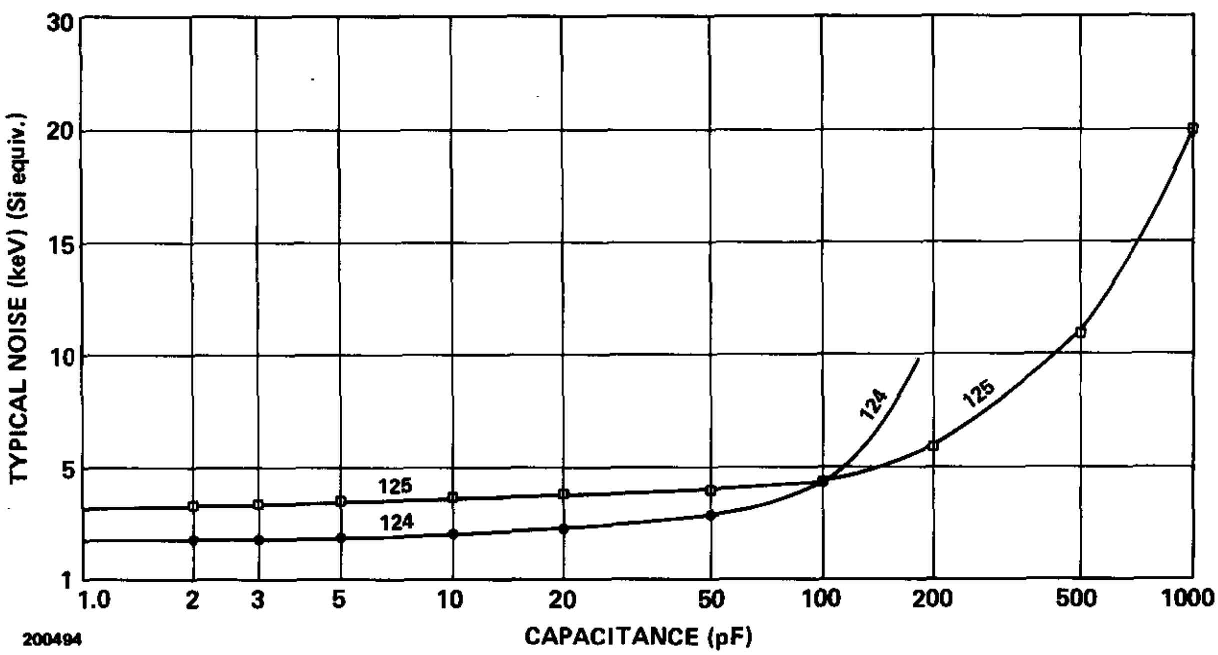


Fig. 2.1. Resolution vs Input Capacitance.

3. INSTALLATION

3.1 CONNECTION TO DETECTOR

A direct connection with shielded coaxial cable should be made between the detector and the BNC connector labeled Input on the front panel. This cable must be kept as short as possible to minimize the input capacitance into the preamplifier and to thus minimize the noise in the system. Also, it is preferable to use 93Ω or 100Ω cable rather than 75Ω or 50Ω cable, since the capacity per foot is less for the higher impedance cables. Type RG-62/U cable is recommended; its impedance is 93Ω and its capacity is 13.5 pF/ft. An adapter, ORTEC C-17, may be used on the input connector to permit use of Microdot connectors and cables. In some installations it may be possible to use an adapter for direct attachment of the detector to the preamplifier with no cable at all. After the input cable has been installed, the electronic noise performance of the preamplifier can be predicted by calculating the cable capacity from the above information, adding the capacity expected from the detector, and referring to the table in Section 2 of typical performance versus input capacity.

3.2 CONNECTION TO A SHAPING MAIN AMPLIFIER

The preamplifier can be used to drive a long 93Ω line to a shaping main amplifier and is designed to be directly compatible with the ORTEC main amplifiers. It can be used with any shaping main amplifier if a power supply is used to furnish the preamplifier power requirements.

3.3 INPUT POWER

Power for the 124 or 125 is supplied through the captive power cord and Amphenol connector. This connector can be connected to the mating power output connector on any ORTEC main amplifier or on an ORTEC 114 Preamplifier Power Supply. The preamplifier's power requirements are added to the operating power requirements of the amplifier or power supply.

3.4 TEST PULSE

A voltage test pulse can be accepted through the Test input connector on the rear panel of the preamplifier without the use of an external terminator. The Test input of the preamplifier has an input impedance of 93Ω and its circuit provides a charge-termination. The shape of this pulse should be a fast rise (less than 10 μs) followed by a slow exponential decay back to the baseline (200 to 400 μs). The input amplitude can be set to any desired level if the conversion gain of the preamplifier is known.

While the test pulses are being furnished into the Test input, connect either the detector (with bias applied) or its equivalent capacitance to the Input connector on the front panel of the preamplifier.

4. OPERATION

4.1 GENERAL

Figure 4.1 is a simplified block diagram of the circuits in an ORTEC 124 or 125 Preamplifier. An understanding of its circuits is helpful in understanding the operation of the unit.

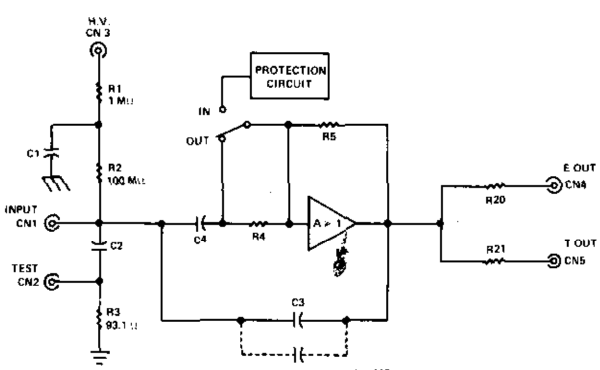


Fig. 4.1. Simplified Block Diagram of ORTEC 124 and 125 Preamplifiers.

4.2 DETECTOR BIAS

The amount of bias required by the detector will be specified with the detector. The bias is accepted into the preamplifier through the SHV Bias connector and then is furnished through a 100 MΩ load resistor to the Signal Input connector on the front panel. If the detector leakage is appreciable, a notable voltage drop will occur across the series load resistor in the preamplifier, and this must be considered when the level furnished from the detector bias supply is adjusted. When a high-leakage detector is to be used and its drop across the load resistor would be excessive, the load resistance can be decreased by installing the 10 MΩ resistor that is furnished with the preamplifier; this resistor can be connected in parallel with R2 by adding it to the holes that are already in the printed circuit board. Prevent touching resistor R2 when making this installation and also when the 10 MΩ resistor is removed for use with a low-leakage detector.

4.3 LINEAR OUTPUT

The charge-sensitive loop is essentially an operational amplifier with capacitive feedback. The feedback capacitor in the 124 is C3, with a value of 1 pF. In the 125, C3 is shunted by C11 with a value of 3.9 pF. The gain of the 125 can be increased, if desired, by removing either C3 or C11 from the feedback circuit. DC feedback is applied through R5.

The rise time of the charge-sensitive loop increases as external capacity increases. External capacity is a function of the detector and its cabled connection to the preamplifier input.

The output from the preamplifier is available simultaneously through both the E and T output connectors. The pulses through these connectors are identical, are isolated from each other, and are series-terminated for 93Ω cable.

The preamplifier output is a voltage step. The silicon equivalent amplitude of the step is 45 mV/MeV for the 124 and 10 mV/MeV for the 125. The dynamic range of the output with an integral nonlinearity of less than ±0.05% is ±8 V open circuit. When the output is terminated in 93Ω, the dynamic range is limited to ±4 V.

4.4 INPUT PROTECTION

A provision is built into the preamplifier to protect its input FET from damage when high-voltage transients are applied to its input. These transients can result from any one or more causes, including detector breakdown, moisture condensation on the input connector, short circuits or uncharged capacitance connected across the input while bias is being applied through the preamplifier, or disconnection of a bias voltage without first reducing it gradually to zero.

The protection circuit is installed in the preamplifier when the unit is shipped from the factory. Although it offers protection to the FET, it also causes some degradation of the noise performance of the preamplifier and this increases as capacity increases. For comparison, the table below shows how the typical noise factors shown in the specifications in Section 2 are affected. The performance specifications refer to operation with the protection circuit out of the preamplifier.

Noise vs Capacity for the 124

Detector Capacity (pF)	Typical Noise with Protection Out (keV)	Typical Noise with Protection In (keV)
0	1.8	1.8
20	2.25	2.3
50	2.95	3.3
100	4.1	4.9

Noise vs Capacity for the 125

Detector Capacity (pF)	Typical Noise with Protection Out (keV)	Typical Noise with Protection In (keV)
0	3.0	3.0
100	4.3	5.2
200	5.8	7.9
500	11.0	17.0
1000	20.0	32.2

With the protection circuit in, the emitter lead of Q10 is attached to the junction of resistors R4 and R5, at the input to the amplifier. To take the protection circuit out, simply remove the emitter lead from the convenient standoff and install a jumper from that standoff across to another at the junction of R4 and C4. A formed jumper is taped inside the preamplifier case to be used for this purpose when operation is desired with the protection circuit out of the preamplifier.

4.5 GAIN CHANGE

The circuit of the preamplifier is that of an operational amplifier. Its conversion gain is controlled by the feedback capacity, using C3 in the 124 and both C3 and C11 in the 125. If the gain of the 125 is too small, it can be increased easily by removing one of these capacitors from the circuit. If C3 is removed, the gain will be increased by about 20%. If C3 is left in the circuit and C11 is removed, the gain will be increased to about 5 times its normal amount. In either case, when one of these capacitors is removed from the circuit in order to change the conversion gain, the capacitor should be kept for future use when restoration of the original circuit is desired.

5. MAINTENANCE INSTRUCTIONS

5.1 TESTING PERFORMANCE

As ordinarily used in a counting or spectroscopy system, the preamplifier is one part of a series system involving the source of particles to be analyzed, the detector, the preamplifier, the main amplifier, and the pulse height analyzer. When proper results are not being obtained and tests for proper performance of the preamplifier and the other components are indicated, it is important to realize that rapid and logical testing is possible only when the individual components are separated from the series system. In proving the performance of the preamplifier it should be removed from the system and be dealt with alone, by providing a known electrical input signal and testing for proper output signal with an oscilloscope as specified below.

1. Use a voltage pulse in the Test jack, as outlined in Section 3.4. The polarity of the test pulse signal should be in agreement with the expected signal input polarity from a detector.

2. If a suitable input signal has been obtained for the preamplifier as outlined in Section 4, the performance of the instrument may be checked by observing the pulse waveform at the Output jack. If an input signal of 45 mV has been obtained as described above, an output pulse amplitude of about 100 mV can be expected from the 124 or 20 mV from the 125.

3. The noise contribution of the preamplifier may be verified by two basic methods. In either case, the normal capacity of the detector and associated cables should be replaced by a capacitor of equal value connected to the Det. Input jack. This is necessary because the noise contribution of the preamplifier is dependent upon input capacity, as can be seen from the noise specifications given in Section 2. The only meaningful statement of the noise level of the preamplifier is one that relates to the spread caused by the noise in actual spectra. This can be measured and expressed in terms of the full width at half maximum (FWHM) of a monoenergetic signal after passing through the preamplifier and main amplifier system. The noise performance referenced in Section 2 is stated in these terms, and verification methods will be described. If desired, the preamplifier can be tested with no external capacity on the Det. Input jack, in which case the noise width should be approximately that shown for zero external capacity. In any case, the input jack and capacitors, when used, should be completely shielded electrically. A wrapping of aluminum foil around the input jack will suffice for testing at zero capacity.

4. The preamplifier must be tested in conjunction with an associated main amplifier that provides the required pulse shaping. The typical noise performance given in Section 2 is based on main amplifier pulse shaping consisting of equal RC differentiation and integration of 2-μs time constant. For comparison of these tabulated values, it is preferable to test the preamplifier under identical pulse shaping conditions. It is also important to ensure that the noise level of the input stage of the associated main amplifier does not contribute materially to the total noise. This is usually no problem provided that input attenuators, if any, on the main amplifier are set for minimum attenuation.

5. If a multichannel pulse height analyzer is used following the main amplifier, testing of the noise performance can be accomplished merely by using a calibrated test pulse generator with charge terminator, as outlined in step 1. With only the charge terminator connected to the Det. Input jack, the spread of the pulser peak thus analyzed will be due only to the electronic noise contribution of the preamplifier and main amplifier. The analyzer can be calibrated in terms of keV per channel by observing two different pulser peaks of known energy, and the FWHM of a peak can be taken directly from the analyzer readout.

6. It is also possible to determine the noise performance of the preamplifier by the use of a wide-bandwidth rms ac voltmeter such as the Hewlett-Packard 400D, reading the main amplifier output noise level and correlating with the expected pulse amplitudes per keV of input signal under the same conditions. Again, a calibrated test pulse generator is required for an accurate measurement.

In this method the preamplifier and main amplifier are set up as they would be used normally but with a dummy capacitor (or no capacity) on the Det. Input jack, and with the ac voltmeter connected to the amplifier output. The noise voltage indicated by the meter, designated E_{rms}, is read and noted. Then, a test pulse of known energy, E_{in} (in keV), is applied to the input jack, and the amplitude of the resulting output pulse, E_{out}, is measured in volts with an oscilloscope. The noise spread can then be calculated from the formula

$$\text{FWHM (keV, Si det)} = \frac{2.66\,(E_{rms})\,(E_{in})}{E_{out}}$$

where E_{rms} is output noise in volts on the 400D meter, E_{in} is input signal in keV particle energy, and E_{out} is output signal in volts corresponding to the above input. If the gain of the shaping amplifier is adjusted so that the output voltage is 2.66 V, then the meter reading will be directly in keV FWHM except for a scale factor. [The factor 2.66 is the product of two relations: correction from rms to FWHM (2.35), and correction of the 400D meter from sinewave to white noise (1.13).]

7. The noise performance of the preamplifier, as measured by these methods, should not differ significantly from that given in the specifications in Section 2.

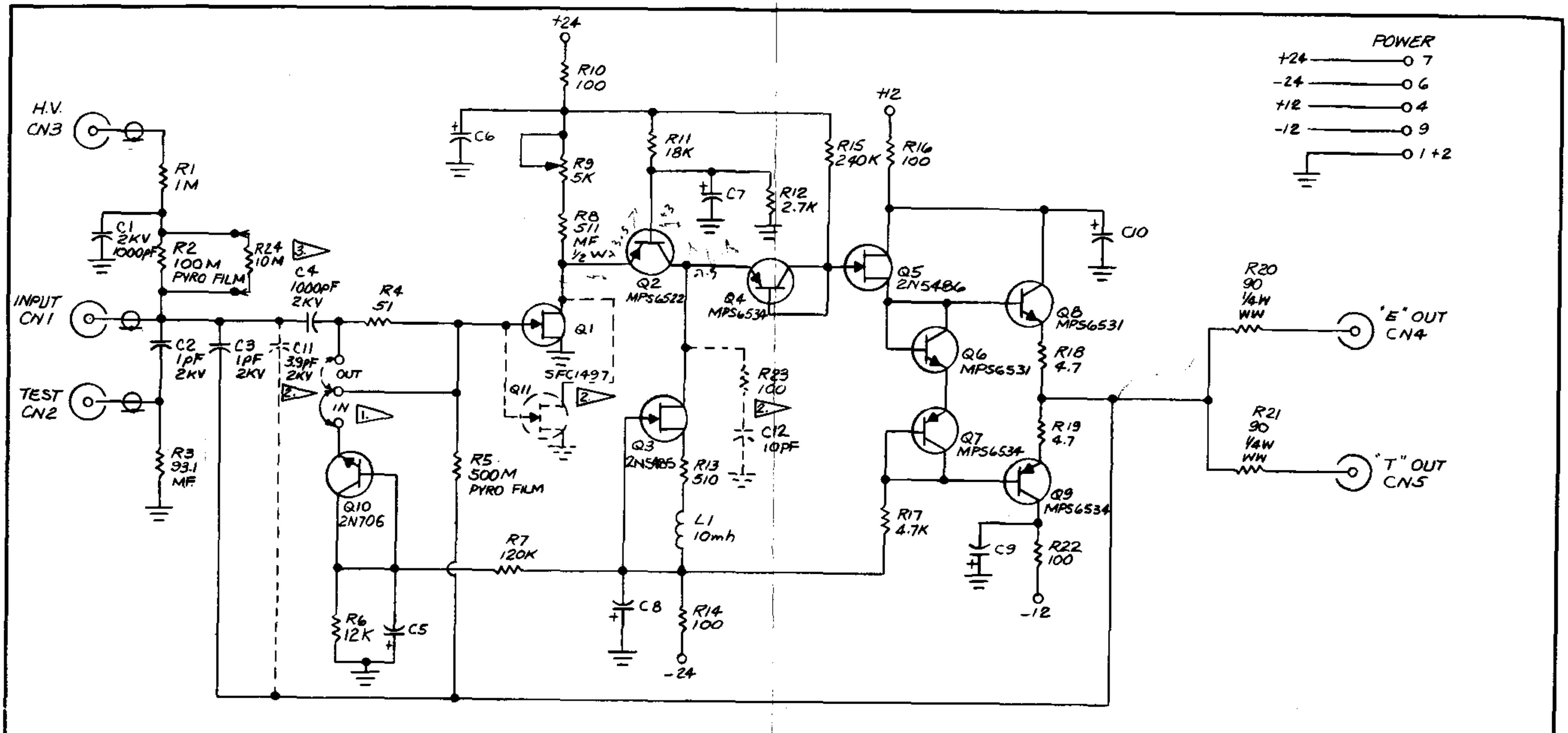
8. If, during testing of the preamplifier and detector, the noise performance of the preamplifier has been verified as outlined in the preceding section or is otherwise not suspected, a detector may be tested to some extent by duplicating the noise performance tests with the detector connected in place and with normal operating bias applied. The resulting combined noise measurement, made either with an analyzer or by the voltmeter method, indicates the sum in quadrature of the separate noise sources of the amplifier and the detector. In other words, the total noise is given by $(N_{tot})^2 = (N_{det})^2 + (N_{amp})^2$.

9. Each quantity is expressed in keV FWHM. The quantity N_{det} is known as the "noise width" of the detector, and is included as one of the specified parameters of each ORTEC semiconductor detector. By use of the above equation and with a knowledge of the noise of the preamplifier, the noise width of the detector can be determined. The significance of this noise width in evaluating the detector is subject to interpretation, but generally the actual resolution of the detector for protons or electrons will be approximately the same as the noise width; the resolution of the detector for alpha particles will be poorer than the noise width. The most useful application of determining the noise width of a detector is in the occasional monitoring of this quantity to verify that the detector characteristics have not undergone any significant change during use.

5.2 FACTORY REPAIR SERVICE

The ORTEC 124 or 125 Preamplifier may be returned to the factory for repair service at a nominal cost for any service other than warranty repairs. Our standard procedure requires that each repaired instrument receive the same extensive quality control that is provided for a new instrument. Please contact the Customer Service Department before shipping the instrument to the factory.

The transistor types installed in your instrument may differ from those shown in the schematic diagram. In such cases, necessary replacements can be made with either the type shown in the diagram or the type actually used in the instrument.



NOTES: UNLESS OTHERWISE SPECIFIED:

1. PROTECTION CIRCUIT.
2. USED IN MODEL 125
3. C4 IS 9000pF IN MODEL 125
4. ALL CAPACITORS ARE 6.8μF, 25V
5. ALL RESISTORS ARE IN OHMS.

Q11
R23
C12
L1

REV	ECN NO	DATE	APD
C	124-5 125-5	4-1-71	BD
B	124-4, 125-4	2-2-71	BD
A	124-2	11-14-70	BD

REVISIONS

UNLESS OTHERWISE SPECIFIED
DIMENSIONS IN INCHES
TOLERANCES
FRACTIONS ±1/64 | DECIMALS .XX ±.01 .XXX ±.005 | ANGLES ±0°30' | FINISH ✓

MATERIAL

APPLIED PRACTICES

ORTEC INCORPORATED

100 MIDLAND ROAD, OAK RIDGE, TENNESSEE 37830

TITLE: MODEL 124 & 125 PREAMPLIFIER

DRAFTSMAN: J.D.W. DATE: 6-9-70
RESPONSIBLE ENGINEER: JOEL AYERS
CHECKED
ENG. APPROVAL: DATE: 7-17-70
SCALE
MFG. APPROVAL: B. Downing DATE: 7-20-70
DWG. REVISED: Shirley DATE: 11-19-70
RELEASED FOR MFG.
DRAWING NO. 124-0101-S1