

**Model 142IH
Preamplifier
Operating and Service Manual**

Advanced Measurement Technology, Inc.

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

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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.



NOTICE

This preamplifier has been shipped to you with its protection circuit connected into the input circuit. The protection circuit prevents destruction of the input FET due to large transients that may occur during abnormal operating conditions and serves as an impedance matching termination for the input cable from the detector. The presence of the protection circuit imposes only a slight resolution degradation. With the protection circuit installed, the preamplifier is immune to almost anything the operator is likely to do that causes transients at either the detector input or 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, would not be true if the protection circuit were taken out, in which case the input FET is very susceptible to destruction by transients at the input connector on the preamplifier.

If the input protection circuit must be taken out for any reason, this involves disconnecting one transistor lead and installing a jumper across a 51 Ω series resistor. The Warranty of the 142IH is void if the protection circuit is taken out unless all of the following precautions are taken:

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

2. Discharge the bias circuitry before making **any** connections to the Input connector and before disconnecting the preamplifier from the detector.
3. To discharge the bias circuitry, connect a low impedance (shorting cap is preferred) for at least one minute across the Bias connector on the preamplifier.

The input circuit will be destroyed if the Input connector is shorted while the bias components are charged, and the quality of these capacitors is such that they will retain a charge through a long period of time. Such a short could result from connecting a detector, cable, or other capacitive device such as a voltmeter probe. A short circuit, either short term or continuous, will cause the applied bias (stored on C2) to be coupled directly to the input transistor, causing a catastrophic breakdown.

If a variable bias supply is used, merely turn down the voltage control to zero and leave it for at least one minute. This will suffice since the bias circuitry can discharge itself through the output of the bias supply.

Sometimes it is necessary to simply disconnect the bias supply, such as is the case 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 Bias connector on the rear panel of the preamplifier. **DO NOT SHORT THE INPUT CONNECTOR** on the front panel of the instrument unless the input circuitry has been completely discharged.

ORTEC 142IH PREAMPLIFIER

1. DESCRIPTION

The ORTEC 142IH charge-sensitive Preamplifier is designed as a minimum-cost general-purpose unit. It is intended for use in systems where the detector, rather than the preamplifier, is the major noise source in the system or in systems where the ultimate in performance is not required and the cost of the system must be minimized. It can be used with semiconductor detectors, proportional counters, scintillation counters, ionization chambers, etc.

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 142IH Preamplifier includes a 100-M Ω load resistor, R4, and any detector leakage current will have to pass through this resistance as well as through R1, 1.5 M Ω , in series. A considerable voltage drop will be expected across this 100-M Ω resistor for a detector with high leakage, and resistor R3 (shipped as an accessory) can be installed in parallel with R4; R3 has a value of only 10 M Ω .

An input protection circuit is built into the preamplifier. It protects the input FET from any large transient voltages that would otherwise damage the transistor. This is discussed in the Notice inside the front cover. The protection circuit also provides a damping resistance on the input so that relatively long cable lengths can be used between the detector and the preamplifier without disrupting the system stability.

A Test Pulse connector with built-in charge terminator is provided for use with a pulse generator such as the ORTEC 419, 448, or 480 to simulate the signal from the detector. This allows a check of the

system performance while an experiment is in progress.

The 142IH will accommodate up to ± 3000 V for the detector. The output pulse polarity is the same as the applied bias polarity. The 142IH Preamplifier output can be connected to a shaping main amplifier such as the ORTEC 451, 485, or 572 for energy spectroscopy or to a timing filter amplifier such as the ORTEC 474 for time spectroscopy. Output connectors are provided so that both types of analysis can be operated simultaneously.

If it is necessary to open the case for any reason, observe the following instructions carefully to prevent serious injury to yourself and/or damage to the instrument.

DANGER Observe the steps that are included in the Notice at the front of the manual to discharge the high voltage and prevent shock; **the voltage levels that can be used are lethal** and the capacitors are very high quality so they retain a charge much longer than normally expected.

Do not touch the high-megohm resistors, R4 and R7, with your bare fingers; the presence of skin oil can reduce the resistance of the component and alter operating characteristics.

See Section 4 for instructions that involve the protection circuit.

2. SPECIFICATIONS

2.1. PERFORMANCE

NOISE Increases with increasing input capacitance. Typical performance values, based on silicon equivalent of $\epsilon = 3.6$ eV at $\tau = 2\mu\text{s}$, are 1.9 keV at 0 pF; these degrade to 4.6 keV at 100 pF and to 35 keV at 1000 pF.

RISE TIME Based on a +0.5 V signal through either output into a 93 Ω circuit and measured from 10% to 90% of peak amplitude; 20 ns at 0 pF and 50 ns at 100 pF.

SENSITIVITY Nominal, measured through either output, 15 mV/MeV Si.

ENERGY RANGE 0 to 100 MeV Si.

ENERGY RATE 3×10^5 MeV/s.

DYNAMIC INPUT CAPACITANCE 10,000 pF.

INTEGRAL NONLINEARITY $\leq 0.05\%$ for 0 to ± 7 V open circuit, or ± 3.5 V terminated in 93 Ω .

TEMPERATURE INSTABILITY $\leq \pm 100$ ppm/ $^\circ$, 273 to 323 K (0 to 50 $^\circ$ C).

DETECTOR BIAS ISOLATION ± 3000 V.

OPEN LOOP GAIN $\geq 40,000$.

2.2. INPUTS

INPUT Accepts input signal from a detector and extends operating bias to the detector.

BIAS Accepts the bias voltage for the detector from a bias supply.

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

2.3. OUTPUTS

E AND T (for Energy and Timing) Two connectors furnish identical signals through two output paths; either or both outputs can be used as required, and they are interchangeable; $R_o = 93\Omega$ through each connector and the output polarity is opposite from the input pulse polarity (output pulse polarity is the same as bias polarity).

2.4. CONNECTORS

INPUT and BIAS Type SHV.

TEST PULSE, E, and T Type BNC.

POWER CABLE 10 ft (3 m) captive power cable, ORTEC 121-C1; longer lengths available from ORTEC on special order.

2.5. ELECTRICAL AND MECHANICAL

POWER REQUIRED Furnished from NIM bin and power supply through any ORTEC main amplifier, or from an ORTEC 114 Preamplifier Power Supply; built-in captive cable is compatible with either source.

+24 V, 30 mA; -24 V, 10 mA; +12 V, 15 mA;
-12 V, 15 mA.

DIMENSIONS 1.5 x 2.4 x 4.5 in., plus 10-ft cable (38 x 61 x 114 mm, plus 3 m cable).

3. INSTALLATION

3.1. CONNECTION TO DETECTOR

A direct connection with shielded cable should be made between the detector and the Input SHV connector on the preamplifier. The performance of the 142IH Preamplifier, like that of all similar instruments, is degraded as the capacity at the input increases. Therefore it is important that the length of coaxial cable used between the detector and the preamplifier be kept at the minimum length that is

necessary. Also it is preferable to use 93 Ω or 100 Ω characteristic impedance cable rather than 75 Ω or 50 Ω cable because the capacity per foot is less for the cable with the higher characteristic impedance. Type RG-62/U cable is recommended; this has a 93 Ω impedance and a capacitance of 13.5 pF/ft (40.1 pF/m). An AMP 51426-2 connector mates with the SHV connector on the 142I Preamplifier.

Once the input cable installation has been made, the electronic noise performance of the 142IH can be predicted by calculating the cable capacity from the above information and adding the capacity expected from the detector.

3.2. CONNECTION TO AMPLIFIERS

Either or both the E and T outputs of the 142IH can be connected to an amplifier input for further processing. The output impedance through either of these connectors is 93Ω , providing a series termination for 93Ω cable so that long cable lengths can be driven easily. Although the outputs are marked E (for Energy) and T (for Timing), the pulse characteristics are identical and the circuits are interchangeable.

In an energy spectroscopy system, the preamplifier output is furnished into a shaping main amplifier. In a timing spectrometer system, the preamplifier output is furnished into a timing filter amplifier. With the dual output connections on the 142IH, the signals can be furnished simultaneously to both types of spectrometer systems. If either the E or T output connector is not being used, it should simply be left open-circuited (unterminated).

3.3. INPUT POWER

Power for the 142IH is supplied through the Power Cable that is captive through the rear panel of the unit. The normal connection for this power cable is included on the rear panel of the mating ORTEC amplifier, furnishing ± 12 V and ± 24 V from the bin and power supply in which the amplifier is operated. If this facility is not available or if such a connection would increase the loading on the bin and power supply beyond its maximum rated capacity, use an ORTEC 114 Preamplifier Power Supply to furnish the operating power requirements through the captive cable. The ORTEC 114 can furnish power for two ORTEC preamplifiers simultaneously if desired.

3.4. TEST PULSE

A voltage test pulse for energy calibration can be accepted through the Test Pulse input connector on the 142IH without the use of an external charge

terminator. The test input of the preamplifier has an input impedance of 93Ω and its circuitry provides charge injection to the preamplifier input. The shape of this pulse should be a fast risetime (less than 40 ns) followed by a slow exponential decay back to the baseline (200 to 400 μ s). While the test pulses are being furnished, connect either the detector (with bias applied) or the equivalent capacitance (without bias applied) to the Input connector on the 142IH.

The Test Pulse input may be used in conjunction with the output of a pulser such as the ORTEC 419 or 448 to calibrate the preamplifier E output amplitude in terms of energy for calibration of a multichannel analyzer. However, due to stray coupling between the test circuit and other portions of the preamplifier circuitry, the transient performance of the preamplifier is best determined by connecting the actual detector signal through the Input connector instead of using the pulse generator output signals for this calibration.

A voltage test pulse for transient response in the 142IH can be accepted through a charge terminator and into the Input connector on the 142IH. If external capacitance is to be included for these tests, an SHV tee can be inserted between the Input connector and the charge terminator, and this will then accommodate the test capacitances. Do not furnish any bias during these tests.

3.5. DETECTOR BIAS INPUT

Operating bias for the detector is supplied to the Bias connector on the 142IH and, through a filter and a large bias resistance, to the Input signal connector. From there it is furnished out through the signal input cable to the detector.

Connect a cable from the detector bias supply (ORTEC 428 or 459 is typical) to the Bias connector on the 142IH. Type SHV connectors are used in this high-voltage circuit and the mating cable should be furnished with the bias supply module.

4. OPERATION

4.1. GENERAL

When the 142IH is installed according to the appropriate information in Section 3, it operates at all times when power is applied from the power source. The power is furnished from either the bin and power supply through a mating amplifier or from an ORTEC 114 Preamplifier Power Supply.

Figure 4.1 is a simplified block diagram of the circuits in the 142IH Preamplifier. The complete

circuit is shown in schematic 142IH-0201-S1, included at the back of the manual. When the protection circuit is in, the diode clamp to ground from a point in the input circuit will protect the input FET transistor from large transients, which are not a part of the input pulse information. When the protection circuit is out, there is no clamp to ground and a series input resistor is shorted by a jumper.

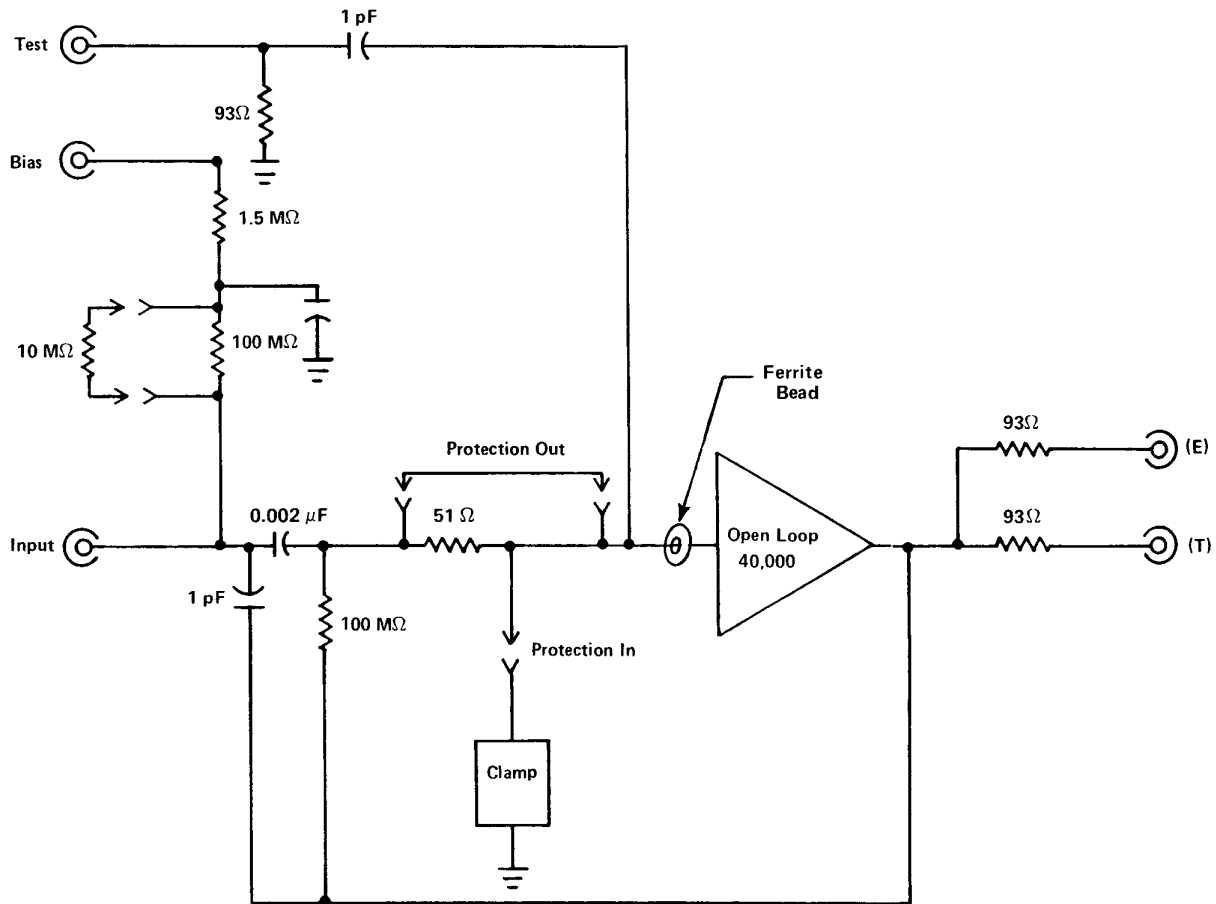


Fig. 4.1. Simplified Block Diagram of the 142IH Preamplifier.

4.2. DETECTOR BIAS

The amount of bias required to operate the detector is specified in the data furnished with the detector. The bias that is accepted into the preamplifier through the SHV Bias connector is furnished through the load resistance (about 100 M Ω) to the Input SHV connector of the preamplifier. If the leakage current through the detector is appreciable, a notable voltage drop will occur across the series load resistance in the preamplifier, and this must be added to the detector requirement when the bias supply level is adjusted.

With the protection circuit in, the input cable can be removed and reconnected without catastrophic damage to the preamplifier even with bias applied to the circuit; but the user must be very cautious to prevent touching the interior of the connector with anything other than a good insulator because potentially lethal high voltage can be present on the center pin of the Input connector under these conditions.

With the protection circuit out, the operating bias level **must be reduced gradually to zero** before the detector is either connected to or disconnected from the Input connector on the 142IH.

4.3. ENERGY OUTPUT

The charge-sensitive loop is essentially an operational amplifier with a capacitive feedback through a 1-pF capacitor. The conversion gain is approximately 45 mV/MeV (Si equivalent). A dc feedback is applied through a 100-M Ω resistor.

The energy signal from the preamplifier is a fast risetime voltage step with an exponential return to the baseline with a time constant of 100 μ s. The polarity of signals through the E output is inverted from the signal polarity at the output of the detector. When a positive bias polarity is used for the detector, its output pulses are negative and so the E output of the preamplifier is positive.

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

4.4. TIMING OUTPUT

The T output connector provides an alternate path for the same output pulses that are furnished through the E output connector. The intent is to provide both connections for convenience when the 142IH Preamplifier is used to drive two systems - one for energy spectroscopy and the other for timing spectroscopy.

4.5. INPUT PROTECTION

A provision is built into the preamplifier to protect the input FET from damage when there are high-voltage transients at its input. These transients can result from any one or more of many causes including detector breakdown, moisture condensation on the Input connector, short circuits or uncharged capacitance connected across the input while bias is applied, 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 a slight degradation of the noise performance of the preamplifier and this increases as detector capacity increases.

With the protection circuit in, the emitter lead of Q11 is attached to the junction between resistor R5 and the FET input. Transistor Q11 is connected as a diode, with both the base and the collector tied to ground through R8. This prevents the voltage in the input circuit from rising beyond the safe limit for the FET input. To take the protection circuit out, simply remove the emitter lead of Q11 from its circuit connection and install a wire jumper across R5.

In order to take full advantage of the risetime capabilities of the 142IH for timing experiments (typical risetimes of 20 to 300 ns for input capacitances from 1 to 500 pF), the total cable length should be kept as short as possible. Due to vagaries in the system installation - ground loops, stray inductances, etc. - and since the maximum cable length is a factor in the input capacitance of the preamplifier, it is not possible to give absolute numbers. In general, it is desirable to keep the length of the input cable less than two feet so that the risetime performance with low capacity detectors will not be degraded significantly.

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 the 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 system. In proving the performance of the preamplifier, it should be removed from the system and be dealt with alone by providing known electrical signals through the input and testing for the proper output signals with an oscilloscope as specified in the following steps:

1. Furnish a voltage pulse to the Test Pulse connector as outlined in Section 3.4. The polarity of the test pulse signal should agree with the expected signal input polarity from a detector.
2. Using a calibrated pulser, the 142IH output, either E or T, should be inverted from the input and have a nominal scale factor of 45 mV per 1 MeV equivalent energy (Si).
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 capacity of equal value placed across the Input connector, and no bias should be applied. This is necessary because the noise contribution of the preamplifier is dependent upon input capacity. The only meaningful statement of the noise level 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 the main amplifier in the system.

The noise performance referenced in the Specifications 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 Input connector, in which case the noise width should be approximately that shown for zero external capacity. In any case, the Input connector and

capacitors, when used, should be completely shielded electrically. A wrapping of aluminum foil around the Input connector or a shielding cap attached to the connector 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 obtained using an ORTEC 572 Spectroscopy Amplifier on which 2- μ s time constants have been selected as specified. 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 the input attenuator, if any, on the main amplifier is set for minimum attenuation.
5. If a multichannel analyzer is used to measure the main amplifier output pulses, testing of the noise performance can be accomplished by merely using a calibrated test pulse generator with a charge terminator. With only the charge terminator connected to the 142IH Input, the spread of the pulser peak thus analyzed will be due to only the noise contribution of the preamplifier and the 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 computed directly from the analyzer readout.
6. It is also possible to determine the noise performance of the preamplifier by use of a wide bandwidth rms ac voltmeter such as the Hewlett-Packard 3400A, reading the main amplifier output noise level and correlating it with expected pulse amplitudes per keV of signal through the input under the same conditions. Again, a calibrated 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) in the Input connector of the 142IH, and with the ac voltmeter connected to the main amplifier output. The noise level indicated on the voltmeter, designated E_{rms} , is then read and

noted. Then a test pulse of known energy, E_{in} (in keV), is applied to the input 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

$$FWHM (keV, Si Det) = \frac{2.35(E_{rms})(E_{in})}{E_{out}}$$

where E_{rms} is output noise in volts on the 3400A meter, E_{in} is the input signal in keV particle energy, and E_{out} is the output signal in volts corresponding to the above input. If the gain of the shaping amplifier is adjusted so that the output pulse height is 2.35 V for an input of 1 MeV equivalent input charge, then the rms meter will be calibrated to read directly in energy (1 mV = 1 keV).

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 previous steps 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 by either the analyzer or 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 its specified parameters. 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 is related directly to the noise width in its normal applications. The most useful purpose for determining this quality for the detector is to occasionally monitor the detector noise width to verify that its characteristics have not undergone any significant changes during use.

10. Use an ORTEC 419 Precision Pulse Generator with a matched charge termination to measure the risetime of the 142IH through the T or E output connector. Connect the 419 output through the charge terminator to the Input of the 142IH and use an oscilloscope with a fast risetime (1 ns if possible). The risetime of the preamplifier can then be computed by:

$$(\text{Total risetime})^2 = (\text{Preamplifier risetime})^2 + (\text{Pulser risetime})^2 + (\text{Oscilloscope risetime})^2$$

The risetime of the 419 is typically 3 ns.

5.2. FACTORY REPAIR

This instrument can be returned to ORTEC for service and repair at a nominal cost. The 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 the necessary 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 factory.