Models 142A, 142B, and 142C
Preamplifiers
Operating and Service Manual

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Manual Revision D

Advanced Measurement Technology, Inc.

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

WARRANTY

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

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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.

CONTENTS

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 under abnormal operating conditions and imposes only a slight resolution degradation and increased rise time. The preamplifier is thus immune to almost anything the operator is likely to do that causes transients either at the detector input 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 over-voltage, 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 and rise time cannot be tolerated, the protection circuit can be removed by simply disconnecting one transistor lead and installing a wire jumper that is included with the preamplifier.

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

1. **COMPLETELY DISCHARGE** the detector bias circuit 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) across the Detector Bias connector on the preamplifier for at least 20 seconds.

The input circuit will be destroyed if the Detector Input connector is shorted while the detector 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, capacitor, or other capacitive device such as a voltmeter probe. A short circuit, either short term or continuous, will cause the applied bias voltage (stored on C2) to be coupled through C2 directly to the input transistor, causing a 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 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 Detector Bias connector on the rear panel of the unit. **DO NOT SHORT** the Detector Input connector on the front panel.

ORTEC MODEL 142A, 142B, and 142C PREAMPLIFIERS

1. DESCRIPTION

The ORTEC 142A, 142B, and 142C Preamplifiers are charge-sensitive units that are designed for use with room-temperature-operated silicon surface-barrier detectors. They are designed to give the ultimate in both energy and timing resolution, with no compromise through either output circuit. The 142A Preamplifier is designed to operate over a detector input capacitance range from 0 to 100 pF; the 142B is for detector input capacitance of 100 to 400 pF; and the 142C from a capacitance of 400 to 2000 pF. The 142A and 142B can operate with higher capacitance, but with performance characteristics that are slightly degraded.

The 142A Preamplifier has a low noise intercept and a moderate slope. The 142B and 142C have a moderate noise intercept and a low slope and are preferred for high-capacitance detectors and high-energy measurements. The wide bandwidth of the 142B is compatible with detector capacitances greater than 100 pF but less than 400 pF and should not be used for capacitances less than 100 pF. The 142C should not be used with detectors less than 400 pF capacitance.

All three models in the 142 Series feature a transformer- coupled differentiated timing output that is directly compatible with most timing applications.

The energy range expected in typical applications is from 0 to 200 MeV. Two simultaneous outputs are provided; the output marked E is for energy measurements and the output marked T is for timing applications. Either or both outputs may be used as desired, since their circuits are isolated from each other. For best results, however, the T output should be terminated in 50 Ω when not in use.

A bias circuit is included to accept the operating voltage required by the surface-barrier detector. The bias input circuit in the preamplifier includes a 100-MΩ load resistor, and any detector leakage current will have to pass through this high resistance. A considerable voltage drop will be expected across this load resistor for a high-leakage detector, and a smaller value of resistance can then be substituted. A 10-MΩ resistor is furnished as an accessory to the preamplifier to be soldered in parallel with the 100-MΩ load resistor when it is required (Section 4.2).

An input protection circuit is built into the preamplifier circuits to protect the input FET from any large transient voltages that would otherwise damage the transistor. This is discussed in the Notice on page vi.

An internal rise time compensation adjustment is accessible through a hole in the case of the unit. See Section 4.5 for adjustment information.

Under normal conditions, the case of the preamplifier should not be opened. However, it is necessary to remove the cover for the addition of the 10-MΩ) resistor in the bias circuit or for removing or reconnecting the input protection circuit. Whenever the case is opened for any purpose, observe the following instructions carefully:

1. Do not touch the high-value resistors, R4 and R7, with your fingers; the presence of skin oil can reduce the resistance of the component.

2. Observe the steps that are included in the Notice on page vi to discharge the high voltage to prevent shock; the capacitors in this preamplifier are very high quality and retain a charge much longer than is normally expected.

See the information in Section 4 for instructions that cover the action to be taken in the bias or protection circuit.

2. SPECIFICATIONS

2.1. PERFORMANCE

NOISE (Figs. 2.1 and 2.2)

Model	Detector Capacitance (PF)	Maximum Noise (KeV) (Si)
142A	0	1.60
142A	100	3.40
142B	100	3.20
142B	1000	19.00
142C	400	7.20
142C	1000	14.50
142C	2000	27.00

INTEGRAL NONLINEARITY ≤0.03%

TEMPERATURE INSTABILITY
142A <±50 ppm/°C from 0 to 50°C.
142B <±100 ppm/°C from 0 to 50°C.
142C <±100 ppm/°C from 0 to 50°C.

OPEN LOOP GAIN
142A >40,000
142B >80,000
142C >80,000

CHARGE SENSITIVITY (Si equivalent)
142A Nominally 45 mV/MeV
142B Nominally 20 mV/MeV
142C Nominally 20 mV/MeV

ENERGY RANGE
142A 0 — 200 MeV
142B 0 — 400 MeV
142C 0 — 400 MeV

RISE TIME, 0 to +0.5 V Pulse at E output on 93Ω Load (Fig. 2.3)
142A <5 ns at 0 pF; < 12 ns at 100 pF.
142B <5 ns at 100 pF; < 25 ns at 1000 pF.
142C <11 ns at 400 pF; < 20 ns at 1000 pF.

DECAY TIME
142A Nominally 500 µs.
142B Nominally 1000 µs.
142C Nominally 1000 µs.

RECOMMENDED RANGE OF INPUT CAPACITANCE
142A 0 to 100 pF.
142B 100 to 400 pF.
142C 400 to 2000 pF.

DETECTOR BIAS VOLTAGE ±1000V maximum.

2.2. INPUTS

INPUT Accepts input signals 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 voltage pulses from a pulse generator for instrument and system calibration; R_{in} = 93Ω.

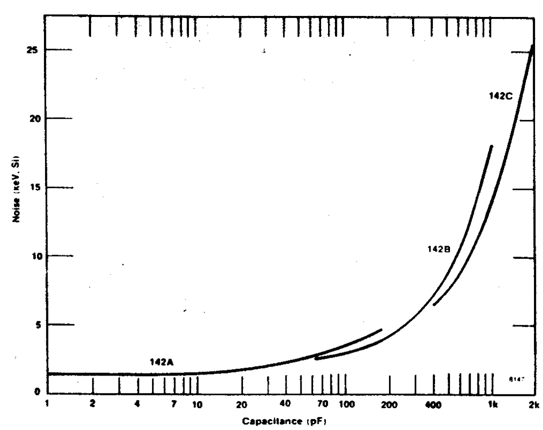

Fig. 2.1. Typical Noise as a Function of Capacitance Measured with an ORTEC 572 Amplifier and 2-µs Time Constant.

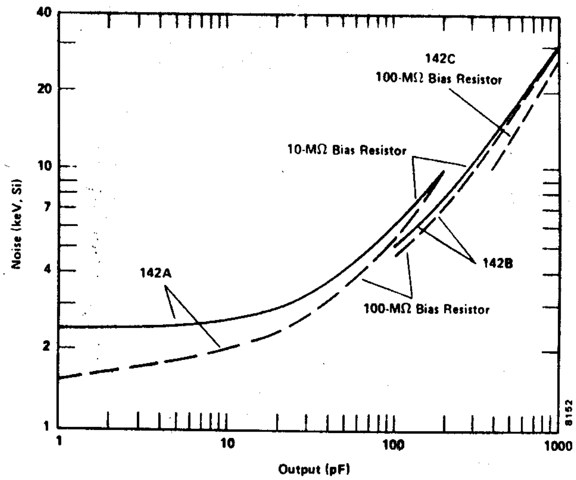

Fig. 2.2. Typical Noise as a Function of Capacitance Measured with an ORTEC 572 Shaping Amplifier and 0.5-µs Time Constant.

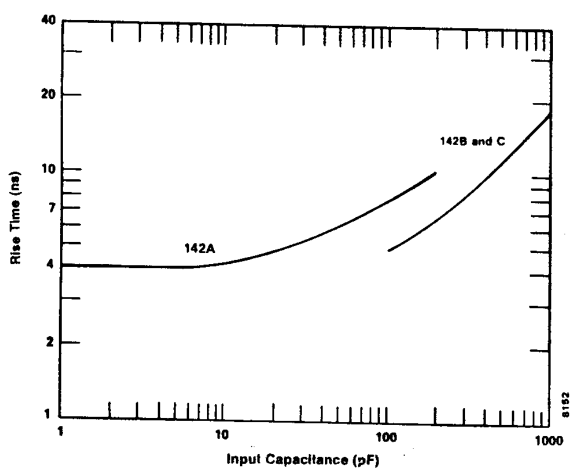

Fig. 2.3. Typical Rise Time Data for 142 Preamplifiers with Rise Time Compensation Optimized at Each Data Point.
(Values given are for a +0.5-V signal into 93Ω from the E channel.)

2.3. OUTPUTS

E Furnishes the output signals through R_o = 93 Ω for energy measurements; polarity is opposite from input pulse polarity (Fig. 2.4.).

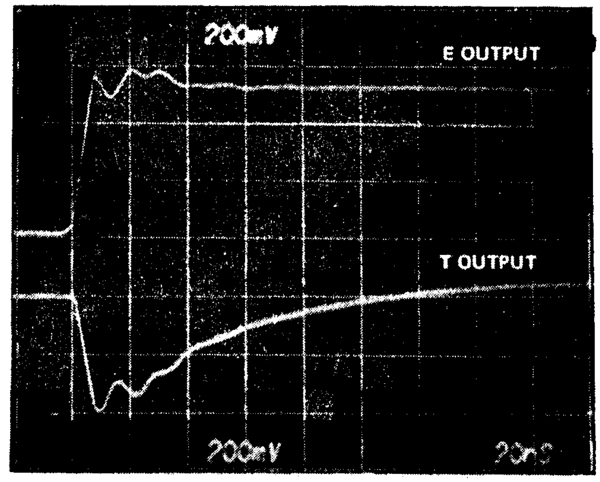

Fig. 2.4. 142A,B, and C Outputs; Detector Bias Polarity Positive.

T Furnishes a differentiated output signal compatible with typical 50 Ω timing system requirements; polarity is the same as the input pulse polarity (Fig. 2.4.).

2.4. CONNECTORS

INPUT, TEST, E, AND T 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 lengths available from ORTEC on special order.

2.5. ELECTRICAL AND MECHANICAL

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

142A +24 V, 20 mA; -24 V, 1 0 mA; +1 2 V, 15 mA; -12 V, 15 mA.
142B +24 V, 40 mA; -24 V. 10 mA; +12 V, 15 mA; -12 V, 15 mA.
142C +24 V, 40 mA; -24 V, 10 mA; +12 V, 15 mA; -12 V, 15 mA.

DIMENSIONS 3.8l x6.l x8.89cm(l.5 x2.375 x3.5in.) plus 10-ft cable.

3. INSTALLATION

3.1. CONNECTION TO DETECTOR

A direct connection with 93 Ω or 100 Ω shielded cable should be made between the detector and the Input connector on the preamplifier. For best results, the length of this cable must be as short as possible. This will not only minimize the preamplifier noise (due to the capacitive loading of the cable) but will also maintain the stability of the preamplifier. The complex impedance presented to the preamplifier input that is due to transmission line effects acting on the detector system impedance can disrupt the stability of the whole system. The interconnecting cable, which acts as an impedance transformer, must be kept as short as possible for the system to remain compatible with the wide bandwidth of the preamplifier. Due to vagaries in the detector system, a definite maximum length cannot be specified but is typically 24 inches for the 142A and 15 inches for the 142B and 142C.

Type RG-62/U cable is recommended for the detector to preamplifier connection. This is 93 Ω cable with a capacity of 13.5 pF/ft.

After the input cable has been installed, the electronic noise performance of the preamplifier can be predicted by adding the capacity furnished by the detector to the capacity of the cable. The cable capacity can be calculated from its length and its rated capacity per foot. Figures 2.1 and 2.2 show typical performance at two commonly-used amplifier shaping time constants, based on the total input capacitance.

3.2. ENERGY OUTPUT CONNECTION TO MAIN SHAPING AMPLIFIER

The E output of the preamplifier can be used to drive a long 93 Ω line to a shaping main amplifier and is designed to be directly compatible with ORTEC main amplifiers. It can be used with any shaping main amplifier if a power supply is also used to furnish the preamplifier power requirements that are available on all ORTEC main amplifiers.

3.3. TIMING OUTPUT CONNECTION TO TIMING MODULES

The T output of the preamplifier can be used to drive a long, terminated 50 Ω cable to a timing module. A typical timing module is an amplifier, fast discriminator, or a time-to-amplitude converter. When not being used, the T output should be terminated in 50 Ω.

For a positive detector bias voltage polarity, the T output signal polarity is negative, since the timing channel operates noninverting with respect to the detector output. For ORTEC ruggedized surface-barrier detectors which require a negative detector bias polarity, the E output may be used as the source of a negative timing pulse or the T output can be inverted through a suitable amplifier.

3.4. INPUT OPERATING POWER

Power for the 142 Preamplifiers is supplied through the captive power cord and 9-pin Amphenol connector. This connector can be attached to the mating power connector on any ORTEC main amplifier or 114 Preamplifier Power Supply. The preamplifier's power requirements are added to the operating power, requirements of the amplifier or power supply to which it is connected.

3.5. TEST PULSE

A voltage test pulse for energy calibration can be accepted through the Test input connector on the 142 without the use of an external terminator. The Test input of the preamplifiers has an input impedance of 93 Ω and its circuitry provides charge injection to the preamplifier input. The shape of this pulse should be a fast rise time (less than 10 ns) followed by a slow exponential decay back to the baseline (200 to 400 μs). While test pulses are being furnished to the Test input, connect either the detector (with bias applied) or its equivalent capacitance to the Input connector on the 142.

The Test input may be used in conjunction with a pulser such as the ORTEC 419 or 448 to calibrate the preamplifier E Output amplitude in terms of energy or for multichannel analyzer calibration. 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 signals.

A voltage test pulse for transient response in the 142 can be accepted through a charge terminator and into the detector Input connector. If external capacitance is to be included for these tests, a BNC 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.

3.6. DETECTOR BIAS INPUT

Operating bias for the detector is supplied to the Bias connector through a filter and 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 is typical) to the Bias connector on the 142. The connectors used in this high-voltage circuit are type SHV.

4. OPERATION

4.1. GENERAL

Figure 4.1 is a simplified block diagram of the circuitry in the 142A, 142B, and 142C Preamplifiers. Capacitor C34 is not included in the 142A but is included in the 142B and C. Resistor R3 is furnished as an accessory to the preamplifier and can be installed in parallel with R4 for those applications where the detector leakage current is great enough to cause too much voltage drop across R4. Where the leakage current is small, R3 should not be installed in the circuit because it would tend to degrade the noise performance.

4.2. DETECTOR BIAS

The amount of bias required by the detector is specified in the data furnished with the detector. The bias accepted into the preamplifier through the SHV Bias connector is furnished through R2 and R4 (approximately 100 MΩ) to the Input BNC connector of the preamplifier. If the detector leakage current is appreciable, a notable voltage drop will occur across the series load resistor in the preampliflier, and this must be added to the detector requirement when the 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 R3, the 10-MΩ resistor, in parallel with R4 as indicated in Fig. 4.1. This must be done very carefully to prevent damage to the preamplifier circuits and requires that the case be opened. Use the following suggestions:

1. Remove the source of bias and short the Bias connector for at least 20 seconds (see Notice on page iv).

2. Remove the case to expose the preamplifier circuits. Locate but **do not touch** the 100-MΩ resistor, R4. Resistor R3 will be soldered in parallel with R4.

3. Be very careful to prevent excessive heating of any components in the preamplifier while soldering the leads of R3 to the leads of R4 so that the resistances are in parallel. Be sure that each solder joint is clean, smooth, and shiny after assembly; when high voltage is applied to this circuit, corona leakage may develop at any sharp points that may be left.

4. When operation with a low-leakage detector is desired, remove R3 from the circuit carefully, observing all of the above precautions.

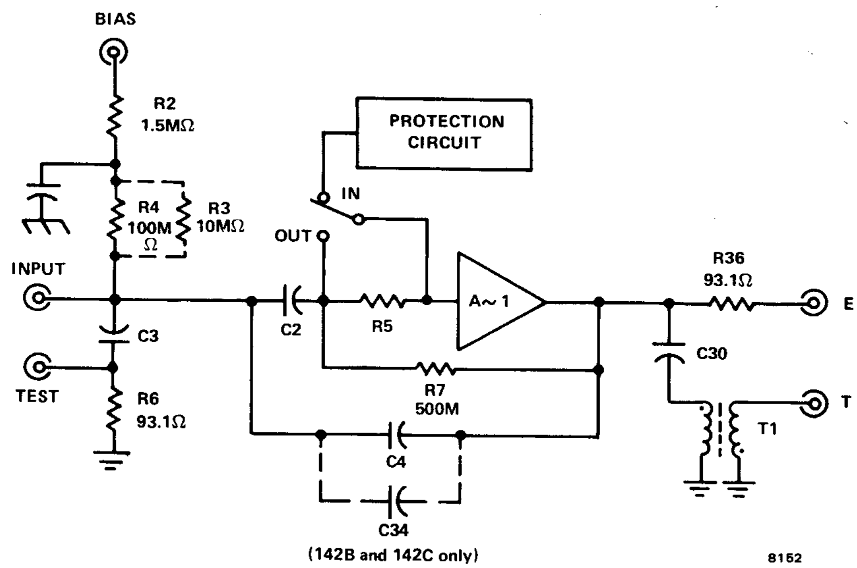

Fig. 4.1. Simplified Block Diagram of the Circuitry in ORTEC's 142A, 142B, and 142C Preamplifiers.

4.3. ENERGY OUTPUT

The charge-sensitive loop is essentially an operational amplifier with capacitive feedback. The feedback capacitor in the 142A is C4, with a value of 1 pF, and the conversion gain is nominally 45 mV/MeV. The 142B and C circuits add C34 in parallel with C4 for a total feedback capacitance of 2 pF, and the conversion gain is about 20 mV/MeV. The conversion gain of either preamplifier can be increased by decreasing the value of the feedback capacity but a subsequent increase in rise time will result.

The upper limit on the conversion gain is the stray capacity in the circuit with C4 (and C34) completely removed. The stray capacity is about 0.1 toO.2 pF. If less conversion gain is desired, the value of the feedback capacity can be increased, but this may affect the stability of the preamplifier. The maximum recommended additional capacity is 1.5 pF for the 142A and 0.5 pF for the 142B and C.

The energy output signal from the preamplifier is a fast-rise-time voltage step with an exponential return to the baseline; the 142A pulse decays in about 500 µs and the 142B and C pulses decay in about 1000 µs. The polarity of these output pulses is inverted from the signal polarity at the detector output. When the (normal) positive bias polarity is used for the detector, the detector output pulses are negative and the E output of the preamplifier is positive (Fig. 2.4). When ORTEC ruggedized surface-barrier detectors are used as the input to the preamplifier, negative bias is required and this results in positive detector pulses and negative E output pulses from the preamplifiers. The output rise times are slightly longer for operation with detectors biased with negative voltage since the preamplifier has been optimized for widest bandwidth for the most common detector mounting configuration.

4.4. TIMING OUTPUT

As indicated in Fig. 4.1, the T output from the preamplifier is a transformer differentiated and inverted version of the E output. This differentiation removes low-frequency noise for better timing results. Due to the differentiation of the charge loop output, any overshoot present will appear to increase the rise time of the timing output (Fig. 4.2). This, however, does not affect typical timing experiment results since it is the initial slope of the waveform that carries the information of importance in timing. Similarly, due to stewing effects and large signal bandwidth considerations within the charge loop, the large-signal rise time is slightly longer than that specified for the 142 series at 1.0 V (0.5 V terminated) at the E output. Again, however, this has no impact on a typical timing experiment since the slope of the leading edge is maintained over the whole dynamic range of the preamplifier, and since discriminator thresholds are typically set well below 1.0 V.

In Fig. 4.2, the rise time of the T output appears to be longer than that for the E output but this is not necessarily true. The 10% and 90% check points on the E rise time are based on the E_{final} level, which is less than the initial overshoot. On the other hand, the 10% and 90% check points on the T rise time are based on the peak level of the initial overshoot, which is relatively more than the final value for the E output.

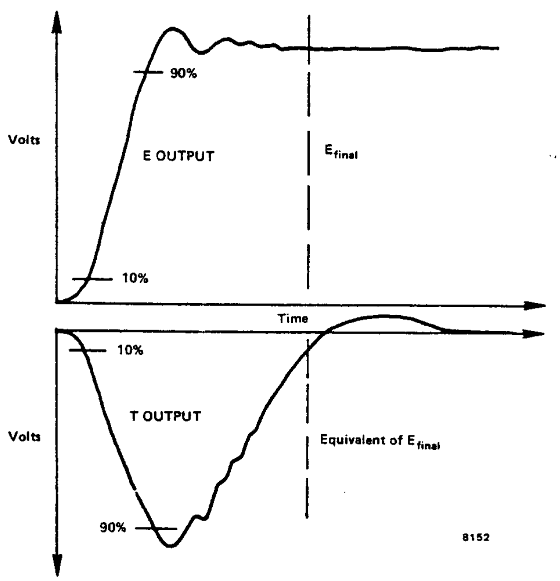

Fig. 4.2. Output Rise Time Measurements.

4.5. COMPENSATION ADJUSTMENT

CAUTION

Do not use a metal screwdriver for this adjustment; there is a possibility of high-bias voltage leakage on the printed circuit that could cause a shock.

A bandwidth compensation control is accessible to the user of the 142 to optimize the rise time of the T and E output signals for a change of detector capacitance. Although this is not necessary for energy measurements, a typical timing experiment will provide the best timing resolution when the rise time is optimized with this control. The adjustment is accessible through an opening in the bottom of the case and should be adjusted with a small plastic screwdriver or a TV tuning tool.

When the 142 Preamplifier is shipped from the factory, the compensation adjustment has been set for the specified rise time resolution for a 0-pF input capacity; in the 1428, the adjustment has been made for a 100-pF input capacity; in the 142C, the adjustment has been made for 400 pF. For optimum results for other input capacities, the control should be adjusted under actual operating conditions.

If the control has been adjusted for optimum bandwidth for a specific input capacity and the input circuit is then changed to provide less capacity, control readjustment is necessary so that the preamplifier will not oscillate. If the input capacity is increased from the value for which the adjustment has been made, the preamplifier should be stable and should not oscillate.

In the 142B and C there is a ferrite bead on the lead between the input capacitor and the first amplifier stage. This bead will permit the use of input cable lengths up to about 15 in. When the input cable length is appreciably less than 15 in., this bead may be removed and the rise time characteristics may be improved by a factor of as much as 30%. Also, the experimenter may use the bandwidth control to underdamp the preamplifier to obtain even faster rise times than those that are specified.

4.6. INPUT PROTECTION

A provision is built into the preamplifier to protect the input FET stage from damage when high-voltage transients are applied to 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 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, which increases as detector capacity increases.

With the protection circuit in, the emitter lead of Q11 is attached to the input of the first FET stage and this prevents the voltage at that point from increasing beyond the safe range for the FET input. Resistor R5 protects both the clamp and the FET from damage. To take the protection circuit out, simply remove the emitter lead of Q11 from its circuit connection and install a wire jumper across R5. A formed wire jumper is included as an accessory in the shipping bag and is to be used for this purpose when operation is desired with the protection circuit bypassed.

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 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 the proper output signals with an oscilloscope as specified below.

1. Furnish a voltage pulse to the Test connector, as outlined in Section 3.5. The polarity of the test pulse signal should agree with the expected signal input polarity from a detector.

2. Using a calibrated pulser, the 142A E output should be inverted from the input polarity and should have a nominal scale factor of 45 mV output per 1 MeV equivalent energy (Si). The 142B and C E outputs should also be inverted from the input polarity and have about 20 mV per 1 MeV input equivalent energy. The timing outputs should have the same polarity as the inputs with a scale factor of about 20% less than the signals through the E outputs.

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 Input connector. 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 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 the time constants have been set 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 input attenuators, if any, on the main amplifier are set for minimum attenuation.

5. If a multichannel analyzer is used following the main amplifier, testing of the noise performance can be accomplished by merely using a calibrated test pulse generator with charge terminator, as outlined in step 1. With only the charge terminator connected to the Input of the 142, the spread of the pulser peak thus analyzed will be due only to the 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 computed 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 3400A, 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 Input connector of the 142, and with the ac voltmeter connected to the main amplifier output. The noise voltage indicated on 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 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

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

where E_{rms} is output noise in volts on the 3400A 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 pulse height is 2.35 V for an input of 1 MeV equivalent charge, then the rms meter will be calibrated 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 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.

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

$$(\text{Total rise time})^2 = (\text{Preamp rise time})^2 + (\text{Pulser rise time})^2 + (\text{Oscilloscope rise time})^2.$$

The rise time of the 419 is typically 3 ns.

5.2. CLEANING

If it is necessary to clean the components and/or the printed circuit in the 142 at any time, use only methanol as a cleaning solvent. Do not use compressed air or other source of pressurized gas unless it is known to be clean and free of compressor oil, and do not use any cleaning agent other than methanol.

5.3. FACTORY REPAIR

This instrument can be returned to ORTEC 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 ORTEC, (865) 482-4411, before sending in an instrument for repair to obtain shipping instructions and so that the required Return Authorization Number can be assigned to the unit. Write this number on the address label and on the package to ensure prompt attention when it reaches the factory.