Model 480
Pulser
Operating and Service Manual

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Advanced Measurement Technology, Inc.
a/k/a/ ORTEC®, a subsidiary of AMETEK®, Inc.

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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.

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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.

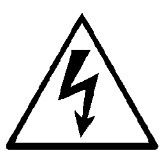
WARNING Indicates a hazard that could result in bodily harm if the safety instruction is not observed.

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.

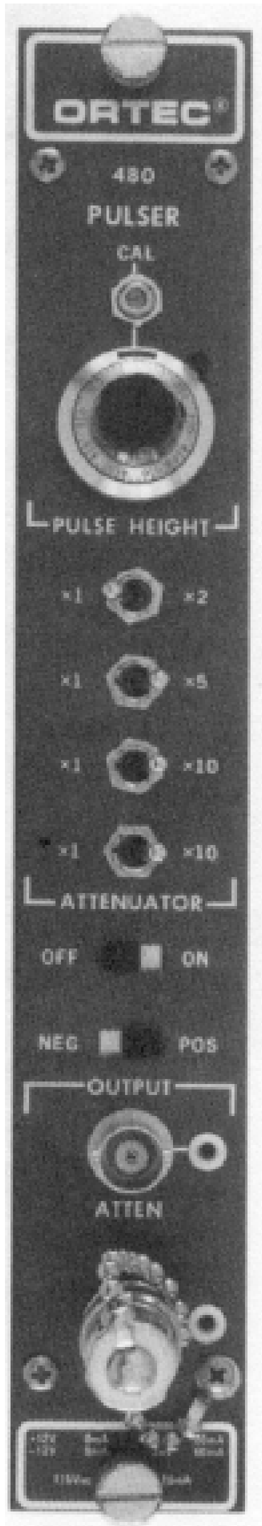
Cleaning Instructions

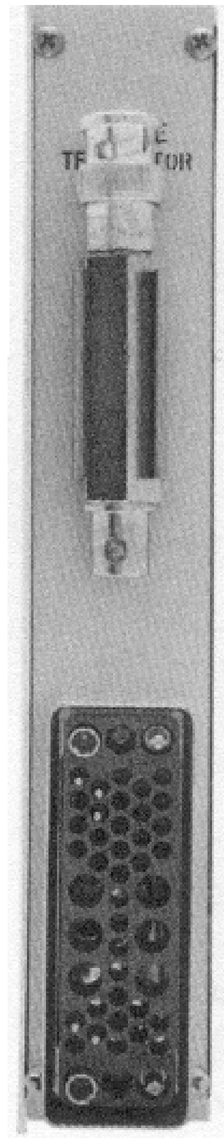
To clean the instrument exterior:

- 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.


ORTEC®
480
PULSER
CAL
PULSE HEIGHT
×1 ×2
×1 ×5
×1 ×10
×1 ×10
ATTENUATOR
OFF ON
NEG POS
OUTPUT
ATTEN



ORTEC MODEL 480
PULSER

1. DESCRIPTION

1.1. GENERAL

The ORTEC 480 is a modular pulse generator designed to simulate the detection of a nuclear particle reaction in a solid-state or scintillation detector. The unit features good stability as a function of temperature and time, 1% overall accuracy, and a front panel Cal control which enables it to be calibrated to read directly in terms of equivalent energy deposited in a detector. The pulses are generated with a mercury relay switch whose frequency is the frequency of the ac line. The instrument has an internal stable reference voltage that is effectively independent of the modular power supply and ac line voltage changes. The unit has four attenuator toggle switches for a maximum attenuation of 1000:1. The direct output precedes the attenuator switch and provides a means of stable oscilloscope triggering. Two terminators are provided with the 480: a charge terminator and a 100Ω voltage terminator. The use of a charge terminator allows the voltage output pulse of the 480 to be converted to a charge pulse for subsequent amplification by a charge-sensitive preamplifier. A holder is provided on the rear panel to store the charge terminator when it is not in use.

This instrument is designed to meet the recommended interchangeability standards of US DOE Report TID-20893 (Rev.). An ORTEC 4001/4002 Series Bin and Power Supply provides all necessary power through the rear module power connector. The ORTEC 400 Series is designed so that it is not possible to overload the Bin Power Supply with a full complement of modules in the Bin. However, this may not be true when the Bin contains modules of other than ORTEC design. All signal levels and impedances are compatible with other modules in the ORTEC 400 Series.

1.2. BASIC FUNCTION

The 480 provides output pulses that are characterized by a fast rise time and a slow exponential decay time. These pulses are generated by charging a capacitor to an internal reference voltage through a mercury relay and then discharging the capacitor through the switching action of the mercury relay into a fixed resistive load. The use of mercury-wetted relay contacts provides a very fast rise time, typically less than 5 nsec 10-90% rise time, with an absolute minimum of contact bounce or other perturbations of the waveform for the first few microseconds. The output impedance of the pulse generator on both the direct and attenuated output is 100Ω. The direct output provides a trigger pulse that allows the stable synchronization of an oscilloscope or other timing equipment from a signal which does not vary in amplitude as the attenuators are switched in and out. The attenuated output has a series of pi-attenuators between the mercury-wetted relay contacts and the output BNC connector. This allows the attenuation of the signal by a fixed amount, depending upon the particular switch operated in the series attenuator. The primary purpose of the pulse generator is to simulate radiation detection signals. Since the pulses are generated from an electromechanical device (the mercury-wetted relay), the frequency of the pulse generator is correspondingly rather slow, i.e., the frequency of the ac line.

2. SPECIFICATIONS

2.1. PERFORMANCE

Temperature Stability 0.01%/°C, 0 to 50°C.

Line Voltage Stability 0.005% per 10% change in line voltage.

Ripple and Noise 0.003% of pulse amplitude.

Nonlinearity ±0.25% of full scale.

Rise Time Exponential waveform, <10 nsec (10 to 90%).

Fall Time Exponential decay with 200- or 400-μsec time constant (depending on whether or not the direct output is terminated).

2.2. CONTROLS

Cal 22-turn potentiometer on front panel, covers >2:1 amplitude span for normalization of Pulse Height control to read directly in equivalent energy.

Pulse Height Front panel potentiometer, controls output pulse height from zero volts to the maximum determined by the Attenuator switches, the Cal control setting, and the termination load.

Attenuator Front panel switches, provide step attenuation over 1000:1 range with 1% resistors (X2, X5, X10, X10).

Off/On Front panel slide switch, allows internal relay to be driven from the ac line.

Neg/Pos Front panel slide switch, determines polarity of the output signal.

2.3. OUTPUTS

Atten Front panel BNC connector provides positive or negative dc-coupled output with an impedance of 100Ω.

Direct Front panel BNC connector provides positive or negative dc-coupled. 0- to 10-V pulse into a high impedance and 0- to 5-V max pulse into 100Ω. This is equivalent to a range of 0- to 220-MeV energy referred to a silicon detector, when used with associated charge terminator.

Accessories Included One 100Ω voltage terminator and one charge terminator.

2.4. ELECTRICAL AND MECHANICAL

Power Required

+24 V 60 mA; +12 V, 0 mA;
-24 V 60 mA; -12 V, 0 mA.
115 V ac, 8 mA (used only to drive relay).

Weight (Shipping) 4.1 lb (1.86 kg).

Weight (Net) 2.1. lb (0.95 kg).

Dimensions NIM-standard single-width module (1.25 by 8.714 in.) Per TID-20893 (Rev.).

3. INSTALLATION

3.1. GENERAL

The 480 contains no internal power supply but is used in conjunction with an ORTEC 4001/4002 Series Bin and Power Supply, which is intended for rack mounting. Therefore if vacuum tube equipment is operated in the same rack with the 480, there must be sufficient cooling air circulating to prevent any localized heating of the 480 and the associated Bin and Power Supply. The temperature of equipment mounted in racks can easily exceed 120°F (50°C) unless precautions are taken. The 480 should not be subjected to temperatures in excess of 120°F.

3.2. CONNECTION TO POWER

Always turn off the Bin Power Supply when inserting or removing modules. The 4001/4002 has test Points on the Power Supply control Panel to monitor the dc voltages. When using the 480 outside the 4001/4002, ensure that the power jumper cable used properly accounts for the Power Supply grounding circuits provided in the recommended standards of US DOE TID-20893 (Rev.). Both high-quality and power-return ground connections are provided to ensure proper reference voltage feedback into the Power Supply, and these must be preserved in remote installations. Care must also be exercised to avoid ground loops when the module is operated outside the Bin.

If the 480 should be inserted in a bin that has no ac voltage distribution, the unit will not operate since the relay is driven from the ac line on pins 33 and 41.

4. OPERATION

4.1. PANEL CONTROLS

Cal A 22-turn potentiometer on the front panel varies the output pulse height continuously over a 2.5:1 range (approximately) to allow for normalization of the Pulse Height dial setting.

Pulse Height The Pulse Height potentiometer on the front panel controls is the output pulse height from zero volts to the maximum determined by the Attenuator toggle switches and the termination load. This 10-turn potentiometer has a calibration linearity of ±0.25%.

Attenuators Four toggle switches on the front panel control pi-attenuators in the attenuated output line; the maximum attenuation is 1000:1. These switches have an accuracy controlled by 1% metal film resistors and depend upon the attenuated output being terminated in 100Ω.

Off/On This front panel slide switch allows the internal relay to be driven from the ac line. The frequency of the ac line will be 50 to 60 Hz.

Neg/Pos The Polarity of the output signal will be either negative (-) or Positive (+) as determined by the setting of this front panel slide switch.

4.2. INITIAL TESTING AND OBSERVATION OF PULSE WAVEFORMS

See Section 6.1 for test performance data.

4.3. CONNECTOR DATA

CN 1 The Direct Output BNC connector provides a dc-coupled output that looks back directly at the relay and has an output impedance of 100Ω. The output of this connector provides a constant output voltage for a given setting of the Pulse Height control independent of the position of the Attenuator switches. Output voltage range is from 0 to 5 V maximum into 100Ω and 0 to 10 V into a high impedance. The direct output may or may not be terminated with a 100Ω terminator. If the direct output is terminated with a 100Ω terminator, the decay time of the output pulse will change from a nominal value of 400 µsec to a value of 200 µsec. The polarity of the Direct Output pulse will be either negative or positive as determined by the Neg/Pos switch.

CN 2 The Attenuated Output BNC connector provides a dc-coupled output connector with an output impedance of 100Ω. The attenuated output has the Attenuators in series with it. The use of these switches therefore alters the pulse amplitude appearing at the attenuated output for a given setting of the Pulse Height control. The attenuated output should always be terminated with 100Ω. The polarity of the output pulse will be determined by the Neg/Pos switch.

TPI An oscilloscope test point is on the front panel for monitoring the signal on the Direct Output BNC connector CN1. This test point has a 470Ω series resistor connecting it to CN1.

TP2 An oscilloscope test point is also on the front panel for monitoring the signal on Attenuated Output BNC connector CN2. This test point has a 470Ω series resistor connecting it to CN2.

4.4. TYPICAL OPERATING CONSIDERATIONS

Charge and Voltage Terminators A charge terminator that consists of a 100Ω shunt resistor with a 2-pF series capacitor is supplied for use with ORTEC charge-sensitive preamplifiers. When this terminator is used, the maximum output pulse is 5 V on 10 pC (220 MeV for silicon diode detectors). When the charge terminator is used to drive a charge-sensitive preamplifier, a coaxial cable having an impedance of approximately 100Ω (RG-62/U) should be used between the pulse generator and the charge terminator. The terminator should be located at the input connector of the preamplifier. The charge terminator may be used with or without a detector being applied to the input of a preamplifier. If a detector is connected to the preamplifier, detector bias must be applied to reduce the effective detector capacity shunting the charge-sensitive preamplifier input. Also, with the charge terminator used simultaneously with a semiconductor detector, it must be remembered that the charge terminator effectively shunts the detector with approximately 2.5 pF of shunt capacity, which will correspondingly degrade the signal-to-noise performance of the preamplifier.

For voltage drive to an instrument under test, use coaxial cable having an impedance of approximately 100Ω (RG-62/U) between the pulse generator and the instrument under test. Place a 100Ω termination at the instrument end of the cable in shunt with the input of the instrument.

Calibrating the Test Pulser and Amplifier for Energy Measurements The 480 may easily be calibrated so that the maximum Pulse Height dial reading (1000 divisions) is equivalent to a specific MeV loss in a radiation detector. The procedure is as follows:

1. Connect the detector to be used to the spectrometer system, i.e., preamplifier, main amplifier, and biased amplifier.

2. Allow particles from a source of known energy (alpha particles, for example) to fall on the detector.

3. Adjust the amplifier gains and the bias level of the biased amplifier to give a suitable output pulse.

4. Set the pulser Pulse Height potentiometer at the energy of the alpha particles striking the detector (e.g., for a 5.1-MeV alpha particle, set the dial at 510 divisions).

5. Turn on the pulser; use the Cal potentiometer and the Attenuator switches to set the output due to the pulser to the same pulse height and shape as the pulse obtained in step 3.

Amplifier Noise and Resolution Measurements As shown in Fig. 4.1, a preamplifier, amplifier, pulse generator, oscilloscope, and wide-band rms voltmeter, such as the Hewlett- Packard 400D, are required for this measurement. Connect a suitable capacitor to the input to simulate the detector capacitance desired. To obtain the resolution spread due to noise:

1. Measure the rms noise voltage (E_{rms}) at the linear amplifier output.

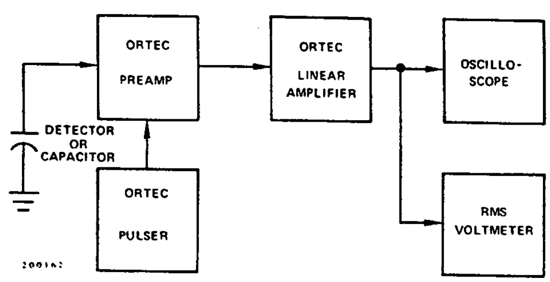


Fig. 4.1. Measuring Amplifier and Detector Noise Resolution.

2. Turn on the 480 and adjust the linear amplifier output to any convenient readable voltage, E_o, as determined by the oscilloscope.

The full width at half maximum (FWHM) resolution spread due to the amplifier noise is then N(FWHM) = 2.66 E_{rms} E_{dial}/E_o, where E_{dial} is the pulser dial reading in MeV, and the factor 2.66 is the correction factor for rms to full width at half maximum (2.35) and noise to rms meter correction (1.13) for average indicating voltmeters such as the Hewlett-Packard 400D. The resolution spread will depend upon the total input capacity, since the capacitance degrades the signal-to-noise ratio much faster than the noise. A typical resolution spread versus external input capacitance in the RC mode is shown in Fig. 4.2.

Amplifier Noise and Resolution Measurements Using a Pulse Height Analyzer Probably the most convenient method of making resolution measurements is with a pulse height analyzer as shown by the setup illustrated in Fig. 4.3. The amplifier noise resolution spread can be measured correctly with a pulse height analyzer and the 480 as follows:

1. Select the energy of interest with the 480, and set the linear amplifier and biased amplifier gain and bias level controls so that the energy is in a convenient channel of the analyzer.

2. Calibrate the analyzer in keV per channel, using the purser. (Full scale on the pulser dial is 10 MeV when calibrated as described in "Calibrating the Test Pulser and Amplifier for Energy Measurements."

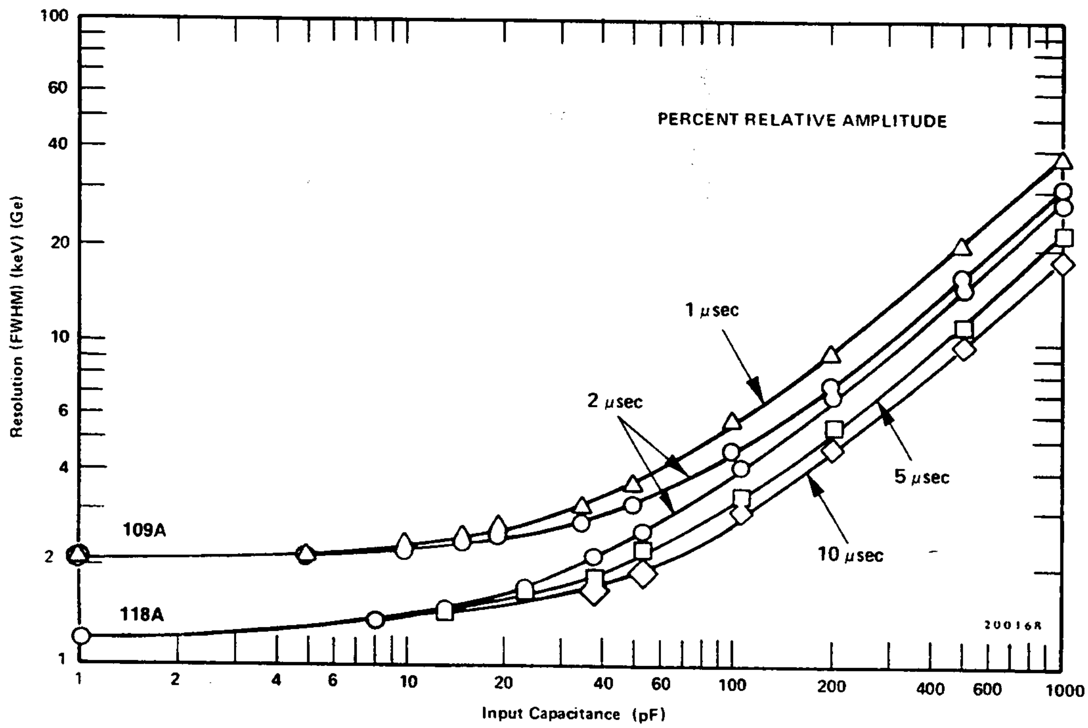


Fig. 4.2. Resolution Spread vs External Input Capacity.

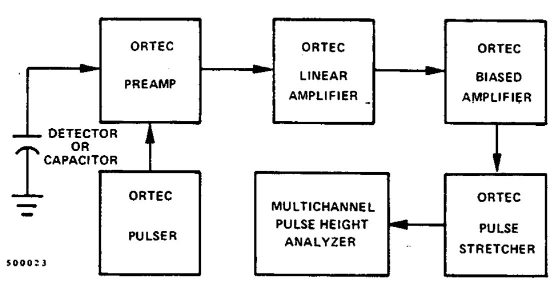


Fig. 4.3. Measuring Resolution with a Pulse Height Analyzer.

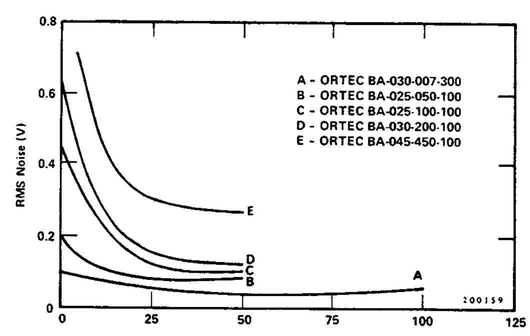


Fig. 4.4. Amplifier and Detector Noise vs Bias Voltage.

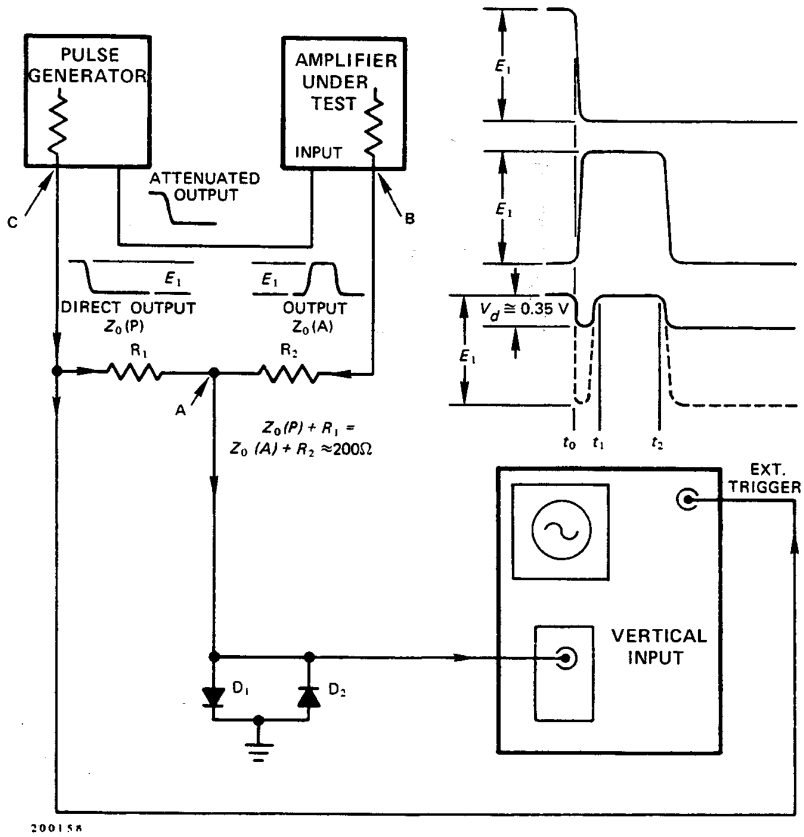


Fig. 4.5. Measuring Linearity by the Null-Balance Method.

3. Then obtain the amplifier noise resolution spread by measuring the FWHM of the pulser spectrum. The detector noise resolution spread for a given detector bias can be determined in the same manner by connecting a detector to the preamplifier input. The amplifier noise resolution spread, of course, must be subtracted. The detector noise will vary with detector size and bias conditions as indicated in Fig. 4.4 and possibly with ambient conditions.

Amplifier Linearity Measurements The measurement of amplifier linearity can be quickly and simply done by utilizing the method outlined in Fig. 4.5. The method consists of bucking out two voltage signals from low-impedance sources and measuring the amplitude differential at a null point.

The following conditions of Fig. 4.5 should be considered when linearity measurements are made. The output impedance of the Direct Output must be 100Ω. The amplifier must be set in the inverting mode of operation; i.e., for the negative input shown, the amplifier must produce a positive Output Pulse. The impedance seen from point A to ac, or signal, ground via point C should be equal to the impedance seen from point A to ac, or signal, ground via point B. The diodes D should be germanium units with high g_m. The diodes can be replaced with high-frequency germanium transistors with the base connected to the collector so that the emitter-base functions as the diode. Transistors suitable for this test include 2N779, 2N964, 2N976, 2N2048. The diodes serve as bipolar voltage clamps to limit the voltage swing at point A to the forward voltage drop across the diodes. The diode-resistor network should be constructed so as to minimize the stray capacitance around this network. The network should be physically located on the oscilloscope input connector for the same reason.

Initially the output of the Pulser and amplifier should be set for 10 V. This should be measured with cars, and consideration should be given for the output impedance of both the Pulser and amplifier. By observing the waveshape at point A (Fig. 4.5), the fine gain of the amplifier and the attenuation controls should be adjusted until a null is obtained between time t_1 and t_2. At null, the sensitivity of the oscilloscope should be set to 10 mV/cm for best resolution of the null measurement.

The actual measurement of linearity is accomplished by dialing the Pulse Height dial to 0, resulting in the amplifier output being reduced to zero. Since the Pulser supplies signals in parallel both to the bridge for null and to the amplifier, varying the Pulser output will have no effect on the null if perfect amplifier linearity is assumed.

As an example of this method, assume that the amplifier under test has essentially zero output impedance. Set R1 equal to 100Ω and R2 equal to 200Ω. Let diodes D1 and D2 be 2N2048 connected as diodes. Only one-half of the actual amplifier output voltage can be measured directly at point A due to the superposition of the outputs of the Pulse generator via R1 and the amplifier via R2. To specify nonlinearity as a percentage of full Output voltage, the calibration of 10 mV/cm will be equal to 10 mV/5 V or 0.2% per cm. Therefore it is seen that 0.1% is quite easily resolved.

In addition to linearity measurements, it is obvious that this method can be quite useful in measurements of temperature stability.

Pulse Height Analyzer Calibration With the Pulser calibrated to read directly in terms of energy as described earlier in this section, the calibration of a complete spectrometry system from preamplifier to multichannel analyzer, i.e., analog to digital converter (ADC), can readily be accomplished by simply feeding into the preamplifier a calibrated energy signal and observing the corresponding channel into which it is assigned by the ADC.

An important consideration in this test involves ensuring that the linear system "goes through zero," and that the output of the pulse generator is properly terminated. The attenuator switches in the 480 have an accuracy controlled by 1% metal film resistors and could be used to digitally check the linearity of the spectrometer. In addition to the attenuator accuracy, the Pulse Height control has independent integral nonlinearity of ±0.25%. This control therefore allows an integral linearity curve of the ADC to be taken over the continuous range of the ADC, i.e., from zero to the maximum address of the ADC. Due to the better integral linearity control, continuous scanning with the Pulse Height control is the recommended method of checking for system linearity. The linearity of the ADC can therefore be determined by having previously taken the linearity curve of the amplifier and preamplifier as outlined earlier in this section.

5. MAINTENANCE

5.1. TESTING PERFORMANCE OF THE PULSER

The following information is intended as an aid in the installation and checkout of the 480. These instructions present information on front panel controls, waveforms at test points, and output connectors.

The following, or equivalent, test equipment is needed:

Tektronix Model 580 Series Oscilloscope
100Ω BNC Terminators
Vacuum Tube Voltmeter

Before testing the performance of the 480, take the following preliminary steps:

1. Visually check the module for possible damage due to shipment.

2. Connect ac power to NIM-standard Bin and Power Supply, 0RTEC 401 /402.

3. Plug module into Bin and check for proper mechanical alignment.

4. Switch ac power on and check the dc Power Supply voltages at the test points on the 402.

The performance test consists of the following:

1. Set the front panel controls on the 480 as follows:
   a. relay switch to On,
   b. polarity switch to Pos,
   c. Cal set to full clockwise and Pulse Height control to 1000,
   d. all Attenuator switches set to X1 position,
   e. Direct Output terminated in 100Ω and kept terminated in 100Ω throughout the test.

2. Apply power to the Bin and listen for running of the mercury relay, which will be characterized by a low frequency hum (50 or 60 Hz).

3. Set the relay switch to Off. Measure the dc voltage from the wiper of the Pulse Height switch on the rear panel to ground. It should be greater than 9 V.

4. Dial the Cal control fully counterclockwise and again measure the dc voltage from the wiper of the Pulse Height switch to ground. It should be less than 4 V. Turn the Cal control clockwise until the voltage is 10 V.

5. Set the relay switch to On.

6. Measure the pulse at the direct output test point TP1.

The pulse amplitude should be between the limits of 4.0 and 6.0 V. The, pulse rise time (10-90%) should be less than 10 nsec; the pulse fall time to one-half of its maximum amplitude should be between 230 and 290 µsec. Do not remove the 100Ω terminator from the Direct Output.

7. Terminate attenuated output with 100Ω. Measure the pulse at the attenuated Output test point. The pulse amplitude should be between the limits of 4.0 and 6.0 V. The pulse rise time (10-90%) should be less than 10 nsec; the pulse fall time to one-half of its maximum amplitude should be between 110 and 150 µsec.

8. Adjust the Pulse Height dial for a Pulse of 800 mV at the attenuated output test point. As the Attenuator switches are switched in, the output pulse should be between the following limits:

OUTPUT PULSE (mV)

Setting	X2	X5	X10	X10
Original	800	800	800	800
Lower	360	144	72	72
Upper	440	176	88	88

9. Set the Polarity switch to Neg. There should be no change in amplitude from the Pos position. Observe the output with a sweep of 5 msec/cm and look for "skipping" or other erratic behavior of the relay.

5.2. ADJUSTMENT OF DECAY TIME OF OUTPUT PULSE

As the 480 is normally supplied, the decay time of the output pulse is essentially fixed. The output Pulse will decay with the time constant of 400 µsec if the Attenuated output only is terminated in 100Ω and will decay with a time constant of approximately 200 µsec if both the Direct and Atten Outputs are terminated. In the event that a time constant shorter than 200 µsec is desired, it is necessary to parallel a fixed resistor from the normally open contact of the mercury-wetted relay to ground. The value of this shunting resistor will depend upon the exponential time constant desired. The addition of this resistor should physically be in close proximity to the actual relay; that is to say, the resistor should be added directly onto the etched circuit board. Decay time constants as short as 10 µsec can be accomplished quite easily.

5.3. TABULATED TEST POINT VOLTAGES

The following voltages are intended to indicate the typical dc voltages measured on the etched circuit board. In some cases the circuit will perform satisfactorily even though due to component variations there may be some voltages that measure outside the given limits. Therefore the voltages given should not be taken as absolute values, but rather are intended to serve as an aid in troubleshooting.

All voltages are measured from ground with dvm having input impedance of 10 MΩ or greater. Polarity switch set to Neg.

Transistor No. and Element	Q1C	Q2C
Lower voltage limit	+6.4	+12.8
Upper voltage limit	+7.4	+14.8

5.4. SUGGESTIONS FOR TROUBLESHOOTING

In situations where the 480 is suspected of malfunction, it is essential to verify such malfunction in terms of simple pulse generator impulses at the output. In consideration of this, the 480 must be disconnected from its position in any system, and routine diagnostic analysis performed on the Pulser with a vacuum tube voltmeter and oscilloscope. It is imperative that testing not be performed with any amplifier system until the Pulser performs satisfactorily by itself. The testing instructions of Section 6.1 of this manual and the circuit description in Section 5 are intended to provide assistance in locating the region of trouble and repairing the malfunction. The guide plate and shield cover can be completely removed from the module to enable oscilloscope and voltmeter observations with a minimum chance of accidentally short circuiting portions of the etched board.

The 480 may be returned to ORTEC for repair service at nominal cost. Our standard procedure requires that each repaired instrument receive the same extensive quality control tests that a new instrument receives. Contact our Customer Service Department, (865) 483-2231, for shipping instructions before returning an instrument.

Bin/Module Connector Pin Assignments For Standard Nuclear Instrument Modules per DOE/ER-0457T.

Pin	Function	Pin	Function
1	+3 V	23	Reserved
2	- 3 V	24	Reserved
3	Spare bus	25	Reserved
4	Reserved bus	26	Spare
5	Coaxial	27	Spare
6	Coaxial	*28	+24 V
7	Coaxial	*29	- 24 V
8	200 V dc	30	Spare bus
9	Spare	31	Spare
10	+6 V	32	Spare
11	- 6 V	*33	117 V ac (hot)
12	Reserved bus	*34	Power return ground
13	Spare	35	Reset (Scaler)
14	Spare	36	Gate
15	Reserved	37	Reset (Auxiliary)
*16	+12 V	38	Coaxial
*17	- 12 V	39	Coaxial
18	Spare bus	40	Coaxial
19	Reserved bus	*41	117 V ac (neutral)
20	Spare	*42	High-quality ground
21	Spare	G	Ground guide pin
22	Reserved		

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