# Model 427A
# Delay Amplifier
# Operating and Service Manual

This manual Applies to instruments marked
“Rev 22" on rear panel

Printed in U.S.A.

ORTEC® Part No. 733210
Manual Revision B

1202

## 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.

ORTEC's exclusive liability is limited to repairing or replacing at ORTEC's option, items found by ORTEC to be defective in workmanship or materials within one year from the date of delivery. ORTEC's liability on any claim of any kind, including negligence, loss, or damages arising out of, connected with, or from the performance or breach thereof, or from the manufacture, sale, delivery, resale, repair, or use of any item or services covered by this agreement or purchase order, shall in no case exceed the price allocable to the item or service furnished or any part thereof that gives rise to the claim. In the event ORTEC fails to manufacture or deliver items called for in this agreement or purchase order, ORTEC's exclusive liability and buyer's exclusive remedy shall be release of the buyer from the obligation to pay the purchase price. In no event shall ORTEC be liable for special or consequential damages.

### 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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## 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. |

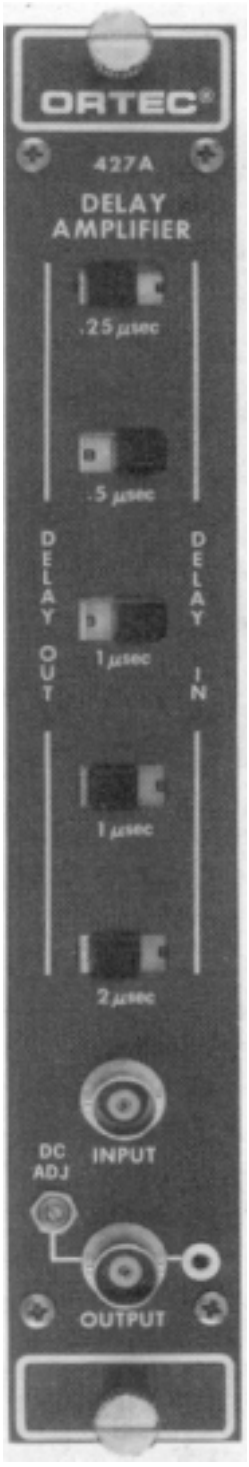
### Cleaning Instructions

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.


ORTEC
427A
DELAY
AMPLIFIER
.25 μsec
.5 μsec
DELAY OUT
1 μsec
DELAY IN
1 μsec
2 μsec
DC ADJ
INPUT
OUTPUT


OUTPUT
93 Ω

# ORTEC MODEL 427A
# DELAY AMPLIFIER

## NOTICE

Slide switches are used in the 427A to select the desired amount of signal delay. The contacts of these switches are coated with a lubricant to prevent them from oxidizing. If this lubricant is removed from a portion of the contact, oxidation will occur and made it difficult for the switches to make contact properly. If a switch does not make contact, the signal will either not appear at the output or appear at a reduced amplitude. When the switches do not make contact, simply operate them a few times; this will remove the oxide and restore the contacts to their proper state.

## 1. DESCRIPTION

The ORTEC 427A Delay Amplifier has a nominal gain of unity and can delay a linear or logic signal from zero to 4.75 µs in 0.25-µs increments. The amount of delay is selected by five front panel switches. This delay is accomplished by inserting any combination of five delay lines of .025, 0.5, 1.0; 1.0 and 2.0 µs in series with the signal path. These delay lines are terminated in their characteristic impedances at both ends to minimize impedance mismatching and resultant pulse reflections on the lines.

The 427A features a gain of 1 from the input to the output. It is completely dc-coupled from the input to the output, which permits the delay amplifier to be used in high count rate circuits with excellent fidelity. Any required baseline restoration may be accomplished at the most convenient place, either before or after the 427A.

NOTE: The 427A has a limited bandwidth as shown in the Specifications. Consequently, this instrument should not be used to delay signals of varying bandwidth. Such signals are obtained when a biased amplifier without a stretcher is used following a shaping amplifier. The ORTEC 444 Biased Amplifier has an internal stretcher that precedes the biased amplifier section and therefore produces constant bandwidth signals. In older spectroscopy systems using a biased amplifier and stretcher (the 408 and 411) the droop of the stretched output was so large that the biased amplifier had to be used before the stretcher. In these systems the 427A should follow the stretcher in the signal path.

## 2. SPECIFICATIONS

### 2.1. PERFORMANCE

**GAIN** Unity ±2% at zero delay.

**GAIN VARIATION WITH DELAY** ±10%, −2% for any combination of delays (bipolar pulse, 0.5 µs shaping time).

**FEEDTHROUGH AND DELAY RIPPLE** <2% (bipolar pulse, 0.5 µs shaping time).

**PROPAGATION DELAY** 200 ns typical.

**DELAY LINE TOLERANCES** ±5%.

**RISE TIME AND BANDWIDTH AS A FUNCTION OF DELAY**

| Delay (µS) | Maximum Rise Time (ns) | Minimum Bandwidth (MHZ) |
|---|---|---|
| 0 | 280 | 1.25 |
| 0.25 | 280 | 1.25 |
| 0.5 | 290 | 1.20 |
| 1.0 | 310 | 1.13 |
| 2.0 | 340 | 1.03 |
| 3.0 | 360 | 0.972 |
| 4.0 | 370 | 0.945 |
| 4.5 | 380 | 0.920 |
| 4.75 | 400 | 0.875 |

**INTEGRAL NONLINEARITY** <±0.05%, 0 to +10 V.

**TEMPERATURE INSTABILITY** Gain shift of the amplifier is <±0.01% per °C; additional shift of −0.013% per °C should be expected for each microsecond of delay used; operating temperature range, 0 to 50°C.

### 2.2. CONTROLS

**LINEAR DELAY** Any combination of the following: 0.25, 0.5, 1.0, 1.0, and 2.0 µs; maximum 4.75 µs.

**DC OUTPUT LEVEL ADJ** ±1 V.

**DC OUTPUT LEVEL INSTABILITY** <0.1 mV/°C.

**INPUT AND OUTPUT CONNECTORS** BNC; types UG-1094/U and UG-1094A/U.

### 2.3. INPUTS

**POLARITY** Either positive or negative.

**SIGNAL SPAN** ±10 V linear range.

**IMPEDANCE** >1kΩ, dc-coupled.

### 2.4. OUTPUTS

There are 2 outputs, each with a linear range of 0 to ±10 V, 0 to ±11 V maximum.

**IMPEDANCE** <0.1Ω dc-coupled, short-circuit protected, front panel BNC; 93Ω dc-coupled, rear panel BNC.

### 2.5. POWER REQUIRED

+24 V, 30 mA; −24 V, 30 mA.

## 3. INSTALLATION

### 3.1. GENERAL

The 427A is used in conjunction with an ORTEC 4001/402 Series Bin and Power Supply, which is intended for rack mounting; therefore if vacuum tube equipment is operated in the same rack with the 427A, there must be sufficient cooling by circulating air to prevent any localized heating of the all-transistor circuitry used through out the module. The equipment mounted in racks should not be subjected to temperatures in excess of 120°F (50°C).

### 3.2. CONNECTION TO POWER

Since the 427A contains no internal power supply, it must obtain power from a Nuclear Standard Bin and Power Supply such as the 4001A/402A. It is recommended the Bin Power Supply be turned off when modules are inserted or removed. ORTEC modules are designed so that the Bin Power Supply cannot be overloaded even when there is a full complement of modules in the Bin. Since this may not be true, however, when the Bin contains modules other than those of ORTEC design, the Power Supply voltages should be checked after modules are inserted. The 4001A/402A has test points on the Power Supply control panel to monitor the dc voltages.

When using the 427A outside the 4001A/402A Bin and Power Supply, be sure that the jumper cable used properly accounts for the power supply grounding circuits provided in the recommended AEC standards of TID-20893 (Rev). Both high-quality and power-return ground connections are provided to ensure proper reference voltage feedback into the power supply, and they must be preserved in remote cable installations. Care must also be exercised to avoid ground loops when the module is not operated in the Bin.

### 3.3. SIGNAL CONNECTIONS TO 427A

The 427A input is compatible with all linear output signals of ORTEC modular electronic instruments. The medium-speed logic pulse of these instruments is also suitable for use with the 427A; however, the rise time of logic pulse will be increased considerably because of the limited bandwidth of the 427A. (See Specifications for bandwidth and rise time vs delay.) The signal range of the input is from 0 to 10 V. The input pulse shape can be as narrow as 300 to 400 ns or as long as infinity.

The connecting coaxial cable should be terminated in its characteristic impedance at the input connector when cable lengths exceed

approximately 4 ft (see Fig. 3.1). The input impedance of the 427A is approximately 1100Ω. It is recommended that RG-62/U or RG-63/U coaxial cable be used because of their relatively high impedance of 93Ω and 125Ω respectively. Baseline restoration will normally be accomplished in the linear amplifier. The input dc level furnished into the 427A should be zero with no signal present, and this will normally be adjusted in the linear amplifier output. The 427A has a dc-coupled output with a dc-level adjustment for a range of ±1 V. This permits the input to the analyzer to be normalized in order to establish its zero-energy crossover calibration.

### 3.4. LINEAR OUTPUT SIGNAL CONNECTIONS AND TERMINATING IMPEDANCE

The source impedance of the 0- to 10-V standard linear outputs of most ORTEC instruments is furnished through a series impedance of either 0.1Ω or 93Ω, depending on the connector that is used for the connection to the next module. When the interconnecting cable is short, such as maximum of 4 ft, this will not usually result in any interference problems even though impedance matching is disregarded. However, if a cable longer than approximately 4 ft. is necessary in a linear output, it should be terminated in a resistive load equal to the impedance in order to prevent oscillations.

There are three general methods of termination that are used. The simplest of these is shunt termination at the receiving end of the cable. A second method is series termination at the sending end. The third is a combination of series and shunt termination, where the cable impedance is matched both in series at the sending end and in shunt at the receiving end. The most effective method is the combination, but termination by this method reduces the amount of signal strength at the receiving end to 50% of that which is available in the sending instrument.

To use shunt termination at the receiving end of the cable, connect the 1Ω output of the sending device through 93Ω cable to the input of the receiving instrument. Then use a BNC tee connector accept both the interconnecting cable and 100Ω resistive terminator at the input connector of the receiving instrument. Since the input impedance of the receiving instrument is normally 1000Ω or more, the effective instrument input impedance with the 100Ω terminator will be of the order of 93Ω, and this correctly matches the cable impedance.

For series termination, use the 93Ω output of the sending instrument for the cable connection. Use 93Ω cable to interconnect this into the input of the receiving instrument. The 1000Ω (or more) normal input impedance at the input connector represents an essentially open circuit, and the series impedance in the sending instrument now provides the proper termination for the cable.

For the combination of series and shunt termination, use the 93Ω output of the sending instrument for the cable connection and use 93Ω cable. At the input for the receiving instrument, use a BNC tee to accept both the interconnecting cable and a 100Ω resistive terminator. Note that the signal span at the receiving end of this type of receiving circuit will always be reduced to 50% of the signal span furnished by the sending instrument.

For your convenience, ORTEC stocks the proper terminators and BNC tees, or you can obtain them from a variety of commercial sources.

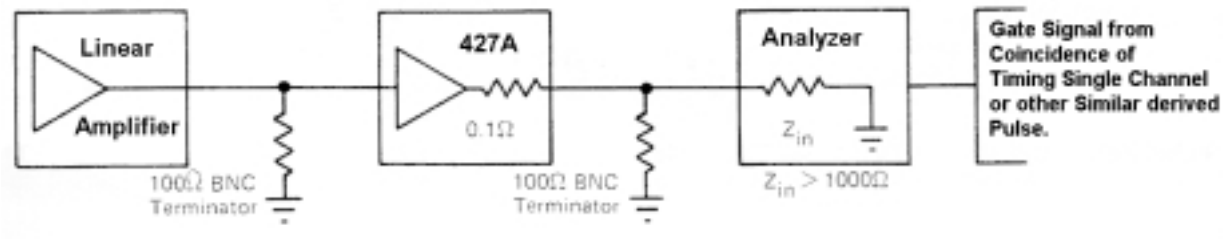



Fig. 3.1. Block Diagram of a System Using Proper Cables and Terminators.

# 4. OPERATING INSTRUCTIONS

## 4.1. INITIAL TESTING AND OBSERVATION OF PULSE WAVEFORMS

Refer to Section 5.1 of this manual for information concerning testing performance and observing pulse waveforms.

## 4.2. CONNECTOR DATA

**INPUT**

The INPUT BNC connector accepts the incoming pulse that is delayed (temporarily stored) in passing through the amplifier. The input impedance is approximately 1100Ω dc-coupled. The dc level of the signal line furnished to the input of the 427A should be adjusted to zero volts when no signal is present on the line. The input voltage rated range is 0 to ±10 V, and the voltage gain in nominally unity.

**OUTPUT**

There are two OUTPUT BNC connectors, one on the front panel and one on the rear panel. The output driving impedance for the front panel connection is approximately 0.1Ω and it is short-circuit protected. The connector on the rear panel furnishes the same output through a 93Ω series impedance. The dc output level is adjustable with a front panel screwdriver control for a range of ±1 V to normalize it for the next instrument into which the signal is being furnished, and both the 1Ω and 93Ω outputs are dc-coupled. The output test point is a convenient location for checking the dc output level with a voltmeter or an oscilloscope.

## 4.3. TYPICAL OPERATING CONSIDERATIONS

There is a propagation delay in the 427A of approximately 200 ns. This delay is present between the input and output connectors when all of the delay switches are set at OUT and is added to any delay that is switched in during operation.

The 427A is typically used in a linear system after the main pulse-shaping amplifier. It is also directly compatible with, and can be driven from, any ORTEC linear output circuit. The input and output signal range is rated from 0 to 10 V, positive or negative. After the desired amount of delay has been selected, the 427A output should be checked with an oscilloscope to ensure that the dynamic range of the unit is not exceeded. The gain of the 427A is nominally unity, but in increases to approximately 1.1 when all of the delay (4.75 µs) is selected.

# 5. MAINTENANCE

The testing instructions given here and the circuit descriptions in Section 5 should provide assistance in locating the region of trouble and in remedying the malfunction. The information given in Section 5.1 relates to front panel controls and waveforms at test points and output connectors.

## 5.1. TESTING PERFORMANCE OF THE DELAY AMPLIFIER

**Test Equipment Needed (or Equivalent)**

ORTEC 419 Pulse Generator
Tektronix Model 580 Series Oscilloscope
100Ω BNC Terminators
Digital Voltmeter
ORTEC 572 Amplifier

**Preliminary Procedures**

1. Visually check the module for possible damage due to shipment.
2. Connect ac power to the Nuclear Standard Bin ORTEC 4001A/402A.
3. Plug the module into the bin and check for proper mechanical alignment.
4. Switch on the ac power and check the dc power supply voltages at the test point on the 402A Power Supply control panel.

**Delay Amplifier**

There are no internal adjustments to be made on the 427A; therefore testing is simply a matter of observing the input and output waveforms:

1. Connect the output of the 419 Pulse Generator into the input of the amplifier.
2. Set the amplifier controls as follows:
   Gain 20
   Shaping Time Constants 0.5 µs
3. Connect the bipolar output of the amplifier to the INPUT of the 427A through RG-62/U cable, and terminate the cable at the input of the 427A with a 100Ω terminator. Insure that all DELAY switches are in the OUT position.
4. Vary the amplitude of the 427A OUTPUT by adjusting the 419 Pulser; there should be no distortion of the signal as it is varied from 0 to 10V.
5. Raise the output amplitude of the 419 until the 427A saturates; the saturation level should not be less than 11 V.
6. Adjust the 419 for a 10-V output signal from the 572 and leave it at this setting for the remainder of the test.
7. The output of the 427A should be 10 V and should occur about 200 ns after the input signal.
8. Switch each individual delay line into the circuit and ensure that the 427A output remains at 10 V and is delayed the appropriate amount.
9. Switch all delay lines into the circuit. The 427A output should be approximately 11 V and delayed 4.75 µs from the input signal.
10. Monitor the output dc level and vary potentiometer R14 over its full range. The dc level should vary to ±1 V; reset to zero volts.

## 5.2. CHANGING THE AMPLIFIER GAIN

The gain of the output cable driver loop is given by the ratio R17 (R12 + R13). The gain of this loop can be changed as much as 20% by increasing or decreasing the value of R17.

## 5.3. SUGGESTIONS FOR TROUBLESHOOTING

When the 427A is suspected of malfunctioning, it is essential to verify such malfunctioning in terms of simple pulse generator impulses at the input and output. First, the 427A must be disconnected from its position in any system. Then routine diagnostic analysis can be performed with a test pulse generator and an oscilloscope. It is imperative that testing not be performed with a source and detector until the Delay Amplifier performs satisfactorily with the test pulse generator. The side plates can be completely removed from the module to permit oscilloscope and volt-meter observations with a minimal chance of accidentally short circuiting portions of the etched board.

Failure to properly terminate interconnecting cables can result in oscillations in the system.

## 5.4. FACTORY REPAIR

This instrument can be returned to the ORTEC factory for service and repair at a nominal cost. Our standard procedure for repair ensures the same quality control and checkout that are used for a new instrument. Always contact Customer Services 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.

**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.