Model 416A
Gate and Delay Generator
Operating and Service Manual

Printed in U.S.A. ORTEC® Part No. 733160 1202
Manual Revision E

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.

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.

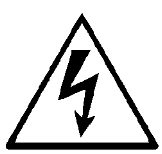
WARNING Indicates a hazard that could result in bodily harm if the safety instruction is not observed.

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.

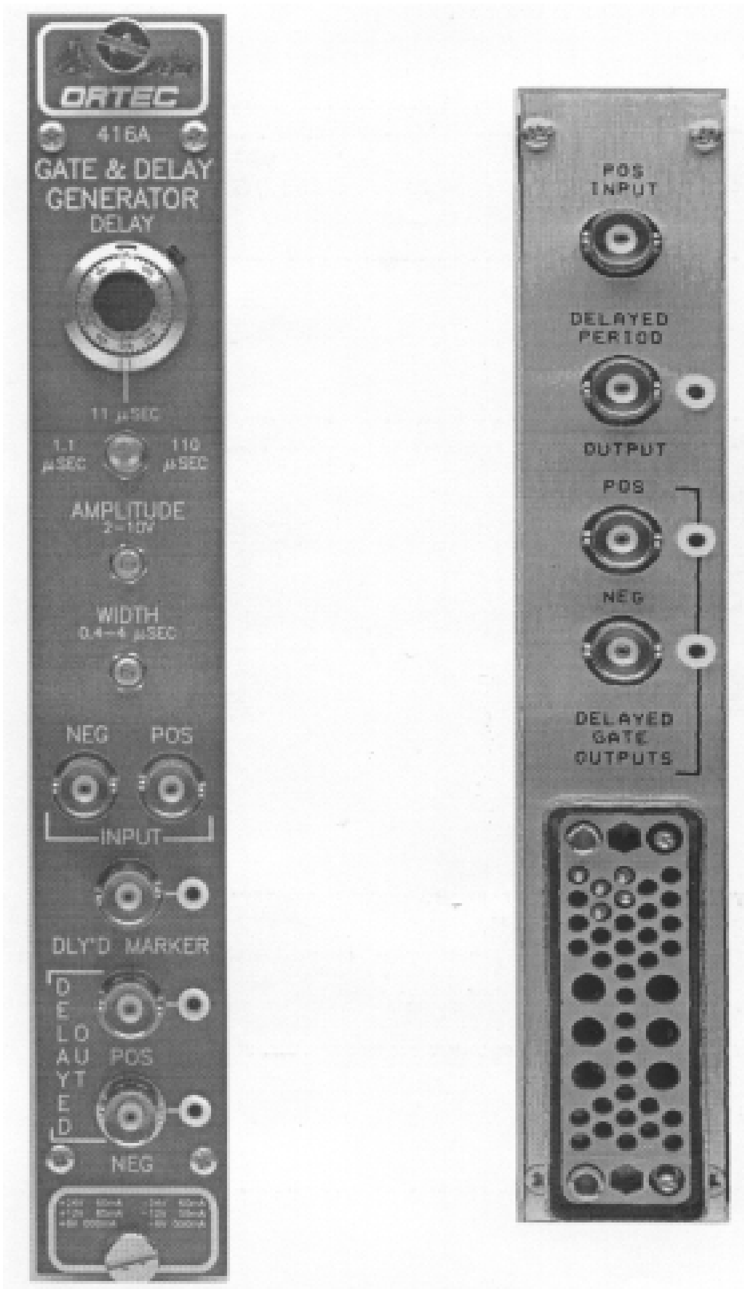
Cleaning Instructions

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
416A
GATE & DELAY GENERATOR
DELAY
11 µSEC
1.1 µSEC
110 µSEC
AMPLITUDE
2–10V
WIDTH
0.4–4 µSEC
NEG
POS
INPUT
DLY'D MARKER
DELAYED OUT
POS
NEG
POS INPUT
DELAYED PERIOD
OUTPUT
POS
NEG
DELAYED GATE OUTPUTS

ORTEC MODEL 416A
GATE AND DELAY GENERATOR

1. DESCRIPTION

The ORTEC 416A Gate and Delay Generator is a single-width module that conforms to DOE/ER-0457T. It accepts either polarity of logic pulses, provides an adjusted delay for each input pulse, and generates output pulses with both polarities that have an adjusted amplitude and width. It serves as a convenient interface between logic pulse origin and its end use.

Typical applications for the 416A include gating multichannel analyzers for either coincidence or anticoincidence control, alignment of coincidence timing between two channels of information that use dissimilar pulse-shaping modes, and start and/or stop logic pulses for a time to pulse height converter. The logic pulse delay is adjustable from 0.1 through 110 µs in three overlapping ranges. The amplitude of both polarities of output pulses is adjustable within the range of 2 to 10 V. The output pulse width can be adjusted within the range of 400 ns through 4 µs.

Operation is simple and reliable. The flexibility of the 416A permits it to be normalized to the input requirements of all currently available nuclear instruments and to many other applications.

2. SPECIFICATIONS

2.1. CONNECTORS

Delay Nonlinearity ≤±2%.

Delay Temperature Instability ≤±0.03% of adjusted Delay per °C.

Delay Generator Dead Time Adjusted Delay plus 200 ns on 1.1-µs range, 300 ns on 11-µs range, and 1 µs on 110-µs range.

Output Generator Dead Time Adjusted Width plus 0.2 µs.

Delay Jitter ≤0.02% of selected range.

2.2. CONTROLS

Delay 10-turn locking potentiometer with direct-reading duo-dial for continuous adjustment within the range selected by the locking 3-position toggle switch:
1.1 µs Selects the range of 0.1 to 1.1 µs for the Delay potentiometer.
11 µs Selects a 1 to 11 µs range.
110 µs Selects a 1 0 to 110 µs range.

Amplitude Front-panel screwdriver control permits the output pulse amplitude to be adjusted within the range of 2 to 10 V, both polarities (i.e., +2 to +10 V and -2 to -10 V).

Width Front-panel screwdriver control permits the width of output pulses to be adjusted within the range of 400 ns to 4 µs.

2.3. INPUTS

Pos Front- and rear-panel BNC connectors; +2 V pulse minimum, 12 V maximum; 100-ns minimum width, dc-coupled; impedance 1000 Ω.

Neg Front-panel BNC connector accepts NIM-standard fast negative logic pulses; -250 mV pulse minimum; 5 ns minimum width, dc-coupled; impedance 50 Ω.

2.4. OUTPUTS

Delayed Out, Pos/Neg Front- and rear-panel BNC connectors, with test points, provide simultaneous output pulses with identical characteristics except for opposite polarity; impedance ≤10 Ω.

Delayed Period Rear-panel BNC connector, with test point, provides positive pulse width equal to the adjusted Delay; amplitude +5 V; rise time ≤50 ns; impedance ≤10 Ω.

Dly'd Marker Front-panel BNO connector, with test point, provides NIM-standard fast negative logic pulse at the end of delay time. Amplitude, -0.6 V into 50 Ω load; rise time $\leq$1 0 ns; width $\leq$25 ns; impedance $\leq$10 Ω.

2.5. ELECTRICAL AND MECHANICAL

Power Required The Model 416A derives its power from a standard NIM bin/power supply. The power required is +24 V, 60 mA; -24 V, 60 mA; +12 V, 85 mA; and -12 V, 85 mA.

Weight
Net 1.3 kg (2.8 lb).
Shipping 2.2 kg (4.8 lb).

Dimensions NIM-standard single-width module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

3. INSTALLATION

3.1. GENERAL

The 416A Gate and Delay Generator is designed for installation and operation in an ORTEC 4000 Series Bin and Power Supply or equal. The Bin and Power Supply is designed for relay rack mounting and is usually installed in a rack that houses other electronic equipment. Therefore any vacuum tube equipment or other source of heat that operates in the same rack with the 416A must be sufficiently cooled with circulating air to prevent localized heating of the transistors and integrated circuits in the 416A. The temperature of equipment mounted in racks can easily exceed 120°F (50°C), the maximum limit for safe operation of the 416A, unless precautions are taken.

3.2. CONNECTION TO POWER

The 416A does not contain its own power supply but obtains all the required operating power from the Bin and Power Supply in which it is installed for operation. Turn off the Bin Power supply when inserting or removing a module. The Power Supply voltages should be checked after all modules have been inserted to determine that the voltage levels remain within their rated tolerances. The 4000 Series have test points on the Power Supply control panel to permit monitoring the dc voltages easily.

3.3. INPUT CONNECTIONS

Determine the polarity and characteristics of the input pulses that are to be furnished. Use the matching input connector on the 416A; if positive pulses are furnished, use either the front or rear panel connector and furnish the pulses through a nominal 100-Ω cable; if NIM-standard negative pulses are furnished, use the front panel Neg Input connector and furnish the pulses through 50-Ω cable.

3.4. OUTPUT CONNECTIONS

A Delayed and Delayed Gate Output connector for each polarity is included on both the front and rear panels of the 416A for convenience. Although both polarities may be used simultaneously, the two connectors for either positive or negative polarity should not be used simultaneously. If reflections should occur in the output circuits, match the impedance of the output cable at the input of the instrument to which the pulses are furnished from the 416A.

4. OPERATING INSTRUCTIONS

4.1. GENERAL

When the 416A Gate and Delay Generator is installed in the Bin and Power Supply and power is turned on, the module is ready for operation.

Logic pulses are accepted through the input circuit, provided that they have the matching polarity for the input connector used and that their amplitude is sufficient to trigger a response in the 416A. A pulse source that is furnished through the Pos Input will trigger a response when its amplitude exceeds +2 V. A pulse source that is furnished through the Neg Input will trigger a response when its amplitude exceeds about -100 mV.

The input pulse is delayed and then is used to generate a pair of output pulses that are identical except for polarity. The width and amplitude of the output pulses can be adjusted with front panel controls to normalize them to the intended application in a gating circuit or other similar function.

In addition to the delayed output positive and negative signals that are normalized by control adjustments, there are two other output connectors for signals that are not adjustable but are typically designed to be used in nuclear instrument applications. One is the Delayed Period Output connector for which the signal rises from 0 to nominally +5 V through the adjusted delay interval. The other connector is Dly'd Marker, which furnishes a NIM-standard fast negative logic signal at the end of the adjusted delay interval.

Use the connectors that are appropriate for the functions for which the logic outputs will be used.

4.2. MATCHING IMPEDANCE

Both input and output circuits should be cabled and terminated in characteristic impedances to prevent reflections of the logic pulses. This rule is less important for positive inputs and for delayed outputs than for negative inputs and delayed marker outputs, but should be considered for all circuits when pulse fidelity is a requirement.

Negative inputs and delayed marker outputs require 50-Ω cables and terminators for correct operation. The 416A Neg Input circuit is terminated internally with the characteristic 50-Ω impedance. If the Dly'd Marker output connector is used, check to see that the input impedance in the circuit that it is driving has the 50-Ω termination, or furnish the proper termination for the cable when it is connected.

The remaining input and output circuits normally operate best with nominal 100-Ω cables and terminators.

4.3. TYPICAL APPLICATIONS

Figures 4.1 through 4.3 are block diagrams for typical systems in which the 416A can be used. Figure 4.4 is a timing diagram that illustrates how the 416A can be adjusted when it is installed in the circuit of Fig. 4.3. These diagrams are intended as typical application arrangements but do not imply that the normalizing functions of the 416A are limited to these circuits.

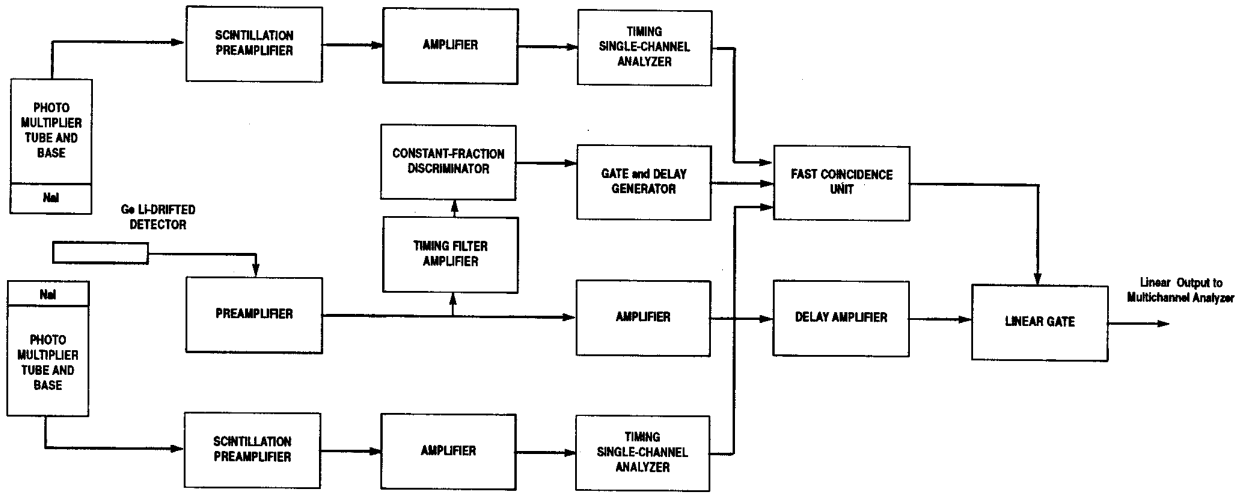


Fig. 4.1. Block Diagram for System Using Gamma-Ray Pair Spectrometer .

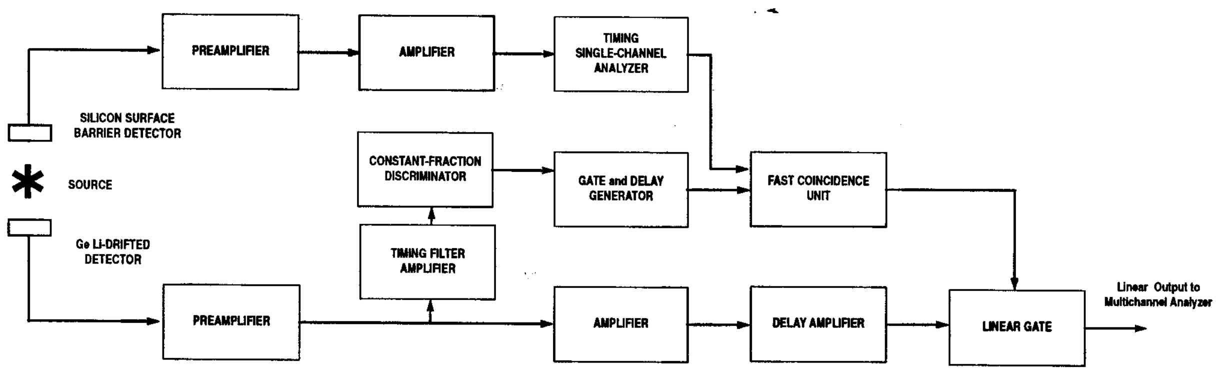


Fig. 4.2. Block Diagram for Gamma-Ray Charged-Particle Coincidence Experiment.

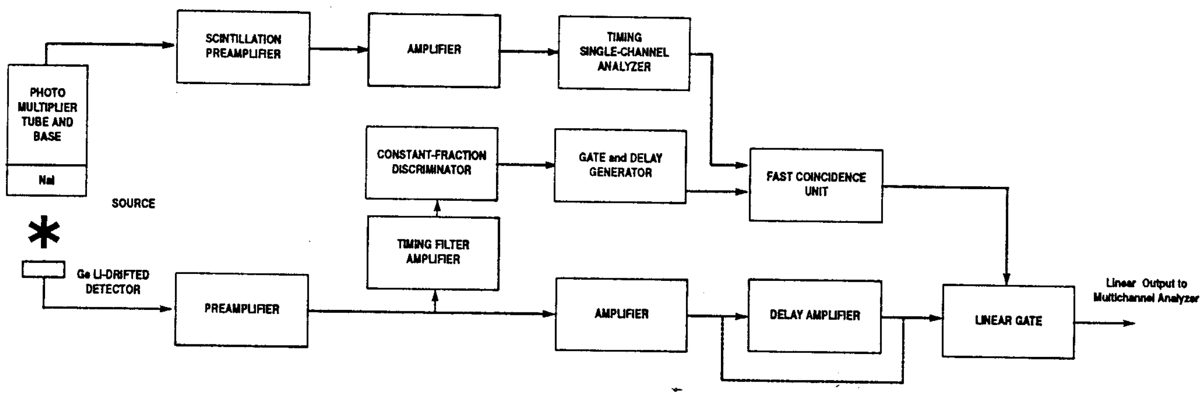


Fig. 4.3. Gamma-Gamma System for Measuring Resolution Spread and Amplitude Changes with Counting Rate.

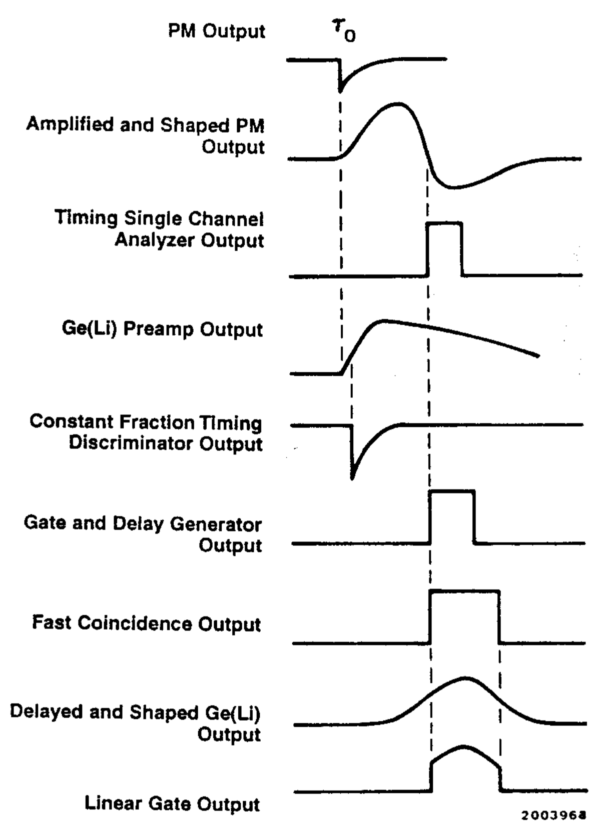


Fig. 4.4. Signal Time Alignment Chart for Fig. 4.3.

5. CIRCUIT DESCRIPTION

Diodes D6, D7, and D8, D9 form input protection circuits to protect the unit from large amplitude input signals. Q13, Q14, and Q15 form a dc-coupled Schmitt trigger. The width of the Schmitt trigger output will be the same as the input signal or the busy time of the 416A, whichever is the longer. The current pulse at the collector of Q14 is differentiated by L2. The positive leading edge of this signal is passed by D1 to the base of Q1. Q1, Q02, Q3, Q4, and Q21 form the delay monostable multivibrator. When triggered, this multivibrator sets a voltage step onto capacitor C4, C5, C21, and C22 (depending upon range). These capacitors are then discharged with a constant current furnished by Q4. The amplitude of this current is controlled by delay potentiometer R11. Since the discharge is by a constant current, the delay will be a linear function of R11.

Diode D2 provides the bias necessary to hold Q2 in the conduction state until the multivibrator is triggered, at which time the voltage pulse from the emitter of Q3 is fed through C4, C5, C21, and C22 to cut off the diode. It will remain cut off until the end of the delay period. At the end of the delay period Q21 is turned on to cause the multivibrator to recover rapidly In order to keep pileup inputs from influencing the delay period, current switch Q23, Q24 senses the busy time of the delay multivibrator and blocks the input by causing Q22 to hold the input Schmitt trigger on. The delay output pulse is fed through C3 to the delay output buffer emitter-follower Q5 and then to the delay period output. This pulse is also differentiated by L1 and fed to the base of Q6, which is a normally cutoff trailing edge of the delay period pulse. This signal is then fed to the delay marker output. The inversion of the delay marker appears on the collector of Q6 and is fed through C8 to the base of Q7. Q7, Q8, and Q9 compose the delayed gate pulse generator monostable multivibrator. When this multivibrator is triggered, the current flowing through Q8 will be switched through Q7 to Q9 and onto capacitor C11. C11, R29, and width control R28 determine the gate generator pulse width. A 20% to 100% fraction of this pulse, determined by the amplitude control R24 and trim potentiometer R25, is fed through C12 to the base of Q10. Q10 is a phase splitter which forms two pulses of equal amplitude but opposite polarity. The positive pulse appears on the emitter of Q10 and is dc-coupled to the base of Q11; the negative pulse appears on the collector of Q10 and is dc-coupled to the base of Q12. Q11 and Q12 are a NPN/PNP pair that are both in the cutoff state until the delayed gate pulse arrives, at which time they turn on for the period of the gate pulse and present the gate output to their respective output connectors.

The negative input signal is coupled through the protection circuit D8, D9 to the base of Q16. Q16 and Q17 form a current switch pair that switches the current out of Q16 into Q17 when the negative threshold is exceeded. This threshold voltage is the same as the base voltage of Q17, normally −250 mV. This current is dumped on Q17 load resistor R59 and appears as a negative voltage to tunnel diode D11. D11 is normally in its low conduction state and when turned on by a pulse will switch to a negative 0.5-V state and remain for the input signal width. This signal appears on the base of Q18, which, with Q19, forms another current switch pair. Q18 is normally conducting while Q19 is cut off. When the tunnel diode D11 turns on, the negative voltage on the base of Q18 switches the current out of Q18, allowing the collector voltage to go positive. This positive voltage excursion turns on the input Schmitt trigger via Q22. Q22 performs the same functions as 013.

6. MAINTENANCE AND CALIBRATION

6.1. TESTING PERFORMANCE

To test the operation of this unit, first test the operation of the delay multivibrator section. Insert an input trigger pulse and check for an output from the delay period output. Monitor the width of the delay period output, vary the delay potentiometer, R11, through its range, and also check the operation of the range selector switch, S1. This pulse width should be equal to the desired delay time except for a small propagation delay of about 25 ns. With the trigger present, if there is no delay period output, the trouble is immediately isolated to the delay multivibrator. Usually the first test to perform is that of measuring dc voltages and comparing them with the voltages given in Table 6.1. If this does not isolate the trouble, then use an oscilloscope for waveform checks. If the delay period output pulse is present, check for an output from the delayed marker output BNC. If the delayed marker output does not exist, then the problem is immediately isolated to the circuit surrounding Q6. If a delayed marker output exists but there is no gate pulse output, this indicates that the gate multivibrator is not being correctly triggered. Again the best test is a dc-voltage measurement test and comparison against the tabulated voltages.

6.2. CALIBRATION ADJUSTMENTS

A trim potentiometer (R25) on the printed circuit is provided to calibrate the pulse gate output amplitude control. It should be adjusted so that the dc voltage on the collector of Q8 is +0.4 V with no signal and with amplitude control set to maximum (cw). No other adjustments are necessary.

6.3. DELAY RANGE CHANGES

If a delay range other than 0.1 to 110 µs is desired, select one of the switch positions, and replace the selected capacity for that switch position with an amount calculated with the following formula. The new range will still have a ratio of 11:1 between its maximum and minimum limits. The formula for the replacement capacity is

$$C = 2.5 \times 10^{-4} \times delay_{max}$$

where C is in farads and delay is in seconds, or C is in µF and delay is in µs.

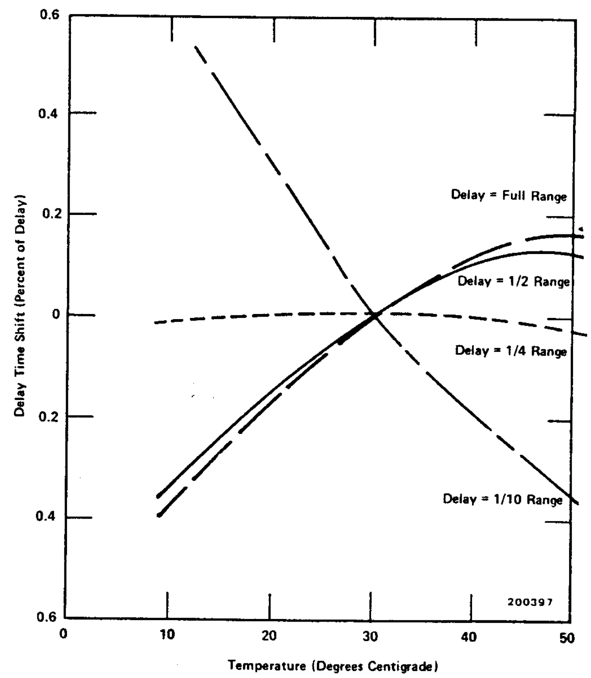


Fig. 6.1. Delay Stability vs Temperature Curves.

6.4. GATE WIDTH RANGE CHANGES

If a gate width range other than 0.4 to 4 µs is desired, replace C11 with an amount of capacity calculated with the following formula. The new range will still have a ratio of 10:1 between its maximum and minimum limits. The formula for the replacement capacity is

$$C = 2.3 \times 10^{-4} \times width_{max}$$

where C is in farads and width is in seconds, or C is in µF and width is in µs.

For proper operation with gate width >15 ms, C12 will require a larger value. The RC time constant of (C12) (R30) should be at least X3 of the maximum gate width.

6.5. FACTORY REPAIR

The 416A Gate and Delay Generator 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 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. This number should be written on the address label and on the package to ensure proper handling when it is received at the ORTEC factory.

Table 6.1. dc Voltage Measurements.

Checkpoint	Average Value (V)	Checkpoint	Average Value (V)
Q13B	±0.1	Q6C	–11.8
Q22B	0	Q8B	+0.6
Q20B	+0.6	Q8C*	+9.4
Q14B	+1.8	Q8C**	+0.5
Q13,14,20,22,22E	+1.2	Q9E	+12.4
Q15E	+12.5	Q10B	–0.25
Q23B	+12.5	Q10E	+0.5
Q24B	+13	Q10C	–0.45
Q1B	0	Q11E	0
Q2B	+0.7	Q12E	0
Q2C	+5	Q16B	0
Q3B	+12	Q17B	+0.1
Q4B	+21.5	Q18B	+0.1
Q5B	–0.6	Q19B	–0.2

Note: All voltages are read with respect to ground with a VTVM, with no signal input, and with all front panel potentiometers in the zero position (ccw).

* With Amplitude controls set at minimum.

** With Amplitude controls set at maximum.

BIN/MODULE CONNECTOR PIN ASSIGNMENTS
FOR STANDARD NUCLEAR INSTRUMENT MODULES PER DOE/ER-0457T

Pin	Function	Pin	Function
1	+3 volts	23	Reserved
2	–3 volts	24	Reserved
3	Spare Bus	25	Reserved
4	Reserved Bus	26	Spare
5	Coaxial	27	Spare
6	Coaxial	*28	+24 volts
7	Coaxial	*29	–24 volts
8	200 volts dc	30	Spare Bus
9	Spare	31	Spare
*10	+6 volts	32	Spare
*11	–6 volts	*33	117 volts 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 volts	38	Coaxial
*17	–12 volts	39	Coaxial
18	Spare Bus	40	Coaxial
19	Reserved Bus	*41	117 volts ac (Neut.)
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.