INSTRUCTION MANUAL

452

SPECTROSCOPY AMPLIFIER

Serial No. 49

Purchaser

Date Issued

ORTEC
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ORTEC 452 SPECTROSCOPY SYSTEM

Manual Change Sheet

In schematic diagram 452-0101-S1, change the value of C50 from 190 pF to 82 pF, and change diode D19 from 1N4009 to 1N270.

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A NEW STANDARD TWO-YEAR WARRANTY FOR ORTEC ELECTRONIC INSTRUMENTS

ORTEC warrants its nuclear instrument products, other than preamplifier FET input transistors, vacuum tubes, fuses, and batteries, to be free from defects in workmanship and materials for a period of twenty-four months from date of shipment provided that the equipment has been used in a proper manner and not subjected to abuse. Repairs or replacement, at ORTEC option, will be made on in-warranty instruments, without charge, at the ORTEC factory. Shipping expense will be to the account of the customer except in cases of defects discovered upon initial operation. Warranties of vacuum tubes and semiconductors made by their manufacturers will be extended to our customers only to the extent of the manufacturers' liability to ORTEC. Specially selected vacuum tubes or semiconductors cannot be warranted. ORTEC reserves the right to modify the design of its products without incurring responsibility for modification of previously manufactured units. Since installation conditions are beyond our control, ORTEC does not assume any risks or liabilities associated with methods of installation or with installation results.

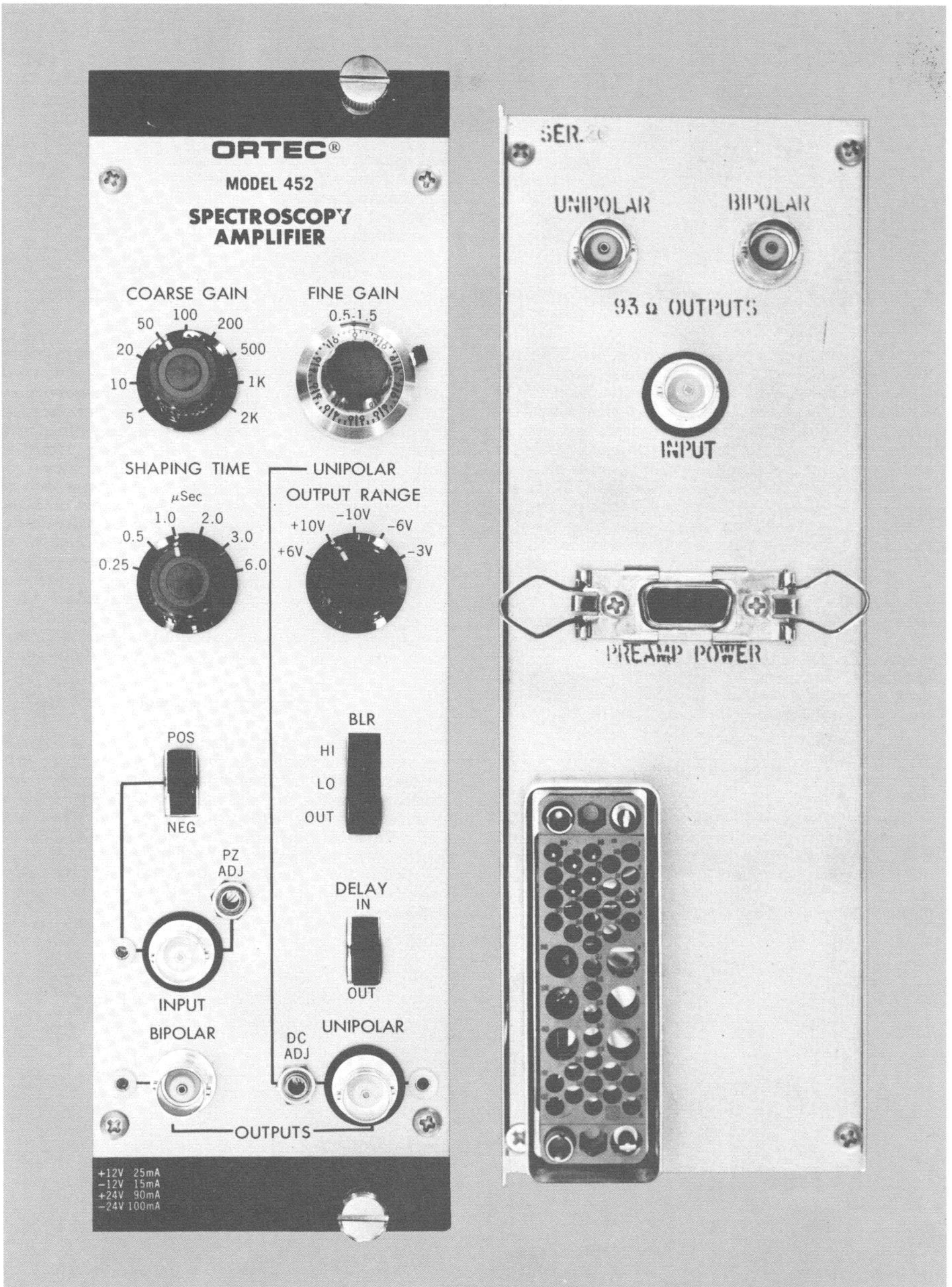
QUALITY CONTROL

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.

ORTEC must be informed in writing of the nature of the fault of the instrument being returned and of the model and serial numbers. Failure to do so may cause unnecessary delays in getting the unit repaired. Our 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 Railway Express or United Parcel Service to the nearest ORTEC repair center. Instruments 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 will be repaired at the standard charge unless they have been grossly misused or mishandled, in which case the user will be notified prior to the repair being done. A quotation will be sent with the notification.

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 we may assist in damage claims and in providing replacement equipment if necessary.


ORTEC®
MODEL 452
SPECTROSCOPY AMPLIFIER
COARSE GAIN
5
10
20
50
100
200
500
1K
2K
FINE GAIN
0.5-1.5
SHAPING TIME
μSec
0.25
0.5
1.0
2.0
3.0
6.0
UNIPOLAR
OUTPUT RANGE
+6V
+10V
-10V
-6V
-3V
POS
NEG
BLR
HI
LO
OUT
PZ ADJ
DELAY
IN
OUT
INPUT
BIPOLAR
DC ADJ
UNIPOLAR
OUTPUTS
+12V 25mA
-12V 15mA
+24V 90mA
-24V 100mA
SER.
UNIPOLAR
BIPOLAR
93 Ω OUTPUTS
INPUT
PREAMP POWER

ORTEC 452 SPECTROSCOPY AMPLIFIER

1. DESCRIPTION

1.1 GENERAL DESCRIPTION

The ORTEC 452 Spectroscopy Amplifier is a double-width NIM module with a versatile combination of switch-selectable pulse shaping and output characteristics. It features extremely low noise, wide gain range, and excellent overload response for universal application in high-resolution spectroscopy. It accepts input pulses of either polarity which originate in germanium or silicon semiconductor detectors, in scintillation detectors with either fast or slow scintillators, in proportional counters, in pulsed ionization chambers, in electron multipliers, etc.

The 452 has a dc input impedance of approximately 1000Ω and accepts either positive or negative input pulses with rise times <650 ns and fall times >25 μs. Six integrate and differentiate time constants are switch-selectable to provide optimum shape for resolution and count rate. The first differentiation network has variable pole-zero cancellation that can be adjusted to match preamplifiers with >25 μs decay time. The pole-zero cancellation drastically reduces the undershoot after the first clip and greatly improves overload characteristics. In addition, the amplifier contains an active filter-shaping network that optimizes the signal-to-noise ratio and minimizes the overall resolving time. Both unipolar and bipolar outputs are provided simultaneously on the front and rear panels.

The unipolar output should be used for spectroscopy when dc coupling can be maintained from the 452 Amplifier to the analyzer. A BLR (Base Line Restoration) circuit is included in the 452 for improved performance at high count rates. A switch on the front panel permits this circuit to be switched out, set for low count rates, or set for high count rates. When using the direct-coupled input of the various analyzers, a variety of voltage requirements exist. To meet these requirements the 452 unipolar output can be selected for full-scale voltage of −3 V, ±6 V, or ±10 V. The unipolar output dc level can be adjusted from −1 V to +1 V. This output permits the use of the direct-coupled input of analyzers with a minimum amount of interface problems. The 452 bipolar output may be preferable for spectroscopy when operating into an ac-coupled system at high counting rates.

The 452 can be used for crossover timing when used in conjunction with an ORTEC 407 Crossover Pickoff or a 420A or 455 Timing Single Channel Analyzer. The ORTEC Timing Single Channel Analyzers feature a minimum of walk as a function of pulse amplitude and incorporate a variable delay time on the output pulse to enable the crossover pickoff output to be placed in time coincidence with other outputs. A switch-selectable 2-μs delay is provided on the unipolar output to aid in obtaining the proper spacing of the linear pulse in a coincidence-gated system.

The 452 has complete provisions, including power, for operating any ORTEC solid-state preamplifier such as the 109A, 113, 118A, 120, 124, and 125. Preamplifier pulses should have a rise time of 0.25 μs or less to properly match the amplifier filter network and a decay time >25 μs for proper pole-zero cancellation. The 452 input impedance is 1000Ω. When long preamplifier cables are used, the cables can be terminated in series at the preamplifier end or in shunt at the amplifier end with the proper resistors. The output impedance of the 452 is about 0.1Ω at the front-panel connectors and 93Ω at the rear-panel connectors. The front-panel outputs can be connected to other equipment by single cable going to all equipment and shunt terminated at the far end. If series termination is desired, the rear-panel connectors can be used in connecting the 452 to other modules (see Section 3).

Gain changing is accomplished by varying feedback networks. These networks are varied in such a manner that the band width of the feedback amplifier stages remains essentially constant regardless of gain, and therefore rise-time changes with gain switching (which cause crossover walk) are limited to small variations.

1.2 POLE-ZERO CANCELLATION

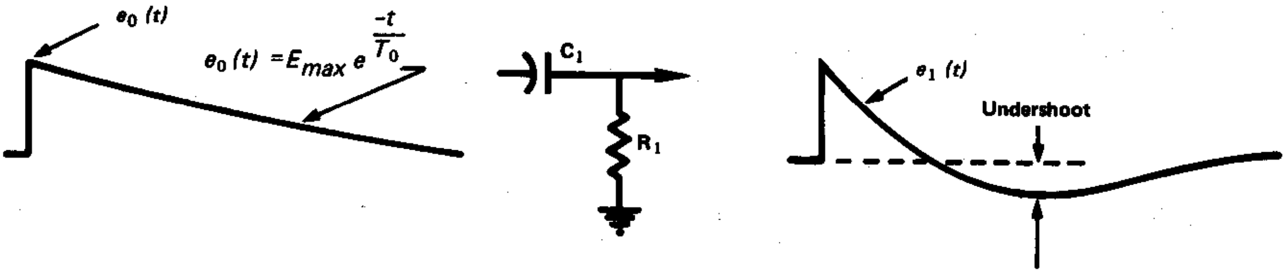
Pole-zero cancellation is a method for eliminating pulse undershoot after the first differentiating network. The technique employed is described by referring to the waveforms and equations shown in Figs. 1.1 and 1.2. In an amplifier not using pole-zero cancellation, the exponential tail on the preamplifier output signal (usually 50 to 500 μs) causes an undershoot whose peak amplitude is roughly

$$\frac{\text{undershoot amplitude}}{\text{differentiated pulse amplitude}} = \frac{\text{differentiation time}}{\text{preamplifier pulse decay time}} .$$

For a 1-μs differentiation time and a 50-μs preamplifier pulse decay time, the maximum undershoot is 2% and decays with a 50-μs time constant. Under overload conditions this undershoot is often sufficiently large to saturate the amplifier during a considerable portion of the undershoot, causing excessive dead time. This effect can be reduced by increasing the preamplifier pulse decay time (which generally reduces the counting rate capabilities of the preamplifier) or compensating for the undershoot by using pole-zero cancellation.

Pole-zero cancellation is accomplished by the network shown in Fig. 1.2.

The pole $[1/s + (1/T_0)]$ due to the preamplifier pulse decay time is cancelled by the zero $[s + (K/R_2C_1)]$ of the network. In effect, the dc path across the differentiation capacitor adds an attenuated replica of the preamplifier pulse to just cancel the negative undershoot of the clipping network.



Equations:

Charge loop output × First clipping network = Clipped pulse with undershoot

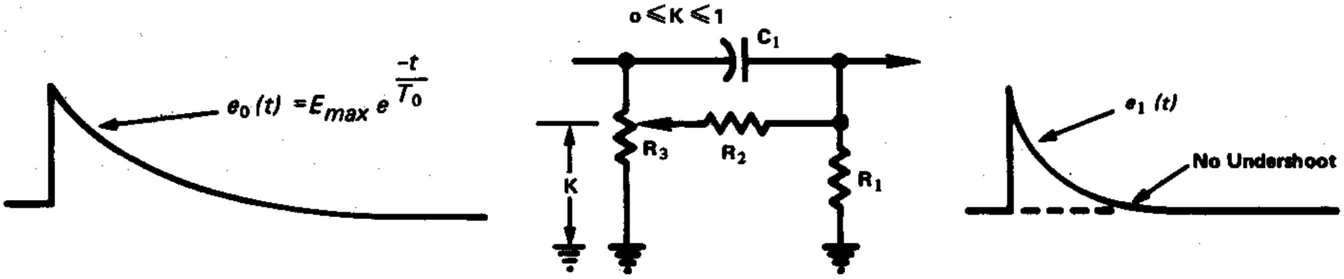
$$E_{max}\, e^{\frac{-t}{T_0}} \times G(t) = e_1(t)$$

$$E_{max} \frac{1}{s + \frac{1}{T_0}} \times \frac{s}{s + \frac{1}{R_1 C_1}} = E_1(s); \text{ Laplace Transform}$$

2.00409

$$\frac{E_{max}}{T_0 - T_1} T_0\, e^{\frac{-t}{T_1}} - T_1\, e^{\frac{-t}{T_0}} = e_1(t); \text{ where } T_1 = R_1 C_1$$

Fig. 1.1. Clipping in an Amplifier Without Pole-Zero Cancellation.



Charge loop output × Pole-zero cancelled clipping network = Clipped pulse without undershoot

Pole zero cancel by letting $s + \frac{1}{T_0} = s + \frac{K}{R_2 C_1}$ or:

$$E_{max}\, e^{\frac{-t}{T_0}} \times G(t) = e_1(t)$$

$$\frac{E_{max}}{s + \frac{R_1 + R_2}{R_1 R_2 C_1}} = \frac{E_{max}}{s + \frac{1}{R_p C_1}} = E_1(s); \text{ where } R_p = \frac{R_1 R_2}{R_1 + R_2}$$

$$E_{max} \frac{1}{s + \frac{1}{T_0}} \times \frac{s + \frac{K}{R_2 C_1}}{s + \frac{R_1 + R_2}{R_1 R_2 C_1}} = E_1(s); \text{ Laplace Transform}$$

$$E_{max}\, e^{\frac{-t}{R_p C_1}} = e_1(t)$$

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Fig. 1.2. Differentiation (Clipping) in a Pole-Zero-Cancelled Amplifier.

Total preamplifier-amplifier pole-zero cancellation requires that the preamplifier output pulse decay time be a single exponential decay and matched to the pole-zero-cancellation network. The variable pole-zero-cancellation network allows accurate cancellation for all preamplifiers having 25 μs or greater decay times. The network is factory adjusted to 50 μs, which is compatible with all ORTEC FET preamplifiers. Improper matching of the pole-zero-cancellation network will degrade the overload performance and cause excessive pileup distortion at medium counting rates. Improper matching causes either an undercompensation (undershoot is not eliminated) or an overcompensation (output after the main pulse does not return to the baseline and decays to the baseline with the preamplifier time constant). The pole-zero adjust is accessible from the front panel of the 452 and can easily be adjusted by observing with an oscilloscope the baseline with a monoenergetic source or pulser having the same decay time as the preamplifier under overload conditions. The adjustment should be made so that the pulse returns to the baseline in the minimum time with no undershoot.

1.3 ACTIVE FILTER

When only FET gate current and drain thermal noise are considered, the best signal-to-noise ratio (Fig. 1.3) occurs when the two noise contributions are equal for a given pulse shape. The Gaussian pulse shape of this amplifier requires a single RC differentiate and n equal-RC integrates, where n approaches infinity. The Laplace transform of this transfer function is

$$G(s) = \frac{s}{[s + (1/RC)} \times \frac{1}{[s + (1/RC)]^n} \quad n \to \infty,$$

where the first factor is the single differentiate and the second factor is the n integrates. The 452 Active filter approximates this transfer function.

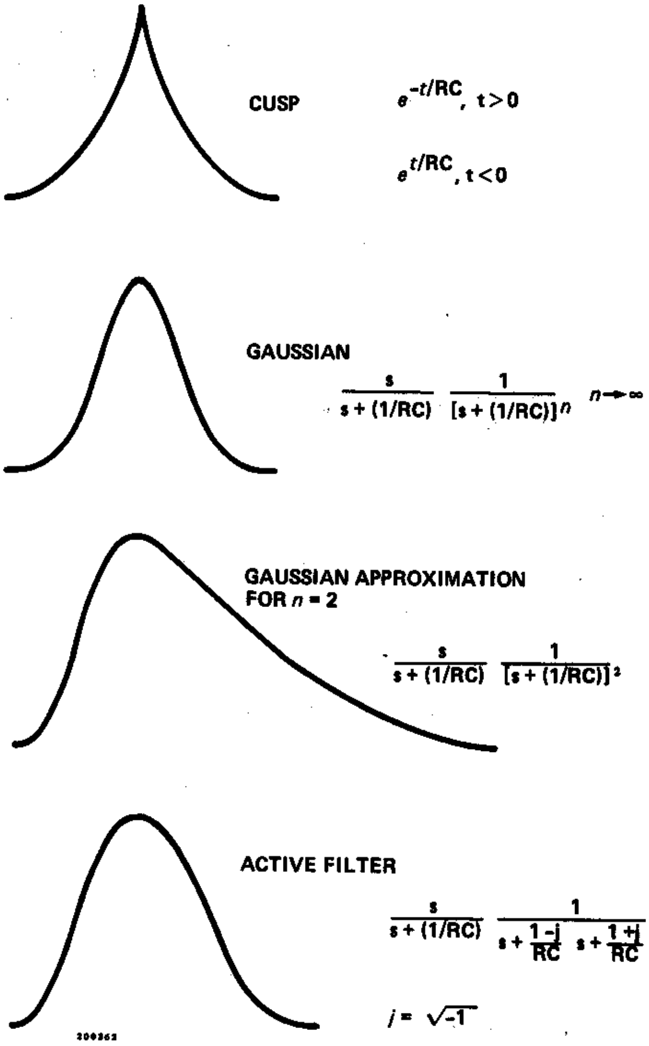

Fig. 1.3. Pulse Shapes for Good Signal-to-Noise Ratios.

2. SPECIFICATIONS*

PERFORMANCE

GAIN RANGE 9-position Coarse selection from X5 to X2000 and 10-turn potentiometer for Fine adjustment from X0.5 to X1.5; total gain is the product of Coarse and Fine Gain settings; Coarse Gain factors are obtained by feedback techniques.

SHAPING FILTER Front-panel switches permit selection of integration and differentiation time constants (τ = 0.25, 0.5, 1, 2, 3, or 6 μs); time to Unipolar peak = 2τ; time to Bipolar crossover = 2.8τ.

INTEGRAL NONLINEARITY <0.05%.

NOISE <4 μV (Unipolar) or <7 μV (Bipolar), referred to the input, with 3-μs shaping and Coarse Gain ⩾100.

TEMPERATURE STABILITY

GAIN 0.005%/°C, 0 to 50°C.

DC LEVEL <0.1 mV/°C, 0 to 50°C.

CROSSOVER WALK ⩽+2 ns for 100:1 dynamic range.

COUNT RATE STABILITY A pulser peak at 85% of analyzer range shifts less than 0.2% in the presence of 0 to 5 x 10^4 random counts/sec from a ^{137}Cs source with its peak stored at 75% of analyzer range, using 1-μs filter time constants.

OVERLOAD RECOVERY Recovers to within 2% of rated output from 1000X overload in 2.5 non-overloaded Bipolar pulse widths, using maximum gain and ⩾0.5-μs shaping time constants.

CONTROLS

FINE GAIN 10-turn precision potentiometer for continuously variable direct reading gain factor of X0.5 to X1.5.

COARSE GAIN 9-position switch, selects feedback resistors for gain factors of X5, 10, 20, 50, 100, 200, 500, 1K, and 2K.

INPUT POLARITY Slide switch, sets input circuit for either Pos or Neg input polarity.

UNIPOLAR OUTPUT 5-position switch, selects either Pos or Neg Unipolar output and amplitude.

PZ ADJ Potentiometer to adjust Pole-Zero cancellation for decay times from 25 μs to ∞.

DC ADJ Potentiometer to adjust the DC level for Unipolar outputs; range ±1.0 V.

DELAY Slide switch, selects either 2-μs delayed (In) or prompt (Out) output for the Unipolar signals.

BLR 3-position slide switch, selects baseline restorer function; Hi for duty cycles >15%, Lo for duty cycles <15%, or Out.

SHAPING 6-position switch, selects time constants of 0.25, 0.5, 1, 2, 3, or 6 μs.

INPUT

Switch-selectable active baseline restorer rate; positive or negative output from a preamplifier; max linear input 5.5 V; max input 20 V.

RISE TIME 10 to 650 ns.

DECAY TIME 25 to 2000 μs.

IMPEDANCE ~1000Ω; dc-coupled.

OUTPUTS

UNIPOLAR Prompt or delayed with full-scale linear range of –3, ±6, or ±10 V as selected; ±12 V max; active filter-shaped; dc-restored, with switch-selectable active baseline restorer rate, and baseline level adjustable to ±1.0 V; impedance <0.1Ω front panel and 93Ω rear panel; short-circuit protected

BIPOLAR Prompt output with positive lobe leading, with linear range 0 to ±10 V independent of Unipolar range and polarity; ±12 V max; active filter-shaped; impedance <0.1Ω front panel and 93Ω rear panel; short-circuit protected.

CONNECTORS

INPUT BNC (UG-1094/U), front panel.

UNIPOLAR OUTPUT BNC (UG-1094/U), front panel for Z_0 <0.1Ω; rear panel for Z_0 = 93Ω.

BIPOLAR OUTPUT BNC (UG-1094/U), front panel for Z_0 <0.1Ω; rear panel for Z_0 = 93Ω.

PREAMP Standard ORTEC power connector for mating preamplifier; Amphenol type 17-10090, rear panel.

ORDERING INFORMATION

POWER REQUIRED +24 V, 90 mA; +12 V, 25 mA; -24 V, 100 mA; -12 V, 15 mA.

WEIGHT (Shipping) 6 lb 9 oz (~2.95 kg).

WEIGHT (Net) 3 lb 13 oz (~1.80 kg).

DIMENSIONS Standard double-width module (2.70 by 8.714 in.) per TID-20893 (Rev.).

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*Checked in accordance with methods outlined in IEEE Standards No. 301, USAS N42.2, IEEE Transactions, Vol NS-16(6) (December 1969).

3. INSTALLATION

3.1 GENERAL

The 452 used in conjunction with a 401A/402A Bin and Power Supply is intended for rack mounting; therefore any vacuum tube equipment operating in the same rack with the 452 must be sufficiently cooled by circulating air to prevent localized heating of the all-semiconductor circuitry used throughout the 452. The temperature of equipment mounted in racks can easily exceed 120°F (50°C) unless precautions are taken.

3.2 CONNECTION TO PREAMPLIFIER

The preamplifier output signal is connected to the 452 through the BNC connector on the front or rear panel labeled Input. The input impedance is 1000Ω and is dc-coupled to ground; therefore the output of the preamplifier must be either ac-coupled or have approximately zero dc voltage under no-signal conditions.

The 452 incorporates pole-zero cancellation in order to enhance the overload characteristics of the amplifier. This technique requires matching the network to the preamplifier decay time constant in order to achieve perfect compensation. The network is variable and factory adjusted to 50 μs to approximately match all ORTEC FET preamplifiers. If other preamplifiers or more careful matching is desired, the adjustment is accessible from the front panel. Adjustment is easily accomplished by using a monoenergetic source and observing the amplifier baseline with an oscilloscope after each pulse under overload conditions. Adjustment should be made so that the pulse returns to the baseline in a minimum of time with no undershoot.

Preamplifier power of +24 V, +12 V, -12 V, and -24 V is available on the preamplifier power connector.

When using the 452 with a remotely located preamplifier (i.e., preamplifier-to-amplifier connection through 25 ft or more of coaxial cable), care must be taken to ensure that the characteristic impedance of the transmission line from the preamplifier output to the 452 input is matched. Since the input impedance of the 452 is 1000Ω, sending end termination will normally be preferred; i.e., the transmission line should be series terminated at the output of the preamplifier. All ORTEC preamplifiers contain series terminations that are either 93Ω or variable; coaxial cable type RG-62/U or RG-71/U is recommended.

3.3 CONNECTION OF TEST PULSE GENERATOR

Connection of Pulse Generator to the 452 Through a Preamplifier. The satisfactory connection of a test pulse generator such as the ORTEC 419 or equivalent depends primarily on two considerations: the preamplifier must be properly connected to the 452 as discussed in Section 3.2, and the proper input signal simulation must be applied to the preamplifier. To ensure proper input signal simulation, refer to the instruction manual for the particular preamplifier being used.

Direct Connection of Pulse Generator to the 452. Since the input of the 452 has 1000Ω input impedance, the test pulse generator will normally have to be terminated at the amplifier input with an additional shunt resistor. In addition, if the test pulse generator has a dc offset greater than 1 V, a large series isolating capacitor is also required since the input of the 452 is dc-coupled. The ORTEC Test Pulse Generators are designed for direct connection. When any of these units are used, they should be terminated with a 100Ω terminator at the amplifier input or used with at least one of the output attenuators set at IN. (The small error due to the finite input impedance of the amplifier can normally be neglected.)

Special Test Pulse Generator Considerations for Pole-Zero Cancellation. The pole-zero-cancellation network in the 452 is factory adjusted for a 50-μs decay time to match ORTEC FET preamplifiers. When a tail pulser is connected directly to the amplifier input, the PZ ADJ should be adjusted if overload tests are to be made (other tests are not affected). See Section 6.2 for the details.

If a preamplifier is used and a tail pulser connected to the preamplifier test pulse input, similar precautions are necessary. In this case, the effect of the pulser decay must be removed, i.e., a step input should be simulated. Details for this modification are also given in Section 6.2.

3.4 CONNECTION TO POWER

The 452 contains no internal power supply and therefore must obtain power from a Nuclear Standard Bin and Power Supply such as the ORTEC 401A/402A. It is recommended that the Bin power supply be turned off when modules are inserted or removed. The ORTEC NIM modules are designed so that it is not possible to overload the Bin power supply with a full complement of modules in the Bin. Since, however, this may not be true when the Bin contains modules other than those of ORTEC design, the power supply voltages should be checked after the modules are inserted. The 401A/402A has test points on the Power Supply control panel to monitor the dc voltages.

3.5 SHAPING CONSIDERATIONS

The shaping time constant on the 452 Amplifier is switch-selectable in steps of 0.25, 0.5, 1, 2, 3, and 6 μs.The choice of the proper shaping time is generally a compromise between operating at high counting rates and operating with the best signal-to-noise ratio. For scintillation counters the energy resolution largely depends on the scintillator and photomultiplier, and therefore a shaping time constant of about four times the decay time constant of the scintillator is a reasonable choice (for NaI, a 1-μs shaping time constant is about optimum). For gas proportional counters the collection time constant is normally in the 0.5- to 5-μs range and the 2-μs or greater resolving time will generally give optimum resolution. For surface barrier semiconductor detectors a 1- or 2-μs resolving time will generally provide optimum resolution. Shaping time for Ge(Li) detectors will vary from 1 to 6 μs, depending upon the size, configuration, and collection time of the specific detector and preamplifier. When a charge-sensitive preamplifier is used, the optimum shaping time constant to minimize the noise of a system can be determined by measuring the output noise of the system and dividing it by the gain of the system. Since the 452 has almost constant gain for all shaping modes, the optimum shaping can be determined by measuring the output noise of the 452 with a voltmeter as each of the shaping modes is selected.

The 452 provides both the unipolar and bipolar outputs. The unipolar output pulse should be used in applications where the best signal-to-noise ratio (resolution) is desired, such as high-resolution spectroscopy using semiconductor detectors. Use of the unipolar output with baseline restoration will also give excellent resolution at high counting rates. The bipolar output should be used in high count rate systems when the analyzer system is ac-coupled and noise, or resolution, is a secondary consideration.

3.6 USE OF DELAYED OUTPUT

The prompt output is used for normal spectroscopy applications. The delayed output (equal in amplitude to the prompt output, but delayed by 2 μs) is used in coincidence experiments where the output may be delayed to compensate for time delays in obtaining the coincidence information. The considerations regarding the proper choice of shaping for the delayed output are discussed in Section 3.5.

3.7 *OUTPUT CONNECTIONS AND TERMINATING CONSIDERATIONS*

Since the 452 unipolar output is normally used for spectroscopy, it is designed with a great amount of flexibility in order to interface this output with an analyzer. A BLR circuit is included in this output for improved performance at high count rate. A switch permits this circuit to be switched out, set for low count rates, or set for high count rates. When using the direct-coupled input of the various analyzers, a variety of voltage requirements exist. To meet these requirements the 452 unipolar output can be selected for full range voltages of -3 V, ±6 V, or ±10 V. The unipolar output dc level can be adjusted from -1 V to +1 V to set the zero intercept on the analyzer when the direct-coupled input is used. The bipolar output, with a 0- to 10-V range regardless of the unipolar range setting, can be used for crossover timing or may be preferable for spectroscopy when operating into ac-coupled systems at high counting rates. Typical system block diagrams for a variety of experiments are described in Section 4.

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 to accept both the interconnecting cable and a 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 in 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.

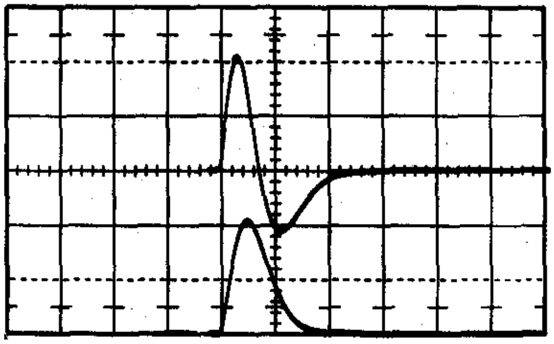
3.8 SHORTING OR OVERLOADING THE AMPLIFIER OUTPUTS

All outputs of the 452 are dc-coupled with an output impedance of about 0.1Ω. If the output is shorted with a direct short circuit or the amplifier counting rate exceeds 35% duty cycle, the output stage will limit the peak current of the output so that the amplifier will not be harmed.

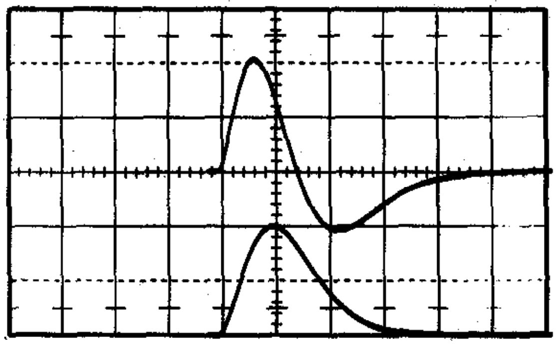
4. OPERATING INSTRUCTIONS

4.1 INITIAL TESTING AND OBSERVATION OF PULSE WAVEFORMS

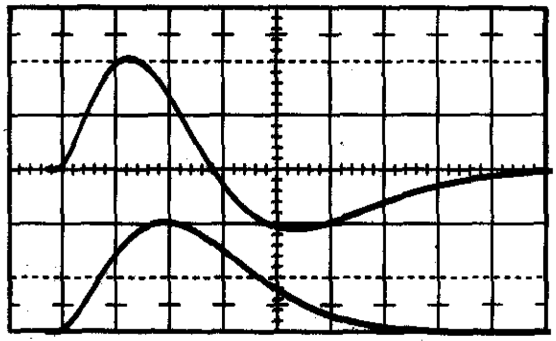
Refer to Section 6 for information on testing performance and observing waveforms at front-panel test points. Figure 4.1 shows some typical waveforms.



Shaping Time 0.5 µs



Shaping Time 1 µs



Shaping Time 2 µs

Fig. 4.1. Typical Effects of Shaping Time Selection on Output Waveforms. All waveforms taken with horizontal = 2 µs/cm and vertical = 5 V/cm.

4.2 FRONT-PANEL CONTROLS

GAIN A course-gain switch and a fine-gain 10-turn locking precision potentiometer selects the gain factor. For equal time constants the gain is read directly; switch positions, 5, 10, 20, 50, 100, 200, 500, 1000, and 2000, and continuous fine-gain range is 0.5 to 1.5 (500 to 1500 dial divisions).

INPUT POLARITY Slide switch sets the input circuit for either POS or NEG input polarity.

PZ ADJ Control to set the pole-zero cancellation for optimum matching to the preamplifier pulse decay characteristics, range 25 µs to infinity.

UNIPOLAR OUT RANGE Switch selects output polarity and full-scale ranges of -3 V, ±6 V, or ±10 V.

DC ADJ Potentiometer to adjust the dc level of unipolar output; range ±1.0 V.

DELAY Slide switch selects either 2-µs delay (IN) or prompt (OUT) output of the unipolar signals.

BLR 3-position slide switch selects baseline restorer function; HI for duty cycles >15%, LO for duty cycles <15%, or OUT.

SHAPING 6-position switch selects equal integrate and differentiate time constants of 0.25, 0.5, 1, 2, 3, and 6 µs.

4.3 FRONT-PANEL CONNECTORS (All Type BNC)

INPUT Positive or negative with rise time 10 to 650 ns; decay time must be greater than 25 µs for proper pole-zero cancellation. Input impedance is 1000Ω dc-coupled. Maximum linear input signal is 5.5 V with a maximum limit of ±20 V.

OUTPUTS Two BNC connectors with output impedance <0.1Ω. Each output can provide up to ±10 V and is dc-coupled and short-circuit protected.

UNIPOLAR This output features separate selection for full voltage range, polarity, and baseline restoration rate. The dc level is adjustable for offset to ±1.0 V. The unipolar pulse shape is determined by the settings of the shaping time constant switch. Unipolar range, polarity, BLR, and delay are independent of the bipolar output (see Fig. 4.1 for output pulse waveforms).

BIPOLAR Bipolar pulse is prompt with positive lobe leading and the pulse shape is selected by the shaping time constant switch. Linear range is 0 to ±10 V; independent of unipolar range. The crossover walk of this output is <±2 ns for 100:1 dynamic range.

4.4 REAR-PANEL CONNECTORS

INPUT Positive or negative with rise time 10 to 650 ns; decay time must be greater than 25 µs for proper pole-zero cancellation. Input impedance is 1000Ω dc-coupled. Maximum linear input signal is 5.5 V with a maximum limit of ±20 V.

OUTPUTS The unipolar and bipolar pulses are brought to the rear panel on BNC connectors. The specifications of these outputs are the same as those for the front-panel connectors except that the output impedance is 93Ω at these connectors.

PREAMP POWER Standard power connector for mating with ORTEC preamplifiers; ±24 V and ±12 V.

4.5 GENERAL CONSIDERATIONS FOR OPERATION WITH SEMICONDUCTOR DETECTORS

Calibration of Test Pulser. The ORTEC 419 Pulser, or equivalent, is easily calibrated so that the maximum pulse height dial reading (1000 divisions) is equivalent to 10 MeV loss in a silicon 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 gain 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 5.47-MeV alpha particle, set the dial on 547 divisions).
5. Turn on the Pulser, and use the NORMALIZE potentiometer and attenuators to set the output due to the pulser for the same pulse height as the pulse obtained in step 3. Lock the NORMALIZE dial and do not move again until recalibration is necessary.

The pulser is now calibrated; the PULSE HEIGHT dial reads in MeV if the number of dial divisions is divided by 100.

Amplifier Noise and Resolution Measurements. As shown in Fig. 4.2., the preamplifier, amplifier, pulse generator, oscilloscope, and a 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 amplifier noise:

1. Measure the rms noise voltage (E_{rms}) at the amplifier output.
2. Turn on the ORTEC 419 Precision Pulse Generator and adjust the pulser output to any convenient readable voltage, E_o, as determined by the oscilloscope.

The full width at half maximum (FWHM) resolution spread due to amplifier noise is then

$$N(FWHM) = \frac{2.66\, E_{rms}\, E_{dial}}{E_o},$$

where E_{dial} is the pulser dial reading in MeV, and 2.66 is the factor for rms to FWHM (2.34) and noise to rms meter correction (1.13) for average-indicating voltmeters such as the Hewlett-Packard 400D. A true rms voltmeter does not require the latter correction factor.

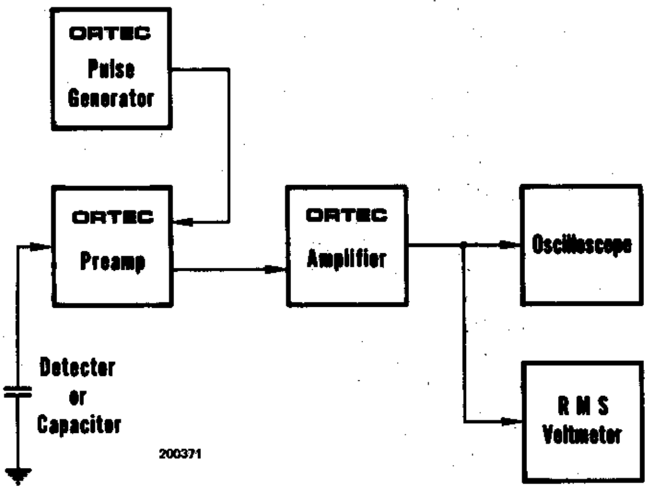


Fig. 4.2. System for Measuring Amplifier and Detector Noise Resolution.

The resolution spread will depend upon the total input capacitance, since the capacitance degrades the signal-to-noise ratio much faster than the noise. A typical resolution spread versus external input capacitance for the ORTEC 120 Preamplifier and the 452 Amplifier is shown in Fig. 4.3.

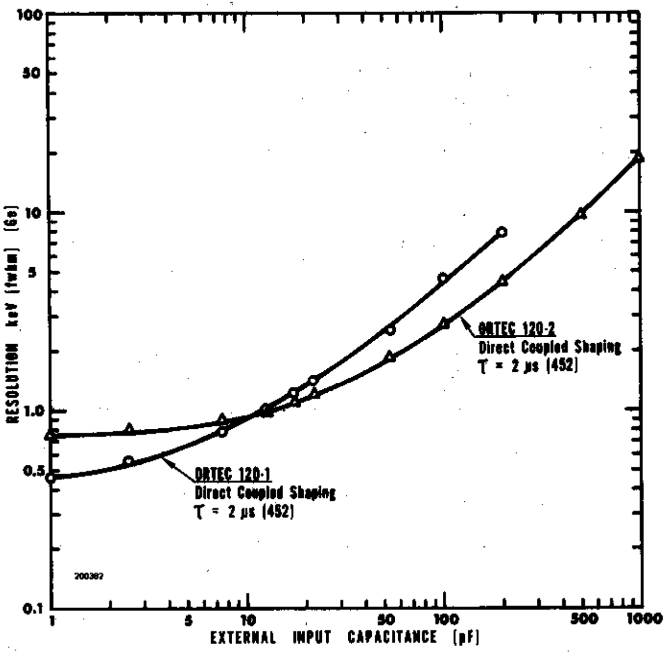


Fig. 4.3. Resolution Effects of Capacitance.

Detector Noise Resolution Measurements. The same measurement just described can be made with a biased detector instead of the external capacitor used to simulate the detector capacitance. The resolution spread will be larger because the detector contributes both noise and capacitance to the input. The detector noise resolution spread can be isolated from the amplifier noise spread if the detector capacity is known, since

$$(N_{det})^2 + (N_{amp})^2 = (N_{total})^2 \ ,$$

where N_{total} is the total resolution spread and N_{amp} is the amplifier resolution spread with the detector replaced by its equivalent capacitance.

The detector noise tends to increase with bias voltage, but the detector capacitance decreases, thus reducing the resolution spread. The overall resolution spread will depend upon which effect is dominant. Figure 4.4 shows curves of typical total noise resolution spread versus bias voltage, using the data from several ORTEC silicon surface-barrier semiconductor radiation detectors.

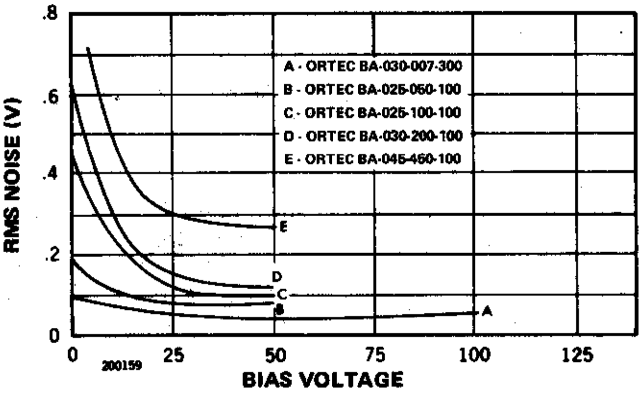


Fig. 4.4. Noise as a Function of Bias Voltage.

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. 4.5.

The amplifier noise resolution spread can be measured directly with a pulse height analyzer and the mercury pulser as follows:

1. Select the energy of interest with an ORTEC 419 Pulse Generator, and set the 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 pulser (full scale on the pulser dial is 10 MeV when calibrated as described in "Calibration of Test Pulser").

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 must be subtracted as described in "Detector Noise Resolution Measurements". The detector noise will vary with detector size and bias conditions and possibly with ambient conditions.

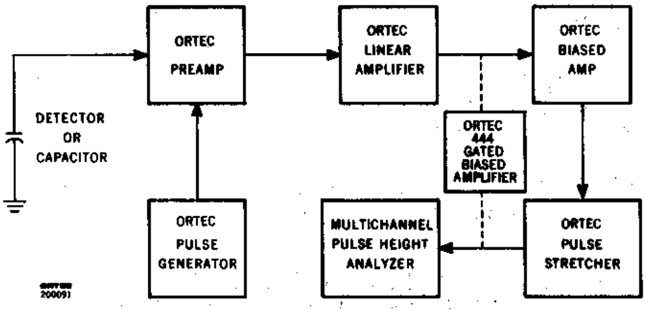


Fig. 4.5. System for Measuring Resolution with a Pulse Height Analyzer.

Current-Voltage Measurements for Silicon and Germanium Detectors. The amplifier system is not directly involved in semiconductor detector current-voltage measurements, but the amplifier serves well to permit noise monitoring during the setup. The detector noise measurement is a more sensitive method of determining the maximum detector voltage which should be used, because the noise increases more rapidly than the reverse current at the onset of detector breakdown. Make this measurement in the absence of a source.

Figure 4.6 shows the setup required for current-voltage measurements. The ORTEC 428 Bias Supply is used as the voltage source. Bias voltage should be applied slowly and reduced when noise increases rapidly as a function of applied bias. Figure 4.7 shows several typical current-voltage curves for ORTEC silicon surface-barrier detectors.

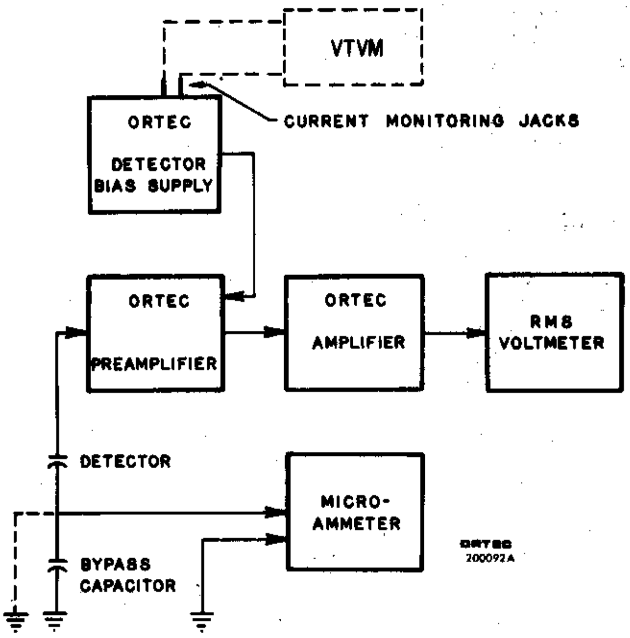


Fig. 4.6. System for Detector Current and Voltage Measurements.

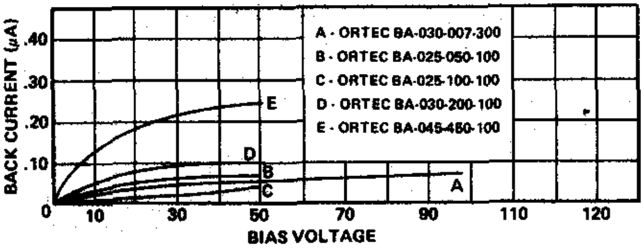


Fig. 4.7. Silicon Detector Back Current vs Bias Voltage.

When it is possible to float the microammeter at the detector bias voltage, the method of detector current measurement shown by the dashed lines in Fig. 4.6 is preferable. The detector is grounded as in normal operation and the microammeter is connected to the current monitoring jack on the 428 Detector Bias Supply.

Preamplifier—Main Amplifier Gain Adjustments as a Function of Input Particle Energy. With the input energy at a constant, or maximum, known value, the following method is recommended for adjusting the total system gain of the preamplifier and main amplifier to an optimum value.

1. The primary design criterion for the preamplifier is the best signal-to-noise ratio at the output; therefore the preamplifier should be operated with the gain switch in its maximum gain position. This will result in the best signal-to-noise ratio available, and at the same time the absolute voltage amplitude of the preamplifier signal will be maximized.

2. Since the fine-gain control of the 452 is an attenuator, it should be set to as near maximum as possible by manipulation of the coarse gain.

3. The unipolar output range should be set to the input range of the analyzer.

4.6 OPERATION IN SPECTROSCOPY SYSTEMS

High-Resolution Alpha-Particle Spectroscopy System. The block diagram of a high-resolution spectroscopy system for measuring natural alpha-particle radiation is shown in Fig. 4.8. Since natural alpha-particle radiation only occurs above several MeV, an ORTEC 444 Biased Amplifier is used to suppress the unused portion of the spectrum. Alpha-particle resolution is obtained in the following manner:

1. Using maximum preamplifier gain, medium amplifier gain, and minimum biased amplifier gain and bias level, accumulate the alpha peak in the multichannel analyzer.

2. Slowly increase the bias level and biased amplifier gain until the alpha peak is spread over 5 to 10 channels and the minimum to maximum energy range desired corresponds to the first and last channels of the analyzer.

3. Calibrate the analyzer in keV per channel using the pulser and the known energy of the alpha peak (see "Calibration of Test Pulses"), or two known energy alpha peaks.

4. The resolution can be obtained by measuring the FWHM of the alpha peak in channels and converting to keV.

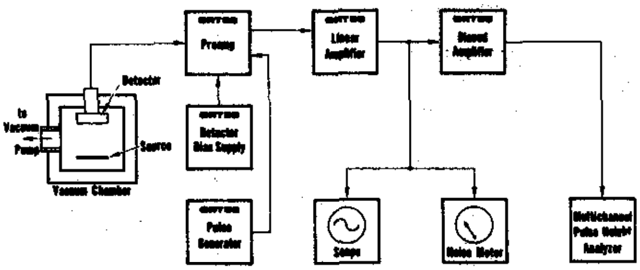


Fig. 4.8. System for High-Resolution Alpha-Particle Spectroscopy.

High-Resolution Gamma Spectroscopy System. A high-resolution gamma system block diagram is shown in Fig. 4.9. Although a biased amplifier is not shown (a larger channel analyzer being preferred), it can be used if only a smaller channel analyzer is available and only higher energies are of interest.

When using lithium-drifted germanium detectors cooled by a liquid-nitrogen cryostat, it is possible to obtain resolutions from about 1 keV FWHM up (depending on the energy of the incident radiation and the size and quality of the detector). Reasonable care is required to obtain such results. Some guide lines for obtaining optimum resolution are:

1. Keep interconnection capacities between the detector and preamplifier to an absolute minimum (no cables).

2. Keep humidity low near the detector-preamplifier junction.

3. Operate in amplifier and preamplifier gain regions which provide the best signal-to-noise ratio.

4. Operate at the highest allowable detector bias to keep the input capacity low.

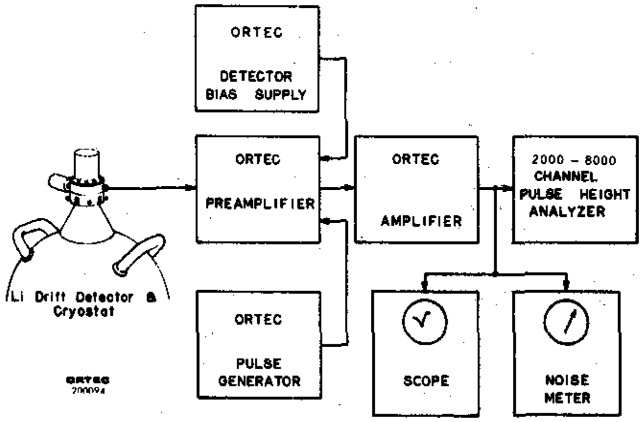


Fig. 4.9. System for High-Resolution Gamma Spectroscopy.

Scintillation Counter Gamma Spectroscopy Systems. The ORTEC 452 can be used in scintillation counter spectroscopy systems as shown in Fig. 4.10. The amplifier clipping time constants should be selected in the region of 0.5 to 1.0 μs for NaI or plastic scintillators. For scintillators having longer decay times, longer time constants should be selected.

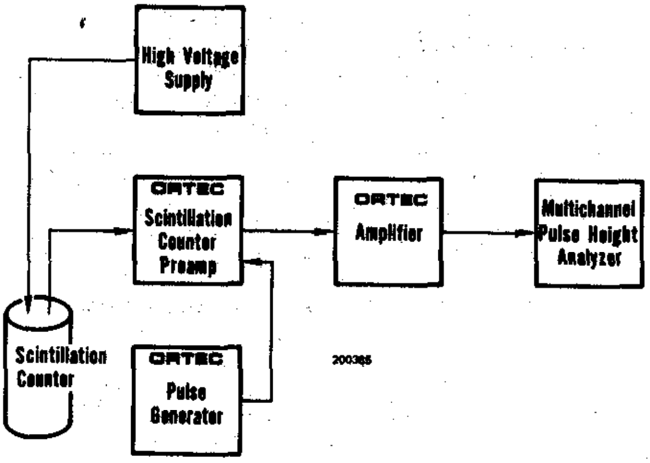


Fig. 4.10. Scintillation Counter Gamma Spectroscopy System.

X-Ray Spectroscopy Using Proportional Counters. Space charge effects in proportional counters operated at high gas amplification tend to degrade the resolution capabilities drastically at x-ray energies, even at relatively low counting rates. By using a high-gain low-noise amplifying system and lower gas amplification, these effects can be reduced and a considerable improvement in resolution can be obtained. The block diagram in Fig. 4.11 shows a system of this type. Analysis can be accomplished by simultaneous acquisition of all data on a multichannel analyzer or counting a region of interest in a single channel analyzer window with a scaler and timer or counting rate meter.

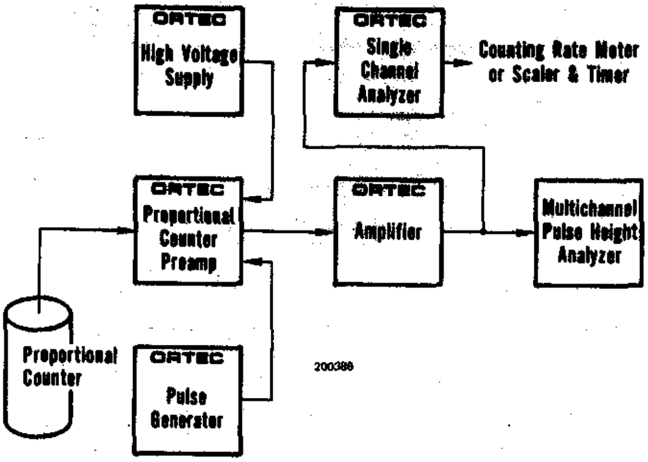


Fig. 4.11. High-Resolution X-Ray Energy Analysis System.

4.7 OTHER EXPERIMENTS

Block diagrams illustrating how the 452 and other ORTEC 400 Series modules can be used in experimental setups are given in Figs. 4.12–4.15.

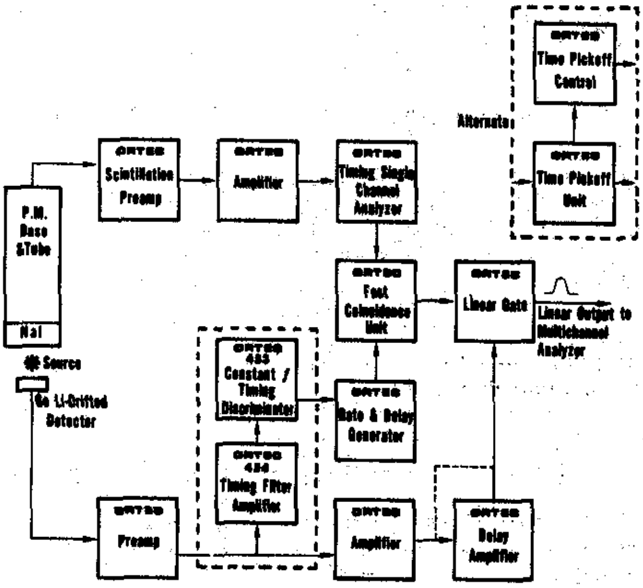


Fig. 4.12. Gamma-Gamma Coincidence Experiment.

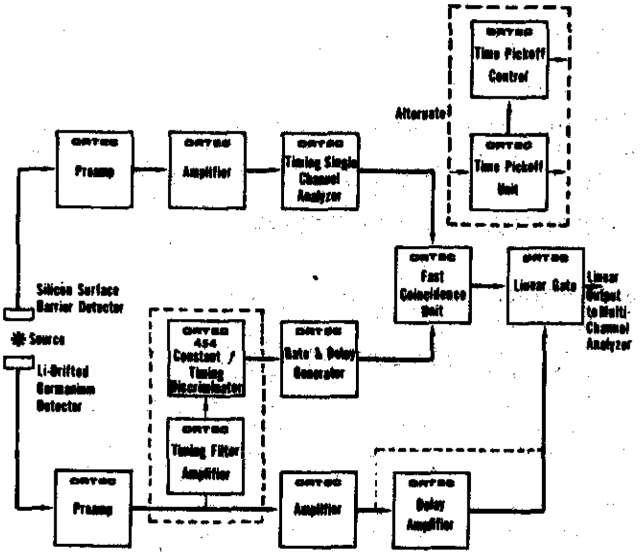


Fig. 4.13. Gamma-Ray Charged-Particle Coincidence Experiment.

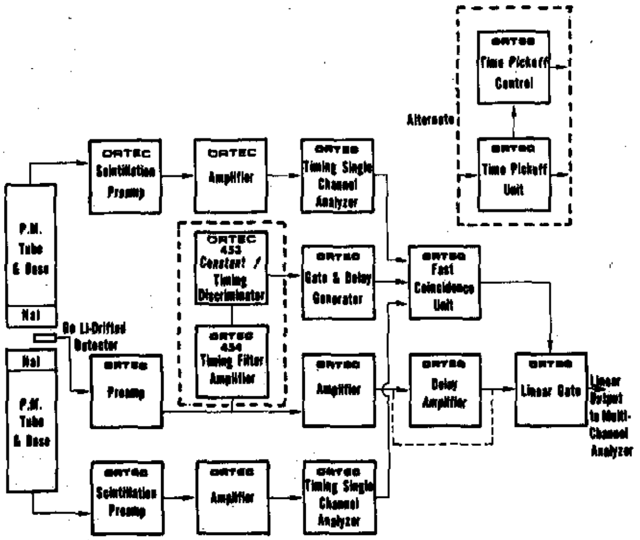


Fig. 4.14. Gamma-Ray Pair Spectrometer.

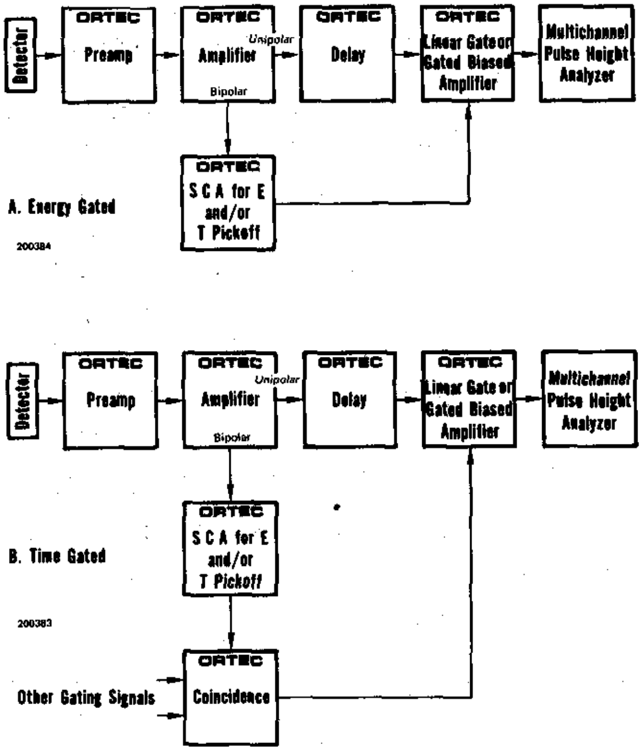


Fig. 4.15. General System Arrangement for Gating Control.

4.8 BASELINE RESTORER (BLR)

Function

DC Level. The operation of the 452 in the system is quite straightforward. The Output Range Switch selects the span of the output voltage to be -3 V, ±6 V, or ±10 V for the Unipolar Output. This allows a matching to all ADC inputs. *On some ADC's the input has a zero offset adjust to set the* zero channel intercept which controls a dc level internally in the ADC, normally operating in the ac-coupled mode; however, when direct access is used, this dc offset adjust is to some degree disabled by the output impedance of the driving amplifier (in this case, the 452 which controls the *amount of that dc voltage). Since the 452 dc output level* controls the zero intercept of these ADC's, this dc level is front-panel adjustable between +1.0 V and -1.0 V. The manual for the ADC used should be referred to for determining the desired dc level.

Controls. The BLR rate switch (S4) has three positions, Out, Lo, and Hi, and selects the rate of dc restoration. The Out mode is used when the count rate is low to moderate and best energy resolution (the least noise width contribution) is required. In many experimental systems the Lo *position of the BLR switch may give better results than the* Out position, even at low count rates. This will especially be true if the system is microphonic or a ground loop exists. The Lo and Hi restore modes provide a selectable restoration rate and therefore a very much higher count *rate capability for the same amount of pileup distortion.* The restorer should be used whenever high count rates (approximately 5000 to 10,000 counts/sec) are to be encountered. BLR switch selects the restorer capacitor to allow optimum restoration for each range of count rates, *or bypasses the BLR when it is set at* Out. (See Fig. 4.16 for aid in selection of the best BLR rate.)

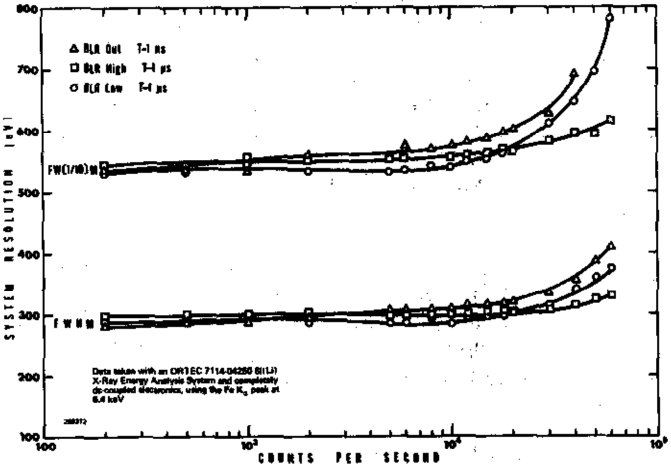


Fig. 4.16. Effects of Baseline Restorer on Resolution.

Used in a System

If the 452 is used in a system that also includes a nonlinear element such as a biased amplifier, the system must be dc-coupled up to the nonlinear element or be dc-restored prior to it in order to obtain good pulse height resolution. If the output from the nonlinear element is ac-coupled, dc restoration is required again before the pulses are fed into a pulse height analysis system (multichannel analyzer, for example) to obtain the best pulse height resolution versus count rate. These precautions are satisifed by using an ORTEC 444 Biased *Amplifier at moderate count rates,* since it contains a dc restoration circuit. Of course, it is necessary to have dc coupling following the dc restoration through to the pulse height analysis system.

Some of the analog-to-digital converters associated with multichannel analyzers are not dc-coupled at their normal input and contain no method of dc restoration; however, some of these analyzers do allow direct access to their linear gate circuitry in the so-called Mössbauer analysis mode. Other ADC's have a built-in dc restorer capable of restoring the long time constant associated with the ac-coupling capacitor in the ADC prior to the dc restorer point. In these cases, one may obtain a reasonably high count rate, i.e., of the order of 10,000 to 15,000 counts/sec, of high-resolution data by dc restoration externally and coupling directly into the ADC in the normal mode. This means that there are two steps of dc restoration. If, however, very high count rates are to be encountered, one should assure dc coupling in these ADC's as well and dc restoration externally by means of the 452.

4.9 METHODS OF CONNECTION TO VARIOUS ANALYZERS

There are many ADC's in use in nuclear research and the variety of input requirements is almost as broad as the variety of ADC's used. The ADC's listed below and the block diagrams of Figs. 4.17 and 4.18 outline methods of connecting the 452 into the system in such a way that it will perform its function and supply an analysis signal to the ADC through a dc-coupled network. Note that in some cases it is necessary to feed two signals to the ADC. One of these, which is the dc-coupled signal to be analyzed, goes directly to the gate circuit, while the second signal goes to the normal input and is used merely as a trigger signal to initiate analysis since some of the ADC's pick off the trigger signal to initiate analysis from the normal (0 to 10 V) input.

Various manufacturers of multichannel analyzers and their recommended method of dc coupling of specific ADC's are given below. Figure 4.17 applies when no trigger is needed, and Fig. 4.18 applies when an external trigger is indicated. If information in excess of that given is necessary, contact the analyzer manufacturers for further details.

A. RIDL (NUCLEAR-CHICAGO) Models 34-12B, 34-27, 22-Series.

PACKARD INSTRUMENTS

INTERTECHNIQUE

Direct access available through the dc or Mössbauer Input (trigger required).

B. NORTHERN SCIENTIFIC

Direct access available on all models (no trigger required).

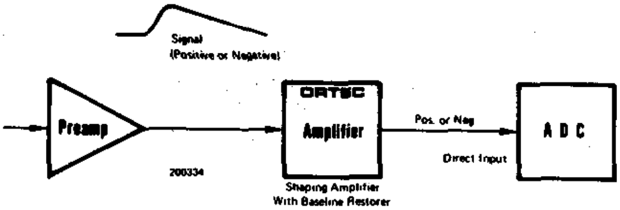


Fig. 4.17. Analyzer Connection with No Trigger Required.

C. NUCLEAR DATA

ADC Model	Direct Input (V)	Modification	Trigger Condition
ND-120	-3	Short out 0.01-μF capacitor on ADC board, base of T-1	None Req.
ND-130	-3		
ND-110	-2.5	None (use Mössbauer Input)	None Req.
ND-160F	-3	None (use Direct)	None Req.
ND-161F	-3	Short out 0.018-μF capacitor on ADC board, base of T-1	None Req.
ND-2200	0-5 (offset baseline)	Short out capacitor 09D8 on board	No trigger required if operated in open gate
ND-3300	+10	Short out 0.01-μF capacitor on ALG board	Trigger required

D. TMC ANALYZER AND ADC DIRECT INPUT REQUIREMENTS

Model No.	Signal Required (V)	Modifications
102 Analyzer	0 to -4	Yes^a
213 ADC	0 to +8	Yes^b
401D Analyzer	0 to -4	Yes^a
404C Analyzer	0 to -4	Yes^a
461 ADC	0 to -8	No
1001 Analyzer	0 to -4	Yes^c
1004 Analyzer	0 to -4	Yes^a
1010 Analyzer	0 to -4	Yes^c
217B ADC	0 to -4	Yes^c

^{a}Add signal input and trigger input for Linear Gate.
^{b}Add signal input and special trigger input.
^{c}Add signal input to Linear Gate circuit.

E. TULLAMORE (Victoreen) signal 0 to +10 V

Model No.	Modification	Trigger	dc Level (V)
PIP-400	Short C-203	None	~+1.5
SCIPP Series	Short C-403	None	~+1.5
ICADC	None	None	~ 0

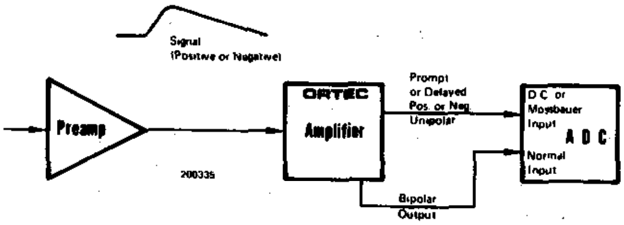


Fig. 4.18. Analyzer Connection When Trigger Is Required.

5. CIRCUIT DESCRIPTION

The 452 contains six basic feedback amplifiers and a base line restoration (BLR) circuit as shown in the block diagram (452-0201-B1). The input amplifier (A1) is an ORTEC 908-6 amplifier 0A-3B-15 with a polarity switching arrangement on the input to connect the signal to either the inverting or noninverting input. When the input polarity switch is set to the polarity of the input pulse, the output pulse from A1 will always be negative. The gain of this stage (~2.6) is set by R7 and R8 for positive polarity when the coarse gain is set between 50-2K. The gain of A1 is changed to approximately one (R9/R7) for coarse-gain settings between 20 and 5.

The gain for negative input pulse is the same as for positive; however, resistors R1, R3, and R4 also enter into the gain expressions.

Immediately following the first stage is the first differentiation and pole-zero-cancellation network; i.e., C9, R16, and R12 form this network for a 1-μs shaping time constant. R12 permits adjustment of the zero in the network so that it will cancel the preamplifier pole. See Section 1.2 for a discussion of pole-zero cancellation.

The second amplifier is composed of Q1 - Q8 and Q43 used as a Zener to improve overload recovery. The gain of this stage is set by R19, R20, R21, or R22, depending on the coarse-gain setting. Resistors R20, R21, and R22 have selectable capacitors in parallel with them to produce the first integrator in the 452. These capacitors (C12 - C29) are selected by switch S3C — S3B. The pulse gain from the output of A1 to the output of A2 can be set by the coarse-gain switch to 2.5, 5, or 10 when equal time constants are selected.

The fine-gain control is an attenuator composed of R39 and R40. The wiper arm of R39 (precision 10-turn potentiometer) selects the portion (0.33 to 1.0 and labeled as 0.5 to 1.5 on the front-panel dial) of the output voltage from A2 to be fed to A3.

Amplifier A3 is a noninverting amplifier composed of Q9-Q18. The gain of this stage is 1.5, 3, 6, or 12, depending on the feedback resistor selected by the coarse-gain switch. The gain setting resistors are R51, and R52, R53, R54, or R55.

Amplifier A4 consists of Q19 - Q26. The feedback network of this stage comprises the active filter in the 452. This network produces two complex poles and a zero. The zero is cancelled by the pole produced by the first integrate in the second stage (A2). The gain of A4 is varied (2, 4, or 10) by varying the input resistance (R74, R75, or R76).

Since the 452 is dc-coupled throughout, it is necessary to stabilize the dc level by some method to prevent excessive drift with temperature change. This stabilization network (Q27 - Q30) monitors the output dc voltage of A4 and sends an error signal back to A2 (base of Q2) if the output of A4 moves away from ground. The output dc level of A4 varies about 2 mV as the temperature is changed from 0 to 50°C.

The signal is routed in two directions from the output of A4. It is connected to A6 through a second selectable differentiation network to provide a bipolar ouptut. The bipolar signal is provided on the front and rear panels by BNC connectors with an output impedance of <0.1Ω on the front panel and 93Ω on the rear panel. Transistors Q41 and Q42 limit the output current to provide short-circuit protection. The signal is also routed to the unipolar output amplifier (A5) from A4. A BLR (Base Line Restoration) circuit and a delay line can be inserted in the signal path between A4 and A5 if desirable.

The BLR circuit is an active type of restoration circuit consisting of Q31 - Q38. The restoration rate (Hi or Lo) is determined by the value of the input coupling capacitor (C78 for Lo and C77 in series with C78 for Hi). When S4 is placed to the Out position, the BLR circuit is completely bypassed.

The 2-μs delay line can be either bypassed or inserted in series with the signal path by switch S5. When the delay line is connected in the circuit, it is terminated in its characteristic impedance on both ends.

Switch S6 permits amplifier A5 to be used as an inverting or noninverting amplifier with selectable output ranges on the unipolar output of -3 V, ±6 V, or ±10 V. A front-panel-mounted potentiometer (R137) permits adjustment of the unipolar output dc level between ±1 V. Transistors Q39 and Q40 limit the output current and provide short-circuit protection for the unipolar output.

6. MAINTENANCE

6.1 TEST EQUIPMENT REQUIRED

In order to adequately test the specifications of the ORTEC 452, the following equipment should be utilized:

ORTEC 419 Precision Pulse Generator

Tektronix Model 547 Series Oscilloscope with a Type 1A1 Plug-In or equivalent

Hewlett-Packard 400D RMS Voltmeter

6.2 PULSER MODIFICATIONS FOR OVERLOAD TESTS

Since the 452 incorporates variable pole-zero cancellation, factory adjusted to approximately 50 µs, when either the ORTEC 419 or 204 Pulse Generator is used to check overload, it should be connected as shown in Fig. 6.1, and the pole-zero cancellation adjusted to compensate for the fall time of the pulse generator.

If the pulser output is fed into a charge-sensitive preamplifier such as the ORTEC 109A, 118A, 120, 124, or 125 through a small capacitor to simulate the output of a semiconductor detector, the decay time of the pulser will cause an additional pole in the transform equation of the preamplifier output. This additional pole will degrade any overload measurements. In order to eliminate the pole, the pulser must be pole-zero cancelled as shown in Fig. 6.2.

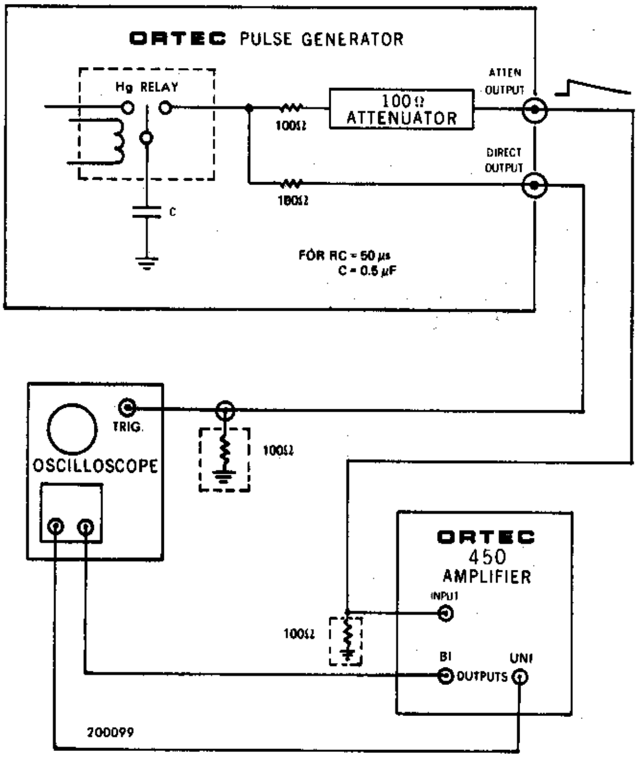


Fig. 6.1. Pulse Generator Modifications.

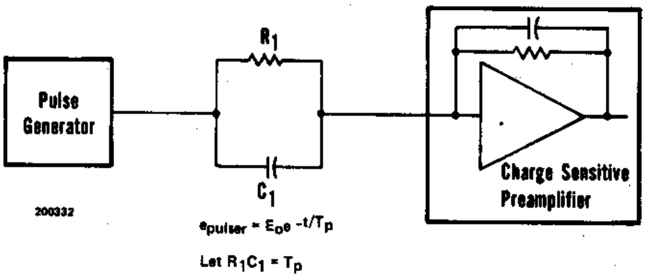


Fig. 6.2. Pole-Zero Cancellation of a Pulser Output.

6.3 PULSER TEST*

Functional Checks

1. Set the 452 controls as follows:

Coarse Gain	2K
Fine Gain	1.5
Input Polarity	Pos
Shaping Time Constant	1 µs
Unipolar Output Range	+10 V
Delay	Out
BLR	Out

2. Connect a positive pulser to the 452 as shown in Fig. 6.1 and adjust the pulser to obtain 10 V at the 452 Unipolar Output. This should require an input pulse of 3.3 mV. The Bipolar Output should also be 10 V.

3. Monitor the Unipolar Output and change the Output Range switch to −10, +6, −6, and −3 and then return to +10 V. The Unipolar Output should have changed to each selected level while the Bipolar Output remained at 10 V.

4. Place the Delay switch to the In position. The Unipolar pulse should be delayed 2 µs from its original position. Return the Delay switch to Out.

5. Change the Input Polarity switch to Neg and then back to Pos while monitoring the outputs for a polarity inversion.

6. Monitor the Unipolar Output dc level and ensure that the output will vary at least ±1.0 V with the DC ADJ. Reset to zero volts.

7. Obtain a 10-V output with maximum gain. Decrease the Coarse Gain switch stepwise from 2K to 5 and ensure that the output amplitude changes by an appropriate amount. Return the Coarse Gain switch to 2K.

8. Decrease the Fine Gain to 0.5, at which time the output should decrease by a factor of 3. Return the Fine Gain control to maximum.

9. The shaping time constant (τ) should be set at 1 µs and the time to the peak of the Unipolar pulse should be 2 τ (2 µs). Change the shaping time constant to 0.25, 0.5, 2, 3, and 6 µs and check to see that the time to the peak of the Unipolar pulse is 2 τ for each time constant. Return to 1-µs shaping time constant.

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*See IEEE Standards No. 301, USAS N42.2; IEEE Trans. NS-16(6) (December 1969).

10. Repeat step 9 while monitoring the bipolar output. Ensure that the time from the beginning of the bipolar pulse to the crossover time is 2.8 τ.

Overload Tests

1. Set the gain to maximum and τ = 1 μs and obtain a 10-V output. Increase the pulser amplitude by X200 and observe that the Unipolar Output returns to within 200 mV of the baseline within 17 μs. It will probably be necessary to vary the PZ ADJ control on the front panel in order to cancel the pulser pole and minimize the return to the baseline.

2. Increase the pulse amplitude by X1000 above the 10-V setting and observe that the Bipolar Output returns to within 200 mV of the baseline within 25 μs. An external voltage source to the pulser may be required in order to obtain an approximate 3.3-V pulser output on X1000 overload.

Linearity

The integral nonlinearity can be measured by the technique shown in Fig. 6.3. In effect,the negative pulser output is substracted from the positive amplifier output, causing a null point which can be measured with high sensitivity. The pulser amplitude must be varied between 0 and 10 V (using an external voltage source for the pulser), and the amplifier gain and pulser attenuator must be adjusted to give zero voltage at the null point with a 10-V output. The variation in the null point as the pulser is varied from 10 V to zero is a measure of the nonlinearity. Since the subtraction network also acts as a voltage divider, this variation must be less than (10 V Full Scale) x (±0.05% Max Nonlinearity) x (½ for Divider Network) = ±2.5 mV Max Null Point Variation.

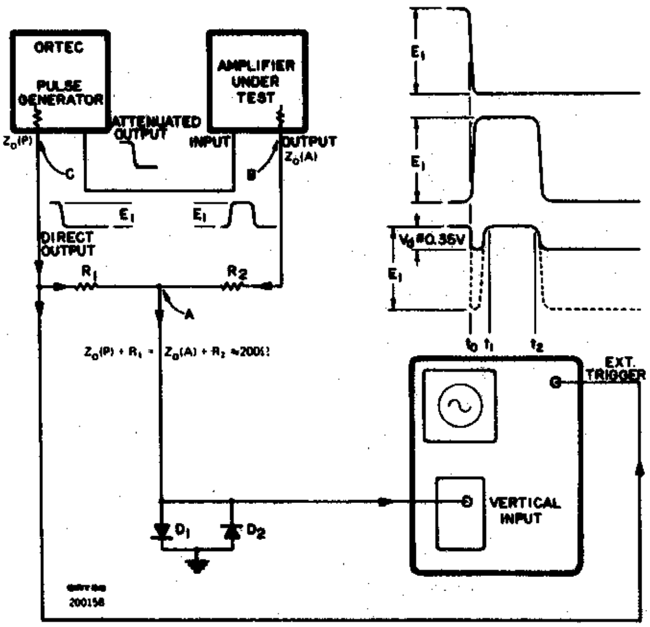


Fig. 6.3. Circuit Used to Measure Nonlinearity.

Output Loading

With the same setup as in "Linearity" adjust the amplifier output to 10 V and observe the null point change when the output is terminated in 100Ω. The change should be less than 5 mV.

Noise

Measure the noise at the amplifier output at maximum amplifier gain and 3-μs shaping time constant using the RMS Voltmeter for single and double clipping. The noise should be less than

4 μV x 3000 gain/1.13 = 10.6 mV for single clipping,
7 μV x 3000 gain/1.13 = 18.6 mV for double clipping.

The 1.13 is a correction factor for the average reading voltmeter and would not be required for a true rms voltmeter. Both inputs must be terminated in 100Ω for this measurement.

Crossover Walk with Amplifier (Amplifier and SCA)

With the setup of Fig. 6.4, obtain a 10-V amplifier output at an amplifier coarse gain of 20. Attenuate the pulser by X10, using only the pulser attenuator switches. The shift in the 420A should be less than ±2 ns. The "Walk Adj" trimpotentiometer on the 420A must be adjusted properly in order to make this measurement.

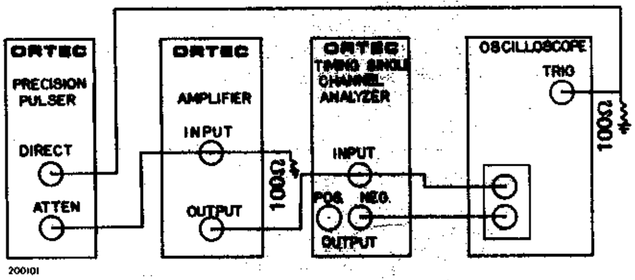


Fig. 6.4. Circuit Used to Measure Crossover Walk of the Amplifier and Single Channel Analyzer.

Crossover Walk with Amplitude (Amplifier Only)

The crossover walk of only the amplifier can be measured with the setup shown in Fig. 6.5. The 421 Integral Discriminator (or any other leading-edge discriminator) and the 416 Gate and Delay Generator are used to delay the trigger of the oscilloscope so that the crossover of the amplifier can be viewed on the shortest time scale of the oscilloscope (10 ns/cm). Two identical high-frequency attenuator pads must be used for this measurement (the 419 Pulser attenuator can be used if the attenuator of another 419 Pulser is used for the other attenuator). The pulser and the amplifier gain are adjusted so that there is an 8- to 10-V bipolar output at the oscilloscope, with the first attenuator having X20 attenuation and the second attenuator having no attenuation. Observe the crossover on the oscilloscope and remove the X20 attenuation from the first and add it to the second attenuator. The crossover walk under these conditions should be less than ±1 ns.

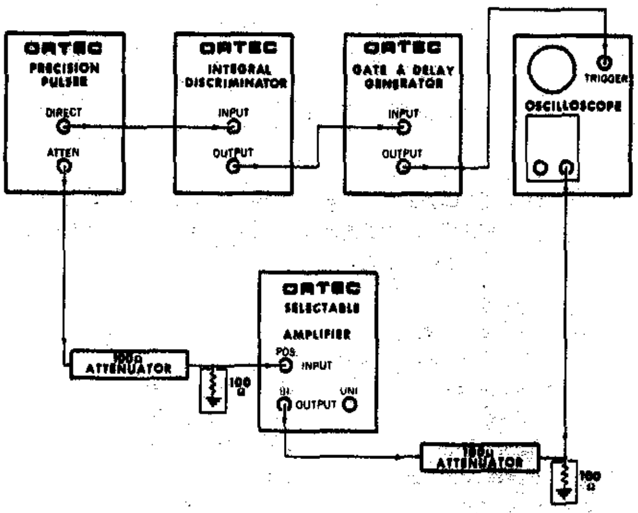


Fig. 6.5. Circuit Used to Measure Crossover Walk of the Amplifier Only.

Counting Rate Changes

Resolution spread and amplitude changes with counting rate can be measured with the setup shown in Fig. 6.6. Pulser pulses are mixed at the amplifier input with preamplifier pulses from a ^{137}Cs source, and the delayed mixed output is fed to a 442 Linear Gate. A 421 Integral Discriminator and a 416 Gate and Delay Generator are used to open the linear gate at the proper time to accept a shaped pulser pulse from the amplifier delayed output. Adjust the Amplifier gain so that the ^{137}Cs peak will store at about the 70% level (≈ channel 2900 in a 4096 Analyzer) in the pulse height analyzer, and then adjust the pulser amplitude to store at the 84% level (≈ channel 3450 in a 4096 analyzer). Change the ^{137}Cs source position until the counting rate as measured by the ratemeter is approximately 50,000 counts/sec. Two spectra are then accumulated, one with the ^{137}Cs source present and one with the ^{137}Cs source removed. Using a 1-μs shaping time constant, the pulser peak in the presence of the ^{137}Cs source should be shifted no more than 0.2% (seven channels for 4096 Analyzer) as compared to the pulser-only spectrum. Refer to Fig. 4.16 for the effects of baseline restorer on resolution.

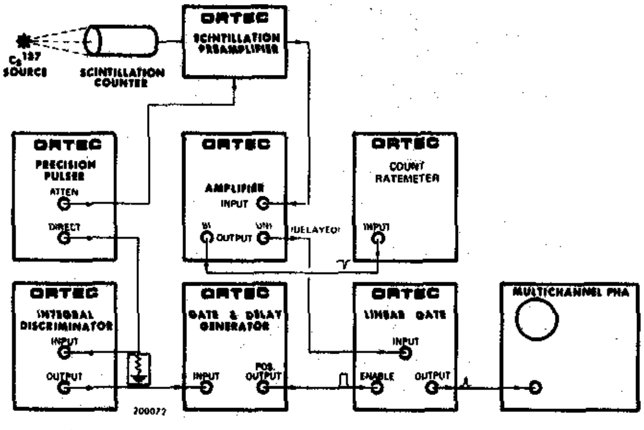


Fig. 6.6. Circuit Used to Measure Resolution Spread and Amplitude Changes at Various Count Rates.

6.4 SUGGESTIONS FOR TROUBLESHOOTING

If the 452 is suspected of malfunctioning, it is essential to verify such malfunctioning in terms of simple pulse generator impulses at the input. The 452 must be disconnected from its position in any system, and routine diagnostic analysis performed with a test pulse generator and oscilloscope. It is imperative that testing not be performed with a source and detector until the amplifier performs satisfactorily with the test pulse detector.

The testing instructions in Section 6.3 of this manual and the circuit descriptions in Section 5 should provide assistance in locating the region of trouble and repairing the malfunction. The two side plates can be completely removed from the module to enable oscilloscope and voltmeter observations with a minimal chance of accidentially short-circuiting portions of the etched board.

The 452 may be returned to ORTEC for repair service at nominal cost. Our standardized procedure requires that each repaired instrument receive the same extensive quality control tests that a new instrument receives.

Possible Problems and Solutions

Problem Unable to get a 10-V pulse on the Unipolar Output.

Solution Place the Unipolar Output range switch to 10 V.

Problem Unipolar Output pulse is distorted and limited at 2 to 3 V in amplitude.

Solution Change the input polarity switch to the opposite polarity if the BLR switch is in the Hi or Lo position. The pulse entering the BLR circuit must be the proper polarity to prevent distortion.

Problem Unable to get a pulse at the output.

Solution Reposition all front-panel switches to ensure that they are making good contact. If this does not solve the problem, the unit can be returned to ORTEC for repair. If an attempt is made to repair the unit, the following steps should be taken:

1. Set the coarse gain switch to 5 and check the dc voltage at tests points T1-T8 (refer to schematic and table in Section 6.5).
2. If the voltage at T1 is out of limits, check for broken printed circuits lines or replace Amp 1.
3. If the voltage is out of limits at T2-T5, short the base of Q2 to ground and recheck the voltages. The dc voltages should now locate the defective stage and component.
4. If the voltage is out of limits at T6, select the Out position with the BLR switch and recheck the voltages to locate the defective component.
5. If the voltage is out of limits at T7, check for broken printed circuit lines and Q41 and Q42. Replace Amp 3.
6. If the voltage is out of limits at T8, check for broken printed circuit lines and Q39 and Q40. Next select −10 V on the Output Range switch and ground pin 4 of Amp 2. Recheck voltage at T8. If it is still out of limits, replace Amp 2.

6.5 TABULATED TEST POINT VOLTAGES ON ETCHED BOARD

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 variation, there may be some voltages that measure different from the given values. Therefore the voltages given should not be taken as absolute values, but rather are intended to serve as an aid in troubleshooting.

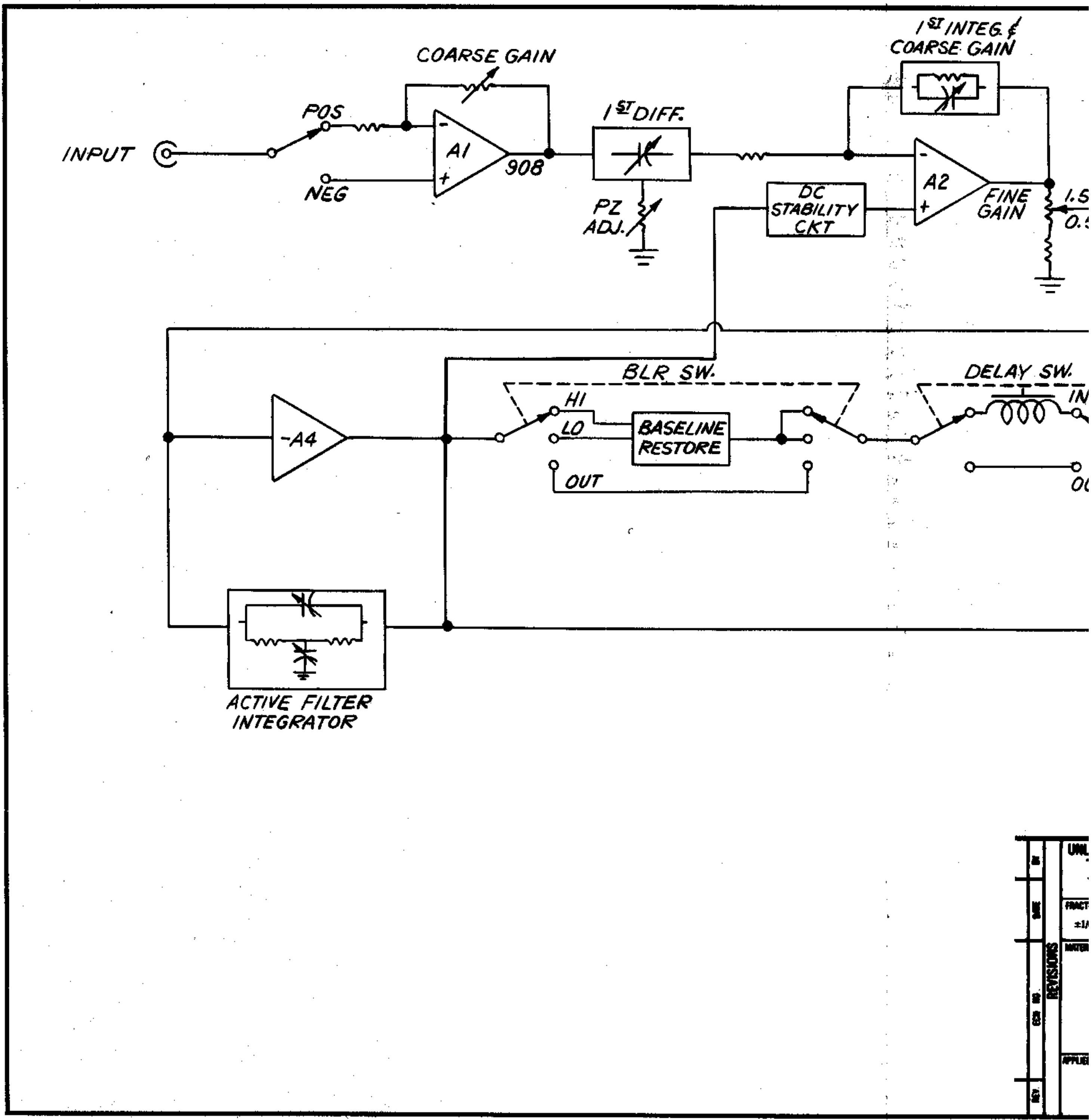
All the voltages listed below were measured with no input signal, with input terminated in 100Ω, and with all potentiometers at fully clockwise.

LOCATION	VOLTAGE	LOCATION	VOLTAGE
A1 pin 4	0 V	Q23C	+0.6 V
pin 7	0 V	T5	0 V
pin 10	0 V	T4	0 V
Q1B	0 V	Q29B	0 V
Q2B	0 V	Q29C	+5.6 V
Q2C	+17.4 V	Q30B	0 V
Q3B	-13.9 V	Q30C	+5.6 V
Q5C	+ 0.6 V	Q31B	+6 V
T-2	0 V	T6	0 V
Q9B	0 V	Q34B	-12 V
Q9C	+19.8 V	Q39B	+14.2 V
Q10B	0 V	Q40B	-14.0 V
Q10C	+ 21.4	Q41B	+14.2 V
		Q42B	-14.0 V
Q11B	-13.8 V	A2 pin 4	0 V
Q13C	0 V	pin 7	0 V
T3	0 V	pin 10	0 V
Q19B	0 V	A3 pin 4	0 V
Q19C	+18.5 V	pin 7	0 V
Q20B	0 V	pin 10	0 V
Q20C	+17.1 V		
Q21B	-13.7 V		

BIN/MODULE CONNECTOR PIN ASSIGNMENTS FOR AEC STANDARD NUCLEAR INSTRUMENT MODULES PER TID-20893

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	Carry No. 2
*10	+6 volts	32	Spare
*11	- 6 volts	*33	115 volts ac (Hot)
12	Reserved Bus	*34	Power Return Ground
13	Carry No. 1	35	Reset
14	Spare	36	Gate
15	Reserved	37	Spare
*16	+12 volts	38	Coaxial
*17	- 12 volts	39	Coaxial
18	Spare Bus	40	Coaxial
19	Reserved Bus	*41	115 volts ac (Neut.)
20	Spare	*42	High Quality Ground
21	Spare	G	Ground Guide Pin
22	Reserved		

These pins are installed and wired in parallel in the ORTEC 401A Modular System Bin.


INPUT
POS
NEG
COARSE GAIN
A1
908
1ST DIFF.
PZ ADJ.
1ST INTEG. &
COARSE GAIN
DC STABILITY CKT
A2
FINE GAIN
1.5
0.5
BLR SW.
HI
LO
OUT
BASELINE RESTORE
DELAY SW.
IN
OU
-A4
ACTIVE FILTER INTEGRATOR
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BY
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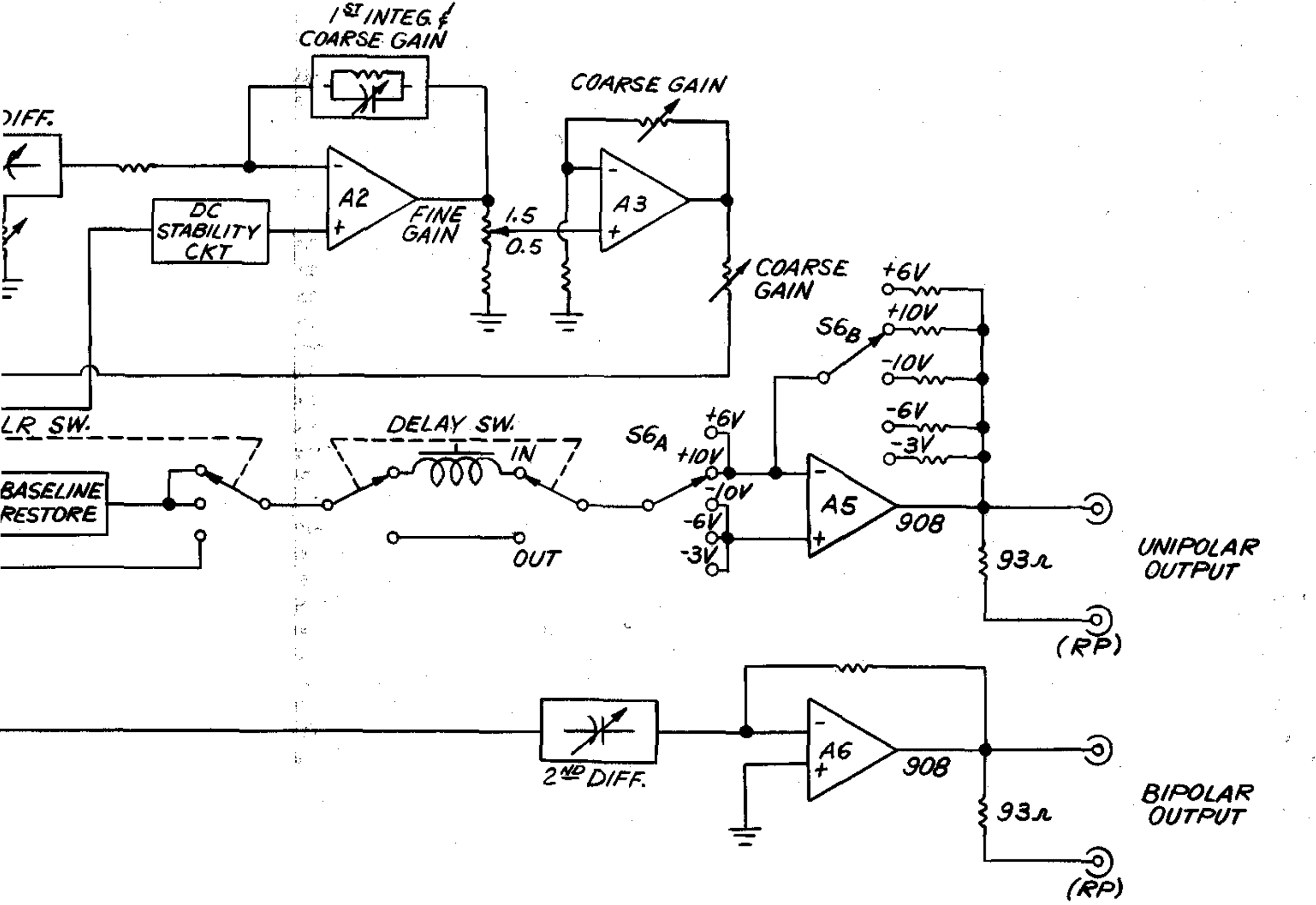
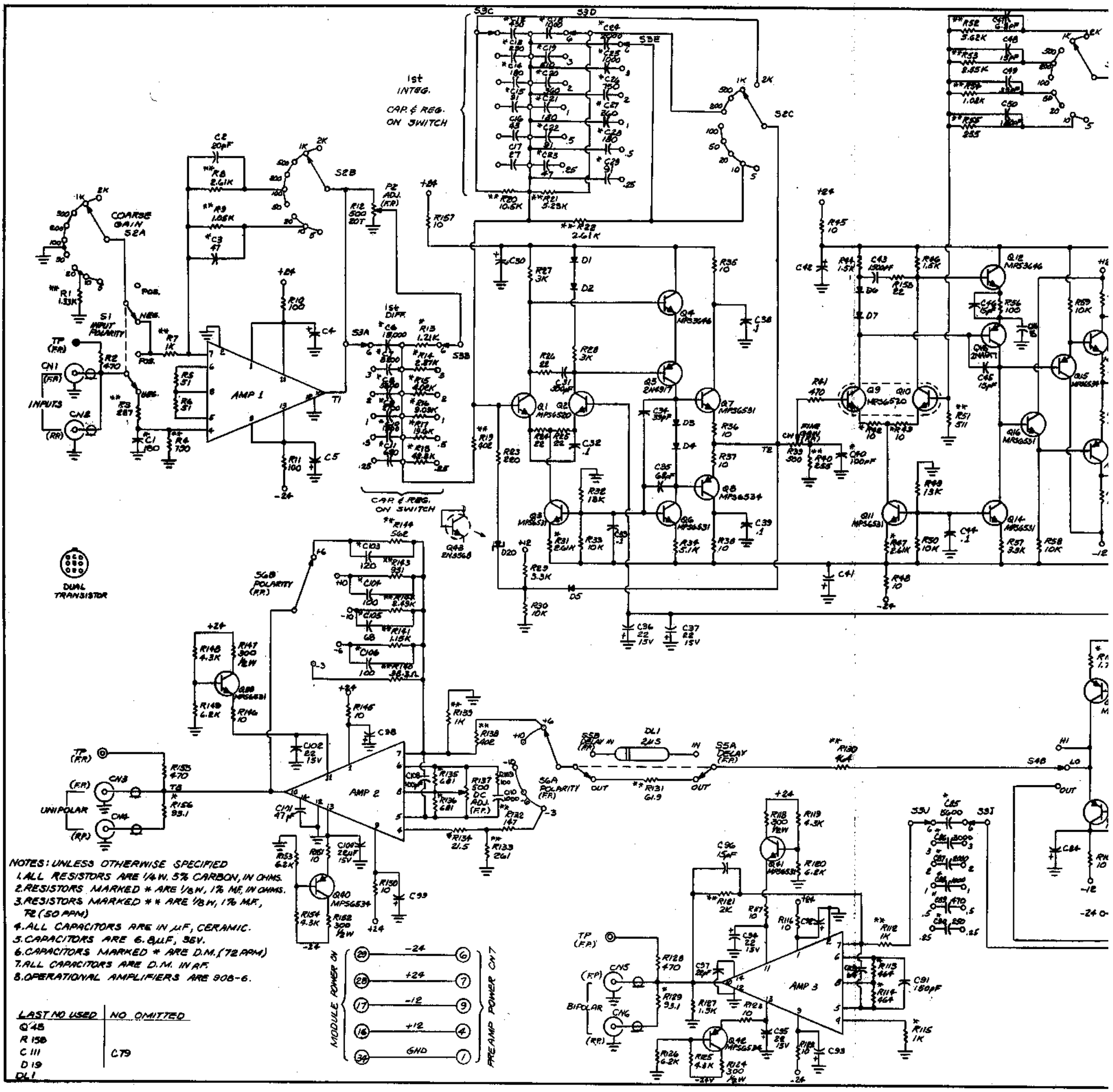
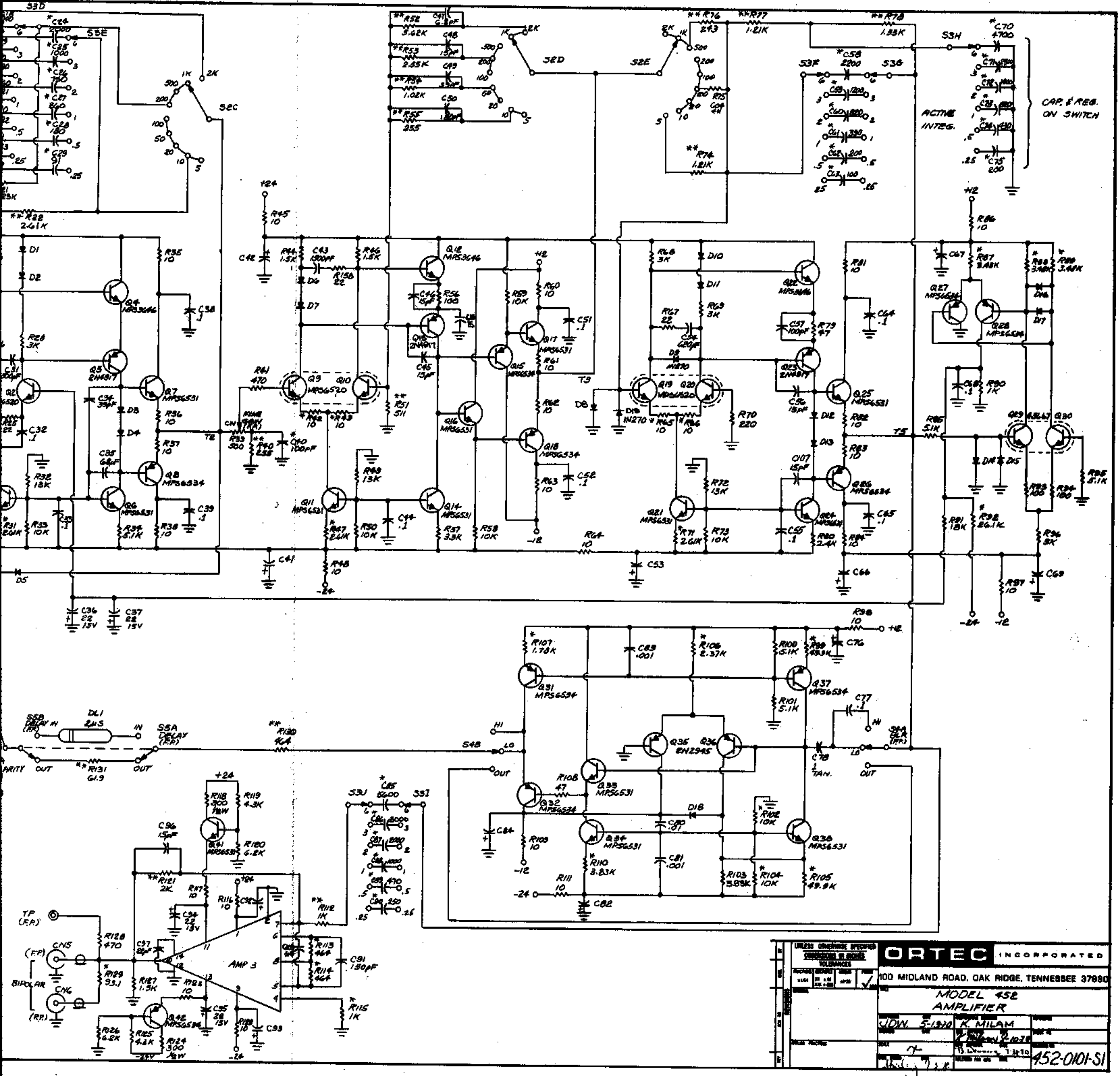


REVISIONS: BY / DATE / ECN NO. / REV	UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES TOLERANCES	**ORTEC** INCORPORATED		
	FRACTIONS ±1/64 DECIMALS XX ±.01 XXX ±.005 ANGLES ±0°30' FINISH ✓ RMS	100 MIDLAND ROAD, OAK RIDGE, TENNESSEE 37830		
	MATERIAL	TITLE AMPLIFIER BLOCK DIAGRAM		
		DRAFTSMAN D. NOE DATE 6-23-70	RESPONSIBLE ENGINEER K. MILAM	REFERENCE
		CHECKED DATE	ENG. APPROVAL K Milam DATE 6/25/70	STOCK NO.
	APPLIED PRACTICES	SCALE NONE	MFG. APPROVAL B Denning DATE 8-19-70	DRAWING NO. 452-0201-B1
		DWG. ISSUED Shirley DATE 9-3-70	RELEASED FOR MFG. DATE	



NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL RESISTORS ARE 1/4 W. 5% CARBON, IN OHMS.
2. RESISTORS MARKED * ARE 1/8 W, 1% MF, IN OHMS.
3. RESISTORS MARKED * * ARE 1/8 W, 1% M.F., T2 (50 PPM)
4. ALL CAPACITORS ARE IN µF, CERAMIC.
5. CAPACITORS ARE 6.8 µF, 35V.
6. CAPACITORS MARKED * ARE D.M. (72 PPM)
7. ALL CAPACITORS ARE D.M. IN pF.
8. OPERATIONAL AMPLIFIERS ARE 908-6.

LAST NO USED	NO OMITTED
Q 45	
R 158	
C 111	C79
D 19	
DL1	



ORTEC INCORPORATED

100 MIDLAND ROAD, OAK RIDGE, TENNESSEE 37830

MODEL 452

AMPLIFIER

JDW 5-1970

K. MILAM

452-0101-S1