

ARTISAN®
TECHNOLOGY GROUP

Your **definitive** source for quality pre-owned equipment.

Artisan Technology Group
(217) 352-9330 | sales@artisantg.com | artisantg.com

Full-service, independent repair center
with experienced engineers and technicians on staff.

We buy your excess, underutilized, and idle equipment
along with credit for buybacks and trade-ins.

Custom engineering
so your equipment works exactly as you specify.

- Critical and expedited services
- In stock / Ready-to-ship
- Leasing / Rentals / Demos
- ITAR-certified secure asset solutions

Expert team | Trust guarantee | 100% satisfaction

All trademarks, brand names, and brands appearing herein are the property of their respective owners.

Find the *Mirion / Canberra Industries 1416* at our website: ***Click HERE***

SPECTROSCOPY AMPLIFIER
MODEL 1416B

Instruction Manual

December, 1973

CANBERRA INDUSTRIES
45 Gracey Avenue
Meriden, Connecticut 06450

Telephone: 203-238-2351

Serial No._____

WARRANTY

Canberra-Manufactured Equipment

Equipment manufactured by Canberra Industries, Inc. is warranted against defects in materials and workmanship for a period of twelve months from date of shipment, provided that the equipment has been used in a proper manner as detailed in the instruction manuals. Repairs or replacement, at Canberra's option, will be made without charge at the Canberra factory during this warranty period. Except for the case of defects discovered upon initial operation, shipping expense to Canberra is to be paid by the customer; shipping expense to return the repaired equipment will be paid by Canberra.

The customer must obtain shipping instructions, including an *Authorized Return Number* (ARN), before returning any equipment to the Canberra factory. Compliance with this provision by the customer shall be a condition of this warranty. In giving shipping instructions, Canberra shall not, therefore, assume any liability in connection with the shipment. If, upon receipt of the equipment, Canberra determines that such equipment is not defective within the terms of this warranty, the customer shall pay to Canberra upon invoice, the cost of all transportation and cost of repairs at the then prevailing Canberra repair rate.

This warranty shall not apply to equipment that has been modified or serviced by other than Canberra service personnel, or to failures caused by defective equipment not supplied by Canberra.

This warranty applies only to equipment manufactured by Canberra. On other equipment supplied by Canberra, the full warranty, and only that warranty offered by the original manufacturer, will be passed on to the customer.

WARRANTY ON EQUIPMENT NOT MANUFACTURED BY CANBERRA

Canberra's basic one-year warranty applies only to equipment manufactured by Canberra. Although Canberra may frequently supply, as part of systems, equipment manufactured by other companies, the only warranty that shall apply to such non-Canberra equipment is that warranty offered by the original manufacturer.

Canberra will, upon request, state what warranties are offered by the original manufacturers of such items as computers, teletype machines, printers, plotters, and other non-Canberra equipment which may be supplied as part of a Canberra system. In no case, however, will Canberra assume any liability for such equipment other than to pass on to its customer whatever warranty is supplied by the original manufacturer.

WARRANTY ON SOFTWARE

Canberra will warrant system operation with *Canberra Laboratory Automated Software Systems* (CLASS) only. If the customer decides to use software other than CLASS, Canberra assumes *no* responsibility. Engineering assistance, however, for non-CLASS software is available to the user and should be contracted separately if desired.

ON-SITE WARRANTY OPTION

The basic Canberra warranty applies only to equipment manufactured by Canberra which is *returned to the factory.* If equipment must be repaired at the customer's site, the actual repair labor and parts will be provided at no charge during the warranty period. However, travel expenses to and from the customer's site, and living expenses while on site, shall be paid by the customer unless an on-site warranty option has been purchased. This option may only be purchased prior to shipment of the equipment to the customer.

The on-site warranty option provides for free on-site warranty work (Canberra pays all travel and living expenses) within the first 60 days after delivery of equipment to the customer. If installation is ordered from Canberra, the 60 day period commences upon completion of the initial installation. After the 60 day period, labor and materials used on site will still be covered by the basic warranty, but the customer shall pay for all travel and living expenses incurred for any on-site service.

The price of this 60 day on-site warranty option is $300.00 or two percent (2%) of the entire system list price, whichever is greater.

The on-site warranty option is available only within the contiguous forty-eight (48) United States and Canada.

After the 60 day on-site warranty period, or after initial installation of the equipment, a maintenance contract may be purchased. This is to be contracted through Canberra's Customer Engineering Department. Contact the factory for details concerning maintenance contracts.

INSTALLATION

Installation of equipment purchased from Canberra shall be the sole responsibility of the customer unless it is specifically contracted for at the prevailing Canberra field service rates. To insure timely installation after receipt of equipment, it is recommended that installation be contracted for at the time the equipment is ordered.

REPAIRS

Any Canberra-manufactured instrument no longer in its warranty period may be returned, freight prepaid, to our factory for repair and realignment. When returning instruments for repair, contact the factory for shipping instructions and an *Authorized Return Number* (ARN).

All correspondence concerning repairs should include Model Number and a description of the problem observed.

Once repaired, all equipment passes through our normal pre-shipment checkout procedure, and will meet or surpass its original specifications when returned. Return shipping expense on out-of-warranty repairs will be charged to the customer.

For instruments out of warranty, the customer must supply a purchase order number for the repair before the item will be returned.

SHIPPING DAMAGE

Shipments should be carefully examined when received for evidence of damage caused by shipping. If damage is found, immediately notify Canberra and the carrier making delivery, as the carrier is normally responsible for damage caused in shipment. Carefully preserve all documentation to establish your claim. Canberra will provide all possible assistance in damage claims.

SPECTROSCOPY AMPLIFIER
MODEL 1416B

CONTENTS

Page

SHORT FORM INSTRUCTIONS . . . . . *ii*

1 INTRODUCTION 1-1

2 SPECIFICATIONS

2.1 Inputs 2-1
2.2 Outputs 2-1
2.3 Performance 2-1
2.4 Connectors 2-2
2.5 Power 2-2
2.6 Physical 2-2

3 OPERATING INSTRUCTIONS

3.1 Initial Operation 3-1
3.2 Control Functions 3-3
3.3 Testing Specifications 3-11
3.4 Connection to the Multichannel Analyzer 3-15
3.5 Timing 3-18

SHORT FORM INSTRUCTIONS

You have just received what Canberra Industries believes to be the finest nuclear pulse amplifier ever produced. We are confident that you will obtain the best system resolution you have ever obtained with this amplifier. If you wish to try the amplifier immediately in a live system, follow the instructions below:

1. Connect the preamp output to the front panel INPUT connector.

2. Set the controls as follows, in the order specified:

FINE GAIN	9.0
COARSE GAIN	maximum possible before saturation of spectral peak of interest
SHAPING	2 microseconds (factory preset)
INPUT POLARITY	as determined by preamp output
OUTPUT POLARITY	as determined by the following element in the system
OUTPUT MODE	UNI(polar)
COUNT RATE	LOW
FINE GAIN	readjust *slightly* if desired, *not* below 70% of maximum

3. Observe the A output on an oscilloscope; adjust the Pole/Zero control until the pulse neither undershoots nor returns to the baseline with the preamp time constant (check Section 3.2.5 if uncertain as to the setting).

4. Connect the B output (DC restored) to your existing system for best overall performance (check Section 3.4 for proper connection to a multichannel analyzer).

5. These are probably the optimum settings; the most critical (which should be explored for better resolution) are the SHAPING, the OUTPUT MODE if high count rates are present, and the COUNT RATE control; try different combinations of these controls to ascertain the best settings for your particular system.

6. Take data and compare to the best you have previously obtained.

7. After satisfying yourself on the question of resolution, turn to Section 3.0 and follow the familiarization procedure listed there.

SECTION 1

INTRODUCTION

The Model 1416B has two principal applications. Because of its near-optimum Gaussian pulse shaping, extremely low noise contribution, and highly stable linear design, the Spectroscopy Amplifier offers unmatched performance as the main shaping amplifier in a high resolution gamma spectroscopy system, in combination with a cooled Ge(Li) detector, low noise FET input preamplifier, and biased post amplifier. For spectroscopy applications, the integral DC restoration of the Model 1416B adds significant improvement to the count-rate performance of linear pulse analysis systems.

The Model 1416B is ideally suited for fast coincidence and other zero-crossing applications, as it offers extremely low crossover jitter and excellent overload performance.

The usefulness and application of the Canberra Model 1416B is enhanced by the following unique design features not found in comparable amplifiers: Adjustable pulse shaping time constants, front panel Count Rate optimization, front panel Pole/Zero adjustment, ten-turn Fine Gain control, both Normal and DC Restored outputs, front panel output DC level adjustments, and ultra-low noise design (less than 5 microvolts referred to the input at 2 microsecond UNI(polar) shaping).

SECTION 2

SPECIFICATIONS

2.1 INPUTS

SIGNAL INPUT

Polarity: Positive or negative tail pulse
Amplitude: 0 to 6 volts before input saturation; 12 volts maximum
Rise time: 0 to 500 nanoseconds
Fall time: 30 to 1000 microseconds
Input impedance: 1000 ohms, DC coupled

COMMON MODE INPUTS

Two inputs via rear panel BNC connectors. One input accepts the input signal, the other accepts the noise and cable pickup signals from a second input cable for subtraction from the input signal to be processed
Input impedance: 1000 ohms, DC coupled

2.2 OUTPUTS

A OUT

Polarity: Unipolar or bipolar, positive or negative
Amplitude: 0 to 10 volt linear pulses; 11 volts saturation unterminated
Pulse shape: Near-Gaussian
Output impedance: Less than 1 ohm, DC coupled

B OUT

Polarity: Unipolar or bipolar, positive or negative
Amplitude: 0 to 10 volt pulses; 11 volts saturation unterminated
Pulse shape: Near-Gaussian, DC restored
Output impedance: Less than 1 ohm, DC coupled

2.3 PERFORMANCE

LINEARITY

Better than ±0.05% integral 0.2 to 10 volts output, into 100 ohms

SHAPING

Selectable unipolar or bipolar time constants of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, or 3.5 microseconds, near-Gaussian pulse shape

GAIN STABILITY

Better than ±0.005% per ^{o}C, better than ±0.01% over 24 hours of constant temperature

GAIN CONSTANCY

Constant amplifier gain for unipolar to bipolar shaping to within 3%; constant gain for different time constants to within 5%

OVERLOAD RECOVERY

Recovery to within 2% of baseline from 1000X overload within two non-overloaded pulse widths at full gain for any bipolar shaping time constants

DC LEVEL STABILITY	Better than 2mV/°C (0 to 50°C), better than 10mV over 24 hours of constant temperature
CROSSOVER WALK	Less than ±4 nanoseconds over 20:1 dynamic range (0.5 volts to 10.0 volts) including contribution of Canberra Model 1437 Timing SCA; less than ±8 nanoseconds over 50:1 dynamic range
NOISE	Less than 7 microvolts referred to the input at full gain and 1 microsecond unipolar shaping, less than 5 microvolts at 2 microsecond unipolar shaping, less than 10 microvolts at 1 microsecond bipolar shaping
GAIN	Maximum gain 2000; adjustable via front panel controls over 192:1 range
COMMON MODE REJECTION	Better than 250:1 between common mode inputs for any input polarity
COUNT RATE STABILITY	Less than 0.10% gain change (Cesium 137 peak) in presence of 50 kHz pulser input, DC restored output

2.4 CONNECTORS

SIGNAL INPUT	BNC, UG-1094/U, front panel
COMMON MODE INPUTS	Two BNC, UG-1094/U, rear panel
OUTPUTS	Two BNC, UG-1094/U, front panel
PREAMP POWER	Amphenol 17-10090, rear panel

2.5 POWER

+24V	— 45mA	+12V	— 20mA
-24V	— 45mA	- 12V	— 25mA

2.6 PHYSICAL

SIZE	Standard single-width module (1.35 inches wide) per TID-20893
WEIGHT	2.2lb.

SECTION 3

OPERATING INSTRUCTIONS

3.1 INITIAL OPERATION

3.1.1 SETUP

1. Insert the amplifier into an AEC compatible bin such as the Canberra Model 1400. Set the POWER switch to ON.

2. Connect a tail pulse generator with an output rise time less than 250 nanoseconds and fall time greater than 30 microseconds to the INPUT connector of the amplifier. The output of the pulse generator should ideally be variable from 5mV to 6 volts, and must not in any case be greater than 6 volts for proper amplifier functioning.

3. Connect A OUT of the Model 1416B to an oscilloscope set for 2V/cm vertical and 2.0 microsec/cm horizontal calibration. Trigger the oscilloscope externally from the unattenuated output of the input pulser.

4. Set the pulse generator for an output of +15mV.

5. Set the amplifier controls as follows:

COARSE GAIN	16
FINE GAIN	10.0
SHAPING	2.0 microseconds (internal adjustment)
MODE	UNI(polar)
INPUT	POS
COUNT RATE	LOW (affects B OUT only)
OUTPUT POLARITY	POS

3.1.2 INITIAL CHECKOUT

1. Observe A OUT on the oscilloscope; it should appear approximately as shown in Figure 3-1.

2. Turn the COARSE GAIN control to 8 and to 4; observe the pulse output decrease in amplitude by factors of two.

3. Rotate the FINE GAIN control counter-clockwise and observe the pulse output decrease in amplitude over a 3:1 range; be sure to read Section 3.2.2 before using the amplifier in a live system.

4. The Model 1416B Spectroscopy Amplifier has provisions for internally selecting time constants of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, and 3.5 microseconds (near-Gaussian shaping).

To select the desired time constant, do the following:

a. Looking at the front of the module, remove the left side cover. Three rows of pins will be exposed in the center of the printed circuit board. The time constants for each row are printed, on the circuit board, at the end of the associated rows of pins.

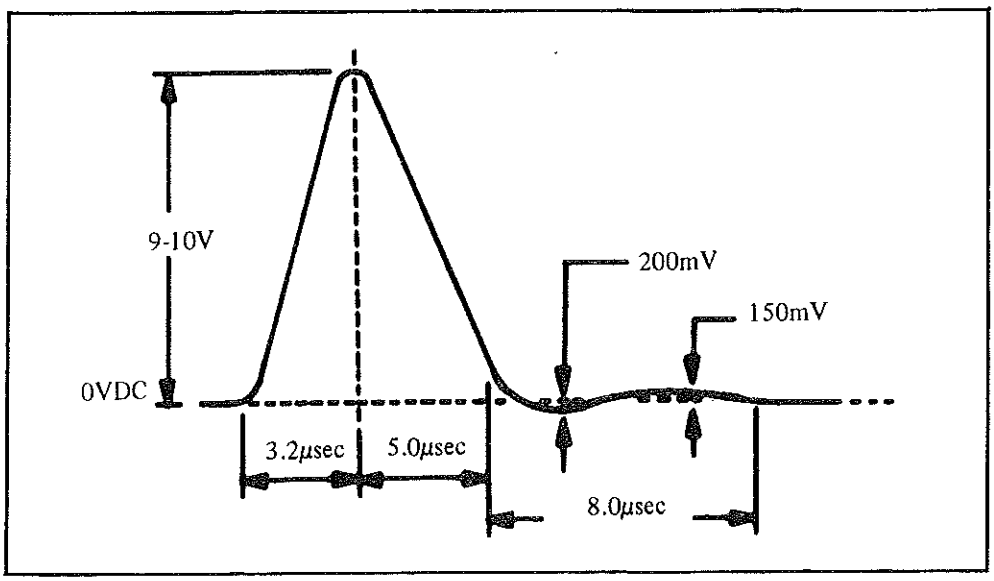


FIGURE 3-1. A OUT Waveform

b. Insert the jumper plug (or plugs) provided in the row (or rows) which will give the desired time constant. The time constants are additive: e.g., to obtain a time constant of 2.5 microseconds, insert a jumper plug in the 2.0 microsecond row and one in the 0.5 microsecond row.

c. Replace the side cover and operate the unit in the normal manner.

5. Switch to the NEG position on the OUTPUT POLARITY control and observe the inverted (negative) output.

6. Return all controls and the jumper to their initial settings.

7. Increase the vertical gain on the oscilloscope by a factor of ten, and with a small jewelers screwdriver, rotate the POLE/ZERO adjustment about ten turns counter-clockwise then twenty turns clockwise; observe the effect on the output pulse; the optimum setting for the particular fall time constant of the pulser is when the pulse returns to the baseline most rapidly. Figure 3-2 illustrates the effect of the POLE/ZERO adjustment—three accompanying single-sweep oscillograms are also included. The theoretical explanation for this effect and its impact on system resolution and overload is given in section 3.2.5.

8. Switch the MODE control to the BI(polar) position and observe the bipolar output pulse shape (see Figure 3-3, page 3-6).

9. Repeat Section 3.1 for the DC restored B OUT on the Model 1416B and observe that the shaping will be essentially the same as A OUT.

10. Increase the vertical gain on the oscilloscope by a factor of ten and set the horizontal sweep rate to 10 microsec/cm, while observing the positive 9-10 volt UNI(polar) B OUT signal. Flipping the front panel RATE control to its three possible positions will show a pronounced effect on the signal return to the Baseline. The HI position should produce the shortest recovery time; and the LOW position the longest. MED position recovery time should be between these limits.

3.1.3 ADDITIONAL FAMILIARIZATION

1. Using a BNC "tee" connector feed the input pulse into both COMMON MODE inputs on the rear panel of the Model 1416B.

2. Using a small screwdriver, adjust the COMMON MODE TRIM control on the rear panel, while observing the amplifier output on the oscilloscope; the optimum control setting occurs when the minimum amplifier baseline to peak output is observed; the application of this control—and of the common mode inputs—is described in Section 3.2.10.

3.2 CONTROL FUNCTIONS

3.2.1 COARSE GAIN

This front panel rotary switch covers a 64:1 range in seven binary steps. It is not necessarily always advantageous to obtain all possible gain from the preamplifier at the expense of main amplifier gain in an experimental situation; data should be taken at maximum preamp gain and at minimum preamp gain (after readjusting the Spectroscopy Amplifier gain accordingly) to see which obtains better resolution.

3.2.2 FINE GAIN

This front panel ten-turn wirewound potentiometer covers a 3:1 gain range. As a consequence, the question arises as to which of two equivalent gain conditions—high FINE GAIN with low COARSE GAIN, or low FINE GAIN with high COARSE GAIN—is preferable. In general, the rule of thumb is to set the FINE GAIN as high as possible, letting the COARSE GAIN fall where it may.

Figure 3-4, which is a plot of the amplifier noise referred to the input versus gain control settings, illustrates the reason for this choice. In nearly every case, the higher FINE GAIN setting yields the lower amplifier noise. This is especially true at the lower COARSE GAIN values, where most practical systems will operate.

Note that the COARSE GAIN control is so arranged that the user can not make the error of stumbling into a setting that penalizes him heavily in terms of amplifier noise referred to the input, unless he cannot in fact use any higher gain setting. This has been achieved by having the COARSE GAIN control begin to have an effect near the amplifier output, where the least following amplification will magnify and add to amplifier noise after signal attenuation. Its effect then moves in successive steps back toward the input, accepting this increasing penalty only when absolutely required.

3.2.3 TIME CONSTANTS

An internal jumper plug (or plugs) allows the selection of seven equal integration and differentiation nearly-Gaussian time constants of 0.5, 1, 1.5, 2, 2.5, 3, or 3.5 microseconds. Virtually any time constant larger than 0.2 microseconds may be obtained at the factory. For the appropriate component values for any desired time constant, contact the factory.

3.2.4 INPUT POLARITY

This front panel toggle switch permits the user to match the amplifier input (preamp output) signal polarity, whether it be positive or negative. The Model 1416B has a fixed 1000 ohm input impedance.

It is advisable to terminate the input impedance in 93 ohms when a long 93 ohm cable separates the preamp and amplifier, to prevent spurious oscillations and reflections due to impedance mismatch.

3.2.5 POLE/ZERO

This front panel twenty-two turn screwdriver adjustment permits the precise elimination of undershoots on the amplifier pulse after the first differentiation, for all input pulses whose fall time constant exceeds 30 microseconds.

NOTE

Whether utilizing the A OUT or B OUT in your existing system, optimum POLE/ZERO compensation should be performed while observing A OUT UNI(polar) pulses. The B OUT circuitry introduces DC restoration which masks the POLE/ZERO adjustment.

A classical problem in nuclear pulse amplifier design is that nominally singly differentiated pulses actually have two differentiations; the first by the amplifier first differentiation circuitry itself, whose time

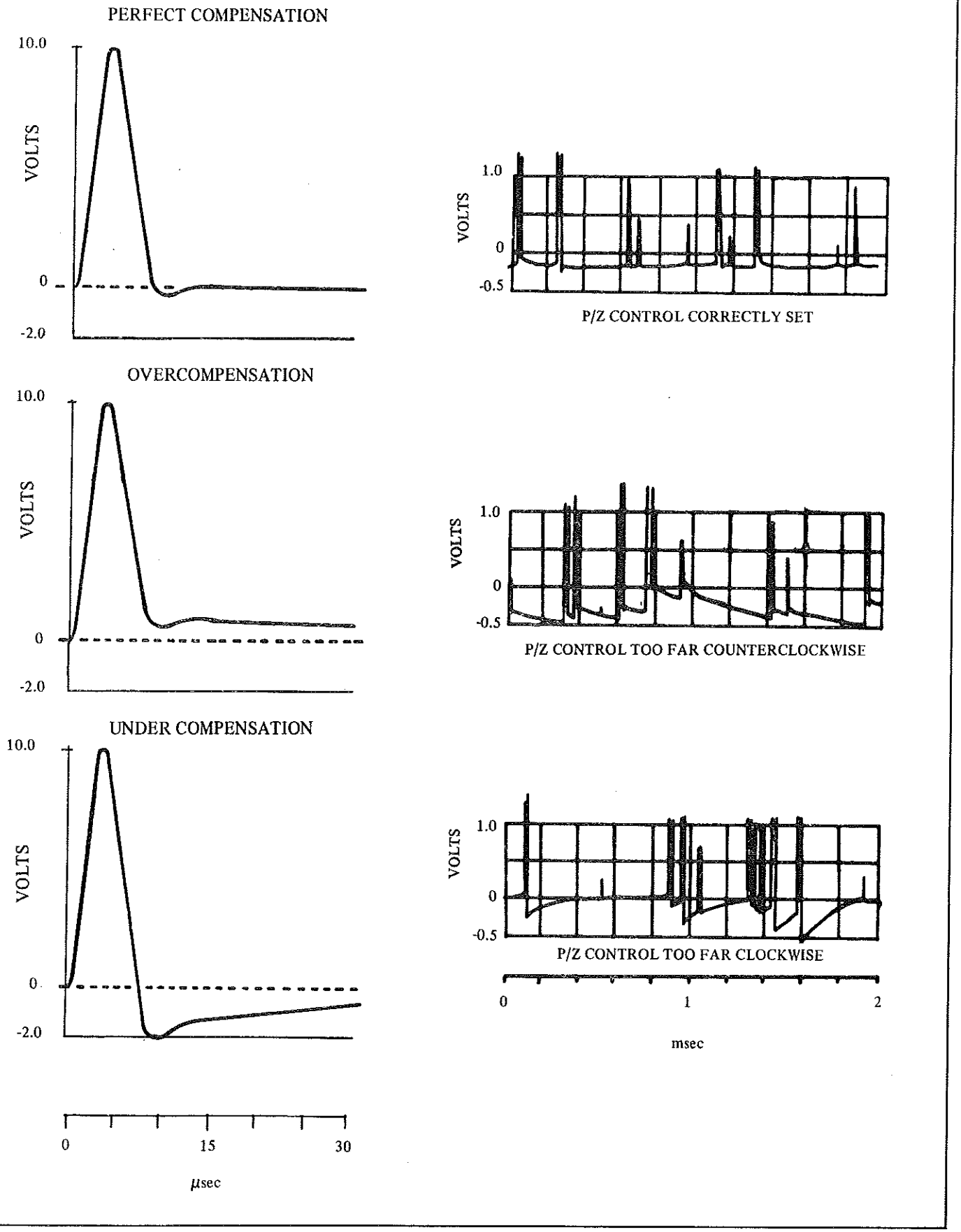


FIGURE 3-2. Effect of POLE/ZERO Adjustment (A OUT)

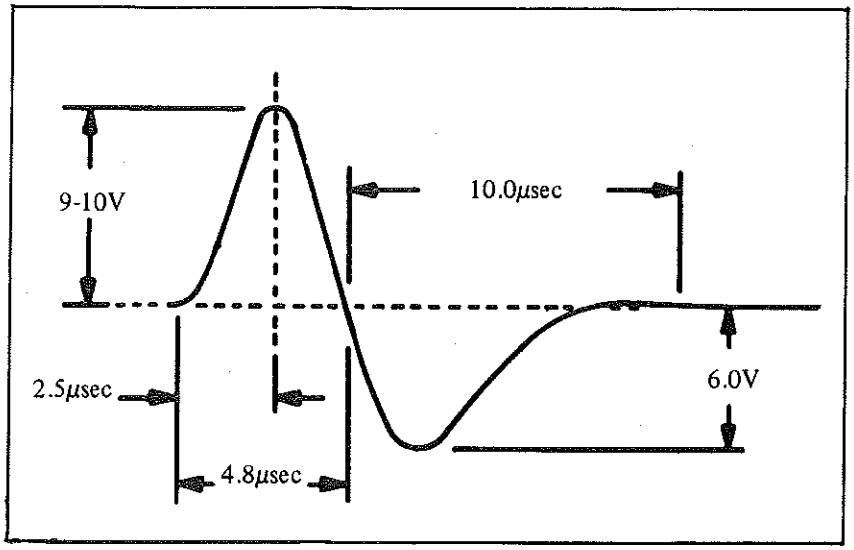


FIGURE 3-3. BI(polar) Output Pulse Shape

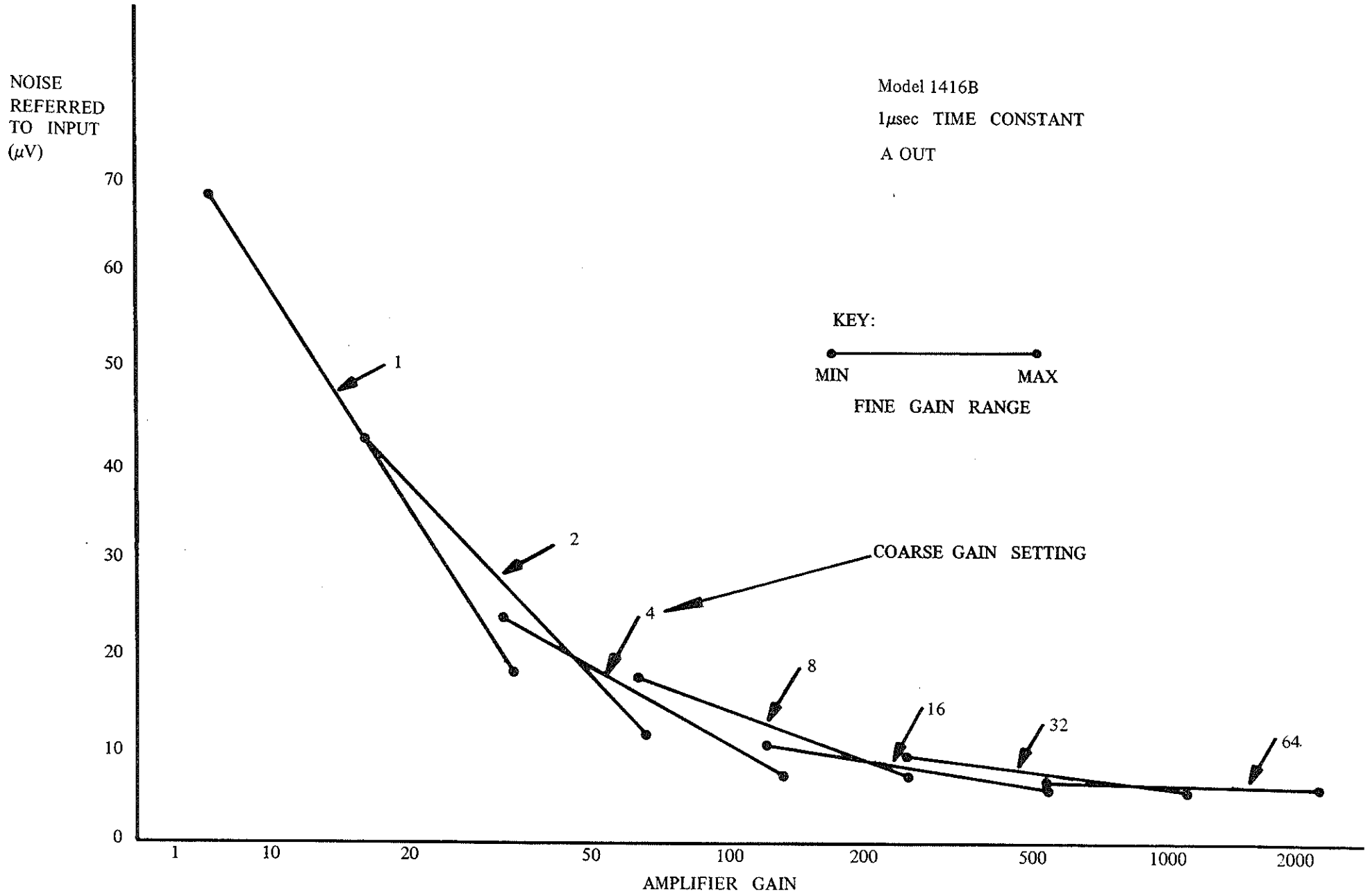


FIGURE 3-4. EQUIVALENT INPUT NOISE VERSUS GAIN SETTINGS

constant may range from 100 nanoseconds up to 10 microseconds; the second by the preamplifier circuitry, whose fall time constant usually ranges from 40 to 1000 microseconds. Thus, the "singly differentiated" pulse actually appears as shown in Figure 3-5.

The undershoot has an amplitude roughly equal to the primary pulse times the ratio of the amplifier differentiating time constant to the preamplifier fall time constant. For example, if the preamp fall time constant is 50 microseconds, a one microsecond first differentiated pulse ten volts high will have an undershoot equal to

$$\frac{(10)(1)}{50} = 200\text{mV}$$

This undershoot causes two aggravating effects. Under amplifier overload conditions, if the undershoot saturates the amplifier, it is blocked not only until the primary lobe recovers, but also until the undershoot recovers (at the much slower rate of the preamp fall time constant).

Second, if the count rate is sufficiently high, succeeding pulses may fall into the undershoot of preceding pulses, subtracting from their apparent pulse height and causing peaks to broaden on the low energy side.

POLE/ZERO cancellation compensates for this effect, by artificially adding a Laplace "zero" to cancel the Laplace "pole" due to the preamplifier fall time constant, removing the undershoot caused by the preamplifier. In its simplest form, the original differentiating network is compensated by the addition of a single resistor (see Figure 3-6).

This technique is fully effective only if the input pulse to the network is composed of a single exponential fall time constant—thus, problems will be encountered in trying to compensate the fall time constants contained in the more complex pulse arising when a pulse generator with fall time constant T_1 feeds a preamplifier with fall time constant T_2, which in turn feeds the main amplifier. One may compensate for either time constant, but not both simultaneously.

The compensation circuit must in practice be variable, to permit adjustment for the range of fall time constants that may be encountered in the field. In the Canberra Spectroscopy Amplifiers, this compensation range extends from 30 microseconds upward, covering all commercially available preamplifiers.

In the practical case, adjustment is best done live, by observing the A OUT UNI(polar) pulses from the amplifier with the detector and preamplifier attached. The only difficulty that is encountered is that the system noise obscures the undershoots when the adjustment is reasonably close. One aid is to increase the amplifier gain by X8 or more for the purposes of this adjustment. If low energy tailing is observed on spectral peaks, it may be a sign that the POLE/ZERO adjustment is incorrect.

Once adjusted for a given preamplifier, the adjustment need not be changed; any gain settings, COUNT RATE switch positions, and UNI(polar) or BI(polar) output modes may be selected with assurance that the adjustment is still correct.

If the amplifier shaping time constant is changed, minor adjustment may be necessary to the POLE/ZERO control because of internal component tolerances.

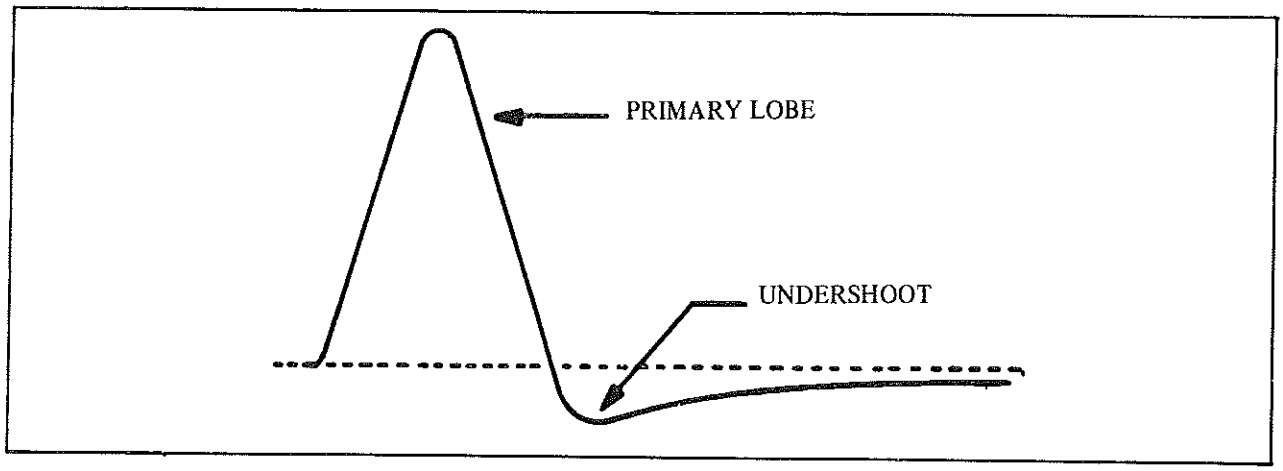


FIGURE 3-5. "Singly Differentiated" Pulse

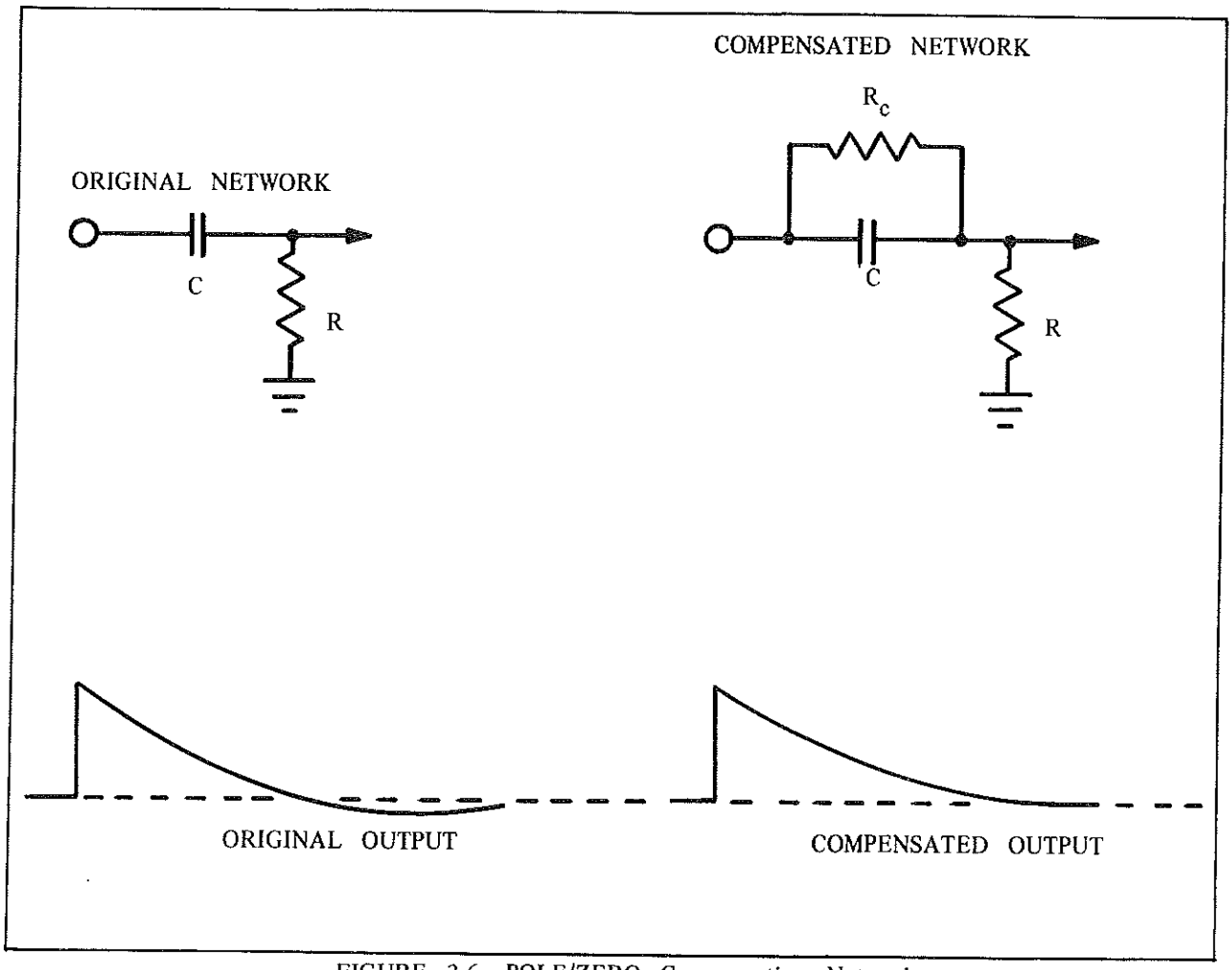


FIGURE 3-6. POLE/ZERO Compensation Network

3.2.6 OUTPUT MODE

This front panel toggle switch permits the selection of UNI(polar) or BI(polar) outputs. This switch simultaneously affects A OUT and B OUT.

3.2.7 OUTPUT POLARITY

This front panel toggle switch permits the user a choice of either positive or negative outputs, simultaneously affecting A OUT and B OUT.

3.2.8 COUNT RATE

This front panel toggle switch optimizes the performance of the amplifier for high, medium, or low counting rates. This switch effects the DC restored B OUT only.

The value of the coupling capacitor to the internal DC restorer is selected by this switch. In general, the higher the capacitor, the lower the added noise to the signal, and the smaller the capacitor, the more effective is the DC restoration. Thus, as count rate increases, the optimum setting moves to smaller and smaller capacitor values.

In the LOW and MED positions, the DC restoration is due to the AC impedance of the restorer diodes, giving the least additional noise to the restored signal. In the HI position, the restorer diodes are coupled to a feedback amplifier, lowering the effective AC impedance to approximatley 1 ohm, for more precise clamping of the baseline. The penalty for this improved clamping is increased noise on the output signal.

The Canberra Spectroscopy Amplifier leaves the choice to the user; the best of the three positions depends upon the character and magnitude of his system noise, and upon the count rates being encountered.

Above 25,000 counts per second or so, the HI RATE position is generally best, especially when the DC stability of the baseline is of most importance. Below this count rate, only empirical investigation can decide. Generally, the LO RATE position is usually best below 10,000 counts per second.

3.2.9 DC LEVEL ADJUSTMENTS

There are two front panel twenty-two turn screwdriver adjustments to set A OUT and B OUT DC levels to zero volts. The B OUT DC level adjustment has a range of ±2.0 volts in order to match the input DC level offset of a DC coupled multichannel analyzer. (See Section 3.4.)

3.2.10 COMMON MODE SELECTOR AND C.M. TRIM REJECTION BALANCE CONTROL

The INPUT MODE toggle switch on the rear panel disables the front panel input (C.M. position) and enables the rear panel Common Mode inputs or, in the NORM(al) position, disables the rear panel Common Mode inputs.

When the Common Mode input capability is used, the rear panel C.M. TRIM Rejection Balance control should be adjusted for its optimum setting with the system and all cables as they will actually be used, as described in Section 3.1.3.

Common Mode inputs are useful when the amplifier is used far from its associated preamplifier (e.g., 50 feet or more), especially in environments high in low frequency and line frequency interference. The theory is straight-forward; if a cable, in all respects identical to the preamp to amplifier cable

except that it is merely grounded at the preamp end rather than being connected to the preamp, is laid along the path of the true signal cable, both will pick up the same noise while only one will have the true signal. If the output from the bogus cable is inverted and summed with the output from the true cable, the signals common to both (i.e., noise and pickup will cancel, while the signals appearing on only one (i.e., the true signal) will be unaffected.

The true signal cable is connected to the rear panel POS or NEG input (as appropriate), while the bogus cable is connected to the remaining input. Using this technique, noise and pick up may be reduced by more than 250:1.

3.3 TESTING SPECIFICATIONS

3.3.1 SYSTEM RESOLUTION

Basically, the procedure to be followed is outlined in the Short-Form instructions preceding the body of this manual. The critical settings which may strongly affect system resolution are:

Shaping Time Constant
Output Mode (unipolar or bipolar)
Count Rate Optimization (high, medium, or low)

The optimum settings depend strongly on the characteristics of the individual system; ratio of low frequency to high frequency noise, system hum and ripple and ground loop problems, and count rate being encountered. Empirical experimentation is far simpler (and probably faster) than any attempt at analytical evaluation of the optimum control settings.

One procedure that is often illuminating is to take a test run with your existing system before beginning the evaluation of your Canberra Spectroscopy Amplifier. This provides an "all other things being equal" benchmark against which the results later obtained may validly be compared.

3.3.2 LINEARITY

One of the simplest and most accurate tests is to set up the system shown in Figure 3-7.

This test is performed by adjusting the pulser attenuator and amplifier gain so that with a ten volt high level (Direct) output from the pulser, the output from the amplifier is also exactly ten volts. This may be ascertained by adjusting the pulser attenuator and amplifier gain so that the null point observed on the oscilloscope is at exactly the same level as the baseline with the highest oscilloscope vertical gain.

When this condition is obtained, turn the pulser height control downward from ten volts to the lowest level that will still trigger the oscilloscope, and observe the maximum difference between the baseline and the null point. The integral linearity of the amplifier under test is then equal to:

$$\frac{\text{(Maximum deviation in volts)} \times 2 \times 100\%}{10 \text{ volts}}$$

The maximum deviation must thus be less than ±2.5mV in order to meet the ±0.05% specification.

The test may be explained as follows: Integral nonlinearity is the maximum deviation from the straight line plotted on an output vs. input plot from zero output to rated output (10 volts), divided by the rated output, stated as a percentage.

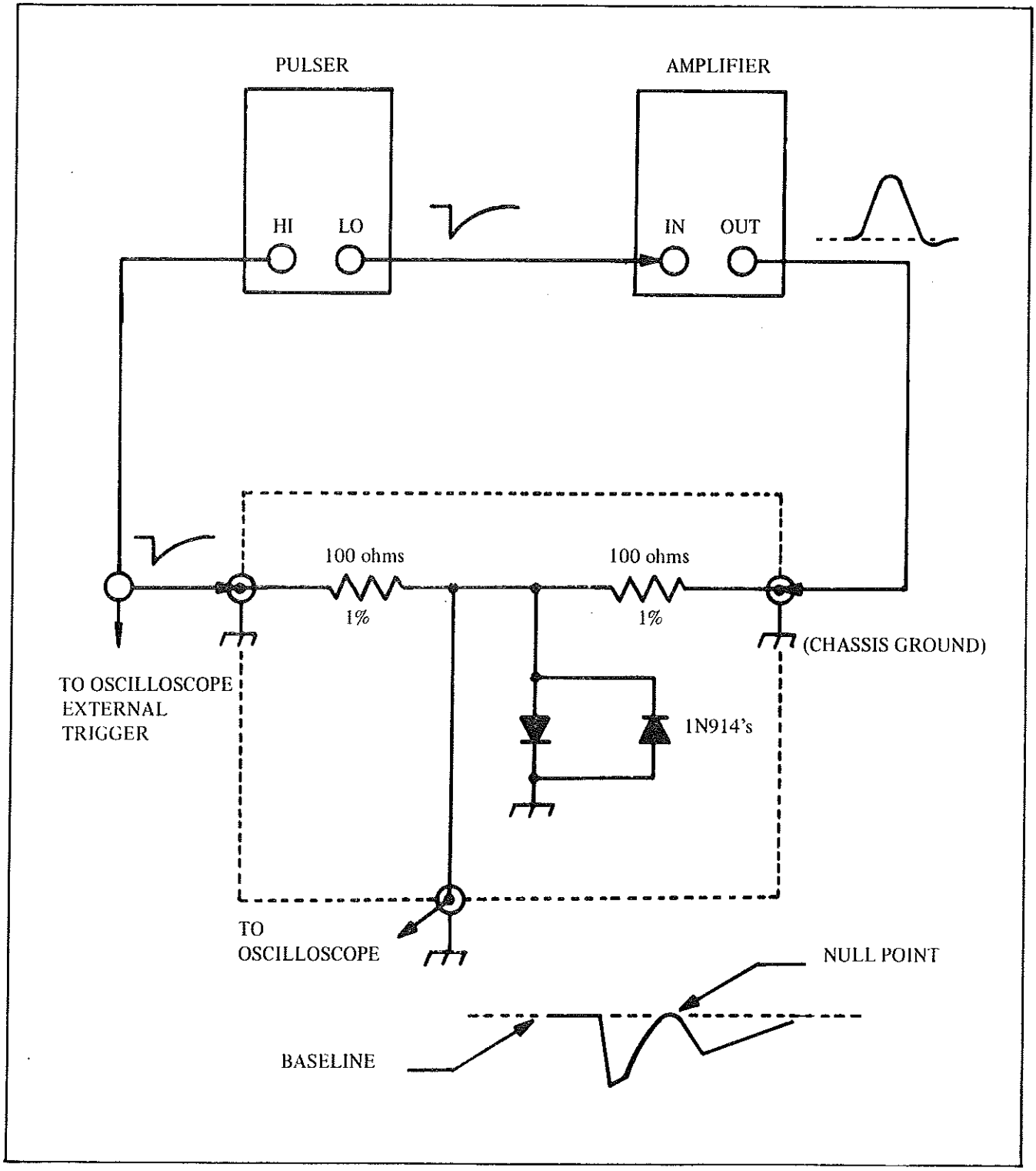


FIGURE 3-7. Test Setup for Linearity Check

This calculation is performed electronically by the test described above by setting:

$$\text{OUTPUT} = (K)\,(\text{INPUT})$$

where K is the pulser attenuation factor (and the gain of the amplifier). As the input is decreased, the amplifier gain should remain constant (output should decrease linearly); whether or not it does is tested by comparing the output to a signal known to decrease linearly with the amplifier input – the pulser Direct Output which is related to the Attenuated Output by a passive attenuator. The factor of two must be included because the summing network also serves as a voltage divider, decreasing the apparent deviation by a factor of two.

Note that nonlinearity and instability in the pulser output do not enter into the question, because both Direct and Attenuated Outputs will be affected identically, save for the negligible effect of the pulser's attenuator instabilities over the short time period required for the test. Instabilities in the baseline level on the oscilloscope are due to oscilloscope triggering and DC level fluctuations, and need not be of concern in this test.

3.3.3 GAIN STABILITY

This specification is extremely difficult to test without somewhat elaborate test equipment because of the difficulty of assuring that the measuring instruments are stable and because of the relatively long test periods required.

Temperature stability can most simply be observed by duplicating the test setup of Section 3.3.2, except that the amplifier is placed in a temperature chamber. The effect of temperature excursions may be observed by plotting the deviation between the baseline and null point versus chamber temperature. The calculation is performed as in Section 3.3.2 if the amplifier output is initially ten volts.

Long-term stability tests could also be performed in this fashion if the test pulser attenuator resistors and the summing circuit resistors are protected from temperature variations during the test period. This test is extremely tedious, as the oscilloscope does not record any excursions, and only the situation at the moment can be observed. Thus, constant observation is required.

The maximum deviation permitted for temperature is $\pm 0.25\text{mV}/^{\circ}\text{C}$; the maximum deviation over 24 hours is $\pm 0.5\text{mV}$ at constant temperature and power supply voltages; if the initial amplifier output is ten volts.

3.3.4 GAIN CONSTANCY

This test is simply performed by storing a test pulser output from the amplifier in an analyzer and switching from UNI(polar) to BI(polar) shaping; the change in peak position should be less than 3% – if a greater excursion is noted, make sure that the analyzer itself is not pulse shape sensitive by checking the apparent change on an oscilloscope at the maximum vertical sensitivity obtainable which allows the output peak to be observed.

In similar fashion, the gain versus shaping may be observed; a shift of 5% or less is specified.

Note that the test setup of 3.3.2 cannot be used unless the pulser output is a square, flat-topped pulse, as the amplifier output peak point occurs at different times for the unipolar and bipolar pulses, destroying the equivalence established with the Direct Output tail pulse.

3.3.5 OVERLOAD RECOVERY

Set the amplifier under test to its maximum gain position (gain approximately equal to 2000). Feed in, via a very short cable, a 5mV test pulser input, so that a ten volt output is obtained. Using the pulser attenuator switches only, increase the pulser output to give 5 volts (a 1000X overload on the amplifier).

Observe a non-overloaded bipolar pulse and record the time it takes to reach 2% of the baseline (basically, into the noise). Repeat with an overloaded bipolar output. The overloaded pulse should reach 2% of the baseline in less than twice the period required for the non-overloaded pulse.

NOTE

The amplifier POLE/ZERO control must be adjusted to match the pulser fall time constant (observed with a UNI(polar) A output) before this test can be attempted.

3.3.6 DC LEVEL STABILITY

This specification can most easily be tested with a digital voltmeter when performing the gain stability tests of Section 3.3.3.

3.3.7 COUNT RATE STABILITY

This test is rather simply performed by setting up a live system at a moderate count rate (say 1000 counts per second), observing the position of a prominent peak in a multichannel analyzer, and repeating at a higher count rate such as 50,000 counts per second. The shift in the peak position should be less than 0.10% (one channel in 1000) over this count rate range. Since many laboratories do not have energetic enough sources or large enough detectors to reach the requisite count rate, it may be necessary to artificially increase the count rate using a tail pulse generator which has a variable frequency, such as the Canberra Model 1407R.

To perform this test, establish the live system with a Cesium 137 peak storing in Channel 850. Then inject pulses into the Test pulse input of the preamp used so that the pulser peak stores in Channel 950. Note that the fall time constant of the test pulser output should be as near to that of the preamp as possible, and that the COUNT RATE switch on the amplifier should be in the HI RATE position. Be sure that the amplifier POLE/ZERO adjustment is correct for the preamplifier being used.

NOTE

The Multichannel Analyzer must be DC coupled. A DC Restorer must be used at its input to prevent baseline shifts with count rate when testing A OUT.

3.3.8 CROSSOVER WALK

Obtain a ten volt BI(polar) A output from the amplifer with the gain set at its minimum value. Connect the A output to a Canberra Model 1437 Timing SCA with the BASELINE control set at its

minimum value and the WINDOW WIDTH control at its full range setting. Trigger the oscilloscope from the test pulser and observe the SCA Output from the Model 1437.

Using the pulser attenuator switches only, reduce the pulser output by a factor of 20; the output of the Timing SCA should shift by less than ±4 nanoseconds. Repeat the test with an output attenuation of 50. The Model 1437 output should shift less than ±8 nanoseconds.

3.3.9 NOISE

Set the amplifier to maximum gain (about 2000). Measure the noise (no input) signal at the A OUT BNC using a true RMS or average reading voltmeter. If an average reading voltmeter is used, multiply the reading by 1.13 to convert from average to true RMS. The readings obtained should be less than the following values:

SHAPING	OUTPUT NOISE (TRUE RMS)	NOISE REFERRED TO INPUT
1 microsecond UNI	14 millivolts	7 microvolts
2 microsecond UNI	10 millivolts	5 microvolts
1 microsecond BI	20 millivolts	10 microvolts

Be sure that the input(s) are terminated in 100 ohms when making this test.

3.3.10 GAIN

Set the amplifier to maximum gain and determine the input pulse necessary to obtain a ten-volt output. The input required should be less than 5mV, for a gain of 2000.

3.3.11 COMMON MODE REJECTION

Feed the same 5 volt pulse into both rear panel inputs of the Model 1416B. Observe the test pulser output on an oscilloscope in order to be sure that the amplitude is 5 volts when feeding the amplifier inputs.

Set the amplifier to minimum gain and observe its output on an oscilloscope. Adjust the rear panel C.M. TRIM control for minimum output amplitude. This minimum output should be less than 20mV from the baseline to the largest peak.

3.4 CONNECTION TO THE MULTICHANNEL ANALYZER

All commercial main amplifiers have at least one ac coupling, and must be followed by a DC Restorer (either as a separate module or in the next system link), for optimum high count rate performance. In the 1416B, there is no need for external means of baseline restoration, as this feature is already incorporated internally, and is available at the B OUT BNC connector.

A DC Restorer should generally be connected as the last link in the system before pulse height analysis. In addition, if a Linear Gate or Biased Amplifier is used, these modules must be totally DC coupled. If they are not, a second DC Restorer is needed before the multichannel analyzer.

The following Canberra modules are totally DC coupled and need not be followed by a second DC Restorer:

Model 1454 Linear Gate and Stretcher
Model 1452 Linear Gate
Model 1450 Dual Linear Gate
Model 1451 Linear Gate
Model 850 Linear Gate
Model 1452 Linear Gate
Model 1462 Biased Amplifier
Model 1467 Biased Amplifier
Model 1464 Restorer/Rejector
Model 1468 Live Time Corrector/
Pile-up Rejector
Model 8100 Multichannel Analyzer
Model 8040 Analog-to-Digital Converter
Model 8060 Analog-to-Digital Converter

Some multichannel analyzers of other manufacturers have internal DC restoration. In general, these are suitable only to about 10kHz. These analyzers should be DC coupled before the Model 1416B is used if count rates beyond 10kHz are to be encountered.

Multichannel analyzers fall into two classes, from the viewpoint of DC coupling to the input circuitry: those requiring an input to the Normal input as well as to the DC coupled input in order to trigger the ADC (Class I), and those not requiring this second input (Class II).

To connect the Model 1416B to your analyzer, first determine if it is in Class I or Class II.

Class I ADC
Intertechnique
Nuclear Data ND-3300
Packard
RIDL 34-12
TMC (most models)

Class II ADC
Northern Scientific
Nuclear Data (except ND-3300)
TMC
Victoreen

If your analyzer is not listed above, call the manufacturer for instructions for connecting a DC Restorer.

If your multichannel analyzer is of the Class I type, a prompt linear signal for the Normal input to trigger the ADC, and a delayed linear signal for the DC coupled input is required. (A DC coupled Delay Amplifier such as the Canberra Model 1459 is required since the Model 1416B amplifier provides only prompt outputs (see Figure 3-8).) Modification of the Class I ADC is necessary if a DC coupled input is not provided. The following Class I ADCs can be modified simply (or require no modifications):

Class I ADCs

ADC	MODIFICATIONS
Intertechnique Nuclear Data ND-3300	Use dc or Mossbauer input Short 0.01 microfarad capacitor on ALG board
Packard	Use dc or Mossbauer Input
RIDL 34-12	Use dc or Mossbauer Input
TMC Class I	Contact the manufacturer: Technical Instruments, Inc., North Haven, Conn.

Connection to a Class I ADC: See Figure 3-8.

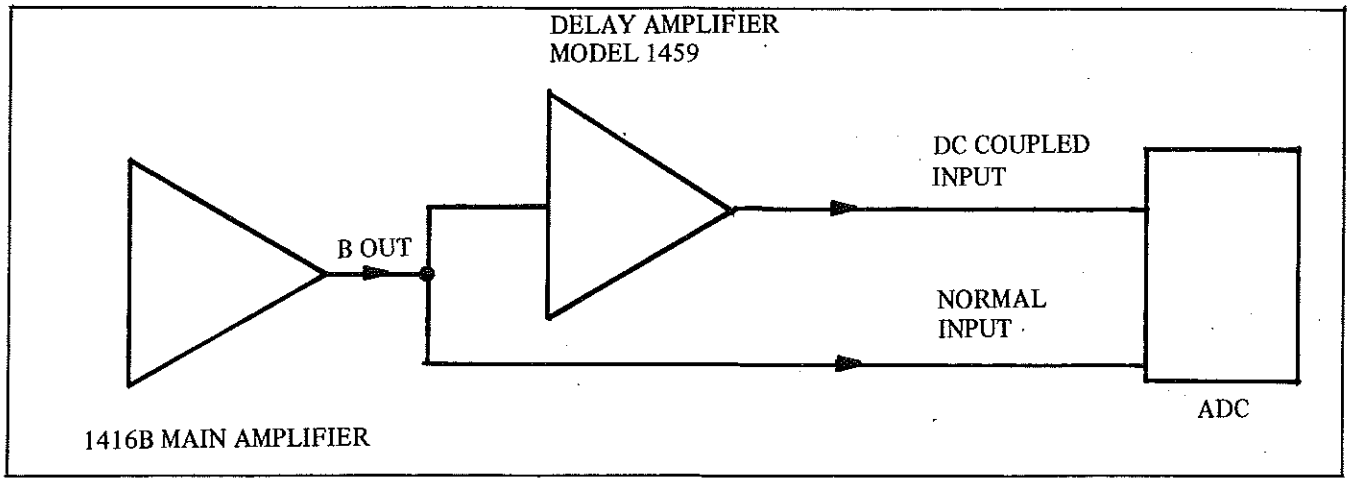


FIGURE 3-8. Connection to Class I ADC

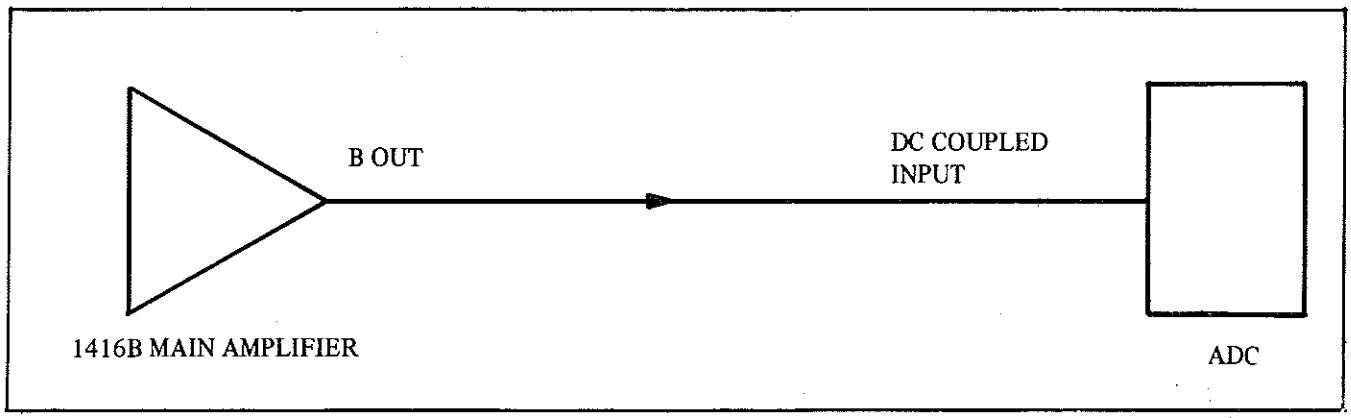


FIGURE 3-9. Connection to a Class II ADC

If your multichannel analyzer is of the Class II type, simply use the Direct or DC coupled input, being mindful of the polarity, range, and DC level input requirements. If the Class II ADC does not have a DC coupled input, but can be simply modified to provide this feature, do so. The following Class II ADCs can be modified simply (or require no modifications):

Class II ADCs

ADC	MODIFICATIONS
Nuclear Data	
ND-120 ND-130	Short 0.01 microfarad capacitor (base of T-1) on ADC board
ND-161F	Short 0.018 microfarad capacitor switch to direct ADC; -3V input.
ND-2200	Short capacitor 09D8 on ADC board
Canberra	None Required
Victoreen	
PIP-400	Short C-203
SC1PP Series	Short C-403
ICADC	No modification needed
TMC Class II	Contact the manufacturer for instructions: Technical Instruments, Inc., North Haven, Conn.
Northern Scientific	No modification needed

Connection to a Class II ADC: See Figure 3-9.

After modification, measure the DC offset level at the DC coupled input, and set the B output DC level of the Model 1416B to the same value.

Canberra Industries' engineering staff will be happy to provide aid in modifying your ADC. Send a copy of the ADC schematic, and detailed instructions will be sent to permit your staff to perform the required modifications. There is no charge for this service.

3.5 TIMING

Extremely low crossover jitter and excellent overload performance makes the Model 1416B ideally suited for fast coincidence and other zero-crossing applications.

Only the A OUT is suitable for timing since the internal DC restorer in the B OUT circuitry will affect the timing stability of the baseline crossing point in the BI(polar) mode. When UNI(polar) shaping is required, leading-edge timing must be used and the internal DC restoration will effect the timing accuracy by its action of suppressing part of the output signal (measurable in millivolts). This suppression has the same effect as raising the bias threshold of the timing pickoff circuit. For fast leading-edge timing, it is necessary to use the signal as it comes from the preceding preamplifier.

Artisan Technology Group is an independent supplier of quality pre-owned equipment

Gold-standard solutions

Extend the life of your critical industrial, commercial, and military systems with our superior service and support.

We buy equipment

Planning to upgrade your current equipment? Have surplus equipment taking up shelf space? We'll give it a new home.

Learn more!

Visit us at **artisantg.com** for more info on price quotes, drivers, technical specifications, manuals, and documentation.

Artisan Scientific Corporation dba Artisan Technology Group is not an affiliate, representative, or authorized distributor for any manufacturer listed herein.

We're here to make your life easier. How can we help you today?

(217) 352-9330 | sales@artisantg.com | artisantg.com

ARTISAN® TECHNOLOGY GROUP