INSTALLATION OF STREAMLINE PRE-AMPLIFIERS

MODEL 137CP2-2 for "P" TYPE DETECTORS ORTEC p/n 635020

MODEL 137CN2-2 for "N" TYPE DETECTORS ORTEC p/n 635010

MODEL 139-2 for HPGe and SILICON LEPS ORTEC p/n 635030

MOUNTING THE PRE-AMPLIFIER ON THE CRYOSTAT

Clean the 4 pin feed-thru with methanol and freon. Blow dry with dry nitrogen. Carefully fit the pre-amplifier onto the cryostat and 4 pin feed-thru. Secure with the screws and lockwashers provided. It may be necessary to re-position the lockwashers under the head of the screws since new pre-amplifiers are delivered with the lockwashers on the bottom of the assembly under the nuts. Tighten the screws firmly. Make sure the floating connector receptacle on the pre-amplifier mates with the feed-thru and is pushed onto the pin to the same position as the three fixed connector receptacles. Connect the two floating connector receptacles on the side of the pre-amplifier to the two single pin feed-thru's that connect to the thermal resistor inside the cryostat for the HIGH VOLTAGE SHUTDOWN feature of the pre-amplifier. These two connections have no polarity and may be connected in any order.

INITIAL CHARGE LOOP ADJUSTMENT

Place a shorting connector (an SHV cable end with the shield connected to the center pin) on the input of the high voltage filter to drain off any residual voltage left on the detector and/or high voltage filter capacitors. D.C. power is now applied to the pre-amplifier from the rear panel of an E.G.&G. ORTEC 572 amplifier and a connection is made from the pre-amplifier output cable to the 572 input connector with a 93 ohm co-axial cable. A D.C. voltmeter is connected between the ground wire on the pre-amplifier and the top of a yellow capacitor (see Fig.1) to measure the output of the charge loop. With no high voltage applied to the detector there will be no leakage current and the output of the charge loop should be 0.0volts. Adjust the drain current potentiometer (see Fig.1) to cause the output of the charge loop to be 0.0volts plus or minus 20millivolts. Remove the shorting connector from the input of the high voltage filter and remove the D.C. voltmeter from the pre-amplifier.

CHARGE LOOP THEORY OF OPERATION (VERY BASIC)

Refer to the schematic of the pre-amplifier that shows the detector crystal, cryogenic FET and feedback resistor in the cryostat connected to the pre-amplifier. You have now adjusted the drain current of the FET and therefore adjusted the gain characteristics of the entire charge loop until the loop is balanced with 0.0volts on the output of the charge loop. Since there is no current flowing through the detector and feedback resistor there is 0.0volts on the gate of the FET. This is a desired condition and usually represents a condition of optimum performance for the charge loop and entire pre-amplifier. The function of the charge loop (in addition to converting the collected charge resultant from the interaction of an incident photon to a voltage pulse) is to hold the gate of the FET at 0.0volts over a wide range of energy and count rate combinations.

POLE ZERO (PZ) ADJUSTMENT

Apply high voltage of the proper polarity and magnitude to the input of the high voltage filter. Connect the UNIPOLAR output of the 572 amplifier to an oscilloscope. Select the proper polarity of input on the 572. Select a shaping time of 10 microseconds (makes this adjustment of pre-amplifier PZ easier to accomplish). Select the PZ ADJ position of the BLR toggle switch on the 572 (disables the baseline restorer which would interfere with the PZ adjustment). Place a CO^{57} source in front of the detector and adjust the gain of the 572 to give a 10volt peak on the oscilloscope with no saturation. Renove the CO^{57} source and replace it with a CS^{137} source. Adjust the PZ adjustment potentiometer on the pre-amplifier (see Fig,1) for proper pole zero response. See Section 7 of the detector operator's manual (attached) for a description of proper pole zero response. The pre-amplifier pole zero adjustment is a long time constant PZ adjustment and is very critical for good peak shape. Once this adjustment is made it need not be changed for any change in amplifier parameters. An alternate adjustment procedure is described in the 572 manual utilizing a squarewave generator and may be accomplished if any difficulties are found with the above method.

CHARGE LOOP ADJUSTMENT FOR MINIMUM NOISE

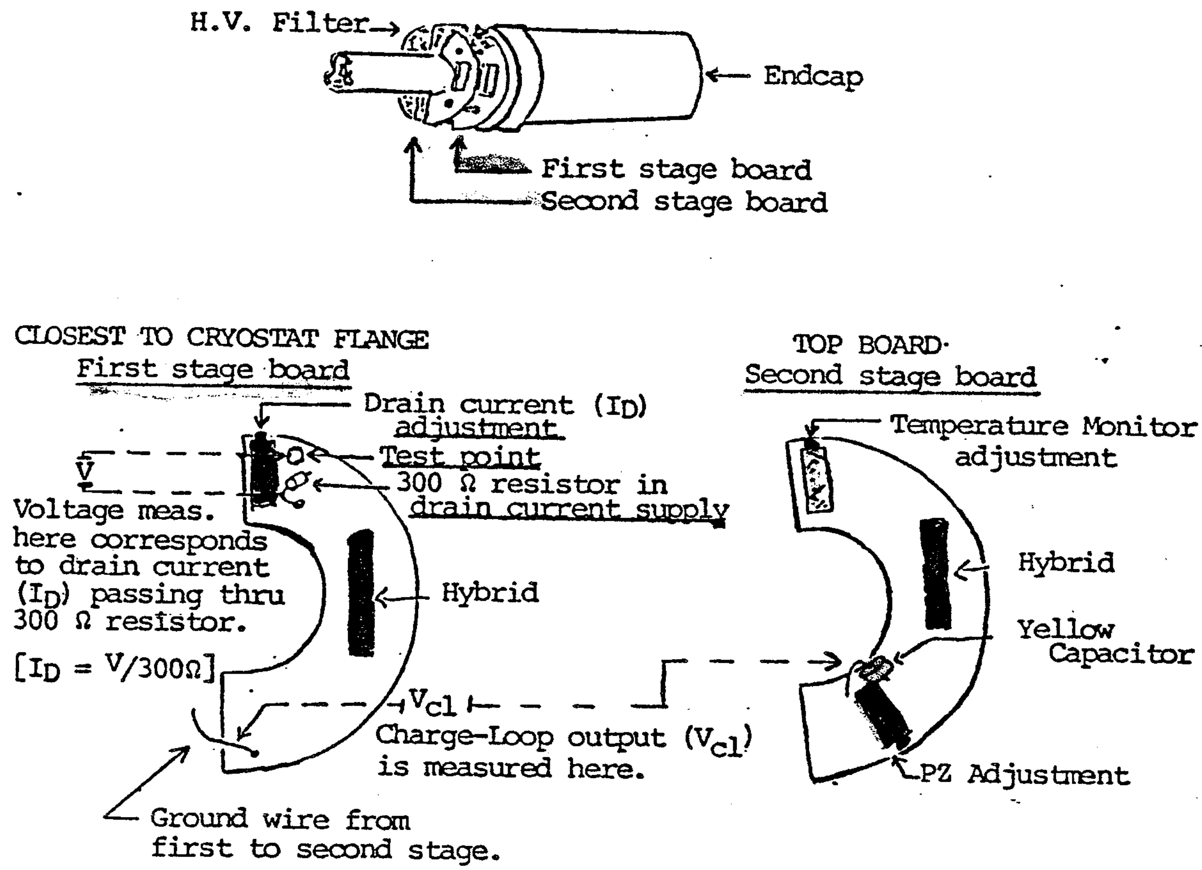
Connect the UNIPOLAR output of the 572 to an A.C. R.M.S. voltmeter. In order to facilitate the reading of the electronic noise of the cryogenic FET, feedback resistor and pre-amplifier only, it will be extremely helpful to shield the detector from stray radiation. Select 6 microseconds shaping time on the 572 (10 microseconds for silicon LEPS). Select a gain of 500 on the 572 and select a voltmeter range to give at least a mid-scale deflection of the meter. The fine gain of the 572 may be used to keep the R.M.S. voltmeter deflection above mid-scale. Note the reading of the voltmeter. Turn the FET drain current adjust potentiometer on the pre-amplifier (see Fig.1) ½ turn clockwise, wait for at least 30 seconds for the reading to stabilize and note the voltmeter reading. Continue with these steps until you notice a definite increase in the voltmeter reading (noise). Now start back in a counterclockwise direction of the FET drain current adjust potentiometer, ½ turn at a time, looking for a null, or minimum reading. The null represents the optimum setting of the FET drain current potentiometer and will give the best (lowest) system noise. You may find it necessary to repeat this procedure several times to assure yourself that you are at the null for it is at times not very well defined. If, in the rare case where no null is found, you find the potentiometer at the end of its range, go back to the INITIAL CHARGE LOOP ADJUSTMENT procedure and set the charge loop output to 0.0volts D.C. with no high voltage applied and a shorting connector on the high voltage filter input.

HIGH VOLTAGE SHUTDOWN ADJUSTMENT

Assure that the detector has been cold for at least 6 hours. Connect the HIGH VOLTAGE SHUTDOWN cable from the pre-amplifier to the REMOTE SHUTDOWN connector on the rear panel of an E.G.&G. ORTEC 459 BIAS SUPPLY (S/N 1350 or higher). Turn on the 459 and adjust for the proper high voltage. The LED (light emmitting diode) on the 459 may or may not be lighted and the meter on the 459 may or may not indicate the selected voltage at this time. The shutdown setpoint potentiometer is located on the top board of the pre-amplifier (see Fig.1). Turn this potentiometer clockwise enough to reach the end of its range (could be 20 turns). At this time the 459 will be enabled (LED on, meter indicating selected voltage and high voltage present at the SHV connector on the rear panel). While watching the above indications. slowly turn the shutdown setpoint potentiometer counterclockwise. Apoint will be reached where the 459 will be disabled (LED will not be lighted, meter will indicate 0 volts and no high voltage will be present at the SHV connectors on the rear panel of the 459). The preceding steps check the high voltage shutdown circuit for proper operation. The following steps calibrate the shutdown circuit. Once again turn the shutdown setpoint potentiometer clockwise to the end of its range. Now turn the potentiometer counter-clockwise for 2 complete turns. The shutdown circuit is now calibrated and will disable the 459 if warmup occurs (NOTE: It is necessary for pre-amplifier power to be on for warmup protection.).

OVERRANGE CHECKOUT (NO ADJUSTMENT)

Observe the output D.C. level of the REMOTE OVERRANGE cable of the pre-amplifier on an oscilloscope. Bring a high activity source (approx. 100 microcuries of CO^{60} or CS^{137}) near the detector. Verify that the output D.C. level changes from approx. 0volts to approx. +5volts for "P" type detectors and from approx. 0volts to approx. -5volts for "N" type and LEPS detectors. This is an indication that the charge loop is beginning to saturate (charge loop can no longer hold the gate of the FET to 0.0volts) and is not an indication of any particular count rate. For Gamma Gages with an LED OVERRANGE indicator, the LED will illuminate to indicate an overrange condition.



NOTE:

1) No D.C. offset adjustment
2) No drain voltage (V_D) adjustment
3) Drain current adjustment and charge-loop output measurement (V_{cl}) are made as for the 120-5 preamplifier.
4) The PZ adjustment is made as for the 120-5 preamplifier.

FIG. 1

7. SYSTEM OPERATION

7.1. ASSEMBLING AN ENERGY SPECTROSCOPY SYSTEM

After the dewar has been filled, allow time to assure complete cooling of the detector element (6 hours, unless otherwise specified). The detector is then connected as part of a complete energy spectroscopy system (Fig. 7.1). Included are the detector with its attached preamplifier and high-voltage filter, a main amplifier, a count-rate meter, a biased amplifier (optional), a multichannel analyzer, a precision pulse generator, a detector bias supply, and an oscilloscope.

Connections between the preamplifier and the detector and between the high-voltage filter and the detector are made through the cryostat vacuum feedthroughs within the electronics shield. Detector bias (operating voltage) is furnished from the detector bias supply and must be cabled to the detector's high-voltage filter. Use RG-59A/U cable, or the equivalent, with SHV connectors. The captive power cable from the preamplifier is attached to the preamp power connector on the main amplifier. The remaining connections within the spectroscopy system are made using RG-62A/U, or equivalent, with BNC connectors. In addition, connect the attenuated output from the precision pulse generator to the test input of the preamplifier, and connect the preamplifier output to a main amplifier input.

The unipolar output of the main amplifier should be connected to both the oscilloscope and the multichannel analyzer or biased amplifier (if used). A BNC Tee may be needed or separate amplifier outputs may be used.

The system should be dc-coupled all the way from the preamplifier through the multichannel analyzer. If any of the modules have optional connectors or switches to select the type of coupling, be sure that dc-coupling is used. Also be sure that the power to all equipment, including the oscilloscope, is furnished from the same ac-power source to help prevent ground loops.

7.2. CABLE TERMINATION

Connecting your system with proper cable impedance termination is important. Three general methods of termination are used. The simplest of these is a shunt termination at the receiving end of the cable. A second method is series termination at the sending end. The third method 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.

All EG&G ORTEC preamplifiers contain 93Ω series terminations. The preamplifier of your detector system is capable of driving at least 500 feet of 93Ω cable. When connected to an EG&G ORTEC amplifier (or most other modern spectroscopy amplifiers), no additional termination is required if the length of the interconnecting cable is less than 50 feet. For greater distances, terminate the amplifier input with a 100Ω termination to ground.

The cable connecting the amplifier output to the input of the pulse height analyzer or the biased amplifier should also be properly terminated. EG&G ORTEC amplifiers have front panel outputs of $<1\,\Omega$ and rear panel outputs of 93Ω. The input of the typical pulse height analyzer or biased amplifier is 1000Ω or more. Shunt termination at the receiving end may be achieved by using a BNC Tee connector to attach both the 93Ω interconnecting cable and a 100Ω terminator to the input of the receiving instrument. Series termination is provided by simply connecting the 93Ω output of the amplifier to the input of the

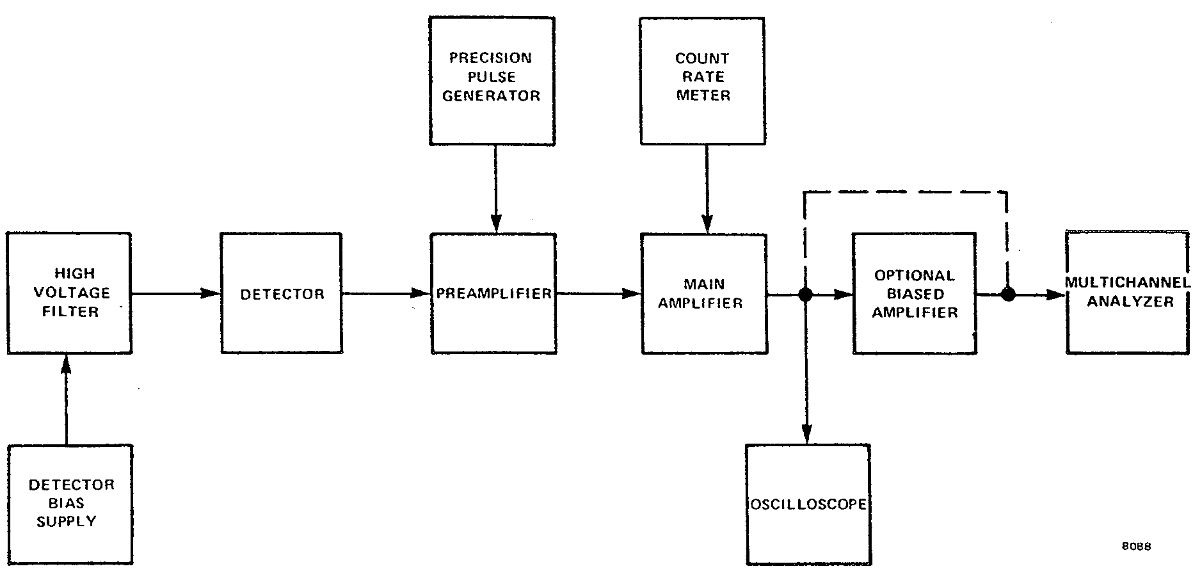


Fig. 7.1. Connection of Components in a Typical Energy Spectroscopy System.

receiving instrument with 93Ω cable. For the combination of series and shunt termination, the 93Ω amplifier output is used together with the 100Ω terminator at the input of the receiving instrument. The use of both series and shunt termination is most effective, but it is not always advised because it reduces the signal amplitude by 50%. Similar considerations apply when connecting a biased amplifier output to the input of the pulse height analyzer.

7.3. SHAPING TIME, NOISE, AND PULSE PILEUP

The selection of shaping time, τ, strongly affects the amount of system noise and the degree of pulse pileup experienced. The proper shaping time should be chosen to strike a balance between noise and pulse pileup effects according to the application requirements.

Almost all of the noise of your spectroscopy system is attributable to the cryogenic electronic components of the input FET stage of the preamplifier and to the detector element itself. Special care in the selection of these components and cooling of the FET are important to minimize this noise. However, this noise is viewed through the amplifier filter network so that the effective system noise depends on the filter time constant or shaping time.

The system noise has three primary components as referenced to the preamplifier input: series noise, parallel noise, and 1/f noise. Considering both the frequency response and the bandwidth of the filter, it is found that series noise is proportional to $1/\sqrt{\tau}$, parallel noise is proportional to $\sqrt{\tau}$, and 1/f noise is independent of τ. As a result, a graph showing noise as a function of time constant will exhibit a minimum point with the noise increasing as the time constant either increases or decreases from that point. The noise minimum or "noise corner" is the ideal time constant for your system strictly from the point of view of electronic noise. Typical noise corner values are 4 to 8 μs for coaxial germanium detectors (GEM, GMX, GLI, and GWL), 6 to 10 μs for planar germanium LEPS (GLP), and 10 to 14 μs for planar Si(Li) detectors (SLP).

Pulse pileup at the amplifier output depends strongly on count rate and time constant. The larger the time constant, the longer the signal is away from the baseline for a given pulse. Thus the larger the time constant, the greater is the probability that an additional pulse or pulses will occur while the signal is away from the baseline due to a previous pulse. The probability of pulse pileup also increases with increasing count rate. That fraction of pulses which will be piled-up is approximately $1 - e^{-R\tau_d}$, where R is the count rate and τ_d is the dead time associated with each pulse. Measured with an oscilloscope at the amplifier output, τ_d is equal to the pulse width just above the baseline plus the pulse risetime.

The effects of pulse pileup increase the system dead time, increase the spectral background (especially at higher energies), produce shifts and fluctuations in the signal baseline, and degrade the system's resolution. All of these effects, except for increased system dead time, may be reduced by the use of a baseline restorer and a pulse-pileup rejector. At lower count rates, the major source of system dead time is the analyzer processing time. At higher count rates, pulse pileup at the amplifier output often becomes the major source of dead time. It should be pointed out that dead time due to pulse pileup is not routinely measured by the analyzer unless specific provisions are made. With EG&G ORTEC electronics such provision is simply made by connecting the main amplifier busy output to the analyzer busy input.

Modern amplifiers have active-shaping networks which produce smaller pulse widths for a given time constant than previously obtainable. Thus for a given time constant, higher count rates are now feasible with less deleterious effects than were observed in the past. Conversely, for a given count rate, the use of longer time constants is often permitted.

Each spectroscopist must consider the benefits of reduced pulse pileup at shorter time constants versus decreased system noise at longer time constants. The appropriate shaping time is then selected (often by trial and error) according to particular application requirements.

At EG&G ORTEC, the selection of time constant used for detector system performance testing is governed by IEEE Std. 325-1971 (Reaffirmed 1977), "Standard Test Procedures for Germanium Gamma-Ray Detectors." Section 4, Detector Energy Resolution, of this document states:

"Pulse shaping methods and time constants suitable for optimum performance of the detector should be used, but their nature must be clearly specified and recorded as described in IEEE Std. 301-1969."

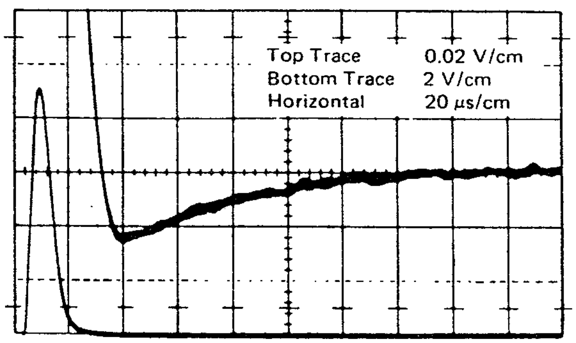
Therefore, our low count rate (1000 cps) specifications of energy resolution are often made at relatively long time constants to achieve optimum performance by minimizing noise. At such time constants, a spectroscopist using a modern amplifier should be able to achieve good results up to several thousand counts per second. At higher count rates, shorter time constants (e.g., 2–3 μs) may provide better results.

7.4. POLE-ZERO AND DC OUTPUT LEVEL ADJUSTMENTS

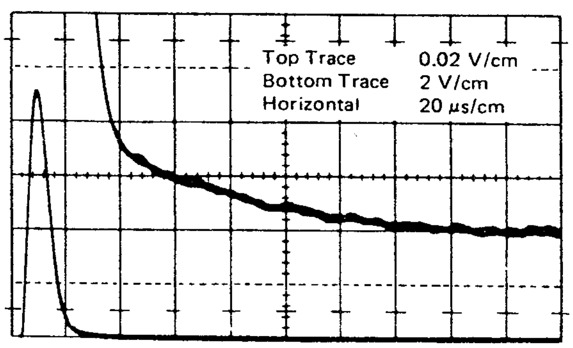
The pole-zero adjustment must be made for the signal to return promptly to the baseline after each pulse. Failure to make this adjustment properly will greatly increase pulse-pileup effects and result in low or high side tailing on spectral peaks, greatly degrading high-count-rate performance.

To set the pole-zero adjustment of your main amplifier when using your GEM Series detector, bring a radioactive source (^{60}Co for coaxial detectors, ^{137}Cs or ^{57}Co for LEPS or Si(Li) detectors) near your detector. Adjust the source distance to achieve a total rate between 500 and 3000 counts per second. Observe the unipolar output with an oscilloscope with enough vertical gain to allow the baseline to be observed in detail. For a pulse height of 8 to 10 V, a vertical sensitivity of 50 mV/cm is usually adequate. (See the following comments on overloading). As amplifier gain is changed, the oscilloscope sensitivity is adjusted in inverse proportion. For the main amplifier pole-zero adjustment, the horizontal sweep time should be set to achieve a pulse width of 2 to 4 cm.

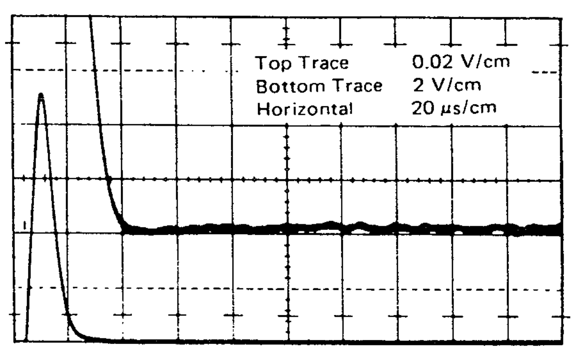
The amplifier pole-zero adjustment should be made so that the trailing edge of each pulse returns to the baseline without overshoot or undershoot (Fig. 7.2). Some older amplifiers may produce a small hump or other artifact on the trailing edge of each pulse that cannot be changed by pole-zero adjustment. In addition, some detector systems introduce a slight overshoot or other pulse tail defect that cannot be eliminated. When such artifacts or defects are present, adjust the pole-zero in such a way as to minimize the time that the signal is away from the baseline.



Undercompensated Pole-Zero.



Overcompensated Pole-Zero.



Properly Adjusted Pole-Zero.

Fig. 7.2. Pole-Zero Adjustment as Seen With an Oscilloscope.

The oscilloscope must be dc-coupled and must not contribute distortion in the observed waveforms. Many oscilloscopes will overload for an 8- to 10-V signal when the vertical sensitivity is greater than 100 mV/cm. This produces an apparent pulse defect which greatly resembles a pole-zero problem. The effect may be worse if the oscilloscope is slightly out of adjustment. Oscilloscope overload may be prevented by clipping off the top of each pulse by using the clamp circuit shown in Fig. 7.3 at the oscilloscope input.

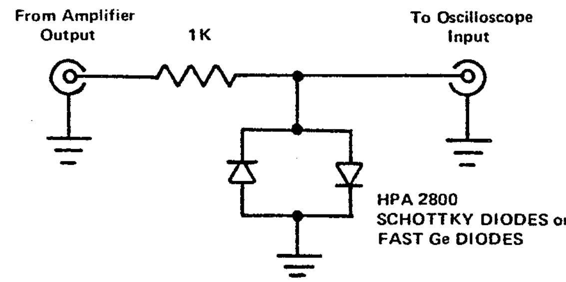


Fig. 7.3. Circuit Diagram for Clamp Network Used to Prevent Overloading the Input to the Oscilloscope Vertical Amplifier.

Your detector system preamplifier also contains a pole-zero adjustment. To check the preamplifier pole-zero, reduce the oscilloscope sweep time until the pulse is 1 to 2 mm wide. Then look for undershoot or overshoot following each pulse. If both pole-zero adjustments are properly set, the baseline should appear smooth (little ragged appearance). Again, amplifier or detector system anomalies may produce minor defects in pulse shape which cannot be removed by pole-zero adjustment. **The preamplifier pole-zero adjustment has been properly set at the factory and should not need readjustment. However, if some adjustment becomes needed in time, please contact EG&G ORTEC Customer Service or your local representative.**

If the methods described herein are carefully applied, your pole-zero adjustment can be made with high accuracy. However, another method using a square-wave pulser may allow a more precise adjustment. Please refer to an EG&G ORTEC amplifier manual for the details of this method.

The dc-output level of your main amplifier and biased amplifier (if used) should be set to zero. To do this, observe the amplifier output with an oscilloscope set to a sensitive vertical gain (at most, 50 mV/cm). Then ground the input of your oscilloscope and adjust the vertical height to align the trace with the center line on the measurement grid. Again look at the amplifier signal and adjust the dc level (see your amplifier manual) until the baseline of the output signal is also aligned with the center line on the oscilloscope measurement grid. The dc level is now set to zero. It is extremely important that the input signal into the analog-to-digital converter (ADC) of the pulse height analyzer has a dc level close to zero. Failure to achieve this may result in a substantial loss of counts (often manifested as an unexplained drastic efficiency loss) or in an inconveniently large energy slope intercept for the resulting spectrum. These effects depend upon the characteristics of particular analyzers.

7.5. COMMON SETUP PROBLEMS: MICROPHONICS, GROUND LOOPS, AND PICKUP

All detector systems will exhibit some signal response (microphonics) when subjected to excessive vibration, mechanical shock, or very loud noise. A detector system that exhibits such behavior to an excessive degree is said to be microphonic.

The preamplifier input at the gate of the input field-effect transistor (FET) must be extraordinarily sensitive to small current pulses. If anything electrically connected to the gate lead moves on the order of angstroms with respect to any surfaces at the high-voltage bias potential, the change in capacitance induces a current pulse that results in a substantial output signal. Vibrations of the high-voltage surfaces with respect to ground on the filter side of the detector can also produce microphonic response. Such a response is usually less significant because its magnitude is reduced by the large filter capacitor and by coupling through the relatively small detector capacitance. The use of a cooled FET makes detector systems much less sensitive to microphonics because it greatly reduces the length of the critical FET gate lead.

There are several things that a spectroscopist should do to minimize microphonics. The detector system and its dewar should never sit directly upon a hard concrete floor or similar hard surface through which vibrations from pumps and equipment are easily transmitted. Instead, the dewar should be shock-mounted in some way. One recommended method of doing this is to set the dewar on a section of plywood which has a 1- to 2-in. piece of polyurethane foam sandwiched between it and the floor. If this much elevation of the dewar is not permissible, even a 1/4-in. piece of foam placed between the dewar and the floor will be of substantial benefit. When possible, all parts of the cryostat or dewar should be prevented from contacting vibrating objects or objects which might transmit vibrations. Loud noises in the general vicinity of an operating detector system should be avoided.

If you must operate your system in an environment which is highly conducive to microphonics, several adjustments may be made to minimize the resulting effects. The use of shorter shaping time constants ($\sim$2 μs) will often greatly reduce microphonic signal response at the expense of increased system noise. Setting the amplifier baseline restorer to "auto" or "high" is usually helpful.

If your detector system exhibits excessive microphonics when operated under reasonable conditions, EG&G ORTEC will repair it in accordance with the Warranty Statement.

Improper system grounding can cause ground loops which may induce apparent electrical oscillations. Ground loops can result when several different electronic system components are "grounded" in different places which may be at slightly differing near-ground potentials. Make sure all components of your spectroscopy system share one effective common ground. If your building has an electrical system which is not well grounded, consult a competent electrician. Another common cause of ground loops is a poor grounding connection through a faulty coaxial cable or a loose BNC connector on a cable or panel. Trace down and eliminate such problems by trial and error replacement while closely observing the resulting baseline noise on your oscilloscope.

Signal pickup can occur even in properly grounded systems. Radio frequency electromagnetic waves may be picked up from a radio station, a particle accelerator, or other sources. Although your detector system is well shielded, additional RF shielding may be useful under extreme circumstances.

Pickup over the ac power line can also be a problem. YOUR SYSTEM SHOULD NOT BE OPERATED ON CIRCUITS COMMON TO ELECTRIC MOTORS AND OTHER ELECTRICALLY NOISY EQUIPMENT. See an electrician about supplying an isolated power line or contact EG&G ORTEC Customer Service for recommendations about obtaining an appropriate ac line conditioner.

7.6. THE INITIAL APPLICATION OF BIAS

Before applying bias to the detector, apply power to the other components in the system. Observe the unipolar output from the main amplifier on the oscilloscope. For preliminary testing, use a main amplifier gain of about 40 for coaxial detectors and 100 for LEPS and Si(Li) detectors. Adjust the oscilloscope gain for a baseline width of 1 to 2 cm and observe the system noise.

A 60- or 120- Hz sine wave with superimposed noise indicates a gross ground loop. This should be found and eliminated. If there is any ripple at these frequencies, it should be very small in comparison to the amplitude of the white noise. A complete inspection for smaller spurious oscillations may be made after the detector is under bias. Occasionally, the system may appear dead when no bias has been applied. If the application of a small amount of bias ($\sim$30 V) results in appearance of the white noise, there is no problem.

Apply about 200 V of bias of the correct polarity to the detector. The noise amplitude should decrease because the detector capacitance decreases as the depletion of charge carriers begins. Application of the wrong bias polarity can cause the noise amplitude to either increase greatly or drop completely to zero and remain there. This might also occur if the detector has been damaged in shipment.

If the detector bias polarity is correct and the reaction is normal, increase the detector bias gradually in steps of about 200 V while observing the oscilloscope. The noise amplitude should normally continue to decrease down to a minimum. With the prescribed gain, the final baseline width should be about 10 to 20 mV. It is normal for the noise to completely disappear for several seconds following changes in bias voltage. During the stepwise voltage increases, if the noise disappears and does not reappear within 15 seconds, reduce the bias immediately, 100 V at a time, until the noise reappears. The detector may be tested for resolution at this reduced bias level. However, a detector problem is indicated unless your high-voltage power supply is significantly uncalibrated or the detector has not been allowed to cool completely.

When the bias voltage has been raised to that level specified in the Quality Assurance Data Sheet, the noise amplitude may have increased slightly above the minimum level noted above, but the increase should never exceed 10%. At this level of noise, any spurious oscillations or baseline disturbances due to ground loops, pickup, or microphonics should be clearly visible. Eliminate such problems before the detector system performance is evaluated. Before attempting to make definite performance measurements, allow the detector system to stabilize, with bias applied, for at least 30 minutes.