SPECTROSCOPY AMPLIFIER
Model 2012

Operator's Manual

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FIGURE LISTING

Section 1. Introduction

1.1 GENERAL DESCRIPTION

The Model 2012 Spectroscopy Amplifier was designed using the latest integrated circuit technology to insure a long lifetime of reliable and precise operation. The key to the performance of this instrument is a cleverly designed baseline restorer which, because of its symmetrical characteristics, provides high resolution for both Ge and HPGe detectors. The reset pulses of the optical preamplifier of the HP Ge detector are no problem to the Model 2012.

Although it is a high performance instrument, the Model 2012 is also very versatile. It has all the characteristics necessary to make it useful with scintillation photomultipliers, gas proportional counters, surface barrier detectors, high purity Ge and of course Ge(Li) detectors. High gain, low noise, selectable time constants, and count rate optimization are several of the more important features designed into the amplifier.

1.2 APPLICATIONS

This section is not intended as a complete survey of applications. It is intended to highlight the most important features of the module and to indicate representative areas where they might be applied.

1.2.1 The NaI(Tl) Life Time System

The Model 2012 amplifier is a versatile spectroscopy grade instrument capable of high count rate performance when used with a variety of detectors. Selectable shaping time constants of 0.5 and 2 μsec for use with NaI(Tl), Gas Proportional, Silicon Surface Barrier, Ge(Li), and high purity Germanium detectors, are pushbutton selectable inside the unit.

Excellent count rate performance from this amplifier does not require the adjustment of variable restorer rates and thresholds. A symmetrical restorer automatically compensates for a wide range of count rates. The gain range, temperature stability and non-linearity specifications enable the Model 2012 to be used in many applications requiring long counting times.

One application, diagrammed in figure 1-1, shows the 2012 being used with four separate detector systems, each utilizing the Model 2012 as the amplifier element. Each of the amplifier outputs is directed to 1024 channels of the MCA memory by a mixer/router. The Ge(Li), and Gas Proportional detectors utilize a 2 μsec shaping time constant while the Surface Barrier uses 0.5 μsec. The NaI Life Time System uses the Model 2012 Unipolar output to time the occurrence of a gamma event from each detector.

The two timing SCA outputs are then translated by a TAC into a pulse spectrum proportional to the time difference between the output signals.

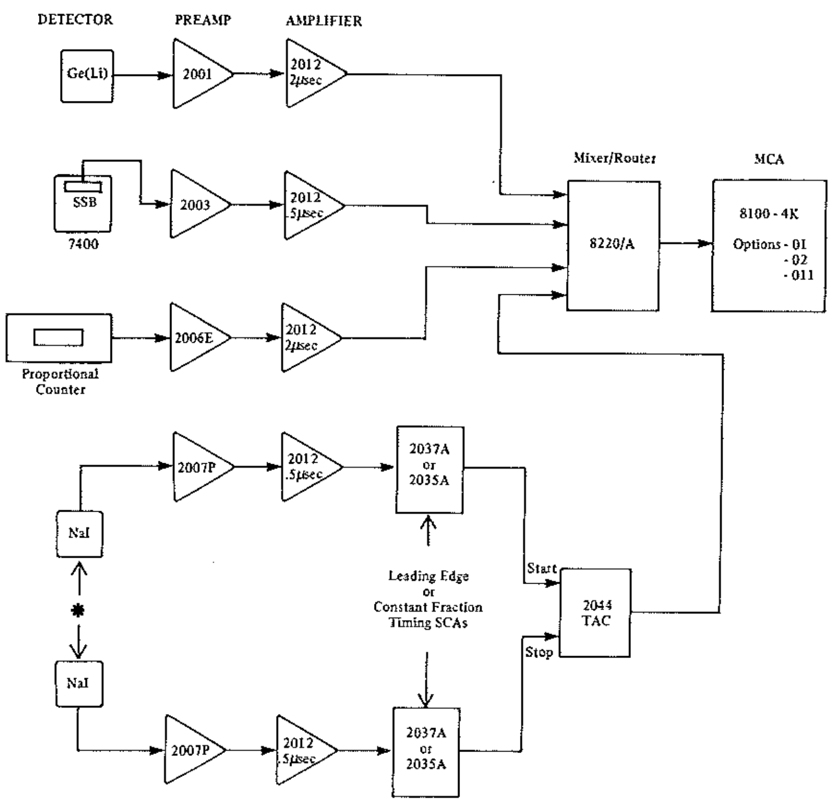


Figure 1-1. NaI(Tl) Life Time System

Section 2. Specifications

2.1 INPUTS

(SIGNAL) INPUT—Accepts positive or negative linear pulses from an associated preamplifier. Input BNC connectors located on front and rear panels.

Amplitude: 0 to ±2 Volts for a linear output; ±12 Volt maximum.

Rise Time: Less than the shaping time constant selected.

Decay Time Constant: 30 μseconds to ∞.

Input Impedance: Approximately 1k Ohms.

2.2 OUTPUTS

UNIPOLAR OUTPUT—Provides positive-only linear pulses. BNC connectors are located on the front and rear panels. Short circuit protected.

Amplitude: Linear to +10 Volts, 12 Volts maximum.

Timing: Prompt.

Shaping: Active filter near-Gaussian shaped.

Coupling: DC restored.

Factory calibrated for 0 ±5 mV dc.

Front Panel Z_{out}: less than 1 ohm or 93 ohms, internally selectable.

Rear Panel Z_{out}: 93 ohms.

2.3 PERFORMANCE

GAIN RANGE—Continuously adjustable from X12 to X1280, product of the Coarse and Fine Gain Controls. Coarse Gain Steps are: X4, X8 X16, X32, X64, and X128. Fine Gain Range covers: X3 to X10.

OPERATING TEMPERATURE RANGE—0 to + 50°C.

GAIN DRIFT—Less than ± 0.0075%/°C of full scale.

DC LEVEL DRIFT—Less than ± 50 μV/°C.

INTEGRAL NONLINEARITY—Less than ±0.05% of full scale linear output range.

OVERLOAD RECOVERY—Will recover to within ± 2% of the full scale output in 2 pulse widths for a x 1000 overload with the pole/zero cancellation properly set.

PULSE SHAPING—Near-Gaussian shape: One differentiator, two active integrators, and only one secondary time constant (Approximately 50 msec); time to peak is approximately 1.75 times the shaping time constant.

SHAPING TIME CONSTANTS—0.5 μsec or 2 μsec unipolar shaping; internally switch selectable.

NOISE CONTRIBUTION—With 2 μsec shaping time constant, less than 7 μV rms referred to the input for any gain greater than 100.

RESTORER—Time variant (gated); on continuously.

COUNT RATE PERFORMANCE—Unipolar Output, 2 μsec shaping.

SPECTRUM BROADENING—FWHM of a ^{60}Co, 1.33 MeV gamma peak for an incoming count rate of 2 kcps to 50 kcps and a 9 volt pulse height will typically change less than 16%.

PEAK SHIFT—The peak position of a ^{60}Co, 1.33 MeV gamma peak for an incoming count rate of 2 kcps to 50 kcps and a 9 volt pulse height will shift less than ±0.024%.

POWER SUPPLY SENSITIVITY

Supply	Amp dc level
+24 V	10 mV/volt
-24 V	10 mV/volt
+12 V	6 mV/volt
-12 V	5.5 mV/volt

Supply	Amp gain
+24 V	0.028%/volt
-24 V	0.028%/volt
+12 V	0.011%/volt
-12 V	0.0022%/volt

2.4 INTERNAL CONTROLS

TIME CONSTANTS—Internal push-button switch to select shaping time constant of 0.5 or 2.0 μsec.

Z_{out}—2 position jumper plug that selects the front panel UNIPOLAR OUTPUT impedance of less than 1 ohm or approximately 93 ohms. Shipped in the low impedance position.

2.5 CONNECTOR TYPES

INPUT—Front and rear panel, BNC.

UNIPOLAR OUTPUT—Front and rear panel, BNC.

TEST POINT—Unipolar Output, front panel, Selectro-SkT-41.

PREAMP POWER—Rear panel, Amphenol 17-10090.

2.6 POWER REQUIREMENTS

+24 V dc — 45 mA
- 24 V dc — 50 mA
+12 V dc — 40 mA
- 12 V dc — 30 mA

2.7 PHYSICAL

SIZE—Standard single-width NIM module 3.43 x 22.13 cm (1.35 x 8.71 inches).
NET WEIGHT—1.0 kg (2.2 lbs).
SHIPPING WEIGHT—1.8 kg (4.0 lbs).

Section 3. Controls and Connectors

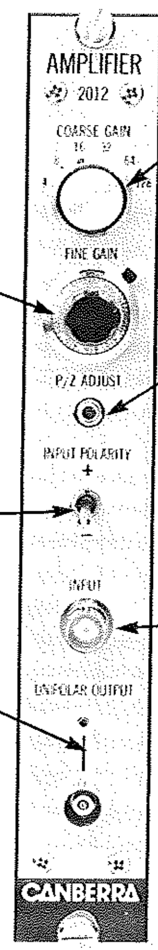
3.1 GENERAL

Complete understanding of the purpose of the various controls and connectors is essential for the proper operation of the Model 2012 and it is recommended that this section be read before proceeding with the operation of the module.

3.2 FRONT PANEL

FINE GAIN
Ten turn precision potentiometer selects variable gain factor from X3 to X10. Resetability within ± 0.03%.

COARSE GAIN
Six position rotary switch selects gain factors of X4, X8, X16, X32, X64 and X128; multiplied by the FINE GAIN control settings.



POLE ZERO
22 turn screwdriver adjust potentiometer to compensate for the undershoot caused by the preamplifier fall-time constant. Adjustable for preamplifier fall-time range of 30 μsec. to ∞.

INPUT POLARITY
Toggle switch to set the Model 2012 for the polarity of the incoming preamplifier signal.

INPUT
Accepts positive or negative linear pulses from associated preamplifier. Signal requirements are: Amplitude 0 to ± 12 volts maximum; Rise time less than shaping time constant; Decay time constant 30 μsec to ∞; Z_{in} approximately 1k ohms.

UNIPOLAR OUTPUT
Provides a positive near-Gaussian output pulse; Reference Section 2.2 for signal specifications. Test point is provided, test point output impedance is 470 ohms.

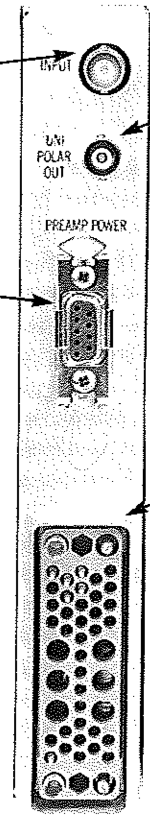
Figure 3-1. Front Panel Controls and Connectors.

3.3 REAR PANEL

INPUT
Additional input wired in parallel with the front panel signal Input BNC Connector.

PREAMP POWER
Provides power for any Canberra preamplifier; Model 1708 preamplifier requires a special cable.

PIN	FUNCTION
1	Ground
2	Clean Ground
4	+12 V dc
6	- 24 V dc
7	+24 V dc
9	- 12 V dc



UNIPOLAR OUTPUT
Signal specifications are identical to the front panel output except for 93 ohm series-connected output impedance only.

MODULE POWER
Connector accepts operating voltages from an AEC standard NIM bin/power supply, such as the Canberra Model 2000.

PIN	FUNCTION
16	+12 V dc
17	- 12 V dc
28	+24 V dc
29	- 24 V dc
34	Ground
42	Clean ground

Figure 3-2. Rear Panel Connectors

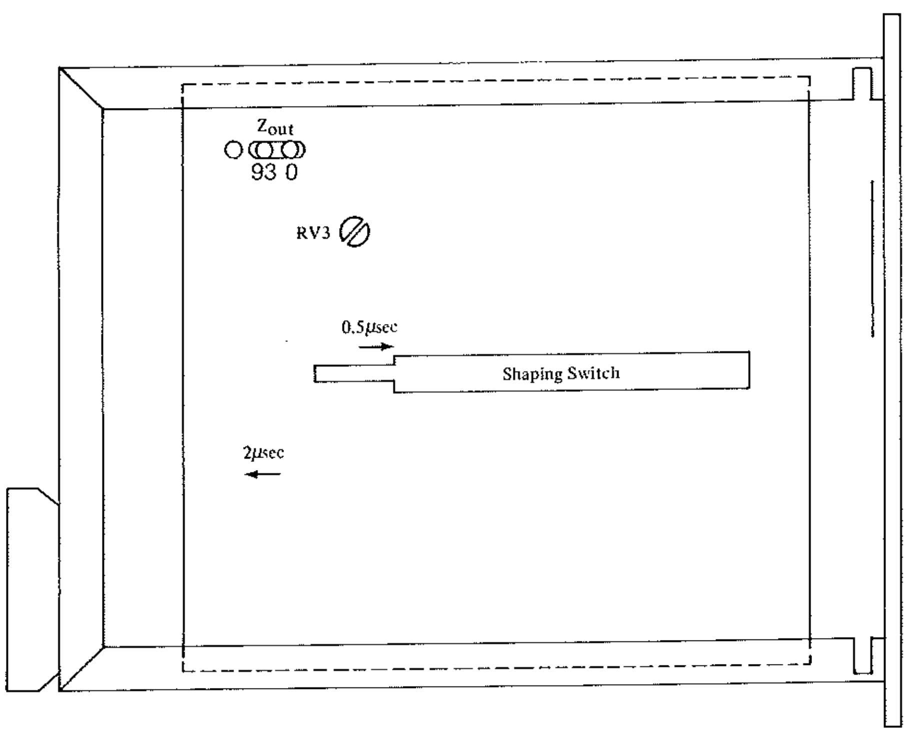


Figure 3-3. Internal Controls, Left Side Cover Removed.

Section 4. Operating Instructions

4.1 GENERAL

The purpose of this section is to familiarize the user with the operation of the Model 2012 Amplifier and to check that the unit is functioning correctly. Since it is difficult to determine the exact system configuration in which the module will be used, explicit operating instructions cannot be given. However, if the following procedures are carried out, the user will gain sufficient familiarity with this instrument to permit its proper use in the system at hand.

4.2 SPECTROSCOPY SYSTEM OPERATION

The following instructions apply to obtaining the maximum performance capabilities of the Model 2012 depending on operating and system needs.

4.2.1 System Setup

A block diagram of a typical Canberra gamma spectroscopy system is shown in Figure 4-1.

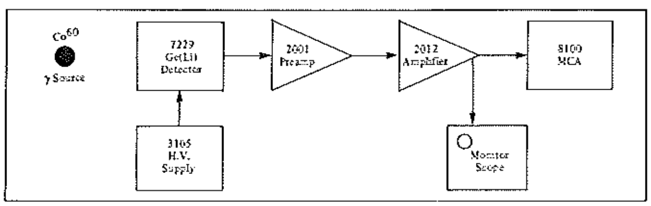


Figure 4-1. Typical Gamma Spectroscopy System.

1. INTERNAL CONTROLS

   Prior to installation and set up the internal jumper plug and shaping switch should be set to their desired position. See Figure 3-3.

   A Z_{out} jumper plug is provided which controls the output impedance of the front panel (only) UNIPOLAR OUTPUT. The output impedance can be changed from 0 ohms to 93 ohms. The rear panel output has a fixed output impedance of 93 ohms, series connected.

   When using the front panel low impedance output, short lengths of interconnecting coaxial cable need not be terminated. To prevent possible oscillations, longer cable lengths should be terminated at the receiving end in a resistive load equal to the cable impedance (93 ohms for type RG-62/U cable).

   The rear panel 93 ohms output may be safely used with RG-62/U cable up to a few hundred feet. However, the 93 ohm impedance is in series with the load impedance, and a decrease in the total signal range may occur. For example, a 50% loss will result if the load impedance is 93 ohms.

2. Insert the Model 2012 into a standard NIM Bin. Preamp power is provided by means of a connector located on the rear panel of the Model 2012 amplifier. Allow the total system to warm up and stabilize.

3. Set the Model 2012 controls as indicated below:

   a. | | |
   |---|---|
   | Shaping: | 2 μsec (Internal) |
   | COARSE GAIN: | 16 |
   | FINE GAIN: | 2.2 |

   This will give approximately a 9 volt output when using a preamp gain of 100 mV/MeV and a ^{60}Co source.

   b. Set the INPUT POLARITY switch to match the output polarity of the preamp.

4. Install a "Tee" Connector on the Model 2012 Amp Output. Connect one end to the ADC Input on the Analyzer. The ADC must be direct coupled for linear input signals to fully exploit the count rate capabilities of the Model 2012 Amplifier. All Canberra ADC's are dc coupled.

   Connect the second end of the "Tee" Connector to an oscilloscope and monitor the UNIPOLAR OUTPUT.

4.2.2 Performance Adjustments

a. The Pole/Zero is extremely critical for good high count rate resolution. See note 1 on page 6. Adjust the radiation source count rate between 2 kcps and 25 kcps. While observing the UNIPOLAR OUTPUT on the scope, adjust the Pole/Zero so that the trailing edge of the near-Gaussian pulse returns to the baseline with no over-or under-shoots. Figure 4-2a shows the correct setting of the Pole/Zero control, with Figure 4-2b and 4-2c showing under- and over-compensation for the preamplifier decay time constant. Notice some small amplitude signals with long decay times in Figure 4-2a. These are due to charge trapping in the detector and cannot be corrected by the Pole/Zero control.

b. Pole Zero adjustment using a square wave and preamp test input. See Note 2 on page 7.

   Driving the preamp test input with a square wave, will allow a more precise adjustment of the amplifier P/Z.

   1. The Amplifier's controls should be basically set for its intended application: coarse gain, shaping, input polarity.

   2. Adjust the square wave generator for a frequency of approximately 2 kHz.

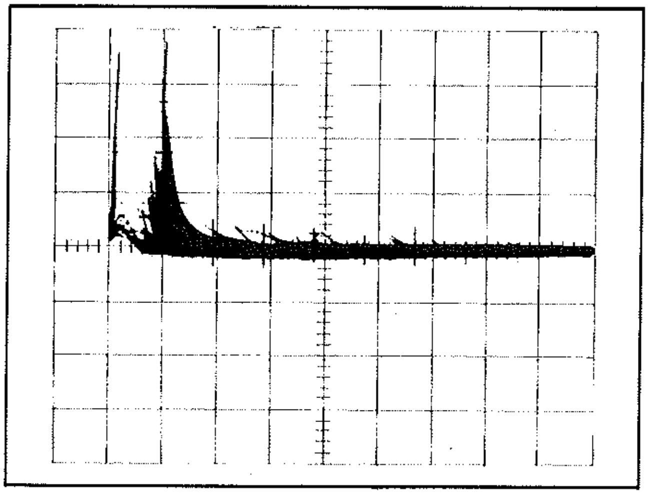


Figure 4-2a
Correct Pole/Zero Compensation

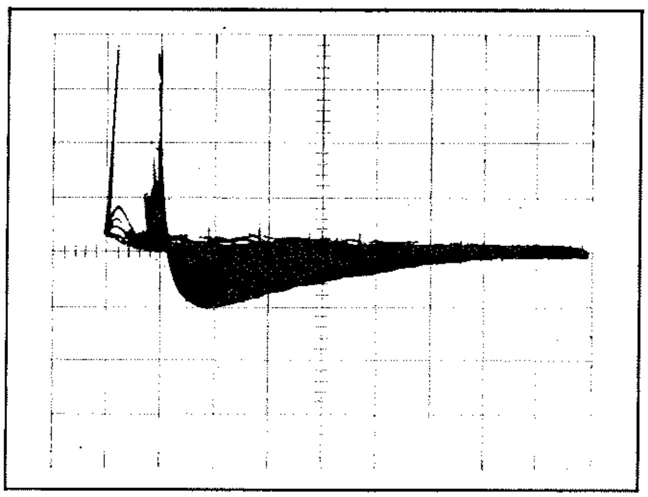


Figure 4-2b
Undercompensated Pole/Zero

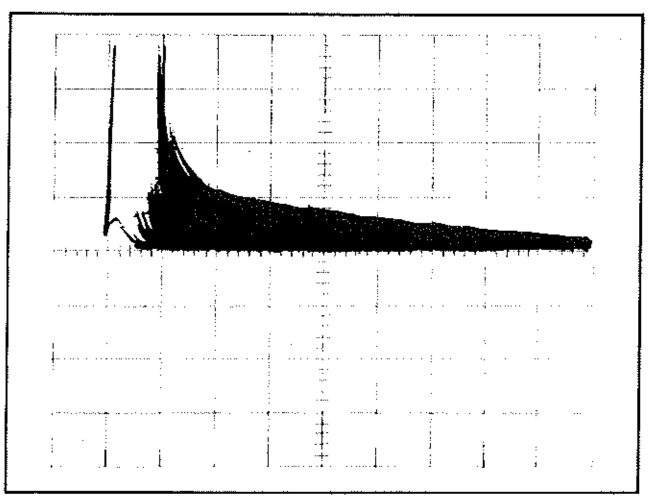


Figure 4-2C
Overcompensated Pole/Zero

Figure 4-2.
Pole/Zero adjustment with a Live source (^{60}Co)

3. Connect the Square Wave generator's output to the Preamp's Test Input.

4. Remove all radioactive sources from the vicinity of the detector.

5. Set the scope's channel 1 vertical sensitivity to 5 volts/cm., and adjust the main time base to 0.1 msec/cm. Monitor the Model 2012's UNIPOLAR OUTPUT and adjust the Square Wave generator's amplitude control (attenuator) for output signals of ±8 volts.

   Note: Both positive and negative near-Gaussian pulses will be observed at the output.

6. Reduce the Scope vertical sensitivity to 50 mV/cm. See Note 1 below.

   Figure 4-3a shows the correct setting of the Pole/Zero control. Figures 4-3b and 4-3c show under - and over-compensation for the preamplifier decay time constant.

   As illustrated in Figure 4-3a, the UNIPOLAR OUTPUT signal should have a clean return to the baseline with no bumps, overshoots or undershoots.

c. HPGe detectors and Si Systems with Optical Feedback Preamps.

   For normal Si systems the Pole/Zero is usually set at ∞, fully counter-clockwise. However, on some systems the Pole/Zero may need to be slightly adjusted for optimum overload recovery of the preamp's reset pulse.

NOTE 1:
At high count rates the Pole/Zero adjustment is extremely critical for maintaining good resolution and low peak shift. For a precise and optimum setting of the Pole/Zero a scope vertical sensitivity of 50 mV/cm should be used. Higher scope sensitivities can also be used, but result in a less precise Pole/Zero adjustment. However, scopes such as the Tektronix Models 454 and 475 will overload for a 10 volt input signal when the vertical sensitivity is set for 50 mV/cm. Overloading the scope input will distort the signal's recovery to the baseline. Thus the Pole/Zero will be incorrectly adjusted resulting in a loss of resolution at high count rates. To prevent overloading the scope, a clamping circuit, such as the illustrated in Figure 4-4, can be used at the scope input.

Oscilloscope
Vertical: 50 mV/cm
Horizontal: 10 μsec/cm

Source ^{60}Co
1.33 MeV Peak: 7V amplitude
Count Rate: About 3 kcps
Shaping: 2 μsec

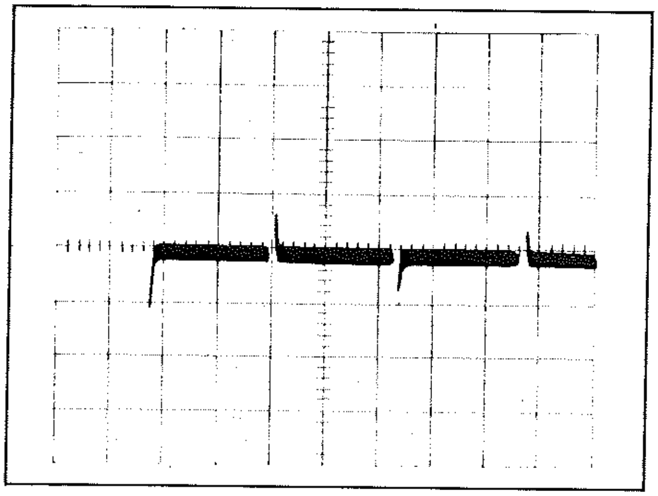


Figure 4-3a
Correct Pole/Zero Compensation

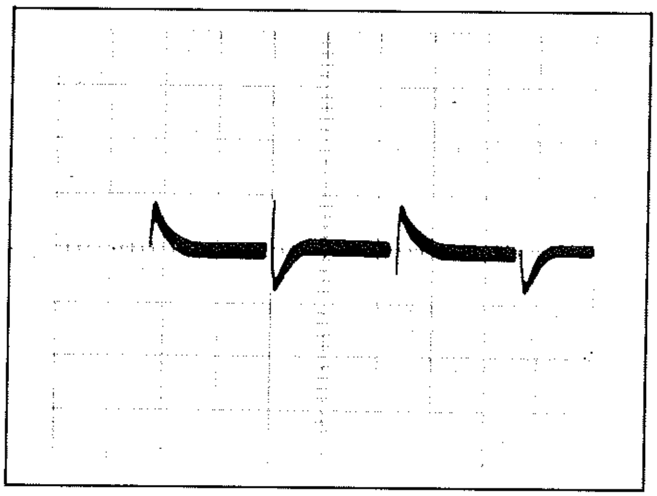


Figure 4-3b
Undercompensated Pole/Zero

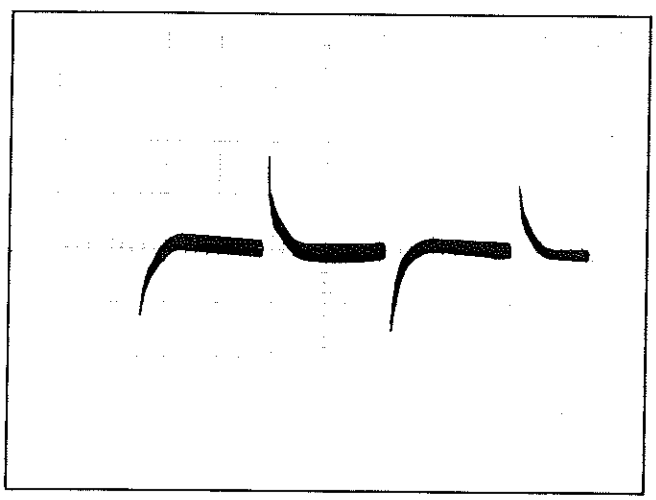


Figure 4-3c
Overcompensated Pole/Zero

Figure 4-3. Pole/Zero Adjustment using square wave pulse and preamp test input.

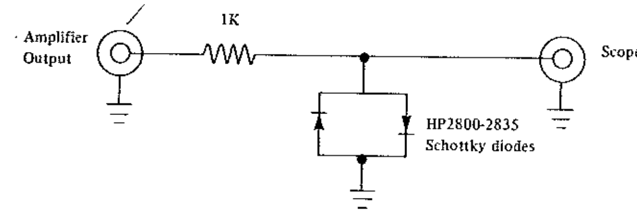


Figure 4-4. Scope Input Clamp.

NOTE 2:
When adjusting the Pole/Zero using the square wave technique, the calibration square wave generated by the oscilloscope can be used. Most scopes generate a 1 kHz square wave used to calibrate the vertical gain and probe compensation. Connect the scope CALIBRATION Output through an attenuator to the preamp test input and perform 4.2.2b steps 1 and 4, 5, 6.

d. AMP DC LEVEL
The AMP OUTPUT dc level is factory calibrated to ± 1 millivolt. The adjustment is made internally by RV3 and covers a range of ± 100 millivolt.

e. MCA CONTROLS
To get optimum resolution, the Lower Level Discriminator on the ADC should be set just above the noise so that the effects of pile-up are minimized.

4.2.3 Resolution Versus Count Rate and Shaping

The 2 μsec shaping time constant is optimum for Ge(Li) detector systems over a wide range of incoming count rates. Larger shaping time constants offer a better signal to noise (S/N) ratio, resulting in better resolution. However as the count rate increases, the effects of pile up will degrade the resolution much sooner. The optimum shaping time constant depends on the detector (such as its size, configuration and collection characteristics), preamplifier and incoming count rate. Below is a list of optimum shaping time constants for some other common detectors.

Detector	Optimum Shaping (μsec)
Scintillation Photomultiplier	0.5
Gas Proportional Counters	0.5 or 2
Silicon Surface-Barrier	0.5 or 2
Cooled Silicon	8 or 12

Oscilloscope
Vertical: 50 mV/cm.
Horizontal: 0.2 μsec/cm

The Model 2012 is normally factory set for 0.5 μsec or 2 μsec shaping time constants. However the shaping time constants can be changed to 8 μsec and 12 μsec to be compatible with cooled Silicon detectors. Change the components as follows:

1. Change C1 from 560 pF to 9100 pF
2. Change C2 from 1600 pF to 560 pF
3. Change R1 from 19.1k ohms to 22.6k ohms
4. Change R2 from 52.3k ohms to 11k ohms
5. Change C3 from 130 pF to 2000 pF
6. Change C4 from 360 pF to 1300 pF
7. Change C5 from 200 pF to 2400 pF
8. Change C6 from 510 pF to 1600 pF
9. Change C25 from 47 pF to 1000 pF
10. Change C26 from 200 pF to 510 pF

All resistors are RN60C; all capacitors are 1% silver mica.

4.3 RESOLUTION DESTROYING INTERFERENCES

a. Vibration transmitted to the detector and cryostat. This can be through the floor or mounting, as well as direct audio coupling through the air. Vibration isolators in the mounting and sound absorbing covers around the detector can reduce this problem.

b. The close proximity of a radio station can be picked up by the "dipstick" of the cryostat. Good contact between the dipstick and the cryostat can often help solve this problem. Beware of grounding the cryostat and dipstick as this may increase power line frequency (50 or 60 Hz) ground loops.

c. Ground Loops: power line frequency interference can be caused by long cable connections between the detector, preamplifier and shaping amplifier. There is no general solution for this problem. As a first step, the preamp should use the power supplied by the main shaping amplifier. Second, the system should have a single point house ground. For example, on a general system connect the NIM Bin to house ground via the ac line cord. Isolate all other equipment requiring ac voltage from the house ground. Connect all the chassis in the system to the grounded NIM Bin using heavy braided wire.

d. High voltage power supplies: generally, the HVPS should float from power line ground with the only ground being made at the preamplifier through the high voltage connecting cable.

e. Analyzer EMI: if the detector is located within 3 to 5m (10 to 15 feet) of a multichannel analyzer containing a ferrite core memory. It can receive EMI (electro-magnetic interference). This is due to high memory core currents during the memory cycle of the analyzer. The only practical cure for this problem is to operate the analyzer in the "Live" Mode of accumulation. In this way, the memory cycle only operates while no signal is being analyzed.

f. Is the output of the spectroscopy amplifier and the input of the ADC fully compatible? This may seem an obvious consideration, but it is commonly overlooked. The shaping time constant as stated on the spectroscopy amplifier is *not* the rise time of its output signal. In the case of a Model 2012 Amplifier, the time-to-peak of the AMP OUTPUT is 1.75X the shaping time constant. Therefore, a 12 μsec shaped pulse requires 21 μsec to reach full amplitude. Many analyzers will not handle this; instead of analyzing the peak of the signal, they analyze a percentage of the rise time.

g. Amplifier parasitic oscillations: if the cable connecting the front panel outputs of the amplifier to the ADC exceed 3 to 6m (10 to 20 feet) in length, oscillations can occur. The cure is to use RG-62/U cable (93 ohm impedance) and terminate the ADC end of the cable with a 93.1 ohm metal film resistor. Alternatively, the 93 ohm output impedance of the amplifier can be used with no terminator.

Section 5.
Performance Check

5.1 GENERAL

The Purpose of this section is for checking the performance of the Model 2012 Amplifier. The checkout will serve to verify the module is in good operating order without making internal adjustments. If the Model 2012 should not meet the performance requirements given in this procedure, it is strongly suggested that the unit be sent back to the factory for calibration and/or repair. The instructions which follow are primarily directed toward the Model 2012 only. Please refer to the instruction manuals of the other equipment used if questions or difficulties in their use arise.

5.2 RECOMMENDED EQUIPMENT

In order to perform the checkout procedure detailed in subsequent steps, the following equipment (or equivalents) will be required.

a. Canberra Model 2000 Bin/Power Supply

b. Canberra Model 1407 Reference Pulser

c. Calibrated dual trace 100 MHz oscilloscope (Tektronix 454, 475, etc.)

d. RMS Noise Meter (Hewlett Packard HP-400H)

e. $4^1/_2$ digit, $\pm$ 0.1% full scale accuracy Digital Voltmeter (DVM) (Data Precision 3500)

5.3 NIM VOLTAGE CHECK

With a DVM, measure the NIM Power Supply voltages and adjust if they are outside of the following ranges:

+24 V:	+23.98 V	to	+24.02 V
- 24 V:	- 23.98 V	to	- 24.02 V
+12 V:	+11.99 V	to	+12.01 V
- 12 V:	- 11.99 V	to	- 12.01 V

5.4 CURRENT MEASUREMENTS

a. Apply power to the Model 2012 and measure the currents. They should be within the following ranges:

+24 V	35 mA	to	55 mA
+12 V	30 mA	to	50 mA
- 12 V	20 mA	to	40 mA
- 24 V	40 mA	to	60 mA

NOTE: A greater deviation in currents indicates a faulty unit. Gross errors would probably be due to faulty or reversed capacitors, shorted or open transistors, etc.

5.5 AMPLIFIER OPERATIONAL CHECKS

5.5.1 Initial Setup

a. Set the controls as follows:

Model 2012 Controls—

COARSE GAIN:	4
FINE GAIN:	10
SHAPING:	2 μsec. (internal)
POLE/ZERO:	Fully CCW
INPUT POLARITY:	POS

Model 1407—

PULSE HEIGHT:	5.4 (2.7 if modified 1407)
NORMALIZE:	10
POS/NEG:	POS
LINE/OFF/90 Hz:	90 Hz
RISE TIME:	MIN
FALL TIME:	400 μsec.
ATTENUATION:	x10

b. Connect a 93 or 100 ohm terminator to the Model 2012's rear panel INPUT.

c. Connect the Model 1407 ATTEN OUTPUT to the Model 2012's front panel INPUT with RG-62 coax cable.

d. Connect the Model 1407 NORMAL OUTPUT to the External Trigger input of the scope. Set the scope triggering to External, Positive Slope.

5.5.2 Output

a. Connect the UNIPOLAR OUTPUT to the scope with RG-62 coax cable, using a "Tee" connector at the scope. You should observe the near-Gaussian shaped pulse shown in Figure 5-1

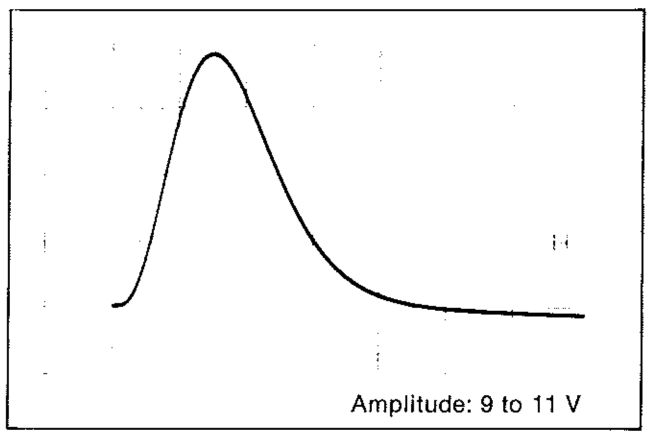


Figure 5-1
AMP OUTPUT [2V/cm.,2 μsec/cm.]

b. Adjust the Model 1407 PULSE HEIGHT until the UNIPOLAR OUTPUT amplitude is +9.9 to 10.1 V.

c. Place jumper plug J4 in the 93 ohm position. Connect a 93 ohm terminator to the "Tee" connector at the scope input. The amplitude of the pulse should be +4.8 to 5.2 V. Remove the 93 ohm terminator.

d. Place Jumper Plug J4 in the 0 ohm position.

e. Connect the 93 ohm terminator; the amplitude should not decrease by more than 100 mV. There should be no discernible distortion in the pulse shape. Remove the terminator.

f. Set the Model 1407 ATTENUATION to X1. The UNIPOLAR OUTPUT pulse should be clamped at +11.5 to 12.5 V.

g. Set the Model 1407 ATTENUATION to X10.

5.5.3 Pole/Zero Adjustment

a. Set the Model 1407 FALL TIME to 50 μsec.

b. Observe the UNIPOLAR OUTPUT on the scope and adjust the Pole/Zero control so that the tail of the Gaussian pulse returns to the baseline as fast as possible with NO under or overshoot, as in Figure 5-2.

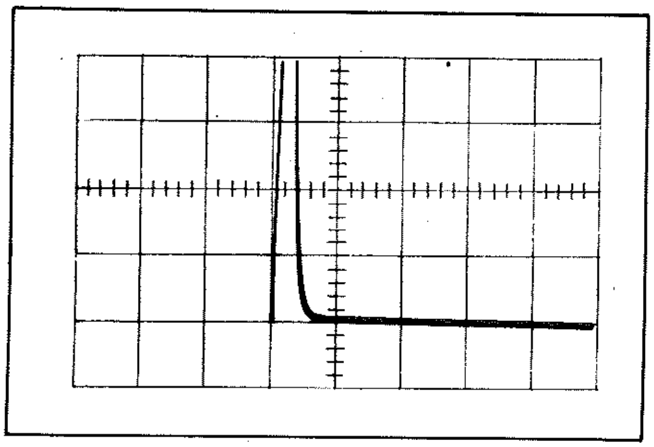


Figure 5-2
Pole Zero Adjustment, AMP OUTPUT [0.5 V/cm., 20 μsec/cm.]

5.5.4 Coarse and Fine Gain Controls

a. Set the Model 2012 COARSE GAIN to 128; FINE GAIN to 10.0

b. Connect the UNIPOLAR OUTPUT to the scope with RG-62 coax cable.

c. Set the Model 1407 ATTENUATION to X500. Adjust the Model 1407 PULSE HEIGHT until the output pulse attains an amplitude of +9.9 to +10.1 V.

d. Measure the unipolar output amplitude for each COARSE GAIN setting. The amplitudes should reduce proportionately with each COARSE GAIN setting.

e. Set the Model 2012 COARSE GAIN to 128.

f. Monitor the UNIPOLAR OUTPUT on the scope and turn the 2012 FINE GAIN Control to minimum. The amplitude of the output pulse should decrease approximately 1/3.

g. Return the FINE GAIN to maximum.

5.6 SHAPING CHECKS

a. Set the Model 2012 to 2 μsec. shaping.

b. Set the Model 1407 ATTENUATION to X500. Adjust the Model 1407 PULSE HEIGHT until the output pulse attains an amplitude of 9.9 to 10.1 volts.

c. Observe the UNIPOLAR OUTPUT on the scope. Set the Model 2012 SHAPING Switch to 0.5 μsec; the output amplitude should be 8.5 to 10.5 volts.

d. Measure the UNIPOLAR OUTPUT pulse width at the 100 mV points (1% amplitude). They should be within the following ranges. Pole/Zero the amplifier for each shaping.

Shaping	Amp Output Pulse Width
0.5 μsec.	3.4 to 5 μsec.
2 μsec.	11 to 16 μsec.

5.7 NOISE MEASUREMENT

a. Set the Model 2012 controls as follows:

COARSE GAIN: 16
SHAPING: 2 μsec.

b. Install side covers on the Model 2012.

c. Connect a 93 ohm terminator to the Model 2012's rear panel signal INPUT BNC connector.

d. Connect a "Tee" connector to the Model 2012's front panel INPUT. Using RG-62 coax cable, connect one side of the "Tee" connector to the Model 1407 Pulser ATTEN OUTPUT. Using RG-62 coax cable, connect the other end of "Tee" connector to the scope input. You will observe a positive tail pulse on the scope. Set the Model 1407 ATTENUATION to X10 and adjust the PULSE HEIGHT until the tail pulse attains an amplitude of 100 mV.

e. Monitor the UNIPOLAR OUTPUT on the scope and adjust the Pole/Zero control for no under or overshoots, see Figure 5.2. Adjust the Model 2012 FINE GAIN for an output pulse amplitude of +9.9 to +10.1 volts.

f. Remove the "Tee" connector and cables from the Model 2012 INPUT. Leave the 93 ohm terminator on the rear panel INPUT. Set the Model 1407 LINE/OFF/90Hz switch to OFF. Connect the UNIPOLAR OUTPUT to the Noise Meter with RG-62 coax cable and measure the noise. It should be 0.58 mV maximum for an averaging meter and 0.66 mV maximum for a true RMS voltmeter.

5.8 LINEARITY CHECK

Note: To perform this test, the Model 1407 must be modified for a 20 V output.

Integral nonlinearity is a measure, expressed in percentage, of maximum deviation when a straight line is compared to an output versus input plot. The output is exercised over its full dynamic range. A test for nonlinearity can be conducted using the resistive summing network shown in Figure 5-3.

The test is performed by first adjusting the amplifier gain, polarity and pulser attenuation so that a negative 10 volt (NORMAL) pulser output produces a positive 10 volt amplifier output. The pulser NORMAL output should be -10 volts coincident with the amplifier output peak. Next, while observing the summing point on the oscilloscope, the amplifier fine gain is carefully adjusted to make the null point equal to the baseline. The oscilloscope vertical gain should be set to obtain the desired resolution.

When this condition is obtained, turn the Model 1407 PULSE HEIGHT control downward from 10 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 nonlinearity of the amplifier under test is then equal to:

$$\frac{\text{(Maximum deviation in volts) x2 x100\%}}{\text{10 volts}}$$

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

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's direct output meets this requirement since it is related to the amplifier input 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 measurement, because both direct and attenuated outputs will be affected identically, save for 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, dc level fluctuations and noise, and need not be of concern in this test.

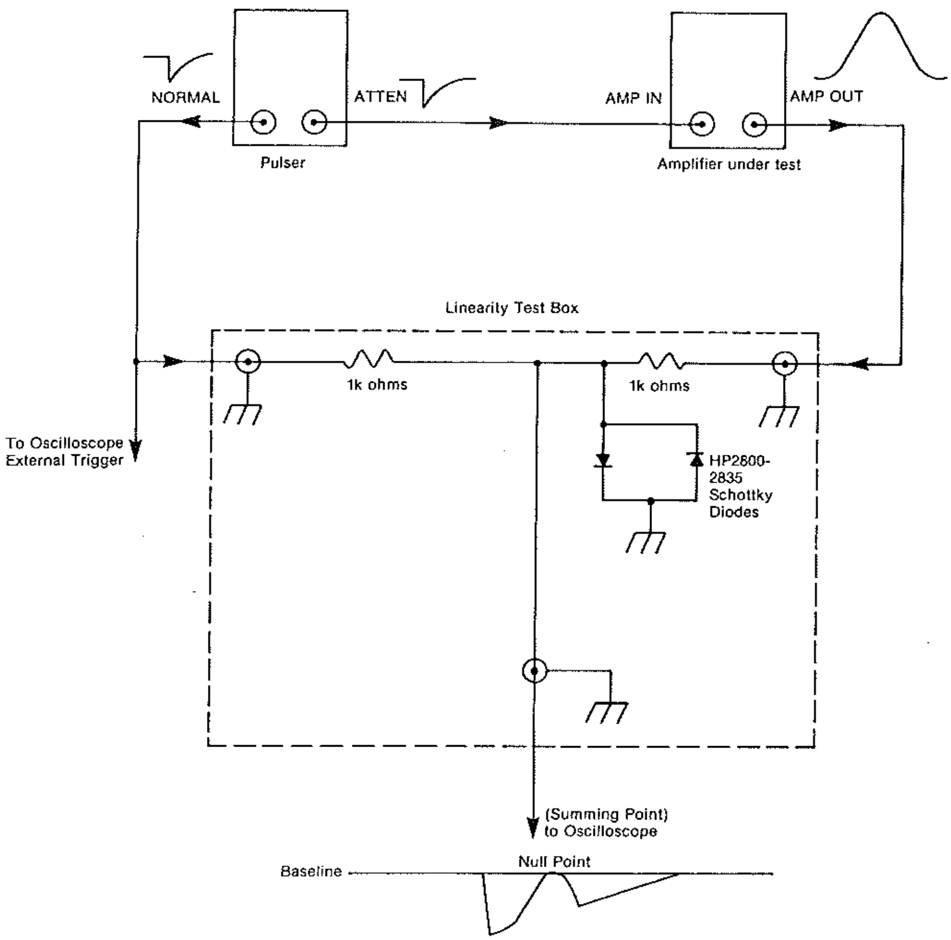


Figure 5-3. TEST SETUP; LINEARITY CHECK

Section 6.
Theory of Operation

6.1 GENERAL

This section of the manual contains a description of the circuitry used in the Model 2012 Amplifier. Components are referred to by "reference designations" such as Q2, C5, and R10. Throughout the following circuit analysis, refer to the circuit schematics following this section.

6.2 BLOCK DIAGRAM DESCRIPTION (Figure 6-1)

The preamp signal enters either the front panel INPUT BNC (J1) or the rear panel INPUT BNC (J101). The signal is differentiated by C1 or C2 and the appropriate amplifier input resistance selected by S2, and pole/zeroed by RV1 and R1 or R2. The signal is then amplified by gain amplifiers K1 and K2. Amplifier K1 is either inverting or noninverting depending on the position of switch S2. The amplified signal is next integrated by the complex pole integrator. The integrated signal is used to drive the combination output amplifier, real pole integrator and dc restorer. The processed signal is then connected to the front and rear panel BNC connectors. J3 and J102.

6.3 CIRCUIT DESCRIPTION

6.3.1 Gain Amplifiers

Most of the gain (K1 and K2) is accomplished before the integration occurs. As a result the input amplifier K1 is the dominant noise source. Each of the two gain stages operate at relatively low closed loop gains providing stable operation with time and temperature.

Amplifiers K1 (Q14 through Q19) and K2 (Q8 through Q13) are both basically the same configuration. Therefore only K1 will be fully described.

6.3.2 Input Amplifier K1

The differential input pair Q19 drives common base transistors Q18 and Q15. Transistors Q18 and Q15 operate at low current levels, providing a high output impedance to drive output transistors Q17 and Q14 through (common source) FET Q16. The necessary current to drive the FET and circuit capacitors at high frequencies is derived directly from the input transistor Q19, through the low impedance of Q18 and Q15. This gives a slew rate for the amplifier of 140 volts per microsecond. C12 provides feedback for closed loop stability, and allows the amplifier to follow a 100 nanosecond rise time signal without losing feedback control. Since the gain amplifiers do not require dc stability and are operated as inverting amplifiers, a constant current source is not needed in the emitters of Q19. Transistors Q17 and Q14 are biased on by R30 and R33, with the junction of R31 and R32 providing the low impedance output.

The first differentiation network, Pole/Zero cancellation circuitry and input polarity selection are located at the input of K1. The SHAPING switch, S3, (sections S1 through S3 and sections P1 through P3) selects the passive differentiator capacitors C1 and C2 and Pole/Zero compensating resistors R1 and R2 for the selected time constant. Pole/Zero control RV1 sets the degree of Pole/Zero compensation. Input polarity is selected by switch S2. For POS input polarity, gain is determined by R23 and R15. With NEG input polarity, the gain is determined by the combination of R23, R15, R12 and R13. Diode D1 prevents charge accumulation on C11 during overload, enhancing good overload recovery.

6.3.3 GAIN AMPLIFIER K2

Amplifier K2 is an inverting gain amplifier with its gain controlled by the ratio of the series combination of input resistors R46 through R51, selected by the COARSE GAIN switch S1a and the feedback resistor R65. Diodes D3 and D4 provide overload protection. Capacitor C35 ac couples the signal to the amplifier summing junction. Pot RV2 and resistor R92 form the network in the feedback circuit which controls the FINE GAIN adjustment. Diode D2 prevents charge accumulation on C33 during overload, enhancing good overload recovery.

6.3.4 Integrator Amplifier A5

Active integrator A5 provides complex-pole pairs which have the locus of the poles equidistant from the origin. The real part of the complex poles are equal to the pole of the input differentiator. The real pole of the last integrator (output amplifier A3) is 1.6 times this value. Active filter networks for A5 are selected by the SHAPING switch S3, sections (C1, C2, C3 and E1, E2, E3) for the desired time constant.

Amplifier A5 is a wide-band, high slew-rate, integrated circuit operational amplifier. It is connected in a non-inverting configuration with a dc gain of 2, determined by R5 and R6.

The output of integrator A5 is connected through an RC filter network, R17, R24 and C15, back to the summing junction of gain amplifier K2 for dc stabilization of amplifier K2.

6.3.5 AMP Output Integrator and Driver

The unipolar output amplifier is comprised of A3 and a power output driver, Q1, Q2 and Q3. Integrated circuit A3 is a wide-band, high slew-rate operational amplifier. The overall amplifier (op-amp and driver) provides an inverting gain of 2 with single-pole integration (C25 and

C26) to minimize noise introduced after the integration amplifier A5.

The output driver transistors are biased Class "AB". Diodes D11, D14 and current source Q2 keep both output transistors biased on.

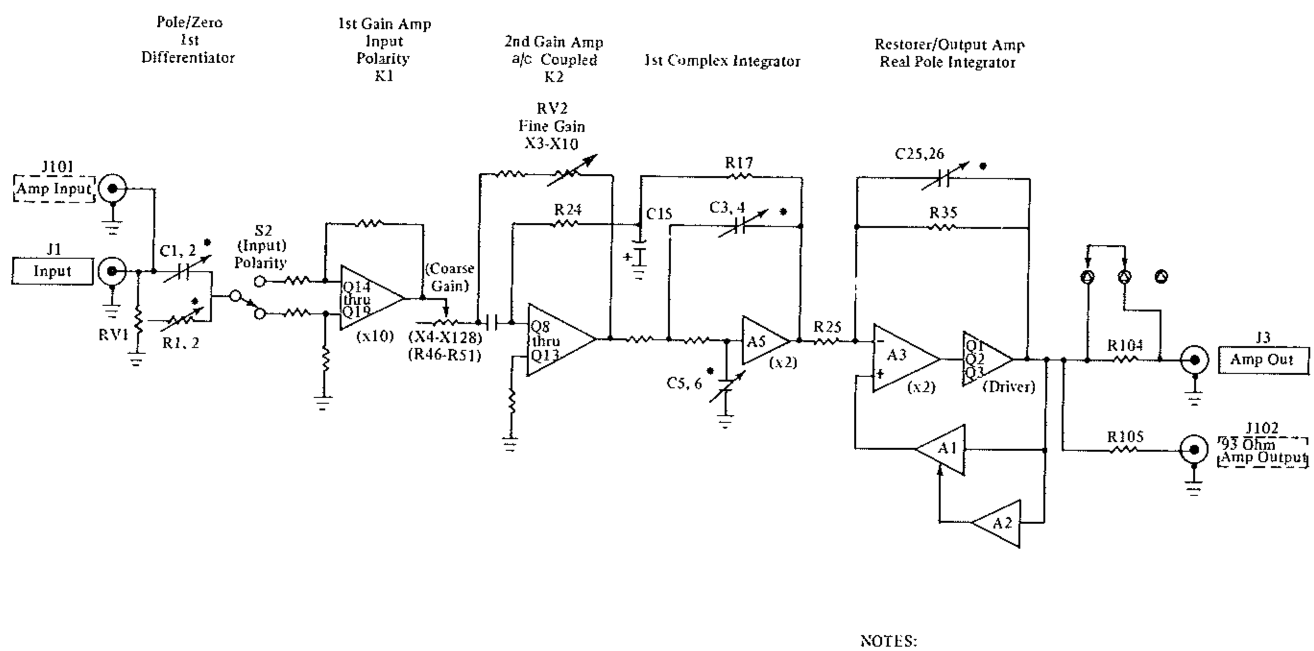
Diodes D12 and D13 provide short circuit protection. When a short circuit is connected to the output and the voltage drop across R71 or R72 equals or tries to exceed the diode drops of D12 or D13 (about 600 mV), diodes D12 or D13 will forward bias and limit the output current to approximately ± 200 mA. Diodes D9 and D10 provide limiting so that the output transistors do not go into saturation, preventing base-emitter charge storage.

Two UNIPOLAR OUTPUTS are provided. The front panel output provides two impedances: less than 1 ohm, or 93 ohms, internally selectable by J4. The low output impedance can drive several feet of 93 ohm coax cable, whereas the 93 ohm output can drive hundreds of feet of 93 ohm coax cable. The rear panel output has a fixed 93 ohm series-connected output impedance.

6.3.6 Restorer

The restorer circuitry consists of the output amplifier A3, transistor array A1, dual differential comparator A2 and transistors Q4, Q5, Q7, Q29 and Q30. The restorer is a transconductance type amplifier; that is, it monitors the output voltage of the UNIPOLAR OUTPUT (TP1) and develops a constant current of the correct polarity at its output (junction of Q4 collector and A1e pin 15). This generates a voltage on C24 which is buffered by FET Q6 and summed at A3 pin 3, forcing the output of the Output Amplifier (TP1) to 0 Volts, maintaining the baseline. When A2 detects a signal, its output causes Q29 to turn off. Q7 switches on a current sufficient to back-bias curent source 1a of A1 which disables the restorer. Capacitor C40 ac couples to transistor Q29 preventing restorer latch-up. The UNIPOLAR OUTPUT signal (TP1) is clamped by network D15 and D16 and connected to the comparator input A2 pins 5 and 2.

The negative restorer gate threshold is set at - 100 mV by resistors R103 and R100. The positive threshold is variable and dependent on the setting of the coarse gain switch S1b and resistors R94 through R99. Pot RV3 adjusts the offset of the restorer output and UNIPOLAR OUTPUT (TP1) to 0 ± 5 mV.



NOTES:
1. • - Indicates a Simultaneous-Change (Shaping Switch).
2. ⊗ - Indicates a Cambion Socket.
3. [solid box] - Indicates a Front Panel Component
4. [dashed box] - Indicates a Rear Panel Component.

Figure 6-1.
Model 2012 Block Diagram

BASIC WARRANTY

Equipment manufactured by Canberra Industries, Inc. is warranteed 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. During the warranty period, repairs or replacement will be made at Canberra's option on a return to factory basis. The transportation cost, including insurance, to and from Canberra, is the responsibility of the Customer except for defects discovered within 30 days after receipt of equipment where shipping expense will be paid by Canberra to and from Canberra.

The customer must obtain an authorized customer service return number 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 be deemed to have assumed any responsibility or liability in connection with the shipment.

The Canberra Basic 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, (travel time labor, 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 express warranties set forth herein are the only warranties with respect to the products, or any materials or components purchased from others and furnished by Canberra, and there are no other warranties, expressed or implied. The warranty of merchantibility is expressly limited as herein provided and all warranties of fitness are expressly disclaimed and excluded. Canberra shall have no liability for any special, indirect or consequential damages, whether from loss of production or otherwise, arising from any breach of warranty hereunder or defect or failure of any product or products sold hereunder.

EXCLUSIONS

Warranty service is contingent upon the proper use of all equipment and does not cover equipment which has been modified without Canberra's written approval or which has been subjected to unusual physical or electrical stress as determined by Canberra Service personnel. Canberra Industries shall be under no obligation to furnish warranty service (preventive or remedial): (1) if adjustment, repair or parts replacement is required because of accident, neglect, misuse, failure of electrical power, air conditioning, humidity control, transportation, or causes other than ordinary use; (2) if the equipment is maintained or repaired or if attempts to repair or service equipment are made by other than Canberra personnel without the prior approval of Canberra.

This warranty does not cover detector damage caused by warm-up or by neutrons or heavy charged particles. Damage from these causes is readily identifiable as described in the manual accompanying each detector.

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, if any.

Canberra will, upon request, offer, as an option, warranty coverage for non-Canberra equipment such as computers and peripherals sold as part of a system supplied by Canberra. Quotations on this coverage may be obtained by contacting Canberra Customer Service or any of our sales staff.

SOFTWARE

Canberra warrants software media from defects discovered within 30 days after receipt.

Canberra assumes no responsibility for user-written programs or programs published as part of information exchange in Canberra periodicals.

Engineering assistance for software development is available and can be contracted through the Sales Department.

INSTALLATION

Installation of equipment purchased from Canberra shall be the sole responsibility of the customer unless the installation 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.

ON-SITE WARRANTY OPTION

The On-Site Warranty Option provides for free on-site warranty work (Canberra pays all travel and living expenses) within the first 90 days after delivery of equipment to the customer. If installation is ordered from Canberra, the 90 day period commences upon completion of the initial installation. After the 90 day period, labor and materials used on site will still be covered by the basic warranty, but the customer shall pay for all travel expenses—travel time labor and living expenses incurred for any on-site service.

A maintenance contract may be purchased covering the period after the 90 days on-site warranty period, or after initial installation of the equipment. This is to be contracted through Canberra Customer Service.

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 Customer Service Department for shipping instructions and an Authorized Customer Service Return Number.

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

Once repaired, all equipment passes through our normal preshipment checkout procedure. 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 processing damage claims.

Due to the delicate nature of cooled detectors [Ge(Li) and Si(Li)], Canberra requires that delivery to and from air freight terminals be handled with special care. Do not ship such Detectors without first obtaining advice from our Traffic Department.

RETURN SHIPMENTS

Canberra Customer Service Department must be notified in advance if equipment is to be returned for any reason. Canberra can suggest the best means of shipping and will be able to expedite the shipment in case it is lost or delayed in transit.

The customer must obtain an authorized customer service return number 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 be deemed to have assumed any responsibility or liability in connection with the shipment.

Equipment should be returned to your area service center or to Canberra, Meriden. For shipment from outside the U.S., our shipping address is:

Kamino Air Transport, Inc.
JFK International Airport, New York
FOR: CANBERRA INDUSTRIES, INC.
Meriden, Connecticut 06450 U.S.A.

SERVICE AND SERVICEABILITY

Canberra has gone to great lengths to insure that the instruments provided are functionally modular and therefore easy to service. In addition to modularity, Canberra has embarked on an extensive System Service Program to provide a totally responsive service capability. Complete Service Contracts with special arrangements for 24 hour response and weekend standby services are available from Canberra. For a detailed description of our Customer Service Program, please contact our Systems Service Department in Meriden, Connecticut, U.S.A.