ORTEC 490B
Amplifier and
Single Channel Analyzer
Operating and Service Manual

This manual applies to instruments
"Rev 06" on rear panel

Rev Level 07.

Printed in U.S.A.

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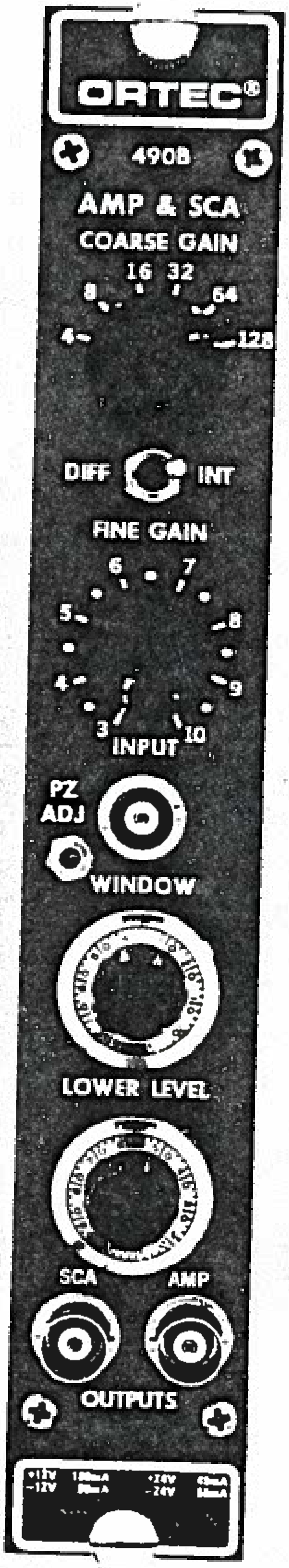
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490B
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INPUT
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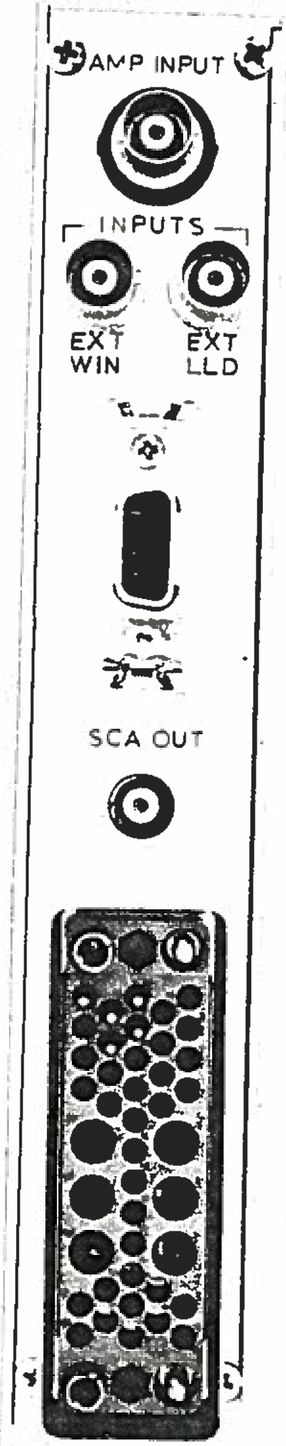
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ORTEC 490B
AMPLIFIER AND SINGLE CHANNEL ANALYZER

1. DESCRIPTION

1.1. GENERAL

The ORTEC 490B Amplifier and Single Channel Analyzer is a NIM-standard single-width module designed to conform to the specifications outlined in TID-20893 (Rev). It includes both a low-noise shaping amplifier and a single channel analyzer.

The amplifier is designed for use with various types of radiation detectors and preamplifiers. It is particularly suited for use with proportional counters and scintillation detectors normally used in x-ray and nuclear spectroscopy, as well as in x-ray diffraction and Mössbauer experiments. The high gain that can be obtained permits proportional counters to be operated with lower potentials for improved gain vs count rate stability. The short resolving time of the amplifier provides a high counting rate capability without sacrifice in the excellent resolution of proportional counters.

The single channel analyzer (SCA) in the 490B is dc-restored to maintain the peak in an adjusted window without shifts due to changes of count rates. This permits stable operation with narrow window widths, with wide variations of count rates during an experiment such as those that are usually present during x-ray diffraction studies. The lower level can be adjusted with a front panel control or it can be furnished by an external voltage from a mating ORTEC 487 Digital Spectrum Scanner. When the front panel toggle switch is set to select the Differential mode of operation, the window width can also be adjusted with either a front panel control or can be furnished as a dc level through a rear panel connector. When the toggle switch is set to select the Integral mode of operation, or whenever the sum of the adjusted lower level and window is greater than 10 V, the SCA operates as an integral discriminator to generate an output if the amplified input exceeds the lower level. An internal jumper permits selection of a range for the front panel Window control of either 0 to 10 V or 0 to 1 V.

The SCA output signal occurs just after the peak of the input signal from the amplifier, and its very small time shift with changes of input peak amplitude makes the 490B ideal for use in slow coincidence or gating applications.

1.2. AMPLIFIER

The 490B Amplifier accepts either positive or negative input pulses to a maximum of 12 V into a 1000Ω input impedance and provides adjustable pole-zero cancellation. With 0.5 μs time constants the input pulses are shaped for a near-optimum semi-Gaussian shape. Gain is continuously adjustable from X12 to X1280. The Pos/Neg switch is accessible through the left side panel and must be set to match the polarity of the input signals. The output is positive. Another switch mounted on the printed circuit and available through the left side panel of the module selects either a Unipolar or a Bipolar output; the Bipolar output has a positive leading portion. The linear range of the output is 0 to 10 V, with saturation at 12 V. Low noise, excellent linearity, and good temperature stability are features of the Amplifier portion of the 490B. The Amplifier output is connected internally into the SCA and is also available through a front panel BNC connector.

The 490B has complete provisions, including power, for operating any ORTEC solid-state preamplifier. Preamplifier pulses should have a rise time of less than 0.25 μs to properly match the Amplifier filter network. The preamplifier pulse decay time can be matched by the adjustable pole-zero cancellation network if it is at least 40 μs; the PZ Adj control on the front panel is factory-preset at 50 μs to match standard ORTEC preamplifiers.

The Amplifier gain is adjusted with constant-impedance T attenuators. Therefore the bandwidth of the feedback amplifier stages involved in switching remains essentially constant for any gain selection, and rise-time changes due to gain switching (resulting in walk of the timed output signal from the SCA) are very small.

The input impedance is 1000Ω. When long preamplifier cables are used, the cables can be terminated in series at the preamplifier end or in shunt at the amplifier end with an impedance that matches the cable impedance.

The Amplifier output impedance through the front panel connector is 93.1Ω. This signal source can be connected directly to external equipment through 93Ω cable without additional termination. No connections are required for the Amplifier output because the same signals are connected internally to the SCA portion of the 490B, and the external Amplifier output is intended for auxiliary use of the amplified signals.

1.3. POLE-ZERO CANCELLATION

Pole-zero cancellation is a method for eliminating pulse undershoot after the first differentiating network. The technique used is described by the waveforms and equations shown in Figs. 1.1 and 1.2. In an amplifier without pole-zero cancellation the exponential tail on the preamplifier output signal (usually 50 to 500 μs) causes an undershoot with a peak amplitude that is a percentage of the differentiated pulse amplitude roughly equal to the ratio of differentiation time to preamplifier pulse decay time. This undershoot is very undesirable because it

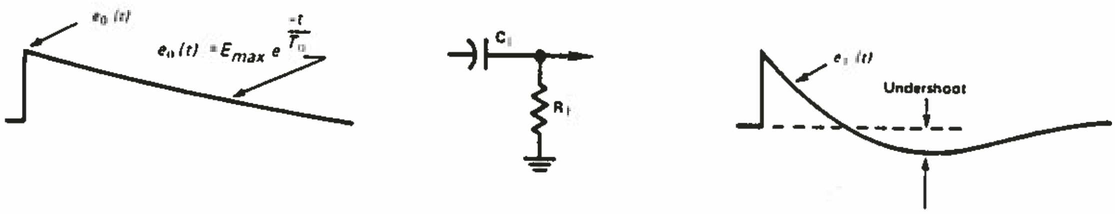


Fig. 1.1. Differentiation in an Amplifier Without Pole-Zero Cancellation.

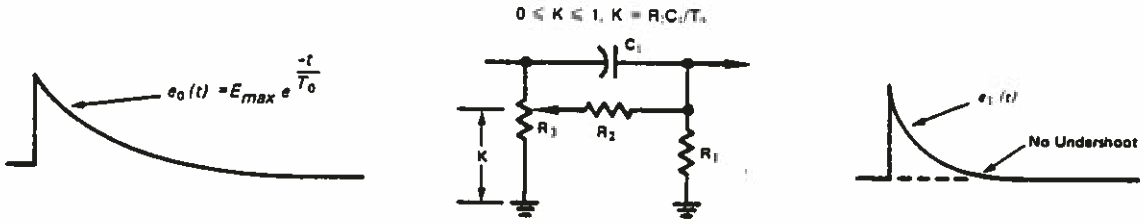


Fig. 1.2. Differentiation (Clipping) in a Pole-Zero-Cancelled Amplifier.

causes spectrum smearing and poor overload recovery. Pole-zero cancellation is accomplished in the 490B by the network shown in Fig. 1.2.

Total preamplifier-amplifier pole-zero cancellation requires that the preamplifier output pulse decay time be a single exponential decay and matched to the pole-zero cancellation network. The variable pole-zero cancellation network allows accurate cancellation for all preamplifiers having 40 μs or greater decay times. The network is factory adjusted to 50 μs, which is compatible with all ORTEC FET preamplifiers. Improper matching of the pole-zero cancellation network will degrade the overload performance and cause excessive pileup distortion at medium counting rates. Improper matching causes either an undercompensation (undershoot is not eliminated) or an overcompensation (output after the main pulse does not return to the baseline and decays to the baseline with the preamplifier time constant). The pole-zero trim potentiometer is accessible on the front panel of the 490B and can be adjusted easily by observing the baseline with a monoenergetic source or pulser having the same decay time as the preamplifier under overload conditions.

1.4. ACTIVE FILTER

The optimum pulse shape for the lowest signal-to-noise ratio in nuclear radiation equipment is the cusp (Fig. 1.3). Unfortunately, this shape is not physically realizable and is very difficult to approximate. A pulse shape that can

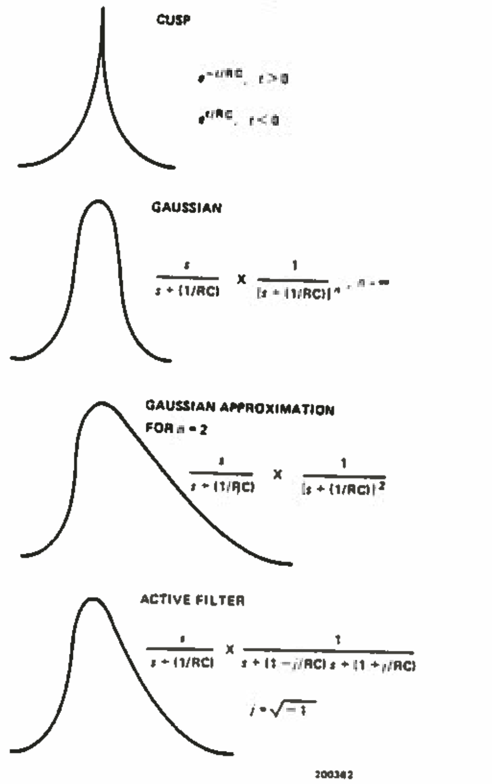


Fig. 1.3. Pulse Shapes for Good Signal-to-Noise Ratios.

be simulated (the Gaussian shape in Fig. 1.3) requires a single RC differentiate and a quantity, n, of equal integrates where n approaches infinity. The Laplace transform of this transfer function is

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

where the first factor is the single differentiate and the second factor is the n integrates. The 490B active filter attempts to simulate this transfer function with the simplest possible circuit.

The 490B active filter circuit is shown in Fig. 1.4. The major attraction of the active RC filter is the simple synthesis of a complex pulse shape resulting in a significant reduction in size, complexity, and cost. For a given resolving time (RC) the time response of the filter network depends only on K (see the circuit equations in Fig. 1.4). For K = 1 the transfer function simplifies to

$$\frac{e_o}{e_i} = \frac{1/R^2C^2}{s^2 + \frac{2s}{RC} + \frac{1}{R^2C^2}} \qquad \frac{1/R^2C^2}{[s + (1/RC)]^2}.$$

which is an n = 2 approximation to the Gaussian pulse shape (see Fig. 1.3). For K = 2 (the actual case for the ORTEC filter) the transfer function becomes

$$\frac{e_o}{e_i} = \frac{2/R^2C^2}{s^2 + \frac{2s}{RC} + \frac{2}{R^2C^2}} = \frac{2/R^2C^2}{s + \frac{1+j}{RC} s + \frac{1-j}{RC}} \qquad j = \sqrt{-1}.$$

In this case the complex roots cause an underdamped effect that reduces the resolving time and results in a more symmetrical pulse shape (see Fig. 1.3).

1.5. SINGLE CHANNEL ANALYZER

The Amplifier output is connected internally as the SCA input. It is dc-restored for a baseline shift less than 10 mV at a 100-kHz rate with a full amplitude signal. The mode of operation of the SCA is selected with a front panel toggle switch, marked DIFF and INT. When the switch is set at DIFF, the peak amplitude of the amplified signal must exceed the adjusted lower level by no more than the adjusted window width so that an output pulse will be generated. When the switch is set at INT, the peak amplitude of the amplified pulse must exceed the adjusted lower level to generate an output; the window adjustment has no effect in this mode.

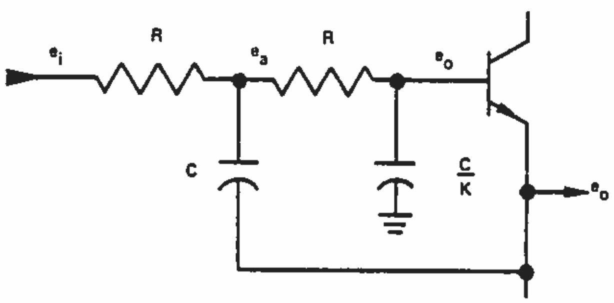
The Lower Level bias is switch-selectable between the (Int) adjustment of the front panel 10-turn Lower Level control and the (Ext) signal that can be furnished through the EXT LLD connector on the rear panel. The switch that selects the effective source is mounted on the printed circuit board and is accessible through the left side panel of the module.

The Window adjustment is also switch-selectable, using another slide switch that is mounted on the printed circuit and is accessible through the left side panel. When this switch is set at INT, the adjustment is made with the front panel 10-turn Window control. When the slide switch is set at EXT, the effective window is from the adjusted lower level to a level that is the sum of the lower level plus a dc signal that is then furnished through the EXT WIN connector on the rear panel. The basic range of the window, using internal control, is 0 to 10 V where 0 V is equal to the adjusted lower level. By using a jumper on the printed circuit, the effective window range can be changed to 0 to 1 V. When using the external window the range is 0 to 10 V.

An SCA output pulse with an amplitude of about +5 V and a width of 0.5 μs occurs at a fixed time following the peak of the amplified input pulse. The delay from the peak to the output is about 200 ns. The SCA output is available through BNC connectors on both the front and the rear panels.

1.6. PREAMPLIFIER POWER OUTPUT

Four standard dc power levels are made available through the preamplifier power output connector on the rear panel. This connector is wired for compatibility with any ORTEC FET preamplifier and extends the dc levels that are available from the NIM-standard bin and power supply in which the 490B must be installed for operation.



Equations

$$e_o = e_a \frac{K/sC}{R + K/sC} = e_a \frac{K}{K + sRC}$$

$$\frac{e_i - e_a}{R} = \frac{e_a - e_o}{R} + \frac{e_a - e_o}{1/sC}$$

Eliminating e_a and solving for the transfer function

$$\frac{e_o}{e_i} = \frac{K/R^2C^2}{s^2 + \frac{2s}{RC} + \frac{K}{R^2C^2}}$$

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Fig. 1.4. ORTEC 490B Active Filter.

2. SPECIFICATIONS

Amplifier

2.1. PERFORMANCE

SHAPING Approximately Gaussian; peak amplitude at 0.8 μs for unipolar and 0.7 μs for bipolar; crossover at 1.3 μs for bipolar; time constants nominally 0.5 μs.

GAIN 12 to 1280 with Coarse Gain control of 4, 8, 16, 32, 64, and 128; Fine Gain continuous control of X3 to X10.

INTEGRAL NONLINEARITY ≤±0.15% from 0 to 10 V.

NOISE ≤14 and ≤22 μV rms respectively for unipolar and bipolar outputs and maximum gain, with $\tau = 0.5$ μs.

TEMPERATURE INSTABILITY 0.02%/°C, 0 to 50°C.

COUNTING RATE STABILITY The gain for a pulser spectrum at 85% of full scale will change <±0.25% when modulated by 5×10^4 counts/s of random signals from a ^{137}Cs source-detector combination with the photopeak at 70% of full scale, using bipolar output.

OVERLOAD RECOVERY After a X400 overload, the Amplifier operated at full gain will recover to within 2% of the baseline within 2.5 nonoverloaded pulse widths for bipolar output; degrades to X200 for unipolar output.

2.2. CONTROLS

COARSE GAIN Six-position switch, to select Coarse Gain factor for Amplifier; factors are 4, 8, 16, 32, 64, and 128.

FINE GAIN Single-turn potentiometer for continuous adjustment of Fine Gain factor from X3 to X10.

PZ ADJ Front panel screwdriver adjustment to match the amplifier shaping to the preamplifier decay time; adjustable for preamplifier decay times from 25 μs to 2000 ms.

POS/NEG Slide switch mounted on the printed circuit board and operated through the side cover to select the polarity of the Amplifier input.

UNI/BI Slide switch mounted on the printed circuit board and operated through the side cover selects either Unipolar or Bipolar Amplifier output.

2.3. INPUT

AMP INPUT Positive or negative (switch-selectable through side cover), 12 V absolute maximum, 1000Ω input impedance; pole-zero cancellation to match ORTEC preamplifiers; BNC (1094A/U) connectors on front and rear panels.

2.4. OUTPUT

AMP Positive unipolar or bipolar, with positive phase leading, 0–10 V linear range, 12 V maximum; 93Ω driving source impedance; BNC connector (1094/U) on front panel.

2.5. PREAMPLIFIER POWER

Furnished through Amphenol Type 17-10090 connector on rear panel for operation of ORTEC-compatible preamplifiers.

Single Channel Analyzer

2.6. PERFORMANCE

OUTPUT TIMING Timed ~150 ns from peak of output pulse from Amplifier. Walk (SCA output time shift vs amplifier output pulse height) <50 ns for 50:1 change in output amplitude.

EXT LLD When the printed circuit board-mounted Lower Level Reference switch is on Ext, this rear panel BNC connector accepts the Lower Level biasing (an input of 0 to −10 V on this connector corresponds to a signal in the range of 0 to 10 V for the Lower Level discriminator setting). Input impedance, 1000Ω.

EXT WIN When the printed circuit board-mounted External Window Reference switch is on Ext, this rear panel BNC connector accepts a 0 to +10 V signal to determine the window width between the ranges of 0 to 10 V or 0 to 1 V as selected by an internal jumper. Input impedance, 1000Ω.

NONLINEARITY <0.25% of full scale (integral) for both discriminators.

PULSE PAIR RESOLUTION For lower level threshold ≥100 mV, ≤1-μs pulse pair resolution over full dynamic range.

TEMPERATURE INSTABILITY ≤0.01%/°C, 0 to 50°C for the LLD and window discriminators.

POWER SUPPLY SENSITIVITY Lower Level discriminator referenced directly to the −12 V Bin supply; Window discriminator referenced directly to the +12 V Bin supply.

2.7. CONTROLS

LOWER LEVEL 10-turn precision potentiometer for adjustment of Analyzer discriminator bias level; range, 0.1 to 10 V.

WINDOW 10-turn precision potentiometer on front panel for adjustment of Analyzer window width; this allows the differential mode to be operated from 0 to 1 V or 0 to 10 V, as selected by the internal jumper.

LOWER LEVEL REFERENCE Slide switch mounted on the printed circuit board and operated through the side cover selects the source of Lower Level bias. Int position selects front panel control; Ext selects Lower Level bias through rear panel connector.

WINDOW REFERENCE Slide switch mounted on the printed circuit board and operated through the side cover selects the source for the Window Reference voltage. Int position selects front panel control; Ext selects Ext Win input connector on rear panel.

DIFF/INT Front panel toggle switch to select the SCA operating mode from:
Differential LL sets the baseline level (0–10 V) and the Window control sets the window width between 0–1 V or 0–10 V.
Integral LL sets a single discriminator threshold (0–10 V) and the Window control is disabled.

2.8. INPUTS

SCA internally connected to amplifier output; impedance level of 1000Ω; input uses an active dc restorer to provide <10-mV baseline shift at 100-kHz rate with full amplitude input signals.

EXT LLD Input from 0 to −10 V, 1000Ω input impedance; rear panel connector.

EXT WIN Input from 0 to +10 V, 1000Ω input impedance; rear panel connector.

2.9. OUTPUT

SCA OUT Nominally 5 V, 0.5 μs wide, <10Ω driving source impedance; BNC connectors (1094/U) front and rear panels.

2.10. ELECTRICAL AND MECHANICAL

POWER REQUIRED
+24 V, 45 mA; +12 V, 160 mA;
−24 V, 55 mA; −12 V, 90 mA.

DIMENSIONS Single-width NIM instrument (1.35 by 8.714 in.) per TID-20893.

3. INSTALLATION

3.1. GENERAL

The 490B, used in conjunction with a 401-402 Series Bin and Power Supply, is intended for rack mounting. Therefore other equipment operated in the same rack must be sufficiently cooled by circulating air to prevent any localized heating of the 490B. The temperature of equipment mounted in racks can easily exceed the recommended maximum of 120°F (50°C) unless these precautions are taken. To obtain the minimum sensitivity to temperature, the 490B should not be exposed to high-velocity drafts of cooling air, especially if the temperature of the cooling air is not stable.

3.2. CONNECTION TO POWER

The 490B contains no internal power supply but must obtain its necessary operating power from a NIM-standard Bin and Power Supply such as the ORTEC 401A/402A. It is recommended that the Power Supply be turned off when modules are inserted or removed. ORTEC NIM modules are designed so that it is not possible to overload the Power Supply when there is a full complement of modules in the Bin. However, this may not be true if the Bin contains modules of other than ORTEC design. In such instances the Power Supply voltages should be checked after the modules are inserted. The ORTEC 401A/402A has test points on the Power Supply control panel to monitor the dc voltages. The Power Supply voltages should read within ±0.5% of their nominal values for proper operation of NIM-standard instruments.

3.3. CONNECTION OF TEST PULSE GENERATOR

To the 490B Through a Preamplifier The satisfactory connection of a test pulse generator such as the ORTEC 480 or equivalent depends primarily on two considerations: the preamplifier must be properly connected to the 490B and the 490B must be installed as discussed in Section 3.2, and the proper input signal simulation must be applied to the test input of the preamplifier. To ensure proper input signal simulation, refer to the instruction manual for the particular preamplifier being used.

Direct Connection to the 490B Since the input of the 490B has 1000Ω input impedance, the test pulse generator will normally have to be terminated at the Amplifier input with an additional shunt resistor. If the pulser is used to measure the 490B overload recovery it is necessary to adjust the 490B PZ Adj control to match the pulser decay time.

3.4. CONNECTION TO PREAMPLIFIER

The preamplifier output signal is connected to the 490B BNC connector marked Input. The impedance seen at the input is 1000Ω, dc-coupled to ground; therefore the preamplifier output must not have a large dc offset voltage level under no-signal conditions. The front panel Input and the rear panel Amp Input are electrically the same point in the circuit.

When using the 490B with a remotely located preamplifier (i.e., preamplifier output to amplifier input connection through 25 ft or more of coaxial cable), ensure that the characteristic impedance of the cable is matched. Since the input impedance of the 490B Amplifier is 1000Ω, sending end termination will normally be preferred; i.e., the transmission line should be series-terminated at the output of the preamplifier. All ORTEC preamplifiers contain series terminations that are either 93Ω or variable.

The 490B Amplifier incorporates pole-zero cancellation in order to enhance the overload characteristics of the amplifier. This technique requires matching the network to the preamplifier decay time constant in order to obtain optimum compensation. The network is variable and factory-adjusted to 50 μs to match all ORTEC FET preamplifiers. If another preamplifier is used, or if more careful matching is desired, the trim is accessible from the front panel. Adjustment is accomplished easily by using a monoenergetic pulse source and observing the Amplifier baseline after each pulse under overload conditions.

Preamplifier power at +24 V, −24 V, +12 V, and −12 V is available through the preamplifier power connector, located on the rear panel of the module.

3.5. AMPLIFIER OUTPUT CONNECTIONS

The Amplifier output is brought out on the front panel. The front panel Amp Output BNC connector is series-terminated with 93Ω.

3.6. OUTPUT CONNECTIONS AND TERMINATING CONSIDERATIONS

The 490B Amplifier output can be switch-selected for either a unipolar or a bipolar output. The unipolar output should be used for high-resolution spectrometry applications with semiconductor detectors. The bipolar output should be used in applications requiring high counting rates. Typical system block diagrams for a variety of experiments are described in Section 4.

There are three general methods of termination that are used. The simplest of these is shunt termination at the receiving end of the cable. A second method is series termination at the sending end. The third is a combination of series and shunt termination, where the cable impedance is matched both in series at the sending end and in shunt at the receiving end. The most effective method is the combination, but termination by this method reduces the amount of signal strength at the receiving end to 50% of that which is available in the sending instrument.

For series termination, use the 93Ω output of the sending instrument for the cable connection. Use 93Ω cable to interconnect this into the input of the receiving instrument. The 1000Ω (or more) normal input impedance at the input connector represents an essentially open circuit, and the series impedance in the sending instrument now provides the proper termination for the cable.

For the combination of series and shunt termination, use the 93Ω output in the sending instrument for the cable connection and use 93Ω cable. At the input for the receiving instrument, use a BNC tee to accept both the interconnecting cable and a 100Ω resistive terminator. Note that the signal span at the receiving end of this type of receiving circuit will always be reduced to 50% of the signal span furnished by the sending instrument.

For your convenience ORTEC stocks the proper terminators and BNC tees, or you can obtain them from a variety of commercial sources.

3.7. SHORTING THE AMPLIFIER OUTPUT

The Amplifier output of the 490B is ac-coupled with an output impedance of 93Ω. This output may be shorted indefinitely without catastrophic damage.

3.8. CONNECTION WITH EXTERNAL SCA BASELINE

An external baseline may be used with the SCA portion of the 490B through the rear panel Ext LLD (external lower level) Input BNC connector. A voltage level of 0 to −10 V on this input corresponds to 0 to full scale on the baseline (or Lower Level). This input is directly compatible with the output characteristics of the ORTEC 487 Digital Spectrum Scanner. The Ext LLD Input impedance is 1000Ω dc-coupled to ground.

3.9. CONNECTION WITH EXTERNAL WINDOW CONTROL

An external signal can be accepted to control the effective window width in the SCA portion of the 490B. The signal is furnished through the Ext Win connector on the rear panel and a slide switch, accessible through the side panel, must be set for External Window. A voltage level of 0 to +10 V on this input corresponds to 0 to 10 V on the front panel Window control.

3.10. SCA OUTPUT CONNECTIONS

Both the front and rear panel SCA outputs provide low-impedance drive and are capable of driving a total of ten 1000Ω loads. For cable lengths longer than 10 ft, the coaxial cable should be terminated at the receiving end with its characteristic impedance.

4. OPERATING INSTRUCTIONS

4.1. FRONT PANEL CONTROLS AND CONNECTORS

FINE GAIN A single-turn potentiometer giving a continuous gain adjust of 3 to 10.

COARSE GAIN A 6-position rotary switch to provide coarse amplifier gain settings of 4, 8, 16, 32, 64, or 128.

PZ ADJ A trim potentiometer to adjust the pole-zero-cancellation network for varying preamplifier decay time constants from 40 μs to infinity.

SCA MODE A toggle switch selects either Differential (window) mode operation or Integral (discriminator) mode operation.

LOWER LEVEL A 10-turn potentiometer adjustable from zero to 10 V, which determines the threshold setting for the Lower Level discriminator. (When the Lower Level Reference switch on the side panel is in the Ext position, the Lower Level control is disabled and discriminator bias is provided from the Ext LLD Input connector on the rear panel. An input of 0 to −10 V on this connector corresponds to a range of 0 to 10 V for the Lower Level discriminator setting.)

WINDOW A 10-turn potentiometer adjustable from zero to 10 V, which determines the width of the window of acceptance above the adjusted lower level when operating in the Differential mode. (When the Window Reference switch on the side panel is in the Ext position, the Window control is disabled and a dc level is accepted through the Ext Win connector on the rear panel. An input of 0 to +10 V on this connector corresponds to a range of 0 to 10 V.)

INPUT BNC connector for preamplifier pulses having either polarity. Preamplifier pulses should have less than 0.25-μs rise time and a 50-μs decay time constant. Input positive or negative (switch-selectable on rear panel), 12 V absolute maximum, 1000Ω input impedance.

AMP OUTPUT BNC connector positive unipolar or bipolar, with positive phase leading, 0 to 10 V linear range, 12 V maximum; 93Ω driving source impedance.

SCA OUTPUT BNC connector; positive logic pulse, nominally 5 V amplitude, 0.5-μs width, ⩽10Ω driving source impedance capable of driving up to a total of ten 1000Ω inputs.

4.2. REAR PANEL CONNECTORS

AMP INPUT A BNC connector that is wired in parallel with the front panel Input connector.

EXT WIN A BNC connector that accepts a dc level of 0 to +10 V for the window width; a side panel switch must select the Ext Window Ref.

EXT LLD A BNC connector that accepts a dc level of 0 to −10 V full scale for the lower level discriminator threshold; a side panel switch must select Ext Lower Level Ref.

PREAMPLIFIER POWER A 9-pin Amphenol type 17-10090 connector extends the ±12 and ±24 V dc levels from the bin and power supply to a mating ORTEC transistorized preamplifier.

SCA OUT A BNC connector that is wired in parallel with the front panel SCA Output connector.

4.3. SIDE PANEL CONTROLS

WINDOW REF A 2-position slide switch selects the source of control for the width of the differential mode window. Int selects the front panel Window control and an internal jumper. Ext selects the signal that is furnished through the rear panel Ext Win connector.

INPUT POLARITY A 2-position slide switch selects an input circuit that is compatible with the polarity of input pulses from the preamplifier, either Neg or Pos.

LOWER LEVEL REF A 2-position slide switch selects the source of control for the lower level discriminator threshold. Int selects the front panel Lower Level control. Ext selects the signal that is furnished through the rear panel Ext LLD connector; a voltage of 0 to −10 V on this connector corresponds to a range of 0 to +10 V on the Lower Level discriminator.

UNI/BI 2-position slide switch. Either unipolar (Uni) or bipolar (Bi) amplifier output pulses are available. The gains are approximately matched in both modes.

4.4. INITIAL TESTING AND OBSERVATION OF PULSE WAVEFORMS

Refer to Section 6 of this manual for information and testing performance of pulse waveforms.

4.5. TYPICAL APPLICATIONS

Three typical applications of the 490B are described here. One is with a semiconductor detector as shown in Fig. 4.1. The exceptionally wide dynamic range and the high stability and resolution of the 490B provide the capabilities necessary for long-term experiments of this nature.

Another typical application is in an x-ray diffraction experiment as shown in Fig. 4.2. The capability of the 490B to accept a wide variety of input signals and its wide dynamic range and high stability make the 490B particularly useful for this application. The small size of the 490B allows the total x-ray diffraction electronics to be contained in a single Bin and Power Supply with a resultant savings in both cost and space.

A number of 490B Amplifier and Single Channel Analyzers may be used to generate routing signals for a multichannel analyzer in an experiment requiring subdividing of the memory on a pulse-to-pulse basis or in a multiparameter analysis experiment (Fig. 4.3).

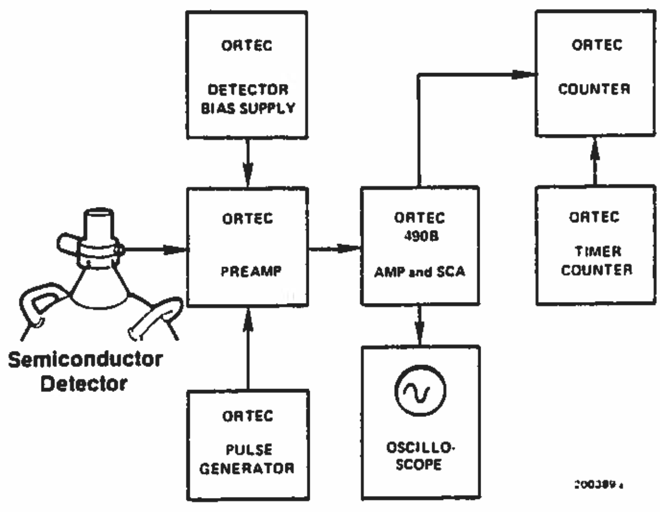


Fig. 4.1. Ge(Li) Gamma Spectroscopy System Using 490B.

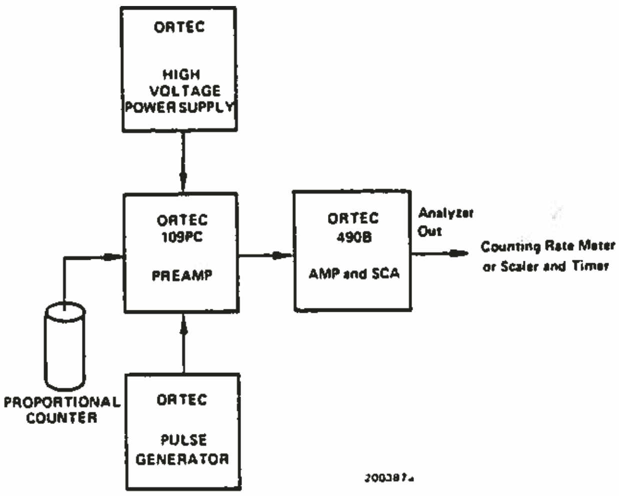


Fig. 4.2. System for Use in X-Ray Diffraction Experiments.

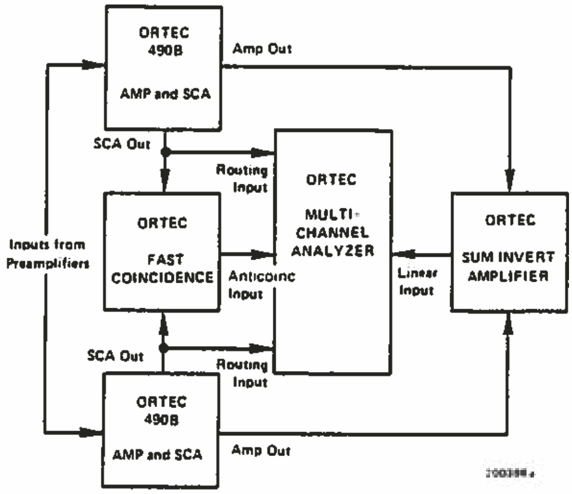


Fig. 4.3. Use of the 490B in Multichannel Analyzer Routing.

5. CIRCUIT DESCRIPTION

5.1. AMPLIFIER

The Amplifier contains four basic stages. The input stage provides the function of polarity inversion and additional amplification before the first clip to improve the noise characteristics of the amplifier.

Two gain stages are integrated circuit amplifiers which provide wide-band gain. Gain changing is accomplished by constant-impedance T attenuators and a constant-impedance potentiometer. The variable pole-zero-cancelled first clipping network is between the input stage and the first attenuator.

The active filter is described in general in Section 1.4. The filter is followed by the unipolar-bipolar switch which allows a choice of either unipolar or bipolar clipped pulses. A resistor in the unipolar path compensates for the added loss in the bipolar path and results in essentially equal amplitude output for either shaping mode.

The output driver stage provides the additional gain necessary to raise the maximum linear output to 10 V. The stage also has sufficiently low output impedance to drive terminated or unterminated connecting cables.

INPUT STAGE Referring to the circuit diagram (490B-0201-S1), the input stage consists of a long-tail differential amplifier Q9 and Q10 driving a common-emitter output stage, Q11. The output is fed back through R43 and C20. Zener diode D1 regulates the voltage for Q10C and Q11E.

When the Neg input is used, the base voltage at Q10 follows the input voltage at the base of Q9. The Pos input is terminated in 100Ω under this condition and the gain is then [R43(R43+R31+R32)/(R34+R36)(R31+R32)]. When the Pos input is used, the gain is R43/R31.

POLE-ZERO-CANCELLED FIRST CLIP The pole-zero first differentiate consists of C19, R40, R41, and R55:

$$\frac{(R41)\ (C19)}{K} = \tau_{preamp}$$

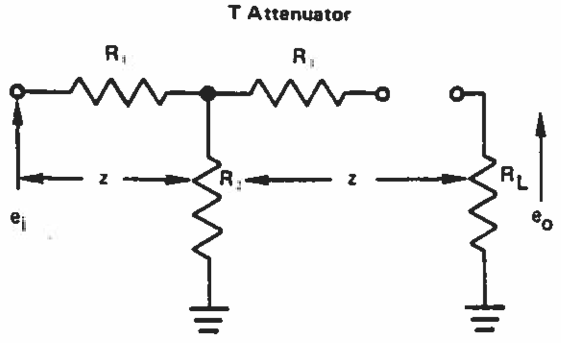
and

$$\frac{R41\ (R40+R55)}{R41+R40+R55}\ C19 = \tau_{diff}$$

where τ_{preamp} is the input decay time constant (50 μs), τ_{diff} is the differentiation time constant (0.44 μs), and K is the fractional trim potentiometer resistance ratio (0⩽K⩽1). The derivation of these equations is discussed in Section 1.3.

CONSTANT-IMPEDANCE ATTENUATORS Constant-impedance T attenuators are employed in the 490B; their formulas are given in Fig. 5.1.

GAIN STAGES Both gain stages utilize integrated circuit differential amplifiers in operational amplifier feedback circuits. The circuit has an open loop gain of greater than 1000 and a gain-bandwidth product greater than



$R_L = Z = 1000\Omega$

$R_2 = \frac{2ZK}{K^2 - 1}$

$R_1 = Z\frac{K - 1}{K + 1}$

$K = \frac{e_i}{e_o}$

Fig. 5.1. ORTEC 490B Attenuator Networks.

1000 MHz. The integrated circuit contains a differential amplifier input driving a grounded emitter amplifier with an emitter-follower output. The dc input and output levels of the stages (IC1 and IC2) are at approximate ground. Phase lag roll-off networks between pin 1 and 14 and between 9 and 10 are necessary for amplifier stability.

ACTIVE FILTER The basic active-filter circuit is described in detail in Section 1.4. The filter network requires a unity gain amplifier which consists of emitter-follower Q16 and the constant-current source Q15. An additional integration stage consists of the filter R83, C37, and Q14.

PROMPT OUTPUT DRIVER STAGE The output driver stage consists of a grounded emitter amplifier Q18, with a high-impedance constant-current load Q17, and a dc-offset-cancelling emitter-follower quad consisting of Q19, Q20, Q21, and Q22. The output is fed back to the input through R93. dc-level potentiometer R101 is used to adjust the dc output to zero volts.

REMOVAL OF ISOLATION CAPACITORS When the dc-level trim potentiometer is properly adjusted, the output driver stage output is at zero volts dc. Therefore capacitors C50, C51, and C52, isolating the output driver stage from the output, can be replaced by a wire (short across the capacitors), resulting in a dc-coupled output. With the dc-coupled condition the output will still sustain a direct short without catastrophic damage except that there will be no signal to drive the SCA portion of the 490B, so the short must be removed to permit operation.

5.2. SINGLE CHANNEL ANALYZER

IC101, IC102, and IC103 are high-gain differential voltage comparators that function as discriminators by operating in a biased amplifier mode; i.e., the noninverting input is biased negative with respect to the inverting input. When an input pulse exceeds the bias threshold, the IC acts as a very high gain direct-coupled amplifier that generates an output for any input that just exceeds the bias threshold by a few millivolts. ICs 104, 105, and 106 are NOR logic packages, each including two dual-input NOR gates with RTL logic. The circuit functions as a NOR gate for positive input signals and generates a negative (ground) output when either input is positive, and as a NAND gate for negative (ground) inputs by generating a positive output only when both inputs are at ground.

The Amplifier output is internally connected to the SCA input, where it is buffered by emitter-follower Q102. The signal at the Q102 emitter is ac-coupled to the lower level and window discriminators, IC101 and IC102; however, this signal is dc-restored by the modified Robinson diode restorer circuitry consisting of Q103 through Q106. The lower level reference voltage set either by the Lower Level control or from an external source is coupled through the baseline restorer circuit and presented at the noninverting input of both the lower level and window discriminators. The inverting input of the lower level discriminator, IC101, is referenced to ground so that the lower level discriminator will fire when the input signal exceeds the bias at its noninverting input.

The inverting input of the window discriminator is referenced to the selected source, Int or Ext, set by S6 on the printed circuit. When the switch is set for Int, the window width is adjusted by the front panel Window control; an internal jumper provides a range of either 0 to 10 V or 0 to 1 V for the front panel control. When the switch is set for Ext, the window width is equal to the dc level that is furnished through the rear panel Ext Win connector.

When operating in the Differential mode (selected with a front panel toggle switch, S5), the window discriminator triggers and inhibits an SCA output when the input signal exceeds the sum of the Lower Level and Window signals and/or adjustments.

The peak detection circuitry, consisting primarily of Q109, Q108, Q111, and IC103, is used to strobe the output of the lower level discriminator when the Amplifier output pulse has reached its peak. This coincidence function is performed at pins 1 and 2 of logic gate IC104. The timing output pulse at pin 7 of IC104 is inverted by Q112, differentiated by C78 and R156, and presented at the pin 3 input of IC105. If the Amplifier output pulse peak is less than the lower level setting, no analyzer output is generated.

For Differential operation, if the Amplifier pulse exceeds the lower level by an amount greater than the window width, the window discriminator is triggered and the positive signal at pin 5 of IC105 blocks the timing signal at pin 3 so that no analyzer output is generated. Only if the Amplifier output pulse peak falls within the analyzer window does the timing signal at pin 3 of IC105 pass through the gate to trigger output monostable IC106, Q113, and Q114.

For Integral operation, the signal from IC105-7 is low and this enables IC105-6 to respond to each output from the lower level discriminator with no inhibit response to the window discriminator.

When a signal passes through IC105-6, this triggers the output monostable. The shape of the output pulse, furnished through both the front and rear panel BNC connectors, is about 0.5 μs wide with an amplitude of approximately +5 V.

6. MAINTENANCE

6.1. TESTING PERFORMANCE

The following test descriptions are intended as an aid in the original installation and any succeeding checkout of the 490B.

TEST EQUIPMENT The following test equipment is recommended for testing the 490B. Equivalent test equipment can be used if appropriate changes are made in the test procedures.

ORTEC 448, 419, or 480 Pulse Generator
Tektronix 540 Series Oscilloscope with Type 1A1 plug-in unit
Hewlett-Packard 3439A Voltmeter

PRELIMINARY PROCEDURES

1. Visually check the module for possible damage during shipment.

2. Insert module into Bin and check for proper mechanical alignment.

3. Connect ac power to the NIM-standard Bin (e.g., ORTEC 401A/402A).

4. Turn on ac power and check the dc power voltages at the test points on the 401A Power Supply control panel.

PULSER USED FOR OVERLOAD TESTS Since the 490B incorporates variable pole-zero cancellation in the amplifier, factory adjusted to 50 μs, either the pulser output must have a 50 μs decay or the pole-zero cancellation network must be reset to match the decay time of the pulser.

If the pulser output is fed into a charge-sensitive preamplifier, it cannot be used to test overload. If this test is desired, a square wave pulse generator with a precise flat top is needed.

OPERATIONAL TESTS Using the setup shown in Fig. 6.1, make the following initial settings:

Pulser output polarity	Positive
Lower Level Reference	Internal
Window Reference	Internal
Uni/Bi	Unipolar
Pos/Neg	Positive
Window jumper	1 V
Coarse Gain	128
Fine Gain	10
Lower Level	5.00
Window control	1.00
Diff/Int switch	Differential

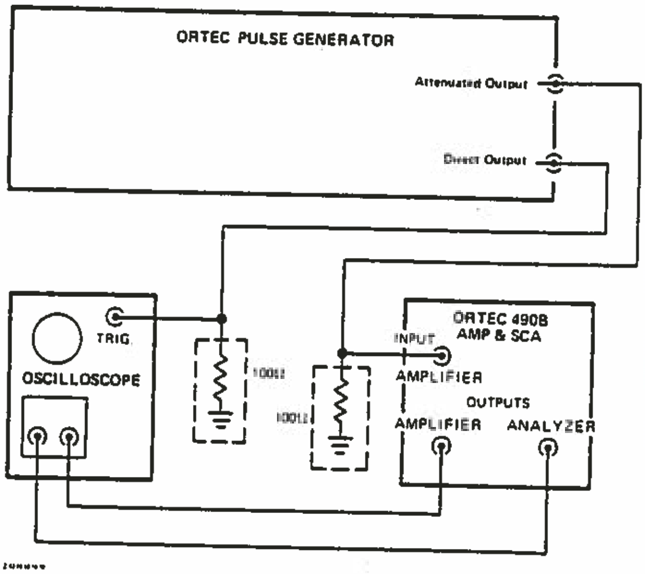


Fig. 6.1. Pulser Connections for Overload Tests.

Adjust the Normalize and Pulse Height controls on the pulser so that a 10-V unipolar signal is obtained on the Amp Output of the 490B.

FINE GAIN Decrease the Fine Gain control to 3. The Amplifier output pulse should have decreased to approximately 3.0 V.

COARSE GAIN Decrease the Coarse Gain control to 64, 32, 16, 8, 4. The Amplifier output pulse should decrease by a factor of approximately 2 for each step.

LOWER LEVEL CONTROL Set the pulser Pulse Height control to 5.00. Adjust the pulser Normalize and Attenuation controls and the gain controls on the 490B until the 490B Analyzer is half triggering. The Amplifier output pulse should be approximately 5 V amplitude.

1-V WINDOW RANGE Increase the pulser Pulse Height dial until the Analyzer output signal just disappears. This should happen at a Pulse Height setting of 5.10.

POS/NEG Switch the pulser polarity switch to Negative and the 490B Pos/Neg switch to Neg. The Amplifier output pulse should be positive, 10 V amplitude.

UNI/BI Switch the Uni/Bi switch to Bi. The Amplifier output pulse should be bipolar with positive leading portion remaining approximately 10 V in amplitude.

6.2. TABULATED TEST POINT VOLTAGES

The following voltages are intended to indicate maximum dc voltage variations as a means of detecting malfunctioning in the event of instrument failure. These voltages are recorded during the initial checkout of the instrument and placed on file for future reference.

Before making voltage checks, check to see that all 401A/402A line voltages are within 0.05 V of their proper values.

Location	Typical dc Voltage
Emitter Q11	−15.9
Collector Q11	0.0
Pin 12 IC1	+0.05
Pin 12 IC2	+0.5
Emitter Q16	+1.5
Junction R105-106*	0.0
Pin 8 IC101	+11.3
Pin 4 IC101	−6.2
Pin 8 IC102	+11.3
Pin 4 IC102	−6.2
Pin 8 IC103	+11.3
Pin 4 IC103	−6.2
Collector Q115	+3.8

*Adjustable by trim potentiometer R101.

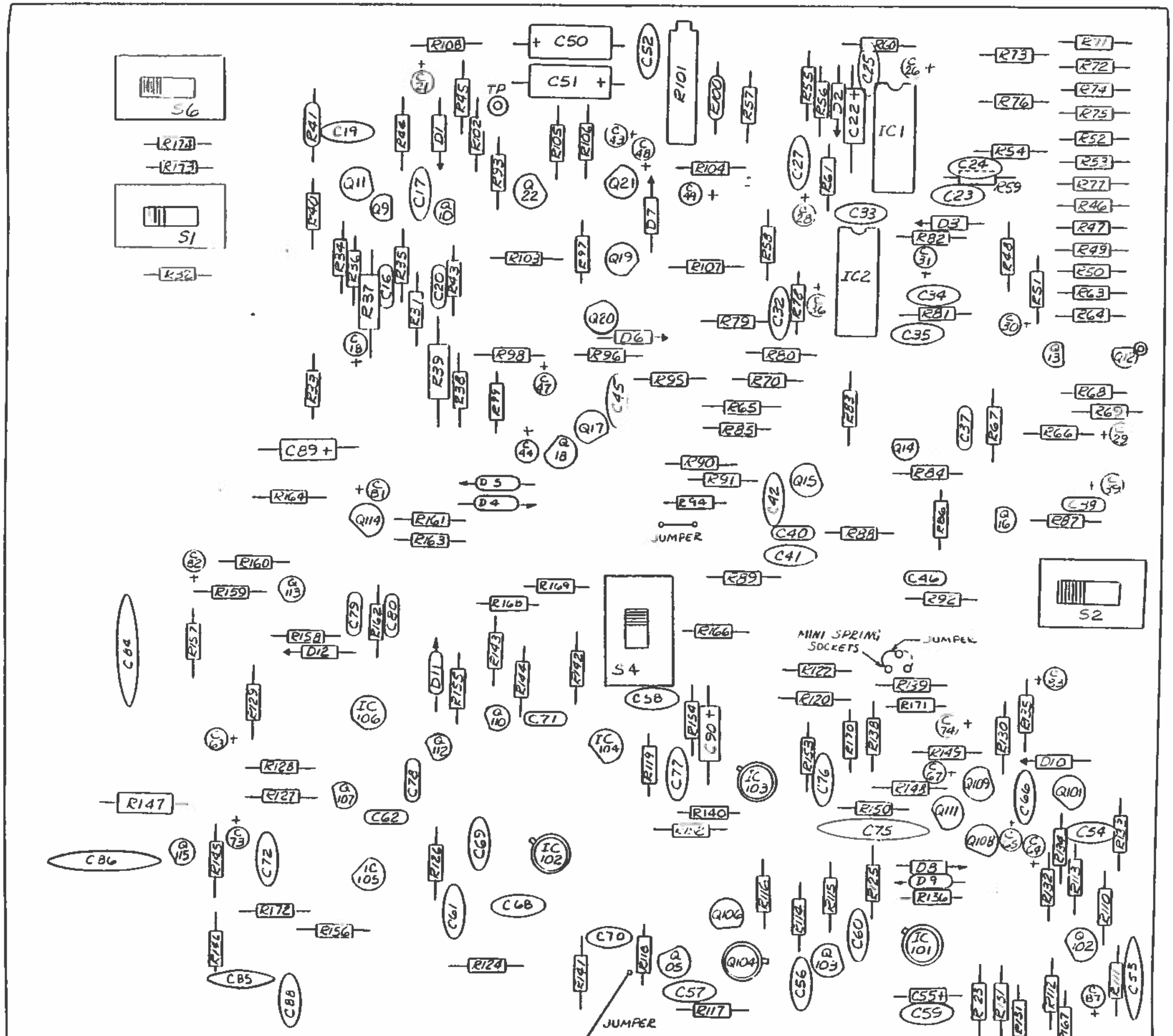
6.3. FACTORY REPAIR

This instrument can be returned to ORTEC for service and repair at a nominal cost. Our standard procedure for repair ensures the same quality control and checkout that are used for a new instrument. Always contact ORTEC Customer Services at (615) 482-4411 before sending in an instrument for repair, to obtain shipping instructions and so that the required Return Authorization Number can be assigned to the unit. Write this number on the address label and on the package to ensure prompt attention when it reaches the ORTEC factory.

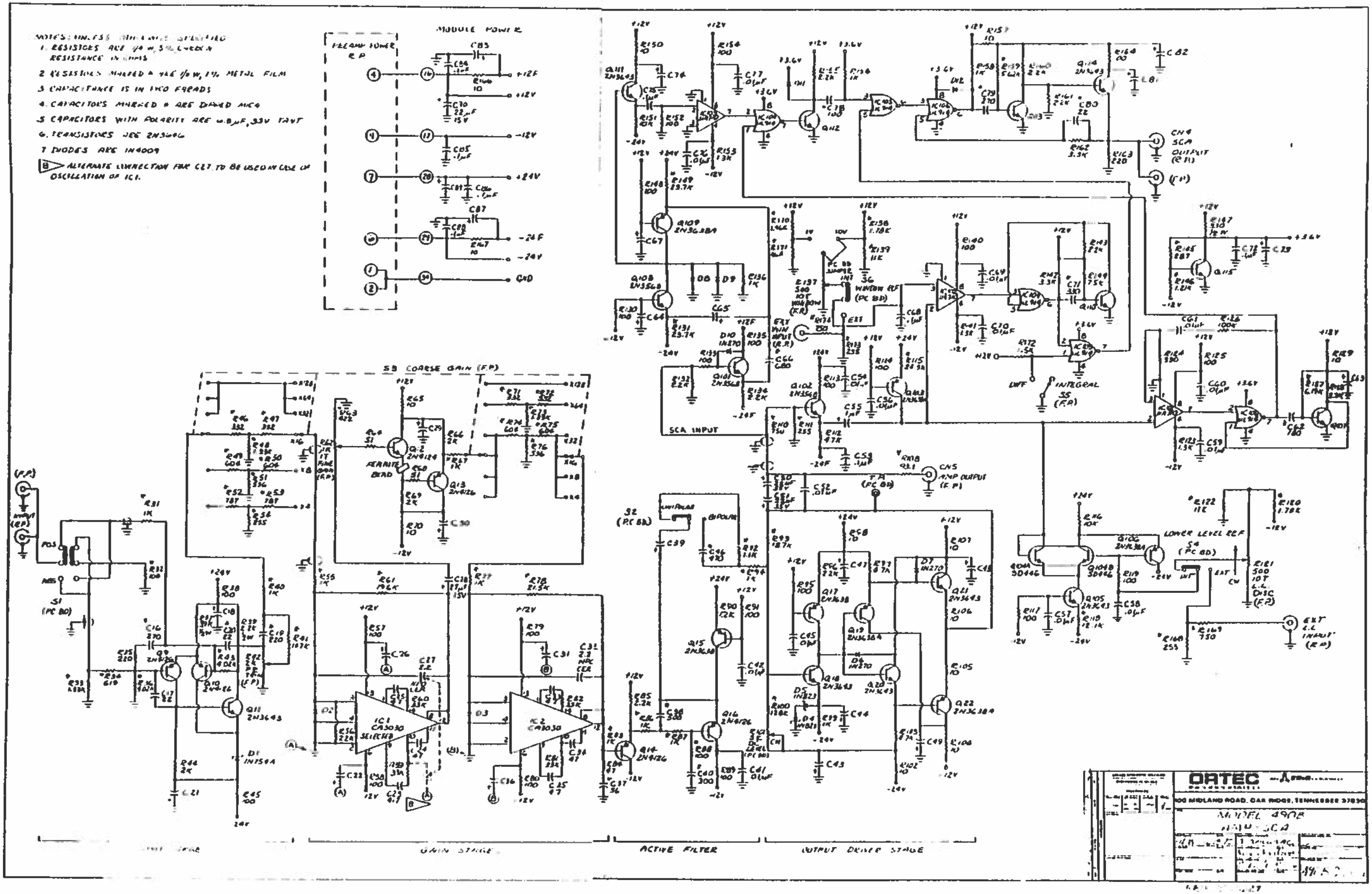
BIN/MODULE CONNECTOR PIN ASSIGNMENTS FOR AEC STANDARD NUCLEAR INSTRUMENT MODULES PER TID-20893

Pin	Function	Pin	Function
1	+3 volts	23	Reserved
2	−3 volts	24	Reserved
3	Spare Bus	25	Reserved
4	Reserved Bus	26	Spare
5	Coaxial	27	Spare
6	Coaxial	*28	+24 volts
7	Coaxial	*29	−24 volts
8	200 volts dc	30	Spare Bus
9	Spare	31	Spare
*10	+6 volts	32	Spare
*11	−6 volts	*33	115 volts ac (Hot)
12	Reserved Bus	*34	Power Return Ground
13	Spare	**35	Reset (Scaler)
14	Spare	**36	Gate
15	Reserved	**37	Reset (Auxiliary)
*16	+12 volts	38	Coaxial
*17	−12 volts	39	Coaxial
18	Spare Bus	40	Coaxial
19	Reserved Bus	*41	115 volts ac (Neut.)
20	Spare	*42	High Quality Ground
21	Spare	G	Ground Guide Pin
22	Reserved		

Pins marked (*) are installed and wired in ORTEC 401A and 401B Modular System Bins.
Pins marked (*) and (**) are installed and wired in EG&G/ORTEC−HEP M250/N and M350/N NIMBINS.



490B-0201 (A)


NOTES: UNLESS OTHERWISE SPECIFIED
1. RESISTORS ARE 1/4 W, 5% CARBON
RESISTANCE IN OHMS
2 RESISTORS MARKED * ARE 1/8 W, 1% METAL FILM
3 CAPACITANCE IS IN MICO FARADS
4. CAPACITORS MARKED # ARE DIPPED MICA
5 CAPACITORS WITH POLARITY ARE 6.8μF, 35V TANT
6. TRANSISTORS ARE 2N3646
7 DIODES ARE 1N4009
B ALTERNATE CONNECTION FOR C27 TO BE USED IN CASE OF OSCILLATION OF IC1.
MODULE POWER
PREAMP POWER R.P.
S3 COARSE GAIN (F.P.)
SCA INPUT
INTEGRAL
LOWER LEVEL REF
AMP OUTPUT (F.P.)
SCA OUTPUT (R.P.)
EXT L.L. INPUT (R.P.)
GAIN STAGE
ACTIVE FILTER
OUTPUT DRIVER STAGE
ORTEC
100 MIDLAND ROAD, OAK RIDGE, TENNESSEE 37830
MODEL 490B