SCINTILLATION DETECTOR PREAMPLIFIER Model 2005

1086

Operator's Manual

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SCINTILLATION DETECTOR PREAMPLIFIER
Model 2005

CONTENTS

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Model 2005

Section 1
INTRODUCTION

The Canberra Model 2005 represents the latest advance in charge sensitive preamplifiers designed primarily for use with scintillation detectors. The preamplifier converts the ionization charge developed in the detector during each absorbed nuclear event to a step function pulse output whose amplitude is proportional to the total charge accumulated in that event. The pulse decays exponentially with a time constant of 50 microseconds (nominal) to segregate successive events in high count rate applications.

As can be seen in the functional schematic (Figure 1-1) the first stage functions as an operational integrator yielding an output voltage proportional to the accumulated charge. The second stage functions as a selectable gain differentiator/buffer. Conversion factors of nominally 4.5mV/pC or 22.7mV/pC are selected by a jumper plug on the printed circuit board inside the unit. The higher scale factor is especially useful for best signal-to-noise ratio in experiments involving low energy sources. The differentiator circuit includes a pole/zero adjustment to return the unipolar pulse signal to a reference or baseline level without overshoot.

The noise level for the Model 2005 is equivalent to less than one femtocoulomb with a source capacitance of Opf, using 2 microsecond near-Gaussian pulse shaping, and degrades at less than 0.1fC/pf. Typical noise performance with other pulse shaping time constants can be seen in Figure 2-1.

The charge rate capability of the Model 2005 has been demonstrated in excess of 9 x 10^{-6} coulombs per second. The fast rise time of 15ns is maintained over a wide range of detector source capacitance, and is more than adequate for the charge collection times of NaI (Tl) scintillation detectors.

In order to take advantage of the high count rate capability of the 2005, a high count rate main shaping amplifier, such as the Canberra Model 2010 is recommended. Other amplifiers may have count rate limits of their own. Timing analysis may be done with such units as the Canberra Model 1427 ARC Timing Unit or other NIM modules as needs dictate. At low energies, the system timing performance may benefit from the higher gain setting.

A test input is provided on the Model 2005 to assist system setup and simple troubleshooting. Charge coupling through this input is nominally 33 picocoulomb/volt. The nominal voltage gain through the preamplifier test input is 150mV/V for the output scale factor of 4.5mV/pC and 750mV/V for the output scale factor of 22.7mV/pC.

Power for the Model 2005 is usually supplied from the associated Canberra pulse shaping amplifier. The power lines are filtered within the Model 2005 to provide high noise immunity. A ten foot power cable is provided with the preamp.

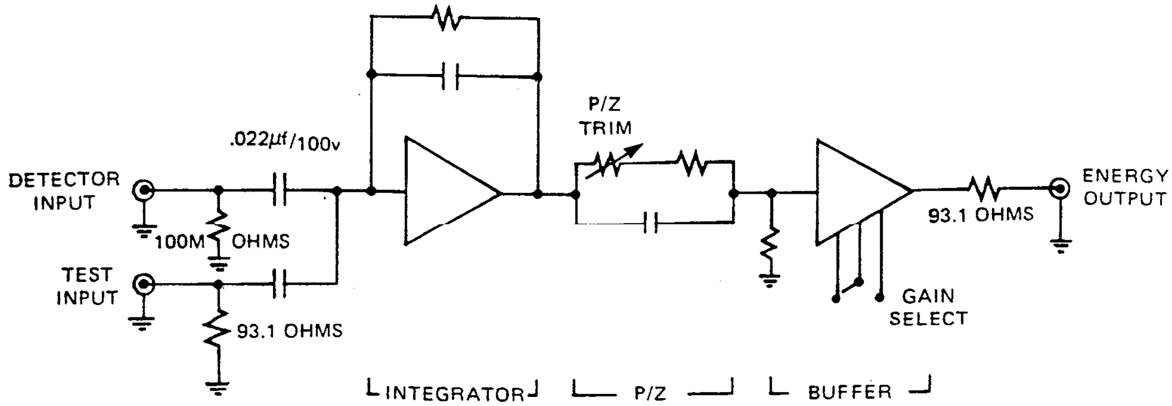


Figure 1-1
Functional Schematic, Model 2005

Section 2
SPECIFICATIONS

2.1 INPUTS

DETECTOR INPUT

Accepts decoupled charge pulses from scintillation detector PMT's. Input limit ± 100VDC.

TEST INPUT

Accepts a positive or negative signal, which is then differentiated as a charge coupled signal to the preamp input at nominally 33 picocoulomb/V. Voltage gain to the output is nominally 150mV/V or 750mV/V depending upon selection of preamp sensitivity of 4.5mV/pC or 22.7mV/pC respectively. Input impedance is 93 ohms.

2.2 OUTPUT

Provides unipolar voltage pulses linearly proportional in peak amplitude to the charge input, inverting. Decay time constant is 50 microseconds (± 10%). Output swing range is ± 10V open circuit. Output impedance is 93 ohms,series connected, DC coupled. Output DC offset is 0 ± 50mVDC (at gain of 4.5mV/pC) or 0 ± 150mVDC (at gain of 22.7mV/pC).

2.3 PERFORMANCE

INTEGRAL NONLINEARITY

Less than ± 0.02% for an output swing of up to ± 10V (unterminated).

GAIN STABILITY

Better than ± 0.01%/° C (± 100ppm/° C) over a range of 0 to +50° C. Better than ± 0.01% over 24 hours at constant temperature after 1 hour stabilization.

CHARGE SENSITIVITY

4.5mV per picocoulomb or 22.7mV per picocoulomb as selected by jumper plug on printed circuit board internal to the unit. Shipped in the 4.5mV/pC gain position. Gain tolerance is ± 10% due to absolute tolerance of component parts.

NOISE AND RISE TIME

Using a Canberra Model 2010 Spectroscopy Amplifier set at 2μsec Unipolar near-Gaussian shaping, noise behavior is summarized as follows:

C source in picofarads	Noise Charge Coulombs RMS	Rise Time in nanoseconds
0	$< 1 \times 10^{-15}$	< 15
100	$< 1.1 \times 10^{-15}$	< 16
500	$< 1.5 \times 10^{-15}$	< 16

Noise performance for other shaping time constants and source capacitances is depicted in Figure 2-1.

CHARGE RATE CAPACITY

9×10^{-6} coulombs/second

2.4 CONNECTOR TYPES AND CABLES

DETECTOR INPUT	BNC
TEST INPUT	BNC
ENERGY OUTPUT	BNC
POWER	Amphenol 17-20090
CABLE	A ten foot power cable with required connectors is supplied with the preamplifier.

2.5 POWER REQUIREMENTS

+12 VDC - 2mA
- 12 VDC - 2mA
+24 VDC - 20mA
- 24 VDC - 14mA

Supplied from associated main shaping amplifier.

2.6 PHYSICAL

SIZE	See Figure 2-2 for details.
NET WEIGHT	12 ounces (0.34 kg).
SHIPPING WEIGHT	Approximately 18 ounces (0.5 kg).

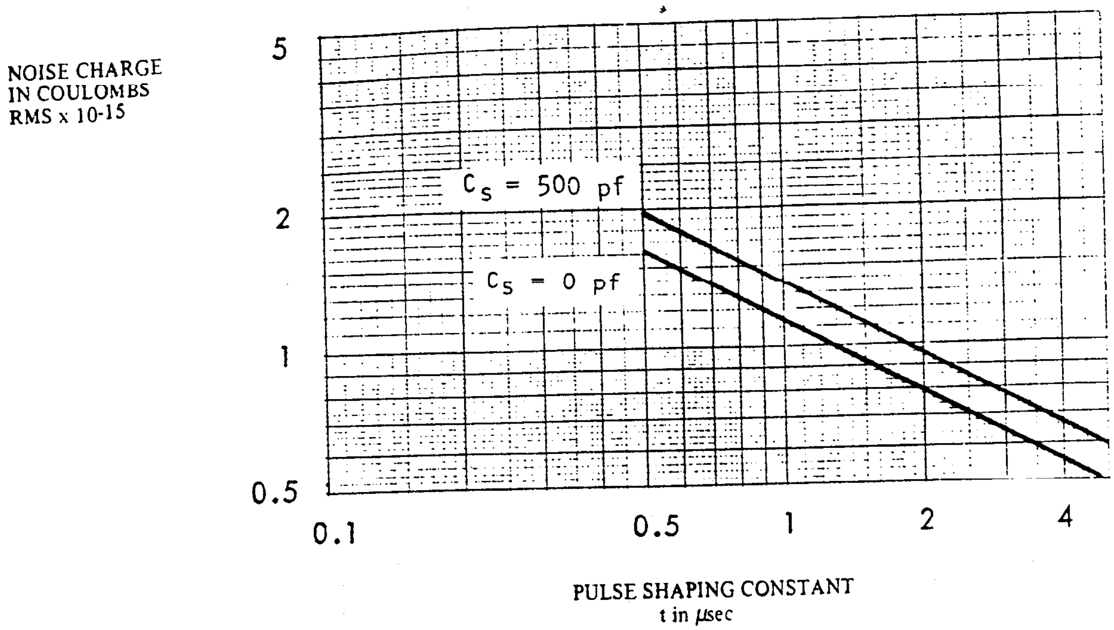


Figure 2-1
Typical Electronic Noise Behavior of Model 2005 for various pulse shaping time constants.

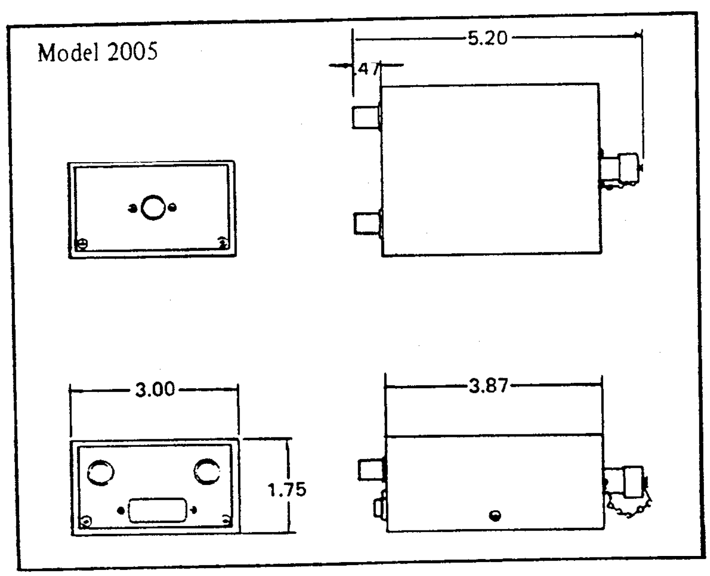


Figure 2-2
Outline Drawing

Section 3
ADJUSTMENTS AND CONNECTORS

3.1 GENERAL

Complete understanding of the purpose of the adjustments and connectors is required for the proper operation of the Model 2005 Preamplifier and it is recommended that this section be read before proceeding with the operation of the instrument.

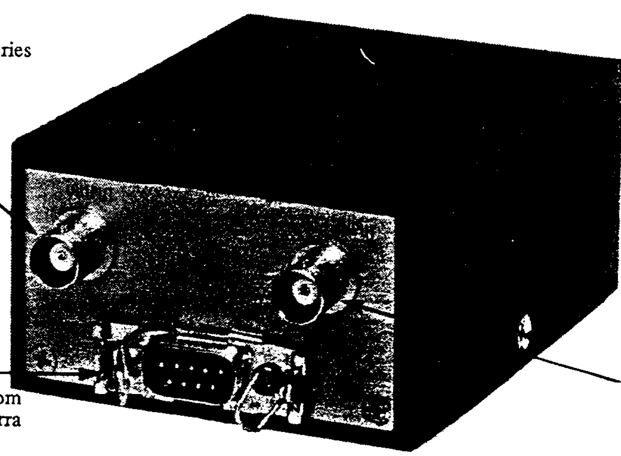
3.2 FRONT PANEL

DETECTOR INPUT
Accepts charge pulses from detector via BNC connector.

Figure 3-1
Front Panel, Model 2005

3.3 REAR PANEL

OUTPUT
93 ohm output impedance series connected.

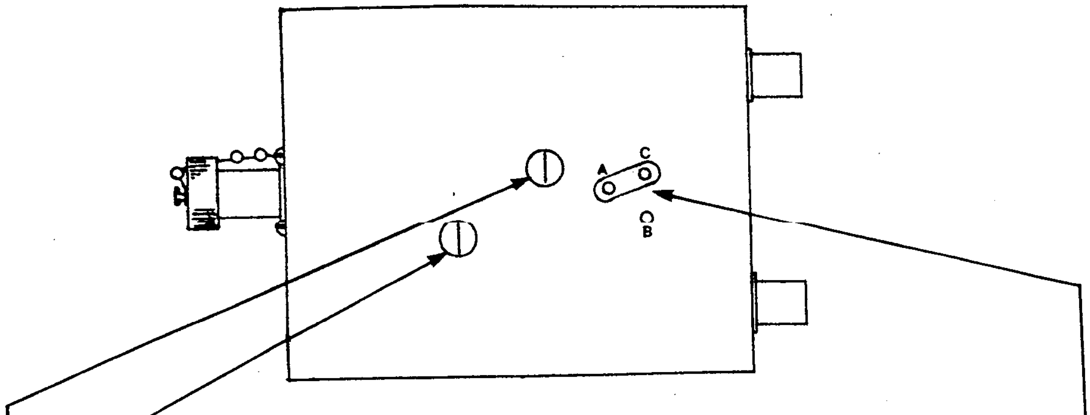


POWER
Accepts ±12 and ±24 VDC from main amplifier, or Canberra Model 2000.

TEST INPUT
Charge coupled to preamp input at 33 picocoulomb/volt. Input impedance is 93 ohms.

Figure 3-2
Rear Panel, Model 2005

3.4 INTERNAL



RV1 adjusts damping of the charge integrator amplifier to provide best pulse for given detector source capacitance.

RV2 adjusts pole/zero for optimum Unipolar pulse response at output. Factory set.

Jumper Plus sets output scale factor. Set A-C for 4.5mV/pC, A-B for 22.7mV/pC.

Figure 3-3
Internal Adjustments, Model 2005

3.5 ADJUSTMENT PROCEDURE

While the Preamplifiers have been carefully calibrated at the factory, the user may desire to alter either the pole/zero or rise time/damping adjustments for specific experiments.

The following procedures detail the most effective method of making the desired adjustments. The user is advised to defer making these adjustments until he has read sections 4 and 5 (Installation and Operating Instructions).

Required Equipment:

a) Function Generator providing variable 0-10 volts square wave output, with tise time less than 25nsec, and a sync output (HP 3310, Data Dynamics 5109 or equivalent).

b) Calibrated Oscilloscope, rated DC-150MHz minimum (Tektronix 454, 475 or equivalent).

3.5.1 POLE/ZERO TRIM

The following method uses the Function Generator square wave output to calibrate the Pole/Zero precisely, in lieu of the more common approximations made using various sources presented to the detector. The adjustment is properly an electrical one, and is not influecned by detector variances. Hence, it is usually set just once. The same technique is equally valid for the Preamp/Amplifier interface in adjusting the Amplifier's input differentiator Pole/Zero. That setting does change between each Preamplifier and Amplifier, and the instructions which follow provide the optimum setting here as well.

1. Verify Bin power is OFF before making connections to preamp. Scope and Function Generator should be ON, and warmed up. Amplifier should be installed in Bin, or wired to Bin power source.

2. Connect preamp power cable between Preamp and Amplifier.

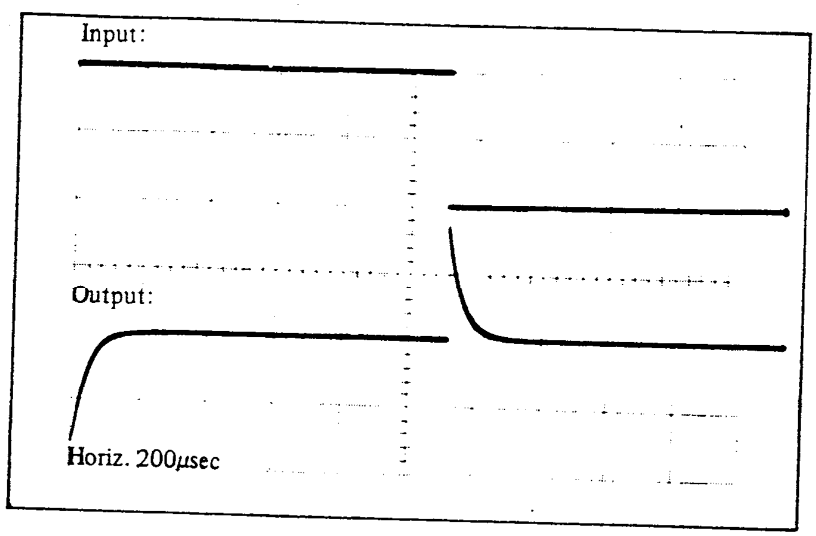
3. Connect shielded cables BNC/BNC between:
   Preamp OUTPUT and scope channel B input;
   Function Generator SYNC output and scope external trigger input;
   Function Generator signal output and "tee" inserted at scope channel A input:
   Scope channel A "tee" and Preamplifier TEST INPUT

4. Set:

Function Generator output	. . . .1 volt pk-pk square wave
Frequency	. . . . 500Hz
SCOPE:	
Channel A	. . . . 0.5V/div., DC coupled
Channel B	. . . . 0.1V/div., DC coupled
Display	. . . . Alternate, ext. triggered, 200µsec/cm

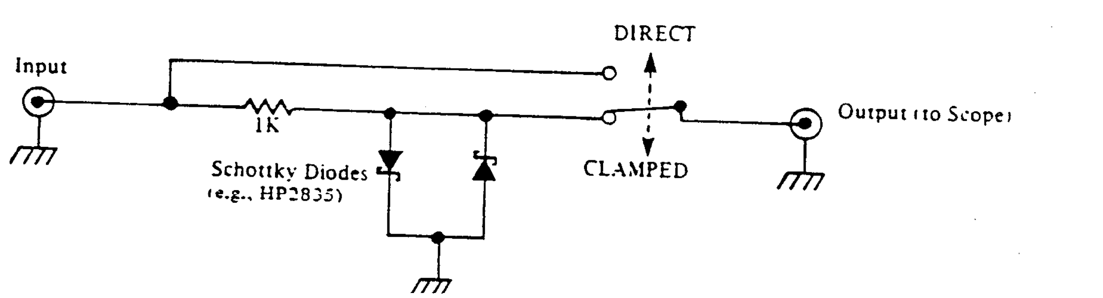
Set jumper plug inside Preamplifier to "A" and "C". Apply power to the Bin power supply.

5. Apply power to the Bin power supply. Observe scope dual trace for display as shown in the following picture:



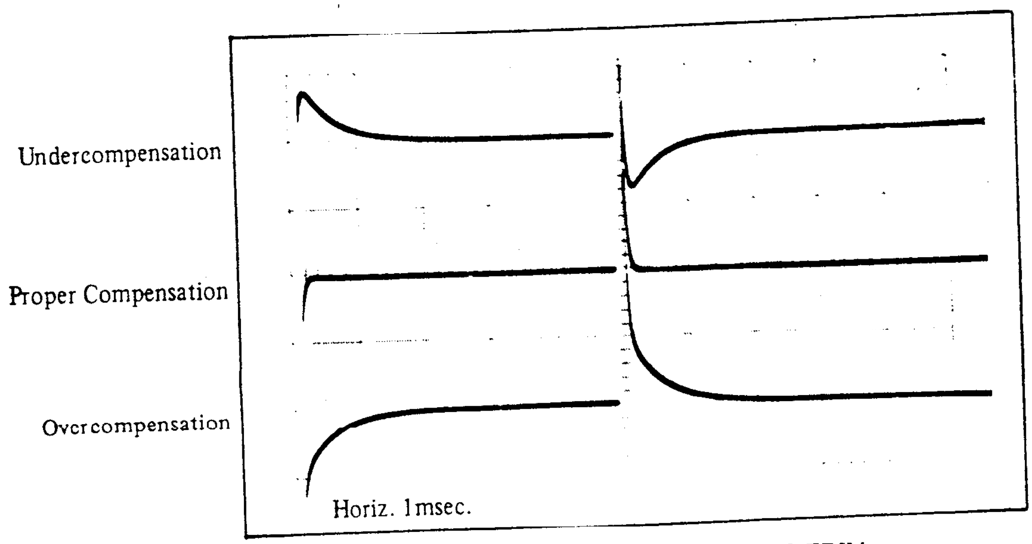
6. Set scope to display Channel B only and decrease sensitivity to 0.5V/div. Increase Function Generator level for a display of approximately ± 1.5V peak (3V pk-pk).

The following clamp circuit will be very useful in establishing the Pole/Zero trim. It should preferably be mounted in a miniature box (e.g. Pomona 2417, with BNC plugs to attach directly to scope input).



7. Install Schottky clamp box on input to Channel B, reconnect coax cable. Set switch to DIRECT and verify wave form essentially same as in (2) above.

8. Set switch to CLAMPED, change scope to 20mV/div. (vert.) and 1mSec/div. (horiz.). Set Function Generator frequency to 100Hz. Now adjust RV2 for best pulse response as illustrated in center trace of photo below. Proper compensation requires a flat line. without overshoot or long tailing. Preamp Pole/Zero is now set precisely.



MODEL 2005 PREAMP. POLE/ZERO TRIM

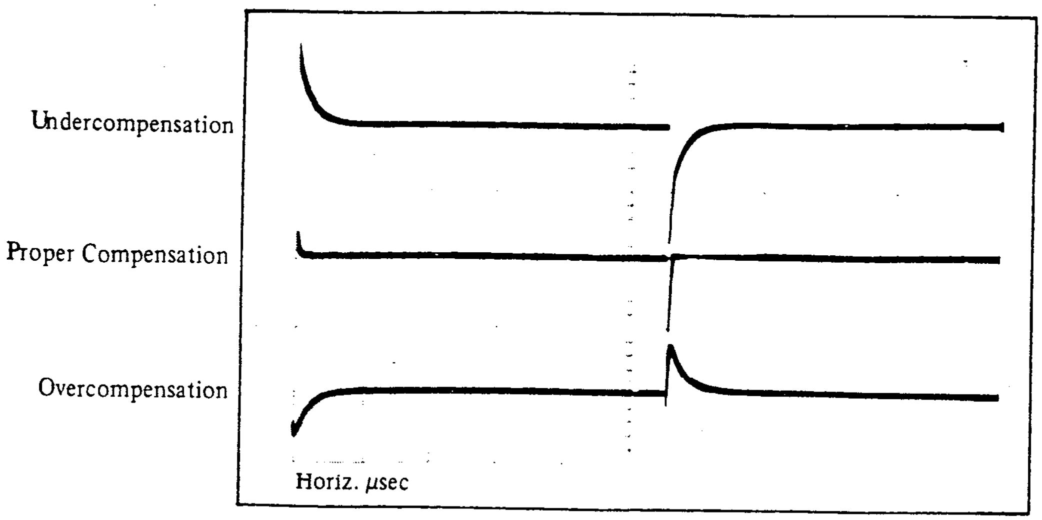
9. Reduce Function Generator output to a minimum, set frequency to about 500Hz. Move coax cable at the Preamp OUTPUT and reconnect to Amplifier UNIPOLAR OUTPUT. Add a coax cable between Preamp OUTPUT and Amplifier INPUT.

10. Set Amplifier controls as follows:

    Gain: X100 (using coarse and fine controls)
    Shaping: 2 microseconds
    Range: 10 volts
    Input Polarity: positive
    Output Polarity: positive
    Restorer: OFF

11. Set switch on Schottky clamp box to DIRECT. Adjust Function Generator for a scope Channel B display of 20 pk-pk, using 5V/div. scale, and a time base of 200μsec/div.

12. Set switch on Schottky clamp box to CLAMPED, change scope display to 100mV/div. and adjust the Amplifier Pole/Zero front panel trim pot for best pulse response as below:



MODEL 2005 AMPL. POLE/ZERO TRIM

13. Amplifier Pole/Zero is now set precisely.

The above procedure may seem lengthy at first, but it is really quite simple and straightforward.

Section 4
INSTALLATION

4.1 NOISE CONSIDERATIONS

It must be remembered that any capacitance added to the input of the preamplifier will increase the noise contribution and degrade the rise time of the preamplifier. Input capacitance should be minimized by using the shortest possible interconnecting coaxial cable between the detector and preamp. Choose a cable with minimum capacity per unit length such as RG-62A/U, with 44pf per meter.

4.2 MOUNTING

The Model 2005 may be set or mounted in any desired position. Good practice would suggest a location as close to the detector as practicable. Because of the high charge gain and the presence of detector high voltage, the Preamplifier is inherently somewhat microphonic. The user may wish to use some vibration isolating material at his discretion.

NOTE: It is presumed that the unit will be used with the decoupled anode output of a PMT or other low voltage source. Consequently, the voltage limit for the DETECTOR INPUT is ± 100VDC. Do not exceed this limit, as the unit may be damaged.

Section 5
OPERATING INSTRUCTIONS

5.1 GENERAL

The purpose of this section is to familiarize the user with the Model 2005 Preamplifier and to check that the unit is operating correctly. Since it is difficult to determine the exact system configuration in which the unit will be used, explicit operating instructions cannot be given. However, if the following procedure is carried out, the user will gain sufficient familiarity with the instrument to permit its proper use in the system at hand.

The instructions which follow may be best carried out with the Preamplifier on a test bench, separated from the detector. Keep the dust cap secured on the input BNC connector.

Because the input is charge sensitive, and ultra high impedances are involved, the Preamplifier is inherently somewhat microphonic. Testing should only be done with the Preamplifier chassis cushioned on a block of foam rubber, and the cover securely fastened to the frame.

The charge gain of the Preamplifier is set by the position of a jumper plug in the approximate center of the printed circuit board. The Preamp is shipped with the jumper set from "A" to "C" giving a nominal charge gain of 4.5mV/picocoulomb, and the nominal voltage gain between TEST INPUT and OUTPUT is 150mV/V. With the jumper set from "A" to "B" the nominal charge gain is 22.7mV/picocoulomb, equivalent to approximately 235mV/Mion-pairs, and the nominal voltage gain between TEST INPUT and OUTPUT is 750mV/V. Set the jumper to the scale factor desired before use.

5.2 INITIAL SETUP

1. Connect the Preamplifier to a source of low voltage power (± 12 and ± 24 VDC) such as from a Canberra main shaping amplifier using the ten foot cable provided. Keep power OFF initially.

2. Connect the output of the Preamplifier to one input channel of a dual trace oscilloscope. Set the vertical sensitivity to 50mV/div. DC coupled, and the time base to 10μsec/div.

3. Connect the ATTENuated output of a tail pulse generator (such as Canberra Model 1407 Reference Pulser) to the TEST INPUT of the Preamplifier with a "tee" connection to the second input channel of the oscilloscope. Set the Pulser to (-) output, 90Hz, minimum rise time and maximum fall time. Set the vertical sensitivity of the oscilloscope second channel initially at 0.5V/div., DC coupled.

4. Connect the Pulser NORMAL output to the oscilloscope trigger input and set the oscilloscope up for external triggering on the + slope.

5.3 INITIAL CHECKOUT

1. Switch the main power ON.

2. Adjust the Pulser output for a 2V peak negative pulse on the scope. Observe the Preamplifier OUTPUT to be approximately 300mV peak positive (for 4.5mV/pC scale factor), or 1.5V peak positive (for 22.7mV/pC scale factor).

3. Reduce the Pulser output to 20mV peak, and set the polarity to negative.

4. Connect the Preamplifier OUTPUT to the INPUT of a low noise Spectroscopy Amplifier (such as Canberra Model 2010) and move the oscilloscope first channel input to the Amplifier UNIPOLAR OUTPUT. Set the Amplifier to 2μsec shaping.

5. Connect an AC Voltmeter to the Amplifier UNIPOLAR OUTPUT on the rear panel. If the Voltmeter is a true RMS type adjust the Amplifier COARSE and FINE GAIN for a peak output pulse of 6.6V. If the voltmeter is an average reading type calibrated to read RMS on a sinusoid, set the Amplifier gain for a peak output pulse of 7.5V. The meter will now be calibrated to read 10mV=1fC RMS of system noise.

6. Switch the Pulser OFF, disconnect it from the Preamp TEST INPUT and place the dust cap on the DETECTOR INPUT. Read the 0pf noise of the Preamp plus Amplifier on the voltmeter. Note: A slightly lower reading is obtained using the higher scale factor (jumper plug from "A" to "B") by virtue of the improved noise weighting between Preamp and Amplifier.

7. Noise tests may be made for simulated detector source capacitances by adding test capacitors (properly shielded) to the input. For the Model 2005, the capacitors should be a low noise type, preferably porcelain, mounted in a BNC connector and shielded.

5.4 COMMON OPERATING PROBLEMS

All of the many possible contributors to less than optimum performance cannot be listed here. The purpose of this section is to note the usual causes of loss of resolution, and to suggest curative steps.

Do not expect to diagnose all problems with a detector, a Preamplifier, a main Amplifier and a multichannel analyzer. The system records results, it does not necessarily lead to the identification of causes. A good, modern oscilloscope (Tektronix type 453, 454, 465 or 475) will be needed. Also, a high quality tail pulse generator (Canberra 1407 or equivalent) will be extremely useful.

However, the simplext test is to connect your detector, apply bias, present a source, and accumulate data. Be sure a pulser is not feeding the Preamplifier while the data is accumulating or resolution loss may result. If the results obtained are far different from what is expected, it then becomes necessary to troubleshoot the system.

First, observe the Amplifier output on an oscilloscope at various time base and amplitude settings. Is the Amplifier properly pole/zero cancelled (do the output pulses cause undershoots that persist for longer than two or more main pulse widths)? The Canberra Model 1413 and 2010 Spectroscopy Amplifiers have a built-in DC Restorer. Set the main Amplifier pole/zero cancellation by the procedure given in the Amplifier manual, or Section 3 of this manual.

The next step is to remove all sources and, with the detector still connected and bias applied, to apply a test pulse to the TEST INPUT of the Preamplifier. Make sure the pulser polarity is correct. Set the amplitude of the pulser so that its peak occurs near the region of the peak of the source previously used.

Observe the output of the amplifier without DC restoration. Note that the amplifier is not properly pole/zero cancelled for the pulser feeding the Preamp (due to the extra time constant of the pulser). This is of no consequence for a pure pulser input. Are the baseline fluctuations of 60 to 120Hz frequency? A ground loop is indicated. Insert all system line plugs into the same outlet. Or, are the baseline fluctuations of random frequency between 10Hz and 15,000Hz? If so, clap your hands near the detector and look for increased noise of this type. The area may be too noisy, causing microphonic problems.

If low frequency noise still is a serious problem, it may be necessary to use the Low Rate mode of the Canberra main amplifier's built-in DC restorer.

If high frequency noise is observed, is it random or periodic? Periodic noise is a sign of electronics failure; isolate the cause by observing the Preamplifier OUTPUT. Is the same pattern observed, or is the problem in the main Amplifier? Random high frequency noise may be detector load resistor or input capacitor breakdown.

Next, accumulate a pulser peak on the analyzer. Calculate its resolution. Repeat with the detector removed and the input connector of the preamplifier shielded. You now have three resolution figures available for essentially equal energy peaks: source; pulser and biased detector connected; pulser without detector connected. Denote these by R_S, R_D, and R_E, respectively.

If R_E is acceptable, but R_D is greater than 1 femto coulomb RMS plus 1×10^{-18} coulomb RMS per pf of detector and connection capacitance, then the problem is either in the detector (microphonics, excess leakage current noise, breakdown due to moisture or grime on the detector output connector) or in the Preamplifier (leaky input capacitor, dirty or moist detector load resistor, dirty or moist detector input connector).

If R_E and R_D are acceptable, but the live spectrum (R_S) is not as good as expected, the problem is probably in the detector (bad detector, poor charge collection, insufficient bias) or in the electronics following the Preamplifier (count rate too high, improper Amplifier pole/zero cancellation, wrong main Amplifier time constant, wrong position of restorer, wrong Amplifier shaping-bipolar vs. unipolar, improper Amplifier shaping for the ADC being used, ADC cannot take the count rate, Amplifier or ADC drift).

These many alternatives are not easy to check. Substituting, one-by-one other detectors, Preamplifiers, Amplifiers and multichannel analyzers may help pinpoint the problem. Checking the above common problems will aid in spotting the source of the trouble.

Going through the steps mentioned above help to eliminate obvious problems and will provide a good starting point for the final troubleshooting step. Call Canberra: (203) 238-2351. With the information collected above, our advice will be far more concise and to the point.

Section 6
THEORY OF OPERATION

6.1 FUNCTIONAL DESCRIPTION (Refer to electrical schematic B-17370)

The Model 2005 Spectroscopy Preamplifier functionally consists of three stages: a charge-to-voltage converter (integrator), a differentiator (p/z) and a buffer section.

6.2 DETAILED CIRCUIT DESCRIPTION

The integrator may be analyzed in terms of conventional operational amplifier theory where Q1 through Q6 function collectively to provide a large voltage gain, low output impedance and high input impedance. C15 closes the loop as the feedback impedance Zf, while C14 acts as the source impedance Zs. The closed loop input (Q1 gate) to output (Q4 emitter) voltage gain may then be calculated as Av=Zf/Zs=C14/C15.

Specifically, the input FET operates at a fairly low drain-to-source voltage (4 V dc nominal) and a bias current conducive to high signal gain and low noise (5–10 mA). R1 defines this current. R4 is a level shifter. AC current flows from Q1 via C3 into Q3. Gain is increased as a consequence of using an active current source (Q5) with an output impedance of several megohms as a load to the collector of Q3. At this point dominant pole compensation is provided by C4, C5 and RV1 to stabilize the voltage gain with respect to frequency.

Buffer action is provided by emitter follower Q4 and constant current source Q6 to drive the next stage. R14 furnishes a DC feedback path and in combination with C15 defines the integration time constant.

The pole/zero stage acts to compensate this same time constant by the use of RV2, R27 and C6. R18 and C6 are responsible for adding the nominal 50 microsecond tail pulse. Such an arrangement keeps the pulse precisely unipolar and aids in achieving the best resolution and overload recovery possible.

The buffer stage consisting of Q7 through Q11 is again configured using the operational amplifier approach. Q7 and Q8 are biased as a differential pair with Q9 providing voltage gain, level translation and a voltage swing of ± 10V. D2 and D3 provide the static forward bias for the push-pull emitter follower outputs Q10 and Q11. The output transistors provide current gain for driving cable lengths without pulse degradation. The loop is closed by either R21 or R22 depending upon which gain option is chosen.

If the higher gain is chosen, then:

$$Av = \frac{Rs + Rf}{Rs} = \frac{R20 + R22}{R20}$$

When the lower gain option is chosen, then:

$$Av = \frac{Rs + Rf}{Rs} = \frac{R20 + R21}{R20}$$

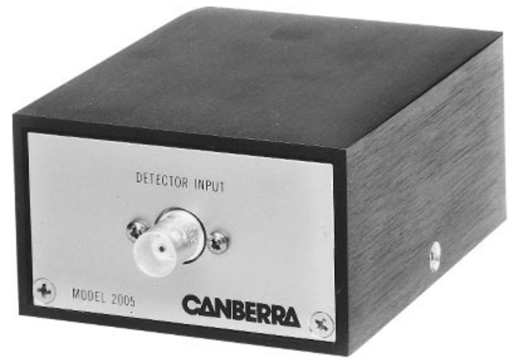
as dictated by classical operational amplifier theory.

Standard LC decoupling of the supply lines is employed to minimize problems caused by noise pickup and induction effects in the power cable.

Model 2005
Scintillation Preamplifier

Features

- Low noise design: less than 10^{-15} coulombs rms
- High charge rate capacity (up to 9 µC/s) for high count rate applications
- FET input, diode protected
- Fast risetime: less than 15 ns



Description

The Canberra Model 2005 is a charge sensitive preamplifier which collects the charge output from scintillation/photomultiplier detectors for presentation to a pulse shaping main amplifier. For the typical application with input from the decoupled anode signal from a photomultiplier tube base, the preamplifier generates a positive polarity energy pulse output.

Functionally the unit operates as an integrator utilizing an operational type configuration by which the potential difference across the feedback capacitor is directly proportional to the charge accumulated from the detector input. The integrator is followed by a pole/zero cancellation circuit for optimum overload performance, and a differentiator to provide the 50 µs tail pulse. In addition, a buffer stage allows the Model 2005 to drive a long cable length without pulse degradation.

Charge conversion gains of nominally 4.5 or 22.7 millivolts per picocoulomb may be selected by a jumper plug on the printed circuit board inside the unit. Power for the unit is usually supplied from the associated main amplifier through the 3 m (10 ft) power cable provided with the preamp.

Specifications

INPUTS

DETECTOR INPUT – Accepts charge pulse from scintillation/photomultiplier detector.
TEST INPUT – Charge coupled to preamp input at 33 pC/V; Z_{in} = 93 Ω.

OUTPUTS

ENERGY OUTPUT – Inverted tail pulse; rise time as in Table 1; 50 µs fall time constant, up to ±10 V; Z_{out} = 93 Ω; direct coupled.

PERFORMANCE

OPERATING TEMPERATURE RANGE – 0 to 50 °C.
INTEGRAL NONLINEARITY – <±0.02% for up to ±10 V output.
GAIN DRIFT – <±0.01% per °C (±100 ppm/°C).
NOISE OUTPUT PERFORMANCE – See Table 1.
CHARGE SENSITIVITY – 4.5 mV/pC or 22.7 mV/pC, internally selected.
HIGH CHARGE RATE CAPABILITY – Up to 9 µC/s.

CONNECTORS

POWER – Amphenol 17-20090.
DETECTOR INPUT, TEST INPUT, ENERGY OUTPUT – BNC.
3 m (10 ft) compatible preamplifier power cable with required connectors is supplied with the preamp.

POWER REQUIREMENTS

+24 V dc – 20 mA	+12 V dc – 2 mA
–24 V dc – 14 mA	–12 V dc – 2 mA

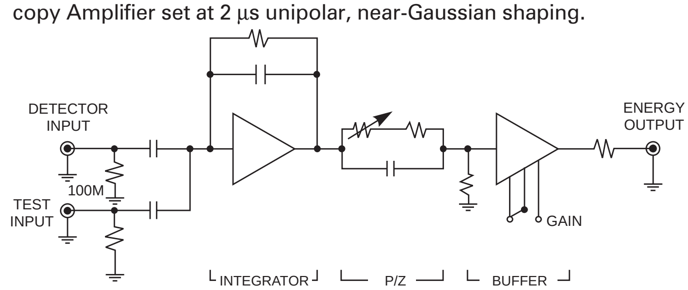
PHYSICAL

SIZE – 7.6 x 10.2 x 4.4 cm (3 x 4 x 1.75 in.).
NET WEIGHT – 0.31 kg (0.69 lb).
SHIPPING WEIGHT – Approximately 0.48 kg (1.06 lb).

Table 1

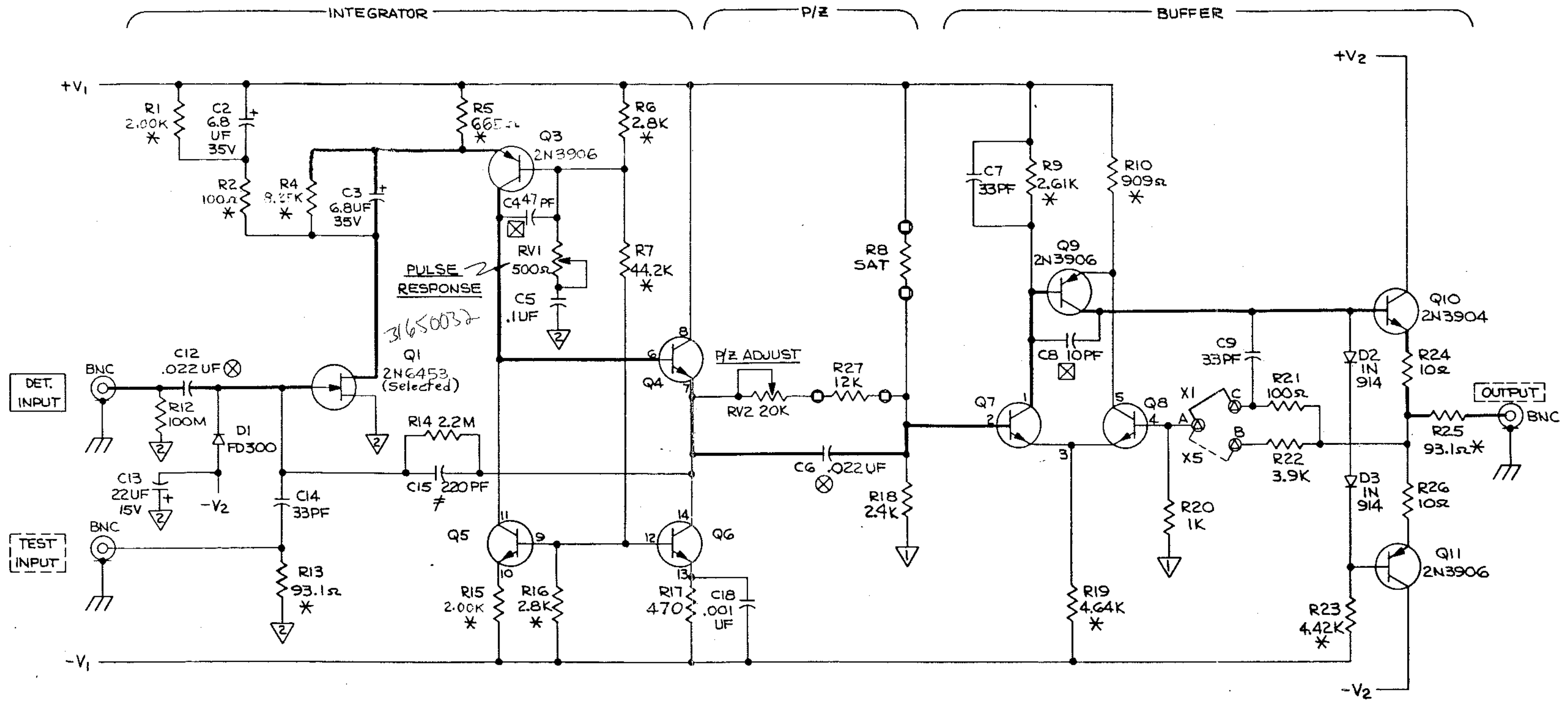
Model	C_{source} in Picofarads	Noise in Coulombs rms	Rise Time in Nanoseconds
2005	0	1 x 10^{-15}	<15
	500	1.5 x 10^{-15}	<16

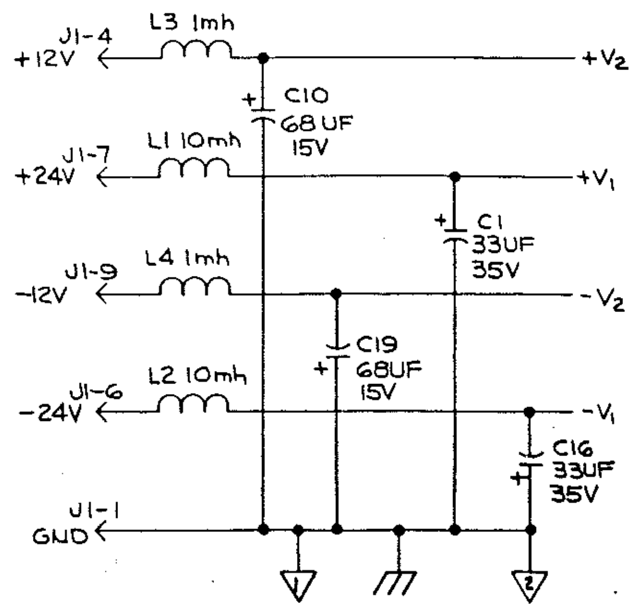
Noise performance measured using Canberra Model 2020 Spectroscopy Amplifier set at 2 µs unipolar, near-Gaussian shaping.



Functional Schematic

REV	CHANGE	ECN	BY	DATE	APPD
A	REVISED & INITIAL REL.	1886	ZP	7-7-78	
B	REVISED		DRW	7-19-78	
C	SEE ECN	1910	JH	8-7-78	RN





NOTES:

1. THERE ARE NO 4-WAY TIES ON THIS SCHEMATIC.
2. UNLESS NOTED ALL RESISTORS ARE 1/4W, 5%.
3. ✱ INDICATES RNGOC RESISTOR 1%.
4. ⊠ INDICATES NPO CAPACITOR.
5. ⊗ INDICATES POLYCARB CAPACITOR.
6. ⊖ INDICATES AMP SOCKET.
7. ⊘ INDICATES CAMBION SOCKET.
8. Q4 THRU Q8 CONTAINED IN A1-LM3146A.
9. FOR P/L SEE DWG #A-17289 FOR 2005 & #A-17446 FOR 2005E
10. ≠ INDICATES MICA CAPACITOR.

LAST DESIGNATION	
INTEGRATED CIRCUIT	A1
RESISTOR	R27
CAPACITOR	C19
TRANSISTOR	Q11
DIODE	D3
POT	RV2

REV	CHANGE	ECN	DATE	BY
F	REVISED AR13168	4581	9-12-86	RJB
E	CHG C6 & R18	2762	2-18-81	F.
D	CHANGED C6	2721	1-5-81	JDC

DRAWN D. WEST	DATE 6-8-78	
CHKD	6-8-78	
APPD MECH		
APPD ELEC D. FERRARA	7-18-78	
NEXT ASSY		
USED ON		

SCHEMATIC
PREAMPLIFIER
MODEL 2005

CANBERRA

DRAWING NO. B-17370 REV. F

SHT 1 OF 1

SCALE — DO NOT TEMPLATE DRAWING