# Model 2007P
# PM Tube Base/Preamp

User's Manual

9231602B

ISO 9001 SYSTEM CERTIFIED

CE

# Table of Contents

# 1. Introduction

The Model 2007P Tube Base-Preamplifier provides the high voltage divider network for correctly biasing all 10-stage photomultiplier tubes (PMTs) used for nuclear spectroscopy. This network is intended for use with a positive high voltage for tubes which operate with their photocathodes near ground potential.

The network includes a focus control for adjusting the detector resolution performance, and a gain trim control for matching outputs of several detectors when used in arrays.

Designed to be compatible with the Model 802 series Scintillation Detectors (or equivalent), the tube base connects directly to the pins of the PMT, providing a compact integrally mounted assembly.

The 2007P also contains a low noise charge-sensitive preamplifier, which recovers the charge pulse at the anode pin of the PMT and converts it to a positive voltage pulse output. The peak amplitude of each output pulse is linearly proportional to the total charge output of the PMT during each amplified photo event. The pulse decays at a nominal 50 μs time constant.

The Model 2007P includes a diode protection network on the preamplifier input to prevent damage to the circuits from the sudden application or removal of bias voltage. A test input is also provided to aid system testing, gain calibration, or troubleshooting. Preamplifier power is usually derived from the associated pulse shaping amplifier. A 3 m (10 ft) power cable is supplied with the Model 2007P.

# 2. Controls and Connectors

This is a brief description of the 2007P's controls and connectors. For more detailed information, refer to Appendix A.

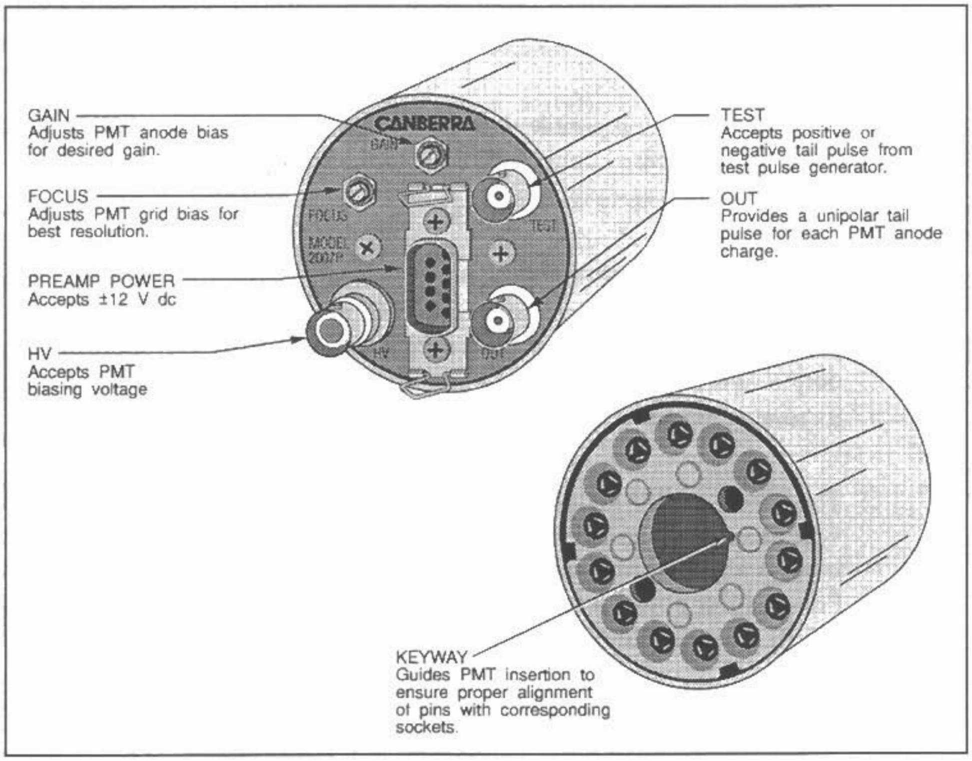


Figure 1 Front and Rear Panel Controls and Connectors

# 3. Installation

The tube base preamp is intended to mount coaxially with the Model 802 series scintillation detectors simply by mating the PMT pins into the tube socket. The scintillator should, of course, be handled with care in mating, and protected from shock.

Consistent with good operating practice for the PMT, the high voltage full bias should not be applied immediately; it should be raised and lowered over several seconds.

The Model 2007P is diode protected for occasional faults and for high-voltage arcing. A primary consideration here will be the instantaneous noise current in the PMT, which may take a considerable time to settle.

Steady state dissipation in the PMT bias network has been minimized, in order to prevent degradation of background "dark" currents due to local heating. Hence no particular care need be expended in providing any heat sinking for the tube base.

# 4. Operation

## Setup

Connect the Model 2007P to the Photomultiplier Tube (PMT). Be certain to align the key on the PMT with the keyway on the Model 2007P before attempting to insert the PMT pins into the tube base socket. See the rear panel illustration (Figure 1) for the location of the keyway.

Using a small screwdriver, turn the Model 2007P GAIN control to its extreme clockwise position, which will provide the highest possible gain, and adjust the FOCUS control to about mid-range.

Connect a high-voltage cable between the Model 2007P HV connector and the High Voltage Power Supply. Connect a signal cable between the Model 2007P OUT connector and the amplifier's input. Connect the preamplifier power cable between the preamp power (9-pin) connectors on the Model 2007P and the amplifier. Note that for a PMT, the amplifier must be capable of 0.5 μs shaping.

**WARNING** Never connect or disconnect the tube base preamp while the high voltage is ON.

## The Gain Control

The GAIN control matches the gain of two or more PMTs in a multiple detector system. If a single PMT is being used, the control should be left in the extreme clockwise position.

To match the gain of several PMTs, it is necessary to know the gain of each detector. Collect several thousand counts in a peak of $^{137}Cs$ (for instance) and record the number of the peak channel. Repeat for each PMT.

Place the MCA's cursor in the lowest recorded channel found in the preceding paragraph and adjust the GAIN controls of each PMT in turn so that all will collect the peak in that same peak channel.

# The Focus Control

The FOCUS control is used to obtain the best possible resolution with a given PMT. Resolution is defined as the ability of the detector to differentiate between two peaks that are close together in energy. Thus the narrower the peaks, the better the peak separation and the better the resolution.

Start with the FOCUS control set about the middle of its range. By checking the resolution several times with a slight adjustment of the FOCUS control each time, the point of best resolution can be found.

# Resolution

The full width of the peak at half of its maximum value (FWHM) is used to determine the resolution:

$$\text{Resolution} = \frac{\text{FWHM}}{\text{Peak Position}}$$

where Peak Position and FWHM are expressed in channels. The performance of a scintillation detector is usually specified in terms of its resolution for the 662 keV peak of $^{137}$Cs.

To determine the resolution, collect a peak of 10 000 counts of $^{137}$Cs. Half maximum of the peak would be 5000 counts, but it is unlikely that there will be a channel that contains exactly 5000 counts. Therefore, it is necessary to interpolate the data.

Record the following information:

a. The peak channel. That is, the channel with 10 000 counts.

b. The counts in the channel just below FWHM on the left side of the peak. Counts $<5000$.

c. The counts in the channel at or just above FWHM on the left side of the peak. Counts $\geq 5000$.

d. The number of the channel at or just above FWHM on the left side of the peak.

e. The number of the channel at or just above FWHM on the right side of the peak.

f. The counts in the channel at or just above FWHM on the right side of the peak. Counts ≥5000.

g. The counts in the channel just below FWHM on the right side of the peak. Counts <5000.

Using the information gathered above, apply the following formula:

$$\text{Resolution} = \frac{e - d + \frac{b}{c} + \frac{f}{g}}{a} = \text{resolution expressed as a decimal fraction.}$$

The resolution will be in the range of 0.06 to 0.09 (6% to 9%) for a Canberra Series 802 Scintillation Detector.

By adjusting the FOCUS control slightly to one side or the other of mid-range and doing another resolution check, it will be apparent that the resolution has been improved (the number is smaller) or has been degraded (the number is larger).

By doing several successive approximations, the best resolution will be found. The FOCUS control can be left in that position as long as the same PMT and Model 2007P are associated. It would be helpful however, to check for best resolution from time to time to be sure that there is no change with time.

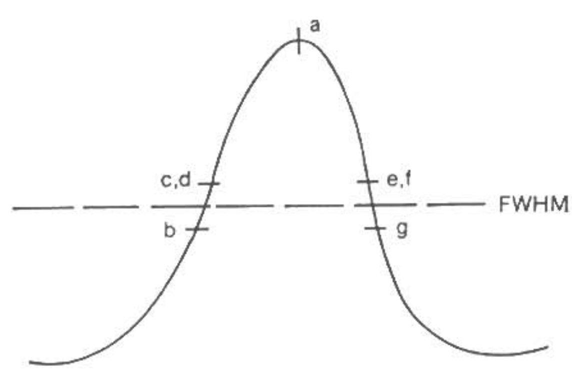


Figure 2 Resolution Calculation

# Preventative Maintenance

Preventative maintenance is not required for this unit.

When needed, the unit may be cleaned. Remove power from the unite before cleaning. Use only a soft cloth dampened with warm water and make sure the unit is fully dry before restoring power. *Do not* use any liquids directly on the preamp housing, front, or rear panels.

# 5. Circuit Description

The Model 2007P consists of two functionally separate sections. The voltage divider provides the photomultiplier tube (PMT) with the proper operating potentials and the preamplifier converts the charge output of the PMT into a proportional voltage.

Specifically, the bias network chosen for the PMT provides the nominal distribution of accelerating potentials between dynode sections that has found to yield the best performance for nuclear applications. Capacitors C9 and C10, provided between the anode and upper two dynodes, bypass large signal current occurring under moderately high pulse amplitude conditions. RV3 permits independent control, of PMT grid potential for optimization of resolution, while RV2 permits PMT gain to be adjusted by modifying the potential applied at the top of the divider string.

The preamplifier section functions as an operational integrator with Q1 in the common source configuration providing a high open loop gain by virtue of the ac bootstrap action furnished by C5.

Q1 also allows a high input impedance by virtue of its gate input, while Q2 provides current gain and low output impedance.

The loop is then closed by the integrating capacitor C3, with R5 providing dc stability in addition to facilitating the discharge of C3. RV1 enables the adjustment of output dc offset at the same time allowing the gate of Q1 to be biased slightly negative.

The sensitivity of the preamp to charge may be calculated by noting that all charge transferred from the PMT anode through C2 collects on C3, creating a potential difference across C3 according to the relationship:

$Q = CV$ or $V/Q = 1/C3$
Since $C3 = 220$ pF, $V/Q = 1/220$ pF $= 4.5$ mV/pC

Filtering of the HV input is provided by C8 while standard LC decoupling of the low voltage supply lines is employed to minimize problems caused by noise pickup in the power cable.

# A. Specifications

## Inputs

DETECTOR SIGNAL - The preamp input is ac coupled internally to the anode through pin 11 of the PM tube socket.

HV - Accommodates PM tube bias up to 2 kV dc maximum.

TEST - Positive or negative tail pulse from test pulse generator; charge coupled at 30 pC/volt; $Z_{in}$ = 93 Ω.

PREAMP POWER - ±12 V dc from associated main amplifier through compatible cable provided.

## Outputs

PREAMP SIGNAL - Inverted tail pulse; rise time <20 ns; fall time, 50 µs nominal; up to +10 V through series connected 93 Ω resistor; direct coupled.

## Controls

FOCUS - Single turn screwdriver adjustment for optimization of resolution.

GAIN - Single turn screwdriver adjustment for trimming HV.

## Performance

INTEGRAL NONLINEARITY - <± 0.04% for up to +10 V output.

GAIN DRIFT - <± 0.01%/°C (± 100 ppm/°C).

PM TUBE BIAS ISOLATION - +2000 V dc, maximum.

NOISE - <0.1 fC.

CHARGE SENSITIVITY - 4.5 mV/pC, nominal.

DIVIDER BIAS - Total resistance 7.2 MΩ, nominal; 10 dynodes at 72 V per kV dc of detector bias; anode limiting resistor 560 kΩ.

FOCUS RANGE - 72 V to +145 V per kV dc of detector bias.

GAIN RANGE - Varies total PMT bias between 92% and 100% of applied high voltage.

## Connectors

POWER - Amphenol 17 series.

OUTPUT and TEST - BNC

HV - SHV

PM TUBE SOCKET - Cinch Jones 3M-14

## Power Requirements

PREAMP - ±12 V dc at 15 mA.

HV - 0-2 kV dc at 0-300 µA

## Physical

SIZE - 7.6 x 5.8 cm (3 x 2.3 in.), length x diameter

NET WEIGHT - 0.14 kg (0.3 lb)

SHIPPING WEIGHT - 1.2 kg (2.7 lb)

## Environmental

OPERATING TEMPERATURE – 0 to 50 °C.

RELATIVE HUMIDITY – Up to 80%, non-condensing.

Tested to the environmental conditions specified by EN 61010, Installation Category I, Pollution Degree 2.

# B. Installation Considerations

This unit complies with all applicable European Union requirements.

Compliance testing was performed with application configurations commonly used for this module; i.e. a CE compliant NIM Bin and Power Supply with additional CE compliant application-specific NIM were racked in a floor cabinet to support the module under test.

During the design and assembly of the module, reasonable precautions were taken by the manufacturer to minimize the effects of RFI and EMC on the system. However, care should be taken to maintain full compliance. These considerations include:

- A rack or tabletop enclosure fully closed on all sides with rear door access
- Single point external cable access
- Blank panels to cover open front panel Bin area
- Compliant grounding and safety precautions for any internal power distribution
- The use of CE compliant accessories such as fans, UPS, etc.

Any repairs or maintenance should be performed by a qualified Canberra service representative. Failure to use exact replacement components, or failure to reassemble the unit as delivered, may affect the unit's compliance with the specified EU requirements.

CANBERRA

# Warranty

Canberra (we, us, our) warrants to the customer (you, your) that for a period of ninety (90) days from the date of shipment, software provided by us in connection with equipment manufactured by us shall operate in accordance with applicable specifications when used with equipment manufactured by us and that the media on which the software is provided shall be free from defects. We also warrant that (A) equipment manufactured by us shall be free from defects in materials and workmanship for a period of one (1) year from the date of shipment of such equipment, and (B) services performed by us in connection with such equipment, such as site supervision and installation services relating to the equipment, shall be free from defects for a period of one (1) year from the date of performance of such services.

If defects in materials or workmanship are discovered within the applicable warranty period as set forth above, we shall, at our option and cost, (A) in the case of defective software or equipment, either repair or replace the software or equipment, or (B) in the case of defective services, reperform such services.

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