REFERENCE PULSE GENERATOR
Model 1407

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Section 1
INTRODUCTION

1.1 GENERAL

The Canberra Model 1407 Reference Pulse Generator provides a source of stable 60 or 90 Hz tail pulses (simulating the output from a detector/preamplifier combination) for system alignment or for checking system stability and linearity.

The Model 1407 offers variable rise time via front panel switch selection from less than 10 to 250 nanoseconds and variable fall time via front panel switch selection from 20 to 400 microseconds. Amplitude is continuously variable by ten-turn potentiometer control from 0 to 10 volts with 0.1% control linearity. A second front panel ten-turn potentiometer permits normalization of the output to read directly in keV or MeV.

Front panel precision attenuators permit reduction of the Attenuated Output by factors of X2, X5, X10, X10, X10, or any product of these values. By front panel switch selection, the pulser output frequency may be selected for LINE or 90 Hz, to permit easy measurement of system resolution loss due to line frequency ripple.

1.2 APPLICATIONS

The Model 1407 provides pulses that simulate the output of a detector/preamplifier combination (i.e., short rise time and long, exponential decay time). This module can therefore be used to provide pulses of known amplitude (corresponding to specific energy losses in a detector) which are useful in setting up and evaluating spectroscopy and counting systems.

Specifically, the Model 1407 can be used to evaluate amplifier noise and linearity, to align the delays on coincidence systems, to calibrate pulse height analyzers, to evaluate system stability, and generally to check the overall operation of a system before beginning experimental runs.

SPECIFICATIONS

2.1 PERFORMANCE

STABILITY	Better than 0.005%/°C; better than 0.001%/10% line voltage change.
LINEARITY	Better than 0.1% integral.
FREQUENCY STABILITY	Same as line frequency for LINE, better than 5% for 90 Hz.
ATTENUATION ACCURACY	Attenuator constructed of 0.1% resistors.
ATTENUATION STABILITY	Better than 50 parts per million per °C.

2.2 CONTROLS

PULSE HEIGHT	Ten-turn potentiometer to select pulse amplitude from 0 to 10 volts unterminated. For proper rise and fall times the unused output should be terminated with 93 ohms.
NORMALIZE	Ten-turn potentiometer to permit normalizing pulse height potentiometer reading to keV or MeV; 2:1 adjustment range.
MODE	Front panel Toggle switch to select POS or NEG output polarity, or to disable the mercury relay.
FREQUENCY	Front panel toggle switch to select LINE or 90 Hz repetition rate.
ATTENUATOR	Front panel toggle switches to select X2, X5, X10, X10, X10 attenuation for attenuated output.
RISE TIME	Front panel rotary switch to select MIN, 20, 50, 100, 250 nanosecond rise time, into 93 ohms, (ATTEN output only).
FALL TIME	Front panel rotary switch to select 20, 50, 100, 200, 400 microsecond fall time constant into 93 ohms. Fall time control affects both outputs. For proper fall time constants, an attenuation factor must be selected or either of the outputs must be terminated with 93 ohms.

2.3 OUTPUTS

NORMAL	Tail pulses with amplitude 0 to ± 10 volts unterminated; fall time selected by the front panel controls; rise time always min.; used primarily for triggering purposes when observing the ATTEN(uated) output; output impedance 93 ohms. If the NORMAL output is to be observed without attenuation the ATTEN(uated) output should be properly terminated with 93 ohms.
ATTEN(uated)	Same as NORMAL output except divided by the combination of attenuation factors selected; output impedance 93 ohms. If the ATTEN(uated) output is to be observed with no attenuation factor and no termination, the NORMAL output should be terminated with 93 ohms.

2.4 POWER

+24V	–	25mA	+12V	–	20mA
- 24V	–	25mA	- 12V	–	20mA

2.5 PHYSICAL

SIZE	Standard double width module (2.70 inches wide) per TID-20893.
NET WEIGHT	2.8 lbs. (1.26 kg.).
SHIPPING WEIGHT	7.8 lbs. (3.5 kg.).

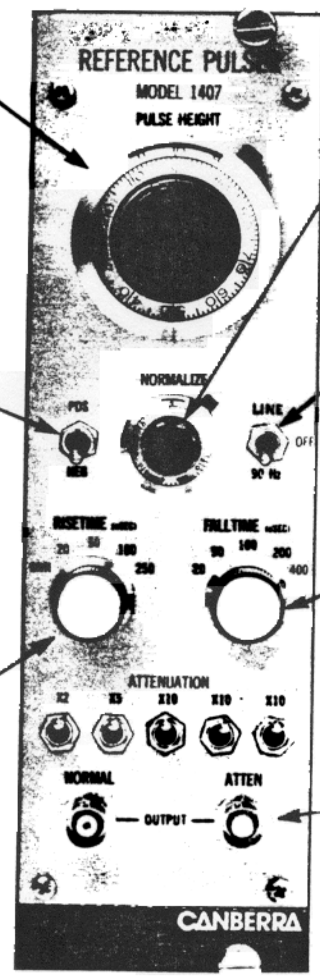
SECTION 3

CONTROLS, INDICATORS, ADJUSTMENTS, AND CONNECTORS

3.1 GENERAL

Complete understanding of the purpose of the various controls and connectors is required for the proper operation of the Model 1407, and it is recommended that this section be read before proceeding with the operation of the instrument.

3.2 FRONT PANEL (Refer to Figure 3-1.)



PULSE HEIGHT
A ten-turn potentiometer used to select output pulse amplitude between 0 and 10 volts unterminated.

NORMALIZE
A ten-turn potentiometer used to normalize the Model 1407 output so that the PULSE HEIGHT potentiometer can be read directly in keV or MeV. Use of this control is described in Section 5.1.

FREQUENCY
A front panel toggle switch used to select LINE or 90 Hz pulse repetition rate. The third position (OFF) disables the mercury relay, resulting in no output at all.

MODE
A front panel, 3-position toggle switch which selects POS or NEG output polarity.

FALL TIME
A front panel rotary switch used to select the 100% to 37% (of full amplitude) fall time of the pulse. Fall times available are 20, 50, 100, 200, and 400 microseconds.

RISE TIME
A front panel rotary switch used to select the 10% to 90% (of full amplitude) rise time of the pulse. Rise times available are 20, 50, 100, 250 and MIN(imum) nanoseconds; MIN(imum) rise time is less than 10 nanoseconds, usually on the order of 7 or 8 nanoseconds.

ATTENUATION
A front panel toggle switch used to select X2, X5, X10, X10, X10 attenuation of the output determined by the PULSE HEIGHT control. These attenuators add in a multiplicative fashion giving a maximum attenuation factor of 10,000.

OPERATING INSTRUCTIONS

4.1 GENERAL

The purpose of this section is to familiarize the user with the operation of the Model 1407 "Reference Pulse Generator" 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 INSTALLATION

The Canberra Model 2000 Bin and Power Supply or other bin and power supply systems conforming with the mechanical and electrical standards set by AEC Report TID-20893 (Rev.) will accommodate the Model 1407. The right side cover of the NIM module acts as a guide for insertion of the instrument. Secure the module in place by turning the two front panel captive screws clockwise until finger tight. *It is recommended that the NIM bin power switch be OFF whenever the module is installed or removed.*

The Model 1407 can be safely operated where the ambient air temperature is between 0°C and +50°C (+120°F maximum). Perforations in the top and bottom sides permit cooling air to circulate through the module. *When relay rack mounted along with other "heat generating" equipment, adequate clearance should be provided to allow for sufficient air flow through both the perforated top and bottom covers of the NIM bin.*

4.3 OPERATION

4.3.1 SETUP

1. Insert module in AEC compatible base unit/power supply such as Canberra Model 1400: turn on power switch.
2. Connect ATTEN(uated) output of Model 1407 to oscilloscope (2V/cm, 1 microsec/cm) with a 93 ohm termination. Also terminate the unused NORMAL output with 93 ohms.
3. Switch all ATTENUATION controls to OFF position.
4. Switch frequency control to LINE.
5. Set RISE TIME switch at 20 nsec.
6. Set FALL TIME switch at 20 μsec.
7. Set NORMALIZE control at its maximum value.
8. Set mode switch at POS(itive).

4.3.2 INITIAL CHECKOUT

1. Rotate PULSE HEIGHT control and observe amplitude of output pulse: with all attenuation switches OUT the output pulse can be varied continuously from 0 to +5 volts.
2. Switch mode control to NEG(ative) and observe that negative output is of the same absolute amplitude as when in POS mode; return mode control to POS.

3. Switch in one or more of the ATTEN(uation) controls and observe the reduced amplitude of the ATTEN output; also observe NORMAL output on oscilloscope, and notice that this output is identical to the ATTEN output except that it is unaffected by the ATTENUATION controls. The NORMAL output can be used as a trigger for the oscilloscope when observing the ATTEN output.

4. Observe effect on output pulse shape when RISE TIME and FALL TIME settings are changed; these "times" represent the time for the pulse to go from 10% to 90% of full amplitude (RISE) and from 100% to 37% (FALL).

5. With PULSE HEIGHT and ATTENUATION controls at any convenient setting, decrease the NORMALIZE control setting and observe the decreased amplitude of the output pulse. Calibration of the Model 1407 with this NORMALIZE control is covered in Section 5.1.

APPLICATIONS

5.1 CALIBRATING THE PULSER FOR ENERGY MEASUREMENTS

The Model 1407 can easily be calibrated so that the PULSE HEIGHT dial reading is equivalent to a specific MeV or keV energy loss in a radiation detector. The procedure for this is as follows:

1. Connect the spectrometer system (i.e. detector, preamplifier, amplifier, and possibly biased amplifier) to an oscilloscope or to a multichannel analyzer.

2. Connect the Model 1407 output to the test pulser input of the preamplifier.

3. Allow a source of known energy (alpha particles, for example) to radiate upon the detector.

4. Adjust the amplifier gain and the bias level of the biased amplifier to give a suitable output pulse.

5. Set the PULSE HEIGHT potentiometer at the energy of the particles striking the detector (e.g., for a 5.48 MeV alpha particle, set the dial at 548 divisions).

6. Turn on the Model 1407; using the ATTENUATION switches, the NORMALIZE potentiometer, and the RISE TIME and FALL TIME switches, adjust the pulser output to the same pulse height and shape as the pulse obtained in paragraph 4 above. The PULSE HEIGHT control setting can now be changed at will, and read directly in terms of MeV.

5.2 AMPLIFIER NOISE AND RESOLUTION MEASUREMENTS

5.2.1 GENERAL

The Model 1407 can be used to determine the noise contribution of a spectroscopy amplification system (i.e., noise due to the preamplifier and amplifier). An oscilloscope and a wide band RMS voltmeter, such as the Hewlett Packard 400E are required for this measurement.

1. Connect the Model 1407 to the preamplifier, amplifier, oscilloscope, and rms voltmeter as shown in Figure 5-1.

2. Connect a suitable capacitor to the input to simulate the detector capacitance desired.

5.2.2 OBTAINING THE RESOLUTION LOSS DUE TO SYSTEM NOISE

1. Turn on the Model 1407 Pulser and adjust the linear amplifier output to any convenient readable voltage, E_o as determined on the oscilloscope.

2. Turn off the Model 1407 and, without changing any amplifier settings, measure the rms noise voltage (E_{rms}) at the linear amplifier output.

3. For any given energy pulse, E_{dial} (where E_{dial} is the Model 1407 PULSE HEIGHT setting read directly in MeV or keV), the full width at half maximum (FWHM) resolution spread due to system noise is then: $N\ (FWHM) = 2.66\ E_{rms}\ E_{dial}/E_o$. The constant 2.66 is the correction factor for rms to FWHM (2.35) and noise to rms meter correction (1.13) for average indicating voltmeters such as the Hewlett Packard 400E.

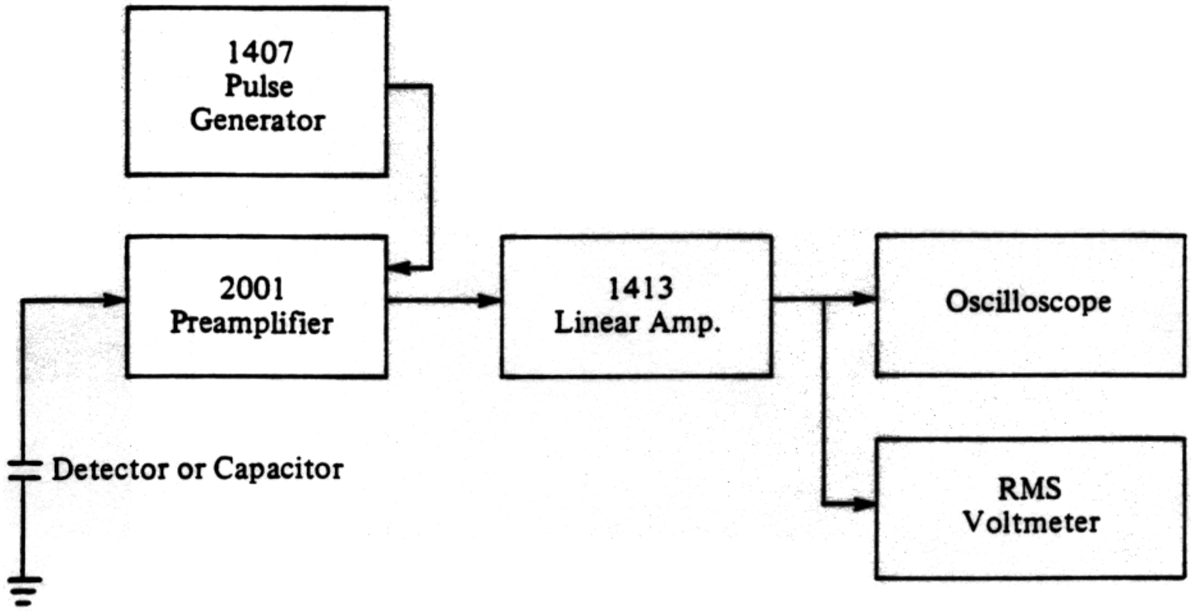


Figure 5-1. Measuring Amplifier Noise Resolution

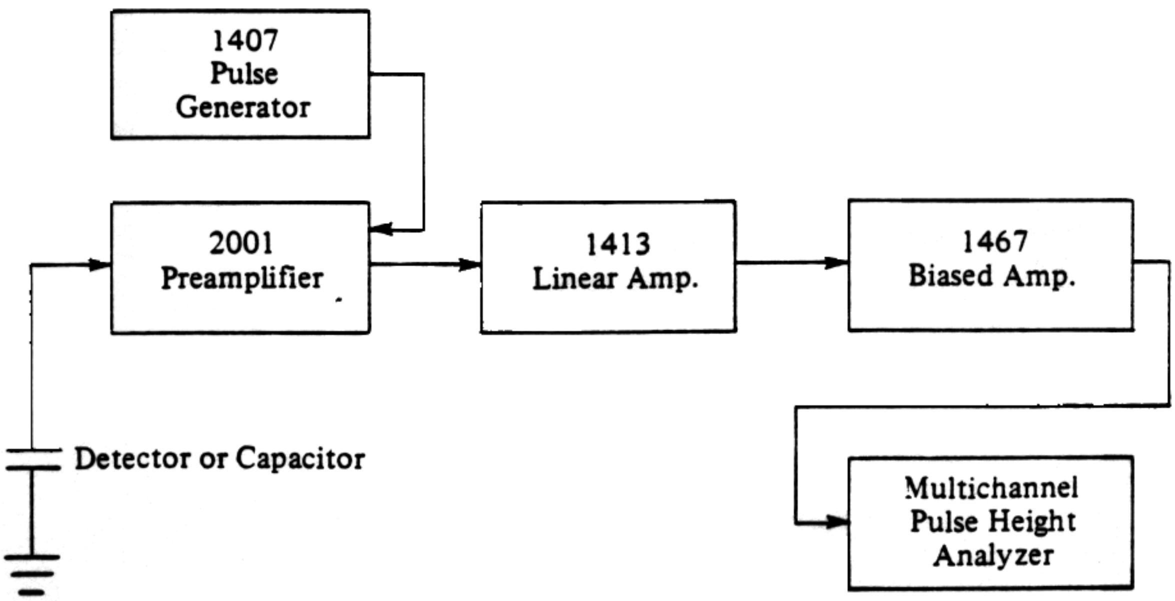


Figure 5-2. Measuring Resolution with a Pulse Height Analyzer

4. Comparing the amplifier system noise N(FWHM) to the actual resolution obtained with a detector and radioactive source, the user can now determine how much of total resolution spread is due to the detector and how much is due to the electronics.

5.3 AMPLIFIER NOISE AND RESOLUTION MEASUREMENTS USING A MULTICHANNEL ANALYZER

The amplifier system noise resolution spread can be measured most easily with a Model 1407 and a multichannel analyzer as follows:

1. Connect capacitor, preamplifier, amplifier, biased amplifier, pulser, and multichannel analyzer as shown in Figure 5-2.

2. Select the energy of interest with the Model 1407, and set the amplifier and biased amplifier controls so that the energy is in a convenient channel of the analyzer.

3. Using the Model 1407, calibrate the analyzer in keV per channel.

4. The amplifier system noise resolution spread can now be obtained by measuring the full width at half maximum peak height of the pulser spectrum.

5.4 AMPLIFIER LINEARITY MEASUREMENTS

One of the simplest and most accurate tests, amplifier linearity, can be obtained by setting up the system shown in Figure 5-3.

This test is performed by adjusting the pulser attenuator and amplifier gain so that with a ten volt high level (NORMAL) output from the pulser, the output from the amplifier is also exactly ten volts. This may be ascertained by adjusting the attenuator and amplifier gain so that the null point observed on the oscilloscope is at exactly the same level as the baseline with the highest oscilloscope vertical gain.

When this condition is obtained, turn the Model 1407 PULSE HEIGHT control down from ten 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 linearity of the amplifier under test is then equal to:

$$\frac{(\text{Maximum deviation in volts}) \times 2 \times 100\%}{10 \text{ volts}}$$

The test may be explained as follows: integral nonlinearity is the maximum deviation from the straight line plotted on an output vs. input plot from zero output to rated output (10 volts), divided by the rated output, stated as a percentage.

This calculation is performed electronically by the test described above by setting:

$$\text{Output} = (K)\ (\text{Input})$$

where K is the pulser attenuation factor (and the gain of the amplifier). 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 NORMAL Output which is related to the ATTEN(uated) output by a passive attenuator.

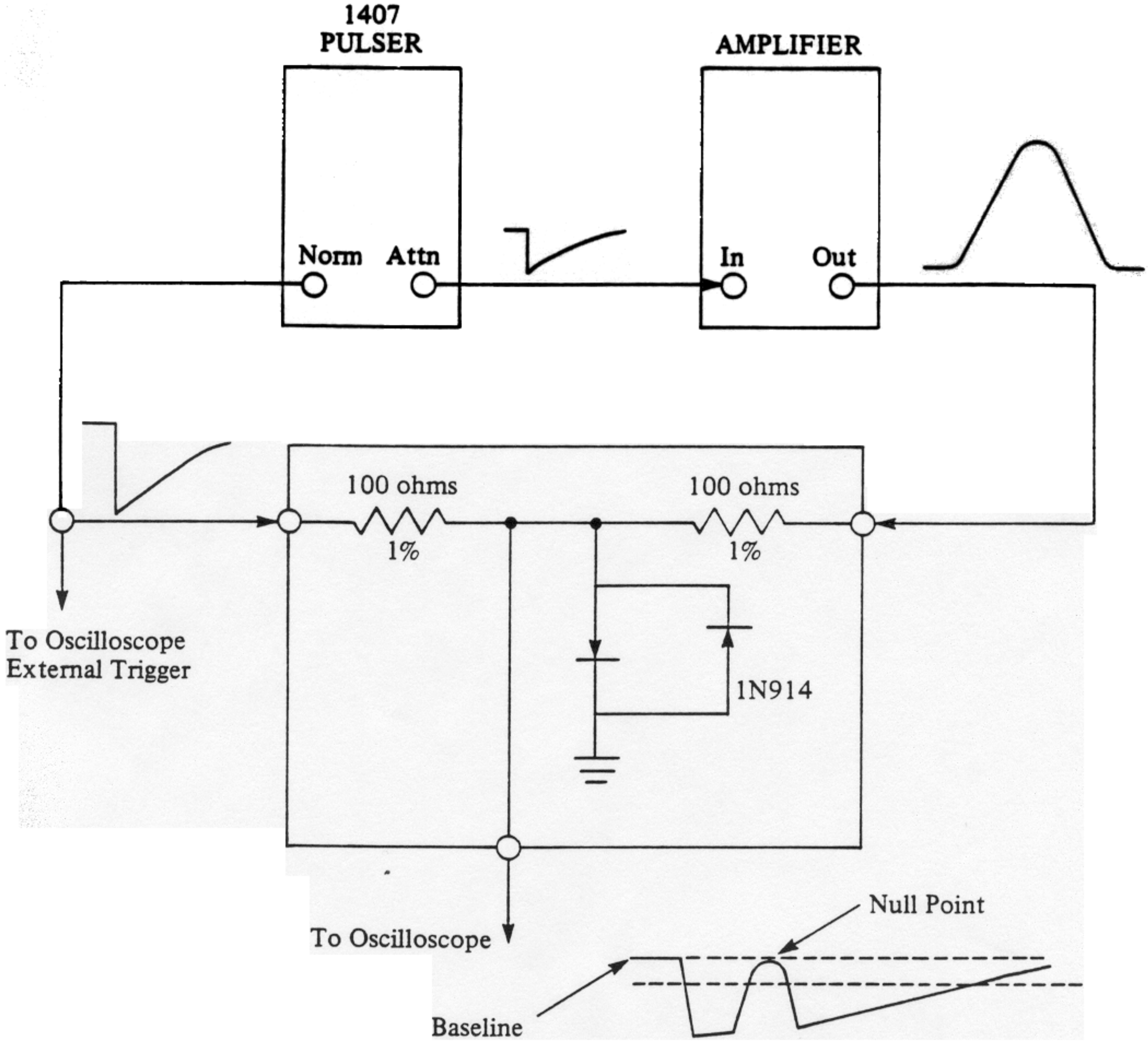

1407
PULSER
AMPLIFIER
Norm
Attn
In
Out
100 ohms
1%
100 ohms
1%
1N914
To Oscilloscope
External Trigger
To Oscilloscope
Null Point
Baseline

Figure 5-3

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 the question, because both NORMAL and ATTEN(uated) outputs will be affected identically, save for the negligible effect of the pulser's attenuator instabilities over the short time required for the test.

Instabilitites in the baseline level on the 'scope are due to oscilloscope triggering and DC level fluctuations, and need not be of concern in this test.