SINGLE CHANNEL ANALYZER
Model 2031

Instruction Manual

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Section 1
INTRODUCTION

1.1 GENERAL DESCRIPTION

The Canberra Model 2031 analyzes the peak amplitude of energy pulses from nuclear pulse shaping amplifiers, and generates its logic output (SCA) for input analog pulses between the levels referenced by the LOWER LEVEL (E) and WINDOW (ΔE) front panel ten-turn controls. Timing is set as the trailing edge of the input signal crosses the (E) reference.

The SCA output may be used to assist in a wide variety of applications from simple noise removal to extraction of a narrow energy range from a wide spectrum of signals for energy analysis. The sharp, precise threshold discrimination levels are exceptionally stable (drift less than ± 0.005%/°C, full scale). The DC coupled input allows excellent baseline stability limited only by the shaping amplifier's restorer. These significant features permit excellent amplitude discrimination, even in high count rate spectra.

The LOWER LEVEL (E) threshold is calibrated by reference to the regulated NIM supply voltages, and is usable over the range from +0.02VDC to +10.0VDC. Linearity of control is limited only by the specified ± 0.25% maximum nonlinearity of the front panel potentiometer.

The WINDOW (ΔE) threshold is also calibrated by reference to the regulated NIM supply voltages, and is usable over the range from the LOWER LEVEL (E) setting to +10.0VDC. A front panel ΔE RANGE switch allows use of a 1.0 volt full scale range for very fine adjustments of the desired window.

The SCA output logic signal is positive logic and is adjustable in peak amplitude for compatibility with interfacing instruments. The output is source matched with a 50 ohm series resistive termination to prevent ringing due to reflections on an unterminated cable, and the resulting multiple counting frequently experienced. The instrument is shipped with a socketed resistor which limits the output to +5V nominal (open circuit) for direct interface with common TTL circuitry. The user may remove the resistor (1 for each output) to obtain a +8V nominal open circuit voltage for instruments requiring the NIM pulse level, or +4V nominal into the 50 ohm load termination which some other instruments provide. This flexibility allows the user to adapt the output signal to his needs without risking the problem encountered with improperly driven cables.

Careful attention has been paid to minimize reflections of the fast logic pulses back onto the analog input. Thus the logic output is isolated from chassis to prevent circulating pulse currents in the instrument Bin.

1.2 APPLICATIONS:

The Model 2031 SCA is most useful in Spectroscopy systems requiring precise, stable energy discrimination of detected nuclear events.

The logic output may be used in counting, noise stripping or narrow window analysis where specific timing of successive events is of secondary significance. A common application of the SCA is in conjunction with a counter/timer, where the energy discrimination function will confine the counter to a desired spectrum.

In conjunction with a multichannel analyzer (MCA) and delay unit, an added energy discrimination path provided by the SCA allows the MCA to be gated only on an acceptible energy signal. This reduces the overload and system dead time for the MCA, and allows for higher signal resolution.

The output may also be useful for monitoring or control purposes (e.g., detection of cosmic overloading pulses in a sensitive experiment), or other needs of the creative experimenter.

Section 2
SPECIFICATIONS

2.1 INPUTS

SIGNAL INPUT	Amplitude: positive unipolar or bipolar (positive lobe leading), 0.02 to 10.0VDC. Pulse Width: 0.2 to 40 microseconds at half maximum (equivalent to active RC shaping of 0.1 to 20 microseconds). Input impedance: 1 K ohms.

2.2 OUTPUTS

SCA	Amplitude: positive logic +5VDC nominal. Adjustable to +8VDC nominal by removing socketed resistor. Pulse width: 0.5 microseconds nominal. Rise and fall time: less than 25 nanoseconds. Output impedance: 50 ohms, series connected. Timing reference: trailing edge of input signal crossing LLD reference.

2.3 PERFORMANCE

DISCRIMINATOR NONLINEARITY	less than ± 0.25% of full scale.
DISCRIMINATOR STABILITY	better than ± 0.005%/^{o}C (± 50 ppm/^{o}C) of full scale averaged over 0-50^{o}C ambient range, referenced to NIM class A supply +12.0VDC line.
DISCRIMINATOR RANGE	better than 500:1
DISCRIMINATOR PULSE PAIR RESOLUTION	less than 0.65 microseconds, typical

2.4 CONTROLS

LOWER LEVEL (E)	Front panel ten turn dial potentiometer. Control range +0.02 to +10.0VDC.
WINDOW (ΔE)	Front panel ten turn dial potentiometer. Control range from setting of LOWER LEVEL (E) control to +10.0VDC
ΔE RANGE	Front panel toggle switch 1v or 10v window width.

2.5 CONNECTORS

All signal connectors are BNC, UG-1094/U. SCA outputs are isolated from chassis panels.

2.6 POWER REQUIREMENTS

+12VDC	–	135mADC
-12VDC	–	5mADC

2.7 PHYSICAL

SIZE	Standard single width module 1.35 inches wide by 8.714 inches high (3.42 cm x 22.13 cm) per TID-20893 (rev.)
WEIGHT	1.3 lb (0.8 kg.)

Section 3
CONTROLS AND ADJUSTMENTS

3.1 GENERAL

This section describes the functions of the controls, and the adjustments which the user can make, in the Model 2031, SCA. It is recommended that this section be read before proceeding with operation of the instrument.

3.2 FRONT PANEL CONTROLS

The LOWER LEVEL (E) control is a ten turn dial potentiometer which provides the reference voltage for the Lower Level Discriminator. When the input pulse signal exceeds this baseline level, an LLD logic pulse is generated internally. The indicator is scaled linearly for the 0-10VDC rated input signal range of the instrument.

The WINDOW (ΔE) control is also a ten turn dial potentiometer. Its voltage is summed with that provided by the LOWER LEVEL (E) control to provide the reference voltage for the Upper Level Discriminator. An input signal exceeding this level generates a ULD logic pulse. An input signal which exceeds the LLD but not the ULD generates the logical SCA output.

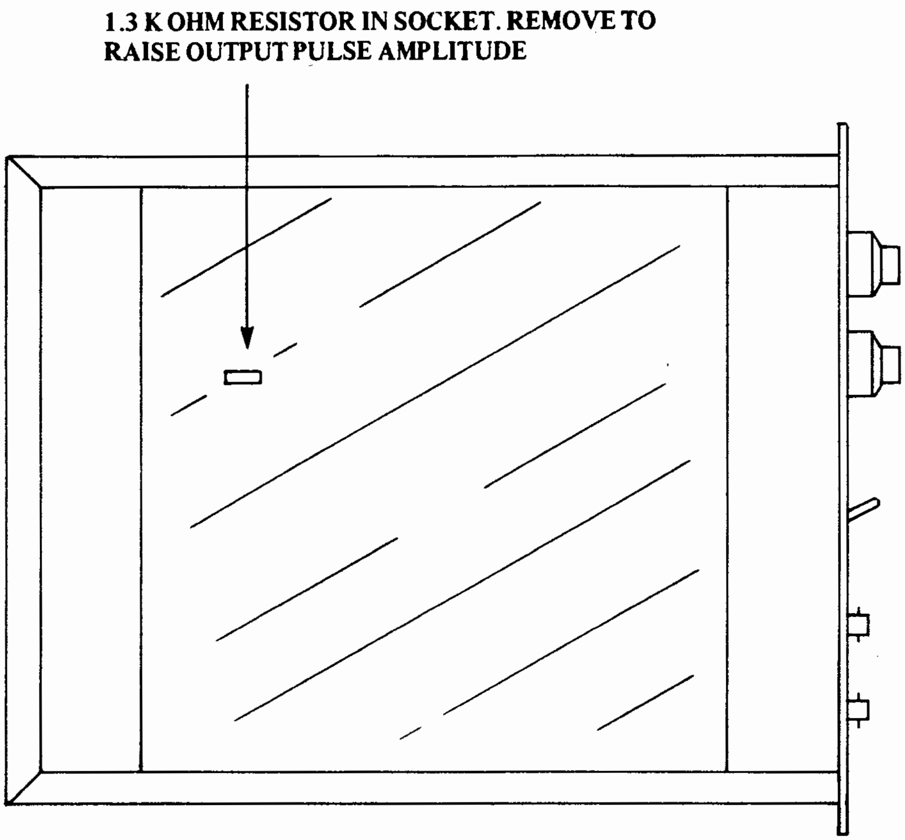
The ΔE RANGE switch simply sets the full rotation range of the WINDOW (ΔE) control as 1.0VDC or 10.0VDC.

3.3 INTERNAL ADJUSTMENTS

The trimming potentiometers internal to the instrument are carefully calibrated during factory test to provide the precise low end and full scale limits for the front panel controls. The user should normally have no need to readjust these, but if adjustments are necessary, the setup and general procedure in Section 4 should be followed. The functions of the trimming potentiometers are as follows:

RV1:	Full Scale Adjust for WINDOW (ΔE)
RV2:	Full Scale Adjust for LOWER LEVEL (E)
RV3:	Full Scale Adjust for 1V RANGE (ΔE)
RV4:	Low End Adjust for WINDOW (ΔE)
RV5:	Transfer Gain Adjust for (E) + (ΔE)
RV6:	Low End Adjust for LOWER LEVEL (E)

The adjustments for output pulse voltage level can be found on the printed circuit board at the rear of the unit (see sketch below). The unit is shipped with a socketed 1.3 K ohm carbon resistor. With the resistor installed the output pulse is clamped at +5VDC nominal, open circuit. With the resistor removed, the output voltage will be +8VDC nominal open circuit, and +4VDC nominal into a 50 ohm load.



INTERNAL VIEW, LEFT SIDE

Section 4
OPERATING INSTRUCTIONS

4.1 GENERAL

The purpose of this section is to familiarize the user with the Model 2031 SCA, 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 this instrument to permit its proper use in the system at hand.

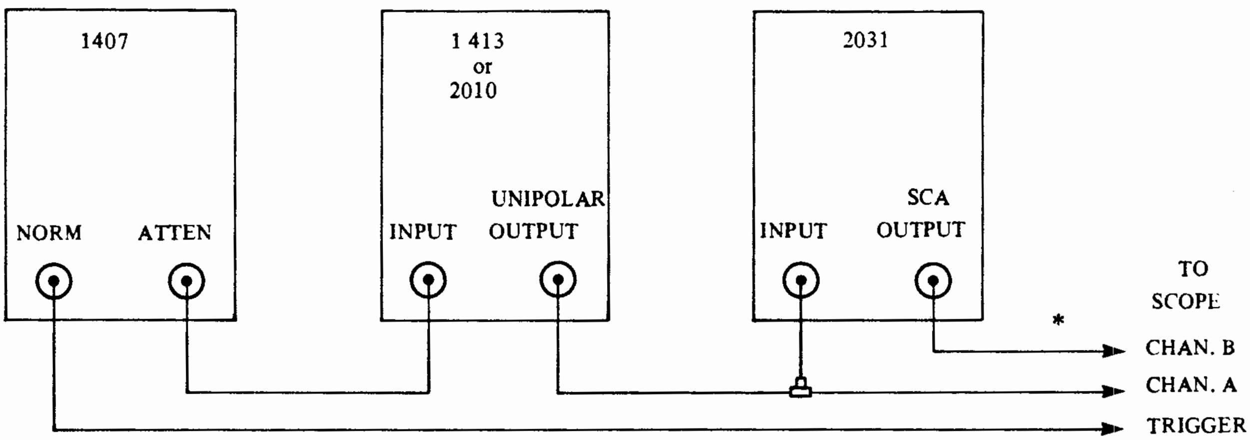
4.2 INITIAL SETUP

In order to perform the bench checkout procedure below, the following equipment (or equivalents) will be required:

Canberra Model 2000 Bin/Power Supply
Canberra Model 1407 Tail Pulse Generator
Canberra Model 1413 or 2010 Spectroscopy Amplifier
Calibrated Dual trace oscilloscope (Tektronix 453, 465, etc.)

Install the Models 2031, 1407, and 1413 or 2010 in the Bin, with the power initially OFF.

Interconnect the units as shown below:



Cables are RG-62/U, except * is RG-58/U

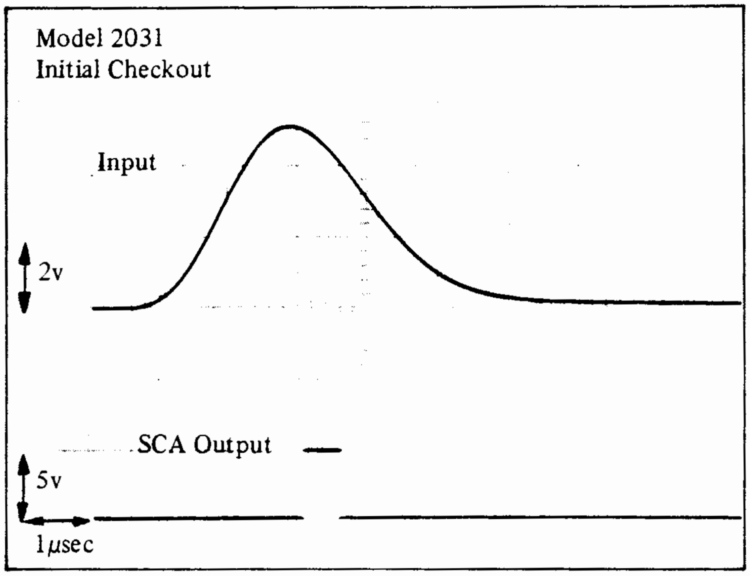
Reference control settings:

Model 1407	to positive polarity, 50μsec. fall time, PULSE HEIGHT and attenuation as necessary.
Model 1413 or 2010	to x10 coarse gain, 1 microsecond shaping, restorer low. Pole/Zero trimmed to 1407.
Model 2030:	LOWER LEVEL (E) to 5.00, WINDOW (ΔE) to 1.00, ΔE RANGE switch to 10v, LLD REF MODE switch to INT.

SCOPE: Channel A: 2v/cm
Channel B: 5v/cm
Time Base 1μsec/cm, externally triggered.

4.3 INITIAL CHECKOUT

Apply power to the Bin, and set the 1407 to 90Hz rate. Increase the amplifier output slowly until an SCA output pulse appears. Verify the peak amplitude of the input signal to be approximately 5v. Typical scope waveforms are shown in the photo below.

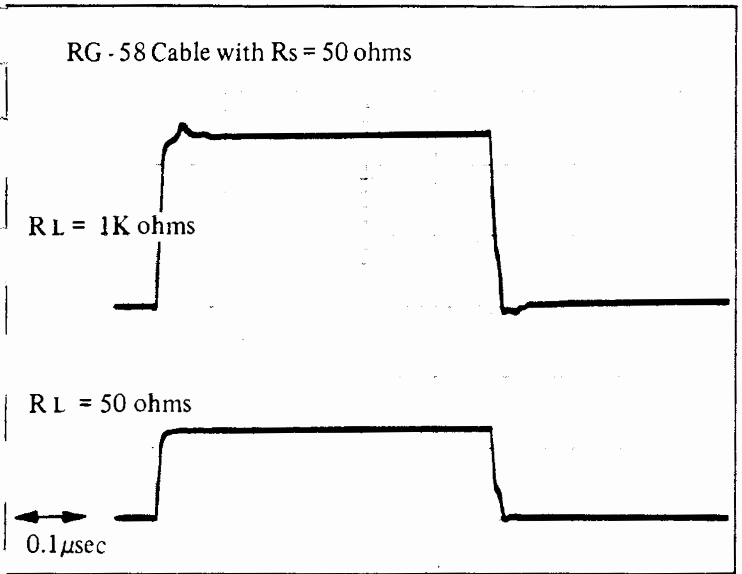


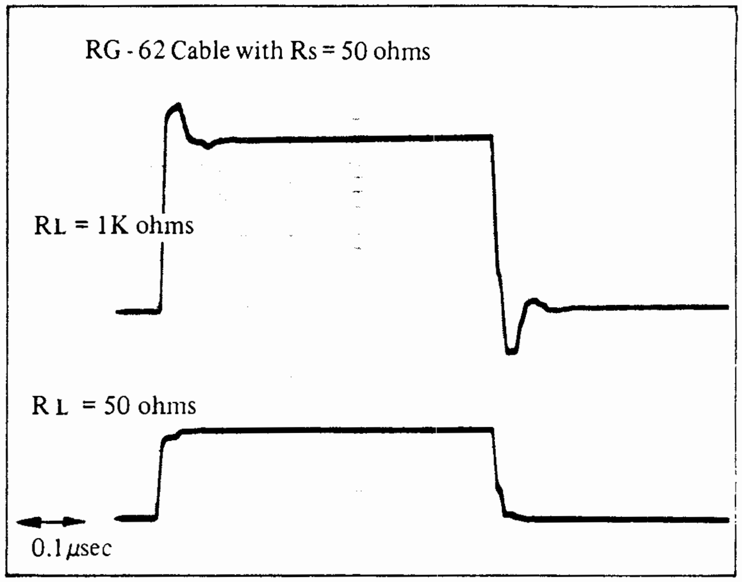
Now increase the amplifier output further until the SCA output pulse disappears. Verify the peak amplitude of the input signal to be approximately 6v.

As the Model 2031 has been carefully calibrated in factory test, the precision of this casual examination is limited by the calibration of the user's oscilloscope. The instrument may be exercised over its full rated range with this setup if the user wishes, but adjustments of internal trimpots should not be attempted without a more exacting test technique.

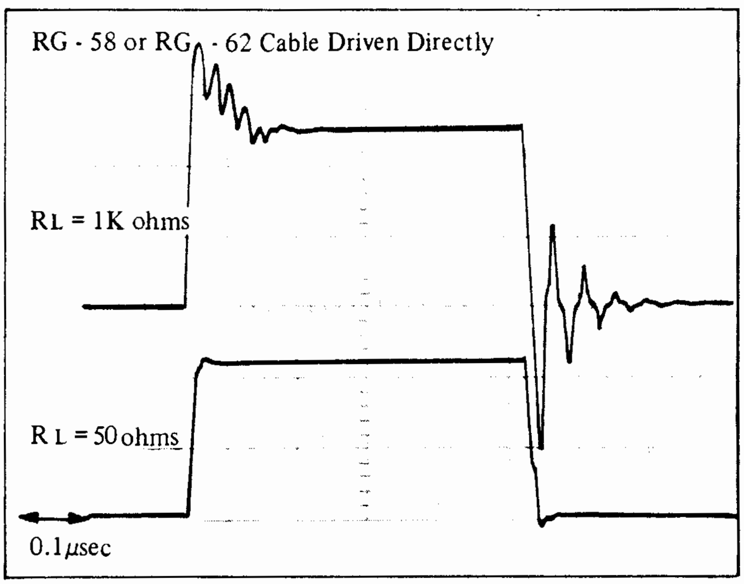
4.4 REFERENCE DATA ON CABLES

The following photographs depict a typical output pulse at the load end of the designated RG-58/U cable, and the same point using RG-62 cable. In each case the photographs illustrate high impedance (1 K ohm) and 50 ohm termination conditions. Clearly the fastest, cleanest pulse is realized with the RG-58/U cable. With the source match provided, loading effects are limited to amplitude changes only. RG-58/U cable is therefore recommended for best compatibility with the SCA output.





The picture below illustrates the same pulses with a source mismatch caused by driving the cables with the transistor switches directly. The waveforms indicate how important and effective source matching is in eliminating instabilities which cause phenomena such as multiple counting or triggering. For this reason the Model 2031 provides source matched outputs, and load end terminations are not necessary.



Section 5
THEORY OF OPERATION

5.1 GENERAL

The Model 2031 SCA analyzes energy pulses from spectroscopy shaping amplifiers by comparing the peak voltage levels of those input pulses against stable D.C. reference voltages set by the front panel controls. Comparisons are made for a lower level discrimination (LLD), and an upper level discrimination (ULD). Pulses between the two levels (within the window) are recognized as the SCA output.

5.2 DISCRIMINATORS

The pulse discrimination takes place in the precision dual comparator A5. The LLD reference voltage for the comparator is of course set by the LOWER LEVEL (E) front panel control. A4, as a voltage follower, prevents loading of the potentiometer. A2 sums the voltages set by the LOWER LEVEL (E) and WINDOW (ΔE) front panel controls and provides the ULD reference voltage. RV5 adjusts the summing gain precisely to allow correct adjustment of the window. The other RV adjustments are for full scale range or low end (offset) corrections.

The LLD output is taken at pin 12 of A4, which yields a positive pulse whose width represents the time span in which the input signal exceeds the reference.

The ULD output is taken at pin 7 of A5, which also yields a positive pulse whose width represents the time span in which the input signal exceeds that reference.

The input signal to both comparator sections is DC terminated, and divided to a voltage consistent with the differential rating of the component. Over-voltages are diode clamped to +6v and - 1v nominal.

5.3 LOGIC AND TIMING

The trailing edge of the LLD signal on A5 pin 5 is used to initiate the one-shot A3. This one-shot is set for a 0.5 microsecond nominal pulse, and enables the SCA output. The output on pin 5, pulsing high, is gated with the outputs of the R-S latch formed by A1a and A1d. If the latch was just tripped because the input pulse exceeded the ULD threshold as outputted at A5 pin 7, then A1b would logically AND to a low pulse at A1 pin 6, and yield no output pulse. If the latch was not tripped, the logical AND would occur thru A1c pulsing low at A1 pin 8, thereby yielding the SCA output pulse.

As the 0.5 microsecond nominal pulse terminates, the second one-shot in A3 is triggered (pin 1). This pulse is nominally 0.1 microsecond wide (pin 4 low), sufficient to reset the ULD latch prior to the next pulse input. Pulse pair resolution is of course limited directly by the sum of these two periods.

5.4 OUTPUT CIRCUITS

The output circuit design is a variant on the conventional totem pole which permits limiting the output pulse amplitude simply without affecting speed of response. The active high-active low circuit also permits proper output termination for driving 50 ohm cable with fast pulses with minimal radiation and reflection problems, and assures protection of the circuit from accidental load faults.

As described in Section 3.3 the user may adjust the output pulse voltage to his requirements quite simply by using the socketed resistor.