Supplemental Instructions for $\gamma\gamma$ Coincidence with ^{22}Na

Overview of the Experiment

^{22}Na is a radioactive element that decays by converting a proton into a neutron. This process can be done through the β^+ decay or the electron capture(EC) process. In the β^+ decay that you will study today, the proton decays into a neutron by emitting a positron (β^+) and neutrino (ν_e). The positron will annihilate with an electron and produce two photons at 180^o to each other. The goal of this experiment is to measure gamma rays and determine this very specific angular correlation experimentally.

To detect gamma rays, you will use two scintillation counters. When a gamma ray is incident upon the scintillation crystal that is sealed within the aluminum casing, electron showers are produced which cause the crystal to scintillate or create photons in a given spectrum. These photons will travel into the photo-multiplier tube (PMT), the brown portion of detector, where the photons are converted into electrons to generate a small signal. The PMT requires a large voltage (900V) in order to generate the electron showers so please be careful when handling them. The generated signal is quite weak (on the order of milliVolts) and requires amplification, which is handled by the preamplifier base. Two cables are connected to the pre-amp base: the HV power cable and the signal coaxial cable. The HV cable plugs into the Ortec 556 HV Power Supply (HVPS). The HV cable from both detectors plug into the same HV supply.

Each detector's signal cable plugs into a "Spectroscopy Amplifier" (Canberra 2020). A detailed description of the nature of amplifiers, in our case a Semi-Gaussian Pulse Shaper, can be found with the lab handout (p65). The specifics about the Canberra 2020 can also be found in the handout (p107). Generally speaking, the amplifier takes the signal and provides a nice, smooth, semi-gaussian shape of specific time width, amplified to a desired voltage. In this experiment, you will amplify your signals until the most energetic gamma ray, at 1.274 MeV, is at 6V. An important fact to note: once the amplification is set, there is a linear relation between voltage on the oscilloscope and the energy of the detected gamma ray.

To properly measure the coincidence, you need to select the signal that came from the positron annihilation (a 511keV gamma ray). This selection can be done with the Single Channel Analyzer (SCA). You will be using two models of SCAs but they both operate the same. A detailed description of the Ortec 551 SCA is included with the lab handout on p255 and the more general SCA description is on p249. In the operating mode used for this experiment, the lower level setting defines a minimum energy requirement. The upper level setting defines a maximum energy requirement. When a signal within the energy "window" is received, a "TRUE" logic pulse is sent through the SCA output. By adjusting the settings properly, you can define a small window about the 511 keV gamma ray and thereby selecting only annihilation photons.

With the two detectors selecting only 511 keV photons, you need to count how many times both detectors see a photon, or how often are the two signals in coincidence. A universal coincidence module will be used (description on p336). If two "TRUE" pulses are received in a certain time window by the coincidence module, the coincidence module will send out another "TRUE" pulse. These output pulses are then counted by the scalar module. Since you are trying to measure the rate of coincidence, you must keep track of the time while the scalar is counting.

Setting the correct amplification (step 2)

The PMT signal enters the Spectroscopy Amplifier through a connection in the back of the NIM module. In the front, the two dials at the top of the module adjust the amplification. The unit has a unipolar and bipolar output that is well described in the lab handout. For this experiment, you will use the unipolar output. You should connect the output to channel 1 on the analog oscilloscope. The channel 1 setting should be 2V/division. The trigger mode should be internal and set to trigger on channel 1. The time scale should be set to about 10μs.

At this point, you need to make sure all the settings on your HVPS and Spec Amp are at their lowest voltage and amplification settings. Now, you should set the voltage to 900V on the HVPS. If the scope is triggering properly, you will see multiple faint traces on the left side of the screen that seem to be shifting and constantly changing. Depending on the amplification, you may need to adjust the channel 1 setting to 1V/division or 0.5V/division initially. If the trace is difficult to see, you may need to block out some of the room lights to see the faint traces.

The more often a trace occurs, the brighter it will appear on the analog scope. If you refer to figure 13.2 in the lab handout, you will notice that the 0.511 MeV peak occurs more frequently in the ^{22}Na spectrum. Therefore, the brightest trace you see on the scope is the 0.511 MeV signal. If you block out enough light, you will notice a trace with a peak voltage about 2-3 times larger than the 0.511 MeV signal, but it will be about one-third as bright. That peak is the 1.274 MeV peak. On the Spec Amp, you should adjust the magnification knob so the 1.274 MeV peak is about 6V. You will need to repeat this procedure for both PMT/Spec Amp signals.

Calibrating the Single Channel Analyzer (step 3)

Leaving the settings from above intact, you need to connect the Spec Amp unipolar output to the SCA input and to the delay generator. The delay generator merely delays a signal by the specified amount. The delay generator output is then connected to Channel 1 on your oscilloscope. You should set your delay generator to delay the signal by 2μs. The output of the SCA should be connected to the External Trigger on the oscilloscope. The SCA "Lower Level" should be set to 0.0 (the minimum) and the "Upper Level" should be set to 10.0 (the maximum). The delay should be set to 0.0 (the minimum) as well.

A short explanation of the above setup should enlighten you as to its purpose. The oscilloscope basically functions as an ultra-fast, electronic camera that takes pictures of a signal when it's trigger is fired. The trigger in the scope merely checks to see if the signal has crossed the "trigger level" in the appropriate direction (positive or negative slope, depending on the scope setting). For example, if you are measuring a 2V peak-to-peak sine wave and have set the trigger level at 0.5V on the rising slope, the beginning of the scope trace will be at 0.5V on the far left of the screen and increase to 1V before turning over and proceeding in a sinusoidal fashion. You can see this with the setup above by setting the scope to trigger "internally" on channel 1. The traces shown on the scope are triggered by anything that passes above the trigger level.

However, you need to select a region around the 0.511 keV signal (the brightest trace) with the SCA. You will use the scope's external trigger capability to do this. Instead of internally deciding when to "take the picture", the scope can be told when to take it by the use of an external trigger. Our external trigger will be the output from the SCA. If you will recall from the introduction section, the SCA sends a TRUE pulse whenever the input signal falls within a specified range. If you set that range to select the 0.511 MeV signal, the external trigger will force the scope to only take pictures of those signals.

There are two complications. The first problem is that you don't know what is the setting range on the SCA. To deal with this, you will start with SCA settings at the maximum window range. As you watch the trace and change the settings, you will slowly begin to notice some traces disappearing permanently as you "close the window" around the target peak of 0.511 MeV.

Second, I failed to mention one small little detail about the SCA. The device is not omniscient. It does not know before hand (*a priori* is a phrase you will hear many times in physics) if a signal is in the right range or not. Therefore, it will take some time to decide whether or not to send a TRUE pulse. To account for this delay, as you may have guessed, you will use the delay generator to slow the arrival of the source signal in order for the SCA to decide if it qualifies. Without delaying the signal, the SCA TRUE pulse would tell the scope to take the picture too late and you would only see the very end of the signal, which will not help you select the 0.511 MeV signal. You can observe this late triggering directly by setting the delay generator to 0.0μs and use the external trigger on the scope.

Now, on with the show. With the SCA settings at their widest value, the scope trigger should be set to external. You should notice that the signal trace is more towards the center of the scope screen because of the delay we have put into the system. You should begin by lowering the "Upper Level" until you reach a region somewhat above the bright trace (0.511 MeV). Then, you should raise the "Lower Level" until the traces below the bright peak are gone. Once you have one channel set (i.e. one PMT/Spec Amp/SCA), you should proceed to do the same procedure on the second channel.

Using the coincidence module (a.k.a. "We've wired it up the way it said to, but the rate is so slow. We'll be here forever!")

In general, it is difficult to find two NIM modules (the electronics used in this experiment) that work at the same exact rate. Therefore, one combination of modules will work faster than another. As a result, coincidence measurements could be very difficult to make. Fortunately, physicists have known about these problems for the past 50 years. Each SCA module has a delay generator built into them. By adjusting one module, the signal can be made to arrive at the same time as another module.

The best way to do this involves using the digital oscilloscope. You will need to connect both SCA outputs into the scope (channel 1 and channel 2). The scope should be set to trigger on channel 1 and to display both traces. In this configuration, you will constantly see the channel 1 TRUE pulse but occasionally you will see the channel two TRUE pulse. Most likely, they will not be at the same time, or same horizontal position on the screen. You can adjust the delay on either of the modules to line up the two signals to arrive at approximately the same time.

EXPERIMENT 13

Gamma-Gamma Coincidence

EQUIPMENT NEEDED FROM EG&G ORTEC

- Two 113 Scintillation Preamplifiers
- Two 266 Photomultiplier Tube Bases
- Two Bins and Power Supplies
- Two 551 Timing Single-Channel Analyzers
- 426 Linear Gate
- 567 Time-to-Amplitude Converter and SCA
- Two 556 High Voltage Power Supplies
- 480 Pulser
- 418A Universal Coincidence
- 875 Counter
- Two 575A Amplifiers
- 427A Delay Amplifier
- 719 Timer
- Two 905-3 NaI(Tl) 2- x 2-in. Scintillation Detectors and PM Tubes
- ACE-2K MCA System including suitable IBM PC (other EG&G ORTEC MCAs may be used)
- Oscilloscope
- 10-μCi ^{22}Na source
- Source Kit SK-1G
- 306 Gamma-Gamma Angular Correlation Table with rotating detector and shields
- ORC-13 Cable Set

Purpose

Two annihilation quanta are radiated from a ^{22}Na source in coincidence with each other for each radiation event that will be measured in this experiment. The purpose of the experiment is to verify that these quanta emanate from the source with an angular separation of 180°.

Introduction

Sodium-22 is an excellent source for a simple gamma-gamma coincidence experiment. The decay scheme for this isotope is shown in Fig. 13.1. From the decay scheme it can be seen that 99.95% of the time the decay occurs by positron emission and electron capture through the 1.274-MeV state of ^{22}Ne. Ninety percent of these decay events occur with positron emission, which then annihilate and produce a pair of 0.511-MeV gamma rays that can be seen in the gamma spectrum.

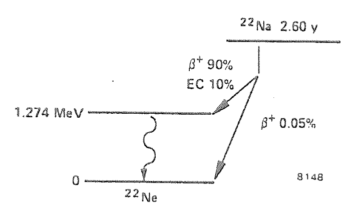


Fig. 13.1. Decay Scheme for ^{22}Na.

Figure 13.2 shows a typical gamma spectrum for ^{22}Na that was obtained with an NaI(Tl) detector. The 0.511-MeV peak will usually be quite a bit more intense than the 1.274-MeV peak, primarily because of the detector efficiency differences at the two energy levels (see Experiment 3) and the annihilation process.

Figure 13.3 shows a typical instrument configuration for measuring a gamma-gamma coincidence. The ^{22}Na source is usually covered with a thin absorber such as a thin piece of metal or plastic. Positrons from the source will lose energy in the absorber by dE/dx and will be annihilated in the absorber. The NaI(Tl) detectors will see an approximate point source of radiation. When the positrons are annihilated, two 0.511-MeV gammas will leave the source with an angular separation of 180°.

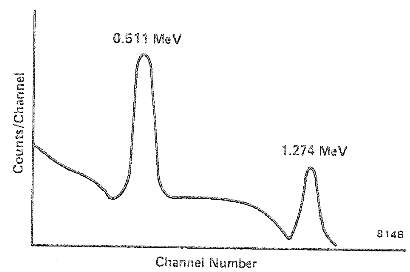


Fig. 13.2. NaI(Tl) Spectrum of ^{22}Na.

Experimentally this pair of gamma rays is detected and measured with one detector that is fixed and another detector that can rotate about the source. Figure 13.4 shows some of the details of a rotating assembly that is used for the experiment.

The ^{22}Na coincidence experiment will use three different electronic system configurations. In the first, the events that enter the two detectors will have to produce pulses that overlap each other to indicate that a coincidence exists, and the counter will then count the number of coincidences that are sensed during its timed counting interval. In the second, a pulse from the movable detector will enable the gate of the 426 Linear Gate, and any corresponding pulse from the fixed detector that arrives within the adjusted gate width interval will be considered coincident and will be counted in the counter. In the third setup, the 567 Time-to-Amplitude Converter, (TAC), and SCA will be used to measure the variations in time at which the coincident events are sensed by the two detectors; a counter can count all of the coincidences that occur within about a 500-ns range, and then an MCA can be used to obtain a spectrum of the precise timing variations.

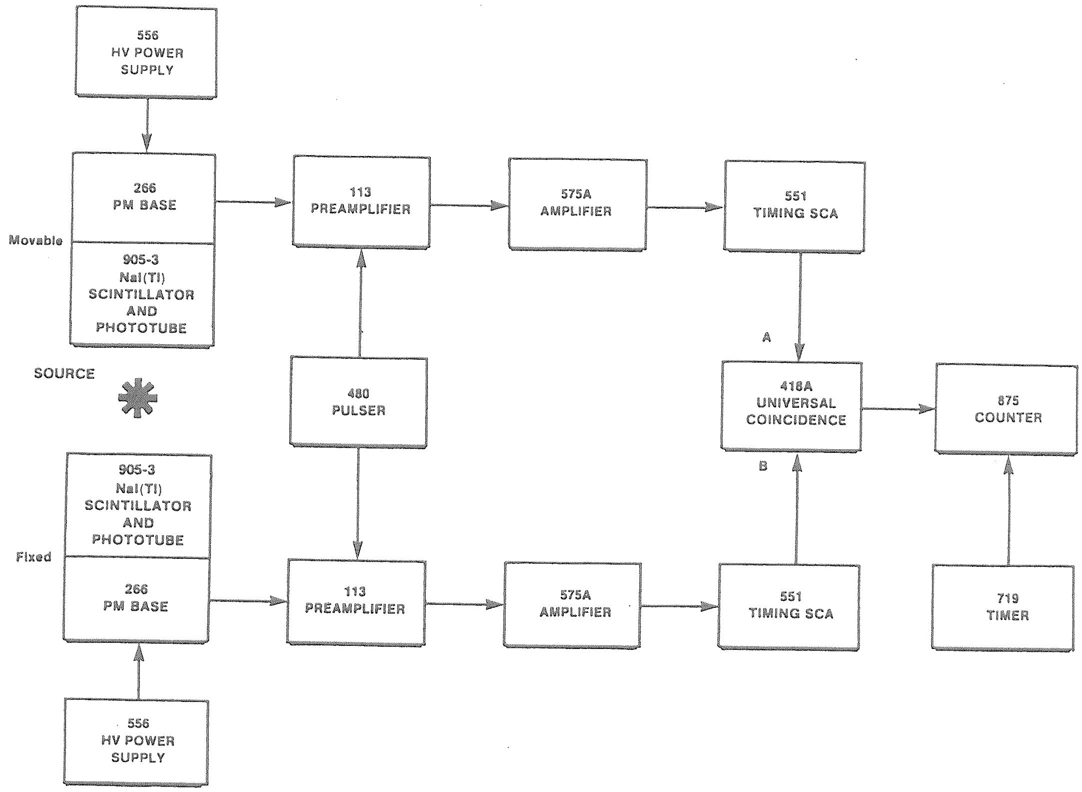


Fig. 13.3. Electronics for Experiment 13.1.

The student should complete Experiment 9 before starting this experiment and should be somewhat familiar with the principles of coincidence measurements.

EXPERIMENT 13.1

Overlap Coincidence Method for Measuring Gamma-Gamma Coincidence of ^{22}Na

Procedure

1. Set up the electronics as shown in Fig. 13.3. Use Fig. 13.4 as a guide to arranging the two detectors.

2. Set the 575A Amplifiers for negative input and unipolar output. Adjust the gain of both amplifiers so that the 1.274-MeV line of ^{22}Na results in ~6 V pulses at the outputs.

3. Set the 551 Timing SCAs for Integral mode. Set the Delay controls at minimum and the Lower-Level dials at 40/1000. Use the SCA outputs.

4. Connect the SCA Out from one of the 551 Timing SCAs to the A input of the 418A and connect the output from the other 551 to the B input of the 418A. Set the 418A Coincidence Requirements switch at 2 and the Resolving Time at maximum (2 μs). Set the A and B toggle switches at Coinc and set the C, D, and E toggle switches at Off. With the source removed and the 480 Pulser turned on, the 418A output will indicate coincidence for the two signal paths. Turn off the 480 and return the source.

5. Set the 719 Timer for a long timing period, such as 8 min, and permit the 875 Counter to operate while the movable detector is rotated slowly to both sides of 0°. The counting rate should be maximum at $\theta = 0°$.

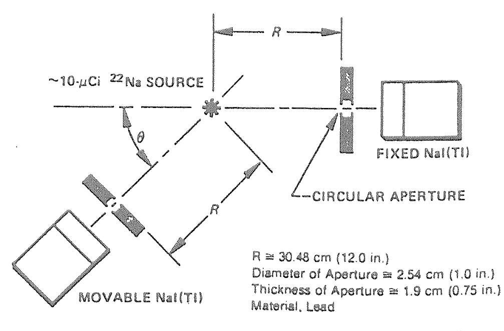


Fig. 13.4. Mechanical Arrangement of Detectors on EG&G ORTEC 306 Angular Correlation Table.

6. Set the timer for a long enough accumulation period to provide reasonable statistics at the points of interest and fill in the values in Table 13.1.

EXERCISE

Plot the data in Table 13.1 on linear graph paper. For each counting rate, (N), the statistical variation $\pm\sqrt{N}$ should be included on the graph. Figure 13.5 shows a typical set of data for this experiment.

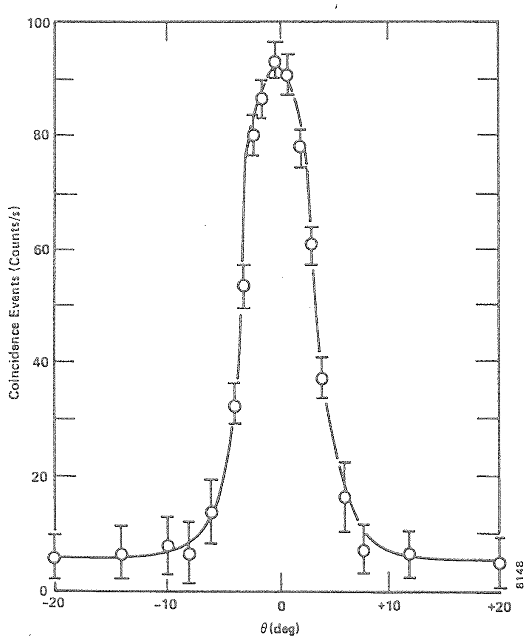


Fig. 13.5. Coincidence Data.

Table 13.1

θ (deg) Positive	Counts/s	θ (deg) Negative	Counts/s
0		0	
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	
8		8	
10		10	
14		14	
20		20	
25		25	

EXPERIMENT 13.2

Linear Gate Method for Measuring Gamma-Gamma Coincidence of ^{22}Na

Procedure

1. Set up the electronics as shown in Fig. 13.6. Use the same mechanical detector placement as in Experiment 13.1.

2. Using the ^{22}Na source, adjust the gain of each 575A Amplifier for an output of ~6 V for the 1.274-MeV gamma line.

3. Remove the source. Turn on the pulse generator and adjust the Pulse-Height dial, the Cal control, and the attenuators so that the amplifier output pulses are the same as in step 2.

4. Look at the output of the 426 Linear Gate with the oscilloscope. If the timing is correct, a unipolar pulse should be observed whose amplitude is proportional to the pulse-height dial setting on the 480. Vary the pulse height and see that there is a linear response. If no output pulses are seen from the 426, adjust the Delay time of the 551 on the movable detector side and recheck the Gate Width control on the 426 until output pulses are seen normally.

5. Turn off the pulser and return the ^{22}Na source to its proper position as shown in Fig. 13.4. Measure the angular distribution of pulse rates from the system as in Experiment 13.1, using the angles in Table 13.1.

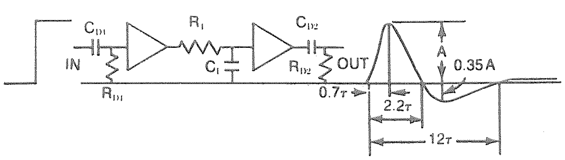
6. (Alternate) The output of the Linear Gate can be fed into an MCA. The spectrum should resemble Fig. 13.2 except that the 1.274-MeV peak will not be present. The coincidence requirement has virtually eliminated this peak from the spectrum.

EXERCISE

Plot the data on linear graph paper as in Experiment 13.1. Compare the count rates at $\theta = 0°$.

Si(Li) detectors is achieved at much longer time constants (in the range from 6 to 20 μs). Such long time constants impose a severe restriction on the counting rate capability. Consequently, energy resolution is often compromised by using shorter shaping time constants, in order to accommodate higher counting rates.

Figure 11 demonstrates the bipolar output pulse obtained when a second differentiator is inserted just before the amplifier output. Double differentiation produces a bipolar pulse with equal area in its positive and negative lobes. It is useful in minimizing baseline shift with varying counting rates when the electronic circuits following the amplifier are ac-coupled. It is also convenient for zero-crossover timing applications. The drawbacks of double differentiation relative to single CR differentiation are a longer pulse duration and a worse signal-to-noise ratio.



$$\tau = R_{D1}C_{D1} = R_I C_I = R_{D2}C_{D2}$$

Fig. 11. Doubly-Differentiated CR-RC-CR Shaping.

Pole-Zero Cancellation

In the simple CR-RC circuit described in Fig. 9, there is a noticeable undershoot as the amplifier pulse attempts to return to the baseline. This is a result of the long exponential decay on the preamplifier output pulse. At medium to high counting rates, a substantial fraction of the amplifier output pulses will ride on the undershoot from a previous pulse. The apparent pulse amplitudes measured for these pulses will be too low, which leads to a broadening of the peaks recorded in the energy spectrum. Most spectroscopy amplifiers incorporate a pole-zero cancellation circuit to eliminate this undershoot. The benefit of pole-zero cancellation is improved peak shapes and resolution in the energy spectrum at high counting rates.

Figure 12 illustrates the pole-zero cancellation network, and its effect. In Fig. 12(a), the preamplifier signal on the left is applied to the input of the normal CR differentiator circuit in the amplifier. The output pulse from the differentiator exhibits the undesirable undershoot. The following equation applies:

$$\frac{\text{Undershoot Amplitude}}{\text{Pulse Amplitude}} = \frac{\text{Differentiator Time Constant}}{\text{Decay Time Constant of Preamp Pulse}}$$

For a given preamplifier decay time constant, longer amplifier shaping time constants yield larger undershoots.

In Fig. 12(b), the resistor R_{pz} is added in parallel with capacitor C_D, and adjusted to cancel the undershoot. The result is an output pulse exhibiting a simple exponential decay to baseline with the desired differentiator time constant. This circuit is termed a "pole-zero cancellation network" because it uses a zero to cancel a pole in the mathematical representation by complex variables. Virtually all spectroscopy amplifiers incorporate this feature, with the pole-zero cancellation adjustment accessible through the front panel. Exact adjustment is critical for good spectrum fidelity at high counting rates. Some of the more sophisticated amplifiers simplify this task with an automatic PZ-adjusting circuit.

Semi-Gaussian Pulse Shaping

By replacing the simple RC integrator with a more complicated active integrator network (Fig. 13), the signal-to-noise ratio of the pulse-shaping amplifier can be improved by 17% to 19% at the noise corner time constant. This is important for semiconductor detectors, whose energy resolution at low energies and short shaping time constants is limited by the signal-to-noise ratio. Amplifiers incorporating the more complicated filters are typically called "semi-Gaussian shaping amplifiers" because

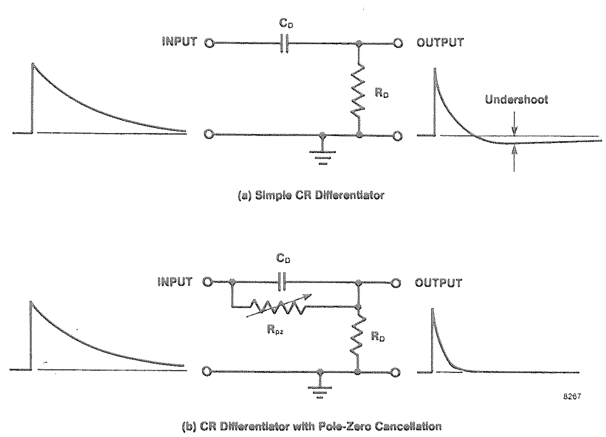


Fig. 12. The Benefit of Pole-Zero Cancellation.

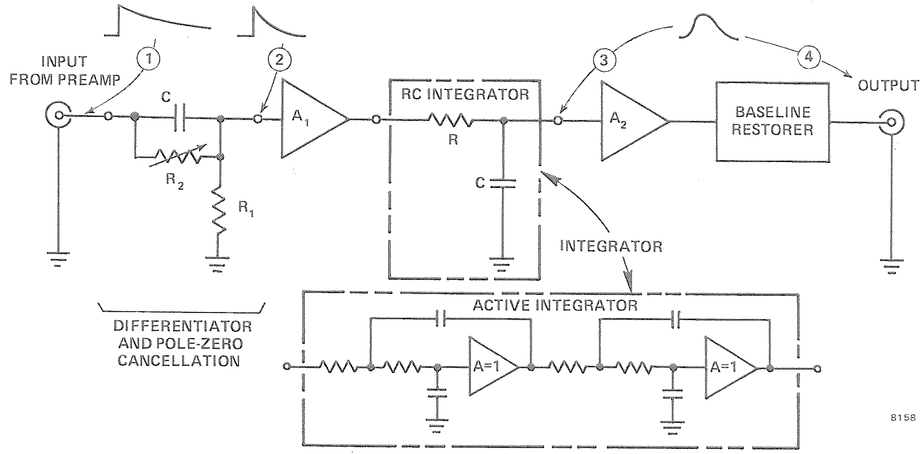
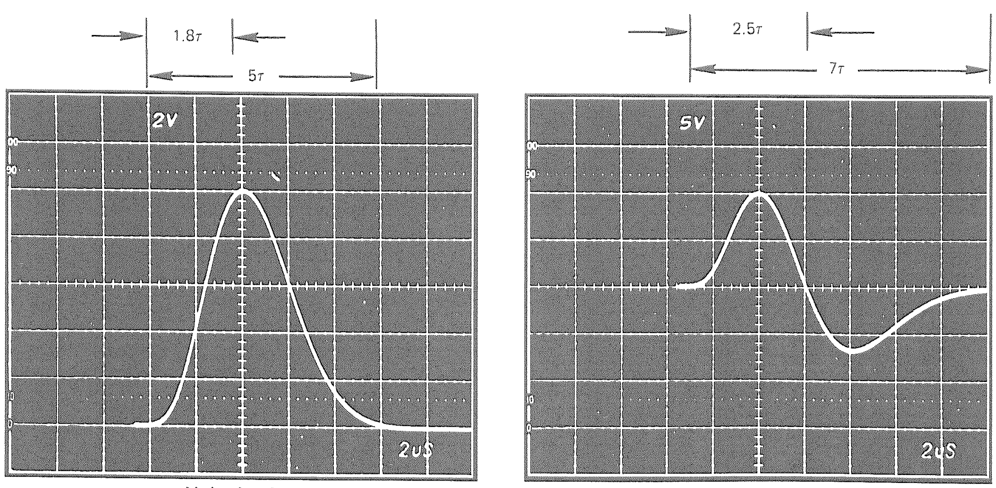


Fig. 13. Pulse Shaping in the Semi-Gaussian Shaping Amplifier.

their output pulse shapes crudely approximate the shape of a Gaussian curve [Fig. 14(a)]. A further advantage of the semi-Gaussian pulse shaping is a reduction of the output pulse width at 0.1% of the pulse amplitude. At the noise corner time constant, semi-Gaussian shaping can yield a 22% to 52% reduction in output pulse width compared with the CR-RC filter. This leads to better baseline restorer performance at high counting rates. The reduction in pulse width corresponds to a 9% to 13% reduction in the amplifier dead time per pulse.

Although the unipolar output pulse from a semi-Gaussian shaping amplifier is normally the better choice for energy spectroscopy [Fig. 14(a)], a bipolar output is typically also available [Fig. 14(b)]. The bipolar output is useful in minimizing baseline shift with varying counting rates when the electronic circuits following the amplifier are ac-coupled. It is also convenient for zero-crossover timing applications. The drawbacks inherent in the bipolar output relative to the unipolar output are a longer pulse duration and a worse signal-to-noise ratio.



a. Unipolar Output.

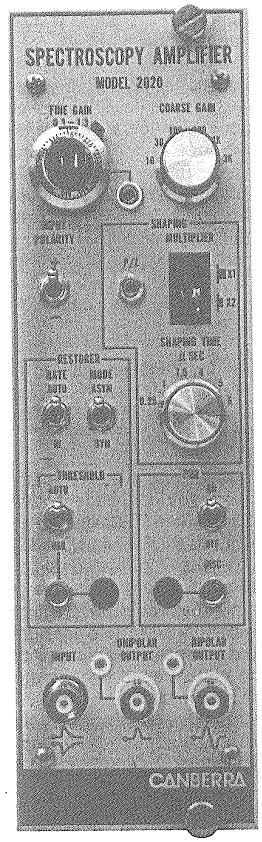
b. Bipolar Outputs.

Fig. 14. Typical (a) Unipolar, and (b) Bipolar Output Pulse Shapes from a Semi-Gaussian Shaping Amplifier.

Model 2020
Spectroscopy Amplifier

Features

- Pile up rejection/Live time correction
- 12 selectable shaping time constants
- Super Fine Gain Control
- Unique active baseline restorer with:
  1. Automatic or fixed restorer rates
  2. Automatic or manual threshold
  3. Selectable symmetry
- Noise ≤ 3.4 μV
- DC drift ≤ ±10 μV/°C



Description

The Canberra Model 2020 Spectroscopy Amplifier offers the modern spectroscopist more performance, features and flexibility than any other nuclear pulse amplifier available today. Functionally, the Model 2020 provides in a double width NIM module an exceptional spectroscopy amplifier, a gated active baseline restorer, a pulse pileup rejector and a live time corrector.

Canberra's near-Gaussian filter shaping, well known and now emulated by others in the industry, has been refined in the Model 2020 for improved pulse symmetry, minimum sensitivity of output amplitude to variations in detector rise time, and maximum signal to noise ratio. For a given shaping time constant, the improved pulse symmetry minimizes the pulse dwell time by tucking in the trailing skirt of the unipolar pulse shape. This allows a faster return to the baseline. The result is superior energy resolution, count rate, and throughput performance. Unipolar shaping is achieved with one differentiator and two active filter integrators. The differentiator is placed early in the amplifier to insure good overload recovery. The integrators are placed late to minimize noise contribution from the gain stages. The amplifier offers 12 front panel switch selectable pulse SHAPING time constants of 0.25, 0.5, 1, 1.5, 2, 3, 4, 5, 6, 8, 10 and 12 μs.

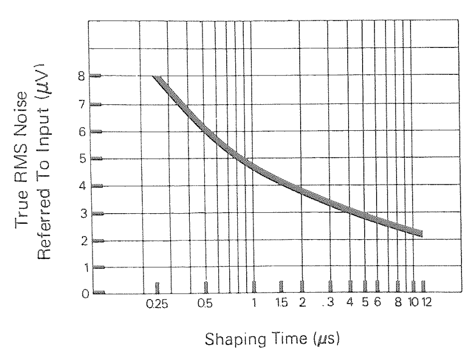


Figure 1.
Typical Model 2020 Unipolar Output True rms Noise (referred to input for gain of 100) vs. Shaping Time constant.

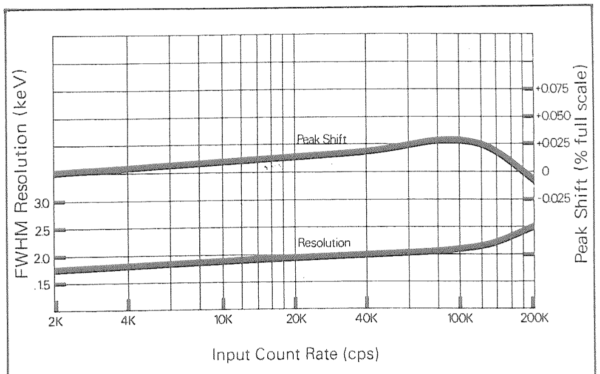


Figure 2.
Typical Model 2020 Resolution and Peak Shift Stability vs. Counting Rate for 2 μs shaping, AUTO Restorer Rate, AUTO Restorer Threshold, ASYM Restorer Mode and a 1.33 MeV ^{60}Co Gamma Peak.

The gated dc restorer offers automatic features on both the restorer threshold and restorer rate, assuring the best possible low and high count rate performance. Amplifier performance is very much dependent on the restorer rate and threshold settings, so the 2020 includes circuitry which continuously samples the amplifier output noise and count rate, and automatically sets the respective restorer threshold and rate with precision for optimum performance. The restorer is also flexible: the discriminating researcher can overide the automatic restorer features. Setting the RESTORER RATE and THRESHOLD switches to their manual positions High and VARiable respectively, allows manual optimization. A front panel LED is provided as a user aid when setting the restorer threshold manually.

The flexibility of the restorer is further enhanced by providing SYMmetrical or ASYMmetrical restorer modes. The symmetrical restorer mode is used for detector systems which exhibit baseline discontinuities resulting from excessive noise and/or high voltage effects, preamp reset pulses and preamp secondary time constants. The asymmetrical restorer mode virtually eliminates charge accumulation and correlated noise on the restorer holding capacitor. This restorer mode is especially suited for use with high resolution detector systems that exhibit minimal baseline discontinuities and whose signals have a clean monotonic return to the baseline. The result is superior resolution/count rate performance when compared to more conventional methods.

Simultaneous UNIPOLAR and BIPOLAR outputs are available at both front and rear panel BNC connectors. The unipolar signal can be delayed 2 μs, or with the 2020-4 option by 4 μs. The bipolar output can be used for counting, timing, or gating.

The internal live time corrector and pileup rejector allows quantitative gamma spectrum analysis nearly independent of system count rate. By connecting the ADC's Linear Gate (LG) signal to the Model 2020 and connecting the Model 2020's REJECT and Dead Time (DT) signals to the ADC and live timer, the Model 2020 and associated ADC together perform pileup rejection and live time correction. During the amplifier and ADC processing time, the Model 2020 inspects for pileup and permits the ADC to convert only those detector signals resulting from a single energy event. To compensate for rejected pulses and amplifier and ADC dead times, a system dead is generated by the live time correction function. The system dead time is the composite dead time of the ADC and Model 2020, extending the collection time by the appropriate amount. A front panel LED is provided as a user aid when setting the PUR DISCriminator.

The Model 2020's exceptional dc stability and ultra low noise ensure that optimum performance is realized. Together with its broad gain range (X3 to X3900), 12 shaping time constants, pileup rejection and live time correction, the Model 2020 offers uncompromising performance when used with Germanium, Silicon, Scintillation, Gas Proportional and Surface Barrier detectors.

Specifications

INPUTS

INPUT - Accepts positive or negative pulses from an associated preamplifier; amplitude: ±10 V divided by the selected gain, ±12 v maximum; rise time: less than SHAPING time constant; decay time constant: 40 μs to ∞ for 0.25, 0.5, 1, 1.5, 2, 3, and 4 μs shaping time constants, 100 μs to ∞ for 5, 6, 8, 10 and 12 μs shaping time constants; input impedance: ≈ 1 kilohm; front and rear panel BNC connectors.

LG (LINEAR GATE) - Receives a standard TTL logic signal from the ADC. Indicates to the Model 2020 that the ADC has accepted and is processing an event; input is TTL compatible, logic low when ADC accepts input, returning to a logic high at the conclusion of the ADC acquisition cycle; accessible through rear panel PUR Connector.

PUR INHIBIT - Receives a standard TTL logic signal from associated pulsed optical feedback preamplifier used to extend the Model 2020 DT signal, inhibit and reset the pileup rejector during the preamplifier's reset cycle; internal jumper selects the option of either positive true or negative true logic pulses; rear panel BNC connector.

OUTPUTS

UNIPOLAR OUTPUT - Provides positive, linear actively filtered near-Gaussian shaped pulses; amplitude linear to +10 V, 12 V max.; dc restored; output dc level factory calibrated to 0 ± 5 mV, front panel output impedance less than 1 ohm or ≈ 93 ohms, internally selectable; rear panel output impedance ≈ 93 ohms; short circuit protected; prompt or delayed 2 μs (4 μs with 2020-4 option); front and rear panel BNCs.

BIPOLAR OUTPUT - Provides prompt positive lobe leading linear active filter bipolar shaped pulses; amplitude linear to +10 V, 12 V max., negative lobe is approximately 70% of positive lobe; dc coupled; output dc level ± 25 mV; front panel output impedance <1 ohm or ≈ 93 ohms; internally selectable; rear panel output impedance ≈ 93 ohms; short circuit protected; front and rear panel BNCs.

DT (DEAD TIME) - Provides a negative logic signal and when "OR"ed together with the ADC dead time, at the ADC's live timer, provides live time correction for the amplifier and pileup rejector. Open collector with 1 kilohm pull up resistor through 47 ohm output resistor. Logic low when system is busy, logic high otherwise. BNC connector located on rear panel.

REJECT - Provides a standard TTL logic signal used to initiate an ADC reject sequence for corresponding piled up events; internal jumper selects positive true or negative true logic pulse; 50 ohm output impedence. Accessible through rear panel PUR Connector.

ICR (INCOMING COUNT RATE) - Provides a standard TTL logic signal corresponding to input count rate, positive true, width nominally 150 ns, 50 ohm output impedance; rear panel BNC connector. PUR must be selected.

FRONT PANEL CONTROLS

COARSE GAIN - 6-position rotary switch selects gain factors of X10, X30, X100, X300, X1000 and X3000.

FINE GAIN - Ten-turn locking dial precision potentiometer selects variable gain factor of X0.3 to X1.3; resetability ≤ 0.03%.

SUPER FINE GAIN - 22-turn screwdriver potentiometer to select gain with an adjustment resolution of better than 1 in 16 000 or 0.0063%.

INPUT POLARITY - 2-position toggle switch to set the Model 2020 for the polarity of the incoming preamplifier signal.

P/Z - 22-turn screwdriver pole zero potentiometer to optimize amplifier baseline recovery and overload performance for the preamplifier fall time constant and the Model 2020's pulse shaping chosen; 40 μs to ∞ for 0.25, 0.5, 1, 1.5, 2, 3 and 4 μs SHAPING time constants, 100 μs to ∞ for 5, 6, 8, 10 and 12 μs SHAPING time constants.

SHAPING TIME - 6-position rotary switch; provides 0.25, 1, 1.5, 4, 5 and 6 μs basic shaping time constants.

MULTIPLIER - Multiplies SHAPING TIME setting by X1 or X2 giving additional shaping time constants of 0.5, 2, 3, 8, 10 and 12 μs, a total of 12 shaping time constants.

RESTORER RATE - 2-position toggle switch to set the baseline restorer rate (slew rate); AUTO: the baseline restorer rate is automatically optimized by internal circuitry as a function of unipolar output signal duty cycle and count rate; High: when selected sets the baseline restorer to a fixed high rate.

RESTORER MODE - 2-position toggle switch to select SYMmetrical or ASYMmetrical baseline restorer modes.

THRESHOLD AUTO/VAR - 2-position toggle switch to set the baseline restorer threshold; AUTO: the baseline restorer threshold is automatically optimized by internal circuitry as a function of the unipolar output signal noise level; VARiable: provides a manual variable baseline threshold adjustment range of 0 V to 200 mV dc. The negative (referenced to the UNIPOLAR OUTPUT) threshold is set at -500 mV dc. An LED indicator is provided as a user-aid for set up convenience.

PUR ON/OFF - 2-position toggle switch to enable (ON) or disable (OFF) the pileup rejector and live time corrector.

PUR DISC - 22-turn screwdriver adjustment potentiometer for optimizing the pileup rejector discriminator threshold level. Provides a variable range of 0 to 550 mV. An LED indicator is provided to aid the user when setting the PUR DISC just above the system noise.

INTERNAL CONTROLS

UNIPOLAR DELAY - 2 jumper plugs provided to select UNIPOLAR output to prompt (OUT) or delayed 2 μs (IN), or 4 μs on option 2020-4. Shipped in the prompt (OUT) position.
UNIPOLAR Z_{out} - Jumper plug provides $Z_{out} \leq 1$ ohm or $\approx$ 93 ohms for the front panel BIPOLAR output. Shipped in the ≤ 1 ohm position.
BIPOLAR Z_{out} - Jumper plug provides $Z_{out} \leq 1$ ohm or $\approx$ 93 ohms for the front panel BIPOLAR output. Shipped in the ≤ 1 ohm position.
INB-INB/ - Jumper plug J5 allows the PUR INHIBIT input to accept either positive true or negative true logic signals. Shipped in the INB (positive true) position.
REJ-REJ/ - Jumper plug J6 allows the reject output to be a positive true or negative true logic signal. Shipped in the REJ (positive true) position.
L/E - Jumper plug J7 selects a linear or exponential restorer response. Shipped in the L (linear) position.

PERFORMANCE

Amplifier

GAIN RANGE - Continuously variable from X3 to X3900.
OPERATING TEMPERATURE RANGE - 0 to 50°C.
GAIN DRIFT - $\leq \pm 0.0075\%/°C$.
DC LEVEL DRIFT - UNIPOLAR output: $\leq \pm 10$ μV/°C; BIPOLAR OUTPUT: $\leq \pm 50$ μV/°C.
INTEGRAL NON-LINEARITY - $\leq \pm 0.05\%$, over total output range for 2 μsec shaping.
CROSSOVER WALK - BIPOLAR output: $\leq \pm 3$ ns for 50:1 dynamic range and 2 μs shaping when used with Canberra Model 2037A Edge/Crossover Timing Single Channel Analyzer.
OVERLOAD RECOVERY - UNIPOLAR (BIPOLAR) output recovery to within $\pm$ 2% (1%) of full scale output from X1000 overload in 2.5 (2.0) non-overloaded pulse widths, at full gain, any shaping time constant and pole-zero cancellation properly set.
NOISE CONTRIBUTION - ≤ 3.2 μV true rms UNIPOLAR (7.1 μV BIPOLAR) output referred to input, 3 μs shaping and amplifier gain ≥ 100.
PULSE SHAPING - Near-Gaussian shape; one differentiator (two for bipolar), two active filter integrators; UNIPOLAR time to peak: 2.35X shaping time; pulse width: 7.3X shaping time; BIPOLAR time to crossover: 2.8X shaping time, time to peak, pulse width and crossover times measured at 0.1% of full scale output.
RESTORER - Active gated.
*SPECTRUM BROADENING - The FWHM of a ^{60}Co 133 MeV gamma peak for an incoming rate of 2 kcps to 100 kcps and a 9 V pulse height will typically change less than 14% for 2 μs shaping, AUTO Restorer Rate, AUTO Restorer Threshold and ASYM Restorer Mode.
COUNT RATE STABILITY - The peak position of a ^{60}Co 1.33 MeV gamma peak for an incoming count rate of 2 kcps to 100 kcps and 9 V pulse height will typically shift less than 0.024% for 2 μs shaping, AUTO Restorer Rate, AUTO Restorer Threshold and ASYM Restorer Mode.

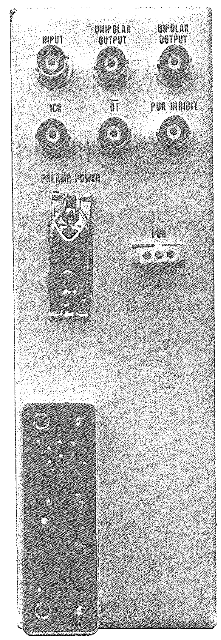
*Note: These results may not be reproducible if associated detector exhibits an inordinate amount of long rise time signals.

Pileup Rejector/Live Time Corrector

PULSE PAIR RESOLUTION - ≤ 500 ns.
MINIMUM DETECTABLE SIGNAL - Limited by detector/preamp noise characteristics.
ADC INTERFACE - Compatible Canberra ADCs are available and can be ordered using the following designations:
Model 8075
Model 8076
Model 8077
Series 35 PLUS MCA
For use with older Canberra systems, detailed instructions are provided in the 2020 manual to allow the user to adapt his ADC to interface with the Model 2020 for pileup rejection and live time correction.

CONNECTORS

With the exception of the PUR and PREAMP POWER connectors, all signal connectors are BNC type.



PUR - Molex plug 03-06-1031.
PREAMP POWER - Rear panel, Amphenol, type 17-10070.
ACCESSORIES - C1514 PUR/LTC and DT cables.

POWER REQUIREMENTS

+24 V dc — 130 mA +12 V dc — 150 mA
-24 V dc — 165 mA -12 V dc — 80 mA

PHYSICAL

SIZE - Standard double-width NIM module 6.86 X 22.12 cm (2.70 X 8.71 inches) per TID-20893 (rev.)
NET WEIGHT - 1.3 kg (2.9 lbs.)
SHIPPING WEIGHT - 2.3 kg (5.0 lbs.)

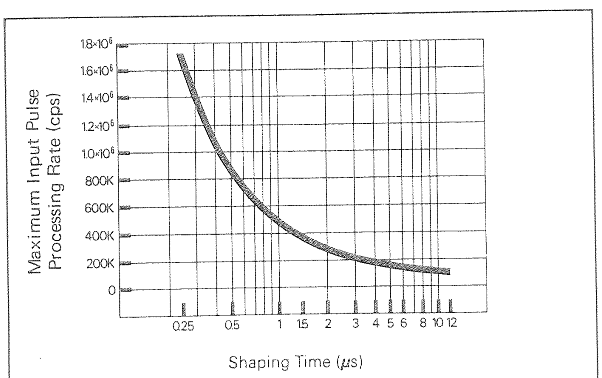


Figure 3.
Typical Model 2020 Maximum Input Pulse Processing Rate versus shaping time constant.

*Maximum Input Pulse Processing Rate: Maximum amplifier input count rate (pulses per second) for which the amplifier's dc restorer maintains the baseline at ground reference.

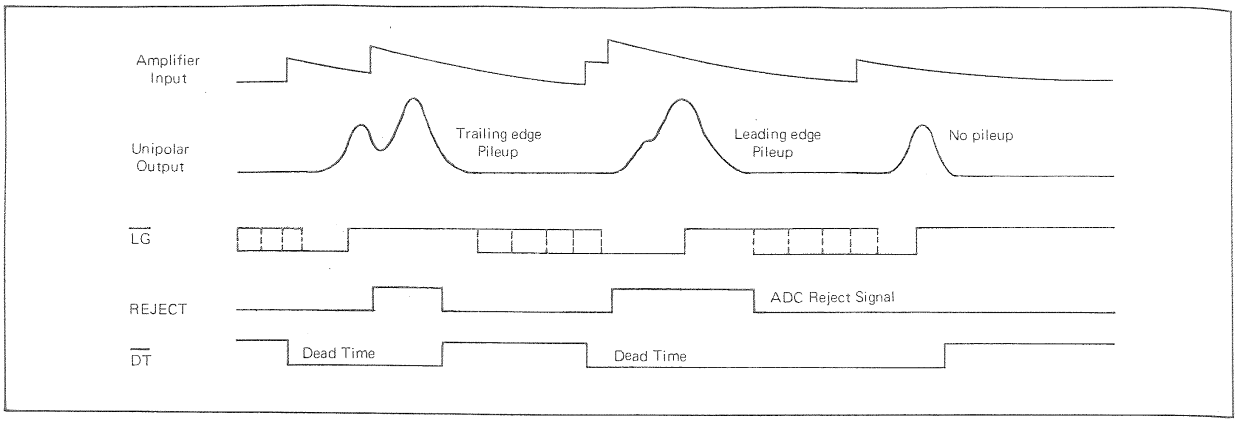


Figure 4.
Relationship of Amplifier and Pileup Rejector Signals.

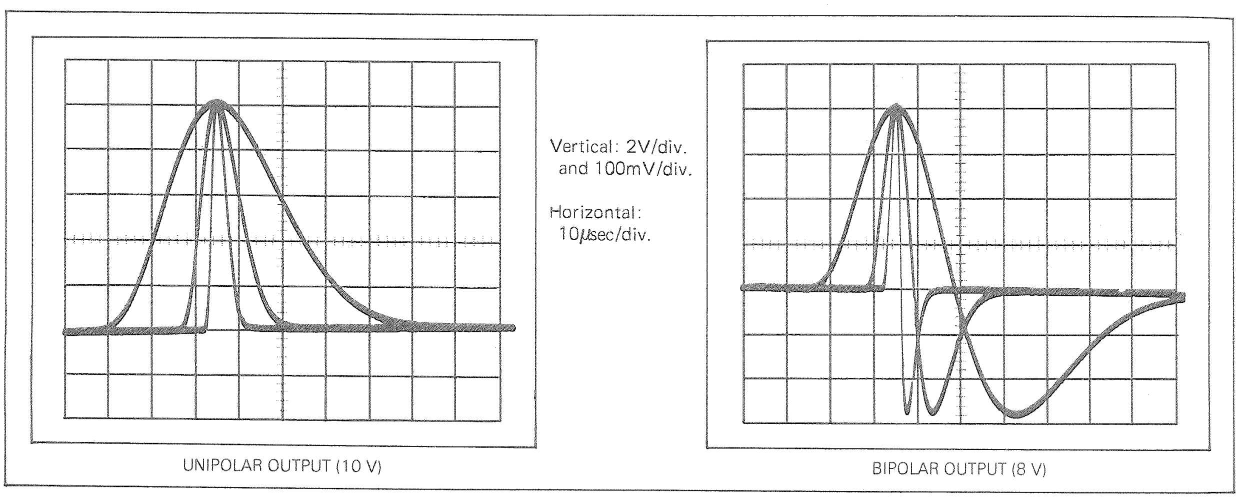


Figure 5.
Model 2020 SHAPING selected for 12, 4 and 1.5 μs.

During the amplifier and ADC processing time, the Model 2020 inspects for pileup and permits the ADC to convert only those detector signals resulting from a single energy event, see Figure 6.

Note the reduction in amplitude of both sum peaks and background. Also note the improved resolution of the sum peaks. The background reduction and improved resolution are directly indicative of the Pileup Rejector's capabilities, since only sum peak pulses which are indeed 100% in coincidence should be processed.

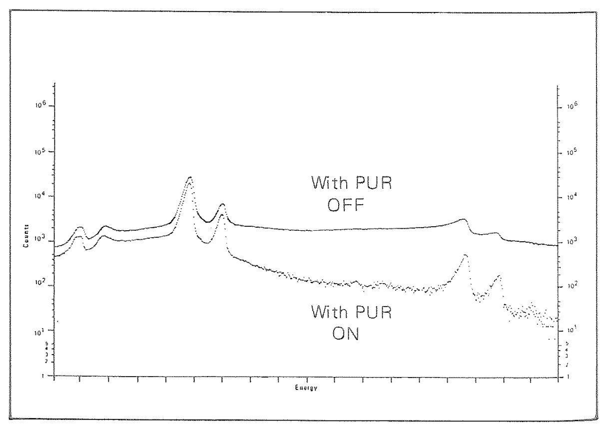


Figure 6.
^{57}Co spectrum at 80 kcps and 4 μs shaping.

Detector: Canberra Model GC2020
MCA: Canberra Model 9102
Amplifier: Canberra Model 2020
Spectrum: ^{57}Co at 60 kcps

551
Timing Single-Channel Analyzer

The EG&G ORTEC Model 551 Timing Single-Channel Analyzer performs the dual functions of single-channel pulse-height analysis and timing signal derivation.

The patented* trailing-edge constant-fraction timing technique provides unexcelled timing on either unipolar or bipolar signals and shows better results than are possible with conventional leading-edge discriminators.

With SCAs that utilize leading-edge timing, the rise time of the input pulses causes degradation of time resolution because the pulses have varying amplitudes.

Constant-fraction timing compensates for varying amplitudes and essentially eliminates this timing shift, giving consistently better timing results.

For the internally set 50% fraction, the output occurs soon after the midpoint on the linear input trailing edge to facilitate gating and accumulation of data at very high input rates. This technique also minimizes timing shift and dead time when used with sodium iodide, silicon, and germanium detectors, thereby allowing better system time resolution and higher counting rates.

The constant-fraction technique makes it possible to realize significant improvements in time resolution in most timing applications. Notice that analysis is made of the main amplifier output. This technique allows optimization of time resolution and extension of dynamic range for neutron-gamma discrimination and other timing applications. Walk of <3 ns for 100:1 dynamic range using input pulses from a pulser is possible.

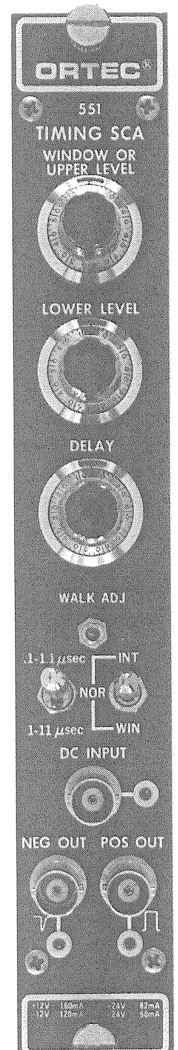
The Model 551 is versatile, with three basic operating modes provided. In the Window mode, the unit operates as a high-resolution, narrow (0 to 10%) window, single-channel analyzer. For wide-window applications, the Normal mode is used. In this mode the upper-level and lower-level controls are independently variable from 0 to 10 V, and an output is generated for pulses analyzed between the levels. Through use of the separate rear-panel LL Out and UL Out outputs, the unit can operate as a dual wide-dynamic-range integral discriminator for leading-edge timing or for pulse routing.

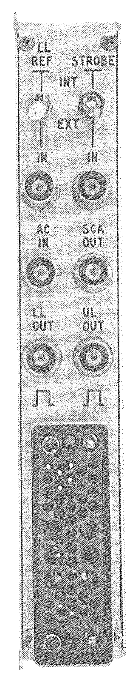
The dc-coupled input of the Model 551 makes it possible to take full advantage of the baseline restoration of the main amplifier for maximum performance at widely varying counting rates.

The continuously adjustable output delay (two ranges covering 0.1 to 11 μs) makes it possible to align output signals that have actual time differences without a need for additional delay devices or modules. Alternatively an External strobe input can be used to cause an SCA output at the desired time.

For an application where it is desirable to scan an entire spectrum, an external base-line sweep input is provided via the rear-panel LL Ref Ext BNC connector. In this mode of operation, the baseline (lower-level threshold) on which a window is riding is swept through an energy range and the count rate is recorded as a function of energy.

- **Single-channel analyzer and timing signal derivation**
- **Trailing-edge constant-fraction timing provides walk <±3 ns for 100:1 dynamic range**
- **Integral, normal, and window modes**
- **Separate lower-level and upper-level discriminator outputs**
- **DC-coupled**
- **Adjustable delay 0.1 to 11 μs**
- **Provision for external baseline sweep**





*U.S. Patent No. 3,714,464.

Timing Single-Channel Analyzer (continued)

Specifications

PERFORMANCE

DYNAMIC RANGE 200:1.

PULSE-PAIR RESOLVING TIME Output pulse width plus Delay (as selected by the front-panel Delay controls), plus 100 ns for fast NIM output or plus 200 ns for positive NIM output. Minimum resolving time for negative output 220 ns; for positive output 800 ns.

THRESHOLD TEMPERATURE INSTABILITY ≤±0.01%/°C of full scale, 0 to 50°C using a NIM Class A power supply (referenced to −12 V).

DISCRIMINATOR NONLINEARITY ≤±0.25% of full scale (integral) for both discriminators.

DELAY TEMPERATURE INSTABILITY ≤±0.03%/°C of full scale, 0 to 50°C.

DELAY NONLINEARITY <±2% of delay range.

WINDOW WIDTH CONSTANCY ≤±0.1% variation of full-scale window width over the linear range 0 to 10 V.

MINIMUM INPUT THRESHOLD 50 mV for lower-level discriminator.

TIME SHIFT vs PULSE HEIGHT (WALK)

Walk (ns)		Dynamic
System A	System B	Range
±1.0	±2.0	10:1
±2.5	±4.0	50:1
±3.0	±8.0	100:1

System A: Using an EG&G ORTEC Model 460 Amplifier, single delay-line mode, integrate ≤0.1 µs with 1-µs delay line.

System B: Using an EG&G ORTEC Model 570, 571, or 572 Amplifier, unipolar output with 0.5-µs shaping time. Input from EG&G ORTEC Model 419 Pulser.

CONTROLS

LOWER LEVEL Front-panel 10-turn potentiometer adjustable from 0 to 10 V; when the rear-panel LL Ref mode switch is set on Int, determines the threshold setting for the lower-level discriminator. When the LL REF mode switch on the rear panel is in the EXT position, this control is ineffective.

WINDOW OR UPPER LEVEL Front-panel 10-turn potentiometer determines the window width (0 to +1 V) in the Window mode or the upper-level (0 to +10 V) threshold in the Normal mode. This control is disabled in the Integral mode.

INT/NOR/WIN Front-panel 3-position locking toggle switch selects one of three operating modes:

Integral LL sets a single-discriminator threshold (0 to +10 V) and UL is disabled.
Normal UL and LL are independently adjustable levels (0 to +10 V).
Window LL sets the baseline level (0 to +10 V) and UL sets the window width (0 to +1 V).

DELAY RANGE Front-panel locking toggle switch selects delay ranges of 0.1 to 1.1 µs or 1.0 to 11 µs.

DELAY Front-panel 10-turn potentiometer for continuous adjustment of output delay over selected range. In the external strobe mode the delay control adjusts the automatic reset time from ≈5 µs to 50 µs.

WALK ADJUST Front-panel screwdriver adjustment for precise setting of walk compensation.

LL REF MODE Rear-panel 2-position locking toggle switch selects either the front-panel LL potentiometer or the voltage signal applied to the rear-panel LL REF EXT connector as the LL discriminator reference threshold.

STROBE Rear-panel 2-position locking toggle switch selects either Internal or External source for the SCA output signal strobe function.

INPUTS

SIGNAL INPUT Front-panel dc-coupled BNC connector accepts positive unipolar or bipolar signal, 0 to +10 V linear range, ±12 V maximum; width 100 ns; 1000-Ω input impedance. Rear-panel ac-coupled BNC connector accepts positive unipolar or bipolar signal, 0 to +10 V linear range, ±100 V maximum; width 0.2 to 10 µs; 1000-Ω input impedance.

LL REF EXT When the rear-panel LL REF mode switch is on EXT, the rear-panel LL REF EXT BNC connector accepts the lower-level biasing (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). Input protected to ±24 V.

EXT STROBE INT When the rear-panel EXT/INT STROBE locking toggle switch is in EXT, the rear-panel EXT STROBE IN BNC connector accepts a positive NIM-standard input, nominally +5 V, 500 ns wide, to cause an output to occur from the SCA. The external strobe should be given within 5 µs (or 50 µs as determined by the front-panel Delay control) of the linear input. At the end of this period, the Model 551 resets its internal logic without producing an output signal.

OUTPUTS

SCA POS OUT Front- and rear-panel BNC connectors provide positive NIM-standard output, nominally +5 V; 500 ns wide; 10-Ω output impedance. For internal strobe the output occurs at the midpoint of the linear input trailing edge plus the output Delay as selected by the front-panel controls. For external strobe the output occurs at the time of strobe signal.

SCA NEG OUT Front-panel BNC connector provides fast NIM-standard output, nominally −16 mA (−800 mV on 50-Ω load); width ≤20 ns; rise time ≤5 ns; ≤10-Ω output impedance. Output occurs at the mid-point of the linear trailing edge plus the output Delay as selected by the front-panel controls.

LL OUT Rear-panel BNC connector provides positive NIM-standard output, nominally +5 V, 500 ns wide; ≤10-Ω output impedance. Output occurs as leading edge of linear input crosses the LL threshold.

UL OUT Rear-panel BNC connector provides NIM-standard output, nominally +5 V, 500 ns wide; ≤10-Ω output impedance. Output occurs as leading edge of linear input crosses the UL threshold.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +12 V, 160 mA; −12 V, 110 mA; +24 V, 90 mA; −24 V, 50 mA.

WEIGHT
Net 1.1 kg (2.5 lb).
Shipping 2.25 kg (5.0 lb).

DIMENSIONS NIM-standard single-width module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

Related Equipment

The Model 551 is compatible with all EG&G ORTEC amplifiers and other amplifiers having a 0 to 10 V positive, linear output range.

Ordering Information

To order, specify:

Model	Description
551	Timing Single-Channel Analyzer

Contents

Introduction

The amplitude of the analog pulse at the output of a spectroscopy amplifier is typically proportional to the charge released in the detector or to the energy of the detected event. Selection of a range of signal levels at the output of the amplifier is equivalent to the selection of a range of energies or charge for these events. This selection can be accomplished by the use of discriminators and single-channel analyzers (SCAs). A discriminator produces an output logic pulse only if its input signal exceeds a preset threshold level. A single-channel analyzer produces an output logic pulse only if the peak amplitude of its input signal falls within the pulse-height window that is established with two preset threshold levels.

Figure 1 shows three pulses that might be provided from a main amplifier to an integral discriminator. The first pulse has an amplitude less than the adjusted discriminator threshold and generates no output logic signal. Each of the last two pulses has sufficient amplitude to produce an output logic signal. The output signals indicated in Fig. 1 are generated when the leading edge of the input signal crosses the discriminator threshold level. Therefore, the time of the output response is a function of the amplitude and rise time of the input signals. This amplitude and rise time dependence leads to "time walk" of the output signal relative to the beginning of the input pulse. The discriminator output is produced earlier by pulses with larger amplitudes and later by pulses with lower amplitudes.

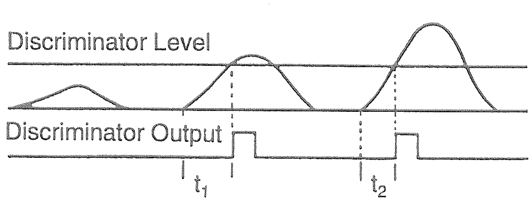


Fig. 1. Integral Discriminator Output Triggering.

Figure 2 shows three pulses that might be provided from a main amplifier to an SCA. Only the B pulse satisfies the conditions necessary to produce an SCA output logic signal.

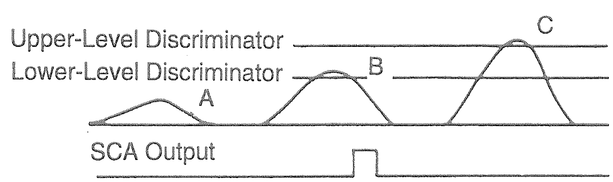


Fig. 2. Single-Channel Analyzer Function.

Removal of the upper-level-discriminator restrictions from the SCA allows it to be used as an integral discriminator. If the upper-level restrictions were removed from the unit whose output is shown in Fig. 2, both pulses B and C would be marked by logic outputs.

Single-Channel Pulse-Height Analyzers (continued)

Three primary modes of discriminator operation are available in EG&G ORTEC SCAs: Integral, Normal, and Window. In the Integral mode of operation, the SCA can function as an integral discriminator, as indicated in the preceding paragraph. In the SCA Normal mode of operation, the upper-level and lower-level thresholds are independently adjustable. In the SCA Window mode, the upper-level threshold control is used to establish a voltage level that is added to the lower-level threshold voltage to yield the upper-level discriminator threshold level. Thus, when the lower-level setting is changed, the upper-level threshold changes by the same amount. An external voltage reference for the lower-level discriminator can be supplied to scan the window through a preselected range of pulse heights.

Unlike an integral discriminator, the output logic signal from a single-channel analyzer must be produced after the input pulse reaches its maximum amplitude. This timing sequence must provide sufficient time for the SCA logic circuitry to determine if the input signal exceeded the upper-level threshold.

EG&G ORTEC provides two basic types or classifications of SCAs: non-timing SCAs and timing SCAs. The technique used to produce the output logic signals from an SCA determines its classification. Non-timing units, such as the Models 550A, and 850, produce an SCA output pulse if the input signal is within the window settings. The output occurs when the trailing edge of the input signal recrosses the lower-level threshold. Figure 3 shows two superimposed output pulses from a main amplifier that meet the window requirements of the single-channel analyzer. The output from the non-timing SCA for each pulse is shown below the pulses. Since the linear input pulses are referenced to the same starting time, it is clear that the output logic signals exhibit "time walk" relative to the input pulses.

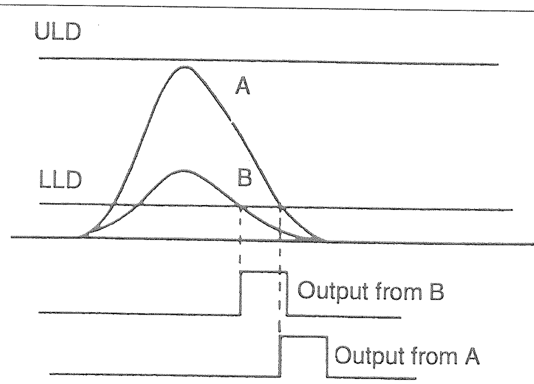


Fig. 3. Non-Timing SCA Output Triggering.

Timing SCAs, such as the EG&G ORTEC Models 551, 552, 553, and 590A, produce SCA output logic signals that are precisely related in time to the occurrence of the event being measured. This time relationship implies that the time of occurrence of the SCA output signal is "walk-free" or nominally independent of the amplitude of the input signal, for a given rise time. In addition to simple counting applications, the time-related output can be used for coincidence measurement, pulse-shape discrimination, and other applications where the precise time of occurrence is important.

Figure 4 shows two pulses from a main amplifier and the response for a peak-detection single-channel analyzer such as the Model 590A Amplifier and Timing Single-Channel Analyzer. Although the amplitudes of the amplifier pulses differ, their peaks occur at approximately the same time, and the SCA outputs are produced when the peaks of the input pulses are detected.

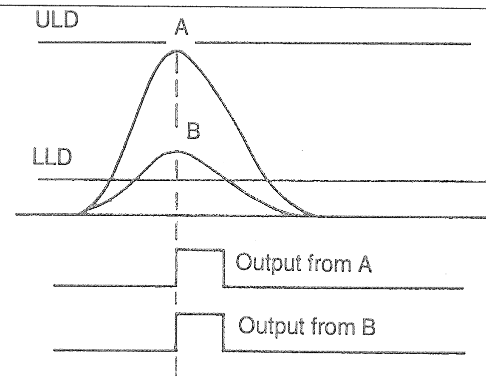


Fig. 4. Peak-Sensing SCA Output Triggering.

The conventional zero-crossing technique has been widely used for timing single-channel analyzers. This technique utilizes the zero-crossing of the bipolar output signal from a pulse-shaping amplifier to derive timing information, and uses the peak amplitude of the pulse for the energy range information. Figure 5 shows two bipolar pulses provided from a main shaping amplifier. Both pulses meet the SCA window requirements. Each output signal is generated when the corresponding input signal crosses the baseline. Figure 5 illustrates that the time of occurrence of the SCA output signals is precisely related to the occurrence of the detected event and is independent of input signal amplitude. Either double-delay-line-shaped pulses or RC-shaped pulses may be used, but the former provide better timing resolution. The bipolar output from delay-line amplifiers such as the Model 460 is well suited to zero-crossover timing with the EG&G ORTEC Model 552, because the input signal crosses the baseline with a large slope even when the pulse amplitude is low.

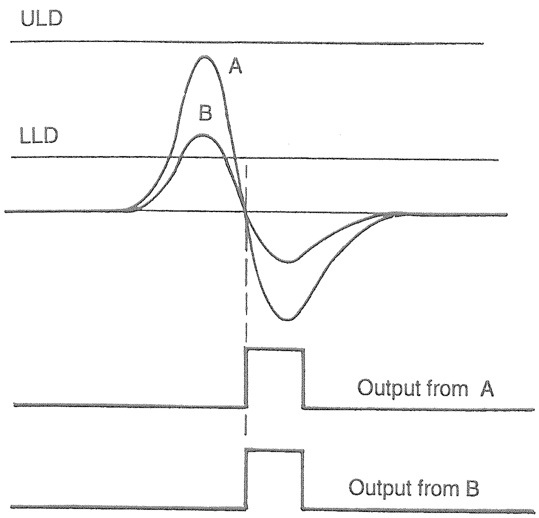


Fig. 5. Zero-Crossover SCA Output Triggering.

The bipolar output signal from a double-delay-line shaping amplifier crosses the baseline at a fixed fraction that is effectively 50% of the charge collected from the detector. Thus, conventional zero-crossing timing can be considered as timing at a constant fraction of the input signal amplitude. A trailing-edge constant-fraction technique* can be used with either unipolar or bipolar signals to derive a time-pickoff pulse after the peak time of the signal from the shaping amplifier. This technique is extremely useful when incorporated in timing single-channel analyzers. Figure 6 illustrates the trailing-edge constant-fraction technique for two unipolar input signals of identical rise times but different amplitude. The time of occurrence of the output signals is independent of output signal amplitudes.

The trailing-edge constant-fraction timing technique is available with three EG&G ORTEC SCAs: Models 551, 552, and 553.

The Model 552 can also be used as a pulse-shape analyzer. The best known application of this technique is in the separation of the neutron and gamma responses of some scintillators. Collection time differences for the two types of radiation result in shape or rise time variations in the signals from a spectroscopy amplifier. When used with an EG&G ORTEC Time-to-Amplitude Converter, the Model 552 can resolve these shape variations over a 200:1 dynamic range of input signal amplitudes. The Model 552 accomplishes the shape measurement of the input signals by evaluating the timing at two different fractions.

*The basic circuit for implementing this technique is patented by EG&G ORTEC, U.S. Patent No. 3,714,464.

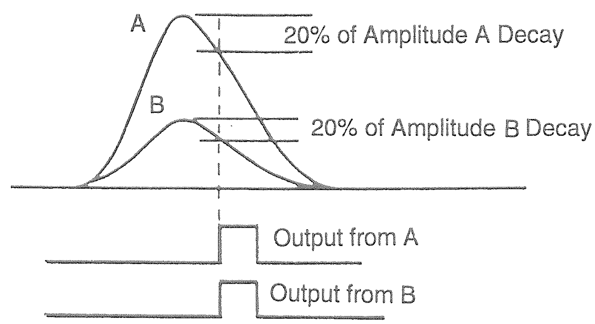


Fig. 6. Constant-Fraction SCA Output Triggering.

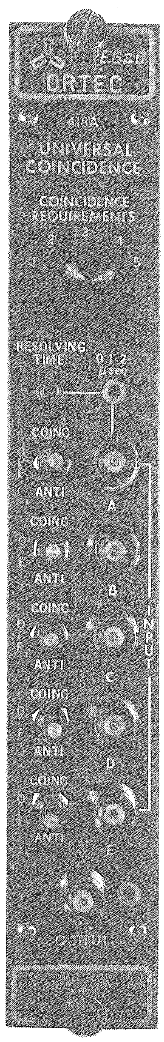
The following Selection Guide provides comparative data for all EG&G ORTEC Single-Channel Analyzers.

Single-Channel Analyzer Applications Guide

Model	Recommendations
550A	Versatile, economical, general-purpose counting.
551	SCA plus constant-fraction timing.
552	SCA plus constant-fraction timing and pulse-shape analysis.
553	Economical constant-fraction timing and SCA.
590A	Cost efficient, includes built-in amplifier.
850	Economical, four SCAs in a single-width module for general-purpose counting.

418A
Universal Coincidence

- **Provides coincidence determinations using majority logic**
- **Five, positive-polarity, dc-coupled inputs**
- **Coincidence, Anticoincidence, or Off selectable for each input**



The EG&G ORTEC Model 418A is a Universal Coincidence unit with five dc-coupled inputs. Each input is accepted through a convenient front-panel connector.

Input A accepts an input signal with a width of 50 ns or more and regenerates an internal signal that will be used for coincidence comparisons. The Input A signal width is adjustable for a resolving time of 100 ns to 2 μs, and this range is available with a front-panel control.

The function of each input is selectable, and its signal can be used for coincidence or anticoincidence or can be disabled. This permits various combinations of input signal relations to be selected without adding or removing cables in the system.

Another feature that simplifies operating flexibility without changing any cables is a selectable number of inputs that are required to satisfy a coincidence. For example, if the selector shown is set at 2, an overlap between any two inputs that are selected for the coincidence function will cause an output to be generated. If any one or more inputs are selected for anticoincidence, all outputs are inhibited while such signals are present. Because any combination of input signal effects can be selected easily at the front panel, the Model 418A is a Universal Coincidence unit that can be adapted to any coincidence system arrangement.

Specifications

PERFORMANCE

INPUT A RESOLVING TIME 100 ns to 2 μs; controlled by a front-panel, 20-turn, screwdriver adjustable potentiometer; inputs B, C, D, and E controlled by input pulse width.

TEMPERATURE INSTABILITY
Input A Change in resolving time, τ, <±0.1%/°C.

Inputs B, C, D, E Change in resolving time, τ, <±0.05%/°C for τ = 500 ns.

OPERATING TEMPERATURE 0 to 50°C.

CONTROLS

COINCIDENCE REQUIREMENTS Selects number of inputs necessary to satisfy a coincidence requirement (majority logic).

INPUT CONTROLS Five 3-position toggle switches select Coincidence, Anticoincidence, or Off (disabled).

INPUTS

POLARITY +2 V minimum, 30 V maximum.

PULSE WIDTH 50 ns to dc.

CONNECTORS BNC (UG-1094/U) on front panel.

INPUT IMPEDANCE >1.5 kΩ, dc-coupled.

OUTPUTS

AMPLITUDE +5 V.

PULSE WIDTH 500 ns.

CONNECTORS BNC (UG-1094/U) on front and rear panels.

OUTPUT IMPEDANCE <10 Ω, dc-coupled.

ELECTRICAL AND MECHANICAL

POWER REQUIREMENTS The Model 418A derives its power from a standard NIM bin/power supply. The power required is +24 V, 105 mA; –24 V, 95 mA; +12 V, 50 mA; and –12 V, 30 mA.

WEIGHT
Net 0.9 kg (2.0 lb).
Shipping 2.25 kg (5.0 lb).

DIMENSIONS Standard single-width NIM module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

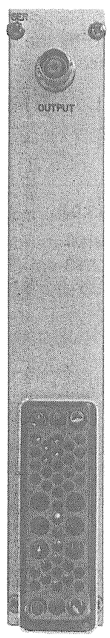
Related Equipment

Input signals to the Model 418A can be from any timing instrument providing a positive output signal from 2 to 30 V. The output of the Model 418A provides a logic signal suitable for driving any of the medium-speed logic modules in the EG&G ORTEC product line, but it is more typically used as a gating signal such as a gate-enable signal to a multichannel analyzer.

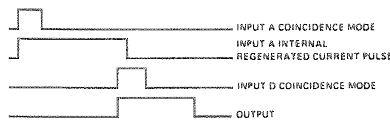
Ordering Information

To order, specify:

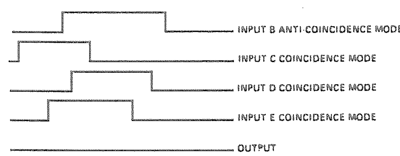
Model	Description
418A	Universal Coincidence



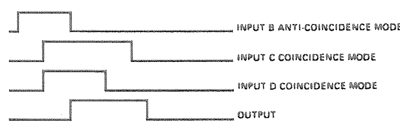
Coincidence Requirements When Switch Setting is 2.



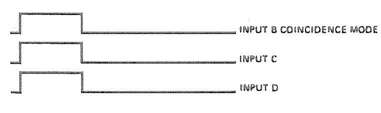
Coincidence Requirements When Switch Setting is 2.



Coincidence Requirements When Switch Setting is 3.



Coincidence Requirements When Switch Setting is 2.



Coincidence Requirements When Switch Setting is 4.