

ORTEC

Model 463
Constant Fraction
Discriminator

Operating and Service Manual

This manual applies to instruments
"Rev 08" (on rear panel)

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STANDARD WARRANTY FOR ORTEC INSTRUMENTS

ORTEC warrants its instruments other than preamplifier FET input transistors, vacuum tubes, fuses, and batteries to be free from defects in workmanship and materials for a period of twelve months from date of shipment provided that the equipment has been used in a proper manner and not subjected to abuse. Repairs or replacement, at ORTEC option, will be made on in-warranty instruments, without charge, at the ORTEC factory. Shipping expense will be to the account of the customer except in cases of defects discovered upon initial operation. Warranties of vacuum tubes and semiconductors made by their manufacturers will be extended to our customers only to the extent of the manufacturers' liability to ORTEC. Specially selected vacuum tubes or semiconductors cannot be warranted. ORTEC reserves the right to modify the design of its products without incurring responsibility for modification of previously manufactured units. Since installation conditions are beyond our control, ORTEC does not assume any risks or liabilities associated with methods of installation or with installation results.

QUALITY CONTROL

Before being approved for shipment, each ORTEC instrument must pass a stringent set of quality control tests designed to expose any flaws in materials or workmanship. Permanent records of these tests are maintained for use in warranty repair and as a source of statistical information for design improvements.

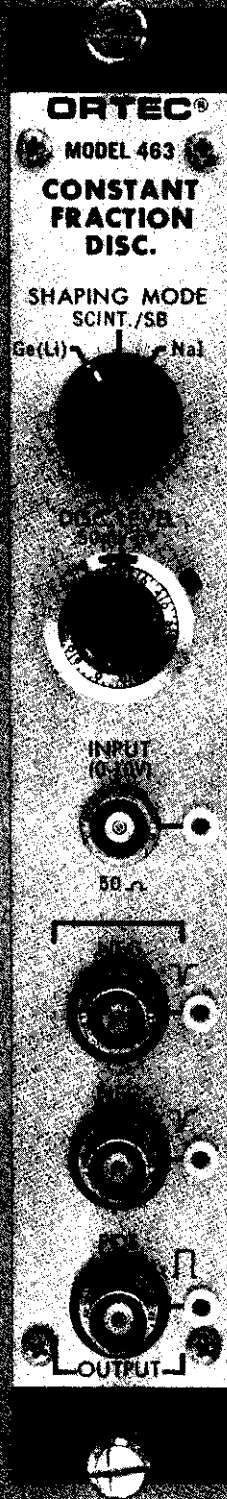
REPAIR SERVICE

If it becomes necessary to return this instrument for repair, it is essential that you contact our Customer Services in

advance of its return. ORTEC must be informed, either in writing or by telephone [(615) 482-4411], of the nature of the fault of the instrument being returned and of the model, serial, and revision ("Rev" on rear panel) numbers. Failure to do so may cause unnecessary delays in getting the unit repaired. Our standard procedure requires that instruments returned for repair pass the same quality control tests that are used for new-production instruments. Instruments that are returned should be packed so that they will withstand normal transit handling and must be shipped **PREPAID** via Air Parcel Post or United Parcel Service to the nearest ORTEC repair center. Instruments being returned that are damaged in transit due to inadequate packing will be repaired at the sender's expense, and it will be the sender's responsibility to make claim with the shipper. Instruments not in warranty will be repaired at the standard charge unless they have been grossly misused or mishandled, in which case the user will be notified prior to the repair being done. A quotation will be sent with the notification.

DAMAGE IN TRANSIT

Shipments should be examined immediately upon receipt for evidence of external or concealed damage. The carrier making delivery should be notified immediately of any such damage, since the carrier is normally liable for damage in shipment. Packing materials, waybills, and other such documentation should be preserved in order to establish claims. After such notification to the carrier, please notify ORTEC of the circumstances so that we may assist in damage claims and in providing replacement equipment if necessary.



ORTEC 463 CONSTANT FRACTION DISCRIMINATOR

1. GENERAL

The ORTEC 463 Constant Fraction Discriminator provides logic outputs that are used for precise timing signals. Fast logic outputs are derived from input pulses from almost any style of nuclear detector. The Constant Fraction technique of obtaining timing signals ensures accuracy and precision through a wide dynamic range of input signals. The details of shaping are all selected properly by a front panel switch that is marked for the four most common types of detectors in current use.

The types of detectors with which the 463 can be used are Ge(Li), NaI(Tl), fast plastic scintillators, and surface barrier, identified on the 463 by a front panel selector switch, with the last two detectors marked "Scint" and "SB". Because of the signal shapes from a Ge(Li) detector, an ORTEC 454 Timing Filter Amplifier should be included between the preamplifier and the 463 when this type of detector is used as a pulse source. The use of a 454 is also advantageous when detector signals require amplification.

This easily used single-width module virtually eliminates timing walk caused by amplitude (energy) and also pulse

shape variations. When used with the ORTEC 454 Timing Amplifier, it generates a walk-free timing signal that can be obtained from any detector over a 100:1 dynamic range of pulse heights.

The adjustments and selections are simple. Just set the input discriminator to the lowest energy level of interest, select the appropriate detector switch setting, and connect the input and output cables, and it is ready to operate. The 463 then provides the most stable timing signal, suitable for even the most sophisticated time spectroscopy measurement.

For convenience, monitor test points are included for inspection of input and output signals and of the specially shaped internal signal that is used to derive the walk-free timing signal. The selections of the compatible delay and attenuation are made automatically by the switch selection of the detector type. The benefits of this modern Constant Fraction technique are obtained without any necessity for calculations and experimentations.

2. SPECIFICATIONS

PERFORMANCE

INPUT PULSE CHARACTERISTICS Accepts negative pulses to 10 V without saturation; protected to 100 V for duty cycle of 10%; $t_r \geq 1$ nsec.

REFLECTIONS Typically $< 10\%$ for 0- to 10-V amplitude range and rise time ≥ 1 nsec.

LOWER LEVEL DISCRIMINATOR
Temperature Drift ≤ 0.5 mV/ $^{\circ}$ C, 0 to 50 $^{\circ}$ C.

Integral Nonlinearity $\leq \pm 0.3\%$.

WALK AND DYNAMIC RANGE

Ge(Li) Mode $< \pm 2$ nsec for range of 100 mV to 10 V with 40-nsec t_r .

Scint/SB Mode $< \pm 150$ psec for range of 100 mV to 10 V (using signal from Naton-136 and RCA-8575 PM tube).

NaI Mode $< \pm 0.5$ nsec for range of 100 mV to 10 V with 5-nsec t_r .

DELAY TEMPERATURE STABILITY ≤ 10 psec/ $^{\circ}$ C, 0 to 50 $^{\circ}$ C, for 1-V input signal with ≤ 2 -nsec t_r .

CONTROLS

SHAPING MODE 3-position selector switch selects delay and fraction for optimum Constant Fraction timing signal derivation according to the type of detector:

Ge(Li) Selects 12-nsec delay and compatible fraction for optimum shaping of signals from Ge(Li) detectors.

Scint/SB Selects ~ 2 -nsec delay and compatible fraction for optimum shaping of signals from fast plastic scintillators or from surface barrier detectors.

NaI Selects ~ 2 -nsec delay and compatible fraction for optimum shaping of signals from NaI(Tl) and similar scintillators; also selects an internal dead time of ~ 1 μ sec from the leading edge of the input signal to prevent multiple triggering on slow decay waveforms.

DISC. LEVEL 10-turn precision locking potentiometer adjusts trigger level of the lower level discriminator; range -50 mV to -5 V.

INPUT

Type BNC connector on front panel accepts input signals from preamplifier or from shaping amplifier; dc-coupled and baseline restored; normal range from Disc Level to -10 V ; $Z_{in} 50\Omega$.

OUTPUTS

NEG Two NIM-standard Fast Negative logic output signals generated separately and furnished through two type BNC connectors on front panel; nominal -16 mA (800 mV on 50Ω load), width $\leq 10\text{ nsec}$, $t_r \leq 2.5\text{ nsec}$.

POS NIM-standard Slow Positive logic output signal furnished through type BNC connector on front panel; nominal $+5\text{ V}$, width 500 nsec , $t_r \leq 25\text{ nsec}$; $Z_o \leq 10\Omega$.

ELECTRICAL AND MECHANICAL

POWER REQUIREMENTS

$+24\text{ V}$, 25 mA ; $+12\text{ V}$, 28 mA ;
 -24 V , 90 mA ; -12 V , 170 mA .

WEIGHT (SHIPPING) 4.5 lb (2 kg).

WEIGHT (NET) 2.5 lb (1.1 kg).

DIMENSIONS NIM-standard single-width module (1.35 by 8.714 in.) per TID-20893 (Rev.).

3. INSTALLATION

3.1. GENERAL

The 463 is used in conjunction with an ORTEC 401/402 Bin and Power Supply, which is intended for rack mounting. Therefore if vacuum tube equipment is operated in the same rack, there must be sufficient cooling with circulating air to prevent any localized heating of the all-transistorized circuitry used throughout the 463. The temperature of equipment mounted in racks can easily exceed the recommended maximum limit of 120°F (50°C) unless these precautions are taken.

3.2. CONNECTION TO POWER

Always turn off power for the Power Supply before inserting or removing modules. The ORTEC 400 Series of modular instruments is designed so that the Power Supply cannot be overloaded when there is a full complement of modules in the Bin. Since, however, this may not be true when the Bin contains modules other than those of ORTEC design, use the convenient test points on the front panel of the 401/402 to check each Power Supply voltage level after all modules have been inserted.

3.3. INPUT CONNECTION

The input circuit of the 463 is designed for use with 50Ω cable. The input impedance is 50Ω ; so no external terminator is required for this connection.

The input can come from a detector or photomultiplier directly, provided that the negative input pulse will have sufficient amplitude to exceed a Disc Level setting in the 463. When an amplitude requires amplification or when additional pulse shaping is required [such as with Ge(Li)

coaxial detectors], an ORTEC 454 Timing Filter Amplifier can be used between the detector and the input to the 463.

3.4. OUTPUT CONNECTIONS

There are three outputs on the 463, and all connectors are located on the front panel. Two of these are NIM-standard Fast Negative pulses that are generated separately and are therefore completely isolated. The third is a NIM-standard Slow Positive pulse. All three pulses are furnished for each input pulse that exceeds the Disc Level setting.

The Fast Negative output pulses are intended for timing applications such as the Start and Stop inputs to a time to pulse height converter. Either or both may be used and the alternate connector does not need to be terminated when it is not being used. Since the NIM-standard Fast Negative pulse is a current pulse and since it is intended for use with a 50Ω load, you should use 50Ω cable to connect it to the point where it will be used and that point must be terminated in 50Ω . Normally the instrument that receives the pulse will have a 50Ω input impedance; if it does not, use an external termination at the receiving end of the cable.

The NIM-standard Slow Positive output pulses can be used for coincidence work or can be counted directly in a scaler or ratemeter. It is normal to use 93Ω cable to transfer this voltage pulse that is furnished through the output impedance of $\leq 10\Omega$. For cable lengths longer than 2 meters ($\sim 7\text{ ft}$) it is recommended that the cable be terminated in its characteristic impedance. This output can also drive a terminated 50Ω cable, but with a slightly reduced amplitude.

4. OPERATION

After the 463 has been installed and interconnected as described in Section 3, the only operating functions that are required are the setting of the Mode switch and an adjustment of the Disc Level control.

Normally the Mode switch can be set at the switch position that corresponds to the type of detector being used. Set the switch at Ge(Li) for signals from a germanium coaxial detector; set it at Scint/SB if the detector is either a fast plastic scintillator or a surface barrier type; or set it at NaI for use with a slower type of scintillator. If the input signal to the 463 is furnished from a signal source having

a rise time that is longer than 20 nsec, the Ge(Li) switch position may provide more satisfactory operation than the Scint/SB position. See Section 7, "Applications," for further suggestions.

The function of the Disc Level adjustment is to permit selection of signals of interest and to eliminate response to smaller signals. The proper setting of this control depends on the range of signal amplitudes that are furnished into the input. The range is from -50 mV to -5 V with the precision 10-turn potentiometer used for precise setting and excellent resettability.

5. CIRCUIT DESCRIPTION

The signal, in a range of 0 to -10 V, is applied through Input connector CN1 and routed to a 50Ω T attenuator consisting of R7, R8, and R9. The output from the T attenuator has half of the input signal amplitude and is limited to approximately -6 V and $+0.8$ V by diodes D2 and D3.

The signal from the T attenuator goes to the base of Q2 and to the Shaping Mode switch, S1. Q1 and Q2 form a matched pair to translate the zero baseline and furnish it and the signal into a fast differential comparator, IC1. When the signal at the base of Q2 exceeds the level selected by the Disc Level control, R11, the output at pin 8 of IC1 switches from its high state of ~ -0.8 V to its low state of ~ -1.6 V. The low state is applied to pin 5 of IC4B to enable the And gate for the zero-crossing signal that will come from IC2.

The second connection for the output from the T attenuator is through Shaping Mode switch S1. For each switch-selected shaping mode the signal is split and routed through an attenuation network and R19 to the base of Q3 and through a delay cable DL1 and R21 to the base of Q4. The switched routing provides a shaping that is optimum for each mode selection. For Ge(Li) the signal to Q3 goes through R1 while the signal for Q4 goes through R2 and DL2A. For Scint/SB, the signal to Q3 passes through R6 while the signal to Q4 passes through R5. For NaI the signal to Q3 goes through R3 and the signal to Q4 goes through R4.

The shaped signals through the matched pair, Q3 and Q4, are applied to comparator IC2. When zero-crossing occurs, the signal at pin 8 of IC2 shifts to the low state and is applied to the And gate IC4B at pin 4; this is the gate that has been enabled to accept the signal by the output from

IC1. The output waveform from IC2 is also buffered through Q21 to permit oscilloscope observation at TP1.

Waveforms to show comparative timing of the signals in this portion of the 463 are shown in Figs. 5.1 and 5.2. The detection of the zero-crossing point that will be seen at TP1 is the waveform in Fig. 5.2 identified as the Zero-Crossing signal from pin 8 of IC2. This signal is automatically adjusted so that the zero-crossing point will always occur at the proper time. It is accomplished by making the signal comparison with an adjusted dc baseline level that is furnished from the switch-selected Walk

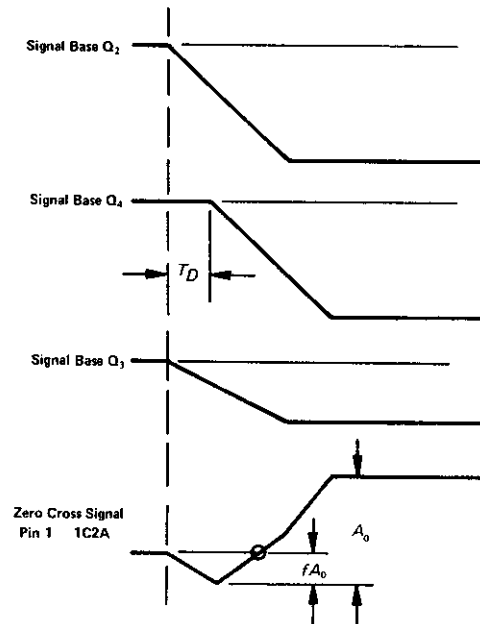


Fig. 5.1. Ideal Pulse Shapes Illustrating the Constant Fraction Discriminator Operation.

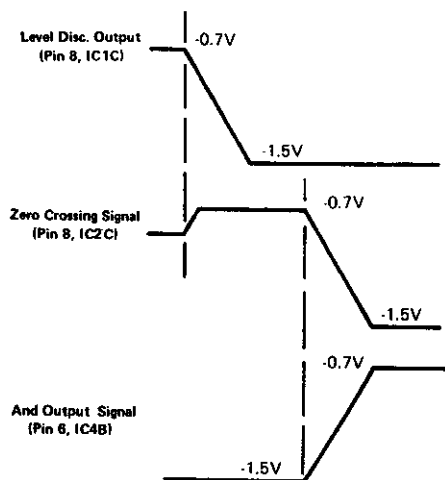


Fig. 5.2. Signal Shapes Illustrating Detection of the Zero-Crossing Point of Constant Fraction Signal.

Adjust potentiometer, R45, R89, or R90. This comparison is made by IC3. When the zero-crossing baseline goes negative with respect to pin 2 of IC3, the comparator output goes from its low to its high state of ~ 1 V. At this time Q9 is conducting, Q8 is off, and C7 is charged slowly toward +24 V by current through R37. This positive excursion is applied through Q7 to the base of Q6 to increase the current through the collector of Q6. The increasing current causes the V_{be} of Q3 to increase and provides a negative offset voltage at the pin 4 input of IC2. This offset is amplified and inverted through IC2 for a positive excursion back to pin 3 of IC3 that causes IC3 to change back to its low state and to thus decrease

the offset voltage at pin 4 of IC2. This negative feedback control stabilizes the zero-crossing point against drifts due to power supply voltage variations, slight variations in the input dc level, or aging of components. After the internal Walk Adjust is performed on the 463 at the factory, no further adjustments should be required unless components are interchanged in the instrument.

The detected zero-crossing signal at pin 6 of IC4B triggers a monostable, IC5A and IC5B. The monostable period is ~ 100 nsec for Ge(Li) and Scint/SB selections of S1 and is increased to ~ 1 μ sec for the NaI mode selection. The longer reset time used for the NaI mode prevents multiple outputs on the trailing edge of the NaI signals.

The positive-going signal at the pin 2 output of IC5B triggers a line receiver, IC5C. The negative-going signal at pin 8 of IC5C is routed to both pin 1 of IC4A and pin 12 of IC5C. The effect of IC4A and R49 is to invert and delay the output of IC5C. IC4C sums this delayed positive signal with the negative signal from pin 8 of IC5C to form a narrow positive pulse at pin 11 of IC4C. This shaped signal is then routed to two current switches to produce the two negative logic signals through CN2 and CN3. Q10 and Q11 form the current switch for the output through CN3, and Q18 and Q19 form the current switch for the output through CN2. Each output signal is approximately 16 mA and is intended to drive a low impedance of typically 50Ω . The positive-going signal at pin 3 of IC4A triggers a positive output monostable, Q12 to Q16. This provides a positive logic signal output through CN4.

6. MAINTENANCE

6.1. GENERAL

The ORTEC 463 should require no regular maintenance other than replacement of components that have failed due to age. The three calibrations described below may be required if internal components are replaced.

If a 463 is suspected of malfunction, disconnect it from all circuit interconnections and check the voltages at the check points listed in Table 6.1. These voltages are nominal values and are furnished only as a guide for troubleshooting in the instrument. The values have been measured with the Shaping Mode switch set at Scint/SB and with the Disc Level control fully counterclockwise at 5 minor dial divisions.

6.2. LEVEL DISCRIMINATOR ZERO ADJUSTMENT

Connect a source of -50 -mV pulses, ≥ 10 nsec wide, to the 463 Input. Set the mode switch at Scint/SB and adjust the

Disc Level control to 5 minor divisions for 50 mV. Observe the Pos output of the 463 with an oscilloscope and adjust R77 on the bottom of the 463 for half-firing.

Readjust the input signal to -1 V and adjust the Disc Level control to again obtain half-firing. The Disc Level control should be set at 1 major division ± 10 minor divisions. If the Disc Level control is not within 10 minor divisions, re-adjust R77 and repeat the procedure.

6.3. WALK ADJUSTMENT

If the 463 is suspected of having excessive walk, test it for conformance to operating standards with the following steps. The tests are outlined separately for each of the 3 operating modes of the 463.

Ge(Li) Mode Figure 6.1 shows a system that can be used to check the 463 walk in the Ge(Li) mode. A slow rise-time

Table 6.1. Typical Voltages at Suggested Check Points

Check Point	Voltage	Check Point	Voltage
Q1E	-0.65	IC3, pin 3	-1.1
Q1B	-0.002	IC3, pin 4	-6.2
Q2E	-0.65	IC3, pin 7	+1.6
Q2B	-0.008	IC3, pin 8	+10.8
IC1, pin 3	-0.8	IC4, pin 8	-0.8
IC1, pin 4	-1.7	IC4, pin 9	-1.6
IC1, pin 1	-1.7	IC4, pin 12	-0.8
IC1, pin 2	-0.8	IC4, pin 13	-0.8
IC1, pin 8	-1.7	IC5, pin 11	-1.2
Q3E	-0.65	IC5, pin 3	-1.7
Q3B	-0.009	IC5, pin 4	-0.8
Q4E	-0.65	IC5, pin 1	-0.8
Q4B	-0.009	IC5, pin 2	-1.7
IC2, pin 1	-1.2	IC5, pin 6	-1.2
IC2, pin 2	-1.2	Q10E	-1.5
IC2, pin 12	-1.2	Q10B	-0.8
IC2, pin 13	-1.2	Q18E	-1.5
IC2, pin 8	-1.2	Q12B	-0.1
Q5E	-12.6	Q12C	+3.5
Q6E	-12.6	Q13B	-0.3
Q6B	-11.35	Q14E	+2.7
Q8E	-10.70	Q15B	+0.6
Q8B	-16.6	Q15C	+0.4
Q8C	-10.7	Q17E	-5.2
Q9E	+0.65		

(~100-nsec) pulse with a maximum amplitude of about -10 V is applied to the 463 Input. When the Neg output is observed, it should not move more than ± 2 nsec with respect to the trigger applied to the oscilloscope for any combinations of X2, X5, and X10 attenuator settings. Adjust R45 for minimum walk.

Scint/SB Mode Use the system shown in the block diagram of Fig. 6.2 to test the walk of the 463 in its Scint/SB mode. For any combination of attenuator settings of X1, X2, X5, and X10 (but not for X100) the observed walk should be less than ± 150 psec. A dynamic range of only 50:1 has been suggested because the HP8004A provides a maximum output amplitude of 5 V. If a pulser is available with a rise time of ≤ 2 nsec and an amplitude of 10 V, the 463 walk should be tested for the range of 10 V to 100 mV. Adjust R89 for minimum walk.

Be careful when making this measurement to consider the Tektronix Attenuator characteristics. It is not uncommon for an insertion delay variation of ± 100 psec to exist in the attenuator. Verify the delay consistency of the attenuator before making the walk test, since 100 psec is equivalent to $< 1/8$ -inch difference in signal path length and is likely to exist for most attenuator units.

Nal Mode This test is identical to the procedure outlined for Scint/SB mode except that the rise time of the signal

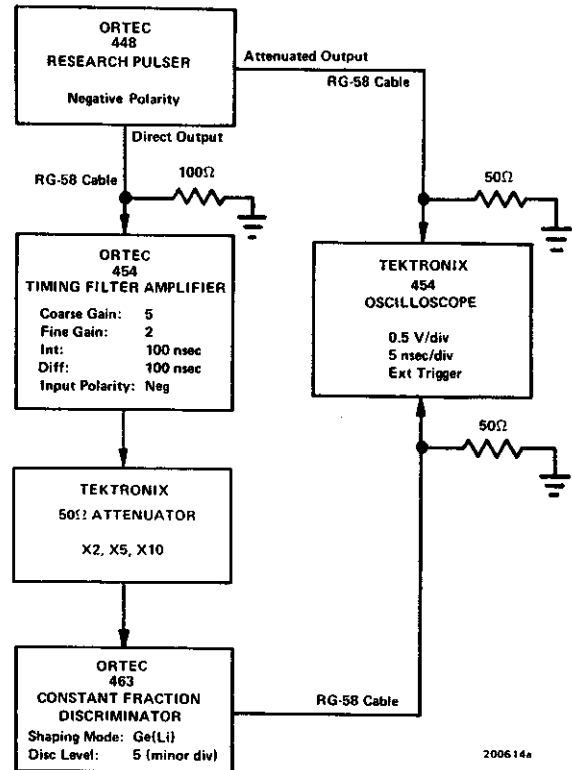


Fig. 6.1. Block Diagram of System for Walk Test of the ORTEC 463 in the Ge(Li) Mode.

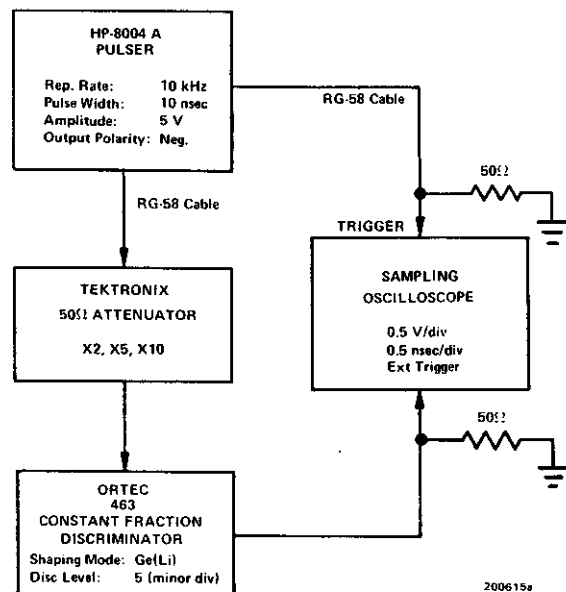


Fig. 6.2. Block Diagram of System for Walk Test of the ORTEC 463 in the Scint/SB Mode.

to the 463 should be about 5 nsec to simulate more closely the signal from a NaI scintillator. The walk should not exceed ± 0.5 nsec in this mode for a range of input pulse heights from 10 V to 100 mV. Adjust R90 for minimum walk.

7. APPLICATIONS

7.1. TIMING WITH FAST SCINTILLATORS

Figure 7.1 shows a typical system for timing with fast scintillation detectors such as Nation-136, Pilot B, NE-102, NE-111, NE-213, etc. The 463 Constant Fraction Discriminator is used in the stop channel of the time to pulse height converter. Figures 7.2 and 7.3 are typical timing spectra that were taken with this system. The spectrum of Fig. 7.2 was taken with a narrow dynamic range (20:1) of pulse heights on both start and stop channels, and the spectrum of Fig. 7.3 was taken with a wide dynamic range (100:1). See the Bibliography at the end of this section for a list of more detailed discussions on timing with fast scintillators.

The input to the 463 should have approximately 10-V pulses for the Compton edge of the 511-keV gamma in order to obtain a 100:1 dynamic range. The lower level discriminator should be set at ~ 50 mV. For some tubes the 50Ω back termination internal to the tube base must be removed to accomplish the maximum dynamic range.

7.2. TIMING WITH LARGE Ge(Li) DETECTORS

Figure 7.4 is a block diagram of another gamma-gamma coincidence system. In this system the start channel uses a fast scintillator and the stop channel employs a large coaxial Ge(Li) detector. A typical plot of the time resolution as a function of energy is shown in Fig. 7.5 for a large Ge(Li) detector, and a typical timing spectrum for a wide dynamic range is shown in Fig. 7.6.

To obtain the maximum dynamic range, the maximum pulse height of interest should correspond to ~ 10 V at the output of the ORTEC 454 Timing Filter Amplifier. Slight saturation will not distort the timing spectrum if the 10% to 90% rise time for the saturation pulses is greater than 20 nsec. The Int (Integrate) time constant should be no greater than 5 or 10 nsec and the Diff (Differentiate) time constant should be >100 nsec on the 454 Amplifier.

If an early peak appears in the time spectrum, it usually means that the Level Discriminator is set slightly too low on the 463 and that it is enabled falsely.

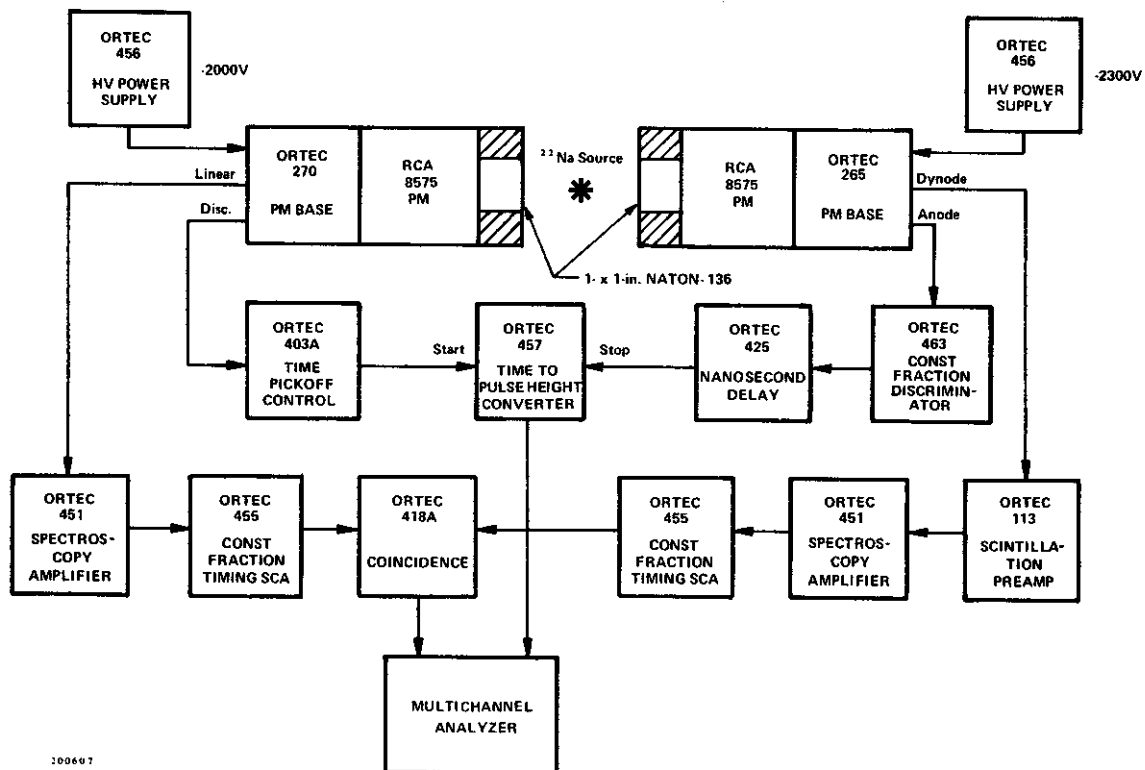


Fig. 7.1. A System for Gamma-Gamma Lifetime Measurement.

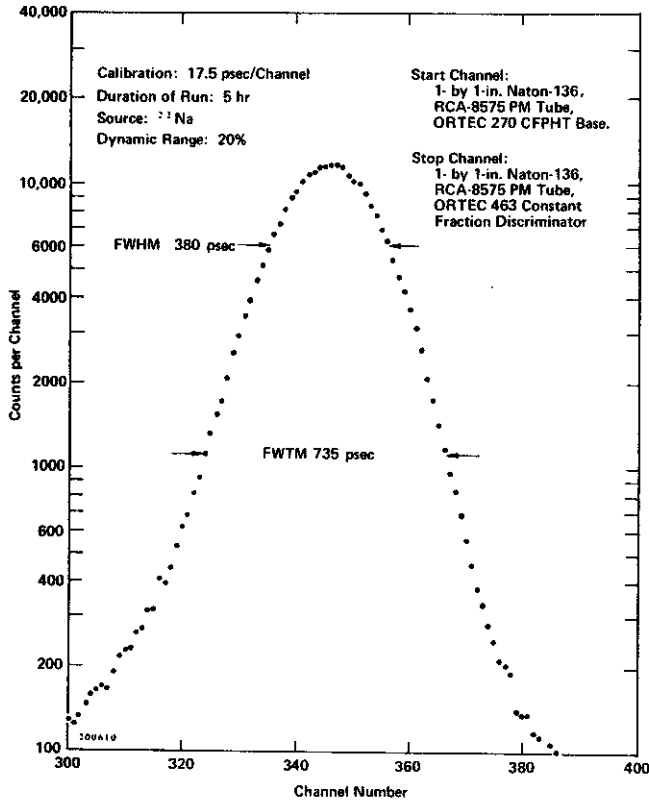


Fig. 7.2. Timing Over a Narrow Dynamic Range with the System of Fig. 7.1.

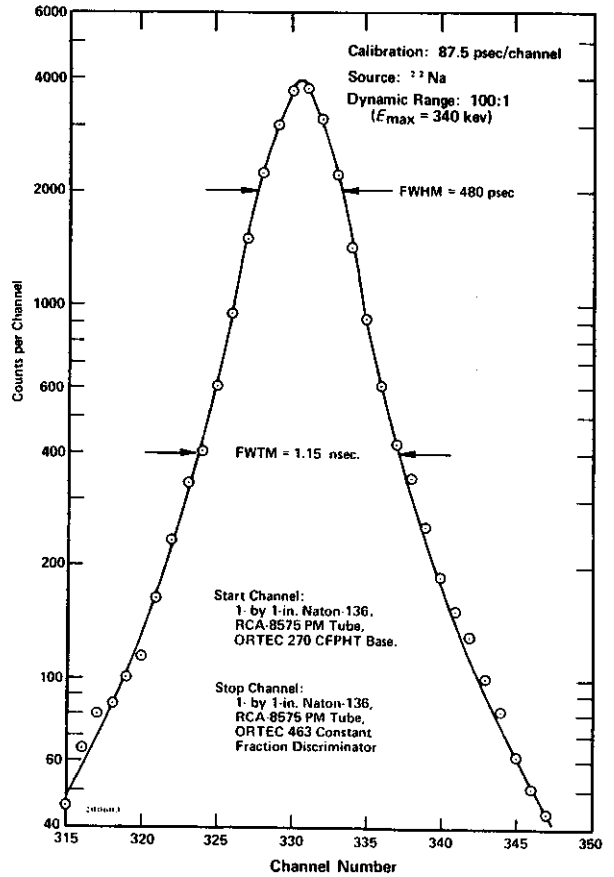


Fig. 7.3. Timing Over a Wide Dynamic Range with the System of Fig. 7.1.

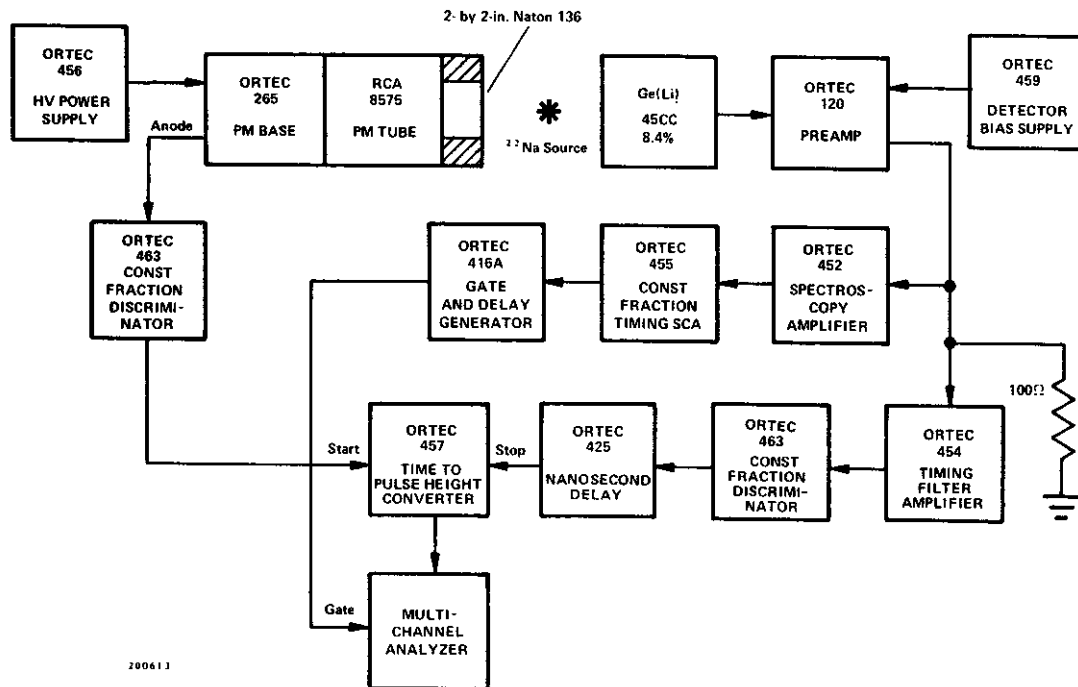


Fig. 7.4. Gamma-Gamma Coincidence System Using Plastic Scintillator and a Large Ge(Li) Coaxial Detector.

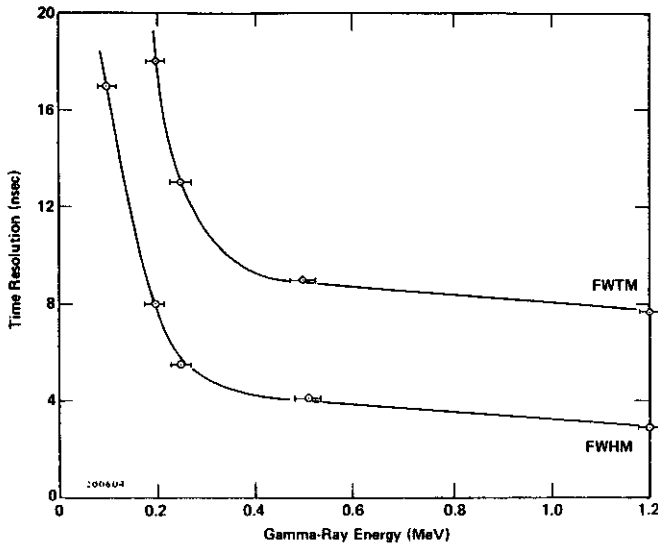


Fig. 7.5. Time Resolution of a Ge(Li) Detector as a Function of Energy.

For a detailed discussion of the Amplitude-Rise-Time-Compensation (ARC) technique used in the 463 and of other areas relating to timing with Ge(Li) detectors, refer to the Bibliography at the end of this section.

7.3. TIMING WITH SURFACE BARRIER DETECTORS

The system shown in Fig. 7.7 can be used to check the timing resolution of a surface barrier detector. An ORTEC 130 Surface Barrier Detector and Preamplifier is being tested, with its response time compared to a light pulse that is generated in an RCA Ga-As laser. The duration of the light pulse can be 10 nsec or less, and its intensity can be controlled by adjusting the voltage applied to

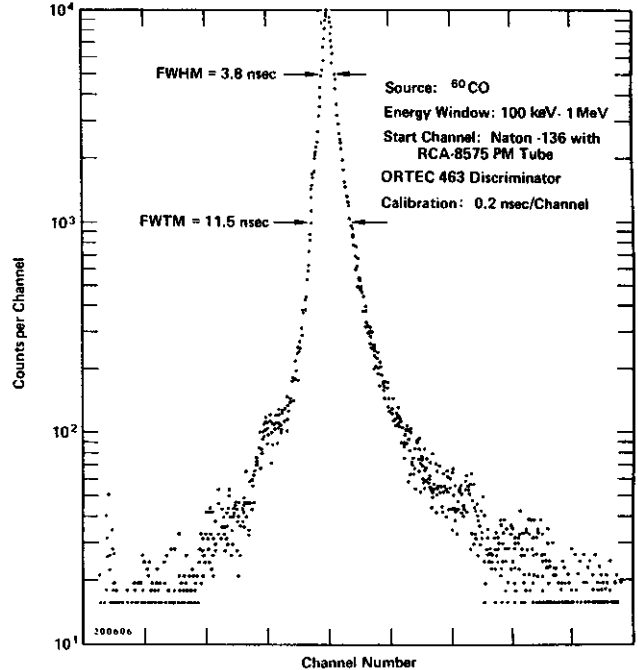


Fig. 7.6. Typical Timing Spectrum with Wide Dynamic Range Using the System of Fig. 7.4.

the laser. The detected light per laser burst can be adjusted to correspond to an alpha energy if a weak alpha source is placed in the vicinity of the detector. With the single channel analyzer calibrated for an equivalent charged particle energy, a simulated timing test can be performed for any energy.

For the ORTEC 130 Surface Barrier Detector system, as for most surface barrier detectors, the rise time of the

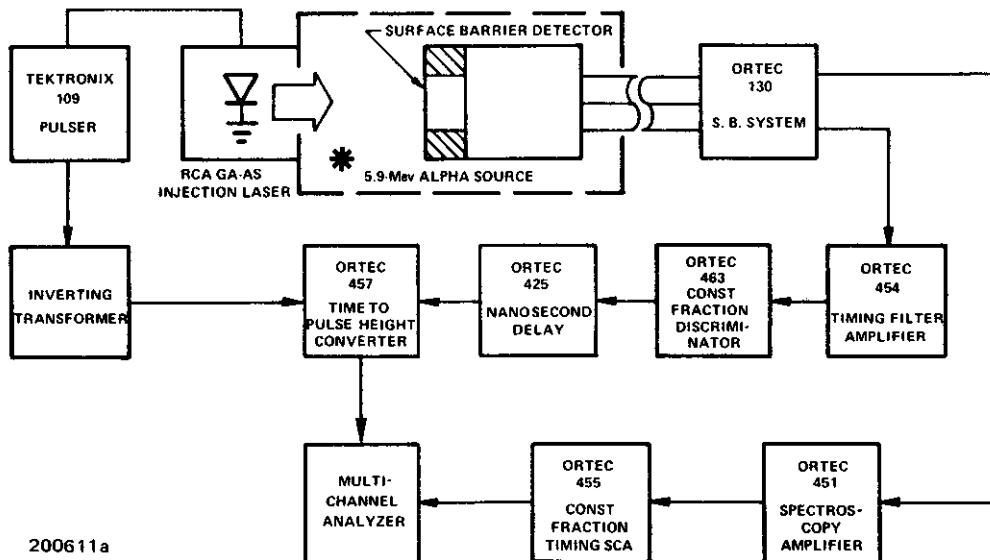


Fig. 7.7. System for Testing Time Resolution of the ORTEC 130 Surface Barrier System.

pulse from the preamplifier fast output will be less than ~ 20 nsec. For such systems the 463 should be operated in the Scint/SB mode for a time to crossover of ~ 2 nsec. For surface barrier systems with the ORTEC 454 Timing Filter Amplifier operating on the preamplifier slow output, with a rise time of >20 nsec, the 463 should operate in the Ge(Li) mode. The time to crossover in the Ge(Li) mode is ~ 18 nsec; so this shaping is best for signals that originate in most charge-sensitive preamplifiers.

Figure 7.8 is a typical timing spectrum taken with the 463 and using the system shown in Fig. 7.7 for a detector of $100\text{-}\mu\text{m}$ depletion depth. The timing spectrum in Fig. 7.9 was obtained with the same system for a detector with a depletion depth of $1975\text{ }\mu\text{m}$. These two spectra illustrate the usefulness of the surface barrier detector system in a pulsed distance-measuring application. The distance resolution for a single laser burst with a light return equivalent to 5.5 MeV would be about 3 in., and this intensity is small compared to the output capability of such lasers. If the time interval is averaged for several laser bursts, the distance resolution could be reduced to only a small fraction of an inch.

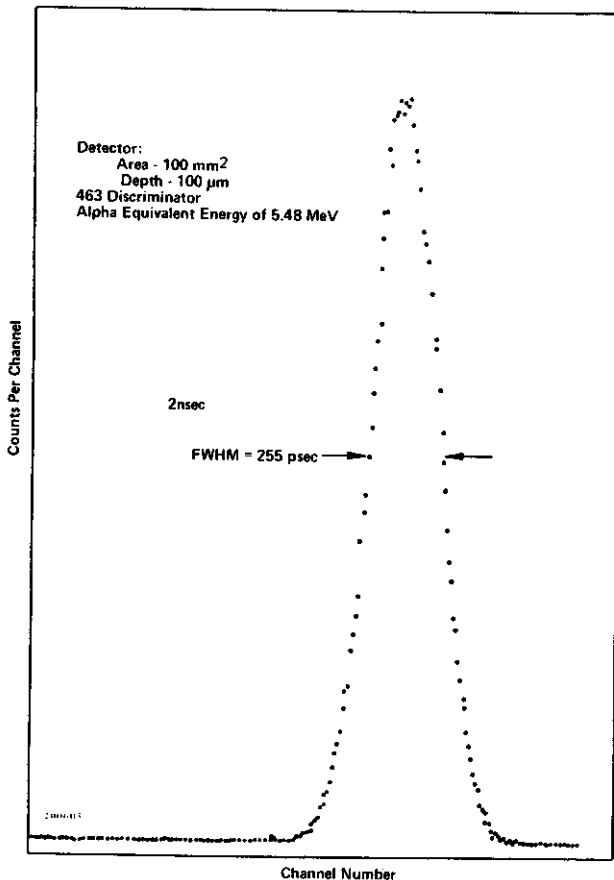


Fig. 7.8. Typical Timing Spectrum for a $100\text{-}\mu\text{m}$ Surface Barrier Detector Using the System of Fig. 7.7.

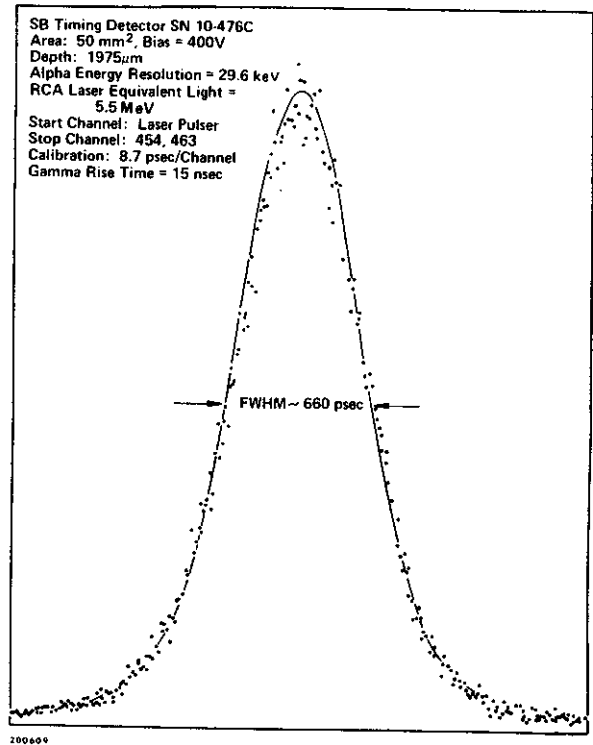
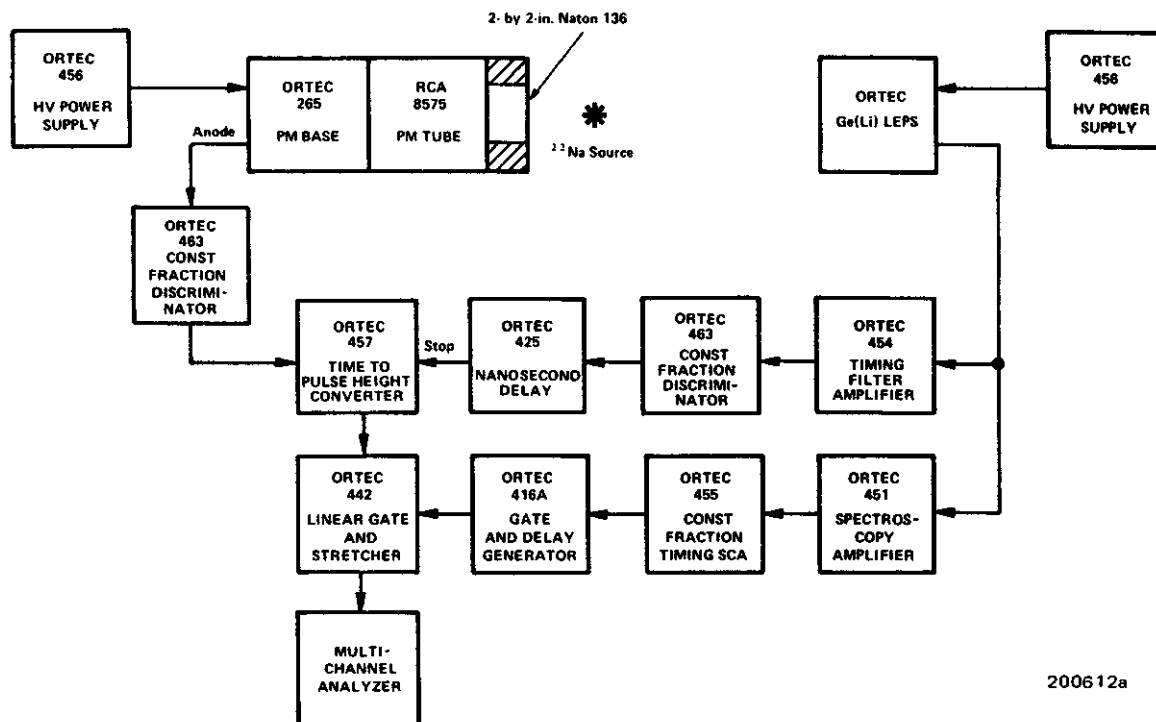


Fig. 7.9. Typical Timing Spectrum for a $1950\text{-}\mu\text{m}$ Surface Barrier Detector Using the System of Fig. 7.7.

7.4. TIMING WITH HIGH-RESOLUTION LOW-ENERGY PHOTON SPECTROMETERS

A system that illustrates a method for measuring lifetimes of excited states at extremely low energies is shown in Fig. 7.10. The start channel for the ORTEC 457 Time to Pulse Height Converter is a plastic scintillation detector with an RCA-8575 photomultiplier tube and uses the 463 set for the Scint/SB mode as the fast discriminator. The stop channel is a 6-mm Low Energy Photon Spectrometer (LEPS) Ge(Li) detector operating with a fast timing system composed of a 454 Timing Filter Amplifier and a 463 Constant Fraction Discriminator. The 454 is operated with its Int (Integrate) not greater than 10 nsec and the Diff (Differentiate) ≥ 100 nsec. The 454 gain should be adjusted so that the highest energy of interest corresponds to ~ 10 V at the 454 output. Operate the 463 in its Ge(Li) mode, with time to crossover about 18 nsec.

Figure 7.11 shows the timing resolution versus deposited energy for a typical 6-mm LEPS detector. The system of Fig. 7.10 was used to obtain the data points. A ^{22}Na source is used to produce two coincident 511-keV gamma rays from positron annihilation. The start channel detects one of the gammas, and a Compton-scattered event in the LEPS will occasionally produce the energy selected by the 451, 455, and 416 slow channel to gate the multichannel analyzer and permit time to be measured for that coincident event. By selecting the energy of interest with the



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Fig. 7.10. Fast Coincidence System Using a Ge(Li) 6-mm Low Energy Photon Spectrometer.

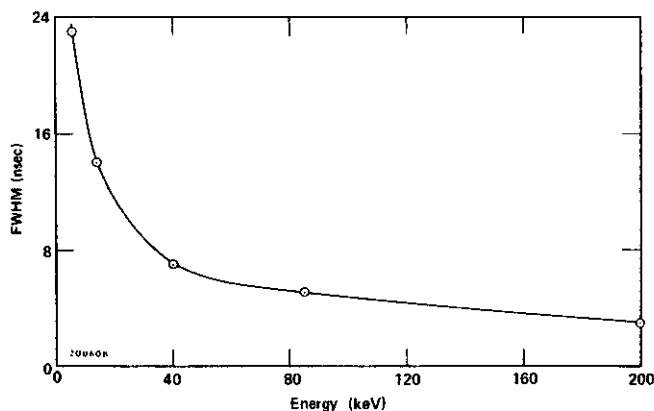


Fig. 7.11. Time Resolution vs Energy for a 6-mm Low Energy Photon Spectrometer.

451 and 455, the Compton scattering can produce a timing spectrum at the desired energy.

The system with the block diagram in Fig. 7.10 can also be used for a lifetime measurement of an excited state. A typical example is seen in the decay from the 136-keV state of ^{57}Co . The decay from the 136-keV state to the ground state is by way of 122 keV to a 14-keV state, and the electron has an approximate 100-nsec lifetime in the 14-keV state. Thus the start channel can be activated by the 122-keV gamma ray, and the slow channel of the stop side can be adjusted to observe only the 14-keV gamma ray; the lifetime of the 14-keV state can then be

measured and recorded. A spectrum showing typical results of this measurement is shown in Fig. 7.12.

7.5. TIMING WITH NaI(Tl) SCINTILLATORS

This type of measurement is similar to timing with fast scintillators except for one additional problem that must be considered. The photoelectron statistics are so poor for low-energy gamma-ray that individual photoelectron events near the trailing edge of the NaI(Tl) pulses will trigger the 463. Thus a single scintillation event can

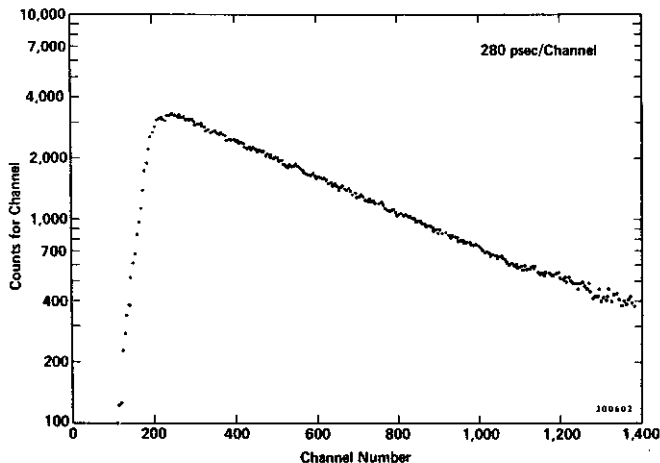


Fig. 7.12. Spectrum of the Lifetime of the 14-keV State in the Decay of ^{57}Co .

produce two or more discriminator output pulses. In the 463 this problem is overcome by using the NaI mode in which an internal dead time of $\sim 1 \mu\text{sec}$ is generated. The 463 can then be operated in the NaI mode and be used

successfully on even longer decay scintillators, but the internal dead time may have to be increased to prevent multiple triggering; to increase the dead time, increase the capacitance of C4.

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3. W.J. McDonald and D.A. Gedcke, "Electronics for Fast Neutron Work," p. 56 in *International Symposium on Nuclear Electronics, Versailles, September 1968*, Vol. 1.

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4. R.L. Chase, "Pulse Timing System for Use with Gamma Rays on Ge(Li) Detectors," *Rev. Sci. Instr.* **39**(9), 1318 (1968).
5. R.L. Graham, I.K. MacKenzie, and G.T. Ewan, "Timing Characteristics of Large Coaxial Ge(Li) Detectors for Coincidence Experiments," *IEEE Trans. Nucl. Sci.* **NS-13** (1), 72 (1966).

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6. A. Alberigi Quaranta, "On the Information Available from the Rise-Time of the Charge Pulse Supplied by a Semiconductor Particle Detector," *Nucl. Instr. Methods* **35**, 93 (1965).
7. M. Moszyński and B. Bengtson, "Plasma Delay and Plasma Time Jitter in Subnanosecond Timing with Surface Barrier Detectors," *Nucl. Instr. Methods* **91**, 73 (1971).

APPENDIX

REPLACEABLE PARTS

ORDERING INFORMATION

The Replaceable Parts List shown below contains information needed for ordering spare and/or replacement parts. Each listing indicates the reference designator number, the part number, a description of the component, and the part manufacturer and manufacturer's part number.

All inquiries concerning spare and/or replacement parts and all orders for same should include the model serial, and revision ("Rev" on rear panel) numbers of the instruments involved and should be addressed to the Customer Service Department at 100 Midland Road, Oak Ridge, Tennessee 37830. The Manager of Customer Services can be reached

by telephone at (615) 482-4411. The minimum order for spare and/or replacement parts is \$25.00.

ORDERING INFORMATION
FOR PARTS NOT LISTED

In order to facilitate the ordering of a part not listed below, the following information should be submitted to the Customer Service Department:

1. the instrument model number,
2. the instrument serial number,
3. revision ("Rev" on rear panel) number,
4. a description of the part,
5. information as to the function and location of the part.

The solid-state-device (diodes, transistors, and integrated circuits) types installed in your instrument may differ from those shown in the schematic diagram and parts list. In such cases, necessary replacements can be made with either the type shown or the type actually installed in the instrument.

Replaceable Parts List

REFERENCE DESIGNATOR	ORTEC PART NO.	DESCRIPTION	MFR.	MFR. PART NO.
463-0100	5004 46572			
13	9109 41425	Dial, 10-Turn	05721	HEL #2606
14	9097 41339	Connector, BNC	95712	DGE #UG1094/U
15	9097 41340	Connector, BNC, Ins.	91836	KET #KC79-46
16	9126 41597	Washer, BNC, Insulated	ORTEC	410-0106A
19	9109 41431	Knob, 1/4"	86797	RGN #RB750-1/4D
32	9097 42938	Contact Pin, Double	81312	WIN #100-0811P
33	5007 46601	Switch Assembly	ORTEC	463-0300
R11	9051 40818	1 K 10-T Pot.	05721	HEL #7246
R75	9015 40219	470 Ω 1/4W 5% C	01121	ABC CB
R76	9015 40219	470 Ω 1/4W 5% C	01121	ABC CB
R82	9015 40219	470 Ω 1/4W 5% C	01121	ABC CB
R86	9015 40219	470 Ω 1/4W 5% C	01121	ABC CB

Replaceable Parts List (continued)

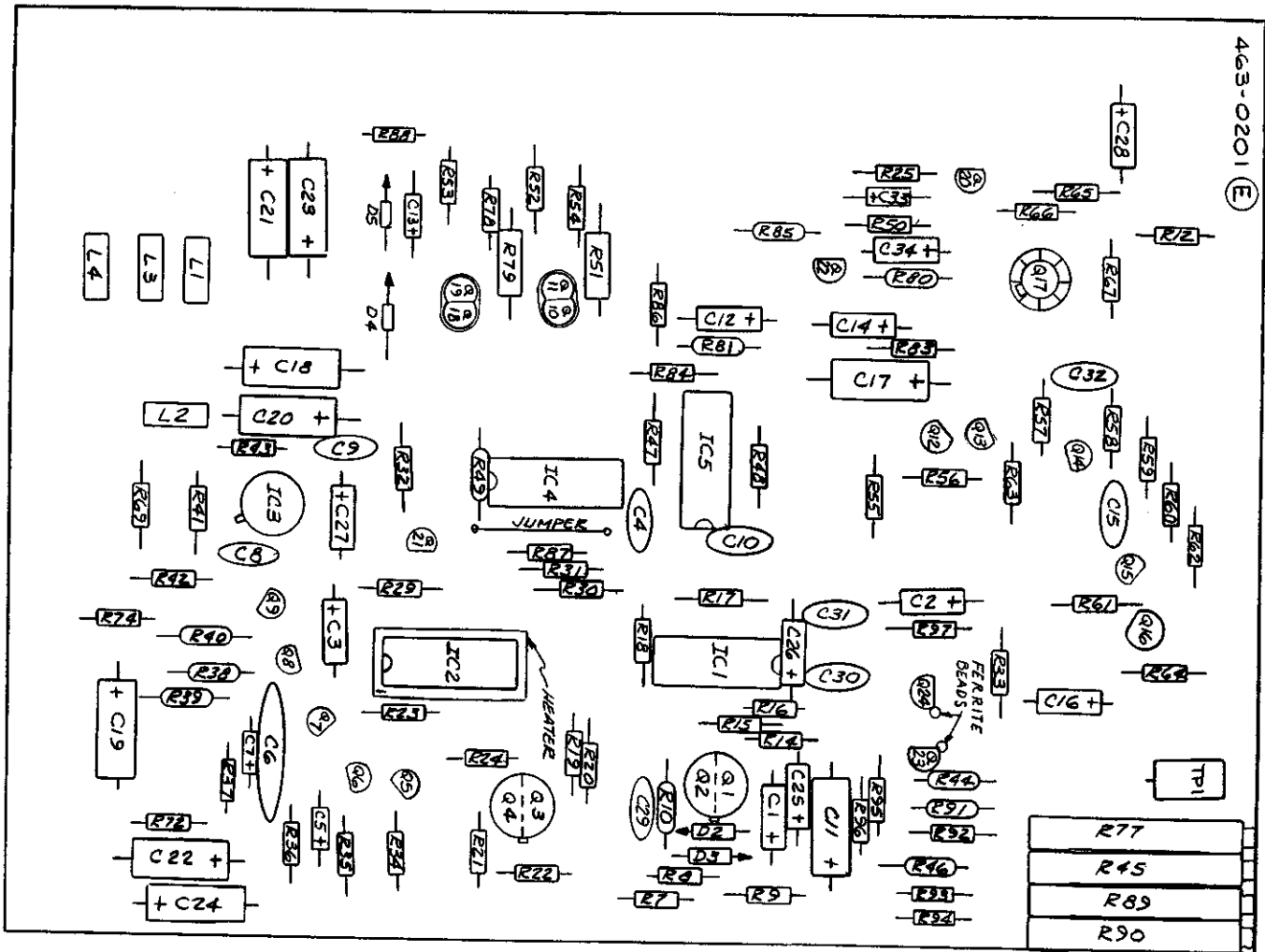
REFERENCE DESIGNATOR	ORTEC PART NO.	DESCRIPTION	MFR.	MFR. PART NO.
463-0200	5007 46573			
C1	9065 40942	1 uf 20% 35V Tan.	80183	SPR #150D105X0035A2
C2	9065 40942	1 uf 20% 35V Tan.	80183	SPR #150D105X0035A2
C3	9065 40942	1 uf 20% 35V Tan.	80183	SPR #150D105X0035A2
C4	9055 40855	0.01 uf 20% 50V Disc.	80183	SPR #C023K101F103M
C5	9065 40942	1 uf 20% 35V Tan.	80183	SRR #150D105X0035A2
C6	9055 40846	0.1 uf 20% 50V Disc.	80183	SPR #C023K101L104M
C7	9065 40942	1 uf 20% 35V Tan.	80183	SPR #150D105X0035A2
C8	9055 40855	0.01 uf 20% 50V Disc.	80183	SPR #C023K101F103M
C9	9055 40855	0.01 uf 20% 50V Disc.	80183	SPR #C023K101F103M
C10	9059 40893	500 pf 2% 500V D.M.	84171	ARC #DM15-501G
C11	9065 40948	6.8 uf 20% 35V Tan.	80183	SPR #150D685X0035B2
C12	9065 40942	1 uf 20% 35V Tan.	80183	SPR #150D105X0035A2
C13	9065 40942	1 uf 20% 35V Tan.	80183	SPR #150D105X0035A2
C14	9065 40942	1 uf 20% 35V Tan.	80183	SPR #150D105X0035A2
C15	9059 40886	100 pf 2% 500V D.M.	84171	ARC #DM15-101G
C16	9065 40948	6.8 uf 20% 35V Tan.	80183	SPR #150D685X0035B2
C17	9065 40948	6.8 uf 20% 35V Tan.	80183	SPR #150D685X0035B2
C18	9065 40948	6.8 uf 20% 35V Tan.	80183	SPR #150D685X0035B2
C19	9065 40948	6.8 uf 20% 35V Tan.	80183	SPR #150D685X0035B2
C20	9065 40948	6.8 uf 20% 35V Tan.	80183	SPR #150D685X0035B2
C21	9065 40948	6.8 uf 20% 35V Tan.	80183	SPR #150D685X0035B2
C22	9065 40948	6.8 uf 20% 35V Tan.	80183	SPR #150D685X0035B2
C23	9065 40948	6.8 uf 20% 35V Tan.	80183	SPR #150D685X0035B2
C24	9065 40948	6.8 uf 20% 35V Tan.	80183	SPR #150D685X0035B2
C25	9065 40942	1 uf 20% 35V Tan.	80183	SPR #150D105X0035A2
C26	9065 40942	1 uf 20% 35V Tan.	80183	SPR #150D105X0035A2
C27	9065 40942	1 uf 20% 35V Tan.	80183	SPR #150D105X0035A2
C28	9065 40942	1 uf 20% 35V Tan.	80183	SPR #150D105X0035A2
C29	9059 40882	15 pf 5% 500V D.M.	84171	ARC #DM15-150J
C30	9059 40908	39 pf 5% 500V D.M.	84171	ARC #DM15-390J
C31	9059 40908	39 pf 5% 500V D.M.	84171	ARC #DM15-390J
C32	9059 40886	100 pf 20% 500V D.M.	84171	ARC #DM15-101G
C33	9065 40942	1 uf 20% 35V Tan.	80183	SPR #150D105X0035A2
C34	9065 40942	1 uf 20% 35V Tan.	80183	SPR #150D105X0035A2
D2	9080 44193	Diode - HPA-2800	04404	HPA #5082-2800
D3	9080 44193	Diode - HPA-2800	04404	HPA #5082-2800
D4	9080 44217	Diode - 1N4153	80368	SYL
D5	9080 44217	Diode - 1N4153	80368	SYL
H-1	9109 48641	Temperature Stabilizer	KLX	KLX #7STH
IC-1	9079 44089	IC - MC1035	80211	MOT
IC-2	9079 44090	IC - MC1235	80211	MOT
IC-3	9079 41815	IC - 710C	13715	FSC #U5B771039X
IC-4	9079 49491	IC - MC1010	80211	MOT
IC-5	9079 44089	IC - MC1035	80211	MOT

Replaceable Parts List (continued)

REFERENCE DESIGNATOR	ORTEC PART NO.	DESCRIPTION	MFR.	MFR. PART NO.
463-0200 Cont'd	5007 46573			
Q1 & Q2	9078 47798	Transistor - SGC2539	01295	TII (Matched)
Q3 & Q4	9078 47798	Transistor - SGC2539	01295	TII (Matched)
Q5	9078 41086	Transistor - 2N3646	13715	FSC
Q6	9078 41086	Transistor - 2N3646	13715	FSC
Q7	9078 41086	Transistor - 2N3646	13715	FSC
Q8	9078 41086	Transistor - 2N3646	13715	FSC
Q9	9078 41075	Transistor - 2N3638	13715	FSC
Q10	9078 47845	Transistor - MPS2369	80211	MOT (Selected - Red)
Q11	9078 47845	Transistor - MPS2369	80211	MOT (Selected - Red)
Q12	9078 41086	Transistor - 2N3646	13715	FSC
Q13	9078 41086	Transistor - 2N3646	13715	FSC
Q14	9078 41086	Transistor - 2N3646	13715	FSC
Q15	9078 41086	Transistor - 2N3646	13715	FSC
Q16	9078 41083	Transistor - 2N3643	13715	FSC
Q17	9078 43688	Transistor - 2N4036	86684	RCA
Q18	9078 47845	Transistor - MPS2369	80211	MOT (Selected - Red)
Q19	9078 47845	Transistor - MPS2369	80211	MOT (Selected - Red)
Q20	9078 43655	Transistor - MPS6531	80211	MOT
Q21	9078 43652	Transistor - MPS3640	80211	MOT
Q22	9078 43650	Transistor - MPS6534	80211	MOT
Q23	9078 43650	Transistor - MPS6534	80211	MOT
Q24	9078 43653	Transistor - MPS6531	80211	MOT
R7	9027 40581	16.2 Ω 1/8W 1% MF	IRC	IRC CEA
R8	9027 40581	16.2 Ω 1/8W 1% MF	IRC	IRC CEA
R9	9027 40574	68.1 Ω 1/8W 1% MF	IRC	IRC CEA
R10	9027 40489	100 Ω 1/8W 1% MF	IRC	IRC CEA
R12	9027 40518	1.33 K 1/8W 1% MF	IRC	IRC CEA
R14	9027 40514	750 Ω 1/8W 1% MF	IRC	IRC CEA
R15	9027 40514	750 Ω 1/8W 1% MF	IRC	IRC CEA
R16	9015 40219	470 Ω 1/4W 5% C	01121	ABC CB
R17	9015 40222	680 Ω 1/4W 5% C	01121	ABC CB
R18	9015 40220	510 Ω 1/4W 5% C	01121	ABC CB
R19	9015 40209	100 Ω 1/4W 5% C	01121	ABC CB
R20	9015 40206	47 Ω 1/4W 5% C	01121	ABC CB
R21	9015 40209	100 Ω 1/4W 5% C	01121	ABC CB
R22	9015 40271	51 Ω 1/4W 5% C	01121	ABC CB
R23	9015 40271	51 Ω 1/4W 5% C	01121	ABC CB
R24	9015 40271	51 Ω 1/4W 5% C	01121	ABC CB
R25	9027 40582	787 Ω 1/8W 1% MF	24546	CGW C-4
R29	9015 40238	4.7 K 1/4W 5% C	01121	ABC CB
R30	9015 40220	510 Ω 1/4W 5% C	01121	ABC CB
R31	9015 40229	1.5 K 1/4W 5% C	01121	ABC CB
R32	9027 40484	51.1 Ω 1/8W 1% MF	24546	CGW C-4
R33	9027 40484	51.1 Ω 1/8W 1% MF	24546	CGW C-4
R34	9027 40508	909 Ω 1/8W 1% MF	IRC	IRC CEA

Replaceable Parts List (continued)

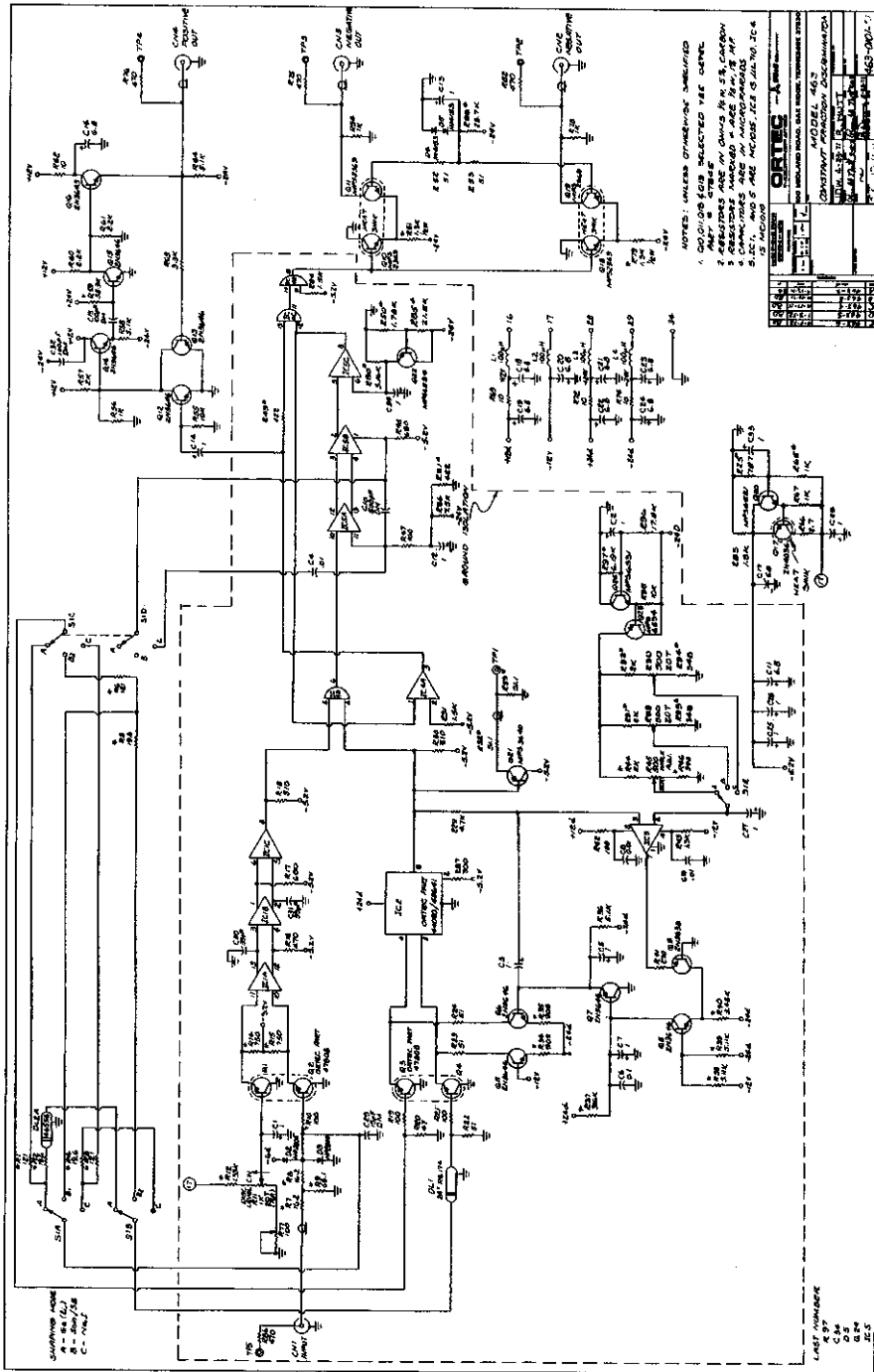
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R35	9027 40508	909 Ω 1/8W 1% MF	IRC	IRC CEA
R36	9015 40239	5.1 K 1/4W 5% C	01121	ABC CB
R37	9027 40604	316 K 1/8W 1% MF	IRC	IRC CEA
R38	9027 40534	5.11 K 1/8W 1% MF	IRC	IRC CEA
R39	9027 40534	5.11 K 1/8W 1% MF	IRC	IRC CEA
R40	9027 40530	3.48 K 1/8W 1% MF	IRC	IRC CEA
R41	9015 40214	270 Ω 1/4W 5% C	01121	ABC CB
R42	9015 40209	100 Ω 1/4W 5% C	01121	ABC CB
R43	9015 40287	1.3 K 1/4W 5% C	01121	ABC CB
R44	9027 40522	2 K 1/8W 1% MF	IRC	IRC CEA
R45	9051 40830	500 Ω 20-T Cer. Pot.	73138	BEK #78P-R500
R46	9027 40504	348 Ω 1/8W 1% MF	24546	CGW C-4
R47	9015 40209	100 Ω 1/4W 5% C	01121	ABC CB
R48	9015 40222	680 Ω 1/4W 5% C	01121	ABC CB
R49	9027 40507	422 Ω 1/8W 1% MF	24546	CGW C-4
R50	9027 40520	1.78 K 1/8W 1% MF	24546	CGW C-4
R51	9030 62382	1.3 K 1/2W 1% MF	24546	CGW C-6
R52	9015 40271	51 Ω 1/4W 5% C	01121	ABC CB
R53	9015 40271	51 Ω 1/4W 5% C	01121	ABC CB
R54	9015 40226	1 K 1/4W 5% C	01121	ABC CB
R55	9015 40245	10 K 1/4W 5% C	01121	ABC CB
R56	9015 40226	1 K 1/4W 5% C	01121	ABC CB
R57	9015 40231	2 K 1/4W 5% C	01121	ABC CB
R58	9015 40239	5.1 K 1/4W 5% C	01121	ABC CB
R59	9027 40559	38.3 K 1/8W 1% MF	24546	CGW C-4
R60	9015 40232	2.2 K 1/4W 5% C	01121	ABC CB
R61	9015 40232	2.2 K 1/4W 5% C	01121	ABC CB
R62	9015 40202	10 Ω 1/4W 5% C	01121	ABC CB
R63	9015 40236	3.3 K 1/4W 5% C	01121	ABC CB
R64	9015 40239	5.1 K 1/4W 5% C	01121	ABC CB
R65	9027 40515	1 K 1/8W 1% MF	24546	CGW C-4
R66	9015 43949	2.7 Ω 1/4W 5% C	01121	ABC CB
R67	9015 40226	1 K 1/4W 5% C	01121	ABC CB
R69	9015 40202	10 Ω 1/4W 5% C	01121	ABC CB
R72	9015 40202	10 Ω 1/4W 5% C	01121	ABC CB
R74	9015 40202	10 Ω 1/4W 5% C	01121	ABC CB
R77	9051 43745	100 Ω 20-T Cer. TPT	83138	BEK #78P-R100
R78	9015 40226	1 K 1/4W 5% C	01121	ABC CB
R79	9030 62382	1.3 K 1/2W 1% MF	24546	CGW C-6
R80	9027 40529	3.16 K 1/8W 1% MF	24546	CGW C-4
R81	9027 40507	422 Ω 1/8W 1% MF	24546	CGW C-4
R83	9015 40230	1.8 K 1/4W 5% C	01121	ABC CB
R84	9015 40229	1.5 K 1/4W 5% C	01121	ABC CB
R85	9027 40553	21.5 K 1/8W 1% MF	24546	CGW C-4
R86	9027 40538	7.5 K 1/8W 1% MF	24546	CGW C-4



**BIN/MODULE CONNECTOR PIN ASSIGNMENTS
FOR AEC STANDARD NUCLEAR INSTRUMENT MODULES
PER TID-20893**

Pin	Function	Pin	Function
1	+3 volts	23	Reserved
2	-3 volts	24	Reserved
3	Spare Bus	25	Reserved
4	Reserved Bus	26	Spare
5	Coaxial	27	Spare
6	Coaxial	*28	+24 volts
7	Coaxial	*29	-24 volts
8	200 volts dc	30	Spare Bus
9	Spare	31	Spare
*10	+6 volts	32	Spare
*11	-6 volts	*33	115 volts ac (Hot)
12	Reserved Bus	*34	Power Return Ground
13	Spare	**35	Reset (Scaler)
14	Spare	**36	Gate
15	Reserved	**37	Reset (Auxiliary)
*16	+12 volts	38	Coaxial
*17	-12 volts	39	Coaxial
18	Spare Bus	40	Coaxial
19	Reserved Bus	*41	115 volts ac (Neut.)
20	Spare	*42	High Quality Ground
21	Spare	G	Ground Guide Pin
22	Reserved		

Pins marked (*) are installed and wired in ORTEC 401A and 401B Modular System Bins.
Pins marked (*) and (**) are installed and wired in EG&G/ORTEC-HEP M250/N and M350/N NIMBINS.



- NOTES: UNLESS OTHERWISE SPECIFIED
1. 500 Ω RES SELECTED VEE CEREAL
 2. RESISTORS ARE IN OHMS UNLESS OTHERWISE SPECIFIED
 3. RESISTORS MARKED W ARE 1% TYPICAL
 4. RESISTORS MARKED M ARE 5% TYPICAL
 5. RESISTORS MARKED S ARE 10% TYPICAL
 6. RESISTORS MARKED T ARE 20% TYPICAL
 7. RESISTORS MARKED Z ARE 50% TYPICAL
 8. RESISTORS MARKED W ARE 10% TYPICAL
 9. RESISTORS MARKED X ARE 20% TYPICAL
 10. RESISTORS MARKED Y ARE 50% TYPICAL
 11. RESISTORS MARKED Z ARE 100% TYPICAL
 12. UNLESS OTHERWISE SPECIFIED

PARTS LIST		QUANTITY		DESCRIPTION			
Q1, Q2	2N3638	2	DIFFERENTIAL PAIR	Q3, Q4	2N3638	2	DIFFERENTIAL PAIR
Q5, Q6	2N3638	2	COMMON EMITTER	Q7, Q8	2N3638	2	DIFFERENTIAL PAIR
R1, R2, R3, R4, R5, R6, R7, R8, R9, R10	RESISTORS	10	VARIOUS VALUES	C1, C2, C3, C4	CAPACITORS	4	VARIOUS VALUES

LAST NUMBER
 R 27
 Q 3
 C 4
 S 2