Model 583B
Constant Fraction Differential Discriminator

Operating Manual

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Manual Revision D

Advanced Measurement Technology, Inc.

a/k/a/ ORTEC®, a subsidiary of AMETEK®, Inc.

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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 Customer Services be contacted in advance of its return so that a Return Authorization Number can be assigned to the unit. Also, ORTEC must be informed, either in writing, by telephone [(865) 482-4411] or by facsimile transmission [(865) 483-2133], 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. The ORTEC 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 designated ORTEC repair center. The address label and the package should include the Return Authorization Number assigned. 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 should follow the same procedure and ORTEC will provide a quotation.

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 assistance can be provided in making damage claims and in providing replacement equipment, if necessary.

CONTENTS

SAFETY INSTRUCTIONS AND SYMBOLS

This manual contains up to three levels of safety instructions that must be observed in order to avoid personal injury and/or damage to equipment or other property. These are:

DANGER Indicates a hazard that could result in death or serious bodily harm if the safety instruction is not observed.

WARNING Indicates a hazard that could result in bodily harm if the safety instruction is not observed.

CAUTION Indicates a hazard that could result in property damage if the safety instruction is not observed.

Please read all safety instructions carefully and make sure you understand them fully before attempting to use this product.

SAFETY WARNINGS AND CLEANING INSTRUCTIONS

DANGER	Opening the cover of this instrument is likely to expose dangerous voltages. Disconnect the instrument from all voltage sources while it is being opened.

WARNING	Using this instrument in a manner not specified by the manufacturer may impair the protection provided by the instrument.

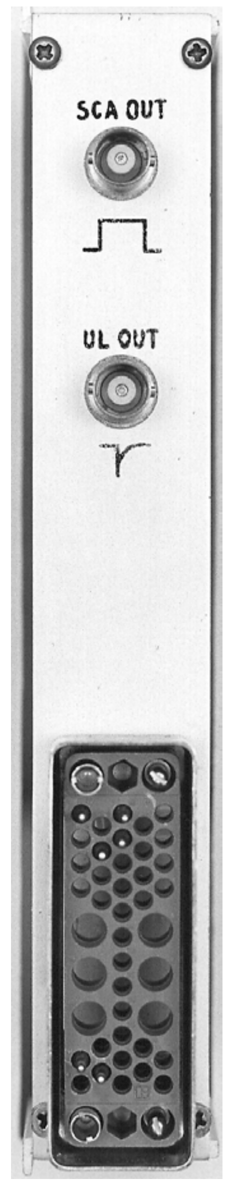
Cleaning Instructions

To clean the instrument exterior:
- Unplug the unit from the ac power supply.
- Remove loose dust on the outside of the instrument with a lint-free cloth.
- Remove remaining dirt with a lint-free cloth dampened in a general-purpose detergent and water solution. Do not use abrasive cleaners.

CAUTION	To prevent moisture inside of the instrument during external cleaning, use only enough liquid to dampen the cloth or applicator.

- Allow the instrument to dry completely before reconnecting it to the power source.


ORTEC
583B
CF DIFF DISC
UPPER LEVEL
LOWER LEVEL
DIFF
CF
INT
SRT
DELAY
INPUT
WALK
WIDTH
CF MON
BK OUT
TIMING OUTPUTS


SCA OUT
UL OUT

ORTEC MODEL 583B
CONSTANT FRACTION DIFFERENTIAL DISCRIMINATOR

1. DESCRIPTION

The ORTEC Model 583B Constant Fraction Differential Discriminator/Single-Channel Analyzer is a single-width NIM module that generates accurate timing output signals for a variety of applications. It accepts input pulses in the range of 0 to −10 V and generates NIM fast negative outputs and a slow positive output that are based on the Constant Fraction time derivation. The 583B can be operated as an integral discriminator or as a single-channel analyzer (SCA) for the anode signals from fast photomultiplier tubes. It provides excellent timing characteristics for a wide dynamic range of input signal amplitudes.

The input impedance of the 583B is 50 Ω, and the NIM fast logic output signals are designed for termination in 50 Ω. A NIM slow positive SCA output is also furnished with an output impedance of <10 Ω.

Although input pulses can range from 0 to −10 V, the discriminator levels range from −30 mV to −5 V. This discriminator range is adequate for most applications.

1.1. DISCRIMINATION AND SINGLE-CHANNEL ANALYSIS

The 583B has a front-panel toggle switch that lets you choose between integral (INT) and differential (DIFF) discriminator. When the 583B is operated as an integral discriminator (integral mode), each input pulse that exceeds the adjusted lower-level threshold set on the 583B front panel causes a set of timing output signals to be generated. To generate the timing output signals in differential mode, the input signal must exceed the lower-level threshold and must not exceed the upper-level threshold for approximately 10 ns after the Constant Fraction zero-crossing time. This is the principle of fast single-channel analysis.

NOTE In differential mode, you must set the lower-level threshold to a lower value than the upper-level threshold, or the 583B will not generate a timing output signal.

Other features of the 583B include:

- A slow rise-time reject function.
- A variable width blocking one-shot.

The front-panel SRT setting gives you a slow rise-time reject feature that inhibits the discriminator response to input signals that would cause leading-edge timing.

The 583B also has a connector and width-adjustment potentiometer for generating and controlling a blocking one-shot pulse. This blocking one-shot is initiated simultaneously with the timing output signals, and prevents the unit from generating additional timing output signals during the selected blocking period.

1.2. CONSTANT FRACTION PRINCIPLE

In the Constant Fraction technique, an input signal to the constant fraction (CF) circuitry is delayed, and a fraction of the undelayed pulse is subtracted from it. A bipolar signal is generated, and its zero crossing is detected and used to produce an output logic pulse.The CF shaping delay is controlled by the length of cable externally connected between the two DELAY connectors on the front panel. This shaping delay should be optimized for each specific application. Optimization requires prior knowledge of the rise-time and nominal width of the input signals to the 583B.

1.3. INPUT/OUTPUT CHARACTERISTICS

The 583B accepts negative input signals up to −10 V without saturation. The primary usage of the 583B is expected to be with the anode signals from photomultiplier tubes. However, for integral-mode applications, other sources of negative signals, such as timing filter amplifiers, may also be used.

If an input signal satisfies the logic conditions established with the 583B, four output pulses are simultaneously initiated:

- Two timing output signals from the front-panel TIMING OUTPUTS connectors. These are separate, negative NIM fast-logic pulses, nominally 5 ns in width.

- A slow positive NIM output through a rear-panel BNC.

- The blocking output from the front-panel BK OUT connector. This is a negative current pulse similar to a NIM fast-logic pulse, except that the width is determined by the front-panel WIDTH control potentiometer. The width of the blocking output is set by the period of the internal blocking one-shot, which can range from ≤15 ns to ≥1000 ns.

In addition, an upper level output pulse is generated when the internal upper-level discriminator is triggered by an input signal. This is a NIM standard fast-negative logic pulse, and is generated in both differential and integral modes.

2. SPECIFICATIONS

2.1. PERFORMANCE

INPUT PULSE Accepts negative input pulses from 0 to −10 V without saturation; input protected against overload; reflections ≤10% for input risetime ≥2 ns.

DISCRIMINATOR RANGES
Upper Level −30 mV to −5 V
Lower Level −30 mV to −5 V

THRESHOLD INTEGRAL NONLINEARITY ≤±0.5% of full scale.

THRESHOLD INSTABILITY ≤±0.1 mV/°C, 0–50°C.

TIME WALK ≤±75 ps for 100:1 dynamic range; integral mode with external shaping delay ~2 ns, input risetime ≤1 ns, input pulse width ~10 ns, threshold = 30 mV.

PROPAGATION DELAY Nominally 18 ns with external shaping delay ~2 ns.

BLOCKING WIDTH Variable from ≤15 to ≥1000 ns.

MINIMUM PULSE-PAIR RESOLUTION ~50 ns for input pulse width ≤10 ns, or pulse width at the arming threshold +40 ns for input pulse width ≥10 ns.

2.2. CONTROLS

UPPER LEVEL Front-panel, 5-turn precision locking potentiometer used to determine the upper-level (UL) discriminator threshold setting.

LOWER LEVEL Front-panel, 5-turn precision locking potentiometer used to determine the lower-level (LL) discriminator threshold setting. Also automatically adjusts the threshold level for the constant-fraction pick-off arming discriminator. Adjustable internally from 0.5 to 1.0 times the LL threshold (factory set to 0.5).

DISCRIMINATOR MODE Front-panel, 2-position locking toggle switch selects one of two modes:

- **DIFF (differential)** Functions as an SCA. The LL and UL thresholds are each independently adjustable from −30 mV to −5 V. To produce an output pulse, the input signal must cross the LL threshold, but must not cross the UL threshold within approximately 10 ns after the constant-fraction zero-crossing time.

- **INT (integral)** Functions as an integral discriminator. The LL threshold sets the minimum input signal amplitude required to produce an output pulse. The UL discriminator is not used to determine the timing response from the instrument.

TIMING MODE Front-panel, 2-position locking toggle switch selects one of two modes:

- **CF (constant fraction)** The instrument operates in the constant-fraction timing mode. The constant-fraction attenuation factor is internally set at 0.2. An external 50-Ω cable must be provided for the constant-fraction shaping delay.

- **SRT (slow-rise-time reject)** Inhibits output signals that would be produced by leading-edge timing from the LL and UL discriminators. An input signal that does not cross the LL threshold before the constant-fraction zero-crossing time does not produce an output pulse. In DIFF mode, an input signal that does not cross the UL threshold before the constant-fraction zero-crossing time will not be inhibited by the UL discriminator from producing an output pulse.

DELAY A pair of front-panel BNC connectors that accept 50-Ω coaxial cable to set the required constant-fraction shaping delay; total delay is ~0.7 ns plus the delay of the external cable.

WALK ADJUST Front-panel, 20-turn screwdriver adjustment for setting the walk compensation for each application.

WALK MONITOR Front-panel test point, adjacent to the walk adjust potentiometer, permits monitoring the actual dc voltage that is set for the zero-crossing reference; normally set in the range of −0.5 mV to +2 mV.

CF MONITOR Front-panel BNC connector that allows observation of the constant-fraction bipolar timing signal; 50-Ω cable and 50-Ω terminator required.

WIDTH ADJUST Front-panel, 20-turn screwdriver adjustment for setting the width of the pulse at the blocking output; variable from ≤15 to≥1000 ns.

2.3. INPUT

Front-panel BNC connector accepts negative input signals from 0 to −10 V without saturation; 50 Ω, direct-coupled; input protected against overloads; reflections ≤10% for input rise time ≥2 ns.

2.4. OUTPUTS

TIMING Two front-panel BNC connectors provide simultaneous NIM-standard fast negative logic signals.

BLOCKING (BK) Front-panel BNC connector provides a NIM-standard fast negative logic signal that occurs simultaneously with the timing outputs; inhibits further timing pulses from being generated during the blocking period; variable from ≤15 to≥1000 ns.

POSITIVE SCA Rear-panel BNC connector provides a NIM-standard slow positive logic signal. Occurs simultaneously with timing outputs.

UPPER LEVEL (UL) Rear-panel BNC connector provides a NIM-standard fast negative logic signal. Occurs as the leading edge of the input signal crosses the UL threshold.

2.5. ELECTRICAL AND MECHANICAL

POWER REQUIRED +12 V, 120 mA; +6 V, 0 mA; −6 V, 650 mA;−12 V, 80 mA.

WEIGHT
Net 0.85 kg (1.9 lb).
Shipping 1.85 kg (4.1 lb).

DIMENSIONS NIM-standard, single-width module per DOE/ER-0457T, U.S. NIM Committee, May 1990; Standard NIM Instrumentation System, NTIS, U.S. Department of Commerce, Springfield, Virginia 22161).

3. INSTALLATION

3.1. GENERAL

The 583B power requirements must be furnished from a NIM-standard bin and power supply such as the ORTEC Model 4001A/4002D Series. Note that −6-V power is required in addition to ±12 V. The bin and power supply into which the 583B will normally be installed for operation is designed for rack mounting. If the equipment is rack mounted, there must be adequate ventilation to prevent any localized heating in the 583B above the maximum limit of 50°C (323 K).

3.2. POWER CONNECTION

Turn off the bin power supply before inserting or removing any modules.

To ensure proper operation, check that the dc voltage levels of the power supply are correct after all modules have been installed in the bin. ORTEC bins and power supplies include convenient monitoring test points on the power supply control panels.

3.3. INPUT CONNECTION

The 583B’s front-panel input connector accepts negative input pulses. This input is terminated internally in 50 Ω. Connect the negative input signal source to this connector through a 50-Ω coaxial cable.

3.4. OUTPUT CONNECTIONS

The primary outputs of the 583B are the NIM-standard fast negative logic signals from the front-panel TIMING OUTPUTS BNC connectors. The circuits driving these two connectors are separate so each timing output can be used independently. Each negative NIM output used must be terminated in 50 Ω, and 50-Ω cable must be used for the interconnections. Unused outputs do not need termination.

The rear-panel SCA OUT output provides a NIM-standard slow positive pulse that is initiated simultaneously with the timing outputs on the front panel. This output can be used with instruments such as counters or ratemeters that require positive input signals. In most applications, the interconnection can be made with 93-Ω cable, terminated in 100 Ω or more.

3.5. CF DELAY CABLE

The CF time derivation circuit is not complete until an external length of 50-Ω cable has been connected between the two DELAY connectors on the front panel. The total CF shaping delay is equal to the external CF shaping delay, $t_{d(Ext)}$, plus approximately 0.7 ns.

We expect that the 583B will be used primarily in fast timing or counting experiments with scintillators and photomultiplier tubes (PMTs). In these applications, the total CF shaping delay, $t_{d(Tot)}$, is selected so that the zero crossing of the bipolar timing signal occurs when the attenuated, undelayed portion of the CF signal has reached its maximum amplitude. Therefore, the zero crossing occurs at the same fraction of the input pulse height regardless of the amplitude of the input signal.

Selecting the CF shaping delay for best timing performance with a given scintillator and PMT usually requires experimentation.

- Apply the randomly generated signals from the PMT anode to the 583B input.
- Each of the two DELAY connectors should be terminated with a 50-Ω terminator.
- The CF MON signal can then be observed on a fast oscilloscope (bandwidth ≥300 MHZ) terminated in 50 Ω and triggered internally.

The CF MON signal then represents the attenuated, undelayed portion of the CF signal with no delayed signal subtracted from it. When the appropriate length of CF shaping delay is added, the resulting bipolar signal at the CF MON output will cross the baseline at a time that corresponds to the peak amplitude previously observed with the attenuated and undelayed signal. A useful empirical formula for the initial trial selection of the external shaping delay is:

$$t_{d(Ext)} \cong 1.1\, t_r - 0.7\ ns$$

where t_r is the 10–90% rise time of the anode pulses.

- Walk adjustment can then be set while observing the delayed CF MON signal on a fast oscilloscope triggered externally by a timing output signal from the 583B. The WALK potentiometer should be adjusted so that the bipolar constant fraction signals for all amplitudes cross through the baseline at approximately the same time.

Figure 1(a) illustrates the anode signals from an RCA 8850 PMT with a 1-in. × 1-in. KL236 scintillator and a ^{60}Co source. Figures 1(b) and (c) show the resulting delayed CF MON signal seen on a sampling oscilloscope, triggered by the 583B timing output. The CF shaping delay and walk adjustment have been set properly and the spread in the zero-crossing time is less than 100 ps.

4. OPERATION

The 583B accepts negative input signals in the range of 0 to −10 V. For each input pulse that satisfies the 583B's logic criteria, four output logic pulses are initiated simultaneously:

- Two timing output signals from the front-panel TIMING OUTPUTS connectors. These are separate, negative NIM fast-logic pulses, nominally 5 ns in width.
- A slow positive NIM output through a rear-panel BNC.
- The blocking output from the front-panel BK OUT connector. This is a negative current pulse similar to a NIM fast-logic pulse, except that the width is determined by the front-panel WIDTH control potentiometer. The width of the blocking output is set by the period of the internal blocking one-shot, which can range from ≤15 ns to ≥1000 ns.

NOTE For optimal walk and jitter performance, the CF MON output should always be terminated into 50 Ω. Either view the CF MON signal with a 50-Ω input scope or place a 50-Ω terminator on the CF MON output.

4.1. DIFFERENTIAL MODE

The LL threshold must be set to a lower value than the UL threshold, or the 583B will not generate a timing output signal. In addition, the input signal must not exceed the UL threshold for approximately 10 ns after the CF zero-crossing time.

Each of the threshold controls has a range of −30 mV to −5 V. Each input pulse that exceeds the UL threshold generates an UL output through the rear-panel connector. The UL output occurs when the leading edge of the input signal exceeds the UL threshold.

4.2. INTEGRAL MODE

To generate a timing output, the input signal must exceed the LL threshold. The UL inhibit function is not used as the criterion for a timing output pulse. A UL output pulse is generated when the input signal exceeds the UL threshold.

4.3. SLOW RISE-TIME REJECT MODE

An SRT timing mode can be used to ensure that leading-edge time walk is not introduced by either the LL or UL discriminator. Leading-edge timing can occur for input signals with exceptionally long risetimes; and for amplitude-and-rise-time-compensated (ARC) timing with input signals that exceed the threshold of interest by only a slight amount. In SRT mode, an input signal that does not cross the LL threshold before the CF zero-crossing time will not produce a timing output pulse. In differential mode, an input signal that does not cross the UL threshold before the zero-crossing time will not be inhibited by the UL discriminator from producing an output pulse.

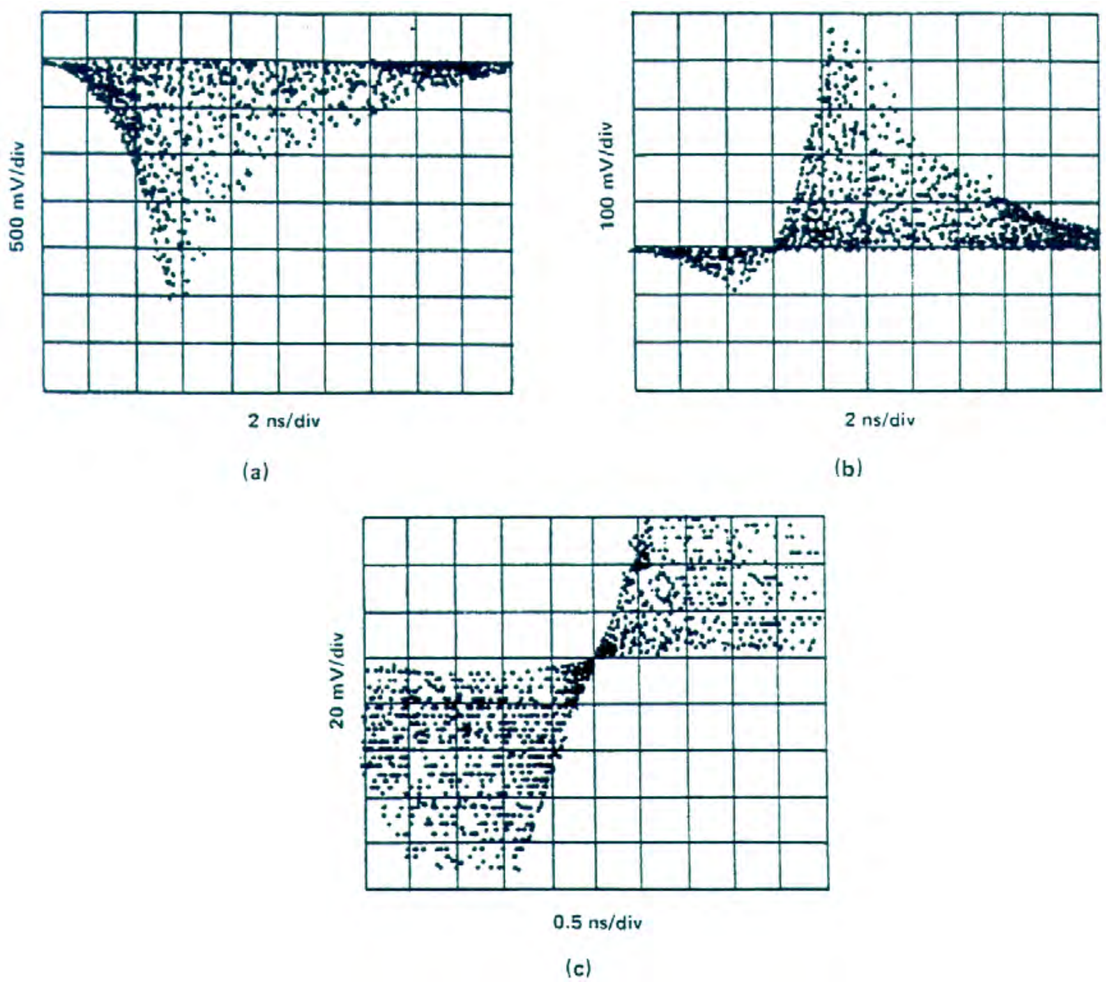


Fig. 1. (a) RCA 8850 PMT Anode Signal with a 1-in. × 1-in. KL236 Scintillator and ^{60}Co Source. (b) Constant Fraction Zero Crossing Monitor Signal, Triggered by the Discriminator Output for the Anode Signal Shown Above. (c) Expanded View of the Constant Fraction Zero Crossing Monitor Signal.

5. TYPICAL APPLICATIONS

5.1. GENERAL

The 583B can be used in a variety of applications in which precise timing information and energy selection capability are needed. Both criteria can be determined for input pulses from PMTs and scintillators. However, the use of the 583B as an integral discriminator is not limited to this type of detector. Other sources of fast negative pulses in the range of 0 to −10 V can be used as inputs for the integral discriminator.

In the CF technique, the time derivation is insensitive to pulse height variations for input signals with a given, fixed rise time. Their signal amplitudes must not exceed the operating range of the instrument.

There are two general system arrangements in which the 583B will be used most often: (1) the fast timing coincidence or measurement system and (2) the fast/slow system. Each of these systems are explained in the following sections.

5.2. FAST SYSTEM

Figure 2(a) shows the instruments required for a simplified fast-timing coincidence system.

Each CF discriminator simultaneously generates the timing information and determines the energy range of interest. If two detected events fall within the selected energy ranges and are coincident within the resolving time selected for the coincidence unit, the time-to-pulse-height converter (TPHC) is gated on to accept the delayed, precise timing information. Thus, the TPHC will process start-stop signals only if these events are of the correct energy and coincident. The CF discriminators are operated in differential mode for this application so they can be used for energy-range selection. The maximum range of coincident signals that will gate the TPHC is set by the fast coincidence unit. The histogram of timing signal differences is accumulated in the multichannel analyzer (MCA).

5.3. FAST/SLOW SYSTEM

Figure 2(b) is the block diagram for a typical fast/slow timing measurement system. In this system, the CF discriminators are operated in integral mode. Output signals from these discriminators occur at the count rate associated with the single events that exceed the 583B's LL threshold setting. This count rate can be an order of magnitude greater than the coincidence rate at which the TPHC is strobed. Note, however, that the TPHC in this system is strobed, not gated, and the converter must handle the full singles rate. In this system, the energy selection and coarse coincidence criteria are determined in the slow linear side channels by the timing SCA units.

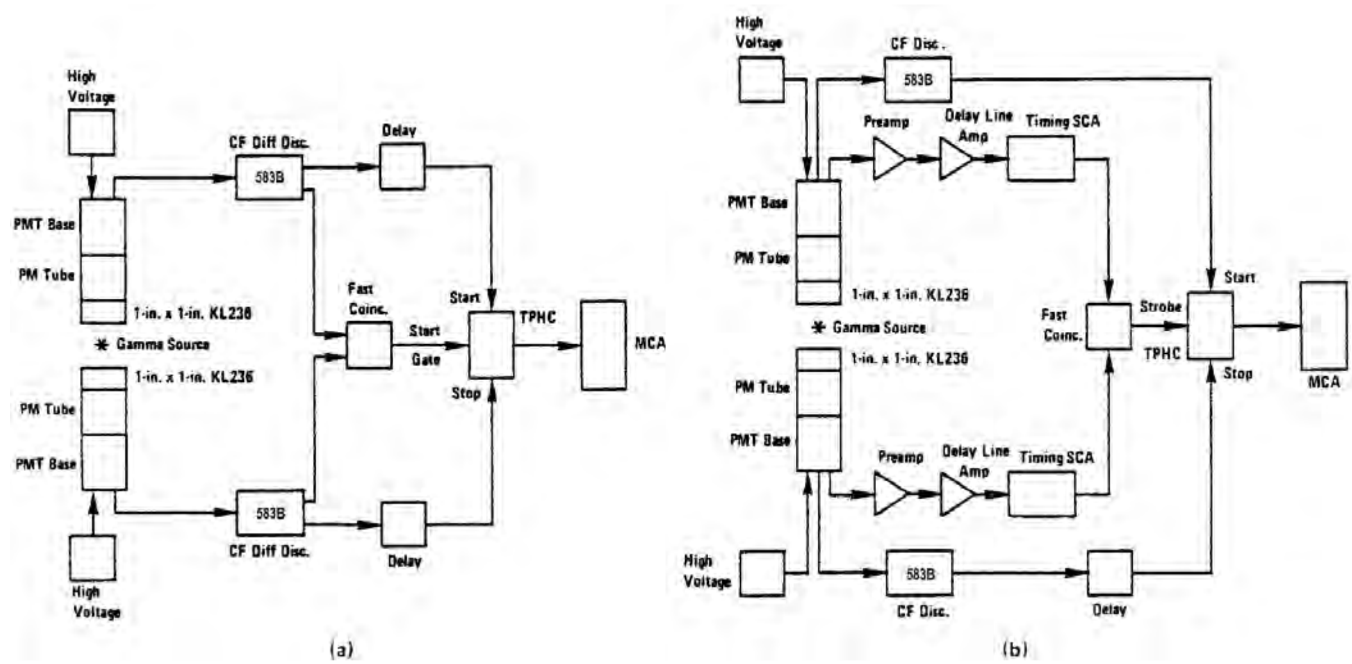


Fig. 2. Typical Fast (a) and Fast/Slow (b) Timing Coincidence Systems for Gamma-Gamma Measurements with Scintillators and PMTs.

6. REFERENCES

The following publications give more information on typical coincidence measuring systems in which the 583B can be extremely useful. In addition, see the reference/tutorial sections of the ORTEC catalog, which you can obtain either in print or on our website.

1. M.O. Bedwell and T.J. Paulus, "A New Constant Fraction Timing System with Improved Time Derivation Characteristics," *IEEE Trans. Nucl. Sci.*, NS-23(1), 234–243 (1976).

2. M.O. Bedwell and T.J. Paulus, "A Constant Fraction Differential Discriminator for Use in Fast Timing Coincidence Systems," presented at the IEEE Nucl. Sci. Symposium, Washington, D.C., October, 1978.

3. W.H. Hardy II and K.G. Lynn, "A New Approach to Timing: the Fast-Fast System," *IEEE Trans. Nucl. Sci.*, NS-23(1), 229–233 (1976).

BIN/MODULE CONNECTOR PIN ASSIGNMENTS FOR AEC STANDARD NUCLEAR INSTRUMENT PER DOE/ER-0457T

Pin	Function	Pin	Function
1	+3 V	23	Reserved
2	−3 V	24	Reserved
3	Spare Bus	25	Reserved
4	Reserved Bus	26	Spare
5	Coaxial	27	Spare
6	Coaxial	*28	+24 V
7	Coaxial	*29	−24 V
8	200 V dc	30	Spare Bus
9	Spare	31	Spare
*10	+6 V	32	Spare
*11	−6 V	*33	117 V 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 V	38	Coaxial
*17	−12 V	39	Coaxial
18	Spare Bus	40	Coaxial
19	Reserved Bus	*41	117 V ac (Neutral)
20	Spare	*42	High-Quality Ground
21	Spare	G	Ground Guide Pin
22	Reserved		

Pins marked (*) are installed and wired in ORTEC's Model 4001A and 4001C Modular System Bins.