Model CF8000
Octal Constant Fraction Discriminator
Operating and Service Manual

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Manual Revision D

0305

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.

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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.

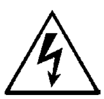
WARNING Indicates a hazard that could result in bodily harm if the safety instruction is not observed.

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.

In addition, the following symbol may appear on the product:

ATTENTION–Refer to Manual



DANGER–High Voltage

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:

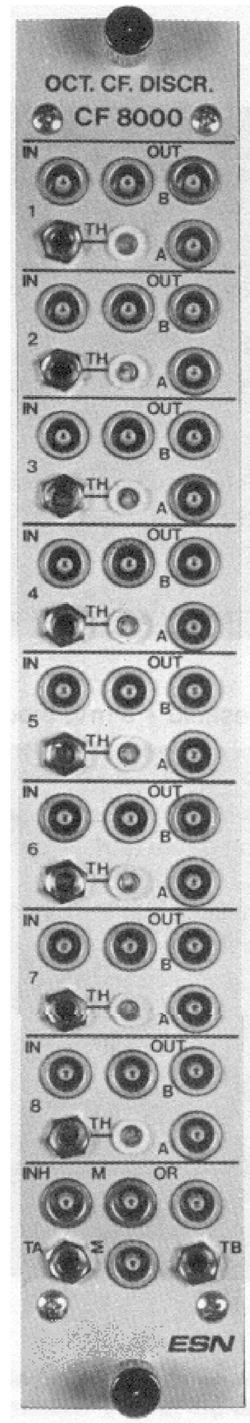
- Unplug the instrument from the ac power supply.
- Remove loose dust on the outside of the instrument with a lint-free cloth.
- Remove remaining dirt with a lint-free cloth dampened in a general-purpose detergent and water solution. Do not use abrasive cleaners.

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-ESN

CF 8000
OCTAL CONSTANT FRACTION
DISCRIMINATOR



FEATURES:

- 8 Independent CFD channels
- Automatic walk adjustment
- Multiplicity output
- OR logic output
- Analog sum output
- Inhibit input
- ECL Outputs
- Energy Outputs
- Internal delay

APPLICATIONS:

* High-density timing experiments
- PMT or solid-state detectors
- Time-of-flight measurements

The powerful Model CF 8000 Octal Constant Fraction Discriminator has the performance and features necessary for even the most demanding experiments. It contains 8 constant fraction discriminators in a single-width NIM module.

Exclusive features of the Model CF 8000 include internal shaping delay, automatic walk adjustment, an analog summation output, and built-in logic functions to minimize external logic requirements.

The input signals can range from 0 to -5 V. Each input has a separate threshold adjustment, with front-panel monitor, which may range from -10 mV to -1 V.

For each channel there are 3 fast NIM logic outputs: 1- “A” and 2- “B” outputs. The “A” output is an updating output with adjustable deadtime. There is a single deadtime adjustment for all 8 “A” outputs, and a single width adjustment for all 16 “B” logic outputs. There are also 8 rear-panel ECL outputs which have the same width as the “B” outputs.

ORTEC MODEL CF8000
OCTAL CONSTANT FRACTION DISCRIMINATOR

1. INTRODUCTION

Constant fraction timing makes use of the knowledge that, for a given pulse shape from a detector/preamplier combination, there is an optimum triggering or discrimination to minimize walk. This optimum fraction varies for pulses of different rise-times.; but for pulses of constant rise-time, it does exist.

The technique operates by inverting the attenuating the pulse from which a time signal is to be derived and adding it back to the delayed (non-inverted, non-attenuated) signal itself. Fig. 1 illustrates the process.

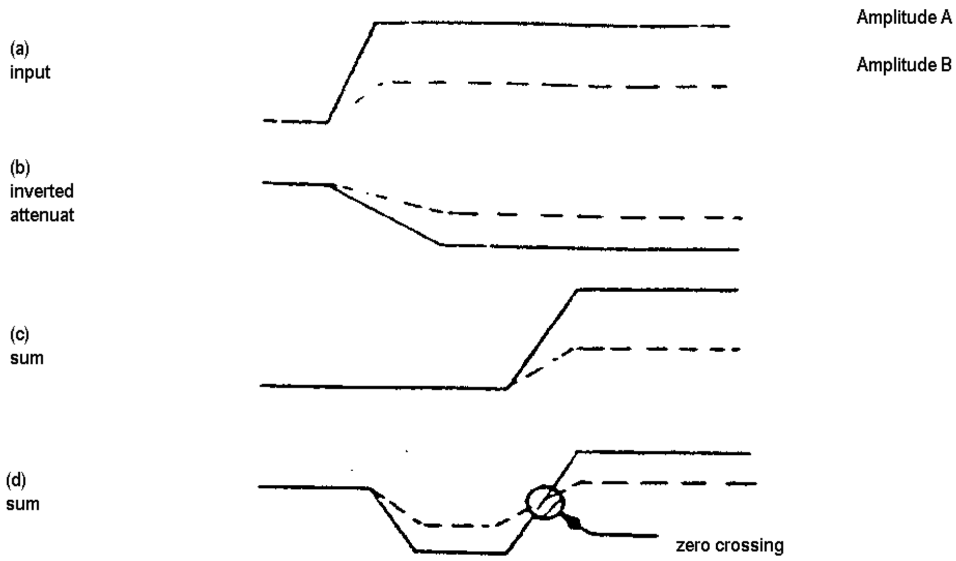


Fig. 1. Constant fraction pulse shaping.

This technique essentially eliminates the “walk” errors caused by signals of constant rise-time, but varying amplitudes.

The technique described above does not compensate for detector rise-time variation. See Fig. 2 which illustrates the result with two pulses of equal amplitude, but varying rise-time.

To compensate for varying rise-times requires a further elaboration of the timing system. The elaboration is to modify the delay time of the non-attenuated, non-inverted signal shown in Fig. 1(c) to a value less than the shortest rise-time that will be encountered. Fig. 3 illustrates the result for two signals of the same amplitude, but differing rise-times, when the delay is set to less than this critical value. Use of this technique does require that certain restrictions upon minimum and maximum signal inputs must be observed.

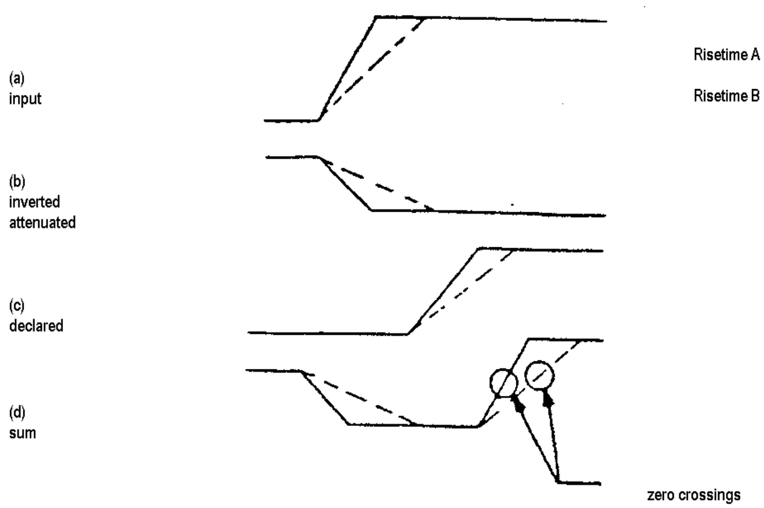


Fig. 2. Constant fraction pulse shaping with varying rise-times.

Use of this technique does require that certain restrictions upon minimum and maximum signal inputs must be observed

Constant fraction timing yields greatly improved time resolution with large Ge(Li) detectors. As an example, one detector timing curve, as measured by the FWHM of the time peak width for known coincident events, was reduced from 6.3 ns to 4.2 ns by using constant fraction timing instead of leading edge timing with a very low energy acceptance range. The improvement is much greater for wide energy range.

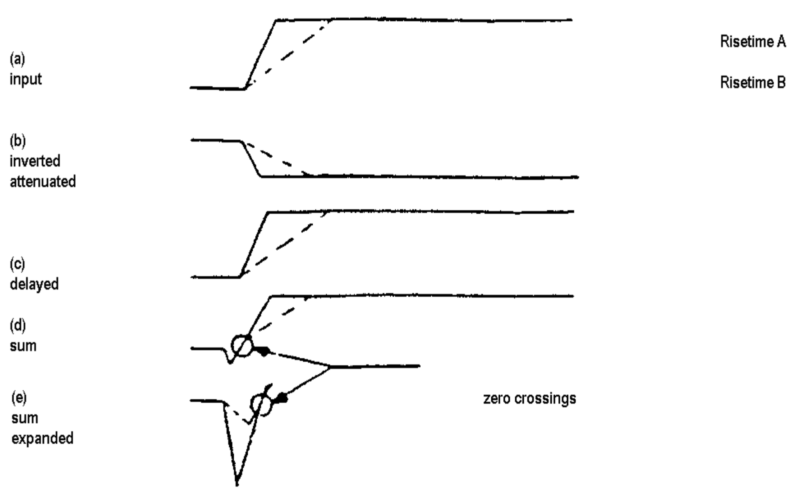


Fig. 3. Pulse shaping for constant fraction timing with rise-time compensation.

2. SPECIFICATIONS

WALK Less than ±150 ps from –20 mV o –2 V. Pulse width = 10 ns, delay = ns, threshold at minimum.

INPUT/OUTPUT RATE 20 MHz maximum

PULSE-PAIR RESOLUTION Less than 50 ns

TRANSMISSION DELAY 13 ns, “A” outputs; 16 ns, “B” outputs typically

THRESHOLD TEMPERATURE INSTABILITY Less than ±100 ppm/°C from 0 to +50 °C.

THRESHOLD CONTROL (TH) 20-turn front-panel screwdriver adjustment for each discriminator channel; variable from –10 mV to –1 V.

THRESHOLD MONITOR Front-panel test point, located to the right of the Threshold control, outputs actual threshold voltage.

WIDTH ADJUSTMENTS (TA and TB) 20-turn, front-panel screwdriver adjustments to set the deadtime of output “A: and width of “B” Fast NIM logic outputs. Both are adjustable from 20 to 200 ns.

DELAY Internal PCB jumper setting allows the proper shaping delay to be selected. 5 possible positions: 2, 4, 6, 8, or 10 ns. Other delays available on order.

INPUTS Front-panel LEMO connector for each channel. Input range, 0 to –5 V; protected to –100 V. Impedance, 50 Ohm, dc-coupled.

INHIBIT INPUT Front-panel LEMO connector accepts negative Fast-NIM signal Active-low signal disables “B” logic outputs.

“A” LOGIC OUTPUTS (A) 8 front-panel LEMO connectors provide adjustable-dead-time, updating Fast-NIM logic signal for inputs above threshold setting. Rise time, 5 ns; fall time 20 ns; amplitude 0.8 V. minimum. Dead time settable from 20 to 200 ns by 20-turn front-panel screwdriver adjustment (TA).

“B” LOGIC OUTPUTS (B) 16 front-panel LEMO connectors provide adjustable-width, Fast-NIM logic signal for inputs above threshold setting. Rise time, 5 ns; fall time 20 ns; amplitude 0.8 V. minimum. Width settable from 20 to 200 ns by 20-turn, front- panel screwdriver adjustment (TB).

MULTIPLICITY OUTPUT (M) Front-panel LEMO connector provides pulse signal whose amplitude is proportional to the number of “B” logic outputs active at any instant. Amplitude range, nominally 0 to –0.5 V. with 50-Ω load.

3. PRINCIPLES OF OPERATION

The input pulse (labeled C_1 in Fig. 4) is split into two parts. One part (labeled A in Fig. 4) is attenuated and applied to the inverting input of a fast differential discriminator. The other part (labeled B in Fig. 4) is delayed and then applied to the non-inverting input of the same discriminator.

The output voltage of this discriminator is determined by the difference of the input voltages. This pulse (labeled AB in Fig. 4) crosses the threshold voltage of the following gate at V_{88},[1] if the voltages at the inputs are equal. From this crossing the timing information is derived.

In order to derive the timing information from a fraction of the maximum amplitude of the input pulse, the timing has to be done at the time of occurrence of this maximum i.e. one has to wait with the timing until the maximum amplitude is known. Thus one has the condition that the maximum of the attenuated pulse - which corresponds to the maximum of the input pulse - has to cross the delayed pulse at the particular selected fraction. This condition leads immediately to the following relation:

$$\tau_{dealer} = \tau_{rise}(1 - \text{fraction})$$

Using the idealized pulse shapes of Fig. 4.

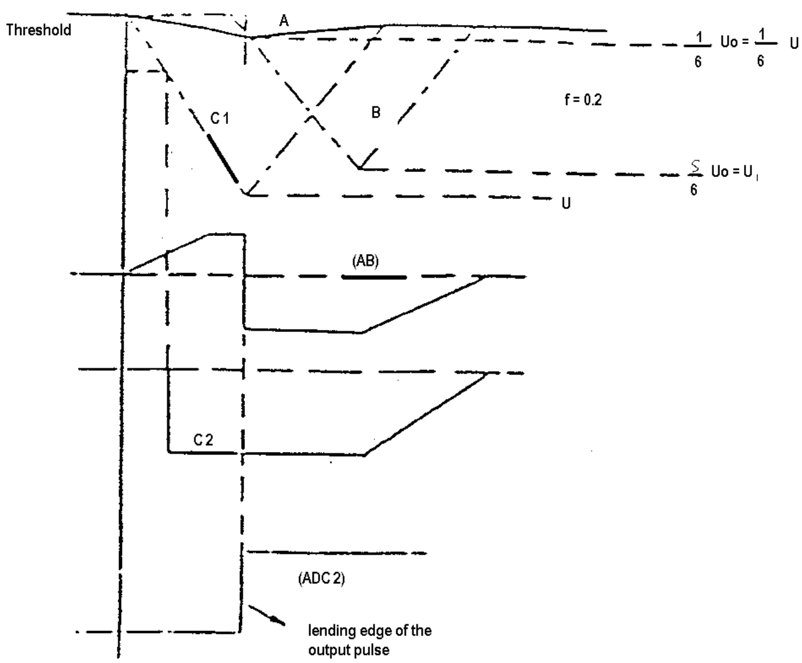


Fig. 4. Pulse shapes at the specified points in the electronic circuit of Fig. 5. The propagation delays of the I. C's are not included in order to display the time resolutions more clearly.

The validity of the approximations made by assuming such idealized pulse shapes has been checked for various values of fraction and the delay time.

We have varied independently the fraction from 0.1 to 0.5 and the ratio of the delay time to the rise-time from 0.4 to 1.0. We found that the time resolution remains essentially constant for fractions between 0.1 & 0.3 for higher fraction (e.g. f = 0.5) the resolution deteriorates somewhat.

The variation of the delay time does not affect time resolution, as long as it satisfied the given relation within a factor of 2. This seems plausible, since the actual pulse shape is not as pointed as our idealization, but varies more smoothly with time.

[1]Nominally, VH = −0.8 V, V88 = −1.2 V, VL + −1.8V; see also the data sheets.

4. TIMING DISCRIMINATOR

This circuit is fulfilled by applying ECL integrated circuits with a propagation delay of 4 ns.

A — signal after the main differential amplifier tract.
B — signal at output of leading edge discriminator.
C — signal from the coincidence gate.
D — signal from the RS-trigger.

Fig. 6 explains the principle of the timing discriminator operation. The differential amplifier in the main stage of the timing discriminator shapes a bi-polar signal from the input signal as already described. Thus, uniform logic signal (A) will be formed at the output due to the high amplification (10^3) and the limitation.

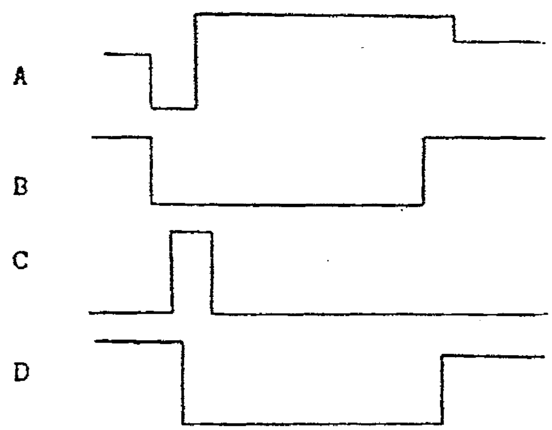


Fig. 6. Timing diagram of the timing discriminator pulses.

Performance of the GSI Constant Fraction Discriminators CF 4000 and CF 8000

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GSI Darmstadt
*Universitat Mainz, Participant of the GSI student program
**Universitat GreBen, Participant of the GSI student program

Since 1980 constant fraction discriminators (CFD) have been built at GSI, following the design of M. M. Maier, Marburg, LGL-Berkeley. The number of channels built has been doubled every year resulting in more than 100 channels in 1983. In 1962, the new 8-channel version with internal delay hybrids, gated baseline restores, inhibit input, and outputs for energy, time (ECL) common multiplicity. Sum-energy, and logical OR was produced first for the GSI/LBL Plastic-Ball collaboration. This CF 8000 has become available for experiments at the UNILAC in 1983 and has been added to the GSI NIM-pool. During the GSI student program intensive tests had been made with constant fraction discriminators.

The purpose of a discriminator in nuclear electronics is to produce a standard output signal from an analog input signal to define the time of an event. The constant fraction discriminator gives an output signal at a fixed delay after a constant fraction of the pulse's rise-time. This guarantees good time information for pulses of constant shapes within a wide range of amplitudes.

For the measurement of the delay as a function of the dynamic range of input signals. A pulser signal has been fed into the CFD time output stopped a time-to-amplitude converter (TAC) that was started by a reference signal. The time differences have been measured using a multi-channel analyzer(MCA). The delay of the attenuator has been taken into account. The correction factors have been determined by measuring the phase differences at different attenuation factors at 200 MHz with a vestor voltmeter. The systematic errors of this correction have been = 8.5 ps. Fig. 1 shows the delay as a function of the amplitude of the input signal (log scale) for different constant fraction discriminators. The test pulsers have had a rise time of 5 ns and a decay time of 15 ns. The walk adjustments for the CF 4000. TC 454, and ORTEC 934 have been done by optimizing the performance curves. The resulting walk has been about 2 mV more positive than the well known equal brightness recipe for CF 4000 and TC 454. The bigger shift of the CF 8000 is due to the symmetric walk adjust. Done by the automatic baseline restorer instead of the better asymmetric adjust.

Fig. 2 shows the performance of the CFDs at a faster rise-time of the test pulses. The large time shift at high pulse amplitudes for CF 4000, CF 8000 and TC 454 are a property of the fast discriminator C SP9637 used in these modules. The ORTEC 934 using the older AM687 IC does not show that behavior. An improvement of the rise at large amplitudes might be possible using the already announced new IC AM 9687.

For longer decay time pulses the delay of the CFD is rather insensitive as soon as it is long enough 108-10 times the rise time. The course setting of the delay possible in the CF 8000 is thus sufficient. The threshold setting has no influence on the performance above the threshold.

The temperature stability of the CF 4000 has been measured to be less than 3 ps/°C. Due to reduce the power consumption by the circuit design the count rate capability is not higher than 15 MHz for the CF 4000 and 40 MHz for the CF 8000 depending on the dead time setting. There is no decline of the performance with increasing count rate.

For a 5-V input signal there is not triggering of other channels as long as the threshold is higher than 3–4 mV for both the CF 4000 and the CF 8000.

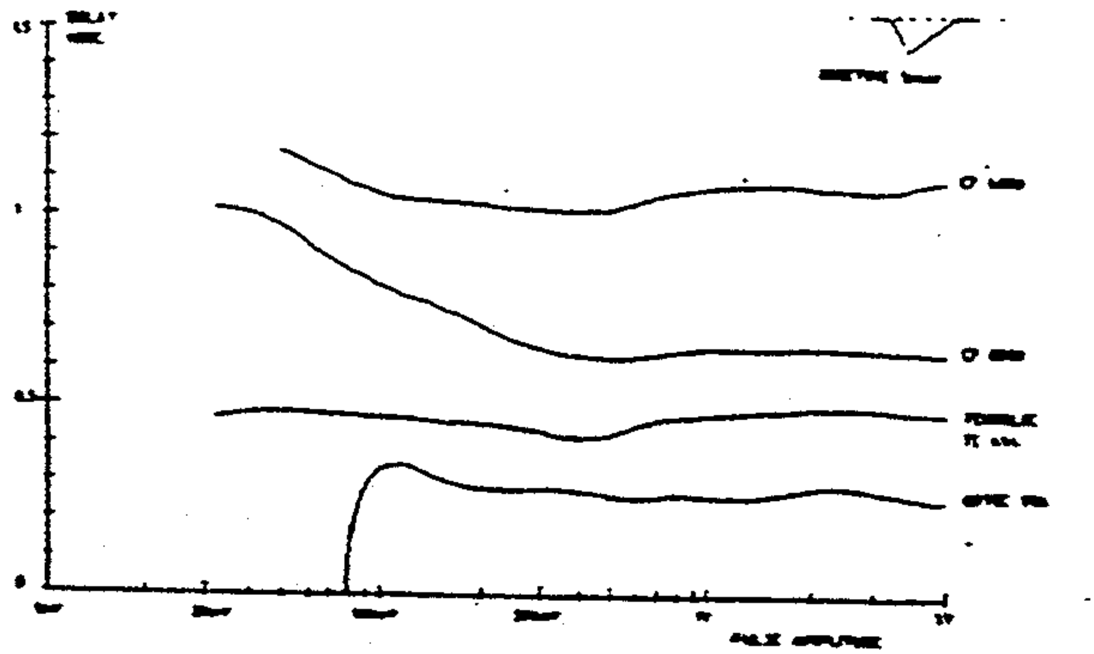


Fig. 1. Delay as a function of the amplitude of the input signal for different constant fraction discriminators. CF4000: fraction f = 0.25, delay t = 5 ns (1 m) threshold u = 10 mV; CF 8000: f = 0.4, t = 6 ns, u = 10 mV; TC 454: f = 0.2, t = 5 ns (1 m). U = 30 mV, 12 interval attenuation; ORTEC 934: f = +0.2, t = 5 ns (1 m), u = 30 mV.

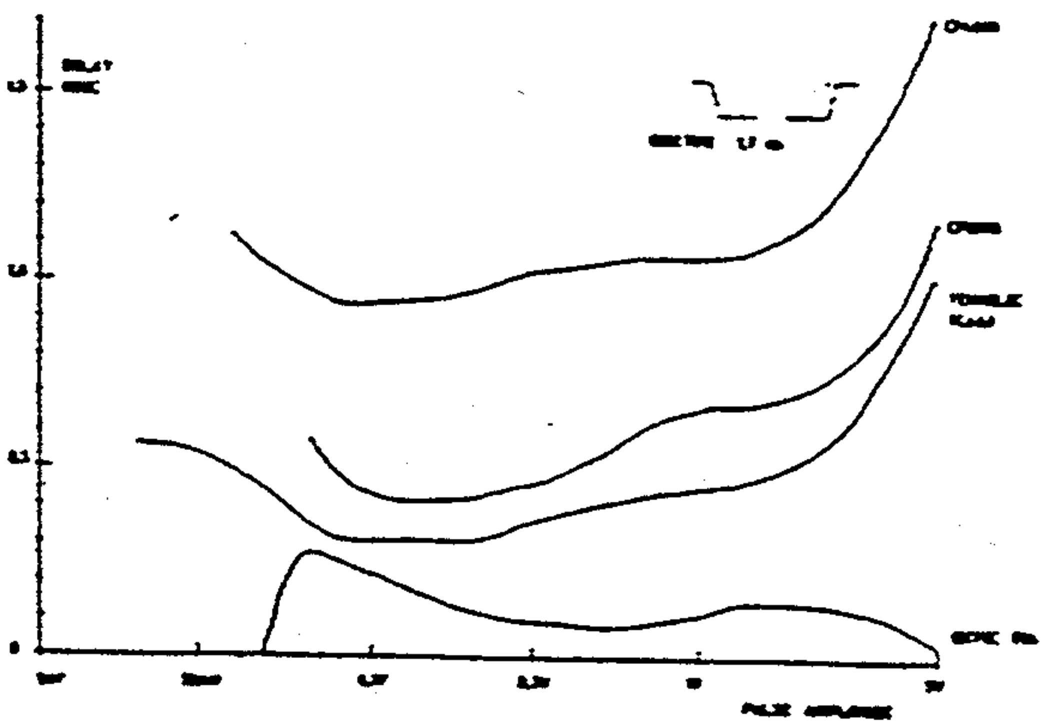
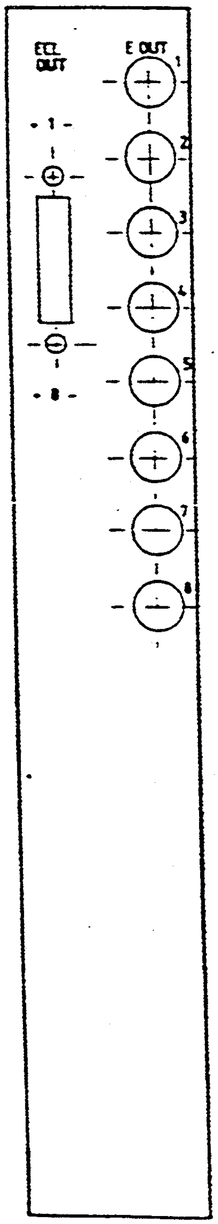


Fig. 2. Same as Fig. 1 except rise time of input signal is now 1.7 ns.

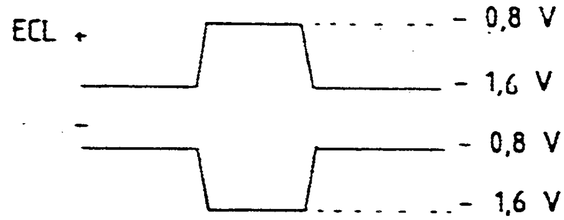
CF 8000

(REAR PANEL)



ANALOG OUT (AC COUPLED)

OUT B; WIDTH= TB



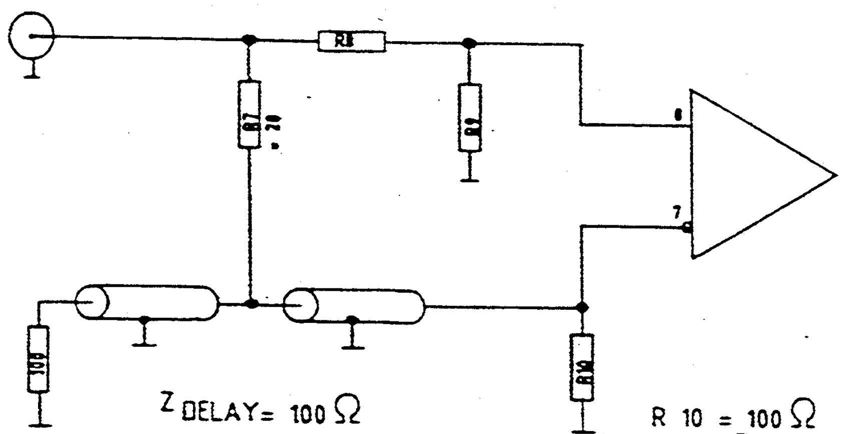
DIFFERENTIAL LINE
LINE IMPEDANCE : 112 Ω

DELAY TIME : 2,4, ... 10 ns
USING 10 ns HYBRID DELAY PLUG IN
bestücken

AVAILABLE ALSO :
6,12, ... 30ns (30 ns PLUG IN)
10,20, ... 50ns (50 ns PLUG IN)

CF 8000

SELECTING FRACTION



Z DELAY= 100 Ω

R 10 = 100 Ω
=Z DELAY

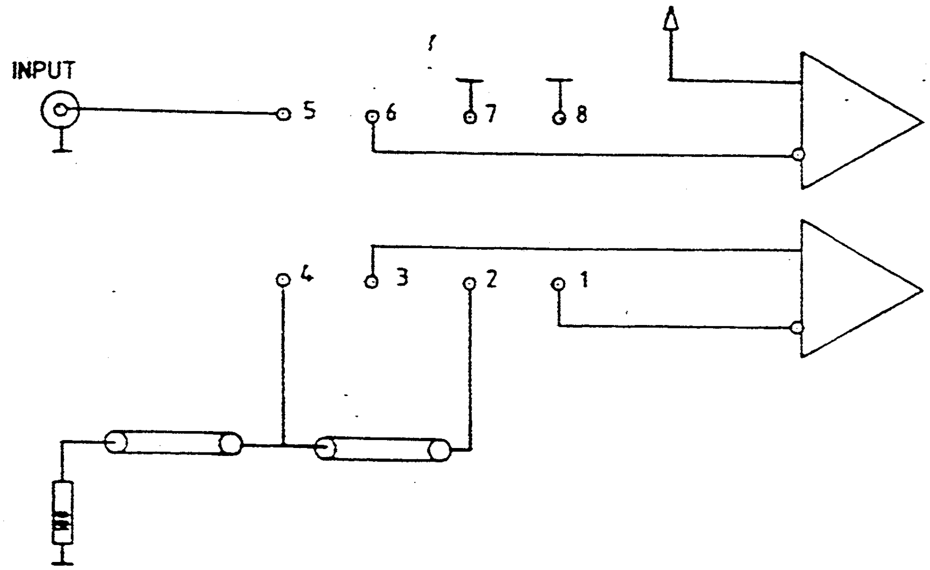
1.) 70 Ω || (R8 + R9) = 50 Ω

R8 + R9 = 175 Ω

2.) R9 = 175 Ω • $\frac{50\Omega}{70\Omega}$ • f = 125 x f

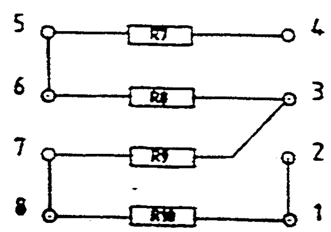
R8 = 175 - R9

		f = 0,2	f = 0,4
R7 =	20 Ω	20 Ω	20 Ω
R8 =	175 Ω - R9	150 Ω	125 Ω
R9 =	125 Ω x f	25 Ω	50 Ω
R10 =	100 Ω	100 Ω	100 Ω



A. TO CHANGE THE FRACTION ·

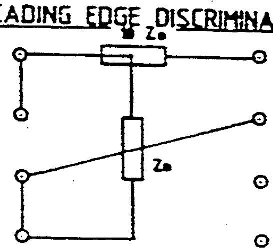
RESISTORS R3 AND R4 HAVE
TO BE CHANGED USING THE
FOLLOWING RELATION



CF

FRACTION= f
R7 = 20Ω
R10= 100Ω
R8 = 175Ω - R9
R9 = 125Ω·f

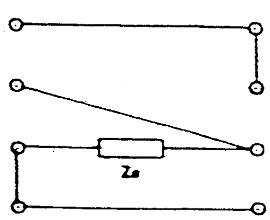
B. USING CF 8000 AS A
LEADING EDGE DISCRIMINATOR



LE

Zo = 50Ω

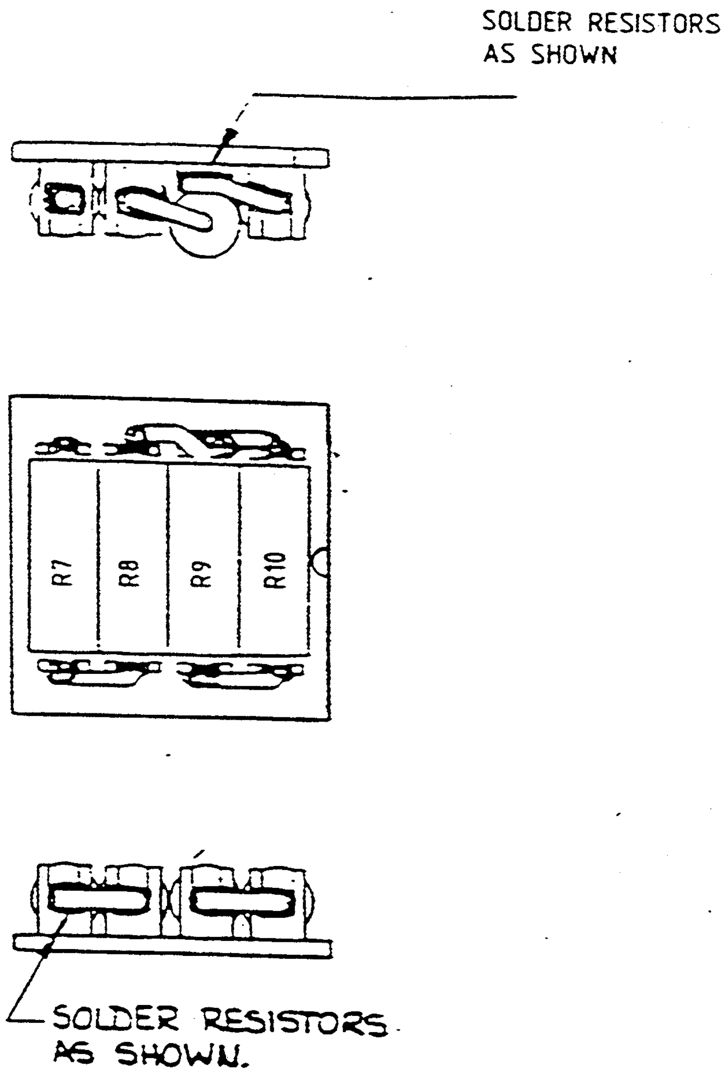
C. USING CF 8000 AS A
ZERO CROSSING DISCRIMINATOR



Z/C

Zo = 50Ω

CF 8000
FRACTION PLUG IN



DETAIL A

SCALE: 4:1
TYP. 8 PLCS