CONSTANT FRACTION DISCRIMINATOR
Model 1428

Instruction Manual

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CONTENTS

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Section 1

INTRODUCTION

A constant fraction discriminator (CFD) is used to extract time information from radiation detectors. It can be used with semi-conductor or scintillation detectors. In the case of a semiconductor detector system the input signal for the CFD is derived from the output of the preamplifier via a Timing Filter AMP or a Differentiation (usually a coupling capacitor from the preamplifier output of 1 pF to 10pF to the input of the CFD is sufficient) if signal polarity is negative. In a scintillation detector system it is derived from the anode of the photo-multiplier tube. In a CFD, timing is obtained by triggering at a constant fraction of the amplitude of the input signal so, if the shape of the risetime does not change, a time signal is produced that is independent of amplitude and risetime. The constant fraction triggering is achieved by subtracting the delayed input signal from a fraction of the original input signal, thereby developing a non-symmetrical bipolar waveform. The zero crossing of the bipolar waveform is at a constant fraction of the input signal. The 20% fraction used in this particular design is a compromise between different kinds of detectors and uses. It can be changed on request. A block diagram of the CFD is shown in Figure 1.

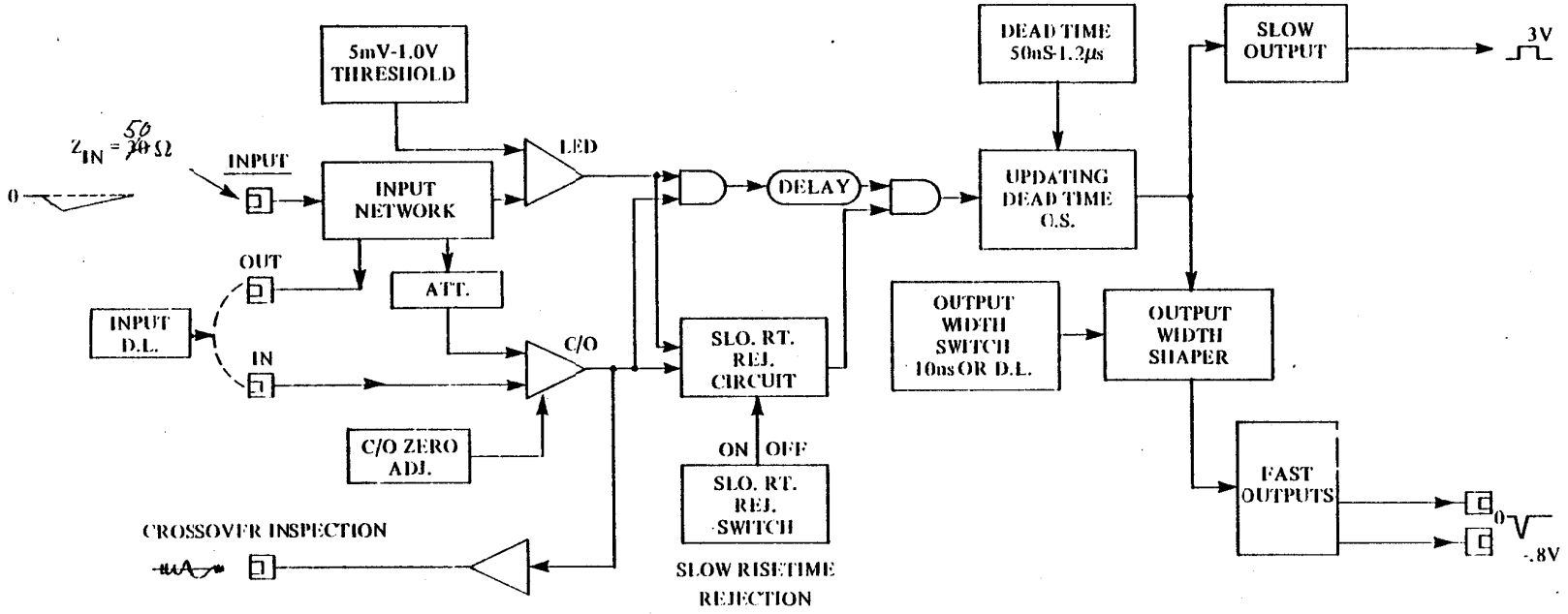

Figure 1-1. Constant Fraction Discriminator, Block Diagram

Section 2

SPECIFICATIONS

2.1 INPUTS

NEGATIVE	5mV to -5V linear signal: Z_{in} = 50 ohms: risetime 1nsec. or longer: front panel BNC. protected to -100V (limited by input resistor dissipation)

2.2 OUTPUTS

INSPECT	displays output signal of Zero Cross discriminator: is used to set Zero Cross discriminator with walk ADJUST potentiometer
DELAY (Rear Panel)	2 BNC connector: for a 50 ohm delay cable must be connected to match risetime of input signal: t delay $\approx$ 0.2tr for Germanium Detectors: t delay $\approx$ 0.8tr for other detectors
FAST OUT	two independent fast NIM outputs 20nsec wide and 18mA into 50 ohms; risetime 5.0nsec.
SLOW OUT	independent output positive signal 2 volts on 50 ohms; risetime 10nsec typical; Slow output width is equal to internal dead time

2.3 CONTROLS

THRESHOLD	variable from -5mV to -1V
WALK ADJUST	sets the Zero Cross discriminator
MODE	sets LET, Leading Edge Timing; CFT, Constant Fraction Timing; CFRR, Constant Fraction with Slow Risetime Reject
WIDTH	controls width of slow output which is equal to the deadtime of the 1428 (screwdriver adjust)

2.4 PERFORMANCE

INPUT AMPLITUDE RANGE	-5mV to -5V linear
WALK	(CF Mode) for a dynamic range of 1:500, < 1ns: for 1:100, < 200psec
WALK	for LE < 300psec from X2 to 20 times threshold
COUNTING RATE	> 10MHz: limited by deadtime setting
PULSE PAIR RESOLUTION	< 80nsec: limited by deadtime setting
THRESHOLD STABILITY	0.1% per ^{o}C for 24 hours

TEMPERATURE RANGE	0 to 50°C
LINEARITY	0.25%
TYPICAL DELAY CABLE LENGTH (50 Ohms. RG58/U)	plastic, NaI and Si(Sb) cable 1.5' to 3-1/3' (45.72cm to 40.64cm) for planar Germanium cable 3–1/3' to 7' (40.64cm to 213.36cm) for coax. Ge(Li) cable 7' to 14' (213.36cm to 426.72cm); allow ≈ 1.5ns/foot for time delay

2.5 POWER REQUIREMENTS

+12VDC – 130mA
- 12VDC – 450mA

2.6 PHYSICAL

SIZE	single width NIM module (1.35 inches wide) (3.43cm) per TID-20893(Rev.)
NET WEIGHT	2 lb (0.9 kg)
SHIPPING WEIGHT	3 lb (1.35 kg)

SECTION 3
INPUT REQUIREMENTS

3.1 SIGNAL

The input is dc coupled and internally terminated in 50 ohms. The signal should be a fast rising negative pulse less than three volts in amplitude. Correct operation of the discriminator depends on the signal baseline being near ground potential (± 15mv).

3.2 INPUT DELAY LINE

A short length of coaxial cable (50Ω) should be connected between the input delay line IN-OUT BNCs on the front panel. The delay chosen should depend on the type of detector and application. If the risetime and shape of the detector signal is constant (e.g. scintillators, or a thin silicon detector) a delay equal to about 0.8 times the signal risetime should be used. If the risetime changes, as in thick germanium detectors, a delay equal to about 0.1 or 0.2 times the detector's collection time should be used for all cases where the signal/noise ratio is large. A longer delay and a bigger fraction may be needed for low energies where the signal/noise becomes small.

SECTION 4
OPERATION

4.1 GENERAL

The purpose of this section is to familiarize the user with the operation of the Model 1428 Constant Fraction Discriminator and to check that the unit is functioning correctly. Since it is difficult to determine the exact system configuration in which the module will be used, explicit operating instructions cannot be given. However, if the following procedures are carried out, the user will gain sufficient familiarity with this instrument to permit its proper use in the system at hand.

4.2 THRESHOLD

The THRESHOLD control is a 10-turn helipot mounted on the front panel. It provides a range of adjustment from 5 mV to -1.0V. It should be adjusted so that the leading-edge discriminator is triggering just above noise.

4.3 C/O ADJ

The crossover trigger level is adjusted by a screwdriver control on the front panel. It sets the threshold of the crossover discriminator. The front end of the Model 1428 has a DC coupled input, therefore the C/O adjustment can only be made correctly when its input is connected to the signal source. If the signal source has an offset greater than ± 6mv the C/O ADJ. cannot be set correctly. The adjustment is performed by observing the C/O inspect BNC (terminated in 50 ohms) on an oscilloscope and adjusting the C/O ADJ.

When using the Model 1428 with an attenuator and pulse generator, it may be necessary to readjust the WALK ADJUST if the resistance of attenuator changes with each of its settings. Care must be taken using the pulse generator that its zero offset is small and does not change for different attenuator settings.

The normal adjustment for the inspect BNC is to see noise between two evenly saturated lines on the oscilloscope (Figure 2). For better walk using fast detectors a setting where the noise just disappears into the bottom line should be used (Figure 3). This will cause some loss in counting efficiency.

4.4 OUTPUTS

Other than the L.E. and C/O inspect output, the CFD has three outputs. There are one slow (wide) and two fast (clipped) outputs.

4.4.1 SLOW OUTPUTS

The slow output is on the front panel and T.T.L. compatible (+3V into 50 ohms) with a width equal to the width of the internal up-dating dead-time one-shot. The dead-time range is from about 50 ns to 1.0μs, and is adjustable internally with a control on the circuit board. The risetime of the slow output is less than 10 nsec.

4.4.2 FAST OUTPUTS

There are two independent negative outputs (-0.8 V into 50Ω). The fast outputs are clipped pulses that occur at the beginning of the dead-time pulse. The fast out pulses are clipped by a built in 20 ns clipper. The risetime of the fast output is less than 2 ns. The two fast negative outputs are on the front panel.

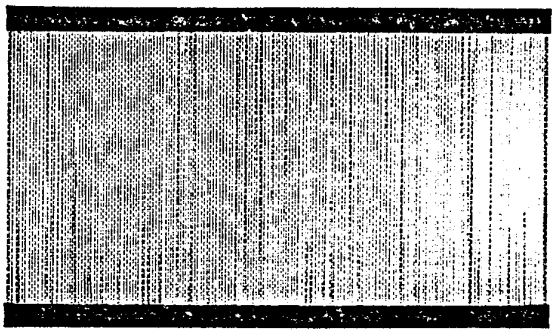

Figure 2. C/O inspect waveform
using a fast oscilloscope
with normal adjust. connected to a Ge detector.

Figure 3. C/O inspect waveform
using fast detectors.

4.5 THREE POSITION MODE SWITCH

4.5.1 CFRR (Constant Fraction with Rise Time Rejection)

This position of the mode switch is used to prevent outputs resulting from input signals that are too slow to obtain a correct constant fraction. Since the leading edge discriminator triggers at a higher level than the crossover discriminator it is possible for a slow risetime signal to cause the leading edge discriminator to trigger after the crossover discriminator. This effect will cause tailing or a satellite peak in a time spectrum. This is avoided by setting the switch to this position.

4.5.2 CF (Constant Fraction)

In the OFF position the slow risetime rejection circuit is disabled and the CFD produces an output for all input signals above the discriminator threshold.

4.5.3 L.E.T. (Leading Edge Timing)

In the L.E.T. mode the module is used as a leading edge discriminator with the same threshold as discussed in the CFD description, (-5mV to -1.0 V).