LBL-6707

FAST TIMING DISCKIMINATOR

C. C. LO
Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720

July 11, 1977

Prepared for the NASA-Goddard Space Flight Center under Contract NDPR No. S-55772A and the U. S. Energy Research and Development Administration under Contract W-7405-ENG 48.

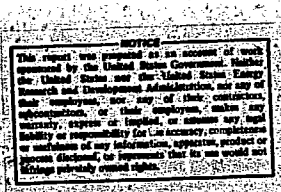


Table of Contents

FAST TIMING DISCRIMINATOR

C. C. Lo
Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720

July 11, 1977

Introduction

The processing of pulses with very fast risetimes for timing purposes involves many problems because of the large equivalent bandwidths involved. For pulses with risetimes in the 150 ps range (and full widths at half maximum (FWHM) of 400 ps) bandwidths in excess of 1GHz are required. Furthermore, these very narrow pulses with current amplitudes as small as 1 mA carry very small charges ($<10^{-12}$ coulomb), therefore, requiring very sensitive trigger circuits. The difficulty increases when timing characteristics in the picosecond range are sought expecially when a wide input signal amplitude range causes a time-walk problem. The fast timing discriminator described here has a time-walk of approximately $\pm$ 75 ps over the input signal range from 80 mV to 3V.

Circuit Operation

Figure 1 is a complete schematic of the discriminator. Signals enter at PG_2 and R_1; R_2, CR_1-CR_2 serve as an amplitude limiter for high amplitude pulses. The signal is injected into

the tunnel diode CR_3 through transformer T_1. Bias on CR_3 is set by R_3 and R_4, R_3 being a ten turn potentiometer mounted on the front panel for low threshold adjustment while R_4 is mounted on the rear panel and used for adjustment of the lowered limits such that CR_3 would not oscillate with R_3 set at the most counter clockwise position. L_1 and CR_4 serve as a non-linear load. When the voltage exceeds the preset threshold across CR_3, the diode is triggered producing a pulse whose width is determined by L_1. This pulse passes through R_6 and CR_5, to the tunnel diode CR_6 in the driver stage. When this diode is triggered it produces a pulse which is used to drive the comparator, M_1 which, in turn, drives the five output stages.

Performance

Since the signal pulse energy is below 1 x 10^{-12} coulomb, it is logical to use a tunnel diode as trigger element. Both tunnel diode stages are one-shot leading-edge-trigger-multivibrators. The walk characteristics of leading edge discriminators depends on the threshold setting of the discriminator and on the risetime and amplitude of the input pulse.

The time walk characteristics were measured as a function of input pulse amplitude using the system shown in Figure 2. The output pulse from the HP215A is shaped by a snap-diode pulse shaping network. The function of this circuit is to speed up the 10-90% risetime of the pulse from 800 ps to 170 ps. The width of the pulse is set by the width adjustment control on the HP pulse generator except in case of the 250 ps pulse width

where a clipping stub is used at the output of the snap diode shaper to differentiate the main pulse and provide a shorter pulse. Figure 3A and 4A show the 400 ps and 250 ps pulse respectively. Figure 3B and 4B show the output pulse from discriminator B and A respectively.

For an input pulse having a risetime of 170 ps and a pulse width of 400 ps at the FWHM points, the time-walk over a dynamic range from 80 mV to 3V is ± 75 ps. For an input pulse having a risetime of 170 ps and pulse width of 250 ps at the FWHM points, the time-walk over the same dynamic range is ± 150 ps. The time-walk characteristics as a function of amplitude are shown in Figs. 5 and 6.

Operation Requirement

The discriminators are built in a single width NIM module and require ± 6V and + 12V to operate. The front panel threshold adjustment sets the first tunnel diode stage bias; this adjust- will affect the time-walk in the low signal amplitude range. To obtain the best walk characteristic over the widest dynamic range, the threshold setting should be set at the most sensitive position (just above the oscillation threshold of the tunnel diode). The driver stage threshold bias does not normally need adjustment. For stable operation the discriminators should be powered at all times. A brief summary of likely fault conditions is given in Appendix I.

A print list of the discriminator is given in Appendix II.

Acknowledgments

This work was performed as a part of the program of the Electronics Research and Development Group of the Lawrence Berkeley Laboratory, University of California, Berkeley, and was supported by the National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Maryland, and the Energy Research and Development Administration, Washington, D. C.

Appendix 1: Trouble Shooting

Symptoms	Possible Cause and Correction
Random output pulses without input	1. Front panel threshold setting too sensitive. (Readjust in a clockwise direction) 2. Driver stage bias too high.
No output pulse	1. Check power supply to the discriminators. 2. Check input pulse. 3. Use high-impedance wideband probe to trace the signal from input to output, stage by stage. 4. Make proper adjustments or replace defective components.
Excessive walk	1. Check input pulse-width, amplitude and risetime making sure they meet the input specifications; 150-170 ps, 10-90% pulse risetime with a pulse width of 400 ps at the FWHM points. 2. Improper threshold bias adjustment. 3. Improper driver bias adjustment.

Figure Captions

1. Schematic diagram of the fast timing discriminator.
2. System block diagram of the time-walk measuring system.
3A. 400 ps input signal pulse.
3B. Output pulse from discriminator B.
4A. 250 ps input signal pulse.
4B. Output pulse from discriminator A.
5. Discriminator time-walk characteristics as a function of the amplitude of a signal pulse having a width of 400 ps at FWHM.
6. Discriminator time-walk characteristics as a function of the amplitude of a signal pulse having a width of 250 ps at FWHM.
7. Front panel of the fast timing discriminator.
8. Rear panel of the fast timing discriminator.
9. Wiring side of the printed circuit board of the fast timing discriminator.
10. Component side of the printed circuit board of the fast timing discriminator.

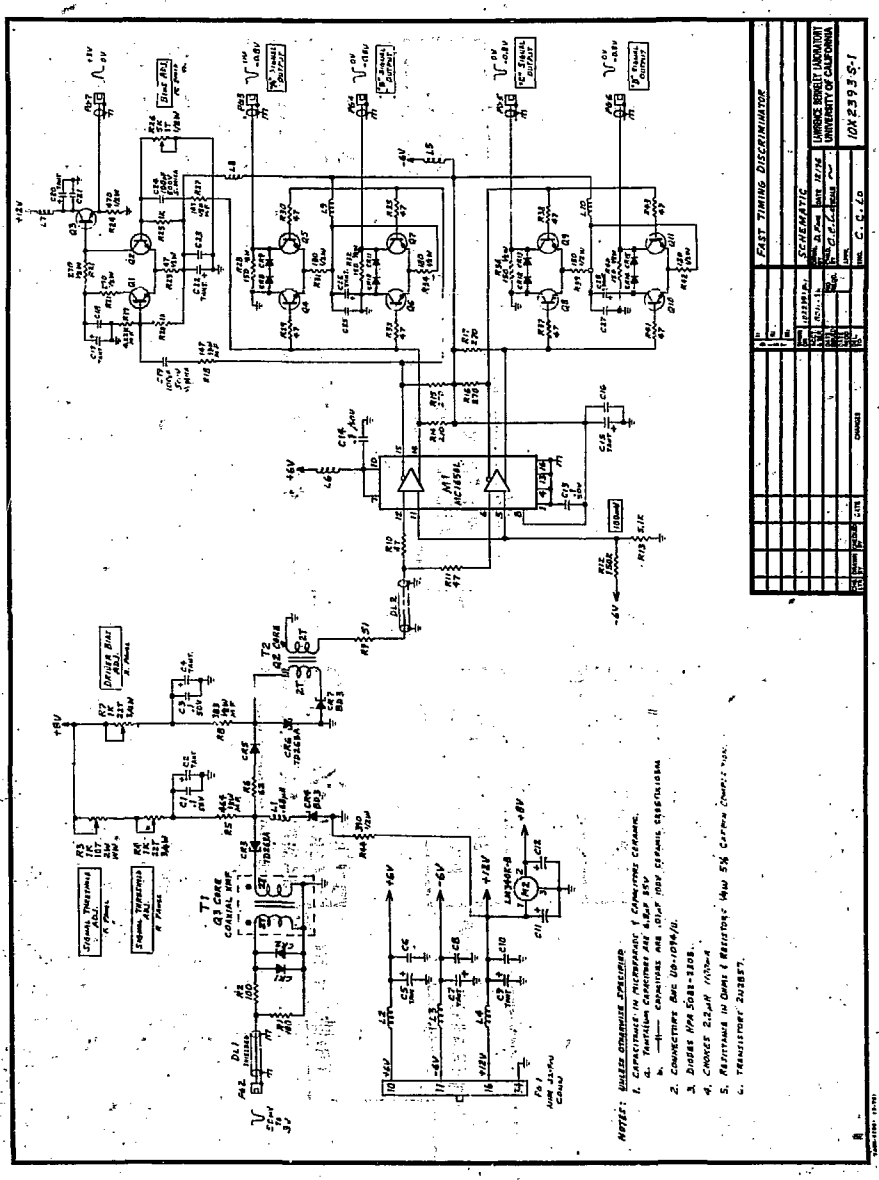

FAST TIMING DISCRIMINATOR
SCHEMATIC
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
ION 23935-1
XBL 778-9917

Fig. 1

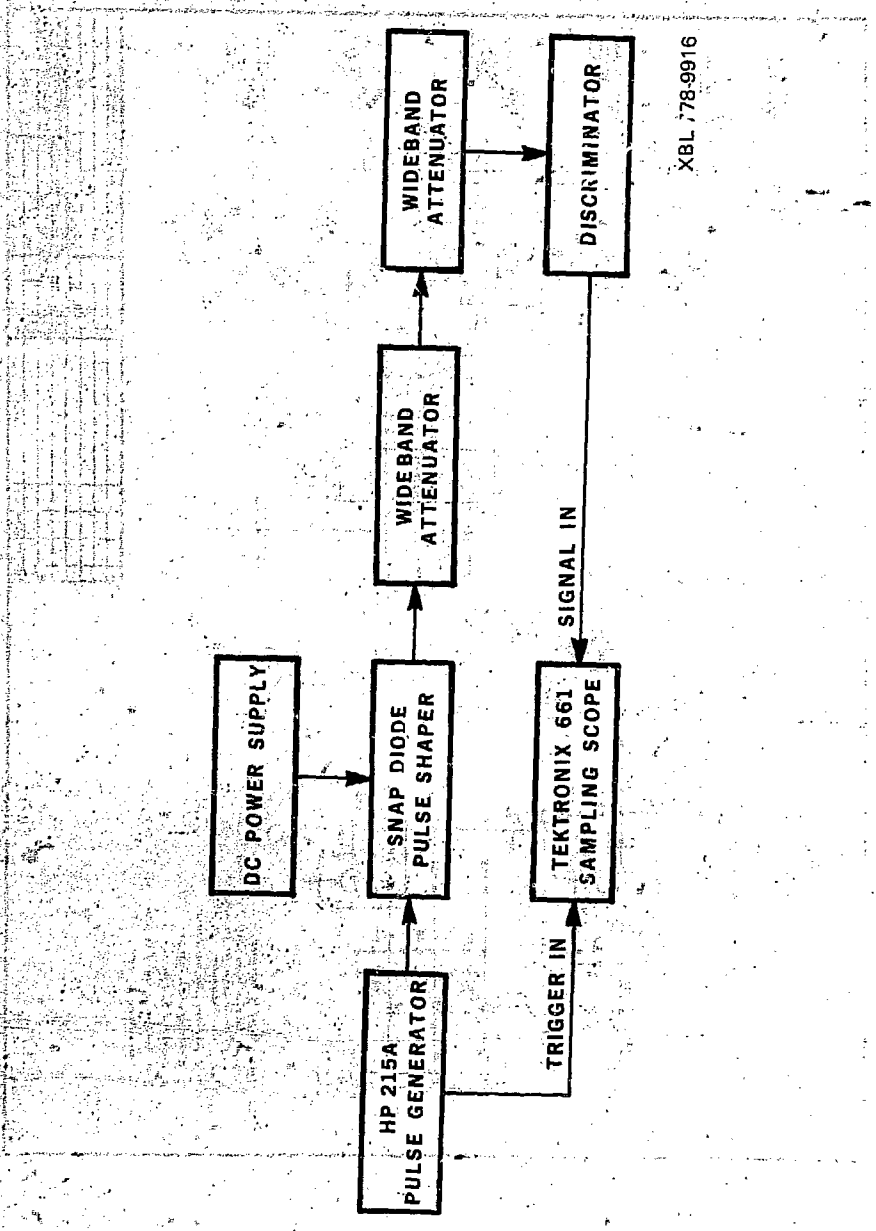

WIDEBAND ATTENUATOR
DISCRIMINATOR
XBL 778-9916
WIDEBAND ATTENUATOR
SIGNAL IN
DC POWER SUPPLY
SNAP DIODE PULSE SHAPER
TEKTRONIX 661 SAMPLING SCOPE
HP 215A PULSE GENERATOR
TRIGGER IN

FIG. 2

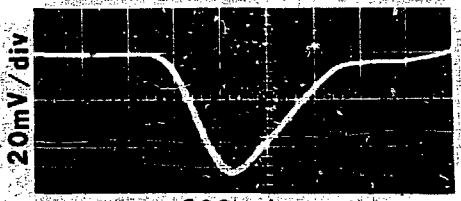
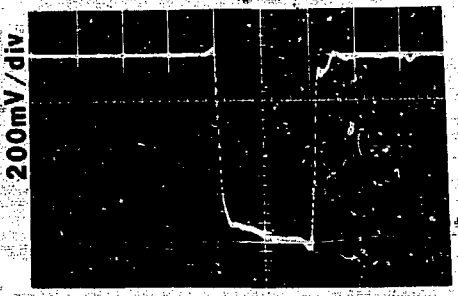


Fig. 3A



XBB 778-7456

Fig. 3B

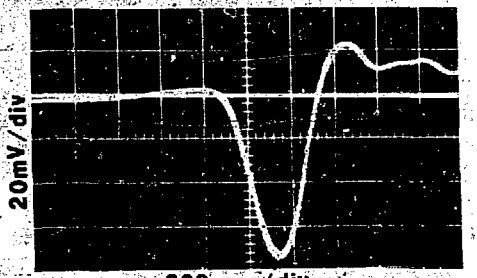
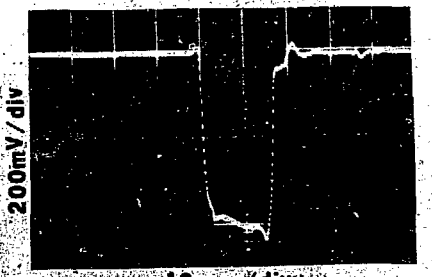


Fig. 4A



XBB 778-7457

Fig. 4B

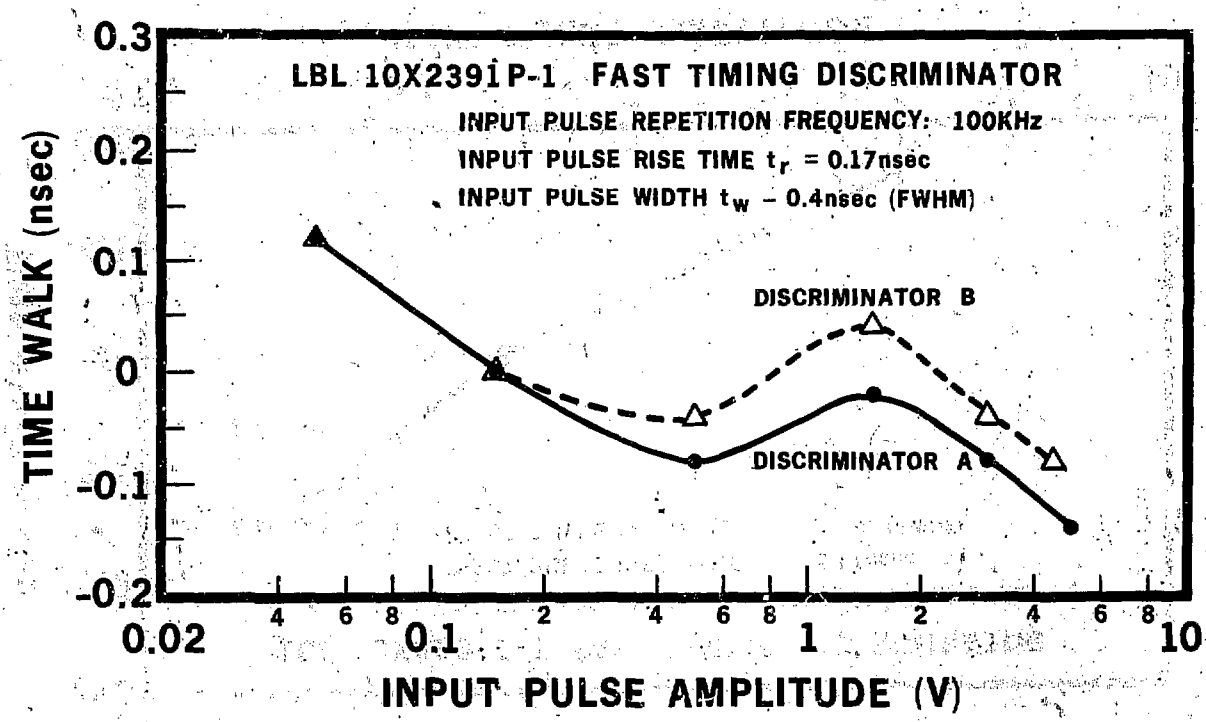

LBL 10X239iP-1 FAST TIMING DISCRIMINATOR
INPUT PULSE REPETITION FREQUENCY: 100KHz
INPUT PULSE RISE TIME t_r = 0.17nsec
INPUT PULSE WIDTH t_w – 0.4nsec (FWHM)
DISCRIMINATOR B
DISCRIMINATOR A
TIME WALK (nsec)
0.3
0.2
0.1
0
-0.1
-0.2
0.02
4
6
8
0.1
2
4
6
8
1
2
4
6
8
10
INPUT PULSE AMPLITUDE (V)
XBL 778-9914

Fig. 5

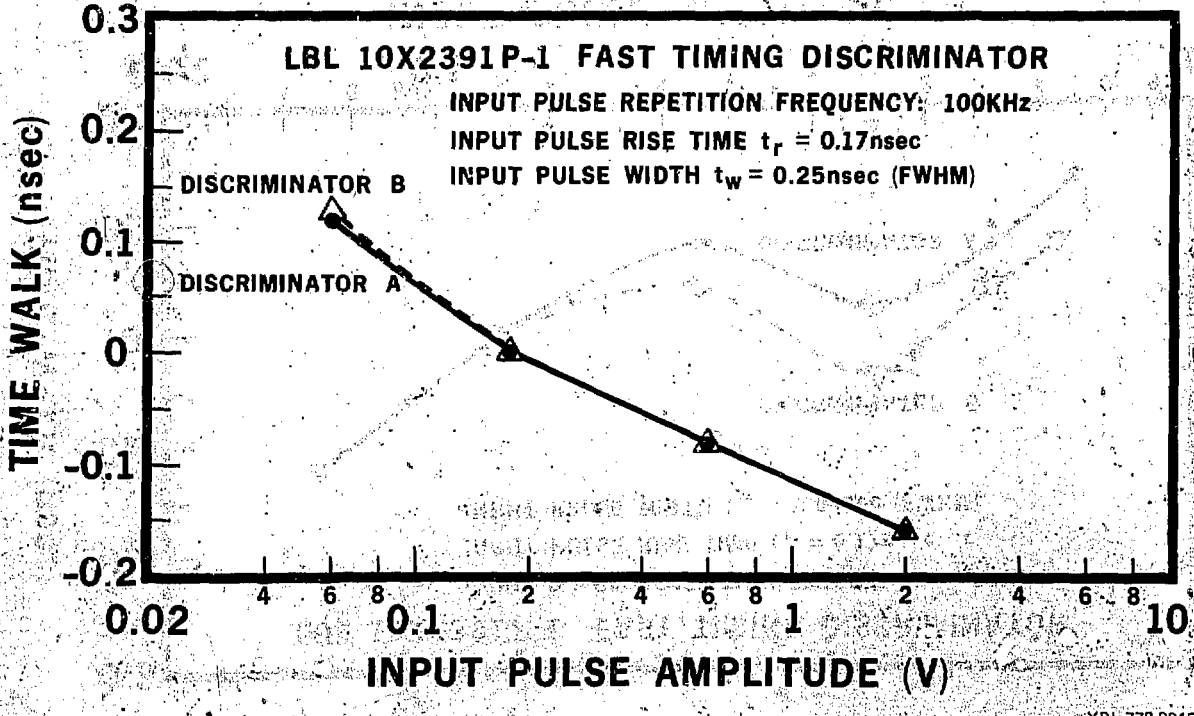
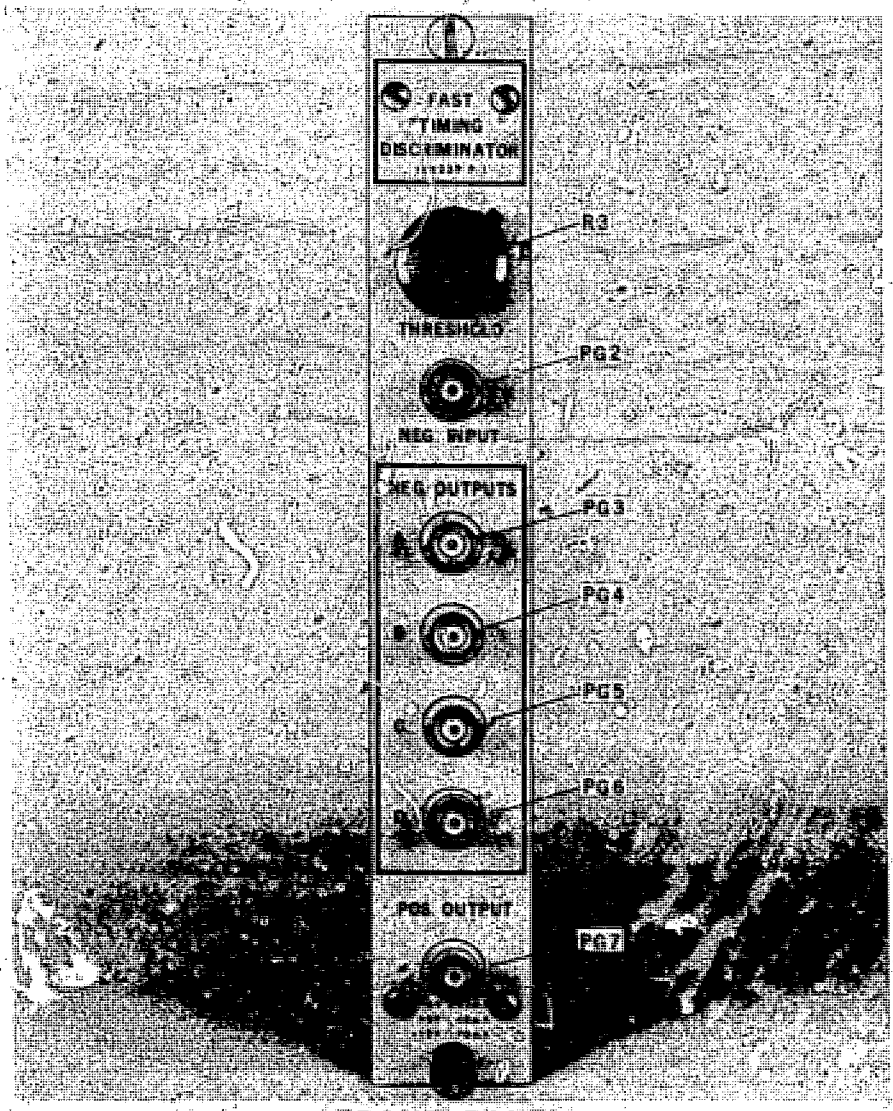

LBL 10X2391P-1 FAST TIMING DISCRIMINATOR
INPUT PULSE REPETITION FREQUENCY: 100KHz
INPUT PULSE RISE TIME t_r = 0.17nsec
INPUT PULSE WIDTH t_w = 0.25nsec (FWHM)
DISCRIMINATOR B
DISCRIMINATOR A
TIME WALK (nsec)
0.3
0.2
0.1
0
-0.1
-0.2
0.02
0.1
1
10
INPUT PULSE AMPLITUDE (V)
XBL 778-9915

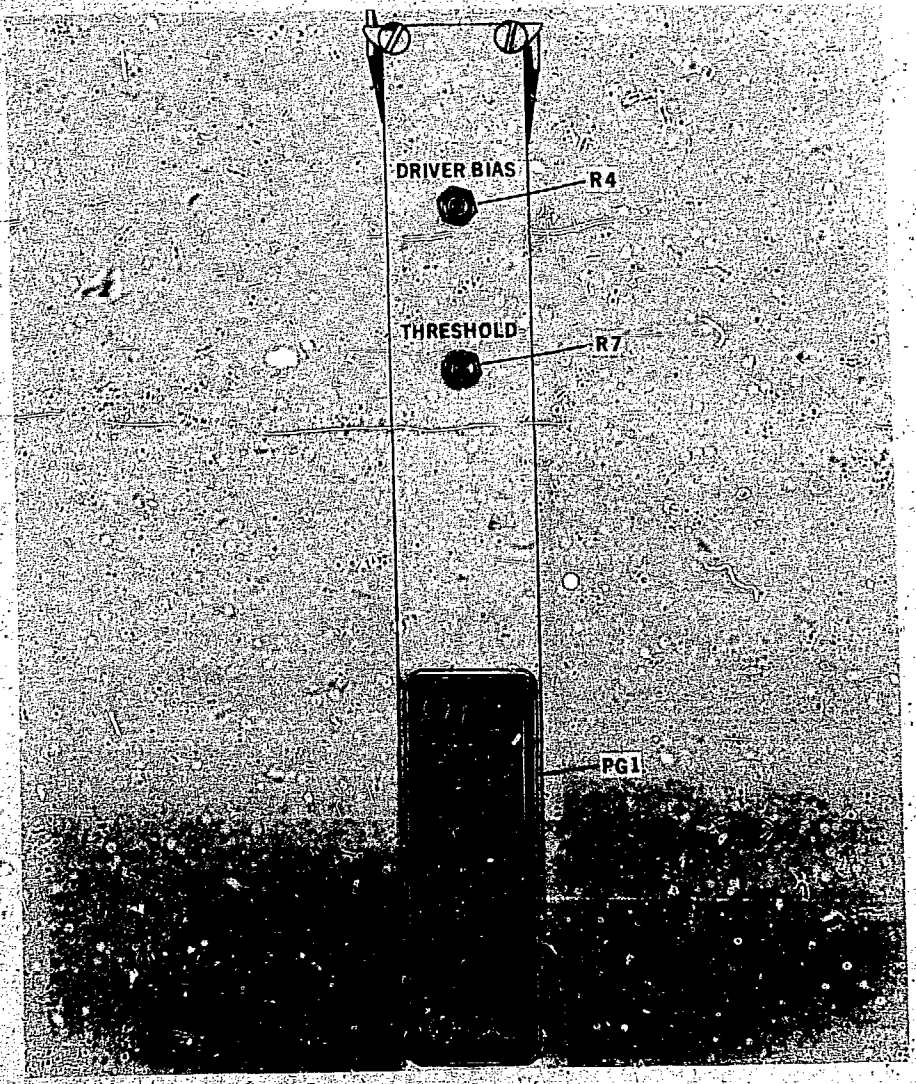
Fig. 6



FRONT PANEL

Fig. 7

XBB 775-5282A



REAR PANEL

Fig. 8

XBB 775-5280A

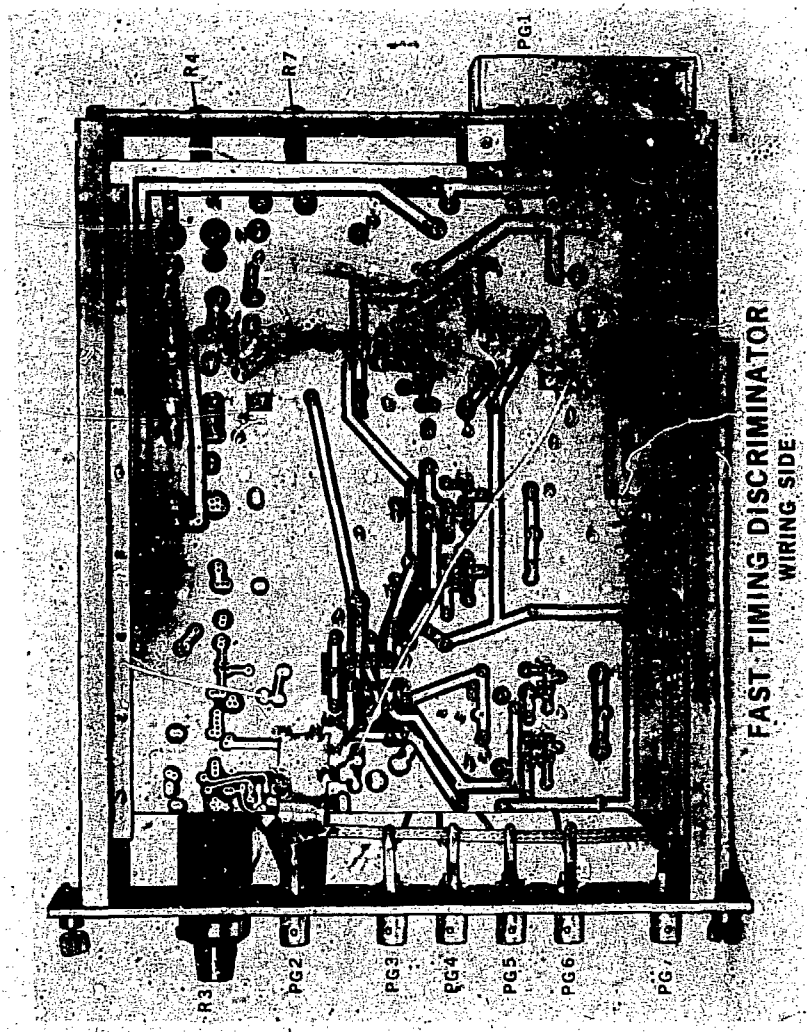

R4
R7
PG1
R3
PG2
PG3
PG4
PG5
PG6
PG7
FAST TIMING DISCRIMINATOR
WIRING SIDE
XBB 775-5281A

Fig. 9

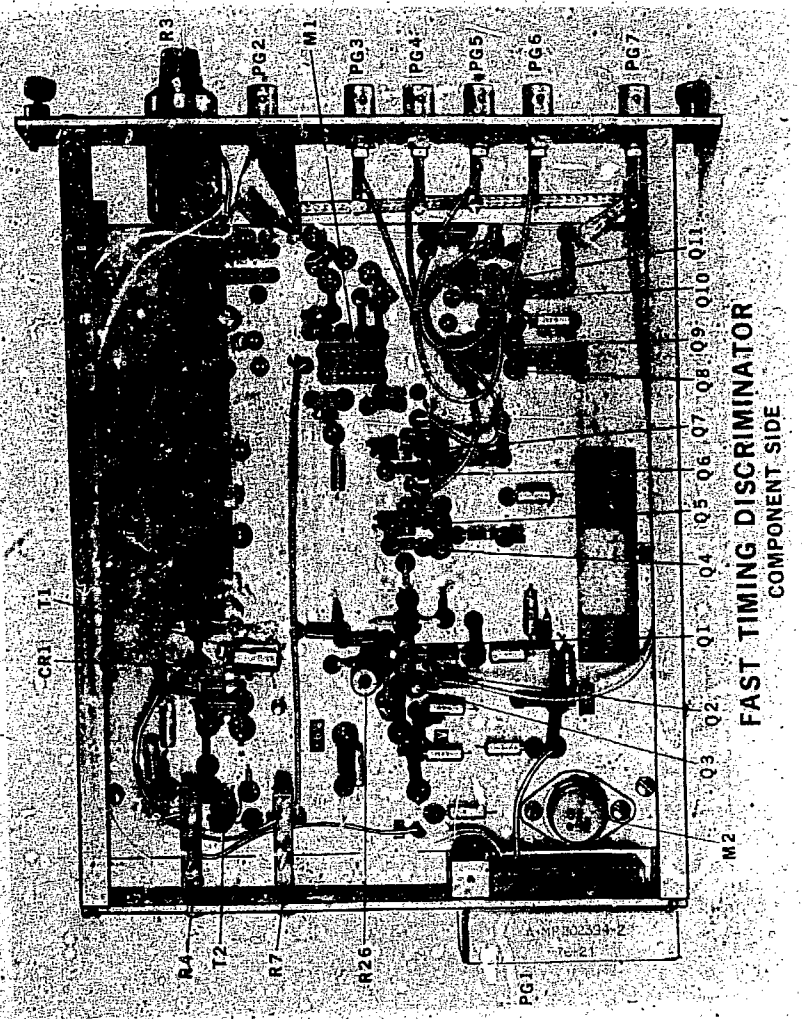

R3
PG2
M1
PG3
PG4
PG5
PG6
PG7
Q11
Q10
Q9
Q8
Q7
Q6
Q5
Q4
Q1
Q2
Q3
M2
CR1
T1
R4
T2
R7
R26
PG1
FAST TIMING DISCRIMINATOR
COMPONENT SIDE
XBB 775-5278A

Fig. 10

Appendix II

Fast Timing Discriminator
Print List for
10X2391 P - 1

DRAWING NO.	CHANGE LTR	TITLE	NO. PER UNIT
10X2393 S-1		SCHEMATIC	
10X2391 C-1		COMPONENT LIST	
		HOLE SCHEDULE	
		COMPONENT LAYOUT	
6U4972A		ETCHED WIRING ARTWORK	
		DRILL TAPE	
		BOARD OUTLINE	
10X2391 M-1		FRONT PANEL	
10X2391 M-2		REAR PANEL	
10X2391 J-1		FRONT PANEL SILKSCREEN	
10X2391 J-2		REAR PANEL SILKSCREEN	
10X2393 A-1		ASSEMBLY	

REFERENCE:

11X3051 P-1	NIM Single Width Module
11X3042 A-3	Connector Pin Functions
11X3042 A-4	Connector Layout and Hardware

10X2391 P-1

CHG. | DRWN. BY | CHKD. BY | DATE | CHANGES | REL TO | ENGR. | DRWN. BY D. Fong | DATE 12/76 | SCALE | CHKD. BY | APPR. George Fizka

Fast Timing Discriminator

PRINT LIST

LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA

10X2391 P-1

7600-B269 (3-76)

PARTS LIST

FOR DRAWING NO. 10X2391S-1

TITLE: FAST TIMING DISCRIMINATOR

10X2391C-1

STORES INFORMATION ONLY

REQUESTED BY	DATE	EXT.	ACCOUNT NO.	TAG OR SERIAL NO.
DELIVER TO	BLDG.	ROOM	UNITS REQD.	MARK PACKAGES

REVISIONS DATE

3 OF 3 SHEETS

DRAWN George Zizka

DATE 12/76

CHK'D.

APPR. C.C.C.

DESIGNATION	REQ'D	DESCRIPTION	SPECIFICATION	UCLRL CAT. NO.		B.O.
R14-R7	4	RESISTOR 270Ω, 1/4W, 5% CARBON, FIXED		5905	16475	
R20,25	2	" 1KΩ, " " " "		"	16489	
R29,30,33,35,37, 38,41,43	8	" 47Ω, " " " "		"	16457	
R44	1	RESISTOR 390Ω, 1/2W, 5% CARBON, FIXED		"	16632	
R21,22	2	" 270Ω, " " " "		"	16628	
R24	1	" 470Ω, " " " "		"	16634	
R23	1	" 47Ω, " " " "		"	16610	
R28,32,36.40	4	" 150Ω, " " " "		"	16622	
R31,34,39,42	4	" 180Ω, " " " "		"	16624	
R5	1	RESISTOR 464Ω, 1/8W, 1%, METAL FILM, FIXED		"	17601	
R8	1	" 383Ω, " " " "	"	"	17599	
R18,27	2	" 147Ω, " " " "	"	"	17589	
R3	1	RESISTOR, VARIABLE, 1000Ω, 2W, 10T, WW	BECKMAN MODEL 7266	"	52809	
R4,7	2	" " " , 3/4W,22T	SPECTROL MODEL 70Y	"	63166	
R26	1	" " 500Ω, 1/8W, 1T	C.T.S.385	"	47712	
R19	1	RESISTOR 4.22 K, 1/8W, 1% METAL FILM, FIXED		"	17624	

RL-463 (Rev.10'64)

LBL-6707

PARTS LIST

FOR DRAWING NO.	TITLE	
10X2391S-1	FAST TIMING DISCRIMINATOR	10X2391C-1

STORES INFORMATION ONLY				REVISIONS DATE	2 OF 3 SHEETS
REQUESTED BY / DATE	EXT.	ACCOUNT NO.	TAG OR SERIAL NO.		DRAWN George Zizka
DELIVER TO / BLDG.	ROOM	UNITS REQD.	MARK PACKAGES		DATE 12/76
					CHK'D.
					APPR. C.C.Co

DESIGNATION	REQ'D.	DESCRIPTION	SPECIFICATION	UCLRL CAT. NO.		B.O.
PG1 (cont'd.)	1	GROUND GUIDE PIN	AMP #202514-1	5935	49166	
	5	PIN 22-20		"	47336	
PG2 - PG7	6	BNC UG-1094/U CONNECTOR		"	53270	
C6,8,10,16,18,21, 23,25,27	9	CAPACITOR .01 MF/100V CERAMIC	CKOBX103M	5910	56357	
C1,3,13,14	4	" .1 MF/50V	CK058X104A	"	57931	
C2,4,5,7,9,11,12, 15,17,20,22,26, 28	12	" 6.8 MF/35V 10% TANTALUM		"	57843	
C19,24	2	" 100pF, SILVERED MICA, 500V		"	48423	
NIM MODULE	1	MODULE NUC 8 3/4 PMF 875-1		5975	47926	
DIAL	1	DUO DIAL, BECKMAN 1/4" SHAFT, 15 TURNS		"	43403 or 62930	
R1, 2	2	RESISTOR 100Ω, 1/4W 5% CARBON, FIXED		5905	16465	
R6	1	" 62Ω, " " " "		"	16459	
R9		" 51Ω, " " " "		"	16458	
R10,11		" 47Ω, " " " "		"	16457	
R12	1	" 150Ω, " " " "		"	16469	
R13	1	" 5.1KΩ, " " " "		"	16506	

PARTS LIST

FOR DRAWING NO. 10X2391S-1

TITLE: FAST TIMING DISCRIMINATOR

10X2391C-1

STORES INFORMATION ONLY

REQUESTED BY	DATE	EXT.	ACCOUNT NO.	TAG OR SERIAL NO.
DELIVER TO	BLDG.	ROOM	UNITS REQD.	MARK PACKAGES

REVISIONS DATE

1 OF 3 SHEETS

DRAWN George Zizka

DATE 12/76

CHK'D

APPR. C.C.H.

DESIGNATION	REQ'D.	DESCRIPTION	SPECIFICATION	UCLRL CAT. NO.		B.O.
Q1 - Q11	11	TRANSISTOR 2N2857		5961	46197	
M1	1	MC1650L INTEGRATED CIRCUIT	MOTOROLA	-	-	
M2	1	LM340 K-8 VOLTAGE REGULATOR	NATIONAL SEMICONDUCTOR	-	-	
CR1,CR2,CR5	3	HPA5082-2303, DIODE, H.C.		5961	50913	
CR3,CR6	2	TD263A DIODE, TUNNEL	GENERAL ELECTRIC	5961	48466	
CR4, CR7	2	BD3 DIODE	" "	-	-	
CR8,CR10,CR12, CR14	4	Q6-100 DIODE	" "	5961	29259	
CR9,CR11,CR13,CR15	4	1N4447 DIODE Si		5961	49418	
L1	1	CHOKE .68μH/1165mA		5950	43593	
L2 - L10	9	CHOKE 2.2μH/1100mA		5950	42060	
T1	1	CORE, MAGNETIC Q3	INDIANA GENERAL	5950	51741	
T2	1	CORE, MAGNETIC Q2	" "	5950	51742	
PG 1	1	MALE BLOCK	AMP #202515-5	5935	47332	
	1	INTERNAL HOOD	#202394-2	"	47348	
	1	GUIDE PIN	#200833-1	"	47334	
	1	GUIDE SOCKET	#200835-4	"	47335	

LBL-6707

RL-483 (Rev.10 84)