Department

Subject Lab Techniques II

Name John SEGAL

Address

National Brand

43-648

# Computation Notebook

Dennison Stationery Products Co., Framingham, MA 01701

0 73333 43648 8

75 Sheets
11¾" x 9¼"
4x4 Quad.

130

Base and tube for background measurements
Setup for measuring charge on a raindrop

Charge on a drop tests
Ken's feedback analysis 135
RG-58C/U, A/U & RG59U impedance mismatch demo I

First try at a resistive base for 8575 PMT

Further study of 8575 resistive base 140

145

150

Check of wire chamber signals for Photon Calorimeter

152

8/17/94

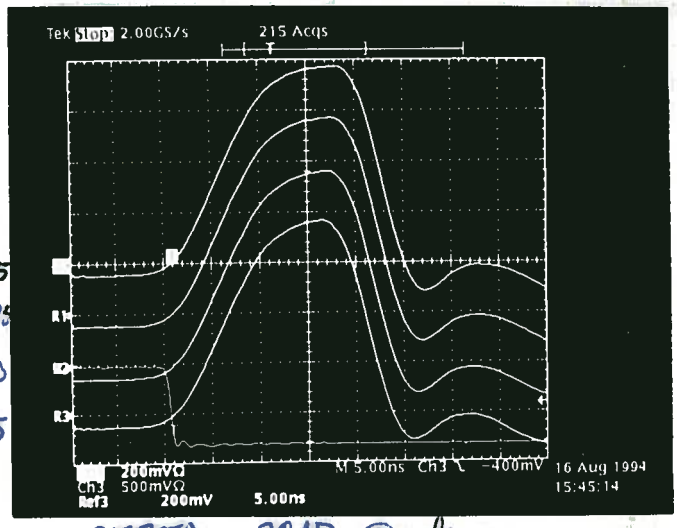
These photos are continued from LAb Techniques I.

In order to look at larger injected charge the attenuation is reduced to 20dB.

The rise time was held fixed while the input step amplitude was varied.

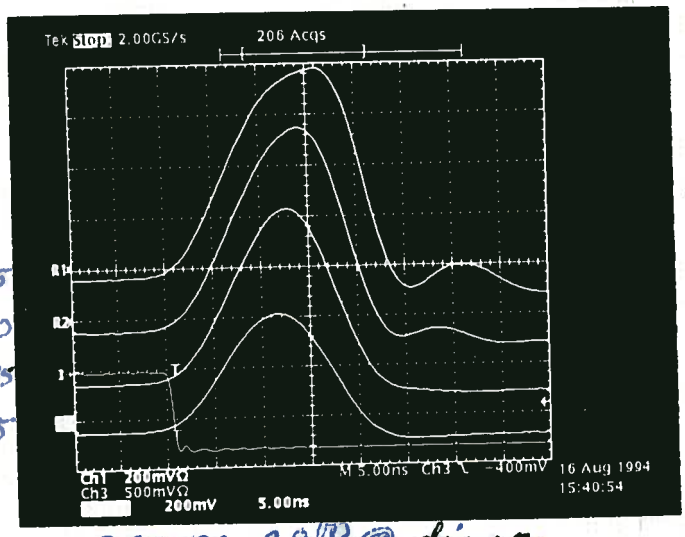
Rise time not recorded. Looking at p. 150 of L.T. I it would appear the rise time is 15 ns.

1175fC 2.5
1058fC 2.25
940fC 2.0
823fC 1.15




27350C 20dB @ discr.

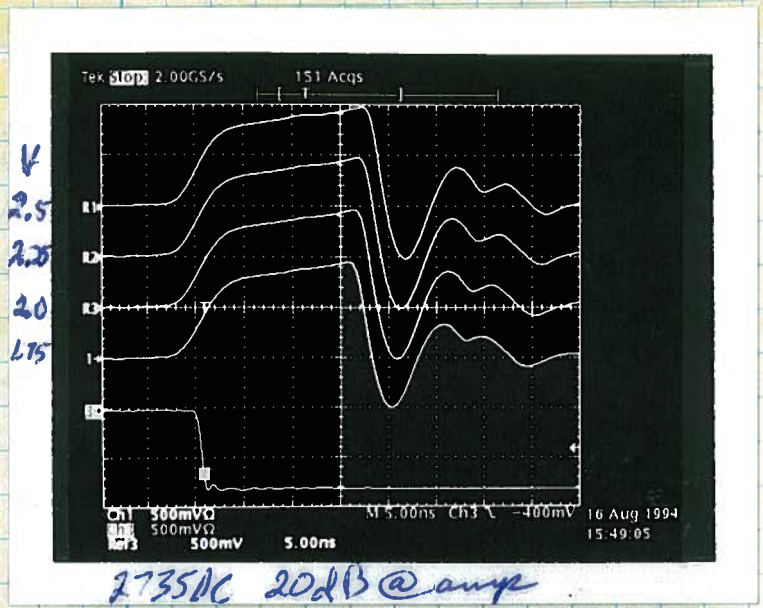
705fC 1.5
470fC 1.0
353fC .75
235fC .5




27350C 20dB @ discr.

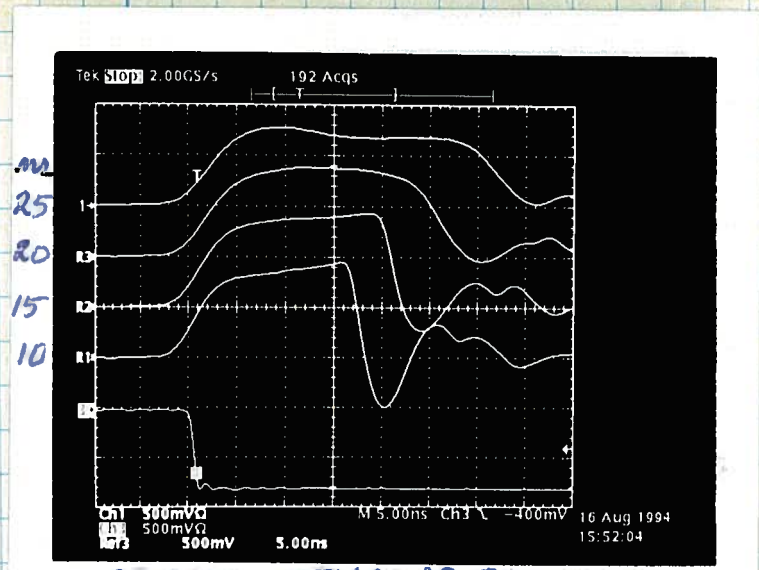
Input step rise time held fixed at 10ns. Amplitude varied.

Saturation?



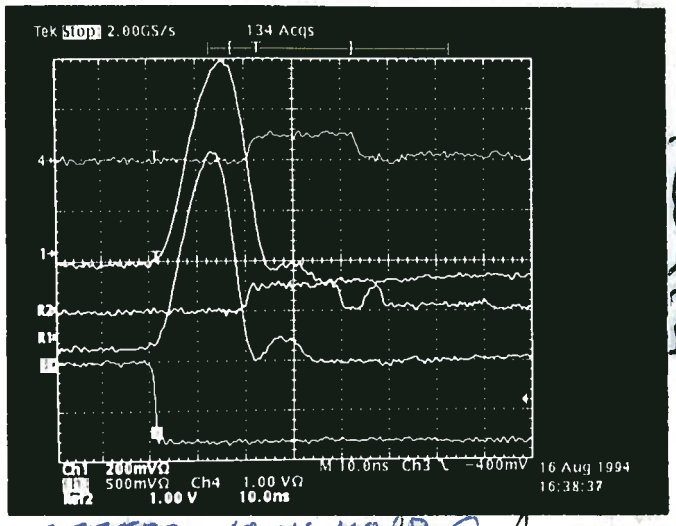

2735DC 20dB @ amp

Rise time of input step varied.
(Step pulse is 1μs wide)




2735DC 1.75V 20dB @ amp

Too fast a rise can make the difference.
DAC value not recorded, but the same for both photos.
Ch4 is output of Lecroy card through a balun.



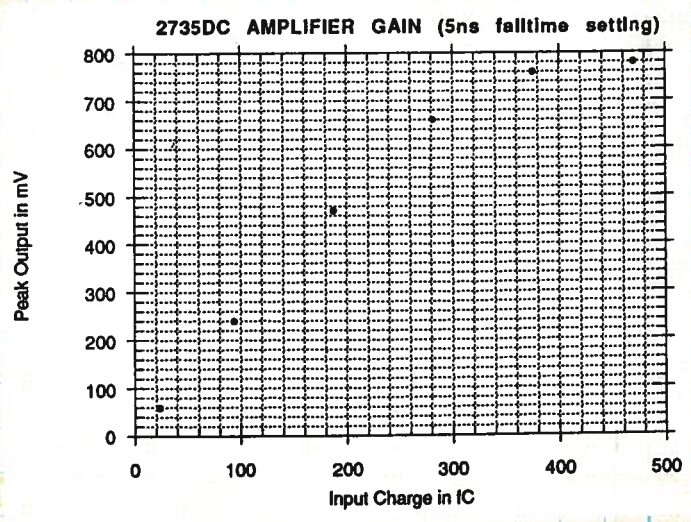

2735DC 10.0V 40dB @ discr.

Looking at p. 149 & 150 of L.T. I

5ns rise time @ discr.

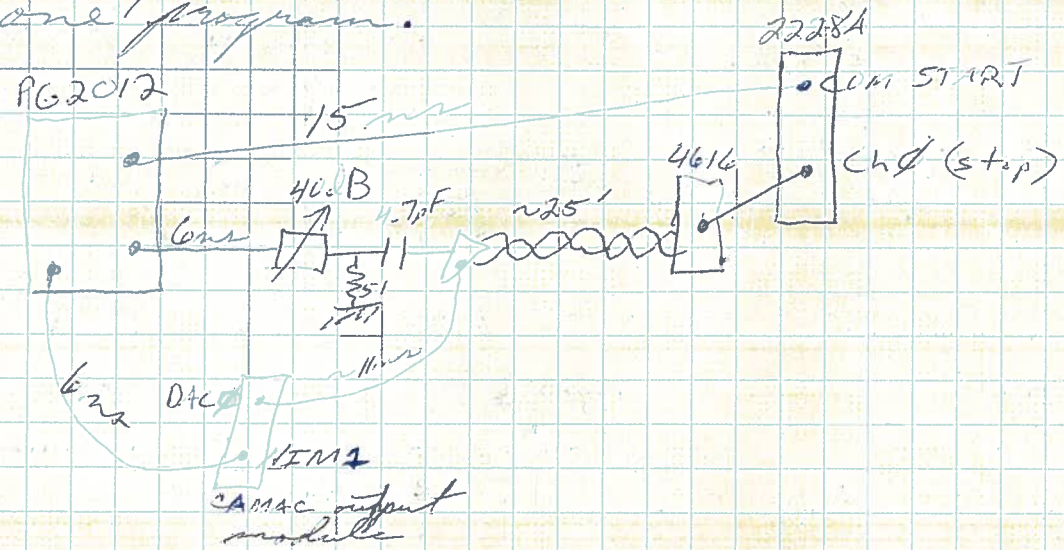
| pulse height mV | input fC | mV/fC | ×2 |
|---|---|---|---|
| 1.1×20=22 | 23.5 | .94 | 1.88 |
| 1.8×50=90 | 94 | .96 | 1.92 |
| 1.8×100=180 | 188 | .96 | 1.92 |
| 2.6×100=260 | 282 | .92 | 1.84 |
| 3.5×100=350 | 376 | .93 | 1.86 |
| 4.4×100=440 | 470 | .94 | 1.88 |
| 3.0×20=60 | 23.5 | 2.55 | |
| 4.8×50=240 | 94 | 2.55 | |
| 4.7×100=470 | 188 | 2.50 | |
| 3.3×200=660 | 282 | 2.34 | |
| 3.8×200=760 | 376 | 2.02 | |
| 3.9×200=780 | 470 | 1.66 | |

N277L



5/24

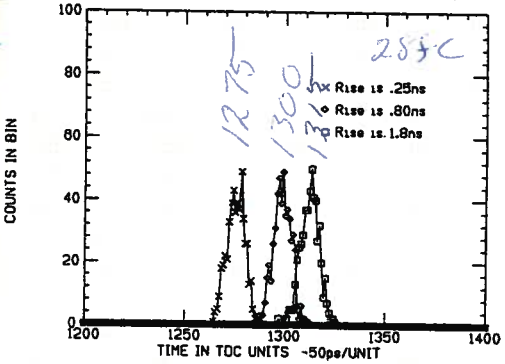
The program to acquire data is re-written. Both fast + slow rise times are combined in one program.



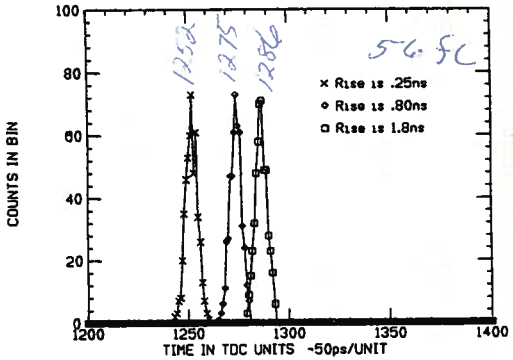

DAC Ø level = 4Ø for N277L (1.57V)

= 2Ø for 2735DC (.784V)

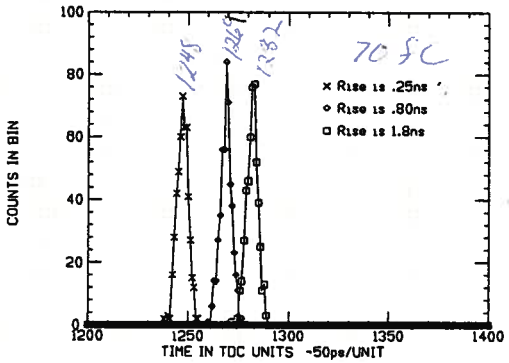
2735DC 0pF 0.60V STEP/40dB ON 4.7pF



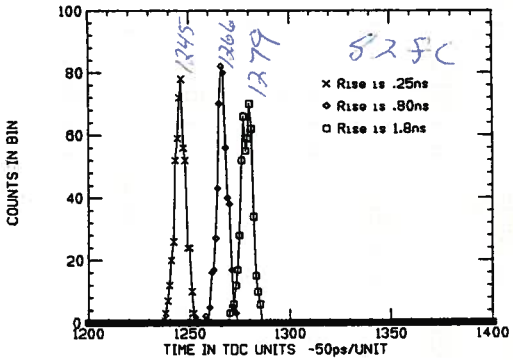

2735DC 0pF 1.20V STEP/40dB ON 4.7pF



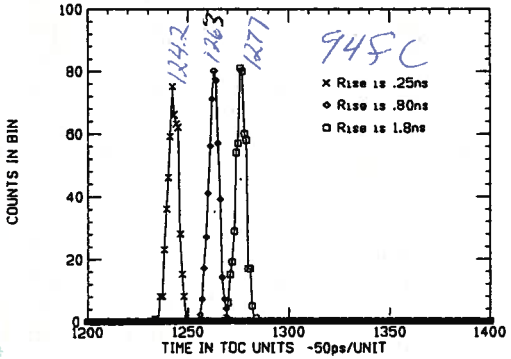

2735DC 0pF 1.50V STEP/40dB ON 4.7pF



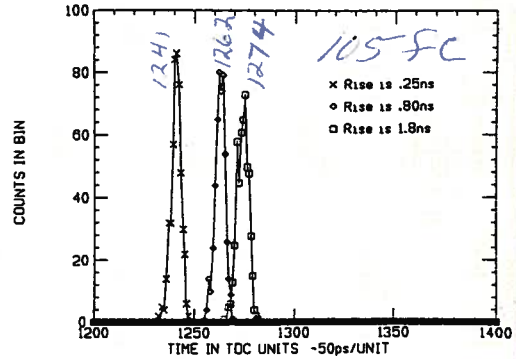

2735DC 0pF 1.75V STEP/40dB ON 4.7pF




2735DC 0pF 2.00V STEP/40dB ON 4.7pF

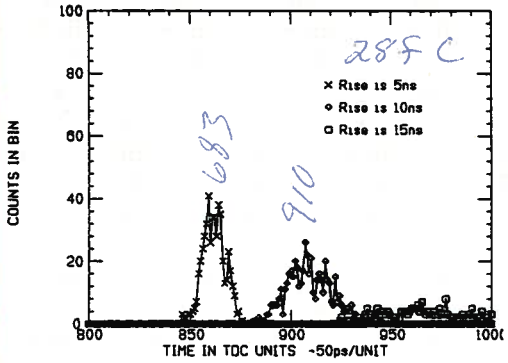



2735DC 0pF 2.25V STEP/40dB ON 4.7pF

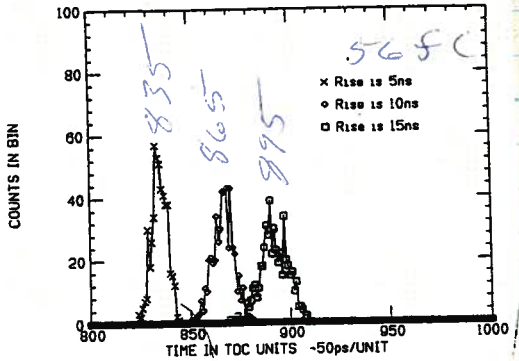



@ 1.8 ns 1286 − 1274 = 12 ⇒ ~.6 ns walk

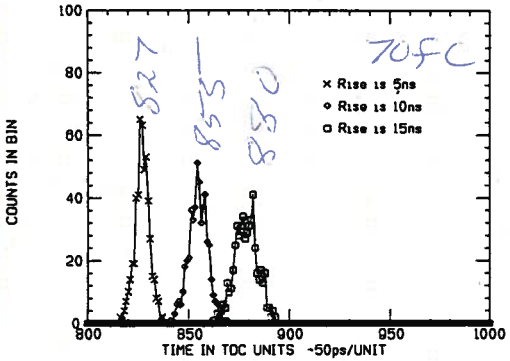
2735DC 0pF 0.60V STEP/40dB ON 4.7pF



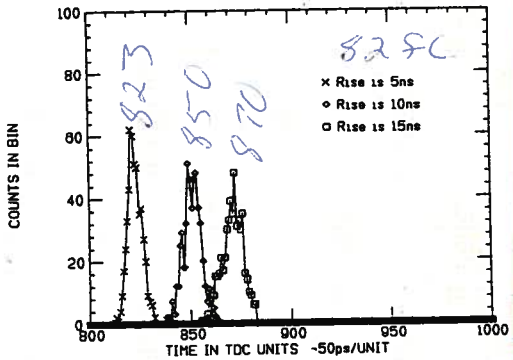

2735DC 0pF 1.20V STEP/40dB ON 4.7pF



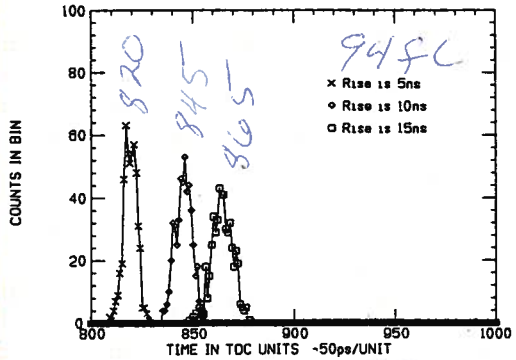

2735DC 0pF 1.50V STEP/40dB ON 4.7pF



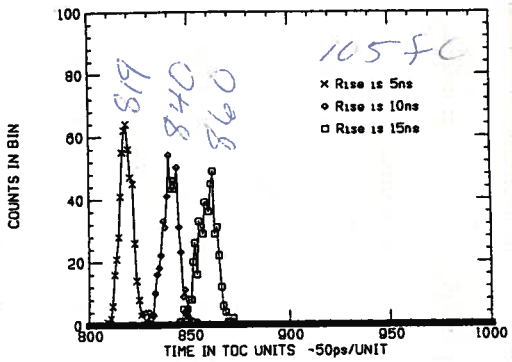

2735DC 0pF 1.75V STEP/40dB ON 4.7pF



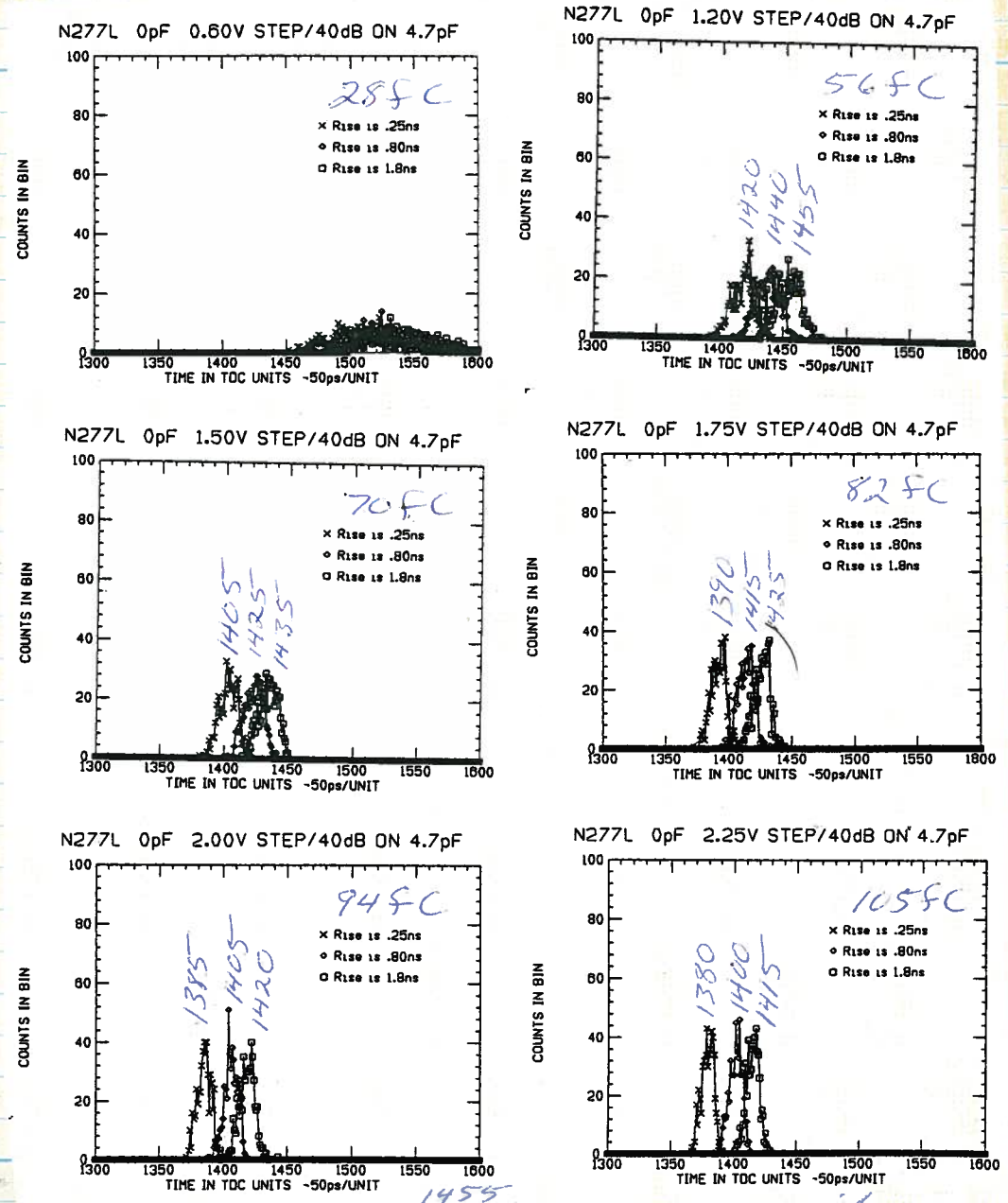

2735DC 0pF 2.00V STEP/40dB ON 4.7pF



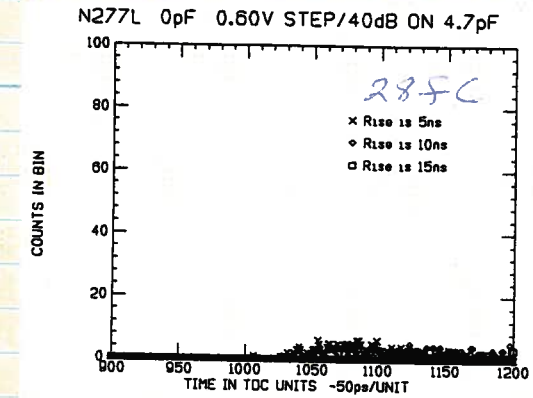

2735DC 0pF 2.25V STEP/40dB ON 4.7pF

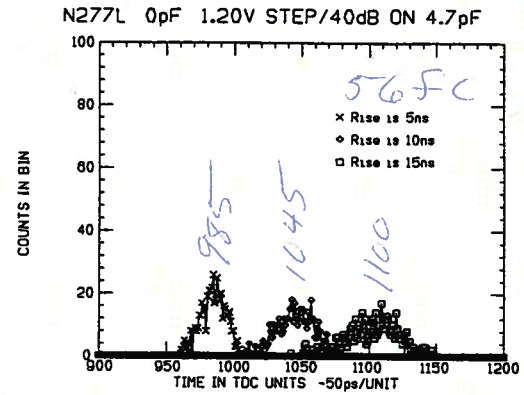


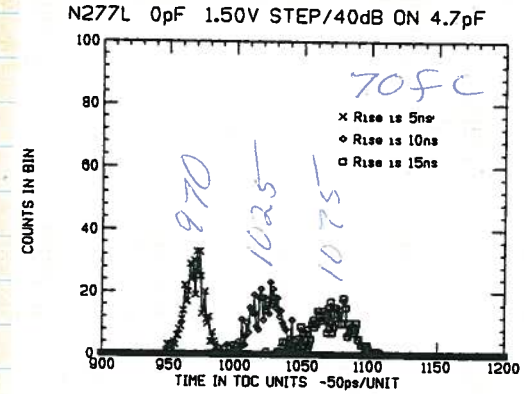

@ 5ns 835 − 819 = 16 ns walk

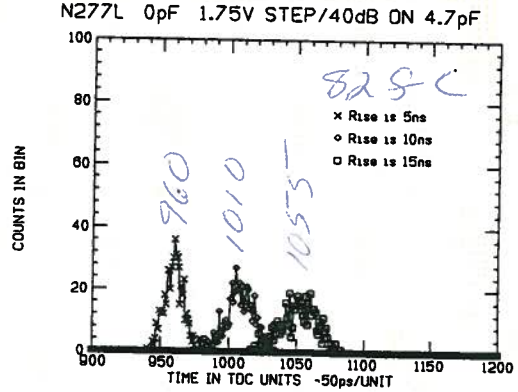


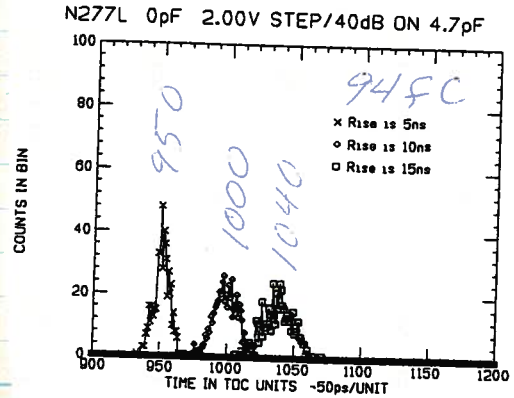

@ 1.8ns $\frac{1455 - 1415}{40}$ ⇒ ~2ns walk

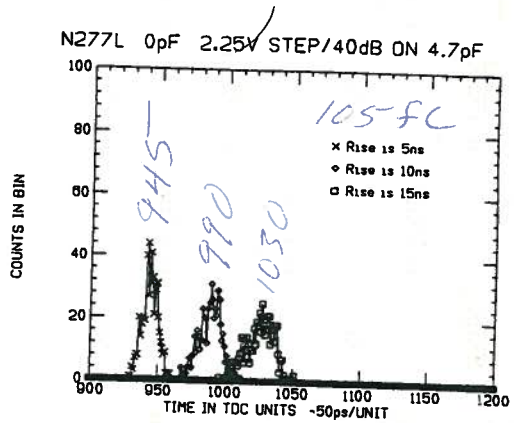


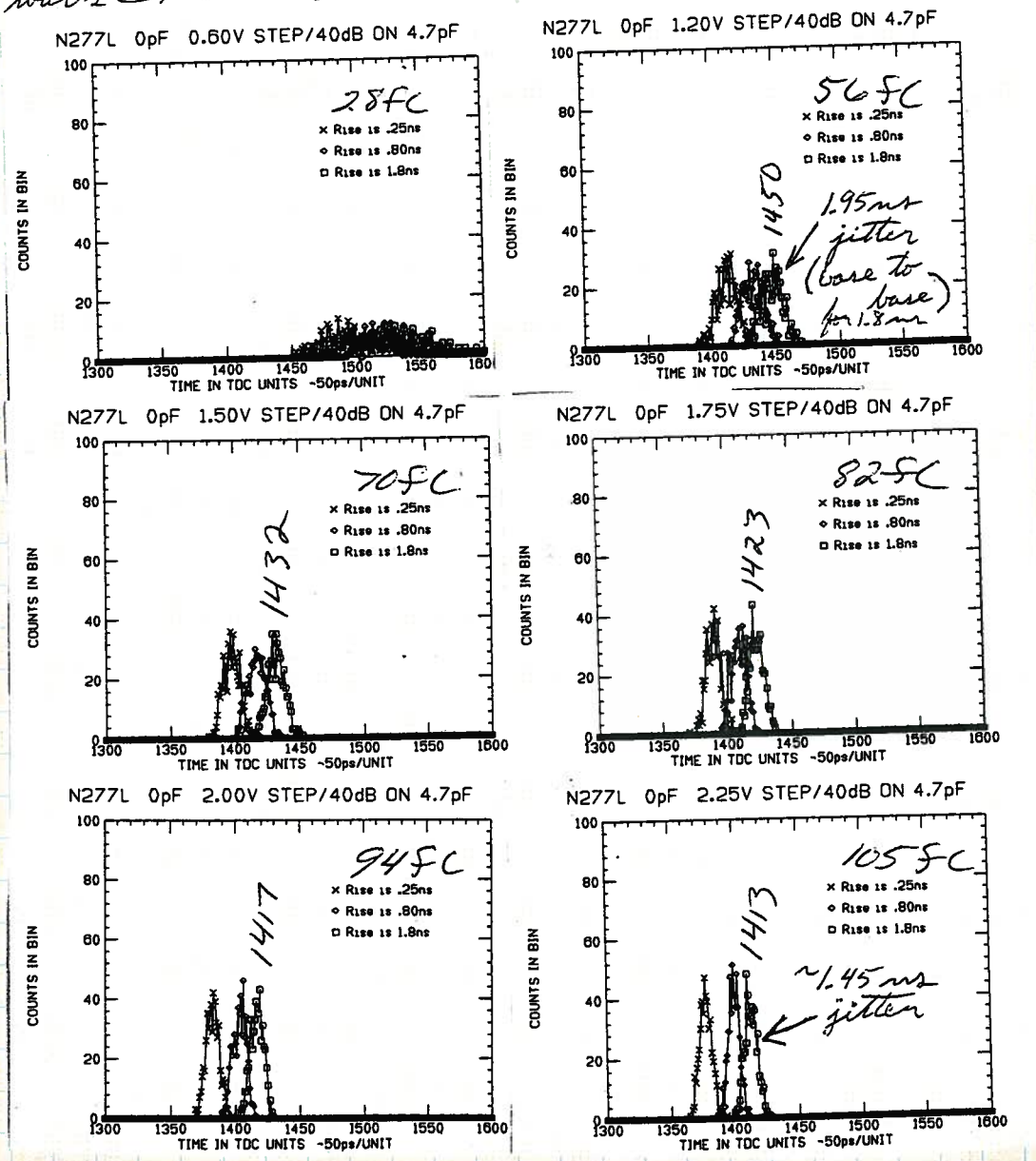



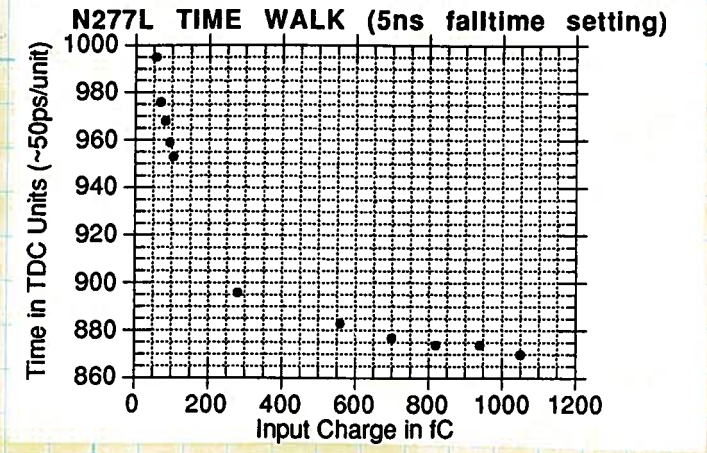

(2) 5ns $\frac{985 - 945}{40}$ ⇒ ~2ns walk

Timewalk + jitter of 2735DC + N-277-L 9/3/94

The program used for pp. 8-12 was re-written to include varying the attenuation (20dB or 40dB). The runs were redone and are consistent with pp. 8-12.

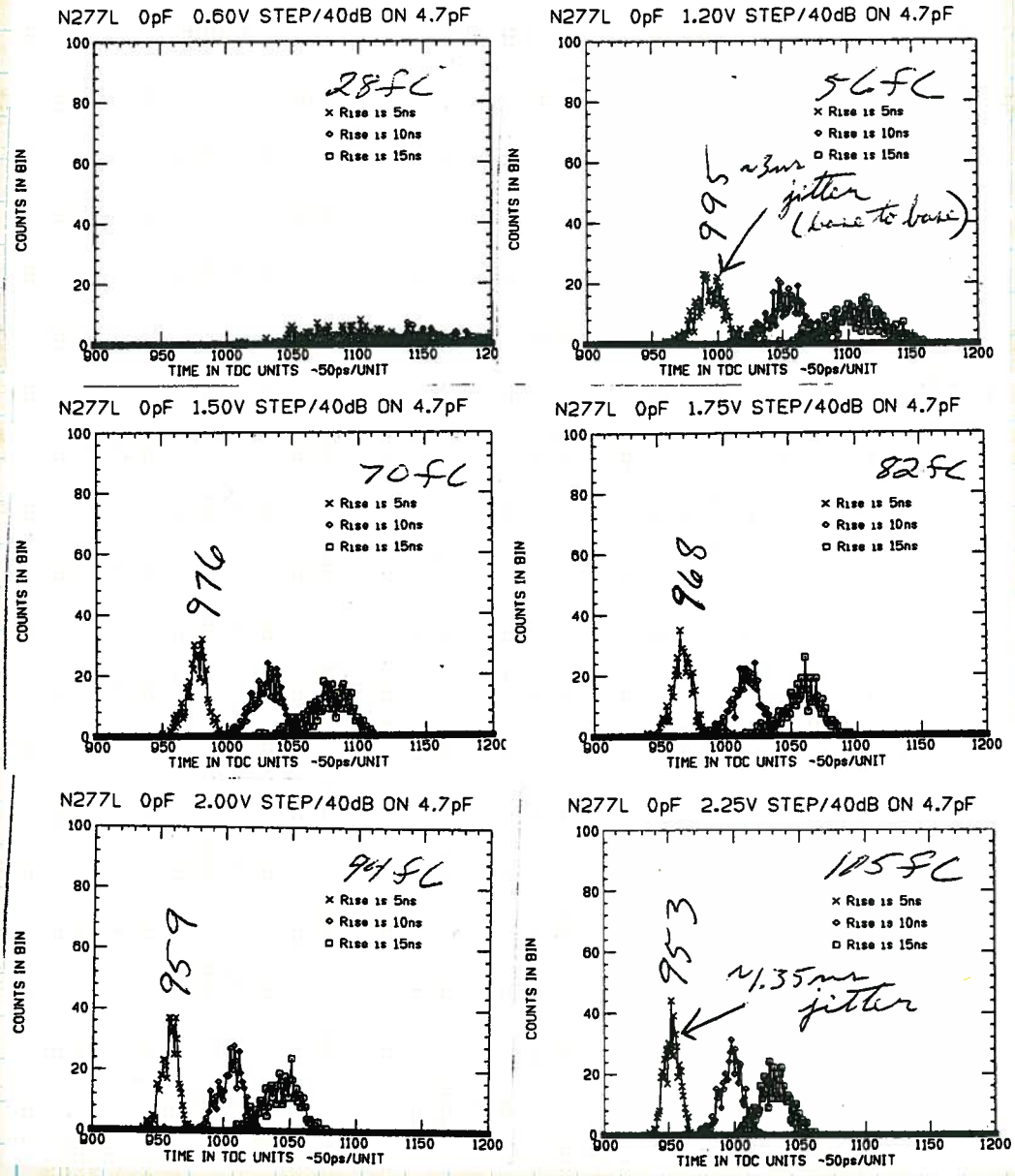
walk @ 1.8ns 56 → 105 fC in $\frac{1450 - 1413}{37 \text{ bins}}$ ⇒ ~1.9ns



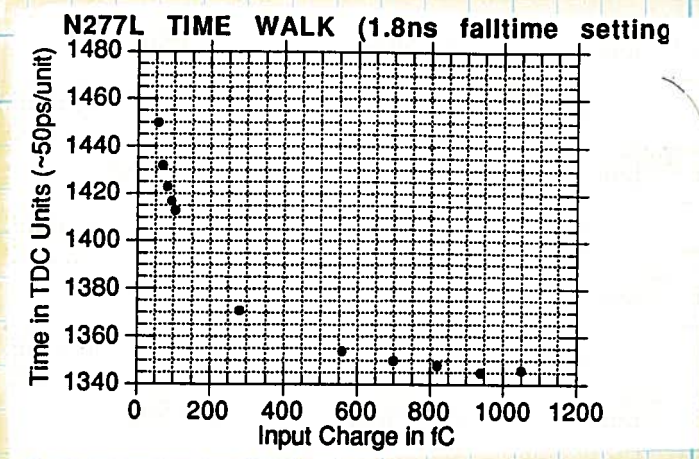



plot of data p. 14 & p. 16

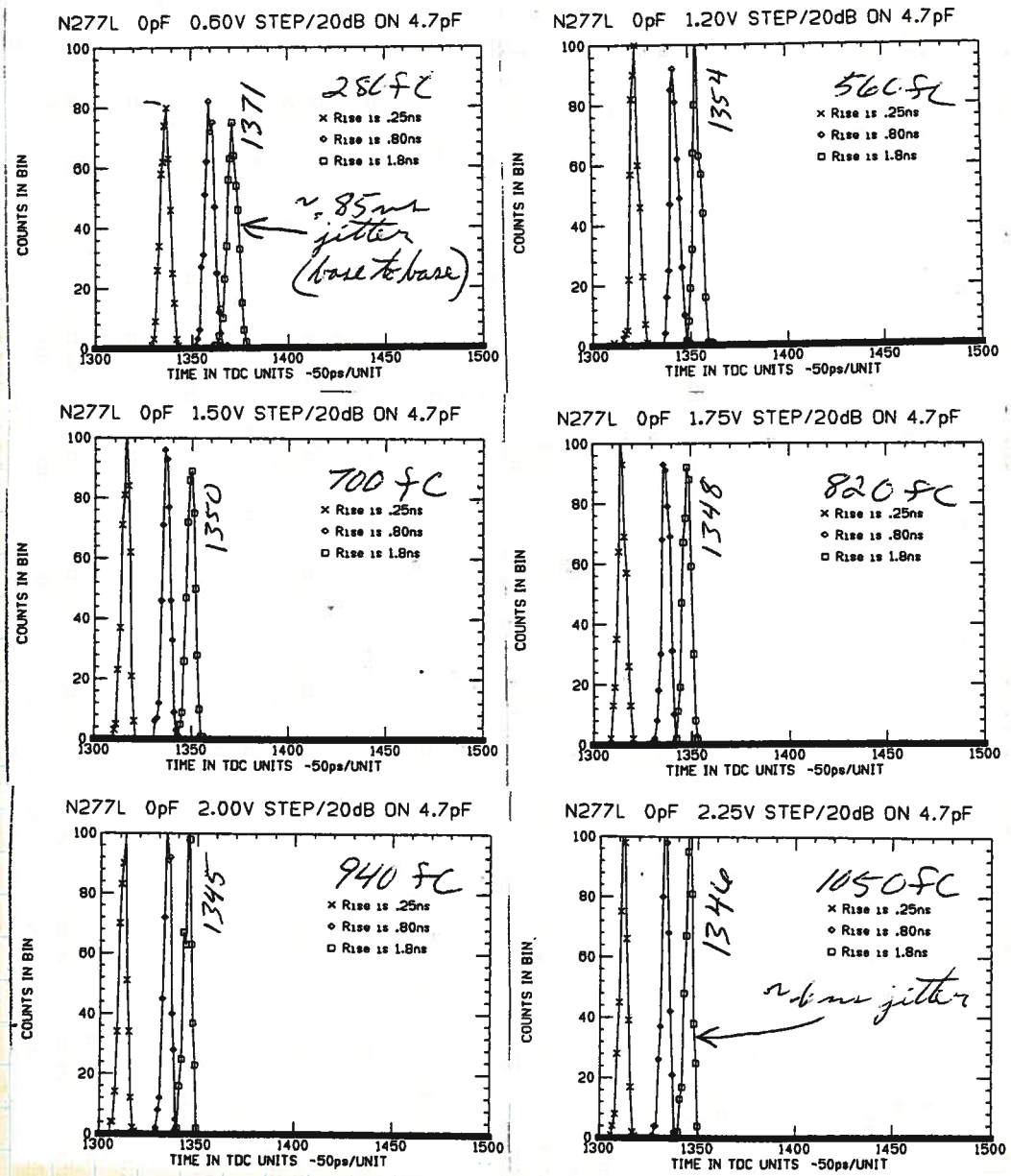
walk @ 5ns 56→105 fC is $\frac{995 - 953}{42\,bins}$ ⇒ ~2.1 ns



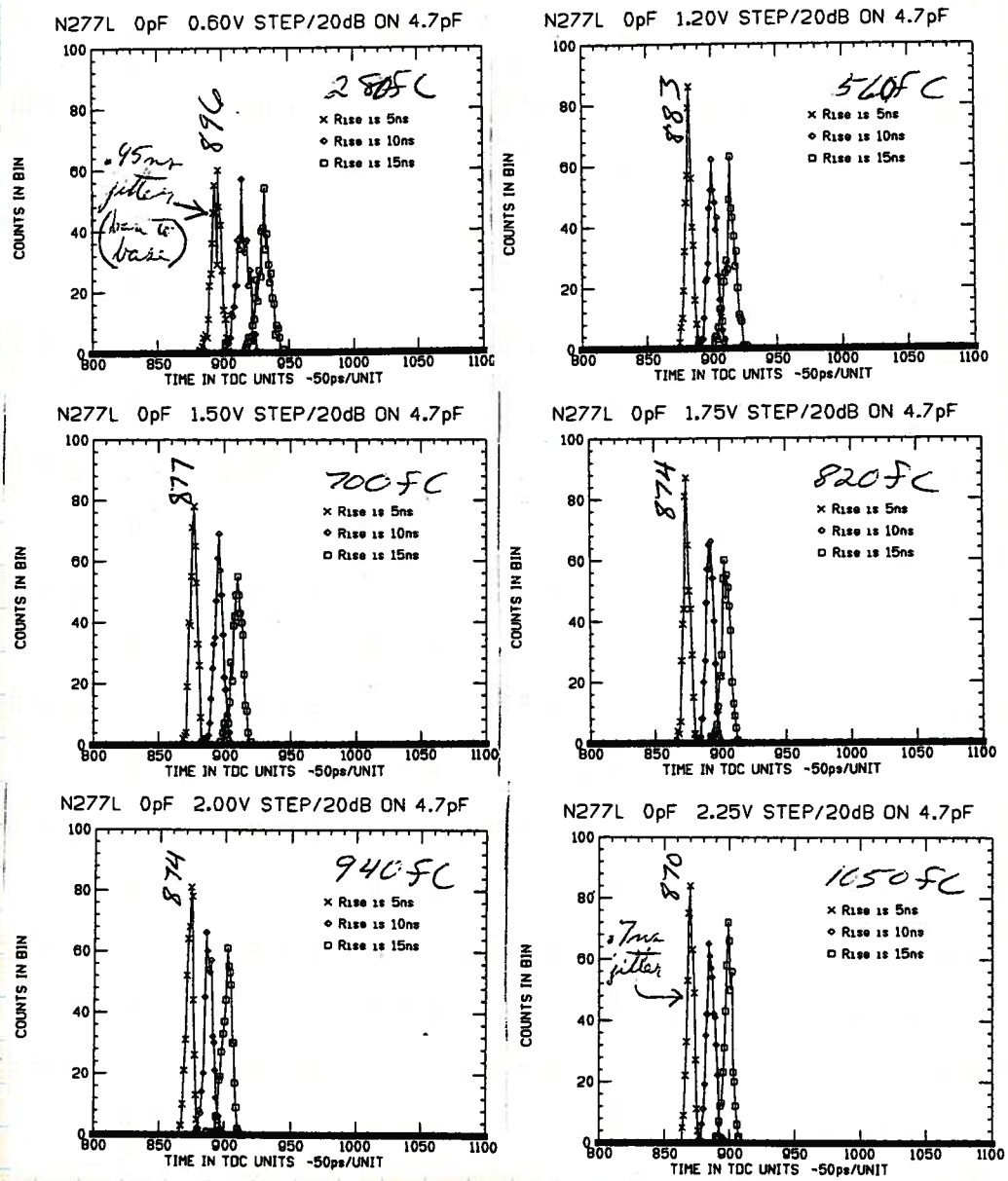
plot of p.13 & p.15 data



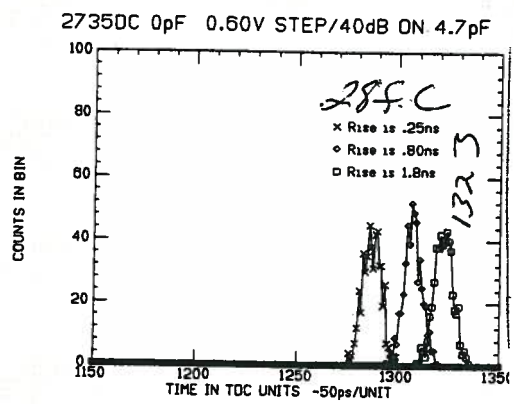

walk @ 1.8ns 280→1050 fC is $\frac{1371 - 1346}{25 \text{ bins}} \Rightarrow 1.25$ ns

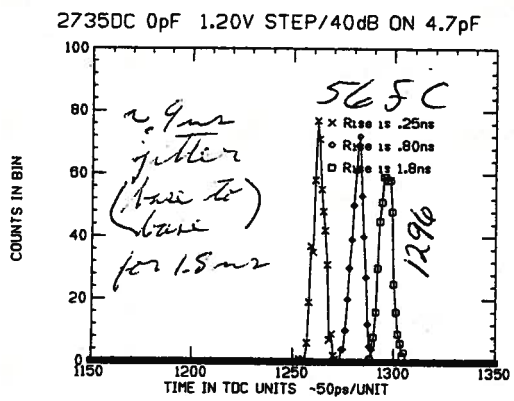


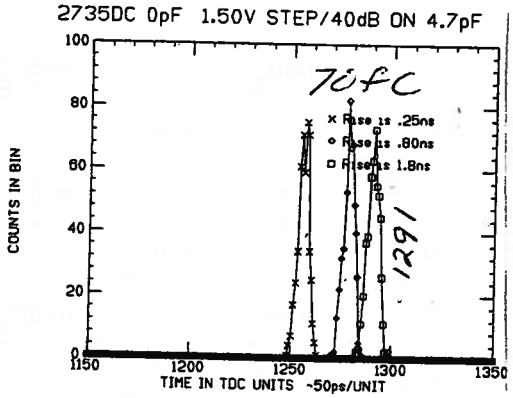
walk @ 5ns 280 → 1050 fC in $\frac{896-870}{26}$ bins ⇒ ~1.3 ns

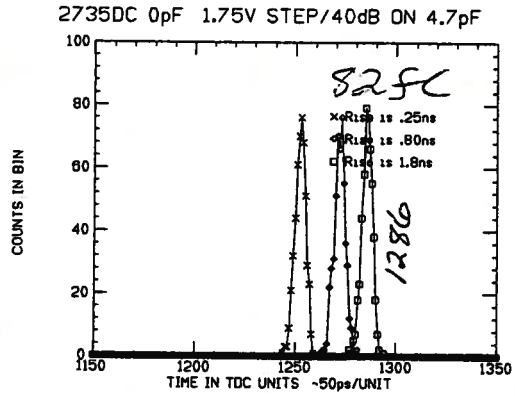


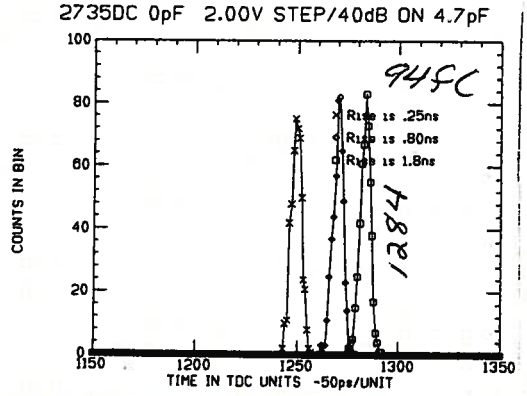
walk @ 1.8ns 56 → 105 fC is $\frac{1296 - 1280}{16 \text{ bins}} \Rightarrow \approx .8$ ns

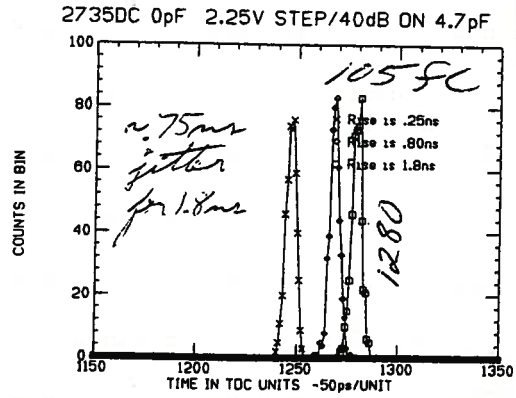


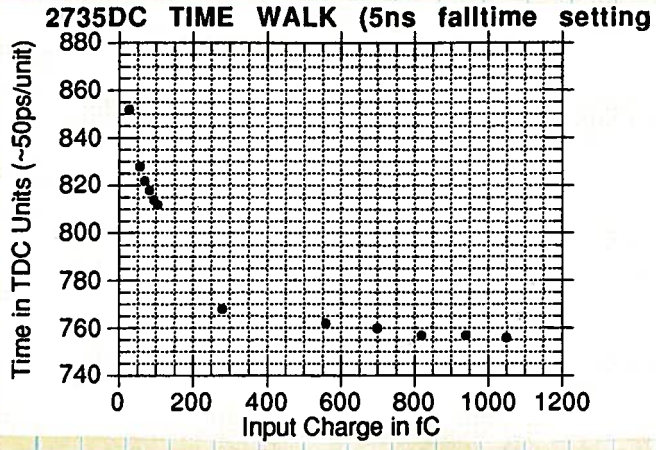



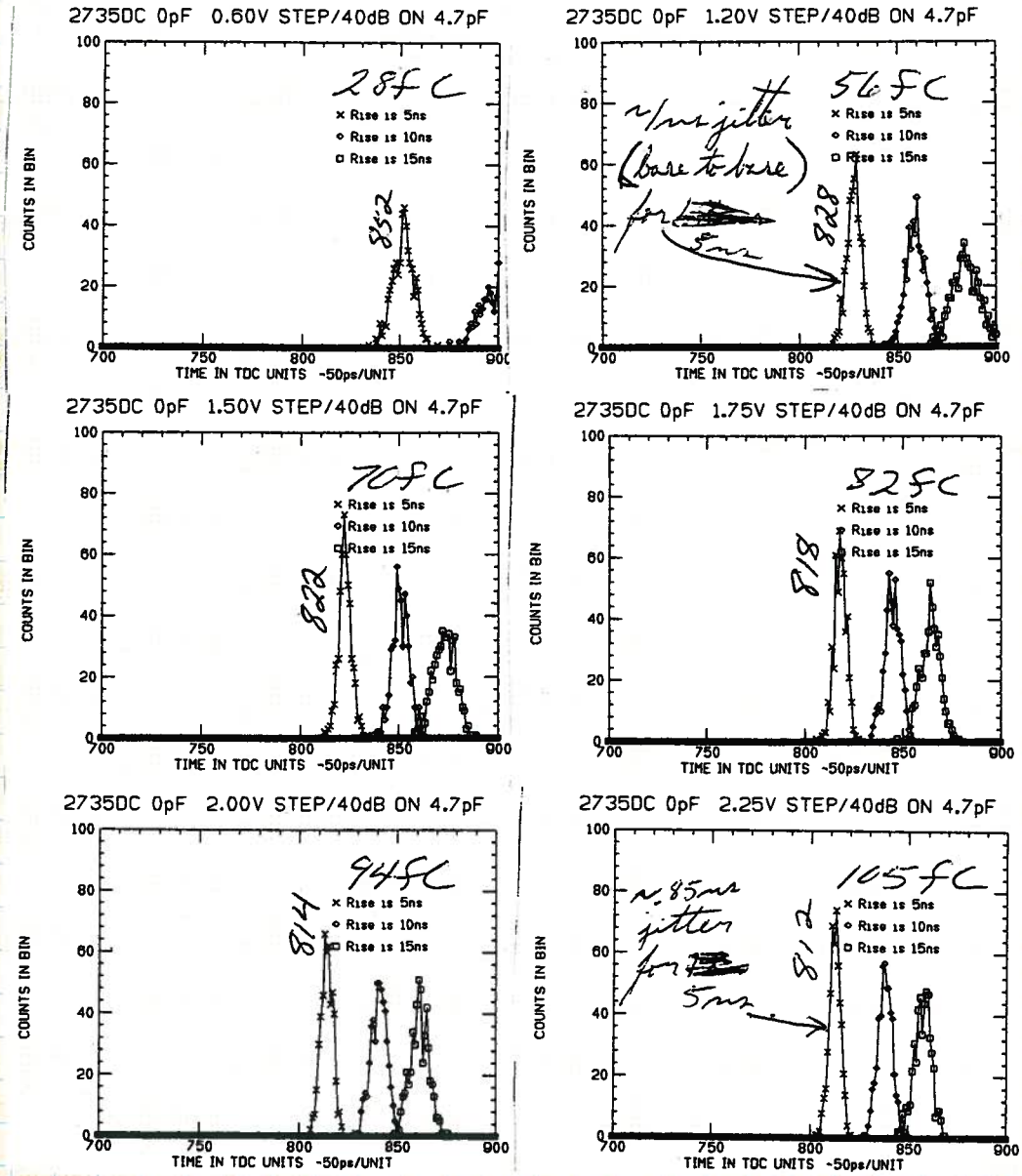



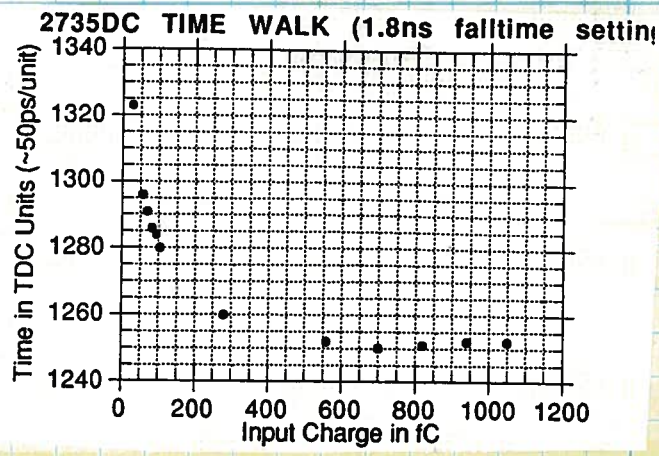



Plot of data on p. 18 and p. 20

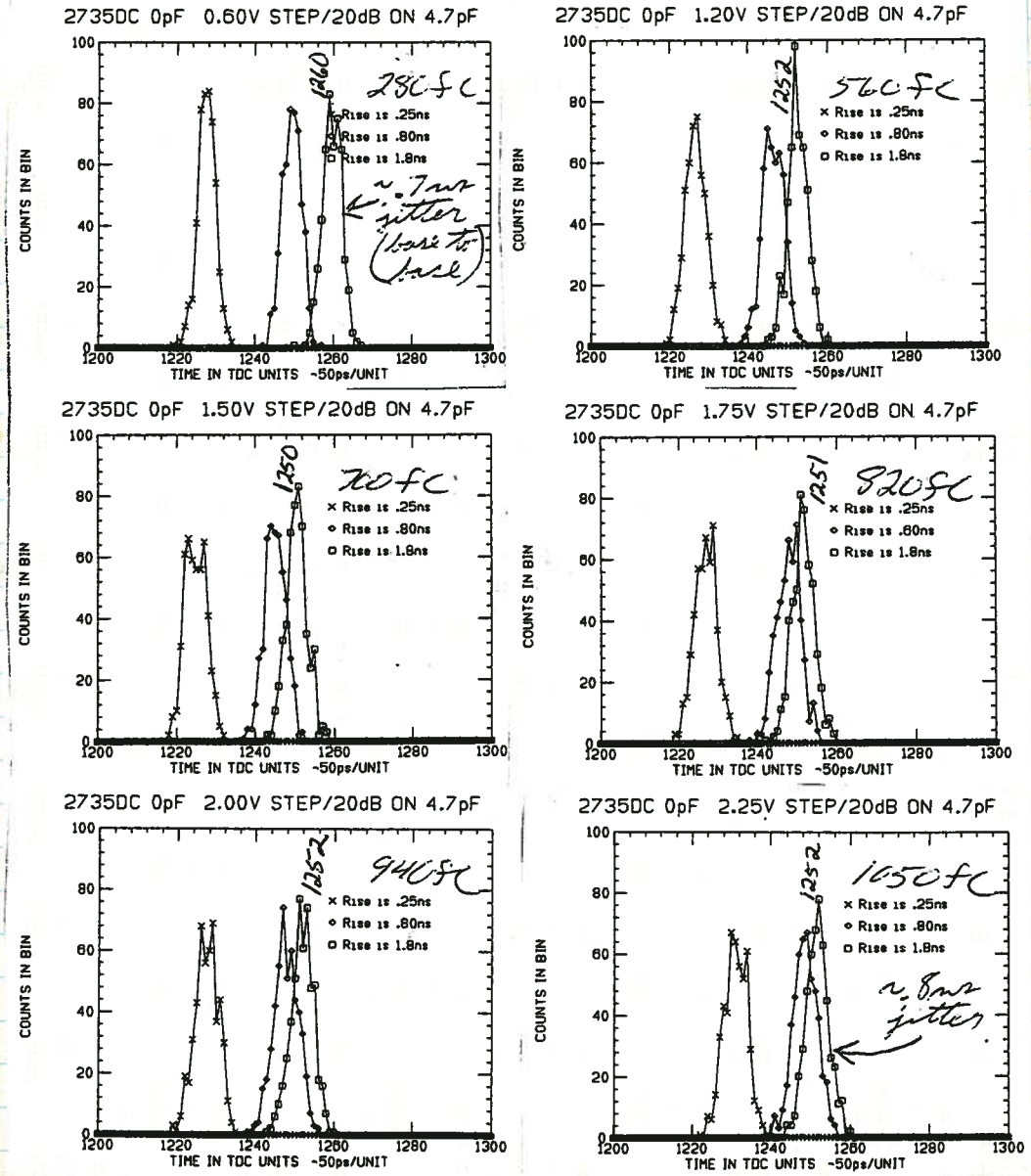
walk @ 5ns 56→105 fC is $\frac{828-812}{16}$ bins ⇒ ≈ 8 ns



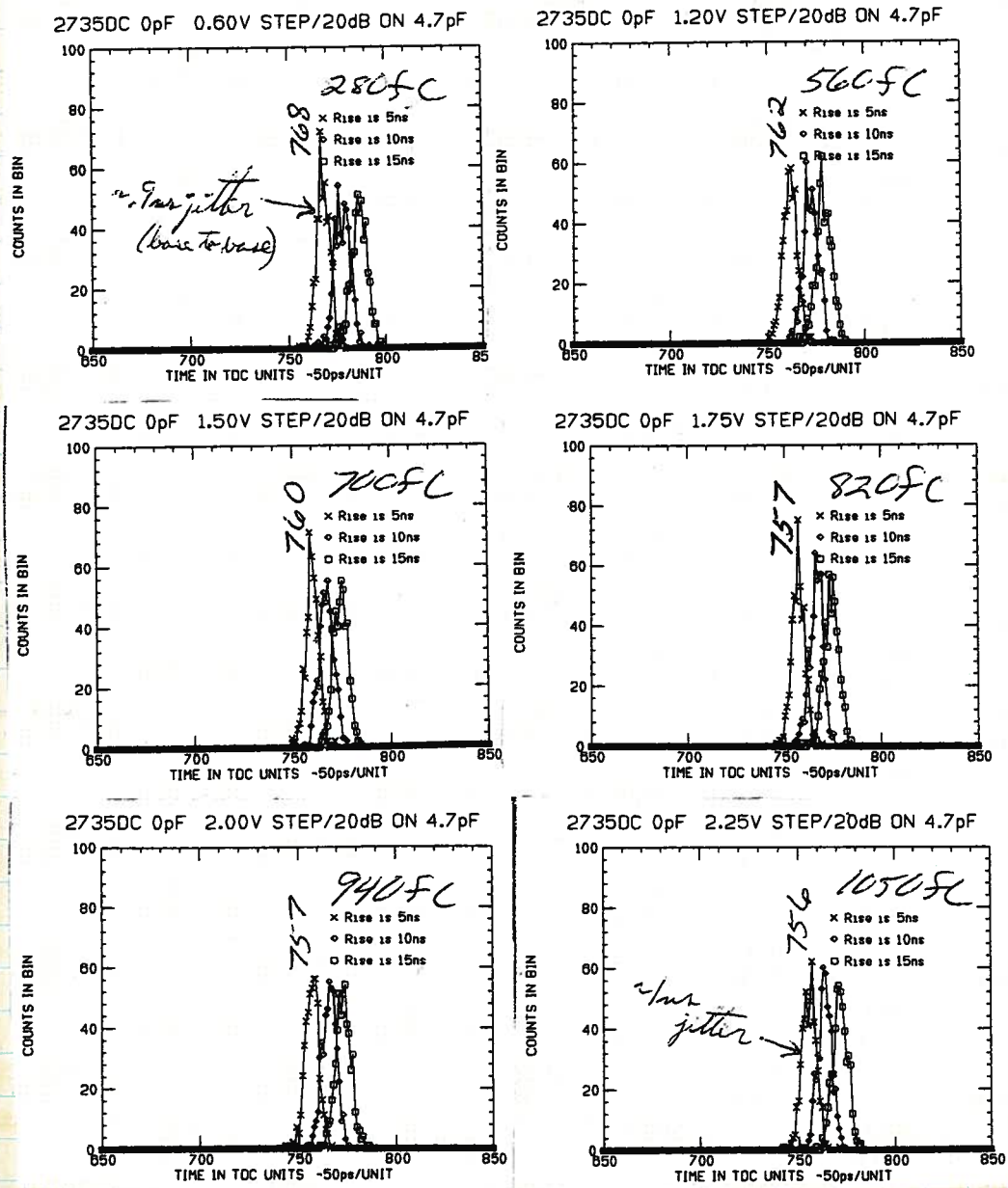
Plot of data on p. 17 and p. 19




walk @ 1.8ns 280 → 1050 fC is $\frac{1260 - 1252}{\text{8 bins}}$ ⇒ ≈ 4ns



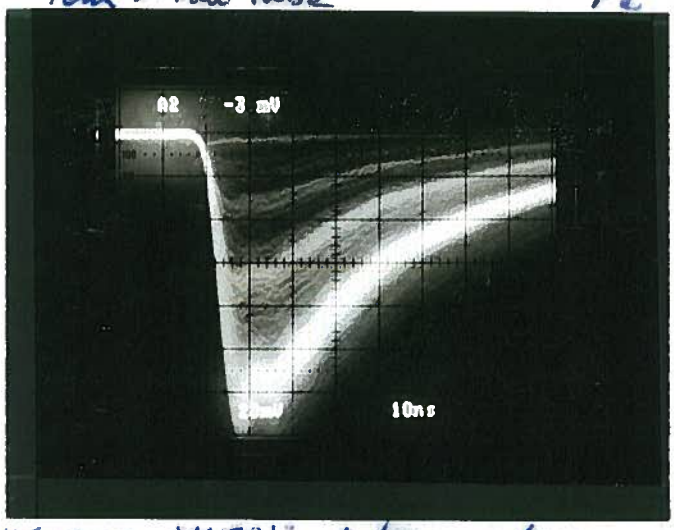
walk @ 5mV 250 → 1650 fC is $\frac{768 - 756}{12}$ bins ⇒ ~.6 ns



FPP Straw Tube Ar/Eth 62/38 9/6

Saturday I hooked up one straw tube to gas and +HV. There are small sections of FPP tubes for testing. 1cm diameter. 0.3 mil Alon 4-5 mil mylar. 25.4 μm (?) diam. wire. Ar/Eth 62/38%. 100μCi $Fe^{55}$ source against the tube. Tube is horizontal. Amp is decoupled from wire by 100pF. 1 Meg in series w/ HV supply.

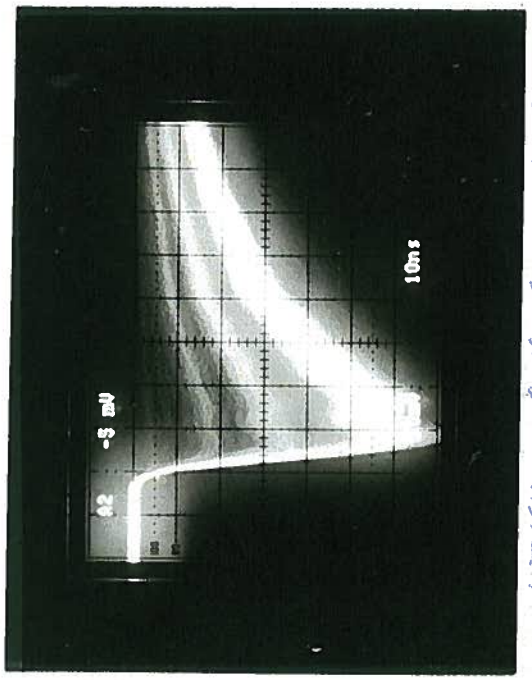
1cm Straw tube $Fe^{55}$



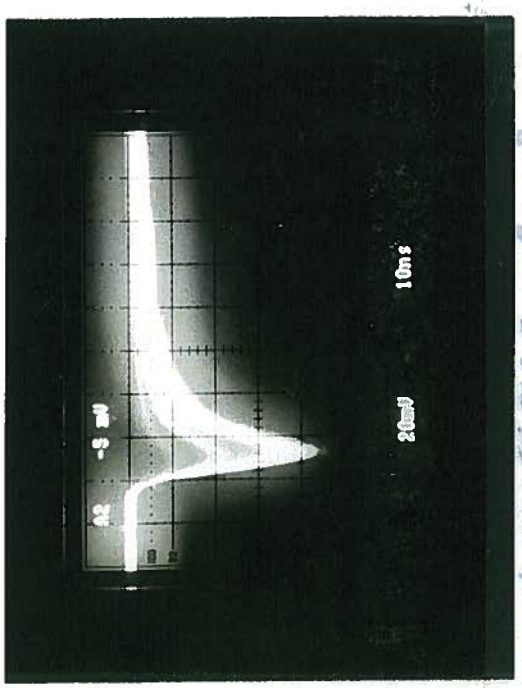

HFA3127 +1670V Ar/Eth 62/38%

This was Saturday. +/- 12.0V on HFA3127

These two bottom plots were taken monday. Far end of tube terminated in stainless plate.

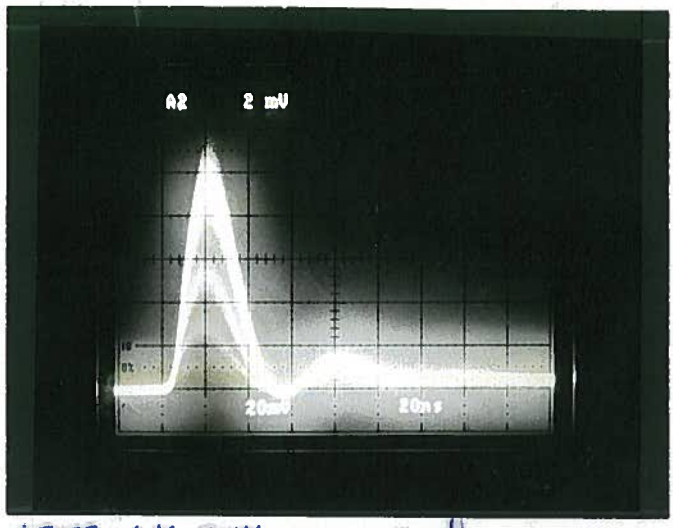



+1675V GND wire cont. open end.

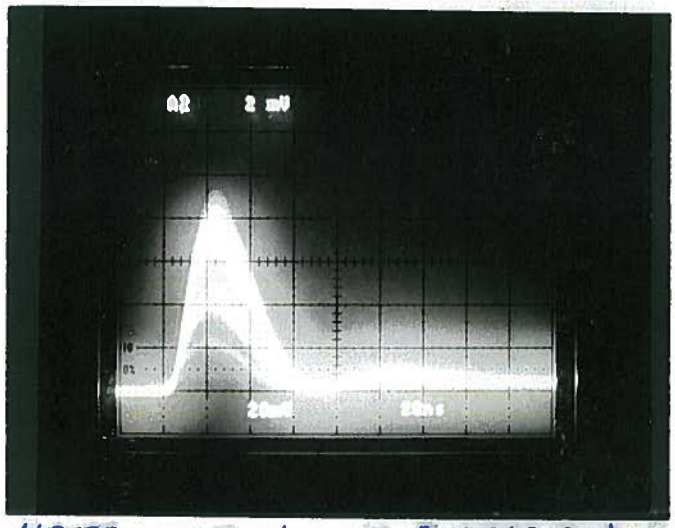



+1675V 1000pF 360Ω on far end.

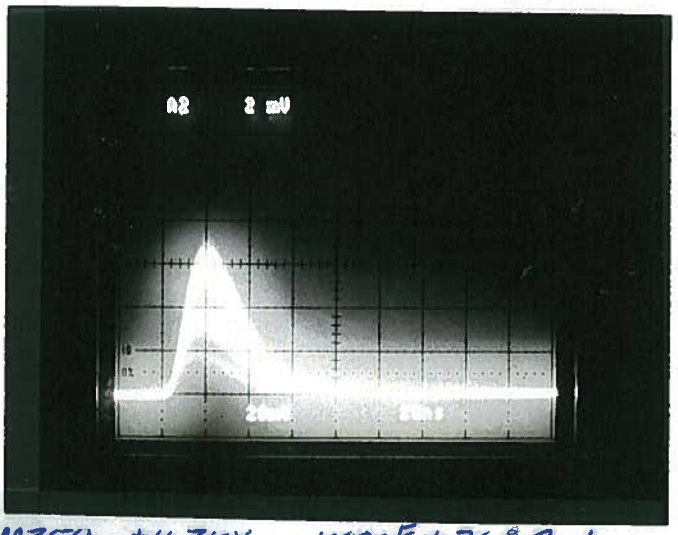
The LM359
supply = +11V




LM359 +16.74V open end

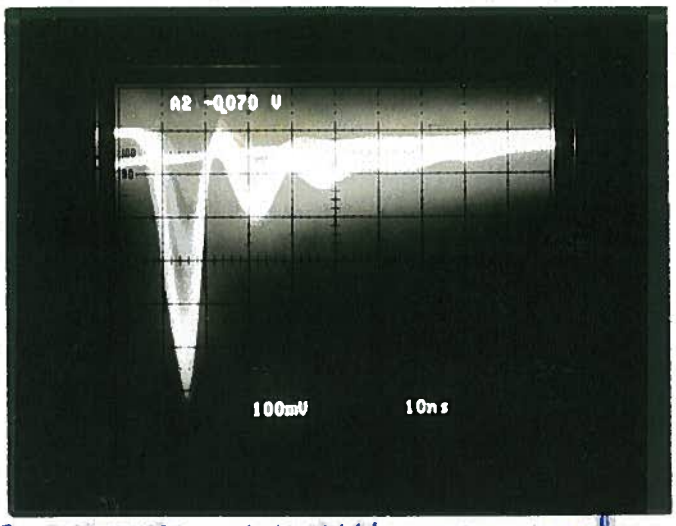



LM359 +16.76V 22pF & 360Ω term.



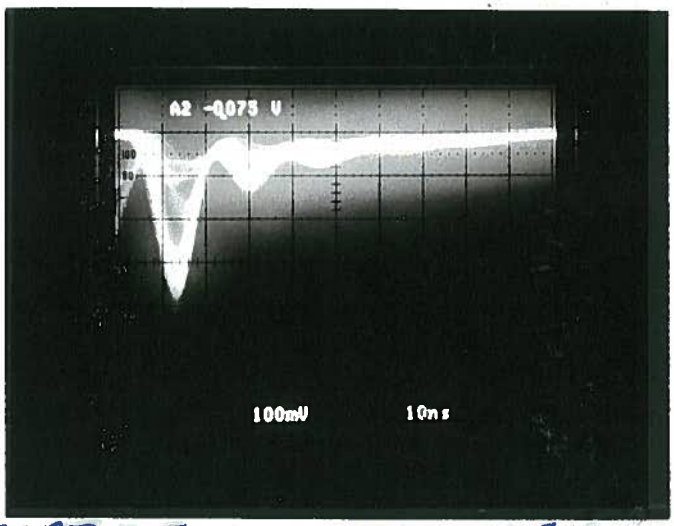

LM359 +16.75V 1000pF & 360Ω term.

The 3227SOIC amp
±12V supplies




3227SOIC +16.76V open end

Bootstrapping not in place. See p. 63 & 64 of this book.
2/1/95 JS



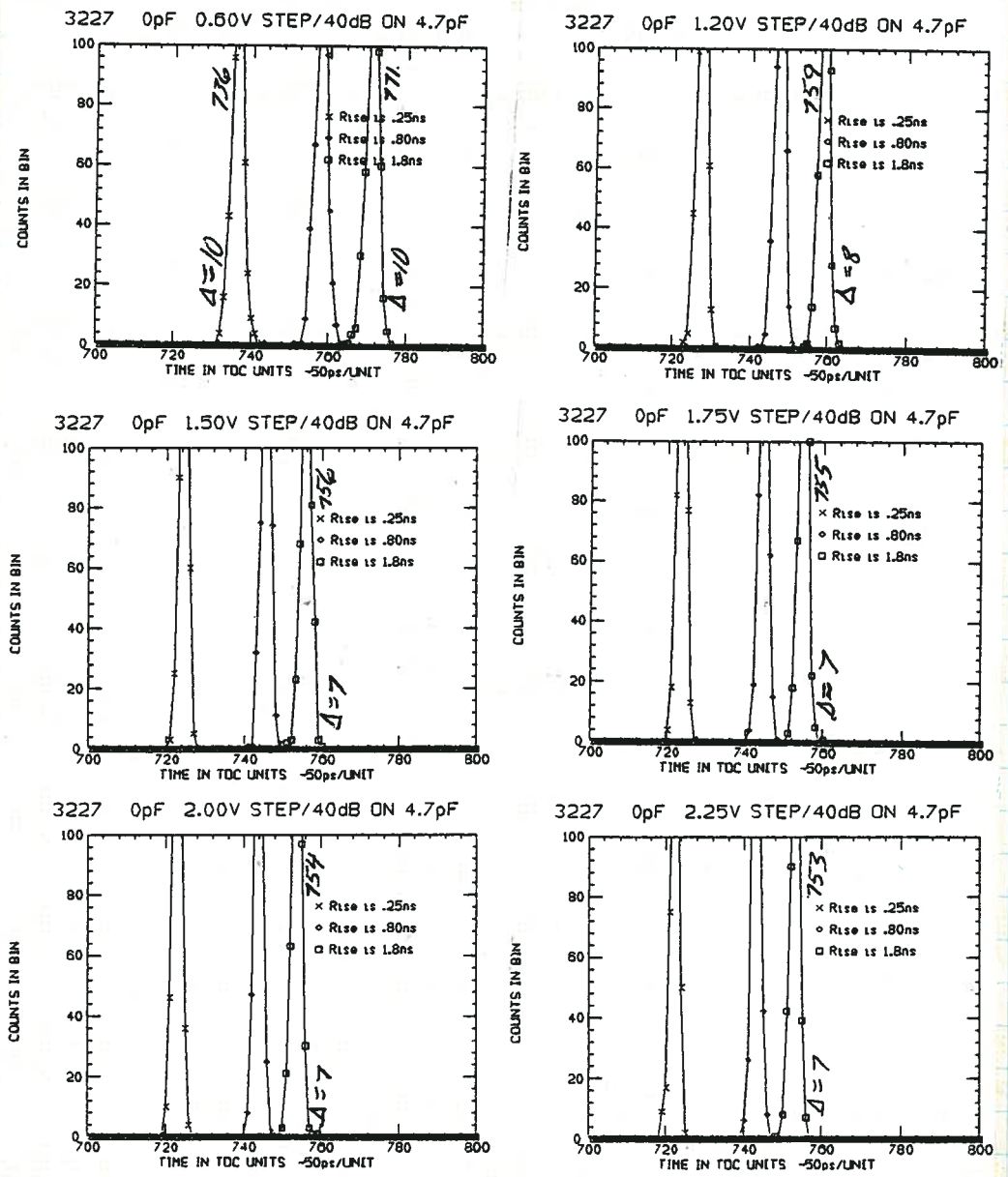

3227SOIC +16.76V 1000pF & 360Ω term

10/4 Timewalk & jitter of 3227 Amp HA2624

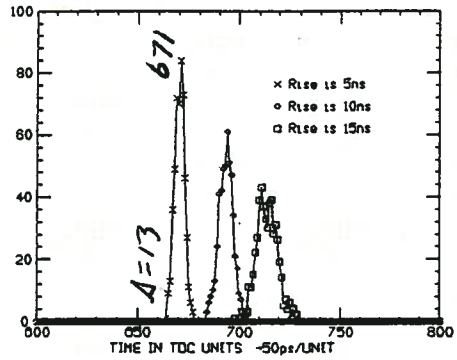
~~Same program used~~ This was done on Sep. 25

The program used on pp 13-20 was modified to accomodate a single ended signal being run into a Phillips 7106 discriminator.

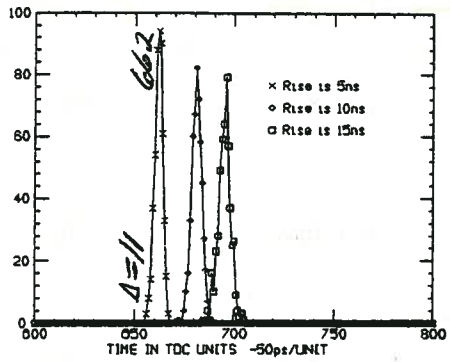
Setup similar to that for pp. 13-20 except for 7106 discriminator.



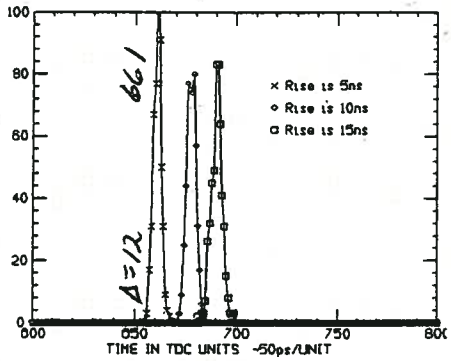
3227 0pF 0.80V STEP/40dB ON 4.7pF



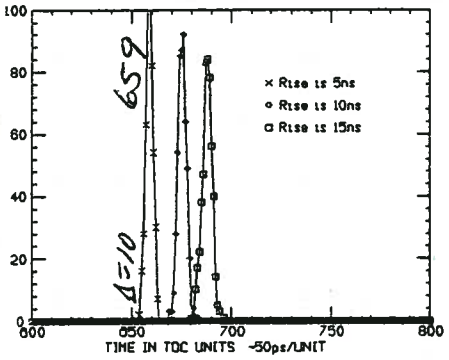

3227 0pF 1.20V STEP/40dB ON 4.7pF



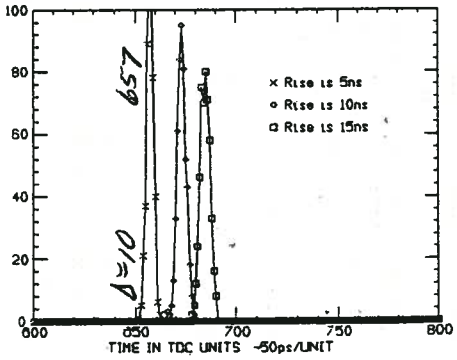

3227 0pF 1.50V STEP/40dB ON 4.7pF



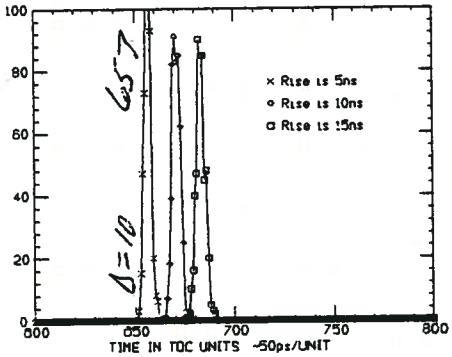

3227 0pF 1.75V STEP/40dB ON 4.7pF

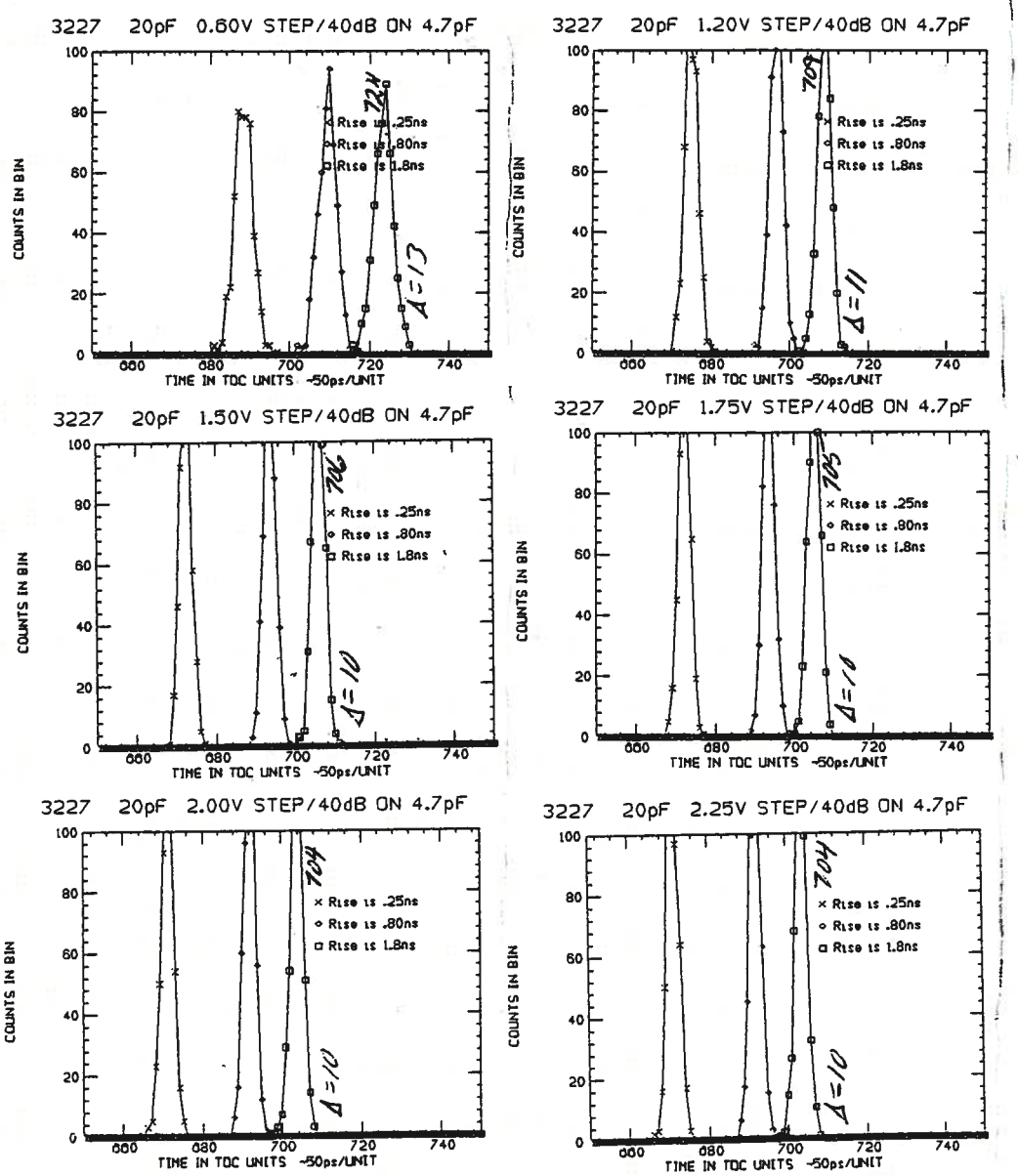


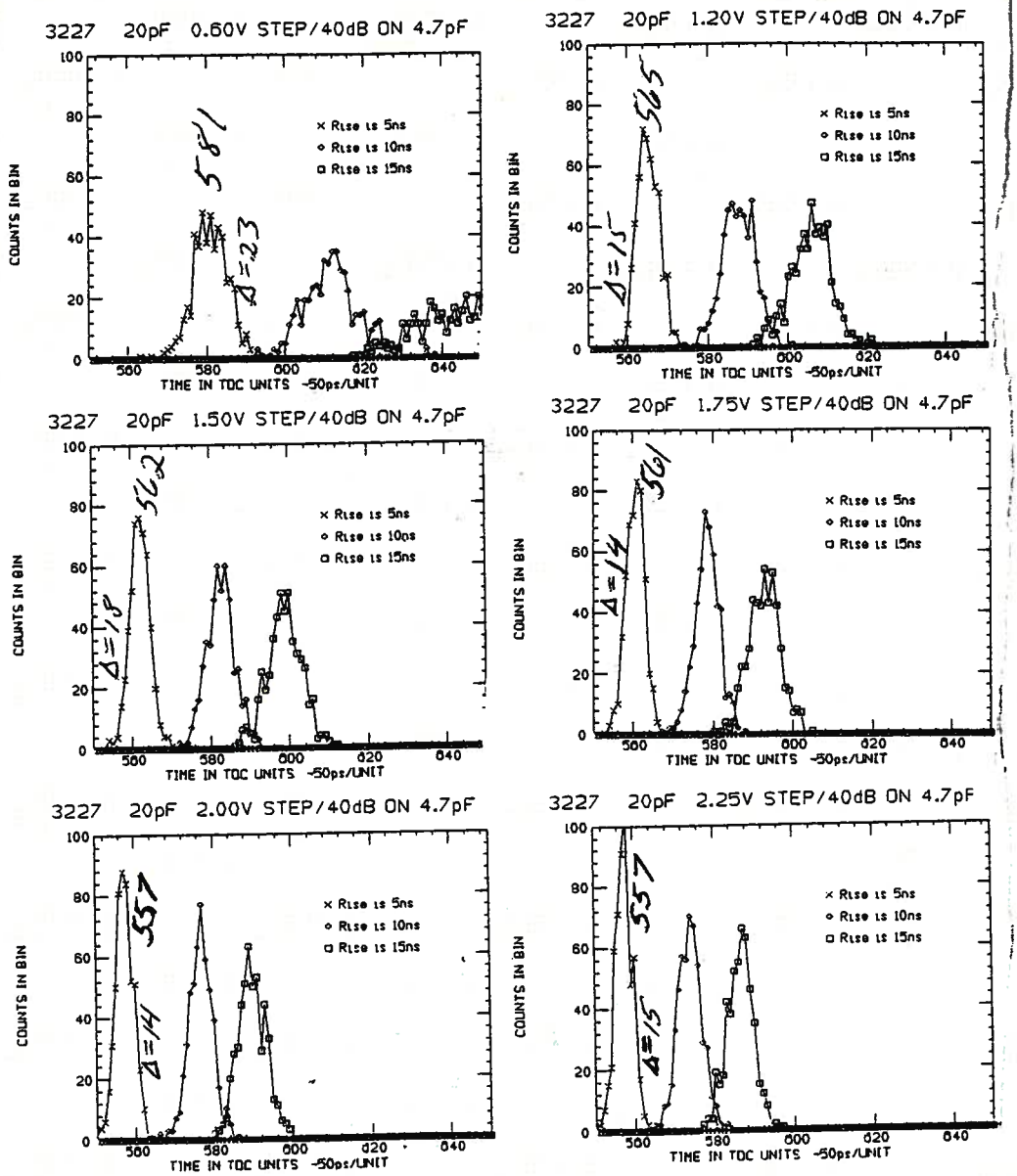

3227 0pF 2.00V STEP/40dB ON 4.7pF

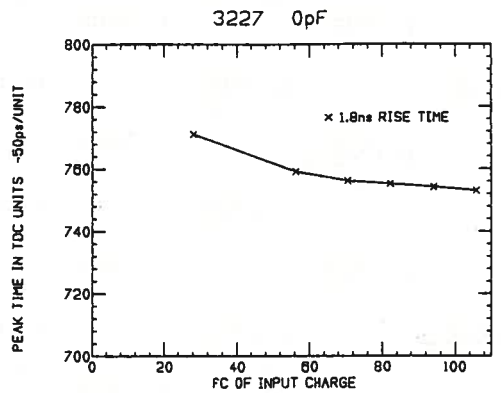


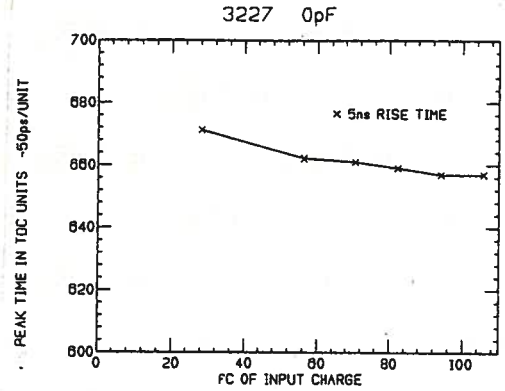

3227 0pF 2.25V STEP/40dB ON 4.7pF

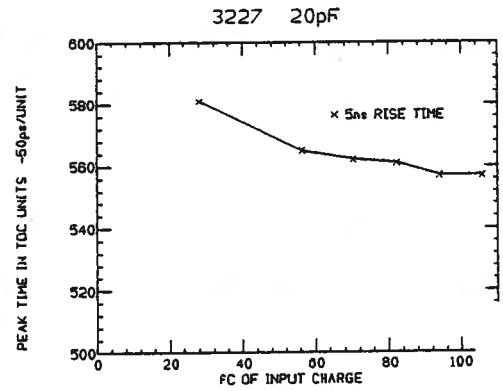


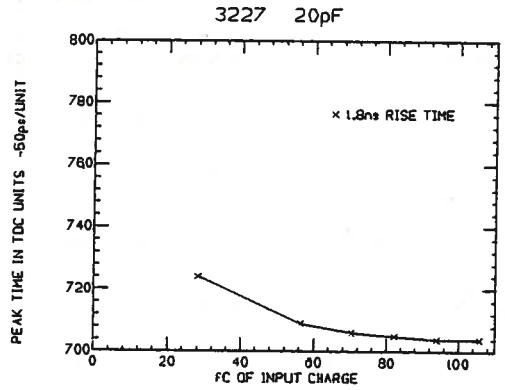

3227 20pF 0.60V STEP/40dB ON 4.7pF
3227 20pF 1.20V STEP/40dB ON 4.7pF
3227 20pF 1.50V STEP/40dB ON 4.7pF
3227 20pF 1.75V STEP/40dB ON 4.7pF
3227 20pF 2.00V STEP/40dB ON 4.7pF
3227 20pF 2.25V STEP/40dB ON 4.7pF
× Rise is .25ns
◇ Rise is .80ns
□ Rise is 1.8ns
COUNTS IN BIN
TIME IN TDC UNITS -50ps/UNIT
Δ=13
Δ=11
Δ=10
Δ=10
Δ=10
Δ=10

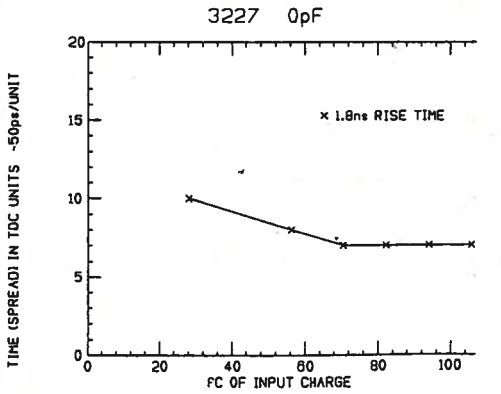

3227 20pF 0.60V STEP/40dB ON 4.7pF
3227 20pF 1.20V STEP/40dB ON 4.7pF
3227 20pF 1.50V STEP/40dB ON 4.7pF
3227 20pF 1.75V STEP/40dB ON 4.7pF
3227 20pF 2.00V STEP/40dB ON 4.7pF
3227 20pF 2.25V STEP/40dB ON 4.7pF
× Rise is 5ns
◇ Rise is 10ns
□ Rise is 15ns
COUNTS IN BIN
TIME IN TDC UNITS -50ps/UNIT
581
Δ=23
565
Δ=15
562
Δ=18
561
Δ=14
557
Δ=14
557
Δ=15

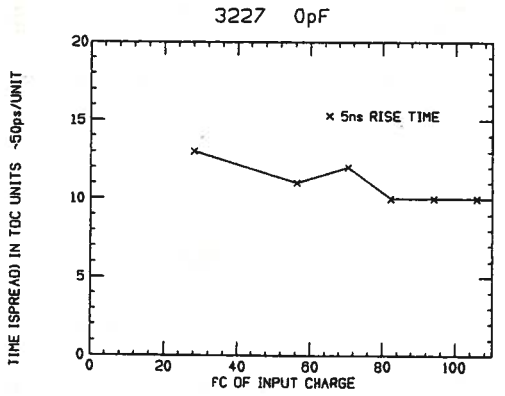

3227 0pF
× 1.8ns RISE TIME
PEAK TIME IN TDC UNITS -50ps/UNIT
FC OF INPUT CHARGE

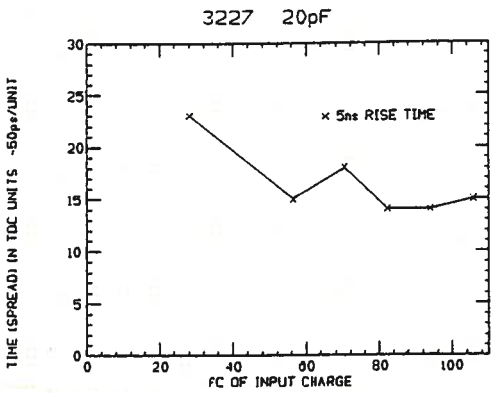

3227 0pF
× 5ns RISE TIME
PEAK TIME IN TDC UNITS -50ps/UNIT
FC OF INPUT CHARGE

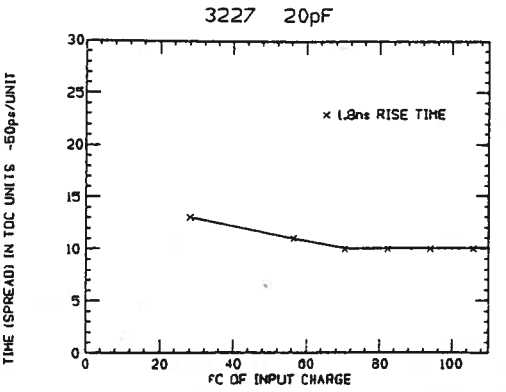

3227 20pF
× 5ns RISE TIME
PEAK TIME IN TDC UNITS -50ps/UNIT
FC OF INPUT CHARGE

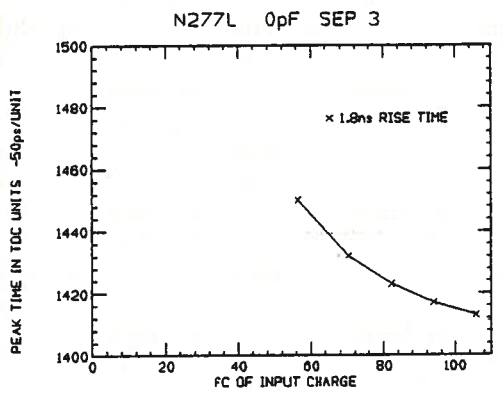

3227 20pF
× 1.8ns RISE TIME
PEAK TIME IN TDC UNITS -50ps/UNIT
FC OF INPUT CHARGE

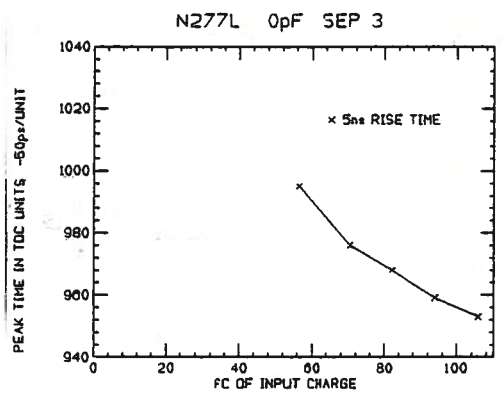

3227 0pF
× 1.8ns RISE TIME
TIME (SPREAD) IN TDC UNITS -50ps/UNIT
FC OF INPUT CHARGE

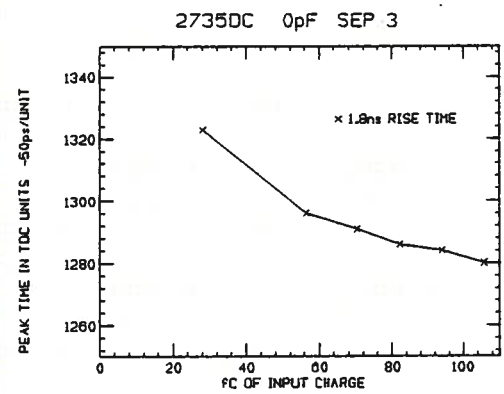

3227 0pF
× 5ns RISE TIME
TIME (SPREAD) IN TDC UNITS -50ps/UNIT
FC OF INPUT CHARGE

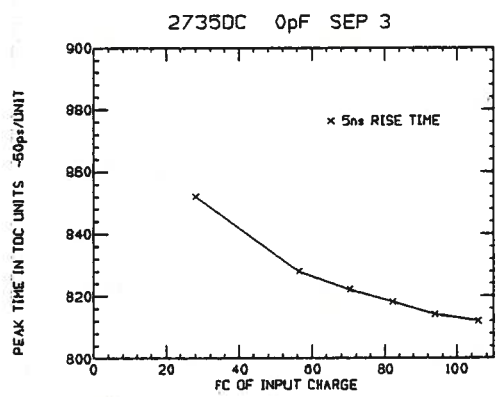

3227 20pF
× 5ns RISE TIME
TIME (SPREAD) IN TDC UNITS -50ps/UNIT
FC OF INPUT CHARGE

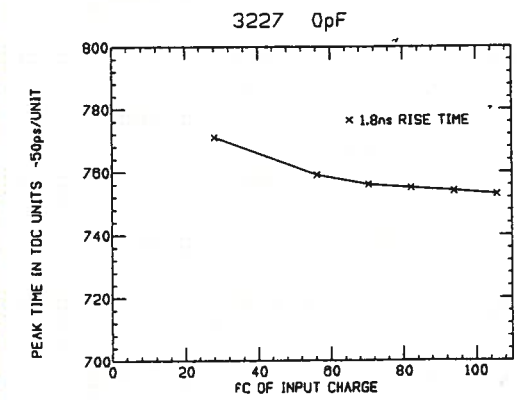

3227 20pF
× 1.8ns RISE TIME
TIME (SPREAD) IN TDC UNITS -50ps/UNIT
FC OF INPUT CHARGE

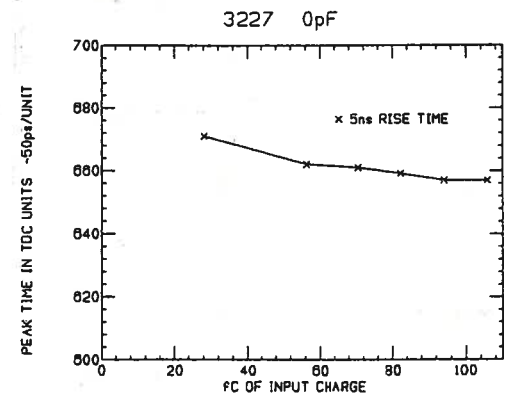

N277L 0pF SEP 3
× 1.8ns RISE TIME
PEAK TIME IN TDC UNITS -50ps/UNIT
FC OF INPUT CHARGE


N277L 0pF SEP 3
× 5ns RISE TIME
PEAK TIME IN TDC UNITS -50ps/UNIT
FC OF INPUT CHARGE

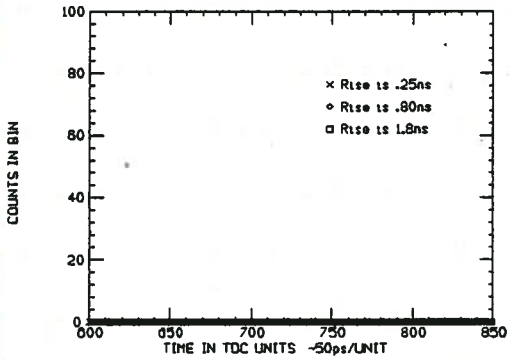

2735DC 0pF SEP 3
× 1.8ns RISE TIME
PEAK TIME IN TDC UNITS -50ps/UNIT
FC OF INPUT CHARGE


2735DC 0pF SEP 3
× 5ns RISE TIME
PEAK TIME IN TDC UNITS -50ps/UNIT
FC OF INPUT CHARGE

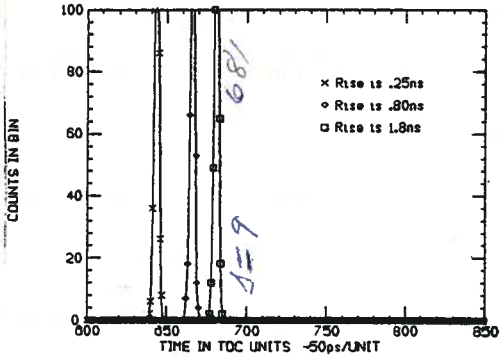

3227 0pF
× 1.8ns RISE TIME
PEAK TIME IN TDC UNITS -50ps/UNIT
FC OF INPUT CHARGE


3227 0pF
× 5ns RISE TIME
PEAK TIME IN TDC UNITS -50ps/UNIT
FC OF INPUT CHARGE

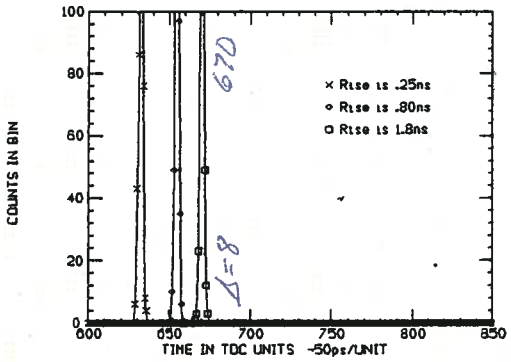
9624 0pF 0.60V STEP/40dB ON 4.7pF



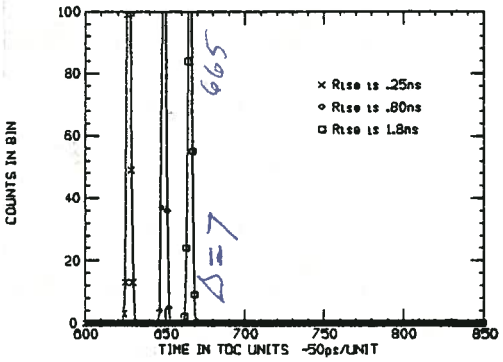

9624 0pF 1.20V STEP/40dB ON 4.7pF



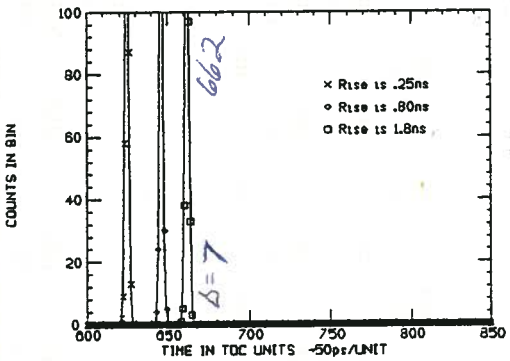

9624 0pF 1.50V STEP/40dB ON 4.7pF



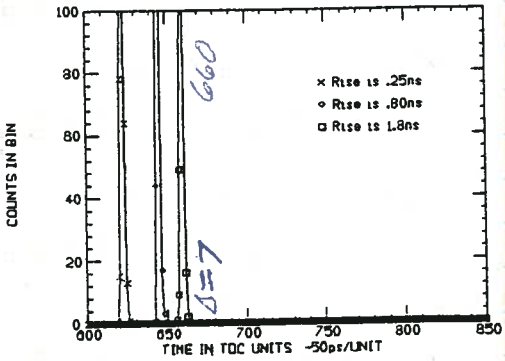

9624 0pF 1.75V STEP/40dB ON 4.7pF

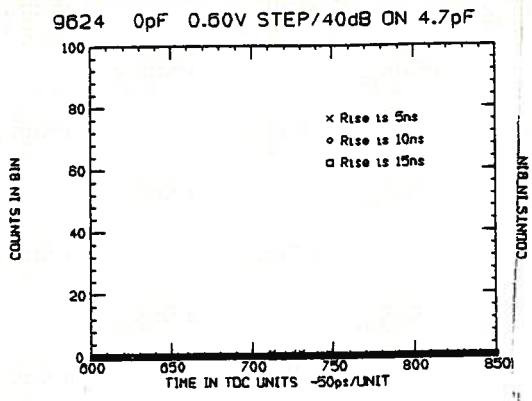


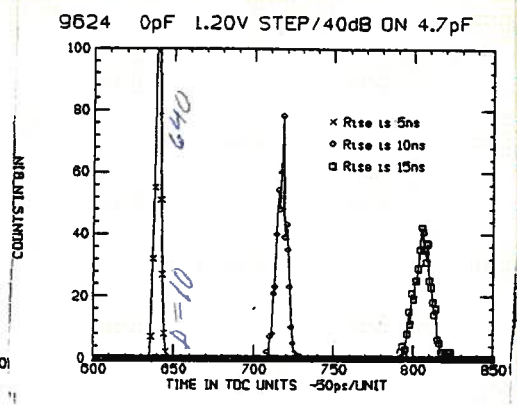

9624 0pF 2.00V STEP/40dB ON 4.7pF

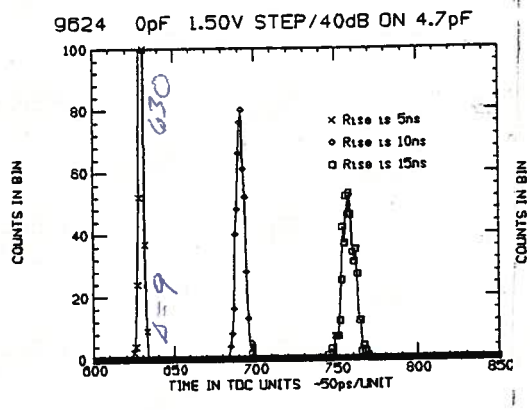


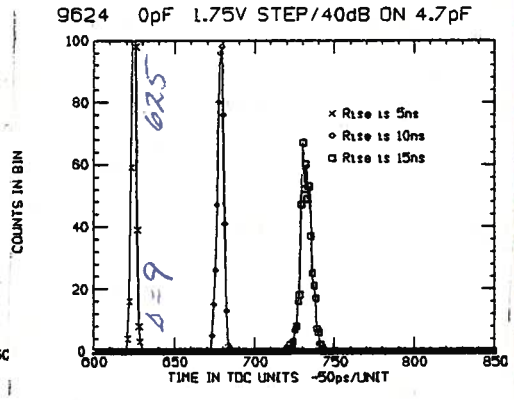

9624 0pF 2.25V STEP/40dB ON 4.7pF

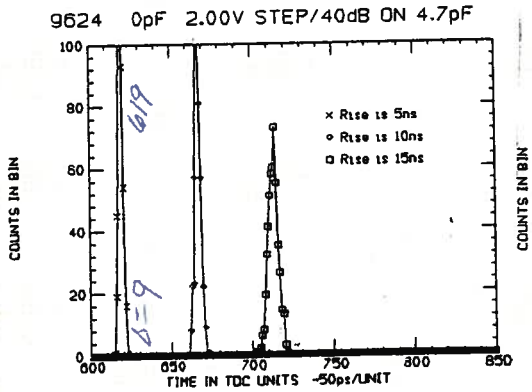


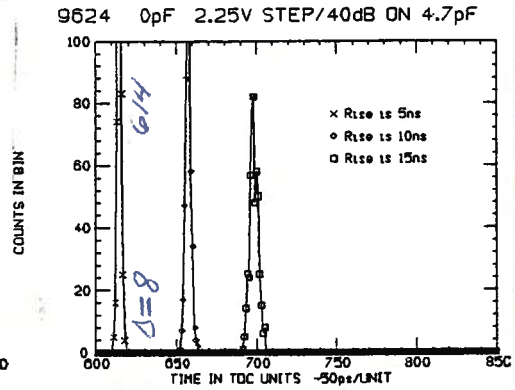

9624 0pF 0.60V STEP/40dB ON 4.7pF
× Rise is 5ns
∘ Rise is 10ns
□ Rise is 15ns
COUNTS IN BIN
TIME IN TDC UNITS -50ps/UNIT


9624 0pF 1.20V STEP/40dB ON 4.7pF
640
Δ=10
× Rise is 5ns
∘ Rise is 10ns
□ Rise is 15ns
COUNTS IN BIN
TIME IN TDC UNITS -50ps/UNIT

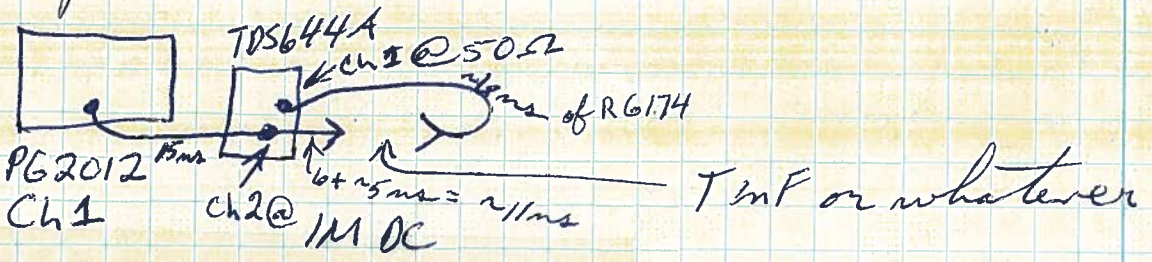

9624 0pF 1.50V STEP/40dB ON 4.7pF
630
Δ=9
× Rise is 5ns
∘ Rise is 10ns
□ Rise is 15ns
COUNTS IN BIN
TIME IN TDC UNITS -50ps/UNIT

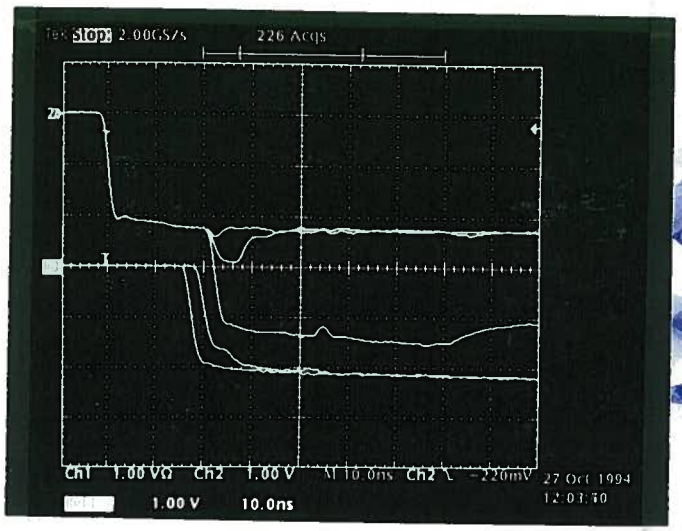

9624 0pF 1.75V STEP/40dB ON 4.7pF
625
Δ=9
× Rise is 5ns
∘ Rise is 10ns
□ Rise is 15ns
COUNTS IN BIN
TIME IN TDC UNITS -50ps/UNIT


9624 0pF 2.00V STEP/40dB ON 4.7pF
619
Δ=9
× Rise is 5ns
∘ Rise is 10ns
□ Rise is 15ns
COUNTS IN BIN
TIME IN TDC UNITS -50ps/UNIT


9624 0pF 2.25V STEP/40dB ON 4.7pF
614
Δ=8
× Rise is 5ns
∘ Rise is 10ns
□ Rise is 15ns
COUNTS IN BIN
TIME IN TDC UNITS -50ps/UNIT

10/27 Impedance Mismatch RG174 to T'nF
JS

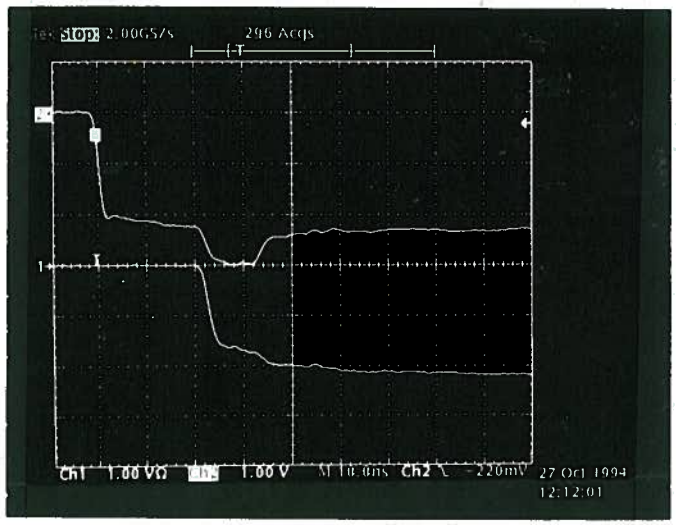


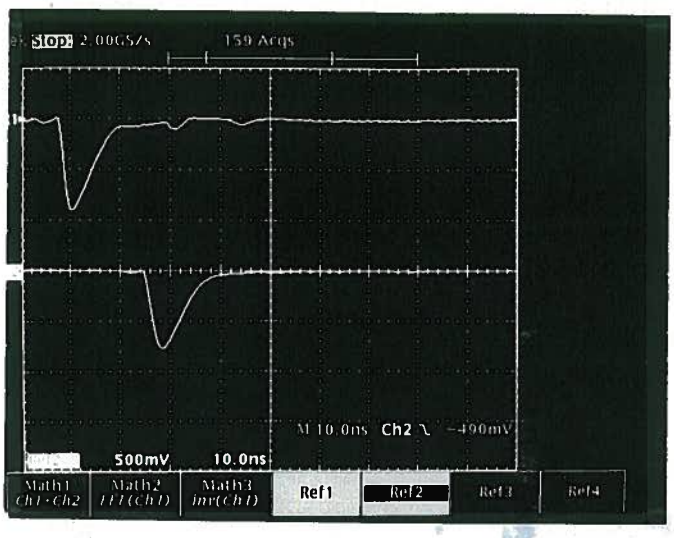

Ch 2
Upper trace is with coupling pins
Lower trace is 2 section of T'nF

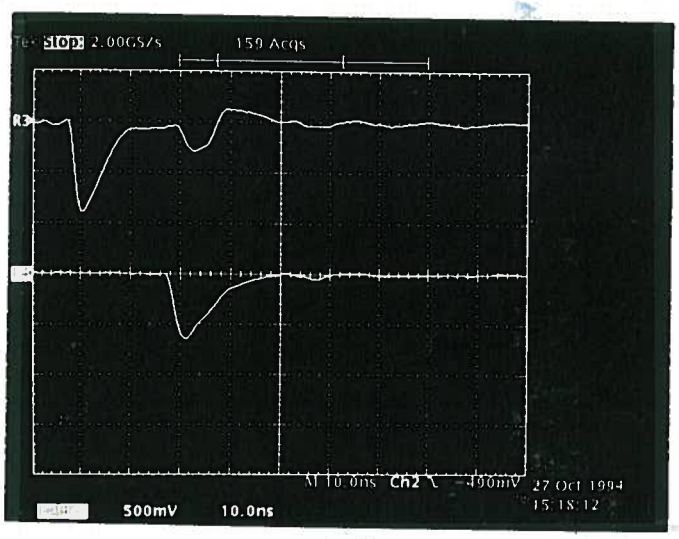
open end (pulser wants to see 50Ω load. Ringing)

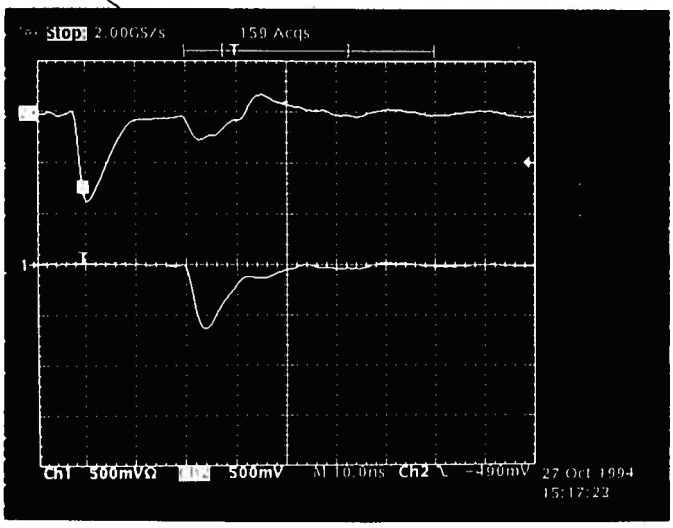
ch 1
Earlier trace is with coupling pins
Later trace is 2 section of T'nF




2 sections of T'nF

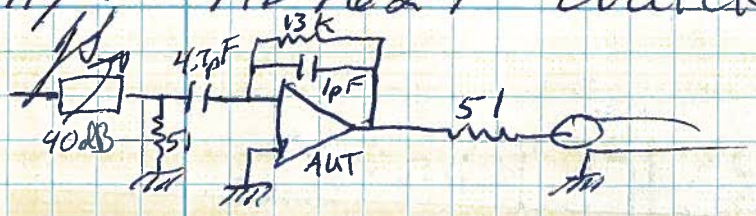

Stop: 2.00GS/s
159 Acqs
M 10.0ns Ch2 ∖ -490mV
500mV
10.0ns
Math1 Ch1-Ch2
Math2 FFT(Ch1)
Math3 inv(Ch1)
Ref1
Ref2
Ref3
Ref4

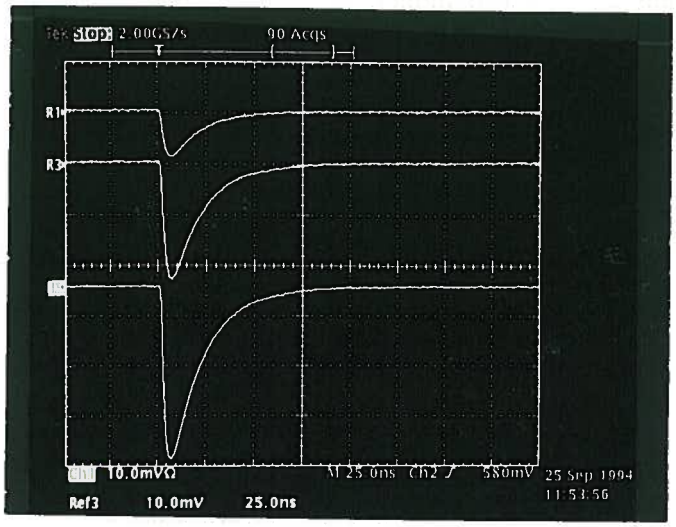

Stop: 2.00GS/s
159 Acqs
M 10.0ns Ch2 ∖ -490mV
27 Oct 1994
15:18:12
500mV
10.0ns


Stop: 2.00GS/s
159 Acqs
Ch1 500mVΩ
500mV
M 10.0ns Ch2 ∖ -490mV
27 Oct 1994
15:17:23

# 11/6 AD9624 Quick Look

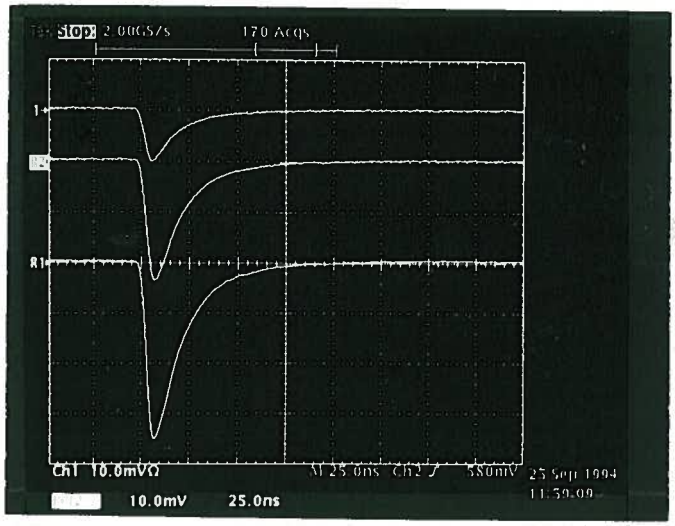
(This was done a few weeks ago)




1.8ns rise on 40dB & 4.7pF

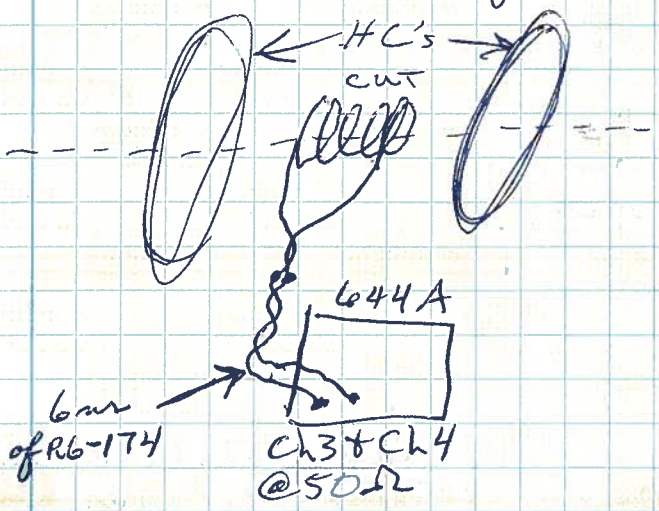
- 6V step
- 1.5V step
- 2.25V step



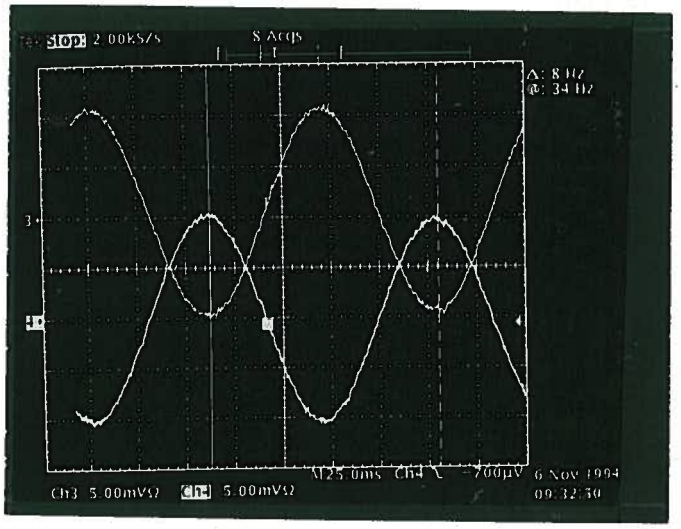

Same as above except 5ns rise

# Quick look Inductive Pickup RG-213 11/6 JA

Put a roll (~3/4 full) of ~~RG-213~~ Intercomp 50Ω Low Loss Coaxial Cable in the detector group's Helmholtz coil. Roll is from Bob Michael's cable delay testing. With the Sorensen 55-180 power supply in current mode an ~8 Hz oscillation can be generated. Voltage limit must be set low enough to prevent supply from settling down. With supply at 20A;




CUT is roughly centered ± 6"

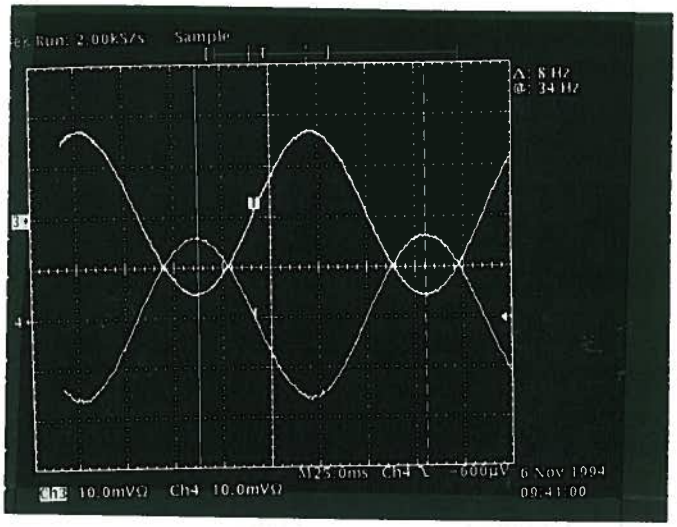



Shortly after flipping supply for. Dies down after a couple of minutes.

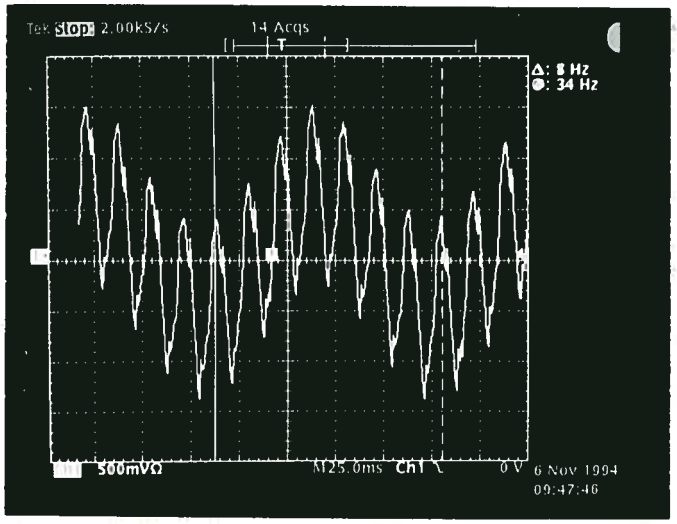
Supply voltage limit adjusted to provide steady oscillations. See next page.

26A @ 6.0V to coil
(read from supply display)

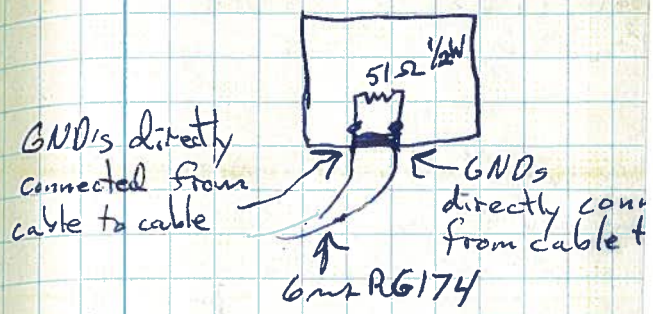
Voltage limit set to 6.0V. Current set to 20A. After turn on get steady oscillations.



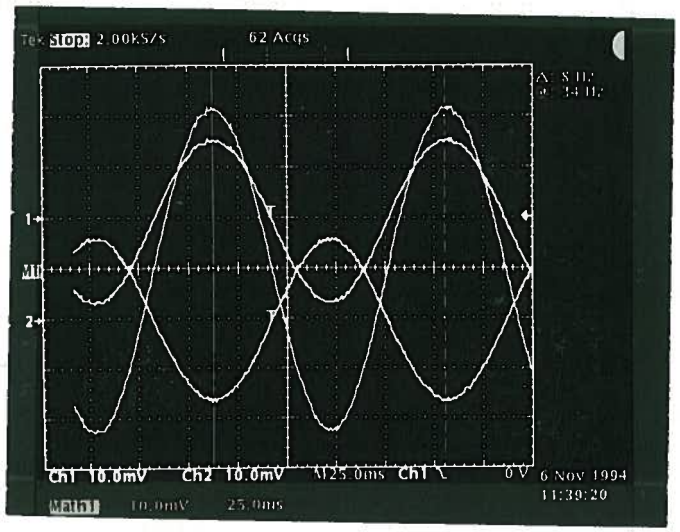

Scope removed from circuit. Cable ends connected together with a barrel connector. FET probe used to look at "+" output of supply. GND clip not connected to anything.



Disassembled setup.
Reassembled to try 50Ω in series w/cable.




Same setup as p. 36

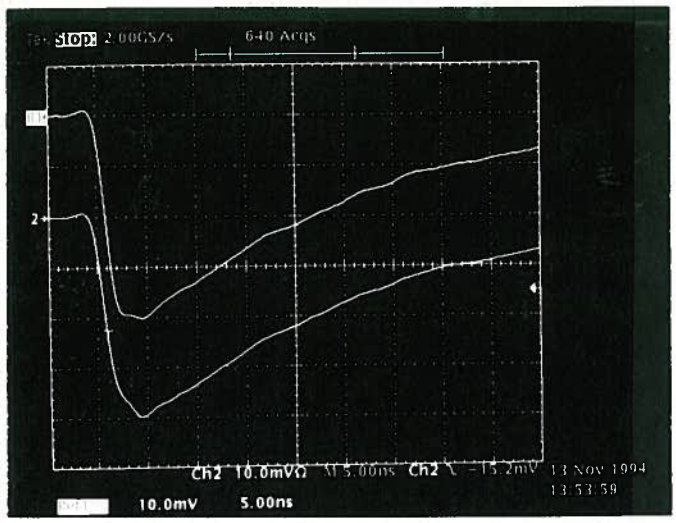



With supply in voltage mode @ 0.5V get 3A read from supply display
1.0V 5A
1.5V 7A

11/20

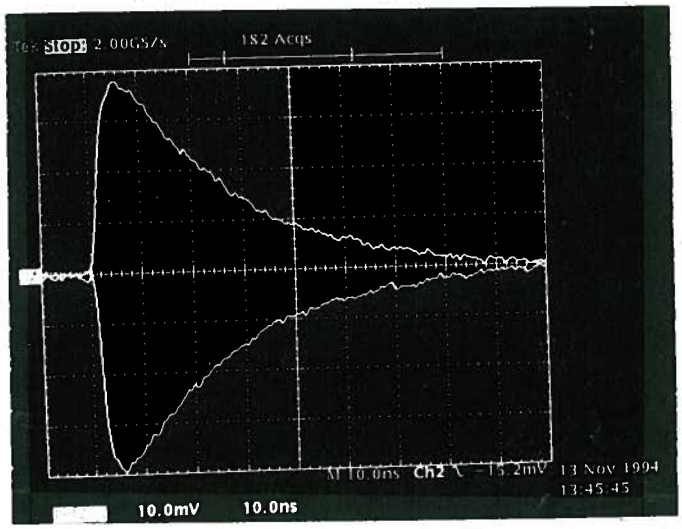
# AMUXTTL + Balun Comparison

The PC amp is used to check responses to a differential pulse.
PC amp driven by a 2.25V step pulse 1.8ns rise & fall from PG2012 pulser.
40dB on 1.0pF for input charge.
$V_{supply} = \pm 4.6V$

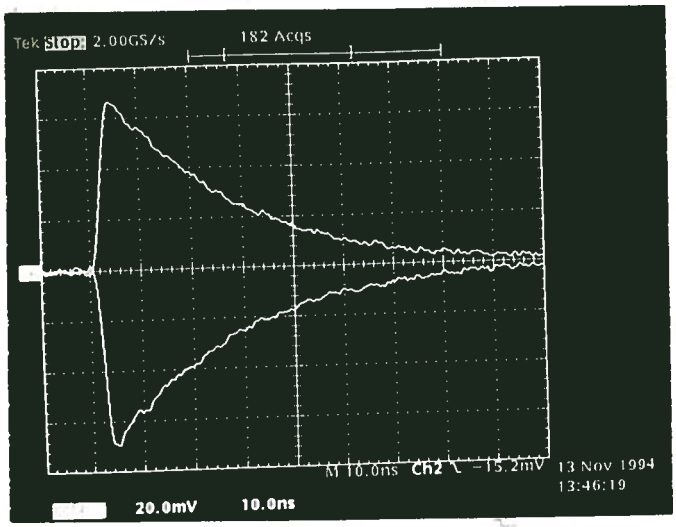



6" of flat cable pair
Single core balun
+15ns RG174

Response to both rising & falling edges




6" of flat cable pair
Small double core balun and 15ns RG174




1 section of TmF
2 sections of TmF
to 4 MUX TTL
05 m RG174

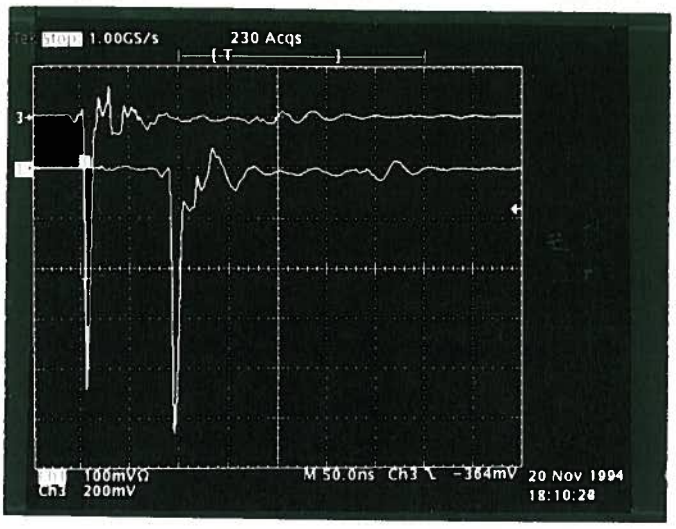
The amplitude of each channel is measured with the same input. 1 section of TmF is moved from channel to channel. (line to line)

66.6 mV
67.0
66.8
66.6
67.6
68.2
67.8
66.8
66.6
67.0
65.6
66.6
66.2
65.6
64.0
65.4

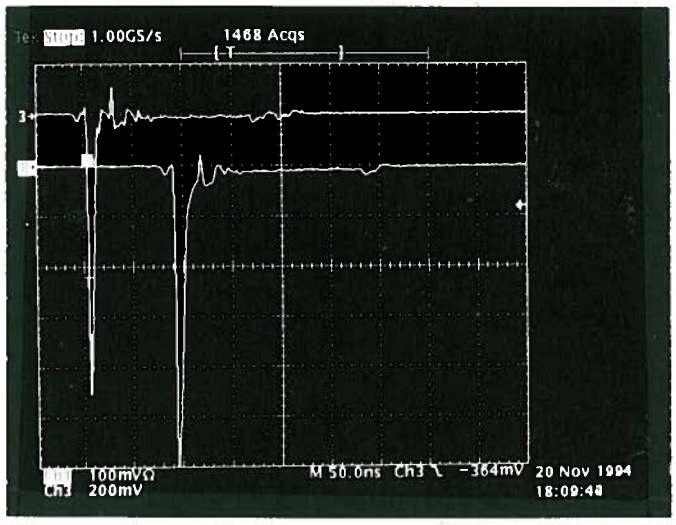
11/20/94 RG-174 to AMP Ribbon Coax Impedance Match

Same setup as p. 32.

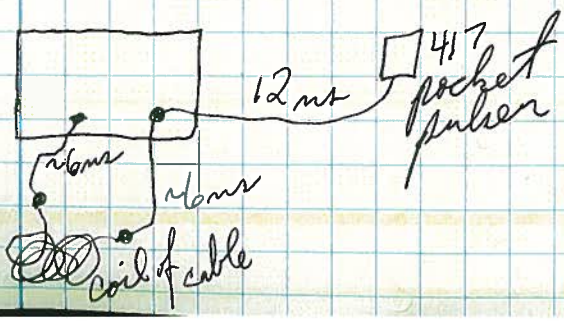
Coil of 50Ω ribbon coax from AMP is tested




Driving shield
Center conn. grnded.



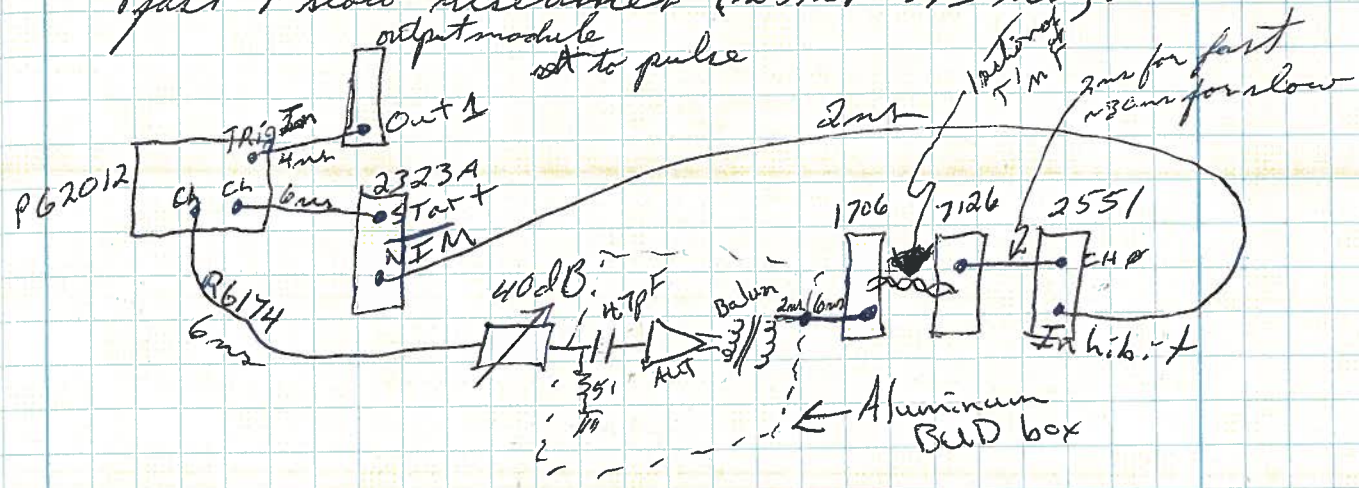

Driving central conductor.
shield grounded

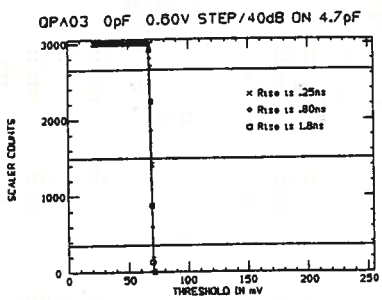


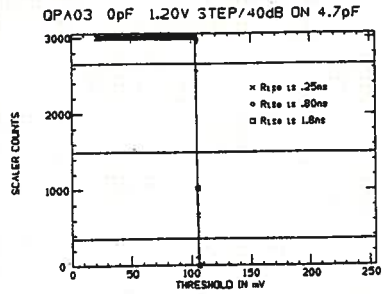
QPAØ3 Gain + Noise (UVA layout) 12/4

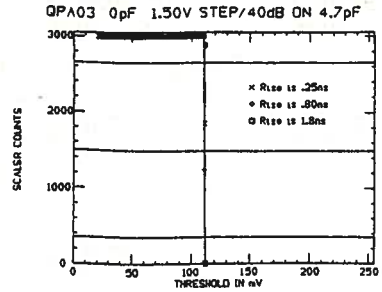
Setup is similar to p 118 of Lab Techniques I.

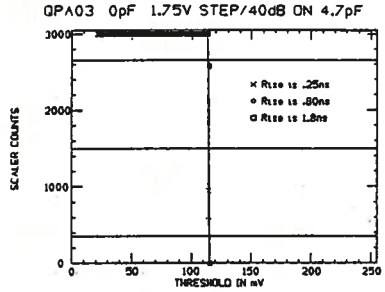
Program is rewritten as AMPTEST.FOR to incorporate fast + slow risetimes (.25ns → 15 ns).

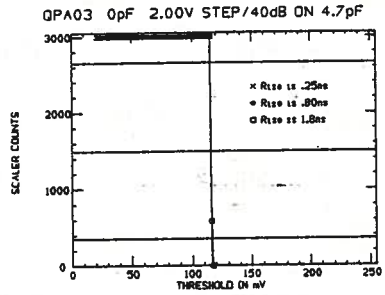


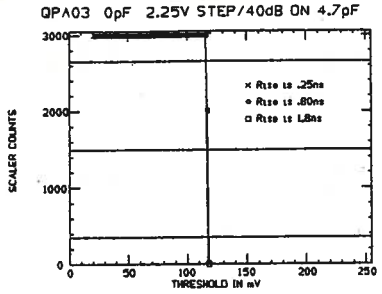


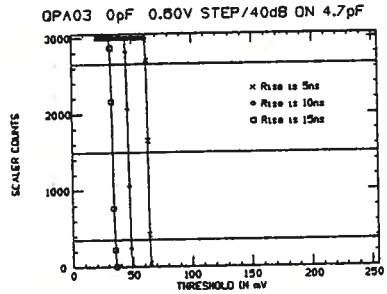



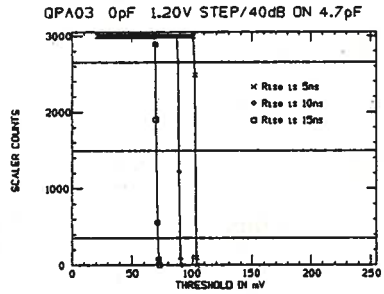



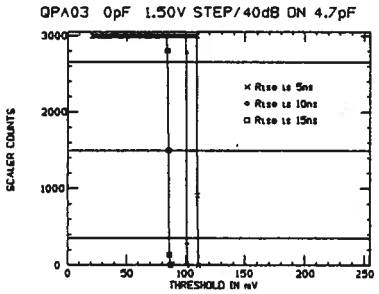



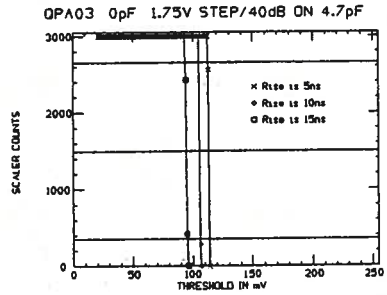



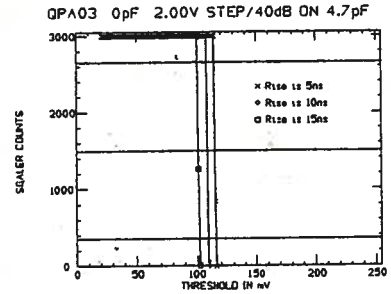



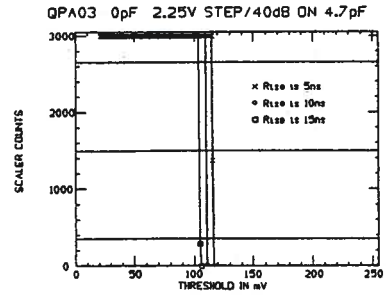



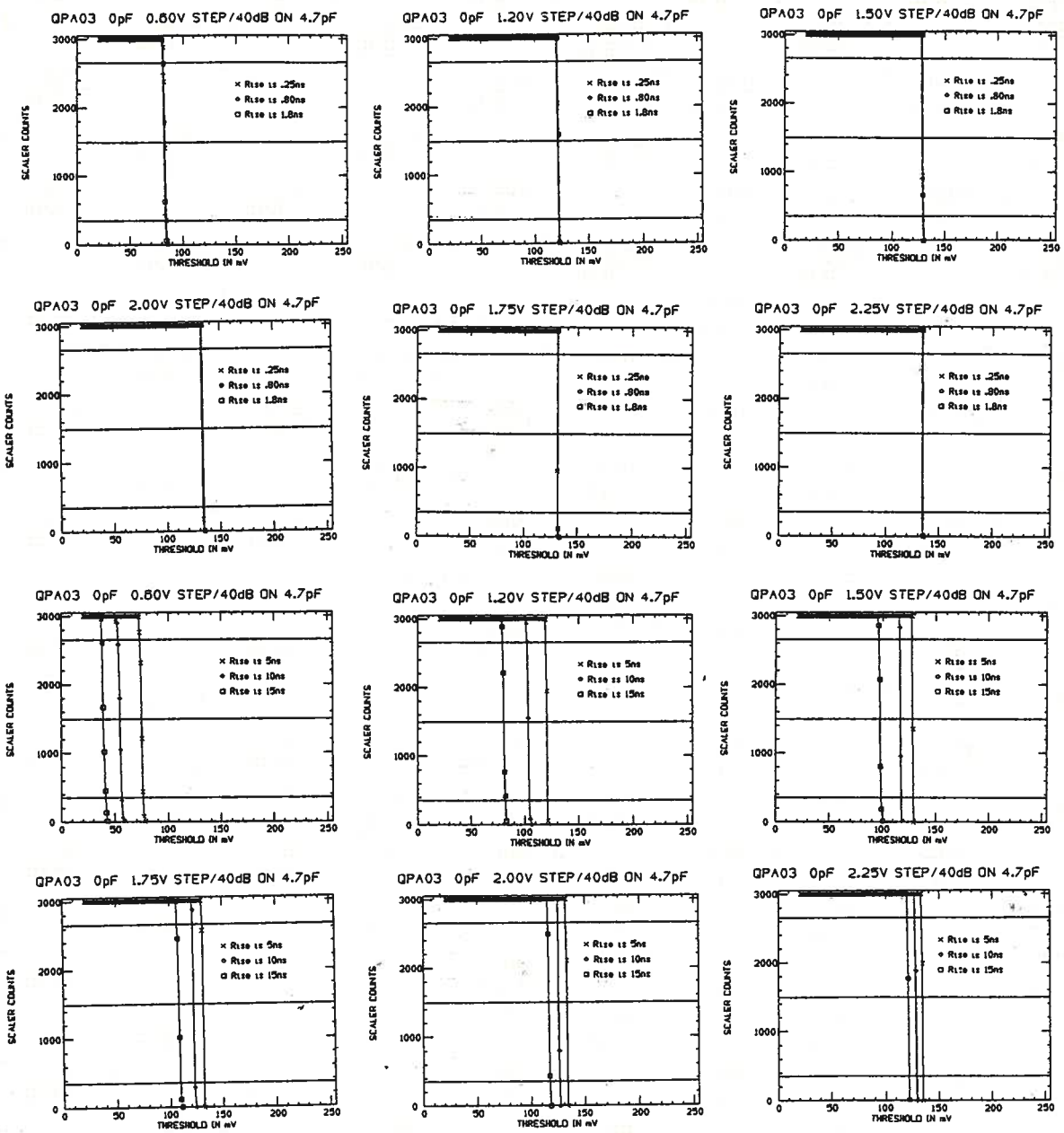



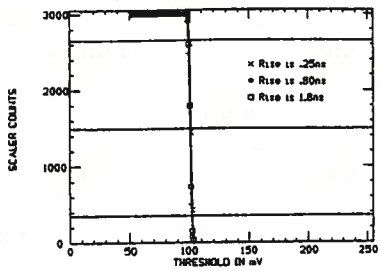




$V_{supply} = 3.50V$

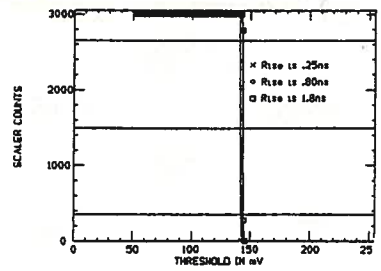



$V_{supply} = 3.75V$

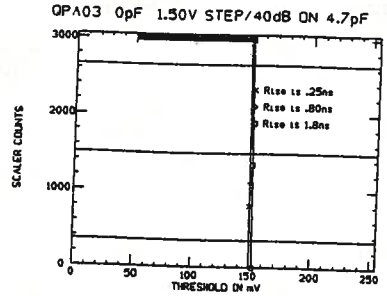
QPA03 0pF 0.60V STEP/40dB ON 4.7pF



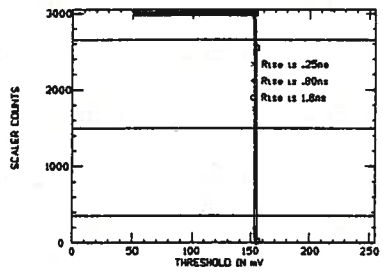

QPA03 0pF 1.20V STEP/40dB ON 4.7pF



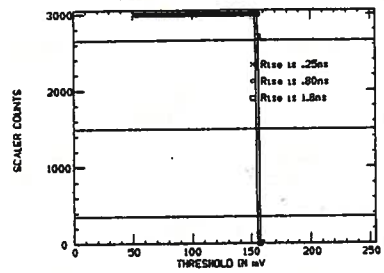

QPA03 0pF 1.50V STEP/40dB ON 4.7pF



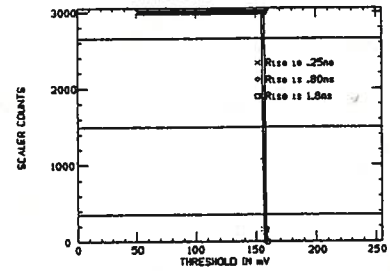

QPA03 0pF 1.75V STEP/40dB ON 4.7pF



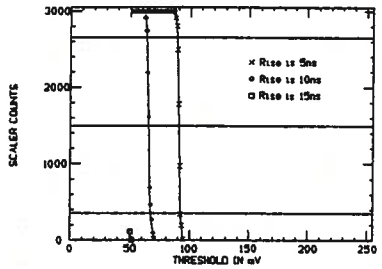

QPA03 0pF 2.00V STEP/40dB ON 4.7pF



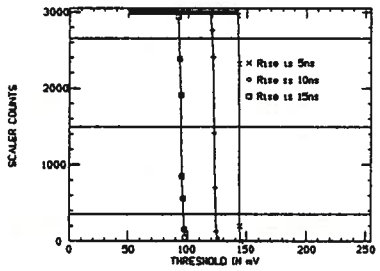

QPA03 0pF 2.25V STEP/40dB ON 4.7pF



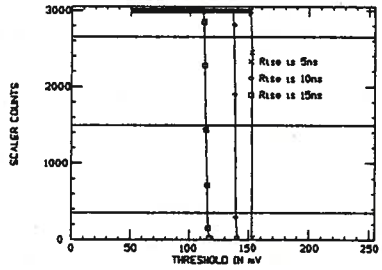

QPA03 0pF 0.60V STEP/40dB ON 4.7pF



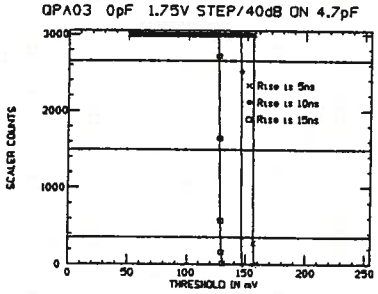

QPA03 0pF 1.20V STEP/40dB ON 4.7pF



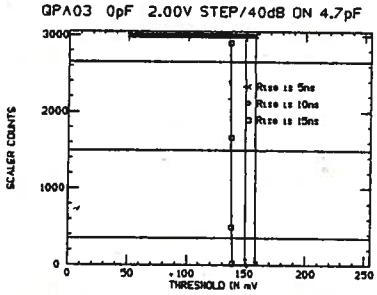

QPA03 0pF 1.50V STEP/40dB ON 4.7pF



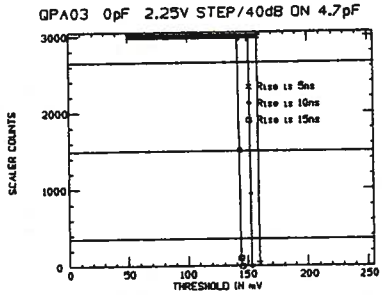

QPA03 0pF 1.75V STEP/40dB ON 4.7pF




QPA03 0pF 2.00V STEP/40dB ON 4.7pF




QPA03 0pF 2.25V STEP/40dB ON 4.7pF

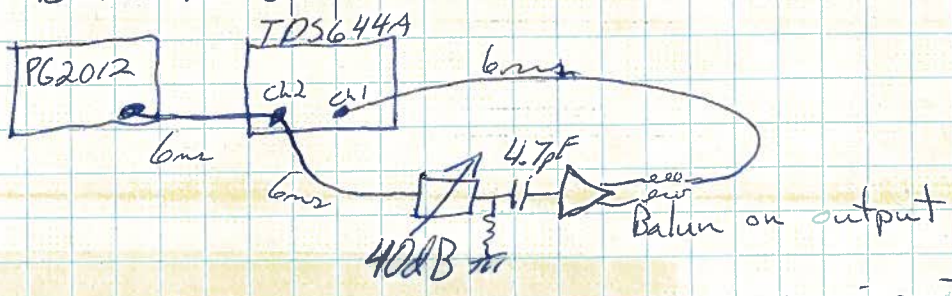


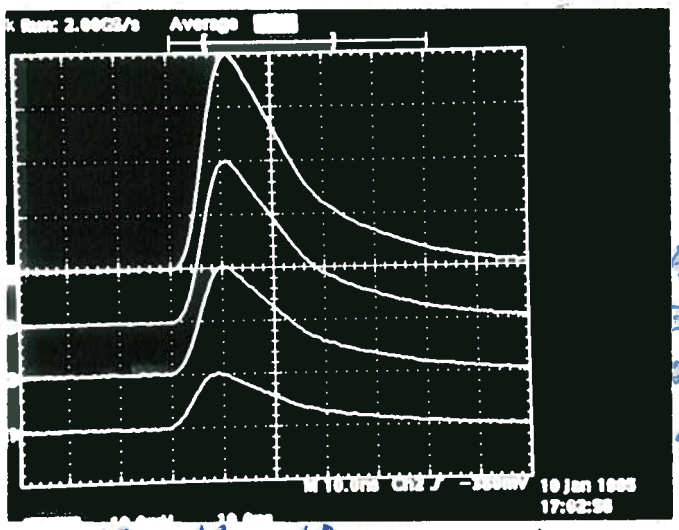

$V_{supply} = 4.09V$

# E711 Preamp Gain

1/10

Fujitsu chip. Amp used at Fermilab PS on various experiments (e.g. E771)
MB43458

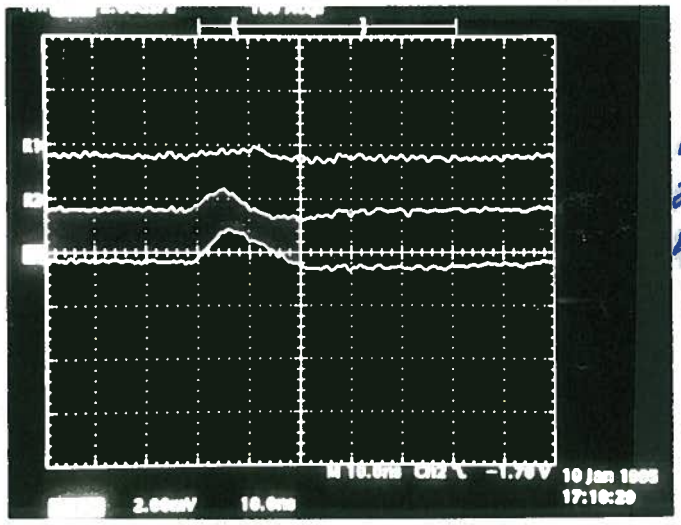



10mV 10ns

or input step voltage
-V

Looking at channel 3 of the preamp




With channel 3 of the preamp driven with a -4V step these are the outputs of channels 1, 2 and 4 of the preamp. Channels are on the same fujitsu chip.

CEBAF
The Continuous Electron Beam Accelerator Facility

# Hall A Prototype VDC Gas Gain Measurements

January 10, 1995

H. Fenker and J. Segal

This report documents results obtained when we measured the gas gain of the Hall A Prototype Vertical Drift Chamber (VDC). The purpose of the measurement was to determine the gain to within about 50% in order to facilitate estimates of the aging rate of the chamber at the required operating voltage. The operating voltage (cathode voltage) required for efficient (or precise) chamber behavior varies with the electronic threshold. Typically the latter is set as low as practical but above the point at which the electronics oscillates. Then the cathode voltage is raised until efficient operation is achieved. If the required cathode voltage is then too high for stable or long term operation of the detector, one must improve the electronic environment (grounding, shielding, etc.) or install improved electronics (a preamplifier, for example).

The gain measurement technique we used was to observe the total charge produced in an avalanche which was initiated by an X-ray from an $^{55}Fe$ source. In the 75/25 $Ar/CO_2$ gas used, the number of ion pairs created by such a 5900 eV X-ray is

| Gas | Ionization Potential | Fraction | Ion Pairs |
|---|---|---|---|
| Argon | 26 eV | 0.75 | 170 |
| $CO_2$ | 33 eV | 0.25 | 45 |
| | | **Total** | 215. |

Thus, if we observed 21,500 electrons we would say the gas gain was 100.

In order to actually observe the charge signal it is necessary to use a low-noise amplifier at the output of the wire chamber. We used a EG&G 142PC preamplifier which is specified to charge sense with a gain of 6.5 V/pC. To check this we constructed the circuit shown in Fig. 1 and measured the preamplifier gain to be 4.8 V/pC. This measurement and the manufacturer's specification agree within our tolerance. At this point we verified certain features of the preamplifier and test circuit as:

- short rise time (~ 30 ns);
- amplifier output linear with attenuator input up to almost 6V at the output;
- output peak voltage insensitive to pulser output width or risetime (<100 ns)
- output returns-to-baseline in about 75 μs, as specified.

The chamber gain can now be measured in a straightforward manner. The signal from one anode wire was coupled directly (via about 10cm of RG59) to the preamplifier input. With an $^{55}Fe$ source illuminating the chamber two bright bands were clearly observed on the oscilloscope. The higher one corresponds to the X-ray peak (5.9 keV), while the lower one is the Argon (photoluminescence) escape peak at about (5.9 - 3.2 = 2.7) keV. Fig. 2 is

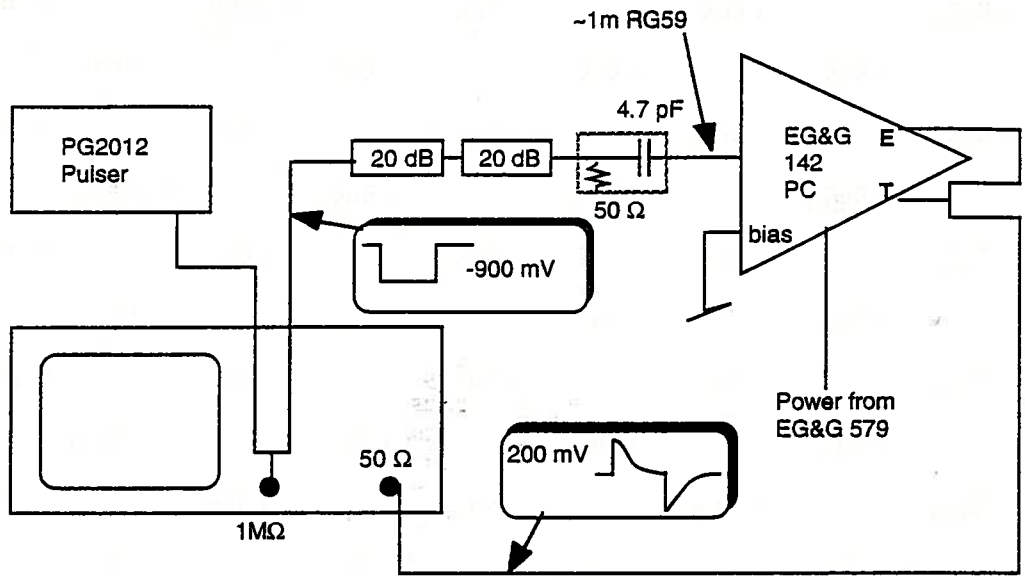



Figure 1. The Circuit Used to Measure the Gain of the 142PC Preamplifier.

a photograph of the QVT spectrum (taken in 'V' mode) from the observation made with $V_{cathode}$ = 3000 V.

Figs. 3a - 3f are 'scope photographs made at the indicated cathode voltages. The middles of the X-ray bands were estimated by eye on these images and the adjustable cursor placed there to facilitate measuring the average peak voltage. The positions thus determined are indicated on the photographs. The measurements are presented in Table 2 and Fig. 4.

| Cathode HV | $V_{peak}$ (mV) | $Q_{meas}$ (fC) | Gas Gain |
|---|---|---|---|
| 2900 | 386 | 80 | 2.5E+3 |
| 3000 | 630 | 131 | 4.1E+3 |
| 3100 | 1020 | 212 | 6.6E+3 |
| 3200 | 1660 | 345 | 10.8E+3 |
| 3250 | 2110 | 439 | 13.7E+3 |
| 3300 | 2880 | 600 | 18.8E+3 |

Table 2. Results of the Output Pulse Observations and Conversion into Wire Chamber Gas Gain for 75/25 Ar/$CO_2$.

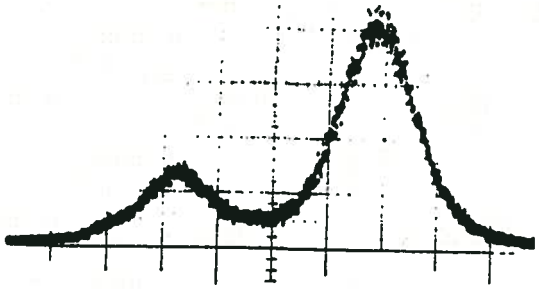


Figure 2. Peak-Voltage Spectrum Obtained with a QVT for $Fe^{55}$ Drift Chamber Pulses with 3000 V on the Cathodes.

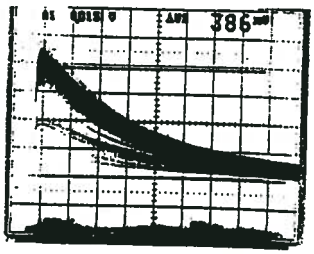



Figure 3a. 2900 V

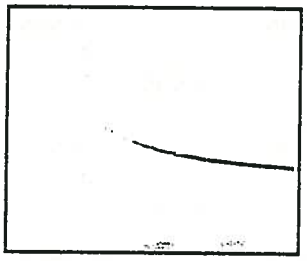


Figure 3b. 3000 V

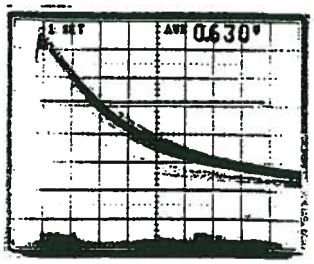



Figure 3c. 3100 V

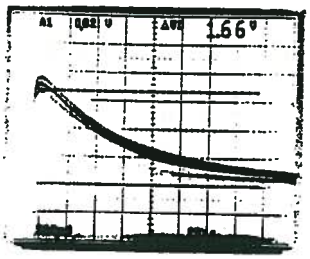
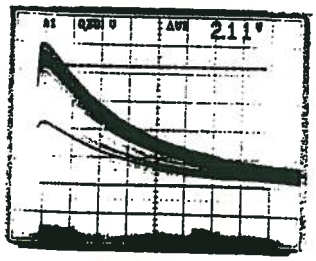



Figure 3d. 3200 V




igure 3e. 3250 V

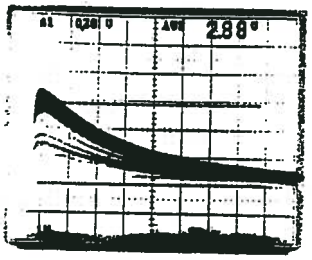
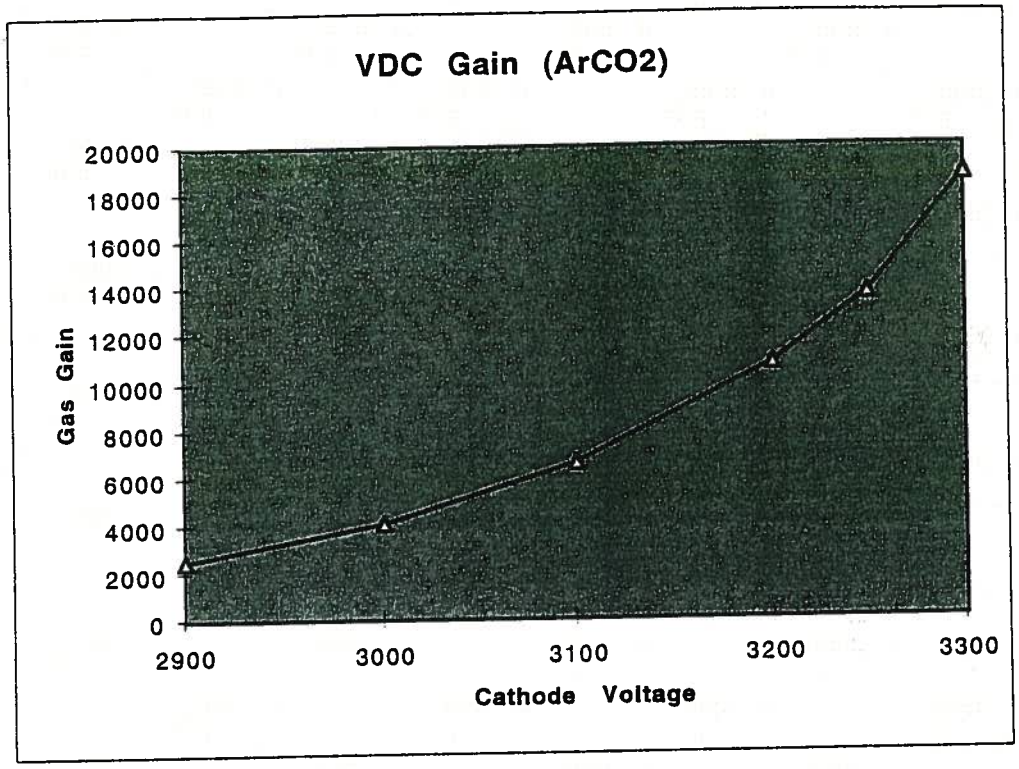



Figure 3f. .3300 V




- Figure 4. VDC Gas Gain as a Function of Cathode Voltage

Measured gain of L42PC preamp

50ns leading edge on steps

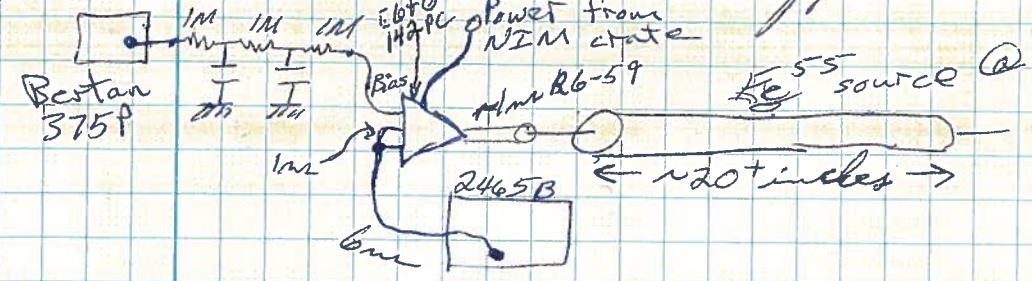
200V step from 40dB on 4.7pF = 42fC

~4 div × 50mV/div ≅ 200mV peak output

⇒ 4.8V/pC

42fC × 6.5mV/fC ≅ 273mV (close)

# 1/14 FPP Straw Tube Prototype Gas Gain




~½" $H_2O$ back pressure

Ioniz. Pot. for Ethane ($C_2H_6$) ~~11.6eV~~ 24eV (average)


Ar/Eth 62/38% 1400V

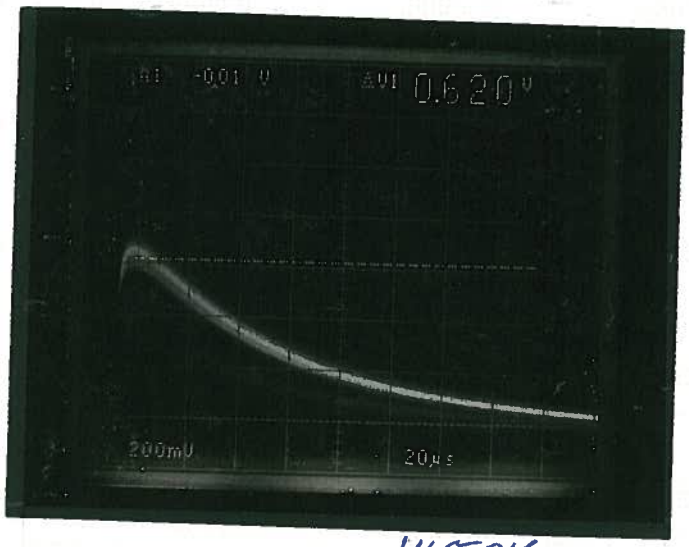
From Ar/$CO_2$

~~43V~~ .385

~~27fC~~ 80fC

~~G = 2.3 × 10³~~ ← From Ar/$CO_2$

$G = 2.1 \times 10^3$




1450V

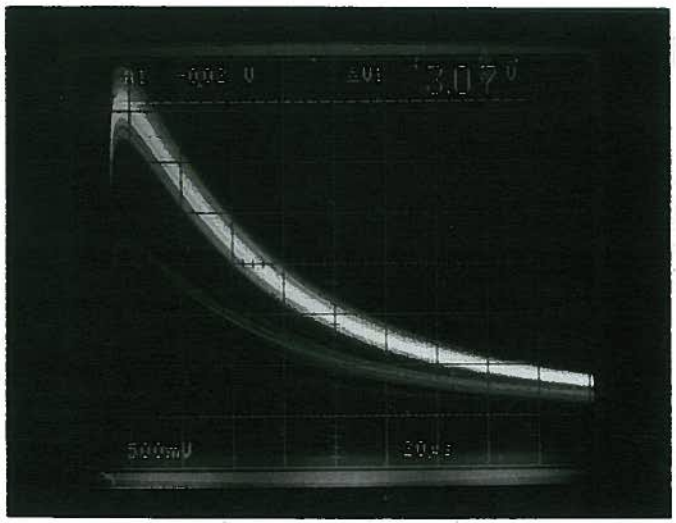
129fC

~~G = 3.8 × 10³~~

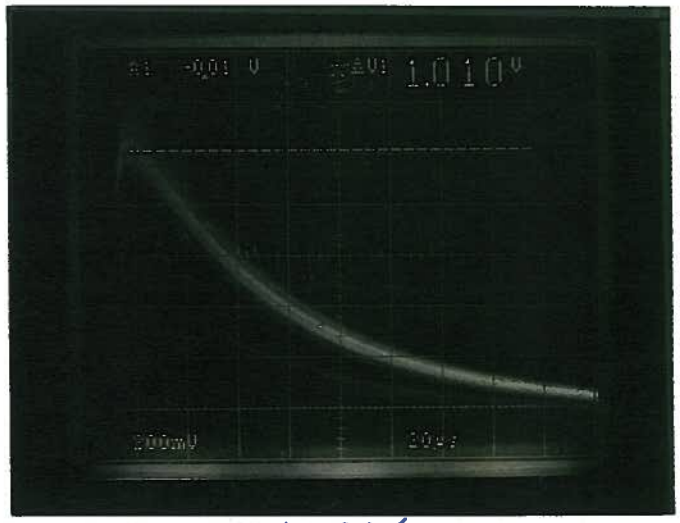
$G = 3.4 \times 10^3$

640fC

~~G=1.9x10^4~~
G=1.7x10^4




1600V



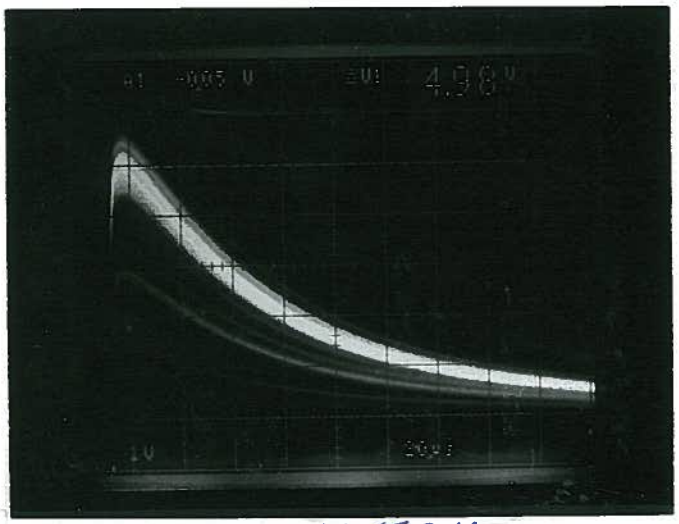

1500V

210fC

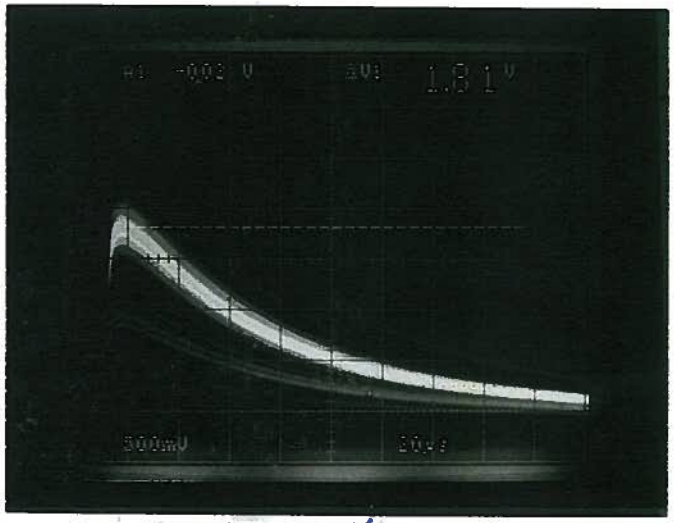
~~G=6.1x10^3~~
G=5.6x10^3

1038fC

~~G=3x10^4~~
G=2.7x10^4




1650V



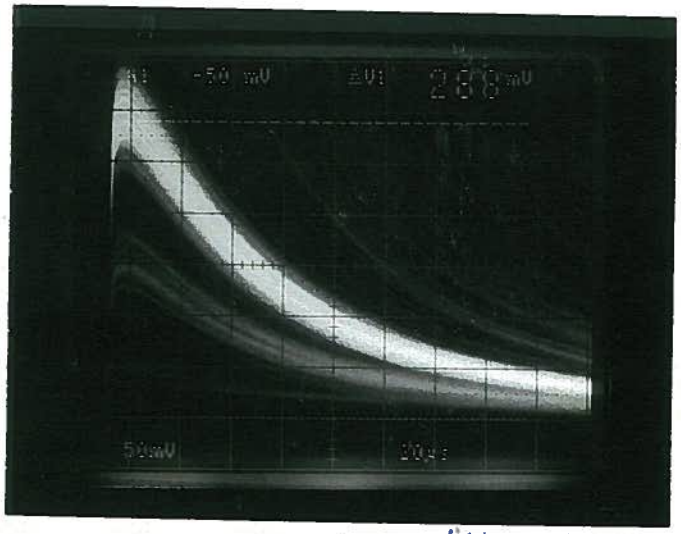

1550V

377fC

~~G=1.1x10^4~~
G=7.4x10^3

60fC

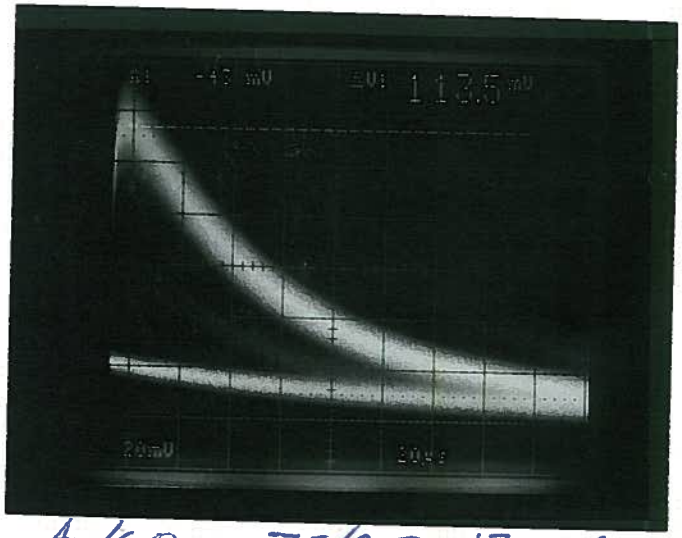
$G = 1.7 \times 10^3$




1400V

24fC

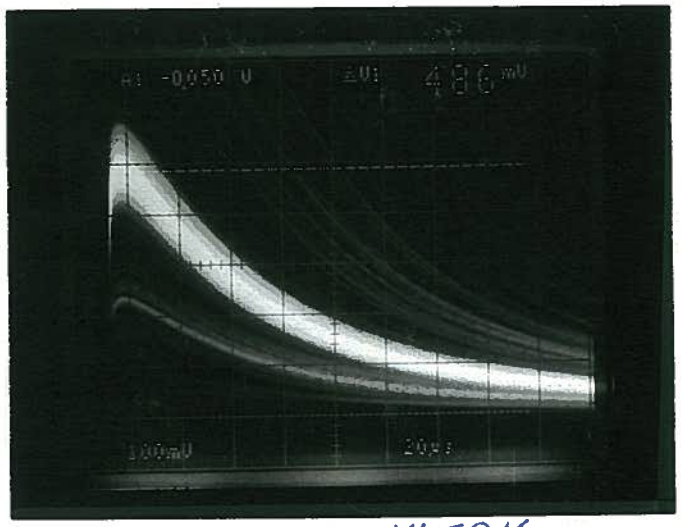
$G = 7 \times 10^2$




Ar/$CO_2$ 75/25 1300V

101fC

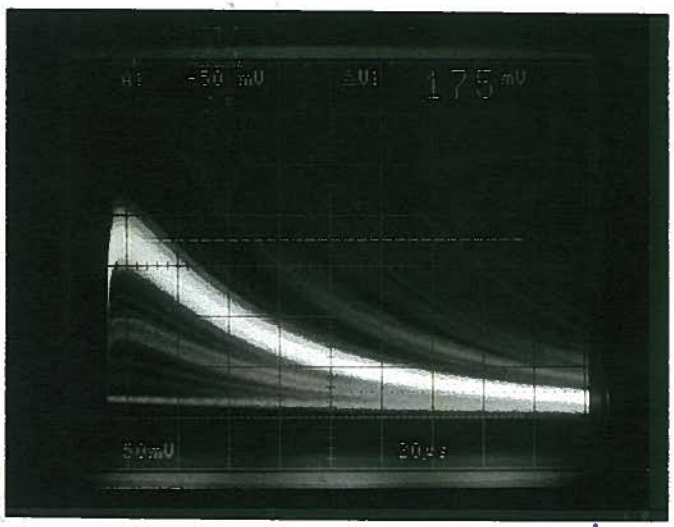
$G = 2.9 \times 10^3$




1450V

36fC

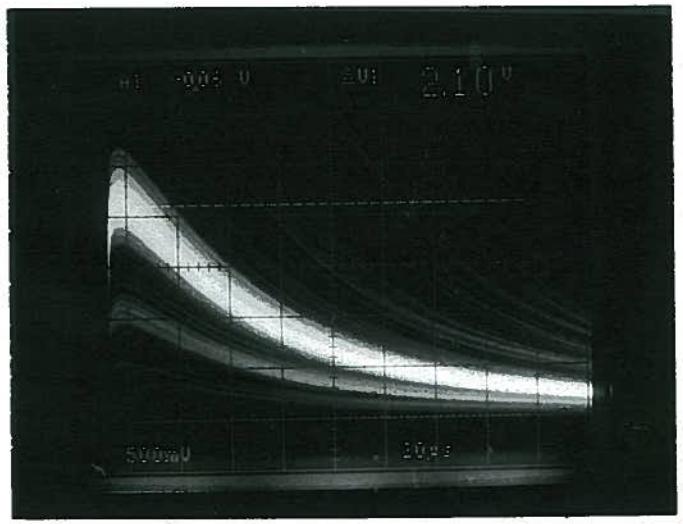
$G = 1 \times 10^3$




1350V

438 fC

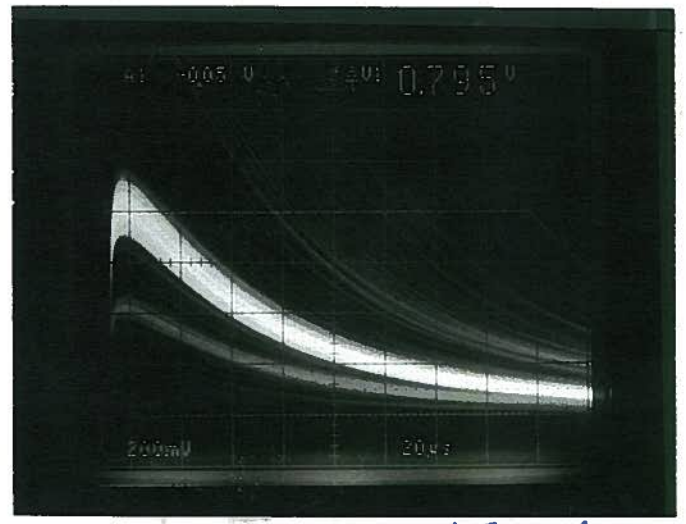
$G = 1.3 \times 10^4$




1600 V

166 fC

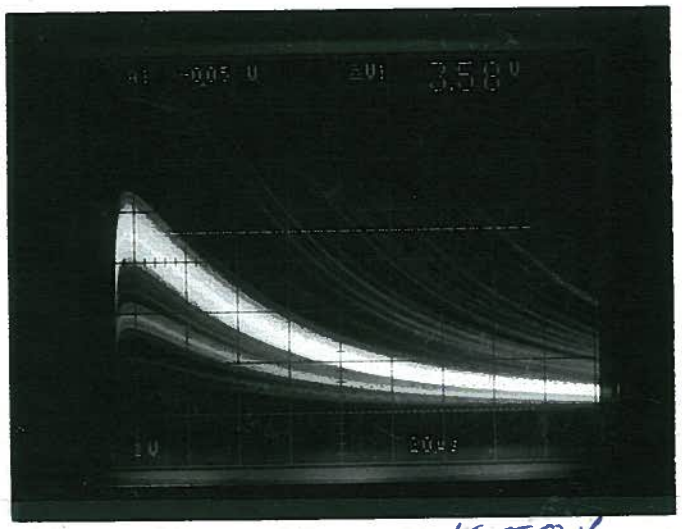
$G = 4.8 \times 10^{-3}$




1500 V

746 fC

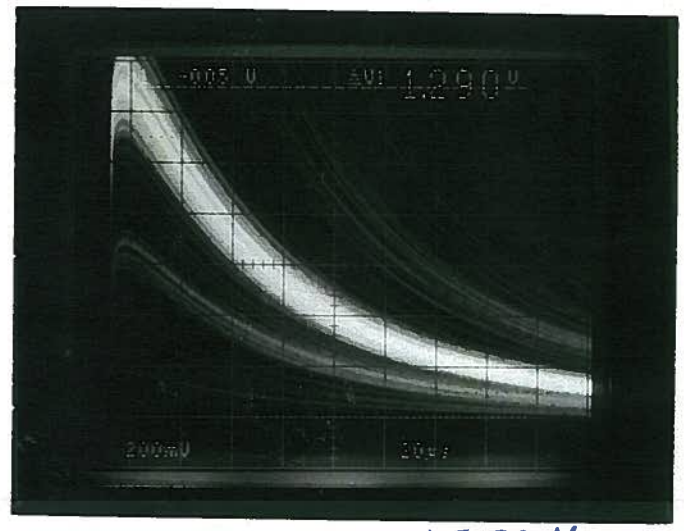
$G = 2.2 \times 10^4$



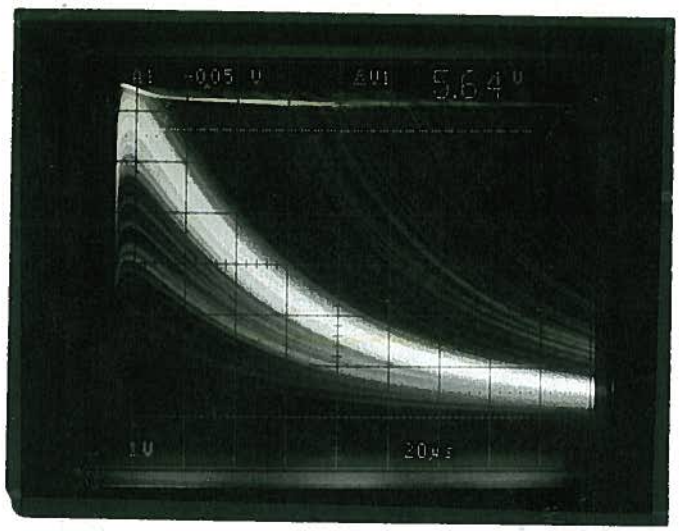

1650 V

269 fC

$G = 7.8 \times 10^{-3}$




1550 V




1700V

1175 fC

$G = 3.4 \times 10^4$

For Ar/Eth 62/38

Assuming 62% of interactions are with Ar and 38% are with Eth

if $x$ = total ion pairs produced

average energy for ion pair production is for

Ar = 26 eV

Eth = 24 eV

$CO_2$ = 33 eV

$(.62x)(26\,eV) + (.38x)(24\,eV) = 5900\,eV$ for $Fe^{55}$

$x = \frac{5900}{16.12 + 9.12}$

$\cong 234$ ion pairs

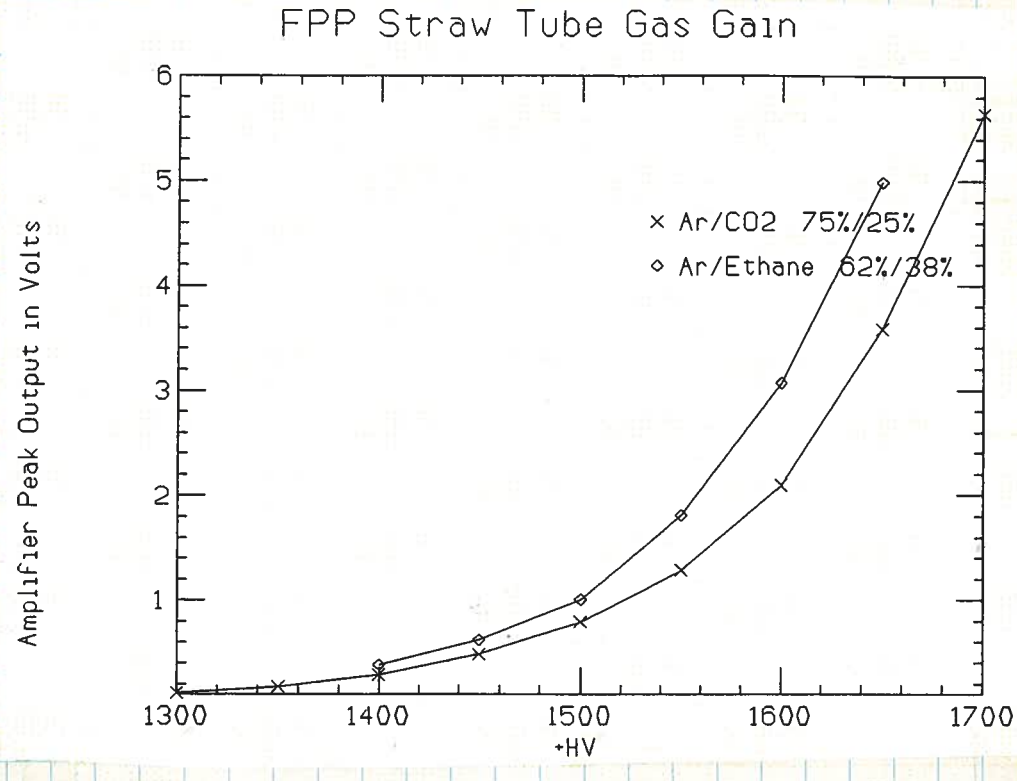
for Ar/$CO_2$ 75/25

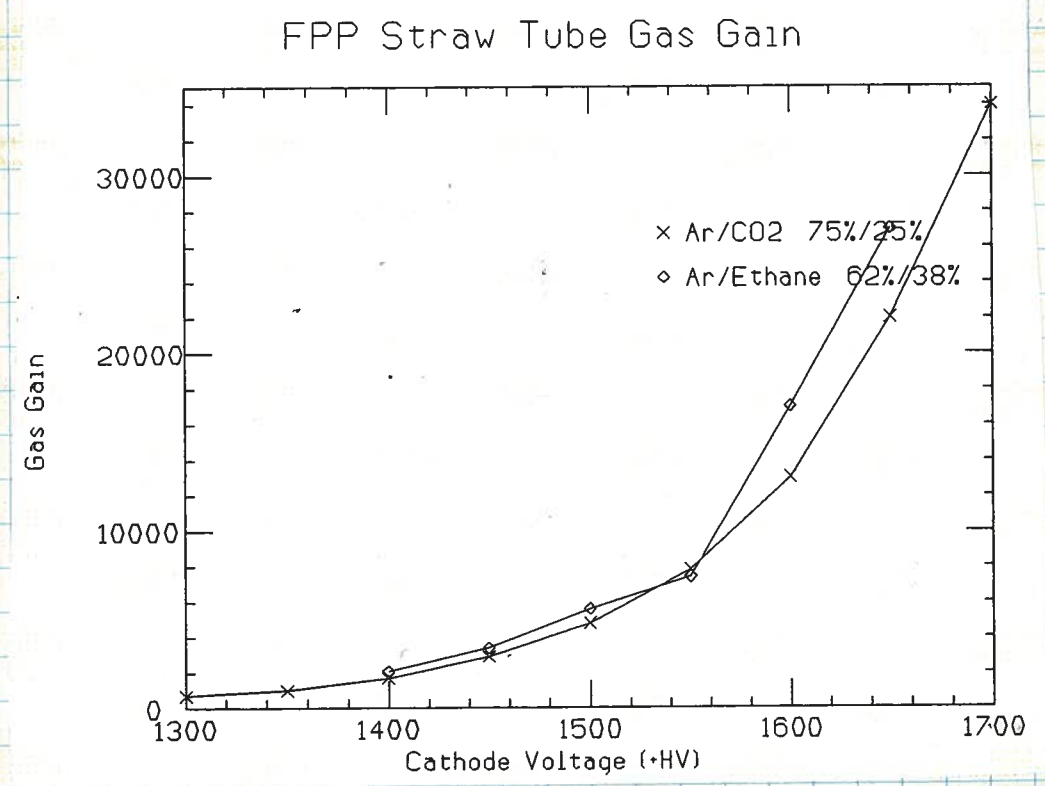
$(.75x)(26\,eV) + (.25x)(33\,eV) = 5900\,eV$

$x = \frac{5900}{19.5 + 8.25}$

$\cong 213$ ion pairs (Howard got 215 on p. 46)

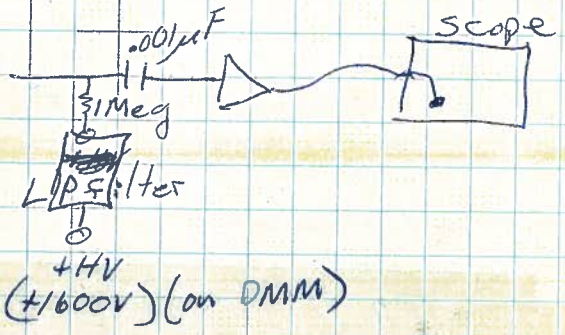
I used 215 for G calculation


FPP Straw Tube Gas Gain
Amplifier Peak Output in Volts
6
5
4
3
2
1
1300
1400
1500
1600
1700
+HV
× Ar/CO2 75%/25%
◇ Ar/Ethane 62%/38%

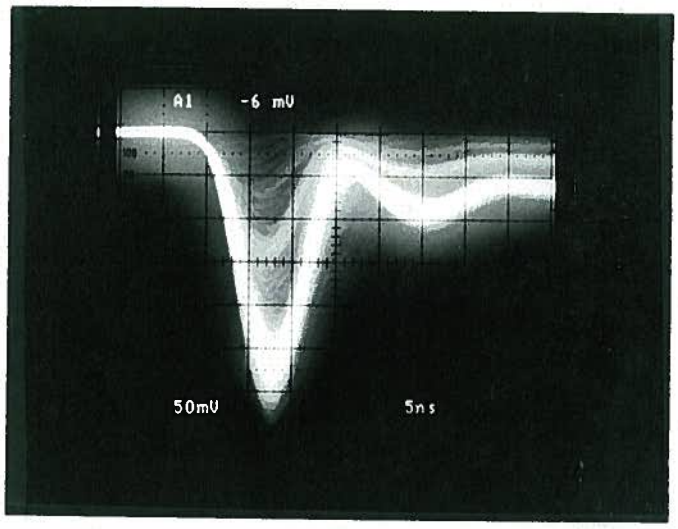

FPP Straw Tube Gas Gain
Gas Gain
30000
20000
10000
0
1300
1400
1500
1600
1700
Cathode Voltage (+HV)
× Ar/CO2 75%/25%
◇ Ar/Ethane 62%/38%

1/28 Tektronix TDS 744A Demonstration

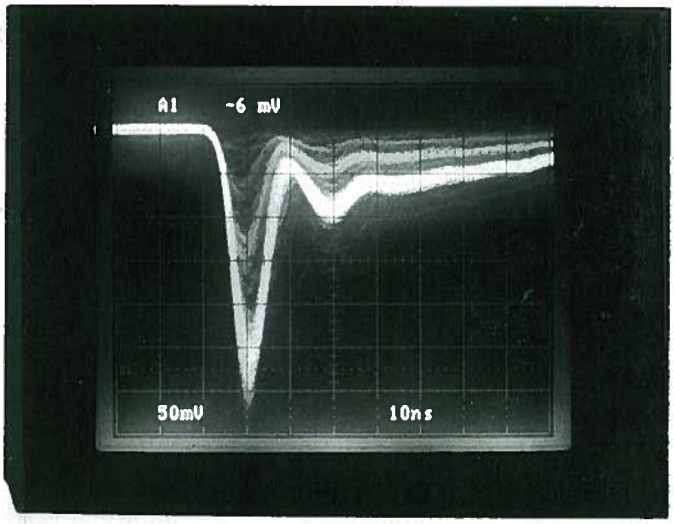
The TDS 744A is used to look at one of the FPP straw tubes with A/EHL 62/388 and the 322750IC amplifier




Substrate bootstrap is removed!

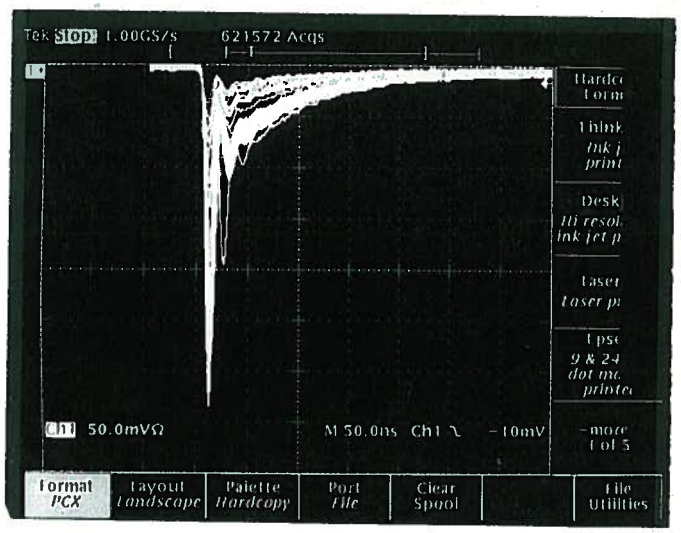



2465B scope
$Fe^{55}$ on chamber

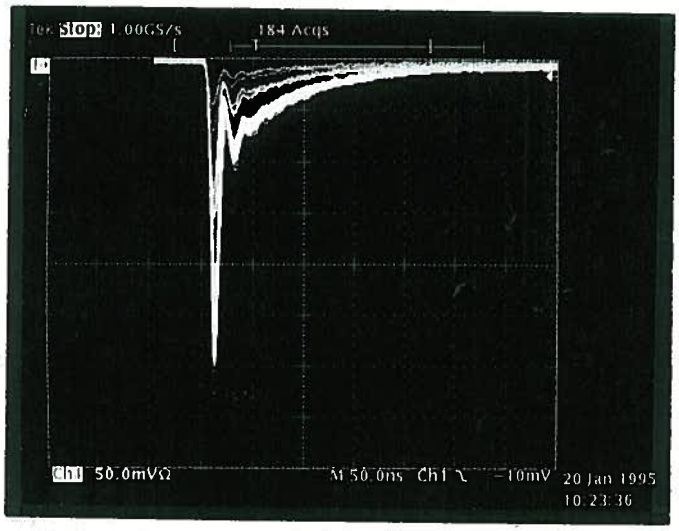



same as above

Looking at the chamber output with the TDS744A. It is possible to see rate variations as the $Fe^{55}$ source is waved over the chamber. See pictures below. Both were taken at a fairly low rate. At higher rates the traces tend to washout. Shortest persistence time is 250ms. Perhaps a shorter persistence and more "grey scaling" would improve the display.




TDS 744A
$Fe^{55}$ on chamber
Shows tendency to "washout"




One of the better shots.
Same setup as above photo

1/30 VDC Crosstalk - A Quick Look

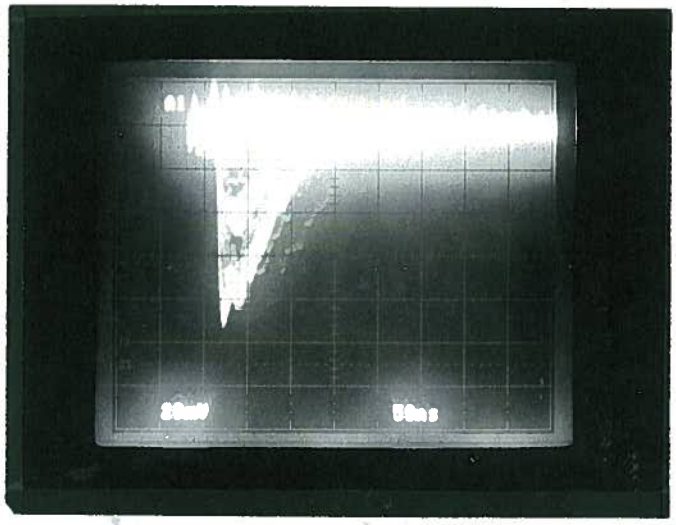
1/4 Doing ~1/23

Looking at VDC with $Fe^{55}$. Ar/$CO_2$ 75/25 (welding grade)

Using UVA-QPA03 preamp.

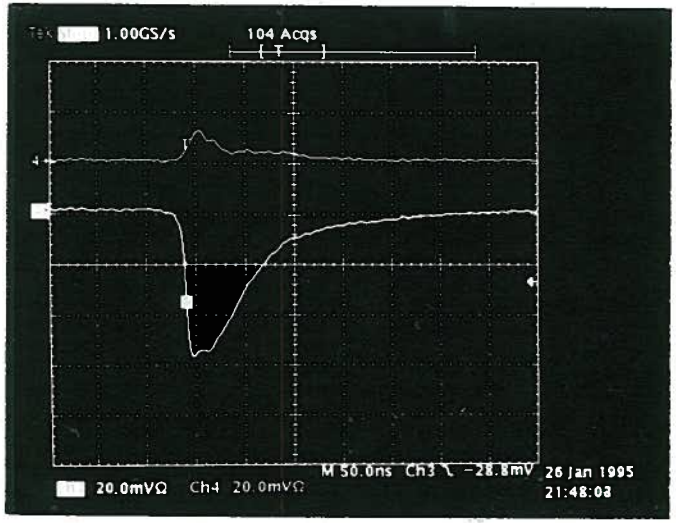
Gain adjusted so amp is not saturating. Set to 3500V on both cathodes. Afterwards I checked and found they were at 3600V!

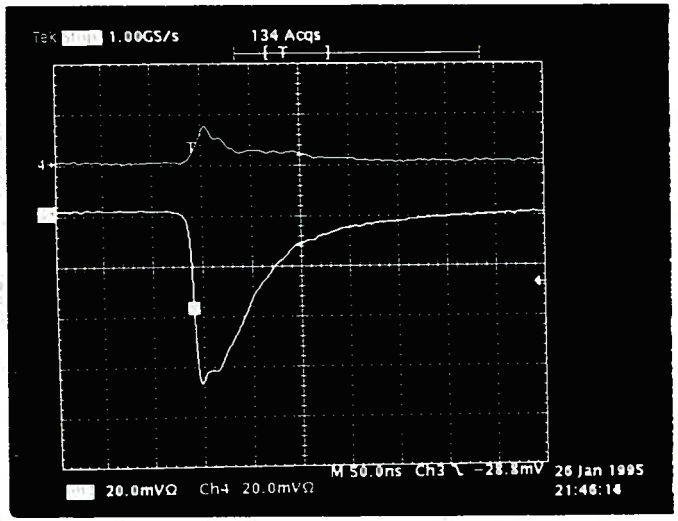
Output of amp, through a balun and 6 m of RG174. Single core balun on Ch.3. Small copper pipe, 2 cork balun on ch.3.

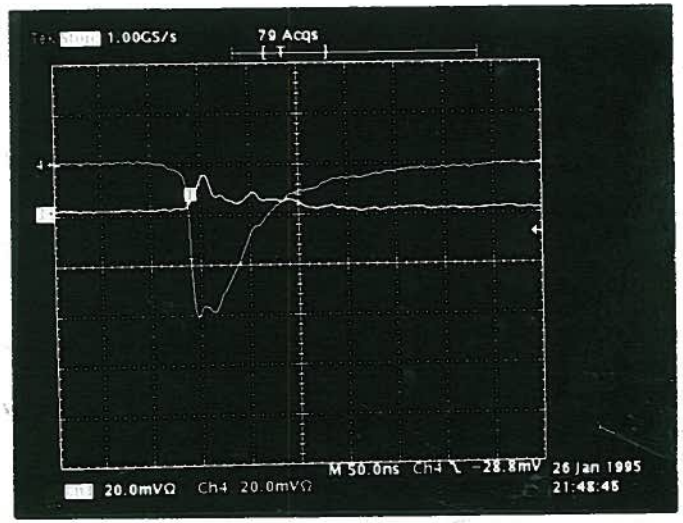


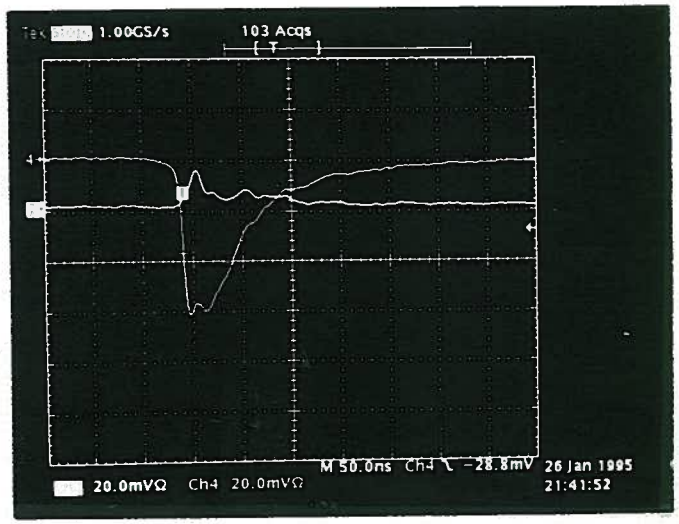

Checked on the 2467B to verify polarity of signal.

The TDS6444 is set to average 64 traces. The Channels 3 & 4 are of adjacent wires. Taken from 2 different sets of 2 wires (in same set of 16 wires). 2 different QPA03 chips. One each time.


1.00GS/s
104 Acqs
M 50.0ns Ch3 ∖ -28.8mV
26 Jan 1995
21:48:03
20.0mVΩ Ch4 20.0mVΩ

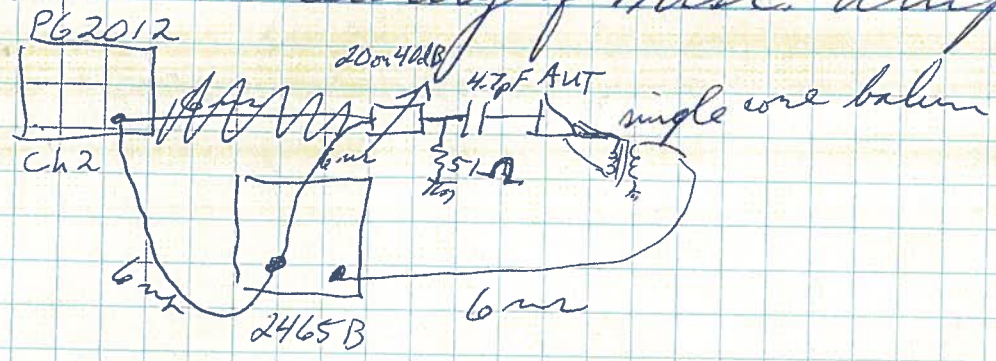

1.00GS/s
134 Acqs
M 50.0ns Ch3 ∖ -28.8mV
26 Jan 1995
21:46:14
20.0mVΩ Ch4 20.0mVΩ


1.00GS/s
79 Acqs
M 50.0ns Ch4 ∖ -28.8mV
26 Jan 1995
21:48:45
20.0mVΩ Ch4 20.0mVΩ


1.00GS/s
103 Acqs
M 50.0ns Ch4 ∖ -28.8mV
26 Jan 1995
21:41:52
20.0mVΩ Ch4 20.0mVΩ

1/30

# Gain Linearity of Misc. Amps

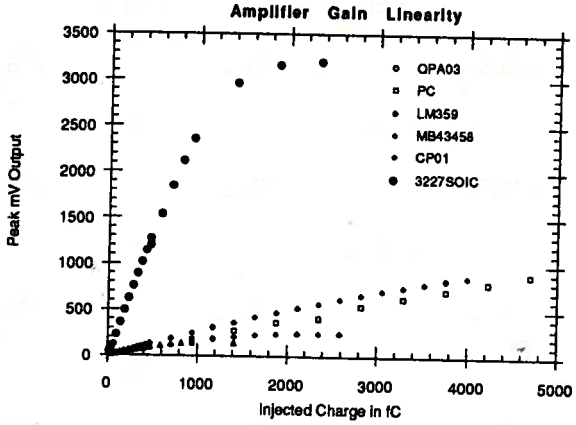


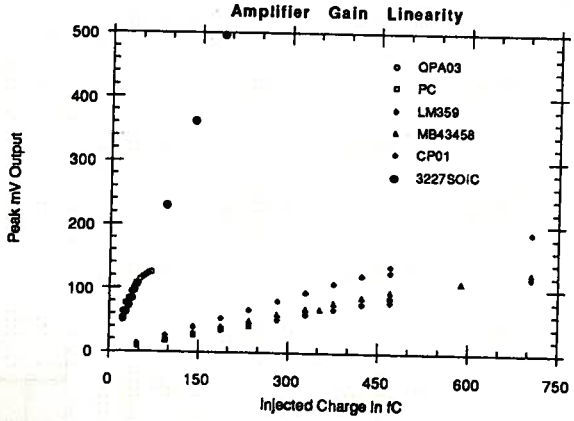
Pulse step size is varied and attenuation is also varied.

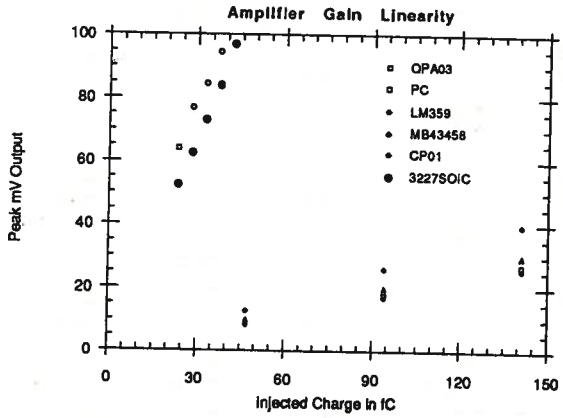
Just for reference →

OPA03 1V step 40dB 3.5V supply

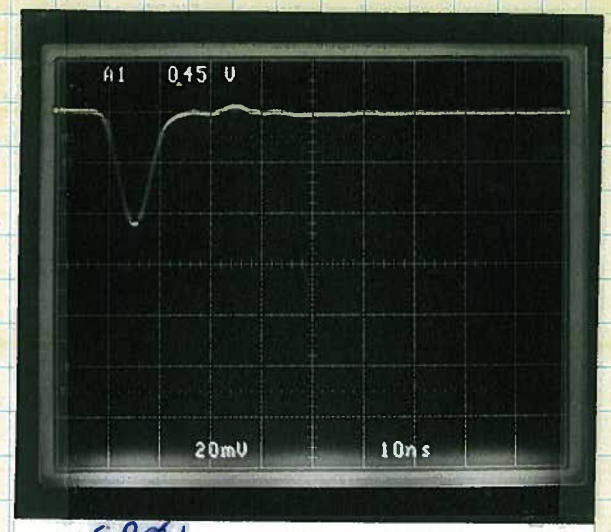
Summary of results – all 3 plots are of same data set.



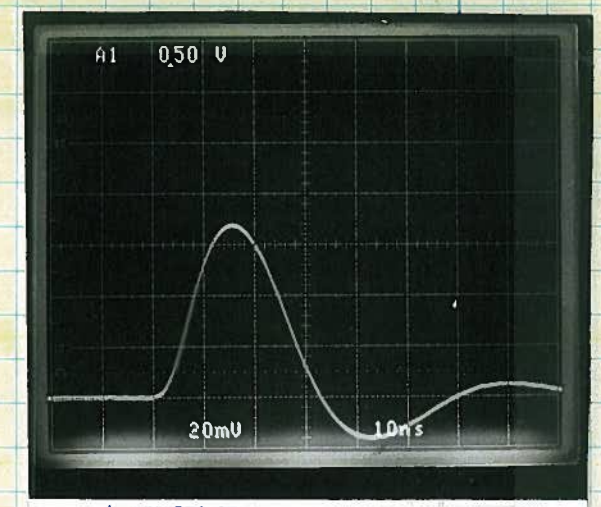




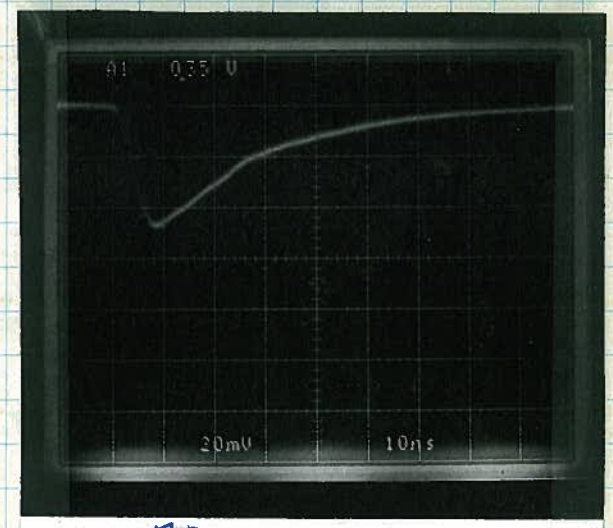
Amp responses to 5V step 40dB



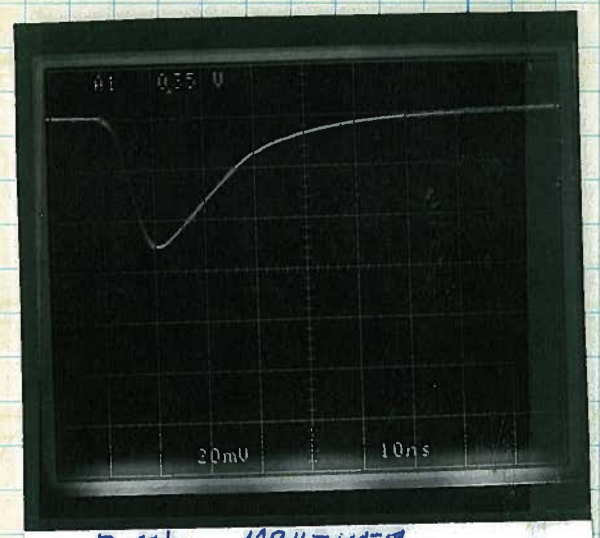

CPØ1



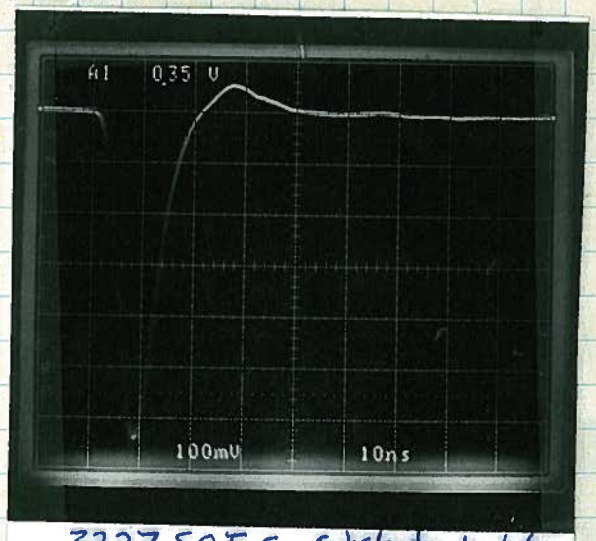

LM359



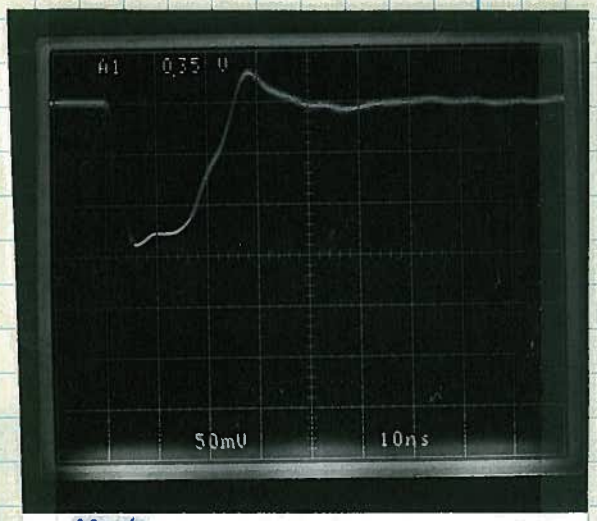

PC.



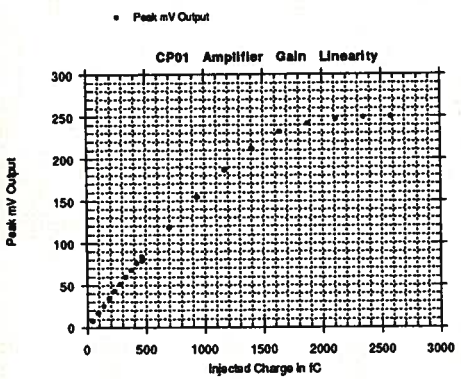

Fujitsu MB43458

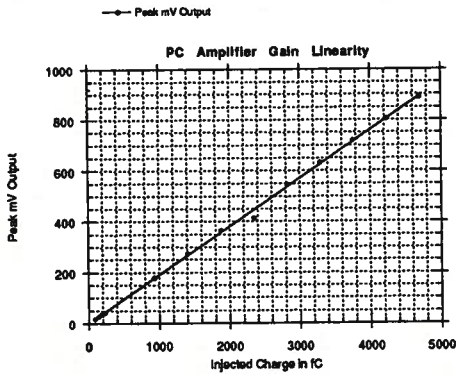


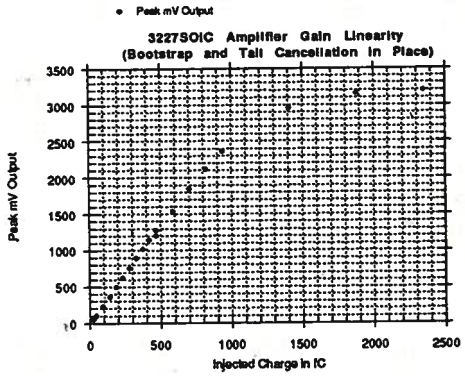

3227 SOIC substrate bootstrap

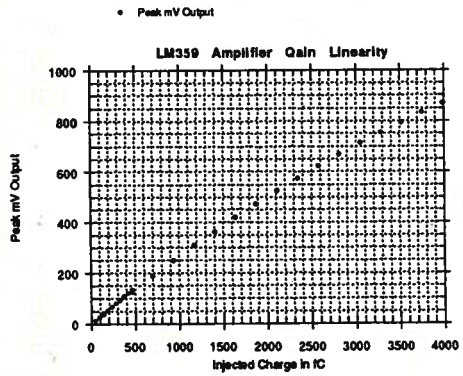


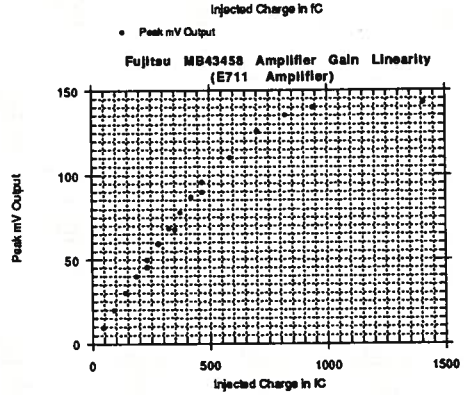

QPAØ3

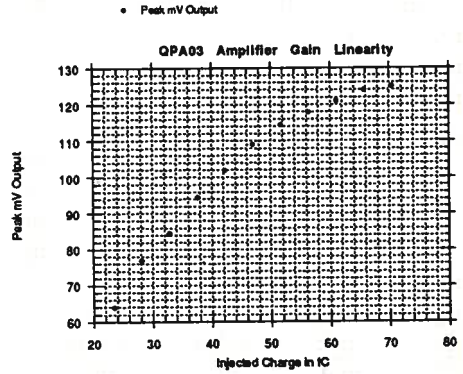

Peak mV Output
CP01 Amplifier Gain Linearity
Peak mV Output
Injected Charge in fC


Peak mV Output
PC Amplifier Gain Linearity
Peak mV Output
Injected Charge in fC


Peak mV Output
3227SOIC Amplifier Gain Linearity
(Bootstrap and Tail Cancellation in Place)
Peak mV Output
Injected Charge in fC


Peak mV Output
LM359 Amplifier Gain Linearity
Peak mV Output
Injected Charge in fC


Peak mV Output
Fujitsu MB43458 Amplifier Gain Linearity
(E711 Amplifier)
Peak mV Output
Injected Charge in fC


Peak mV Output
QPA03 Amplifier Gain Linearity
Peak mV Output
Injected Charge in fC

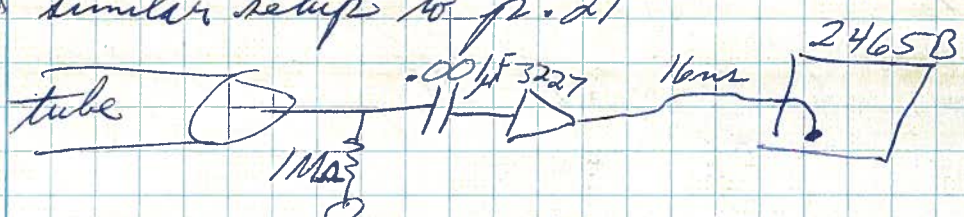
# 3227 50IC & FPP Straw Tube

2/1

JS

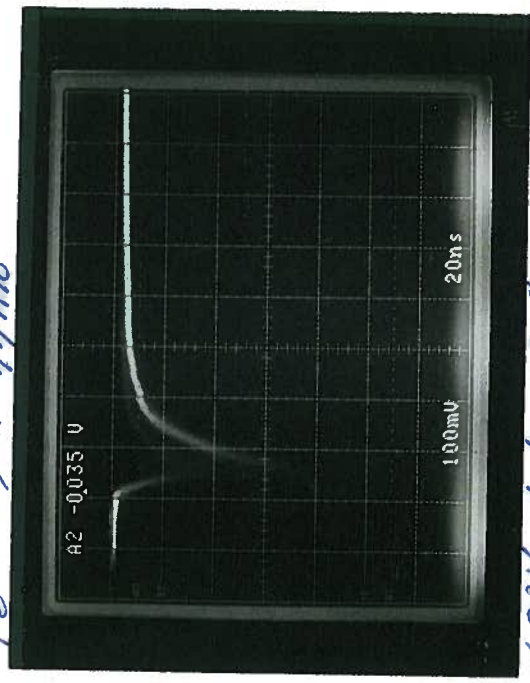
Source in midpoint of tube.

similar setup to p. 21



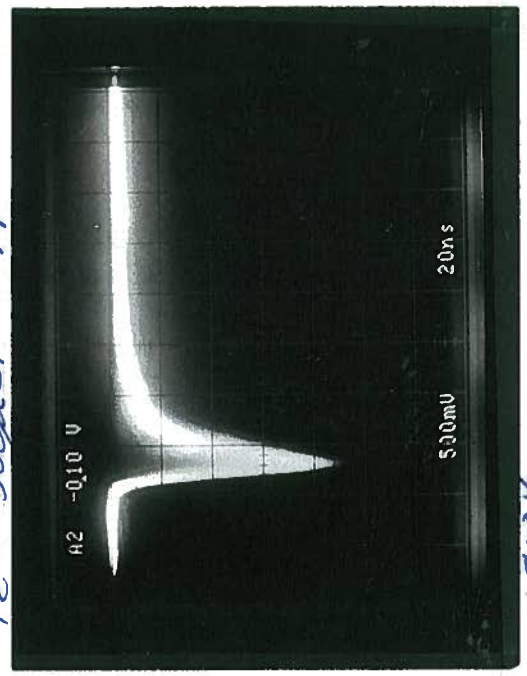

Ar/$CO_2$ 75/25

+HV (HV filter used from p. 50)



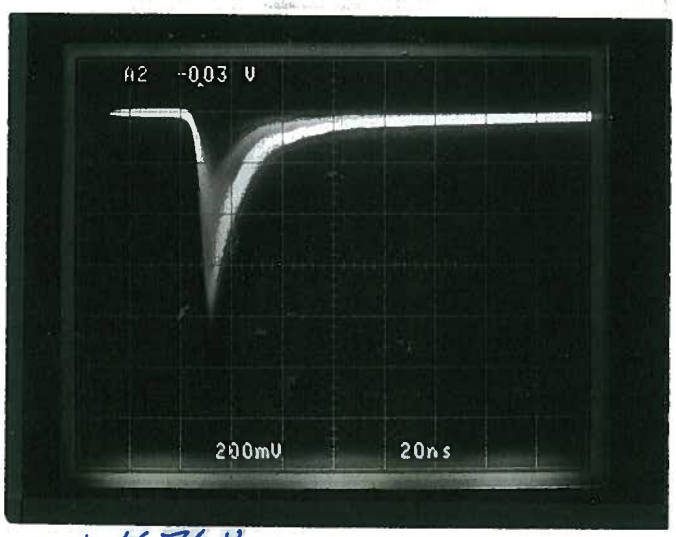

Fe 55 100μCi 4/1/1990

1600V Ar/$CO_2$ 75/25 3227 50IC



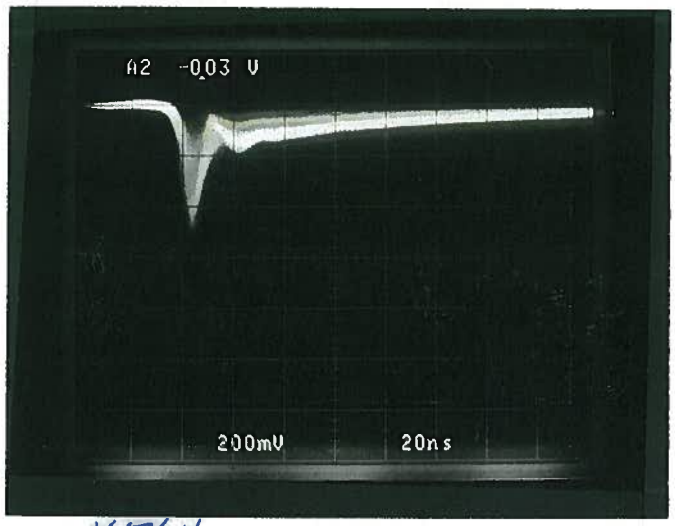

Fe 55 500μCi 1994

1800V

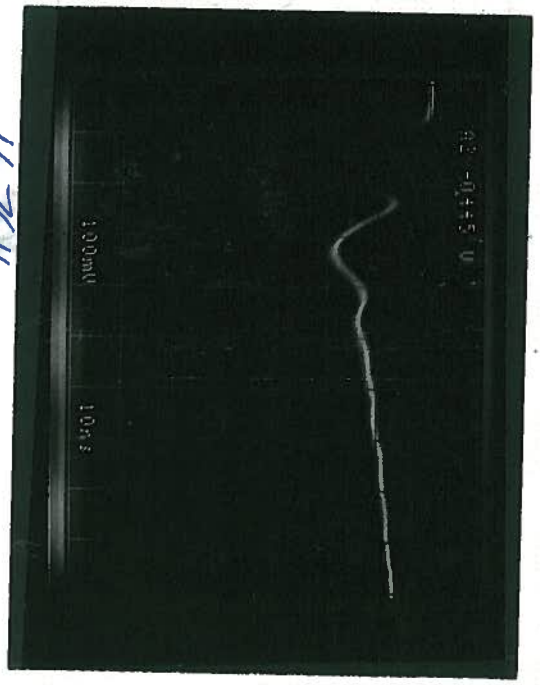



+1676V

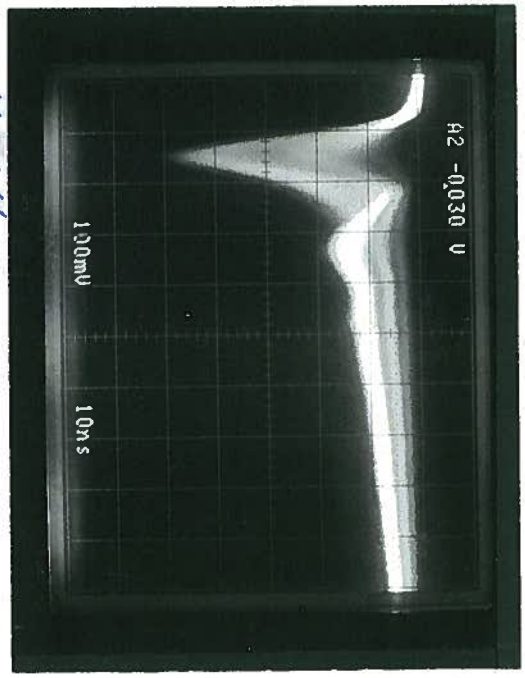
The feedback capacitor to "bootstrap" the substrate is reversed. All three photos are of the same thing. Just different scales. Compare with photos on p. 23 of this book.




16761



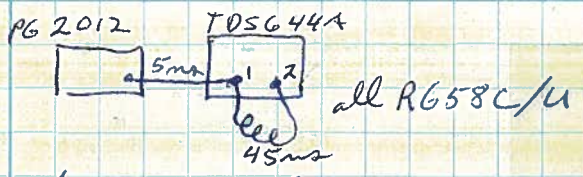

16761



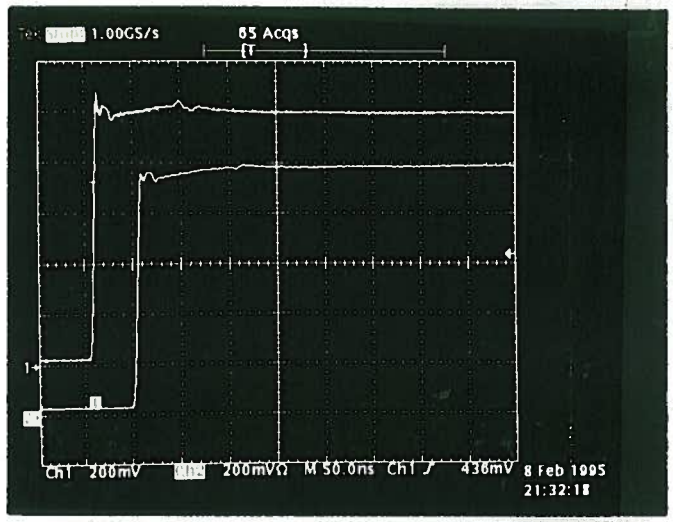

16761

# Patch Panel Evaluation

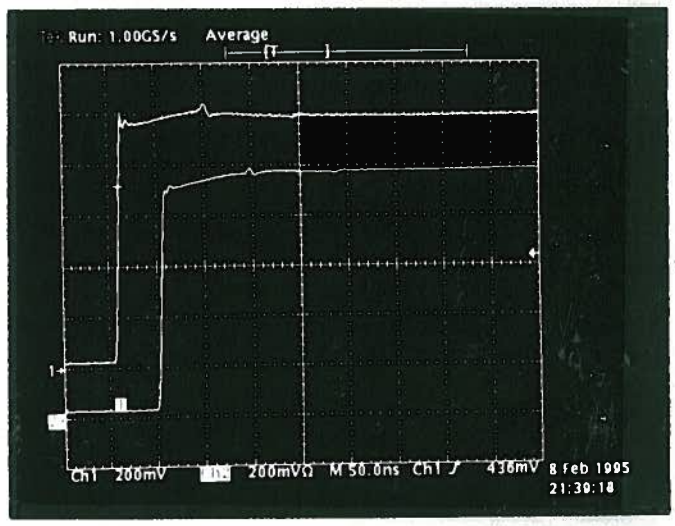
2/8/95

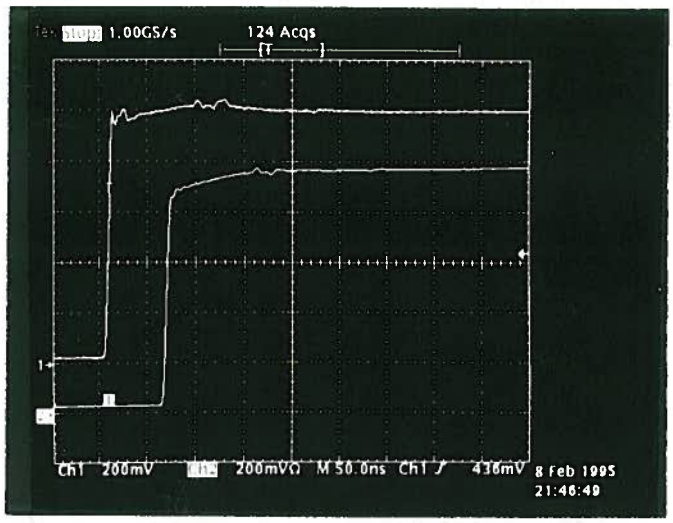


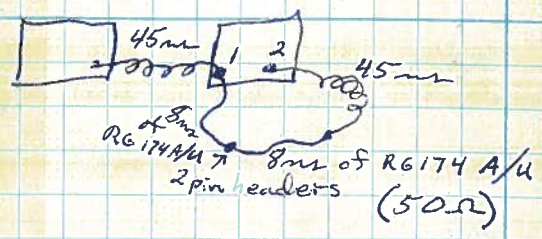

Using Ch2 of PG2012
5ns risetime
width = 2000ns
1 Volt step

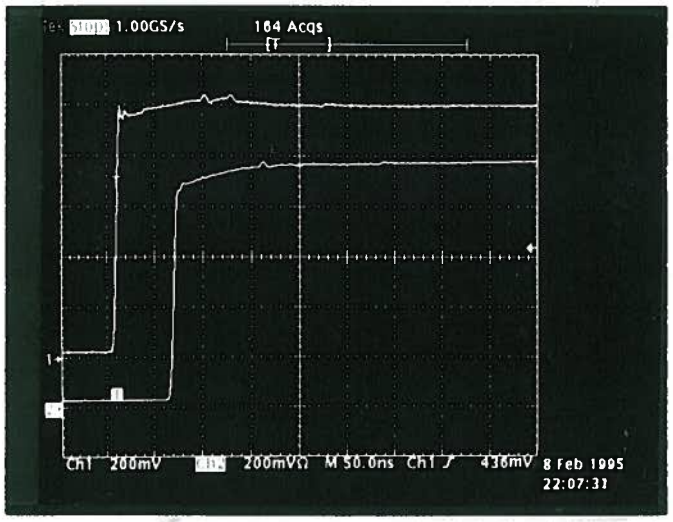



5ns replaced with another 45ns of RG58C/U

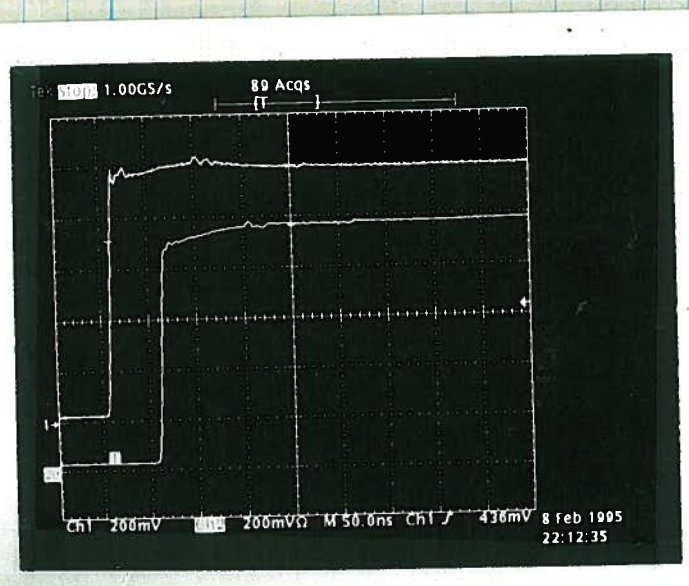


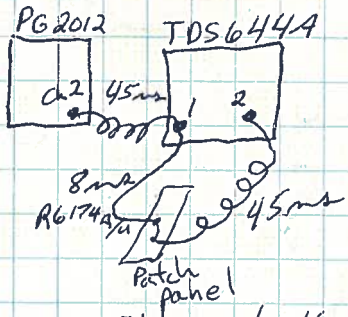


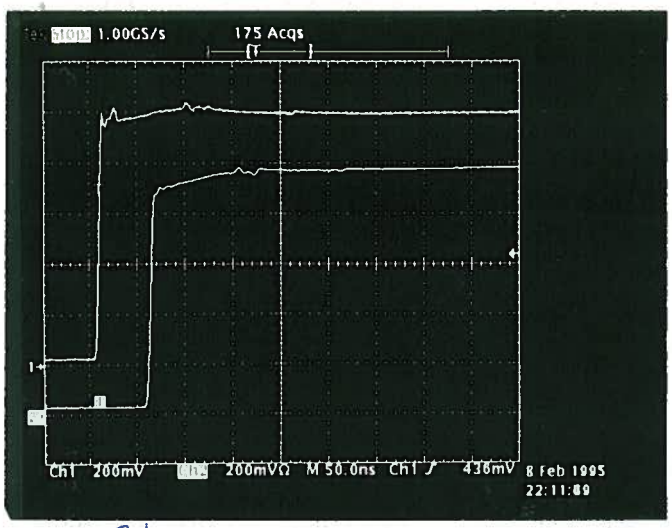







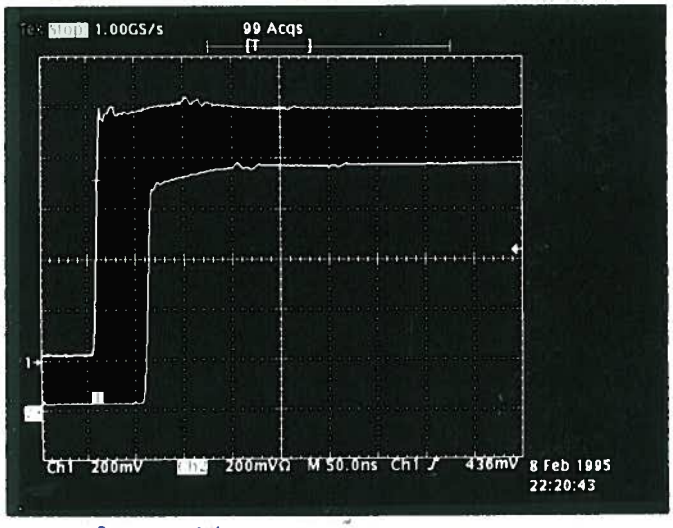




Channel 16
(best case channel)
Simple 2 layer patch panel board




Ch 12

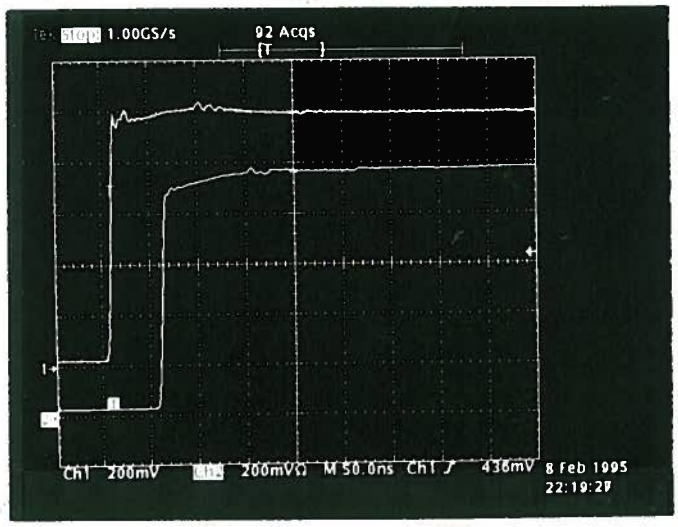
Same as previous photo.
Ch 12 (worst case channel)




Det Ch 15

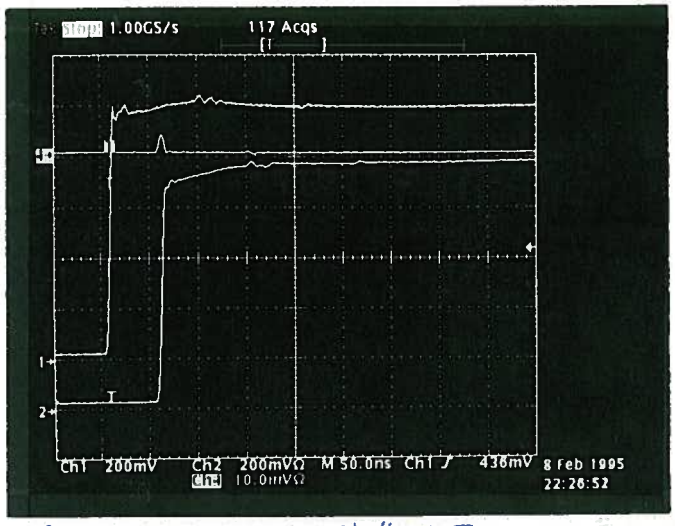
Same setup except this is detector group's multilayer patch panel board.

Ch 15 is best case channel

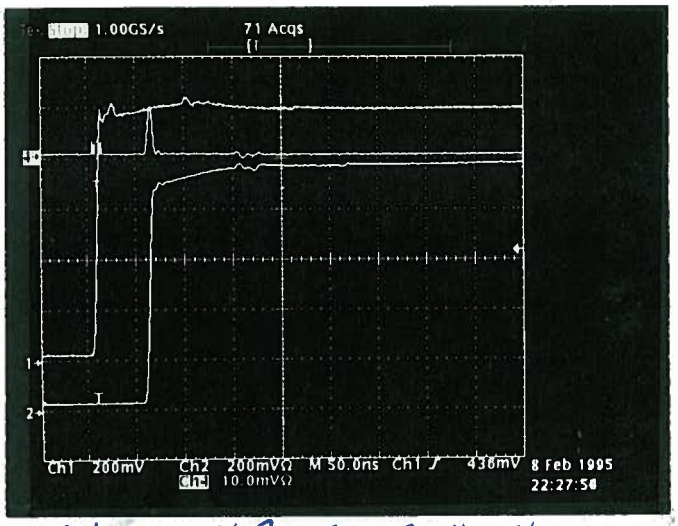



Det Ch 16

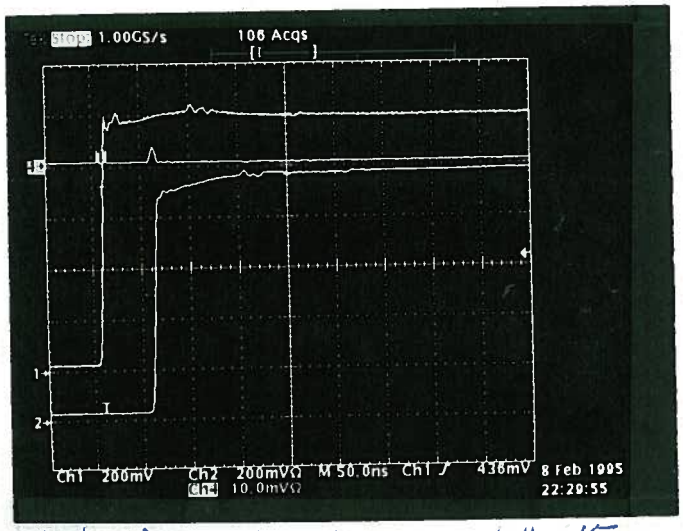
Same as above
Ch 16 is worst case channel



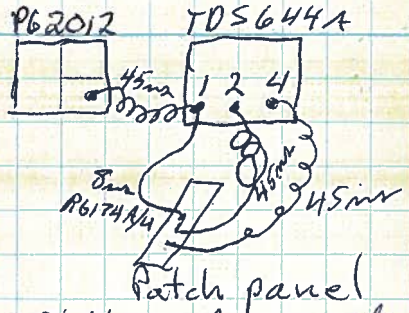

2 layer Ch2=16 Ch4=15




2 layer Ch2=12 Ch4=11




Det. Drive 16 Ch2=16 Ch4=15




Ch4 is adjacent channel off patch panel. Next to driven channel.

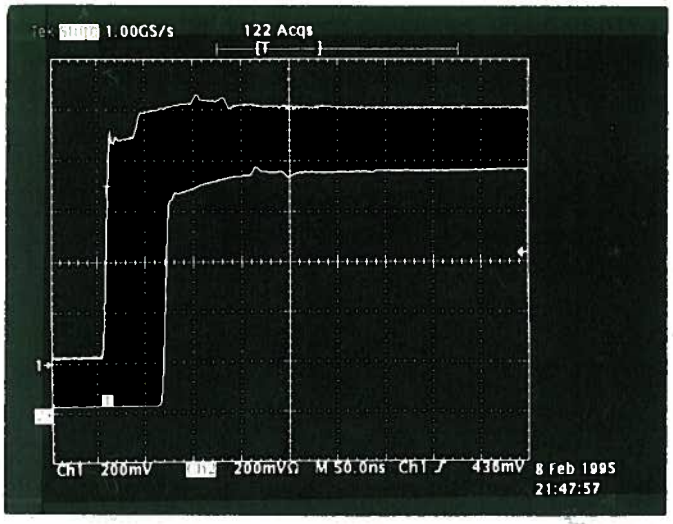
Best case channel

Same as above except worst case channel

Also some tiny bit of x-talk on channel 14! Ok, very tiny, but still... ~1mV even if 13 is terminated with 50Ω.

Same as above except detector grounds patch panel. Best case channel.

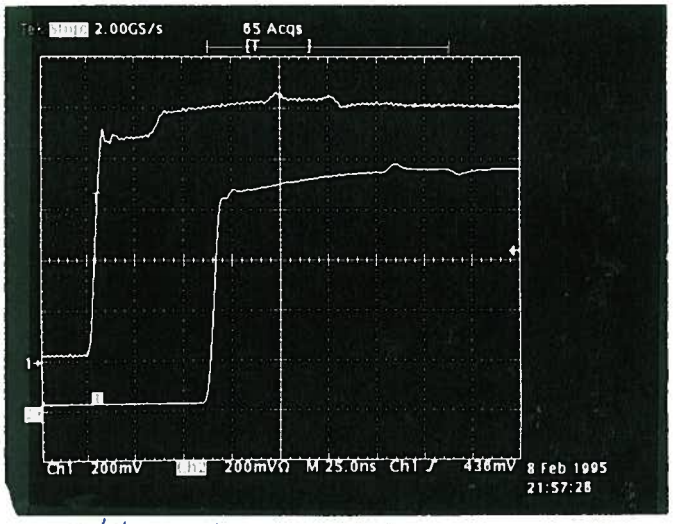
A quick check of all channels seem similar.




While doing the second photo on p. 66 I found an anomalous RG174 cable. Labeled "2"

Same setup as middle photo on p. 66

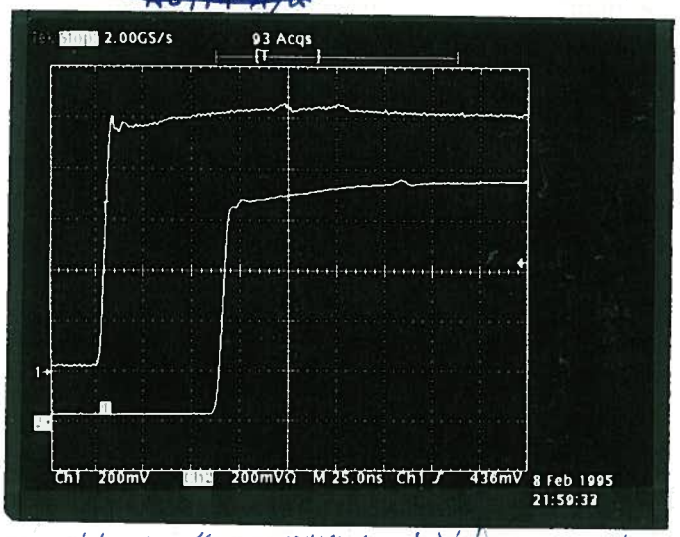
cable shows M17/119-RG174 in yellowish lettering




cable "2"

Same as above except expanded time scale

~~RG174 A/U~~

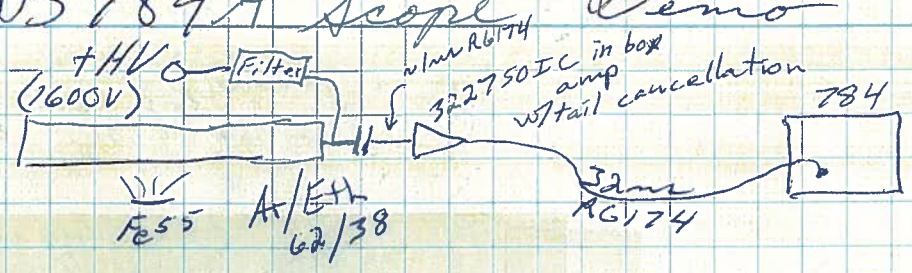


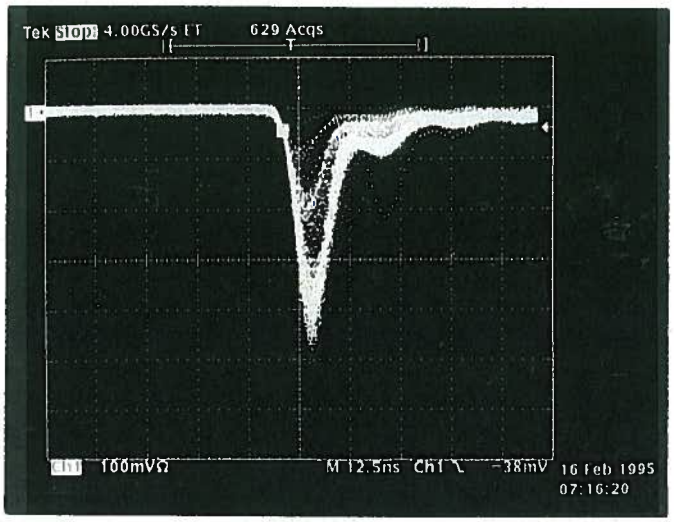

cable "6" "4" & unlabeled are similar

Cable "6" shows M17/119-RG174 in white lettering

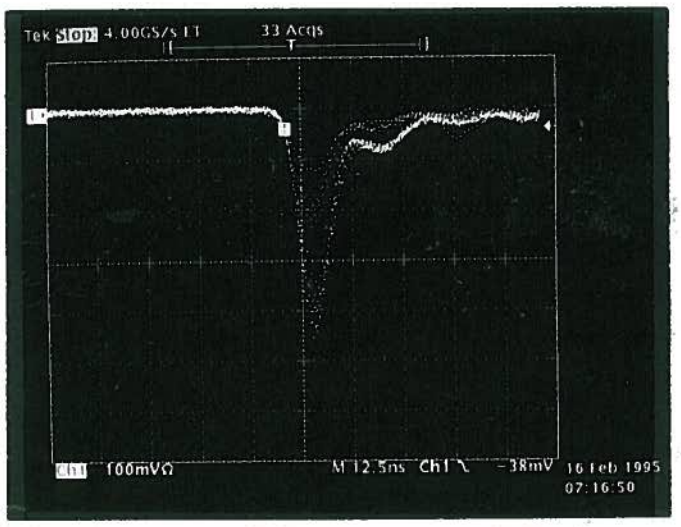
Cables "4" & unlabeled show RG174 A/U on them

2/16 TDS 784A Scope Demo



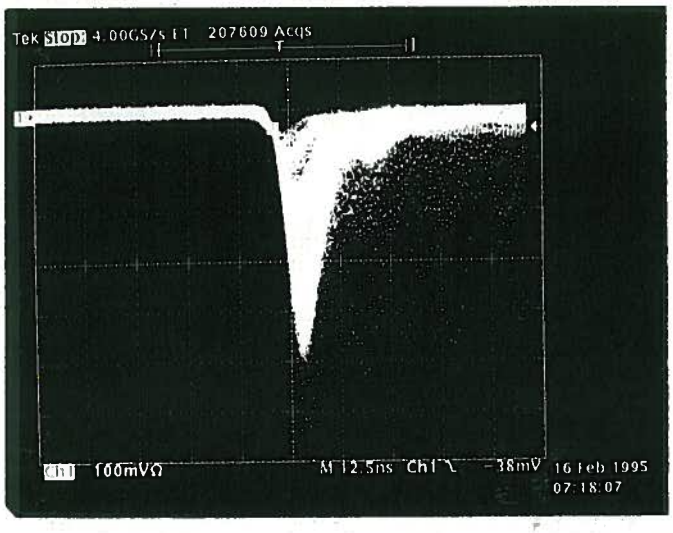



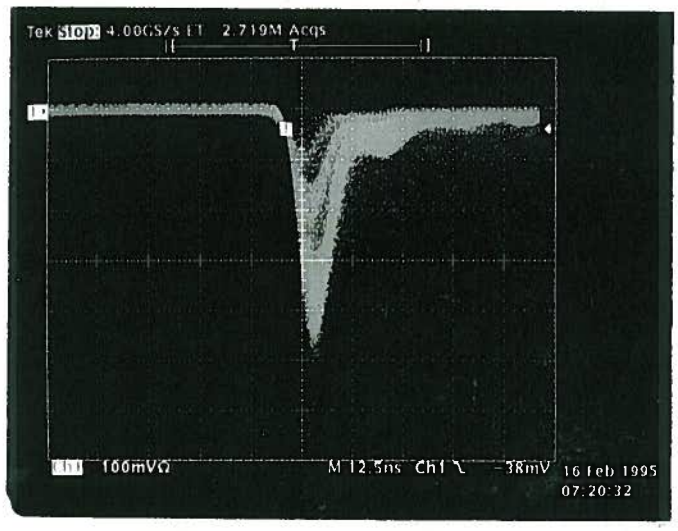

Scope on dustavu
100μCi source 4/1990
~1cm from tube.
Scope stopped at a random
time by front panel
button. Gray scale:
250ms persistence




Same source @ ~4cm+
or 5cm?
(guessed by eye)

500 μCi Source 11/16/94
@ ~ 1cm



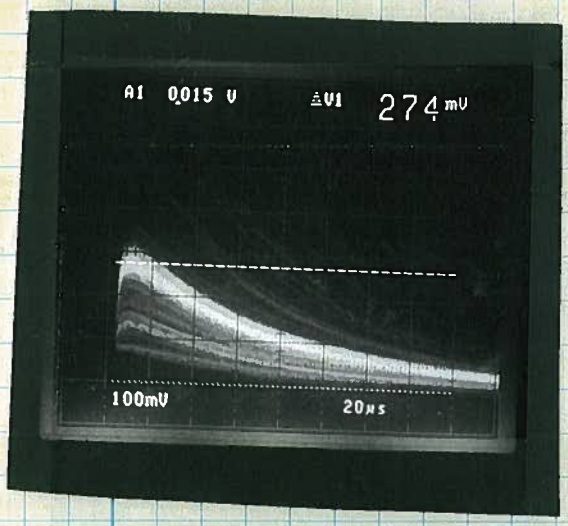

Similar to above except display intensity is reduced.

2/23 VDC Gas Gain Ar/EtOH 62/38%

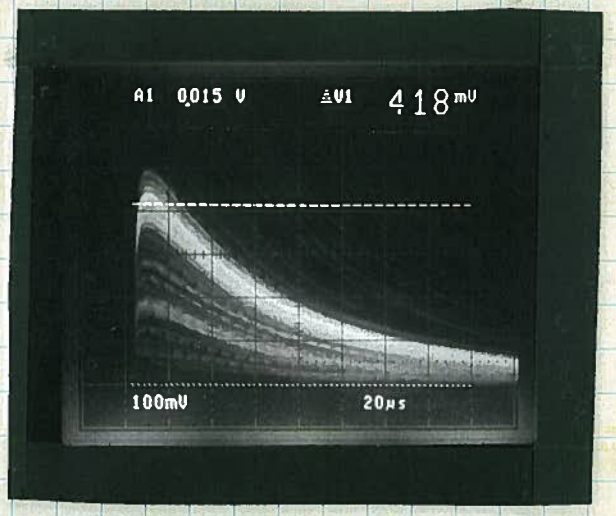
Similar setup to p. 46 of this book.
Full size VDC. all three planes at the same voltage. 100MΩ in series with each plane

Time started is 9PM. Reach 3400V @ ~9:20PM
Gas flowing @ ~3 ft³/hr since 6PM on 2/22.
Looking at fire ~ middle of top plane. Gas input is to the top plane. Source ~ center of face.

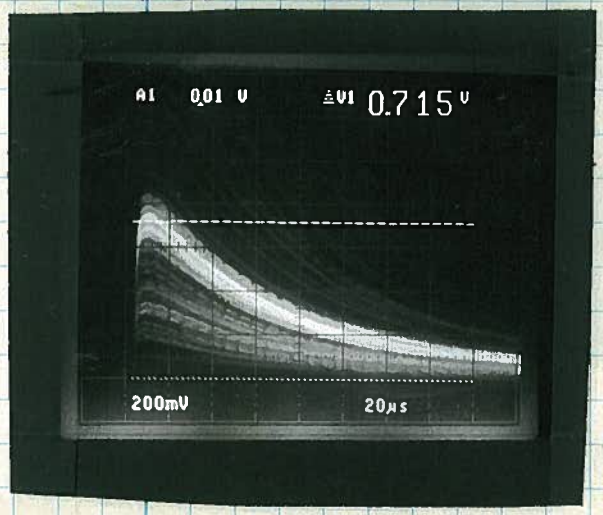
2900V



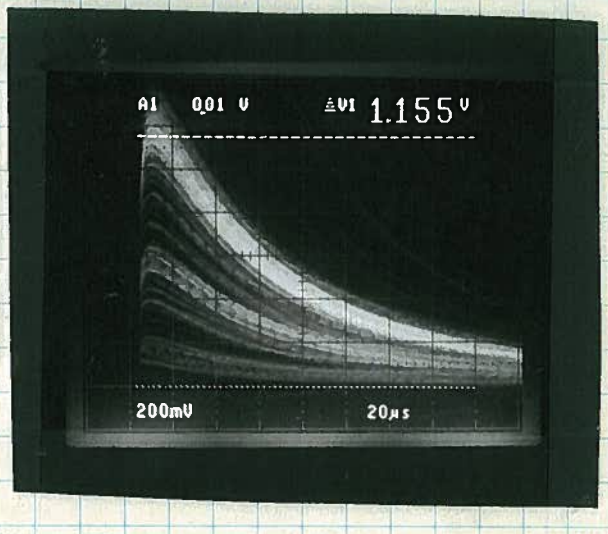

3000V



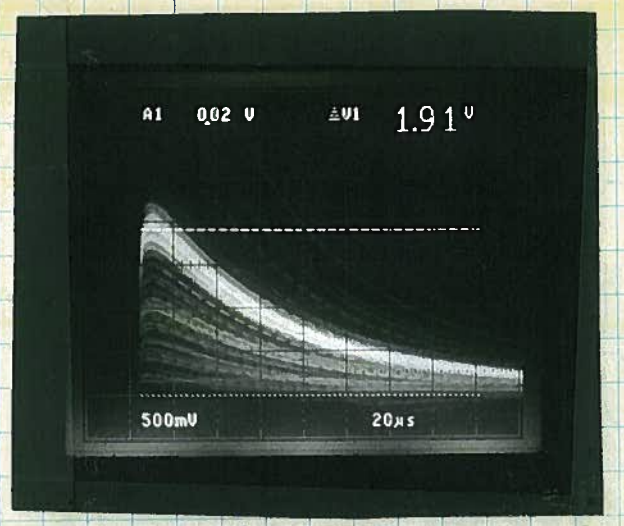

↓3100V↓



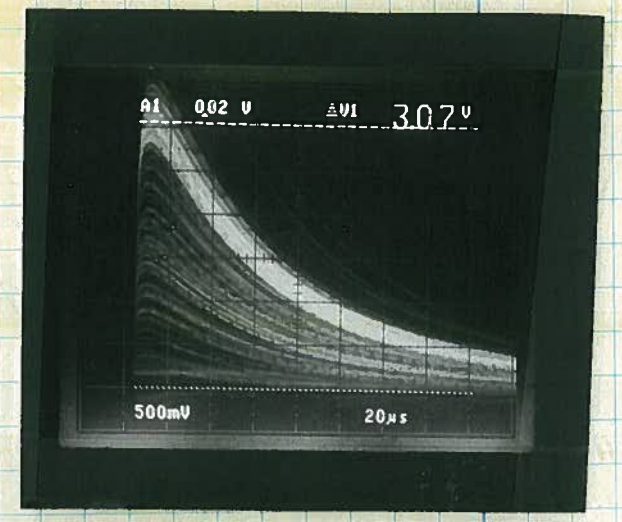

↓3200V↓



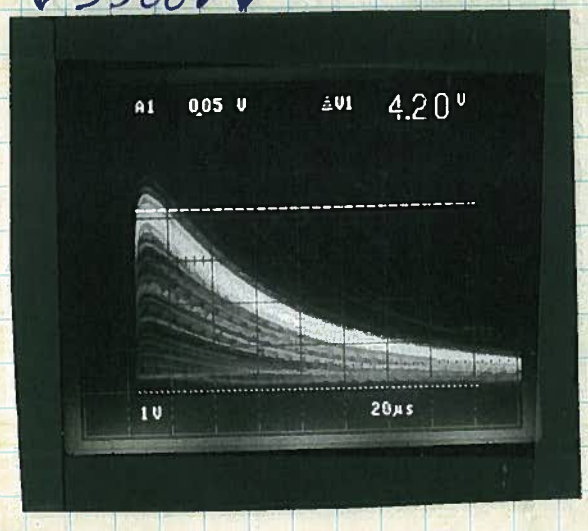
3300V



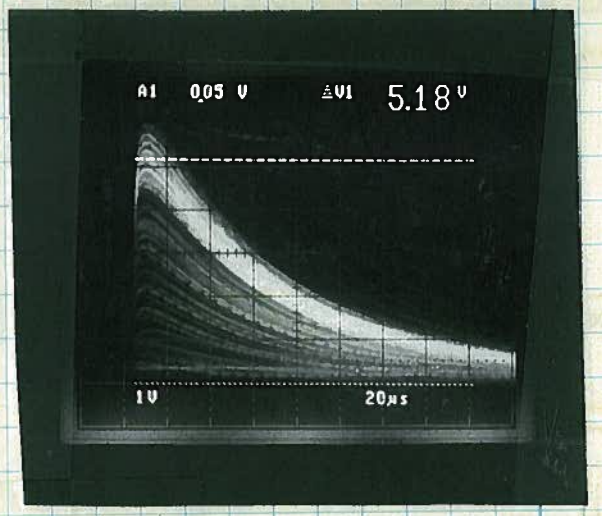

3400V

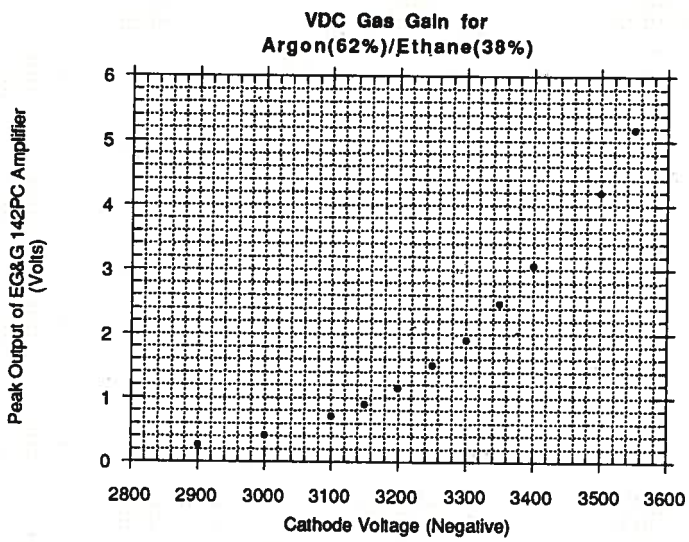



↓3500V↓

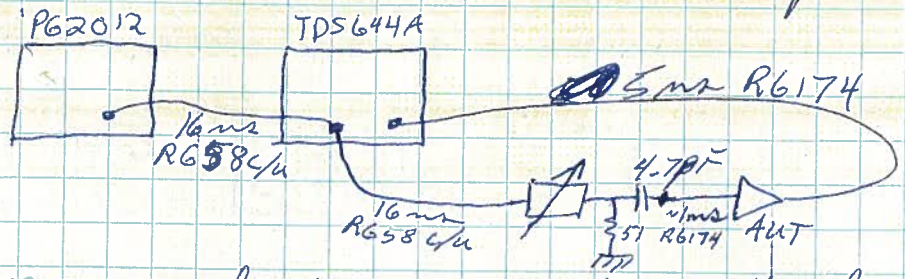



↓3550V↓



2/26 3227 50IC in "Little Duke" package Linearity



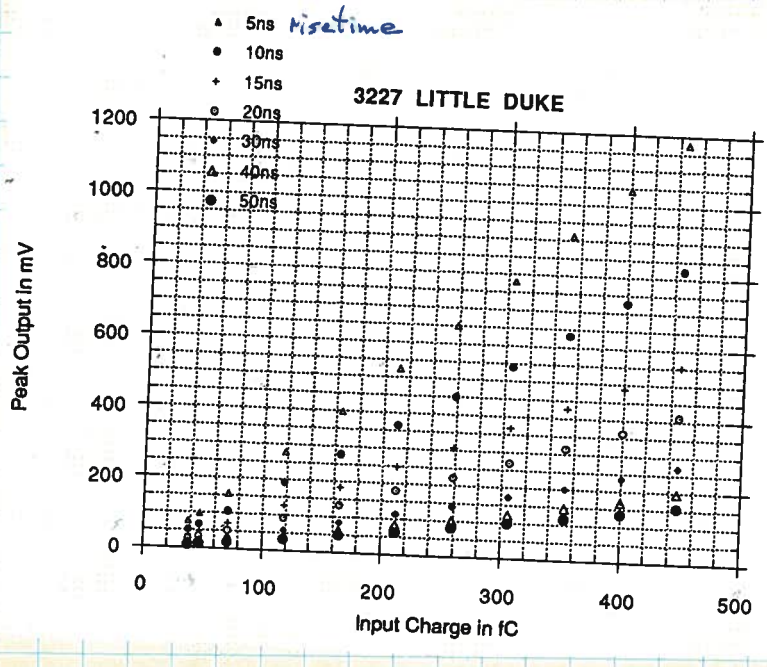

TDS644A set to average 64 traces. Use low measurement on channel to get pulse height.

| | | | 30ns | 40ns | 50ns | 5ns | 10ns | 15ns | 20ns |
|---|---|---|---|---|---|---|---|---|---|
| 38fC | 40dB | .8V | 15 | 12 | 9 | 79 | 53 ~~55~~ | 36 | 26 |
| 47fC | | 1.0 | 19 | 13 | 12 | 99 | 68 | 45 | 34 |
| 71fC | | 1.5 | 31 | 21 | 17 | 154 | 105 | 71 | 47 |
| 118 | | 2.5 | 53 | 37 | 29 | 279 | 192 | 127 | 91 |
| 165 | | 3.5 | 77 | 51 | 41 | 398 | 281 | 185 | 133 |
| 212 | | 4.5 | 102 | 70 | 54 | 522 | 366 | 244 | 176 |
| 259 | | 5.5 | 126 | 90 | 66 | 650 | 450 | 306 | 190 |
| 306 | | 6.5 | 150 | 110 | 86 | 780 | 532 | 366 | 268 |
| 353 | | 7.5 | 174 | 114 | 102 | 916 | 632 | 428 | 258 |
| 400 | | 8.5 | 194 | 130 | 102 | 1044 | 724 | 490 | 302 |

Scope measurement not set up correctly

Page #1 - 3227_LITTLE_DUKE

| | fC | 5ns | 10ns | 15ns | 20ns | 30ns | 40ns | 50ns | J |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 38.000 | 76.000 | 52.000 | 37.000 | 27.000 | 18.000 | 13.000 | 10.000 | |
| 2 | 47.000 | 98.000 | 68.000 | 46.000 | 34.000 | 22.000 | 16.000 | 13.000 | |
| 3 | 71.000 | 156.00 | 107.00 | 72.000 | 52.000 | 33.000 | 24.000 | 20.000 | |
| 4 | 118.00 | 278.00 | 193.00 | 128.00 | 93.000 | 59.000 | 42.000 | 34.000 | |
| 5 | 165.00 | 398.00 | 278.00 | 184.00 | 135.00 | 86.000 | 63.000 | 50.000 | |
| 6 | 212.00 | 524.00 | 356.00 | 248.00 | 181.00 | 115.00 | 84.000 | 63.000 | |
| 7 | 259.00 | 650.00 | 452.00 | 306.00 | 224.00 | 142.00 | 102.00 | 82.000 | |
| 8 | 306.00 | 780.00 | 540.00 | 366.00 | 270.00 | 174.00 | 124.00 | 100.00 | |
| 9 | 353.00 | 912.00 | 632.00 | 428.00 | 316.00 | 202.00 | 148.00 | 118.00 | |
| 10 | 400.00 | 1044.0 | 728.00 | 488.00 | 364.00 | 236.00 | 170.00 | 136.00 | |
| 11 | 447.00 | 1176.0 | 824.00 | 552.00 | 412.00 | 270.00 | 198.00 | 158.00 | |



BELDEN

## **Solid Bare Copper Wire** American Wire Gage

| Gage (AWG or B&S) | Nominal Diameter Inches | Nominal Diameter mm | Circular Mil Area | Weight Pounds per M | Resistance @ 68 F Ohms per M |
|---|---|---|---|---|---|
| 10 | .1019 | 2.59 | 10380.0 | .01183 | .9989 |
| 11 | .0907 | 2.30 | 8234.0 | 24.92 | 1.260 |
| 12 | .0808 | 2.05 | 6530.0 | 19.77 | 1.588 |
| 13 | .0720 | 1.83 | 5178.0 | 15.68 | 2.003 |
| 14 | .0641 | 1.63 | 4107.0 | 12.43 | 2.525 |
| 15 | .0571 | 1.45 | 3260.0 | 9.858 | 3.184 |
| 16 | .0508 | 1.29 | 2583.0 | 7.818 | 4.016 |
| 17 | .0453 | 1.15 | 2050.0 | 6.200 | 5.064 |
| 18 | .0403 | 1.02 | 1628.0 | .0049 | 6.385 |
| 19 | .0359 | .912 | 1200.0 | 3.899 | 8.051 |
| 20 | .0320 | .813 | 1020.0 | 3.092 | 10.15 |
| 21 | .0285 | .724 | 812.1 | 2.452 | 12.80 |
| 22 | .0253 | .643 | 640.4 | 1.945 | 16.14 |
| 23 | .0226 | .574 | 511.5 | 1.542 | 20.36 |
| 24 | .0201 | .511 | 404.0 | 1.223 | 25.67 |
| 25 | .0179 | .455 | 320.4 | .9699 | 32.37 |
| 26 | .0159 | .404 | 253.0 | .7692 | 40.81 |
| 27 | .0142 | .361 | 201.5 | .6100 | 51.47 |
| 28 | .0126 | .320 | 159.8 | .4837 | 64.90 |
| 29 | .0113 | .287 | 126.7 | .3836 | 81.83 |
| 30 | .0100 | .254 | 100.5 | .3042 | 103.2 |
| 31 | .0089 | .226 | 79.7 | .2413 | 130.1 |
| 32 | .0080 | .203 | 63.2 | .1913 | 164.1 |
| 33 | .0071 | .180 | 50.13 | .1517 | 206.9 |
| 34 | .0063 | .160 | 39.75 | .1203 | 260.9 |
| 35 | .0056 | .142 | 31.52 | .09542 | 331.0 |
| 36 | .0050 | .127 | 25.00 | .07568 | 417.8 |
| 37 | .0045 | .114 | 19.83 | .0613 | 512.1 |
| 38 | .0040 | .102 | 15.72 | .04759 | 646.6 |
| 39 | .0035 | .089 | 12.20 | .03774 | 847.8 |
| 40 | .0031 | .079 | 9.61 | .02993 | 1080.0 |

Information from National Bureau of Standards Copper Wire Tables—Handbook 100.





BELDEN

## **Stranded Tinned Copper Wire** American Wire Gage

| Gage (AWG or B&S) | Stranding | Nominal O.D. of Strand | Approximate O.D. Inches | Approximate O.D. mm | Circular Mil Area | Weight Pounds per M | Resistance at 68 F Ohms per M |
|---|---|---|---|---|---|---|---|
| 36 | 7/44 | .002 | .006 | .153 | 28.00 | .085 | 371.0 |
| 34 | 7/42 | .0025 | .0075 | .191 | 39.25 | .121 | 264.8 |
| 32 | 7/40 | .0031 | .0093 | .203 | 67.27 | .203 | 164.0 |
| 32 | 19/44 | .002 | .010 | .229 | 56.00 | .225 | 164.0 |
| 30 | 7/38 | .004 | .012 | .305 | 112.00 | .339 | 103.2 |
| 30 | 19/42 | .0025 | .0125 | .318 | 70.25 | .212 | 103.2 |
| 28 | 7/36 | .005 | .015 | .381 | 175.0 | .529 | 64.9 |
| 28 | 19/40 | .0031 | .016 | .406 | 109.2 | .330 | 64.9 |
| 27 | 7/35 | .0056 | .017 | .457 | 219.52 | .664 | 51.47 |
| 27 | 19/41 | .0035 | .0175 | .445 | 137.2 | .415 | 51.47 |
| 26 | 19/36 | .0050 | .021 | .533 | 250.00 | .757 | 41.48 |
| 26 | 19/39 | .0040 | .0200 | .508 | 159.0 | .481 | 41.48 |
| 24 | 7/32 | .008 | .024 | .610 | 448.00 | 1.355 | 23.3 |
| 24 | 19/37 | .0045 | .0225 | .584 | 281.0 | .850 | 23.3 |
| 24 | 19/36 | .0050 | .024 | .610 | 475.00 | 1.430 | 21.06 |
| 24 | 19/40 | .0031 | .0155 | .394 | 187.0 | .565 | 21.06 |
| 22 | 7/30 | .0100 | .030 | .762 | 700.00 | 2.120 | 14.74 |
| 22 | 19/34 | .0063 | .0315 | .787 | 374.0 | 1.130 | 14.74 |
| 22 | 26/36 | .0050 | .030 | .762 | 650.00 | 1.97 | 15.94 |
| 22 | 19/35 | .0100 | .031 | .794 | 1,000.00 | 3.02 | 10.12 |
| 20 | 19/32 | .0080 | .037 | .940 | 1,216.00 | 3.68 | 8.83 |
| 20 | 26/34 | .0063 | .038 | .914 | 1,015.0 | 3.07 | 10.02 |
| 20 | 41/36 | .0050 | .036 | .914 | 1,025.00 | 3.10 | 10.02 |
| 18 | 7/26 | .0159 | .048 | 1.22 | 1,792.00 | 5.42 | 6.46 |
| 18 | 16/30 | .0100 | .047 | 1.20 | 1,500.00 | 4.84 | 6.46 |
| 18 | 19/30 | .0100 | .049 | 1.24 | 1,900.00 | 5.75 | 5.67 |
| 18 | 41/34 | .0063 | .047 | 1.20 | 1,627.29 | 4.92 | 6.37 |
| 18 | 65/36 | .0050 | .047 | 1.20 | 1,625.00 | 4.91 | 6.64 |
| 16 | 7/24 | .0201 | .060 | 1.52 | 2,628.00 | 8.56 | 3.67 |
| 16 | 19/29 | .0113 | .058 | 1.47 | 2,428.00 | 7.35 | 3.67 |
| 16 | 26/30 | .0100 | .059 | 1.50 | 2,800.00 | 7.87 | 4.00 |
| 16 | 65/34 | .0063 | .059 | 1.50 | 2,575.00 | 7.79 | 4.00 |
| 16 | 105/36 | .0050 | .059 | 1.50 | 2,625.00 | 7.95 | 3.99 |
| 14 | 7/22 | .0253 | .076 | 1.93 | 4,400.00 | 13.30 | 2.31 |
| 14 | 19/27 | .0142 | .071 | 1.85 | 3,830.4 | 11.59 | 2.70 |
| 14 | 41/30 | .0100 | .075 | 1.85 | 4,100.00 | 12.40 | 2.51 |
| 14 | 105/34 | .0063 | .075 | 1.85 | 4,187.5 | 12.61 | 2.49 |
| 12 | 7/20 | .0320 | .096 | 2.44 | 6,537.168.0 | 21.66 | 1.46 |
| 12 | 19/25 | .0179 | .093 | 2.36 | 6,087.6 | 18.43 | 1.70 |
| 12 | 65/30 | .0100 | | 2.41 | 6,300.0 | 19.06 | 1.62 |
| 12 | 165/34 | .0063 | .095 | 2.41 | 6,548.9 | 19.82 | 1.58 |
| 10 | 37/26 | .0159 | .1157 | 2.92 | 9,353.8 | 28.31 | 1.04 |
| 10 | 65/28 | .0126 | .120 | 2.95 | 10,319.4 | 31.9 | 1.09 |
| 10 | 105/30 | .0100 | .118 | 2.95 | 10,500.0 | 31.78 | .98 |

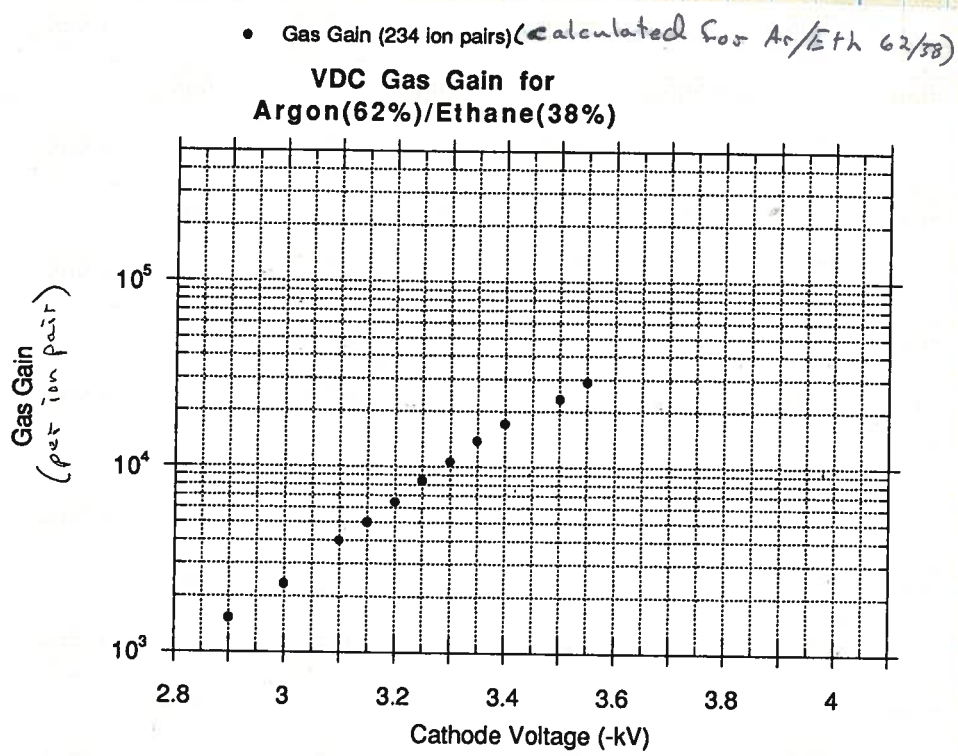
Information from National Bureau of Standards Copper Wire Tables—Handbook 100

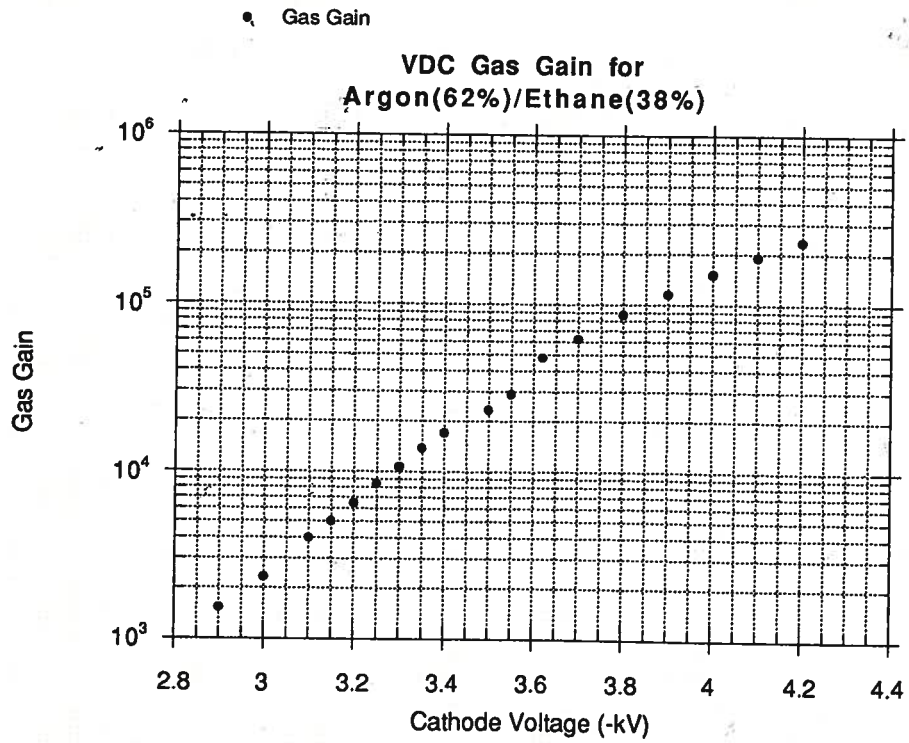
# STRANDED TINNED COPPER WIRE TABLE OF DATA

| AWG Size | Stranding | Nom. O.D. of Strand | Approx. O.D. | Circular MIL Area | Wt. Lbs./ 1000 Ft. | Ohms Per 1,000 Ft.* |
|---|---|---|---|---|---|---|
| 36 | 7/44 | .002 | .006 | 28.00 | .085 | 371.0 |
| 34 | 7/42 | .0025 | .0075 | 43.75 | .132 | 237.0 |
| 32 | 7/40 | .0031 | .008 | 67.27 | .203 | 164.0 |
| 32 | 19/44 | .002 | .009 | 76.00 | .230 | 136.4 |
| 30 | 7/38 | .004 | .012 | 112.00 | .339 | 103.2 |
| 30 | 19/42 | .0025 | .012 | 118.75 | .359 | 87.3 |
| 28 | 7/36 | .005 | .015 | 141.75 | .529 | 64.9 |
| 28 | 19/40 | .0031 | .016 | 182.59 | .553 | 56.7 |
| 27 | 7/35 | .0056 | .018 | 219.52 | .664 | 51.47 |
| 26 | 7/34 | .0063 | .019 | 277.83 | .841 | 37.3 |
| 26 | 10/36 | .0050 | .021 | 250.00 | .757 | 41.48 |
| 26 | 19/38 | .0040 | .020 | 304.00 | .920 | 34.43 |
| 24 | 7/32 | .008 | .024 | 448.00 | 1.356 | 23.3 |
| 24 | 10/34 | .0063 | .023 | 396.90 | 1.201 | 26.09 |
| 24 | 19/36 | .0050 | .024 | 475.00 | 1.430 | 21.08 |
| 24 | 41/40 | .0031 | .023 | 384.40 | 1.160 | 25.59 |
| 22 | 7/30 | .0100 | .030 | 700.00 | 2.120 | 14.74 |
| 22 | 19/34 | .0063 | .031 | 754.11 | 2.28 | 13.73 |
| 22 | 26/36 | .0050 | .030 | 650.00 | 1.97 | 15.94 |
| 20 | 10/30 | .0100 | .035 | 1000.00 | 3.025 | 10.32 |
| 20 | 19/32 | .0080 | .037 | 1216.00 | 3.68 | 8.63 |
| 20 | 26/34 | .0063 | .036 | 1031.94 | 3.12 | 10.05 |
| 20 | 41/36 | .0050 | .036 | 1025.00 | 3.10 | 10.02 |
| 18 | 7/26 | .0159 | .048 | 1769.60 | 5.36 | 5.86 |
| 18 | 16/30 | .0100 | .047 | 1600.00 | 4.84 | 6.48 |
| 18 | 19/30 | .0100 | .049 | 1900.00 | 5.75 | 5.46 |
| 18 | 41/34 | .0063 | .047 | 1627.29 | 4.92 | 6.37 |
| 18 | 65/36 | .0050 | .047 | 1625.00 | 4.91 | 6.39 |
| 16 | 7/24 | .0201 | .060 | 2828.00 | 8.56 | 3.67 |
| 16 | 19/29 | .0113 | .058 | 2426.30 | 7.35 | 4.27 |
| 16 | 26/30 | .0100 | .059 | 2600.00 | 7.87 | 4.00 |
| 16 | 65/34 | .0063 | .059 | 2579.85 | 7.81 | 4.02 |
| 16 | 105/36 | .0050 | .059 | 2625.00 | 7.95 | 3.99 |
| 14 | 7/22 | .0253 | .073 | 4480.0 | 13.56 | 2.31 |
| 14 | 19/27 | .0142 | .073 | 3830.4 | 11.49 | 2.70 |
| 14 | 41/30 | .0100 | .073 | 4100.0 | 12.40 | 2.53 |
| 14 | 105/34 | .0063 | .073 | 4167.5 | 12.61 | 2.49 |
| 12 | 7/20 | .0320 | .096 | 7168.0 | 21.69 | 1.45 |
| 12 | 19/25 | .0179 | .093 | 6087.6 | 18.43 | 1.70 |
| 12 | 65/30 | .0100 | .095 | 6500.0 | 19.66 | 1.75 |
| 12 | 165/30 | .0063 | .095 | 6548.9 | 19.82 | 1.58 |

| AWG Size | Stranding | Nom. O.D. of Strand | Approx. O.D. | Circular MIL Area | Wt. Lbs./ 1000 Ft. | Ohms Per 1,000 Ft.* |
|---|---|---|---|---|---|---|
| 10 | 37/26 | .0159 | .115 | 9353.6 | 28.31 | 1.11 |
| 10 | 49/27 | .0142 | .116 | 9878.4 | 29.89 | 1.09 |
| 10 | 105/30 | .0100 | .116 | 10,530.0 | 31.76 | .98 |
| 8 | 49/25 | .0179 | .147 | 15,699.6 | 47.53 | .67 |
| 8 | 133/29 | .0113 | .147 | 16,984.1 | 51.42 | .61 |
| 8 | 655/36 | .0050 | .147 | 16,625.0 | 49.58 | .62 |
| 6 | 133/27 | .0142 | .184 | 26,812.8 | 81.14 | .47 |
| 6 | 259/30 | .0100 | .184 | 25,900.0 | 78.35 | .40 |
| 6 | 1050/36 | .0050 | .184 | 26,250.0 | 79.47 | .386 |
| 4 | 133/25 | .0179 | .232 | 42,613.0 | 129.01 | .243 |
| 4 | 259/27 | .0143 | .232 | 52,214.4 | 158.02 | .20 |
| 4 | 1666/36 | .0050 | .232 | 41,650.0 | 126.10 | .25 |
| 2 | 133/23 | .0226 | .292 | 67,936.4 | 205.62 | .152 |
| 2 | 259/26 | .0159 | .292 | 65,475.2 | 198.14 | .16 |
| 2 | 665/30 | .0100 | .292 | 66,500.0 | 201.16 | .157 |
| 2 | 2646/36 | .0050 | .292 | 66,150.0 | 200.28 | .157 |
| 1 | 133/22 | .0253 | .328 | 85,133.3 | 257.60 | .121 |
| 1 | 259/25 | .0179 | .328 | 82,983.6 | 251.20 | .125 |
| 1 | 817/30 | .0100 | .328 | 81,700.0 | 247.10 | .127 |
| 1 | 2109/34 | .0063 | .328 | 83,706.2 | 253.29 | .124 |
| 1/0 | 133/21 | .0285 | .368 | 108,035.9 | 327.05 | .096 |
| 1/0 | 259/24 | .0201 | .368 | 104,636.0 | 316.76 | .099 |
| 1/0 | 1045/30 | .0100 | .368 | 104,500.0 | 316.11 | .099 |
| 1/0 | 2660/34 | .0063 | .368 | 105,575.4 | 319.47 | .098 |
| 1/0 | 4214/36 | .0050 | .368 | 105,350.0 | 318.96 | .098 |
| 2/0 | 133/20 | .0320 | .414 | 136,192.0 | 412.17 | .077 |
| 2/0 | 259/23 | .0226 | .414 | 132,297.2 | 400.41 | .077 |
| 2/0 | 1330/30 | .0100 | .414 | 133,000.0 | 402.33 | .077 |
| 2/0 | 3325/34 | .0063 | .414 | 131,969.2 | 399.33 | .077 |
| 2/0 | 5292/36 | .0050 | .414 | 132,300.0 | 400.55 | .077 |
| 3/0 | 259/22 | .0253 | .464 | 163,195.9 | 501.7 | .062 |
| 3/0 | 427/24 | .0201 | .464 | 172,508.0 | 522.2 | .059 |
| 3/0 | 1661/30 | .0100 | .464 | 166,100.0 | 502.45 | .062 |
| 3/0 | 4256/34 | .0063 | .464 | 168,920.6 | 511.15 | .061 |
| 3/0 | 6713/36 | .0050 | .464 | 167,825.0 | 508.11 | .061 |
| 4/0 | 259/21 | .0285 | .522 | 210,385.7 | 638.88 | .049 |
| 4/0 | 427/23 | .0226 | .522 | 218,111.6 | 660.01 | .047 |
| 4/0 | 2104/30 | .0100 | .522 | 210,400.0 | 636.46 | .049 |
| 4/0 | 5320/34 | .0063 | .522 | 211,150.8 | 638.89 | .049 |
| 4/0 | 8512/36 | .0050 | .522 | 212,800.0 | 644.27 | .049 |

*Resistance in Ohms per 1000 ft. at 68°F (20°C)

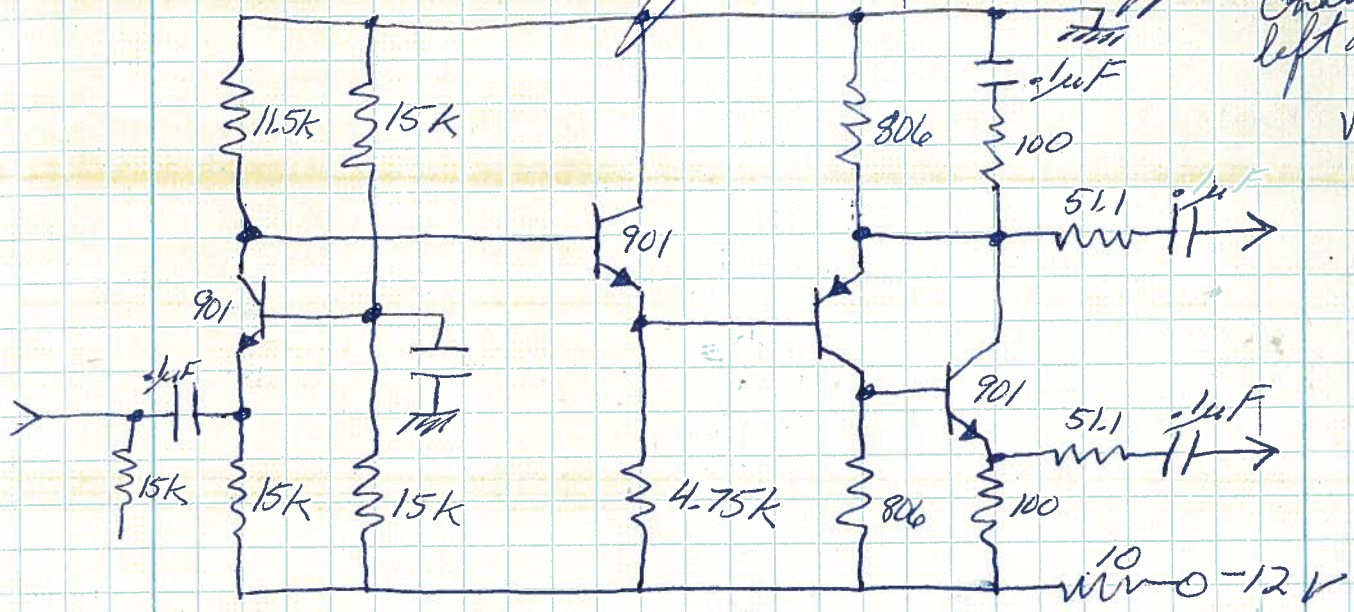

Gas Gain (234 ion pairs) (calculated for Ar/Eth 62/38)
VDC Gas Gain for
Argon(62%)/Ethane(38%)
Gas Gain
(per ion pair)
$10^5$
$10^4$
$10^3$
2.8
3
3.2
3.4
3.6
3.8
4
Cathode Voltage (-kV)

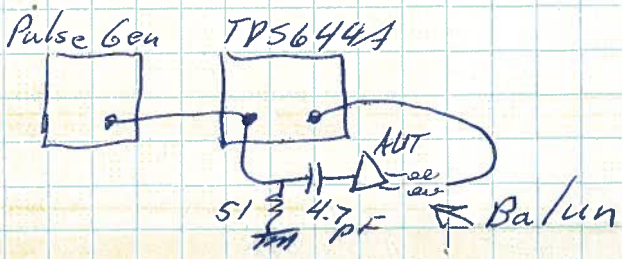

Gas Gain
VDC Gas Gain for
Argon(62%)/Ethane(38%)
Gas Gain
$10^6$
$10^5$
$10^4$
$10^3$
2.8
3
3.2
3.4
3.6
3.8
4
4.2
4.4
Cathode Voltage (-kV)

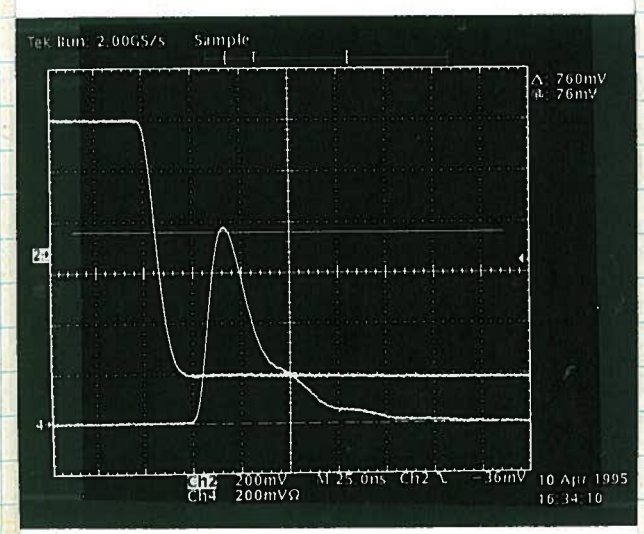
# PC Amp Revisited

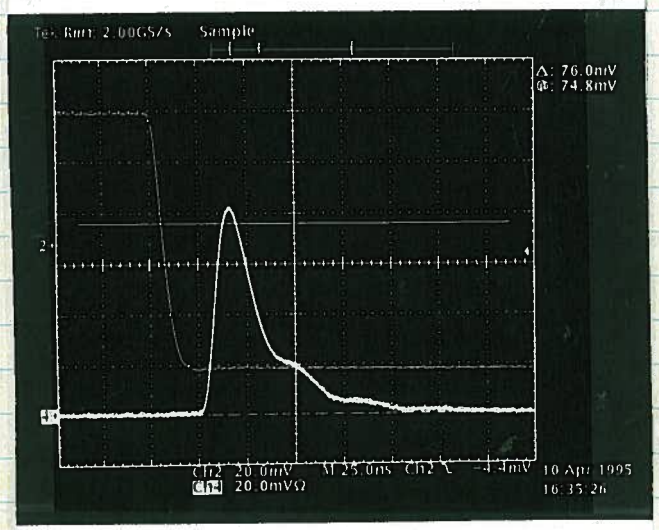
4/10/95

PC Amp from p. 30 of VOL I ~~[illegible]~~ has the remaining 15 channels stuffed. The one channel is left as on p. 30 of Vol I

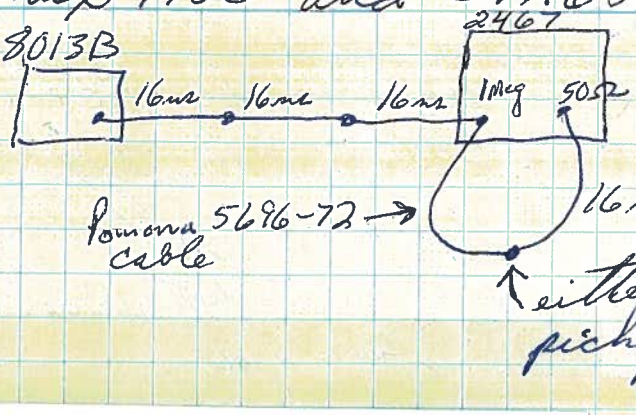


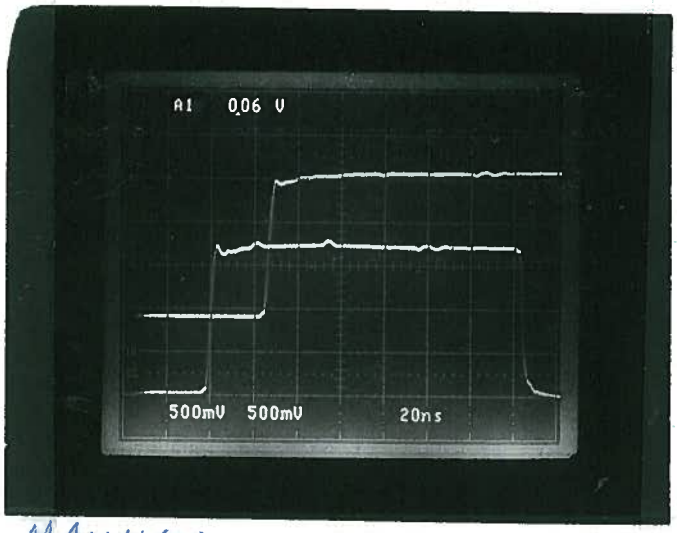
Time, Max 4100 and OPA650 RG-58 pickoff
in March 96
JS





No MAX4100

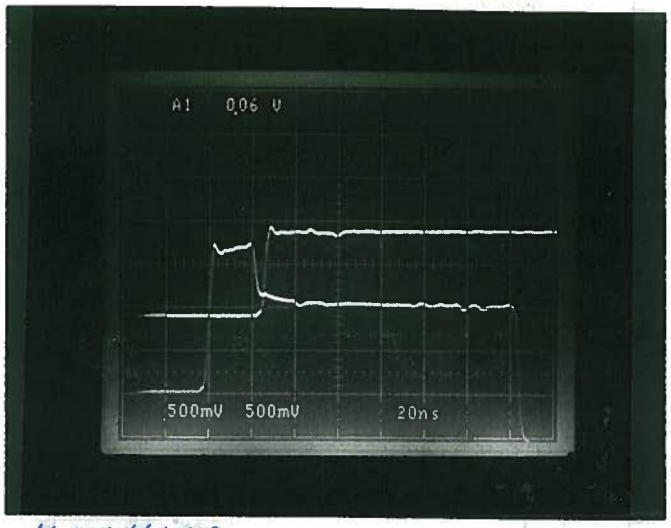
Barrel connector in place.




MAX4100

MAX4100 in small pomona box inserted. DC power is on.

DC power is off

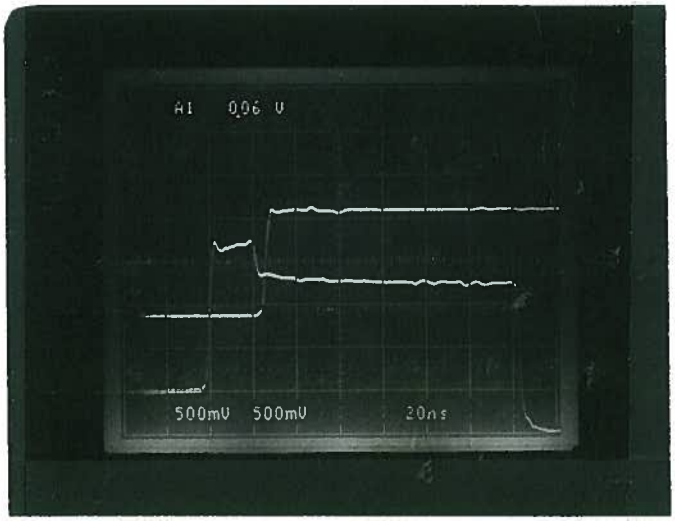



MAX4100

OPA650 in small pomona box is inserted. DC power is on.


OPA650

DC power is off.

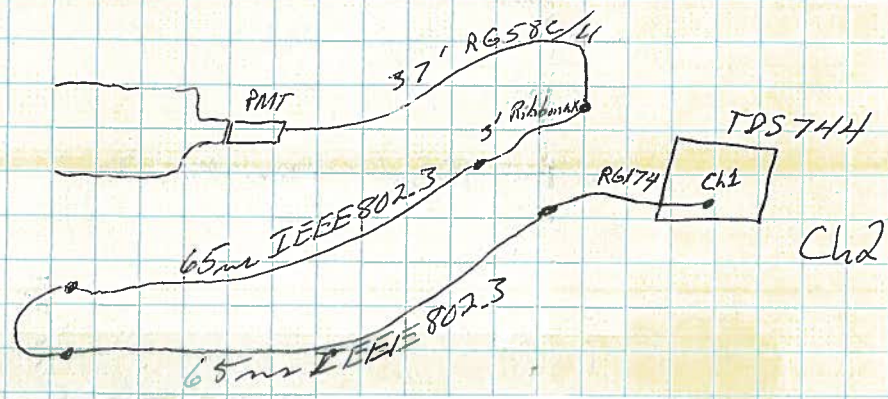


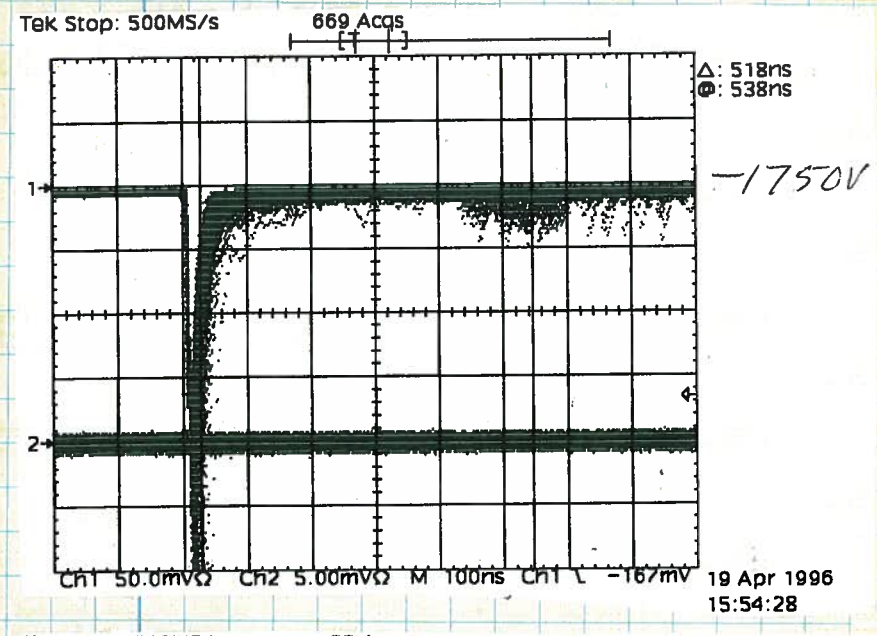

OPA650

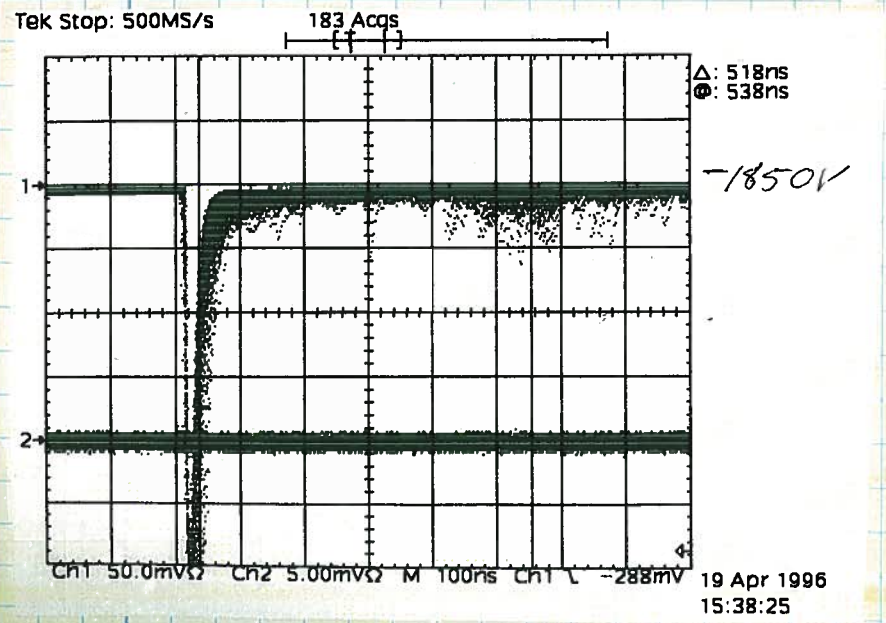
4/19
[illegible]
[illegible]

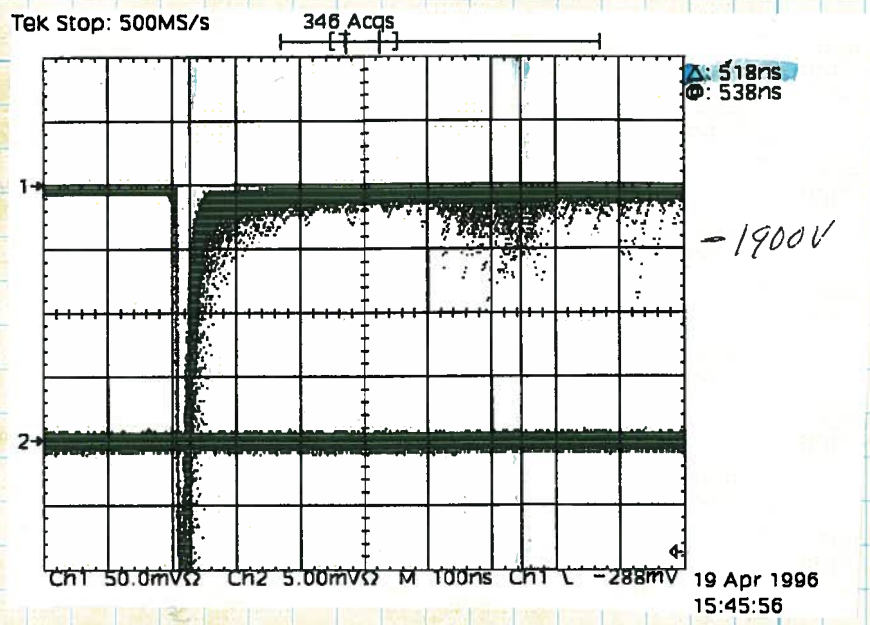
# Secondary Pulsing on TOF PMTs

Amongst other problems we have after pulsing of the PMTs for the TOF scintillators.



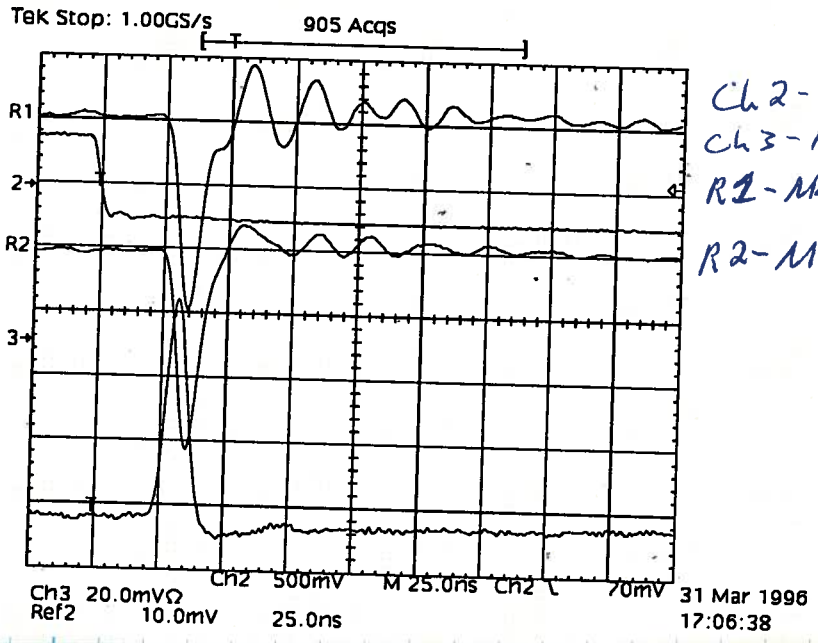




Tek Stop: 500MS/s
346 Acqs
Δ: 518ns
@: 538ns
1→
2→
-1900V
Ch1 50.0mVΩ Ch2 5.00mVΩ M 100ns Ch1 ⌊ -288mV
19 Apr 1996
15:45:56

4/21/96 LeCroy Pickoff Using MAX435

Comparison of MAX435 with FET probe.
MAX435 is off pickoff board made for differential pickoff.
Long lead is standard board setup. Short lead has input trace trimmed as far as board will allow. Grounded input has ~.75" 28 GA wire.
Power is derived off LeCroy card.
Output is through balun and ~5m of RG174
This was actually done on 5/31.




Ch2 - input tap
Ch3 - FET probe
R1 - MAX435 with "long" lead
R2 - MAX435 with "short" lead

Etched a ground plane circuit board to sit on the LeCroy card. This will give a minimal lead length for both + & − inputs. − input is grounded input. $R_{SET}$ is 7.5 kΩ.


Ch3 of scope in FET probe at + input of MAX435 card. Scope set to average 10 traces.

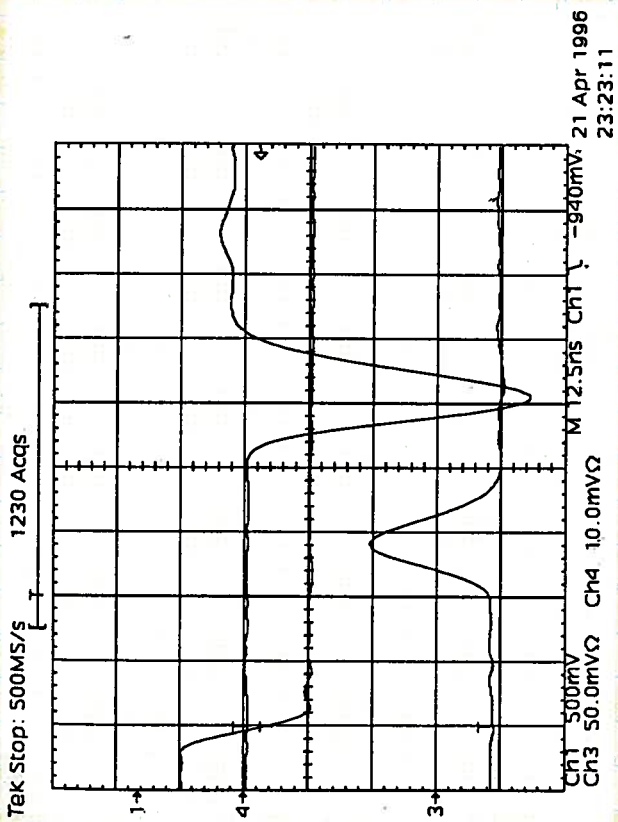
Ch4 is Balun output
Ch3 is FET probe
Both on channel 1 of the 2735

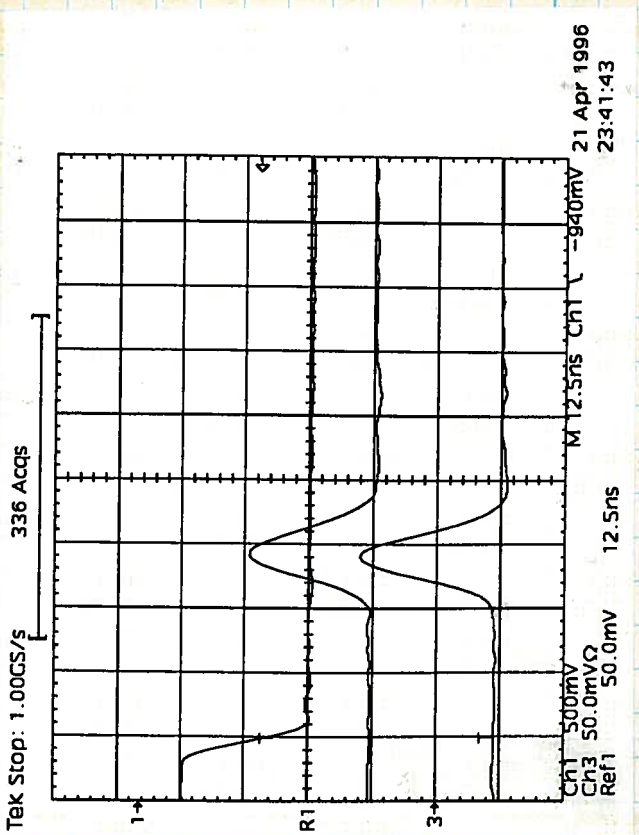
Channel 1 is pulsed

Ch3 is FET at 407 input of channel 1 of 2735 (channel 2 is pulsed)

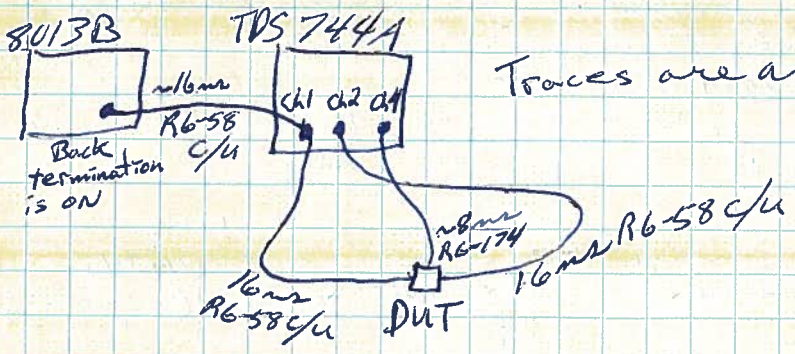
R1 is FET at 407 input of channel 1 of 2735 with MAX435 card, also (channel 1 is pulsed)

~10% loss in pulse height due to MAX435



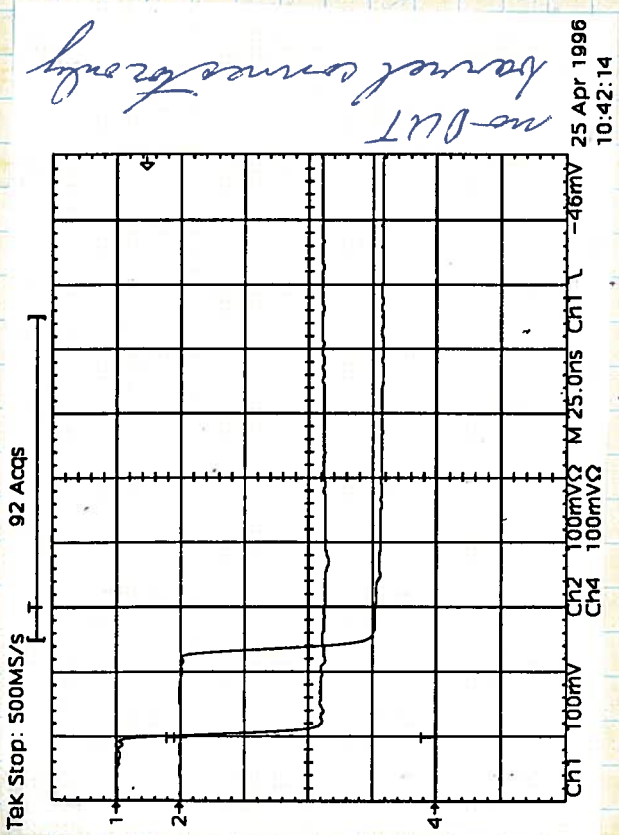



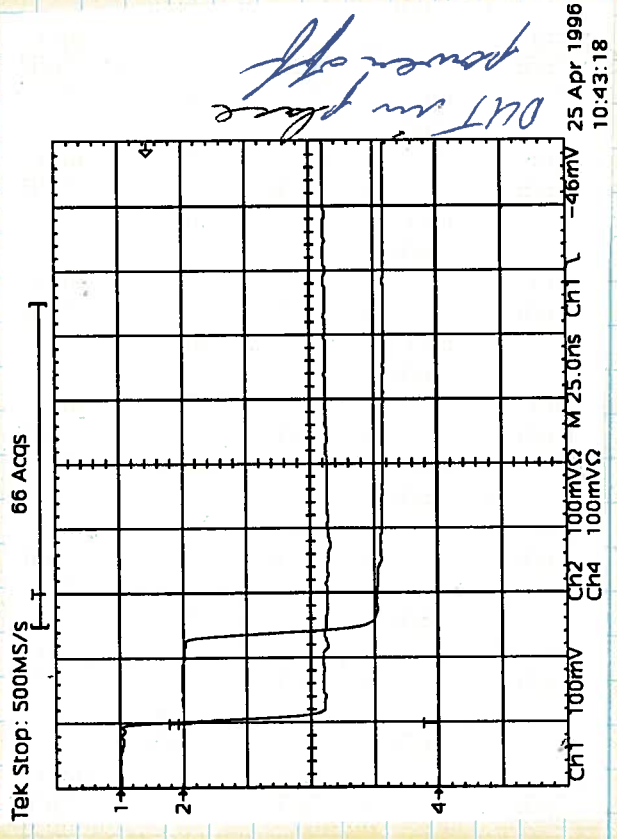
4/25/96 MAX435 Pickoff for RG-58
RS

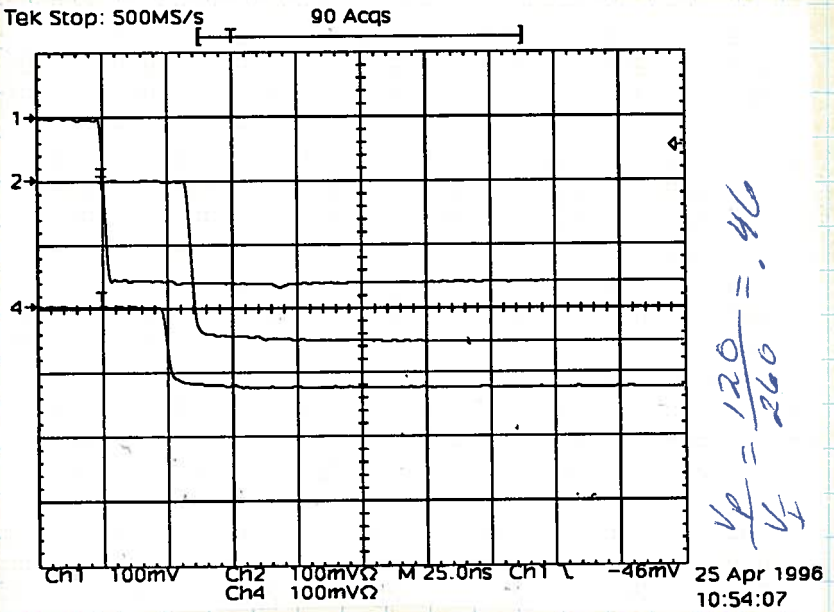



Traces are average of 16

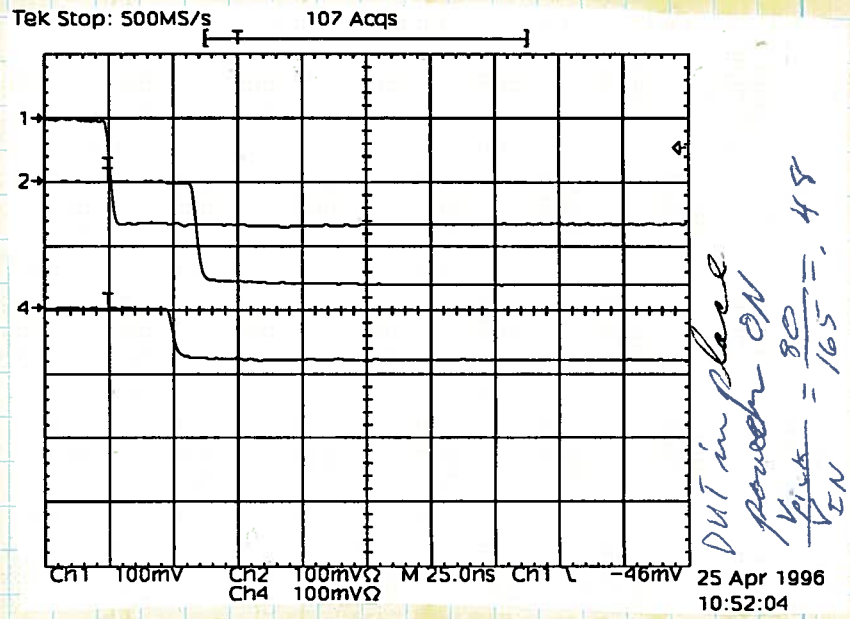
for MAX435 $R_{gain} = 200\Omega$ $R_{load} = 51.1\Omega$ $R_{set} = 7.5k\Omega$
V = 9V battery



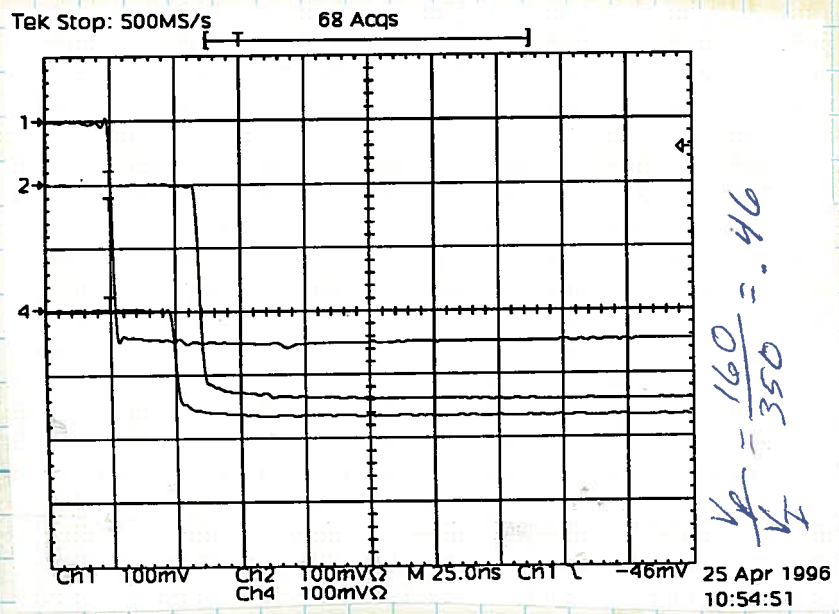





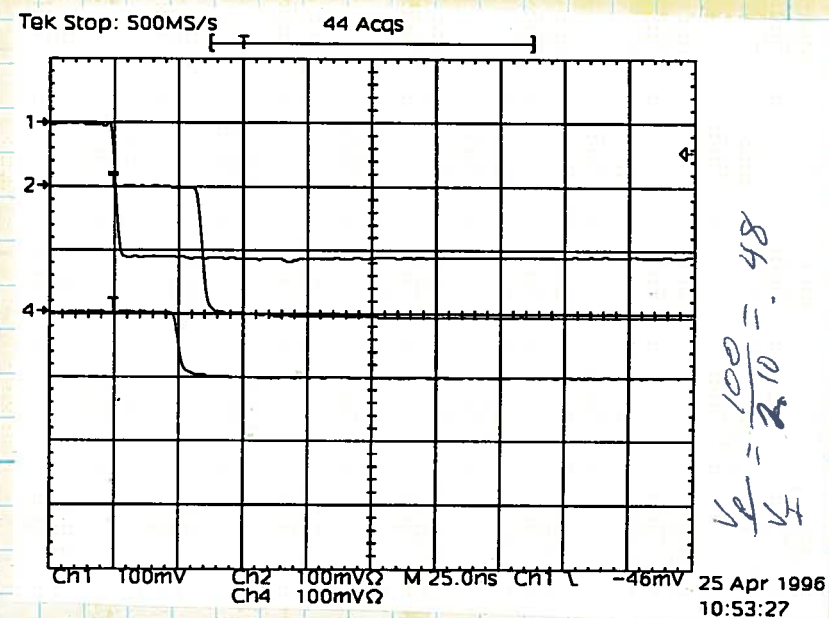

$V_e/V_f = 120/260 = .46$



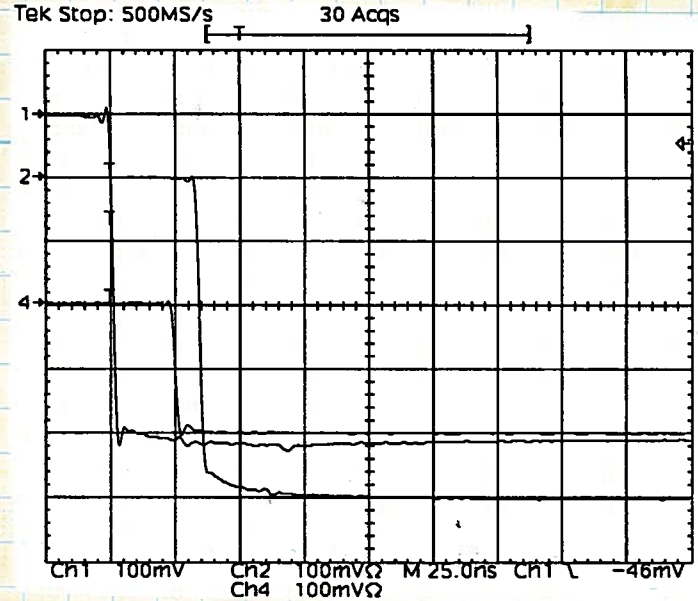

DUT in place
power ON
$V_{out}/V_{IN} = 80/165 = .48$



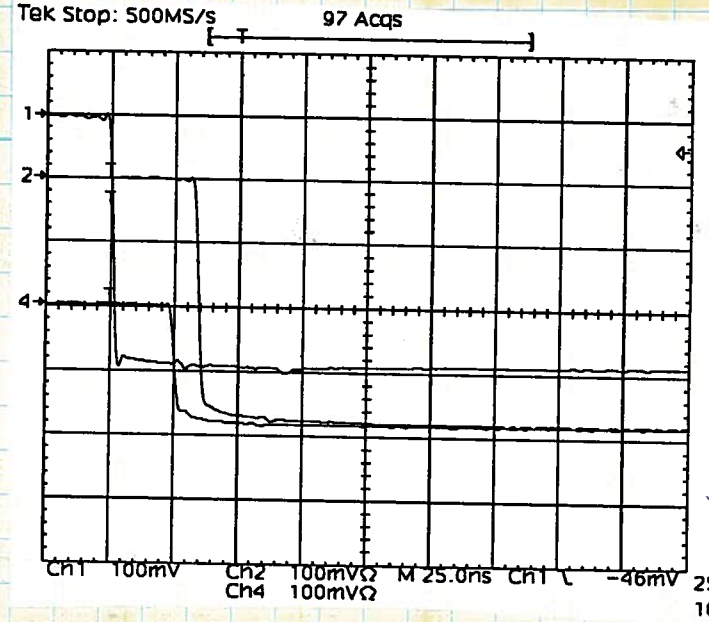

$V_e/V_f = 160/350 = .46$



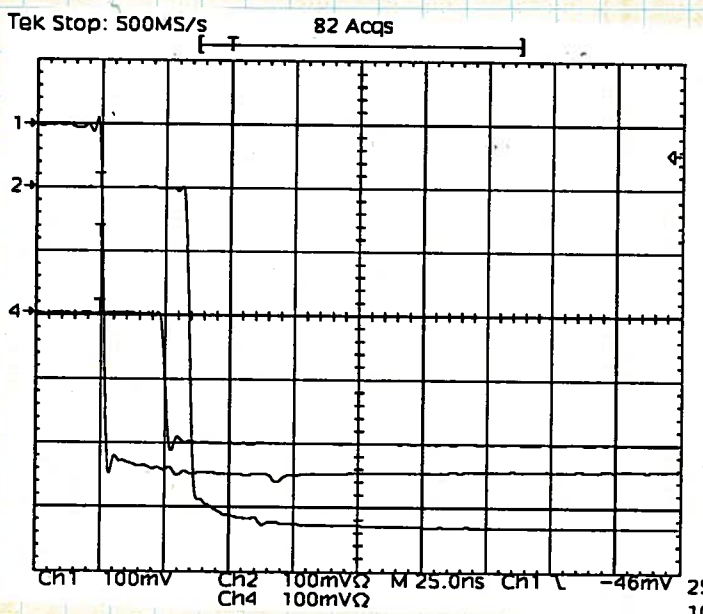

$V_e/V_f = 100/210 = .48$



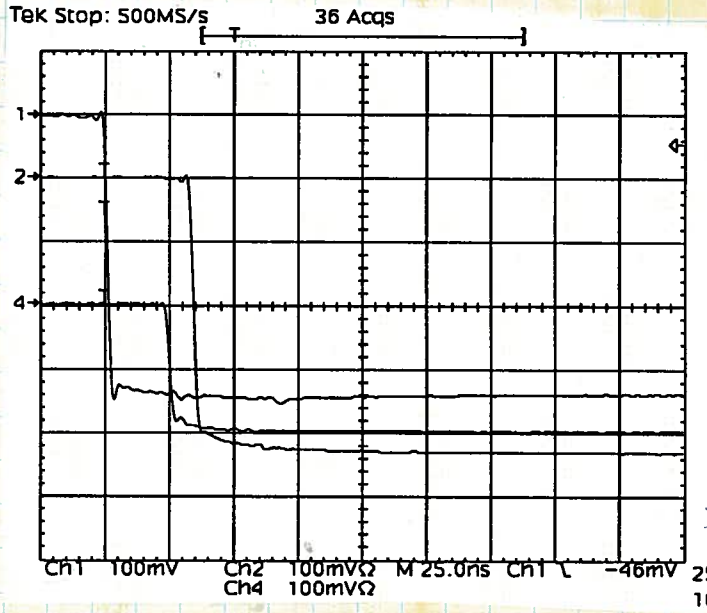

$V_P/V_H = 200/515 = .39$



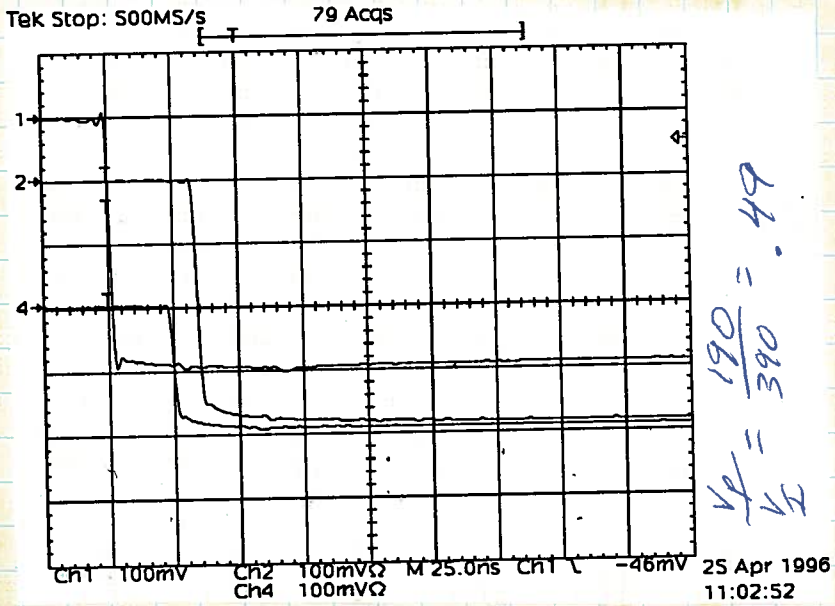

$V_P/V_H = 180/390 = .46$



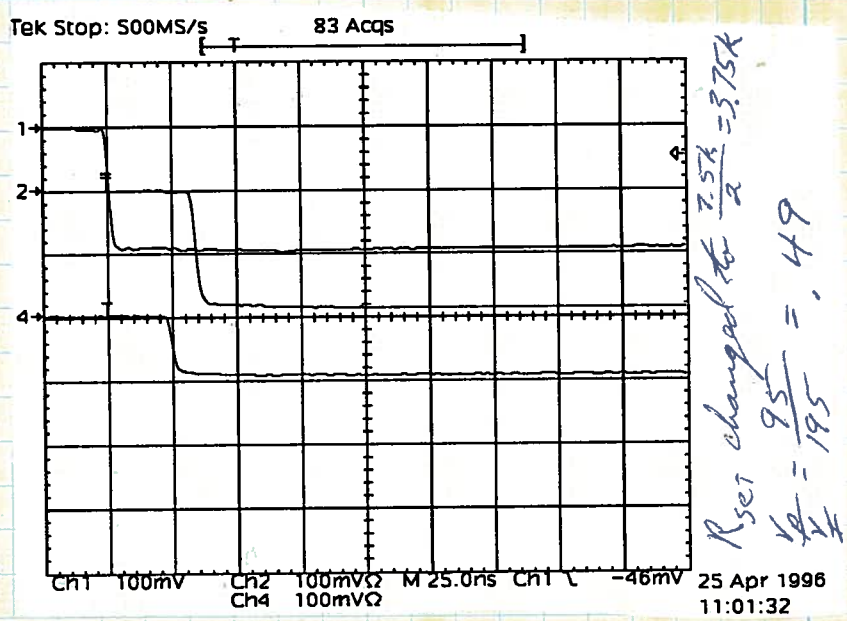

$V_P/V_H = 200/540 = .37$




$V_P/V_H = 200/440 = .45$

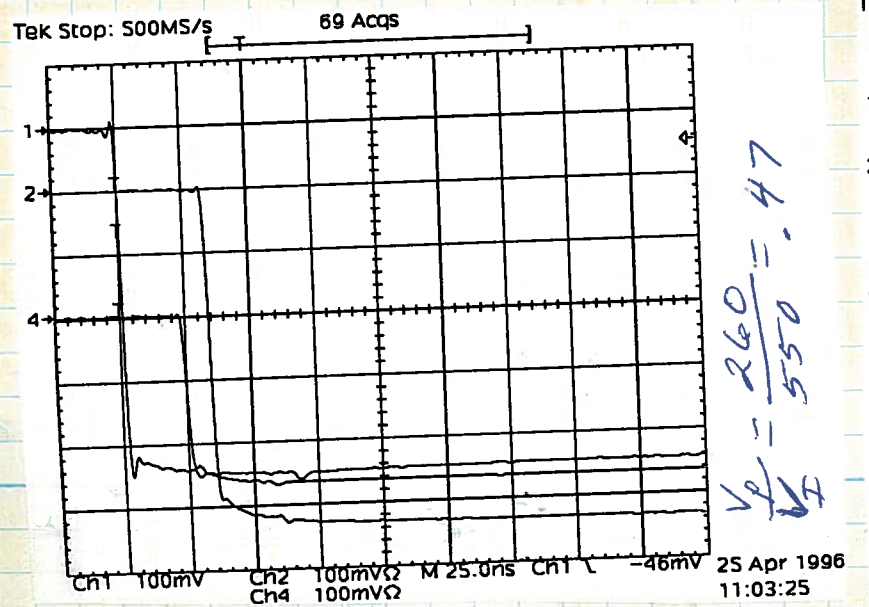



$V_f/V_t = \frac{190}{390} = .49$

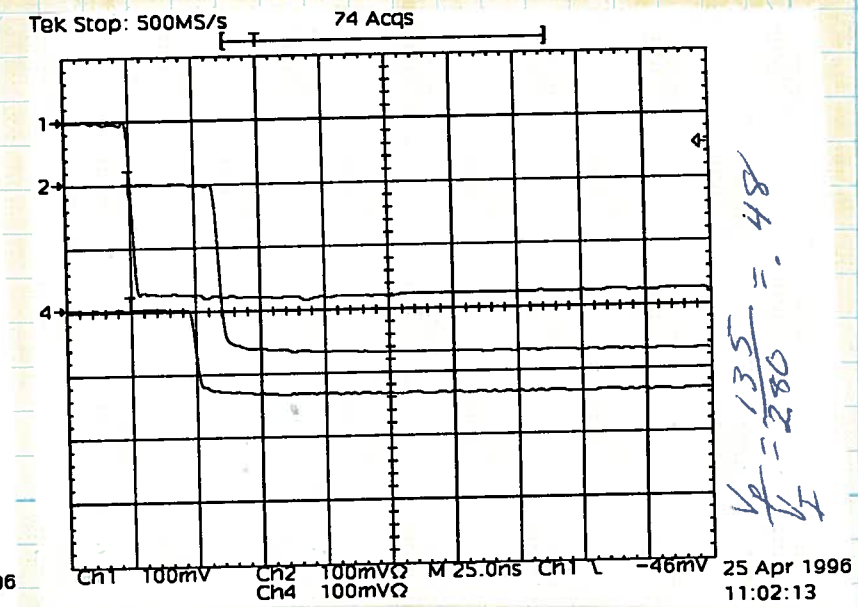



$R_{set}$ changed to $\frac{7.5K}{2} = 3.75K$

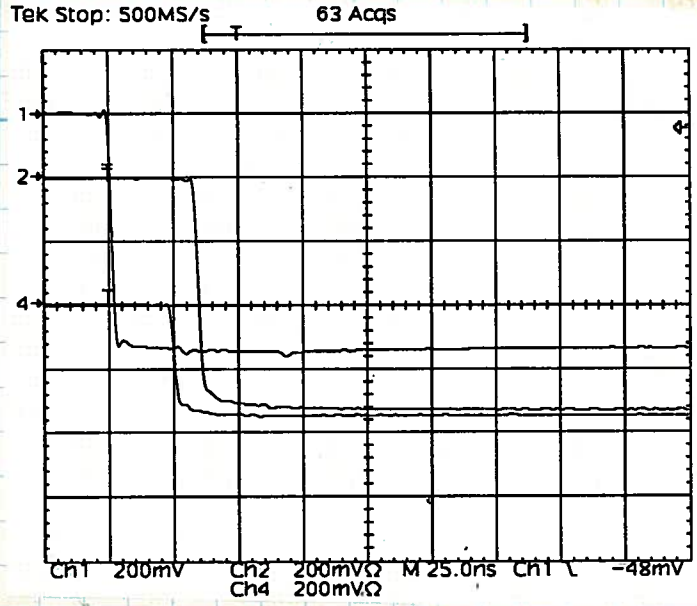
$V_f/V_t = \frac{95}{195} = .49$



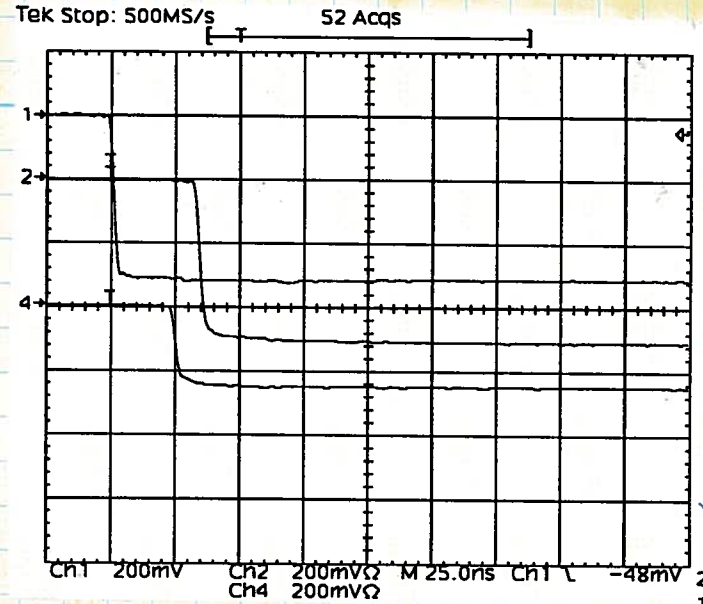

$V_f/V_t = \frac{260}{550} = .47$



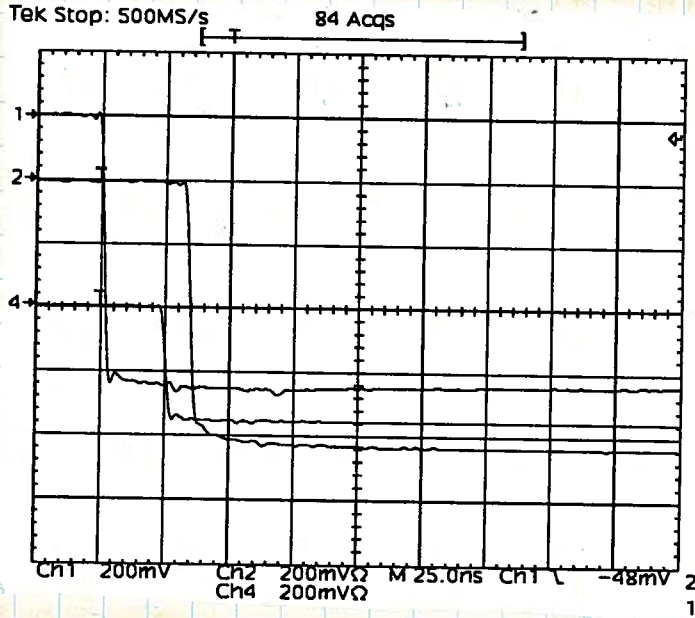

$V_f/V_t = \frac{135}{280} = .48$



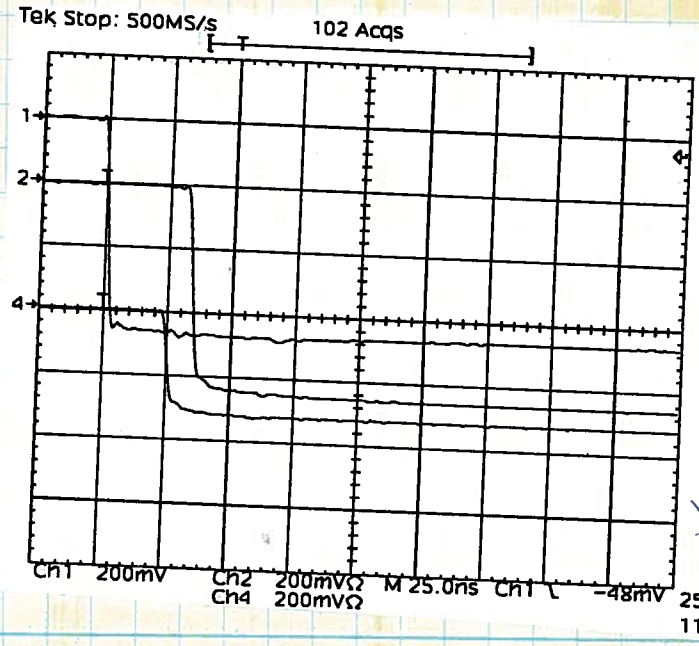

$V_P/V_I = 350/740 = .47$



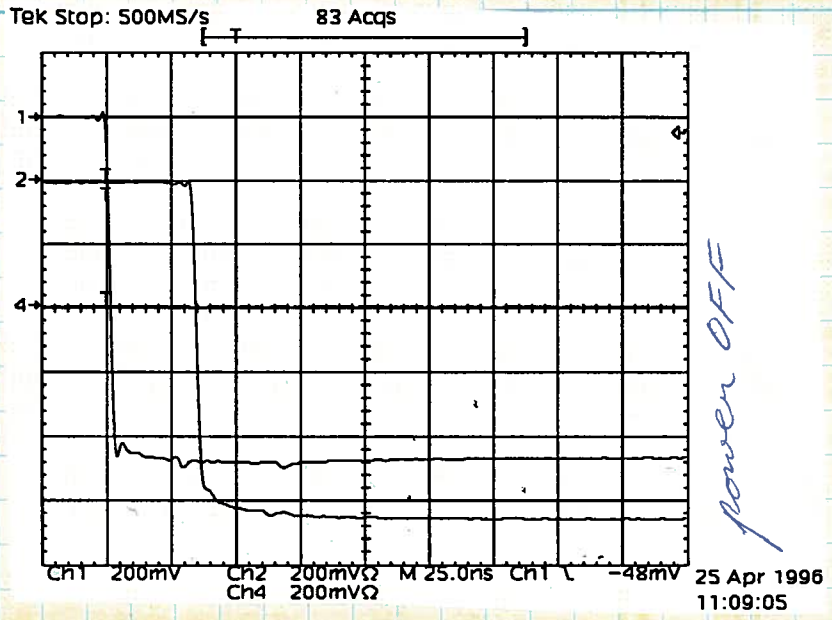

$V_P/V_I = 240/520 = .46$



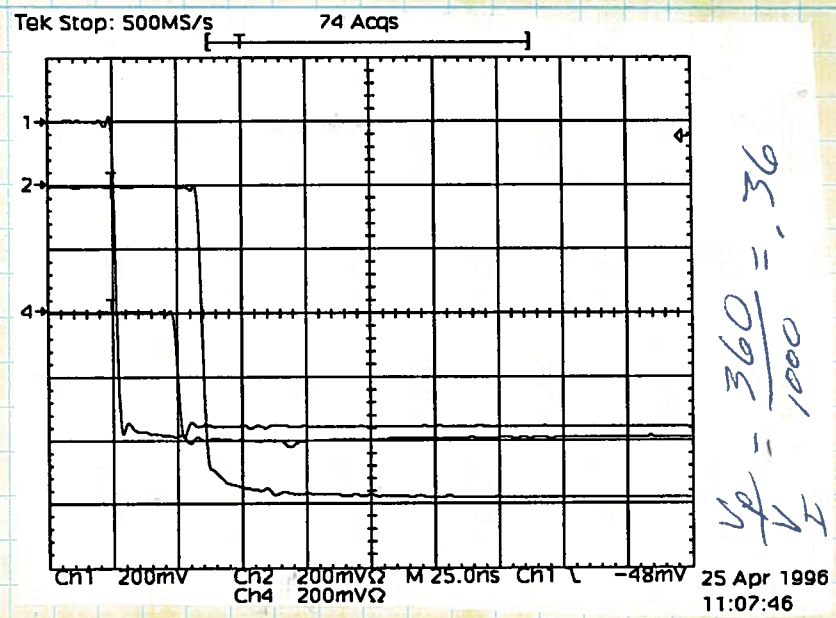

$V_P/V_I = 360/840 = .43$



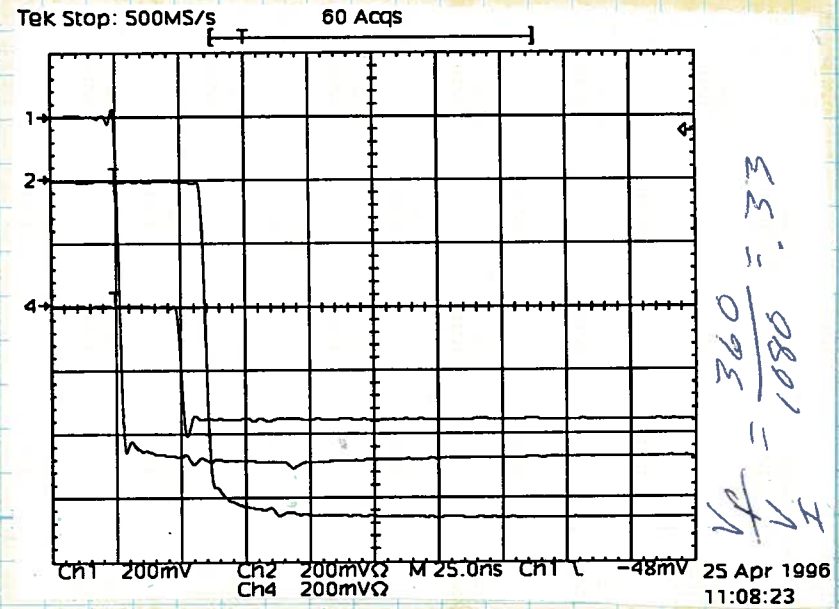

$V_P/V_I = 320/660 = .48$



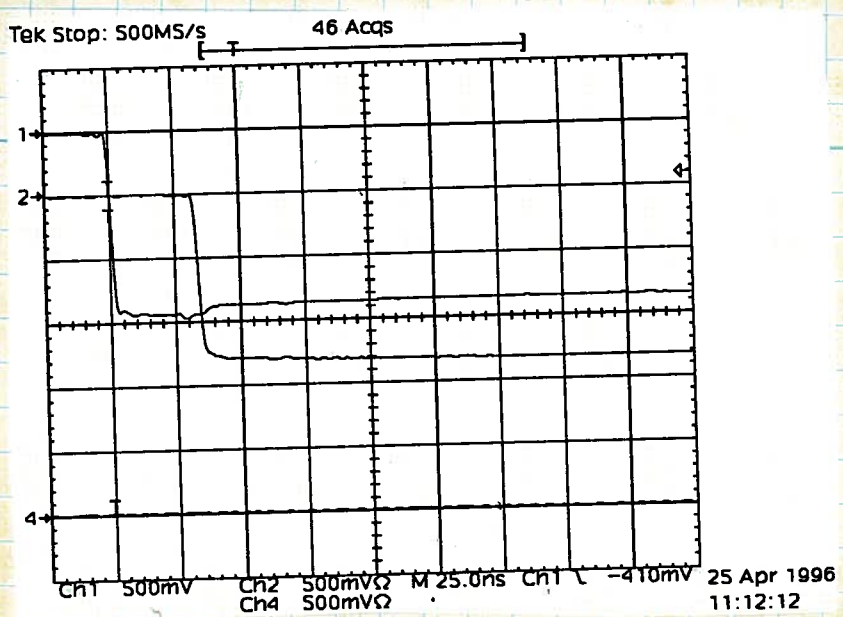

power OFF

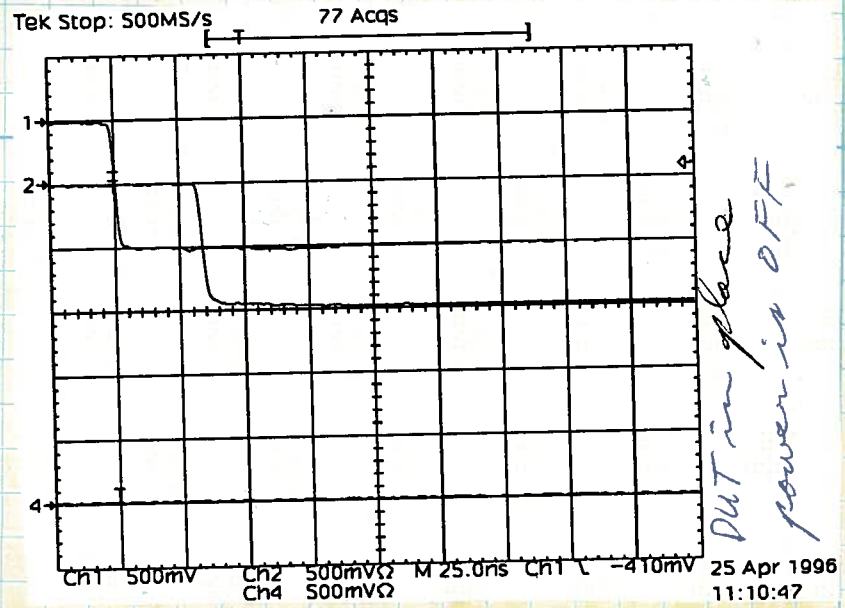



$V_f/V_i = 360/1000 = .36$

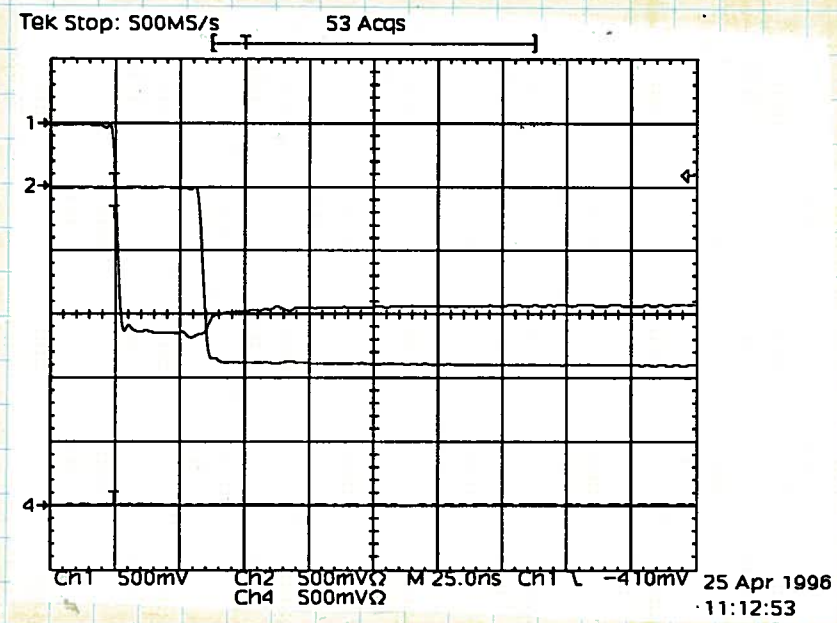


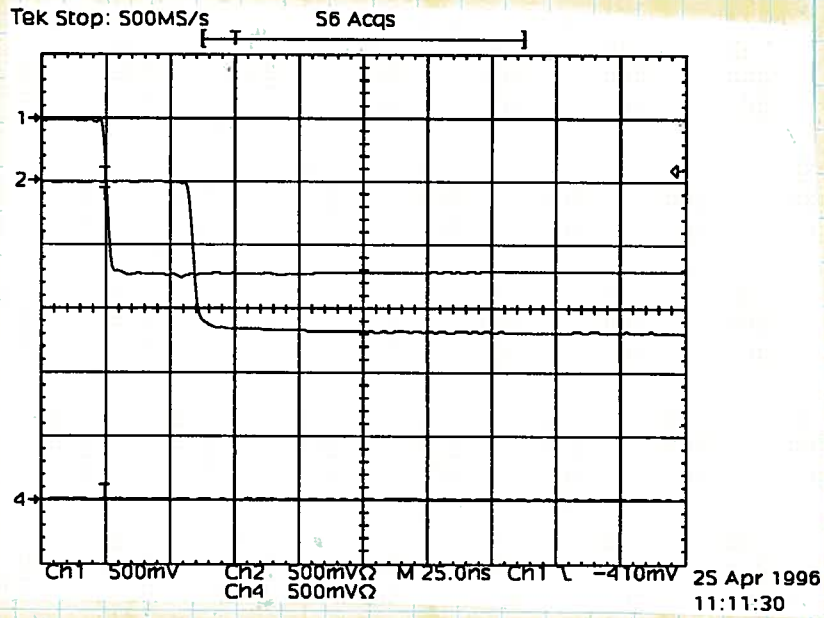

$V_f/V_i = 360/1080 = .33$

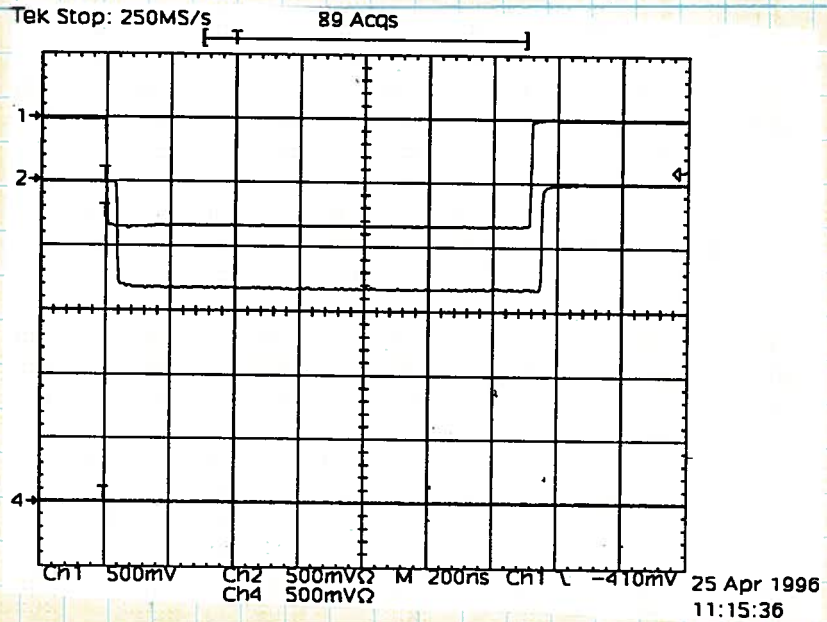


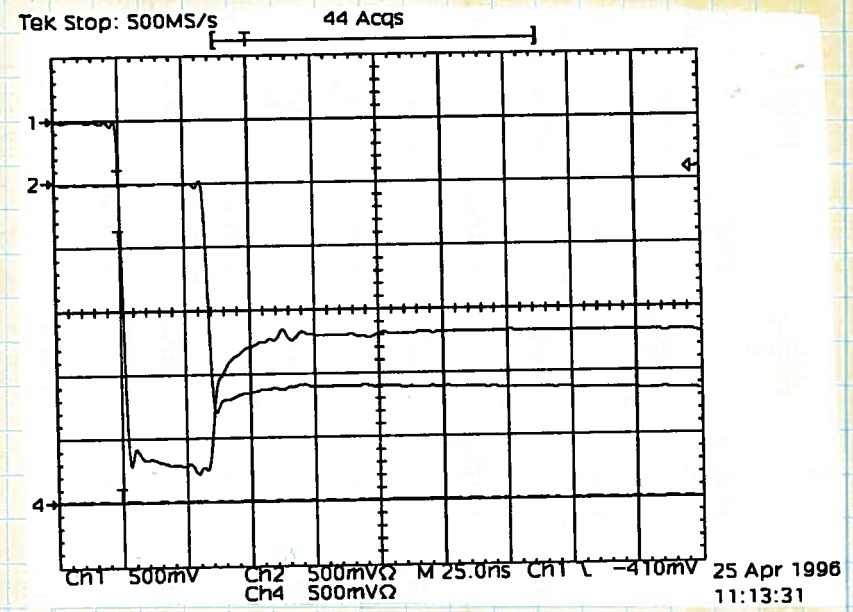



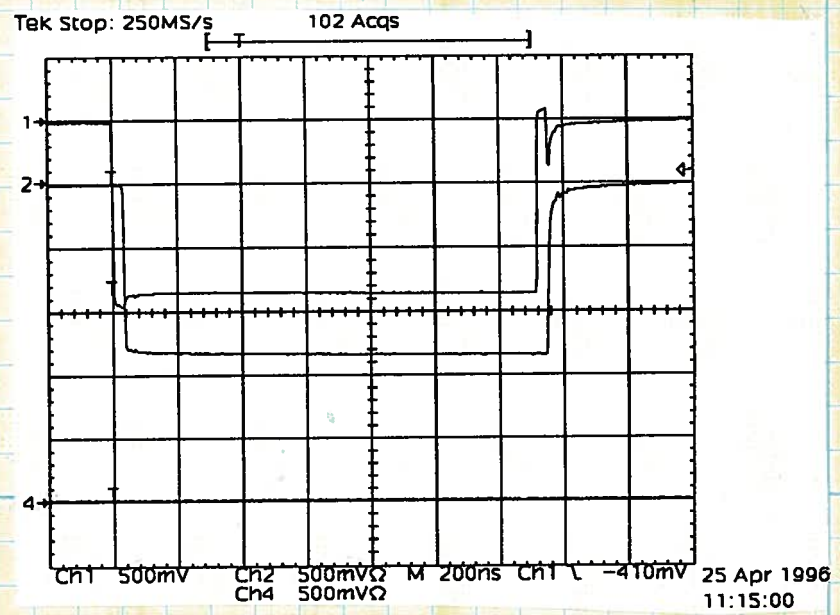

DUT in place
power in OFF

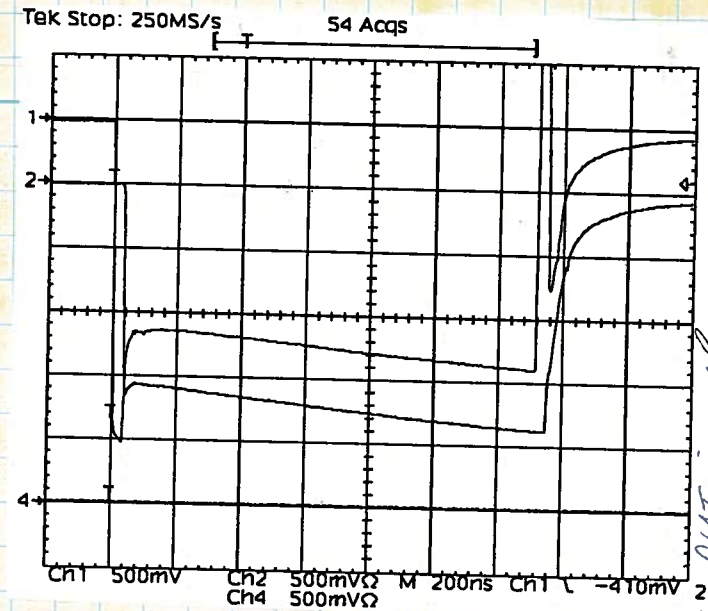


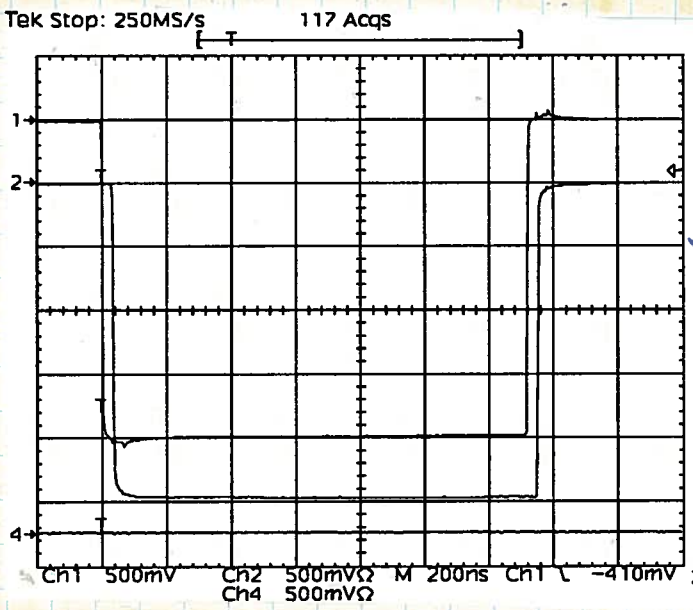

Tek Stop: 250MS/s
89 Acqs
Ch1 500mV Ch2 500mVΩ M 200ns Ch1 ⌊ −410mV
Ch4 500mVΩ
25 Apr 1996
11:15:36


Tek Stop: 500MS/s
44 Acqs
Ch1 500mV Ch2 500mVΩ M 25.0ns Ch1 ⌊ −410mV
Ch4 500mVΩ
25 Apr 1996
11:13:31

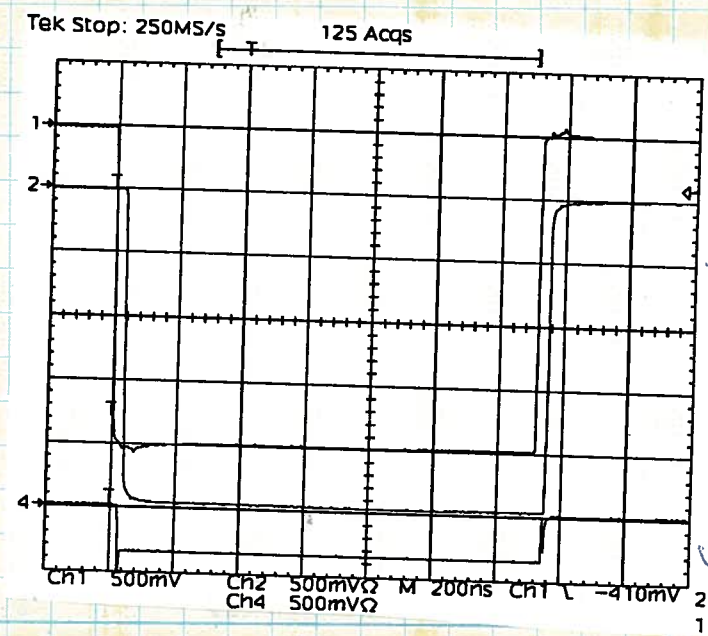

Tek Stop: 250MS/s
102 Acqs
Ch1 500mV Ch2 500mVΩ M 200ns Ch1 ⌊ −410mV
Ch4 500mVΩ
25 Apr 1996
11:15:00




DUT in place
power in OFF



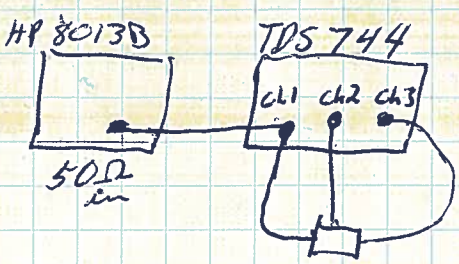

Same except no DUT
barrel connector only



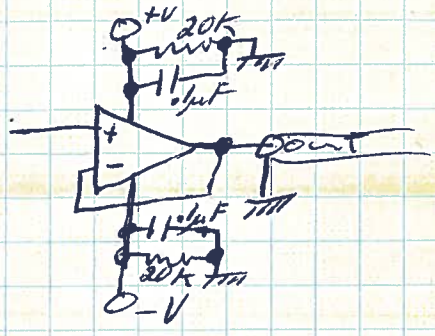

Same except
power in ON

# OPA655 Pickoff for RG-58

5/25




all cables are ~~10~~ ns of RG-58C/U (or something close)




DIP package used

## SPECIFICATIONS

$V_S$ = ±5 V, $V_O$ = ±5V, $R_F$ = 100Ω and $R_L$ = 100Ω, unless otherwise noted; $R_G$ = 0 for G = +1

| PARAMETER | CONDITIONS | OPA655P, U MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|
| **FREQUENCY RESPONSE** | | | | | |
| Closed-Loop Bandwidth | Gain = +1V/V, $V_O$ = 200mVp-p | | 400 | | MHz |
| | Gain = +2V/V, $V_O$ = 200mVp-p | | 185 | | MHz |
| | Gain = +5V/V, $V_O$ = 200mVp-p | | 57 | | MHz |
| | Gain = +10V/V, $V_O$ = 200mVp-p | | 24 | | MHz |
| Gain-Bandwidth Product | | | 240 | | MHz |
| Slew Rate | G = +1, 1V Step | 210 | 290 | | V/μs |
| Over Temperature | | 200 | | | V/μs |
| Rise Time | 0.2V Step | | 1 | | ns |
| Fall Time | 0.2V Step | | 1 | | ns |
| Settling Time 0.01% | G = +1, 1V Step | | 11 | | ns |
| 0.1% | G = +1, 1V Step | | 8 | | ns |
| 0.2% | G = +1, 1V Step | | 6 | | ns |
| Harmonic Free Dynamic Range | G = +1, 1, 5MHz | 75 | 90 | | ns |
| | $V_O$ = 1V, $R_L$ = 100Ω | | | | dBc |
| Differential Gain | 3.58MHz, 0 to 1.4V, $R_L$ = 150Ω | | 0.006 | | % |
| Differential Phase | 3.58MHz, 0 to 1.4V, $R_L$ = 150Ω | | 0.009 | | degrees |
| Bandwidth for 0.1dB Flatness | G = +2, 2Vp-p | | 30 | | MHz |
| **OFFSET VOLTAGE** | | | | | |
| Input Offset Voltage | | | ±1 | ±2 | mV |
| Over Temperature | | | ±10 | | μV/°C |
| Power Supply Rejection (+$V_S$) | $V_S$ = 4.50V to 5.50V | 55 | 70 | | dB |
| (−$V_S$) | | 50 | 65 | | dB |
| **INPUT BIAS CURRENT** | | | | | |
| Input Bias Current | $V_{CM}$ = 0V | | −5 | −50 | pA |
| Over Temperature | $V_{CM}$ = 0V | | | −3.2 | nA |
| Input Offset Current | $V_{CM}$ = 0V | | ±2 | ±50 | pA |
| Over Temperature | $V_{CM}$ = 0V | | | ±3.2 | nA |
| **NOISE** | | | | | |
| Input Voltage Noise | | | | | |
| Noise Density f = 100kHz | | | 20 | | nV/√Hz |
| f = 1MHz | | | 8 | | nV/√Hz |
| f = 10MHz | | | 6 | | nV/√Hz |
| f = 0.1MHz to 100MHz | | | 6 | | nV/√Hz |
| Integrated Voltage Noise, 1MHz to 100MHz | | | 60 | | μVrms |
| Input Bias Current Noise | | | | | |
| Current Noise Density, f = 10Hz to 2MHz | | | 1.3 | | pA/√Hz |
| **INPUT VOLTAGE RANGE** | | | | | |
| Common-Mode Input Range | | ±2.5 | ±2.15 | | V |
| Over Temperature | | ±5 | | | V |
| Common-Mode Rejection | $V_{CM}$ = ±0.5V | 55 | 70 | | dB |
| **INPUT IMPEDANCE** | | | | | |
| Differential | | | $10^{12}$ ∥ 1.2 | | Ω ∥ pF |
| Common-Mode | | | $10^{12}$ ∥ 1.0 | | Ω ∥ pF |
| **OPEN-LOOP GAIN** | | | | | |
| Open-Loop Voltage Gain | $V_O$ = ±2V, $R_L$ = 100Ω | 53 | 58 | | dB |
| Over Temperature | $V_O$ = ±2V, $R_L$ = 100Ω | 50 | | | dB |
| **OUTPUT** | | | | | |
| Voltage Output | $R_L$ = 100Ω, G = +1 | ±3.0 | ±3.4 | | V |
| Over Temperature | | ±2.8 | | | V |
| Current Output | | ±35 | ±60 | | mA |
| Over Temperature | | ±28 | | | mA |
| Short-Circuit Output Current | | | ±140 | | mA |
| Output Resistance | 0.1MHz, G = +1 | | 0.04 | | Ω |
| **POWER SUPPLY** | | | | | |
| Specified Operating Voltage | | | ±5 | | V |
| Operating Voltage Range | $T_{MIN}$ to $T_{MAX}$ | ±4.75 | | ±5.25 | V |
| Quiescent Current | $T_{MIN}$ to $T_{MAX}$ | ±21 | ±25 | ±29 | mA |
| Over Temperature | | | | ±31 | mA |
| **TEMPERATURE RANGE** | | | | | |
| Specification: P, U | | −40 | | +85 | °C |
| Thermal Resistance, $\theta_{JA}$ | | | | | |
| P | | | 100 | | °C/W |
| U | | | 125 | | °C/W |

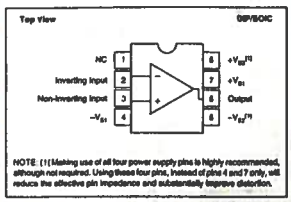




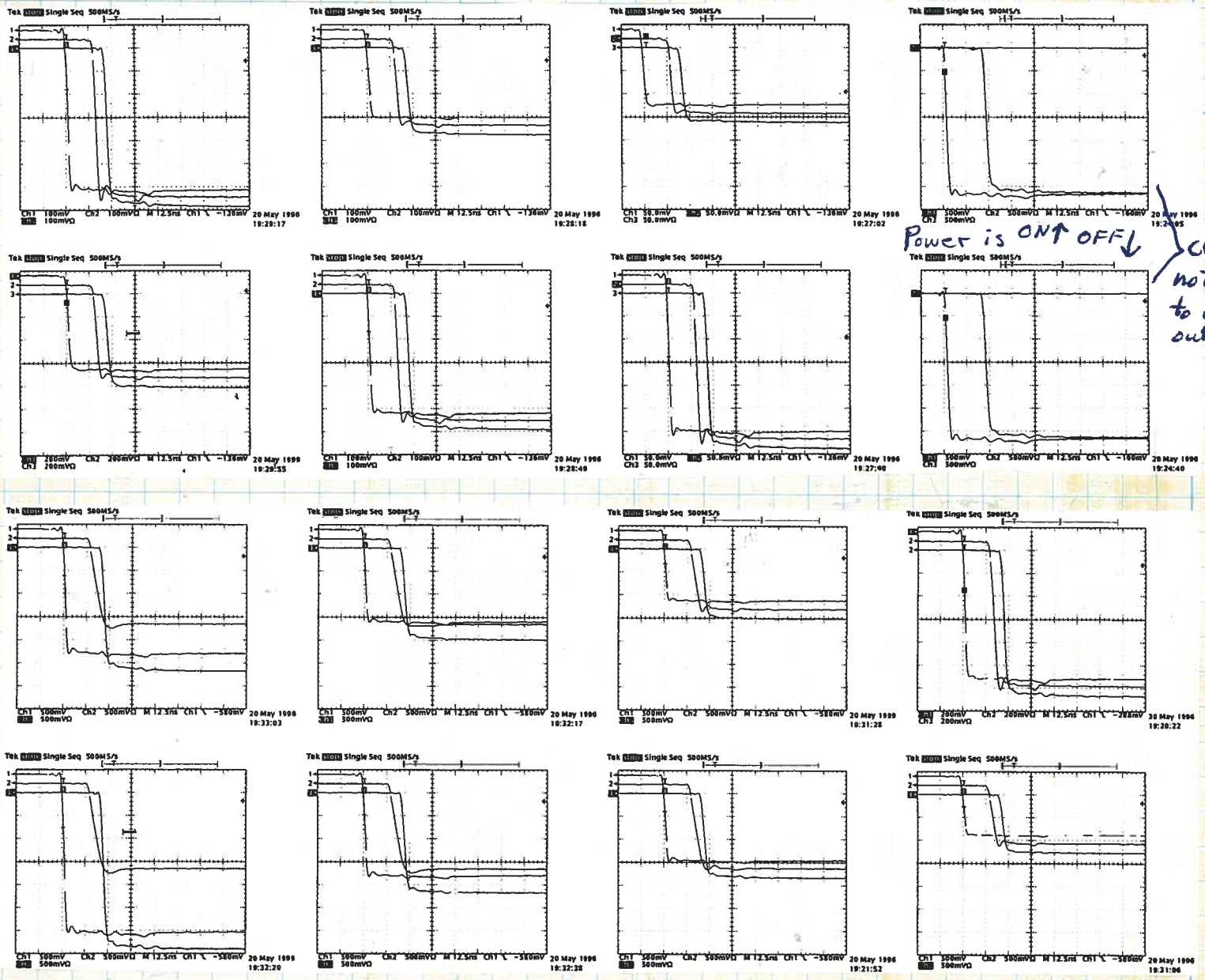
## ABSOLUTE MAXIMUM RATINGS

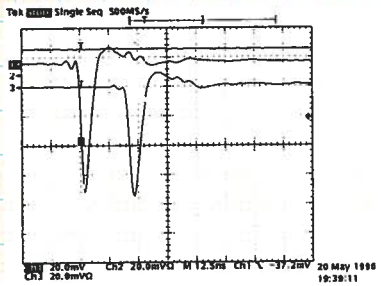
| | |
|---|---|
| Total Supply Voltage Across Device ($V_S$ max) | 11V |
| Internal Power Dissipation | See Thermal Considerations |
| Differential Input Voltage | $V_S$ (max) |
| Common-Mode Input Voltage Range | ±$V_S$ |
| Storage Temperature Range: P, U | −40°C to +125°C |
| Lead Temperature (soldering, 10s) | +300°C |
| (soldering, SOIC 3s) | +260°C |
| Junction Temperature ($T_J$) | +175°C |

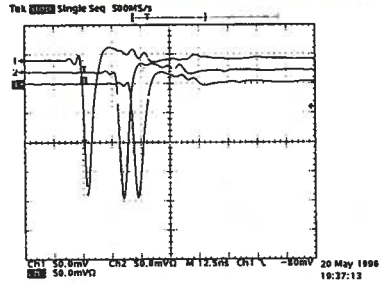
## PIN CONFIGURATION

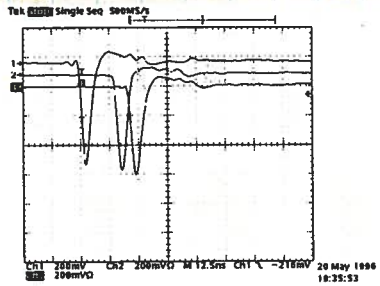


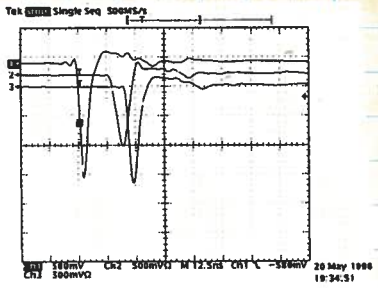

NOTE: (1) Making use of all four power supply pins is highly recommended, although not required. Using these four pins, instead of pins 4 and 7 only, will reduce the effective pin impedance and substantially improve distortion.

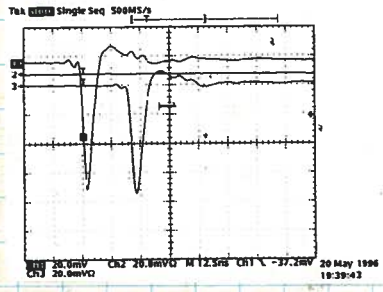

Tek Stop Single Seq 500MS/s
Ch1 100mV Ch2 100mVΩ M 12.5ns Ch1 ∖ -136mV
Ch3 100mVΩ
20 May 1996
19:29:17
Tek Stop Single Seq 500MS/s
Ch1 100mV Ch2 100mVΩ M 12.5ns Ch1 ∖ -136mV
Ch3 100mVΩ
20 May 1996
19:28:18
Tek Stop Single Seq 500MS/s
Ch1 50.0mV Ch2 50.0mVΩ M 12.5ns Ch1 ∖ -136mV
Ch3 50.0mVΩ
20 May 1996
19:27:02
Tek Stop Single Seq 500MS/s
Ch1 500mV Ch2 500mVΩ M 12.5ns Ch1 ∖ -160mV
Ch3 500mVΩ
20 May 1996
19:24:05
Power is ON↑ OFF↓
Ch2 is not connected to amp output
Tek Stop Single Seq 500MS/s
Ch1 200mV Ch2 200mVΩ M 12.5ns Ch1 ∖ -136mV
Ch3 200mVΩ
20 May 1996
19:29:55
Tek Stop Single Seq 500MS/s
Ch1 100mV Ch2 100mVΩ M 12.5ns Ch1 ∖ -136mV
Ch3 100mVΩ
20 May 1996
19:28:49
Tek Stop Single Seq 500MS/s
Ch1 50.0mV Ch2 50.0mVΩ M 12.5ns Ch1 ∖ -136mV
Ch3 50.0mVΩ
20 May 1996
19:27:00
Tek Stop Single Seq 500MS/s
Ch1 500mV Ch2 500mVΩ M 12.5ns Ch1 ∖ -160mV
Ch3 500mVΩ
20 May 1996
19:24:40
Tek Stop Single Seq 500MS/s
Ch1 500mV Ch2 500mVΩ M 12.5ns Ch1 ∖ -580mV
Ch3 500mVΩ
20 May 1996
19:33:03
Tek Stop Single Seq 500MS/s
Ch1 500mV Ch2 500mVΩ M 12.5ns Ch1 ∖ -580mV
Ch3 500mVΩ
20 May 1996
19:32:17
Tek Stop Single Seq 500MS/s
Ch1 500mV Ch2 500mVΩ M 12.5ns Ch1 ∖ -580mV
Ch3 500mVΩ
20 May 1996
19:31:28
Tek Stop Single Seq 500MS/s
Ch1 200mV Ch2 200mVΩ M 12.5ns Ch1 ∖ -280mV
Ch3 200mVΩ
20 May 1996
19:20:22
Tek Stop Single Seq 500MS/s
Ch1 500mV Ch2 500mVΩ M 12.5ns Ch1 ∖ -580mV
Ch3 500mVΩ
20 May 1996
19:32:20
Tek Stop Single Seq 500MS/s
Ch1 500mV Ch2 500mVΩ M 12.5ns Ch1 ∖ -580mV
Ch3 500mVΩ
20 May 1996
19:32:38
Tek Stop Single Seq 500MS/s
Ch1 500mV Ch2 500mVΩ M 12.5ns Ch1 ∖ -580mV
Ch3 500mVΩ
20 May 1996
19:21:52
Tek Stop Single Seq 500MS/s
Ch1 500mV Ch2 500mVΩ M 12.5ns Ch1 ∖ -580mV
Ch3 500mVΩ
20 May 1996
19:31:06

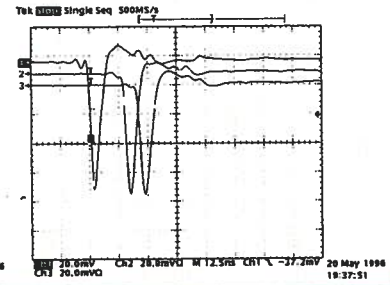

Tek Stop Single Seq 500MS/s
Ch1 20.0mV Ch2 20.0mVΩ M 12.5ms Ch1 ∖ -37.2mV
Ch3 20.0mVΩ
20 May 1996
19:39:11

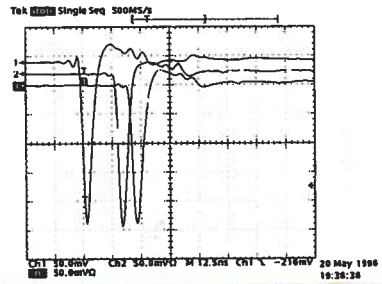

Tek Stop Single Seq 500MS/s
Ch1 50.0mV Ch2 50.0mVΩ M 12.5ms Ch1 ∖ -80mV
Ch3 50.0mVΩ
20 May 1996
19:37:13

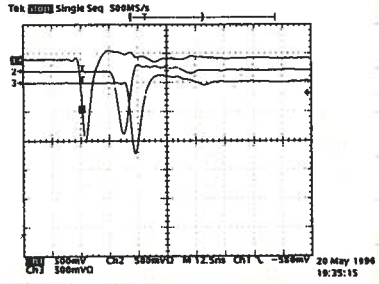

Tek Stop Single Seq 500MS/s
Ch1 200mV Ch2 200mVΩ M 12.5ms Ch1 ∖ -216mV
Ch3 200mVΩ
20 May 1996
19:35:53

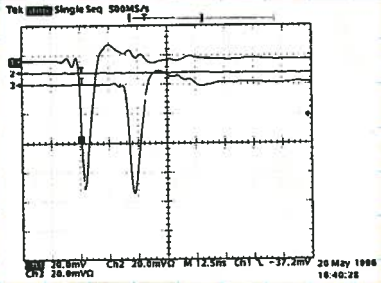

Tek Stop Single Seq 500MS/s
Ch1 500mV Ch2 500mVΩ M 12.5ms Ch1 ∖ -584mV
Ch3 500mVΩ
20 May 1996
19:34:51


Tek Stop Single Seq 500MS/s
Ch1 20.0mV Ch2 20.0mVΩ M 12.5ms Ch1 ∖ -37.2mV
Ch3 20.0mVΩ
20 May 1996
19:39:43


Tek Stop Single Seq 500MS/s
Ch1 20.0mV Ch2 20.0mVΩ M 12.5ms Ch1 ∖ -37.2mV
Ch3 20.0mVΩ
20 May 1996
19:37:51

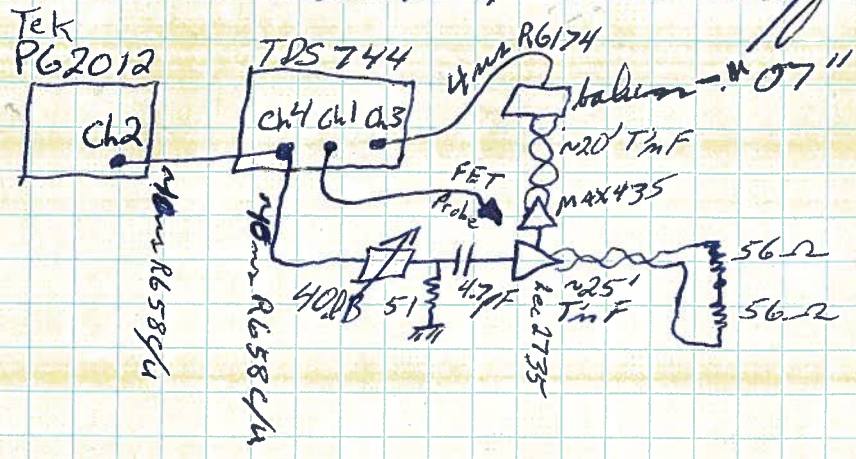

Tek Stop Single Seq 500MS/s
Ch1 50.0mV Ch2 50.0mVΩ M 12.5ms Ch1 ∖ -216mV
Ch3 50.0mVΩ
20 May 1996
19:36:38


Tek Stop Single Seq 500MS/s
Ch1 500mV Ch2 500mVΩ M 12.5ms Ch1 ∖ -584mV
Ch3 500mVΩ
20 May 1996
19:35:15


Tek Stop Single Seq 500MS/s
Ch1 20.0mV Ch2 20.0mVΩ M 12.5ms Ch1 ∖ -37.2mV
Ch3 20.0mVΩ
20 May 1996
18:40:28

5/27 2735DC With MAX435 Pickoff Cards

JA



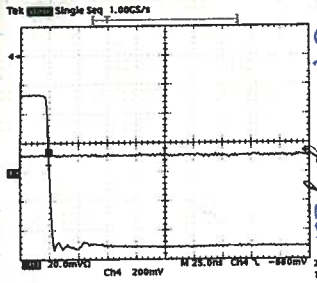

The DC level at the input to the MVL407 on the 2735 is different for channel 1 on the 2735. The offset is approximately 20mV closer to GND than the other 15 channels. This was verified on three other unmodified 2735 cards.

Plots on p. 99 for modified 2735 show smaller DC level difference than I recall seeing. All 3 unmodified cards were similar to labels on lower section of p. 99

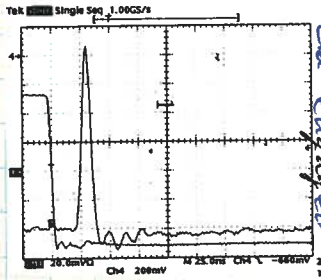
Approximately a 15% reduction in pulse height from the addition of the MAX435.

unmodified 2735 | modified 2735

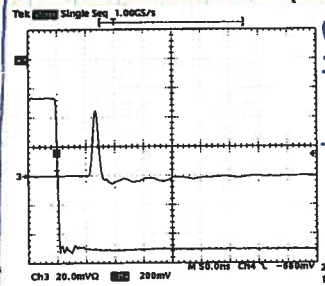
unmodified 2735 ← | → modified 2735



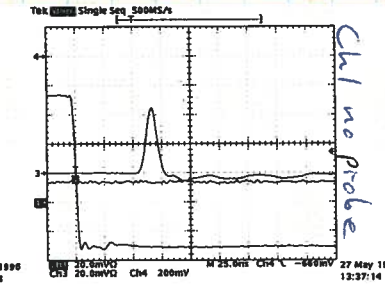

Ch2 probe not engaged



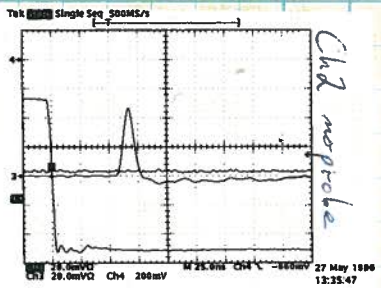

Ch2 probe engaged



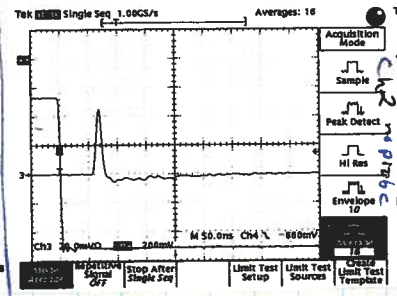

Ch1 no probe



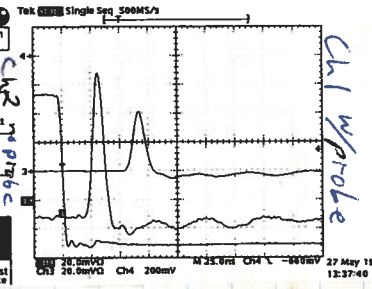

Ch1 no probe



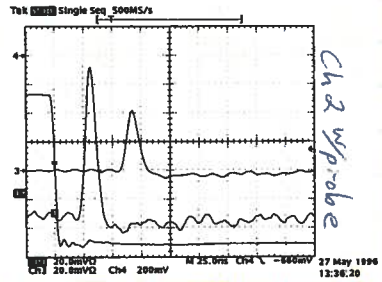

Ch2 no probe



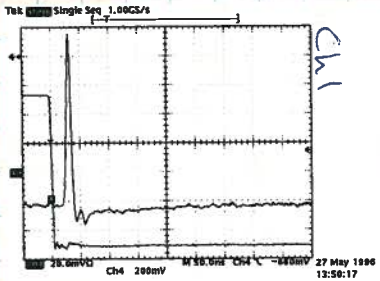

Ch2 no probe



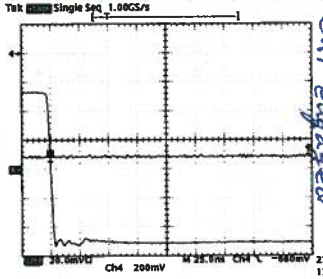

Ch1 w/probe



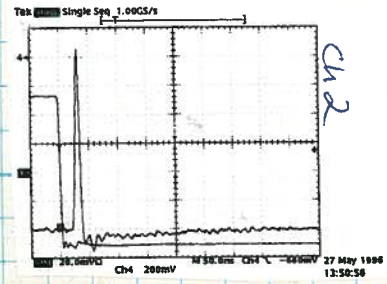

Ch2 w/probe



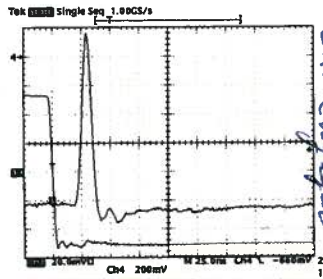

Ch1




Ch1 probe not engaged

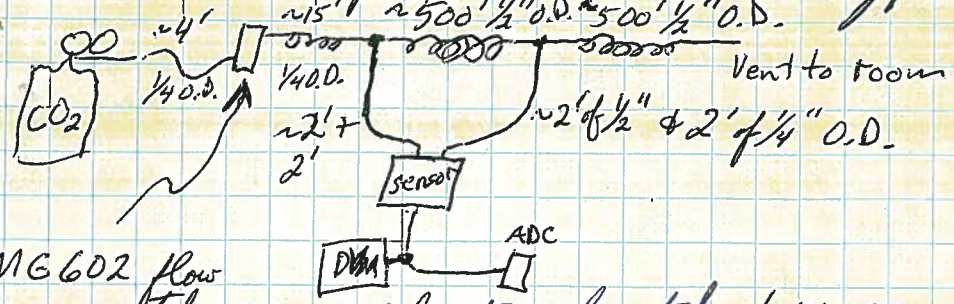



Ch2




Ch1 probe engaged

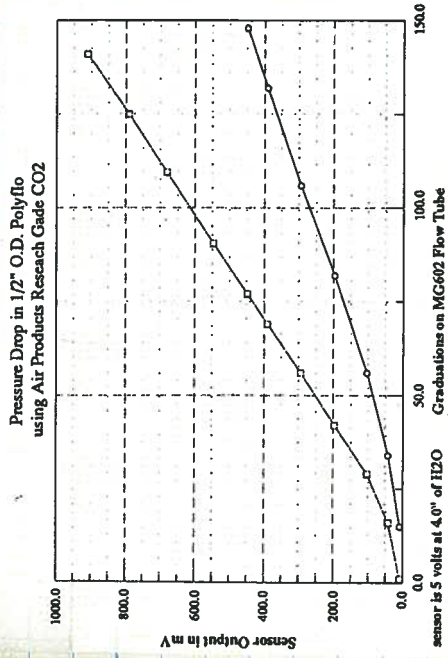
6/15/96 Pressure Drop in 1/2" O.D. Polyflo Tubing
JS

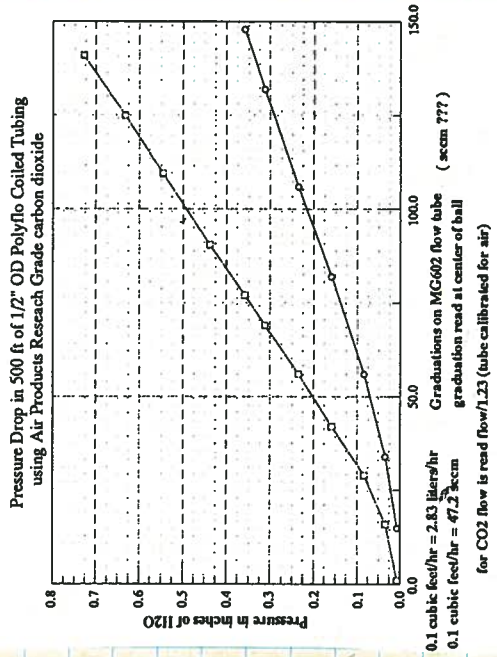



MG602 flow tube

no calibration for tube! JS 6/19

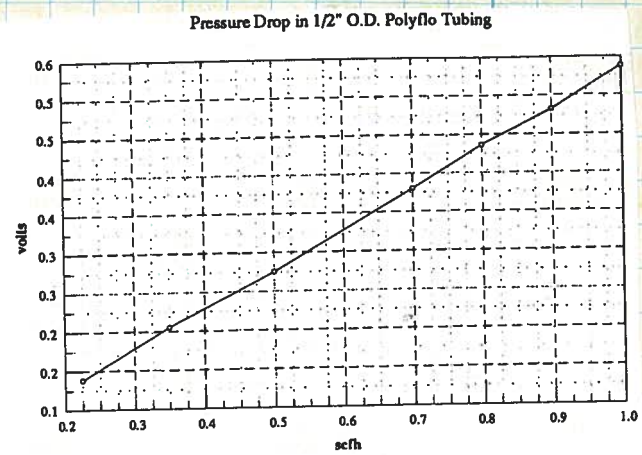
| Black Balls at | Steel Ball at | DVM in mV | |
|---|---|---|---|
| Off | Off | -6 | |
| 15 | 1 | 9 | .0072 |
| 34 | 16 | 43 | .0344 |
| 56 | 29 | 104 | .0832 |
| 82 | 42 | 197 | .158 |
| 106 | 56 | 294 | .235 |
| 132 | 69 | 390 | .312 |
| 148 | 77 | 448 | .358 |
| | 90.5 | 547 | .438 |
| | 109.5 | 681 | .545 |
| | 125 | 790 | .632 |
| | 141 | 910 | .728 |
| | off | -3 | |

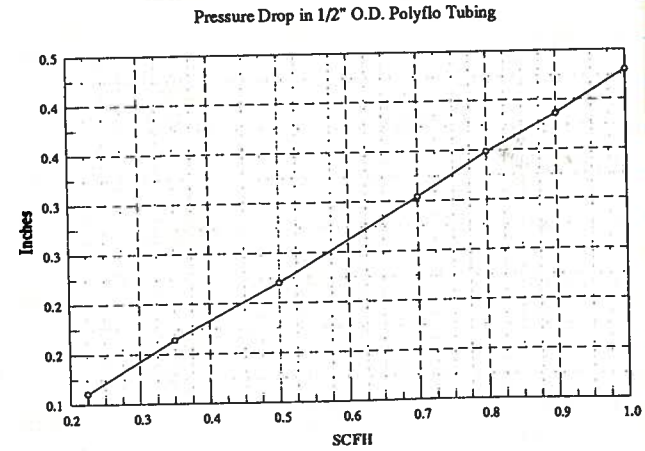


6/19
JH + HCF

Same as on p. 100 except use a Dwyer 0→1 SCFH inexpensive flowmeter.




4.0 inches of pressure gives a 5 volt sensor output

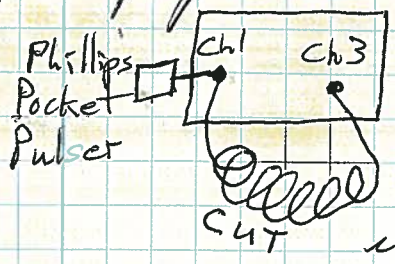
0.1 SCFH = 47.2 sccm

$$\phi = \frac{\pi a^4 \Delta p}{8 \eta l}$$

$\eta$ in g/cm sec  $\Delta p$ in dynes/cm$^2$

(dynes/cm$^2$) × .00040174 = in of $H_2O$

12/23/96 Propagation Velocity of IEEE 802.3 Cables

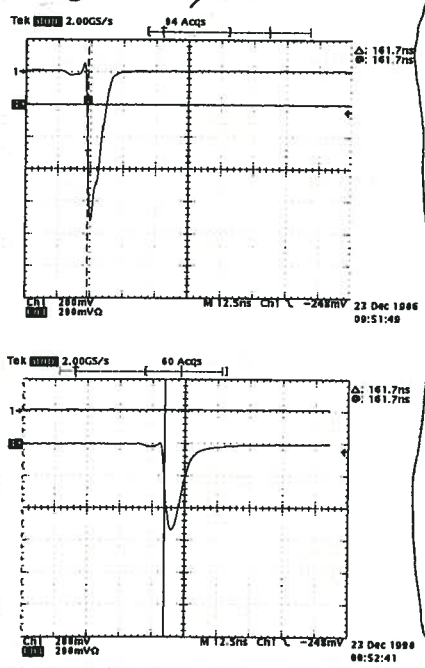



CH1 is at high impedance
CH3 is at 50Ω

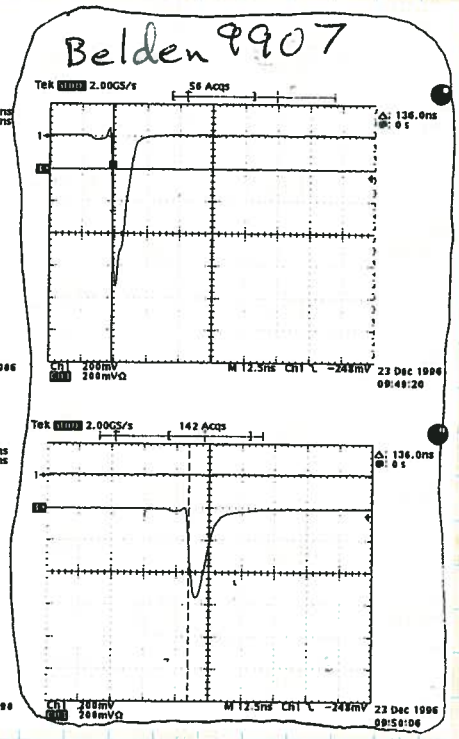
Pocket pulser is plugged into BNC "T" with LEMO to BNC & BNC "M" to BNC "M".

Comparing two 105' cables (carefully cut to length)
one of Belden 9907 and one of Alpha RG-58C/U

RG-58C/U




Belden 9907




105' = 32.004m

2.998E8 m/s

$$v_{prop} = \frac{32.004}{\Delta t}$$

$\frac{1.979}{2.998} = .66c$

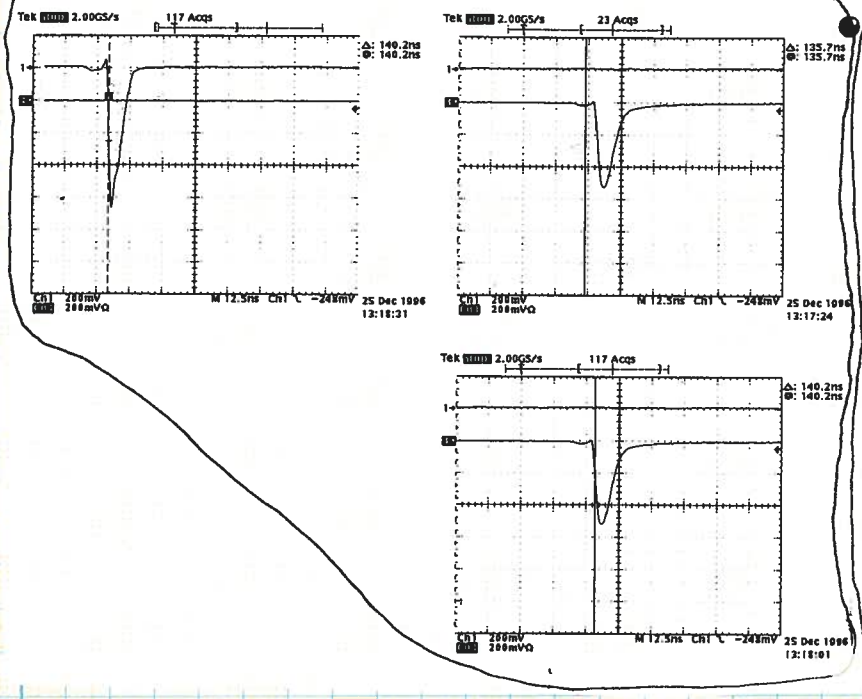
$\frac{2.353}{2.998} = .78c$

More Propagation Velocities of IEEE802.3 Cables 12/25/96

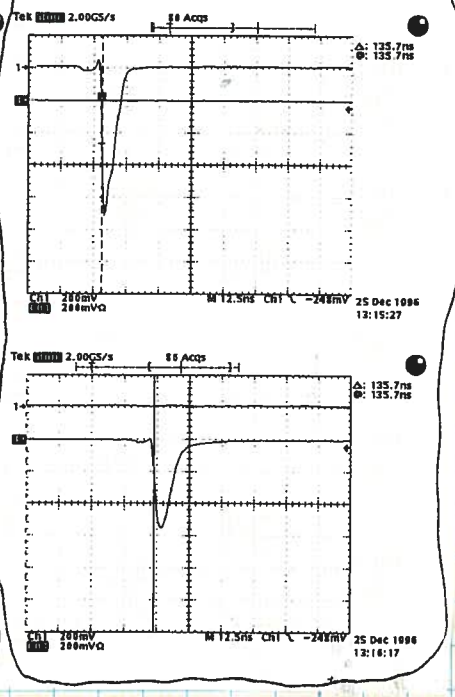
Same setup as on p. 102 JA

One cable is Comscope equivalent to Belden 9907. The other cable is an unknown manufacturer. It has a dark grey jacket.

Grey Jacketed IEEE802.3

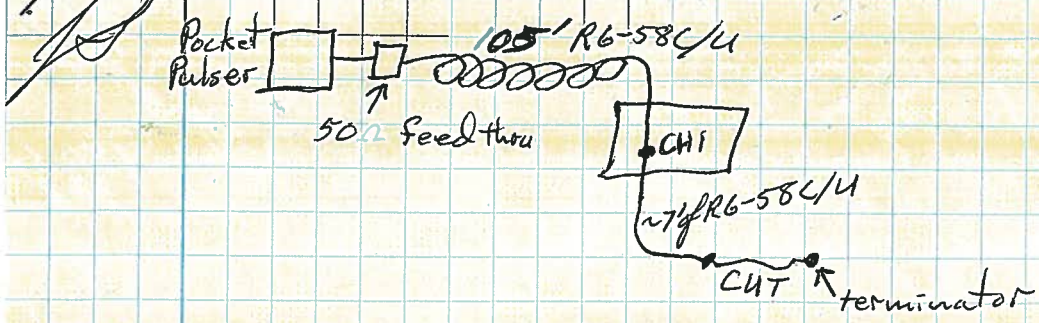



Comscope IEEE802.3




$$\frac{2.283}{2.998} = .76c \qquad \frac{2.358}{2.998} = .79c$$

12/25 Quick Looks At Molex Cable Assembly

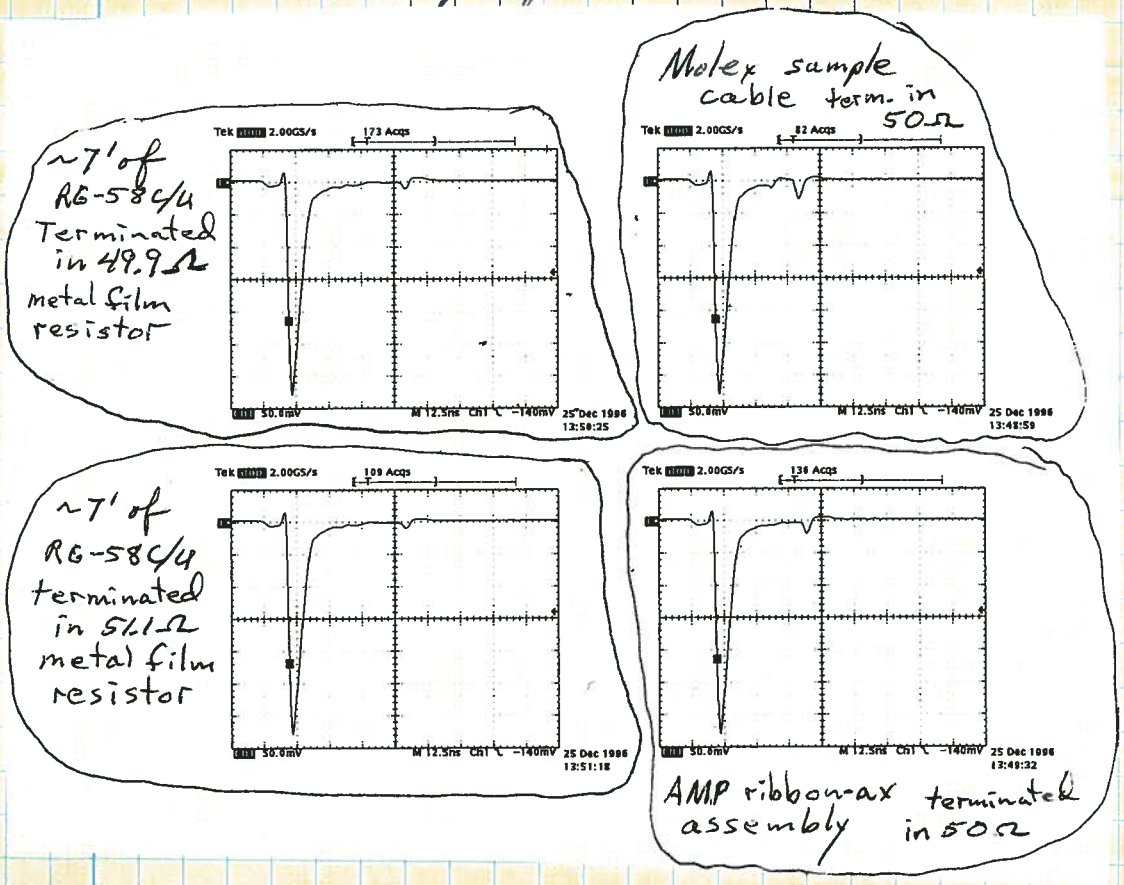



AMP ribbon-ax assembly is one already in use in Hall A

Molex sample is ~3' long with BNC on one end & 2pin connector on the other end. 2 pin connector can be popped in & out of multi-contact housing. Good for trigger?

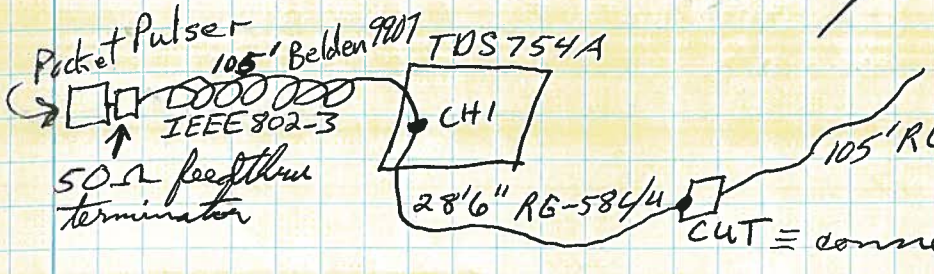
An additional piece of ~7' RG-58C/U was also used for the CUT. Two terminators assembled were tried out

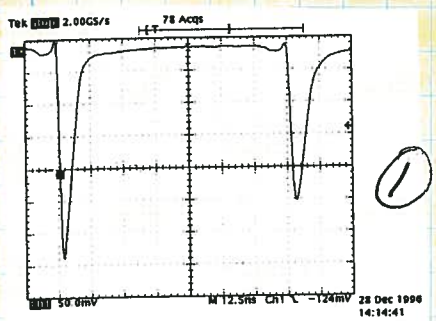
Terminators for miniature coax were the 50Ω 34 contact ones bought for the CAMAC discriminators.



# Further Molex Cable Investigations

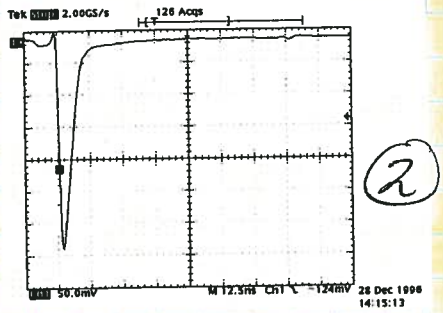
12/28/96



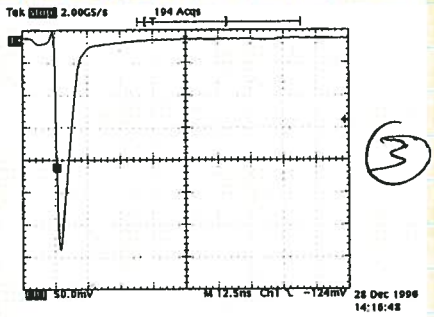

(1)

No cable attached. 28'6" section is open ended.



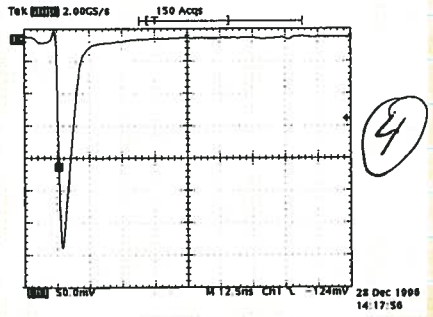

(2)

UG-914/U connector & 105' of cable barrel is marked 91836 UG-914/U



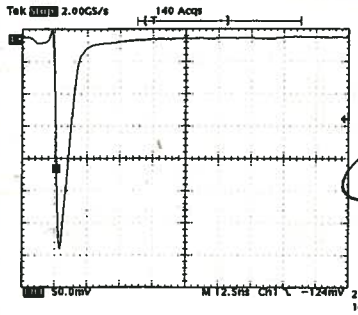

(3)

BNC "T" marked 91836 UG-274A/U & 105'



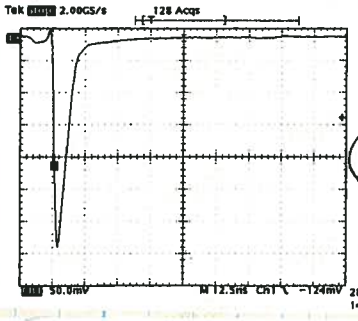

(4)

& 105' Barrel marked M55339/16-00914 91836 759-1



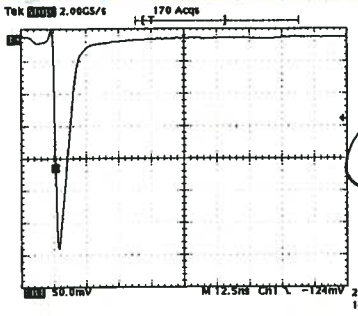

(5)

unmarked commercial grade barrel
&105'



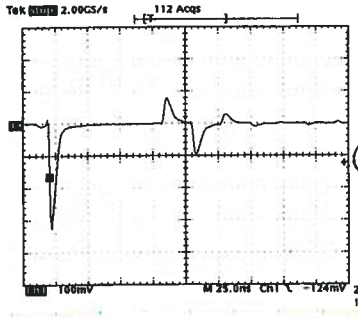

(6)

ATC insulated feedthru used on patch panel & 105'
marked ATC BNC _ _ _ _ _ _
can't read the numbers



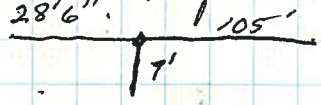

(7)

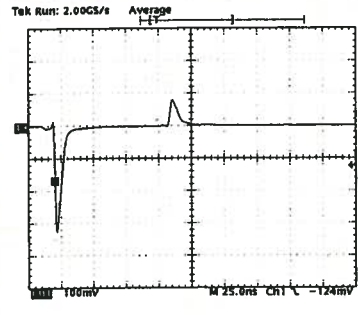
BNC "T" marked 74868 UG-274 A/U
& 105'




(8)

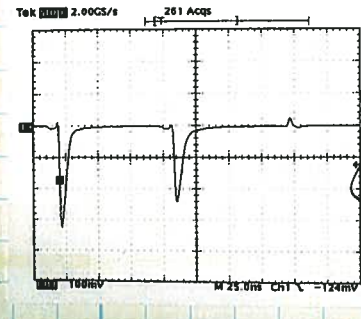
BNC "T" from (3) & 105'
with commercial grade barrel (5) &
7' of RG-58 C/U unterminated



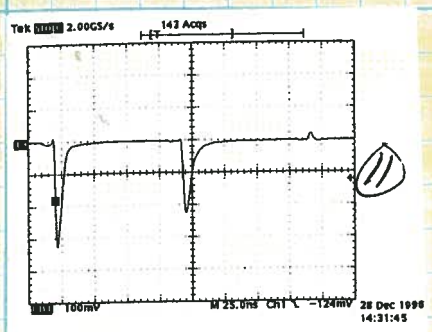

(9)

same as (8) except 7' section is terminated with 51.1 Ω based on p. 104



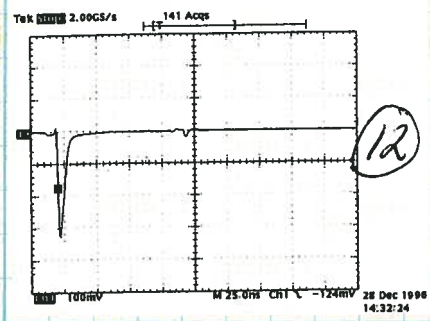

(10)

cable disconnected as in (1)



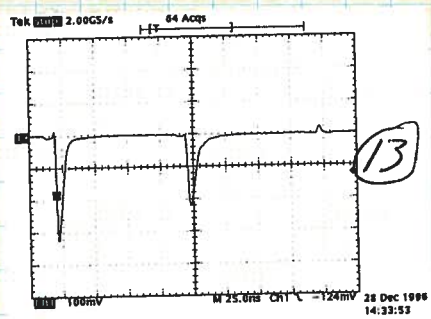

(11)

with Molex cable assembly attached and unterminated.



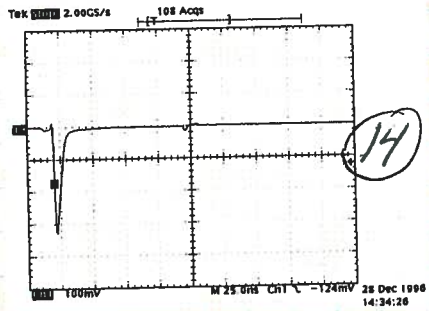

(12)

same as (11) except 50Ω terminator in place




(13)

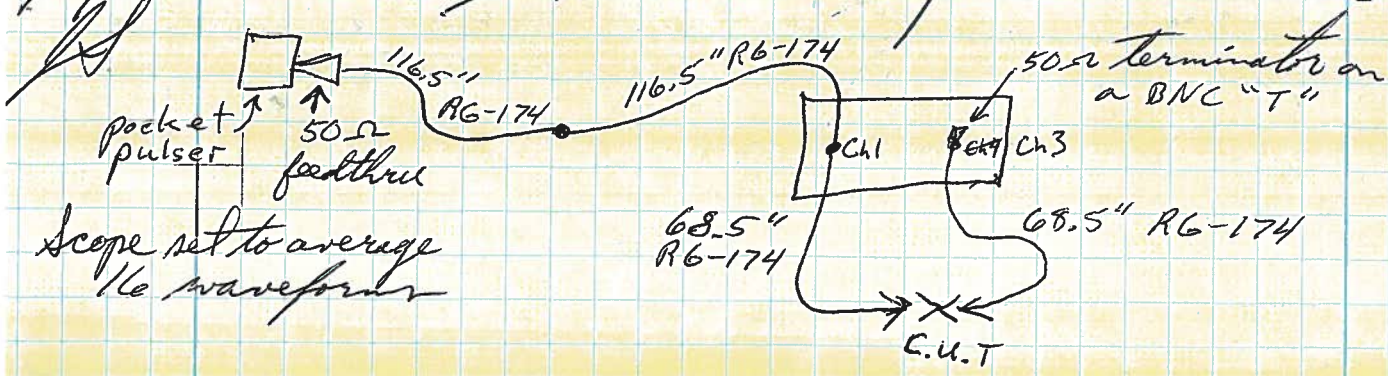
with AMP ribbonax assembly attached and unterminated.



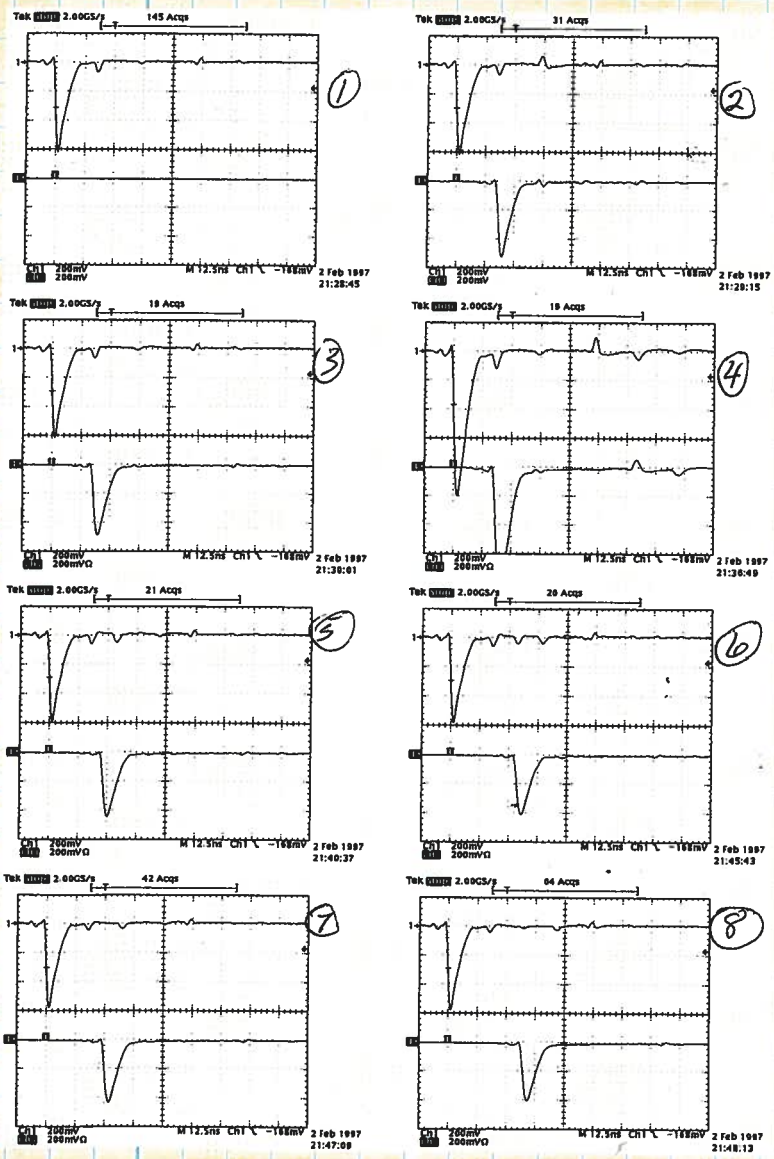

(14)

same as (13) except 50Ω terminator is in place

# 2/2/97 Meritec & 3M Molex RG-178 Impedance Match




Scope set to average 16 waveforms




① "T" not connected to Ch3

② Ch3 @ 1MΩ & terminator on "T"

③ Ch3 @ 50Ω internal

④ Ch3 @ internal 50Ω feedthru removed

Will use 50Ω feedthru and internal terminator

⑤ longest Meritec cable is CUT

⑥ ⑦ & ⑧ are a bit confused. My notes show 4 waveforms. Apparently I didn't save one to disk. My notes show;

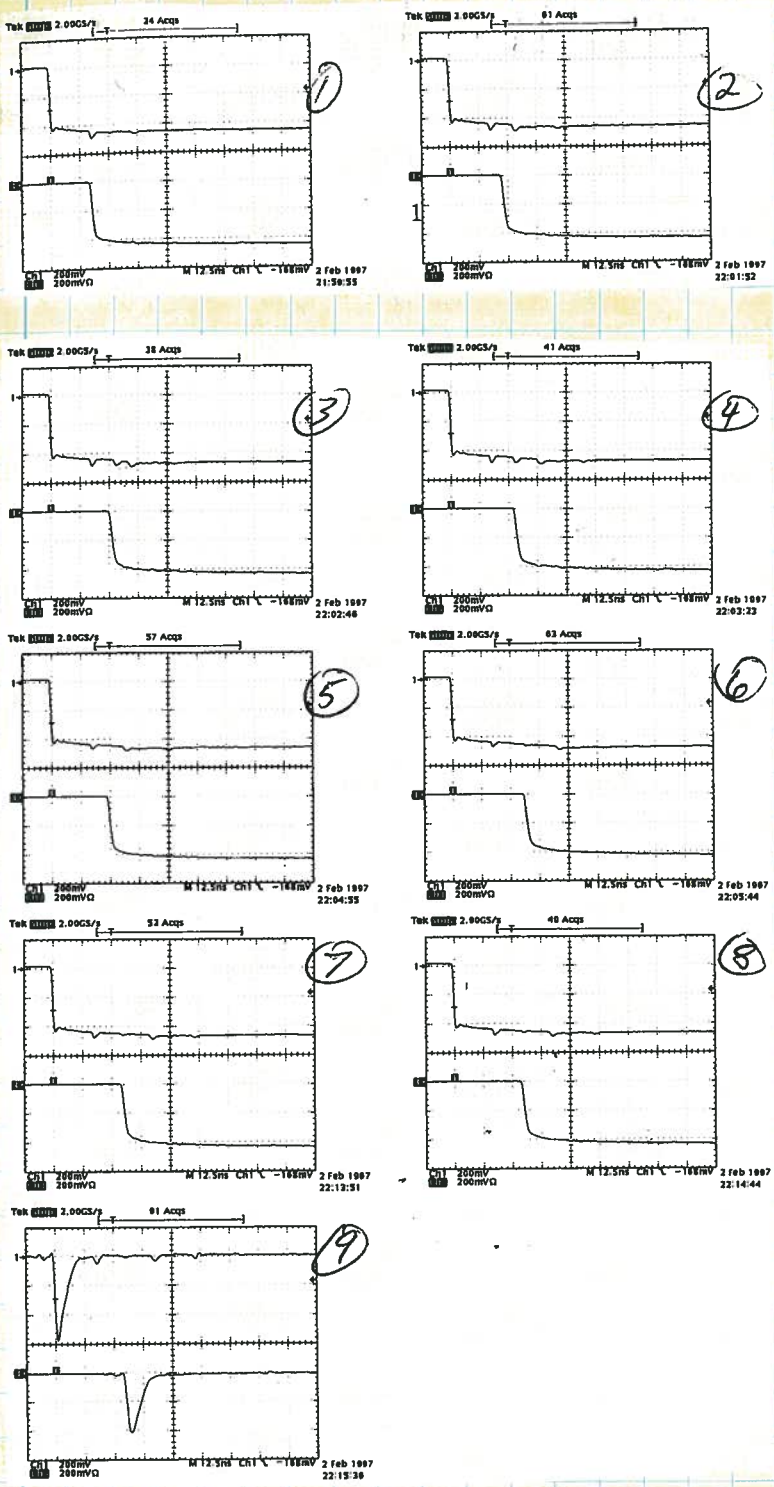
longest + one of the other two

longest + one more longest

CUT is one of Molex

one of Molex + one of Molex

Pocket pulser & 50Ω feedthru replaced by Tektronix PG2012.




① CUT is only 2 pin connector/jumper/splice (whatever)

② CUT is one of longer Meritec cable

③ CUT is one of longer Meritec + 1 of shorter Meritec

④ CUT is two of longer Meritec

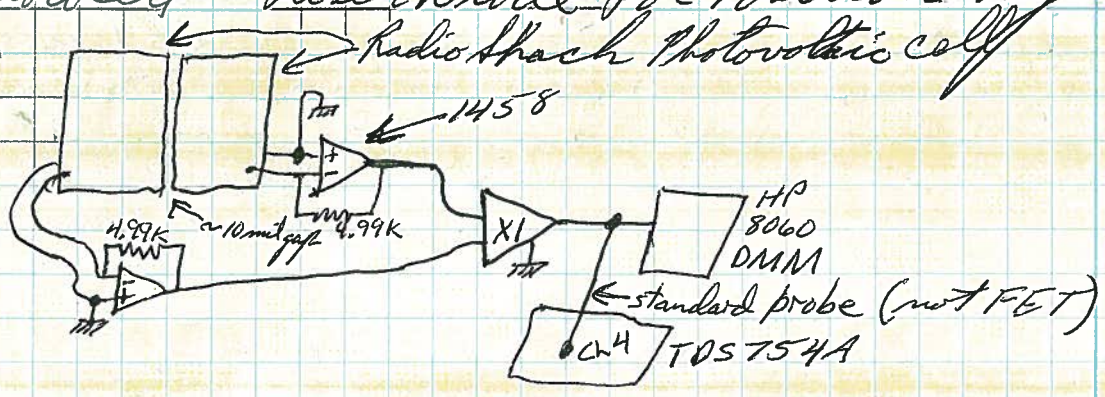
⑤ CUT is one of Molex assemblies

⑥ CUT is two of Molex assemblies

⑦ & ⑧ are the same setup (I hit Hardcopy twice) CUT is 2 sections of AMP ribbon-ax. BNC ends are joined with a BNC barrel. Used lines 2 & 16 of cable.

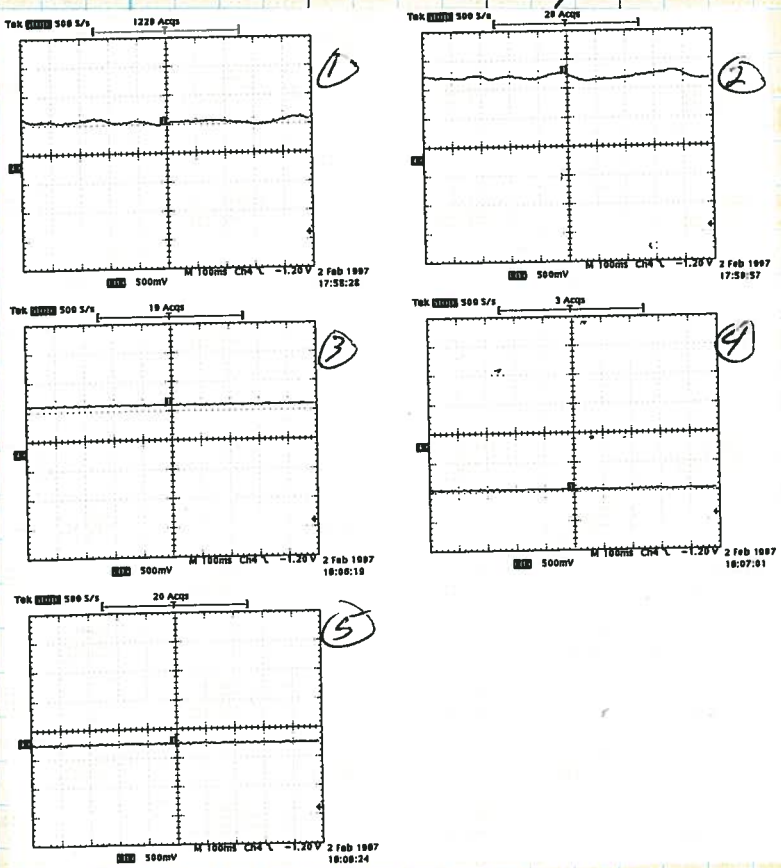
⑨ same as ⑧ except PG2012 replaced by pocket pulser & 50Ω feedthru

2/3/97 Photocell - Laser Diode For Positioning




Laser pointer gave some erratic results yesterday. I brought in the laserdiode from P-134 off Lab Technique I. That gave stable results, but a much lower output signal.

The two upper pictures are of the laser pointer approximately centered between the two cells. ~20 feet away. The pointer was on for ~5 minutes before picture taken.




(3) is APC driver & diode ~1/2" in front of left side cell

(4) is APC driver & diode ~1/2" in front of right side cell

(5) is APC driver & diode ~centered between the two cells

Radio Shack Photovoltaic Cell 2/8

Photocell exposed to room light in Rm 122 provided about ~.33 mA (measured with Tenma 72-060 DMM. An inexpensive one)

~1.35 mA of current when Radio Shack LX1000 pointer is shined from 11 3/4" away. Made sure dot fell between 2 of the metal stripes on the front side.

~1.35 mA from 2" away

~.09 mA with white 5 1/2" deep, 3" ID PVC pipe covering the photocells

2/15/97 Coherent Instruments Div. Laser Diode

Part # 0220-999-00
SYS, VLM2-1RL 1mW 670nm

@ ~5.2V supply, diode module draws 64mA. After current is increasing with time. Seems to be a temperature dependence. Wrapping my hand around the module makes the current increase faster.
Current is at 68.3mA
Removing my hand and blowing on the module drops the current to ~67.8mA.
Current increases again after I stop blowing

Connect Radio Shack photovoltaic cell to Fluke 8060A DMM.
Ambient light gives .344mA
Laser @ 5V gives .800mA. Light strikes a metal stripe. After a few minutes it reads .806mA
Moving the spot around the maximum current is .818mA and minimum is .805mA
Current remains @ .806mA while voltage on module is increased to 9V

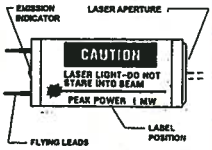
**ALS®**
APPLIED LASER SYSTEMS

Visible Laser Module (VLM™):
User Safety Precautions and Instructions

SAFETY PRECAUTIONS:

1. This product is classified as a Class II laser according to CDRH standards.
2. Since a laser beam can be damaging to the eyes, DO NOT look into the laser aperture when the laser is in operation. The emission indicator shows when laser is on.
3. Be aware that laser light can also be dangerous when reflected off a mirror-like surface.
4. For further safety information regarding lasers, refer to ANSI-Z136.1 STANDARD FOR THE SAFE USE OF LASERS, available from the Laser Institute of America, Tel (407) 380-1553.
5. CAUTION - Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous laser light exposure.


PULSED VERSION — CONTINUOUS VERSION




(MANUAL P/N 430-99032-001 REV C)

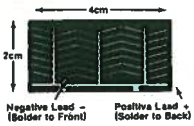
(continued on other side)

USER INSTRUCTIONS:

1. Electrical connection to the VLM™ is made through the red lead or the outside of the module (+) and the black lead or the end of the module (-). For safety reasons DO NOT permanently attach unit using alligator clips. The VLM™ has reverse polarity protection.
2. A voltage source of 5 to 10 VDC must be used. An adapter socket to supply power to the VLM™ is available. Contact your dealer for details.
3. CAUTION: The VLM™ contains a device sensitive to static and large transient spikes. If these spikes exceed 35 V, the VLM™ may be damaged.
4. DO NOT attempt to solder wire to the body or back of the VLM™. This will void the warranty and possibly damage the device.
5. POWER SUPPLIES: The VLM™ may be powered by either battery or line supplies. To avoid warranty questions: if line supply is used, ALS recommends that a pre-regulator, typically a 7805 or equivalent, be connected between the power supply and the VLM™ to filter out any transients. While recommended operating voltages for the VLM™ are between 5 VDC & 10 VDC, the VLM™ runs cooler and more efficiently at lower voltages.
6. SWITCHES: Any switch used in conjunction with a battery must have a low enough resistance to assure at least 5 VDC measured at the VLM™. If the battery is small, a momentary switch is best; however, with a 9 V battery a rocker or slide switch could be used.
7. Your VLM™ carries Applied Laser Systems' two-year limited warranty. You must fill out and return the Product Registration Card enclosed. The VLM™ contains no external controls, housing access or user serviceable items. If a failure occurs, DO NOT try to open or otherwise enter the VLM™; doing so will void the warranty. Simply call Applied Laser Systems at (503) 474-6560 and ask for a Return Authorization Number. Package the VLM™ and return it along with your Return Authorization Number to:

**ALS®**
APPLIED LASER SYSTEMS
ATTN: Customer Service
2160 NW Vine Street
Grants Pass, OR 97526 USA
Tel: (503) 474-6560
FAX: (503) 476-5105

FRONT VIEW




A solar cell is a silicon semiconductor device which converts light energy directly into electricity. A typical 2 x 4cm cell will produce 0.45 volt and up to 0.275 amp of usable current. The power generated is affected by the load resistance (circuit powered by cell), strength of sunlight and temperature.

*Be extremely careful when soldering leads.* Use only a very fine wire (#28 or thinner) and use a small soldering iron (less than 50 watts). Solar cells may be connected in series to produce more voltage and in parallel to produce more current.

**Absolute Maximum Ratings**
Voltage (short circuit): 0.55V
Current (short circuit): 0.3A
Test conditions: Full sunlight at noon on a clear day at 25°C (78°F)

276-124

Assembled in U.S.A.
With Domestic and Foreign Components
Custom Packaged in USA for Radio Shack
A Division of Tandy Corp., Fort Worth, TX 76102

# Quick Look at Sensitivity of Laser Positioning

3/23/97

Using laser and photocells from p. 112

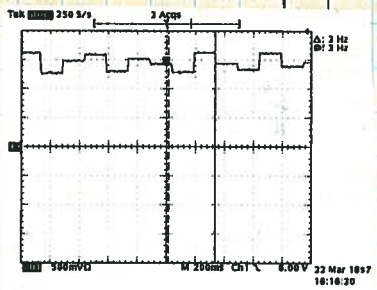
Setup laser and photocells at opposite end of the light table in rm 122. ~8'6" apart. Spot size on photocells is 3-4mm in diameter

The output of the photovoltaic cells is fed into the sample and hold circuit. This gives the difference of the two cells and background subtraction.

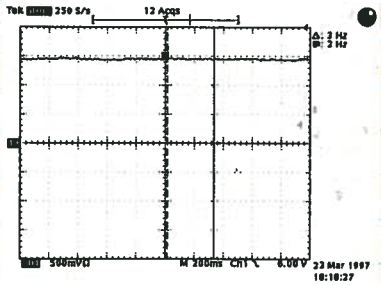
The output of the S&H circuit is monitored with an FET probe on CH1 of the TDS754 scope.

(well, not quite first)

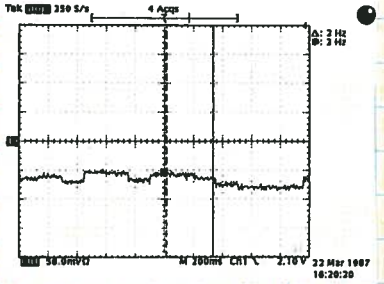
First, the laser is tried without a light shield on the photocells. Erratic output is due to 120Hz modulation of the room lights.

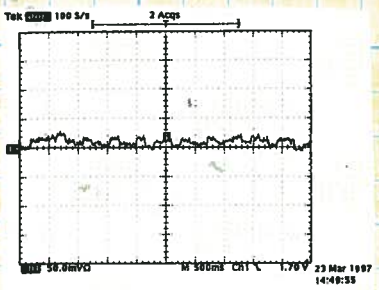



Same as above with a light shield in place. Light shield is a tube of black flocked paper from Edmund. The tube is placed immediately in front of the photocell. Black felt is used to cover the photocell stand.

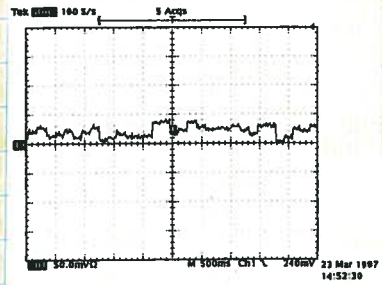



Same as above with a 1.5V offset on CH1.
If this is due to some instability of the laser it should be less noticeable when the spot is centered between the two photocells. This was tried a little earlier. See next page.
The erratic output seems to be from the switching of the laser. Perhaps it will improve with a real circuit board layout.



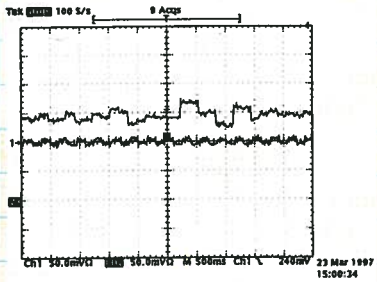



Light shield is in place. This is the noise with the spot on one side of the photocells. CH1 has a DC offset applied.

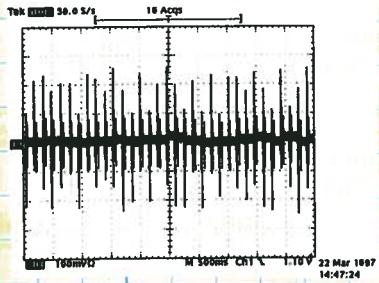



This is the noise with the laser spot centered.

Note that the amplitude is comparable to the upper picture.



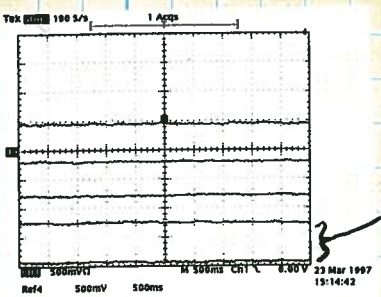

Noise with the laser centered as above. CH2 is noise on 5V rail. CH2 has 5V offset applied to it.




Same as second picture above. This is in envelope mode to show the switching noise in the circuit CH1 only.

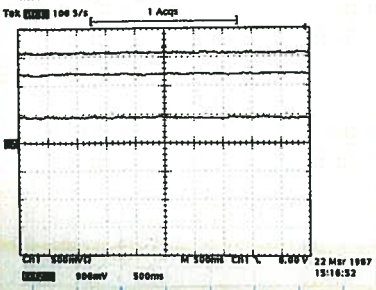
Photovoltaic cells are mounted on an angle on unit that which can be moved by turning a 10-24 screw. Cells are moved ⊥ to the laser beam. 1 turn ⇒ 42 mils ½ turn ⇒ 21 mils ¼ turn ⇒ 10 mils

Stepping the spot across the ~~center~~ gap (~25 mil gap) of the two photocells. Using ¼ turns except for this one which is ½ turn.

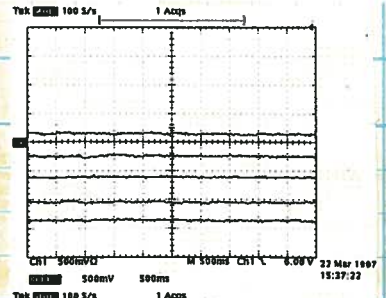


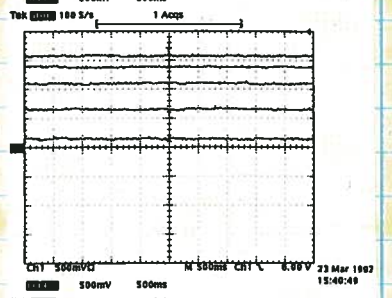

Traces stored in Ref's to allow displaying multiple positions on one picture.

Moving from left side (looking from laser) to right side of beam.

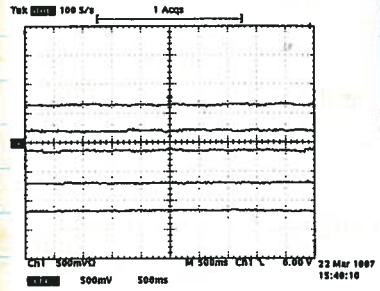


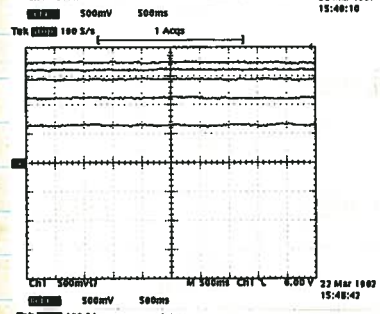
A piece of 5 mil (thickness) mylar is placed in front of the laser. ~⊥ to the beam.
1/4 turn stepping over the center gap



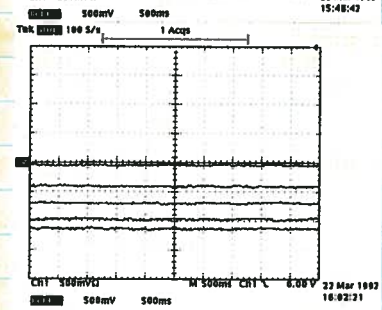



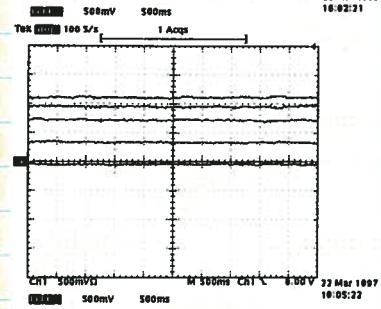

Mylar is held by tape to be ~45° to the laser beam.
1/4 turn stepping.

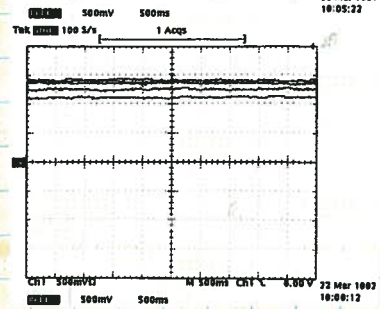



A piece of 2 mil thick kapton is placed in front of the laser.
~⊥ to the laser beam.
1/4 turn stepping.

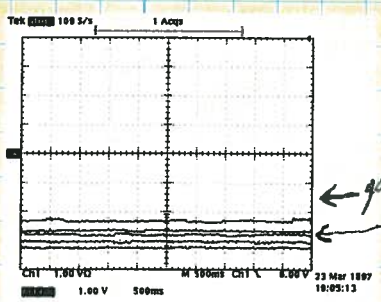


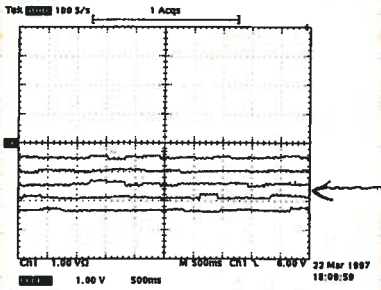
Setup is moved to the aisle of the High Bay.
This gives a separation of ~111" for the laser and photovoltaic cells.
The spot size is ~1.5 cm with annular rings at greater diameters.
This is a tracing of approximate dimensions & edges of the rings. Spot shined on paper + then traced.

Note: The pictures below all have a 1.5V offset. I forgot to remove the offset after the pictures at the bottom of pg. 113.

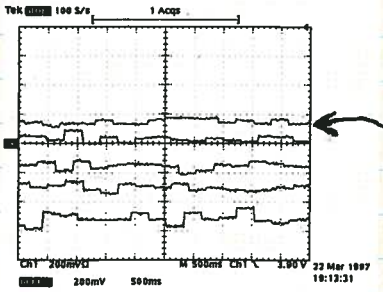



1 turn stepping. Except for one ½ turn here which was done by mistake

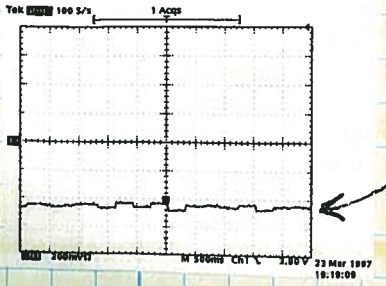
gap is here




gap is here

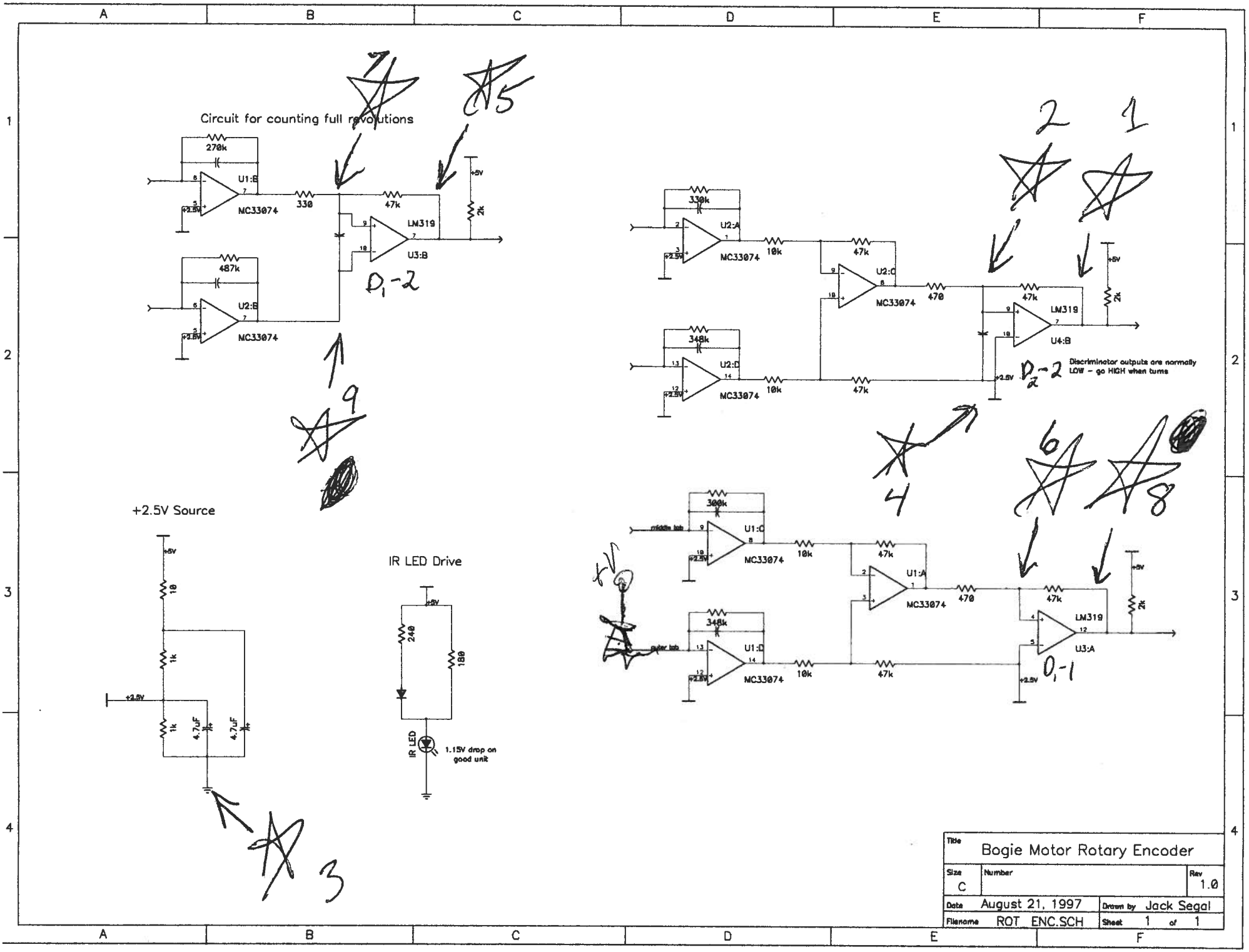



Vertical changed because I thought I was getting close to the gap.




2 mil thick kapton put in front of laser beam

these two traces are of the same setup ~~except~~ except the lower picture has kapton in front of the laser




| | |
|---|---|
| Title | Bogie Motor Rotary Encoder |
| Size | C |
| Number | |
| Rev | 1.0 |
| Date | August 21, 1997 |
| Drawn by | Jack Segal |
| Filename | ROT ENC.SCH |
| Sheet | 1 of 1 |

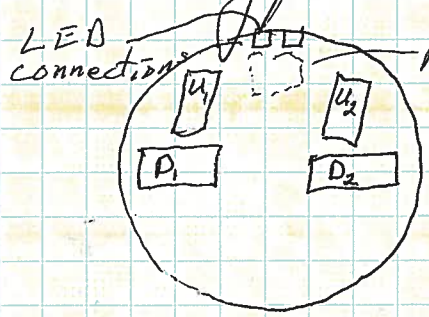
# Bogie Motor Shaft Encoders

8/21/97

The encoders are Renco model RHS21-P3.

I have a good one and a "bad" one.

Looking from component side of PCB:

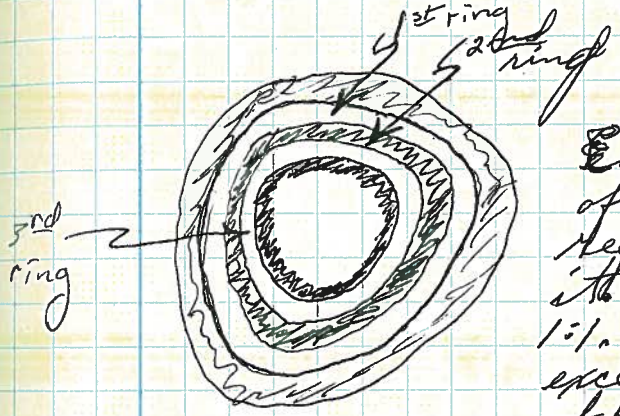



$U_1$ & $U_2$ are MC33074 quad op amps

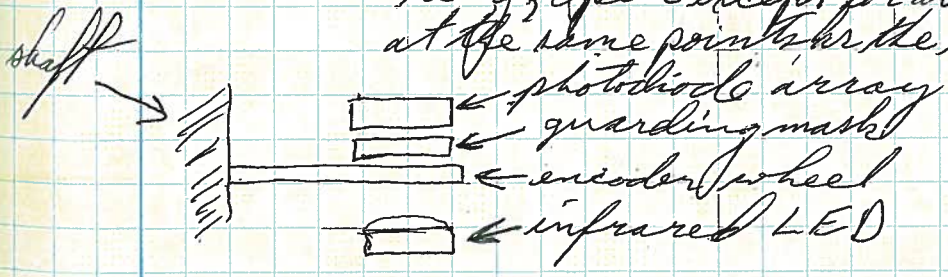
$D_1$ & $D_2$ are LM319 dual comparators

LED is infrared - checked with infrared detector tab from Radioshack

Receiver appears to be an array of photodiodes. eight diodes in 2 arrays of 4




Encoder wheel has ~~two~~ three bands of significance. Outer band has a regular array of slits (radial) around it. Ratio of clear to obscured seems to be 1:1. Next ring inward is all metalized except for a small array of about 6 slits at one point of the circumference. The next ring inward is the opposite of the middle ring, open except for about 6 small stripes at the same points as the slits in the 2nd ring.




$U_1$ & $U_2$ amps are $U_1$-1, $U_1$-2, $U_1$-3, etc. In same rotational sense as pin numbering.

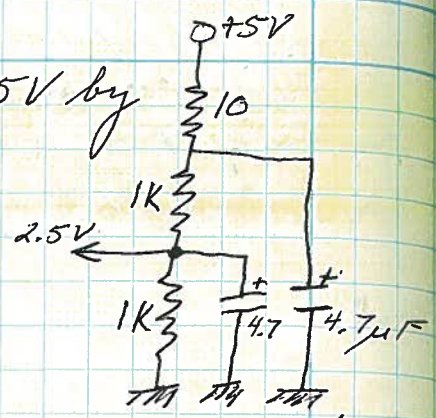
$U_1$-2 & $U_2$-2 are for the 4 PDs for the inner rings. They connect to the inner tab of PD package. Innermost tab in the radial sense.

$U_1$-3 connects to middle tab of PD package on its side of the package.

$U_1$-4 connects to outer tab of PD package

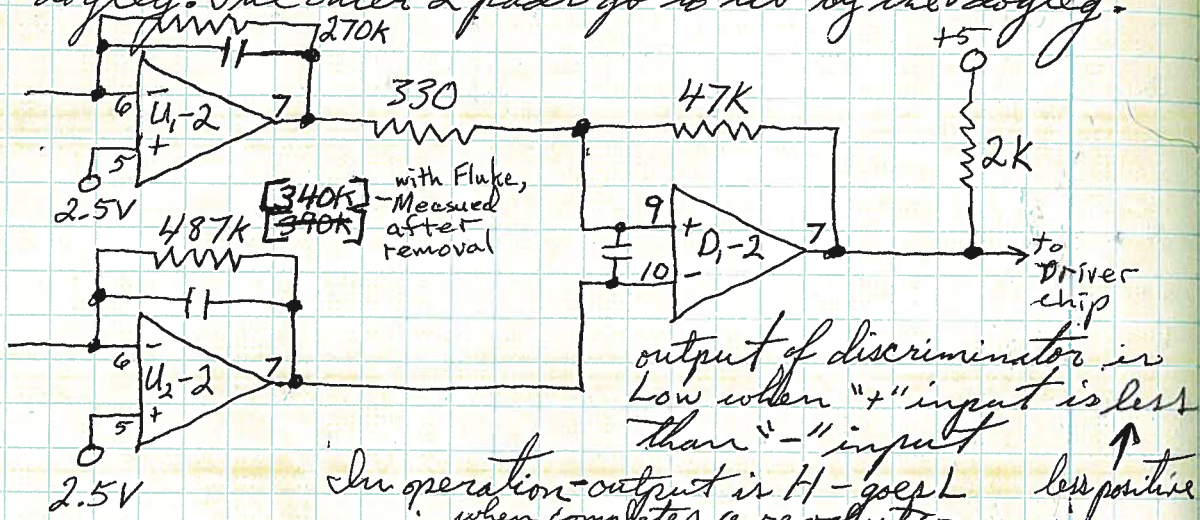
All voltage measurements are made using an FET probe on the TDS754A.

A +2.5 V reference is generated from +5V by




Circuit for counting full revolutions. On PD array the inner 4 are used for this. There is a dogleg trace at the inner end of the PD package. The two inner most pads both go to the output tab away from the dogleg. The outer 2 pads go to tab by the dogleg.

Resistor values are from the bad encoder. Values which differ on the good encoder are shown in brackets [value]




output of discriminator is Low when "+" input is less than "−" input ↑ less positive

In operation - output is H - goes L when completes a revolution

When the marks on the inner two rings pass over PD

Output of $U_1$-2 drops ~180mV
[(2.5V − ~80mV) drops to (2.5V − ~260mV)]

Output of $U_2$-2 rises ~180mV
[(2.5V − ~280mV) rises to (2.5V − ~100mV)]

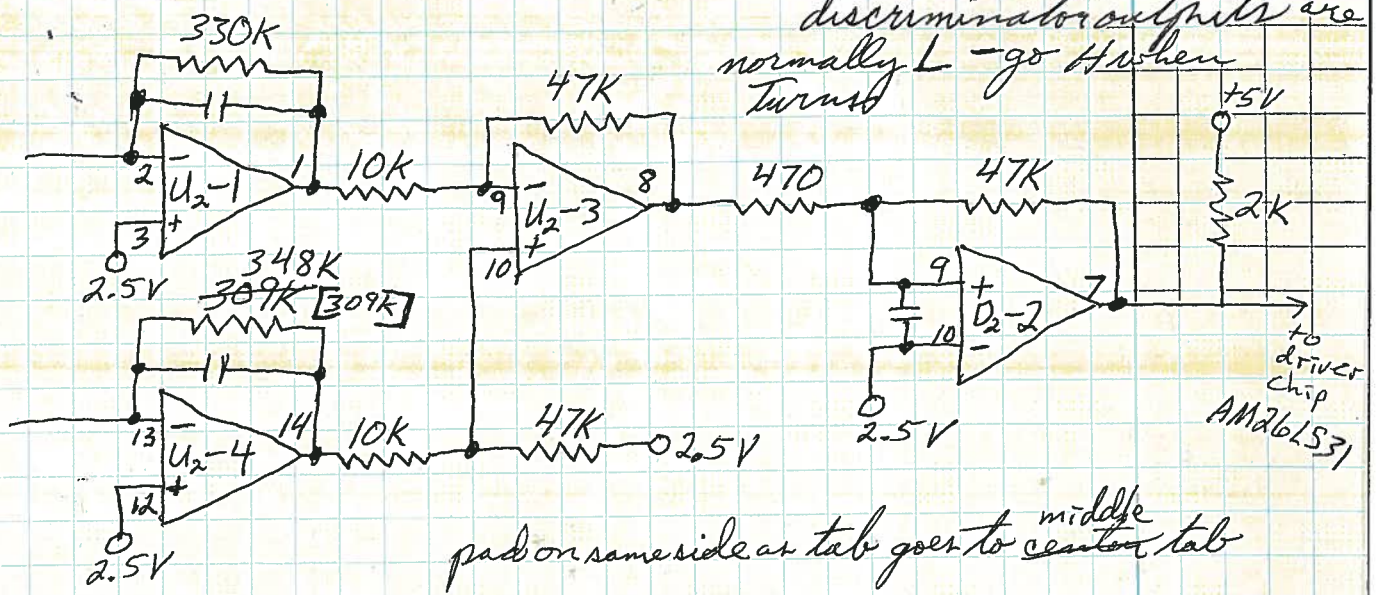
Output (mV below 2.5V) (when marks not over PD)

encoder section seems to be insensitive to ambient light →

| Which Chip | good encoder | bad encoder |
|---|---|---|
| $U_1$-2 output | ~−100mV | ~−400mV ← eg. ~2.1V |
| $U_2$-2 output | ~−280mV | ~−1V |
| $D_1$-2 "+" input* | ~−50mV | ~−400mV ← eg. ~2.1V |
| $D_1$-2 "−" input* | ~−300mV | ~−1V |

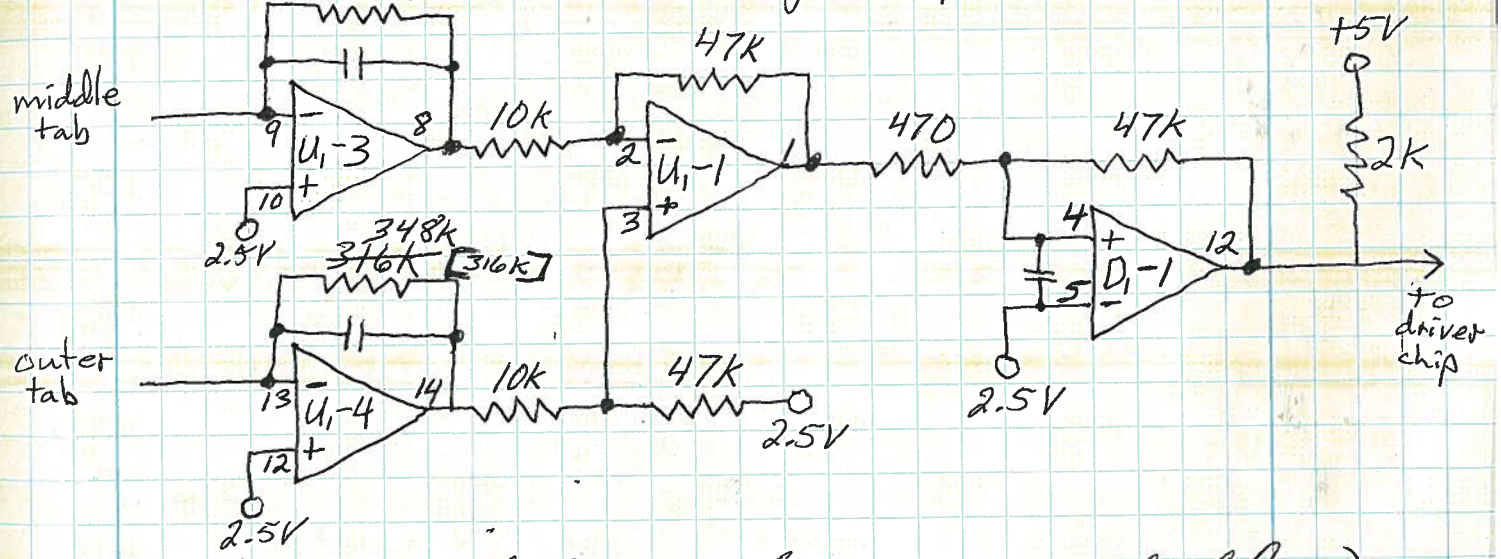
Output of "Bad" encoder $D_1$-2

discriminator outputs are normally L — go H when Turned




pad on same side as tab goes to ~~center~~ middle tab

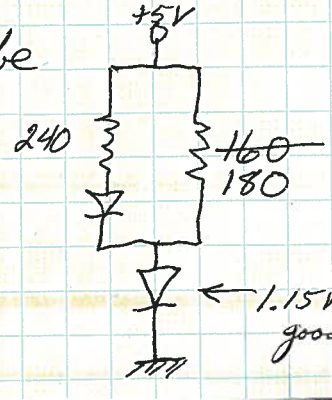
outer tab goes to pad on other side




Voltages on inputs of comparators (2.5V ~~zero~~ indicate 0mV)

| chip | good encoder | bad encoder |
|---|---|---|
| $D_1$-1 "−" input | ~−25mV | ~−25mV ← i.e. 2.475V |
| $D_1$-1 "+" input | 1.0Vpp @ ~2.5V | 1.25Vpp @ ~(2.5V−350mV) 2.150V |
| $D_2$-2 "+" | ~.5Vpp @ (2.5−.75V) | 1.25Vpp @ ~(2.5−125mV) |

IR LED drive seems to be

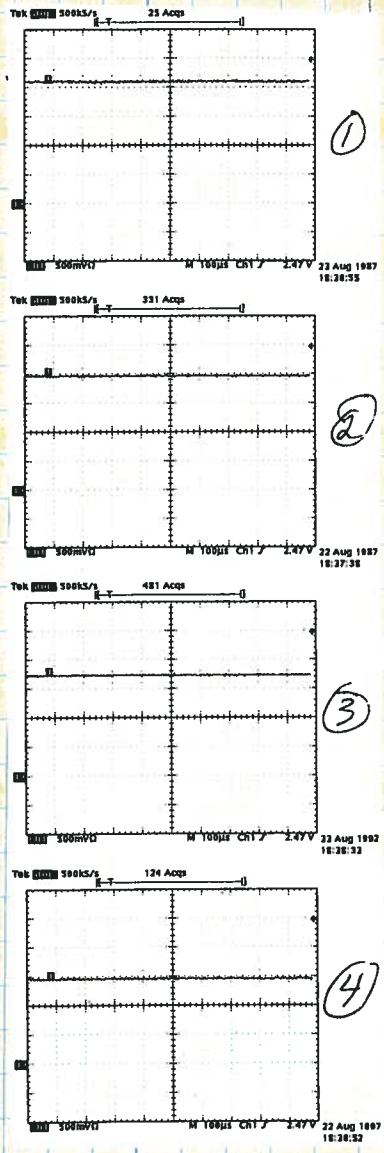



(measured on good encoder. LED removed & drop checked with Fluke)

8/22

Verified $D_1$-2 does not change output state during a full rotation. On the bad encoder.

The extremes of the outputs of the amplifiers $U_1$-2 & $U_2$-2 are shown for the bad encoder. (actually these are the comparator inputs) (on $D_1$-2)




① pin 9
at a point of rotation away from the mark on the inner ring

② pin 9
when the mark gives ~ max deflection downward

③ pin 10
when the mark gives max deflection upward

④ pin 10
at a point of rotation away from the mark on the inner ring

8/24
JA

Using Fluke DMM:

| | bad | good |
|---|---|---|
| across LED | 1.357V | 1.320 |

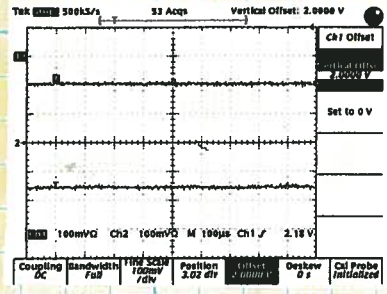
| | | |
|---|---|---|
| LED left leg | 1.400 | 1.353 |
| LED right leg | 0.042 | 0.033 |
| Diode (?) left | 1.400 | 1.353 |
| right | 4.166 | 4.190 |
| 180Ω high | 5.008 | 5.016 |
| low | 1.400 | 1.354 |
| 240Ω high | ~~4.113~~ 5.008 | 5.016 |
| low | 4.113 | 4.162 |
| end of trace connected to diode right | 4.113 | 4.162 |
| ~2.5V ref | 2.442 | 2.439 |

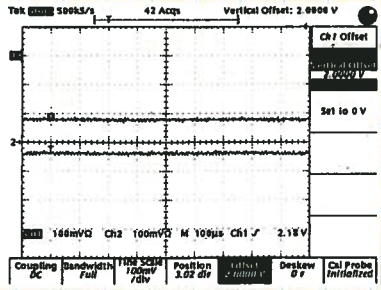
These measurements seem to bear out the inferred circuit at the bottom of p. 119 of this volume.

Voltage drop across the "diode" is 4.190 − 1.353 = 2.837V on good encoder

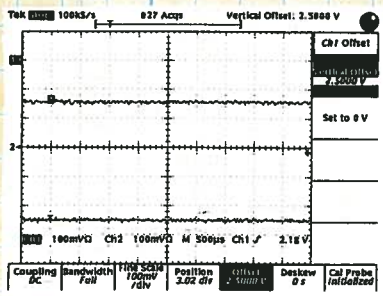
Current through 240Ω is $\frac{.854}{240} = 3.6\,mA$ on good encoder

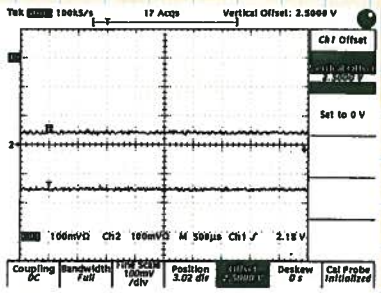
Current through 180Ω is $\frac{3.662}{180} = 20\,mA$ on good encoder



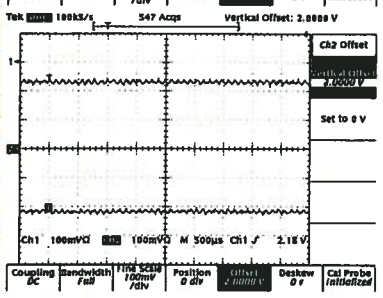



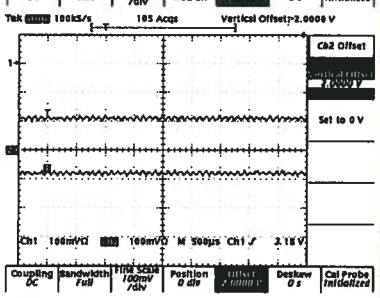

Upper trace is $U_1$-4 } bad decoder
Lower is $U_1$-3
Outputs at the two extremes of value
2 V offset both channels



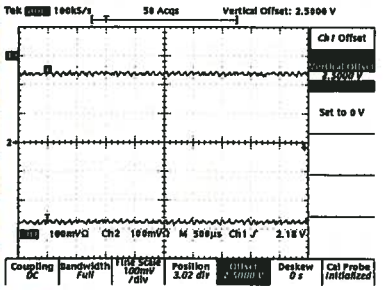



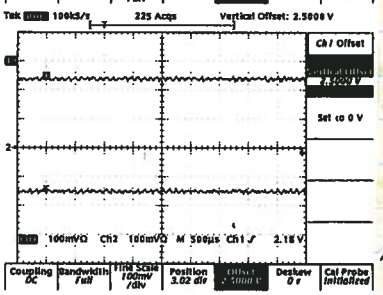

Upper trace is $U_1$-4 } good decoder
Lower is $U_1$-3
Outputs at the two extremes of value
2.5 V offset both channels



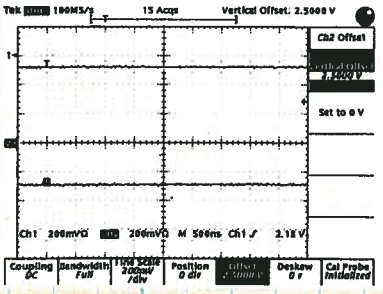



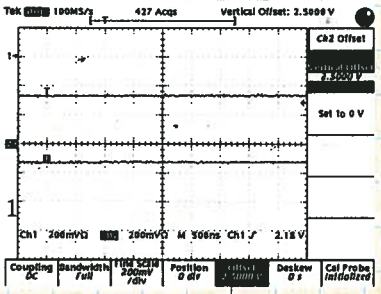

Upper trace is $U_2$-1 } bad decoder
Lower is $U_2$-4
Outputs at the two extremes of value
2.0 V offset both channels



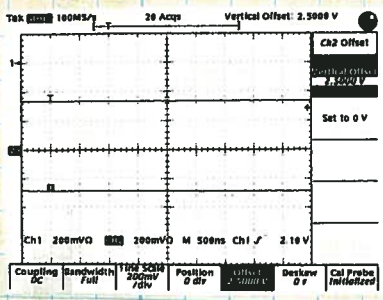



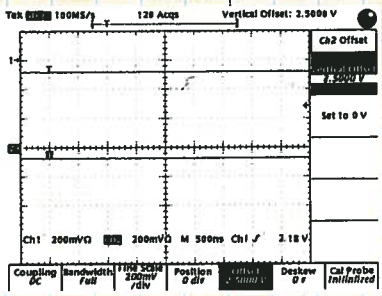

Upper trace is $U_2$-1 } good decoder
Lower trace is $U_2$-4
Outputs at the two extremes of value
2.5 V offset both channels
Note: PD connection to $U_2$-1 lost during attempt to remove PD from board (prior attempt)




Upper trace is $U_1$-2 } good decoder
Lower is $U_2$-2
Outputs at the two extremes of value
2.5 V offset both channels




Upper trace is $U_1$-2 output
Lower is $D_1$-2 "+" input
at ~ the two extremes of value

Note the hysteresis on $D_1$-2 "+" input (compare to $U_1$-2 output in both pictures)

$U_1$-4 output good encoder 2.5V-.14V to 2.5V-.26V $\Delta$=120mV
bad encoder 2V-.1V to 2V-.22V $\Delta$=120mV

drop of 460mV for "baseline"
bad has 348k for feedback
good has 316k

348k · 1.3μA = 464mV
↑
from next one ↓

$U_1$-3 output good encoder 2.5V-.25V to 2.5V-.15V $\Delta$=100mV
bad encoder 2V-.15V to 2V-.04V $\Delta$=110mV

drop of 400mV for "baseline"
both good & bad have 300k for feedback
⇒ 1.3μA

~~$U_2$-1 output 2.5V-.06V to 2V-.07V gives 370mV~~
~~1.3μA · 330k~~
$U_2$-1 doesn't count since PD connection is broken!!

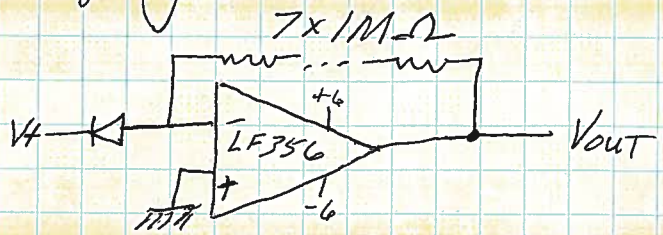
$U_2$-4 output good encoder 2.5-.27 to 2.5-.15 $\Delta$ = 120mV
bad encoder 2-.22 to 2-.08 $\Delta$ = 140mV

drop of 450mV for "baseline"
348k · 1.3μA = 464mV

8/31/75

# Diode Leakage Currents

Trying to measure leakage currents

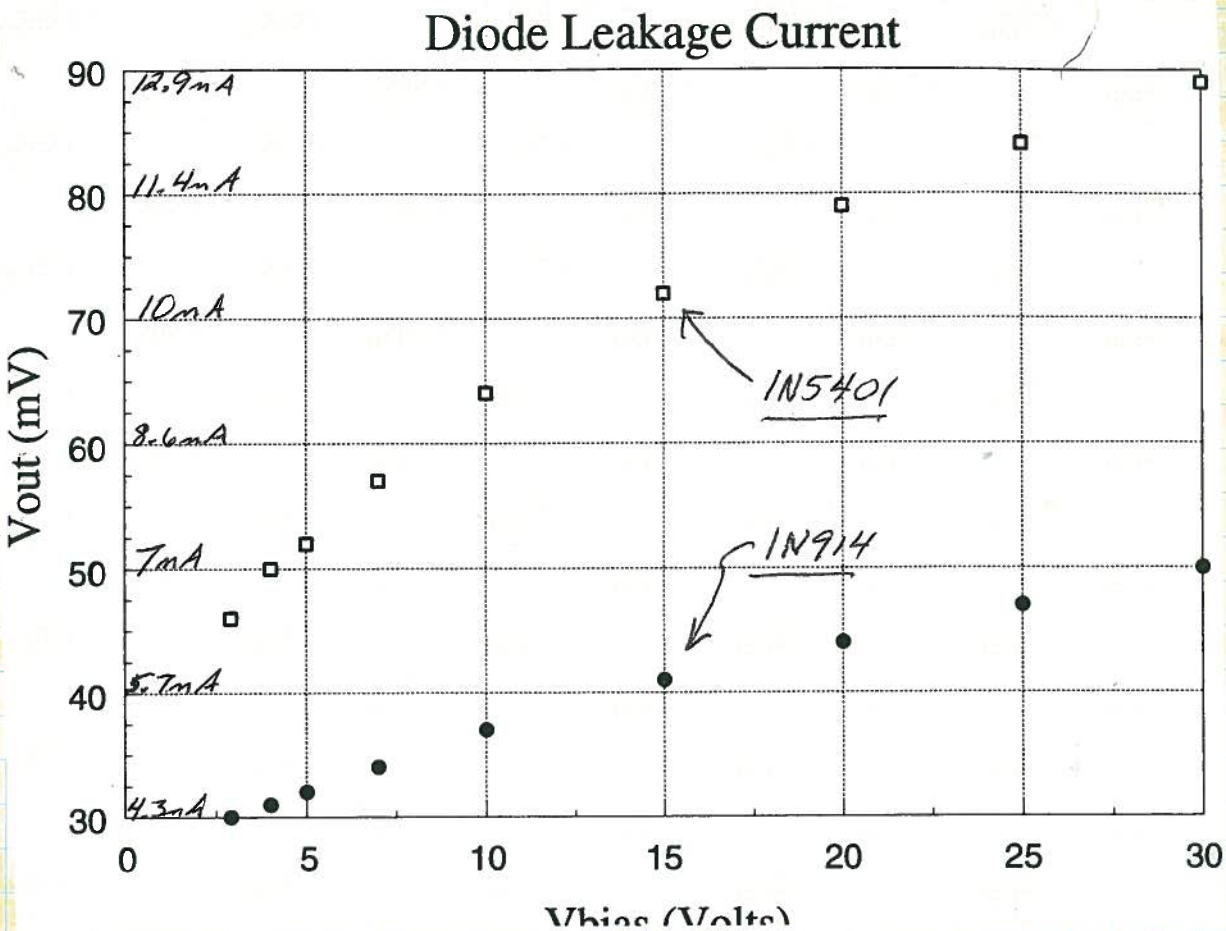



Looking at output with no input on "−"
0.0mV using Wavetek DM73A
1N914 diode to V+ = 2.9V inserted at "−" input.
allowed to settle for ~1 min $V_{OUT}$ = −29.4mV
30.3mV with fluorescent light on the diode
With penlight I get ~150mV − 28.9mV =
not real stable
light off (before turned on)

1N914 - unknown manuf. & date
Motorola 1N5401 dated 8248

| V+ | $V_{OUT}$ | $V_{OUT}$ |
|---|---|---|
| 2.9V | −29.5mV | −46mV |
| 4.0 | 31.4 | 50 |
| 5.0 | 32 | 52 |
| 7.0 | 34 | 57 |
| 10.0 | 37 | 64 |
| 15.0 | 41 | 72 |
| 20.0 | 44 | 79 |
| 25.0 | 47 | 84 |
| 30.0 | 50 | 89 |

The 914 does not "see" the $Fe^{55}$ source with V+ = 2.5V
1N5401 also does not "see" the source (@ V+ = 30.0V)
$Fe^{55}$ is listed as 500μCi

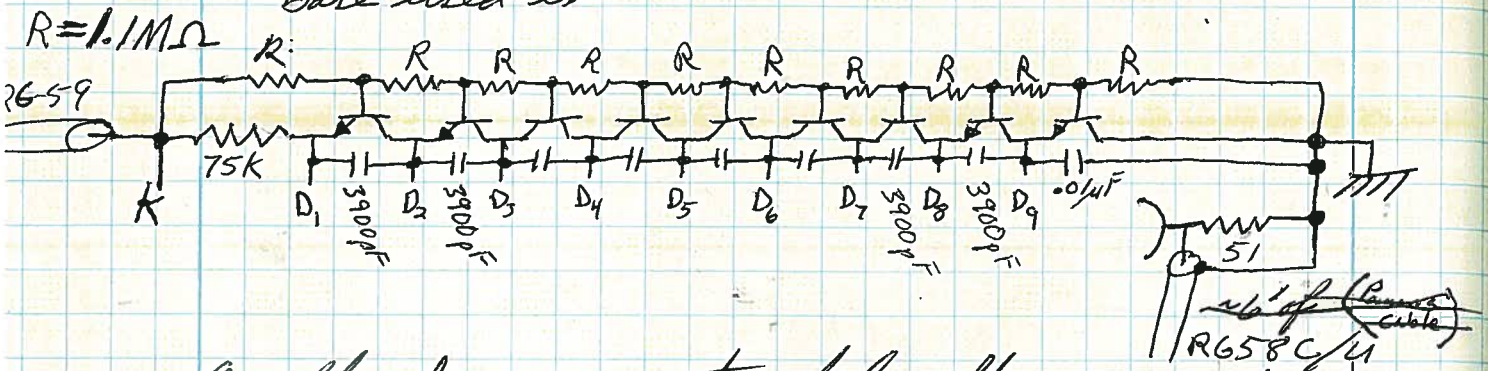

Diode Leakage Current
Vout (mV)
Vbias (Volts)
90
80
70
60
50
40
30
0
5
10
15
20
25
30
12.9mA
11.4mA
10mA
8.6mA
7mA
5.7mA
4.3mA
1N5401
1N914

10/25 First look at 931B PMT

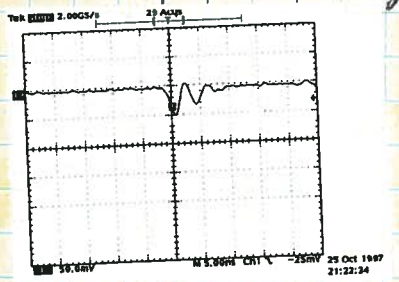
Trying a transistorized base for a 931B.

Trying for a fast, high rate tube for background rates.

Base used is



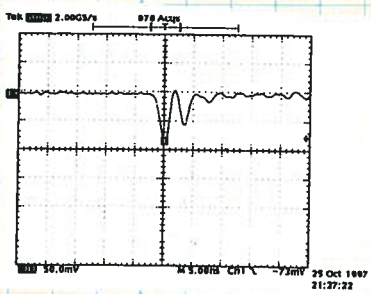

Another base is constructed with 100kΩ between all stages. .01μF from D9 to GND, also.

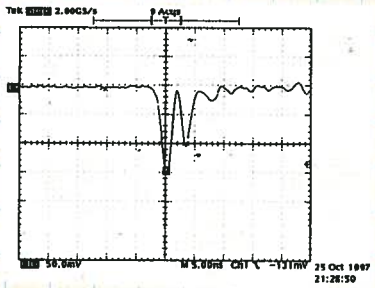



output of 931B with NO scintillator on it.
Output of cosmic pulse or dark current pulse?? ("noise")

Can't see $Fe^{55}$ source with the tube. 500μCi in '94

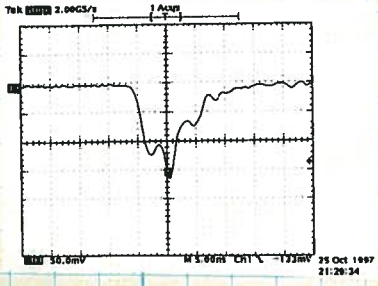
~6' of 50Ω POMONA cable from base BNC to scope.
Scope input set to 1MΩ. BNC "T" with a 50Ω terminator on it is used at scope.

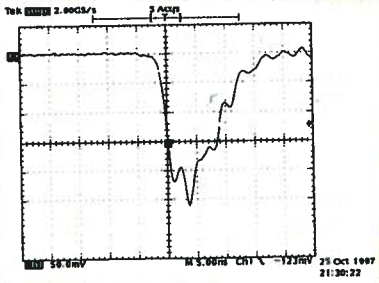


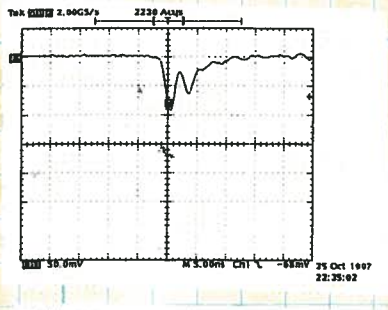

a couple of "noise" pulses from PMT with scintillator attached

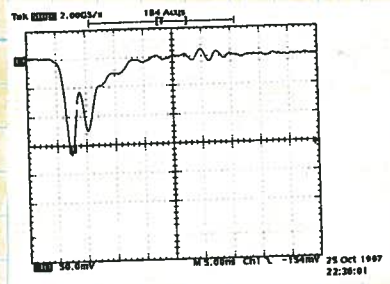
Using $Fe^{55}$ gives pulses similar to these.



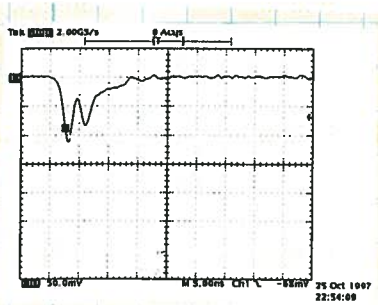




Larger pulses from PMT with scint attached.
← No source
Probably cosmics

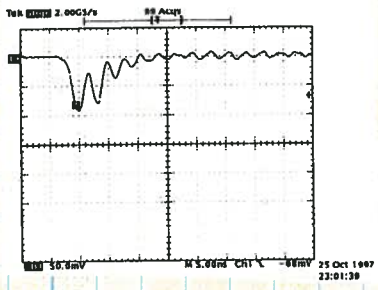



Typical pulses from ~~radiation~~ bare with PMT with scint. attached



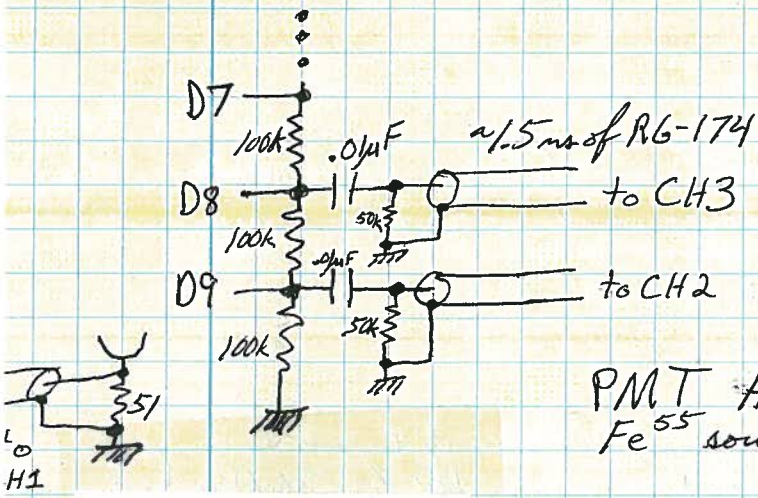

added another ~6' piece of POMONA cable to the output



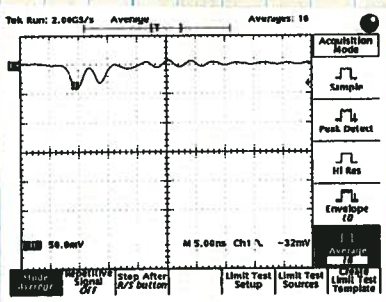

Removed extra ~6' POMONA cable.
Removed .01μF from D9 to GND, also.

10/26 Continuing 931B Investigations
JS

Modified resistive base to bring out a signal from D9 and D8 as well as from the anode.

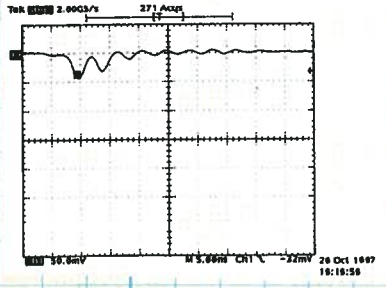



PMT HV set to -900V
$Fe^{55}$ source set on scint attached to PMT.



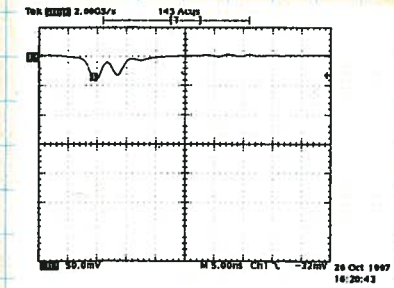

1.5ns RG-174 cables are unterminated

AVG set to 16



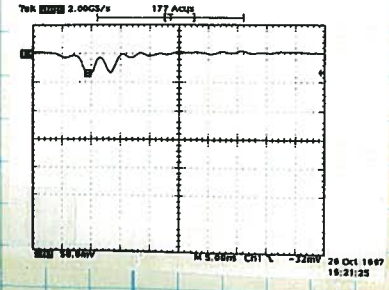

terminated D8 cable with 50Ω BNC.
D9 unterminated

AVG 16 traces



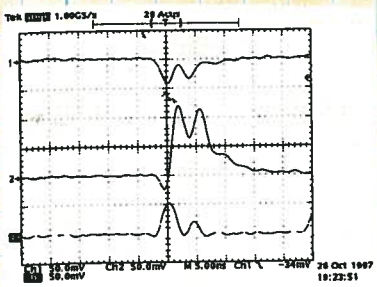

Both D8 & D9 cables are terminated in 50Ω

AVG set to 16



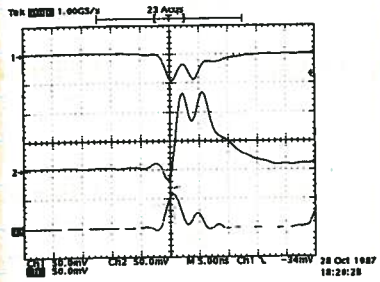

D8 cable ~~short~~ terminated in 50Ω
D9 cable terminated in a shorting cap.

AVG set to 16

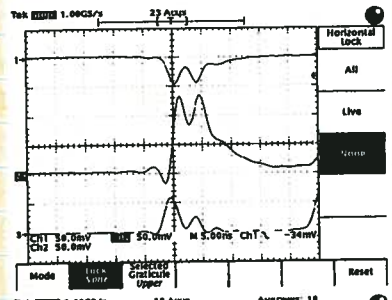


~6' of POMONA cable added to each RG-174 cable.
Connected to scope with BNC "T" & 50Ω terminator.

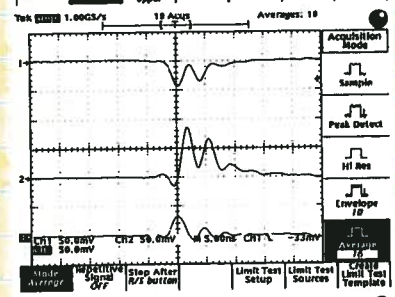
typical pulses



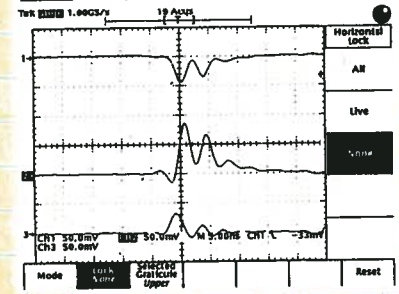
scope set to AVG16



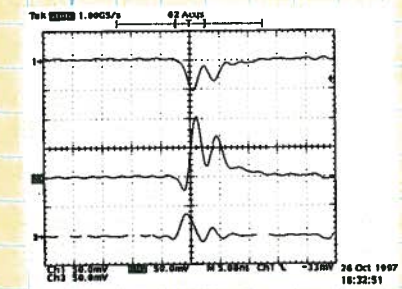
shifted CH2 + CH3 to the left by ~1 ns
to correct for additional RG-174 as compared
to anode cable length
(same as above except for shifted)



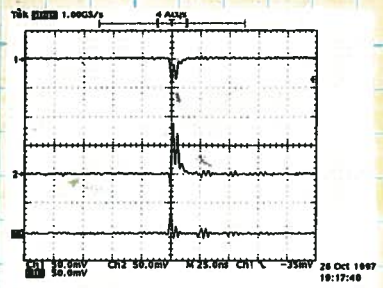
reset horizontals



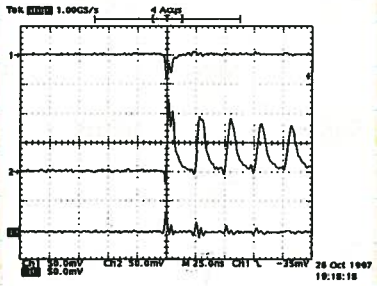
shifted CH2 + CH3 to the left by ~1 ns
(same as above except for shifted)



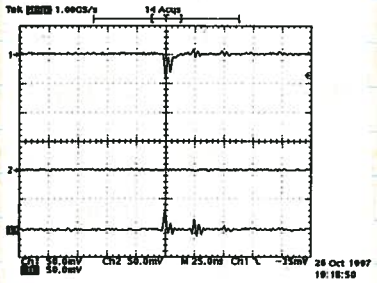
typical pulse – CH2 & CH3 are still shifted
by ~1 ns



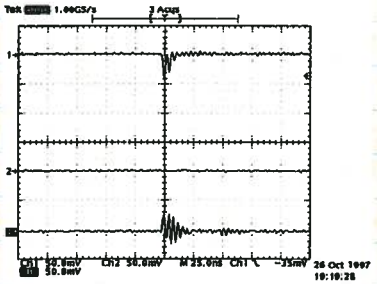

typical pulse



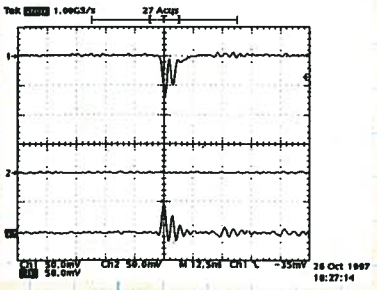

50Ω terminator removed from D9 cable




D9 BNC "T" removed from scope input

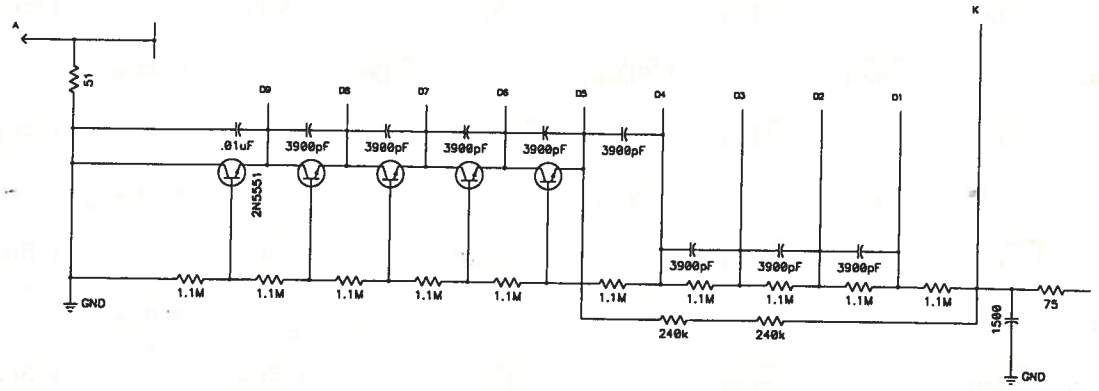



POMONA cable detached from RG-174 cable on D9




D9 RG-174 cable removed from D9
.01μF capacitor attached to ground directly
(50K also removed)

Base and Tube for Background Measurements done 10/27 JJ written on 11/9/97



11/8 Setup for Measuring Charge on a Raindrop

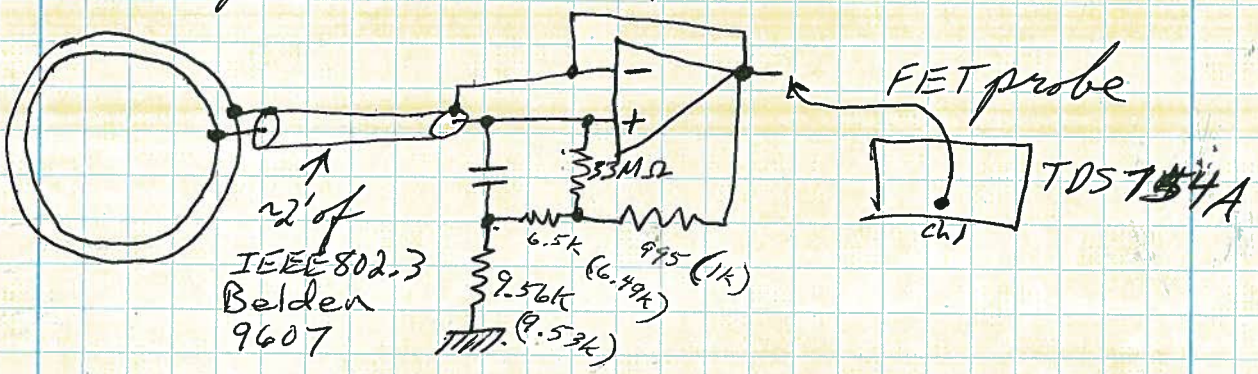
This idea was from the ~~Sept.~~ August issue of Scientific American.

Measure the induced charge on a cylinder as the raindrop falls through the axis.

Two sheets of copper are wound on an aluminum tube. One on the inside, the other on the outside. Aluminum tube has ID of 2 7/8" OD of 3"

The copper was held to its shape with tape while the seam was soldered. We thus have two copper tubes. One fits inside the other. The smaller diameter copper tube is also ~ 1/2" shorter than the other tube.

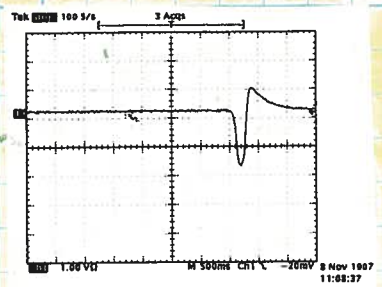
The larger diameter copper tube is used as a guard for the inner tube. Thus the guard extends ~ 1/4" above and below the ~~e~~ ends of the smaller copper tube.



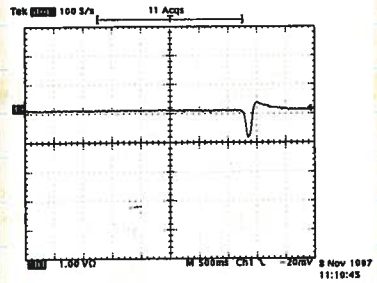

Outer tube has tape built up on its ID. This holds the inner copper tube in place by friction. The coax cable is attached at one end of the 2 tube assembly

A LF356 and a CA3140 are compared. The CA3140 seems to oscillate. It quiets down if I hold my hand against the outer guard copper cylinder.

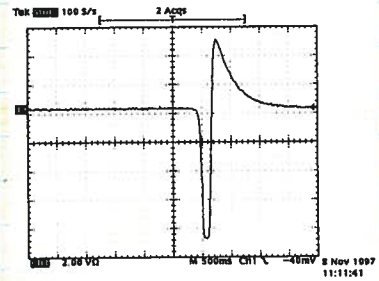
The safety cap of an "x-acto" knife is taped to the end of a small diameter brass tube. The cap is rubbed against my jacket to build up a static charge and then poked into the tube.



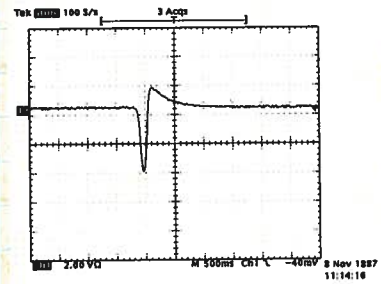

LF356 amp with a "small" charge on the plastic safety cap.



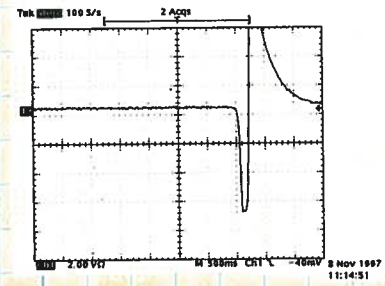

CA3140 amp with the same charge on the cap. "Same charge" in that the cap was not rubbed on the jacket. It was just lying around while the amps were swapped.

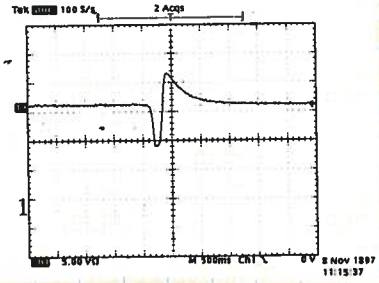



CA3140 amp after the cap was rubbed against the jacket again




LF356 amp. The cap was just lying around while the amps were swapped.




LF356 amp after the cap was rubbed against the jacket. Both pictures are of cap with the "same" charge.

So, how much charge does one raindrop carry?
From Sci. Am. article the typical reading is ~0.3V. This is with a following stage with a gain of $1 + \frac{24k}{1k} = 25$
$\Rightarrow$ 12mV for a typical raindrop

11/10 JS

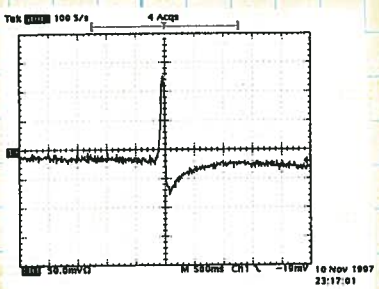
# Charge on a Drop Tests

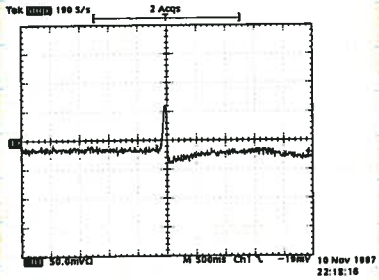
The setup used on p. 132 & 133 is tested with charged drops of water. The water is squeezed out of a squirt bottle onto a plastic bag. Then it is allowed to run off the bag and through the copper tubes. The amp used is a CA3140 with .01μF bypass from V+ to V−. It is stable in this configuration. It is NOT the same CA3140 used on p. 132.

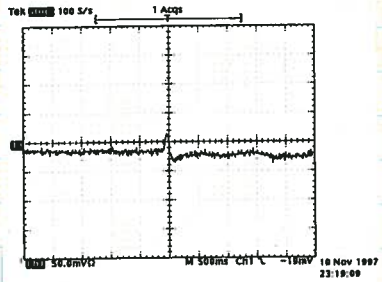
The pulse height does bear some direct relation to the size of the drop.

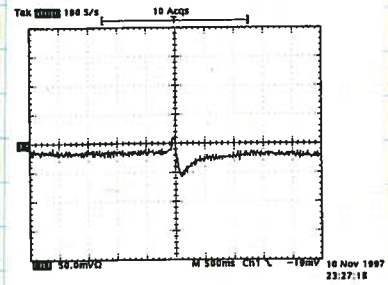
Typical pulses out are shown.

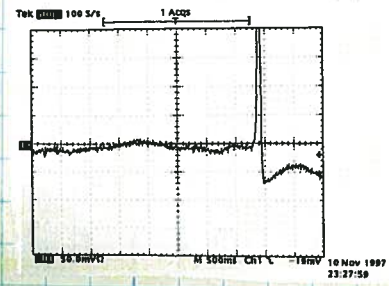
The plastic bag was rubbed against miscellaneous objects to try to add charge to it.

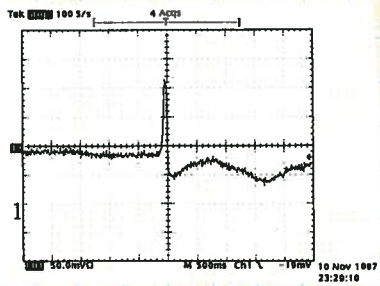


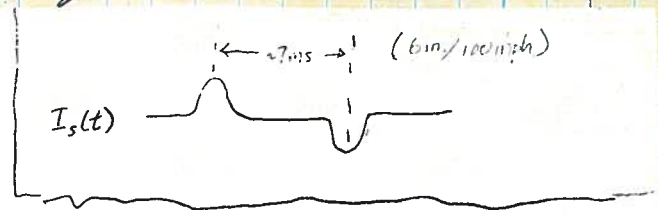



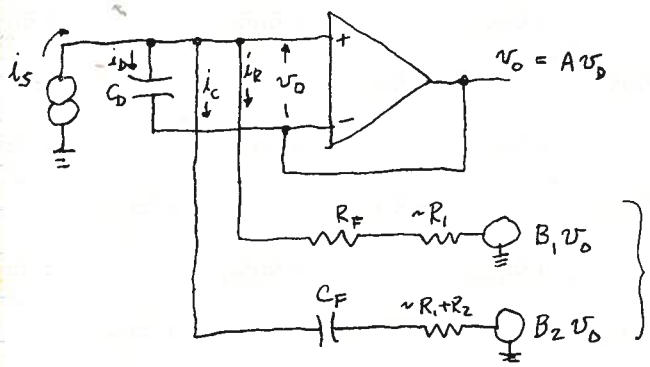



# Ken's Feedback Analysis (For rain monitor) 11/29/97 KN




Thevenin-equiv of feedback network

$$1 - B_1 = \frac{R_1}{R_1+R_2+R_3} = \frac{1}{307} = 3.3\times10^{-3}$$

$$1 - B_2 = \frac{R_1+R_2}{R_1+R_2+R_3} = \frac{7}{307} = 2.4\times10^{-3}$$

$$i_s = i_D + i_C + i_R$$

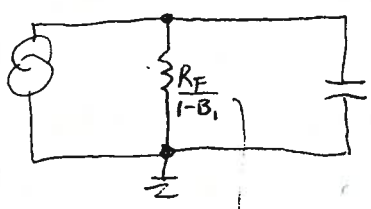
$$i_D \frac{1}{j\omega C} = v_D = \frac{v_o}{A} \Rightarrow i_D = v_o\, j\omega \frac{C_D}{A}$$

$$(v_o + v_D - B_1 v_o) = i_R(R_F + \cancel{R_1}^{\,0}) \Rightarrow i_R = v_o \frac{1}{R_F}\left(1 - B_1 + \frac{1}{A}\right)$$

$$(v_o + v_D - B_2 v_o) = i_C\left(\frac{1}{j\omega C_F} + \cancel{B_1 R_2}^{\,0}\right) \Rightarrow i_C = v_o\, j\omega C_F\left(1 - B_2 + \frac{1}{A}\right)$$

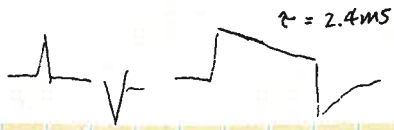
$$i_s = v_o\left[\frac{1}{R_F}(1-B_1) + j\omega C_F(1-B_2) + \frac{1}{A}\left(j\omega(C_D+C_F) + \frac{1}{R_F}\right)\right]$$

$$\Rightarrow \quad v_o = i_s \frac{R_F/1-B_1}{1 + j\omega R_F C_F\left(\frac{1-B_2}{1-B_1}\right) + \frac{1}{A(1-B_1)}\left(1 + j\omega(C_D+C_F)R_F\right)}$$




$$C_F(1-B_2) = 1000\text{pf} * 2.4\times10^{-3} = 2.4\text{pf}$$

$$\frac{33\text{M}\Omega}{3.3\times10^{-3}} = 10\text{G}\Omega$$

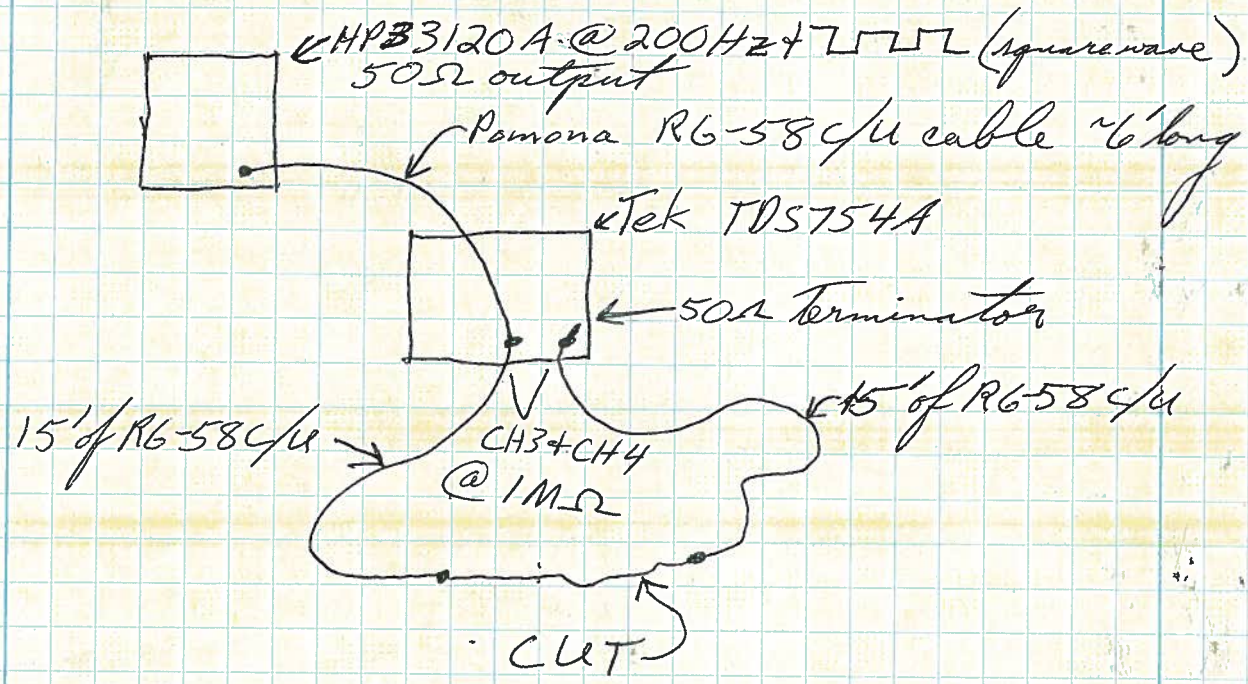


12/14/97 RG-58C/U, RG-58A/U and RG-59U Impedance
DA

# Mismatch Demo I

Trying to get a visual demonstration of impedance mismatch problems with different cables.

Cables are
- RG-58C/U
- RG-58A/U
- RG-59U

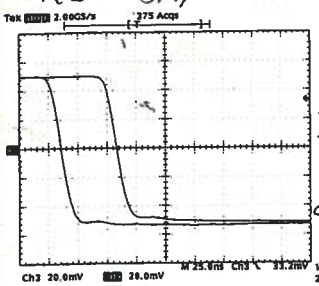



Note the fall time of ~20ns.

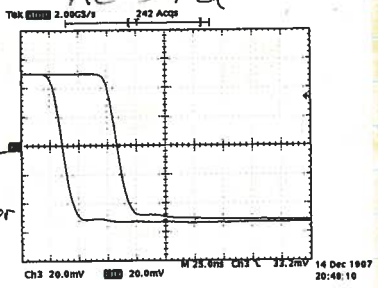
Cable lengths measured by laying the cable on the floor of room 122 of FEL and counting floor tiles, then cutting the cable to length. 6" & 12" measured with a ruler. Cable lengths are <u>before</u> the connectors were attached.
i.e. cables cut to 3, 5 & 10 floor tiles length.
Also, 15' cables are 15 floor tiles length.

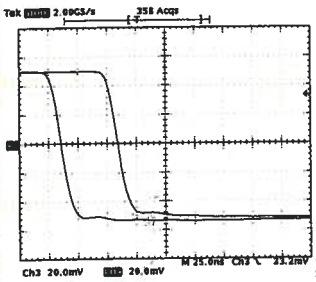
CUT RG-58A/U

CUT RG-59U

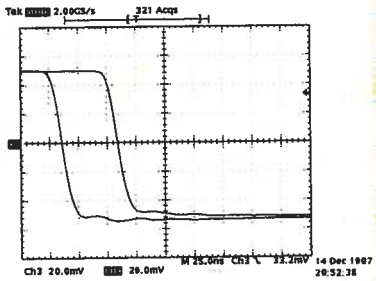


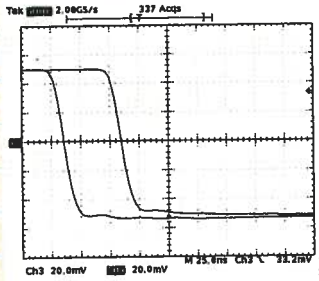

CUT IS just a BNC barrel connector



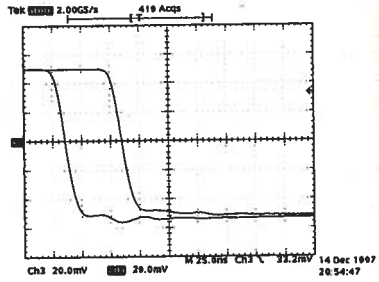



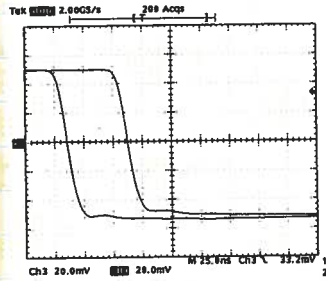

6" long



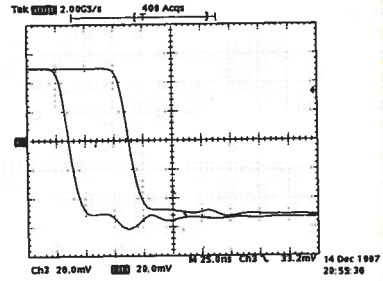



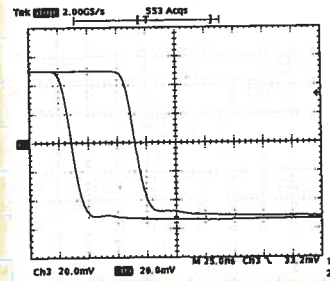

1' long



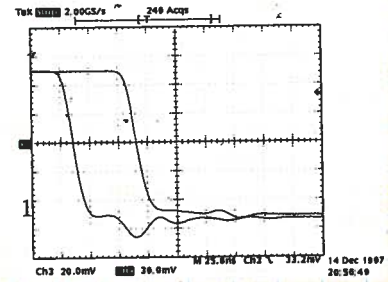



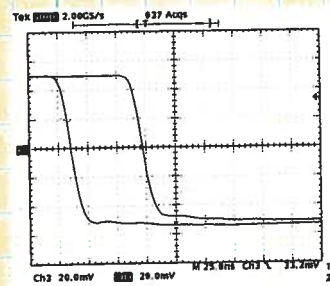

3' long



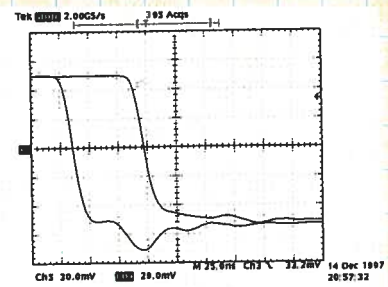



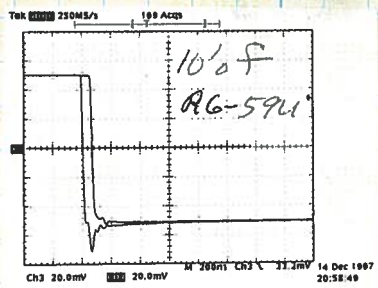

5' long

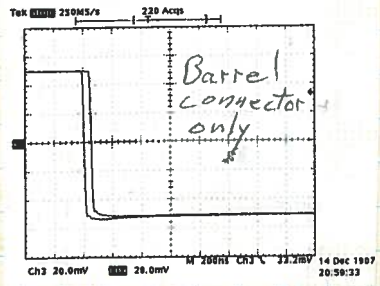



10' long



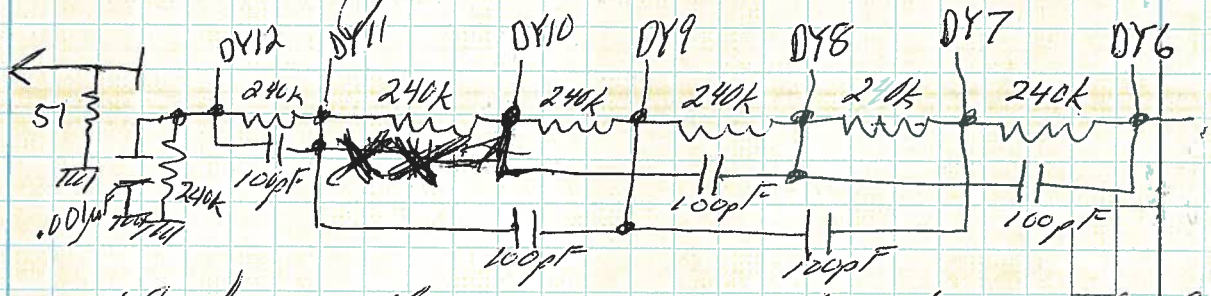



5/31
A

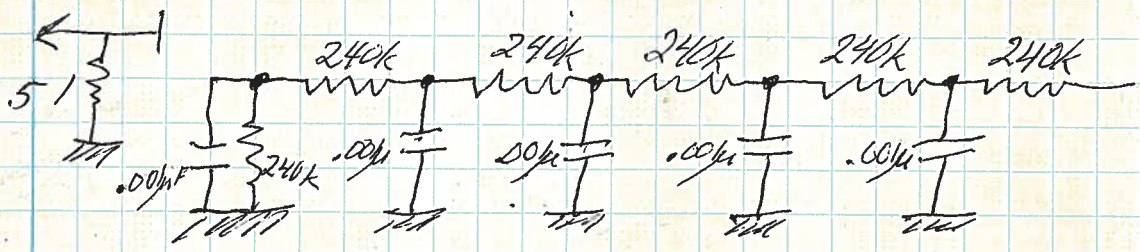
# First Try at a Resistive Base for 8575 PMT

Assembled a passive base for testing the 8575's.
Approximated the suggested divider "C" from the Burle catalog. Use R = 240k
1.6R = 330k
4R = 390k + 200k(pot) + 390k

The base displays ringing similar to the ringing of the 931B base on p. 126 of this lab book. Except the ringing is more pronounced.
The ringing had a period of ~1.5 divisions



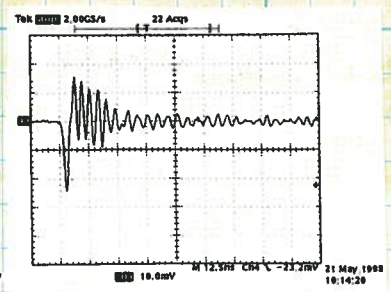

Thinking the ringing was due to some feedback loop using the capacitors I re-did the divider.

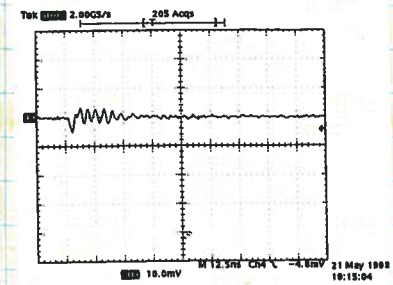



The ringing is similar. I believe the frequency has changed. It seems to me that the ringing of the upper divider to have been ~1.5 divisions @ 1ms/div.

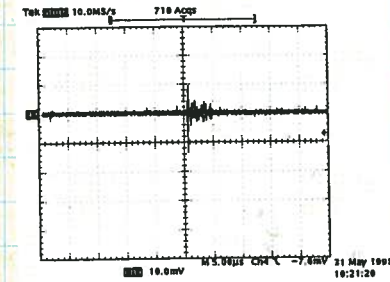
$Cs^{137}$ source & a scrap piece of ~1cm thick scintillator are taped to the front of the tube. (cathode)

Typical pulses showing ringing

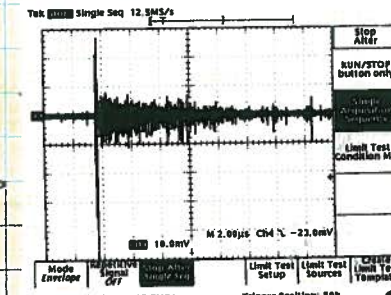


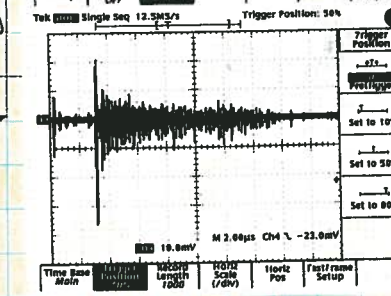

In InstaVu mode




Envelope mode
50 envelopes

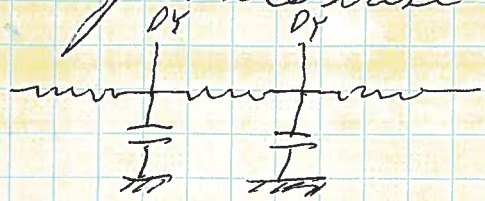



This is about the full extent in time for the afterpulsing in the PMT

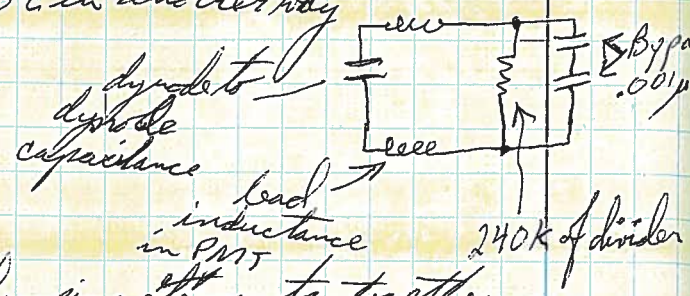


6/1 Further Study of 8575 Resistive Base

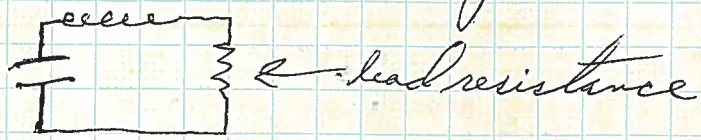
Looking at the base on the lower half of p. 158




or in another way




ignoring the 240K and lumping elements together




looking just at

resonance is $\nu_0 = \frac{1}{2\pi\sqrt{LC}}$

$$\omega^2 = \frac{1}{LC}$$

10nH + 10pF ⇒ 503MHz
20nH + 20pF ⇒ 251MHz

for these values and the critical damping point for an RLC of $\frac{R^2}{4L^2} = \frac{1}{LC}$

$$R^2 = \frac{4L}{C}$$

$R_{crit.} = \cancel{15\,\Omega}$ 63Ω for 250MHz values

~~which gives a τ of $\frac{2L}{R}$ = 2.7ns~~

for envelope of $Ae^{-\frac{t}{\tau}}$

for 40nH + 10pF ⇒ 251MHz
and $R_{crit} = 126.5\,\Omega$
⇒ τ = .6ns

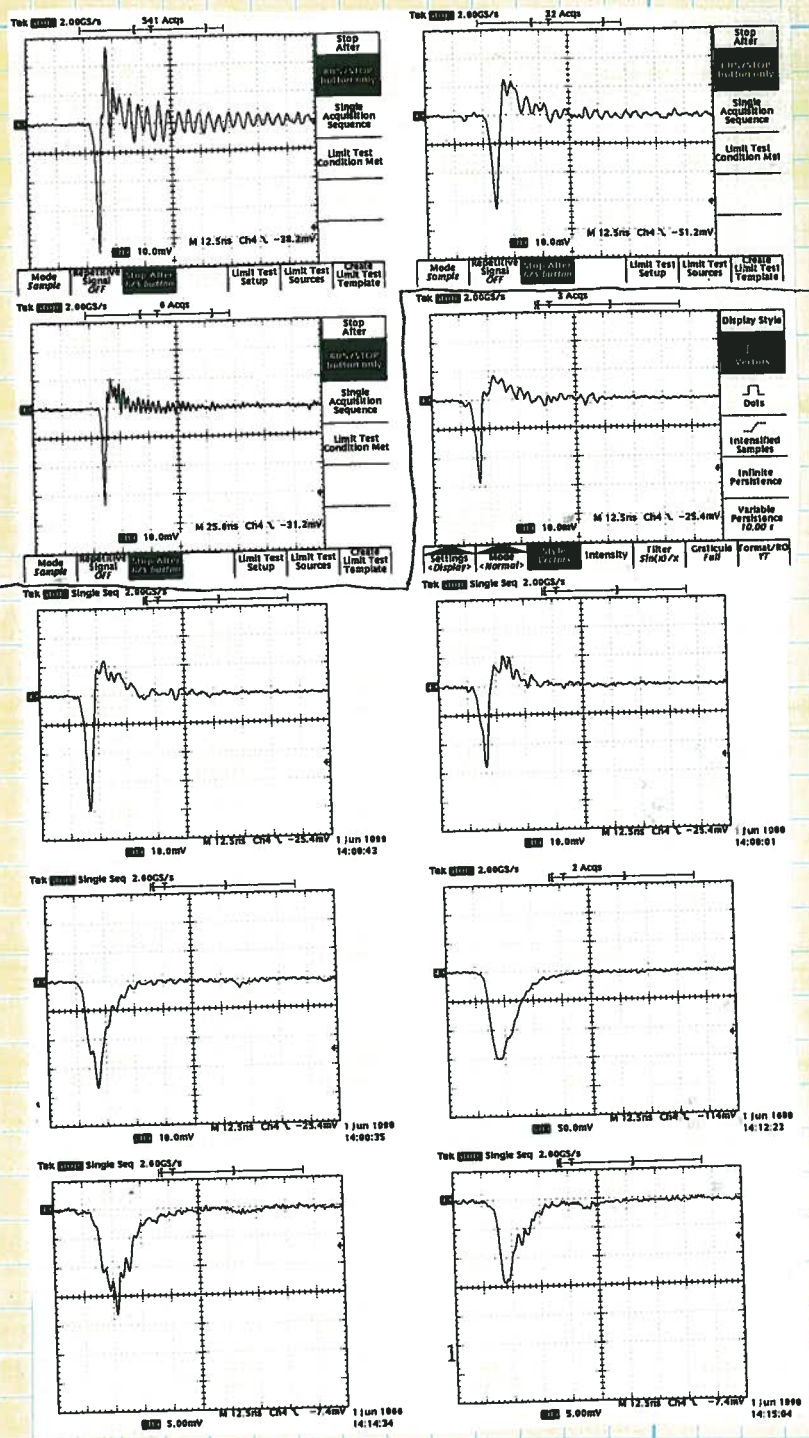
I put 15 ohms in series with the dynodes.

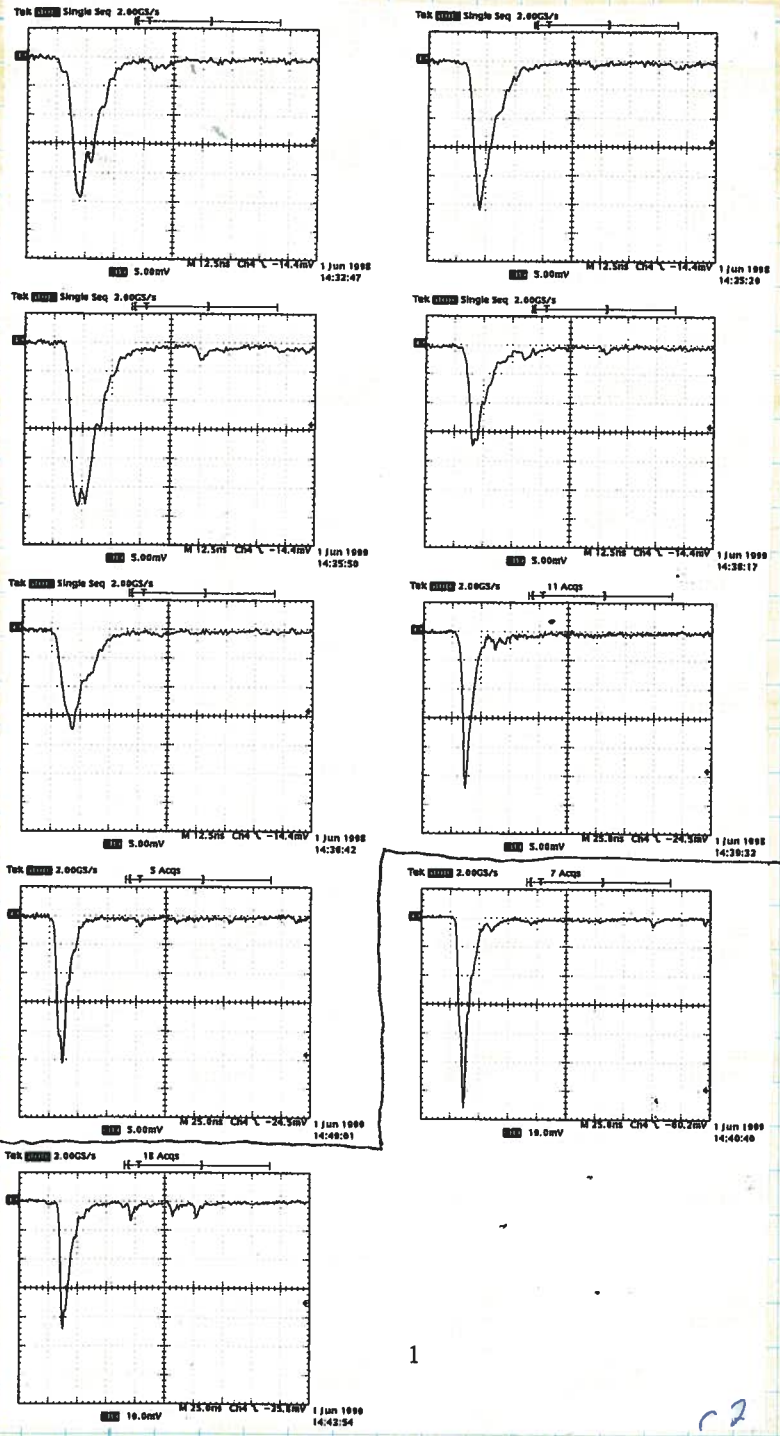
-2400V

15 ohms in series with dynode 12

15 ohms in series with dynodes 12 & 11

-2400V






1

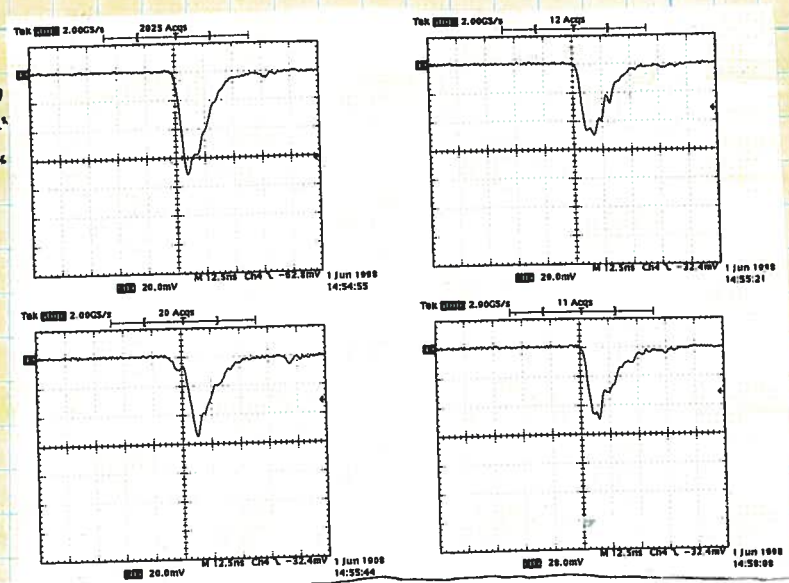
15 ohms in series with dynodes 12, 11 & 10, 9 & 8

−2200V

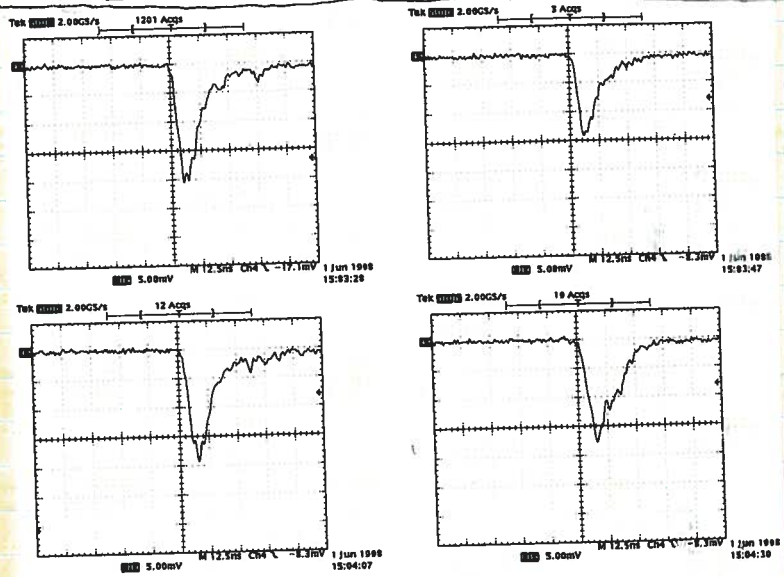
same as above except −2400V

C2

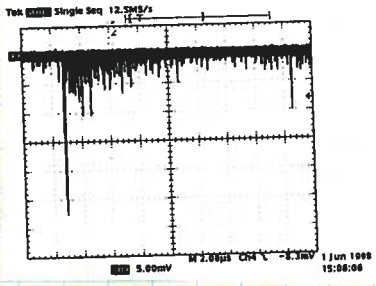
Same base as on p. 142.
New tube from Burle.
-1800V




2nd tube George Lolor and Zipis removed from the scintillators due to low gain.
Same base as above.
-2400V




envelope mode
5D envelope




1

10/3

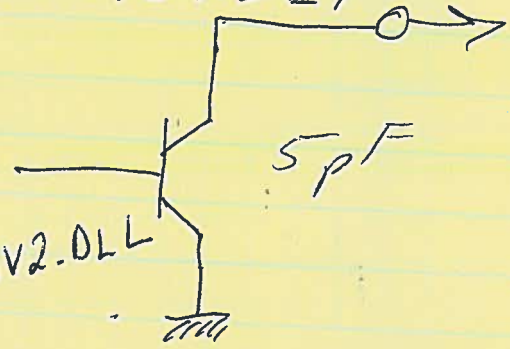
Borrowed an electronic capacitance meter from Hall B. With the leads attached it reads ~~82.4pF~~ 78pF. Attaching the leads to the 1st + ~~2nd~~ 3rd dynodes from the cathode gives a reading of 82.4pF.

Dynode 2 was floating!

$\Rightarrow$ ~4.4pF for dynode to dynode

12pF from DY1 to DY2. 6pF for leads used.
Same from DY2 to DY3.
Same from DY1 to DY3.

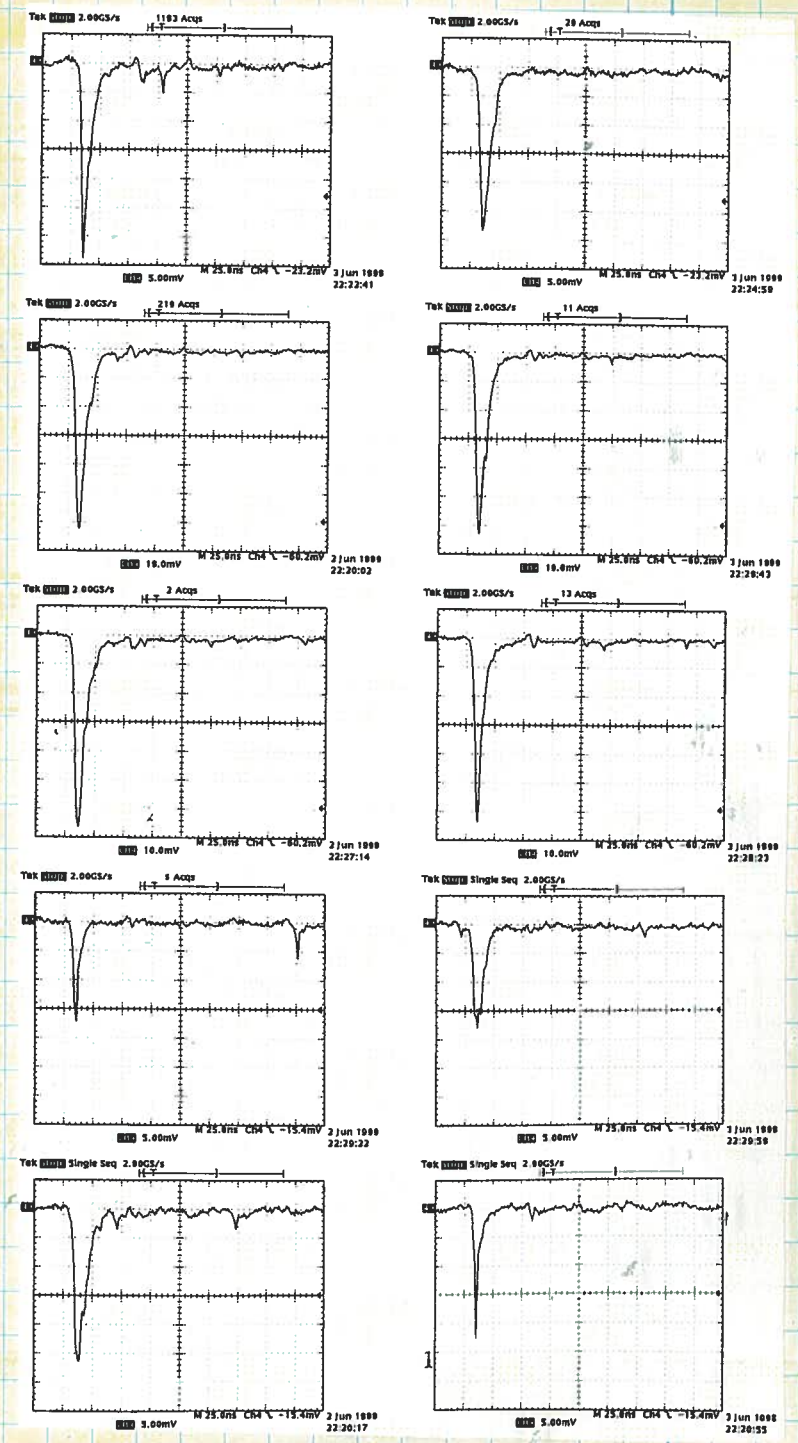
ØØ1Ø4B34F5EF
S/N 6MD134F5EF



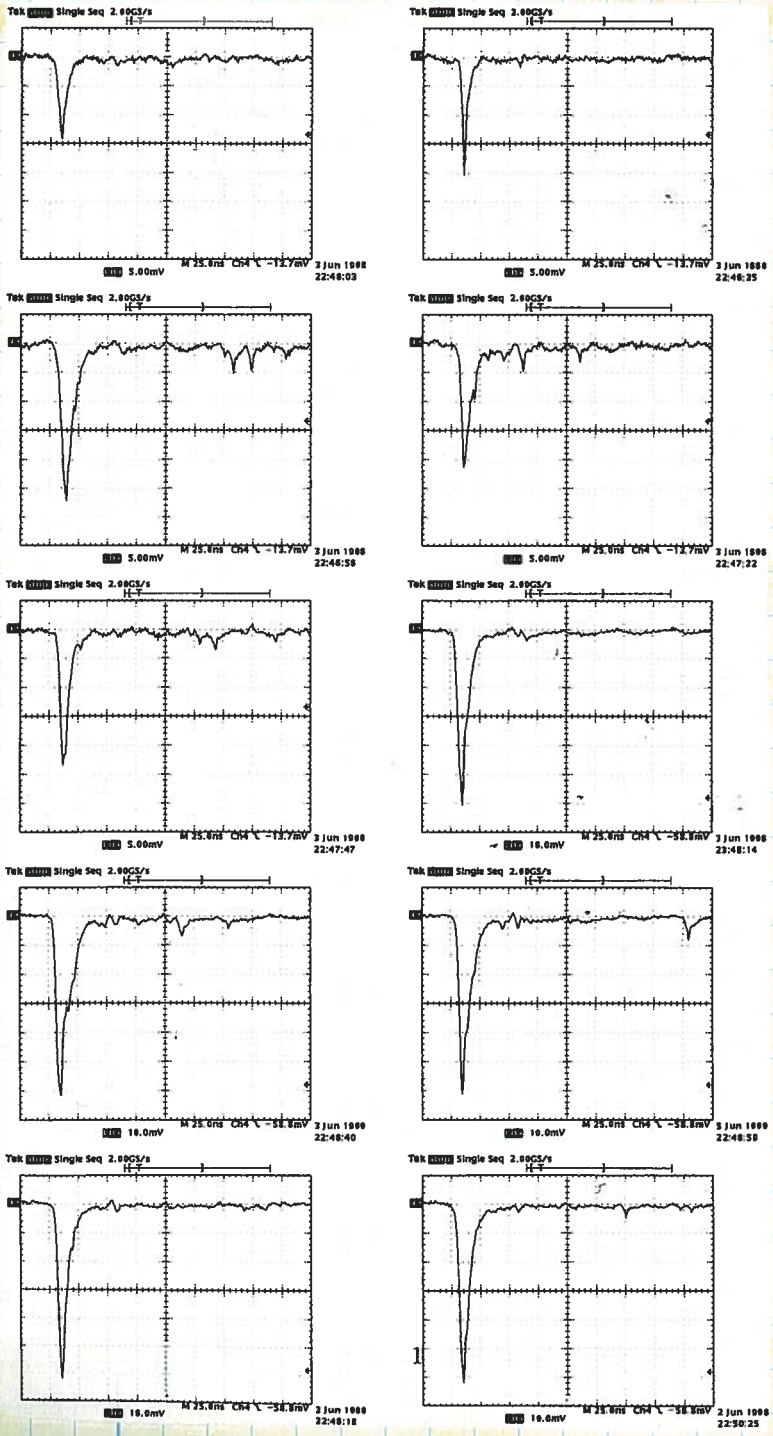

82.4
78.0
4.4pF

$L = \frac{1}{w^2 C}$ .3μH??

15 Ω in series with last 5 dynodes 12, 11, 10, 9 & 8
.001 μF caps are removed



No 15 Ω resistors
No capacitors

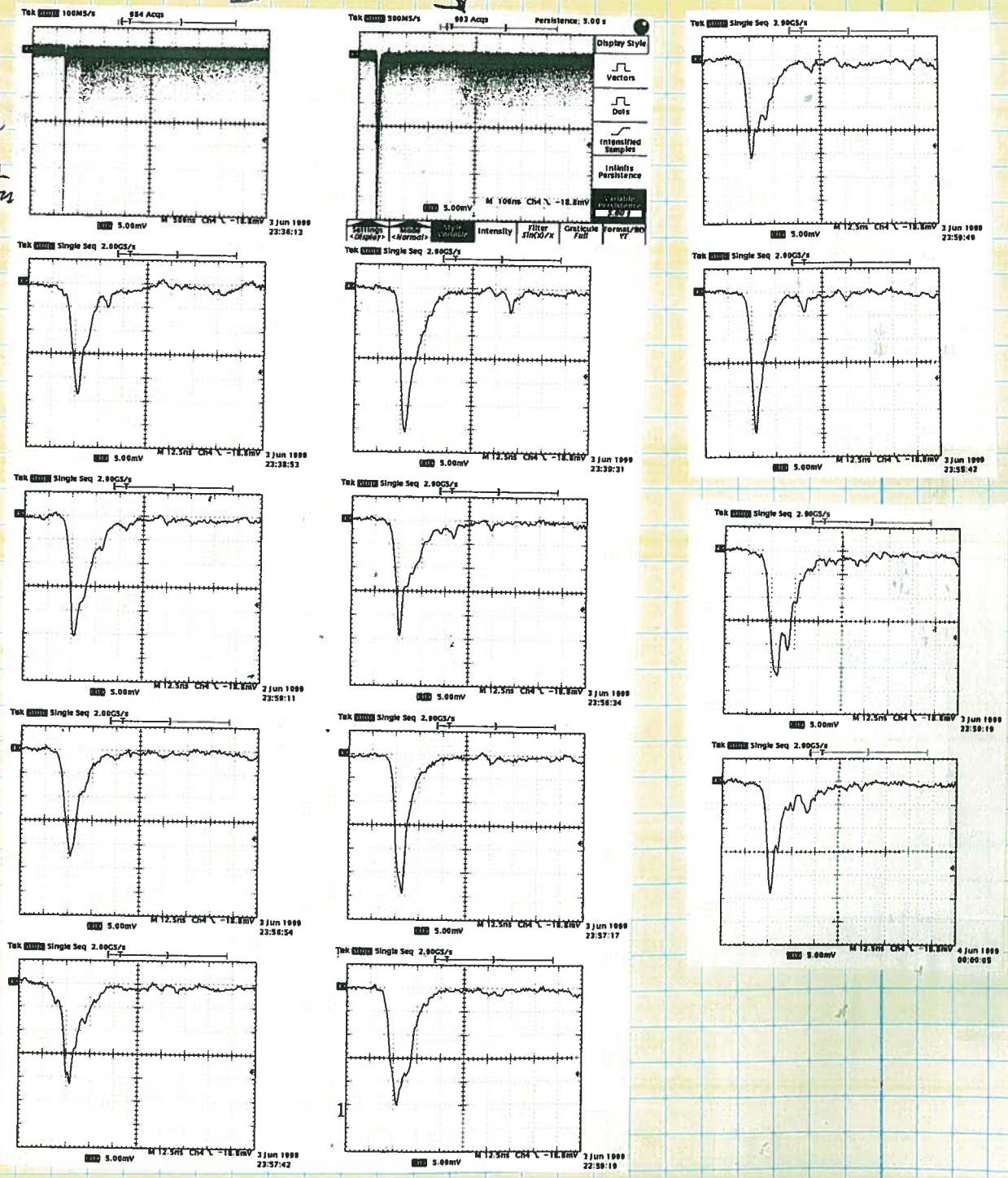


5 sec persistence

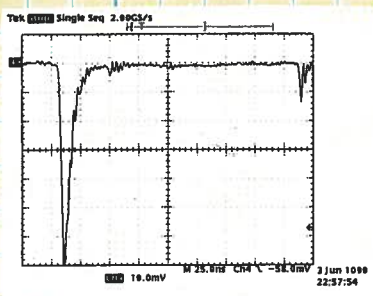
no 15 ohm resistors

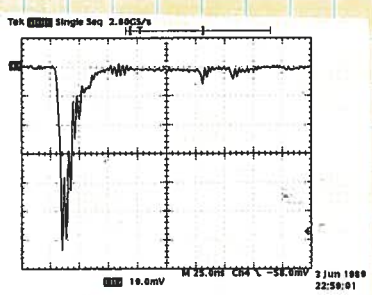
no capacitors

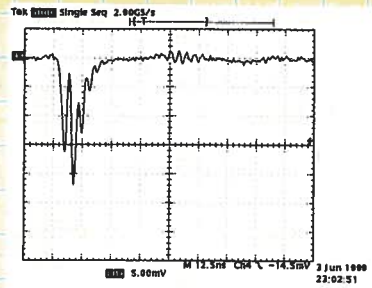
source about 1 inch away from scintillator (lower rate)

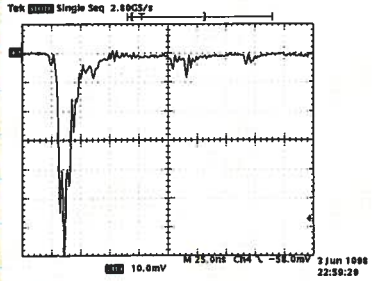


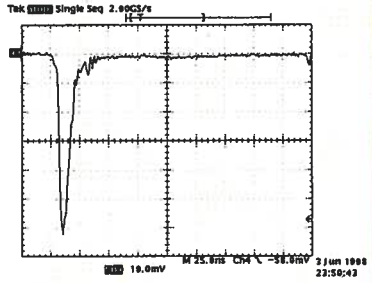
Dynode 12 (last one) bypassed to gnd with .001μF

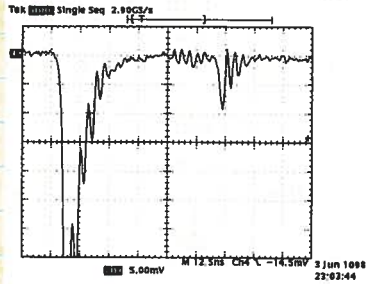


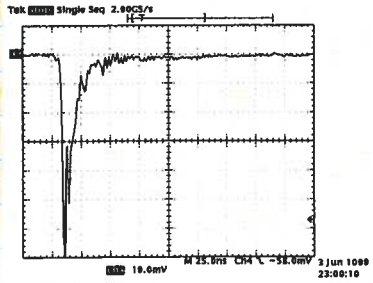



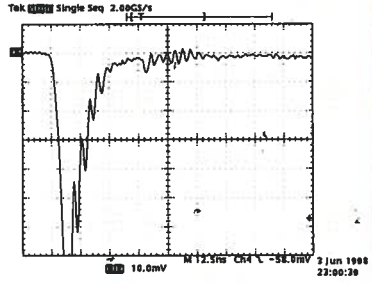



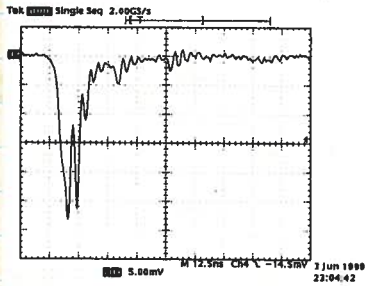



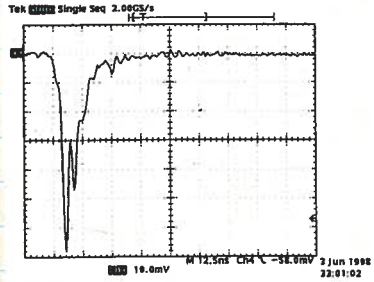



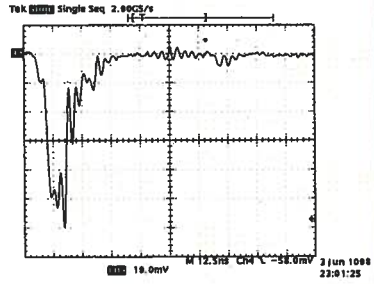



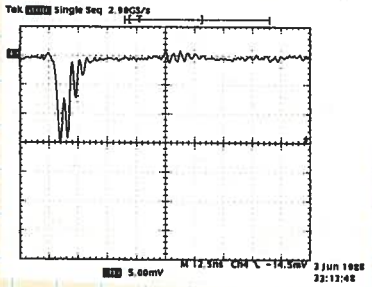



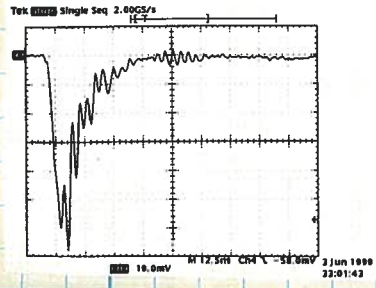



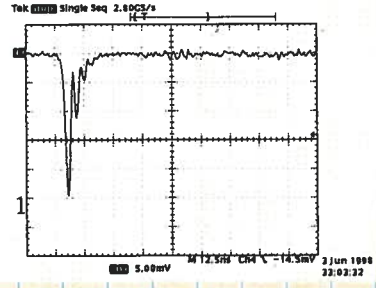



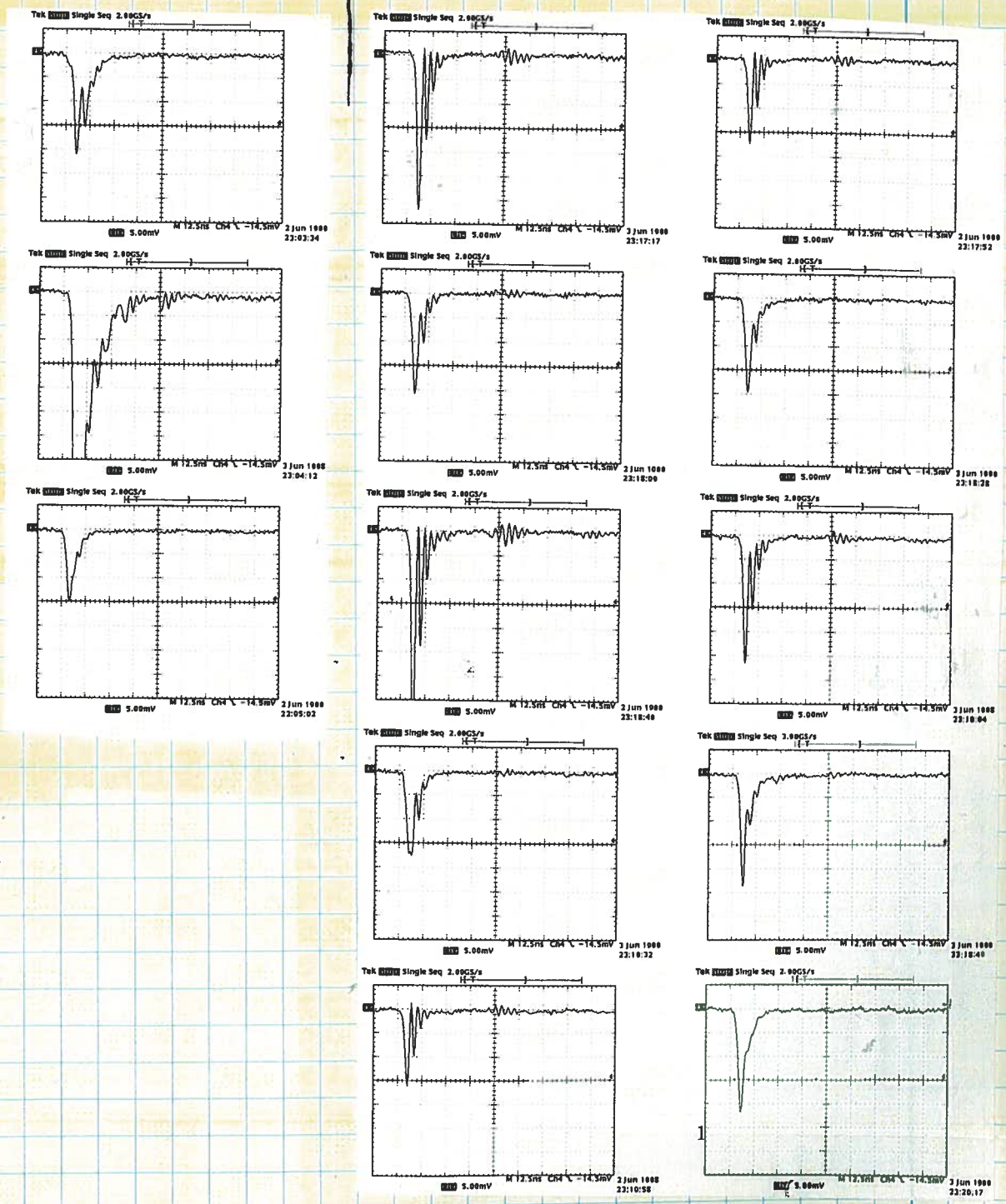



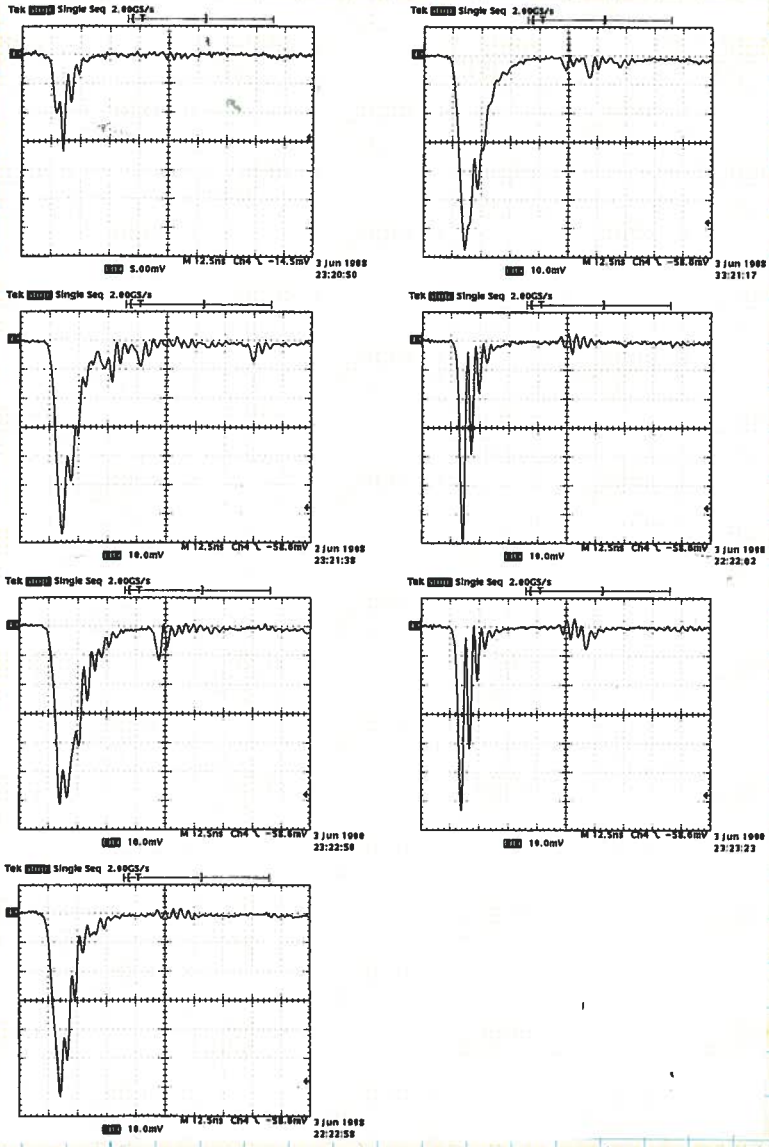



source against scintillator

dynode 12 bypassed - source ~1 inch way from scint. (lower rate)






Dynode 12 bypassed with .001μF

Source ~1" away from scint. (lower brate)

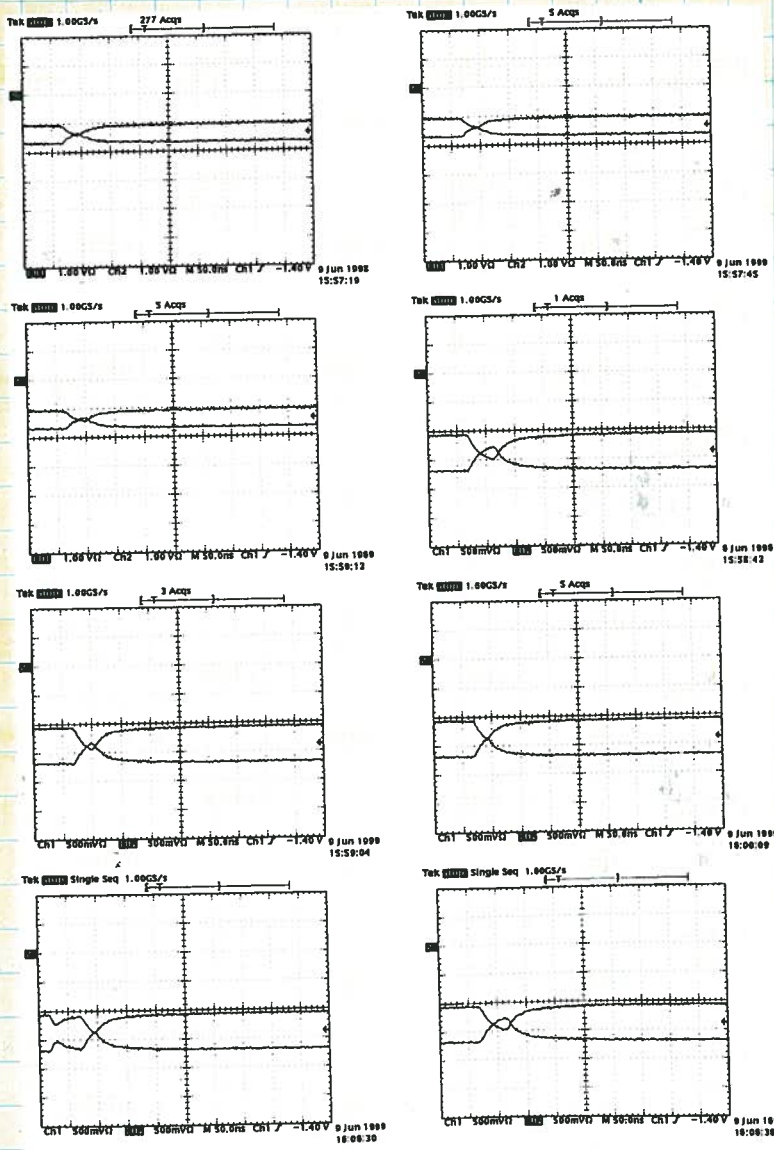
# Check of Wire Chamber for Photon Calorimeter 6/9/98

Looking at Bogdan W.'s wire chamber setup for the photon calorimeter on the floor.

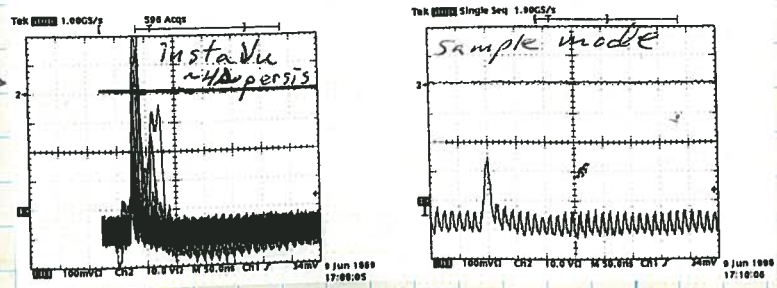
-2510 V (on Betan monitor output)
$Sr^{90}$ source ~1.5" from chamber
2 FET probes on pins of T'nF "T" at input of 4448 module

200' of T'nF from 2735 to latch modules.

Typical ECL signals at input of 4448

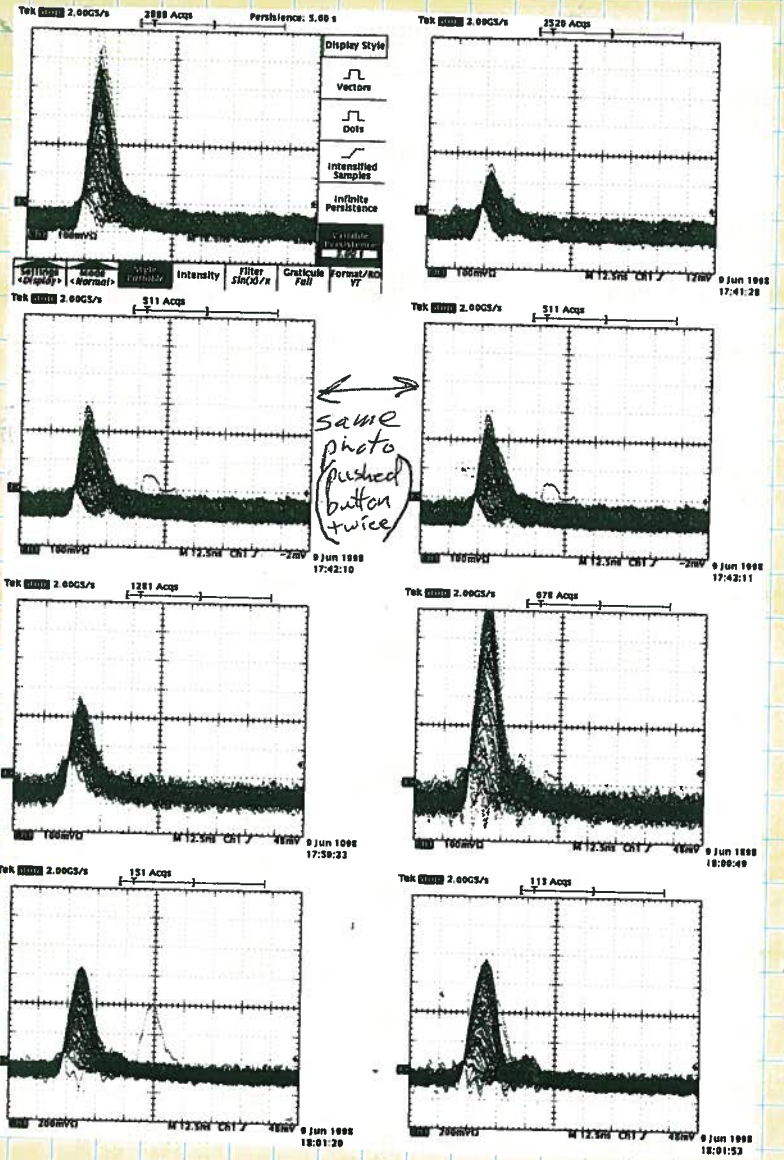



$Sr^{90}$ source held closer to the chamber. → FET probe on the 2735 card. Amplifier output.



FET probe on amplifier output.
$Fe^{55}$ source taped to hole in center of cover over the chamber.

2510V




2300V

2400V

same photo (pushed button twice)

2400V

Blew fuse on −5.2V input of card. Replaced card.

2400V

2550V

2550V

2600V

The threshold supply is set to 1.06V ⇒ −9mV at input of comparator
⇒ ~~42~~ → 46mV signal at comparator input

FET probe was on top end of 220 Ω resistor to gnd after L.C. combination out of amplifier