HEAVY ION SINGLE EVENT EFFECTS RADIATION TEST REPORT

Part Type : OP400Y

Quad Low Offset, Low Power Operational Amplifier

Manufacturer : Analog Devices

Report Reference : ESA_QCA0412S_C

Issue : 01

Date : July 7, 2004

ESA Contract No 13528/99/NL/MV COO-16 dated 05/01/04

European Space Agency Contract Report

The work described in this report was done under ESA contract.
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ESTEC Technical Officer: R. Harboe Sorensen

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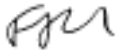
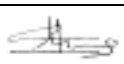
Checked by :	F.X Guerre		Date :	July 7, 2004
Approved by :	J. F. Mounes		Date :	July 7, 2004

Heavy ion SET characterization of OP400Y, Quad Low Offset, Low Power Operational Amplifier

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1 Abstract

Under ESA Contract No 13528/99/NL/MV COO-16 dated 05/01/04 covering "Radiation Evaluation of COTS Semiconductor Components: "Radiation evaluation of parts for the ATV project", the Analog Devices, OP400Y, Quad Low Offset, Low Power Operational Amplifier was radiation assessed.

Heavy ion radiation results, focusing on Single Event Transient (SET) effects, are reported in this report.

2 INTRODUCTION

This report presents the results of a Single Event Effects (SEE) test program carried out on OP400Y Quad Low Offset, Low Power Operational Amplifier from Analog Devices.
Test was conducted on 2 flight lot samples delivered by the ESA ATV project.
These devices were used during heavy ion tests carried out at the European Heavy Ion Irradiation Facility (HIF) at Cyclone, Université Catholique de Louvain – June 2004.
This work was performed for ESA/ESTEC under ESA Contract No 13528/99/NL/MV COO-16 dated 05/01/04.

3 REFERENCE DOCUMENTS

RD1. OP400Y data sheet
RD2. Annex 2 of ATV/MMS/EPG/FX/026.04 dated 13/02/0-4
RD3. Single Event Effects Test method and Guidelines ESA/SCC basic specification No 25100
RD4. The Heavy Ion Irradiation Facility at CYCLONE, UCL document, Centre de Recherches du Cyclotron (IEEE NSREC'96, Workshop Record, Indian Wells, California, 1996)

4 DEVICE INFORMATION

4.1 OP400Y

The OP400Y is a Quad Low Offset, Low Power Operational Amplifier in a 14-PIN ceramic DIP package.

Relevant device identification information is presented here after and photos of device with die identification and die dimensions are shown in Figure 1.

Part type:	OP400Y
Manufacturer:	Analog Devices
Package:	14-Pin Cerdip
Quality Level:	Hi-Rel
Date Code:	0028A
Top marking:	see photo in Figure 1

4.2 Sample preparation

Three samples were delidded mechanically.

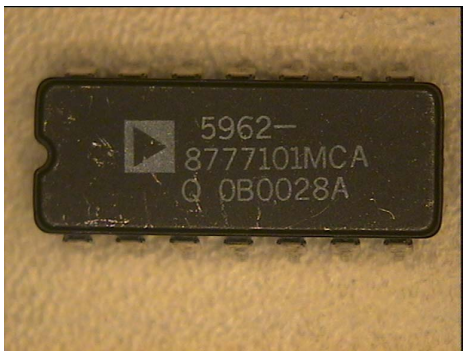


Photo 1 – Top marking

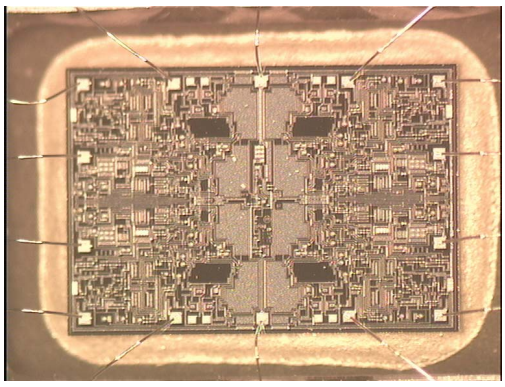


Photo 2 – die, full view

Die dimensions:
3.1 mm x 4.6 mm

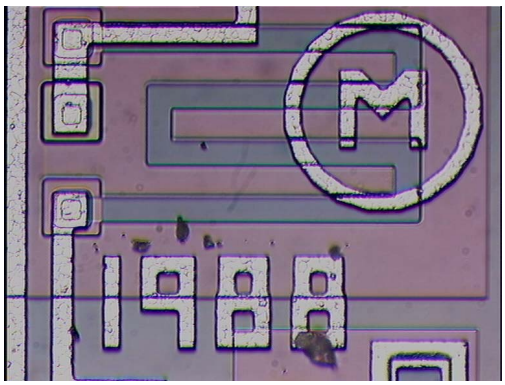


Photo 3 – die, marking, detail 1

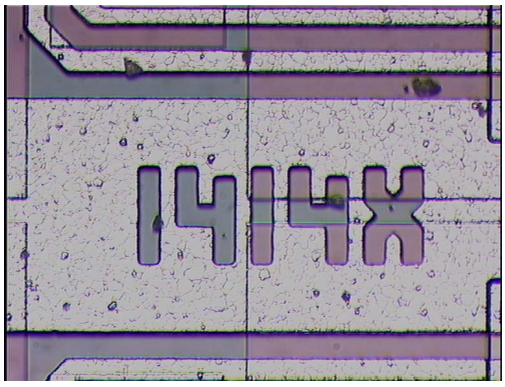


Photo 4 – die, marking, detail 2

Figure 1 – OP400Y sample identification

5 Test Definition

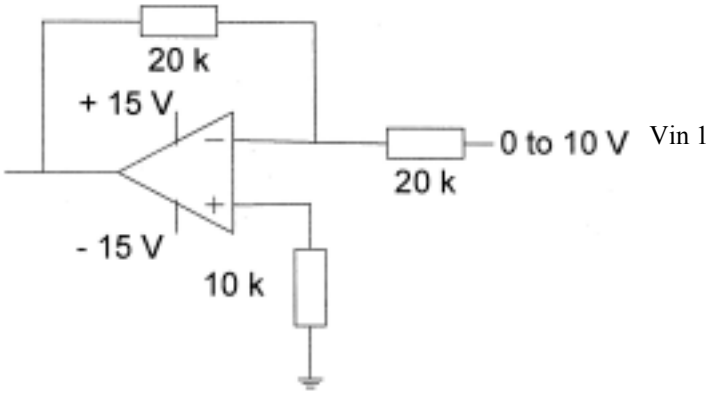
5.1 Test Set-up

The basic set-up consists in monitoring DUT amplifier output voltage with an oscilloscope and count the number of transient pulses (SET).
All the SETs occurring during a run, are recorded which allows for the identification of both SETs envelop and worst case event.
For each set-up configuration and for a given LET, two runs are generally performed, one to detect positive SET pulses the other one to detect negative SET pulses.

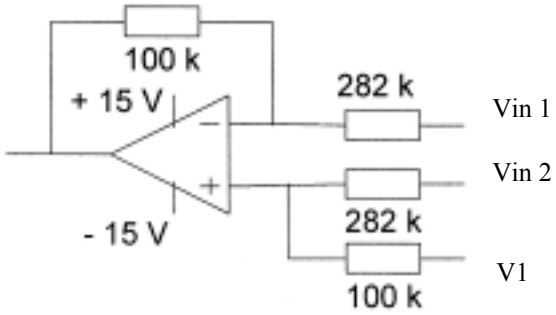
5.2 Test Configuration

In accordance with RD2, 4 different set-up conditions have been used and are presented here below.

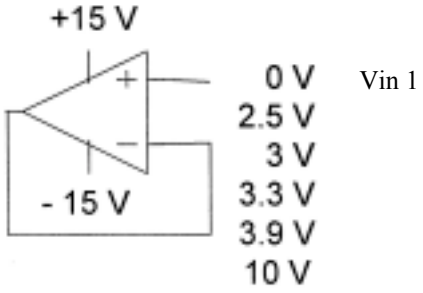
5.2.1 Set-up 1



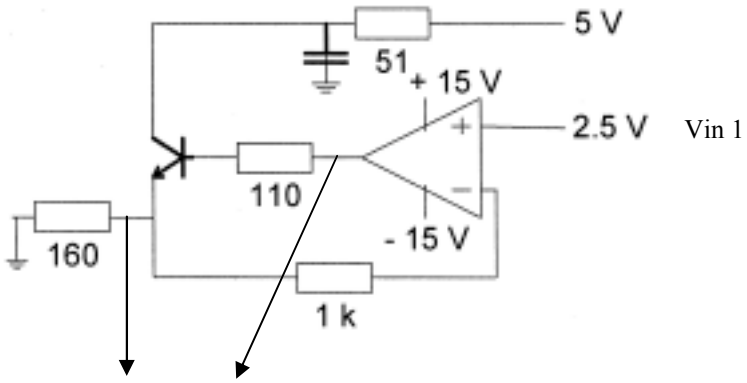
5.2.2 Set-up 2



5.2.3 Set-up 3



5.2.4 Set-up 4



6 UCL TEST FACILITY

Test at the cyclotron accelerator was performed at Université de Louvain (UCL) in Louvain-La-Neuve (Belgium) under HIREX Engineering responsibility.

6.1 Beam Source

In collaboration with the European Space Agency (ESA), the needed equipment for single events studies using heavy ions was built and installed on the HIF beam line in the experimental hall of Louvain-La-Neuve cyclotron.
CYCLONE is a multi particle, variable energy, cyclotron capable of accelerating protons (up to 75 MeV), alpha particles and heavy ions. For the heavy ions, the covered energy range is between 0.6 MeV/AMU and 27.5 MeV/AMU. For these ions, the maximal energy can be determined by the formula:

$$110\ Q^2/M,$$

where Q is the ion charge state, and M is the mass in Atomic Mass Units.
The heavy ions are produced in a double stage Electron Cyclotron Resonance (ECR) source. Such a source allows producing highly charged ions and ion "cocktails". These are composed of ions with the same or very close M/Q ratios. The cocktail ions are injected in the cyclotron, accelerated at the same time and extracted separately by a fine tuning of the magnetic field or a slight changing of the RF frequency. This method is very convenient for a quick change of ion (in a few minutes) which is equivalent to a LET variation.

6.2 Dosimetry

The current UCL Cyclotron dosimetry system and procedures were used.

6.3 Used ions

The UCL ions used are listed in the table below.

Ion	Energy	LET	Range (Si)
	(MeV)	(MeV.cm²/mg)	µm
20Ne4	78	5.85	45
40Ar8	150	14.1	42
84Kr17	316	34	43

Table 1- UCL ions and features thereof

6.4 Beam set-up

The use of a tilt angle allows for additional effective LET values.
For each run, the following information is given in the detailed results tables provided in the next paragraph (paragraph 7) :

- Run Number
- Device S/N
- Set-up
- Bias conditions (V1, Vin1, Vin2)
- Output voltage triggering level
- Pulse (↓↑)
- Ion type
- Tilt angle
- LET
- Fluence
- Test Duration
- Averaged flux
- SETs (with a pulse width >= 5ns and a pulse height >=0.25V)
- SETs (all pulses triggered with 0.25V)

7 RESULTS

SET triggering level was set to +/-0.250mV around the amplifier output voltage.
For each LET value, negative SETs and positive SETs have been detected during two distinct runs.
The detailed results per run are presented in Table 2.
Typical events recorded for negative SETs are shown in Figure 2 (Run 22, LET=22.8) and for positive SETs (run 23, LET = 22.8) in Figure 3.
To evaluate the influence of the LET value on the SET height and width, the following paragraphs present for each set-up and then for each run, the SET envelop (pulses with a width >= 5ns and a height >=0.25V) and the worst case SET.
No SET could be detected for set-up #4 with the scope connected to the load or to the amplifier output (run153 to 155)

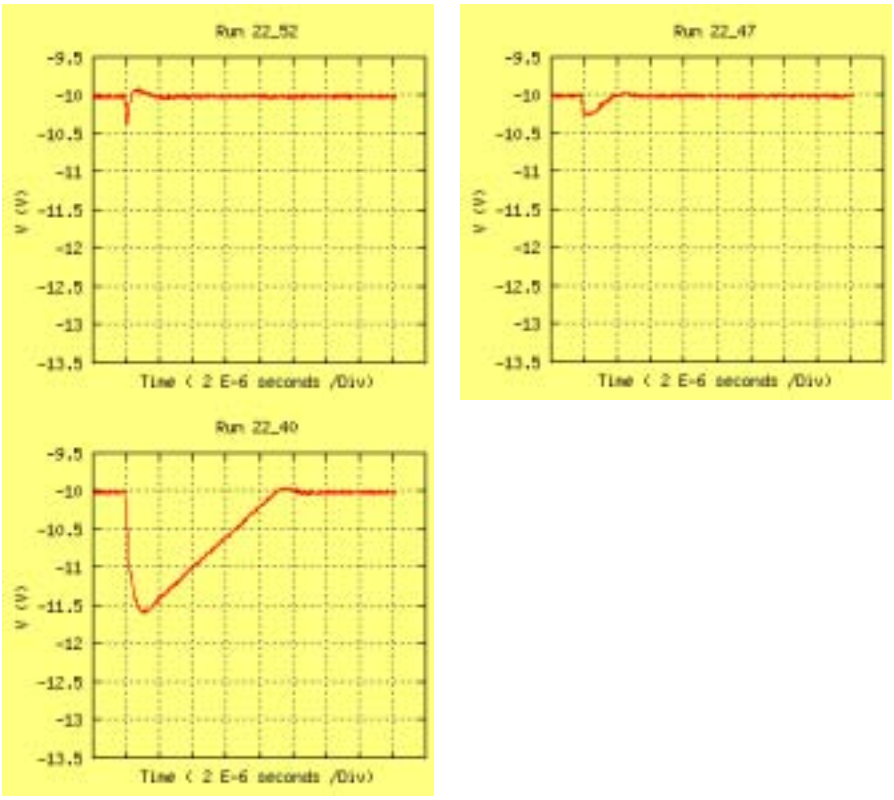


Figure 2 – Run 22, LET=22.8, typical SETs

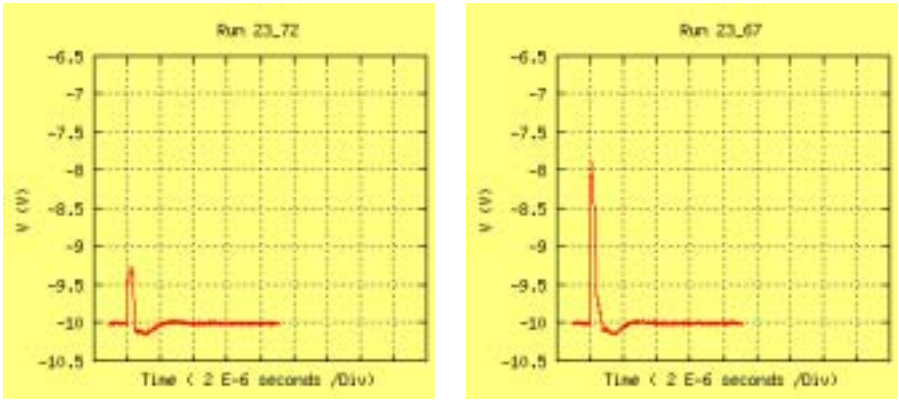
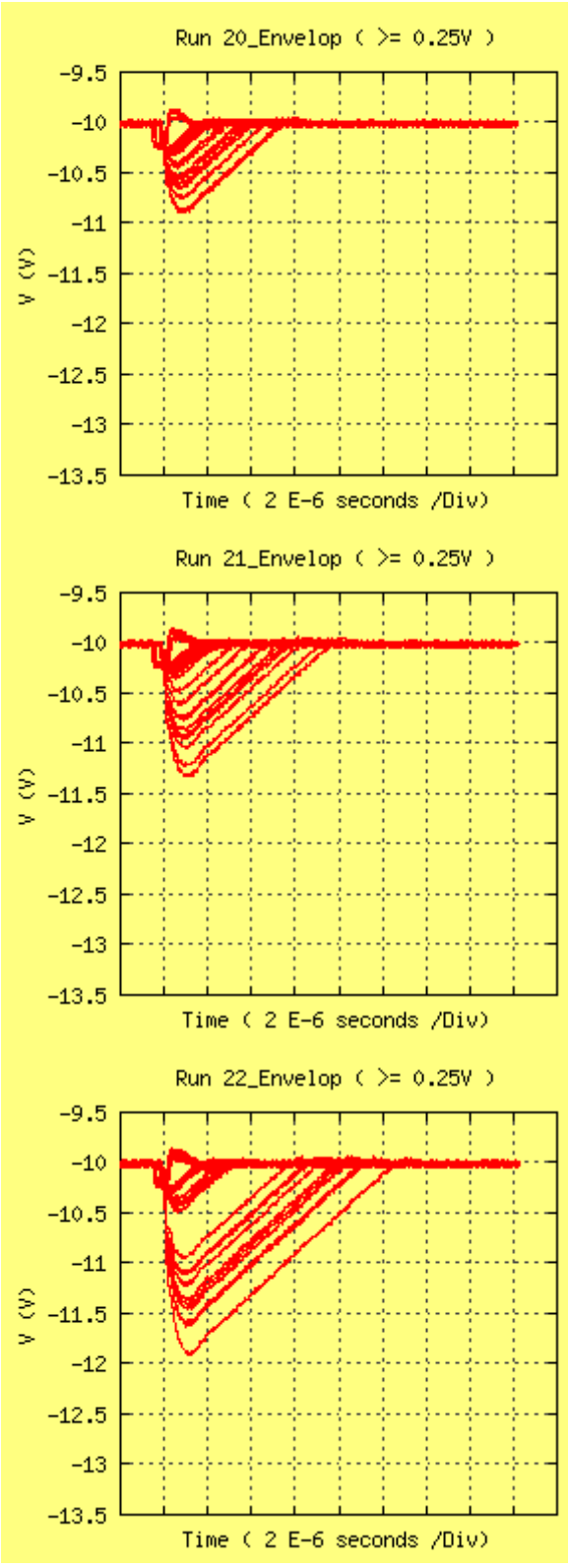
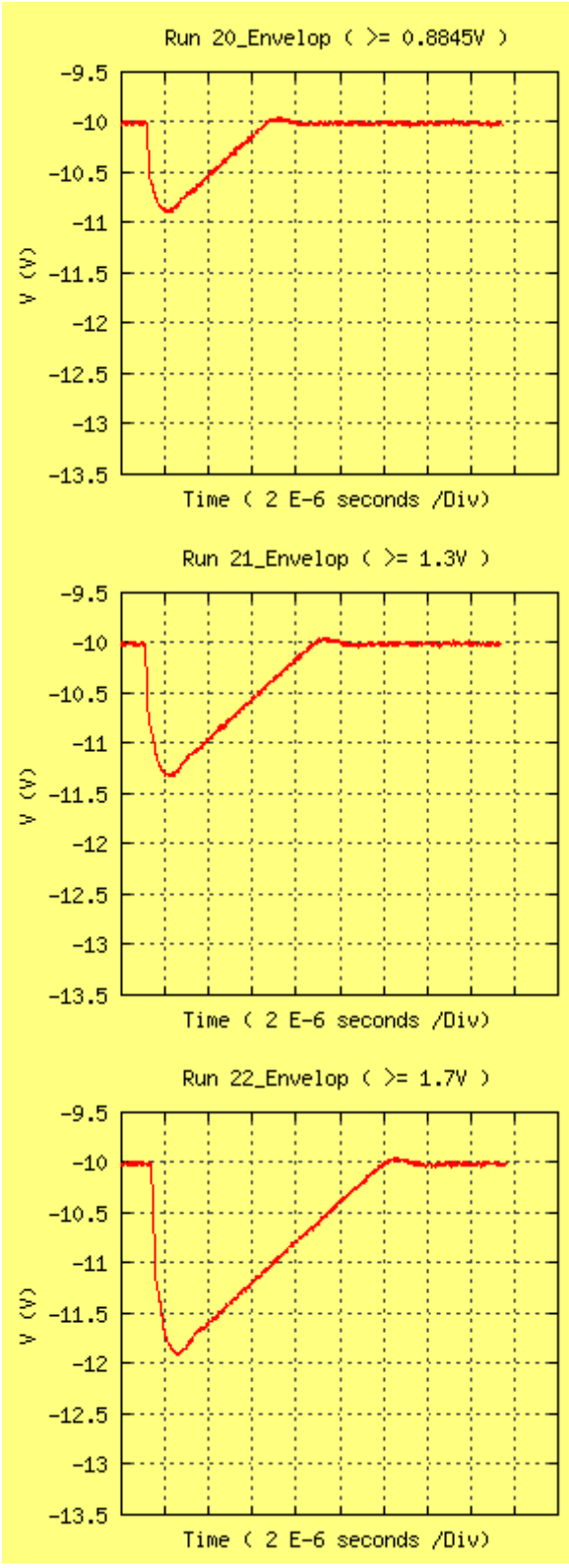


Figure 3 – Run 23, LET=22.8, typical SETs

7.1 Set-up 1-1, negative SETs, Vin=10V, Output1

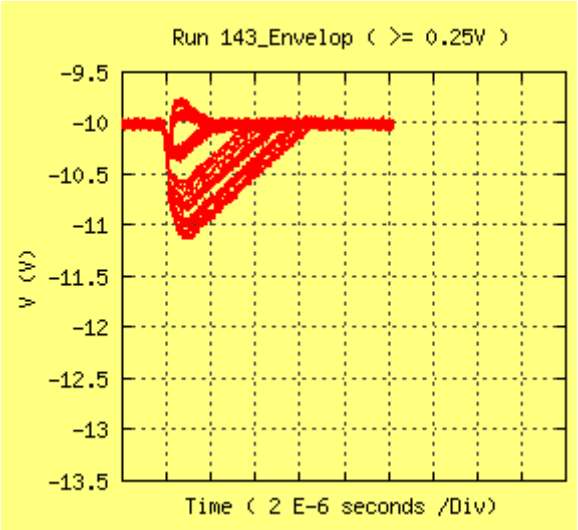


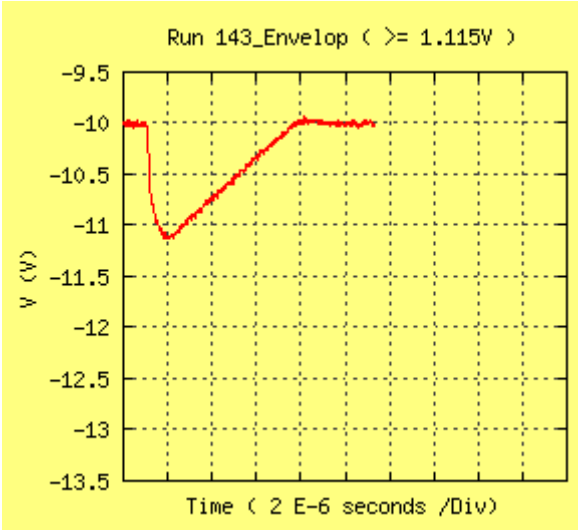


Run20
Set-up 1-1
Vin = 10V
Trig= -10.25V
LET 14.1
Fluence 1 E+06

Run21
Set-up 1-1
Vin =10V
Trig= -10.25V
LET 19.94
Fluence 1 E+06

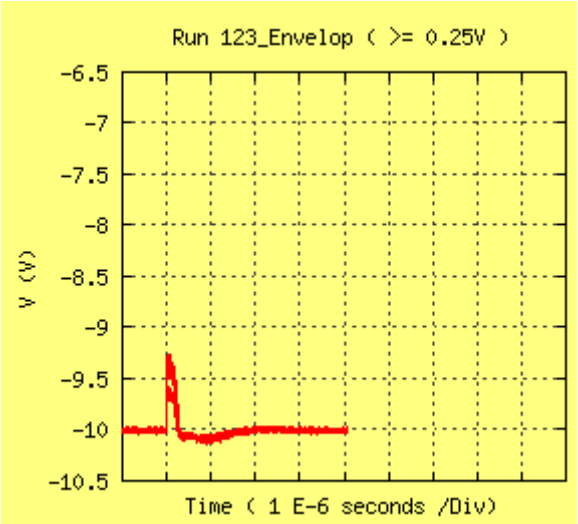
Run22
Set-up 1-1
Vin =10V
Trig= -10.25V
LET 28.2
Fluence 1 E+06

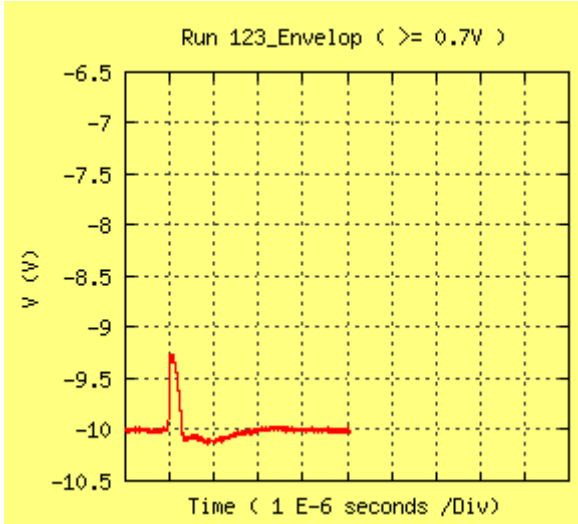




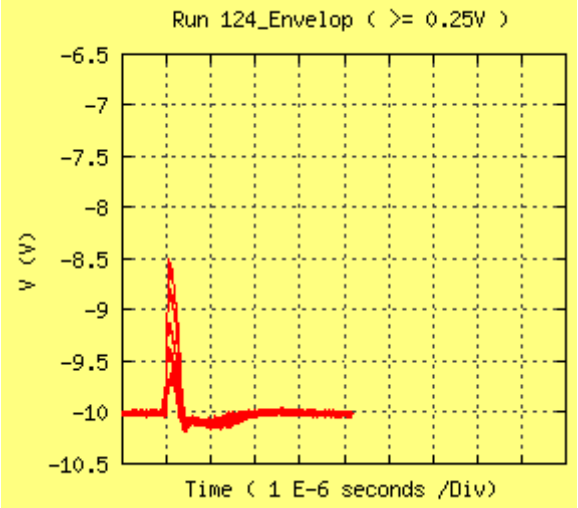
Run143
Set-up 1-1
Vin =10V
Trig= -10.25V
LET 34
Fluence 1 E+05

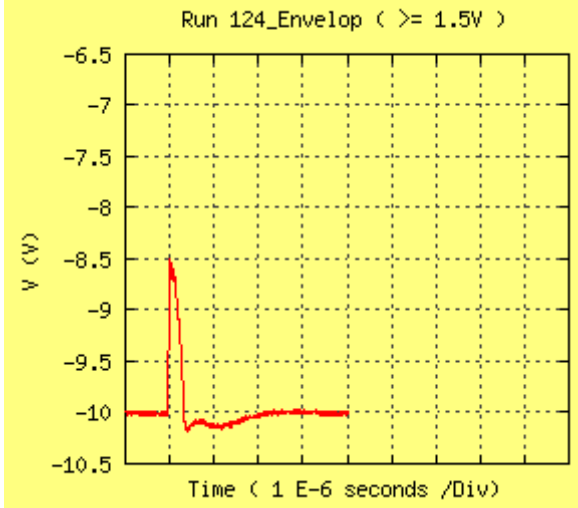
7.2 Set-up 1-1, positive SETs, Vin=10V, Output1



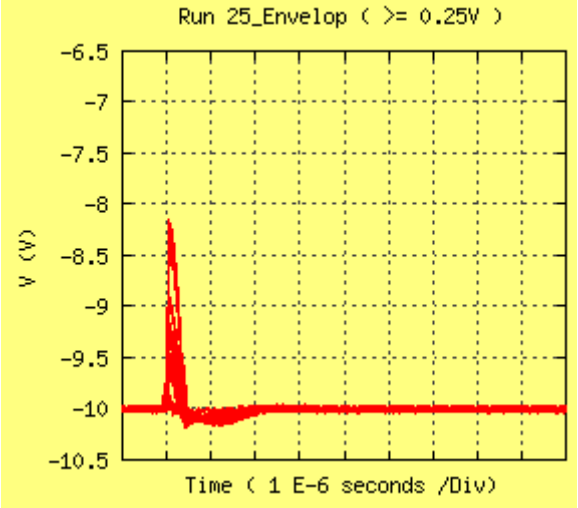


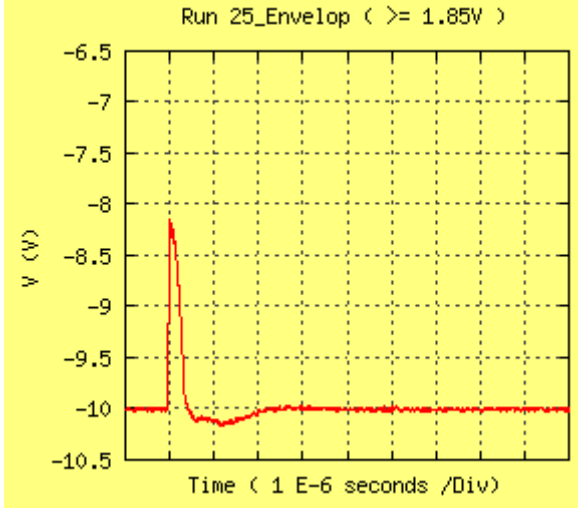
Run123
Set-up 1-1
Vin =10V
Trig= -9.75V
LET 5.85
Fluence 5 E+05



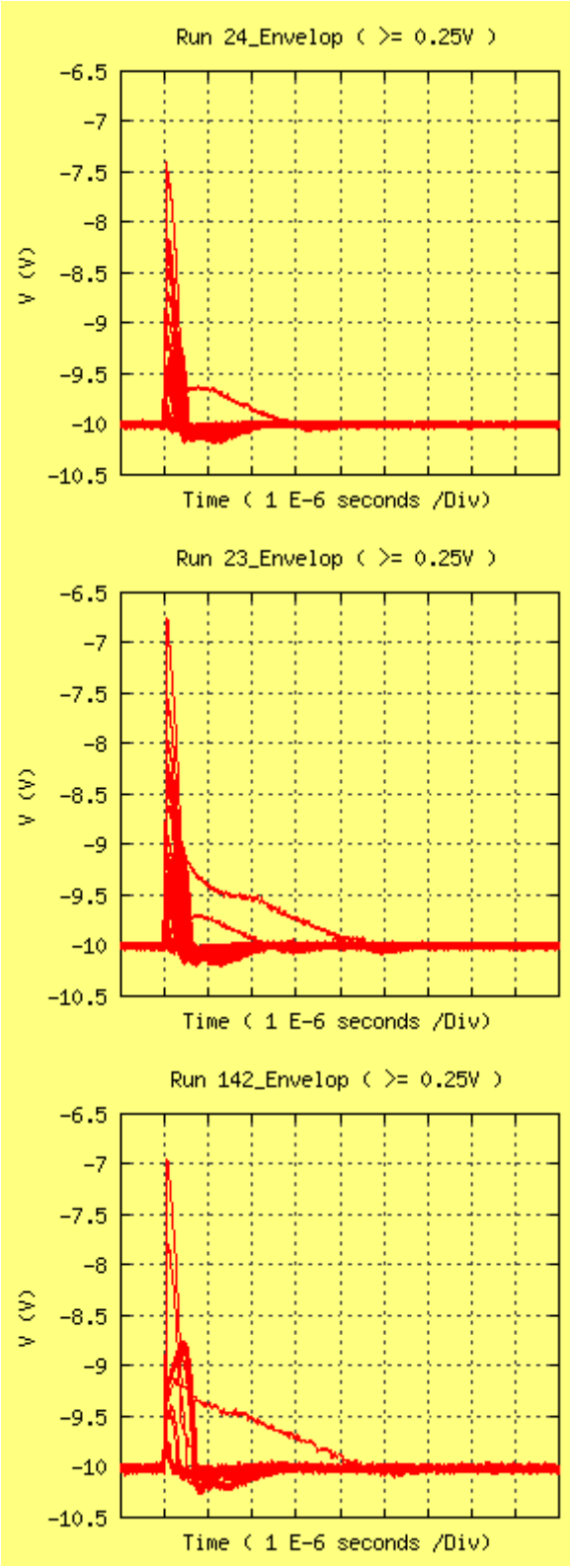


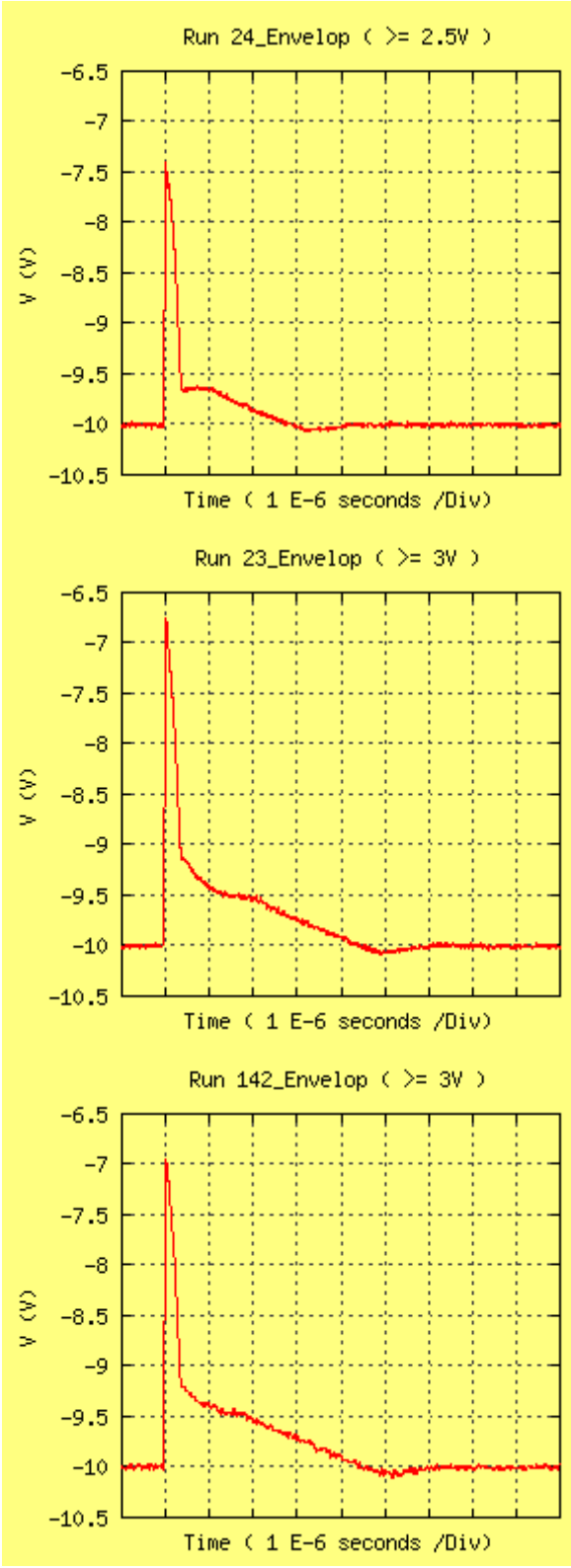
Run124
Set-up 1-1
Vin =10V
Trig= -9.75V
LET 11.7
Fluence 5 E+05





Run25
Set-up 1-1
Vin =10V
Trig= -9.75V
LET 14.1
Fluence 1 E+06



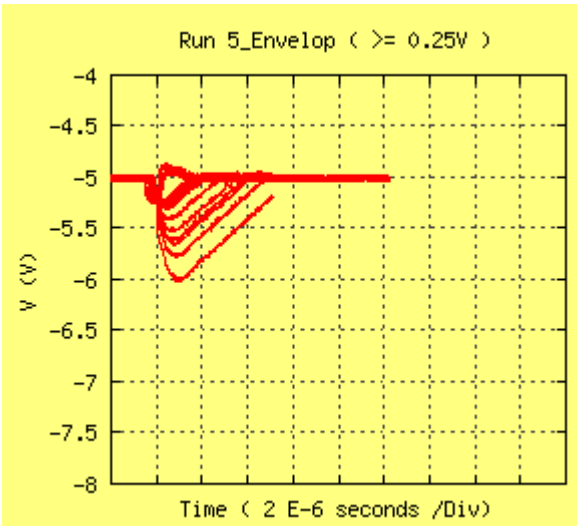


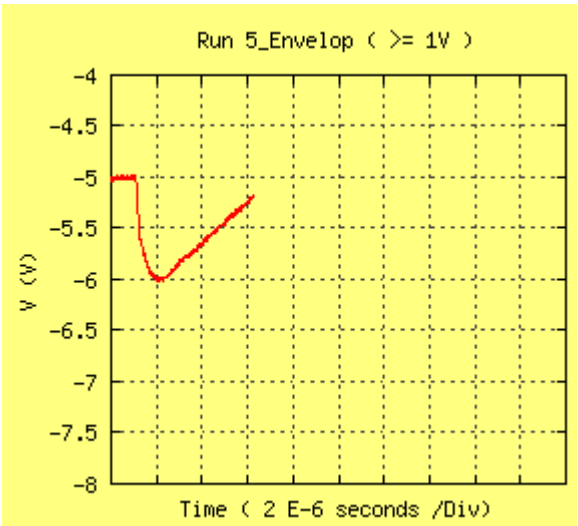
Run24
Set-up 1-1
Vin =10V
Trig= -9.75V
LET 19.94
Fluence 1 E+06

Run23
Set-up 1-1
Vin =10V
Trig= -9.75V
LET 28.2
Fluence 1 E+06

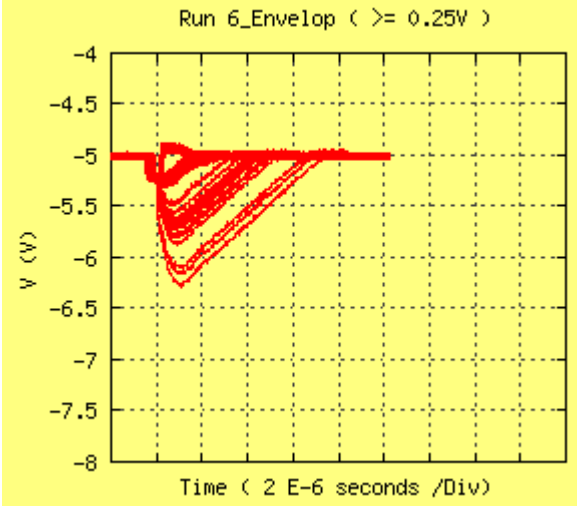
Run142
Set-up 1-1
Vin =10V
Trig= -9.75V
LET 34
Fluence 1 E+05

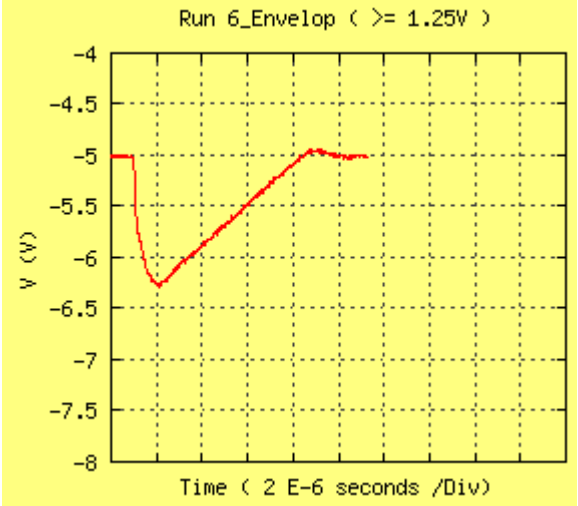
7.3 Set-up 1-1, negative SETs, Vin=5V, Output1



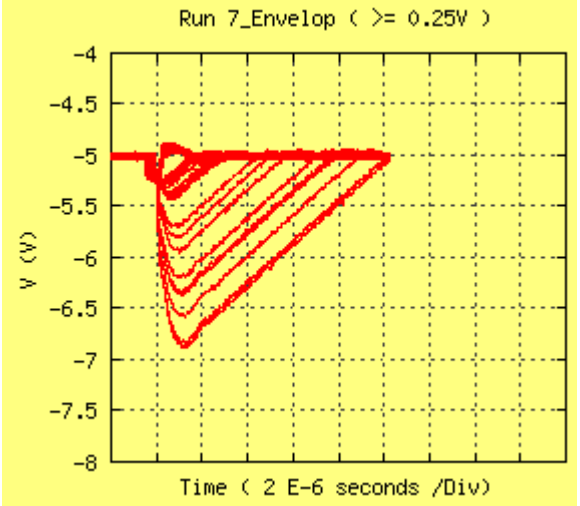


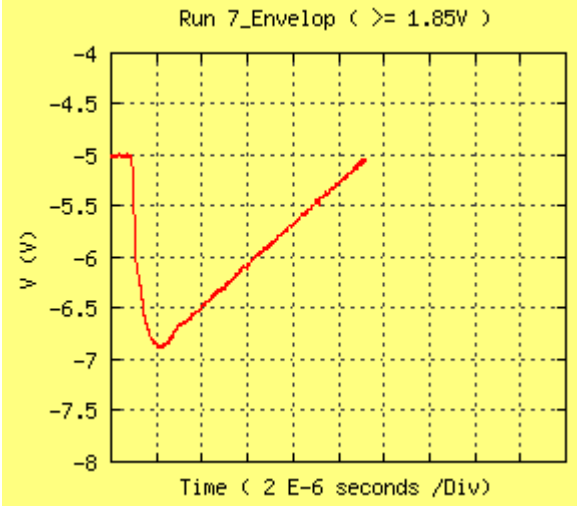
Run5
Set-up 1-1
Vin =5V
Trig= -5.25V
LET 14.1
Fluence 1 E+06



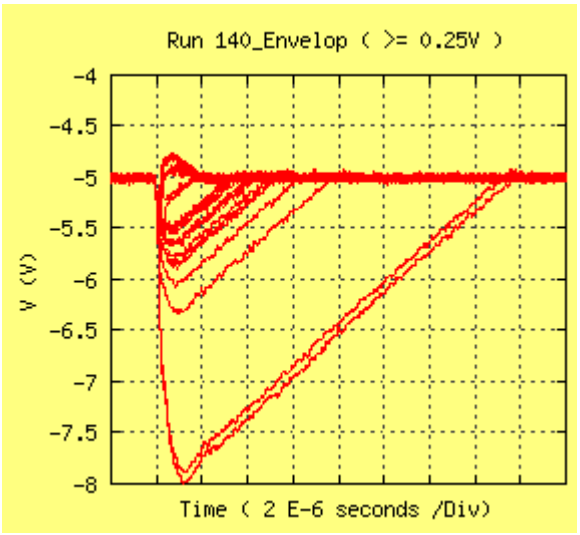


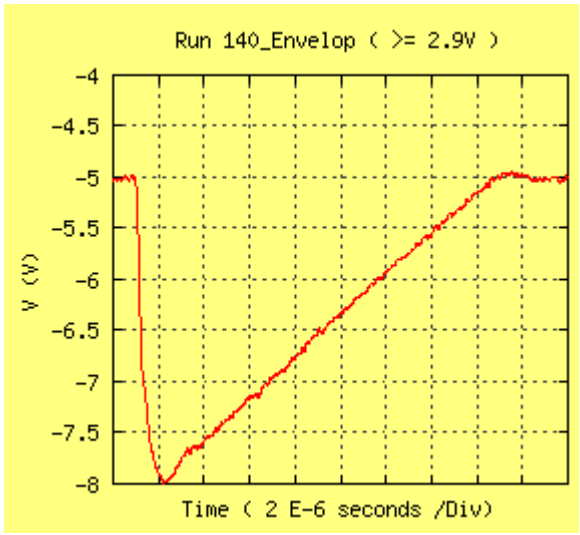
Run6
Set-up 1-1
Vin =5V
Trig= -5.25V
LET 19.94
Fluence 1 E+06





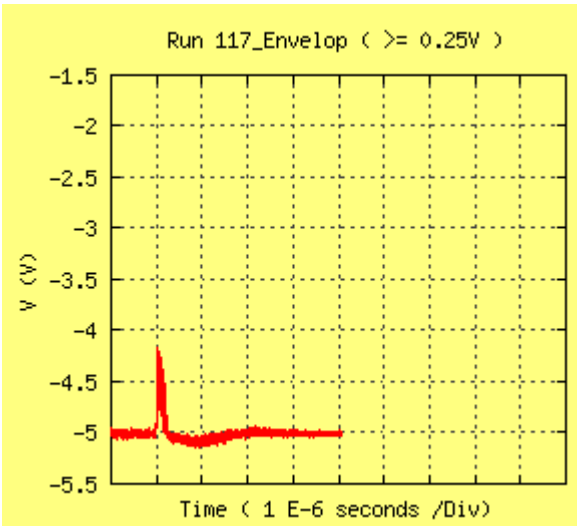
Run7
Set-up 1-1
Vin =5V
Trig= -5.25V
LET 28.2
Fluence 1 E+06

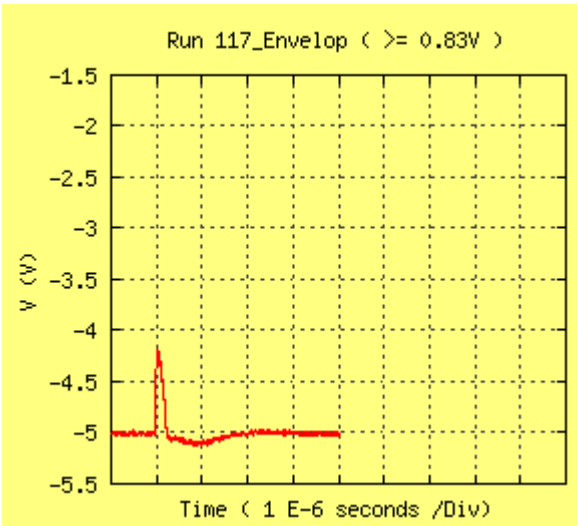




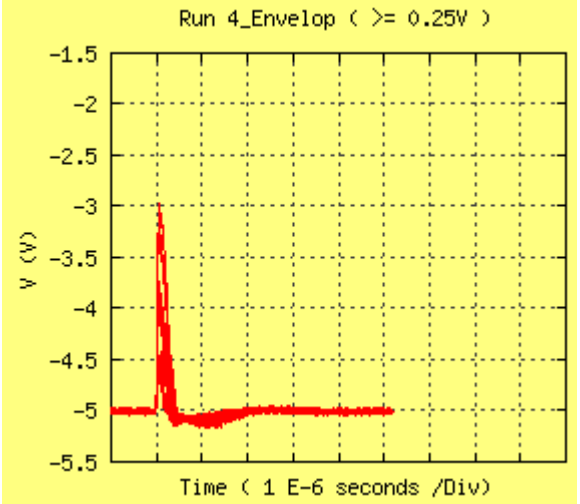
Run140
Set-up 1-1
Vin =5V
Trig= -5.25V
LET 34
Fluence 1 E+05

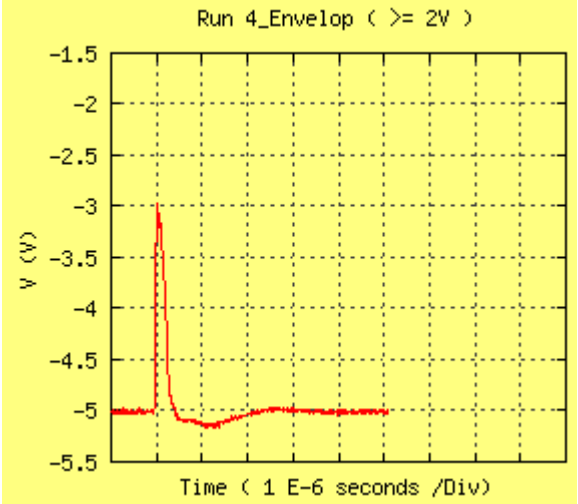
7.4 Set-up 1-1, positive SETs, Vin=5V, Output1



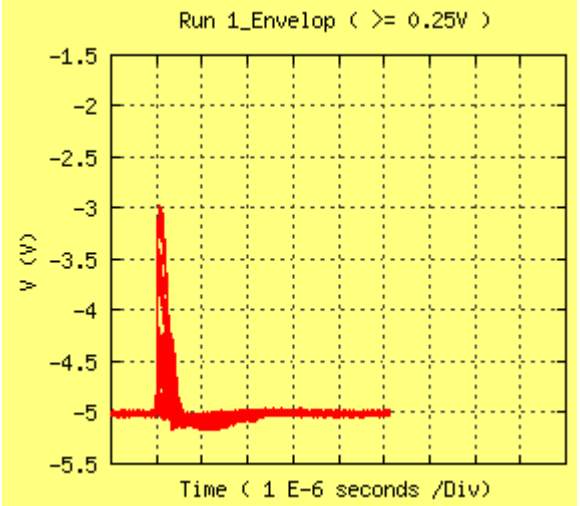


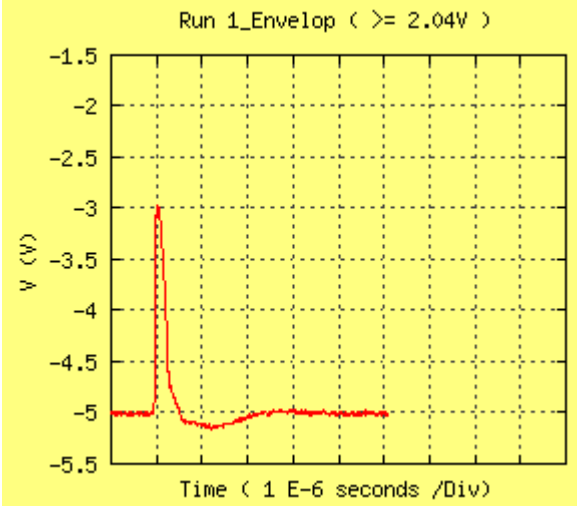
Run117
Set-up 1-1
Vin =5V
Trig= -4.75V
LET 5.85
Fluence 5 E+05



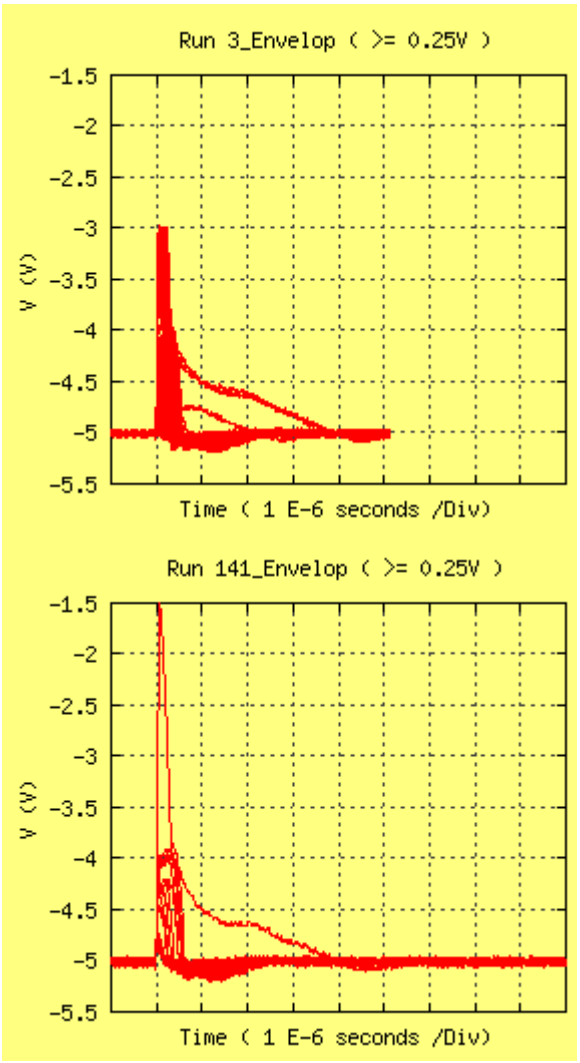


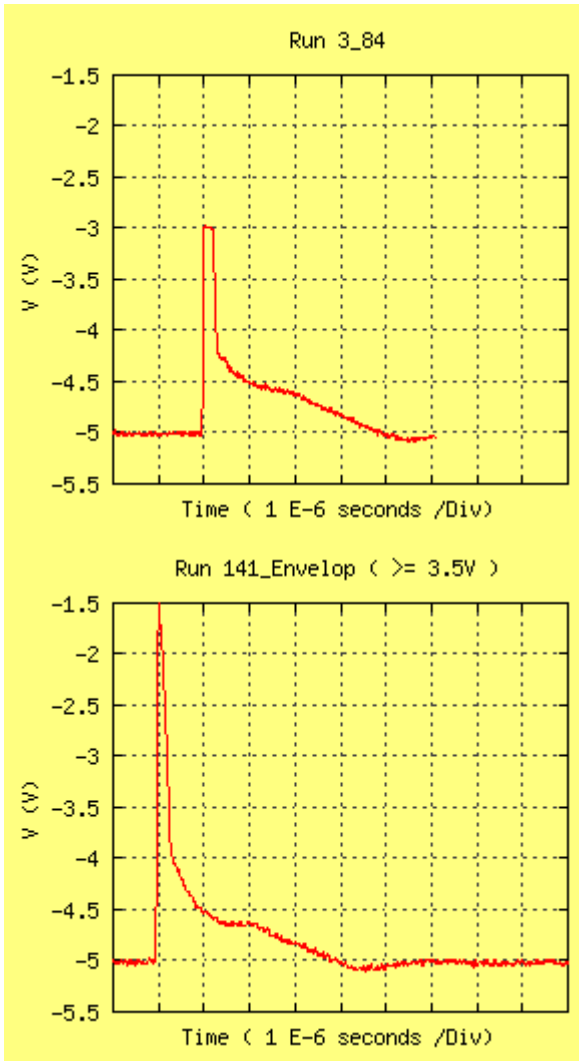
Run4
Set-up 1-1
Vin =5V
Trig= -4.75V
LET 14.1
Fluence 1 E+06





Run2
Set-up 1-1
Vin =5V
Trig= -4.75V
LET 19.94
Fluence 1 E+06

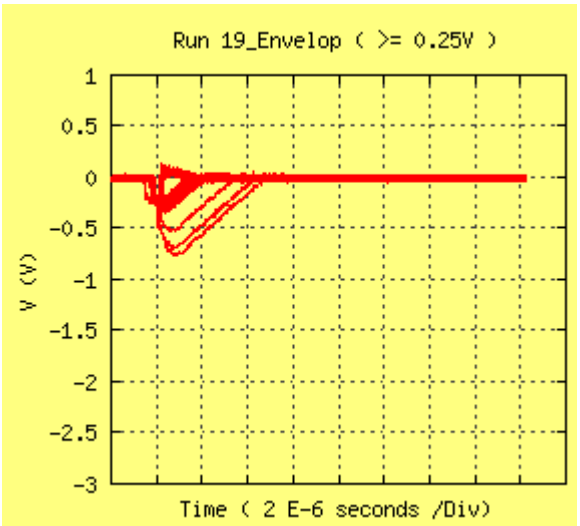


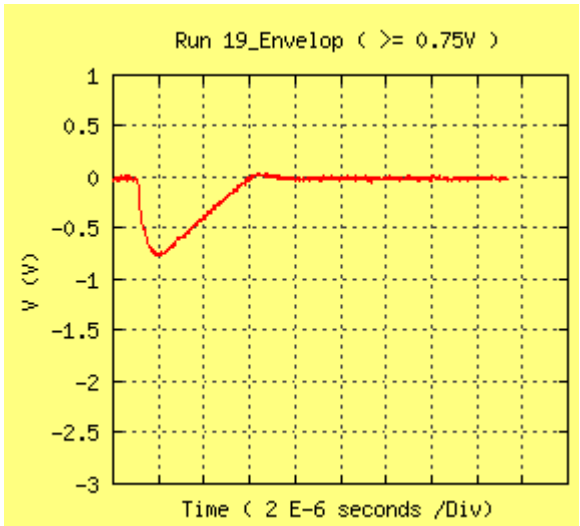


Run3
Set-up 1-1
Vin =5V
Trig= -4.75V
LET 28.2
Fluence 1 E+06

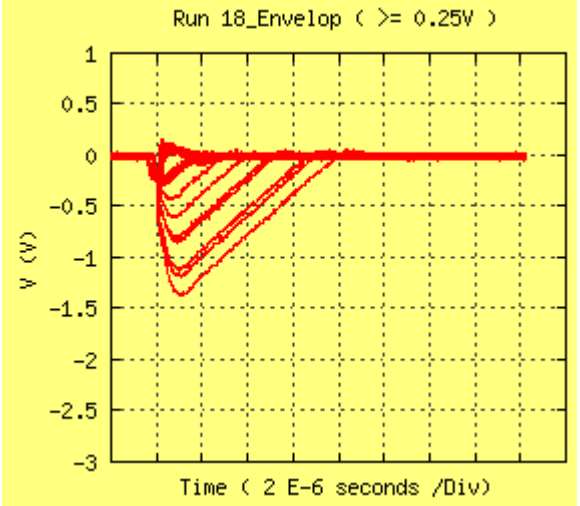
Run141
Set-up 1-1
Vin =5V
Trig= -4.75V
LET 34
Fluence 1 E+05

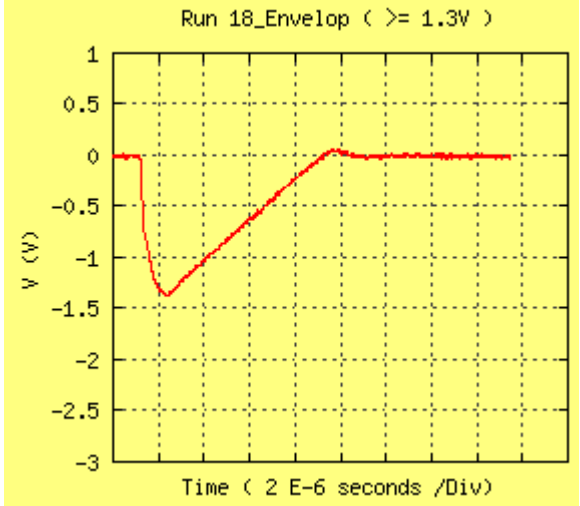
7.5 Set-up 1-1, negative SETs, Vin=0V, Output1



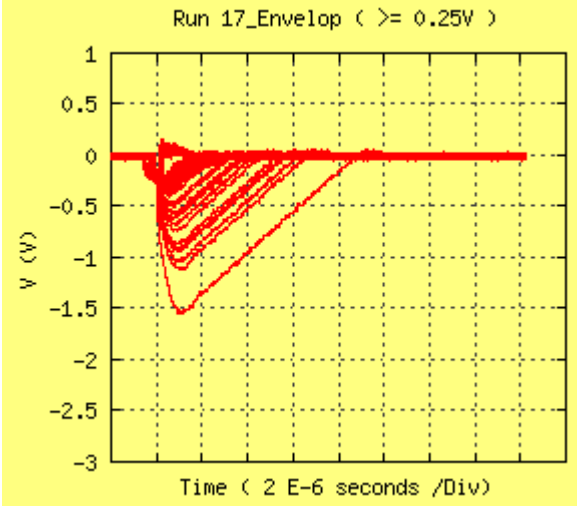


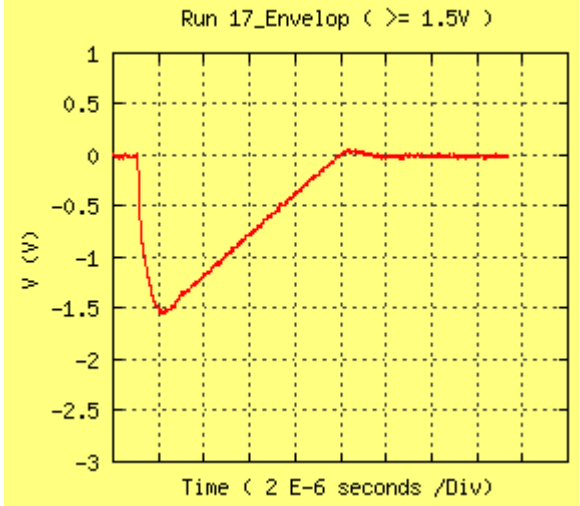
Run19
Set-up 1-1
Vin =0V
Trig= -0.25V
LET 14.1
Fluence 1 E+06



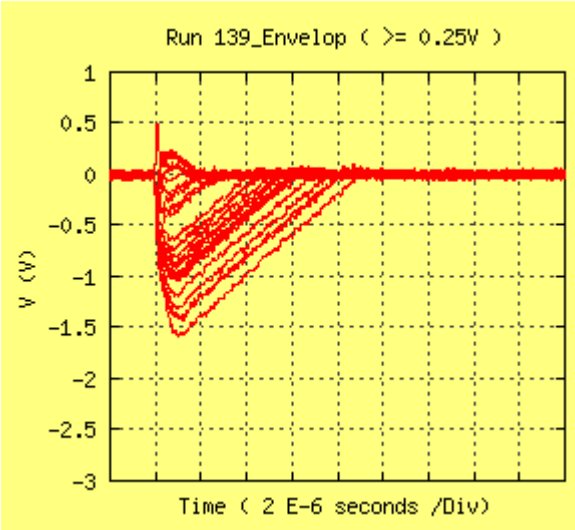


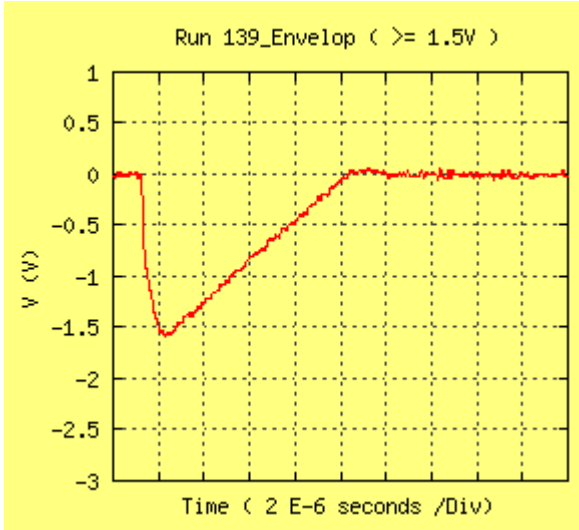
Run18
Set-up 1-1
Vin =0V
Trig= -0.25V
LET 19.94
Fluence 1 E+06





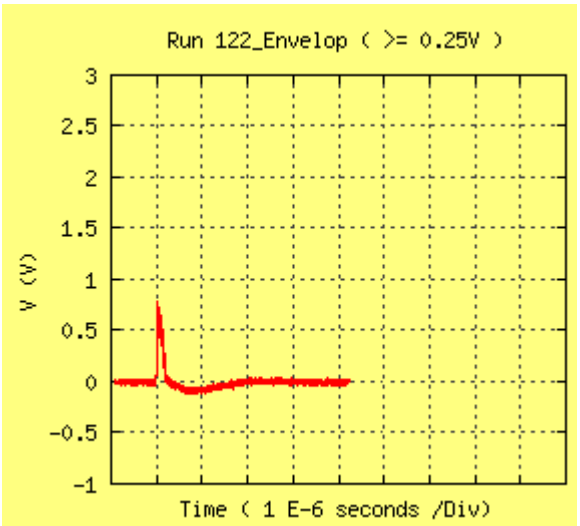
Run17
Set-up 1-1
Vin =0V
Trig= -0.25V
LET 28.2
Fluence 1 E+06

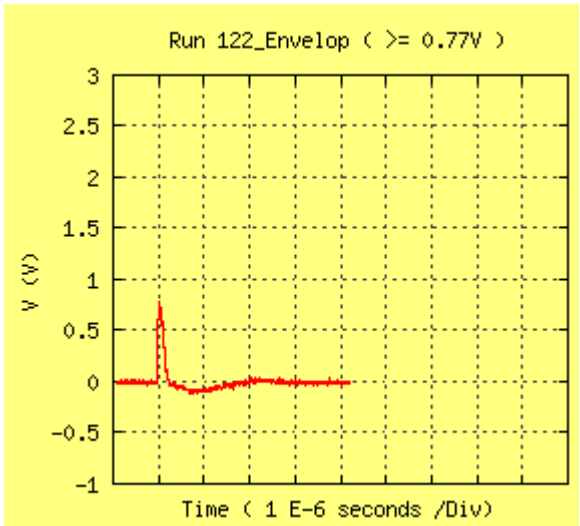




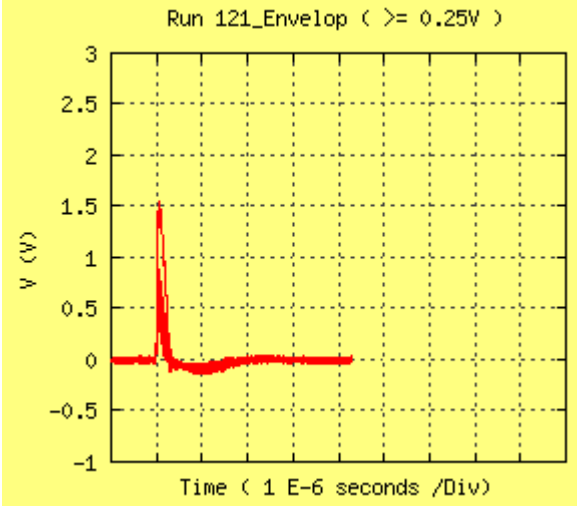
Run139
Set-up 1-1
Vin =0V
Trig= -0.25V
LET 34
Fluence 1 E+05

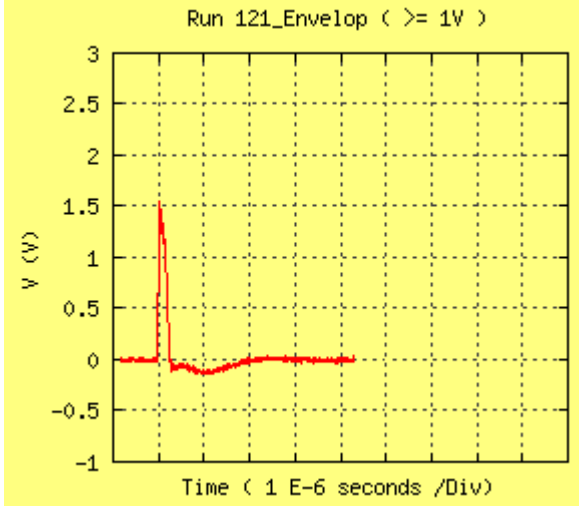
7.6 Set-up 1-1, positive SETs, Vin=0V, Output1



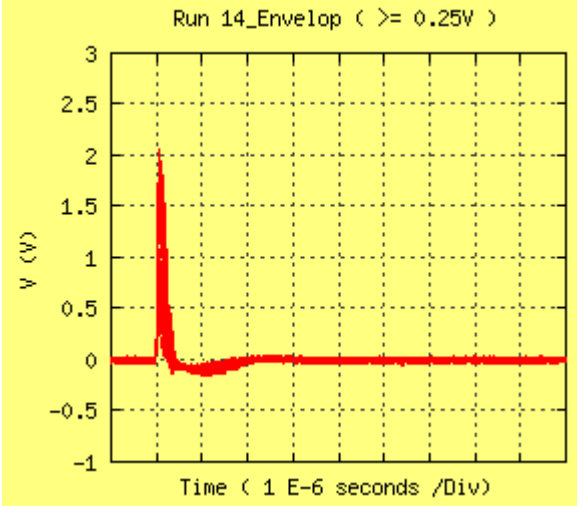


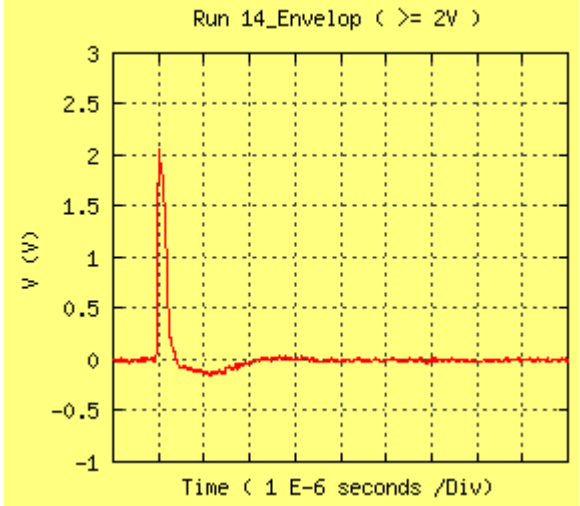
Run122
Set-up 1-1
Vin =0V
Trig= 0.25V
LET 5.85
Fluence 5 E+05



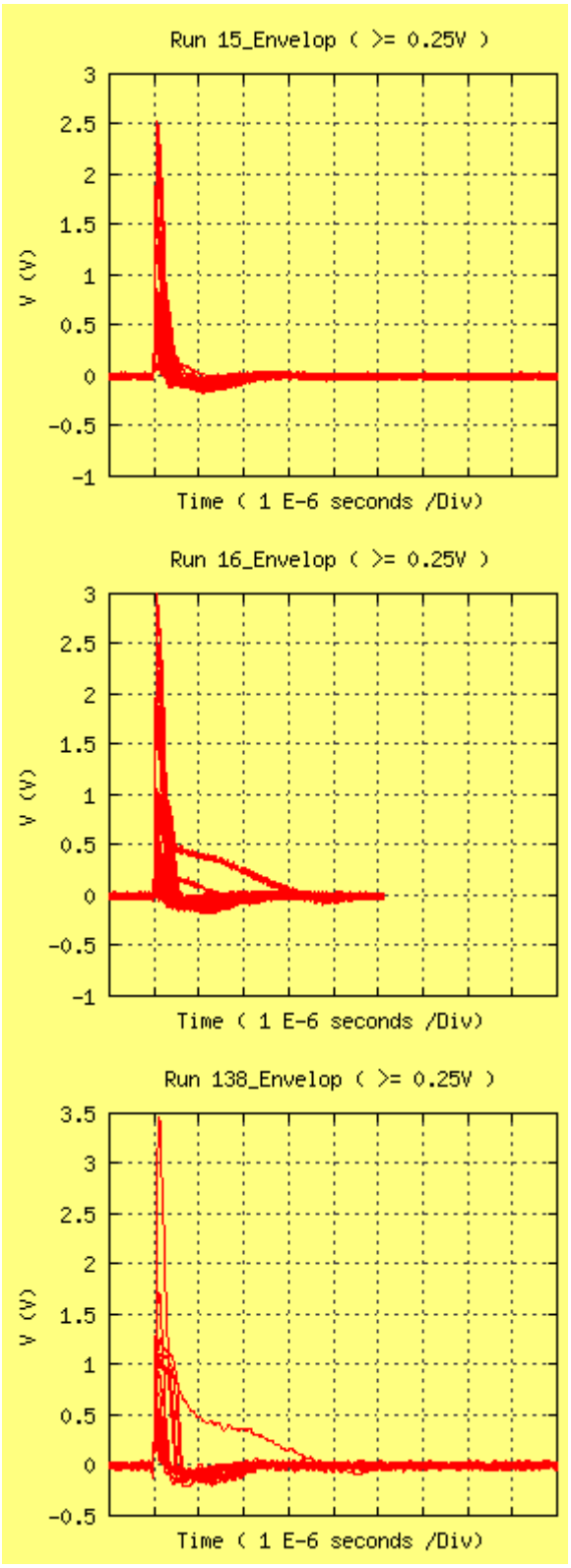


Run121
Set-up 1-1
Vin =0V
Trig= 0.25V
LET 11.7
Fluence 5 E+05





Run14
Set-up 1-1
Vin =0V
Trig= 0.25V
LET 14.1
Fluence 1 E+06



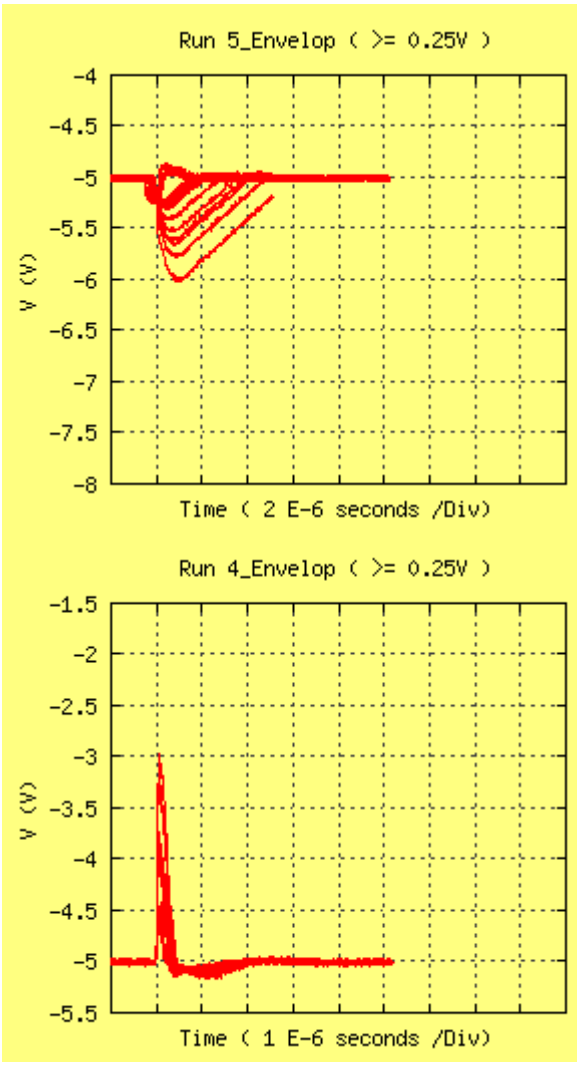
Run15
Set-up 1-1
Vin =0V
Trig= 0.25V
LET 19.94
Fluence 1 E+06

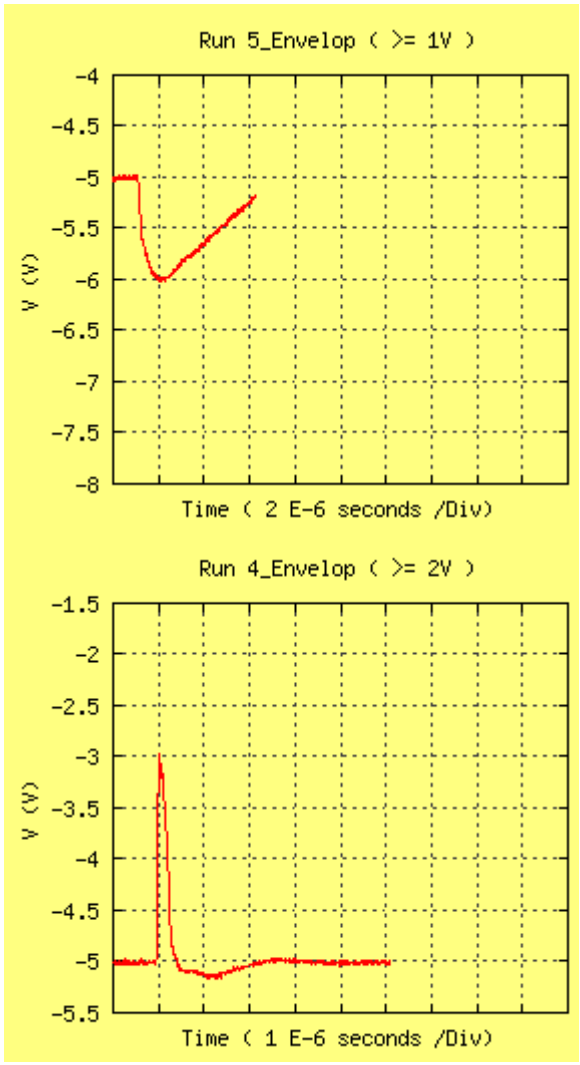
Run16
Set-up 1-1
Vin =0V
Trig= 0.25V
LET 28.2
Fluence 1 E+06

Run138
Set-up 1-1
Vin =0V
Trig= 0.25V
LET 34
Fluence 1 E+05

7.7 Setup 1, comparison between the 4 amplifiers outputs, with Vin =5v

7.7.1 Output 1-1

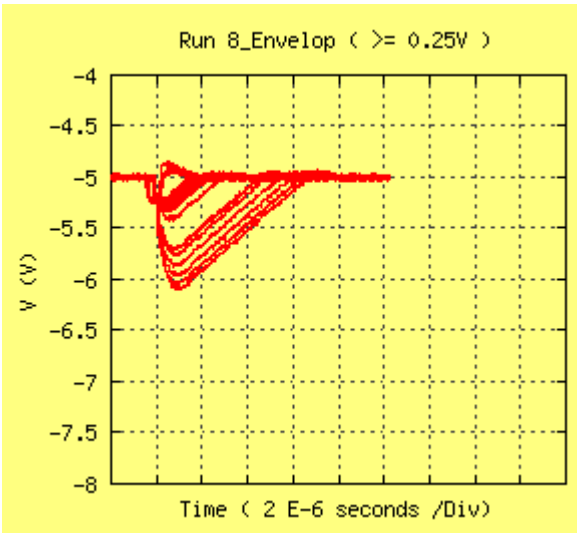


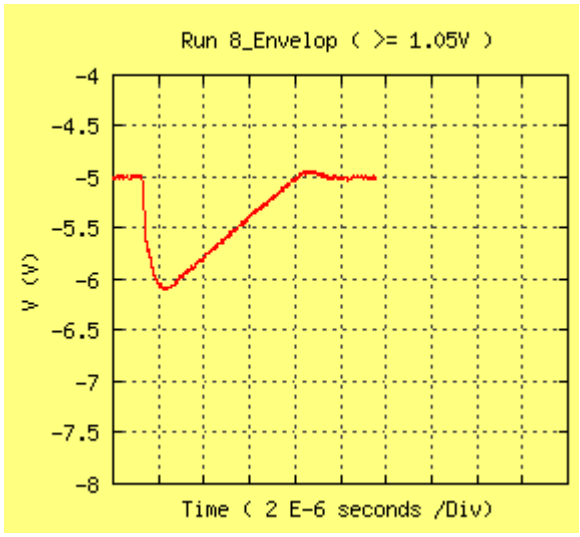


Run5
Set-up 1-1
Vin =5V
Trig= -5.25V
LET 14.1
Fluence 1 E+06

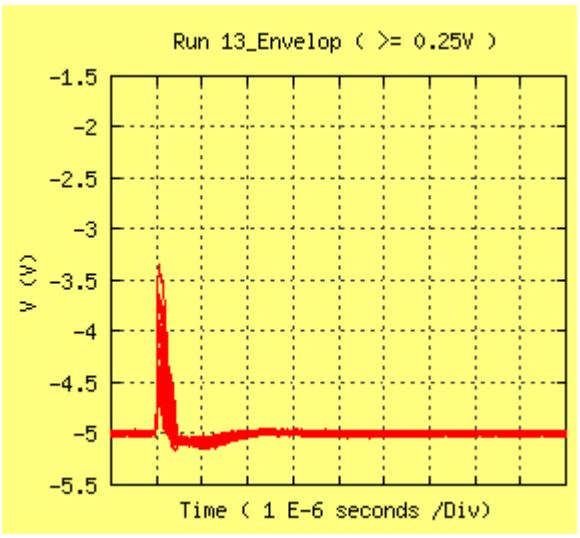
Run4
Set-up 1-1
Vin =5V
Trig= -4.75V
LET 14.1
Fluence 1 E+06

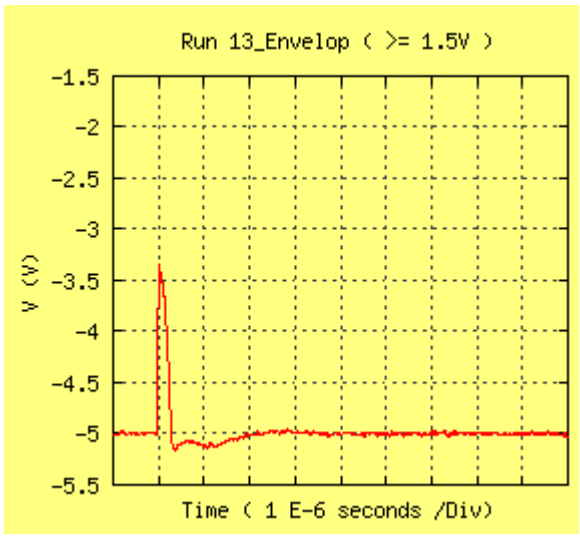
7.7.2 Output 1-2





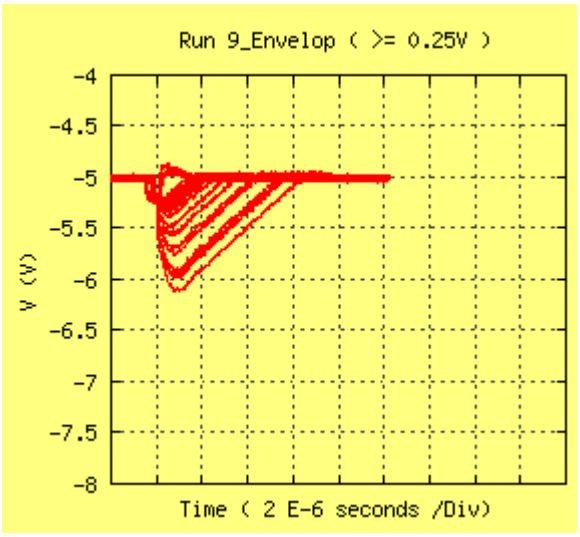
Run8
Set-up 1-2
Vin =5V
Trig= -5.25V
LET 14.1
Fluence 1 E+06

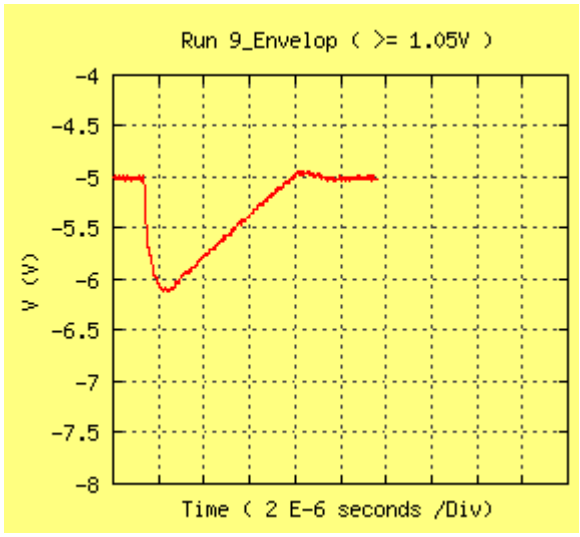




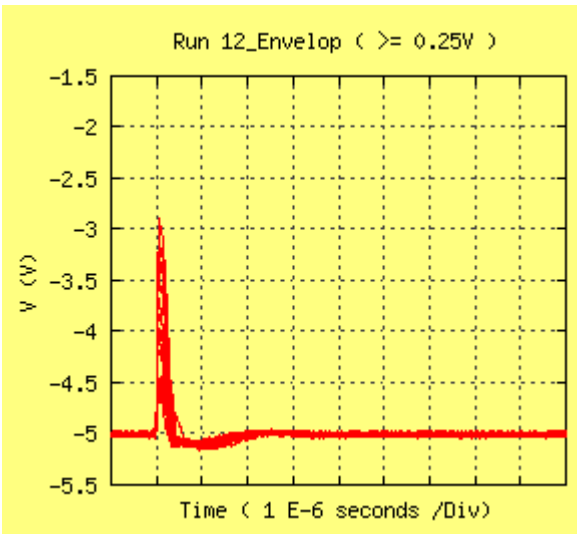
Run13
Set-up 1-2
Vin =5V
Trig= -4.75V
LET 14.1
Fluence 1 E+06

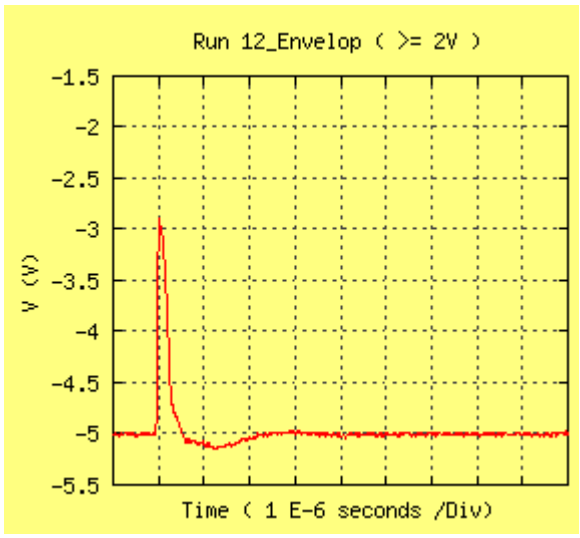
7.7.3 Output 1-3





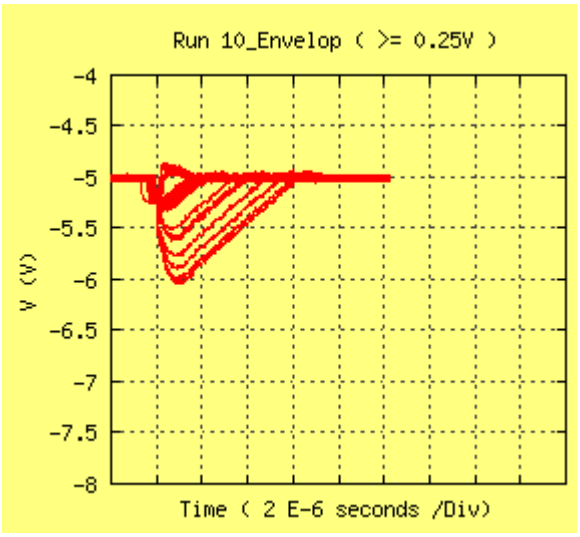
Run9
Set-up 1-3
Vin =5V
Trig= -5.25V
LET 14.1
Fluence 1 E+06

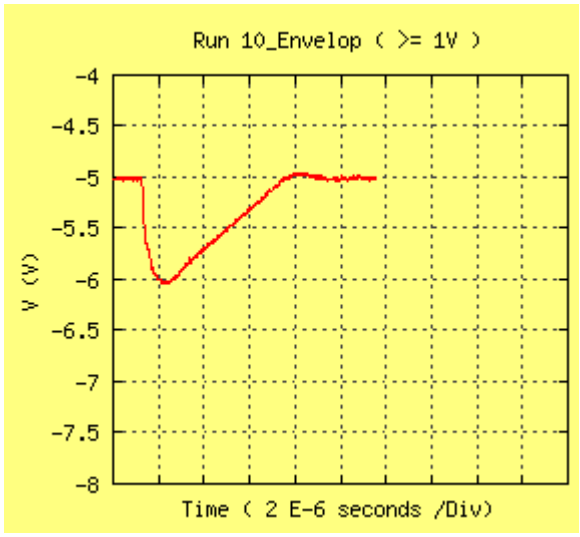




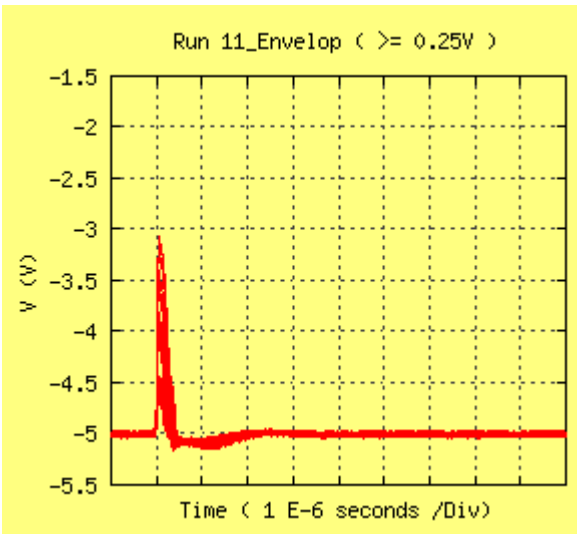
Run12
Set-up 1-3
Vin =5V
Trig= -4.75V
LET 14.1
Fluence 1 E+06

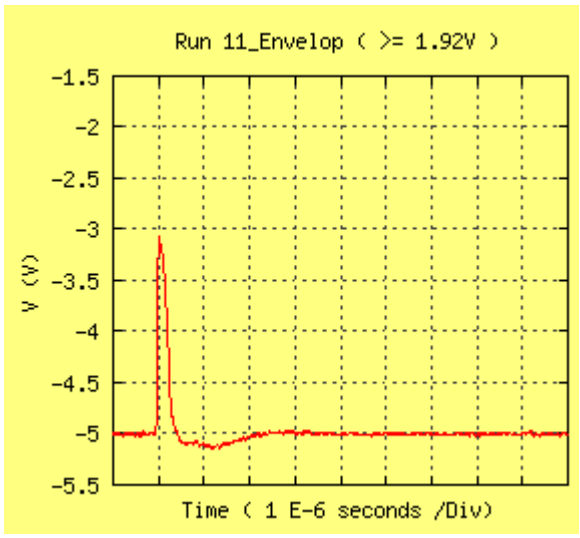
7.7.4 Output 1-4





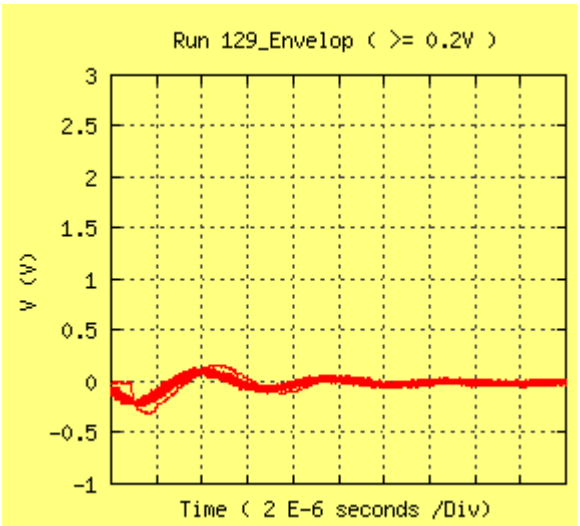
Run10
Set-up 1-4
Vin =5V
Trig= -5.25V
LET 14.1
Fluence 1 E+06

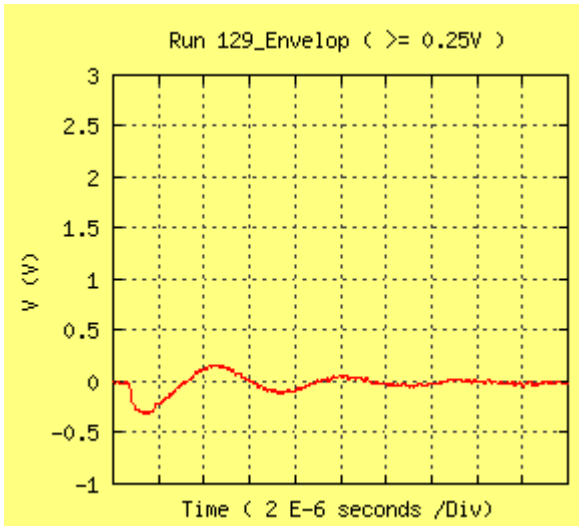




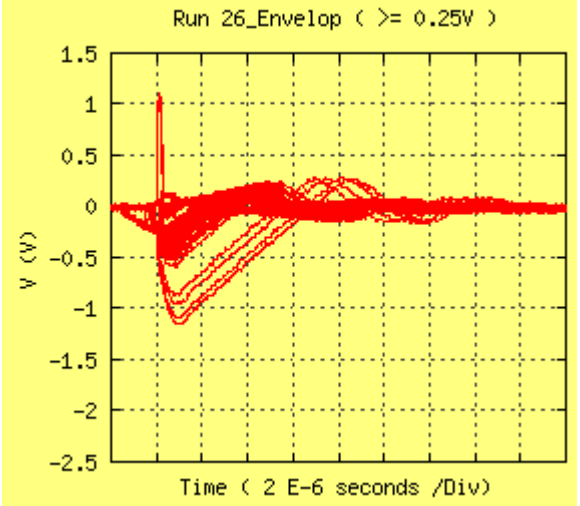
Run11
Set-up 1-4
Vin =5V
Trig= -4.75V
LET 14.1
Fluence 1 E+06

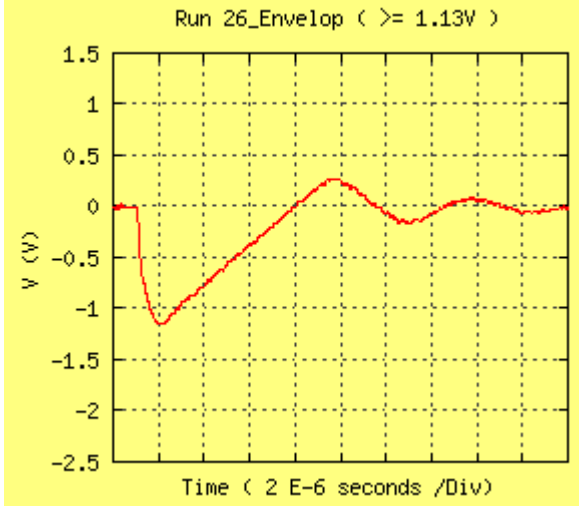
7.8 Set-up 2-1, negative SETs, V1=0V, Vin1=Vin2=0V, Output1



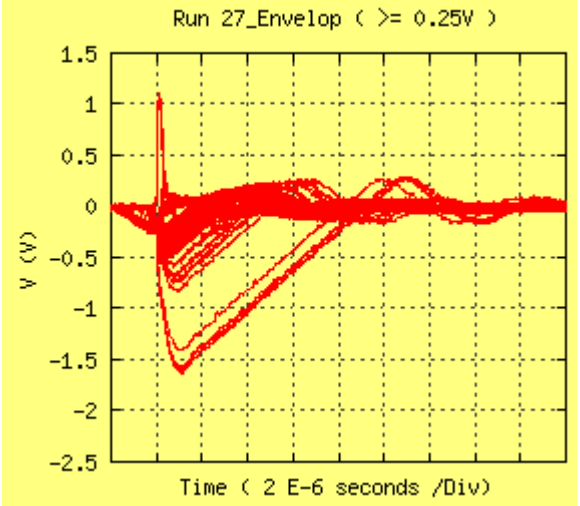


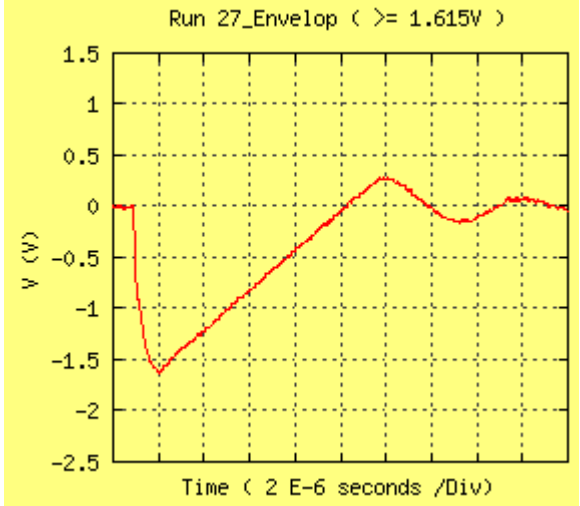
Run129
Set-up 2-1
V1 =0V
Vin1=Vin2=0V
Trig= -0.25V
LET 11.7
Fluence 5 E+05



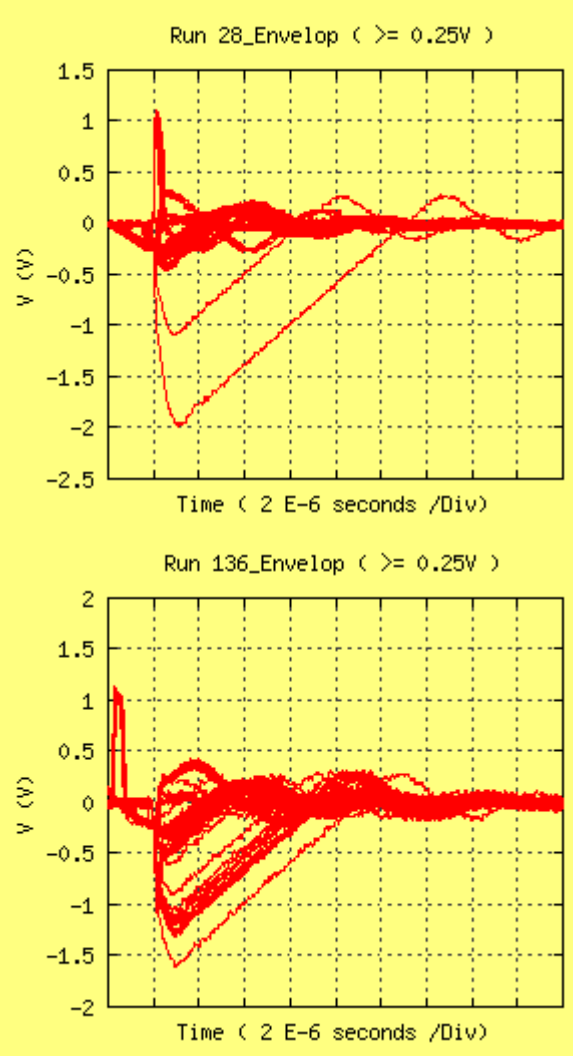


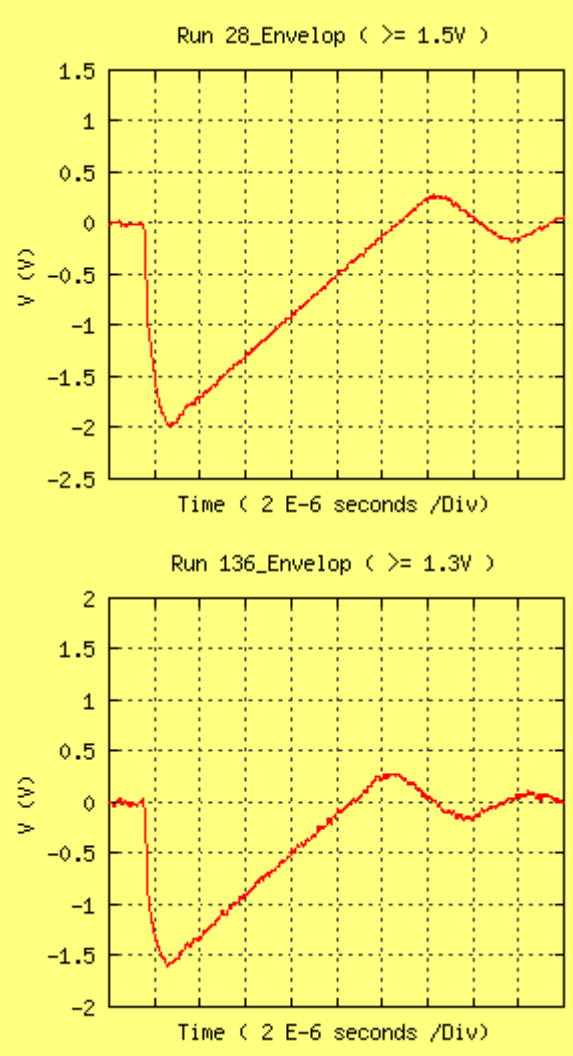
Run26
Set-up 2-1
V1 =0V
Vin1=Vin2=0V
Trig= -0.25V
LET 14.1
Fluence 1 E+06





Run27
Set-up 2-1
V1 =0V
Vin1=Vin2=0V
Trig= -0.25V
LET 19.94
Fluence 5 E+05

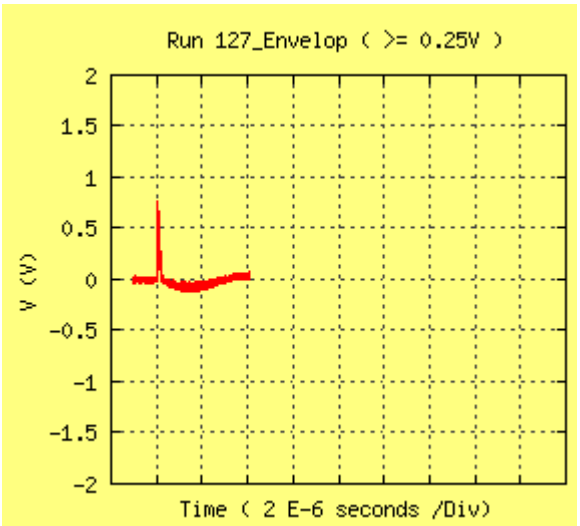


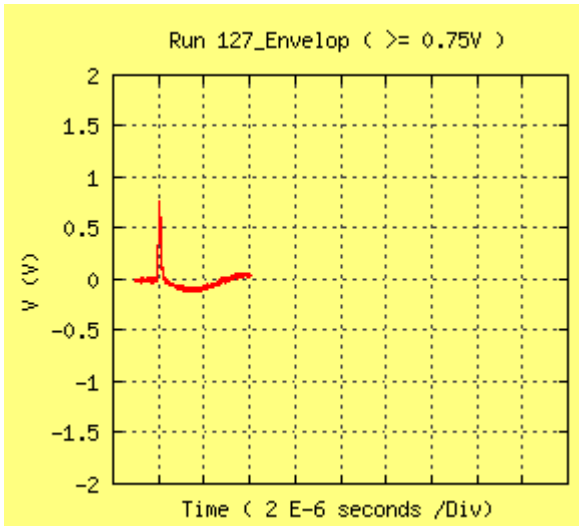


Run28
Set-up 2-1
V1 =0V
Vin1=Vin2=0V
Trig= -0.25V
LET 28.2
Fluence 5 E+05

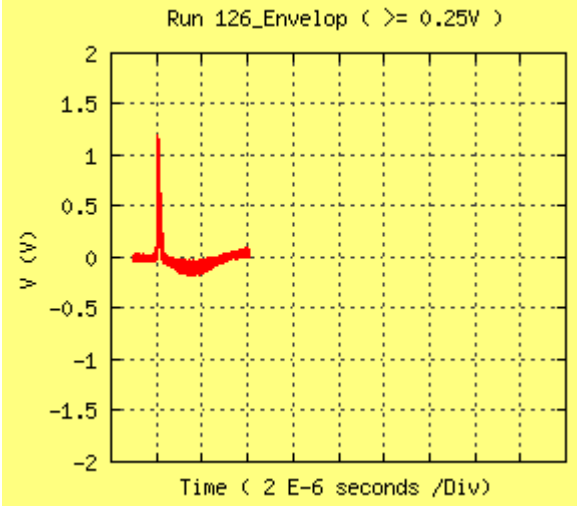
Run136
Set-up 2-1
V1 =0V
Vin1=Vin2=0V
Trig= -0.25V
LET 34
Fluence 1 E+05

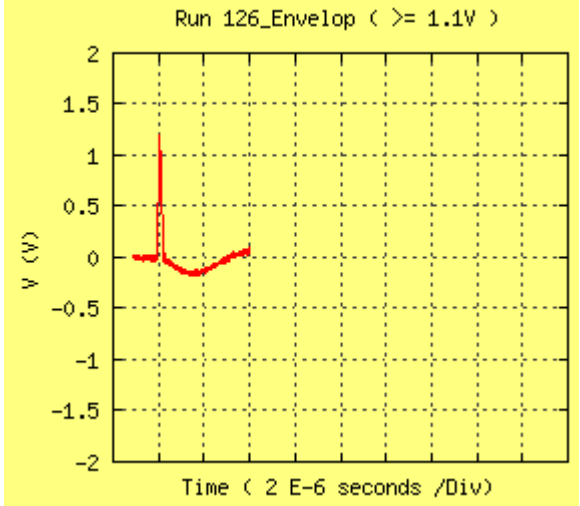
7.9 Set-up 2-1, positive SETs, V1=0V, Vin1=Vin2=0V, Output1



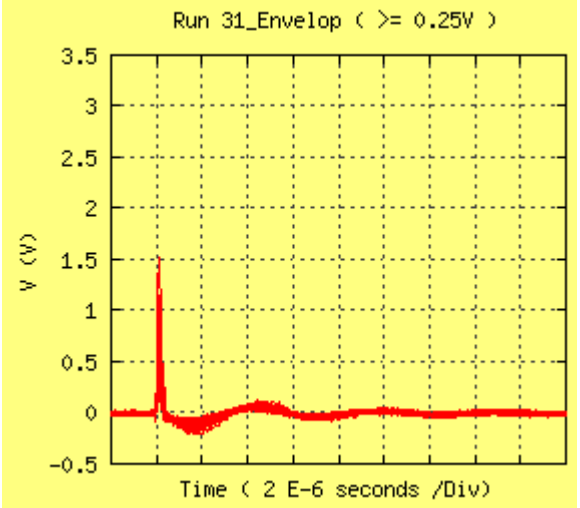


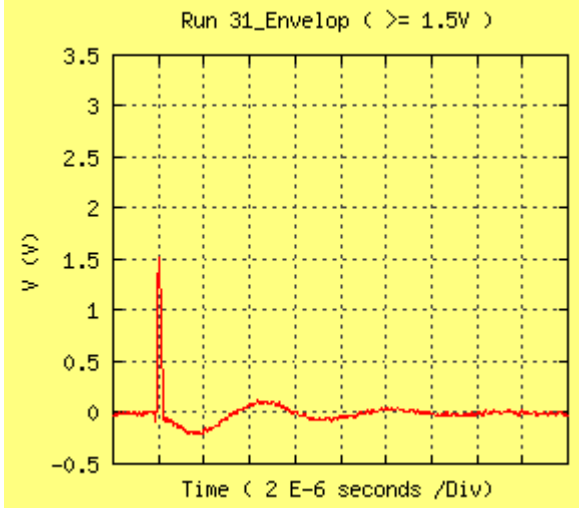
Run127
Set-up 2-1
V1 =0V
Vin1=Vin2=0V
Trig= +0.25V
LET 5.85
Fluence 5 E+05



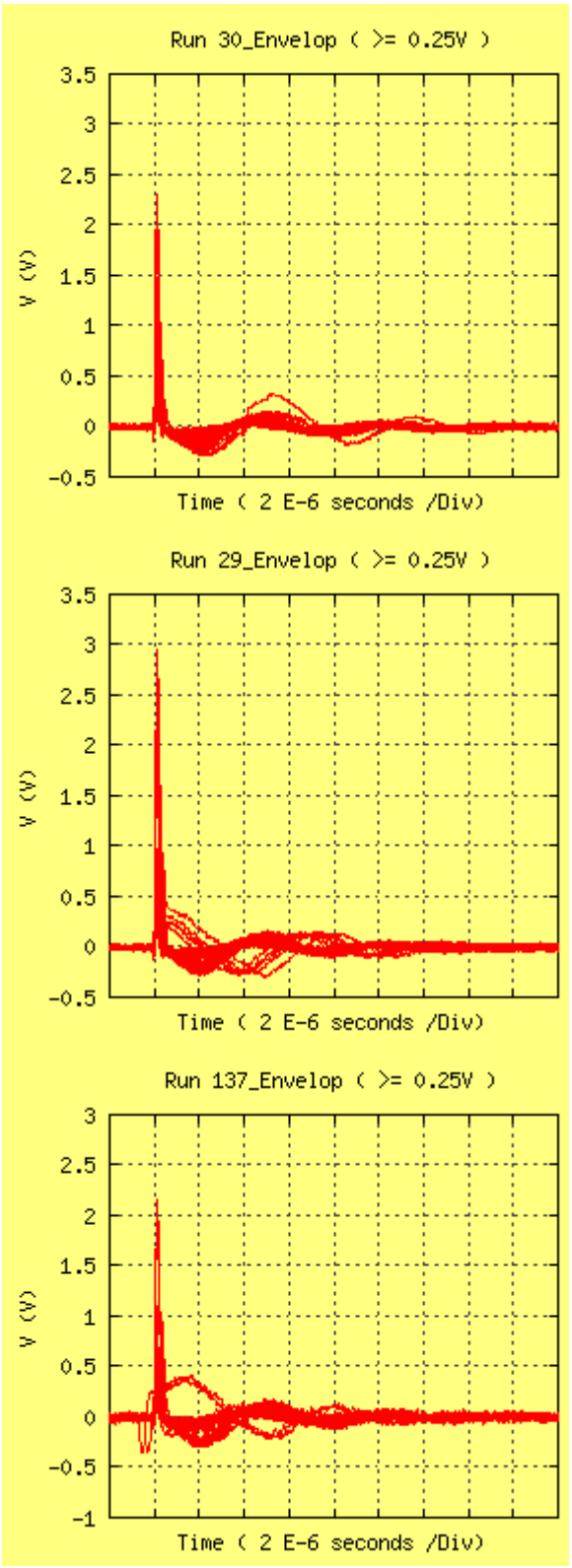


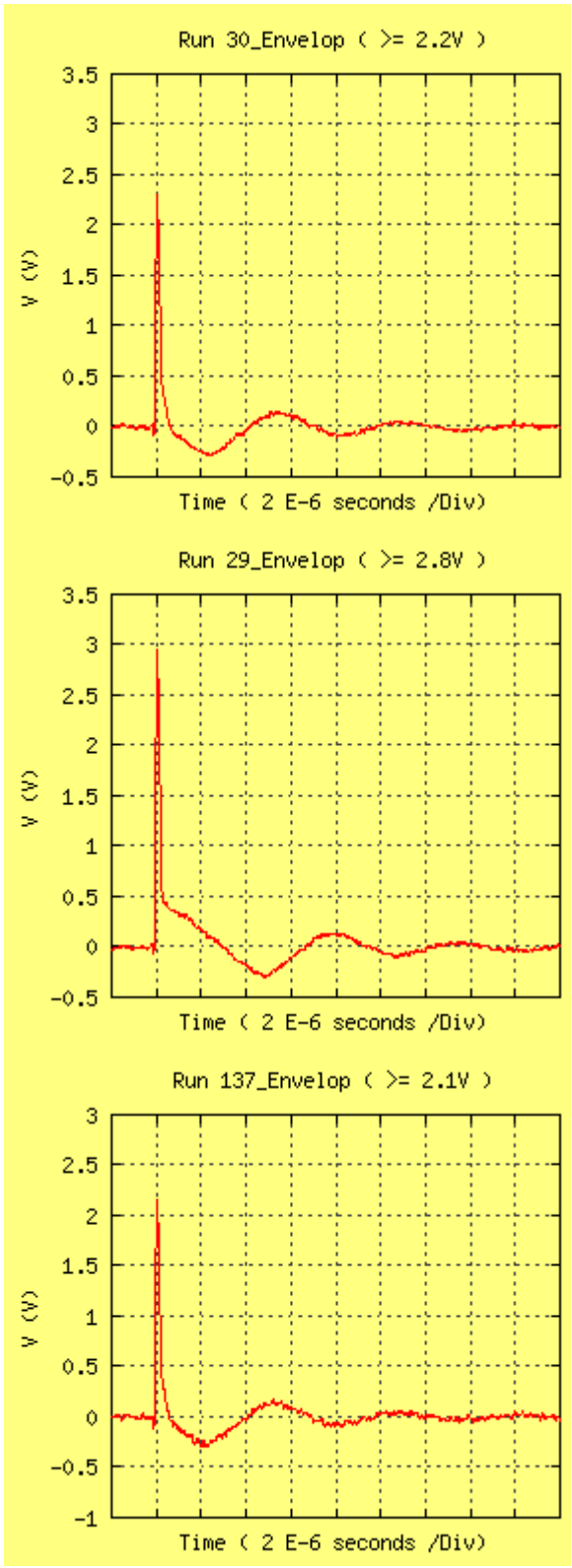
Run126
Set-up 2-1
V1 =0V
Vin1=Vin2=0V
Trig= +0.25V
LET 11.7
Fluence 5 E+05





Run31
Set-up 2-1
V1 =0V
Vin1=Vin2=0V
Trig= +0.25V
LET 14.1
Fluence 5 E+05



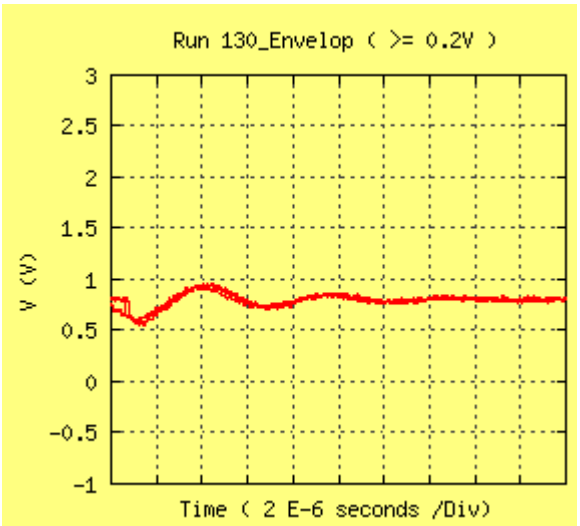


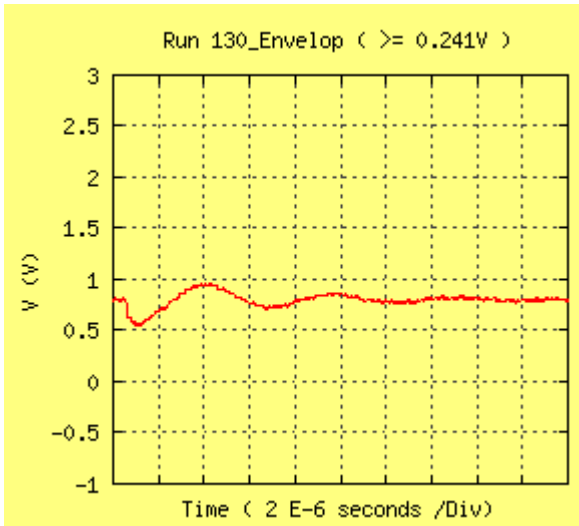
Run30
Set-up 2-1
V1 =0V
Vin1=Vin2=0V
Trig= +0.25V
LET 19.94
Fluence 5 E+05

Run29
Set-up 2-1
V1 =0V
Vin1=Vin2=0V
Trig= +0.25V
LET 28.2
Fluence 5 E+05

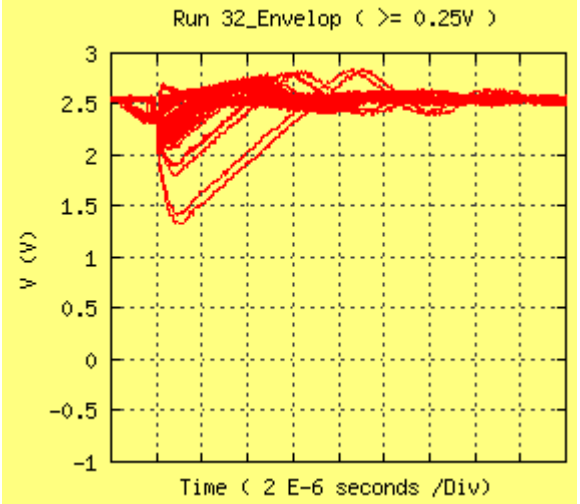
Run137
Set-up 2-1
V1 =0V
Vin1=Vin2=0V
Trig= +0.25V
LET 34
Fluence 1 E+05

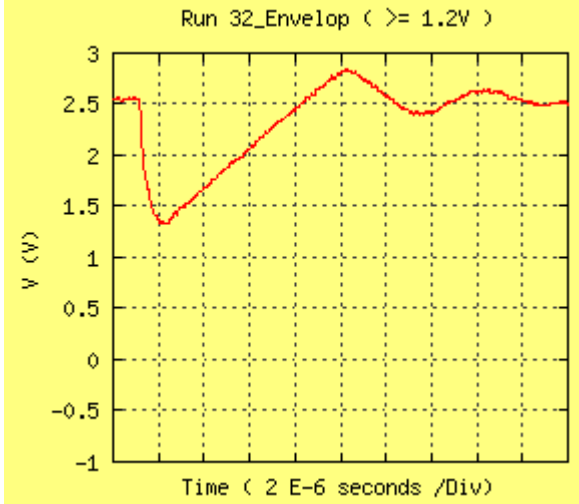
7.10 Set-up 2-1, negative SETs, V1=2.56V, Output1



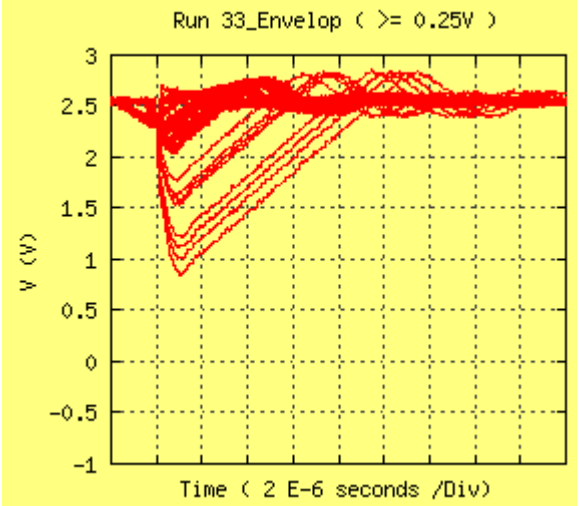


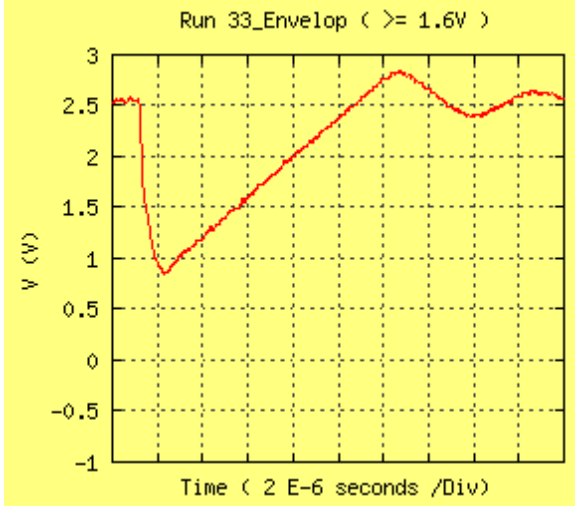
Run130
Set-up 2-1
V1 =2.56V
Vin1=0V
Vin2=5V
Trig= 0.55V
LET 11.7
Fluence 5 E+05



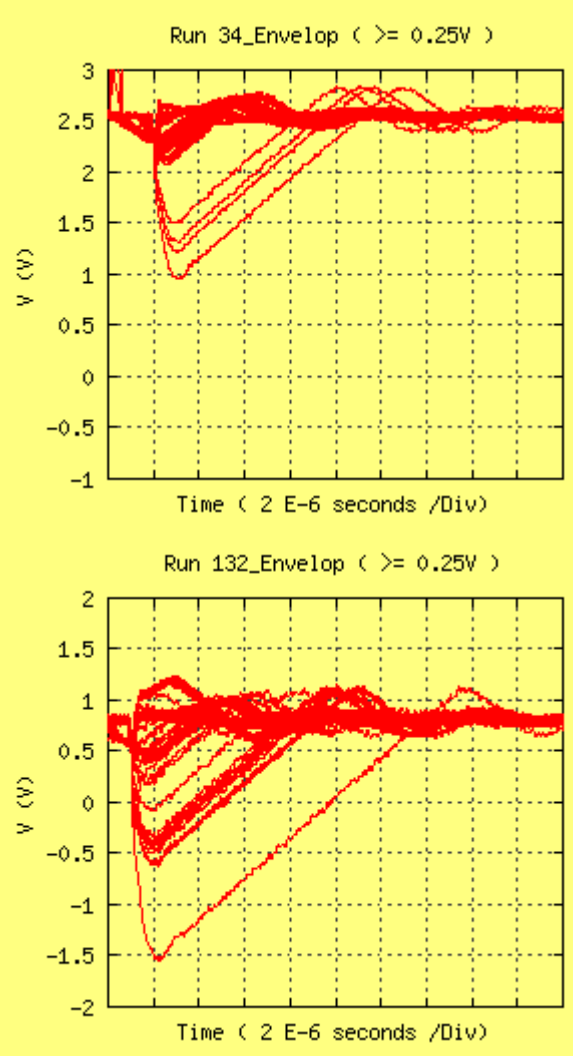


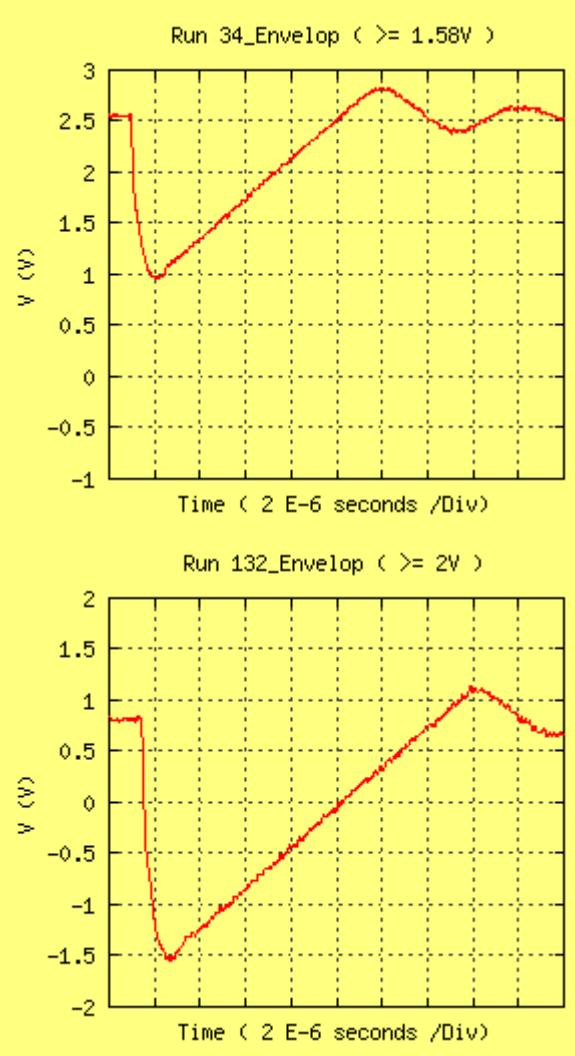
Run32
Set-up 2-1
V1 =2.56V
Vin1=0V
Vin2=0V
Trig= 2.31V
LET 14.1
Fluence 5 E+05





Run33
Set-up 2-1
V1 =2.56V
Vin1=0V
Vin2=0V
Trig= 2.31V
LET 19.64
Fluence 5 E+05

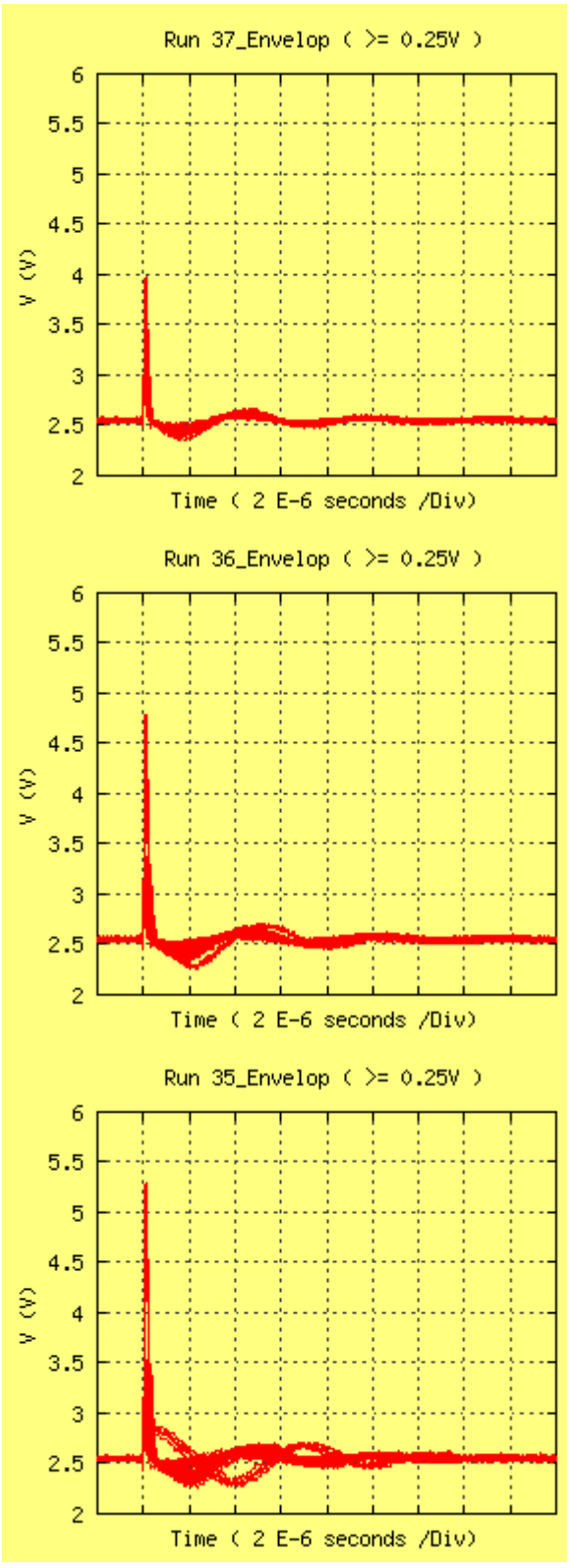




Run34
Set-up 2-1
V1 =2.56V
Vin1=0V
Vin2=0V
Trig= 2.31V
LET 28.2
Fluence 5 E+05

Set-up 2-1
V1 =2.56V
Vin1=0V
Vin2=5V
Trig= 0.55V
LET 34
Fluence 1 E+05

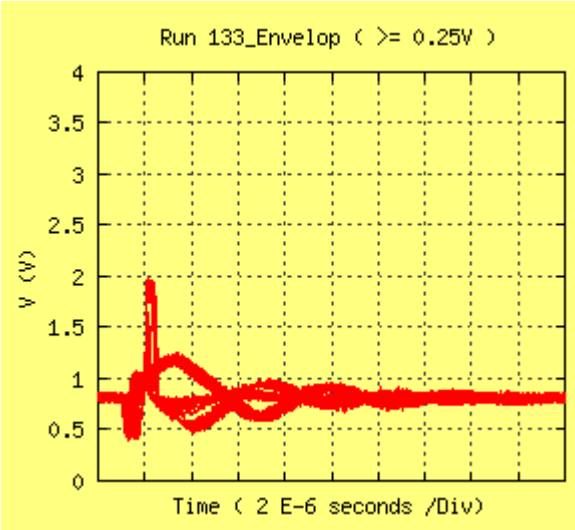
7.11 Set-up 2-1, positive SETs, V1=2.56V, Output1

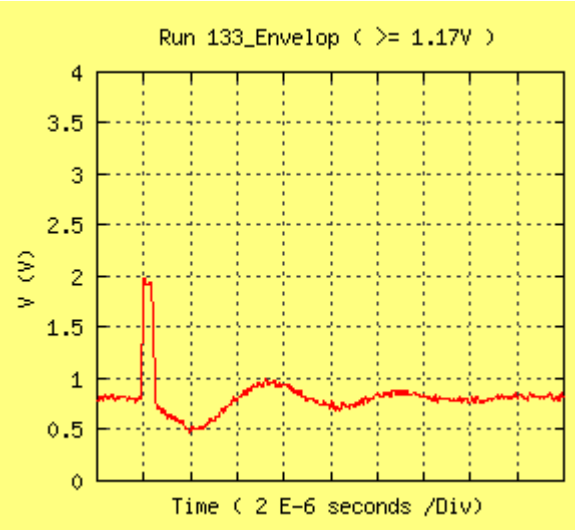


Run37
Set-up 2-1
V1 =2.56V
Vin1=0V
Vin2=0V
Trig= 2.81V
LET 14.1
Fluence 5 E+05

Run36
Set-up 2-1
V1 =2.56V
Vin1=0V
Vin2=0V
Trig= 2.81V
LET 19.94
Fluence 5 E+05

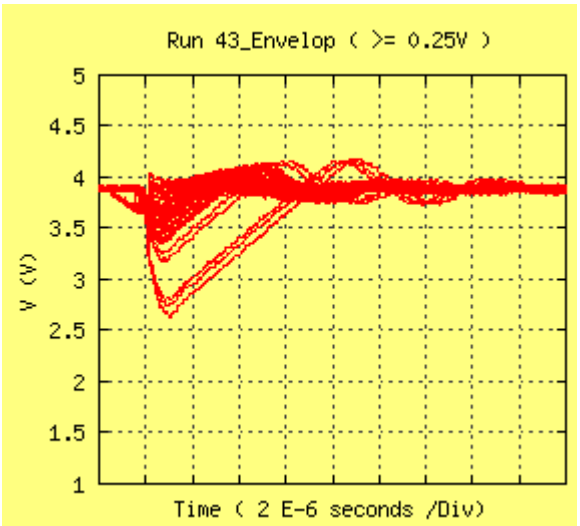
Run35
Set-up 2-1
V1 =2.56V
Vin1=0V
Vin2=0V
Trig= 2.81V
LET 28.2
Fluence 5 E+05

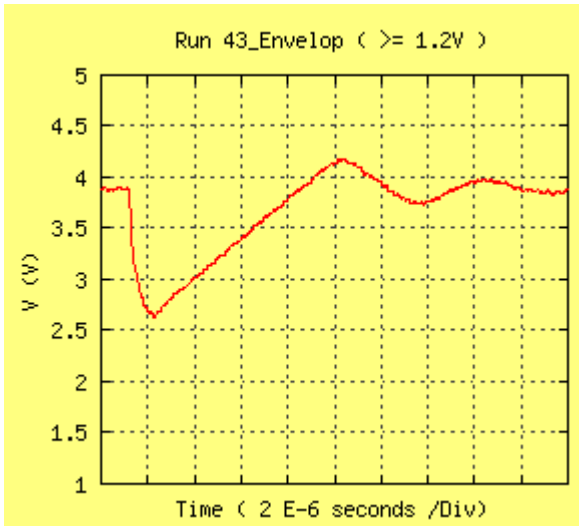




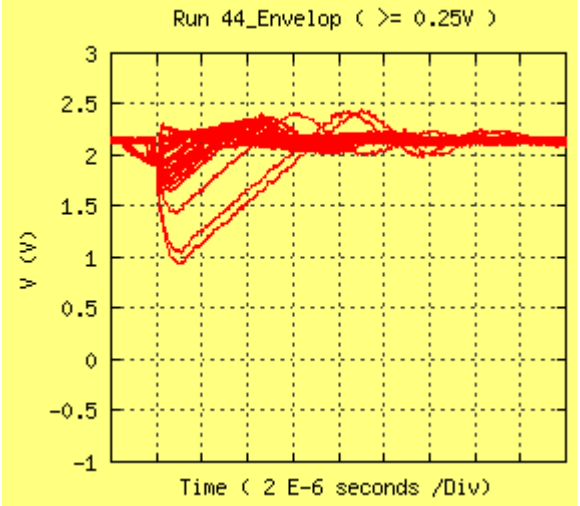
Run133
Set-up 2-1
V1 =2.56V
Vin1=0V
Vin2=5V
Trig= 1.05V
LET 34
Fluence 5 E+05

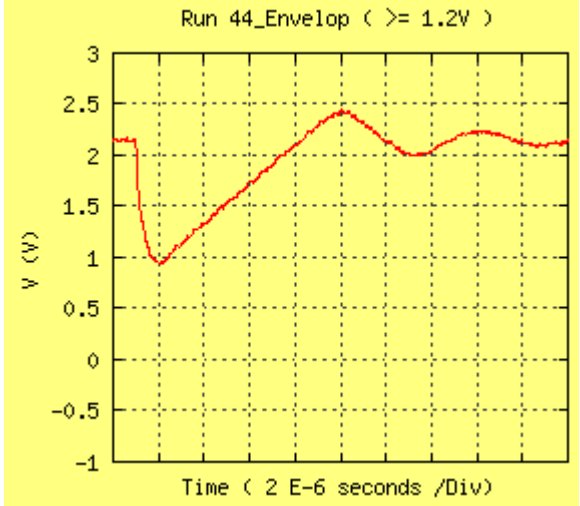
7.12 Set-up 2-1, negative SETs, V1=3.9V, Output1



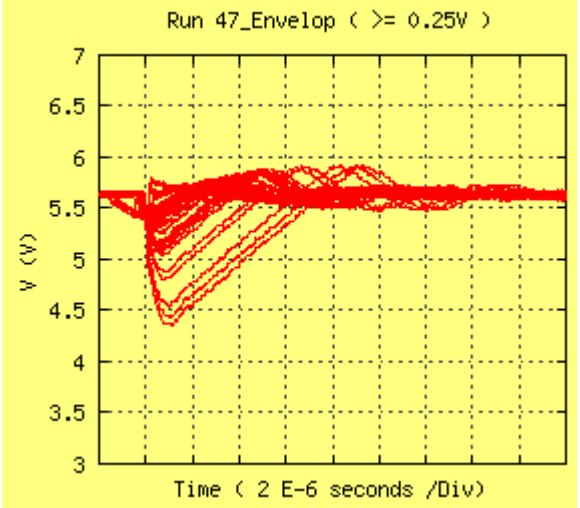


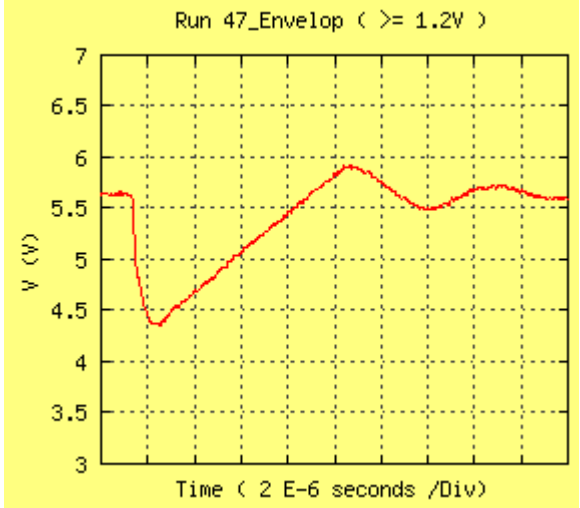
Run43
Set-up 2-1
V1 =3.9V
Vin1=0V
Vin2=0V
Trig= 3.65V
LET 14.1
Fluence 5 E+05



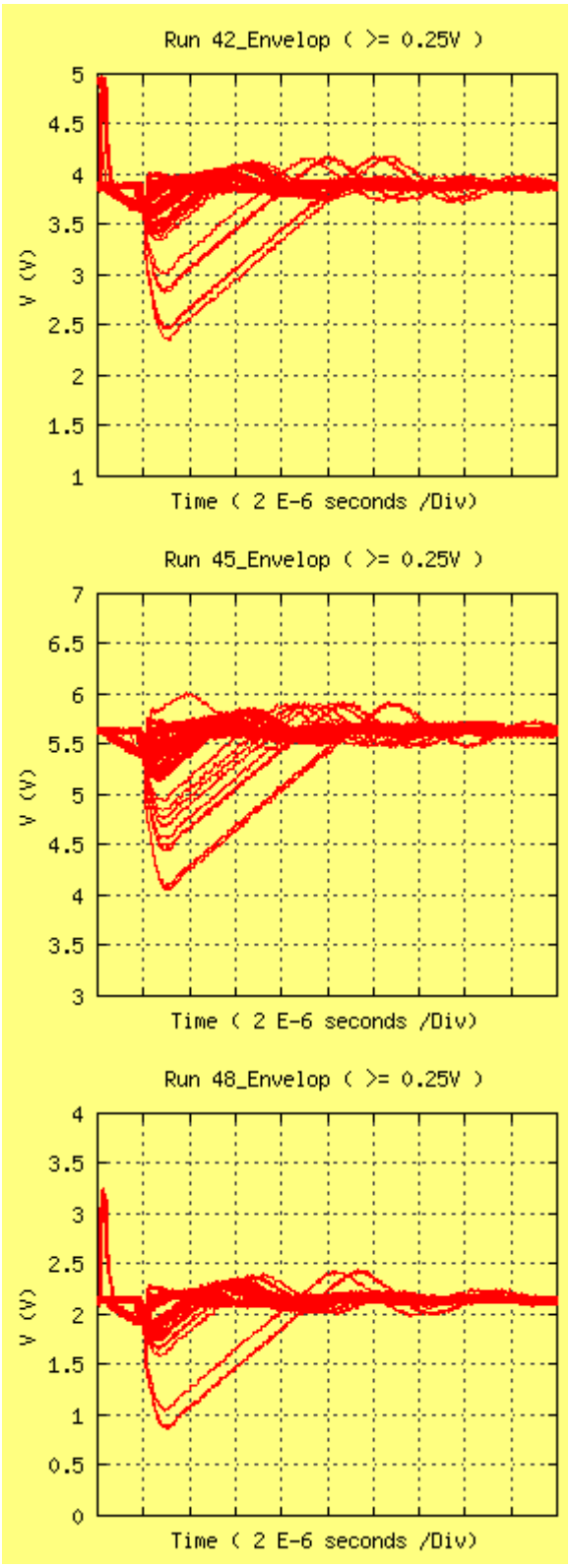


Run44
Set-up 2-1
V1 =3.9V
Vin1=5V
Vin2=0V
Trig= 3.65V
LET 14.1
Fluence 5 E+05





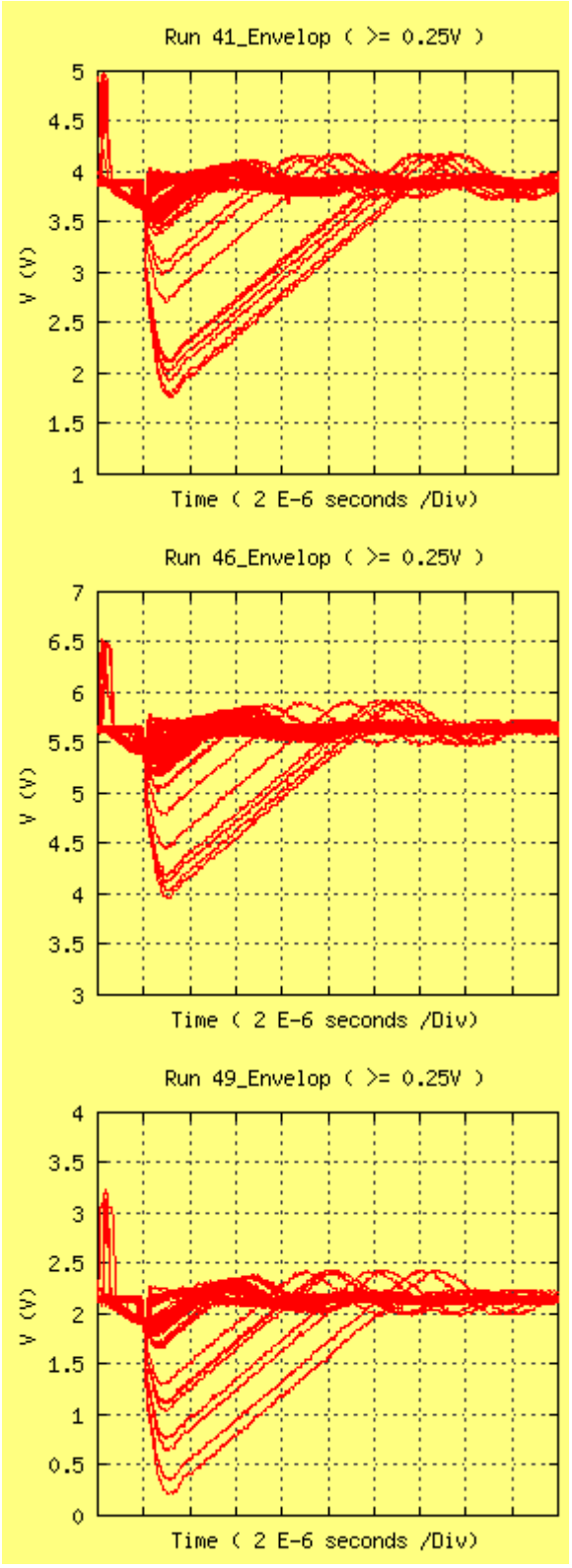
Run47
Set-up 2-1
V1 =3.9V
Vin1=0V
Vin2=5V
Trig= 5.45V
LET 14.1
Fluence 5 E+05



Run42
Set-up 2-1
V1 =3.9V
Vin1=0V
Vin2=0V
Trig= 3.65V
LET 19.94
Fluence 5 E+05

Run45
Set-up 2-1
V1 =3.9V
Vin1=0V
Vin2=5V
Trig= 5.45V
LET 19.94
Fluence 5 E+05

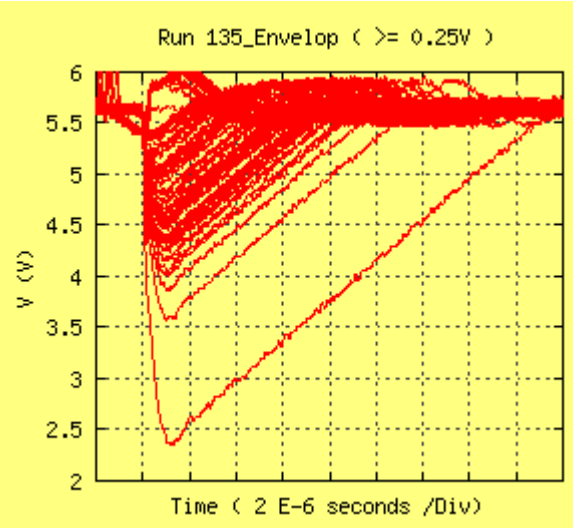
Run48
Set-up 2-1
V1 =3.9V
Vin1=5V
Vin2=0V
Trig= 3.65V
LET 19.94
Fluence 5 E+05

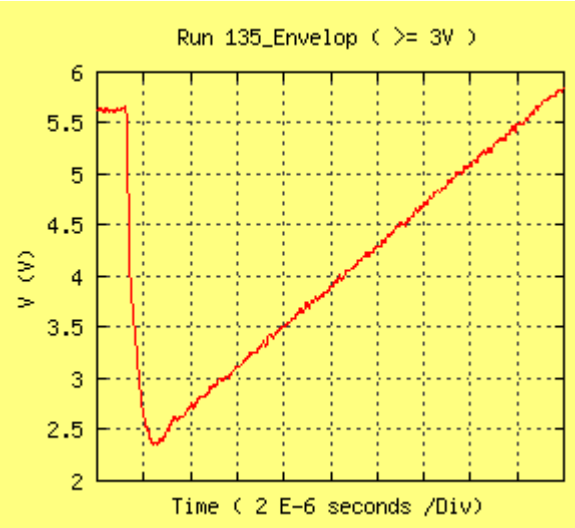


Run41
Set-up 2-1
V1 =3.9V
Vin1=0V
Vin2=0V
Trig= 3.65V
LET 28.2
Fluence 5 E+05

Run46
Set-up 2-1
V1 =3.9V
Vin1=0V
Vin2=5V
Trig= 5.45V
LET 28.2
Fluence 5 E+05

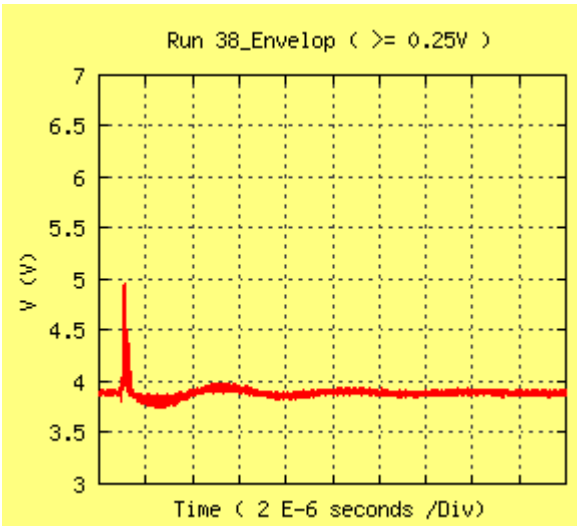
Run49
Set-up 2-1
V1 =3.9V
Vin1=5V
Vin2=0V
Trig= 1.9V
LET 28.2
Fluence 5 E+05

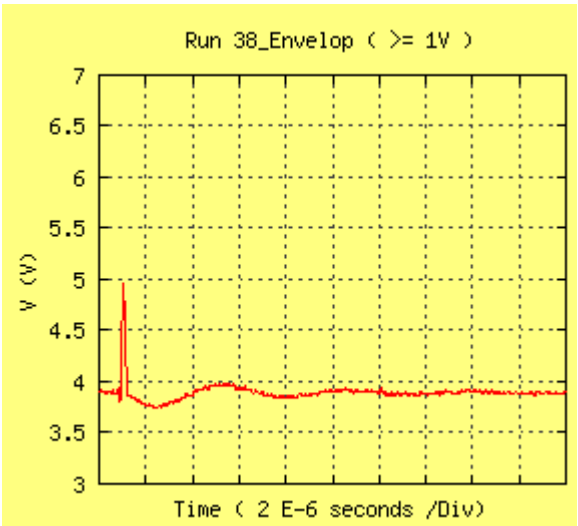




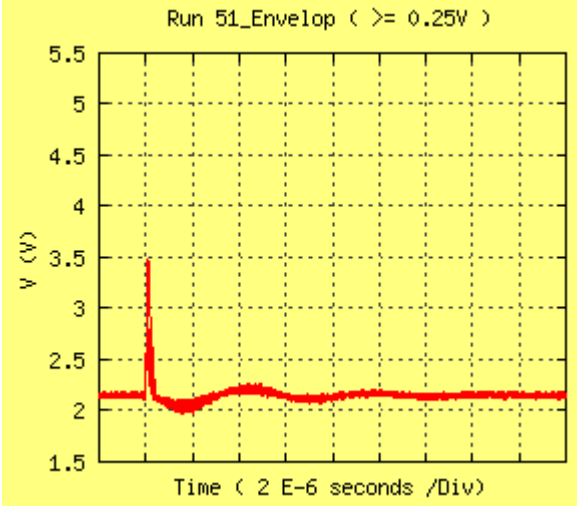
Run135
Set-up 2-1
V1 =3.9V
Vin1=0V
Vin2=5V
Trig= 5.45V
LET 34
Fluence 1 E+05

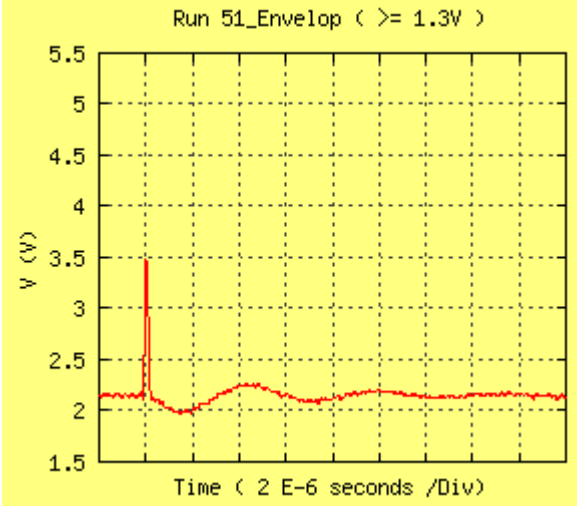
7.13 Set-up 2-1, positive SETs, V1=3.9V, Output1



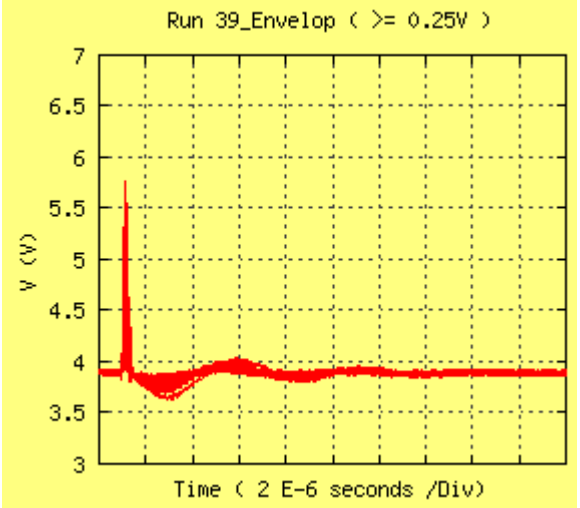


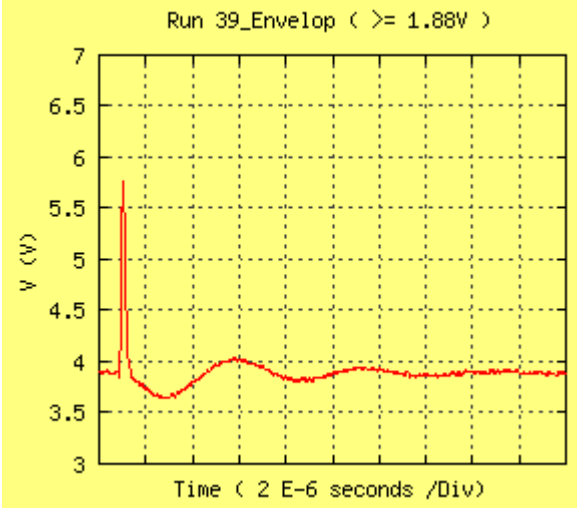
Run38
Set-up 2-1
V1 =3.9V
Vin1=0V
Vin2=0V
Trig= 4.15V
LET 14.1
Fluence 5 E+05



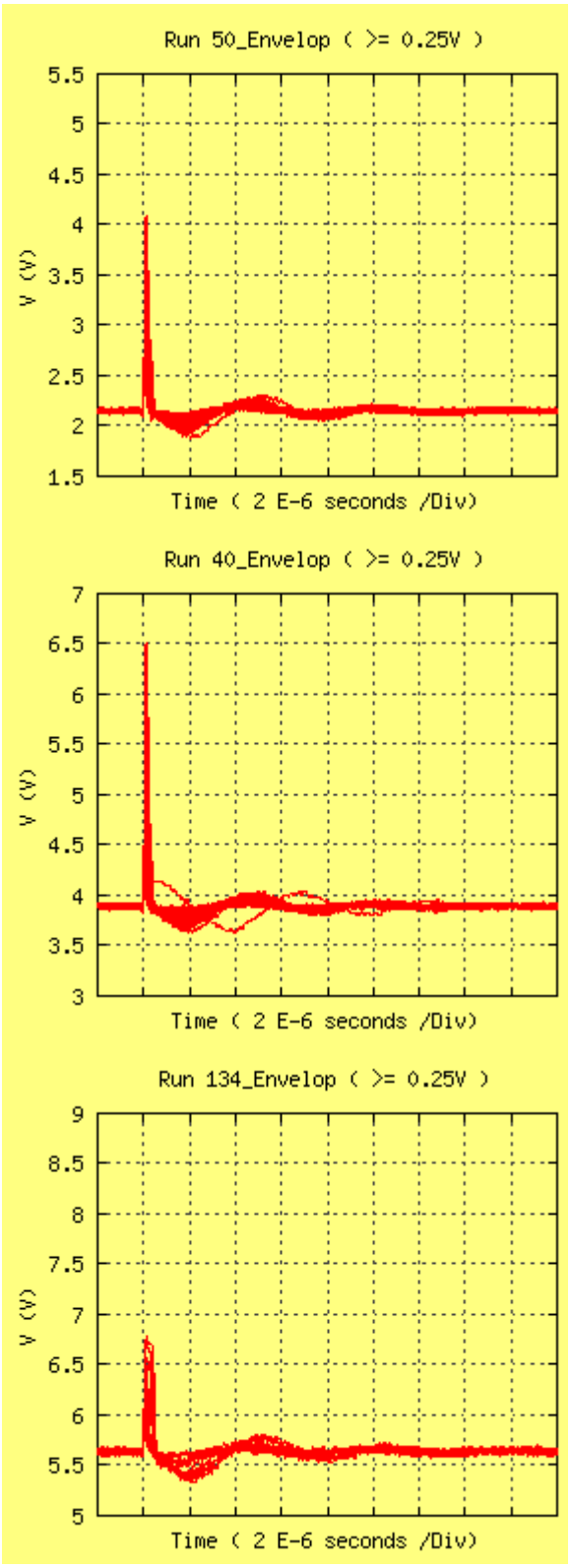


Run51
Set-up 2-1
V1 =3.9V
Vin1=5V
Vin2=0V
Trig= 2.4V
LET 14.1
Fluence 5 E+05





Run39
Set-up 2-1
V1 =3.9V
Vin1=0V
Vin2=0V
Trig= 4.15V
LET 19.94
Fluence 5 E+05

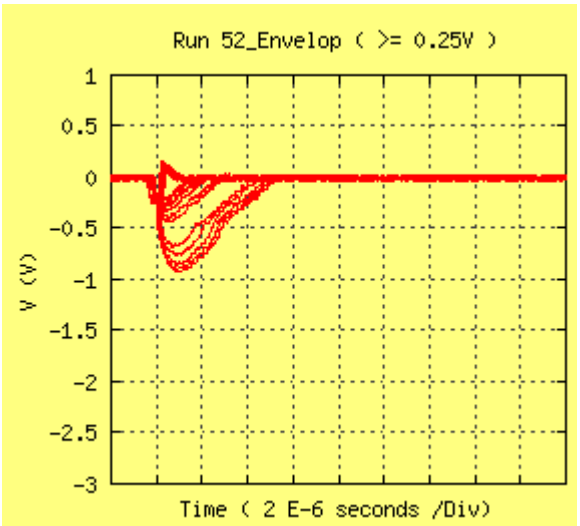


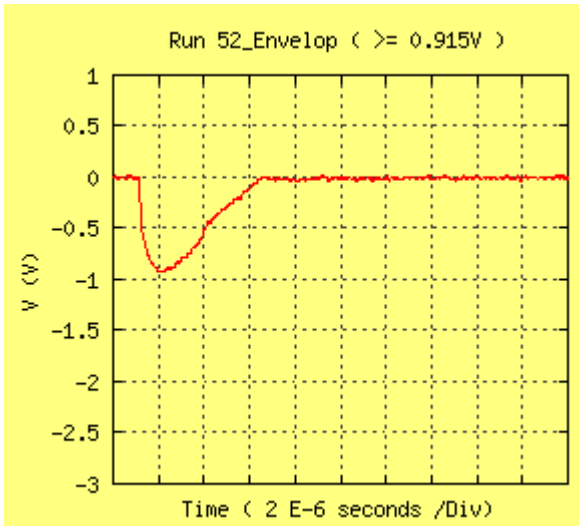
Run50
Set-up 2-1
V1 =3.9V
Vin1=5V
Vin2=0V
Trig= 2.4V
LET 19.94
Fluence 5 E+05

Run40
Set-up 2-1
V1 =3.9V
Vin1=0V
Vin2=0V
Trig= 4.15V
LET 28.2
Fluence 5 E+05

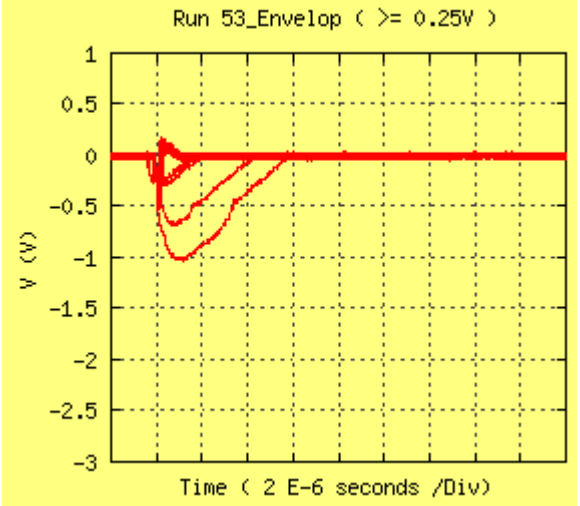
Run134
Set-up 2-1
V1 =3.9V
Vin1=0V
Vin2=5V
Trig= 5.85V
LET 34
Fluence 1 E+05

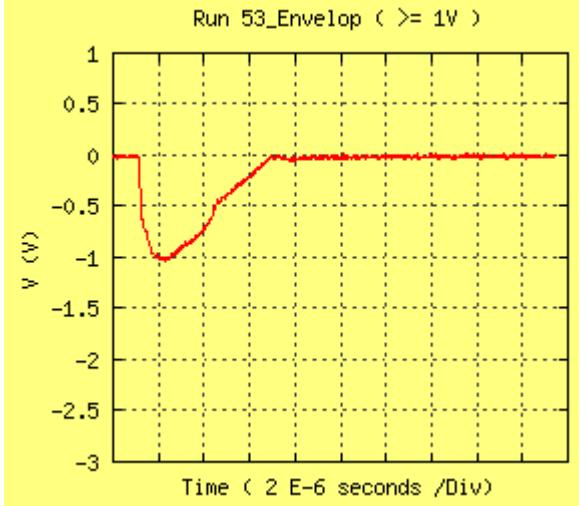
7.14 Set-up 3-1, negative SETs, V1=0V, Output1



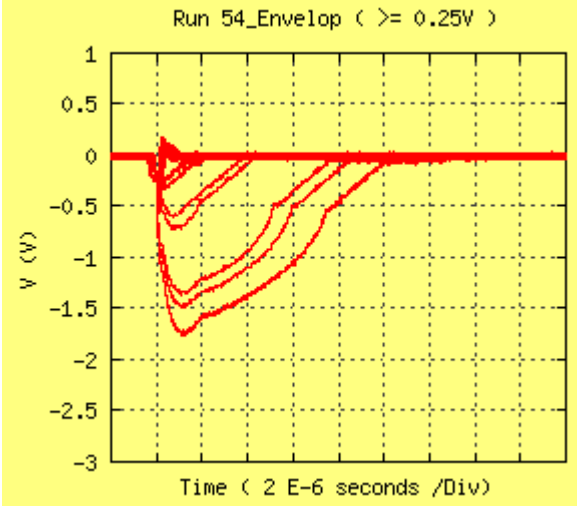


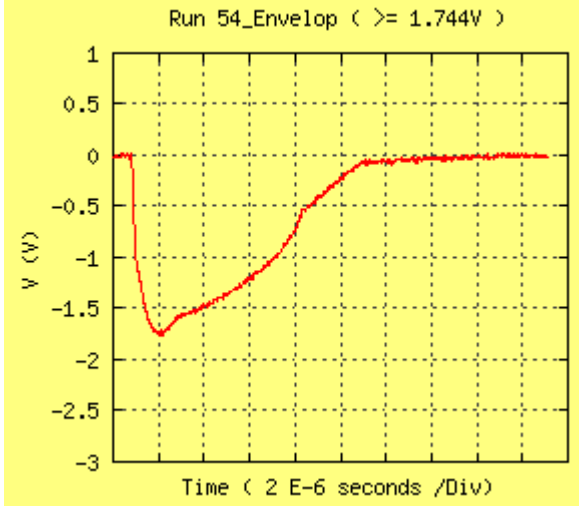
Run52
Set-up 3-1
Vin1=0V
Trig= -0.25
LET 14.1
Fluence 5 E+05



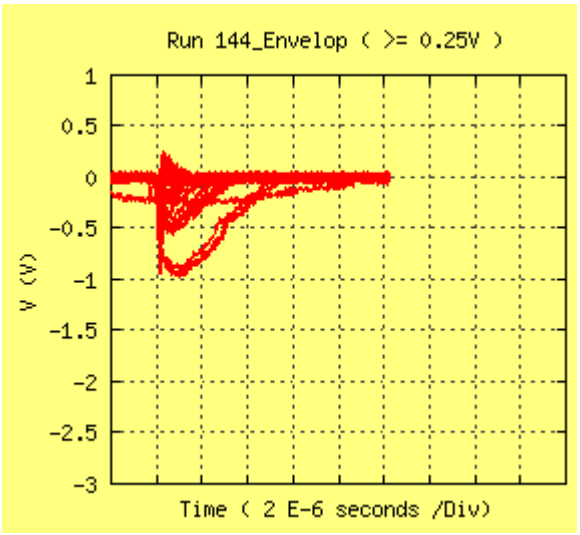


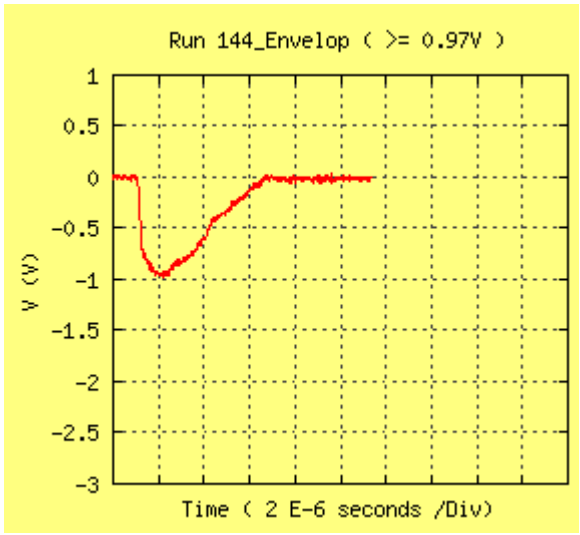
Run53
Set-up 3-1
Vin1=0V
Trig= -0.25
LET 19.94
Fluence 5 E+05





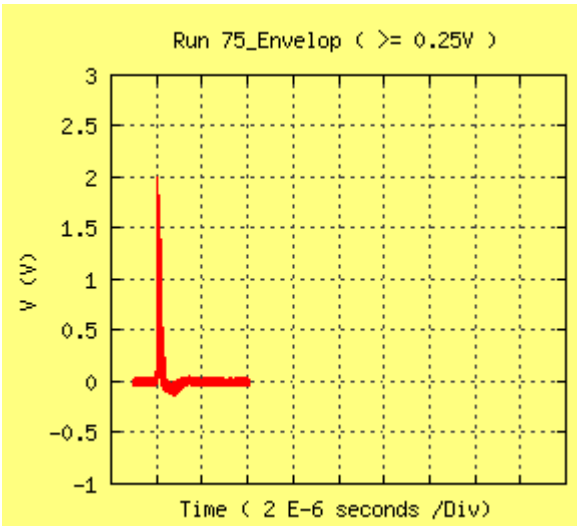
Run54
Set-up 3-1
Vin1=0V
Trig= -0.25
LET 28.2
Fluence 5 E+05

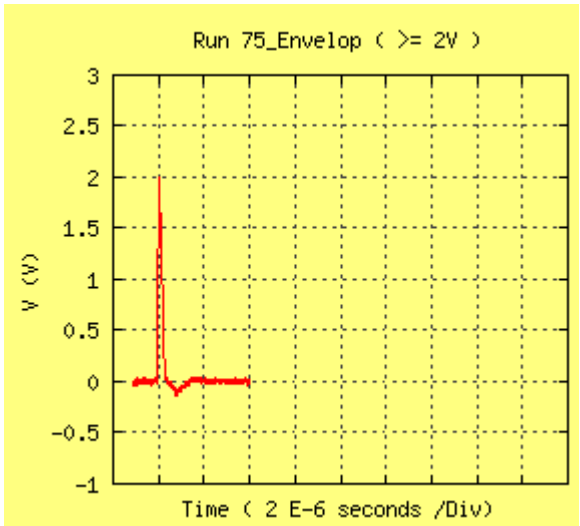




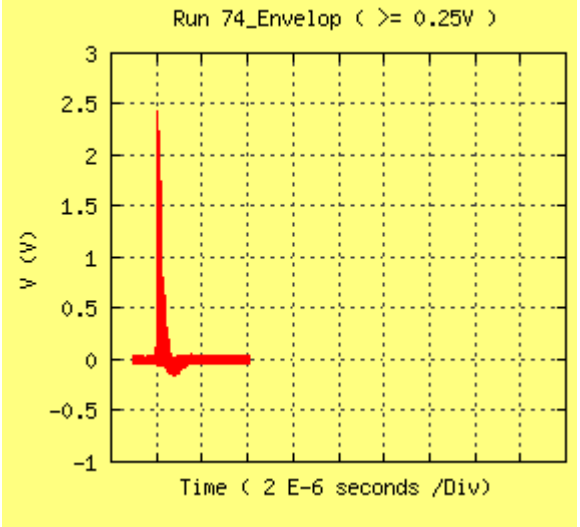
Run144
Set-up 3-1
Vin1=0V
Trig= -0.25
LET 34
Fluence 1 E+05

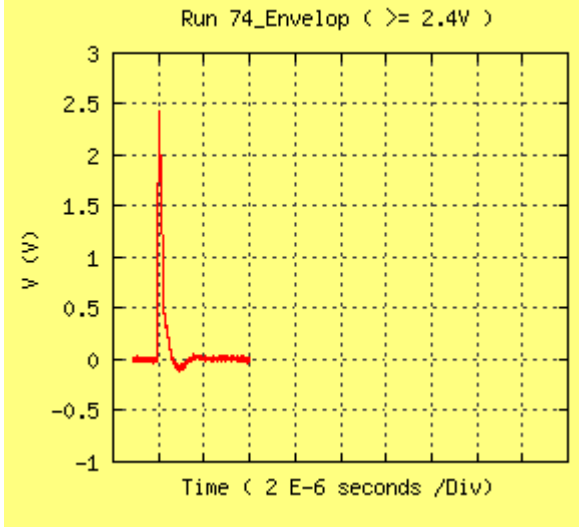
7.15 Set-up 3-1, positive SETs, V1=0V, Output1



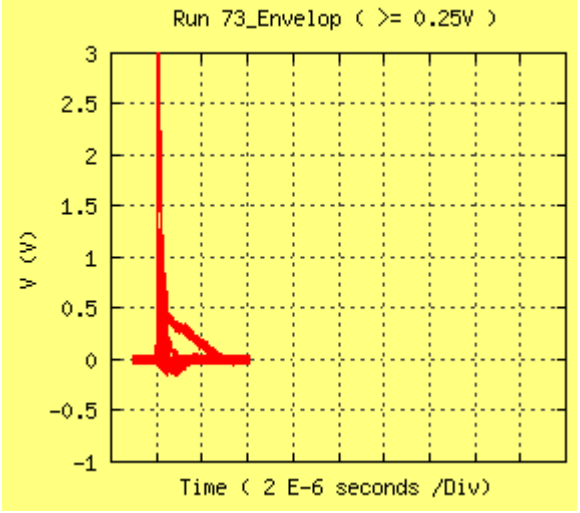


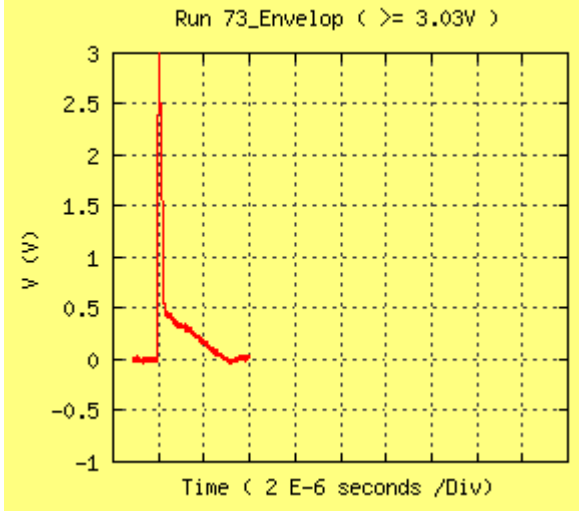
Run75
Set-up 3-1
Vin1=0V
Trig= +0.25
LET 14.1
Fluence 5 E+05



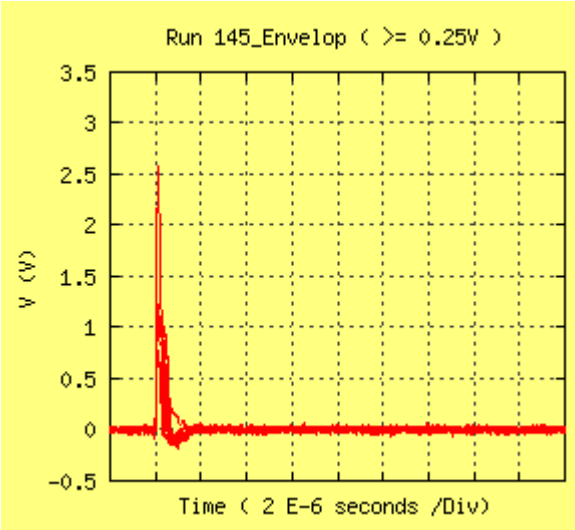


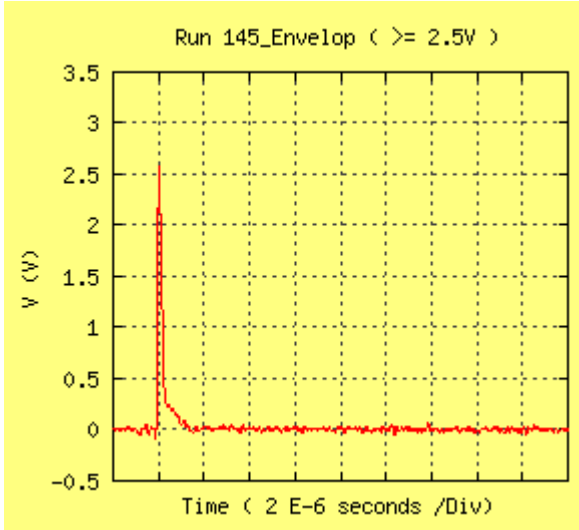
Run75
Set-up 3-1
Vin1=0V
Trig= +0.25
LET 19.94
Fluence 5 E+05





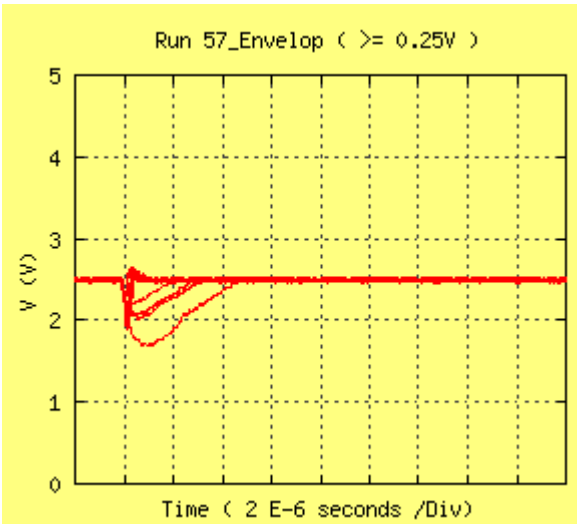
Run73
Set-up 3-1
Vin1=0V
Trig= +0.25
LET 28.2
Fluence 5 E+05

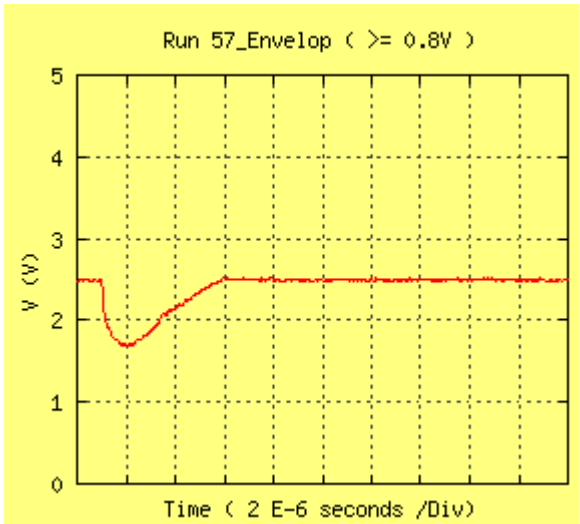




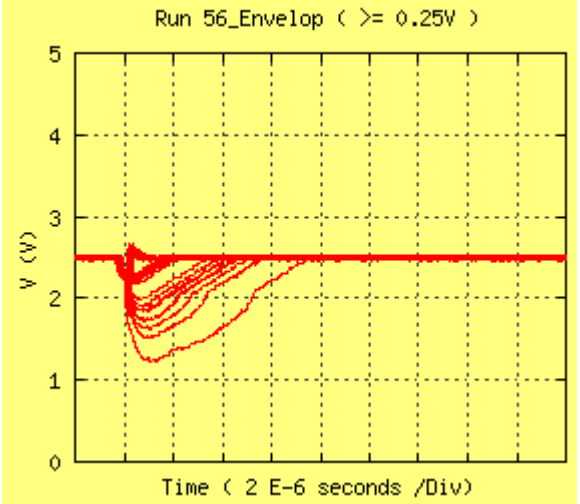
Run145
Set-up 3-1
Vin1=0V
Trig= +0.25
LET 34
Fluence 1 E+05

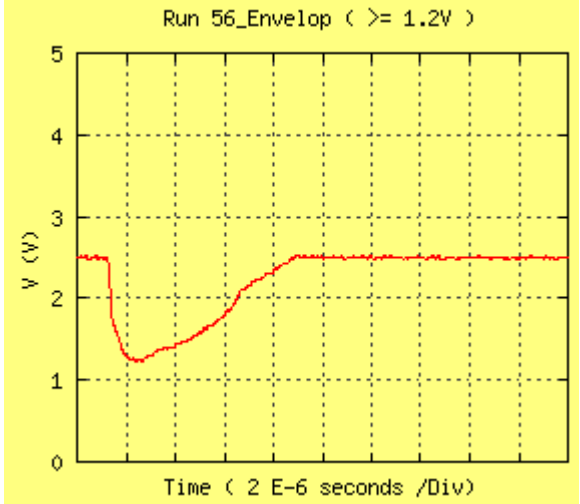
7.16 Set-up 3-1, negative SETs, V1=2.5V, Output1



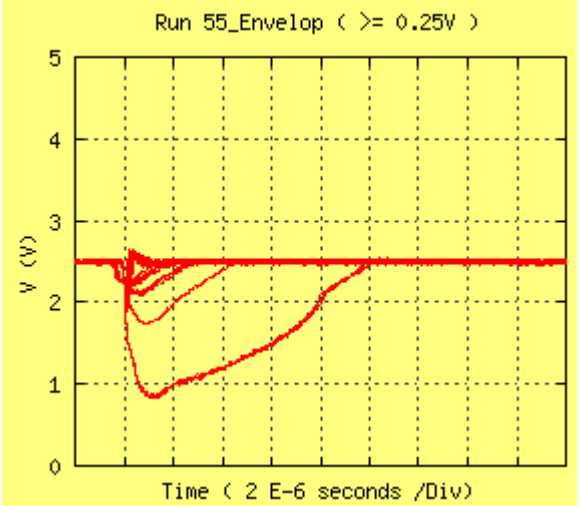


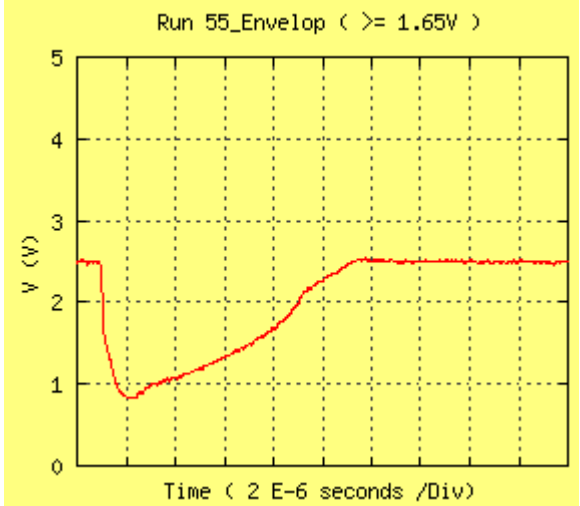
Run57
Set-up 3-1
Vin1=2.5V
Trig= 2.25
LET 14.1
Fluence 5 E+05



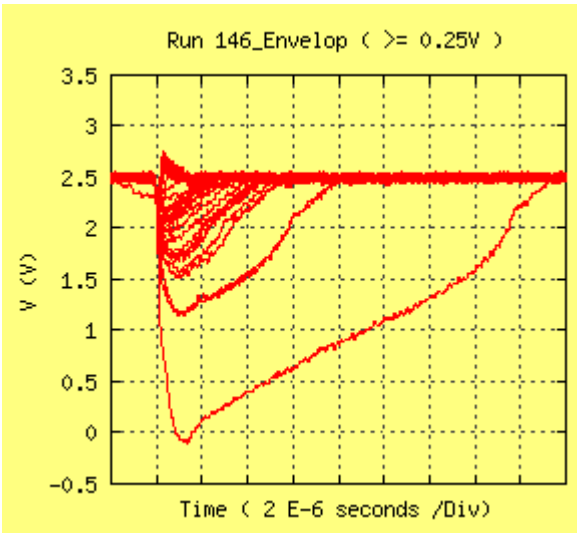


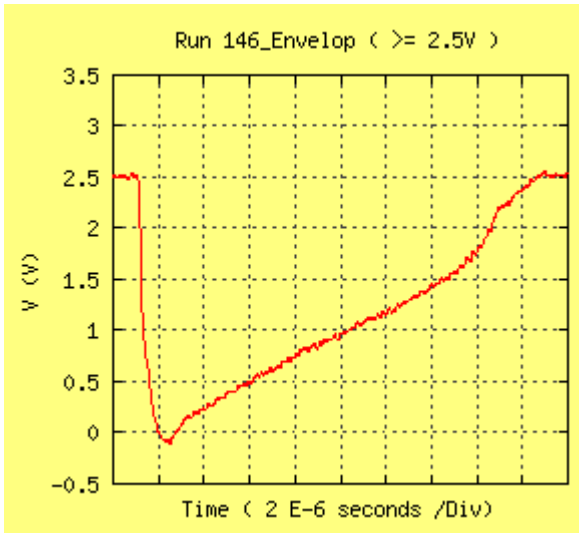
Run56
Set-up 3-1
Vin1=2.5V
Trig= 2.25
LET 19.94
Fluence 5 E+05





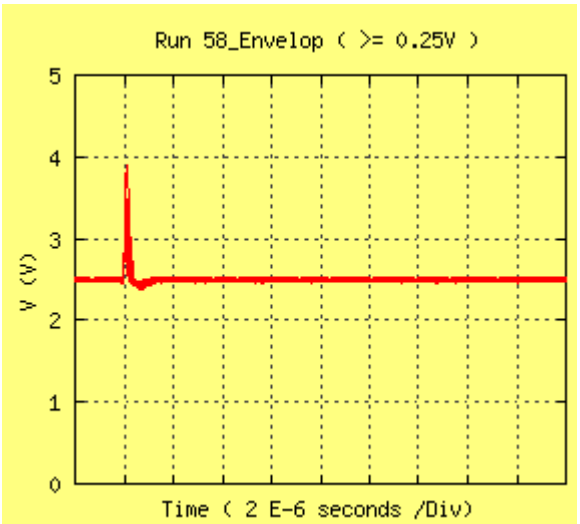
Run55
Set-up 3-1
Vin1=2.5V
Trig= 2.25
LET 28.2
Fluence 5 E+05

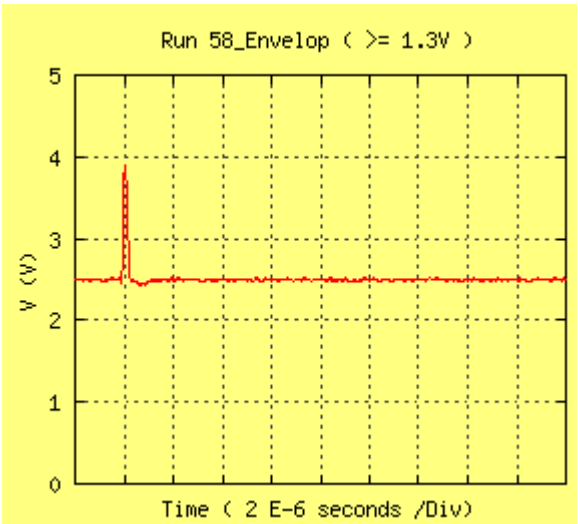




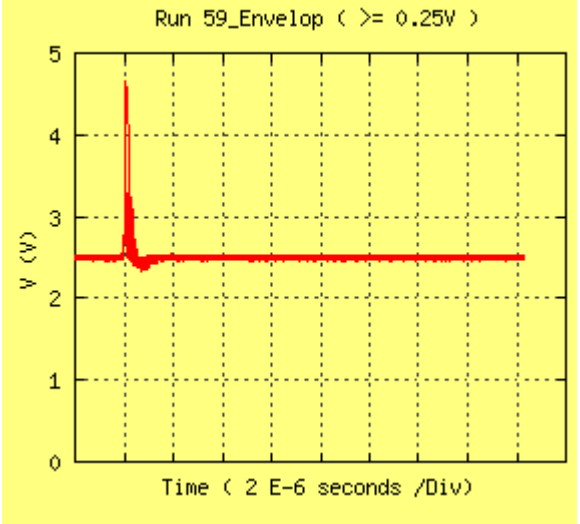
Run146
Set-up 3-1
Vin1=2.5V
Trig= 2.25
LET 34
Fluence 1 E+05

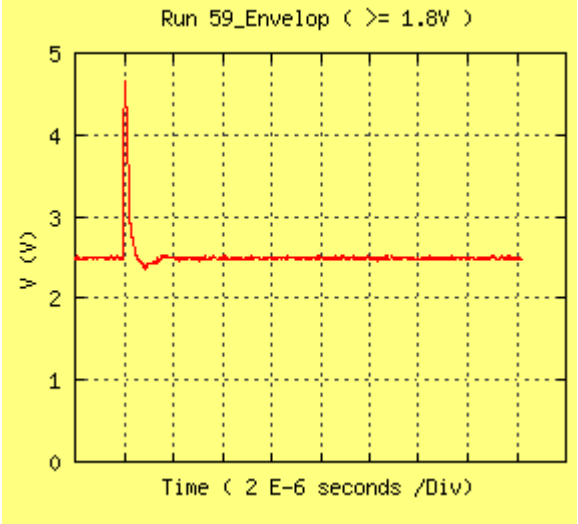
7.17 Set-up 3-1, positive SETs, V1=2.5V, Output1



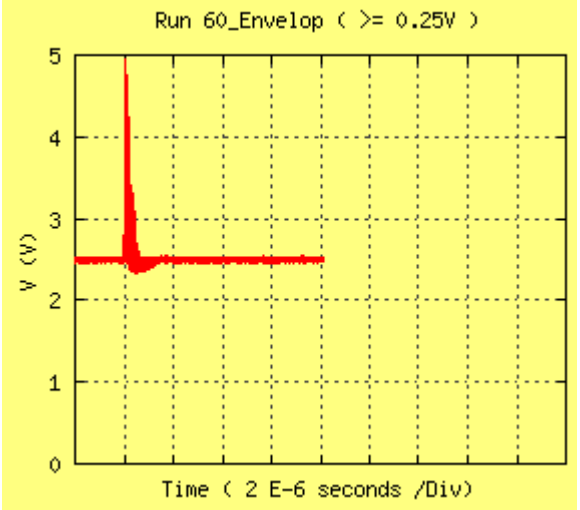


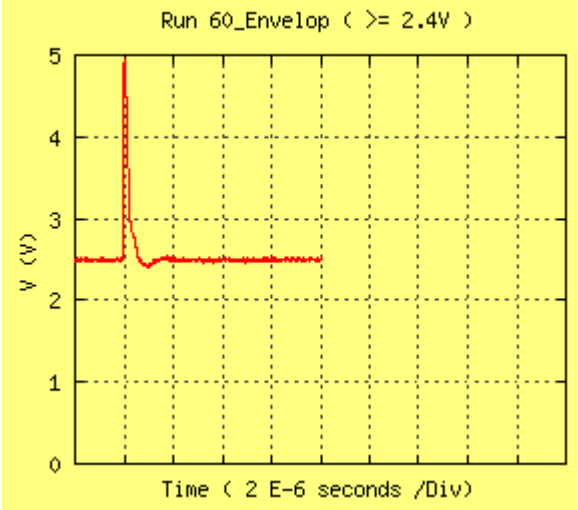
Run58
Set-up 3-1
Vin1=2.5V
Trig= 2.75
LET 14.1
Fluence 5 E+05



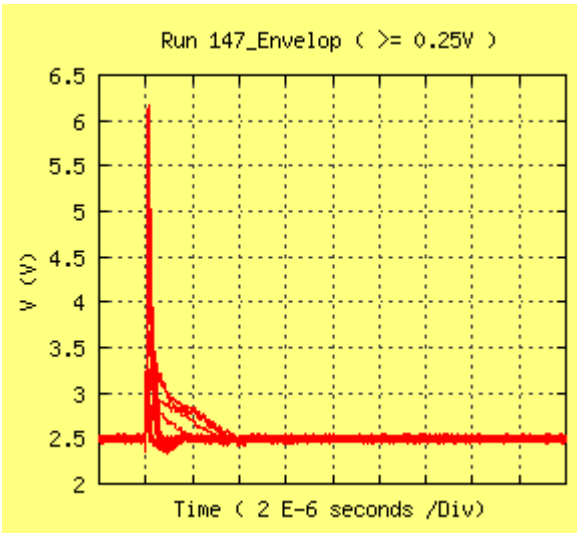


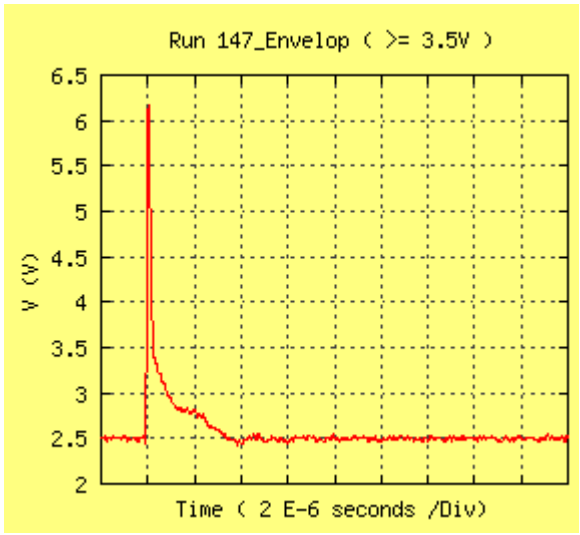
Run59
Set-up 3-1
Vin1=2.5V
Trig= 2.75
LET 19.94
Fluence 5 E+05





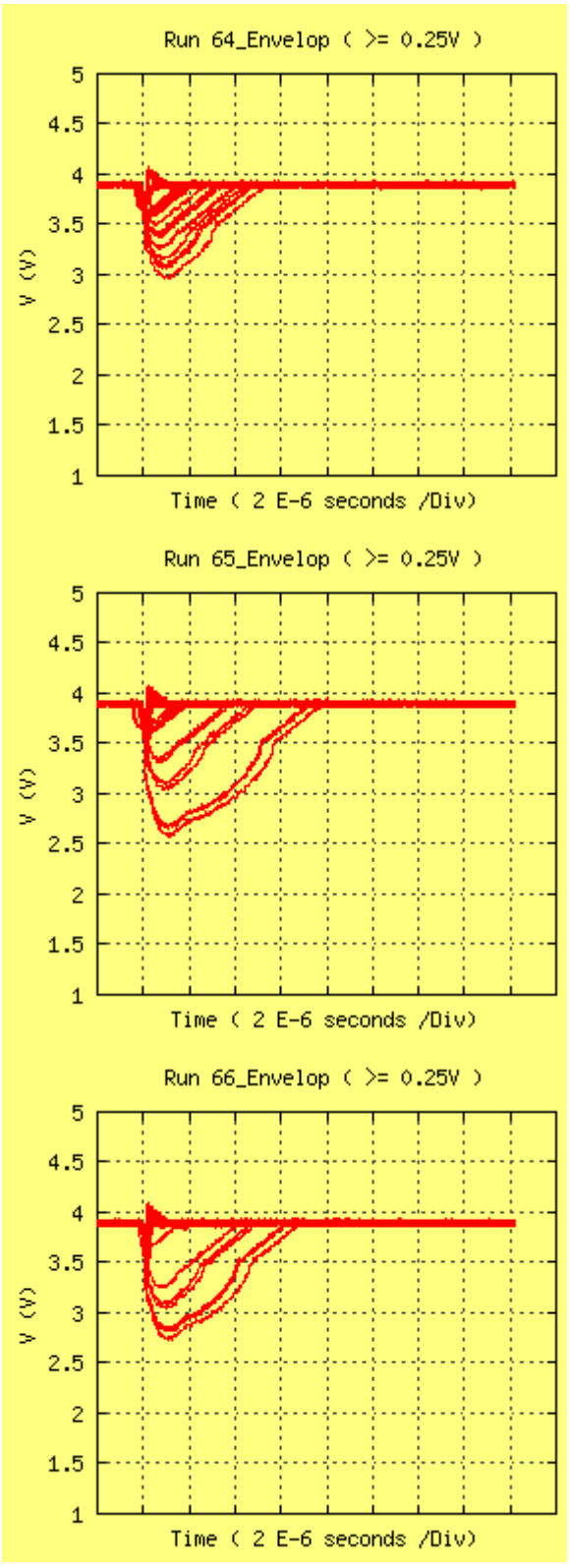
Run60
Set-up 3-1
Vin1=2.5V
Trig= 2.75
LET 28.2
Fluence 5 E+05





Run147
Set-up 3-1
Vin1=2.5V
Trig= 2.75
LET 34
Fluence 1 E+05

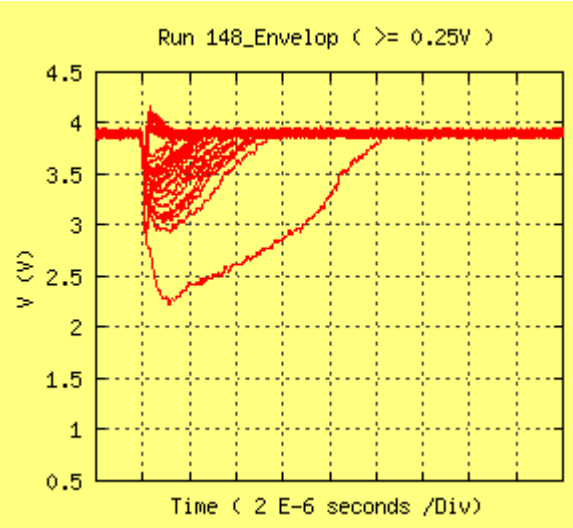
7.18 Set-up3-1, negative SETs, V1=3.9V, Output1

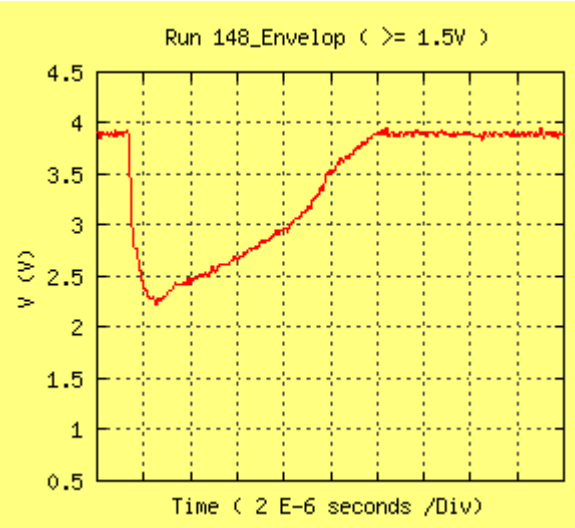


Run64
Set-up 3-1
Vin1=3.9V
Trig= 3.65
LET 14.1
Fluence 5 E+05

Run65
Set-up 3-1
Vin1=3.9V
Trig= 3.65
LET 19.94
Fluence 5 E+05

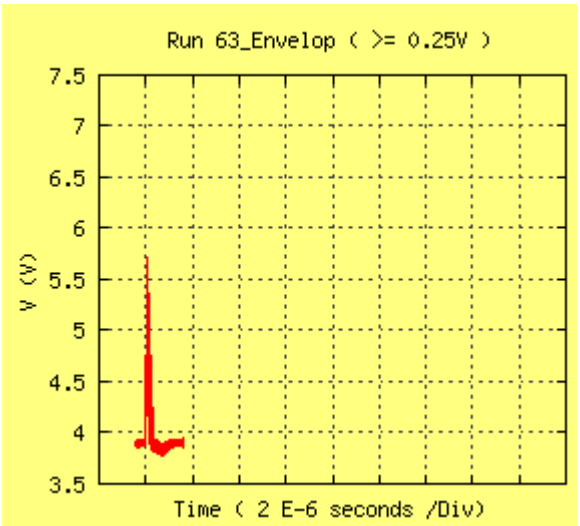
Run66
Set-up 3-1
Vin1=3.9V
Trig= 3.65
LET 28.2
Fluence 5 E+05

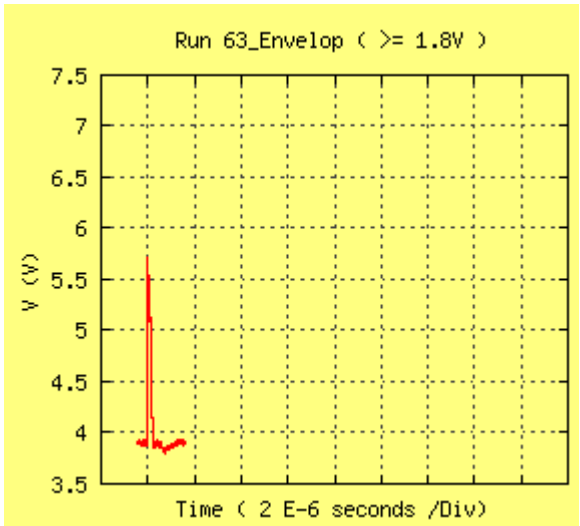




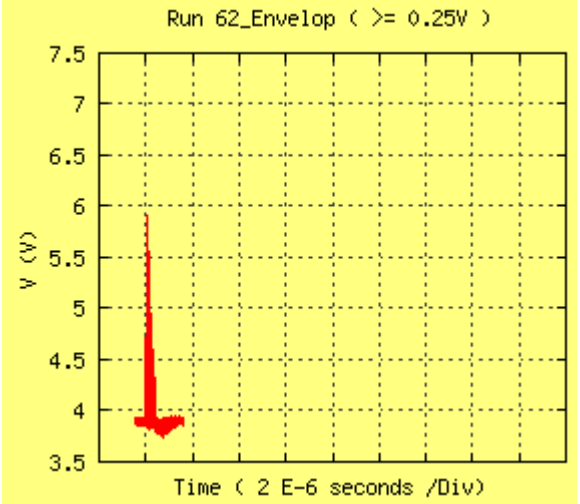
Run148
Set-up 3-1
Vin1=3.9V
Trig= 3.65
LET 34
Fluence 1 E+05

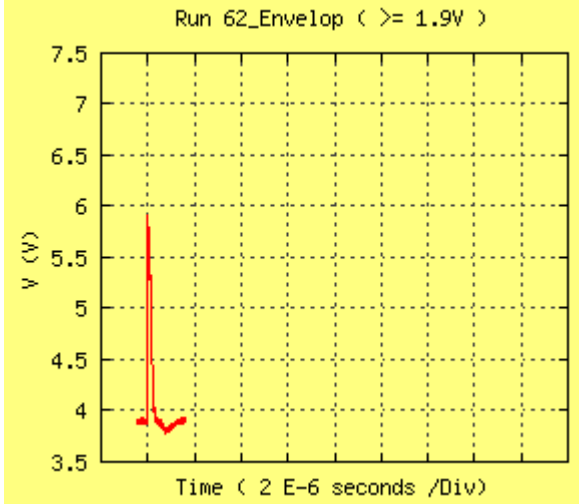
7.19 Set-up3-1, positive SETs, V1=3.9V, Output1



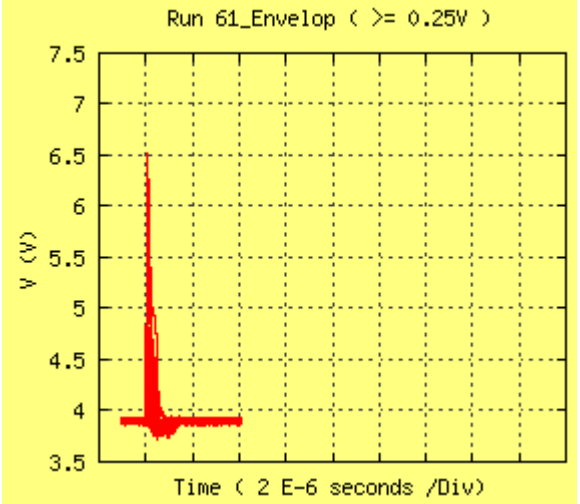


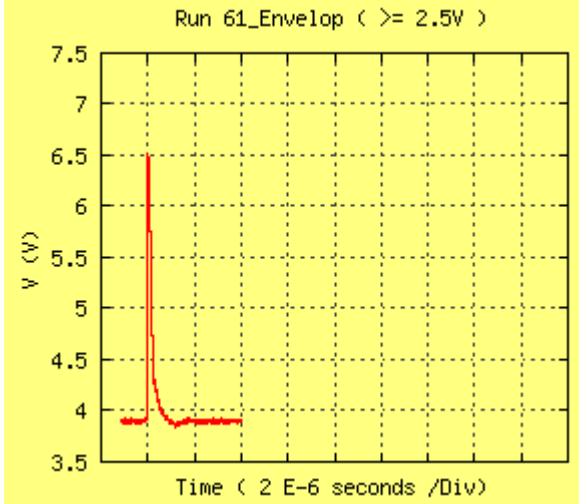
Run63
Set-up 3-1
Vin1=3.9V
Trig= 4.15
LET 14.1
Fluence 5 E+05



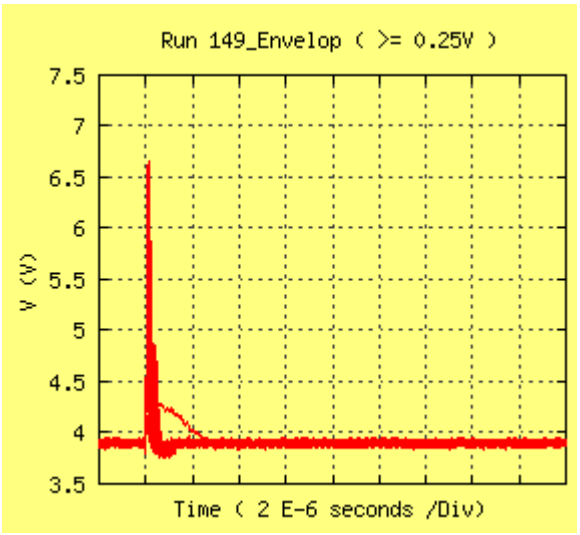


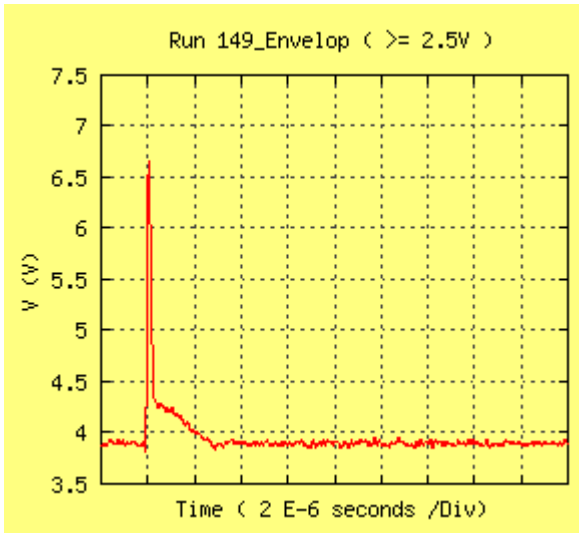
Run62
Set-up 3-1
Vin1=3.9V
Trig= 4.15
LET 19.94
Fluence 5 E+05





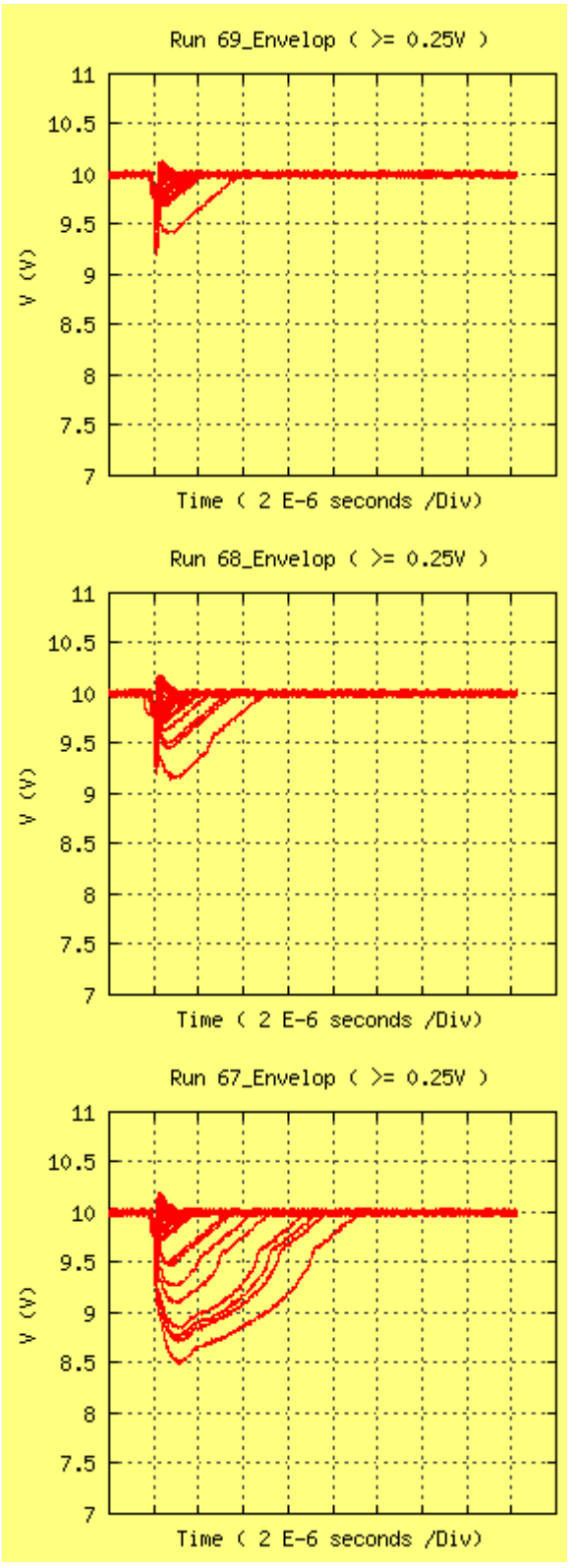
Run61
Set-up 3-1
Vin1=3.9V
Trig= 4.15
LET 28.2
Fluence 5 E+05





Run149
Set-up 3-1
Vin1=3.9V
Trig= 4.15
LET 34
Fluence 1 E+05

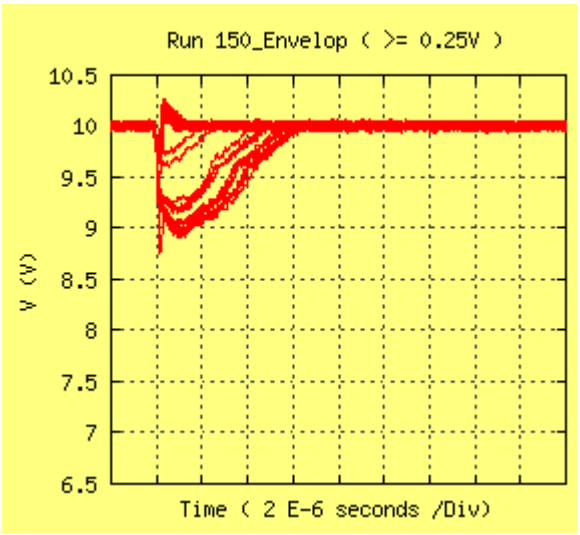
7.20 Set-up 3-1, negative SETs, V1=10V, Output1

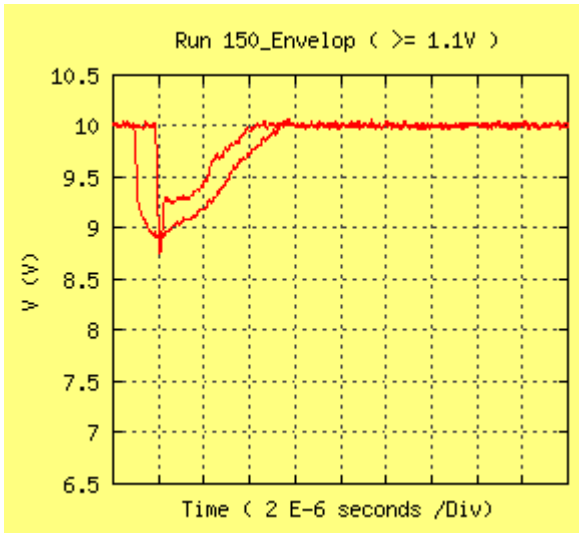


Run69
Set-up 3-1
Vin1=10V
Trig= 9.75
LET 14.1
Fluence 5 E+05

Run68
Set-up 3-1
Vin1=10V
Trig= 9.75
LET 19.94
Fluence 5 E+05

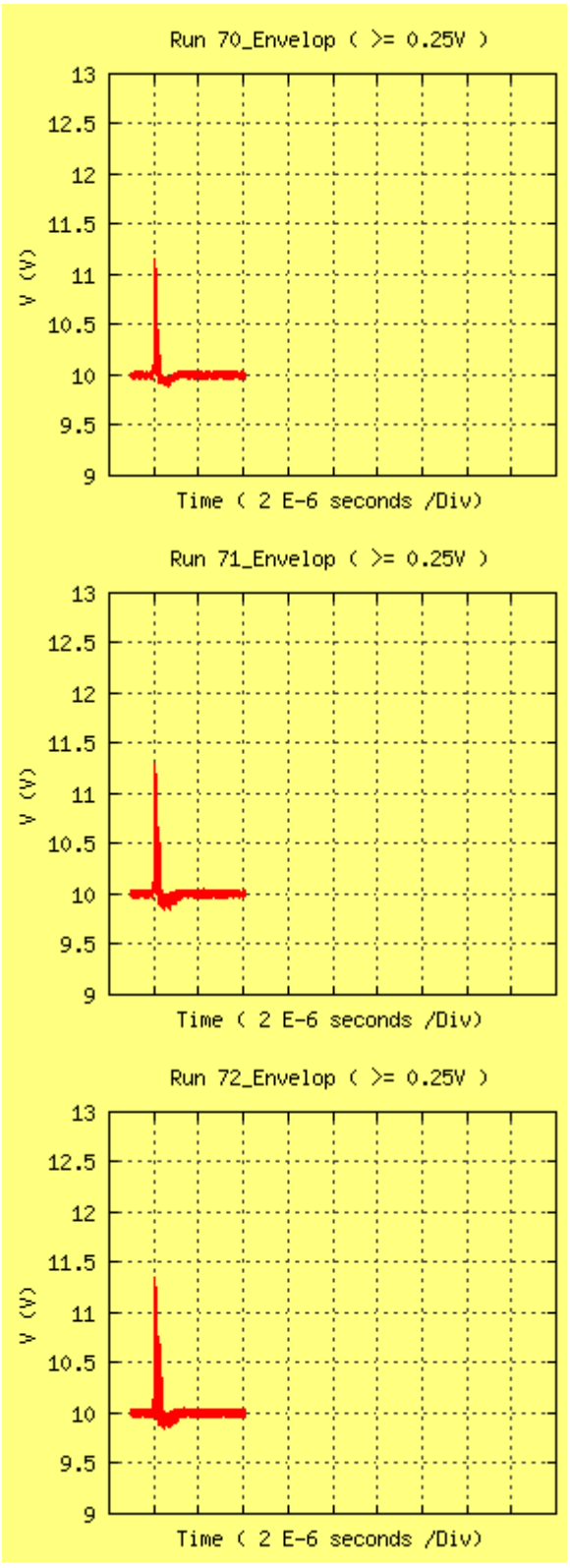
Run67
Set-up 3-1
Vin1=10V
Trig= 9.75
LET 28.2
Fluence 5 E+05





Run150
Set-up 3-1
Vin1=10V
Trig= 9.75
LET 34
Fluence 1 E+05

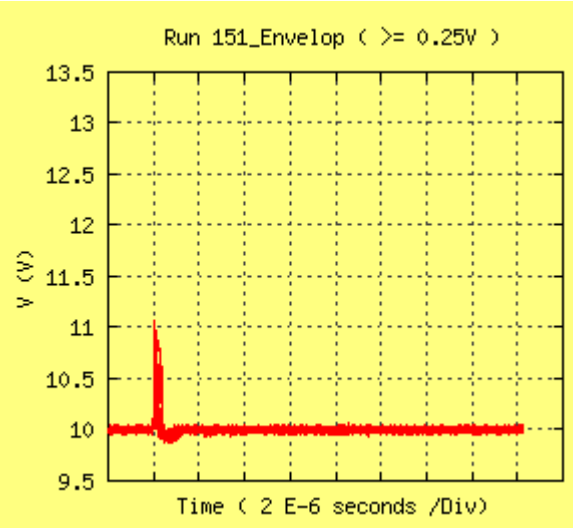
7.21 Set-up 2-1, positive SETs, V1=10V, Output1

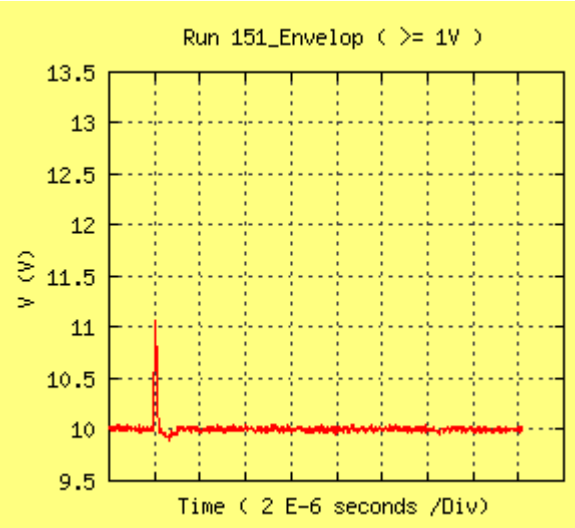


Run70
Set-up 3-1
Vin1=10V
Trig= 10.25
LET 14.1
Fluence 5 E+05

Run71
Set-up 3-1
Vin1=10V
Trig= 10.25
LET 19.94
Fluence 5 E+05

Run72
Set-up 3-1
Vin1=10V
Trig= 10.25
LET 28.2
Fluence 5 E+05





Run151
Set-up 3-1
Vin1=10V
Trig= 10.25
LET 34
Fluence 1 E+05

Table 2 – Detailed results per run

Run #	Device S/N	Set-up-Output #	V1 (V)	Vin1 (V)	Vin2 (V)	Output trig level (V)	Pulse (↓↑)	Ion	Tilt angle (deg.)	LETeff MeV/(mg/cm²)	Fluence (#/cm²)	IradTime (s)	MeanFlux (#/cm²*s)	SET Height >=0.25V & Width >=5ns	SET trig 0.25V
Run125	1	1-1		10		-10.25	↓	20Ne4	60	11.7	503537	132	3824	0	0
Run20	1	1-1		10		-10.25	↓	40Ar8	0	14.1	1004607	152	6630	31	65
Run21	1	1-1		10		-10.25	↓	40Ar8	45	19.94	1005044	212	4738	40	59
Run22	1	1-1		10		-10.25	↓	40Ar8	60	28.2	1001642	254	3944	53	69
run143	1	1-1		10		-10.25	↓	84Kr17	0	34	102067	86	1191	39	101
Run123	1	1-1		10		-9.75	↑	20Ne4	0	5.85	506900	66	7700	6	6
Run124	1	1-1		10		-9.75	↑	20Ne4	60	11.7	502837	137	3673	11	11
Run25	1	1-1		10		-9.75	↑	40Ar8	0	14.1	1008477	108	9369	46	125
Run24	1	1-1		10		-9.75	↑	40Ar8	45	19.94	1004426	167	6007	68	79
Run23	1	1-1		10		-9.75	↑	40Ar8	60	28.2	1002803	255	3933	100	106
run142	1	1-1		10		-9.75	↑	84Kr17	0	34	100031	80	1243	20	25
Run118	1	1-1		5		-5.25	↓	20Ne4	0	5.85	501442	79	6314	0	0
Run119	1	1-1		5		-5.25	↓	20Ne4	60	11.7	500416	161	3110	0	1
Run5	1	1-1		5		-5.25	↓	40Ar8	0	14.1	1005919	157	6417	38	117
Run6	1	1-1		5		-5.25	↓	40Ar8	45	19.94	1000065	207	4833	73	139
Run7	1	1-1		5		-5.25	↓	40Ar8	60	28.2	1002793	232	4323	73	117
run140	1	1-1		5		-5.25	↓	84Kr17	0	34	100399	74	1353	31	92
Run117	1	1-1		5		-4.75	↑	20Ne4	0	5.85	506209	77	6546	9	9
Run4	1	1-1		5		-4.75	↑	40Ar8	0	14.1	1008295	130	7781	42	43
Run2	1	1-1		5		-4.75	↑	40Ar8	45	19.94	1008909	145	6946	67	74
Run3	1	1-1		5		-4.75	↑	40Ar8	60	28.2	1000144	241	4143	137	144
run141	1	1-1		5		-4.75	↑	84Kr17	0	34	100368	65	1549	23	26
Run120	1	1-1		0		-0.25	↓	20Ne4	60	11.7	501337	169	2961	0	1
Run19	1	1-1		0		-0.25	↓	40Ar8	0	14.1	1005532	144	6973	43	156
Run18	1	1-1		0		-0.25	↓	40Ar8	45	19.94	1000164	209	4785	65	148
Run17	1	1-1		0		-0.25	↓	40Ar8	60	28.2	1003409	288	3479	85	140
run139	1	1-1		0		-0.25	↓	84Kr17	0	34	102572	49	2088	33	90
Run122	1	1-1		0		0.25	↑	20Ne4	0	5.85	503065	74	6780	5	5
Run121	1	1-1		0		0.25	↑	20Ne4	60	11.7	500072	173	2883	15	15
Run14	1	1-1		0		0.25	↑	40Ar8	0	14.1	1001961	109	9219	62	63
Run15	1	1-1		0		0.25	↑	40Ar8	45	19.94	1002058	185	5418	94	126
Run16	1	1-1		0		0.25	↑	40Ar8	60	28.2	1004334	273	3682	154	165
run138	1	1-1		0		0.25	↑	84Kr17	0	34	101415	76	1329	22	31
Run8	1	1-2		5		-5.25	↓	40Ar8	0	14.1	1003430	136	7386	45	90
Run13	1	1-2		5		-4.75	↑	40Ar8	0	14.1	1005761	114	8830	45	50
Run9	1	1-3		5		-5.25	↓	40Ar8	0	14.1	1000933	150	6652	49	132
Run12	1	1-3		5		-4.75	↑	40Ar8	0	14.1	1004518	114	8819	36	38
Run10	1	1-4		5		-5.25	↓	40Ar8	0	14.1	1002957	115	8725	54	116
Run11	1	1-4		5		-4.75	↑	40Ar8	0	14.1	1006125	111	9083	54	55
Run128	2	2-1	0	0	0	-0.25	↓	20Ne4	0	5.85	501464	60	8419	0	0
run129	2	2-1	0	0	0	-0.25	↓	20Ne4	60	11.7	502463	152	3316	57	72
Run26	2	2-1	0	0	0	-0.25	↓	40Ar8	0	14.1	1007276	119	8455	80	337

Run #	Device S/N	Set-up-Output #	V1 (V)	Vin1 (V)	Vin2 (V)	Output trig level (V)	Pulse (↓↑)	Ion	Tilt angle (deg.)	LETeff MeV/(mg/cm²)	Fluence (#/cm²)	IradTime (s)	MeanFlux (#/cm²*s)	SET Height >=0.25V & Width >=5ns	SET trig 0.25V
Run27	2	2-1	0	0	0	-0.25	↓	40Ar8	45	19.94	504269	137	3684	180	258
Run28	2	2-1	0	0	0	-0.25	↓	40Ar8	60	28.2	503483	155	3255	178	215
run136	2	2-1	0	0	0	-0.25	↓	84Kr17	0	34	100613	72	1395	80	155
Run127	2	2-1	0	0	0	0.25	↑	20Ne4	0	5.85	506309	72	7022	6	6
Run126	2	2-1	0	0	0	0.25	↑	20Ne4	60	11.7	500681	138	3630	23	23
Run31	2	2-1	0	0	0	0.25	↑	40Ar8	0	14.1	502962	109	4628	26	26
Run30	2	2-1	0	0	0	0.25	↑	40Ar8	45	19.94	500601	164	3051	48	66
Run29	2	2-1	0	0	0	0.25	↑	40Ar8	60	28.2	501924	242	2070	48	76
run137	2	2-1	0	0	0	0.25	↑	84Kr17	0	34	100166	50	1997	29	45
run131	2	2-1	2.56	0	5	0.55	↓	20Ne4	0	5.85	506363	69	7342	0	0
run130	2	2-1	2.56	0	5	0.55	↓	20Ne4	60	11.7	500990	136	3688	4	4
Run32	2	2-1	2.56	0	0	2.31	↓	40Ar8	0	14.1	500793	118	4241	47	220
Run33	2	2-1	2.56	0	0	2.31	↓	40Ar8	45	19.94	500119	178	2815	145	235
Run34	2	2-1	2.56	0	0	2.31	↓	40Ar8	60	28.2	501468	247	2033	158	221
run132	2	2-1	2.56	0	5	0.55	↓	84Kr17	0	34	100969	54	1858	76	139
Run37	2	2-1	2.56	0	0	2.81	↑	40Ar8	0	14.1	503382	118	4263	23	23
Run36	2	2-1	2.56	0	0	2.81	↑	40Ar8	45	19.94	502823	170	2952	41	55
Run35	2	2-1	2.56	0	0	2.81	↑	40Ar8	60	28.2	500203	251	1994	41	63
run133	2	2-1	2.56	0	5	1.05	↑	84Kr17	0	34	101152	62	1641	51	60
Run43	2	2-1	3.9	0	0	3.65	↓	40Ar8	0	14.1	501972	106	4756	53	193
Run44	2	2-1	3.9	5	0	3.65	↓	40Ar8	0	14.1	500724	98	5097	45	193
Run47	2	2-1	3.9	0	5	5.45	↓	40Ar8	0	14.1	501829	127	3936	54	202
Run42	2	2-1	3.9	0	0	3.65	↓	40Ar8	45	19.94	502130	140	3586	155	252
Run45	2	2-1	3.9	0	5	5.45	↓	40Ar8	45	19.94	501542	248	2025	146	270
Run48	2	2-1	3.9	5	0	3.65	↓	40Ar8	45	19.94	501171	169	2960	132	192
Run41	2	2-1	3.9	0	0	3.65	↓	40Ar8	60	28.2	502263	211	2379	164	238
Run46	2	2-1	3.9	0	5	5.45	↓	40Ar8	60	28.2	501382	266	1882	170	262
Run49	2	2-1	3.9	5	0	1.9	↓	40Ar8	60	28.2	501529	240	2087	129	167
run135	2	2-1	3.9	0	5	5.45	↓	84Kr17	0	34	101019	64	1585	84	111
Run38	2	2-1	3.9	0	0	4.15	↑	40Ar8	0	14.1	500605	115	4355	28	28
Run51	2	2-1	3.9	5	0	2.4	↑	40Ar8	0	14.1	503375	124	4048	23	24
Run39	2	2-1	3.9	0	0	4.15	↑	40Ar8	45	19.94	501662	145	3454	36	49
Run50	2	2-1	3.9	5	0	2.4	↑	40Ar8	45	19.94	501230	169	2961	41	55
Run40	2	2-1	3.9	0	0	4.15	↑	40Ar8	60	28.2	501206	217	2306	46	73
run134	2	2-1	3.9	0	5	5.85	↑	84Kr17	0	34	100150	60	1681	10	18
Run52	1	3-1		0		-0.25	↓	40Ar8	0	14.1	503346	98	5124	30	52
Run53	1	3-1		0		-0.25	↓	40Ar8	45	19.94	500142	140	3572	31	87
Run54	1	3-1		0		-0.25	↓	40Ar8	60	28.2	501341	202	2486	48	82
run144	1	3-1		0		-0.25	↓	84Kr17	0	34	100577	47	2139	50	115
Run75	1	3-1		0		0.25	↑	40Ar8	0	14.1	504433	111	4554	40	40
Run74	1	3-1		0		0.25	↑	40Ar8	45	19.94	503598	168	2993	58	58
Run73	1	3-1		0		0.25	↑	40Ar8	60	28.2	500132	225	2226	75	75
run145	1	3-1		0		0.25	↑	84Kr17	0	34	100462	96	1045	10	10
Run57	1	3-1		2.5		2.25	↓	40Ar8	0	14.1	503422	103	4866	27	81

Run #	Device S/N	Set-up-Output #	V1 (V)	Vin1 (V)	Vin2 (V)	Output trig level (V)	Pulse (↓↑)	Ion	Tilt angle (deg.)	LETeff MeV/(mg/cm²)	Fluence (#/cm²)	IradTime (s)	MeanFlux (#/cm²*s)	SET Height >=0.25V & Width >=5ns	SET trig 0.25V
Run56	1	3-1		2.5		2.25	↓	40Ar8	45	19.94	503479	147	3417	58	107
Run55	1	3-1		2.5		2.25	↓	40Ar8	60	28.2	502075	198	2542	41	55
run146	1	3-1		2.5		2.25	↓	84Kr17	0	34	101255	46	2202	44	111
Run58	1	3-1		2.5		2.75	↑	40Ar8	0	14.1	503966	96	5242	20	20
Run59	1	3-1		2.5		2.75	↑	40Ar8	45	19.94	500604	132	3802	31	45
Run60	1	3-1		2.5		2.75	↑	40Ar8	60	28.2	500058	214	2334	78	80
run147	1	3-1		2.5		2.75	↑	84Kr17	0	34	100118	43	2337	24	31
Run64	1	3-1		3.9		3.65	↓	40Ar8	0	14.1	500319	107	4694	35	107
Run65	1	3-1		3.9		3.65	↓	40Ar8	45	19.94	502720	149	3364	45	101
Run66	1	3-1		3.9		3.65	↓	40Ar8	60	28.2	500796	213	2349	56	96
run148	1	3-1		3.9		3.65	↓	84Kr17	0	34	101045	54	1859	44	100
Run63	1	3-1		3.9		4.15	↑	40Ar8	0	14.1	504562	109	4643	28	28
Run62	1	3-1		3.9		4.15	↑	40Ar8	45	19.94	500735	152	3305	55	55
Run61	1	3-1		3.9		4.15	↑	40Ar8	60	28.2	500896	208	2409	59	59
run149	1	3-1		3.9		4.15	↑	84Kr17	0	34	100070	64	1570	25	33
Run69	1	3-1		10		9.75	↓	40Ar8	0	14.1	504710	107	4735	31	116
Run68	1	3-1		10		9.75	↓	40Ar8	45	19.94	502007	143	3506	46	225
Run67	1	3-1		10		9.75	↓	40Ar8	60	28.2	501546	216	2319	57	102
run150	1	3-1		10		9.75	↓	84Kr17	0	34	100603	52	1925	68	122
Run70	1	3-1		10		10.25	↑	40Ar8	0	14.1	501716	106	4754	19	19
Run71	1	3-1		10		10.25	↑	40Ar8	45	19.94	500752	148	3375	28	28
Run72	1	3-1		10		10.25	↑	40Ar8	60	28.2	500289	214	2335	53	53
run151	1	3-1		10		10.25	↑	84Kr17	0	34	100823	63	1608	10	11
Run78	3	4-1		2.5		2.25	↓	40Ar8	60	28.2	500611	377	1327	0	0
run152	3	4-1		2.5		2.25	↓	84Kr17	0	34	100548	59	1718	0	0
run153	3	4-1		2.5		2.25	↓	84Kr17	0	34	100352	76	1315	0	0
Run76	3	4-1		2.5		2.75	↑	40Ar8	0	14.1	502464	115	4371	0	0
Run77	3	4-1		2.5		2.75	↑	40Ar8	60	28.2	500819	284	1762	0	0
run154	3	4-1		2.5		2.75	↑	84Kr17	0	34	100032	51	1954	0	0
run155	3	4-1		2.82		2.57	↓	84Kr17	0	34	101870	56	1805	0	0

8 CONCLUSION

Heavy ion tests were conducted on 2 flight lot parts for the ATV project, OP400Y, Quad Low Offset, Low Power Operational Amplifier from Analog Devices, using the heavy ions available at the European Heavy Ion Irradiation Facility (HIF) at Cyclone, Université Catholique de Louvain, Belgium.

The different set-ups as defined in MMS document (see RD2) have been used.

Both negative and positive events were detected.

For each run, in addition to the number of SETs, the corresponding SETs envelop and SET worst case have been included in the present report so that the influence of the LET value on SET height and width can be evaluated.