Single Event Radiation Test Report

Type	:	LM 139
Parts Description	:	Quad Comparator
Manufacturer	:	Motorola, Intersil

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to astrium-rad-914

Issue/ Revision	Date	Change	Page
1	30.05.00	New document	All
1A	13.06.00	Completed 'Test Performed by' list	1
		Units corrected to read MeV/mg/cm2	several
		Table 2.1 added: Results for type I bias (5V)	6
		Table 2.2 added: Results for type II bias (12V)	7
		Figure 2.1 units corrected: cross section [cm2]/comparator	8
		Figure 4.1.2: Photo added	11
		Figure 5.1.1 added: MOT SN206, 5V bias, Ar with LET = 14,1 ...	15
		(all other figures 5.1.x renumbered accordingly)	

WORD 97

Table of Contents

Table of Figures

Table of Tables

1 GENERAL

1.1 Scope

This test report details the results of the Heavy Ion Single Event Effects testing performed on the LM 139 Quad Comparator on 25.05.2000.

1.2 Documents

1.2.1 Applicable Documents

1.2.2 Reference Documents

RD1 ESA/SCC Basic Specification No. 25100, 'Single Event Effects Test Method and Guidelines

2 SUMMARY OF TEST AND RESULTS

Two devices of the Motorola LM 139 and two devices of the Intersil RadHard LM 139 have been submitted to heavy ion testing at the ESA Heavy Ion Test Facility (HIF) at UCL in Louvain-la-Neuve in Belgium.

The devices under test (DUT) are listed in detail in para. 3.

Two different bias conditions have been applied to each of the DUTs. Equal circuits are used in space applications:

I) Vcc = 5V, Vdiff.input = 160 mV

II) Vcc = 12V, Vdiff.input = 4,02 V

Details are given in para 4.

Results

TABLE 2.1 – RESULTS FOR TYPE I BIAS (5V)

Type Designation	Manufacturer	Test SN	Observed effect at below LET value [MeV/mg/cm2]: T = Transient, L = Latch-up, n = Not Tested								
			11,7	14,1	19,9	28,2	34	48,1	55,9	68	111,8
LMC139J	Motorola	206	-	-	T	T	T	T	T	T	T
910300404B	Motorola	214	n	n	n	T	n	n	n	n	T
HS1-139RH	Intersil	201	n	n	n	n	n	n	T	n	T
H5962F9861301QXC	Intersil	210	n	n	n	n	n	n	T	n	T

TABLE 2.2 – RESULTS FOR TYPE II BIAS (12V)

Type Designation	Manufacturer	Test SN	Observed effect at below LET value [MeV/mg/cm2]: T = Transient, L = Latch-up, n = Not Tested

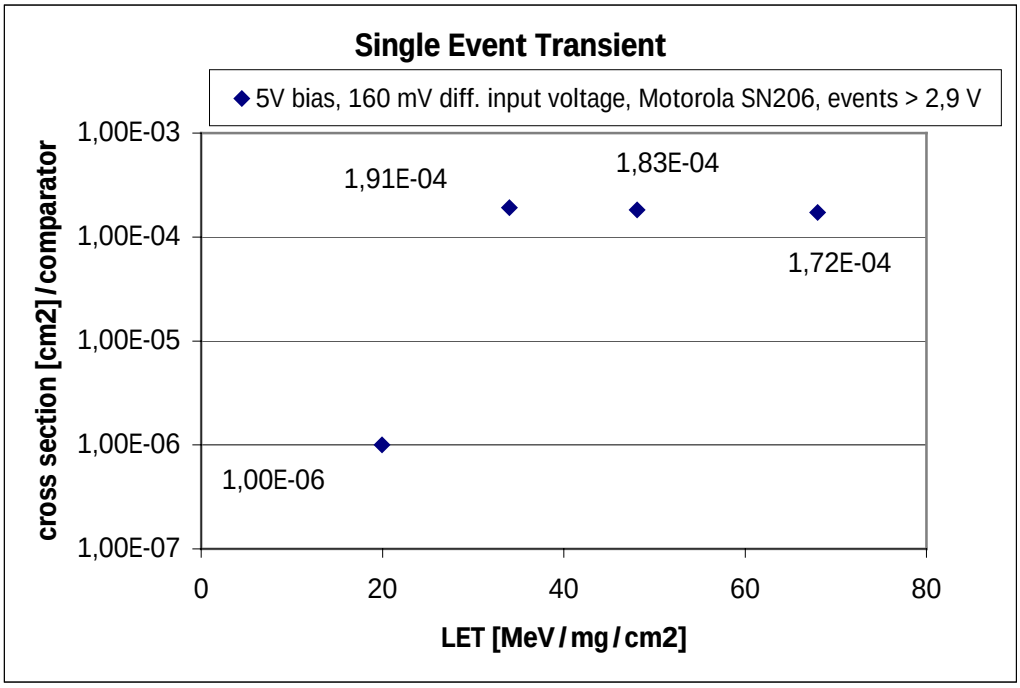
			11,7	14,1	19,9	28,2	34	48,1	55,9	68	111,8
LMC139J	Motorola	206	n	n	n	-	n	n	n	-	-
910300404B	Motorola	214	n	n	n	-	n	n	n	n	-
HS1-139RH	Intersil	201	n	n	n	n	n	n	T	n	T
H5962F9861301QXC	Intersil	210	n	n	n	n	n	n	T	n	T

a) Motorola LMC139J, SN206, 5V bias

The cross section curve for all events exceeding the voltage threshold of 2,9 V is shown in Figure 2.1. Storage Oscilloscope prints of all of the transient events are provided in para. 5.5.

No destructive events have occurred up to LET = 111,8 MeV/mg/cm2.

FIGURE 2.1 – MOT LM139A SINGLE EVENT TRANSIENT CROSS SECTION CURVE



b) Motorola LMC139J, SN206, 12V bias

No events have been recorded up to LET = 111,8 MeV/mg/cm2.

c) For all other devices Storage Oscilloscope prints of the transients are shown in para 5.1 to 5.4. For those tests the events have not been counted. No destructive events have occurred up to LET = 111,8 MeV/mg/cm2.

A major difference has been observed in the sensitivity to heavy ions between the Intersil devices and the Motorola devices at the 12V bias condition (type II). The Motorola devices had

no transients at the output up to the maximum tested LET = 111,8 MeV/mg/cm2, whereas the Intersil devices did show transients.

3 COMPONENT DETAILS

TABLE 3.1 – LM139A DEVICES UNDER TEST

Type Designation	Manufacturer	Origin	Datecode	Original SN	Test SN
LMC139J	Motorola	Ulm Lifetestsamples	9345	35	206
910300404B	Motorola	Cluster store	9343	81	214
HS1-139RH	Intersil	Intersil	N/A	DE14	201
H5962F9861301QXC	Intersil	astrium FN	X9905AAAP	N/A	210

4 TEST DETAILS

4.1 Irradiation Bias

Two different bias conditions have been realised for this test. Equal circuits are used in space applications:

I) Vcc = 5V, Vdiff.input = 160 mV

II) Vcc = 12V, Vdiff.input = 4,02 V

The schematic diagram is given in Figure 4.1.1. At each of the DUT positions on the PCB both circuits are implemented utilizing 2 of the 4 comparators available within the LM139. The DUT positions on the test PCB are shown in Figure 4.1.2.

The wiring of the PCB to the external equipment - power supplies, storage Oscilloscope and counters – is shown in Figures 4.1.3 and 4.1.4.

Of this wiring the counter has not been used for several of the test runs (for reasons of spurious counts due to the high sensitivity of the counter inputs). A simplified version, only connecting DUT position 1 to a counter with appropriate threshold setting possibilities, has been implemented for the test run with the results shown in para. 5.5.

FIGURE 4.1.1 – SCHEMATICS OF THE ELECTRICAL BIAS CONDITIONS

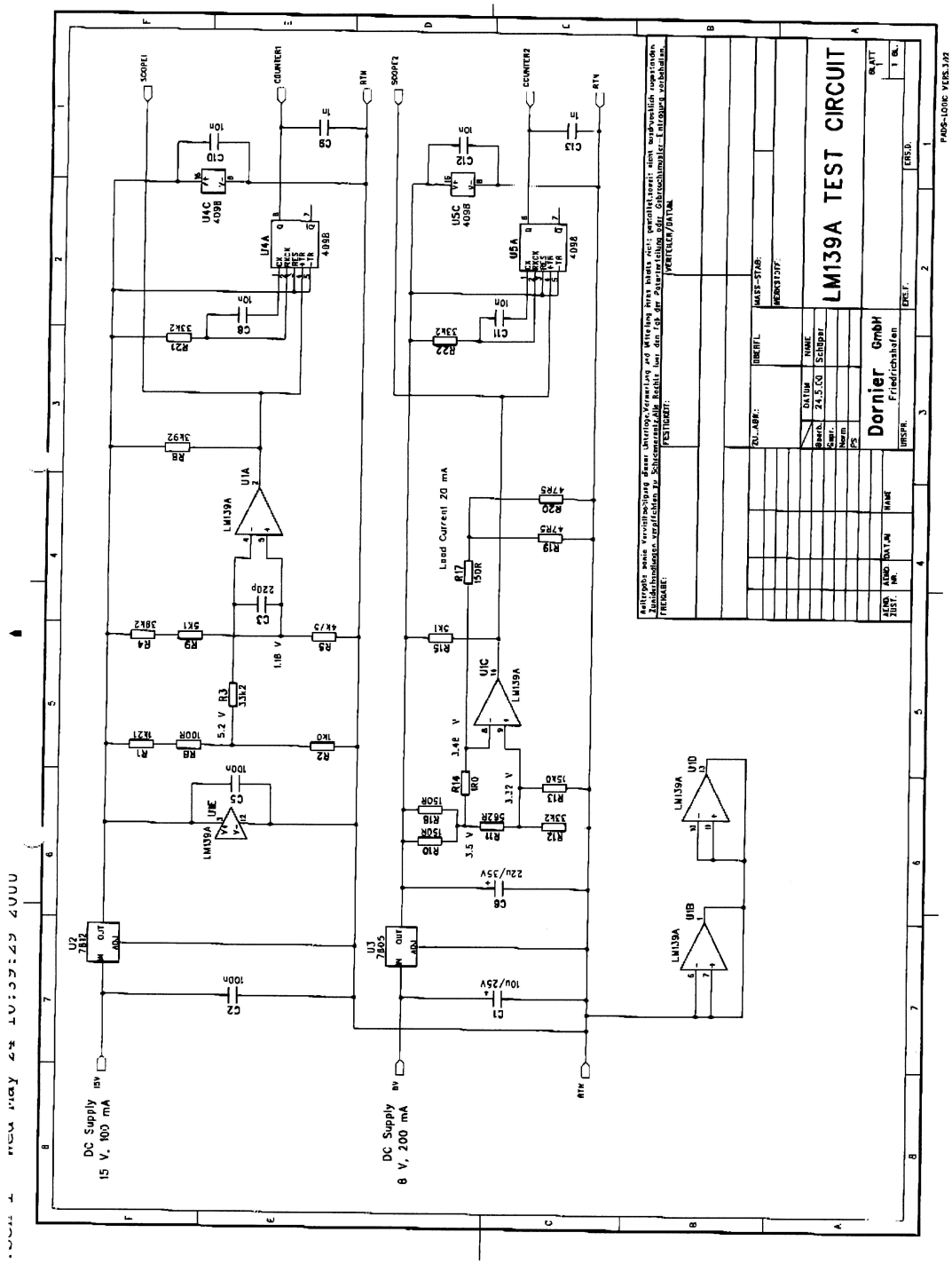
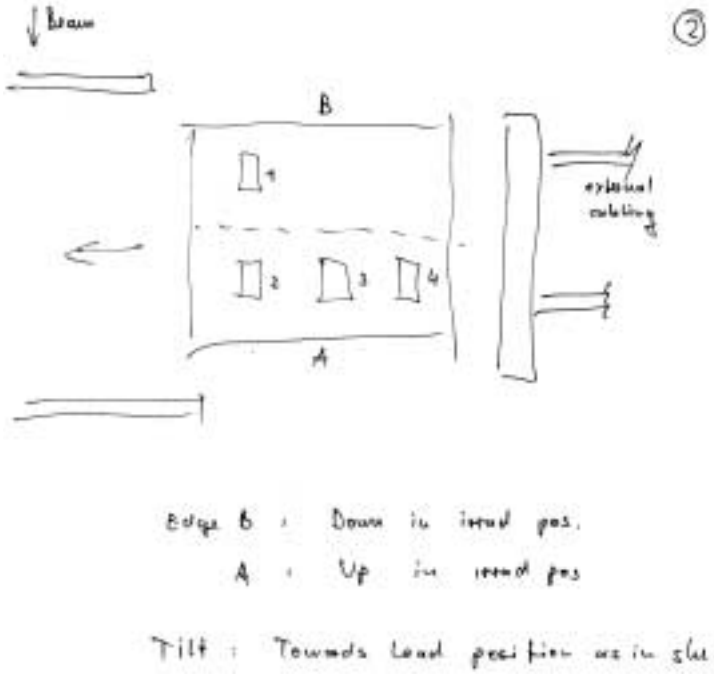


FIGURE 4.1.2 – DUT POSITIONS ON TEST PCB



DUT positions:

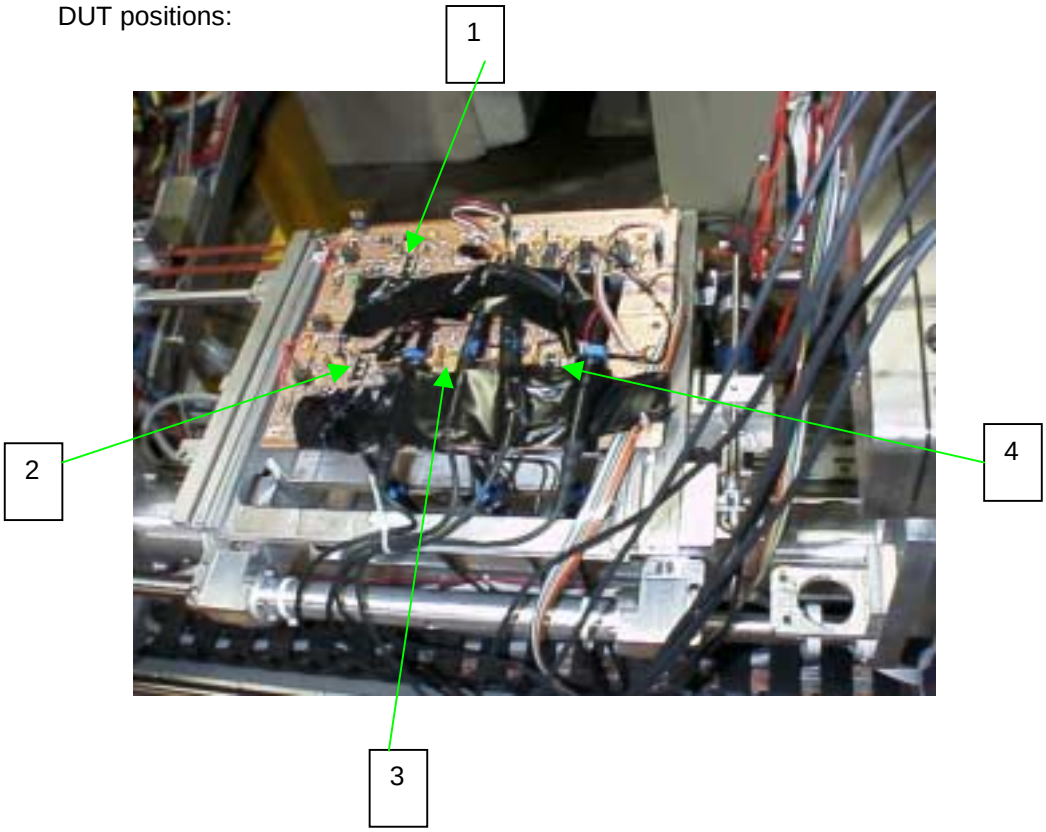


FIGURE 4.1.3 – OVERALL WIRING OF THE TEST SETUP

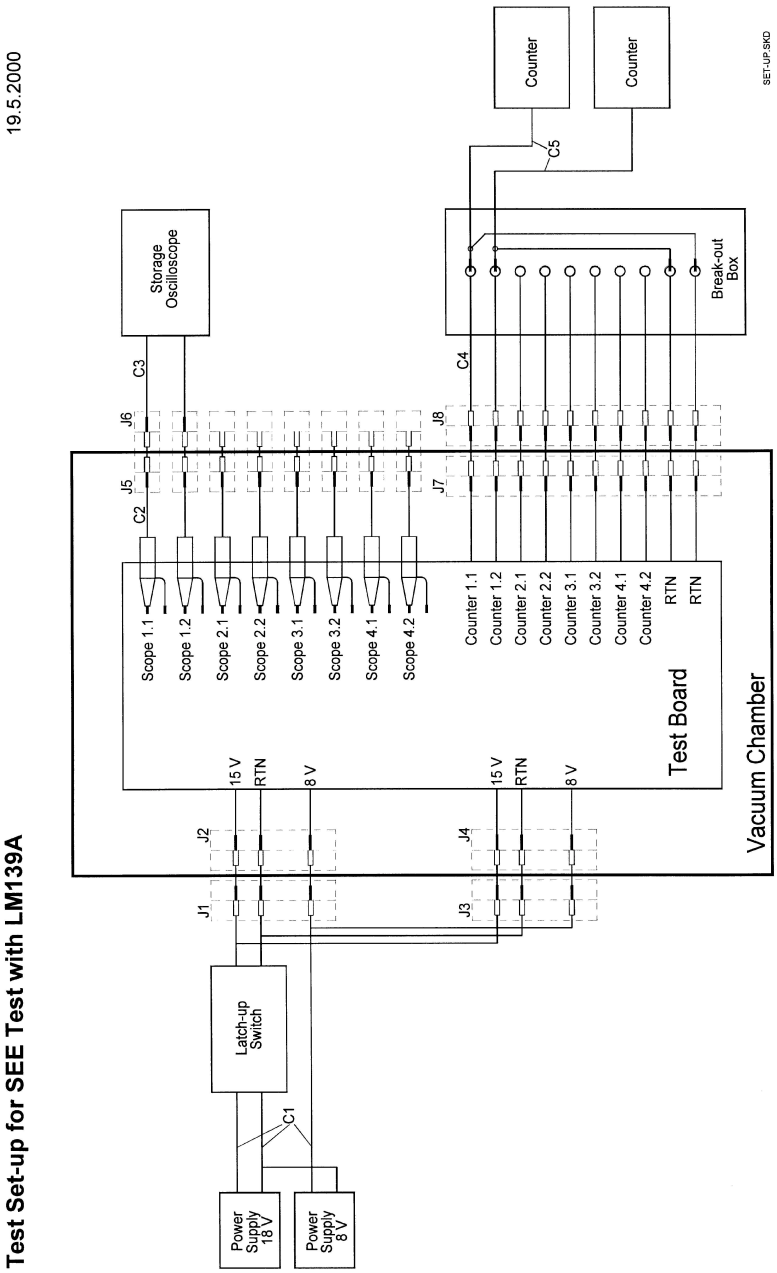


FIGURE 4.1.4 - OVERALL WIRING OF THE TEST SETUP (LEGEND)

Connectors:

J1: Type: Cannon D 25 Sockets
Signals:
- Pin 1: +18 V
- Pin 2: +18 V
- Pin 7: +8 V
- Pin 8: +8 V
- Pin 24: RTN
- Pin 25: RTN

J2: Type: Cannon D 25 Pins
Signals: same as J1

J3: same as J1

J4: same as J2

J5: Type: 8 x BNC male (Part of oscilloscope probe)
Signal: Scope 1.1 through 4.2

J6 Type: 2 x BNC male (Part of BNC cable to oscilloscope)
Signal: Scope 1.1 through 4.2

J7: Type: Cannon D 25 Pins
Signals:
- Pin 1: Counter 1.1
- Pin 2: Counter 1.2
- Pin 3: Counter 2.1
- Pin 4: Counter 2.2
- Pin 5: Counter 3.1
- Pin 6: Counter 3.2
- Pin 7: Counter 4.1
- Pin 8: Counter 4.2
- Pin 24: RTN
- Pin 25: RTN

J8: Type: Cannon D 25 Sockets
Signals: same as J5

Cables:

C1: 0.5 mm² litz wire, 4 mm red and black plugs to power supplies, total length: 3 m

C2: Oscilloscope cable with BNC connector

C3: BNC to BNC cable

C4: AWG 24 wire, part of break-out box

C5: BNC to 4 mm plugs cable

4.2 Heavy Ion Beam

The test has been performed at the ESA Heavy Ion Test Facility (HIF) at UCL in Louvain-La-Neuve in Belgium.

Ion species, Energies, LET values and particle concentrations used for testing are listed in Table 4.1. Flux and Fluence values reported in Table 4.1 are typical values as noted during testing.

TABLE 4.1 – HEAVY IONS USED

Ion	Energy [MeV]	Range [µm Si]	LET [MeV/mg/cm2]	Tilt angle [°]	LETeff [MeV/mg/cm2]	Flux [N/cm2 sec]	Fluence [N/cm2]
20 Ne 4+	78	45	5,85	60	11,7	5600	1e6
40 Ar 8+	150	42	14,1	0	14,1	8000	1e6
			14,1	45	19,94	16000	1e6
			14,1	60	28,2	10000	1e6
84 Kr 17+	316	43	34	0	34	10000	1e6
			34	45	48,08	10000	1e6
			34	60	68	12000	1e6
132 Xe 26+	459	43	55,9	0	55,9	10000	1e6
			55,9	0	111,8	10000	1e6

5 DETAILED TEST RESULTS

5.1 Motorola LMC139J, SN206, DC9345

- position no. 1 on PCB
- no counter has been used for this run, only graphical data of the event signature captured by the storage Oscilloscope has been sampled
- due to incomplete adjustment of the testheads (not the complete cable length has been taken into account) a linear error in signal amplitude is has occurred. Therefore all signal amplitudes have to be multiplied by the factor of 5
- the additional capacitance introduced by the total cable length increases the signal rise times by 420ns
- for detailed bias description refer to para. 4.1. In the following result listing both bias circuits are simply refered to by the comparator supply voltage.

FIGURE 5.1.1 - MOT SN206, 5V BIAS, AR WITH LET.EFF = 14,1 MEV/MG/CM2

NO EVENT RECORDED – therefore no Storage Oscilloscope print

FIGURE 5.1.2 - MOT SN206, 5V BIAS, AR WITH LET.EFF = 28,2 MEV/MG/CM2

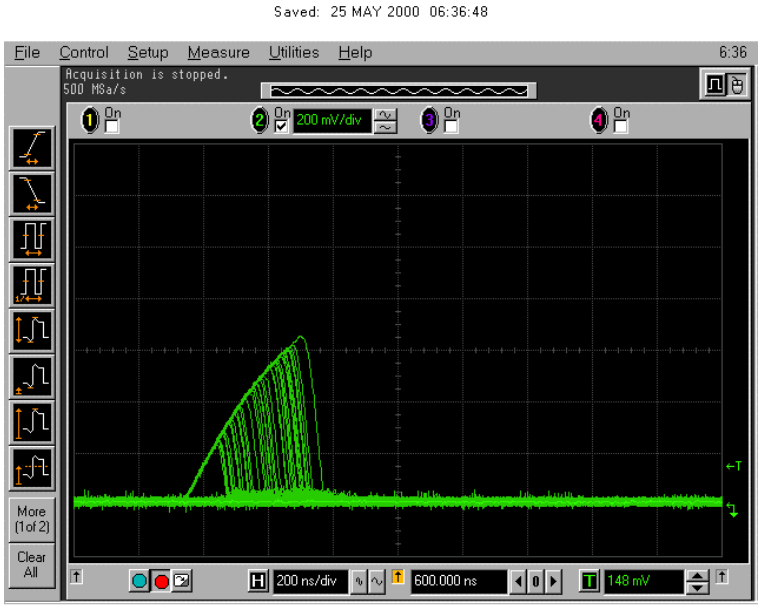
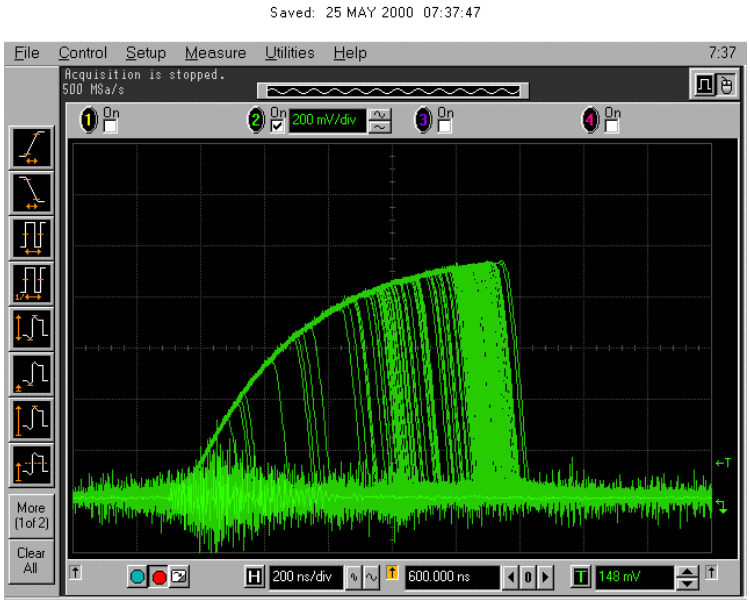


FIGURE 5.1.3 - MOT SN206, 12V BIAS, AR WITH LET.EFF = 28,2 MEV/MG/CM2

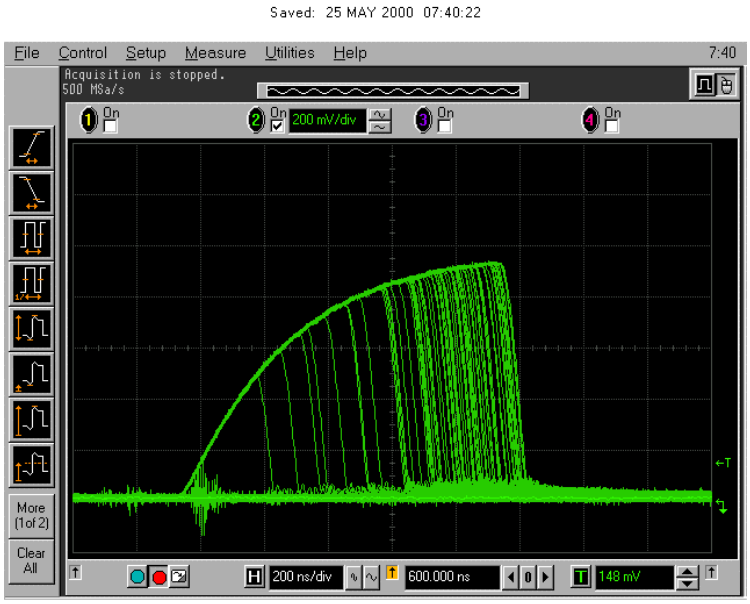
NO EVENT RECORDED – therefore no Storage Oscilloscope print

FIGURE 5.1.4 - MOT SN206, 5V BIAS, XE WITH LET.EFF = 55,9 MEV/MG/CM2



Acquisition	Sampling mode real time Memory depth automatic Memory depth 1004pts Sampling rate automatic Sampling rate 500 MSa/s Averaging off 9-bit BW Filter off Interpolation on
Channel 2	Scale 200 mV/div Offset 600 mV BW limit off Coupling DC Impedance 1M Ohm Attenuation 10.00 : 1 Atten units ratio Skew 0.0 s
Time base	Scale 200 ns/div Position 600.000 ns Reference center
Trigger	Mode edge Sweep auto Hysteresis normal Holdoff time 60 ns Coupling DC Source channel 2 Trigger level 148 mV Slope rising

FIGURE 5.1.5 - MOT SN206, 5V BIAS, XE WITH LET.EFF = 111,8 MEV/MG/CM2



Acquisition	Sampling mode real time Memory depth automatic Memory depth 1004pts Sampling rate automatic Sampling rate 500 MSa/s Averaging off 9-bit BW Filter off Interpolation on
Channel 2	Scale 200 mV/div Offset 600 mV BW limit off Coupling DC Impedance 1M Ohm Attenuation 10.00 : 1 Atten units ratio Skew 0.0 s
Time base	Scale 200 ns/div Position 600.000 ns Reference center
Trigger	Mode edge Sweep auto Hysteresis normal Holdoff time 60 ns Coupling DC Source channel 2 Trigger level 148 mV Slope rising

FIGURE 5.1.6 - MOT SN206, 12V BIAS, XE WITH LET.EFF = 111,8 MEV/MG/CM2

NO EVENT RECORDED – therefore no Storage Oscilloscope print

5.2 Motorola LM139 (910300404B) SN214, DC9343

- position no. 4 on PCB
- no counter has been used for this run, only graphical data of the event signature captured by the storage Oscilloscope has been sampled
- due to incomplete adjustment of the testheads (not the complete cable length has been taken into account) a linear error in signal amplitude is has occurred. Therefore all signal amplitudes have to be multiplied by the factor of 5
- the additional capacitance introduced by the total cable length increases the signal rise times by 420ns
- for detailed bias description refer to para. 4.1. In the following result listing both bias circuits are simply refered to by the comparator supply voltage.

FIGURE 5.2.1 - MOT SN214, 5V BIAS, AR WITH LET.EFF = 28,2 MEV/MG/CM2

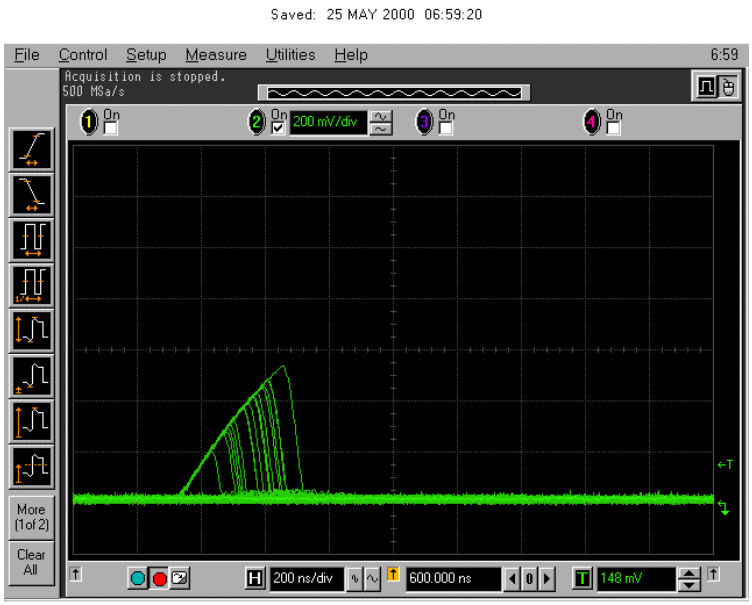


FIGURE 5.2.2 - MOT SN214, 12V BIAS, AR WITH LET.EFF = 28,2 MEV/MG/CM2

NO EVENT RECORDED – therefore no Storage Oscilloscope print

FIGURE 5.2.3 - MOT SN214, 5V BIAS, XE WITH LET.EFF = 111,8 MEV/MG/CM2

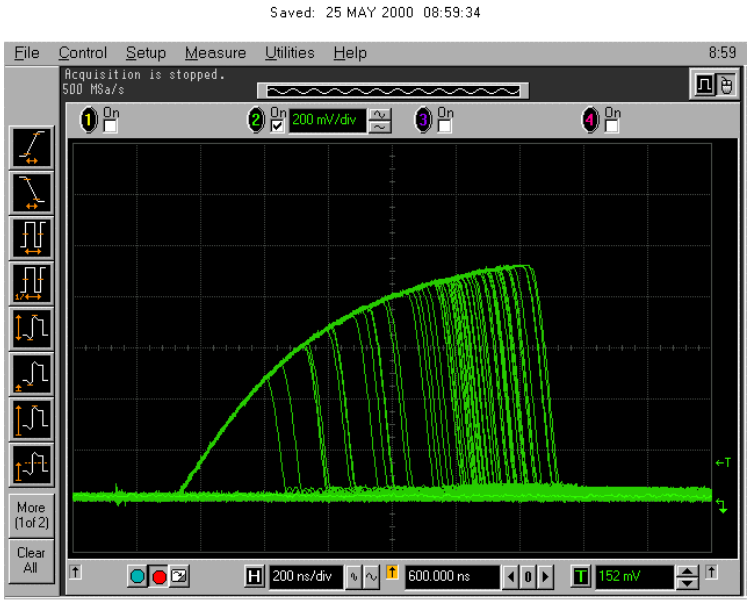


FIGURE 5.2.4 - MOT SN214, 12V BIAS, XE WITH LET.EFF = 111,8 MEV/MG/CM2

NO EVENT RECORDED – therefore no Storage Oscilloscope print

5.3 Intersil HS1-139RH SN201, no DC available

- position no. 2 on PCB
- no counter has been used for this run, only graphical data of the event signature captured by the storage Oscilloscope has been sampled
- due to incomplete adjustment of the testheads (not the complete cable length has been taken into account) a linear error in signal amplitude is has occurred. Therefore all signal amplitudes have to be multiplied by the factor of 5
- the additional capacitance introduced by the total cable length increases the signal rise times by 420ns
- for detailed bias description refer to para. 4.1. In the following result listing both bias circuits are simply refered to by the comparator supply voltage.

FIGURE 5.3.1 – INTERSIL SN201, 5V BIAS, XE WITH LET.EFF = 55,9 MEV/MG/CM2

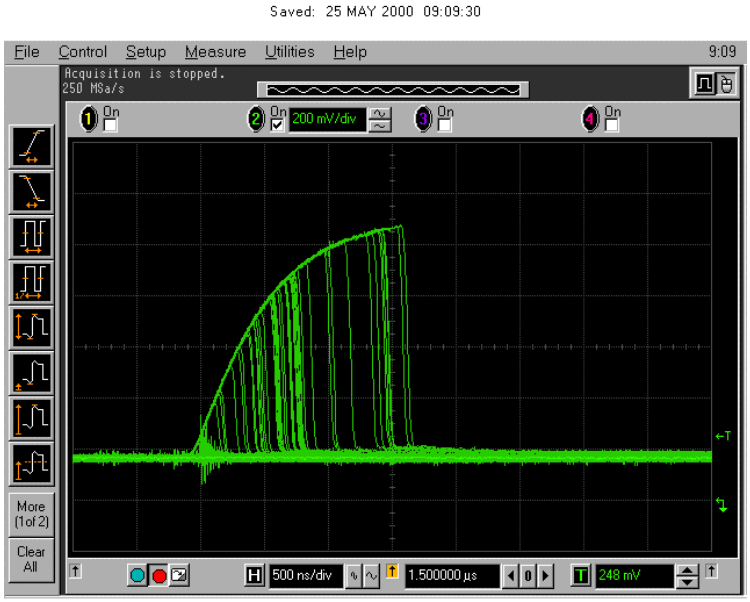
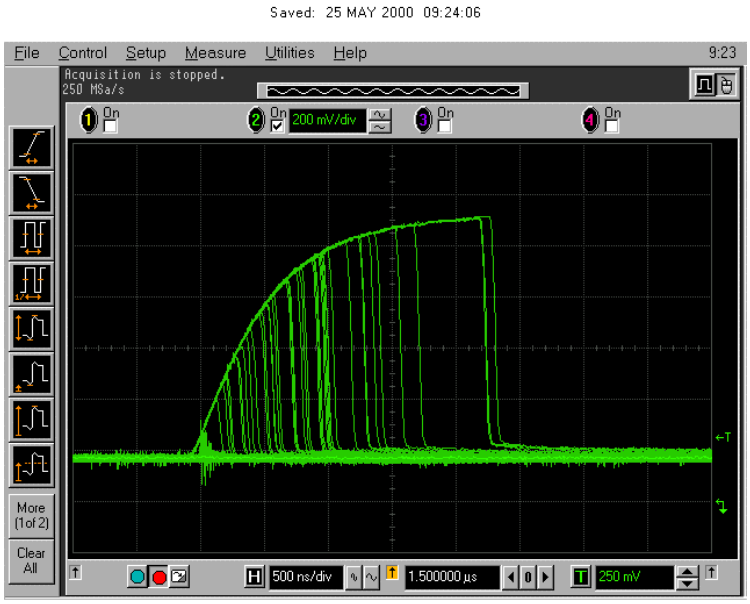


FIGURE 5.3.2 – INTERSIL SN201, 12V BIAS, XE WITH LET.EFF = 55,9 MEV/MG/CM2

Acquisition	Sampling mode real time Memory depth automatic Memory depth 1255pts Sampling rate automatic Sampling rate 250 MSa/s Averaging off 9-bit BW Filter off Interpolation on
Channel 2	Scale 1.00 V/div Offset 3.000 V BW limit off Coupling DC Impedance 1M Ohm Attenuation 10.00 : 1 Atten units ratio Skew 0.0 s
Time base	Scale 500 ns/div Position 1.500000 µs Reference center
Trigger	Mode edge Sweep auto Hysteresis normal Holdoff time 60 ns Coupling DC Source channel 2 Trigger level 810 mV Slope rising

FIGURE 5.3.3 – INTERSIL SN201, 5V BIAS, XE WITH LET.EFF = 111,8 MEV/MG/CM2



Acquisition	Sampling mode real time Memory depth automatic Memory depth 1255pts Sampling rate automatic Sampling rate 250 MSa/s Averaging off 9-bit BW Filter off Interpolation on
Channel 2	Scale 200 mV/div Offset 600 mV BW limit off Coupling DC Impedance 1M Ohm Attenuation 10.00 : 1 Atten units ratio Skew 0.0 s
Time base	Scale 500 ns/div Position 1.500000 µs Reference center
Trigger	Mode edge Sweep auto Hysteresis normal Holdoff time 60 ns Coupling DC Source channel 2 Trigger level 250 mV Slope rising

FIGURE 5.3.4 – INTERSIL SN201, 12V BIAS, XE WITH LET.EFF = 111,8 MEV/MG/CM2

Acquisition	Sampling mode real time Memory depth automatic Memory depth 1255pts Sampling rate automatic Sampling rate 250 MSa/s Averaging off 9-bit BW Filter off Interpolation on
Channel 2	Scale 1.00 V/div Offset 3.000 V BW limit off Coupling DC Impedance 1M Ohm Attenuation 10.00 : 1 Atten units ratio Skew 0.0 s
Time base	Scale 500 ns/div Position 1.500000 µs Reference center
Trigger	Mode edge Sweep auto Hysteresis normal Holdoff time 60 ns Coupling DC Source channel 2 Trigger level 810 mV Slope rising

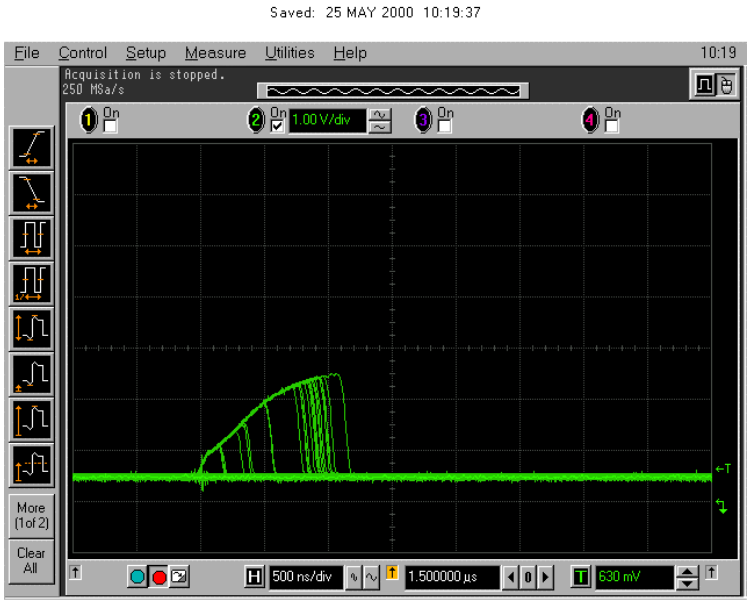
5.4 Intersil HS1-139RH SN210, no DC available

- position no. 2 on PCB
- no counter has been used for this run, only graphical data of the event signature captured by the storage Oscilloscope has been sampled
- due to incomplete adjustment of the testheads (not the complete cable length has been taken into account) a linear error in signal amplitude is has occurred. Therefore all signal amplitudes have to be multiplied by the factor of 5
- the additional capacitance introduced by the total cable length increases the signal rise times by 420ns
- for detailed bias description refer to para. 4.1. In the following result listing both bias circuits are simply refered to by the comparator supply voltage.

FIGURE 5.4.1 - INTERSIL SN210, 5V BIAS, XE WITH LET.EFF = 55,9 MEV/MG/CM2

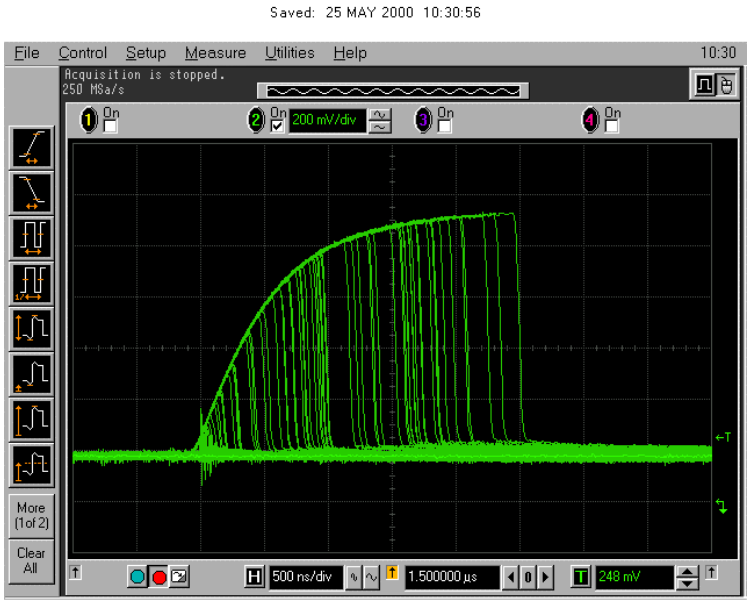
Acquisition	Sampling mode real time Memory depth automatic Memory depth 1255pts Sampling rate automatic Sampling rate 250 MSa/s Averaging off 9-bit BW Filter off Interpolation on
Channel 2	Scale 200 mV/div Offset 600 mV BW limit off Coupling DC Impedance 1M Ohm Attenuation 10.00 : 1 Atten units ratio Skew 0.0 s
Time base	Scale 500 ns/div Position 1.500000 µs Reference center
Trigger	Mode edge Sweep auto Hysteresis normal Holdoff time 60 ns Coupling DC Source channel 2 Trigger level 250 mV Slope rising

FIGURE 5.4.2 - INTERSIL SN210, 12V BIAS, XE WITH LET.EFF = 55,9 MEV/MG/CM2



Acquisition	Sampling mode real time Memory depth automatic Memory depth 1255pts Sampling rate automatic Sampling rate 250 MSa/s Averaging off 9-bit BW Filter off Interpolation on
Channel 2	Scale 1.00 V/div Offset 3.000 V BW limit off Coupling DC Impedance 1M Ohm Attenuation 10.00 : 1 Atten units ratio Skew 0.0 s
Time base	Scale 500 ns/div Position 1.500000 µs Reference center
Trigger	Mode edge Sweep auto Hysteresis normal Holdoff time 60 ns Coupling DC Source channel 2 Trigger level 630 mV Slope rising

FIGURE 5.4.3 - INTERSIL SN210, 5V BIAS, XE WITH LET.EFF = 111,8 MEV/MG/CM2



Acquisition	Sampling mode real time Memory depth automatic Memory depth 1255pts Sampling rate automatic Sampling rate 250 MSa/s Averaging off 9-bit BW Filter off Interpolation on
Channel 2	Scale 200 mV/div Offset 600 mV BW limit off Coupling DC Impedance 1M Ohm Attenuation 10.00 : 1 Atten units ratio Skew 0.0 s
Time base	Scale 500 ns/div Position 1.500000 µs Reference center
Trigger	Mode edge Sweep auto Hysteresis normal Holdoff time 60 ns Coupling DC Source channel 2 Trigger level 248 mV Slope rising

FIGURE 5.4.4 - INTERSIL SN210, 12V BIAS, XE WITH LET.EFF = 111,8 MEV/MG/CM2

Acquisition	Sampling mode real time Memory depth automatic Memory depth 1255pts Sampling rate automatic Sampling rate 250 MSa/s Averaging off 9-bit BW Filter off Interpolation on
Channel 2	Scale 1.00 V/div Offset 3.000 V BW limit off Coupling DC Impedance 1M Ohm Attenuation 10.00 : 1 Atten units ratio Skew 0.0 s
Time base	Scale 500 ns/div Position 1.500000 µs Reference center
Trigger	Mode edge Sweep auto Hysteresis normal Holdoff time 60 ns Coupling DC Source channel 2 Trigger level 630 mV Slope rising

5.5 Motorola LMC139J SN206, DC 9345 (event count & full amplitude)

- position no. 1 on PCB
- for this run a counter is used. The threshold for counting events is set to 2,5V. In addition graphical data of the event signature captured by the storage Oscilloscope has been sampled
- the testheads have been adjusted taking into account the total cable length. Signal amplitudes in the following Storage Oscilloscope prints are correct.
- the additional capacitance introduced by the total cable length and the fully compensated testheads increases the signal rise times by 520ns
- for detailed bias description refer to para. 4.1. In the following result listing both bias circuits are simply refered to by the comparator supply voltage.

FIGURE 5.5.1 – MOT SN206, 5V BIAS, NE WITH LET.EFF = 11,7 MEV/MG/CM2

Flux: 5600 N/cm2 sec, Fluence: 1e6

NO EVENT RECORDED – therefore no Storage Oscilloscope print

FIGURE 5.5.2 – MOT SN206, 5V BIAS, AR WITH LET.EFF = 19,94 MEV/MG/CM2

Flux: 16000 N/cm2 sec, Fluence: 1e6

No of counts: 1

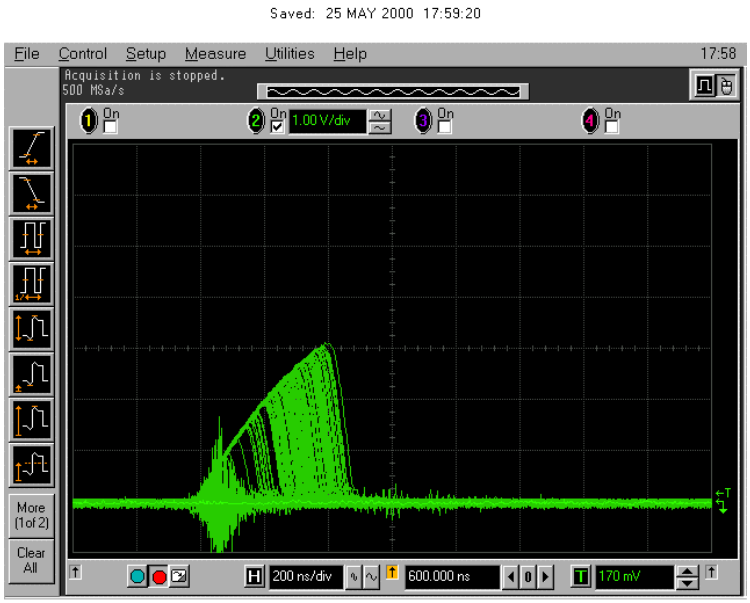
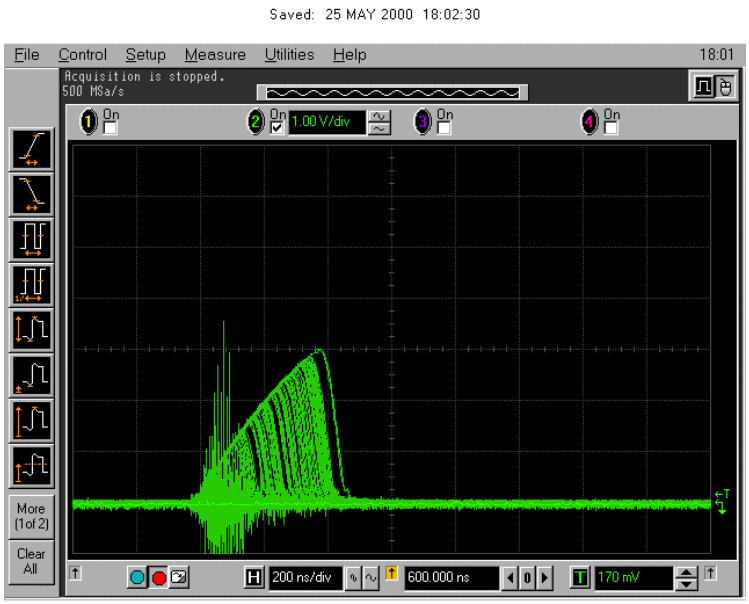


FIGURE 5.5.3 - MOT SN206, 5V BIAS, AR WITH LET.EFF = 28,2 MEV/MG/CM2

Flux: 10000 to20000 N/cm2 sec, Fluence: 1e6

No of counts: 0



Note: The burst positioned at the onset of the events on the time axis is environmental noise

FIGURE 5.5.4 - MOT SN206, 12V BIAS, AR WITH LET.EFF = 28,2 MEV/MG/CM2

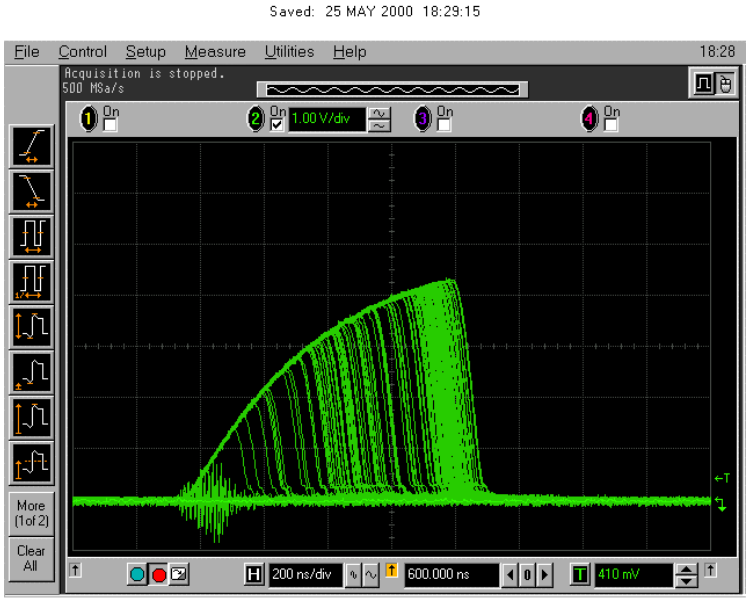
Flux: 10000 N/cm2 sec, Fluence: 1e6

NO EVENT RECORDED – therefore no Storage Oscilloscope print

FIGURE 5.5.5 - MOT SN206, 5V BIAS, KR WITH LET.EFF = 34 MEV/MG/CM2

Flux: 10000 N/cm2 sec, Fluence: 1e6

No of counts: 191

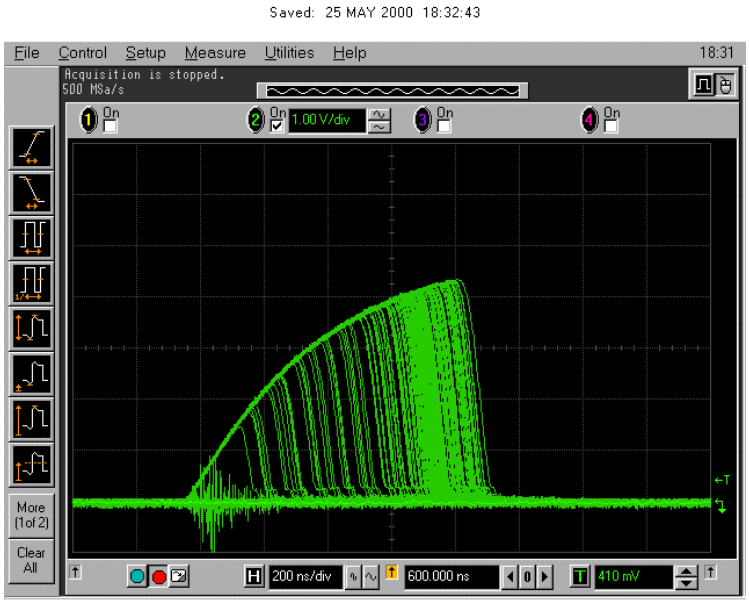


Note: The burst positioned at the onset of the events on the time axis is environmental noise

FIGURE 5.5.6 - MOT SN206, 5V BIAS, KR WITH LET.EFF = 48,08 MEV/MG/CM2

Flux: 10000 N/cm2 sec, Fluence: 1e6

No of counts: 183

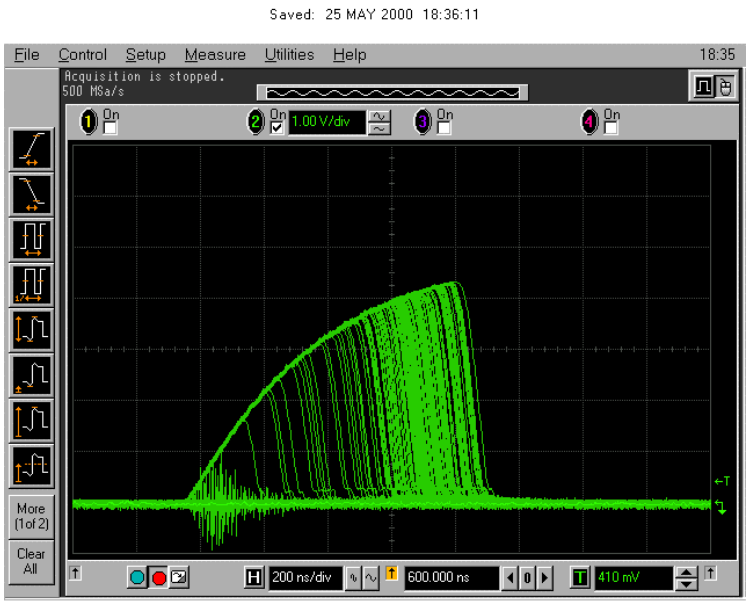


Note: The burst positioned at the onset of the events on the time axis is environmental noise

FIGURE 5.5.7 - MOT SN206, 5V BIAS, KR WITH LET.EFF = 68 MEV/MG/CM2

Flux: 12000 N/cm2 sec, Fluence: 1e6

No of counts: 172



Note: The burst positioned at the onset of the events on the time axis is environmental noise

FIGURE 5.5.8 - MOT SN206, 12V BIAS, KR WITH LET.EFF = 68 MEV/MG/CM2

Flux: 12000 N/cm2 sec, Fluence: 1e6

NO EVENT RECORDED – therefore no Storage Oscilloscope print