



HEAVY ION SINGLE EVENT EFFECTS RADIATION TEST REPORT

Part Type : LM185

2V5 Voltage Reference Diode

Manufacturer : National Semiconductor

Report Reference : ESA_QCA0401S_C

Issue : 01



Date : February 10, 2004

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

European Space Agency Contract Report

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Heavy ion SEE characterization of LM185 2V5 Voltage Reference Diode

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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", LM185-2.5 Voltage Reference Diodes, were radiation assessed.

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

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2 INTRODUCTION

This report presents the results of a Single Event Effects (SEE) test program carried out on LM185-2.5 Micropower Voltage Reference Diodes, from National Semiconductor.

Test was conducted on Hi-Rel samples delivered by ESA.

These devices were used for heavy ion test at the Brookhaven National Laboratory (BNL) facility, at Long Island, New York, USA – January 17/18, 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. LM185 data sheet

RD2. ATV-RIBRE-DFX-0281-03, EADS fax dated 22/08/03, page 2

RD3. Single Event Effects Test method and Guidelines ESA/SCC basic specification No 25100

RD4. Brookhaven National Laboratory, SEU Test Facility, User Guide, revised January, 1997

4 DEVICE INFORMATION

4.1 LM185

LM185 is a micropower 2-terminal bandgap voltage regulator diode.

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

| | |
|-----------------------|-----------------------------------|
| Part type: | LM185 |
| Manufacturer: | National Semiconductor |
| Package: | TO-46 |
| Quality Level: | Hi-Rel |
| Date Code: | 0134 |
| Detail specification: | SMD 5962-8759402XA (WE5000017484) |
| Die Marking: | G185C |

4.2 Sample preparation

The 3 samples delivered were delidded mechanically.

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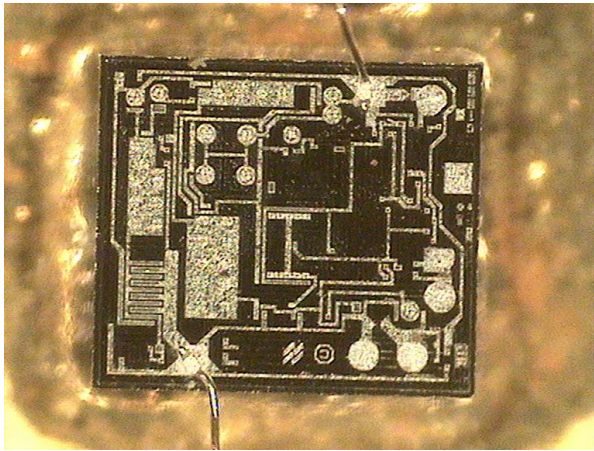


Photo 1 – Die full view

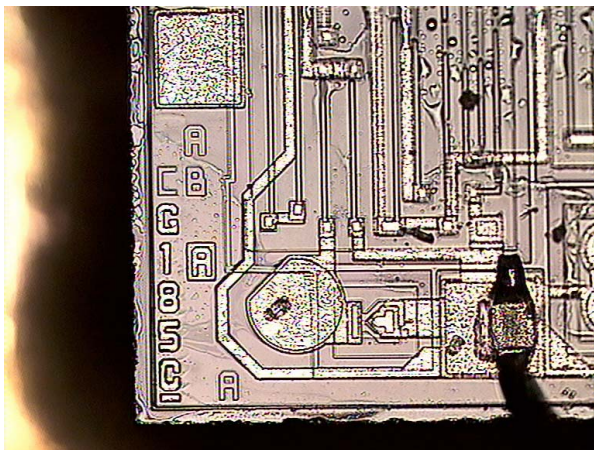


Photo 2 – Die marking

Figure 1 – LM185 photos

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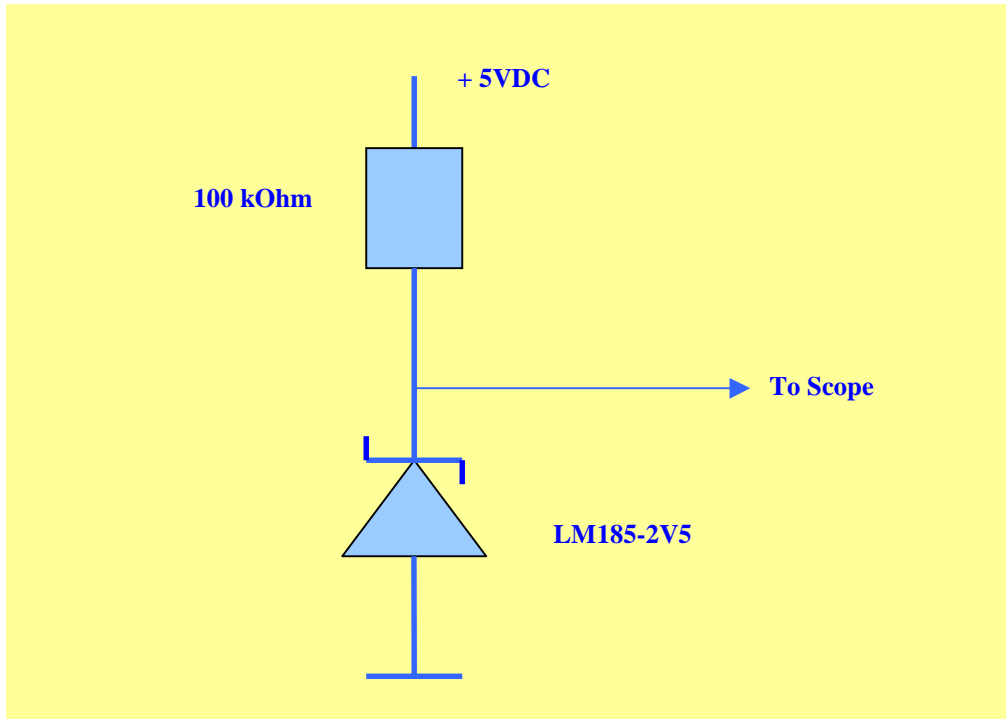
5 Test Definition

5.1 Test Set-up

The basic test set-up consists in monitoring the diode output voltage with an oscilloscope and count the number of pulses (SET).

5.2 Test Configuration

(in accordance with RD2)



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6 BNL TEST FACILITY

Test at the Tandem Van de Graaff accelerator was performed at Brookhaven National Lab, Upton, New York (USA) under HIREX Engineering responsibility.

RD4 document provides a description of this facility.

6.1 Dosimetry

The current BNL Tandem dosimetry system and procedures were used.

6.2 Used ions

| Ion | Energy MeV | LET(Si) Mev/(mg/cm ²) | Range (Si) μm |
|--------|---------------|--------------------------------------|------------------|
| F-19 | 140 | 3.38 | 120.4 |
| Cl-35 | 199 | 11.73 | 59.41 |
| Ni-58 | 265 | 26.58 | 42.23 |
| Au-197 | 333 | 81.44 | 27.53 |

Table 1 – BNL ions selection

6.3 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
- Date/Time
- Device ID
- Ion type
- Energy
- Range
- LET
- Tilt angle and Roll
- Test Duration
- Averaged flux
- Fluence
- Equivalent dose per run and per sample
- SET
- Cross-section

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7 RESULTS

Following a few initial test runs with both negative and positive triggering levels, the final SET triggering level, was set to -50 mV. Only positive SET events were recorded as a result of negative initial events having a positive overshoot as detailed later.

The detailed results per run are presented in Table 2.

The corresponding SET cross-section per device vs. Effective LET is plotted on Figure 2.

Typical examples of SET events are shown in Figure 3 to Figure 9. On these Figures, one can note that the diode output level is higher than the maximum output voltage specified (wc is 2.53V). It was found that LM185 die was sensitive to light and that was the cause of this voltage increase.

SETs waveform shape consists first, in a negative signal (worst case amplitude observed as low as 400mV with a FWHM pulse duration of up to 20µS), which, then, can be followed by a positive pulse (worst case amplitude of up to 200 mV with a FWHM of up to 40µS).

At lower LET, most of the SETs observed during Run 8 & 9, are similar to the one shown in Figure 8. However, a few events could have greater amplitudes but typically 100 mV with a FWHM pulse of up to 15µS, were seen. Figure 9 shows a worst-case low LET event (LET = 3.38 MeV.cm²/mg).

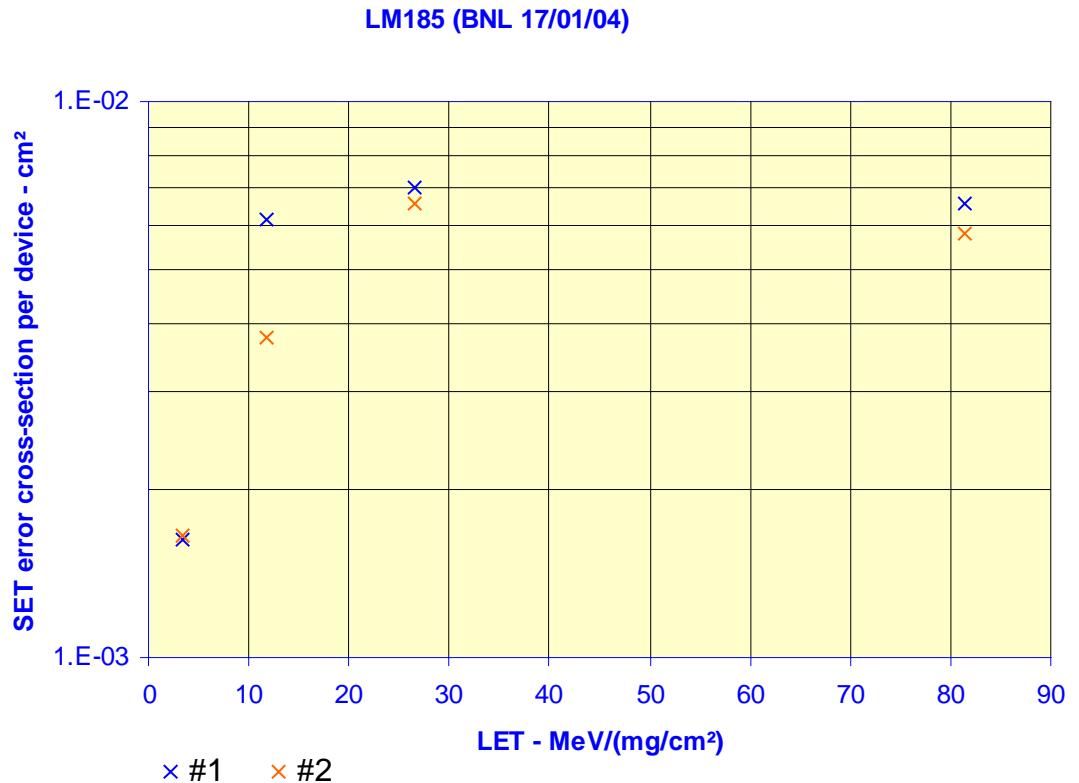


Figure 2 – SET error cross-section per device vs. Effective LET

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Run 3

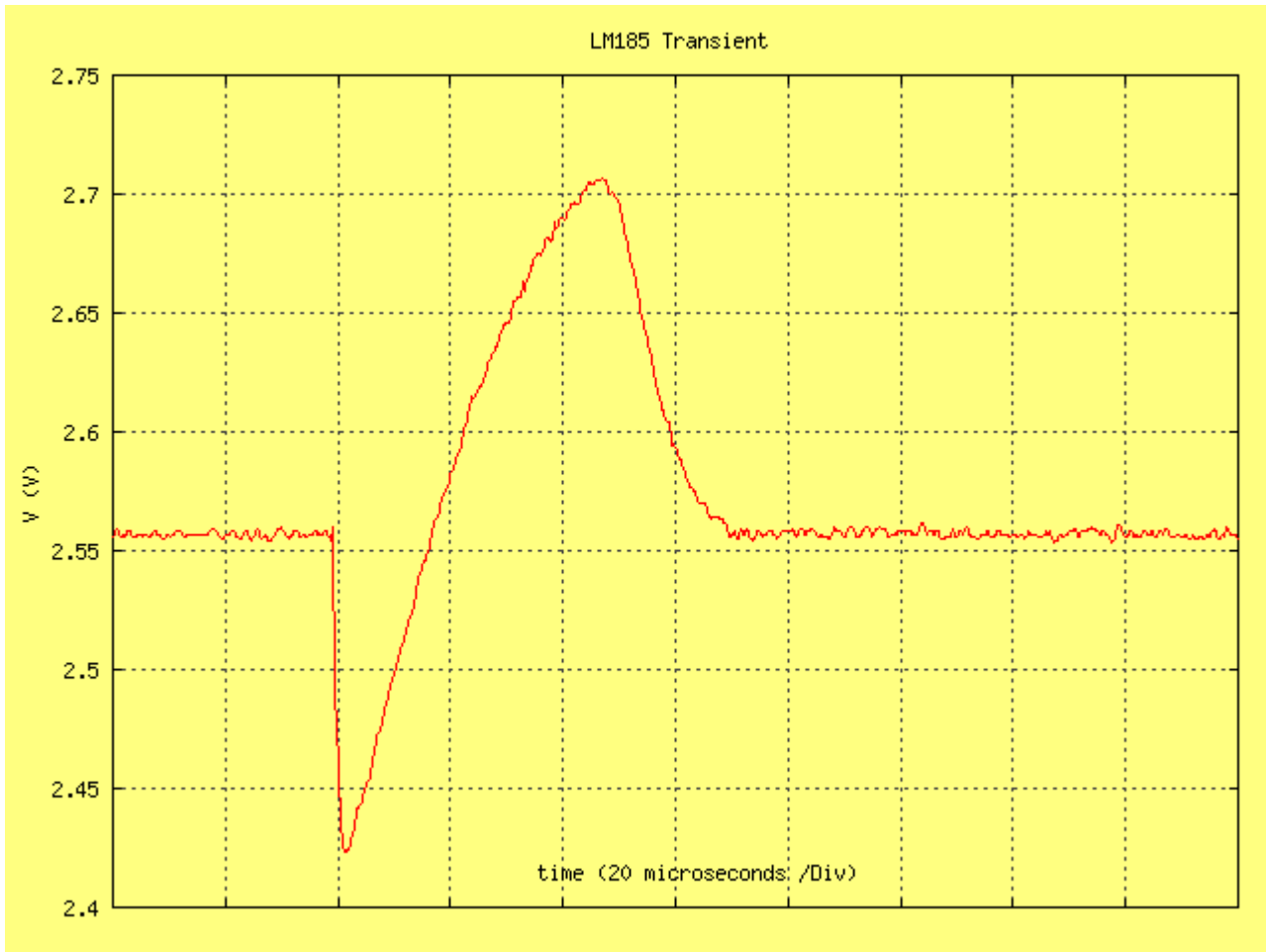


Figure 3 – Run 3, transient

| | | | |
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Run 5

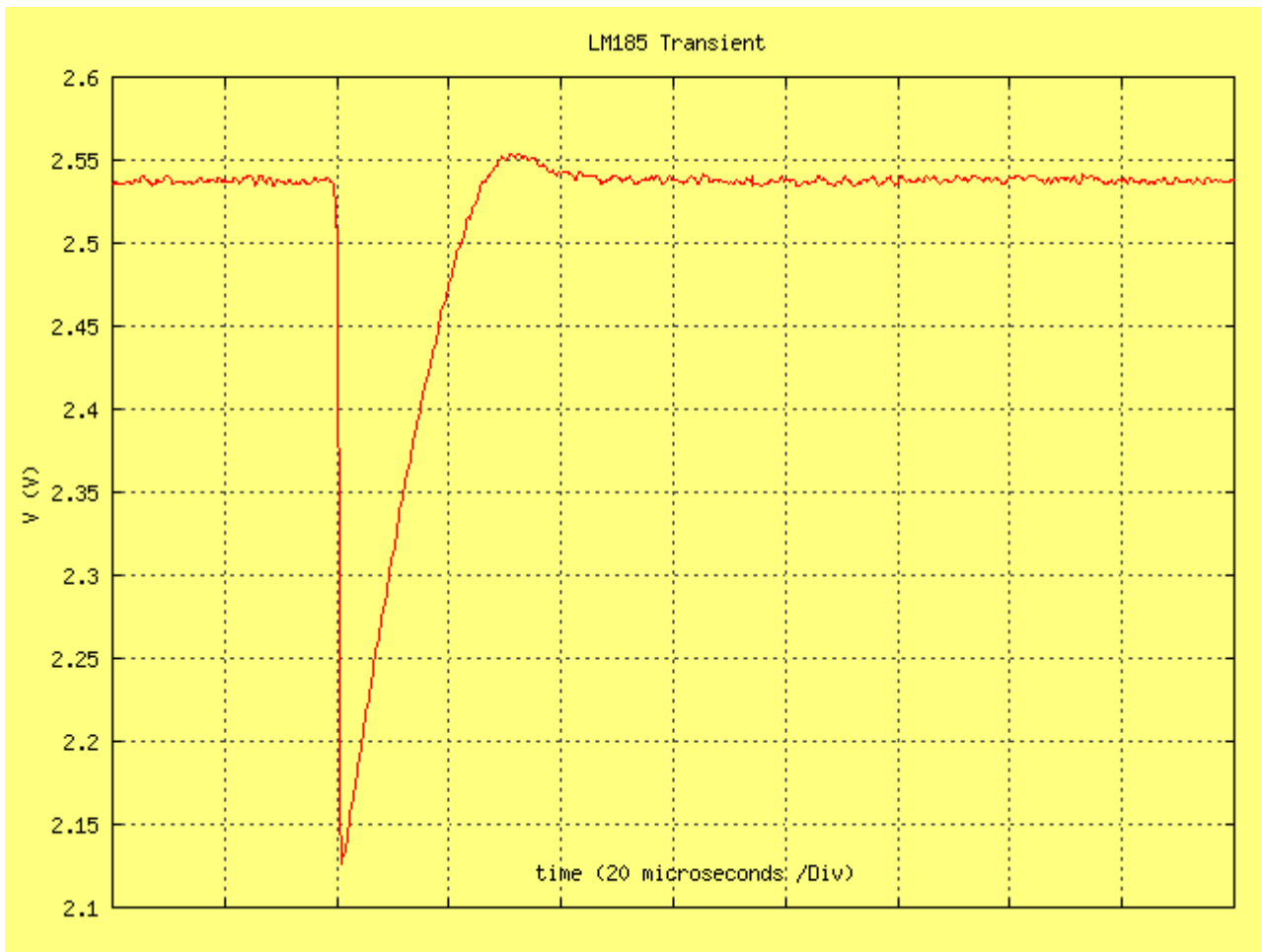


Figure 4 – Run 5, transient, worst case recorded, trigger down

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Run 5

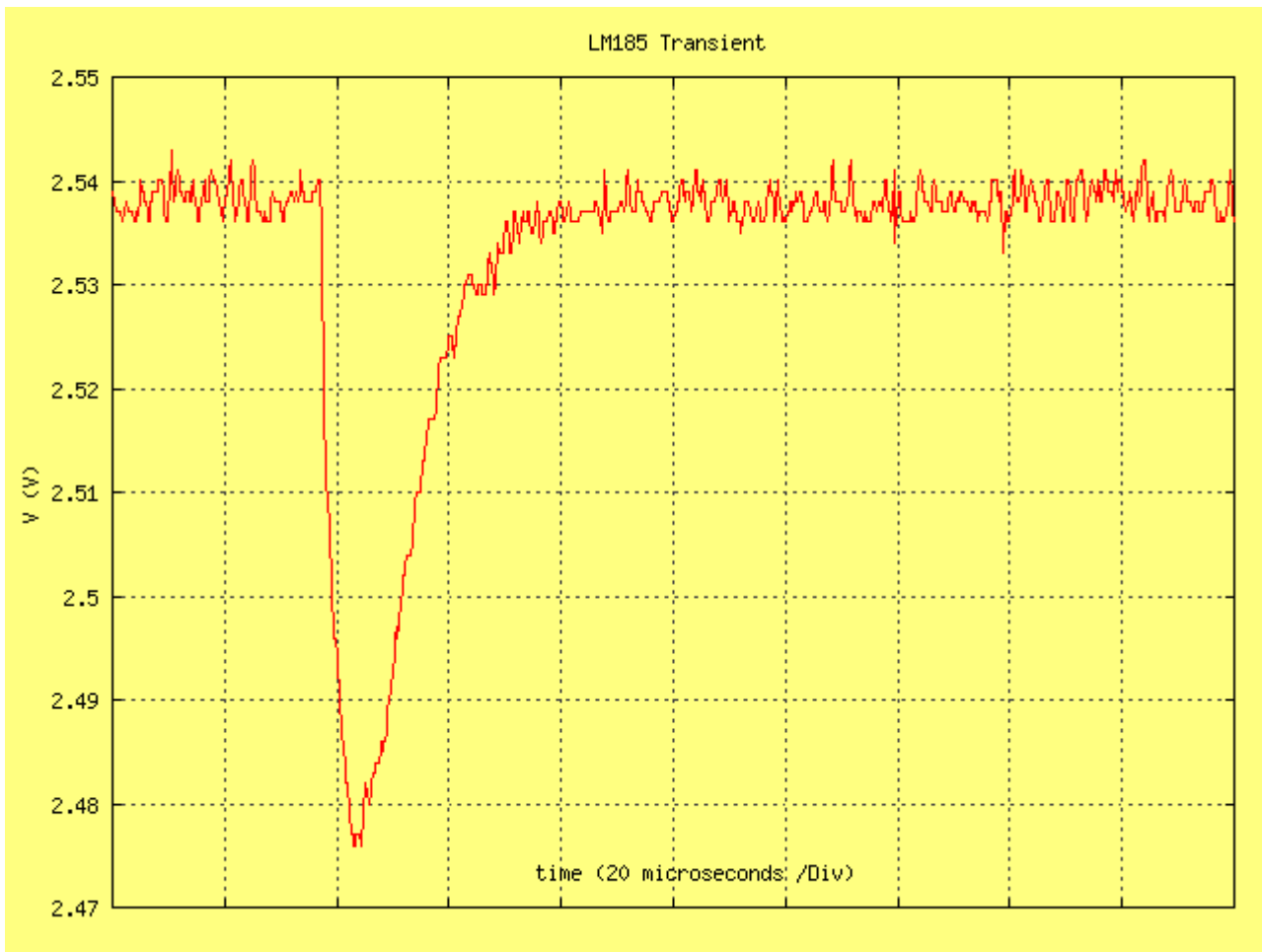


Figure 5 – Run 5, transient, small amplitude

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Run 5

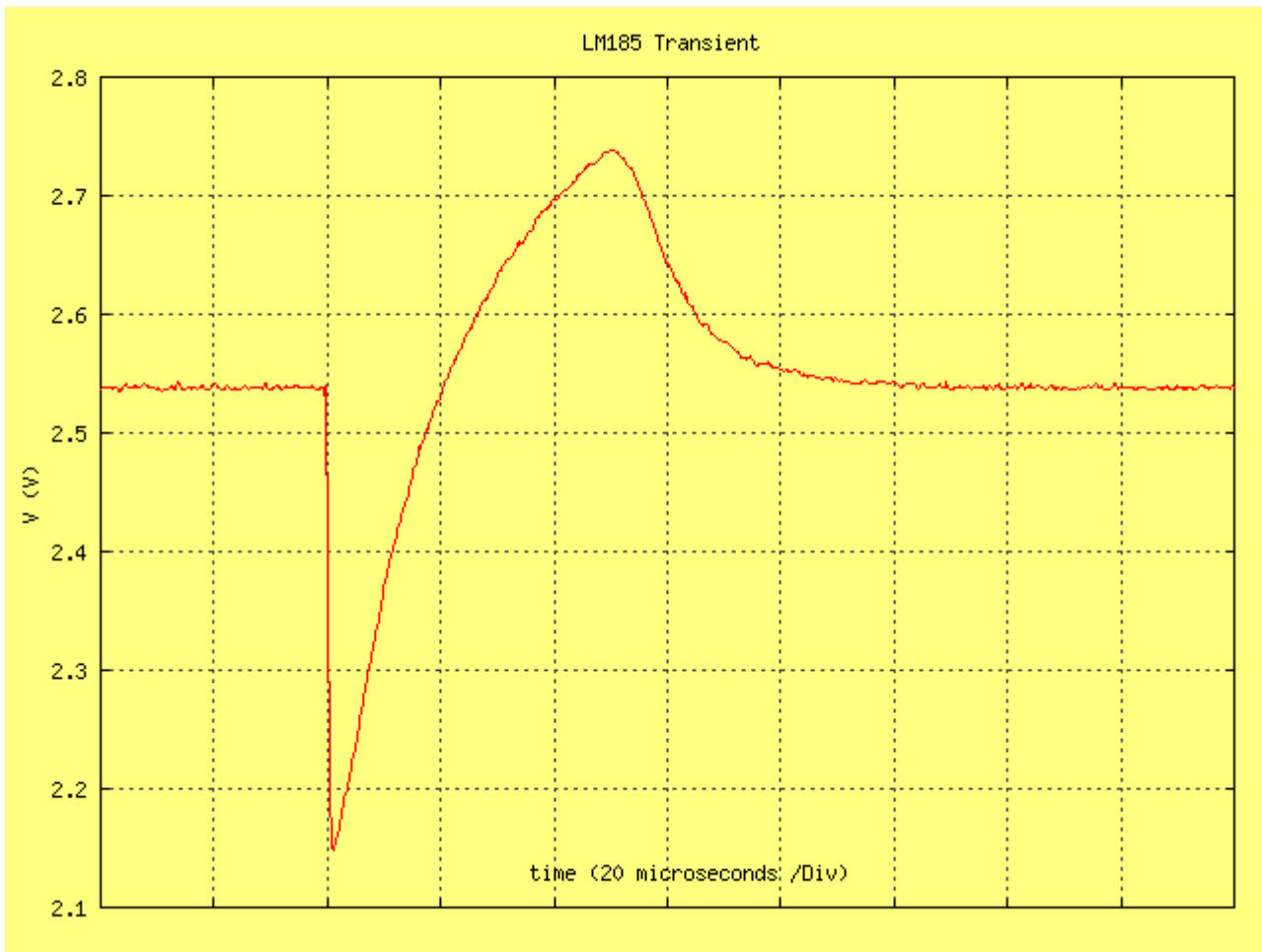


Figure 6 – Run 5, transient

| | | | |
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Run 7

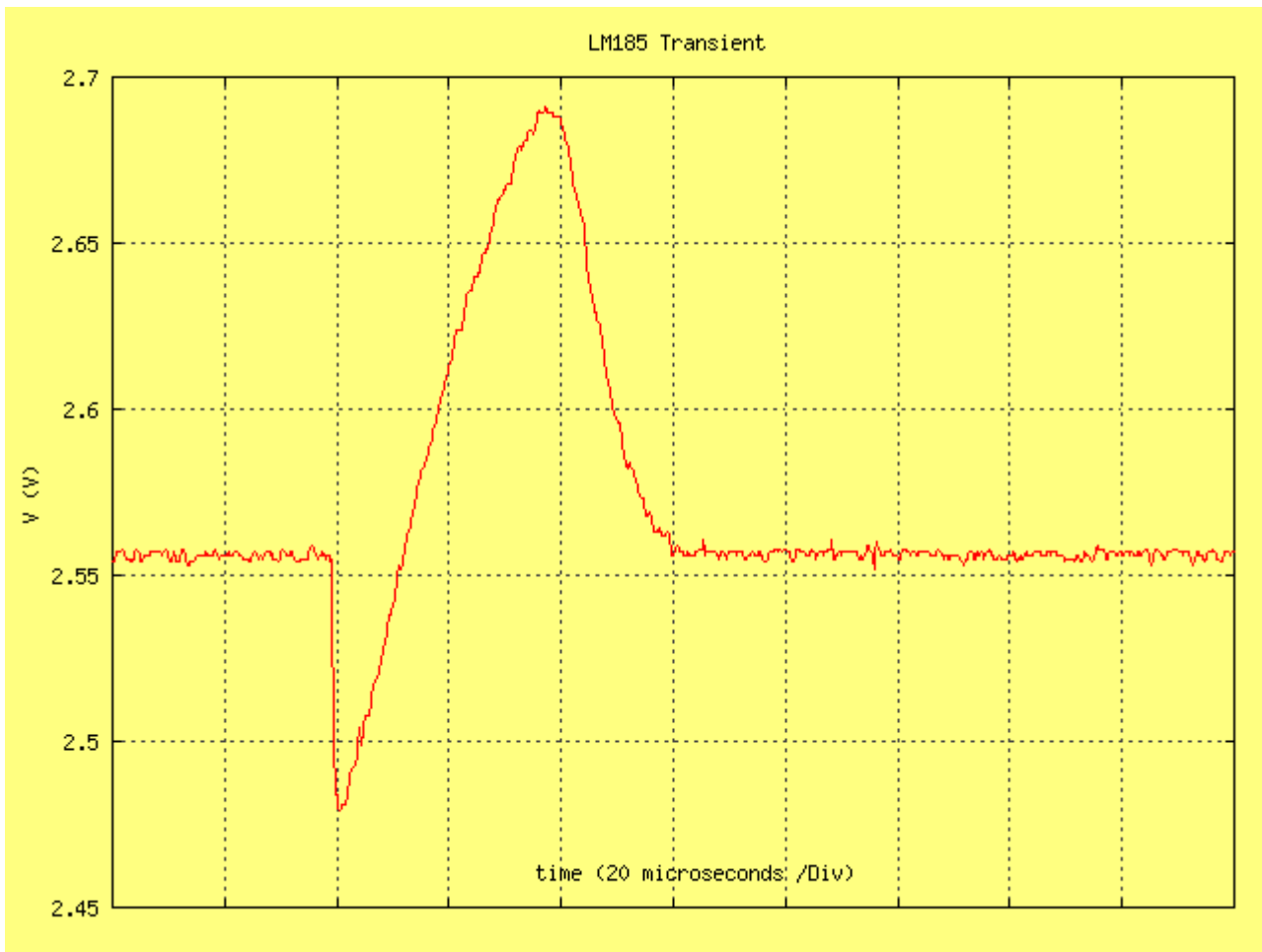


Figure 7 – Run 7, transient

| | | | |
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Run 9

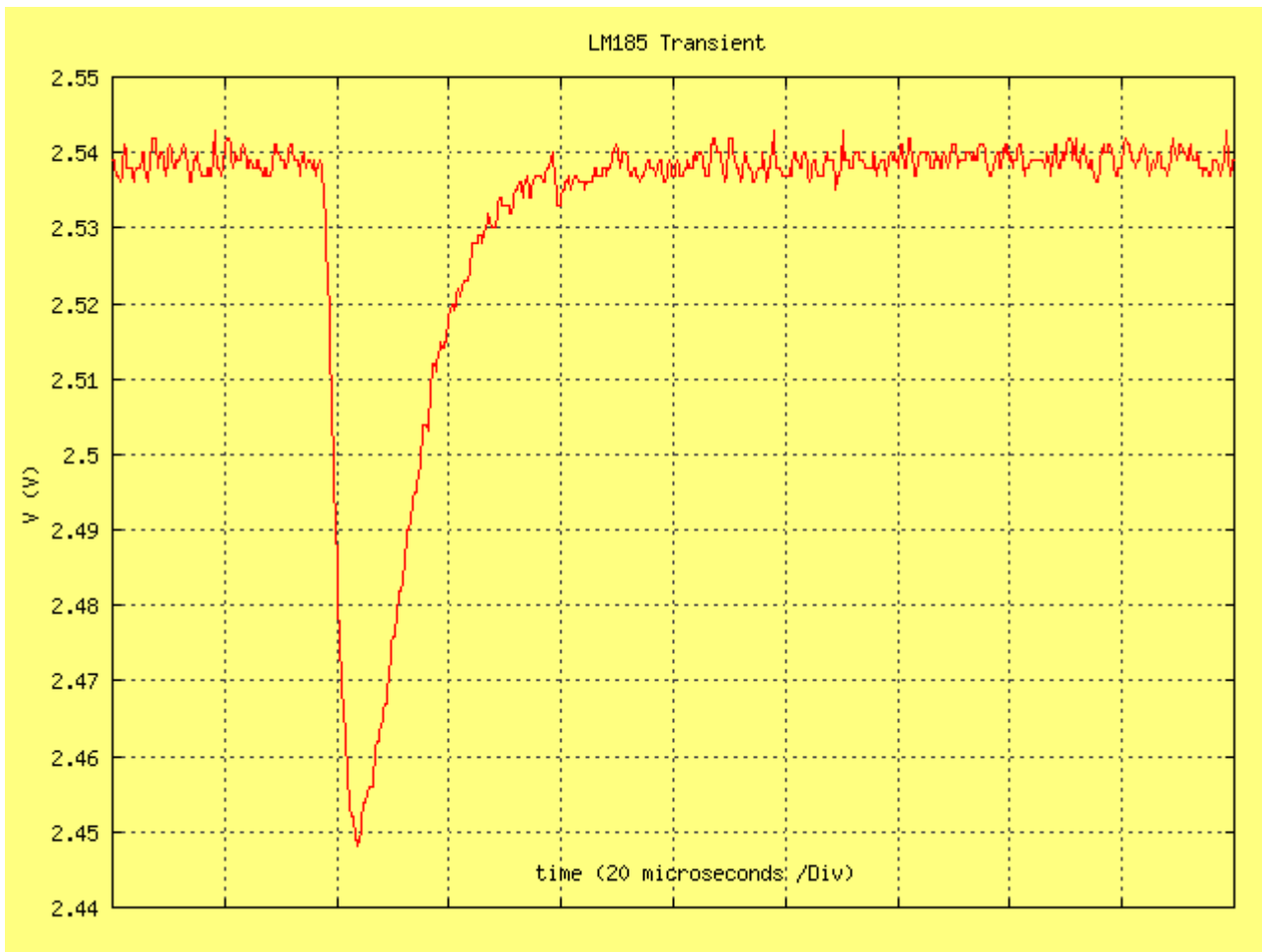


Figure 8 – Run 9, transient, typical

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Run 9

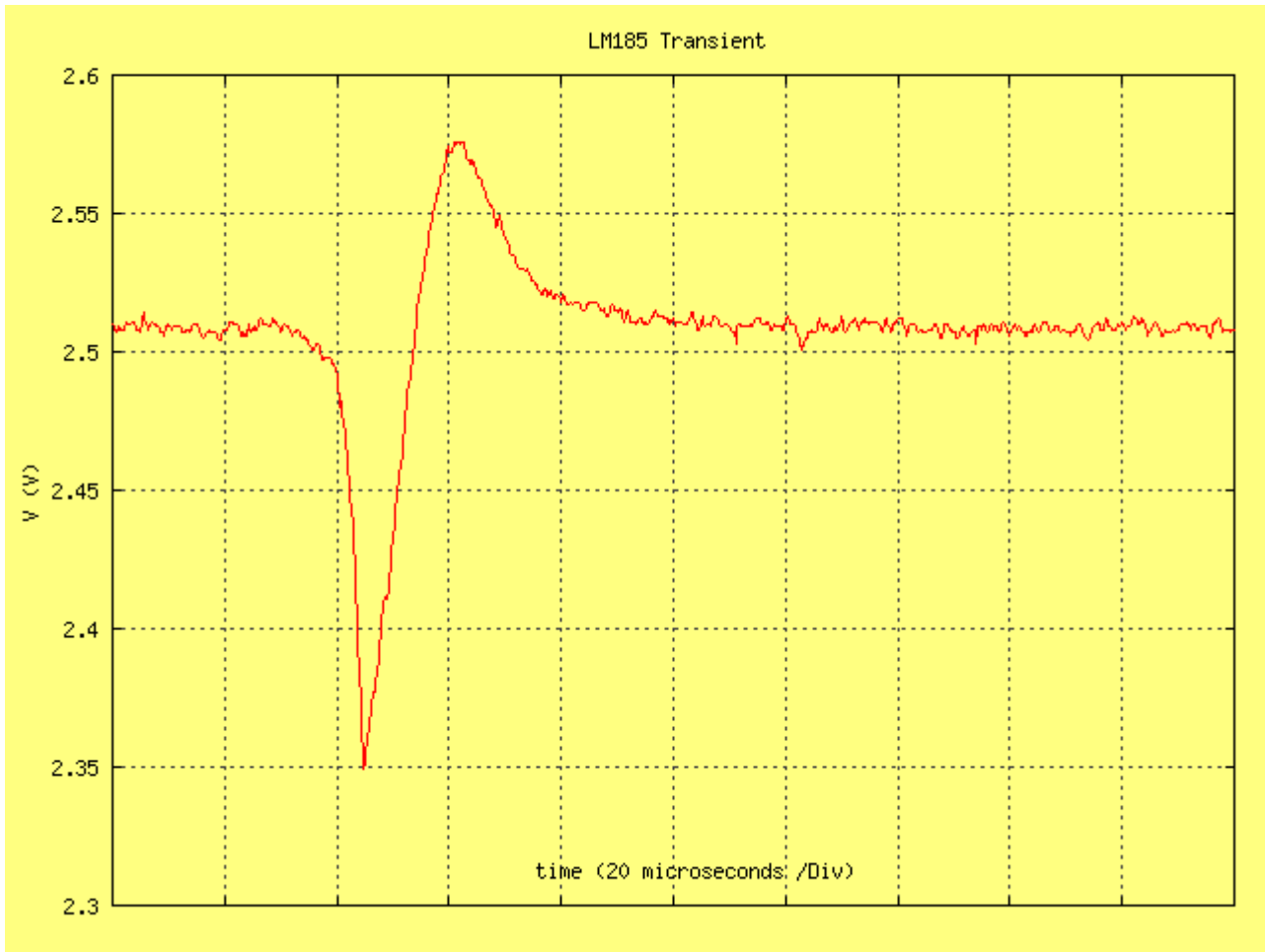


Figure 9 – Run 9, transient, worst case recorded

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| Run # | Date/Time | DeviceID | Ion | Energy MeV | Range um | LET(Si) MeV.cm ² /mg | Tilt deg | Roll deg | Time sec | Flux #/cm ² /sec | Fluence #/cm ² | Dose RAD(Si) | TotalDose RAD(Si) | Events | SET Cross-section cm ² |
|-------|----------------|----------|--------|------------|----------|---------------------------------|----------|----------|----------|-----------------------------|---------------------------|--------------|-------------------|--------|-----------------------------------|
| 2 | 17/1/04 19:41 | D1 | Au-197 | 333 | 27.53 | 81.44 | 0 | 0 | 370.4 | 4.23E+01 | 1.57E+04 | 2.05E+01 | 2.94E+03 | 103 | 6.57E-03 |
| 5 | 17/1/04 20:16 | D1 | Ni-58 | 265 | 42.23 | 26.58 | 0 | 0 | 132.3 | 1.22E+02 | 1.62E+04 | 7.64E+00 | 2.95E+03 | 113 | 6.99E-03 |
| 6 | 17/1/04 20:34 | D1 | Cl-35 | 199 | 59.41 | 11.73 | 0 | 0 | 100.9 | 1.74E+02 | 1.76E+04 | 3.45E+00 | 2.96E+03 | 108 | 6.14E-03 |
| 9 | 17/1/0 21:18 | D1 | F-19 | 140 | 120.4 | 3.38 | 0 | 0 | 466.1 | 1.37E+02 | 6.40E+04 | 3.48E+00 | 2.95E+03 | 104 | 1.63E-03 |
| 3 | 17/1/04 19:52 | D2 | Au-197 | 333 | 27.53 | 81.44 | 0 | 0 | 388.9 | 4.44E+01 | 1.73E+04 | 2.26E+01 | 2.35E+01 | 100 | 5.80E-03 |
| 4 | 17/1/04 20:12 | D2 | Ni-58 | 265 | 42.23 | 26.58 | 0 | 0 | 102 | 1.52E+02 | 1.55E+04 | 6.83E+00 | 4.14E+01 | 101 | 6.53E-03 |
| 7 | 17/1/04 20:38 | D2 | Cl-35 | 199 | 59.41 | 11.73 | 0 | 0 | 128.6 | 2.09E+02 | 2.69E+04 | 5.08E+00 | 4.65E+01 | 101 | 3.75E-03 |
| 8 | 17/1/04 21 :07 | D2 | F-19 | 140 | 120.4 | 3.38 | 0 | 0 | 427.5 | 1.39E+02 | 5.95E+04 | 2.57E+00 | 4.91E+01 | 99 | 1.66E-03 |

Table 2 - Heavy ion detailed results per run

| | | | |
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8 CONCLUSION

Heavy ion tests were conducted on two Hi-Rel samples of LM185 2V5 Voltage Reference Diode from National Semiconductor, using the heavy ions available at the Tandem Accelerator facility at Brookhaven National Lab (BNL), Long Island, New York, USA.

Negative SET events were still observed on both devices at the lowest LET tested at, a LET of 3.38 MeV.cm²/mg. Asymptotic SET cross-section for all SET events (triggering level -50 mV) is recorded to be in the order of 6 and 7 E-3 cm² per device.

Worst-case negative SET pulses had amplitudes in the order of 400mV with a FWHM of up to 20 μs. The follow on worst-case positive pulse reached amplitudes of up to 200mV with a FWHM duration of up to 40 μs.
