# PROTONS TEST REPORT

## ESA study: “Survey of Critical Components for 150 kRad Power Systems”

## ESTEC Contract N° 22831/09/NL/AF refers

**Part Type : SOC2222A**

**Package : CCP-3**

**Description : NPN Small Signal transistors**

**Manufacturer: STMicroelectronics**

**Alter Technology Group Spain Purchase Order N° ATGSP-TL-09-JC-CO-9 dated 11/27/2009**

**Alter Technology Group Spain Project Manager: David NUNEZ**

| | | | | |
|---|---|---|---|---|
| **Hirex reference :** | HRX/TID/0940 | Issue : 01 | Date : | June 03rd, 2011 |
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## CHANGE RECORD

| ISSUE | DATE | PAGE | DESCRIPTION OF CHANGES |
|---|---|---|---|
| 01 | June 03rd, 2011 | All | Original Issue |

# PROTONS TEST REPORT
# on
# SOC2222A
# NPN Small Signal transistors

# From STMicroelectronics

## TABLE OF CONTENTS

# 1 Introduction

In the scope of the ESA study: “Survey of Critical Components for 150 kRad Power Systems”, a protons test of the STMicroelectronics SOC2222A, NPN Small Signal transistors has been performed up to a total fluence of about 2E11 p/cm$^2$, in response to Alter Technology Group Spain purchase order reference ATGSP-TL-09-JC-CO-9 that refers to ESTEC contract N° 22831/09/NL/AF.

Displacement damage effects were investigated using 60 MeV protons energy. Devices were irradiated at UCL in Louvain - Belgium.

The purpose of this test was to characterize degradation due to proton displacement damage so a further mission analysis could determine their suitability for flight use. This test was conducted on samples provided by Alter Technology Group Spain.
Test has been performed in accordance with Hirex Engineering Radiation Test Plan HRX/SPE/0225 issue 1 dated 04/19/2011.

A complete set of electrical measurements together with graphical representation of measured parameters with respect to Equivalent Fluence levels received is provided.

# 2 Applicable and Reference Documents

## 2.1 Applicable Documents

- Hirex Engineering Radiation Test Plan: HRX/SPE/0225 issue 2 dated 09/08/2011
- Alter Technology Group Proposal: ATGSP-OF-648/2009 Issue 1
- Minutes of Meeting: MM-SRP-ATG-0001 dated 29/10/2009
- Hirex specification: Total Ionizing dose test general procedure.
- ESCC detail specification: 5201-002

## 2.2 Reference Documents

- STMicroelectronics datasheet: Doc ID 16558 Rev 1, October 2009

# 3 Test Samples

7 samples of the SOC2222A devices were tested (6 + 1 control sample).
Allocation of samples used for testing is provided in the following table. Serial numbers were arbitrarily defined by Hirex.

| Serial Number | Samples Allocation |
|---|---|
| 1 | Control sample |
| 2 | Biased OFF |
| 3 | Biased OFF |
| 4 | Biased OFF |
| 5 | Biased OFF |
| 6 | Biased OFF |
| 7 | Biased OFF |

Identification of the SOC2222A is given below:

**Part Number:** SOC2222ASW

**Top Marking:** -

**Inspection lot:** DOC01283

**Date Code:** -

# 4 Experimental Conditions

## 4.1 Radiation Source Description

The protons exposures were performed at the UCL facility in Louvain-la-Neuve - Belgium.
The Proton Irradiation facility (Light Ion irradiation Facility or LIF) was used for this experiment. The corresponding experimental set-up is shown in Figure 1.

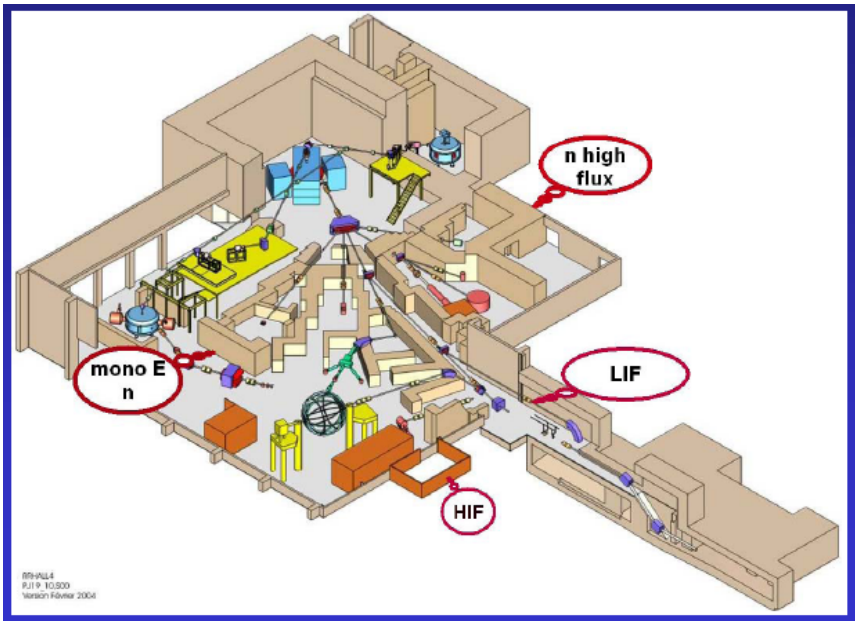



**Figure 1 : LIF layout and typical experimental set-up**

Light Ion irradiation Facility is characterized by the following beam parameters:
• Initial Proton Energies: 65 MeV;
• Energy Range: 9.3 – 62 MeV using energy degraders (See figure 2)
• Beam Flux at 62 MeV is between 10p/cm2/sec to 5E8 p/cm2/sec
• Irradiation Area: 8 cm diameter maximum

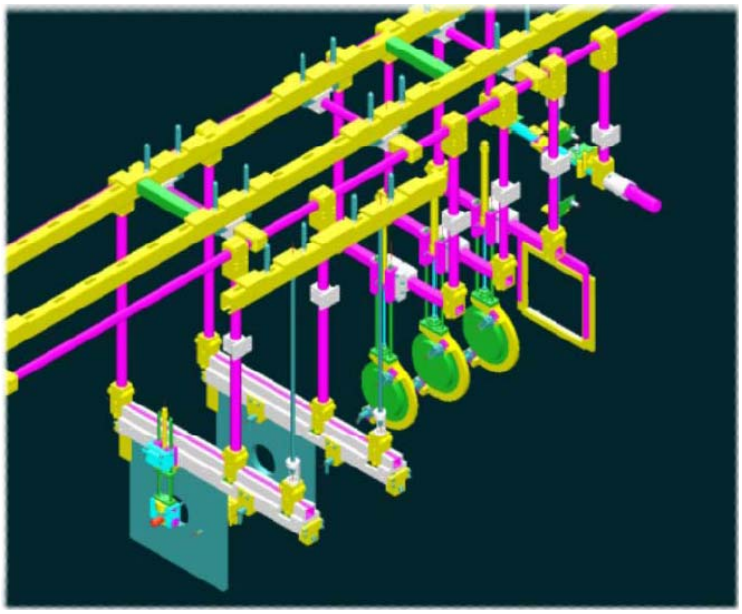


**Figure 2: LIF Energy degraders**

The irradiation conditions used for this test are provided in the following tables:

| Fluence Steps | Total Fluence | Flux | Equivalent Total Dose | T |
|---|---|---|---|---|
| p/cm² @60MeV | p/cm² @60MeV | p/cm²/s | Rad (Si) | °C |
| 0 | 0 | | 0 | |
| 2E+11 | 2E+11 | 5.00E+08 | 27.5E+3 | 25 |

## 4.2 Bias during Dose Exposures and Measurements conditions

### 4.2.1 Bias conditions

During exposures all samples were biased OFF with all pins connected to ground.

### 4.2.2 Electrical Measurements

Electrical parameters test program principle for SOC2222A is provided in Figure 3.

A HP4142 DC tester and a network analyzer HP8714ES were used to perform required measurements.

A dedicated test fixture and a test board were designed to ensure proper measurement conditions.

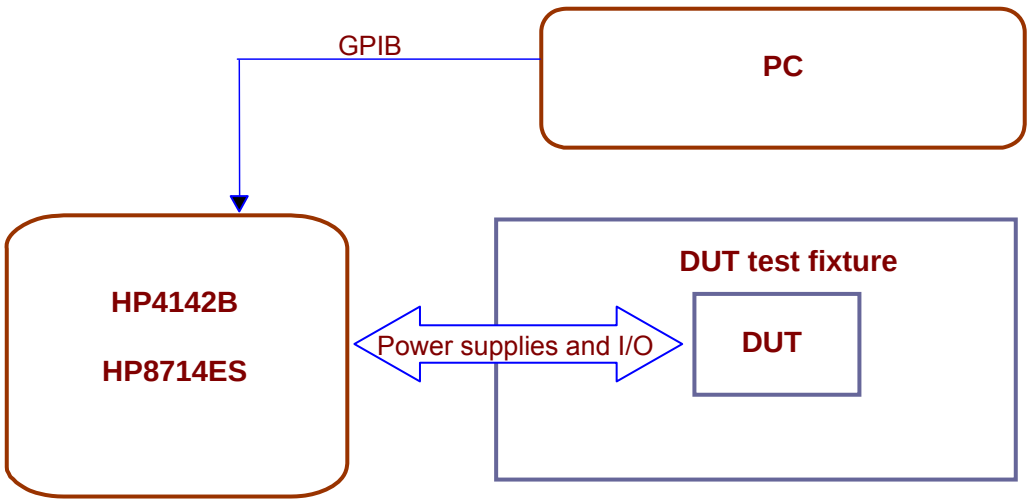



**Figure 3 : SOC2222A test program principle**

Electrical parameters test conditions and limits used for performing this test are given in Table 1.

| N° | Symbols | Characteristics | Test Conditions | Limits | | Units |
|---|---|---|---|---|---|---|
| | | | | Min | Max | |
| 1 | $I_{CBO}$ | Collector-Base Cut-off Current | $V_{CB}$ = 60V | - | 10 | nA |
| 2 | $I_{EBO}$ | Emitter-Base Cut-off Current | $V_{EB}$ = 3V | - | 10 | nA |
| 3 | $I_{CEO}$ | Collector-Emitter Cut-off Current | $V_{CE}$ = 40V | | 10 | nA |
| 4 | $V_{(BR)CBO}$ | Collector-Base Breakdown Voltage | $I_C$ = 100µA | 75 | - | V |
| 5 | $V_{(BR)CEO}$ | Collector-Emitter Breakdown Voltage | $I_C$ = 30mA, Note 1 | 40 | - | V |
| 6 | $V_{(BR)EBO}$ | Emitter-Base Breakdown Voltage | $I_E$ = 100µA | 6 | - | V |
| 7 | $V_{CE(SAT)}$ | Collector-Emitter Saturation Voltage | $I_C$ = 150mA, $I_B$ = 15mA Note 1 | - | 0.3 | V |
| 8 | $V_{BE(SAT)}$ | Base-Emitter Saturation Voltage | $I_C$ = 150mA, $I_B$ = 15mA Note 1 | - | 1.2 | V |
| 9 | $H_{FE1}$ | Forward-Current Transfer Ratio | $I_C$ = 100µA, $V_{CE}$ = 10V Note 1 | 35 | - | |
| 10 | $H_{FE2}$ | Forward-Current Transfer Ratio | $I_C$ = 1mA, $V_{CE}$ = 10V Note 1 | 50 | - | |
| 11 | $H_{FE3}$ | Forward-Current Transfer Ratio | $I_C$ = 10mA, $V_{CE}$ = 10V Note 1 | 75 | | |
| 12 | $H_{FE4}$ | Forward-Current Transfer Ratio | $I_C$ = 150mA, $V_{CE}$ = 10V Note 1 | 100 | 300 | |
| 13 | $F_T$ | Gain Bandwidth Product | $V_{CE}$=20V, $I_C$=20mA | 300 | 1000 | MHz |

Note 1 - Pulse measurement: Pulse Width ≤300µs, duty cycle 1%.

**Table 1 : Measured electrical parameters**

# 5 Conclusion

A proton displacement damage test was carried out by Hirex Engineering under Alter Technology Group Spain contract on the STMicroelectronics SOC2222A NPN Small Signal transistors in CCP-3 package.

Each device was exposed at room temperature to a protons flux of 60 MeV incident energy up to a total fluence of 2E+11p/cm².

A summary of failed parameters is provided in the following table.
Parameters not listed remained within specification limits all along testing.
Detail test results are presented in the following section.

| Parameters | Failure Level between : | Comments |
|---|---|---|
| ICEO | 0 & 2E+11p/cm² | |

**Table 2 : Summary of parameters failure levels**

# 6 Test Results

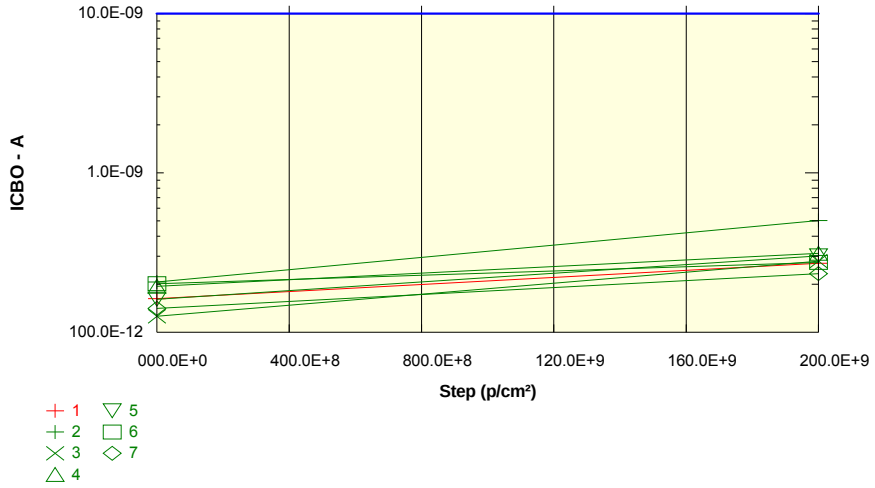
Test results including tables and graphics are provided in this section for each measured parameter.

Parameter measurements values are plotted versus Equivalent Fluence levels for 60 MeV incident energy protons. Fluences are expressed in protons/cm$^2$ in Silicon.

For each parameter, a drift calculation table is provided computing the drift between a given exposure step with respect to initial readings:

$$\Delta\text{(Parameter value)}=\text{(Parameter value}_{POSTRAD}\text{)} - \text{(Parameter value}_{PRERAD}\text{)}$$

**Test conditions : PROTONS**
**Parameter : Collector-Base cut-off current : ICBO**
**Vcb = 60V**
Unit : A
Spec Limit Max : 10.0E-09
Spec limits are represented in bold lines on the graphic.



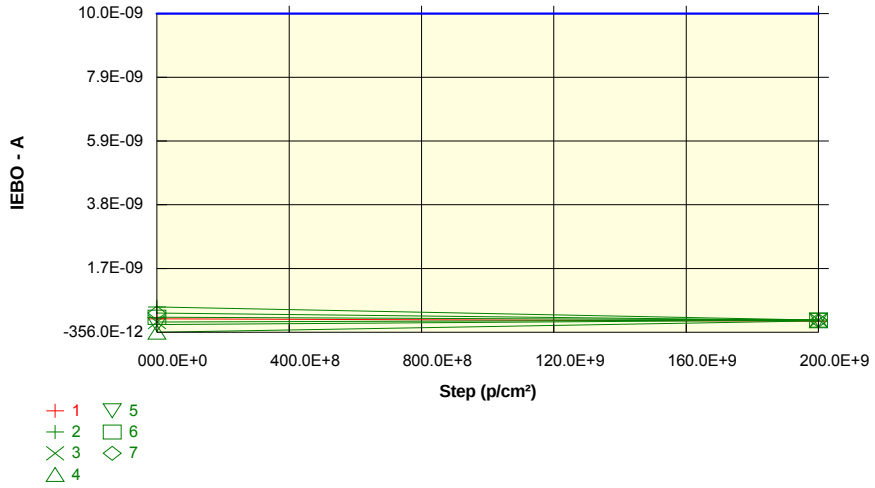

**Measurements**

| ICBO | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| 1_REF | 162.5E-12 | 270.4E-12 |
| OFF samples | | |
| 2 | 206.6E-12 | 503.2E-12 |
| 3 | 126.0E-12 | 279.4E-12 |
| 4 | 194.2E-12 | 313.0E-12 |
| 5 | 160.9E-12 | 301.8E-12 |
| 6 | 201.8E-12 | 274.2E-12 |
| 7 | 141.2E-12 | 233.4E-12 |
| Statistics | | |
| Min | 126.0E-12 | 233.4E-12 |
| Max | 206.6E-12 | 503.2E-12 |
| Average | 171.8E-12 | 317.5E-12 |
| Sigma | 31.0E-12 | 86.7E-12 |

**Drift Calculation**

| ICBO | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| OFF samples | | |
| 2 | - | 296.60E-12 |
| 3 | - | 153.40E-12 |
| 4 | - | 118.80E-12 |
| 5 | - | 140.90E-12 |
| 6 | - | 72.40E-12 |
| 7 | - | 92.20E-12 |
| Average | - | 145.72E-12 |
| Sigma | - | 72.81E-12 |

**Test conditions : PROTONS**
**Parameter : Emitter-Base cut-off current : IEBO**
**Veb = 3V**
Unit : A
Spec Limit Max : 10.0E-09
Spec limits are represented in bold lines on the graphic.



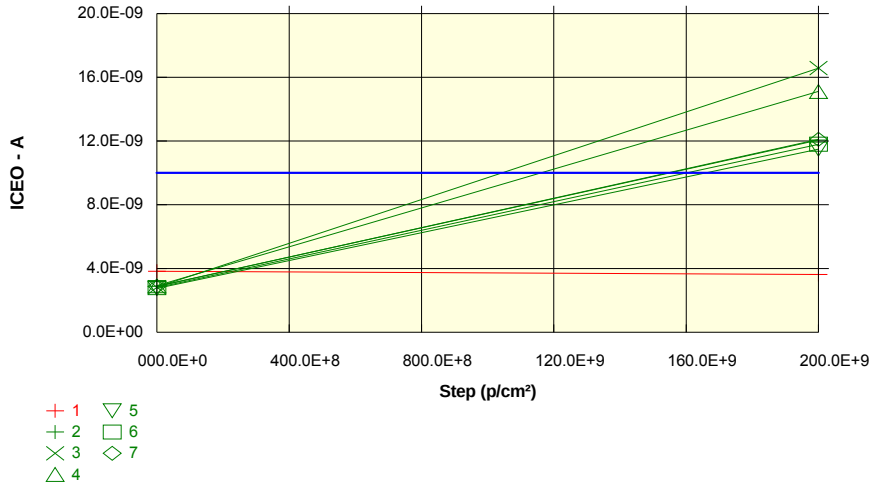

**Measurements**

| IEBO | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| 1_REF | 78.0E-12 | 3.0E-12 |
| OFF samples | | |
| 2 | 466.0E-12 | 35.2E-12 |
| 3 | -20.0E-12 | 44.2E-12 |
| 4 | -356.0E-12 | 14.2E-12 |
| 5 | -105.8E-12 | 40.1E-12 |
| 6 | 129.4E-12 | 34.6E-12 |
| 7 | 271.2E-12 | 26.3E-12 |
| Statistics | | |
| Min | -356.0E-12 | 14.2E-12 |
| Max | 466.0E-12 | 44.2E-12 |
| Average | 64.1E-12 | 32.4E-12 |
| Sigma | 264.9E-12 | 9.8E-12 |

**Drift Calculation**

| IEBO | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| OFF samples | | |
| 2 | - | -430.80E-12 |
| 3 | - | 64.18E-12 |
| 4 | - | 370.24E-12 |
| 5 | - | 145.88E-12 |
| 6 | - | -94.78E-12 |
| 7 | - | -244.88E-12 |
| Average | - | -31.69E-12 |
| Sigma | - | 261.72E-12 |

**Test conditions : PROTONS**
**Parameter : Collector-Emitter cut-off current : ICEO**
**Vce = 40V**
Unit : A
Spec Limit Max : 10.0E-09
Spec limits are represented in bold lines on the graphic.



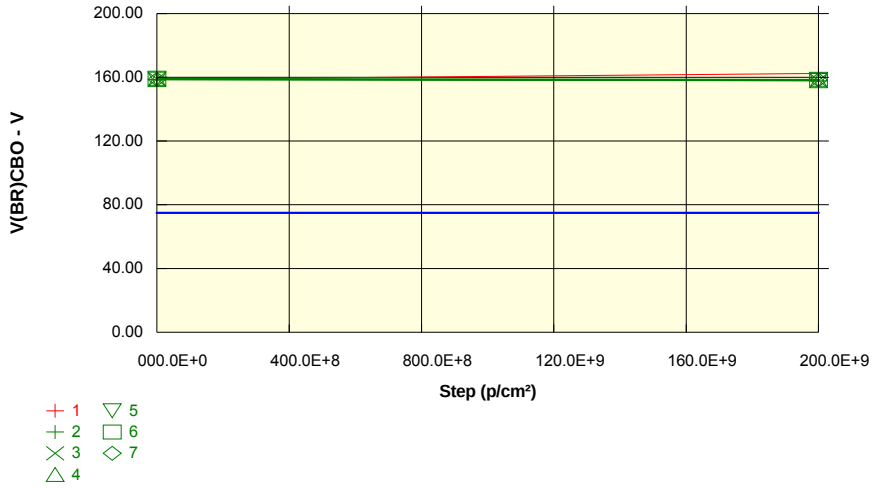

**Measurements**

| ICEO | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| 1_REF | 3.8E-09 | 3.6E-09 |
| OFF samples | | |
| 2 | 2.9E-09 | 12.1E-09 |
| 3 | 2.8E-09 | 16.6E-09 |
| 4 | 2.9E-09 | 15.1E-09 |
| 5 | 2.7E-09 | 11.5E-09 |
| 6 | 2.8E-09 | 11.8E-09 |
| 7 | 2.9E-09 | 12.1E-09 |
| Statistics | | |
| Min | 2.7E-09 | 11.5E-09 |
| Max | 2.9E-09 | 16.6E-09 |
| Average | 2.8E-09 | 13.2E-09 |
| Sigma | 58.5E-12 | 1.9E-09 |

**Drift Calculation**

| ICEO | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| OFF samples | | |
| 2 | - | 9.17E-09 |
| 3 | - | 13.74E-09 |
| 4 | - | 12.20E-09 |
| 5 | - | 8.75E-09 |
| 6 | - | 9.00E-09 |
| 7 | - | 9.22E-09 |
| Average | - | 10.35E-09 |
| Sigma | - | 1.91E-09 |

**Test conditions : PROTONS**
**Parameter : Collector-Base breakdown voltage : V(BR)CBO**
**Ic = 100µA**
Unit : V
Spec Limit Min : 75.00
Spec limits are represented in bold lines on the graphic.



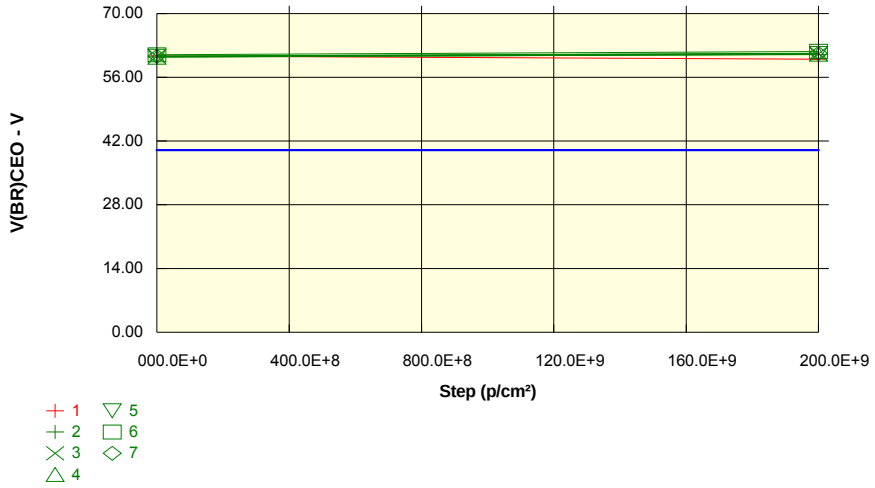

**Measurements**

| V(BR)CBO | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| 1_REF | 158.80 | 162.39 |
| OFF samples | | |
| 2 | 158.56 | 157.81 |
| 3 | 158.85 | 158.05 |
| 4 | 158.55 | 157.89 |
| 5 | 158.81 | 158.13 |
| 6 | 159.38 | 158.79 |
| 7 | 158.80 | 158.41 |
| Statistics | | |
| Min | 158.55 | 157.81 |
| Max | 159.38 | 158.79 |
| Average | 158.83 | 158.18 |
| Sigma | 0.28 | 0.33 |

**Drift Calculation**

| V(BR)CBO | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| OFF samples | | |
| 2 | - | -750.00E-03 |
| 3 | - | -800.00E-03 |
| 4 | - | -660.00E-03 |
| 5 | - | -679.99E-03 |
| 6 | - | -590.00E-03 |
| 7 | - | -390.00E-03 |
| Average | - | -645.00E-03 |
| Sigma | - | 132.00E-03 |

**Test conditions : PROTONS**
**Parameter : Collector-Emitter breakdown voltage : V(BR)CEO**
**Ic = 30mA (pulse width 300µs)**
Unit : V
Spec Limit Min : 40.00
Spec limits are represented in bold lines on the graphic.



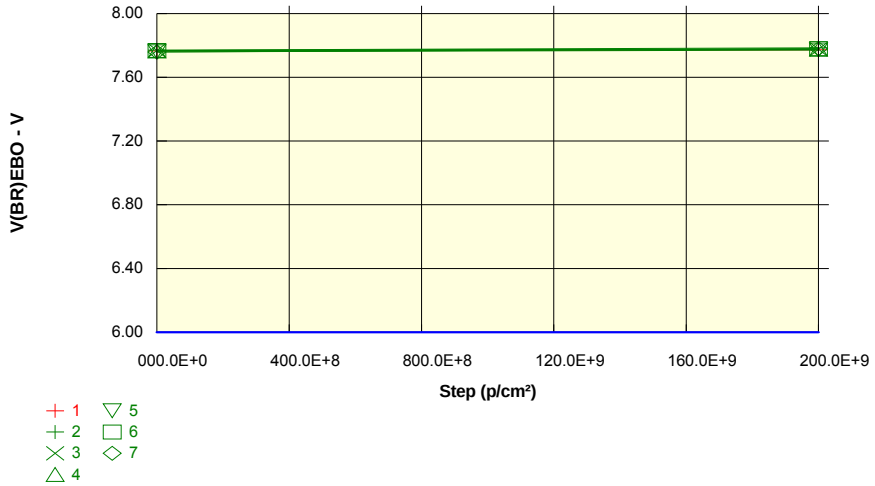

**Measurements**

| V(BR)CEO | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| 1_REF | 60.67 | 59.99 |
| OFF samples | | |
| 2 | 60.47 | 61.01 |
| 3 | 60.60 | 61.15 |
| 4 | 60.42 | 61.07 |
| 5 | 60.65 | 61.25 |
| 6 | 60.95 | 61.70 |
| 7 | 60.63 | 61.28 |
| Statistics | | |
| Min | 60.42 | 61.01 |
| Max | 60.95 | 61.70 |
| Average | 60.62 | 61.24 |
| Sigma | 0.17 | 0.22 |

**Drift Calculation**

| V(BR)CEO | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| OFF samples | | |
| 2 | - | 540.00E-03 |
| 3 | - | 548.00E-03 |
| 4 | - | 650.00E-03 |
| 5 | - | 604.00E-03 |
| 6 | - | 752.00E-03 |
| 7 | - | 658.00E-03 |
| Average | - | 625.33E-03 |
| Sigma | - | 72.39E-03 |

**Test conditions : PROTONS**
**Parameter : Emitter-Base breakdown voltage : V(BR)EBO**
**Ie = 100µA**
Unit : V
Spec Limit Min : 6.00
Spec limits are represented in bold lines on the graphic.



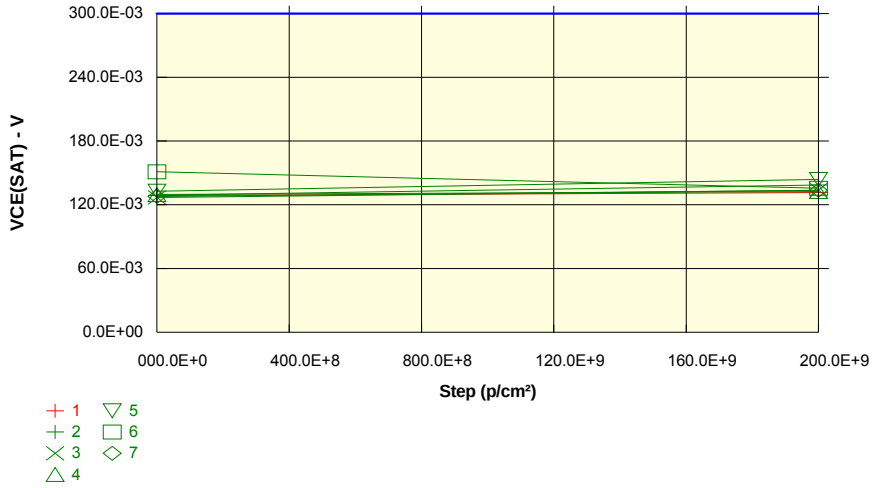

**Measurements**

| V(BR)EBO | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| 1_REF | 7.77 | 7.77 |
| OFF samples | | |
| 2 | 7.77 | 7.79 |
| 3 | 7.77 | 7.78 |
| 4 | 7.77 | 7.78 |
| 5 | 7.76 | 7.77 |
| 6 | 7.77 | 7.78 |
| 7 | 7.76 | 7.78 |
| Statistics | | |
| Min | 7.76 | 7.77 |
| Max | 7.77 | 7.79 |
| Average | 7.77 | 7.78 |
| Sigma | 0.00 | 0.00 |

**Drift Calculation**

| V(BR)EBO | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| OFF samples | | |
| 2 | - | 14.40E-03 |
| 3 | - | 7.60E-03 |
| 4 | - | 10.00E-03 |
| 5 | - | 11.20E-03 |
| 6 | - | 12.00E-03 |
| 7 | - | 20.80E-03 |
| Average | - | 12.67E-03 |
| Sigma | - | 4.17E-03 |

**Test conditions : PROTONS**
**Parameter : Collector-Emitter saturation voltage : VCE(SAT)**
**Ic = 150mA ; ib = 15mA (pulse width 300µs)**
Unit : V
Spec Limit Max : 300.0E-03
Spec limits are represented in bold lines on the graphic.



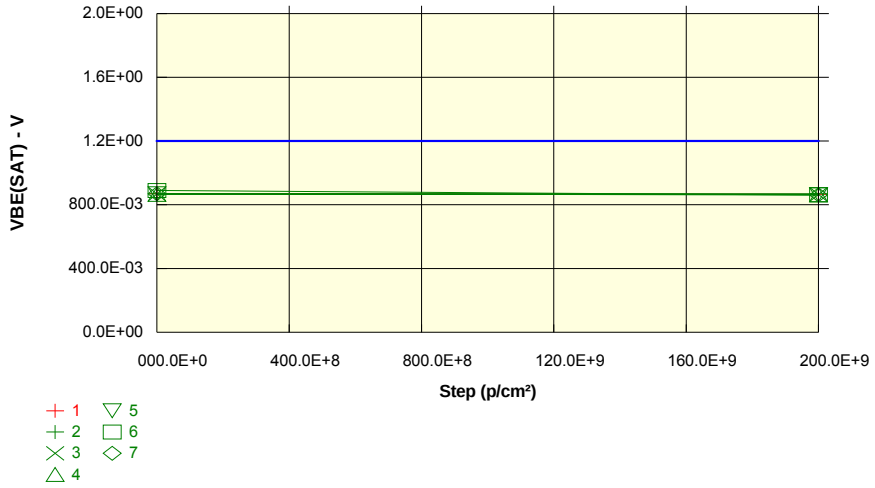

**Measurements**

| VCE(SAT) | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| 1_REF | 128.6E-03 | 131.6E-03 |
| OFF samples | | |
| 2 | 129.0E-03 | 138.6E-03 |
| 3 | 126.9E-03 | 133.7E-03 |
| 4 | 129.6E-03 | 132.5E-03 |
| 5 | 132.8E-03 | 143.8E-03 |
| 6 | 151.0E-03 | 135.5E-03 |
| 7 | 127.8E-03 | 133.6E-03 |
| Statistics | | |
| Min | 126.9E-03 | 132.5E-03 |
| Max | 151.0E-03 | 143.8E-03 |
| Average | 132.8E-03 | 136.3E-03 |
| Sigma | 8.3E-03 | 3.9E-03 |

**Drift Calculation**

| VCE(SAT) | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| OFF samples | | |
| 2 | - | 9.60E-03 |
| 3 | - | 6.84E-03 |
| 4 | - | 2.88E-03 |
| 5 | - | 11.04E-03 |
| 6 | - | -15.48E-03 |
| 7 | - | 5.88E-03 |
| Average | - | 3.46E-03 |
| Sigma | - | 8.86E-03 |

**Test conditions : PROTONS**
**Parameter : Base-Emitter saturation voltage : VBE(SAT)**
**Ic = 150mA ; ib = 15mA (pulse width 300µs)**
Unit : V
Spec Limit Max : 1.2E+00
Spec limits are represented in bold lines on the graphic.



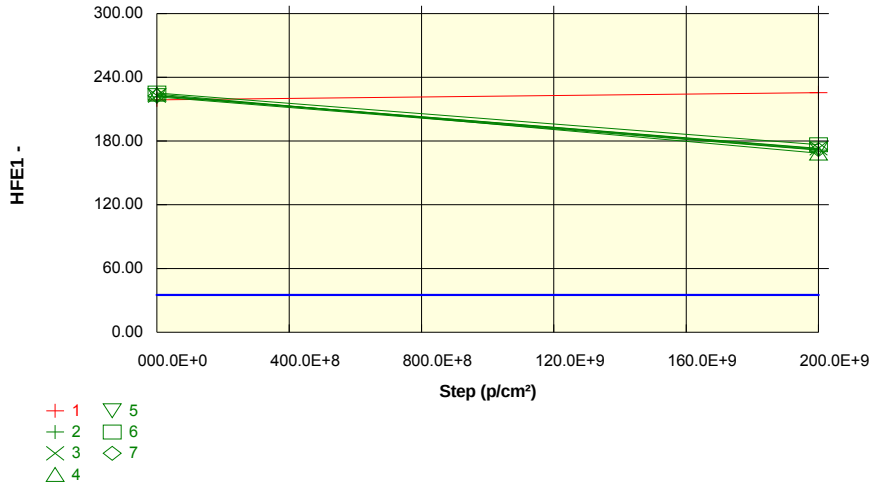

**Measurements**

| VBE(SAT) | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| 1_REF | 869.8E-03 | 865.9E-03 |
| OFF samples | | |
| 2 | 869.1E-03 | 869.2E-03 |
| 3 | 867.3E-03 | 865.1E-03 |
| 4 | 865.7E-03 | 863.4E-03 |
| 5 | 868.9E-03 | 864.8E-03 |
| 6 | 889.4E-03 | 861.6E-03 |
| 7 | 869.4E-03 | 862.7E-03 |
| Statistics | | |
| Min | 865.7E-03 | 861.6E-03 |
| Max | 889.4E-03 | 869.2E-03 |
| Average | 871.6E-03 | 864.5E-03 |
| Sigma | 8.1E-03 | 2.4E-03 |

**Drift Calculation**

| VBE(SAT) | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| OFF samples | | |
| 2 | - | 79.99E-06 |
| 3 | - | -2.20E-03 |
| 4 | - | -2.32E-03 |
| 5 | - | -4.12E-03 |
| 6 | - | -27.88E-03 |
| 7 | - | -6.64E-03 |
| Average | - | -7.18E-03 |
| Sigma | - | 9.48E-03 |

**Test conditions : PROTONS**
**Parameter : Forward-Current Transfer Ratio : HFE1**
**Ic = 100µA ; Vce = 10V (pulse width 300µs)**
Unit :
Spec Limit Min : 35.00
Spec limits are represented in bold lines on the graphic.



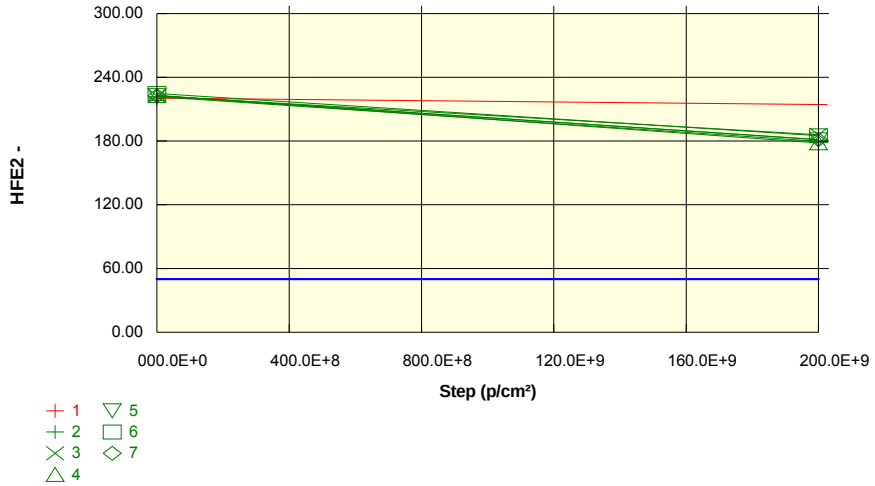

**Measurements**

| HFE1 | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| 1_REF | 218.90 | 225.60 |
| OFF samples | | |
| 2 | 221.63 | 171.43 |
| 3 | 222.83 | 173.09 |
| 4 | 224.22 | 168.67 |
| 5 | 222.80 | 172.64 |
| 6 | 225.20 | 176.60 |
| 7 | 222.53 | 171.99 |
| Statistics | | |
| Min | 221.63 | 168.67 |
| Max | 225.20 | 176.60 |
| Average | 223.20 | 172.40 |
| Sigma | 1.17 | 2.35 |

**Drift Calculation**

| HFE1 | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| OFF samples | | |
| 2 | - | 1.32E-03 |
| 3 | - | 1.29E-03 |
| 4 | - | 1.47E-03 |
| 5 | - | 1.30E-03 |
| 6 | - | 1.22E-03 |
| 7 | - | 1.32E-03 |
| Average | - | 1.32E-03 |
| Sigma | - | 74.12E-06 |

**Test conditions : PROTONS**
**Parameter : Forward-Current Transfer Ratio : HFE2**
**Ic = 1mA ; Vce = 10V (pulse width 300µs)**
Unit :
Spec Limit Min : 50.00
Spec limits are represented in bold lines on the graphic.



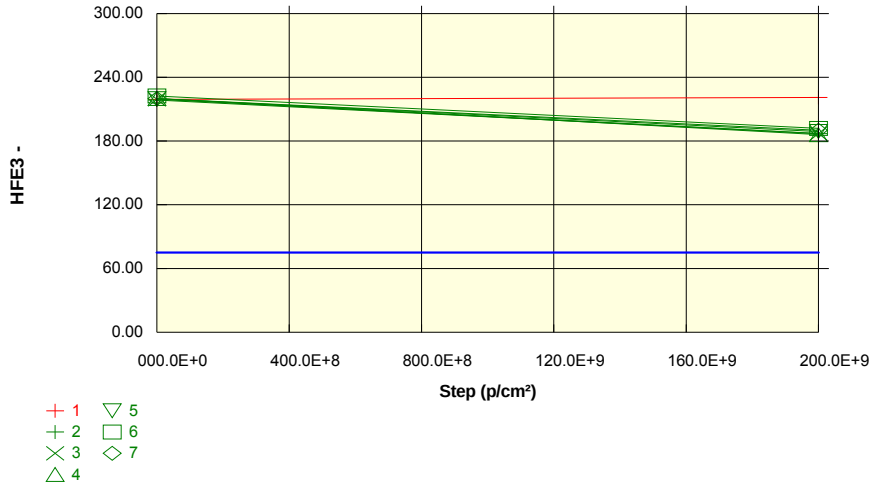

**Measurements**

| HFE2 | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| 1_REF | 220.29 | 214.36 |
| OFF samples | | |
| 2 | 221.68 | 179.62 |
| 3 | 222.40 | 185.93 |
| 4 | 222.87 | 178.29 |
| 5 | 222.77 | 181.29 |
| 6 | 224.88 | 185.08 |
| 7 | 222.54 | 181.37 |
| Statistics | | |
| Min | 221.68 | 178.29 |
| Max | 224.88 | 185.93 |
| Average | 222.86 | 181.93 |
| Sigma | 0.98 | 2.75 |

**Drift Calculation**

| HFE2 | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| OFF samples | | |
| 2 | - | 1.06E-03 |
| 3 | - | 881.97E-06 |
| 4 | - | 1.12E-03 |
| 5 | - | 1.03E-03 |
| 6 | - | 956.16E-06 |
| 7 | - | 1.02E-03 |
| Average | - | 1.01E-03 |
| Sigma | - | 75.65E-06 |

**Test conditions : PROTONS**
**Parameter : Forward-Current Transfer Ratio : HFE3**
**Ic = 10mA ; Vce = 10V (pulse width 300µs)**
Unit :
Spec Limit Min : 75.00
Spec limits are represented in bold lines on the graphic.



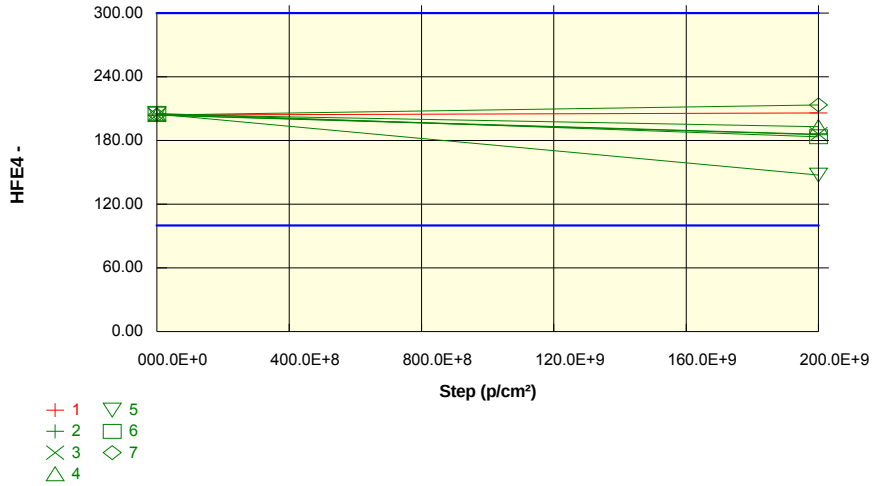

**Measurements**

| HFE3 | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| 1_REF | 219.14 | 221.03 |
| OFF samples | | |
| 2 | 218.72 | 186.94 |
| 3 | 219.33 | 187.17 |
| 4 | 219.95 | 186.03 |
| 5 | 219.82 | 188.99 |
| 6 | 222.41 | 191.95 |
| 7 | 220.07 | 190.20 |
| Statistics | | |
| Min | 218.72 | 186.03 |
| Max | 222.41 | 191.95 |
| Average | 220.05 | 188.55 |
| Sigma | 1.15 | 2.05 |

**Drift Calculation**

| HFE3 | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| OFF samples | | |
| 2 | - | 777.12E-06 |
| 3 | - | 783.49E-06 |
| 4 | - | 828.91E-06 |
| 5 | - | 742.04E-06 |
| 6 | - | 713.44E-06 |
| 7 | - | 713.42E-06 |
| Average | - | 759.74E-06 |
| Sigma | - | 41.34E-06 |

**Test conditions : PROTONS**
**Parameter : Forward-Current Transfer Ratio : HFE4**
**Ic = 150mA ; Vce = 10V (pulse width 300µs)**
Unit :
Spec Limit Min : 100.00
Spec Limit Max : 300.00
Spec limits are represented in bold lines on the graphic.



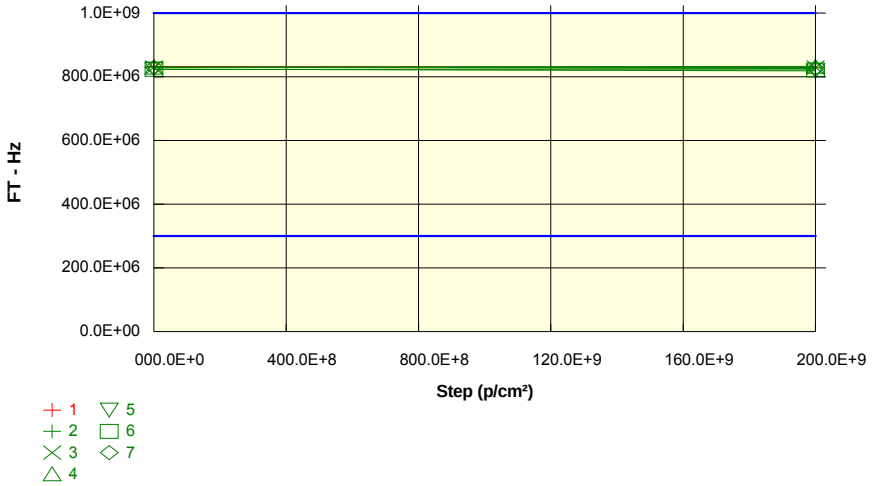

**Measurements**

| HFE4 | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| 1_REF | 204.05 | 205.86 |
| OFF samples | | |
| 2 | 203.90 | 185.31 |
| 3 | 204.08 | 185.82 |
| 4 | 204.48 | 193.04 |
| 5 | 204.80 | 147.36 |
| 6 | 205.52 | 183.54 |
| 7 | 203.95 | 213.47 |
| Statistics | | |
| Min | 203.90 | 147.36 |
| Max | 205.52 | 213.47 |
| Average | 204.45 | 184.76 |
| Sigma | 0.57 | 19.56 |

**Drift Calculation**

| HFE4 | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| OFF samples | | |
| 2 | - | 491.79E-06 |
| 3 | - | 481.48E-06 |
| 4 | - | 289.99E-06 |
| 5 | - | 1.90E-03 |
| 6 | - | 582.85E-06 |
| 7 | - | -218.71E-06 |
| Average | - | 588.44E-06 |
| Sigma | - | 644.23E-06 |

**Test conditions : PROTONS**
**Parameter : Gain Bandwidth Product : FT**
**Vce = 20V ; Ic = 20mA**
Unit : Hz
Spec Limit Min : 300.0E+06
Spec Limit Max : 1.0E+09
Spec limits are represented in bold lines on the graphic.




**Measurements**

| FT | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| 1_REF | 832.5E+06 | 830.2E+06 |
| OFF samples | | |
| 2 | 829.5E+06 | 827.8E+06 |
| 3 | 829.3E+06 | 829.1E+06 |
| 4 | 830.6E+06 | 832.7E+06 |
| 5 | 824.3E+06 | 818.7E+06 |
| 6 | 823.2E+06 | 821.3E+06 |
| 7 | 829.7E+06 | 825.7E+06 |
| Statistics | | |
| Min | 823.2E+06 | 818.7E+06 |
| Max | 830.6E+06 | 832.7E+06 |
| Average | 827.8E+06 | 825.9E+06 |
| Sigma | 2.9E+06 | 4.7E+06 |

**Drift Calculation**

| FT | 0 p/cm² | 2E+11 p/cm² |
|---|---|---|
| OFF samples | | |
| 2 | - | -1.72E+06 |
| 3 | - | -190.98E+03 |
| 4 | - | 2.11E+06 |
| 5 | - | -5.67E+06 |
| 6 | - | -1.89E+06 |
| 7 | - | -4.00E+06 |
| Average | - | -1.90E+06 |
| Sigma | - | 2.51E+06 |