PROTONS TEST REPORT

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

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

Part Type : 2N2920A

Package : CCP-6

Description : NPN Small Signal, double matched 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/0921	Issue : 02	Date :	April 20th, 2012
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CHANGE RECORD

ISSUE	DATE	PAGE	DESCRIPTION OF CHANGES
01	June 01st, 2011	All	Original Issue
02	April 20th, 2012	4	Change serial numbers on table

PROTONS TEST REPORT
on
2N2920A
NPN Small Signal, double matched transistors

From STMicroelectronics.

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1 Introduction

In the scope of the ESA study: “Survey of Critical Components for 150 kRad Power Systems”, a protons test of the STMicroelectronics. 2N2920A, NPN Small Signal, double matched 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 Test Plan HRX/SPE/0226 issue 3 dated 09/21/2010.

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

2 Applicable and Reference Documents

2.1 Applicable Documents

- Hirex Engineering Radiation Test Plan: HRX/SPE/0226 issue 3 dated 09/21/2010
- 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: 5207-002

2.2 Reference Documents

- STMicroelectronics. datasheet: Doc ID 15383 Rev 2, January 2010

3 Test Samples

7 samples of the 2N2920A 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	Allocation
17	Control sample
2	Biased OFF
3	Biased OFF
4	Biased OFF
7	Biased OFF
15	Biased OFF
16	Biased OFF

Identification of the 2N2920A is given below:

Part Number: SOC2920A

Top Marking: none

Inspection lot: -

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.

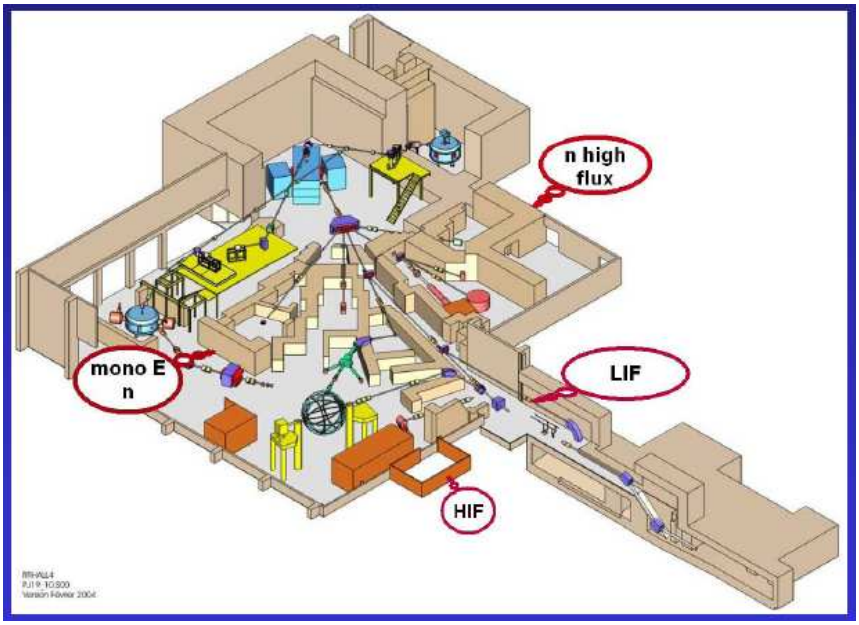


Figure 1 : LIF layout and typical experimental set-up

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

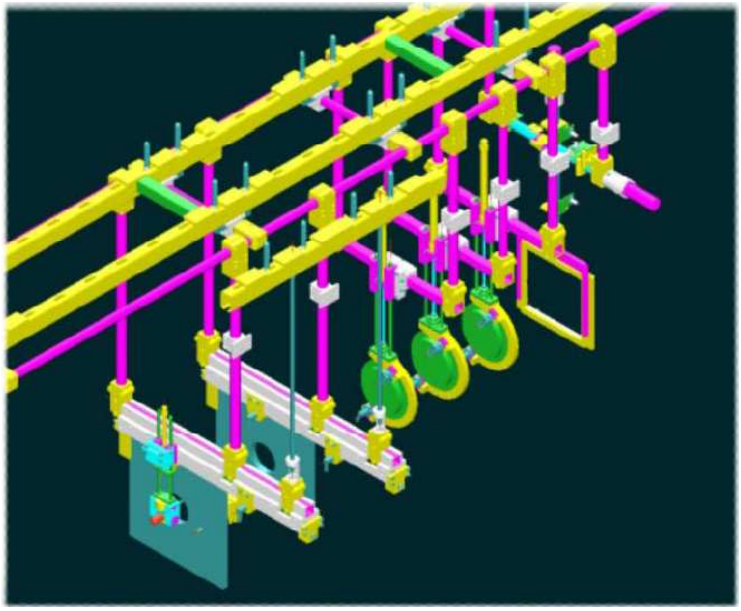


Figure 2: LIF Energy degraders

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

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 2N2920A 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.

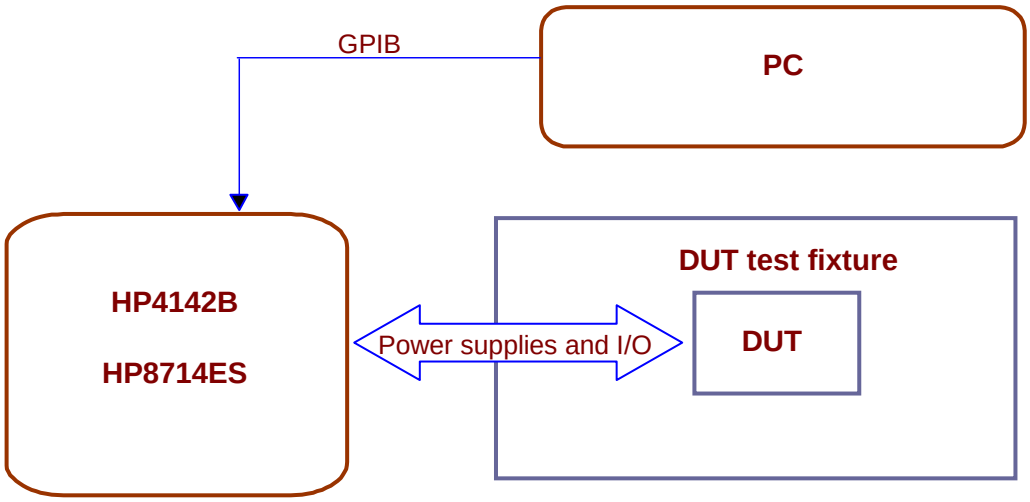


Figure 3 : 2N2920A test program principle

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

Parameter	Description	Conditions	Limit		unit
			Min	Max	
I_{CBO}	Collector-Base cut-off current	V_{CB} = 45V	-	2	nA
I_{EBO}	Emitter-Base cut-off current	V_{EB} = 5V	-	2	nA
I_{CEO}	Collector-Emitter cut-off current	V_{CE} = 5V	-	2	nA
$V_{(BR)CBO}$	Collector-Base breakdown voltage	I_C = 10µA	60	-	V
$V_{(BR)CEO}$	Collector-Emitter breakdown voltage	I_C = 10mA, Note 1	60	-	V
$V_{(BR)EBO}$	Emitter-Base breakdown voltage	I_E = 10µA	6	-	V
$V_{CE(SAT)}$	Collector-Emitter saturation voltage	I_C = 1mA, I_B = 0.1mA Note 1	-	0.35	V
H_{FE1}	DC current gain	I_C = 100µA, V_{CE} = 5V Note 1	225	-	-
H_{FE2}	DC current gain	I_C = 1mA, V_{CE} = 5V Note 1	300	-	-
H_{FE3}	DC current gain	I_C = 5mA, V_{CE} = 5V Note 1	300	-	-
H_{FE4}	DC current gain	I_C = 10mA, V_{CE} = 5V Note 1	300	-	-
H_{FE3-1}/H_{FE3-2}	Forward Current Transfer Ratio Comparison	I_C = 1mA, V_{CE} = 5V	0.8	1.2	-
H_{FE3-1}/H_{FE3-2}	Forward Current Transfer Ratio Comparison	I_C = 5mA, V_{CE} = 5V	0.8	1.2	-
H_{FE4-1}/H_{FE4-2}	Forward Current Transfer Ratio Comparison	I_C = 10mA, V_{CE} = 5V	0.8	1.2	-
$\Delta\lvert V_{BE1}-V_{BE2}\rvert$	Base-Emitter Voltage Differential	I_C = 1mA, V_{CE} = 5V		2	mV
$\Delta\lvert V_{BE1}-V_{BE2}\rvert$	Base-Emitter Voltage Differential	I_C = 5mA, V_{CE} = 5V		2	mV
$\Delta\lvert V_{BE1}-V_{BE2}\rvert$	Base-Emitter Voltage Differential	I_C = 10mA, V_{CE} = 5V		2	mV
F_T	Gain Bandwidth Product	I_C = 0.5mA, V_{CE} = 5V	60	-	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. 2N2920A NPN Small Signal, double matched transistors in CCP-6 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.

Gain Bandwidth Product parameter F_T was found slightly below minimum specification limit at initial measurements step. No significant drift was observed on this parameter after exposure.

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_1	0 and 2E+11p/cm².	
ICEO_2	0 and 2E+11p/cm².	

Table 2 : Summary of failed parameters

6 Test Results

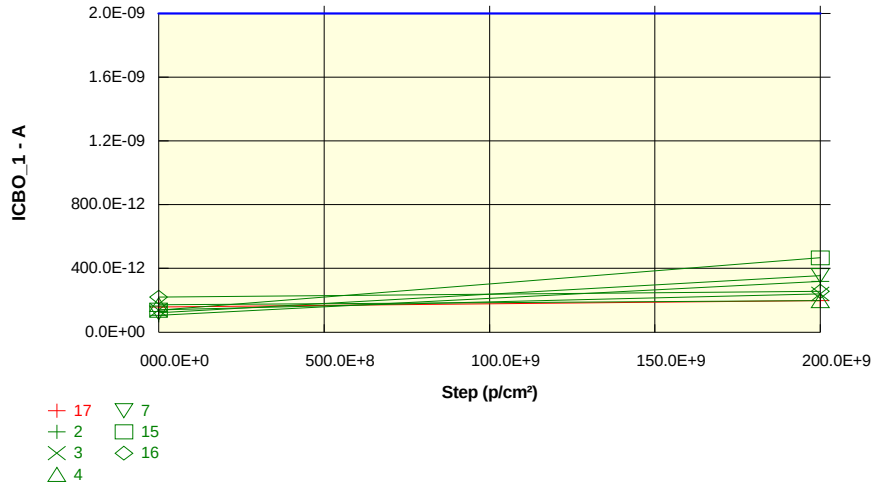
Test results including tables and graphics are provided in this section for each measured parameter.

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_1
Vcb = 45V
Unit : A
Spec Limit Max : 2.0E-09
Spec limits are represented in bold lines on the graphic.



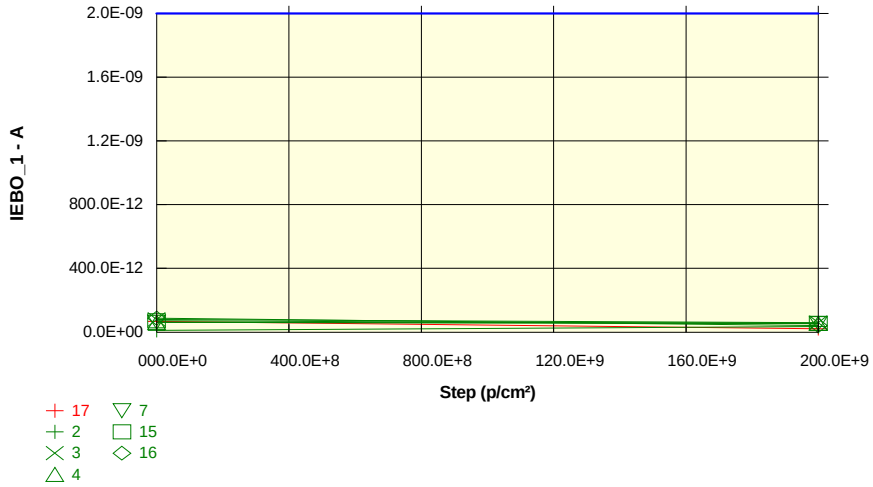
Measurements

ICBO_1	0 p/cm²	2E+11 p/cm²
17_REF	158.8E-12	197.3E-12
OFF samples		
2	105.4E-12	318.8E-12
3	139.0E-12	240.4E-12
4	172.6E-12	198.0E-12
7	121.0E-12	355.6E-12
15	138.0E-12	466.8E-12
16	219.8E-12	256.4E-12
Statistics		
Min	105.4E-12	198.0E-12
Max	219.8E-12	466.8E-12
Average	149.3E-12	306.0E-12
Sigma	37.6E-12	88.4E-12

Drift Calculation

ICBO_1	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	213.34E-12
3	-	101.36E-12
4	-	25.40E-12
7	-	234.58E-12
15	-	328.80E-12
16	-	36.60E-12
Average	-	156.68E-12
Sigma	-	110.77E-12

Test conditions : PROTONS
Parameter : Emitter-Base cut-off current : IEBO_1
Veb = 5V
Unit : A
Spec Limit Max : 2.0E-09
Spec limits are represented in bold lines on the graphic.



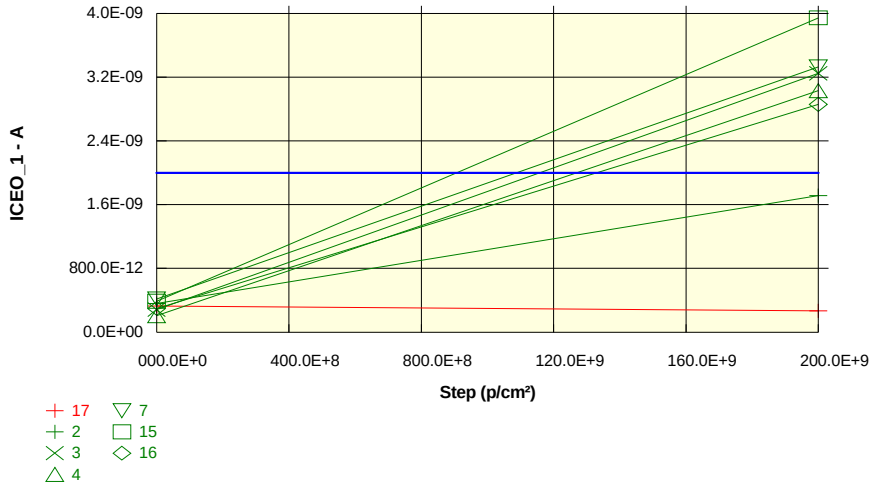
Measurements

IEBO_1	0 p/cm²	2E+11 p/cm²
17_REF	68.0E-12	21.6E-12
OFF samples		
2	11.8E-12	34.9E-12
3	79.6E-12	60.2E-12
4	61.4E-12	55.7E-12
7	62.6E-12	55.2E-12
15	71.4E-12	54.4E-12
16	87.0E-12	41.9E-12
Statistics		
Min	11.8E-12	34.9E-12
Max	87.0E-12	60.2E-12
Average	62.3E-12	50.4E-12
Sigma	24.3E-12	8.9E-12

Drift Calculation

IEBO_1	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	23.10E-12
3	-	-19.38E-12
4	-	-5.72E-12
7	-	-7.40E-12
15	-	-17.00E-12
16	-	-45.12E-12
Average	-	-11.92E-12
Sigma	-	20.29E-12

Test conditions : PROTONS
Parameter : Collector-Emitter cut-off current : ICEO_1
Vce = 5V
Unit : A
Spec Limit Max : 2.0E-09
Spec limits are represented in bold lines on the graphic.



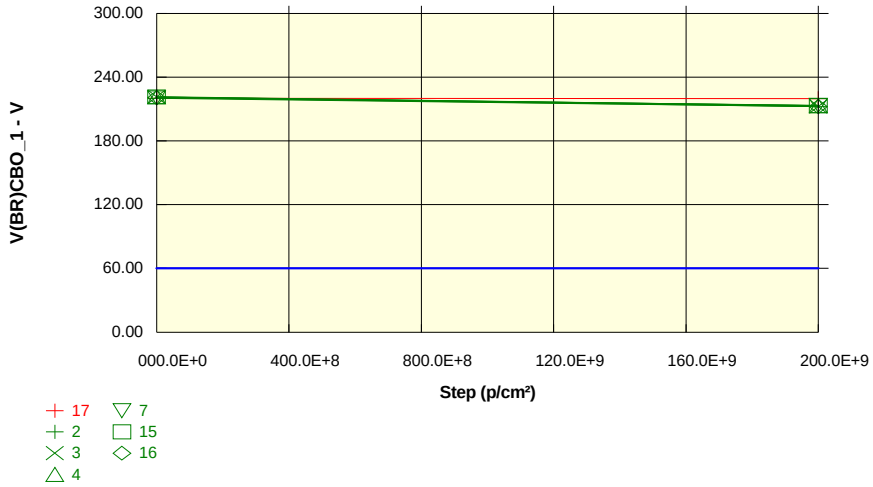
Measurements

ICEO_1	0 p/cm²	2E+11 p/cm²
17_REF	326.8E-12	266.4E-12
OFF samples		
2	361.4E-12	1.7E-09
3	282.4E-12	3.3E-09
4	207.4E-12	3.0E-09
7	417.0E-12	3.3E-09
15	387.8E-12	3.9E-09
16	296.8E-12	2.9E-09
Statistics		
Min	207.4E-12	1.7E-09
Max	417.0E-12	3.9E-09
Average	325.5E-12	3.0E-09
Sigma	70.9E-12	676.2E-12

Drift Calculation

ICEO_1	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	1.35E-09
3	-	2.97E-09
4	-	2.82E-09
7	-	2.92E-09
15	-	3.56E-09
16	-	2.56E-09
Average	-	2.70E-09
Sigma	-	671.87E-12

Test conditions : PROTONS
Parameter : Collector-Base breakdown voltage : V(BR)CBO_1
Ic = 10µA
Unit : V
Spec Limit Min : 60.00
Spec limits are represented in bold lines on the graphic.



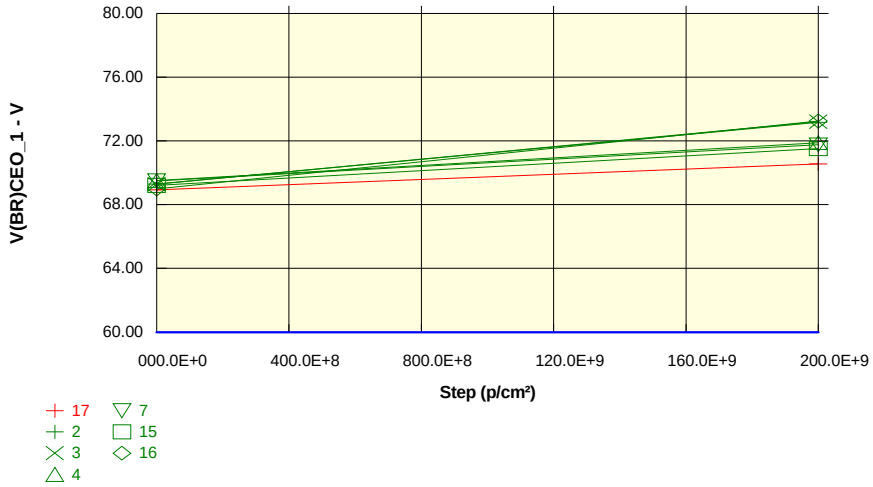
Measurements

V(BR)CBO_1	0 p/cm²	2E+11 p/cm²
17_REF	220.42	220.10
OFF samples		
2	220.40	212.41
3	221.61	212.57
4	221.80	213.32
7	220.65	213.55
15	221.54	213.30
16	220.83	212.41
Statistics		
Min	220.40	212.41
Max	221.80	213.55
Average	221.14	212.93
Sigma	0.53	0.47

Drift Calculation

V(BR)CBO_1	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	-7.99E+00
3	-	-9.04E+00
4	-	-8.48E+00
7	-	-7.10E+00
15	-	-8.24E+00
16	-	-8.42E+00
Average	-	-8.21E+00
Sigma	-	589.82E-03

Test conditions : PROTONS
Parameter : Collecor-Emitter breakdown voltage : V(BR)CEO_1
Ic = 10mA
Unit : V
Spec Limit Min : 60.00
Spec limits are represented in bold lines on the graphic.



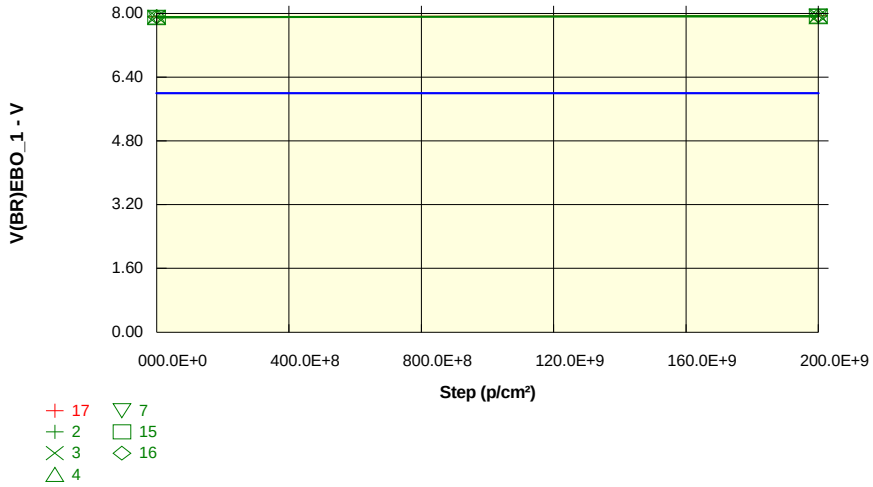
Measurements

V(BR)CEO_1	0 p/cm²	2E+11 p/cm²
17_REF	68.95	70.55
OFF samples		
2	69.29	73.19
3	69.29	73.22
4	69.52	71.90
7	69.49	71.76
15	69.22	71.53
16	69.00	73.25
Statistics		
Min	69.00	71.53
Max	69.52	73.25
Average	69.30	72.47
Sigma	0.17	0.75

Drift Calculation

V(BR)CEO_1	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	3.90E+00
3	-	3.93E+00
4	-	2.38E+00
7	-	2.26E+00
15	-	2.31E+00
16	-	4.26E+00
Average	-	3.17E+00
Sigma	-	862.37E-03

Test conditions : PROTONS
Parameter : Emitter-Base breakdown voltage : V(BR)EBO_1
Ie = 10µA
Unit : V
Spec Limit Min : 6.00
Spec limits are represented in bold lines on the graphic.



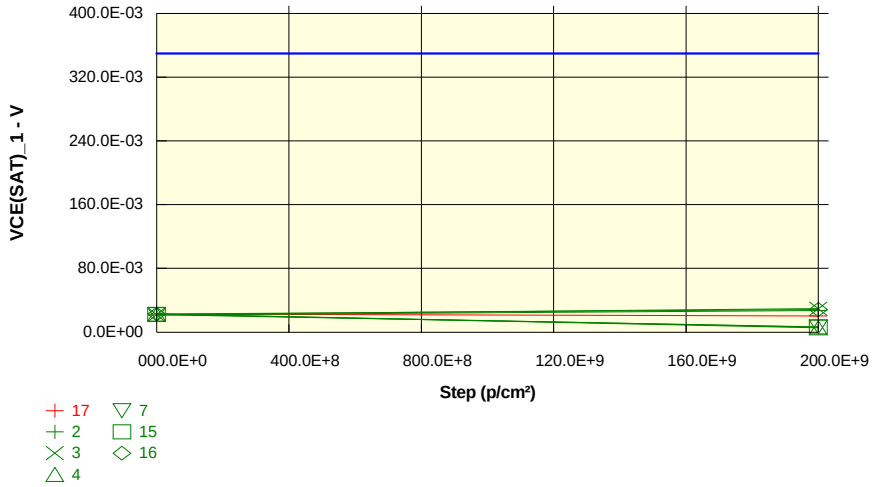
Measurements

V(BR)EBO_1	0 p/cm²	2E+11 p/cm²
17_REF	7.92	7.94
OFF samples		
2	7.92	7.94
3	7.92	7.95
4	7.91	7.92
7	7.91	7.93
15	7.89	7.94
16	7.92	7.95
Statistics		
Min	7.89	7.92
Max	7.92	7.95
Average	7.91	7.94
Sigma	0.01	0.01

Drift Calculation

V(BR)EBO_1	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	26.80E-03
3	-	31.60E-03
4	-	7.60E-03
7	-	20.80E-03
15	-	49.20E-03
16	-	28.40E-03
Average	-	27.40E-03
Sigma	-	12.45E-03

Test conditions : PROTONS
Parameter : Collector-Emitter saturation oltage : VCE(SAT)_1
Ic = 1mA ; ib = 100µA
Unit : V
Spec Limit Max : 350.0E-03
Spec limits are represented in bold lines on the graphic.



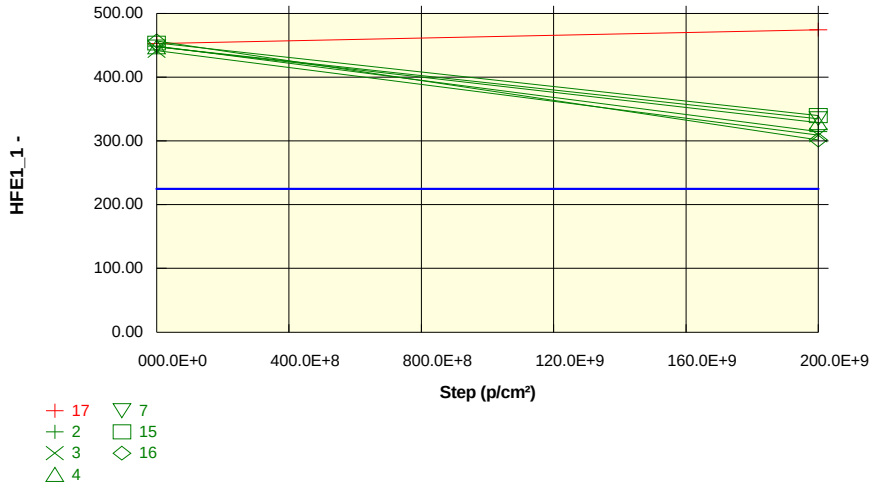
Measurements

VCE(SAT)_1	0 p/cm²	2E+11 p/cm²
17_REF	22.6E-03	20.2E-03
OFF samples		
2	21.6E-03	27.2E-03
3	21.9E-03	29.4E-03
4	22.6E-03	5.5E-03
7	22.4E-03	6.4E-03
15	22.0E-03	6.8E-03
16	22.6E-03	28.3E-03
Statistics		
Min	21.6E-03	5.5E-03
Max	22.6E-03	29.4E-03
Average	22.2E-03	17.3E-03
Sigma	395.6E-06	11.1E-03

Drift Calculation

VCE(SAT)_1	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	5.60E-03
3	-	7.48E-03
4	-	-17.12E-03
7	-	-16.00E-03
15	-	-15.24E-03
16	-	5.68E-03
Average	-	-4.93E-03
Sigma	-	11.22E-03

Test conditions : PROTONS
Parameter : DC current gain : HFE1_1
Ic = 100µA ; Vce = 5V
Unit :
Spec Limit Min : 225.00
Spec limits are represented in bold lines on the graphic.



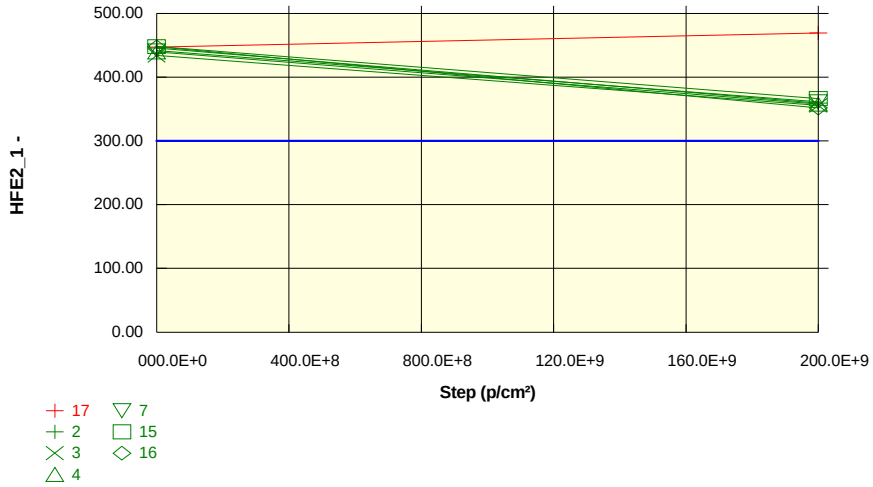
Measurements

HFE1_1	0 p/cm²	2E+11 p/cm²
17_REF	453.04	474.70
OFF samples		
2	448.81	314.59
3	442.06	309.30
4	448.06	328.85
7	447.77	335.12
15	453.76	340.07
16	457.02	301.83
Statistics		
Min	442.06	301.83
Max	457.02	340.07
Average	449.58	321.63
Sigma	4.75	13.95

Drift Calculation

HFE1_1	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	950.65E-06
3	-	970.96E-06
4	-	809.05E-06
7	-	750.67E-06
15	-	736.74E-06
16	-	1.13E-03
Average	-	890.52E-06
Sigma	-	138.40E-06

Test conditions : PROTONS
Parameter : DC current gain : HFE2_1
Ic = 1mA ; Vce = 5V
Unit :
Spec Limit Min : 300.00
Spec limits are represented in bold lines on the graphic.



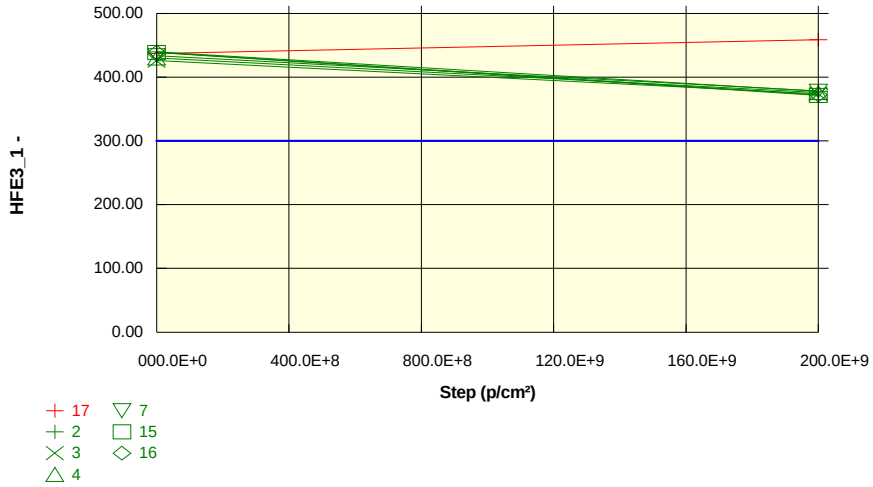
Measurements

HFE2_1	0 p/cm²	2E+11 p/cm²
17_REF	447.43	469.59
OFF samples		
2	446.01	359.48
3	434.58	355.93
4	439.91	357.92
7	441.60	361.65
15	448.42	366.57
16	447.75	351.87
Statistics		
Min	434.58	351.87
Max	448.42	366.57
Average	443.04	358.90
Sigma	4.89	4.58

Drift Calculation

HFE2_1	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	539.70E-06
3	-	508.42E-06
4	-	520.75E-06
7	-	500.67E-06
15	-	497.91E-06
16	-	608.52E-06
Average	-	529.33E-06
Sigma	-	38.08E-06

Test conditions : PROTONS
Parameter : DC current gain : HFE3_1
Ic = 5mA ; Vce = 5V
Unit :
Spec Limit Min : 300.00
Spec limits are represented in bold lines on the graphic.



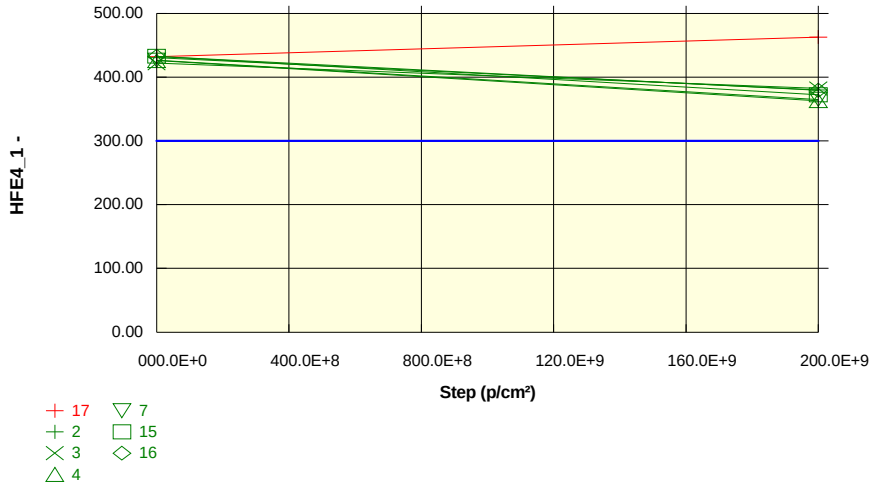
Measurements

HFE3_1	0 p/cm²	2E+11 p/cm²
17_REF	437.33	459.01
OFF samples		
2	440.07	378.12
3	426.11	374.28
4	430.39	375.80
7	434.09	378.38
15	438.74	371.61
16	439.36	372.44
Statistics		
Min	426.11	371.61
Max	440.07	378.38
Average	434.79	375.10
Sigma	5.16	2.59

Drift Calculation

HFE3_1	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	372.33E-06
3	-	324.96E-06
4	-	337.50E-06
7	-	339.15E-06
15	-	411.79E-06
16	-	408.96E-06
Average	-	365.78E-06
Sigma	-	34.64E-06

Test conditions : PROTONS
Parameter : DC current gain : HFE4_1
Ic = 10mA ; Vce = 5V
Unit :
Spec Limit Min : 300.00
Spec limits are represented in bold lines on the graphic.



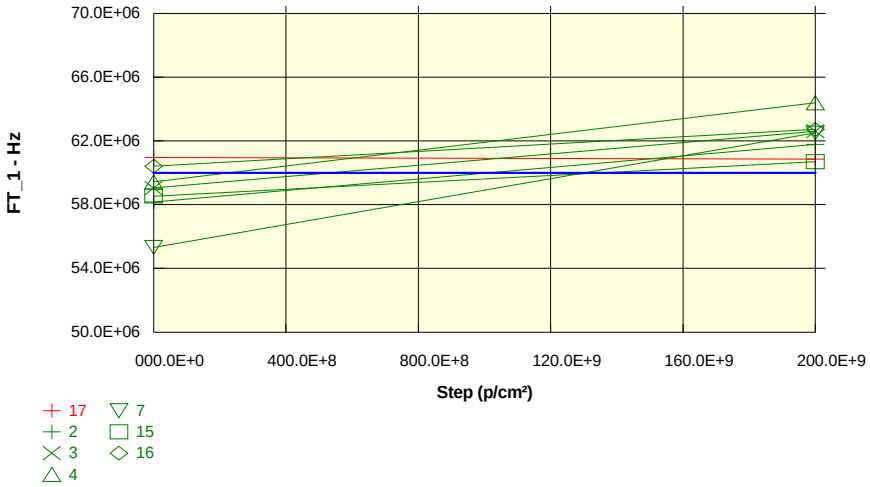
Measurements

HFE4_1	0 p/cm²	2E+11 p/cm²
17_REF	432.23	463.14
OFF samples		
2	431.15	380.05
3	422.30	382.53
4	426.31	363.17
7	426.84	365.40
15	433.20	372.59
16	432.85	379.63
Statistics		
Min	422.30	363.17
Max	433.20	382.53
Average	428.77	373.90
Sigma	3.95	7.46

Drift Calculation

HFE4_1	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	311.84E-06
3	-	246.15E-06
4	-	407.79E-06
7	-	393.95E-06
15	-	375.47E-06
16	-	323.83E-06
Average	-	343.17E-06
Sigma	-	55.63E-06

Test conditions : PROTONS
Parameter : Gain bandwidth product : FT_1
Ic = 500µA ; Vce = 5V
Unit : Hz
Spec Limit Min : 60.0E+06
Spec limits are represented in bold lines on the graphic.



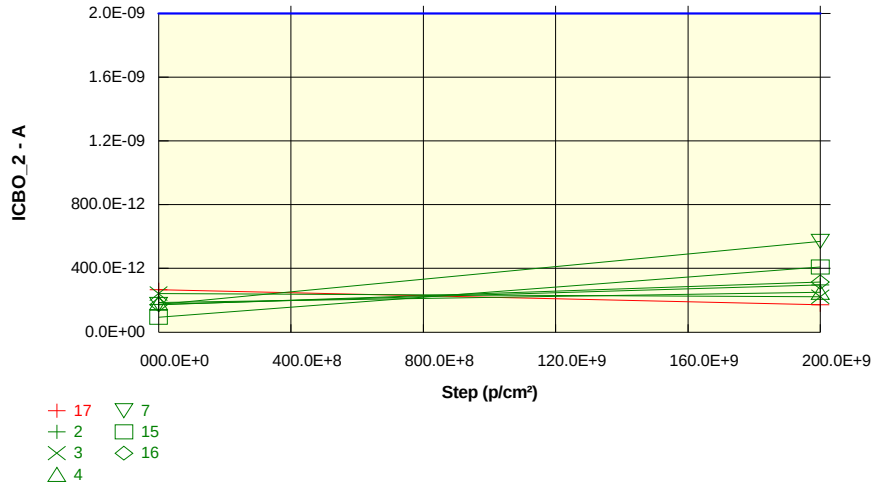
Measurements

FT_1	0 p/cm²	2E+11 p/cm²
17_REF	61.0E+06	60.9E+06
OFF samples		
2	58.2E+06	61.8E+06
3	59.1E+06	62.6E+06
4	59.4E+06	64.4E+06
7	55.3E+06	62.5E+06
15	58.5E+06	60.7E+06
16	60.4E+06	62.7E+06
Statistics		
Min	55.3E+06	60.7E+06
Max	60.4E+06	64.4E+06
Average	58.5E+06	62.5E+06
Sigma	1.6E+06	1.1E+06

Drift Calculation

FT_1	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	3.62E+06
3	-	3.57E+06
4	-	4.97E+06
7	-	7.18E+06
15	-	2.17E+06
16	-	2.31E+06
Average	-	3.97E+06
Sigma	-	1.71E+06

Test conditions : PROTONS
Parameter : Collector-Base cut-off current : ICBO_2
Vcb = 45V
Unit : A
Spec Limit Max : 2.0E-09
Spec limits are represented in bold lines on the graphic.



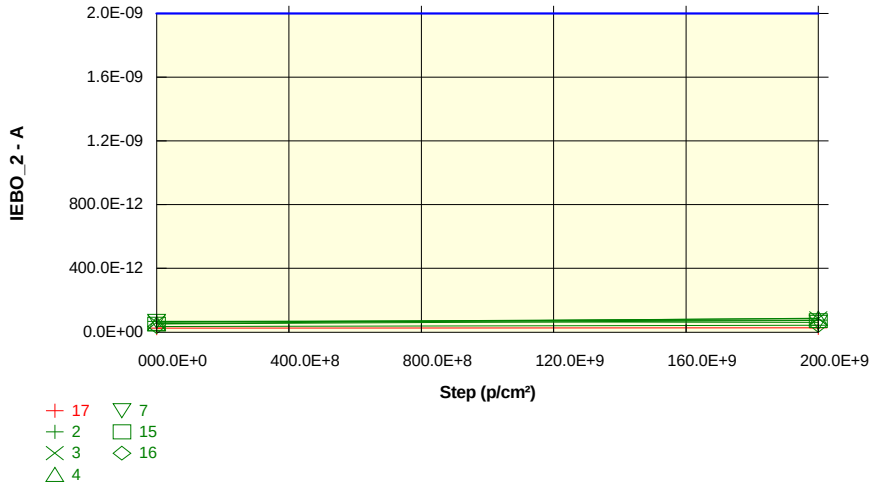
Measurements

ICBO_2	0 p/cm²	2E+11 p/cm²
17_REF	266.2E-12	170.8E-12
OFF samples		
2	174.1E-12	297.2E-12
3	242.4E-12	221.4E-12
4	185.2E-12	250.6E-12
7	173.2E-12	570.2E-12
15	93.4E-12	408.8E-12
16	172.0E-12	314.7E-12
Statistics		
Min	93.4E-12	221.4E-12
Max	242.4E-12	570.2E-12
Average	173.4E-12	343.8E-12
Sigma	43.4E-12	117.0E-12

Drift Calculation

ICBO_2	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	123.06E-12
3	-	-21.00E-12
4	-	65.40E-12
7	-	397.00E-12
15	-	315.40E-12
16	-	142.74E-12
Average	-	170.43E-12
Sigma	-	143.20E-12

Test conditions : PROTONS
Parameter : Emitter-Base cut-off current : IEBO_2
Veb = 5V
Unit : A
Spec Limit Max : 2.0E-09
Spec limits are represented in bold lines on the graphic.



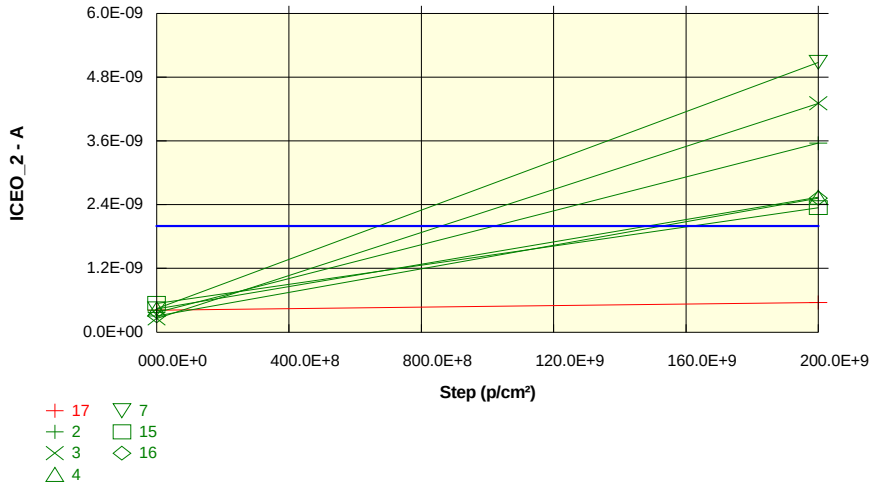
Measurements

IEBO_2	0 p/cm²	2E+11 p/cm²
17_REF	25.4E-12	26.0E-12
OFF samples		
2	66.4E-12	75.9E-12
3	60.6E-12	86.3E-12
4	54.0E-12	87.2E-12
7	67.8E-12	60.4E-12
15	51.0E-12	72.5E-12
16	36.2E-12	42.6E-12
Statistics		
Min	36.2E-12	42.6E-12
Max	67.8E-12	87.2E-12
Average	56.0E-12	70.8E-12
Sigma	10.7E-12	15.5E-12

Drift Calculation

IEBO_2	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	9.52E-12
3	-	25.68E-12
4	-	33.24E-12
7	-	-7.36E-12
15	-	21.48E-12
16	-	6.40E-12
Average	-	14.83E-12
Sigma	-	13.49E-12

Test conditions : PROTONS
Parameter : Collector-Emitter cut-off current : ICEO_2
Vce = 5V
Unit : A
Spec Limit Max : 2.0E-09
Spec limits are represented in bold lines on the graphic.



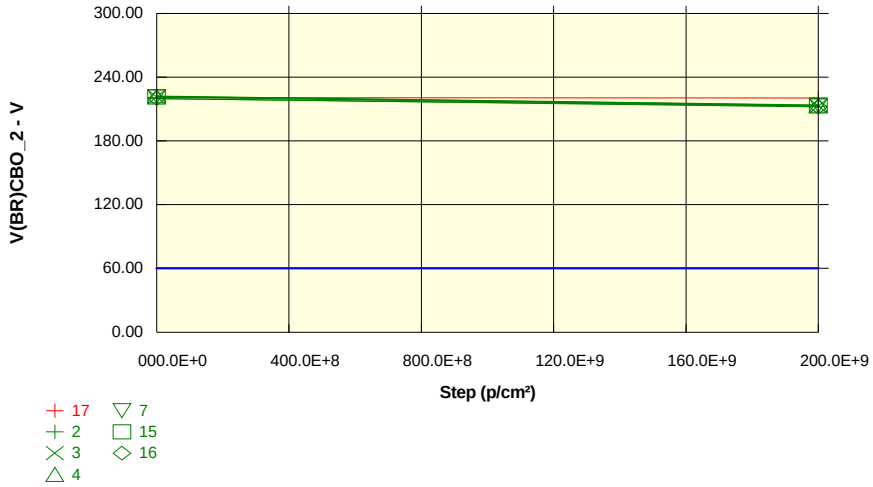
Measurements

ICEO_2	0 p/cm²	2E+11 p/cm²
17_REF	411.6E-12	560.3E-12
OFF samples		
2	371.2E-12	3.6E-09
3	258.0E-12	4.3E-09
4	437.2E-12	2.5E-09
7	440.0E-12	5.1E-09
15	542.6E-12	2.3E-09
16	307.0E-12	2.5E-09
Statistics		
Min	258.0E-12	2.3E-09
Max	542.6E-12	5.1E-09
Average	392.7E-12	3.4E-09
Sigma	93.7E-12	1.0E-09

Drift Calculation

ICEO_2	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	3.19E-09
3	-	4.05E-09
4	-	2.10E-09
7	-	4.64E-09
15	-	1.80E-09
16	-	2.22E-09
Average	-	3.00E-09
Sigma	-	1.06E-09

Test conditions : PROTONS
Parameter : Collector-Base breakdown voltage : V(BR)CBO_2
Ic = 10µA
Unit : V
Spec Limit Min : 60.00
Spec limits are represented in bold lines on the graphic.



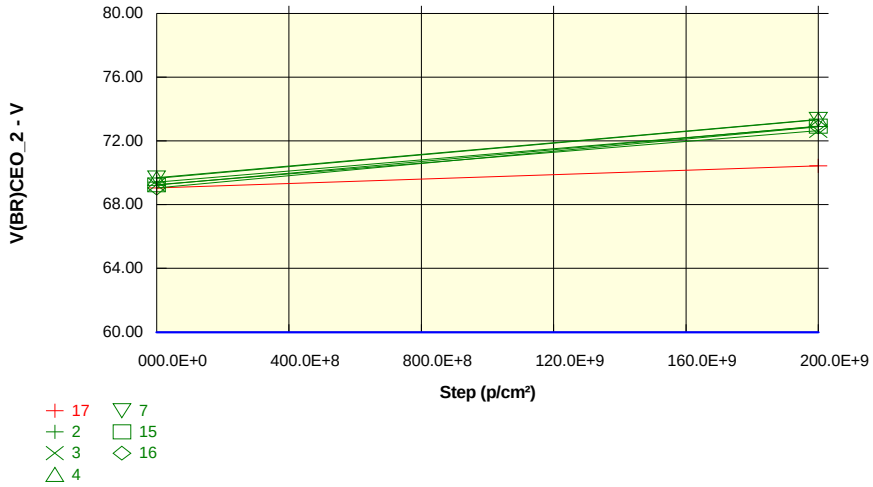
Measurements

V(BR)CBO_2	0 p/cm²	2E+11 p/cm²
17_REF	220.84	220.50
OFF samples		
2	219.97	212.81
3	221.38	213.02
4	222.36	214.04
7	221.88	213.69
15	221.32	212.90
16	219.99	212.17
Statistics		
Min	219.97	212.17
Max	222.36	214.04
Average	221.15	213.11
Sigma	0.90	0.61

Drift Calculation

V(BR)CBO_2	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	-7.16E+00
3	-	-8.36E+00
4	-	-8.32E+00
7	-	-8.19E+00
15	-	-8.42E+00
16	-	-7.82E+00
Average	-	-8.05E+00
Sigma	-	441.65E-03

Test conditions : PROTONS
Parameter : Collecor-Emitter breakdown voltage : V(BR)CEO_2
Ic = 10mA
Unit : V
Spec Limit Min : 60.00
Spec limits are represented in bold lines on the graphic.



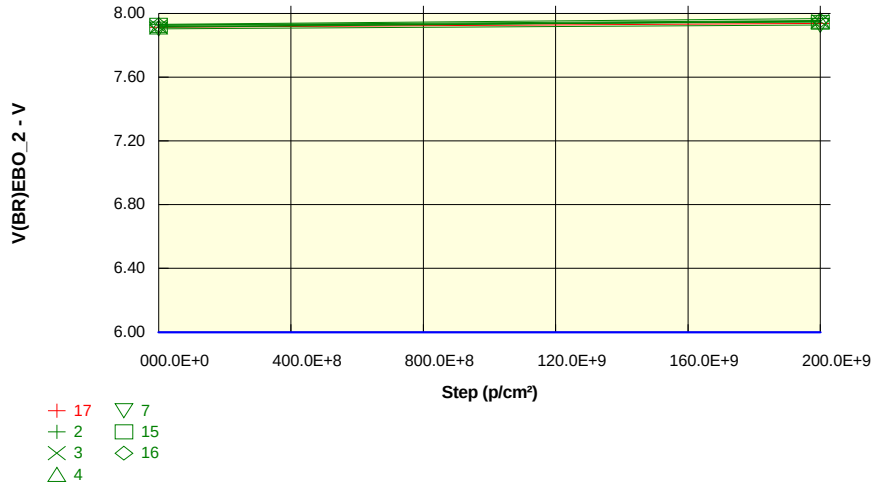
Measurements

V(BR)CEO_2	0 p/cm²	2E+11 p/cm²
17_REF	69.04	70.44
OFF samples		
2	69.43	72.92
3	69.25	72.65
4	69.66	73.34
7	69.69	73.36
15	69.24	72.93
16	69.06	72.88
Statistics		
Min	69.06	72.65
Max	69.69	73.36
Average	69.39	73.01
Sigma	0.23	0.26

Drift Calculation

V(BR)CEO_2	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	3.49E+00
3	-	3.40E+00
4	-	3.68E+00
7	-	3.67E+00
15	-	3.69E+00
16	-	3.83E+00
Average	-	3.63E+00
Sigma	-	141.79E-03

Test conditions : PROTONS
Parameter : Emitter-Base breakdown voltage : V(BR)EBO_2
Ie = 10µA
Unit : V
Spec Limit Min : 6.00
Spec limits are represented in bold lines on the graphic.



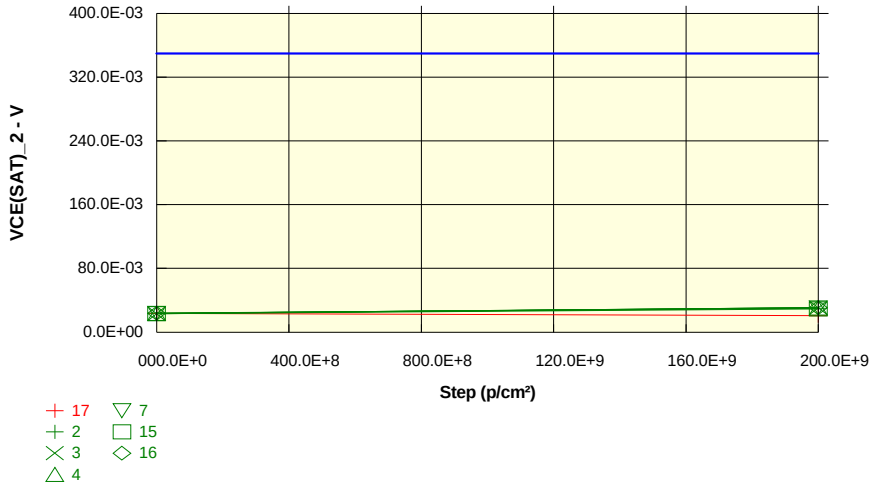
Measurements

V(BR)EBO_2	0 p/cm²	2E+11 p/cm²
17_REF	7.91	7.94
OFF samples		
2	7.93	7.97
3	7.92	7.95
4	7.91	7.95
7	7.90	7.93
15	7.93	7.95
16	7.93	7.96
Statistics		
Min	7.90	7.93
Max	7.93	7.97
Average	7.92	7.95
Sigma	0.01	0.01

Drift Calculation

V(BR)EBO_2	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	35.20E-03
3	-	33.20E-03
4	-	37.20E-03
7	-	23.20E-03
15	-	20.00E-03
16	-	28.40E-03
Average	-	29.53E-03
Sigma	-	6.28E-03

Test conditions : PROTONS
Parameter : Collector-Emitter saturation oltage : VCE(SAT)_2
Ic = 1mA ; ib = 100µA
Unit : V
Spec Limit Max : 350.0E-03
Spec limits are represented in bold lines on the graphic.



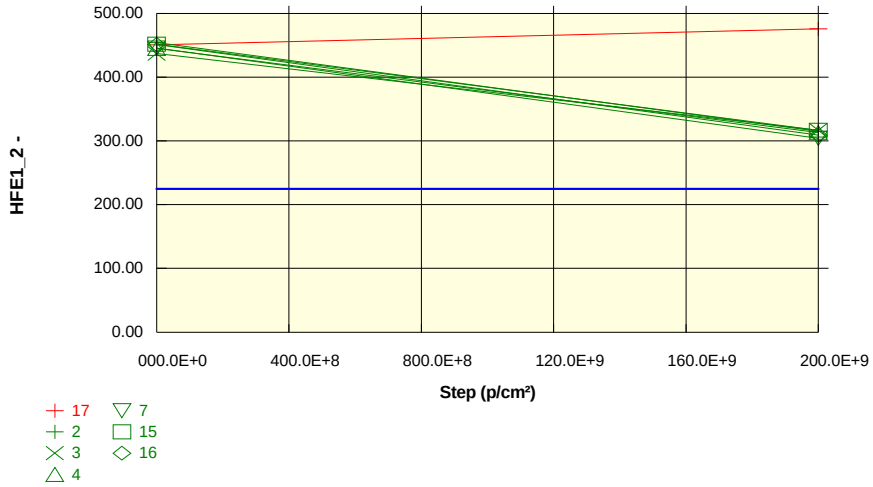
Measurements

VCE(SAT)_2	0 p/cm²	2E+11 p/cm²
17_REF	23.5E-03	20.6E-03
OFF samples		
2	24.0E-03	30.2E-03
3	23.1E-03	30.6E-03
4	23.5E-03	30.3E-03
7	23.8E-03	30.6E-03
15	23.1E-03	29.3E-03
16	23.6E-03	30.9E-03
Statistics		
Min	23.1E-03	29.3E-03
Max	24.0E-03	30.9E-03
Average	23.5E-03	30.3E-03
Sigma	310.4E-06	520.7E-06

Drift Calculation

VCE(SAT)_2	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	6.20E-03
3	-	7.52E-03
4	-	6.84E-03
7	-	6.80E-03
15	-	6.16E-03
16	-	7.32E-03
Average	-	6.81E-03
Sigma	-	509.86E-06

Test conditions : PROTONS
Parameter : DC current gain : HFE1_2
Ic = 100µA ; Vce = 5V
Unit :
Spec Limit Min : 225.00
Spec limits are represented in bold lines on the graphic.



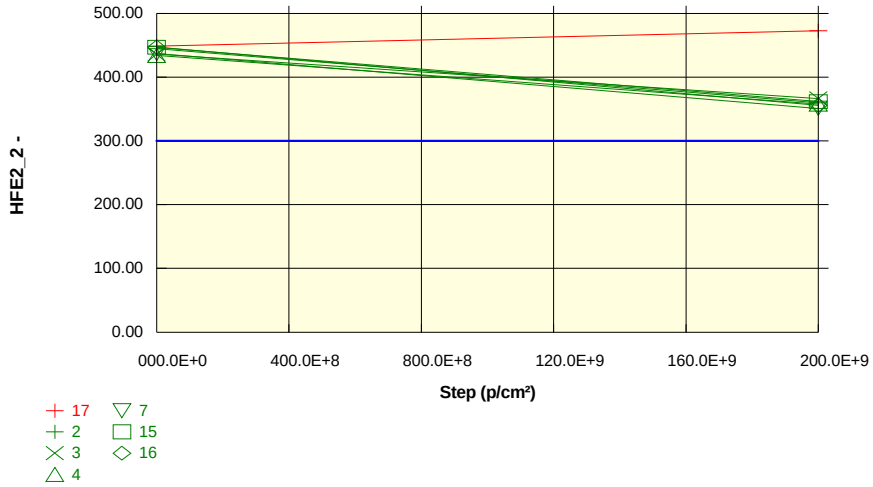
Measurements

HFE1_2	0 p/cm²	2E+11 p/cm²
17_REF	450.81	476.19
OFF samples		
2	454.34	315.45
3	437.52	316.85
4	445.39	313.63
7	446.02	304.46
15	452.01	316.86
16	451.47	309.13
Statistics		
Min	437.52	304.46
Max	454.34	316.86
Average	447.79	312.73
Sigma	5.61	4.54

Drift Calculation

HFE1_2	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	969.04E-06
3	-	870.45E-06
4	-	943.29E-06
7	-	1.04E-03
15	-	943.63E-06
16	-	1.02E-03
Average	-	964.80E-06
Sigma	-	56.13E-06

Test conditions : PROTONS
Parameter : DC current gain : HFE2_2
Ic = 1mA ; Vce = 5V
Unit :
Spec Limit Min : 300.00
Spec limits are represented in bold lines on the graphic.



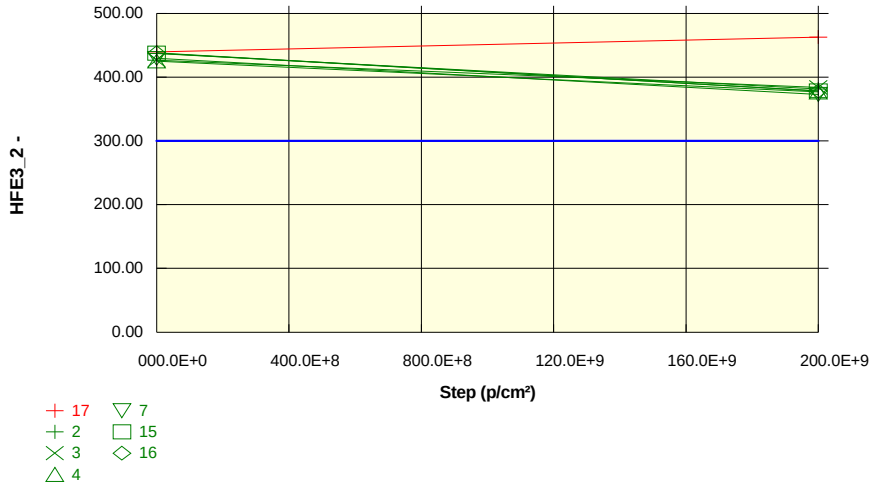
Measurements

HFE2_2	0 p/cm²	2E+11 p/cm²
17_REF	449.06	473.07
OFF samples		
2	444.97	360.13
3	436.33	366.60
4	434.60	358.06
7	437.50	351.32
15	447.05	361.92
16	447.34	356.01
Statistics		
Min	434.60	351.32
Max	447.34	366.60
Average	441.30	359.01
Sigma	5.27	4.77

Drift Calculation

HFE2_2	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	529.46E-06
3	-	435.89E-06
4	-	491.89E-06
7	-	560.72E-06
15	-	526.14E-06
16	-	573.46E-06
Average	-	519.59E-06
Sigma	-	45.66E-06

Test conditions : PROTONS
Parameter : DC current gain : HFE3_2
Ic = 5mA ; Vce = 5V
Unit :
Spec Limit Min : 300.00
Spec limits are represented in bold lines on the graphic.



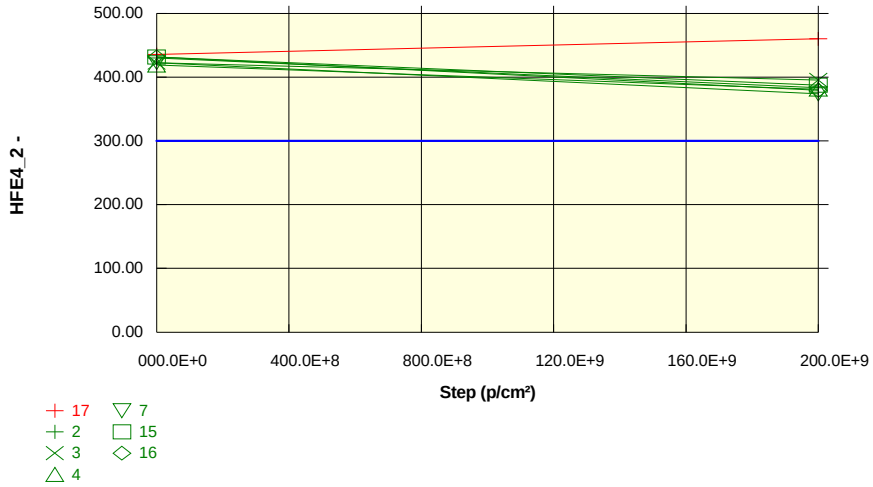
Measurements

HFE3_2	0 p/cm²	2E+11 p/cm²
17_REF	440.10	463.35
OFF samples		
2	437.49	381.63
3	427.17	384.30
4	425.55	376.93
7	429.56	372.98
15	437.88	378.88
16	438.60	378.38
Statistics		
Min	425.55	372.98
Max	438.60	384.30
Average	432.71	378.85
Sigma	5.42	3.55

Drift Calculation

HFE3_2	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	334.56E-06
3	-	261.17E-06
4	-	303.12E-06
7	-	353.11E-06
15	-	355.60E-06
16	-	362.85E-06
Average	-	328.40E-06
Sigma	-	35.90E-06

Test conditions : PROTONS
Parameter : DC current gain : HFE4_2
Ic = 10mA ; Vce = 5V
Unit :
Spec Limit Min : 300.00
Spec limits are represented in bold lines on the graphic.



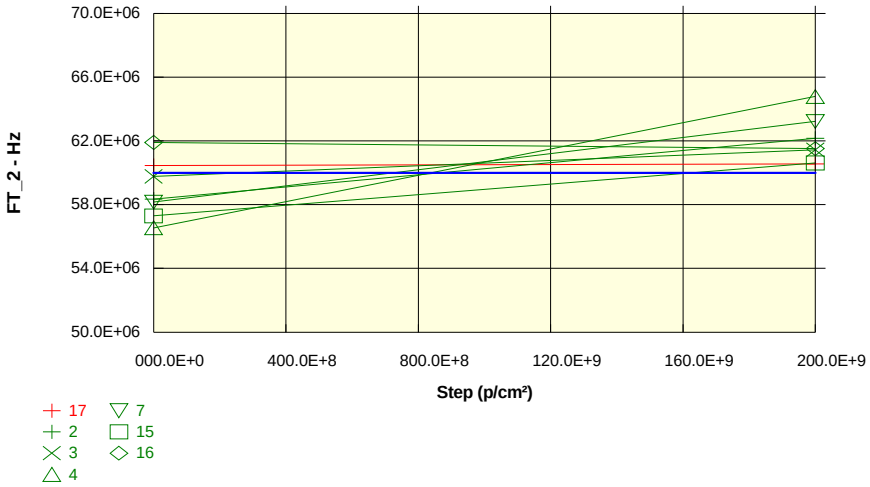
Measurements

HFE4_2	0 p/cm²	2E+11 p/cm²
17_REF	435.58	460.38
OFF samples		
2	430.39	383.77
3	423.07	395.72
4	419.18	381.44
7	423.15	374.07
15	432.02	387.56
16	431.94	379.60
Statistics		
Min	419.18	374.07
Max	432.02	395.72
Average	426.62	383.69
Sigma	5.03	6.76

Drift Calculation

HFE4_2	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	282.29E-06
3	-	163.37E-06
4	-	236.03E-06
7	-	310.06E-06
15	-	265.53E-06
16	-	319.23E-06
Average	-	262.75E-06
Sigma	-	52.29E-06

Test conditions : PROTONS
Parameter : Gain bandwidth product : FT_2
Ic = 500µA ; Vce = 5V
Unit : Hz
Spec Limit Min : 60.0E+06
Spec limits are represented in bold lines on the graphic.



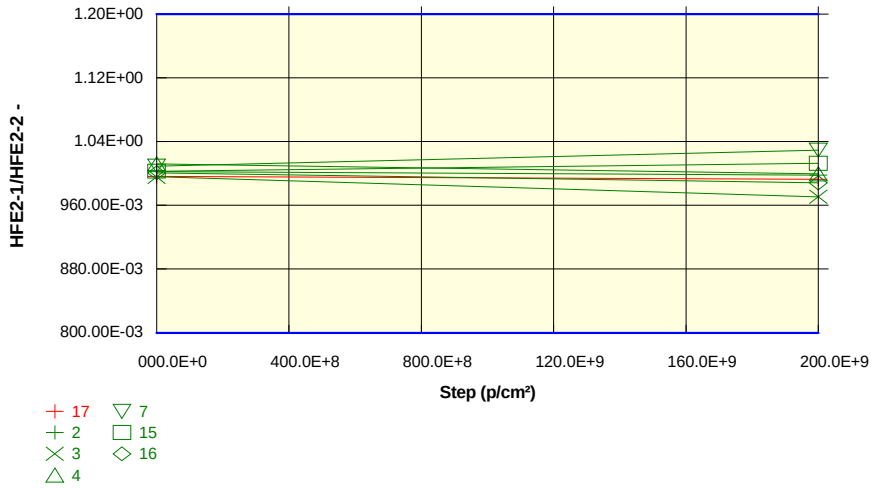
Measurements

FT_2	0 p/cm²	2E+11 p/cm²
17_REF	60.5E+06	60.6E+06
OFF samples		
2	58.4E+06	62.2E+06
3	59.8E+06	61.5E+06
4	56.5E+06	64.8E+06
7	58.2E+06	63.2E+06
15	57.3E+06	60.6E+06
16	61.9E+06	61.5E+06
Statistics		
Min	56.5E+06	60.6E+06
Max	61.9E+06	64.8E+06
Average	58.7E+06	62.3E+06
Sigma	1.8E+06	1.4E+06

Drift Calculation

FT_2	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	3.82E+06
3	-	1.67E+06
4	-	8.24E+06
7	-	5.07E+06
15	-	3.33E+06
16	-	-382.15E+03
Average	-	3.62E+06
Sigma	-	2.69E+06

Test conditions : PROTONS
Parameter : Forward current transer ratio comparison : HFE2-1/HFE2-2
Ic = 1mA ; Vce = 5V
Unit :
Spec Limit Min : 800.00E-03
Spec Limit Max : 1.20E+00
Spec limits are represented in bold lines on the graphic.



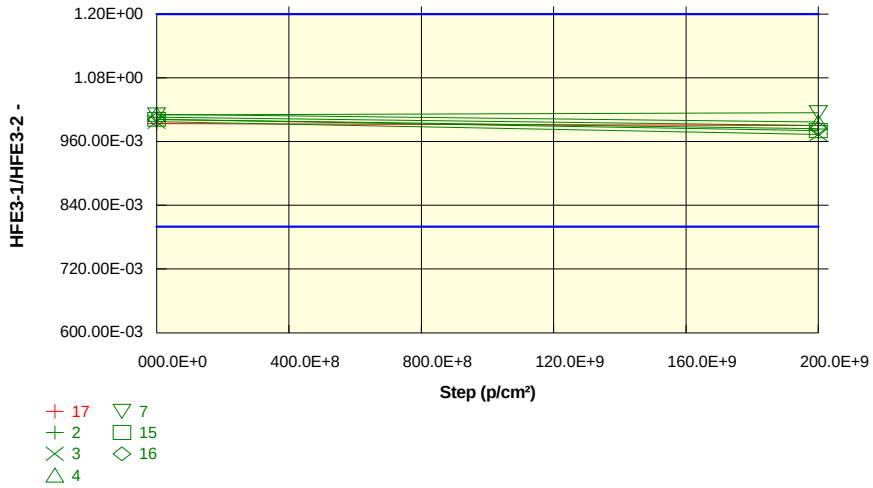
Measurements

HFE2-1/HFE2-2	0 p/cm²	2E+11 p/cm²
17_REF	996.37E-03	992.65E-03
OFF samples		
2	1.00E+00	998.20E-03
3	995.98E-03	970.90E-03
4	1.01E+00	999.61E-03
7	1.01E+00	1.03E+00
15	1.00E+00	1.01E+00
16	1.00E+00	988.38E-03
Statistics		
Min	995.98E-03	970.90E-03
Max	1.01E+00	1.03E+00
Average	1.00E+00	999.89E-03
Sigma	5.38E-03	18.33E-03

Drift Calculation

HFE2-1/HFE2-2	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	4.13E-03
3	-	25.94E-03
4	-	12.46E-03
7	-	-19.27E-03
15	-	-9.64E-03
16	-	12.67E-03
Average	-	4.38E-03
Sigma	-	15.03E-03

Test conditions : PROTONS
Parameter : Forward current transer ratio comparison : HFE3-1/HFE3-2
Ic = 5mA ; Vce = 5V
Unit :
Spec Limit Min : 800.00E-03
Spec Limit Max : 1.20E+00
Spec limits are represented in bold lines on the graphic.



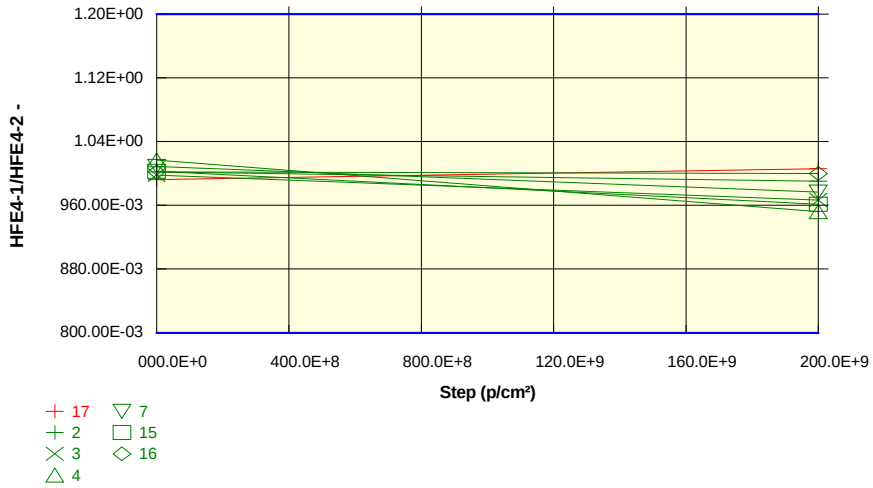
Measurements

HFE3-1/HFE3-2	0 p/cm²	2E+11 p/cm²
17_REF	993.71E-03	990.63E-03
OFF samples		
2	1.01E+00	990.78E-03
3	997.51E-03	973.94E-03
4	1.01E+00	997.00E-03
7	1.01E+00	1.01E+00
15	1.00E+00	980.80E-03
16	1.00E+00	984.30E-03
Statistics		
Min	997.51E-03	973.94E-03
Max	1.01E+00	1.01E+00
Average	1.00E+00	990.22E-03
Sigma	4.96E-03	13.06E-03

Drift Calculation

HFE3-1/HFE3-2	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	15.16E-03
3	-	24.27E-03
4	-	14.24E-03
7	-	-3.83E-03
15	-	21.56E-03
16	-	17.68E-03
Average	-	14.85E-03
Sigma	-	9.05E-03

Test conditions : PROTONS
Parameter : Forward current transer ratio comparison : HFE4-1/HFE4-2
Ic = 10mA ; Vce = 5V
Unit :
Spec Limit Min : 800.00E-03
Spec Limit Max : 1.20E+00
Spec limits are represented in bold lines on the graphic.



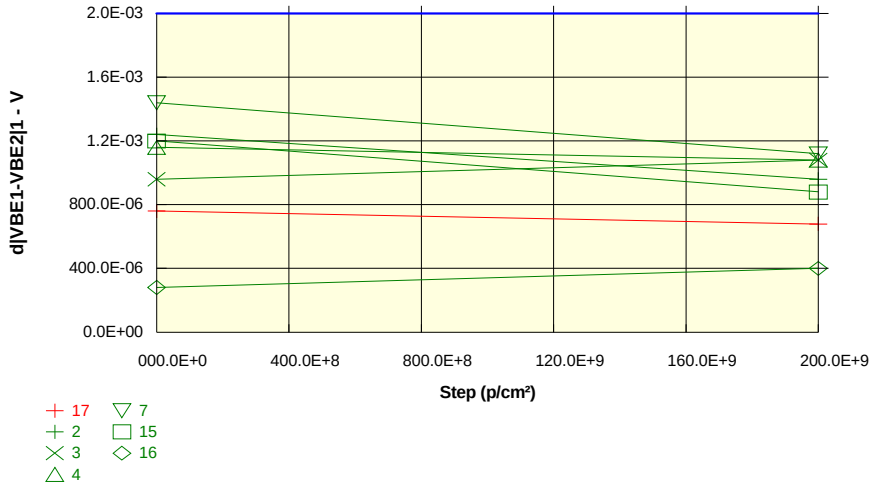
Measurements

HFE4-1/HFE4-2	0 p/cm²	2E+11 p/cm²
17_REF	992.31E-03	1.01E+00
OFF samples		
2	1.00E+00	990.32E-03
3	998.16E-03	966.67E-03
4	1.02E+00	952.11E-03
7	1.01E+00	976.82E-03
15	1.00E+00	961.39E-03
16	1.00E+00	1.00E+00
Statistics		
Min	998.16E-03	952.11E-03
Max	1.02E+00	1.00E+00
Average	1.01E+00	974.57E-03
Sigma	6.18E-03	16.56E-03

Drift Calculation

HFE4-1/HFE4-2	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	11.53E-03
3	-	32.64E-03
4	-	67.02E-03
7	-	32.38E-03
15	-	42.89E-03
16	-	2.00E-03
Average	-	31.41E-03
Sigma	-	21.07E-03

Test conditions : PROTONS
Parameter : Base-Emitter voltage differential : d|VBE1-VBE2|1
Ic = 1mA ; Vce = 5V
Unit : V
Spec Limit Max : 2.0E-03
Spec limits are represented in bold lines on the graphic.



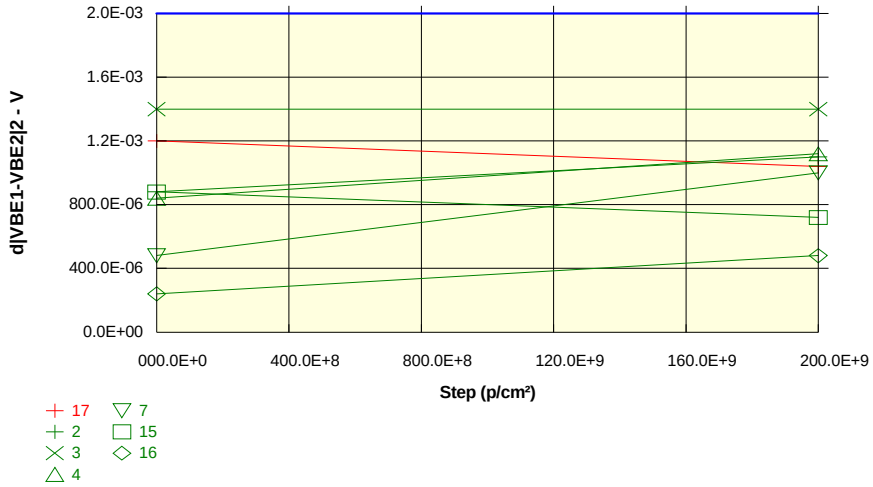
Measurements

d|VBE1-VBE2|1	0 p/cm²	2E+11 p/cm²
17_REF	760.0E-06	680.0E-06
OFF samples		
2	1.2E-03	960.1E-06
3	960.0E-06	1.1E-03
4	1.2E-03	1.1E-03
7	1.4E-03	1.1E-03
15	1.2E-03	880.0E-06
16	280.0E-06	400.0E-06
Statistics		
Min	280.0E-06	400.0E-06
Max	1.4E-03	1.1E-03
Average	1.0E-03	920.0E-06
Sigma	370.5E-06	246.6E-06

Drift Calculation

d|VBE1-VBE2|1	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	-279.95E-06
3	-	120.02E-06
4	-	-79.99E-06
7	-	-320.06E-06
15	-	-319.99E-06
16	-	119.98E-06
Average	-	-126.66E-06
Sigma	-	192.41E-06

Test conditions : PROTONS
Parameter : Base-Emitter voltage differential : d|VBE1-VBE2|2
Ic = 5mA ; Vce = 5V
Unit : V
Spec Limit Max : 2.0E-03
Spec limits are represented in bold lines on the graphic.



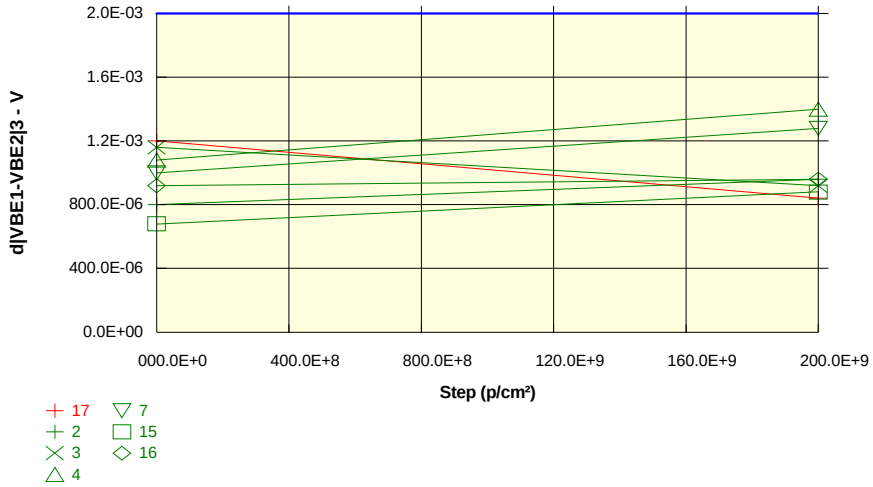
Measurements

d|VBE1-VBE2|2	0 p/cm²	2E+11 p/cm²
17_REF	1.2E-03	1.0E-03
OFF samples		
2	880.0E-06	1.1E-03
3	1.4E-03	1.4E-03
4	840.0E-06	1.1E-03
7	480.0E-06	1.0E-03
15	880.0E-06	720.0E-06
16	240.0E-06	480.0E-06
Statistics		
Min	240.0E-06	480.0E-06
Max	1.4E-03	1.4E-03
Average	786.7E-06	970.0E-06
Sigma	362.7E-06	296.6E-06

Drift Calculation

d|VBE1-VBE2|2	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	220.01E-06
3	-	-5.28E-09
4	-	279.99E-06
7	-	520.04E-06
15	-	-160.02E-06
16	-	240.03E-06
Average	-	183.34E-06
Sigma	-	215.55E-06

Test conditions : PROTONS
Parameter : Base-Emitter voltage differential : d|VBE1-VBE2|3
Ic = 10mA ; Vce = 5V
Unit : V
Spec Limit Max : 2.0E-03
Spec limits are represented in bold lines on the graphic.



Measurements

d|VBE1-VBE2|3	0 p/cm²	2E+11 p/cm²
17_REF	1.2E-03	840.0E-06
OFF samples		
2	800.0E-06	960.0E-06
3	1.2E-03	920.0E-06
4	1.1E-03	1.4E-03
7	1000.0E-06	1.3E-03
15	680.0E-06	880.0E-06
16	920.0E-06	960.0E-06
Statistics		
Min	680.0E-06	880.0E-06
Max	1.2E-03	1.4E-03
Average	940.0E-06	1.1E-03
Sigma	162.9E-06	198.2E-06

Drift Calculation

d|VBE1-VBE2|3	0 p/cm²	2E+11 p/cm²
OFF samples		
2	-	160.03E-06
3	-	-240.03E-06
4	-	319.94E-06
7	-	280.03E-06
15	-	200.03E-06
16	-	39.98E-06
Average	-	126.67E-06
Sigma	-	186.79E-06