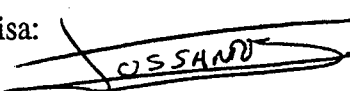
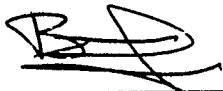
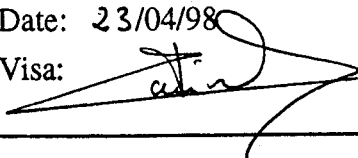


<p>MATRA MARCONI SPACE</p>	<p>Groupe Expertise Radiations</p>	<p>Ref: DOF/DEC/RP8.150 Issue: 00 Date: 17/04/98 Page: 1/11</p>
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CL-MMP-RP-0252*

TOTAL DOSE STEADY-STATE IRRADIATION
 OF
IRFM 150 (DC 9745)
POWER TRANSISTOR N-CHANNEL MOSFET
 from
INTERNATIONAL RECTIFIER

JE	HB	LB	AG	PH	CP
X				X	X
CLUSTER II		26 MEI 1998			FILE 240 CHRONO 2022
JP	CE	MS	ESOC		

Written by	Verified by	Approved by
Name: Ph. DOS SANTOS	Name: B. DOUCIN	Name: Th. CARRIERE
Date: 16/04/98	Date: 23/04/98	Date: 23/04/98
Visa: 	Visa: 	Visa: 

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ANNEX :

- **Log(Id)=f(Vg) for Sn1.**
- **Plot and table of tested parameters versus total dose and annealing.**

I. DOCUMENTATION**I.1 APPLICABLE DOCUMENTS:**

I. PRO2. 001

MATRA Procedure for Total Dose Steady-State Irradiation on Active Devices.

I.2 REFERENCE DOCUMENTS:

MIL STD 883 D., Method 1019-4

Steady State Irradiation Procedure.

ESA/SCC 22900-3

ESA Basic Specification for Total Dose Steady-State Irradiation.

DOF/DEC/TP 7.465

Test plan

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II. TEST PLAN

II.1 PARTS REFERENCES

REFERENCES	
Type:	IRFM 150
Manufacturer:	International Rectifier
Place:	USA
Packaging:	TO 254
FUNCTION	
N-channel enhancement power Mosfet Transistor	
TECHNOLOGY	
HEXFET III	
PARTS PROCUREMENT	
Origin	: MMS-UK (CLUSTER PROJECT)
Level	:
Date Code	: 9745
Wafer lot number	:
Number of Parts	: 6 (5 Irradiated + 1 Ref.)
DETAIL SPECIFICATION	
DOF/DEC/TP 7.465	

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II.2 ELECTRICAL MEASUREMENTS

TEST TYPE						
Type:	Remote electrical measurements done at room temperature					
TEST FACILITY						
Place:	MATRA VELIZY					
Material:	HP4155A / Curve Tracer Tektronix 370A					
Calibration Date:	01/97 and 02/98					
TESTED PARAMETERS						
Parameter Name	Fig n°	Symbol	Test Conditions	Min	Max	Unit
Gate Threshold Voltage	1	Vgs(th)	Id = 250µA , Vds ≥ Vgs.	2	4	V
Off-State Drain Current	2	Idss	Vds = 80V, Vgs = 0 V.	-	25	µA
Static Drain Source ON Resistance	3	Rds(on)	Vgs = 10V, Id = 20A Pulse width ≤ 300µs	-	70	mΩ
Forward Transconductance	4	GFS	Vds ≥ 15V, Id = 20A Pulse width ≤ 300µs	9	-	S

Notes:

- All electrical measurements were made within one hour of termination of the irradiation step.
- Figure numbers refer to the figures showing variation of each parameter with total dose and annealings at the end of this document.

II.3 EXPERIMENTAL CONDITIONS.

IRRADIATION FACILITY	
Place	: MATRA VELIZY (France)
Type	: Cobalt 60 Shepherd 484
Activity	: <9 Curies
Calibration Date	: January 98.
EXPOSURE TYPE	
Type:	Multiple Exposures
Steps:	0, 5, 10.1, 16.8, 23.7, 37.7, 59.3 kRad[Si] + annealing at 25°C and 100°C
BIASING CONDITIONS	
<p>The diagram shows a MOSFET circuit. A 10V DC source is connected to a 10 kOhms resistor. The other end of the resistor is connected to the Gate (G) pin of the MOSFET. The Drain (D) pin and the Source (S) pin are both connected to a common ground symbol.</p>	
COMMENTS	
<p>4 parts were biased in Static On mode, 1 part was biased in Static Off mode with all pins connected to ground.</p>	

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III TEST REPORT

III.1 EXPERIMENTAL CONDITIONS

PARTS IDENTIFICATION						
Manufacturer Marking	IR BeO 94-7489 R Δ 9745					
Serial Numbers						Control
Manuf. Marking	1	2	3	4	5	0
Biasing Mode	On	On	On	On	Off	unbiased

IRRADIATION TEST SEQUENCE						
Step n°	Date In Date Out	Description	Dose Rate kRad[Si]/h	Exp. Time h	Dose kRad[Si]	Total Dose kRad[Si]
0		Initial Elect. Measurements				
1 1a	09/03/98 11/03/98	Irradiation Electrical Meas.	0.105	47.4	5	5
2 2a	11/03/98 13/03/98	Irradiation Electrical Meas.	0.105	48.6	5.1	10.1
3 3a	13/03/98 16/03/98	Irradiation Electrical Meas.	0.105	63.5	6.7	16.8
4 4a	16/03/98 18/03/98	Irradiation Electrical Meas.	0.125	55.2	6.9	23.7
5 5a	18/03/98 23/03/98	Irradiation Electrical Meas.	0.126	110.75	14	37.7
6 6a	23/03/98 30/03/98	Irradiation Electrical Meas.	0.126	171.5	21.6	59.3
7 7a	30/03/98 31/03/98	Annealing 25° Electrical Meas.		25.3		
8 8a	31/03/98 9/04/98	Annealing 100° Electrical Meas.		210.8		

III.2 EXPERIMENTAL RESULTS

III.2.1. Parametric tests:

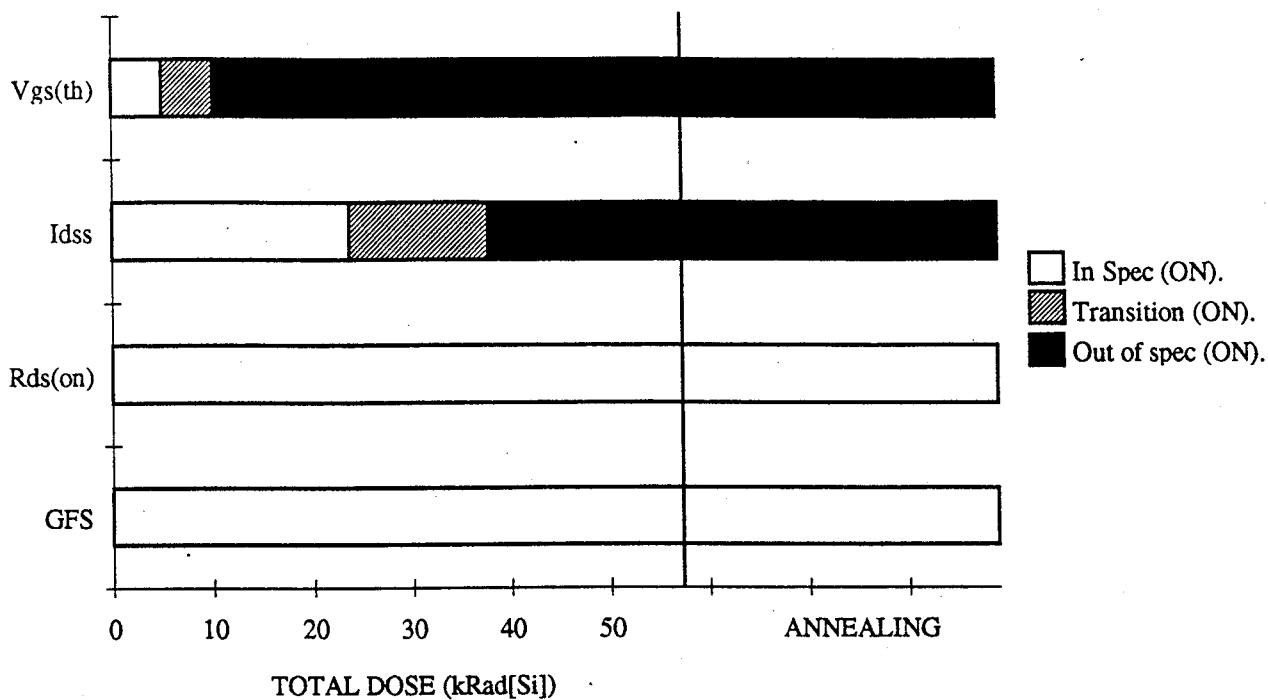
The evolution of each parameter as a function of the total dose and annealings is plotted at the end of the report.

The following table summarizes the evolution of the measured parameters with irradiation and annealings for each biasing conditions.

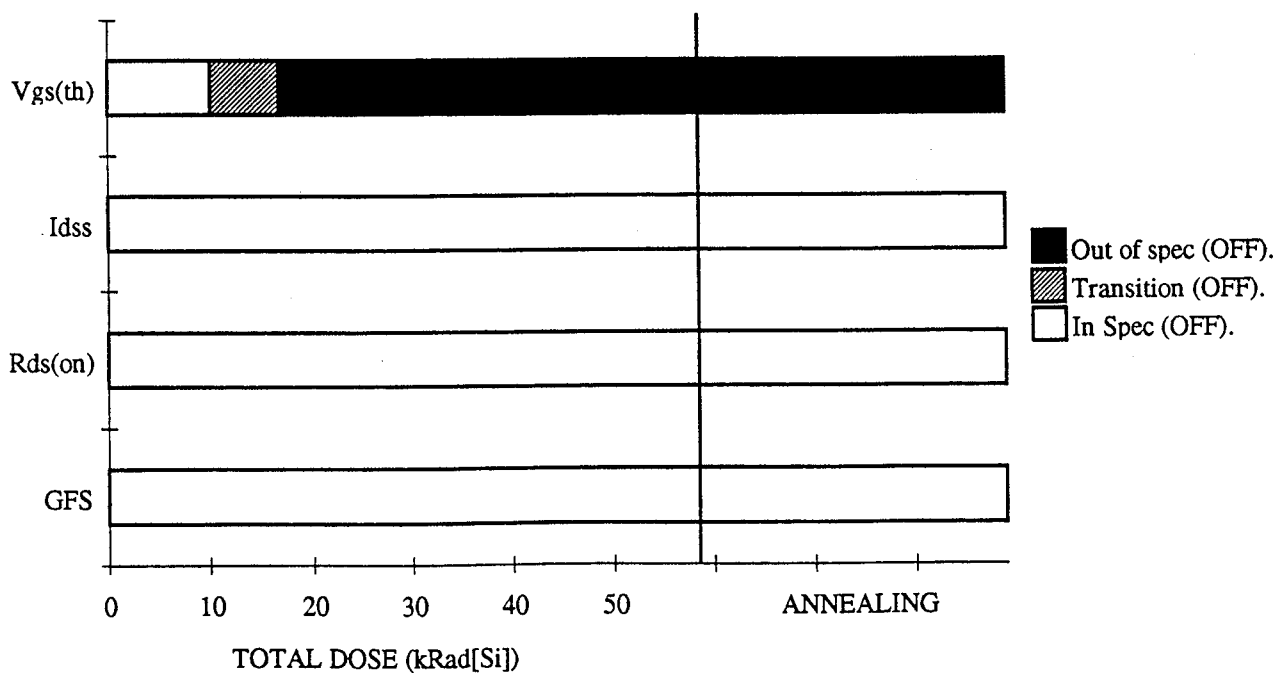
In the construction of these charts,

- 1/ A parameter is considered to be out of specification if the parameter is measured out of specification on one or more devices.
- 2/ A parameter is considered to be in specification only up to the last step for which all irradiated devices remain inside the parameter specification.
- 3/ The step during which a parameter goes out of specification (or recovers) is called transition step.

Static On Mode



Static Off Mode



III.2.2. Post irradiation effects.

Step 1 :

Temperature : Room temperature

Duration : 25h

Biasing : biased as during irradiation

Step 2 :

Temperature : 100°C

Duration : 210h

Biasing : biased as during irradiation

For parts biased in On mode : For 3 parts out of 4, parameters Vgs(th) and Idss come back to specification after 100°C annealing. One part (Sn1) exhibit a partial recovery and still remain out of specification limits after 100°C annealing.

For part biased in Off mode : Vgs parameter remains out of specification limits after 100°C annealing.

III.2.3 Problems encountered / Discussion

Evolution during irradiation of Id versus Vgs is given in annex for part 1, biased in static On mode. This characterization performed on a HP4155A permits to observe the activation of parasitic MOS transistors. As dose increases, the main parasitic transistor exhibits a strong increase of leakage current, whatever Vgs. This phenomenon is related to charge trapping in the thick isolation oxides, allowing a current track around the gate. Therefore, Vgs(th) measurement performed at 59.3 kRad is not representative of the real commutation level of the transistor which is lower than the measurement performed.

IV CONCLUSION

Total dose steady-state irradiation test using gamma rays from Cobalt 60 has been carried out on 5 (4 parts biased in Static On mode, and 1 part biased in Static Off mode) **N-Channel Power Transistors IRFM150 (DC 9745)** from **INTERNATIONAL RECTIFIER**, up to 59.3kRad at low dose rate (< 0.126 kRad/h).

The results indicates :

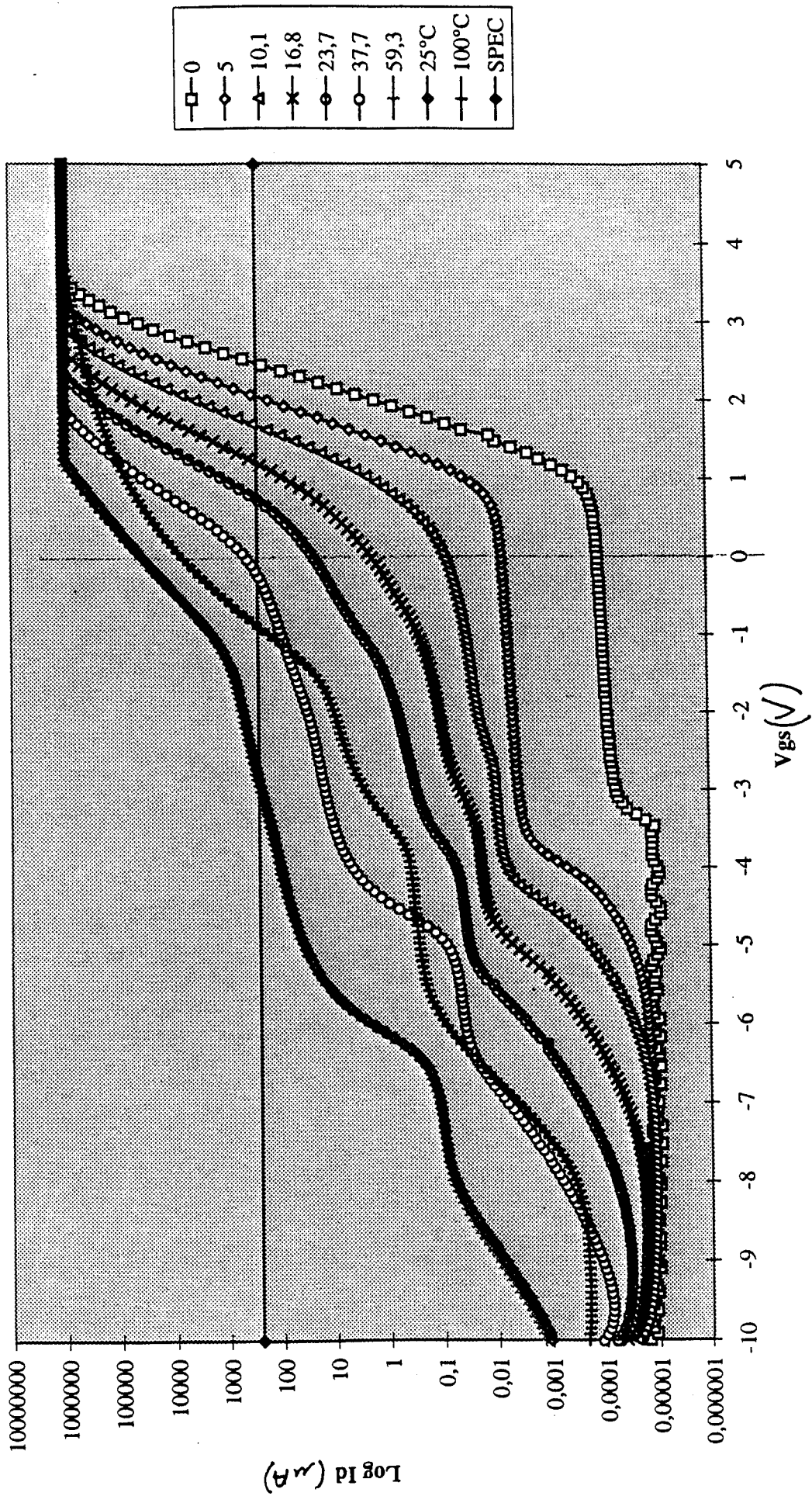
- All parts stay within specification up to 6 kRad (by interpolation with specified limits).
- Parameters affected by irradiation are :
 - Vgs(th) : Out of specification around 6 kRad.
Mean drift equals to -72mV/kRad up to ≈30kRad.
 - Idss : Out of specification around 23.7kRad. For Sn1, Idss was measured around 50mA at 59kRad.
- Degradation is less important for part biased in Static Off mode.
- One part (Sn1) degrades stronger than the others parts. The evolution of characteristic versus total dose (Log Id=f(Vgs) at Vds=10V) is plotted in annex.

A comparison with another date code from the same manufacturer is indicated on the following table :

Report Ref.	Manuf.	DC	Tolerance	Dose rate
RP8.150	IR	9745	6 kRad	<= 360Rad/h
RP7.373	IR	9629	5 kRad	<= 360Rad/h

Log Id = f(Vgs) for Sn1

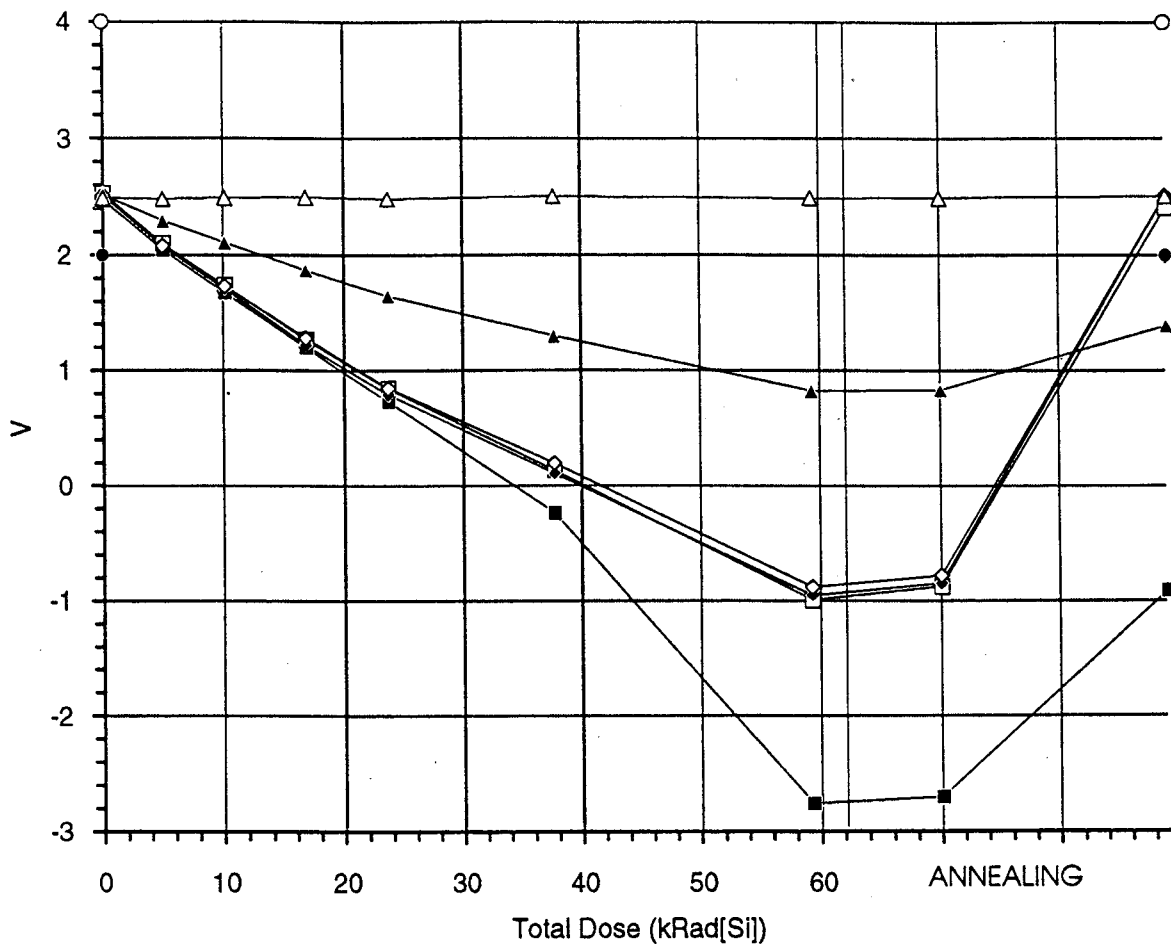
$V_{DS} = 10V$.



Total Dose Radiation Testing

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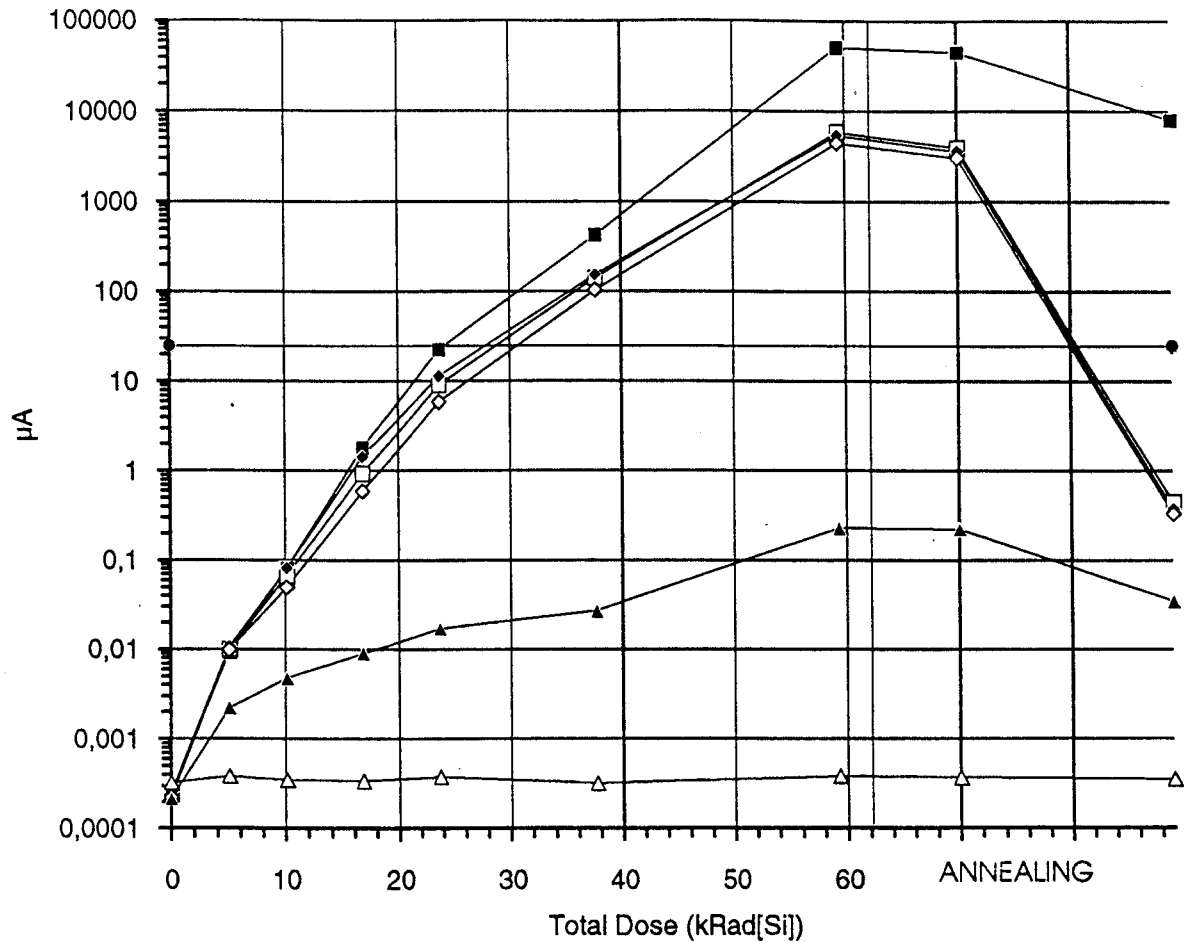
Date:	March 98		Figure	1
Component	Type:	IRFM 150	Date Code:	9745
			Manufacturer:	INTERNATIONAL RECTIFIER
Irradiation	Dose Rate:	<= 0.36 kRad/h.	Irradiation Conditions: Static On (Sn 1 to 4), Off(Sn5).	
Test	Parameter:	Vgs(th)	Test conditions: Vds> Vgs, Id =250 µA.	



Comments: The last two points correspond to the post annealing measurements.

Dose		0	5	10,1	16,8	23,7	37,7	59,3	25°C	100°C				
1 (On)	—■—	2,474	2,048	1,677	1,200	0,735	-0,232	-2,754	-2,700	-0,910				
2 (On)	—□—	2,532	2,099	1,737	1,275	0,847	0,135	-0,989	-0,876	2,408				
3 (On)	—●—	2,531	2,082	1,707	1,224	0,795	0,106	-0,954	-0,845	2,508				
4 (On)	—◇—	2,511	2,081	1,731	1,286	0,852	0,199	-0,877	-0,776	2,510				
5 (Off)	—▲—	2,515	2,298	2,111	1,871	1,648	1,299	0,826	0,831	1,394				
Mean(Ref)	—△—	2,497	2,486	2,496	2,499	2,486	2,505	2,488	2,493	2,506				
Spec(Min)	—●—	2								2				
Spec(Max)	—○—	4								4				

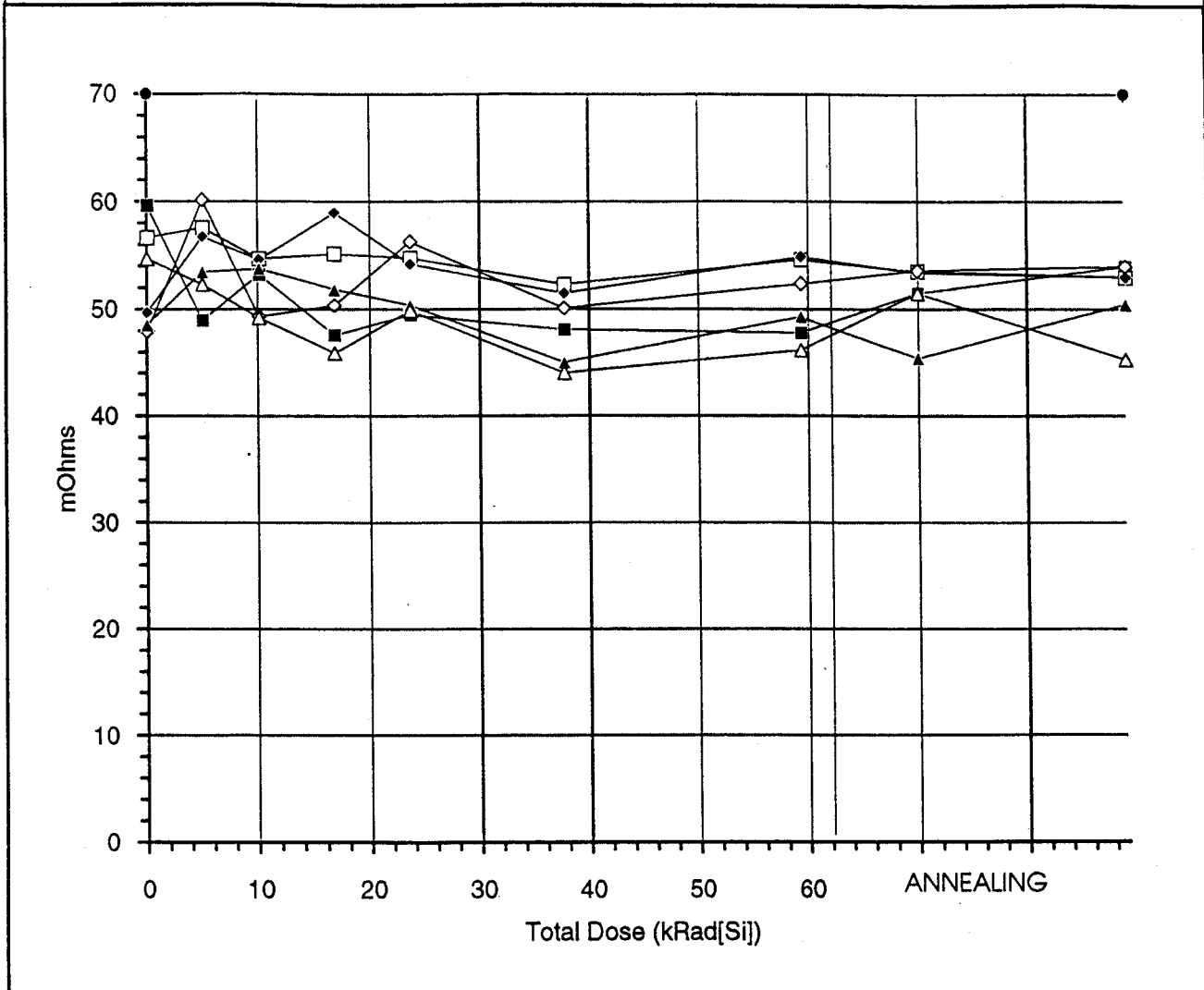
Date:	March 98	Figure	2
Component	Type: IRFM 150	Date Code: 9745	Manufacturer: INTERNATIONAL RECTIFIER
Irradiation	Dose Rate: <= 0.36 kRad/h.	Irradiation Conditions: Static On (Sn 1 to 4), Off(Sn5).	
Test	Parameter: Idss	Test conditions: Vgs=0V, Vds=80V.	



Comments: The last two points correspond to the post annealing measurements.

Dose		0	5	10,1	16,8	23,7	37,7	59,3	25°C	100°C				
1 (On)	—■—	3E-04	0,0093	0,081	1,819	22,36	422,4	51622	45310	8153				
2 (On)	—□—	2E-04	0,0101	0,067	0,944	9,031	141,7	5976	3971	0,455				
3 (On)	—◆—	3E-04	0,0108	0,081	1,442	11,36	153,5	5434	3630	0,38				
4 (On)	—◇—	2E-04	0,01	0,049	0,598	5,864	103,8	4460	3058	0,334				
5 (Off)	—▲—	2E-04	0,0022	0,005	0,009	0,017	0,027	0,231	0,223	0,035				
Mean(Ref)	—△—	3E-04	0,0004	4E-04	3E-04	4E-04	3E-04	4E-04	4E-04	4E-04				
Spec(Max)	—●—	25								25				

Date: March 98		Figure 3	
Component	Type: IRFM 150	Date Code: 9745	Manufacturer: INTERNATIONAL RECTIFIER
Irradiation	Dose Rate: <= 0.36 kRad/h.	Irradiation Conditions: Static On(Sn1 to 4), Off(Sn5).	
Test	Parameter: Rds(on)	Test conditions: Vgs=10V, Id=20A.	



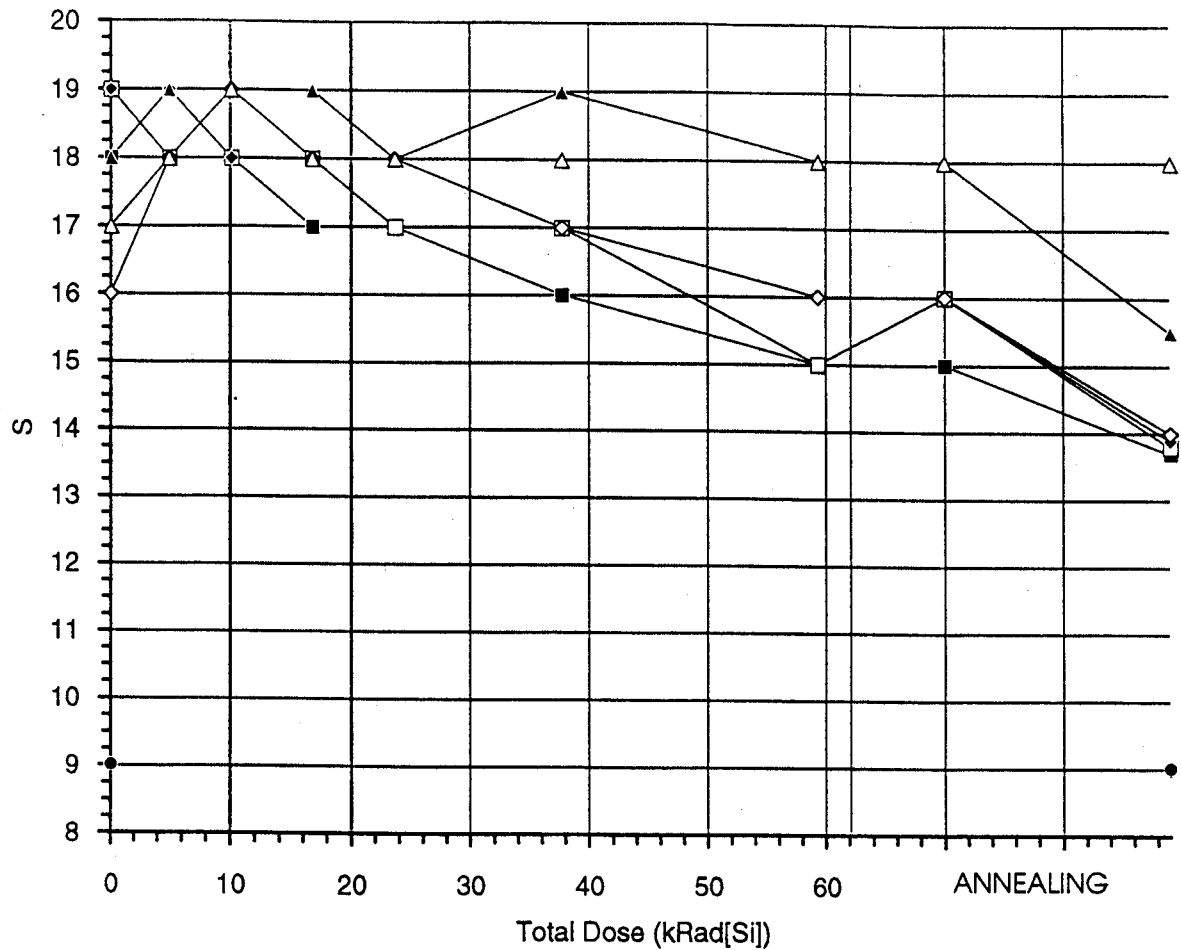
Comments: The last two points correspond to the post annealing measurements.

Dose		0	5	10,1	16,8	23,7	37,7	59,3	25°C	100°C				
1 (On)	■	59,70	49,00	53,20	47,60	49,50	48,10	47,80	51,50	54,00				
2 (On)	□	56,70	57,60	54,70	55,20	54,80	52,30	54,60	53,50	53,00				
3 (On)	◆	49,70	56,80	54,60	59,00	54,20	51,50	54,90	53,40	53,00				
4 (On)	◇	48,00	60,20	49,30	50,40	56,30	50,10	52,40	53,60	54,00				
5 (Off)	▲	48,60	53,50	53,80	51,90	50,40	45,00	49,30	45,40	50,50				
Mean(Ref)	△	54,70	52,30	49,20	45,90	49,90	44,00	46,20	51,50	45,30				
Spec(Max)	●	70								70				

Total Dose Radiation Testing

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Date: March 98		Figure 4	
Component	Type: IRFM 150	Date Code: 9745	Manufacturer: INTERNATIONAL RECTIFIER
Irradiation	Dose Rate: <= 0.36 kRad/h.	Irradiation Conditions: Static On(Sn1 to 4), Off(Sn5).	
Test	Parameter: GFS	Test conditions: Vds=15V, Id=20A.	



Comments: The last two points correspond to the post annealing measurements.

Dose		0	5	10,1	16,8	23,7	37,7	59,3	25°C	100°C				
1 (On)	—■—	18	18	18	17	17	16	15	15	14				
2 (On)	—□—	19	18	18	18	17	17	15	16	14				
3 (On)	—◆—	19	19	18	18	18	17	16	16	14				
4 (On)	—◇—	16	18	19	18	18	17	16	16	14				
5 (Off)	—▲—	18	19	19	19	18	19	18	18	16				
Mean(Ref)	—△—	17	18	19	18	18	18	18	18	18				
Spec(Min)	—●—	9								9				