RADIATION TEST SUMMARY

PART TYPE : 2N7236

DESCRIPTION : P-CHANNEL MOSFET

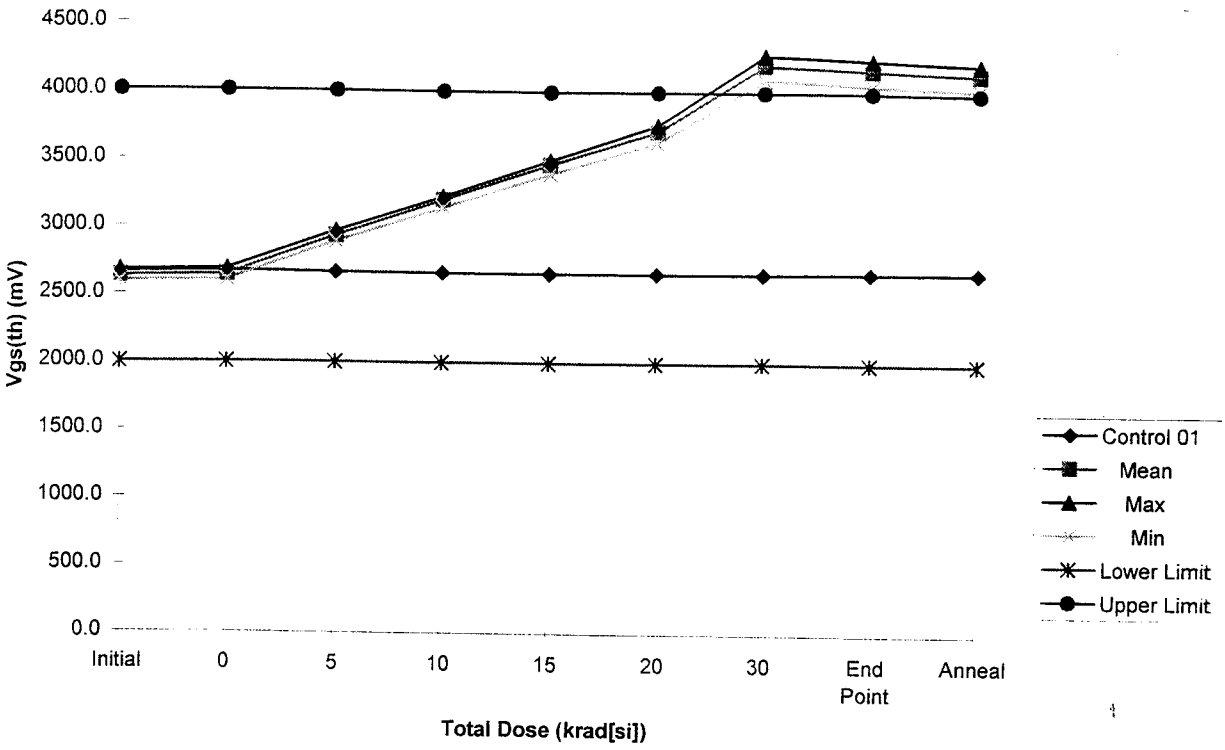
REPORT NO. : RD 209

PARAMETERS PLOTTED :

VGS(th)

NOTE : The results for the remaining parameters showed no significant change and hence plots were not considered necessary.

Radiation Results for Vgs(th)



Dose (kRad)	Control 01	Mean	Max	Min	Lower Limit	Upper Limit	Std.Dev.
	(mV)	(mV)	(mV)	(mV)	(mV)	(mV)	
Initial	2662.6	2630.6	2673.7	2595.3	2000	4000	32.73
0	2668.6	2639.6	2684.1	2601.2	2000	4000	34.88
5	2660.2	2929.7	2964.0	2886.3	2000	4000	32.71
10	2660.1	3199.6	3222.9	3141.7	2000	4000	38.77
15	2657.7	3466.7	3497.9	3397.1	2000	4000	47.62
20	2659.4	3712.4	3758.3	3630.9	2000	4000	58.02
30	2656.5	4204.4	4277.7	4097.3	2000	4000	81.16
End Point	2666.4	4169.0	4243.3	4055.6	2000	4000	84.69
Anneal	2672.4	4144.3	4217.8	4030.6	2000	4000	85.92

Lot size for statistics : 4 devices

RD 209 Date code 9616

ENVISAT-1 RD209 RIR 73542	IRRADIATION TEST PLAN NO. PO-PL-IGG-PL-0027 1	Issue No. 1 Date: OCTOBER 1995 Page: 1/4 2	Rev. NA Date: NA

Component No. JANS2N7236 3	Component Designation: TRANSISTOR, MOSFET, P-CHANNEL, POWER TYPE 2N7236 4	Irradiation Spec No. NA Iss. Rev. 5

Specifications Generic MIL-S-19500 Iss. J Detail MIL-S-19500/595 Iss. A 6	Acceptance Evaluation ___ Element Diffusion ___ Lot X 7	Electrical Measurements In-situ ___ Remote X 8	Project/Programme ENVISAT-1 9

Manufacturer: Name: Int. Rectifier Address: Hurst Green, Oxted Surrey, England 10	Test Facility: Name: ERA Address: LEATHERHEAD, SURREY ENGLAND 11	Originator: IGG CT Name: S THACKER 12

Radiation Source COBALT 60 13	Sample Size: 4 Control Device: 1 (Each Test) 14	Exposure Single ___ Multiple X 15	Annealing Test YES X NO ___ 16	Radiation Level: See Below 17

Single Exposure
Dose [Krad(Si)]
Dose Rate [rad(Si)/s]
Exposure Time

Not applicable 18

Multiple Exposure:

Irradiation Steps	In accordance with the applicable Appendix to this Plan for each test.
Dose [Krad(Si)]	
Dose Rate [rad(Si)/s]	
Exposure Time(s)	

19

Bias Requirements: During and after Exposure (for remote Electrical Measurements): YES

Bias Conditions:
Test Circuits: The Electrical Bias circuit is given in Figure 1 in the applicable Appendix to this Plan.

Shielding: Shielding is required to minimize dose enhancement effects caused by low energy, scattered radiation. The test units shall be enclosed in a Pb/Al container of Pb 1.5mm minimum, surrounding on inner shield of 0.7 to 1.0mm Al. 20

Irradiation Test Sequence(applied for each radiation test per the applicable Appendix to this plan). 21

Test Step	Description	Requirements
1	Irradiation Test Samples Selection	Quantity 5 devices shall be selected from the lot delivered to IGG.
2	Serialisation	Serialisation - (if the devices are not already serialised) Test units shall be serialised 1 to 4 and the control unit shall be 5.
3	Initial Electrical Measurements (at IGG)	Per Table A herein - (Read-and-Record) - on all 5 parts at IGG. (See Remarks 1 and 2).
4	Initial Electrical Measurements (at ERA)	Per Table A herein - (Read-and-Record) - on all 5 parts at ERA. (See Remarks 1 and 2).
5	Set-up of Test	Verify Bias Circuit and Voltages (In-situ) for 4 test units.

Irradiation Test Sequence (Cont.) 21

Test Step	Description	Requirements
6	Irradiation Exposure	Verify radiation dose rate and position in the chamber to achieve required dose. Verify and witness duration of exposure to achieve required dose.
7	Intermediate Electrical Measurement (at ERA)	Bias to be maintained until test is performed. Test per Table A herein - (Read-and-Record) - on all 5 parts. Test to be performed immediately upon removal from chamber (less than 10 mins interval). Upon completion of test 4 test units shall be replaced in bias circuit and returned to chamber. Maximum interval between two consecutive exposures to be 30 mins. (See Remark 2).
8 to 7 + 3n	Repeat Set-up/Exposure/Test sequence upto a Final Total Dose as per the applicable Appendix	Repeat Steps 5, 6, 7 for a total of n cycles (see applicable Appendix). (See Remark 3)
8 + 3n	End Point Electrical Measurements (at IGG)	Per Table A herein - (Read-and-Record) - on all 5 parts at IGG. (See Remarks 2 and 4).
9 + 3n	Annealing	Bias shall be maintained during Annealing for 4 test units. Annealing shall be at room temperature for 168 hours.
10 + 3n	Final Electrical Measurements (at IGG)	Per Table A herein - (Read-and-Record) - on all 5 parts at IGG (See Remark 2).
11 + 3n	Total Dose Irradiation Test Report	ESA/SCC No. 22900

Remarks 22

1. The initial electrical measurements performed at IGG (Test Step 3) shall be performed within 24 hours of the initial electrical measurements at ERA (Test Step 4).
2. All electrical testing shall be performed on the same set of equipment in order to achieve correlation of results both at IGG and ERA. All results plus details of any failures shall be advised to Project.
3. The set-up/exposure/test sequence shall be stopped for any device that exhibits repeated functional failure.
4. The End Point electrical measurements (Test Step 8 + 3n) performed at IGG shall be performed within 24 hours of the last electrical measurement at ERA (Test Step 7 + 3n).

TABLE A - ELECTRICAL MEASUREMENTS AT ROOM TEMPERATURE - T_{amb} = +25 ±5°C BEFORE, AT INTERMEDIATE POINTS, AND ON COMPLETION OF IRRADIATION.

NO.	CHARACTERISTICS	SYMBOL	MIL-STD-750 TEST METHOD	TEST CONDITIONS	LIMITS		UNIT
					MIN.	MAX.	
1	Breakdown Voltage Drain to Source	BV_{DSS}	3407 Bias Cond. C	I_D = -1.0mAdc V_{GS} = 0	-100	-	Vdc
2	Gate Threshold Voltage	$V_{GS(th)}$	3403	V_{DS} = V_{GS} I_D = -0.25mAdc	-2.0	-4.0	Vdc
3	Gate Current	I_{GSS}	3411 Bias Cond. C	V_{GS} = -20Vdc V_{DS} = 0	-	-100	nAdc
4	Drain Current	I_{DSS}	3413 Bias Cond C	V_{DS} = -80Vdc V_{GS} = 0	-	25	µAdc
5	Drain Source ON Resistance 1	$r_{DS(ON)1}$	3421	V_{GS} = -10Vdc I_D = -11Adc (Notes 2 and 3)	-	0.20	Ω
6	Drain Source ON Resistance 2	$r_{DS(ON)2}$	3421	V_{GS} = -10Vdc I_D = -18Adc (Notes 2 and 3)	-	0.22	Ω

NOTES

1. The limits specified in this Table only apply to the first intermediate electrical measurements at dose 5Krad(Si). For all other intermediate, end point and final electrical measurements, these limits shall not apply but the tests shall be performed and the result recorded for information and characterisation purposes.

   Parametric failures to the limits given in this Table could possibly occur at any irradiation level greater than 5Krad(Si).

2. Pulsed: Pulse Width $\leq$ 300uS, Duty Cycle $\leq$2%.

3. Measured within 2mm of case.

This appendix defines the specific radiation test requirements applicable to the following ENVISAT-1 user(s):-

USER CODE	USER COMMENT
MWCESC	Ref. N/A

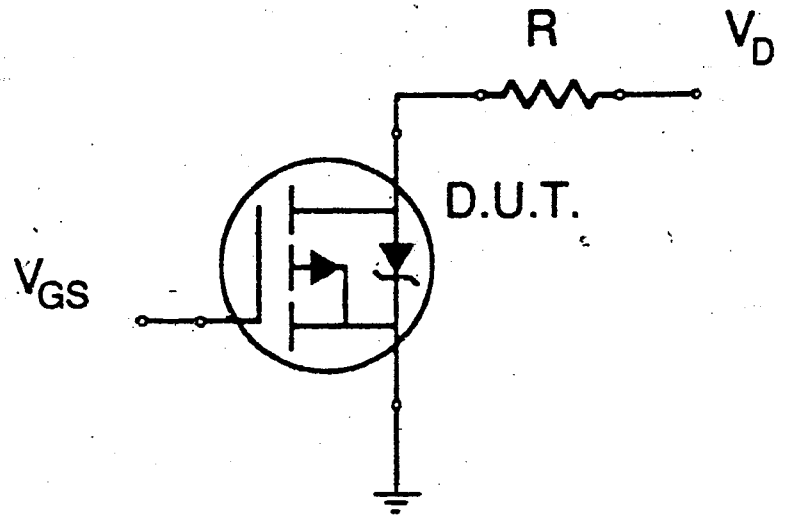
The following specific requirements shall apply:-

a) MULTIPLE EXPOSURE/IRRADIATION STEPS:

Irradiation Steps (n)	1	2	3	4	5
Dose [Krad(Si)]	5	5	5	5	10
Accumulated Dose[Krad(Si)]	5	10	15	20	30
Dose Rate [rad(Si)/s] (See note)	3	3	3	3	3
Exposure Time(s) (See note)	1667	1667	1667	1667	~~1667~~ 3333

Note: The dose rates and exposure times given are nominal conditions and may be adjusted during irradiation testing to achieve convenient test points. The actual dose rate shall not exceed 3rad(Si)/s. The dose rates and exposure times used during the testing shall be recorded for each test step.

b) ELECTRICAL BIAS CIRCUIT FOR IRRADIATION TESTING:-



NOTES: i) Bias conditions V_{GS} = -10Vdc, V_D = -30Vdc

ii) R = 300Ω ± 1% to give I_D = -100mAdc

SZ-TESTSYSTEME Statistics 03 Vers. 2.15 for TA07F
RD209_2N7236_INIT_EMS_@_I66 / V1.0 15/8/96 PAR

Results file : RD209_2N7236_INIT_EMS_@_I66 from: 28.10.96 / 10:00:30
Operator : PAUL RUSSELL
Part number : 2N7236
Lot number : RD209
Order number : D/C 9618
Vendor : IR
: CONTROL S/No 01 ; RAD SAMPLE S/NoS 3,5,7,9.
: INITIAL EMS @ I66
: 2N7236 PO-PL-IGG-0027 ISS 1 / V1.0 15/8/96 PAR

Test steps

1.	-V(BR)DSS		100.0	...	700.0	V
2.	-VGS		2000.0	...	4000.0	mV
3.	-IGSS (FWD)	(	0.0	). . .	100.0	nA
4.	-IGSS (REV)	(	0.0	). . .	100.0	nA
5.	-IDSS	(	0.0	). . .	25.0	uA
6.	RDS on.	(	0.000	). . .	0.200	Ohm
7.	RDS on	(	0.000	). . .	0.220	Ohm

	1	3	5	7	9
1.1 [V]	123.6	124.2	124.4	124.0	125.1
2.1 [mV]	2662.6	2685.3	2673.7	2620.4	2632.8
3.1 [nA]	1.5	1.2	1.2	1.8	1.3
4.1 [nA]	1.3	1.1	1.1	1.6	1.3
5.1 [uA]	0.0	0.0	0.0	0.0	0.0
6.1 [Ohm]	0.123	0.123	0.124	0.128	0.129
7.1 [Ohm]	0.125	0.125	0.125	0.130	0.131

IR7 IRGTSYSTEME Statistics 03 Vers. 2.15 for TA07F
RD209_2N7236_INIT_EMS_@_ERA / V1.0 15/8/96 PAR

Results file : RD209_2N7236_INIT_EMS_@_ERA from: 30.10.96 / 08:31:22
Operator : PAUL RUSSELL
Part number : 2N7236
Lot number : RD209
Order number : D/C 9618
Vendor : IR
: CONTROL S/No 01 ; RAD SAMPLE S/NoS 3,5,7,9.
: INITIAL EMS @ ERA
: 2N7236 PO-PL-IGG-PL-0027 ISS 1 / V1.0 15/8/96 PAR

Test steps

1.	-V(BR)DSS		100.0	700.0	V
2.	-VGS		2000.0	4000.0	mV
3.	-IGSS (FWD)	(	0.0	100.0	nA
4.	-IGSS (REV)	(	0.0	100.0	nA
5.	-IDSS	(	0.0	25.0	uA
6.	RDS on	(	0.000	0.200	Ohm
7.	RDS on	(	0.000	0.220	Ohm

	1	3	5	7	9
1.1 [V]	123.3	123.3	124.0	123.6	124.8
2.1 [mV]	2668.6	2601.2	2684.1	2627.1	2645.9
3.1 [mA]	1.3	1.3	1.3	1.3	1.3
4.1 [mA]	1.2	1.2	1.2	1.2	1.2
5.1 [uA]	0.0	0.0	0.0	0.0	0.0
6.1 [Ohm]	0.121	0.120	0.120	0.125	0.125
7.1 [Ohm]	0.122	0.122	0.123	0.127	0.128

```
OZ-TESTSYSTEME  Statistics 03   Vers. 2.15  for TA07F
RD209_2N7236_EMS_@_5_KRAD          / V1.0 15/8/96 PAR
================================================================================
Results file    : RD209_2N7236_EMS_@_5_KRAD   from: 30.10.96 / 10:03:12
Operator        : PAUL RUSSELL
Part number     : 2N7236
Lot number      : RD209
Order number    : D/C 9610
Vendor          : IR
                : CONTROL S/No 01 ; RAD SAMPLE S/NoS 3,5,7,9
                : EMS @ 5 KRAD
                : 2N7238 PO-PL-IGG-PL-0027 ISS 1 / V1.0 15/8/96 PAR
--------------------------------------------------------------------------------
Test steps

  1. -V(BR)DSS                          100.0     ...     700.0     V
  2. -VGS                              2000.0     ...    4000.0     mV
  3. -IGSS (FWD)                  (      0.0    )...     100.0     nA
  4. -IGSS (REV)                  (      0.0    )...     100.0     nA
  5. -IDSS                        (      0.0    )...      25.0     uA
  6.  RDS on                      (      0.000  )...       0.200   Ohm
  7.  RDS on                      (      0.000  )...       0.220   Ohm
--------------------------------------------------------------------------------
```

	1	3	5	7	9
1.1 [V]	123.5	123.2	123.8	123.4	124.7
2.1 [mV]	2660.2	2886.3	2864.0	2926.7	2941.6
3.1 [mA]	1.4	1.4	1.4	1.3	1.4
4.1 [mA]	1.3	1.3	1.3	1.3	1.3
5.1 [uA]	0.0	0.0	0.0	0.1	0.1
6.1 [Ohm]	0.123	0.117	0.120	0.125	0.126
7.1 [Ohm]	0.125	0.119	0.122	0.128	0.129

```
SZ-TESTSYSTEME  Statistics 03   Vers. 2.15  for TA07F
RD209_2N7236_EMS_@_10_KRAD        / V1.0 15/8/96 PAR
================================================================================
Results file    : RD209_2N7236_EMS_@_10_KRAD   from: 30.10.96 / 10:07:35
Operator        : PAUL RUSSELL
Part number     : 2N7236
Lot number      : RD209
Order number    : D/C 9616
Vendor          : IR
                : CONTROL S/No 01 ; RAD SAMPLE S/NoS 3,5,7,9
                : EMS @ 10 KRAD
                : 2N7236 PO-PL-IGG-PL-0027 ISS 1 / V1.0 15/8/96 PAR
--------------------------------------------------------------------------------
Test steps

  1. -V(BR)DSS                          100.0    ...     700.0     V
  2. -VGS                              2000.0    ...    4000.0     mV
  3. -IGSS (FWD)                  (      0.0    )...     100.0     nA
  4. -IGSS (REV)                  (      0.0    )...     100.0     nA
  5. -IDSS                        (      0.0    )...      25.0     uA
  6.  RDS on                      (      0.000  )...       0.200   Ohm
  7.  RDG on                      (      0.000  )...       0.220   Ohm
--------------------------------------------------------------------------------
```

	1	3	5	7	9
1.1 [V]	123.8	123.3	124.1	123.7	124.9
2.1 [mV]	2660.1	3141.7	3222.9	3214.4	3219.5
3.1 [mA]	1.4	1.4	1.5	1.5	1.5
4.1 [mA]	1.3	1.2	1.3	1.4	1.3
5.1 [uA]	0.0	0.3	0.2	0.6	0.5
6.1 [Ohm]	0.124	0.119	0.122	0.128	0.129
7.1 [Ohm]	0.126	0.121	0.125	0.131	0.132

```
OZ-TESTSYSTEME  Statistics 03   Vers. 2.15  for TA07F
RD209_2N7236_EMS_@_15_KRAD        / V1.0 15/8/96 PAR
================================================================================
Results file    : RD209_2N7236_EMS_@_15_KRAD   from: 30.10.96 / 10:38:57
Operator        : PAUL RUSSELL
Part number     : 2N7236
Lot number      : RD209
Order number    : D/C 9616
Vendor          : IR
                : CONTROL S/No 01 ; RAD SAMPLE S/NoS 3,5,7,9,
                : EMS @ 15 KRAD
                : 2N7236 PO-PL-IGG-PL-0027 ISS 1 / V1.0 15/8/96 PAR
--------------------------------------------------------------------------------
Test steps

  1. -V(BR)DSS                          100.0    ...     700.0     V
  2. -VGS                              2000.0    ...    4000.0     mV
  3. -IGSS (FWD)                  (       0.0   )...     100.0     nA
  4. -IGSS (REV)                  (       0.0   )...     100.0     nA
  5. -IDSS                        (       0.0   )...      25.0     uA
  6.  RDS on                      (       0.000 )...       0.200   Ohm
  7.  RDS on                      (       0.000 )...       0.220   Ohm
--------------------------------------------------------------------------------
```

	1	3	5	7	9
1.1 [V]	123.9	123.3	124.0	123.7	125.0
2.1 [mV]	2657.7	3397.1	3474.5	3487.1	3487.9
3.1 [mA]	1.6	1.6	1.6	1.6	1.6
4.1 [mA]	1.5	1.5	1.5	1.5	1.5
5.1 [uA]	0.0	0.7	0.6	1.2	1.1
6.1 [Ohm]	0.126	0.120	0.125	0.130	0.131
7.1 [Ohm]	0.128	0.123	0.127	0.134	0.135

```
97 TESTSYSTEME  Statistics 03    Vers. 2.15  for TA07F
RD209_2N7236_EMS_@_20_KRAD          / V1.0 15/8/96 PAR
================================================================================
Results file    : RD209_2N7236_EMS_@_20_KRAD    from: 30.10.96 / 11:23:20
Operator        : PAUL RUSSELL
Part number     : 2N7236
Lot number      : RD209
Order number    : D/C 9616
Vendor          : IR
                : CONTROL S/No 01 ; RAD SAMPLE S/NoS 3,5,7,9.
                : EMS @ 20 KRAD
                : 2N7236 PO-PL-IGG-PL-0027 ISS 1 / V1.0 15/8/96 PAR
--------------------------------------------------------------------------------
Test steps

  1. -V(BR)DSS                          100.0     ...      700.0     V
  2. -VGS                              2000.0     ...     4000.0     mV
  3. -IGSS (FWD)                  (      0.0    )...      100.0     nA
  4. -IGSS (REV)                  (      0.0    )...      100.0     nA
  5. -IDSS                        (      0.0    )...       25.0     uA
  6.  RDS on                      (      0.000  )...        0.200   Ohm
  7.  RDS on                      (      0.000  )...        0.220   Ohm
--------------------------------------------------------------------------------
```

	1	3	5	7	9
1,1 [V]	123.7	123.3	124.1	123.7	124.9
2,1 [mV]	2658.4	3630.8	3711.1	3758.3	3748.1
3,1 [nA]	1.5	1.5	1.5	1.5	1.5
4,1 [nA]	1.4	1.4	1.4	1.4	1.4
5,1 [uA]	0.0	1.0	1.0	1.5	1.5
6,1 [Ohm]	0.124	0.121	0.126	0.131	0.132
7,1 [Ohm]	0.126	0.124	0.129	0.135	0.136

```
SZ-TESTSYSTEME  Statistics 03   Vers. 2.15  for TA07F
RD209_2N7236_EMS_@_30_KRAD        / V1.0 15/8/96 PAR
================================================================================
Results file    : RD209_2N7236_EMS_@_30_KRAD   from: 30.10.96 / 11:38:30
Operator        : PAUL RUSSELL
Part number     : 2N7236
Lot number      : RD209
Order number    : D/C 9616
Vendor          : IR
                : CONTROL S/No 01 ; RAD SAMPLE S/NoS 3,5,7,9
                : EMS @ 30 KRAD
                : 2N7236 PO-PL-IGG-PL-0027 ISS 1 / V1.0 15/8/96 PAR
--------------------------------------------------------------------------------
Test steps

  1. -V(BR)DSS                          100.0     ...     700.0     V
  2. -VGS                              2000.0     ...    4000.0     mV
  3. -IGSS (FWD)                  (      0.0    )...     100.0     nA
  4. -IGSS (REV)                  (      0.0    )...     100.0     nA
  5. -IDSS                        (      0.0    )...      25.0     uA
  6.  RDS on                      (      0.000  )...       0.200   Ohm
  7.  RDS on                      (      0.000  )...       0.220   Ohm
--------------------------------------------------------------------------------
```

	1	3	5	7	9
1.1 [V]	123.8	123.3	124.1	123.6	125.0
2.1 [mV]	2656.5	4087.3 F	4186.8 F	4277.7 F	4255.5 F
3.1 [nA]	1.7	1.5	1.6	1.6	1.6
4.1 [nA]	1.6	1.4	1.5	1.5	1.5
5.1 [uA]	0.0	1.6	1.6	2.3	2.2
6.1 [Ohm]	0.125	0.125	0.129	0.136	0.137
7.1 [Ohm]	0.127	0.128	0.133	0.140	0.142

GZ-TESTSYSTEME Statistics 03 Vers. 2.15 for TA07F
RD209_2N7236_END_POINT_EMS / V1.0 15/8/96 PAR

Results file : RD209_2N7236_END_POINT_EMS from: 31.10.96 / 13:30:23
Operator : PAUL RUSSELL
Part number : 2N7236
Lot number : RD209
Order number : D/C 9616
Vendor : IR
: CONTROL S/No 01 ; RAD SAMPLE S/NoS 3,5,7,9
: END POINT EMS
: 2N7236 PO-PL-I66-PL-0027 ISS 1 / V1.0 15/8/96 PAR

Test steps

1.	-V(BR)DSS		100.0	700.0	V
2.	-VGS		2000.0	4000.0	mV
3.	-IGSS (FWD)	(	0.0	100.0	nA
4.	-IGSS (REV)	(	0.0	100.0	nA
5.	-IDSS	(	0.0	25.0	uA
6.	RDS on	(	0.000	0.200	Ohm
7.	RDS on	(	0.000	0.220	Ohm

	1	3	5	7	9
1.1 [V]	123.5	124.0	124.1	123.7	125.0
2.1 [mV]	2666.4	4055.6 F	4154.1 F	4243.3 F	4223.0 F
3.1 [mA]	0.2	0.3	0.3	0.2	0.3
4.1 [mA]	0.2	0.3	0.3	0.3	0.3
5.1 [uA]	0.0	2.1	1.6	2.2	2.1
6.1 [Ohm]	0.122	0.129	0.131	0.136	0.130
7.1 [Ohm]	0.124	0.133	0.135	0.141	0.143

SZ-TESTSYSTEME Statistics 03 Vers. 2.15 for TA07F
RD209_2N7236_POST_ANNEAL_EMS / V1.0 15/8/96 PAR

Results file : RD209_2N7236_POST_ANNEAL_EMS from: 08.11.96 / 14:24:04
Operator : PAUL RUSSELL
Part number : 2N7236
Lot number : RD209
Order number : D/C 9616
Vendor : IR
: CONTROL S/No 01 ; RAD SAMPLE S/NoS 3,5,7,9
: POST ANNEAL EMS
: 2N7236 PO-PL-I66-PL-0027 ISS 1 / V1.0 15/8/96 PAR

Test steps

1.	-V(BR)DSS		100.0	...	700.0	V
2.	-VGS		2000.0	...	4000.0	mV
3.	-IGSS (FWD)	(	0.0	)...	100.0	nA
4.	-IGSS (REV)	(	0.0	)...	100.0	nA
5.	-IDSS	(	0.0	)...	25.0	uA
6.	RDS on	(	0.000	)...	0.200	Ohm
7.	RDS on	(	0.000	)...	0.220	Ohm

	1	3	5	7	9
1.1 [V]	123.4	123.9	124.1	123.6	124.9
2.1 [mV]	2672.4	4030.6 F	4125.7 F	4217.8 F	4203.2 F
3.1 [nA]	1.6	1.6	1.6	1.6	1.6
4.1 [nA]	1.5	1.5	1.5	1.5	1.5
5.1 [uA]	0.0	2.1	1.6	2.2	2.0
6.1 [Ohm]	0.121	0.130	0.131	0.137	0.138
7.1 [Ohm]	0.123	0.133	0.135	0.142	0.143