

Total dose radiation and electrical testing of 2N2907A bipolar transistors

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Title	Total dose radiation and electrical testing of 2N2907A bipolar transistors
Customer	Die Devices
Customer reference	SS1387
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1 Introduction

Die Devices has contracted Radtest Ltd (“Radtest”) to undertake the electrical and total dose radiation testing of a set of 2N2907A bipolar transistors. This report describes the samples and the test procedure and summarises the results.

2 Reference documents

The following documents form part of and shall be read in conjunction with this report. The relevant issues shall be those in effect on the date of issue of this document.

- RD1 Radtest Ltd quotation reference DIE0124, dated 22 January 2024;
- RD2 Die Devices purchase order number SS1387;
- RD3 ESCC basic specification no. 22900, issue 5, “Total dose steady-state irradiation test method”, June 2016;
- RD4 Mil-Std-883, method 1019.9, “Ionizing Radiation (Total Dose) Test Procedure”;
- RD5 “Total dose test plan for 2N2907A bipolar transistors for Die Devices”, Radtest Ltd test plan reference REP572, issue 2, dated 16/02/2024;
- RD6 “PNP transistor bare die, 2N2907A”, Die Devices data sheet rev. 1.0, dated 02/09/17.

3 Description of the components to be tested

Manufacturer’s designation: 2N2907A
Manufacturer’s name: Die Devices
Manufacturer’s address: Trafalgar House, Tharston Industrial Estate, Norwich, NR15 2PD
Package designation: TO-39
Component family: bipolar transistor
Component group: PNP transistor
Component designation: 2N2907A
Generic test specification number: N/A
Detail test specification number: N/A
Datasheet reference: RD6

Sample size: five biased, five unbiased and one control sample
Wafer lot identification: 7GHW-7309 Wafer # 4
Date code: 2415

3.1 PACKAGE PREPARATION

Figs. 1 shows the package and the labelling on the outside of the packaged samples, as received. Individual sample serial numbers were scribed onto each package prior to irradiation. No package preparation is required for total dose testing.



Fig. 1: set of samples

3.2 FUNCTIONAL DESCRIPTION OF THE SAMPLES

The 2N2907A is a low power PNP bipolar transistor.

3.3 SAMPLE DISPOSITION

Table 1 shows the selection of samples for the irradiation.

Sample number	To be used for
1	Control
2	Biased
3	Biased
4	Biased
5	Biased
6	Biased
7	Unbiased
8	Unbiased
9	Unbiased
10	Unbiased
11	Unbiased

Table 1: disposition of the test samples

4 Parameters measured

The following measurements were made, as listed in table 2. The DUTs were powered by low noise, ripple-free, Agilent B1500A SMUs during the measurements. All measurements were made to an accuracy of $\pm 1\%$ or better.

Parameter	Test conditions
$V_{BR(CBO)}$	$I_C = -10\mu A$
$V_{BR(CEO)}$	$I_C = -10mA$
$V_{BR(EBO)}$	$I_E = -10\mu A$
I_{CBO}	$V_{CB} = -50V$
I_{EBO}	$V_{EB} = -4V$
I_{CEX}	$V_{CE} = -30V, V_{EB} = -0.5V$
$V_{CE(sat)}$ pulsed	$I_B = -15mA, I_C = -150mA$ $I_B = -50mA, I_C = -500mA$
$V_{BE(sat)}$ pulsed	$I_B = -15mA, I_C = -150mA$ $I_B = -50mA, I_C = -500mA$
hFE	$V_{CE} = -10V, I_C = -0.1mA$ $V_{CE} = -10V, I_C = -1mA$ $V_{CE} = -10V, I_C = -10mA$ $V_{CE} = -10V, I_C = -150mA$ pulsed $V_{CE} = -10V, I_C = -500mA$ pulsed

Table 2: list of electrical parameters measured

5 Test conditions and hardware

5.1 TEST CONDITIONS

Electrical testing was undertaken before irradiation and after each of six dose steps and two annealing stages, as listed in table 3. This test was carried out with electrical measurements conducted in the not in-flux manner. Electrical bias was removed from the samples and the samples were transported on the bias board between the irradiation facility and the measurement facility and back again for the next irradiation.

5.2 BIAS CONDITIONS DURING IRRADIATION

The custom bias board comprised ten individual sockets, as shown in fig. 2. Samples 2 to 6 were irradiated under the electrical bias condition shown in fig. 3 ('biased on'). Samples 7 to 11 were irradiated with their leads electrically shorted together ('biased off').

The supply voltage and current were monitored at intervals of one minute during irradiation. No deviations were observed.

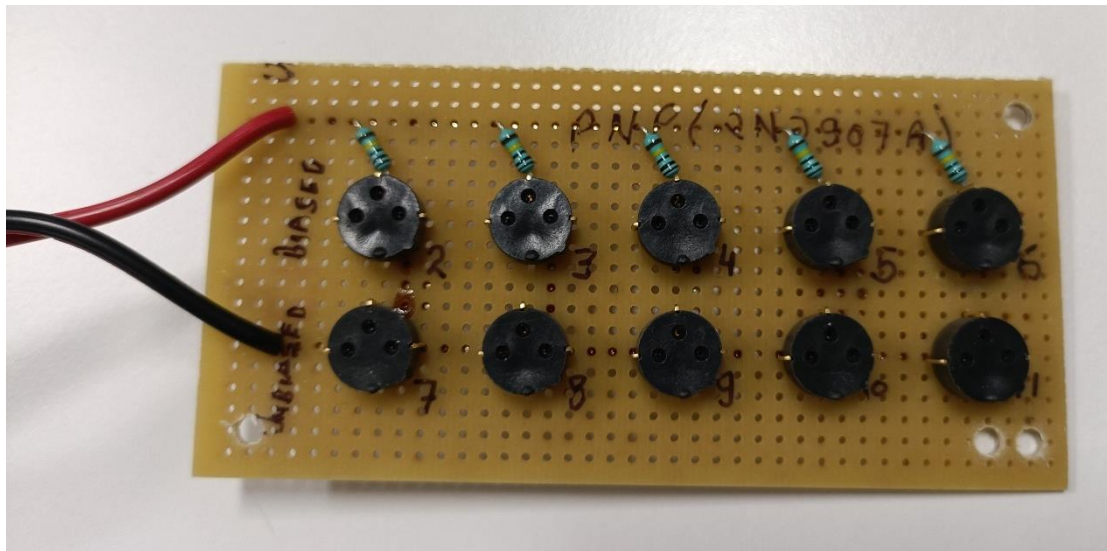


Fig. 2: the bias board used for this work

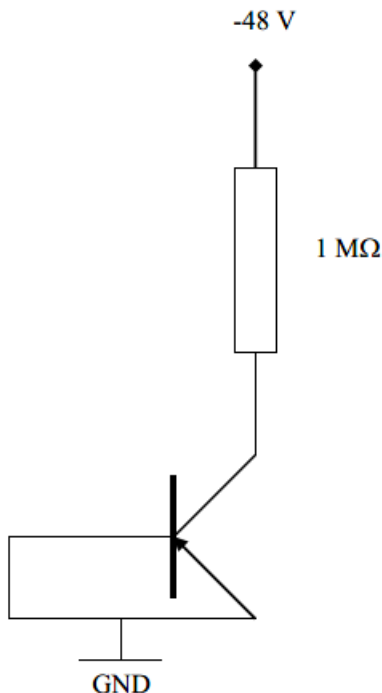


Fig. 2: bias arrangement during irradiation

5.3 POST-IRRADIATION PROCEDURE

In accordance with RD3, the time between the end of an irradiation and the start of the electrical measurements was no more than one hour. The time to perform the electrical measurements and to return the devices for the subsequent irradiation, if any, was no more than two hours from the end of the previous irradiation.

The sequence of electrical measurements was the same for each set of measurements made.

5.4 TEST INSTRUMENTATION

Table 3 lists the test instruments used during the work and provides details of their calibration status.

Code	Manufacturer	Description	Serial no	Date last calibrated	Date next calibration due
DS01	PTW	Unidos E dosemeter	1250	16/09/2022	16/09/2024
DS03	PTW	TN31010 ion chamber	5937	14/09/2022	14/09/2024
ET01	Agilent	B1500A parameter analyser	JP49320110	07/03/2024	07/03/2025
ET34	Lufft	Opus 20 barometer	169.0314.0802.022	27/06/2023	27/06/2024

Table 3: list of calibrated instruments used for the work.

6 Radiation environment

6.1 RADIATION SOURCE

MRC Cell 4 at Harwell was used for the irradiation. This facility is fitted with four cobalt-60 sources emitting gamma radiation with a mean energy of 1.25MeV/photon. All four sources were used for this work.

6.2 DOSIMETRY

The dose rate was determined by measurements with a TN31010-1 ionisation chamber, manufactured by PTW and allocated the reference number DS03 in Radtest's calibration register, in conjunction with a Unidos E reader, reference number DS01. These measurements were made on 14 March 2024.

6.3 RADIATION DOSE STEPS

Table 4 lists the start and end times for each irradiation and both annealing stages. All irradiations were carried out on 20 March 2024.

Level	Dose step (krad[Si])	Start date/time	End date/time
1	1	20/03/24 07:45:00	20/03/24 07:45:17
2	10	20/03/24 09:31:22	20/03/24 09:34:20
3	25	20/03/24 11:01:30	20/03/24 11:06:22
4	40	20/03/24 12:35:00	20/03/24 12:39:52
5	50	20/03/24 14:16:00	20/03/24 14:19:15
6	100	20/03/24 15:34:30	20/03/24 15:50:43

Table 4: radiation test levels and times

6.4 RADIATION DOSE RATE

The measured dose rate was 2.07 kGy[H₂O]/hr, with an uncertainty of $\pm 10\%$. This dose rate was converted to silicon as a reference material by multiplying by a factor of 0.916, giving a dose rate of 1.90 kGy[Si]/hr or 190 krad[Si]/hr.

The irradiation sequence covered a period of less than 24 hours and so no correction for the decay of the radioisotope was applied.

7 Results

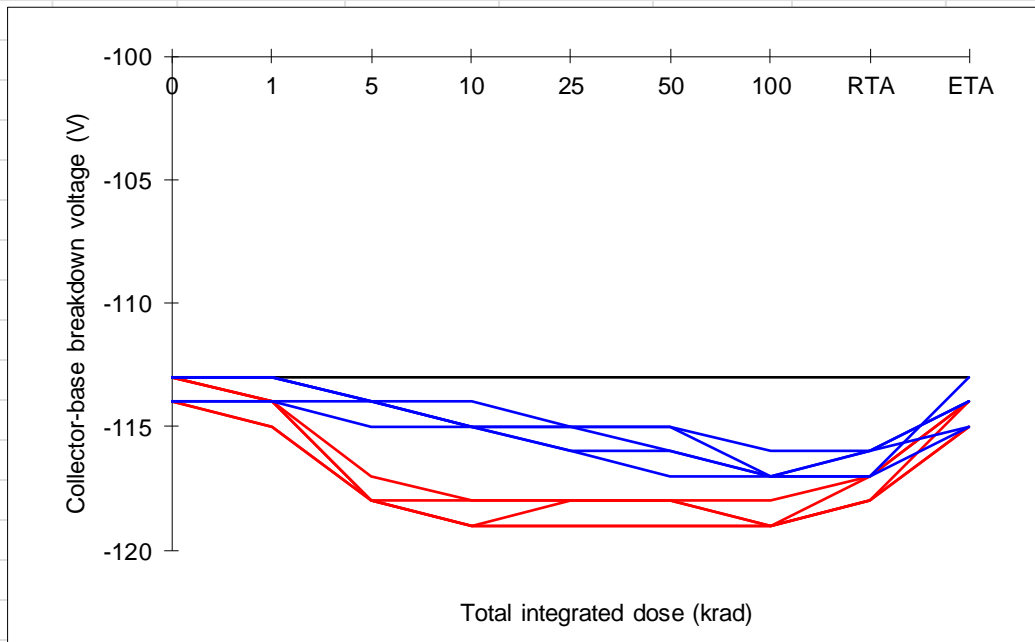
The results are presented firstly as graphs of each parameter, with data for each test sample at each dose step. Data for the control samples are indicated by a black line. Data for the irradiated samples are shown as red ('biased on') or blue ('biased off') lines.

Secondly, the results are presented in tabular format, with the measured data from each dose step shown as an individual table page.

For all of the parameters except gain, at no point during the work did any of the test samples show a measurement result that fell outside of the specification limits. For gain, there were some out of specification measurement results after 100krad and the room temperature anneal for collector current values of 0.1 (two samples) and 1mA (one sample). However, these all recovered to be back within specification after the elevated temperature anneal.

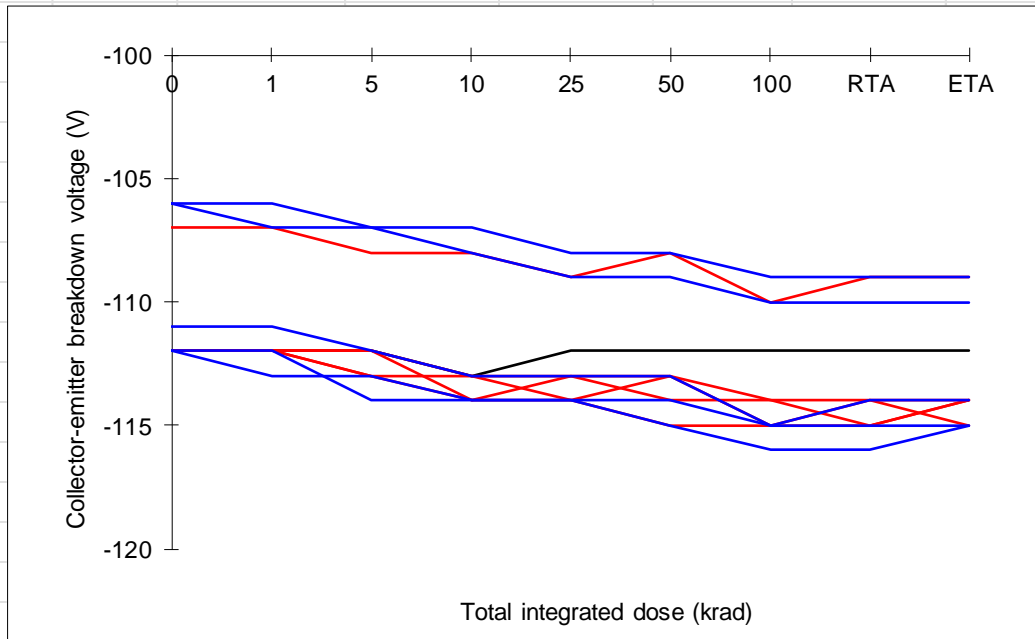
7.1 $V_{BR(CBO)}$

Type number:	2N2907A	Test dates:	14/03/2024 - 28/03/2024
Category:	PNP bipolar transistor	Samples:	1/10
Manufacturer:	Die Devices	Spec.	Min. -60V
Parameter:	Collector-base breakdown voltage ($I_C = -10\mu A$)		
Test equipment:	B1500A		
Ambient temperature during irradiation:	20°C		
Radiation source:	MRC cell 4, Harwell, UK		
Radiation type:	Gamma		
Energy:	1.25 MeV/photon		
Electrical conditions during irradiation:	Devices 2 - 6 biased, 7 - 11 unbiased		



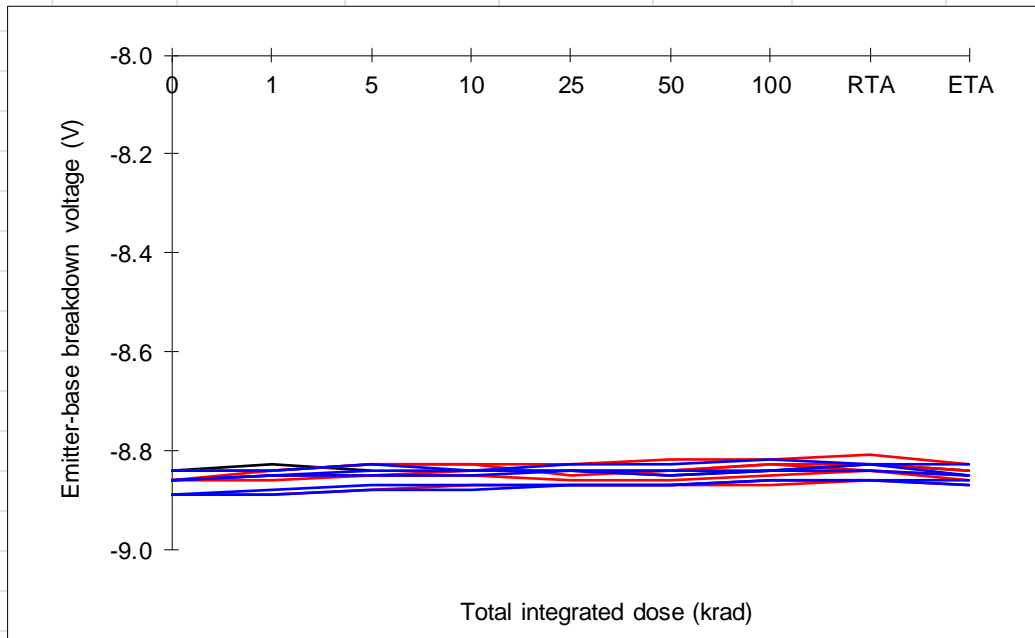
7.2 $V_{BR(CEO)}$

Type number:	2N2907A	Test dates:	14/03/2024 - 28/03/2024
Category:	PNP bipolar transistor	Samples:	1/10
Manufacturer:	Die Devices	Spec.	Min. -60V
Parameter:	Collector-emitter breakdown voltage ($I_C = -10mA$)		
Test equipment:	B1500A		
Ambient temperature during irradiation:	20°C		
Radiation source:	MRC cell 4, Harwell, UK		
Radiation type:	Gamma		
Energy:	1.25 MeV/photon		
Electrical conditions during irradiation:	Devices 2 - 6 biased, 7 - 11 unbiased		



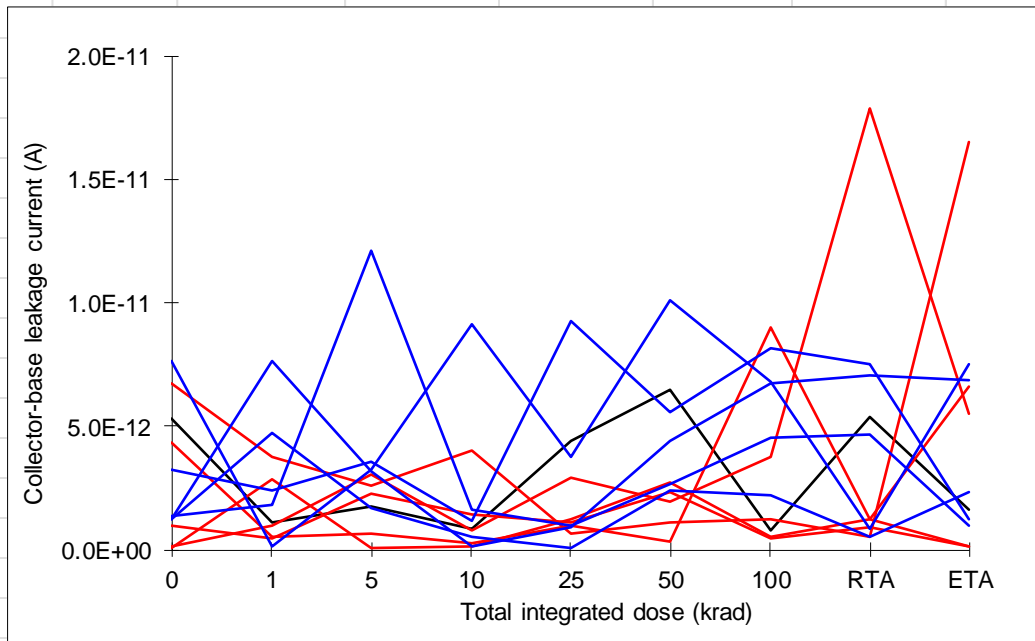
7.3 $V_{BR(EBO)}$

Type number:	2N2907A	Test dates:	14/03/2024 - 28/03/2024
Category:	PNP bipolar transistor	Samples:	1/10
Manufacturer:	Die Devices	Spec.	Min. -5V
Parameter:	Emitter-base breakdown voltage ($I_E = -10\mu A$)		
Test equipment:	B1500A		
Ambient temperature during irradiation:	20°C		
Radiation source:	MRC cell 4, Harwell, UK		
Radiation type:	Gamma		
Energy:	1.25 MeV/photon		
Electrical conditions during irradiation:	Devices 2 - 6 biased, 7 - 11 unbiased		



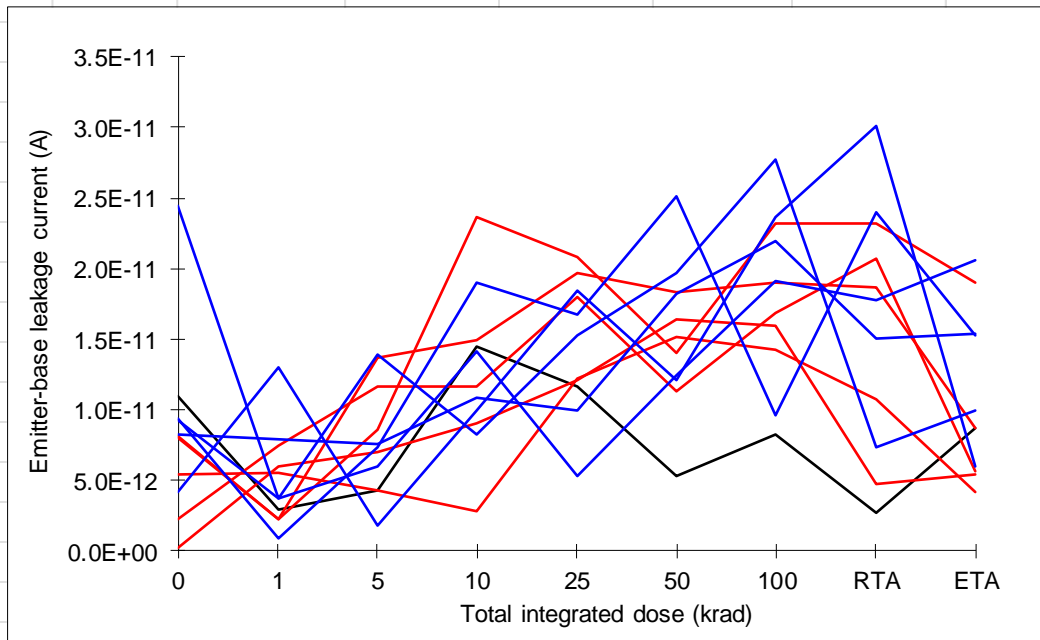
7.4 I_{CB0}

Type number:	2N2907A	Test dates:	14/03/2024 - 28/03/2024
Category:	PNP bipolar transistor	Samples:	1/10
Manufacturer:	Die Devices	Spec.	Max. -10nA
Parameter:	Collector-base leakage current ($V_{CB}=-50V$)		
Test equipment:	B1500A		
Ambient temperature during irradiation:	20°C		
Radiation source:	MRC cell 4, Harwell, UK		
Radiation type:	Gamma		
Energy:	1.25 MeV/photon		
Electrical conditions during irradiation:	Devices 2 - 6 biased, 7 - 11 unbiased		



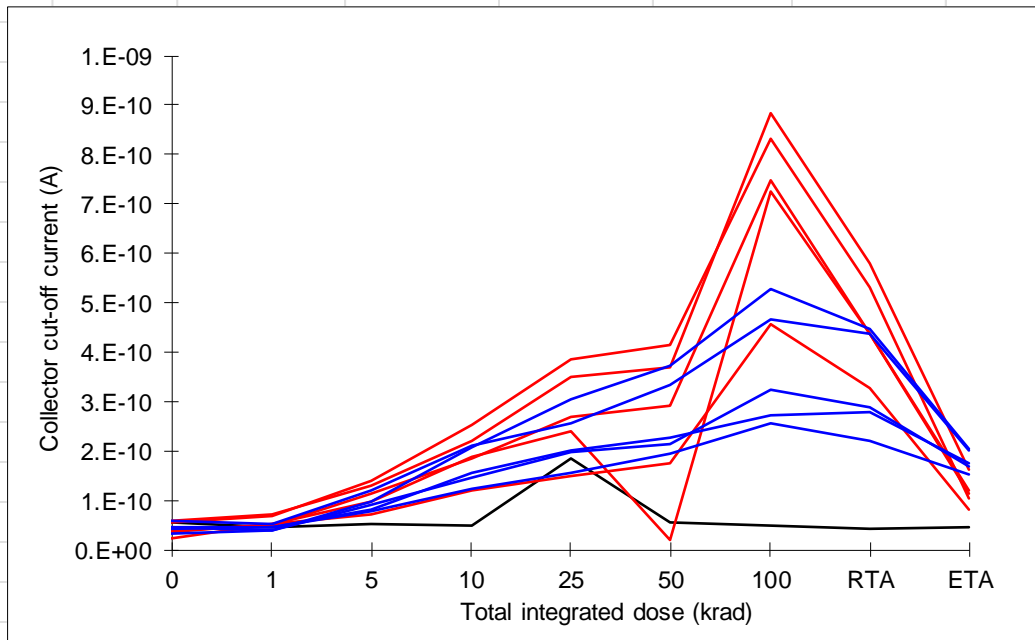
7.5 I_{EBO}

Type number:	2N2907A	Test dates:	14/03/2024 - 28/03/2024
Category:	PNP bipolar transistor	Samples:	1/10
Manufacturer:	Die Devices	Spec.	Max. -50nA
Parameter:	Emitter-base leakage current ($V_{EB}=-4V$)		
Test equipment:	B1500A		
Ambient temperature during irradiation:	20°C		
Radiation source:	MRC cell 4, Harwell, UK		
Radiation type:	Gamma		
Energy:	1.25 MeV/photon		
Electrical conditions during irradiation:	Devices 2 - 6 biased, 7 - 11 unbiased		



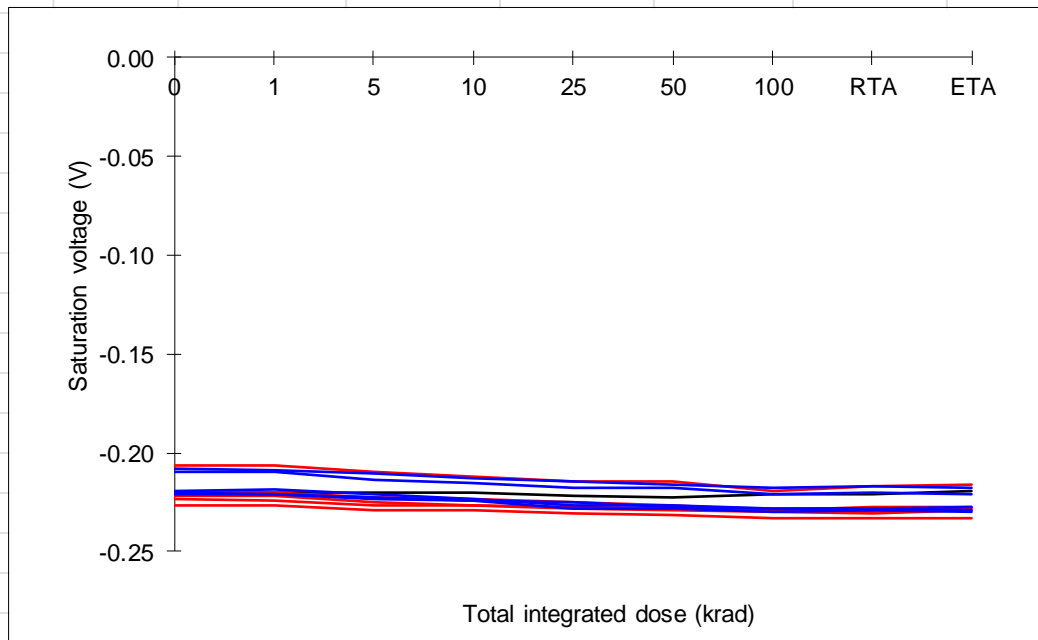
7.6 I_{CEX}

Type number:	2N2907A	Test dates:	14/03/2024 - 28/03/2024
Category:	PNP bipolar transistor	Samples:	1/10
Manufacturer:	Die Devices	Spec.	Max. -50nA
Parameter:	Collector cut-off current ($V_{CE}=-30V, V_{EB}=-0.5V$)		
Test equipment:	B1500A		
Ambient temperature during irradiation:	20°C		
Radiation source:	MRC cell 4, Harwell, UK		
Radiation type:	Gamma		
Energy:	1.25 MeV/photon		
Electrical conditions during irradiation:	Devices 2 - 6 biased, 7 - 11 unbiased		



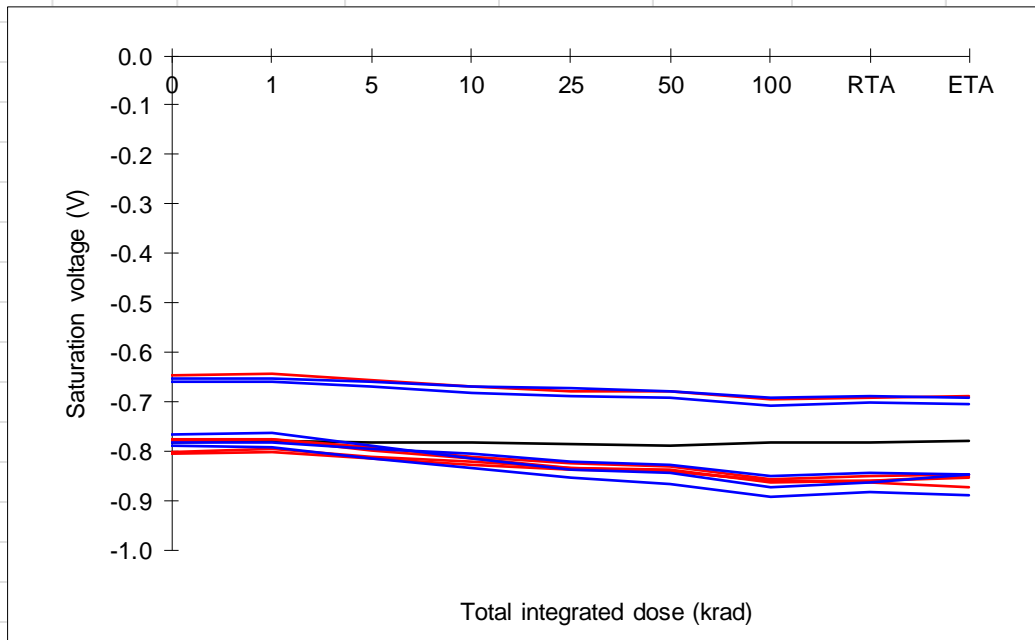
7.7 $V_{CE(SAT)1}$

Type number:	2N2907A	Test dates:	14/03/2024 - 28/03/2024
Category:	PNP bipolar transistor	Samples:	1/10
Manufacturer:	Die Devices	Spec.	Max. -0.4V
Parameter:	$V_{CE(sat)}$ saturation voltage ($I_B=-15mA$, $I_C=-150mA$)		
Test equipment:	B1500A		
Ambient temperature during irradiation:	20°C		
Radiation source:	MRC cell 4, Harwell, UK		
Radiation type:	Gamma		
Energy:	1.25 MeV/photon		
Electrical conditions during irradiation:	Devices 2 - 6 biased, 7 - 11 unbiased		



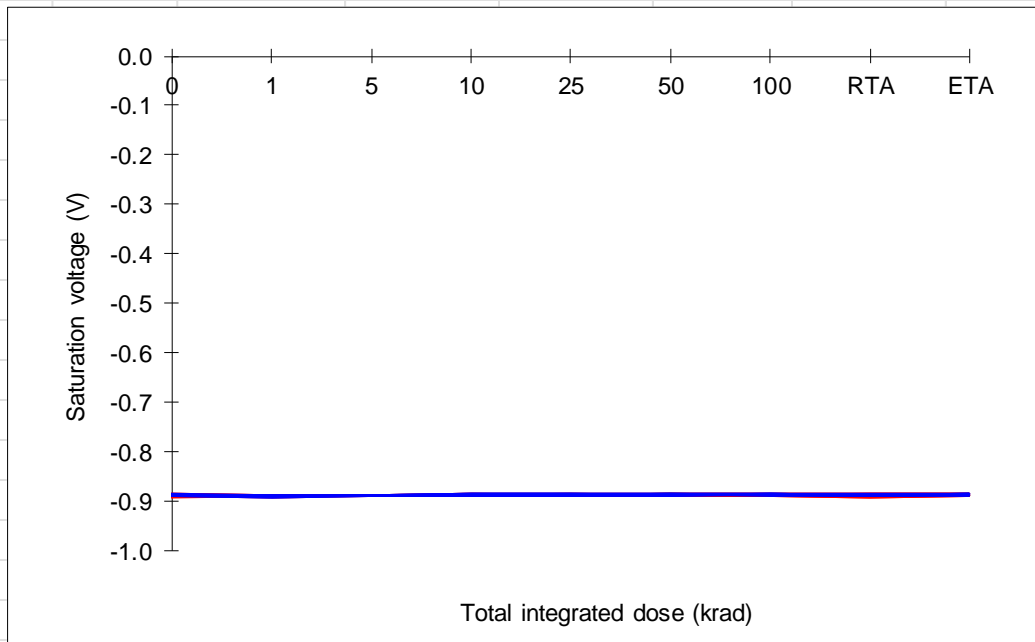
7.8 $V_{CE(SAT)2}$

Type number:	2N2907A	Test dates:	14/03/2024 - 28/03/2024
Category:	PNP bipolar transistor	Samples:	1/10
Manufacturer:	Die Devices	Spec.	Max. -1.6V
Parameter:	$V_{CE(sat)}$ saturation voltage ($I_B=-50mA$, $I_C=-500mA$)		
Test equipment:	B1500A		
Ambient temperature during irradiation:	20°C		
Radiation source:	MRC cell 4, Harwell, UK		
Radiation type:	Gamma		
Energy:	1.25 MeV/photon		
Electrical conditions during irradiation:	Devices 2 - 6 biased, 7 - 11 unbiased		



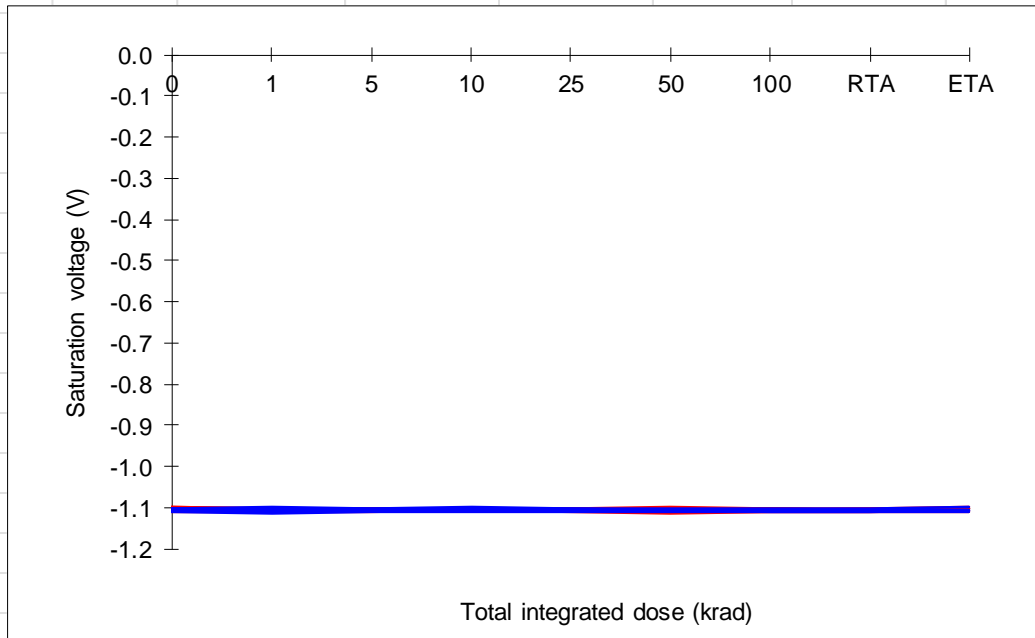
7.9 $V_{BE(SAT)1}$

Type number:	2N2907A	Test dates:	14/03/2024 - 28/03/2024
Category:	PNP bipolar transistor	Samples:	1/10
Manufacturer:	Die Devices	Spec.	Max. -1.3V
Parameter:	$V_{BE(sat)}$ saturation voltage ($I_B=-15mA$, $I_C=-150mA$)		
Test equipment:	B1500A		
Ambient temperature during irradiation:	20°C		
Radiation source:	MRC cell 4, Harwell, UK		
Radiation type:	Gamma		
Energy:	1.25 MeV/photon		
Electrical conditions during irradiation:	Devices 2 - 6 biased, 7 - 11 unbiased		



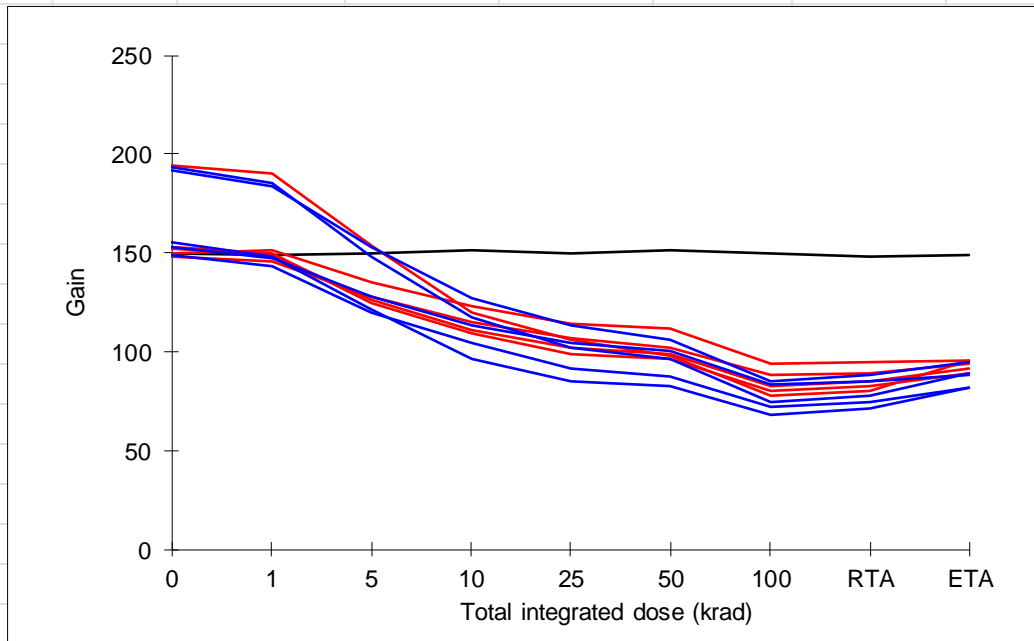
7.10 $V_{BE(SAT)2}$

Type number:	2N2907A	Test dates:	14/03/2024 - 28/03/2024
Category:	PNP bipolar transistor	Samples:	1/10
Manufacturer:	Die Devices	Spec.	Max. -2.6V
Parameter:	$V_{BE(sat)}$ saturation voltage ($I_B=-50mA$, $I_C=-500mA$)		
Test equipment:	B1500A		
Ambient temperature during irradiation:	20°C		
Radiation source:	MRC cell 4, Harwell, UK		
Radiation type:	Gamma		
Energy:	1.25 MeV/photon		
Electrical conditions during irradiation:	Devices 2 - 6 biased, 7 - 11 unbiased		

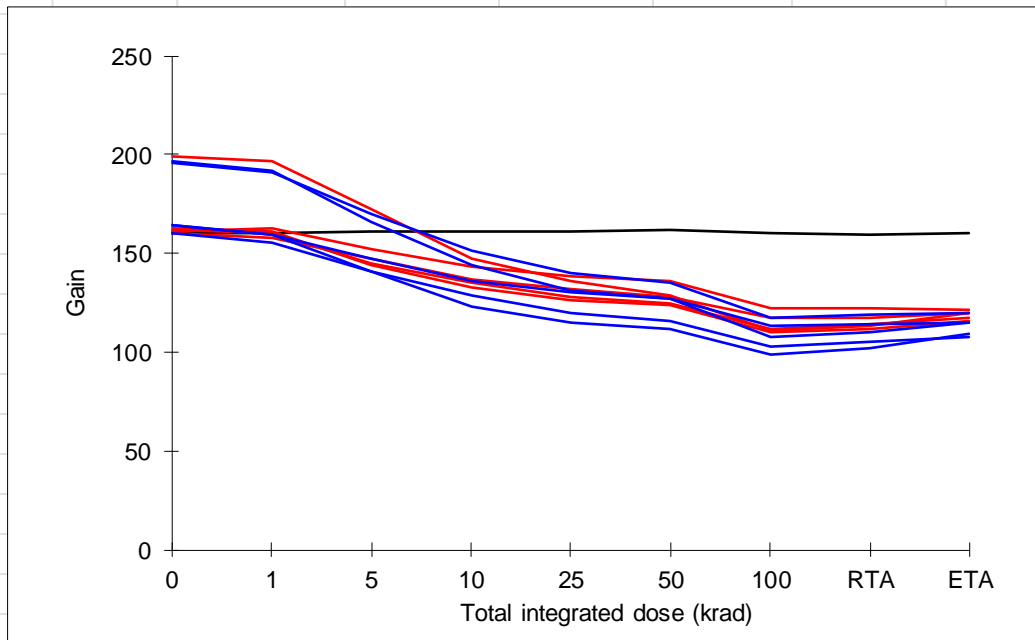


7.11 H_{FE}

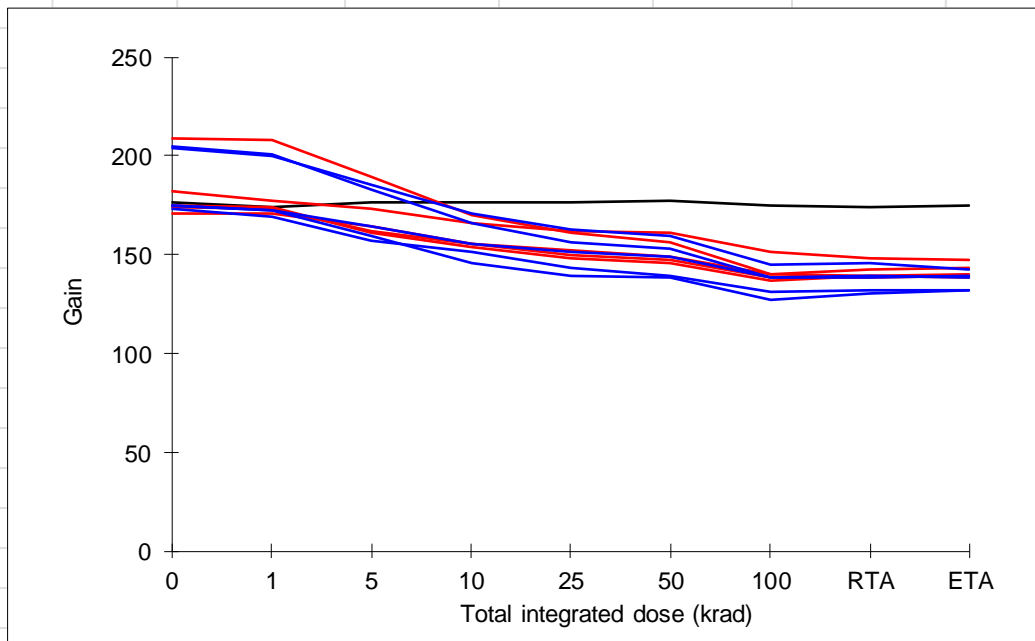
Type number:	2N2907A	Test dates:	14/03/2024 - 28/03/2024
Category:	PNP bipolar transistor	Samples:	1/10
Manufacturer:	Die Devices	Spec.	Min. 75
Parameter:	h_{FE} gain ($V_{CE}=-10V$, $I_C=-0.1mA$)		
Test equipment:	B1500A		
Ambient temperature during irradiation:	20°C		
Radiation source:	MRC cell 4, Harwell, UK		
Radiation type:	Gamma		
Energy:	1.25 MeV/photon		
Electrical conditions during irradiation:	Devices 2 - 6 biased, 7 - 11 unbiased		



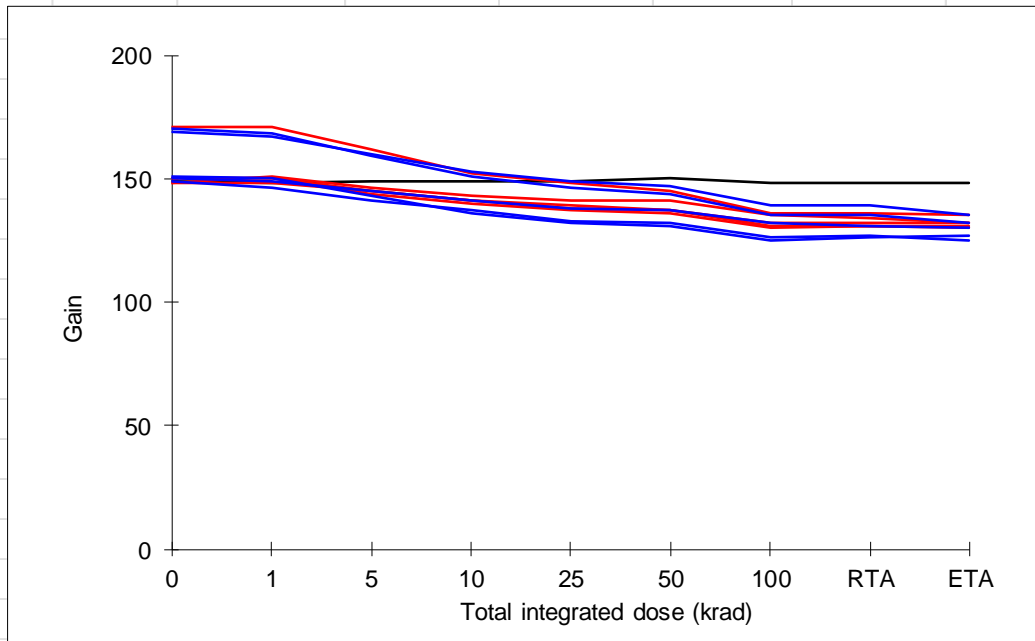
Type number:	2N2907A	Test dates:	14/03/2024 - 28/03/2024
Category:	PNP bipolar transistor	Samples:	1/10
Manufacturer:	Die Devices	Spec.	Min. 100
Parameter:	h_{FE} gain ($V_{CE}=-10V$, $I_C=-1mA$)		
Test equipment:	B1500A		
Ambient temperature during irradiation:	20°C		
Radiation source:	MRC cell 4, Harwell, UK		
Radiation type:	Gamma		
Energy:	1.25 MeV/photon		
Electrical conditions during irradiation:	Devices 2 - 6 biased, 7 - 11 unbiased		



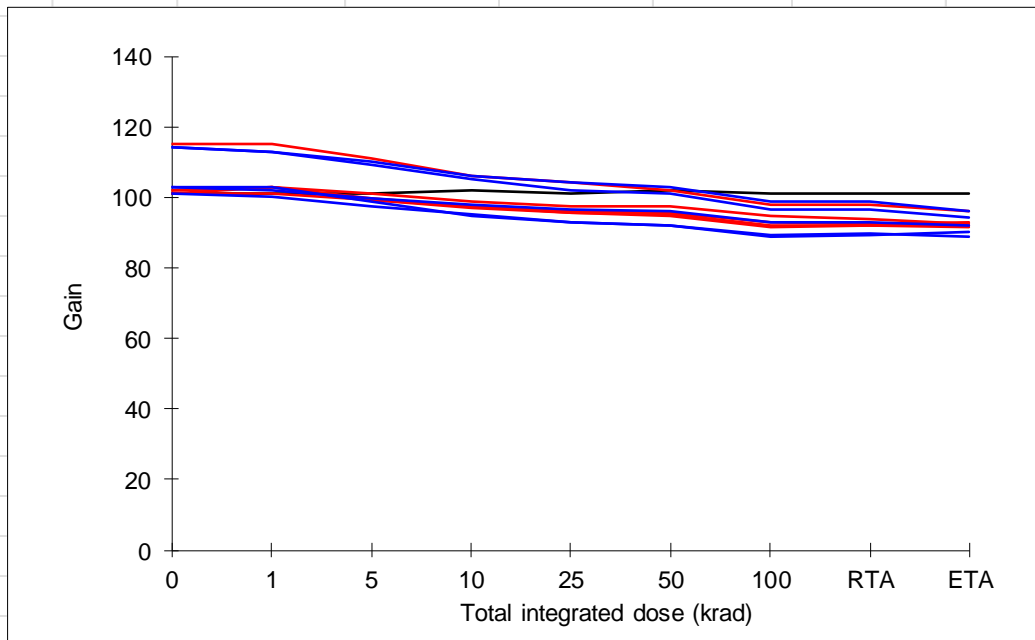
Type number:	2N2907A	Test dates:	14/03/2024 - 28/03/2024
Category:	PNP bipolar transistor	Samples:	1/10
Manufacturer:	Die Devices	Spec.	Min. 100
Parameter:	h_{FE} gain ($V_{CE}=-10V, I_C=-10mA$)		
Test equipment:	B1500A		
Ambient temperature during irradiation:	20°C		
Radiation source:	MRC cell 4, Harwell, UK		
Radiation type:	Gamma		
Energy:	1.25 MeV/photon		
Electrical conditions during irradiation:	Devices 2 - 6 biased, 7 - 11 unbiased		



Type number:	2N2907A	Test dates:	14/03/2024 - 28/03/2024
Category:	PNP bipolar transistor	Samples:	1/10
Manufacturer:	Die Devices	Spec.	Min. 100
Parameter:	h _{FE} gain (V _{CE} =-10V, I _C =-150mA)		
Test equipment:	B1500A		
Ambient temperature during irradiation:	20°C		
Radiation source:	MRC cell 4, Harwell, UK		
Radiation type:	Gamma		
Energy:	1.25 MeV/photon		
Electrical conditions during irradiation:	Devices 2 - 6 biased, 7 - 11 unbiased		



Type number:	2N2907A	Test dates:	14/03/2024 - 28/03/2024
Category:	PNP bipolar transistor	Samples:	1/10
Manufacturer:	Die Devices	Spec.	Min. 50
Parameter:	h _{FE} gain (V _{CE} =-10V, I _C =-500mA)		
Test equipment:	B1500A		
Ambient temperature during irradiation:	20°C		
Radiation source:	MRC cell 4, Harwell, UK		
Radiation type:	Gamma		
Energy:	1.25 MeV/photon		
Electrical conditions during irradiation:	Devices 2 - 6 biased, 7 - 11 unbiased		



Type number:	2N2907A	Test number:	1
Category:	PNP bipolar transistor	Date:	14/03/2024
Manufacturer:	Die Devices	Time:	14:03
Date code:	N/K	Total integrated dose:	0 krad
Test equipment:	B1500A	Time since irradiation:	-
Test program:	DIE 2N2907A test V1-00		
Parameters tested:	Multiple parameters		

DUT		$h_{FE} \pm 1\%$ ($I_C=0.1mA$)	$h_{FE} \pm 1\%$ ($I_C=1mA$)	$h_{FE} \pm 1\%$ ($I_C=10mA$)	$h_{FE} \pm 1\%$ ($I_C=150mA$)	$h_{FE} \pm 1\%$ ($I_C=500mA$)
1	Control	150	160	176	149	101
2		148	160	171	148	101
3		153	163	175	150	102
4		194	199	209	171	115
5		152	162	174	150	102
6		150	161	182	148	101
7		193	197	205	170	114
8		155	164	175	151	103
9		149	160	173	149	101
10		153	164	175	150	103
11		192	196	204	169	114

Tested by: NG

Type number:	2N2907A	Test number:	2
Category:	PNP bipolar transistor	Date:	20/03/2024
Manufacturer:	Die Devices	Time:	08:44
Date code:	N/K	Total integrated dose:	1 krad
Test equipment:	B1500A	Time since irradiation:	0h 39m
Test program:	DIE 2N2907A test V1-00		
Parameters tested:	Multiple parameters		

DUT		I_{EBO}	I_{CBO}	I_{CEX}	$V_{(BR)EBO}$	$V_{(BR)CBO}$	$V_{(BR)CEO}$
		A ± 1%	A ± 1%	A ± 1%	V ± 1%	V ± 1%	V ± 1%
1	Control	2.95E-12	1.10E-12	4.45E-11	-8.83	-113	-112
2		7.50E-12	5.50E-13	4.98E-11	-8.85	-114	-112
3		2.30E-12	2.85E-12	7.16E-11	-8.84	-115	-112
4		2.25E-12	1.00E-12	6.92E-11	-8.89	-114	-107
5		5.50E-12	3.75E-12	5.29E-11	-8.84	-115	-112
6		6.00E-12	4.50E-13	5.06E-11	-8.86	-114	-112
7		3.70E-12	1.80E-12	3.88E-11	-8.88	-113	-107
8		8.50E-13	7.65E-12	4.37E-11	-8.84	-114	-113
9		1.30E-11	1.00E-13	3.99E-11	-8.85	-114	-112
10		3.75E-12	2.40E-12	4.55E-11	-8.85	-113	-111
11		7.95E-12	4.70E-12	5.24E-11	-8.89	-113	-106

DUT		$V_{CE(sat)1}$	$V_{CE(sat)2}$	$V_{BE(sat)1}$	$V_{BE(sat)2}$
		V ± 1%	V ± 1%	V ± 1%	V ± 1%
1	Control	-0.220	-0.781	-0.891	-1.103
2		-0.224	-0.796	-0.892	-1.111
3		-0.222	-0.778	-0.891	-1.103
4		-0.206	-0.646	-0.890	-1.101
5		-0.221	-0.778	-0.891	-1.109
6		-0.227	-0.802	-0.891	-1.106
7		-0.210	-0.662	-0.894	-1.113
8		-0.219	-0.764	-0.889	-1.100
9		-0.221	-0.792	-0.890	-1.104
10		-0.221	-0.782	-0.891	-1.106
11		-0.209	-0.655	-0.892	-1.109

Tested by: NG

Type number:	2N2907A	Test number:	2
Category:	PNP bipolar transistor	Date:	20/03/2024
Manufacturer:	Die Devices	Time:	08:44
Date code:	N/K	Total integrated dose:	1 krad
Test equipment:	B1500A	Time since irradiation:	0h 39m
Test program:	DIE 2N2907A test V1-00		
Parameters tested:	Multiple parameters		

DUT		$h_{FE} \pm 1\%$ ($I_C=0.1mA$)	$h_{FE} \pm 1\%$ ($I_C=1mA$)	$h_{FE} \pm 1\%$ ($I_C=10mA$)	$h_{FE} \pm 1\%$ ($I_C=150mA$)	$h_{FE} \pm 1\%$ ($I_C=500mA$)
1	Control	149	160	174	148	101
2		146	158	171	148	101
3		150	161	174	150	103
4		190	197	208	171	115
5		149	160	173	150	103
6		151	163	177	151	103
7		185	192	201	168	113
8		148	159	172	150	103
9		143	155	169	146	100
10		147	159	172	149	102
11		184	191	200	167	113

Tested by: NG

Type number:	2N2907A	Test number:	3
Category:	PNP bipolar transistor	Date:	20/03/2024
Manufacturer:	Die Devices	Time:	10:12
Date code:	N/K	Total integrated dose:	10 krad
Test equipment:	B1500A	Time since irradiation:	0h 38m
Test program:	DIE 2N2907A test V1-00		
Parameters tested:	Multiple parameters		

DUT		I_{EBO}	I_{CBO}	I_{CEX}	$V_{(BR)EBO}$	$V_{(BR)CBO}$	$V_{(BR)CEO}$
		A ± 1%	A ± 1%	A ± 1%	V ± 1%	V ± 1%	V ± 1%
1	Control	4.30E-12	1.75E-12	5.07E-11	-8.84	-113	-112
2		1.17E-11	6.50E-13	1.14E-10	-8.85	-118	-112
3		1.37E-11	5.00E-14	1.31E-10	-8.83	-118	-113
4		8.60E-12	3.05E-12	1.39E-10	-8.88	-118	-108
5		4.30E-12	2.60E-12	9.82E-11	-8.83	-118	-113
6		7.05E-12	2.25E-12	7.18E-11	-8.85	-117	-112
7		1.39E-11	1.21E-11	9.80E-11	-8.87	-114	-107
8		7.30E-12	3.20E-12	8.12E-11	-8.83	-114	-113
9		1.75E-12	3.25E-12	9.21E-11	-8.84	-115	-114
10		6.00E-12	3.55E-12	7.67E-11	-8.85	-114	-112
11		7.60E-12	1.70E-12	1.20E-10	-8.88	-114	-107

DUT		$V_{CE(sat)1}$	$V_{CE(sat)2}$	$V_{BE(sat)1}$	$V_{BE(sat)2}$
		V ± 1%	V ± 1%	V ± 1%	V ± 1%
1	Control	-0.220	-0.782	-0.889	-1.102
2		-0.227	-0.812	-0.890	-1.110
3		-0.225	-0.798	-0.890	-1.105
4		-0.209	-0.657	-0.889	-1.102
5		-0.223	-0.794	-0.891	-1.108
6		-0.229	-0.814	-0.891	-1.104
7		-0.214	-0.671	-0.891	-1.111
8		-0.221	-0.789	-0.890	-1.101
9		-0.223	-0.816	-0.889	-1.104
10		-0.224	-0.797	-0.890	-1.108
11		-0.210	-0.662	-0.890	-1.107

Tested by: NG

Type number:	2N2907A	Test number:	3
Category:	PNP bipolar transistor	Date:	20/03/2024
Manufacturer:	Die Devices	Time:	10:12
Date code:	N/K	Total integrated dose:	10 krad
Test equipment:	B1500A	Time since irradiation:	0h 38m
Test program:	-		
Parameters tested:	Multiple parameters		

DUT		$h_{FE} \pm 1\%$ ($I_C=0.1mA$)	$h_{FE} \pm 1\%$ ($I_C=1mA$)	$h_{FE} \pm 1\%$ ($I_C=10mA$)	$h_{FE} \pm 1\%$ ($I_C=150mA$)	$h_{FE} \pm 1\%$ ($I_C=500mA$)
1	Control	150	161	176	149	101
2		128	147	164	145	99
3		125	144	161	144	99
4		154	172	189	162	111
5		126	145	162	145	100
6		135	152	173	146	101
7		148	166	183	159	109
8		121	141	159	143	99
9		120	141	157	141	97
10		128	147	164	145	100
11		153	170	185	160	110

Tested by: NG

Type number:	2N2907A	Test number:	4
Category:	PNP bipolar transistor	Date:	20/03/2024
Manufacturer:	Die Devices	Time:	11:44
Date code:	N/K	Total integrated dose:	25 krad
Test equipment:	B1500A	Time since irradiation:	0h 38m
Test program:	DIE 2N2907A test V1-00		
Parameters tested:	Multiple parameters		

DUT		I_{EBO}	I_{CBO}	I_{CEX}	$V_{(BR)EBO}$	$V_{(BR)CBO}$	$V_{(BR)CEO}$
		A ± 1%	A ± 1%	A ± 1%	V ± 1%	V ± 1%	V ± 1%
1	Control	1.45E-11	8.50E-13	4.92E-11	0.00	-113	-113
2		1.17E-11	2.50E-13	1.86E-10	-8.84	-119	-114
3		1.49E-11	1.00E-13	2.20E-10	-8.83	-119	-113
4		2.36E-11	7.50E-13	2.53E-10	-8.87	-118	-108
5		2.80E-12	4.00E-12	1.88E-10	-8.83	-119	-114
6		9.00E-12	1.45E-12	1.19E-10	-8.85	-118	-113
7		8.25E-12	1.65E-12	2.07E-10	-8.87	-115	-108
8		1.90E-11	1.00E-13	1.55E-10	-8.84	-115	-114
9		9.95E-12	9.15E-12	1.46E-10	-8.84	-115	-114
10		1.41E-11	1.15E-12	1.24E-10	-8.85	-115	-113
11		1.08E-11	5.50E-13	2.10E-10	-8.88	-114	-107

DUT		$V_{CE(sat)1}$	$V_{CE(sat)2}$	$V_{BE(sat)1}$	$V_{BE(sat)2}$
		V ± 1%	V ± 1%	V ± 1%	V ± 1%
1	Control	-0.220	-0.782	-0.889	-1.102
2		-0.227	-0.822	-0.891	-1.108
3		-0.226	-0.817	-0.890	-1.103
4		-0.213	-0.671	-0.887	-1.102
5		-0.224	-0.811	-0.889	-1.106
6		-0.229	-0.828	-0.888	-1.103
7		-0.215	-0.682	-0.890	-1.111
8		-0.224	-0.816	-0.887	-1.099
9		-0.224	-0.834	-0.887	-1.103
10		-0.224	-0.806	-0.888	-1.104
11		-0.213	-0.670	-0.889	-1.107

Tested by: NG

Type number:	2N2907A	Test number:	4
Category:	PNP bipolar transistor	Date:	20/03/2024
Manufacturer:	Die Devices	Time:	11:44
Date code:	N/K	Total integrated dose:	25 krad
Test equipment:	B1500A	Time since irradiation:	0h 38m
Test program:	DIE 2N2907A test V1-00		
Parameters tested:	Multiple parameters		

DUT		$h_{FE} \pm 1\%$ ($I_C=0.1mA$)	$h_{FE} \pm 1\%$ ($I_C=1mA$)	$h_{FE} \pm 1\%$ ($I_C=10mA$)	$h_{FE} \pm 1\%$ ($I_C=150mA$)	$h_{FE} \pm 1\%$ ($I_C=500mA$)
1	Control	151	161	176	149	102
2		115	137	155	141	97
3		109	133	154	140	97
4		120	147	170	152	106
5		111	135	155	141	97
6		123	143	166	143	99
7		117	144	166	151	105
8		96	123	146	136	95
9		104	129	151	137	95
10		113	136	155	141	98
11		127	151	171	153	106

Tested by: NG

Type number:	2N2907A	Test number:	5
Category:	PNP bipolar transistor	Date:	20/03/2024
Manufacturer:	Die Devices	Time:	13:24
Date code:	N/K	Total integrated dose:	40 krad
Test equipment:	B1500A	Time since irradiation:	0h 44m
Test program:	DIE 2N2907A test V1-00		
Parameters tested:	Multiple parameters		

DUT		I_{EBO}	I_{CBO}	I_{CEX}	$V_{(BR)EBO}$	$V_{(BR)CBO}$	$V_{(BR)CEO}$
		A ± 1%	A ± 1%	A ± 1%	V ± 1%	V ± 1%	V ± 1%
1	Control	1.17E-11	4.40E-12	1.83E-10	-8.84	-113	-112
2		1.80E-11	9.50E-13	2.69E-10	-8.84	-118	-114
3		1.97E-11	1.25E-12	3.51E-10	-8.85	-119	-114
4		2.08E-11	2.90E-12	3.85E-10	-8.87	-118	-109
5		1.22E-11	6.50E-13	2.41E-10	-8.83	-119	-113
6		1.21E-11	1.10E-12	1.49E-10	-8.86	-118	-113
7		1.53E-11	1.00E-12	3.04E-10	-8.87	-115	-109
8		1.67E-11	9.00E-13	2.01E-10	-8.83	-116	-114
9		1.85E-11	3.75E-12	1.98E-10	-8.84	-116	-114
10		5.30E-12	9.25E-12	1.56E-10	-8.84	-115	-113
11		1.00E-11	5.00E-14	2.55E-10	-8.87	-115	-108

DUT		$V_{CE(sat)1}$	$V_{CE(sat)2}$	$V_{BE(sat)1}$	$V_{BE(sat)2}$
		V ± 1%	V ± 1%	V ± 1%	V ± 1%
1	Control	-0.222	-0.786	-0.891	-1.105
2		-0.228	-0.836	-0.889	-1.111
3		-0.228	-0.834	-0.887	-1.103
4		-0.214	-0.678	-0.887	-1.101
5		-0.225	-0.826	-0.890	-1.107
6		-0.231	-0.837	-0.889	-1.103
7		-0.218	-0.690	-0.890	-1.109
8		-0.226	-0.838	-0.888	-1.101
9		-0.228	-0.856	-0.888	-1.104
10		-0.225	-0.822	-0.888	-1.106
11		-0.215	-0.674	-0.889	-1.108

Tested by: NG

Type number:	2N2907A	Test number:	5
Category:	PNP bipolar transistor	Date:	20/03/2024
Manufacturer:	Die Devices	Time:	13:24
Date code:	N/K	Total integrated dose:	40 krad
Test equipment:	B1500A	Time since irradiation:	0h 44m
Test program:	DIE 2N2907A test V1-00		
Parameters tested:	Multiple parameters		

DUT		$h_{FE} \pm 1\%$ ($I_C=0.1mA$)	$h_{FE} \pm 1\%$ ($I_C=1mA$)	$h_{FE} \pm 1\%$ ($I_C=10mA$)	$h_{FE} \pm 1\%$ ($I_C=150mA$)	$h_{FE} \pm 1\%$ ($I_C=500mA$)
1	Control	150	161	176	149	101
2		107	132	152	139	96
3		99	126	148	137	95
4		106	136	161	148	104
5		102	128	150	138	96
6		114	138	162	141	98
7		102	131	156	146	102
8		85	115	139	132	93
9		92	120	143	133	93
10		104	130	151	138	97
11		113	140	163	149	104

Tested by: NG

Type number:	2N2907A	Test number:	6
Category:	PNP bipolar transistor	Date:	20/03/2024
Manufacturer:	Die Devices	Time:	14:59
Date code:	N/K	Total integrated dose:	50 krad
Test equipment:	B1500A	Time since irradiation:	0h 40m
Test program:	DIE 2N2907A test V1-00		
Parameters tested:	Multiple parameters		

DUT		I_{EBO}	I_{CBO}	I_{CEX}	$V_{(BR)EBO}$	$V_{(BR)CBO}$	$V_{(BR)CEO}$
		A ± 1%	A ± 1%	A ± 1%	V ± 1%	V ± 1%	V ± 1%
1	Control	5.30E-12	6.50E-12	5.47E-11	-8.85	-113	-112
2		1.14E-11	3.00E-13	2.91E-10	-8.84	-118	-113
3		1.83E-11	2.70E-12	3.69E-10	-8.84	-119	-115
4		1.41E-11	1.95E-12	4.13E-10	-8.87	-118	-108
5		1.52E-11	1.10E-12	2.00E-11	-8.82	-119	-114
6		1.65E-11	2.30E-12	1.75E-10	-8.86	-118	-113
7		1.97E-11	2.65E-12	3.71E-10	-8.87	-115	-109
8		2.52E-11	4.40E-12	2.27E-10	-8.83	-117	-114
9		1.22E-11	1.01E-11	2.13E-10	-8.84	-116	-115
10		1.24E-11	5.55E-12	1.94E-10	-8.85	-116	-113
11		1.83E-11	2.40E-12	3.34E-10	-8.87	-115	-108

DUT		$V_{CE(sat)1}$	$V_{CE(sat)2}$	$V_{BE(sat)1}$	$V_{BE(sat)2}$
		V ± 1%	V ± 1%	V ± 1%	V ± 1%
1	Control	-0.223	-0.789	-0.888	-1.104
2		-0.229	-0.843	-0.891	-1.113
3		-0.229	-0.838	-0.889	-1.103
4		-0.215	-0.681	-0.887	-1.100
5		-0.227	-0.831	-0.891	-1.109
6		-0.231	-0.842	-0.887	-1.106
7		-0.218	-0.693	-0.889	-1.109
8		-0.227	-0.845	-0.887	-1.102
9		-0.229	-0.866	-0.889	-1.107
10		-0.227	-0.828	-0.888	-1.106
11		-0.216	-0.680	-0.888	-1.108

Tested by: JV

Type number:	2N2907A	Test number:	6
Category:	PNP bipolar transistor	Date:	20/03/2024
Manufacturer:	Die Devices	Time:	14:59
Date code:	N/K	Total integrated dose:	50 krad
Test equipment:	B1500A	Time since irradiation:	0h 40m
Test program:	DIE 2N2907A test V1-00		
Parameters tested:	Multiple parameters		

DUT		$h_{FE} \pm 1\%$ ($I_C=0.1mA$)	$h_{FE} \pm 1\%$ ($I_C=1mA$)	$h_{FE} \pm 1\%$ ($I_C=10mA$)	$h_{FE} \pm 1\%$ ($I_C=150mA$)	$h_{FE} \pm 1\%$ ($I_C=500mA$)
1	Control	151	162	177	150	102
2		102	128	149	137	95
3		97	124	146	136	95
4		98	129	156	145	102
5		99	125	147	137	95
6		112	136	161	141	98
7		96	127	153	144	101
8		83	112	138	131	92
9		87	116	139	132	92
10		100	127	149	137	96
11		106	135	159	147	103

Tested by: JV

Type number:	2N2907A	Test number:	7
Category:	PNP bipolar transistor	Date:	20/03/2024
Manufacturer:	Die Devices	Time:	16:08
Date code:	N/K	Total integrated dose:	100 krad
Test equipment:	B1500A	Time since irradiation:	0h 18m
Test program:	DIE 2N2907A test V1-00		
Parameters tested:	Multiple parameters		

DUT		I_{EBO}	I_{CBO}	I_{CEX}	$V_{(BR)EBO}$	$V_{(BR)CBO}$	$V_{(BR)CEO}$
		A ± 1%	A ± 1%	A ± 1%	V ± 1%	V ± 1%	V ± 1%
1	Control	8.30E-12	8.00E-13	5.01E-11	-8.84	-113	-112
2		1.69E-11	9.00E-12	7.49E-10	-8.83	-118	-115
3		1.90E-11	5.00E-13	8.85E-10	-8.83	-119	-115
4		2.32E-11	3.75E-12	8.31E-10	-8.87	-119	-110
5		1.42E-11	1.25E-12	7.25E-10	-8.82	-119	-114
6		1.59E-11	4.50E-13	4.55E-10	-8.85	-119	-114
7		2.77E-11	4.55E-12	5.27E-10	-8.86	-117	-110
8		9.65E-12	6.75E-12	2.73E-10	-8.82	-117	-115
9		2.36E-11	6.80E-12	3.24E-10	-8.84	-117	-116
10		1.91E-11	8.15E-12	2.57E-10	-8.84	-117	-115
11		2.20E-11	2.20E-12	4.65E-10	-8.86	-116	-109

DUT		$V_{CE(sat)1}$	$V_{CE(sat)2}$	$V_{BE(sat)1}$	$V_{BE(sat)2}$
		V ± 1%	V ± 1%	V ± 1%	V ± 1%
1	Control	-0.221	-0.785	-0.891	-1.103
2		-0.229	-0.861	-0.889	-1.111
3		-0.230	-0.863	-0.889	-1.105
4		-0.219	-0.696	-0.886	-1.102
5		-0.229	-0.856	-0.891	-1.109
6		-0.233	-0.862	-0.888	-1.103
7		-0.221	-0.708	-0.888	-1.110
8		-0.228	-0.873	-0.887	-1.101
9		-0.230	-0.893	-0.887	-1.105
10		-0.229	-0.850	-0.887	-1.106
11		-0.218	-0.693	-0.889	-1.109

Tested by: NG

Type number:	2N2907A	Test number:	7
Category:	PNP bipolar transistor	Date:	20/03/2024
Manufacturer:	Die Devices	Time:	16:08
Date code:	N/K	Total integrated dose:	100 krad
Test equipment:	B1500A	Time since irradiation:	0h 18m
Test program:	DIE 2N2907A test V1-00		
Parameters tested:	Multiple parameters		

DUT		$h_{FE} \pm 1\%$ ($I_C=0.1mA$)	$h_{FE} \pm 1\%$ ($I_C=1mA$)	$h_{FE} \pm 1\%$ ($I_C=10mA$)	$h_{FE} \pm 1\%$ ($I_C=150mA$)	$h_{FE} \pm 1\%$ ($I_C=500mA$)
1	Control	150	160	175	148	101
2		88	117	140	132	93
3		80	110	137	130	92
4		78	111	140	136	98
5		83	112	138	131	92
6		94	122	151	135	95
7		75	108	138	135	97
8		68	99	127	125	89
9		72	103	131	126	89
10		83	113	138	132	93
11		85	117	145	139	99

Tested by: NG

Type number:	2N2907A	Test number:	8
Category:	PNP bipolar transistor	Date:	21/03/2024
Manufacturer:	Die Devices	Time:	17:04
Date code:	N/K	Total integrated dose:	100 krad + RTA
Test equipment:	B1500A	Time since irradiation:	25h 14m
Test program:	DIE 2N2907A test V1-00		
Parameters tested:	Multiple parameters		

DUT		I_{EBO}	I_{CBO}	I_{CEX}	$V_{(BR)EBO}$	$V_{(BR)CBO}$	$V_{(BR)CEO}$
		A ± 1%	A ± 1%	A ± 1%	V ± 1%	V ± 1%	V ± 1%
1	Control	2.75E-12	5.40E-12	4.15E-11	-8.83	-113	-112
2		2.08E-11	1.25E-12	4.37E-10	-8.83	-117	-114
3		1.87E-11	1.25E-12	5.80E-10	-8.84	-118	-115
4		2.32E-11	1.79E-11	5.31E-10	-8.86	-118	-109
5		1.07E-11	5.00E-13	4.35E-10	-8.81	-118	-115
6		4.70E-12	9.00E-13	3.28E-10	-8.84	-117	-114
7		7.35E-12	4.65E-12	4.47E-10	-8.86	-116	-110
8		2.40E-11	7.05E-12	2.79E-10	-8.83	-117	-115
9		3.01E-11	8.50E-13	2.89E-10	-8.83	-117	-116
10		1.78E-11	7.50E-12	2.19E-10	-8.84	-116	-114
11		1.51E-11	5.00E-13	4.36E-10	-8.86	-116	-109

DUT		$V_{CE(sat)1}$	$V_{CE(sat)2}$	$V_{BE(sat)1}$	$V_{BE(sat)2}$
		V ± 1%	V ± 1%	V ± 1%	V ± 1%
1	Control	-0.221	-0.783	-0.891	-1.106
2		-0.230	-0.861	-0.892	-1.112
3		-0.231	-0.861	-0.887	-1.104
4		-0.217	-0.692	-0.887	-1.103
5		-0.227	-0.851	-0.892	-1.109
6		-0.233	-0.865	-0.888	-1.106
7		-0.220	-0.704	-0.891	-1.112
8		-0.228	-0.863	-0.888	-1.102
9		-0.229	-0.884	-0.889	-1.107
10		-0.228	-0.844	-0.891	-1.107
11		-0.217	-0.689	-0.891	-1.109

Tested by: NG

Type number:	2N2907A	Test number:	8
Category:	PNP bipolar transistor	Date:	27/03/2024
Manufacturer:	Die Devices	Time:	17:04
Date code:	N/K	Total integrated dose:	100 krad + RTA
Test equipment:	B1500A	Time since irradiation:	25h 14m
Test program:	DIE 2N2907A test V1-00		
Parameters tested:	Multiple parameters		

DUT		$h_{FE} \pm 1\%$ ($I_C=0.1mA$)	$h_{FE} \pm 1\%$ ($I_C=1mA$)	$h_{FE} \pm 1\%$ ($I_C=10mA$)	$h_{FE} \pm 1\%$ ($I_C=150mA$)	$h_{FE} \pm 1\%$ ($I_C=500mA$)
1	Control	148	159	174	148	101
2		89	117	139	132	93
3		82	112	139	131	92
4		80	113	142	136	98
5		85	114	138	131	92
6		94	122	148	134	94
7		78	110	138	135	97
8		71	102	130	126	89
9		74	105	132	127	90
10		85	114	139	131	93
11		88	119	146	139	99

Tested by: NG

Type number:	2N2907A	Test number:	9
Category:	PNP bipolar transistor	Date:	28/03/2024
Manufacturer:	Die Devices	Time:	11:51
Date code:	N/K	Total integrated dose:	100 krad + ETA
Test equipment:	B1500A	Time since irradiation:	188h 1m
Test program:	DIE 2N2907A test V1-00		
Parameters tested:	Multiple parameters		

DUT		I_{EBO}	I_{CBO}	I_{CEX}	$V_{(BR)EBO}$	$V_{(BR)CBO}$	$V_{(BR)CEO}$
		A ± 1%	A ± 1%	A ± 1%	V ± 1%	V ± 1%	V ± 1%
1	Control	8.75E-12	1.60E-12	4.56E-11	-8.84	-113	-112
2		5.60E-12	1.50E-13	1.12E-10	-8.84	-114	-114
3		8.75E-12	6.60E-12	1.63E-10	-8.85	-115	-114
4		1.90E-11	5.50E-12	1.03E-10	-8.87	-115	-109
5		4.15E-12	1.65E-11	1.21E-10	-8.83	-114	-114
6		5.45E-12	1.00E-13	8.02E-11	-8.86	-114	-115
7		1.00E-11	9.50E-13	2.03E-10	-8.86	-114	-110
8		1.53E-11	6.85E-12	1.75E-10	-8.83	-115	-115
9		5.95E-12	7.50E-12	1.68E-10	-8.85	-113	-115
10		2.06E-11	1.25E-12	1.52E-10	-8.85	-114	-114
11		1.54E-11	2.30E-12	2.02E-10	-8.87	-115	-109

DUT		$V_{CE(sat)1}$	$V_{CE(sat)2}$	$V_{BE(sat)1}$	$V_{BE(sat)2}$
		V ± 1%	V ± 1%	V ± 1%	V ± 1%
1	Control	-0.220	-0.781	-0.891	-1.103
2		-0.228	-0.850	-0.891	-1.111
3		-0.229	-0.853	-0.887	-1.102
4		-0.216	-0.690	-0.886	-1.100
5		-0.228	-0.849	-0.890	-1.106
6		-0.233	-0.874	-0.888	-1.104
7		-0.221	-0.706	-0.887	-1.109
8		-0.227	-0.848	-0.887	-1.099
9		-0.230	-0.889	-0.889	-1.106
10		-0.229	-0.849	-0.888	-1.106
11		-0.218	-0.694	-0.888	-1.107

Tested by: NG

Type number:	2N2907A	Test number:	9
Category:	PNP bipolar transistor	Date:	28/03/2024
Manufacturer:	Die Devices	Time:	11:51
Date code:	N/K	Total integrated dose:	100 krad + ETA
Test equipment:	B1500A	Time since irradiation:	188h 1m
Test program:	DIE 2N2907A test V1-00		
Parameters tested:	Multiple parameters		

DUT		$h_{FE} \pm 1\%$ ($I_C=0.1mA$)	$h_{FE} \pm 1\%$ ($I_C=1mA$)	$h_{FE} \pm 1\%$ ($I_C=10mA$)	$h_{FE} \pm 1\%$ ($I_C=150mA$)	$h_{FE} \pm 1\%$ ($I_C=500mA$)
1	Control	149	160	175	148	101
2		94	120	140	132	93
3		89	116	138	130	91
4		96	120	143	135	96
5		92	117	139	131	92
6		96	121	147	132	92
7		89	115	139	132	94
8		82	109	132	127	90
9		82	108	132	125	89
10		89	115	138	130	92
11		95	120	142	135	96

Tested by: NG