

# Unisys

DATE: October 16, 1997  
TO: G. Rose/312  
FROM: K. Sahu/300.1  
SUBJECT: Radiation Report on: 2N2880  
Project: GOES I-M  
Job #: M78294  
Project part #: 2N2880

PPM-97-049

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K. LaBel/735  
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OFA Library/300.1

A radiation evaluation was performed on 2N2880 to determine the total dose tolerance of these parts. A brief summary of the test results is provided below. For detailed information, refer to Tables I through IV and Figure 1.

The total dose testing was performed using a Co<sup>60</sup> gamma ray source. During the radiation testing, eight parts were irradiated under bias (see Figure 1 for bias configuration) and two parts were used as control samples. The total dose radiation levels were 25.0, 50.0, 75.0, and 100.0 kRads.\* The dose rate was 1.062 kRads/hour (0.17 Rads/s). See Table II for the radiation schedule and effective dose rate calculation. After the 100.0 kRad irradiation, the parts were annealed and measured after 72 hours and 240 hours at 25°C. After each radiation exposure and annealing treatment, parts were electrically tested according to the test conditions and the specification limits\*\* listed in Table III.

Initial electrical measurements were made on 10 samples. Eight samples (SN's 3, 4, 5, 6, 7, 8, 9, and 10) were used as radiation samples while SN's 1 and 2 were used as control samples. All parts passed all tests during initial electrical measurements.

After the 25.0, 50.0, 75.0, and 100 kRad irradiations, all parts showed a significant decrease in HFE2 ( $V_{CC}=5V$ ,  $I_C=100mA$ ), HFE3 ( $V_{CC}=2V$ ,  $I_C=100mA$ ) and HFE6 ( $V_{CC}=2V$ ,  $I_C=1A$ ). All parts also showed a significant increase in storage time. No significant change was noted in any of the parametric tests. **All parts passed all tests except SN 4 for HFE6. It fell marginally below the specification limit of 40 with a reading of 39 at 50 kRads and remained at 39 through annealing.**

After annealing the parts for 72 hours at 25°C, parts showed some recovery in the HFE parameters and the storage time measurement.

After annealing the parts for 240 hours at 25°C, parts showed no significant additional recovery in the HFE parameters and only some recovery in the storage time measurement.

Table IV provides a summary of the test results with the mean and standard deviation values for each parameter after each irradiation exposure and annealing step. Table V provides details of the measurements of HFE2, HFE3, HFE6, and Storage Time for each part.

Figures 2, 3, 4, and 5 show the results of the HFE and storage time measurements after each irradiation exposure and annealing step. A closer examination of the figures indicates that SN's 9 and 10, which had significantly higher HFE2 and HFE3 readings compared to all other parts, showed significant degradation in Storage Time after each radiation step. This indicates that the doping profiles for SN's 9 and 10 may be very different from those of the

\* The term Rads, as used in this document, means Rads (silicon). All radiation levels cited are cumulative.

\*\* These are manufacturer's pre-irradiation data specification limits. The manufacturer provided no post-irradiation limits at the time these tests were performed.

other parts. This data also indicates that the measurements of the gain parameters (HFE2 and HFE3) can be used to identify parts which are likely to have large increases in storage time when exposed to ionizing radiation.

Any further details about this evaluation can be obtained upon request. If you have any questions, please call me at (301) 731-8954.

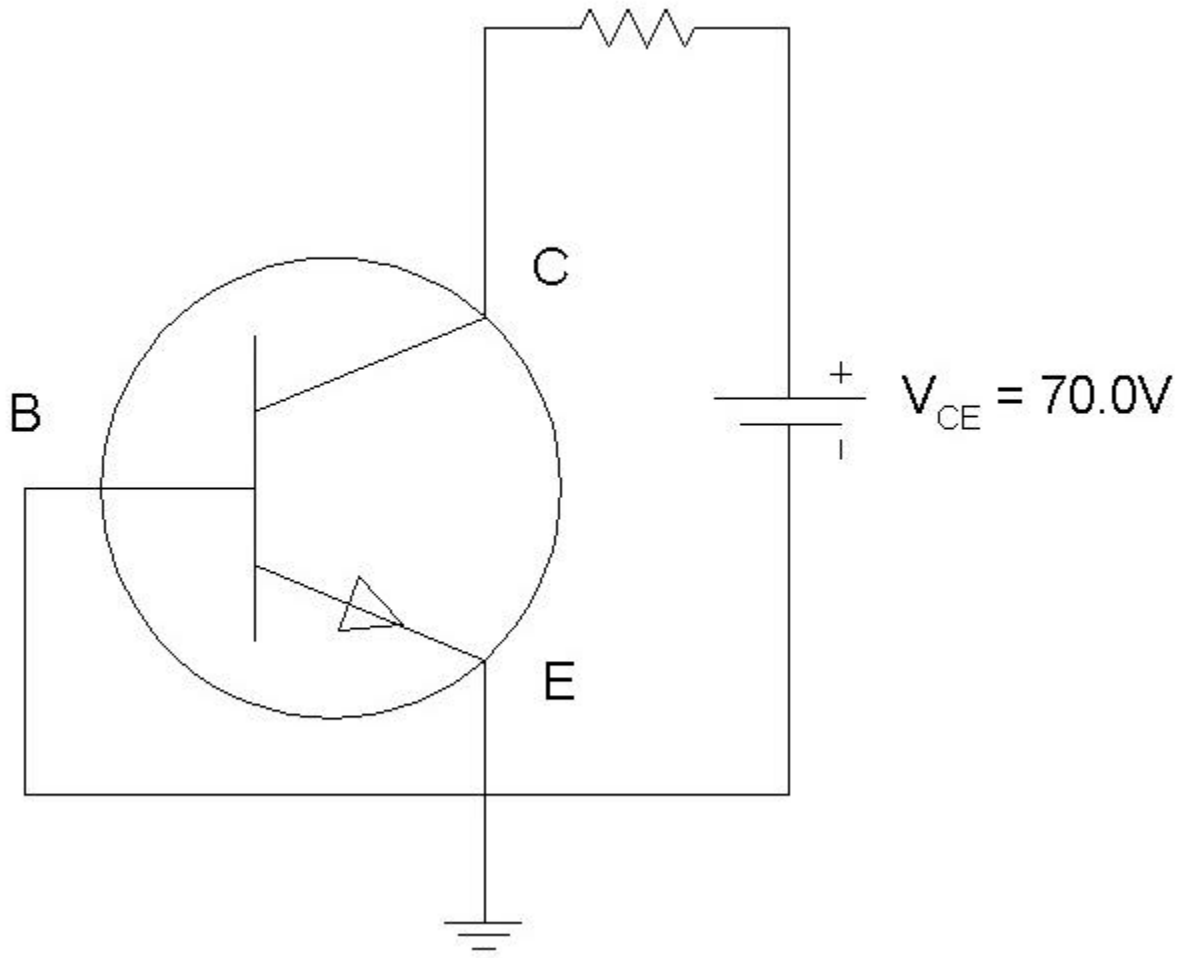
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Figure 1. Radiation Bias Circuit for 2N2880



Resistor is  $22k\Omega \pm 5\%$ ,  $\frac{1}{2}W$ .

TABLE I. Part Information

Generic Part Number:	2N2880
GOES I-M Part Number	2N2880
Charge Number:	M78294
Manufacturer:	Solitron
Lot Date Code (LDC):	9644
Quantity Tested:	10
Serial Number of Control Samples:	1, 2
Serial Numbers of Radiation Samples:	363, 364, 365, 366, 367, 368, 369, and 370
Part Function:	Transistor
Part Technology:	Hybrid Transistor
Package Style:	TO-5
Test Equipment:	Testronics/Bench Tests
Test Engineer:	S. Norris

- The manufacturer for this part guaranteed no radiation tolerance/hardness.

TABLE II. Radiation Schedule for 2N2880

EVENT.....	DATE
1) INITIAL ELECTRICAL MEASUREMENTS .....	08/28/97

2) 25.0 KRAD IRRADIATION (1.062 KRADS/HOUR) .....	09/29/97
POST-25.0 KRAD ELECTRICAL MEASUREMENT .....	09/30/97
3) 50.0 KRAD IRRADIATION (1.062 KRADS/HOUR) .....	10/01/97
POST-50.0 KRAD ELECTRICAL MEASUREMENT .....	10/02/97
4) 75.0 KRAD IRRADIATION (1.062 KRADS/HOUR) .....	10/02/97
POST-75.0 KRAD ELECTRICAL MEASUREMENT .....	10/03/97
5) 100.0 KRAD IRRADIATION (1.062 KRADS/HOUR).....	10/03/97
POST-100.0 KRAD ELECTRICAL MEASUREMENT .....	10/04/97
6) 72 HOUR ANNEALING @25°C.....	10/04/97
POST-72 HOUR ANNEAL ELECTRICAL MEASUREMENT.....	10/07/97
7) 240 HOUR ANNEALING @25°C .....	10/07/97
POST-240 HOUR ANNEAL ELECTRICAL MEASUREMENT.....	10/14/97

Effective Dose Rate =  $100,000 \text{ RADS}/5 \text{ DAYS}=833.3 \text{ RADS}/\text{HOUR}=0.231 \text{ RADS}/\text{SEC}$

The effective dose rate is lower than that of the individual radiation steps as it takes into account the interim-annealing step.

PARTS WERE IRRADIATED AND ANNEALED UNDER BIAS, SEE FIGURE 1.

Table III. Electrical Characteristics of 2N2880 /1

Test #	Parameter	Units	Test Conditions	Spec. min	Lim. max
1	VBR CBO	V	$I_C = 10\text{mA}$	200	
2	VBR CEO	V	$I_C = 10\text{mA}$	175	
3	VBREBO	V	$I_E = 10\text{mA}$	8	
4	ICBO	mA	$V_{CB} = 60\text{V}$		0.1
5	IEBO	mA	$V_{BE} = 5\text{V}$		0.1
6	ICEO	mA	$V_{CE} = 50\text{V}$		100
7	VCESAT	V	$I_C = 1\text{A}, I_B = 0.1\text{A}$		0.25
8	VBESAT	V	$I_C = 1\text{A}, I_B = 0.1\text{A}$		1.2
9	HFE 2 /2		$V_{CE} = 5\text{V}, I_C = 100\text{mA},$ <b>Pulse Width = 300ms</b>	10	
10	HFE 3 /2		$V_{CE} = 2\text{V}, I_C = 100\text{mA},$ <b>Pulse Width = 300ms</b>	10	
11	HFE 6 /2		$V_{CE} = 2\text{V}, I_C = 1\text{A},$ <b>Pulse Width = 300ms</b>	40	
12	Storage Time /3	ns		/4	/4

Notes:

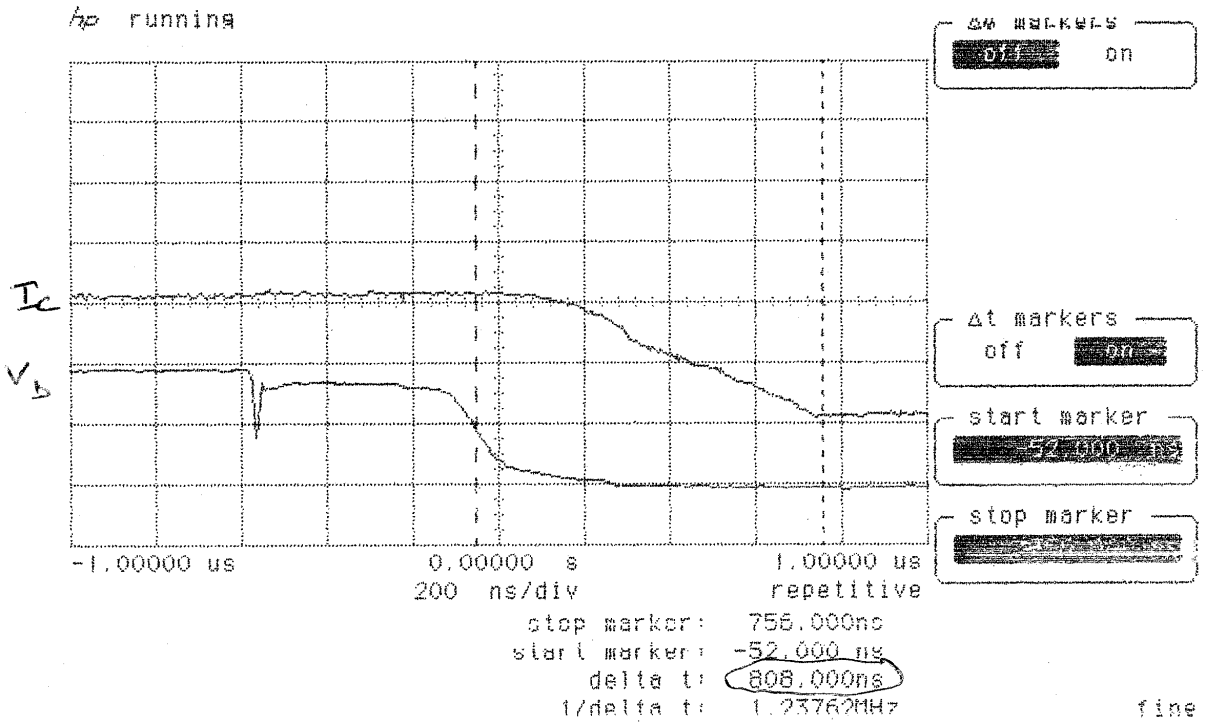
1/ These are the manufacturer's non-irradiated data sheet specification limits. The manufacturer provided no post-irradiation limits at the time the tests were performed.

2/ HFEs measurements were made on a curve tracer using a pulse width of 300μs.

3/ See Figure 6 for details on Storage Time measurements.

4/ The manufacturer provided no specification limits for this test.

Figure 6: Storage Time Wave Capture



	Sensitivity	Offset	Probe	Coupling	Impedance
Channel 1	1.00 V/div	1.98875 V	10:1	dc	1M ohm
Channel 2	8.00 mV/div	16.5000 mV	1:1	ac LF rej	1M ohm

Trigger Mode: Edge  
 On the Negative Edge of Channel 1  
 Trigger Level(s)  
 Channel 1 = -375.000 mV (noise reject OFF)  
 Holdoff = 40.000 ns

**TABLE IV: Summary of Electrical Measurements After Total Dose Exposures and Annelaing for 2N2880 /1**

Test #	Parameters	Units	Spec. Lim. /2 min max		Total Dose Exposure (kRads)										Annealing		Annealing	
					Initial		25.0		50.0		75.0		100.0		72 hours @25°C		240 hours @25°C	
					mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
1	VBRCBO /3	V	200		P		P		P		P		P		P		P	
2	VBRCBO /3	V	175		P		P		P		P		P		P		P	
3	VBRCBO /3	V	8		P		P		P		P		P		P		P	
4	ICBO	nA		100	-0.1	0.1	0.3	0.3	0.7	0.3	1.4	0.3	2.2	0.5	2.4	0.4	2.3	0.4
5	IEBO	nA		100	-0.3	0.2	-0.4	0.2	-0.2	0.2	-0.1	0.2	0.3	0.2	0.1	0.2	0.1	0.2
6	ICEO	mA		100	0.001	0.0003	0.001	0.0002	0.001	0.0004	0.001	0.0003	0.002	0.0004	0.003	0.0004	0.002	0.0004
7	VCESAT	V		0.25	0.13	0.005	0.13	0.005	0.14	0.005	0.14	0.007	0.14	0.008	0.14	0.007	0.14	0.007
8	VBESAT	V		1.2	0.9	0	0.9	0	0.9	0	0.9	0	0.9	0	0.9	0	0.9	0
9	HFE 1 Vcc=2V, Ic=10mA	/4	30		259	114												
10	HFE 2 Vcc=5V, Ic=100mA		10		342	167	301	137	266	118	258	111	241	101	251	106	252	105
11	HFE 3 Vcc=2V, Ic=100mA		10		329	154	292	129	260	112	251	105	224	85	244	101	244	99
12	HFE 4 Vcc=2V, Ic=300mA	/4	10		148	27												
13	HFE 5 Vcc=2V, Ic=500mA	/4	10		115	29												
14	HFE 6 Vcc=2V, Ic=1A		40		56	7.2	54	6.0	51	5.5	51	5.4	48	6.0	51	5.5	50	5.3
15	Storage Time	ns			862	54	838	37	1243	597	1426	779	1497	759	1467	766	1458	800

- Notes:
- 1/ The mean and standard deviation values were calculated over the eight parts irradiated in this testing. The control samples remained constant throughout the testing and are not included in this table.
  - 2/ These are manufacturer's pre-irradiation data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time the tests were performed.
  - 3/ "P" ("F") means that all parts passed (failed) this test at this step, nPmF means that n parts passed and m parts failed this test at this step.
  - 4/ These measurements were made only during initial electrical testing.

**Radiation sensitive parameters: HFE2, HFE3, HFE6, Storage Time.**



Table V: Performance of Critical Parameters for Each Part after Total Dose Exposures and Annealing 1/

SN	Parameter	Test Conditions	Spec. Limit		800µs HFE		300µs HFE	Total Ionizing Dose (kRads)				Annealing	Annealing
			min	max	Initial (Solitron)	Initial (Unisys)	Initial (Unisys)	25	50	75	100	72 hrs@25°C	240 hrs@25°C
1	HFE 2	Vce=5V, Ic=100mA	10		124	116	123	126	121	121	119	124	121
	HFE 3	Vce=2V, Ic=100mA	10		122	114	120	125	119	120	118	121	119
	HFE 6	Vce=2V, Ic=1A	40		48	50	40,41	42	41	41	40.4	41.1	41
	Storage Time (ns)						808	796	800	800	800	800	800
2	HFE 2	Vce=5V, Ic=100mA	10		132	126	136	136	130	130	128	132	134
	HFE 3	Vce=2V, Ic=100mA	10		126	124	132	133	129	130	128	130	131
	HFE 6	Vce=2V, Ic=1A	40		45	50	40,42	41.3	40	40	39	40.4	40.6
	Storage Time (ns)						800	800	800	802	805	800	800
3	HFE 2	Vce=5V, Ic=100mA	10		195	218	230	211	194	190	183	185	190
	HFE 3	Vce=2V, Ic=100mA	10		192	215	232	209	190	187	178	182	185
	HFE 6	Vce=2V, Ic=1A	40		54	68	50,52	48	49	48.5	47.1	49	49
	Storage Time (ns)						800	790	850	950	1000	1000	1000
4	HFE 2	Vce=5V, Ic=100mA	10		205	182	198	190	170	169.5	158	162	164
	HFE 3	Vce=2V, Ic=100mA	10		194	178	190	178	165	164	153	159	157
	HFE 6	Vce=2V, Ic=1A	40		48	54	42,41.6	42	38.7	39	38	39.2	38.4
	Storage Time (ns)						848	844	900	926	1020	980	945
5	HFE 2	Vce=5V, Ic=100mA	10		245	238	260	229	198	194	178	194	192
	HFE 3	Vce=2V, Ic=100mA	10		238	233	253	224	196	193	176	180	188
	HFE 6	Vce=2V, Ic=1A	40		64	72	55,55	56	51	52	48	51.5	51.5
	Storage Time (ns)						836	814	950	1000	1100	1000	1000
6	HFE 2	Vce=5V, Ic=100mA	10		245	228	244	216	194	190	185	187	188
	HFE 3	Vce=2V, Ic=100mA	10		241	225	236	213	192	188	180	184	185
	HFE 6	Vce=2V, Ic=1A	40		63	69	52,52.6	52	49.5	51	40	50.5	50
	Storage Time (ns)						868	884	990	1000	1100	1050	1000
7	HFE 2	Vce=5V, Ic=100mA	10		279	258	277	252	224	215	200	207	210
	HFE 3	Vce=2V, Ic=100mA	10		271	255	273	247	220	211	197	204	206
	HFE 6	Vce=2V, Ic=1A	40		63	69	55,55.5	52.6	50	51	49	50.2	50.5
	Storage Time (ns)						872	820	900	1010	1090	1090	1020
8	HFE 2	Vce=5V, Ic=100mA	10		279	258	279	246	222	213	200	212	211
	HFE 3	Vce=2V, Ic=100mA	10		271	255	276	243	217	210	197	208	208
	HFE 6	Vce=2V, Ic=1A	40		64	76	58,58.8	51.1	55	54.6	53.2	54.5	54.3
	Storage Time (ns)						864	800	850	980	1050	1040	1020
9	HFE 2	Vce=5V, Ic=100mA	10		560	507	561	495	425	413	377	406	409
	HFE 3	Vce=2V, Ic=100mA	10		527	485	529	471	416	396	276	390	390
	HFE 6	Vce=2V, Ic=1A	40		70	77	59,59.7	57.4	54	53.7	51.8	54	51
	Storage Time (ns)						990	900	2000	2890	2900	2900	2980
10	HFE 2	Vce=5V, Ic=100mA	10		658	619	684	574	505	480	448	458	452
	HFE 3	Vce=2V, Ic=100mA	10		628	592	645	549	485	462	431	442	434
	HFE 6	Vce=2V, Ic=1A	40		78	86	69,68.3	62.5	59	58.8	57.4	58.8	58
	Storage Time (ns)						814	850	2500	2650	2716	2680	2695

Note:

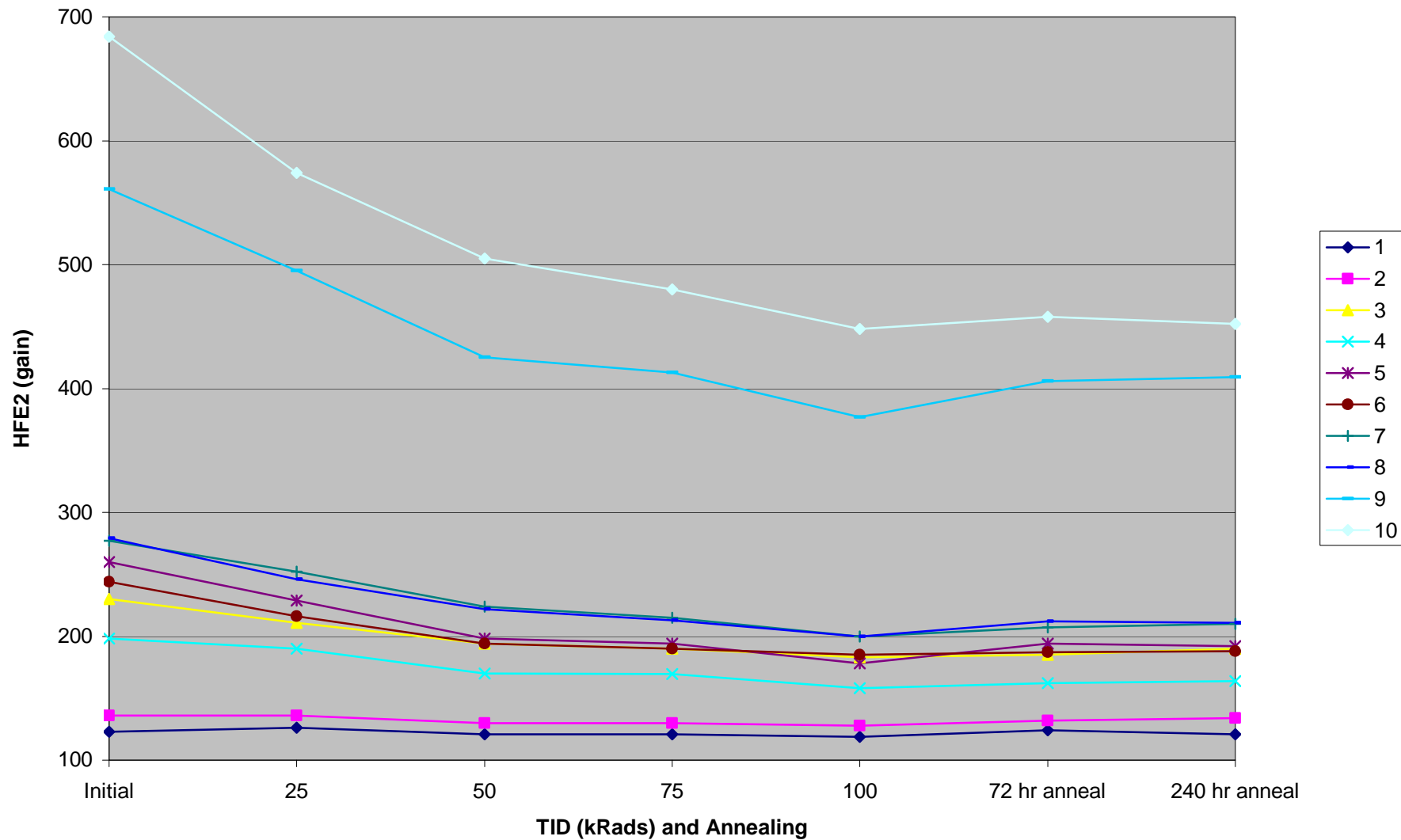
1. SN's 1 and 2 are control samples.

Table V: Performance of Critical Parameters for Each Part after Total Dose Exposures and Annealing 2/3

SN	Parameter	Test Conditions	Spec. Limit		80qs HFE			30qs HFE				Total Ionizing Dose (kRads)				Annealing 72 hrs@25°C	Annealing 240 hrs@25°C
			min	max	Initial (Solitron)	Initial (Unisys)	Initial (Unisys)	25	50	75	100						
1	HFES 1	Vce=2V, Ic=10mA	30		110	99	105.107										
	HFES 2	Vce=5V, Ic=100mA	10		124	116	123										
	HFES 3	Vce=2V, Ic=100mA	10		122	114	120										
	HFES 4	Vce=2V, Ic=300mA	10		93	115	83										
	HFES 5	Vce=2V, Ic=500mA	10		65	94	70										
	HFES 6	Vce=2V, Ic=1A	40		48	50	40.41										
		Storage Time					808										
2	HFES 1	Vce=2V, Ic=10mA	30		115	106	111.112										
	HFES 2	Vce=5V, Ic=100mA	10		132	126	136										
	HFES 3	Vce=2V, Ic=100mA	10		126	124	132										
	HFES 4	Vce=2V, Ic=300mA	10		91	125	86										
	HFES 5	Vce=2V, Ic=500mA	10		62	97	70										
	HFES 6	Vce=2V, Ic=1A	40		45	50	40.42										
		Storage Time					800										
3	HFES 1	Vce=2V, Ic=10mA	30		171	164	175.176										
	HFES 2	Vce=5V, Ic=100mA	10		195	218	230										
	HFES 3	Vce=2V, Ic=100mA	10		192	215	232										
	HFES 4	Vce=2V, Ic=300mA	10		132	219	133										
	HFES 5	Vce=2V, Ic=500mA	10		82	160	102										
	HFES 6	Vce=2V, Ic=1A	40		54	68	50.52										
		Storage Time					800										
4	HFES 1	Vce=2V, Ic=10mA	30		149	127	136.136										
	HFES 2	Vce=5V, Ic=100mA	10		205	182	198										
	HFES 3	Vce=2V, Ic=100mA	10		194	178	190										
	HFES 4	Vce=2V, Ic=300mA	10		116	175	100										
	HFES 5	Vce=2V, Ic=500mA	10		71	120	76										
	HFES 6	Vce=2V, Ic=1A	40		48	54	42.41.6										
		Storage Time					848										
5	HFES 1	Vce=2V, Ic=10mA	30		209	191	204.204										
	HFES 2	Vce=5V, Ic=100mA	10		245	238	260										
	HFES 3	Vce=2V, Ic=100mA	10		238	233	253										
	HFES 4	Vce=2V, Ic=300mA	10		157	227	140										
	HFES 5	Vce=2V, Ic=500mA	10		95	170	109										
	HFES 6	Vce=2V, Ic=1A	40		64	72	55.55										
		Storage Time					836										
6	HFES 1	Vce=2V, Ic=10mA	30		218	185	205										
	HFES 2	Vce=5V, Ic=100mA	10		245	228	244										
	HFES 3	Vce=2V, Ic=100mA	10		241	225	236										
	HFES 4	Vce=2V, Ic=300mA	10		154	223	136										
	HFES 5	Vce=2V, Ic=500mA	10		92	162	104										
	HFES 6	Vce=2V, Ic=1A	40		63	69	52.52.6										
		Storage Time					868										
7	HFES 1	Vce=2V, Ic=10mA	30		245	215	227.227										
	HFES 2	Vce=5V, Ic=100mA	10		279	258	277										
	HFES 3	Vce=2V, Ic=100mA	10		271	255	273										
	HFES 4	Vce=2V, Ic=300mA	10		162	250	141										
	HFES 5	Vce=2V, Ic=500mA	10		93	172	109										
	HFES 6	Vce=2V, Ic=1A	40		63	69	55.55.5										
		Storage Time					872										
8	HFES 1	Vce=2V, Ic=10mA	30		241	201	230										
	HFES 2	Vce=5V, Ic=100mA	10		279	258	279										
	HFES 3	Vce=2V, Ic=100mA	10		271	255	276										
	HFES 4	Vce=2V, Ic=300mA	10		164	256	178										
	HFES 5	Vce=2V, Ic=500mA	10		94	186	117										
	HFES 6	Vce=2V, Ic=1A	40		64	76	58.58.8										
		Storage Time					864										
9	HFES 1	Vce=2V, Ic=10mA	30		421	370	403										
	HFES 2	Vce=5V, Ic=100mA	10		560	507	561										
	HFES 3	Vce=2V, Ic=100mA	10		527	485	529										
	HFES 4	Vce=2V, Ic=300mA	10		232	480	162										
	HFES 5	Vce=2V, Ic=500mA	10		108	261	117										
	HFES 6	Vce=2V, Ic=1A	40		70	77	59.59.7										
		Storage Time					990										
10	HFES 1	Vce=2V, Ic=10mA	30		508	453	490.490.10										
	HFES 2	Vce=5V, Ic=100mA	10		658	619	684										
	HFES 3	Vce=2V, Ic=100mA	10		628	592	645										
	HFES 4	Vce=2V, Ic=300mA	10		275	575	191										
	HFES 5	Vce=2V, Ic=500mA	10		123	306	186										
	HFES 6	Vce=2V, Ic=1A	40		78	86	69.68.3										
		Storage Time					814										

Notes:  
 1. SN's 1 and 2 are control samples.  
 2. P (F) means the part passed (failed) this test at this level.

**Figure 2: HFE2 (Vcc=5V, Ic=100mA) vs Total Ionizing Dose**



**Figure 3: HFE3 (Vcc=2V, Ic=100mA) vs Total Ionizing Dose**

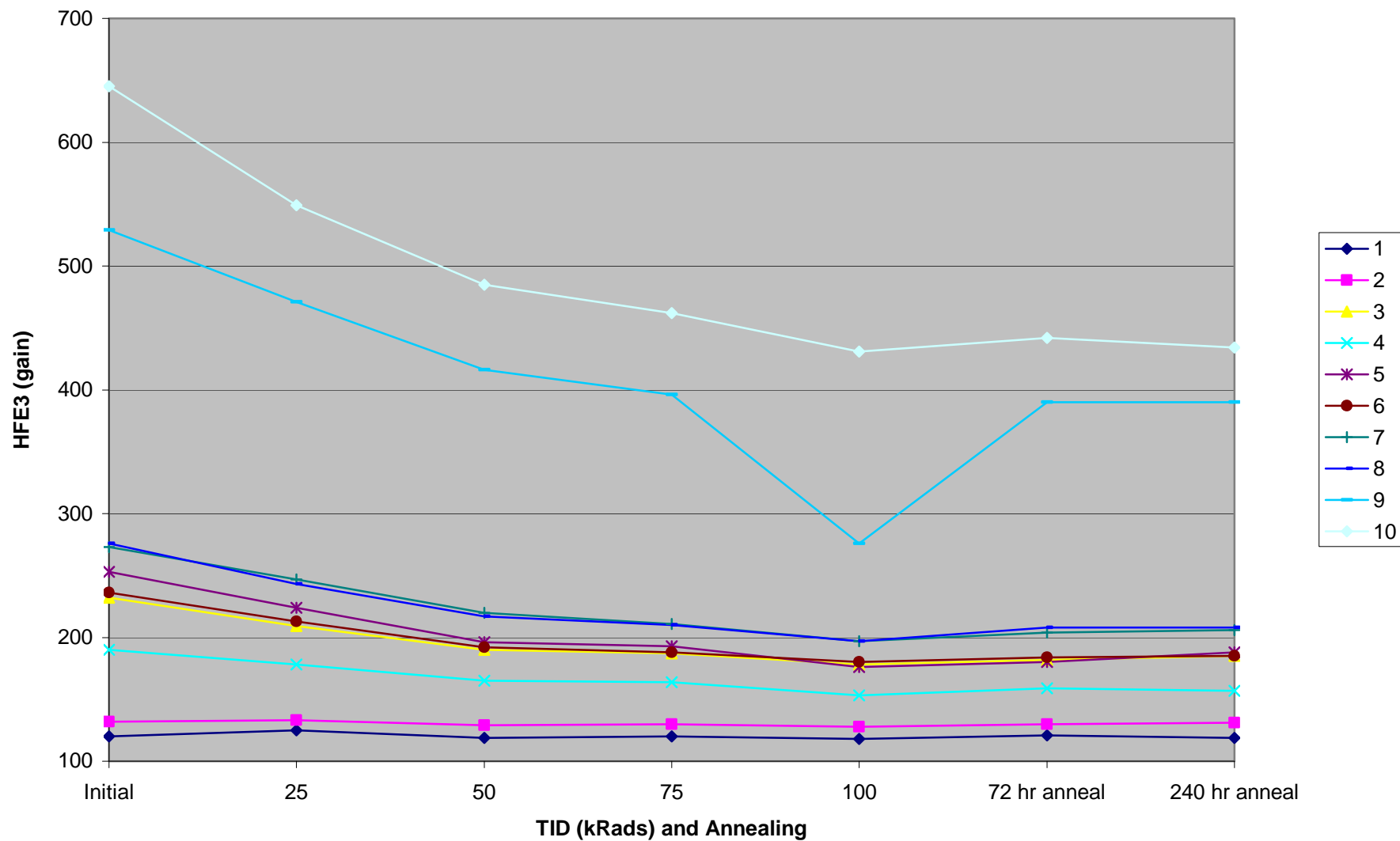
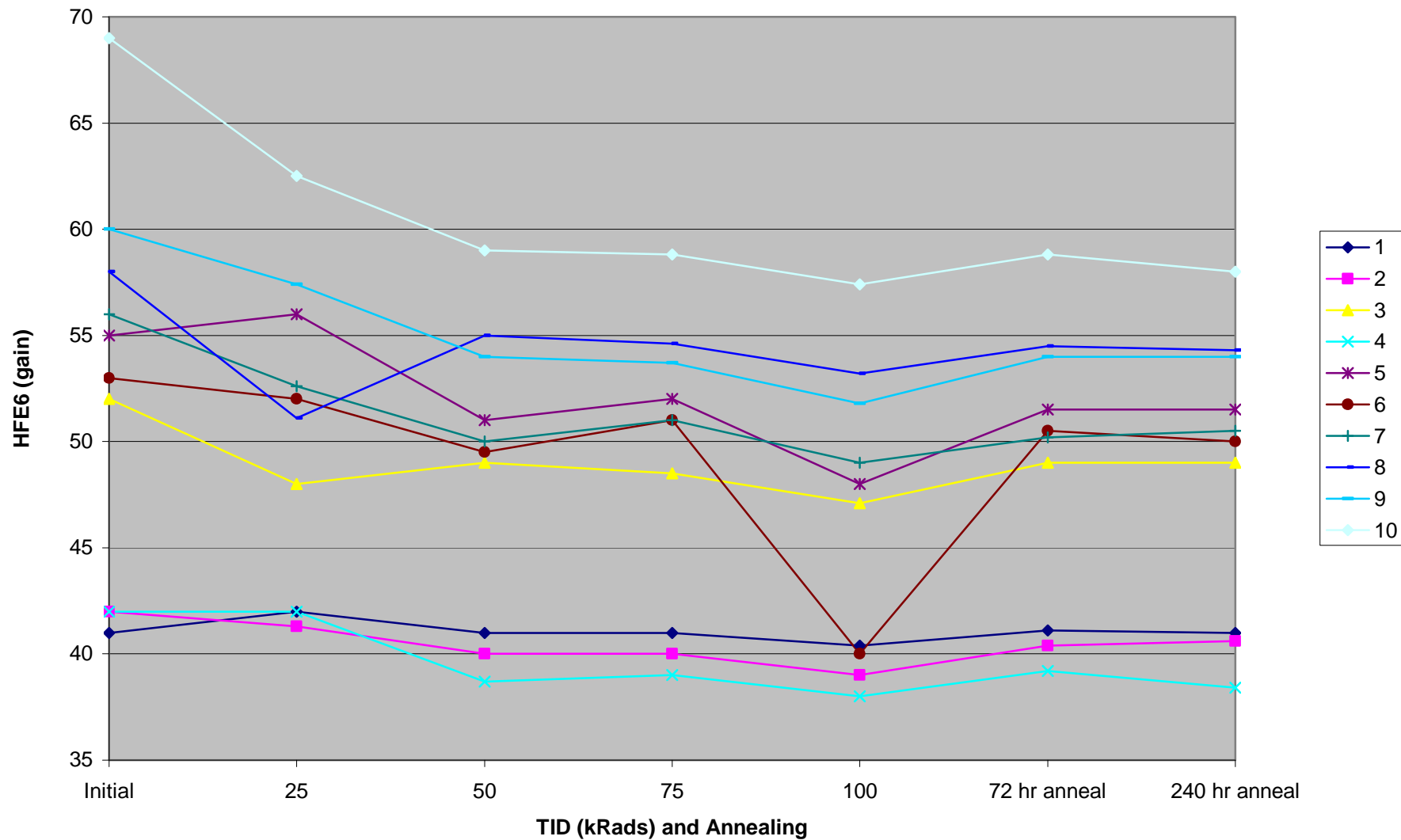


Figure 4: HFE6 (Vcc=2V, Ic=1A) vs Total Ionizing Dose



**Figure 5: Storage Time vs Total Ionizing Dose**

