Radiation Testing to Determine the TID Susceptibility and SEL LET Thresholds of COTS Devices, 13 Different Types, for the GAIA Project.

by

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Abstract

Candidate COTS devices in plastic packages were Co-60 TID and heavy ion SEL tested as part of a radiation pre-screening programme for GAIA. Thirteen different device groups were tested with three devices per group. Two times 39 devices were installed into the same test PCB to be used at both the Co-60 and Heavy ion test sites.

Selected Radiation Test Components:

Part no.	Description	Manufacturer
AD8028	Op amp 190MHz +5V single supply, rail-to-rail	Analog Devices
AD8065	Op amp 145MHz FET input +5V single supply, rail-to-rail	Analog Devices
LMH6622	Dual op amp +/-5V supply not rail-to rail	National Semiconductor
LMH6628	Dual op amp +/-5V supply not rail-to rail	National Semiconductor
LT1806	Op amp 325MHz +5V single supply, rail-to-rail	Linear Technology
EL7202	Dual 2A MOSFET driver	Intersil Elantec
EL7156	Single 3.5 MOSFET driver	Intersil Elantec
EL7457	Quad 2A MOSFET driver TTL inputs	Intersil Elantec
ICL7667	Dual 1A MOSFET driver	Intersil
ADG712	Quad analogue switch 4ohm11ns, +5V single supply	Analog Devices
ADG719	Single analogue switch 4ohm 7ns, +5V single supply	Analog Devices
MAX313	Quad analogue switch 15ohm100ns, 44V max. +/-5V min.	Maxim
SST175	PFET Ron 125ohm Vgs 3-6V Ton 25ns	Vishay

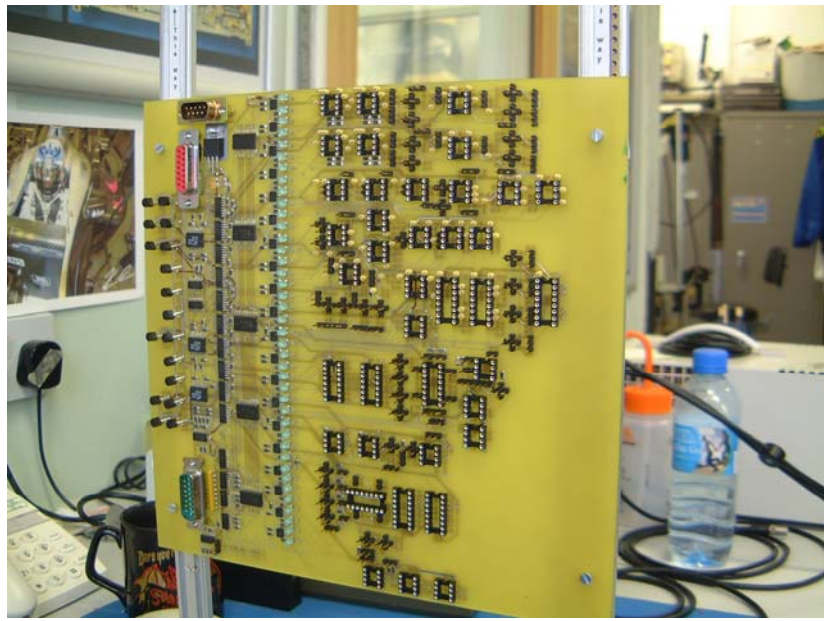
Test Hardware I.

PCB: To Accommodate 13 groups of 3 device types
Main Functions: 3 with respect to each of the 39 DUTs

1 Characterisation of component parameters pre and post irradiation.

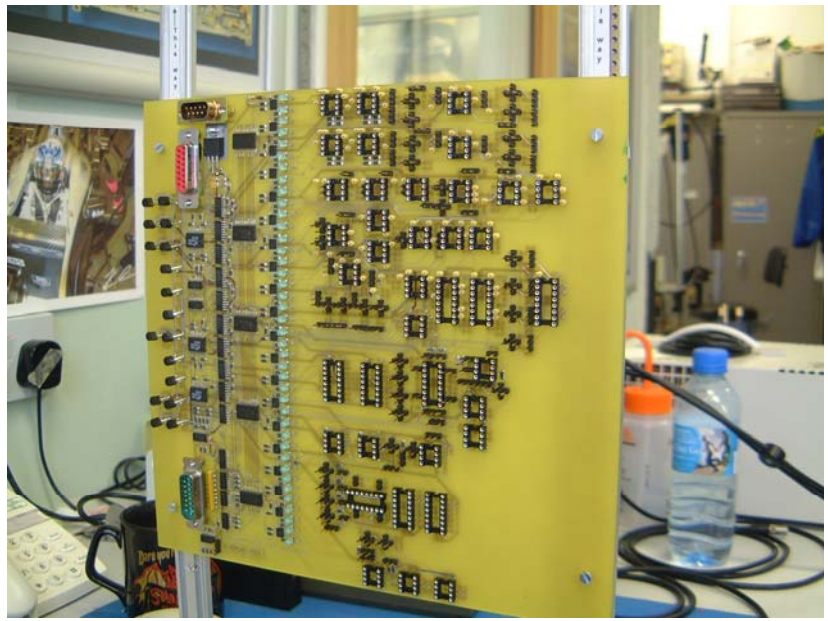
2 Stimulation/biasing of devices during irradiation.

3 Monitoring each devices supply current during irradiation. (Latch-up protection/reset)



Test Software I.

Software: LabVIEW
Main Functions: 4 (for TID)



1 Monitor the 39 device currents from the test PCB via USB.

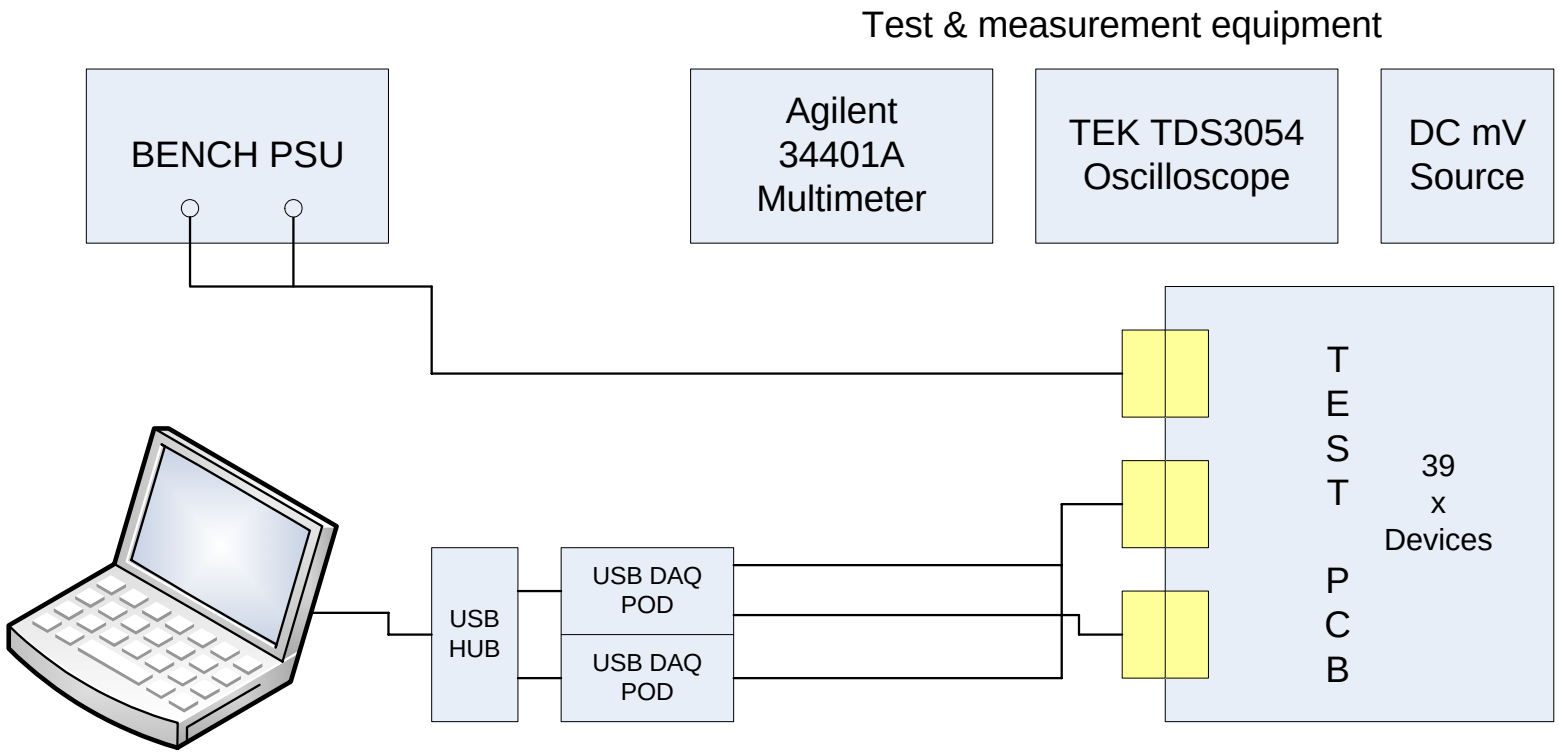
2 Switch off any device that consistently draws a high current (>Th. Point).

3 Display the current of all 39 devices

4 Log to file every minute each device current.

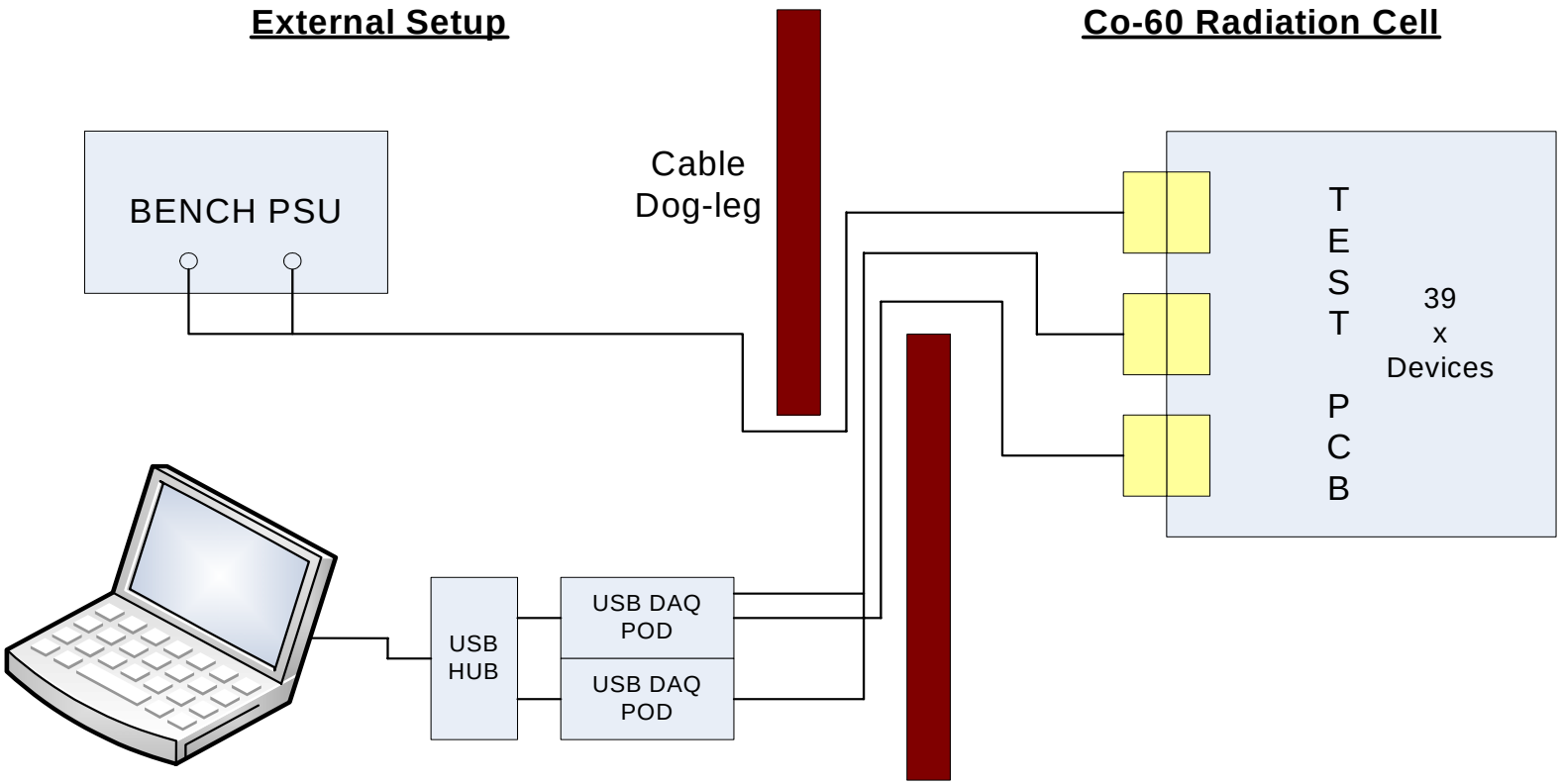
Test Hardware – Characterisation Setup I.

Characterise each device prior to irradiation

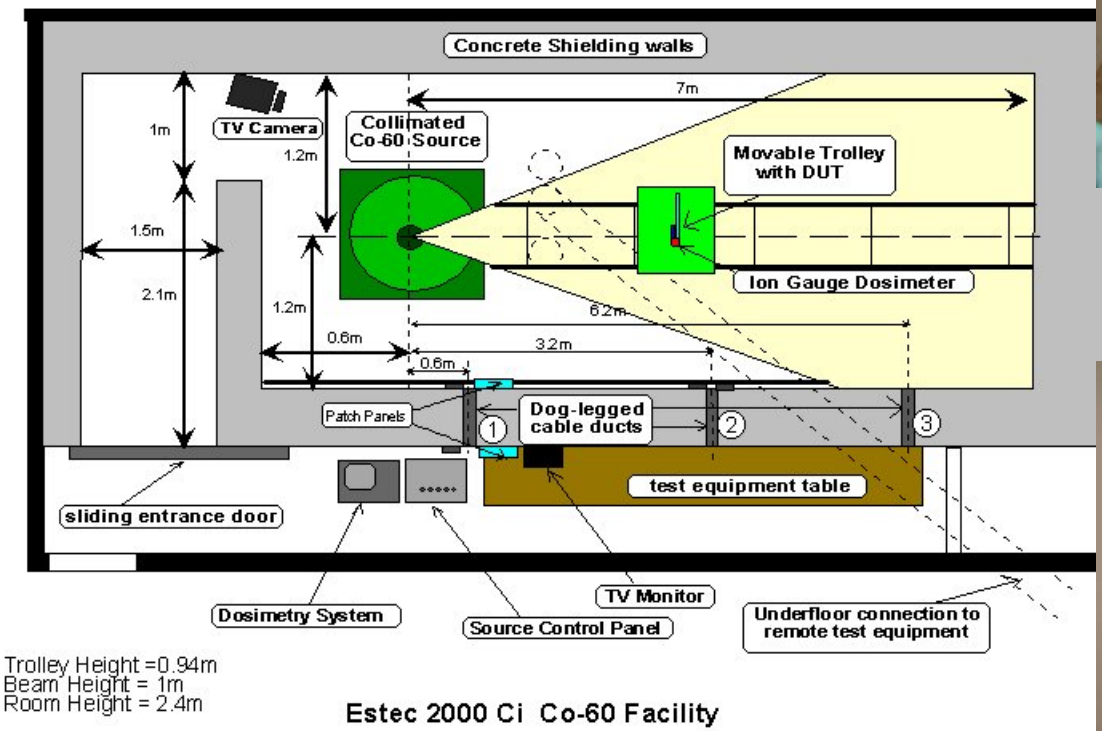


Re-characterise each device following irradiation.

Total Ionising Dose Test Setup:



Total Ionising Dose Co-60 Facility:



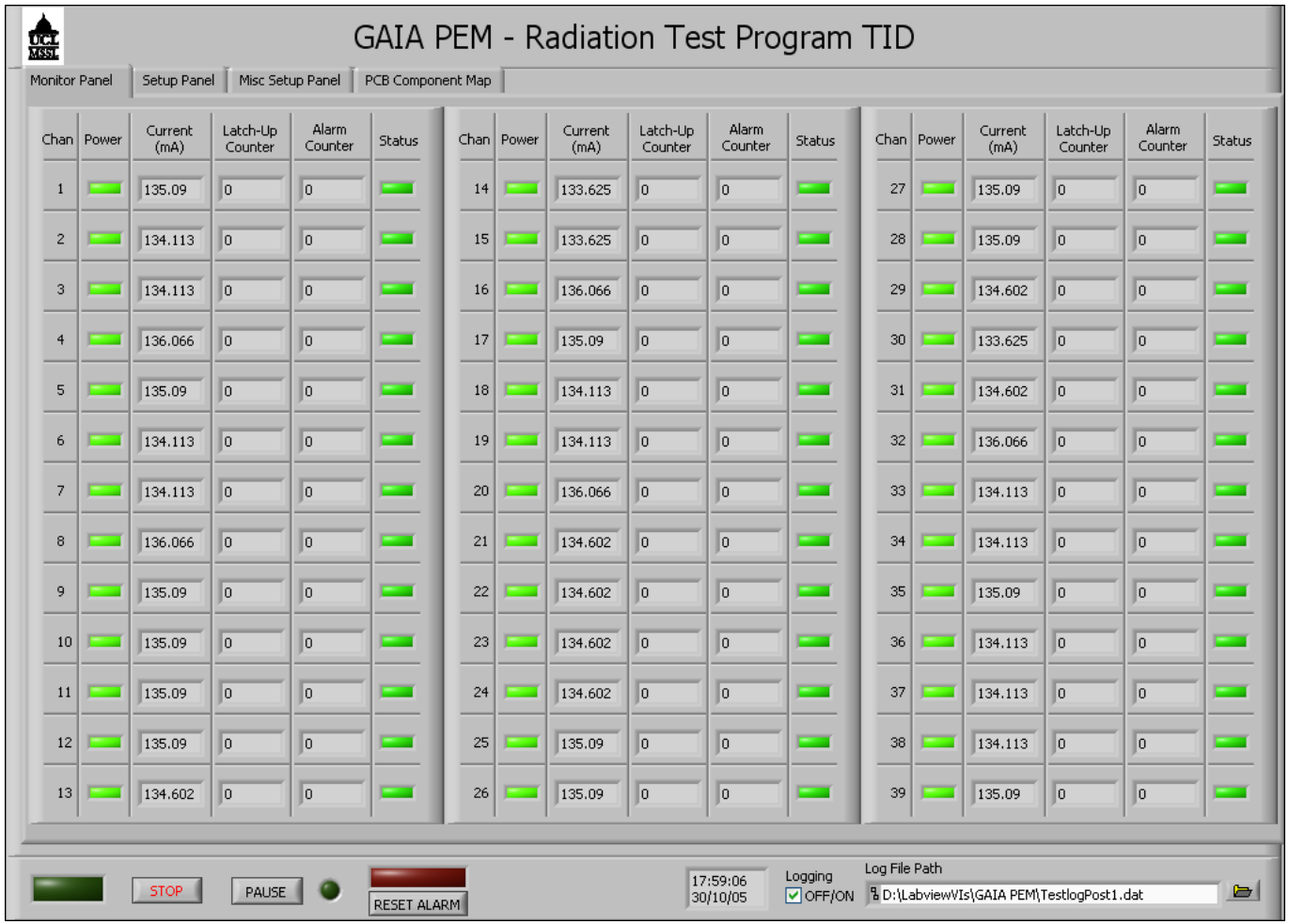
Trolley Height =0.94m
Beam Height = 1m
Room Height = 2.4m

Estec 2000 Ci Co-60 Facility

Total Ionising Dose Test Conditions:

- All 39 devices installed into the test PCB
- Expose to Co-60 source – dose rate 24.02 Rads(Si)/min.
- Stop irradiation when a TID of 20kRads(Si) is achieved.
- Remove 1 of each type of DUT (13 device types).
- Expose to Co-60 source – dose rate 24.02 Rads(Si)/min.
- Stop irradiation when a TID of a further 30kRads(Si) or total of 50kRads(Si) has be achieved.
- Anneal at room temperature for 48 hours unbiased.
- Re-characterise each device following irradiation.

Total Ionising Dose Test: Monitor Front Panel



Total Ionising Dose: Results

EL7202CS (B527X5) – Intersil, High Speed, Dual, Power MOSFET Driver

Device # 10 20Krad(Si)

Device: EL7202 **Dosage:** 20 k Rad(Si)
Device # 10 **Date:** 17/10/05 **Date:** 02/11/05

Symbol	Parameter	Conditions		Pre-Irradiation			Post-Irradiation			Manufacturer specification			Post Delta	Units	Pass	Notes
				Min	Typical	Max	Min	Typical	Max	Min	Typical	Max				
I_S	Supply current	I/P=OFF			0.084			0.419			n/a		0.335	mA	YES	
		I/P=ON			0.084			0.126			4.5	7.5	0.042	mA	YES	
$t_{D(on)}$	Turn-on delay	Load = 120nF & 100R	A		46			51			18	25	5.000	ns	YES	
			B		46			51					5.000		YES	
$t_{D(off)}$	Turn-off delay		A		38			60			20	25	22.000	ns	YES	
			B		36			60					24.000		YES	
t_R	O/P Rise time		A		20			17			10	20	-3.000	ns	YES	
			B		19			17					-2.000		YES	
t_F	O/P Fall time		A		14			14			13	20	0.000	ns	YES	
			B		15			14					-1.000		YES	
$I_{ST(rise)}$	Shoot through current - O/P rising				244			234			n/a		-10.000	mA	YES	
$I_{ST(fall)}$	Shoot through current - O/P falling				140			142			n/a		2.000	mA	YES	
$t_{D(on)}$	Turn-on delay	Load = 380pF & 20R	A		40			47			18	25	7.000	ns	YES	
			B		40			47					7.000		YES	
$t_{D(off)}$	Turn-off delay		A		35			59			20	25	24.000	ns	YES	
			B		34			60					26.000		YES	
t_R	O/P Rise time		A		11			10			10	20	-1.000	ns	YES	
			B		11			10					-1.000		YES	
t_F	O/P Fall time		A		6			7			13	20	1.000	ns	YES	
			B		6			7					1.000		YES	
$I_{ST(rise)}$	Shoot through current - O/P rising				164			128			n/a		-36.000	mA	YES	
$I_{ST(fall)}$	Shoot through current - O/P falling				298			71			n/a		-227.000	mA	YES	

Total Ionising Dose: Results

EL7202CS (B527X5) – Intersil, High Speed, Dual, Power MOSFET Driver

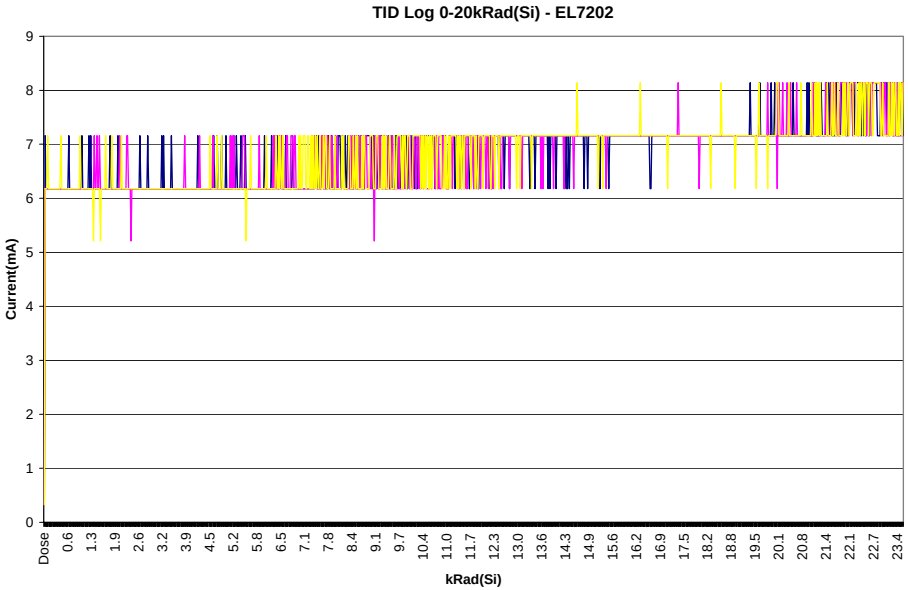
Device # 11 50Krad(Si)

Device: EL7202 **Dosage:** 50 k Rad(Si)
Device # 11 **Date:** 17/10/05 **Date:** 02/11/05

Symbol	Parameter	Conditions		Pre-Irradiation			Post-Irradiation			Manufacturer specification			Post Delta	Units	Pass	Notes
				Min	Typical	Max	Min	Typical	Max	Min	Typical	Max				
I_S	Supply current	I/P=OFF			0.079			0.575			n/a		0.496	mA	YES	
		I/P=ON			0.08			0.333			4.5	7.5	0.253	mA	YES	
$t_{D(on)}$	Turn-on delay	Load = 120nF & 100R	A		46			18			18	25	-28.000	ns	YES	
			B		37			18					-19.000		YES	
$t_{D(off)}$	Turn-off delay		A		36			63			20	25	27.000	ns	YES	
			B		36			63					27.000		YES	
t_R	O/P Rise time		A		19			51			10	20	32.000	ns	YES	
			B		19			51					32.000		YES	
t_F	O/P Fall time		A		15			15			13	20	0.000	ns	YES	
			B		15			15					0.000		YES	
$I_{ST(rise)}$	Shoot through current - O/P rising				248			220			n/a		-28.000	mA	YES	
$I_{ST(fall)}$	Shoot through current - O/P falling				156			142			n/a		-14.000	mA	YES	
$t_{D(on)}$	Turn-on delay	Load = 380pF & 20R	A		41			48			18	25	7.000	ns	YES	
			B		40			48					8.000		YES	
$t_{D(off)}$	Turn-off delay		A		35			63			20	25	28.000	ns	YES	
			B		34			63					29.000		YES	
t_R	O/P Rise time		A		11			11			10	20	0.000	ns	YES	
			B		11			11					0.000		YES	
t_F	O/P Fall time		A		6			8			13	20	2.000	ns	YES	
			B		6			8					2.000		YES	
$I_{ST(rise)}$	Shoot through current - O/P rising				164			94			n/a		-70.000	mA	YES	
$I_{ST(fall)}$	Shoot through current - O/P falling				264			132			n/a		-132.000	mA	YES	

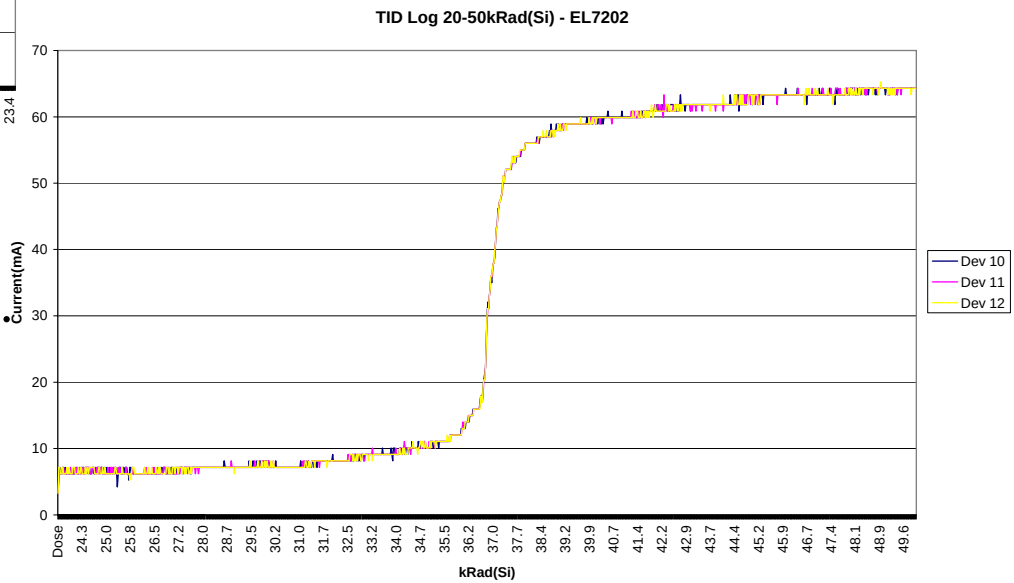
Total Ionising Dose: Results

EL7202CS (B527X5) – Intersil, High Speed, Dual, Power MOSFET Driver



Current graph – 0 to 20kRads (Si)

Current graph – 20 to 50kRads (Si)

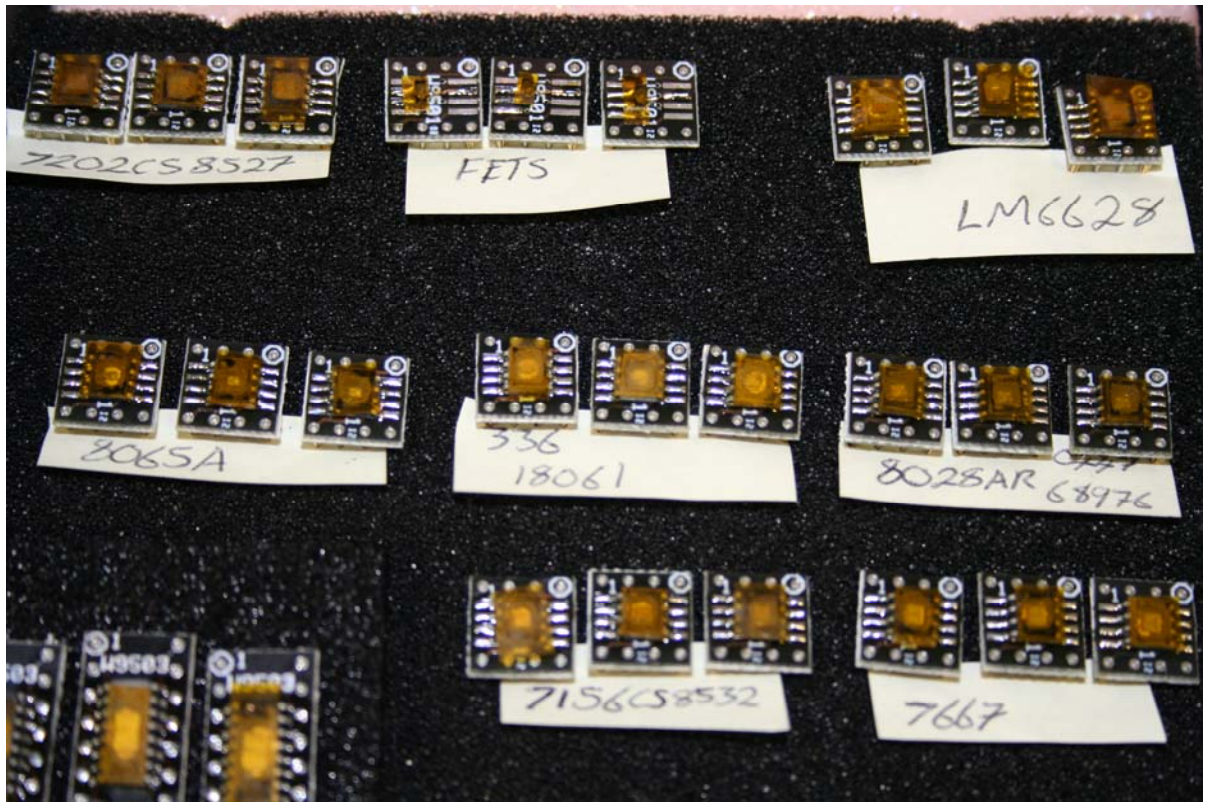


Small increase in supply current, acceptable change of propagation delays following TID of 50krads (Si).
Current monitoring failed at approximately 37krads (Si).
TID Tolerance ~50krad(Si).

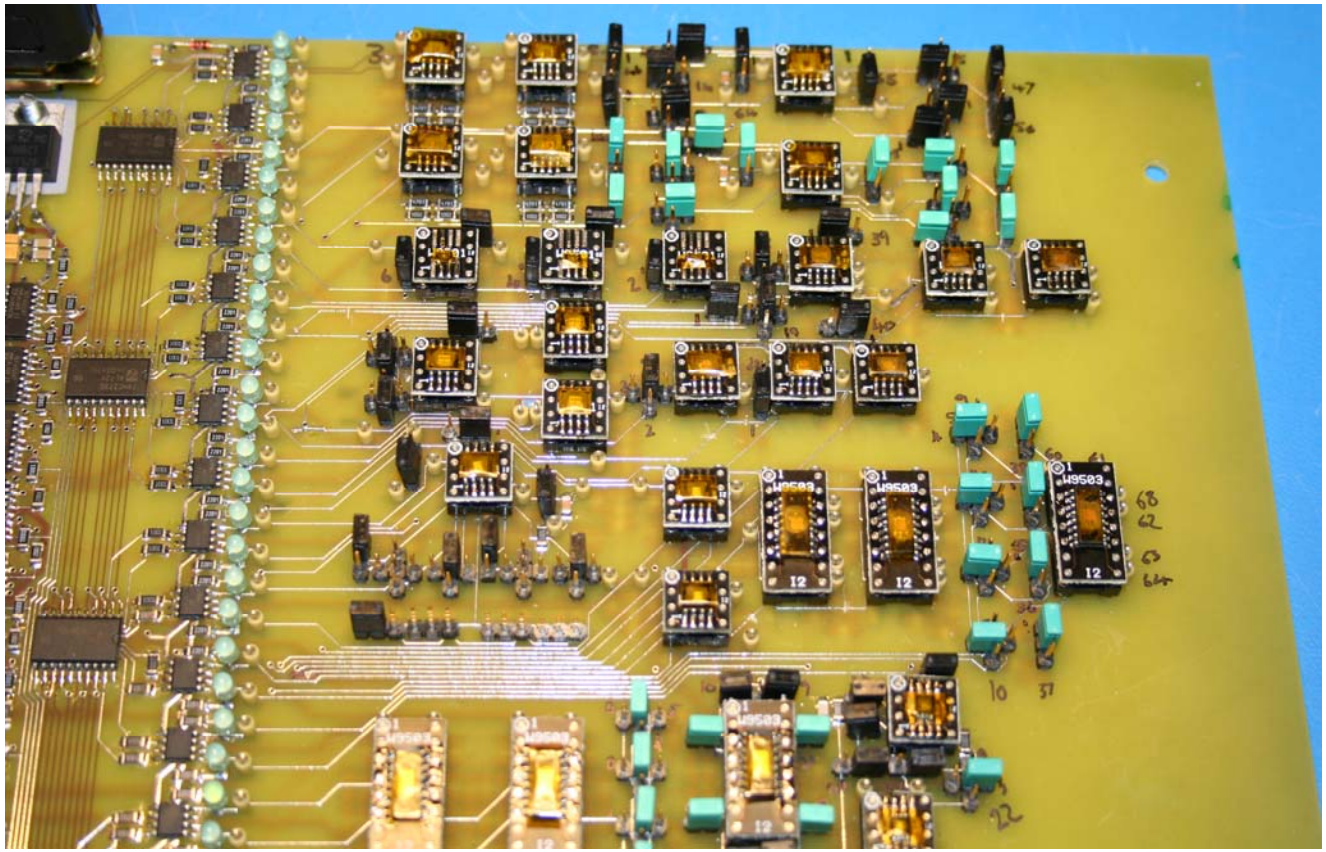
Total Ionising Dose: Summary Results

Device Type	TID Tolerance krad(Si)
AD8028	>50
AD8065	<20
LMH6622	>50
LMH6628	>50
LT1806	<20
EL7202	~50
EL7156	<20
EL7457	~50
ICL7667	~50
ADG712	<20
ADG719	<20
MAX313	<20
SST175	>50

Single Event Latch-up: Components de-lidded



Single Event Latch-up: Components de-lidded on PCB



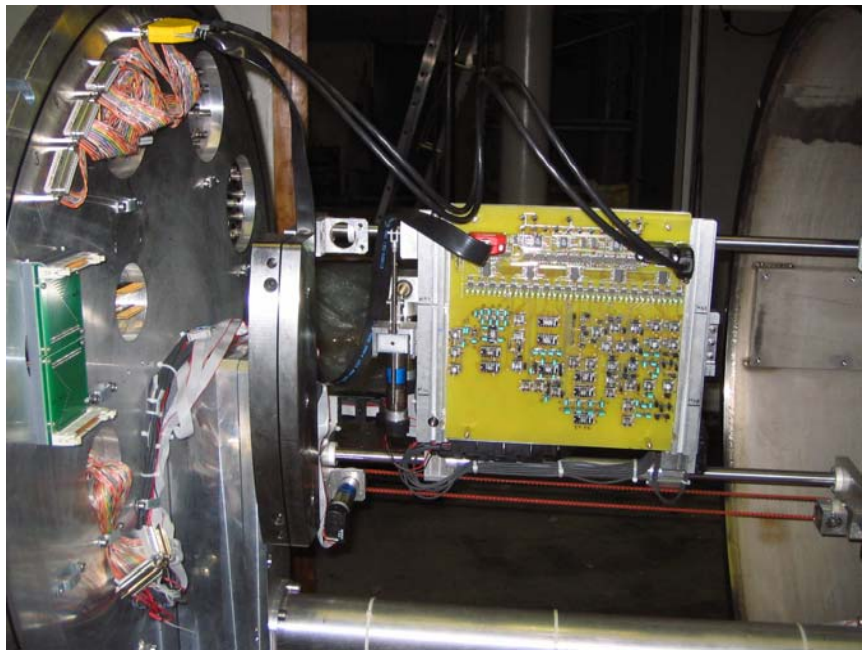
Single Event Latch-up: PCB Inside the HIF Chamber

PCB: To Accommodate 13 groups of 3 device types
Main Functions: 3 with respect to each of the 39 DUTs

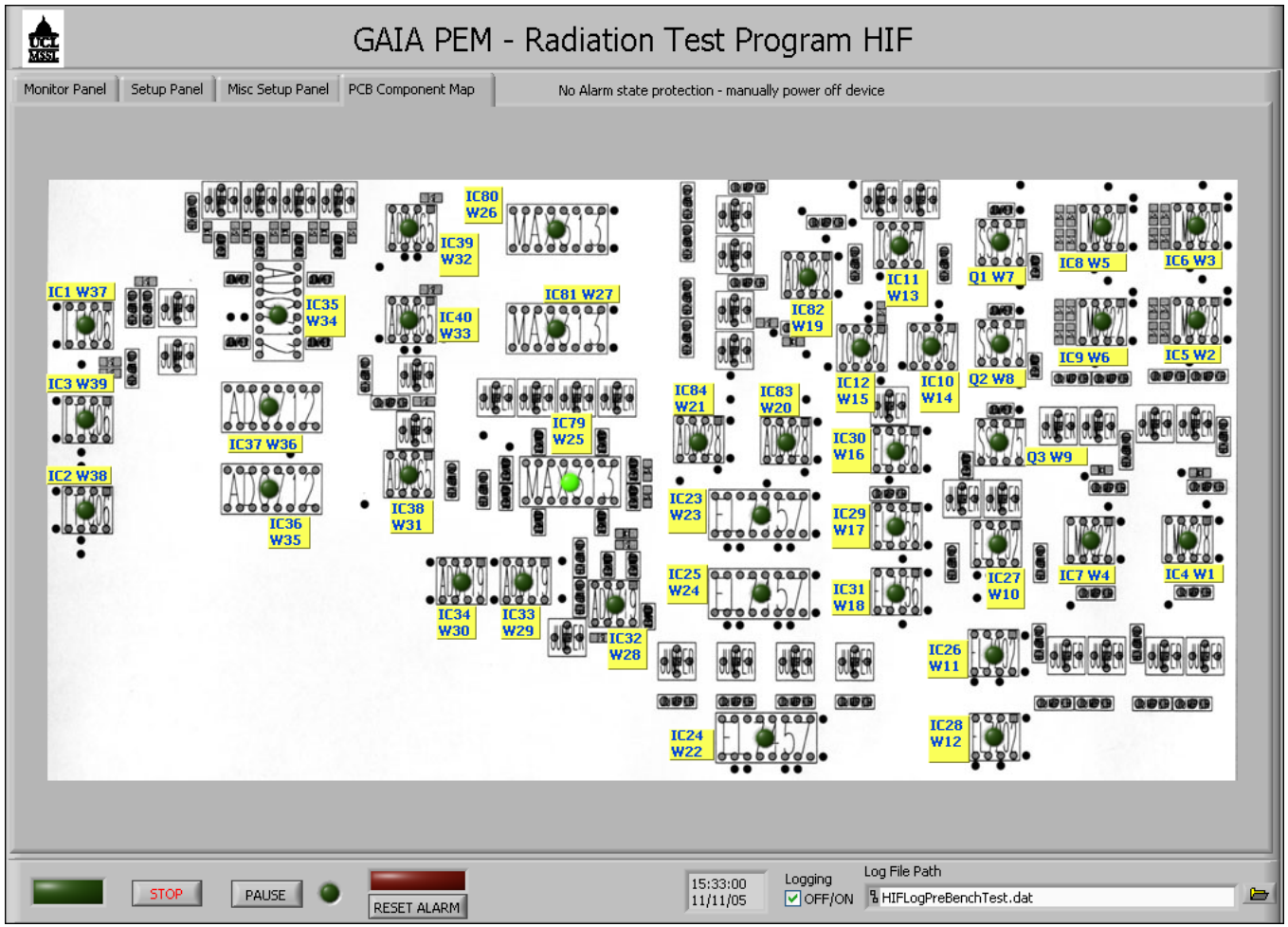
1 Stimulation/biasing of an individual device during irradiation.

2 Monitoring each device's supply current during irradiation.

3 Providing Latch-up protection and reset during irradiation.



Single Event Latch-up: Control Panel



Single Event Latch-up: Results

Device	ID	Ion Species	Energy (MeV)	Effective LET (MeV.cm²/mg)	Fluence Reached #/(cm².s)	Tilt Angle (degrees)	Test Time (Secs)	Total Latch-ups
EL7457	W24	132 Xe 26+	459	55.9	1005718	0	-	0
				79	1005345	45	189	0
	W23	132 Xe 26+	459	55.9	1004531	0	118	0
				79	1004176	45	167	0
ADG712	W36	20 Ne 4+	78	8.3	1010139	45	62	0
		40 Ar 8+	150	14.1	1006268	0	42	0
				20	1016739	45	61	5
		84 Kr 17+	316	34	1021422	0	48	14
		132 Xe 26+	459	55.9	1004300	0	124	29
	W35	20 Ne 4+	78	8.3	1018640	45	45	0
		40 Ar 8+	150	14.1	1001358	0	45	3
				20	1006012	45	62	8
		84 Kr 17+	316	34	1008805	0	71	19
		132 Xe 26+	459	55.9	1004981	0	117	23
	W34	20 Ne 4+	78	8.3	1007114	45	50	0
		40 Ar 8+	150	14.1	1009855	0	51	2
				20	1007952	45	61	8
		84 Kr 17+	316	34	1004426	0	70	23
MAX313	W25	132 Xe 26+	459	55.9	1004116	0	123	0
				79	1002903	45	178	0
	W27	132 Xe 26+	459	55.9	1002179	0	108	0
				79	1001886	45	175	0
ADG806S	W33	132 Xe 26+	459	55.9	1004474	0	97	0
				79	1000109	45	131	0
	W31	132 Xe 26+	459	55.9	1007317	0	79	0
				79	1003213	45	107	0
	[illegible]	132 Xe 26+		[illegible]	101[illegible]	0	80	[illegible]

		132 Xe [illegible]		[illegible]9		[illegible]5		
	W14	132 Xe 26+		55.9		0		
				79		45		0
SST175	W8	132 Xe 26+	[illegible]	55.9	101[illegible]5	0		0
				79	1000584	45		0
	W9	132 Xe 26+	459	55.9	1000446	0	6[illegible]	0
				79	1003023	45	97	0
EL7202	W10	132 Xe 26+	459	55.9	1012903	0	62	0
				79	1006902	45	87	0
	W11	132 Xe 26+	459	55.9	1006171	0	63	0
				79	1009236	45	84	0
EL7156	W18	132 Xe 26+	459	55.9	1014011	0	60	0
				79	1000094	45	87	0
	W17	132 Xe 26+	459	55.9	1009001	0	62	0
				79	1000061	45	86	0
LMH6628	W2	132 Xe 26+	459	55.9	1006300	0	58	0
				79	1012283	45	81	0
	W3	132 Xe 26+	459	55.9	1001039	0	58	0
				79	1011231	45	83	0

Single Event Latch-up: Summary Results

Device Type	SEL LET Threshold ($MeV.cm^2/mg$)
AD8028	>80
AD8065	>80
LMH6622	>80
LMH6628	>80
LT1806	20
EL7202	>80
EL7156	>80
EL7457	>80
ICL7667	>80
ADG712	8.3-14.1
ADG719	8.3-14.1
MAX313	>80
SST175	>80

Overall: Summary Results – Only Two Listed!

Part no.	Notes	TID tol. krad(Si)	SEL LET_{th} MeV.cm2/mg	OK for Use?
AD8028	No significant change of any parameter	>50	>80	Yes
AD8065	Slight increase in input bias current, rise and fall times, and reduced stability	<20	>80	No

Conclusions:

- Efficient radiation pre-screening testing was carried out on COTS devices covering TID and SEL
- 39 devices, 13 different device groups were Co-60 tested
- 39 devices, 13 different device groups were Latch-up tested
- The same test PCB/setup was used at both test sites
- The Co-60 testing at ESTEC took 40 hours!
  using a dose rate of 1.44 Krad(Si)/hour to 20 Krad(Si)
  for 13 devices & 50 Krad(Si) for 26 devices
- The SEL testing at UCL took 6 hours!
  using Xe, Kr, Ar and Ne ions
  over 76 runs! to fluences of 1.0E6 ions/cm2
- All this as a joint venture between -
  Mullard Space Science Laboratory and ESTEC