



Total Ionization Dose: Gamma Radiation  
Test Results for Isocom Transistor Optocouplers 2009

## INTRODUCTION

The main objective of this assessment of the ISOCOM transistor series of optocouplers to determine the susceptibility of the devices to Total Dose Gamma Radiation.

Total Dose Radiation Testing can severely degrade the performance and characterisation of optocouplers. Ionisation radiation causes bulk ionization of all materials resulting in the creation of non-radioactive trapped charges in the diffusion region of the devices with a resultant loss in efficiency. The degradation normally relates to Current Transfer Ratio (CTR) defined as the ratio of Output Current (IC) to the Input Current (IF).

This Total Dose Test Report details the work carried out on a sample of ISOCOM's transistor optocouplers in accordance with the ESA Contract covering Radiation Testing of Transistor family equivalent Optocouplers to:

- i) Characterize optocoupler degradation under gamma irradiation in the framework requirements of Total Dose Steady State Irradiation Specification ESA/SCC 22900.
- ii) Compare radiation sensitivity with Transistor family devices available on the market for space applications.

The Report focuses on:

- i) Parameter shifts in Current Transfer Ratio (CTR) created by the build up of trapped charges; and
- ii) Testing with different Bias Conditions to establish their influence on CTR degradation and the worse case damage condition of radiation on optocouplers.

Unbiased, 1mA and 10mA biased devices were irradiated at the European Space Research and Technology Centre ("ESTEC") in Noordwijk in The Netherlands up to a total dose fluency of approximately 150krad(Si).

A complete set of electrical measurements, including CTR, Vce, If and IR, together with graphs of measured parameters with respect to the total Ionisation dose received are provided in Appendix A for all the samples delivered to ESTEC by ISOCOM Limited. All tests were conducted at ESTEC by ESA and ISOCOM Limited.

## IRRADIATION TEST SEQUENCE

A total dose of 150krad(Si) was reached at the ESTEC Co-60 facility in 7 dose steps of 4krad, 16krad, 8krad, 17krad, 7krad, 70krad and 28krad respectively in accordance with the irradiation test sequence shown in Table 2 below.

**TABLE 2**

RUN	Date	Start Time	Stop Time	Run Time	Distance from source	Dose Rate (water)	TID Rads (water)	CUM dose (water)	CUM dose (si)
No.	(d/m/yr)	(h.min)	(h.min)	(mins)	(cms)	(rad/min)	(krad)	(krad)	(krad)
1	22/10/08	13.27	17.11	224	128.1	20.1	4.5024	4.50	4.05
	22/10/08	17.45							
2	23/10/08		8.46	901	127.5	20.3	18.2723	22.77	20.50
3	23/10/08	9.26	17.00	454	128.1	20.1	9.1254	31.90	28.71
	23/10/08	17.32							
4	24/10/08		9.20	948	129.0	19.8	18.7704	50.67	45.60
5	24/10/08	10.18	17.03	405	129.0	19.8	8.0069	58.68	52.81
	24/10/08	18.03							
6	27/10/08		9.30	3807	127.4	20.3	77.2821	135.96	122.36
	27/10/08	10.52							
7	28/10/08		13.24	1592	129.7	19.6	31.1395	167.10	150.39
	Total			8331	mins	20.1	avg dose rate		
				5.8	days				

Commencing 22 October 2008, the irradiation tests were conducted over a period of six days. The average dose rate was 20 Rad(Si)/min and the total dose of 150Krad(Si) exceeded the original target standard dose of up to 100Krad(Si).

The optocouplers were electrically tested to space requirement specification within one hour of leaving the radiation chamber after each step run. The test results were recorded and are summarized in Appendix A.

The electrical control system for Ionisation was setup to provide a 5 Volt supply to the printed circuit board. Resistors on the printed circuit board provided a constant current of 1mA to the first row of devices and 10mA to the second row in Figures 8 and 9 . The third row was unbiased in the OFF condition and all the input and output leads of the optocouplers were connected to the ground.

The control system in Figure 2 above shows if there is any sudden change in performance of the devices by an increase in current supplied to the PC board. The control system supplied 5 Volts and the total current was monitored during irradiation.

## ANNEALING

Post radiation the devices were left at 25°C under bias conditions for 24 hours as a recovery process. After the recovery process, the devices were subject to accelerated ageing under bias conditions at an oven temperature of 100°C for 168 hours. The results are shown on line 8 (24 hour recovery process) and line 9 (accelerated ageing process) of the test data in Appendix A.

## ELECTRICAL MEASUREMENT

The optocoupler test conditions and limits for the 29 electrical test parameters in Appendix A, numbered 0 to 28, are shown in Table 3 below.

TABLE 3		LIMITS (CHANGE IF NEEDED)					
	PARAMETER	UNIT	MIN	MAX	MIN%	MAX%	
0	0- I <sub>r</sub>	[pA]	-10,000,000	0	-100%	100%	
1	1- V <sub>f</sub>	[V]	0.8	1.5	100%	100%	
2	2- VCE Brkdown	[V]	40	9999	-100%	100%	
3	3- VCB Brkdown	[V]	45	9999	100%	100%	
4	4- VBE Brkdown	[V]	-9999	-7	-100%	100%	
5	5- I <sub>c</sub> Off	[pA]	0	100,000	100%	100%	
6	6- CTR	[%]	200	1000	-100%	100%	
7	7- VCE saturation	[mV]	10	300	100%	100%	
8	8- Photosensitivity	[uA]	-100	-5	-100%	100%	
9	9- I <sub>c</sub> On	[mA]	2	10	100%	100%	
10	10- VCE sat 1	[mV]	10	300	-100%	100%	
11	11- VCE sat 2	[mV]	10	300	100%	100%	
12	CTR @I <sub>f</sub> 1mA (V <sub>ce</sub> 5V)	[%]	200	1000	-100%	100%	
13	CTR @I <sub>f</sub> 2mA (V <sub>ce</sub> 5V)	[%]	200	1000	100%	100%	
14	CTR @I <sub>f</sub> 5mA (V <sub>ce</sub> 5V)	[%]	200	1000	-100%	100%	
15	CTR @I <sub>f</sub> 10mA (V <sub>ce</sub> 5V)	[%]	200	1000	100%	100%	
16	CTR @I <sub>f</sub> 20mA (V <sub>ce</sub> 5V)	[%]	200	1000	-100%	100%	
17	CTR @I <sub>f</sub> 1mA (V <sub>ce</sub> 10V)	[%]	200	1000	100%	100%	
18	CTR @I <sub>f</sub> 2mA (V <sub>ce</sub> 10V)	[%]	200	1000	-100%	100%	
19	CTR @I <sub>f</sub> 5mA (V <sub>ce</sub> 10V)	[%]	200	1000	100%	100%	
20	CTR @I <sub>f</sub> 10mA (V <sub>ce</sub> 10V)	[%]	200	1000	-100%	100%	
21	CTR @I <sub>f</sub> 20mA (V <sub>ce</sub> 10V)	[%]	200	1000	100%	100%	
22	H <sub>fe</sub> @I <sub>b</sub> 1uA	[---]	50	1000	-100%	100%	
23	H <sub>fe</sub> @I <sub>b</sub> 5uA	[---]	50	1000	100%	100%	
24	H <sub>fe</sub> @I <sub>b</sub> 10uA	[---]	50	1000	-100%	100%	
25	H <sub>fe</sub> @I <sub>b</sub> 20uA	[---]	50	1000	100%	100%	
26	H <sub>fe</sub> @I <sub>b</sub> 40uA	[---]	50	1000	-100%	100%	
27	H <sub>fe</sub> @I <sub>b</sub> 50uA	[---]	50	1000	100%	100%	
28	H <sub>fe</sub> @I <sub>b</sub> 80uA	[---]	50	1000	-100%	100%	

The parameters were monitored during each radiation step and a record was taken of each parametric characterisation of the sample optocouplers. Measurements were taken immediately after each step in accordance with the one hour maximum duration prescribed in Specification ESA/SCC 22900.

During each step the radiation control equipment was monitored before and after electrical measurement.

The same test conditions applied for the ageing process of the optocouplers.

The test data for parameters 0 to 28 is shown in Appendix A.

## **CONCLUSION**

The sample ISOCOM IS49 TRANSISTOR family optocouplers are radiation hard to a dose level of up to 150krad(Si) and are performing well within ESA's requirements for European Space Applications.

The detailed test results in Appendix A show the individual parameter characterization with respect to emitter performance, detector performance and performance of the optocoupler as a whole.

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