SURVEY OF CRITICAL COMPONENTS FOR 150KRads(Si) POWER SYSTEMS

ESA CONTRACT Nº: 22831/09/NL/AF

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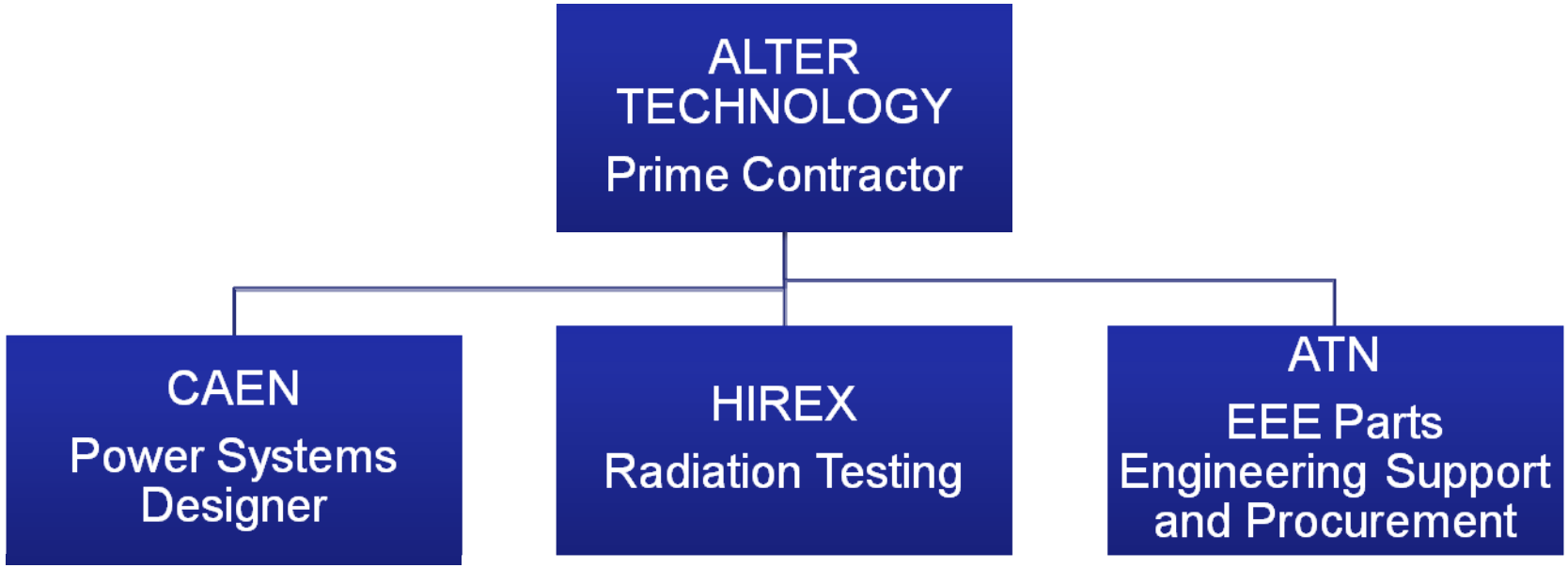
PROJECT STRUCTURE



CONTRACT DESCRIPTION

The study is devided in two phases:

1. Components irradiated under protons beam (see PROTONS TEST R).
2. Gamma total Ionizing Dose test up to 400 Krad(Si) (see TOTAL IONIZING DOSE TEST)

After each phase, the corresponding test reports have been generated and provided to ESA.

A final summary is included in this presentation.

PARTS TESTED

PART TYPE0	PACKAGE	FAMILY	MANUFACTURER	MARKING	INFORMATION	DATE CODE
HS-4424B	FP-16	Microcircutis	Intersil	logo HS9-4424BRH delta /PROTO	Lot 2010011989	-
IS-1009	TO-206AB	Microcircutis	Intersil	logo IS2-1009RH /PROTO	Lot 2010011986	-
IS-139ASRH	FP-20	Microcircutis	Intersil	logo IS9-139ASRH delta /PROTO	Lot 2010011988	-
IS-1825ASRH	FP-20	Microcircutis	Intersil	logo IS9-1825ASRH /PROTO delta back: serial	-	-
IS-1845ASRH	FP-18	Microcircutis	Intersil	logo IS-1845ASRH /PROTO delta	-	-
IS9-2100ARH	FP-16	Microcircutis	Intersil	logo IS9-2100ARH delta /PROTO	Lot 2010011987	-
OLH7000	DIP-08	Optoelectronics	Isolink Inc.	ISOLINK OLH7000-0011 delta 0721	-	0721
OLS449	LCC-06	Optoelectronics	Isolink Inc.	S OLS449 0949	-	0949
2N3637	TO-39	Transistors	Microsemi Corp.	MSC MSF2N3637 SAMPLE serial	-	-
2N5154	TO-39	Transistors	Microsemi Corp.	MSC E1023 F2N5154	-	1023/1029
LM124	DIP-14	Microcircutis	National Semiconductor	logo H5A0517Z delta RM124AJ	-	-
RHF43B	FP-08	Microcircutis	STMicroelectronics	logo date code F0623701 VXC Q FR	-	DC 0810
2N2920A	LCC-06	Transistors	STMicroelectronics	-	Lot 31016A	-
2N3810	LCC-06	Transistors	STMicroelectronics	-	Lot 31018A	-
SOC2222A	LCC-03	Transistors	STMicroelectronics	-	DOC01283	-
SOC2907A	LCC-03	Transistors	STMicroelectronics	-	DOC01284	-
SOC3700	LCC-03	Transistors	STMicroelectronics	-	DOC01285	-

PROTON TEST

- Parts have been tested up to a proton fluence of about 2E+11 p/cm^2.
- Generated damage has been investigated using 60MeV protons energy. Devices were irradiated at UCL in Louvain – Belgium.
- The purpose of these tests were to characterize degradation due to proton displacement damage so a further mission analysis could determine their suitability for flight use.
- For each part, a complete set of electrical measurements were performed and a graphical representation generated with respect to equivalent fluence levels received.
- Six (6) samples per part type were irradiated (3 biased and 3 OFF), and one control unit used.

PROTON TEST SUMMARY RESULTS

PART-TYPE	FAMILY	MANUFACTURER	PARAMETRICAL FAIL	STEP
IS-1009	Microcircutis	Intersil	Vref	Final
IS-1845ASRH	Microcircutis	Intersil	PSRR(CS)	Initial
OLH7000	Optoelectronics	Isolink Inc.	Forward Current Gain K1	Initial
			Forward Current Gain K2	Initial
OLS449	Optoelectronics	Isolink Inc.	Ic(on)	Final
			Vce(sat)	Final
2N3637	Transistors	Microsemi Corp.	Hfe2	Final
			Hfe3	Final
2N5154	Transistors	Microsemi Corp.	Ft	Initial
			Hfe1	Final
			Hfe2	Final
LM124	Microcircutis	National Semiconductor	Many	Final
2N2920A	Transistors	STMicroelectronics	Ft	Initial
			Iceo_1	Final
			Iceo_2	Final
2N3810	Transistors	STMicroelectronics	Iceo_1	Final
			Iceo_2	Final
SOC2222A	Transistors	STMicroelectronics	Iceo	Final
SOC2907A	Transistors	STMicroelectronics	Iceo	Final
SOC3700	Transistors	STMicroelectronics	Iceo	Final

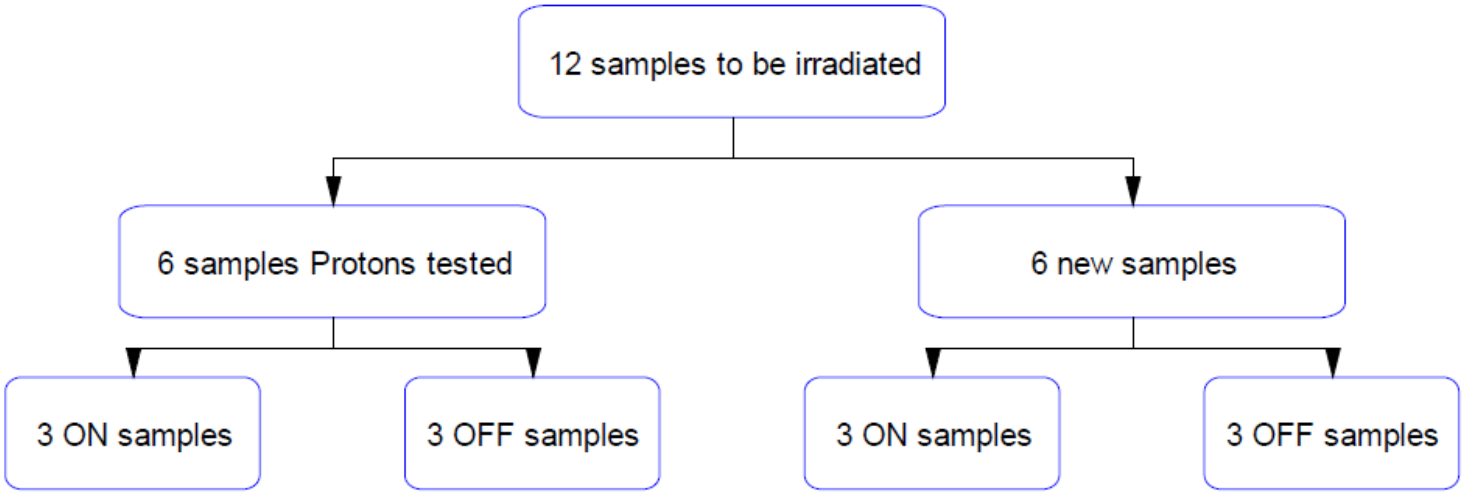
NOTE: Devices not included in this table showed all parameters remaining under specification limits all along testing.

TOTAL IONIZING DOSE TEST

- Parts have been tested up to accumulated dose of about 426KRad(Si).
- The dose exposure were performed at UCL in Louvain – Belgium. A cobalt 60 (Co^{60}) source was used.
- During dose exposures, devices under test have been irradiated at an ambient temperature of 24ºC ± 6ºC.
- The purpose of these tests were to evaluate total dose withstanding to investigate the parts suitability for being used in space applications.
- For each part, a complete set of electrical measurements together with graphical representation of measured parameters with respect to total dose received was provided. A test summary is added to this presentation.

TOTAL IONIZING DOSE TEST

- TID tests have been performed taking into account the following samples distribution.



NOTE: Sample distribution may slightly vary depending on samples availability and proton test results. For specific distribution of each part-type check the detailed test report.

TOTAL IONIZING DOSE TEST

- TID test steps were finally established as follows.

Irradiation step Krad(Si)	Dose rate rad/h	Annealing step hours	Temperature ºC
0	0		
10	36		Room
20	36		Room
50	36		Room
100	36		Room
150	100[1]		Room
200	300[1]		Room
250	300[1]		Room
300	300[1]		Room
250	300[1]		Room
400	300[1]		Room
		24	Room
		168	100

1) Due to the maintenance period planned at UCL at the end of December and in order to perform subsequent requested exposures steps up to 400 Krad(Si), the dose rate of the last steps has been change, in agreement with ESA, from 36rad(Si)/h to 100rad(Si)/h and from 100rad(Si)/h to 300rad(Si)/h as indicated.

TOTAL IONIZING DOSE TEST

Code for the following table:

- Under TID testing columns:
  - PROTONS: Results on parts submitted to proton test before TID.
  - TID: Results on parts only submitted to TID test.
  - STEP: Test step where parameter was tested out of specification. The parametrical failure thus occurred between the previous step and the noted one.

- Parameters failing during test have been noted except when too many were affected. This has been noted in the Comments column.

TOTAL IONIZING DOSE TEST

				TID								ANNEALING RECOVERY			
				ON				OFF							
PART-TYPE	FAMILY	MANUFACTURER	PARAMETER FAIL	PROTONS	STEP	TID	STEP	PROTONS	STEP	TID	STEP	NO	PARTIAL	COMPLETE	COMMENT
HS-4424B	Microcircutis	Intersil	Iil_A	x	10.8	x	20.7	x	10.8	x	20.7	x			
			Iil_B	x	55.6	x	55.6	x	20.7	x	20.7	x (OFF)		x (ON)	
IS-1009	Microcircutis	Intersil	Vref	x	Initial	x	245.7	x	Initial	x	11.7	x (OFF proton)	x (OFF TID)	x (ON)	
			DVZ/DIZ					x	159.3	x	207			x	
			Rz2					x	104.4	x	159.3			x	
IS-139ASRH	Microcircutis	Intersil	Many												Too many parameters
IS-1825ASRH	Microcircutis	Intersil	Many												Too many parameters
IS-1845ASRH	Microcircutis	Intersil	PSRR(CS)												Too many parameters
OLH7000	Optoelectronics	Isolink Inc.	Forward Current Gain K1	x	Initial	x	Initial	x	Initial	x	Initial				No drift during exposition
			Forward Current Gain K2	x	Initial	x	Initial	x	Initial	x	Initial				No drift during exposition
OLS449	Optoelectronics	Isolink Inc.	Ic(on)	x	Initial			x	Initial	x	55.6	x (proton)		x (OFF TID)	
			Vce(sat)					x	20.7					x (OFF proton)	
			Ice(off)2					x	274.2					x (OFF proton)	
			Icb(off)					x	416.7					x (OFF proton)	
2N3637	Transistors	Microsemi Corp.	Hfe1	x	53.1	x	204.3	x	53.1	x	53.1	x (OFF)		x (ON)	
			Hfe2	x	Initial	x	22.5	x	8.1	x	8.1	x			
			Hfe3	x	Initial	x	22.5	x	8.1	x	22.5	x			
			Hfe4	x	22.5	x	53.1	x	8.1	x	22.5	x			
2N5154	Transistors	Microsemi Corp.	Ft	x	Initial	x	Initial	x	Initial	x	Initial				No drift during exposition
			Hfe1	x	Initial	x	8.1	x	Initial	x	8.1	x			
			Hfe2	x	8.1	x	8.1	x	Initial	x	53.1	x			
LM124	Microcircutis	National Semiconductor	Many												Too many parameters
RHF43B	Microcircutis	STMicroelectronics	IIB1PL_IIB1+	x	162.9	x	162.9							x (ON)	
			IIB2PL_IIB2+	x	162.9	x	162.9							x (ON)	
			IIB1MO_IIB1-	x	162.9	x	162.9							x (ON)	
			IIB2MO_IIB2-	x	162.9	x	162.9							x (ON)	
2N2920A	Transistors	STMicroelectronics	Many												Too many parameters
2N3810	Transistors	STMicroelectronics	Iceo_1												Too many parameters
			Iceo_2												Too many parameters
SOC2222A	Transistors	STMicroelectronics	Iceo												
			Hfe	x	324.9	x	324.9	x	324.9	x	324.9			x	
SOC2907A	Transistors	STMicroelectronics	Iceo												
			Hfe1	x	48.6	x	91.8	x	48.6	x	91.8	x			
			Hfe2	x	91.8	x	91.8	x	91.8	x	91.8	x			
			Hfe3	x	196.2	x	240.3	x	196.2	x	240.3	x			
SOC3700	Transistors	STMicroelectronics	Iceo												
			Hfe1	x	324.8			x	386.1					x (protons)	

NOTE: Devices not included in this table showed all parameters remaining under specification limits all along testing.

CONCLUSSIONS

PARTS SUBMITTED TO PROTON TEST

- Parts previously submitted to protons tests show an early parametrical failure scheme due to the cumulative effect.

- Parts not meeting the specification limits after proton exposure are typically the ones also showing parametrical failures at TID test (on parts submitted to proton tests and *new* ones). Deviations may not appear on the same parameters.
  - Exceptions:
    - HS-4424, IS-139ASRH and IS-1825ASRH from Intersil and RHF43B from STM passed the proton test but showed parametrical deviations at TID test.

- Many parts didn't recover after proton exposure showing parametrical failures at initial step during TID test.

CONCLUSSIONS

DOSE RATE

- Most of the parametrical failures have been detected before 100Krad(Si) step.
  - Exceptions:
    - IS-1009 from Intersil
    - OLS-449 from Isolink
    - RHF43B from STM: This part was rated to 300Krad(Si) ELDRS.
    - SOC2222 from STM: This part belonged to a selected wafer.
    - SOC3700 from STM: This part belonged to a selected wafer
- Very rarely, parts not showing deviations before 100Krad(Si) have showed them at later steps.
  - Exceptions:
    - RHF43B from STM: This part was rated to 300Krad(Si) ELDRS.
    - SOC2222 from STM: This part belonged to a selected wafer.
    - SOC3700 from STM: This part belonged to a selected wafer

CONCLUSSIONS

BIASING CONDITIONS

- Seems not to have a predominant effect but OFF biasing it is seen as a worst case for most of the parts showing parametrical failures appearing at slightly earlier steps.
  - Exception: RHF43B where ON biasing is a worst case.
- Results are not 100% homogeneous for all parameters.
  - Biasing conditions seems also to show a slightly different response depending on the parameter
- It does not have any predominant effect on annealing recovery.

THANK YOU FOR YOUR ATTENTION

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