

CAPACITOR AND RESISTORS WITH EXTENDED OPERATING TEMPERATURE RANGE

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INTRODUCTION

During the last decade, a growing number of applications demanding higher power electrical consumption have emerged in some industrial sectors such as in the military, automotive or space ones. Consequently, electrical components with higher temperature range and rating voltage operation are needed. In addition, the good thermal characteristics of Silicon Carbide (SiC) and Gallium Nitride (GaN) allow the fabrication of devices

suitable for working in such extreme conditions. In order to satisfy these demands, an evaluation of selected capacitors and resistors for future space SiC & GaN applications is presented.

Such activity has been performed under the framework of ESA Contract 4000109461/13/NL/PA awarded by ALTER TECHNOLOGY.

PARTS SELECTION

Following market analysis, a dedicated survey among a set of capacitors and resistors among the most used technologies have been selected. Study includes existing ESCC qualified parts and also some new technologies with certain space heritage.

An initial survey of current resistors and capacitors used for space applications has been provided. The most significant customers were contacted to assess specific application to conclude a potential scenario including following parts:

- Existing ESCC qualified parts
- NASA & JAXA Qualified parts
- Non Qualified European parts

The following table provides the final proposed list for this study:

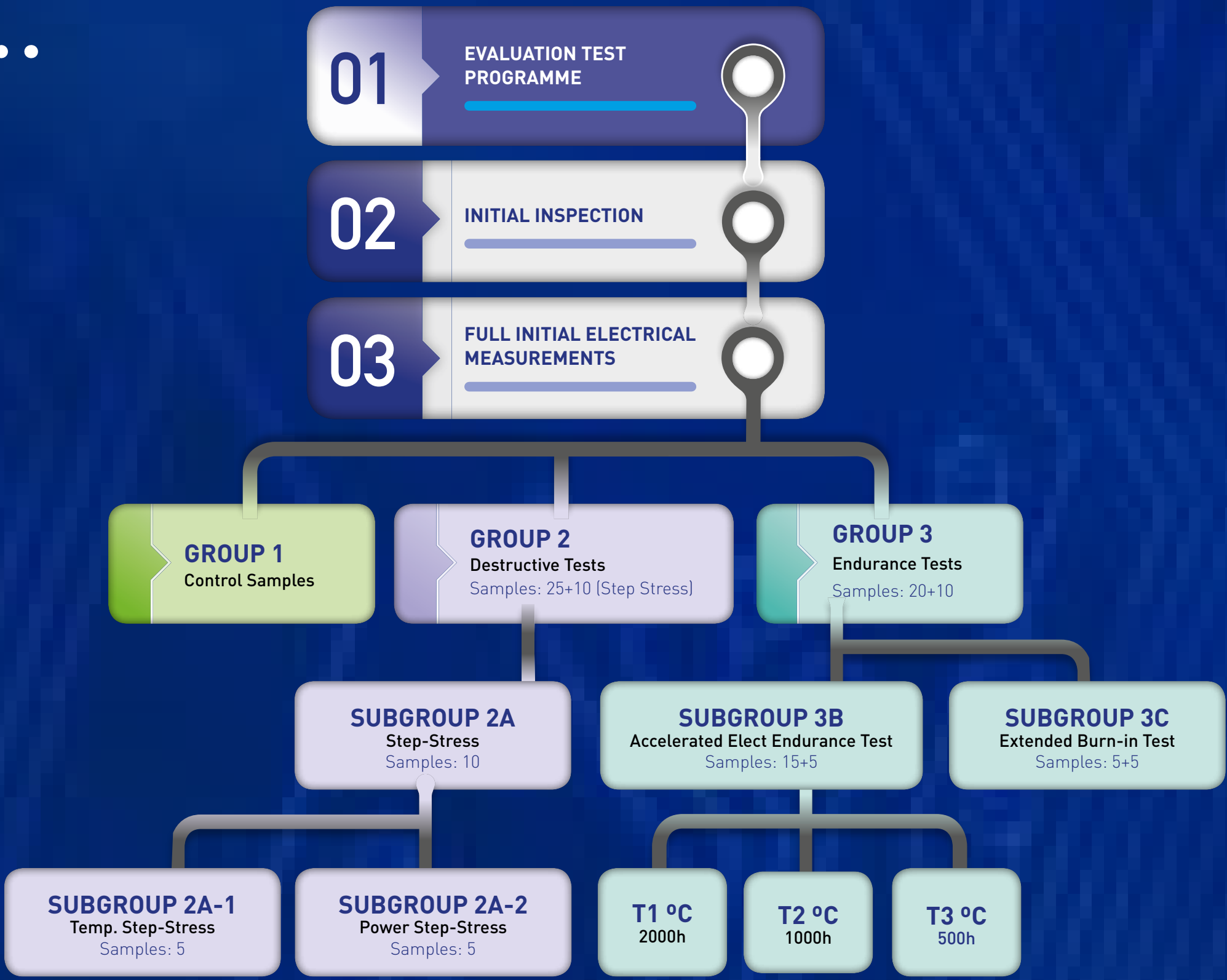
	TECHNOLOGY	OPERATING TEMPERATURE RANGE (°C)
CAPACITORS	Chip tantalum	- 55 to + 175
	SMD Low ESR Tantalum	- 55 to + 125
	Tantalum, chip in hermetic package	- 55 to + 230
	High RF MLC Surface Mount	- 55 to + 125
	Multilayer Ceramic	- 55 to + 150
RESISTORS	Thin Film wraparound, chip	-55 to + 215
	Z1-Foil, chip	-55 to + 240
	Ultra-High Precision Foil Wraparound Chip	-55 to + 225
	Thin film, chip	-55 to + 155
	Thick Film Chip	-55 to + 155

EVALUATION PLAN

A set of different tests were performed with the aim of constructing a derating curve with extended temperature conditions: Tests include full electrical characterization as well as thermal shocks and

voltage temperature (V-T) step stress processes and to conclude, an accelerated life test of 2000 hours long at new proposed max operating temperature.

PROPOSED TEST FLOW



SUMMARY OF TEST RESULTS:

CAPACITOR	DATASHEET INFO		TEST RESULTS					
	Rated Voltage Vr (V)	Tmax (°C)	TEST 1 (150°C, 2000h)		TEST 2 (150°C, 2000h)		TEST 3 (170°C, 2000h)	
			Applied Vol- tage	Results (pass)	Applied Vol- tage	Results (pass)	Applied Vol- tage	Results (pass)
A	50	150	4xVr	3/3	5xVr	3/3	4xVr	3/3
B	50	150	4xVr	3/3	5xVr	2/3	4xVr	2/3
C	25	125	Vr	2/3	1.2xVr	0/3	1.2xVr	0/3
	16							
D	50	230	Vr	2/3	1.2xVr	0/3	1.2xVr	0/3
	63							
E	35	175	Vr	3/3	1.2xVr	3/3	1.2xVr	1/3
	16							

RESISTOR	DATASHEET INFO		TEST RESULTS					
	Rated Power (W)	Tmax (°C)	TEST 1 (150°C, 2000h)		TEST 2 (150°C, 2000h)		TEST 3 (170°C, 2000h)	
			Power Applied (W)	Results (pass)	Power Applied (W)	Results (pass)	Power Applied (W)	Results (pass)
A	1 (@ 70°C)	155	0.62W	3/3	1.2W	3/3	0.62W	0/3
B	0.12 (@ 70°C)	225	0.16W	0/3	0.32W	0/3	0.16W	0/3
C	0.125 (@ 155°C)	155	0.16W	0/3	0.3W	0/3	0.16W	0/3
D	0.0375 (@ 215°C)	215	0.16W	2/3	0.32W	0/3	0.16W	0/3
E	0.0125 (@ 220°C)	225	0.16W	0/3	0.32W	0/3	0.16W	0/3

CONCLUSIONS

Due to the low amount of cumulated testing time and number samples, it is not possible to derive any specific new derating rules, however the following devices seem to be very good candidates for further testing and possibly delta qualification for high temperature applications.

As an initial approach, delta qualification is proposed to be performed with a minimum samples size of 50 parts per type to be tested up to max updated rating conditions in order to have enough components hours and accumulated failures so to have proper statistical values to derive new derating rules.

CAPACITORS	MANUFACTU-	TECHNOLOGY	DATASHEET Tmax (°C)	TEST RESULTS (3pcs/part type per test)		
	A	Multilayer Ceramic	150	TEST 1 (150°C)	TEST 2 (150°C)	TEST 3 (170°C)
				3 OK	3 OK	3 OK
RESISTORS	B	Multilayer Ceramic	150	3 OK	2 failures at 1700h, 1 OK	1 failure at 1000h, 2 OK
	B	Chip Tantalum	175	3 OK	3 OK	700h, 1900h, 1 OK
	C	Thick Film Chip	155	3 OK	3 OK	failures at 200h, 700h, 1000h
RESISTORS	D	Thin Film wraparound chip	215	1 failure at 700h, 2 OK	failures at 200h, 1000h, 2000h	failures at 400h, 700h, 700h