Assessment of ECSS-Q-ST-60-13 for COTS Passive Components

Space Passive Component Days, 4th International Symposium
11-14 October 2022 ESA/ESTEC, Noordwijk, The Netherlands

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ABSTRACT

In recent years, the use of commercial quality parts in Space market has been increasing, driving the different actors involved to release standards and test flows in order to accommodate its use to the requirements of such a harsh environment.
With this in mind, the ECSS-Q-ST-60-13C was released in order to define the product assurance requirements for the use of these parts in Space mission and provide a unified approach. While this standard focused on active parts, a new issue, just already released, includes provisions for commercial passive parts, also distinguishing between purely commercial and automotive components.
In the framework of ESA contract ESA RFP/3-16705/20/NL/FE/hh for *Assessment of ECSS-Q-ST-60-13 for COTS Passive Components*, Alter Technology has performed different tasks with the goal of analyzing the capacity of the testing flow outlined in the new revision of ECSS-Q-ST-60-13C in relation to the evaluation/screening/qualification of commercial components.
The results obtained reinforce the maturity and robustness of automotive components, making them especially suitable as potential candidates for New Space missions, low cost-high risk projects. The performance of Constructional Analysis and Life Test has proven to be a strong asset to sustain this assertion.

INTRODUCTION

During last years, the rapidly increasing introduction of COTS parts within Space sector has responded to two different reasons: while the first one being the many constellation missions projected, which requires cheaper parts that will perform for a shorter time on a lower quality mission, the second reason is even more interesting: the wide portfolio of COTS parts from different manufacturers assures that almost always you can find a commercial component that fits your design in terms of parameters. This is especially true for passive parts, where the vast variety of components surpasses for much the portfolio of Space parts. Being aware of the situation with these two arguments in mind, ESA has updated its ECSS-Q-ST-60-13C to include passive parts and to differentiate between purely commercial and automotive qualified parts as per AEC-Q.

For validating the test flow that was included in the new revision of ECSS-Q-ST-60-13C, Alter Technology performed the 4 subsequent tasks, under ESA contract No. 4000131550/20/NL/FE/hh.

Task 1: Inventory & Test Reports Collection: this consists of the collection of test reports of previously procured commercial EEE parts in the frame of ESA projects.

Task 2: Parts Procurement Selection & Test Plan Definition: consists of the selection of passive components' technologies, types and related part numbers. In addition, Task 2 consists of the definition of the test plan according to the proposed one in ECSS-Q-ST-60-13C rev1.
Task 3: Parts Procurement & Testing in accordance with the test plans defined during task 2.
Task 4: Parts Selection: this task will consist of selecting the most interesting components to be stored as per centralized storage.

With the performance on these four tasks, we aim to reach the following objectives:

- Collect the information available for passive COTS components in the recent ESA programs.
- Selection of commercial passive parts considered interesting from the technological or performance point of view and to apply the existing test flow defined in ECSS-Q-ST-60-13 Rev.1.
- Proceed with the test.
- Deep review of the test results and discussion about how the test performed in accordance to forthcoming ECSS document have been able to evaluate/screen/qualify commercial components. Pros and cons of the new approach will be gathered as well as proposal for improvement for the ECSS-Q-ST-60-13C Rev1 in case is needed.

TASK 1

For this task, the list of all commercial parts used in CPPA missions by Alter was provided to ESA. Including test results and available stock from previous missions. A quick summary of the information obtained is shown in Table 1.
Apart from this, ongoing PLATO CPPA has made use of some additional automotive capacitors which have been upscreened, such as KCM55 capacitors from Murata and Kemet's C1812-AUTO series.

TASK 2

After review of main portfolios from worldwide manufacturers and based on the current market trends, a preliminary set of commercial and automotive capacitors and resistors was selected. Then, final list of potential candidates for further testing was agreed with ESA. Although it is noted that task 2 initially included the complete definition of the test plans to be performed over the parts, the types selected will be subjected to initial Constructional Analysis in order to maximize the internal understanding of the parts and to tailor the subsequent Evaluation/Screening and Qualification test to validate the new approach included in ECSS-Q-ST-60-13. Commercial and automotive parts have been selected, prioritizing those types either with a higher demand in new space applications or with functions expected to be 'technology drivers' in the coming years.

Table 2 provides a quick summary of the final list of parts selected for procurement and testing. During next paragraph, we will also get deeper on the description of each part.

TASK 3

In relation to this task, the initial constructional analysis plus additional activities considered were performed on the parts listed in Table 2 once they were procured. Procurement was made through standard distribution channels, considering it as a common way to procure commercial and automotive parts, mainly from stocks. It is to be highlighted that manufacturer Kemet provided themselves samples free of charge for this study.

Table 1: Previous procurement of COTS parts upscreened

Project	Status
Lisa Pathfinder	No commercial parts used. Not all parts in space grade "High-rel" but upscreening from commercial parts philosophy was not already used
Solar Orbiter	Included. Few commercial parts + upscrenning used (pioneer). Additional testing performed over high-rel/space parts but out of COTS approach for this reporting contract
Sentinel-3	No (Commercial parts + upscreening) performed by ALTER procurement
BepiColombo	Only two commercial parts + upscreening. Performance was not available in Space parts
MTG	No (Commercial parts + upscreening) performed by ALTER procurement
Euclid	No (Commercial parts + upscreening) considered for ALTER procurement. Additional test performed but for delta characterization over space parts (mostly Cryogenic). Commercial parts+upscreening were accepted but out of CPPA framework and therefore these data can't be shared as part of this study
JUICE	Included, important consideration for COTS+upscreening, mainly on active devices

Table 2: Final list of parts for procurement and testing

Family	Part Number	Part Type	Manufacturer
Capacitors	06035C104K4T2A	0603 Type II (X7R) 100nF 10% 50V	AVX
Capacitors	MKS4F051506I00KSSD	MKS4 15uF 10% 250V 2-pin	WIMA
Capacitors	T541X337K010AT6730	T541 330uF ±10% 10V Case X	Kemet
Capacitors	C0603C105K8RACAUTO	0603 10VDC 1uF 10% X7R AEC-Q200	Kemet
Capacitors	A798D477M2R5ATE009	A798 470uF 2.5V 9mOhm AEC-Q200	Kemet
Resistors	CRCW080510K0FKTA	CRCW0805 10K 1% 100ppm/ºC 1/8W	Vishay
Resistors	WSL2512R1000FTA	WSL2512 0.1 Ohm 1% 1W	Vishay
Resistors	CMB02070X1002FB200	CMB0207 10K 1% 0,4W 500V MELF	Vishay Beyschlag

Table 3: Description and testing performed on each part

Description	Part Number procured	Mnfr	Test @ ALTER
Automotive MLCC, multiple chip size 0402, 0603, 0805, 1206, 1210, 1812	06035C104K4T2A (0603 Type II (X7R) 100nF 10% 50V)	AVX	Constructional Analysis Life test + temperature characterization
Metallized Polyester (PET) Capacitors 0.01 µF to 10 µF, 50 to 630Vdc	MKS4F051506I00KSSD (MKS4 15uF 10% 250V 2-pin)	Wima	Constructional Analysis Life test
Polymer Electrolytic High Reliability series (HRA) 2.5 to 63Vdc	T541X337K010AT6730 (T541 330uF ±10% 10V Case X)	Kemet	Constructional Analysis Life test already performed as part of EPPL documentation
MLCC Automotive grade X7R dielectic, 6.3 to250Vdc	C0603C105K8RACAUTO (0603 10VDC 1uF 10% X7R AEC-Q200)	Kemet	Constructional Analysis

Description	Part Number procured	Mnfr	Test @ ALTER
Surface Mount Aluminum Organic Capacitor 2-25V	A798D477M2R5ATE009 (A798 470uF 2.5V 9mOhm AEC-Q200)	Kemet	Constructional Analysis
Lead (Pb)-Bearing Thick Film, Rectangular Chip Resistors 1R to 10M, 100 and 200ppm/K	CRCW080510K0FKTA (CRCW0805 10K 1% 100ppm/ºC 1/8W)	Vishay	Constructional Analysis Life test
Power Metal Strip® Resistors, Low Value (Down to 0.0005R), Surface-Mount	WSL2512R1000FTA (WSL2512 0.1 Ohm 1% 1W)	Vishay Dale	Constructional Analysis
High Pulse Load Carbon Film MELF Resistors	CMB02070X1002FB200 (CMB0207 10K 1% 0,4W 500V MELF)	Vishay Beyschlag	Constructional Analysis

In total, Constructional Analysis was performed on on 8 types, Life Test on 3 types and Temperature Characterization on 1 of the capacitors. This is summarized in Table 3. It should be highlighted the lack of failures in the test sequence performed, indicating a high level of reliability on the parts tested. This confidence level is well sustained in the AEC-Q200 characteristic for most of the types tested. Only anomalies detected, that were expected, was the pure tin finish on some of the components. Even though complete test flow proposed in ECSS-Q-ST-60-13Rev1 for commercial and automotive resistors and capacitors were not executed on the types selected due to on-going discussion of testing at that time, Constructional Analysis and Life Test performed on the parts have shown a robust internal structure and high performance in terms of reliability for all parts.

The performance of the testing could be followed via VirtualLab, a platform from ATN which allow users to follow testing in real time, contacting via chat with laboratory technicians to make questions, comment results, ask for additional pictures or steps, etc. Results were delivered to ESA through this platform.

TASK 4

ATN will store the types procured in an environmentally controlled area and will include them in the listing of available parts for future ESA missions by using the existing centralized storage tool in Alter platform www.doEEEt.com. Available parts are as shown in Table 4.

Table 4: Storage available of procured parts

Part Number	Part Type	Manufacturer	Supplier	ATN storage
06035C104K4T2A	0603 Type II (X7R) 100nF 10% 50V	AVX	Mouser	142
MKS4F051506I00KSSD	MKS4 15uF 10% 250V 2-pin	WIMA	Mouser	47
T541X337K010AT6730	T541 330uF ±10% 10V Case X	Kemet	Kemet (FoC)	93
C0603C105K8RACAUTO	0603 10VDC 1uF 10% X7R AEC-Q200	Kemet	Mouser	193

A798D477M2R5ATE009	A798 470uF 2.5V 9mOhm AEC-Q200	Kemet	Kemet (FoC)	93
CRCW080510K0FKTA	CRCW0805 10K 1% 100ppm/ºC 1/8W	Vishay	Mouser	95
WSL2512R1000FTA	WSL2512 0.1 Ohm 1% 1W	Vishay	Mouser	193
CMB02070X1002FB200	CMB0207 10K 1% 0,4W 500V MELF	Vishay Beyschlag	Mouser	193

CONCLUSION

It is understood that activities performed are not at the level of a complete Evaluation-Screening and qualification sequence detailed in new ECSS-Q-ST-60-13C Rev1. It should be noted that the testing of the procured commercial parts was maximized while the total cost of procurement was minimised. Following this approach, it was preferred to increase the number of Constructional Analysis over a wider range of parts instead of performing a complete sequence over only one type. This has allowed to have positive feedback in terms of internal constructions of all parts tested, showing robust technologies for all the automotive types.

Based in the procurement and testing performed, the following conclusions are provided:

- Most devices selected for this study are qualified for automotive market in accordance with AEC-Q200. The especial consideration of these parts in of ECSS-Q-60-13C Rev1 is a natural step for this standard. Constructional analysis performed on all parts in this study reinforces the maturity and robustness of these components, making them especially suitable as potential candidates for New Space missions, low cost-high risk projects.
- Samples from MLCC capacitors and Thick film resistors were submitted to 2000 hours duration life test over 40 and 54pieces respectively. The reason behind performing this demanding test over these particular families is linked to their massive introduction for New Space projects, cubesats and launchers. In both cases, the results showed no anomalies and confirming the suitability of these parts for certain missions.
- CSAM has not been performed on the parts. The potential ingress of humidity on tested plastic parts and its link with delamination degradation has not been studied in this case.
- Two types from European manufacturers, WIMA and Vishay Beyschlag, have been submitted to constructional analysis. In the case of WIMA capacitors, life test has been performed to the same conditions of Space parts showing no significant degradation.

ACKNOWLEDGEMENTS

This study would not have been possible without the contribution of manufacturers, with the special attention to Wima and Kemet. In the case of Kemet, most of the parts provided for this study were provided free of charge and in a very short time.
Special acknowledgement to ESA Technical Officer Mr. Leo Farhat and Mr. Joaquin Jimenez for their collaboration and continuous support in this study.