



COTS Automotive Capacitors Procurement and Evaluation Case Study for SME Space Hardware Manufacturer

EPCI – ESA Case Study

ESCCON, 11th March 2021

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OUTLINE

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- Purpose of the Study
- Tantalum and Ceramic Capacitor Technologies
- Automotive Requirements & Delta Analysis

Procurement & Purchasing

- PN Selection, Search & Documentation
- Communication with Distributors & Manufacturers
- Ordering & Deliverable

Capacitor Ageing Test Evaluation

- Ageing Test
- Automotive vs COTS level Comparison



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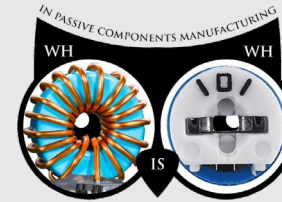


ABC of CLR ePassiveBook
on-line handbook on capacitors,
resistors, inductors and
mounting guidelines



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- Established 2015, Elektra 2016 Finalist
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Active visitors: ~ **40K/month**
Google Search views: **1.8 million views /month**
Google Search clicks: **35 thousands clicks / month**
Newsletter: > **650** subscribers related to passive components
Top countries: USA, India, Germany, UK, Canada, France, Sweden



Europe
30%



Americas
32%

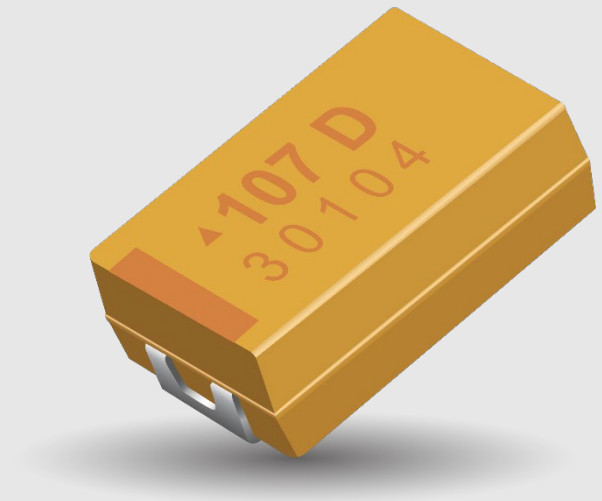
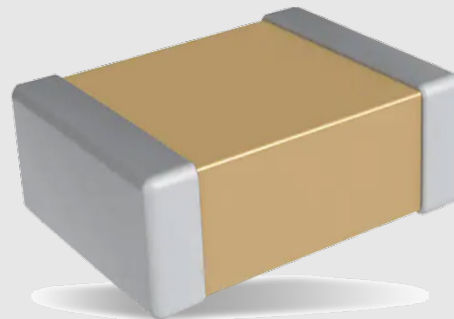


Asia
31%

Introduction

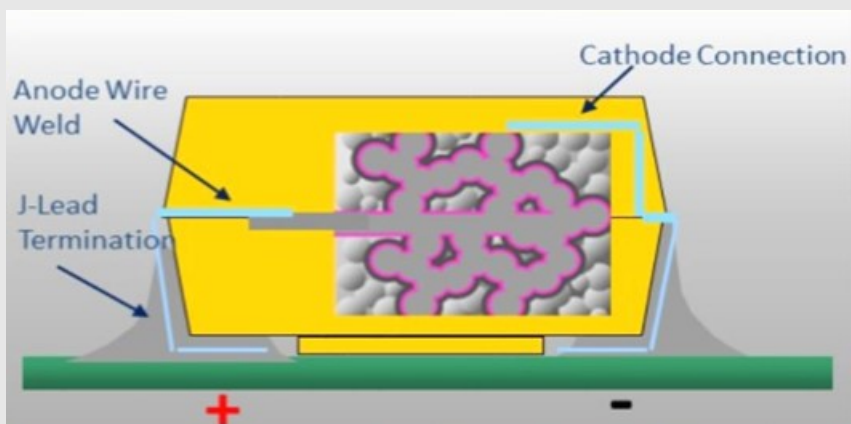
Purpose of the Study

- **Simulate Procurement of Automotive & COTS Capacitors for Space Projects by a SME Space Hardware Manufacturer**
- Monitor the Procurement Process & Communication on **Tantalum and MLCC Ceramic Capacitors**
- Technical, Administrative and Document Support
- Compare Automotive AEC-Q200 and COTS+ Procurement Process
- Evaluate Tantalum & MLCC AEC-Q200 vs COTS+ Performance under **168h Ageing Test**



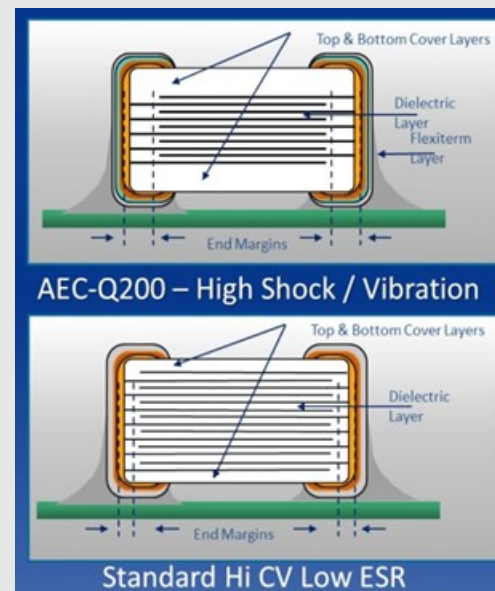
Introduction – Tantalum & MLCC Capacitor Technologies

Tantalum Capacitors



Tantalum Capacitor Construction – common structure for AEC-Q200 and standard grade; source: AVX

- **No major construction differences** Auto/COTS vs Standard grade
- Auto design may have **more conservative CV & FV ratio**



MLCC Ceramic Capacitors

MLCC construction comparison AEC-Q200 vs standard grade; source: AVX

- **Major construction differences** Auto/COTS vs Standard grade
- Design parameters:
 - high end margins
 - less number of layers
 - thicker dielectric
 - flexible terminations
- **Significantly lower CV**

Introduction – Auto AEC-Q200 Requirements & Availability

AEC-Q200 Revision D minimum requirements for qualification of passive electrical devices.

In base document the general requirements includes:

- Qualification and Requalification conditions
- Qualification Tests
- Qualification Sample Size Requirements

Specific to tantalum and ceramic capacitors:

- Methods Referenced Tantalum and Ceramic Capacitors
- Ceramic/Tantalum Process Change Qualification guidelines for the Selected Test
- Acceptance Criteria for Ceramic COG, X7R and X5R SMD Capacitors
- Acceptance Criteria for Tantalum and Niobium Oxide Capacitors

Note: AEC-Q200 define qualification test requirements only. Quality system documents such as PPAP/APQP are now part of the latest IATF 16949 quality system certification.

In the event of conflict in the AEC-Q200 requirements, the product can be supplied following order of precedence applies:

1. The purchase order
2. The user's individual device specification
3. The AEC-Q200 document
4. The AEC-Q200 family other specific documents
5. The supplier's data sheet

Observation

AEC-Q200 data-package is not necessary publicly available document. It shall be available upon request; however, manufacturer has the right to request confidentiality agreement prior providing these documents.

The data, test method, calculations, and internal criteria need not be demonstrated or performed on the qualification of every new device but should be available to the user **upon request**.

Note: This information may be subject to a confidentiality agreement, since it contains proprietary information of the supplier.

Introduction – AEC-Q200 vs ESA ESCC Space Delta Analysis

Automotive vs ESCC specification delta analysis

Tantalum and MLCC Class II Capacitors

		Tantalum	MLCC
Tantalum	AECQ-200	ESCC 3012	ESCC 3009
Burn-in	not required	168h level B with serialisation	96h 2xVr
100% X-Ray	not required	level B	not required
Electrical Measurement RT	at 25±5°	at +22 ±3°C	at +20 ±2°C
Storage 1000hrs, no BIAS	Hi Temp 125C	-55/85/125	not required
Temp Cycling -55/125C	1000 cycles	5 cycles	10 cycles
Humidity	85/85 1k hrs, Vr biased	56days damp heat	85/85 1k hrs, 1.5V
Operation Life	125C, 2/3Vr Ta; 125C Vr MLCC, 1k hrs	125C, 2/3Vr and 85C Vr 2k hrs	125C 2xVr 2k hrs
Mechanical Shock	1500g for 0.5s	50g 11ms	not required
Vibration	5g 20min 12cycles	20g 20min 12cycles	not required
Resistance to soldering heat	260C for 10s	not required	not required
Solderability	+235°C 4 s	+235°C 4 s	+235°C 4 s
Electrical Characterisation	-55/85/125 ta, 125C MLCC	-55/85/125	125C
Terminal Strength	17.7N 60s	5N 10s	5N 10s
Climatq Sequence	not required	Dry Heat, Damp Heat, Cold, Low Air Pressure	not required
Board Flex	MLCC only, 60s holding time	NA	not required
Beam Load Test	MLCC only	NA	not required
Surge Voltage	not required	1000cycles 330hms	not required

more strict requirements

Mandatory Burn-In

Three passive component manufacturers were contacted by online **email support link** and questioned:

- a] 100unit order for tantalum and ceramic automotive grade capacitors
- b] technical question about automotive parts reliability

The response from manufacturers on 100unit online order can vary by individual person handling the request. Feedback received sorted from the most often:

- “for non-modular quantities please check our distributors contact list, in case of sample request please fill up this form”
- “you can request such quantity as samples for your evaluation board, please see the link here.”
- “no response” within two weeks after the online/email request

Handling of technical question:

- “we have forwarded your question to our colleagues that will answer to you in follow up email”
- “for technical questions please check our online knowledge library with most of the common answers”

Observations

- Small volume of parts ~100 units is possible to get as a “sample” free of charge upon justification of “high” business opportunity or “interesting opportunity”. The “interesting opportunity” may include also space applications. **Non-modular Qty request – ask Disty**
- In general, it does not look to be a good idea to **combine request for purchasing and technical question in one email**. There are different group of support people handling such requests and co-ordination is sometimes fuzzy on side of manufacturers.
- Some manufacturers however are introducing **direct contact email to their FAEs and experts online** for technical questions. New trend is to have even a live chat with their experts. This seems to be a better way for getting direct, high quality response to technical questions then contacting a local manufacturer representative or writing an email to their general support email address.

Four DISTRIBUTORS were contacted by online **email support link** and questioned:

- a] 100unit order for tantalum and ceramic automotive grade capacitors
- b] technical question about automotive parts reliability

The contacted distributors types under the survey:

- global “universal” distributor of wide range of electronic active and passive components
- global “specialist” distributor focusing passive components
- “catalogue” parts distributor
- COTS up-screening testhouse

Observations

- No issue to order 100units of non-modular samples from all distributors
- Some distributors request “extra fee” in range of 5 EUR for non-modular quantities (tape cut)
- The tape cut by distributor may be link with other issue for MSL sensitive parts
- Automotive AEC-Q200 parts in the distributor online stocks are clearly identified and traceable
- AEC-Q200 datapackage is a legitimate request even for 100units. However, it may not be available with the product, also documentation control can be an issue. No one in the survey asked for any confidentiality agreements. All distributors in survey are providing AEC-Q200 documents as free of charge service – once/if available from manufacturer

- **Manufacturers are not willing in general to support orders for small, non-modular quantities** on automotive parts as a direct business (in difference to space grade components).
- On the other hand, they can be interested to discuss use of their parts in space to get a space heritage of commercial automotive parts (in current market conditions) and in this case to provide extra support (technical assistance, direct shipment of parts and free samples).
- **The small quantities** can be ordered from **all distributors** within **3 workdays** with clear identification of automotive parts. Attention must be paid for ordering of small quantities of **MSL sensitive parts** as the distributor has to open/cut/re-tape the originally sealed dry pack components inhouse OR full reel purchase has to be made.
- **AECQ-200 documentation** is not generally published/downloadable, but **available upon request mostly free of charge**. The documentation control may however raise some concerns on issue control, a direct request to the manufacturer through their dedicated contact on their website/online is also sometimes possible.
- **For technical support and asking for specific data it may be better to contact the original manufacturers directly** - if they have a dedicated contact on their web or even live chat support.
- **COTS** dedicated parts are available with long details ~ **17weeks**, but clear communication, traceability and **certificate**

Types selected for purchase & testing

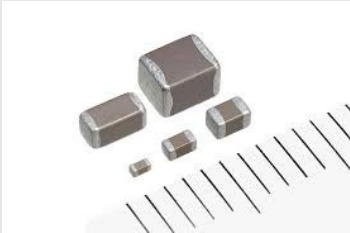
Tantalum capacitor:

A case 1206, 10uF, 10V (max CV available in both Auto and COTS)

Test Sample	MFG	GRADE
#1	Supplier 1	Automotive
#2	Supplier 2	Automotive
#3	Supplier 3	Automotive
#4	Supplier 1	COTS



MLCC capacitor:



10uF 25V, X7R, 1210 case (max CV available for Auto)

Test Sample	MFG	GRADE
#1	Supplier 4	Automotive
#2	Supplier 5	Automotive
#3	Supplier 6	Automotive

Note: there is no 10uF 25 1210 case COTS grade MLCC available, lower CV available only

470nF 25V X7R 1210 (low CV, max available for COTS)

Test Sample	MFG	GRADE
#4	Supplier 1	Automotive
#5	Supplier 1	CECC/COTS

DISTRIBUTORS PARTS Online Database search issues

- “special” low ESR tantalum or surge robust series is not in stock, full reel orders are accepted only
- Distributors’ database is showing incorrect search results: Supplier 3 part in distributor database was **not marked as AEC-Q200 qualified** while manufacturer datasheet state the series is AEC-Q200. This degraded search filter results not showing supplier 3 parts as automotive part.
- **wrong presentation materials in link** – tantalum wet capacitors on SMD part
- **wrong capacitor value in PN description** – 470nF 25V MLCC described as 206uF

Description:	Multilayer Ceramic Capacitors MLCC - SMD/SMT 25V 206uF X7R 1210 10% AEC- Q200
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Datapack request:

- Manufacturer product datasheets are available in pdf to download from distributor website.
- Request for AECQ-200 data on the capacitors was actioned after placement of order

AEC-Q200 DATAPACK request from distributor based on placed order



Calling distributor telephone hotline at weekday 1PM

“all operators are busy,
please hold the line” ...

... after waiting 10minutes online I gave up and wrote an email to their contact email



Email communication

EPCI

Distributor

Can you please send me
AEC-Q200 datapack on
Capacitors under # order ?

1 hour

“What is AEC-Q200
datapackage?”

AEC-Q200 datapack is ...

24 hours

“for AEC-Q200
please contact
manufacturers
directly, we do not
provide this data”.



AEC-Q200 DATAPACK request

EPCI

Can you please send me AEC-Q200 datapack on Capacitors under # order from your authorized distributor?

Manufacturers – Online Support



Supplier 1,2 - general email online simple questionnaire to fill.
Supplier 3 – component type (capacitors) specific contact email
Supplier 4,5,6 - very detailed questionnaire including application details, potential market and PN.

filled questionnaire:

End Customer	European based space electronics manufacturer (SME)
Project	general support technology evaluation
Application	space hardware
Start Operation Production (SOP) ..	2-5 years
Estimated Annual Usage	in thousands of parts annually

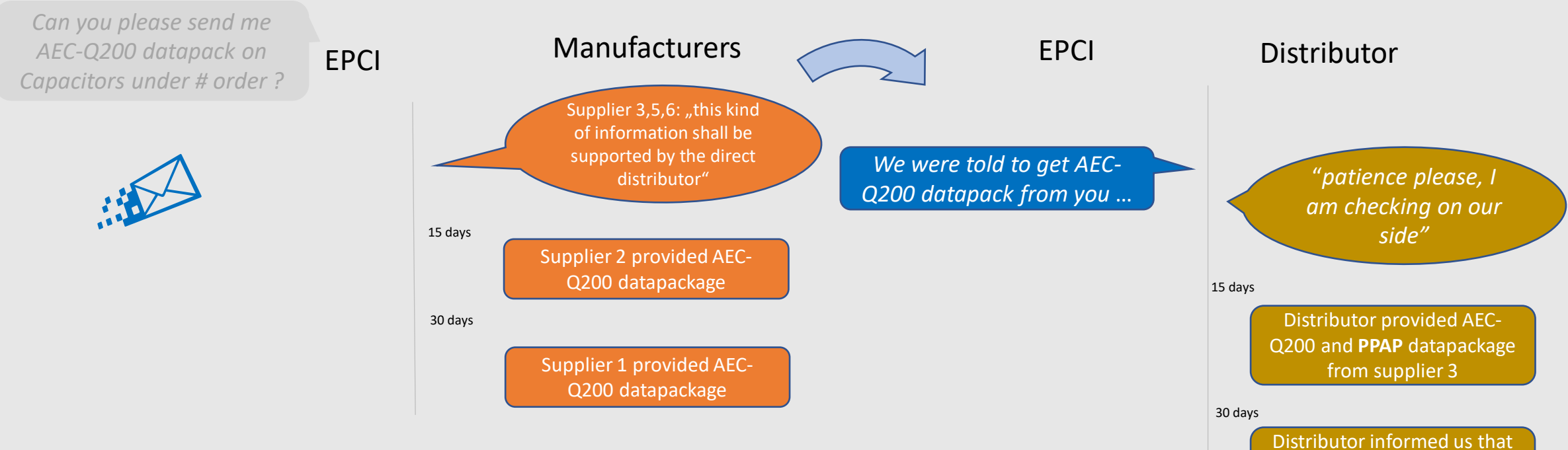
Supplier 1: immediate **automatic email** acknowledgement response

Supplier 2: immediate **personal** response asking on project specific numbers and questionnaire details

Suppliers 3,4,5 no immediate email feedback

Supplier 6: immediate automated email response with summary of the query, reference number and useful contacts to follow up

Email communication



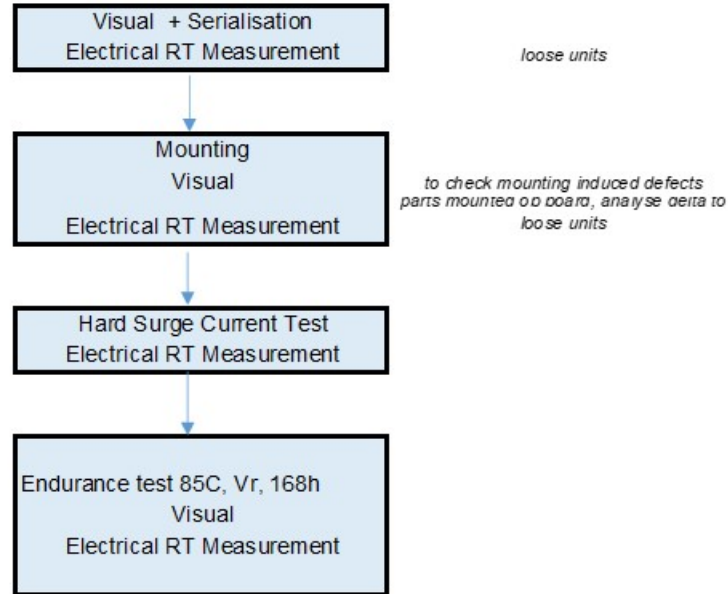
AEC-Q200 DATAPACK DELIVERY SUMMARY TABLE

Tantalum Capacitors						MLCC capacitors					
Supplier 1		Supplier 2		Supplier 3		Supplier 4		Supplier 5		Supplier 6	
who	response	who	response	who	response	who	response	who	response	who	response
supplier	30 days	supplier	15 days	distributor	15 days*	distributor	declined#	distributor	declined#	distributor	declined#

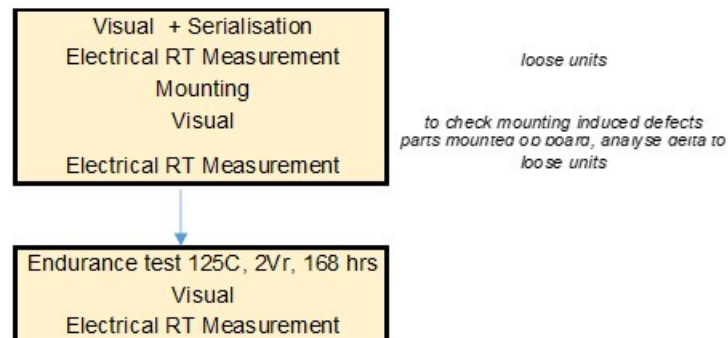
* including PPAP

CANNOT PROVIDE DOCUMENT TO SPACE APPLICATION CUSTOMER

ETP proposal tantalum capacitors (250 commercial and 500 COTS components)

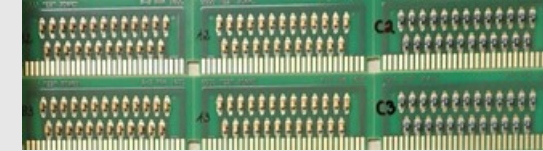


ETP proposal MLCC capacitors (250 commercial and 500 CECC components)



Tantalum capacitor:

A case 1206, 10uF, 10V



Test Sample

#1
#2
#3
#4

MFG

Supplier 1
Supplier 2
Supplier 3
Supplier 1

GRADE

Automotive
Automotive
Automotive
COTS

MLCC capacitor:

10uF 25V, X7R, 1210 case:



Test Sample

#1
#2
#3

MFG

Supplier 4
Supplier 5
Supplier 6

GRADE

Automotive
Automotive
Automotive

470nF 25V X7R 1210

Test Sample

#4
#5

MFG

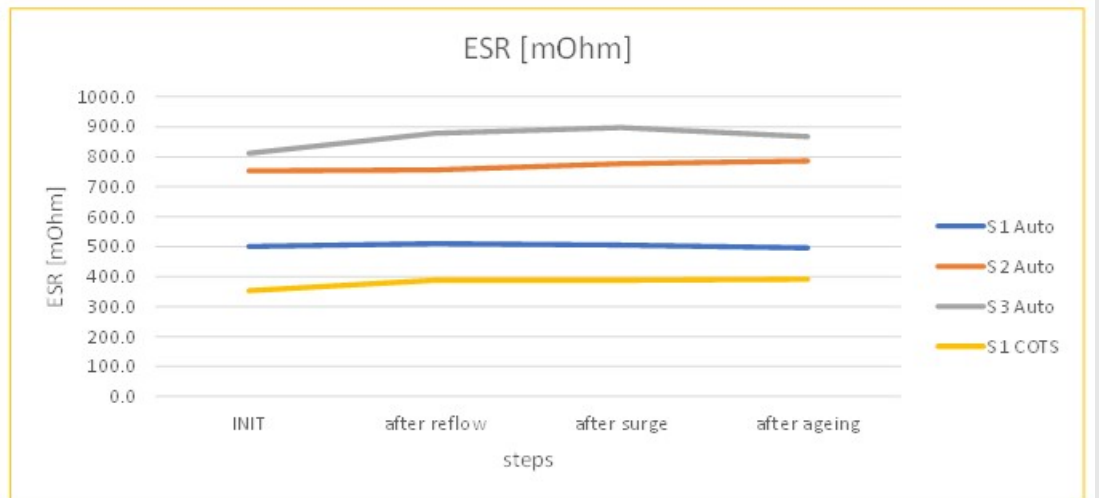
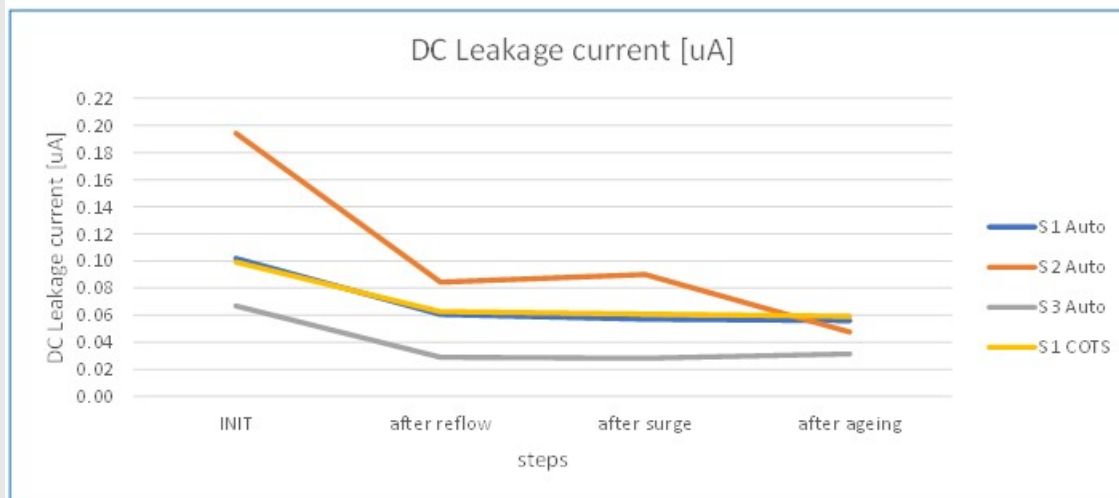
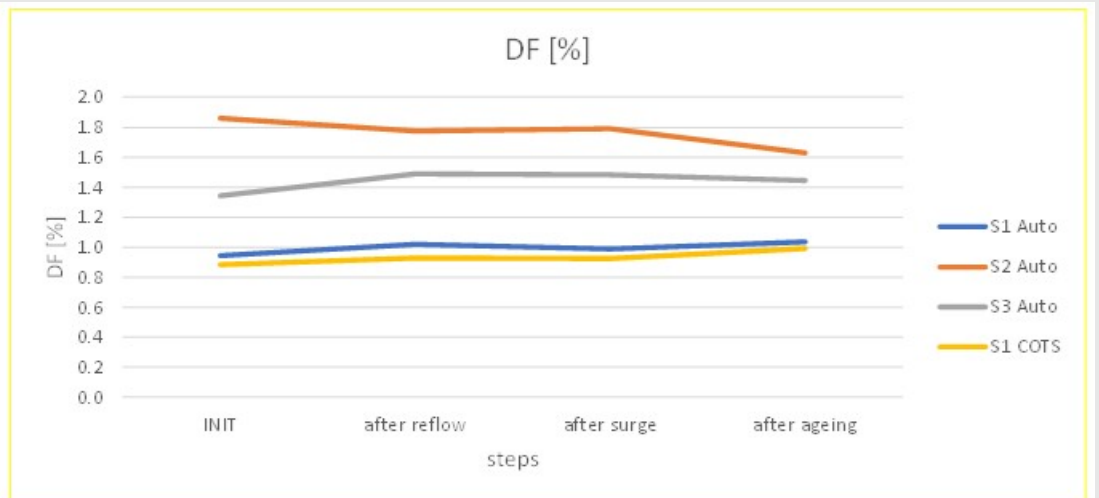
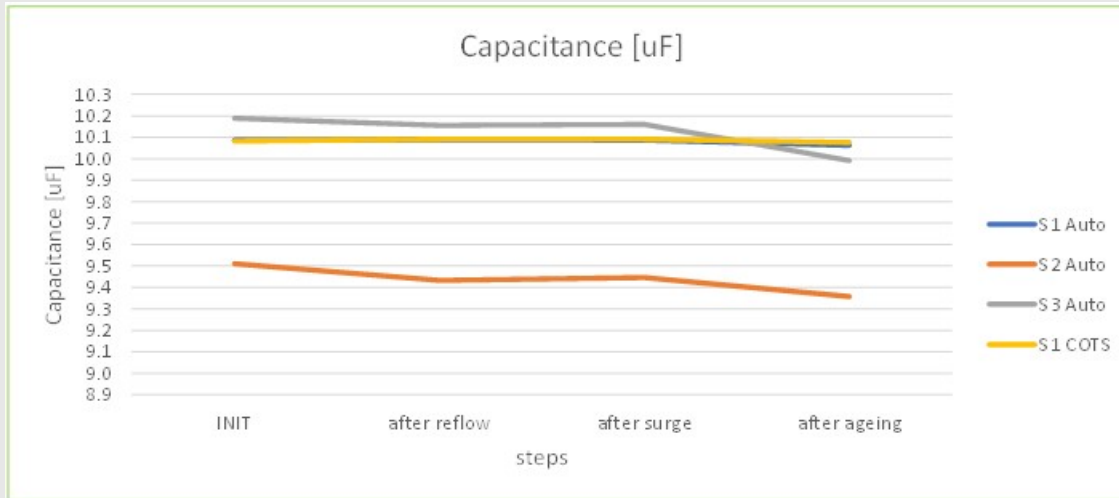
Supplier 1
Supplier 1

GRADE

Automotive
CECC/COTS

Ageing & Test Evaluation

Test Results – Tantalum Capacitors – Median Electrical Parameters



Ageing & Test Evaluation

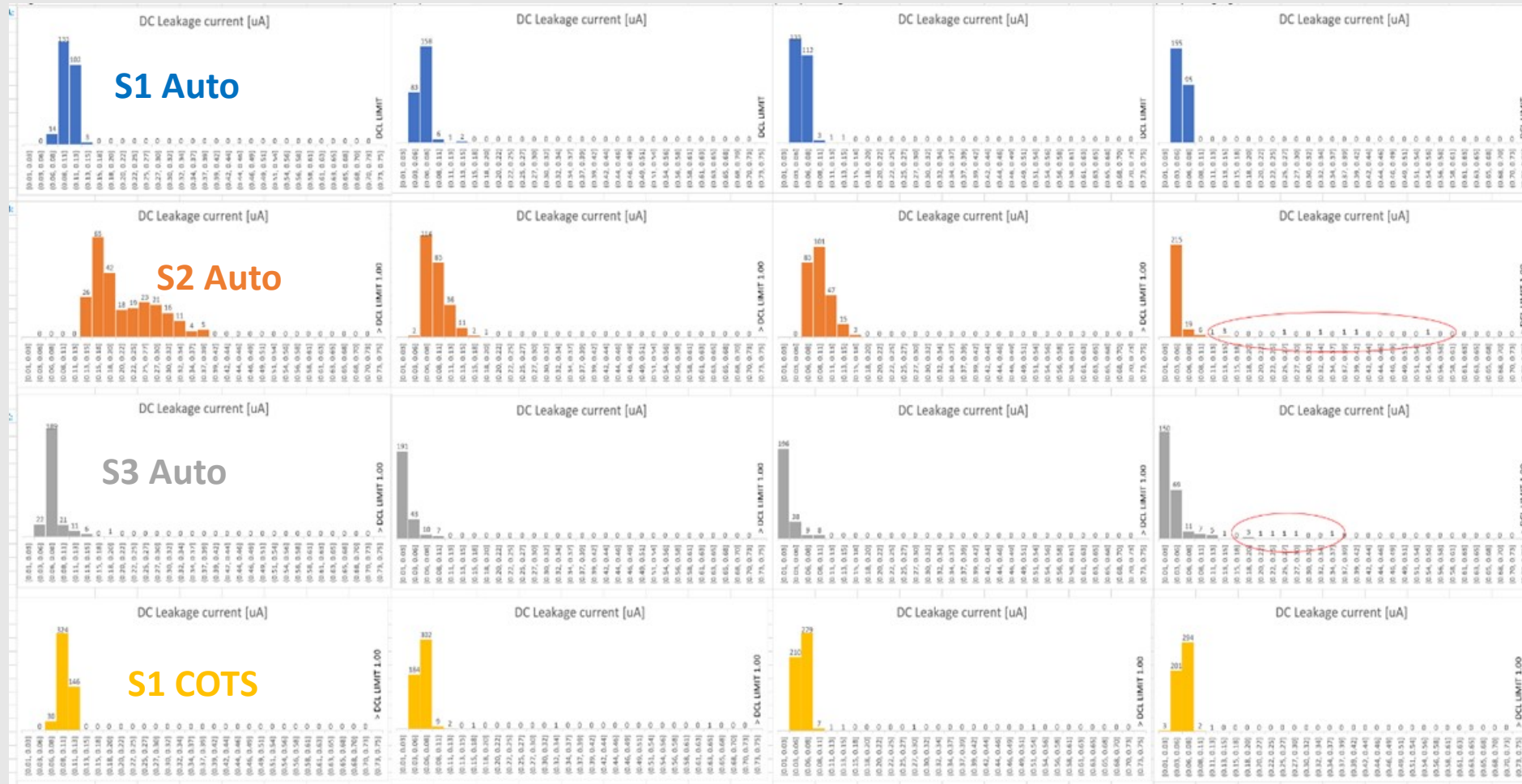
Test Results – Tantalum Capacitors – DCL histogram

INITIAL LOOSE

POST MOUNT REFLOW

POST SURGE

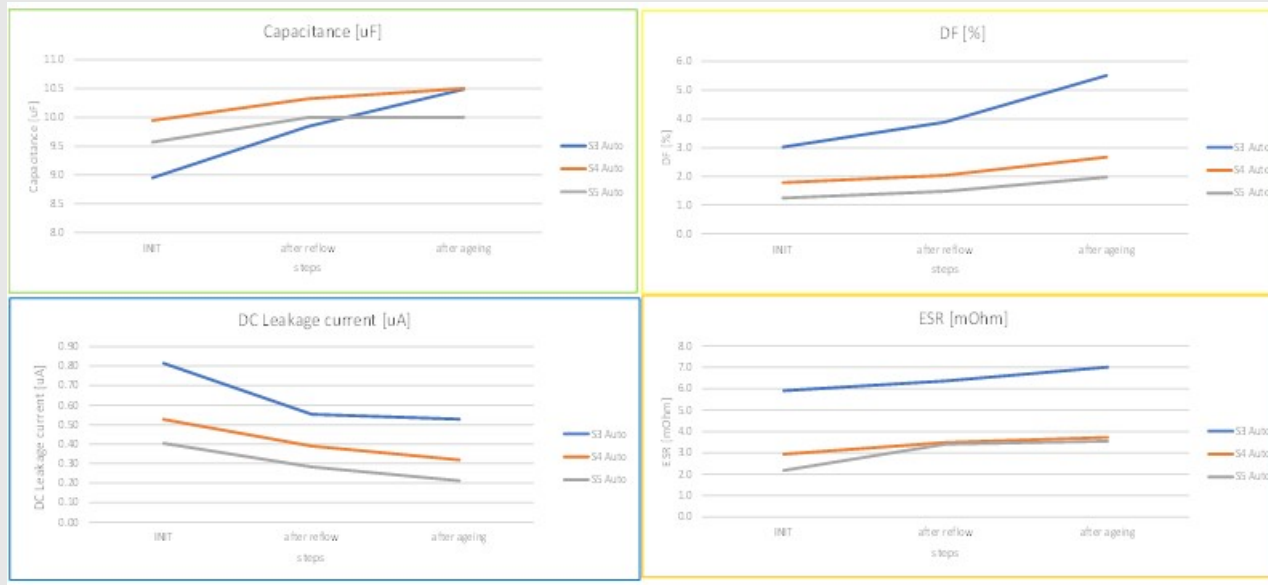
POST 168h AGEING at VR, 85C



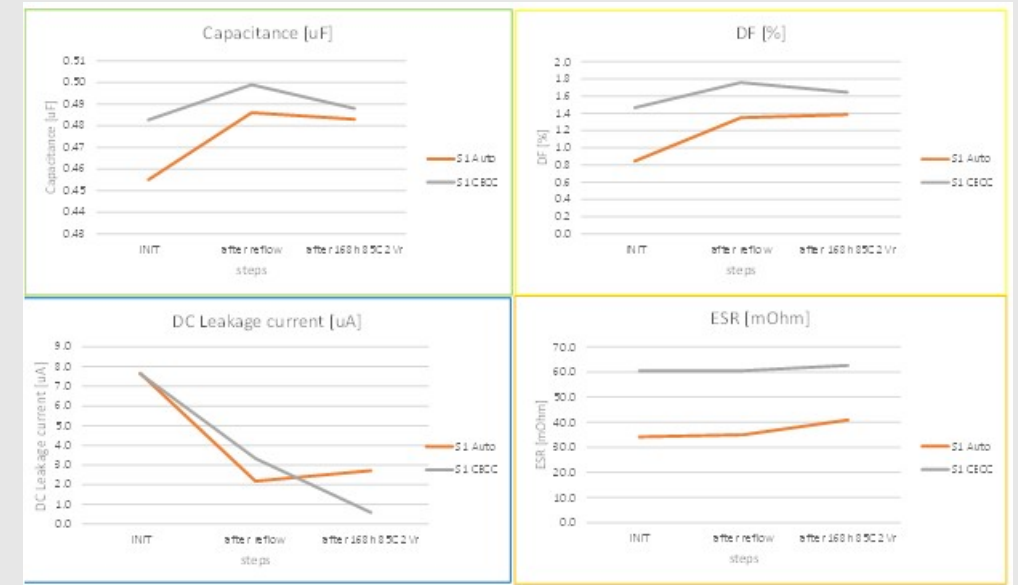
Ageing & Test Evaluation

Test Results – MLCC Capacitors

MLCC capacitor:
10uF 25V, X7R, 1210 case:



470nF 25V X7R 1210



Ageing & Test Evaluation

Test Results – MLCC Capacitors – DCL histogram

MLCC capacitor:
10uF 25V, X7R, 1210 case:

470nF 25V X7R 1210

INITIAL LOOSE

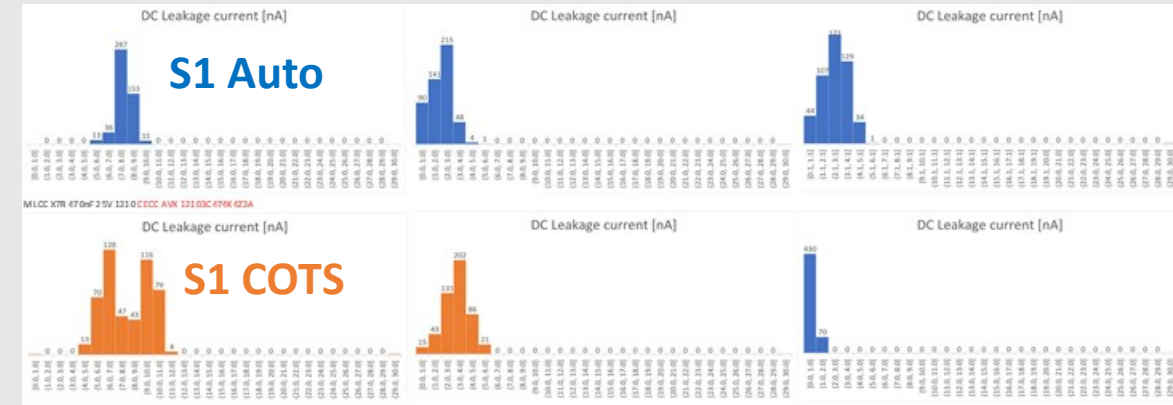
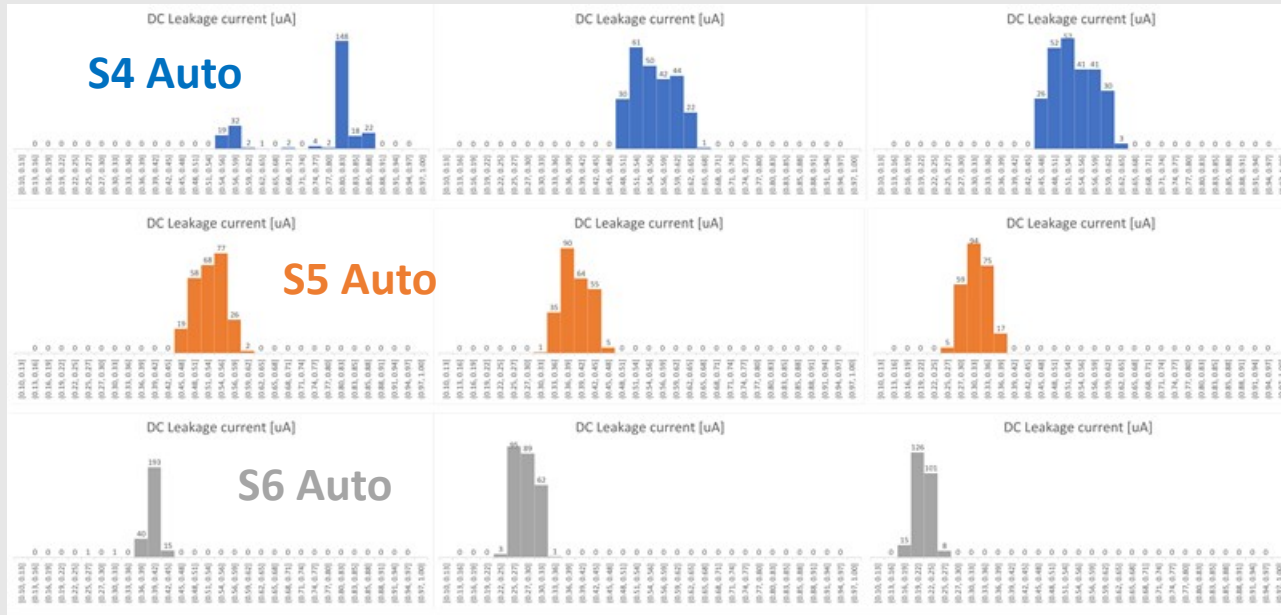
POST MOUNT REFLOW

POST 168h AGEING at 2xVR, 125C

INITIAL LOOSE

POST REFLOW

POST 168h AGEING at 2xVR, 125C



Test Summary

- Electrical parameters of automotive & COTS/CECC tantalum and MLCC capacitors confirms effective screening testing and limits during manufacturing.
- **All tested tantalum and MLCC capacitors passed the ETP testing without any failures and meet manufacturer specifications.**
- All tantalum capacitors from all vendors in auto and COTS show high grade of robustness against hard surge current.
- COTS tantalum capacitors exhibited high grade of robustness against hard surge current. DCL current and other el.parameters were stable and all parts successfully self-healed during the 168h 85C 1xVr ageing without any flyers.
- **168h ageing at 85°C/1xVr on tantalum capacitors have been proved as an effective process** to stabilize its DCL with potential to improve reliability by removal of suspicious distribution tail parts by dynamic screening limits post ageing.
- **168h ageing at 125C 2xVr on 10uF 25V X7R 1210 MLCCs capacitors does not show any major impact to the measured electrical parameters.** There were some differences observed in behaviour between the 470nF 25V X7R 1210 MLCC automotive commercial grade and CECC/COTS capacitors in test.
 - Differences in capacitance distribution and DF/ESR values suggests that the two capacitor groups may have a different design (thickness of dielectric, layer structure, number of layers)
 - ESR and DF of Auto CECC parts split into two distributions after board mounting thermal stress and stabilised after the 168h ageing. This was not the case of CECC/COTS parts
 - DCL of CECC/COTS parts significantly decreased after the 168h ageing that was not case of automotive commercial parts. This phenomenon has not yet been explained - pending discussion with the manufacturer.

CONCLUSIONS



- **Component types and construction knowledge is required before purchasing.** It is better to study, understand and select appropriate component type from concrete manufacturer before the procurement process. If the user is SME and have to buy through distributors there is a **number of errors in their database** and thus the search function may not be reliable. Technical support from distributor may be also varying.
- **Traceability of the auto parts is at very high level** (required by automotive standards) and it should not be considered as an issue for space industry. (apart of MSL non-modular parts that require attention)
- **AEC-Q200 datapackage is not a public document** and may not be necessary available. **Getting the AEC-Q200 through supply chain and distribution may also take some time and communication resources.**
- Tantalum capacitors seems to be very robust and manufacturers are not so concerned about using their automotive products in SME space hardware. This is not the case of **MLCC capacitors**, where all manufacturers declare **NO LIABILITY** to their **automotive parts for space application** and refused to provide AEC-Q200 datapackage.
- The test quantity may not be reasonable to make a general conclusion, nevertheless, there were **no significant issues with the robustness of automotive grade tantalum and MLCC capacitors** and they performed well in the evaluation testing.
- On the other hand, testing of the original **COTS / CECC** level suggests that these parts have a more conservative component design focusing more reliability and robustness. This can be observed on **lower shift of electrical parametric during the stress conditions** and/or better recovery during ageing step.
- **168h ageing have been proved as an effective process to stabilize DCL distribution of capacitors**

INVITATION

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3rd PCNS Passive Conference Networking Symposium

7 - 10 SEPTEMBER, 2021, MILANO, ITALY



TOPICS

- MATERIALS & PROCESSES
- DESIGN & CONSTRUCTION
- MEASUREMENT & TEST
- QUALITY & RELIABILITY
- TECHNOLOGY & ROADMAPS
- APPLICATIONS
- NEW DEVELOPMENT
- MODELLING & SIMULATION

COMPONENTS

- CAPACITORS
- INDUCTORS & TRANSFORMERS
- RESISTORS
- FUSES
- FILTERS
- RF PASSIVES
- PASSIVE SENSORS
- CONNECTORS & CABLES
- CRYSTALS & OSCILLATORS

IMPORTANT DATES

- **31 Jan 21** Call for Papers Deadline
- **2 Apr 21** Abstract deadline
- 31 Apr 21 Notice of acceptance
- 9 Jun 21 Paper deadline
- 16 Jun 21 Preliminary programme
- 16 Jun 21 Early registration up to
- 23 July 21 Final programme
- **7-10 Sep 21** Conference Dates



3rd PCNS

7-10th Sep 2021, Milano, Italy

- International conference dedicated to Passive Components
- Bi-annual event hosted by European university
- 3rd PCNS 2021 hosted by Politecnico di Milano university
- Intended as Hybrid event with streamed live speakers

Theme:

Reliability & Sustainability of Passive Components

The theme will be elaborated in conference Workshop, Hot Topic Panel Discussion, Keynote and papers selection preferences.

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Call for Papers

deadline 2nd April 2021

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Thank You !

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