YAGEO GROUP

Ta Polymer Capacitors Trends & Challenges – SDV

Key Performance in Autonomous Driving and Sensing Applications

Cristina MotaCaetano

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About the Authors

Cristina Mota Caetano
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Received Masters in Material Science from IST (Technical University of Lisbon). In 1997, started as R&D engineer, with Siemens Matsushita, Germany. From 1999 to 2012, held various R&D and Material & Process Development management roles at EPCOS and KEMET Electronics. Since 2012, have served as the Technical Product Marketing Director for the Tantalum Product Business Unit at KEMET, an Yageo Company,

Keith Moore
Product Management Director,
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Graduated with degrees in Chemistry and Chemical Engineering. From 1997 to 2015, served in various technical roles focused on the development and manufacturing of tantalum and aluminum products. In 2015, moved into KEMET's product management team as a technical product manager. During which time, served as the ECIA chair for P2-5 Solid Electrolytic Capacitors (Tantalum, Niobium, Aluminum) committee and as the US delegate for IEC TC40 (Capacitors and Resistors for Electronic Equipment) meetings. In 2020, accepted product management responsibilities for Tantalum and Aluminum polymer products.

Rosa Davila
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Holds a Bachelor of Science in Industrial Chemistry and a Masters in Materials Science. Joined KEMET in 2010 as a New Product Development Engineer and has held various engineering positions for Tantalum PBU. Since June 2021, has worked as Technical Product Manager for Ta and Al Polymer Capacitors. Supports customers in Americas, as well as global SSD and HDD customers. Currently serves as the ECIA chair for P2-5 Solid Electrolytic Capacitors (Tantalum, Niobium, Aluminum) committee and as the US delegate for IEC TC40 (Capacitors and Resistors for Electronic Equipment) meetings.

Outline

- Trends and Challenges
- Application and Capacitor Requirements
- Product Offering
- Product Capability
- Future Direction

Trends and Challenges

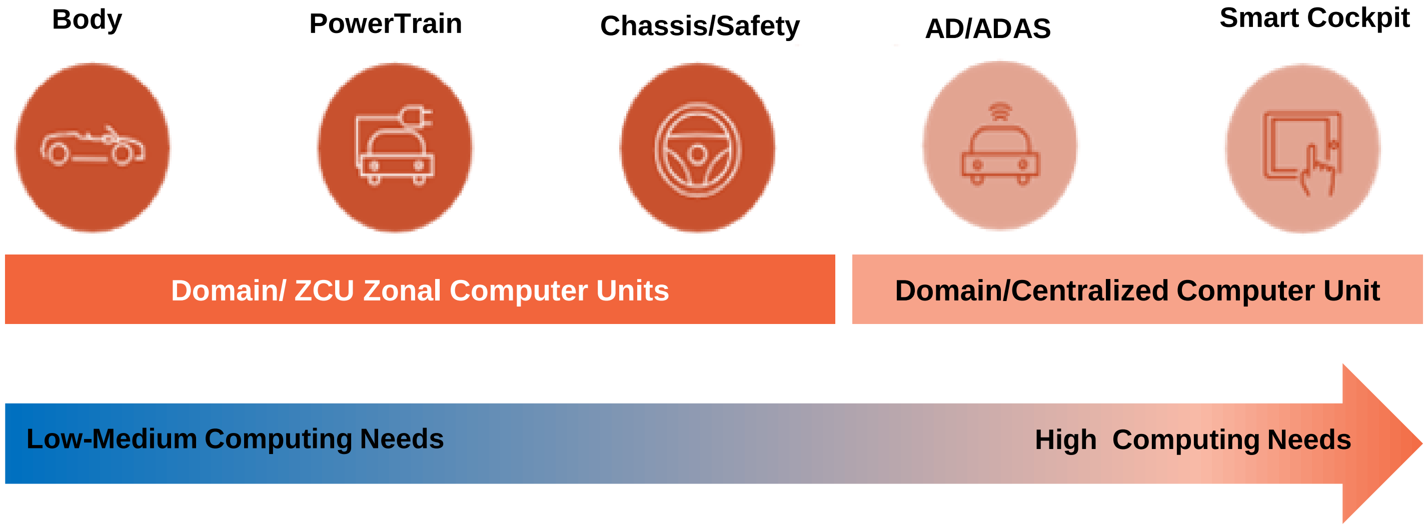
Rise of Components

Rise of Software-Defined Vehicles

Rise of Domain, Zonal, and Central Compute Units

Trends and Challenges

Automotive Domain Requirements



	Electronic Compute Unit (ECU)	Domain Compute Unit (DCU)	Zonal Compute Unit (ZCU)	Central Compute Unit (CCU)
CAGR 2023-2030 (%) Projected Value 2030 ($B)	-2% $73B	+29% $44B	+44% $3B	+45% $10B

Source: McKinsey Center for Future Mobility: https://www.mckinsey.com/industries/semiconductors/our-insights/getting-ready-for-next-generation-ee-architecture-with-zonal-compute#/

Trends and Challenges

SENSING
Data Aquisition

GPS
LIDAR
CAMERA
RADAR

PERCEPTION
Data Processing

Localization
Object Recognition
Object Tracking

DECISION
Makes decisions and issue commands

Prediction
Path Planning
Obstacle Avoidance

Operating System

Hardware Platform

Increase Autonomy Level → Increase on Processing Capabilities

Volumetric Efficiency

Thermal Management and Extended Mission Profiles

Efficient Power Management

Application and Capacitor Requirements

Application Requirements		**Capacitor Requirements**
Smaller Components	⇨	Higher Cap Per Unit Volume
Lower Loss Components	⇨	Lower ESR, Lower Thermal Resistance
Higher Reliability	⇨	Higher Category Temperature, Longer Life

Automotive Polymer Capacitor
AEC-Q200 Requirements

Stress	Condition
High Temperature Exposure (Storage)	MIL-STD-202 Method 108 (125˚C, Unpowered, 1000 hours)
Temperature Cycling	JESD22 Method JA-104 (-55˚C to 125˚C, 1000 Cycles)
Biased Humidity	MIL-STD-202 Method 103 (85˚C, 85%RH, V_r, 1000 hours)
High Temperature Operational Life	MIL-STD-202 Method 108 (125˚C, 0.67 V_r, 1000 hours)
External Visual and Physical Dimensions	MIL-STD-883, method 2009 and JESD22-B100
Resistance to Solvents	MIL-STD-202 Method 215
Mechanical Shock	MIL-STD-202 Method 213
Vibration	MIL-STD-202 Method 204
Resistance to Soldering Heat	MIL-STD-202 Method 210
Solderability	J-STD-002
Electrical Characterization	User specification
Terminal Strength	AEC-Q200-006

Source:
AEC-Q200 Rev E – March 20th, 2023 – Table 1 – Stress Qualification for Tantalum (MnO_2 and Polymer) and Niobium Capacitors

Automotive Polymer Capacitor
Product Offering

Size Range (metric)	3.2 mm x 1.6 mm x 1.2 mm 7.3 mm x 4.3 mm x 4.0 mm
Capacitance Range - µF	1 - 680
Voltage Range – Volts	2.5 - 75
Category Temperature - ºC	125 - 150
Lowest ESR (25ºC, 100kHz) – mΩ	6
Maximum Ripple Current (+45ºC, 100kHz) - Amps	8.7

Automotive Polymer Capacitor

EIA 7343-28, 470 µF, 2.5 V, 6 mΩ

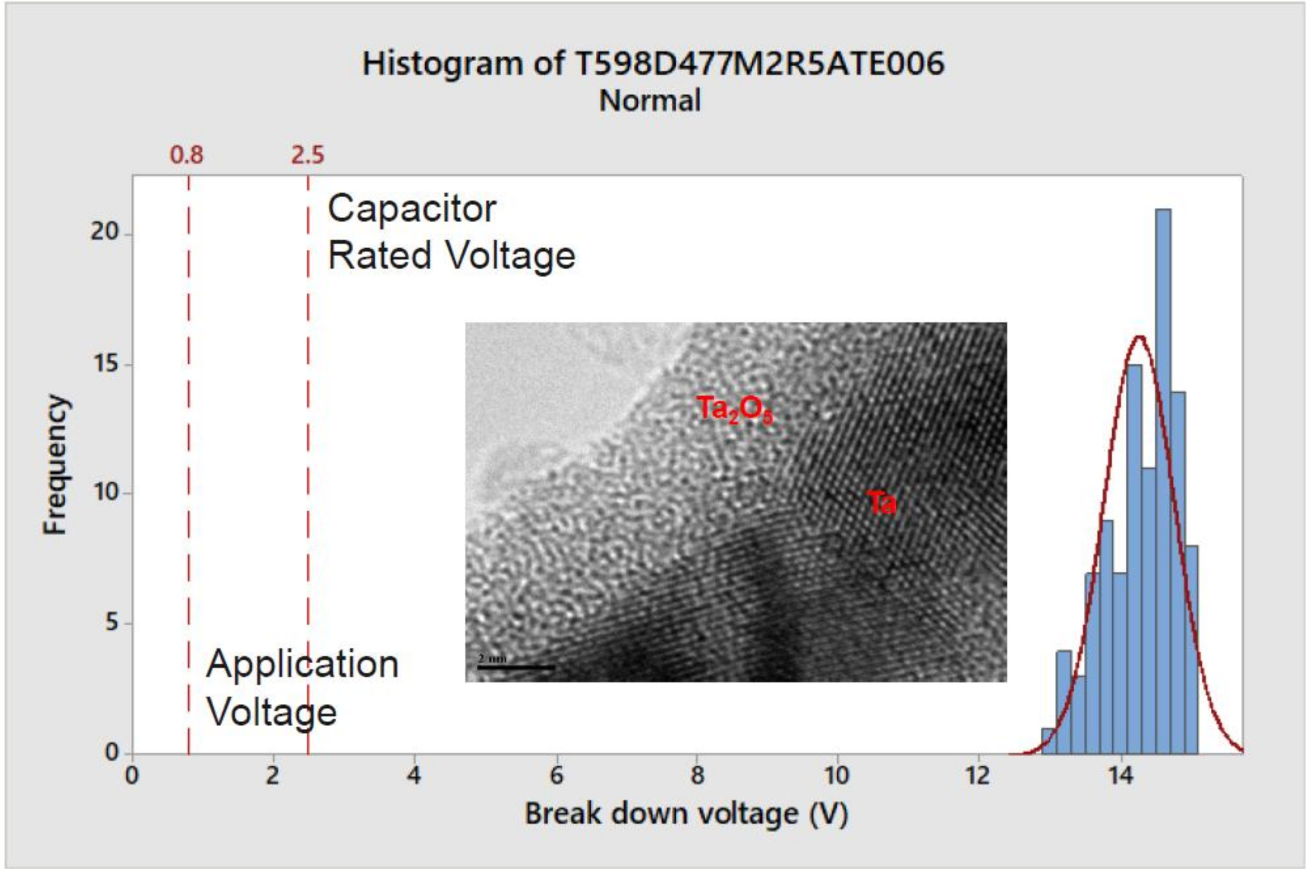


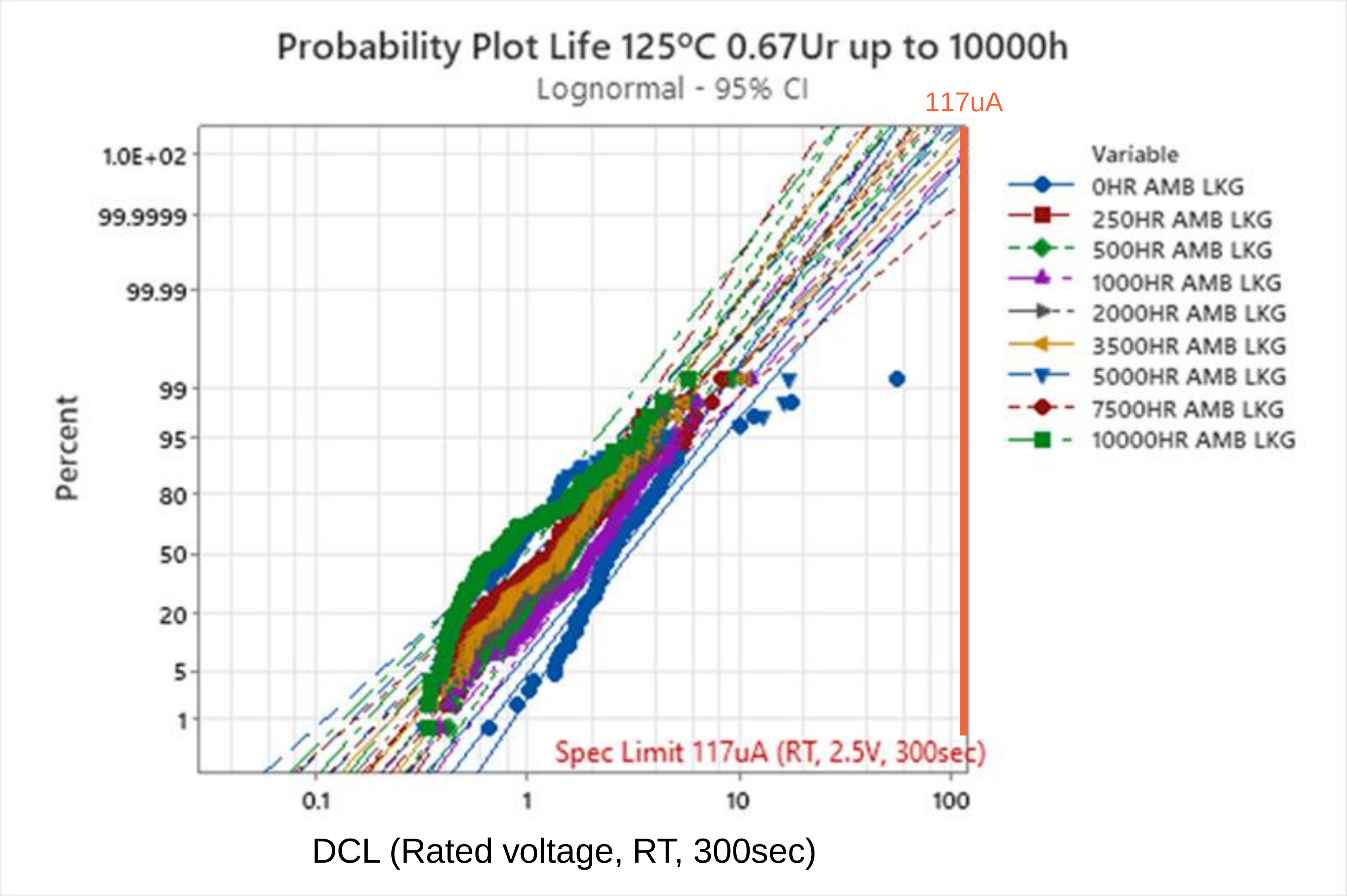
Photo Source:
Innovation Center, Greenville, South Carolina
High Resolution TEM Transmission Electron Microscope – Crystalline Structure of Tantalum and Amorphous structure of the dielectric anodic oxide Ta_2O_5

- High Volumetric Efficiency
- Conservative Design
- Robust Dielectric

Automotive Polymer Capacitor

Extended 125ºC / 0.67 Vr Life Testing, 2,000 hr → 10,000 hr

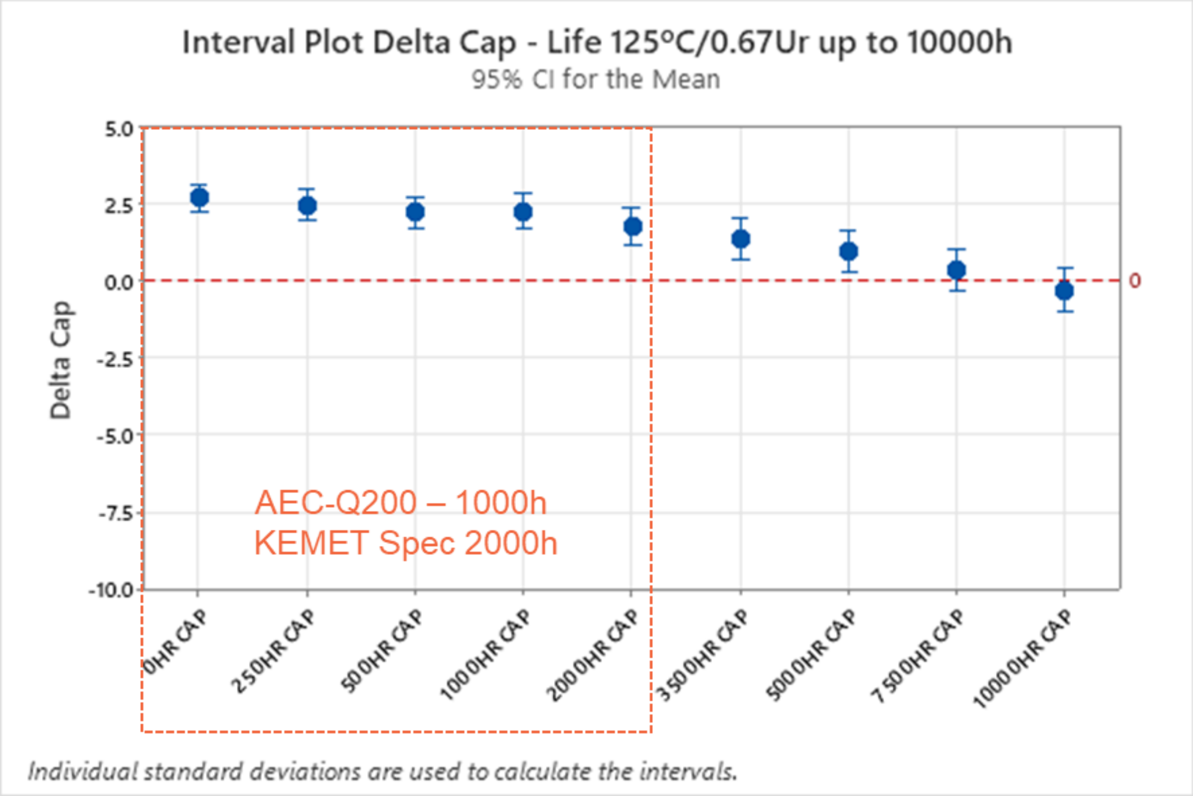
Leakage



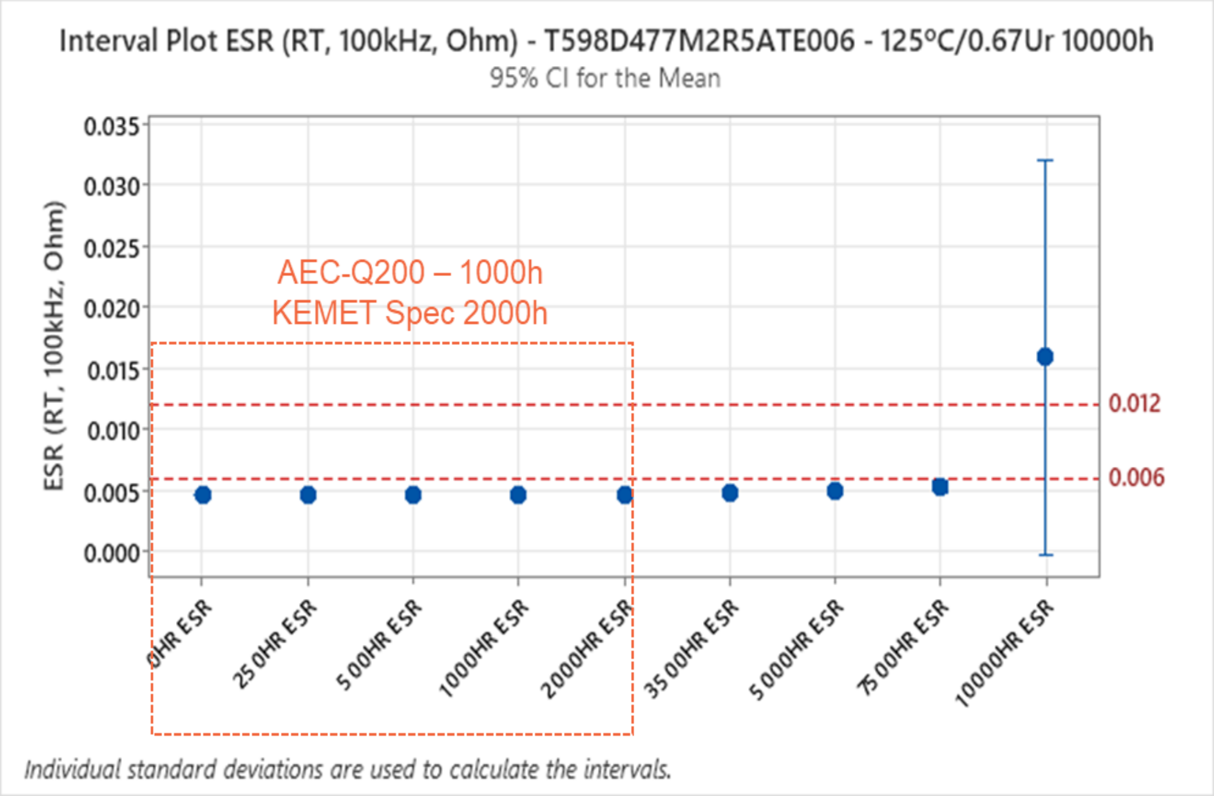
Automotive Polymer Capacitor

Extended 125ºC / 0.67 Vr Life Testing, 2,000 hr → 10,000 hr

120 Hz Capacitance



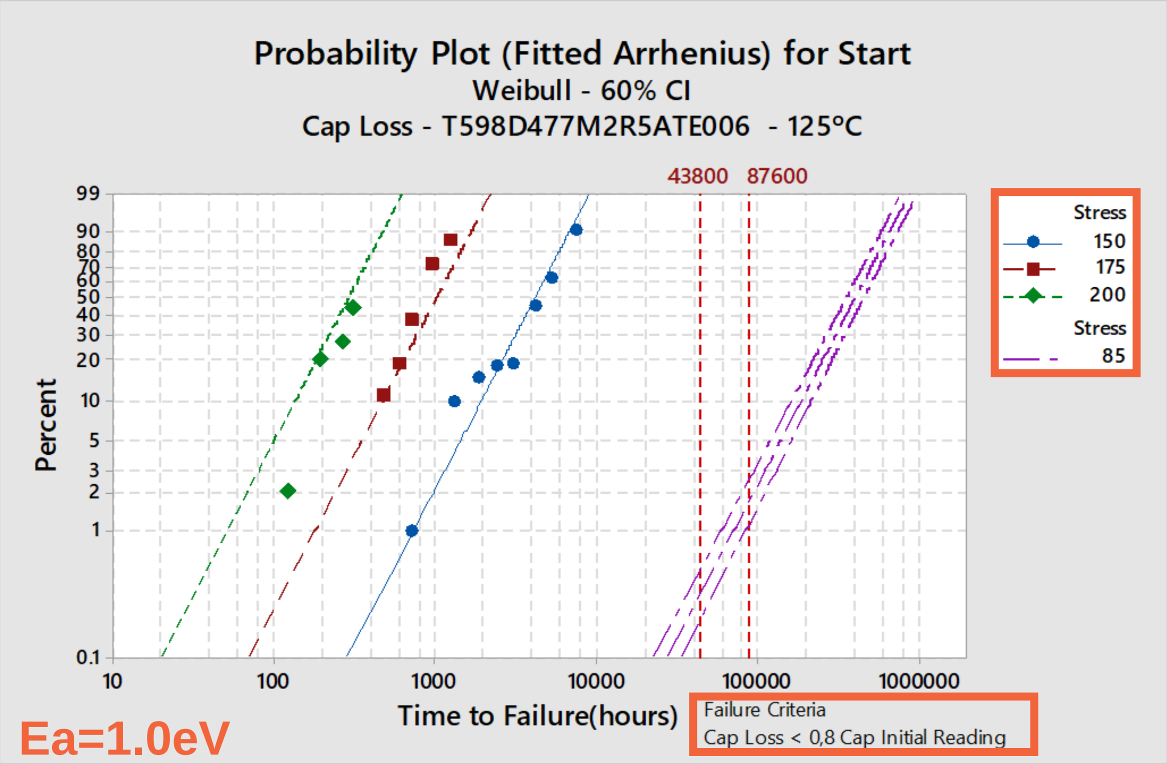
100kHz ESR



Automotive Polymer Capacitors

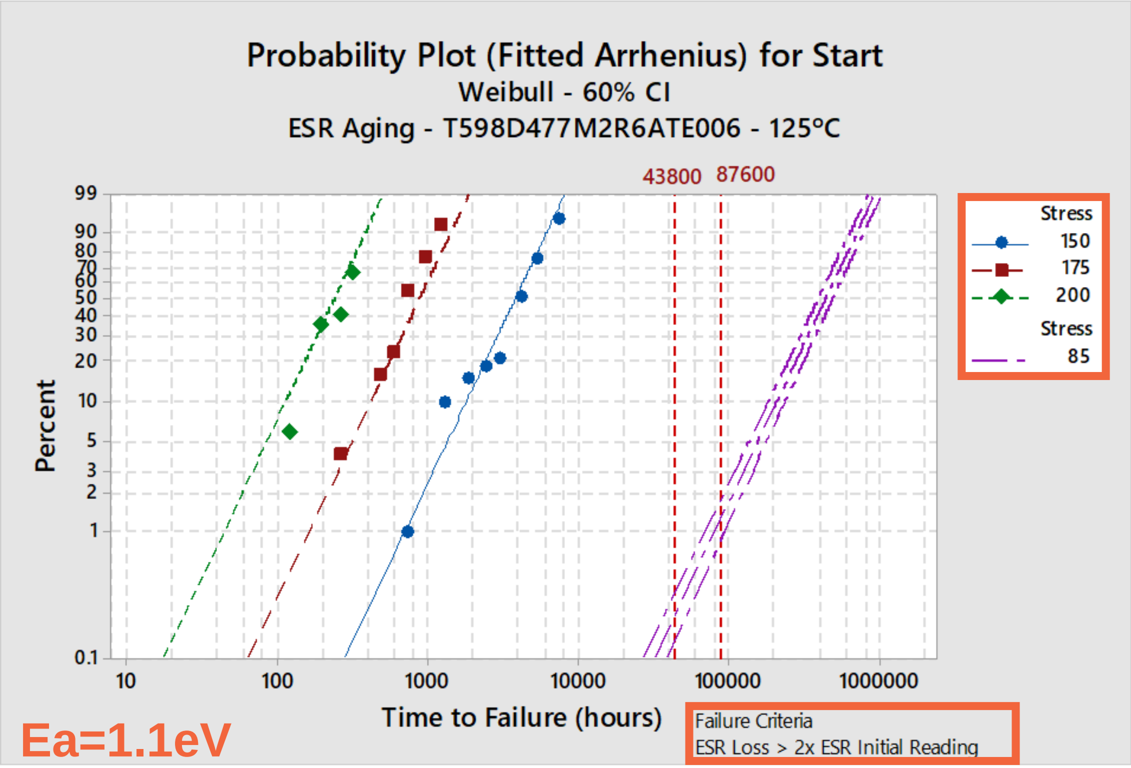
Capacitance and ESR Loss *Modelling*

Capacitance



Ea=1.0eV

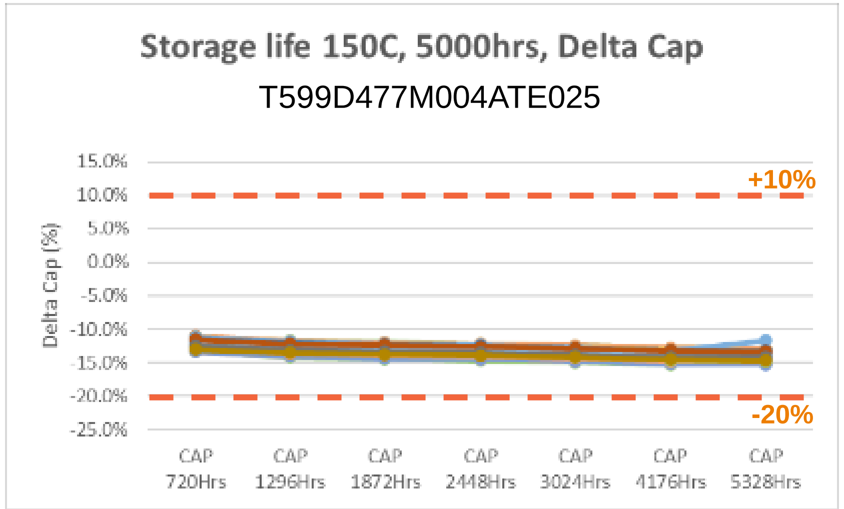
ESR

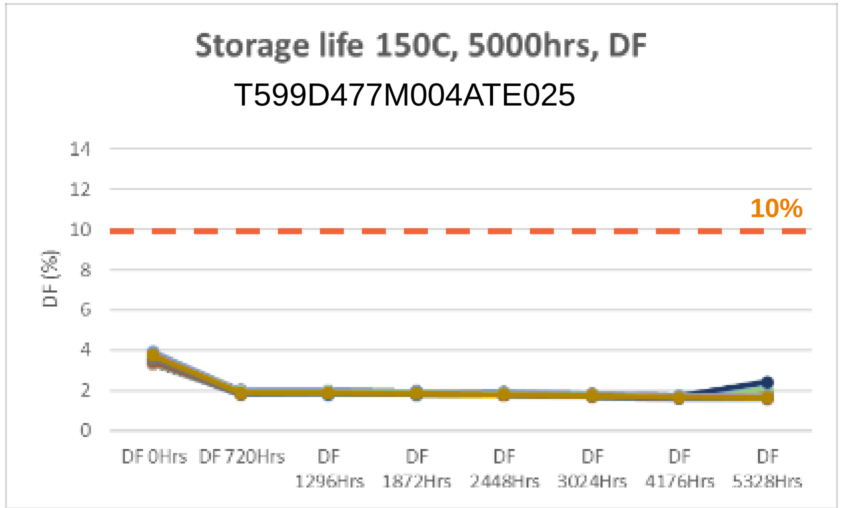


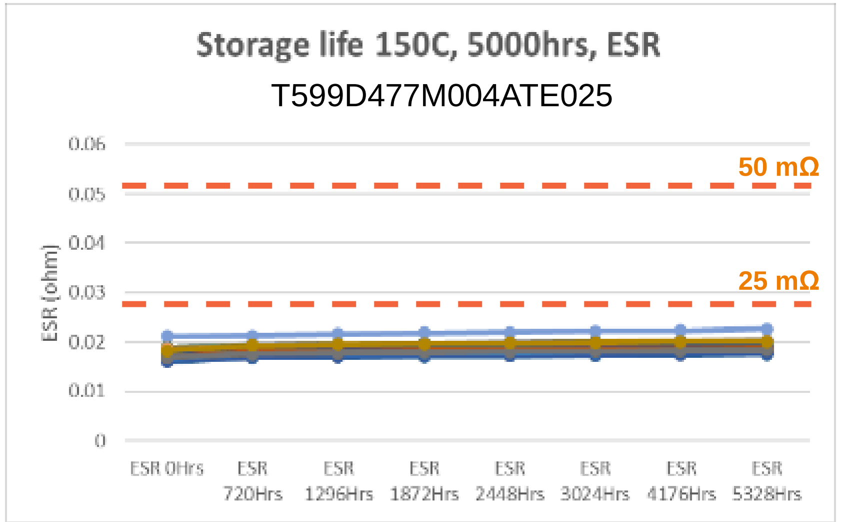
Ea=1.1eV

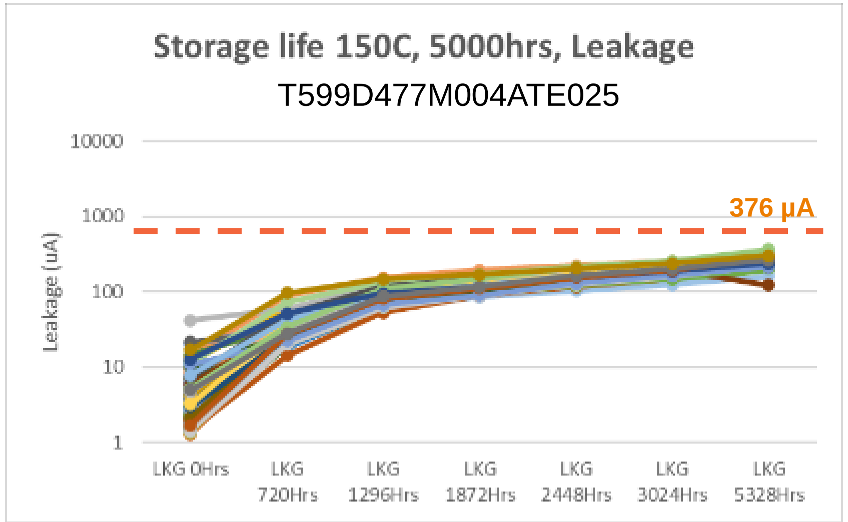
Automotive Polymer Capacitors

Extended Category Temperature, 125ºC → 150ºC



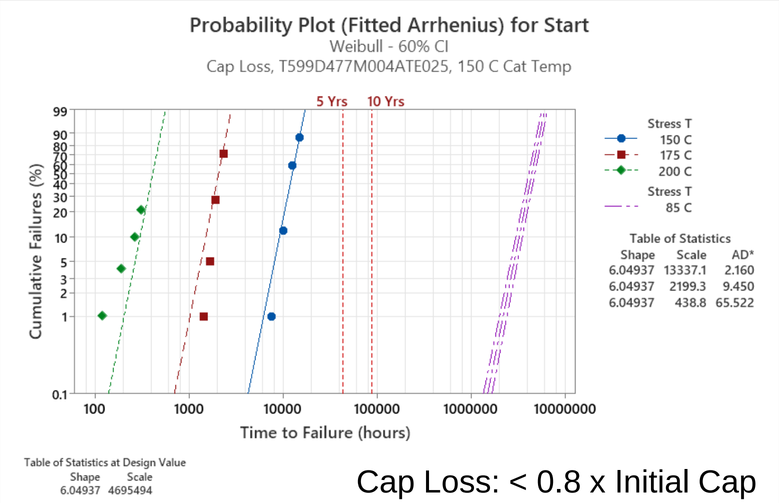




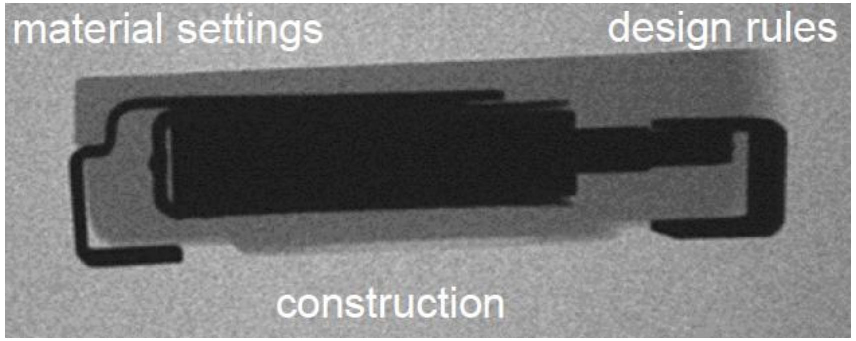


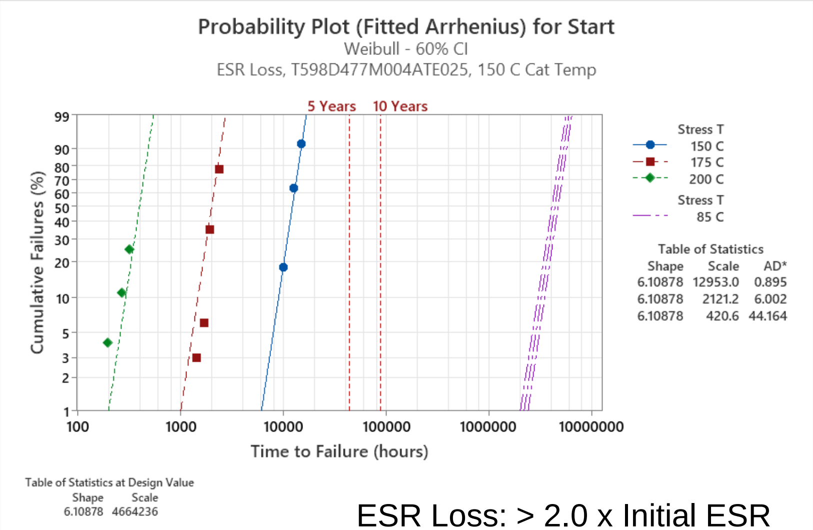
Automotive Polymer Capacitors

Extended Category Temperature, 125ºC → 150ºC



Cap Loss: < 0.8 x Initial Cap





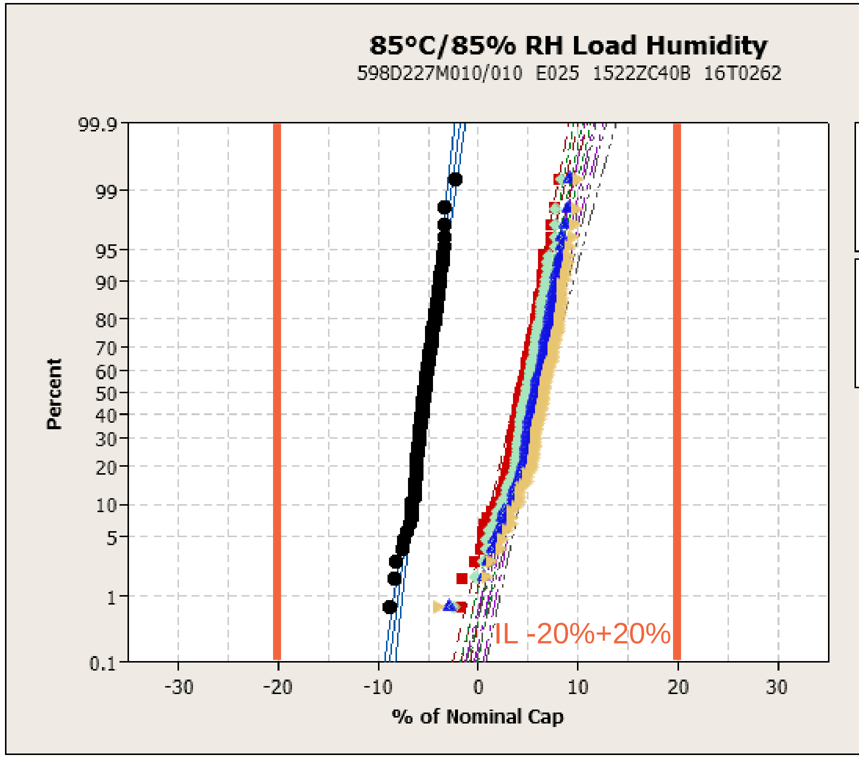
ESR Loss: > 2.0 x Initial ESR

Temperature Reference (ºC)	150
Ea - activation energy (eV)	1.18
Boltzman Constant	8.62E-05

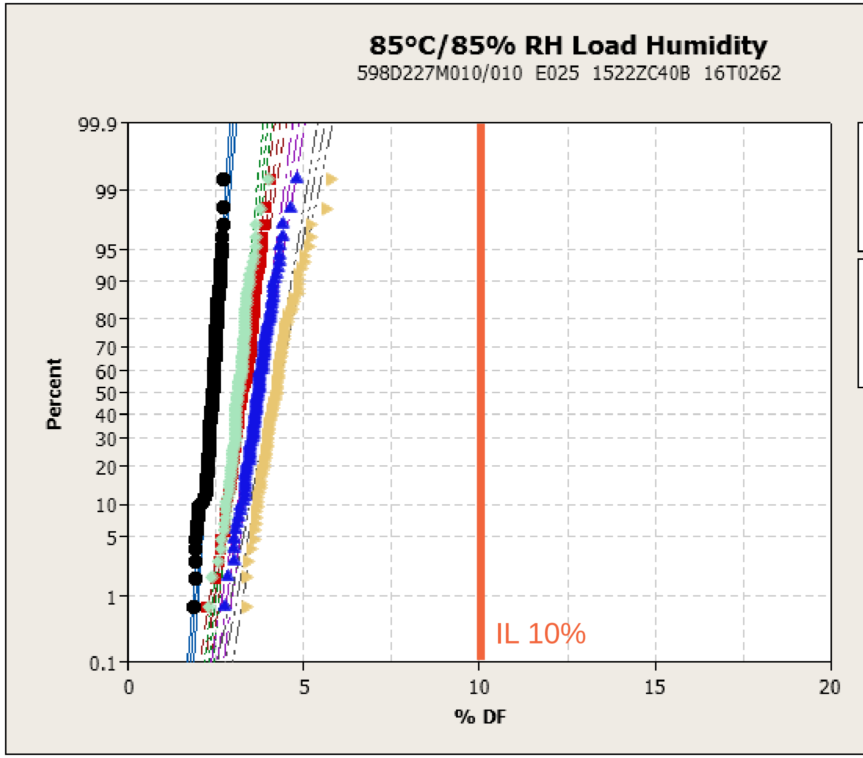
Temperature (ºC)			Accelaration Temp (x)	Lo	Lx (h)	Years
25			785938	5000	3929692465	448595
40			86960	5000	434798985	49635
65			3423	5000	17116400	1954
75			1069	5000	5345397	610
76			955	5000	4775620	545
85			356	5000	1781493	203
90			210	5000	1052072	120
100			77	5000	382794	44
105			47	5000	235579	27
111			27	5000	133780	15
125			8	5000	38177	4

Automotive Polymer Capacitors

Extended 85ºC / 85%RH / Vr Humidity Bias, 1000 h → 2000h



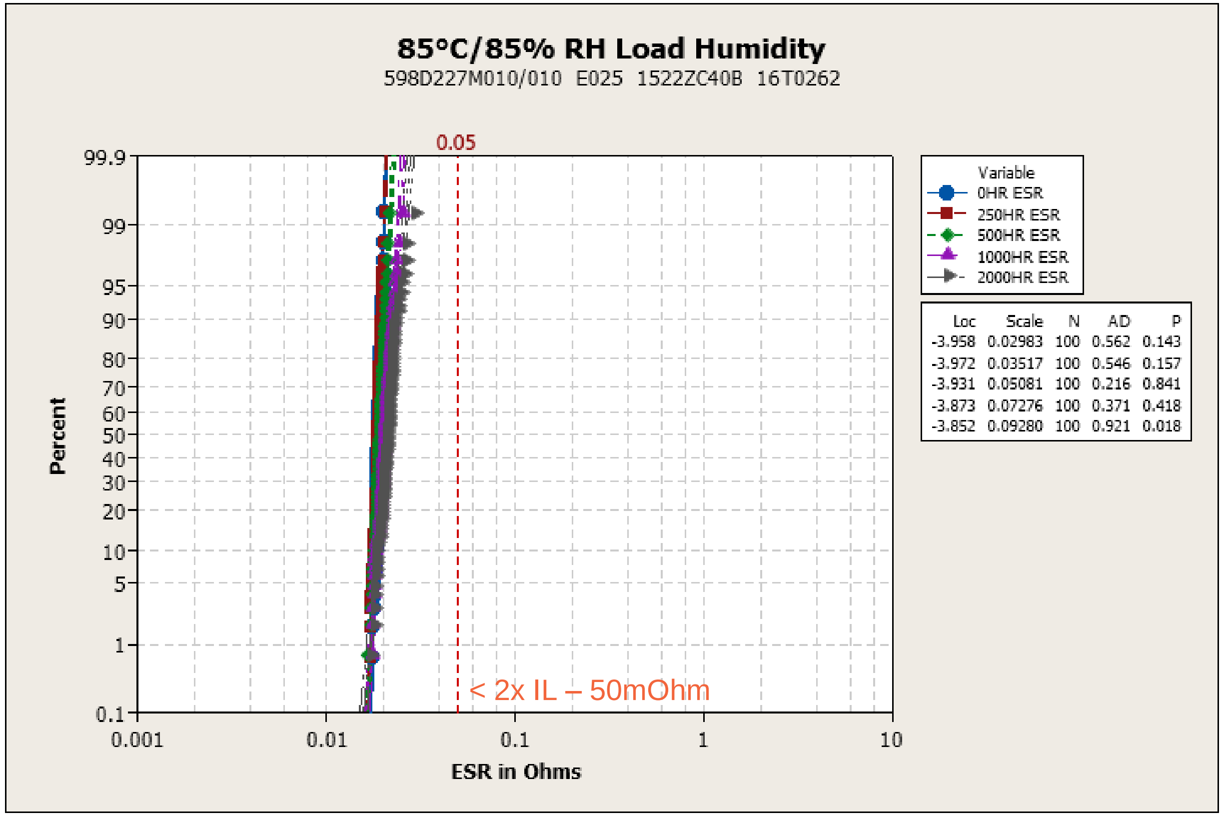
Mean	StDev	N	AD	P
-5.264	1.139	100	0.410	0.338
4.214	1.886	100	0.937	0.017
4.828	1.834	100	1.122	0.006
5.655	1.939	100	1.210	<0.005
6.337	2.099	100	1.575	<0.005

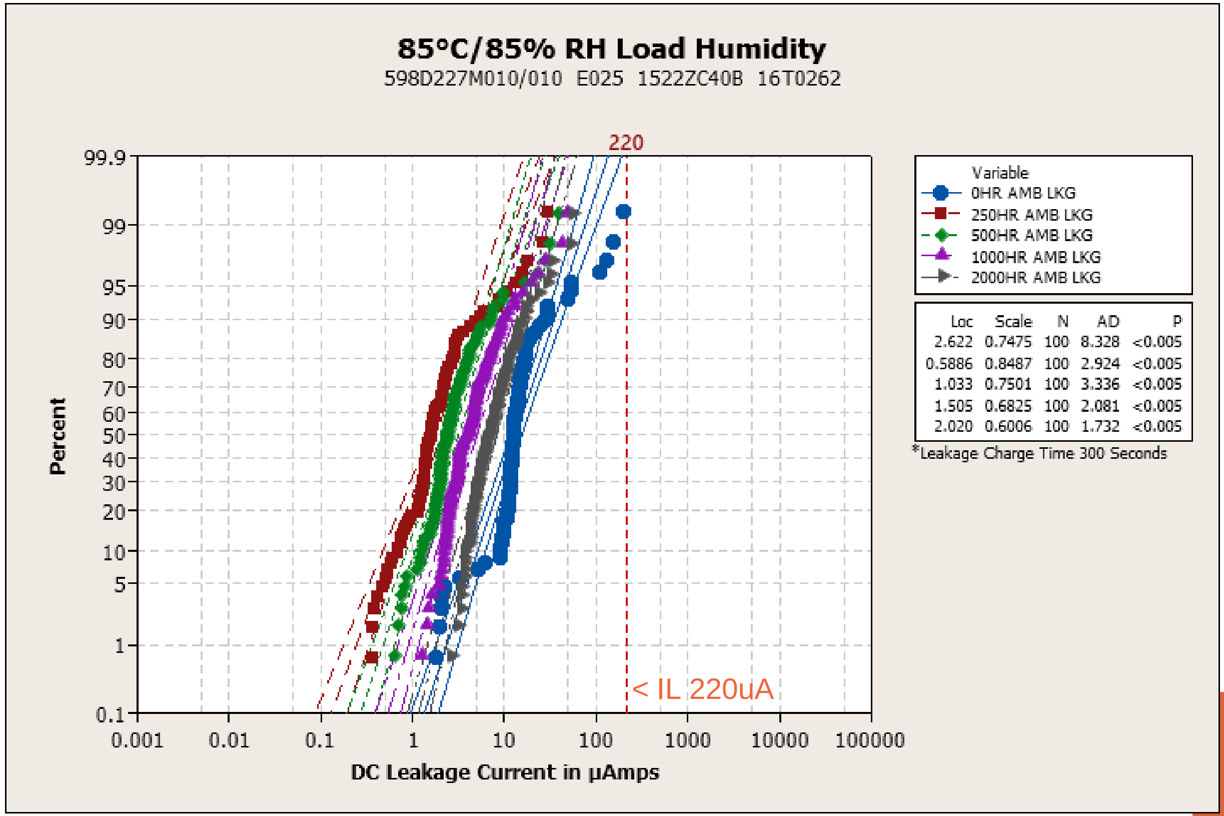


Mean	StDev	N	AD	P
2.409	0.1952	100	2.046	<0.005
3.289	0.3445	100	0.534	0.168
3.163	0.2716	100	0.497	0.208
3.720	0.3756	100	0.212	0.851
4.201	0.4601	100	0.921	0.019

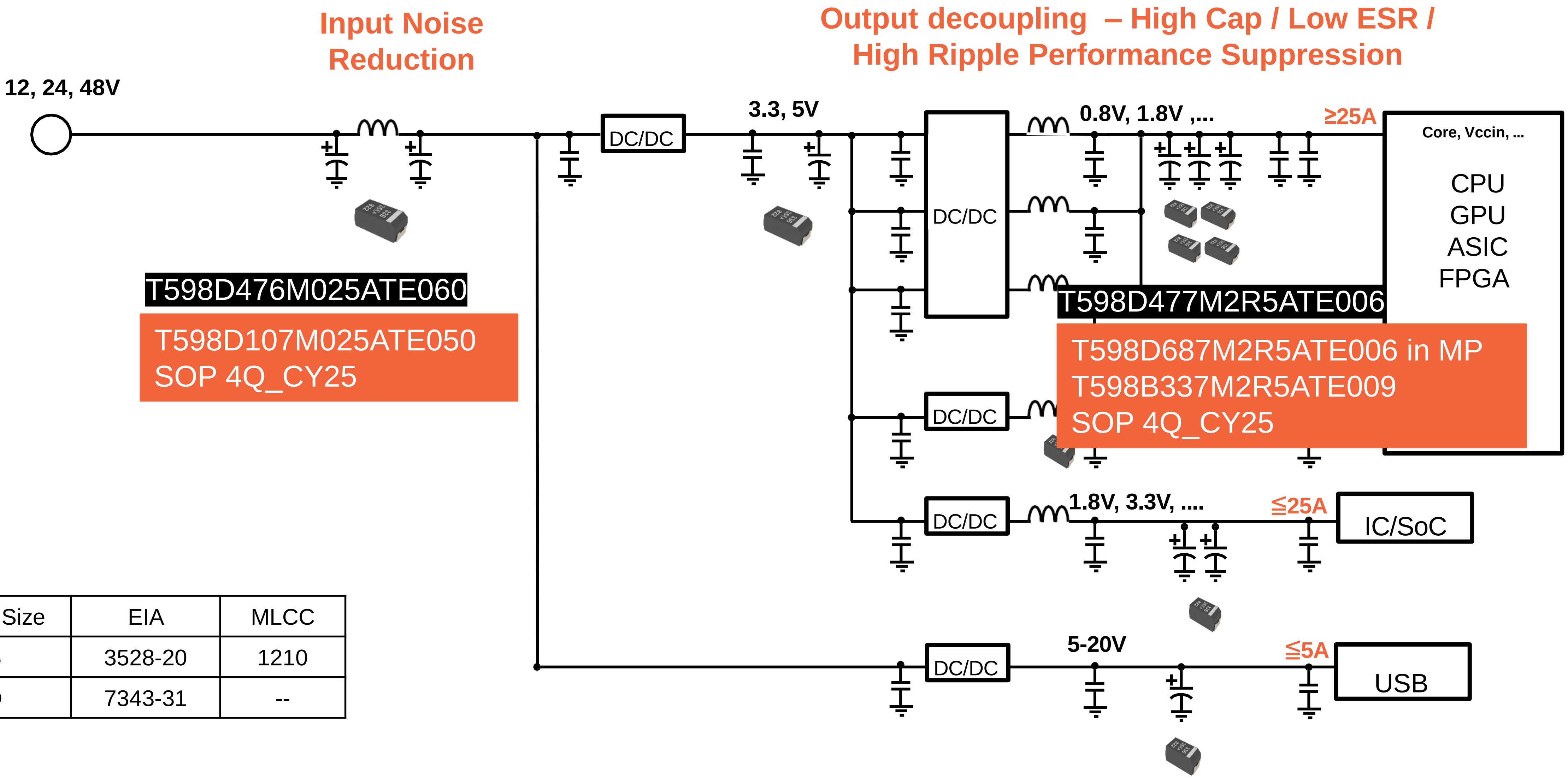
Automotive Polymer Capacitors

Extended 85ºC / 85%RH / Vr Humidity Bias, 1000 h → 2000h





Future Direction



Case Size	EIA	MLCC
B	3528-20	1210
D	7343-31	--

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Thank you!謝謝你!

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