IEEE PSMA Capacitor Committee Industry Sessions 2020

Aluminum Electrolytic Capacitors for Industrial Applications

TDK Electronics AG
Aluminum & Film Capacitors Business Group • CAP ALU PD
Munich, Germany
July, 2020
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Product Design
Aluminum Electrolytic Capacitors

Background:
• 10 years experience in development and design-in of aluminum electrolytic capacitors
• Responsible for product design of aluminum electrolytic capacitors for industrial applications

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Agenda

• Introduction TDK Aluminum Electrolytic capacitors
• Portfolio and target applications
• Outlook and new developments
• Simulation support
Introduction TDK Aluminum Electrolytic capacitors

Geographic Footprint: TDK CAP ALU

TDK benefit
Three capacitor factories on three continents and key materials from inhouse production

Aluminum Electrolytic Capacitors
• TDK Foil Italy/ Iceland (production of aluminum foil for Electrolytic Capacitors)
Agenda

• Introduction TDK Aluminum Electrolytic capacitors
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Product Spectrum and Application - Industrial

**Screw terminals**
- Applications:
  - Drives
  - Wind energy generator
  - UPS
  - Traction
  - SMPS

**4-pin Snap-in/Solder pins**
- Applications:
  - Drives
  - Solar Inverter
  - UPS
  - SMPS

**Snap-in**
- Applications:
  - Drives
  - Solar Inverter
  - SMPS
  - UPS
  - Automotive

**Capacitors for pulse applications**
- Applications:
  - Flashlight
  - Medical applications
  - Welding applications
Datacenters & 5G
Extraordinary requirements for electrolytic capacitors

AC/DC SMPS
-Switches & Routers
➔ DC-link: Compact SI

HVAC Systems
-Drive in Precision air-con
➔ DC-link: ST & SI
-Drive in Heat exchanger
➔ DC-link: High Temp SI

AC/DC SMPS
-Servers
➔ DC-link: Compact SI

UPS Systems
-AC UPS
-DC UPS
➔ DC-link:
ST & SI in AC UPS
SI in DC UPS

Trend to

High operating temperatures >105°C

Compactness
capacitance / volume
Automotive

“Industrial” components move to automotive

- Motor management
- Transmission control
- Fan control
- On-board charger
- DC/DC converter (48 V boardnet)
- Wiper control
- Power steering
- Boost Start Generator (BSG)
- Start-stop

Trend to

- Large and complex mission profiles
- Alternative cooling methods
Servo Drives
Rapid Charge/Discharge – Typical requirements for robotics

Typical applications
- Pick and place
- Industrial robots
- Automatic production lines
- ...

Demand
Motor Start ➔ Discharge
Motor Stop ➔ Charge
➔ Frequent Charge / Discharge Cycles

<table>
<thead>
<tr>
<th>Snap-in</th>
<th>Screw terminal</th>
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<tbody>
<tr>
<td>$\Delta U = 150V$</td>
<td>$\Delta U = 150V$</td>
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<tr>
<td>$f = 6Hz$</td>
<td>$f = 3Hz$</td>
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<tr>
<td>50 mio cycles</td>
<td>20 mio cycles</td>
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</table>

➔ No standard specification is existing
➔ Behavior is strongly depending on the actual waveform
➔ Available for industrial Snap-In 105°C B43541, B43544, B43545 and B43547
Tomorrow… and the day after

Hybrid DC-links between FILM and ALU to exploit the benefits of different technologies in one system
### Customized Design

#### Design focus
- Ultra compact
- High ripple current
- Long useful life
- etc.

⇒ Specific capacitor series available

#### Voltage
- ....
- 400V
- 450V
- 500V
- ...

⇒ Customization in 10V steps

#### Capacitance (µF)
- 100, 120, 150, 180, 220, 270, 330, 390, 470, 560, 680, 820, 1000, 1200, 1500, 1800, ...

⇒ Can be adjusted individually

#### Dimensions/Features
- Dimension customization on request
- Bottom cooling / thermal pads
- Copper inserts for highest ripple currents
- Insulation materials PVC, PET, PO (sleeves), PP, ABS (cups)

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**Design in tip:**
The data book only contains select material combinations. Our team will gladly assist you in a tailored design to fit your needs!

**Design in tip:**
Example: Compared to a standard 450V 10.000µF capacitor, a 430V 8.850µF solution can be -20% more cost effective.

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**Design to Cost solution**
e.g. 430V / 8850µF
Agenda

- Introduction TDK Aluminum Electrolytic capacitors
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Product News: Industrial products

Snap-in
- **B43647**
  - 450 V
  - +105 °C /2000 h
  - compact
  - High ripple current

- **B43548**
  - 400 /450 V
  - +105 °C /3000 h

- **B43251**
  - 400 /450 V
  - +125 °C /2000 h

Screw terminal
- **B43707/727**
  - 400/450 V
  - +85 °C /12000 h
  - compact
  - High ripple current

- **B43743/763**
  - 350 … 450 V
  - +105 °C /6000 h

- **B43705/725**
  - 350 … 450 V
  - +85 °C /12000 h

Legend
- Existing
- New in DB2019
- released

125°C
## Compact Snap-In

**Progress**

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**Design in tip:**

In order to utilize the full potential of the state-of-the-art Alu technology for new projects, it’s beneficial to refer to the latest TDK products. Our team will gladly assist you in the selection of the right product to fit your needs!

- **B43640**: 200 ... 450 V, 105 °C/2000 h
- **B43641**: 400 ... 450 V, 105 °C/2000 h
- **B43647**: 450 V, 105 °C/2000 h
- **B43xxx**: 450 V, 105 °C/2000 h
## High ripple current Snap-In Progress

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**TDK • Aluminum Electrolytic Capacitors for industrial applications**
### High ripple current Snap-In

#### Next step

<table>
<thead>
<tr>
<th>$I_{AC} @ 50$Hz</th>
<th>2019</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>145%</td>
<td></td>
<td><strong>Reduced overall length tolerance ($\pm 0.2$ mm) for effective heat sink mounting of capacitor banks</strong></td>
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<td>130%</td>
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<td>115%</td>
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#### Features:
- Low ESR
- Low thermal resistance between base and winding
- Reinforced aluminum can with long-term rigidity
**High ripple current Screw-terminal**

Significantly increased useful life at typical operating conditions

<table>
<thead>
<tr>
<th>Ripple current level</th>
<th>2015</th>
<th>2017</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>130%</td>
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</table>

<table>
<thead>
<tr>
<th>Useful life (@ 50°C, V_R, 2m/s, 80% I_{max,ref})</th>
<th>2015</th>
<th>2017</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>B43706 400 … 500 V 85 °C/12000 h</td>
<td>220%</td>
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<td></td>
</tr>
<tr>
<td>B43706 400 … 500 V 85 °C/12000 h</td>
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<td>180%</td>
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<td>B43705 200 … 450 V 85 °C/12000 h</td>
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<tr>
<td>B43705 200 … 450 V 85 °C/12000 h</td>
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</table>

**Design in tip:**
We recommend to consider the operating conditions in the design in process as soon as possible in order to utilize the full technical potential of the Alu technology.
High ripple current Screw-terminal

Next step

Increase the max. terminal current limit over 100A

- Mechanical strength $\rightarrow$ Higher tightening torque (4Nm $\rightarrow$ 8-12Nm)
- Material and geometry $\rightarrow$ Long lasting low contact resistance
- Surface roughness $\rightarrow$ Highest possible contact surface
- Co-planarity $\rightarrow$ Highest possible contact surface
- Surface corrosion (e.g. Ni plating) $\rightarrow$ Long lasting low contact resistance

Design option for all screw terminal series
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Simulation support
TDK toolbox

- Material based simulation of electrical characteristics
- Power loss calculation at actual operating points

- FEM models for thermal simulations
- Material based simulation of thermal networks

- Useful life calculation tools for complex operating conditions
- Online availability for easy use

- Combination of test results and simulation → Optimized design-in support
- All individual building blocks can be provided to customers for use in internal simulation environment
AlCap: Useful Life Calculation Tool

➔ AlCap = Web-Based Application for Useful Life Calculation of all high-voltage ST and SI Series (Data Book Series)

1. User must specify capacitor type and load profile
2. Calculation results of operating useful life and relevant thermal parameters are displayed
3. Results can be printed/ saved as pdf-files

Design in tip:
The AlCap tool is a public web-based tool, that allows to consider the operating conditions in the design in process of all industrial databook products.

Link: https://www.tdk-electronics.tdk.com/en/180482/design-support/design-tools/alcap-useful-life-calculation-tool