Aluminum Electrolytic vs. Aluminum Polymer Capacitor

APEC 2018 in San Antonio
Industry Session

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Short Introduction of Today‘s Presenter

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Background:

• More than 10 years of work experience in electronics industry
• Background in Electronics, Power Supply Development and formerly worked as Field Application Engineer
• In charge for technical product services and application support of capacitor division at WE

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 Agenda

• Overview about Technologies

• Influence of Input Capacitor

• Influence of Output Capacitor
OVERVIEW ABOUT TECHNOLOGIES
Overview of Electrolytic Capacitors

- Differentiation of electrolytic capacitors:

<table>
<thead>
<tr>
<th>Anode electrode material</th>
<th>Dielectric</th>
<th>Relative permittivity ($\varepsilon_r$) at +20 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al – aluminum</td>
<td>$\text{Al}_2\text{O}_3$– aluminum oxide</td>
<td>9.3</td>
</tr>
<tr>
<td>Ta – tantalum</td>
<td>$\text{Ta}_2\text{O}_5$– tantalum pentoxide</td>
<td>26</td>
</tr>
<tr>
<td>Nb – niobium</td>
<td>$\text{Nb}_2\text{O}_5$– niobium pentoxide</td>
<td>42</td>
</tr>
</tbody>
</table>
Construction of Aluminum Electrolytic Capacitor

- Aluminum Foil (roughened) – Anode
- Aluminum Foil - Cathode
- Separator Paper
- Stitching
- Lead Wire
- Wet element (with electrolyte)
- Aluminum case
- Sealing
Construction of Aluminum Polymer Capacitor

Pretreated anode foil

Separator

Rubber

Cathode foil

Stitched pins

Case
INFLUENCE OF THE INPUT CAPACITOR FOR A BUCK CONVERTER
Influence of the Input Capacitor for a Buck Converter

- Input voltage $U_{in} = 12\text{V}$
- Output voltage $U_{out} = 5\text{V}$
- Load current $1\text{A}$ (ohmic load)
- Frequency $f_{\text{switch}} = 1\text{MHz}$
- Monolithic synchronous converter
- Molded power Inductor
- Input filter
Measurement of Conducted Emission

- Measurement equipment
  - R&S ESRP 3 EMI Test Receiver
  - LISN => ENV216 Two-Line V-Network
  - Measurement in a shielded room
Conducted Emission – Measurement 1

- No input filter
- Input capacitor: WCAP-ASLL 865060343004 => 47µF / 16V => ESR = 411mR / ESL = 19nH

(REDEXPERT: http://we-online.com/re/46RZIMfx)
Conducted Emission – Root Cause

- Symmetrical voltage at the input is:
  \[ u_{\text{sup}}(t) \approx i_{\text{in}}(t) \cdot R_{\text{sup}} + u_{\text{in}}(t) = i_{\text{in}}(t) \cdot R_{\text{sup}} + i_{C,\text{in}}(t) \cdot R_{\text{eq},C} + u_{C,\text{in}}(t) \]

- ESR and ESL should be as small as possible

Possible resonance by \( L_{\text{sup}}, L_{\text{eq},C} \) and \( C_{\text{in}} \)
Conducted Emission – Measurement 2

- No input filter,
- WCAP-PSLP 875105344006 => 47µF / 16V => ESR = 20,7mR / ESL = 3,9nH

(REDEXPERT: http://we-online.com/re/48TxCoJe)
EMC Action – Input Filter

• Definition of input filter

• π-filter with secondary stage inductor
  • MLCC -> WCAP-CSGP
  • Ferrite -> WE-CBF
  • Inductor -> WE-LQS
Conducted Emission – Measurement 4

- Input filter plus input capacitor => WCAP-ASLL 865060343004
Conducted Emission – Measurement 5

- Input filter plus input capacitor => WCAP-PSLP 875105344006
INFLUENCE OF THE OUTPUT CAPACITOR FOR A BUCK CONVERTER
Influence of the Output Capacitor for a Buck Converter

- Input voltage $U_{in} = 12V$
- Output voltage $U_{out} = 5V$
- Load current 1A (ohmic load)
- Frequency $f_{switch} = 1MHz$
- Monolithic synchronous converter
- Molded power Inductor
- Input filter
Influence of the Output Capacitor for a Buck Converter

- Output capacitor => WCAP-ASLL 865060343004 => 47µF / 16V; ESR = 411mR / ESL = 19nH
Output Voltage Ripple – Root Cause

- The symmetrical voltage at the output is:

\[ u_{\text{out}}(t) \approx i_{C,\text{out}}(t) \cdot R_{\text{eq,C}} + u_{C,\text{out}}(t) \]

- ESR as small as possible

Possible differential resonances due to parasitic of the component
Influence of the Output Capacitor for a Buck Converter

- Output capacitor => WCAP-PSLP 875105344006 => 47μF / 16V; ESR = 20,7mR / ESL = 3,9nH

![Graph showing voltage variations](image-url)
Influence of the Output Capacitor for a Buck Converter

- Output capacitor => WCAP-PSLP and WCAP-CSGP
## Conclusion

<table>
<thead>
<tr>
<th>Application</th>
<th>Aluminum Electrolytic</th>
<th>Aluminum Solid Polymer</th>
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</thead>
<tbody>
<tr>
<td>Filter</td>
<td>😊</td>
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<td>DC-DC Converter</td>
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<td>Battery powered appl.</td>
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<td>Low / green energy</td>
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<tr>
<td>Low temperature</td>
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<tr>
<td>High temperature</td>
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<td>Audio</td>
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<tr>
<td>Higher vibration</td>
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Thanks for your attention!