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Active Lifetime Testing of DC-Link Capacitors – Test Setup and Parameter Study

Fabian Dresel*, Jürgen Leib*, Bernd Eckardt*

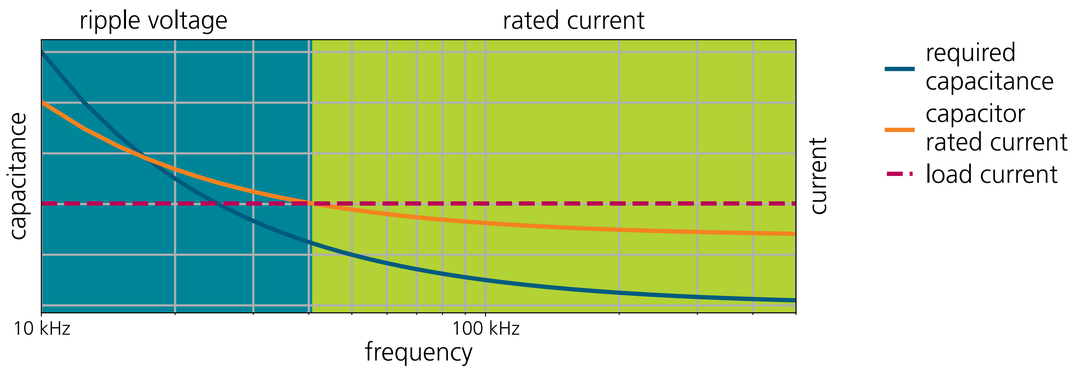
fabian.dresel@iisb.fraunhofer.de

*Fraunhofer Institute for Integrated Systems and Device Technology IISB, Department Power Electronics, Test and Reliability, Erlangen, Germany

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Capacitor Ripple Current Requirements

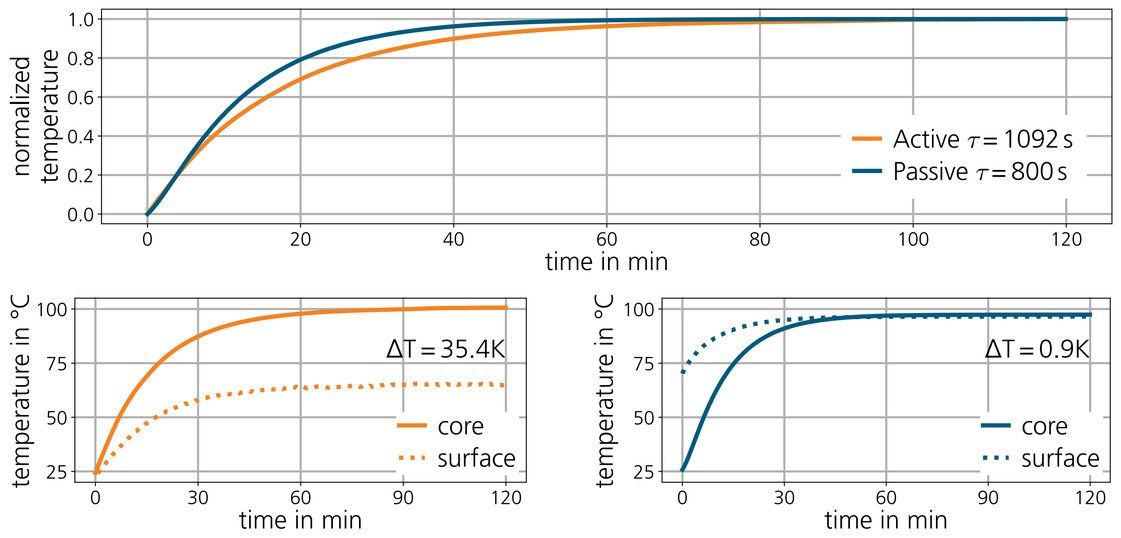
- Required capacitor size is determined by permissible voltage ripple (system level) and capacitor rated current (component level)
- Load current is fixed / determined by application (Power)
- For lower switching frequencies ripple voltage is dominant
- For higher switching frequencies (SiC and GAN) ripple current will be the limiting factor for DC-link capacitors
- Higher switching frequency -> required capacitance decreases / permissible current decreases



Dominating factor for selecting a DC-Link capacitor

Comparison between Active and Passive Heating

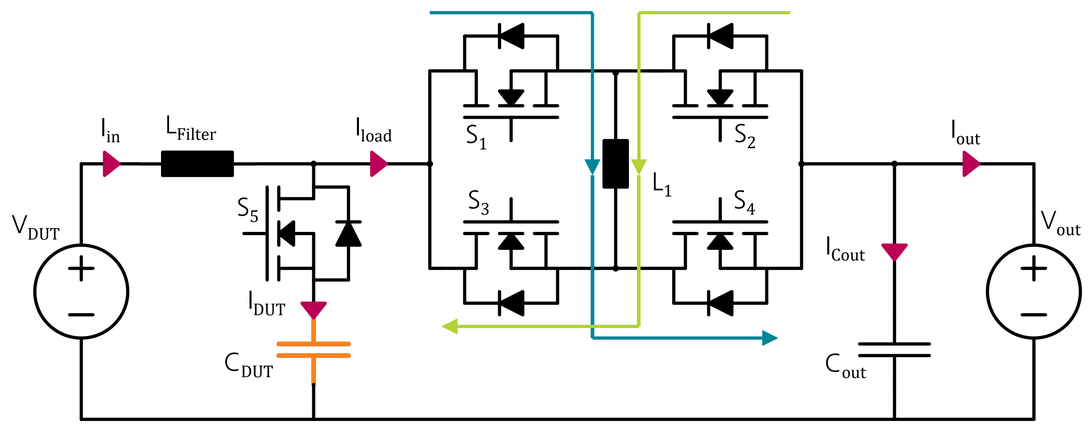
- Passive heating in an oven
- Active heating by proposed setup
- Heating rate in passive heating is faster
- Difference in temperature distribution between core and surface



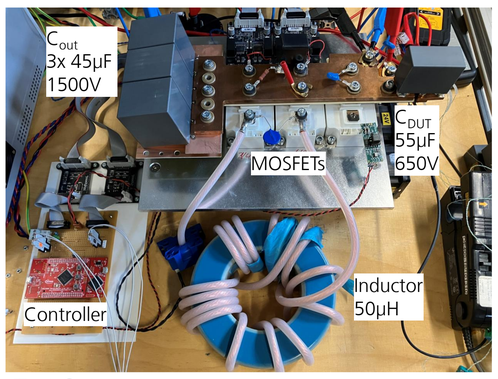
Heating curves during active and passive heating at the core and the surface of the capacitor

Setup for Active Lifetime Testing

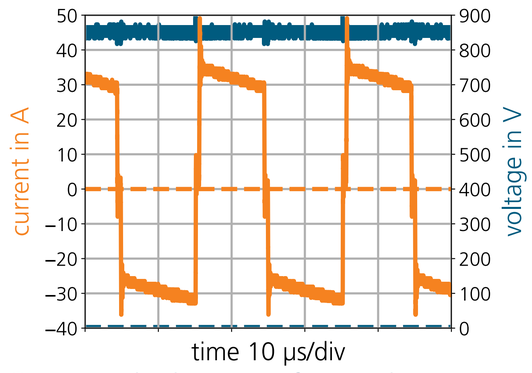
- Application like operating conditions
  - DC-Bias voltage (corrosion) up to 1200V
  - High frequency ripple current up to 500A
  - Variable frequency ripple current with harmonic components (rectangular)
- Operating principle: Shifting charge between C_{DUT} and C_{out}
- Low power consumption (see Table)



Schematic of the proposed test setup



Test Setup



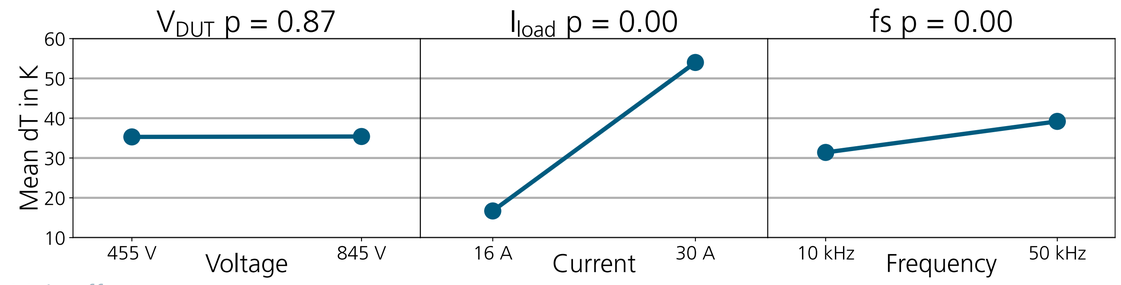
Current and voltage waveform at the capacitor

V_{DUT}	I_{DUT}	P_{DUT}	I_{in}	P_{in}
455 V	30.4 A	13.7 kW	2.8 A	1270 W
650 V	23.6 A	15.0 kW	1.34 A	870 W
845 V	30.3 A	25.4 kW	2.8 A	2380 W

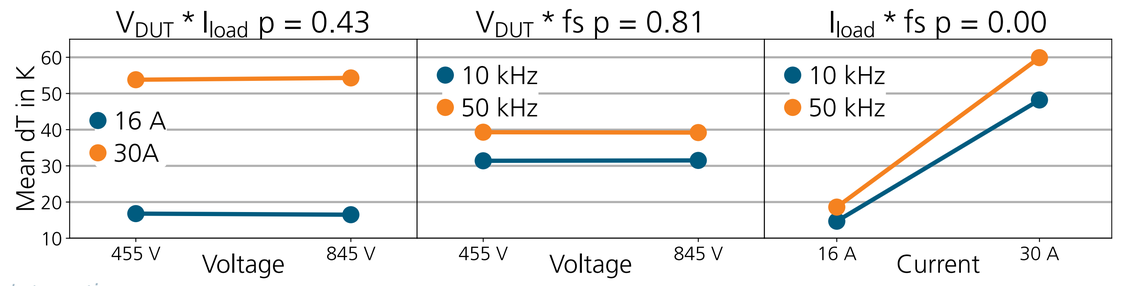
Parameter Study – Self Heating

- Identify influence factors on capacitor self heating
- Temperature measurement inside of the capacitor (optic sensor)
- Sample: 650V, 55µF, 23A (rated)

Parameter	Range
Voltage V_{DUT}	455 V, 650 V, 845 V
Current I_{load}	16 A, 23 A, 30 A
Frequency fs	10 kHz, 30 kHz, 50 kHz



Main effects



Interactions

Key Findings

- A setup for active power cycling for capacitors was developed
- For higher switching frequencies current rating will be the limiting factor for DC-Link capacitors
- Active heating will lead to different temperature distribution in the capacitor compared to passive heating
- Self heating of a capacitor is mainly governed by current load