IRS SYSTEMENTWICKLUNG GMBH

DC-Link Capacitor Validation

AC current stress in lifetime test of DC-Link capacitors including precise component characterization.

21.08.2020

IRS Systementwicklung GmbH
Pfaffenthanner Weg 5 • 93179 Brennberg
www.irs.systems | info@irs.systems

Description

Capacitors are a very common component in every electronic device. For application in electrical vehicles more and more capacitors are used for buffering DC-links in power electronics like inverters, DC/DC-converters, chargers etc. These devices typically draw periodically high peak currents from the DC-link resulting in high stress of the buffer capacitors.

To validate capacitors at such specific stress situations, IRS has developed and built a lifetime tester for capacitors. The lifetime tester applies - besides temperature - both a realistic DC-voltage and an AC-current profile at the same time during long term tests. The main parameters are monitored continuously during this stress phase over hours and days. Measurement data is stored in intervals and deviations from expected behavior are logged immediately.

After specified intervals, the stress is stopped, and capacitor parameters are measured precisely with LCR-meter and a leakage current meter.

Key Facts

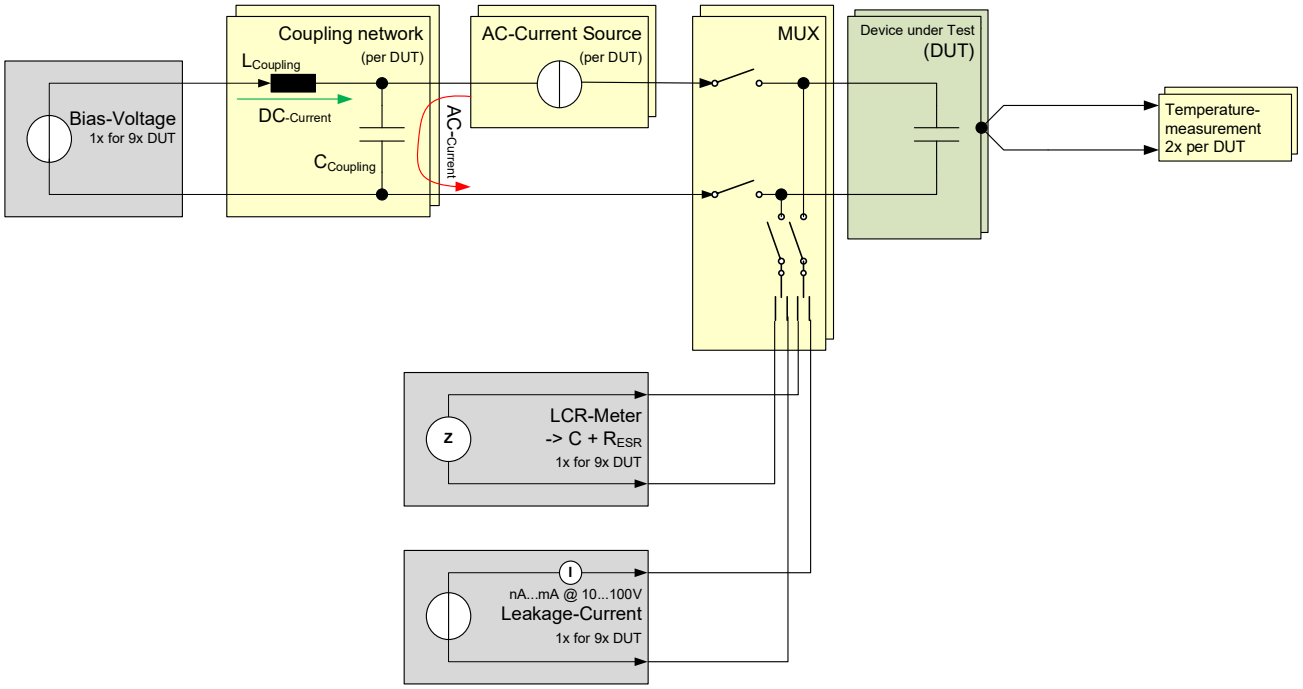
- Stress tests up to $10A_{RMS}$ continuous and $20A_{RMS}$ for short time.
- Flexible current profiles selectable.
- Sine, triangular and rectangular waveforms at different currents.
- Precision characterization with LCR meter and leakage current measurement every few hours.
- Including temperature chamber to simulate stress under environmental conditions.

Use Cases

IRS Systementwicklung GmbH
Pfaffenthanner Weg 5 • 93179 Brennberg
www.irs.systems | info@irs.systems

Technical Description

Following picture shows the basic setup of the test system:



In the green marked block, the capacitor as device under test (DUT) can be found. The system is capable to stress up to 9 DUTs in parallel. Components, which are yellow marked, are available for every DUT separately. Every DUT has its own AC-current-source providing individual and independent current profiles. The temperature of every capacitor may be monitored by two thermocouples.

The DC-voltage (bias voltage) is applied for all DUTs in parallel.

LCR meter and leakage current measurement are multiplexed for a sequential precision measurement.

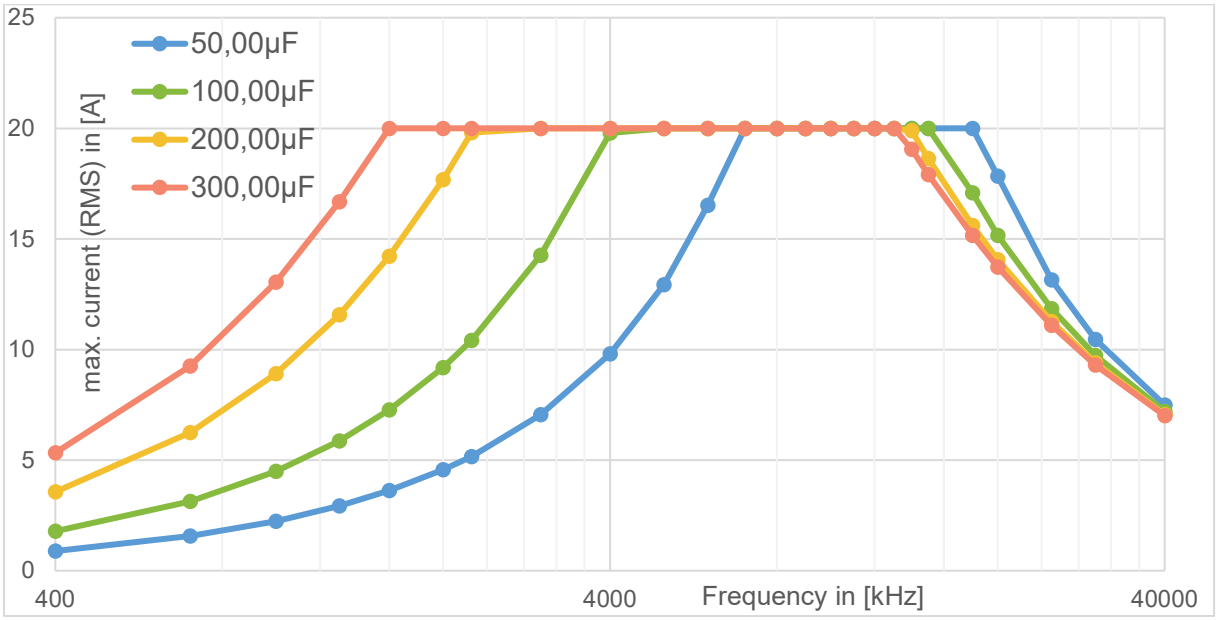
Stress

As stress parameters - besides temperature- both DC-voltages up to 100V and AC-currents up to 20A_{RMS} are applied. To make sure that the AC current only flows through the specific capacitor and doesn't affect the DC-voltage of other capacitors, a coupling network is integrated. The sources are disconnected from the capacitor to enable precise measurements while characterization.

The AC-current-sources have been designed by IRS for very compact systems, with 3 channels in one 6HU 19” rack. They may be used for other applications where a very flexible AC-current up to 40kHz is required.

Each channel includes the coupling network and can provide up to +-10V and 20A_{RMS} per DUT. For applications without coupling network even higher channel density may be accomplished. The system is modular and thus expandable to more DUTs.

Since the capacitors are placed inside a temperature chamber, the wiring between AC-source and DUT requires a length of some meters. Thus, these wires show some inductance, which especially comes into effect at higher frequencies -> higher voltage has to be generated from the AC-source. Measures had been taken to minimize the inductance by appropriate wiring. On the other hand, low capacitances have a higher impedance compared to high capacitances, resulting also in a higher AC-source voltage for the same current. Thus, a typical operating area is the result of these physical limitations as shown in the following figure.



IRS Systementwicklung GmbH
Pfaffenthanner Weg 5 • 93179 Brennberg
www.irs.systems | info@irs.systems

Precision measurements

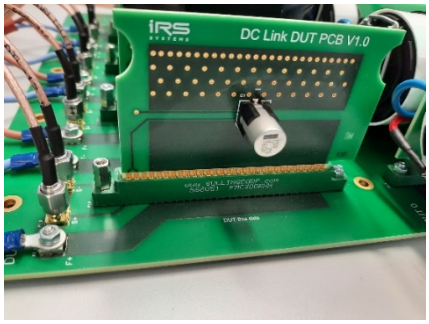
Every few hours during lifetime test a component characterization is performed with an LCR- and a leakage-current-meter.

The following parameters are determined:

- Capacitance
- ESR (Equivalent Series Resistance)
- Leakage current at specified voltage

Please note that not only for stress, but even more for LCR measurements, the wiring to the DUTs is crucial. Inductive, resistive, and capacitive components of the cables have to be compensated by software.

Thus, both design of wiring and layout had to be performed very carefully. Furthermore, a regular calibration is recommended with the enclosed calibration set.



Technical Data

	Min	Typ	Max	Unit
DC voltage range	0		100	V
AC Current Typ=continuous / max=for 20 seconds		10	20	A_{RMS}
AC Voltage	-10		10	V_{pk}
AC frequency	0,1		40	kHz

IRS Systementwicklung GmbH
Pfaffenthanner Weg 5 • 93179 Brennberg
www.irs.systems | info@irs.systems