

# ESR AND ESL OF DC-LINK CAPACITORS

The MFA impedance analyzer – a multipurpose instrument for R&D and quality control – can be used to measure the ESR and ESL of DC-link capacitors over a wide frequency range.



MFA impedance analyzer

## Your task

DC-link capacitors are widely used in the inverter stage where DC electricity is converted back to AC. In electric vehicles, for example, when the coupled insulated gate bipolar transistor (IGBT) switches off, a voltage spike proportional to the parasitic inductance is induced. Reducing the equivalent series inductance (ESL) of the capacitor is therefore important to prevent shock damage. Furthermore, it is desirable to have a low equivalent series resistance (ESR) to enhance device efficiency and suppress heat dissipation. Characterization of low ESL and low ESR with an impedance analyzer is thus crucial when verifying capacitor performance over the frequency range of interest. Such measurements set the benchmark for future component development.

## Rohde & Schwarz solution

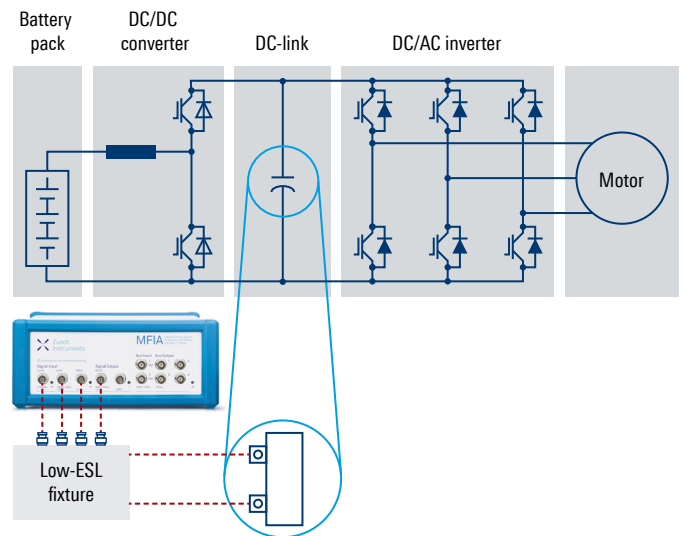
A multi-instrument setup for characterizing ESL and ESR comprises an LCR meter and a combination of oscilloscope and signal generator to derive the ESL and ESR from the equation of self-resonant impedance at a fixed frequency. Using an impedance analyzer with a suitable fixture simplifies the setup and enhances measurement capabilities by providing an understanding of ESR and ESL characteristics for the actual frequency of operation, not

just the frequency specified in the specifications sheet. Both manufacturers of DC-link capacitors and integrators can thus reduce their risks at an early stage.

The MFA impedance analyzer from Zurich Instruments, a Rohde & Schwarz company, is the perfect instrument for characterizing DC-link capacitors. It is capable of performing impedance measurements over a broad range, starting from less than 1 mΩ up to 1 TΩ and beyond – and, thanks to its innovative architecture, it can perform these measurements very rapidly. The LabOne instrument control software provides access to a comprehensive tool-set comprising a sweeper, plotter, scope and many more tools. The software makes it possible to record multiple parameters such as ESR, ESL, C, and D in parallel.

## Precise impedance measurements

Impedance measurement of a DC-link capacitor with the MFA impedance analyzer using a custom low-ESL fixture



## Benefits

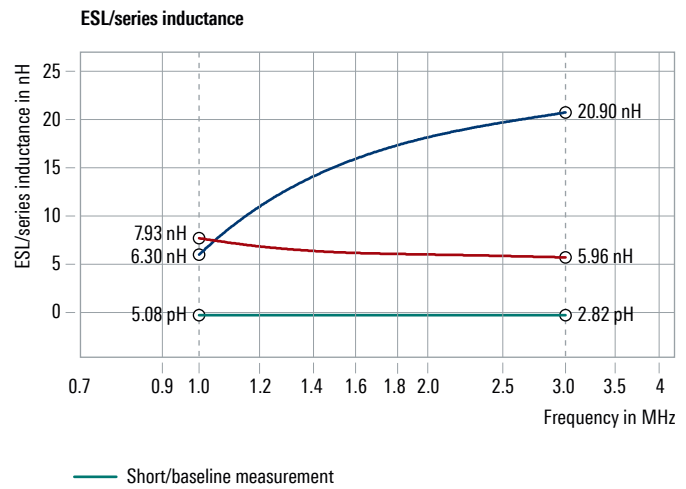
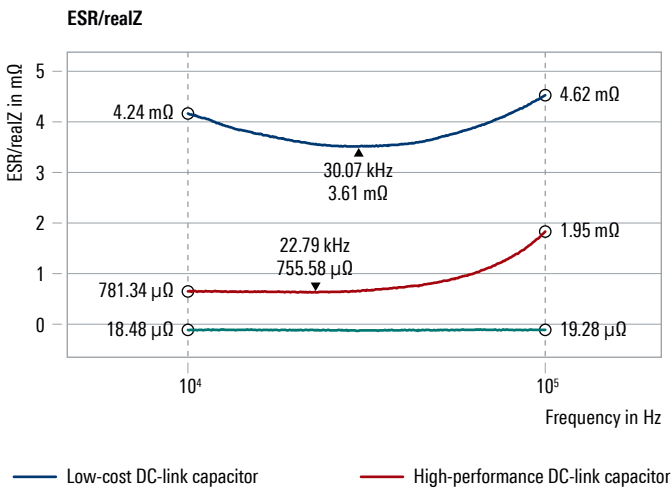
- ▶ **Integrated:** A single instrument allows measurement of ESR, ESL and multiple other parameters such as C or D
- ▶ **Accurate:** Low-Z user compensation achieves reliable and repeatable measurements in the sub-mΩ regime
- ▶ **Intuitive:** With the LabOne user interface, multiple traces can be visualized in the same plot thanks to the time-domain plotter and the frequency-domain sweeper tool
- ▶ **Comprehensive:** Impedance spectroscopy yields more information than a fixed-frequency solution
- ▶ **Comparative:** Export and re-import measurement traces can be used to study aging effects of your components or check measurement reproducibility, for instance

## Why choose the Rohde & Schwarz solution?

- ▶ Includes a compensation advisor enabling the measurement plane to be set at the device connector based on a short-load compensation procedure
- ▶ Reaches a measurement baseline as low as 10 pH and 10 μΩ over a frequency range from 100 Hz to 5 MHz
- ▶ In-situ displays multiple values and traces automatically determined from the built-in equivalent circuits thanks to the LabOne sweeper and plotter tool
- ▶ Allows full API remote control for integration into complex lab environments or production setups
- ▶ Improves traceability by using unique instrument and compensation setting files
- ▶ Achieves high reliability and repeatability thanks to a well defined low-ESL fixture

## ESL and ESR measurements with the the MFIA impedance analyzer

ESL and ESR measurements of low-cost (blue curves) and high-performance (red curves) DC-link capacitors compared with baselines (green curves)



## Summary

The MFIA impedance analyzer from Zurich Instruments can be used to measure the ESR and ESL of DC-link capacitors over a wide frequency range, not just at fixed frequencies. It enables both manufacturers and integrators to confirm specifications quickly and at an early stage to reduce design risks. For production line testing, the API control lets you reduce complexity by making it easy to integrate the MFIA into your test setup.

The MFIA is a flexible instrument with many different impedance measurement modes for characterizing key aspects of your components such as aging effects. For further information, get in touch to set up a demo.

## See also

[www.zhinst.com/applications/impedance-measurements/esr-and-esl-of-dc-link-capacitors](http://www.zhinst.com/applications/impedance-measurements/esr-and-esl-of-dc-link-capacitors)