Zurich Instruments

DC-Link Capacitor Characterization with the MFIA Impedance Analyzer

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Presentation Overview

- Introduction to Zurich Instruments
- Introduction to the MFIA
- Case study: Measurement of ESR and ESL of a DC-Link Capacitor
- What does the DC-Link capacitor do?
- Why is the ESR of interest?
- Why is the ESL of interest?
- Details of Device Under Test (DUT)
- Custom Fixture Details

Zurich Instruments

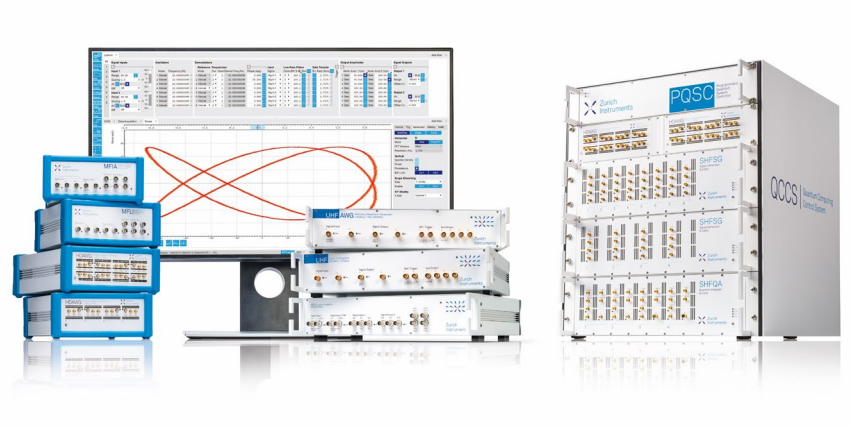
Mission

Provide best-in-class dynamic-signal instruments for advanced R&D labs.

Zurich Instruments

What do we do?

experience LabOne



Hardware

- Adequate speed
- High sensitivity
- Low noise
- High resolution

+

Software

- Efficient workflows
- Functionality & features
- UI & APIs
- Value added over time

→

Instruments

- Quantum control systems
- Lock-in amplifiers
- Boxcar averagers
- Impedance analyzers

Zurich Instruments

Company profile

- Headquarters in Zurich, Switzerland
- Founded in 2008, 100+ people, 25+ nations
- Owned by Rohde & Schwarz technology group since 1st July 2021
- Offices in China, USA, Germany, Japan, Korea, France
- Partners in Australia, India, Poland, Russia

→ Run by scientists for scientists

Zurich Instruments

Introduction to the MFIA

Impedance Analyzer & Precision LCR Meter from 1 mHz to 5 MHz

- Innovative architecture allows wider measurement range and faster measurement speeds
- Matches or surpasses accuracy and precision of traditional impedance analyzers
- LabOne® software provides UI & API suite
- Out of the box experience: start measurements immediately thanks to fast warm up and included MFITF Fixture

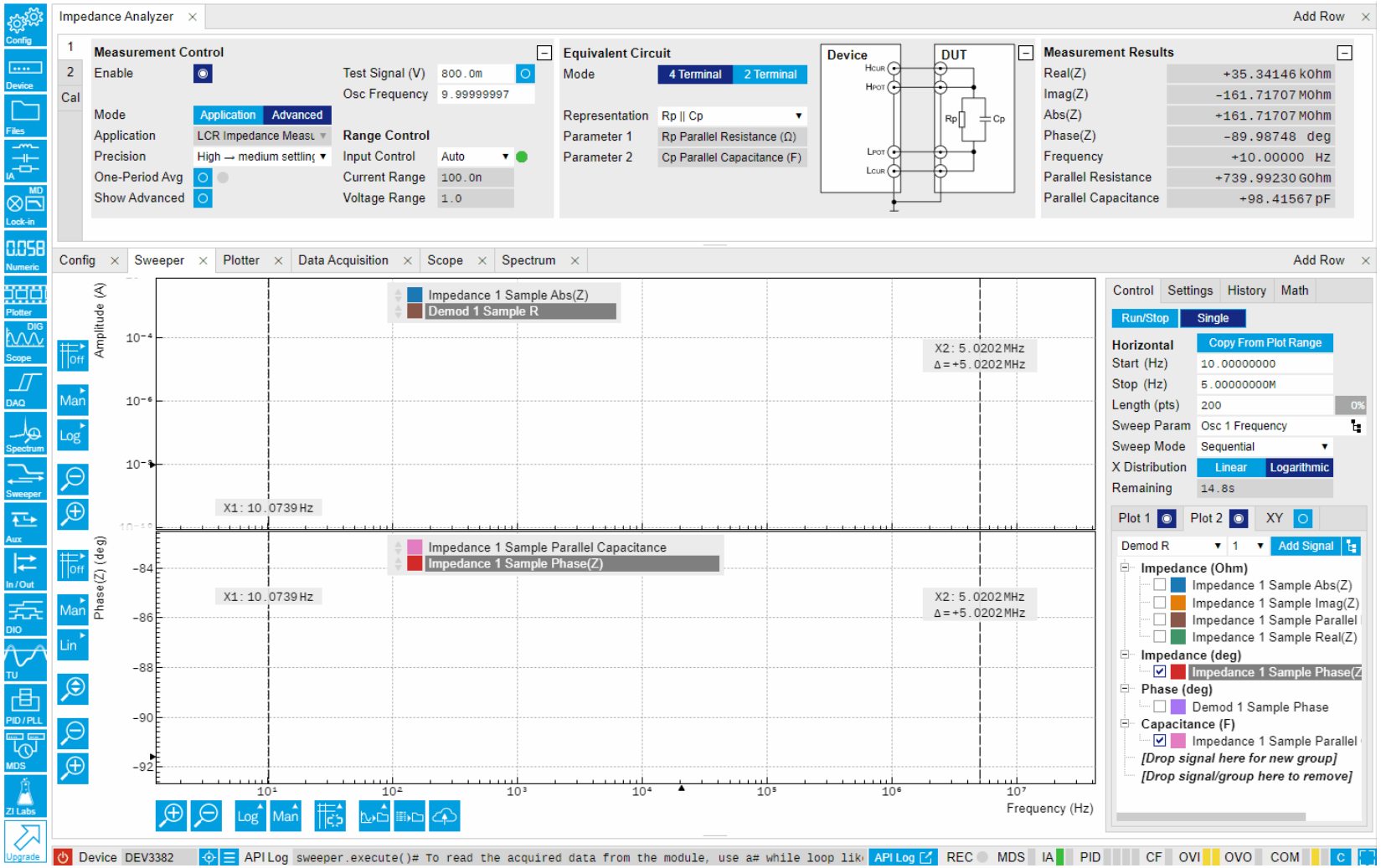
Key MFIA features

- Low Frequency (start sweeping from 1 mHz)
- High impedance (measure to 1 TΩ)
- Fast capacitance measurements in LCR Mode (10 us at 1 MHz)
- LabOne® toolset (Sweeper, Plotter, DAQ, Spectrum Analyzer, Scope…)
- APIs (C, MATLAB®, LabVIEW®, Python, .NET)

MFIA Software

LabOne runs the MFIA

- → Software toolset
- → Impedance Analyzer
- → Sweeper
- → Plotter
- → DAQ
- → Scope
- → Spectrum analyzer
- → Many more

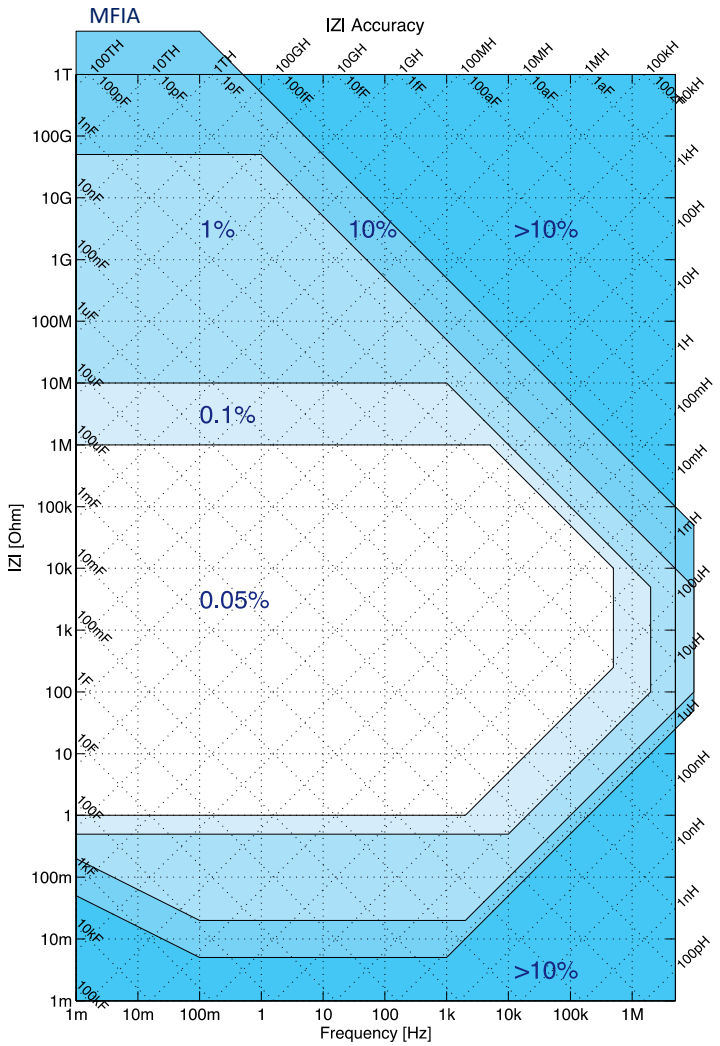


Clear Accuracy Chart

Ensures positive user expectations

Quickly illustrate the following key features:

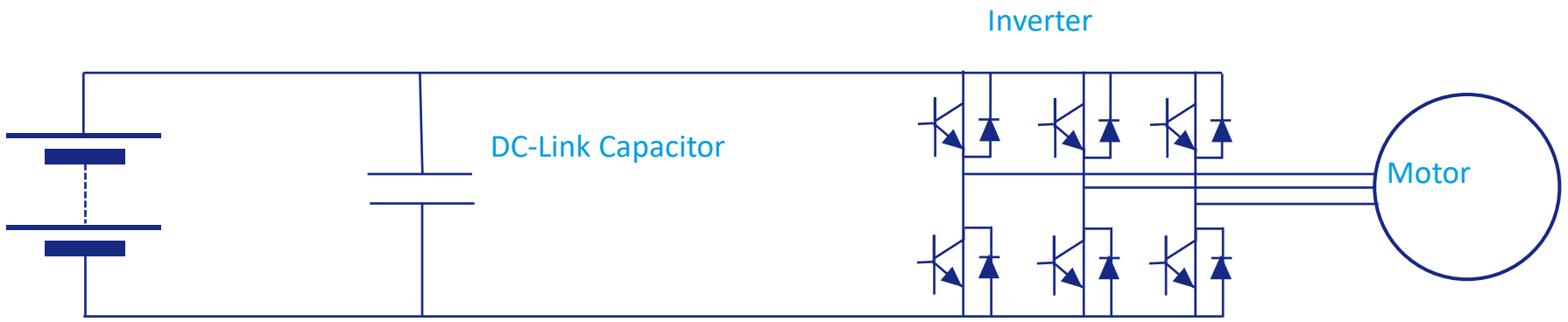
- Wide frequency range
- Wide impedance range
- Widest basic accuracy range
- Lowest frequency 1 mHz
- Highest Impedance 1 TΩ
- Compare to competitors
- Accuracy improves with user compensation



Case Study: ESR & ESL of a DC-Link Capacitor

What does the DC-Link capacitor do?

- Key element in power conversion systems
- Sits between DC source & switching circuit; minimizes voltage dips
- Multiple applications, including EVs



Case Study: ESR & ESL of a DC-Link Capacitor

Why are the ESR and ESL of interest?

- ESR causes power dissipation and thus heat, not ideal for EVs
- Low ESR is desired

- ESL can be considered parasitic inductance
- Energy stored in parasitic inductance causes overshoot during switching
- Low ESL is desired

Case Study 1: ESR & ESL of a DC-Link Capacitor

Details of Device Under Test

- DUT: TDK EPCOS B25655PXXX DC-Link XXX µF
- 120 µF version used in this demo
- Datasheet gives ESR 0.8 mΩ, ESL 15 nH

Ordering code	C_R µF	V_{RDC} V	I_{max} [1] A	L_{self} nH	R_S mΩ	Î kA	I_S kA	tanδ 120 Hz	Dimensions L x W x H mm	Weight kg	Fig.
B25655P9127K151[2]	120	900	120	15	0.8	3.5	11.0	$5 \cdot 10^{-4}$	154 x 72 x 50	0.8	5

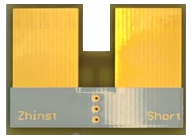
Case Study 1: ESR & ESL of a DC-Link Capacitor

Custom fixture details

1. User Compensation to set zero plane of measurement

The short; we use a low-inductance short where the sensing lines (Hpot) run perpendicular to the driving lines (Hcur)

Now let’s jump to LabOne to run the measurement...



Live measurement

MFIA

- 1. Measurement of ESR and ESL of a DC-Link Capacitor
- The fixture
- The short measurement
- First measurement of RealZ (ESR) and Ls (ESL)
- Second Measurement
- Repeat of First to show repeatability
- Analysis of sweep using the LabOne Math tools

Case Study: ESR & ESL of a DC-Link Capacitor

Key measurement features

- Low baseline of Real Z (ESR) around 50 µΩ
- Low baseline of Ls (ESL) at pH level
- Measurement of ESR & ESL confirms Datasheet
- Frequency dependent expands DUT Knowledge
- Reproducibility very high thanks to custom Fixture

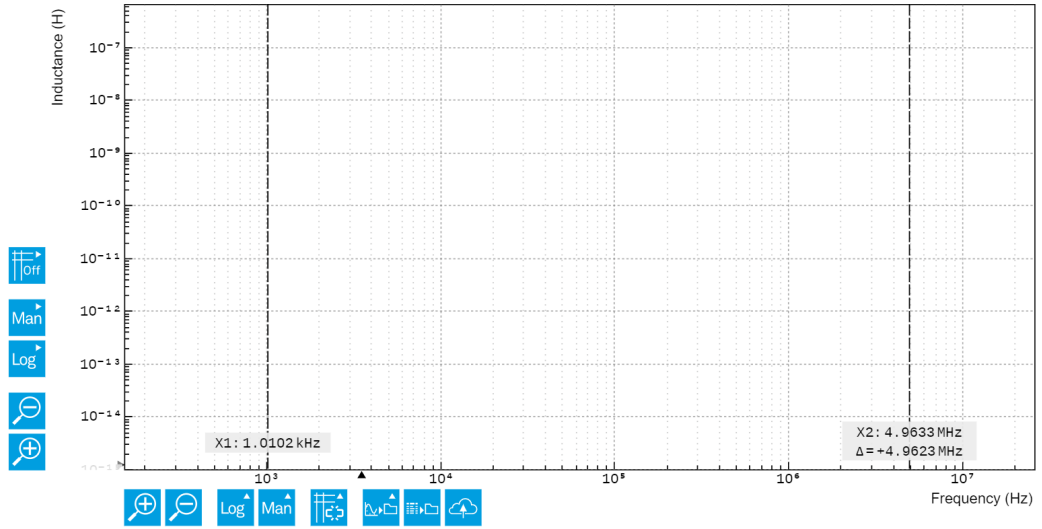
MFIA Applications

DC-Link Capacitor Measurements

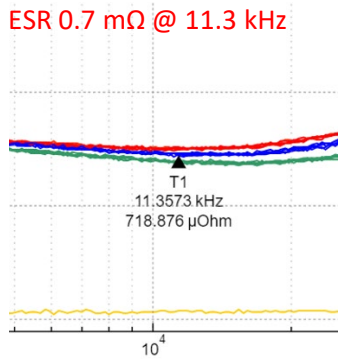
Characterization of low-ESR/ESL

- MFIA measurement over 1 kHz to 5 MHz
- Multiple parameters on the same chart
- Low measurement baseline 20 µΩ / 2 pH
- ESR 0.7 mΩ agrees with expectations
- ESL 9.5 nH agrees with expectations
- Repeatable even after reseat
- Advanced fixture required
- Work in 4-terminal
- S-L User compensation

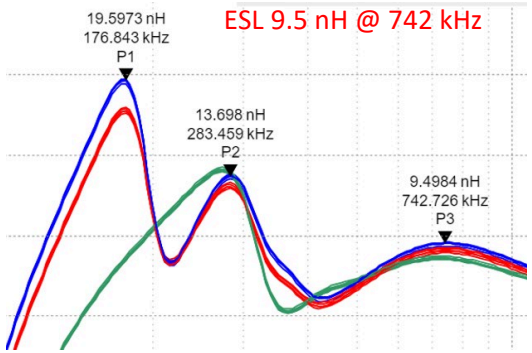
Multi-parameter Overview Sweep



ESR 0.7 mΩ @ 11.3 kHz



ESL 9.5 nH @ 742 kHz



Zurich Instruments

Thank you.

MFIA meets the challenges of impedance characterization today and tomorrow

Contact us today

www.zhinst.com