Het bepalen van de impedantie met de phase sensitieve multimeter analyzers en power analyzers in vermogenselektronica applicaties

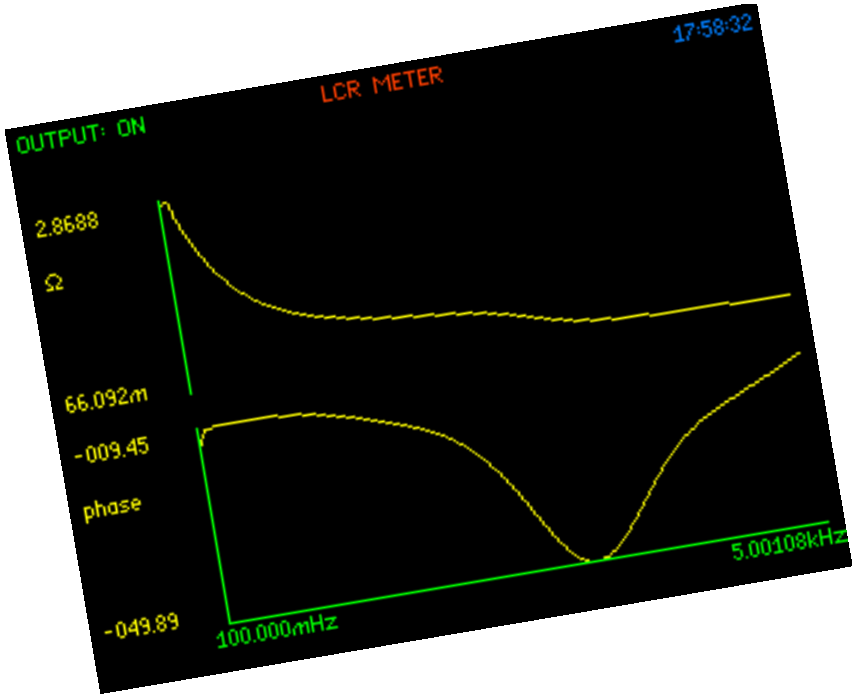
TT&MS

total test and measurement support

René Bos

Frequency response analyses

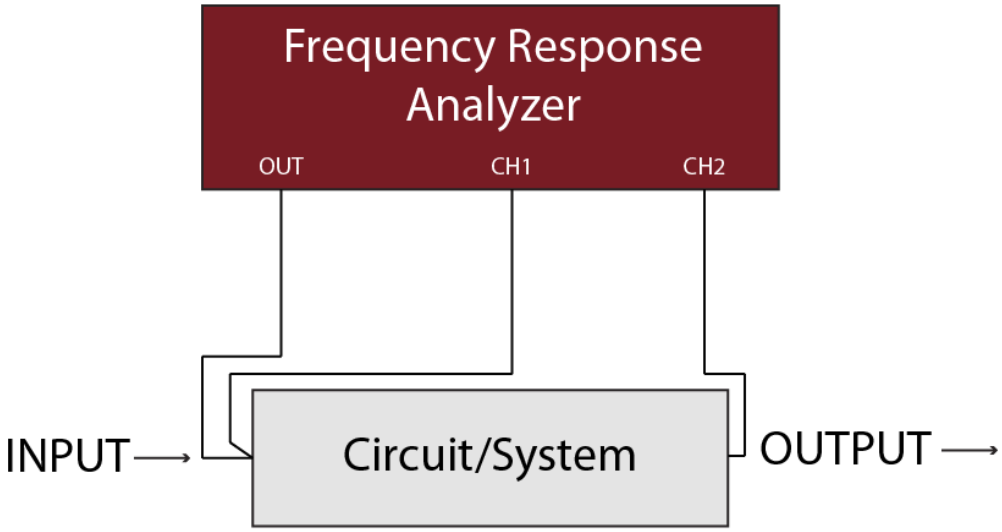
- Introductie FRA / Impedance Analyser
- Phase shift & Impedantie
- Electrochemical Impedance Analysis (EIS)
- Model & presentatie
- EIS praktijk voorbeeld
- HW/SW oplossingen
- Meer FRA toepassingen
- …..



FRA achtergond

Wat is een “Frequency Response Analyser”?

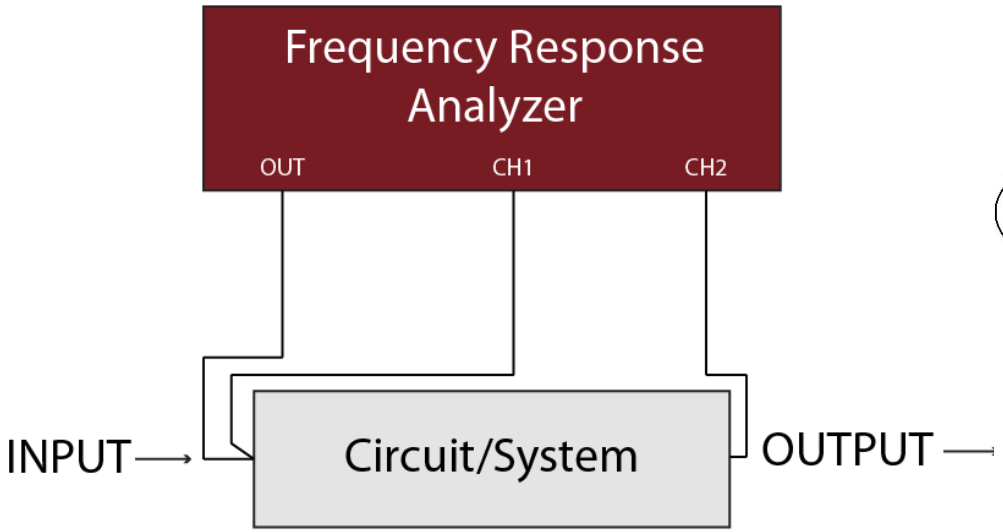
- bevat een signal generator (fixed of freq sweep)
- minimaal 2 Voltage measurement kanalen
- meest gementen parameters : “Gain” (dB) en Phase (degrees)
- Grafische weergave van overdracht / impedantie karakterisiteken.

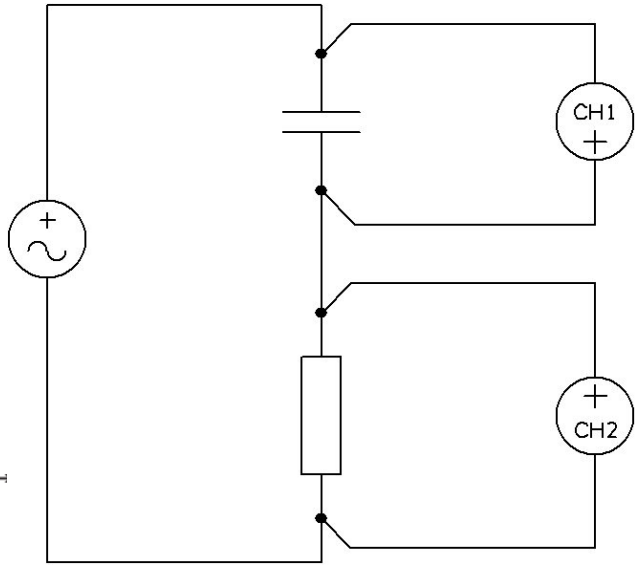


FRA achtergrond

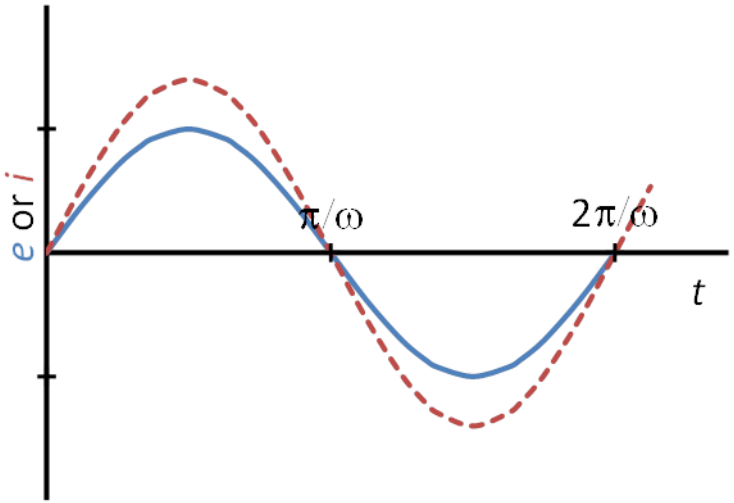
Wat is een “Frequency Impedance Analyser”?

- bevat een signal generator (fixed of freq sweep)
- minimaal 2 Voltage measurement kanalen
- door toevoeging R shunt in de loop (I naar U)
- capaciteit, inductie, impedantie, reactantie…..)

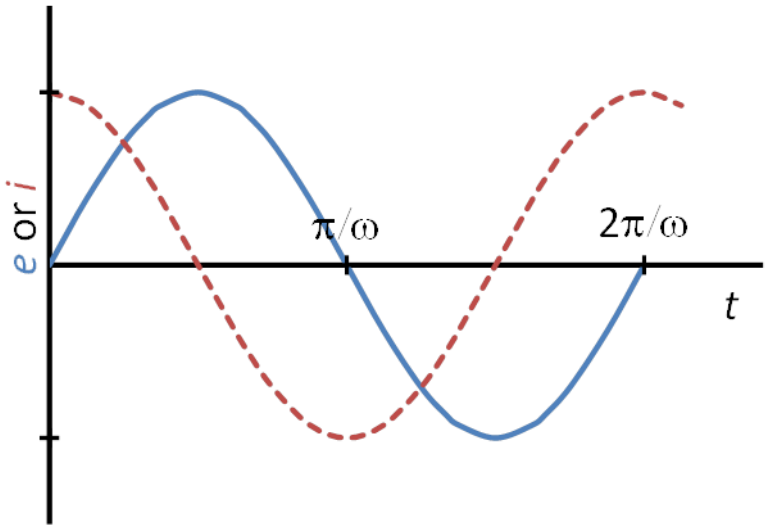




FRA Background – Simplified FRA block diagram



$\dot{E} = \dot{I} R$



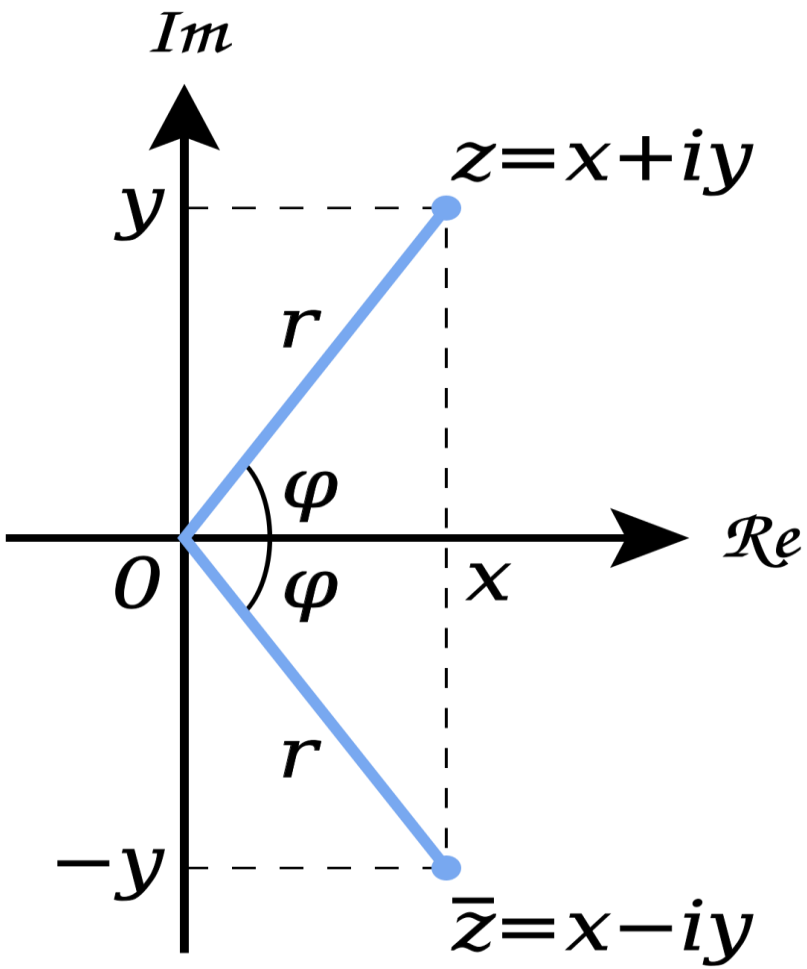
Capacitor $\boxed{\dot{E} = -jX_C\dot{I}}$

$j = \sqrt{-1}$

$X_C = 1/\omega C$

Xc is the impedance of the capacitor
ω is the angular frequency = 2 π f
C is the capacitance of the capacitor

FRA Background – Simplified FRA block diagram

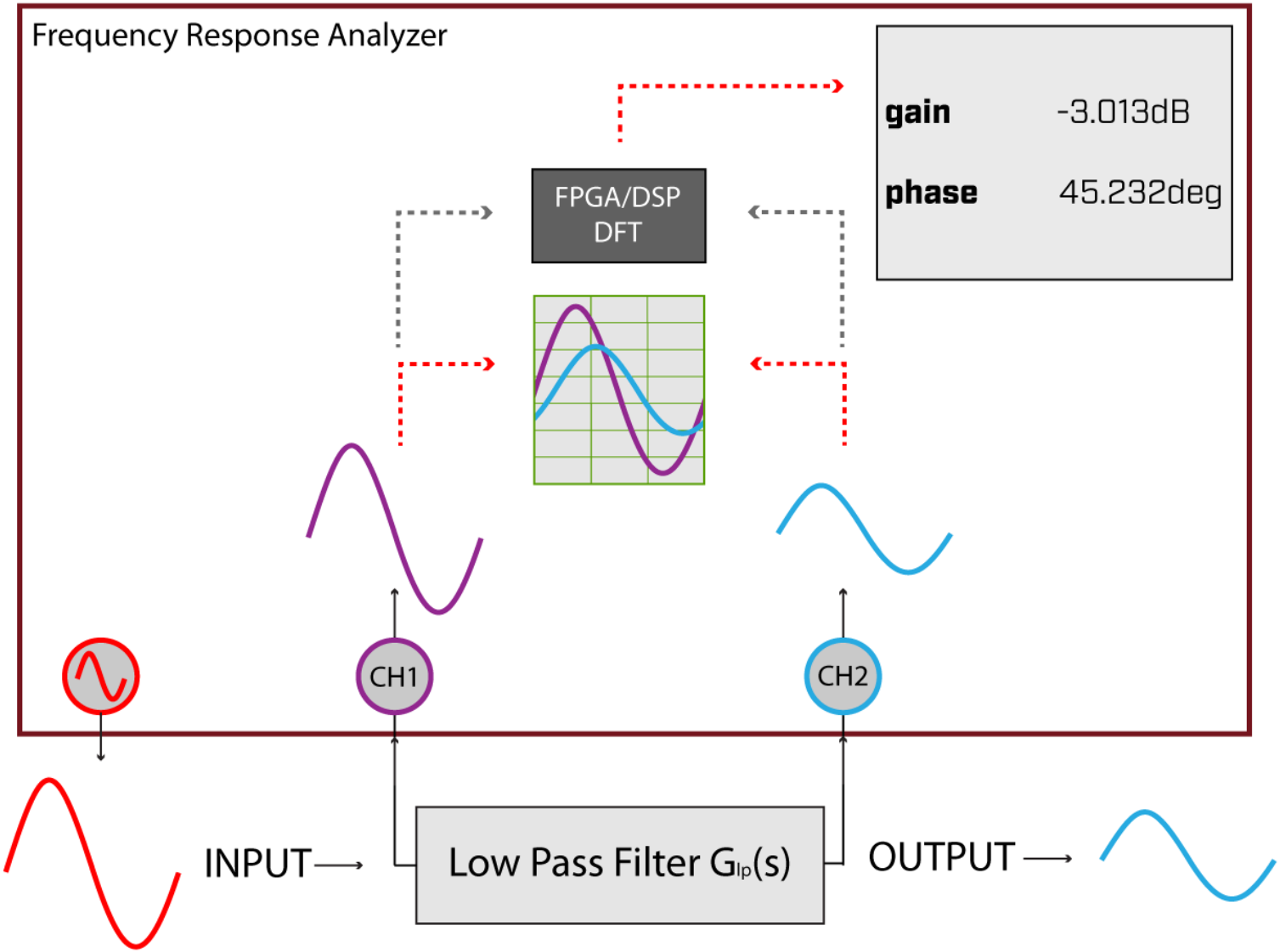


Complex impedantie vlak

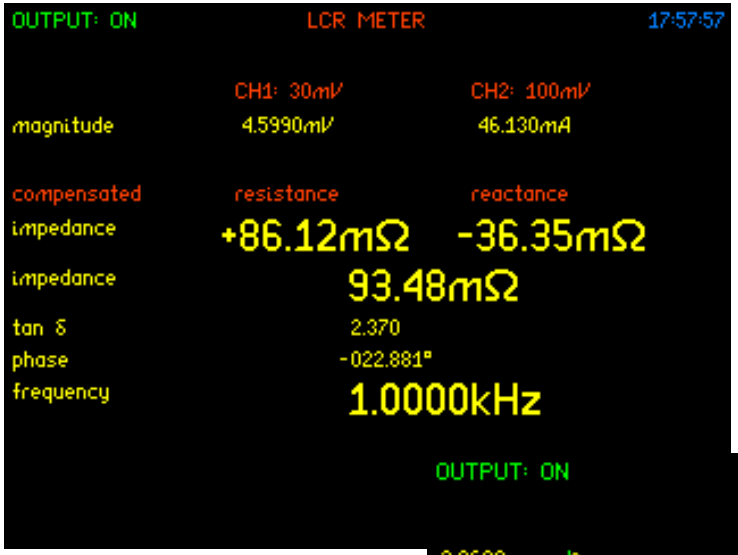
Re: Reële as

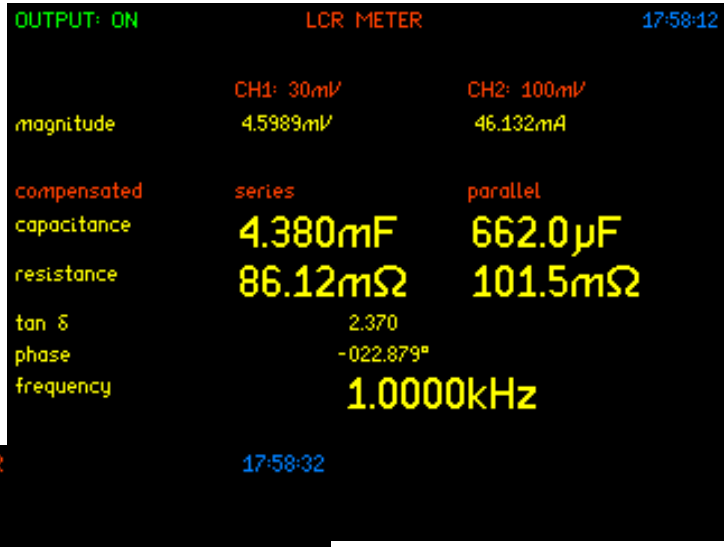
Im: Imaginaire as

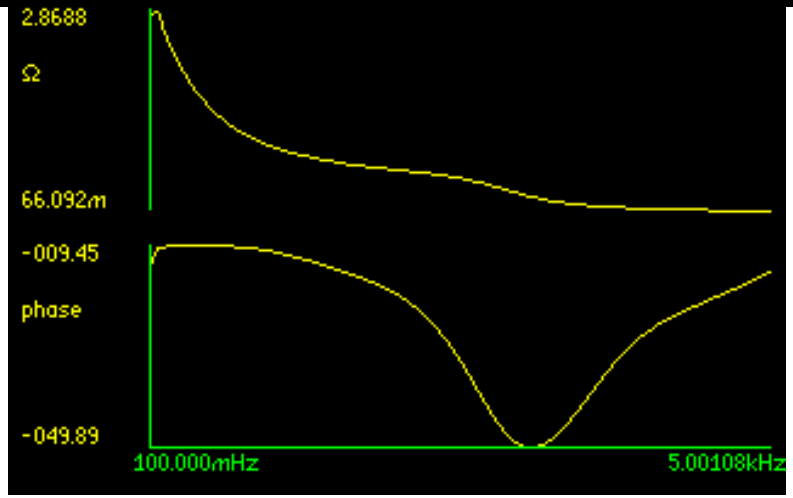
FRA Background – Simplified FRA block diagram



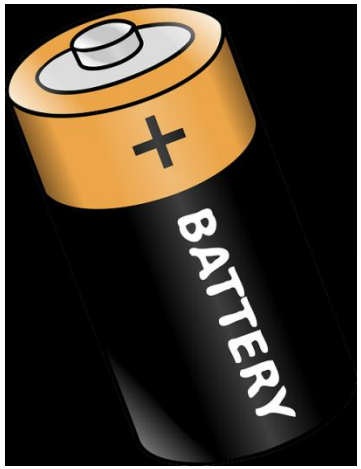
Electrochemical Impedance Spectroscopy

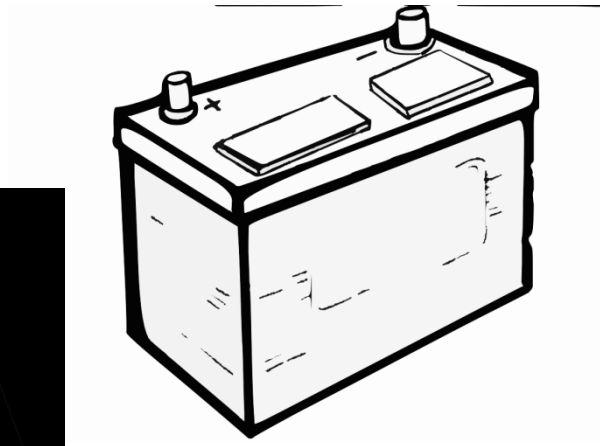


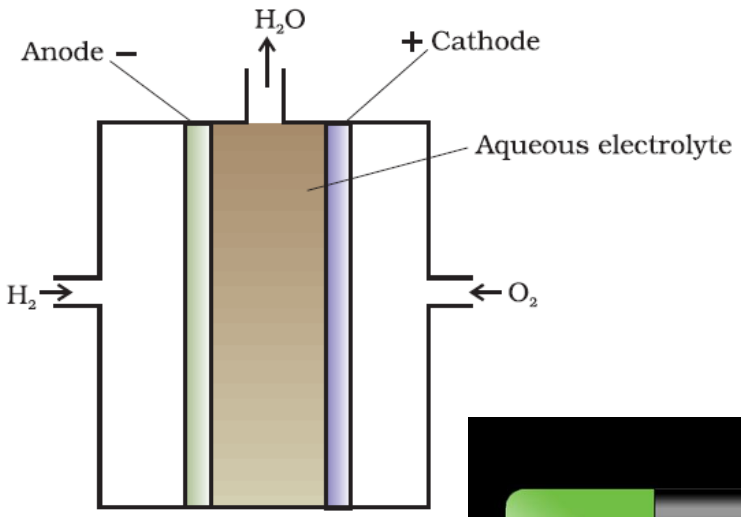


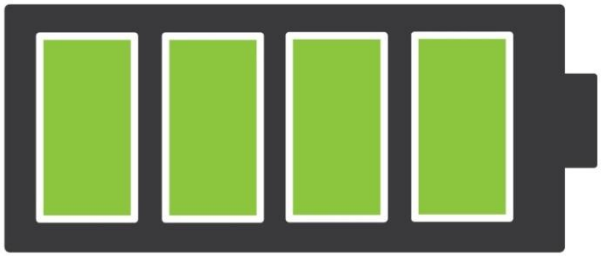


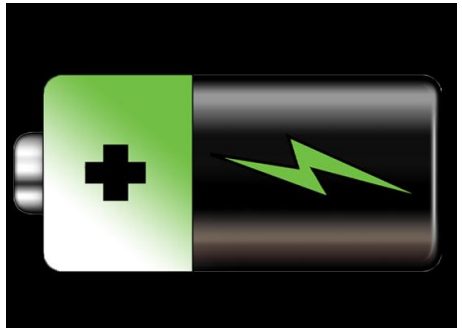
Electrochemical Impedance Spectroscopy

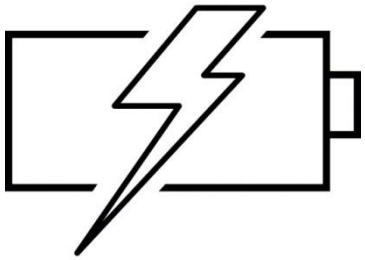


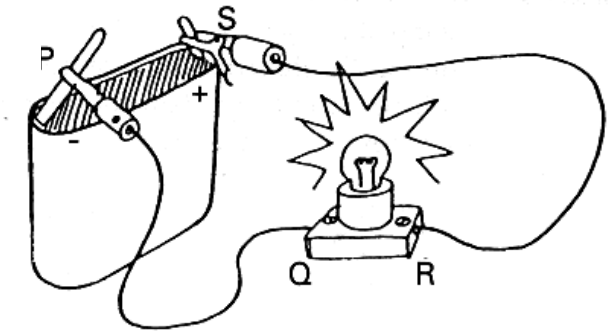












Waarom EIS?

- Karakterisatie van de batt/ accu / cell….

- Gedrag van de load ?
- Ideale manier van laden (PWM lader) ?
- Lading transfer (snel laden / ontladen)
- Voltage drop / energie verlies
- Veranderingen / veroudering
- …….

Hoe een EIS meting uit te voeren

- Door het aanleggen van een relatief klein sinusvormig potentiaal (spanning of stroom) bij een of meerder freq.
- Het meten van de response en het bepalen van de impedantie bij de verschillende freq..

  $Z_\omega = E_\omega / I_\omega$

  - E_ω = Frequency-dependent potential
  - I_ω = Frequency-dependent current
- Plot and analyze

Electrochemical Impedance Spectroscopy

N4L Newtons4th Ltd

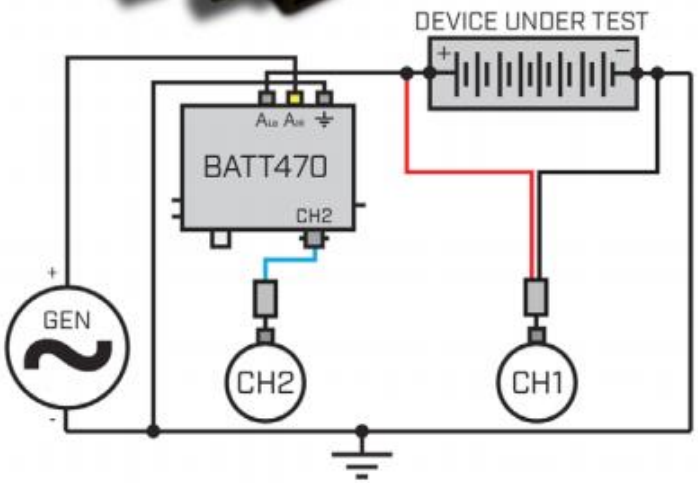
Newtons4th Ltd
office@newtons4th.com
www.newtons4th.com

Battery Cell Impedance Measurement (EIS)

PSM3750 FRA + BATT470m

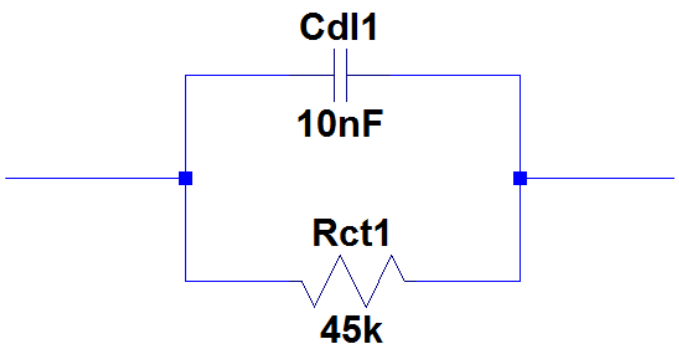
Electrochemical Impedance Analysis Package

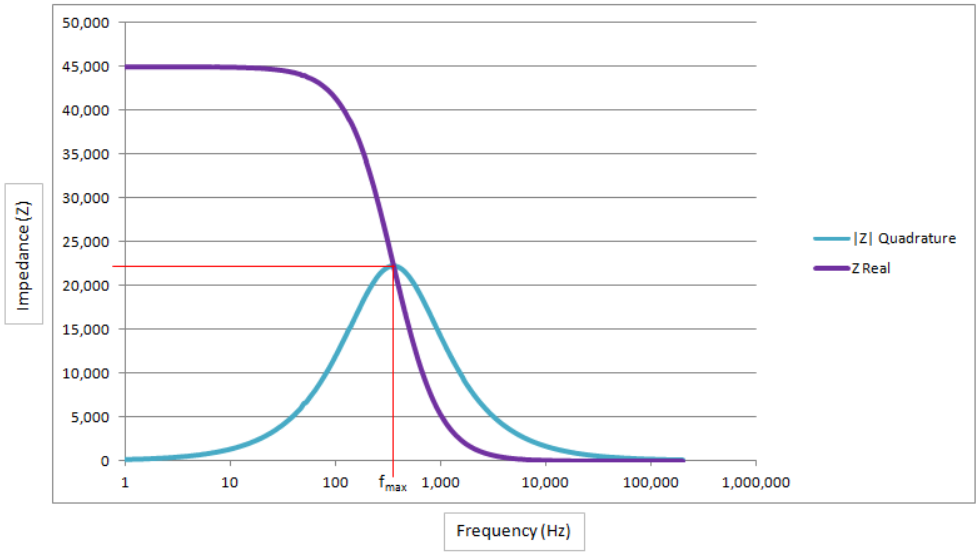
ESF10m

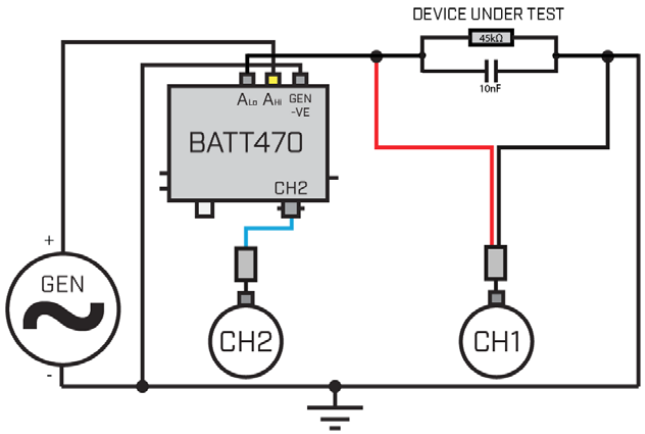


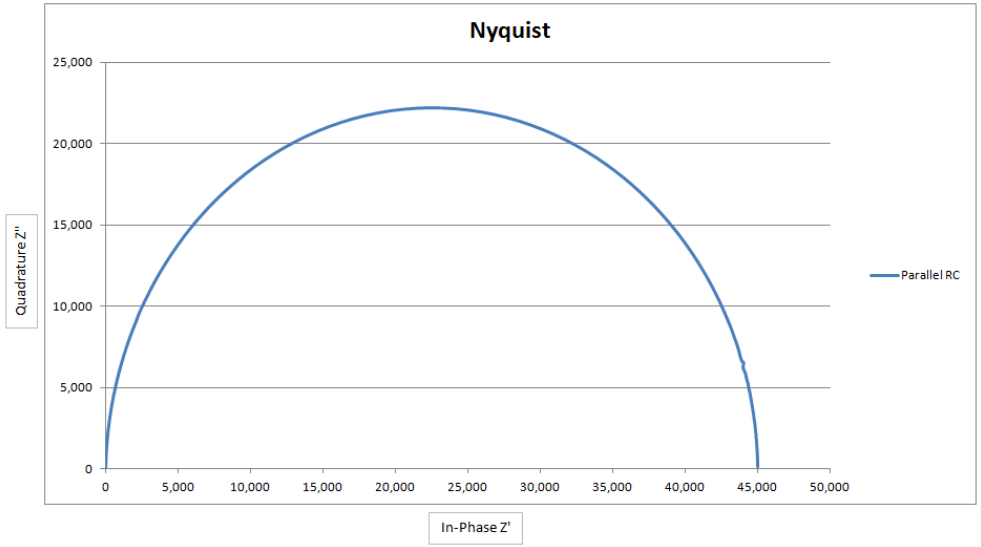
BATT470m

Electrochemical Impedance Spectroscopy

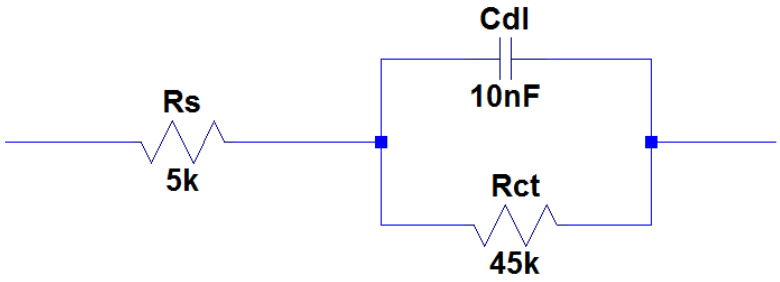




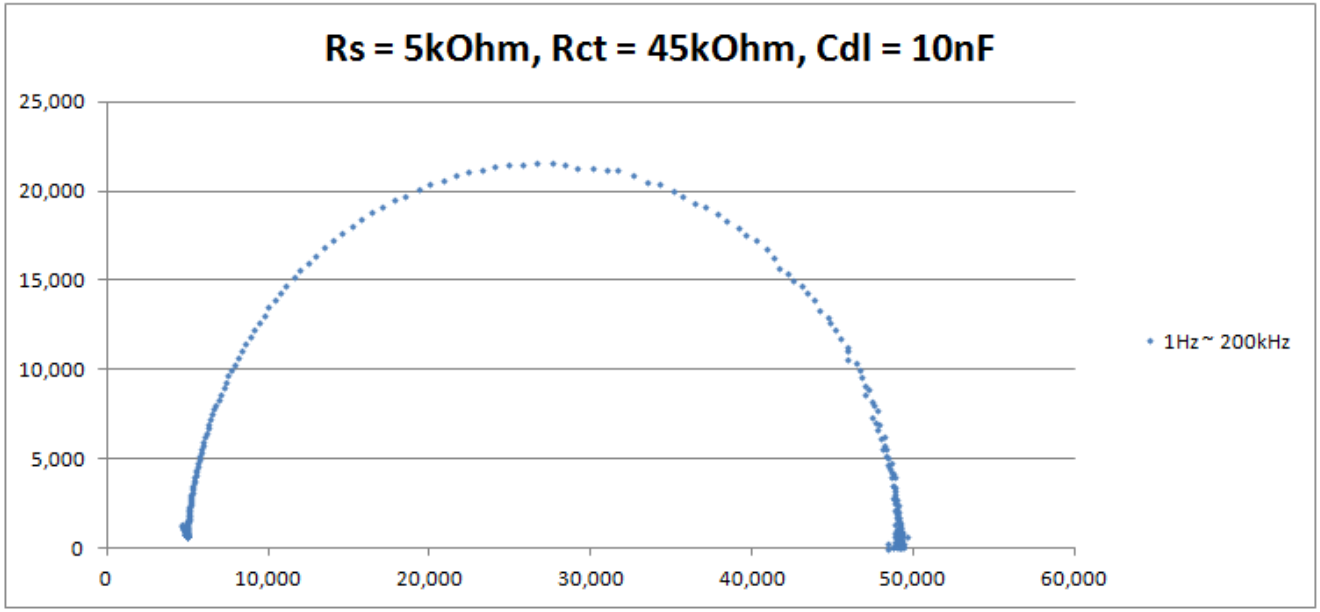




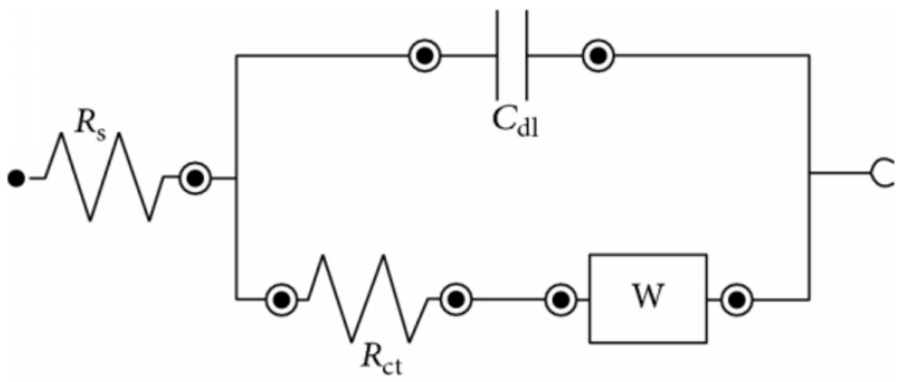
Electrochemical Impedance Spectroscopy



Simplified Randles Cell

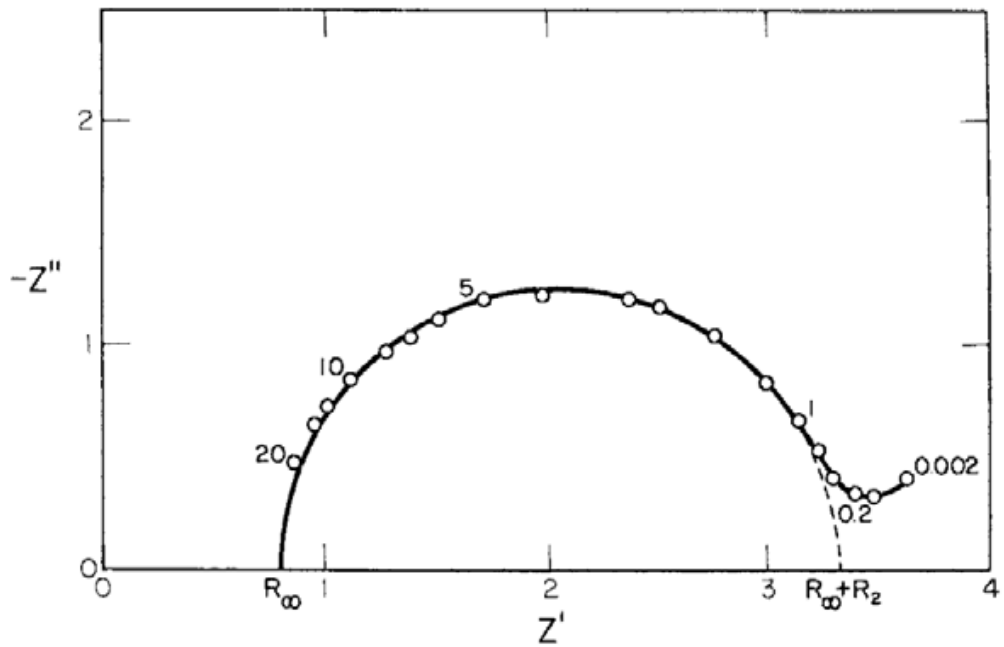


Electrochemical Impedance Spectroscopy



Warburg impedance

(constant phase element)



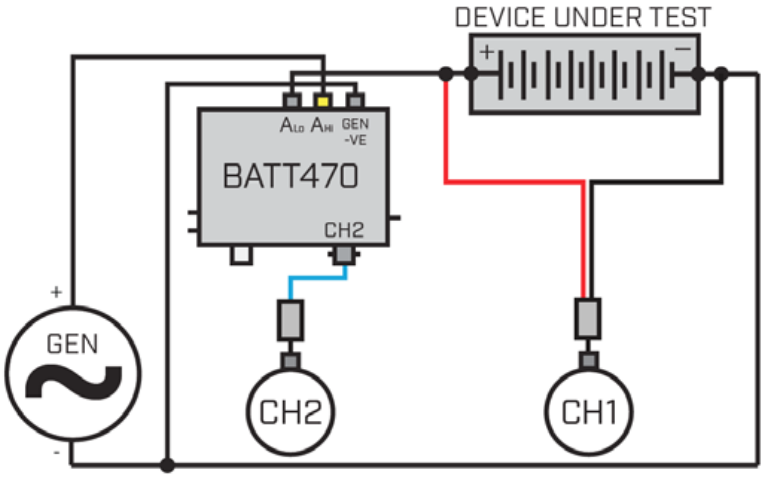
Analyzing EIS: Modeling

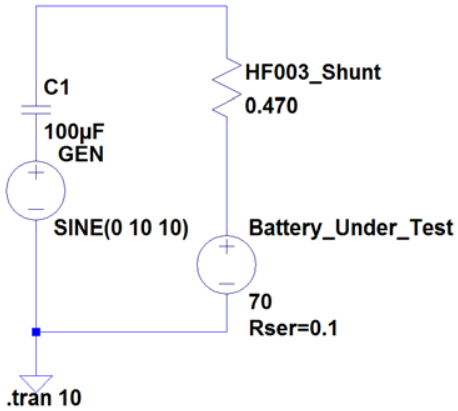
- Elektro chemische cellen zijn te modelleren als een netwerk van passieve elektrische componenten.
- Een zogenaamd “Equivalent circuit”
-
- Zoals de veelgebruikte Randles Cell

Electrochemical Impedance Spectroscopy

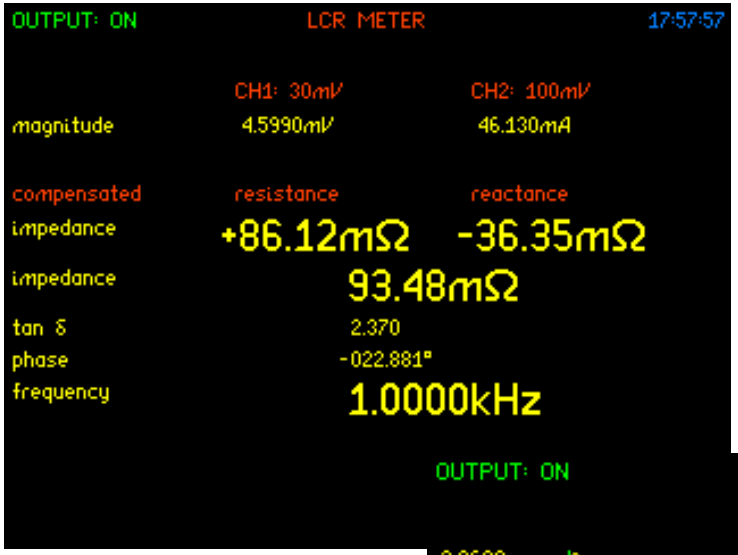
Nominal voltage	1.5 V
Impedance	81 m-ohm @ 1 kHz
Typical weight	24 g (0.8 oz)
Typical volume	8.4 cm^3 (0.5 in^3)
Terminals	Flat
Storage temperature range	5°C to 30°C (41°F to 86°F)
Operating temperature range	-20°C to 54°C (-4°F to 130°F)
Designation	IEC: LR6

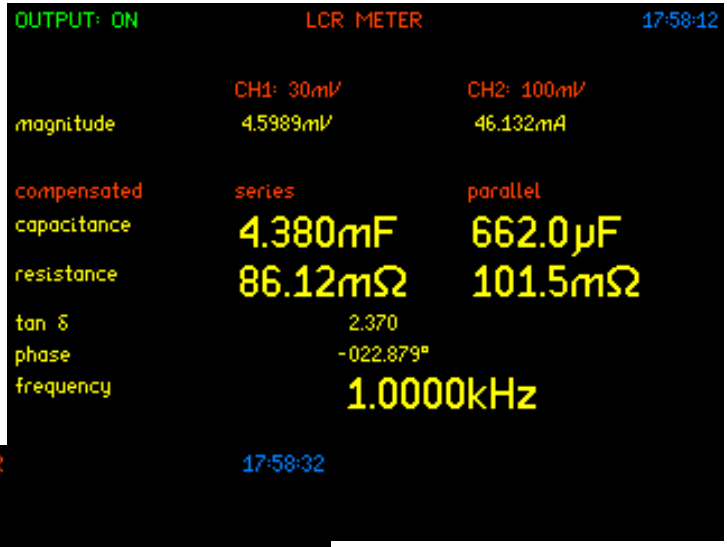
EIS experiment

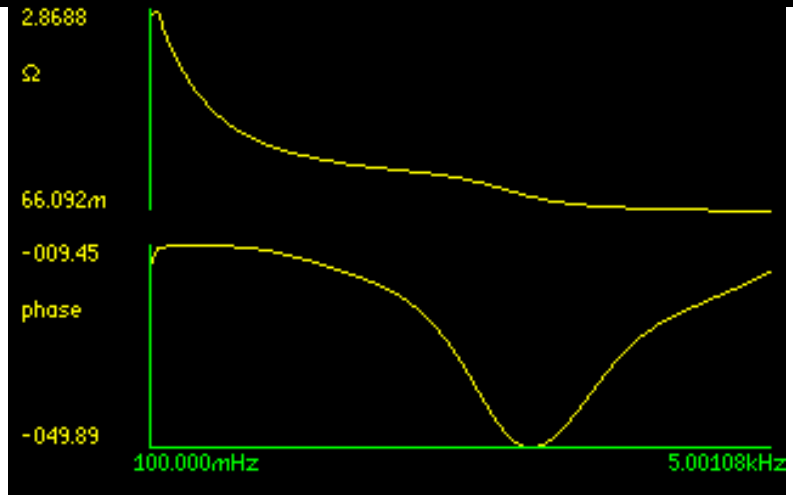




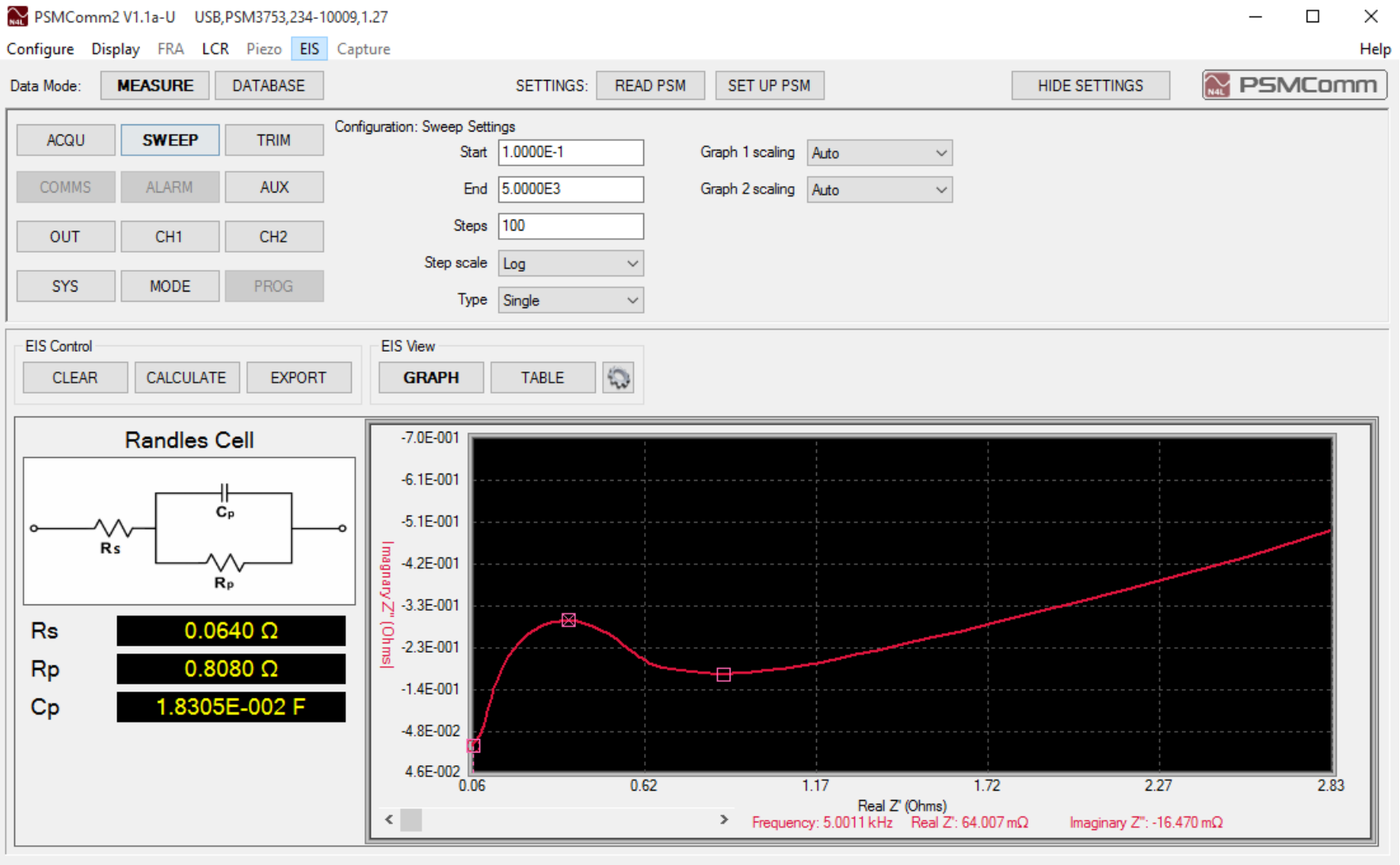
Electrochemical Impedance Spectroscopy



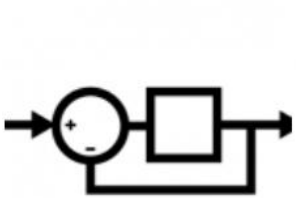




Electrochemical Impedance Spectroscopy

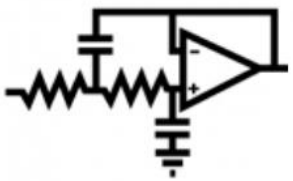


Applications



Control Loop Stability Analysis

Transistor Performance Analysis

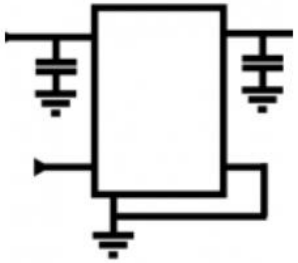


Filter Design

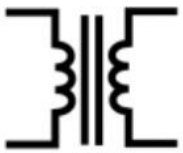
Audio Amplifier Design

OptoCoupler Evaluation

Coax Cable Frequency Response

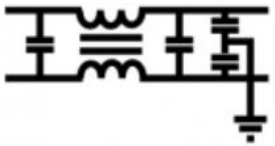


LDO Regulator Evaluation



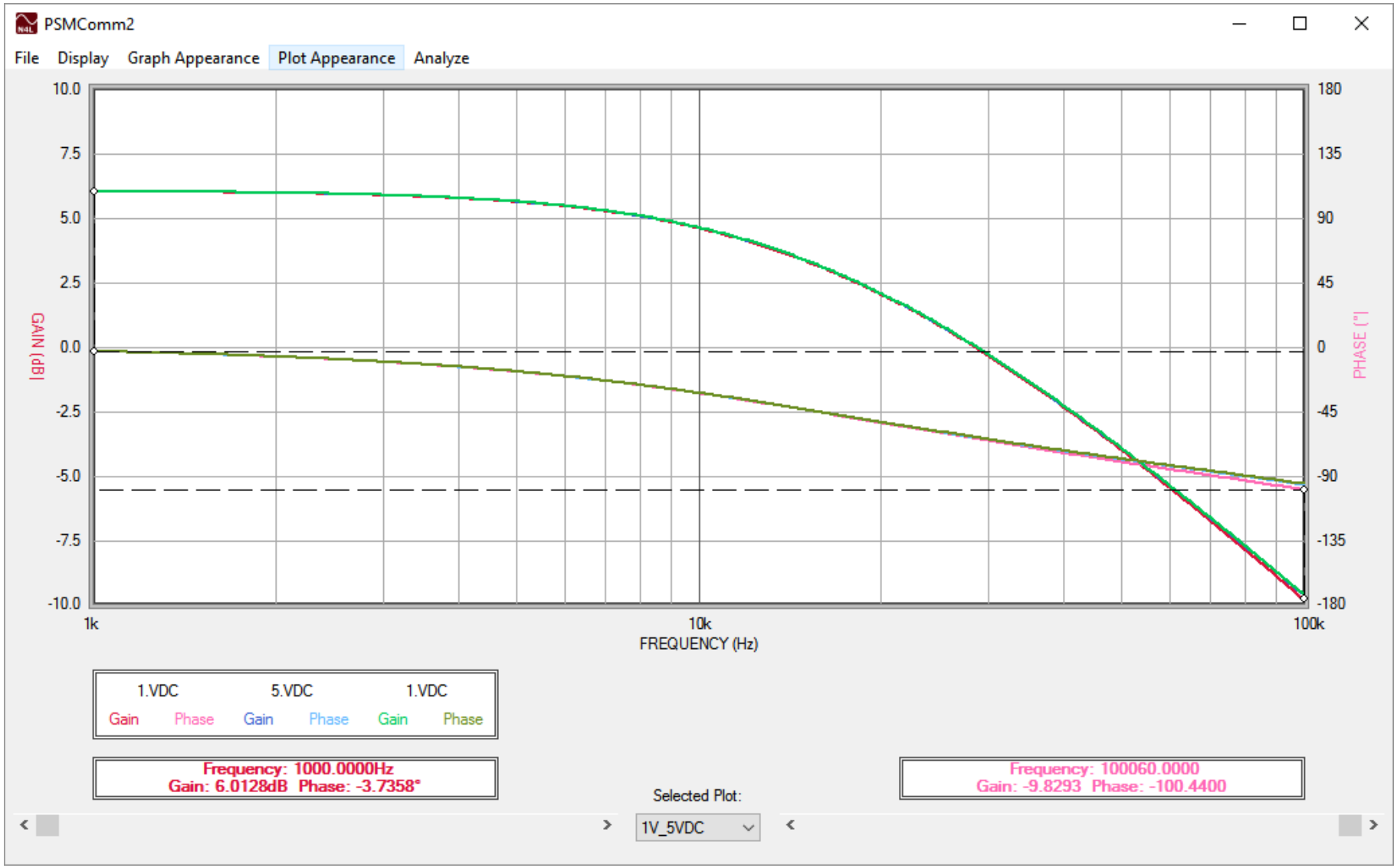
Signal Transformer Performance Evaluation

Cross Talk Testing



RFI/EMC Filter Design

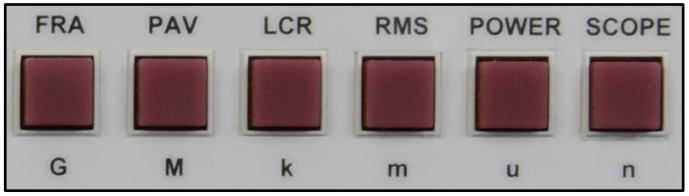
FRA Mode – Active Low Pass Filter Design

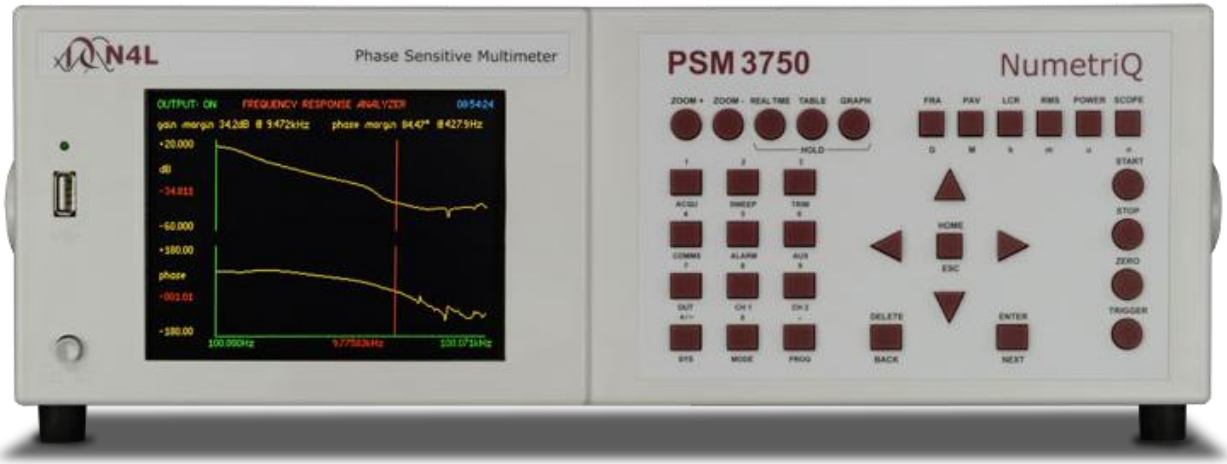


N4L PSM Series – Not just an FRA

The PSM series of instruments offer more than just accurate frequency response (gain/phase) measurement.

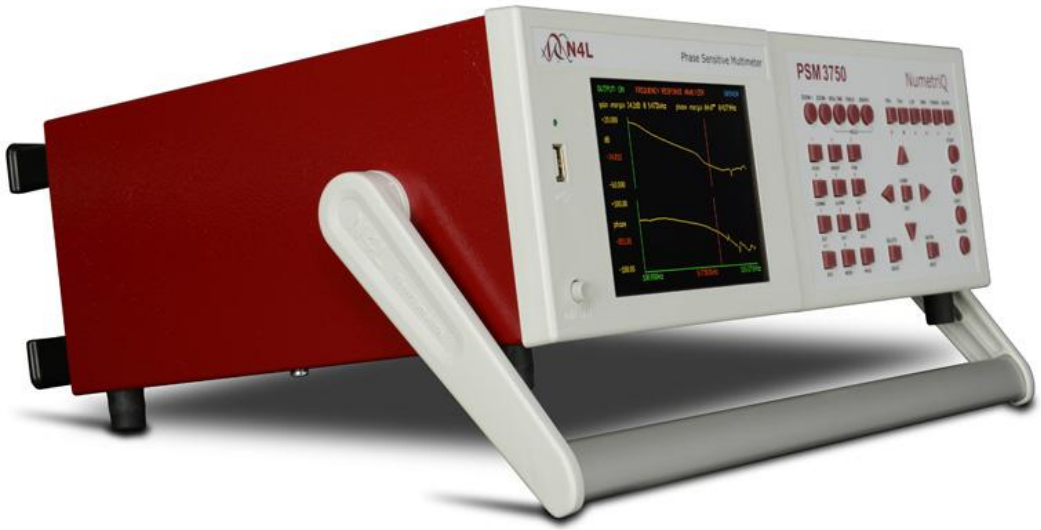
This presentation will explore the various modes within the PSM range of analysers and how you can exploit them during research and development work





N4L Frequency Response Analysers

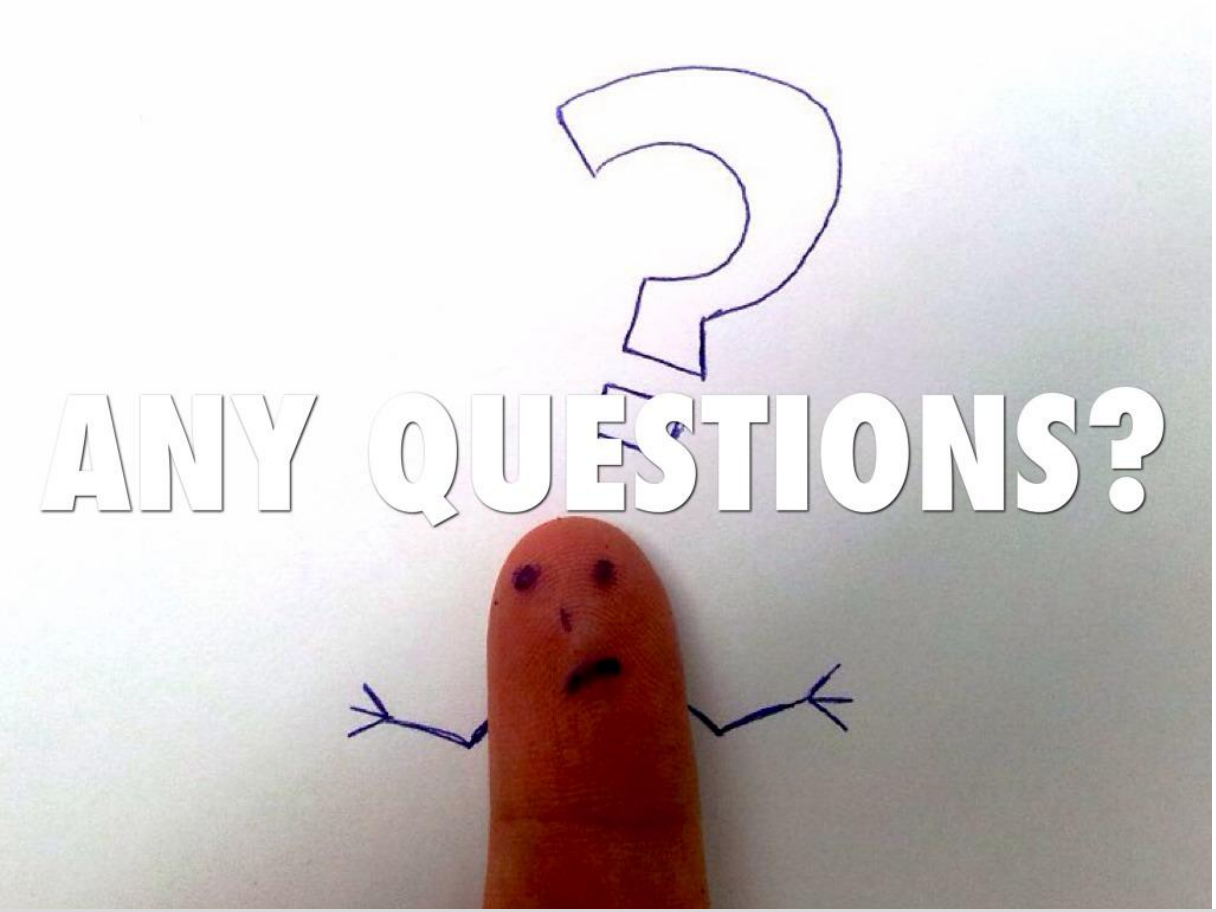
Electrochemical Impedance Spectroscopy



Een “multipurpose tool” voor elke R&D Engineer.

TT&MS
total test and measurement support

Thank you for listening



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