NEISYS
Electrochemical Impedance
Potentiostat Galvanostat Analyzer

Specification

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1 Technical Data

1.1 General

Sample connections	4, 3 and 2 wire, I High, V High, V Low, I Low
System ground modes	Protective earth or floating for grounded samples
Voltage current modes dc and ac	Potentiostat, Galvanostat, and Direct Voltage
System Interface	Ethernet (TCP/IP)
Line voltage	100 – 240 V ac, 50 – 60 Hz
Power consumption	< 30 W

1.2 Environment

Operating temperature	0 °C to 40 °C
Storage temperature	-10 °C to 60 °C
Specification limits	18 °C to 28 °C
Humidity	< 60 %

1.3 Frequency Domain (Impedance) Mode

Frequency range	(3 µHz, 3 mHz) [1] – (100 MHz, 50 MHz, 10 MHz, 1 MHz, 100 kHz) [2]
Impedance range	10^{-4} Ω – 10^{12} Ω (upgradable to 10^{14} Ω)
Capacitance range	1 fF – 1 kF
Inductance range	100 nH – 1 kH
Basic Accuracy:[3]	
|Impedance|, |Capacity|, |Inductance|	0.1 % or 0.03 % [4]
Phase angle δ	0.006° or 0.03° [4]
Loss factor tan(δ)	10^{-4} or $5 \cdot 10^{-4}$ [4]

[1] Depending on Extended Functionality option EXF

[2] Depending on Frequency option

[3] For details, cf. the specification charts in Impedance Measurement Ranges and Accuracy.

[4] Depending on High Accuracy option HAC

1.4 Signal output I High

Voltage at max. current	±10 V ac and dc
Current in to grounded load	±500 mA ac and dc
Min ac output voltage	2 µVrms
Output resistance	0.5 Ω

1.5 Time Domain Mode

Max. sample rate	10^7 or 10^6 samples/s [5]
Sample rate modes	Adjustable for each waveform ramp element or fixed within experiment [6]
Maximal scan rates	60 V/µs or 2.5 A/µs
Minimal pulse duration	0.1 µs or 1 µs [5]

1.5.1 Counter Electrode Polarization I High

Voltage	±10 Vp dc and / or ac max.
Output voltage ranges	0.1 V, 0.5 V, 1.1 V, 2.4 V, 5 V, 11 V
Accuracy and resolution ac + dc	
Potentiostat Mode	Same as for V High, V Low voltage inputs
Direct Voltage Mode	0.1 % of output voltage range ±100 µV accuracy, $3 \cdot 10^{-5}$ of output voltage range resolution
Current	±500 mAp dc and / or ac

[5] Depending on Sample Rate Option

[6] Depending on Extended Functionality option EXF

1.5.2 Accuracy and resolution ac + dc

Galvanostat Mode	Same as for I Low current input
Output Power	5 W max
Max. Internal Power Dissipation	500 mA max. current into shorted load without overheat shutdown
Output Resistance	0.5 Ω
Bandwidth	dc – 100 MHz
Galvanostat voltage limit	0 – 11V
Accuracy	0.1 V
Potentiostat current Limit	5 mA – 500 mA
Accuracy	(1 % or 0.1 % [7]) of value

1.5.3 Reference Voltage Inputs V High, V Low

Configurations	Single or differential configuration
Voltage ranges	±1.1 V, 11 V
DC Accuracy	10^{-4} of range + 10^{-3} of measured value
DC Resolution	10^{-6} of range

Input impedance	> 10^{12} Ω | 10 pF
Input Bias Current	< 1 pA
Bandwidth	dc – 100 MHz

1.5.4 Working Electrode Current Input I Low

Current Ranges	5 nA – 500 mA in factors of 10
DC Accuracy	10^{-4} of range + 10^{-3} of measured value
Resolution	10^{-6} of range
Bandwidth	dc – 100 MHz

[7] Depending on High Accuracy Option HAC

1.5.5 Main Control Loop

Operation modes	Potentiostat, Galvanostat and Direct Voltage
dc accuracy	$3 \cdot 10^{-5}$ of range
Time constants	0.3 ms – 3 s in factors of 3.33
Bandwidth	dc – 10 MHz

2 Impedance Measurement Ranges and Accuracy

2.1 Accuracy of Impedance Measurement with Option HAC

The specifications below applies for

- Direct Voltage or Potentiostat modes
- Time constant 100 µs
- No dc voltage or current
- Auto ranging for impedance measurements on,
- 0.5 s measurement time
  Ac sample voltage ±0.03 Vrms – 7 Vrms
- Sample connected to the front panel BNC terminals

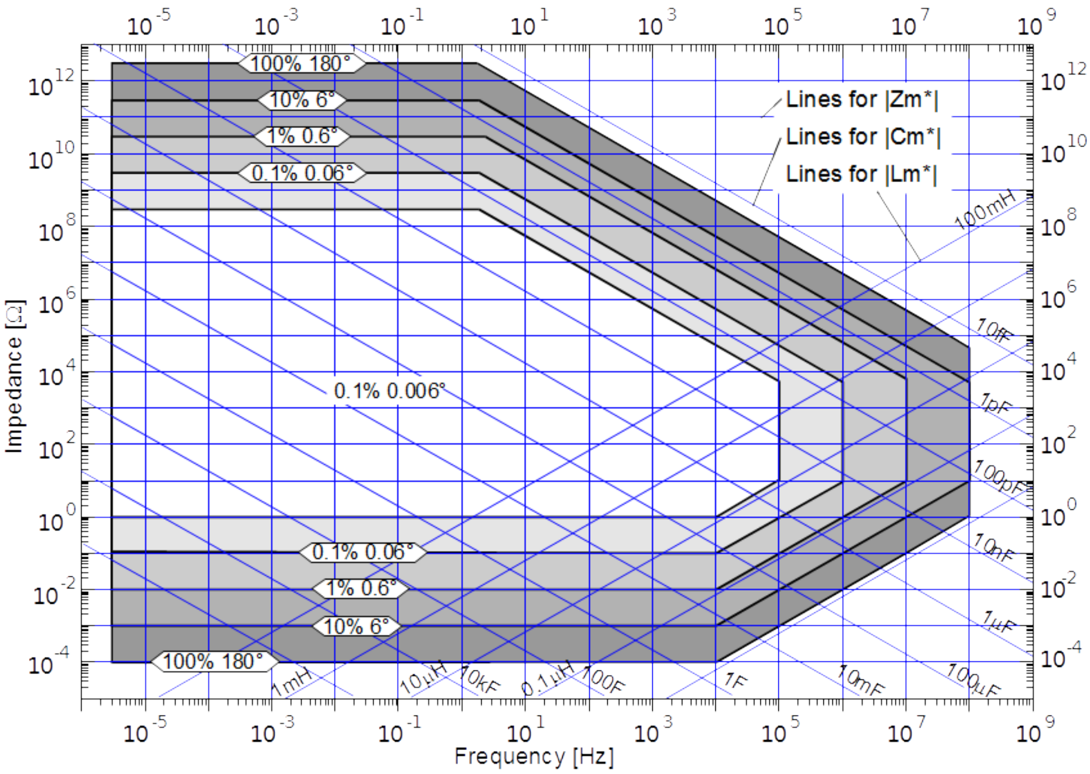

Fig. 1: NEISYS impedance measurement accuracy with option HAC (high accuracy)

For impedance points in the areas between the lines of constant accuracy, the accuracy should be interpolated from the neighboured lines of constant accuracy.

The labels within the inner areas show the accuracy inside.

2.2 Accuracy of Impedance Measurement without option HAC

The specifications below apply for

- Direct Voltage or Potentiostat modes
- Time constant 100 µs
- No dc voltage or current
- Auto ranging for impedance measurements on,
- Measurement time 0.5 s
- Ac sample voltage ±(0.01 – 7 Vrms)
- Sample connected to the front panel BNC terminals

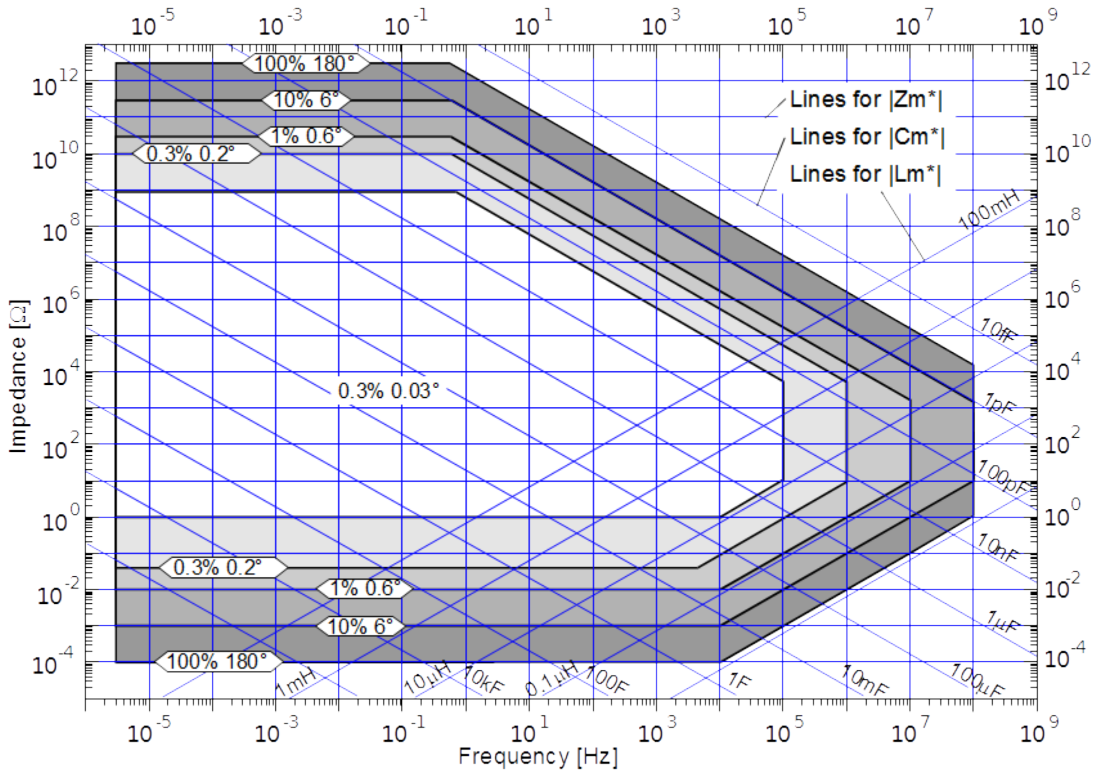

Fig. 2: NEISYS impedance measurement accuracy without option HAC (high accuracy).

For impedance points in the areas between the lines of constant accuracy, the accuracy should be interpolated from the neighboured lines of constant accuracy.

The labels within the inner area shows the accuracy inside.

2.3 How to use the impedance accuracy specification

Consider a measured impedance point *Zm** represented by its absolute value |*Zm**| and phase angle ϕm. The accuracy of *Zm** can be defined by a percentage factor A with respect to |*Zm**| and a phase deviation ϕ.

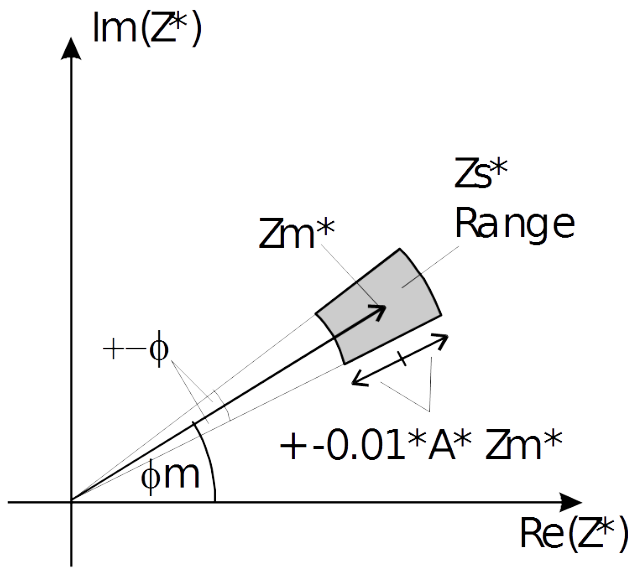

Fig. 3: Definition of accuracy area in dependence of amplitude and phase accuracy.

The true sample impedance *Zs** is in the shaded area.

A and ϕ depend on the frequency and impedance range of *Zm**. They are shown in the diagram on the previous page as lines of constant accuracy. Each line of constant accuracy is labelled by an accuracy specification. The different labels have following meaning:

Line Label	Accuracy Definition on Labelled Line
100% 180°	Limit of the available impedance range measured either by an open sample (top line) or a short sample (bottom line).

Example:

Consider a measured data point *Zm** with |*Zm**| = 10^{11} Ω at 1 Hz. It is located in the accuracy diagram between the constant accuracy line 1 % 0.6° and 10% 6°. By logarithmic extrapolation between the lines one gets the accuracy of about

±3.3 % of |*Zm**| for the |*Zs**| absolute accuracy

and

±2.2° for the absolute *Zs** phase accuracy.

In addition to *Zm**, the accuracy may be determined in the other representations measured capacity *Cm**, measured inductance Lm* or measured admittance *Ym**. These quantities are related to *Zm** by

$$Cm^* = -\frac{j}{\omega\, Zm^*} \tag{1}$$

$$Lm^* = \frac{Zm^*}{j\omega} \tag{2}$$

$$Ym^* = \frac{1}{Zm^*} \tag{3}$$

with ω = 2 π frequency and j = imaginary unit.

As can be seen from the above equations, all conversion only affect the phase angle by constant shift of ±90° (*Lm**, *Cm**) or leave the phase angle unchanged (*Ym**). Therefore the phase accuracy is the same for all four representations and the amplitude accuracy is only affected by the absolute value of each representation. The corresponding lines for |*Cm**| (linear decreasing impedance with ω) and Lm* (linear increasing impedance with ω) are shown in the accuracy specification. The lines for |*Ym**| correspond to the horizontal lines for |*Zm**| if inverted. From these lines, the accuracy can be determined for all representations.