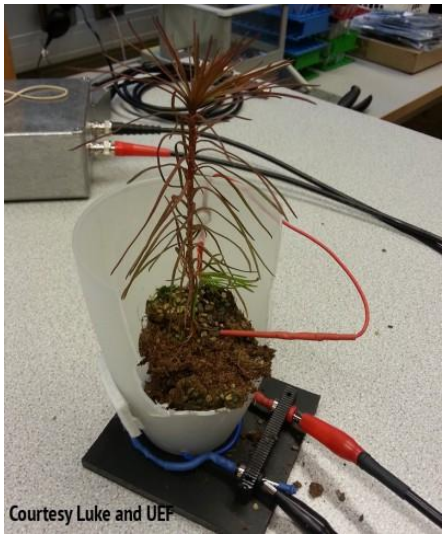
"Simitec - Revealing future of measuring"[1]

EIS-100

Impedance gauge



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DESCRIPTION: Electric Impedance Spectrometer

MECHANICAL

- dimension: 120,5x120,5x59,2 mm (aluminium alloy box, Fig. 1)
- input terminals (two BNC adapters)
- weight ca. 450 g
- protection class IP30

Fig. 1. EIS-100 box.

INPUT

- operating power via a USB2 cable from computer
- input/output signals through coaxial cable joint with BNC adapter. Electrical properties of coaxial cable are considered in footnote [2].

OUTPUT

- signals through USB2 cable to computer

MEASURING RANGE

- impedance 1 kΩ - 10 MΩ
- frequency 1 kHz - 1MHz (c.f. β-dispersion regime [3])
- signal resolution 0.1Hz in the range of 1kHz - 100kHz
- number of frequencies up to 512
- selectable regimes for measuring peak to peak (V_{pp}) signal levels: 200mV, 400mV, 1V and 2V
- averaging 10 measurements per second in Schwan's *β*-dispersion range; 1kHz to 1 MHz, which applies to both calibration and actual measurements.

[2] Specific dispersion of a shielded coaxial cable pair is considered theoretically in user manual. The knowledge of these dispersion properties is useful to understand, because dispersion has impacts to the signals of electric impedance spectroscopy (EIS). Thus, this knowledge helps to plan and execute the EIS measurement. In theoretical simulations the R, C, G and L characteristics of a coaxial cable are used, and these characteristics are appearing in literature.

[3] Repo T., Cao Y., Silvennoinen R. and Ozier-Lafontaine H., Electrical impedance spectroscopy and roots, in: Mancuso, S. (ed.), Measuring Roots - An updated approach, ISBN 978-3-642-22066-1, Springer-Verlag Berlin Heidelberg, Part I Lab Methods, Chapter 2, pp. 25-49, 2012.

ENVIRONMENT

- operating temperature 0 - 40 °C
- storage temperature -20 - 80 °C
- use of ambient humidity non-condensing 20 - 80%
- storage environment humidity non-condensing 10 - 90%

CALIBRATION

- through coaxial cables with aid of separate external resistor (c.f. Fig. 2)

Fig. 2. Calibration impedance cell.

APPLICATION EXAMPLES

- <u>In sensing of properties of the phase changes of water</u> correlated with the Brownian motion of water molecules having higher impedance |Z| level in ice than the impedance of the phase change of tap water[4] at constant electrode distance (Fig. 3).[5]

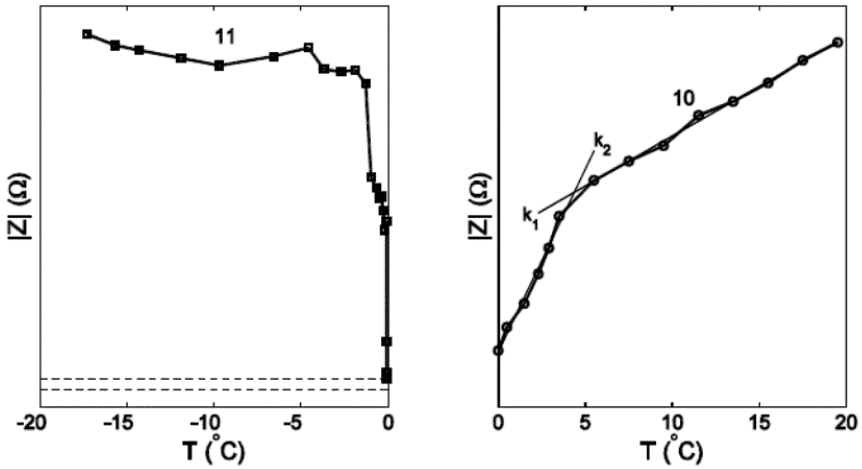

Fig. 3. Phase transition in water: ice left and water right. The horizontal dashed lines indicate the range of variation of impedance moduli (|Z|) in water plotted on ice diagram.

[4] The magnitude responses k_1 and k_2 of |Z| for water, revealing the phase transition at +4°C locate, between the dashed lines on the |Z| response for ice.

[5] Device for determining the phase of water is protected by a patent FI11312.

- In sensing the waters phase change properties within soil is correlated with the Brownian motion of water molecules having higher impedance |Z| in ice, than in water (Fig. 4).

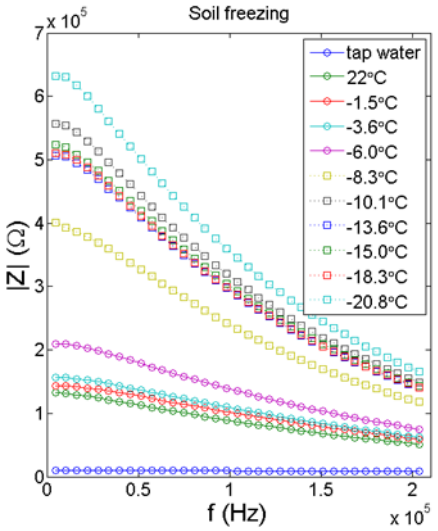

Fig. 4. EIS electrodes in soil for freezing test and the effect of severity of freezing to |*Z*| responses.

- In sensing of bio-properties of roots of a plant seedling (by using a cell connected to EI-gauge, Fig. 5) after different treatments as
  - temperature
  - drought
  - flood
  - fertilization
  - environmental pollutants etc.,
  - affecting changes in ion balance of root tissue.

Fig.5. Seedling cell for EIS measurements.

EIS-100 SPECTROMETER MEASUREMENT SETTINGS AND PLOT

SETTINGS DOMAIN - SETTINGS TABS is shown in Fig. 6.

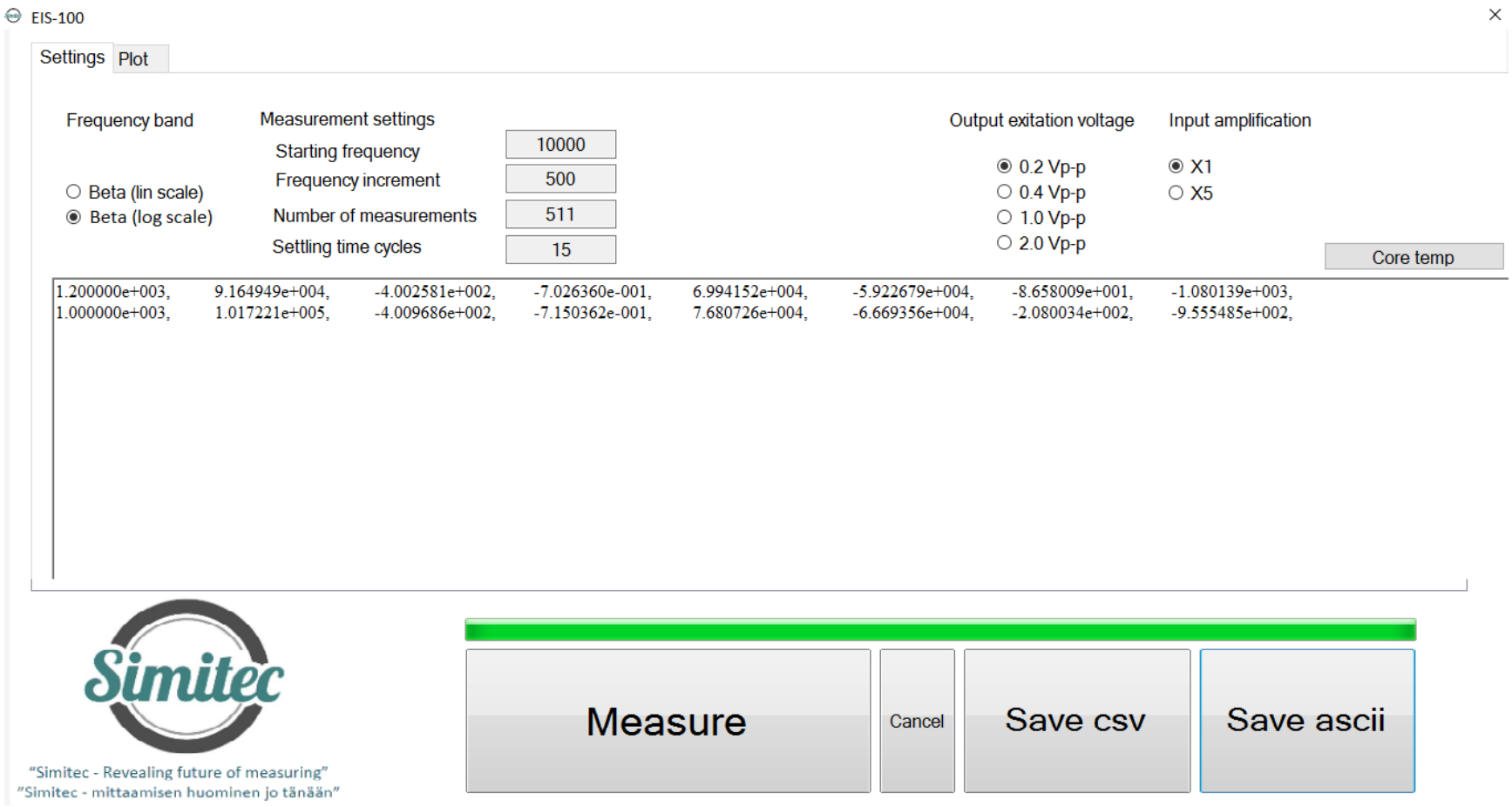

Fig. 6. EIS-100 Spectrometer setting domain, after the setting of the measurement parameters ("Settings"): measurement with "Measure" button, possible interruption of measurement with "Cancel" button, recording of measurement data in either csv and / or ascii format (with buttons "Save csv" and / or "Save ascii").

- Frequency band
  - *Beta* (lin scale) button can be used to select a frequency range (1 kHz -1 MHz). The maximum number of frequencies to be selected is 512. The frequency range is known as Schwan's β-dispersion range. The sampling rates are selectable from the "Starting frequency" button, the frequency increment ("Frequency increment") and the total number of measurement points ("Number of measurements"). It is also possible to select other sample quantities that are smaller than the maximum number of samples.
  - *Beta* (log scale) button can be used to select the entire frequency range (10 kHz -300 kHz). The maximum number of frequencies to choose is 42 and is fixed. The frequencies are listed in the footnote[6]. When "Beta (log scale)" is selected, in the selection icons below, the "Measurement settings" buttons are deactivated: "Starting frequency", "Frequency increment", "Number of measurements" and "Settling time cycles".

- Select the V_{pp} voltage level ("Output excitation voltage") of the sinusoidal measurement signal: $0.2V_{pp}$, $0.4V_{pp}$, $1.0V_{pp}$ or $2.0V_{pp}$.

- If the result obtained with the selected sinusoidal V_{pp} measurement signal proves to be noisy, the noise level can be reduced by internal signal amplification by selecting X5 instead of X1 ("Input amplification"). The buttons X1 and X5 have no effect on the selected V_{pp} level[7].

- Setting the recovery time between the Impedance Measurement by using the “Settling Time Cycles” by entering a numeric value (e.g. 15 is sufficient) in the field.

- In this version, the effect of cables on impedance is not repairable.

- "Core Temp" button can be used to monitor the temperature of the spectrum of the spectrometer (processor) - and no changes can be made through the button.

Recording a measurement result can be done either directly (without preview) or through the preview icon via the "Save csv" and "Save ascii" buttons, which prompts you for a file associated with the recording.

PLOT DOMAIN is shown in Fig.7.

[6] [10339 11223 12183 13225 14355 15583 16915 18362 19932 21636 23486 25494 27674 30040 32609 35397 38423 41709 45275 49146 53348 57910 62861 68236 74071 80404 87279 94742 102843 111636 121181 131543 142790 155000 168253 182639 198256 215207 233608 253583 275265 298802].

[7] Recommended combinations of Vpp, X1 and X5 for different impedance ranges are shown in user manual.

Fig. 7. EIS-100 plotting domain, where the scan of the measurement results ("Plot") within the program is activated. It is also possible to record data from this icon using "Save csv" and / or "Save ascii". Additionally, saving images to jpg format can be done using the "save" keys.

- The "Plot" icon has three preview "Plot settings" options
  1) "| Z | and delta" i.e. impedance module = $\sqrt{\mathrm{Re}^2 + \mathrm{Im}^2}$ and phase angle as a function of frequency,
  2) "Re and Im", i.e. the real and imaginary part of the impedance, as a function of frequency and

3) "-Im (Re)", that is, a negative impedance imaginary part as a function of the real part of the impedance (known as Wessel plot), whereby the parameter is a frequency.

RECOMMENDED CUSTOMER GROUP

- Education
- Schools

PRICE

- EIS-100; Electric Impedance Spectrometer 2 480,00 € (*Device, control unit, USB2 cable and one calibration impedance as shown in Fig.2*)[8]
- EIS-100; Installation media and operating license 890,00 € (*Software and license for software for measuring instrument*)[9]
- EIS-100; Sample cell for the root measurement 150,00 € (*Measuring cell with 1 m coaxial cable pair*)
- EIS-100 (Option); Program called the Appropriate Gain Indicator 450 €. (The program will be embedded into the operating license. This will help the operator select the correct gain range so that the impedance to be measured will not be distorted).
- Laptop (Option)

  Key features (minimum requirements):
  - anti-glare 15.6 "HD WLED Display (1366x768) or better
  - 5th Generation Intel Core i5 2 core processor (max 2.70GHz) or equivalent
  - integrated Intel HD Graphics 5500 graphics card or better
  - 4GB DDR3L memory or more
  - 320GB SATA hard disk or larger
  - WLAN and Bluetooth 4.0
  - min. 2pcs USB 3.0 and 1pc USB 2.0 connectors
  - Gigabit Ethernet (RJ-45) network interface
  - operating system Windows 7 Pro 64bit or higher (e.g. Win10)

IN TOTAL: **3520 € (VAT 0%) [10] ;** EXW Joensuu

[8] Electric Impedance Spectrometer, Laptop and Installation media with operating license are the basic set and are therefore mandatory.

[9] To installation the software there exist several options: (i) The subscriber can do it firsthand, (ii) The supplier can do it through a reliable internet connection, (iii) The subscriber purchases a laptop that meets the above minimum requirements and sends it to the vendor for software installation, or (iv) The supplier purchases the laptop, installs necessary software and invoices the subscriber separately for laptop price and installation work according to the Simitec Ltd service price list.

[10] Changes to prices are reserved.

Terms & Conditions
Equipment CIP JOENSUU (Incoterms 2010). Other terms and conditions according to TK Services 2010. The ownership of the supplied equipment will be transferred to the subscriber when the entire trade amount has been paid to the supplier. Equipment and work not mentioned in this offer and its annexes and other components are treated as additional work.

Delivery terms in the following order: 1. EIS-100 Price list, 2. TK Services 2010

Transfer of risk
The risk is transferred to the Subscriber when the goods are handed over to the subscriber or transported by an independent carrier in accordance with the contract, subject to the delivery clause.
If the item is not handed over at the right time and this is due to the fact that the Subscriber or the Subscriber is involved, the Liability shall be transferred to the Subscriber when the Supplier has done what he or she is required by the contract to enable the transfer.

Delivery time
Delivery time is agreed separately. The Agreement enters into force when the Subscriber's written order confirmation (including e-mail is accepted) has been received and confirmed from the Supplier's side to the Subscriber.

Payment terms
The terms of the offer are as follows. Late interest rate 10.5%.
60% when ordering the total price of item, 14 days net.
40% of the total price of item EXW, 14 days net
Additional work and any other supplies and equipment not included in the delivery will be billed after delivery, 14 days net.

Warranty and maintenance
The warranty for the devices to be delivered is 12 months from the time the equipment is ready for EXW. The warranty does not include travel and accommodation costs.
This offer includes EIS-100 for email and phone support for the warranty period without any charge. If the Subscriber makes his own changes to the EIS-100 system, the warranty will expire. The repair of the program is done by Simitec Ltd and the costs are invoiced according to the company's service price list and they are charged 100% afterwards, 14 days net.
After the warranty period, the training, support and installation services and repair work will be billed according to the current Simitec Ltd service price list and will be charged afterwards at 100%, 14 days net.
For example, the cost of repairing a bug or installing an update will be charged on the basis of work hours and parts used for repair after work.

Fee for additional work
Additional and modifications must be agreed in advance and are based on a service price list. Other costs will be charged to actual amounts based on the Supplier's selling prices and terms and conditions set out in the Job Charging Pricing Schedule.